Suomi NPP/JPSS Land EDR Overview

Products, Applications and J1 Readiness

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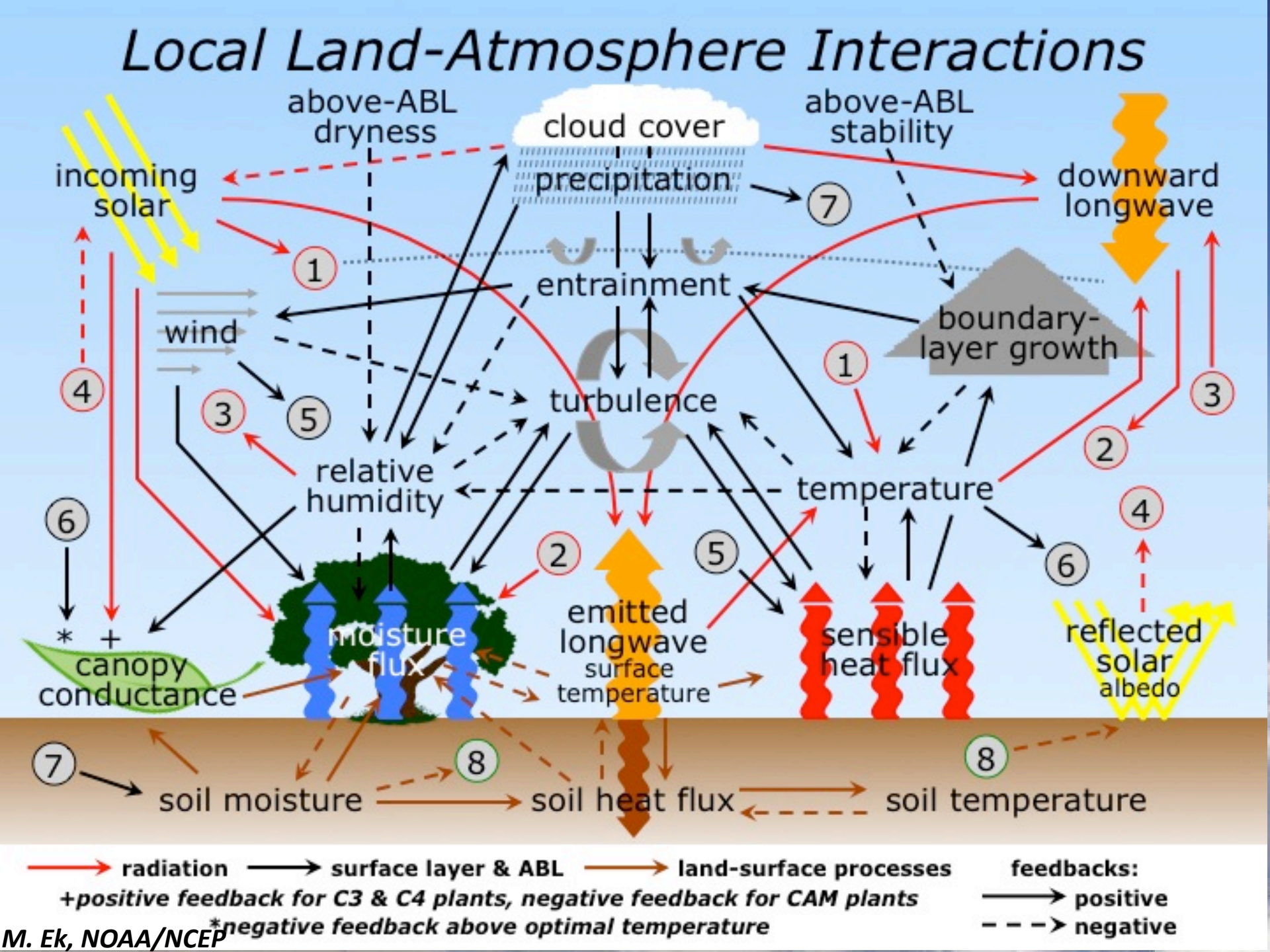
NOAA/NESDIS/STAR
and the NOAA JPSS Land Team
see slides for individual credits

Why monitor land surface?

- Land surface is an important component of the **integrated Earth System**
  - Interactions between land surface and all other "spheres" (e.g. energy, momentum, carbon)
  - Critical role of terrestrial ecosystems
- Most **human activities** take place there e.g.
  - Agriculture
  - Land use and land cover change
  - Urbanization
  - Sources of emissions
- Various **disasters** involve land surface processes e.g.
  - Droughts
  - Floods
  - Fires
  - Insects

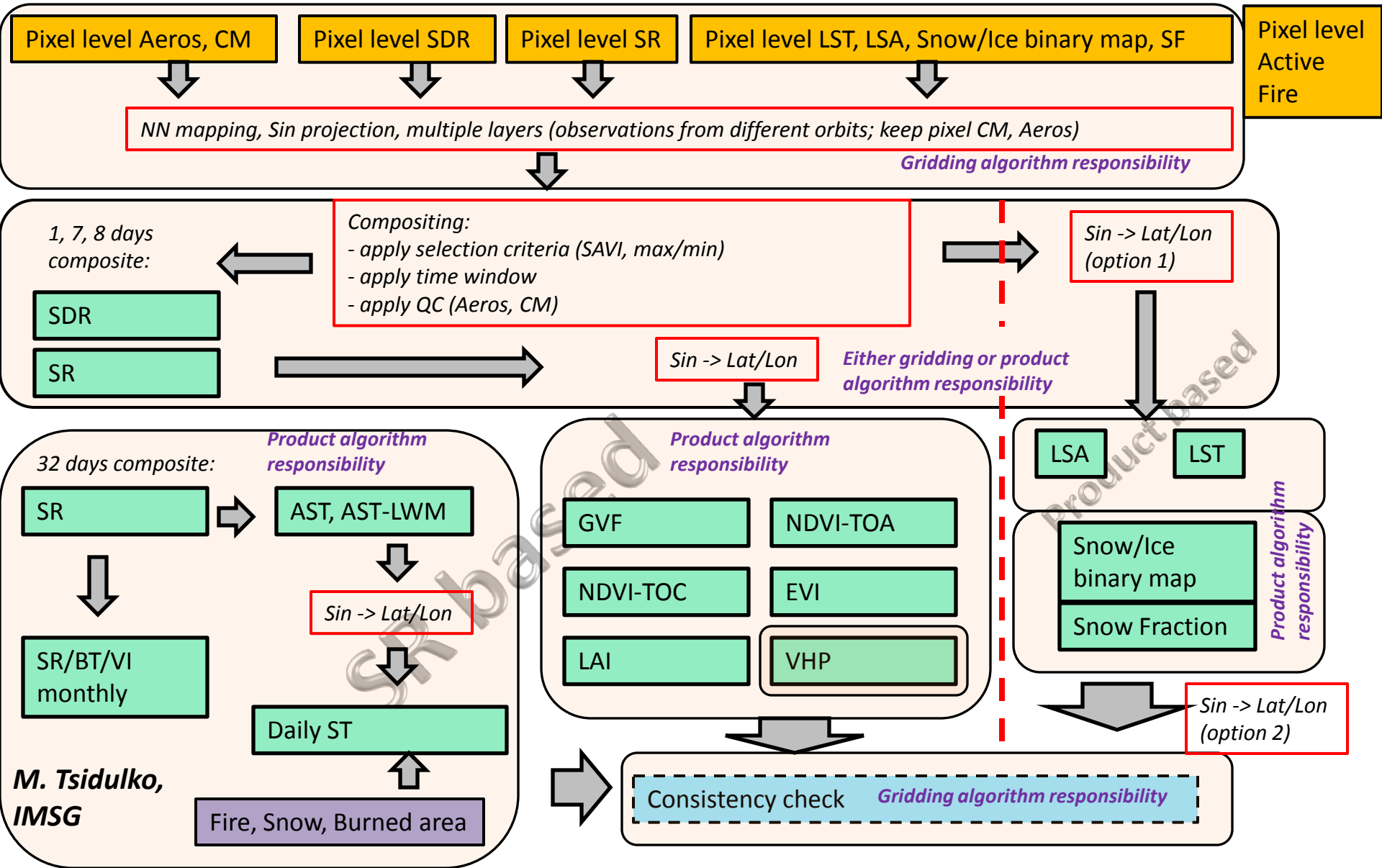
- Land surface variables are critical inputs to numerical **weather and climate models**
  - Previously used climatologies are replaced by real-time data


Local Land-Atmosphere Interactions
above-ABL dryness
cloud cover
above-ABL stability
incoming solar
precipitation
downward longwave
entrainment
wind
boundary-layer growth
turbulence
relative humidity
temperature
canopy conductance
moisture flux
emitted longwave
surface temperature
sensible heat flux
reflected solar
albedo
soil moisture
soil heat flux
soil temperature
radiation
surface layer & ABL
land-surface processes
feedbacks:
positive
negative
+positive feedback for C3 & C4 plants, negative feedback for CAM plants
*negative feedback above optimal temperature
M. Ek, NOAA/NCEP

Land algorithm status

- Land algorithms are currently transitioning to Enterprise solutions
  - changes in retrieval algorithm, product content, format
  - see presentations from the NOAA JPSS Enterprise Workshop for details
  - http://www.star.nesdis.noaa.gov/star/meeting_SJEAW2016.php)
- Long-term product monitoring and maintenance continues
  - http://www.star.nesdis.noaa.gov/jpss/EDRs/index.php
- Product development is directly in synch with operational applications
  - NCEP/EMC land: consistent, gridded, global, 1-km composites
  - biophysical variables for terrestrial ecological studies
  - fire radiative power for smoke/air quality applications
  - etc.
- Preparations for reprocessing are ongoing
  - http://www.star.nesdis.noaa.gov/star/meeting_JPSS2016_LDRW.php

Schematic view of proposed Land Enterprise System

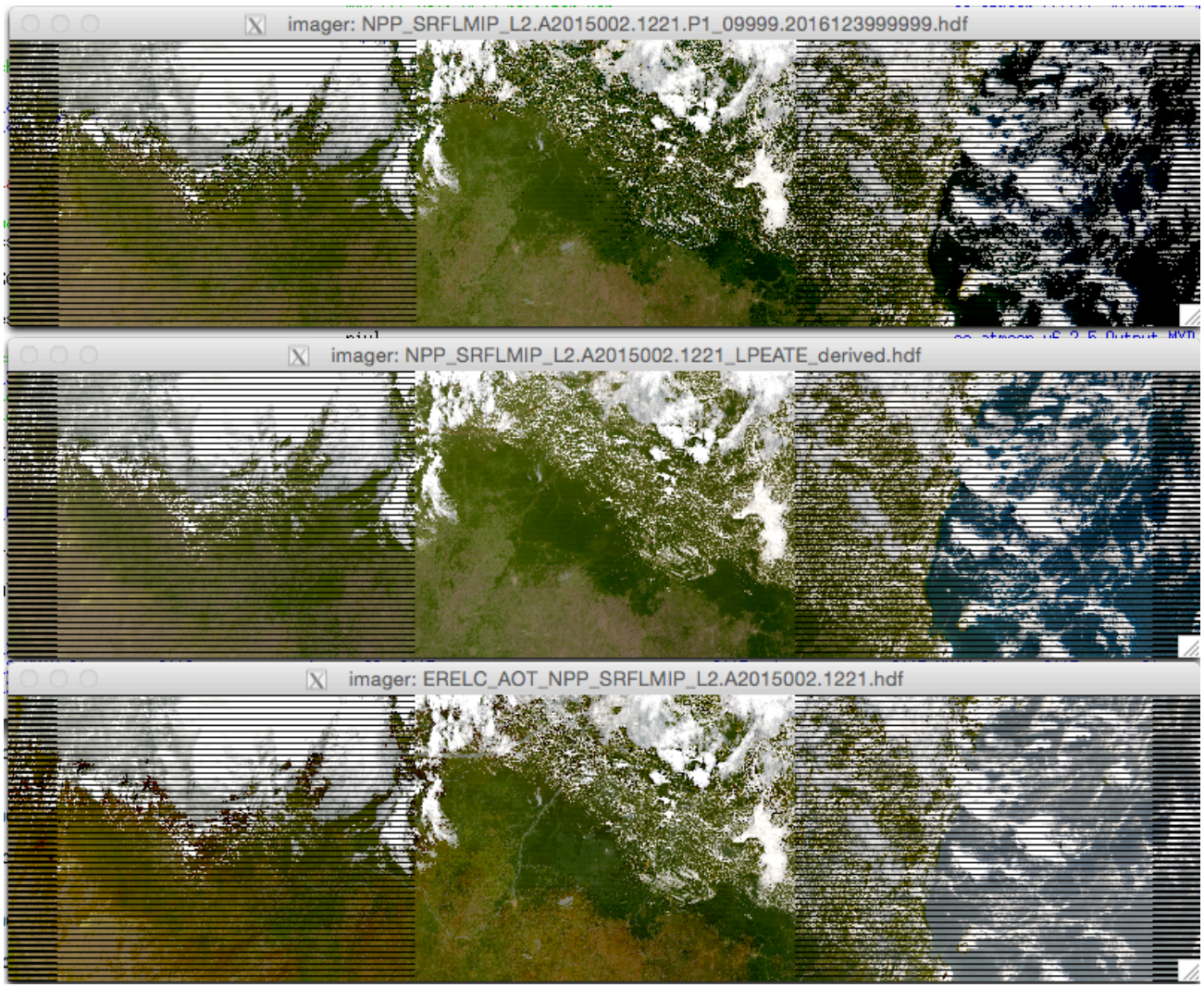


VIIRS Surface Reflectance

NOAA Enterprise

NASA LSIPS C5

NASA LSIPS C6



Critical Design Review for implementation of the NOAA Enterprise version is ongoing.

