SNPP VIIRS Vegetation Index EDR

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STAR JPSS 2014 Science Team Annual Meeting, May 12-16, NCWCP College Park, MD

Outline

- Overview
  - Team Members, Users, Accomplishments
- Algorithm Evaluation:
  - Product Requirements, Algorithm Description, Validation Approach, Product Improvements
- Future Plans
  - Plan for JPSS-1 Algorithm Updates and Validation Strategies, Schedule and Milestones
- Summary

VI EDR Team Members

- Marco Vargas (NOAA/STAR) STAR VI EDR algorithm lead
- Tomoaki Miura (University of Hawaii) VI Cal/Val lead
- Nikolay Shabanov (STAR/IMSG) Product monitoring, algorithm development and validation
- Javzan Azuma (University of Hawaii) Cal/Val Team Member
- Alfredo Huete (UTS) Cal/Val Team Member
- Leslie Belsma (Aerospace) Land JAM
- Alain Sei (NGAS) External Partner, Consultant
- Al Danial (NGAS) External Partner, Consultant
- Michael Ek (NOAA/NCEP) User readiness
- Walter Wolf (NOAA/STAR) AI&T Team Lead

VI EDR Customers/Users

– NCEP

– STAR

– CLASS

– USDA

– USGS

– University of Hawaii at Manoa

– The Climate Corporation

– University of Technology Sydney

VI EDR Accomplishments

- Maturity Reviews
  - Beta Maturity: February 2012
  - Provisional Maturity: August 2013
- Product Improvements: Additional Quality Flags for the VI EDR will be implemented in Mx8.4
- Peer reviewed publications

Vargas, M., T. Miura, N. Shabanov, and A. Kato (2013), An initial assessment of Suomi NPP VIIRS vegetation index EDR, J. Geophys. Res. Atmos., 118, 12,301–12,316, doi:10.1002/2013JD020439.

Obata, K., T. Miura, Y. Yoshioka, and A. Huete (2013), Derivation of a MODIS-compatible EVI from VIIRS spectral reflectance using vegetation isoline equations, J. Appl. Remote Sens. 7, 073467.

TOA NDVI May 01, 2013

VIVIO_npp_d20130501_t2006109_e2007351_b07824_c20140509022958972057_noaa_ops.h5
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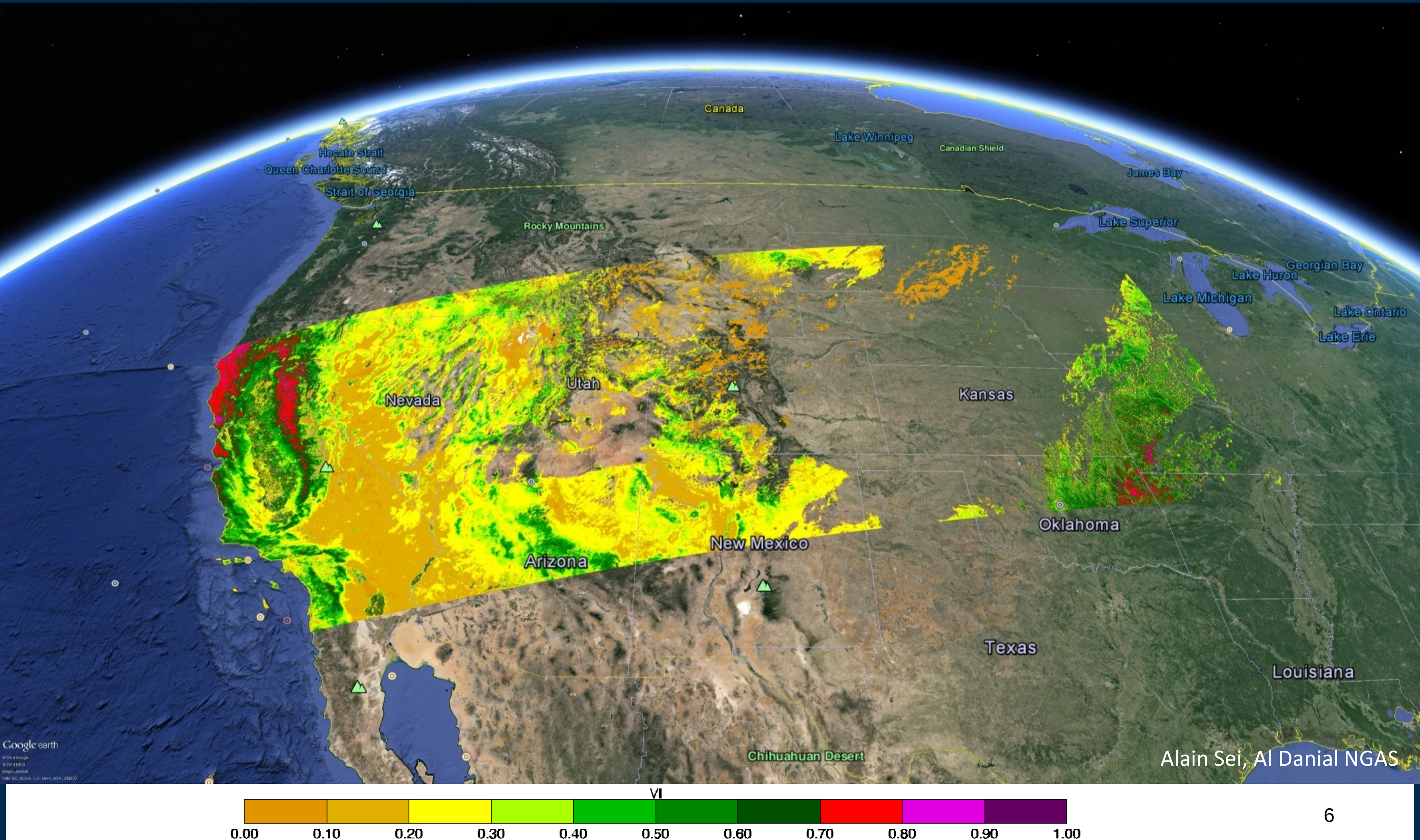

TOA NDVI April 30, 2014

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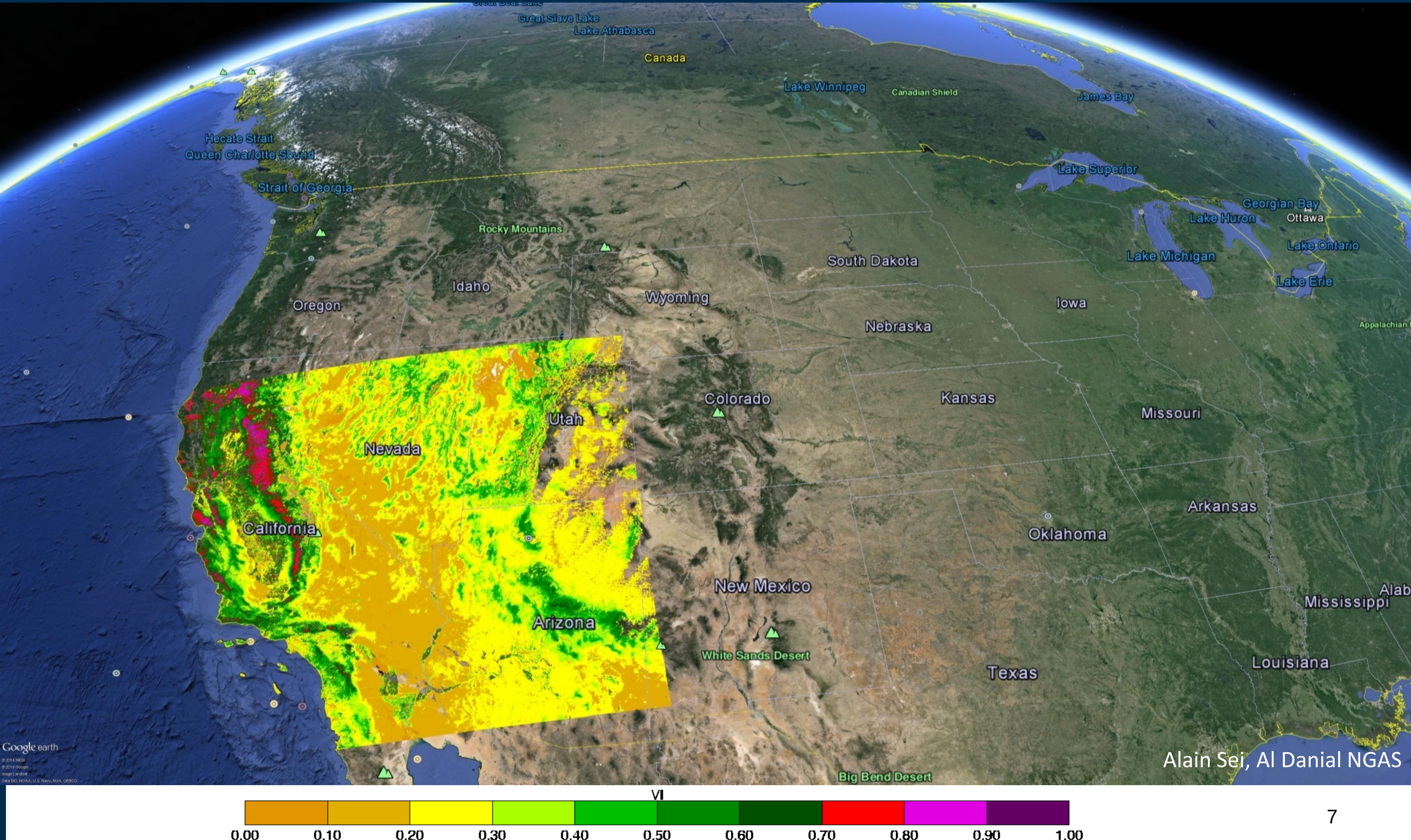
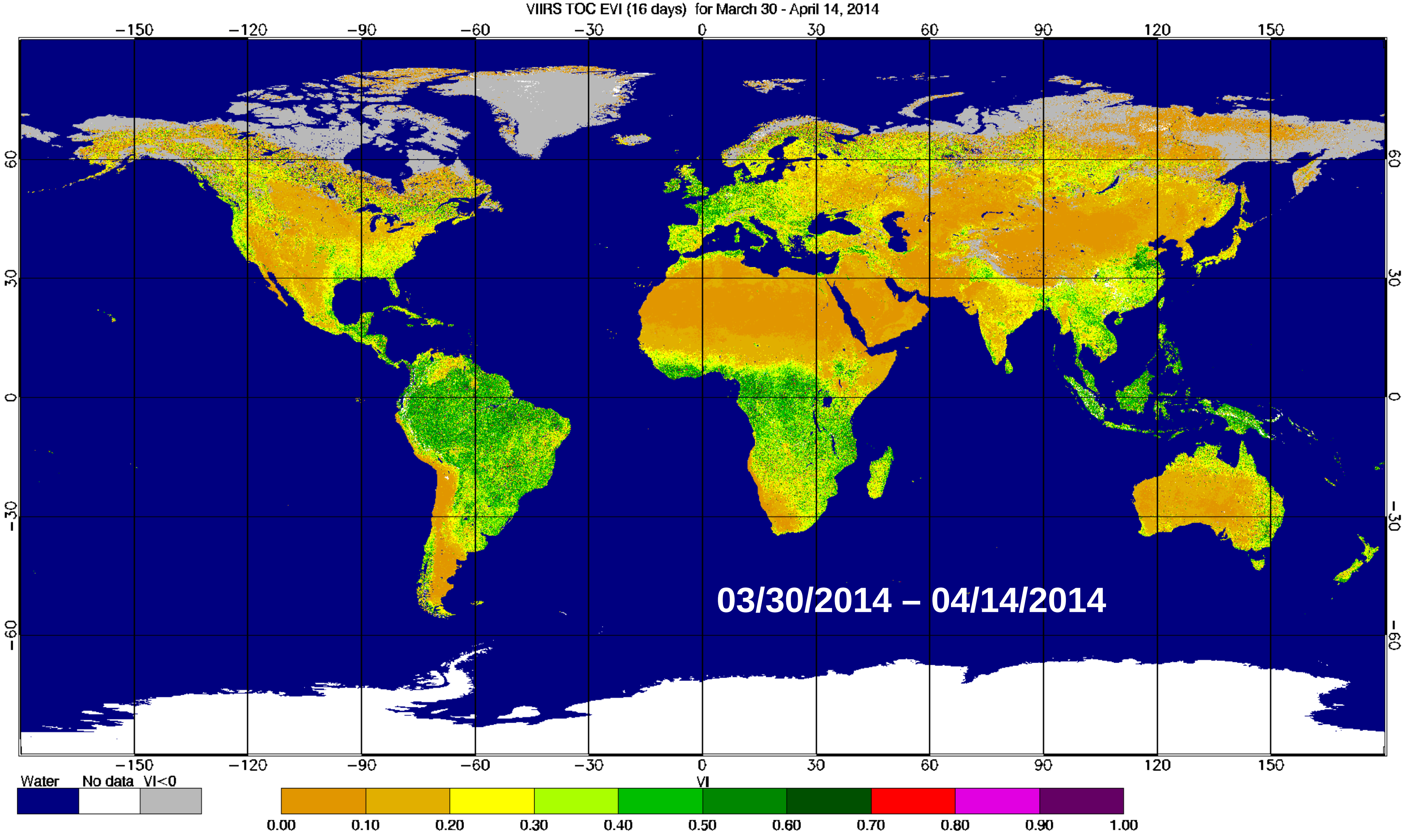
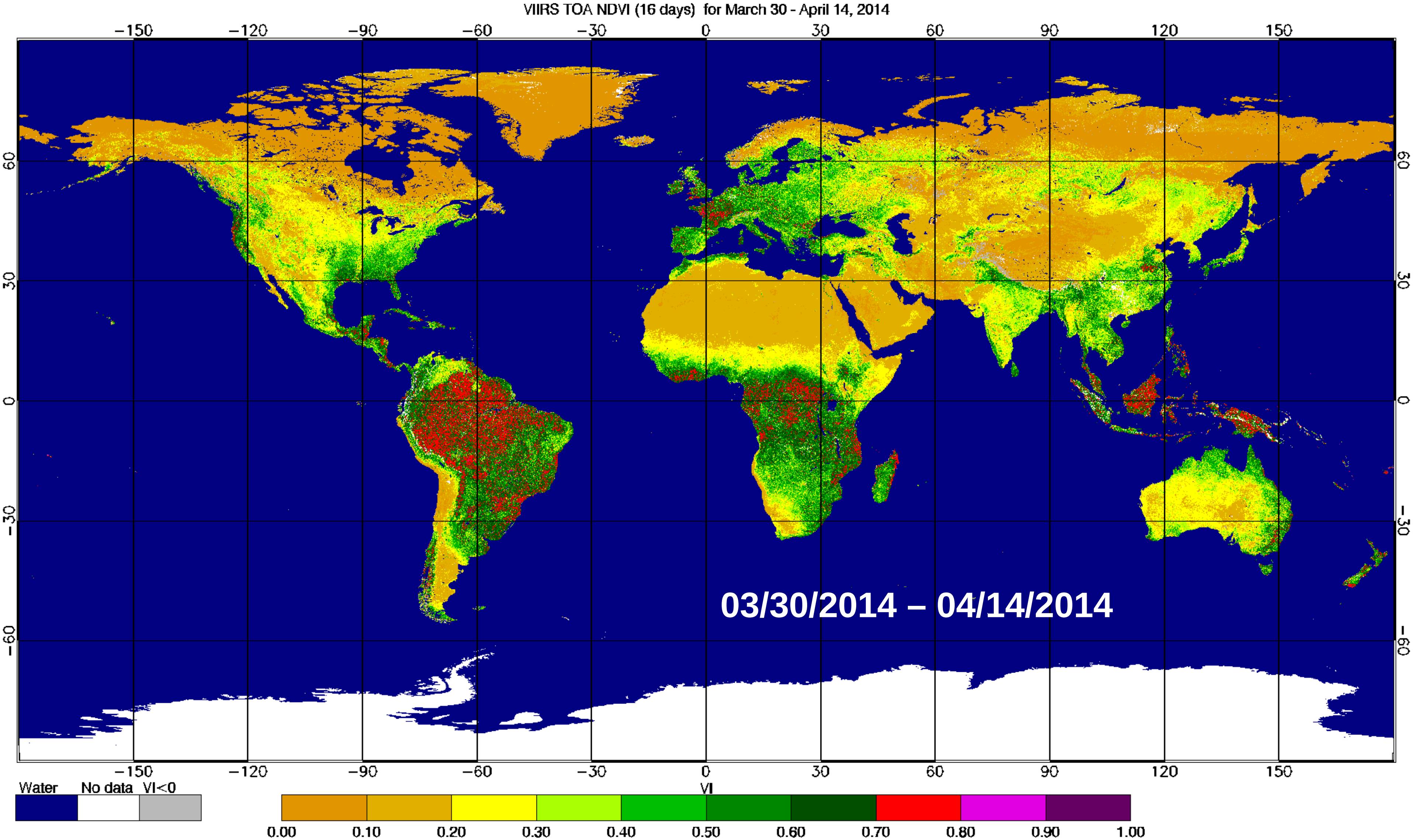


