Land breakout
Welcome and introduction

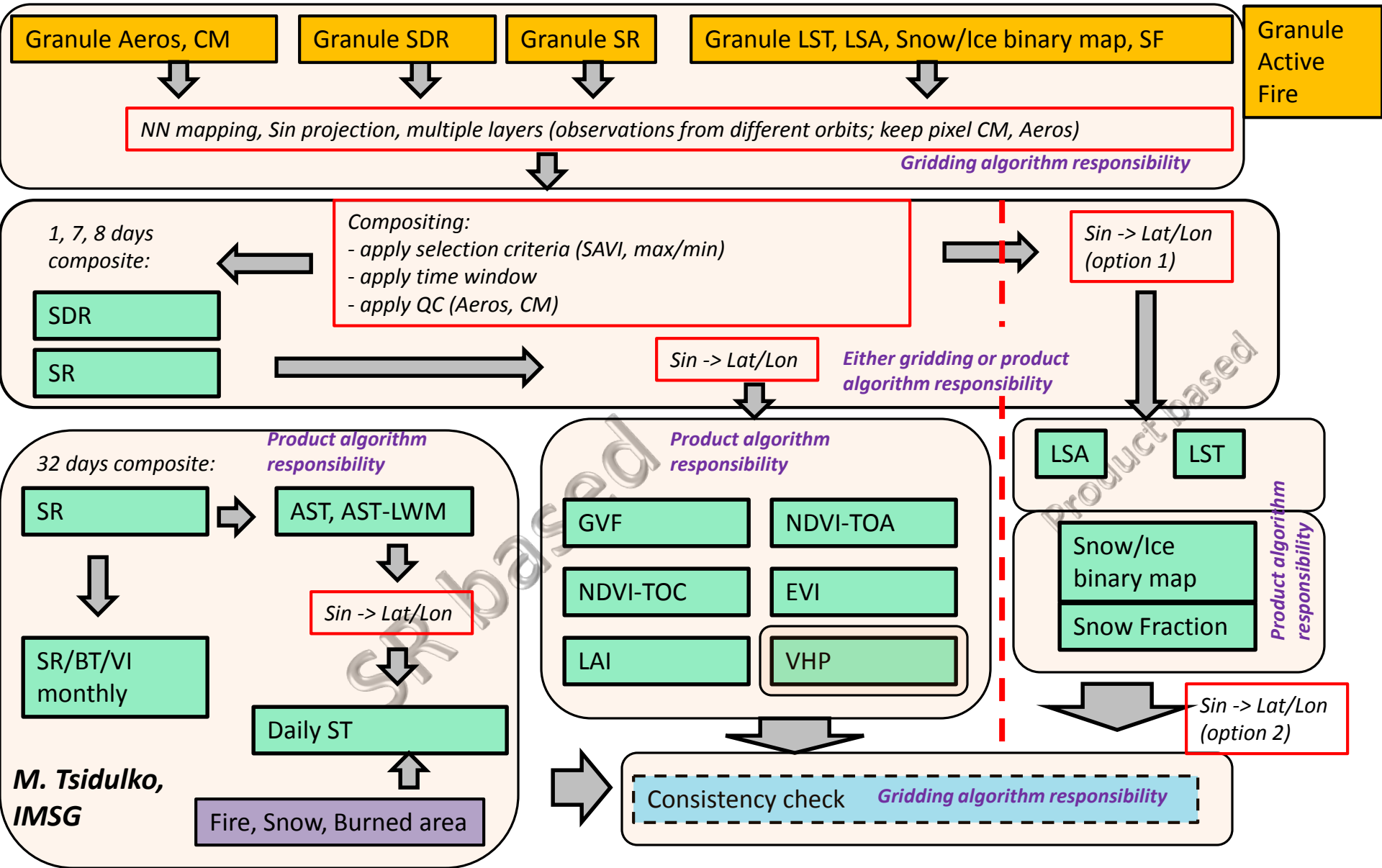
Ivan Csiszar

NOAA/NESDIS/STAR

Land algorithm status

- Algorithms are currently transitioning to Enterprise solutions
  - changes in retrieval algorithm, product content, format
- Preparations for reprocessing are ongoing
- Long-term product monitoring and maintenance continues
  - http://www.star.nesdis.noaa.gov/jpss/EDRs/index.php
- Product development is generally in sync 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
  - National Ice Center (NIC), Navy, NWS Alaska
  - etc.
- NASA ST production / reprocessing ongoing
  - continuing coordination and synchronization for select algorithms
  - implementation challenges
    - NASA-unique SDR, formats, NDE vs. SIPS production systems

Schematic view of proposed Land Enterprise System



Enterprise implementation schedule

- Algorithm readiness
  - Surface reflectance: September 2017
  - VI, LST, LSA: August/September 2017
  - Active Fire – already operational – updates coming
  - Surface Type – annual updates – updates coming
- JPSS-1 readiness
  - Recent 8-day dataset provided to STAR needs to be evaluated
  - Validation schedule updates?
  - Expect some changes in SDR, ECM etc.

Principal issues

- Operational NDE implementation needs more coordination
  - Need to know status of upstream products
  - Need to access to correct versions of upstream products
  - Operational implementation appears to be slower than expected
  - Need to properly plan for update bundles
- Readiness for reprocessing lagging
  - Need SDR evaluation and upstream EDR readiness
- Operational (i.e. OSPO quality monitoring)
  - Need better coordination and notification of issues
- Requirement changes and data access (PDA etc.)
  - User-driven processes
- Operational use of products lagging
  - re-think approaches to the problem
  - How do the products fit into the new NCEP modeling framework?

Agenda (am)

0915 - 1710	***Land*** ***Chair: Ivan Csiszar*** ***ESSIC Room 4102***		
0915 - 0935	*Introduction and Welcome*	Ivan Csiszar	STAR
0935 - 0955	*Surface Reflectance*	Eric Vermote	NASA
0955 - 1015	*Vegetation Product Suite*	Ivan Csiszar	STAR
1015 - 1030	***Break***		
1030 - 1050	*Land Surface Albedo*	Yunyue (Bob) Yu	STAR
1050 - 1110	*Land Surface Temperature*	Yunyue (Bob) Yu	STAR
1110 - 1130	*Active Fire*	Ivan Csiszar	STAR
1130 - 1150	*Vegetation Health*	Felix Kogan	STAR
1150 - 1200	*Discussion*		
1200 - 1315	***Lunch***		

Agenda (pm)

1315 - 1335	*Surface Type and Surface Type Change*	Xiwu (Jerry) Zhan	STAR
1335 - 1355	*Land Product Characterization System*	Kevin Gallo	STAR
1355 - 1415	*NASA Land Science Team Status*	Miguel Román	NASA
1415 - 1435	*CEOS Land Product Validation*	Miguel Román, Tomoaki Miura	NASA
1435 - 1445	*Discussion*	**15:00 – 15:30 Yihua Wu, Weizhong Zheng**	
1445 - 1530	***Break***		
1530 – 1550	*Product Interdependencies, Consistency, Common Gridding and Compositing, Upstream Product Issues*	Open discussion	
1550 – 1610	*Reprocessing*	Open discussion	
1610 - 1630	*New Operational Land Products*	Open discussion	
1630 - 1650	*JPSS - GOES-R Algorithm Integration and Enterprise Products*	Open discussion	
1650 - 1710	*Non-NOAA Satellite Assets*	Open discussion	

Surface Reflectance

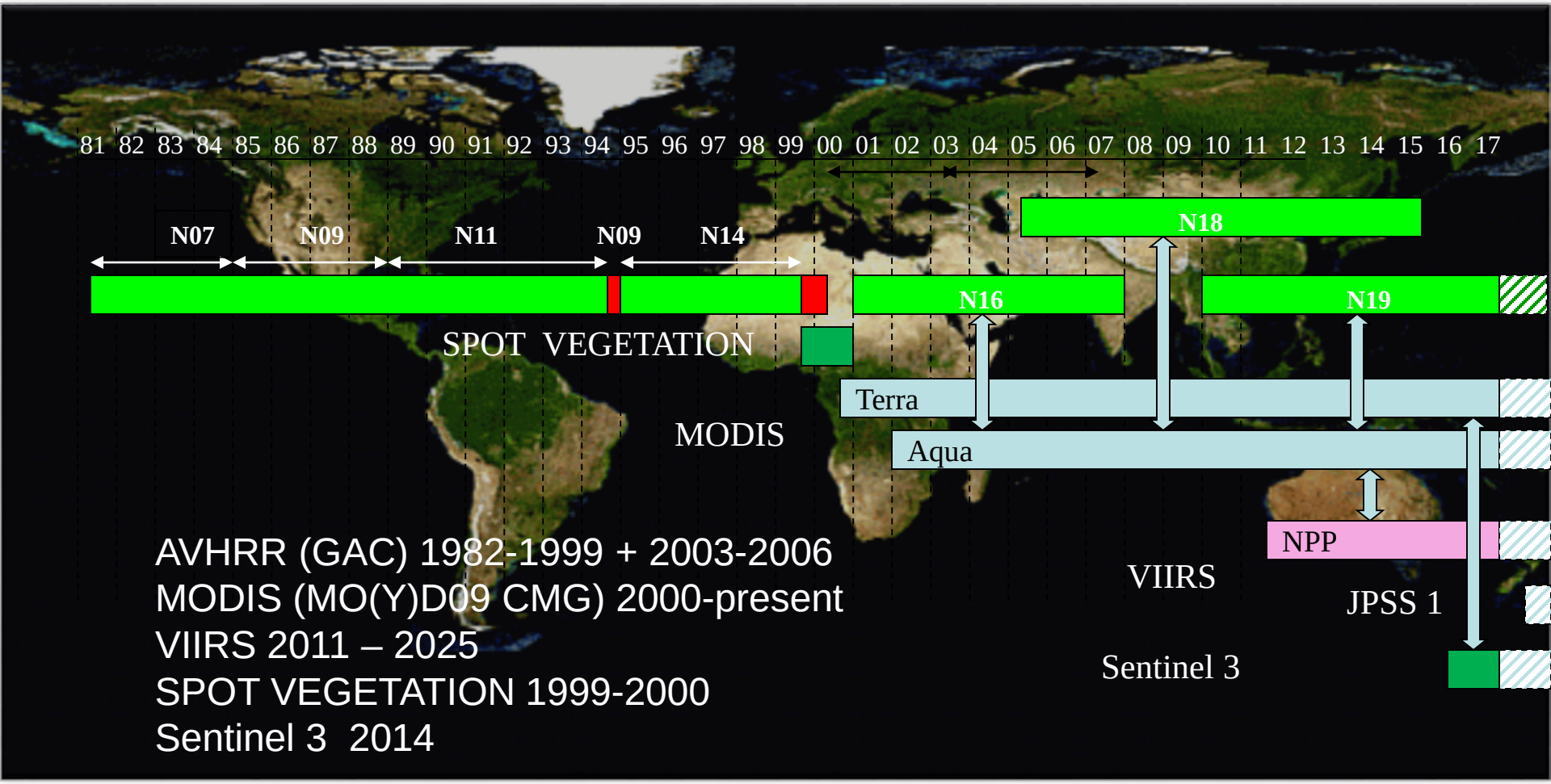
Eric Vermote
NASA GSFC Code 619
eric.f.vermote@nasa.gov

Ivan Csiszar
STAR

Mike Wilson
STAR ASSIST

A Land Climate Data Record

Multi instrument/Multi sensor Science Quality Data Records used to quantify trends and changes



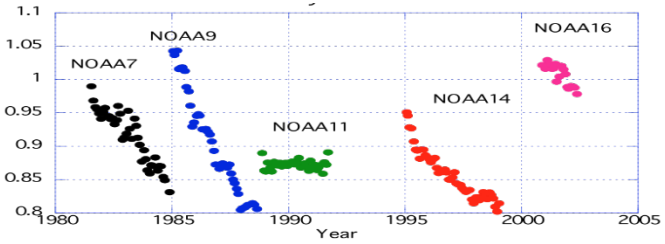
Emphasis on data consistency – characterization rather than degrading/smoothing the data

Land Climate Data Record (Approach)

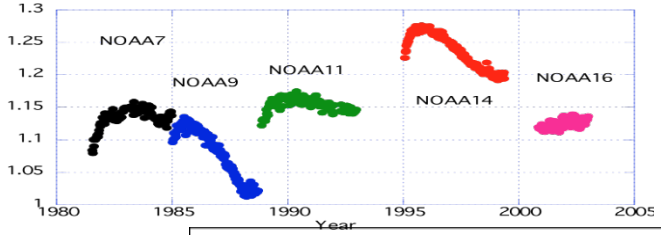
Needs to address geolocation,calibration, atmospheric/BRDF correction issues

CALIBRATION

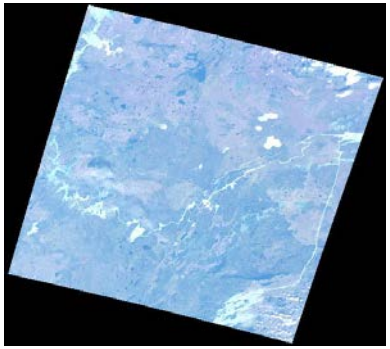
Degradation in channel 1
(from Ocean observations)

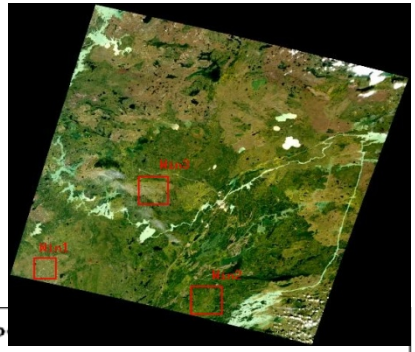


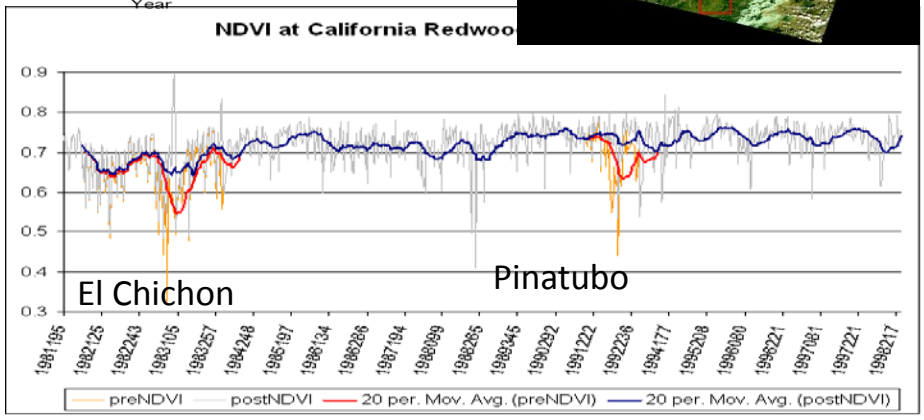
Channel1/Channel2 ratio
(from Clouds observations)



