JPSS STAR Algorithm and Data Products (ADP) Provisional Review

Suomi NPP Vegetation Index EDR

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Vegetation Index EDR Team Members

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- Tomoaki Miura (University of Hawaii) VI Cal/Val lead
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- Alfredo Huete (UTS) Cal/Val Team Member
- Leslie Belsma (Aerospace) Land JAM
- Alain Sei (NGAS) External Partner, Consultant
- Michael Ek (NOAA/NCEP) User readiness
- Jesse Meng (NOAA/NCEP) User readiness
- Ivan Csiszar (NOAA/STAR) STAR Land EDRs Chair
- Jeff Privette (NOAA/NCDC) Product validation lead, Land EDRs Co-Chair

EDR Provisional Maturity Definition

- **Provisional**
  - Product quality may not be optimal
  - Incremental product improvements are still occurring as calibration parameters are adjusted with sensor on-orbit characterization
  - General research community is encouraged to participate in the QA and validation of the product, but need to be aware that product validation and QA are ongoing
  - Users are urged to consult the EDR product status document prior to use of the data in publications
  - Ready for operational evaluation

VIIRS Vegetation Index EDR

- Suomi NPP VIIRS VI EDR consists of two vegetation indices: the "top-of-the-atmosphere (TOA)" **Normalized Difference Vegetation Index** (TOA-NDVI) and the "top-of-canopy (TOC)" **Enhanced Vegetation Index** (TOC-EVI).
  - **TOA NDVI:** is most directly related to absorption of photosynthetically active radiation, but is often correlated with biomass or primary productivity.
  - **TOC EVI:** was developed to optimize the vegetation signal with improved sensitivity in high biomass regions and improved vegetation monitoring through a reduction in atmosphere influences.
- VI EDR provides continuity with NOAA POES **AVHRR** and NASA EOS **MODIS**.
- Vegetation Index (VI) is one key parameter to specify the boundary condition in global climate models, weather forecasting models and numerous remote sensing applications for monitoring environmental state and its change.

Overview of Vegetation Index EDR

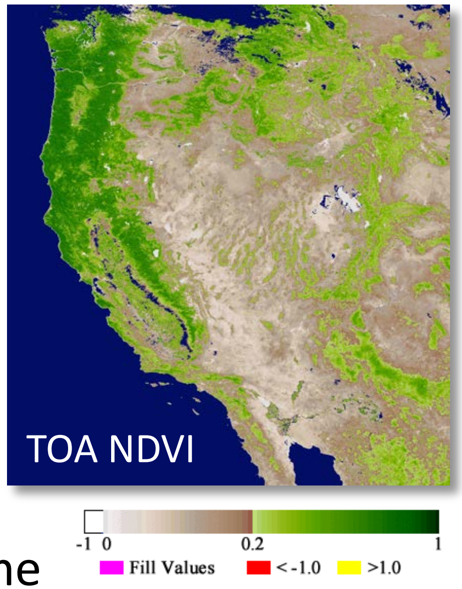
- VIIRS VI EDR uses I1, I2, and M3, and is produced at the VIIRS imagery channel resolution (i.e. 375m at nadir).
- Product Layers:
  - TOA-NDVI
  - TOC-EVI
  - Quality flags (QFs) (e.g., cloud)
- Product Style: Swath/Granule
- File Format: HDF5
- Measurement Exclusion Conditions:
  1) Confidently cloudy
  2) SZA > 85 deg (Nighttime)
  3) Surface classified as ocean
  4) AOT > 1.0 (only for EVI)

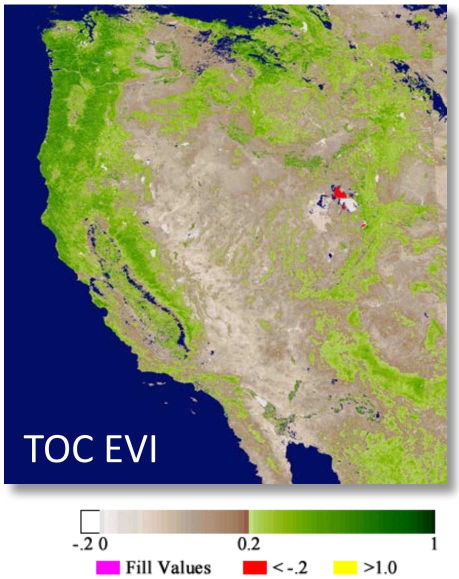
  * Retrievals not performed when some or all of input reflectances are fill-valued.

  * Retrievals performed for LAND including inland water bodies and rivers.
- Assumption for EDR validation is that the **<u>VIIRS SDR is calibrated.</u>**

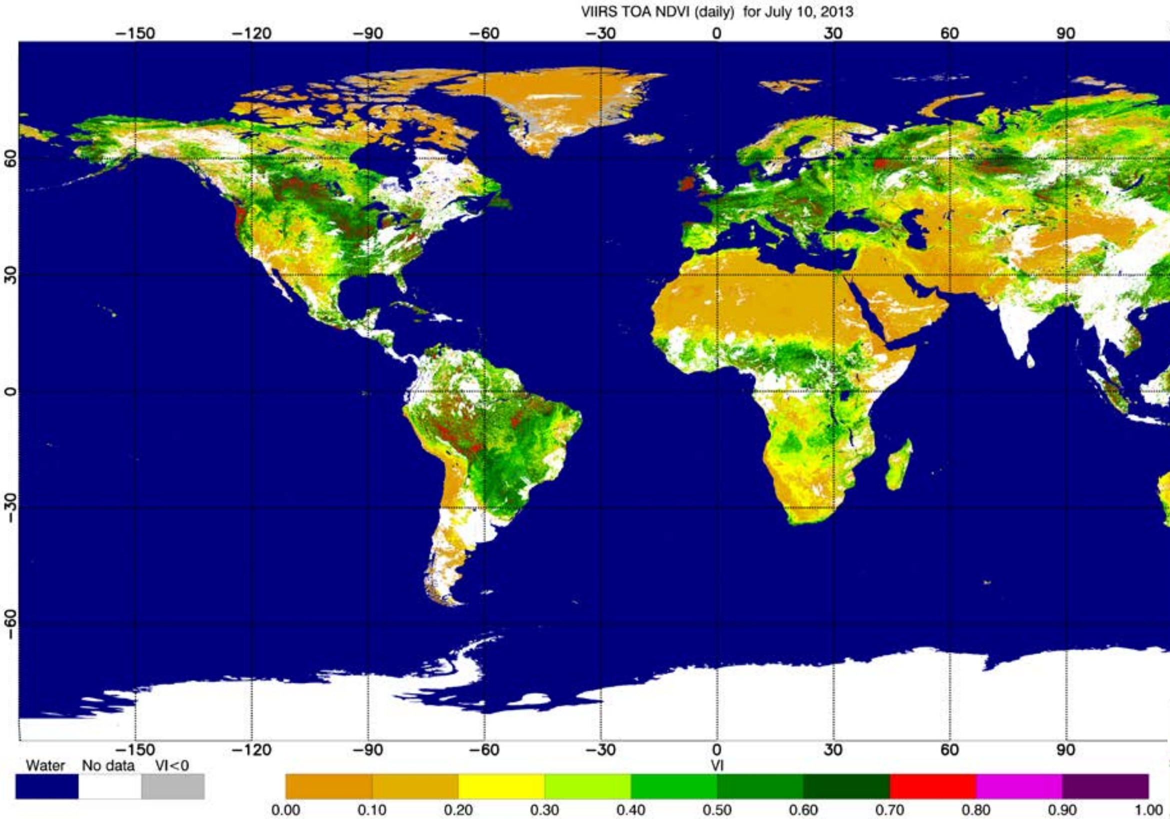
$$NDVI = (\rho_{I2}^{TOA} - \rho_{I1}^{TOA}) / (\rho_{I2}^{TOA} + \rho_{I1}^{TOA})$$

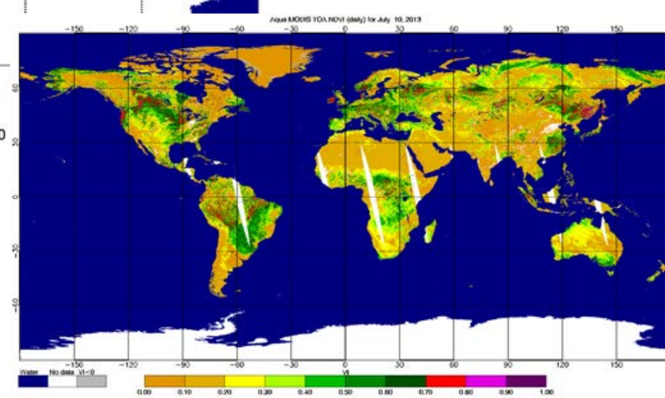
$$EVI = (1+L)\cdot\frac{\rho_{I2}^{TOC} - \rho_{I1}^{TOC}}{\rho_{I2}^{TOC} + C_1\cdot\rho_{I1}^{TOC} - C_2\cdot\rho_{M3}^{TOC} + L}$$





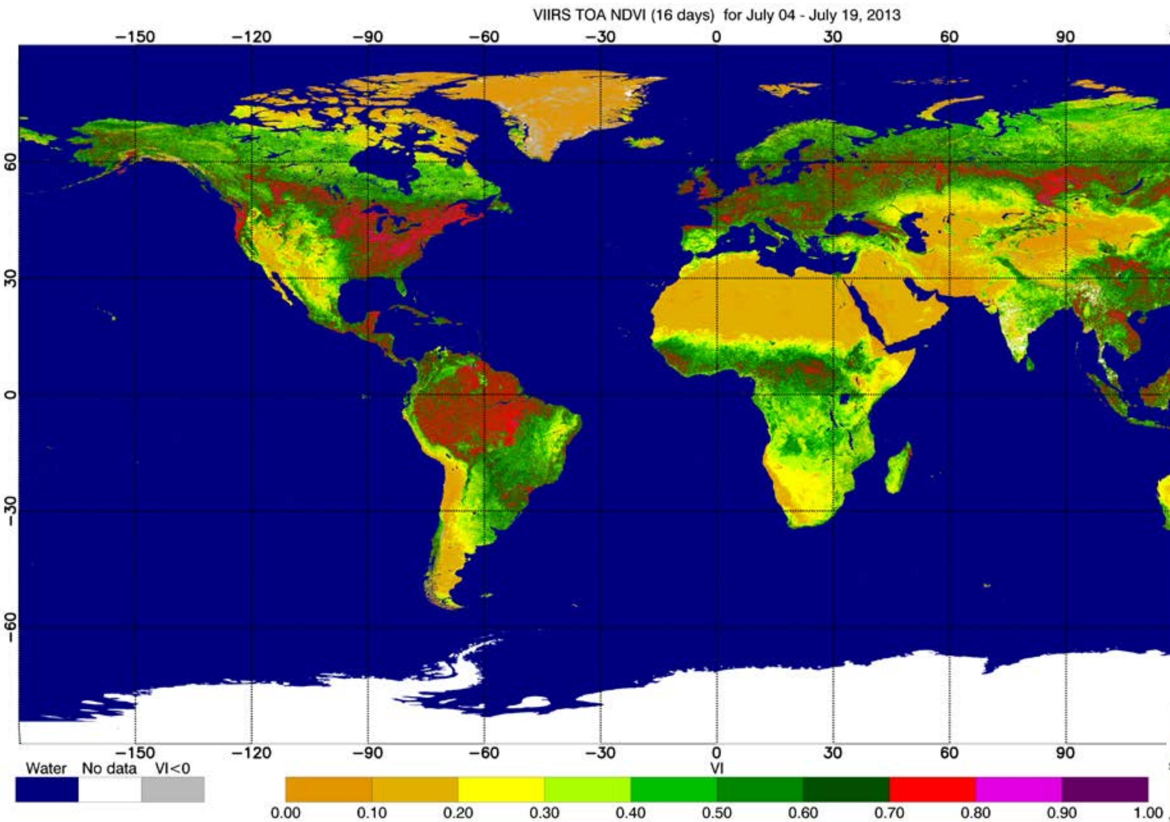
VIIRS TOA NDVI

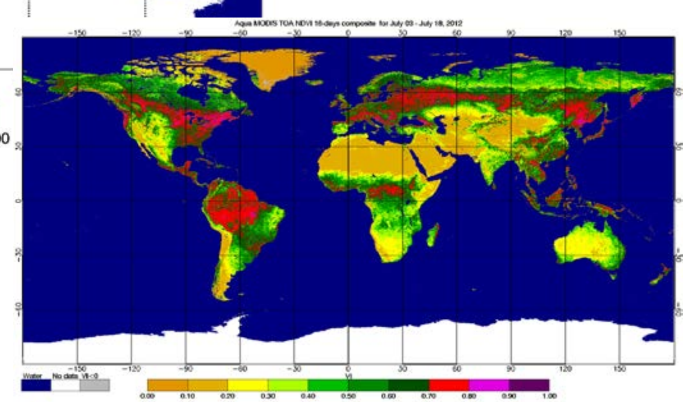




Daily TOA NDVI from VIIRS (main panel) and Aqua MODIS (insert) for July 10, 2013

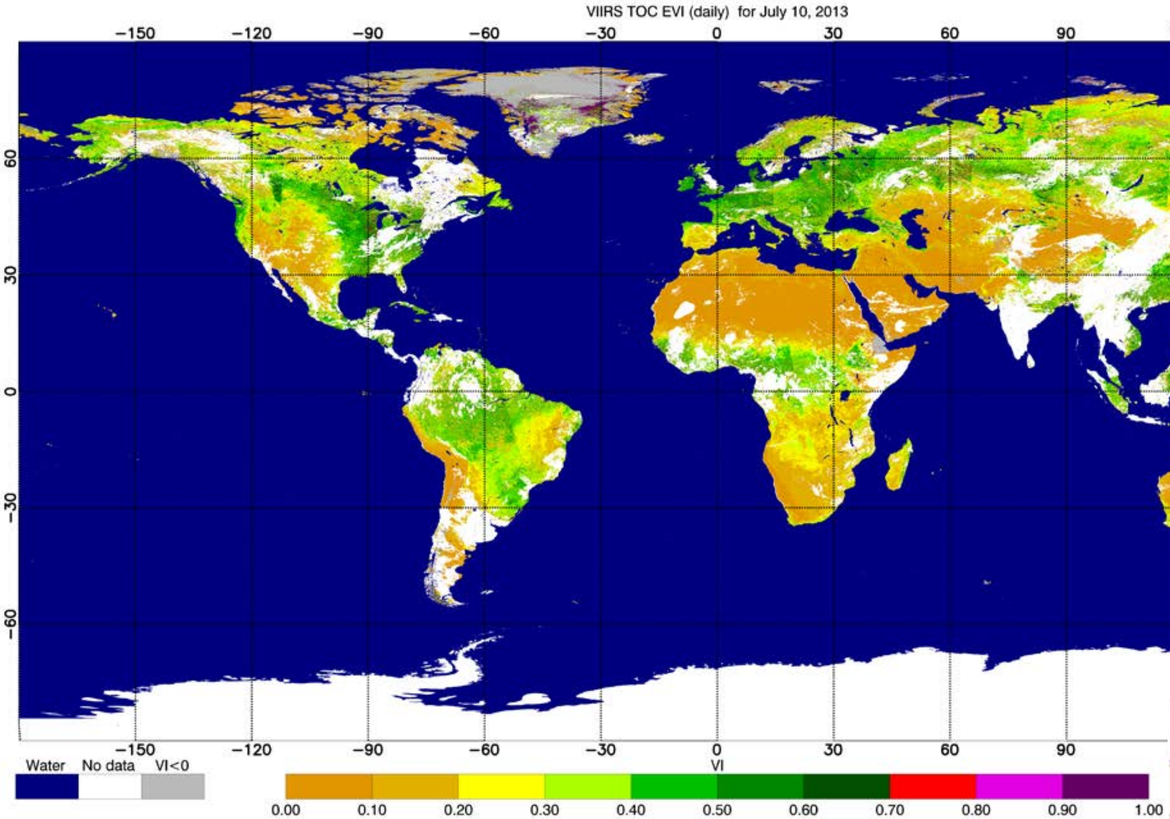
VIIRS TOA NDVI (16-day Composite)

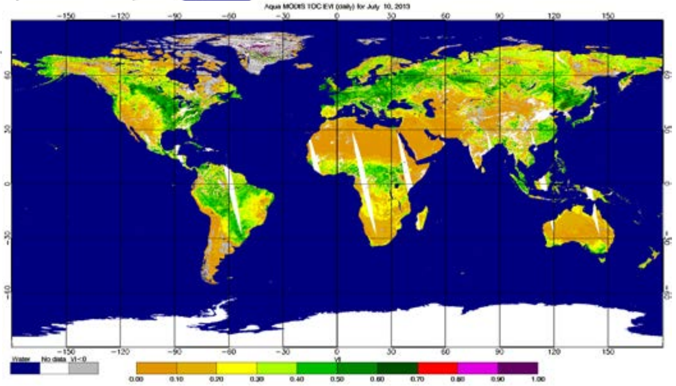




16-day composite TOA NDVI from VIIRS (main panel) and Aqua MODIS (insert) for July 04-19, 2013