TOC EVI
16-day composite



TOA NDVI
16-day composite



VI EDR Product Requirements

Table 5.5.9 - Vegetation Indices (VIIRS)		
EDR Attribute	**Threshold**	**Objective**
Vegetation Indices Applicable Conditions		
1. Clear, land (not ocean), day time only		
a. Horizontal Cell Size	0.4 km	0.25 km
b. Mapping Uncertainty, 3 Sigma	4 km	1 km
c. Measurement Range		
1. NDVITOA	-1 to +1	NS
2. EVI (1)	-1 to +1	NS
3. NDVITOC	-1 to +1	NS
d. Measurement Accuracy - $NDVI_{TOA}$ (2)	0.05 NDVI units	0.03 NDVI units
e. Measurement Precision - $NDVI_{TOA}$ (2)	0.04 NDVI units	0.02 NDVI units
f. Measurement Accuracy - EVI (2)	0.05 EVI units	NS
g. Measurement Precision - EVI (2)	0.04 EVI units	NS
h. Measurement Accuracy - $NDVI_{TOC}$ (2)	0.05 NDVI units	NS
i. Measurement Precision - $NDVI_{TOC}$ (2)	0.04 NDVI units	NS
j. Refresh	At least 90% coverage of the globe every 24 hours (monthly average)	24 hrs.

New for JPSS1

Notes:

1. EVI can produce faulty values over snow, ice, and residual clouds (EVI > 1).
2. Accuracy and precision performance will be verified and validated for an aggregated 4 km horizontal cell to provide for adequate comparability of performance across the scan.

Source: Level 1 Requirements Supplement – Final Version:2.9 June 27, 2013

SNPP VIIRS VI EDR Algorithm Description

- The SNPP VIIRS Vegetation Index EDR consists of two vegetation indices:
  1. Normalized Difference Vegetation Index (NDVI) from top-of-atmosphere (TOA) reflectances
  2. Enhanced Vegetation Index (EVI) from top of canopy (TOC) reflectances.
- These indices are produced at the VIIRS image channel resolution on a daily basis

VI EDR Algorithm

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

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

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)

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

C_1, C_2 and L are constants

VI EDR Validation Approaches

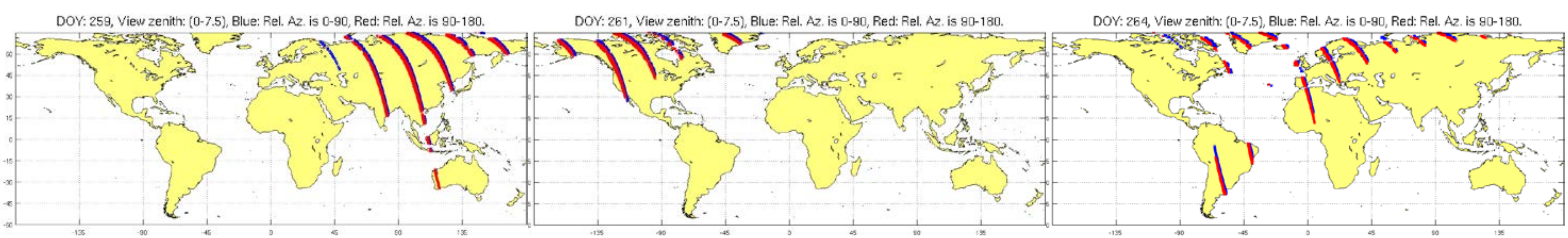
- Validation Using Aqua MODIS as a Reference
  a) Regional – Global Mosaic Analysis
  b) Subset Time Series Analysis

- Validation Using Aeronet-based Surface Reflectance (Matchup analysis) (see poster #23 by Shabanov and Vargas)

- Validation Using Tower Reflectance Data (see poster #22 by Wang, Miura, Kato and Vargas)

VIIRS vs. MODIS Global Comparison

- ***Radiometric accuracies*** of VIIRS TOA NDVI and TOC EVI have been evaluated by comparison with Aqua MODIS
  - Using observation pairs along overlapping orbital tracks
    - Four view zenith (VZ) angle bins: VZ < 7.5º, 20º < VZ < 27.5º, 40º < VZ < 47.5º, 55º < VZ < 62.5º
  - Three days of data for global coverage
    - e.g., DOY 120, 122, and 125, 2014 to complete global coverage
  - APU metrics computed using MODIS as a reference
    - Exclusion conditions: confidently cloudy, solar zenith angle > 65º, ocean, AOT > 1.0; Additional screening: thin cirrus, inland water, cloud adjacency, high aerosol quantity, snow/ice, shadow



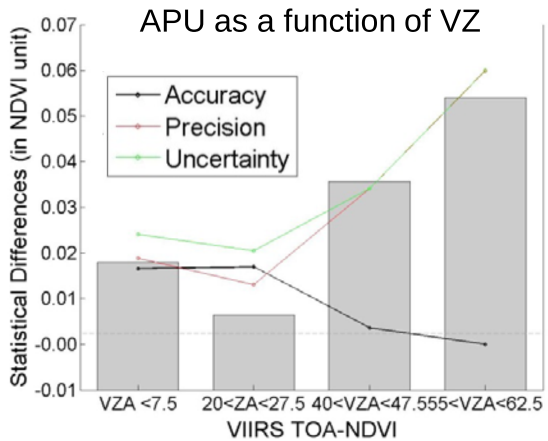
Figures indicating VIIRS-MODIS overlapping orbital tracks (VZ < 7.5º)
(Red = forward scattering geometry; Blue = backward scattering geometry)

VIIRS vs. MODIS APU Metrics

(DOY 056, 058, & 061, 2014)