E. Vermote, NASA

VIIRS VEGETATION INDEX PRODUCTS

- Enterprise Algorithm for Vegetation Products (EAVP) is being developed that will run operationally at NDE
- The new Vegetation products (Phase-1:EVI, EVI2*, NDVI, GVF) will be global gridded at 1* km resolution
- For generating these new vegetation products, the EAVP will ingest the enterprise versions of the VIIRS SDR, CM, SR, and AOT datasets
- These new Vegetation products generated with the EAVP will incorporate all the refinements in sensor calibration (VIIRS SDR), improvements to the input datasets (CM, SR, and AOT), as well as changes/improvements to the VI-EDR algorithm (additional quality flags, new TOC NDVI dataset, improved quality definition, etc)

M. Vargas, STAR

*there is no JPSS requirement yet

FUTURE (PHASE–1) ENTERPRISE ALGORITHM FOR VEGETATION PRODUCTS (EAVP)

The Normalized Difference Vegetation Index (TOA and TOC)

$$NDVI = \frac{\rho_{\text{NIR}} - \rho_{\text{red}}}{\rho_{\text{NIR}} + \rho_{\text{red}}}$$

The Enhanced Vegetation Index (TOC)

$$EVI = 2.5 \frac{\rho_{\text{NIR}} - \rho_{\text{red}}}{\rho_{\text{NIR}} + C_1 \cdot \rho_{\text{red}} - C_2 \cdot \rho_{\text{blue}} + 1}$$

The 2-band EVI (no Blue band)

$$EVI2 = 2.5 \frac{\rho_{\text{NIR}} - \rho_{\text{red}}}{\rho_{\text{NIR}} + 2.4\rho_{\text{red}} + 1}$$

The Green Vegetation Fraction

$$GVF = \frac{EVI - EVI_0}{EVI_\infty - EVI_0}$$

Global Gridded Vegetation Products

- Projection: Geographic Lat/Lon
- Spatial resolution: 0.009 degree (1 km @ nadir)
- Temporal resolution: daily, weekly updated daily, bi-weekly updated daily
- Quality Flags: Land/Water, Coastal, Clouds, Aerosols, Snow/Ice, etc
- Additional Scientific Data Layers: Gridded, composited surface reflectance and observation geometry for use in science/advanced data analysis
- Format: tiled in NetCDF4

M. Vargas, STAR

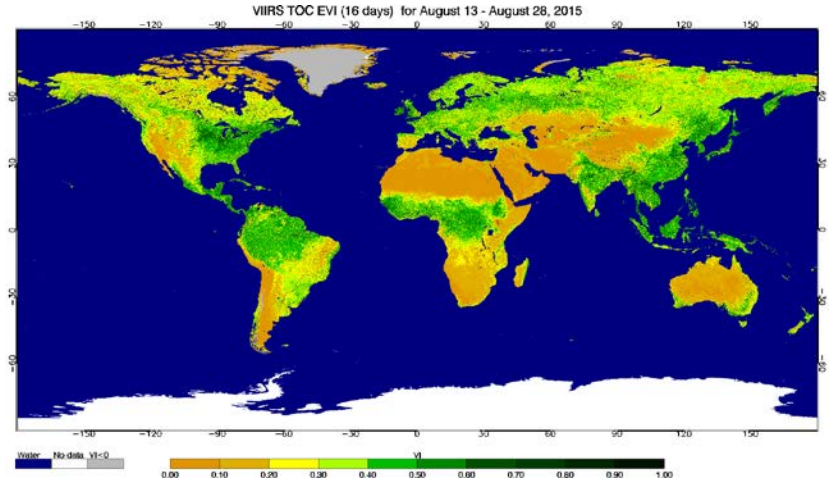
Phase - 2 Enterprise Algorithms for Vegetation Products

Phase - 2 Vegetation Products	Retrieval Strategy
Leaf Area Index (LAI): a measure of the amount of one-sided leaf area per unit ground area in a pixel	Following the MODIS heritage, the VIIRS **LAI** and **FPAR** products will be derived from a lookup table (LUT) based on three-dimensional canopy modeling combined with measurements of reflectance, surface type and viewing geometry
Fraction of Photosynthetically Active Radiation (fPAR): a measure of absorbed photosynthetically-active radiation (PAR) by vegetation	
(Daily) Net Photosynthesis (PSN): net carbon exchange over 1 day (photosynthesis – respiration)	$PSN = \varepsilon \cdot VI \cdot PAR$ **PAR** is the incident photosynthetically active radiation and $\boldsymbol{\varepsilon}$ is the light use efficiency
(Annual) Net Primary Production (NPP): the net flux of carbon from the atmosphere into green plants per unit time, i.e., the amount of vegetable matter produced (net primary production) per year	$NPP = \sum_{annual} PSN$ **NPP** is the time integral of **PSN** over a single year (will therefore be reported annually on a global 1-km grid)

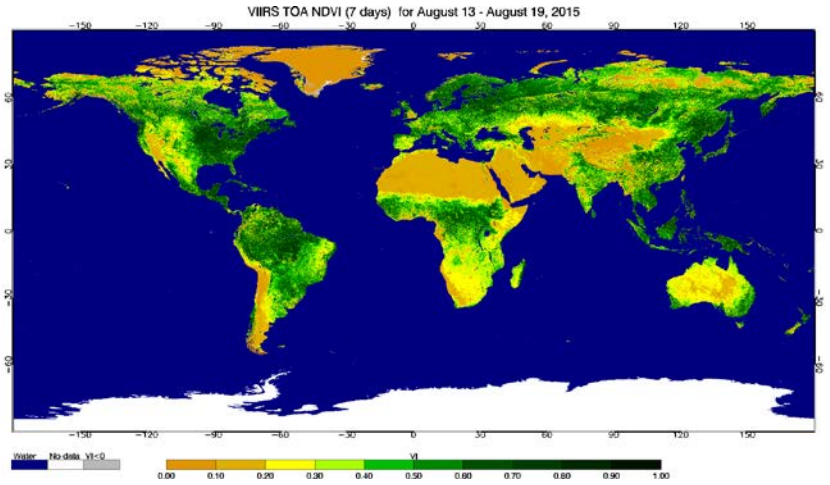
M. Vargas, STAR

Sample Global Gridded VIIRS Vegetation Products

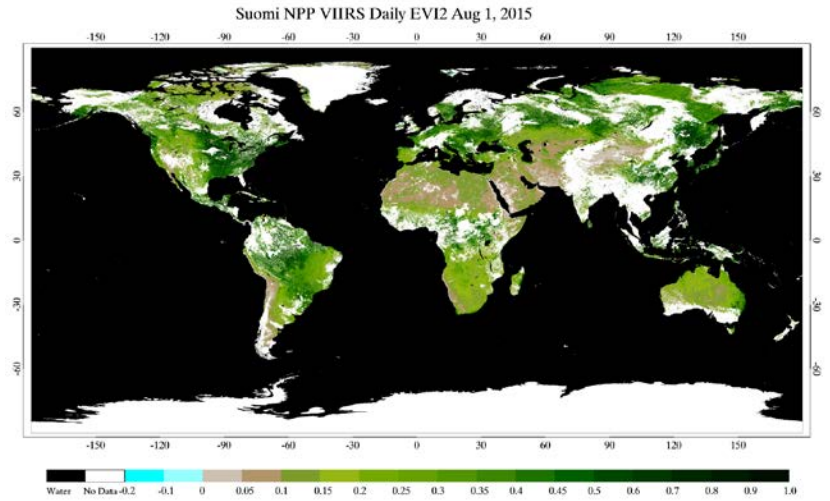
16-day TOC EVI August 13-28, 2015



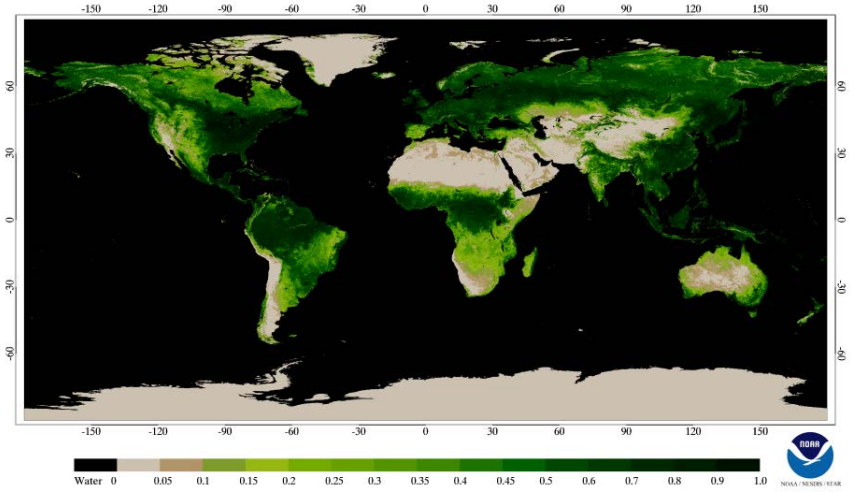
7-day TOA NDVI August 13-19, 2015



Daily TOC EVI2 August 01, 2015



Weekly GVF August 7-13, 2015



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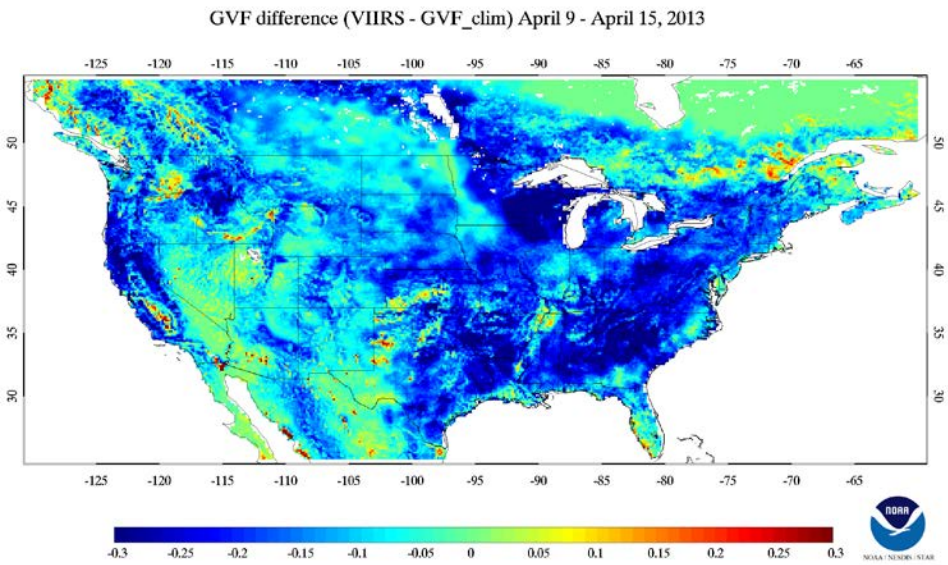
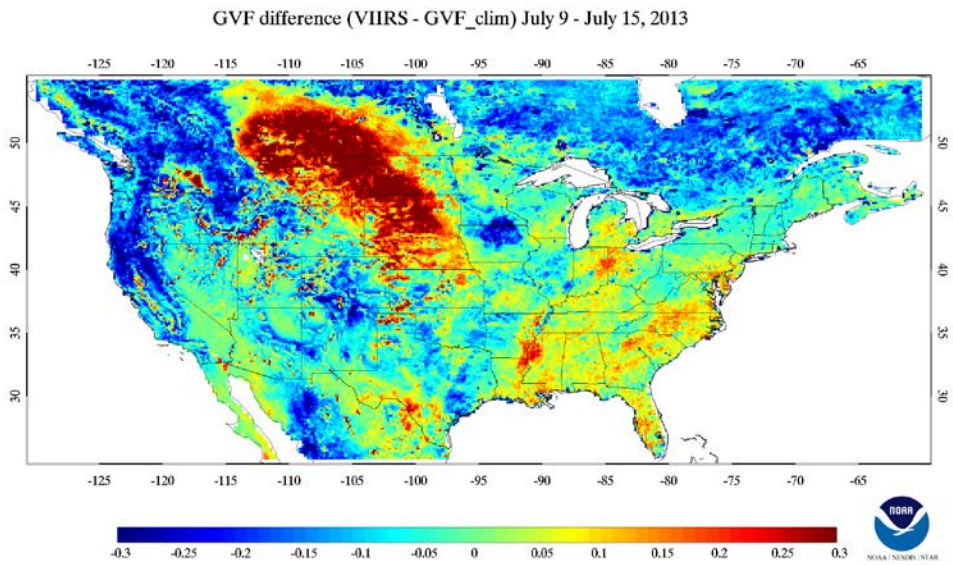
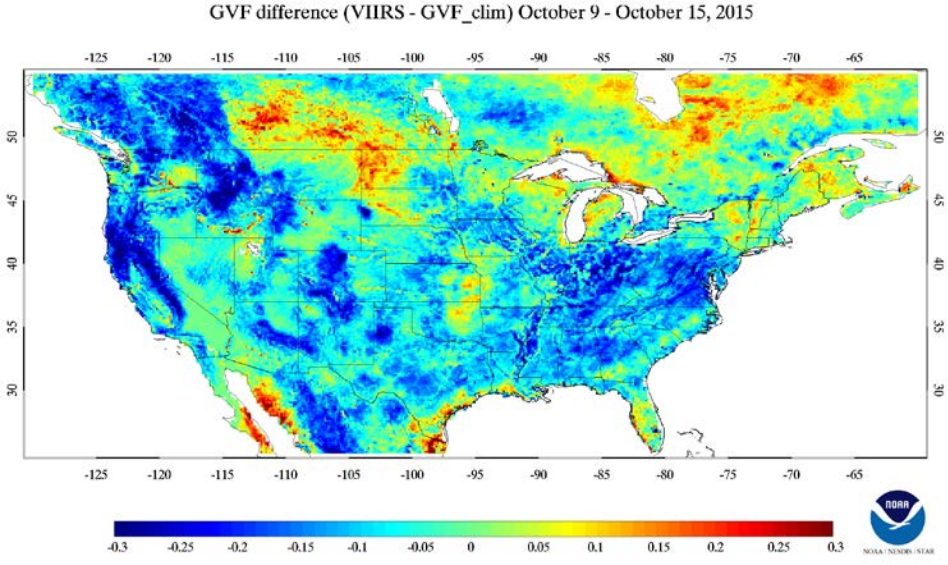
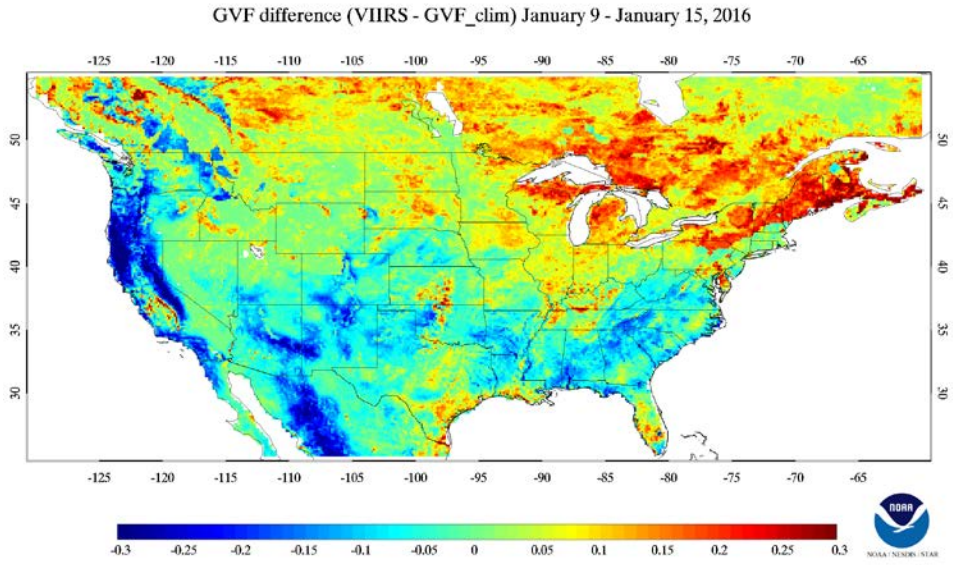
GVF difference (VIIRS-AVHRR clim.)





