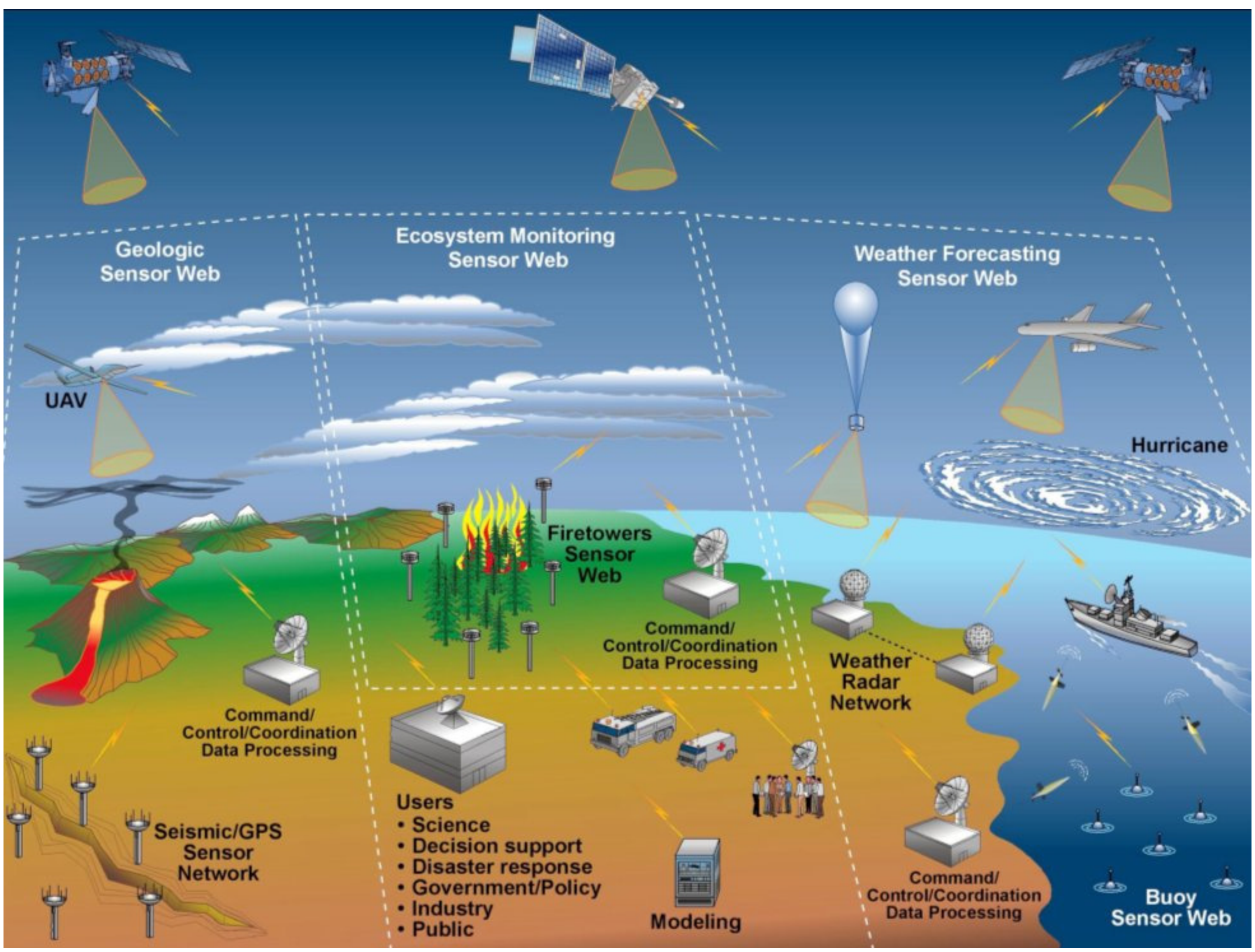
2008 Report from the Earth Science Technology Office (ESTO) Advanced Information Systems Technology (AIST) Sensor Web Technology Meeting

April 2-3, 2008



Acknowledgement

This report represents the extensive effort and support of many individuals both within and outside of the National Aeronautics and Space Administration (NASA) and from the sensor web community. The members of the Earth Science Technology Office (ESTO) Advanced Information Systems Technology (AIST) projects who attended the meeting are listed in the breakout group reports (Sections 3.1, 4.1 and 5.1). The editors would like to acknowledge the work of the AIST team lead, Karen Moe, and the primary authors, Bradley Hartman, April Gillam, and Thomas Eden, from The Aerospace Corporation.

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1 Executive Summary

This report documents the proceedings of the second NASA Earth Science Technology Office sponsored sensor web meeting, which took place on April 2 - 3, 2008. The primary objectives of this meeting were to:

- Increase the awareness and understanding of Earth science sensor web features and benefits within the investigator teams, for the Earth science community, and for NASA managers;
- Interactively explore and document sensor web use case scenarios for Earth science applications, including the Global Earth Observation System-of-System (GEOSS);
- Relate these use cases to the National Research Council's Decadal Survey [DEC 07]; and
- Provide a forum for collaboration and furthering the technology infusion goals of the AIST program, including plans for demonstrating use cases using prototype technology developed by the investigator teams.

Developing use cases as a means of capturing system requirements and processes is a leading edge application of modeling techniques to non-software systems. Traditionally, use cases capture system requirements prior to software development [BITTNER 02]. This technique is uniquely suited to describing the capabilities of the sensor web approach to Earth observation goals. The resulting use cases will serve ESTO's need to describe the benefits that the sensor web concepts bring to NASA's Earth science challenges. All seven (7) thematic focus areas identified in the Decadal Survey were addressed in the use cases developed during this conference, as indicated in Table 1.

Table 1. Decadal Survey Theme Coverage

Decadal Survey Theme	Use Cases
Earth-science applications and societal needs	28
Land-use change, ecosystem dynamics, and biodiversity	17
Weather (including space and chemical weather)	16
Climate variability & change	12
Water resources and the global hydrologic cycle	12
Human health and security	11
Solid-Earth hazards, resources, and dynamics	7

In all, 46 investigators from academia, NASA, and industry were in attendance, representing a broad cross-section of the research being conducted in science, sensor web technologies, and applications. During the meeting, the investigators were divided into three separate groups, each of which focused on a different technology area. These areas were:

1. Middleware 1 – Model Interoperability;
2. Middleware 2 – Systems Management; and
3. Smart Sensors.

While in the breakout groups, investigators presented their works-in-progress, depicting current use cases, from which lively discussions ensued. These use case scenarios were further refined by the investigators in real-time during the conference. After significant discussion and collaboration, several representative use cases were selected from each breakout session for presentation to the conference as a whole. The groups were asked to provide feedback on lessons learned and recommendations for promoting sensor web technologies.

This report describes the proceedings of the conference and also contains a compilation of all 41 sensor web use cases presented and developed during the conference. Key terms, features, architectures, and applications are documented throughout the use cases, which were grouped according to earth science theme, including Atmospheric Composition, Earth Surface & Interior, Climate Variability & Change, Carbon Cycle & Ecosystems, Weather, and Water and Energy Cycle. In addition, the patterns, themes, and technology gaps identified during the conference are documented.

The resulting use case scenarios developed during the conference represent fundamental and practical applications of sensor web technologies to Earth science challenges. Starting from the sensor web concepts, which were clarified and described at the first meeting in 2007, these 2008 use case scenarios were developed to:

- Describe how a distributed collection of resources (e.g., sensors, satellites, forecast models, and supporting systems) can collectively behave as a single, autonomous, task-able, dynamically adaptive and reconfigurable observing system; and
- Describe how raw and processed data, along with associated meta-data, can be collected via a set of standards-based service-oriented interfaces.

The use case scenarios were developed to communicate key sensor web features, including the following:

- The ability to obtain targeted observations through dynamic tasking requests;
- The ability to incorporate feedback to adapt via autonomous operations and dynamic reconfiguration; and
- Improved ease of access to data and information.

Finally, scenarios were developed to highlight key sensor web benefits, such as the following:

- Improved resource usage where selected sensors are reconfigured to support new science questions;
- Improved ability to respond to rapidly evolving, transient phenomena via autonomous rapid reconfiguration, contributing to improved tracking accuracy;
- Demonstrate cost effectiveness, derived from the ability to assemble separate but collaborating sensors and data forecasting systems to meet a broad range of research and application needs; and
- Improved data accuracy, through the ability to calibrate and compare distinct sensor results when viewing the same event.

The NRC Decadal Survey provided the backdrop to the sensor web deliberations. In addition to recommending new Earth observation missions to NASA, the Decadal Survey panels highlighted the significance of the societal benefits resulting from an integrated strategy for science and applications from space. By projecting existing and near-term use cases into the future decade, the use case scenarios developed at this conference are an attempt to illustrate how the capabilities envisioned by the Decadal Survey might be employed.

The conference was successful in addressing all of the above features and benefits of sensor webs to future NASA Earth science goals. During the meeting discussions, additional capabilities were identified and some common themes emerged such as autonomous sensor operations, autonomous data productions, and user support (i.e., tools to support the design and management of sensor webs). The following list highlights the sensor web capabilities that the participants discussed in the use cases detailed in this report.

- Sensor webs, being system-of-systems, are scalable, and supporting technologies allow systems to interoperate, supporting disparate data content and interfaces.
- Sensor webs detect events and respond by autonomously tasking sensor resources and feeding results into models in near real-time.
- Sensor webs have been successfully used to support autonomous flight plans for unmanned aircraft.
- Sensor webs can support calibration and validation of future Decadal missions.
- Sensor web approaches enable autonomous management of sensor resources, notably power and communications for in situ sensors.
- Sensor observations can influence models to improve forecasts and how model predictions can influence sensor observations to collect the most relevant observations at the time they are most needed.

- Sensor webs can improve the accuracy of predictions and the handling of uncertainty in forecast models.
- Sensor webs can also validate model results and design field campaigns to optimize resource use and science results. This involves methods to enable smooth assimilation of in situ and satellite data into models.
- Sensor webs can be implemented using repeatable patterns of assembling sensors and data processing systems, reusing the same middleware systems for different application domains, such as monitoring and responding to a fire or a volcano or a flood.

The set of use case scenarios documented in this report exemplifies a full suite of capabilities to transform sensor data and model outputs into Earth observation information as recommended in the Decadal Survey.

2 Introduction

NASA's February 2005 publication, NASA's Direction 2005 & Beyond, stated, "NASA will develop new space-based technology to monitor the major interactions of the land, oceans, atmosphere, ice, and life that comprise the Earth system. In the years ahead, NASA's fleet will evolve into human-made constellations of smart satellites that can be reconfigured based on the changing needs of science and technology. From there, researchers envision an intelligent and integrated observation network comprised of sensors deployed to vantage points from the Earth's subsurface to deep space. This 'sensor web' will provide timely, on-demand data and analysis to users who can enable practical benefits for scientific research, national policymaking, economic growth, natural hazard mitigation, and the exploration of other planets in this solar system and beyond." [NASA 05]

"As the lead technology office within the Earth Science division of the NASA Science Mission Directorate, the Earth Science Technology Office (ESTO) is focused on the technological challenges inherent in space-based investigations of our planet and its dynamic, interrelated systems." [ESTO 06] The ESTO's Advanced Information Systems Technology (AIST) program, a program to identify, develop, and (where appropriate) demonstrate advanced information system technologies, released a solicitation, AIST Research Opportunities in Space and Earth Sciences (ROSES-05), to focus attention on technologies for sensor webs. The research announcement included the plan to host a series of principle investigator workshops to enhance collaboration and further the technology infusion goals of AIST. The ESTO AIST sensor web program consists of 35 projects, covering a range of topics including smart sensing, sensor web communications and middleware, and enabling model interactions in sensor webs.

In February 2007, the ESTO sponsored its first sensor web meeting, organized by the AIST team and led by Karen Moe. Consisting of the NASA-sponsored sensor web research community, the primary objectives of this meeting included increasing awareness and understanding of sensor webs amongst the participants and the Earth Science community, and defining a sensor web architectural concept (including high-level architectural figures, definitions, and a specification of the scope of the sensor web concept). Refer to the "Report from the Earth Science Technology Office (ESTO) Advanced Information Systems Technology (AIST) Sensor Web Technology Meeting" for more detail. [NASA 07]

In April 2008, the ESTO sponsored its second sensor web meeting, again organized by the AIST team, led by Karen Moe, and consisting of the NASA-sponsored sensor web research community. The primary objectives of this meeting were to define a set of use cases to illustrate how sensor web technology will be used, and to relate these use cases to the Decadal Survey. [DEC07] The goal was to achieve a shared view of sensor web features and benefits to NASA Earth science. This report summarizes the results of that meeting.

2.1 Meeting Preparation

The NASA ESTO invited all investigators from the 35 AIST research projects to participate in the meeting. Prior to the meeting, ESTO asked all investigators to:

- Review the material on use cases, including the NASA-provided use case template to be used during the meeting.
- Define and be prepared to discuss at least one use case.
- Prepare a project poster for the poster session.

The group also investigated the Decadal Survey. An annotated version of the full Decadal Survey report (ref web site) was developed by the ESTO staff to highlight the needs for information technology derived from the stated goals and objectives of the National Research Council panels that were established to create the Earth observations Decadal Survey. Furthermore, the group was aware of the international Group on Earth Observations initiative for the Global Earth Observation System-of-Systems (GEOSS, http://www.epa.gov/geoss) which issued a task to explore the use of sensor webs to achieve the stated societal benefits of GEOSS. NASA is involved with the Committee on Earth Observations (CEOS, http://www.ceos.org) which has committed to be the space research arm of GEOSS. Within the CEOS

Working Group on Information Systems and Services (WGISS, http://wgiss.ceos.org), chaired by Martha Maiden, NASA is a task team that is addressing the sensor web task, and some of the AIST projects are involved in planned demonstrations.

Finally, the ESTO team updated the AIST Capabilities and Needs database for community review, including the sensor web community. These three perspectives – the Decadal Survey, GEOSS and AIST Needs – provided the backdrop for the sensor web use case development. For this report, the results are also related to the NASA Strategic Plan [http://nasascience.nasa.gov/about-us/science-strategy and http://nasascience.nasa.gov/earth-science/focus_area_list] by organizing the use cases according to the six science focus areas.

2.2 Use Case Template

The use case template was designed to capture both the summary as well as information to characterize each case. A check list is included to identify the NASA missions applicable to the use case, whether from the Decadal Survey, or current or near-term future missions. The Decadal Survey was developed with seven societal challenges, reflecting the panels constituted by the National Research Council, which the template listed for use case tracking. Sensor web features and benefits identified in the 2007 report, and AIST Needs and goals rounded out the categorization check list. The contents of the sensor web use case template were modeled after the version in Wikipedia. [http://en.wikipedia.org/wiki/Use_cases]

For the sensor web meeting objectives, the emphasis was placed on the goal, summary, and basic flow of the use case. Traditionally use cases help system developers drive out requirements for software implementation. In this situation use cases help ESTO describe the benefits of the sensor web systems approach for NASA missions and science goals by documenting what the sensor web does in a particular applications but not how it is accomplished. Participants were guided to narrow the scope of their use cases to identify a simple case representative of their sensor web, but not comprehensive. In this way, the use case only tells part of the story regarding capability but it is simple enough to understand in 3 to 4 pages. By reading across use cases, a more complete picture of the sensor web concept is portrayed without getting lost in the details.

The template also included a resource listing that identifies the data and services needed to demonstrate a prototype of the use case. The resource tables include sensor and data types (e.g., satellite, in situ sensor), descriptions and owners, service types and owners for models, event notification (e.g., alerts from seismic monitoring systems), and applications.

2.3 Meeting Process

The meeting began with a brief orientation before dividing the participants into three breakout groups, Middleware 1 (MW1) Model Interoperability, Middleware 2 (MW2) Systems Management, and Smart Sensing (SS). Each breakout group consisted of investigators (approximately 15 per session), ESTO facilitators and staff, and an editor from The Aerospace Corporation. Based on their composition, breakout groups were assigned initial use case categories to help ensure broad coverage of the Decadal Survey, NASA science themes, types of sensor web applications, and features, as depicted in Table 2.

Table 2. Breakout Group Use Case Assignments

	MW1 – Model Interoperability	MW2 – System Management	SS – Smart Sensing
Decadal Survey Mission	DESdynI	HyspIRI	SMAP
Science Focus Area	Earth Surface & Interior	Carbon Cycle & Ecosystems	Water and Energy Cycle
Application	Forecasts	Rapid Response	Sensor Calibration / Validation
Sensor Web Feature	Data Assimilation	Workflow Management	Agent Autonomy

During the breakout sessions, investigators first discussed a single use case as a group. Following this discussion of a mature sensor web scenario that was documented in a sample use case, each group brainstormed additional use case topics before breaking into subgroups to develop those use cases in parallel. During this time, Peter Fox of UCAR, who has extensive experience in developing use cases as well as being a sensor web investigator, and Karen Moe provided consultation on the use case approach for documenting sensor web capabilities. They also looked at the emerging use cases to assess coverage between groups to ensure that a diverse set of use cases would result. Breakout groups MW1, MW2, and SS developed 16, 14, and 11 use cases respectively.

The groups were also tasked to capture lessons learned during the development of their use cases. This feedback included key findings, common use case themes, new themes or AIST needs, and unique perspectives and recommendations for ESTO. Each breakout group selected a subset of their use cases for presentation to the workshop participants during the plenary session at the end of the second day. This subset of use cases featured in this report, and all use cases may be found in Section 11, Appendix C – Use Cases.

Three invited speakers provided insights on relevant work outside of NASA:

- Timothy S. Stryker, National Land Imaging Program, U.S. Geological Survey, provided an overview on the Committee on Earth Observation Satellites (CEOS) and Earth Observations to benefit society. This plenary talk provided the context for developing use cases for GEOSS, which is also mentioned in the Decadal Survey. The societal benefits noted by GEO are very similar to the societal challenges delineated in the Decadal Survey.
- Scott Tilley, Software Engineering Institute, Carnegie Mellon University and the Department of Computer Sciences, Florida Institute of Technology, spoke about some lessons learned, especially identifying difficulties that are rarely reported upon, regarding the migration of legacy components to Service Oriented Architectures (SOA) environments. His presentation clarified what constitutes a SOA (namely operations to support service discovery, implementation and invocation), and addressed common misconceptions about the architecture, standards and technology involved. The sensor web concept takes advantage of the service based approach.
- John J. Garstka, Office of the Under Secretary of Defense (Policy), highlighted key issues associated with the implementation of network-centric operations within the U.S. DoD and how their sensor nets correspond to NASA sensor webs. He discussed the need to address Return On Investment strategies. Transforming the defense forces to use information technology in order to leverage situational awareness to their benefit has some parallels to the Earth observation sensor web monitoring and response capabilities.

The abstracts for these presentations are included in Section 9, Appendix A - Keynote Speakers' Abstracts; abstracts and presentations are available on http://esto.nasa.gov/sensorwebmeeting.

Additionally, the meeting included a poster session at the end of the first day, during which time investigators were given the opportunity to display a poster or set of slides describing their ESTO AIST-funded sensor web research projects. The poster session provided the participants with a forum to discuss their sensor web capabilities and collaborate on future plans and demonstrations. Sharing technology insights and resources, and collaborating on demonstrations are ways the AIST program has sought to aide technology infusion, one of the broad goals of the sensor web solicitation.

2.4 Document Organization

This document is organized in the following manner:

- **Section 1** provides a high-level description of the 2008 Earth Science Technology Office Advanced Information Systems Technology workshop on sensor webs.
- **Section 2** provides some background, summarizes the process of the meeting and briefly describes each section of this report.
- **Section 3** summarizes the sensor web use themes that emerged during the meeting.
- **Sections 4, 5, and 6** summarize the results of the breakout sessions MW1, MW2, and SS respectively.
- **Section 7** summarizes use case coverage with respect to science theme, Decadal Survey categories, AIST needs, and sensor web benefits. This section also describes some next steps.
- **Section 8** contains a list of references used in the creation of this report.
- **Section 9, Appendix A** contains the keynote speakers' abstracts.
- **Section 10, Appendix B** contains a list of acronyms used in this report.
- **Section 11, Appendix C** contains all of the use cases that were developed during the meeting.
- **Section 12, Appendix D** contains brief descriptions of each of the investigators' AIST sensor web projects.

3 Sensor Web Use Themes

Of the more than 40 use cases that were developed, a number of themes have emerged. In these themes, some key capabilities are identified that are made possible by the use of sensor webs. The theme descriptions in this section are based on the use cases and are organized into the 3 groups: (1) Autonomous Sensor Operations, (2) Autonomous Data Production, and (3) User Support. For context, the themes are associated with the major components of the Global Earth Observing System-of-Systems Architecture, as seen in Figure 1. The GEOSS Architecture has three components – observation, data processing, and data exchange and dissemination that map to the architecture underlying many of the sensor web projects in the AIST program.

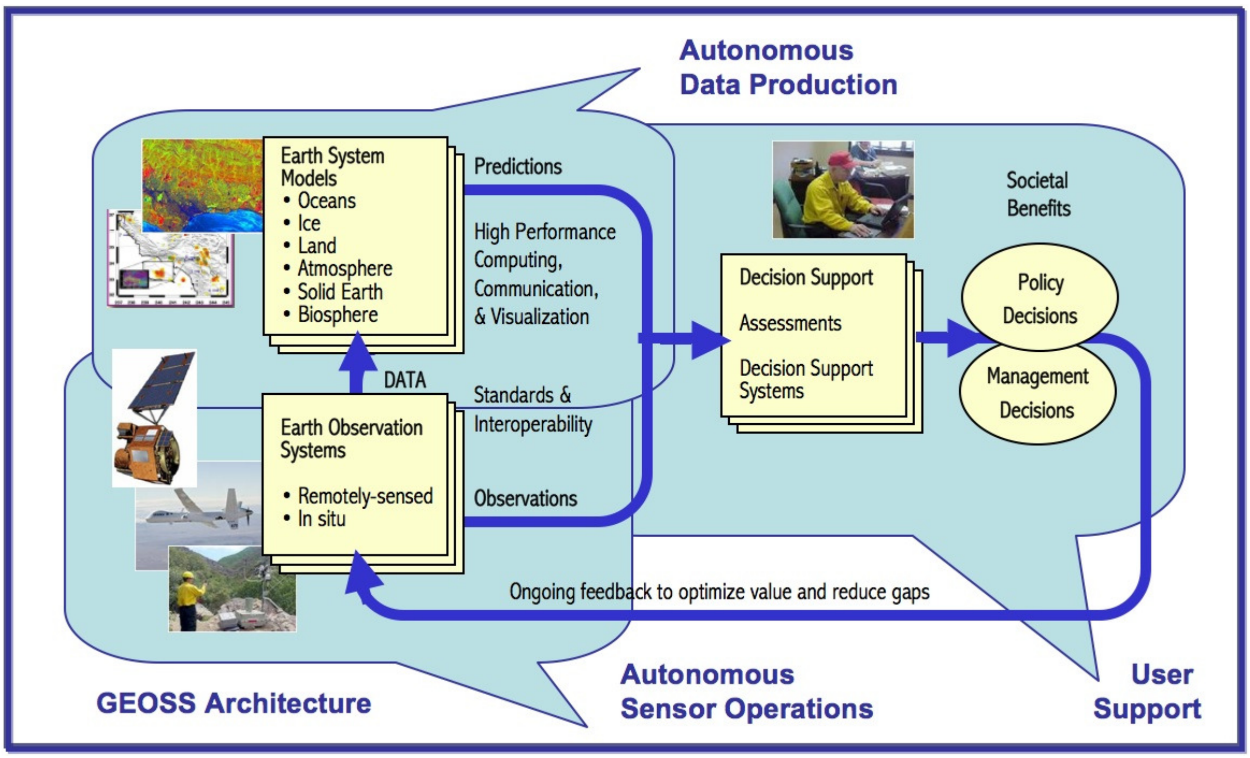


Figure 1. Sensor Web Enabled Themes

3.1 Autonomous Sensor Operations Themes

The autonomous sensor operations grouping addresses sensor web strategies that support the Earth observation component, namely satellites, other sensor platforms and their sensors. The associated ground systems that manage and control the remote sensing and in situ devices are part of this component. The following themes relate to this category of sensor web capabilities supporting sensor operations.

- Rapid response
- Autonomous tasking
- Calibration / validation
- Sensor management
- Improved data downlink

Rapid Response

Sensor webs make more information, and in particular, coordinated and directly relevant user-requested information, to be quickly available.

- **Rapid response** via timely assessment of disaster, situation, prediction of imminent phenomena (e.g., earthquake response including damage assessment and potential for subsequent earthquakes, forest fires, volcanic activity).
- **Improved rapid knowledge and prediction** of conditions and extremes (e.g., geomorphological-based landslide hazard maps and erosion).

Autonomous Tasking

A sensor web makes it possible to use one sensor, a combination of sensors, or a model to autonomously trigger other sensors and, task them to provide: rapid response, improved predictions, timelier sensor operation, better adaptation to the situation/environment, and better targeting of sensor observations.

- **Tasking observations**, **autonomously trigger** space asset data acquisition from in-situ network, monitoring indicates events used to trigger sensor with adjusted sampling rate (e.g., water quality)
- **Monitoring data used for predictions** (e.g., likelihood of volcanic eruptions - data must be rapidly downloaded, processed, and integrated with other data types)
- **Predictive, event-driven, targeted sensing** for use in coordinating the collection and analysis of other phenomena to improve predictions (e.g., improved Storm/Weather Prediction based on Lightning Monitoring and Prediction)
- **Detect and track satellite-observed phenomena**, use differences from forecasts to identify where more frequent observations are needed

Calibration/Validation (Cal/Val)

The calibration and validation of instruments is vital to ensure the quality of the data and the consistency of the results. Sensor webs provide a means whereby multiple sensors that make overlapping measurements can be used for cal/val.

- **Validation** of models (e.g., smoke forecast models, soil moisture).
- In-situ and UAV **calibration** processes for earth-observing instruments (e.g., for characterization of the ice-sheets, to see under tree canopy, soil moisture).
- **Cross-comparison** of readings from various instruments in complementary sensor webs.

Sensor Management

Management of limited resources, such as power, downlink bandwidth, and sensor operating times can increase sensor lifetime, availability, and effectiveness. With a sensor web, the communication among sensors can identify key times for sensor operation as well as when sensor operation is not productive (e.g., during cloud cover).

- **Sensor management**: conserve power and extend longevity of the instrument
- Generic **adaptive control and resource management** technology
- **Coordination of heterogeneous sensors**; monitoring is power, computationally, and bandwidth constrained

Improved data downlink capability

Sensor web technology and coordination can be applied to remote sensing assets and ground stations to increase the amount of data that can be seamlessly down linked.

- Reliable transmission of large data sets over **multiple ground stations** (“multihoming” for seamless handoff)

3.2 Autonomous Data Production Themes

The Earth system models and remote sensing data processing systems comprise the data processing component of the sensor web architecture. High performance processing and distributed analysis systems support the collaboration of interdisciplinary scientists who produce the data and information that end users need to respond to societal needs of the Earth observations. This category of use case themes includes the following:

- Data assimilation
- Forecasting
- Reducing model uncertainty

Data assimilation
Data observations from in situ and remote sensing instruments is often captured at different sampling rates, locations, frequencies, scales, etc., which necessitates software tools to make it possible to assimilate the data into models that have specific data formats and other requirements. Once those tools are available, the power of the many observations that are produced by sensor webs can be exploited.

- **Autonomous ingestion** of space data into ground network decision making
- **Integration of large data volumes** from sensors on the different platforms with different observational constraints and data formats into a common processing system; smart assimilation workflow involves **mining forecasts for interesting weather phenomena**, then determining whether other observations are coincident with the detected events. The assumption is that assimilating other observations of anomalous conditions will improve the forecast (e.g., weather forecasting).
- Dynamic assimilation of data and observations from multi-sensors by re-using standard Web services and the rapid response to be achieved through live link between sensors and science applications.
- Acquisition of **complementary views of objects, events, and processes** using sensor webs of many different instruments, on many different platforms, and in many different modalities.

Forecasting
Sensor webs make possible the capture of a greater number of and multiple types of observations providing data and ultimately information that can be ingested into models to produce higher quality forecasts.

- Improved **model assessment** and **forecasting** (e.g., air quality, earthquake, transport of pollutants)
- **Real-time ("nowcast") and forecasting** for immediate use (e.g., integration of space-based sensor data with in-situ data for search and rescue)

Reduce uncertainties, improve measurement fidelity
Sensor webs provide more coordinated, better directed, improved sampling data in the regions of interest that can be used to reduce uncertainties and increase the accuracy and fidelity of the data used to produce forecasts and data products.

- **Reduced uncertainties in predictions**: predict global land surface conditions, ice sheets, and sea rise with more certainty
- Acquire **high fidelity measurements** to improve predictive skill in numerical model forecasts (e.g., wind)
- **Increased spatial resolution** by combining lower resolution high coverage products with **targeted sensing** higher resolution products
- Through model projections of future changes and assessment of uncertainties through ensemble predictions, perform feedback analysis to target future observations toward optimally reducing knowledge uncertainty.
- Bridging between sporadic observations of high-value sensors to provide temporally persistent observations.
- Making associations between observations of multiple instruments.

3.3 User Support Themes

The user support category addresses the needs of both the end users (i.e., the policy makers and responders) and users who design and configure the end-to-end Earth observing system-of-systems to support the science and societal goals. The following capabilities, enabled by sensor web use cases, emerged as themes:

- Workflow generation
- User access to sensors
- Campaign / mission design

Workflow

The ability to manage workflow in a sensor web facilitates the coordination of such things as (a) scheduling and orchestrated triggering of the operation of multiple instruments based on user requests, model results and needs, (b) platform and sensor configuration, (c) sensor data processing, and (d) automated data product generation.

- **Flight plan generation** (achieve mission goals while satisfying constraints)
- **Workflow generation** and execution (e.g., volcano alert, processing, and product delivery, regional vegetation trends and anomalies)
- **Workflow tasks** for identifying event triggers, tasking sensor assets, processing sensor data, and delivering multiple higher level detection products directly to end users

User Access to Sensors

The philosophy of sensor webs is built on providing users greater access to sensors, more ability to direct when and where they operate, greater coordination (e.g., with other users, with sensors, with models) through scheduling and workflow tools and autonomous operation capabilities.

- Provide users **easy and rapid access of available sensors** that can provide science data products to help manage phenomena and provide situational awareness (e.g., for fire emergency workers to manage wildfires)
- Users request sensor access and tasking with **network centric** system that **manage system constraints and safety**

Campaign / Mission Design Optimization

Campaign and mission design for sensor webs provides the opportunity to incorporate multiple sensors, models, simulation, people, and planning. The communication is automatic, some triggered by events and conditions, and some dependent on people-in-the-loop. This makes it possible to respond more quickly to opportunities and events, to autonomously plan a campaign, automatically process data, and disseminate information and data products from such end-to-end operations.

- Simulators - **design space formulation and population of observation scenarios/systems,** virtual execution and science return validation of the populated observation scenario and observation system concepts (e.g., atmospheric chemistry)
- Planners can **detect** an event, **notify** a human planner who **schedules** observations, which could be **processed** on-board, and even to **autonomously retask** the sensors to obtain additional data; maximize the number of mission goals achieved while satisfying constraints; dynamically combine sensors into a sensor web (e.g., model-based volcano sensor web, disaster response, generate flight plans, response to volcanic eruptions by detecting and tracking the resultant ash clouds)

4 Breakout Group Middleware 1 (MW1) – Model Interoperability

This breakout session focused on developing use cases dealing with modeling and web services. Investigators in this group had expertise or insight into some of the Decadal Survey missions, notably DESDynI, CLARREO, 3-D Winds and others. They are working on sensor webs for use as mission or campaign design, and weather forecasting among other applications. The group was initially tasked to look at the role of forecast models and data assimilation for solid earth applications for the DESDynI. Other missions of keen interest to this group included CLARREO, SMAP and 3D Winds, and additional science domains such as carbon and air quality, ecosystems, and weather. Some of the key sensor web capabilities they are developing include data assimilation and fusion, and web service architectures. As a result, the effort was focused primarily on interoperability solutions for sensor webs and architectures, such as the Service Oriented Architecture (SOA).

4.1 Participants

This section enumerates all of the participants in Breakout Group MW1 and identifies each participant's organization and project title. Missing is one project, Sensor-Web Operations eXplorer (SOX), however a use case by the project lead, Meemong Lee of JPL, is included.

Table 3. Breakout Group MW1 Participants

Name	Organization	Project Title
Marge Cole	NASA ESTO AIST	AIST Facilitator
Vicki Oxenham	NASA ESTO Goddard Space Flight Center	AIST Staff
Thomas Eden	The Aerospace Corporation	Report Editor
Michael Burl	NASA Jet Propulsion Laboratory	Adaptive Sky
Liping Di Genong Yu	George Mason University George Mason University	A General Framework and System Prototypes for the Self-Adaptive Earth Predictive Systems (SEPS)--Dynamically Coupling Sensor Web with Earth System Models
Andrea Donnellan	NASA Jet Propulsion Laboratory	QuakeSim: Enabling Model Interactions in Solid Earth Science Sensor Webs
Stefan Falke Don Sullivan	Northrop Grumman IT, TASC Northrop Grumman IT, TASC	Sensor-Analysis-Model Interoperability Technology Suite
Michael Goodman Helen Conover	NASA Marshall Space Flight Center University of Alabama, Huntsville	Sensor Management for Applied Research Technologies (SMART) - On-Demand Modeling
Paul Houser Yudong Tian	Institute of Global Environment and Society, Inc.	Land Information Sensor Web

David Lary Oleg Aulov	University of Maryland, Baltimore County (UMBC) UMBC	An Objectively Optimized Sensor Web
John Moses	NASA Goddard Space Flight Center	The Detection and Tracking of Satellite Image Features Associated with Extreme Physical Events for Sensor Web Targeting Observing
Mike Seablom Steve Talabac	NASA Goddard Space Flight Center NASA Goddard Space Flight Center	End-to-End Design and Objective Evaluation of Sensor Web Modeling and Data Assimilation System Architectures

4.2 Use Case Challenge

Breakout group MW1 – Model Interoperability – developed a total of fifteen (15) use cases during the workshop, and one (1) additional use case was submitted after the conclusion of the workshop. Four (4) use cases were presented during the feedback plenary session and are featured in this section, with all of the use cases fully documented in Appendix C – Use Cases. The following table enumerates these use cases and indicates the page number of the start of the use case description. Featured use cases are identified by **bold text** in this table.

Table 4. MW1 Use Case Index

Use Case Name	Primary Points of Contact	Page #
Earthquake Response and Forecasting	**Andrea Donnellan**	**101**
Numerical Weather Prediction Doppler Wind Lidar	**Michael Seablom** **Steve Talabac**	**228**
Smart Assimilation of Satellite Data into Weather Forecast Model	**Michael Goodman** **Helen Conover**	**237**
Validating Smoke Forecast Models with Satellite, UAS and Surface Observations	**Stefan Falke** **Don Sullivan**	**95**
Adaptive Sky applied to detection, tracking, and reacquisition of volcanic ash clouds	Michael Burl	55
Carbon Cycle – Biomass	Paul Houser	180
Extreme Event Detection and Tracking for Targeted Observing	John Moses	216
Geomorphology	Paul Houser	107
Hydrology	Paul Houser	263
Predict Global Land Surface Soil Moisture with SMAP observing system simulation experiment (OSSE)	Paul Houser Yudong Tian	129
Quantifying Measurement Requirements for Atmospheric Chemistry Remote Sensing (NASA Atmospheric composition program NRA)	Meemong Lee	63
Satellite and UAS fire observation inputs to smoke forecast models	Stefan Falke Don Sullivan	69
SEPS (Self-Adaptive Earth Predictive Systems) Interoperation	Liping Di	74

for AutoChem Assimilation System	Genong Yu	
SEPS (Self-Adaptive Earth Predictive Systems) Interoperation for Bird Migration Modeling and Avian Flu Prediction	Liping Di Genong Yu	82
Tasking new satellite and UAS observations with smoke forecasts	Stefan Falke Don Sullivan	91
Volcanoes	Andrea Donnellan	142

4.2.1 Smart Assimilation of Satellite Data into Weather Forecast Model

4.2.1.1 Point of Contact

Michael Goodman
NASA Marshall Space Flight Center
michael.goodman@nasa.gov
256-961-7890

Helen Conover
University of Alabama, Huntsville
hconover@itsc.uah.edu
256-961-7807

4.2.1.2 Use Case Goal

The goal of this use case is to improve the assimilation process of satellite data into numerical models. Because assimilation of these large datasets is computationally expensive, we use intelligent processes to determine when interesting weather phenomena are expected and where assimilating satellite observations can improve forecast accuracy. We intend to use community standard protocols for data access and alerts.

4.2.1.3 Use Case Summary

The integration of EOS satellite data from multiple platforms into forecast models is a critical component of NASA's Weather focus area. The complexity lies in the need to integrate large data volumes from sensors on the different platforms with different observational constraints and data formats into a common processing system. This use case identifies these limitations by implementing a SWE-based architecture to autonomously select the optimal observations for assimilation.

The Atmospheric Infrared Sounder (AIRS) creates 3-dimensional maps of air and surface temperature, water vapor, and cloud properties. With 2378 spectral channels, AIRS has a spectral resolution more than 100 times greater than previous IR sounders and provides more accurate information on the vertical profiles of atmospheric temperature and moisture. The AIRS retrieval algorithms provide vertical profiles of temperature and moisture at a 50 km horizontal spacing over a narrow swath. These data provide asynoptic observations to complement the standard radiosonde observing network. The profiles are most accurate in clear and partly cloudy regions and the quality of the AIRS retrieval is determined in real time and transmitted to the user. Note that the future PATH satellite will provide similar data.

AIRS data can provide a key input into the regional data assimilation procedures used to produce short-term regional weather forecasts with the Weather Research & Forecasting (WRF) model. However, the decision on when to include the data and where spatially it will have the most effect for the day-to-day weather conditions over the United States is not trivial. Routine daily assimilation is not performed because of the limited availability of resources and the operational requirement of the National Weather Service for improved forecasts of high impact events. Forecast improvements in low-impact weather systems may not be an effective use of resources, whereas appropriate data assimilation in evolving weather situations or with tropical systems such as hurricanes is likely a more effective use of computer time and associated manpower because of its impact - a direct affect on loss of property and lives. The effective inclusion of AIRS data into regional forecast models could be made possible through autonomous processing of model data fields, Aqua satellite orbit predictions, AIRS instrument data, and required ancillary information through sensor web capabilities and services. Currently, modelers make judgments about when and where to assimilate satellite data after manual examination of near-term forecasts.

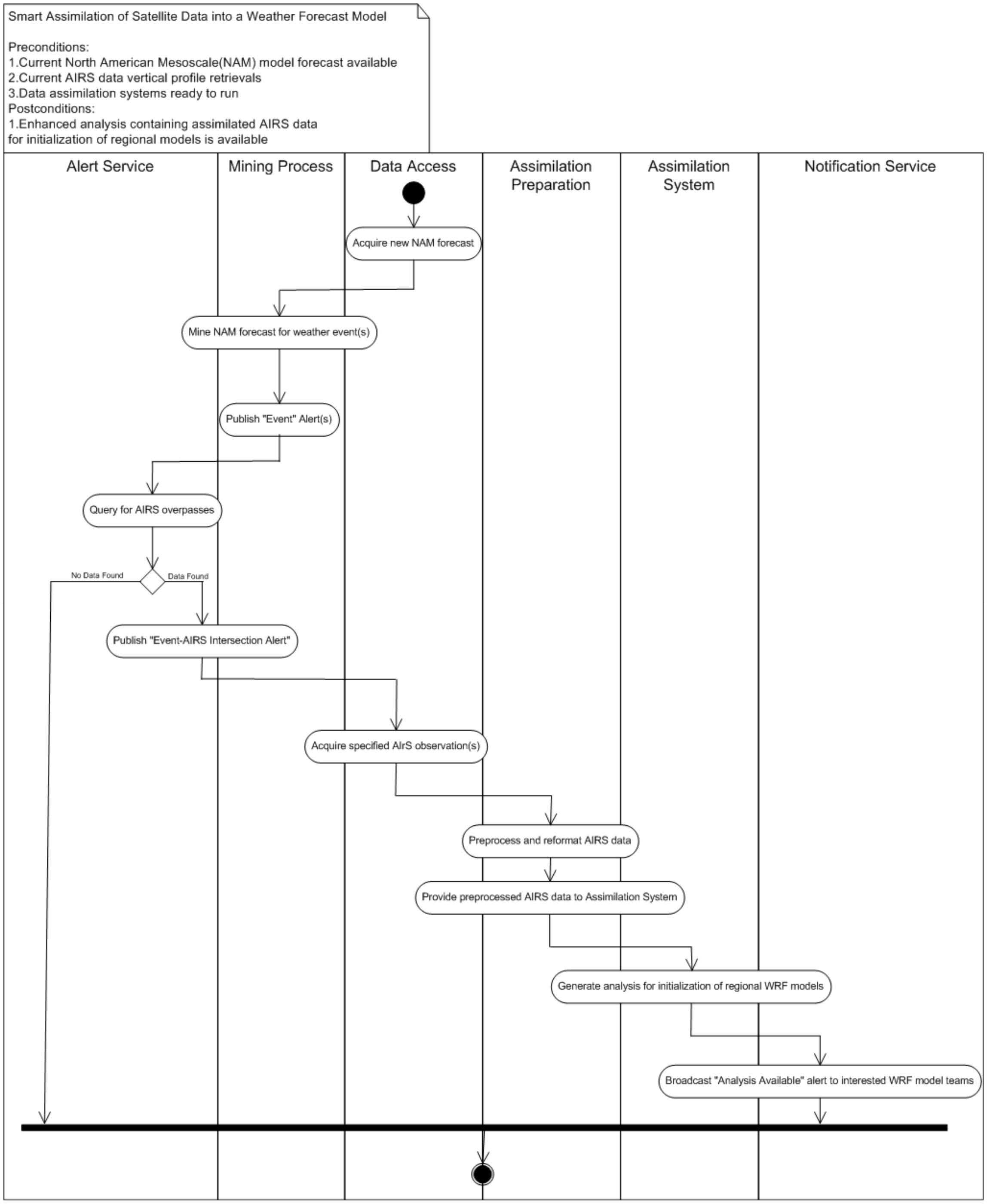


Figure 2. Weather Event Data Flow

Often, a North American Mesoscale (NAM) forecast is used as the initial conditions for a regional WRF model run. The addition of current weather observations (such as those from AIRS) can improve the accuracy of a WRF forecast, but assimilating voluminous satellite observations into the initial conditions is computationally expensive. The smart assimilation workflow involves mining NAM forecasts for interesting weather phenomena, then determining whether AIRS observations are coincident with the detected weather events. The assumption is that assimilating AIRS observations of anomalous weather conditions will improve the forecast.

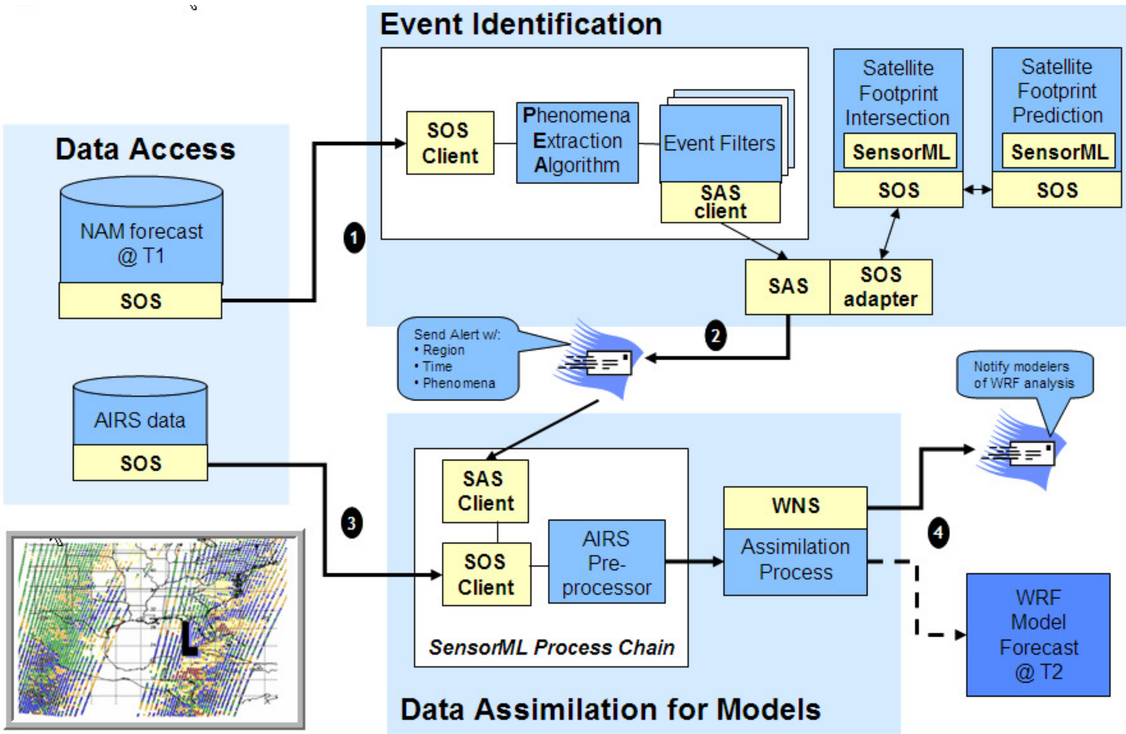


Figure 3. Weather Event System Flow

The use case begins with a forecast from the North American Mesoscale (NAM) model which provides a baseline first guess field for initializing the WRF model. The NAM model is run independent of the AIRS data assimilation system. The NAM forecast is mined for an interesting weather event (e.g., developing low pressure system, frontal system, vorticity maxima) within a selected region of interest using the Phenomena Extraction Algorithm. If a weather event of interest is detected an alert is issued identifying the event, date/time and location. A search is then initiated for coincident AIRS data within the region of interest and time threshold. If a coincident AIRS overpass is confirmed, then the AIRS data are obtained. The AIRS vertical profile data are pre-processed and reformatted for inclusion into the ARPS Data Assimilation System (ADAS). The assimilated data field is then made available as the initial condition field for the WRF model run. An alert is broadcast to WRF model users of the availability of the improved initial field for a WRF run.

4.2.2 Validating Smoke Forecast Models with Satellite, UAS and Surface Observations

4.2.2.1 Point of Contact

Stefan Falke
Northrop Grumman IT, TASC
stefan.falke@ngc.com
314-259-7908

Don Sullivan

4.2.2.2 Use Case Goal

This air quality use case scenario envisions a sensor web that facilitates access, integration and use of multi-source data for purposes of air quality assessment and forecasting. A particular emphasis is placed on the retrospective analysis of large forest fires and the validation of forecast output with satellite and unattended aerial systems (UAS) to improve numerical smoke forecast models.

4.2.2.3 Use Case Summary

To better understand, forecast, and manage air pollution, air quality researchers and managers need to bring together information about a variety of atmospheric constituents from different observational platforms (surface monitoring networks, satellites, sondes, ground-based remote sensors, aircraft, etc.), nonlinear chemical and physical atmospheric processes from meteorological and chemical transport models, emissions and emissions-generating activities, population demographics, exposure-related behavior, and health impacts.

For scientific assessment and analysis of management strategies, this integration can be done using historical datasets. For air quality forecasting to inform the public and manage individual air pollution episodes or events, it is necessary to perform this integration in near real time.

Smoke from biomass burning is an important component of air quality. Quantifying air pollutant emissions from wildfires and prescribed burning is one of the more uncertain inputs to air quality forecasting. Satellite data are being used to help improve the ability to accurately estimate emissions from fires. However, the quality of satellite derived fire products for air quality applications is not well characterized:

- multiple sensors detect fires - which to use?
- missed detections (due to cloud cover)
- false detections
- spatial resolution limitations
- temporal resolution limitations
- size and types of fires detected
- derivation of smoke from satellite and aerial imagery

Types of analyses conducted on satellite derived fire and smoke information include:

- comparison of multiple satellite/aerial products (e.g., EO-1 fires compared with MODIS fires; UAS derived smoke compared with EO-1 or MODIS)
- agreement of satellite/aerial products with ground based observations
- agreement of forecast models with satellite/aerial products

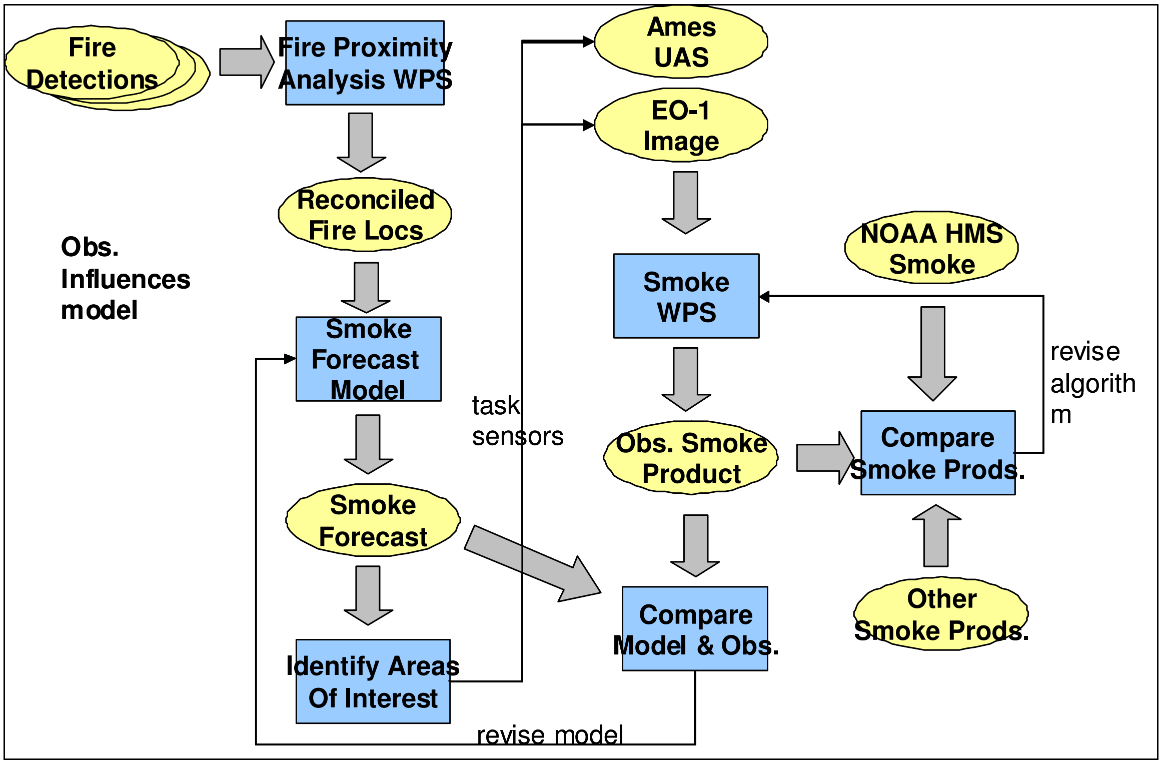


Figure 4. Smoke Forecast Flow

The Air Quality analyst needs to assess the extent and impact of detected wildfire smoke. Using an AQ portal the analyst identifies relevant satellite and aerial sensors to acquire new observations of the wildfire occurrence. The new data is used to validate and refine a smoke forecast, which is made available to analysts and AQ warning systems. The forecasts are used to request new observations from satellite, aerial and ground platforms and compare them with the forecasts.

4.2.3 Earthquake Response and Forecasting

4.2.3.1 Point of Contact

Andrea Donnellan
NASA Jet Propulsion Laboratory
Andrea.Donnellan@jpl.nasa.gov
818-354-4737

4.2.3.2 Use Case Goal

The goal of this Use Case is improved rapid response and earthquake forecasting from NASA's DESDynI mission.

4.2.3.3 Use Case Summary

DESDynI (Deformation, Ecosystem Structure, and Dynamics of Ice) is a combined InSAR/Lidar mission to study, among other things, tectonics surface deformation. Incorporation of surface deformation measurements into tectonic models is proving important for understanding earthquake processes and the resulting size and style of earthquakes. DESDynI will be the first InSAR mission to systematically and globally measure surface deformation at frequent intervals. An estimate 200 earthquakes per year or 1000 earthquakes will be detected over the 5-year duration of the mission. The mission will produce over 200 GB per day of crustal deformation data. These data must be incorporated into models and the large volumes of data drive the need to automated data processing. DESDynI InSAR surface deformation data will provide secular and time varying rates of deformation, which will improve our understanding of long and short-term earthquake processes. Response will be required in the event of a large earthquake. The data must be rapidly downloaded, processed, and integrated with other data types. Earthquake response will include damage assessment and an assessment of stress changes and potential for subsequent earthquakes.

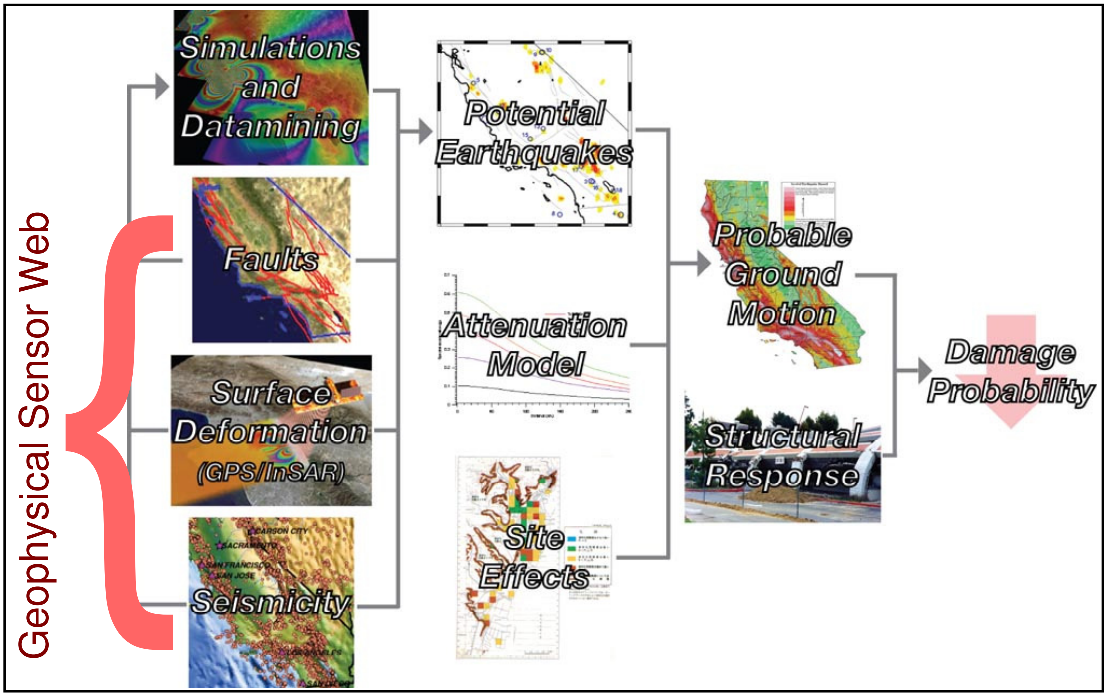


Figure 5. DESDynI Use Case Scenario

4.2.4 Numerical Weather Prediction Doppler Wind Lidar

4.2.4.1 Point of Contact

Michael Seablom
NASA Goddard Space Flight Center
Michael.S.Seablom@nasa.gov
301-286-8580

Steve Talabac
stephen.j.talabac@nasa.gov

4.2.4.2 Use Case Goal

The goal of this Use Case is to acquire high fidelity wind measurements to improve predictive skill in numerical model forecasts and conserve power and extend longevity of the instrument being used.

4.2.4.3 Use Case Summary

A wind lidar is proposed with an inherent ability to perform adaptive targeted measurements. This use case focuses on the “model-driven” sensor web ops concept wherein an atmospheric model is used to identify candidate regions of interest where the lidar may be potentially commanded to make measurements within regions where they would either otherwise not be made or, would be made using the default “survey” instrument measurement modes (e.g., unchanging pulse rate or frequency, power level, on/off duration, etc.). For this use case, we made use of the proposed Global Wind Observing Sounder (GWOS) instrument, depicted in the figure provided in the "Triggers" section. In order to obtain complete vector wind components GWOS must sample an air parcel from at least two different perspectives. The instrument is comprised of multiple coherent and direct lidars that have the ability to operate through four telescopes. Two of the telescopes are oriented in a nominal ±45° azimuth pointing in front of the spacecraft, with the other two similarly oriented pointing aft. The combination of the fore and aft shots produces an estimated horizontal wind vector for multiple vertical levels. As currently designed the instrument can perform approximately 300 million shots in its lifetime with a pulse rates of 5Hz (coherent detection technique) and 100Hz (direct detection technique) respectively.

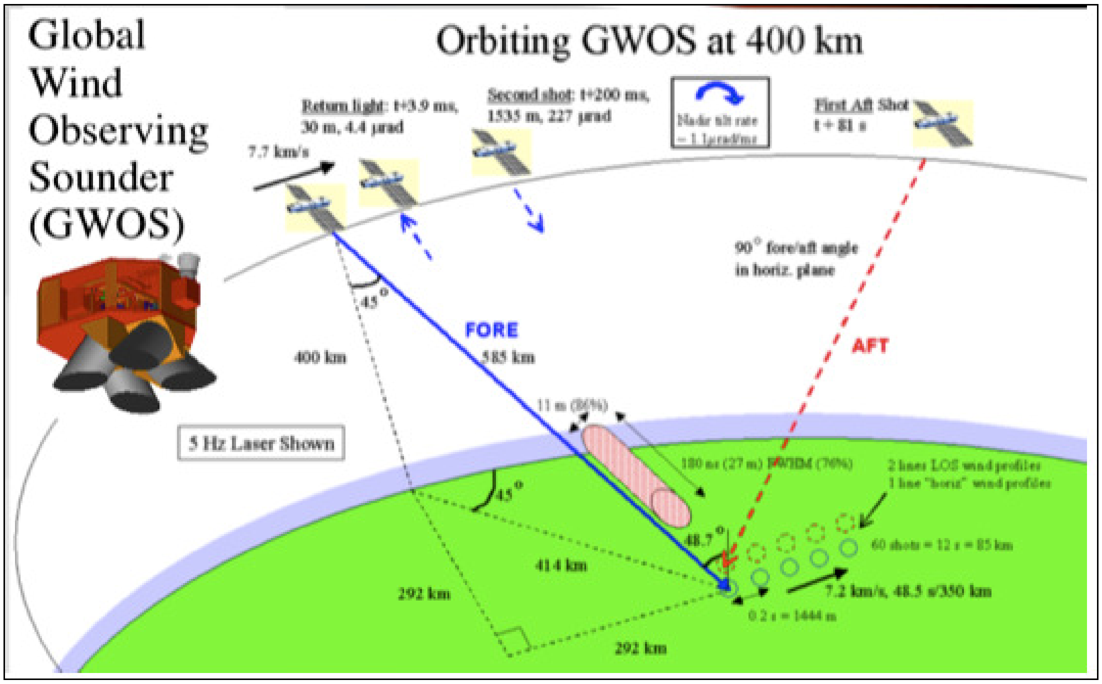


Figure 6. GWOS Operational Scenario

Using model-driven sensor web concepts we are proposing two sensor web scenarios that would modify the GWOS operations. Scenario (1) would minimize the required number of lidar shots without loss of information of the atmospheric state, and Scenario (2) would target data collection for specific regions of the atmosphere that would potentially have the greatest impact on forecast skill. For (1) GWOS would be provided the first guess wind field from a global forecast model. Observed line-of-sight (LOS) winds from the GWOS “fore shot” would be compared with the predicted winds from the model and valid at the time of the observation. If the winds were considered to be in adequate agreement the aft shot would not be performed. If such agreement were ubiquitous there could be a substantial reduction in the lidar’s duty cycle, potentially extending the life of the instrument. For (2) we would use estimates of the model’s forecast error to direct GWOS to target those regions of the atmosphere estimated to be in a state of low predictability, and/or target sensible weather features of interest. We assume to capture the maximum number of targets would require slewing of the spacecraft.

4.3 MW1 – Model Interoperability Conclusions

Two sets of patterns emerged as the participants presented their use cases during the MW1 breakout session. The first set of patterns related to observations and models:

- **Observations influence models**: Results of observations and measurements obtained from the sensor web devices can be effectively used as input to various modeling scenarios, refining the model input which can result in a higher fidelity model output.
- **Models influence observations**: Results obtained from modeling systems can be applied to sensor webs to identify specific events to monitor, resulting in better use of sensor resources.

- **Observations validate models**: Results of observations and measurements obtained from the sensor web devices provide significant correlation to the predicted outcomes from the modeling systems, thus validating the efficacy of the modeling system.

The second set of patterns that emerged during the discussion had to do with the relative maturity level of the use case and its related technology. For an example of a mature level, the air quality field has a robust suite of tools, data resources and sensors. Therefore the resulting use cases are likewise 'mature' because of the availability of mature models or decision support systems. For mature use cases it is more straightforward to build interoperable interfaces between those systems to create sensor webs. Conversely "developing" use cases are built on sensor web components (i.e., the models or sensors) that are still evolving. Table 5. Use Case Maturity Levels depicts this classification:

Table 5. Use Case Maturity Levels

Mature
Smart Assimilation of Satellite data into weather forecast model Bird Migration and Avian Flu AutoChem Atmospheric Chemistry Assimilation System Satellite and UAS fire observation inputs to smoke forecast models Tasking new satellite and UAS observations with smoke forecasts Adaptive Targeting of Wind Lidar to Improve weather forecast skill Earthquake response and forecasting Volcanoes Carbon Cycle Biomass
Developing
Extreme event detection and tracking for targeted observing Validating smoke forecasts with satellite UAS observations Detection, tracking, and reacquisition of volcanic ash clouds Predict Global Land Surface Soil Moisture Hydrology

Several challenges were also identified by the participants. Notable issues included the following:

- Better collaboration between technology developers and mission designers is needed to infuse sensor web technology into scientific observations.
- Tighter coupling between models driving observations for future mission design is desirable, for example, to enable carbon cycle science advances using DESDynI. Currently there's a one-way flow from sensors to models. For the sensor web concepts to progress, mission designers need to appreciate the benefits of having models provide a feedback loop into sensor operations.
- Sensor web enablement within the future missions, such as autonomous sensor response demonstrated in EO-1, is a significant infusion effort.
- Middleware – web services, portals, ontologies, etc., implementation will continue to be a challenge due to slowly maturing technologies.

It is worth noting that the luncheon address of Dr. Scott Tilley dealt directly with the promises and lessons learned from experience in implementing the Service Oriented Architecture. This talk was particularly insightful and timely, given the technology gap identified by the MW1 participants regarding middleware technologies, including web services and portals.

5 Breakout Group Middleware 2 (MW2) – Systems Management

While MW1 focused on models and interoperability, the MW2 – Systems Management breakout group focused on middleware that supports and enhances sensor capabilities. This includes planning and scheduling, adaptive sampling, tasking and feedback loops, and data flow and real-time data streaming within the context of ecology / land use and oceanography science themes. Their sensor webs are used for applications such as rapid response, unmanned vehicle flight planning in support of science campaigns, and coastal water science and management. Some of the key sensor web capabilities under development include operations and communication strategies and algorithms to optimize resource usage, planners and schedulers, and workflow management tools.

5.1 Participants

This section enumerates all of the participants in breakout group MW2 and identifies each participant's organization and project title.

Table 6. MW2 – Systems Management Participants

Name	Organization	Project Title
Phil Paulsen	NASA ESTO Glenn Research Center	AIST Facilitator
Glenn Prescott	NASA ESTO AIST	AIST Staff
April Gillam	The Aerospace Corporation	Report Editor
Payman Arabshahi Andrew Gray	University of Washington NASA Jet Propulsion Lab	A Smart Sensor Web for Ocean Observation: System Design, Modeling, and Optimization
Mohammed Atiquzzaman	University of Oklahoma	Implementation Issues and Validation of SIGMA in Space Network Environment
Prasanta Bose Peter Fox	Lockheed Martin Advanced Technology Center University Corporation for Atmospheric Research	Virtual Sensor Web Infrastructure for Collaborative Science (VSICS)
Michael Botts Susan Ingenthron	University of Alabama, Huntsville University of Alabama, Huntsville	Increasing the Technology Readiness of SensorML for Sensor Webs
William Ivancic Eric Miller	NASA Glenn Research Center General Dynamics General Dynamic Advanced information Systems	Secure, Autonomous, Intelligent Controller for Integrating Distributed Sensor Webs
Stephan Kolitz	Draper Labs	Sensor Web Dynamic Replanning

Dan Mandl Stuart Frye	NASA Goddard Space Flight Center Noblis Inc.	An Inter-operable Sensor Architecture to Facilitate Sensor Webs in Pursuit of GEOSS
Robert Morris	NASA Ames Research Center	Harnessing the Sensor Web through Model-based Observation
Antonio Ortega	University of Southern California	Efficient Sensor Web Communication Strategies Based on Jointly Optimized Distributed Wavelet Transform and Routing
Nikunj Oza	NASA Ames Research Center	Automated Data Assimilation and Flight Planning for Multi-Platform Observation Missions
Fabio Silva Wei Ye	USC Information Science Institute USC Information Science Institute	Satellite Sensornet Gateway (SSG)

5.2 Use Case Challenge

Breakout group MW2 developed fourteen (14) use cases during the meeting. The following three use cases were presented by the group during the feedback, plenary session and are featured in this section.

- A Smart Ocean Sensor Web to Enable Search and Rescue Operations
- Dynamic Plant Monitoring
- Hurricane Workflows

All use cases developed by MW2 may be found in Appendix C – Use Cases. The following table enumerates these use cases and indicates the page number of the start of the use case description. Use Cases featured in this set are identified by **bold text** in Table 7.

Table 7. MW2 Use Case Index

Use Case Name	Primary Points of Contact	Page #
A Smart Ocean Sensor Web to Enable Search and Rescue Operations	**Yi Chao, Andrew Gray, Payman Arabshahi**	**149**
Dynamic Plant Monitoring	**Wei Ye**	**185**
Hurricane Workflows	**Stuart Frye**	**258**
Collaborative Science Resource Allocation	Phil Paulsen, Eric Miller, Will Ivancic	286
Data Mining and Automated Planning for Mobile Instrument Operation	Nikunj C. Oza	159
Dynamic Soil Sampling	Wei Ye	188
Dynamically taskable sensors	Phil Paulsen, Eric Miller, Will Ivancic	289

Improved Storm/Weather Prediction based on Lightning Monitoring and Prediction	Prasanta Bose	222
Mount Saint Helen's Hazard Response	Peter Fox	119
North American Net Primary Production Comparison Using Automated Workflow Generation	Robert Morris, Jennifer Dungan	197
Operationally Responsive Space Element Tasking	Phil Paulsen, Eric Miller, Will Ivancic	119
Seamlessly Download Data	Mohammed Atiquzzaman	292
Water Quality Monitoring	Wei Ye	282
Wildfire Sensor Web	Dan Mandl	209

5.2.1 A Smart Ocean Sensor Web to Enable Search and Rescue Operations

5.2.1.1 Point of Contact

Yi Chao
Jet Propulsion Laboratory
yi.chao@jpl.nasa.gov
818-354-8168

Andrew Gray
University of Washington
Jet Propulsion Laboratory
aagray@u.washington.edu

Payman Arabshahi
University of Washington
payman@ee.washington.edu
206-221-6990

5.2.1.2 Use Case Goal

To deliver ocean nowcast and forecast in real-time to enable US Coast Guard's research and rescue operations by integrating in-situ measurements with satellite observations into a predictive Regional Ocean Modeling System (ROMS).

5.2.1.3 Use Case Summary

The sensor web achieves traceability to science through complimenting existing and planned space science missions. Specifically the web integrates space-based sensor data with in-situ data, these are integrated via the ROMS model, the output of which can be used for achieving a set of scientific objectives, including enhancing the science products of the stand-alone missions (e.g., QuikSCAT, Jason). These science applications (or use cases) may be categorized as indicated in the graphic below. Note that the output of the ROMS model (with integrated space-based and in-situ data) is also useful in planning future space-based missions (investment) dedicated to climate change science. The graphic below presents an overview of the large number of science applications (dozens of possible use cases) for the sensor web being developed in the AIST task “A Smart Sensor Web for Ocean Observation: System Design, Modeling, and Optimization.” The use case presented in this document focuses on one such use case in the **coastal disaster relief operations** category with a particular focus on the **search and rescue** operations.