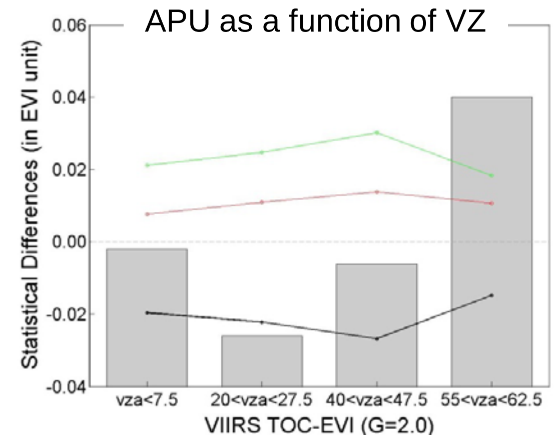
TOA-NDVI

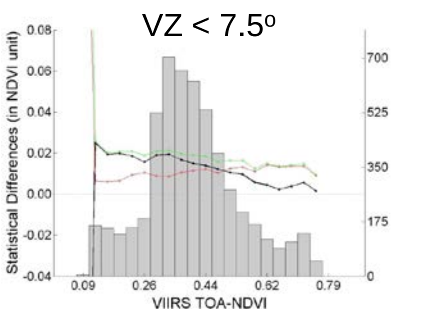
	Summary
A	0.007
P	0.030
U	0.033

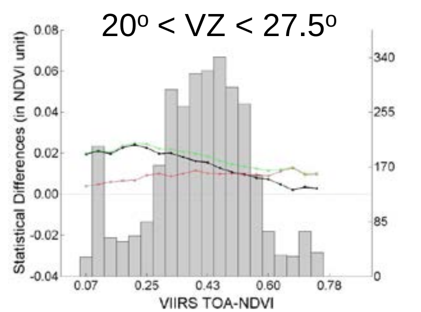


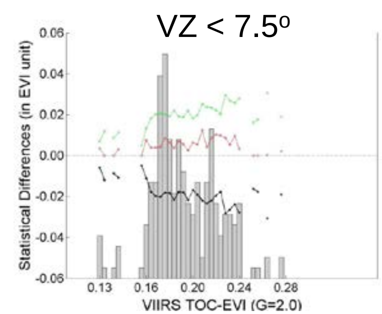
TOC-EVI

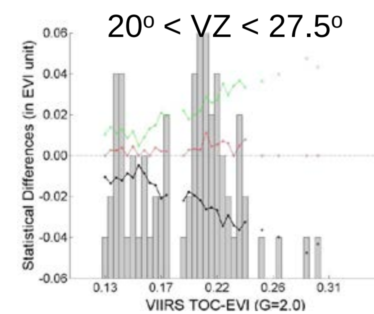
	Summary
A	0.021
P	0.010
U	0.023

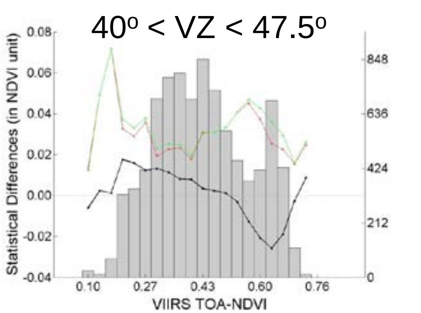


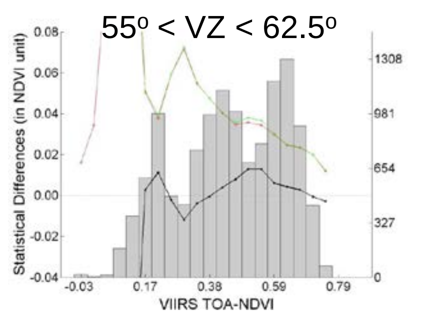


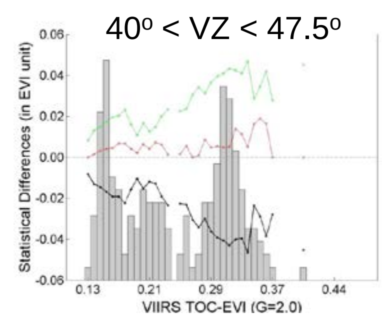


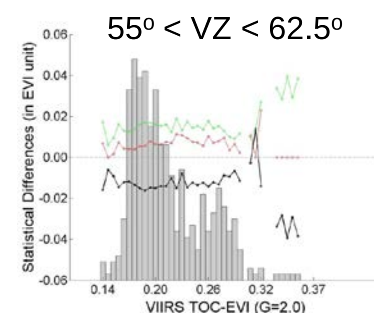






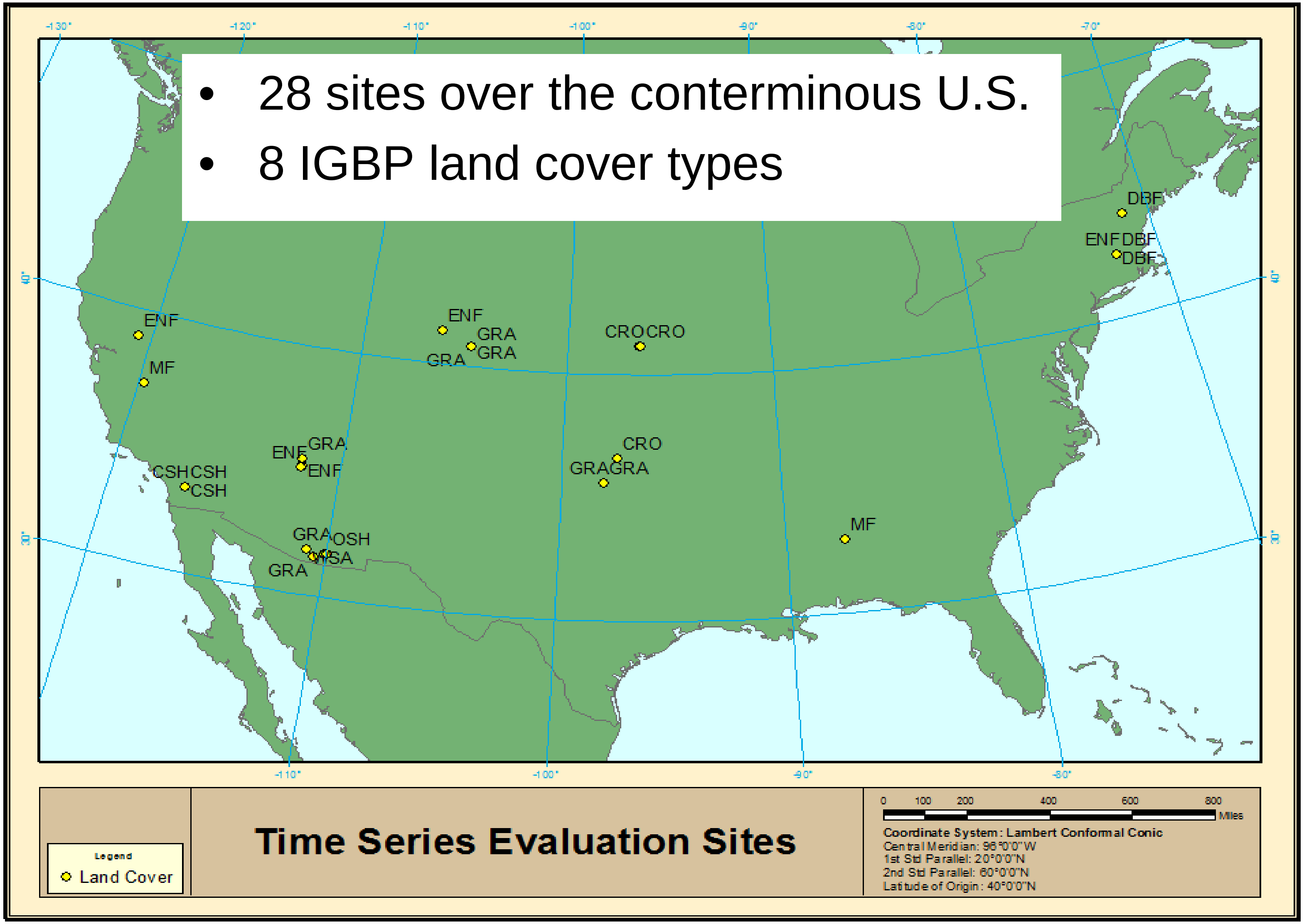






VIIRS Vegetation Index Time Series

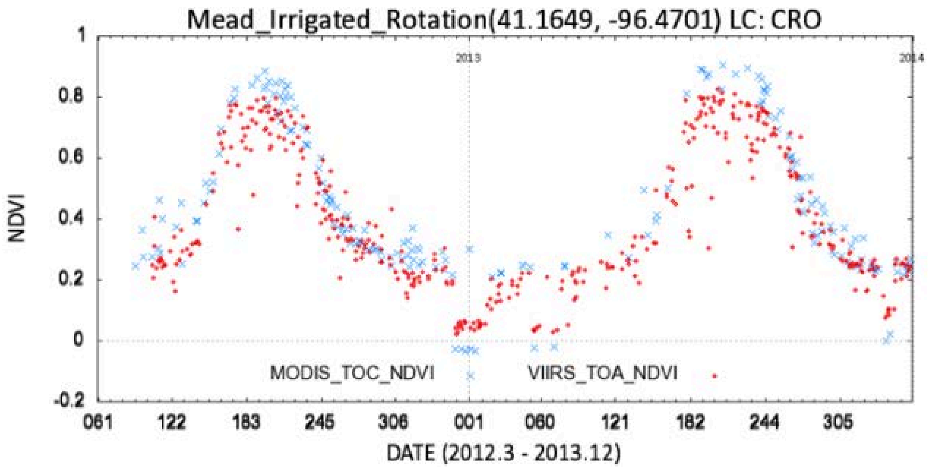
- 28 sites over the conterminous U.S.
- 8 IGBP land cover types

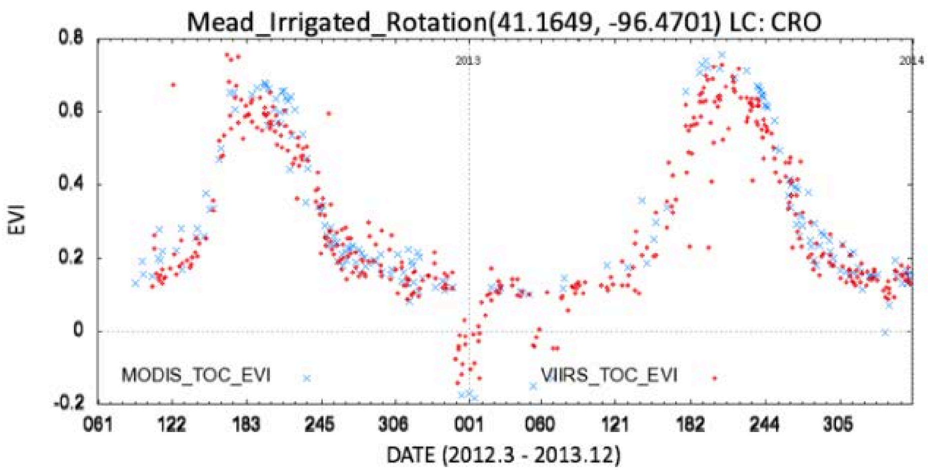


VIIRS Vegetation Index Time Series

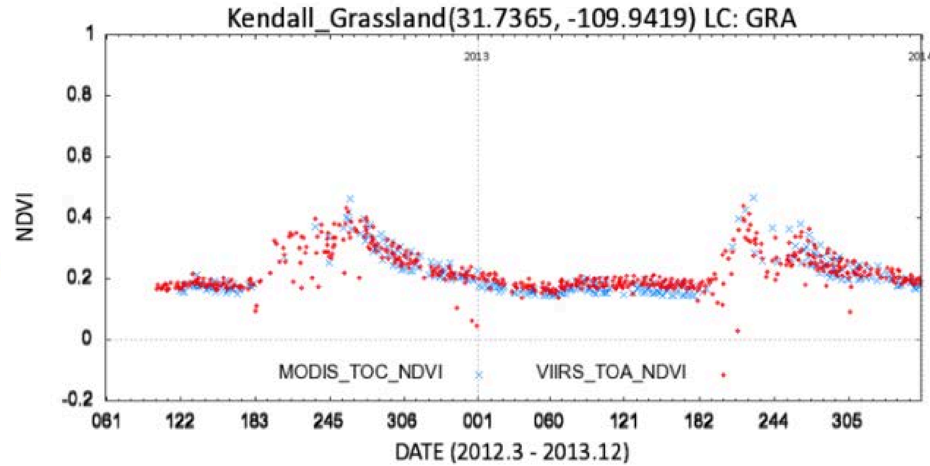
- VIIRS TOA NDVI and TOC EVI showing seasonal patterns comparable to those from the MODIS counterparts
- Higher cloud mask quality in 2013 than in 2012