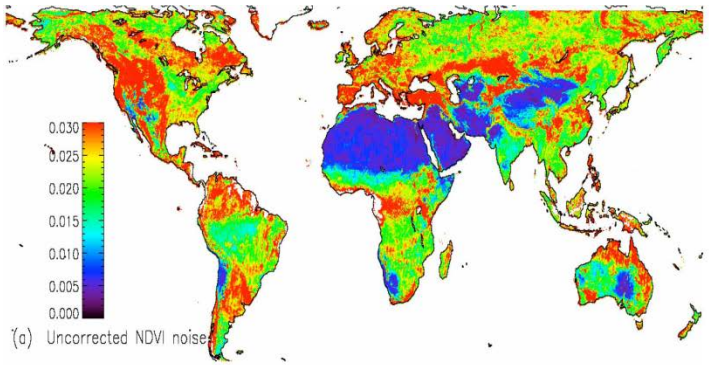
ATMOSPHERIC CORRECTION

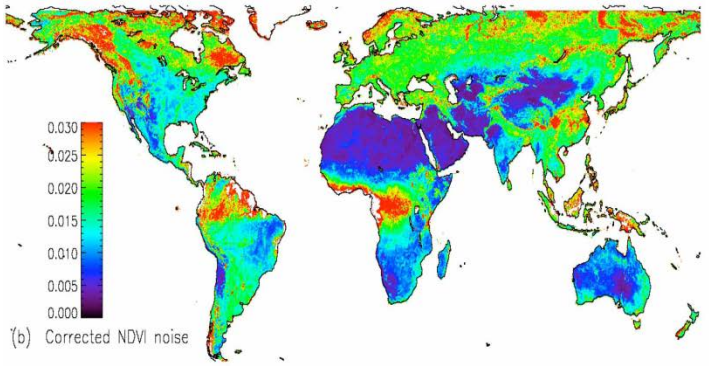


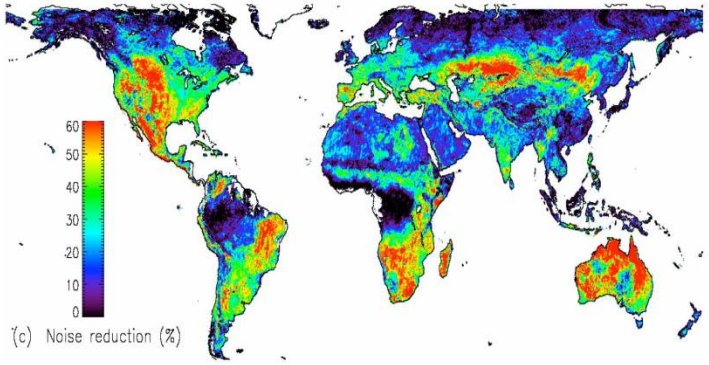




BRDF CORRECTION







Generic Surface Reflectance Algorithm for VIIRS, MODIS Landsat 8…

The surface reflectance algorithm relies on:

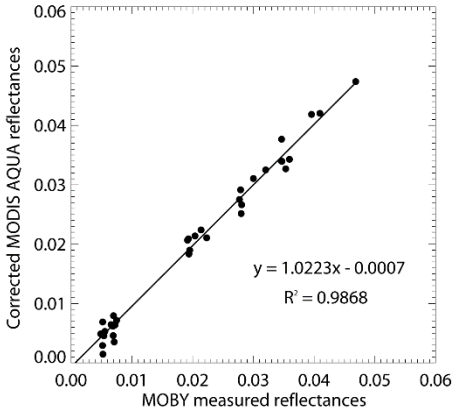
- the use of very accurate (better than 1%) vector radiative transfer modeling of the coupled atmosphere-surface system
- the inversion of key atmospheric parameters (aerosol, water vapor)

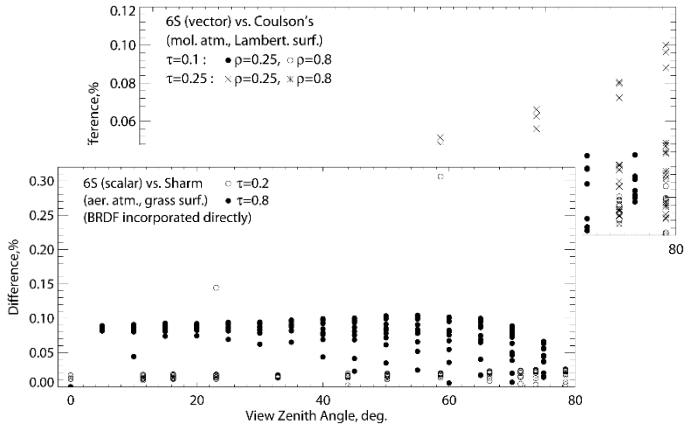
Home page: http://modis-sr.ltdri.org

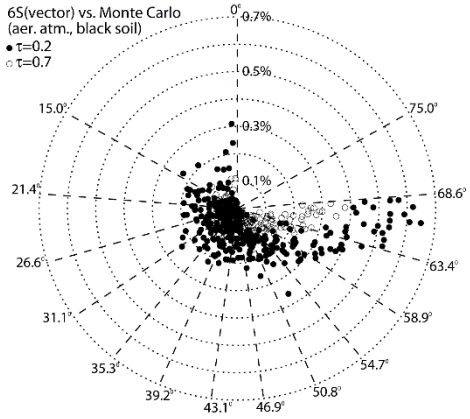
6SV Validation Effort

The complete 6SV validation effort is summarized in three manuscripts:

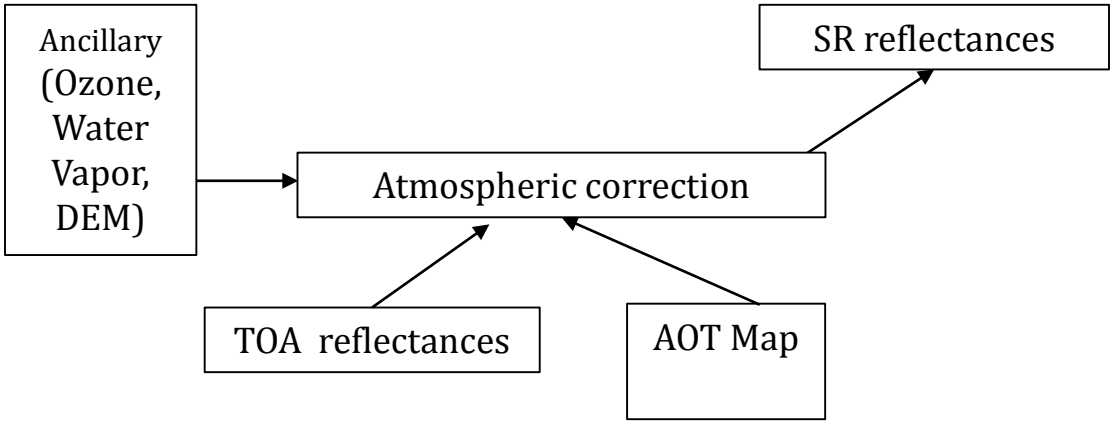
- Kotchenova, S. Y., Vermote, E. F., Matarrese, R., & Klemm Jr, F. J. (2006). Validation of a vector version of the 6S radiative transfer code for atmospheric correction of satellite data. Part I: Path radiance. *Applied Optics*, *45*(26), 6762-6774.
- Kotchenova, S. Y., & Vermote, E. F. (2007). Validation of a vector version of the 6S radiative transfer code for atmospheric correction of satellite data. Part II. Homogeneous Lambertian and anisotropic surfaces. *Applied Optics*, *46*(20), 4455-4464.
- Kotchenova, S. Y., Vermote, E. F., Levy, R., & Lyapustin, A. (2008). Radiative transfer codes for atmospheric correction and aerosol retrieval: intercomparison study. *Applied Optics*, *47*(13), 2215-2226.







Generic flowchart for atmospheric correction



Aerosol inversion

Reading **Inputs, LUT** and **Ancillary data**

ρ_{surf} determined (*) using ρ_{atm}, T_{atm} and S_{atm} **from LUT** assuming AOT, Aerosol model and knowing pressure, altitude, water vapor, ozone…

Using the relationship between the blue surface reflectance (490 nm) and the red surface reflectance (665 nm) known from MODIS, we are able to retrieve the **AOT.**

We loop the AOT until $(\rho_{surf}$ blue / ρ_{surf} red$)_{MSI}$ = $(\rho_{surf}$ blue / ρ_{surf} red$)_{MODIS}$

Aerosol Opt. Thick. and **Aerosol model** for each pixel

The retrieved AOT is used to compute the surface reflectance at 443 and 2190 nm. The **aerosol model** is then derived by minimizing the residual.

$$residual = \frac{\sum_{i=1}^{2}\left(\rho_{surf}^{i} - Ratio_{665}^{i} * \rho_{surf}^{665}\right)}{2}$$

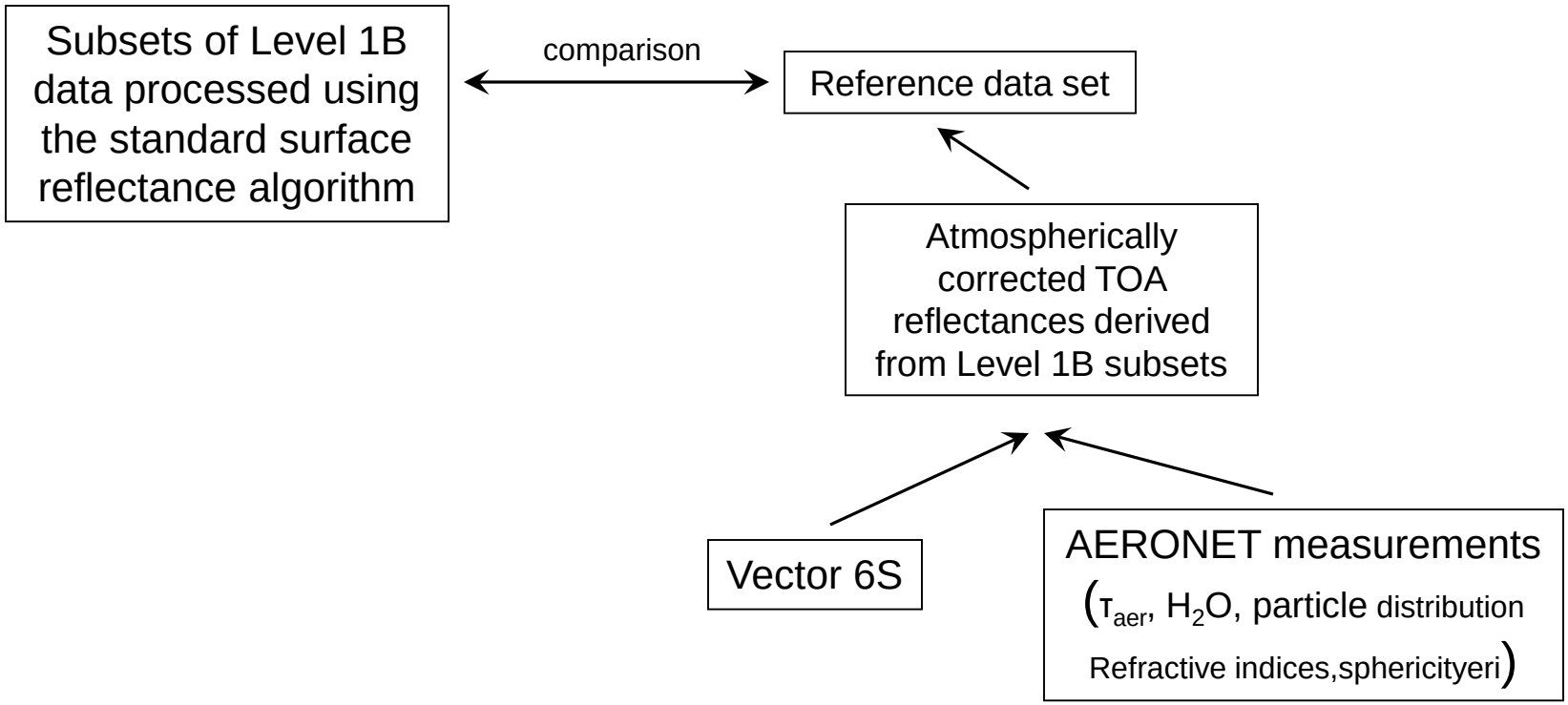
Surface reflectance for each pixel and each band

Computation of **surface reflectances** for all channels

ρ_{surf} determined (*) using ρ_{atm}, T_{atm} and S_{atm} **from LUT** knowing AOT, Aerosol model, pressure, altitude, water vapor, ozone…

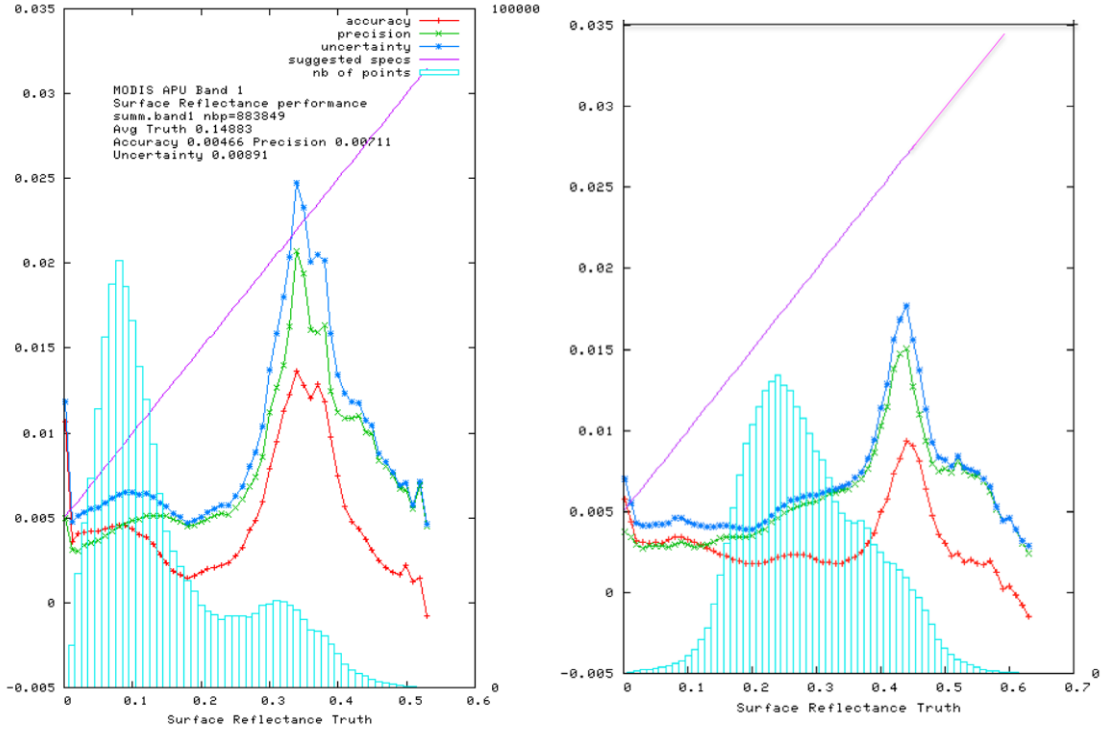
$$(*)\quad \rho_{surf} = \frac{Y}{1 + S_{atm}.Y} \quad \text{with} \quad Y = \frac{1}{T_{atm}.tg^{wv}}\left[\left(\frac{\rho_{TOA}}{tg^{O3}.tg^{others}} - \right) - \left(\rho_{atm} - \rho_{ray}\right).tg^{wv/2} - \rho_{ray}\right]$$