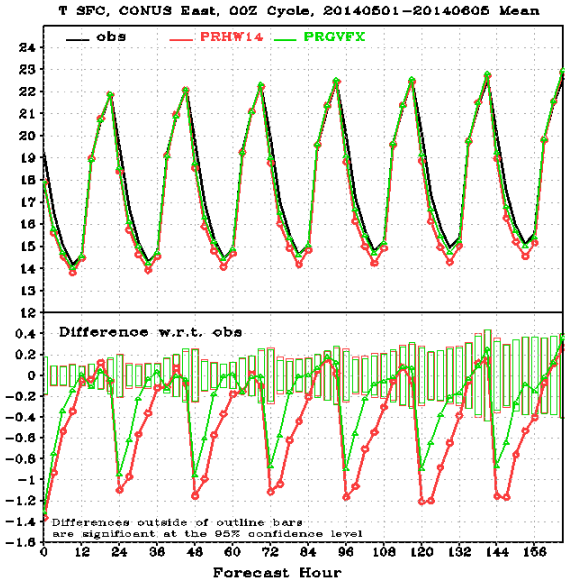




AVHRR GVF “climatology” is higher than VIIRS GVF over vegetated area in spring

M. Vargas, STAR

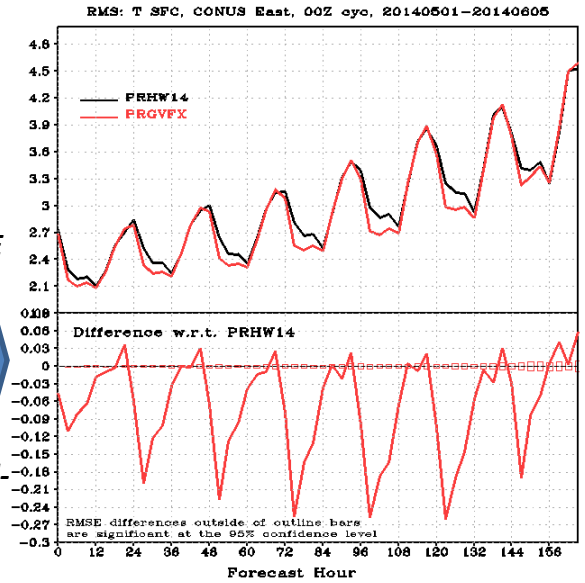
Green Vegetation Fraction Impacts



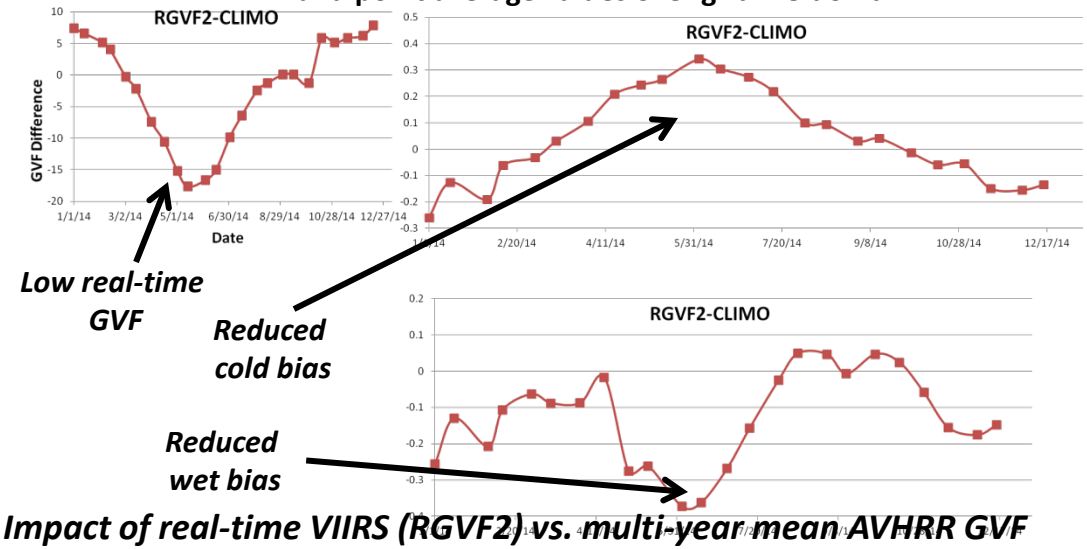
Surface temperature (T_{sfc}) for GFS model runs for the Eastern CONUS for May 1 – June 5, 2014.

T_{sfc} (top) and T_{sfc} [forecast – obs] (bottom). Black: observed; red: control run using multi-year AVHRR; green: experimental run using VIIRS near-real-time data.

T_{sfc} RMSE (top) and RMSE [VIIRS] – RMSE [control] (bottom). Black: control run using multi-year AVHRR; red: experimental run using VIIRS near-real-time data.



NAM land point average values over grid218 domain



Low real-time GVF

Reduced cold bias

Reduced wet bias

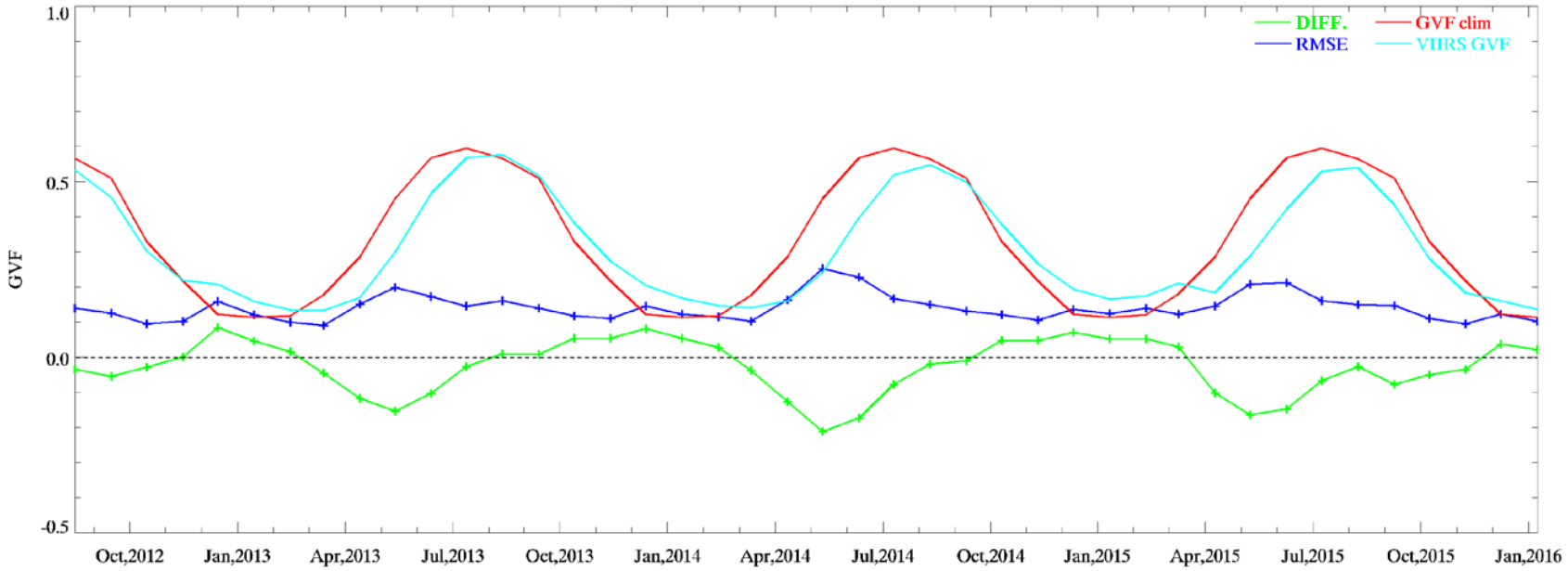
Impact of real-time VIIRS (RGVF2) vs. multi-year mean AVHRR GVF (CLIMO) on NAM near-surface air and dewpoint temperatures in 2014

NWS NGGPS Project: Incorporation of near-real-time Suomi NPP Green Vegetation Fraction and Land Surface Temperature data into NCEP Land modeling suite

PIs: I. Csiszar (STAR), M. Ek (EMC)

Team: M. Vargas, W. Zheng, Y. Wu, Y. Yu, Z. Jiang, Z. Song

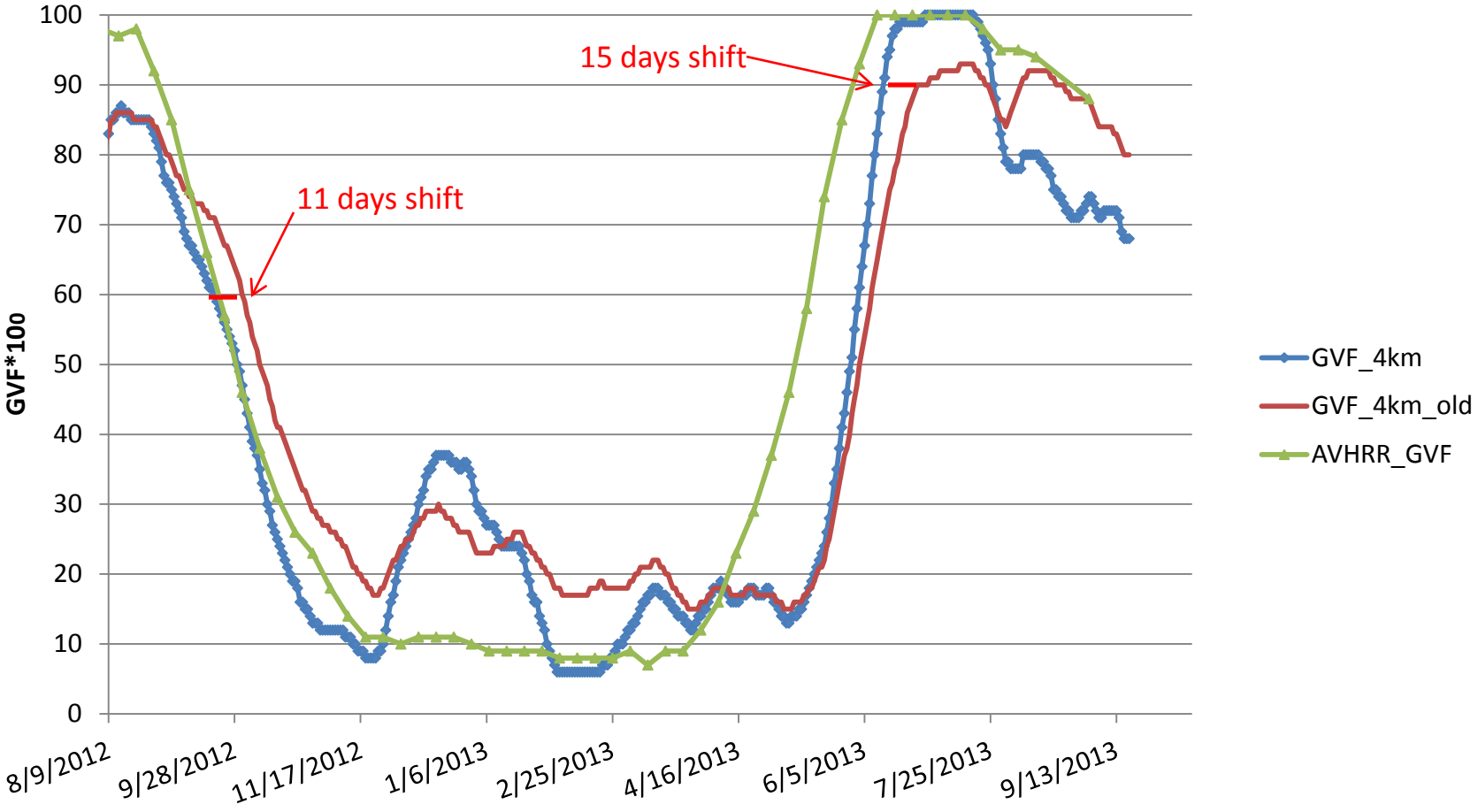
Difference and RMSE between VIIRS and AVHRR GVF Climatology



- Mean GVF climatology is slightly higher than VIIRS GVF
- Positive difference in winter and negative difference in spring and summer
- RMSE is relatively low