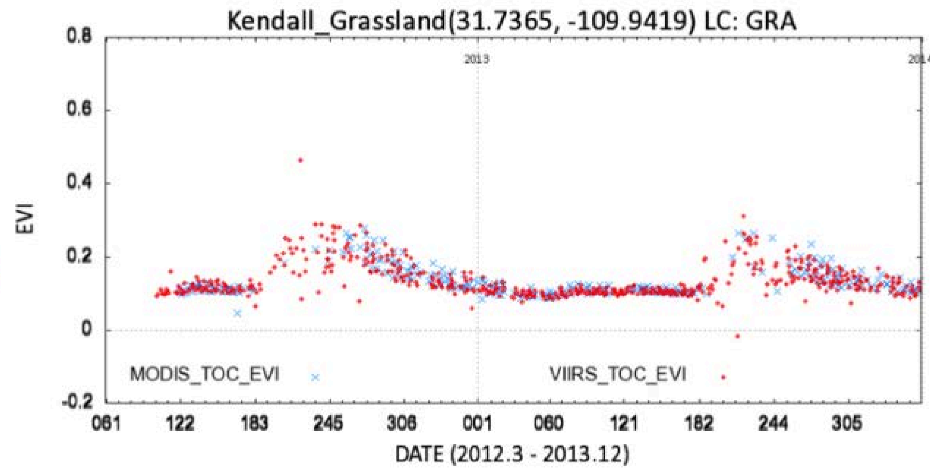
Broadleaf Crop





Grassland

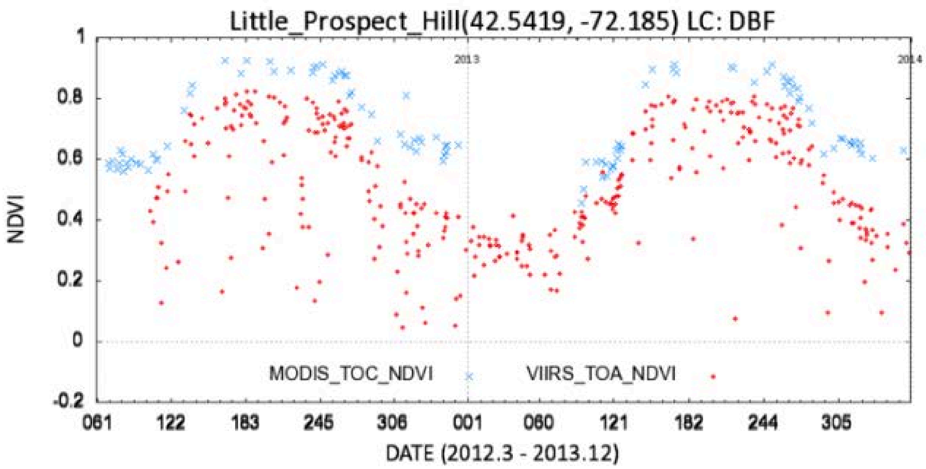


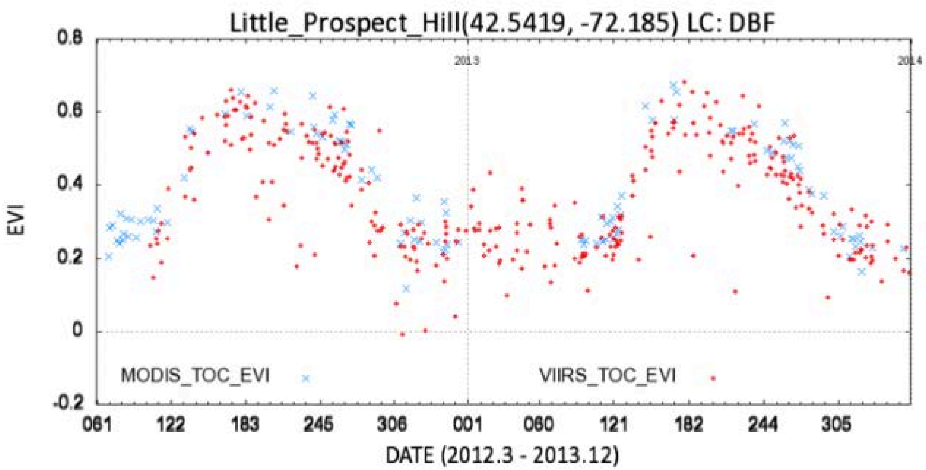


VIIRS Vegetation Index Time Series

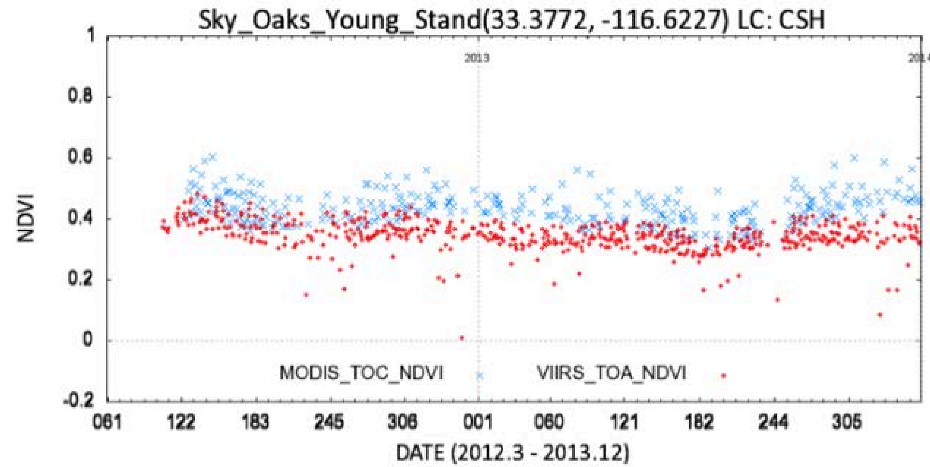
- VIIRS TOA NDVI and TOC EVI showing seasonal patterns comparable to those from the MODIS counterparts
- Higher cloud mask quality in 2013 than in 2012

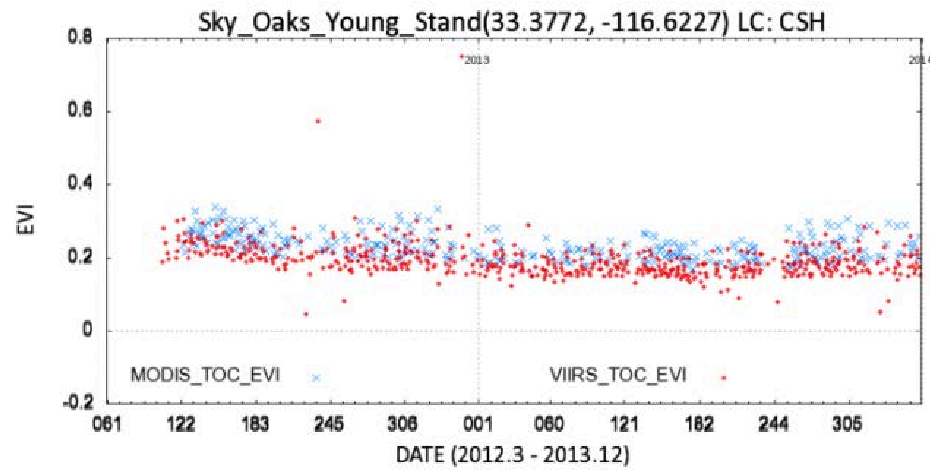
Deciduous Broadleaf Forest





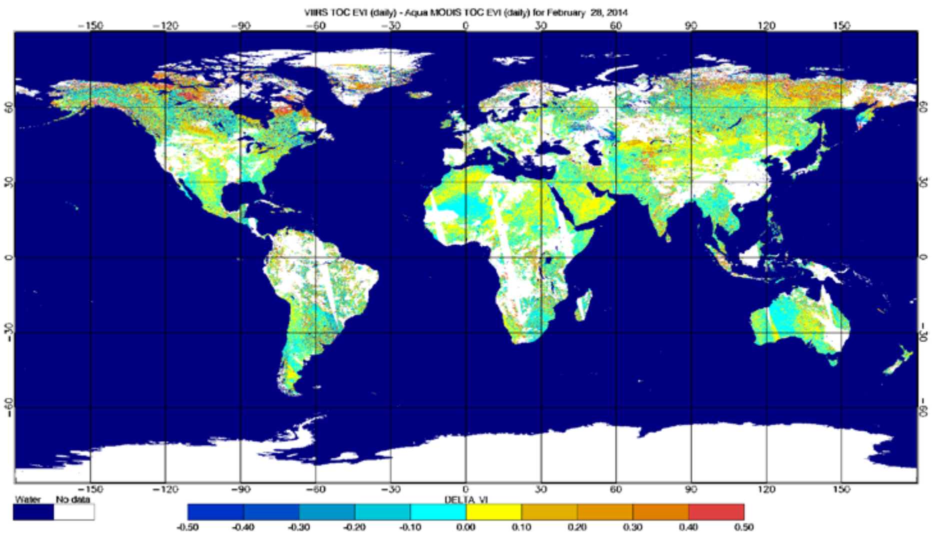
Closed Shrubland

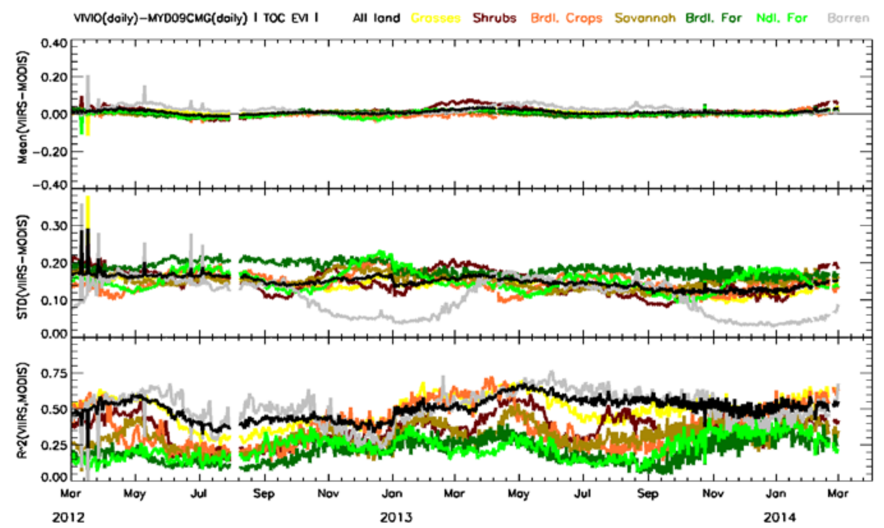


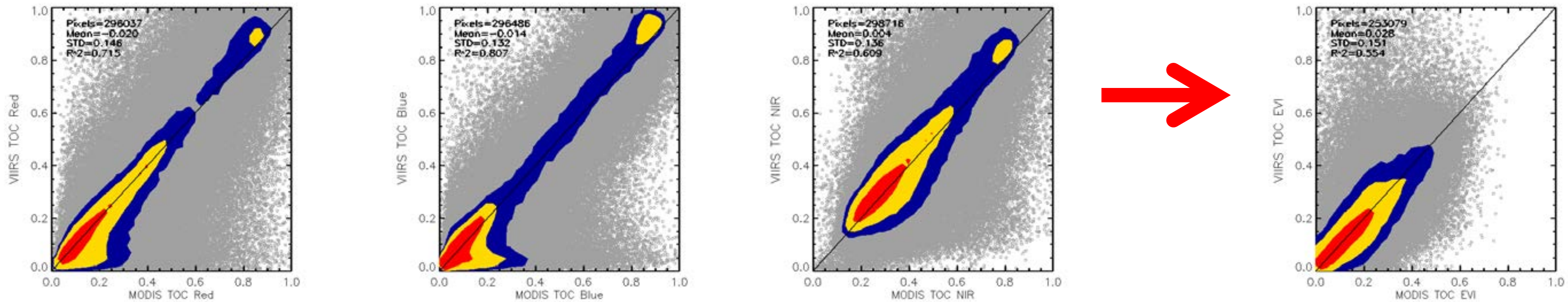


VIIRS Vegetation Index Time Series

Global TOC EVI VIIRS minus MODIS (February 28, 2014)



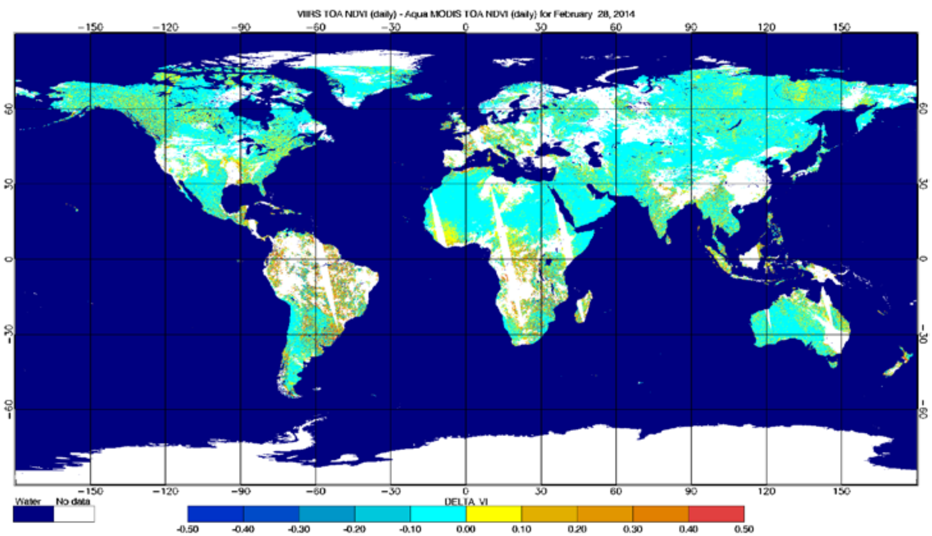


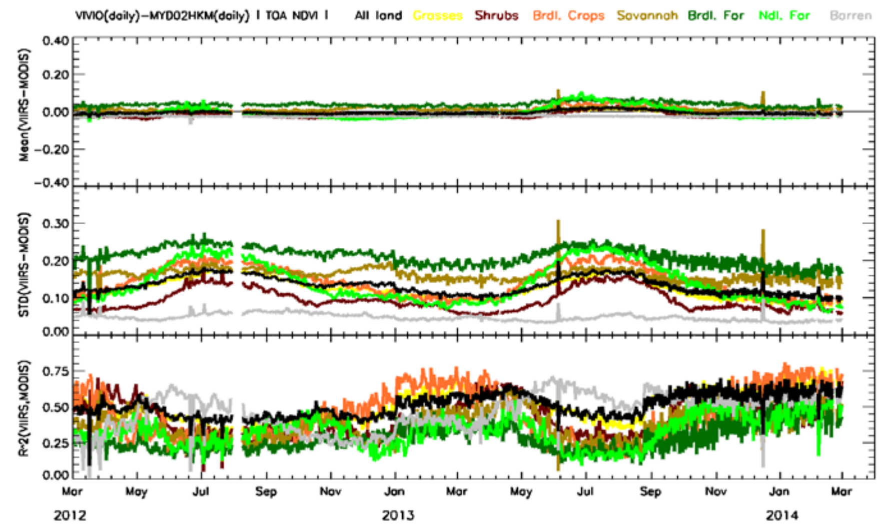


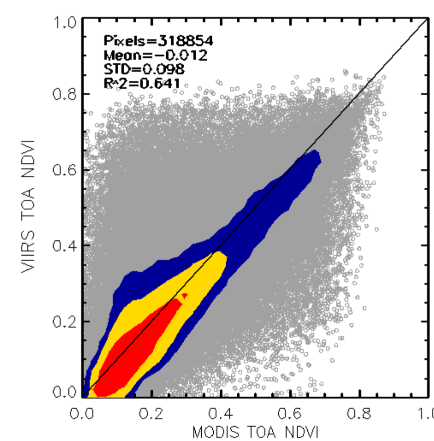
VIIRS and MODIS TOC EVI match each other on a global scale.