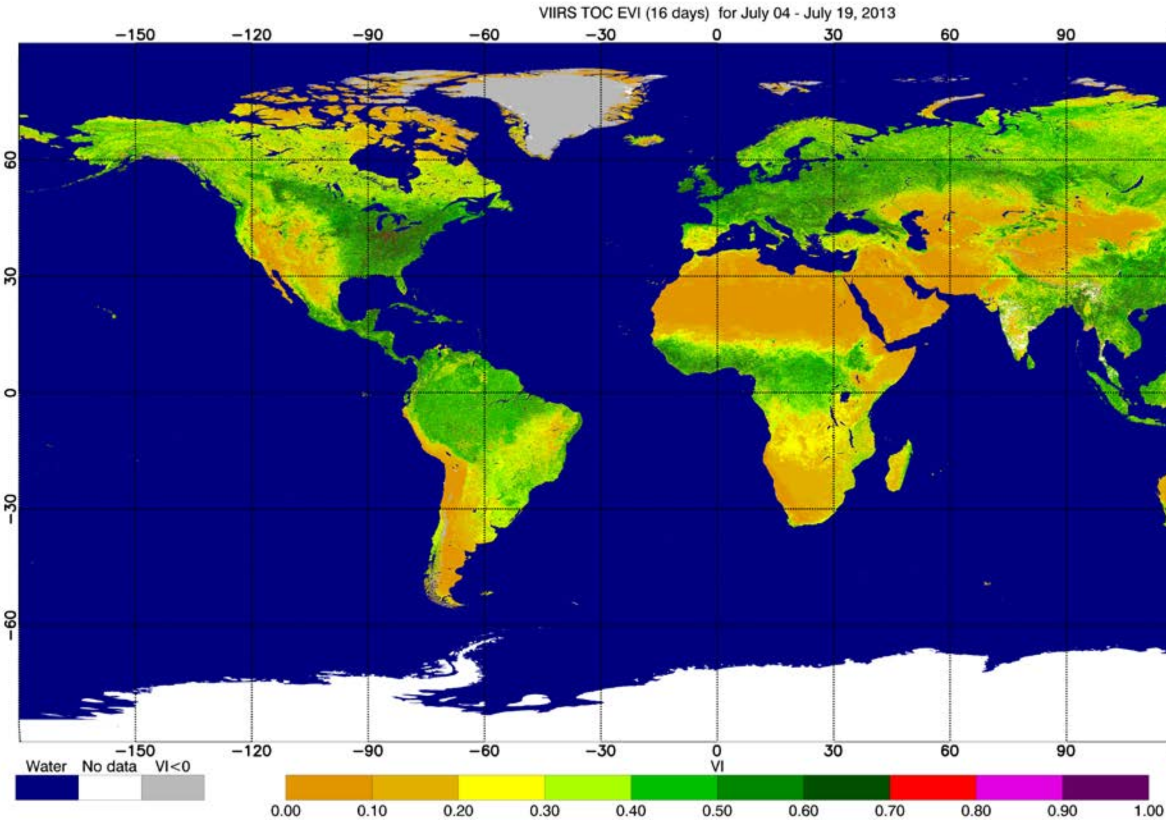
VIIRS TOC EVI

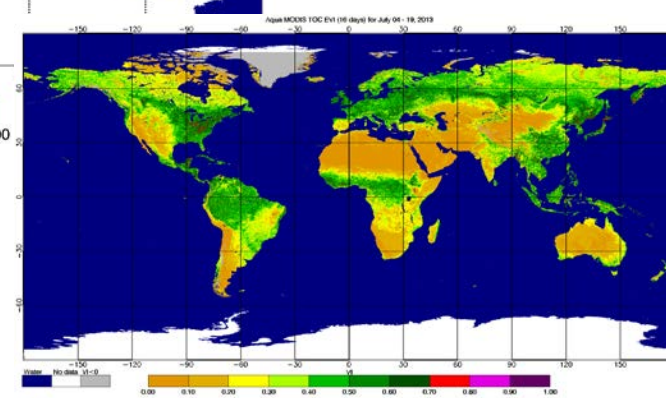




Daily TOC EVI from VIIRS (main panel) and Aqua MODIS (insert) for July 10, 2013

VIIRS TOC EVI (16-day Composite)





16-day composite TOC NDVI from VIIRS (main panel) and Aqua MODIS (insert) for July 04-19, 2013

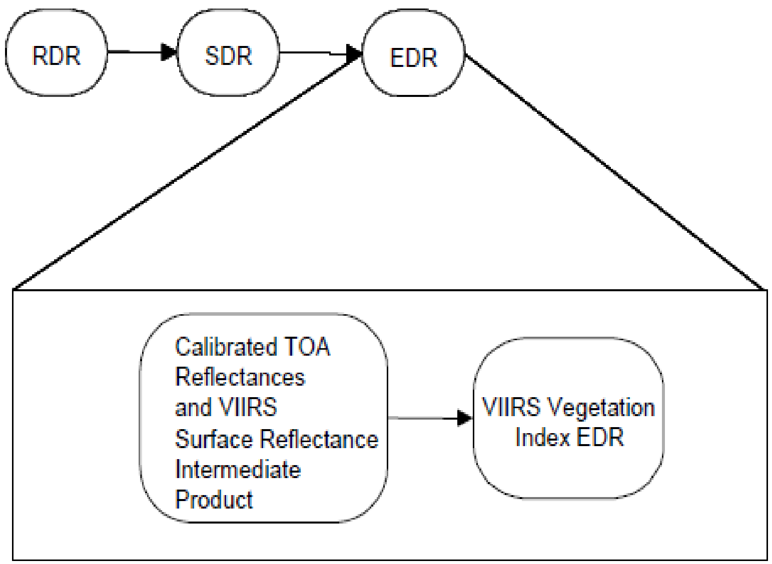
L1RD Requirements

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.
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.		

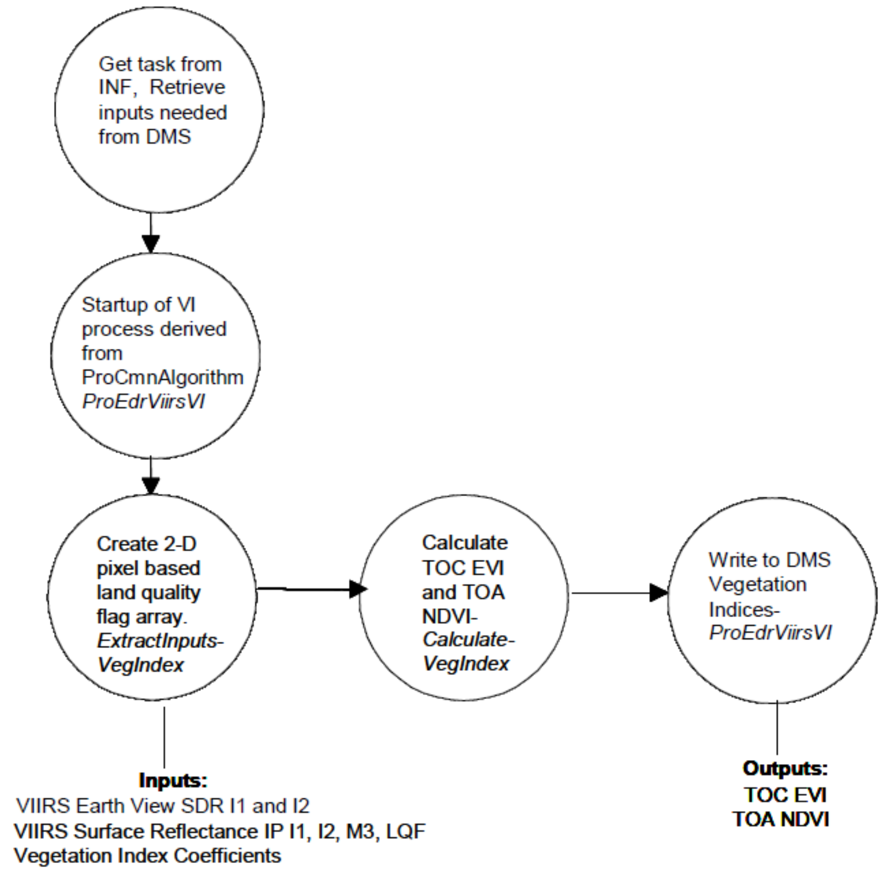
Source: Level 1 Requirements Supplement – Final Version:2.9 June 27, 2013

Vegetation Index EDR Dataflow

- The VIIRS Vegetation Index EDR requires: calibrated TOA reflectances (bands I1, I2), SDR
- Auxiliary data (solar zenith angle)
- Surface Reflectance (bands I1, I2, M3, Land Quality Flags)
- VI coefficients



OAD VIIRS VI EDR 474-00063 January 18, 2012; Figure 1 (Processing chain associated with VIIRS Vegetation Index EDR)



OAD VIIRS VI EDR 474-00063 January 18, 2012; Figure 2 (Data Flow Diagram of Overall VVI EDR Call Sequence from the Main Program)

History of Algorithm Changes/Updates

DR#	Reason	Status
DR 4622	Erroneous quality flag for missing input data	VI-EDR team is preparing an enhanced set of QFs to improve the VI product quality (e.g., DR 7038).
DR 4380	EVI requirements in L1RD in error	Closed
DR 4379	L1RD drops wavelengths, needs to be defined	Closed
DR 4377	Baseline of ephemeral tuning coefficients	Closed
DR 4376	Vegetation Index: L1RD requires NDVI TOC	Remain Open: Discussed at DRAT meeting on August 21, 2013
DR 4297	Thin Cirrus Correction and Flagging	Approved for future re-evaluation. We expect to close this DR before validation stage 1 release (June 2014)
DR 4290	EVI Quality should degrade AOT>1	We expect to close this DR before validation stage 1 release (June 2014)
DR 3375	Byte 0 Quality Flag Structure	Closed
DR 2887	Erroneous thin cirrus test in vegetation index	Closed

Recent DRs

DR#	Reason	Status
DR 7038	**Additional quality flags for VI EDR**	In progress: CCR being generated as of August 21, 2013 (code change in testing at LandPEATE)
DR 7039	**A backup algorithm for EVI over snow/ice and clouds**	(Future work) We expect to close this DR before validation stage 1 release (June 2014)
DR 7041	**Revision of the EVI equation**	(Future work) We expect to close this DR before validation stage 1 release (June 2014)

Performance of Upstream Products

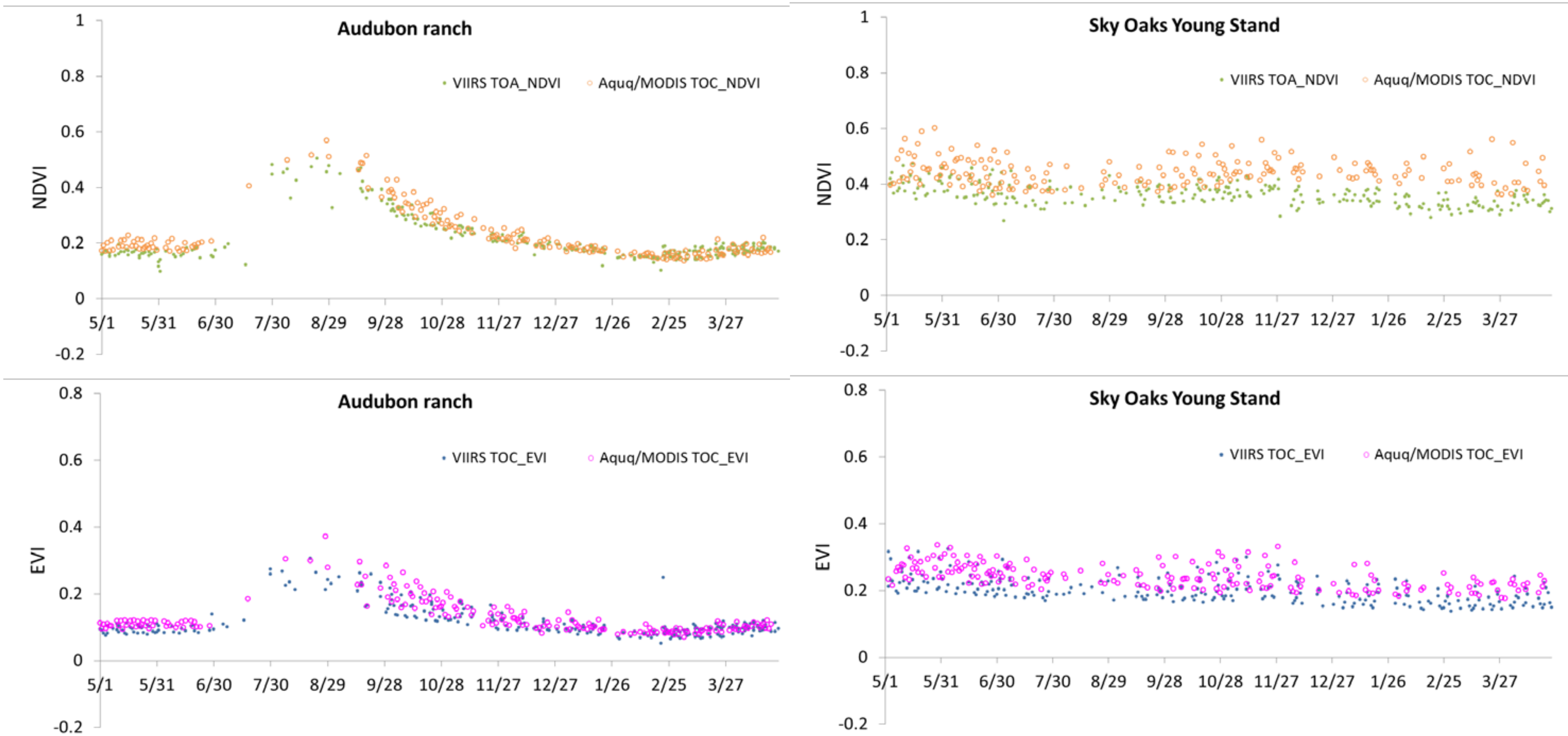
- SDR: Beta (May 2012), Provisional (January 2013)
  – VIIRS SDR quality is very good.
- VCM: Beta (May 2012), Provisional (November 2012)
  – Quality continues to improve (leakage, false alarm, cloud/snow confusion).
- SR-IP: Beta (May 2012), Provisional (Pending upon climatology data fix)
  – Possible overcorrection of aerosol effects associated with the climatology data.

Provisional Maturity Evaluation

- Internal performance evaluation
  - Quality assessment at granule, regional, global levels
- External performance evaluation and validation
  - VIIRS-MODIS subset comparison
  - VIIRS-MODIS regional comparison
  - VIIRS-MODIS-AVHRR global comparison
  - NGAS Cal/Val matchup data analysis
  - Fluxnet data analysis

VIIRS VI Subset Analysis

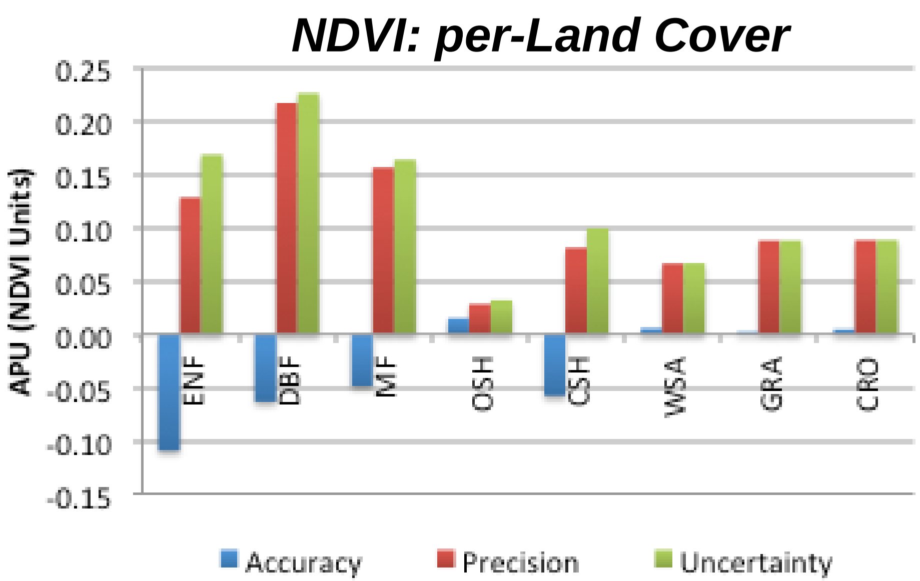
- VIIRS VI temporal profiles depicted nearly the same seasonal patterns as those observed with MODIS over various AmeriFlux & USDA LTAR sites.
  - Both data screened for possible clouds, shadows, heavy aerosols, and snow/ice cover using per-pixel QFs
- VIIRS VI data contained many suspicious quality data which could not be screened using VIIRS VI QFs, but using QFs available in VCM and SR-IP.

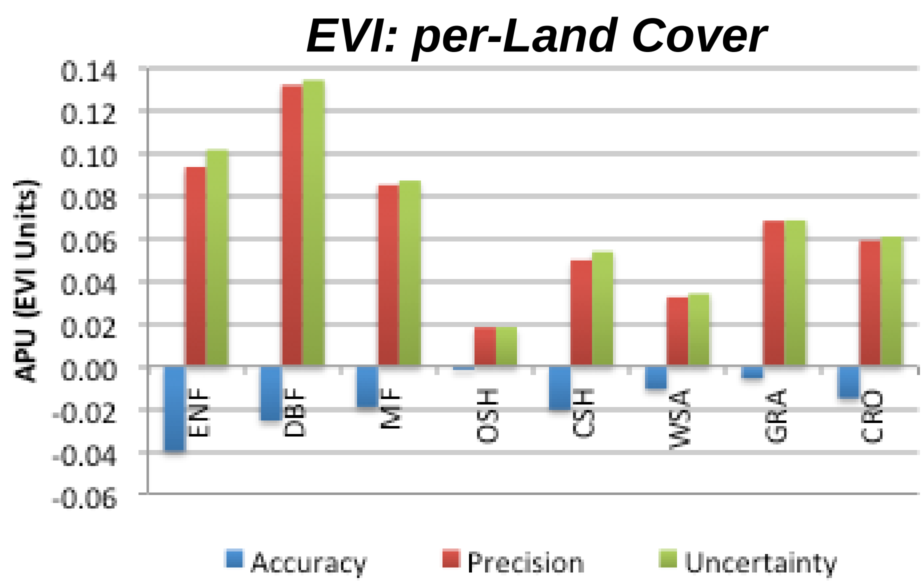


VIIRS VI Subset Analysis (cont.)