M. Vargas, STAR; J. Jiang, Riverside / AER

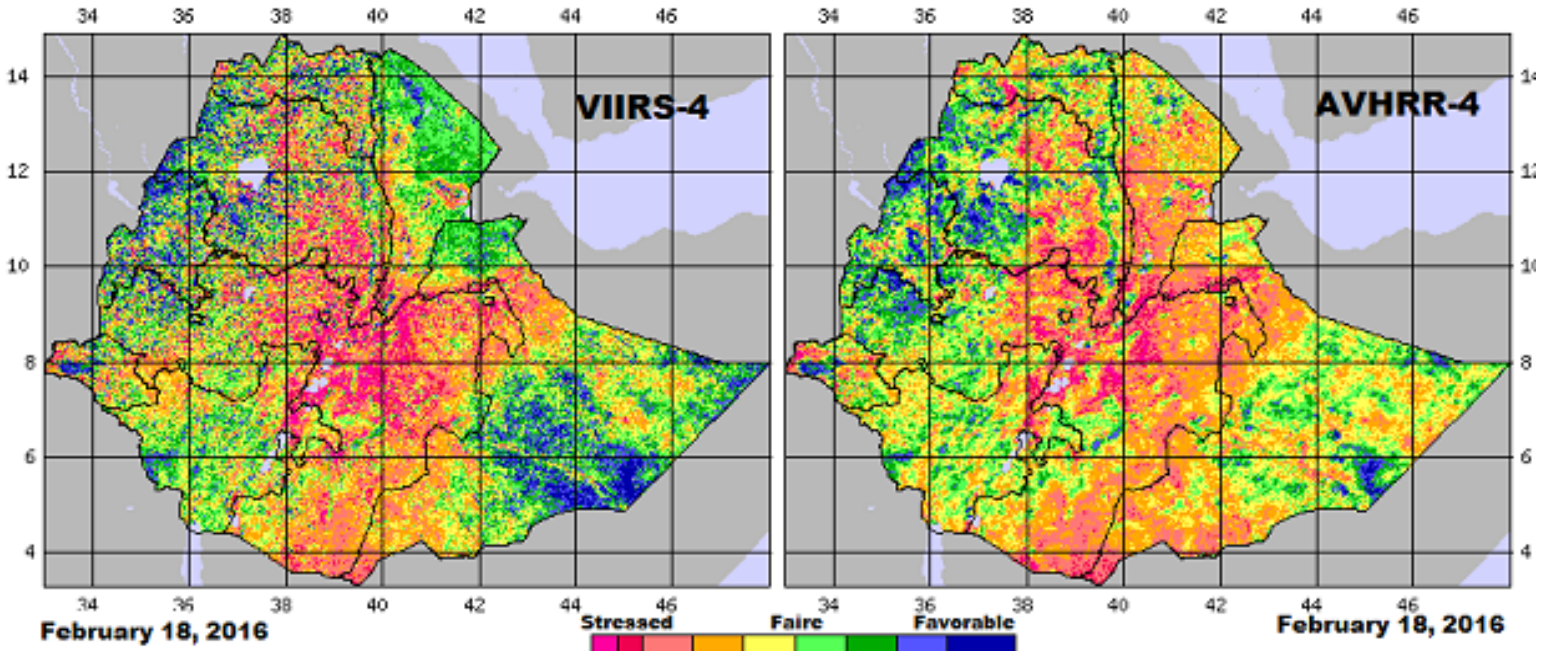
Updated VIIRS GVF at Changbai mountain



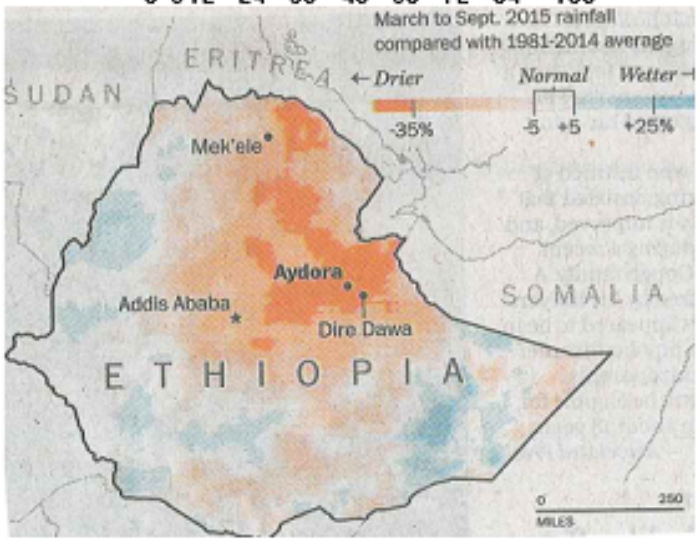
Biome: Mountain Forest

M. Vargas, STAR; J. Jiang, Riverside / AER

Vegetation Health



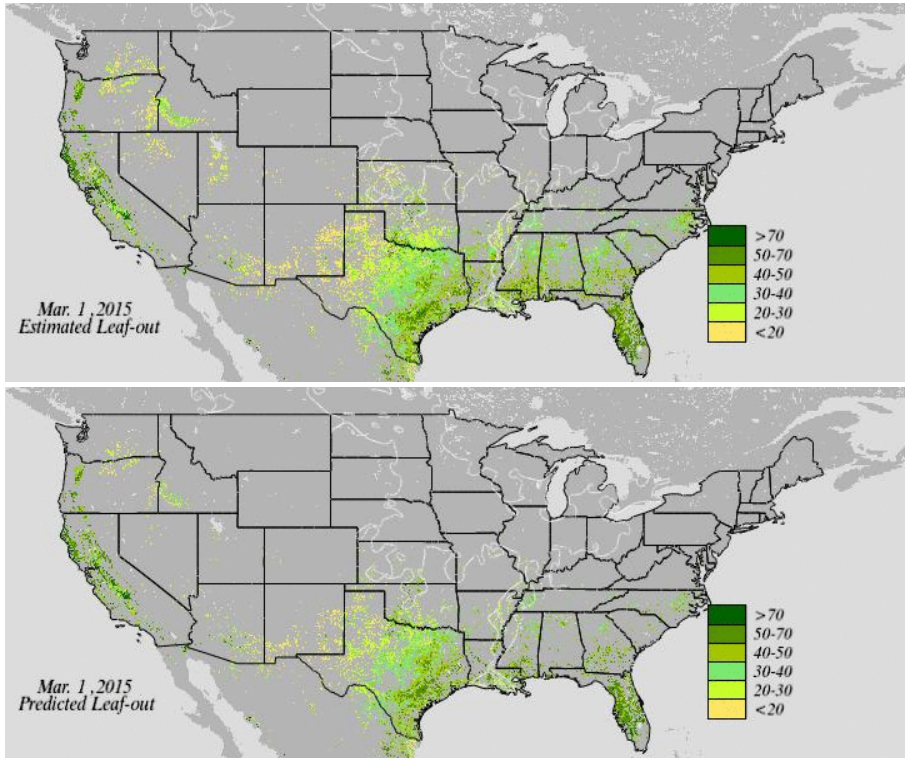
VIIRS vs AVHRR & Precipitation ETHIOPIA 2016



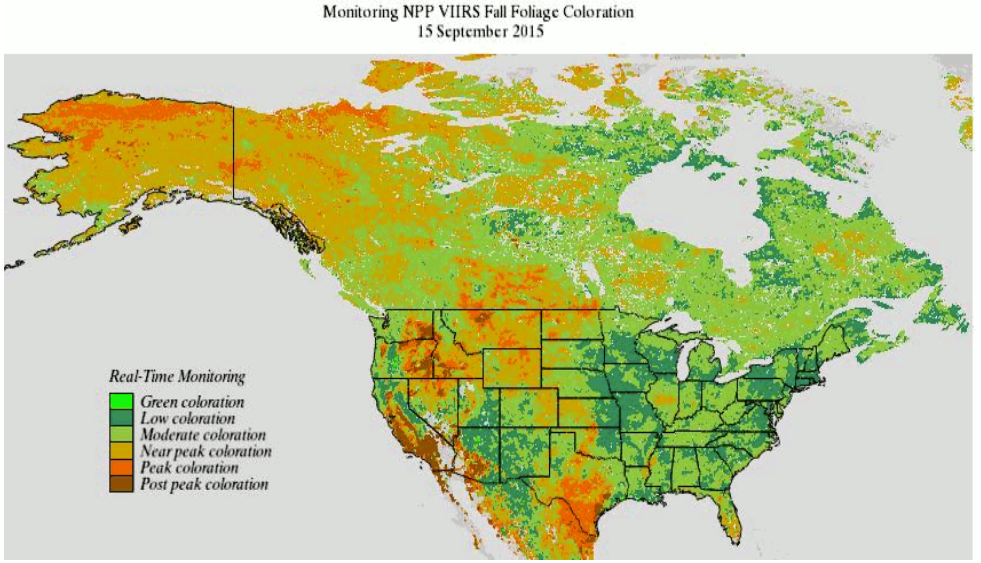
March-September 2015 precipitation anomaly
(deviation from 1981-2014 average)

F. Kogan, STAR

Phenology: monitoring and prediction of vegetation changes



Monitoring and predicting vegetation phenology supports applications in agriculture, ecosystem monitoring, numerical weather prediction and tourism.

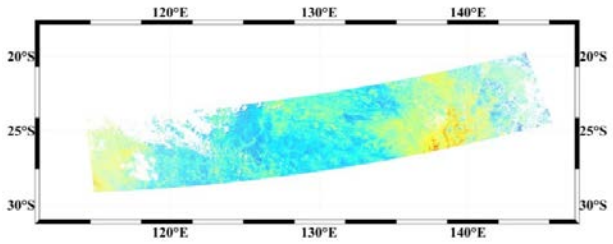


http://www.star.nesdis.noaa.gov/JPSS/EDRs/products_Foliage.php

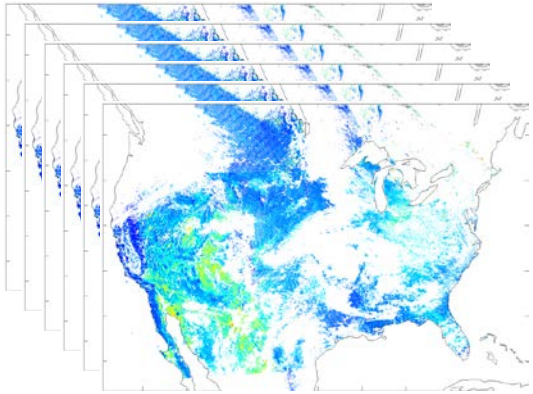
Y. Yu, STAR; X. Zhang, SDSU

Enterprise land surface albedo

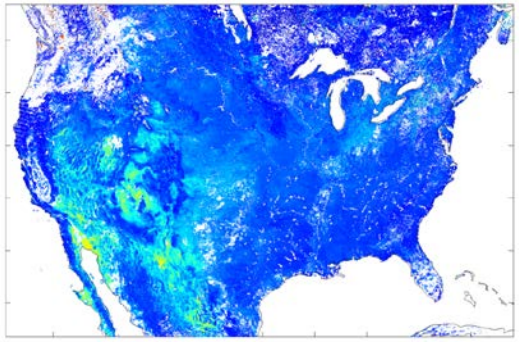
- Quality of SDR, cloud mask and surface types will have direct impacts on albedo retrievals
- Land Surface Albedo reprocessing first will be based on the granule product first
  - Eventually will include a new gridded daily LSA product
- Limited retrospective reference data and validation tools are available.



granule



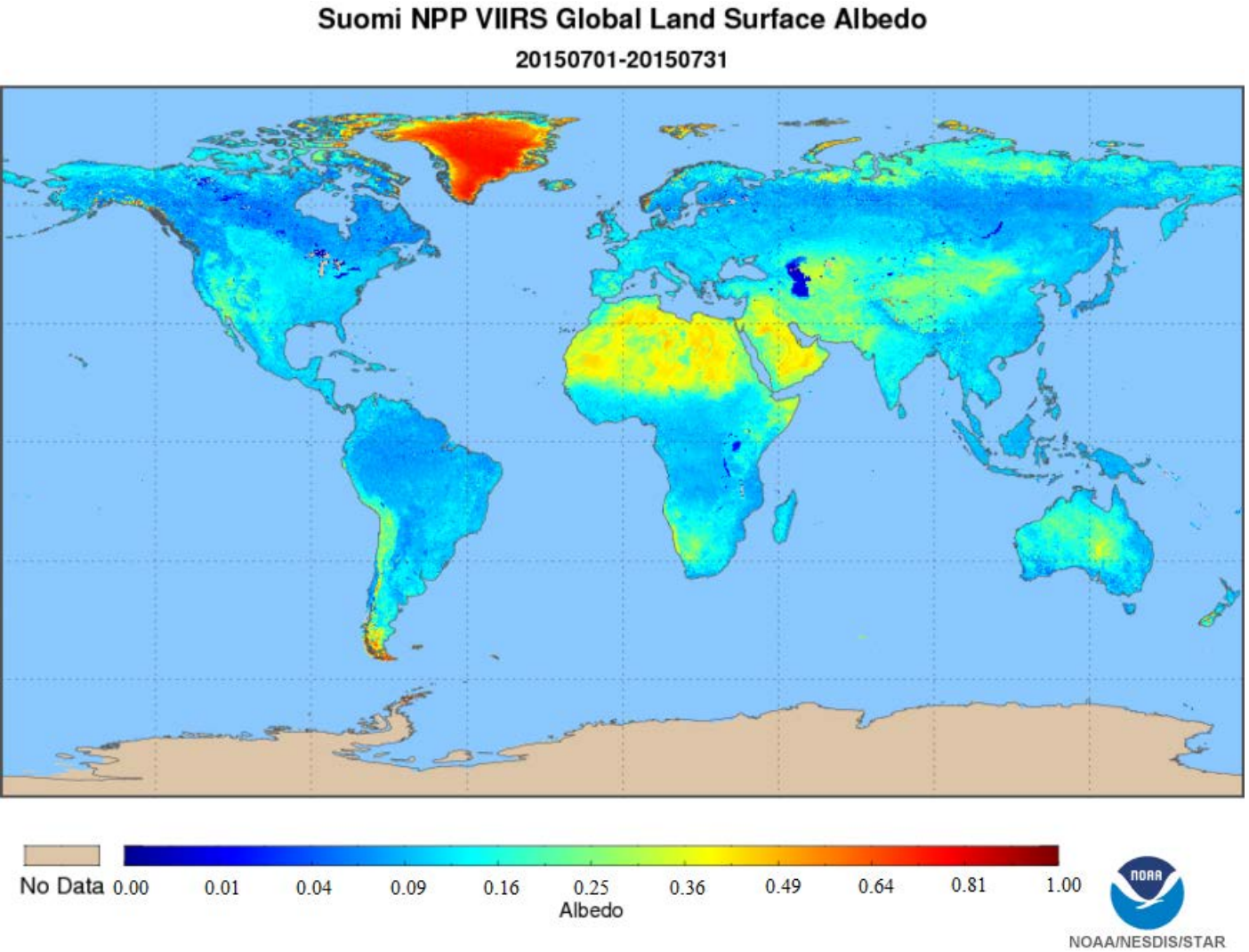
daily gridded



multi-day gridded

Y. Yu, STAR

Albedo: surface energy balance, numerical weather and climate modeling



A gridded albedo product is in development to serve the needs of NOAA's land surface modeling activities.

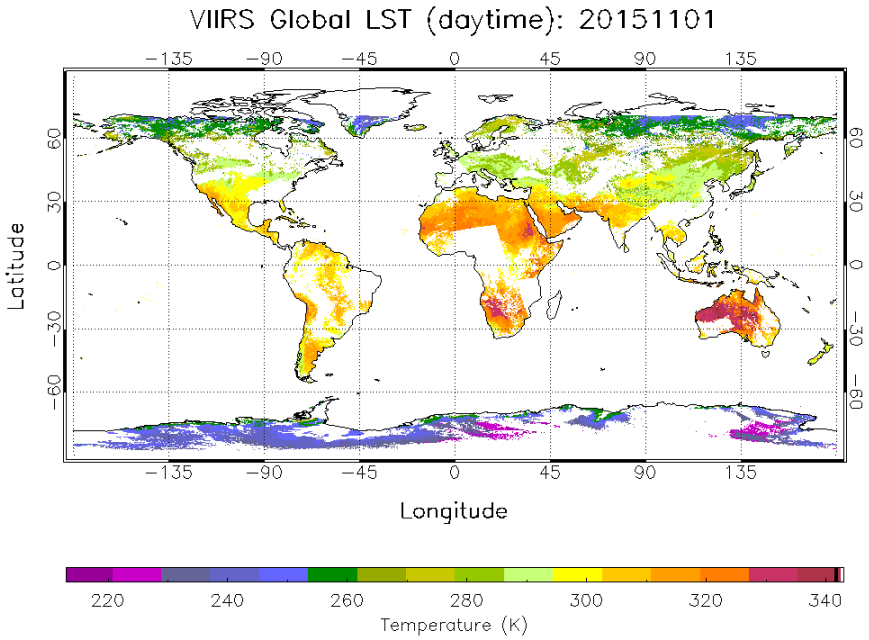
Y. Yu, STAR

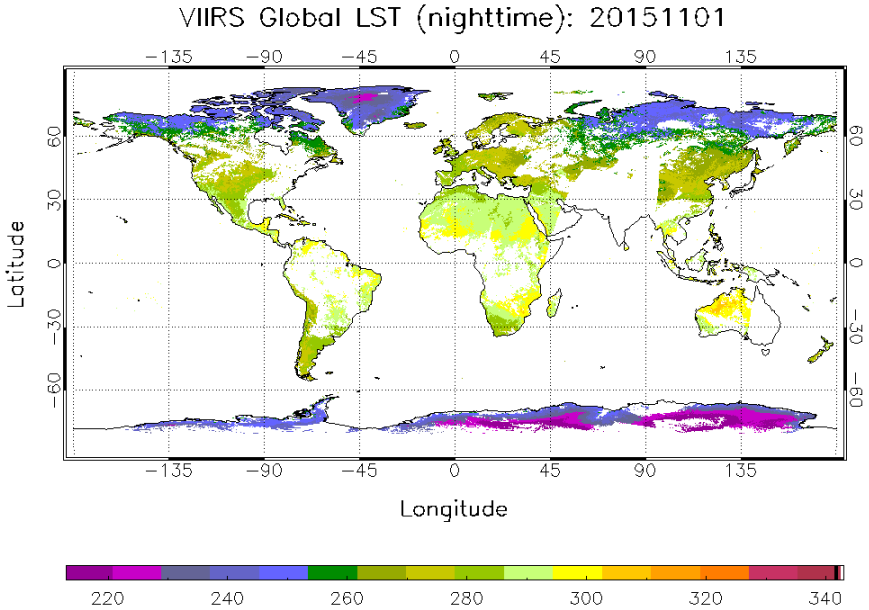
www.star.nesdis.noaa.gov/jpss/albedo.php

Enterprise Land Surface Temperature

- Based on (enterprise) upstream data: SDR, cloud mask, surface type and AOT if possible
- LST production will rely on an enterprise algorithm that applies emissivity data explicitly
- The input/output data structure as well as the QC flags are determined for enterprise LST algorithm
- The software code for the enterprise LST calculation is ready in local environment
- Possible risk is the availability of corresponding water vapor information
- Limited retrospective reference data and validation tools are available.