VIIRS Vegetation Index Time Series

Global TOA NDVI VIIRS minus MODIS (February 28, 2014)



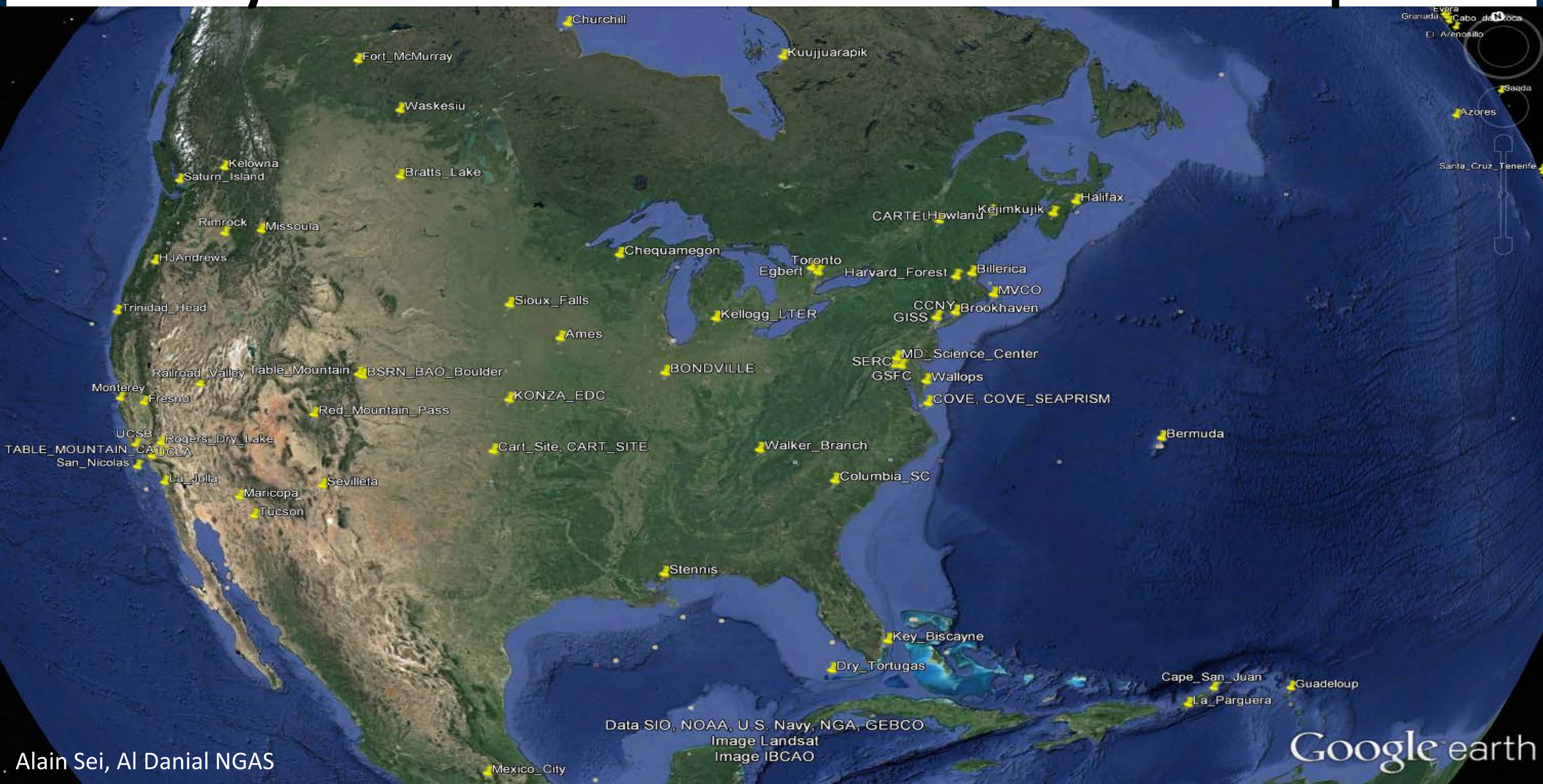




While VIIRS and MODIS TOA NDVI match on a global scale (overall bias is close to 0 in time series), for most typical pixels (highest density in scatterplots), VIIRS tends to underestimate TOA NDVI.

VI EDR Validation Matchup Analysis

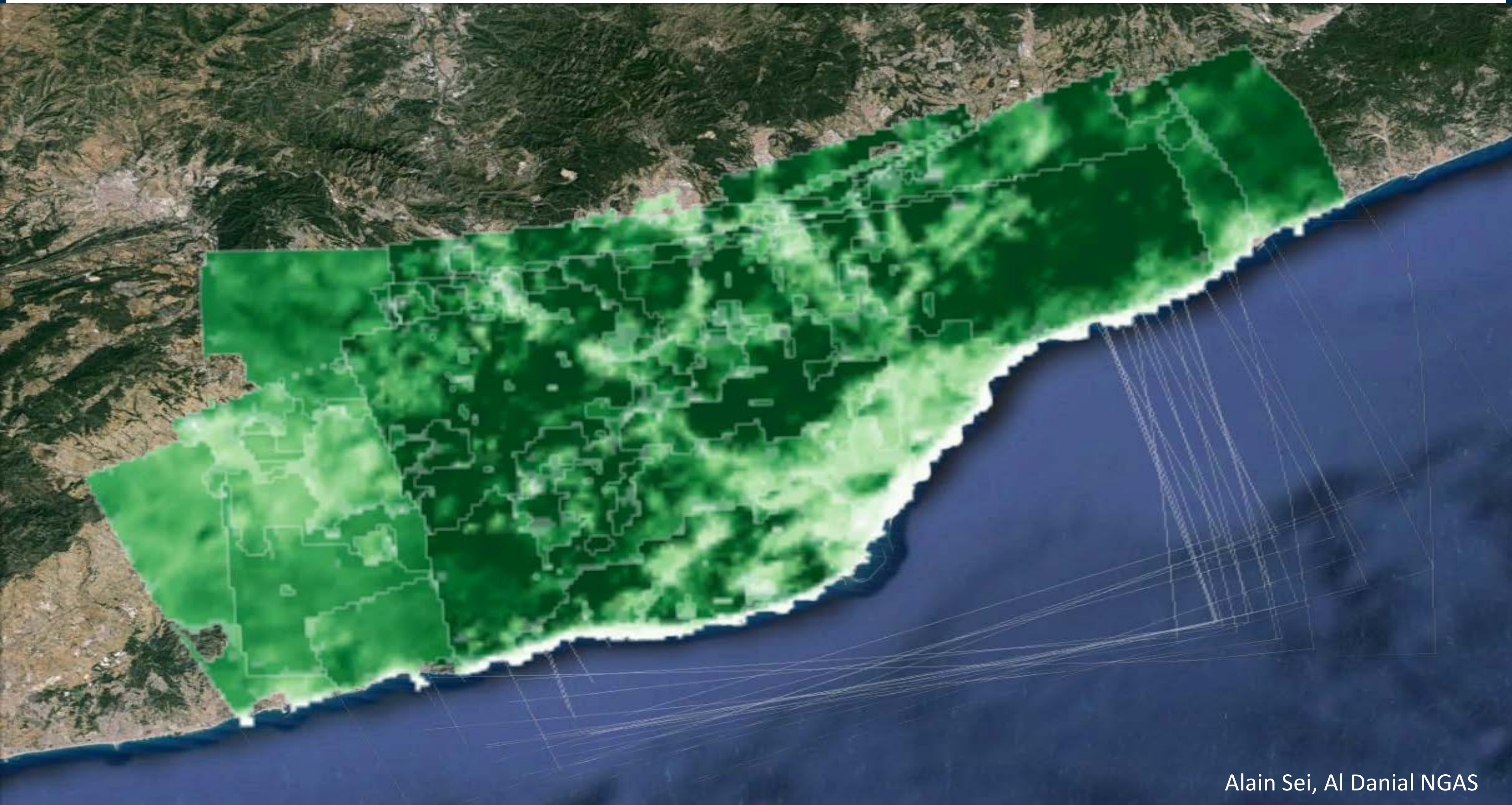
Surface Reflectance and VI cutouts collected daily at 229 Aeronet sites: North America Example



Alain Sei, Al Danial NGAS

VI EDR Validation Matchup Analysis

Example of Cutouts of TOA NDVI at Barcelona. First three weeks in April, 2014



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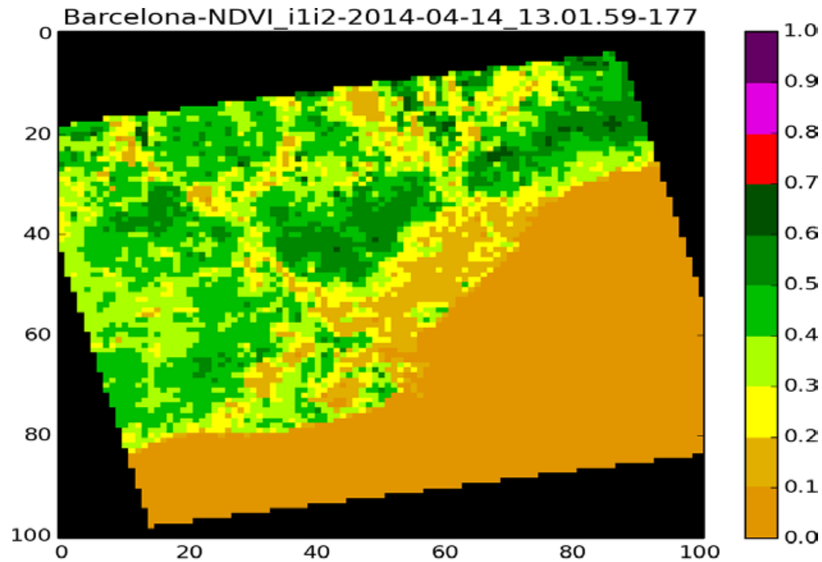
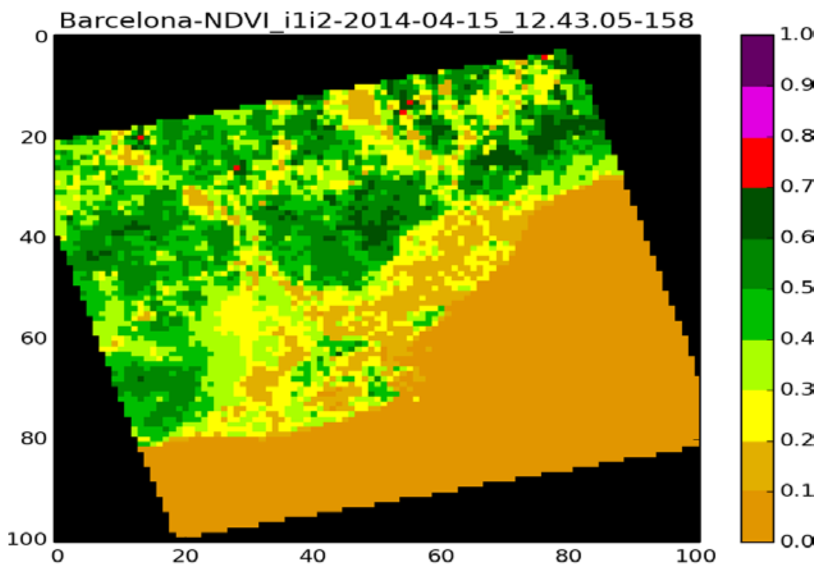
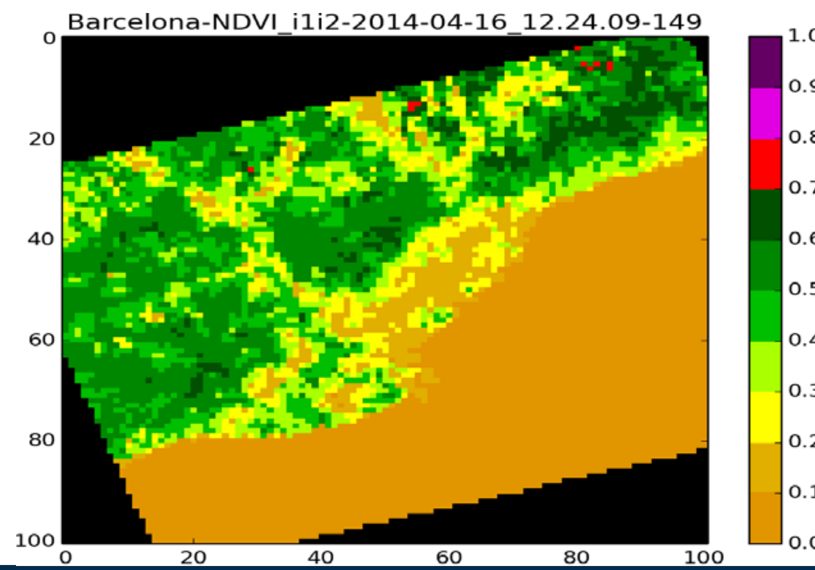
VI EDR Validation Matchup Analysis