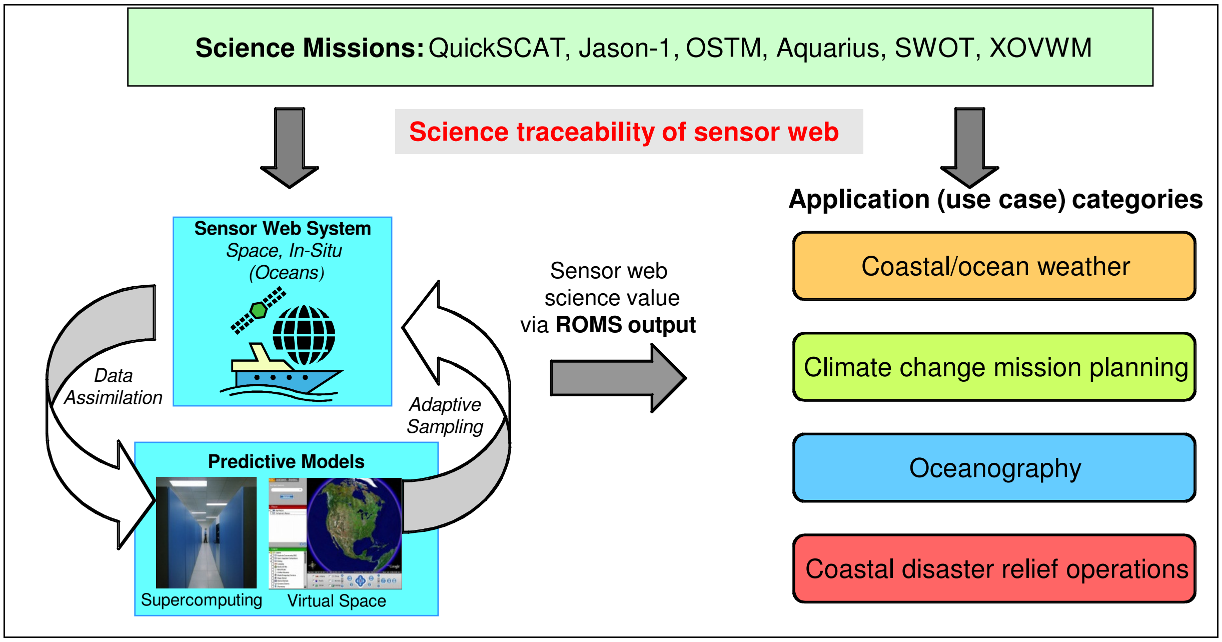


Figure 7. Science Traceability of a Sensor Web

5.2.2 Dynamic Plant Monitoring

5.2.2.1 Point of Contact

Wei Ye
USC Information Sciences Institute
weiye@isi.edu
(310) 448-9107

5.2.2.2 Use Case Goal

Multimodal sensing of plants bloom in response to precipitation.

5.2.2.3 Use Case Summary

The goal of this use case is to study the plants bloom in response to precipitation. Multimodal sensing is applied to capture the dynamic response of plants to seasonal rainfalls after a relatively long period of dry weather. Specifically, we deploy sap flow sensors on some branches of several different species of plants. This sap flow sensor detects the detailed internal activity of plants in response to the environment. In addition, we deploy imaging sensors (remotely-controlled cameras) to capture the bloom of plants. A weather station allows us to detect precipitation or solar radiation, etc.

In order to reduce energy usage—sap flow sensors are powered by batteries and use wireless communication. We will dynamically adjust their sampling period according to environmental events that have been detected. When there has been no rainfall for a relatively long period of time, the plants change very slowly. In this case the sap flow sensors are configured to sample at a low frequency (e.g., 1 sample every 5 or 10 minutes). The camera takes a picture of each plant once a week. When the weather station detects rainfall, we will reconfigure the system to sample more frequently. The sap flow sensor will take 1 sample per minute, and the camera will take a picture twice a day to capture the plants bloom.

An additional trigger is the solar radiation. The plants are much more active with sunlight during day time than during the night. Therefore, during the night, we can have even lower sampling rates (e.g., 1 sample every 30 minutes) than day time. The weather station is able to detect the solar radiation level, which will be used to trigger the change of sap flow sampling rate during the day and night.

5.2.3 Hurricane Workflows

5.2.3.1 Point of Contact

Stuart Frye, SGT Inc.
NASA Goddard Space Flight Center, Code 428
Greenbelt, MD 20771
stuart.frye @nasa.gov
301-286-4797

5.2.3.2 Use Case Goal

This use case describes how an end user would adapt an existing workflow to accomplish a new observation goal.

5.2.3.3 Use Case Summary

Individual web services have been developed that accomplish individual tasks for identifying event triggers, tasking sensor assets, processing sensor data, and delivering multiple higher level detection products directly to end users. For a typical observation sequence, a series of activities has to be accomplished including sensor tasking, basic data processing, and customized detection data product generation and delivery. Users want to have a way to string together multiple services to accomplish these specific goals. Workflows provide this capability.

A wildfire monitoring workflow has been developed that allows a fire analyst to pick a region of interest for fire monitoring, retrieve MODIS hot pixel locations for that region, identify the highest threat location within that region, task the EO-1 satellite to target that location, and provide multiple EO-1 data products to that user. The products include a visible image, a SWIR image showing burned area and active fire that can be seen through clouds, and a hot pixel readout from the Hyperion hyperspectral imager.

If a user is concerned about triggering coverage of a hurricane instead of a wildfire, the user can adapt the wildfire workflow to monitor the hurricane aftermath by pointing the triggering part of the workflow at the National Hurricane Centers landfall prediction web site instead of pulling in MODIS hot pixels for targeting. The threat analysis part of the workflow would be modified to target the eye of the storm landfall point and the EO-1 satellite would be tasked to image that location and the earliest in-view time after landfall. Basic targeting and data processing would not be modified. Individual detection products could still include the set of fire products (visible, SWIR, and hot pixels), but a flood classification algorithm could be added. The user discovers which bands to select for the flood algorithm from the WPS description document.

To make the modifications to the workflow, the user would employ a workflow editor. The editor provides the capability to change the trigger selection and the threat calculation plus adding the new product to the workflow. The wildfire products could be deleted to reduce the delivered data volume.

5.3 MW2 – Systems Management Conclusions

The team identified some themes among the use cases. These include:

- **Workflows** that enable virtual observation, to decide which products to generate and make decisions when there are not sufficient resources to satisfy all user requests. The workflow makes more science and results or products possible at a lower cost. The expectation, for the wildfire system currently being fielded and still under development, is that the sensor web approach will reduce costs by an order of magnitude.

- **Adaptive Sampling** is based on routine monitoring of the environment that detects events that trigger (a) other sensors to operate and (b) changes in sampling frequency. This makes it possible to reduce sensor energy consumption during routine times and to increase measurement frequency during interesting events.
- **Cross-coordination** of sensors makes it possible for in-situ sensors to trigger spacecraft instruments to operate in a given location.
- **Autonomous tasking** occurs when a model predicts events which can then be used to better target sensor resources. A feedback loop also makes it possible to use the observations taken during events to update the models to improve the predictions. Another application of tasking is in data transmission from satellites to ground stations, especially in Low Earth Orbit, to seamlessly handoff transmission from one ground station to another.

The participants in MW2 also provided some observations learned through creating the use cases. Several use cases addressed management issues for communications, sensors and workflow (as noted above). Indeed workflow management appeared in the majority of use cases so this area offers more opportunity for development.

In response to the question of recommendations for next steps, the MW2 group discussed the following points:

- Can a “value chain” analysis be applied to show how sensor webs can produce more science, better science results, or spend less to get the science results?
- The software principle of achieving simplification through abstraction may apply to sensor webs.
- Encourage continuing work to refine use cases, especially the relevance to the Decadal Survey goals. Since the language of computer science is sufficiently different from that used by the hardware and science researchers that the significance, issues, and needs in information systems may not be recognized or understood. The use case approach may help bridge this gap.
- Live demonstrations are good, but not easily duplicated. Capture demos on short DVD media or use animation to convey the capabilities of sensor webs.

Some in this group also noted that the final luncheon speaker, Mr. John Garstka, DoD Office of Force Transformation, spoke about the importance of demonstrating a return-on-investment for infusing technology. This is a strategy that ESTO may pursue to influence the planning for the Decadal Survey missions.

6 Breakout Group Smart Sensing (SS)

With a focus on flight, in-situ, and space borne platforms, Breakout Group SS was assembled to develop use cases having to do with smart sensing; namely, examining autonomous sensors and adaptive resource management and processing, agent technology and sensor fusion for the purpose of increasing the return on investment of sensing technologies. Their initial science themes for sensor web use cases included water and energy cycles, climate change and Earth surface & interior. Participants had insight into the Soil Moisture Active-Passive (SMAP) and Ice, Cloud, and Land Elevation Satellite (ICESat-II) missions from the Decadal Survey, among several others.

6.1 Participants

This section enumerates all of the participants in breakout group SS and identifies each participant's organization and project title.

Table 8. Breakout Group SS Participants

Name	Organization	Project Title
Rob Sherwood	NASA Jet Propulsion Laboratory	AIST Facilitator
Steve Smith	NASA ESTO	AIST Staff
Bradley Hartman	The Aerospace Corporation	Report Editor
Ashit Talukder	NASA Jet Propulsion Laboratory	Autonomous In-situ Control and Resource Management in Distributed Heterogeneous Sensor Webs: CARDS
Ashley G Davies	NASA Jet Propulsion Laboratory	Science Model-Driven Autonomous Sensor Web (MSW
Ayanna M Howard	Georgia Tech Research Corp	Reconfigurable Sensor Networks for Fault-Tolerant In-Situ Sampling
Costas Tsatsoulis	University of Kansas	An Adaptive, Negotiating Multi-Agent System for Sensor Webs
Dipa Suri Gautam Biswas	Lockheed Martin Space Systems Company Vanderbilt University	The Multi-agent Architecture for Coordinated, Responsive Observations
John Dolan Alberto Elfes	Carnegie Mellon University NASA Jet Propulsion Laboratory	Telesupervised Adaptive Ocean Sensor Fleet
Ken Witt Al Underbrink	Institute for Scientific Research, Inc. Sentar, Inc.	Using Intelligent Agents to Form a Sensor Web for Autonomous Mission Operations
Mahta Moghaddam	University of Michigan	Soil Moisture Smart Sensor Web Using Data Assimilation and Optimal Control

Matt Heavner	University of Alaska Southeast	SEAMONSTER: A Smart Sensor Web in Southeast Alaska
WenZhan Song	Washington State University	Optimized Autonomous Space - In-situ Sensorweb
Yunling Lou Steve Chien	NASA Jet Propulsion Laboratory NASA Jet Propulsion Laboratory	Autonomous Disturbance Detection and Monitoring System for UAVSAR
Larry Hilliard	NASA Goddard Space Flight Center	Developing an Expandable Reconfigurable Instrument Node as a Building Block for a Web Sensor Strand

6.2 Use Case Challenge

Breakout group SS on smart sensing developed eleven (11) use cases. Due to time constraints, however, the group decided to present only four (4) of these during the feedback, plenary session at the end of the meeting. Table 9 enumerates all use cases developed by breakout group SS. The four use cases that were presented during the plenary session are highlighted in the table in **bold text** and are also featured in this section. All use cases may be found in Appendix C – Use Cases.

Table 9. SS Use Case Index

Use Case Name	*Primary Points of Contact*	*Page #*
Forest Fire Sensor Web with UAVSAR	**Yunling Lou, Steve Chien**	**191**
Glacier Outburst Flood Water Quality Impact	**Matt Heavner, Dipa Suri, Gautam Biswas**	**253**
Model-based Volcano Sensor Web with Smart Sensors	**Ashley Gerard Davies, Steve Chien**	**111**
Soil Moisture Calibration and Validation for SMAP Products	**Mahta Moghaddam**	**202**
Calibration of Remote-Sensing Instruments Using Re-deployable In-Situ Sensor Networks for Ice Sheet Characterization	Ayanna Howard	155
Coastal Sensor Web for Short- and Long-Duration Event Detection	Ashit Talukder, John Dolan	246
ICESat-II and Deformation, Ecosystem Structure, and Dynamics (DESDynl) using ERINode for Passive Active Interferometric Radiometer w/Interleaved Radar	Larry Hillard	165
Snow and Cold Land Processes (SCLP) using ERINode for Passive Active Interferometric Radiometer w/Interleaved Radar	Larry Hillard	268
Snow Cover Resolution Enhancement Using Targeted Sensing	Steve Chien, Paul Houser, Christa Peters-Lidard	173

Soil Moisture Active-Passive (SMAP) high resolution foliage calibration	Larry Hillard	275
Volcanic hazard event ground-space-ground feedback cycle	Wenzhan Song	135

6.2.1 Model-based Volcano Sensor Web with Smart Sensors

6.2.1.1 Point(s) of Contact

Ashley Gerard Davies
NASA Jet Propulsion Laboratory
Ashley.Davies@jpl.nasa.gov
818-393-1775

Steve Chien
NASA Jet Propulsion Laboratory
Steve.A.Chien@jpl.nasa.gov

6.2.1.2 Use Case Goal

Time is of the utmost importance in a volcanic crisis for the purposes of hazard and risk assessment. The goal of the JPL Model-based Volcano Sensor Web (MSW) is to detect an alert of pending or current volcanic activity, obtain high-resolution data, process the data and disseminate the products to relevant scientists as rapidly as possible, ideally within hours to a few days. We are working towards a fully-autonomous system.

6.2.1.3 Use Case Summary

The MSW is an end-to-end product delivery service, aimed at effusive volcanic eruptions. When the African volcano Nyamulagira (a.k.a. Nyamuragira) in the Democratic Republic of Congo erupted in November 2006, the utility of such a system was demonstrated (illustrated in Figure 8). As local volcanologists were unable to determine the location of the vent, models of possible lava flow paths were poorly constrained. A call went out to the international community to obtain spacecraft data to allow accurate vent location. The autonomous MSW reacted faster than humans in the spacecraft command and control loop. A detection of a plume reported by the Toulouse VAAC was detected by a remote agent of the JPL MSW. The alert information was passed to a planner which inserted an observation (two days later) in the EO-1 observation sequence. Data obtained by the Hyperion visible-infrared hyperspectral imager were processed onboard by data classifiers. Thermal emission from the erupting lava was detected and a summary product down linked within 90 minutes of data acquisition, alerting JPL that onboard detection had been successful. EO-1 retasked itself to obtain additional data at the next possible opportunity. Within 24 hours the entire Hyperion dataset had been down linked and radiometrically corrected. The data underwent additional manual processing to generate image products showing detail of the vent area, which were then emailed to volcanologists in Italy, France and the D. R. Congo. The new flow model output is in the form of maps showing the application of models of lava flow emplacement, based on the updated vent location, knowledge of local topography and assuming an eruption rate based on previous behavior of the volcano. The new maps showed a greater likelihood of flows to the south west of the vent reaching the town of Sake and cutting an important road, and no flows to the east (predicted by models using the original estimated vent location some 2 km away from the location identified in the Hyperion data). This information allowed local authorities to amend disaster plans accordingly. In the end, the eruption was relatively short-lived and Sake was not directly threatened. EO-1 obtained a follow-up observation of Nyamulagira two days after the first, but the target was found to be cloud-covered. In the absence of further alerts, the system re-set itself.

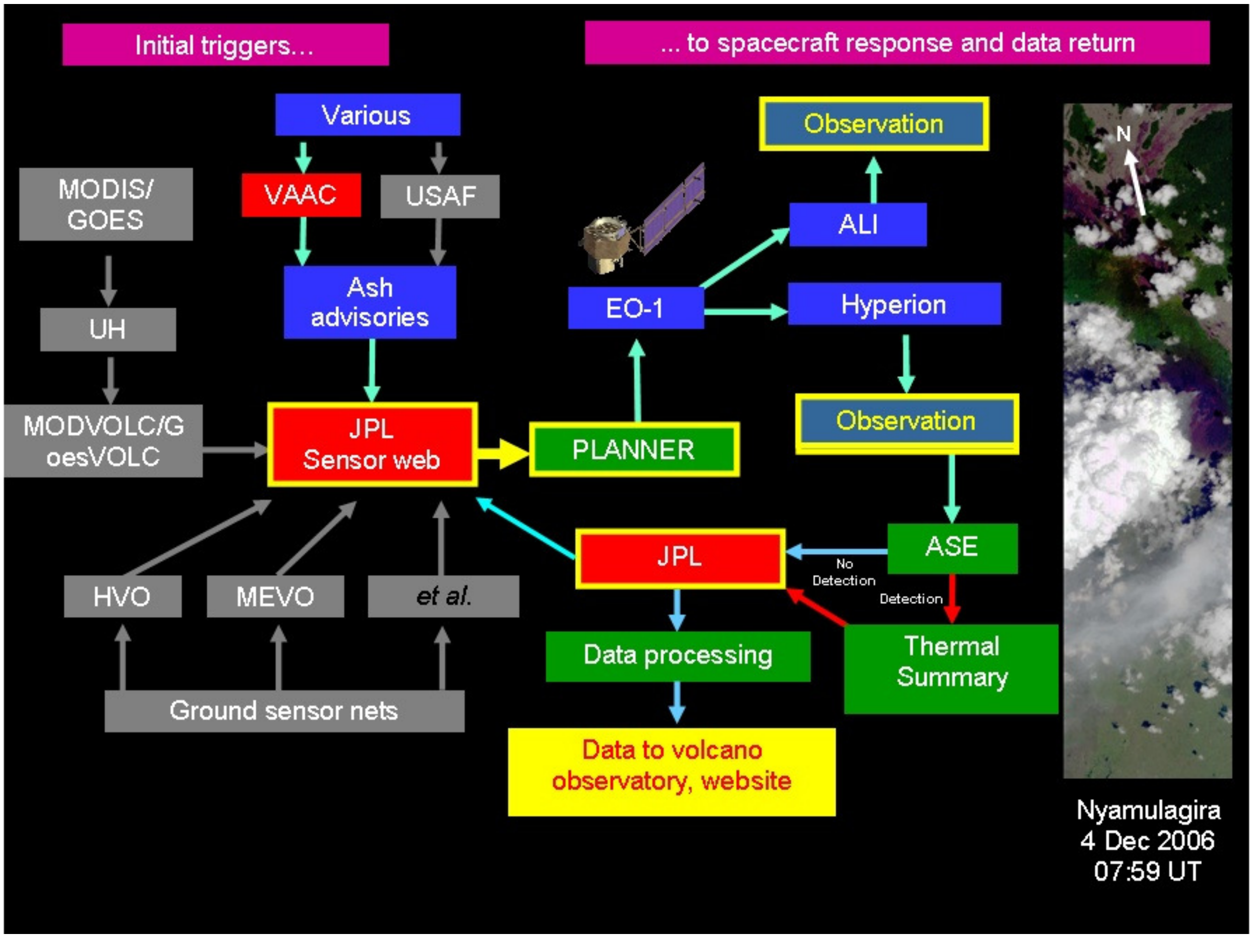


Figure 8. Sensor Web Actions During the 2006 Eruption of Nyamulagira

6.2.2 Soil Moisture Calibration and Validation for SMAP Products

6.2.2.1 Point(s) of Contact

Mahta Moghaddam
University of Michigan, Ann Arbor, MI
mmoghadd@umich.edu
734-647-0244

6.2.2.2 Use Case Goal

The goal of this use case is to provide accurate and cost-effective means of validating and calibrating satellite-derived soil moisture products through smart in-situ sensing.

6.2.2.3 Use Case Summary

This use case enables a guided/adaptive sampling strategy for a soil moisture sparse in-situ sensor network to meet the measurement validation objectives of the space borne radar and radiometer on SMAP with respect to resolution and accuracy. The sensor nodes are guided to perform as a macro-instrument measuring processes at the scale of the satellite footprint, hence meeting the requirements for the difficult problem of validation of satellite measurements. SMAP allows global mapping but with coarse footprints. The total variability in soil-moisture fields comes from variability in processes on various scales. Installing an in-situ network to sample the field for all ranges of variability is impractical. However, a sparser but smarter network can provide the validation estimates by operating in a guided fashion with guidance from its own sparse measurements. A control system is developed and built to command the sensors to turn on at optimal times and locations. The feedback and control take place in the context of a dynamic data assimilation system, and enable a cost-effective and accurate means of accomplishing the validation task. This validation paradigm differs from the traditional one in that the in-situ sensor web optimizes its operation by turning on only a subset of the sensors and only when needed to minimize resource usage while maximizing the accuracy of validation data, as opposed to performing measurements round-the-clock, and over a dense grid.

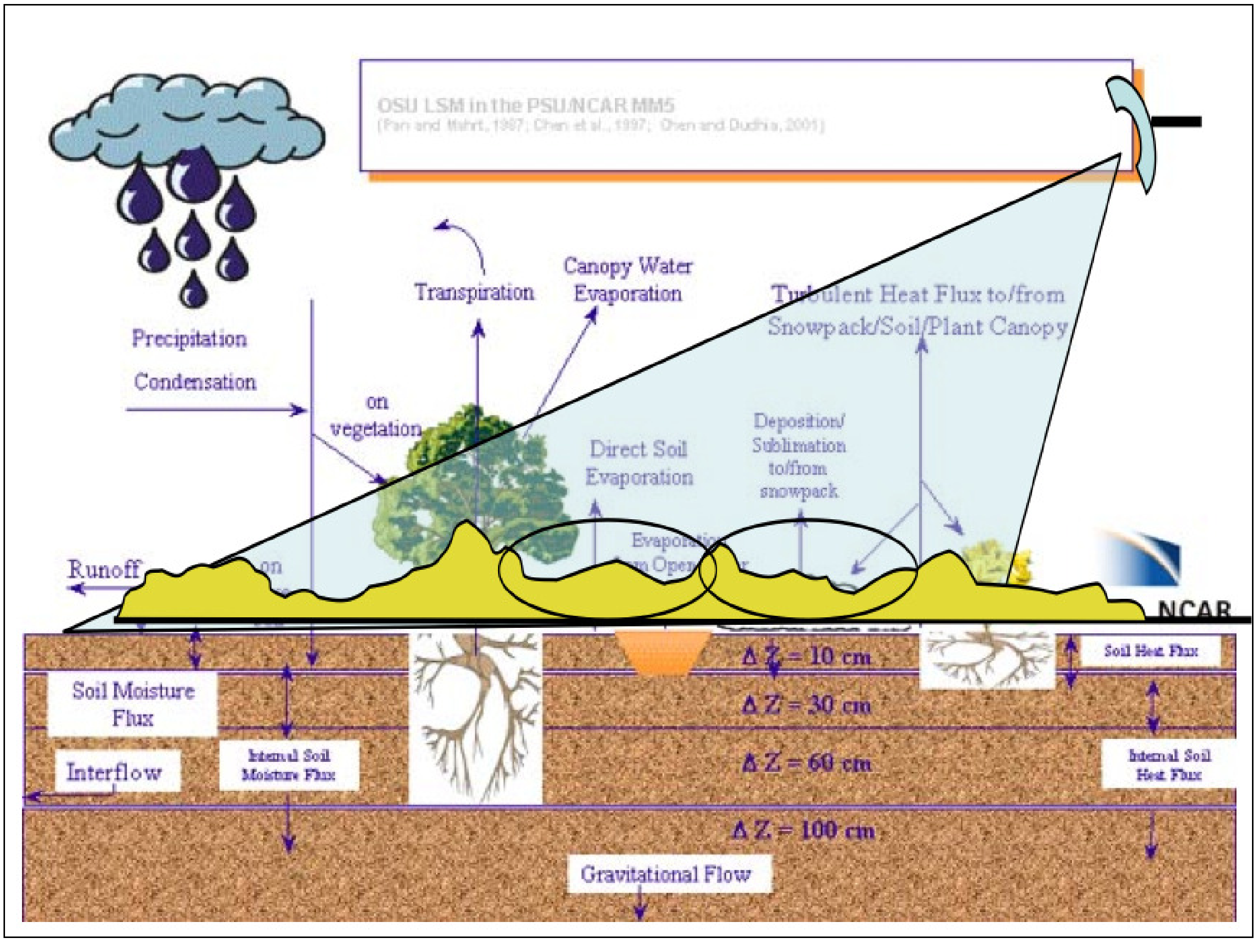


Figure 9. Environmental Contributions to Soil Moisture at Varying Depths

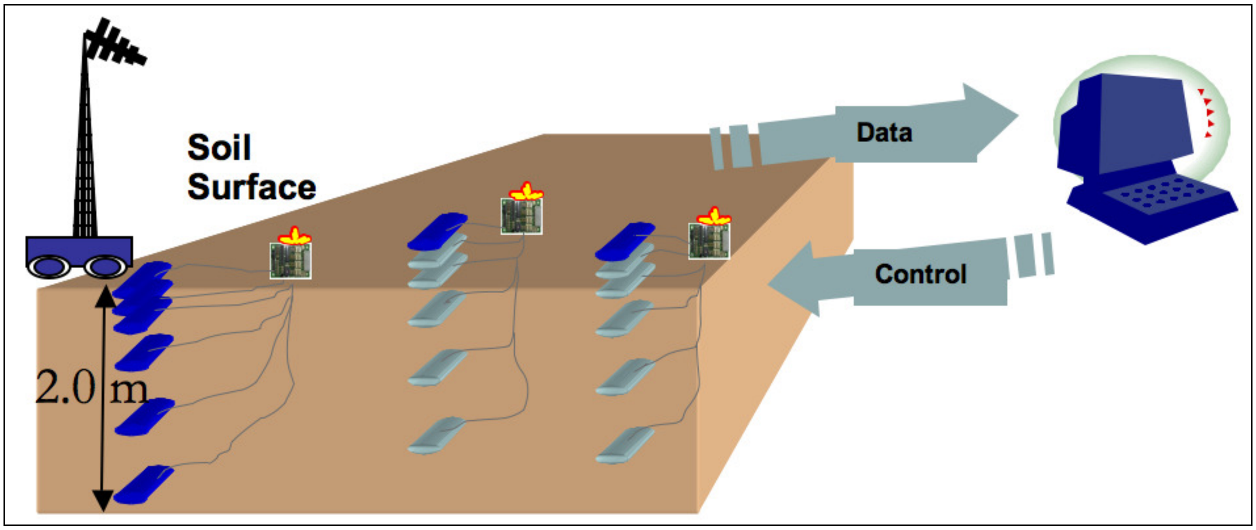


Figure 10. Soil Moisture Cal/Val Sensor Deployment

6.2.3 Forest Fire Sensor Web with UAVSAR

6.2.3.1 Point(s) of Contact

Yunling Lou
NASA Jet Propulsion Laboratory
yunling.lou@jpl.nasa.gov
818-354-2647

6.2.3.2 Use Case Goal

Our goal is to provide critical information for rapid response during a forest fire. This forest fire sensor web is for UAVSAR to trigger on a forest fire alert, plan data acquisition with UAVSAR, collect radar data over the fire site, process data onboard to generate appropriate data products such as fuel load map, downlink the time critical information to disaster response agencies. The onboard automated response capability can also trigger other observational assets to collect data over the fire site.

6.2.3.3 Use Case Summary

We are developing a forest fire sensor web with UAVSAR to demonstrate the autonomous disturbance detection and monitoring system with imaging radars. This sensor web enhances UAVSAR (a high resolution polarimetric L-band imaging radar) with high throughput onboard processing technology and onboard automated response capability to detect wildfire and monitor forest fuel load autonomously. The smart sensor will be OGC compliant, thus allowing us to utilize other OGC compliant Sensor Alert Services and Sensor Observation Services to provide enhanced information such as precise fire location and fire progression prediction to enable autonomous response of other assets and disaster management agencies.

The timeliness of the smart sensor output products can be used for disaster management, agricultural irrigation, and transportation such as shipping. Onboard automated response will greatly reduce the operational cost of the smart sensor. This smart sensor technology is well suited for space flight missions such as DESDynI, SCLP, SMAP, and SWOT, and different science algorithms can be used for a variety of disturbances.

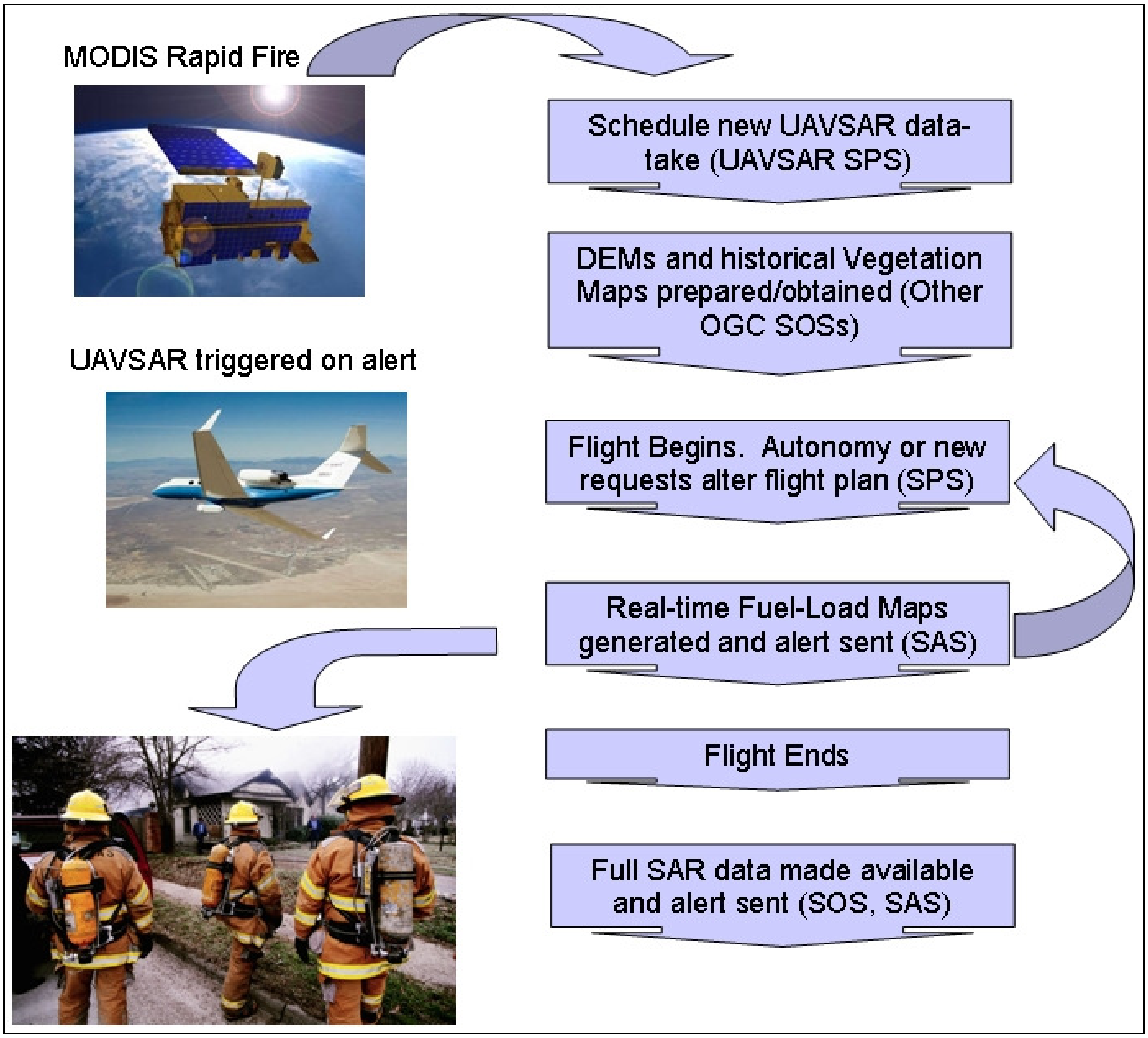


Figure 11. Forest Fire Detection using Sensor Web with UAVSAR

6.2.4 Glacier Outburst Flood Water Quality Impact

6.2.4.1 Point(s) of Contact

Matt Heavner
University of Alaska Southeast, Juneau, AK
heavner@uas.alaska.edu
907-796-6403

Dipa Suri
Lockheed Martin Space Systems Company
dipa.suri@lmco.com
650-424-2092

Gautam Biswas
Vanderbilt University
Biswas@eecsmail.vuse.vanderbilt.edu

615-343-6204

6.2.4.2 Use Case Goal

Scientist needs to know when a glacial lake catastrophically drains and have data to understand impacts on water quality downstream and glacial dynamics while also collecting data to understand long term effects of increased glacial lake formation with climate change.

6.2.4.3 Use Case Summary

Climate change is increasing the amount of glacial lakes. Water quality has great significance for ecology e.g., salmon spawning and primary productivity in the near shore marine environment. Understanding the glacial lakes impacts on glacier dynamics, glaciated watershed, and coastal productivity motivates this use case. Heterogeneous measurements from the watershed need to be coordinated for intense observations when an unpredictable, transient event (outburst lake drainage) occurs. Long term monitoring is ongoing, but is power, computationally, and bandwidth constrained. Instrumentation includes a pressure transducer in the glacial lake; meteorological station for gathering parameters such as temperature, wind speed and direction, and precipitation; a steer able camera; and a water quality sonde. Some of the sensors (such as the pressure transducer) have minimal computation capability and only forward data while others are heterogeneous sensors and computational processors. These nodes are deployed and configured into subnets that are networked through both wired and wireless connections.

In keeping with the notion of a sensor web, these subnets are sources of data that is collected at and processed in a more computationally rich environment in order to facilitate high level analysis and decision making.

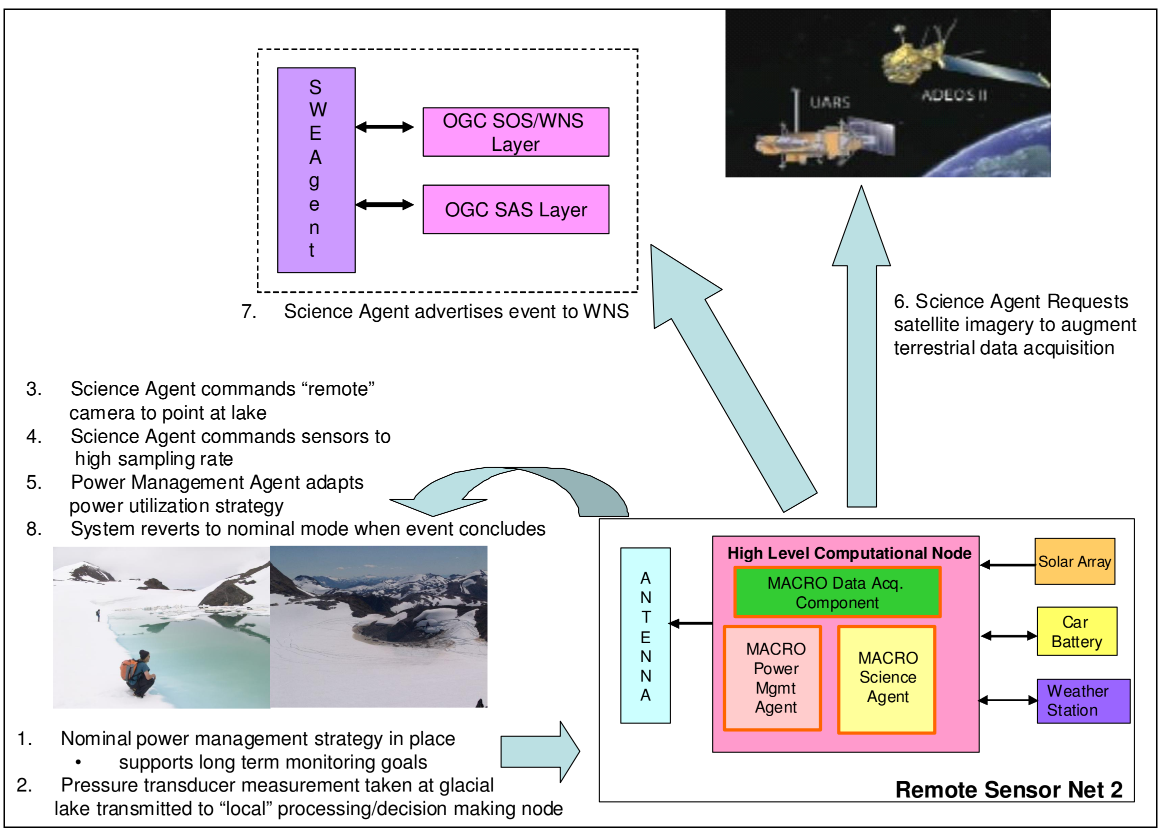


Figure 12. Sensor Web Monitors Impact of Glacial Outburst

6.3 SS – Smart Sensing Conclusions

While developing their use cases, the group noted that most of the use cases fell into at least one of three categories:

- **In-situ networks used for calibration/validation** – some of the use cases (e.g., refer to Section 6.2.2 on page 31) employ in-situ sensors to cost effectively calibrate and validate other sensors (e.g., satellites).
- **Airborne sensors used to increase modality or resolution** – some of the use cases (e.g., refer to Section 11.6.5 on page 268) employ airborne platforms for the purposes of calibration/validation and to increase the resolution of information in regions of interest.
- **Detection of events drives adaptation of sensor nodes** – some of the use cases detect events and adapt to dynamic situations (e.g., refer to Section 11.2.7 on page 135).

Additionally, participants spent some time brainstorming ideas regarding next steps. The following recommendations emerged from these discussions:

- Investigators and NASA/ESTO need to look more closely at the return on investment for the sensor web use cases. This will help to strengthen the business case for the necessity of sensor web technologies.
- Investigators and NASA/ESTO need to strengthen the relevance of the use cases to the Decadal Survey missions.

The group also discussed the following two ideas regarding the promotion of use cases. Both of these ideas were aimed at increasing the relevance and therefore the likelihood of stakeholder buy-in.

- Tailor each use case to the audience instead of developing a single, entirely reusable use case.
- Market use cases intelligently; namely, to market the use cases to the science discipline leads' most important projects.

7 Summary and Conclusions

As stated in Section 2, Introduction, the key outcomes of this meeting were to:

- Define a set of use cases to illustrate how sensor web technology will be used
- Relate these use cases to the Decadal Survey. [DEC07]

7.1 Coverage

The three breakout groups developed a total of 41 use cases. MW1 produced 16 use cases, MW2 produced 14, and SS produced 11. The use cases were placed in a single science theme category, as organized in Appendix C – Use Cases. As seen in the next table, these use cases cover all of the NASA science focus area themes, and in addition, there are 4 cross-cutting use cases that are applicable to all of the science themes.

Table 10. Use Case Coverage with Respect to Science Theme

Atmospheric Composition	Earth Surface & Interior	Climate Variability & Change	Carbon Cycle & Ecosystems	Weather	Water & Energy Cycle	Cross-Cutting
7	6	3	6	5	10	4

The Decadal Survey Categories follow:

- Earth Science Applications & Societal Benefits
- Land Use Change, Ecosystem Dynamics, Biodiversity
- Weather - Space & Chemical
- Climate Variability & Changes
- Water Resources & Global Hydrologic Cycle
- Human Health & Security
- Solid Earth Hazards, Resources, Dynamics

All of these Decadal Survey Categories are addressed by the use cases as well. The following table gives the number of use cases that address each category. Several use cases are cross-disciplinary and thus associated with multiple Decadal Survey Categories.

Table 11. Use Case Coverage with Respect to Decadal Survey Categories

Earth Science Applications & Societal Benefits	Land Use Change, Ecosystem Dynamics, Biodiversity	Weather - Space & Chemical	Climate Variability & Changes	Water Resources & Global Hydrologic Cycle	Human Health & Security	Solid Earth Hazards, Resources, Dynamics
28	17	16	12	12	11	7

One of the PIs indicated that the Decadal Survey has more of a focus on societal benefit whereas at NASA it is the science that has the highest priority. There was general consensus that this is the case.

Additionally, the AIST Needs (Data Collection; Transmission & Dissemination; Data & Information Production; Search, Access, Analysis, Display; and Systems Management) were all addressed by the use cases, as summarized in the following table, which indicates the number of use cases that address each AIST Need. Here again, use cases are associated with many of the Earth science information system needs identified in the AIST list.

Table 12. Use Case Coverage with Respect to AIST Needs

Data Collection	Transmission & Dissemination	Data & Info Production	Search, Access, Anlys, Disp	Systems Mgmt
28	13	22	21	9

7.2 Sensor Web Benefits

The “Report from the Earth Science Technology Office (ESTO) Advanced Information Systems Technology (AIST) Sensor Web Technology Meeting” [NASA 07] identified the following sensor web benefits: (1) improved use and reuse of sensor assets and software services, (2) improved sensor return on investment and cost effectiveness, and (3) improved data quality and value to science. During the meeting there was discussion about sensor web benefits, specifically pointing out that they also provide the ability to improve the accuracy of predictions, handle uncertainty, and are scalable. A sensor web approach can also make systems interoperable, supporting disparate content and interfaces.

In 2008, ESTO updated and restated the Earth science information system goals in the AIST Needs. All of these goals are addressed by the use cases, as summarized in Table 13.

Table 13. Use Case Coverage With Respect to AIST Goals

Increase science data value thru autonomous use	Coordinate multiple observations for synergistic science	Improve interdisciplinary science production environments	Improve access, storage, delivery	Improve system interoperability, standards use	Decrease mission risk/cost thru autonomy
26	**28**	**12**	**18**	**18**	**16**

Easy Does It

A principle that was mentioned more than once during the sensor web meeting is that it is useful to identify what sensor webs provide that makes life easier. Programs should not have to learn a new way to do things each time. Unless there is a clear value, programs with tight budgets and schedules are not likely to support new operating efforts. A number of people at the meeting were in agreement that **one should not have to make major changes to existing systems to join a sensor web**. This approach enhances the value of the program while facilitating access to new and existing resources. By increasing value and decreasing effort, NASA improves its overall return on investment.

Another participant discussed the dichotomy between what the user sees and what is happening in the background. “The latter is what we supply to make the former stuff easy.” **It is important for users to understand what goes on, without all the detail**, ensuring that they are not overwhelmed. Just as a user recognizes they do not understand the complexity of their own computer while still being able to search the world over for products or task the system to create digital files, a user of a sensor web does not need to understand the technological complexity, only that they may search for resources, gather data, and task the system to produce information.

Black Box Analogy

A concept espoused in a similar vein, was to look at the sensor web as a black box. Users interface with the system, solely looking at the capabilities that are external to the black box and not needing to look at the internal structure. Sensor webs can be built in to enable discovery of sensor capabilities, and automatically provide fault tolerance and reconfiguration of resources.

This was illustrated when in a wildfire use case, a PI indicated that firemen want a fire map to know where the fire is now; they do not care about the sensors. To this end, participants discussed the need to set up the mechanisms for sensor web services, and to be able to tailor the sensor web to support a fire scenario, a flood scenario or some other application area.

7.3 Next Steps

Print and Web Media

In the final session of the meeting, discussions were open to recommendations and action items. The discussion topics included print and web media for informing others about sensor webs. Some projects have successfully developed short narrated movies, 3 – 7 minutes long, which include satellite orbit animations or screen captures of user interactions with proposed tools for sensor web users. These animated scenarios are a very effective means of conveying the sensor web capabilities. These movies can be easily migrated to YouTube or posted on project web sites. ESTO also has a sensor web meeting web site (http://esto.nasa.gov/sensorwebmeeting) for hosting demonstration movies. The movies can be easily shared at technical or scientific conferences in oral or poster sessions if live demos are risky. A sensor web poster and brochure would be worth following up by ESTO for these conferences or whenever there is a NASA booth.

Technology Infusion

The Technology Infusion Working Group collaboration web site was successfully used during the generation of the use cases. A wiki has been established to continue dialogue on related topics of sensor web definition and capabilities, benefits and uses, as well as infusion. Final documents and lessons learned can be posted to the public version of the web site for publication. The tech infusion group provides a continued focus on outreach and identifies science and technology conferences which feature geospatial information systems where sensor web topics would be of interest. The group also looks for opportunities to provide coordinated feedback to various standards bodies, particularly the Open Geospatial Consortium (OGC) and the IEEE and ISO standards activities. Sensor web enablement within the future missions, such as autonomous sensor response demonstrated in EO-1, is a significant infusion effort. Finally, the monthly sensor web teleconference forum will continue, nominally on the 4th Tuesday at 2:00 pm eastern time.

Standards

One meeting participant indicated that a good direction for the sensor web approach to take is **web technology and ISO**. Reference implementations are needed. He also pointed out that there are discontinuities in the way NASA funds development between TRL 4 or 5 up to 8; i.e., there isn't funding for the intervening TRL development. Managers want an operating production service rather than demonstrations that have a single instantiation. NASA succeeds very well when the technology is taken on as operations with outside grant funding. Another participant pointed out that an area where the users concerns have not been addressed is mission operations readiness and suggested that NASA needs a Mission Operations Readiness Level in addition to a Technical Readiness Level.

Use Case Refinement

The group discussed the value of refining the use cases and using the template to document scenarios for demonstrating prototypes. Refinement should involve a close look at the NASA business strategy and address return on investment. Strengthening the relevance of the use case to the goals and missions recommended by the Decadal Survey will help. One suggestion is to perform a value-chain analysis to show how sensor webs can produce more science, better science results or provide a faster or cheaper way to get the science results. In the meeting it was recommended that a future sensor web forum be provided to enable more cross-cutting teams of PIs. From an engineering perspective, engaging the science and end users early is invaluable to identify their needs.

Use Case Promotion

There were suggestions to increase the relevance and stakeholder buy-in when taking the use cases to the science community. Consider the audience and tailor the sensor web message accordingly. Focus on appropriate science themes and applications and look to the Decadal Survey for guidance. Since the language of computer science is sufficiently different from that used by the hardware and science researchers that the significance, issues, and needs in information systems may not be recognized or understood. The use case approach is intended to help bridge this gap.

8 References

[BITTNER 02] Kurt Bittner, Ian Spence (2002). Use Case Modeling. Addison Wesley Professional, 2-3. ISBN 0-201-70913-9.

[DEC 07] National Academy of Sciences, “Earth Science and Applications from Space; National Imperatives for the Next Decade and Beyond,” The National Academies Press, Washington, D.C., ISBN 13:978-0-309-10387-9, 2007.

[ESTO 06] National Aeronautics and Space Administration, “ESTO Home Page,” http://esto.nasa.gov/about_esto.html.

[NASA 05] National Aeronautics and Space Administration, “The New Age of Exploration, NASA’s Direction for 2005 and Beyond,” National Aeronautics and Space Administration, NP-2005-01-397-HQ, Washington, DC, Feb. 2005.

[NASA 07] National Aeronautics and Space Administration, “Report from the Earth Science Technology Office (ESTO) Advanced Information Systems Technology (AIST) Sensor Web Technology Meeting,” The Aerospace Corporation, ATR-2007(2105)-1, El Segundo, CA, May 2007.

9 Appendix A - Keynote Speakers' Abstracts

The meeting consisted of the following three keynote speakers:

Table 14. Keynote Speakers

Speaker	*Organization*	*Keynote Title*
Timothy S. Stryker	U.S. Geological Survey (USGS)	Earth Observations to Benefit Societies – A Briefing on the Activities of CEOS
Scott Tilley	Software Engineering Institute, Carnegie Mellon University and Florida Institute of Technology	Migration of Legacy Components to SOA Environments: Some Lessons Learned
John J. Garstka	Office of the Under Secretary of Defense (Policy)	Network-Centric Operations: Insights and Challenges

This appendix contains abstracts provided by each of the keynote speakers.

April 2nd Plenary Speaker

Timothy S. Stryker
National Land Imaging Program
U.S. Geological Survey
Department of the Interior

Title: Earth Observations to Benefit Societies – A Briefing on the Activities of CEOS

Abstract: Mr. Stryker's remarks will provide an overview of the Committee on Earth Observation Satellites (CEOS), and its support to the U.N. Framework Convention on Climate Change (UN FCCC) and the intergovernmental Group on Earth Observations (GEO). He will describe CEOS initiatives vis-à-vis these organizations, and CEOS member agencies' work to implement the space-based component of the Global Earth Observation System of Systems (GEOSS). It is hoped that these remarks will provide a useful context for the development and coordination of sensor webs as critical components of GEOSS.

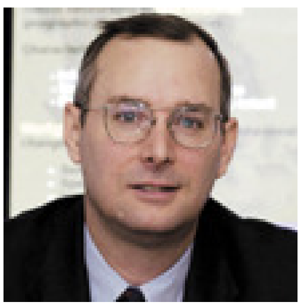
April 2nd Luncheon Speaker

Scott Tilley
Visiting Scientist
Software Engineering Institute
Carnegie Mellon University
and
Professor & Director of Software Engineering
Department of Computer Sciences
Florida Institute of Technology

Title: Migration of Legacy Components to SOA Environments: Some Lessons Learned

Abstract: Service-Oriented Architecture (SOA) is a way of designing, developing, deploying, and managing enterprise systems where business needs and technical solutions are closely aligned. SOA offers a number of potential benefits, such as cost-efficiency and agility. However, adopting SOA is not without considerable challenges. For example, the most common way to implement a SOA-based system is with Web services, but the standards that define Web services are evolving rapidly and many of the tools are still somewhat immature. There is also the question of how to leverage existing legacy assets within a SOA context. The Software Engineering Institute (SEI) has been developing the Service-Oriented Migration and Reuse Technique (SMART) to help organizations analyze legacy systems to determine whether their functionality, or subsets of it, can be reasonably exposed as services in a SOA environment. This talk provides an overview of some of the lessons learned in using SMART. Based on this experience, we have also been developing a SOA research agenda that addresses engineering, business, and operational issues. Selected aspects of this research agenda that are applicable to sensor networks and NASA Earth Science will also be discussed.

April 3rd Luncheon Speaker



John J. Garstka
Special Assistant, Force Transformation & Analysis
DASD Forces Transformation & Resources
ASD(SOLIC/IC)
Office of the Under Secretary of Defense (Policy)

Title: Network-Centric Operations: Insights and Challenges

Abstract: This presentation will highlight key issues associated with implementation of network-centric operations within the U.S. DoD. Insights from network-centric operations case studies will be presented, along with an overview of key implementation challenges faced by military organizations.

10 Appendix B - Acronyms

Acronyms

Table 15. Acronyms

Acronym	Definition
ADAS	ARPS Data Assimilation System
AIRS	Atmospheric Infrared Sounder
AIST	Advanced Information Systems Technology - http://esto.nasa.gov/info_technologies_aist.html
API	Application Programming Interface
APRS	Advanced Regional Prediction System
ARC	Ames Research Center - http://www.nasa.gov/centers/ames/home/index.html
Cal/Val	Calibration & Validation
CEOS	Committee on Earth Observing Systems
CMU	Carnegie Mellon University – http://www.cmu.edu
CONUS	Contiguous United States
DAAC	Distributed Active Archive Center
DESDynI	Deformation, Ecosystem Structure, and Dynamics of Ice
DoD	Department of Defense
DTN	Delay Tolerant Networking
EROS	Earth Resources Observation and Science
ESA	European Space Agency
ESTO	Earth Science Technology Office - http://esto.nasa.gov
FCCC	Framework Convention on Climate Change
FFRDC	Federally Funded Research Data Center
GEO	Group on Earth Observations
GIS	Geographic Information System
GMU	George Mason University – http://www.gmu.edu
GOES	Geostationary Operational Environmental Satellite
GPS	Global Positioning System
GRC	Glenn Research Center - http://www.nasa.gov/centers/glenn/home/index.html
GSFC	Goddard Space Flight Center - http://www.gsfc.nasa.gov
GTRC	Georgia Tech Research Corporation - http://www.gtrc.gatech.edu
GUI	Graphical User Interface
GWOS	Global Wind Observing Sounder
IC	Intelligence Community
ICESat	Ice, Cloud, and land Elevation Satellite - http://icesat.gsfc.nasa.gov
IGES	Institute of Global Environment and Society - http://www.iges.org
IGRA	Integrated Global Radiosonde Archive
InSAR	Interferometric Synthetic Aperture Radar
IR	Infrared
ISO	International Organization for Standardization
JPL	Jet Propulsion Laboratory - http://www.jpl.nasa.gov
K index	Quantifies disturbances in the horizontal component of earth's magnetic field

Acronym	Definition
KML	Keyhole Markup Language
LEO	Low Earth Orbit
Lidar	Light Detecting and Ranging
LMSSC	Lockheed Martin Space Systems Company - http://www.lockheedmartin.com/wms/findPage.do?dsp=fec&ci=14699&sc=400
MODIS	Moderate Resolution Imaging Spectroradiometer
MOPITT	Measurements of Pollution in the Troposphere
MOZART	Model for Ozone And Related chemical Tracers
MSFC	Marshall Space Flight Center – http://www.msfc.nasa.gov
MW1	Middleware 1
MW2	Middleware 2
NAM	North American Mesoscale model
NASA	National Aeronautics and Space Administration - http://www.nasa.gov
NCEP	National Centers for Environmental Prediction
NG	Northrop Grumman
NGA	National Geospatial Intelligence Agency - http://www.nga.mil
NOAA	National Oceanic and Atmospheric Administration
NOSS	Network of Sensor Systems
NPP	Net Primary Production
NRA	NASA Research Announcement
NRCS	Natural Resources Conservation Service
NSF	National Science Foundation - http://www.nsf.gov
NSSTC	National Space Science and Technology Center
OGC	Open Geospatial Consortium - http://www.opengeospatial.org
OWL	Ontology Web Language - http://www.w3.org/2004/OWL
OWL-S	Ontology Web Language for Services - http://www.w3.org/Submission/OWL-S
PATH	Precipitation All-weather Temperature and Humidity mission
PI	Principal Investigator
PWV	Precipitable Water Vapor
RADAR	Radio Detection and Ranging
RDF	Resource Description Framework - http://www.w3.org/RDF
ROI	Return on Investment
ROMS	Regional Ocean Modeling System
ROSES	Research Opportunities in Space and Earth Sciences
RSAC	Remote Sensing Applications Center (Forest Service)
SAR	Synthetic Aperture Radar
SCLP	Snow and Cold Land Processes
SMAP	Soil Moisture Active-Passive
SMART	Sensor Management for Applied Research Technologies project
SNOTEL	SNOw TELemetry - an automated system of snowpack and related climate sensors
SOA	Service Oriented Architecture

Acronym	Definition
SoS	System-of-Systems
SOS	Sensor Observation Service (OGC)
SPoRT	Short-term Prediction and Research Transition center
SPS	Sensor Planning Service (OGC)
SRTM	Shuttle Radar Topography Mission
SS	Smart Sensing
SUA	Special Use Airspace
SWE	Sensor Web Enablement (OGC)
SWIR	Short-wave Infrared
SWOT	Surface Water Ocean Topography
TOPS	Terrestrial Observation and Prediction System
TTNT	Tactical Targeting Network Technology
UAH	University of Alabama - http://www.uah.edu
UAS	Unattended Aerial System
UAS	University of Alaska - http://www.alaska.edu
UAV	Uninhabited Aerial Vehicle
UAVSAR	Uninhabited Aerial Vehicle Synthetic Aperture Radar
UCAR	University Corporation for Atmospheric Research
UCLA	University of California, Los Angeles
UCSD	University of California, San Diego - http://www.ucsd.edu
UDDI	Universal Description, Discovery, & Integration - http://www.uddi.org
UMBC	University of Maryland, Baltimore County - http://www.umbc.edu
USC	University of Southern California – http://www.usc.edu
USC ISI	University of Southern California, Information Sciences Institute - http://www.isi.edu
USFS	Unites States Forest Service
USGS	United States Geological Survey
UW	University of Washington
UWi	University of Wisconsin
VIS/IR	Visible infrared
VMOC	Virtual Mission Operations Center
VSICS	Virtual Sensor Web Infrastructure for Collaborative Science
WCS	Web Coverage Service - http://www.opengeospatial.org/standards/wcs
WFS	Web Feature Service - http://www.opengeospatial.org/standards/wfs
WMS	Web Map Service - http://www.opengeospatial.org/standards/wms
WoW	Web of Webs
WPS	Web Processing Service (OGC)
WRF	Weather & Research Forecasting Model
WRF	Weather Research & Forecasting
WSDL	Web Services Description Language - http://www.w3.org/TR/wsdl
WVHTC	West Virginia High Technology Consortium - http://www.wvhtf.org

Appendix B - Acronyms

11 Appendix C – Use Cases

Appendix C – Use Cases

Each of the three breakout groups developed a set of use cases. This appendix contains all of these use cases, organized by the following six science themes:

- Atmospheric Composition
- Earth Surface & Interior
- Climate Variability & Change
- Carbon Cycle & Ecosystems
- Weather
- Water & Energy Cycle

We added an additional category, ***cross-cutting***, to identify those use cases that were directly applicable to all science themes.

In addition to the use cases, this appendix contains two tables. The first, Table 16, is an index of all the use cases contained in this appendix. Organized first by science theme and second alphabetically, the purpose of this table is to facilitate locating use cases based on use case names or science themes.

The second table, Table 17, contains a categorization of each use case. This table identifies the Decadal Survey theme(s), the Decadal Survey missions, the sensor web features and benefits, and the NASA/AIST categories, science themes, and current & future missions associated with each use case. Throughout this table, an 'x' is used to indicate applicability of a characteristic to a given use case. In the last few columns, however, a 'p' is also used to indicate the most applicable (or **p**rimary) science theme for each use case. This also indicates under which science theme the corresponding use case may be found in this appendix.

Table 16. Use Case Index

Table 17. Use Case Categorization Matrix

Use Case Title	Decadal Survey							Sensor Web							
	Earth Science Apps & Soc Ben	Land use chge, eco dyn, biodiv	Weather - Sp & Chem	Clim variab & chgs	H2O res & glob hydro cyc	Human health & sec	Solid earth haz., res., dyn.	Targeted observations	Incorporate feedback	Ready access to data	Improved use/reuse	Rapid response	Improve cost effect	Improve data qual/sci val	New
Atmospheric Composition															
Adaptive Sky - Bezymianny Ash Cloud Scenario	x					x		x	x			x		x	
Quantifying Measurement Requirements for Atmospheric Chemistry Remote Sensing (NASA Atmospheric composition program NRA)			x					x					x		x
Satellite and UAS fire observation inputs to smoke forecast models	x	x	x			x		x	x						
SEPS (Self-Adaptive Earth Predictive Systems) Interoperation for AutoChem Assimilation System	x		x						x	x	x	x	x	x	
SEPS (Self-Adaptive Earth Predictive Systems) Interoperation for Bird Migration Modeling and Avian Flu Prediction	x	x	x			x			x	x	x	x			
Tasking new satellite and UAS observations with smoke forecasts	x	x	x			x		x	x						
Validating smoke forecast models with satellite, UAS and surface observations	x	x	x			x		x	x						
Solid Earth															
Earthquake Response and Forecasting	x						x	x		x	x	x		x	
Geomorphology															
Model-based Volcano Sensor Web with Smart Sensors							x	x				x			
Mount Saint Helen's Hazard Response	x	x	x	x	x	x	x	x		x	x	x		x	
Operationally Responsive Space Element Tasking	x	x						x	x	x		x	x	x	
Predict Global Land Surface Soil Moisture with SMAP Observing System Simulation Experiment (OSSE)	x				x			x	x	x	x	x	x	x	
Volcanic hazard event ground-space-ground feedback cycle	x						x	x	x			x		x	
Volcanoes	x							x		x	x	x		x	
Climate															
A Smart Ocean Sensor Web to Enable Search and Rescue Operations				x				x	x	x	x			x	
Calibration of Remote-Sensing Instruments Using Re-deployable In-Situ Sensor Networks for Ice Sheet Characterization			x											x	
Data Mining and Automated Planning for Mobile Instrument Operation				x				x	x		x			x	
ICESat-II and Deformation, Ecosystem Structure, and Dynamics (DESDynI) using ERINode for Passive Active Interferometric Radiometer w/Interleaved Radar								x							
Snow Cover resolution enhancement using targeted sensing					x			x						x	

Use Case Title	AIST Categories												Decadal Missions																
	1-Data Collection	2-Transmission & Dissem.	3-Data & Info Production	4-Search, Access, Anlys, Disp	5-Systems Mgmt	A-Incr sci data val thru auto use	B-Coord multi obs for synerg sci	C-Impr interdis sci prod environs	D-Impr access, storage, delivery	E-Impr sys interop, stds use	F-Decr mis risk/cost thru auto	New	ACE	ASCENDS	CLARREO	DESDynI	GACM	GEO-CAPE	GPSRO	GRACE-II	HyspIRI	ICESat-II	LIST	PATH	SCLP	SMAP	SWOT	XOVWM	3D-Winds
Atmospheric Composition																													
Adaptive Sky - Bezymianny Ash Cloud Scenario	x		x	x		x	x						x	x				x			x	x							x
Quantifying Measurement Requirements for Atmospheric Chemistry Remote Sensing (NASA Atmospheric composition program NRA)					x		x								x		x	x											
Satellite and UAS fire observation inputs to smoke forecast models	x			x			x			x			x	x			x	x		x	x								x
SEPS (Self-Adaptive Earth Predictive Systems) Interoperation for AutoChem Assimilation System	x		x	x		x			x	x			x	x	x		x												
SEPS (Self-Adaptive Earth Predictive Systems) Interoperation for Bird Migration Modeling and Avian Flu Prediction			x	x		x	x	x	x	x														x					x
Tasking new satellite and UAS observations with smoke forecasts	x			x			x			x			x	x			x	x		x	x								x
Validating smoke forecast models with satellite, UAS and surface observations	x			x			x			x			x	x			x	x		x	x								x
Solid Earth																													
Earthquake Response and Forecasting	x	x	x	x			x	x	x	x						x													
Geomorphology																													
Model-based Volcano Sensor Web with Smart Sensors	x						x									x		x			x								
Mount Saint Helen's Hazard Response	x	x	x	x	x	x	x	x	x	x																			
Operationally Responsive Space Element Tasking	x	x	x	x	x	x	x		x	x	x																		
Predict Global Land Surface Soil Moisture with SMAP Observing System Simulation Experiment (OSSE)				x		x		x	x	x	x			x												x	x		
Volcanic hazard event ground-space-ground feedback cycle	x						x									x					x								
Volcanoes	x	x	x	x			x	x	x	x						x													
Climate																													
A Smart Ocean Sensor Web to Enable Search and Rescue Operations	x		x	x		x	x		x		x																x	x	
Calibration of Remote-Sensing Instruments Using Re-deployable In-Situ Sensor Networks for Ice Sheet Characterization	x					x										x						x							
Data Mining and Automated Planning for Mobile Instrument Operation	x		x			x	x				x																		
ICESat-II and Deformation, Ecosystem Structure, and Dynamics (DESDynI) using ERINode for Passive Active Interferometric Radiometer w/Interleaved Radar	x						x				x					x						x				x			
Snow Cover resolution enhancement using targeted sensing	x		x			x	x									x					x	x				x			

Use Case Title	Current Missions																	Future Missions								Science Theme							
	ACRIMSAT	Aqua	Aura	CALIPSO	CloudSat	GPM	GRACE	ICESat	JASON-1	LANDSAT7	LAGEOS 1&2	NMP EO-1	QuikSCAT	ADEOS-II	SORCE	Terra	TRMM	Aquarius	GOES-N/O/P	Glory	LDCM	NPOESS	NPP	OSTM	OCO	Atmospheric Composition	Earth Surface & Interior	Climate Variability & Change	Carbon Cycle & Ecosystems	Weather	Water & Energy Cycle	Crosscutting	New
Atmospheric Composition																																	
Adaptive Sky - Bezymianny Ash Cloud Scenario		x		x	x											x			x			x	x			p							
Quantifying Measurement Requirements for Atmospheric Chemistry Remote Sensing (NASA Atmospheric composition program NRA)			x																						x	p							
Satellite and UAS fire observation inputs to smoke forecast models		x	x	x						x						x			x			x	x			p							
SEPS (Self-Adaptive Earth Predictive Systems) Interoperation for AutoChem Assimilation System		x	x													x				x		x			x	p							
SEPS (Self-Adaptive Earth Predictive Systems) Interoperation for Bird Migration Modeling and Avian Flu Prediction		x								x						x			x		x					p							
Tasking new satellite and UAS observations with smoke forecasts		x	x	x						x						x			x			x	x			p							
Validating smoke forecast models with satellite, UAS and surface observations		x	x	x						x						x			x			x	x			p							
Solid Earth																																	
Earthquake Response and Forecasting																											p						
Geomorphology																											p						
Model-based Volcano Sensor Web with Smart Sensors		x										x				x					x	x	x				p						
Mount Saint Helen's Hazard Response																											p						
Operationally Responsive Space Element Tasking																											p						
Predict Global Land Surface Soil Moisture with SMAP Observing System Simulation Experiment (OSSE)		x				x										x	x		x			x					p						
Volcanic hazard event ground-space-ground feedback cycle												x									x	x					p						
Volcanoes																											p						
Climate																																	
A Smart Ocean Sensor Web to Enable Search and Rescue Operations									x				x					x						x				p		x	x		
Calibration of Remote-Sensing Instruments Using Re-deployable In-Situ Sensor Networks for Ice Sheet Characterization																											x	p					
Data Mining and Automated Planning for Mobile Instrument Operation																												p					
ICESat-II and Deformation, Ecosystem Structure, and Dynamics (DESDynI) using ERINode for Passive Active Interferometric Radiometer w/Interleaved Radar																											x	p					
Snow Cover resolution enhancement using targeted sensing		x										x	x			x	x										x	p					

Use Case Title	Decadal Survey							Sensor Web								AIST Categories												Decadal Missions																	Current Missions																	Future Missions								Science Theme							
	Earth Science Apps & Soc Ben	Land use chge, eco dyn, biodiv	Weather - Sp & Chem	Clim variab & chgs	H2O res & glob hydro cyc	Human health & sec	Solid earth haz., res., dyn.	Targeted observations	Incorporate feedback	Ready access to data	Improved use/reuse	Rapid response	Improve cost effect	Improve data qual/sci val	New	1-Data Collection	2-Transmission & Dissem.	3-Data & Info Production	4-Search, Access, Anlys, Disp	5-Systems Mgmt	A-Incr sci data val thru auto use	B-Coord multi obs for synerg sci	C-Impr interdis sci prod environs	D-Impr access, storage, delivery	E-Impr sys interop, stds use	F-Decr mis risk/cost thru auto	New	ACE	ASCENDS	CLARREO	DESDynI	GACM	GEO-CAPE	GPSRO	GRACE-II	HyspIRI	ICESat-II	LIST	PATH	SCLP	SMAP	SWOT	XOVWM	3D-Winds	ACRIMSAT	Aqua	Aura	CALIPSO	CloudSat	GPM	GRACE	ICESat	JASON-1	LANDSAT7	LAGEOS 1&2	NMP EO-1	QuikSCAT	ADEOS-II	SORCE	Terra	TRMM	Aquarius	GOES-N/O/P	Glory	LDCM	NPOESS	NPP	OSTM	OCO	Atmospheric Composition	Earth Surface & Interior	Climate Variability & Change	Carbon Cycle & Ecosystems	Weather	Water & Energy Cycle	Crosscutting	New
Carbon Cycle																																																																													
Carbon Cycle - Biomass	x	x		x				x	x	x	x	x	x	x				x			x	x	x			x			x	x	x		x			x					x	x				x														x	x					x			x				p				
Dynamic Plant Monitoring	x	x			x			x	x	x		x		x		x	x	x	x	x	x			x												x					x																										x						p				
Dynamic Soil Sampling	x	x			x			x	x	x		x		x		x	x	x	x	x	x			x																	x																										x						p		x		
Forest Fire Sensor Web with UAVSAR	x	x					x					x	x	x		x		x			x	x	x	x	x	x					x									x	x	x															x				x										x			p				
North American Net Primary Production comparison using automated workflow generation		x								x	x		x	x				x	x		x	x	x	x	x	x					x															x														x						x	x						p				
Soil Moisture Calibration and Validation for SMAP			x	x	x				x					x		x	x	x		x	x					x					x										x																									x							p				
Wildfire Sensor Web	x	x						x	x	x		x				x	x	x	x		x	x		x	x																					x										x				x														p			
Weather																																																																													
Extreme Event Detection and Tracking for Targeted Observing	x		x	x		x		x	x	x								x	x			x			x								x						x											x										x			x				x							p			
Improved Storm/Weather Prediction based on Lightning Monitoring and Prediction	x		x	x				x		x			x	x		x			x	x	x	x	x	x	x			x																					x																						p		p			GLM
Numerical Weather Prediction Doppler Wind Lidar	x															x					x																							x																														p			
Smart assimilation of satellite data into a weather forecast model	x		x					x			x		x	x			x	x	x		x				x	x													x							x																											p			
Water & Energy Cycle																																																																													
Coastal Sensor Web for Short- and Long-Duration Event Detection	x		x	x		x		x	x			x		x														x					x													x											x	x	x			x	x	x				x									p		
Glacier Outburst Flood Water Quality Impact				x	x			x				x				x					x	x	x								x						x				x												x																								p		
Hurricane Workflows	x	x			x	x		x	x	x	x	x	x	x		x	x	x			x			x	x	x										x																					x																	x		p		
Hydrology	x	x		x				x	x	x	x	x	x	x				x			x	x	x			x				x	x			x		x		x	x	x	x	x				x				x	x									x	x					x									p		
Snow and Cold Land Processes (SCLP) using ERINode for Passive Active Interferometric Radiometer w/Interleaved Radar								x								x						x				x														x																															x				p		
Soil Moisture Active-Passive (SMAP) high resolution foliage calibration			x					x								x						x				x					x										x																									x						x			p		
Water Quality Monitoring	x	x			x			x	x	x		x		x		x	x	x	x	x	x			x																		x																									x						x		p		
Cross-Cutting																																																																													
Collaborative Science Resource Allocation	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x			x	x	x	x	x	x	x																																													x	x	x	x	x	x	p	
Dynamically taskable sensors	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x																																												x	x	x	x	x	x	p	
Seamlessly Download Data	x	x	x	x	x	x	x			x				x			x				x	x		x														x				x				x	x			x										x		x				x				x	x	x	x	x	x	p	

11.1 Atmospheric Composition

11.1.1 Adaptive Sky applied to detection, tracking, and reacquisition of volcanic ash clouds

Point of Contact Name: Michael Burl

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☒ ACE
- ☒ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☒ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☒ HyspIRI
- ☒ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☒ Aqua
- ☐ Aura
- ☒ CALIPSO
- ☒ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☒ Terra
- ☐ TRMM
- ☒ *GOES (NOAA)

Future Missions

- ☐ Aquarius
- ☒ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☒ NPOES
- ☒ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☒ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☒ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☒ Targeted observations
- ☒ Incorporate feedback
- ☐ Ready access to data
- ☐ Improved use/reuse
- ☒ Rapid response
- ☐ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New

AIST Needs Category

- ☒ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation

☐

- ☐ New

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Adaptive Sky applied to detection, tracking, and reacquisition of volcanic ash clouds.

