JPSS1 AND SNPP VIIRS VEGETATION INDEX PRODUCTS

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Outline

- Team Members
- S-NPP VIIRS VI Algorithm & Products
- JPSS-1 Readiness
- Enterprise Algorithm for Vegetation Products
- S-NPP VIIRS VI Reprocessing
- VI Operational Use
- Summary

Team Members

Name	Organization	Roles and Responsibilities
Marco Vargas	NOAA STAR	VI Algorithm Lead
Tomoaki Miura	University of Hawaii	VI Cal/Val lead
Zhangyan Jiang	NOAA STAR/AER	Algorithm and Cal/Val Support
Mingshi Chen	NOAA STAR/IMSG	Algorithm and Cal/Val Support
Anna Kato	University of Hawaii (PhD student)	Cal/Val Support
Ashley Griffin	ASRC Management Services Inc	Land JAM
Walter Wolf	NOAA STAR	STAR AIT Team Lead
Valerie Mikles	NOAA STAR/IMSG	STAR AIT
Michael Ek	NOAA NCEP/EMC	User readiness
Yihua Wu	NOAA NCEP/EMC	User readiness
Weizhong Zheng	NOAA NCEP/EMC	User readiness

IDPS SNPP Operational Algorithm Overview (1/2)

The current IDPS SNPP VIIRS Vegetation Index (VI) EDR consists of two vegetation indices:

1. Normalized Difference Vegetation Index ($NDVI^{TOA}$) from top-of-atmosphere (TOA) reflectances
2. Enhanced Vegetation Index (EVI^{TOC}) from top of canopy (TOC) reflectances.

IDPS SNPP VIIRS VI EDR Algorithm

$$NDVI^{TOA} = (\rho_{I2}^{TOA} - \rho_{I1}^{TOA}) / (\rho_{I2}^{TOA} + \rho_{I1}^{TOA})$$

$$EVI^{TOC} = (1+L) \cdot \frac{\rho_{I2}^{TOC} - \rho_{I1}^{TOC}}{\rho_{I2}^{TOC} + C_1 \cdot \rho_{I1}^{TOC} - C_2 \cdot \rho_{M3}^{TOC} + L}$$

ρ_{M3}^{TOC} Surface reflectance band M3 (488 nm)

ρ_{I1}^{TOC} Surface reflectance band I1 (640 nm)

ρ_{I2}^{TOC} Surface reflectance band I2 (865 nm)

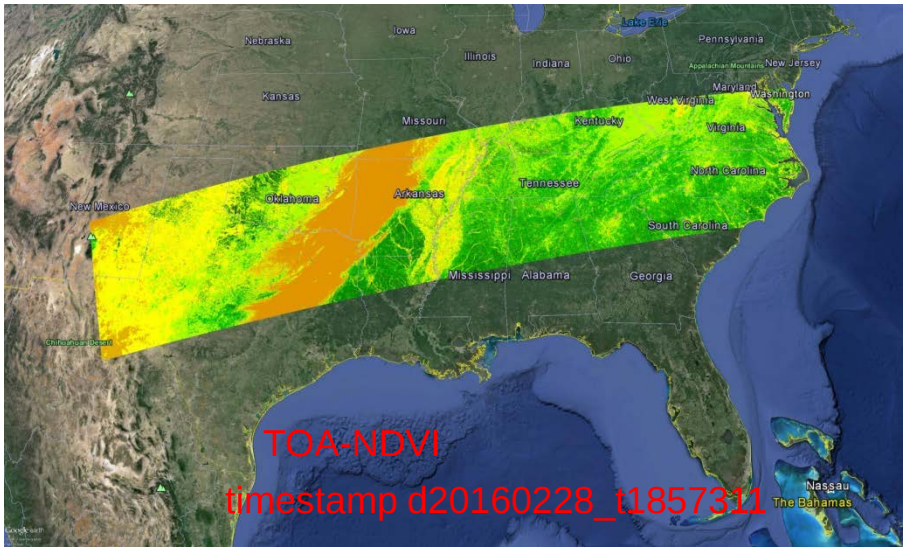
ρ_{I1}^{TOA} Top of the atmosphere reflectance band I1 (640 nm)

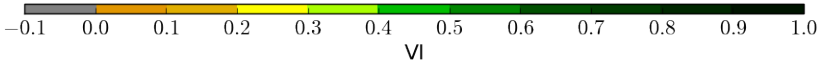
ρ_{I2}^{TOA} Top of the atmosphere reflectance band I2 (865 nm)

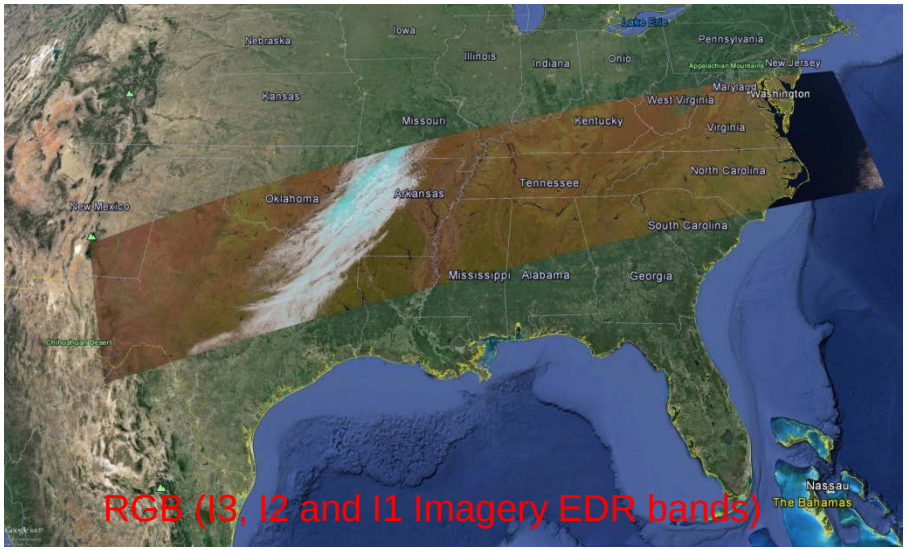
C_1, C_2 and L are constants

IDPS SNPP Operational Algorithm Overview (2/2)

- The VIIRS VI EDR operational product is generated as ~86 seconds granules at Imagery resolution (375m)
- VI EDR is produced over land only and during day time
- Format HDF5
- The granule file contains:
  - TOA NDVI
  - TOC EVI
- Also included in the product are four quality flag (QF) layers on land/water mask, cloud confidence, aerosol loadings, and exclusion conditions
- Product available at NOAA CLASS http://www.class.ncdc.noaa.gov/







NDE SNPP VIIRS Green Vegetation Fraction Product

SNPP VIIRS Green Vegetation Fraction (GVF) Algorithm

- The VIIRS GVF algorithm is a modified version of the Gutman and Ignatov's (1998) GVF algorithm
- The VIIRS GVF algorithm uses the VIIRS I1, I2 and M3 TOC reflectances as input
- The VIIRS GVF is derived form EVI

The Enhanced Vegetation Index (TOC)

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

The Green Vegetation Fraction

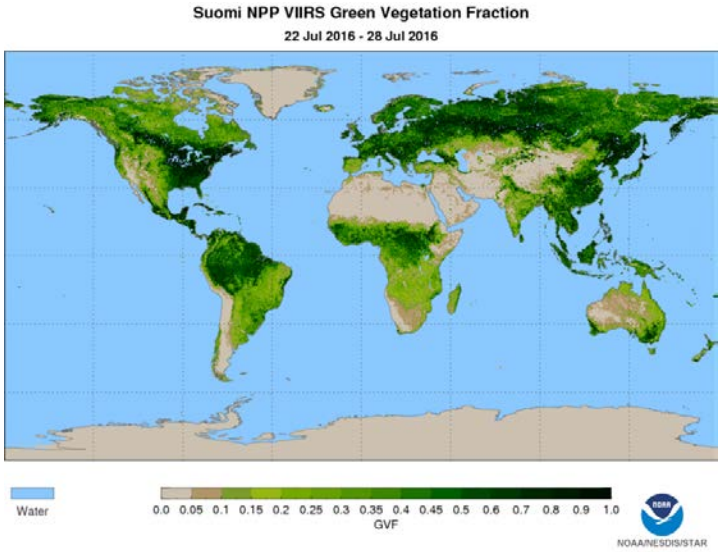
$$GVF = \frac{EVI - EVI_0}{EVI_\infty - EVI_0}$$

The SNPP VIIRS GVF system generates two products

1. *Weekly Global GVF at 4 km res*
2. *Weekly Regional GVF at 1 km res*

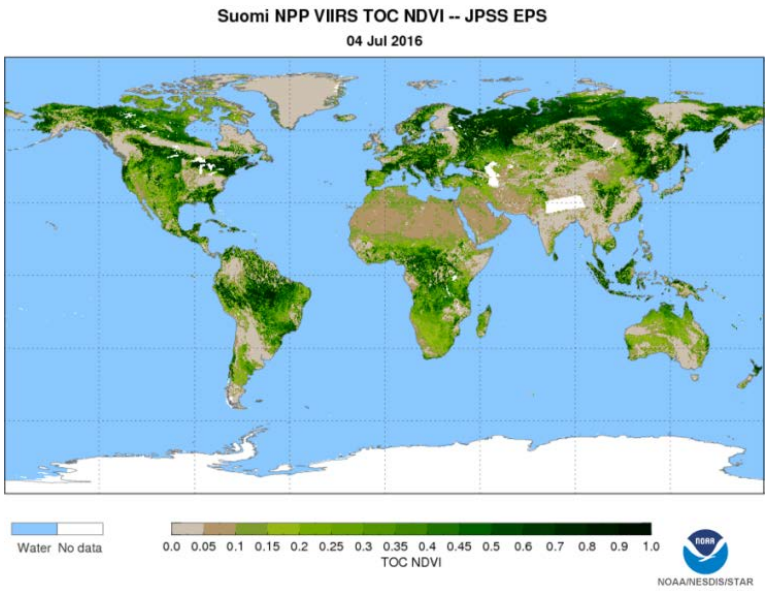
(Lat 7.5°S to 90°N, Lon 130°E to 30°E)