Sinusoidal Projection Allows Colocated 500 m Cells to be Tracked Chronologically







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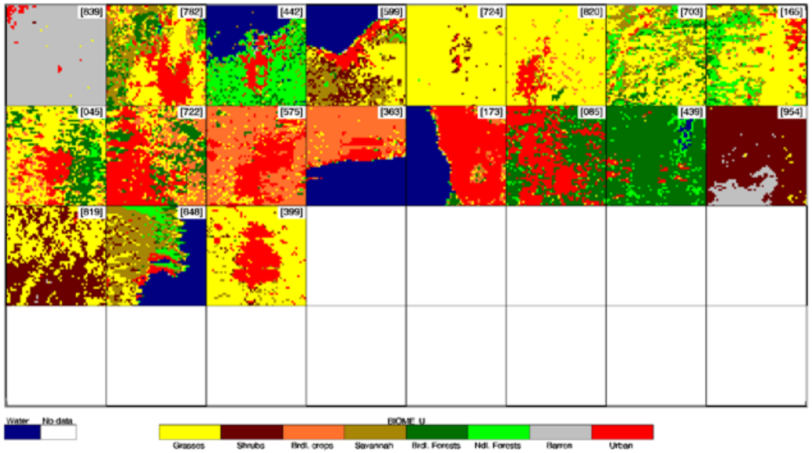
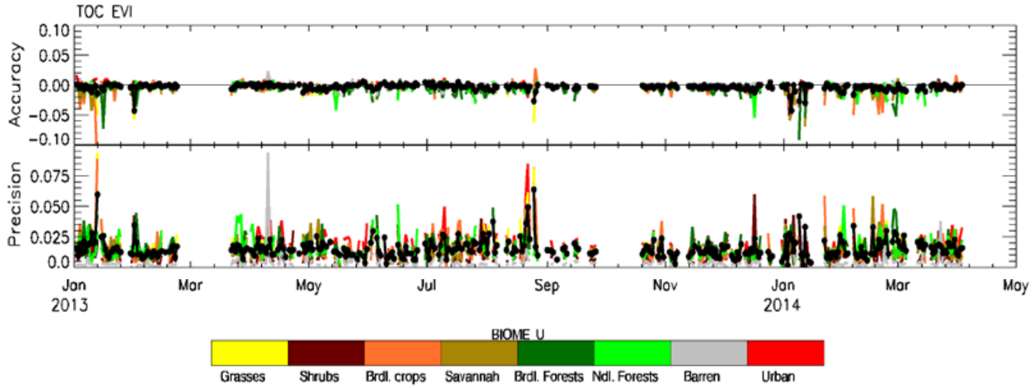
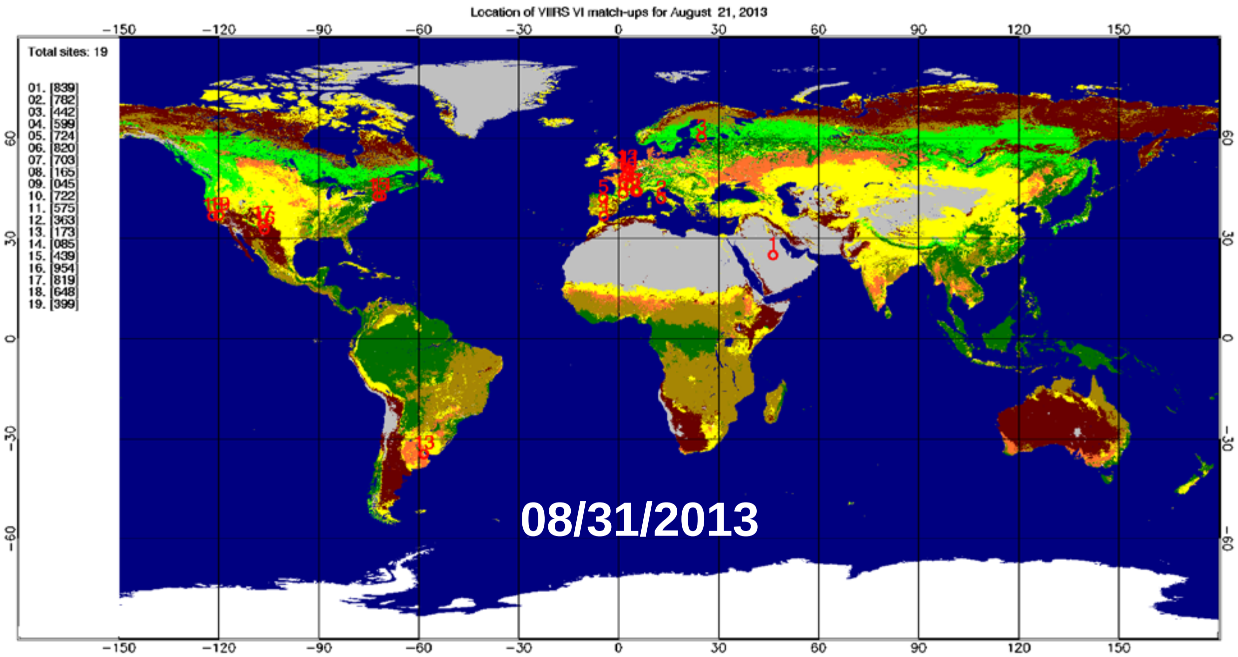
VI EDR Validation Using Aeronet Based SR (Matchup Data)







Sample of global daily distribution of match-up sites (August 21, 2013) covering different surface types and including urban areas. Global Land cover is derived from Combined Terra & Aqua MODIS LAI/FPAR LC product (MCD12C1, ver. 5.1).

VI EDR Product Improvements (DR7038)

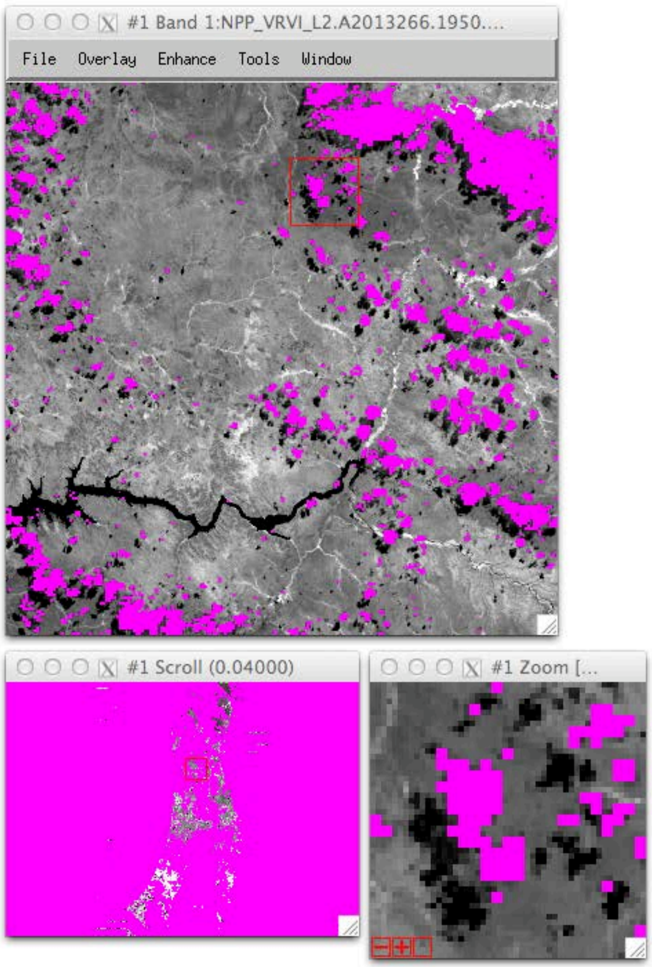
Mapping of Additional QFs (Mx8.4)

- Include the following four additional QFs into QF3_VIIRSVIEDR
  1) snow/ice <= to be copied from Bit 0 of SR IP QF7
  2) adjacent clouds <= to be copied from Bit 1 of SR IP QF7
  3) aerosol quantity <= to be copied from Bits 2-3 of SR IP QF7
  4) cloud shadow <= to be copied from Bit 3 of SR IP QF2

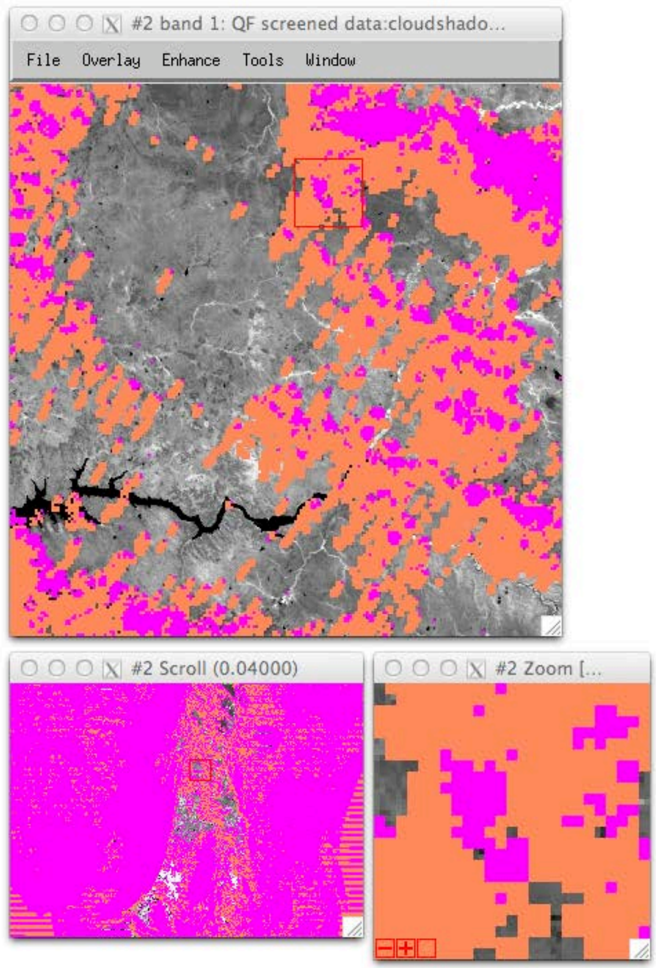
	Current			Proposed, New		
Byte	**Bits**	**VIIRS VI Quality Flag**	**Value**	**Bits**	**VIIRS VI Quality Flag**	**Value**
2 (QF3)	0	Stratification – Solar Zenith Angle	0: SZA < 65 or > 85 1: 65 ≤ SZA ≤ 85	0	Stratification – Solar Zenith Angle	0: SZA < 65 or > 85 1: 65 ≤ SZA ≤ 85
	1	Excl – AOT > 1.0	0: AOT ≤ 1.0 1: AOT > 1.0	1	Excl – AOT > 1.0	0: AOT ≤ 1.0 1: AOT > 1.0
	2	Excl – Solar Zenith Angle > 85 Deg	0: SZA ≤ 85 1: SZA > 85	2	Excl – Solar Zenith Angle > 85 Deg	0: SZA ≤ 85 1: SZA > 85
	3	*spare bit*	*set to 0*	3	Snow/Ice	0: False (no) 1: True (yes)
	4	*spare bit*	*set to 0*	4	Adjacency Clouds	0: False (no) 1: True (yes)
	5	*spare bit*	*set to 0*	5-6	Aerosol Quantity	00: Climatology 01: Low 10: Average 11: High
	6	*spare bit*	*set to 0*			
	7	*spare bit*	*set to 0*	7	Cloud Shadows	0: False (no) 1: True (yes)

VI EDR Product Improvements (DR7038)

TOA NDVI:
Screened for “Confident Cloudy” & “AOT > 1.0”



TOA NDVI:
Screened for “Cloud Shadows”



Additional QF3 Bit 7: Cloud Shadows

“Cloud shadow” QF can be used to screen shadow-affected pixels which produce faulty low NDVI or EVI values.