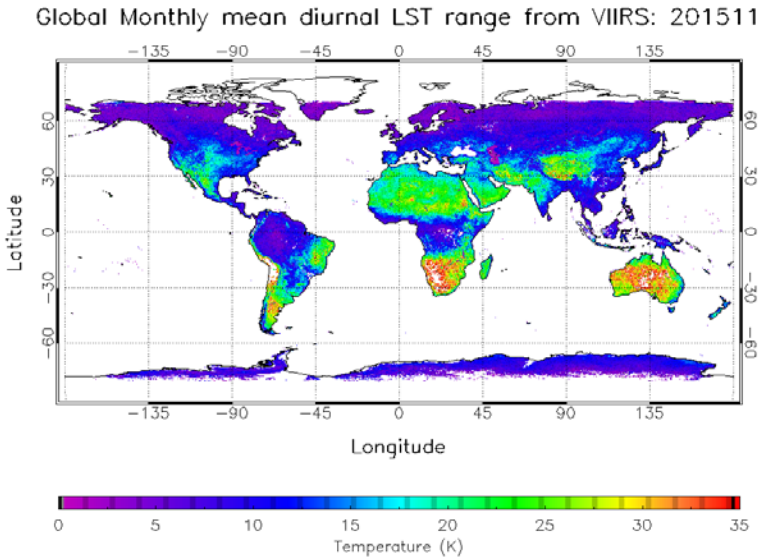
Y. Yu, STAR





Land Surface Temperature: numerical weather, climate modeling, agriculture

A gridded land surface temperature product is in development to serve the needs of NOAA's land surface modeling activities.



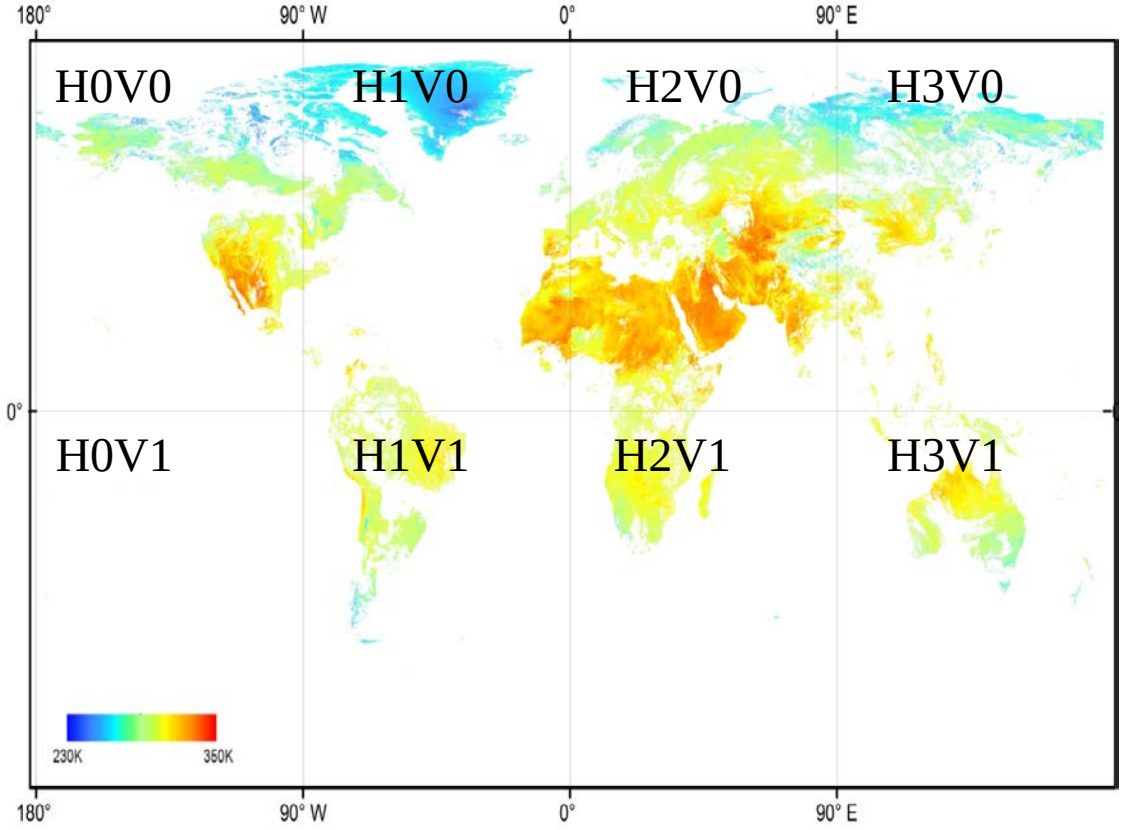
http://www.star.nesdis.noaa.gov/jpss/lst.php

Y. Yu, STAR

VIIRS gridded LST (Level 3 LST,VLSTL3)

- **Gridded composite global products suitable for integration and model performance evaluation**:
- 0.01 degree, daily
- 8 tiles for global, day/night separately, each tile within 150M
- Processing time less than 1.5hr for daily products

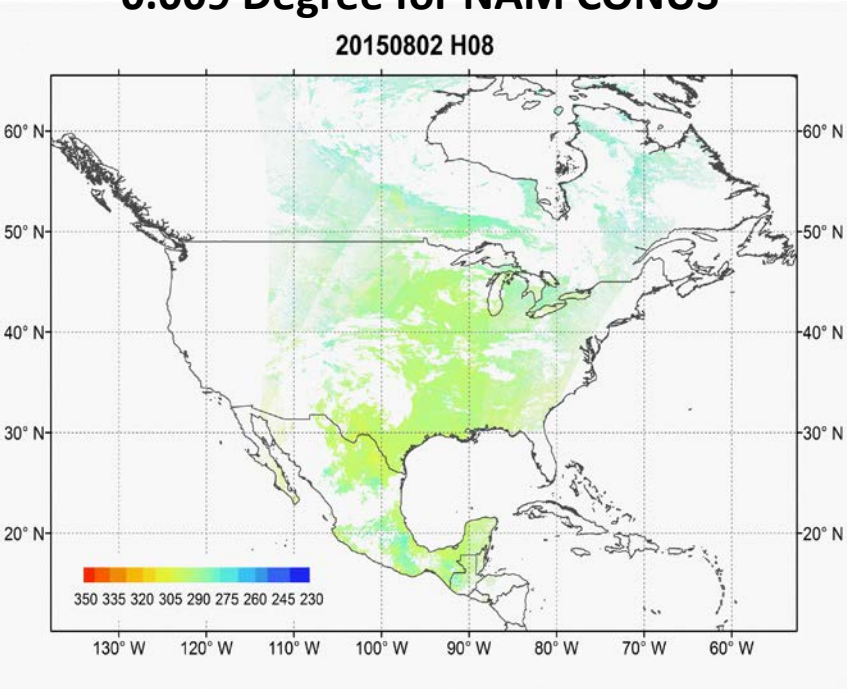
Example products: 20150602 VLSTL3 for Daytime



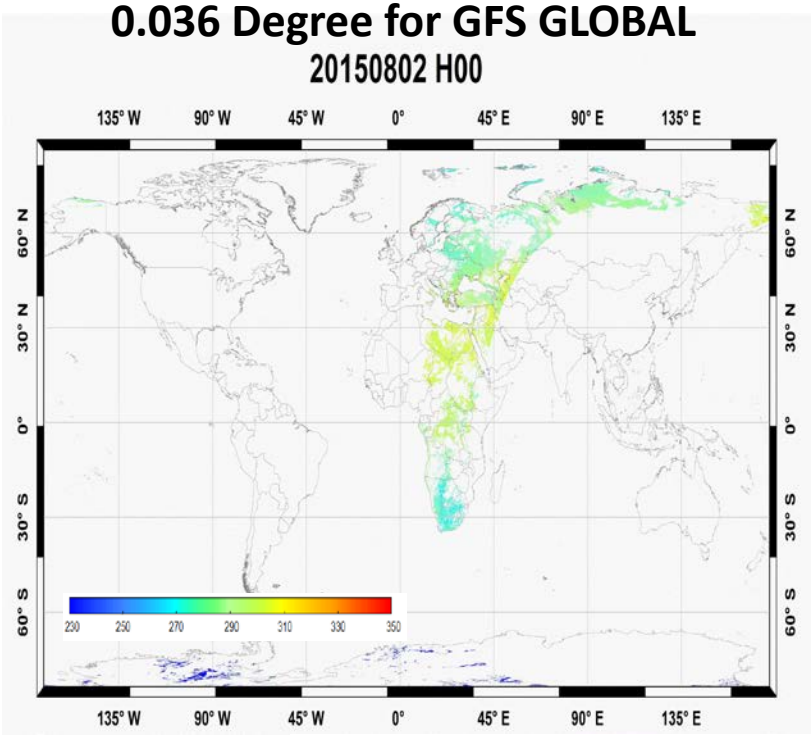
Y. Yu, STAR

Gridded LST Products and their NWP application

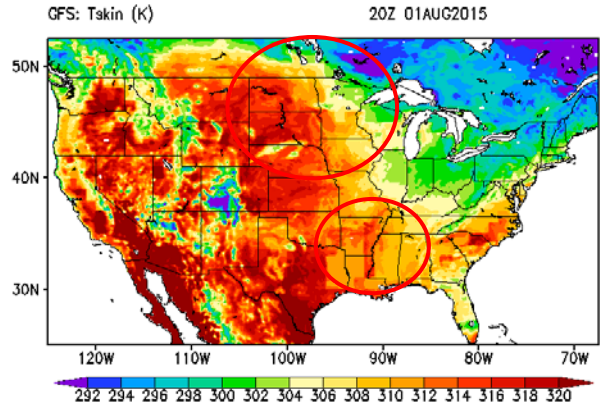
0.009 Degree for NAM CONUS



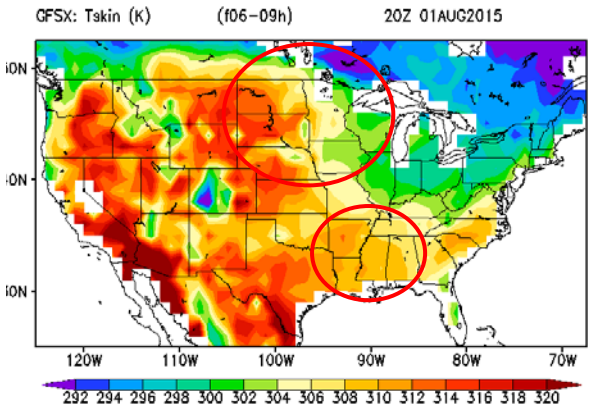
0.036 Degree for GFS GLOBAL



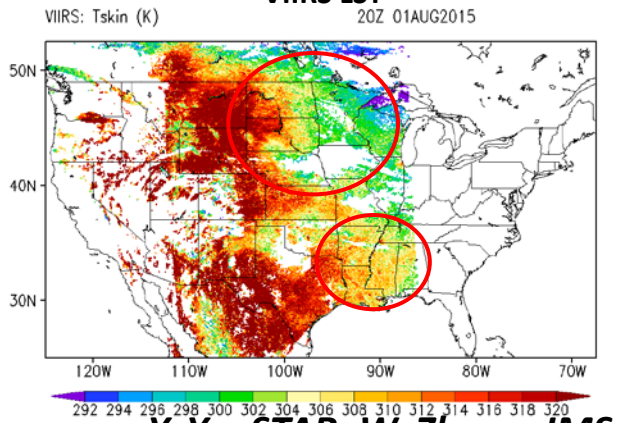
Operational GFS



GFS adjusted land model



VIIRS LST



Y. Yu, STAR; W. Zheng, IMSG

Combining polar and geostationary data for complete coverage

Geostationary data provide the diurnal cycle of land surface temperature and help match satellite measurements with model data.

VIIRS Land Surface Emissivity

VIIRS Land Surface Emissivity (LSE) -- Derived for LST retrieval

Purpose:

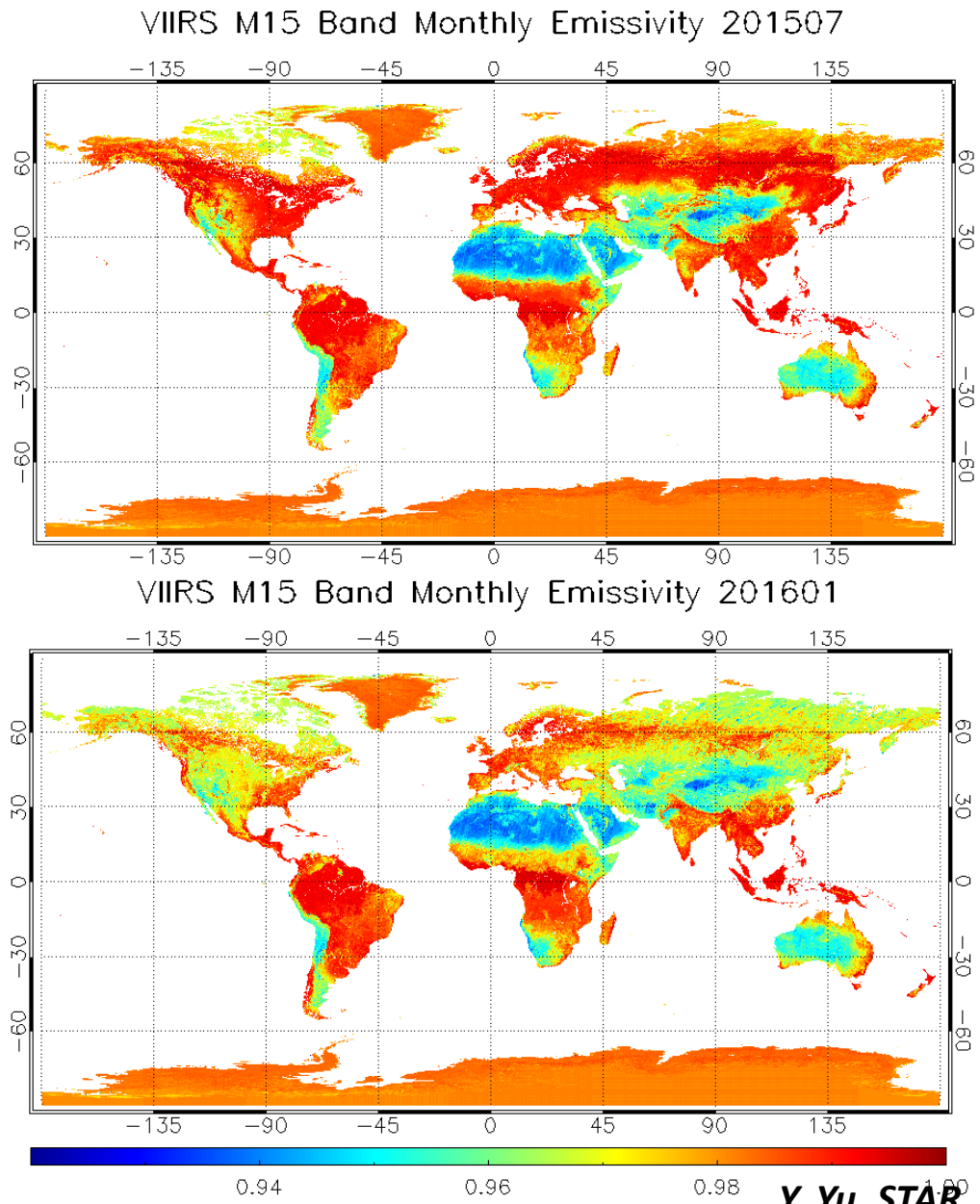
- Enhance LST retrieval and validation
- Support the forecasting model

Method:

- Using historic emissivity product to generate background (soil or snow) emissivity climatology
- Using real time vegetation and snow information to adjust the static emissivity.