Goal

The goal briefly describes what the user intends to achieve with this use case.

Enable observations from multiple sensing assets (satellites, in-situ sensors, etc.) to be dynamically combined into a sensor web that responds quickly to volcanic eruptions by detecting and tracking the resultant ash clouds and acquiring follow-up measurements with the high-resolution, specialty instruments onboard NASA's EOS polar orbiting satellites.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

For this use case, selected Adaptive Sky components are combined to detect, track, and reacquire volcanic ash clouds generated by the October 2007 eruption of Bezymianny Volcano in Kamchatka. The basic strategy leverages the wide area coverage/high temporal sampling of NOAA's geostationary GOES-West satellite and the high spatial resolution/specialty instruments on NASA's polar orbiting satellites (e.g., Terra and the members of the A-Train). Following a trigger signal (hypothetically from the IRIS Global Seismograph Network, but it could instead be from a volcano-specific in-situ instrument or from overhead satellite imagery), we use GOES brightness temperature difference (BTD) image sequences to track features (volcanic ash clouds) over time. This step allows the sensor web to unambiguously associate measurements made in mid-ocean by the MISR (Multi-angle Imaging SpectroRadiometer) instrument on Terra and by the CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarization) with volcanic ash clouds from Bezymianny despite a time separation of ~30 hours and a spatial separation of ~400km from the initial eruption event. To our knowledge this marks the first ever unambiguous daytime observation of a tropospheric volcanic ash cloud with CALIOP and the first joint observations by both MISR and CALIOP of the same volcanic ash cloud (enabling, for example, inter-instrument height-retrieval comparisons). CloudSAT observations in the same area showed no returns indicating extremely small particle sizes consistent with ash. With agile satellites or instruments (capable of pointing), an even richer dataset could be obtained. Other reactions to the ash cloud events are also possible (warnings issued to aircraft, populated areas, incorporation of observations into predictive models, refinements of the models themselves). Similar principles and techniques can be applied to monitor meteorological clouds, rather than volcanic ash clouds with benefits to Weather and Climate modeling.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

The current scenario uses the following sensing "agents":

1. IRIS Global Seismographic Network (global coverage, very rapid detection of events, but limited perspective on the nature of the event and no information on what is happening above the ground).
2. The NOAA GOES-West geostationary satellite (advantage of wide area coverage, high temporal sampling, ability to dwell over an area of interest; disadvantages of limited spatial resolution due to distance, lack of specialty instruments).
3. Terra including the MODIS instrument on Terra (MODIS-Terra) and MISR (advantage of higher spatial resolution, specialized multi-angle imager; disadvantages of overpass then long wait for revisit). The ASTER instrument would be a valuable addition. Other Morning Train assets such as EO-1 (Hyperion instrument) could also be used.
4. The A-Train group including Aqua, CALIPSO, CloudSAT, with the following specific instruments: MODIS-Aqua, CALIOP on CALIPSO, Cloud Profiling Radar (CPR) on CloudSAT.

In addition, a reliable network of communication "agents" is necessary to quickly report trigger events, downlink the satellite data, and route the data to the desired location for processing. (Communications aspects of the sensor web have not been emphasized in our current work.)

There is also a centralized processing "agent" that takes the various inputs (IRIS GSN trigger, GOES data, etc.), makes its calculations and decisions, and then sends out messages to the other agents (e.g., telling a satellite to point at a specific location). Conceivably, some of the intelligence could be decentralized or delegated to the sensing agents; for example, the initial detection step based on the brightness temperature difference could be moved onboard.

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

Limited presence of meteorological clouds over the area(s) of interest as these will limit the effectiveness of most of the envisioned satellite sensing assets. The presence of extensive non-localized seismic activity could also limit the reliability of the seismic trigger.

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

The initial trigger is hypothesized to come from the IRIS Global Seismographic Network (detection of an event of sufficient magnitude that is spatially associated with likely volcanic activity). From a post-mortem analysis of the Bezymianny eruption, such a signal (a magnitude 4.2 earthquake at Bezymianny) was detected just prior to the eruption. At this time, we do not know how reliable this trigger is in terms of receiver operating characteristics (probability of detection versus probability false alarm). Other triggers are also possible, e.g., a volcano-specific in-situ sensor, a general purpose instrument such as a ground-based camera continuously observing a specific volcano, human reports of volcanic activity, direct detection of ash clouds in the overhead satellite imagery. Combining information from several triggers would likely reduce false alarms.

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Eruption event.
2) Detection of volcano-localized seismic event with IRIS GSN.
3) Initiation of ash cloud tracking in vicinity of target using GOES BTD sequences. If needed, auxiliary information such as wind vectors or resources such as an ash cloud propagation model could be included to aid in tracking and to issue warnings to aircraft and other assets potentially affected by ash precipitation.
4) Check for footprint collisions between polar orbiter instruments and tracked ash clouds.
5) Acquire follow-up measurements with polar orbiter instruments, potentially modifying pointing or other instrument parameters to optimize data acquisition.
6) Continue until ash cloud can no longer be observed.

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

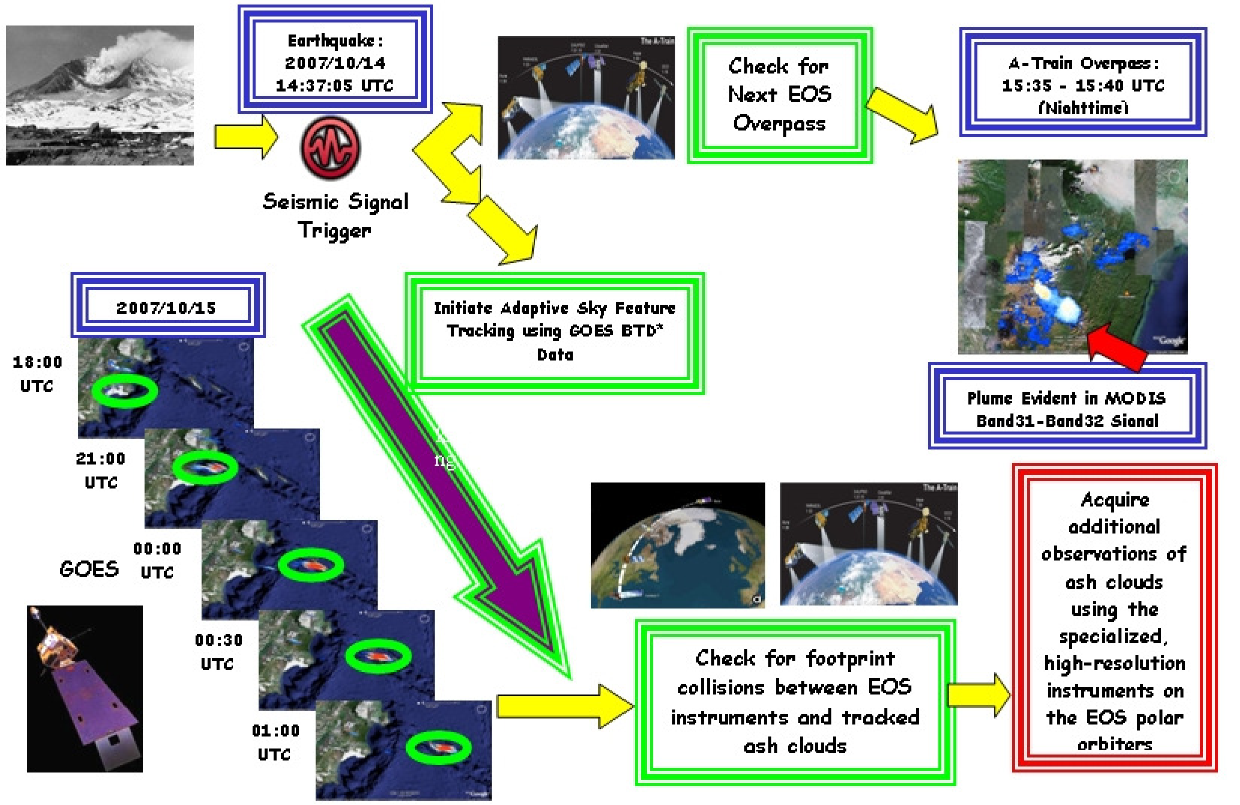
Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

The various instrument observations are organized into an object-centric view that associates all the relevant measurements with the ash cloud(s). This rich multi-modal dataset can be used for scientific study of the dynamics of ash clouds, refinement of ash propagation models, and to assess aircraft risk areas, etc. The raw detection and tracking data can be used to issue warnings to aircraft and people within the ash precipitation zone. (Although some mechanisms already exist for this purpose, our richer multi-instrument datasets may enable more accurate prediction of the hazard zones, e.g., by determining the altitude of the ash clouds, the effect of winds on the propagation and dispersion can be better calculated).

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

A similar approach can be used for meteorological clouds to link the observations made by one instrument with those made by another, e.g., observations made by a ground camera and an overhead satellite or by two satellites at different times. Once the measurements are linked to the same physical object, inter-instrument comparisons can be made, for example, the consistency of various height retrieval methods such as MISR (geometric), CALIOP (direct measurement with lidar), CloudSat (measurement with radar), and MODIS (inference based thermal equilibrium considerations).

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ,	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of	USGS, ESA, etc.	Name of the system which supports

	Etc.		the usage characteristics		discovery and access
Seismic event detection	In situ (but global)		Global monitoring of seismic activity with localization of sources.	IRIS	
Geostationary image sequences	Remote	No cloud cover; ash clouds must dissipate a bit before the BTD technique is effective. Temporal sampling varies from 15 min to 3 hours.	Wide-area coverage with relatively frequent temporal sampling. Special wavelengths allow calculation of brightness temperature difference, which is effective for detecting (partially transparent) ash clouds. Able to view whole disk (although not great toward edges, e.g., high latitude).	NOAA	
MODIS-Terra	Remote	No cloud coverage.	Wide swath, moderate spatial resolution.	NASA	
MISR-Terra	Remote	No cloud coverage.	Multi-angle observations. Able to retrieve height through geometric technique. Also, has aerosol retrieval to indicate shape of particles. Moderate vertical resolution.	NASA	
MODIS-Aqua	Remote	Same as MODIS-Terra.	Same as MODIS-Terra.	NASA	
CALIOP-CALIPSO	Remote	No cloud coverage. Extremely narrow swath.	Lidar. Direct (time of flight) retrieval of height. Best vertical resolution.		
CPR-CloudSAT	Remote	Extremely narrow swath.	Insensitive to extremely small particles.		

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model

No Modeling Services are currently used, but ash forecasting models do exist and could potentially be useful to our sensor web and likewise our sensor web could be useful to the models (e.g., by providing accurate height information to be ingested into the forecasts).					

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
Currently these steps are only simulated, but a fully deployed system would rely on event notification from the IRIS GSN as input. The sensor web could provide				

ash cloud locations and predicted tracks as an output event notification service. Subscribed scientists could also be notified that a new ash cloud data set has been acquired.				

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor
Currently, we only use the data from the sensors (see above) with no direct manipulation of the sensors themselves. However, it would be useful to be able to request specific observations from available				

instruments (e.g., ASTER).				

11.1.2 Quantifying Measurement Requirements for Atmospheric Chemistry Remote Sensing (NASA Atmospheric composition program NRA)

Point of Contact Name:	Meemong Lee

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☐ ASCENDS
- ☒ CLARREO
- ☐ DESDynl
- ☒ GACM
- ☒ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☐ Aqua
- ☒ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions
- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☒ OCO

Decadal Survey Category
- ☐ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☐ Climate variability and changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- ☒ Targeted observations
- ☐ Incorporate feedback
- ☐ Ready access to data
- ☐ Improved use/reuse
- ☐ Rapid response
- ☒ Improve cost effectiveness
- ☐ Improve data quality/science value
- ☒ New (Mission Planning)

AIST Needs Category
- ☐ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☒ 5-Systems Mgmt

- ☐ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation

☐

- ☐ New

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Quantifying Measurement Requirements for Atmospheric Chemistry Remote Sensing (NASA Atmospheric composition program NRA)

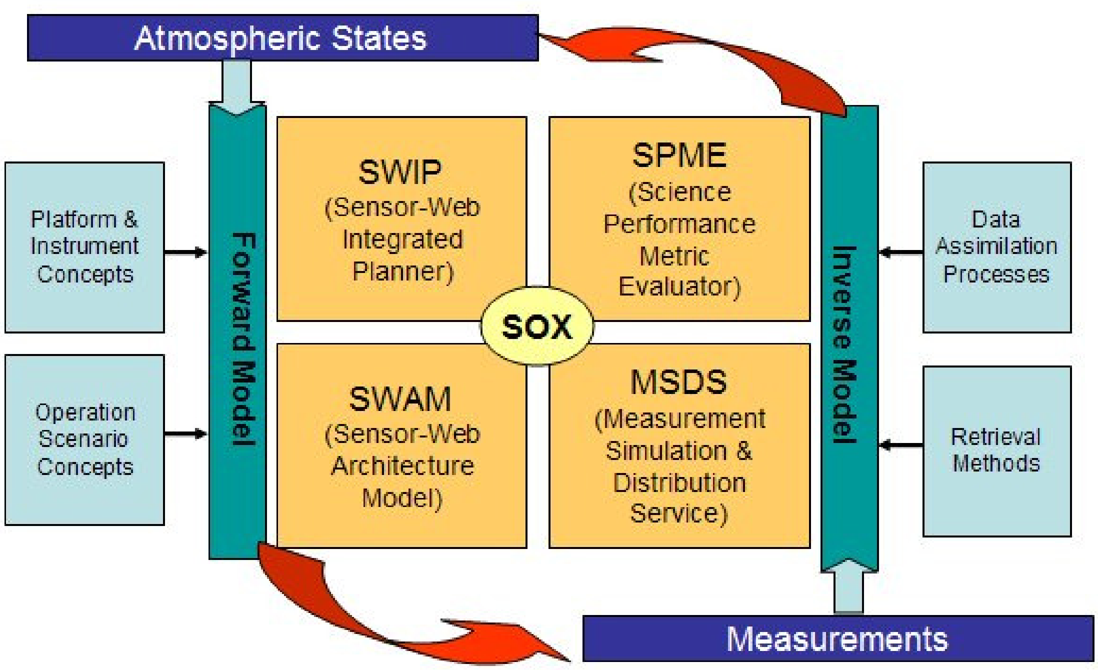
Goal

The goal briefly describes what the user intends to achieve with this use case.

To simulate mission concepts focused on atmospheric composition, and compare their power at answering a number of science questions through a set of quantitative metrics.

Summary

The Sensor-web Operations Explorer (SOX) implements a virtual multi-platform, multi-sensor observation infrastructure that enables integrated air-quality campaigns. This goal is decomposed into four main topics; Sensor-web Integrated Planner (SWIP), Sensor-Web Architecture Model (SWAM), Measurement Simulation and Distribution Service (MSDS), and Science Performance Metric Evaluator (SPME). SWIP is for observation-scenario design-space formulation and population in terms of configuring platforms and instruments. SMAM is for observation-system design-space formulation and population in terms of parametric representation of the performance range of the platforms and instruments. MSDS is for mission simulation and mission data-product synthesis utilizing the platform and instrument performance parameters defined by SWAM and operation scenarios defined by SWIP. Finally, SPME is for analyzing the sensitivity of the observation system and scenario design with respect to the individual campaign and the integrated campaign.



Actors

Primary:

Atmospheric Scientists

- define and create experiment requests
- intermediate user: provides retrieval and assimilation algorithm implementations

- end user: receives science metric

Secondary:
SOX on-line services
- Request manager: logs exploration requests and composes command lines
- Resource manager : monitors availability of the computational resources
- Execution manager : dispatches command lines to available resources
- Status reporter : reports run status and performance benchmark
- Database reporter : displays database entries
- Data reporter : displays database content

Preconditions

1) Phenomena database is available for the specified experiment time
2) Sample list and Instrument list are generated by the SOX design tool
3) Wavelength range is within UV, Vis, and IR.

Triggers

Exploration Requests:
- Observation Scenario Exploration
- Measurement Quality Exploration
- Retrieval Analysis Exploration
- Data Assimilation

Database Service Requests:
- Input signal
- Measurement signal
- Retrieval sensitivity

Basic Flow

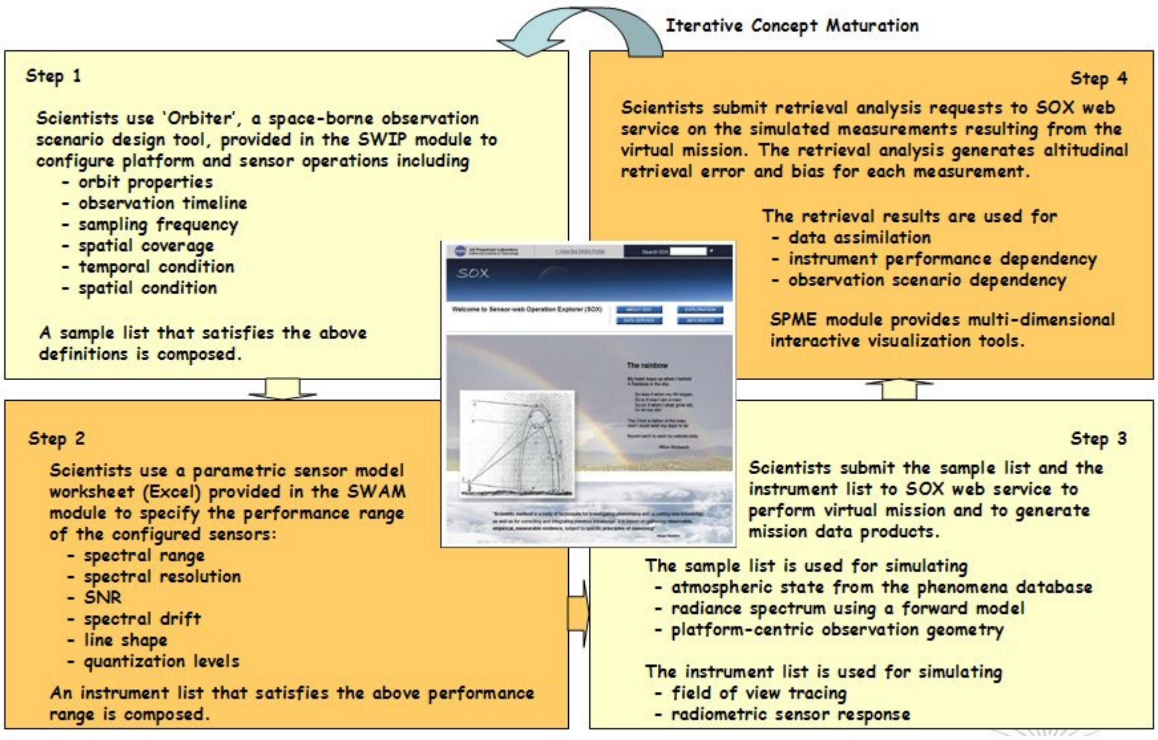
The atmospheric scientists iteratively refine measurement requirements by performing the four major SOX processes:

Step1 : orbit and sampling strategy specification

Step2: platform and instrument performance range specification

Step3: virtual mission execution

Step4: science return analysis



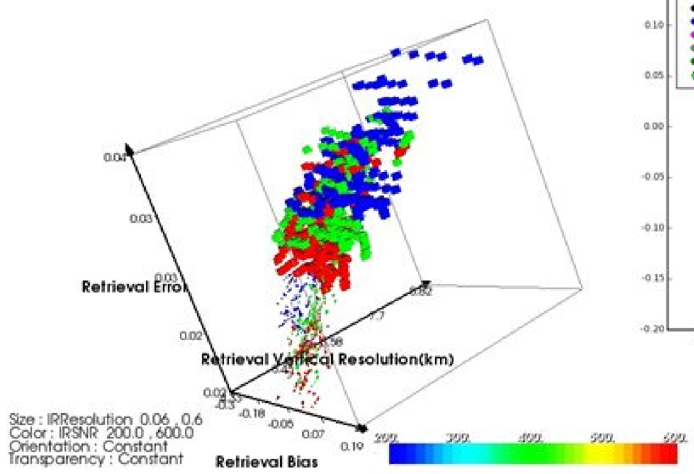
Alternate Flow

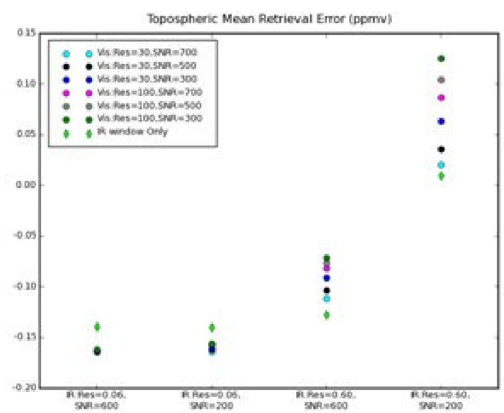
Post Conditions

.CSV file containing retrieval analysis results per measurement

.Netcdf file containing averaging kernels and other intermediate retrieval analysis datasets

Retrieval sensitivity analysis plots (example plot shown below)



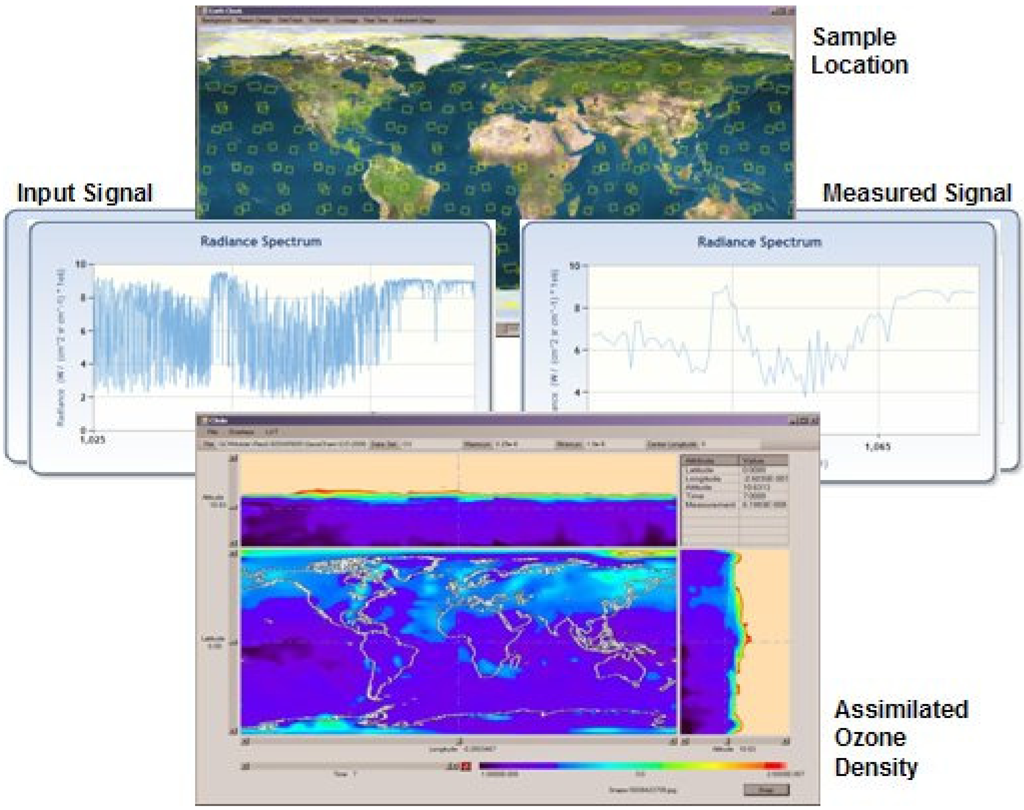


Input signal database

Measurement signal database

4-D dataset containing predicted/estimated trace gas (CO, Ozone, NO2) densities

QuickTime movies

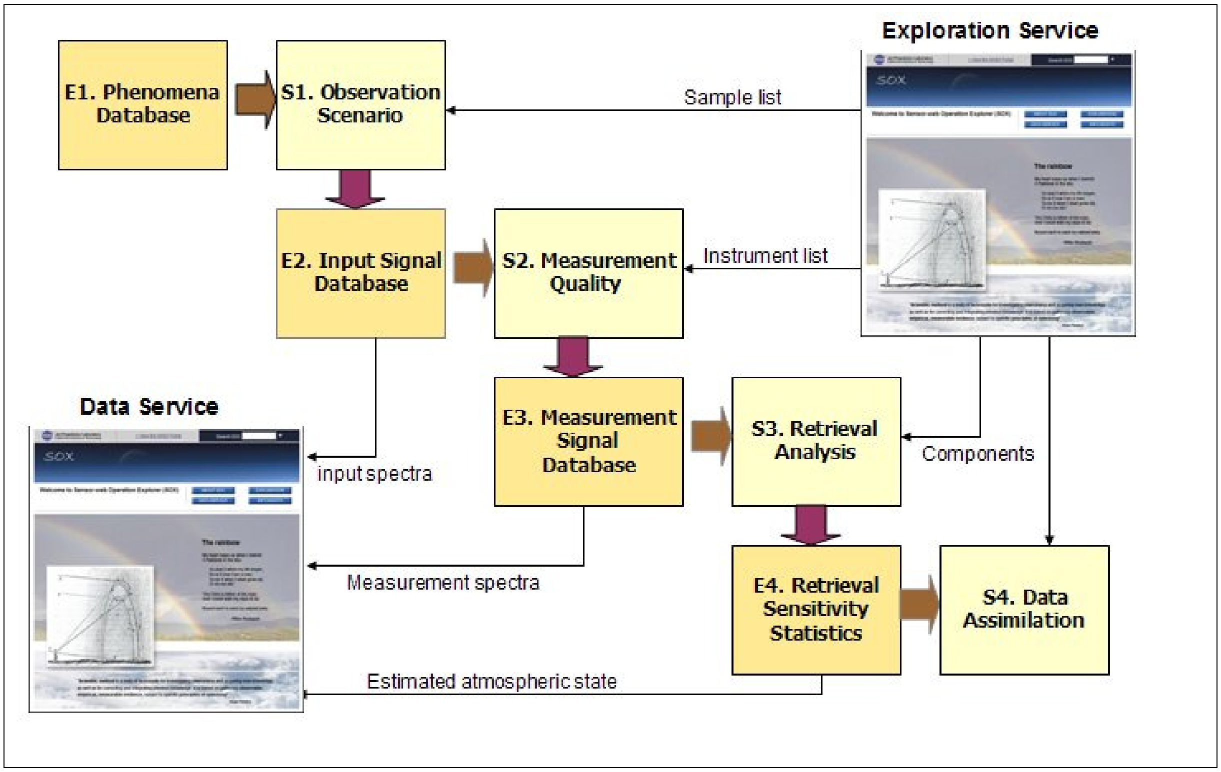


Activity Diagram

There are two types of activities, a science activity type and an engineering activity type. The science activity type includes submission of four types of exploration requests, observation scenario, measurement quality, retrieval analysis, and data assimilation.

The engineering activity type includes four types of database generation services, phenomena, input signal, measurement signal, and retrieval sensitivity statistics.

Scientists access SOX web site to submit the above four requests and retrieve the data products resulting from the requests.


Exploration Service
E1. Phenomena Database
S1. Observation Scenario
Sample list
E2. Input Signal Database
S2. Measurement Quality
Instrument list
Data Service
E3. Measurement Signal Database
S3. Retrieval Analysis
Components
input spectra
Measurement spectra
E4. Retrieval Sensitivity Statistics
S4. Data Assimilation
Estimated atmospheric state

11.1.3 Satellite and UAS fire observation inputs to smoke forecast models

Point of Contact Name: Stefan Falke

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☒ ACE
- ☒ ASCENDS
- ☐ CLARREO
- ☐ DESDynl
- ☒ GACM
- ☒ GEO-CAPE
- ☐ GPSRO
- ☒ GRACE-II
- ☒ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☒ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☒ Aqua
- ☒ Aura
- ☒ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☒ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☒ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☒ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☒ NPOES
- ☒ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☒ Earth Science Apps & Societal Benefits
- ☒ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☒ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☒ Targeted observations
- ☒ Incorporate feedback
- ☐ Ready access to data
- ☐ Improved use/reuse
- ☐ Rapid response
- ☐ Improve cost effectiveness
- ☐ Improve data quality/science value
- ☐ New

AIST Needs Category

- ☒ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☐ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation
- ☐
- ☐ New

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Satellite and UAS fire observation inputs to smoke forecast models

Goal

The goal briefly describes what the user intends to achieve with this use case.

This air quality use scenario envisions a sensor web that facilitates access, integration, and use of multi-source data for purposes of air quality assessment and forecasting. A particular emphasis is placed on the near real time analysis of large forest fires and the assimilation of satellite and unattended aerial systems (UAS) observations to improve numerical smoke forecast models.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

To better understand, forecast, and manage air pollution, air quality researchers and managers need to bring together information about a variety of atmospheric constituents from different observational platforms (surface monitoring networks, satellites, sondes, ground-based remote sensors, aircraft, ...), nonlinear chemical and physical atmospheric processes from meteorological and chemical transport models, emissions and emissions-generating activities, population demographics, exposure-related behavior, and health impacts.

The Air Quality analyst needs to assess the extent and impact of detected wildfire smoke. Using an Air Quality community portal the analyst identifies relevant satellite and aerial sensors to acquire new observations of the wildfire occurrence and vegetation (fuel) characteristics. The new data is analyzed and used as input information for a smoke forecast, which is made available to analysts and AQ warning systems.

Smoke from biomass burning is an important component of air quality forecasting. Quantifying air pollutant emissions from wildfires and prescribed burning is one of the more uncertain inputs to air quality forecasting. Satellite and UAS observations can improve the ability to accurately estimate smoke emissions and transport. However, the quality of satellite and UAS derived fire and land cover products for smoke forecasting is not well characterized:

- multiple sensors detect fires - which to use?
- missed detections (e.g., due to cloud cover)
- false detections
- spatial resolution limitations
- temporal resolution limitations
- size and types of fires detected

Types of analyses conducted on satellite and UAS derived fire information in preparation for their use as inputs to smoke forecast models include:

- comparison of multiple satellite/aerial products (e.g., EO-1 fires compared with MODIS fires; UAS derived smoke compared with EO-1 or MODIS)
- agreement of satellite/aerial products with ground based observations

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary

- Air quality analyst who accesses fire locations, perimeters and vegetation cover as inputs to smoke forecast models
- Satellite and UAS data notification services

Primary actors are the ones who trigger the next stage in the workflow

Secondary

- Smoke forecast models
- Air quality community portal
- Satellite and UAS data access services

Secondary are the end of the workflow or the recipient

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

1. Satellite derived fire occurrence, fire perimeter and vegetation cover data are available
2. Forecast model components are available as services

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

Fires are detected by satellite or UAS observation

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1. Fires are detected and notifications sent to air quality community portals and analysts.
2. Analyst uses air quality community portals to discover latest available sensor observations(MODIS, EO-1, GOES, Ikhana, NDVI)
3. Analyst acquires observations and derived products through web service interfaces
4. Observations and derived products are reconciled, filtered, fused and aggregated
5. Reconciled observations and derived products are assimilated into the smoke forecast models
6. Smoke forecasts are generated including smoke dispersion and particulate matter concentrations

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

Following products result:

- More accurate smoke forecasts
- Smoke forecasts accessible through air quality community portals via standard web service interfaces and visualized in maps, time plots and tables

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
CALPUFF	NGC				
Fishman Smoke Trajectory	NASA Langley				

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
Air Pollution	EPA??, USFS??	High estimated pollution concentrations from forecast (similar to AIRNow)		

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
BlueskyRAINS			
AIRNow			

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor

GOES	NOAA		Every 15 minutes	
FIRE	NASA		During flights	Ikana UAS
PM2.5 FRM	EPA		Daily	AIRS
PM2.5	NPS		Every 3rd day	IMPROVE
PM2.5	EPA		Hourly	AirNOW
Hyperion, ALI	NASA		Once every two weeks	EO-1
MODIS	NASA		Twice daily	Aqua, Terra

11.1.4 SEPS (Self-Adaptive Earth Predictive Systems) Interoperation for AutoChem Assimilation System

Point of Contact Name: Liping Di

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☒ ACE
- ☒ ASCENDS
- ☐ CLARREO
- ☐ DESDynl
- ☒ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☒ Aqua
- ☒ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☒ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☐ GOES-N/O/P
- ☒ Glory
- ☐ LDCM
- ☒ NPOES
- ☐ NPP
- ☐ OSTM
- ☒ OCO

Decadal Survey Category

- ☒ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☐ Targeted observations
- ☒ Incorporate feedback
- ☒ Ready access to data
- ☒ Improved use/reuse
- ☒ Rapid response
- ☒ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New

AIST Needs Category

- ☒ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☐ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation
- ☐
- ☐ New

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

SEPS (Self-Adaptive Earth Predictive Systems) Interoperation for AutoChem Assimilation System

Goal

The goal briefly describes what the user intends to achieve with this use case.

The overall scientific goal is to enable the accurate and near-real-time prediction of the transport of atmospheric pollutants through close interactions between sensors and the model. Technically, this demonstration demonstrates the capability of SEPS to dynamically feed data and serve result of the ESMF-based AutoChem Atmospheric Chemistry Composition Modeling by following open geospatial standards and specifications for Sensor Web; and this also demonstrates the sensor planning capability through the feedback loop of SEPS.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

Three specific objectives are to be achieved in this demonstration: (1) to demonstrate the capability of the Self-Adaptive Earth Predictive Systems in serving live sensor observations to an ESMF-based atmospheric model by following open standards and specifications; (2) to extract data product of the model and serve them to a wide community in the Web environment by following open standards and specifications; and (3) to demonstrate the sensor planning capability. The resulted online system will enable the near-real-time production of suites of products for atmospheric constituents whenever new observations are made.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors:

1. New observations from sensors

Secondary actors:

1. AutoChem atmospheric models
2. Atmospheric scientists
3. Sensor observations from MLS, HIRDLS, TES and OMI on Aqua, SAGE II (Stratospheric Aerosol and Gas Experiment II) sensor aboard the Earth Radiation Budget Satellite (ERBS), Halogen Occultation Experiment (HALOE), Microwave Limb Sounder (MLS), Cryogenic Limb Array Etalon Spectrometer (CLAES), and ISAMS observations on Upper Atmosphere Research Satellite (UARS).

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

1. Archived data availability
2. Planning service availability

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

1. Science driving goals - set by research scientists when they initiate the generation of atmospheric chemistry models.
2. Outputs from the workflow – demand for the further observations.

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, *a conversation or as a story.(as much as required)*

1) Atmospheric scientist set goal product
2) Asynchronously retrieve data requests to archived data servers
3) Submit request to sensor planning service to acquire data and wait for data asynchronously
4) Feed live data to grid data service through transaction operation
5) Alert the data availability through an alert service
6) Suspending workflow continue the process for pre-processing and preparation of observations and data
7) Data aggregation service - a Web-based process – to prepare the data in the format as required by AutoChem
8) Invoke the AutoChem to generate result
9) Retrieve the product back through Export state of ESMF (Earth Science Model Framework) to grid data service through its transaction operation
10) Alert the availability of new product through an alert service
11) This may trigger another round of observation acquisition, model generation, and production.

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

1) If data acquisition failed at the acquisition step, an error message is sent out
2) Human actor may decide if the workflow continues with alternative data or terminates.

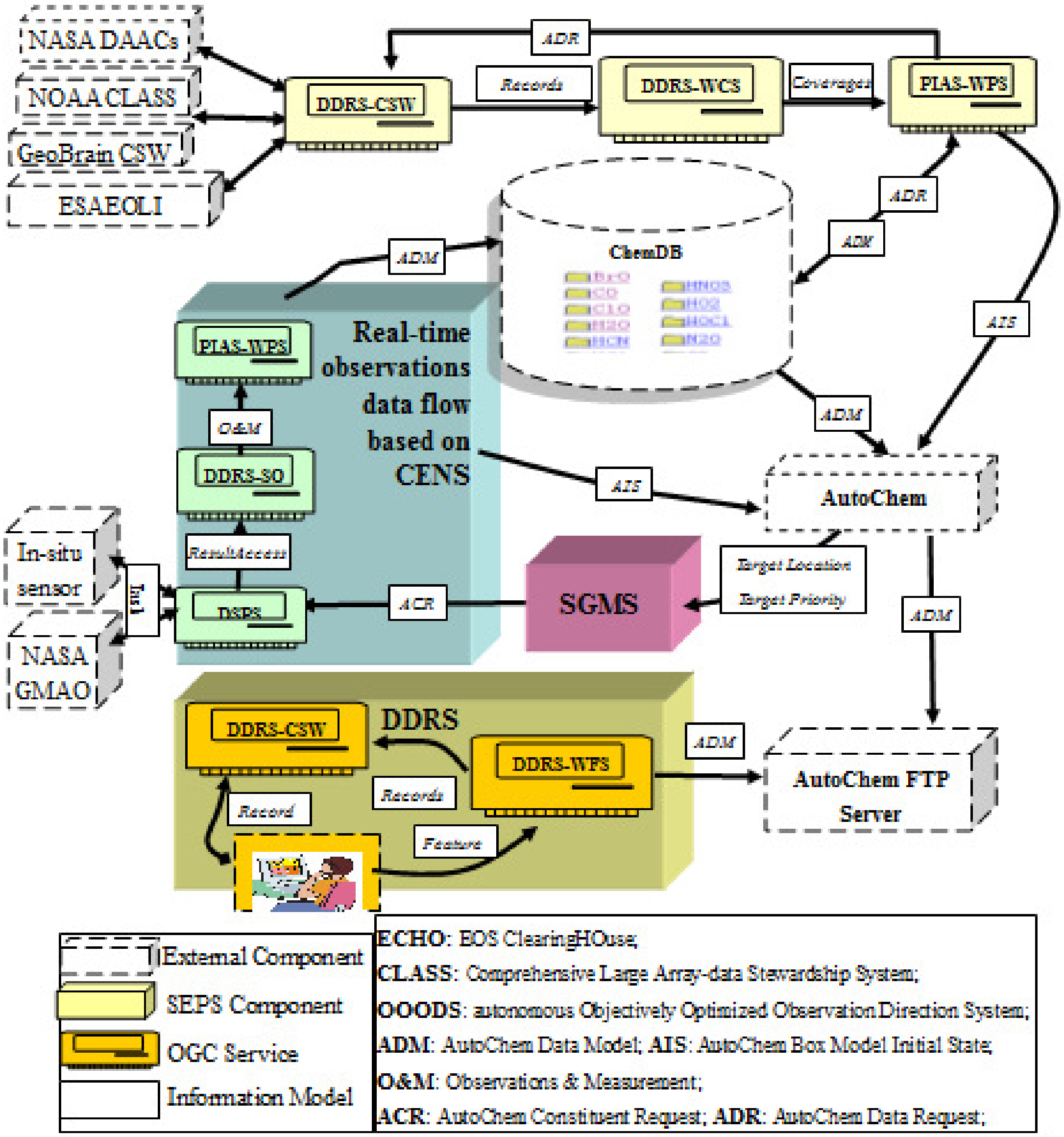
Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

1) New observations were archived in some grid coverage service and available to be re-used
2) New products were made available through grid coverage service
3) A standard catalogue service is also updated with availability of new data and product

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Possible interoperations between AutoChem and SEPS were identified for several phases. The first phase is for SEPS to provide major data to AutoChem through standard services (e.g., WCS and WFS). A workflow will be used to coordinate the pre-processing of observations and data. The results will be accessible through ftp service made available to the community. The second phase will support more data feeding to the AutoChem and retrieval of product from AutoChem model through standard transaction operations of WCS and WFS. Planning services will be supported at a later stage when the implementation and re-development of the planning services is completed.

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

The technical advancement for this demonstration is on bridging two worlds – ESMF and geospatial Web services. ESMF is the domain where scientific models are developed. This would easy the integration of earth science models into the new service-oriented geospatial processing services and data.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access
Aura MLS	Remote	BrO,CH3CN,ClO,CO, GPH ,H2OHCL, HCN,HNO3,HO2, HOCl,IWC, IWR,N2O, O3,OH,RHI ,SO2	There are Daily level 1 calibrated radiance data products at full temporal resolution (every 24.7 seconds) in the HDF5 (dataset/table model) file format since 2004-08-08 00:00:00 and Daily level 2 geolocated geophysical parameter data products at full instrument resolution in the HDF-EOS5 (swath model) file format since 2004-08-08 00:00:00. (http://disc.gsfc.nasa.gov/data/datapool/MLS/)	NASA	GeoBrain CSW NASA ECHO
Aura HIRDLS	Remote	O3, H2O, CH4, N2O, HNO3, N2O5, CFC11, CFC12, ClONO2 NO2	There are Daily level 2 geolocated geophysical parameter data products at full instrument resolution in the HDF-EOS5 (swath model) file format since 2005-01-22 00:00:09. (http://disc.gsfc.nasa.gov/data/datapool/HIRDLS/)	NASA	GeoBrain CSW NASA ECHO
Aura OMI	Remote	NO2, SO2, BrO, OClO, aerosol	There are L1B in HDF-EOS 2(swath model) file format,L2 in HDF-EOS5 (swath model) file format,L2G in HDF-EOS5 (grid model) file format,L3 in both HDF and NetCDF formatsdata since 2004-08-09 18:23:43 (http://disc.gsfc.nasa.gov/data/datapool/OMI/)	NASA	GeoBrain CSW NASA ECHO

Aqua AIRS	Remot e	H2O, O3	There are Level1B radiance data, Level 2 and Level 3 Products.		GeoBrain CSW NASA ECHO

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
AutoChem model	UMBC/GEST, The Atmospheric Chemistry and Dynamics Branch, NASA GSFC	Data Assimilation	Aqua AIRS (Atmospheric Infrared Sounder), Aura HIRDLS (High Resolution Dynamics Limb Sounder), Aura MLS (Microwave Limb Sounder), Aura OMI (Ozone Monitoring Instrument) and Aura TES (Tropospheric Emission Spectrometer)	Per month	ESMF-based AutoChem

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
WNS	GMU	CENS manages the messages past between PIAS, DDRS, and DSPS and coordinate the discovery, preparing, and downloading of data. WNS (Web Notification Service) is the core of the sub-system. A list of active events is managed in an event registry. Changes to the status of		http://csiss.gmu.edu/sensorweb/cens/

		event are notified to corresponding services.		
SAS	GMU			

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
AutoChem	NASA GEST	Serving graphs in the Web environment	www.autochem.info
BPELPower	GMU	Business Process Execution Language (BPEL) engine for Web Services	http://data.laits.gmu.edu:9180/bpelasync/
WCS_T	GMU	Transactional Web Coverage Server 1.1.0	http://data.laits.gmu.edu:8080/pli/www/wcst110.htm
CSW Server	GMU	Using ebRIM CSW server to register and discover EO-1 SOS	http://csiss.gmu.edu/sensorweb/demo.html
SOS	GMU	GOES-12 Imager Sensor Observation Service	http://csiss.gmu.edu/sensorweb/sos/
RESTFul Workflow service	GMU	Interoperation between RESTful web services/workflows and SOA geospatial web services/workflow	http://data.laits.gmu.edu:8088/VWCS_OWS5/index.html
EO-1 SOS	GeoBliki	EO-1 Hyperion Sensor Observation Service	http://eo1.geobliki.com/sos

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/	Short description of the sensor	How often the sensor can	Name of the satellite or system

	manages sensor		observe event	which manages sensor
AIRS on Aqua	NASA		Twice daily (day and night) on a 1:30pm	JPL
MLS, HIRDLS, TES and OMI on Aura	NASA		Every 24.7 seconds	

11.1.5 SEPS (Self-Adaptive Earth Predictive Systems) Interoperation for Bird Migration Modeling and Avian Flu Prediction

Point of Contact Name: Liping Di

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynl
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☒ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☒ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☒ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☒ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☒ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☒ GOES-N/O/P
- ☐ Glory
- ☒ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☒ Earth Science Apps & Societal Benefits
- ☒ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☒ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☐ Targeted observations
- ☒ Incorporate feedback
- ☒ Ready access to data
- ☒ Improved use/reuse
- ☒ Rapid response
- ☐ Improve cost effectiveness
- ☐ Improve data quality/science value
- ☐ New

AIST Needs Category

- ☐ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☒ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation
- ☐
- ☐ New

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

SEPS (Self-Adaptive Earth Predictive Systems) Interoperation for Bird Migration Modeling and Avian Flu Prediction

Goal

The goal briefly describes what the user intends to achieve with this use case.

Avian influenza is one of the dangerous infectious diseases that may cause damage and death in a large area. Migratory bird is one of the carriers that spread the virus to a large area. Migratory bird modeling requires rapid observations from multi-sensors. The goal of the demonstration is to demonstrate the capabilities of SEPS in dynamically assimilating data and observations from multi-sensors by re-using standard Web services and the rapid response to be achieved through live link between sensors and science applications.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

Many of these data were made available to be accessed through some traditional and non-standard access media, such as ftp, web post, documents online, and off-line storage media. The streaming of data into the bird migratory models takes quite an important portion of the precious expertise time. The latency for obtaining these data exists. The project aims at reliving some of the burdens from scientists by bridging data and models through interoperable interfaces and services made available through the SEPS. Currently, GOES data can be lively retrieved, re-projected, re-formatted, and subsetted at using the exposed standard WCS interfaces through the SEPS. These data are needed for the bird migration modeling.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors:

1. Bird migration modelers (human)

Secondary actors:

1. Sensors: NASA MODIS/AMSR, NOAA AVHRR, EO1, in-situ sensors
2. Models: bird migration and avian flu model
3. Portals: OGC WCS,WFS,WMS,CSW, SPS, SOS, SAS,WNS, WPS,

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

1. Data availability
2. Acquisition capability

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

Bird flu occurrence in the world

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Discover archived data source through a catalogue service
2) Access archived data source through raster data service and feature data services

3) Process archived data through processing services in the Web
4) Initiate bird migration and avian flu model
5) Output the initial prediction to science goal management system
6) The science goal management module compare the initial prediction and the scientific goal and evaluate whether the goal is met, if not, make prediction-feedback tasking to real-time data
7) Discover real-time data through a catalogue service
8) plan real-time data through a sensor planning service
9) access real-time data through a sensor observation service
10) process real-time data through a processing unit to input the validating model
11) output prediction
12) client access

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

1) If data acquisition failed, the exception handling routine is triggered.
2) If only inferior quality data are found, human role may decide if the workflow continues or not.

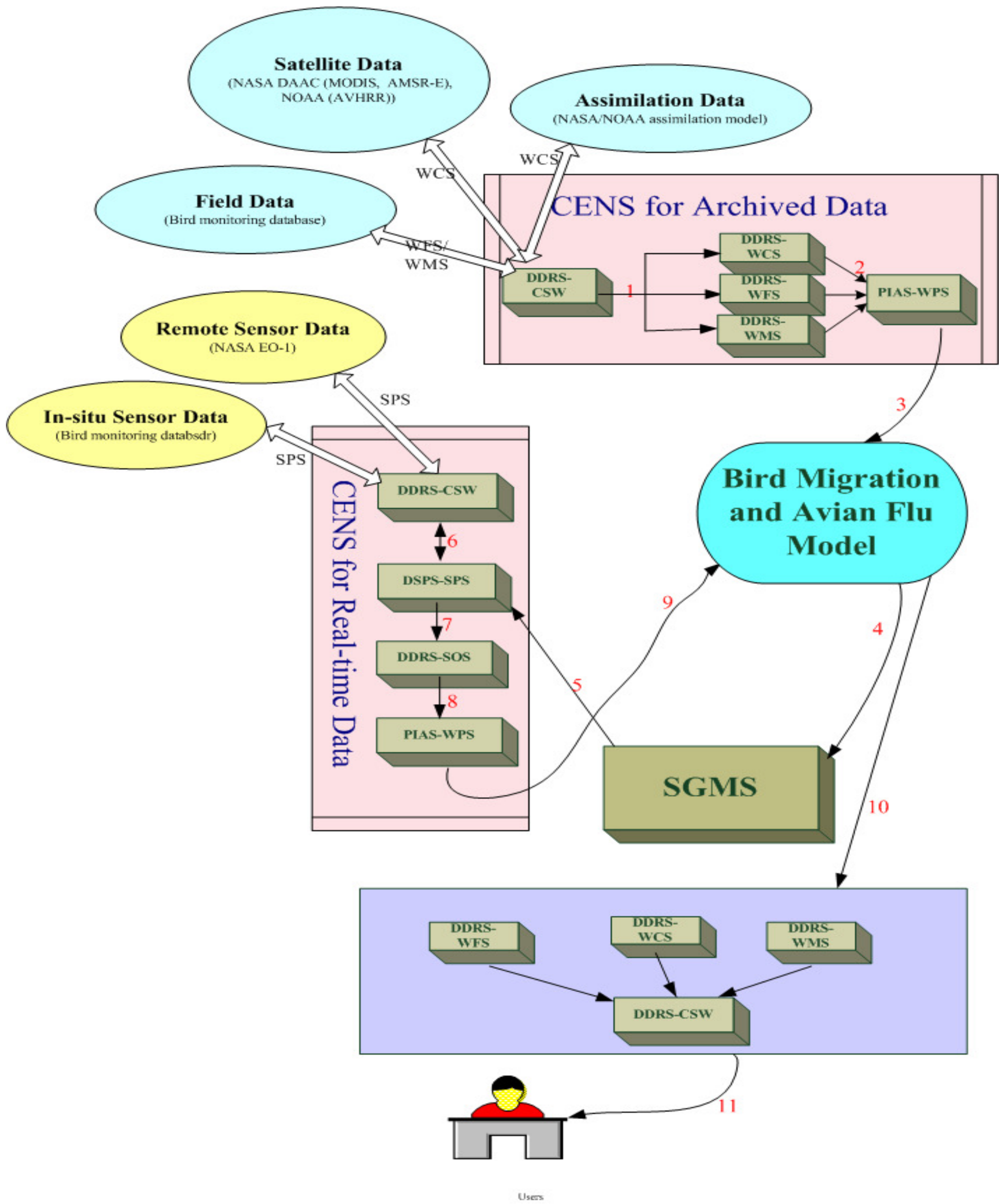
Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

1. New observations
2. Bird migration patterns
3. Bird flu prediction

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



1. archived data discovery	5. task planing	9. processing input validation data
2. archived data access	6. real-time data discovery	10. prediction output
3. model initiation	7. real-time data planning	11. client access
4. initial output	8. real-time data accessing	

Bird migration and avian flu model is driven by the flight energetic cost of the birds and some climate conditions, such as prevailing winds, precipitation. Those driven force can be gotten from different archived data source which will be discovered and accessed by DDRS module and processed though PIAS-WPS to initiate the bird migration and avian flu model in scientist's interest area. DDRS and PIAS are modules of the SEPS framework.

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Human actors are going to play important roles in this workflow. Under the umbrella of virtual product concept, this can be accomplished rigorously with the emerging standards, e.g., BPEL4People (an emerging standard workflow script language to enable the human to act in a complete workflow with a well-defined role).

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access
MOD11A1	Remote	Area: ~1100 x 1100 km Dimensions: 1200 x 1200 rows/columns File Size: ~4 MB compressed Resolution: 1-kilometer (0.93-km) Projection: Sinusoidal LST Data Type: 16-bit unsigned integer Emissivity Data Type: 8-bit unsigned integer Data Format: HDF-EOS	MODIS/Terra Land Surface Temperature/Emissivity	NASA	LP DAAC Data Pool/ EOS DATA GATEWAY
MOD17A2	Remote	Area: ~10 degrees x 10 degrees lat/long Dimensions: 1200 x 1200 rows/columns File Size: ~ 0.2 MB compressed Resolution: 1 kilometer Projection: Sinusoidal Data Format: HDF-EOS	MODIS/Terra Gross Primary Productivity 8-Day L3 Global 1km SIN Grid V005	NASA	LP DAAC Data Pool / EOS DATA GATEWAY
MOD15A2	Remote	Area: ~10 degrees x 10 degrees lat/long Dimensions: 1200 x 1200 rows/columns File Size: ~ 0.2 MB	MODIS/Terra Leaf Area Index/FPAR 8-Day L3 Global 1km SIN Grid	NASA	LP DAAC Data Pool / EOS DATA GATEWAY

		compressed Resolution: 1 kilometer Projection: Sinusoidal Data Format: HDF-EOS			
MOD13A2	Remote	Area: ~10 degrees x 10 degrees lat/long Dimensions: 1200 x 1200 rows/columns File Size: ~ 1 - 22 MB Resolution: 1 kilometer Projection: Sinusoidal Data Format: HDF-EOS	MODIS/Terra Vegetation Indices 16-Day L3 Global 1km SIN Grid V005	NASA	LP DAAC Data Pool / EOS DATA GATEWAY
MOD12Q2	Remote	Image Dimensions = 3 (2 x1200 x 1200 num_modes/row/column) Area = Nominal 10° x 10° lat/long Size = 1200 x 1200 rows/columns Average File Size = 41.3 MB Resolution = Nominal 1 kilometer Projection = Sinusoidal Data Type = 16-bit Unsigned Integer Data Format = HDF-EOS	MODIS/Terra Land Cover Dynamics Yearly L3 Global 1km SIN Grid	NASA	LP DAAC Data Pool / EOS DATA GATEWAY
MOD12Q1	Remote	Area = Nominal 10° x 10° lat/long Size = 1200 x 1200 rows/columns File Size = ~22 MB Resolution = Nominal 1 kilometer Projection = Sinusoidal Data Type = 8-bit	MODIS/Terra Land Cover Type Yearly L3 Global 1km SIN Grid	NASA	LP DAAC Data Pool / EOS DATA GATEWAY

		Unsigned Integer Data Format = HDF-EOS			
MOD44A	Remote	Area = ~ 10° x 10° lat/long Image Dimensions Metrics = 3 (4800X4800X12 row/column/metric) Image Dimensions Change = 2 (4800x4800 row/column) Average File Size = ~ 600 MB Resolution = 250 meters Projection = Sinusoidal Data Format = HDF-EOS	Vegetation Cover Conversion Quarterly L3 Global 250m MODIS/Terra Vegetation Cover Conversion 96-Day L3 Global 250m SIN Grid	NASA	LP DAAC Data Pool / EOS DATA GATEWAY
MOD44B	Remote	Area: ~10 degrees x 10 degrees lat/long File Size: ~1.3 MB Projection: Sinusoidal Data Format: HDF-EOS Dimensions: 2400 x 2400 rows/columns Resolution: 500 meters	MODIS/Terra Vegetation Continuous Fields Yearly L3 Global 500m SIN Grid	NASA	LP DAAC Data Pool / EOS DATA GATEWAY
MOD10A 2	Remote	Area: 1200 km by 1200 km resolution: 500 m Data Format = HDF-EOS	MODIS/Terra Snow Cover 8-day L3 Global 500m Grid	NASA	NSIDC
AMSR-E-L3_Land X	Remote	Resolution: 25 Data Format : HDF-EOS	AMSR-E/Aqua Daily L3 Surface Soil Moisture, Interpretive Parms, & QC EASE-Grids	NASA	NSIDC
AVHRR GIMMS	Remote	Data format: HDF-EOS	a normalized difference vegetation index (NDVI) product available for a 22 year period spanning from 1981	UMD GLCF	http://glcf.umiacs.umd.edu/ data/gimms/

			to 2003.		
{u,v,p}	Assimilation data	Dataformat: NetCDF	Wind field	NOAA	PSD
Precipitation	Assimilation data	Dataformat: NetCDF	Daily mean Precipitation rate	NOAA	PSD
Soil moisture	Assimilation data	Dataformat: NetCDF	Daily mean soil moisture	NOAA	PSD
Soil temperature	Assimilation data	Dataformat : NetCDF	Daily mean soil temperature	NOAA	PSD
ebird	Field data	Dataformat: .txt/.kml	Field monitoring data	National Audubon Society, Cornell Lab of Ornithology	Avian knowledge network

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
NCEP/NARR	NOAA	NCEP's high resolution combined model and assimilated dataset. It covers 1979 to near present and is provided 8-times daily, daily and monthly on a Northern Hemisphere Lambert Conformal Conic grid for all variables.	Wind field {u,v,p} Precipitation rate, Soil moisture, Soil temperature	daily	PSD NARR
NCEP/DOE Reanalysis II	NOAA	A state-of-the-art analysis/forecast system is used to perform data assimilation using data from 1979 through	{u,v,p} Precipitation rate, Soil moisture, Soil temperature	daily	PSD NCEP-DOE Reanalysis 2

		2003. A large subset of this data is available from PSD in its original 4 times daily format and as daily averages.			

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
WNS	GMU	OGC Web Notification Service	GMU	http://data.laits.gmu.edu:8088/cens/wns

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
Bird migration and avian flu prediction	NASA		

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor
EO1 Hyperion	USGS/NASA			

11.1.6 Tasking new satellite and UAS observations with smoke forecasts

Point of Contact Name: Stefan Falke

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☒ ACE
- ☒ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☒ GACM
- ☒ GEO-CAPE
- ☐ GPSRO
- ☒ GRACE-II
- ☒ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☒ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☒ Aqua
- ☒ Aura
- ☒ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☒ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☒ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☒ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☒ NPOES
- ☒ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☒ Earth Science Apps & Societal Benefits
- ☒ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☒ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☒ Targeted observations
- ☒ Incorporate feedback
- ☐ Ready access to data
- ☐ Improved use/reuse
- ☐ Rapid response
- ☐ Improve cost effectiveness
- ☐ Improve data quality/science value
- ☐ New

AIST Needs Category

- ☒ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☐ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation
- ☐
- ☐ New

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Tasking new satellite and UAS observations with smoke forecasts

Goal

The goal briefly describes what the user intends to achieve with this use case.

This air quality use scenario envisions a sensor web that facilitates access, integration, and use of multi-source data used as inputs and outputs for smoke forecast models. A particular emphasis is placed on the near real time analysis of large forest fires and their impact of air quality by using new smoke forecasts to task new satellite and UAS observations.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

To better understand, forecast, and manage air pollution, air quality researchers and managers need to bring together information about a variety of atmospheric constituents from different observational platforms (surface monitoring networks, satellites, sondes, ground-based remote sensors, aircraft, ...), nonlinear chemical and physical atmospheric processes from meteorological and chemical transport models, emissions and emissions-generating activities, population demographics, exposure-related behavior, and health impacts.

Smoke from biomass burning is an important component of air quality forecasting and management. Smoke forecasts predict areas whose air quality is expected to be substantially impacted by transported smoke. The 1-3 day forecasts help managers warn the public of health impacts. Surface sensors are in place to quantify the impact of the smoke on air quality. However, they are limited in spatial and temporal coverage and satellites and UAS fill some of the spatial and temporal gaps of the surface sensors. Satellite and UAS sensors are also needed by air quality analysts to capture observations in areas of high forecast uncertainty.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary

- Smoke forecast model.
- Air quality analyst who uses smoke forecast to task satellite and UAS sensors

Secondary

- Satellite and UAS sensor planning services

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

- Forecast model output is available though a web service interface and air quality community portals
- Taskable satellite and UAS platform sensors are available

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

Smoke forecast predicts substantial air quality impact in populated area.

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1. Smoke forecast model is run
2. Areas (space, time, observation parameter) are identified requiring new sensor observations from satellite and UAS sensors
3. Discover relevant sensors
4. Sensor feasibility request is submitted through standard web service interfaces
5. Submit new sensor tasking requests through standard web service interfaces

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

If sensor feasibility request returns NULL, then end flow

Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

Following products result:

1) Areas predicted to be impacted by smoke available through air quality community portals
2) Satellite and UAS sensors tasked for new observations of areas of interest

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
CALPUFF	NGC				
Fishman Smoke Trajectory	NASA Langley				

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
Air Pollution	EPA??, USFS??	High estimated pollution concentrations from forecast (similar to AIRNow)		

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
BlueskyRAINS			
AIRNow			

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor
GOES	NOAA		Every 15 minutes	
FIRE	NASA		During flights	Ikana UAS
PM2.5 FRM	EPA		Daily	AIRS
PM2.5	NPS		Every 3rd day	IMPROVE
PM2.5	EPA		Hourly	AirNOW
Hyperion, ALI	NASA		Once every two weeks	EO-1
MODIS	NASA		Twice daily	Aqua, Terra

11.1.7 Validating smoke forecast models with satellite, UAS and surface observations

Point of Contact Name: Stefan Falke

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☒ ACE
- ☒ ASCENDS
- ☐ CLARREO
- ☐ DESDynl
- ☒ GACM
- ☒ GEO-CAPE
- ☐ GPSRO
- ☒ GRACE-II
- ☒ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☒ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☒ Aqua
- ☒ Aura
- ☒ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☒ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☒ Terra
- ☐ TRMM

Future Missions
- ☐ Aquarius
- ☒ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☒ NPOES
- ☒ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category
- ☒ Earth Science Apps & Societal Benefits
- ☒ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☒ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- ☒ Targeted observations
- ☒ Incorporate feedback
- ☐ Ready access to data
- ☐ Improved use/reuse
- ☐ Rapid response
- ☐ Improve cost effectiveness
- ☐ Improve data quality/science value
- ☐ New

AIST Needs Category
- ☒ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☐ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation
- ☐
- ☐ New

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Validating smoke forecast models with satellite, UAS and surface observations

Goal

The goal briefly describes what the user intends to achieve with this use case.

This air quality use scenario envisions a sensor web that facilitates access, integration, and use of multi-source data for purposes of air quality assessment and forecasting. A particular emphasis is placed on the retrospective analysis of large forest fires and the validation of forecast output with satellite and unattended aerial systems (UAS) to improve numerical smoke forecast models.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

To better understand, forecast, and manage air pollution, air quality researchers and managers need to bring together information about a variety of atmospheric constituents from different observational platforms (surface monitoring networks, satellites, sondes, ground-based remote sensors, aircraft, ...), nonlinear chemical and physical atmospheric processes from meteorological and chemical transport models, emissions and emissions-generating activities, population demographics, exposure-related behavior, and health impacts.

For scientific assessment and analysis of management strategies, this integration can be done using historical datasets. For air quality forecasting to inform the public and manage individual air pollution episodes or events, it is necessary to perform this integration in near real time.

Smoke from biomass burning is an important component of air quality. Quantifying air pollutant emissions from wildfires and prescribed burning is one of the more uncertain inputs to air quality forecasting. Satellite data are being used to help improve the ability to accurately estimate emissions from fires. However, the quality of satellite derived fire products for air quality applications is not well characterized:

- multiple sensors detect fires - which to use?
- missed detections (due to cloud cover)
- false detections
- spatial resolution limitations
- temporal resolution limitations
- size and types of fires detected
- derivation of smoke from satellite and aerial imagery

Types of analyses conducted on satellite derived fire and smoke information include:

- comparison of multiple satellite/aerial products (e.g., EO-1 fires compared with MODIS fires; UAS derived smoke compared with EO-1 or MODIS)
- agreement of satellite/aerial products with ground based observations
- agreement of forecast models with satellite/aerial products

The Air Quality analyst needs to assess the extent and impact of detected wildfire smoke. Using an AQ portal the analyst identifies relevant satellite and aerial sensors to acquire new observations of the wildfire occurrence. The new data is used to validate and refine a smoke forecast, which is made available to analysts and AQ warning systems. The forecasts are used to request new observations from satellite, aerial and ground platforms and compare them with the forecasts.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary

- Air quality analyst who seeks to assess extent and impact of wildfire smoke.
- Air quality modeller who uses fire locations as inputs and uses smoke products to validate model
- Validation algorithm/tool

Secondary

- Smoke forecast model
- Satellite and UAS sensor data access services

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

1. Satellite derived smoke/aerosol optical depth data are available through a web service interface
2. Forecast model output is available though a web service interface

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

Smoke forecast model run and generates output

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1. Model run complete
2. Discover available sensor data for validation
3. Acquire sensor observations for smoke extent and aerosol optical depth
4. Validate Model thru comparison w/ validation data (validation algorithm)

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

Following products result:

- Smoke forecast output available through air quality community portal
- Validation comparison and processing available through air quality community portals

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
CALPUFF	NGC				
Fishman Smoke Trajectory	NASA Langley				

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
Air Pollution	EPA??, USFS??	High estimated pollution concentrations from forecast (similar to AIRNow)		

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
BlueskyRAINS			
AIRNow			

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor
GOES	NOAA		Every 15 minutes	
FIRE	NASA		During flights	Ikana UAS

PM2.5 FRM	EPA		Daily	AIRS
PM2.5	NPS		Every 3rd day	IMPROVE
PM2.5	EPA		Hourly	AirNOW
Hyperion, ALI	NASA		Once every two weeks	EO-1
MODIS	NASA		Twice daily	Aqua, Terra

11.2 Earth Surface & Interior

11.2.1 Earthquake response and forecasting

Point of Contact Name: Andrea Donnellan

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☒ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☒ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☒ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☒ Targeted observations
- ☐ Incorporate feedback
- ☒ Ready access to data
- ☒ Improved use/reuse
- ☒ Rapid response
- ☐ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New

AIST Needs Category

- ☒ 1-Data Collection
- ☒ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☐ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☒ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation
- ☐
- ☐ New

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Earthquake response and forecasting

Goal

The goal briefly describes what the user intends to achieve with this use case.