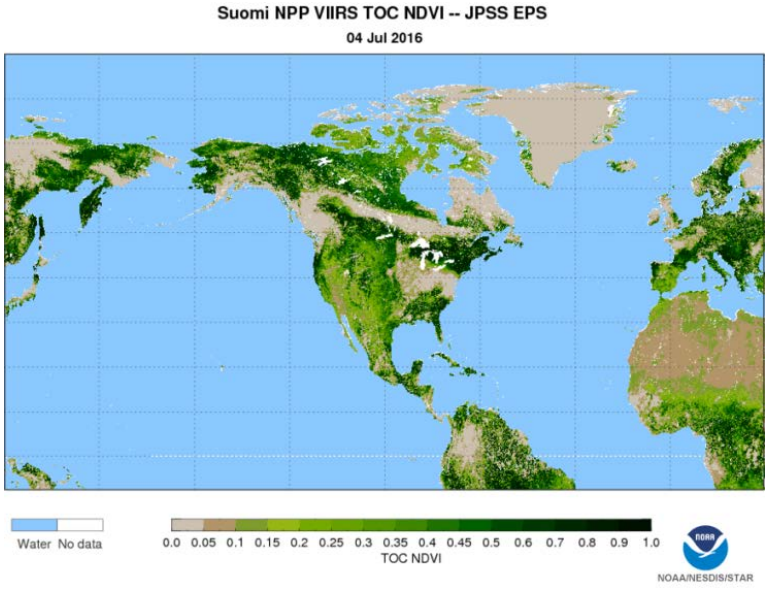
- Weekly (updated daily) GVF products are generated in Lat/Lon projection
- Output File Format: NetCDF4
- The GVF product is available at NOAA/CLASS



NDE 2.0 Vegetation Index Products (under development)

- The NDE Vegetation Products System (VPS) is currently under development
- The NDE VPS will generate:
  - Global Gridded (4km res) TOA NDVI, TOC NDVI, TOC EVI and GVF
  - Regional Gridded (1km res) TOA NDVI, TOC NDVI, TOC EVI and GVF
- Temporal resolution: Daily, Weekly (updated daily), and Bi-weekly (updated daily)
- Format NetCDF4
- Project CDR scheduled in Sep 2016
- Estimated TTO August 2017





S-NPP VIIRS VI EDR and GVF STATUS

IDPS VIIRS VI EDR

- The VI EDR always has met the JPSS performance specifications since the beginning of the SNPP mission
- Product Maturity
  - Beta Maturity: February 2012
  - Provisional Maturity: August 2013
  - Validated Maturity: September 2014
  - IDPS VI EDR LTM in progress

VI EDR Global APU Estimates

Attribute	L1RDS Threshold (VI units)	Validation Results
TOA NDVI Accuracy	0.05	0.019
TOA NDVI Precision	0.04	0.009
TOA NDVI Uncertainty	0.06	0.021
TOC EVI Accuracy	0.05	0.012
TOC EVI Precision	0.04	0.019
TOC EVI Uncertainty	0.06	0.023
TOC NDVI Accuracy	0.05	0.017
TOC NDVI Precision	0.04	0.014
TOC NDVI Uncertainty	0.06	0.022

NDE VIIRS GVF

- Declared operational by on 02/12/2015
- Product maturity: Provisional
- Validated maturity review in Sep 2016

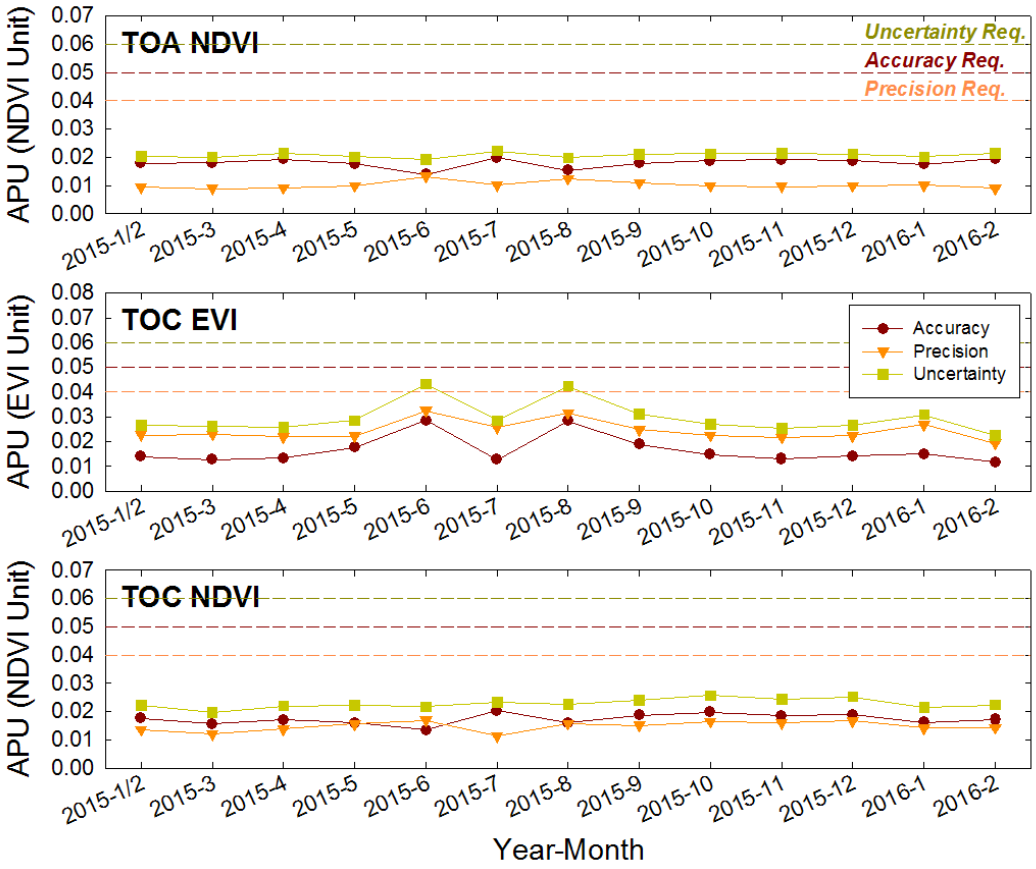
GVF APU Estimates

Attribute	L 1RD Threshold (GVF units)	Validation Results
Measurement Accuracy		
1. Global	0.12	0.076
2. Regional	0.12	0.062
Measurement Precision		
1. Global	0.15	0.096
2. Regional	0.15	0.113
Measurement Uncertainty		
1. Global	0.17	0.126
2. Regional	0.17	0.134

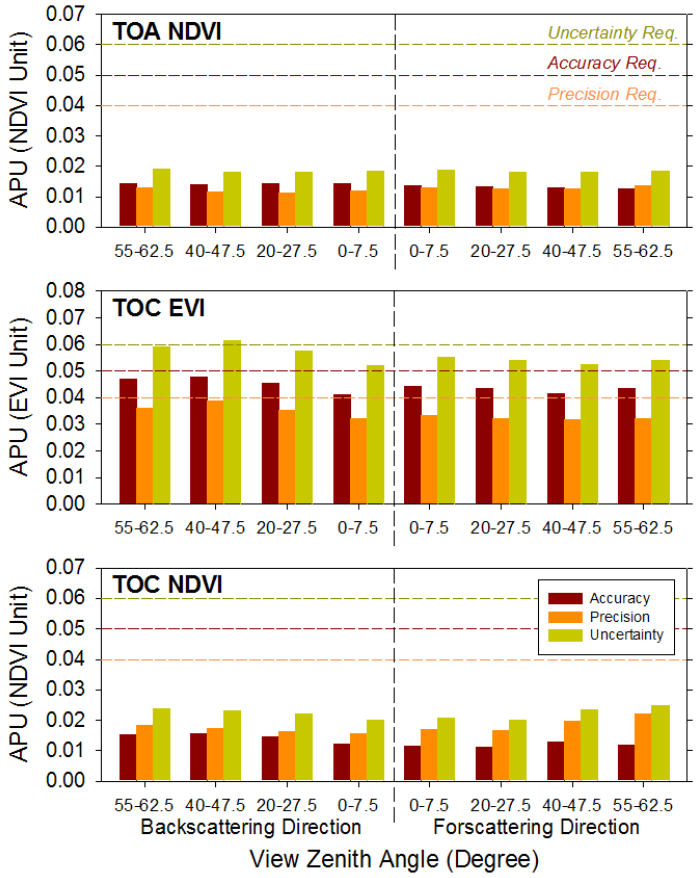
IDPS S-NPP VIIRS VI EDR STATUS: Global APU (LTM)