Main Features:

- Daily global gridded dataset
- Up to 0.009 degree resolution
- VIIRS split window bands (M15&M16)
- QF for each grid
- Uncertainty better than 0.015



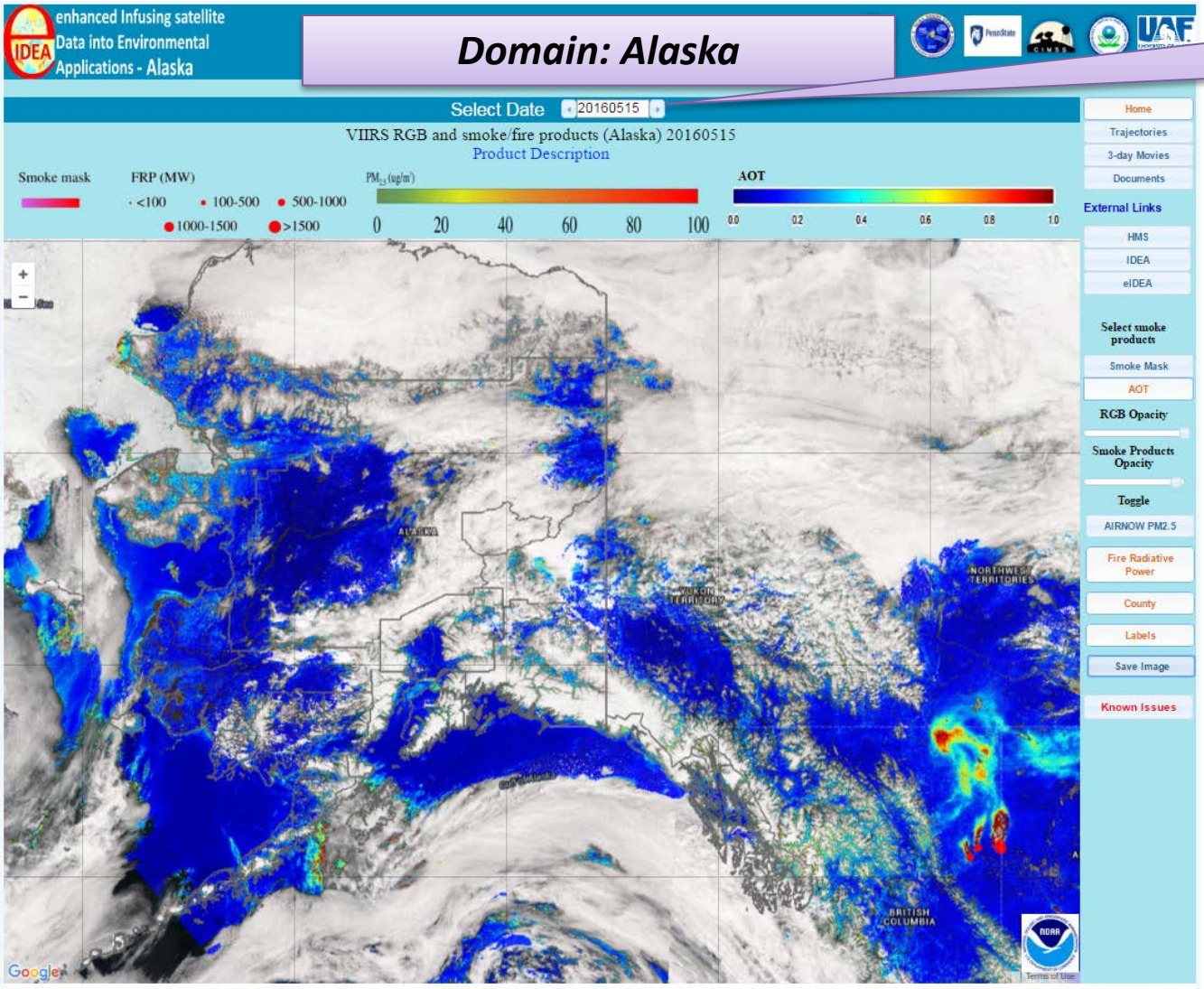
NOAA Operational VIIRS Fire Product Status (2/1)

- Tailored version of the M-band UMD / NASA ST algorithm operational within the Suomi NPP Data Exploitation (NDE) system since March 15, 2016
  - includes fire mask and fire radiative power (FRP)
- Data available from OSPO in simplified text and other formats
  - ftp://satepsanone.nesdis.noaa.gov/FIRE/VIIRS/
- Data available from CLASS
  - currently ftp interface at ftp://ftp-npp.class.ngdc.noaa.gov/
  - pick the date, then to the folder NDE-L2/VIIRS-Active-Fire-EDR-NOAA-Enterprise-Algorithm/
  - ordering capability through the Web interface will be available in August
  - all operational data will be backfilled by late summer from the STAR archive
- Long-term quality monitoring ongoing (including both NDE and IDPS products)
    - https://www.star.nesdis.noaa.gov/jpss/EDRs/products_activeFires.php

NOAA Operational VIIRS Fire Product Status (2/2)

- Ongoing integration into NOAA operational and experimental systems e.g.
  - Hazard Mapping System
  - eIDEA – extended Infusing Satellite Data into Environmental Applications
    - http://www.star.nesdis.noaa.gov/smcd/spb/aq/eidea/
  - NWS Advanced Weather Interactive Processing System (AWIPS-II)
  - High Resolution Rapid Refresh (HRRR) http://rapidrefresh.noaa.gov/HRRRsmoke/
- IDPS production, long-term monitoring and maintenance until all downstream products in NDE / NOAA ESPC Enterprise system
- Other ongoing activities:
  - JPSS-1 testing / preparations
  - preparations for VIIRS SDR reprocessing
  - code integration into CSPP (Community Satellite Processing Package)
  - work towards UMD / NASA I-band / hybrid product transition to operations
  - end user interaction / support - NOAA JPSS Fire and Smoke Initiative
    - RealEarth™ – Google Maps etc.

Web-Based Blended Fire and Smoke Product: eIDEA-Alaska



Calendar to select date of interest

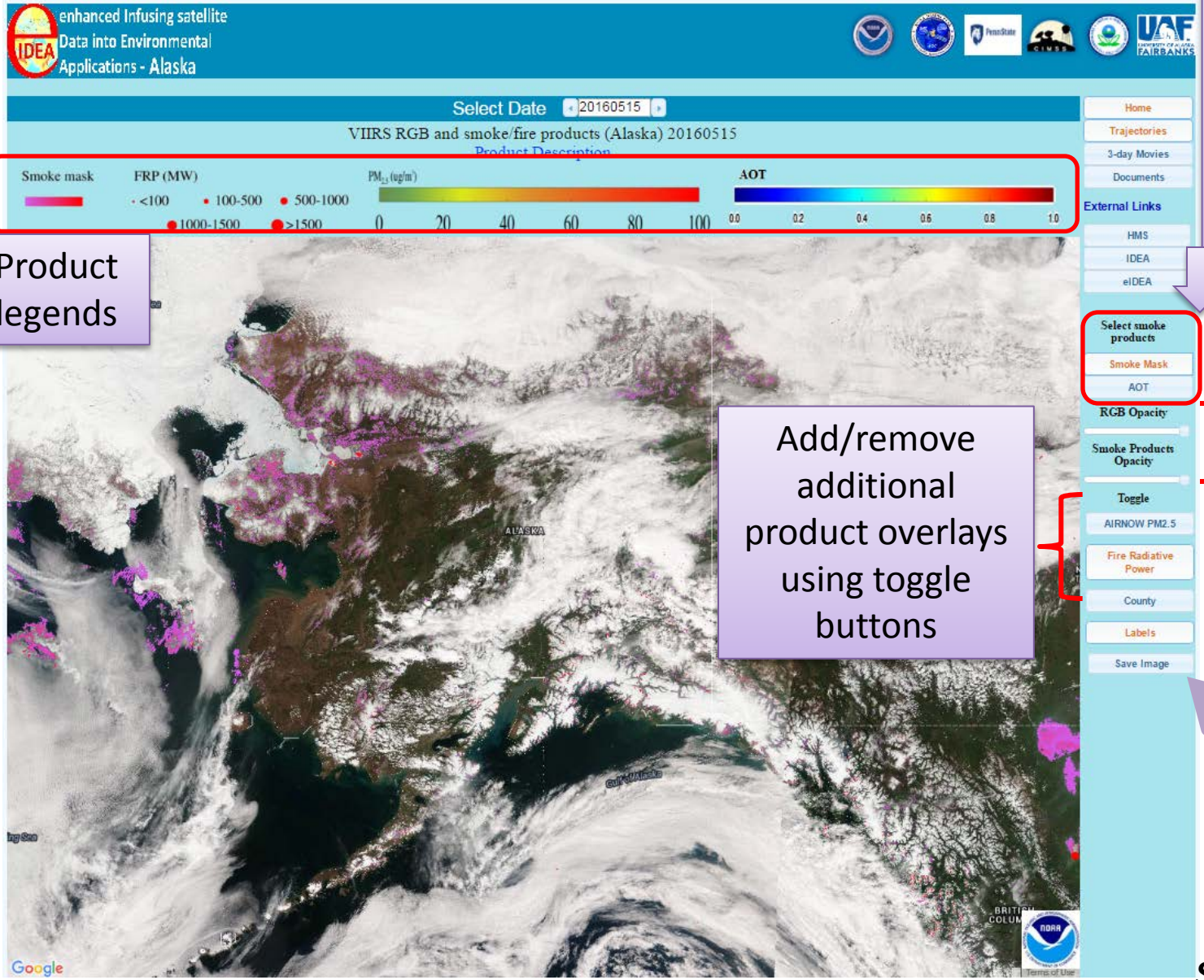
Main product overlay buttons

VIIRS SDR data from GINA DB.
Aerosol and fire products generated at STAR.

http://www.star.nesdis.noaa.gov/smcd/spb/aq/eidea-ak/

S. Kondragunta, STAR

eIDEA-Alaska: Overlays



Product legends

"Smoke Mask" is default smoke product; click on "AOT" or "Satellite Derived $PM_{2.5}$" to switch b/w smoke products