Improved rapid response and earthquake forecasting from NASA's DESDynI mission

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

DESDynI (Deformation, Ecosystem Structure, and Dynamics of Ice) is a combined InSAR/Lidar mission to study, among other things, tectonics surface deformation. Incorporation of surface deformation measurements into tectonic models is proving important for understanding earthquake processes and the resulting size and style of earthquakes. DESDynI will be the first InSAR mission to systematically and globally measure surface deformation at frequent intervals. An estimate 200 earthquakes per year or 1000 earthquakes will be detected over the 5-year duration of the mission. The mission will produce over 200 GB per day of crustal deformation data. These data must be incorporated into models and the large volumes of data drive the need to automated data processing. DESDynI InSAR surface deformation data will provide secular and time varying rates of deformation, which will improve our understanding of long and short-term earthquake processes. Response will be required in the event of a large earthquake. The data must be rapidly downloaded, processed, and integrated with other data types. Earthquake response will include damage assessment and an assessment of stress changes and potential for subsequent earthquakes.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors: NASA, NSF, USGS scientists, mission operators, and data analysts

Secondary actors: FEMA, USGS, Office of Emergency Services, governments

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

- Data from DESDynI are being routinely processed
- Seismic, paleoseismic, and GPS data are readily ingested in to the models
- Models are developed and data are being assimilated
- Web and grid services exist for accessing data and models and running on appropriate computers including high performance computers

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

- Typical trigger will be a large earthquake (M> 6.5 in unpopulated area, M>5 in populated area)
- Detectable changes in strain could also trigger an event

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Earthquake occurs
2) Region is imaged with DESDynI

3) Data are downlinked and processed
4) Additional data (seismic, geological observations, GPS) are collected into web services
5) Data analyzed for damage and type of faulting
6) Results are communicated to appropriate agencies (FEMA, USGS, OES)
7) Stress changes are calculated and are compared to simulations to understand probability of subsequent earthquakes
8) Results are communicated to appropriate agencies
9) Observations are collected over remainder of mission to understand long-term effects

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

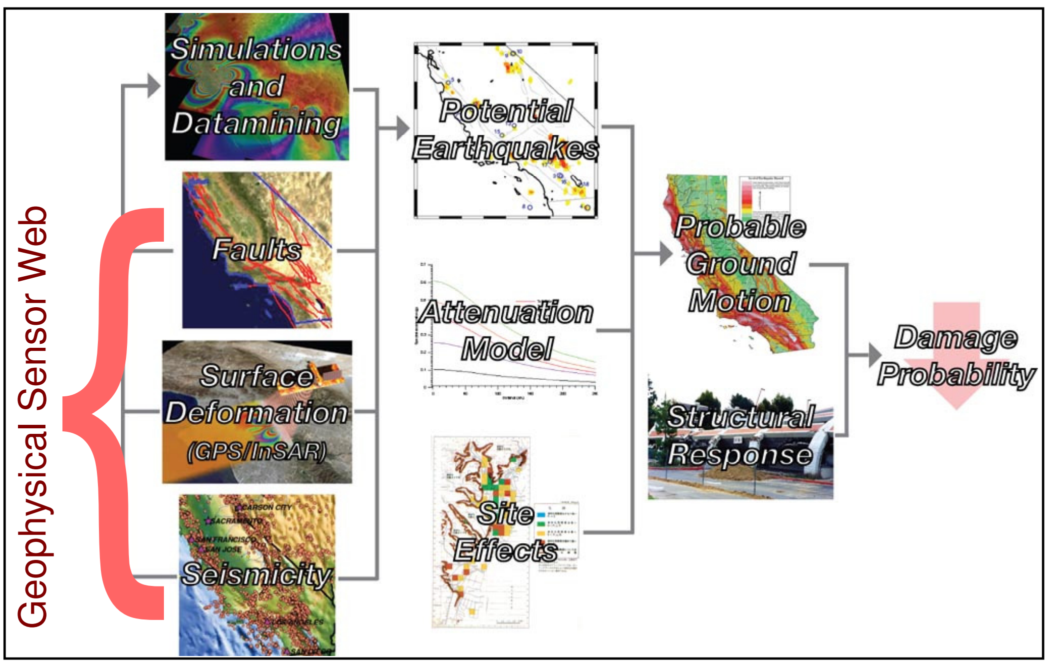
Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

- InSAR imagery available on the web
- Stress change maps available through the portal on the web

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

DESDynI will have many use cases. This is one example. Other events include:

- Tsunamis resulting from earthquakes
- Volcanoes
- Landslides
- Subsidence

- Flooding
- Hurricanes
- Wind events
- Wildfires
- Land use (e.g., clear cutting)
- Ice shelf break up

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access
InSAR	Remote	Surface deformation	To understand fault behavior and interactions	NASA	DESDynI, QuakeSim
GPS Time Series	In situ	Position time series data	For continuous observations and temporal signals	NSF, NASA, USGS	EarthScope Plate Boundary Observatory
GPS Velocities	In situ	Station velocities	For secular and transient velocities	NSF, NASA, USGS	EarthScope Plate Boundary Observatory
Seismicity	In situ	Magnitude and location of earthquakes	For tasking DESDynI image acquisition; pattern recognition for forecasting	USGS, Caltech, Berkeley	California Integrated Seismic Network
Paleoseismology	In situ	Fault data from local observations	Extrapolated to fault segments for modeling	NASA	QuakeTables from QuakeSim
Simulated data	Simulated	Model output from numerous runs	Over timescales longer than observable but for comparison to real data	NASA	QuakeSim

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
GeoFEST	NASA JPL	Finite element model for faults in viscoelastic medium	GPS, InSAR, paleoseismic, seismic	For science modeling and event response	QuakeSim
Simplex	NASA JPL	Inverts for fault motion	GPS, InSAR, paleoseismic	Following events and to understand surface deformation	QuakeSim
Disloc	NASA JPL	Forward model of fault displacement for surface deformation	Paleoseismic and compared to GPS and InSAR surface deformation data	Event response and for understanding surface deformation	QuakeSim
Virtual California	UC Davis	Simulates interacting fault systems	Seismicity, paleoseismic, surface deformation	Operational for doing statistics on the simulations for comparison to observations and events	QuakeSim
PARK	Brown University, USGS	Fault nucleation model	Surface deformation and seismic	Science modeling and event response	QuakeSim
RIPI	UC Davis	Pattern informatics on seismicity for forecasting earthquakes	Seismicity	Continuous and real-time	QuakeSim
RDAHMM	NASA JPL	Time series analysis for GPS network state changes	GPS position time series	Continuous and real-time	QuakeSim

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event

Earthquake	USGS	Earthquake magnitude and location for upstream end of flow		California Integrated Seismic Network; Golden Colorado office for global events

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
QuakeSim: visualization, simulation/modeling tools	NASA	Estimate damage, stress changes, and earthquake potential based on earthquake event information, InSAR imagery, and models/simulations	QuakeSim

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor
Seismometer	USGS, Caltech, Berkeley	Seismometer network detects earthquake location, size, and characteristics	Continuously	California Integrated Seismic Network; Global seismic network
GPS	EarthScope; Scripps/JPL	Produces GPS time series in near real-time and velocities periodically	Continuously (1 Hz); velocity solution periodically (months to years)	Plate Boundary Observatory; Southern California Integrated GPS Network
InSAR	NASA	Orbiting satellite that produces radar imagery for constructing displacement interferograms	Within 8 days	DESDynI

11.2.2 Geomorphology

Point of Contact Name: Paul R. Houser

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynl
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions
- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category
- ☐ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- ☐ Targeted observations
- ☐ Incorporate feedback
- ☐ Ready access to data
- ☐ Improved use/reuse
- ☐ Rapid response
- ☐ Improve cost effectiveness
- ☐ Improve data quality/science value
- ☐ New

AIST Needs Category
- ☐ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☐ A-Increase science data value thru autonomous use
- ☐ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation
- ☐
- ☐ New

Use Case Name
Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Geomorphology

Goal
The goal briefly describes what the user intends to achieve with this use case.

Improve rapid knowledge and prediction of geomorphological conditions and extremes.

Summary
Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

Use DESDynI's capabilities to trace geomorphologic deformation and model sediment movement and erosion / deposition processes that brings change on earth surface and subsurface conditions.

Actors
List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Preconditions
Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

- Data from DESDynI are being routinely processed, or available in this use case from a synthetic "truth" source (i.e., a model)
- Precipitation, elevation, surface runoff gages, vegetation state, land use, and GPS data are readily ingested in to sediment transport models
- Models of landslide prediction and geomorphologic change exist or are developed and are capable of assimilating DESDynI-style data.
- Web and grid services exist for accessing data and models and are running on appropriate computers including high performance computers

Triggers
Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

- Typical trigger will be a combination of significant hydrologic extreme (say a localized torrential rain) on steep and non-uniform topography, or a flash flood on loose top soil, that may bring massive sediment load on flowing water.
- Detectable ancillary sensor web conditions (e.g., precipitation, snow melt, or evapotranspiration extremes) for a prolonged period on geomorphologically unstable region could trigger a landslide event or rapid erosion process.

Basic Flow
Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Sediment movement (erosion, deposition, landslide) occurs
2) Region is imaged with DESDynI
3) Data are downlinked and processed
4) Additional data (soil type, hydrologic and atmospheric observations, GPS) are collected into web services
5) Data analyzed for detecting the geomorphologic deformation
6) Results are communicated to appropriate agencies (needs to list)

7) Geomorphological changes are calculated and analyzed to understand probability of subsequent impacts

8) Results are communicated to appropriate agencies

9) Observations are collected over remainder of mission to understand long-term effects

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

- Landslide hazard maps and erosion /available on the web
- Stress change maps available through the portal on the web

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Premise: The DESDynI is a first wave Decadal Survey mission equipped with both a surface imaging L-Band SAR and LIDAR, with 8 day repeats and 10-100km resolutions. It is capable of measuring surface elevation changes and vegetation structure, which can provide information on a wide range of geomorphologic, solid earth, cryosphere, and hydrologic changes. Our goal here is to explore Sensor Web "use cases" that explore or demonstrate how DESDynI's capabilities can be significantly enhanced when used in a Sensor-Model web framework. Since this is a future remote sensing system, with no contemporary analogue, we will generally be performing these use cases in a OSSE (Observation Simulation Sensitivity Experiment) mode, where we use a model to create a synthetic "truth" that can be sampled by a DESDynI sensor model to allow the sensor-model web use case paradigm to be explored. The spatial extent, time period, and domain for these studies is generally less important than demonstrate the interaction between various sensors, models, and communication frameworks to achieve an improved science or application result. We have identified a number of different use case scenarios below, which is by no means comprehensive, but can provide a baseline of expected DESDynI system enhancements using a sensor web paradigm. It should also be noted that similar use cases can and should be developed for the other decadal survey missions.

DESDynI will have many use cases. These are selected examples - other events include:

- Tsunamis resulting from earthquakes
- Volcanoes
- Landslides
- Subsidence
- Flooding
- Hurricanes
- Wind events
- Wildfires
- Land use (e.g., clear cutting)
- Ice shelf break up

DESDynI's sensors can be applied to a wide range of geomorphologic science from erosion, deposition, landslides, tectonic processes (volcano, earthquake, Tsunamis), and subsidence at a wide range of space and time scales. These advancements in geomorphologic observation have potential to enhance scientific investigation on future geomorphologic condition and their control on long term ecosystem and bio-geo-ecological cycle. DESDynI's sensors can contribute to understand such geomorphologic dynamics and also directly address societal needs of geomorphologic application fields from emergency response to long-term community planning such as river restoration, designing of self-maintaining deltas and delta managements. For this use case, we will need to focus on DESDynI's capabilities to monitor some subset of these applications.

11.2.3 Model-based Volcano Sensor Web with Smart Sensors

Point of Contact Name(s): Ashley Gerard Davies, Steve Chien

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- X DESDynI
- ☐ GACM
- X GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- X HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- X Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- X NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- X Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- X LDCM
- X NPOES
- X NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☐ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- X Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- X Targeted observations (Main Feature)
- ☐ Incorporate feedback
- ☐ Ready access to data
- ☐ Improved use/reuse
- X Rapid response (Main Benefit)
- ☐ Improve cost effectiveness
- ☐ Improve data quality/science value
- ☐ New______________________

AIST Needs Category

- X 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☐ A-Increase science data value thru autonomous use
- X B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation

- ☐ New________________________________

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Model-based Volcano Sensor Web with Smart Sensors

Goal

The goal briefly describes what the user intends to achieve with this use case.

Time is of the utmost importance in a volcanic crisis for the purposes of hazard and risk assessment. The goal of the JPL Model-based Volcano Sensor Web (MSW) is to detect an alert of pending or current volcanic activity, obtain high-resolution data, process the data and disseminate the products to relevant scientists as rapidly as possible, ideally within hours to a few days. We are working towards a fully-autonomous system.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

The MSW is an end-to-end product delivery service, aimed at effusive volcanic eruptions. When the African volcano Nyamulagira (a.k.a. Nyamuragira) in the Democratic Republic of Congo erupted in November 2006, the utility of such a system was demonstrated. As local volcanologists were unable to determine the location of the vent, models of possible lava flow paths were poorly constrained. A call went out to the international community to obtain spacecraft data to allow accurate vent location. The autonomous MSW reacted faster than humans in the spacecraft command and control loop. A detection of a plume reported by the Toulouse VAAC was detected by a remote agent of the JPL MSW. The alert notification was passed to a planner which inserted an observation (for two days later) in the EO-1 operational sequence. Data obtained by the Hyperion visible-infrared hyperspectral imager were processed onboard by data classifiers. Thermal emission from the erupting lava was detected and a summary product downlinked within 90 minutes of data acquisition, alerting JPL that the detection had been successful. EO-1 retasked itself to obtain additional data at the next possible opportunity. Within 24 hours the entire Hyperion dataset had been downlinked and radiometrically corrected. The data underwent additional manual processing to generate image products showing detail of the vent area, which were then emailed to volcanologists in Italy, France and the D. R. Congo. The new flow model output is in the form of maps showing the application of models of lava flow emplacement, based on the updated vent location, knowledge of local topography and assuming an eruption rate based on previous behaviour of the volcano. The new maps showed a greater likelihood of flows to the south west of the vent reaching the town of Sake and cutting an important road, and no flows to the east (predicted by models using the original estimated vent location some 2 km away from the location identified in the Hyperion data). This information allowed local authorities to amend disaster plans accordingly. In the end, the eruption was relatively short-lived and Sake was not directly threatened. EO-1 obtained a follow-up observation of Nyamulagira two days after the first, but the scene was found to be cloud-covered. In the absence of further alerts, the system re-set itself.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary:
Volcano
Scientists
- define and create triggers
- intermediate user: modellers requires precise assessment of eruption parameters

- end user: receives data, assesses situation, acts on results

Secondary:
Sensor Web remote sensing asset (Hyperion)
- collect data (hyperspectral, 0.4-2.4 microns)
- controlled with spacecraft command language (SCL)

spacecraft autonomy agent – ASE (Autonomous Sciencecraft Experiment)
- triggered by sensor web
- triggers additional data takes
- onboard classifiers
- planner
- spacecraft command language

Sensor Web data processing systems
- generate alert in form of web posting (VAAC in this case)
- remote agent to find alert
- parsing software to identify target
- software to radiometrically calibrate data
- software to detect anomalous thermal emission, process spectra to derive thermal emission
- model to derive effusion rate from integrated thermal emission
- software to geolocate data
- software to generate maps
- email application to disseminate products

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

1. Resources are available (no conflict with higher-priority paid scenes or other non-movable scheduled operations)
2. Position of spacecraft (determines hours/days to observation: the sooner, the more useful, in this Use Case)
3. Position of target (e.g., polar targets have more observation opportunities)
4. No or little cloud cover over target at data acquisition time
5. Activity is above detection threshold (else can lead to false negative)

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

External (this Use Case)
- Global: Volcanic Ash Advisory Center: (7 regional centres) ash cloud detections

Other available triggers for current volcano monitoring system

Global
- MODVOLC (U. Hawai'i) processes MODIS data to detect thermal emission.
- US Air Force ash plume detection alerts
- Human interactions: phone/email

Regional
- GOESVolc (U. Hawai'i) processes GOES data to detect thermal emission.
- Terra ASTER alert system (N. Pacific)

Local
- HVO tiltmeter data, Kilauea and Mauna Loa.
- Volcano Monitors: SO_2 detectors operating on Kilauea volcano, HI.
- Mount Erebus Volcano Observatory acoustic alerts

Internal
- ASE thermal classifier
- models of processes output effusion rates, thermal emission

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Alert detected (remote agent, email, human input) by Sensor Web
2) Alert passed to planner; observation request generated
3) EO-1 observation scheduled
4) Hyperion observations obtained. ALI observation also obtained at same time.
5) Observation processed onboard EO-1 by ASE (THERMAL, CLOUD [day])
6) Thermal emission detected
7) ASE retasks EO-1 to obtain additional data
8) THERMAL_SUMMARY product downlinked
9) Notification of eruption detection posted
10) Hyperion and ALI data downlinked and radiometrically corrected (L1R product)
11) Hyperion data geolocated (L1G product)
12) Hyperion L1R radiance data processed to generate thermal output and effusion rate
13) Hyperion data processed to generate images
14) Data, results and products posted on webpage
15) Products emailed to list of interested parties
16) Repeat EO-1 observation obtained

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

Alternate Flow 1
1) At Step 2 above: No room in schedule for observation of target in next 7 days
2) System resets and awaits new alert

Alternate Flow 2
1) Non-detection of thermal emission due to classifier threshold limit (min. 2 pixels) AND/OR
2) Poor weather conditions obscure target (day time only: see result of run of cloud detector)
3) If target cloud-covered, planner requests follow-up observation

Alternate Flow 3
1) Inability to disseminate data due to poor communication infrastructure at destination
2) System operates while communications are restored. No data are lost, but value is reduced.

Alternate Flow 4
1) Spacecraft safeing; software reset.
2) Upload S/W if necessary; restart operations

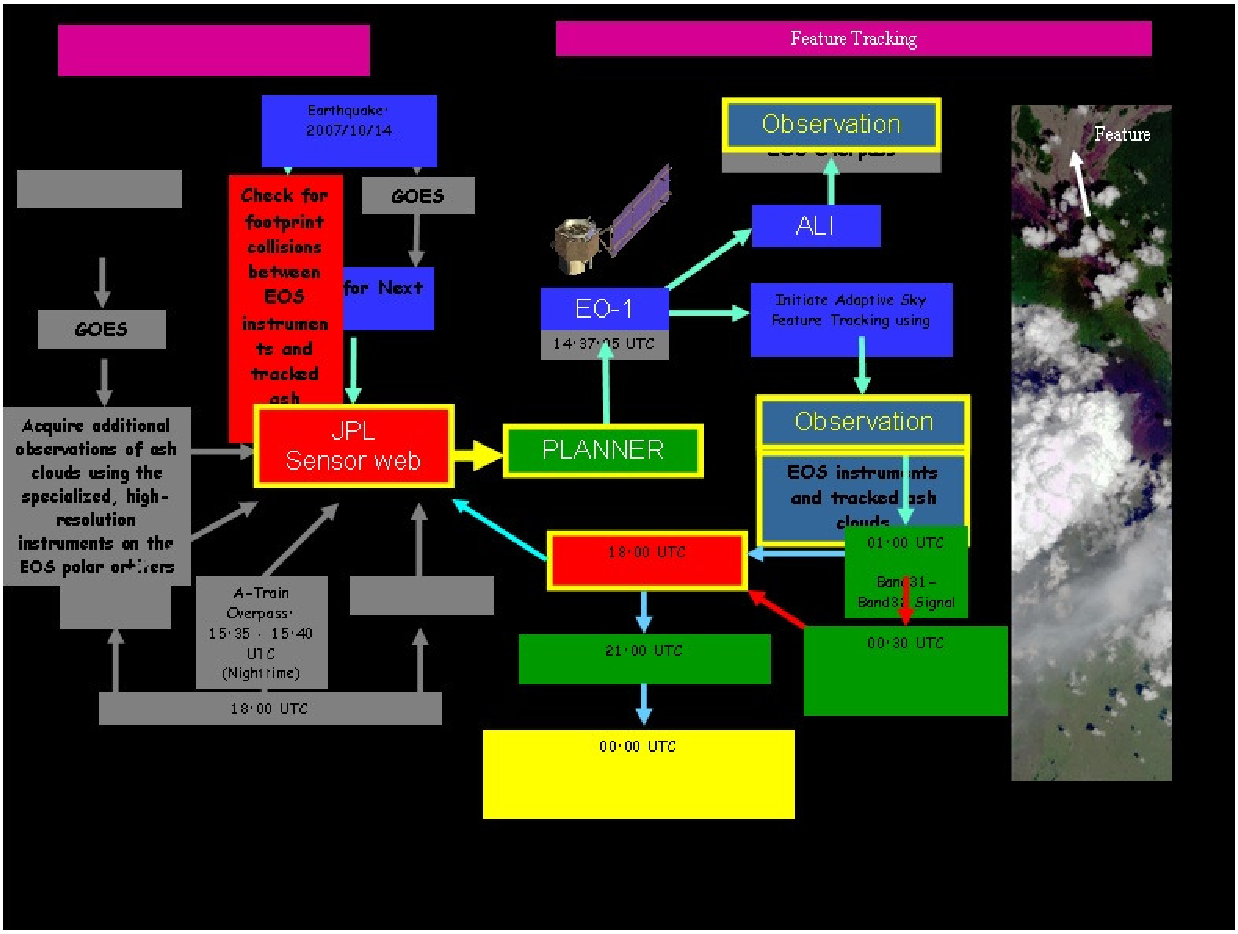
Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

1) Timely volcano observation informs researchers and hazard warning system.
2) System resets to await new volcanic eruption detection.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

1. Model-based Volcano Sensor Web incorporation of future missions: DESDynI (InSAR, use: volcano deformation); GEO-CAPE (hyperspectral and multispectral imagers, use: monitoring thermal emission from geostationary orbit); HyspIRI (hyperspectral imager, use: detection of thermal emission, new deposits). Goal would be to autonomously use and co-ordinate multiple assets for timely observation of volcanic eruption. Data analysis and model output feeds back into operational control to ensure subsequent observations are ultimately controlled by science goals. Multiple assets observe different aspects of the volcano and the eruption, yielding a more detailed understanding than what is capable from data from a single instrument.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access
Hyperion Observation	Remote-sensing	-no cloud cover over vent -day or night	220 bands between 0.4 and 2.4 microns. 30 m/pixel spatial resolution. - data used to detect hottest areas of volcanic activity: ideally suited for detection of new volcanic activity	USGS/NASA-GSFC-JPL	EROS Data Center

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
ASE Thermal classifier	JPL	Part of ASE. Identifies anomalous thermal emission; outputs thermal_summary product (intensities of hot pixels at 12 wavelengths)	Hyperion observation	Once per observation	(1) ASE (2) JPL Model-based Volcano Sensor Web
ASE Cloud Detector	JPL	Part of ASE. Returns cloud cover in daytime Hyperion data	Hyperion observation	Once per observation	(1) ASE (2) JPL Model-based Volcano Sensor Web

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
Alert of activity and summary of eruption	JPL	- posting of products on website (password required) - Email of image/eruption thermal output, estimate of effusion rate	- accessed by password - email lists maintained at JPL	JPL Planner

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
OGC Web Services	JPL	*Sensor Planning Service* (SPS): used to determine if a sensor is available to acquire data *Sensor Observation Service* (SOS): used to retrieve engineering or science data from the SPS *Web Processing Service* (WPS): used to perform a calculation on the acquired remote sensing data *Sensor Alert Service* (SAS): used to publish and subscribe to alerts from space, air, ground assets. Description of assets, processes and products using SensorML	JPL Model-based Volcano Sensor Web
ASE	JPL	Autonomous spacecraft command and control, data analysis.	JPL Sensor Webs

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor
Hyperion	NASA-GSFC	Hyperspectral imager, 0.4-2.4 microns, 30 km long swath, 7.7 km wide swath, 30 m/pixel spatial resolution, spectral resolution 10 nm. ALI: multispectral imager, 0.4-2.5 microns, 38 km wide swath, 30 m/pixel spatial resolution,	Up to 10 times every 16 days for equatorial target, more opportunities as latitude increases	New Millennium Program Earth Observing-1 (EO-1)

		one 10 m/pixel band.		

11.2.4 Mount Saint Helen's Hazard Response

Point of Contact Name: Peter Fox

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions
- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category
- ☒ Earth Science Apps & Societal Benefits
- ☒ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☒ Climate Variability & Changes
- ☒ Water resources & global hydrologic cycle
- ☒ Human health and security
- ☒ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- ☒ Targeted observations
- ☐ Incorporate feedback
- ☒ Ready access to data
- ☒ Improved use/reuse
- ☒ Rapid response
- ☐ Improve cost effectiveness
- ☒ Improve data quality/science value

AIST Needs Category
- ☒ 1-Data Collection
- ☒ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☒ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☒ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation

☐

Use Case Name
Brief.

Determine a range of hazard scenarios resulting from volcanic activity from Mount St. Helens.

Goal

Based on monitoring, known climatology and weather patterns around the Mt. St. Helens volcano region, establish a coordinated transition from quiescent monitoring to active (dynamic) sampling and prediction of local and regional consequences of volcanic eruption ejecta. Overall goal is to identify and calculate/ derive a set of research data products that can be used by a variety of end users without their need to understand the complete details of the data product but with sufficient explanation and verifiability to ensure confidence and trust by users. Data must be transparently importable into users application tools.

Summary
Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

The planning for natural hazards is a priority for both a number of mission agencies (NASA, NOAA, EPA, USGS,). Agency personnel and services create data products both for research, monitoring and hazard, planning.

Actors
List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary: Agency personnel – USGS/CVO, NWS, EPA
Primary: Hazard planner
Primary: Agency monitoring and event detection and alert service
Primary: Agency data and service provision
Secondary: Agency personnel – FAA
Secondary: Agency
Secondary: Hazard authority

Preconditions
Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

Quiescent monitoring: of the MSH volcano by USGS, meteorological conditions by NWS, environment by EPA
Availability of event detection and notification services for (agency-defined) changes in quiescent conditions
Availability of known sensor, data, model and notification services in response to event (real or exercise)

Triggers
Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

Any form of volcanic activity as defined by authoritative agency (USGS), out gassing to eruption
Meteorologically significant change in weather pattern as defined by authoritative agency (NWS)

Presence of anomalous environmental conditions (water, air) as defined by authoritative agency (EPA)
By exercise/ scenario request by requesting entity (FAA, PDX, Civil defense)

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Agencies perform quiescent monitoring
2) USGS/CVO issues alert warning for increasing volcanic activity at MSH
3) Hazard planners alerted
4) Data Product requests sent to agencies (NWS, CVO, EPA) for current assessment
5) USGS/CVO issues eruption report for MSH

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

1) Agencies perform quiescent monitoring
2) Hazard planner invokes a planning exercise for medium severity volcanic out-gassing from MSH coupled with anomalous high-pressure, warm-air weather system expected to remain in the region for 3-4 days.
3) USGS issues synthetic alert based on historical data related to event description
4) NWS issues current and synoptic forecast based on recent climatology of similar conditions and prepares to run ensemble forecast for possible air contamination scenarios
5) EPA is notified and begins environmental and public health and safety analyses based on current conditions and historical/ demographic data.

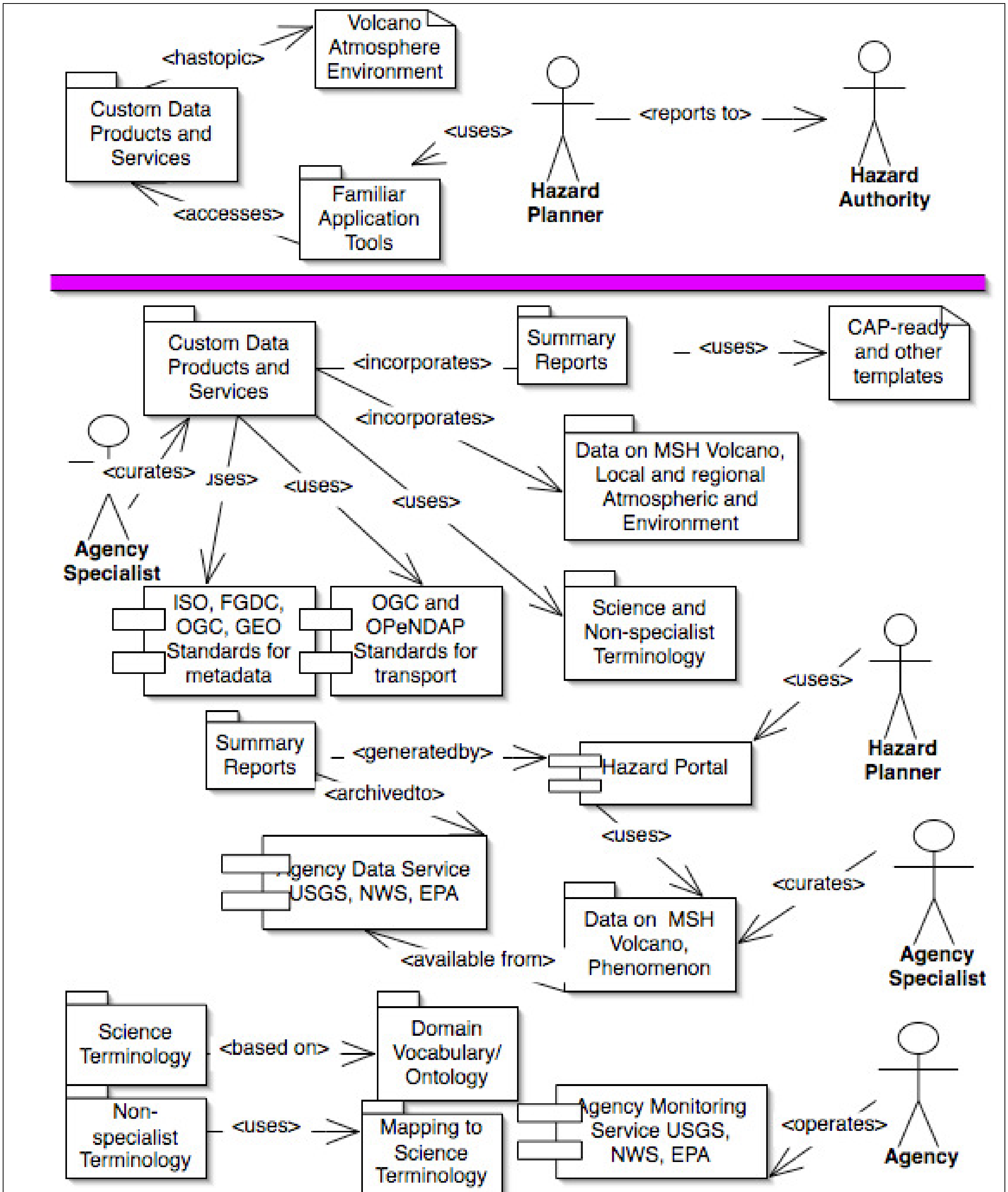
Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

Report delivered to Hazard authority
Data products, summary reports and (quality of) service log trail recorded and made available in a scenario package and archived at agency sites

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Notes
There is always some piece of information that is required that has no other place to go. This is the place for that information.

EPA – Environmental Protection Agency
NWS - National Weather Service
USGS – United States Geological Survey
CAP – Common Alerting Protocol
NOAA – National Oceanographic and Atmospheric Administration
NASA – National Aeronautical and Space Administration
NGO – Non-Governmental Organization
MSH – Mount Saint Helens
CVO – Cascades Volcano Observatory - http://vulcan.wr.usgs.gov/
PDX – Portland International Airport
ISO – International Standards Organization
OGC – Open Geospatial Consortium
FGDC – Federal GeoXX Data Committee
OPeNDAP – Open-source Project for a Network Data Access Protocol
GEOSS – Global Earth Observing System of Systems
WRF – Weather Research and Forecast model

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
WRF	Many	Weather Research and Forecast model			

Event Services

Event	Owner	Description	Subscription	Source System
Anomalous environmental condition	EPA	Northeast Oregon Pilot Study	http://epamap1.epa.gov/emap/nworegon/pages/or_m_bframe.htm	
	NWS/NOAA	MSH monitor	http://www.wrh.noaa.gov/pqr/msh.php	
	NWS/NOAA	Pac-NW Hydrological	http://www.wrh.noaa.gov/total_forecast/getprod.php?wfo=pqr&pil=HMD&si	

		Forecast	d=PTR	
	USGS/CVO	RT Hydrological Monitoring	http://vulcan.wr.usgs.gov/Monitoring/RTData/framework.html	
Volcano warning	USGS/ CVO	Volcanic activity	http://vulcan.wr.usgs.gov/Volcanoes/MSH/framework.html	

Application Services

Application	Owner	Description	Source System
7-day forecast	NWS	http://forecast.weather.gov/MapClick.php?zoneid=ORZ006	
AIRNOW	EPA	http://cfpub.epa.gov/airnow/index.cfm?action=airnow.actiondays	

Sensor resources

Sensor	Owner	Description	Frequency	Source System
Doppler radar	NWS			

11.2.5 Operationally Responsive Space Element Tasking

Point of Contact Name: Phil Paulsen, Eric Miller, Will Ivancic

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☒ Earth Science Apps & Societal Benefits
- ☒ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☒ Targeted observations
- ☒ Incorporate feedback
- ☒ Ready access to data
- ☐ Improved use/reuse
- ☒ Rapid response
- ☒ Improve cost effectiveness
- ☒ Improve data quality/science value

AIST Needs Category

- ☒ 1-Data Collection
- ☒ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☒ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☒ F-Decrease mission risk/cost thru autonomy/automation

Use Case Name
Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Operationally Responsive Space Element Tasking

Goal
The goal briefly describes what the user intends to achieve with this use case.

Provide government agencies, international partners, and the "First Responder" community with timely imagery in the event of a natural disaster.

Summary
Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

When a natural disaster strikes, responding agencies require timely information regarding the affected areas in order to rapidly summarize the situation and to plan relief and recovery efforts. Sensors aboard Earth-orbiting spacecraft acquire data at useful temporal frequencies and spatial resolutions within wavelength regions that enable the discrimination of surface features. Emergency response coordinators at the USGS Center for Earth Resources Observation and Science (EROS) have a lead role in acquiring and distributing such data to domestic and international organizations during times of crisis. Lessons learned from the Katrina and other natural disasters indicated that the current ad hoc methods available for obtaining sensor data are less than optimal. In particular, USGS has reported that it takes as long as three to seven days (on average) to obtain imagery following an event. The processes and paperwork involved also introduce avenues for mistakes which slow the process down and potentially lead to misallocated resources.

In order to alleviate this problem, an automated system, based on earlier research conducted on network centric operations for ESTO, was proposed. This system, called VMOC (Virtual Mission Operations Center), allows non-space professions to quickly request satellite or other platform data products using a secure, simple to use, interface. In addition, the VMOC is also capable of autonomously tasking imagery systems based on triggers from in-situ sensors which sense an event which has exceeded a pre-determined threshold value.

Actors
List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

USGS
Government agencies and the First Responder community (local fire, police, EMS, HazMat, etc…)
U.S. Northern Command
The Centre for Earth Resources Observation and Sciences (EROS)
Virtual Mission Operations Center
Sensor platforms (typically satellite or aircraft based)
In-situ sensors (typically seismic or tsunami sensors)

Preconditions
Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

Predefined sensor platform models (satellite ephemeris, etc…).
Service level agreements with sensor platform owners.
Sensor platform availability. Typically one or more of the following:
EO-1
Landsat

DSMP
ASTER
DMC
SPOT
UAVs

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

Human, government agencies or international partners make a data request based on disaster data obtained from other sources.
Seismic sensor threshold detection.
Tsunami sensor threshold detection.

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) First Responder accesses VMOC and makes a data request or in-situ sensor detects an event beyond a threshold value, triggering a request to VMOC for data from an asset.
2) VMOC prioritizes incoming data requests.
3) VMOC queries mission databases to determine which assets are available that can provide the data products requested in a timely manner.
4) VMOC negotiates machine-to-machine with platform ground stations to obtain the desired services.
5) VMOC informs First Responder when the requested data products will be available.
6) Sensor platforms are tasked and data products are generated.
7) Once downloaded to ground systems, the resulting data products are processed and autonomously routed back to VMOC.
8) VMOC assigns meta tag information to collected data, places a copy in a searchable, permanent archive, and pushes the data to the First Responder who requested it.
9) VMOC publishes the collected data to subscribers who have opted to receive data related to a specific location, data type, etc…

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

Data is pushed to the First Responder who requested it.
Data is published for dissemination to subscribers requesting specific data types or data related to specific locations.
Data is provided with meta tags and permanently stored in a searchable archive.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Appendix C – Use Cases

11.2.6 Predict Global Land Surface Soil Moisture with SMAP observing system simulation experiment (OSSE)

Point of Contact Name: Paul Houser

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☒ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☒ SMAP
- ☒ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☒ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☒ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☒ Terra
- ☒ TRMM

Future Missions
- ☐ Aquarius
- ☒ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☒ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category
- ☒ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☒ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- ☒ Targeted observations
- ☒ Incorporate feedback
- ☒ Ready access to data
- ☒ Improved use/reuse
- ☒ Rapid response
- ☒ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New

AIST Needs Category
- ☐ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☐ B-Coord multiple observations for synergistic science
- ☒ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☒ F-Decrease mission risk/cost thru autonomy/automation
- ☐
- ☐ New

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Predict Global Land Surface Soil Moisture with SMAP observing system simulation experiment (OSSE)

Goal

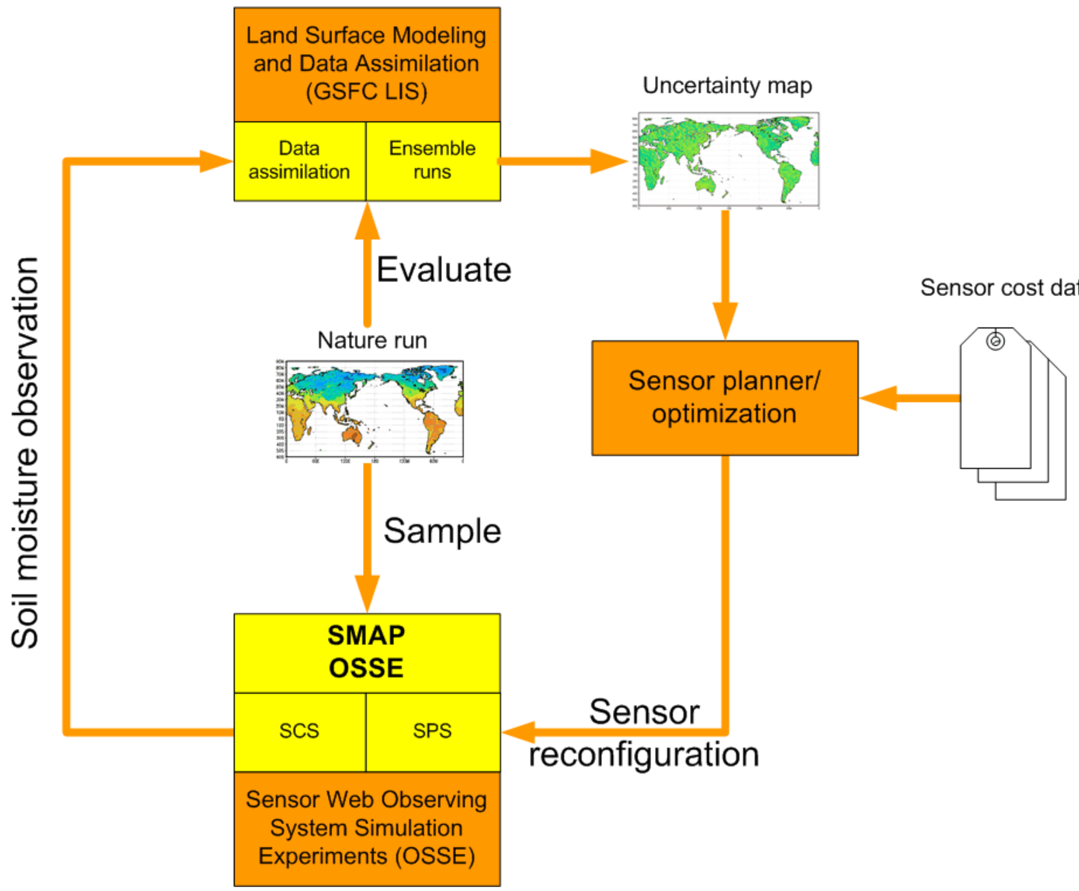
The goal briefly describes what the user intends to achieve with this use case.

To assimilate remote-sensed soil moisture data from SMAP and other future missions, and to predict global land surface soil moisture with less uncertainty

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

This use case documents the course of action of Land Information System and soil moisture sensor webs for better prediction of global land surface soil moisture.



Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors:

Scientist – operate LISW to predict land surface soil moisture and other variables.

User – obtain land surface soil moisture information and predictions

SMAP sensors – provide data from SMAP OSSE and follow reconfiguration instructions

Land surface modeling and data assimilation systems (LSMs) – model and predict land surface soil moisture and other states and fluxes.

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

SMAP observing system simulation experiments (OSSE) is in operation; Land surface modeling and data assimilation system tested, calibrated, initialized and spun up; Base input datasets are readily available.

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

1. User needs new prediction of land surface conditions.
2. SMAP sensors data from SMAP OSSE available.
3. New significant events take place (e.g., storms)
4. LIS finishes a round of simulation/assimilation runs.

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Scientist starts ensembles of land surface models (LSMs) to predict soil moisture.
2) Scientist starts SMAP OSSE with default sampling configuration.
3) SMAP OSSE sensors provide new soil moisture observations.
4) LSMS assimilates SMAP OSSE soil moisture observations.
5) LSMs predict land surface soil moisture.
6) LSMs estimate uncertainties in soil moisture prediction (uncertainty map).
7) User obtains soil moisture predictions and uncertainty estimates.
8) Scientist analyzes soil moisture uncertainty map.
9) Scientist determines new sampling configuration for SMAP OSSE.
10) Scientist computes the cost of the new sampling strategy for SMAP.
11) SMAP sensors receive new sampling configuration
12) SMAP sensors run OSSE
13) SMAP OSSE provides new soil moisture observations
14) LSM produces new land surface predictions

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

Alternative Flow A

1) Scientist finds the new sampling configuration is too costly
2) Scientist refines sampling configuration to reduce cost

Alternative Flow B

1) Scientist finds the prediction in soil moisture is not improved.
2) Scientist refines sampling configuration to improve prediction.

Post Conditions

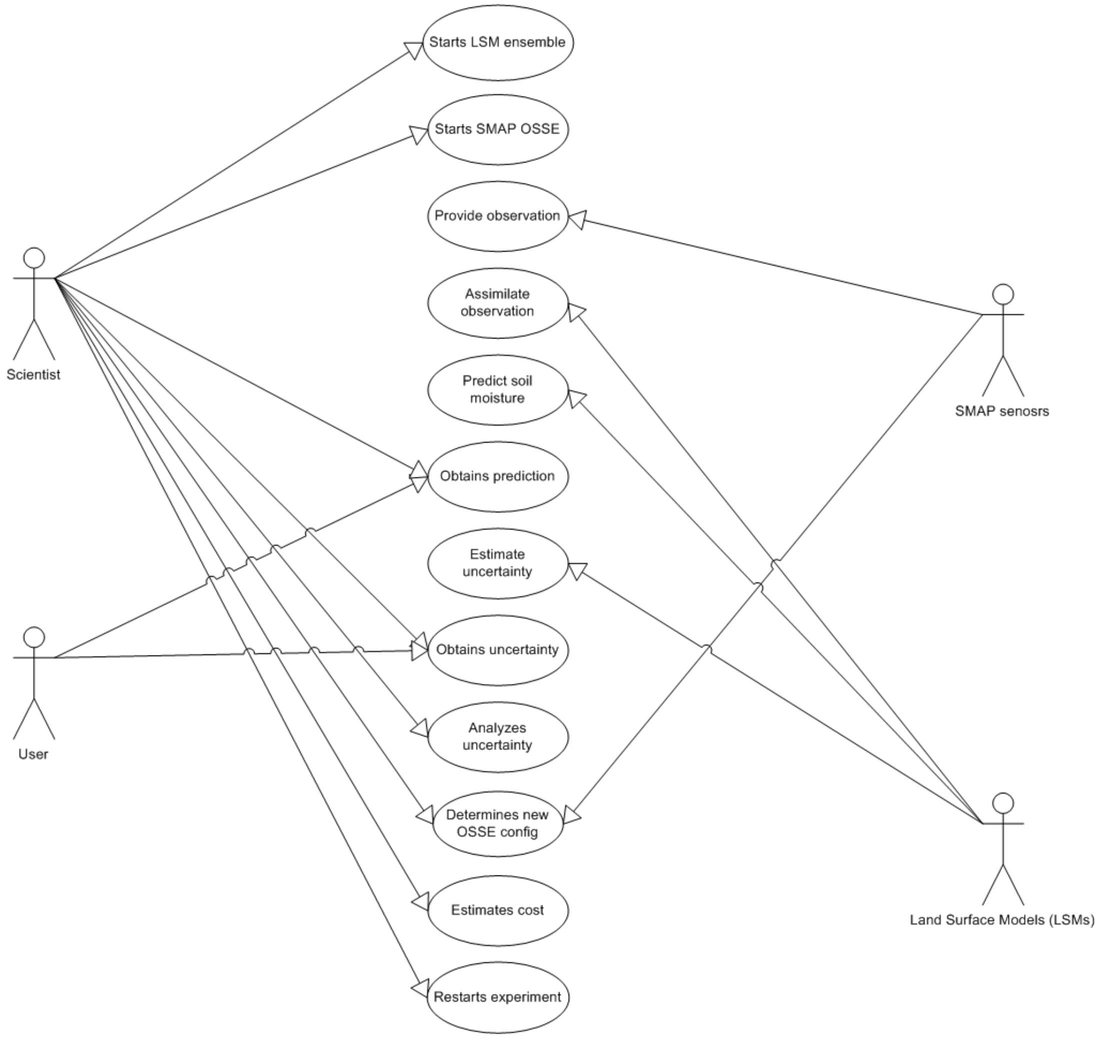
Here we give any conditions that will be true of the state of the system after the use case has been completed.

1. Land surface soil moisture states are updated and to be used as initial conditions for subsequent runs.

2. SMAP OSSE sensors operate under new sampling configuration.
3. Data archive of sensor observations expanded.
4. Expenses for sensor operation incurred; total available funds reduced.
5. User enabled to do verifications of new soil moisture prediction.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access
GDAS	Reanalysis		Global Data Assimilation System	NCEP	

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
LIS	GSFC/NASA	Land Information System			

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
SMAP data available	SMAP OSSE, local	Notifies LSMs when new SMAP observations are available	LSMs	SMAP OSSE

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
LISW Framework	CREW/IGES, GSFC/NASA	Land Information Sensor Web Framework	

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages	Short description of the sensor	How often the sensor can	Name of the satellite or system which manages

	sensor		observe event	sensor
SMAP OSSE	LISW	Soil moisture sensors from OSSE	1 per 3days	SMAP

11.2.7 Volcanic Hazard Event Ground-space-ground Feedback Cycle

Point of Contact Name(s): WenZhan Song

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☒ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☒ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☒ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions
- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☒ LDCM
- ☒ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category
- ☒ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☒ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- ☒ Targeted observations
- ☒ Incorporate feedback
- ☐ Ready access to data
- ☐ Improved use/reuse
- ☒ Rapid response
- ☐ Improve cost effectiveness
- ☒ Improve data quality/science value

AIST Needs Category
- ☒ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☐ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation
- ☐

Use Case Name
Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Volcanic hazard event ground-space-ground feedback cycle

Goal
The goal briefly describes what the user intends to achieve with this use case.

Demonstrate capability to autonomously trigger space asset data acquisition from in-situ network, and autonomous ingestion of space data into ground network decision making.

Summary
Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

The OASIS (Optimized Autonomous Space – In-situ Sensor-web) ground sensor network (Actor 2) responds to a change in the behaviour of the volcano (Actor 1) from background level activity based on pre-set conditions. Data are continuously logged in the USGS database (Actor 3). An OASIS alert is sent to Scientist in Charge (SIC, Actor 4) via a USGS V-Alarm (USGS), and to the OASIS space segment (EO-1) via EO-1's autonomous scheduler (Actor 5). SIC interacts with OASIS ground segment Command and Control (C&C) GUI (Actor 6) and monitors autonomous decisions made by OASIS, including data rates, data routings schemes, data completeness, and EO-1 observation request priorities. SIC may use GUI to override autonomous decisions. SIC interacts with USGS VALVE (Volcano Analysis and Visualization Environment) to visually inspect data, such as deformation, seismicity, tremor levels). If necessary, SIC alerts public entities. Based on its own priorities and flight path, EO-1's Hyperion instrument measures short-wavelength infra-red thermal emission from volcano at earliest opportunity and sends back within 90 minutes of data take: Number of hot pixels; Total thermal emission; Location of each hot pixel (line and sample, and latitude and longitude); compressed Hyperion image of thermally-active area, with overlay of hot pixels. EO-1 products are stored in the USGS database and are viewable through VALVE. OASIS alerts SIC of arrival of space segment data. OASIS C&C autonomously interprets EO-1 data, reallocates network resources, and re-routs data flow accordingly.

Actors
List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary Actors:
- Actor 1: Volcano
- Actor 2: In-situ sensor network
- Actor 3: USGS database
- Actor 4: Scientist in Charge
- Actor 5: EO-1 scheduler
- Actor 5: C&C (Command&Control) software

Secondary Actors:
- USGS VALVE (Volcano Analysis and Visualization Environment)
- USGS V-ALARM

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

1. OASIS ground segment in place on volcano (can be one or many nodes each recording seismic, GPS, infrasound and lightning occurrence).
2. Continuous two-way communication with control centre via radio link.
3. Data is flowing continuously to the USGS database, where it is viewable through VALVE.
4. Communication link to EO-1 planner

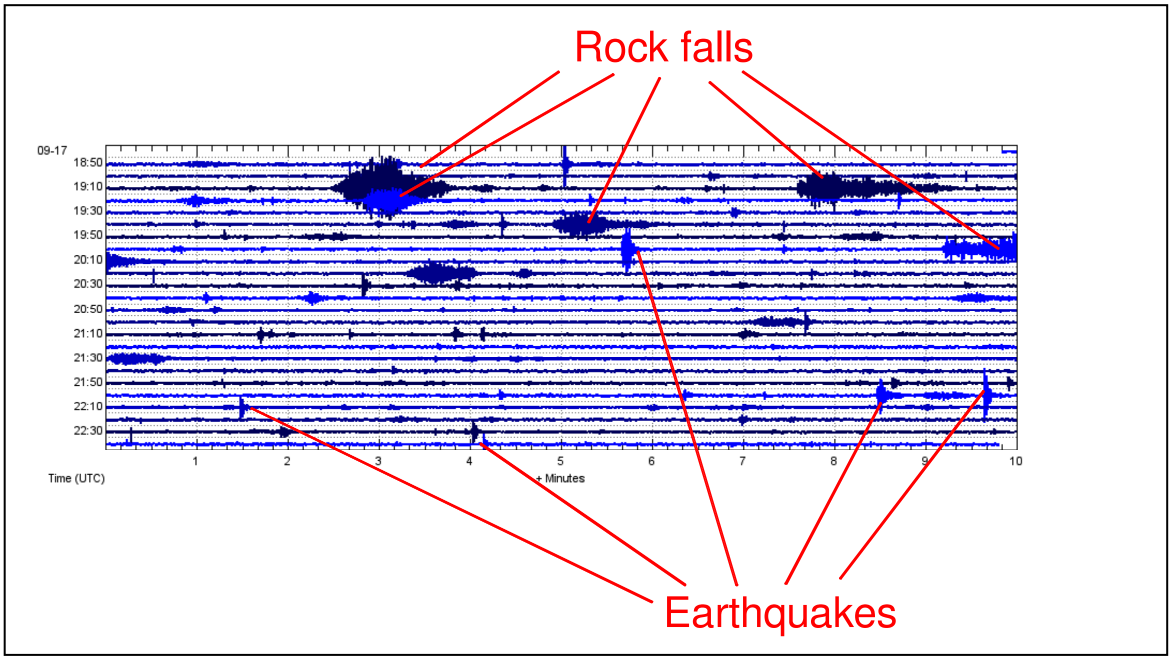


Figure 13. Baseline State of Mt. St. Helens

Triggers

Here we describe in detail the event or events that brings about the or internal. They can be single events or when a set of conditions a

An earthquake swarm, defined by the identification of *n* earthquakes per unit time (see Figure 2). Requests EO-1 observation.

EO-1 detects thermal emission. Requests increase in data acquisition by in situ sensors in areas of interest identified by ASE on EO-1.

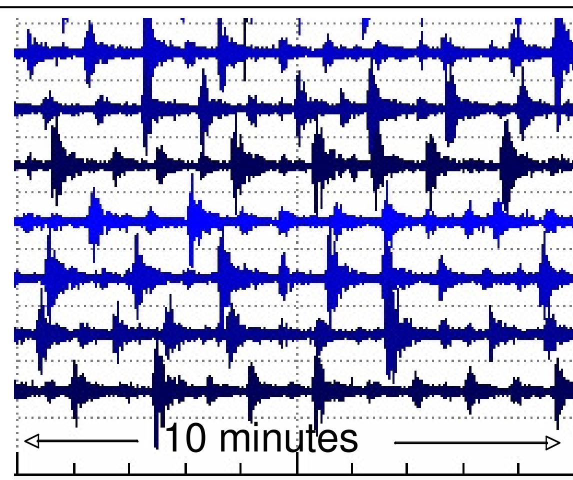


Figure 14: An earthquake swarm recorded on Mt. St. Helens

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) An earthquake swarm is recorded
2) VALVE generates a V-Alarm
3) Alert is sent to SIC and to OASIS C&C
4) OASIS C&C determines ground segment operation: New priorities may be assigned; Re-allocation of bandwidth resources, and re-routing of data flow.
5) EO-1 data request priority (1 to 3) is determined
6) A message is posted to a URL queried by EO-1 scheduler.
7) EO-1 scheduler acknowledges receipt of OASIS data request in form of an email.
8) EO-1 scheduler determines next observation opportunity and emails information back to OASIS C&C.
9) SIC monitors ground network operations through OASIS GUI.
10) SIC inspects scientific data through VALVE.
11) EO-1 data are acquired.
12) “Data acquired” email is autonomously sent to OASIS C&C.
13) EO-1 data products are sent to USGS database and are viewable through VALVE 90 minutes after datatake.
14) OASIS C&C autonomously interprets EO-1 data products. Example: location of hot pixels identified, larger bandwidth is allocated to regions of hot pixels.

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

1) Volcano at Baseline state
2) An earthquake swarm is recorded
3) **VALVE does not generates a V-Alarm**
4) **SIC routinely inspects network operations through OASIS GUI and scientific data through VALVE.**
5) **SIC decides the situation merits a request for EO-1 data request or ground operation adjustment.**
6) **SIC determines EO-1 and/or ground data request priority (1 to 3).**
7) **SIC posts a message to a URL queried by EO-1 scheduler.**
8) Steps 8-14 as shown in “Basic Flow”

Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

System resets and awaits further triggers.
Volcanic activity level is higher & alert level is higher.
Observations and requests continue until system eventually reached basic state.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.

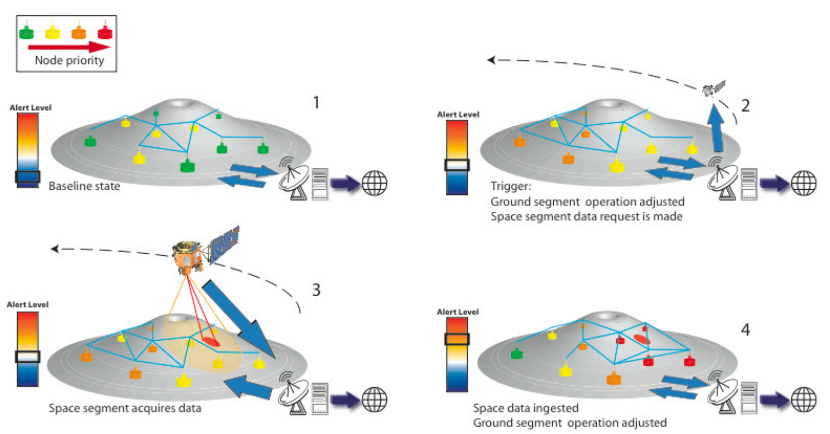


Figure 15. OASIS Ground Triggers Space Asset

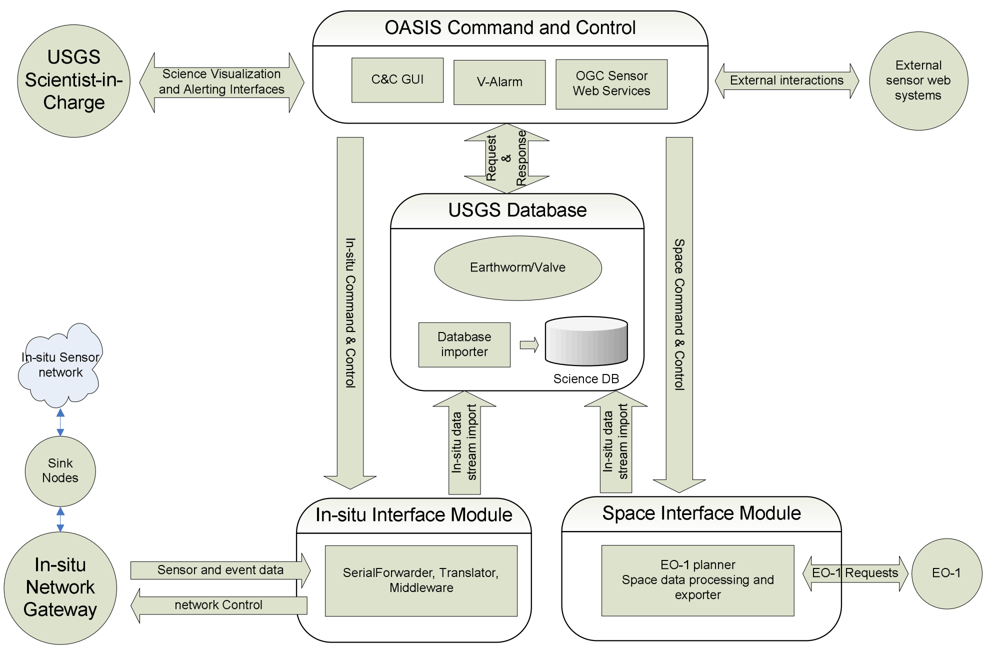


Figure 16. OASIS Sensor Web Architecture

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access
OASIS ground network, St. Helens	In-situ	Sensor node alive (i.e not blown away by volcano)	Seismic – Earthquake and Tremor Infrasound – Explosions GPS – Timing and deformation Lightning – Ash cloud	USGS, NASA, WSU	OASIS
EO-1	Space	No cloud	Hyperion – High resolution near thermal infrared	NASA	Automatic Science Experiment

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model

Event Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
V-Alarm	OASIS / USGS	Volcanic event trigger detection	SIC, EO-1 scheduler	VALVE

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
VALVE	USGS	Volcano Analysis and Visualization Environment	

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages	Short description of the sensor	How often the sensor can observe	Name of the satellite or system which manages

	sensor		event	sensor
Volcano sensors	USGS	Seismic, infrasonic, GPS, lightning	Seismic(100Hz), infrasonic (100Hz), GPS (every 10 sec), lightning (1Hz)	Ground sensor network

11.2.8 Volcanoes

Point of Contact Name: Andrea Donnellan

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☒ DESDynl
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☒ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☒ Targeted observations
- ☐ Incorporate feedback
- ☒ Ready access to data
- ☒ Improved use/reuse
- ☒ Rapid response
- ☐ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New

AIST Needs Category

- ☒ 1-Data Collection
- ☒ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☐ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☒ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation
- ☐
- ☐ New

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Volcanoes

Goal

The goal briefly describes what the user intends to achieve with this use case.

Determine the likelihood of volcanic eruptions

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

Monitor surface deformation of volcanoes to estimate volume and movement of magma in the chamber to forecast the likelihood of a volcanic eruption. Respond to volcanic eruptions to monitor disruption and damage. Simulations can be used to target observations and determine observing interval. DESDynI (Deformation, Ecosystem Structure, and Dynamics of Ice) is a combined InSAR/Lidar mission to study, among other things, volcanoes and related surface deformation. Surface deformation measurements from DESDynI can be inverted for the depth, location, and migration of magma chambers, aiding in understanding and prediction of eruptions. As the eruption occurs DESDynI can be used to image surface disruption and damage. Models of the rate and depth of migration of magma in the chamber can be used to determine the frequency of observations (e.g., weekly, monthly, yearly) given that the duty cycle of the spacecraft will not allow for complete observations of the Earth's landmasses. Rapid response will be required in the event of an imminent or active eruption. The data must be rapidly downloaded, processed, and integrated with other data types.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors: NASA, USGS scientists, mission operators, and data analysts

Secondary actors: FEMA, scientists (USGS, NSF, NASA), governments

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

- Data from DESDynI are being routinely processed
- Seismic, geologic, and GPS data are readily ingested in to the models
- Models are developed and data are being assimilated
- Web and grid services exist for accessing data and models and running on appropriate computers including high performance computers

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

- Typical trigger will be a high rate of or increased surface deformation and seismicity in the vicinity of the volcano
- In the event the imminent eruption is missed, a volcanic eruption will serve as a trigger.

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Active volcano is identified by surface deformation observations from DESDynI
2) Data are downlinked and processed into interferograms of surface deformation
3) Additional data (seismic, geological observations, GPS) are collected into web services federated database
4) Models of magma migration are used to understand magma migration, eruption potential, and to determine required imaging frequency
5) Results are communicated to appropriate agencies (FEMA, USGS)
6) In the event of an eruption DESDynI is used to monitor disruption and damage
7) Measurements are combined with models and are inverted for information about the magma chamber to assess the likelihood of subsequent eruptions
8) Results are communicated to appropriate agencies
9) Observations are collected over remainder of mission to understand long-term processes

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

6)

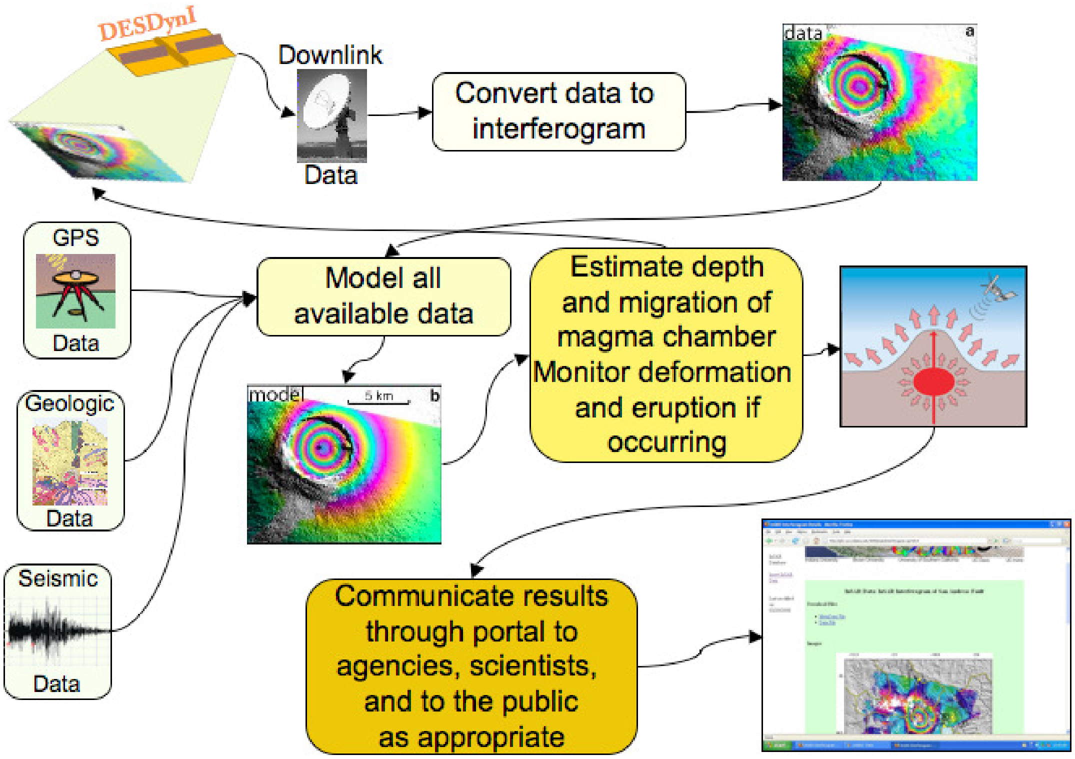
Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

- InSAR imagery available on the web
- Surface deformation maps and model images available through the portal on the web

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

DESDynI will have many use cases. This is one example. Other events include:

- Earthquakes
- Carbon cycle (biomass)
- Hydrology
- Cryosphere (ice shelf break up)
- Geomorphology

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access
InSAR	Remote	Surface deformation	To understand fault behavior and	NASA	DESDynI

			interactions		
GPS Time Series	In situ	Position time series data	For continuous observations and temporal signals	NSF, NASA, USGS	EarthScope Plate Boundary Observatory
GPS Velocities	In situ	Station velocities	For secular and transient velocities	NSF, NASA, USGS	EarthScope Plate Boundary Observatory
Seismicity	In situ	Magnitude and location of earthquakes	For tasking DESDynI image acquisition; pattern recognition for forecasting	USGS	Advanced National Seismic Network
Geology	In situ	Geologic map	Indicates volcano history	USGS, Academia	TBD
Simulated data	Simulated	Model output from numerous runs	Over timescales longer than observable but for comparison to real data	NASA	OSSI TBD

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
Finite element software: GeoFEST, Tecton	NASA JPL, academia	Finite element model for magma chambers	GPS, InSAR, geologic, seismic	For science modeling, targeting strategy, and event response	QuakeSim, TBD
Inversion software	NASA JPL	Inverts surface deformation data for magma chamber	Deformation data: GPS and InSAR	Continuous and real-time	TBD

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
Volcanic eruption	USGS collaborating with NASA	Volcanic inflation or eruption	FEMA, USGS	Cascades Volcano Observatory, Hawaii Volcano Observatory

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
TBD	NASA	Imagery and models offered over a web services portal	Extension of QuakeSim?

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor
Seismometer	USGS, EarthScope	Seismometer network detects volcanic activity	Continuously	Advanced National Seismic Network
GPS	EarthScope; Scripps/JPL	Produces GPS time series in near real-time and velocities periodically	Continuously (1 Hz); velocity solution periodically (months to years)	Plate Boundary Observatory
InSAR	NASA	Orbiting satellite that produces radar imagery for constructing displacement interferograms	Within 8 days	DESDynI

11.3 Climate Variability & Change

11.3.1 A Smart Ocean Sensor Web to Enable Search and Rescue Operations

Point of Contact Name: Yi Chao, Andrew Gray, Payman Arabshahi

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☒ SWOT
- ☒ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☒ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☒ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions
- ☒ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☒ OSTM
- ☐ OCO

Decadal Survey Category
- ☒ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☒ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- ☒ Targeted observations
- ☒ Incorporate feedback
- ☒ Ready access to data
- ☒ Improved use/reuse
- ☐ Rapid response
- ☐ Improve cost effectiveness
- ☒ Improve data quality/science value

AIST Needs Category
- ☒ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☒ F-Decrease mission risk/cost thru autonomy/automation
- ☐

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Search and Rescue Operations

Goal

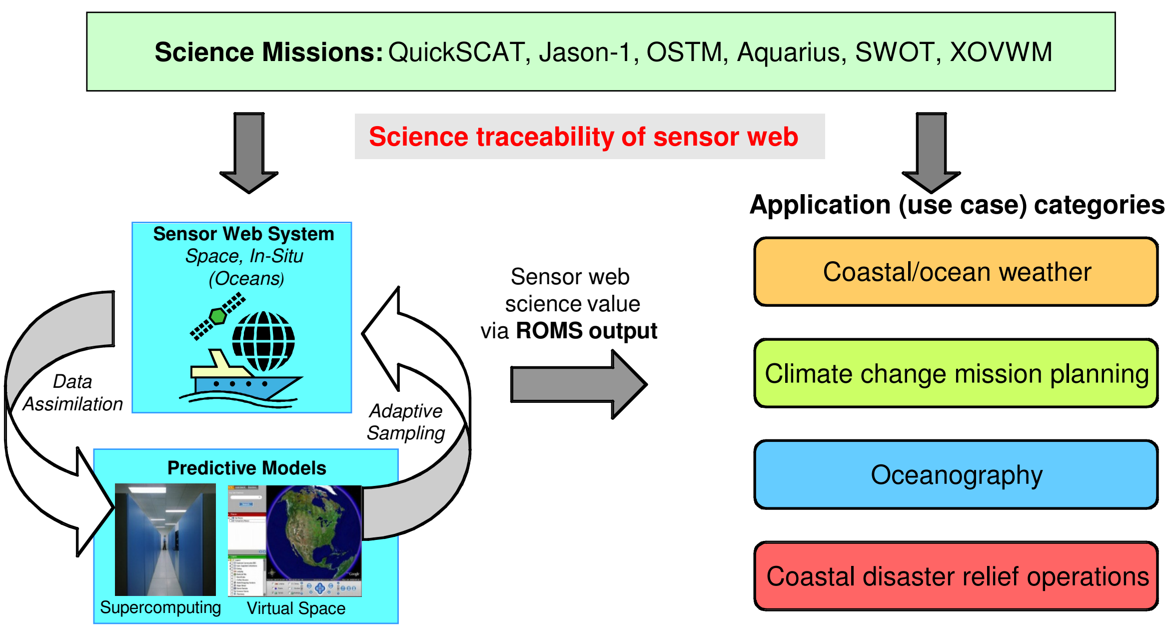
The goal briefly describes what the user intends to achieve with this use case.

To deliver ocean nowcast and forecast in real-time to enable US Coast Guard's research and rescue operations by integrating in-situ measurements with satellite observations into a predictive Regional Ocean Modelling System (ROMS).

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

The sensor web achieves traceability to science through complimenting existing and planned space science missions. Specifically the web integrates space-based sensor data with in-situ data, these are integrated via the ROMS model, the output of which can be used for achieving a set of scientific objectives, including enhancing the science products of the stand-alone missions (e.g., QuikSCAT, Jason). These science applications (or use cases) may be categorized as indicated in the graphic below. Note that the output of the ROMS model (with integrated space-based and in-situ data) is also useful in planning future space-based missions (investment) dedicated to climate change science. The graphic below presents an overview of the large number of science applications (dozens of possible use cases) for the sensor web being developed in the AIST task "A Smart Sensor Web for Ocean Observation: System Design, Modeling, and Optimization." The use case presented in this document focuses on one such use case in the coastal disaster relief operations category with a particular focus on the search and rescue operations.



Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors:

US Coast Guard

Search and rescue workers and volunteers

- Ships
- Planes
- Shore stations
- Computer analysts

Scientists (e.g., oceanographers) and technologists

- In-situ operators: boats, seagliders, underwater sensor networks
- Spacecraft operators
- Basic data processors (data-base maintenance, etc.)

Marine meteorologists

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

Preconditions include

- Access to real-time in-situ and satellite data sets (e.g., QuickSCAT, Jason-1)
- Access to in-situ data sets (optional)
- Access to marine weather forecasts
- A well-calibrated ROMS model over a specific geographic region (e.g., California coastal ocean)
- Data and model forecast delivery mechanism to the end users (i.e., US Coast Guard)

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

A 911 call in the evening reporting a missing sailor outside the Golden Gate of San Francisco Bay

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

A Smart Ocean Sensor Web will execute the following workflow:

1) Instrument operators instruct in-situ instruments (e.g., seagliders, ships, Moorings) to obtain regional data
2) Scientists retrieve satellite data (e.g., ocean wind, sea height) from the NASA DAACs
3) Scientists run the COAMPS weather forecast model, from NRL, that produces wind prediction
4) Scientists preprocess data and perform data quality controls
5) Scientists run the 3D ocean model (ROMS model) to produce the preliminary results (e.g., sea level, wind)
6) Scientists perform data assimilation to improve the first estimate by adding a correction based on the model and data misfit
7) Make predictions of ocean surface current (and other oceanographic variables) up to 48 hours into the future
8) Process the model forecast data and make images
9) Distribute the model forecast to the end users (i.e., US Coast Guard)

US Coast Guard and Research and Rescue Operations

1) Based on the ROMS ocean forecast, the US Coast Guard will estimate the search area over the next 24 hours (e.g., develop such things as error ellipses over lat/long maps etc.)
2) The search and rescue workers will plan (temporally and spatially) the resources (e.g., ships, planes, people) needed to implement the research and rescue operation
3) Rescue workers perform rescue operations

These processes are repeated daily until the missing sailor is found.