- APU metrics derived from VIIRS vs. MODIS subset (LandPEATE) comparisons at 19 sites (AmeriFlux, USDA LTAR, NEON Core)

	VIIRS TOA NDVI (vs. MODIS TOC NDVI)	VIIRS TOC EVI (vs. MODIS TOC EVI)
Accuracy	-0.04	-0.017
Precision	0.13	0.08
Uncertainty	0.13	0.08

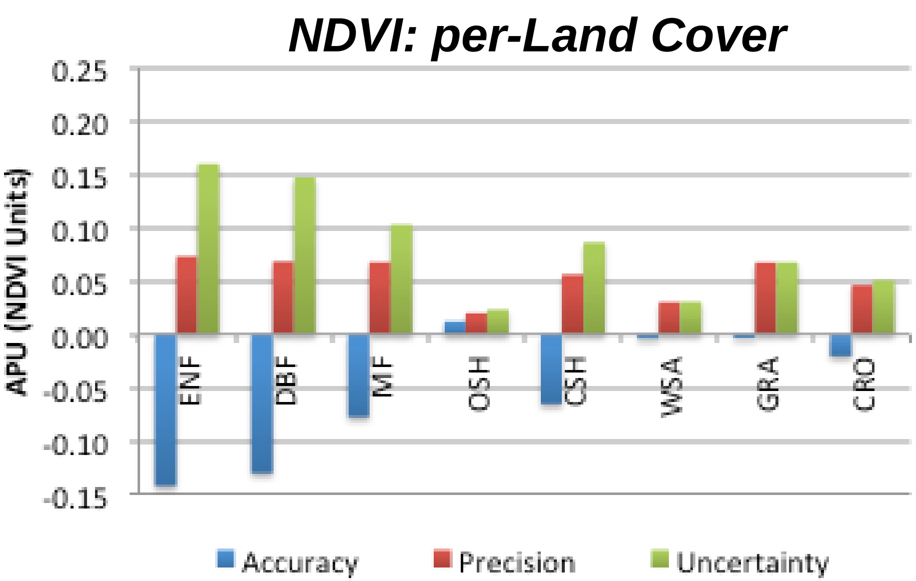


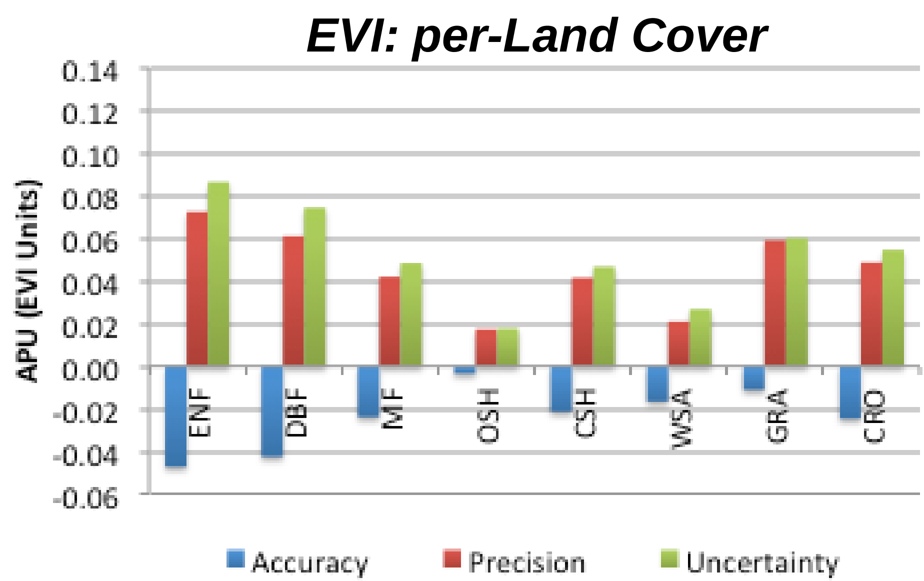


VIIRS VI Subset Analysis (cont.)

- APU metrics derived from VIIRS vs. MODIS subset (LandPEATE) comparisons at 19 sites (AmeriFlux, USDA LTAR, NEON Core)

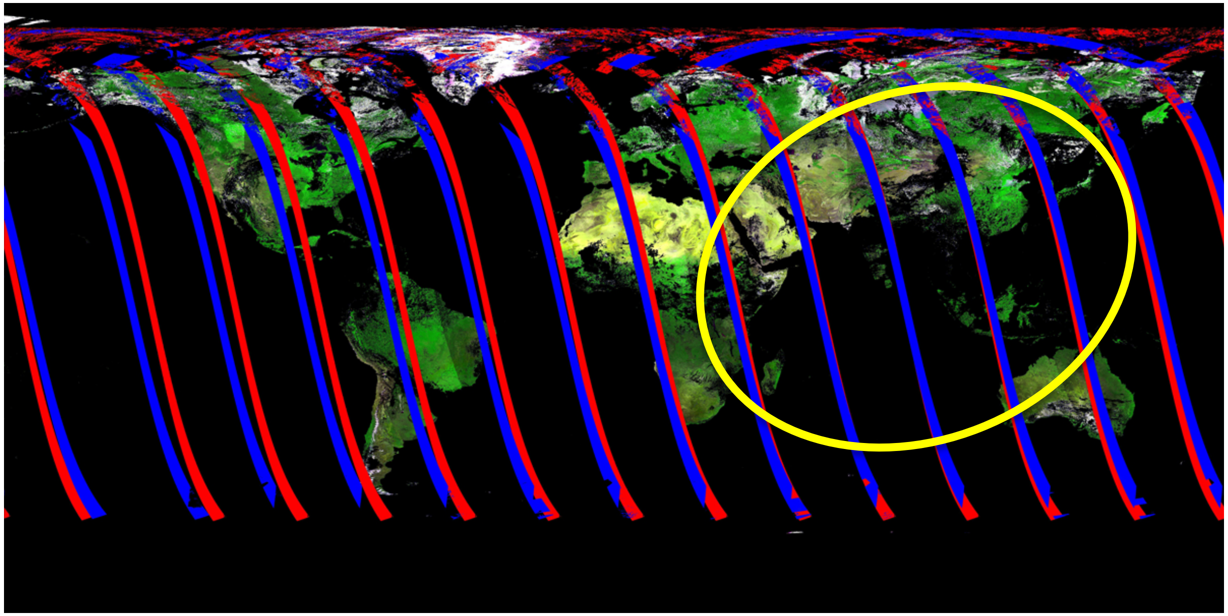
QF-Screened Results	VIIRS TOA NDVI (vs. MODIS TOC NDVI)	VIIRS TOC EVI (vs. MODIS TOC EVI)
Accuracy	-0.05	-0.02
Precision	0.08	0.06
Uncertainty	0.10	0.06





VIIRS VI Regional Analysis

- Regional mosaic comparisons with Aqua MODIS
  - Near-simultaneous nadir observations
    - Overlapped orbital tracks with view zenith angles < ±7.5 degrees
    - Every 8-16 days
    - Solar zenith angle differences of 1-2 degrees
  - Screened for cloud/shadow contaminations by QFs
    - Only using MODIS QA at this point

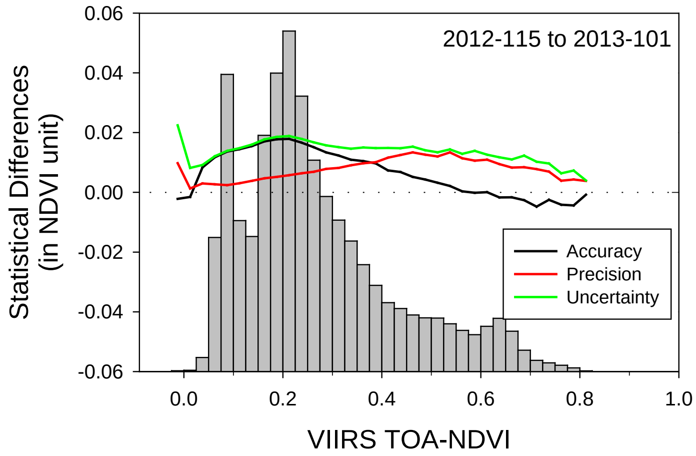


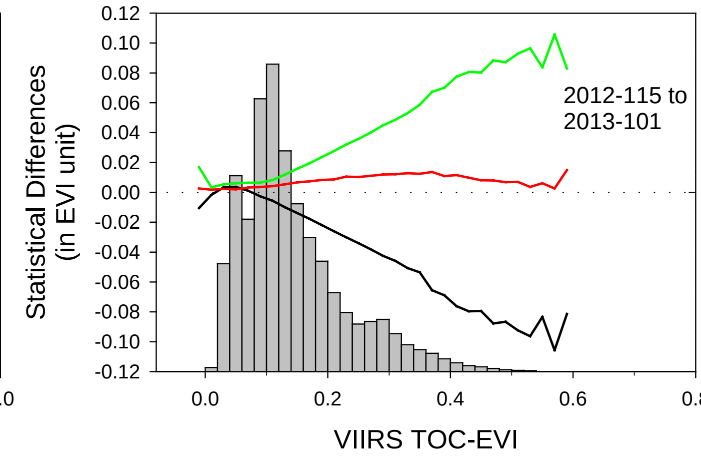
Orbital Tracks with $\theta_v < \pm 10^o$ for 2012-211 (July 29)
Blue: NPP VIIRS
Red: Aqua MODIS

VIIRS VI Regional Analysis

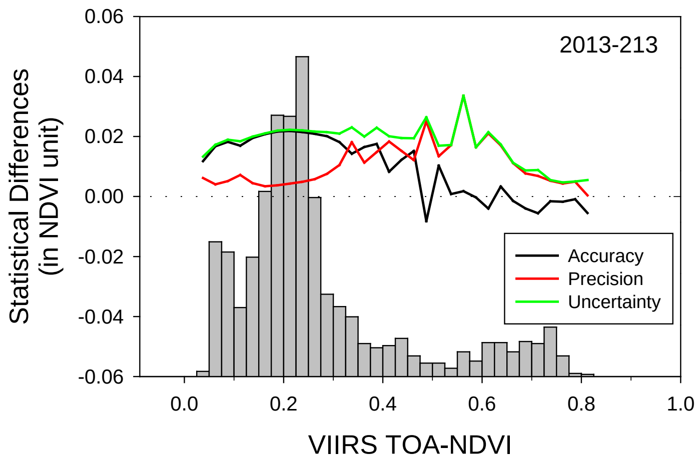
* APU metrics of VIIRS VI EDR (in reference to Aqua MODIS) consistent over time.

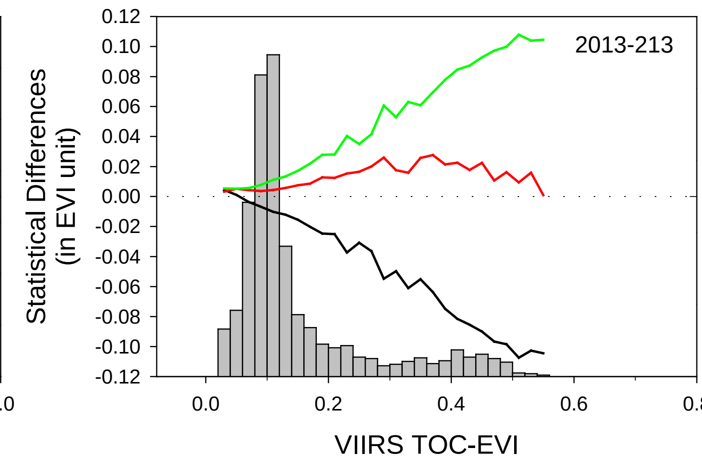
Average performance from May 2012 to April 2013





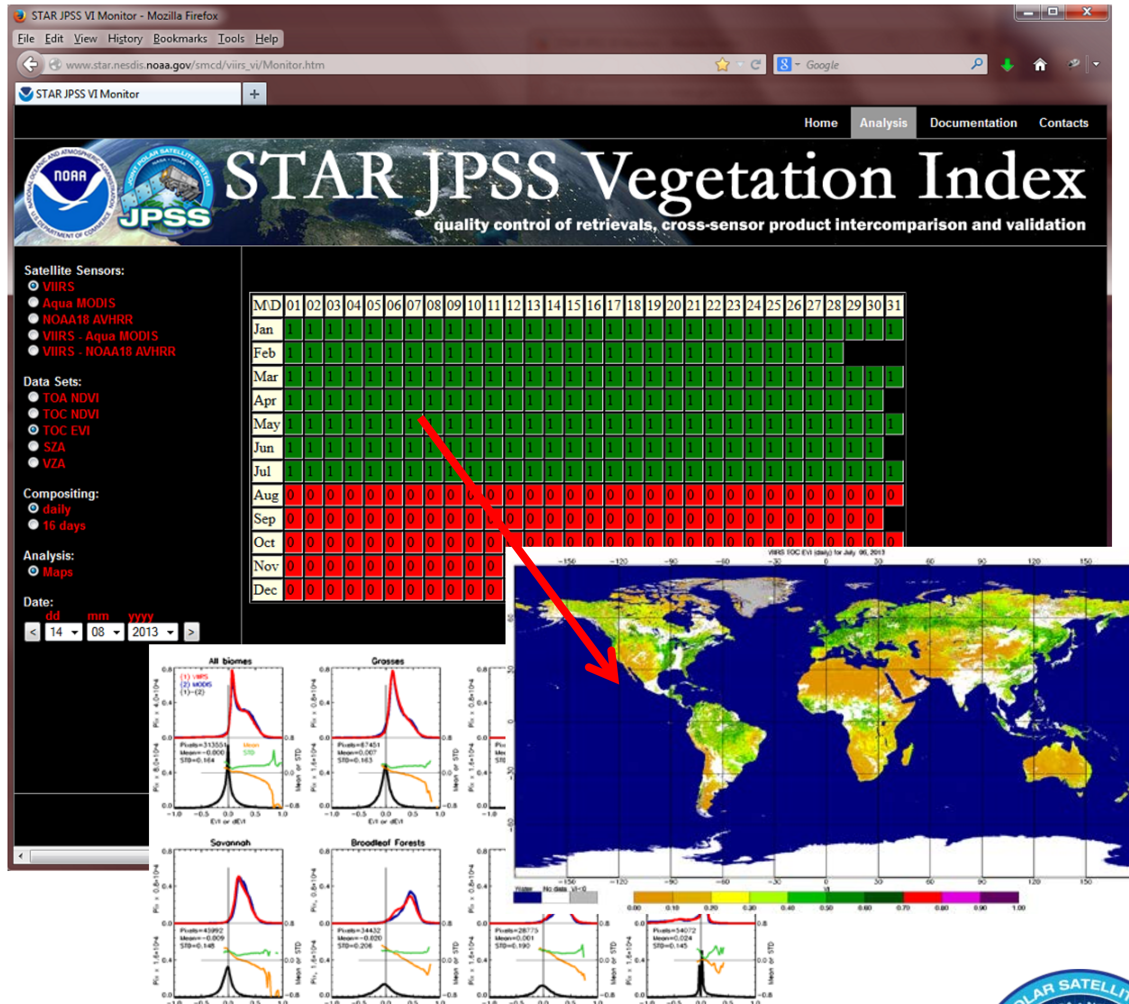
APU for recent data: August 1, 2013





Web-based JPSS VI Quality Control Tool at STAR

- Tool evaluates performance of VIIRS VI product time series at global scale (trace impact of VI and upstream algorithms changes, anomalous retrievals/trends and conformity to physically principles).
- VIIRS VI product is compared with heritage MODIS and AVHRR VI reference products.
- Analysis includes daily and compositing VI and ancillary data (QC, Geometry, etc) maps, histograms, scatter-plots and time series of statistics.
- In the future tool will include validation results using match-up retrievals provided by NG SR/VI Cal/Val tool over AERONET sites.



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

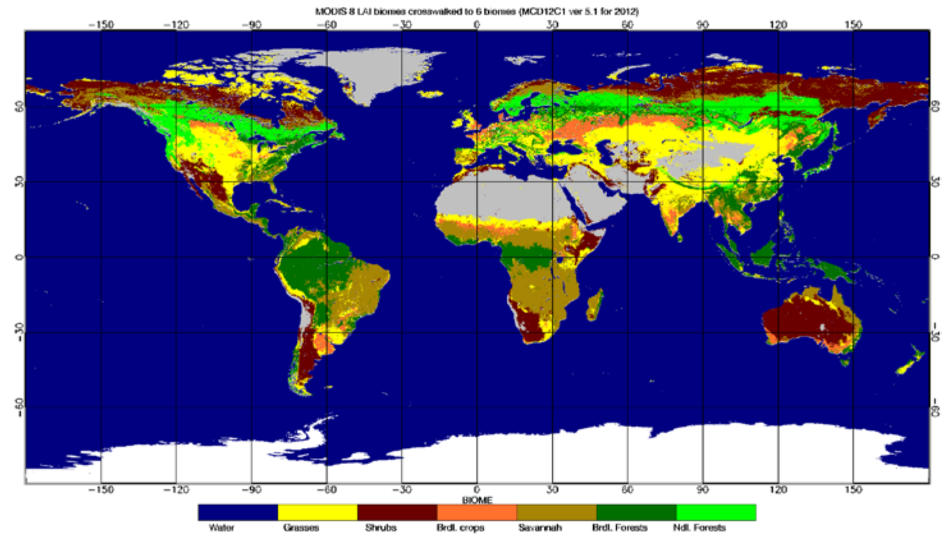
Data Sets Analyzed by the STAR VI Tool

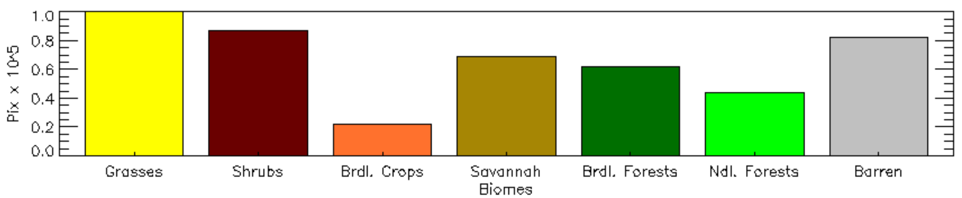
Main Data sources:

- **VIIRS TOA NDVI, TOC NDVI and TOC EVI daily, 7-day and 16-days composites (derived from VIVIO, IVISR and GIMGO products).**
- **Aqua MODIS TOA NDVI, TOC NDVI and TOC EVI, daily and 16-day composites (derived from MYD02HKM, MYD09CMG and MYD13A2 products, Col. 5)**
- **NOAA-18 AVHRR TOA NDVI 7-day composites (internal STAR product).**
- **All data sets were mapped to common grid (CMG, 3600x7200 pix), time series covers March 2012-current.**

Ancillary Data sources:

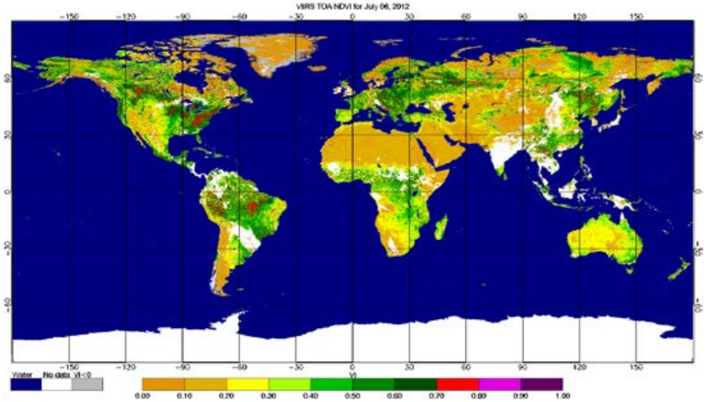
- **Aqua/Terra MODIS LAI 6-biome Land cover (derived from MCD12C1, Col. 5.1 for 2012)**