- VIIRS VI APU meet the L1RDS requirements over time, across seasons and view angles
  - APU derived from global data using Aqua MODIS as a reference
  - VIIRS-MODIS observation pairs from matched orbital tracks used

Global APU Time Series Plot (2015-2016)



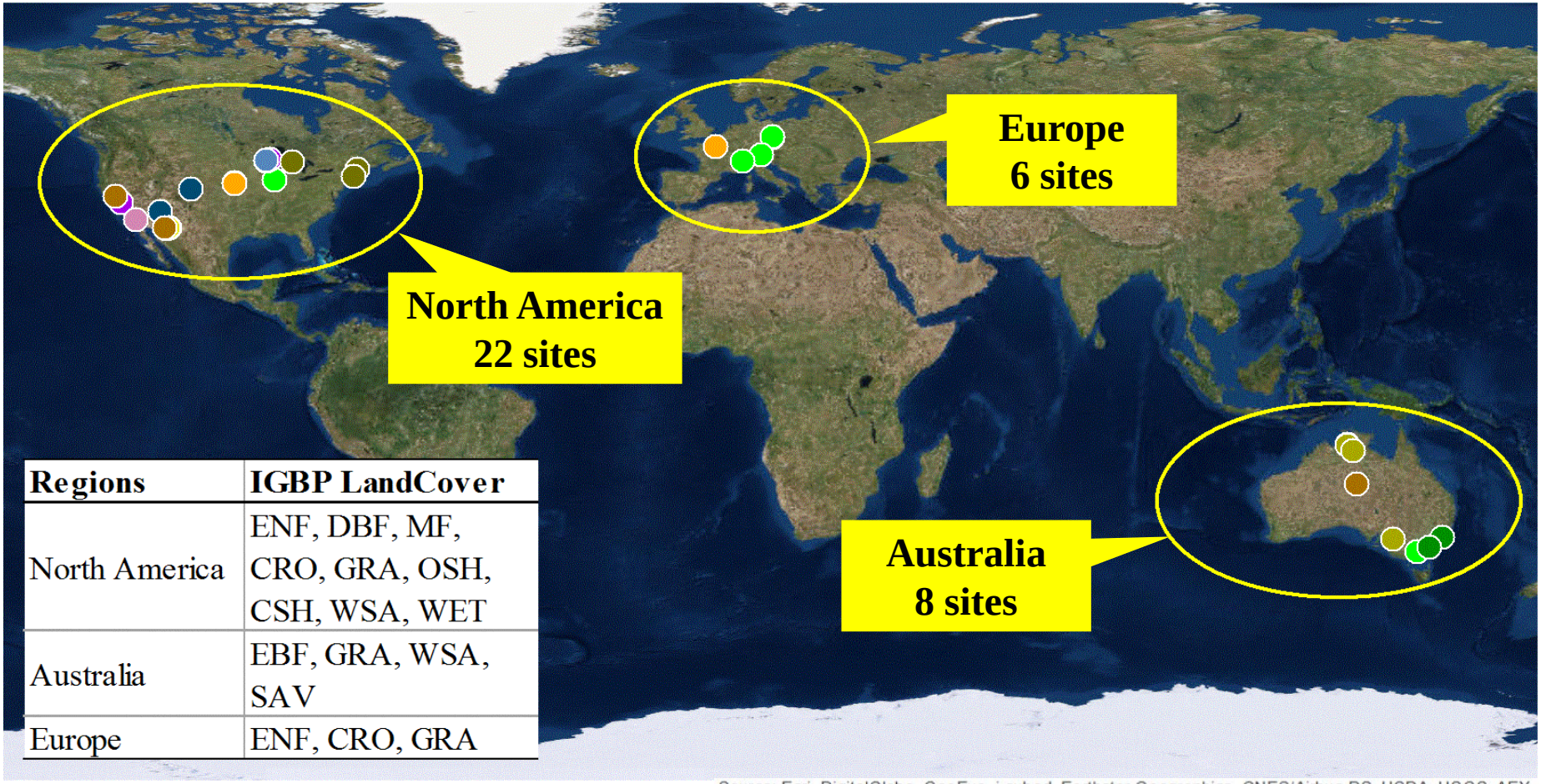
Global APU Across View Angles (Jan – Dec 2015)



IDPS S-NPP VIIRS VI EDR: Temporal Profile Evaluation (LTM)

- Quality of VIIRS VI EDR temporal profiles have been evaluated via visual inspection & comparison with Aqua MODIS

VIIRS Subset Sites for Temporal Profile Evaluation



Regions	IGBP LandCover
North America	ENF, DBF, MF, CRO, GRA, OSH, CSH, WSA, WET
Australia	EBF, GRA, WSA, SAV
Europe	ENF, CRO, GRA

IGBP landcover class (number of site)

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

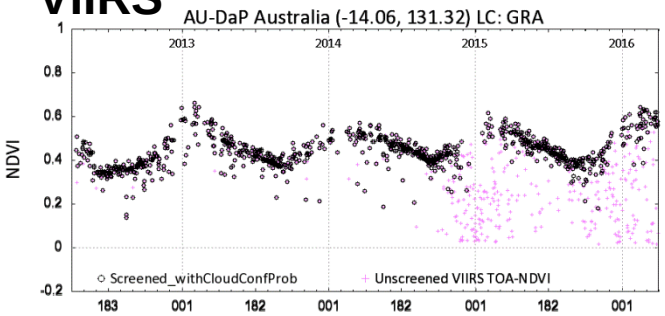
ENF (2) EBF (2) DBF (5) MF (2) CSH (1) OSH (1) GRA (10) CRO (5) WSA (3) SAV (3) WET (1)

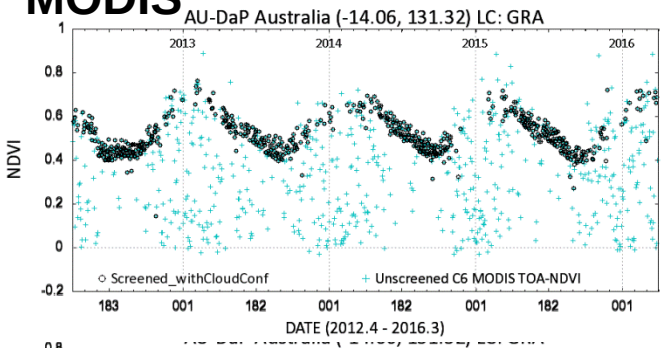
IDPS S-NPP VIIRS VI EDR: Temporal Profile Evaluation (LTM)

- Quality of VIIRS VI EDR temporal profiles evaluated via visual inspection & comparison with Aqua MODIS
  - VIIRS VI temporal profiles matching very well with the MODIS counterparts
  - VCM cloud confidence flag performing well for screening suspicious observations overall
  - VCM and MODIS snow masks somewhat incompatible