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

A smart ocean sensor web will

1) identify the areas of maximum errors in the ocean forecast,
2) estimate the in-situ (e.g., number of gliders, sampling patterns) and satellite (increase the sampling rate) resources required to yield a better ocean forecast; this can be done through the Observing System Simulation Experiments (OSSEs)
3) implement this adaptive sampling strategy
4) feed these new data sets into the ROMS predictive model to issue an improve forecast

with a goal to provide a more accurate environmental information to the US Coast Guard for the real-time search and rescue operations.

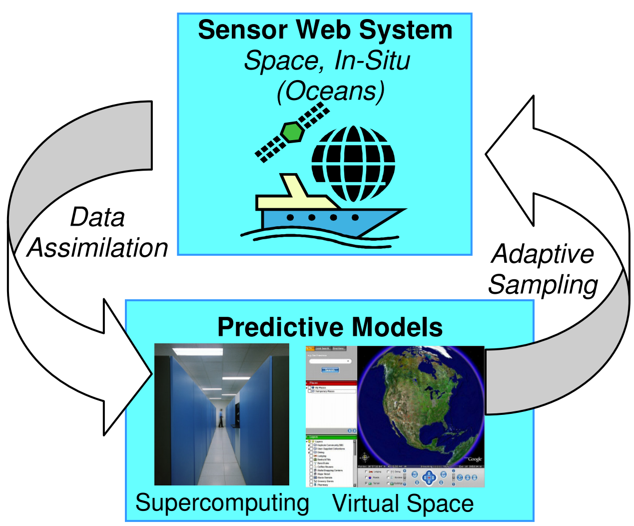
Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

The environment information provided to the US Coast Guard and their impact to guide the search and rescue operations will be archived for post-operation analysis with a goal to improve models, data assimilation schemes, and the marine weather and ocean forecast.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Semi-closed loop dynamic smart ocean sensor web architecture

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System

(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access
Sea surface temperature	Satellite	Multi-sensor & multi-platform	Sea surface temperature is the only data set that is measured at 1-km required by the coast ocean modeling; Some coarser resolution data are complementary and need to be merged with the higher resolution data	NOAA, NASA	AVHRR, GOES, AMSR-E, TMI
Sea surface height	Satellite	Radar sensor penetrating clouds	Provide large-scale boundary conditions for coastal ocean models	NASA	Jason
Ocean vector wind	Satellite	Radar sensor penetrating clouds	A critical forcing function to the ocean; the wind data are contaminated near coastline and the atmospheric model simulated wind has to be used.	NASA	QuikSCAT

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
Regional Ocean Modeling System (ROMS)	Rutgers, UCLA, JPL	ROMS simulates the 3D ocean temperature, salinity and current.	Sea surface temperature, sea surface height, ocean vector wind, vertical profiles of temperature/salinity and current, surface current,	Six hours	Live Access Server via OpenDAP

Event Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
Search and Rescue	US Coast Guard	During a Search and Rescue operation, the US coast guard needs to know the most accurate nowcast and forecast (up to a few days) of the ocean surface current on the hourly basis.	Regional Ocean Modeling System (ROMS) data assimilation and prediction

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor
Gliders	UW	Gliders provide vertical profiles of temperature and salinity, which are critical for accurate ocean forecasting, and can be deployed quickly in the regions of interests	Hours	Seaglider

11.3.2 Calibration of Remote-Sensing Instruments Using Re-deployable In-Situ Sensor Networks for Ice Sheet Characterization

Point of Contact Name(s): Ayanna M Howard

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

☐ ACE
☐ ASCENDS
☐ CLARREO
☒ DESDynI
☐ GACM
☐ GEO-CAPE
☐ GPSRO
☐ GRACE-II
☐ HyspIRI
☐ HyspIRI
☒ ICESat-II
☐ LIST
☐ PATH
☐ SCLP
☐ SMAP
☐ SWOT
☐ XOVWM
☐ 3D-Winds

Current Missions

☐ ACRIMSAT
☐ Aqua
☐ Aura
☐ CALIPSO
☐ CloudSat
☐ GPM
☐ GRACE
☒ ICESat
☐ JASON-1
☐ LANDSAT7
☐ LAGEOS 1&2
☐ NMP EO-1
☐ QuikSCAT
☐ ADEOS-II
☐ SORCE
☐ Terra
☐ TRMM

Future Missions

☐ Aquarius
☐ GOES-N/O/P
☐ Glory
☐ LDCM
☐ NPOES
☐ NPP
☐ OSTM
☐ OCO

Decadal Survey Category

☐ Earth Science Apps & Societal Benefits
☐ Land use change, ecosys. dynamics, biodiv.
☐ Weather - Space and Chemical
☒ Climate Variability & Changes
☐ Water resources & global hydrologic cycle
☐ Human health and security
☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

☐ Targeted observations
☐ Incorporate feedback
☐ Ready access to data
☐ Improved use/reuse
☐ Rapid response
☐ Improve cost effectiveness
☒ Improve data quality/science value

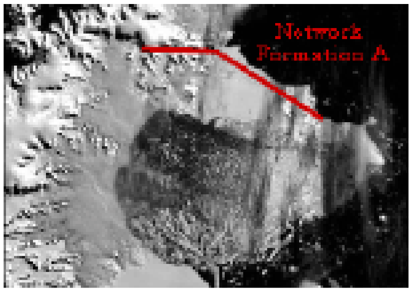
AIST Needs Category

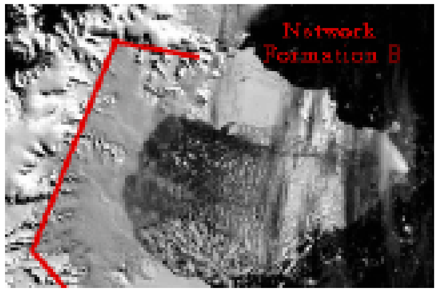
☒ 1-Data Collection
☐ 2-Transmission & Dissem.
☐ 3-Data & Info Production
☐ 4-Search, Access, Analysis, Display
☐ 5-Systems Mgmt

☒ A-Increase science data value thru autonomous use
☐ B-Coord multiple observations for synergistic science
☐ C-Improve interdiscip science production environs
☐ D-Improve access, storage, delivery
☐ E-Improve system interoperability, stds use
☐ F-Decrease mission risk/cost thru autonomy/automation
☐

Appendix C – Use Cases

Use Case Name *Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.* In-Situ Based Sensor Calibration
Goal *The goal briefly describes what the user intends to achieve with this use case.* Ground-truthing: Provide in-situ calibration processes for earth-observing instruments that focus on characterization of the ice-sheets.
Summary *Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.* The motivation of the use-case is that by using multiple in-situ sensor assets that can autonomously reconfigure on the ice-sheet, we can calibrate/validate satellite-based instruments.
Actors *List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.* Climatologists, geologists, glaciologists Remote Satellites (DESDynI, ICESat)
Preconditions *Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.* Access to available satellite-based measurements Estimation of error profile associated with remote instruments Mobile sensor agents have been deployed in glacier environment
Triggers *Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.* Desire to calibrate/validate new instruments focused on ice-sheet characterization
Basic Flow *Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)* 1) Measurement data extracted from remote sensing instruments 2) System calibrates low-resolution sensor measurements with high-resolution in-situ measurements at current location 3) Error profile drives reconfiguration profile to deploy in-situ sensors to new location 4) Continue iteration through workflow process
Alternate Flow *Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.*
Post Conditions *Here we give any conditions that will be true of the state of the system after the use case has been completed.* Development of higher resolution models that can be calibrated with ground-truth
Activity Diagram *Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.*





Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

This research is synergistic with ERIN web sensor strand and using ASE+LIS for snow coverage.

11.3.3 Data Mining and Automated Planning for Mobile Instrument Operation

Point of Contact Name: Nikunj C. Oza

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☐ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☒ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☒ Targeted observations
- ☒ Incorporate feedback
- ☐ Ready access to data
- ☒ Improved use/reuse
- ☐ Rapid response
- ☐ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New

AIST Needs Category

- ☒ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☒ F-Decrease mission risk/cost thru autonomy/automation
- ☐ New

Appendix C – Use Cases

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Tasking an INTEX-B aircraft with mobile instruments to achieve assigned mission goals and science value of observations.

Goal

The goal briefly describes what the user intends to achieve with this use case.

The mission scientist wishes to create a flight plan for the DC-8 that takes one flight every 2-3 days for 35 days. The user wishes to maximize the number of mission goals achieved (measurements at pre-identified locations, instrument calibration with satellites passing overhead) and the science value of the observations subject to constraints on the instrument, flight path, aircraft, flight time, and calibration requirements. The science value is measured in one of two ways: by the discrepancy between MOZART model predictions and AIRS and MOPITT satellite instrument measurements of CO, and by the discrepancy between MOZART predictions and previous INTEX measurements of CO.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

Some missions, such as INTEX, are conducted as a sequence of flights---one per day, typically every 2-3 days, for a predetermined number of days. For example, as part of INTEX-B, a DC-8 was flown on 35 days over a 2.5 month period. Each flight starts and ends at the same point. The aircraft contains multiple instruments that are used to collect measurements on every flight. Every flight day, a flight plan has to be determined in advance and then flown. Numerous mission goals must be satisfied, such as measurements at particular locations, and the instruments must be calibrated by flying at the locations and times covered by satellites. However, numerous constraints must be respected. For example, Special Use Airspaces (SUAs) must be avoided, and the aircraft must fly at the speed and for the amount of time at a given waypoint according to the instruments' constraints. In addition, numerous scientists would like to choose flight waypoints based on the problems they are interested in solving and the process models that they are interested in updating.

Data mining or other methods can be used to generate waypoints for possible inclusion in the next day's flight plan. The automated planner generates one or more flight plans that achieve the mission goals and pass through as many waypoints as possible while respecting all the constraints described in the previous paragraph. These plans and the data mining results are placed in Google Earth or another visualization tool to enable the scientist to choose the desired flight plan. The chosen flight plan is presented to the pilot. The pilot has discretion to adjust the flight based on what s/he sees in the air. After the flight, measurements are downlinked and can be used to generate waypoints for future flights.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Actors: mission scientists, instruments on the target platform, the target platform itself (e.g., DC-8), other instruments (e.g., satellite sensors like AIRS and MOPITT, fixed sensors), process models (e.g., MOZART), data mining tool(s), automated planning tool, visualization tool.

Primary actor: Mission scientists. They ensure that the appropriate models and data are incorporated into the process of selecting flight plans.

Preconditions
Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

Enough must be known about the model predictions and other data to enable mapping from these to some measure of science value. For example, this use case assumes that the MOZART predictions of CO and the satellite measurements of CO are comparable, so that the difference between them is a realistic indication of the accuracy of MOZART. The weather conditions must be conducive to flying the target platform.

Triggers
Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

There are no external triggers. The period during which flights are executed is set well in advance, typically based on expected weather and when the instruments and platform are likely to be available.

Basic Flow
Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) User would use system to collect AIRS and MOPITT measurements, INTEX measurements, and MOZART predictions for one or more previous days for which they are available.
2) Data mining tool would take these data and find waypoints where measurements should be taken. These may represent previous measurements that appear anomalous for which the measurement should be taken again, measurements of a type not well represented in current models (e.g., at particular locations, temperature profiles, or altitudes), or where the difference between model predictions and measurements are high.
3) Flight planning tool takes these waypoints and mission goals, and generates one or more flight plans to satisfy these goals given all the constraints.
4) Visualization tool displays the waypoints and flight plans, together with user-selected parts of the data relevant to choosing the waypoints and flight plans.
5) The user selects from among the generated flight plans and submits them.
6) The flight plan is executed, but with some variation per what the pilot is allowed to do in response to unexpected conditions.
7) The data from the actual flight is downloaded. These data are loaded into other relevant tools to update MOZART and for scientists to analyze separately.
8) The user returns to step 1 to prepare the subsequent flight plan given the new knowledge gained from the first cycle.

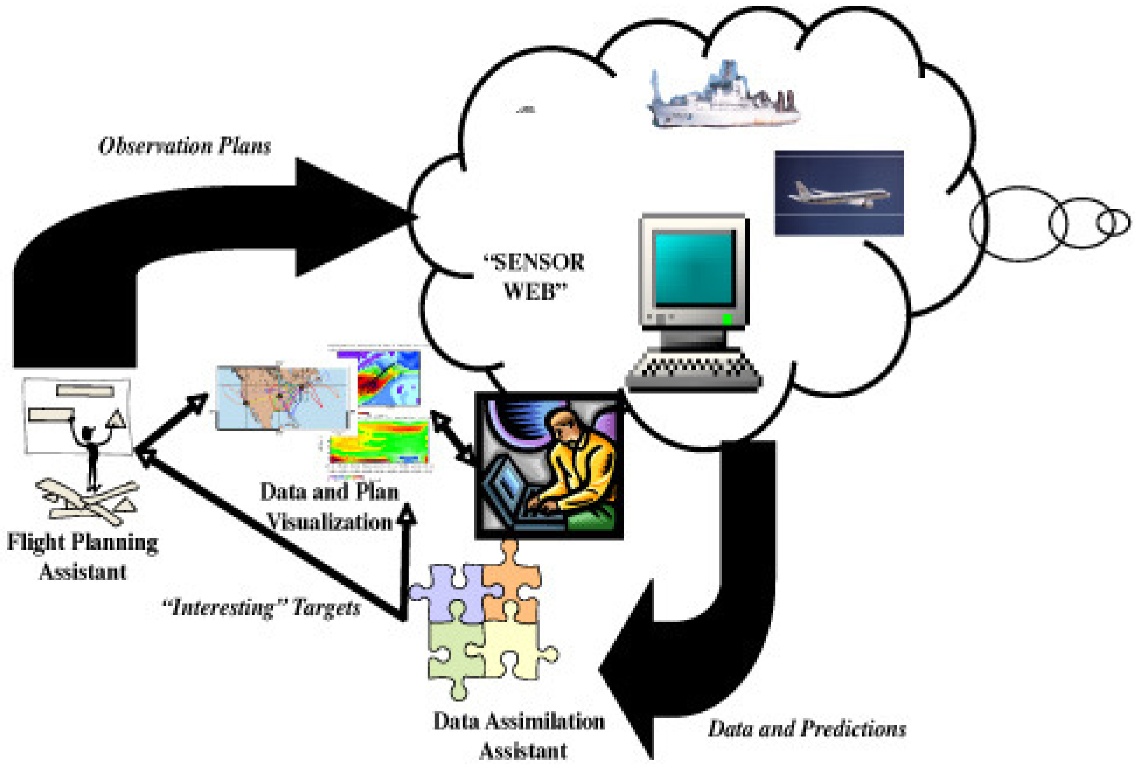
Alternate Flow
Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

1)
2)
3)
4)

Post Conditions
Here we give any conditions that will be true of the state of the system after the use case has been completed.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



This diagram represents the semi-closed loop operation of the data collection, data mining, and flight plan generation.

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ,	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the	USGS, ESA, etc.	Name of the system which supports discovery

	Etc.		usage characteristics		and access
MOPITT	Remote		This contains estimated measurements of CO, which are compared with model predictions.		
AIRS	Remote		This contains estimated measurements of CO, which are compared with model predictions.		

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
MOZART		This model contains predictions of CO, which are compared with remote sensing instruments			

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor

11.3.4 ICESat-II and Deformation, Ecosystem Structure, and Dynamics (DESDynI) using ERINode for Passive Active Interferometric Radiometer with Interleaved Radar

Point of Contact Name: Larry Hilliard

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☒ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☒ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☐ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☒ Targeted observations
- ☐ Incorporate feedback
- ☐ Ready access to data
- ☐ Improved use/reuse
- ☐ Rapid response
- ☐ Improve cost effectiveness
- ☐ Improve data quality/science value
- ☐ New______________________

AIST Needs Category

- ☒ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☐ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☒ F-Decrease mission risk/cost thru autonomy/automation

- ☐ New______________________________

Appendix C – Use Cases

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

ICESat II and DESDynI using ERINode for Passive Active Interferometric Radiometer w/Interleaved Radar(PA(IR)^2), flyable on a Balloon and a UAV on STITCH.

Goal

The goal briefly describes what the user intends to achieve with this use case.

Climatologists using ERINode for Passive Active Interferometric Radiometer w/Interleaved Radar can calibrate ICESat II and DESDynI measurements. Using an ERIN-controlled sensor the user can:

- See high resolution along coastlines, sea ice, snow on freeboard ice, steep terrain
- See high resolution, seasonal variations
- Achieve high angle polarimetric separation for river valleys and through foliage
- Perform high resolution mountain **glacier erosion** assessment

Ice sheet height changes for climate change diagnosis
Surface and ice sheet deformation for understanding natural hazards and climate; vegetation structure for ecosystem health

ICESat-II Clouds, aerosols, ice, and carbon
Ecosystem structure and biomass
Sea ice thickness, glacier surface elevation, glacier velocity
Climate
Ecosystem
Water
DESDynI Ice dynamics (L-band InSAR)
Ecosystem structure and biomass
Heat stress and drought
Vector-borne and zoonotic disease
Surface deformation
Sea ice thickness, glacier surface elevation, glacier velocity
Climate
Ecosystem Health
Health
Solid Earth
Water

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

The poorly understood dynamic response of the ice sheets to climate change is one of the major sources of uncertainty in forecasts of global sea-level rise. DESDynI's InSAR measurements of the variations in ice flow patterns and velocities provide important constraints on their dynamic response to climate change. Such knowledge will help to determine how fast society must adapt to sea-level changes and is crucial in planning the allocation of scarce resources.

The Expandable Reconfigureable Instrument Node (ERIN) can orchestrate interleaved radar and radiometers just like its satellite brethren DESDynI AND ICESAT II (aka CLP Pathfinder). With a node (S/N 002) design projecting to weigh only two or three pounds, the ERIN will bring the Web Sensor Strand (WSS) technique to small Uninhabited Aerial Vehicles (UAVs).

By flying low and slow the DESDynI AND ICESAT II-like measurement (**Sea Ice**) can fly into areas that will help calibrate the DESDynI AND ICESAT II measurement and co-register high resolution data that it can take along curvilinear strips, but measure over and under the forest canopy, in the valley and over the foothills and present those perspectives to the hydrologists independently or simultaneously through their multi-node synchronous operation.

The web strand is essentially an L-Band interferometric baseline that can surround a target area and remain synchronous either through the Global Positioning System(GPS) clock pulse reference or line of sight communication.

By tagging the position of the L-Band radar return for the user, ERIN can interleave radiometer brightness temperature integration periods to infer multiple “looks” for the passive sensor. In post-collection image processing, the web sensor, formed by strands between synchronous nodes can overlay the synthesized array at all the different wavelengths that are interleaved. With COTS technology and a differential GPS, 1 centimeter position determination is the dominant error in reconstructing the L-Band wavefront.

At 20 meters/sec, a slow moving platform, such as the aerotenna, moves less than ¼ of a wavelength per shot when the pulse repetition frequency is 2 msec. Therefore the L-band array “fills in” the web with L-Band return scatter and forward scatter.

Use Case of L-Band “web sensor strand” array, formed by UAV node movement
L-Band wavelength is ~0.22meters
We Chose (PRI=2msec) 500 shots/sec, *PRI is Pulse Repetition Interval
Air speed of UAV: 20m/sec
Therefore “element” movement: 0.04 meters/shot

L-Band Active λ: 0.238095238 meters L-Band Passive λ: 0.2123142 meters

“array element spacing” 0.168 wavelengths “array element spacing” 0.1884wavelengths

Interleaving shorter wavelength radiometers at X-Band, K-Band, and Ka-Band the **S**ynthetic and **T**hinned **I**nterferometry for **T**omographic **C**ryospheric **H**ydrology (**STITCH**) use case will tag the Sea Ice assessment with the same time, position, and bearing tags to co-register the data with the L-Band SAR formed by successive Web Sensor Strands. STITCH is not only an acronym, it also describes the operational data collection method. A demonstrated 30 day coastal coverage mission around the coastline of Antarctica and around Greenland using a balloon and a “stitching” node moving slowly in azimuth but varying the interferometric baseline rapidly with each 2-node synchronous pulse or “strand” representing a baseline.

For the shorter radiometer wavelengths to be interleaved, the pulse repetition interval (PRI) will have to be shortened to PRI= 0.3msec for X-Band, PRI=0.2msec for K-Band, and PRI= 0.1msec for Ka Band. All of these PRI can be kept synchronous with the fast L-Band Pulsed Radar (Pulse width = 30 nsec).

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors can benefit from the co-registration of synchronous satellites and low flying platforms include the following:

- Hydrologists who study soil moisture and transpiration in the water cycle. Polarization effects and low looks under the drip line can calibrate lower resolution satellite measurements.

Secondary actors are interested in targeted areas and calibrations and high resolution data will improve decision-making. These include the following:

- Meteorologists who need to make decisions on snow and it’s effect on national weather service forecasts
- Water Management officials who need to make decisions on snow water storage, reservoirs and drought-stricken areas

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any *assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.*

For Snow and Cold Land Processes-**SWE** models to be believed on SCLP, then ground truth in remote (particularly mountainous) areas must calibrate their global view. A co-registered high resolution data set that is affordable to the secondary actors will calibrate the uncertainties in global models (e.g., **SWE** inside the drip line) and discern dry snow in the hydrological cycle from wet snow where and when they interact.(foothills). ERIN-WSS Technology directly addresses these preconditions.

An unchanging scene on the timescale of 10 minutes (such as SWE), must be present to integrate over target distances ~ curvilinear 10 Km of "shots" at 20 m/sec (UAV air speed).

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

The seasonal camaflouge of photosynthesis, summer foliage, fallen leaves, and freezing and decaying leaves are normal triggers whose variation is a trend that indicates climate change.

Other triggers are extreme winter weather events such as blizzards, ice storms, and rapid melts. These all affect human decision-making, and have indirect effects on flora and fauna.

Deployment of ERIN-WSS technology can help understand the short and long term decisions that need to be made

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) 10 MHz Xtal oscillator is refreshed / synchronized to 1pulse-per-second GPS reference at both nodes (all nodes)
2) 40 MHz digital clock is derived from 10 MHz reference
3) System Clock pulses radar from all system nodes on 10 MHz derived carrier
4) Short radar pulse (30 ns), is snatched on return after 100ns roundtrip
5) System clock closes window on ERIN return
6) Return pulse is downconverted to 3-37 MHz Intermediate Frequency (IF)
7) IF is digitized and tagged w/ time, position, and bearing
8) All return/ forward scatter data is combined w/ time tags at both nodes
9) "Interferometric baseline" model calibrates system geometry out of strand baseline
10) A second pulse is released after 2 msec

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

1) Instead of a PRI "wait period", a radiometer blanking switch can be triggered by the 130 nanosec transmit/return and enable "interleaved" operation.
2) N Radiometer integration periods of M length (where 1.75 sec>N*M) – (e.g., for L-band @ 20 m/sec airspeed, <λ/4 element spacings are captured between pulses.
3) These captured brightness temperatures, tagged with time, position, and bearing may also be synthesized or correlated to the radar.
4) Further, all active and passive data can be co-registered to the big picture.(SMAP and Aquarius)

NOTE: These Alternate Flow steps are essential for the understanding of Sea Level Change, the key measurement of DESDynI

Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

After the Use Case measurement has been completed the ERIN data analysis will show trends that indicate the trend is either permanent (climatic), or synoptic (single events or cyclical). The decision-making processes in water management, and meteorological weather prediction models can direct local decision-makers and even world decision makers when co-registered with the lower resolution satellite measurements of ICESat II and DESDynI.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.

- Sea Ice in Cryosphere on Coastlines ⇉✉ Sea Ice Use case measurement “melting down straight to the bottom” ⇉ Sea Level change prediction strategy/decisions National Weather Service, NASA, EPA
- Snow melt⇉✉ Freeboard Ice assessment Use case measurement “submerging ice” ⇉ climatologists, sea ice and glacier assessment, NOAA,NASA, EPA
- Snow pack⇉✉ Sea Ice Melting threat of avalanche/erosion. Use case measurement “sea ice and glacier erosion” ⇉ climatologist, erosion of the cryosphere

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

The big picture provided by ICESat II at shorter wavelengths and DESDynI at low resolutions relative to ERIN Missions will uncover many target use cases where ERIN will resolve calibration issues due to vegetation camouflage, polarization separation effects, and wet/dry snow mixing and it’s effect on flora and fauna.

This use case of ERIN-WSS Technology can synergistically work with Reconfigurable In-situ network (PI: Ayanna Howard) for calibrations of the local continuum measurement, and to calibrate the Land Information System (LIS) that ties in satellite SMAP/Aquarius measurements at lower resolution and higher coverages.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name) Interleaved radar and radiometer	Grouped synchronous Nodes-strands synthesize a web	e.g., –low and slow/	good view under canopy/ drip line/	NASA, NOAA, USDA, USFS USGS, ESA,	Name of the system which supports discovery and access (from NRC)
Aka **ICESat II and DESDynI**	Local continuum (remote)	High resolution (50-100m)	capture the steepness of the terrain and effects on saltwater mixing /filtering of wetlands/forest canopy and ground vegetation	Lightweight technology will be relevant on solar system planetary exploration also	**NPOESS** Joint Requirements Oversight Council **Climate Working Group**

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
Numerical Weather Prediction Model	NOAA/NWS (ERIN data will provide input to model)	Short description of the model	List of data consumed Radar scatter - σ Brightness Temperature - $T_{b,}$ Both at L-Band time and position tags	How often the model runs	Name of the system which offers access to the model
Seasonal climate models	NASA USDA (ERIN data will provide input to model)	A synthetic aperture radar formed from synchronous "shots", and calibrated returns coverage area	σ^{return}, $\sigma^{forward}$, T_b Tagged with, lat, long, alt, roll, pitch, yaw	One parallel or radial cycle – dump to master node	ERIN and the Image Processor – Master Node

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
International Polar Year (IPY)	NASA/Canadian Space Agency/NSF/ NOAA	International Polar Year is a ground truth campaign visit the cryosphere to witness the "climate trends" of targeted areas – glaciers, snow pack, sea ice	Cold Land Processes Working Group	Al Gore

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
Sea Level change Prediction Water Management	NASA, EPA, National Weather Service, NOAA, DNR/ Corps of Engineers Local/Unique	• Sea Ice in Cryosphere on Coastlines ⇉✉ Sea Ice "melting down straight to the bottom" ⇉ Sea Level change prediction strategy/decisions NOAAs • Snow melt⇉✉ Freeboard Ice assessment Use case measurement "submerging ice" ⇉ climatologists, sea ice and glacier assessment • Snow pack⇉✉ Sea Ice and Glacier threat of avalanche/erosion. Use case measurement "wetlands" ⇉	

		climatologist, erosion of the cryosphere	

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor L-Band radar interleaved w/ X-, K-, Ka Band radiometer on Slow and Low UAV or Balloon	How often the sensor can observe event	Name of the satellite or system which manages sensor
ERIN radar ERIN radiometers	NASA - GSFC	**S**ynthetic and **T**hinned **I**nterferometry for **T**omographic **C**ryospheric **H**ydrology (**STITCH**) use case will tag the Sea Ice assessment with the same time, position, and bearing tags to co-register the data with the L-Band SAR formed by successive Web Sensor Strands.	Coverage area: 30 minutes on batteries/platform limitation For the shorter radiometer wavelengths to be interleaved, the pulse repetition interval (PRI) will have to be shortened	ERIN – Base station – Master Node- Image Processor – co-registration w/**DESDynI AND ICESAT II** flyovers

11.3.5 Snow Cover resolution enhancement using targeted sensing

Point of Contact Name(s): Steve Chien, Paul Houser, Christa Peters-Lidard, Dan Mandl

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- X DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- X HyspIRI
- X ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- X SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- X Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- X NMP EO-1
- X QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- X Terra
- X TRMM

Future Missions

- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- X LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☐ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- X Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☐ Targeted observations
- ☐ Incorporate feedback
- ☐ Ready access to data
- ☐ Improved use/reuse
- ☐ Rapid response
- ☐ Improve cost effectiveness
- X Improve data quality/science value
  - Resolution

AIST Needs Category

- X 1-Data Collection
- ☐ 2-Transmission & Dissem.
- X 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- X A-Increase science data value thru autonomous use
- X B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation
- ☐

Use Case Name
Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Increased resolution data through targeted sensing

Goal
The goal briefly describes what the user intends to achieve with this use case.

Produce models of increased spatial resolution by combining lower resolution high coverage products with targeted higher resolution products, via integrated modelling (e.g., LIS)

Summary
Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

Lower resolution data from MODIS, TRMM, drives snow cover modelling in LIS based on 250m-km/pixel data.
Ensemble modelling in LIS used to derive areas of greatest uncertainty.
Higher resolution sensors such as EO-1 (up to 10m/pixel) are autonomously targeted on these areas.
Higher resolution data is then used to update the model.
End result is model is available at higher resolution.

Actors
List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors: Users of hydrology/snow cover products, scientists modelling these science phenomena. Data via WCS and WPS.
Secondary actors: high coverage sensors/data streams (MODIS, Quikscat) via SOS, WCS, WPS and SAS, high resolution data streams (EO-1) via SPS, SOS, WPS.

Preconditions
Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

All above OGC services as indicated in the actor lists including ongoing snow cover modelling of target area.

Triggers
Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

Updates from sensor data (low res, high res) via SAS.
Updates from modelling (ensemble modelling indicates areas of uncertainty) via WPS/WCS.

Basic Flow
Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Acquire data from lower resolution sensor (SOS, WCS)
2) Ensemble modeling (WPS, WCS)
3) Trigger higher resolution observations of areas of highest uncertainty (SPS, SOS)
4) Update of modeling state (WPS, WCS)

Alternate Flow
Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

1) If data outages due to anomalies, can use rapid response to fill gaps (SPS, SOS, WCS, WPS) and

re-run models (WCS, WPS)

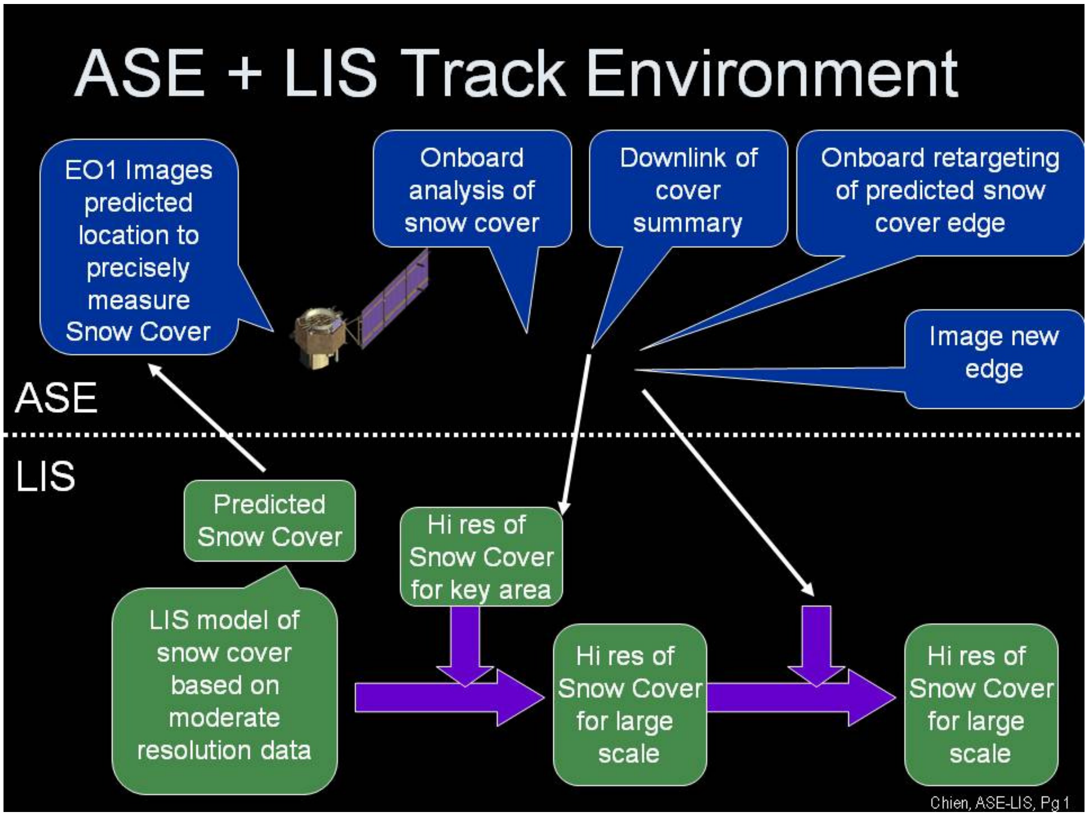
Post Conditions

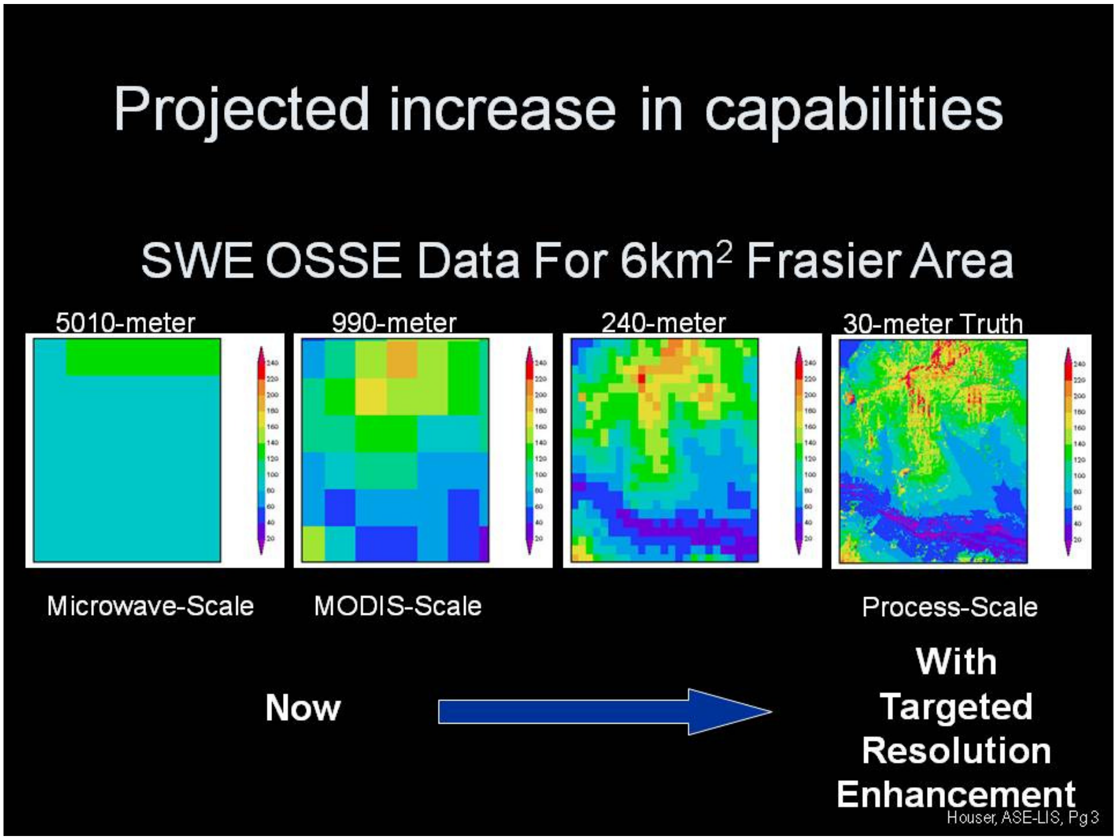
Here we give any conditions that will be true of the state of the system after the use case has been completed.

Higher resolution modeling

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.





Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Return on investment – the ROI is that you can have higher resolution knowledge (via modelling) without requiring flying the higher resolution and coverage instrument (or collection of instruments).

Synergistic with Hiliard UAV and airship sensorweb in that those assets could be coordinated to provide more high resolution data, these would be tasked via SPS and data assimilated via SOS, WCS, WPS.

Synergistic with Howard rover sensorweb in that those assets could be coordinated to provide more high resolution data, these would be tasked via SPS and data assimilated via SOS, WCS, WPS.

Actually both the above could also be used to supplement data dropouts via SPS and data assimilated cia SOS, WCS, WPS.

Can use future sensors Desdyni, Hyspiri, SMAP, Icesat.

Can apply to track ice sheet growth/retreat.

Similar techniques proposed for data processing at Mars using Odyssey/THEMIS instrument.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access
MODIS	Remote	No cloud cover	Used for soil moisture, precipitation	NASA	DAAC
Quikscat	“	“	“	“	
TRMM	“	“	“	“	
EO-1	“	“	“	“	

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
LIS	GSFC-GMU	Snow cover	MODIS, TRMM	daily	

Event Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
Snow cover model runs	LIS team	Using LIS infrastructure, integrated modeling of snow cover predictions and data fill-in		LIS
Sensor data updates available – EO-1	EO-1 Mission	EO-1 SAS, SOS		
Sensor data available MODIS	GSFC	Data updates from MODIS		GSFC DAAC
Sensor data available from TRMM		Data available from TRMM		GSFC
Data available				

from Quikscat				

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor
MODIS	NASA		Multi daily	NASA GSFC
Quikscat	NASA	Scatterometer	Multi daily	
EO-1	NASA	Multispectral, hyperspectral	Multi daily	NASA GSFC
Future sensors	NASA	Multispectral, others.		

11.4 Carbon Cycle & Ecosystems

11.4.1 Carbon Cycle – Biomass

Point of Contact Name: Paul R. Houser

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☒ ASCENDS
- ☒ CLARREO
- ☒ DESDynl
- ☐ GACM
- ☒ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☒ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☒ SMAP
- ☒ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☒ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☒ Terra
- ☒ TRMM

Future Missions
- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☒ NPOES
- ☐ NPP
- ☐ OSTM
- ☒ OCO

Decadal Survey Category
- ☒ Earth Science Apps & Societal Benefits
- ☒ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☒ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- ☒ Targeted observations
- ☒ Incorporate feedback
- ☒ Ready access to data
- ☒ Improved use/reuse
- ☒ Rapid response
- ☒ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New

AIST Needs Category
- ☐ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☒ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☒ F-Decrease mission risk/cost thru autonomy/automation
- ☐
- ☐ New

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Carbon Cycle - Biomass

Goal

The goal briefly describes what the user intends to achieve with this use case.

Improve knowledge and prediction of vegetation, biomass, and carbon cycling and changes.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

Use DESDynI biomass and vegetation structure along with vegetation phenology observations from MODIS/VIIRS to inform a vegetation model about vegetation changes (from fire, harvest, selective logging (radar), weather, wind, land use, urbanization, flooding, etc.) to result in an improved terrestrial carbon flux and storage estimate. Then in turn, abrupt changes predicted by the terrestrial model, or areas of increased uncertainty could be used to target and optimize DESDynI observations (because of the approximate 50% duty cycle). Could also use cloud observations from other satellites to target the Radar and LIDAR observations.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

- Primary actors: NASA, USDA, mission operators, and data analysts
- Secondary actors: FEMA, Office of Emergency Services, agricultural extension

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

- Data from DESDynI are being routinely processed, or available in this use case from a synthetic "truth" source (i.e., a model)
- Precipitation, weather/climate conditions, land use, and GPS data are readily ingested in to high resolution distributed vegetation phenology and dynamics models
- Models of surface vegetation growth and community interaction exist or are developed and are capable of assimilating DESDynI-style data.
- Web and grid services exist for accessing data and models and are running on appropriate computers including high performance computers

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

- Typical trigger will be a significant vegetation change (i.e., 100^2 km forest fire), but could also just be seasonal (expected) change in crop or natural vegetation growth.
- Detectable changes in ancillary sensor web conditions (e.g., lightning, fire, wind, flood, precipitation, evapotranspiration, seasonal climate) could also trigger an sudden vegetation change event

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1. Vegetation change occurs (either incremental growth, or sudden removal by harvest, storm, or fire)(vegetation change can be comparison against baseline condition for threshold trigger) or an alternate sensor (smoke plume or chemical species trigger in the case of fire)

or a drought-trigger via soil moisture anomaly via a high resolution land modeling system. This trigger could also request that DESDynI be deployed in the area, meeting a sensor web objective. A target objective of the system could be a new EPA DSS monitoring the ability of different regions to sequester CO2. Were the monitored state from DESDynI providing feedback that this target could not be met (with combined declining stand and productivity resulting in carbon gain to the atmosphere), this would provide feedback to EPA and other agencies that supplemental CO2 remediation efforts are required.

2. Region is imaged with DESDynI
3. Data are downlinked and processed (data are georeferenced with location information given by GML (geographic Markup Language) accessible by both Land Surface Models and GIS platforms, along with multiple parties.
4. Additional data (precipitation, wind, fire occurrence, GPS, etc.) are collected into web services (and these datastreams are tagged with metadata) so that they can be registered in a centralized registry (UDDI) or accessible via distributed data mining (ADaM)
5. Sensor data are assimilated into real-time vegetation ecology phenology/dynamics model (and this component could be a multiple carbon model ensemble of JULES, CLM, etc) run within a workflow cycle established using BPEL). The DESDynI data could be assimilated into a (Global) Dynamic Vegetation Model. The DESDynI data would be assimilate updated canopy nitrogen which would update the photosynthesis and carbon balance predicted by the model; the respiration component would be updated by assimilated age structure data from DESDynI and temperature data from other satellite systems.
6. If there is a concurrent CO2 measuring satellite (such as the next-generation CO2 LIDAR mission), since DESDynI deployment is outside OCO's operational life, then the model could also include data assimilation with this CO2-LIDAR mission. Data assimilation involving the two systems would probably require using WRF and possibly STILT (a Lagrangian trajectory model) to reduce representational error and ensure that the two satellite footprints (i.e., that of DESDynI and the CO2 LIDAR mission) overlap.
7. Sensor and model results analyzed for vegetation changes, and near-future projection (the changes are compared against decision rules and upon exceeding threshold, communiqué' are issued to appropriate agencies, i.e., NOAA NWS River Forecasting System, local fire authorities).
8. Results are communicated to appropriate agencies (FEMA, USDA, FAS, local governments, transportation authorities)(where their decision support systems would receive a trigger from the DESDynI system, as part of its workflow, and the external Partner Agency DSS would independently run, using data (3D vegetation structure supplementing topography) accessible via commonly formatted data in database.
9. Ecologic model change and ensemble predictions are analyzed to determine "vegetation change hot spots (i.e., Amazonia)"
10. Results are communicated to DESDynI mission managers to target hot spots for additional observations, and process repeats.
11. Observations are collected over remainder of mission to understand long-term effects

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

Other system flows are possible.

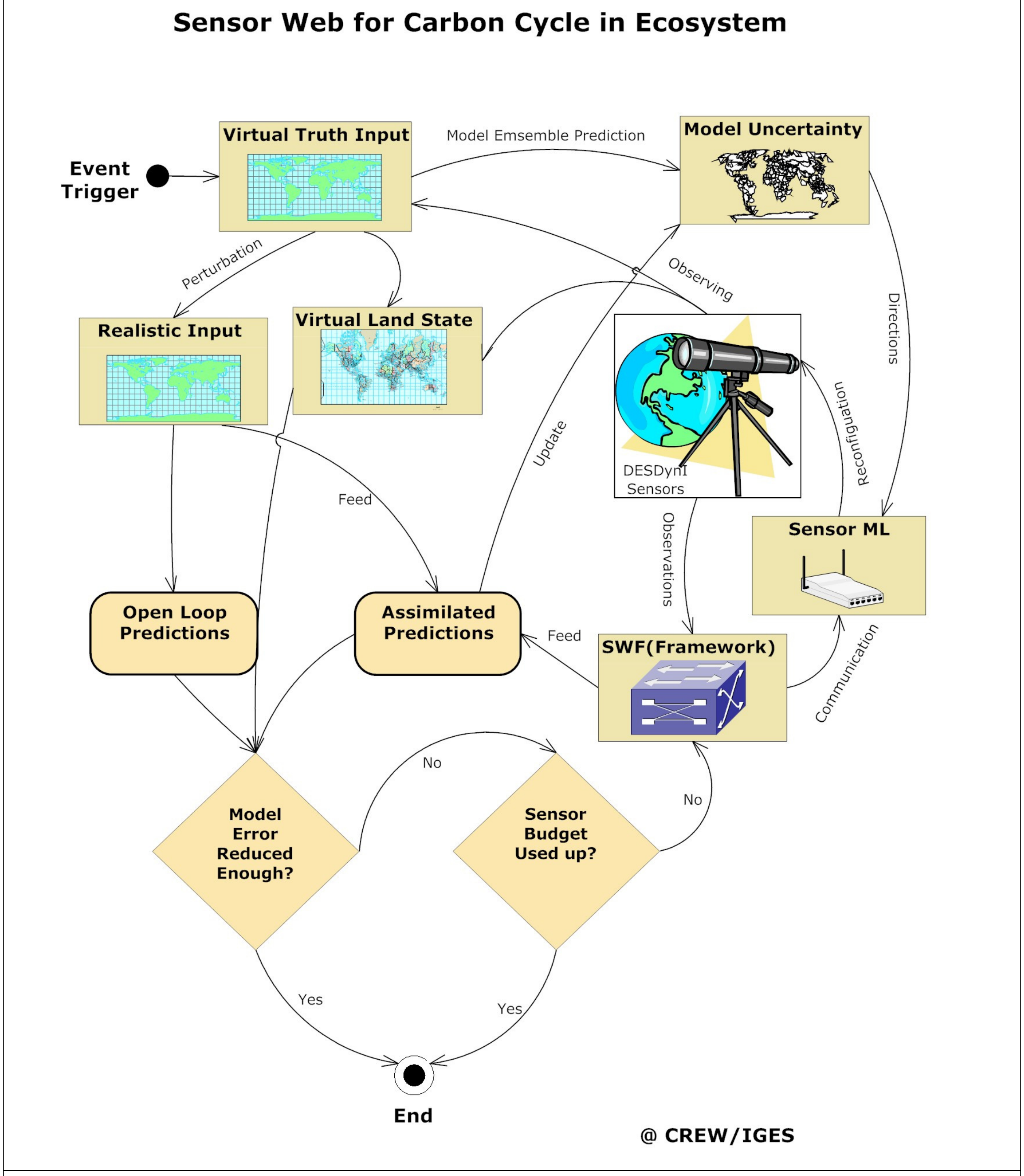
Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

- Vegetation conditions and abrupt change (with change attribute) available on the web in near-real time
- Vegetation change maps available through the portal on the web (identify what portal)

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Premise: The DESDynI is a first wave Decadal Survey mission equipped with both a surface imaging L-Band SAR and LIDAR, with 8 day repeats and 10-100km resolutions. It is capable of measuring surface elevation changes and vegetation structure, which can provide information on a wide range of geomorphologic, solid earth, cryosphere, and hydrologic changes. Our goal here is to explore Sensor Web "use cases" that explore or demonstrate how DESDynI's capabilities can be significantly enhanced when used in a Sensor-Model web framework. Since this is a future remote sensing system, with no contemporary analogue, we will generally be performing these use cases in a OSSE (Observation Simulation Sensitivity Experiment) mode, where we use a model to create a synthetic "truth" that can be sampled by a DESDynI sensor model to allow the sensor-model web use case paradigm to be explored. The spatial extent, time period, and domain for these studies is generally less important than demonstrate the interaction between various sensors, models, and communication frameworks to achieve an improved science or application result. We have identified a number of different use case scenarios below, which is by no means comprehensive, but can provide a baseline of expected DESDynI system enhancements using a sensor web paradigm. It should also be noted that similar use cases can and should be developed for the other decadal survey missions.

DESDynI will have many use cases. These are selected examples - other events include:

- Tsunamis resulting from earthquakes
- Volcanoes
- Landslides
- Subsidence
- Flooding
- Hurricanes
- Wind events
- Wildfires
- Land use (e.g., clear cutting)
- Ice shelf break up

DESDynI's sensors can be applied to a wide range of carbon cycle and ecologic science from vegetation density, structure, biomass and carbon storage to agricultural management and abrupt vegetation change at a wide range of space and time scales. These advancements in ecological observations have potential to directly address societal needs of ecological, carbon cycle and application fields from crop failure, famine, carbon credits and management and mitigation of risks associated with Climate Variability & Change. For this use case, we will focus on using DESDynI's capabilities to monitor vegetation structure, height, and biomass changes. Observations of vegetation greenness, lead area index and photosynthesis from complementary visible-Infrared sensors will be an essential part of this sensor web use case.

11.4.2 Dynamic Plant Monitoring

Point of Contact Name: Wei Ye

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☒ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☒ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions
- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☒ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category
- ☒ Earth Science Apps & Societal Benefits
- ☒ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- ☒ Targeted observations
- ☒ Incorporate feedback
- ☒ Ready access to data
- ☐ Improved use/reuse
- ☒ Rapid response
- ☐ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New______________________

AIST Needs Category
- ☒ 1-Data Collection
- ☒ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☒ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☐ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation

- ☐ New________________________________

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Multimodal Plant Monitoring

Goal

The goal briefly describes what the user intends to achieve with this use case.

Multimodal sensing of plants bloom in response to precipitation.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

The goal of this use case is to study the plants bloom in response to precipitation. Multimodal sensing is applied to capture the dynamic response of plants to seasonal rainfalls after a relatively long period of dry weather. Specifically, we deploy sap flow sensors on some branches of several different species of plants. This sap flow sensor detects the detailed internal activity of plants in response to the environment. In addition, we deploy imaging sensors (remotely-controlled cameras) to capture the bloom of plants. A weather station allows us to detect precipitation or solar radiation, etc.

In order to reduce energy usage—sap flow sensors are powered by batteries and use wireless communication. We will dynamically adjust their sampling period according to environmental events that have been detected. When there has been no rainfall for a relatively long period of time, the plants change very slowly. In this case the sap flow sensors are configured to sample at a low frequency (e.g., 1 sample every 5 or 10 minutes). The camera takes a picture of each plant once a week. When the weather station detects rainfall, we will reconfigure the system to sample more frequently. The sap flow sensor will take 1 sample per minute, and the camera will take a picture twice a day to capture the plants bloom.

An additional trigger is the solar radiation. The plants are much more active with sunlight during day time than during the night. Therefore, during the night, we can have even lower sampling rates (e.g., 1 sample every 30 minutes) than day time. The weather station is able to detect the solar radiation level, which will be used to trigger the change of sap flow sampling rate during the day and night.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors: scientists, system reconfiguration software, weather station
Secondary actors: data acquisition system, sap flow sensors, the imaging sensor (camera)

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

There is no rainfall for a relatively long period of time.

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

Daytime and night time change detected by the solar radiation sensor on a weather station.
Precipitation detected by a weather station.

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the *use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)*

1) There is no rainfall for a relatively long period of time
2) Sap flow sensors are configured to sample at every 5 minutes during the day and 30 minutes during the night
3) An imaging sensor (camera) is configured to take a picture of each plant once every week
4) Solar radiation sensors on the weather station detects the change of day and night
5) Sap flow sensors changes sampling rate according to day time or night time
6) Precipitation is detected by the weather station
7) Sap flow sensors increases sampling rate to 1 sample per minute
8) The imaging sensor now takes two pictures per day

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

Plants have significant bloom after precipitation.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

11.4.3 Dynamic Soil Sampling

Point of Contact Name: Wei Ye

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☒ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions
- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☒ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category
- ☒ Earth Science Apps & Societal Benefits
- ☒ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☒ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- ☒ Targeted observations
- ☒ Incorporate feedback
- ☒ Ready access to data
- ☐ Improved use/reuse
- ☒ Rapid response
- ☐ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New______________________

AIST Needs Category
- ☒ 1-Data Collection
- ☒ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☒ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☐ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation

- ☐ New________________________________

Use Case Name
Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Dynamic Soil Sampling

Goal
The goal briefly describes what the user intends to achieve with this use case.

Capture the nonlinear response of the soil to precipitation.

Summary
Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

Precipitation or irrigation-triggered soil sampling:

This use case studies the dynamic response of soil to precipitation. The potential system consists of an array of sensors in an orchard, including soil moisture, temperature and salinity sensors as well as a weather station. The weather station is able to measure precipitation, wind speed and direction and solar radiation etc. Typically, there may be little change occurring in the soil zone. In this case we could sample soil moisture with the sensor array at a very low frequency (perhaps once per hour or two hours in the soil). However, then a rain/storm comes, or an irrigation event occurs. In the former case, we could detect the event using the weather station. To detect irrigation, we could select a few shallow soil moisture sensors that are located near the entrances of the water path. When either event is detected, we would change the sampling rate of the soil array to once per min or an even greater frequency to capture the very dynamic and nonlinear response by the soil.

Actors
List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors: scientists, remote detection and reconfiguration software, weather station
Secondary actors: data acquisition system, soil moisture sensor array

Preconditions
Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

No precipitation or irrigation in a relatively long period of time.

Triggers
Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

The weather station detects Precipitation.
Selected sallow moisture sensors detect significant change in soil moisture.

Basic Flow
Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) No rain or irrigation events for relatively long time
2) The majority of the soil moisture sensors take readings at low rate (e.g., 1 sample/hour)
3) A few selected shallow soil moisture sensors near the entrance of the water path take readings at a relatively high rate (e.g., 1 sample/min)
4) The weather station samples at a relatively high rate (e.g., 1 sample/min)
5) Either the selected shallow soil moisture sensors detect a significant change, or the weather station

detects precipitation 6) The entire soil moisture array is reconfigured to sample at a high rate (e.g., 1 sample/min or less)
Alternate Flow *Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.*
Post Conditions *Here we give any conditions that will be true of the state of the system after the use case has been completed.* The soil moisture level has been changed significantly.
Activity Diagram *Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.*
Notes *There is always some piece of information that is required that has no other place to go. This is the place for that information.*

11.4.4 Forest Fire Sensor Web with UAVSAR

Point of Contact Name(s): Yunling Lou & Steve Chien

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- x DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- x SCLP
- x SMAP
- x SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- x NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- x Terra
- ☐ TRMM

Future Missions
- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category
- x Earth Science Apps & Societal Benefits
- x Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- x Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- x Targeted observations
- ☐ Incorporate feedback
- ☐ Ready access to data
- ☐ Improved use/reuse
- x Rapid response
- ☐ Improve cost effectiveness
- ☐ Improve data quality/science value
- ☐ New______________________

AIST Needs Category
- x 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- x A-Increase science data value thru autonomous use
- x B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation

- ☐ New_______________________________

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Forest Fire Sensor Web with UAVSAR

Goal

The goal briefly describes what the user intends to achieve with this use case.

Our goal is to provide critical information for rapid response during a forest fire. This forest fire sensor web is for UAVSAR to trigger on a forest fire alert, plan data acquisition with UAVSAR, collect radar data over the fire site, process data onboard to generate appropriate data products such as fuel load map, downlink the time critical information to disaster response agencies. The onboard automated response capability can also trigger other observational assets to collect data over the fire site.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

We are developing a forest fire sensor web with UAVSAR to demonstrate the autonomous disturbance detection and monitoring system with imaging radars. This sensor web enhances UAVSAR (a high resolution polarimetric L-band imaging radar) with high throughput onboard processing technology and onboard automated response capability to detect wildfire and monitor forest fuel load autonomously. The smart sensor will be OGC compliant, thus allowing us to utilize other OGC compliant Sensor Alert Services and Sensor Observation Services to provide enhanced information such as precise fire location and fire progression prediction to enable autonomous response of other assets and disaster management agencies.

The timeliness of the smart sensor output products can be used for disaster management, agricultural irrigation, and transportation such as shipping. Onboard automated response will greatly reduce the operational cost of the smart sensor. This smart sensor technology is well suited for space flight missions such as DESDnyI, SCLP, SMAP, and SWOT, and different science algorithms can be used for a variety of disturbances.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors

Sensor Alert Service: Wildfire observer, MODIS RapidFire

Sensor Observation Service: DEMs, vegetation maps, forest fuel load model, EO-1

Sensor Planning Service: onboard replanning and autonomy software

Portal: Satellite phone and 4-D Geo-browser

Beneficiaries: forest services, disaster management agencies, ecologists

Secondary actors

UAVSAR: collect radar data

Sensor web data processing system:

- Onboard processing to generate high resolution radar imagery
- Radiometrically and polarimetrically calibrate data
- Geolocate data
- Generate forest fuel load map
- Downlink data to a web portal via Iridium satellite phone

Autonomous planning software:

- Triggered by other Sensor Alert Services
- Trigger additional data takes
- Plan new flight lines

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

Forest fire
Initial report of fire
UAVSAR operational and available
Onboard processing capability to generate fuel load map
Sufficient downlink capability

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

Forest fire alert from local fire observer or MODIS RapidFire

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Alert generated by forest fire observer or MODIS RapidFire
2) Alert detected by Sensor Web
3) Alert passed to onboard planner, UAVSAR observation request generated
4) UAVSAR observation obtained
5) Process data onboard to generate fuel load map
6) Downlink information to Forest Services and disaster management authority
7) Generate new alert for other sensor observation assets (e.g., EO-1)
8) Plan new data takes for UAVSAR
9) Repeat steps 4 through 8 until flight ends

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

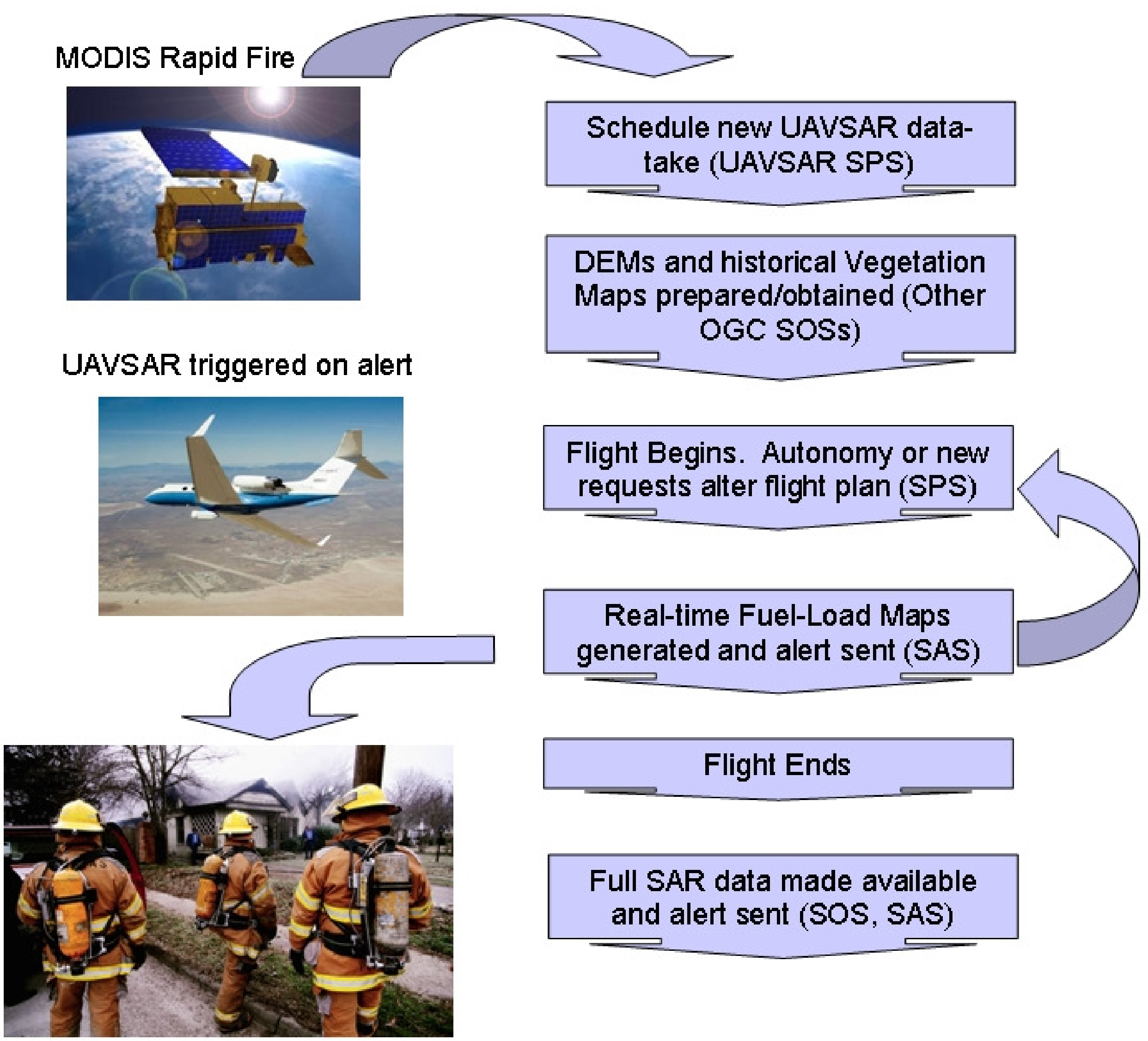
Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

1) Archive data for further analysis and future planning and publish results to ecologists.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

This technology is directly applicable to Decadal radar missions, where we can provide autonomous planning capability either onboard or on the ground. In addition, with change detection algorithms, we will enable DESDnyI to detect and monitor volcanic eruptions, lava flow, flooding, forest fire, freezing and thawing, etc. We will enable real-time monitoring of soil moisture and flooding with SMAP. Finally, onboard autonomous planning software will allow targeted observations of specific events based on external or internal triggers. Examples of external triggers are ground-based sensors or spaceborne sensors such as EO-1 and MODIS. Examples of internal triggers are event detections generated by the onboard processor.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access
Fire observer	In situ	Day or night	Observation of fire with estimated locations	Forest Service	
Hyperion observation	Remote sensing	No cloud cover over forest fire Day or night		USGS/NASA-GSFC-JPL	EROS Data Center

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
Fuel Load Model	JPL	Estimates forest fuel load	L-band polarimetric data from UAVSAR	Onboard, in real time	

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor
UAVSAR	JPL	Airborne L-band polarimetric radar for repeat pass interferometry. Currently deployed with a NASA	As frequently as desired	N/A

		Gulfstream-III. It will also be ready for deployment on a Global Hawk UAV in 2009.		

11.4.5 North American NPP Comparison Using Automated Workflow Generation

Point of Contact Name: Robert Morris, Jennifer Dungan

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☒ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☒ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☒ Terra
- ☐ TRMM

Future Missions
- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☒ NPOES
- ☒ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category
- ☐ Earth Science Apps & Societal Benefits
- ☒ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- ☐ Targeted observations
- ☐ Incorporate feedback
- ☒ Ready access to data
- ☒ Improved use/reuse
- ☐ Rapid response
- ☒ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New______________________

AIST Needs Category
- ☐ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☒ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☒ F-Decrease mission risk/cost thru autonomy/automation

- ☐ New_______________________________

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

North American NPP comparison

Goal

The goal briefly describes what the user intends to achieve with this use case.

Compare the current year's annual net primary production (NPP) map for North America with the 25-year long-term average NPP.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

The Terrestrial Observation and Prediction System TOPS incorporates sensors (MODIS, SRTM), data products (snow cover, land cover type, leaf area index, surface temperature) and models that predict biogeochemical variables. The goal is to exploit the long-term (30 year) record derived from synoptic spectrometers and a model or models that predict the activity of vegetation and compare the current (six month) vegetation activity with this record to investigate and then describe regional trends and anomalies. An automated system for workflow generation and execution allows the goal to be stated in an abstract format familiar to scientists, and to be accomplished without the need for either expert knowledge on the data systems and analyses or specific scripting.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors: scientist users
Secondary actors:
Land Process DAAC
National Centers for Environmental Prediction
Natural Resources Conservation Service data servers
USGS data servers

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

Data acquisition resources (data archives, models, sensors, other processing elements) must be accessible via a *service infrastructure*, for example, services provided by the OGC SWE (Sensor Web Enablement) system. These services provide a protocol and infrastructure for requesting the data that will accomplish the goal. Second, there are assumptions about the memory capacity of the scientist's computer that limits the amount of intermediate data that can be stored. For this example, the assumption is that a single day's worth of past data is retrieved and processed at one processing step. This assumption is applied when the workflow is generated.

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

There are no external triggers. There are temporal triggers that signal the availability of data. The science user provides the initial internal trigger of the system.

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Retrieve 30 year average vegetation records (consisting of subtasks 2 and 3)
2) *Retrieve each record in the desired data set;*
3) *Extract and store the desired values.*
4) Retrieve current vegetation data (consisting of subtask 5)
5) *When the current data are available, retrieve the data.*

6) Compare 30 year average with current data
7) Characterize trends and anomalies.

<u>Alternate Flow</u>

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

In this example, the source of any alternative flow would be a delay in the ability of the system to retrieve or process the data. The basic flow would have the same structure in each of these alternatives.

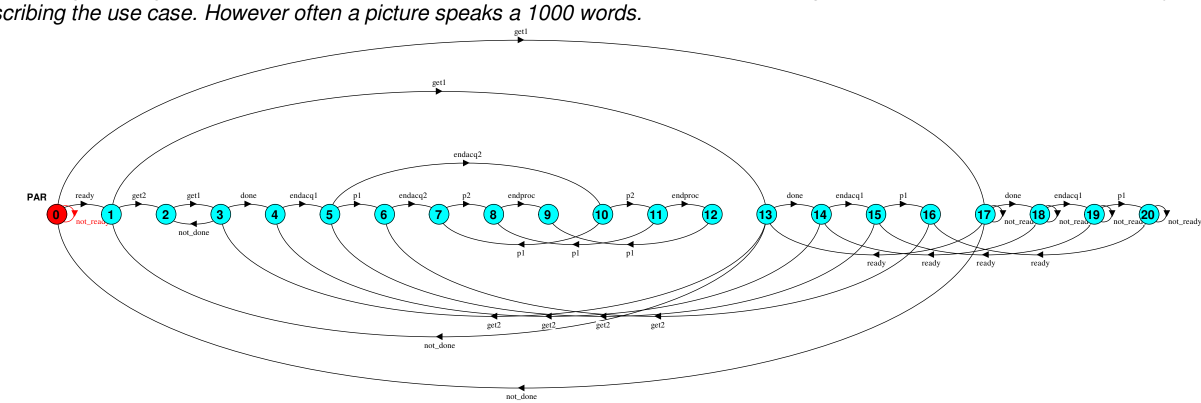
<u>Post Conditions</u>

Here we give any conditions that will be true of the state of the system after the use case has been completed.

The requested data products have been acquired by the scientist.

<u>Activity Diagram</u>

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



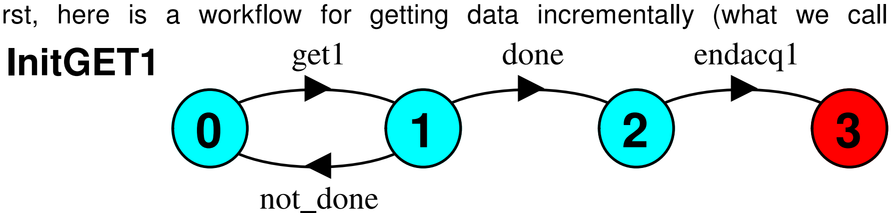
This is a finite state diagram representing the workflow for the problem. The workflow has 20 states, and arcs between states are labelled by the actions that are taken to go from state to state. The complete workflow represents the composition of 4 processes run in parallel: two processes get the data, and two processes process the data. The workflow generator builds this workflow automatically from the initial specification of the problem. A *web manager* executes the flow, also automatically.

<u>Notes</u>

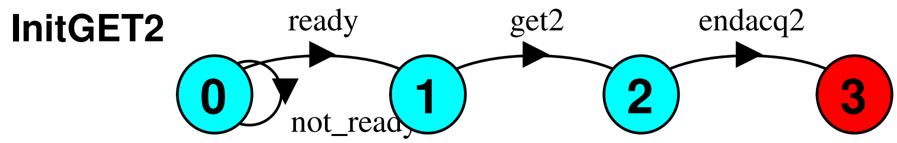
There is always some piece of information that is required that has no other place to go. This is the place for that information.

The workflow diagram above seems complicated, but in fact it is the result of composing four simple workflows.

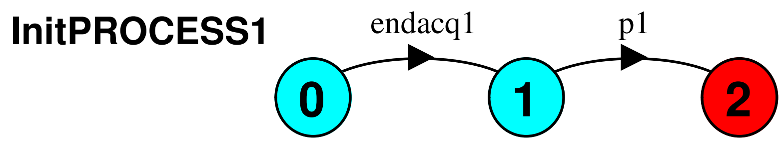
First, here is a workflow for getting data incrementally (what we call *staged* acquisitions).