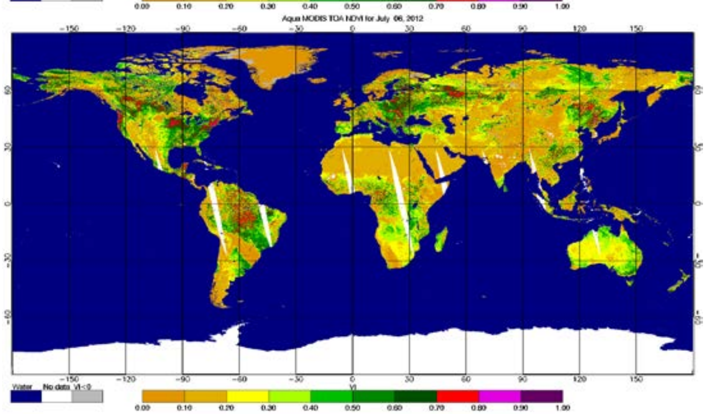


Comparison between VIIRS and MODIS TOA NDVI (Daily)

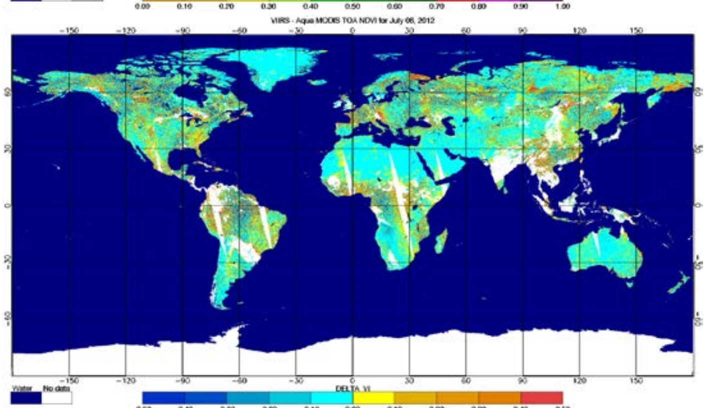
VIIRS



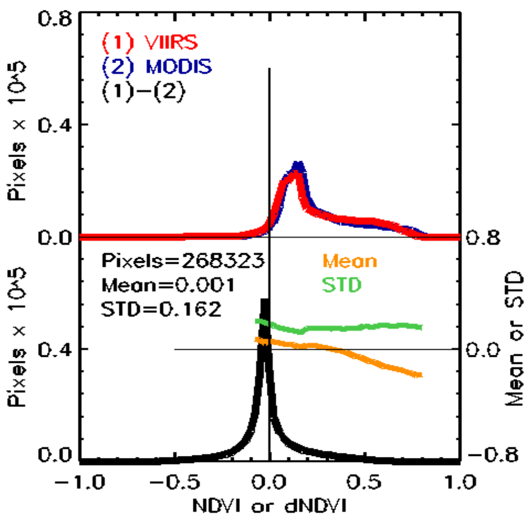
MODIS

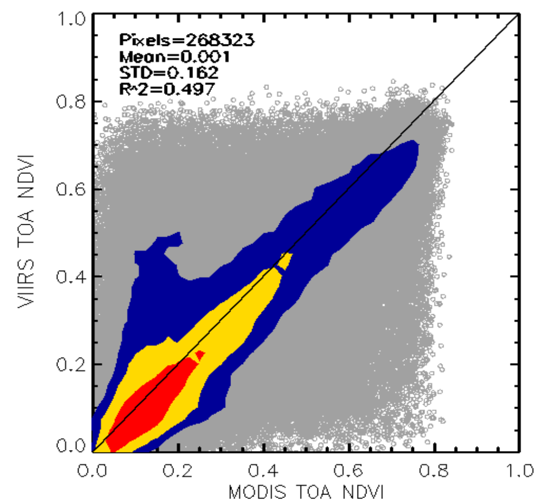


VIIRS minus MODIS

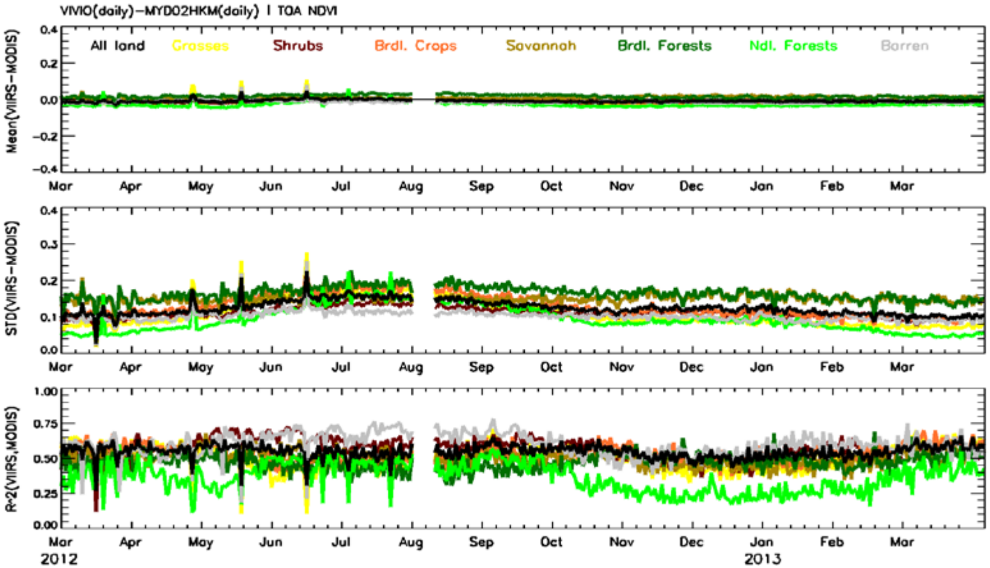


- Daily VIIRS TOA NDVI vs. daily Aqua MODIS TOC EVI for July 06, 2012
- Overall, spatial patterns (gradation of VI from low to high) good agreement between VIIRS and MODIS
- VIIRS Cloud mask (white areas on VIIRS VI map) captures major clouds, but underperforms at Northern High latitudes (i.e., patterns of unexpectedly low VI with sharp edges over Siberia)
- Histograms and scatter-plots of VIIRS and MODIS TOA NDVI indicate good overall consistency. However VIIRS data are slightly lower.



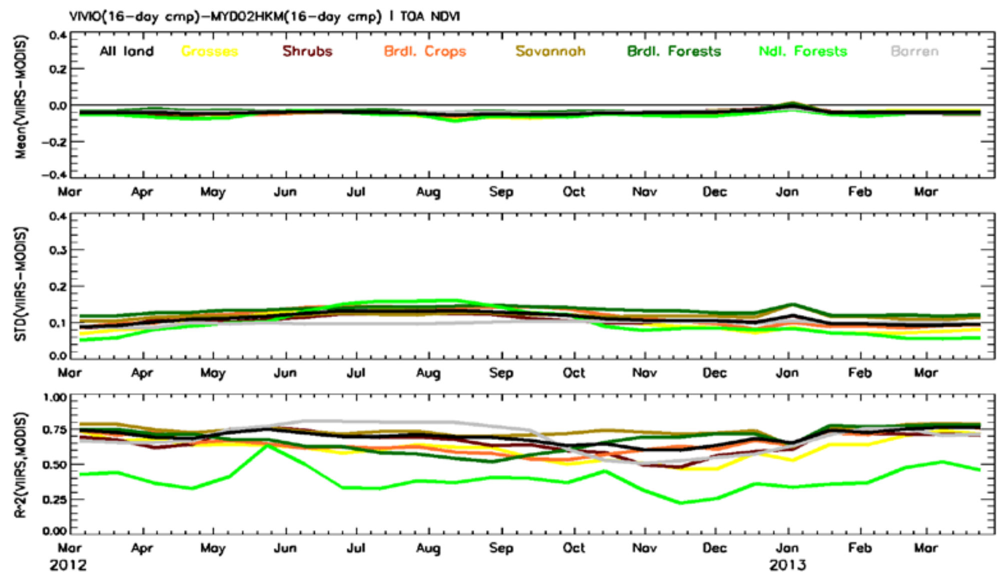


Comparison between VIIRS and MODIS TOA NDVI Time Series



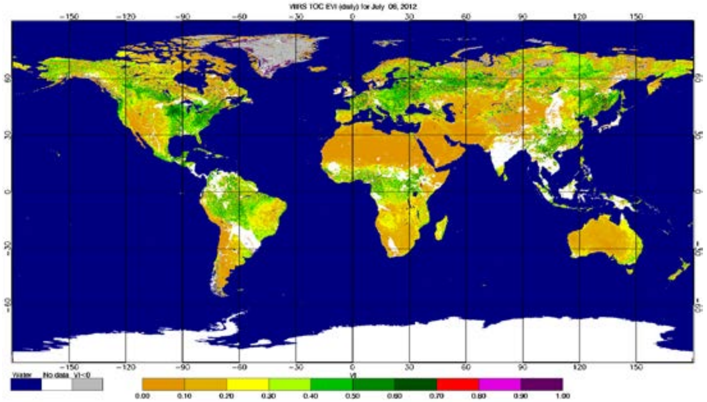
In daily data bias between VIIRS and MODIS is negligible, STD is around 0.15 and highest for Broadleaf forest (highest VI), R^2 is ~0.7 and lowest for Needleleaf forest (probably due to overlapping swath data)

Compositing helps to capture slight systematic underestimation of TOA NDVI by VIIRS (0.01), and also reduces STD (up to 0.1) and improves R^2

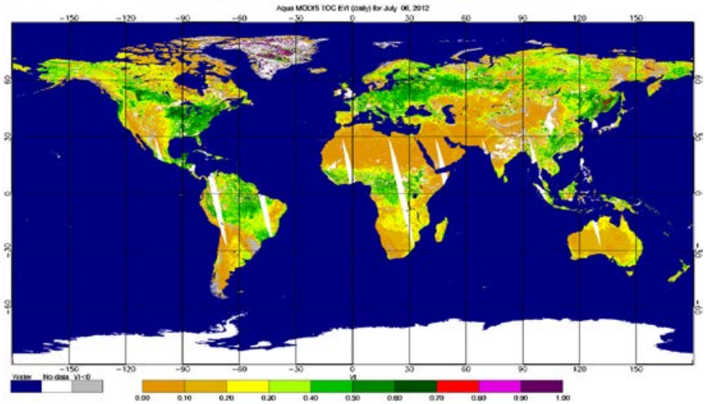


Comparison between VIIRS and MODIS TOC EVI (Daily)

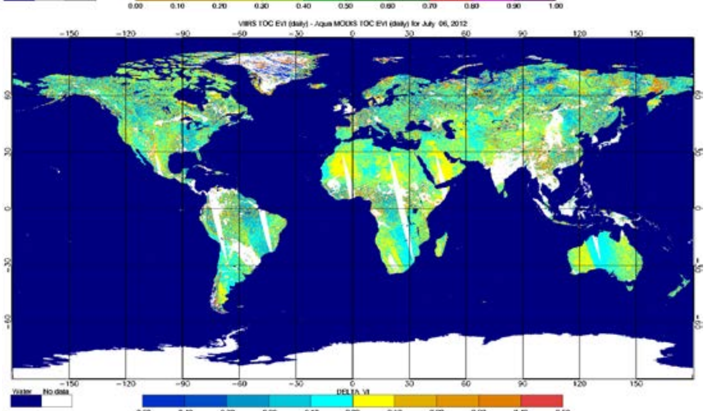
VIIRS



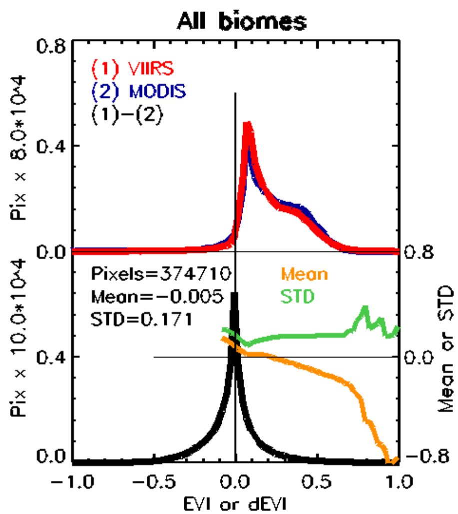
MODIS

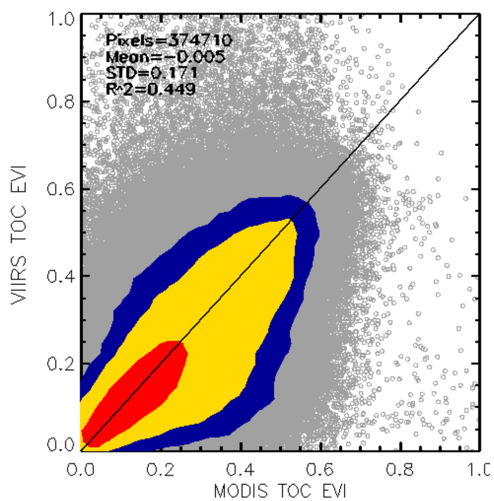


VIIRS minus MODIS

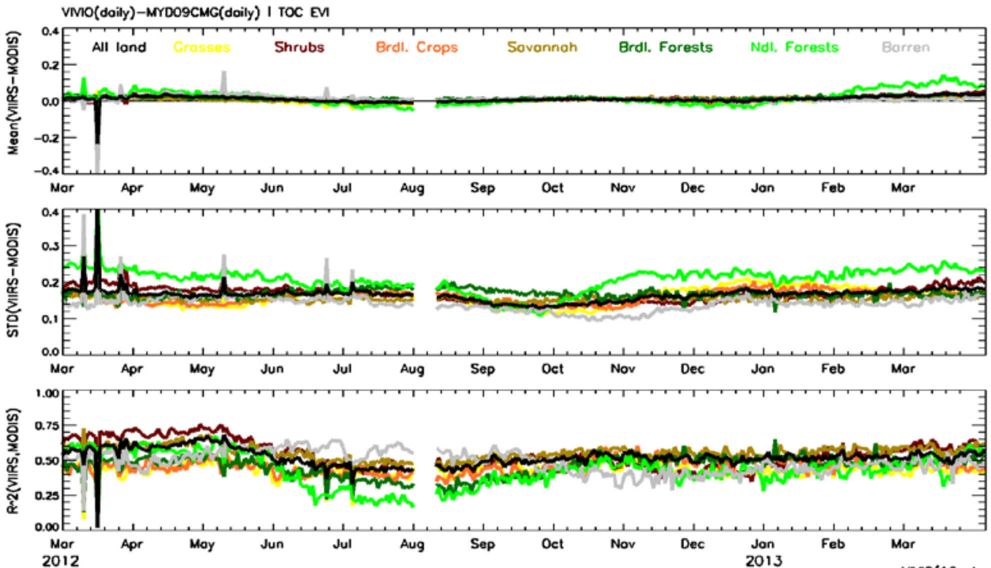


- **Daily VIIRS TOC NDVI vs. daily Aqua MODIS TOC EVI for July 06, 2012**
- **Overall, maps, histograms and scatter-plots of VIIRS and MODIS TOC EVI are consistent**
- **However, TOC EVI exhibits anomalously high values over snow-covered areas at high SZA (i.e., Greenland)**
- **Cloud leakage is noticeable (especially at Northern High latitudes) but is less pronounced compared to case of TOA NDVI (partially because TOC EVI has lower range variations, less saturation, etc).**



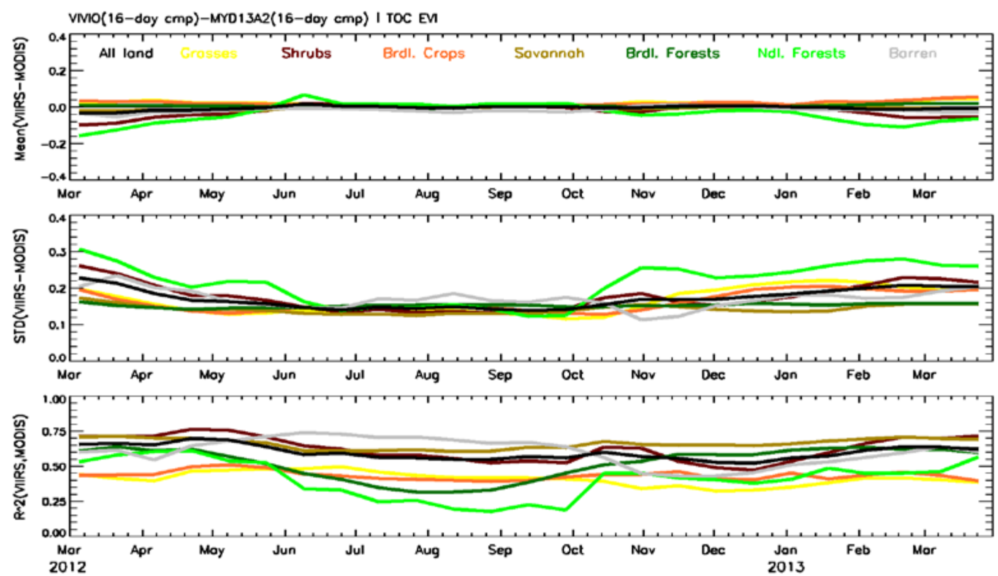


Comparison between VIIRS and MODIS TOC EVI Time Series



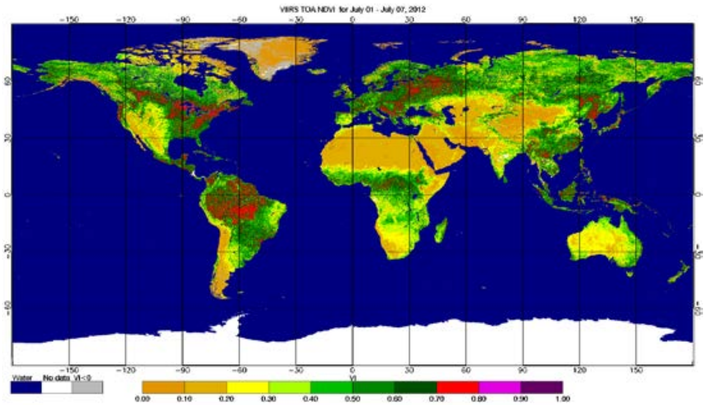
In daily data bias between VIIRS and MODIS is negligible, STD is around 0.2 and, R^2 is ~0.6 and lowest for Needleleaf forests. Note, in contrast to TOA NDVI, for TOC EVI statistics are quite similar across all biome types

- Compositing does not change statistics significatly.