Methodology for evaluating the performance of surface reflectance



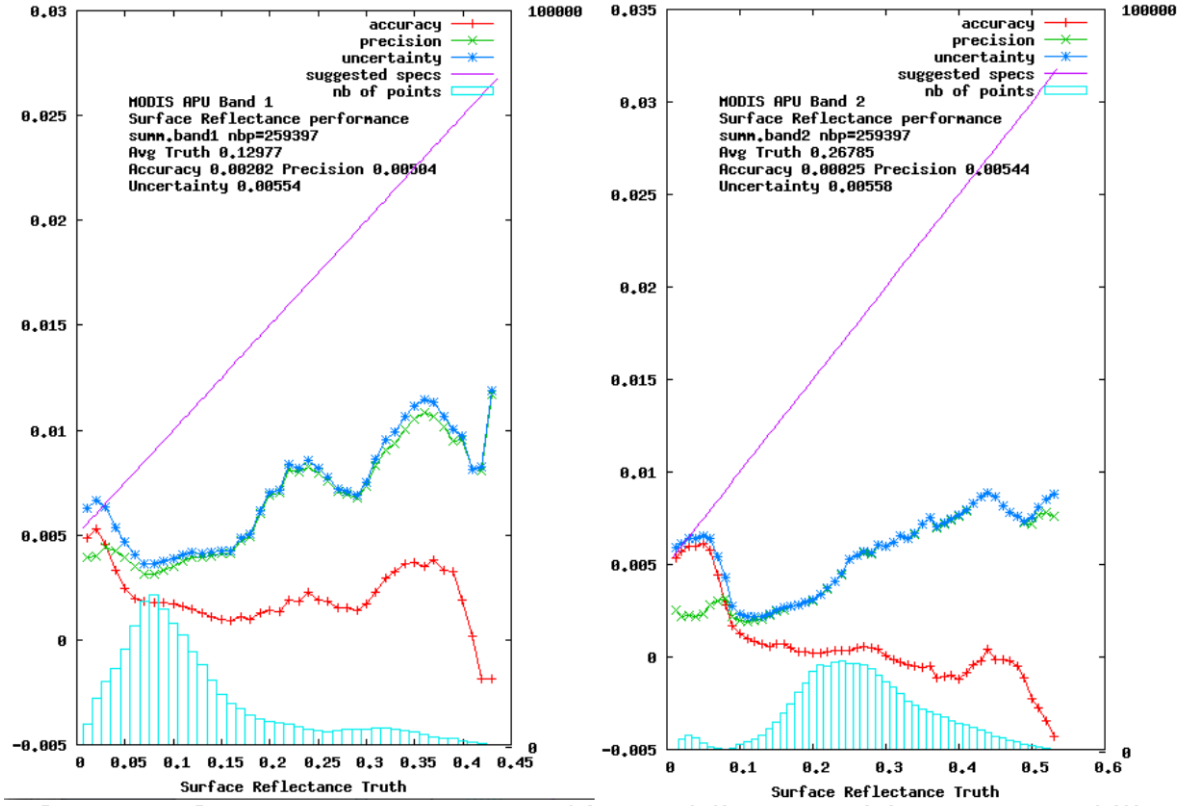
http://mod09val.ltdri.org/cgi-bin/mod09_c005_public_allsites_onecollection.cgi

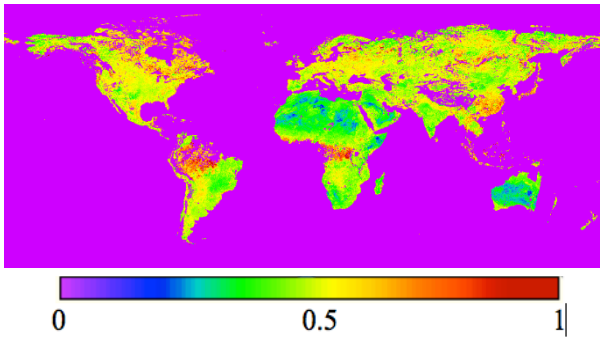
quantitative assessment of performances (APU)



COLLECTION 5: accuracy or mean bias (red line), Precision or repeatability (green line) and Uncertainty or quadratic sum of Accuracy and Precision (blue line) of the surface reflectance in band 1 in the Red (top left), band 2 in the Near Infrared (top right also shown is the uncertainty specification (the line in magenta), that was derived from the theoretical error budget. Data collected from Terra over 200 AERONET sites from 2000 to 2009.

Improving the aerosol retrieval in collection 6 reflected in APU metrics

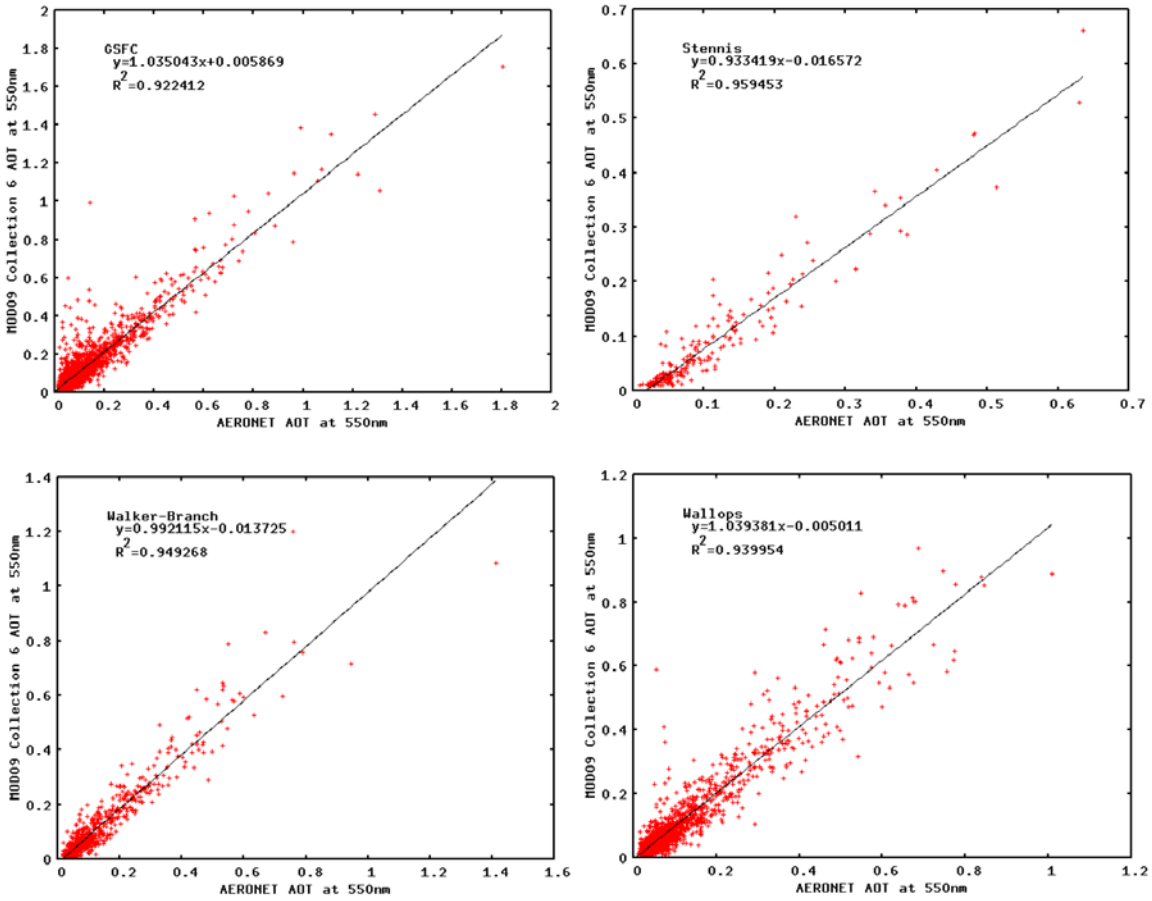




ratio band3/band1 derived using MODIS top of the atmosphere corrected with MISR aerosol optical depth

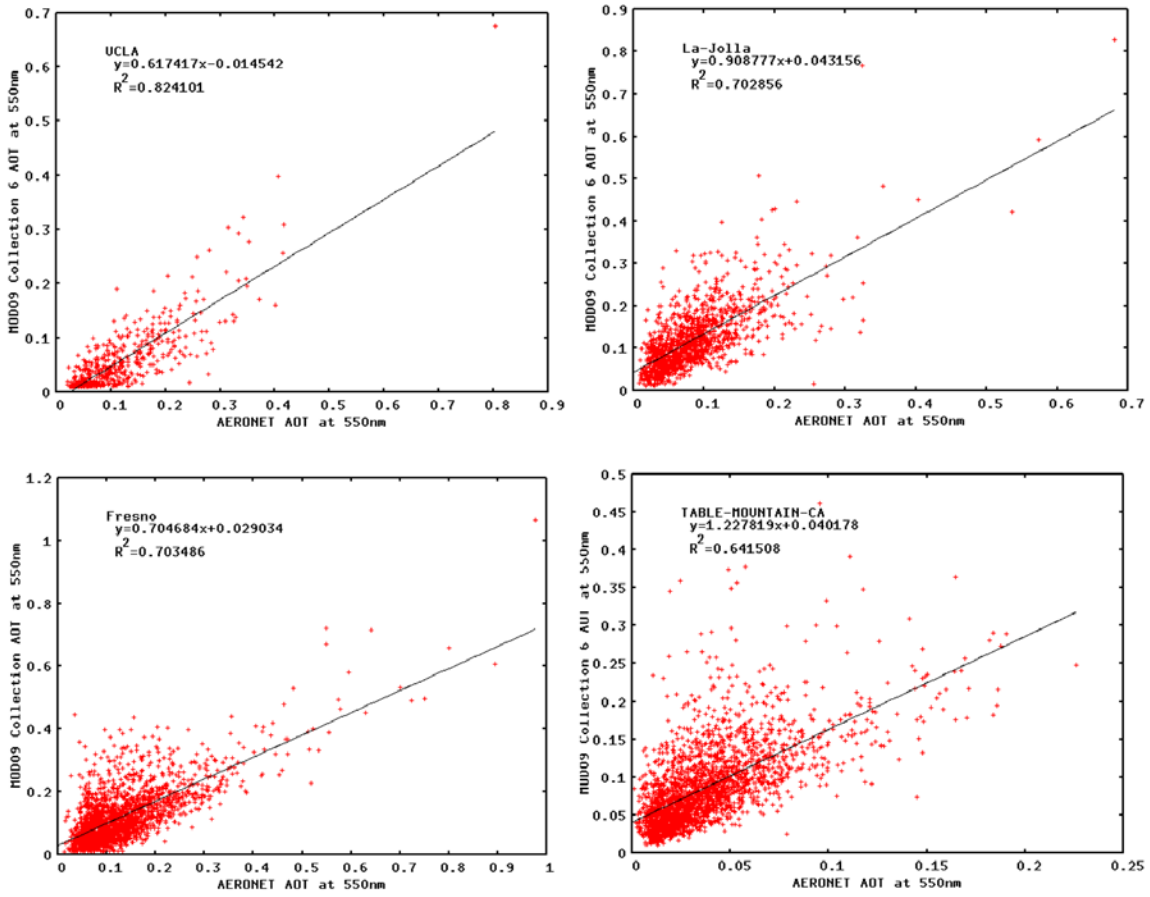
COLLECTION 6: accuracy or mean bias (red line), Precision or repeatability (green line) and Uncertainty or quadratic sum of Accuracy and Precision (blue line) of the surface reflectance in band 1 in the Red (top left), band 2 in the Near Infrared (top right also shown is the uncertainty specification (the line in magenta), that was derived from the theoretical error budget. Data collected from Terra over 200 AERONET sites from 2003.

Aerosol retrieval also shows improvement



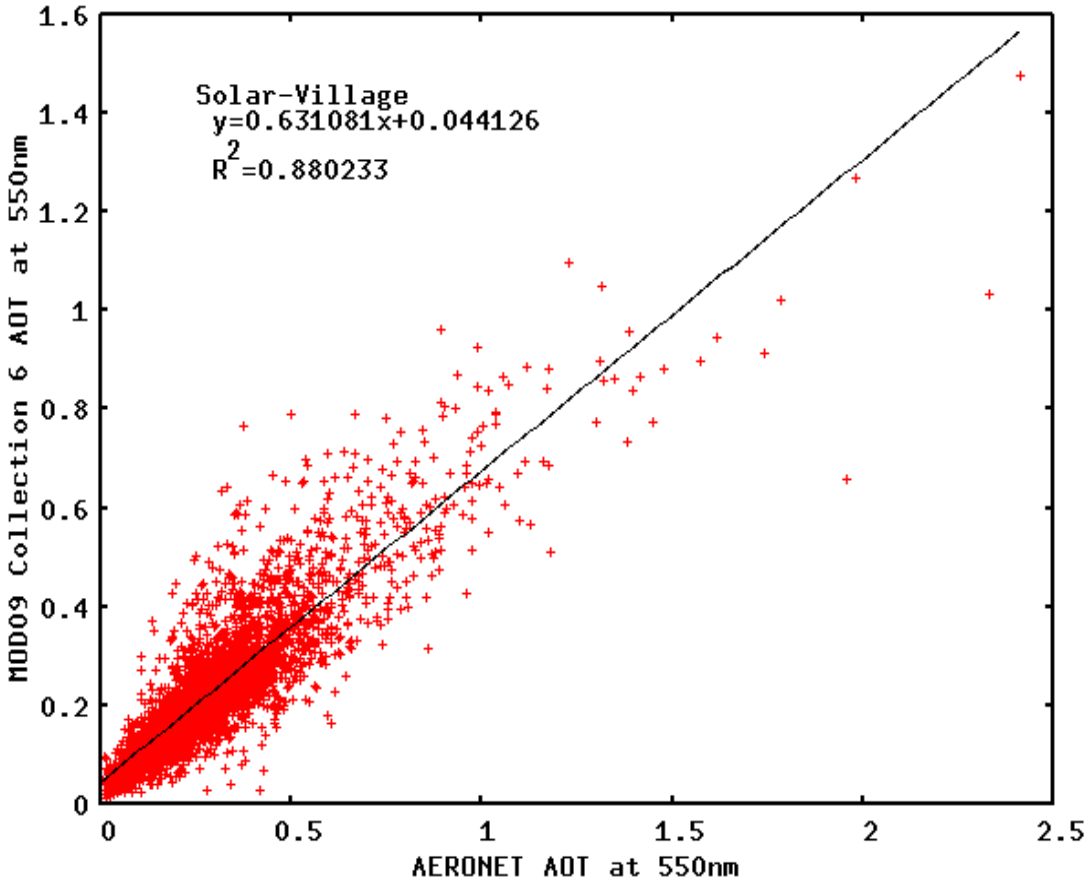
Scatterplot of the MOD09 AOT at 550nm versus the AERONET measured AOT at 550nm for East Coast sites selection: GSFC (top left), Stennis (top right), Walker Branch (bottom left) and Wallops (bottom right).

Aerosol retrieval also shows improvement



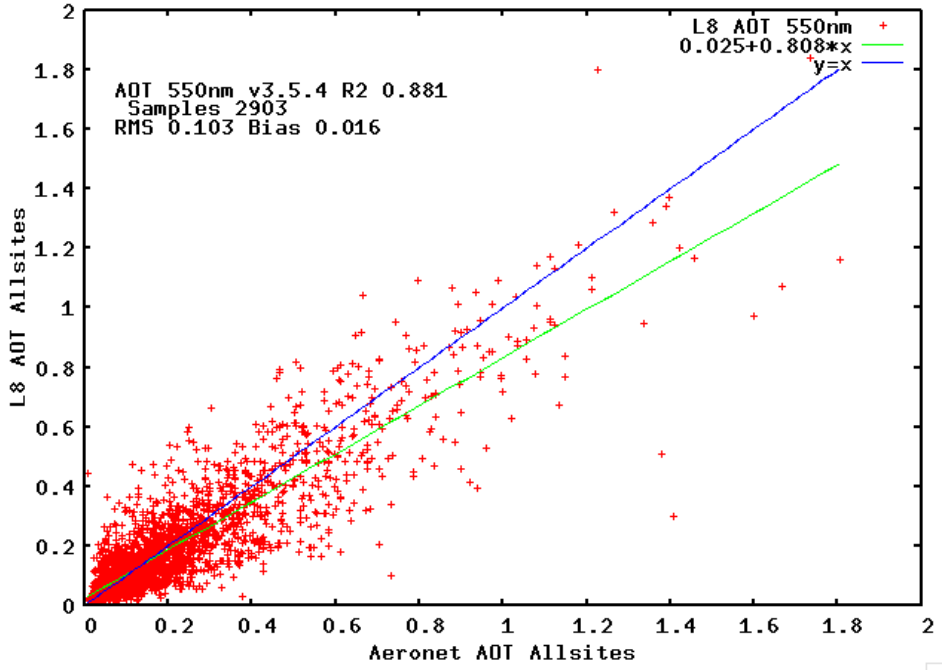
Scatterplot of the MOD09 AOT at 550nm versus the AERONET measured AOT at 550nm for the West Coast sites selection: UCLA (top left), La Jolla (top right), and Fresno (bottom left) and Table Mountain (bottom right).