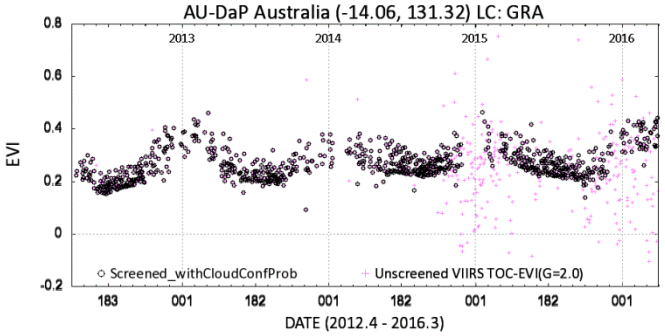
VIIRS | **MODIS**

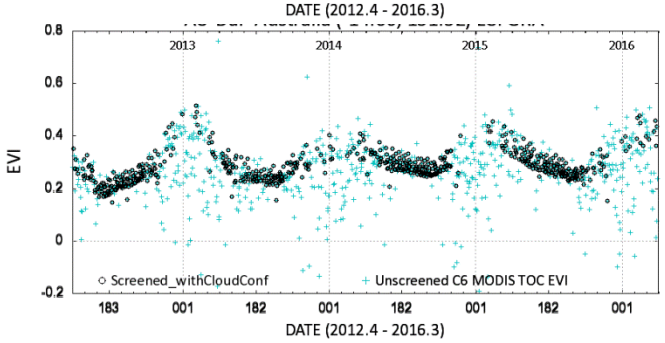
TOA-NDVI



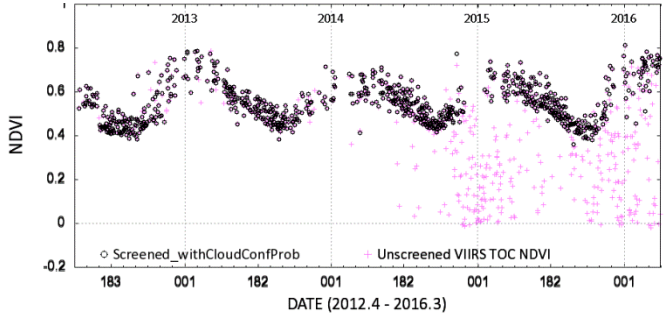


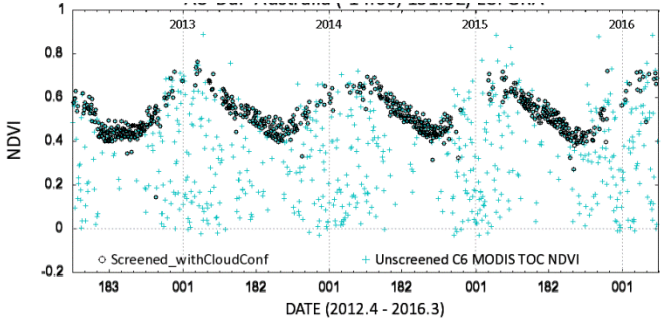
TOC-EVI





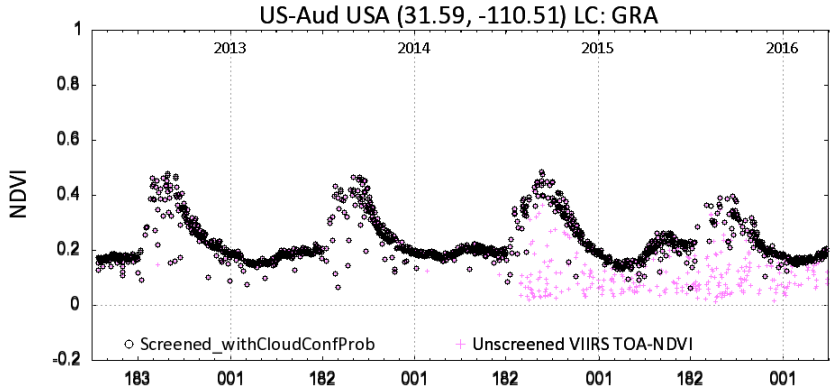
TOC-NDVI



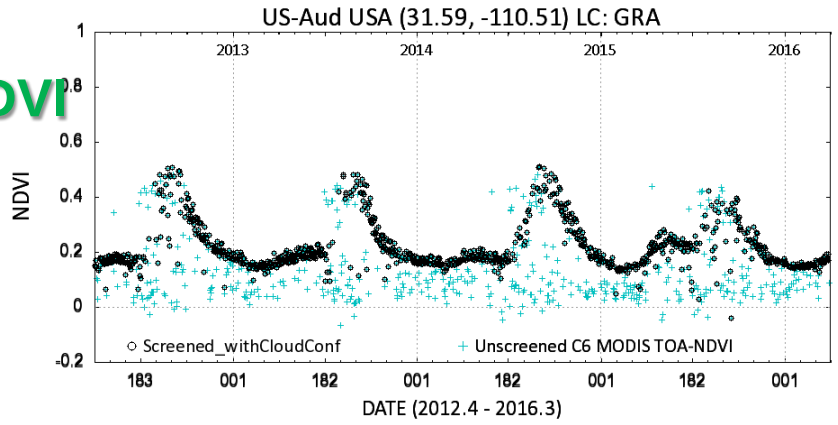


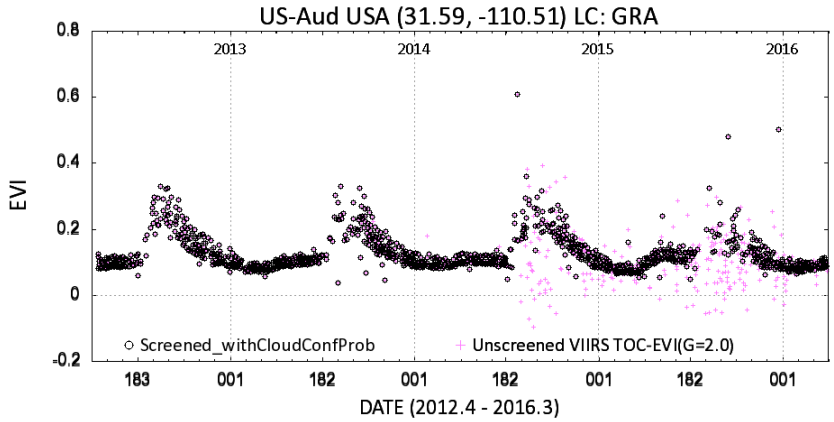
VIIRS VIs vs. MODIS C6 VIs (Cloud screening)