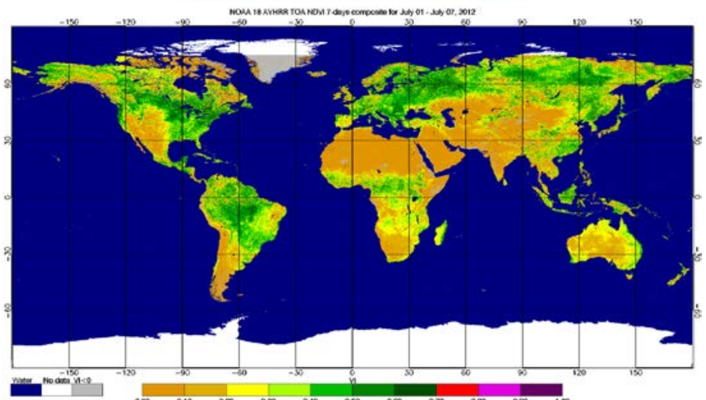


Comparison between VIIRS and AVHRR TOA NDVI 7-day composites

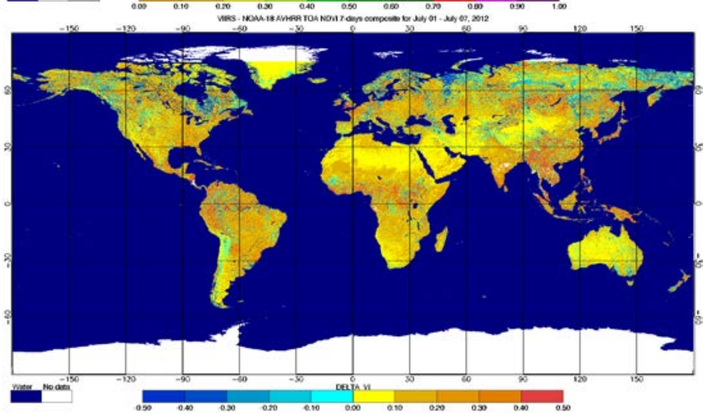
VIIRS



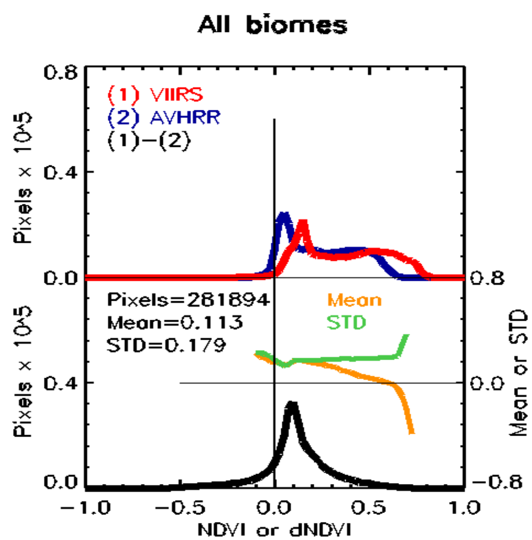
AVHRR

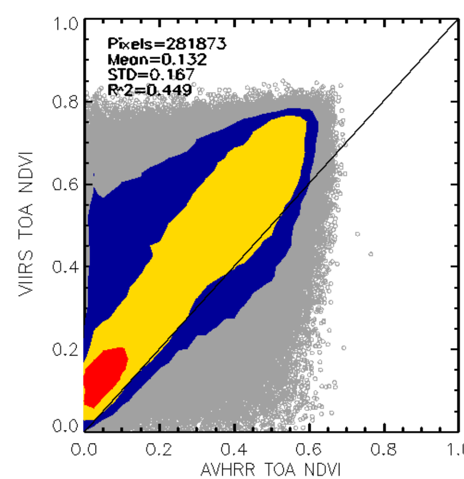


VIIRS minus AVHRR

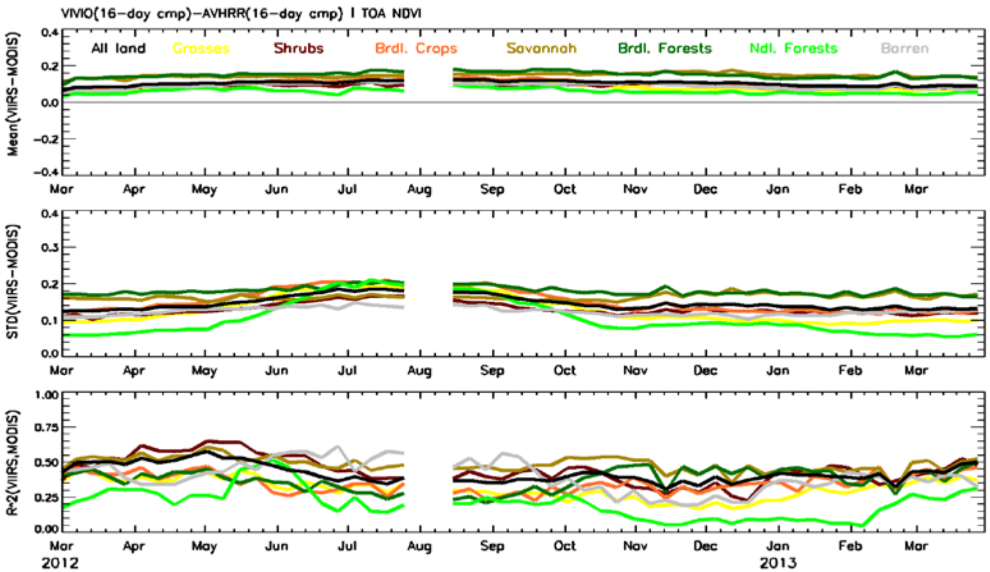


- 7-day composites of VIIRS TOA NDVI vs. 7-day composite NOAA-18 AVHRR TOA NDVI for July 01-07, 2012
- Spatial patterns of VIIRS and AVHRR TOA NDVI correlate, however VIIRS overestimates AVHRR data and overestimation increases with increased value of VI. Map of difference also indicates some areas with underestimation (Northern High Latitudes), but those could be due to artifact related to overlapping swath data
- Histograms of VIIRS and AVHRR data match in shape, but the one for VIIRS is stretched toward higher value. Similar “linear” stretch can be seen in the scatter-plot. This is consistent with the match for spatial patterns.





Comparison between VIIRS and AVHRR TOA NDVI Time Series



VIIRS data systematically overestimates AVHRR over whole annual cycle by about 0.1 Highest overestimation is observed over Broadleaf forests. However, STD is larger than in case of VIIRS-MODIS TOA NDVI comparison. Still correlation is much lower about 0.4, and drops even lower for Needleleaf forests

Summary of VIIRS VI Performance at Global Scale

VIIRS VI data	TOA NDVI		TOC EVI
Reference	NOAA-18 AVHRR	Aqua MODIS	Aqua MODIS
Mean (VIIRS-Reference)	0.108	-0.041	-0.004
STD (VIIRS-Reference)	0.146	0.111	0.172
R^2(VIIRS,Reference)	0.399	0.696	0.597

Notes:

- **Statistics presented are averages composited data (7 days in case of AVHRR and 16 days in case of MODIS)**

Match-up data sets from SR/VI Cal Val Tool for VIIRS VI product Validation

Methodology:

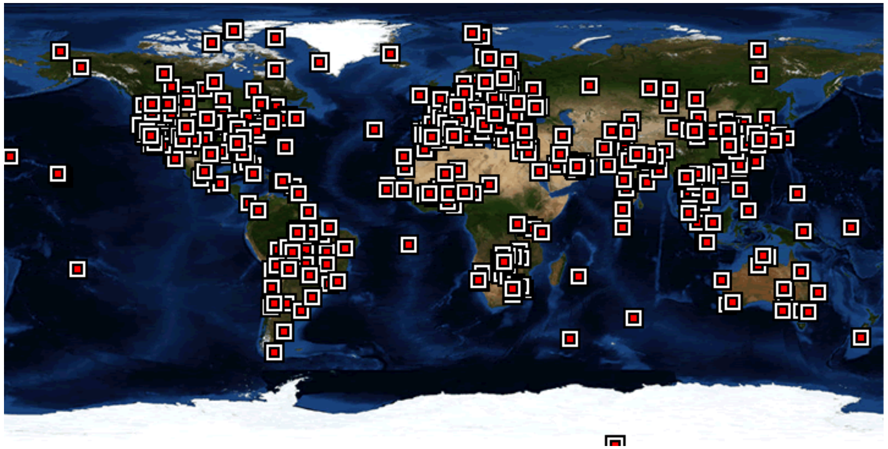
- Operational Cal/Val tool developed by NG to support SR/VI Validation (Alain Sei and Al Danial)
- Tool (1) collects AOD measurements over global AERONET sites and VIIRS TOA Reflectances, (2) performs atmospheric correction using 6S model and (3) outputs simulated TOC Reflectances
- Match-up data sets (VIIRS measured and 6S simulated TOC Reflectances) and ancillary information are reported to support SR/VI Cal/Val work.

Implementation:

- Atmospheric correction is performed for each pixel in the match-up subset.
- Subset corresponds to 101x101 pix area centered at each site (at Imagery resolution)
- Given time window of +/- 45 min (between VIIRS observation and AERONET measurements at site), tool generates ~25 sites per day and stores all match-ups in a single HDF5 file per day
- Match-up data are available at NSIPS, https://nsips.ipo.noaa.gov/ops/cgi-bin/Login.cgi

Future enhancements:

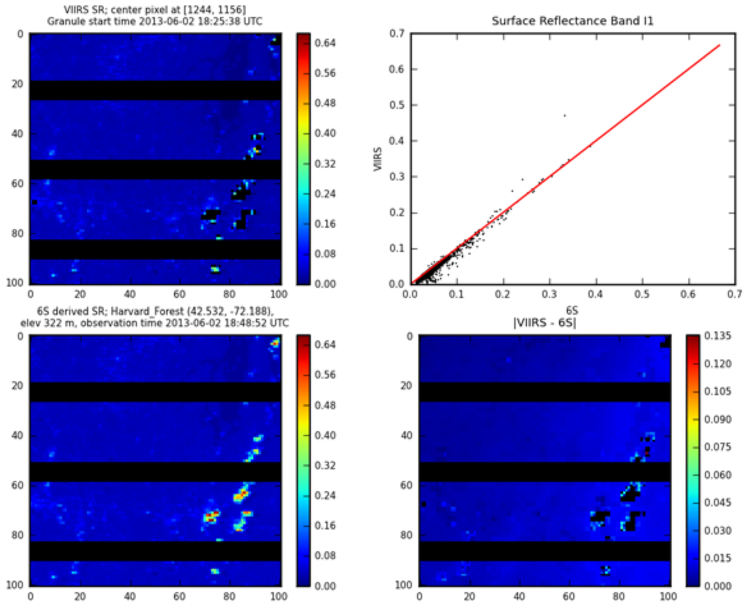
- Continuous time series of VIIRS VI subsets will be collected at NSIPS over select sites, representative range of land cover classes and climatic conditions over the Globe.



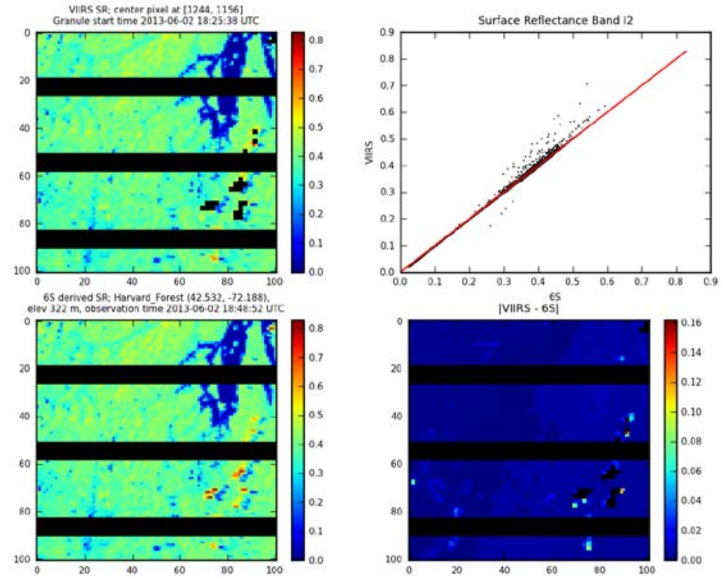
Aeronet sites, http://aeronet.gsfc.nasa.gov/

Match-up data sets from SR/VI Cal Val Tool for VIIRS VI product Validation

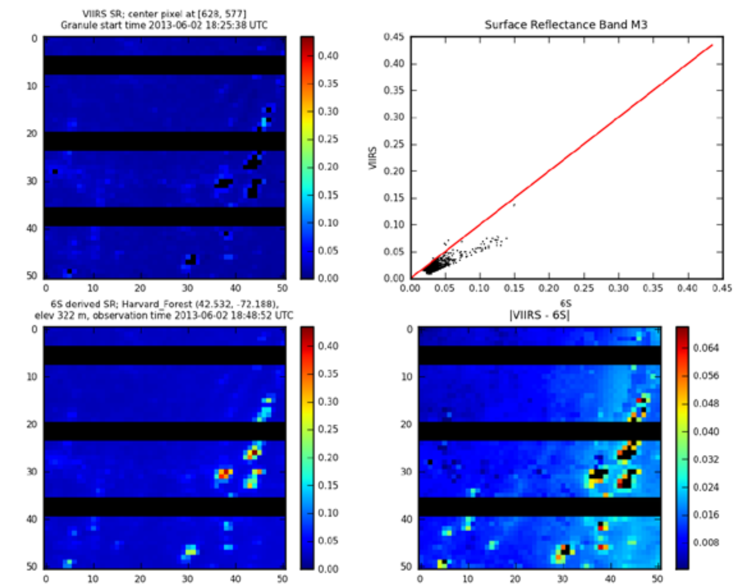
Band I1 (Red)



Band I2 (NIR)



Band M3 (Blue)



Sample output of the SR/VI Cal/Val tool:

- Site: “Harvard Forest”, dense broadleaf forest site in Western Massachusetts
- Date: June 06, 2013
- Results: VIIRS Surface Reflectances are underestimated in Red and especially Blue Channels, while NIR data are slightly overestimated.

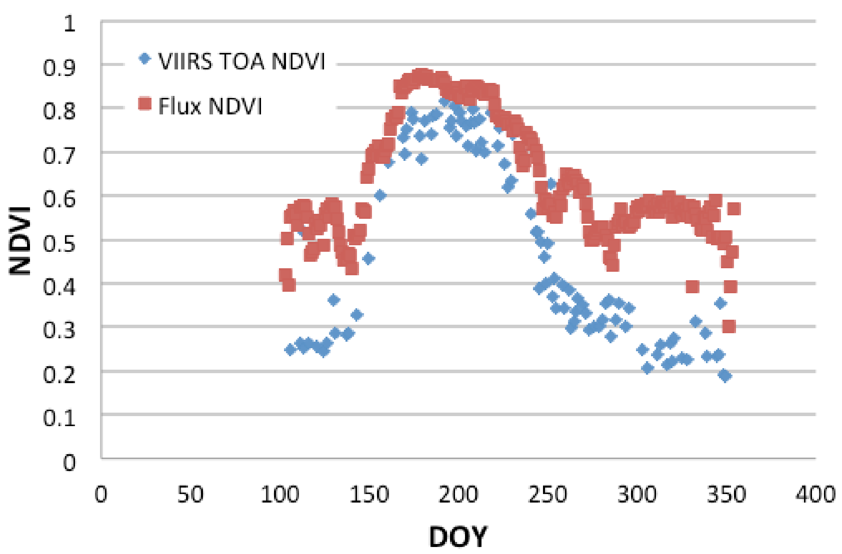
*** The Surface Reflectance and Vegetation Index Calibration and Validation tool was developed by Alain Sei and Al Danial (Northrop Grumman).

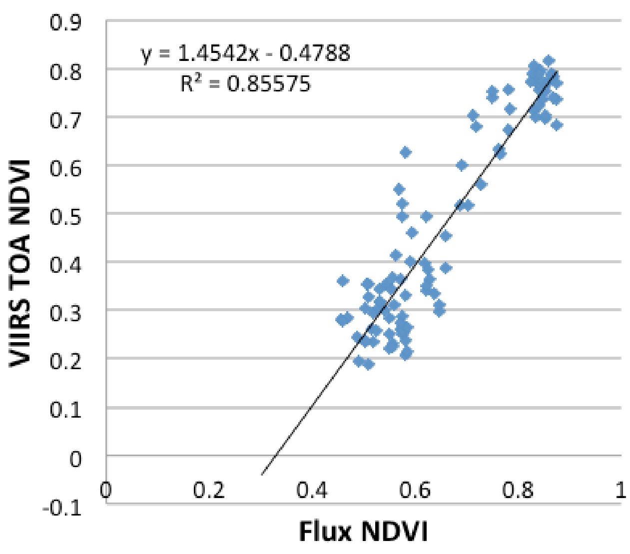
Validation Using FLUXNET Data

- PAR and radiation flux data were processed into *in situ* NDVI and EVI2 for time series validation of VIIRS VI EDR.

Analysis results from 3 AmeriFlux sites in Nebraska, USA

	TOA-NDVI	TOC-EVI
MD	0.19	0.05
MAD	0.29	0.11
RMSE	0.21	0.13





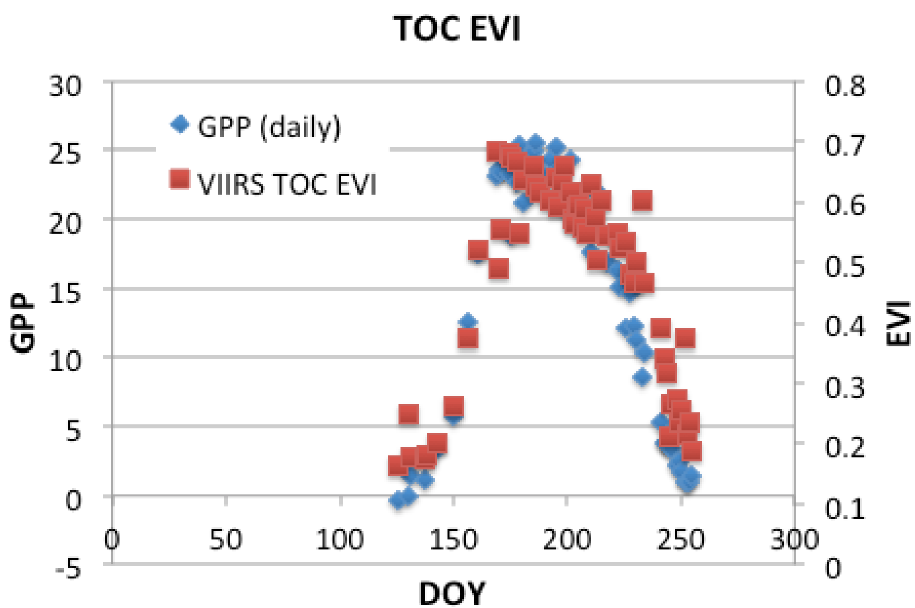
Validation Using FLUXNET Data

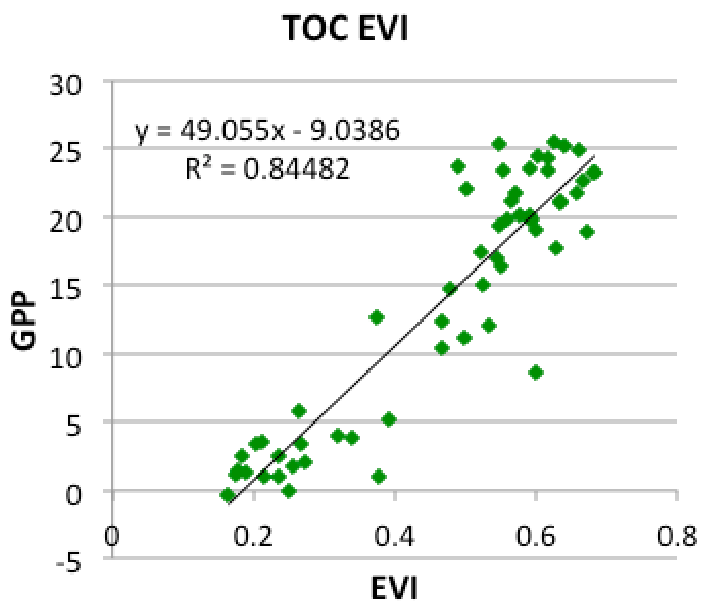
- *In situ* GPP flux data were also used for biophysical validation of VIIRS VI EDR.