Slider bars adjust opacity of RGB and smoke products

Add/remove additional product overlays using toggle buttons

Click "Save Image" to save configuration as a graphics file

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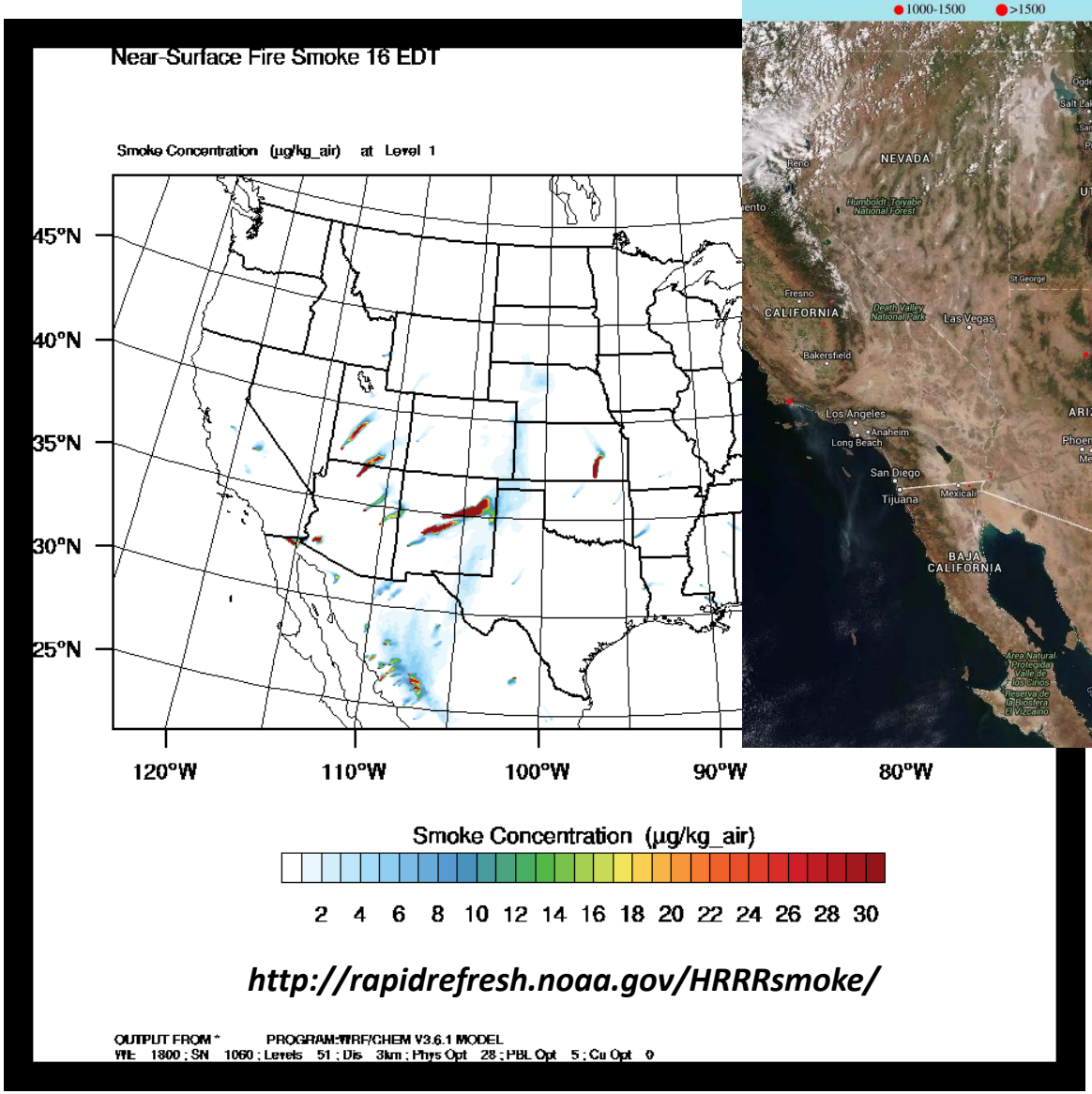
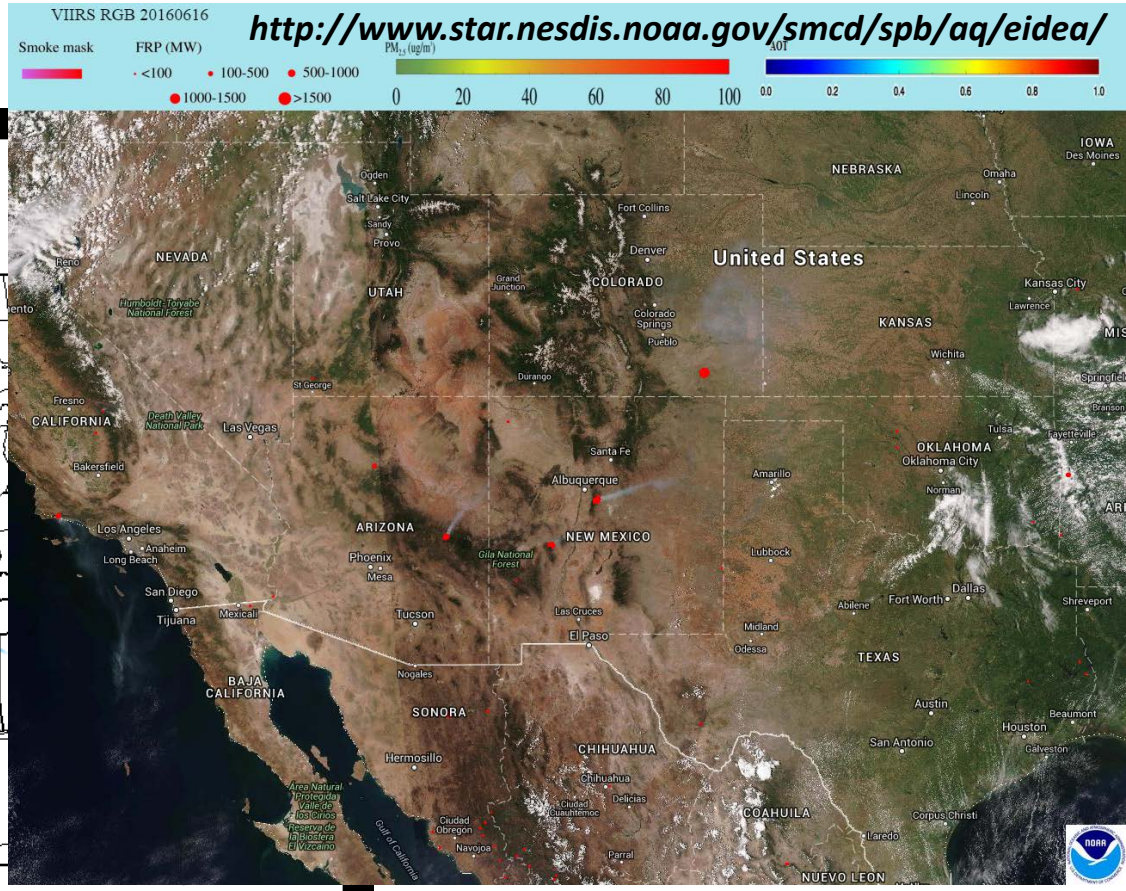
HRRR smoke forecast vs. eIDEA observations



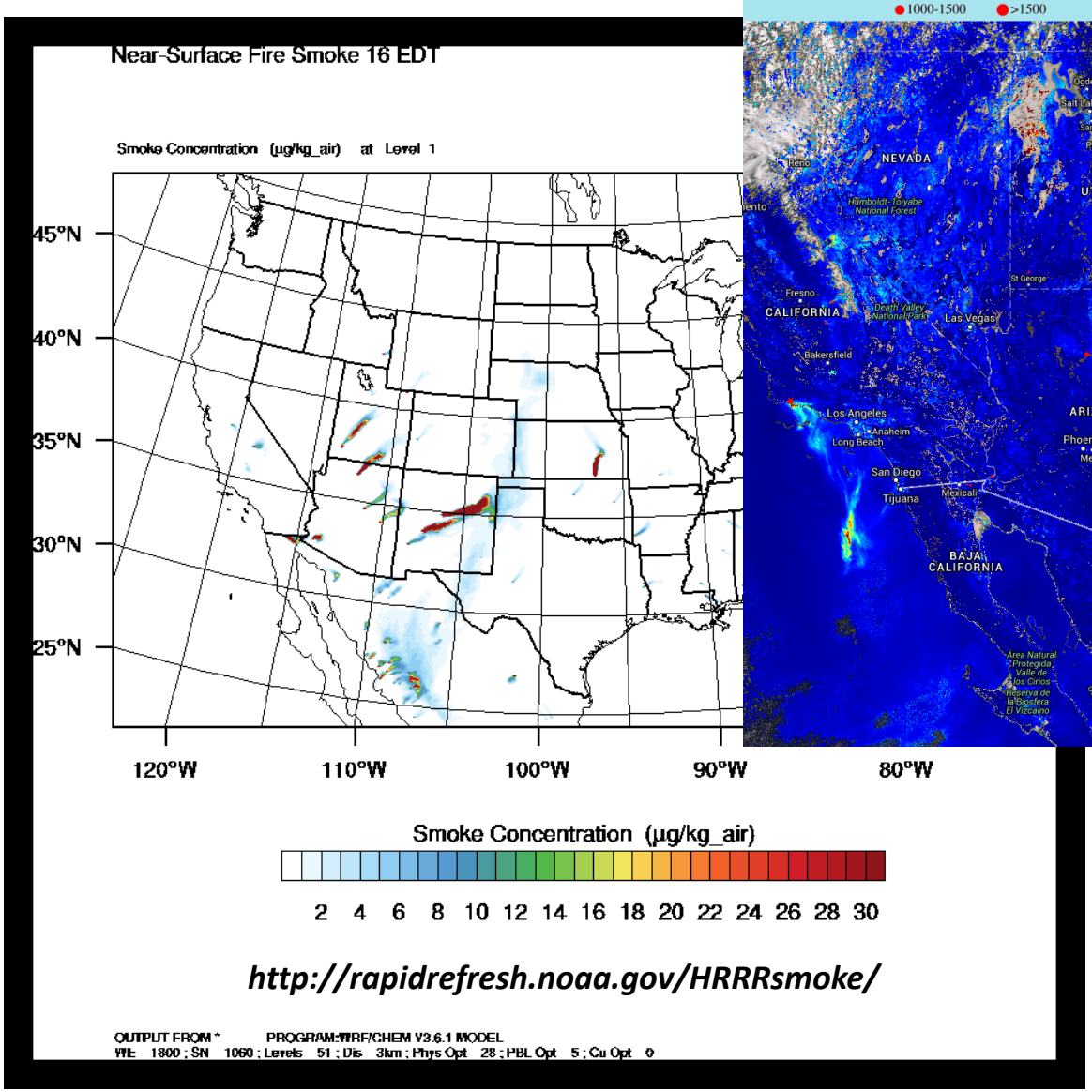


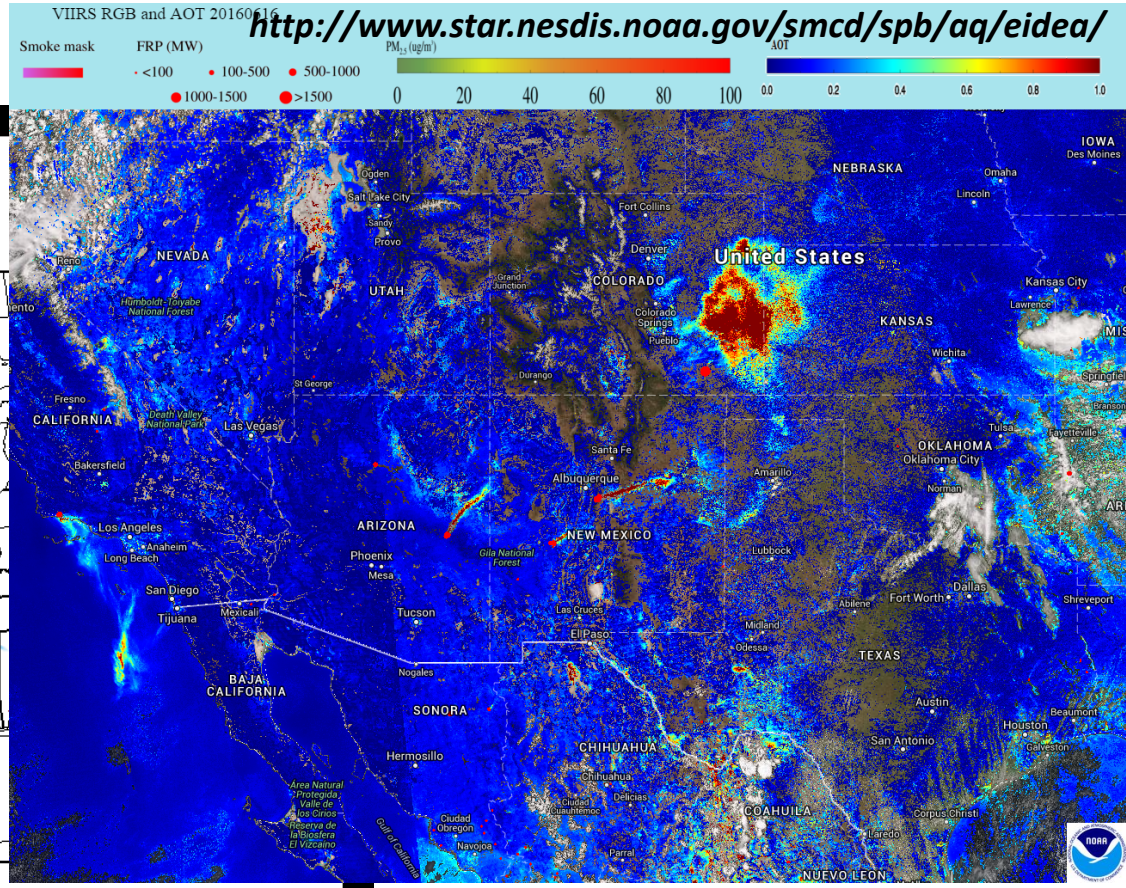
HRRR: High Resolution Rapid Refresh

June 16, 2016

G. Grell, R. Ahmadov, NOAA ESRL
S. Kondragunta, STAR

HRRR smoke forecast vs. eIDEA observations

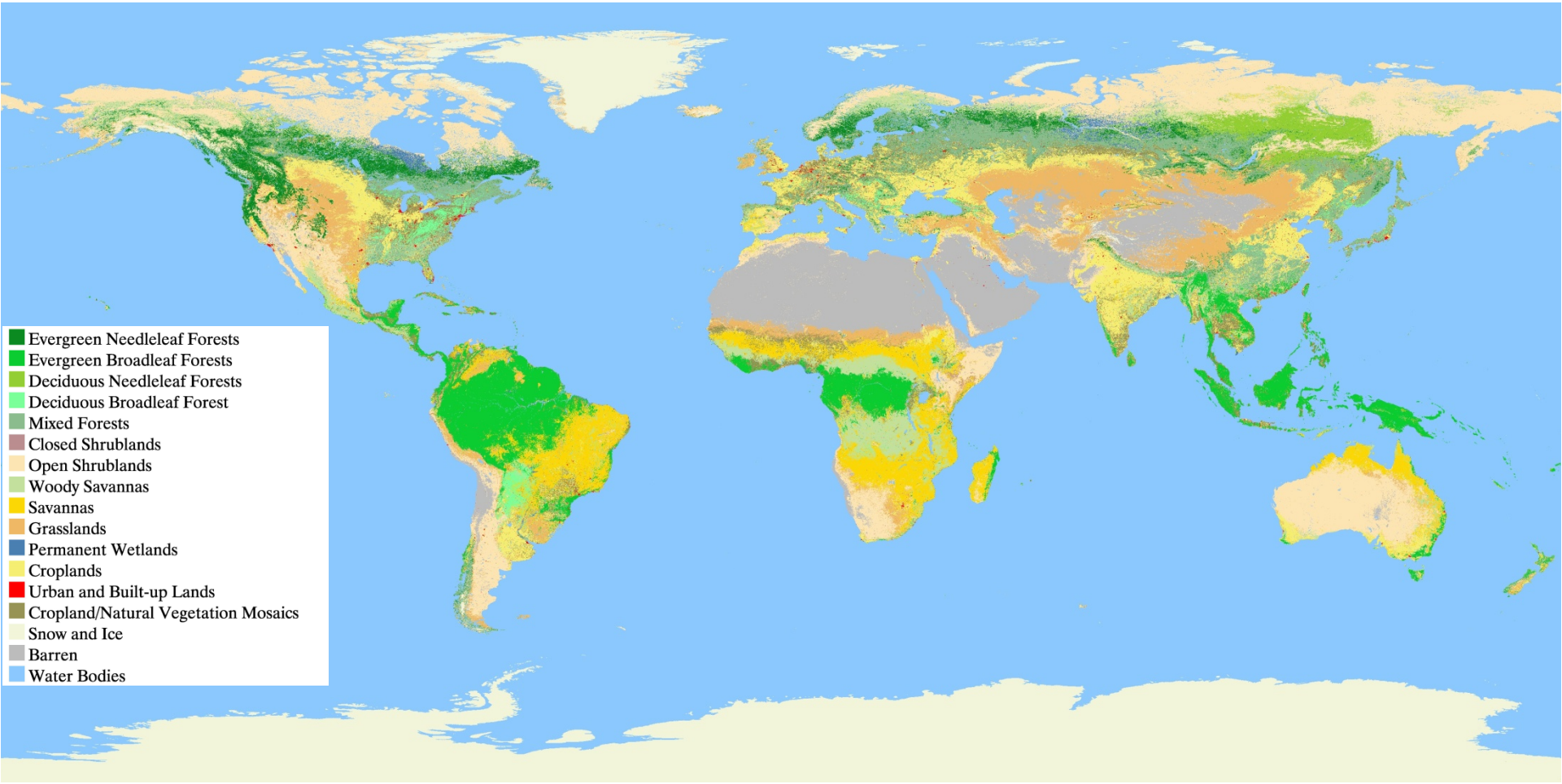




June 16, 2016

G. Grell, R. Ahmadov, NOAA ESRL
S. Kondragunta, STAR

VIIRS Annual Surface Type



A new 1km surface type map is produced every year from VIIRS. The data are used to support numerical weather, climate, hydrological and ecological modeling.