Aerosol retrieval also shows improvement



Scatterplot of the MOD09 AOT at 550nm versus the AERONET measured AOT at 550nm for for a very bright site in Saudi Arabia (Solar Village)

Aerosol retrieval also shows improvement



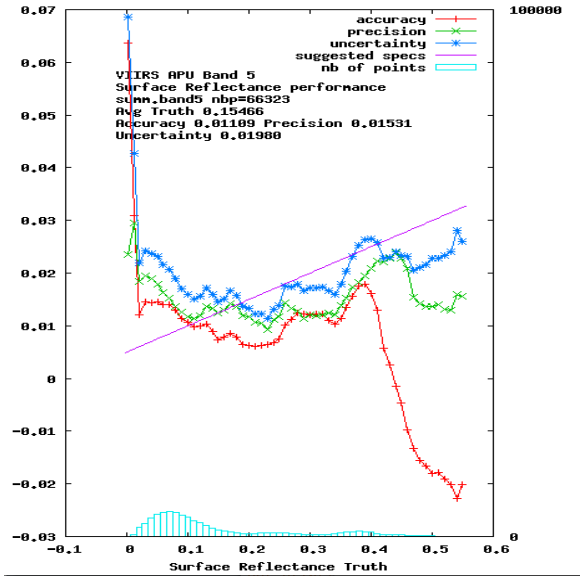
Scatterplot of the Landsat 8 AOT at 550nm versus the AERONET measured AOT at 550nm for all AERONET matchups since Landsat 8 activation

VIIRS Surface reflectance

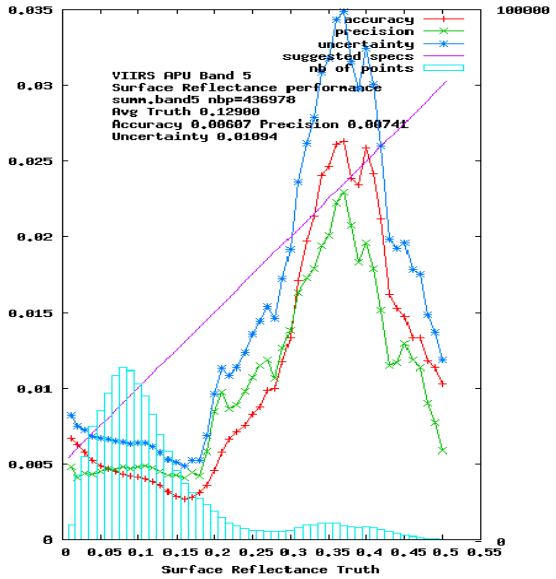
- the VIIRS SR product is directly heritage from collection 6 MODIS and that it has been validated to stage 1-2
- MODIS algorithm refinements from Collection 6 have been integrated into the VIIRS algorithm and are included in the operational product (NDE) equivalent of NASA VIIRS Version 1.

Evaluation of VIIRS SR Algorithm Performance (example Red band)

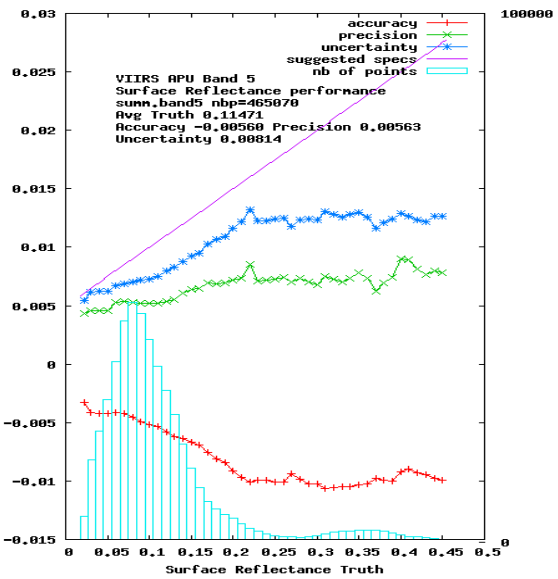
IDPS version



NASA C1.1

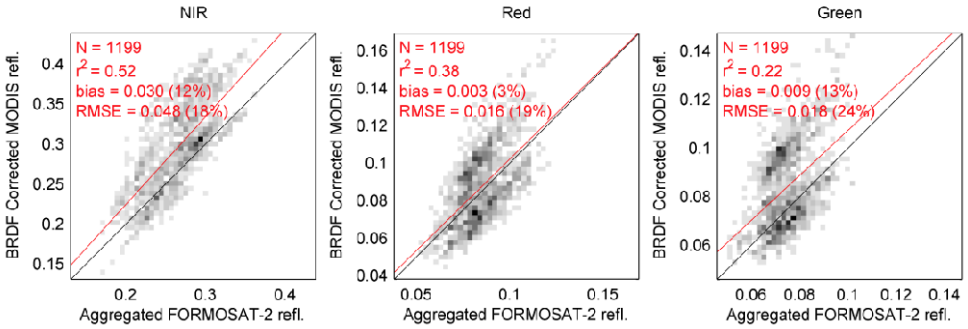


NDE, NASA Version 1

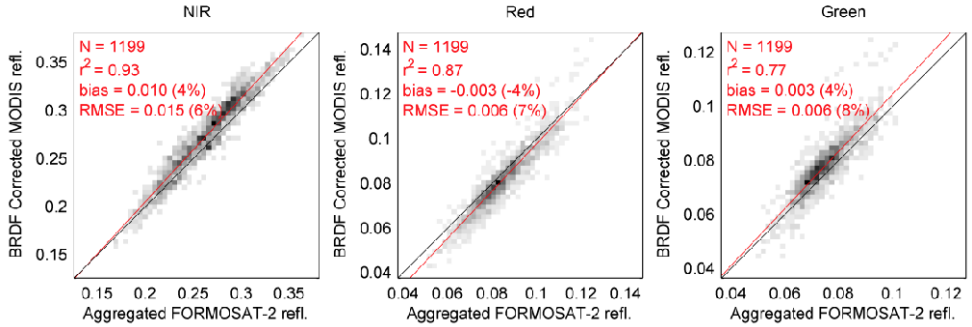


Improvement is clearly visible from IDPS to current NDE version

Use of BRDF correction for product cross-comparison



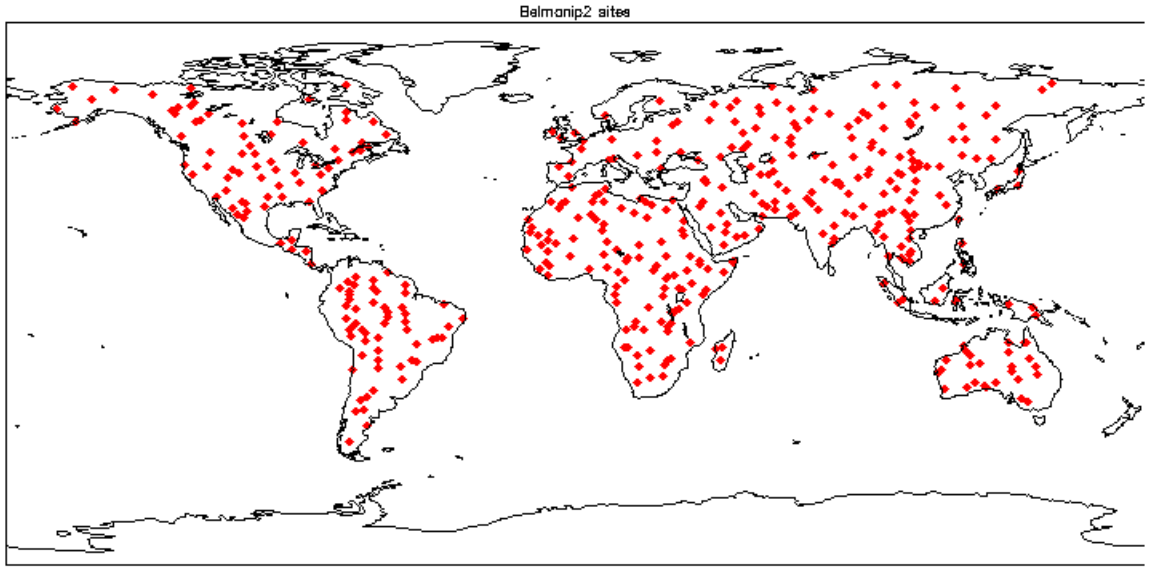
Comparison of aggregated FORMOSAT-2 reflectance and MODIS reflectance. No BRDF correction. Density function from light grey (minimum) to black (maximum); white = no data.



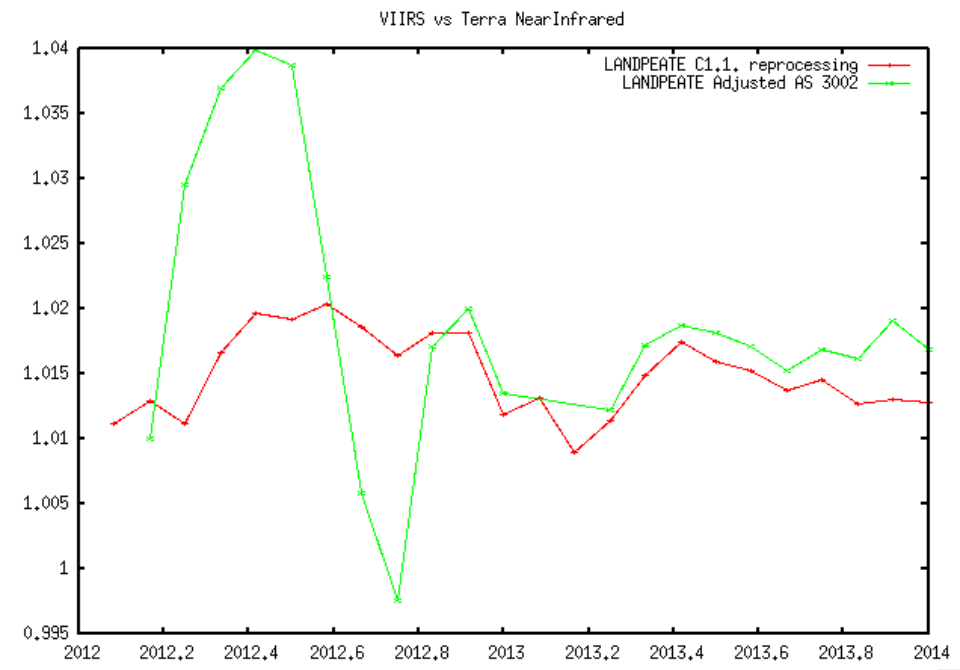
Comparison of aggregated FORMOSAT-2 reflectance and BRDF corrected MODIS reflectance. Corrections were performed with Vermote al. (2009) method using for each day of acquisition, the angular configuration of FORMOSAT-2 data.

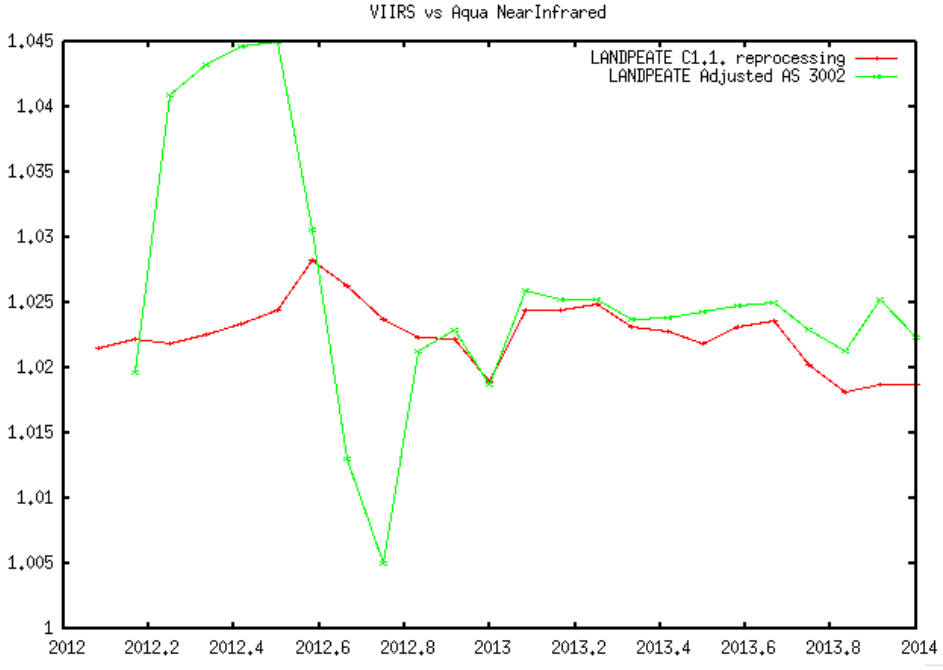
Cross comparison with MODIS over BELMANIP2

The VIIRS SR is now monitored at more than 400 sites (red losanges) through cross-comparison with MODIS.

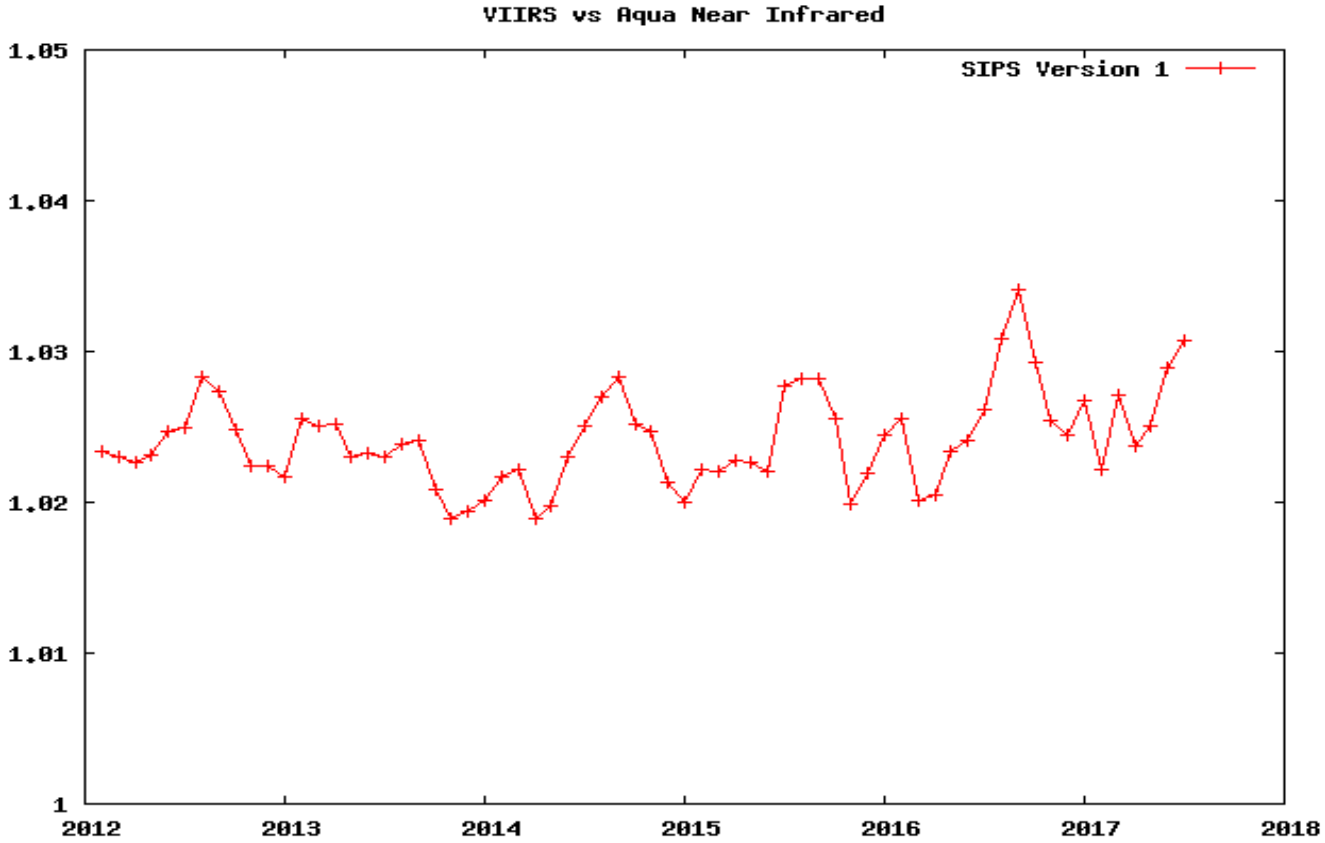


Results over BELMANIP2 (IDPS and C1.1)