Analysis results from 3 AmeriFlux sites in Nebraska, USA

	GPP = f(TOA-NDVI)	GPP = f(TOC-EVI)
MAD	3.21	2.92
RMSE	4.15	3.74

* μmol/m²/s

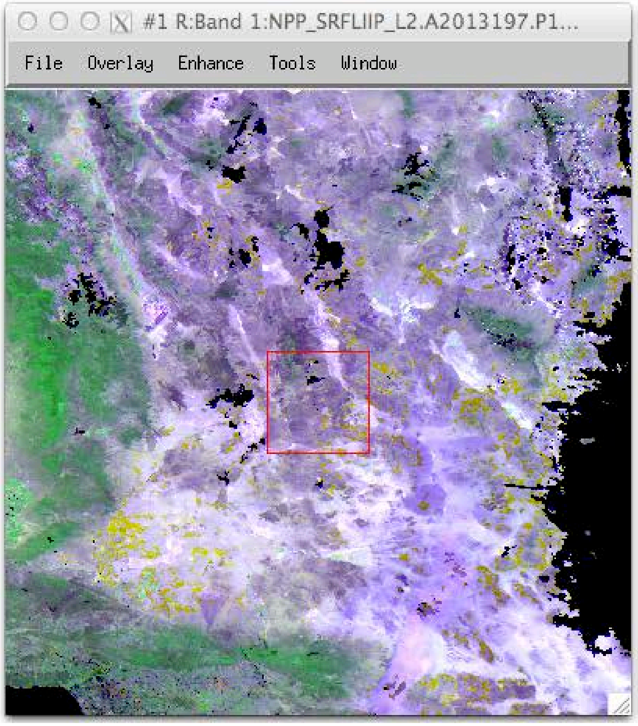




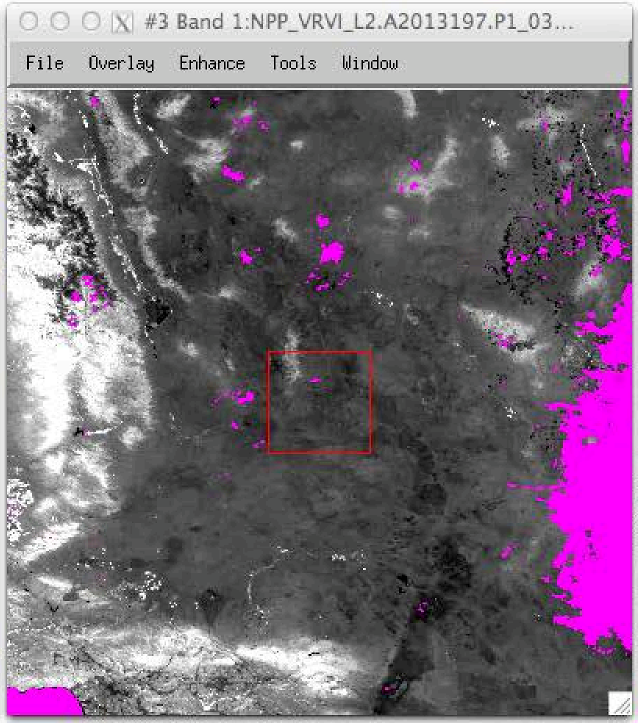
Missing TOC-EVI over Bright Targets

- Many fill-valued pixels found over bright targets only for TOC-EVI
  - Fill-valued M3 surface reflectance, likely due to the overestimation of AOT

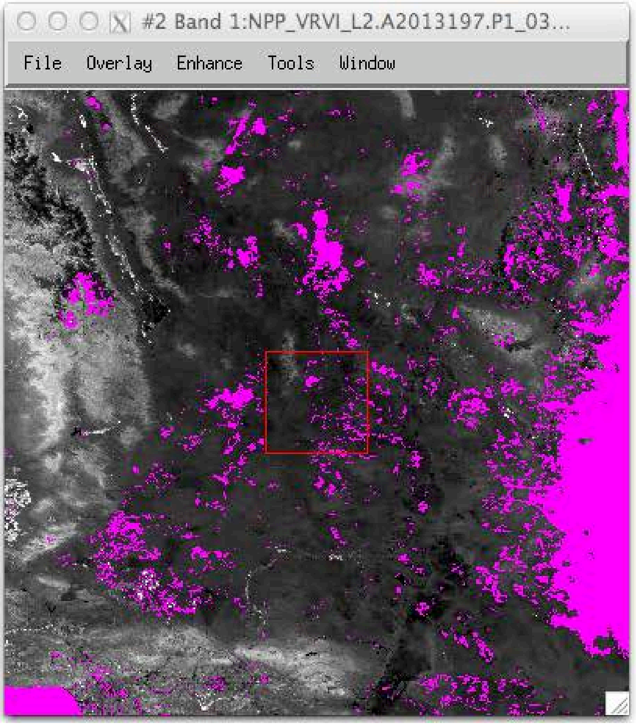
False Color (I1, I2, M3)



TOA-NDVI



TOC-EVI

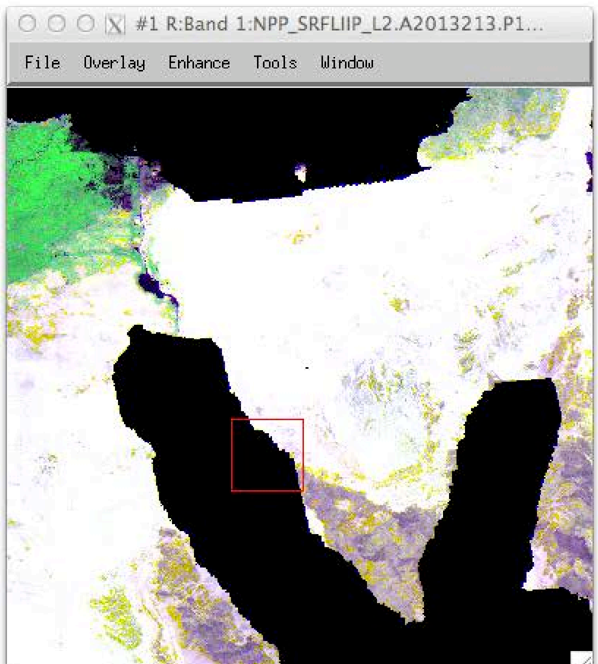


VIIRS EDR over Great Basin & Sonoran Deserts 2013-197 (Mx 6.7)

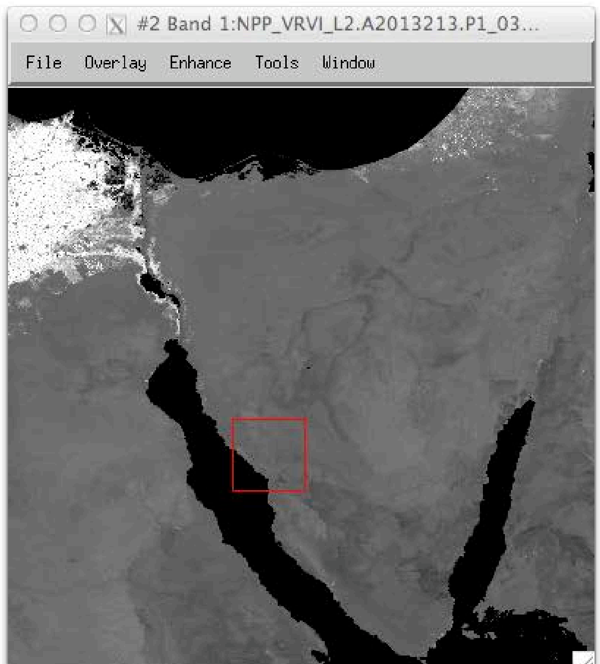
Missing TOC-EVI over Bright Targets

- Surface reflectance not retrieved for I1, I2, and M3 over deserts where NAAPS/Climatology AOT were used and, thus, no TOC-EVI derived

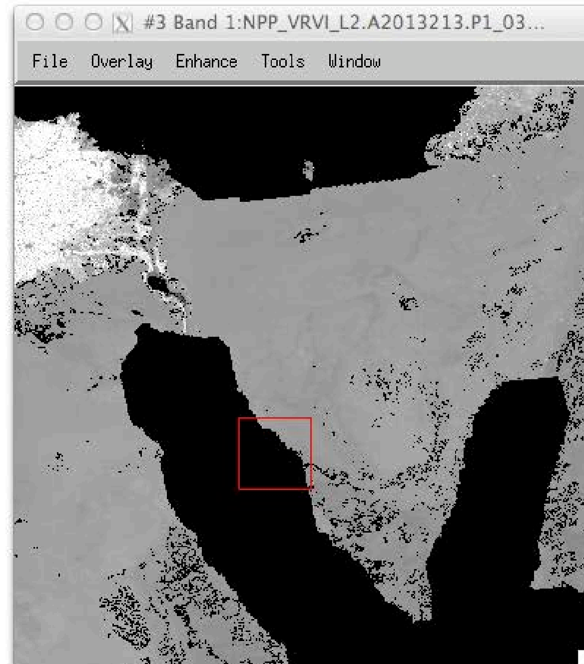
False Color (I1, I2, M3)



TOA-NDVI



TOC-EVI



VIIRS EDR over Egypt (Gulf of Suez)
2013-213 (Mx 6.7)

Evaluation of Cloud Screening in Daily VIIRS VI Methodology

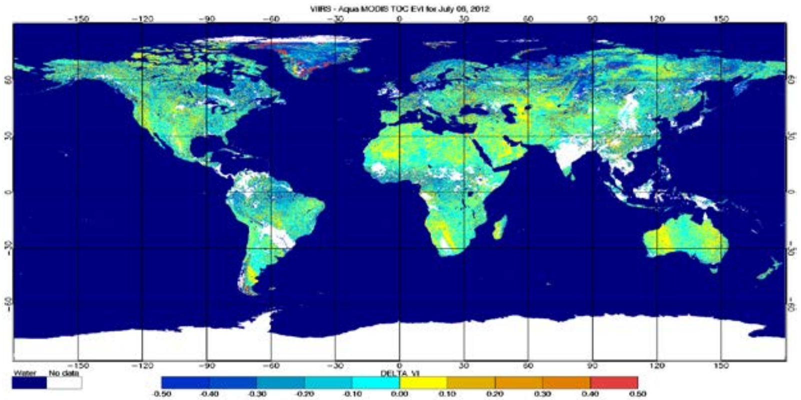
- VIIRS Cloud Mask (VCM) includes 4 categories: Clear, Probably Clear, Probably Cloudy, Cloudy.

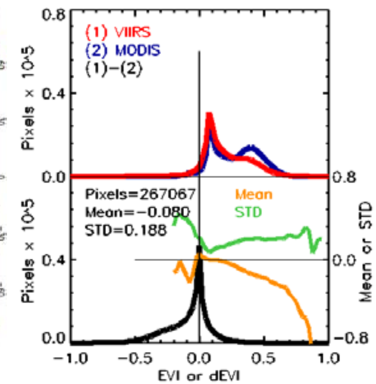
- Objective of this Case Study. Asses screening capabilities of VIIRS Cloud Mask for screening cloud-contaminated pixels in the VIIRS VI product.

- Methodology. Compositing is proven to be an efficient method to generate Cloud-free VI product. Therefore, if one uses as a reference Compositing product and construct VI anomaly = Daily VI – Reference VI. A negative VI anomaly may serve as an indicator of a cloud leakage.

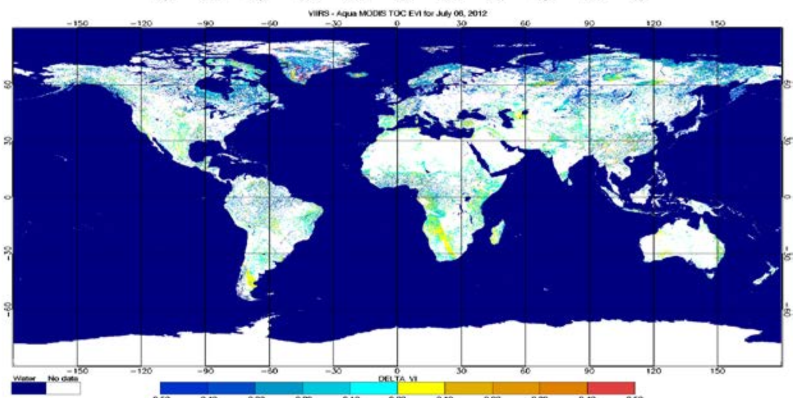
- Implementation. VI anomalies were generated for global daily TOC EVI data. VI anomalies were screened with a range of masks, from most Liberal (VI retained over Clear + Pr. Clear + Pr. Cloudy) to most conservative (VI retained over Clear only). The retained pixels were tested for cloud leakage and false alarms. Analysis presented below is for VIIRS Data for June 06, 2012

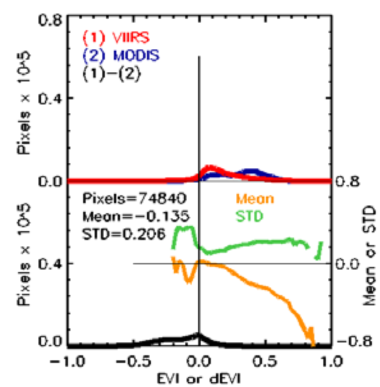
Evaluation of Cloud Screening in Daily VIIRS VI Results



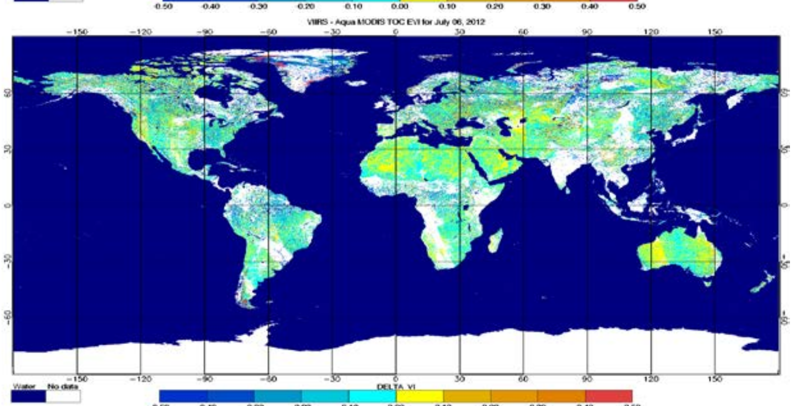


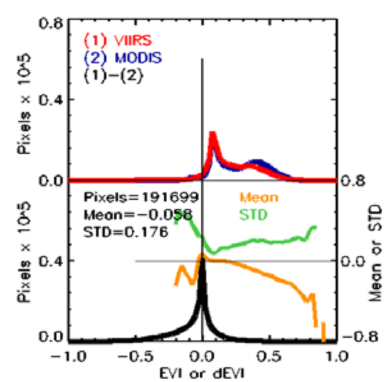
- **VI anomalies over Clear + Pr Clear + Pr Cloudy. Most liberal mask allows large cloud leakage (negative anomalies) especially over Northern High Latitudes. What if we exclude Pr. Clear + Pr. Cloudy pixels?**





- **VI anomalies over Pr. Clear + Pr. Cloudy. Probably categories capture majority of cloud leakage over North, however they include large amount of false alarms over South.**



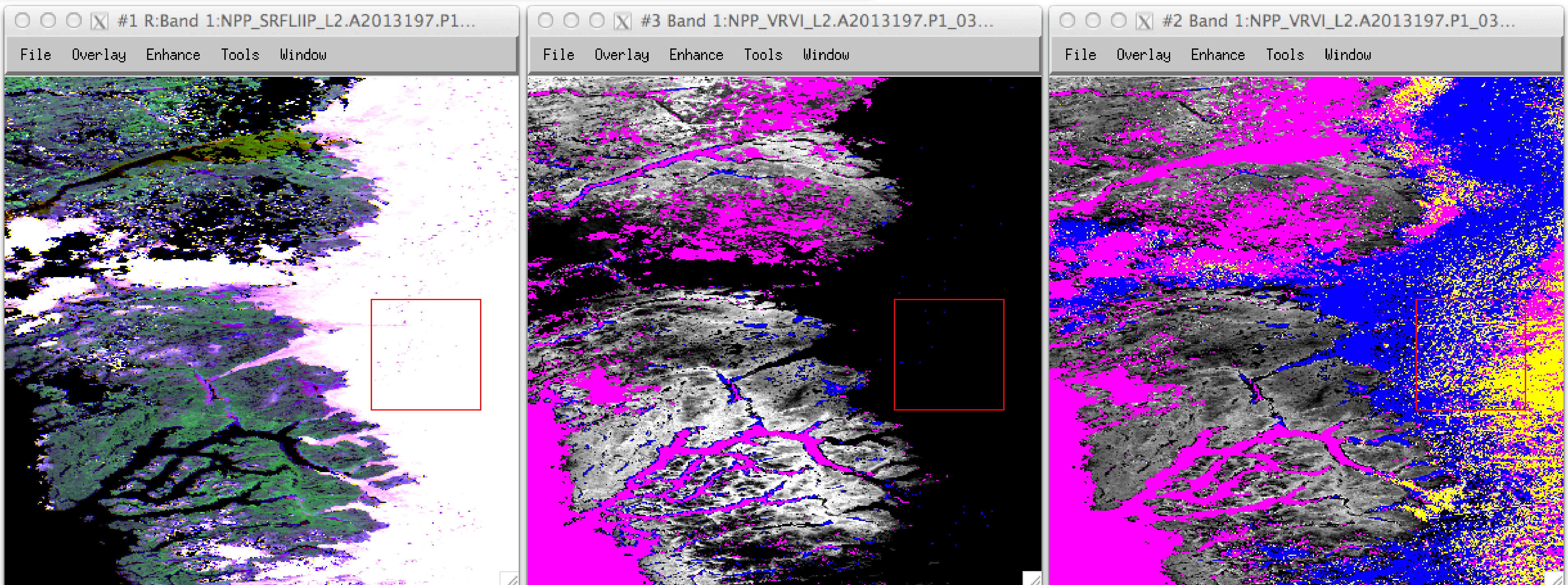


- **VI anomalies over Clear only. Most conservative mask screens most of leakage, in expense of reducing remaining pixels by 25%. However, residual leakage remains.**

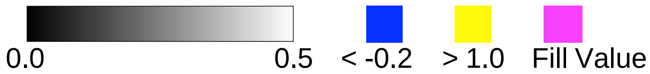
TOC-EVI over Snow/Ice & Clouds

- Erroneous EVI values over snow/ice covered surfaces
  - EVI values become unrealistically high or low.