- Observations remained after cloud screening

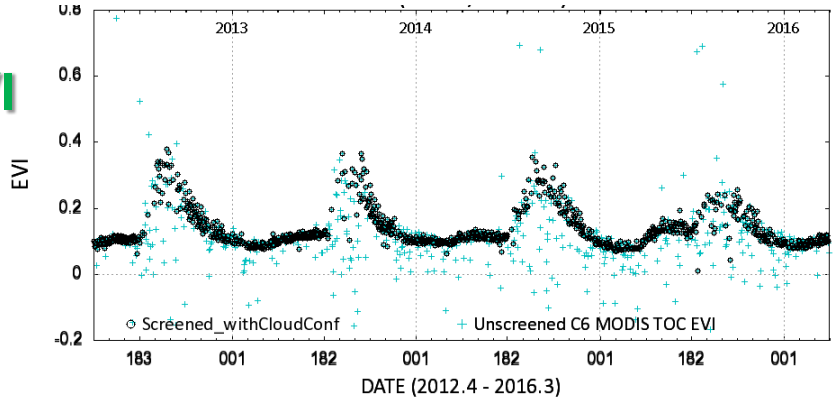


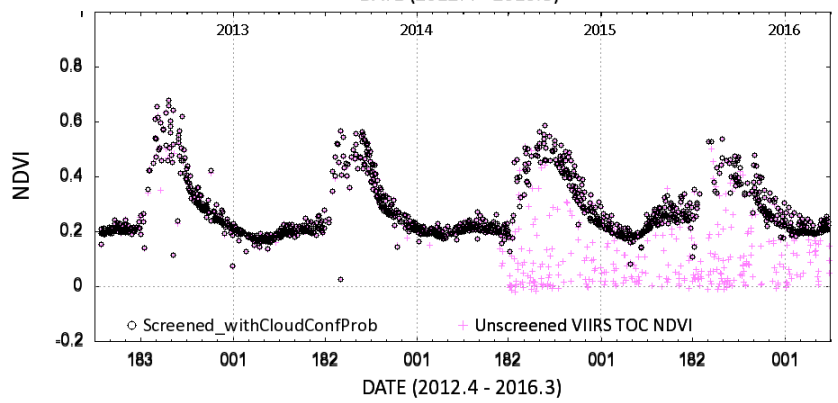
TOA-NDVI



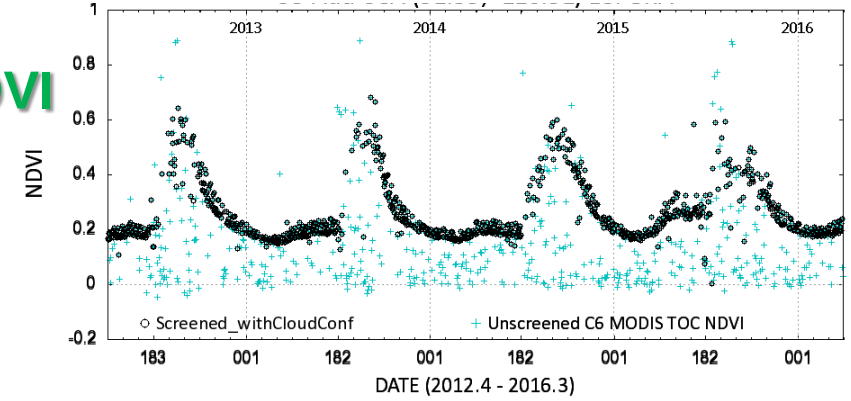


TOC-EVI





TOC-NDVI



IDPS S-NPP VIIRS VI EDR: Inter-Comparison Exercise

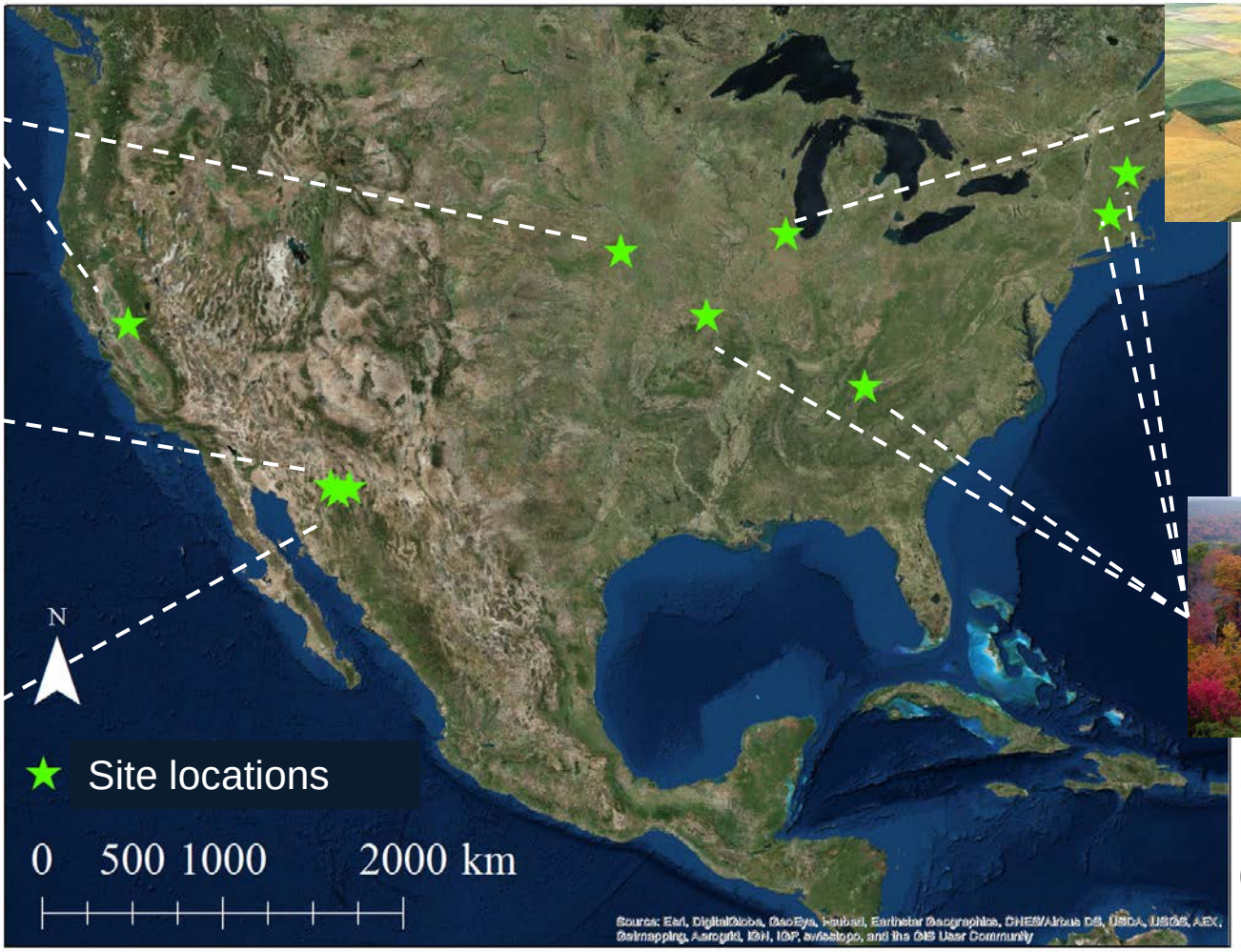
11 flux tower sites across the conterminous U.S.

Temperate grassland (2), Semi-arid grassland (2), Woody savanna (1), Cropland (2), Deciduous forest (4)

Temperate grass (GRA_t)

Semi-arid grass (GRA_{arid})

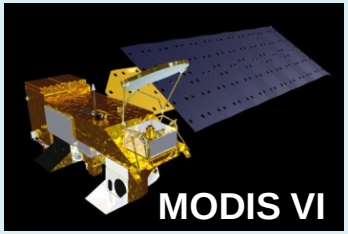
Woody savanna (WSA)



Cropland (CRO)

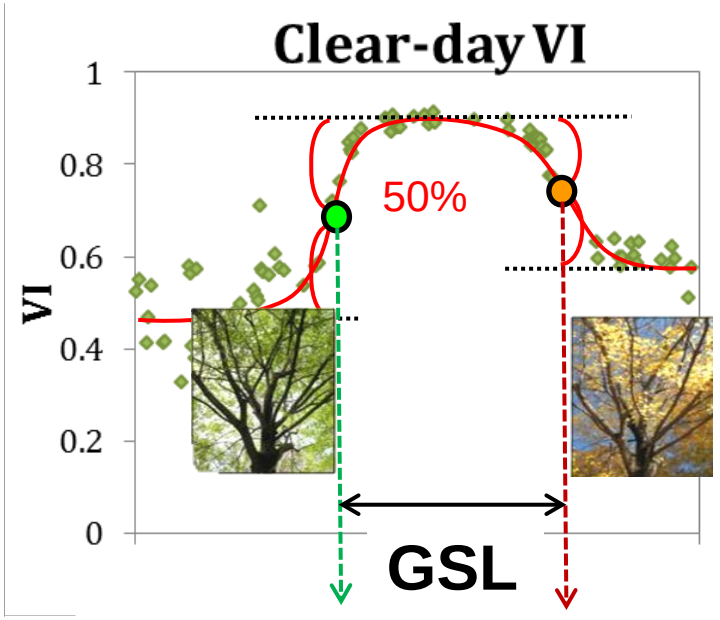
Deciduous Forest (DBF)

Methods



data

Processing



Start-of-Season (**SOS**)

End-of-Season (**EOS**)

Data screening
Satellite: Quality flags
In-situ data: radiation & precipitation

VI time series with data gap

Model Daily VI (Fisher et al., 2006)

Modeled multi-years VI curve

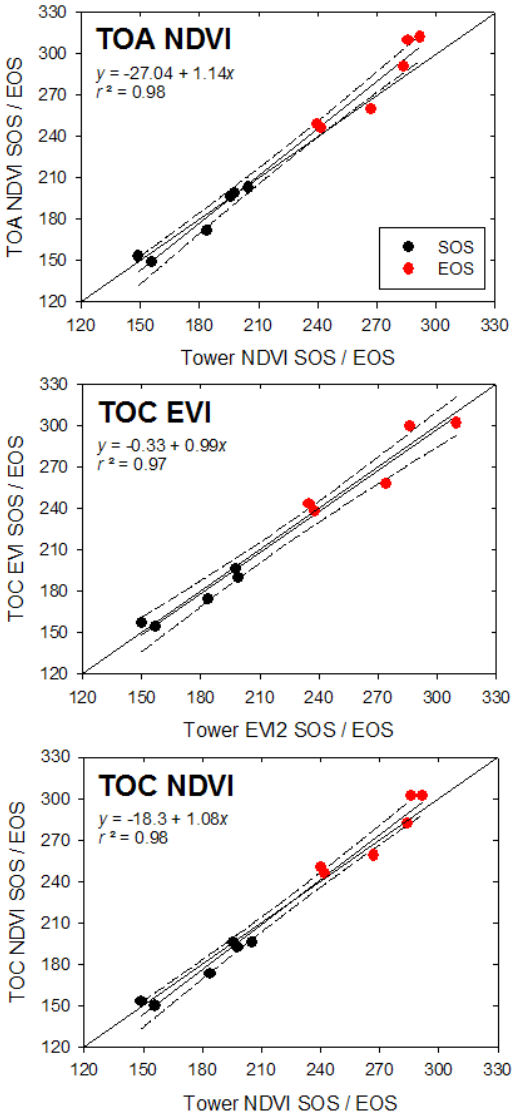
Calculate SOS, EOS, GSL
(Fisher et al., 2007; Zhang et al., 2014)

Multi-years **SOS**, **EOS**, **GSL**

Correlation analysis between SOS & GSL, EOS & GSL
(Spearman's rank correlation, *r*)

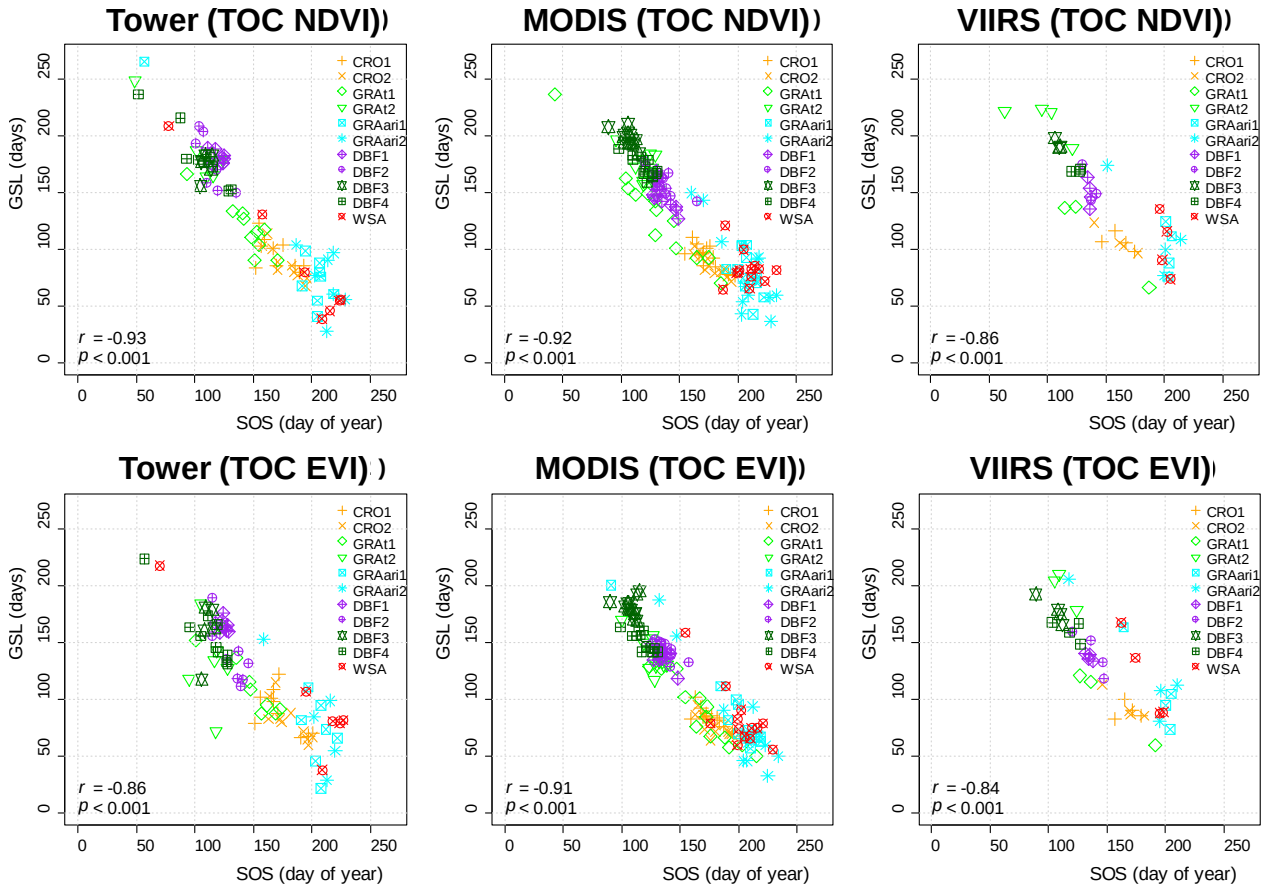
IDPS S-NPP VIIRS VI EDR: Inter-Comparison Exercise

VIIRS vs. *In Situ* Phenological Metrics Cross-Comparison



- VIIRS- & *In Situ*-derived phenological metrics corresponded well (e.g., SOS MD < 5 days; SOS RMSE < 7 days)
- Temporal & spatial treads obtained from VIIRS VI EDR compared well with those from MODIS and *In Situ* VIs.