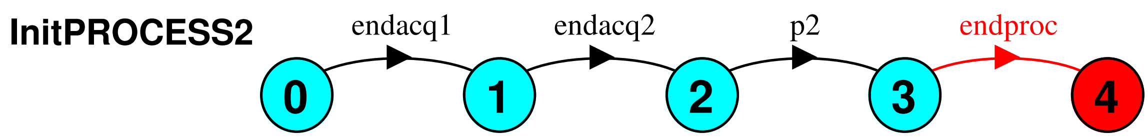
This workflow has a flag “done” that indicates that all the data have been acquired. Second, here is an example of a timed acquisition: in this case, there is a wait (ready) flag that signals when the data are available:



Third, here is a simple flow for processing the data from the first flow:



The action *endacq1* is called a synchronizing action – it forces the process *p1* not to occur until the act of getting is data is complete. Finally, here is the process for comparing the two data sets:



The process action *p2* is a comparison process. It must wait until two data sets are acquired, so it has two synchronizing actions associated with it. The composition of these processes results in the 20 state process described above. The composition is performed automatically. The four processes are executed in parallel.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
MOD15	Remote		Estimate of leaf area index on a per-pixel basis	NASA	
SRTM elevation	Remote			USGS/NASA	
Air temperature and precipitation	In situ		Precipitation and air temperature at station locations	NCEP	
MOD11	Remote		Land surface temperature on a per-pixel basis	NASA	
Snowpack, air temperature, precipitation	In situ		Snowpack, air temperature, precipitation at SNOTEL station locations	NRCS	

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
TOPS	NASA Ames Research Center	A system that brings together data from multiple sources, homogenizes their spatial/temporal bases, and run biogeochemical models to produce outputs related to ecosystem state and processes	See data table above	On demand, daily with aggregations to weekly, monthly and annual time steps	Ecocast

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
N/A				

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
N/A			

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor
N/A				

11.4.6 Soil Moisture Calibration and Validation for SMAP Products

Point of Contact Name(s): Mahta Moghaddam

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☒ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☒ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☒ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☐ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☒ Climate Variability & Changes
- ☒ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☐ Targeted observations
- ☒ Incorporate feedback
- ☐ Ready access to data
- ☐ Improved use/reuse
- ☐ Rapid response
- ☐ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New______________________

AIST Needs Category

- ☒ 1-Data Collection
- ☒ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☒ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☐ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☒ F-Decrease mission risk/cost thru autonomy/automation

- ☐ New______________________________

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Soil Moisture Product Calibration and Validation

Goal

The goal briefly describes what the user intends to achieve with this use case.

To provide accurate and cost-effective means of validating and calibrating satellite-derived soil moisture products through smart in-situ sensing

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

This use case enables a guided/adaptive sampling strategy for a soil moisture sparse in-situ sensor network to meet the measurement validation objectives of the spaceborne radar and radiometer on SMAP with respect to resolution and accuracy. The sensor nodes are guided to perform as a macro-instrument measuring processes at the scale of the satellite footprint, hence meeting the requirements for the difficult problem of validation of satellite measurements. SMAP allows global mapping but with coarse footprints. The total variability in soil-moisture fields comes from variability in processes on various scales. Installing an in-situ network to sample the field for all ranges of variability is impractical. However, a sparser but smarter network can provide the validation estimates by operating in a guided fashion with guidance from its own sparse measurements. A control system is developed and built to command the sensors to turn on at optimal times and locations. The feedback and control take place in the context of a dynamic data assimilation system, and enable a cost-effective and accurate means of accomplishing the validation task. This validation paradigm differs from the traditional one in that the in-situ sensor web optimizes its operation by turning on only a subset of the sensors and only when needed to minimize resource usage while maximizing the accuracy of validation data, as opposed to performing measurements round-the-clock, and over a dense grid.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors: (for a particular use case only)

i) A hydrologist needing to validate large-footprint soil moisture estimates from SMAP in {Fraser Experimental Forest, near Winter Park,} Colorado
ii) weather/met stations providing input data to the system: wind speed & direction, temperature & humidity, rainfall (summer only), snow depth (winter only), and net radiation
iii) physics-based model (Soil-Water-Atmosphere-Plant, SWAP, developed in the Netherlands)

Secondary actors:

i) sensor web in-situ nodes: moisture probes, tower-based radar
ii) satellite instrument engineers at JPL, to fix and maintain their instrument on queue from sensor web that there might be satellite instrument malfunction

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

i) SMAP radar and radiometer on-orbit and operational
ii) Dynamic time evolution model SWAP (or HYDRUS) configured for specific locations of sensor nodes; physical model of spatial correlation of soil moisture field across landscape
iii) Initial state of sensor web:
    1. Initial measurements of soil moisture
    2. Baseline environmental parameters: topography, soil type, vegetation cover
    3. Knowledge of available power (e.g., battery life and usage "cost" of each sensor node

type)

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

This use case will run continuously once initially started. However, it may be re-set and re-started under the following conditions:

i. weather event resulting in new initial conditions (precipitation, fast change in temperature, solar radiation, wind)
ii. any of the above events, severe enough to cause change in landscape (e.g, heavy wind storm or ice storm resulting in felled trees)
iii. human-caused change (cutting trees down by locals w/o knowledge/permission of sensor web scientist – note: this actually happened to one of our MOSS forest sites in Oregon)

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) 2-3 dozen soil moisture probe sensors are in place; each takes measurement of soil moisture at the point scale but at multiple depths; one or two tower-mounted radars will be added to the mix for a larger footprint (but still very small compared to satellite foot-print); each sensor transmits data to coordinator, located at an enclosed hut with power; SWAP or HYDRUS model for temporal soil moisture dynamics at each node is available; met data are recorded and available at each node.
2) Coordinator uses the state of sensor web at current time together with the SWAP soil moisture time evolution model, plus physical model of spatial correlation of soil moisture field across landscape, to determine whether each node needs to perform a measurement at the next time step, or whether it is sufficient to estimate the soil moisture at the next time step by running the model and obtaining a numerical estimate of soil moisture instead.
3) An optimization problem is solved that minimizes the measurement costs, as measured jointly by sensor node power usage and distortion (i.e., error in next state's estimate if no measurement is taken and the SWAP/HYDRUS model is used instead)
4) Results of analysis will be that some sensors are commanded to turn on and measure at the next time step, and some to stand by and wait.
5) The output of the system at any given time is the optimum set of in-situ measurements of soil moisture at point (probe) or synoptic (tower radar) scales, which are then combined statistically to provide a validation/calibration data set for satellite-based estimates of soil moisture at the footprint scale of satellite.

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

1) 2-3 dozen soil moisture probe sensors are in place; each is supposed to take measurement of soil moisture at the point scale but at multiple depths; one or two tower-mounted radars will be added to the mix for a larger footprint (but still very small compared to satellite foot-print); each sensor transmits data to coordinator, located at an enclosed mountain hut with power; SWAP/HYDRUS model for temporal soil moisture dynamics at each node is available; met data are recorded and available at each node.
2) Coordinator realizes that 2/3 of the sensors are malfunctioning or otherwise have not provided their measurements, perhaps due to faulty communication links. Coordinator therefore needs to switch to a different mode of analysis and optimization that relies on only 10 sensors. It will decide to make up for lack of spatial diversity by increasing the temporal density of the working sensors.
3) An optimization problem is solved that minimizes the measurement costs, as measured by sensor node power usage and distortion (i.e., error in next state's estimate if no measurement is taken and the SWAP/HYDRUS model is used instead)

4) Results of analysis will be that some sensors are commanded to turn on and measure at the next time step, and some to stand by and wait.
5) The output of the system at any given time is the optimum sets of in-situ measurements of soil moisture at point (probe) or synoptic (tower radar) scales, which can be combined as statistically appropriate to provide a validation/calibration data set for satellite-based estimates of same.
6) Future versions of this sensor web may include mobile sensors, which can relocate to optimize the spatial coverage given that now a smaller number of sensors are available.

Post Conditions

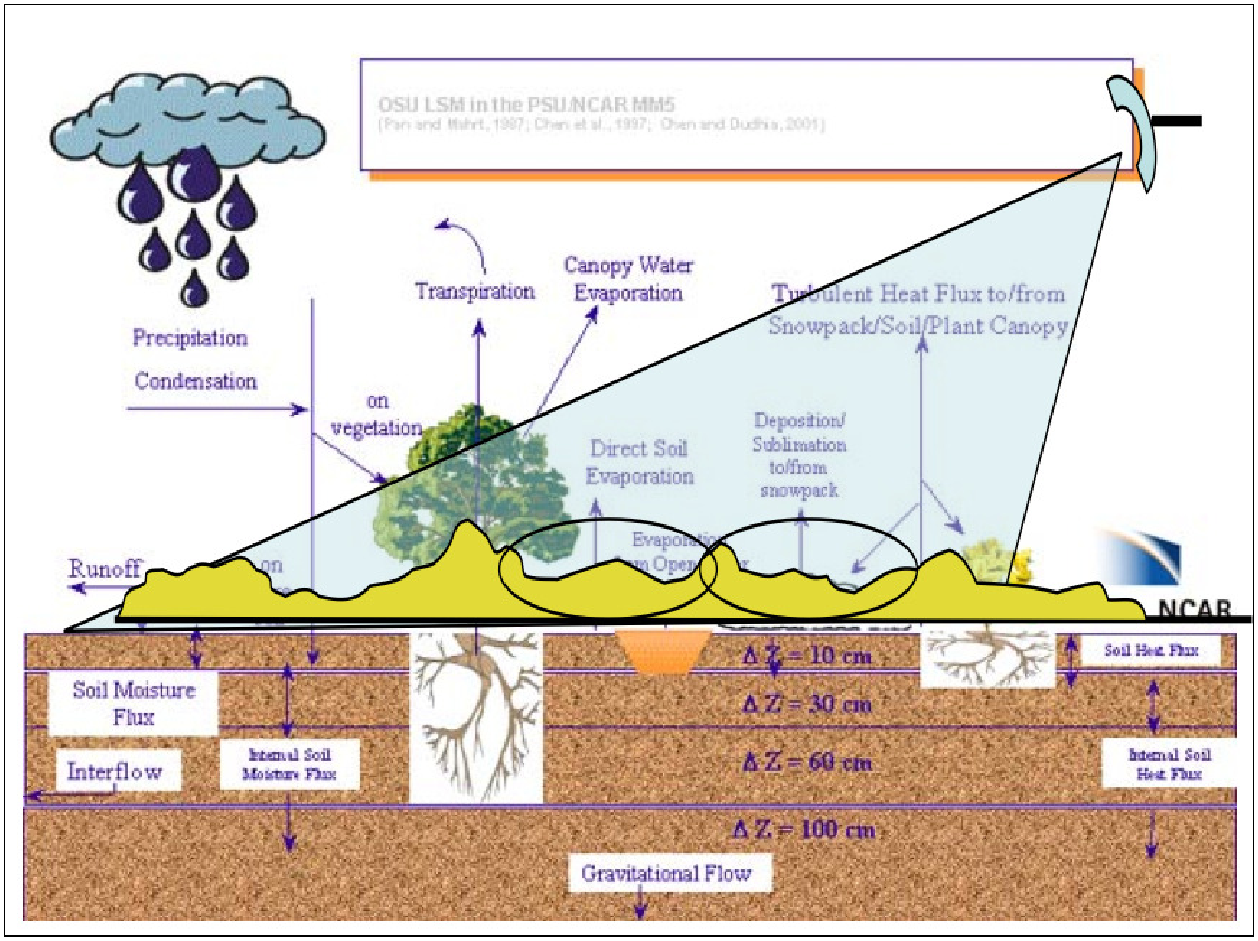
Here we give any conditions that will be true of the state of the system after the use case has been completed.

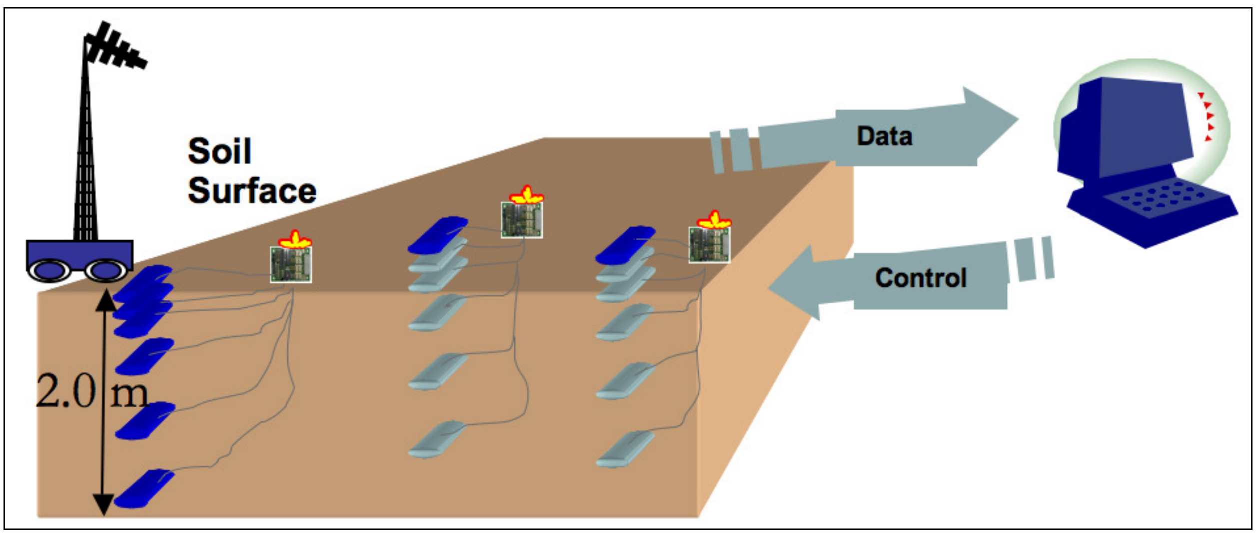
This semi-closed-loop system could run indefinitely, and will provide a running estimate of soil moisture for "all" times (discrete time steps) at spatial scales of interest from a combination of actual measurements and model estimates. After each cycle of the control system operation is complete, the sensors have either performed a measurement or are in stand-by mode. Either way, ***the sensors will be given a set of commands by the coordinator at the next time step***. At the conclusion of every command cycle, the sensor web has produced the most economical, accurate, and ***representative set of in-situ samples that will produce the mean value of the soil moisture field for validation of satellite-derived estimate of soil moisture***.

The total available power to the system uniformly decreases with each command cycle until replenished at predetermined time intervals. This changes the cost-defining strategy at different times.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.





Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

As a follow-on to the current use-case scenario, the SMAP satellite will be a part of this sensor web: SMAP instruments can be invoked by sensor web to change acquisition mode in response to sensed external event such as storms or heat waves, or they could be commanded to turn off if no change has

been predicted on the ground.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
Soils map	Field measured database	Goereferenced, <50m resolution	Soil types at multiple depths, available for US. May need similar information at other locations worldwide	USGS	Web-based GIS database
Vegetation map	Remote sensing (e.g., MODIS, Landsat)	Georectified, <50m resolution	Landcover maps from various satellite sensors	NASA	Multiple web based portals
DEM	Remote sensing (SRTM)	Georectified, <50m resolution	Terrain topography	NASA	JPL web based portal (?)
Metereology	Remote sensing (e.g., TRMM, Cloudsat) and in-situ (local met stations)	Georectified/georeferenced 15-minute coverage for met stations	Frequent data on cloud cover, precipitation, solar radiation, temperature, wind	NASA, local stations	Multiple web based portals for NASA remote sensing data; local comm. Link from met stations

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
Soil-Water-Atmosphere-Plant (SWAP)	Wageningen University, The Netherlands	1D soil moisture time evolution model given environmental forcings and landscape parameters	Information on landscape (soil type, vegetation cover) and metereology	Can run on any time scale (minutes, hours, days, etc.)	Source code available on web
HYDRUS	USDA	1D water flow simulator, single-species solute	Information on landscape (soil type, vegetation cover) and metereology	Can run on any time scale (minutes,	USDA soil salinity lab

		transport, and heat movement, in variably-saturated porous media		hours, days, etc.)	

Event Notification Services

Event	Owner	Description	Subscription	Source System
Severe storms	NOAA	Unusually severs storms that cause sudden change to landscape		
Land-use or land-cover change	Local	Local observers to report any unexpected change in land use or land cover, such as cutting large parches of trees		

Application Services

Application	Owner	Description	Source System

Sensor resources

Sensor	Owner	Description	Frequency	Source System
SMAP	NASA	Soil Moisture Active Passive radar and radiometer instruments	3 days	SMAP
Fraser National Park sensor suite	George Mason University	Grid of 3 dozen sensor sets, 3 levels of soil moisture (5, 20, 50cm), wind speed & direction, temperature & humidity, rainfall (summer only), snow depth (winter only), and net radiation	Controllable	Colorado Sensor Web operated by Paul Houser
Tower radar	U of Michigan	Tower-based multifrequency radar with 50-m foot print and capability of estimating surface to depth soil moisture profiles	Any interval	MOSS tower radar

11.4.7 Wildfire Sensor Web

Point of Contact Name: Dan Mandl

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- x Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- x NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- x Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- x Earth Science Apps & Societal Benefits
- x Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- x Targeted observations
- x Incorporate feedback
- x Ready access to data
- ☐ Improved use/reuse
- x Rapid response
- ☐ Improve cost effectiveness
- ☐ Improve data quality/science value
- ☐ New ___________________

AIST Needs Category

- x 1-Data Collection
- x 2-Transmission & Dissem.
- x 3-Data & Info Production
- x 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- x A-Increase science data value thru autonomous use
- x B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- x D-Improve access, storage, delivery
- x E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation
- ☐ New ___________________

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Tracking wildfires and dissemination of key data

Goal

The goal briefly describes what the user intends to achieve with this use case.

The goal of this use case is to provide users easy and rapid access of available sensors that can provide emergency workers customized science data products to help manage wildfires and provide situational awareness. Historically, it has been difficult and tedious to coordinate an ad hoc set of sensors to image fires in a timely manner. The goal of this sensor web effort is to provide a standardized, efficient interface that will allow sensors to publish their data onto the Internet, and then allow users to subscribe to automatic delivery of customized data products.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

In recent years, fire emergency worker and researchers have sought imagery and data products from wildfires. The Forest service has manually tasked and integrated multiple satellite and air sensors and their data to achieve better situational awareness of fires. Also, researchers have used that data to help better model fire fuel, fire weather and fire behaviour. Because the location of wildfires is not very predictable, matching the plethora of sensor capability that exists to the fires which occur worldwide has not been easy, especially in light of the fact that fires move. In this use case, space-based, air based and ground sensors are tasked, and customized data products are generated and returned. The Forest Service RSAC detects fires and uses MODIS direct download images to identify the fire location. This rough location is used to task EO-1 and Ikhana to acquire higher resolution multi-spectral images to further refine the fire location and extent.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Emergency fire workers.
Remote Sensing Applications Center (RSAC) – fire detection
EO-1 Hyperion sensor
Ikhana Multi-spectral wild fire sensor and IR nose camera
Fire fuel assessment model

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

1. Sensors, models and algorithms are available as OGC SWE web services including Sensor Planning Service (SPS), Sensor Observation Service (SOS) and Web Processing Service (WPS); services use RSS notification feeds
2. Users subscribe to received alerts when certain activities are complete, for example sensors tasked or desired products available using RSS
3. Forest Service RSAC is monitoring the globe for fire alerts
4. Recent MODIS data images for fire region are available
5. Ikhana flight plan is available

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

1. Remote Sensing Applications Center (RSAC) detects fire location which triggers request for higher resolution sensors in EO-1 Hyperion and Ikhana Unmanned Aerial System (UAS) multi-spectral imagers
2. Model analyzing Fire fuel and weather conditions indicate possibility of fires near populated areas (e.g.San Diego) triggers warning to Emergency Fire Workers in the field

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Forest Service Remote Sensing Applications Center (RSAC) detects wild fires in an area, using MODIS on Terra/Aqua as survey sensors. Quick processing of direct downlink MODIS data identifies location of fire (hot spots)
2) Hot spot locations are used to task EO-1 satellite (ALI sensor image) and Ikhana UAS aircraft for higher resolution fire data. EO-1 Geobliki and EPOS systems analyze fire location with respect to EO-1 orbit and Ikhana flight plan to match sensors with targets and automatically generate new EO-1 sensor commands and new Ikhana flight plan.
3) Products from EO-1 and Ikhana sensors are automatically processed onboard and delivered to EO-1 Geobliki where they are available for access via Google Earth by emergency workers.

UAS/Aster/EO-1 Sensor Web Fire Sensor Web Scenario for Aug 27, 2007 - Aug 30, 2007

1. Monday, August 27, 2007 Trigger ASTER image for Wed/Thurs of Castle Rock fire in Idaho if ASTER can see targets in that timeframe
2. Wed, August 29, 2007 morning(Pacific) Steve Wegener posts final UAS flight plan to Ames Collaborative Decision Environment (CDE) web page
3. Wed, August 29, 2007 morning (Pacific) EO-1 Geobliki (Cappelaere) and Draper (Kolitz) retrieve flight plan from CDE
4. Wed, August 29, 2007 morning (Pacific) Geobliki computes targets from MODIS fire hot pixel map via the WFS interface and sends targets to Draper (Kolitz)
5. Wed, August 29, 2007 afternoon (Pacific) Draper (Kolitz) sends revised UAS flight plan to Ames (S. Wegener) - note: Draper sends update cloud predicts to Ames every 6 hours
6. Wed, August 29, 2007 afternoon (Pacific) Draper send E-Mail to Geobliki with selected EO-1 target (screening for least cloudy) and occurring Wed night or Thurs morning
7. Wed, August 29, 2007 afternoon(Pacific) EO-1 Geobliki SPS tasks EO-1 and bumps previously planned image for new image requested
8. Wed, August 29, 2007 2:00 pm (Pacific) UAS takes off
9. Wed, August 29, 2007 evening (Pacific) UAS detects first fire on way to Idaho and then automatically posts (D. Sullivan) new target request for EO-1 via Geobliki SPS
10. Thursday, August 30, 2007 EO-1 images target before UAS lands if selected targets are viewable in that time period

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

Post Conditions

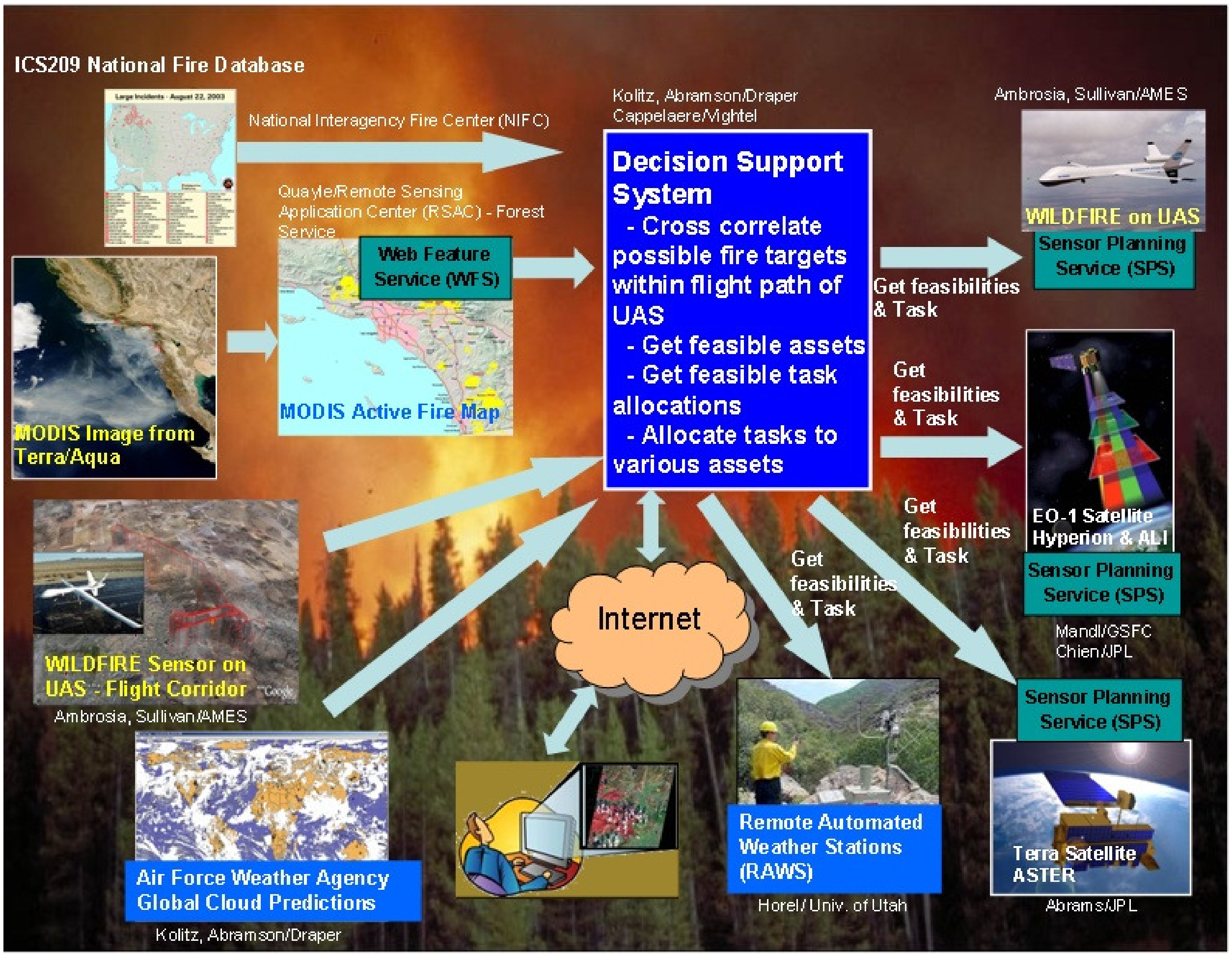
Here we give any conditions that will be true of the state of the system after the use case has been completed.

1. Fire data products are stored and accessible for visualization on Google Earth via kml files
- kml files link to actual data

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.

Specific scenario used August 27-30 2007 for early demo:



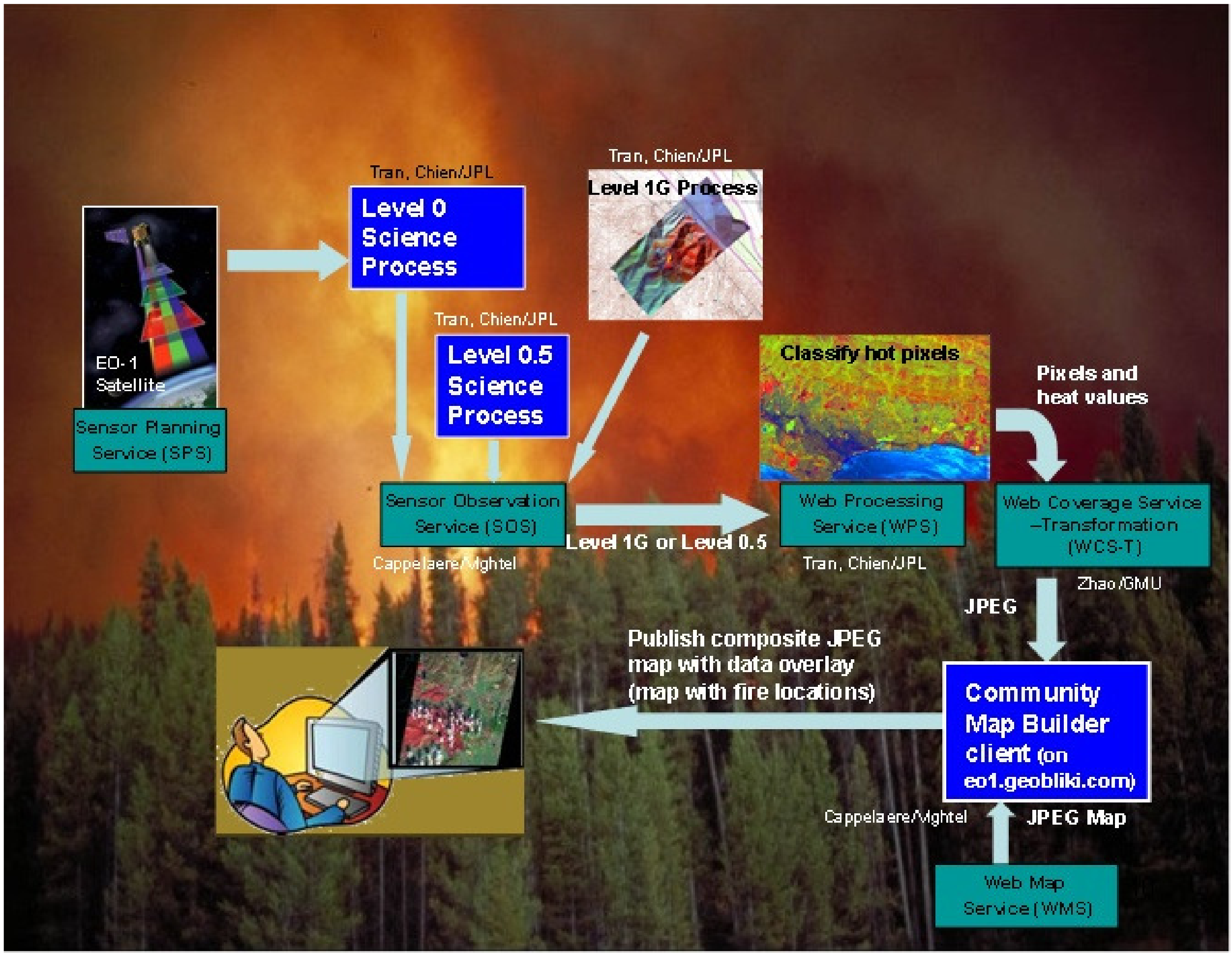


Figure 2 Subset of workflow for demo 1

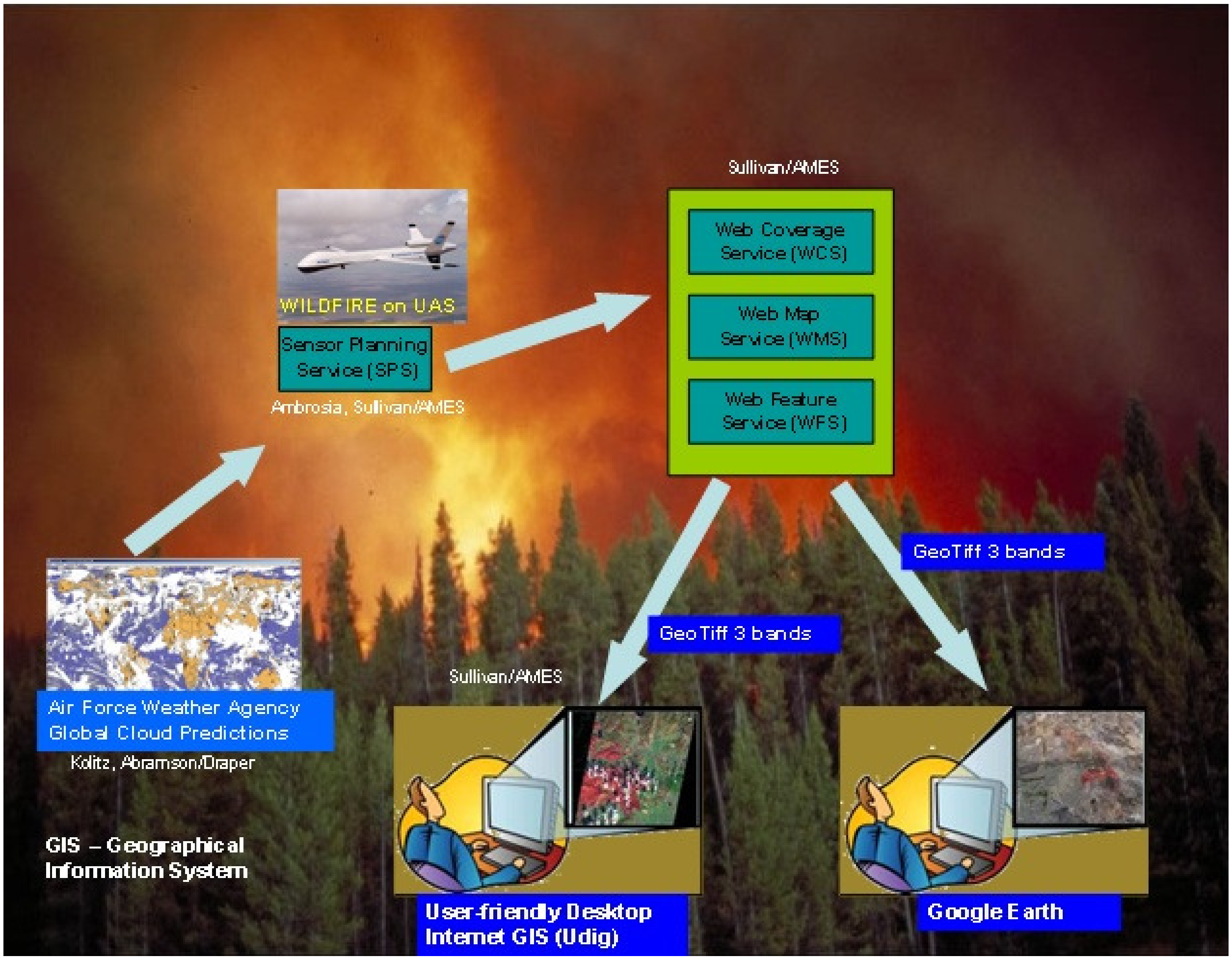


Figure 3 Subset of workflow for demo 1

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

11.5 Weather

11.5.1 Extreme Event Detection and Tracking for Targeted Observing

Point of Contact Name: John F Moses

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynl
- ☐ GACM
- ☒ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☒ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☒ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☒ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☒ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☒ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☒ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☒ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☒ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☒ Targeted observations
- ☒ Incorporate feedback
- ☒ Ready access to data
- ☐ Improved use/reuse
- ☐ Rapid response
- ☐ Improve cost effectiveness
- ☐ Improve data quality/science value
- ☐ New

AIST Needs Category

- ☐ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☐ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation
- ☐
- ☐ New

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Extreme Event Detection and Tracking for Targeted Observing

Goal

The goal briefly describes what the user intends to achieve with this use case.

Detect and track satellite-observed phenomena through time series of imagery from low earth orbit and geostationary instruments. Rank event impacts with respect to earth system models and provide high priority sets of targets. Determine where phenomena-related events differ from forecasts and where models would benefit from more frequent observations. Determine long term climatic trends and frequency of occurrence for improving forecasts and warnings.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

The objective is to construct Web-based service technology components that provide data from the GPM low earth orbit and GOES-R, PATH and GEO-CAPE geostationary instruments in time series on the same earth grid. The technology would provide for rapid integration of science algorithms that perform the detection and tracking of phenomena across instruments. Initial models focus on phenomena associated with severe convective storms.

Phenomena associated with severe storms are incorporated into a model that ranks importance of disparate hemispheric storm events for selection of rapid scanning a 1,000 km sector from geostationary orbit.

Physical phenomena models are encoded into detection algorithms which convert radiance images to prioritized lists of objects (e.g., ranked cloud top positions). Stochastic filters are employed to detect radiance structures visually associated with severe storms. Persistence is determined by tracking through times series of imagery.

Alternate science algorithms include detection and tracking comma-shaped wave clouds and radiance structures for the purpose of determining when numerical forecast models are lagging behind (or ahead) of observed atmospheric behavior. Algorithms for detection and tracking hurricane and tropical storm structures would be added to help determine the value and need for additional observations during development phases.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

1. Physical Scientist in charge of prioritizing satellite and in-situ observing assets.
2. Physical Scientist conducting research into climatic trends and frequency of events, detection of new observable phenomena, and regional/local storm modeling.
3. Citizen observations and response to increase risk of hazardous conditions.

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

1. Geostationary instruments can be tasked to collect 1,000 km high resolution imagery in 1-5 min intervals
2. Low earth orbit instrument maintenance and calibration activities (e.g., GPM) can be scheduled to avoid interfering with observing significant/sensitive environmental events and conditions. Steerable instruments (e.g., GEO-CAPE) can be tasked to point to target positions.
3. Forecast model of atmosphere and surface conditions available at synoptic times

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

Hemisphere or regional instrument radiance observation from geostationary or low earth orbit is complete.

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Map and combine multispectral images to achieve time series of continuous radiance fields on 1km equal area grid for hemisphere. Geostationary imagery is parallax corrected using a model grid of atmosphere temperature profiles.
2) Physical phenomena detection models and algorithms convert radiance images to time series lists of objects and attributes. The object lists are filtered for qualifying radiance structures based on instrument-unique criteria, temperatures, distance and shape criteria, and model atmosphere (e.g., for enhanced-V features associated with severe storms conditions). Objects detected with higher spatial/spectral resolution and better detection methods of the instruments in low earth orbit are associated with objects detected by geostationary instruments. Lifecycle of correlated events detected in low earth orbit are tracked using the more frequent geostationary observations. Future state and position of model radiance structures are forecasted based on distance and time criteria. Structures are clustered and ranked according to long term records of persistence, magnitude, shape, growth as they relate to storm events and environmental conditions. Select highest ranked targets for a rapid scan sector covering sensitive regions in storm-scale forecast models. Lastly, a feedback loop is established from research to operations, to incorporate long term changes and biases in the phenomena models and revise detection and tracking criteria.
3) Task geostationary 1,000 km rapid scan sector, reschedule low earth orbit platform maintenance and/or instrument calibration activities to achieve higher event coverage
4) Prepare storm scale cloud motion vectors for local numerical forecast models (e.g., Rapid Update Cycle forecast model)

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

1) Comma shape wave structures associated with cyclogenesis.
2) Hurricane and tropic storm structures

Post Conditions

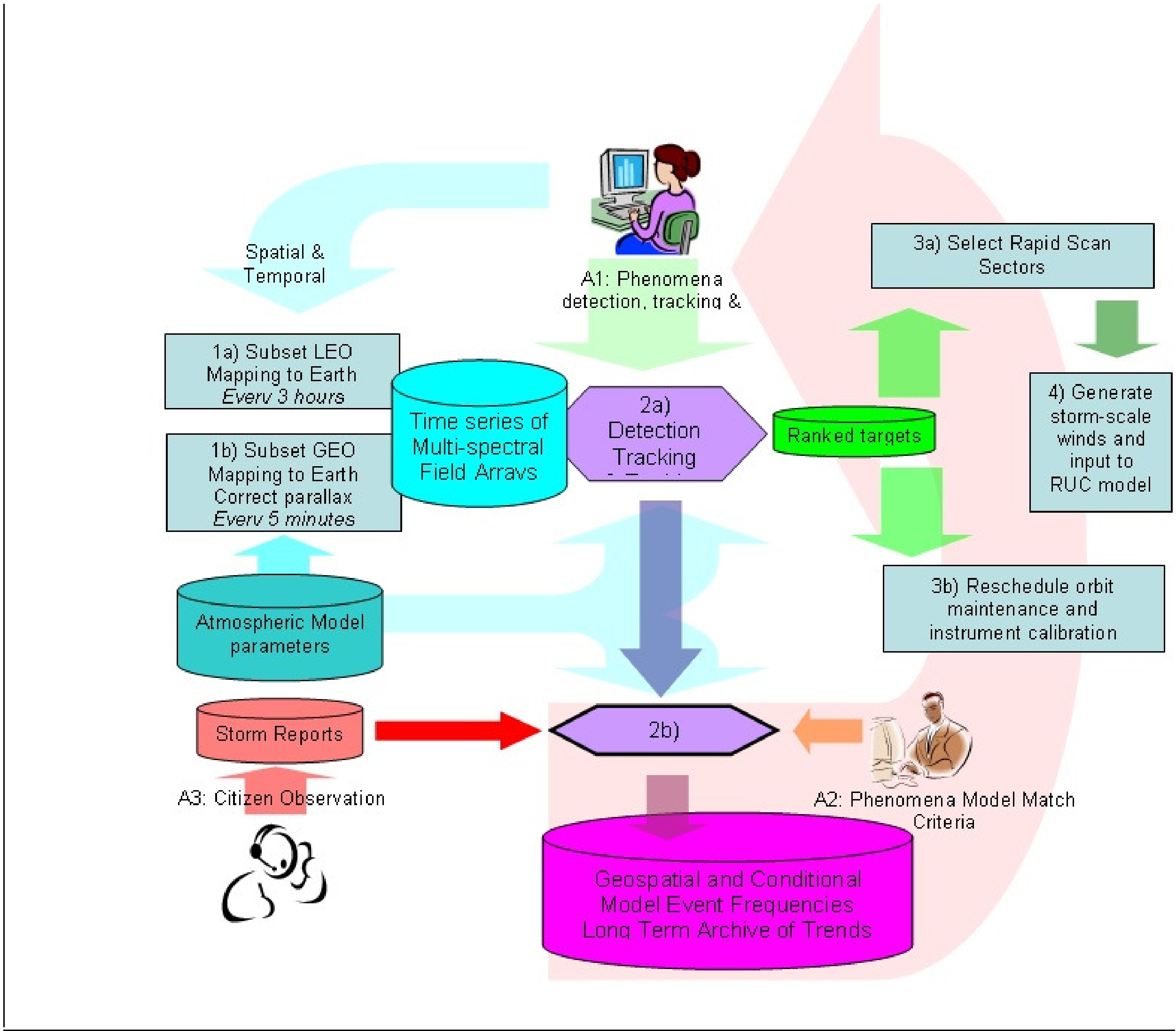
Here we give any conditions that will be true of the state of the system after the use case has been completed.

More accurate local forecast storm position and timing of hazards and risks.

Targets accepted for scheduling additional observations.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access
Severe	In-situ			SPC	SPC Web

storm reports					
Hurricane reports	In-situ			NHC	

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
RUC	NSSL	Rapid Update Cycle	Storm-scale winds	hourly	
WRF		Web portal			

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
Severe weather	NASA	Long term records of satellite phenomena identification and behavior, records of correlated storm reports	Atmosphere research (e.g., PATH, GEO-CAPE, GPM science teams)	
Severe weather	NOAA, NSSL	Likely high winds, hail, tornado	Near real time positions (Storm Prediction Center, NSSL)	NWS, AWIPS

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor
MODIS	NASA	Multispectral	6 hours	Terra, Aqua
Imager	NOAA	Multispectral	1 minute	GOES N/O/P

GPM	NASA	Passive Microwave	3 hours	GPM
GPM	NASA	Radar	12 hours	GPM
ABI	NOAA	Multispectral	1 minute	GOES-R
all-weather sensor suite	NASA	MW array spectrometer	15-30 minutes	PATH
Imaging spectrometer, Steerable event imaging	NASA	Hyperspectral, UV-visible-near-IR wide-area imaging spectrometer (7-km nadir pixel), steerable high-spatial-resolution (250 m) event-imaging spectrometer with a 300-km field of view, and an IR correlation radiometer for CO mapping over a field consistent with the wide-area spectrometer	1 hour	GEO-CAPE

11.5.2 Improved Storm/Weather Prediction based on Lightning Monitoring and Prediction

Point of Contact Name: Prasanta Bose

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☒ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☒ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO
- X GLM - new

Decadal Survey Category

- ☒ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☒ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☒ Targeted observations
- ☐ Incorporate feedback
- ☒ Ready access to data
- ☐ Improved use/reuse
- ☐ Rapid response
- ☒ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New______________________

AIST Needs Category

- ☒ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☒ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☒ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation

- ☐ New______________________________

<u>Use Case Name</u> *Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.* Improved Storm/Weather Prediction based on Lightning Monitoring and Prediction
<u>Goal</u> *The goal briefly describes what the user intends to achieve with this use case.* The goal is to predict, calibrate and adapt lightning events for use in coordinating the collection and analysis of cloud imagery (Cloudsat collector) to improve storm and weather predictions.
<u>Summary</u> *Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.* The use-case involves: i) monitoring and integrating distributed data sources for precipitable water vapor (PWV) and K index based on a lightning prediction model at locations across North America. Such monitoring and prediction is based on a lightning prediction index model developed by Professors. Robert Mazany, Steven Businger, William Roeder, and Seth Gutman. It is a weighted logistic regression based upon PWV, nine-hour change in PWV, and K index. When the index drops below 0.7 (it's range is 0 to 1), it is predicted that lightning will occur during the next 12 hours. ii) Compare predictions with actual lightning data to calibrate and adapt the model; iii) Exploit such lightning event predictions to coordinate collection and analysis of cloud imagery (Cloudsat collector) for prediction of storms. and detailed weather predictions. It is to be noted, that similar use-cases can be created for fire-predictions (where lightning prediction is coordinated with Land and vegetation imagery), Our primary data sources (distributed actors) are the SuomiNet resources for the PWV and a radiosonde archive run by the University of Wyoming for K Index. These sources have over 300 and 100 North American locations respectively, allowing for 35 prediction locations where stations are close enough for coordinated monitoring. Both data sources have publicly available (but substantially different) Web interfaces that are managed by VSICS services to archive their data and convert it to the common VSICS format for interoperability and coordination. Another VSICS service receives their data and computes the index, and a final service logs the index for each location and downloads satellite cloud images from GOES where lightning is predicted to coordinate focused analysis via semantic filtering. We are in the process of linking the use case to a new service that stores information on actual lightning strikes to calibrate and autonomously adapt the model for improved accuracy. Furthermore we plan to explore dependent use-cases that close the loop between the lightning-prediction and cloudsat (other related satellite systems) management services for scheduling collection of data leading to improved utilization of the collection resources.
<u>Actors</u> *List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.* Primary actor – **researchers/analysts** interested in cloud imagery associated with storms, who can use the VSICS middleware to semantically filter the large amount of GOES imagery and store only those images that provide basis for analysis of storms or prediction of storms and precipitation. Other actors are **service providers** for lightning prediction data sources, lightning model developers/providers who interact with the system to search for services, create workflows that integrate the services based on their models and register such abstract services. For closed-loop coordination, we consider **external resource management** actors that schedule and allocate sensor resources.
<u>Preconditions</u> *Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.* At least one service is available and updated regularly/promptly for both K index and PWV(almost always true, the SuomiNet and University of Wyoming services have been very reliable during our

testing). In order to observe images, thunderstorms or their precursor weather conditions must exist at least one prediction site.
The services are registered with service managers and provide their publish/subscribe interfaces

1) Upon startup, user inputs his task as an instance of the abstract model for the lightning index prediction represented as a publish/subscribe dependency structure
2) The user actor queries the PWV and K Index actors for their data ranges (times and locations)
3) These actors reply, and the lightning index actor computes prediction locations and time ranges matching the constraints of the task (they reply with metrics that score the quality of their services)

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

Predictions of lightning trigger image downloading tasks.

Basic Flow: Discover-Bind-Execute

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) The user-actor commits to selected services that best match his constraints
2) The data service actors (PWV and K Index actors) self-configure to respond to the subscriptions and periodically check for updates to their data
3) They publish the results that get forwarded to the Lightning index actor
4) Lightning index actor computes the index as data is returned, sending the index to the GOES actor.
5) GOES actor logs the index, and if it receives an index below the prediction threshold of .7 it begins a task to download the next 12 hours of satellite images at that location.
6) As the data services send the updated data over the course of execution (PWV is updated every hour, K Index every 12 hours) steps 6 and 7 are repeated.

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

Flexible Reconfiguration with a new service that optimizes the Task constraints

1) Another researcher publishes a new service that provides information for improved prediction of lightning strikes with better accuracy, and better reliability.
2) VSICS alerts user to this new service which can be incorporated into workflow and user agrees
3) Links are formed between the new lightning data service and the GOES actor so that image download tasks are also started where lightning is currently observed, allowing the addition of locations outside the limitations of the data services.

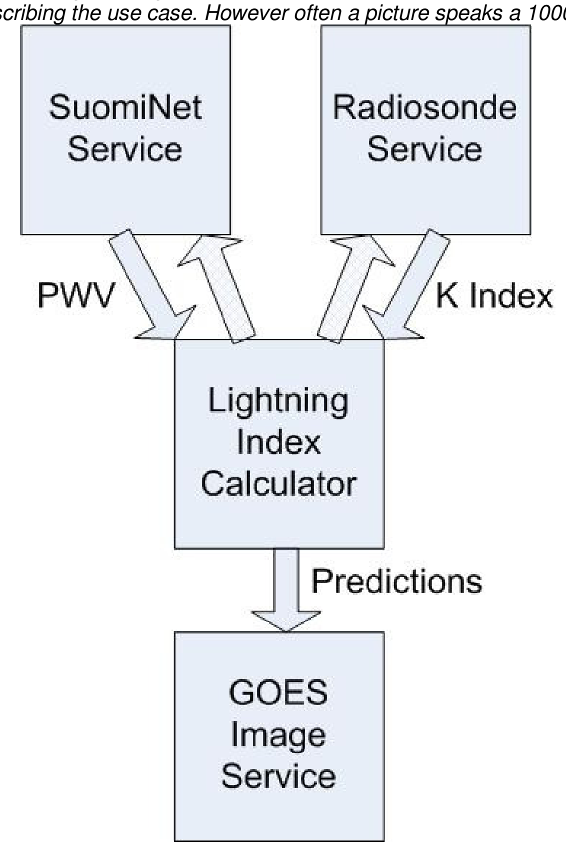
Recovery from Service Failure

1) Normal flow, up to at least the start of the steps 6-7 loop
2) The U. Wyoming K Index service becomes unavailable (the K Index service as that is the one we have an alternate for); either the service sends a message that it cannot continue or the lightning index actor deduces that fact via lack of communication from the data service
3) The VSICS middleware initiates the alternate K Index service (from Integrated Global Radiosonde Archive, IGRA) and reconfigures the communication links – the links to/from the failed service are removed and transferred to the new service.
4) The loop of steps 6-7 in the normal flow continues once the alternate service is added.

Reconfiguring to meet Quality of Service constraints in context of changing conditions

1) Normal flow up to steps 6 and 7
2) The U. Wyoming K Index service reports increasing latency due to overuse
3) Data coordinator initiates the alternate K Index service; unlike the service failure case the communication is maintained with the original service as well
4) Data coordinator uses the metadata from the two K Index services and continued load reports to

route requests; when a request occurs that either can satisfy it is sent to the less busy service.
Post Conditions *Here we give any conditions that will be true of the state of the system after the use case has been completed.* Lightning index will be logged for locations that the user specified and for the time range of execution (as long as data was available). For times/places with index below prediction threshold, the next ~10 hours of satellite imagery will be stored (it is programmed to get the next 12 but the lag between the real time and the time the updated data is available reduced that.)
Activity Diagram *Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.*



Notes *There is always some piece of information that is required that has no other place to go. This is the place for that information.*

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ,	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the	USGS, ESA, etc.	Name of the system which supports

	Etc.		usage characteristics		discovery and access
SuomiNet PWV	In situ		314 stations across N. America taking PWV measurements every ½ hour	UCAR	SuomiNet
U. Wyoming K Index	In situ		Global network of radiosonde stations making upper-atmospheric measurements every 12 hours.	Various	University of Wyoming (Alternate – Integrated Global Radiosonde Archive)
GOES Images	Satellite/ remote		Visible and IR images of North America showing cloud formations	Marshall Space Flight Center (NASA)	NASA Earth Science Office

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
Lightning Prediction Index	Lockheed Martin (see Summary for original authors)	Logistic regression that predicts lightning within 12 hrs.	PWV, 9 hour change in PWV, K Index	As often as updated data is available (currently every hour)	Lightning index actor (VSICS actor)

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
Lightning Strikes	www.guiweather.com	Google Earth kml file updated every 10 minutes of complete global lightning event list. We archive the North American coverage.		Google Earth

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor

11.5.3 Numerical Weather Prediction Doppler Wind Lidar

Point of Contact Name: Michael Seablom

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynl
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☒ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions
- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category
- ☐ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- ☐ Targeted observations
- ☐ Incorporate feedback
- ☐ Ready access to data
- ☐ Improved use/reuse
- ☐ Rapid response
- ☐ Improve cost effectiveness
- ☐ Improve data quality/science value
- ☐ New

AIST Needs Category
- ☒ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☐ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation
- ☐
- ☐ New

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Numerical Weather Prediction Doppler Wind Lidar

Goal

The goal briefly describes what the user intends to achieve with this use case.

Acquire high fidelity wind measurements to improve predictive skill in numerical model forecasts and conserve power and extend longevity of the instrument

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

A wind lidar is proposed with an inherent ability to perform adaptive targeted measurements. This use case focuses on the “model-driven” sensor web ops concept wherein an atmospheric model is used to identify candidate regions of interest where the lidar may be potentially commanded to make measurements within regions where they would either otherwise not be made or, would be made using the default “survey” instrument measurement modes (e.g., unchanging pulse rate or frequency, power level, on/off duration, etc.). For this use case, we made use of the proposed Global Wind Observing Sounder (GWOS) instrument, depicted in the figure provided in the "Triggers" section. In order to obtain complete vector wind components GWOS must sample an air parcel from at least two different perspectives. The instrument is comprised of multiple coherent and direct lidars that have the ability to operate through four telescopes. Two of the telescopes are oriented in a nominal ±45° azimuth pointing in front of the spacecraft, with the other two similarly oriented pointing aft. The combination of the fore and aft shots produces an estimated horizontal wind vector for multiple vertical levels. As currently designed the instrument can perform approximately 300 million shots in its lifetime with a pulse rates of 5Hz (coherent detection technique) and 100Hz (direct detection technique) respectively.

Using model-driven sensor web concepts we are proposing two sensor web scenarios that would modify the GWOS operations. Scenario (1) would minimize the required number of lidar shots without loss of information of the atmospheric state, and Scenario (2) would target data collection for specific regions of the atmosphere that would potentially have the greatest impact on forecast skill. For (1) GWOS would be provided the first guess wind field from a global forecast model. Observed line-of-sight (LOS) winds from the GWOS “fore shot” would be compared with the predicted winds from the model and valid at the time of the observation. If the winds were considered to be in adequate agreement the aft shot would not be performed. If such agreement were ubiquitous there could be a substantial reduction in the lidar’s duty cycle, potentially extending the life of the instrument. For (2) we would use estimates of the model’s forecast error to direct GWOS to target those regions of the atmosphere estimated to be in a state of low predictability, and/or target sensible weather features of interest. We assume to capture the maximum number of targets would require slewing of the spacecraft.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

GWOS - a Doppler Wind Lidar (DWL) mission comprising a hybrid sampling technology that takes advantage of both direct detection and coherent detection sampling methods. The mission objectives are to improve understanding and prediction of: (i) atmospheric dynamics and global atmospheric transport, and (ii) global cycling of energy, water, aerosols, and chemicals. The objectives will be achieved using space based lidar measurements of vertical profiles of the horizontal wind field (i.e., u,v components) to provide a complete global 3-D picture of the dynamical atmospheric state. A benefit of assimilating this 3D wind field will be a more accurate representation of the ICs for the numerical weather models. Salient characteristics are:

- Orbit geometry - circular, sun synchronous, 400km orbit, 97.03 degree inclination, 6:00AM/6:00PM local time for ascending/descending nodes, 15.5 orbits/day.

- Instruments - 4 telescopes (2 forward pointing, 2 aft pointing). Forward and aft elevation pointing angles are 45 degrees for each telescope. Telescope azimuth pointing angles (measured clockwise from spacecraft velocity vector) are: Forward Port (FP) = 311 degrees, Forward Starboard (FS) = 54 degrees, Aft Starboard (AS) = 131 degrees, Aft Port (AP) = 234 degrees.
- Direct detection laser subsystem has 100 HZ pulse repetition frequency (PRF)
- Coherent detection laser subsystem has a 5 HZ PRF
- Each telescope makes a line-of-sight (LOS) wind vector measurement during a 12-second dwell time at 45 atmospheric layers.
- Latency between the start of consecutive telescope measurements is 1.3 seconds.
- Telescope sequencing is: (1) FS, (2) FP, (3) AS, (4) AP
- Spacecraft has sufficient on-board storage to store GEOS-5 (see below) predicted LOS wind vector measurements, associated LOS positional data, and corresponding values for ε, the allowed difference between a predicted LOS measurement made by GEOS-5 and the actual LOS value as measured by GWOS.
- Attitude maneuvers - GWOS is assumed to be able to change its attitude (e.g., roll maneuver) to facilitate off-nadir telescope pointing/LOS measurements.

GEOS-5 - The Goddard Earth Observing System Model, Version 5 (GEOS-5) Data Analysis System (DAS) integrates the GEOS-5 Advanced Global Circulation Model (AGCM) with the Gridpoint Statistical Interpolation (GSI) atmospheric analysis package. Data generated by the GEOS-5 model will be used to generate predicted Line-of-sight (LOS) wind vectors for each cell of a global, uniformly spaced gridded field (e.g., an equirectangular world map projection). A 0.25 degree (north-south direction) by 0.3333 degree (East-West direction) grid is presently used. Predicted LOS wind vectors measurements for 45 atmospheric layers are generated.

Communications architecture - a wideband network that facilitates uploading very large (estimate provided below) volumes of GEOS-5 generated predicted LOS wind vectors to GWOS. Communications architecture components consist of:

- Globally distributed terrestrial-based links (e.g., fiber optic)
- A space-ground communications infrastructure (e.g., global network of TT&C stations; TDRS Single Access S-band or Ka-band capable ground stations) that supports, as a minimum, a 1Mbps forward link capacity.
- A space network that utilized wideband optical crosslinks (e.g., comms satellite-to-GWOS optical links).

Three communications architectures classes must be analyzed for their potential to support GWOS use case uplink performance requirements. For each class, one or more implementation alternatives have been characterized. Note that for TDRS-based architectures, we have assumed use of the capabilities and capacities of only the newer TDRS-H, -I, -J replenishment series.

- Non-TDRS Architectures (present day to 2030)
- S-band forward link using one ground station at Fairbanks, AK
- S-band forward link using three ground stations at Fairbanks, Svalbaard, and McMurdo
- S-band forward link using modified NPOESS SafetyNet ground stations
- Ka-band forward link using modified NPOESS SafetyNet ground stations
- TDRS H-J based Architectures (present day to 2030)
- S-band forward link
- Ka-band forward link
- Future hybrid optical/RF Architecture (>2030)
- Use of RF forward/return links and optical cross links

These architectural alternatives will serve as the basis for developing STK scenarios to quantify

GWOS uplink contact time and duration for each alternative. The analysis will determine whether the required uplink data volumes can be accommodated within the required use case scenario timeframes.

0We have identified five candidate forward link TDRS-based communications architectures that must be analyzed to assess viability in the GWOS use case scenario:

- S-band single access (SA) at 300 Kbps (PSK modulation)
- S-band single access (SA) at 1 Mbps (QPSK modulation)
- S-band single access (SA) at 7 Mbps (BPSK spread spectrum modulation)
- Ka-band single access (SA) at 7 Mbps
- Ka-band single access (SA) at 25 Mbps

Assuming 7 Bytes are required to represent each LOS value, then approximately 244.9MB and 2.04GB respectively are required to represent the LOS values for a global gridded field at 45 layers/cell at a nominal 0.25 degree and 0.1 degree gridded field cell resolution. This first order analysis assumes that the same value for ε is used to compare predicted versus measured LOS values. If it is determined that a unique value for ε must be assigned to each predicted LOS value, and assuming 1 byte is required to represent a value for ε, then the total daily data volumes increase to approximately 280MB and 2.3GB respectively.

In order to transmit a sizable amount of data (> 50Mbytes) within a reasonably short period of time (e.g., ~10 minutes), an uplink transmission rate in excess of 2 Mbps will be required. An uplink data rate of 4 Mbps or greater is desired to stay well within a 10 minute or some other otherwise relatively brief ground station contact time.

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

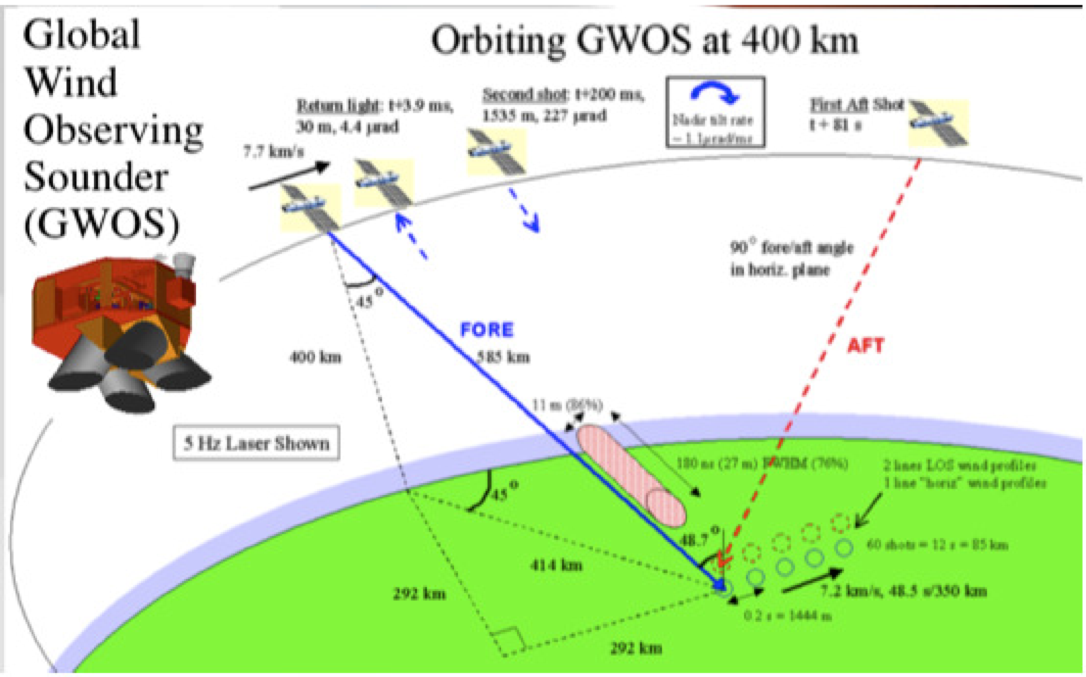
The following information must be generated by GEOS-5 and uploaded to GWOS prior to the point in time when the corresponding actual lidar measurements will be made through the spacecraft telescopes.

- Predicted LOS wind vectors.
- Corresponding predicted LOS measurement positional information (i.e., an agreed upon spatio-temporal coordinate system).
- Corresponding predicted values for "epsilon" (possibly 1:1 value for each predicted LOS measurement).
- All required communications infrastructure elements must be available and capable of providing sufficient uplink bandwidth to support forward links to GWOS (i.e., to uplink required GEOS-5 predicted LOS values).
- Knowledge of the GWOS orbit and attitude
- Knowledge of any required attitude maneuver set-up and settling times to facilitate off-nadir telescope targeting.
- Coordinates of all meteorological targets of interest.

The operations concept for uploading predicted LOS measurements and concomitant preconditions will vary. Not all of the gridded field data must be uplinked to the GWOS spacecraft. For example, if we assume the LOS wind values for the entire global gridded field are updated every 6 hours, the GWOS spacecraft will have completed just under 4 orbits (3.89 orbits) of the earth during that time interval. The amount of GEOS-5 model predicted LOS wind data uplinked to GWOS can potentially be substantially reduced since only those values for a 6 hour GWOS orbital observation period (i.e., 4 orbits) will be required to be stored on-board the spacecraft to compare the predicted forward shot LOS measurements with the GWOS forward-shot-derived LOS wind vector values. As first order magnitude estimate, the data volume that must be uploaded to cover a 6-hour period is one-fourth of the 244.9 MB or about 61MB. The characteristics of the uploaded predicted LOS data is amenable to the application of lossless data compression techniques. A conservative 2:1 lossless compression ratio could potentially further reduce the uplink data volume needed for four consecutive GWOS orbits to about 30 MB.

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.



Feature - Description	Threshold	Ranking
Tropical Cyclones	All discernable	1
Extratropical Cyclones	< 980 hPa	2
Thermal Advection Centers	> 0.25 K/hr at 850hPa	3
Jet Streaks	> 50 m/s above 500hPa; > 35 m/s below 500 hPa	4
Deepening Centers	> 0.5 hPa/hr	5

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

Scenario (1): Power Modulation

1. Operational data assimilation system completes cycle. Model first-guess field is generated. First-guess line-of-sight winds are generated in a spatial and temporal coordinate system that is consistent with the GWOS field of view.
2. The wind fields for a full orbit are uplinked to the spacecraft using one or a combination of the following communications systems:
    - Next generation TDRS
    - "Safety Net" (multiple worldwide ground stations)
    - High latitude TT&C (telemetry, tracking, and communications) terminals
    - Space network optical cross links (e.g., between GWOS and a GEO communications satellite constellation)
3. Acquire forward shots and compare with model first guess line-of-sight winds.
4. If the difference between the fore shot and the model first guess is less than ε, do not schedule

the aft shot. Otherwise, schedule the aft shot.

5. Repeat the process.

Scenario (2): Adaptive Targeting

1. Operational data assimilation system completes cycle. Model first-guess field is generated.
2. Targets are identified by a combination of the following:
    - Ensemble forecasts or adjoint techniques are used to identify "sensitive regions" in the flow;
    - Significant weather phenomena are identified using pattern-recognition techniques;
    - Anomalous patterns identified using corroborating measurements from multiple platforms;
    - Large innovation values are identified;
    - Cloud-free lines of sight are determined;
3. Targets selected via multi-layer hierarchical rule-set with operational override, significance assigned based upon societal/scientific impact, magnitude of uncertainty, coincidence with other platforms.
4. Determine observing method.
5. Telescopes pointing along both sides of nadir (symmetric) or telescopes pointing to one side of nadir (asymmetric) -- based upon availability of clear sky and presence of targets:
    - Standard line-of-sight vs. unique wind measurements;
    - Power and/or frequency modulation;
    - Slewing;
6. Command & control system receives lists of targets and manages all observing system assets.
7. Lidar wind measurements are assigned observation errors and passed to the quality control and to the data assimilation system.
8. Lather, rinse, repeat.

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

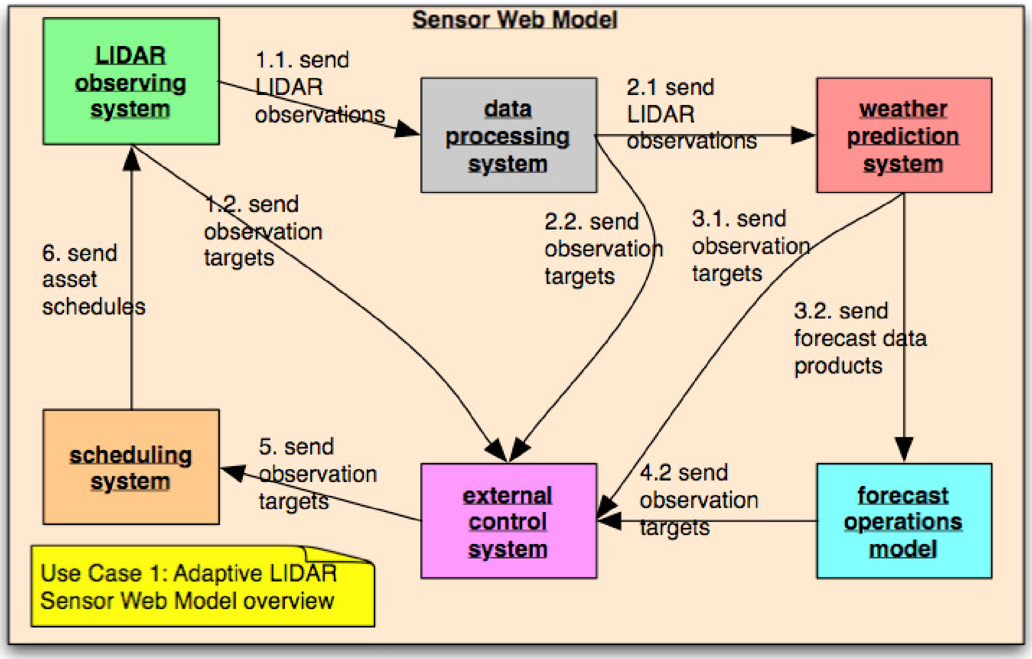
Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

Not applicable - "Basic flow" of the two scenarios as presented is continuous.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

In the case of multiple lidar systems the biases and errors of representativeness must be taken into account. This is an important cross-cutting theme for the sensor web concept in which multiple instruments and models are performing in concert.

As data is the key product of each mission, issues relating to data bias and validation are universally applicable. Fusing data from multiple sensors that are biased relative to each other is a serious issue. Therefore, if each sensor makes its data available as a service, intelligent agents can use directory services to identify all available contemporary data to assist in validation. The intelligent agents could then retrieve the data and use it to form sensor cross-calibrations and inter-instrument bias estimates. Work done under current ESTO grants demonstrates this utility and infusion to the decadal survey missions would have considerable utility. This is particularly true when we remember that several decadal survey missions are relevant to issues where long-term time continuity are an issue, for example, climate change. Typically the long-term record will involve data from multiple instruments each with its own time window of observation. The data from the different time windows can often have significant biases relative to each other. As we are also dealing with potentially large data volumes, possible automation of this task is most desirable.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System

(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access
GEOS-5 derived predicted LOS wind vectors		e.g., – no cloud cover	See Actors Section for description	NASA/GSFC	

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
GEOS-5	NASA/GSFC	The Goddard Earth Observing System Model, Version 5 (GEOS-5) Data Analysis System (DAS) integrates the GEOS-5 Advanced Global Circulation Model (AGCM) with the Gridpoint Statistical Interpolation (GSI) atmospheric analysis package. Data generated by the GEOS-5 model will be used to generate predicted Line-of-sight (LOS) wind vectors for each cell of a global, uniformly spaced gridded field (e.g., an	List of data consumed	Every 6 hours (today). In the future, every 3 hours.	Name of the system which offers access to the model

		equirectangular world map projection).			