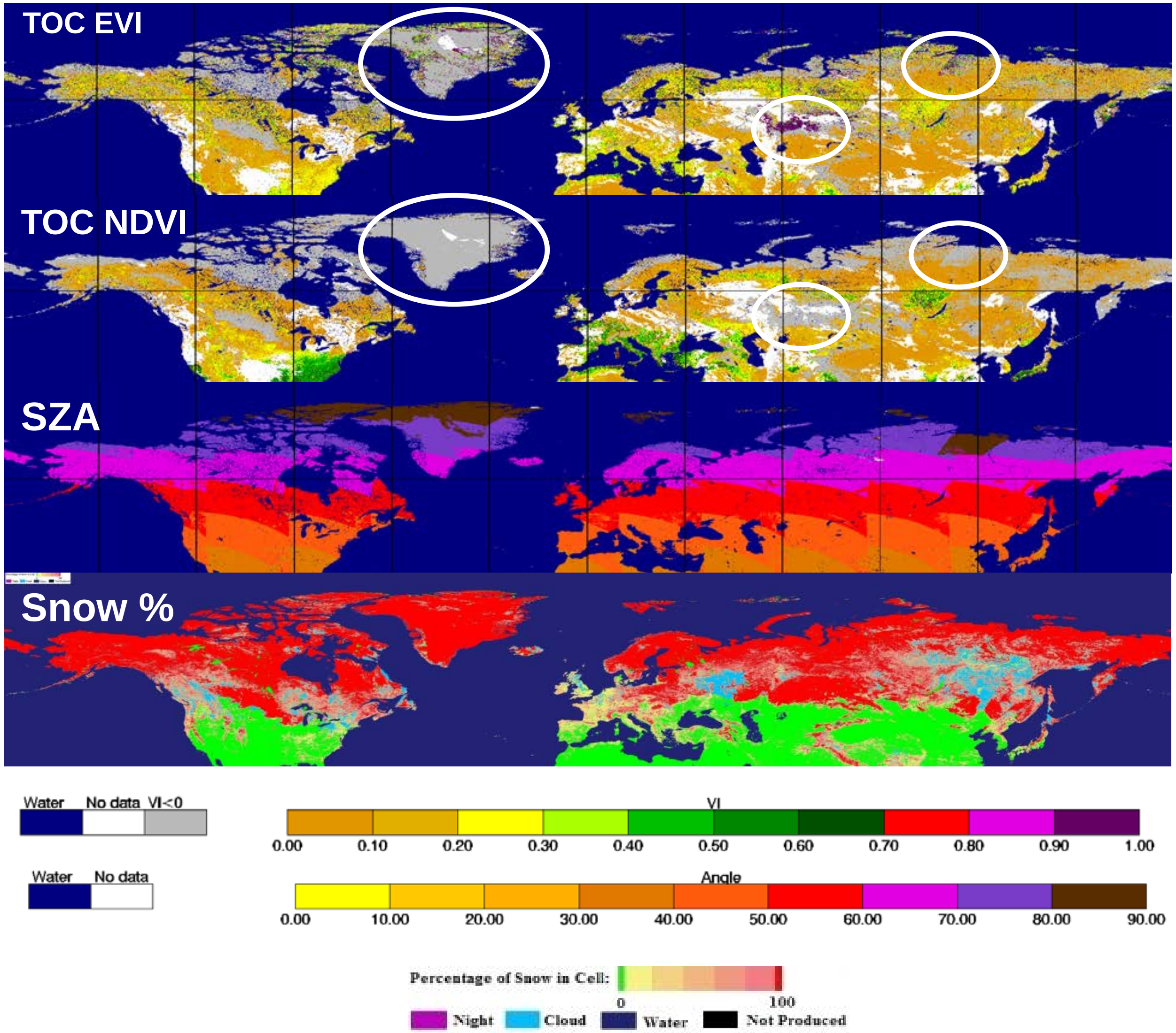
False Color (I1, I2, M3) TOA-NDVI TOC-EVI



VIIRS EDR over Greenland
2013-197 (Mx 6.7)



TOC EVI Anomalous Retrievals over Snow



Vegetation Index is expected to be low or negative over snow covered areas. While this holds for NDVI, this is not always the case for TOC EVI. Over highlighted patches TOC EVI > 1, while TOC NDVI is < 0.

Anomalous TOC EVI retrievals are not persistent, they appear and disappear on a daily basis.

VIIRS VI data are for March 19, 2012. MODIS snow cover is for March 14-22, 2012

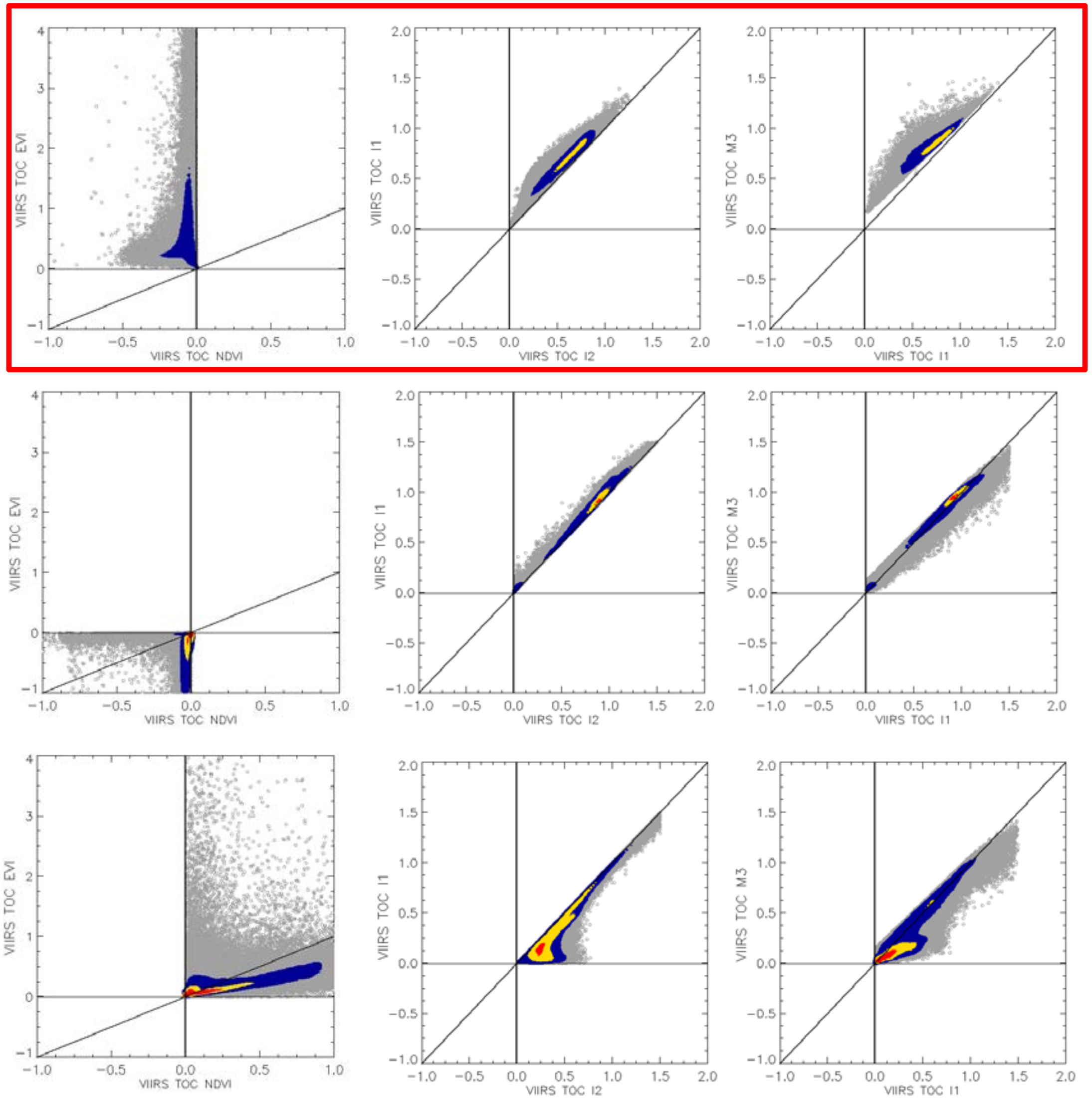
TOC EVI Anomalous Retrievals over Snow

Anomalous retrievals

NDVI<0 EVI>0

NDVI<0 EVI<0

NDVI>0 EVI>0



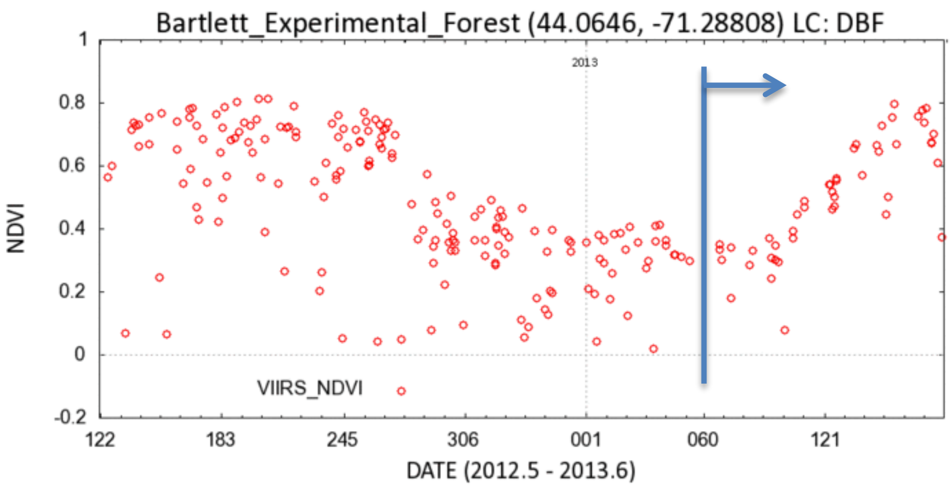
Anomalous retrievals arise due to anomalous relationship between VIIRS channels. For vegetated surfaces NIR>Red>Blue. However, in the anomalous areas the relationship reverses, Blue>Red>NIR.

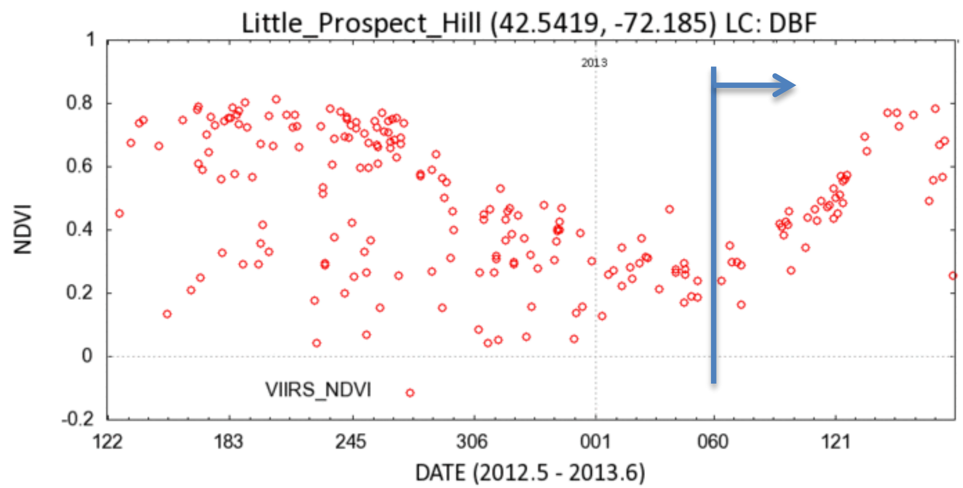
Anomalous retrievals were also were observed in MODIS data

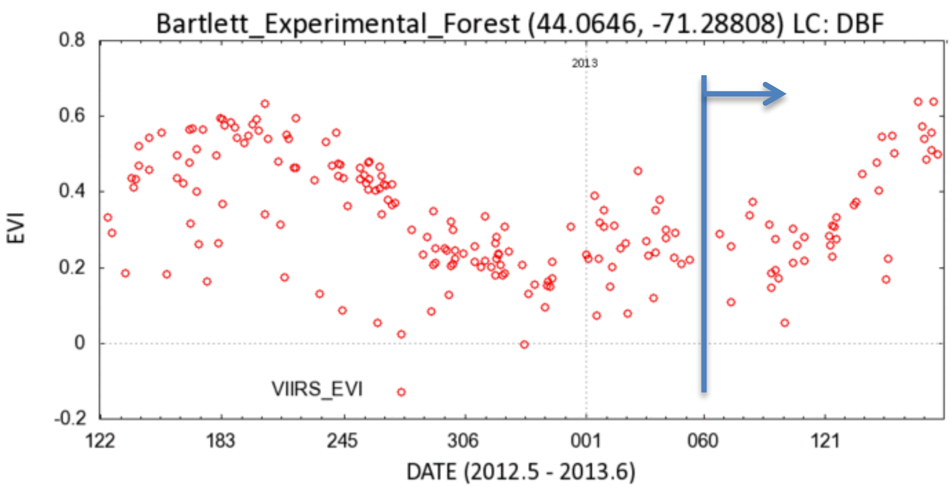
<u>Solution:</u> Implement Back-up algorithm, SAVI (as in MODIS), or EVI2.

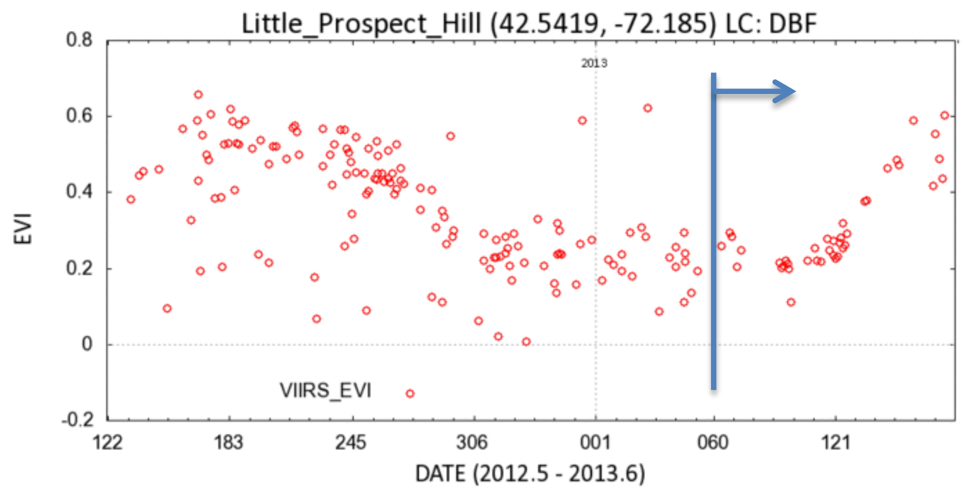
VIIRS VI Temporal Profiles - Unscreened

- An apparent improvement in smoothness of VI time series after Feb 2013 (Mx 6.6)