In Situ vs. MODIS vs. VIIRS Inter-Comparison of Temporal Phenological Trends



NDE S-NPP VIIRS GVF Validation (1/3)

Home GVF

JPSS VIIRS Green Vegetation Fraction

Data Sources:
- VIIRS
- AVHRR
- VIIRS-AVHRR

Data Sets:
- GVF
- Surface Type
- Climatology

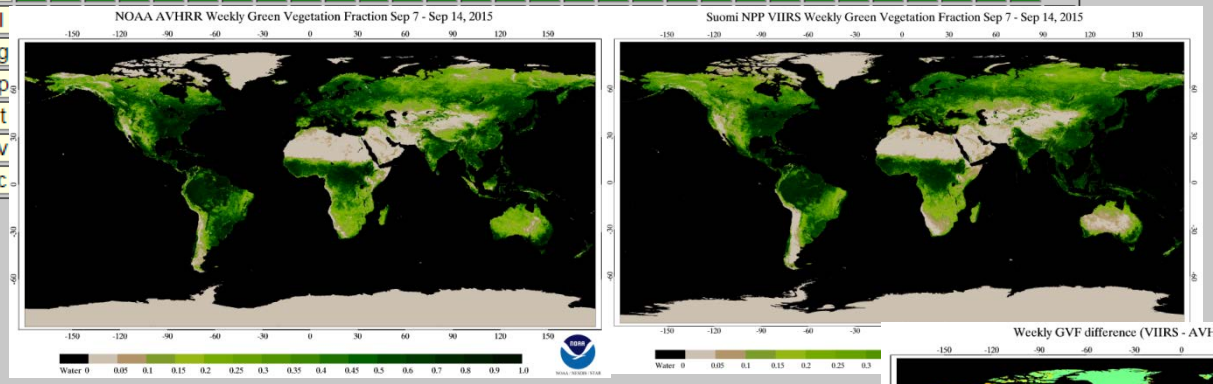
Compositing:
- Daily Rolling Weekly

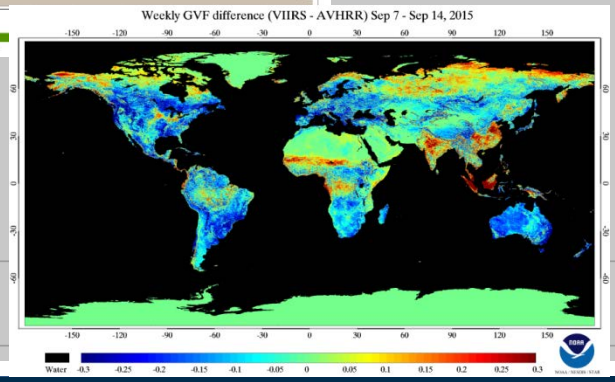
Analysis:
- Availability Tables
- Maps

Date: dd 08 mm 08 yyyy 2016

VIIRS | Year 2016

M\D	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Jan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Feb	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
Mar	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Apr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
May	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jun	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Jul																															
Aug																															
Sep																															
Oct																															
Nov																															
Dec																															



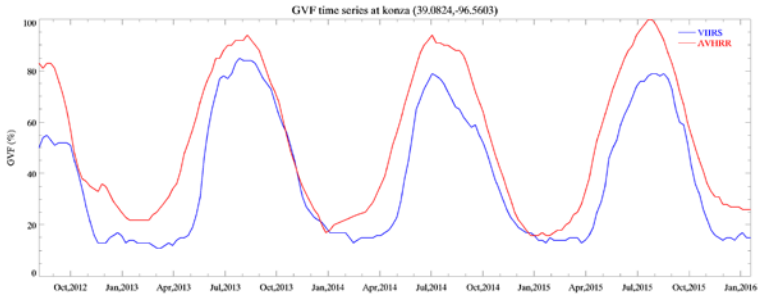


http://www.star.nesdis.noaa.gov/smcd/viirs_vi/gvf/gvf.htm

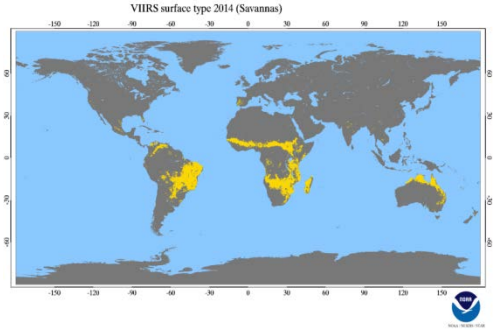
NDE S-NPP VIIRS GVF Validation (2/3)

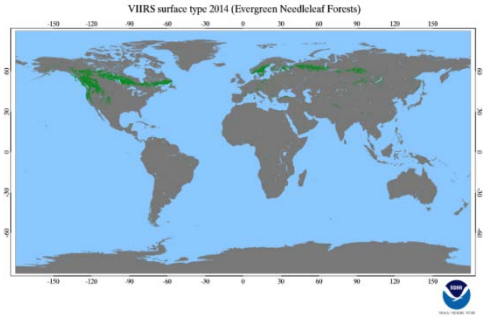
GVF Time Series and Correlative Analysis Between VIIRS and AVHR

GVF Temporal Trajectories VIIRS vs. AVHRR Konza Validation Site

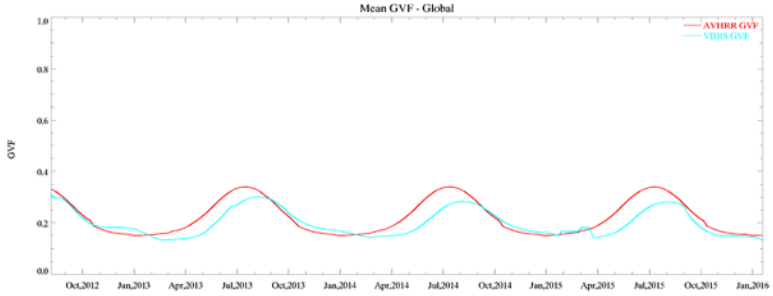


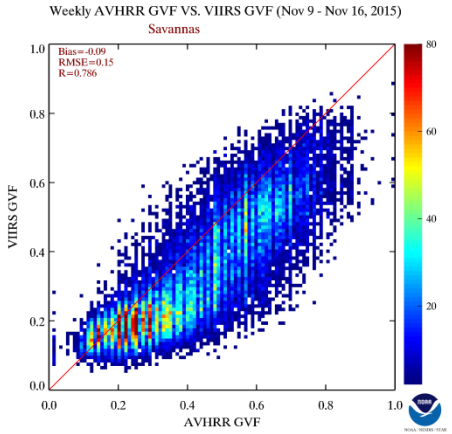
GVF Comparison by Surface Type VIIRS vs. AVHRR