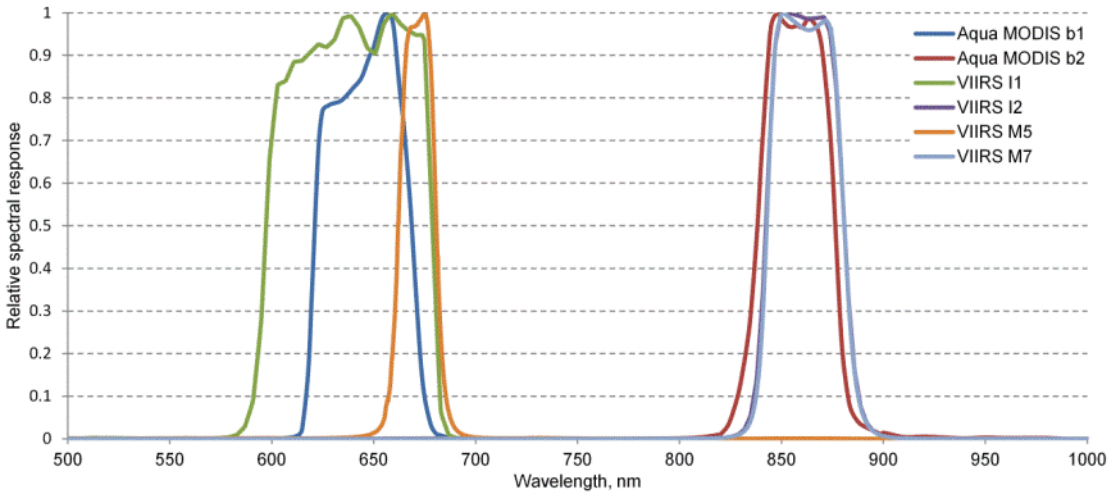
Results over BELMANIP2 (NDE/NASA Version1)



Cross comparison results of the VIIRS and MODIS-Aqua SR product on a monthly basis for the BELMANIP sites reprocessed version NDE/NASA SIPS Version 1 for the near infrared band (M7).

Transitioning from MODIS to VIIRS

- **VIIRS** was launched, in part to provide **continuity** with **MODIS**
- The **VIIRS** will eventually **replace MODIS** for both land science and applications, and add to the coarse-resolution, **long term data record**
- It is, therefore, important to provide the user community with an **assessment of the consistency** of equivalent products from the two sensors



Relative spectral response functions for MODIS/Aqua and VIIRS sensors in the red and NIR spectral domain.

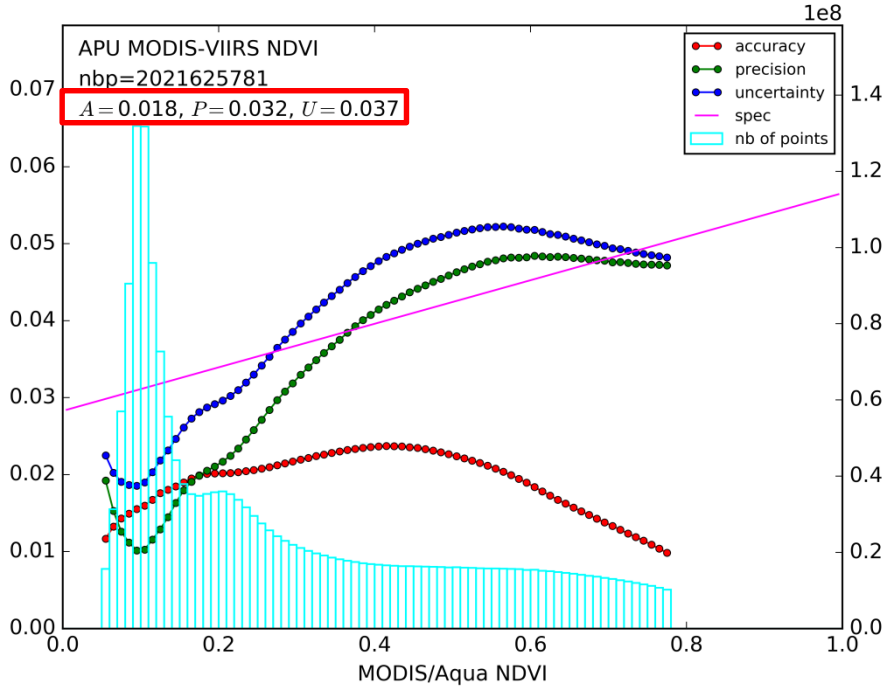
Spectral adjustment:

$$\rho^{M}_{red} = a_{red}\rho^{V}_{red} + b_{red}\rho^{V}_{NIR},$$

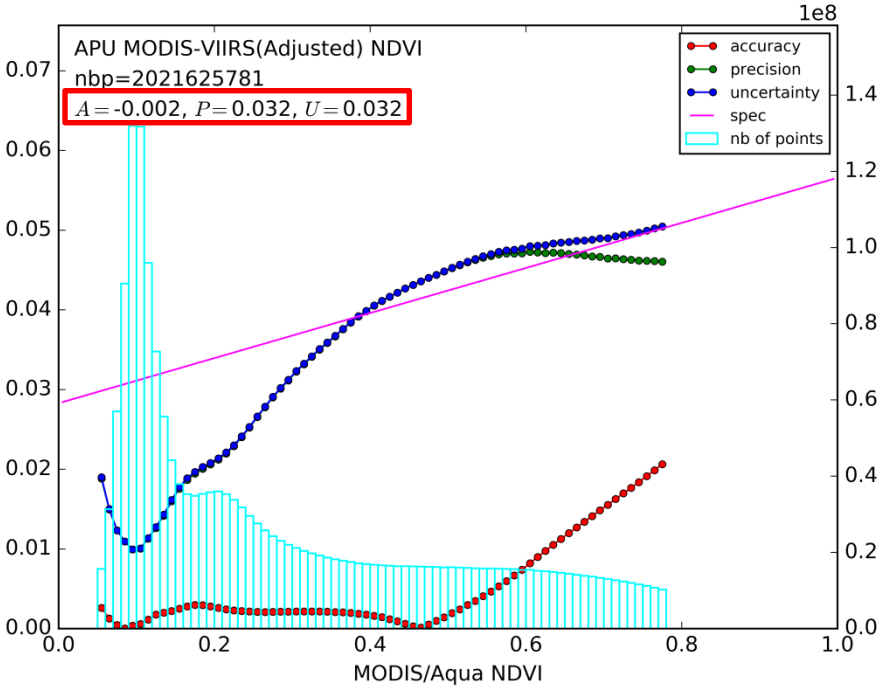
$$\rho^{M}_{NIR} = a_{NIR}\rho^{V}_{red} + b_{NIR}\rho^{V}_{NIR},$$

where ρ^{M}_{red}, ρ^{M}_{NIR}, ρ^{V}_{red}, ρ^{V}_{NIR} are surface reflectance values in red and NIR for MODIS (superscript M) and VIIRS (superscript V), and a_{red}, b_{red}, a_{NIR}, b_{NIR} are conversion coefficients

Transitioning from MODIS to VIIRS



(*a*)

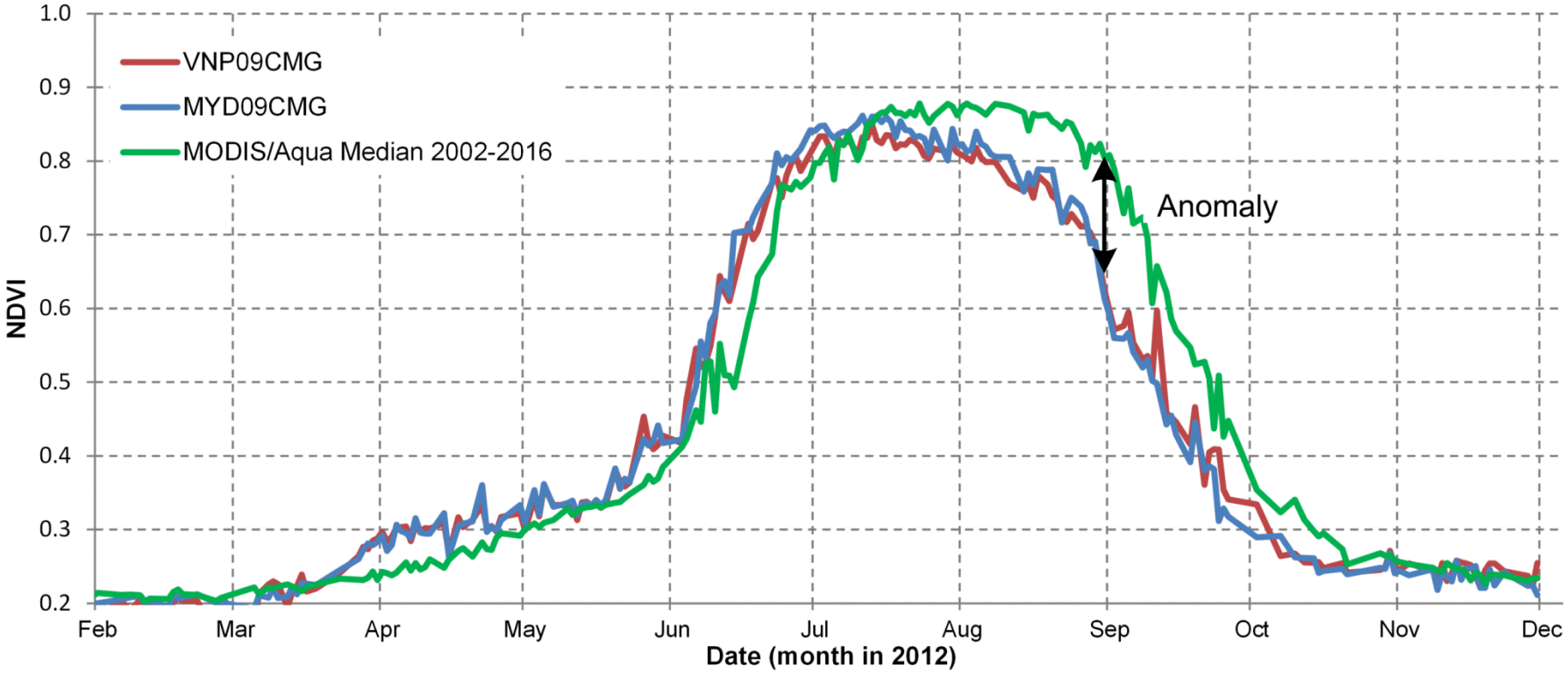


(*b*)

Comparison (in terms of APU) of NDVI's derived from MYD09CMG and VNP09CMG surface reflectance products at global scale (approximately 2×10^9 pixels) for 2012–2016 **without** (*a*) and **with** (*b*) **spectral adjustment of red and NIR bands**. The light blues bars show the number of points used in each bin of NDVI values from MODIS (used as a reference). The APU values are computed for points in each bin and being shown in red (accuracy), green (precision) and blue (uncertainty). The pink line represents the specified uncertainty based on theoretical error budget.

Transitioning from MODIS to VIIRS

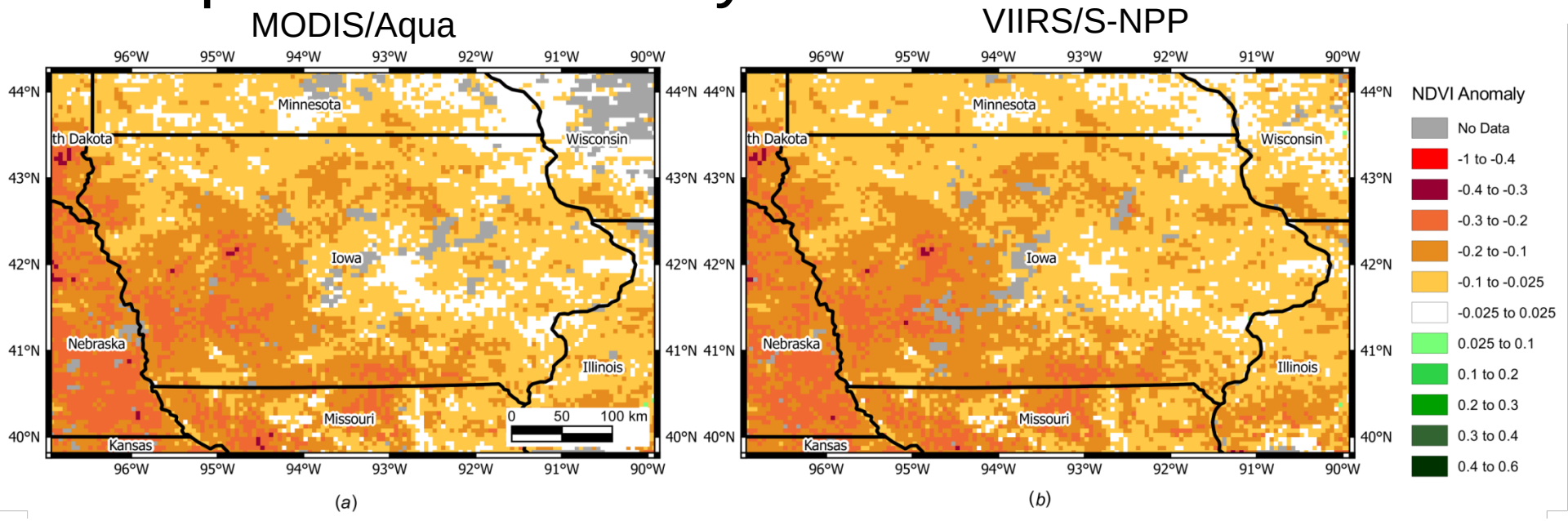
- Temporal consistency



Corn growth dynamics derived from MODIS/Aqua and VIIRS in 2012 in Iowa (US) compared to the median NDVI values for 2002–2016 derived from MODIS/Aqua. Due to a drought, corn growth started to decrease significantly from June which resulted in a 25% yield reduction.

Transitioning from MODIS to VIIRS

- Spatial consistency



NDVI anomalies at 0.05° spatial resolution for the state of Iowa (US) derived from **MODIS/Aqua** (*a*), and **adjusted VIIRS** (*b*) data on August 21, 2012. Anomalies were computed by subtracting NDVI values from the median NDVI values for 2002–2016 derived from MODIS/Aqua.

Surface Reflectance Conversion from IDPS to NDE

- The main issues in the conversion of the surface reflectance code from the IDPS system to NDE were as follows:

1) The code was designed to read and write in HDF-EOS format. NDE does not support HDF-EOS, so NASA developers added HDF-5 capability.

2) The code requires the VIIRS Cloud Mask, Aerosol Optical Depth product, total precipitable water, total column ozone, and surface pressure in order to run. The algorithms that produce these are different in the NDE system. NOAA-STAR developers wrote codes to convert the NDE products into a format that mimics the IDPS version for compatibility.