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor

11.5.4 Smart Assimilation of Satellite Data into a Weather Forecast Model

Point of Contact Name: Michael Goodman

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynl
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☒ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☒ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☒ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☒ Targeted observations
- ☐ Incorporate feedback
- ☐ Ready access to data
- ☒ Improved use/reuse
- ☐ Rapid response
- ☒ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New

AIST Needs Category

- ☐ 1-Data Collection
- ☒ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☐ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☒ F-Decrease mission risk/cost thru autonomy/automation
- ☐
- ☐ New

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Smart Assimilation of Satellite Data into a Weather Forecast Model

Goal

The goal briefly describes what the user intends to achieve with this use case.

Improve assimilation process of satellite data into numerical models. Because assimilation of these large datasets is computationally expensive, we use intelligent processes to determine when interesting weather phenomena are expected, where assimilating satellite observations can improve forecast accuracy. Use community standard protocols for data access and alerts.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

The integration of EOS satellite data from multiple platforms into forecast models is a critical component of NASA's Weather focus area. The complexity lies in the need to integrate large data volumes from sensors on the different platforms with different observational constraints and data formats into a common processing system. This use case identifies these limitations by implementing a SWE-based architecture to autonomously select the optimal observations for assimilation.

The Atmospheric Infrared Sounder (AIRS) creates 3-dimensional maps of air and surface temperature, water vapor, and cloud properties. With 2378 spectral channels, AIRS has a spectral resolution more than 100 times greater than previous IR sounders and provides more accurate information on the vertical profiles of atmospheric temperature and moisture. The AIRS retrieval algorithms provide vertical profiles of temperature and moisture at a 50 km horizontal spacing over a narrow swath. These data provide asynoptic observations to complement the standard radiosonde observing network. The profiles are most accurate in clear and partly cloudy regions and the quality of the AIRS retrieval is determined in real time and transmitted to the user. Note that the future PATH satellite will provide similar data.

AIRS data can provide a key input into the regional data assimilation procedures used to produce short-term regional weather forecasts with the Weather Research & Forecasting (WRF) model. However, the decision on when to include the data and where spatially it will have the most effect for the day-to-day weather conditions over the United States is not trivial. ***Routine daily assimilation is not performed because of the limited availability of resources and the operational requirement of the National Weather Service for improved forecasts of high impact events***. Forecast improvements in low-impact weather systems may not be an effective use of resources, whereas appropriate data assimilation in evolving weather situations or with tropical systems such as hurricanes is likely a more effective use of computer time and associated manpower because of its impact - a direct affect on loss of property and lives. The effective inclusion of AIRS data into regional forecast models could be made possible through autonomous processing of model data fields, Aqua satellite orbit predictions, AIRS instrument data, and required ancillary information through sensor web capabilities and services. ***Currently, modelers make judgements about when and where to assimilate satellite data after manual examination of near-term forecasts.***

Often, a North American Mesoscale (NAM) forecast is used as the initial conditions for a regional WRF model run. The addition of current weather observations (such as those from AIRS) can improve the accuracy of a WRF forecast, but assimilating voluminous satellite observations into the initial conditions is computationally expensive. The smart assimilation workflow involves mining NAM forecasts for interesting weather phenomena, then determining whether AIRS observations are coincident with the detected weather events. The assumption is that assimilating AIRS observations of anomalous weather conditions will improve the forecast.

The use case begins with a forecast from the North American Mesoscale (NAM) model which provides a baseline first guess field for initializing the WRF model. The NAM model is run independent of the AIRS data assimilation system. The NAM forecast is mined for an interesting weather event (e.g., developing low pressure system, frontal system, vorticity maxima) within a selected region of interest using the Phenomena Extraction Algorithm. If a weather event of interest is detected an alert is issued identifying the event, date/time and location. A search is then initiated for coincident AIRS data within the region of interest and time threshold. If a coincident AIRS overpass is confirmed, then the AIRS data are obtained. The AIRS vertical profile data are pre-processed and reformatted for inclusion into the ARPS Data Assimilation System (ADAS). The assimilated data field is then made available as the initial condition field for the WRF model run. An alert is broadcast to WRF model users of the availability of the improved initial field for a WRF run.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary

- Polling process – determine when NAM forecast is available to kick off mining process
- Satellite coincidence process – determine if AIRS data is/will be coincident with identified event
- Assimilation preparation – retrieve AIRS data and preprocess in response to alert
- Assimilation system (e.g., ADAS) - create initial conditions for WRF, assimilating AIRS data when made available to provide improved initial conditions

Secondary

- Mining process – publishes alert when event identified
- Alert service – broadcast alerts when event identified and when satellite data coincident with event
- Notification service – broadcast availability of improved WRF initial conditions with assimilated AIRS data

Data Sources

- NAM model output – CONUS forecasts mined for weather events
- AIRS observations – assimilated if coincident with identified weather events

Models

- North American Mesoscale (NAM) – CONUS model run operationally by NOAA NCEP and used to establish initial conditions for regional forecast models
- Regional forecast models (e.g., WRF) – analyses containing assimilated AIRS data are prepared for initialization of regional models

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

Current North American Mesoscale (NAM) model forecast available

Current AIRS data vertical profile retrievals

Data assimilation system (e.g., ADAS) ready to run

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

Availability of a new NAM forecast (nominally every 6 hours) triggers the Event Identification process, which mines NAM data for weather events of interest

Event Alert triggers query of satellite footprint SOS for coincident AIRS overpasses.

Event–AIRS Intersection Alert when AIRS data is coincident with weather phenomena of interest triggers AIRS data assimilation process.

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the *use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)*

1) Acquire new NAM forecast
2) Mine NAM forecast for weather event(s)
3) Publish “Event” Alert(s) including (event type, time, bounding box)
4) Query satellite footprint SOS for coincident AIRS overpasses
5) Publish “Event-AIRS Intersection Alert” (event type, time, bounding box, AIRS observation footprint, AIRS observation time window)
6) Acquire specified AIRS observation(s)
7) Preprocess and reformat AIRS data
8) Provide preprocessed AIRS data to Assimilation System
9) Generate analysis containing assimilated AIRS data for initialization of regional WRF models
10) Broadcast “Analysis Available” alert to interested WRF model teams

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

1) If no AIRS intersection with identified event, stop (Do not assimilate AIRS data)

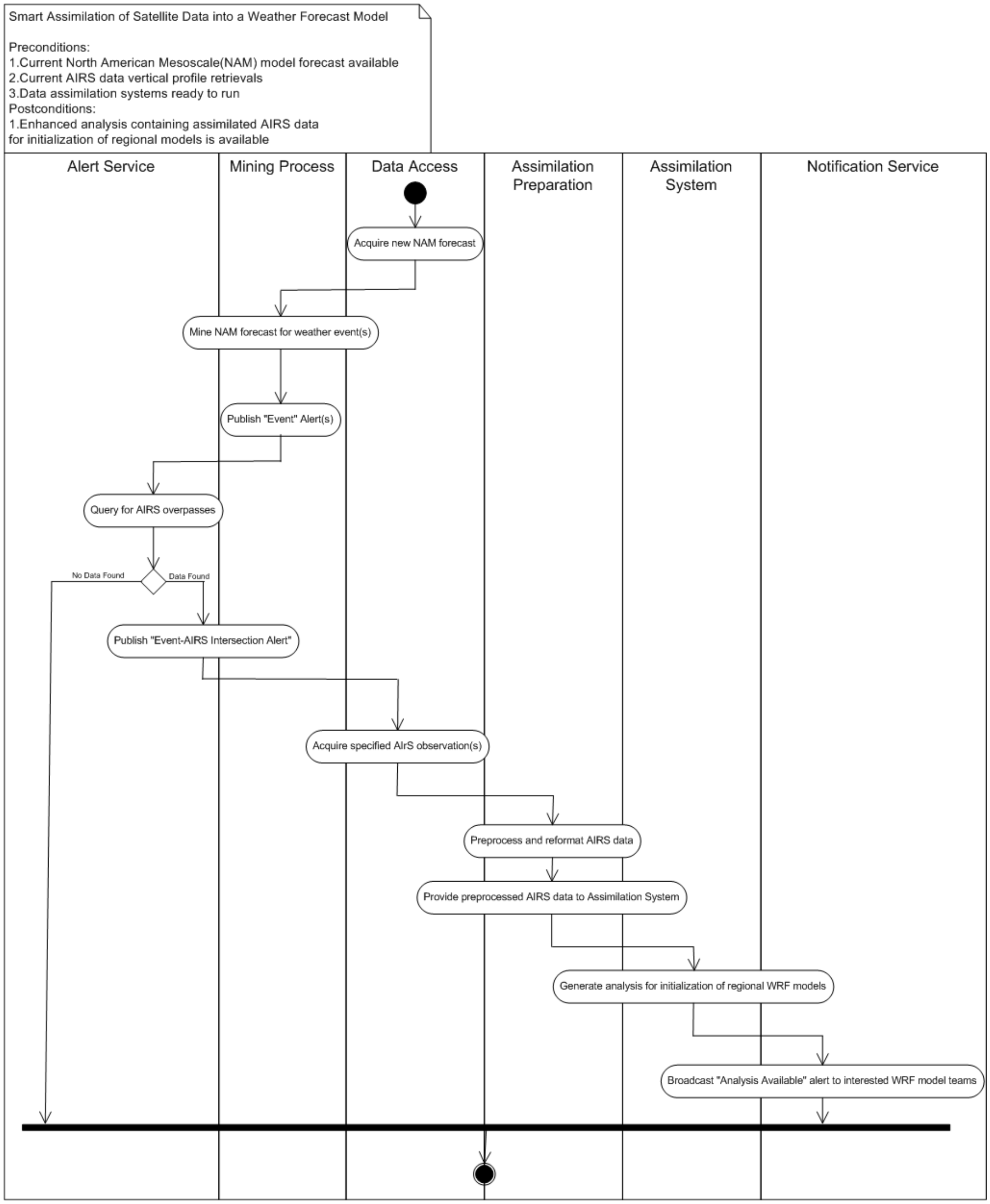
Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

Enhanced analysis containing assimilated AIRS data for initialization of regional models is available.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

ADAS – ARPS Data Assimilation System

AIRS – Atmospheric Infrared Sounder

APRS – Advanced Regional Prediction System

CONUS – Contiguous United States

NAM – North American Mesoscale model

NASA – National Aeronautics and Space Administration

NCEP – National Centers for Environmental Prediction

NOAA – National Oceanic and Atmospheric Administration
NSSTC – National Space Science and Technology Center
PATH – Precipitation All-weather Temperature and Humidity mission
SMART – Sensor Management for Applied Research Technologies project
SPoRT – Short-term Prediction and Research Transition center
UWi – University of Wisconsin
WRF – Weather Research & Forecasting

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access
AIRS	Remote sensed satellite dataset	Profiles in clear or partly cloudy	Atmospheric vertical profiles of temperature and relative humidity	NASA	SPoRT via GSFC DAAC and/or UWi direct broadcast

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
NAM forecast	NOAA/NCEP	The NAM model is a regional mesoscale data assimilation and forecast model system running at 12 km res. and 60 layers. NAM forecasts are produced at 00, 06, 12 and 18 UTC. The NAM forecasts are available at six hour	NASA AIRS atmospheric profile and NAM forecast parameters: mean sea lvl press. 2m rel. humidity 2m skin temper. 6h precipitation Convective available potential energy Convective Inhibition 200mb U & V wind 500mb height	6-hrs	SPoRT via NCEP

		increments out to 84 hours.	500mb temperature 500mb vorticity 850mb height 850mb temperature 850mb vorticity		
WRF	SPoRT	The WRF model is a regional mesoscale data assimilation and forecast model system running at 12 km res. and 37 layers. WRF forecasts are produced every 3hrs from 00 - 21 UTC. The WRF model features a 3d variational ADAS	NAM forecast data as first guess assimilation of AIRS profiles	24hr (1/day)	SPoRT

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
Event alert	SMART project	Weather event identified in NAM forecast	Other mesoscale modelers who want to assimilate their own observations of weather events	SMART
Event-AIRS Intersection	SMART project	AIRS overpass coincident with identified weather event	Assimilation preparation process	SMART
Analysis Available	NASA / NSSTC	Improved initial conditions with assimilated AIRS temperature and moisture observations	Other mesoscale modelers who need improved initial conditions to run WRF	SMART

Application Services

Application	Owner	Description	Source System
(Application	Organization	Short description of the application, DSS or	Name of the system

or DSS name)	that offers the Application	portal	which offers access to this resource

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor
Atmospheric Infrared System AIRS	NASA		2-3 times per day (depending on event size, location and duration)	Aqua

11.6 Water & Energy Cycle

11.6.1 Coastal Sensor Web for Short- and Long-Duration Event Detection

Point of Contact Name: Ashit Talukder, John Dolan

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☒ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☒ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☒ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☒ NMP EO-1
- ☒ QuikSCAT
- ☒ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☒ TRMM

Future Missions
- ☒ Aquarius
- ☒ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☒ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category
- ☒ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☒ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☒ Human health and security
- ☐ Solid earth haz., resources, dynamics

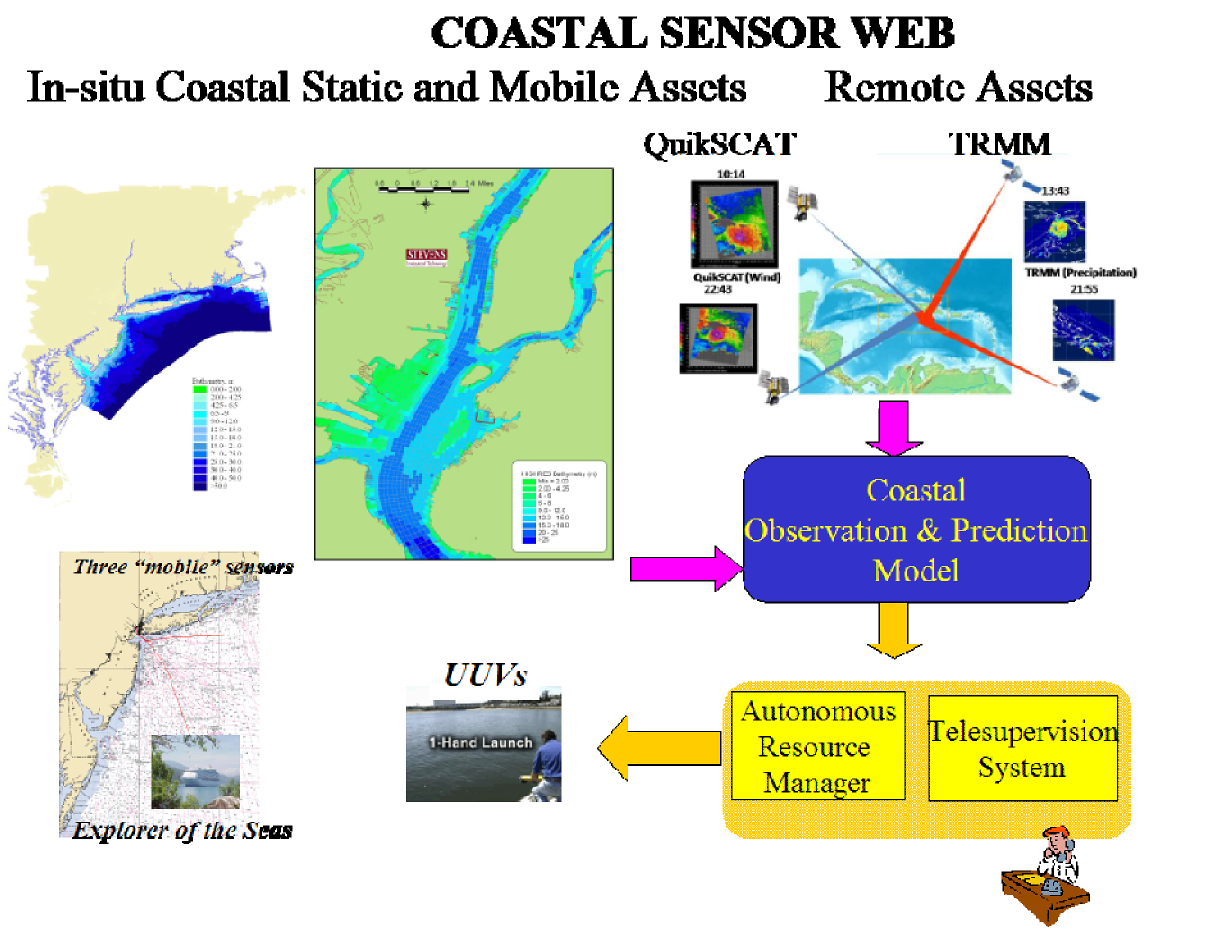
Sensor Web Features & Benefits
- ☒ Targeted observations (4)
- ☒ Incorporate feedback (3)
- ☐ Ready access to data
- ☐ Improved use/reuse
- ☒ Rapid response (1)
- ☐ Improve cost effectiveness
- ☒ Improve data quality/science value (2)
- ☐ New_____________________

AIST Needs Category
- ☒ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☒ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☒ F-Decrease mission risk/cost thru autonomy/automation

- ☐ New_____________________________

Use Case Name *Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.* Coastal Sensor Web for Short- and Long-Duration Event Detection
Goal *The goal briefly describes what the user intends to achieve with this use case.* Autonomous, improved (faster, better, more accurate) detection, prediction, visualization, and characterization of coastal events including harmful algal blooms, storm surges, tsunamis, and plumes by combining in-situ coastal observations with remote observations such as MODIS, QuikSCAT and TRMM (and potentially EO-1). Disseminate science data product of coastal events to multiple customers, including the Coast Guard, maritime community (fishing community and professional/recreational boats users), oceanographers, Departments of Natural Resources, and NOAA. Develop, deploy and demonstrate generic adaptive control and resource management technology and a telesupervision architecture that is applicable to a host of coastal, terrestrial, and remote satellite sensor webs.
Summary *Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.* GOAL: Improved (faster, better, more accurate) detection, prediction, modeling, visualization, and characterization of coastal events including harmful algal blooms, coastal storm surges, tsunamis, and plumes by combining in-situ coastal observations with remote observations such as QuikSCAT. MODIS, and TRMM. *Develop, deploy and demonstrate generic adaptive control and resource management technology and a telesupervision architecture that is applicable to a host of coastal, terrestrial, and remote satellite sensor webs.* PRINCIPAL DOMAIN: Coastal in-situ sensor web such as the NYHOPS (New York Harbor Observation and Prediction) Sensor Web and the OASIS Telesupervised Adaptive Ocean Sensor Fleet and remote satellite measurements such as QuikSCAT, TRMM, MODIS. SUMMARY: Coordinated resource management of the coastal sensor webs with mobile in-situ observations using underwater unmanned vehicles and unmanned surface vehicles in combination with remote QuikSCAT ocean wind speed, TRMM water precipitation, and MODIS multispectral data to achieve better, faster and more accurate prediction and detection of large-scale and small-scale coastal events such as algal blooms, coastal storm surges, and plumes.



Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary Actor (external events)

- Coastal Weather events – harmful algal blooms, coastal storm surge, plume, tsunami
- Ocean observation and prediction model (POM / ECOMSED model and ROMS model)

Primary Actor (end users)

- Coast Guard
- Maritime community (fishing community and professional/recreational boats users)
- Oceanographers
- Departments of Natural Resources
- NOAA

Secondary Actors (things acted on by system)

- Measurement rate and data transmission rate of static sensors
- Movement of mobile sensors (underwater and water surface unmanned vehicles)
- Assimilation of remote QuikSCAT and TRMM satellite measurements into coastal POM / ECOMSED model
- Communication to end-users (emergency management personnel, coast guard, fishing community, etc.)

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any *assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.*

- ❑ Available power at each mobile and static node
- ❑ Location(s) of unmanned systems
- ❑ Available bandwidth across network (connectivity)
- ❑ Operational maritime platforms to deploy sensors
- ❑ Condition(s) of external environment including sensor measurements and weather outlook
- ❑ Prediction from Coastal Model

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

TRIGGERS:

- ❑ Sensor measurements
- ❑ Coastal Model predictions
- ❑ Weather event(s)
  - o Plume (salinity event)
  - o Flooding and unusual rainfall, storms
  - o Water currents, speed and flow direction
  - o Algal blooms
- ❑ Human-induced (telesupervised architecture)
- ❑ Sensor states (constraint trigger such as power, communication links, etc.)

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Static sensors feed measurements into observation and prediction model
2) Potential "threat"/anomaly observation/prediction output by Coastal Model
3) Resource manager controls mobile and fixed assets around regions of interest while keeping system constraints under consideration
4) Human-in-the-loop telesupervised system issues command/control if needed and evaluates recommended actions by autonomous resource manager
5) Remote satellite (QuikSCAT, TRMM, MODIS) measurements input into Coastal Model
6) Higher measurement sampling rates from static in-situ assets and measurements from mobile assets are assimilated into Coastal Model
7) Highly accurate Coastal Model Prediction analyzed and evaluated
8) Actions taken based on new predicted event:
   (a) Podcast/RSS feed to subscribed users,
   (b) Metadata tag added based on observed/predicted event
   (c) Pager messages sent to coast guard (emergency), scientists (analyze) and other users
   (d) Autonomous resource manager redeploys mobile/static assets based on future progression of event(s)
   (e) Visualization of event(s) in 4D geobrowser (e.g., GoogleEarth) disseminated to sensor web users

9) Continuous feedback mechanism continues to manage system resources and detect and track evolving events as they move spatiotemporally

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

1) The Coastal Models (POM / ECOMSED / ROMS) anomaly detection and prediction algorithms miss detecting or predicting the algal bloom, coastal storm surge or plume (false negative). In this case, the telesupervised system kicks in and allows human observers to specify the current and future track of the event of interest to the resource manager, which then uses these manual inputs to allocate sensor web resources. *Resource allocation can also be achieved using only the human in*

the loop.

2) The in situ measurements made by the sensor web indicate that the regions identified by the event detection algorithm from the remotely sensed data do not represent an event such as a harmful algal bloom, coastal storm surge or plume (false positive)

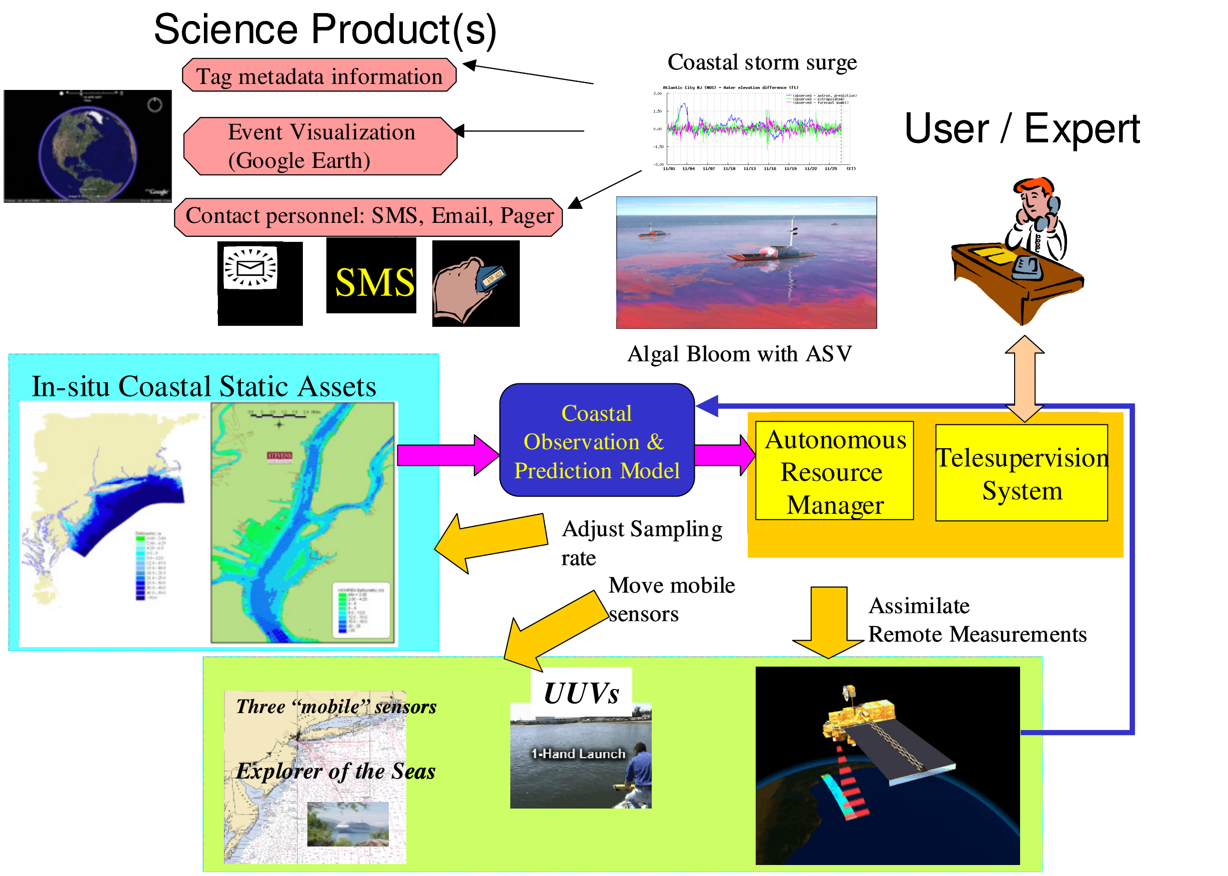
Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

Publication, dissemination, and archiving of reports detailing the event.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ,	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the	USGS, ESA, etc.	Name of the system which supports

	Etc.		usage characteristics		discovery and access
NYHOPS	In-situ	Salinity, water level, pressure, and speed	Multiple in-situ measurements from multiple locations	Stevens Institute of Technology	NYHOPS
OASIS	In-situ	Salinity, water, temperature, wind, fluorescence	Multiple in-situ measurements from multiple locations	Wallops Flight Facility	OASIS

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
ECOMSED	Stevens Institute of Technology	POM / ECOMSED based hydrographic model of the ocean on a high resolution 3-D grid	Freshwater inflow, NOAA weather forecasts, wind velocity	Daily (24 hrs)	NYHOPS

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
Plume or other anomaly	Stevens Institute of Technology		Fishing community, Coast Guard, Emergency Management	NYHOPS (paging and text service, and NYHOPS website)

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages

Appendix C – Use Cases

Sensor	Owner	Description	Frequency	Source System
	sensor			sensor

11.6.2 Glacier Outburst Flood Water Quality Impact

Point of Contact Name(s): Matt Heavner, Dipa Suri, & Gautam Biswas

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☒ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☒ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☒ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☒ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions
- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category
- ☐ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☒ Climate Variability & Changes
- ☒ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- ☒ Targeted observations
- ☐ Incorporate feedback
- ☐ Ready access to data
- ☐ Improved use/reuse
- ☒ Rapid response
- ☐ Improve cost effectiveness
- ☐ Improve data quality/science value
- ☐ New______________________

AIST Needs Category
- ☒ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☒ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation

- ☐ New________________________________

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Glacier Outburst Flood Water Quality Impact

Goal

The goal briefly describes what the user intends to achieve with this use case.

Scientist needs to know when a glacial lake catastrophically drains and have data to understand impacts on water quality downstream and glacial dynamics while also collecting data to understand long term effects of increased glacial lake formation with climate change.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick erview and includes the goal and principal actor.

Climate change is increasing the amount of glacial lakes. Water quality has great significance for ecology e.g., salmon spawning and primary productivity in the near shore marine environment. Understanding the glacial lakes impacts on glacier dynamics, glaciated watershed, and coastal productivity motivates this use case. Heterogeneous measurements from the watershed need to be coordinated for intense observations when an unpredictable, transient event (outburst lake drainage) occurs. Long term monitoring is ongoing, but is power, computationally, and bandwidth constrained. Instrumentation includes a pressure transducer in the glacial lake; meteorological station for gathering parameters such as temperature, wind speed and direction, and precipitation; a steer able camera; and a water quality sonde. Some of the sensors (such as the pressure transducer) have minimal computation capability and only forward data while others are heterogeneous sensors and computational processors. These nodes are deployed and configured into subnets that are networked through both wired and wireless connections.

In keeping with the notion of a sensor web, these subnets are sources of data that is collected at and processed in a more computationally rich environment in order to facilitate high level analysis and decision making.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

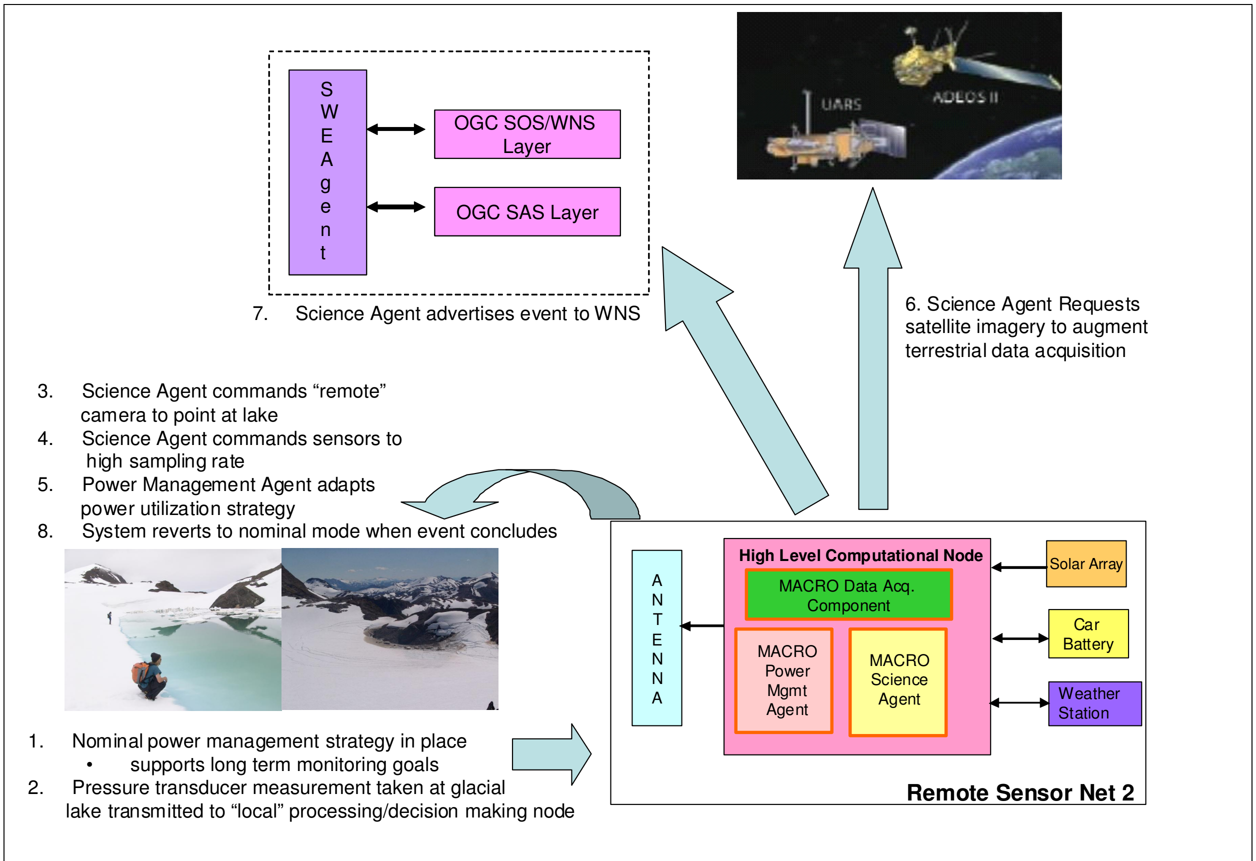
- Scientists (marine ecologists, glaciologists, hydrologists, geologists)
- Science Agents
- Power Management Agents
- Pressure Transducer: measures glacial lake depth
- Cairn Peak Meteorological System: computational resource, communications hub, and meteorological parameters
- Cairn Peak steerable Camera: communication, power and bandwidth constraints, view of lake that drain
- Water Quality Sonde: measures water temperature, turbidity
- Satellites that allows requests for data acquisition
- Differential GPS units on glacier

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

- Long term monitoring is in place with each node operating in accordance with science and power management agents' goals and objectives
- The glacial lake is filling.
- Communications between spatially distributed nodes and to global network.
- Adaptive power management strategies are in place (see MACRO Resource Management

Use Case).
Triggers *Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.* • The pressure transducer measurement gets to the Cairn Peak meteorological (met) station processor that identifies lake drainage. • Alternately, the differential GPS detects a sudden glacier motion and triggers and alert. • The Cairn Peak met station forwards an alert to all other sensors that the event of interest is in process (including a request for overhead imagery). • Return to nominal monitoring when stream turbidity returns to background level • User request based on knowledge of imminent satellite overpass temporarily overrides autonomous power management
Basic Flow *Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)* 1) Pressure Transducer Measurement is forwarded to Cairn Peak met station 2) The Science Agent at the Cairn Peak met station identifies drop in lake pressure 3) The Science Agent at the Cairn Peak met station broadcasts “lake drainage alert” 4) The Science Agent at the Cairn Peak met station transmits request for satellite observation (visible imagery of glacier, imagery of soil moisture, Laser altimetry, InSAR for glacier rise/fall) 5) The Science Agent at the Cairn Peak commands the camera to point to the lake to record drainage 6) The Science Agent in concert with the Power Management Agent reconfigures the glacial GPS units to be in high accuracy, high sample rate mode 7) Similarly the water quality sonde is commanded to an increased sample rate with the potential of exhausting available power since this transient event is high priority. This is an example of individual nodes implementing independent power management strategies. Ideally, the power management strategy adapts to current scenario and predicted future power consumption 8) After the lake drainage impacts on the watershed conclude, the sensor web “resets” for long-term monitoring
Alternate Flow *Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.* 1) If communications is impeded, Cairn peak falls back to low bandwidth satellite uplink and a “lake drainage alert” is propagated to other actors through alternative communications path 2) If power is very limited and camera is unable to participate in observations, higher priority is given to acquiring satellite imagery 3) Both of the above illustrate fault-tolerance and adaptivity of a sensor web
Post Conditions *Here we give any conditions that will be true of the state of the system after the use case has been completed.* After the water quality sonde turbidity drops to background levels, system returns to normal power management strategies and long-term monitoring operating mode. All data stored on sensor platforms are forwarded to database.
Activity Diagram *Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.*



Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
Metereology	local met stations	TBD minute coverage for met stations	Frequent data on local cloud cover, precipitation, solar radiation, temperature, wind	UAS local stations	local comm. network from met stations
Water Quality	Local sonde	Regular water quality sampling	Water temperature, dissolved oxygen, turbidity, pH	UAS local stations	Local comm.. network

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System

(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model

Event Notification Services

Event	Owner	Description	Subscription	Source System
Imminent satellite overpass	NASA/NOAA	Notice of satellite overpass with sensor resources for augmented imagery	List of subscriptions (and owners)	Name of the system which offers this event

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource

Sensor resources

Sensor	Owner	Description	Frequency	Source System
Pressure Transducer	UAS	Sensor that signals lake drainage event	Hourly at low power, 15 seconds during lake outburst	N/A
WebCam	UAS	Camera for local terrestrial imagery	Dependent on local power constraints	N/A
Water Quality Sonde	UAS	Water turbidity	15 minutes at monitoring mode, 15 second during lake outburst	N/A
Laser altimeter	NASA	Surface and ice sheet deformation, Ice sheet height		DESDynI, ICESat, ICESat-II
L-Band radiometer	NASA	Freeze/thaw for water cycle processes		SMAP

11.6.3 Hurricane Workflows

Point of Contact Name: Stu Frye

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- x HyspIRI
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- x NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions
- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category
- x Earth Science Apps & Societal Benefits
- x Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- x Water resources & global hydrologic cycle
- x Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- x Targeted observations
- x Incorporate feedback
- x Ready access to data
- x Improved use/reuse
- x Rapid response
- x Improve cost effectiveness
- x Improve data quality/science value

AIST Needs Category
- x 1-Data Collection
- x 2-Transmission & Dissem.
- x 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- x A-Increase science data value thru autonomous use
- ☐ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- x D-Improve access, storage, delivery
- x E-Improve system interoperability, stds use
- x F-Decrease mission risk/cost thru autonomy/automation
- ☐

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Hurricane Workflow Use Case

Goal

The goal briefly describes what the user intends to achieve with this use case.

This use case describes how an end user would adapt an existing workflow to accomplish a new observation goal.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

Individual web services have been developed that accomplish individual tasks for identifying event triggers, tasking sensor assets, processing sensor data, and delivering multiple higher level detection products directly to end users. For a typical observation sequence, a series of activities has to be accomplished including sensor tasking, basic data processing, and customized detection data product generation and delivery. Users want to have a way to string together multiple services to accomplish these specific goals. Workflows provide this capability.

A wildfire monitoring workflow has been developed that allows a fire analyst to pick a region of interest for fire monitoring, retrieve MODIS hot pixel locations for that region, identify the highest threat location within that region, task the EO-1 satellite to target that location, and provide multiple EO-1 data products to that user. The products include a visible image, a SWIR image showing burned area and active fire that can be seen through clouds, and a hot pixel readout from the Hyperion hyperspectral imager.

If a user is concerned about triggering coverage of a hurricane instead of a wildfire, the user can adapt the wildfire workflow to monitor the hurricane aftermath by pointing the triggering part of the workflow at the National Hurricane Centers landfall prediction web site instead of pulling in MODIS hot pixels for targeting. The threat analysis part of the workflow would be modified to target the eye of the storm landfall point and the EO-1 satellite would be tasked to image that location and the earliest in-view time after landfall. Basic targeting and data processing would not be modified. Individual detection products could still include the set of fire products (visible, SWIR, and hot pixels), but a flood classification algorithm could be added. The user discovers which bands to select for the flood algorithm from the WPS description document.

To make the modifications to the workflow, the user would employ a workflow editor. The editor provides the capability to change the trigger selection and the threat calculation plus adding the new product to the workflow. The wildfire products could be deleted to reduce the delivered data volume.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Disaster Management analysts and first responders are the primary end users.
Models of predicted hurricane landfall are provided by the NOAA Hurricane Center.
Hyperion is used to collect the flood data by tasking the EO-1 SPS.
Level 1 data from Hyperion is provided by the EO-1 SOS.
Detection algorithm runs are provided by the EO-1 WPS.
Subscriptions are provided by Atom Feeds
Feeds are harvested by Google Feedburner

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

The workflow can be initiated manually at the time of an event or setup to run on a continual basis to monitor alerts issued by the National Hurricane Center to activate upon a certain category being reached.

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

Hurricane monitoring trigger would be set when a category 4 or 5 event is broadcast.
The trigger would identify the eye of the storm location by latitude and longitude at landfall. The observation would be taken at the soonest in-view time for EO-1 after the landfall is reached.

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Hurricane center issues warning of category 4 or 5 event and landfall time.
2) Threat is computed as Lat/Lon of storm eye at landfall point.
3) EO-1 in-view is computed by EO-1 Geobliki server.
4) EO-1 is tasked by workflow accessing the EO-1 SPS
5) Data is downlinked and processed to Level0, Level1R, Level1G and posted to SOS.
6) Level1G data bands are processed into classification results via WPS.
7) Detection results are delivered to user in GEOTIFF and KML formats.

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

All products are stored on the EO-1 SOS
If the workflow was instantiated manually, there will be nothing running after
If the workflow was setup to continually operate, the monitoring of the Hurricane Center alerts would be automatically “restarted” by the Workflow engine.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Modification of this workflow could be done to monitor tsunamis by tying to the NOAA tsunami warning system.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name)	Remote, In situ, Etc.	e.g., – no cloud cover	Short description of the dataset, possibly including rationale of the usage characteristics	USGS, ESA, etc.	Name of the system which supports discovery and access
EO-1 L1G	Satellite	No cloud cover for flood classification	Hyperspectral data can identify flooded areas	NASA	Geobliki uses Atom feeds and Feedburner notifications of published products

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
(model name)	Organization that offers the model	Short description of the model	List of data consumed	How often the model runs	Name of the system which offers access to the model
Hurricane Prediction	NOAA	Category and landfall time/location	GOES/POES/DMSP	daily	Hurricane Center

Event Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
Category = 4 or 5	NOAA	Threat threshold exceeded	Workflow setup enters subscription as proxy for user	EO-1 Geobliki Workflow Chaining Service

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
SOS, SPS, WPS	NASA	EO-1 tasking, data processing, and classification algorrithm products	EO-1 Geobliki

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor

Hyperion	NASA	Hyperspectral imager	5 times every 16 days	EO-1

11.6.4 Hydrology

Point of Contact Name: Paul R. Houser

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☐ ASCENDS
- ☒ CLARREO
- ☒ DESDynl
- ☐ GACM
- ☐ GEO-CAPE
- ☒ GPSRO
- ☐ GRACE-II
- ☒ HyspIRI
- ☐ ICESat-II
- ☒ LIST
- ☒ PATH
- ☒ SCLP
- ☒ SMAP
- ☒ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☒ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☒ GPM
- ☒ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☒ Terra
- ☒ TRMM

Future Missions
- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☒ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category
- ☒ Earth Science Apps & Societal Benefits
- ☒ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☒ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- ☒ Targeted observations
- ☒ Incorporate feedback
- ☒ Ready access to data
- ☒ Improved use/reuse
- ☒ Rapid response
- ☒ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New

AIST Needs Category
- ☐ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☒ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☒ F-Decrease mission risk/cost thru autonomy/automation
- ☐
- ☐ New

Use Case Name

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Hydrology

Goal

The goal briefly describes what the user intends to achieve with this use case.

Improve rapid knowledge and prediction of land surface hydrologic conditions and hazardous extremes.

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

Demonstrate DESDynI's capabilities (1) to map land surface inundation extent and change, (2) to monitor the dynamics of surface inundation at near real-time, and (3) to improve knowledge of land surface hydrological conditions and processes as represented in a hydrologic flow-routing and inundation model. Then through model projections of future inundation changes and assessment of uncertainties through ensemble predictions, perform feedback analysis to target DESDynI's future observations toward optimally reducing hydrologic knowledge uncertainty.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors: NASA, NOAA, USGS, Bureau or Reclamation, Army Corps of Engineers, mission operators, and data analysts

Secondary actors: FEMA, Office of Emergency Services, local governments

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

- Data from DESDynI are being routinely processed, or available in this use case from a synthetic "truth" source (i.e., a model)
- Precipitation, elevation, surface runoff gages, vegetation state, land use, and GPS data are readily ingested in to high resolution distributed hydrological models
- Models of surface hydrologic inundation exist or are developed and are capable of assimilating DESDynI-style data.
- Web and grid services exist for accessing data and models and are running on appropriate computers including high performance computers

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

- Typical trigger will be a significant hydrologic extreme (say a 100 year flood at catchment of 100^2 km), that may bring a seasonal (unexpected) change in land or wetland inundation area.
- Detectable changes in ancillary sensor web conditions (e.g., precipitation, snow melt, or evapotranspiration extremes) could trigger an inundation event

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Inundation change occurs
2) Region is imaged with DESDynI

3) Data are downlinked and processed
4) Additional data (precipitation, elevation, in-situ stage & discharge, GPS, etc.) are collected into web services
5) Sensor data are assimilated into real-time hydrologic model
6) Sensor and model results analyzed for inundation change extent, and near-future projection.
7) Results are communicated to appropriate agencies (FEMA, USGS, local governments, transportation authorities)
8) Hydrologic model inundation change and ensemble predictions are analyzed to determine "hydrologic hot spots"
9) Results are communicated to DESDynI mission managers to target hot spots for additional observations, and process repeats.
10) Observations are collected over remainder of mission to understand long-term effects

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

Other system flows are possible.

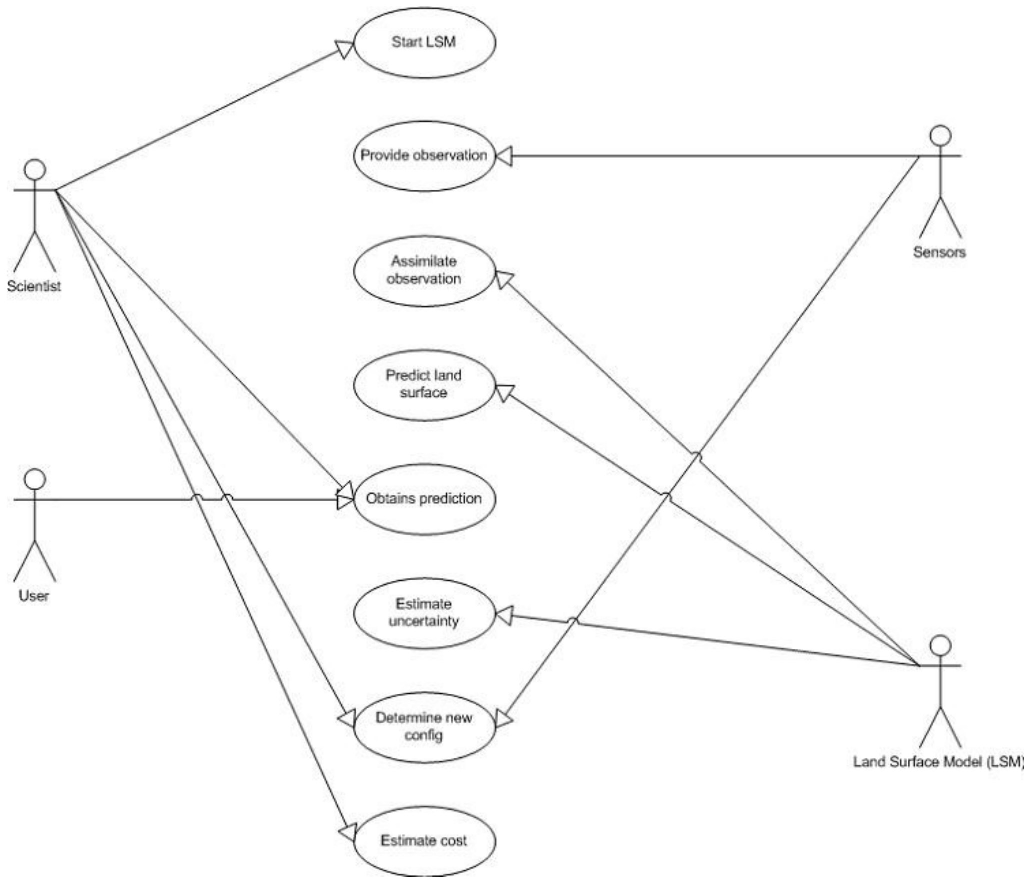
Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

- Inundation and hydrologic conditions available on the web in near-real time
- Inundation change maps available through the portal on the web

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

Premise: The DESDynI is a first wave Decadal Survey mission equipped with both a surface imaging L-Band SAR and LIDAR, with 8 day repeats and 10-100km resolutions. It is capable of measuring surface elevation changes and vegetation structure, which can provide information on a wide range of geomorphologic, solid earth, cryosphere, and hydrologic changes. Our goal here is to explore Sensor Web "use cases" that explore or demonstrate how DESDynI's capabilities can be significantly enhanced when used in a Sensor-Model web framework. Since this is a future remote sensing system, with no contemporary analogue, we will generally be performing these use cases in a OSSE (Observation Simulation Sensitivity Experiment) mode, where we use a model to create a synthetic "truth" that can be sampled by a DESDynI sensor model to allow the sensor-model web use case paradigm to be explored. The spatial extent, time period, and domain for these studies is generally less important than demonstrate the interaction between various sensors, models, and communication frameworks to achieve an improved science or application result. We have identified a number of different use case scenarios below, which is by no means comprehensive, but can provide a baseline of expected DESDynI system enhancements using a sensor web paradigm. It should also be noted that similar use cases can and should be developed for the other decadal survey missions.

DESDynI will have many use cases. These are selected examples - other events include:

- Tsunamis resulting from earthquakes
- Volcanoes
- Landslides
- Subsidence
- Flooding

- Hurricanes
- Wind events
- Wildfires
- Land use (e.g., clear cutting)
- Ice shelf break up

DESDynI's sensors can be applied to a wide range of hydrological sciences from subsidance & aquifer depletion and soil moisture variations and variability studies, to investigation of water budget at a wide range of space and time scales. These advancements in hydrological sciences have potential to directly address societal needs of hydrological application fields from flooding, inundation, droughts, lake and wetland changes to manage and mitigate risks associated with water, environment and ecosystem. For this use case, we will focus on using DESDynI's capabilities to monitor surface inundation, floodplain management, and changes in lakes and wetlands.

11.6.5 Snow and Cold Land Processes (SCLP) using ERINode for Passive Active Interferometric Radiometer with Interleaved Radar

Point of Contact Name: Larry Hilliard

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☒ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☐ Earth Science Apps & Societal Benefits
- ☐ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☐ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☒ Targeted observations
- ☐ Incorporate feedback
- ☐ Ready access to data
- ☐ Improved use/reuse
- ☐ Rapid response
- ☐ Improve cost effectiveness
- ☐ Improve data quality/science value
- ☐ New______________________

AIST Needs Category

- ☒ 1-Data Collection
- ☐ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☐ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☐ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☒ F-Decrease mission risk/cost thru autonomy/automation

- ☐ New_____________________________

Use Case Name
Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.
Snow and Cold Land Processes (SCLP) using ERINode for Passive Active Interferometric Radiometer with Interleaved Radar

Goal
The goal briefly describes what the user intends to achieve with this use case.
Hydrologists using ERINode for a Passive Active Interferometric Radiometer w/Interleaved Radar can calibrate SCLP measurements. Using an ERIN controlled sensor the user can:

- See under tree canopy/ measure canopy effects – of drip line, steep terrain
- See high resolution, seasonal variations
- Achieve high angle polarimetric separation for river valleys and through foliage
- Perform high resolution mountain **S**now **W**ater **E**quivalent assessment

Summary
Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.
The Expandable Reconfigureable Instrument Node (ERIN) can orchestrate interleaved radar and radiometers just like it's satellite brethren SCLP (aka CLP Pathfinder). With a node (S/N 002) design projecting to weigh only two or three pounds, the ERIN will bring the Web Sensor Strand (WSS) technique to small Uninhabited Aerial Vehicles (UAVs).

By flying low and slow the SCLP-like measurement (**SWE**) can fly into areas that will help calibrate the SCLP measurement and co-register high resolution data that it can take along curvilinear strips, but measure over and under the forest canopy, in the valley and over the foothills and present those perspectives to the hydrologists independently or simultaneously through their multi-node synchronous operation.

The web strand is essentially an L-Band interferometric baseline that can surround a target area and remain synchronous either through the Global Positioning System(GPS) clock pulse reference or line of sight communication.

By tagging the position of the L-Band radar return for the user, ERIN can interleave radiometer brightness temperature integration periods to infer multiple "looks" for the passive sensor. In post-collection image processing, the web sensor, formed by strands between synchronous nodes can overlay the synthesized array at all the different wavelengths that are interleaved. With COTS technology and a differential GPS, 1 centimeter position determination is the dominant error in reconstructing the L-Band wavefront.

At 20 meters/sec, a slow moving platform, such as the aerotenna, moves less than ¼ of a wavelength per shot when the pulse repitition frequency is 2 msec. Therefore the L-band array "fills in" the web with L-Band return scatter and forward scatter.

Use Case of L-Band "web sensor strand" array, formed by UAV node movement
L-Band wavelength is ~0.22meters
We Chose (PRI=2msec) 500 shots/sec, *PRI is Pulse Repetition Interval
Air speed of UAV: 20m/sec
Therefore "element" movement: 0.04 meters/shot

L-Band Active λ: 0.238095238 meters L-Band Passive λ: 0.2123142 meters

"array element spacing" 0.168 wavelengths "array element spacing" 0.1884wavelengths

Interleaving shorter wavelength radiometers at X-Band, K-Band, and Ka-Band the **S**low and **L**ow **U**AV for **S**now **H**ydrology (**SLUSH**) use case will tag the SWE assessment with the same time, position, and bearing tags to co-register the data with the L-Band SAR formed by successive Web Sensor Strands.

For the shorter radiometer wavelengths to be interleaved, the pulse repetition interval (PRI) will have to be shortened to PRI= 0.3msec for X-Band, PRI=0.2msec for K-Band, and PRI= 0.1msec for Ka Band. All of these PRI can be kept synchronous with the fast L-Band Pulsed Radar (Pulse width = 30 nsec).

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors, including the following, can benefit from the co-registration of synchronous satellites and low flying platforms:

- Hydrologists who study soil moisture and transpiration in the water cycle. Polarization effects and low looks under the drip line can calibrate lower resolution satellite measurements.

Secondary actors are interested in targeted areas but calibrations and high resolution data will improve decision-making. These include the following:

- Meteorologists who need to make decisions on snow and it's effect on national weather service forecasts
- Water Management officials who need to make decisions on snow water storage, reservoirs and drought-stricken areas

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

For Snow and Cold Land Processes-**SWE** models to be believed on SCLP, then ground truth in remote (particularly mountainous) areas must calibrate their global view. A co-registered high resolution data set that is affordable to the secondary actors will calibrate the uncertainties in global models (e.g., **SWE** inside the drip line) and discern dry snow in the hydrological cycle from wet snow where and when they interact.(foothills). ERIN-WSS Technology directly addresses these preconditions.

An unchanging scene on the timescale of 10 minutes (such as SWE), must be present to integrate over target distances ~ curvilinear 10 Km of "shots" at 20 m/sec (UAV air speed).

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

The seasonal camaflouge of photosynthesis, summer foliage, fallen leaves, and freezing and decaying leaves are normal triggers whose variation is a trend that indicates climate change.

Other triggers are extreme winter weather events such as blizzards, ice storms, and rapid melts. These all affect human decision-making, and have indirect effects on flora and fauna.

Deployment of ERIN-WSS technology can help understand the short and long term decisions that need to be made.

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) 10 MHz Xtal oscillator is refreshed / synchronized to 1pulse-per-second GPS reference at both nodes (all nodes)
2) 40 MHz digital clock is derived from 10 MHz reference
3) System Clock pulses radar from all system nodes on 10 MHz derived carrier
4) Short radar pulse (30 ns), is snatched on return after 100ns roundtrip
5) System clock closes window on ERIN return
6) Return pulse is downconverted to 3-37 MHz Intermediate Frequency (IF)
7) IF is digitized and tagged w/ time, position, and bearing
8) All return/ forward scatter data is combined w/ time tags at both nodes
9) “Interferometric baseline” model calibrates system geometry out of strand baseline
10) A second pulse is released after 2 msec

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

1) Instead of a PRI “wait period”, a radiometer blanking switch can be triggered by the 130 nanosec transmit/return and enable “interleaved” operation
2) N Radiometer integration periods of M length (where 1.75 sec>N*M) – (e.g., for L-band @ 20 m/sec airspeed, <λ/4 element spacings are captured between pulses
3) These captured brightness temperatures, tagged with time, position, and bearing may also be synthesized or correlated to the radar
4) Further, all active and passive data can be co-registered to the big picture.(SMAP and Aquarius)

NOTE: These Alternate Flow steps are essential for the understanding of Snow Water Equivalent the key measurement of SCLP

Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

After the Use Case measurement has been completed the ERIN data analysis will show trends that indicate the trend is either permanent (climatic), or synoptic (single events or cyclical). The decision-making processes in water management, and meteorological weather prediction models can direct local decision-makers and even world decision makers when co-registered with the lower resolution satellite measurements of SCLP.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.

- Snow on Flatlands ⇉♔ Snow Water Equivalent Use case measurement “drying down” ⇉ Weather prediction strategy/decisions National Weather Service, USDA, Agribusiness
- Snow melt⇉♔ Snow Water Equivalent Use case measurement “drying down” ⇉ Rebuild strategy, FEMA, Insurance Business
- Snow pack⇉♔ Snow Water Equivalent threat of avalanche/erosion. Use case measurement “wetlands” ⇉ Corps of Engineers strategy/decisions local officials/inland wetland mitigation also “likelyhood of fire” ⇉ Fire management strategy/decisions – US Forest Service
- **Drought NO Precipitation except in mountains nearby⇉♔ Snow Water EquivalentUse case measurement⇉ Water management strategy/“rationing”decisions water reservoirs – Dept of Natural resources,**

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

The big picture provided by SCLP at low resolutions relative to ERIN Missions will uncover many target use cases where ERIN will resolve calibration issues due to vegetation camaflouge, polarization separation effects, and wet/dry snow mixing and it’s effect on flora and fauna.

This use case of ERIN-WSS Technology can synergistically work with Reconfigureable In-situ network (PI:Ayanna Howard) for calibrations of the local continuum measurement, and to calibrate the Land Information System (LIS) that ties in satellite SMAP/Aquarius measurements at lower

resolution and higher coverages.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name) Interleaved radar and radiometer	Grouped synchronous Nodes-strands synthesize a web	e.g., –low and slow/	good view under canopy/ drip line/	NASA, NOAA, USDA, USFS USGS, ESA,	Name of the system which supports discovery and access (from NRC)
Aka **SCLP**	Local continuum (remote)	High resolution (50-100m)	capture the steepness of the terrain and effects on saltwater mixing /filtering of wetlands/forest canopy and ground vegetation	Lightweight technology will be relevant on solar system planetary exploration also	**NPOESS** Joint Requirements Oversight Council **Snow and Cold Land Processes Working Group**

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
Numerical Weather Prediction Model	NOAA/NWS (ERIN data will provide input to model)	Short description of the model	List of data consumed Radar scatter - σ Brightness Temperature - T_b, Both at L-Band time and position tags	How often the model runs	Name of the system which offers access to the model
Seasonal climate models	NASA USDA (ERIN data will provide input to model)	A synthetic aperture radar formed from synchronous "shots", and calibrated returns coverage area	σ^{return}, $\sigma^{forward}$, T_b Tagged with, lat, long, alt, roll, pitch, yaw	One parallel or radial cycle – dump to master node	ERIN and the Image Processor – Master Node

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event

Soil Moisture Experiment (SMEx)	NASA/USDA NOAA	Soil Moisture Experiment is a ground truth campaign visit the Midwest U.S. to witness the "dry down" of target agicultural areas	NASA/USDA NOAA, Agribusiness	Soil Moisture Community

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
Weather Prediction Emergency Management Forest Management Water Management	National Weather Service, USDA FEMA/ Insurance Industry Interior-USFS DNR/ Corps of Engineers Local/Unique	x Snow on Flatlands ⇉✉ **Snow Water Equivalent** "drying down" ⇉ Weather prediction strategy/decisions x Snow melt/flood⇉✉ Snow Water Equivalent "drying down" ⇉ Rebuild strategy, x Snow pack⇉✉ Snow Water Equivalent threat of avalanche/erosion. Corps of Engineers strategy/decisions local officials/inland wetland mitigation also "likelyhood of fire" ⇉ Fire management strategy/decisions – US Forest Service x **Drought NO Precipitation except in mountains nearby⇉✉ Snow Water EquivalentUse case measurement⇉ Water management strategy/"rationing"decisions water reservoirs – Dept of Natural resources**	

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor L-Band radar interleaved w/ X-, K-, Ka Band radiometer on Slow and Low UAV or Balloon	How often the sensor can observe event	Name of the satellite or system which manages sensor
ERIN radar ERIN radiometers	NASA - GSFC	<u>**S**</u>low and <u>**L**</u>ow <u>**U**</u>AV for <u>**S**</u>now <u>**H**</u>ydrology (**SLUSH**) use case will tag the SWE assessment with the same time, position, and bearing tags to co-register the data with the L-Band SAR formed by successive Web Sensor Strands.	Coverage area: 30 minutes on batteries/platform limitation For the shorter radiometer wavelengths to be interleaved, the pulse repetition interval (PRI) will have to be	ERIN – Base station – Master Node- Image Processor – co-registration w/**SCLP** flyovers

			shortened	

11.6.6 Soil Moisture Active-Passive (SMAP) high resolution foliage calibration

Point of Contact Name: Larry Hilliard

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- [ ] ACE
- [ ] ASCENDS
- [ ] CLARREO
- [ ] DESDynI
- [ ] GACM
- [ ] GEO-CAPE
- [ ] GPSRO
- [ ] GRACE-II
- [ ] HyspIRI
- [ ] ICESat-II
- [ ] LIST
- [ ] PATH
- [ ] SCLP
- [x] SMAP
- [ ] SWOT
- [ ] XOVWM
- [ ] 3D-Winds

Current Missions

- [ ] ACRIMSAT
- [ ] Aqua
- [ ] Aura
- [ ] CALIPSO
- [ ] CloudSat
- [ ] GPM
- [ ] GRACE
- [ ] ICESat
- [ ] JASON-1
- [ ] LANDSAT7
- [ ] LAGEOS 1&2
- [ ] NMP EO-1
- [ ] QuikSCAT
- [ ] ADEOS-II
- [ ] SORCE
- [ ] Terra
- [ ] TRMM

Future Missions

- [x] Aquarius
- [ ] GOES-N/O/P
- [ ] Glory
- [ ] LDCM
- [ ] NPOES
- [ ] NPP
- [ ] OSTM
- [ ] OCO

Decadal Survey Category

- [ ] Earth Science Apps & Societal Benefits
- [ ] Land use change, ecosys. dynamics, biodiv.
- [ ] Weather - Space and Chemical
- [ ] Climate Variability & Changes
- [x] Water resources & global hydrologic cycle
- [ ] Human health and security
- [ ] Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- [x] Targeted observations
- [ ] Incorporate feedback
- [ ] Ready access to data
- [ ] Improved use/reuse
- [ ] Rapid response
- [ ] Improve cost effectiveness
- [ ] Improve data quality/science value
- [ ] New______________________

AIST Needs Category

- [x] 1-Data Collection
- [ ] 2-Transmission & Dissem.
- [ ] 3-Data & Info Production
- [ ] 4-Search, Access, Analysis, Display
- [ ] 5-Systems Mgmt

- [ ] A-Increase science data value thru autonomous use
- [x] B-Coord multiple observations for synergistic science
- [ ] C-Improve interdiscip science production environs
- [ ] D-Improve access, storage, delivery
- [ ] E-Improve system interoperability, stds use
- [x] F-Decrease mission risk/cost thru autonomy/automation

- [ ] New______________________________

Use Case Name *Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.* SOIL MOISTURE ACTIVE-PASSIVE (SMAP) high resolution foliage calibration
Goal *The goal briefly describes what the user intends to achieve with this use case.* Hydrologists using ERINode for a Passive Active Interferometric Radiometer w/Interleaved Radar can calibrate SMAP measurements. Using an ERIN controlled sensor the user can: • See under tree canopy/ measure canopy effects – of drip line, steep terrain • See high resolution, seasonal variations • Achieve high angle polarimetric separation for river valleys and through foliage • Perform coastal salt/fresh water tracking

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

The Expandable Reconfigurable Instrument Node (ERIN) can orchestrate interleaved L-Band radar and radiometers just like it's satellite brethren SMAP and Aquarius. With a node (S/N 002) design projecting to weigh only two or three pounds, the ERIN will bring the Web Sensor Strand (WSS) technique to small Uninhabited Aerial Vehicles (UAVs).

By flying low and slow the SMAP-like measurement can fly into areas that will help calibrate the SMAP measurement and co-register high resolution data that it can take along curvilinear strips, but measure over and under the forest canopy, in the valley and over the foothills and present those perspectives to the hydrologists independently or simultaneously through their multi-node synchronous operation.

The web strand is essentially an L-Band interferometric baseline that can surround a target area and remain synchronous either through the Global Positioning System(GPS) clock pulse reference or line of sight communication.

By tagging the position of the L-Band radar return for the user, ERIN can interleave radiometer brightness temperature integration periods to infer multiple "looks" for the passive sensor. In post-collection image processing, the web sensor, formed by strands between synchronous nodes can overlay the synthesized array at all the different wavelengths that are interleaved. With COTS technology and a differential GPS, 1 centimeter position determination is the dominant error in reconstructing the L-Band wavefront.

At 20 meters/sec, a slow moving platform, such as the aerotenna, moves less than ¼ of a wavelength per shot when the pulse repitition frequency is 2 msec. Therefore the L-band array "fills in" the web with L-Band return scatter and forward scatter.

Use Case of L-Band "web sensor strand" array, formed by UAV node movement
L-Band wavelength is ~0.22meters
We Chose (PRI=2msec) 500 shots/sec, *PRI is Pulse Repetition Interval
Air speed of UAV: 20m/sec
Therefore "element" movement: 0.04 meters/shot

L-Band Active λ: 0.238095238 meters — L-Band Passive λ: 0.2123142 meters

"array element spacing" 0.168 wavelengths — "array element spacing" 0.1884wavelengths

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Primary actors, including the following, can benefit from the co-registration of synchronous satellites and low flying platforms:

- Hydrologists who study soil moisture and transpiration in the water cycle. Polarization effects and low looks under the drip line can calibrate lower resolution satellite measurements.

Secondary actors are interested in targeted areas but calibrations and high resolution data will improve decision-making. These include the following:

- Agribusiness who want to know the health of their crops
- Insurance Companies in flood areas who must quickly make decisions in affected areas
- Water Management officials who need to make decisions on reservoirs and drought-stricken

areas

- <u>Forest service officials</u> may need to deploy web sensors to develop burn control strategies and safety(likelyhood of fire)

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

For L-Band measurements to be believed on SMAP and Aquarius, then ground truth in remote areas must calibrate their global view. A co-registered high resolution data set that is affordable to the secondary actors will calibrate the uncertainties in global models (e.g., soil moisture inside the drip line) and discern fresh water in the hydrological cycle from sea water where they interact.(coastal areas). ERIN-WSS Technology directly addresses these preconditions.

<u>An unchanging scene on the timescale of 10 minutes (such as soil moisture), must be present to integrate over target distances ~ curvilinear 10 Km of "shots" at 20 m/sec (UAV air speed).</u>

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

The seasonal camaflouge of photosynthesis, summer foliage, fallen leaves, and freezing and decaying leaves are normal triggers whose variation is a trend that indicates climate change.

Other triggers are extreme weather events such as floods, droughts, and fire. These all affect human decision-making, and have indirect effects on flora and fauna.

Deployment of ERIN-WSS technology can help understand the short and long term decisions that need to be made.

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) 10 MHz Xtal oscillator is refreshed / synchronized to 1pulse-per-second GPS reference at both nodes (all nodes)
2) 40 MHz digital clock is derived from 10 MHz reference
3) System Clock pulses radar from all system nodes on 10 MHz derived carrier
4) Short radar pulse (30 ns), is snatched on return after 100ns roundtrip
5) System clock closes window on ERIN return
6) Return pulse is downconverted to 3-37 MHz Intermediate Frequency (IF)
7) IF is digitized and tagged w/ time, position, and bearing
8) All return/ forward scatter data is combined w/ time tags at both nodes
9) "Interferometric baseline" model calibrates system geometry out of strand baseline
10) A second pulse is released after 2 msec

<u>Alternate Flow</u>

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

1) Instead of a PRI "wait period", a radiometer blanking switch can be triggered by the 130 nanosec transmit/return and enable "interleaved" operation
2) N Radiometer integration periods of M length (where 1.75 sec>N*M) – (e.g., for L-band @ 20 m/sec airspeed, <λ/4 element spacings are captured between pulses
3) These captured brightness temperatures, tagged with time, position, and bearing may also be synthesized or correlated to the radar
4) Further, all active and passive data can be co-registered to the big picture.(SMAP and Aquarius)

Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

After the Use Case measurement has been completed the ERIN data analysis will show trends that indicate the trend is either permanent (climatic), or synoptic (single events or cyclical). The decision-making processes in water management, crop management, forest management, coastal management, can direct local decision-makers and even world decision makers when co-registered with the lower resolution satellite measurements of SMAP and Aquarius.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.

- Rain⇉✉ Soil moisture Use case measurement "drying down" ⇉ Irrigation strategy/decisions USDA, Agribusiness
- Flood⇉✉ Soil moisture Use case measurement "drying down" ⇉ Rebuild strategy, FEMA, Insurance Business
- Coastal Erosion⇉✉ Soil moisture and Salinity Use case measurement "wetlands" ⇉ Corps of Engineers strategy/decisions local officials/inland wetland mitigation
- Drought Rain⇉✉ Soil moisture Use case measurement "drying down" ⇉ Water management strategy/decisions water reservoirs – Dept of Natural resources,
- Drought NO Rain⇉✉ Soil moisture Use case measurement "likelyhood of fire" ⇉ Fire management strategy/decisions – US Forest Service

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

The big picture provided by Aquarius and SMAP at low resolutions relative to ERIN Missions will uncover many target use cases where ERIN will resolve calibration issues due to vegetation camaflouge, polarization separation effects, and fresh/saltwater mixing and it's effect on flora and fauna.

This use case of ERIN-WSS Technology can synergistically work with Reconfigurable In-situ network (PI: Ayanna Howard) for calibrations of the local continuum measurement, and to calibrate the Land Information System (LIS) that ties in satellite SMAP/Aquarius measurements at lower resolution and higher coverages.

Resources

In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include data and services, and the systems that offer them. This section will call out examples of these resources.