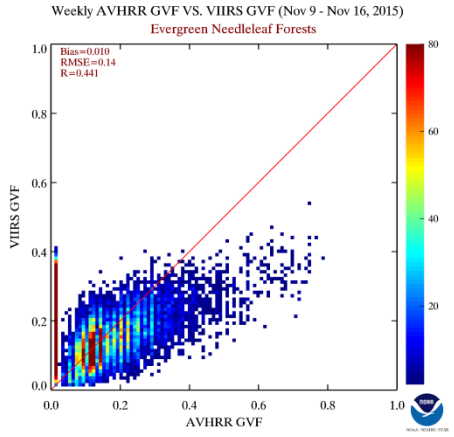




Global GVF Temporal Trajectories VIIRS vs. AVHRR

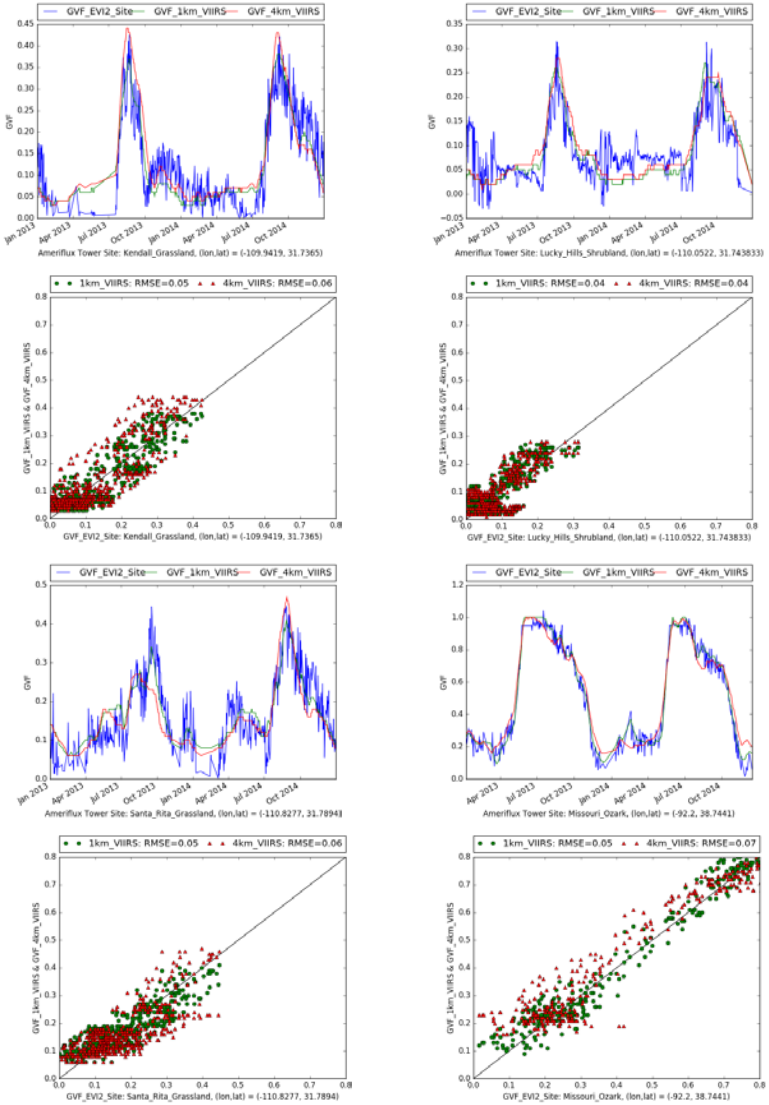






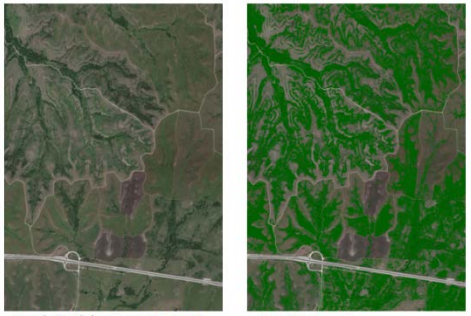
NDE S-NPP VIIRS GVF Validation (3/3)

GVF Time Series Inter-Comparison Using In Situ Networks



Comparison Between VIIRS GVF and Google Earth GVF

Konza

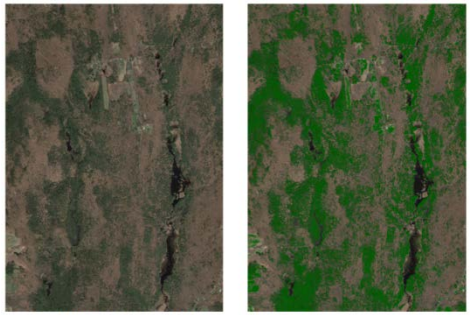


Google Earth image over a 0.036-degree VIIRS GVF pixel (8/13/2014)

Classified image (green vegetation: green)

Google Earth GVF= 0.44
VIIRS GVF= 0.55

Harvard Forest

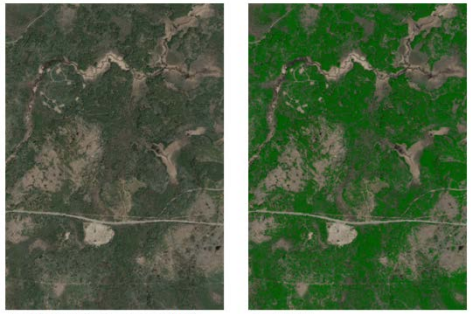


Google Earth image over a 0.036-degree VIIRS GVF pixel (4/27/2016)

Classified image (green vegetation: green)

Google Earth GVF= 0.26
VIIRS GVF= 0.34

Park Falls

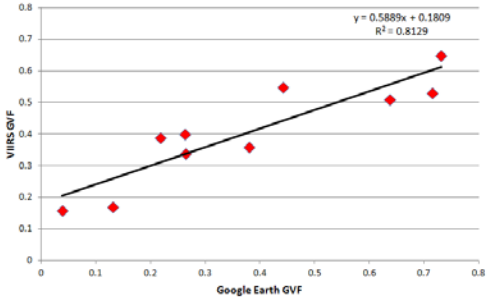


Google Earth image over a 0.036-degree VIIRS GVF pixel (5/10/2013)

Classified image (green vegetation: green)

Google Earth GVF= 0.38
VIIRS GVF= 0.36

Scatter Plot
VIIRS GVF vs. Google Earth GVF

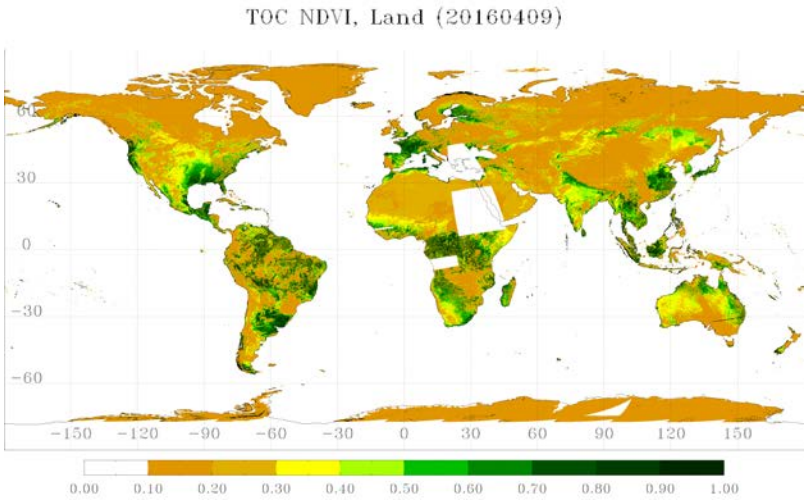


JPSS-1 Readiness (1/3)

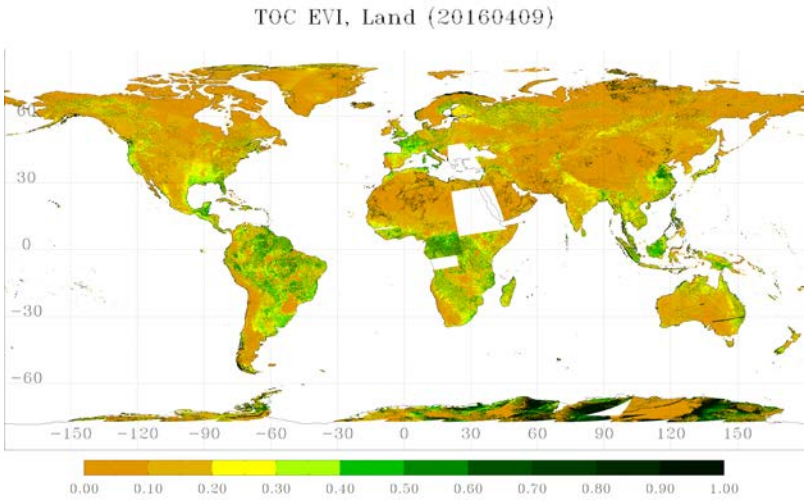
- A new vegetation index, the TOC NDVI, has been added to the JPSS-1 VIIRS VI EDR
- An improved EVI algorithm has been incorporated which stabilizes the EVI performance over snow/ice/cloud-contaminated pixels
- The Block 2.0 VIIRS VI EDR algorithm has been tested (LG2 and OBSAT tests) and it is performing well
- JPSS VI EDR Cal/Val plan was delivered last year
- Cal/Val datasets: J1 Test Data, SNPP VI, MODIS VI, AERONET, FLUXNET
- SNPP Cal/Val tools are being adapted to work with JPSS-1 VI products
- J1 GVF continuity and upgrades project funded
- Schedules and Milestones
  - Beta: October 2017 (VIIRS SDR Beta + 7 months)
  - Provisional: April 2018 (Beta + 6 months)
  - Validated: April 2019 (Provisional + 12 months)

JPSS-1 Readiness (2/3)