3) The naming convention of the files is different between NDE and IDPS, so NOAA-STAR developers wrote scripts to design unique file names.

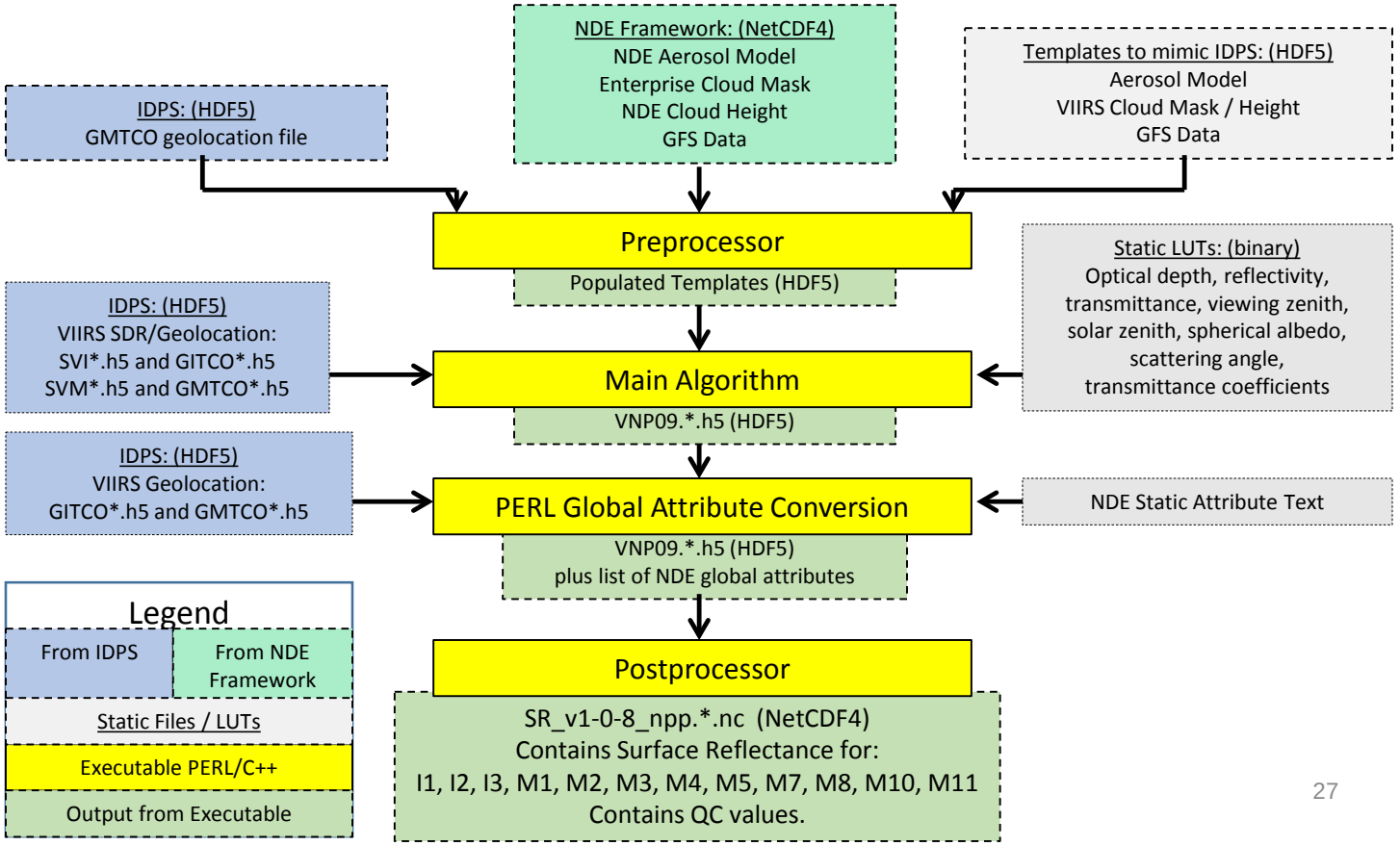
4) Global attributes are different between NDE and IDPS, so NOAA-STAR developers wrote scripts to create both static and dynamic global attributes.

NOAA-STAR Contribution

- NASA provided the main algorithm, while NOAA-STAR provided ancillary codes and scripts to allow the system to run at NDE. These codes/scripts include:
  - Preprocessor: converts the NDE versions of cloud mask, cloud height (which includes the cloud shadow mask), aerosol optical depth, and GFS (which contains surface pressure, total precipitable water, and total column ozone) into HDF-5 files that resemble the IDPS versions of these masks.
  - PERL Global Attribute Conversion: creates both static and dynamic global attributes to append to the final NDE output file.
  - Postprocessor: names the final output file, writes the output, appends the global attributes and designs variable attributes.

- A flow chart of these algorithms follows on the next slide.

Surface Reflectance Algorithm Overview



Known Differences in Surface Reflectance

- Slight variations occur for surface pressure, total column ozone, and total precipitable water, due to upstream algorithm differences.
- Slight variations occur for aerosol optical depth due to upstream algorithm differences.
- Larger variations occur in the cloud mask because of large algorithm differences. Impacts are:
  - The NDE cloud mask does not provide a quality (high, medium, poor, etc.), which impacts the surface reflectance retrieval itself.
  - Quality Flags are impacted by differences in sun glint, snow categorization, and the lack of a thin cirrus flag or a cloud adjacency flag. This affects downstream products.

Conclusions

- Surface reflectance (SR) algorithm is mature and pathway toward validation and automated QA is clearly identified.
- Algorithm is generic and tied to documented validated radiative transfer code so the accuracy is traceable enabling error budget.
- The use of BRDF correction enables easy cross-comparison of different sensors (MODIS,VIIRS,AVHRR, LDCM, Landsat, Sentinel 2 ,Sentinel 3…)
- AERONET is central to SR validation and a “standard” protocol for its use is being defined (CEOS CVWG initiative)

NDE Vegetation Product System (NVPS): Vegetation Indices (VI) and Green Vegetation Fraction (GVF)

Ivan Csiszar, Mingshi Chen, Min Li,
Zhangyan Zhang, Marco Vargas

Project Background

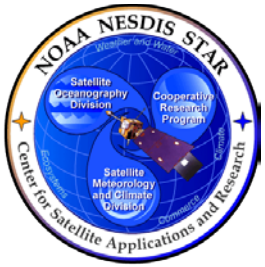
- The GVF system is currently running in NDE and the product suite includes:
  - The Green Vegetation Fraction Global Product
  - The Green Vegetation Fraction Regional Product

- Top of Atmosphere Normalized Difference Vegetation Index (TOA NDVI), Top of Canopy Normalized Difference Vegetation Index (TOC NDVI), and Top of Canopy Enhanced Vegetation Index (TOC EVI) are currently running in IDPS.
  - The VIIRS Vegetation Index Validated Stage 1 Science Maturity Review took place on September 4, 2014. Documentation is available on the STAR/JPSS website: https://www.star.nesdis.noaa.gov/jpss/documents/AMM_All/Land_VI/Validated/VIIRSVIStage1MaturityPresentationtoSTAR.pdf
  - The NDE Vegetation Product Suite Critical Design Review took place on September 29, 2016. Documentation is available on google drive: https://drive.google.com/open?id=0B-kRoSoyMpuAb3JyXzZFUjJUTmc

Project Objectives

- The VIIRS Vegetation Index products will be incorporateded into the GVF system. These include:
  - NDVI at TOA for continuity with AVHRR
  - NDVI at TOC for continuity with MODIS
  - EVI at TOC for continuity with MODIS

NDE Vegetation Products Stakeholders



- Customers/Users
  - NCEP/EMC
  - STAR
  - CLASS
  - USDA
  - USGS
  - NWS/WFO/Spokane WA
  - University of Hawaii at Manoa
  - NASA SPoRT
  - NOAA ESRL

Vegetation Index (VI) External Inputs

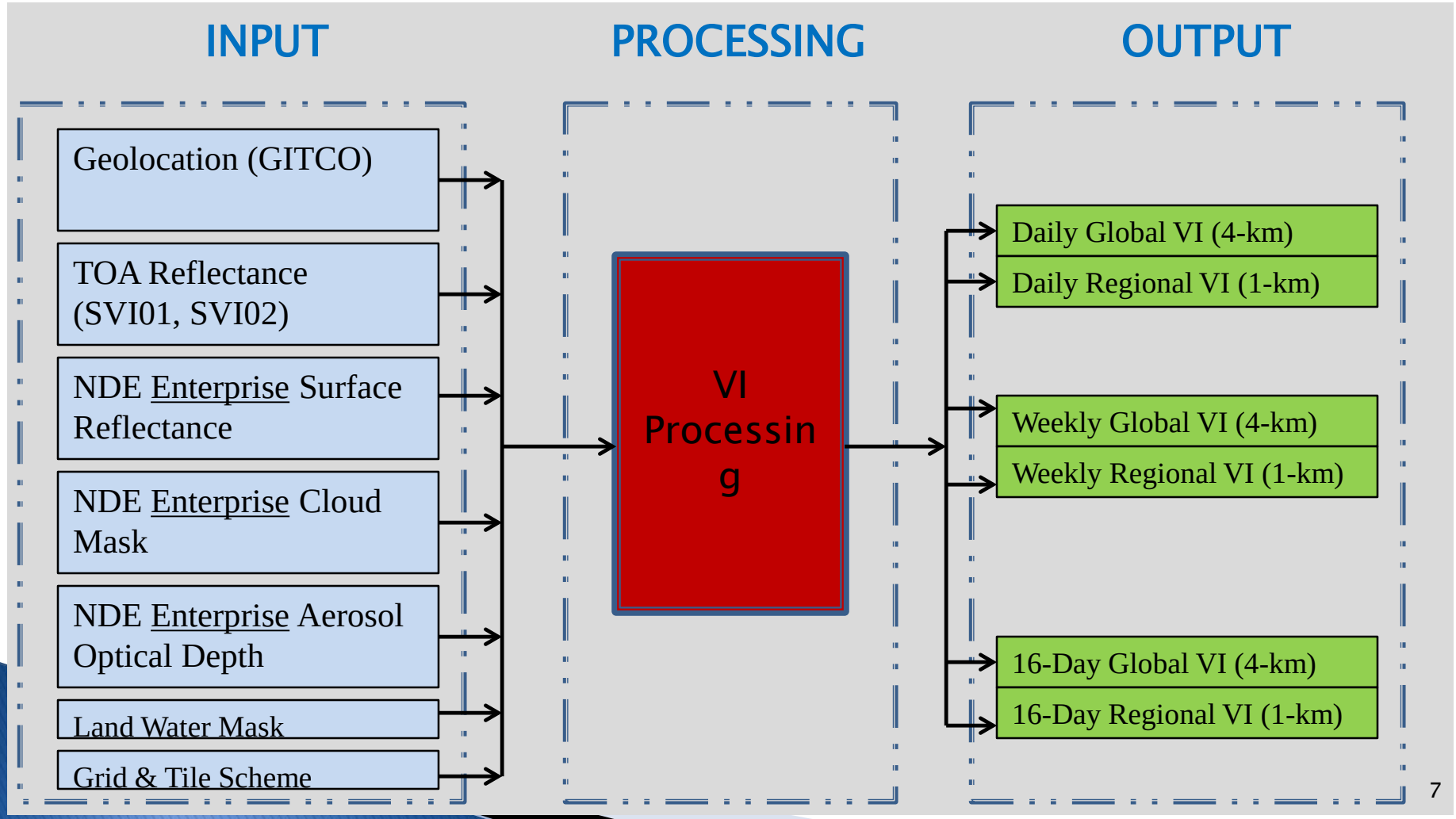
Item	Type	Source	Description
Geolocation (GITCO)	Input	IDPS	VIIRS Terrain Corrected Geolocation and geometry (imagery resolution)
TOA Reflectance (SVI01, SVI02)	Input	IDPS	IDPS VIIRS I1 and I2 SDR bands at imagery solution
Aerosol Optical Depth	Input	NDE EAOT	NDE VIIRS Enterprise aerosol optical depth product (EAOT) at moderate resolution
Cloud Mask	Input	NDE ECM	NDE VIIRS Enterprise Cloud Mask (ECM) at moderate resolution
Surface Reflectance	Input	NDE ESR	NDE VIIRS Enterprise Surface reflectance (ESR) I1, I2 and M3 bands (granule files)
Land Water Mask	Input	Ancillary	Derived from MODIS global water mask (MOD44W) by projecting to the VIIRS GVF grid (used by the operational NDE VIIRS GVF)
Grid and Tile Scheme	Input	Ancillary	The origin and spatial resolution and partition of the VI coordinate system (used by the operational NDE VIIRS GVF)

Outputs

Sample Filename	Data from Filename
VI-GLB*.nc (Global) VI-REG*.nc (Regional) • Daily • 7-Day (Weekly) • 16-Day (Bi-Weekly)	-TOA NDVI -TOC NDVI -TOC EVI -Reflectance I1 -Reflectance I2 -Surface Reflectance I1 -Surface Reflectance I2 -Surface Reflectance M3 -Solar Zenith Angle -Viewing Zenith Angle -Relative Azimuth Angle -Quality Flags: QF1, QF2, QF3, QF4

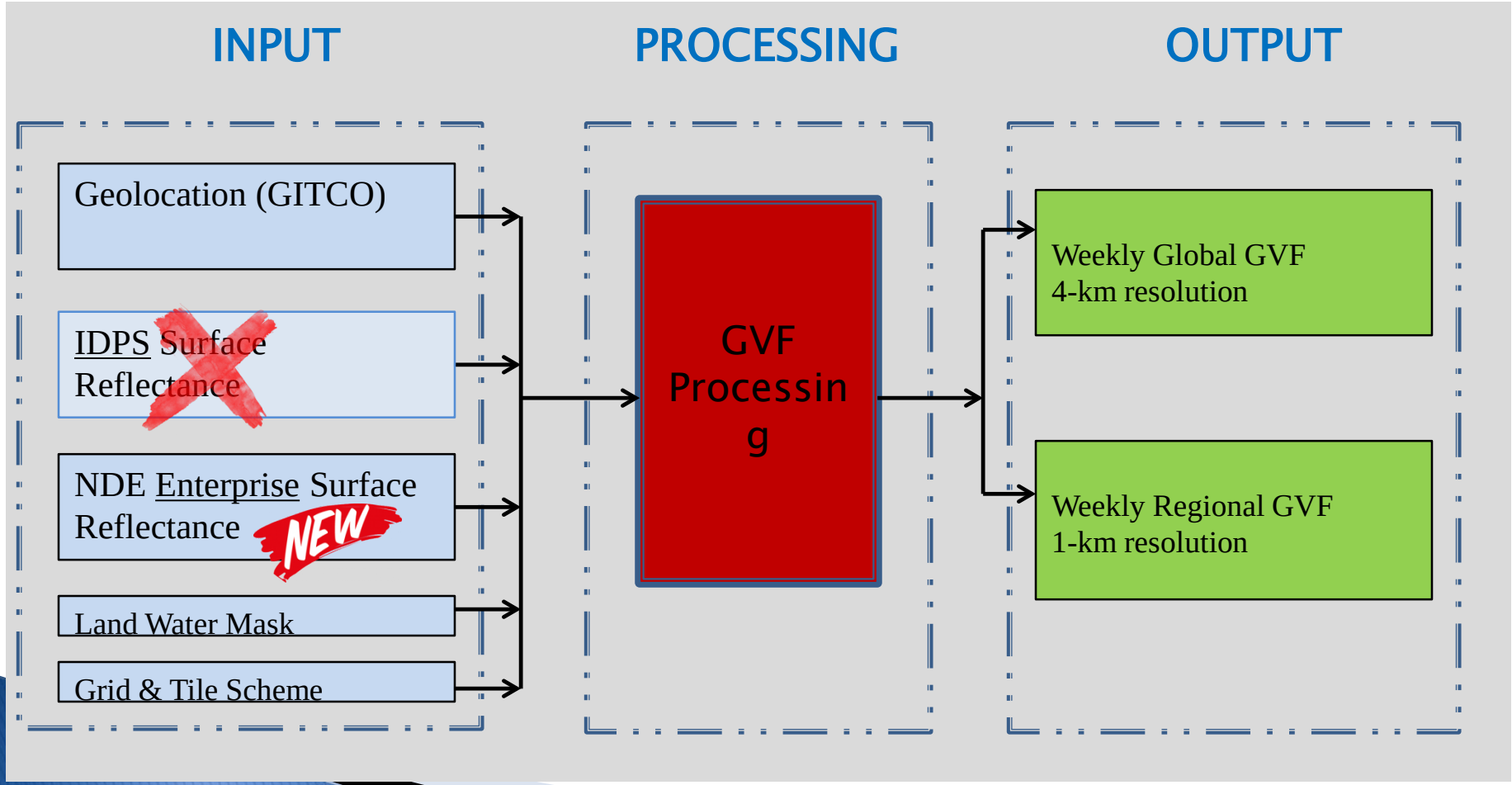
VI Context-Layer

- The Context Layer is the highest level of the software architecture. It describes the flows between the system and its external interfaces