TOC EVI Backup Algorithm Prototype

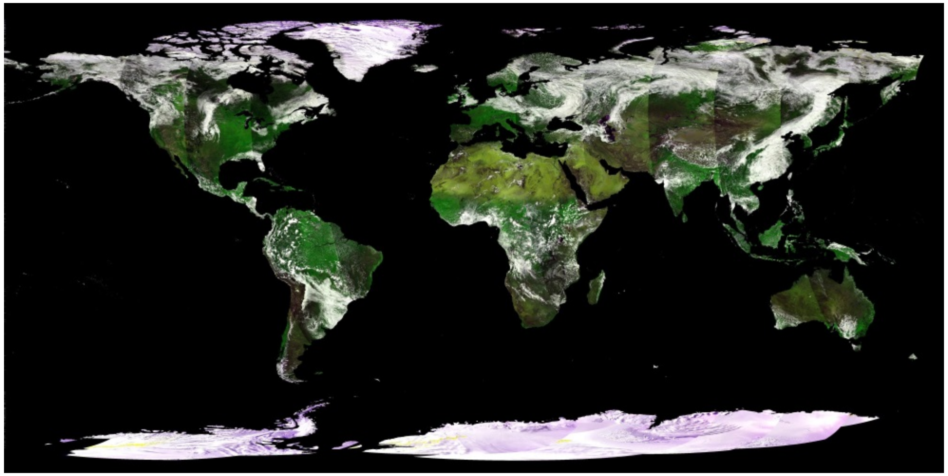
- DR 7039 - A backup algorithm for EVI over snow/ice and clouds
- TOC EVI is unstable over snow/ice and cloud edges
- An EVI backup algorithm is being prototyped based on the MODIS VI algorithm
  – It switches the EVI equation to a two-band EVI equation
- The current set of criteria (prototype) are:
  – If Confident Cloudy or Probably Cloudy or Thin cirrus or Adjacent pixels or snow or snow/ice then switch EVI to EVI2
  – If Inland water or coastal lines then switch EVI to EVI2
  – If M3>0.25 then switch EVI to EVI2
  – If M3<0.25 and M3>0.05 and I1<0.1 7 then switch EVI to EVI2
  – If M3<0.05 and I1<0.0 3 then switch EVI to EVI2

TOC EVI Backup Algorithm Prototype

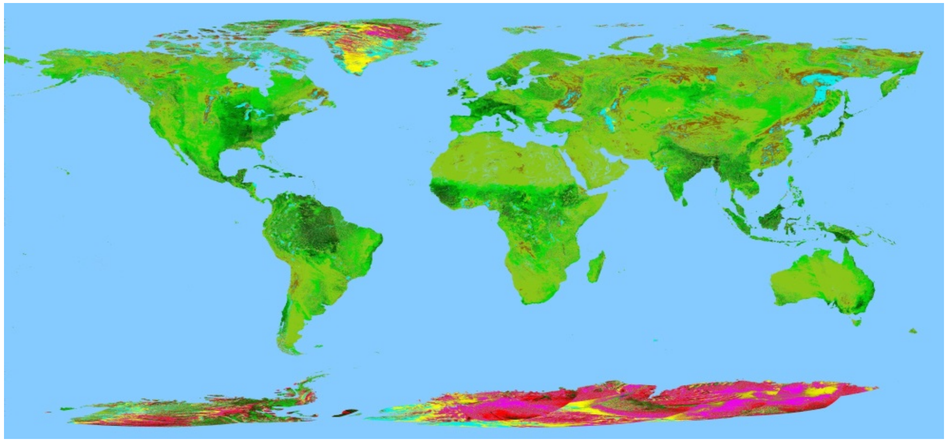
- TOC EVI values are unrealistically high/low over the snow/ice covered areas in the high northern latitude area and most of Antarctica as well as over clouds
- They become around “zero” in the backup algorithm output

VIIRS Data of Sep 23, 2013

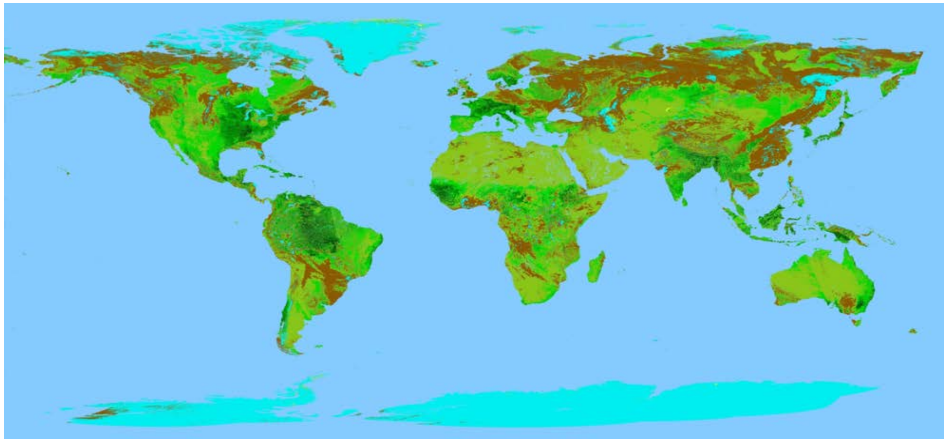
TOC Reflectance (RGB: I1, I2, M3)



TOC EVI Current Algorithm



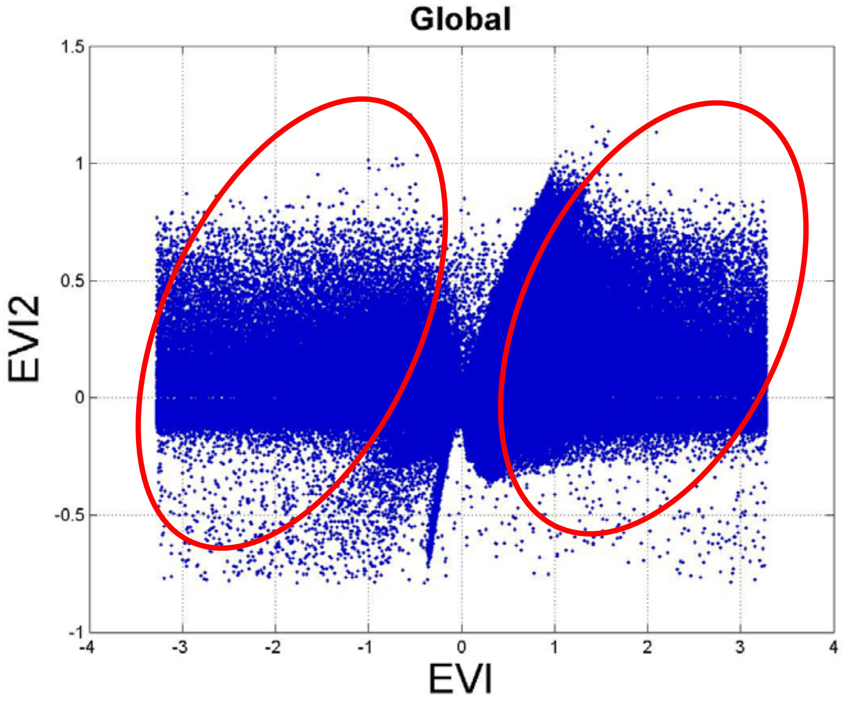
TOC EVI with Backup Algorithm



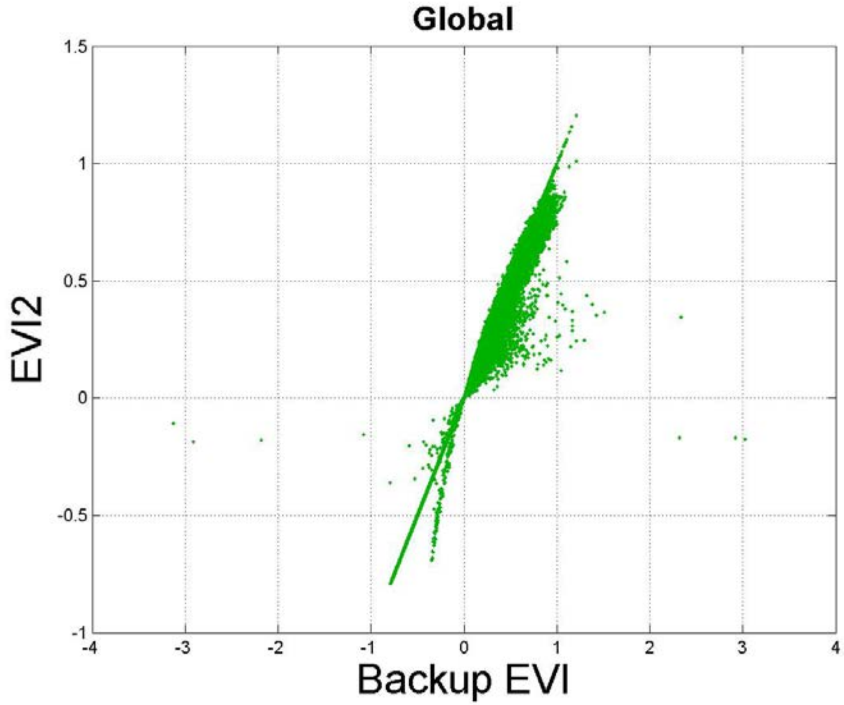
TOC EVI Backup Algorithm Prototype

- Unrealistically high/low EVI values in the current EVI algorithm output (left) are not seen in the output from the EVI backup algorithm (right)

TOC EVI Current Algorithm

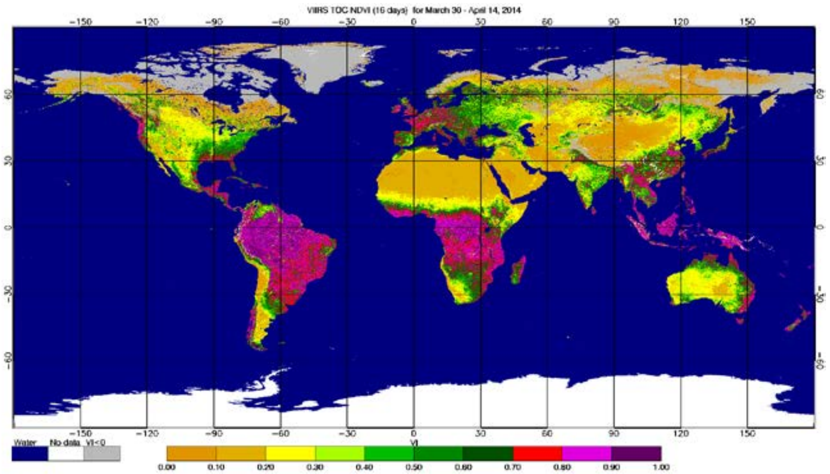


TOC EVI with Backup Algorithm

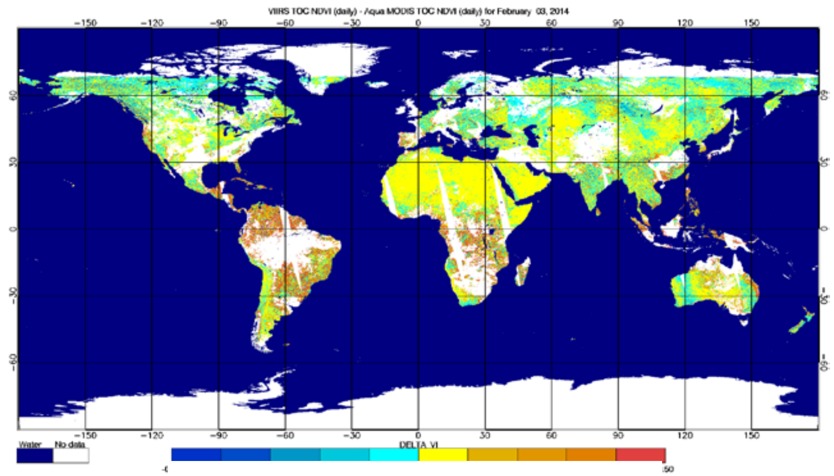


JPSS1 TOC NDVI Development

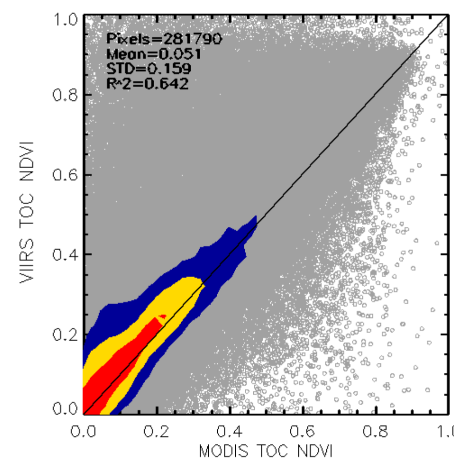
VIIRS derived TOC NDVI March 30 - April 14, 2014 (using S-NPP data)