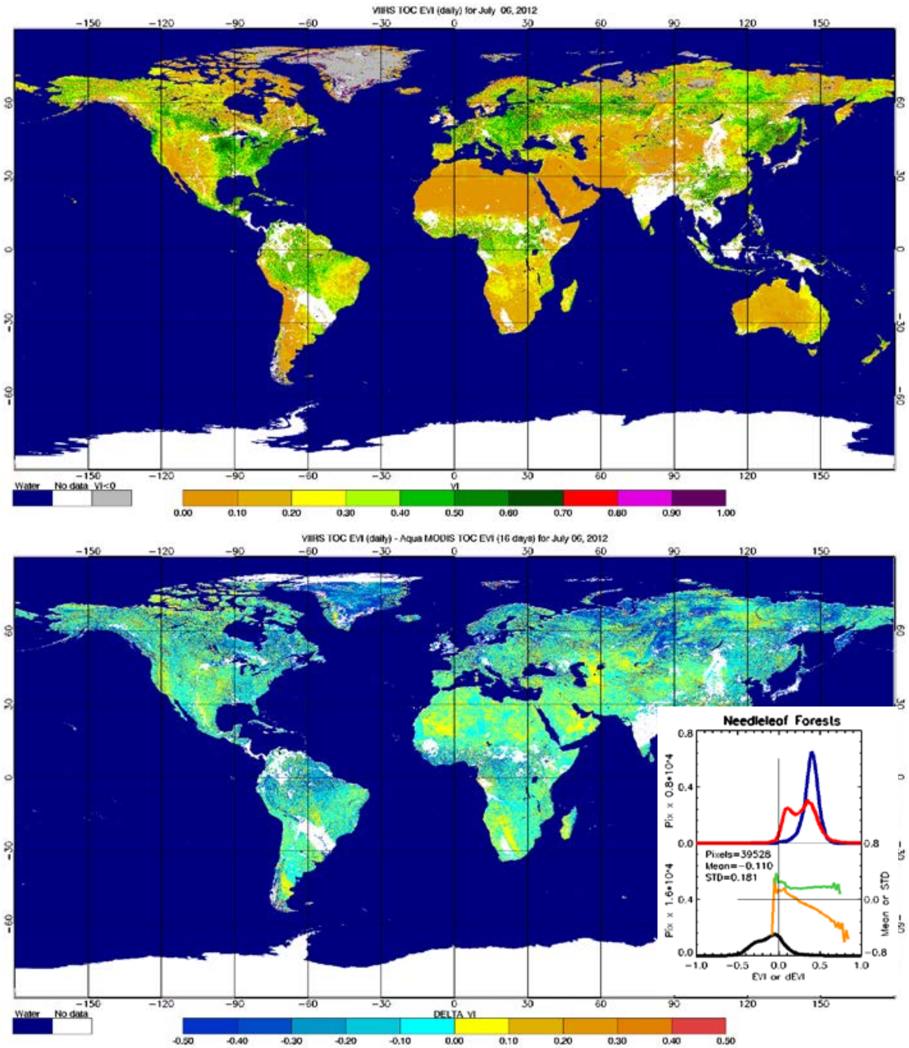




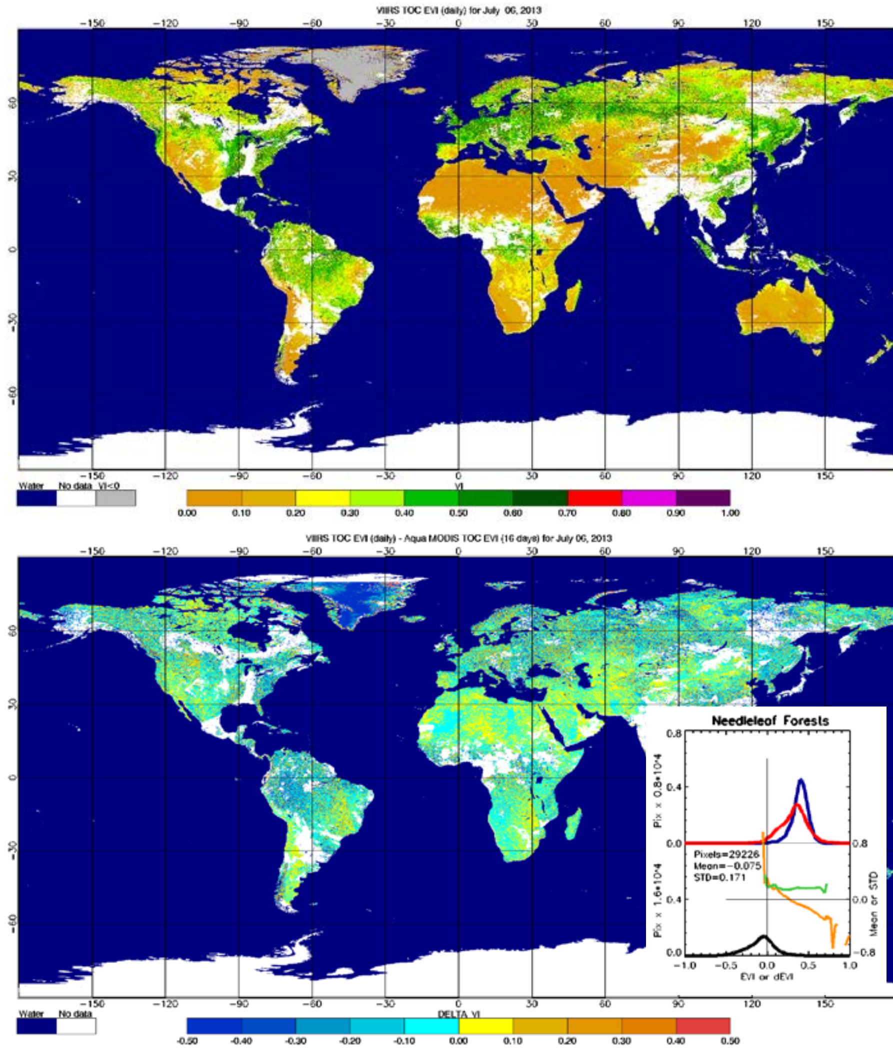


Impact of changes in VCM on TOC EVI

July 06, 2012



July 06, 2013



(On histograms: **VIIRS** **MODIS** **VIIRS-MODIS**)

Improvement in cloud screening is seen over Northern High Lats from 2012 to 2013: less large negative VI anomalies

Pathway Forward for VIIRS VI EDR

1) Adding TOC-NDVI
2) Updating/revising QA fields (DR7038; CCR being generated)
3) Refining the EVI algorithm
   - A backup algorithm over snow/ice covered areas
   - Coefficient adjustment or an EVI2 algorithm
4) EVI equation revision: the gain factor

VIIRS

$$EVI = (1+L)\frac{\rho_{\mathrm{NIR}} - \rho_{\mathrm{red}}}{\rho_{\mathrm{NIR}} + C_1\rho_{\mathrm{red}} - C_2\rho_{\mathrm{blue}} + L}$$

MODIS

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

5) Temporal compositing

Mapping of Additional QFs

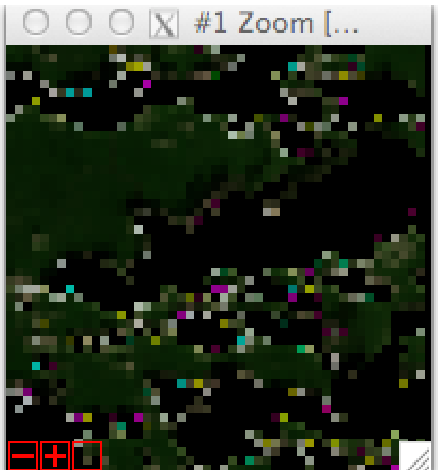
- Include the following four additional QFs into QF3_VIIRSVIEDR
  1) snow/ice <= to be copied from Bit 0 of SR IP QF7
  2) adjacent clouds <= to be copied from Bit 1 of SR IP QF7
  3) aerosol quantity <= to be copied from Bits 2-3 of SR IP QF7
  4) cloud shadow <= to be copied from Bit 3 of SR IP QF2

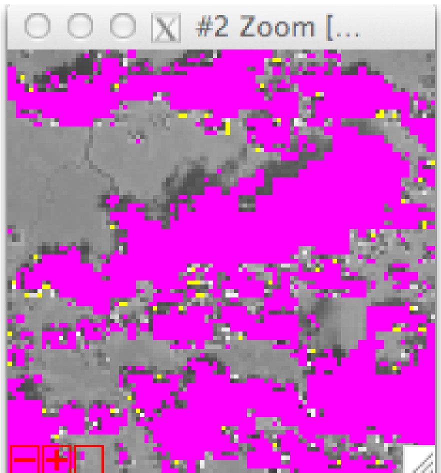
	Current			Proposed, New		
Byte	**Bits**	**VIIRS VI Quality Flag**	**Value**	**Bits**	**VIIRS VI Quality Flag**	**Value**
2 (QF3)	0	Stratification – Solar Zenith Angle	0: SZA < 65 or > 85 1: 65 ≤ SZA ≤ 85	0	Stratification – Solar Zenith Angle	0: SZA < 65 or > 85 1: 65 ≤ SZA ≤ 85
	1	Excl – AOT > 1.0	0: 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)

QF3 Bit 4: Adjacent to Clouds

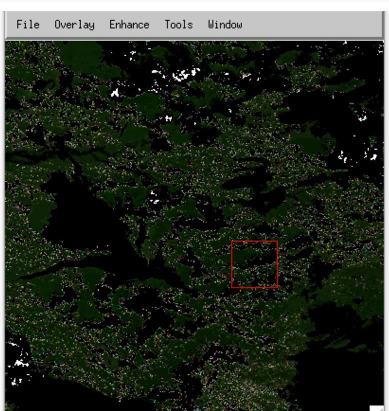
2013-197.1745 (Mx 7.1): Amazon Forest, Brazil

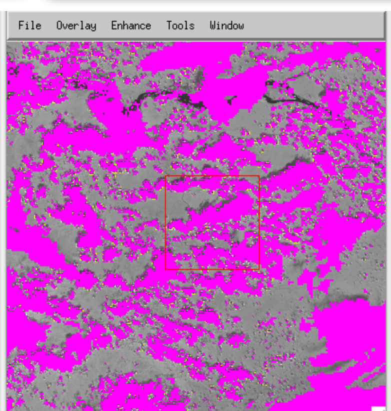
True Color Composite (M5, M4, M3) **TOC EVI** **Adjacency Clouds**

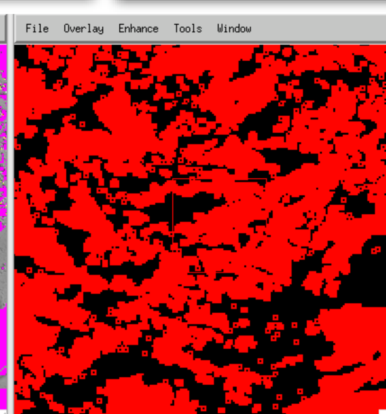




-. There still remain cloud-contaminated pixels adjacent to cloud screened zones. These pixels are labeled and screened by Adjacency Cloud QF





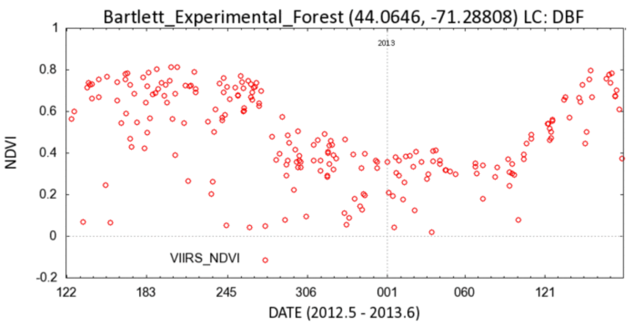


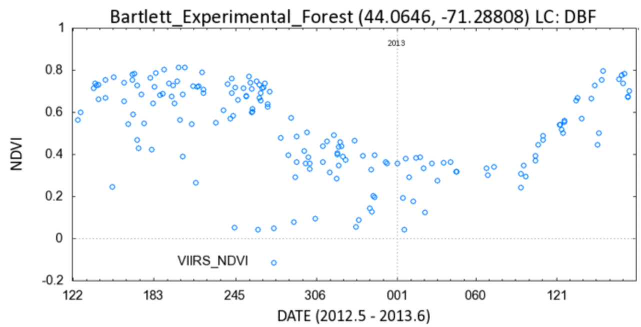
-0.2 1.0 < -0.2 > 1.0 Fill Value

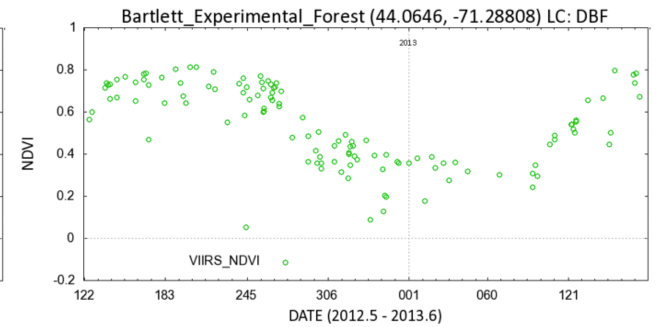
Red: On / Black: Off

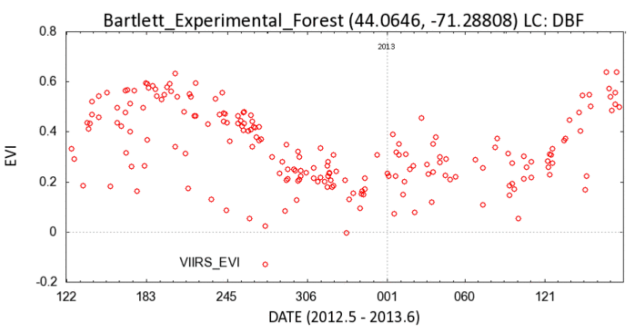
VIIRS VI Cloud Mask and Adjacency Clouds

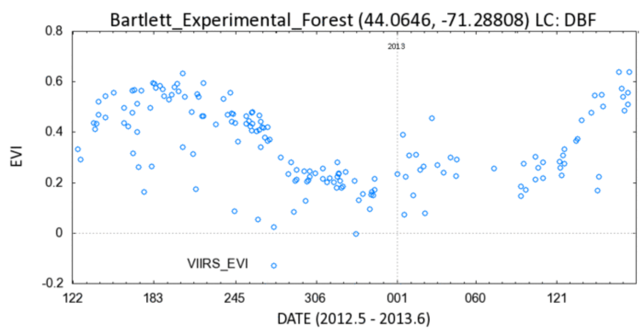
Unscreened	Cloud Screened Using QFs in VI EDR	Cloud Screened Using QFs in VI EDR + Adjacency Cloud Screened Using QFs in VCM

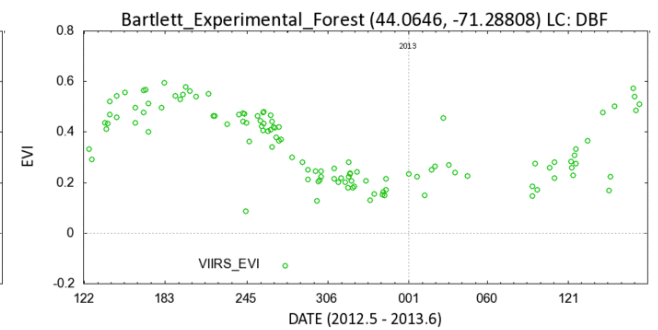






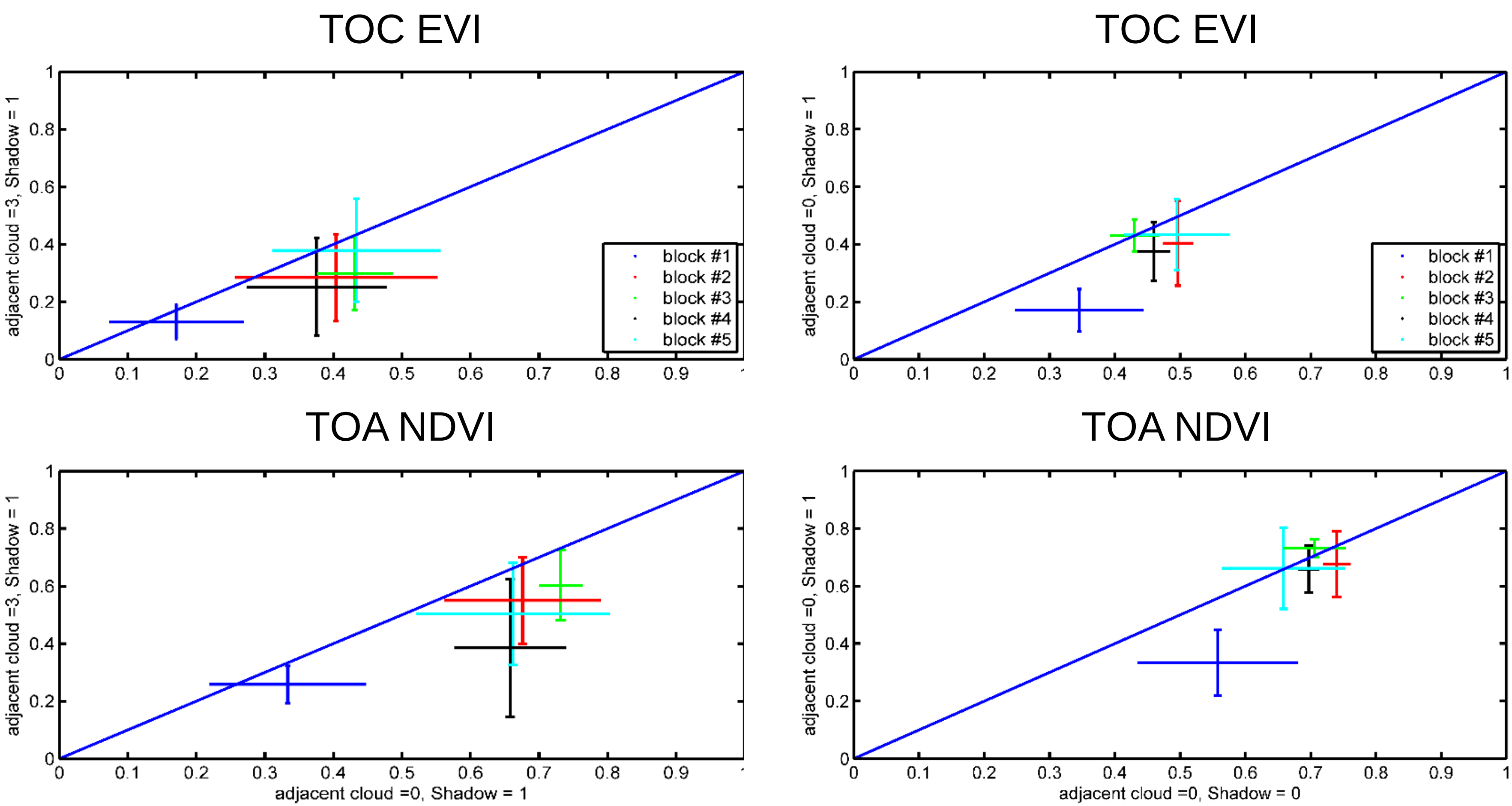






Impacts of Cloud Shadows and Adjacency Clouds

2013-049.1720 (Mx 6.4/6.5): Amazon, Brazil



Pathway Forward for VIIRS VI EDR (cont.)

- Near-term
  - Algorithm refinement
  - Evaluation of TOC NDVI produced from Surface Reflectance IP
  - Validation using Cal/Val Tool, ASRVN, FLUXNET
    - Continue the analysis to increase a number of sites with longer time series
- Mid-to-long term
  - Full evaluation of updated science algorithm and code
  - Validated Stage 1 release of VI EDR by June2014
  - Validated Stage 2 status of VI EDR by January 2015

Users of Vegetation Index EDR Products (Point Of Contact)

- **U. S. Users:**
  - NCEP- National Centers for Environmental Prediction (Michael Ek/Jesse Meng/Yihua Wu/Matthew Rosencrans)
  - STAR – Center for Satellite Applications and Research (Felix Kogan, Wei Guo, Xiaoyang Zhang)
  - CLASS - Comprehensive Large Array-data Stewardship System (John Bates)
  - USDA – United States Department of Agriculture (Eric Luebehusen)
  - The Climate Corporation – Pavel Machalek
  - UH - University of Hawaii – Department of Natural Resources and Environmental Management.
  - USGS – U. S. Geological Survey (Kevin Gallo, Jesslyn Brown, etc)
- **Foreign Users:**
  - UTS - University of Technology Sydney (Alfredo Huete)

Summary of Findings

- Analysis results indicate that the **VIIRS Vegetation Index EDR product is performing well**.
  - Good radiometric performances
  - Improved retrievals expected with improvements in upstream processing
  - Incomplete screening of suspicious quality pixels for a lack of appropriate internal QFs
- **VI EDR will meet the Provisional stage** based on the definitions and the evidence shown.
  - Inclusion of additional QFs to VI EDR (DR7038)
- **VI EDR Provisional Effective Date:**
  - **Contingent upon the Implementation of CCR13-1218**