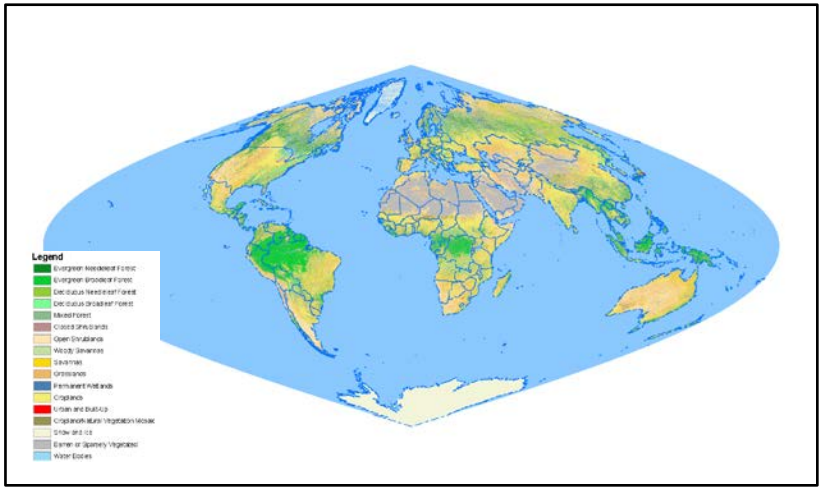
http://www.star.nesdis.noaa.gov/jpss/st.php
http://vct.geog.umd.edu/st/

X. Zhan, STAR

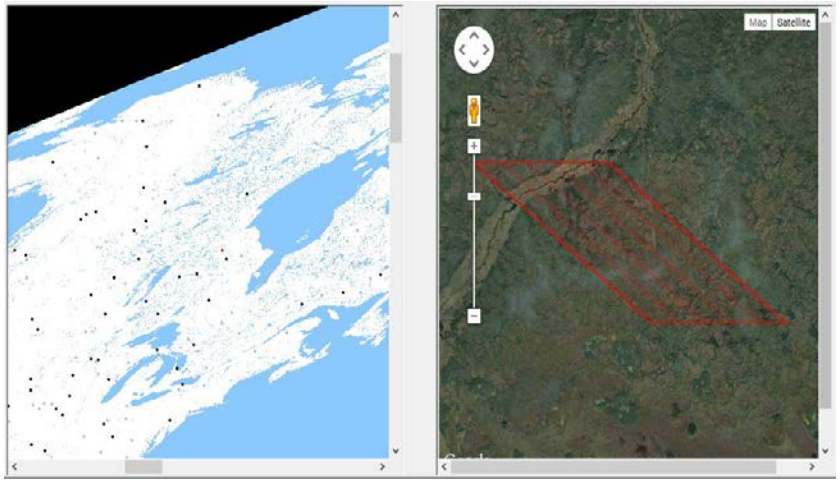
VIIRS Annual Surface Type (AST)

- √ Global Gridded, 1km, 17 IGBP surface type classes. Required typing accuracy ~70%
- √ Generated annually to reflect recent year changes
  - Based on VIIRS gridded surface reflectance products
  - Use Support Vector Machine (SVM) algorithm for classification
  - Training data are the best available
- √ Validated with ~5000 ground "truth" data
- √ Merged with 3 tundra types for NCEP NWP and climate models

Suomi NPP VIIRS Surface Type Map of 2014

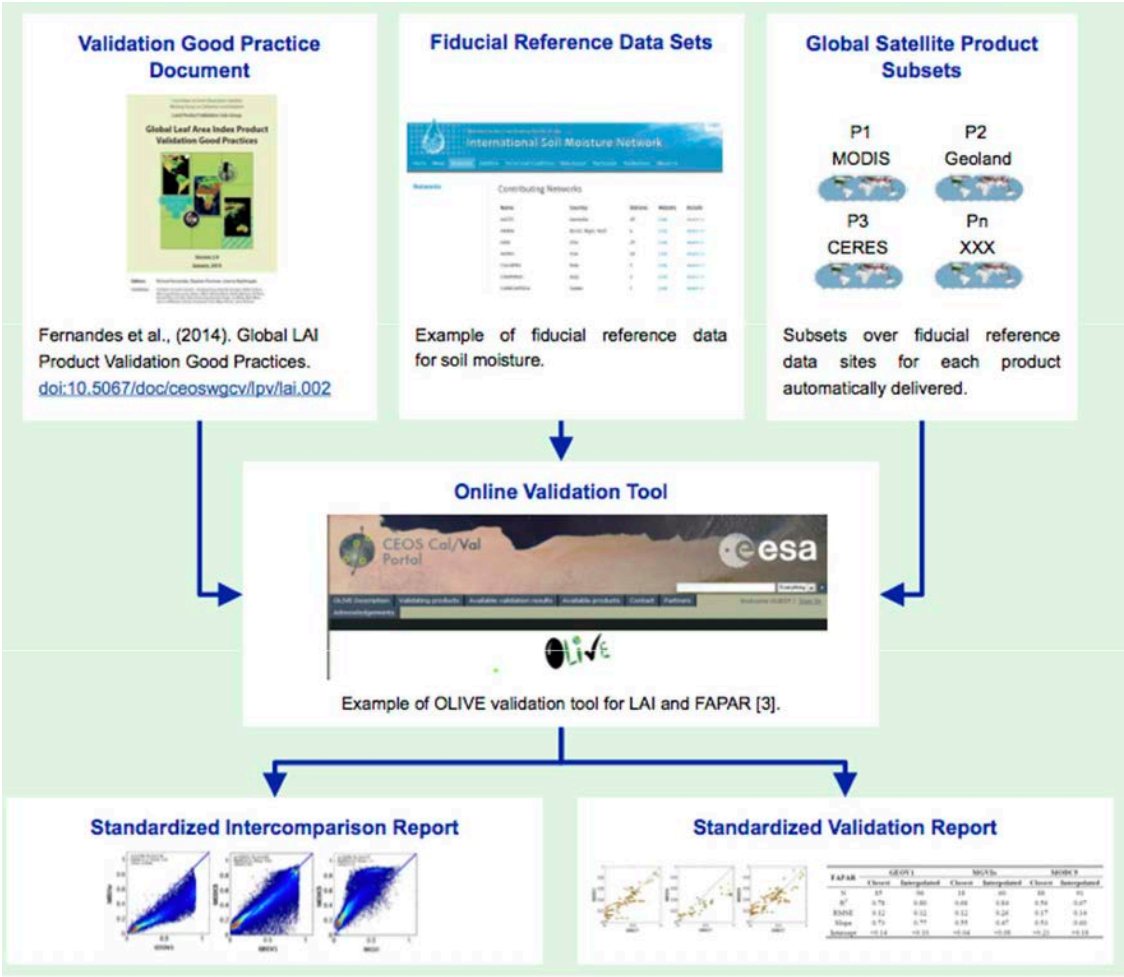


VIIRS Surface Type Validation Data Collection Tool



X. Zhan, STAR

CEOS-WGCV Land Product Validation (LPV) Framework



- ***JPSS Land cal/val team has adopted the CEOS/WGCV LPV framework & validation stages.***
- ***Key JPSS contributions:***
  1. Tower-based reference data (CRN, BSRN-SURFRAD)
  2. Airborne-UAV reference data (MALIBU: Román et al.)
  3. Land Product Characterization System (LPCS: K. Gallo)
- ***Participating CEOS member agencies:*** *NOAA-STAR, NOAA-NCDC, USGS-EROS, NASA-GSFC, ESA-ESRIN.*

CEOS/WGCV/LPV subgroup has developed a framework for land product intercomparison and validation based on: **(1) a citable protocol, (2) fiducial reference data, and (3) automated subsetting**. These components are integrated into an **online platform** where quantitative tests are run, and standardized intercomparison and validation results reported.

M. Román, NASA

Standards and Protocols – LPV Validation Hierarchy

Validation Stage - Definition and Current State		Variable
1	Product accuracy is assessed from a small (typically < 30) set of locations and time periods by comparison with in-situ or other suitable reference data.	**Fapar** **Snow Cover** **Phenology** **LST & Emissivity** **Fire Radiative Power**
2	Product accuracy is estimated over a significant set of locations and time periods by comparison with reference in situ or other suitable reference data. Spatial and temporal consistency of the product and consistency with similar products has been evaluated over globally representative locations and time periods. Results are published in the peer-reviewed literature.	**Leaf Area Index** **Burned Area**
3	Uncertainties in the product and its associated structure are well quantified from comparison with reference in situ or other suitable reference data. Uncertainties are characterized in a statistically rigorous way over multiple locations and time periods representing global conditions. Spatial and temporal consistency of the product and with similar products has been evaluated over globally representative locations and periods. Results are published in the peer-reviewed literature.	**Land Cover** **Albedo** **Soil Moisture**
4	Validation results for stage 3 are systematically updated when new product versions are released and as the time-series expands.	

Adopted by **all CEOS-WGCV subgroups** and LPV sponsor agencies: **NASA** (Terra/Aqua: MODIS, MISR, ASTER, EO-1, Suomi-NPP, SMAP, LANCE**)**, **NOAA** (AVHRR, GOES, Suomi-NPP/JPSS), **USGS** (Landsat-8), **CNES** (SPOT/POLDER), **ESA** (MERIS, Proba-V, Sentinel Land CCI products), **EUMETSAT** (MSG-3/4).

M. Román, NASA

LPCS USGS science for a changing world
Land Product Characterization System

NOAA/USGS Land Product Characterization System

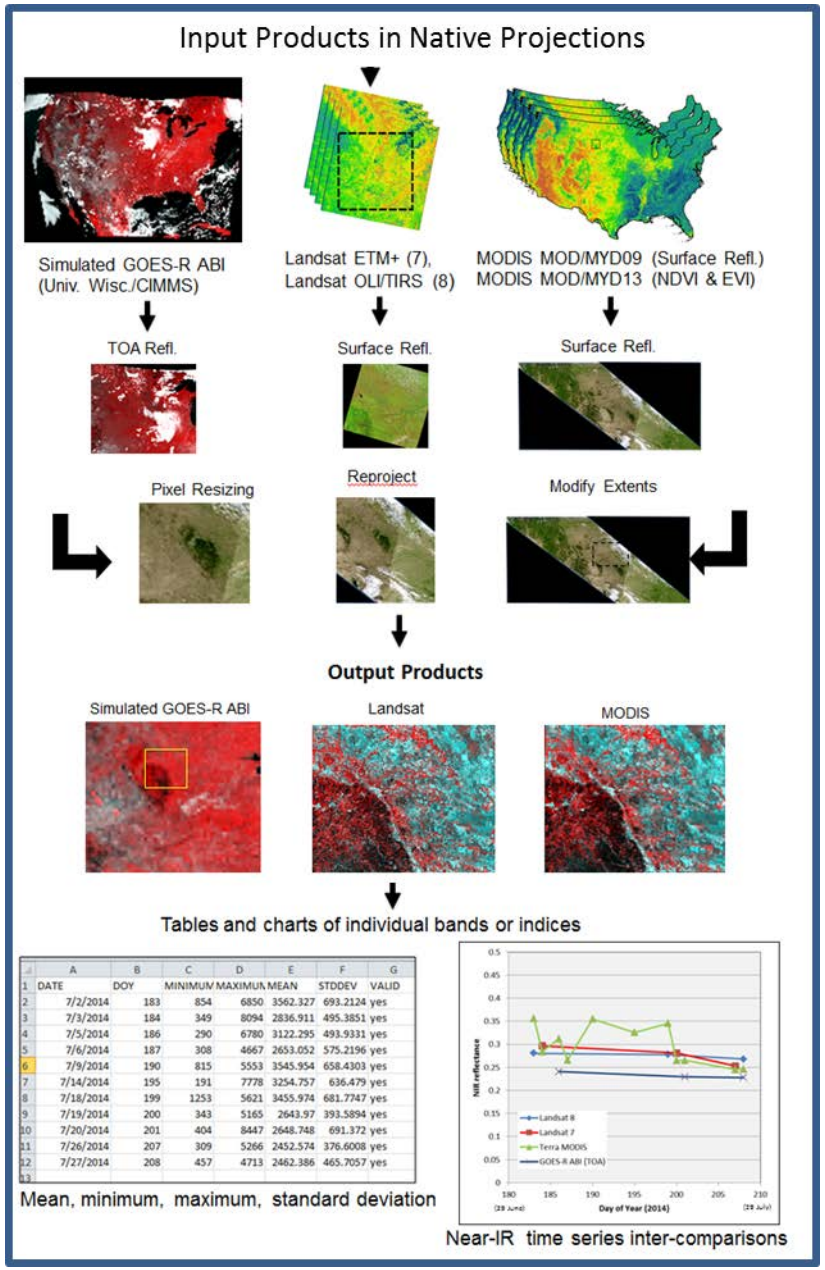
A web-based system that is designed to use moderate- to high-resolution satellite data for the characterization and validation of CEOS-endorsed time series products, including GOES-R ABI, Landsat-8/Sentinel-2, and the Land Science products from MODIS and VIIRS.

The LPCS includes:

- data inventory
- access and
- analysis functions

that will permit selection of data to be easily identified, retrieved, co-registered, and compared statistically through a single interface.

Kevin Gallo: NOAA/NESDIS/STAR
John Dwyer: USGS/EROS
Greg Stensaas: USGS/EROS
Ryan Longhenry: USGS/EROS



Land reprocessing and JPSS-1 readiness

- Test datasets of upstream products are needed for algorithm validation and verification
  - SDR, SR, AOT, VCM
  - Opportunity for accelerated product maturity
  - Training / validation datasets are needed
  - JPSS-1 cal/val plan and CEOS validation protocol, as applicable
- Reprocessing schedule is contingent on
  - Reprocessing of upstream products
    - Reprocessing should be done after evaluation by downstream product teams
  - Readiness of Enterprise algorithm and processing code
    - At least validated maturity Stage 2 level is required
      - Full global and seasonal sampling
- JPSS-1 readiness in general is confirmed
  - Evaluated test datasets provided to STAR
  - Ran select algorithms in STAR environment
    - Further interaction with NDE needed for pre-launch testing

Summary

- Finalizing Enterprise algorithm development and preparations for reprocessing are done in parallel
  - Overall, algorithms will be ready within the next FY for at least the granule-based products
- Reprocessing and data continuity
  - Consistency over the entire mission
  - Continuity (as much as possible) with heritage AVHRR and MODIS data
- Consistency between different geophysical products
  - e.g. signal from all products should indicate vegetated vs. clear land etc.
- Cross-fertilization between NOAA and NASA efforts continues
  - SDR science content consistent or at least well understood
  - Algorithms and formats
  - Validation (including coordination through CEOS)
- Properly stratified evaluation / validation datasets
- Land / cryosphere breakout session: Thursday, August 11