TOC NDVI (VIIRS minus MODIS)



Surface reflectance Intermediate Product (SRIP) data from S-NPP VIIRS is used as test data representing J1 VIIRS surface reflectance in algorithm development



VI-EDR Future Plans

- Validated 1: Expected August 2014
- TOC NDVI will be added to the JPSS-1 VI product suite (Algorithm Change Package will be delivered to DPES in FEB 2015)
- JPSS1 TOC NDVI Critical Design Review (CDR) on May 22, 2014
- TOC-EVI backup algorithm (DR7217)
- Temporal compositing (weekly, 16-day, monthly), and spatial compositing (global) (DR7488)
- Begin JPSS1 validation planning
- Will Continue long term monitoring

Summary

- Analysis results indicate that the VIIRS Vegetation Index EDR operational product is performing well
  - Summary statistics meet the L1 requirements
  - Additional QFs critical in meeting the L1 requirements

- VI EDR will meet Validation 1 status based on the definitions and the analysis performed (summer 2014)

- The JPSS1 TOC NDVI algorithm will be developed to meet the Level 1 Requirements

NDE NUP Green Vegetation Fraction

Marco Vargas[1], Zhangyan Jiang[2], Junchang Ju[2], Ivan Csiszar[1]

[1]NOAA Center for Satellite Applications and Research, College Park, MD,
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GVF Team Members

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- **Junchang Yu (STAR/AER) Development Scientist**
- **Ivan Csiszar (NOAA/STAR) Development Scientist**
- **Mike Ek (NOAA/NCEP/EMC) User readiness**
- **Yihua Wu (NOAA/NCEP/EMC) User readiness**
- **Weizhong Zheng (NOAA/NCEP/EMC) User readiness**
- **Hanjun Ding (NOAA/OSPO) Product Area Lead**
- **Dylan Powell (Lockheed Martin/ESPDS/NDE) AI&T**
- **Tom Schott (NOAA/OSD) Consultant**

GVF Customers/Users

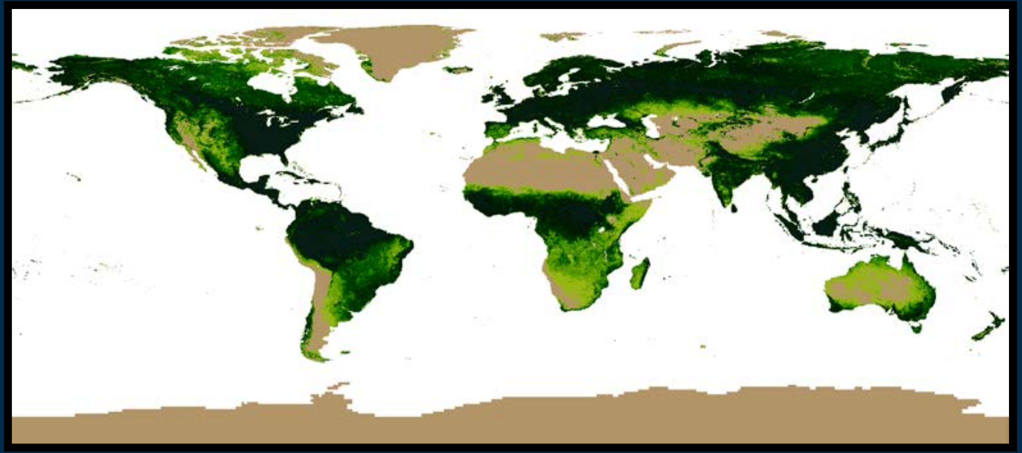
– **NCEP/EMC**
– **CLASS**
– **NASA/SPoRT**

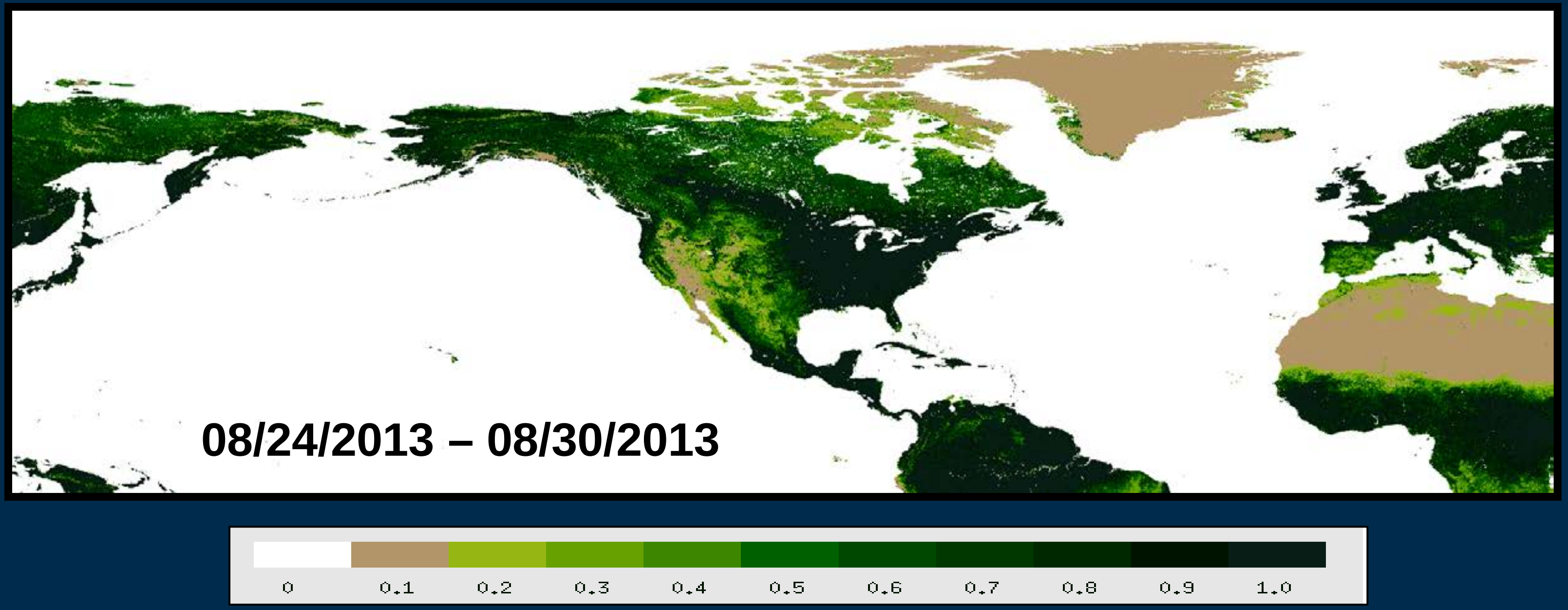
NDE NUP GVF Product

- Green Vegetation fraction (GVF) is defined as the fraction of a pixel covered by green vegetation if it were viewed vertically.
- The current NOAA operational GVF product is derived from AVHRR top of atmosphere NDVI data at 16-km resolution.
- In the Suomi National Polar-orbiting Partnership (SNPP) era, there is a need to produce GVF as a NOAA-Unique Product (NUP) from data from VIIRS for applications in numerical weather and seasonal climate prediction models at NCEP.
- The retrieval algorithm uses VIIRS TOC red (I1), near-infrared (I2) and blue (M3) bands centered at 0.640 μm, 0.865 μm and 0.490 μm, respectively, to calculate the Enhanced Vegetation Index (EVI) and derive GVF from EVI.
- To meet the data needs of NCEP and other potential users, GVF will be produced as a daily rolling weekly composite at 4-km resolution (global scale) and 1-km resolution (regional scale).
- For more information see GVF poster by Jiang et al.

NDE NUP GVF Product

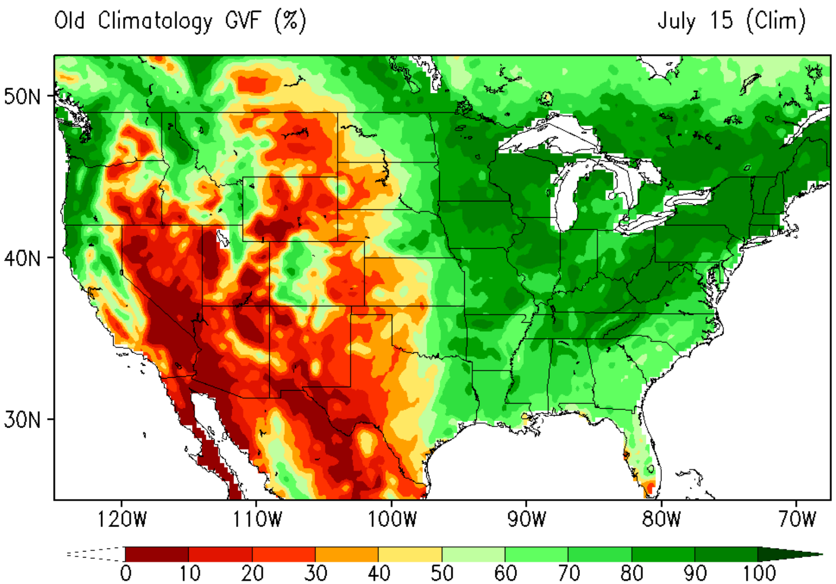
- Two GVF weekly products: global (4km res) and regional (1km res)
- Global GVF product in NetCDF4 format will be archived at CLASS



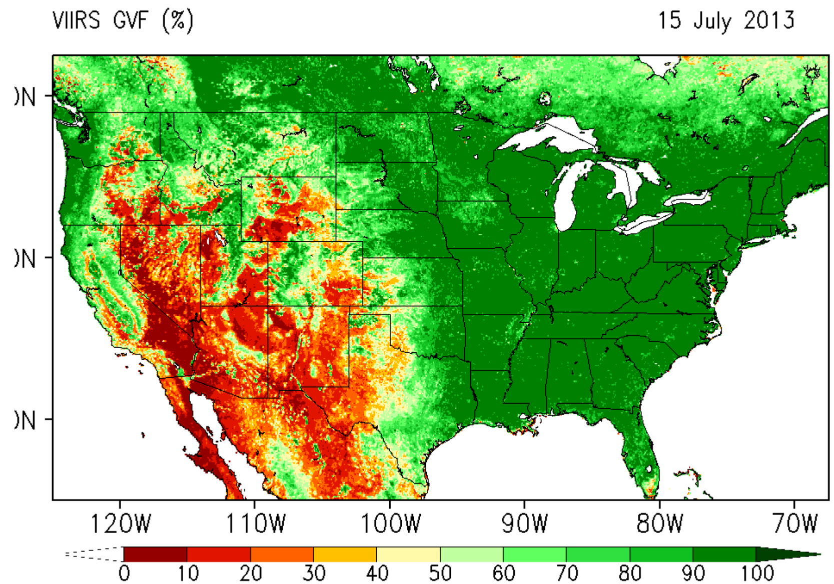


NDE NUP GVF Product

AVHRR (16 km res)



VIIRS (4km res)



- GVF is being tested in the Global Forecast System (GFS).

GVF Accomplishments

- GVF Linux DAP delivered to NDE in April
- GVF system currently undergoing integration and testing in NDE

GVF Future Plans

- GVF transition to operations in Summer 2014
- Planning NUP GVF from VIIRS JPSS1

Thank you