Data:

Data	Type	Characteristics	Description	Owner	Source System
(dataset name) L-Band A/P	Grouped synchronous Nodes-strands synthesize a web	e.g., –low and slow/	good view under canopy/ drip line/	NASA, NOAA, USDA, USFS USGS, ESA,	Name of the system which supports discovery and access (from NRC)
Aka **SMAP** and **Aquarius**	Local continuum (remote)	High resolution (50-100m)	capture the steepness of the terrain and effects on saltwater mixing /filtering of	Lightweight technology will be relevant on solar system planetary exploration	**NPOESS** Joint Requirements Oversight Council **Aquarius** Mission Community

			wetlands/forest canopy and ground vegetation	also	

Modeling Services

Model	Owner	Description	Consumes	Frequency	Source System
Numerical Weather Prediction Model	NOAA (ERIN data will provide input to model)	Short description of the model	List of data consumed Radar scatter - σ Brightness Temperature - $T_{b,\ Both}$ at L-Band time and position tags	How often the model runs	Name of the system which offers access to the model
Seasonal climate models	NASA USDA (ERIN data will provide input to model)	A synthetic aperture radar formed from synchronous "shots", and calibrated returns coverage area	σ^{return}, $\sigma^{forward}$, T_b Tagged with, lat, long, alt, roll, pitch, yaw	One parallel or radial cycle – dump to master node	ERIN and the Image Processor – Master Node

Event Notification Services

Event	Owner	Description	Subscription	Source System
(Event name)	Organization that offers the event	Short description of the event	List of subscriptions (and owners)	Name of the system which offers this event
Soil Moisture Experiment (SMEx)	NASA/USDA NOAA	Soil Moisture Experiment is a ground truth campaign visit the Midwest U.S. to witness the "dry down" of target agicultural areas	NASA/USDA NOAA, Agribusiness	Soil Moisture Community

Application Services

Application	Owner	Description	Source System
(Application or DSS name)	Organization that offers the Application	Short description of the application, DSS or portal	Name of the system which offers access to this resource
Agriculture Management Water Management Coastal Management	USDA DNR/ Corps of Engineers Local/Unique	• Soil moisture "drying down" ⇉ Irrigation strategy/decisions • Drought Rain⇉ strategy/decisions water reservoirs – • Coastal Erosion⇉ Soil moisture and Salinity "wetlands" ⇉inland wetland mitigation	

Forest Management Emergency Management	Interior-USFS FEMA/ Insurance Industry	x Drought NO Rain⇉✉ Soil moisture - “likelyhood of fire” ⇉ Fire x Flood⇉✉ Soil moisture “drying down” ⇉ Rebuild strategy,	

Sensor resources

Sensor	Owner	Description	Frequency	Source System
(sensor name)	Organization that owns/ manages sensor	Short description of the sensor	How often the sensor can observe event	Name of the satellite or system which manages sensor
ERIN radar ERIN radiometers	NASA - GSFC	L-Band radar interleaved w/ L- Band radiometer on Slow and Low UAV or Balloon	Coverage area: 30 minutes on batteries/platform limitation	ERIN – Base station – Master Node- Image Processor – co-registration w/**SMAP, Aquarius** flyovers

11.6.7 Water Quality Monitoring

Point of Contact Name: Wei Ye

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☒ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☒ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☒ Earth Science Apps & Societal Benefits
- ☒ Land use change, ecosys. dynamics, biodiv.
- ☐ Weather - Space and Chemical
- ☐ Climate Variability & Changes
- ☒ Water resources & global hydrologic cycle
- ☐ Human health and security
- ☐ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☒ Targeted observations
- ☒ Incorporate feedback
- ☒ Ready access to data
- ☐ Improved use/reuse
- ☒ Rapid response
- ☐ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New______________________

AIST Needs Category

- ☒ 1-Data Collection
- ☒ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☒ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☐ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation

- ☐ New________________________________

Use Case Name *Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.* Water Quality Monitoring
Goal *The goal briefly describes what the user intends to achieve with this use case.* Monitor river water quality as it is influenced by water level changes due to upstream natural and man-made events.
Summary *Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.* River sampling triggered by stage (water level) change: The goal of this use case is to monitor water quality, and the transport of contaminants at a few sites along the Merced river in central California. We will use electric conductivity (EC), turbidity, and optical dissolved oxygen sensors. The water quality change is usually associated with upstream events that cause water level changes. Here, the precondition is that we have a reasonably steady state situation on our river site. To detect water level changes, we use pressure and temperature sensors, which take readings at every 1 to 5 minutes. The EC, turbidity, optical dissolved oxygen sensors are power hungry, and in order to reduce energy consumption, we only sample these power hungry sensors once per hour. If we see an increase/decrease in water level and/or a change in temperature that is out of the ordinary (i.e., beyond the pattern of change caused by solar radiation each day), then we take this as an indication of changes in reservoir operation or new inputs/outputs upstream. So we increase the sampling frequency of all the sensors to 1 to 5 min to capture the dynamic event.
Actors *List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.* Primary actors: scientists, reconfiguration programs, pressure and temperature sensors to detect water level changes Secondary actors: power hungry sensors: EC, turbidity, optical dissolved oxygen
Preconditions *Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.* 1) The water level stays in a relatively constant range. 2) Regular water level sampling with pressure and temperature sensors (1 sample/min) **3)** Low rate sampling with EC, turbidity, optical dissolved oxygen sensors (1 sample/hour).
Triggers *Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.* Pressure and temperature sensors detect out of the ordinary water level changes.
Basic Flow *Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)* 1) Calculate water-level changes with temperature and pressure sensors 2) Detect significant water level changes in a short period of time 3) When trigger condition is met, increase sampling rate of EC, turbidity, optical dissolved oxygen

sensors (1 sample/min)
Alternate Flow *Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.*
Post Conditions *Here we give any conditions that will be true of the state of the system after the use case has been completed.* Potential contaminants are captured with detailed dynamic changes in the river.
Activity Diagram *Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.*
Notes *There is always some piece of information that is required that has no other place to go. This is the place for that information.*

11.7 Cross-cutting

11.7.1 Collaborative Science Resource Allocation

Point of Contact Name: Phil Paulsen, Eric Miller, Will Ivancic

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions

- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☒ Earth Science Apps & Societal Benefits
- ☒ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☒ Climate Variability & Changes
- ☒ Water resources & global hydrologic cycle
- ☒ Human health and security
- ☒ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☒ Targeted observations
- ☒ Incorporate feedback
- ☒ Ready access to data
- ☒ Improved use/reuse
- ☒ Rapid response
- ☒ Improve cost effectiveness
- ☒ Improve data quality/science value

AIST Needs Category

- ☐ 1-Data Collection
- ☒ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☒ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☒ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☒ F-Decrease mission risk/cost thru autonomy/automation

Use Case Name
Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Collaborative Science Resource Allocation

Goal
The goal briefly describes what the user intends to achieve with this use case.

Reduce costs, improve science return, and enable new mission classes by providing a standards based mechanism for the reliable transmission of large data sets over multiple ground stations

Summary
Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

Currently, due to issues with such things as long and variable delays, arbitrary periods of link disconnection, arbitrary periods of high bit error rates, and large, bidirectional data rate asymmetries, platform developers are often constrained on the amount and type of science that can be conducted on a particular platform. For example, satellites in low Earth orbit typically have intermittent connectivity and short contact times with ground systems. That forces these developers to either limit the size of the data files that their sensors generate, or, fly larger antennas / higher power amplifiers in order to download all data during short windows. Although mechanisms exist to break files into pieces, broadcast them over multiple ground stations, and later reassemble them, these mechanisms are all mission unique and must be developed and maintained at all sites which handle the data. This implies that the user organization must own and maintain those assets. A standards-based approach (called delay tolerant networking or DTN), implemented on-board and in generic ground stations and network systems, would eliminate these issues and allow shared services and costs across a wide variety of communities. Once fully implemented, DTN will improve the reliability of data and command handling, increase the probability of tasking, increase the probability of downloading large images, and improve system throughput and timeliness. In addition, DTN may enable new classes of operationally responsive missions (Micro and Pico class) which typically lack the resources to transmit meaningful amounts of data.

Actors
List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Sensor developers
Platform developers
Ground stations / network operations centers
Satellite operations centers

Preconditions
Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

DTN code on-board the platform.
DTN code in the ground station.
DTN code in network systems.
DTN code in the operations center.
Service level agreements between platforms and service providers are in place.
Asset characteristics are known and captured in databases.

Triggers
Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

N/A

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) On-board sensor generates data.
2) DTN code “bundles” the sensor generated data with control and meta tag information (which describes how to process, store, dispose of, and otherwise handle the data) as well as a new bundle header (used for intermediate addressing) and places the data bundle in temporary storage on-board the platform.
3) A ground station and sensor platform establish contact.
4) Ground station and platform DTN services query each other to identify DTN service requirements.
5) The satellite and ground station negotiate the transfer of bundled files based on link performance metrics, contact time, addressing, and data priorities.
6) Data bundles are downloaded to the ground station.
7) Downloaded data bundles are error checked and receipt acknowledgements are sent to the originating source.
8) The sensor platform erases acknowledged data bundles (freeing up capacity for more science).
9) The ground station forwards the data bundles to the mission operations center.
10) Data bundles are received, error checked, and acknowledged as received.
11) The ground station erases data bundles stored temporarily as a part of this process.
12) The mission operations center unbundles the data.

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

Data is published for dissemination to subscribers requesting specific data types or data related to specific locations.
Data is provided with meta tags and permanently stored in a searchable archive.
Operations logs are also tagged and stored for forensic use following anomalous behavior.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

11.7.2 Dynamically Taskable Sensors

Point of Contact Name: Phil Paulsen, Eric Miller, Will Ivancic

AIST Categorization Check List
Please check relevant items in each category for your use case.

Decadal Missions
- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ HyspIRI
- ☐ ICESat-II
- ☐ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☐ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions
- ☐ ACRIMSAT
- ☐ Aqua
- ☐ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☐ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☐ Terra
- ☐ TRMM

Future Missions
- ☐ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☐ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category
- ☒ Earth Science Apps & Societal Benefits
- ☒ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☒ Climate Variability & Changes
- ☒ Water resources & global hydrologic cycle
- ☒ Human health and security
- ☒ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits
- ☒ Targeted observations
- ☒ Incorporate feedback
- ☒ Ready access to data
- ☒ Improved use/reuse
- ☒ Rapid response
- ☒ Improve cost effectiveness
- ☒ Improve data quality/science value

AIST Needs Category
- ☒ 1-Data Collection
- ☒ 2-Transmission & Dissem.
- ☒ 3-Data & Info Production
- ☒ 4-Search, Access, Analysis, Display
- ☒ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☒ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☒ E-Improve system interoperability, stds use
- ☒ F-Decrease mission risk/cost thru autonomy/automation

<u>Use Case Name</u>

Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Dynamically Taskable Sensors

Goal

The goal briefly describes what the user intends to achieve with this use case.

Provide sensor users with access to mission data and services with an easy to use, network centric interface

Summary

Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

Currently, sensor users must negotiate with platform owners and other, competing sensor users to obtain access to their sensors, once deployed. This process is often complicated by the scarcity of on-board resources available (i.e., power, thermal management, bandwidth, transmit time, etc…) and issues with such things as platform conflicting pointing or stability requirements. Finally, some operations, required for the successful use of a specific instrument, can inadvertently lead to conditions which may cause damage to another, unrelated sensors on the same platform (i.e., a command that causes an imager to slew across the sun, etc…).

In order to alleviate this problem, an automated system, based on earlier research conducted on network centric operations for ESTO, was proposed. This system, called VMOC (Virtual Mission Operations Center), allows sensor users to quickly request sensor access and tasking using a secure, simple to use interface. In addition, the VMOC is capable of prioritizing and deconflicting sensor operations using pre-defined rule sets established by the sensor and platform owners. VMOC can also autonomously prevent inadvertent damage to sensors by vetting all proposed sensor operations against pre-defined operations limits.

Actors

List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

Sensor users
Platform operators
Virtual Mission Operations Center
Communications system providers (who must provide a path for platform rule set updates)

Preconditions

Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

Predefined sensor and platform rule sets and operations limits.
Communications access to platforms for periodic updates to rule lists and ops limits.

Triggers

Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

Multiple, conflicting requests for access to sensors for operations and/or data products.
Requests for sensor operations that exceed available on-board resources.
Requests for sensor operations that exceed predefined safe operations limits.

Basic Flow

Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Sensor users request access to their sensor for tasking or data management.

2) VMOC prioritizes and deconflicts incoming sensor access requests.
3) VMOC queries mission databases to determine which sensor combinations are optimal for the current vehicle configuration / condition.
4) VMOC publishes the results and enables sensor access to selected users.
5) VMOC continuously monitors all sensor / vehicle operations and blocks any sensor task request which will exceed available resources or cause inadvertent damage to on-board sensors.
6) As sensor users complete their individual sensor operations, VMOC reassesses system limits and allows previously denied sensor users controlled access to their sensors, based on pre-existing rules and limits.
7) Any resulting data products are processed and autonomously routed back to VMOC.
8) VMOC assigns meta tag information to collected data and places a copy in a searchable, permanent archive.
9) VMOC publishes the collected data to subscribers who have opted to receive data related to a specific location, data type, etc…

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

Data is published for dissemination to subscribers requesting specific data types or data related to specific locations.

Data is provided with meta tags and permanently stored in a searchable archive.

Operations logs are also tagged and stored for forensic use following anomalous behavior.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.

Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.

11.7.3 Seamlessly Download Data

Point of Contact Name: Mohammed Atiquzzaman

AIST Categorization Check List

Please check relevant items in each category for your use case.

Decadal Missions

- ☐ ACE
- ☐ ASCENDS
- ☐ CLARREO
- ☐ DESDynI
- ☐ GACM
- ☐ GEO-CAPE
- ☐ GPSRO
- ☐ GRACE-II
- ☐ HyspIRI
- ☐ ICESat-II
- ☒ LIST
- ☐ PATH
- ☐ SCLP
- ☐ SMAP
- ☒ SWOT
- ☐ XOVWM
- ☐ 3D-Winds

Current Missions

- ☐ ACRIMSAT
- ☒ Aqua
- ☒ Aura
- ☐ CALIPSO
- ☐ CloudSat
- ☒ GPM
- ☐ GRACE
- ☐ ICESat
- ☐ JASON-1
- ☐ LANDSAT7
- ☐ LAGEOS 1&2
- ☐ NMP EO-1
- ☐ QuikSCAT
- ☐ ADEOS-II
- ☐ SORCE
- ☒ Terra
- ☐ TRMM

Future Missions

- ☒ Aquarius
- ☐ GOES-N/O/P
- ☐ Glory
- ☐ LDCM
- ☒ NPOES
- ☐ NPP
- ☐ OSTM
- ☐ OCO

Decadal Survey Category

- ☒ Earth Science Apps & Societal Benefits
- ☒ Land use change, ecosys. dynamics, biodiv.
- ☒ Weather - Space and Chemical
- ☒ Climate Variability & Changes
- ☒ Water resources & global hydrologic cycle
- ☒ Human health and security
- ☒ Solid earth haz., resources, dynamics

Sensor Web Features & Benefits

- ☐ Targeted observations
- ☐ Incorporate feedback
- ☒ Ready access to data
- ☐ Improved use/reuse
- ☐ Rapid response
- ☐ Improve cost effectiveness
- ☒ Improve data quality/science value
- ☐ New______________________

AIST Needs Category

- ☐ 1-Data Collection
- ☒ 2-Transmission & Dissem.
- ☐ 3-Data & Info Production
- ☐ 4-Search, Access, Analysis, Display
- ☐ 5-Systems Mgmt

- ☒ A-Increase science data value thru autonomous use
- ☒ B-Coord multiple observations for synergistic science
- ☐ C-Improve interdiscip science production environs
- ☒ D-Improve access, storage, delivery
- ☐ E-Improve system interoperability, stds use
- ☐ F-Decrease mission risk/cost thru autonomy/automation

- ☐ New_______________________________

Use Case Name
Give a short descriptive name for the use case to serve as a unique identifier. Consider goal-driven use case name.

Seamlessly Download Data

Goal
The goal briefly describes what the user intends to achieve with this use case.

The goal is to develop communication protocols for seamless download of data from on-board IP-enabled equipment.

Summary
Give a summary of the use case to capture the essence of the use case (no longer than a page). It provides a quick overview and includes the goal and principal actor.

Future Low Earth Orbiting (LEO) spacecrafts will contain IP-enabled equipment that will sense the Earth and send the sensed data to Earth for use by users. The spacecrafts download data whenever they come in contact with a ground station. However, due to rotation of LEO spacecrafts, the duration of contact with ground station is limited, with possibly no connectivity until the spacecraft gets in touch with the next ground station, resulting in intermittent communication connectivity with terrestrial Internet. The objective is to develop mobility management solutions which will allow data to be seamlessly downloaded from spacecrafts during handoff between ground stations and during intermittent disruption in connectivity with ground stations. Concepts based on multihoming and network mobility are used to achieve a seamless handoff and to reduce traffic in the space network.

Actors
List actors, people or things outside the system that either acts on the system (primary actors) or is acted on by the system (secondary actors). Primary actors are ones that invoke the use case and benefit from the result. Identify sensors, models, portals and relevant data resources. Identify the primary actor and briefly describe role.

A satellite losing connection with a ground station results in disruption of communication and consequently triggers the seamless handoff procedure.

The handoff procedure, in turn, results in signaling traffic between on-board equipment and peer computers on Earth.

Preconditions
Here we state any assumptions about the state of the system that must be met for the trigger (below) to initiate the use case. Any assumptions about other systems can also be stated here, for example, weather conditions. List all preconditions.

A satellite should be able to connect to another ground station or to another satellite through which it can reach the terrestrial Internet.

On-board equipment (science instrument and communications equipment) should be IP-enabled.

Triggers
Here we describe in detail the event or events that brings about the execution of this use case. Triggers can be external, temporal, or internal. They can be single events or when a set of conditions are met, List all triggers and relationships.

Loss of ongoing physical layer connectivity between a satellite and a ground station triggers the seamless handoff algorithm.

Basic Flow
Often referred to as the primary scenario or course of events. In the basic flow we describe the flow that would be followed if the use case where to follow its main plot from start to end. Error states or alternate states that might be highlighted are not included here. This gives any browser of the document a quick view of how the system will work. Here the flow can be documented as a list, a conversation or as a story.(as much as required)

1) Satellite looks for alternate ground station
2) Establishes physical layer link with new ground station
3) Requests IP address from the new ground station
4) Sends the new IP address to the peer computer on Earth

5)	Connection with old ground station is lost/terminated
6)	Communication proceeds through the new ground station

Alternate Flow

Here we give any alternate flows that might occur. May include flows that involve error conditions. Or flows that fall outside of the basic flow.

1) If a new ground station is not found, the satellite looks for another satellite through which it can reach ground.

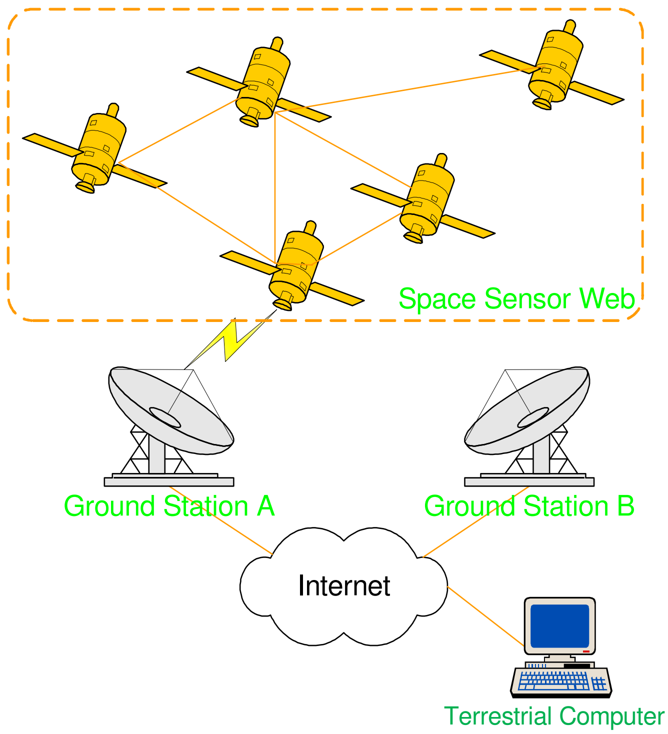
Post Conditions

Here we give any conditions that will be true of the state of the system after the use case has been completed.

Communication with the peer computer on Earth continues through the new ground station.

Activity Diagram

Here a diagram is given to show the flow of events that surrounds the use case. It might be that text is a more useful way of describing the use case. However often a picture speaks a 1000 words.



Notes

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12 Appendix D – Investigators & Research Projects

This appendix contains the list of participants and associated project abstracts, in alphabetical order (by title).

Adaptive Sky

Michael Burl
NASA Jet Propulsion Laboratory, Pasadena, CA

A ubiquitous problem in distributed sensing is relating the observations made by one instrument to the observations made by another instrument. This project aims to connect the dots by creating a toolbox of methods for automatically establishing correspondence between sets of observations. The toolbox will include purely data-driven methods, as well as hybrid approaches that utilize metadata and ancillary information (e.g., sensing geometry and parameters, predictive models based on object dynamics). A well-documented applications programmer interface (API) will be provided to insure that future Earth Science Sensor Webs will be able to leverage this capability in much the same way that the numerical computing community has leveraged tools like the LINear Algebra PACKage (LINPACK) and Numerical Recipes. The toolbox will include classical image co-registration techniques using point, edge, and area features, along with new approaches that make use of viewpoint invariant descriptors. The strengths and weaknesses for onboard application of the implemented methods will be carefully benchmarked and reported. The Adaptive Sky Cloud Science Sensor Web simulation, in which multiple instruments work together to monitor clouds over time, will be developed and illustrated using data from A-Train, Morning Train, and ground-based instruments. This simulation will demonstrate that robust feature correspondence can be used to automatically collect object-centric datasets of high scientific value, which could not otherwise be collected.

An Adaptive, Negotiating Multi-Agent System for Sensor Webs

Costas Tsatsoulis
University of Kansas, Lawrence, KS

The Department of Electrical Engineering and Computer Science of the University of Kansas proposes to perform research under NRA NNH05ZDA001N-AIST. The proposed research develops and tests the technology that allows nodes (pods) in a Sensor Web to collaborate in a rational manner, thus achieving improved sensing through intelligent, informed changes to the behavior of parts of the Sensor Web. Our work treats pods as agents in a multi-agent environment, and uses the observations of a pod or of a group of pods to guide future data collection activities of the Sensor Web or of large pieces of it. We develop techniques to identify significant events in the sensed data, that trigger the need to adaptively form pod coalitions and to collaborate for more effective sensing and processing. We also develop task planning behavior, such that pods not only react to the world they sense, but use this information to plan the execution of their behavior now and in the future, and prepare the appropriate pod coalitions. Rational behavior is achieved through negotiation for sensing and processing resources, assuring that pods agree to collaborate only when it improves the utility of the whole Web. The proposed research involves the areas of multi-agent systems, event monitoring, coalition formation, and negotiation between autonomous agents that leads to maximizing the group utility. The proposed work is of three year duration (August 16, 2006-August 15, 2009). The entry TRL is 2, and the exit TRL is expected to be 5.

Automated Data Assimilation and Flight Planning for Multi-Platform Observation Missions

Nikunj C Oza
NASA Ames Research Center, Mountain View, CA

This project will demonstrate the effectiveness of advanced data assimilation and flight and activity planning software technologies for daily management of Earth Science missions that combine sub-orbital observation with remote sensing data. This work will yield advanced software technologies aimed at improving the science acquired by missions and reducing mission costs by improving the efficiency of operations. We will demonstrate that these technologies yield higher quality flight plans (in terms of science value of measurements) in a shorter time than is currently possible while incorporating much more data and information into the plan generation process.

Autonomous Disturbance Detection and Monitoring System for UAVSAR

Yunling Lou
NASA Jet Propulsion Laboratory, Pasadena, CA

We will develop an autonomous disturbance detection and monitoring system with imaging radar that directly addresses one of NASA's major objectives to develop new space-based and related capabilities to advance Earth observation from space and demonstrate new technologies with the potential to improve future operational systems. This new capability will provide key information for the rapid response of natural disasters, such as hurricane landfall and forest fire, and can be readily extended to other hazards such as earthquake, volcanic eruption, landslide, and flood. The autonomous system will enable targeted observation of short-lived science phenomena or specific geologic features on planetary missions without overwhelming onboard data storage or downlink capacity and will reduce mission operations cost. This system has the potential to benefit the commercial sector by effectively monitoring forest disturbance due to fire, hurricane, or disease infestation. The autonomous system combines the advantage of radar's all weather capability to penetrate through clouds and collect data at night with high fidelity, high throughput onboard processing technology and onboard automated response capability based on specific science algorithms. This smart sensing technology development (Topic Area 1 of the proposal call) leverages the interferometric synthetic aperture radar onboard processor development for the NASA AIST-02 program and onboard automated response experience from Autonomous Sciencecraft Experiment onboard the New Millennium Earth Observation One spacecraft. We will improve the fidelity of the interferometric SAR onboard processor by implementing polarimetric and interferometric calibration capabilities, science algorithms for forestry application, and artificial intelligence for onboard automated response capability. We will develop a prototype smart sensor for demonstration on NASA's UAVSAR, an L-band polarimetric repeat-pass interferometric SAR sys tem. We will use UAVSAR to demonstrate automated response based on its own prior observation and based on external triggers from other sensors in a sensor web. This technology will take three years to develop. We will enter the development at TRL 3. The technology will advance to TRL 4 after 18 months by completing the high fidelity onboard processor development and verifying the automated response capability in a laboratory environment. We will exit the program at TRL 5 by demonstrating the closed-loop smart sensor concept with the UAVSAR instrument. This will reduce the risk, cost, and development time for infusing the smart sensor technology into future spaceborne Earth observing mission.

Autonomous In-situ Control and Resource Management in Distributed Heterogeneous Sensor Webs: CARDS

Ashit Talukder
NASA Jet Propulsion Laboratory, Pasadena, CA

We advance adaptive in-situ workflow and resource control technology in heterogeneous sensor webs to reduce response time, increase data quality and scientific value, and provide “timely relevant data and analysis” to the navigation, fishing, emergency management, and first responder communities in the New York/New Jersey areas. This will directly enable practical benefits for scientific research, national, regional and local decision- and policy-making, socio-economic benefits, and event response and natural hazard mitigation to NASA ESTO.

While the CARDS adaptive control, resource/workflow management, and informationtheoretic event detection technologies will be tested primarily on the NYHOPS maritime observation network, the capabilities developed here could easily by transferred to other regions, other aerial and terrestrial sensor modalities, and remote space-based sensor webs. Possible projects where technology infusion could occur directly as part of this program include California Ocean Current Mapping Program (http://www.cocmp.org) and Alaska Ocean Observing System (http://www.aoos.org).

The Detection and Tracking of Satellite Image Features Associated with Extreme Physical Events for Sensor Web Targeting Observing

John F. Moses
NASA Goddard Space Flight Center, Greenbelt, MD

This project will demonstrate a capability to detect, track and rank radiance structures in satellite image data that are associated with extreme physical events. Our objective is to define key elements of a generalized technology capable of populating cross-discipline target ranking models for Sensor Web application. Our aim is to show technologies that can distinguish structures associated with a variety of visually observable events in imagery.

Secondly, a single interface is desired for event detection and tracking algorithms to access data from multiple, diverse sensors and models. Through this interface, event targeting systems can access data from any sensors and data systems behind the interface.

The third objective is to enable discovery of new physical event detection models by implementing the capability to measure and rank geometric characteristics and show application in detection of the onset of convection, the occurrence of high winds and severe storm events.

We will also make the detection methods available to be evaluated for their ability to determine sensitive areas in weather forecast events.

Developing an Expandable Reconfigurable Instrument Node as a Building Block for a Web Sensor Strand

Phyllis Hestnes
NASA Goddard Space Flight Center, Greenbelt, MD

Developing an Expandable Reconfigurable Instrument Node as a Building Block for a Web Sensor Strand Abstract This document proposes the development of a Web Sensor Strand (WSS) that utilizes an Expandable Reconfigurable Instrument Nodes (ERIN) as a building block. The WSS would utilize multiple ERINs to tie distributed sensors together. Each ERIN would have the ability to know the relative position of at least two other ERINs and would have short-range communications ability with them. With a web of sensors (such as a web of Earth imaging and motion measurements, satellites) distributed either in a specified manner or in a random fashion it is important to make each member of the web radiate in coherence with other members. This enabling technology will be developed using wireless connectivity (a strand) between each node of a web. The Expandable Reconfigurable Instrument Node (ERIN) will provide a semi-closed loop system solution for a variety of sensors. The ERIN baselines a reconfigurable processing technology with required memory to allow on-board processing of science data. Standardized interfaces are provided to allow for interfacing to attitude control instrumentation such as Global Positioning Systems (GPS) and Inertial Measurement Units (IMU). A communications device will be added to the node that would allow for node-to-node communications. For low cost demonstration of the above concept, two Ground Penetrating Radars* separated by some distance on the ground will be used. Proper hardware (ERIN) and software (Web Sensor Strand) will be designed to operate these two physically separate transmitters in coherence with each other. *L-Band radar doesn't penetrate far (~20 cm) but is available through the DB-SAR IRAD (front end control). We want this to be compatible to many different wavelength front ends.

Efficient Sensor Web Communication Strategies Based on Jointly Optimized Distributed Wavelet Transform and Routing

Antonio Ortega
University of Southern California, Los Angeles, CA

Sensor webs performing fine-grained spatiotemporal monitoring of environments have the potential to completely change many existing Earth Science tasks as well as enable new ones. Because power consumption is often a fundamental limitation faced by sensor web nodes, a key challenge in realizing the potential of a sensor web is to enable energy-efficient, high-fidelity transfer of information captured by the sensors. Researchers have noted that energy efficiency can be achieved by a tight coupling of routing and data compression strategies, but much of this work has been theoretical. We propose to develop practical algorithms for joint compression and routing based on distributed wavelet transform techniques. Wavelets are known to be an excellent tool for representation and compression of correlated data. Here we develop compression tools and routing techniques that are optimized for a distributed implementation in a wireless sensor web. Substantial reductions in energy consumption can be achieved with respect to systems that do not use an intra-network wavelet transform. This also leads to improved data fidelity or increased system lifetime for a given energy constraint. Our team brings together expertise in data compression, digital communications and wireless sensor networks. Our work leverages substantial ongoing work (TRL 2) at USC, which has already demonstrated the benefits of the proposed methods. By taking advantage of existing state-of-the-art wireless sensor network facilities at USC we will advance the technology to TRL 5 after the third year. Our deliverables include a demonstration of our proposed techniques in realistic testbed settings.

End-to-End Design and Objective Evaluation of Sensor Web Modeling and Data Assimilation System Architectures

Michael Seablom
NASA Goddard Space Flight Center, Greenbelt, MD

We propose to: (i) design a sensor web architecture that couples future Earth observing systems with atmospheric, chemical, and oceanographic models and data assimilation systems; and (ii) build a sensor web simulator (SWS) based upon the proposed architecture that would objectively quantify the scientific return of a fully functional model-driven meteorological sensor web. Our proposed work is based upon two ESTO-funded studies that have yielded a sensor web-based 2025 weather observing system architecture, and a preliminary SWS software architecture funded by RASC and other technology awards. Sensor Web observing systems have the potential to significantly improve our ability to monitor, understand, and predict the evolution of rapidly evolving, transient, or variable meteorological features and events. A revolutionary architectural characteristic that could substantially reduce meteorological forecast uncertainty is the use of targeted observations guided by advanced analytical techniques (e.g., prediction of ensemble variance). Simulation is essential: investing in the design and implementation of such a complex observing system would be very costly and almost certainly involve significant risk. A SWS would provide information systems engineers and Earth scientists with the ability to define and model candidate designs, and to quantitatively measure predictive forecast skill improvements. The SWS will serve as a necessary trade studies tool to: evaluate the impact of selecting different types and quantities of remote sensing and in situ sensors; characterize alternative platform vantage points and measurement modes; and to explore rules of interaction between sensors and with weather forecast/data assimilation components to reduce model error growth and forecast uncertainty. We will demonstrate key SWS elements using documented 2005 hurricane season events.

Estimation of Entropy with Error Bars: Computing Information-Theoretic Measures of Causality

Kevin Knuth
University at Albany, Albany, NY

The specific aims of this project are to:

1. Develop novel computational techniques that accurately estimate entropy from multidimensional data sets. These methods must be accurate, relatively fast, and must quantify all uncertainties. Without quantifying the uncertainties in the estimates, one is unable to quantify the confidence in the results. Our efforts will focus on applying a recent stochastic integration method called Nested Sampling to a variety of density models such as mixtures of Gaussians, spline-based models and Voronoi cell models.

2. Make these computational techniques publicly available as tools to allow researchers to compute entropies and higher-order information theoretic quantities from data in large datasets of their choosing. These tools will be integrated into the analysis software already developed, or planned on:

   - International Satellite Cloud Climatology Program (ISCCP) http://isccp.giss.nasa.gov/
   - Gewex Radiation Panel http://grp.giss.nasa.gov/plans.html
   - Gewex Cloud System Study–Data Integration http://gcss-dime.giss.nasa.gov
   - Model Evaluation (GCSS–DIME)
   - NASA AISRP Code and Algorithm Library
   - http://astrophysics.arc.nasa.gov/AISRPCodeLibraryServer/index.html

Flow Webs: Mechanism and Architecture for Sensor Webs

Samuel D Gasster
The Aerospace Corporation, El Segundo, CA

Addressing fundamental architectural questions posed by sensor webs, we will prototype and demonstrate the flow web, a simple, novel architecture that captures the conflicting demands of sensor webs: dynamic adaptation to changing conditions, ease of experimentation, rapid recovery from the failures of sensors and models, automated command and control, incremental development and deployment, and integration at multiple levels, in many places, at different times throughout the internet. Flows may be attached to and detached from services at will, even while information is in transit through the flow, permitting "on-the-fly" integration of earth science products and modeling resources in response to changing demands. We will demonstrate the flow web integration of disparate models, agents, and resources into a seamless, autonomous sensor web via FIREWATCH, a wildfire detection and monitoring system, that relies on flow webs for dynamic model and agent integration, autonomous feedback, and resource management. We will advance flow web technology from a TRL of 3 to a TRL 4 by project end.

A General Framework and System Prototypes for the Self-Adaptive Earth Predictive Systems (SEPS) – Dynamically Coupling Sensor Web with Earth System Models

Liping Di
George Mason University, Fairfax, VA

The Self-adaptive Earth Predictive System (SEPS) concept combines Earth System Models (ESM) and Earth Observations (EO) into one system. EO measures the Earth system state while ESM predicts the evolution of the state. A feedback mechanism processes EO measurements and feeds them into ESM during model runs or as initial conditions. A feed-forward mechanism analyzes the ESM predictions against science goals for scheduling optimized/targeted observations. The SEPS framework automates the Feedback and Feed-forward mechanisms (the FF-loop). Scientists from GMU, GSFC, and UBMC will collaborate to 1) develop a general SEPS framework for dynamic, interoperable coupling between ESMs and EO, based on open, consensus-based standards; 2) implement and deploy the framework and plug in diverse sensors and data systems to demonstrate the plug-in-EO-and-play capability; and 3) prototype a Bird- Migration-Model-to-aid-avian-influenza-prediction SEPS and an atmospheric chemistry composition SEPS using this framework, to demonstrate the framework's plug-in-ESM-and-play capability and its applicability as a common infrastructure for supporting the focus areas of NASA research. This project will significantly advance 1) dynamic, interoperable and live coupling of ESM with the sensor web; 2) the sensor web from concept to operation with existing sensors and data sources; and 3) the use of service-oriented architecture in modeling and integration. The project will improve the accuracy and timeliness of monitoring and predicting rapidly changing Earth phenomena, such as severe weather and air pollution. The 3-year project will start in October 2006. The entry TRL is 4 and the exit TRL is 7.

Harnessing the Sensor Web through Model-based Observation

Robert Allan Morris
NASA Ames Research Center, Mountain View, CA

The objective of this project is to build, integrate and demonstrate automated capabilities for model-based observing. By model-based observing we mean the process of coordinating resources in a sensor web based on goals generated from Earth science investigations. Model-based observing will transform the sensor web into a cognitive web, a distributed, goal-directed sensing environment. The benefits of this work will be in improving the efficiency of the sensing resources as well as the science value of the data obtained. The work will significantly leverage the results of previous NASA-funded efforts, including successful efforts funded by the AIST program, as well as emerging web-based information retrieval technologies (SensorML). The work will address three technical challenges: 1) transforming Earth science goals into plans for accomplishing those goals, 2) reconfiguring the web through the execution of the plans, and 3) generating new or revised goals from the results of previous observations. This project realizes the NRA goal of "build[ing]" a direct two way interaction between forecast models and the observing system (topic area 3). This three-year project will solve the three technical challenges listed above in the first two years, resulting in a set of component capabilities that will be integrated and tested in realistic simulated scenarios in the third year. The entry TRL of the component technologies used in this project is 4; the expected exit level of the project is TRL 6. The interdisciplinary team includes expertise in planning/scheduling and Earth science to meet the technical challenges of this project.

Implementation Issues and Validation of SIGMA in Space Network Environment

Mohammed Atiquzzaman
University of Oklahoma, Norman, OK

There is significant interest in deploying the Internet protocol in space. A number of NASA-funded projects are studying the possible use of Internet technologies and protocols to support all aspects of data communication, including handover, with spacecraft. A spacecraft or a constellation of spacecrafts containing Earth observing sensing equipment forms a sensor web which has to be handed off between ground stations. Consequently, researchers at NASA and University of Oklahoma are developing a new handover scheme, called Seamless IP-diversity based Generalized Mobility Architecture (SIGMA). Although the results from simulation and laboratory prototyping have shown very promising performance of SIGMA, its performance in the real space environment has yet to be studied. The objective of this project is to investigate a number of implementation issues of SIGMA for space missions, and evaluate SIGMA on an experimental satellite network to make it ready for space flight missions. Implementation issues to be investigated include survivability, scalability, power awareness, security, and networks in motion using simulation and laboratory prototype testbeds. Evaluation in an experimental satellite involves testing SIGMA (in conjunction with NASA, Cisco and Surrey Satellite Technologies) on the experimental UK-DMC (Disaster Monitoring Satellite). The results of this project will be directly applicable to a number of NASA projects involved in sensing the Earth's environment using Internet protocol in space. This is a three-year project with entry and exit TRLs of 3/5 and 5/6, respectively.

Increasing the Technology Readiness of SensorML for Sensor Webs

Mike Botts
University of Alabama at Huntsville, Huntsville, AL

The Sensor Model Language (SensorML) defines an XML schema for describing any process, but is particularly adapted to the processes of measurement and the post-measurement processing of observations. In addition to defining the lineage of an observation, SensorML provides a web-friendly means for defining executable process chains for on-demand processing of sensor data to higher level observations. SensorML was developed by the PI and initially funded by the AIST program in 2000. SensorML is in the final stages of approval as an OpenGeospatial Consortium (OGC) Technical Specification. We propose to reduce the current challenges involved in implementing and utilizing SensorML by providing a collection of Open Source tools for creating, viewing, validating, mining, and executing SensorML processes. We will also demonstrate the application of these tools, and indeed the application of SensorML, in an end-to-end scenario of relevance to NASA's Earth Science community, including the derivation of SensorML documents by the initial sensor team, the configuration of OGC sensor web services, the development of product algorithms by research scientists, and the ultimate discovery and application of SensorML within the end user's Decision Support Tools. Most applications of SensorML technology, including discovery, implementation, and process execution, currently range in TRL levels from 4-6. During this 3 year effort, we intend to increase the TRL level of all facets of SensorML technology to at least 6, and in some cases 7. The entry TRL levels for the Open Source tools that we have proposed range from 2-4. These will be increased to TRL levels of 4-7.

An Inter-operable Sensor Architecture to Facilitate Sensor Webs in Pursuit of GEOSS

Daniel Mandl
NASA Goddard Space Flight Center, Greenbelt, MD

This project will develop the capability to generically discover and task sensors configured in a modular Sensor Web architecture, in space and in-situ, via the Internet. The proposed technology is thus well suited to assist future Earth science needs for integrating multiple observations without requiring the end-user to have intimate knowledge of the sensors being used. The project will also provide lessons for future mission design. The systems developed will be applicable to all six NASA science focus areas. For development, we will focus our efforts on two phenomena where the investigators have extensive experience within the context of land cover disturbance due to wildfires and severe storm events. Furthermore, the proposed technology will also be applicable to the support of calibration and validation activities of Committee of Earth Observing Satellites (CEOS). The proposed research will demonstrate and validate a path for rapid, low cost sensor integration, which is not tied to a particular system, and thus able to absorb new assets in an easily evolvable coordinated manner. The systems developed will be used to evaluate the efficiency of various sensor combinations and configurations in meeting real world science and applications goals. Finally, the proposed technology will facilitate the United States contribution to the Global Earth Observation System-of-Systems by defining a common sensor interface protocol based upon emerging community standards. We propose to enter at a TRL 3 and exit at TRL 6 during the three-year period of performance. This proposal is being submitted under topic area 1; smart sensing.

Land Information Sensor Web

Paul R Houser
Institute of Global Environment and Society, Inc., Beltsville, MD

This project will develop a prototype Land Information Sensor Web by integrating the Land Information System (LIS) in a sensor web framework will allow for optimal 2-way information flow that enhances land surface modeling using sensor web observations, and in turn allows sensor web reconfiguration to minimize overall system uncertainty. Through continuous automatic calibration techniques and data assimilation methods, LIS will enable on-the-fly sensor web reconfiguration to optimize the changing needs of science and solutions. This prototype will be based on a simulated interactive sensor web, which is then used to exercise and optimize the sensor web modeling interfaces. These synthetic experiments provide a controlled environment in which to examine the end-to-end performance of the prototype, and examine the impact of various design sensor web design trade-offs and the eventual value of sensor webs for particular prediction or decision support. In addition to providing critical Information for sensor web design considerations, this prototype would establish legacy for operational sensor web integration with modeling systems. Though the stand-alone LIS has achieved a TRL of 8, we determine our entry TRL to be 4 as other components are to be implemented and tested. This project will deliver an interoperable TRL 6 plug-and-play components based on LIS that enable data ingest and scientific analysis, the generation of new sensor web data products, connections to major spacecraft schedulers and task managers, metadata transformation and exchange, and data fusion techniques. This project directly addresses topic area 3: Enabling model interactions with sensor webs, and is expected to have a 3-year performance period starting from October 2006.

The Multi-agent Architecture for Coordinated, Responsive Observations

Dipa Suri
Lockheed Martin Space Systems Company, Palo Alto, CA

Remote sensing missions for earth science provide a wealth of information to help us understand the dynamics of our planet. However, the current stovepipe operational model of remote sensing missions, i.e., a single spacecraft transmitting data to dedicated ground operations centers (Fig. 1), introduces untenable latencies in developing data products that hinder model building and refinement as well as timely responses for hazard mitigation. Future missions will operate as part of a sensor web (Fig. 2) comprised of "interlinked platforms with onboard information processing systems capable of orchestrating real-time collaborative operations" [1]. The Multi-agent Architecture for Coordinated, Responsive Observations (MACRO), an extension of our current work on the Adaptive Network Architecture (ANA) is a natural technology for enabling the deployment and operation of a sensor web. The ANA software framework of multiple distributed agents provides localized autonomy on distributed science missions. The MACRO extensions will help overcome current mission limitations by facilitating real-time, reactive data acquisition, analysis, fusion and distribution which will greatly benefit society and scientific discovery/understanding. Our objective over a 3 year period is to mature MACRO from TRL 2/4 to TRL 5 (Sec 2.4), by focusing on two main topics that provide significant value to NASA's earth science missions: - Incorporation of self-describing sensor, processing and measurement models (Sec. 2.2.1.1) - Collaborative observations between agents via onboard planning, scheduling, and resource management (Sec. 2.2.1.2) - Validation on a representative hardware testbed with multiple demonstrations of a realistic earth science mission (Sec. 2.2.1.3).

An Objectively Optimized Sensor Web

David John Lary
University of Maryland, Baltimore County, Baltimore, MD

An autonomous Objectively Optimized Observation Direction System (OOODS) is of great utility for NASA's observation and exploration objectives. In particular, to have a fleet of smart assets that can be reconfigured based on the changing needs of science and technology. This proposal describes an OOODS designed as a sensor web element (plug-in) that is of use both now and for future NASA observing systems. The OOODS would integrate a modeling and assimilation system within the sensor web allowing the autonomous scheduling of the chosen assets and the autonomous provision of analyses to users. The OOODS operates on generic principles that could easily be used in configurations other than the specific examples described here. Metrics of what we do not know (state vector uncertainty) are used to define what we need to measure and the required mode, time and location of the observations, i.e., to define in real time the observing system targets. Metrics of how important it is to know this information (information content) are used to assign a priority to each observation. The metrics are passed in real time to the sensor web observation scheduler to implement the observation plan for the next observing cycle. The same system could also be used to reduce the cost and development time in an Observation Sensitivity Simulation Experiment (OSSE) mode for the optimum development of the next generation of space and ground-based observing systems. The entry TRL is 4 the exit TRL is 7.

Open-source Peer-to-Peer Environment to Enable Sensor Web Architecture

Matt Holland
NASA Goddard Space Flight Center, Greenbelt, MD

Our long-term objective is to enable an evolution of distributed Earth system sensors and related processing/storage components into elements of the Sensor Web by providing a flexible, dynamic, and reliable secure peer-to-peer (P2P) communication environment for these components. This distributed network of highly-accessible devices (peers) is the consequence of supplying a self-organizing "virtual network overlay" protocol-suite-—developed at GSFC from popular open-source P2P software technology—that can distribute data communication tasks among the sensors (viewed as peers, each assigned a peer-role) and control the flow of data. This ultimately will include dynamic monitoring, control, and configuration as well as autonomous operations, real-time modeling and data processing, and secure ubiquitous communications. We assert that our P2P technology provides a general platform for distribution/processing of scientific data, applicable to many different types of science problems, however we will typically pursue the long-term objective through work which applies our technology to some specific "relevancy scenario".

Optimized Autonomous Space - In-situ Sensorweb

WenZhan Song
Washington State University, Pullman, WA

In response to NASA's needs for Earth-hazard-monitoring sensor-web as formulated in NASA's New Age of Exploration study [1] ESTO's Hazard Monitoring [2] study, and NASA's Solid Earth Science Working Group Report [3], we propose to develop a prototype real-time Optimized Autonomous Space - In-situ Sensor-web, with a focus on volcano hazard mitigation and with the goals of: 1. Integrating complementary space and in-situ elements into an interactive, autonomous sensor-web. 2. Advancing sensor-web power and communication resource management technology. 3. Enabling scalability and seamless infusion of future space and in-situ assets into the sensor-web. To meet these goals, we will: 1. Develop a test-bed in-situ array with smart sensor nodes capable of making autonomous data acquisition decisions. 2. Develop new self-organizing topology management algorithms combining hierarchical control architecture with flat routing structure. 3. Develop new bandwidth allocation algorithms in which sensor nodes autonomously determine packet priorities based on mission needs and local bandwidth information in real-time. 4. Develop remote network management and reprogramming tools. 5. Integrate the space and in-situ control such that each element is capable of triggering by the other. 6. Synthesize the sensor-web data ingestion and dissemination through the use of SensorML. 7. Demonstrate end-to-end system performance with the in-situ test-bed at Mount St. Helens, and NASA's Earth Observing One (EO-1) platform. The period of performance will be three years. The development will begin at TRL 2 and is planned to exit at TRL 5. The research will stipulate the "Smart Sensing" topic area.

QuakeSim: Enabling Model Interactions in Solid Earth Science Sensor Webs

Andrea Donnellan
NASA Jet Propulsion Laboratory, Pasadena, CA

We propose to expand the development of our QuakeSim Web Services environment to integrate both real-time and archival sensor data with high-performance computing applications for data mining and assimilation. This work will substantially improve earthquake forecasts, which will ultimately lead to mitigation of damage from this natural hazard. We will federate sensor data sources, with a focus on InSAR and GPS data, for an improved modeling environment for forecasting earthquakes. Improved earthquake forecasting is dependent on measurement of surface deformation as well as analysis of geological and seismological data. Space-borne technologies, in the form of continuous GPS networks and InSAR satellites, are the key contributors to measuring surface deformation. These disparate measurements form a complex sensor web in which data must be integrated into comprehensive multi-scale models. In order to account for the complexity of modeled fault systems, investigations must be carried out on high-performance computers. We will build upon our "Grid of Grids" approach, which included the development of extensive Geographical Information System-based "Data Grid" services. In this project we will extend our earlier approach to integrate the Data Grid components with more improved "Execution Grid" services that are suitable for interacting with high-end computing resources. These services will be deployed on the Columbia computer at NASA Ames and the Cosmos computer cluster at JPL. Our period of performance is October 2, 2006 - Septemember 25, 2009. Entry level TRL of this project is 3 with an exit TRL at the end of the project of 5.

Reconfigurable Sensor Networks for Fault-Tolerant In-Situ Sampling

Ayanna M Howard
Georgia Tech Research Corp, Atlanta, GA

The goal of this proposal is to develop and validate the core technologies needed to enable reconfigurable sensor networks for fault-tolerant in-situ sampling for Earth science applications. The key technologies, which build on prior work done by the proposers, focus on science-driven sensor network diagnosis and topological reconfiguration of sensor networks. Control of reconfigurable sensor networks is fundamentally a difficult problem in which the system must balance issues of power usage, communication versus control, the effectiveness of adapting to the environment as well as to changing science requirements. These issues generally arise due to the limited perception, precision, and range constraints on communication channels that comprise the network. Diagnosis involves identifying and communicating necessary changes in network topology required to achieve science goals and compensate for sensor failure or communication dropouts. Reconfiguration involves physically reconfiguring the network topology based on input from the diagnostic process, in effect establishing a self-adapting sensor network. The novelty of our approach is on the focus of a decentralized versus centralized method of control in which interactions between sensor nodes are modeled topographically and manipulated locally to produce desired global behavior. These technologies will be integrated and demonstrated using a network of mobile sensors applied to a representative Earth science investigation. This proposal is directly responsive to Topic Area 1: Smart Sensing of the NRA Call by enabling "autonomous event detection and reconfiguration of sensor assets." The period of performance is planned as a 36-month effort and has an entry TRL of 3, with a planned exit TRL of 5.

Satellite Sensornet Gateway (SSG)

Aaron Falk
USC Information Sciences Institute, Los Angeles, CA

ISI proposes a technology development program to make sensornets more usable, economical, and manageable for NASA and other Earth scientists by designing and prototyping an open, flexible, remotely-managed Satellite Sensornet Gateway. This gateway provides storage and aggregation of data from wireless sensors, reliable transmission to a central datastore, and sensor instrument management and control. This greatly simplifies sensornet design by isolating common communication and management functions into a flexible, extensible component that can support any in-situ sensornet. The result is that in-situ sensors will become easier to deploy and manage, expanding their use by Earth scientists and enabling new observation systems and datasets. This three year project, scheduled to start in CY08, will design and build a prototype sensornet gateway along with initial NOC and datalogger interface functions. This prototype will be capable of interfacing to NASA GOES and IEEE 802.11 networks. Our assessment is that such a system is currently at TRL 3; our work will advance this concept beyond TRL 6. Our three science collaborators will assist in devising at least two field deployments of our gateway. Additionally, we will create an advisory group to leverage existing technology from the sensornet research community and ensure the prototype SSG is useful to Earth scientists and flexible in ways in which the field is expected to evolve.

Science Model Driven Autonomous Sensor Web (MSW)

Ashley Davies
NASA Jet Propulsion Laboratory, Pasadena, CA

We will create and demonstrate an autonomously-operating Model-based Sensor Web (MSW) capable of determining and tracking the physical state of a dynamic planetary-surface process. The sensor web will use the following technologies: science-based data analysis and modeling and automatic asset tasking. The MSW will be autonomous. It will rapidly process data and derive a deeper understanding of dynamic processes through data modeling. Model output (and process understanding) augments this level of process knowledge iteratively by seeking out additional data to enhance model accuracy, using sensors linked with SensorML. Data science return is therefore maximized, subsequent asset and resource use optimized, and a deeper understanding of the physical processes affecting a dynamic system (an erupting volcano) returned. The base technology developed has applications across many science disciplines (e.g., flooding, cryosphere change). The MSW meets the NASA Strategic Objective “Study the Earth system from space and develop new space-based and related capabilities for this purpose”, with the additional value of developing sensor web technology elsewhere in the Solar System. The proposed work will be completed in 12 months. The entry TRL is 3, and the exit TRL is 5.

SEAMONSTER: A Smart Sensor Web in Southeast Alaska

Matt Heavner
University of Alaska Southeast, Juneau, AK

We will construct a smart sensor web in Southeast Alaska to serve four broad research applications--Science, telecommunications, education and monitoring--with three technological emphases: (1) Network adaptation in response to acquired data and detected events, (2) Network nodes that self-modify their power management strategy, and (3) Flexibility and adaptability to accommodate new sensors, applications, and investigators. The primary product of this project will be a wireless backbone that will drastically reduce operational cost of data return for a broad spectrum of field investigators in the environmental bellwether of Southeast Alaska. This network, anchored in Juneau and extending from the Juneau Icefield to Glacier Bay, will be constructed as an aggregate of subnets tied together by long-range communication technology, particularly radio modems or satellite links. The network will return data on glacier dynamics and mass balance, watershed hydrology, coastal marine ecology, and human impact/hazards monitoring. Additional features include a semi-closed network model that employs common communication standards to import data and export configuration directives, power-miserly nodes, redundant connectivity and a robust network transport protocol. New users will be added by "dry-connecting" at the University of Alaska before proceeding to field deployment. Acquired data will be integrated into environmental science programs in classrooms in Juneau. Project success metrics include area served, return data volume and breadth, installation survival rate and impact on our understanding of the study sites. The three-year project will commence at TRL 4 and conclude at TRL 7 with further latent capacity to support sensor web communications research.

Secure, Autonomous, Intelligent Controller for Integrating Distributed Sensor Webs

William D Ivancic
NASA Glenn Research Center, Cleveland, OH

Glenn Research Center (GRC) proposes 3 year effort to develop key mobile networking technologies, information delivery protocols, and secure, autonomous, machine-to-machine communication and control technologies to enable an evolution of distributed Earth system sensors and processing components into sensor webs. This proposal concentrates on the architecture and development of system building blocks leading to autonomous sensor webs. In particular, GRC will leverage its existing relationships with Cisco Systems, General Dynamics, Universal Space Networks, the Army Battle Labs, the Air Force Battle Labs, Surrey Satellite Technology Limited, and the University of Oklahoma to develop a ground and space-based network and relevant protocols to enable and demonstrate time-critical interoperability between integrated, intelligent sensor webs consisting of space-based and fixed and mobile terrestrial-based assets. Furthermore, GRC plans on developing new relationships with existing sensor web operators and integrate their technologies and sensor webs into the overall system. GRC will first develop the necessary infrastructure and protocols to enable near real-time commanding and access to space-based assets. We shall then integrate General Dynamics' Virtual Mission Operation Center technology and open architecture interfaces with select terrestrial and/or aeronautics-base sensor web to demonstrate time-critical interoperability between integrated, intelligent sensor webs and knowledge generation. In parallel, GRC will work with Cisco Systems to research and deploy advanced mobile networking technology applicable to mobile sensor platforms. The Technology Readiness Level is 2 for all systems with an exit level for mobile network technology at 6 the file delivery and integrated intelligent sensor control at 8!

Semantically-Enabled Scientific Data Integration

Peter A Fox
The University Corporation for Atmospheric Research

We propose to form a collaboration between GEOsciences Network (GEON), Semantic Web for Earth Environment Technologies (SWEET) and Virtual Solar-Terrestrial Observatory (VSTO) to develop and integrate a suite of ontological representations for the Sun-Earth System and apply them to: Scientific Data Integration. The developed search and retrieval data integration capabilities would provide scientific value-added access to specific datasets spanning geological records, climate records, and solar records with a unifying theme of quantifying forcings for climate variability and change. Our baseline data sets include data from vulcanology (rocks), micro, regional and global climate indicators such as temperature and precipitation records, and space-based, ground-based and theoretical constructions of solar irradiance. This fully functional demonstration of the connection or collaboration of existing discipline-specific science and data domains using formal semantic representations of the science terminology (as distinct from attempting to interoperate at a much lower data terminology level) will then enable the connection to be re-used and applied between other NASA research focus areas, i.e., specific scientifically related disciplines that heretofore have been unable to rapidly and effectively exchange science data without the willing participation of experts.

Sensor-Analysis-Model Interoperability Technology Suite

Stefan R Falke
Northrop Grumman IT, TASC, St. Louis, MO

This proposal addresses NASA's requirements for enabling model interactions in sensor webs using service oriented architecture principles and geospatial interoperability standards. Sensor webs provide a new type of dynamic and real-time resource for earth science data analysis and modeling. The future interaction between sensors and models is expected to be bi-directional: sensors provide input data to models; model output provides information for planning where, when and what sensors will measure next. Today's earth science models are not capable of routinely assimilating sensor web observations and less capable of driving sensor measurements. The proposed project will use and extend geospatial interoperability and emerging sensor web standards, such as the Open Geospatial Consortium Sensor Web Enablement specifications, to bridge the gap between sensors and models. The proposed project will develop a Sensor-Analysis-Model Interoperability Technology Suite (SAMITS) that provides a package of standards, technologies, methods, use cases, and guidance for implementing networked interaction between sensor webs and models. SAMITS will foster seamless two-way data and control flow between active sensors and data analysis/modeling tools. SAMITS will be tested through use case applications that tie together atmospheric, air quality, and fire sensors with weather and smoke forecasting models. A tenant of the proposed approach is to reuse and extend existing technologies and development efforts. NASA's return on investment will be maximized and the time to implement two-way interaction between sensors and models minimized if the new technology development reuses existing distributed and interoperable information system components that are already available to assist in information flow between observation databases and models. Technology Readiness Level (TRL): Entry=2/3; Exit=6 Period of performance: 36 months.

Sensor Management for Applied Research Technologies (SMART) - On-Demand Modeling

Michael Goodman
NASA Marshall Space Flight Center, Huntsville, AL

The goal of the Sensor Management for Applied Research Technologies (SMART) On-Demand Modeling proposal is to develop and demonstrate the readiness of Open Geospatial Consortium (OGC) Sensor Web Enablement (SWE) capabilities that integrate both Earth observations and forecast model output into new data acquisition and assimilation strategies. The integrated SWE data assimilation and weather forecast package is relevant to NASA's Weather focus area and other Applications of National Priority (e.g., ecological forecasting through the SERVIR project) and will be responsive to environmental events for scientific research, applications and decision making processes. The proposal will plan, develop, and assimilate NASA satellite data sets into a regional weather forecast model over the southeastern U.S. The NASA Earth Observation System (EOS) satellites make real-time global observations of the Earth with revolutionary spectral and spatial fidelity on a continuous basis in support of NASA's research and applications programs. The challenge of accessing and integrating data from multiple sensors or platforms to address Earth system problems remains an obstacle because of the large data volumes, varying sensor scan characteristics, unique orbital coverage, and the steep learning curve associated with each sensor and data type. The development of sensor web capabilities to autonomously process these data streams (whether real-time or archived) presents an opportunity to overcome these obstacles and facilitate the integration and synthesis of Earth science data and weather model output. This three year proposal will advance information technology capabilities for adaptive data ingest and data fusion from TRL-3 to TRL-7. The first year will focus on the development and validation of the OGC compatible services and linkages (TRL-4/5). The second year will lead to the demonstration of the sensor web through the use of archived satellite data and model runs (TRL-6). The third year will culminate with the system prototype demonstration of real-time satellite assimilation into the WRF forecast model (TRL-7).

Sensor Web Dynamic Replanning

Stephan Kolitz
Charles Stark Draper Laboratory, Cambridge, MA

We will propose to extend the dynamic replanning capability of Draper's Earth Phenomena Observing System (EPOS), which has successfully demonstrated the capability to dynamically replan the activities of NASA space-based sensor assets to maximize the return of useful science measurements (e.g., ensure cloud free targeting). We will propose to enhance and extend EPOS to include the replanning of sensors on UAVs (Unmanned Aerial Vehicles) and USVs (Unmanned Surface Vessels) being fielded by NASA over the next few years. The new dynamic replanning capability will utilize complementary and cooperative suites of heterogeneous sensor assets that can be triggered by observation data and/or predictive models to adaptively respond to significant events and provide enhanced understanding of temporal Earth phenomena. An event-driven use of a sensor web would be to task sensor resources in response to observation-triggered cues for phenomenon, such as harmful algal bloom outbreaks. A model-driven use of a sensor web would be to task sensor resources in response to significant increases in meteorological forecast model error growth due to model sensitivities within specific atmospheric regions. The events and phenomena that present the largest potential payoff to the proposed replanning capability are characterized by being localized and transient and also capable of causing damage to both human life and property, e.g., weather (tornadoes, hurricanes, etc.), harmful algal blooms, volcanic eruptions, ice shelf break-up, seismic activities, oil spills, and search and rescue. In addition, the replanning capability will be enhanced to handle outages and failures of individual sensors.

Sensor-Web Operations Explorer (SOX)

Meemong Lee
NASA Jet Propulsion Laboratory, Pasadena, CA

We will develop a Sensor-web Operations Explorer (SOX) that can perform rapid exploration of dynamically configured air quality measurement scenarios and that can assess the optimality of a measurement scenario employing objective performance metrics (increased science information content, reduced uncertainty, and improved forecasting skill). The measurement scenarios will be executed on a high-fidelity sensor-web simulation system that integrates phenomena models, platform models, and instrument models. During field campaigns, adaptive measurement strategies are essential that account for changing atmospheric and meteorological conditions as well as the number and type of sensors, instruments, and platforms available at any given time. The goal of SOX is to enable users to plan measurement strategies that maximize science data return by identifying where and when specific measurements have the greatest impact. SOX will demonstrate both regional and global scale operations, helping to optimize satellite and sub-orbital resource usage. The SOX system architecture is organized around three sequential process groups: an Observation Design Process, an Observation Execution Process, and an Evaluation Process. The approach for developing SOX is to integrate existing, independently developed and validated high-TRL component modules using four interface subsystems that can be concurrently implemented and verified: - Sensor-Web Architecture Model (SWAM) - Sensor-Web Integrated-campaign Planner (SWIP) - Measurement Simulation and Distribution Service (MSDS) - Science Performance Metric Evaluator (SPME) We will develop the interface subsystems and provide overall system engineering. The work will be performed over a 3-year period. SOX maturity enters this project at TRL <3 and exits at TRL5.

A Smart Sensor Web for Ocean Observation: System Design, Modeling, and Optimization

Payman Arabshahi
University of Washington Applied Physics Laboratory, Seattle, WA

We propose a smart sensor web system composed of mobile and fixed underwater assets, combined with NASA satellite data, for ocean observation. The objectives of this task are to - Design, develop, and test an integrated satellite and underwater acoustic communications and navigation sensor network infrastructure and a semi-closed loop dynamic sensor network for ocean observation and modeling. - Perform science experiments in Monterey Bay, enabled by such a network, and evolve them to growing levels of sophistication over the period of performance (three years). Our approach is unique, in that it offers, for the first time: - A first-of-its-kind ad-hoc multi-hop satellite/acoustic sensor network, incorporating features such as reconfiguration of sensor assets, adaptive sampling and autonomous event detection, targeted observation, location-aware sensing, built-in navigation on mobile nodes (Seagliders), and high-bandwidth, high-power observation on cabled seafloor and moored nodes (mooring systems with vertical profilers). - Strong tie-in with the NASA satellite oceanography and ocean science community, in charge of carrying out new experiments which will overcome limitations in current approaches (undersampling of the ocean and aliasing of high frequency processes such as tides and internal waves). These experiments can also be used for in-situ calibration of data gathered via remote sensing by NASA satellites. This proposal addresses Topic Area 1, Smart Sensing, of the AIST call. .Proposed work will leverage extensive in-house expertise in acoustic networking and ocean science at the University of Washington, and the Jet Propulsion Laboratory. We project an entry of TRL-3 and an exit of TRL-7.

Soil Moisture Smart Sensor Web Using Data Assimilation and Optimal Control

Mahta Moghaddam
University of Michigan, Ann Arbor, MI

The proposed project addresses the topic of "Smart Sensing." It is motivated by a sensor-web measurement scenario including spaceborne and in-situ assets. The objective of the technology proposed is to enable a guided/adaptive sampling strategy for the in-situ sensor network to meet the measurement validation objectives of the spaceborne sensors with respect to resolution and accuracy. The sensor nodes are guided to perform as a macro-instrument measuring processes at the scale of the satellite footprint, hence meeting the requirements for the difficult problem of validation of satellite measurements. The science measurement considered is the surface-to-depth profiles of soil moisture estimated from satellite radars and radiometers, with calibration/validation using in-situ sensors. Satellites allow global mapping but with coarse footprints. The total variability in soil-moisture fields comes from variability in processes on various scales. Installing an in-situ network to sample the field for all ranges of variability is impractical. Our hypothesis is that a sparser but smarter network can provide the validation estimates by operating in a guided fashion with guidance from its own sparse measurements. The feedback and control take place in the context of a data assimilation system. The design and demonstration of the smart sensor web including the control architecture, assimilation framework, and logic actuation are the goals of this project. The proposed technology enables, for the first time, a guided/adaptive sampling strategy for generating optimal, statistically unbiased, calibration/validation data for space-based measurements. The project duration is three years with entry and exit TRLs of 2 and 5, respectively.

Telesupervised Adaptive Ocean Sensor Fleet

John M. Dolan
Carnegie Mellon University, Pittsburg, PA

Earth science research must bridge the gap between the atmosphere and the ocean to foster understanding of Earth's climate and ecology. Typical ocean sensing is done with satellites or in-situ buoys and research ships which are slow to reposition. Cloud cover inhibits study of localized transient phenomena such as a Harmful Algal Bloom (HAB). A fleet of extended-deployment surface autonomous vehicles will enable in-situ study of surface and sub-surface characteristics of HABs, coastal pollutants, oil spills, and hurricane factors. To enhance the value of these assets, we propose a telesupervision architecture that supports adaptive reconfiguration based on environmental sensor inputs ("smart" sensing), increasing data-gathering effectiveness and science return while reducing demands on scientists for tasking, control, and monitoring. We will autonomously reposition smart sensors for HAB study (initially simulated with rhodamine dye) by networking a fleet of NOAA surface autonomous vehicles. In-situ measurements will intelligently modify the search for areas of high concentration. Inference Grid techniques will support sensor fusion and analysis. Telesupervision will support sliding autonomy from high-level mission tasking, through vehicle and data monitoring, to teleoperation when direct human interaction is appropriate. Telesupervised surface autonomous vehicles are crucial to the sensor web for Earth science. We will integrate technologies ranging from TRL 4 into a complete system and reach TRL 6 within two years. In the third year, we will advance the system to TRL 7. This system is broadly applicable to ecological forecasting, water management, carbon management, disaster management, coastal management, homeland security, and planetary exploration.

Using Intelligent Agents to Form a Sensor Web for Autonomous Mission Operations

Kenneth J. Witt

Institute for Scientific Research, Inc., Fairmont, WV

Our team proposes to develop an architecture which shifts sensor web control to a distributed set of intelligent agents versus a centrally controlled architecture. Constellation missions introduce levels of complexity that are not easily maintained by a central management activity. A network of intelligent agents reduces management requirements by making use of model based system prediction, and autonomic model/agent collaboration. The proposed architecture incorporates agents distributed throughout the operational environment that monitor and manage spacecraft systems and self-manage the sensor web system via peer-to-peer collaboration. The intelligent agents are mobile and thus will be able to traverse between on-orbit and ground based systems. This network of intelligent mobile agents will be capable of modeling the future behavior of the subsystems and components that they are assigned to. Using situational awareness, the agents will be able to negotiate activities to self-optimize their subsystem or component. Furthermore, presented with a set of system goals, the network of agents will collaborate within the system to arbitrate the best set of activities to achieve a more global set of goals. With an initial proof of concept already working (TRL 3), the project will build over its proposed three (3) year effort to an end result proof of concept demonstration, at TRL 7. The demonstration will exercise the architectural features and prove applicability across a broad spectrum of Earth Science missions. Building on the team's experience with EO-1 and ST-5, the new demonstration will take steps towards increased levels of autonomy in mission operations.

Virtual Sensor Web Infrastructure for Collaborative Science (VSICS)

Prasanta Bose
Lockheed Martin Advanced Technology Center, Sunnyvale, CA

NASA envisions the development of smart sensor webs, intelligent and integrated observation network that harness distributed sensing assets, their associated continuous and complex data sets, and predictive observation processing mechanisms for timely, collaborative hazard mitigation and enhanced science productivity and reliability. The LMSSC-led Virtual Sensor Web Infrastructure for Collaborative Science (VSICS) effort will design, implement, demonstrate and mature (from TRL 3 to TRL 4 and higher) infrastructure creating a virtual sensor web for sustained coordination of (numerical and distributed) model-based processing, closed-loop resource allocation, and observation planning. VSICS's key ideas include i) rich descriptions of sensors as services based on semantic markup languages like OWL and SensorML; ii) service-oriented workflow composition and repair for simple and ensemble models; iii) event-driven workflow execution based on event-based iv) distributed workflow management mechanisms; and v) development of autonomous model interaction management capabilities providing closed-loop control of collection resources driven by competing targeted observation needs. The VSICS team combines the models and applications knowledge of Dr. Peter Fox (NCAR) in earth science and Dr. Neal Hurlburt (LMSSC) in space science; constraints driven resource allocation and scheduling expertise of Nicola Muscettella (LMSSC) and software architecture development strengths of Dr. Prasanta Bose (LMSSC). The project leverages model-interactions management and planning technologies being developed at LMSSC ATC.