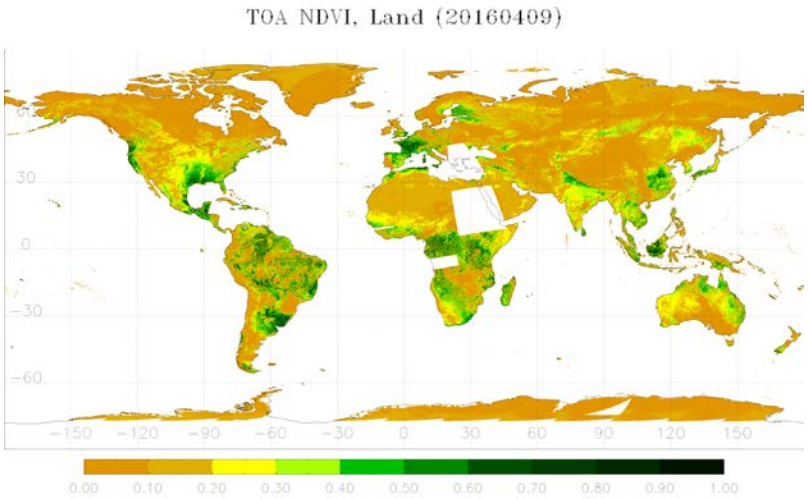
TOC NDVI



TOC EVI

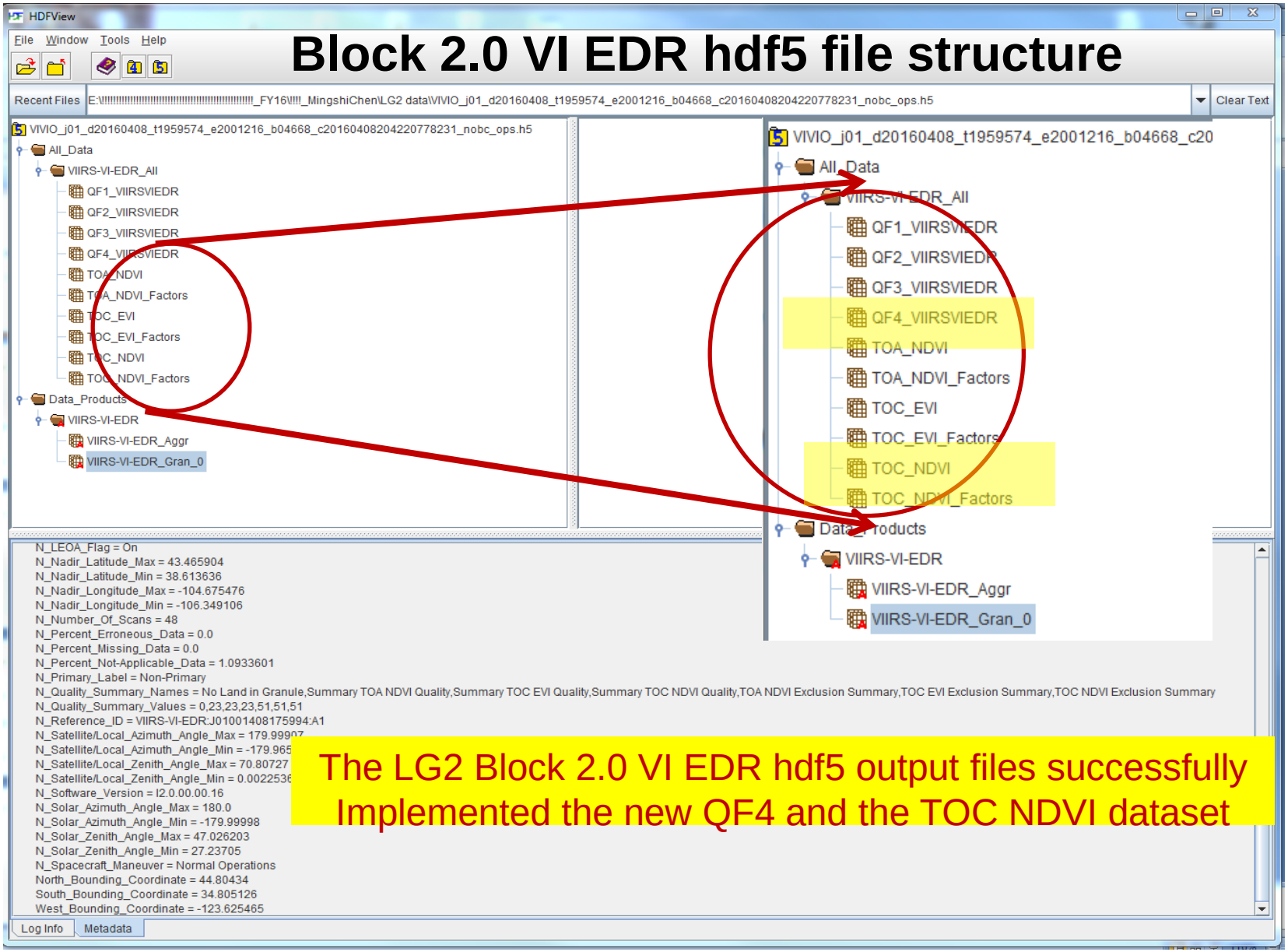


TOA NDVI



LG2 Test (Block 2.0)
20160409

JPSS-1 Readiness (3/3)



The LG2 Block 2.0 VI EDR hdf5 output files successfully Implemented the new QF4 and the TOC NDVI dataset

Enterprise Algorithm for Vegetation Products

- Land algorithms are currently transitioning to Enterprise solutions

- The Enterprise Algorithm for Vegetation products is in the planning stage
- Enterprise Vegetation Products: TOA-NDVI, TOC-NDVI, GVF, EVI, EVI2*, LAI*, fPAR*, PSN* and NPP*
- Global gridded products in Lat/Lon projection
- Spatial resolution: 1 km (0.009 degree)
- Temporal resolution: daily, weekly updated daily, and bi-weekly updated daily
- Output File Format: NetCDF4

*No L1 requirement to create these new products

2-phased Development Strategy

- Implement a 2-phased approach for the development of the Enterprise Algorithm for Vegetation Products

➢ Phase 1

Products to be implemented in this phase:

TOC EVI, TOC EVI2, TOC NDVI, TOA NDVI, GVF

➢ Phase 2

Products to be implemented in this phase:

LAI, fPAR, NPP, PSN

S-NPP VIIRS VI EDR Reprocessing

- The VI Team will reprocess all the VIIRS Vegetation products since the beginning of the SNPP mission, using the Enterprise Algorithm for Vegetation Products (EAVP) that will run operationally at NDE in the near future
- During reprocessing the EAVP will ingest the reprocessed versions (enterprise versions) of the VIIRS SDR, CM, SR, and AOT datasets
- The reprocessed VI products 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)

Operational Use

- VIIRS EVI used to derive VIIRS Green Vegetation Fraction (GVF)
- STAR Land Team members (Csiszar/Vargas/Yu) are working with NCEP/EMC to incorporate the near-real-time Suomi NPP Green Vegetation Fraction into NCEP Land modeling suite
- This effort will lead to the operational use of the existing Suomi NPP GVF product in EMC modeling

Summary

- All the SNPP VIIRS Vegetation Index products are performing well
- The VI Team is ready for the EOC of the JPSS1 VI EDR
- The NDE implementation of the SNPP VI products is under development
- The Enterprise Algorithm for Vegetation Products is being prototyped. STAR Land Team has identified the deficiencies in the requirements and is working on the CCRs
- Reprocessing of the SNPP VIIRS VI products is necessary to 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
- VIIRS VI product validation will be coordinated with CEOS/WGCV LPV which has established a new “Vegetation Index” focus area

For more information on VIIRS Vegetation Products

- http://www.star.nesdis.noaa.gov/jpss/EDRs/products_VegIndex.php
- http://www.star.nesdis.noaa.gov/smcd/viirs_vi/Monitor.htm
- http://www.star.nesdis.noaa.gov/smcd/viirs_vi/gvf/gvf.htm
- http://www.nsof.class.noaa.gov/
- http://www.ospo.noaa.gov/Products
- http://www.star.nesdis.noaa.gov/jpss/
- http://viirsland.gsfc.nasa.gov/Products/GVF.html

Back up slides

Enterprise Algorithm for Vegetation Products

Acronym	Description	Purpose
TOA NDVI	Normalized Difference Vegetation Index, at the top of the atmosphere	Continuity with AVHRR heritage
TOC NDVI	Normalized Difference Vegetation Index, at the top of the canopy	Continuity with MODIS/AVHRR heritage, focused on surface values
EVI / *EVI2	Enhanced Vegetation Index	Continuity with MODIS heritage. Useful parameter for biogeophysical models and scientific interpretation. Complement the NDVI
GVF	Green Vegetation Fraction	Useful parameter for biogeophysical models and scientific interpretation
***LAI**	Leaf Area Index	Useful parameter for biogeophysical models and scientific interpretation
***fPAR**	Fraction of absorbed Photosynthetically Active Radiation	Useful parameter for biogeophysical models and scientific interpretation
***PSN**	Net Photosynthesis	Useful parameter for assessing the magnitude of CO2 transport in the carbon cycle
***NPP**	Net Primary Production	Useful parameter for monitoring of crops and forests

*No L1 requirement to create these new products. The JPSS ATBD for Vegetation Index products describes that those products will be produced

Enterprise Algorithm for Vegetation Products

Product	VIIRS	ABI	AVHRR	MODIS	Users of NOAA Product
TOA NDVI	O	F	O	—	NWS, USDA, USGS
TOC NDVI	R	—	—	O*	
EVI	O	—	—	O*	
EVI2	—	—	—	P*	
GVF	O	F	O	—	NWS/NCEP
LAI	—	—	—	O*	
fPAR	—	—	—	O*	
PSN	—	—	—	O*	
NPP	—	—	—	O*	

O – operational, F – future capability
R – Ready for operational implementation
*P – planned for production at NASA
*MODIS production at NASA