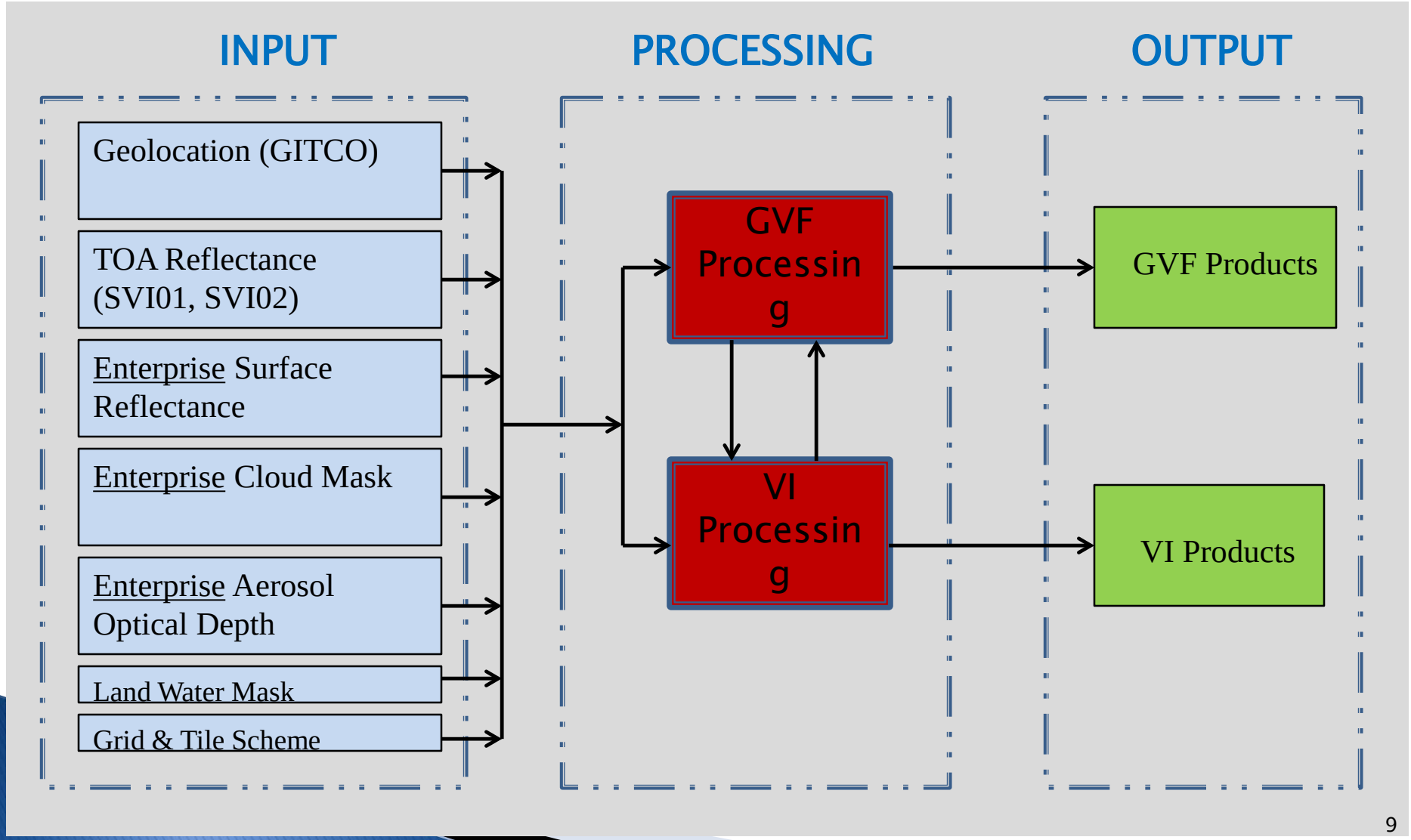


GVF Context–Layer Changes to the GVF system

- IDPS Surface Reflectance is replaced by the NDE Enterprise Surface Reflectance



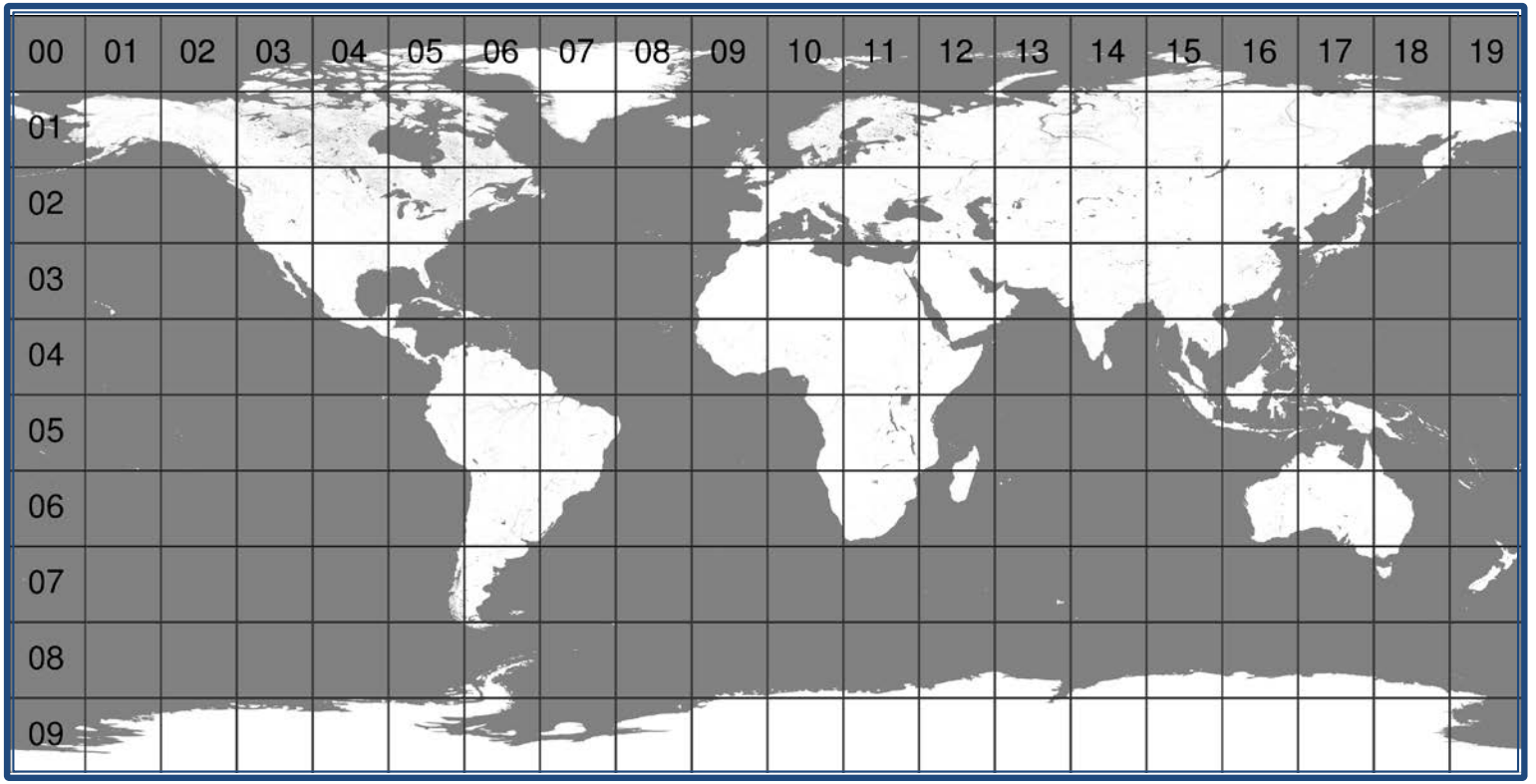
NVPS Context-Layer



The VI Global Grid and Tile Scheme (1/2)

- The VI grid system is divided into square tiles to facilitate parallel computing spatially and therefore faster processing
- The VI grid is a set of tiles that are 18 degrees square
- 200 tiles (20 tiles horizontally and 10 tiles vertically) are needed to cover the entire globe
- Each 18°x 18° tile has 6000 x 6000 grid cells (0.003° pixels)
- The grid provides global coverage in Geographic Lat/Lon projection at a resolution of 0.003°

The VI Global Grid and Tile Scheme (2/2)

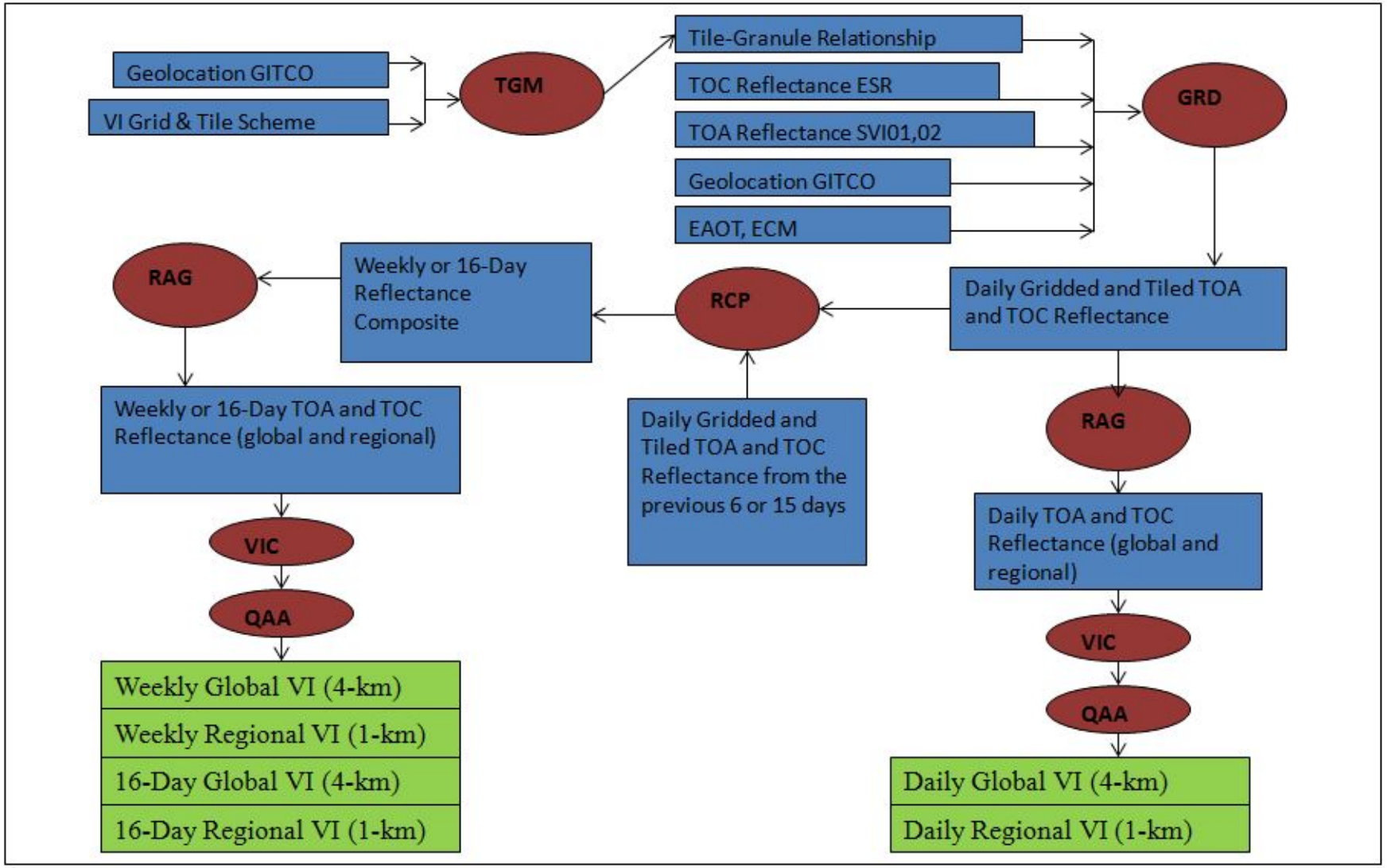


The upper-left corner of the tile map is 180° W, 90°N. Each tile is 18° x 18°, with 6000 x 6000 grid cells (0.003° pixels). Only those tiles that contain land but are not in the Antarctic Region are processed (There are 122 non-fill tiles)

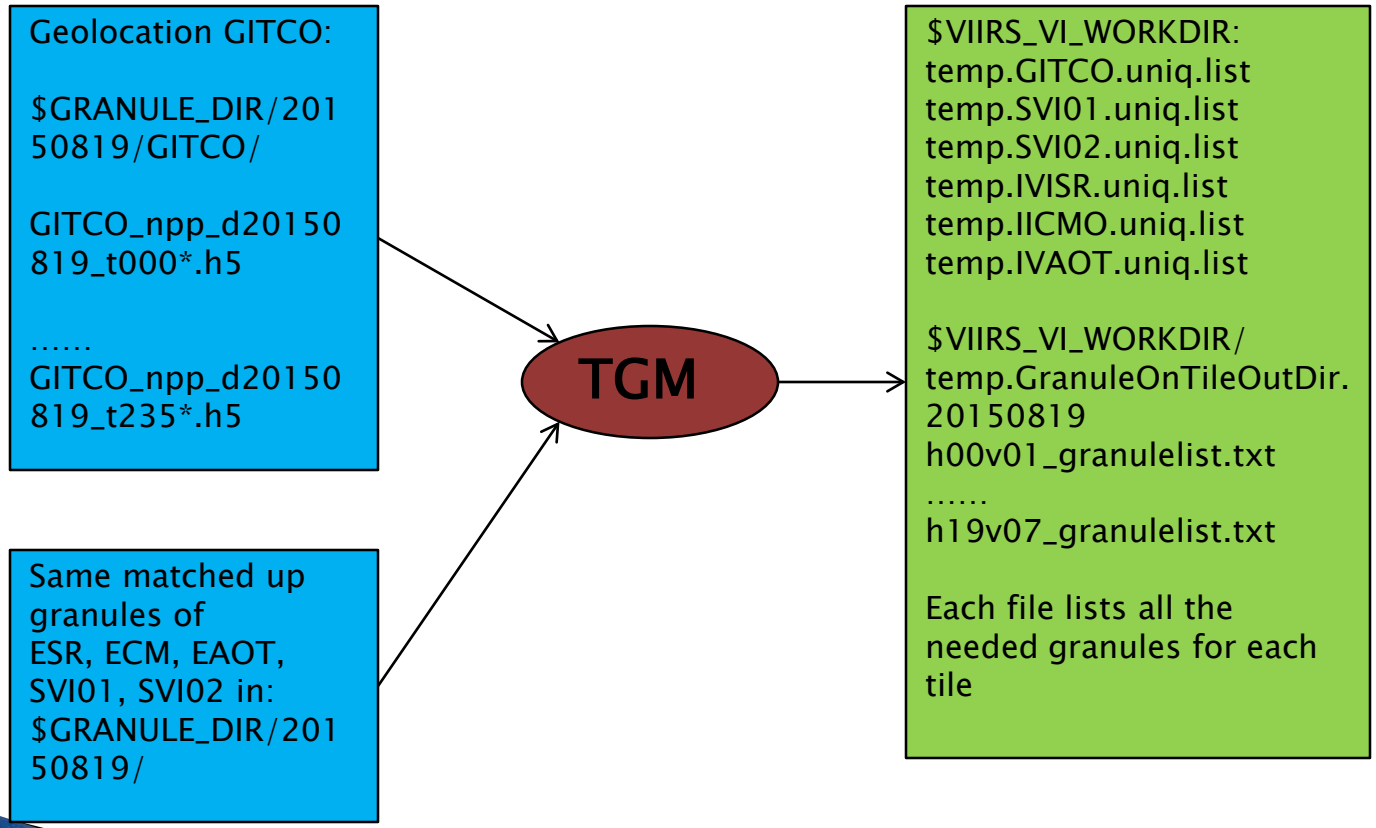
Units of VI Algorithm:

- TGM: Tile Granule Mapper
- GRD: Reflectance Gridder
- RCP: Reflectance Compositor
- RAG: Reflectance Aggregator
- VIC: Vegetation Index Calculator
- QAA: Quality Assurance Assigner

Vegetation Index System–Layer Data Flows



Tile-Granule Mapper (TGM) Unit



Reflectance Gridder (GRD) Unit

All Input Granules:

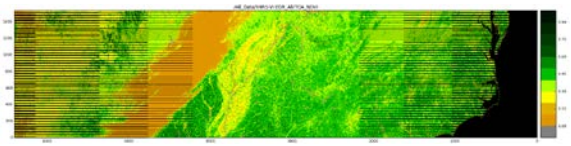
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GITCO/
ESR
EAOT
ECM
SVI01
SVI02

Granulelist:

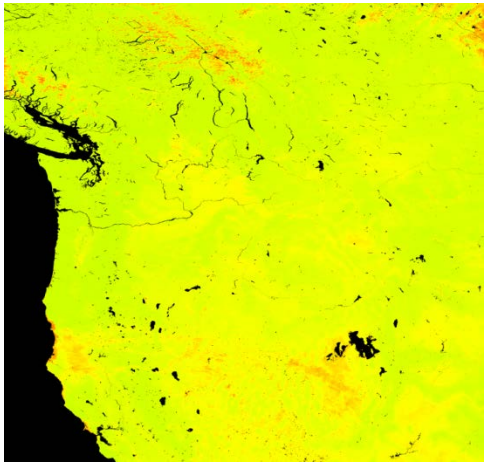
$VIIRS_VI_WORKDIR/
temp.GranuleOnTileOutDir.
20150819
h00v01_granulelist.txt
……
h19v07_granulelist.txt

GRD

$VIIRS_VI_WORKDIR/daily_sr/201
50819/
VI-SR_
s20150819_e20150819_h00v01_
c201704211757510.h5
……
VI-SR_
s20150819_e20150819_h19v07_
c201704212302540.h5



Granule space (one VIIRS granule)



Grid space (one tile)

Reflectance Compositor (RCP) Unit

All the tile files in the past 7 days:

$VIIRS_VI_WORKDIR/daily_sr/20160812/
$VIIRS_VI_WORKDIR/daily_sr/20160813/
……
$VIIRS_VI_WORKDIR/daily_sr/20160818/

→ RCP (weekly) →

$VIIRS_VI_WORKDIR/weekly_sr/20160812-20160818/
VI-SR_s20160812_e20160818_h00v01_c20170425145 0370.h5
……
VI-SR_s20160812_e20160818_h19v07_c20170425165 7040.h5

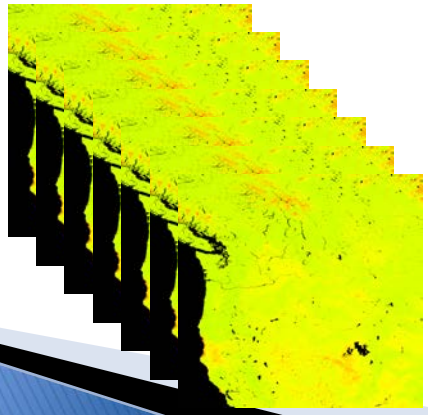
All the tile files in the past 16 days:

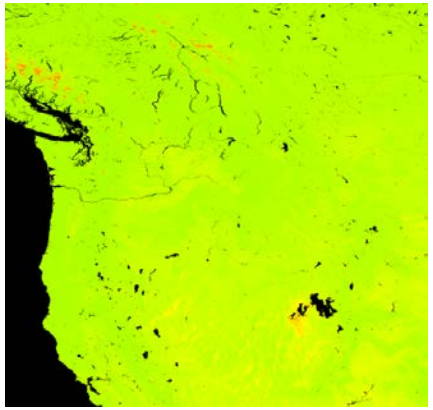
$VIIRS_VI_WORKDIR/daily_sr/20160812/
$VIIRS_VI_WORKDIR/daily_sr/20160813/
……
$VIIRS_VI_WORKDIR/daily_sr/20160827/

→ RCP (biweekly) →

$VIIRS_VI_WORKDIR/biweekly_sr/20160812-20160827/
VI-SR_s20160812_e20160827_h00v01_c20170425145 2200.h5
……
VI-SR_s20160812_e20160827_h19v07_c20170425181 2150.h5

Daily reflectance
(7 or 16 tiles)





Composited reflectance
(weekly or bi-weekly)

Quality Assurance Assigner (QAA) Unit Daily

RAG, VIC, QAA

$VIIRS_VI_WORKDIR/daily_sr/20150819/
VI-SR_s20150819_e20150819_h00v01_c201704211757510.h5
……
VI-SR_s20150819_e20150819_h19v07_c201704212302540.h5

RAG, VIC, QAA
(daily)

$VIIRS_VI_WORKDIR/daily_aasr/20150819/

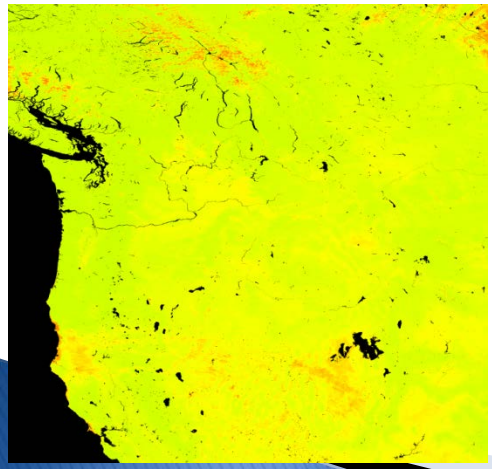
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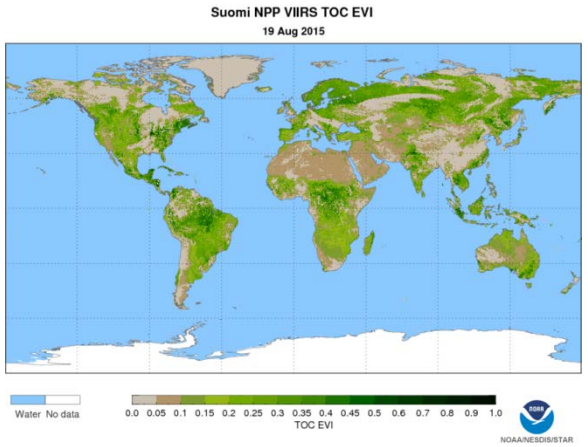
VI-REG_v1r0_npp_s20150819_e20150819_c201704241534310.nc
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VI-EVI-GLB_v1r0_npp_s20150819_e20150819_c201704241434170.tif
VI-EVI-REG_v1r0_npp_s20150819_e20150819_c201704241534310.tif

VI-TOA-NDVI-GLB_v1r0_npp_s20150819_e20150819_c201704241434170.tif
VI-TOA-NDVI-REG_v1r0_npp_s20150819_e20150819_c201704241534310.tif

VI-TOC-NDVI-GLB_v1r0_npp_s20150819_e20150819_c201704241434170.tif
VI-TOC-NDVI-REG_v1r0_npp_s20150819_e20150819_c201704241534310.tif





Daily TOC EVI 2015-08-19

Quality Assurance Assigner (QAA) Unit Weekly or Biweekly

$VIIRS_VI_WORKDIR/weekly_sr/20160812-20160818/
VI-SR_s20160812_e20160818_h00v01_c201704251450370.h5
……
VI-SR_s20160812_e20160818_h19v07_c201704251657040.h5

RAG VIC QAA (weekly)

$VIIRS_VI_WORKDIR/weekly_aasr/20160812-20160818/
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VI-GLB_v1r0_npp_s20160812_e20160818_c201704252004470_stat.txt

VI-REG_v1r0_npp_s20160812_e20160818_c201704252125020.nc
VI-REG_v1r0_npp_s20160812_e20160818_c201704252125020_stat.txt

VI-TOA-NDVI-GLB_v1r0_npp_s20160812_e20160818_c201704252004470.tif
VI-TOA-NDVI-REG_v1r0_npp_s20160812_e20160818_c201704252125020.tif

VI-TOC-NDVI-GLB_v1r0_npp_s20160812_e20160818_c201704252004470.tif
VI-TOC-NDVI-REG_v1r0_npp_s20160812_e20160818_c201704252125020.tif

VI-EVI-GLB_v1r0_npp_s20160812_e20160818_c201704252004470.tif
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……
VI-SR_s20160812_e20160827_h19v07_c201704251812150.h5

RAG VIC QAA (bi-weekly)

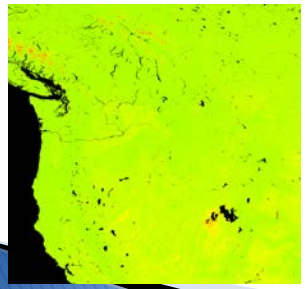
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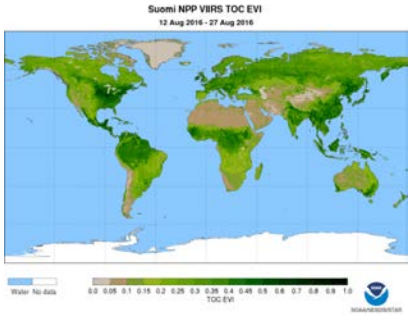
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VI-TOA-NDVI-GLB_v1r0_npp_s20160812_e20160827_c201704252006070.tif
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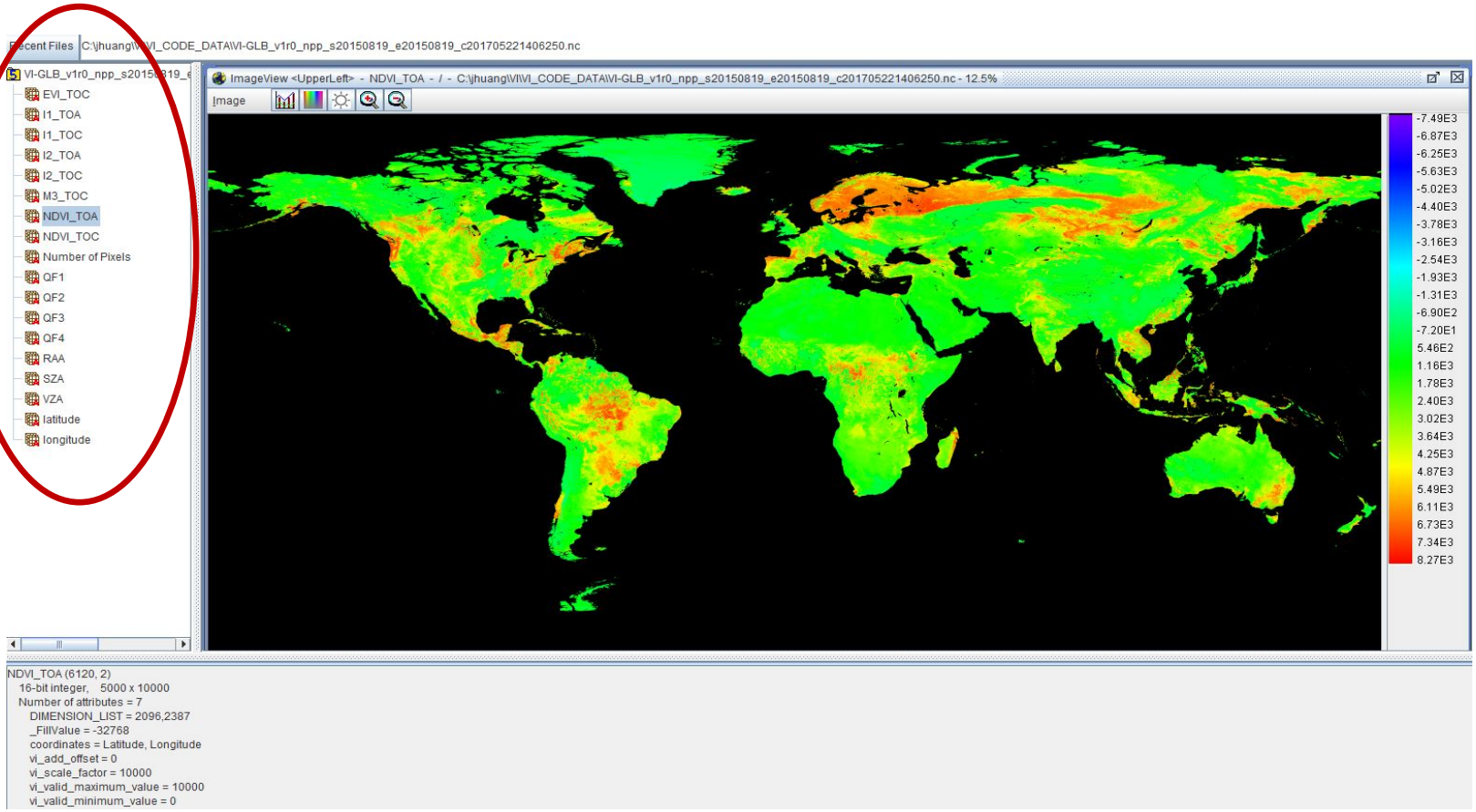
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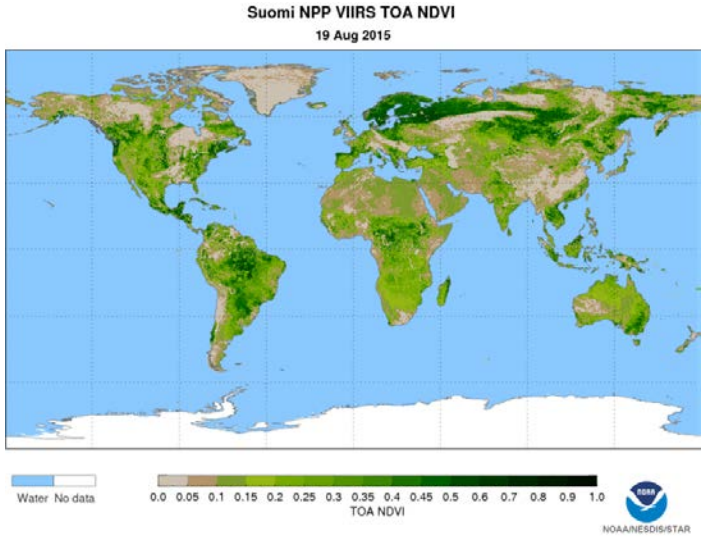
Bi-weekly TOC EVI Aug 12-27, 2016

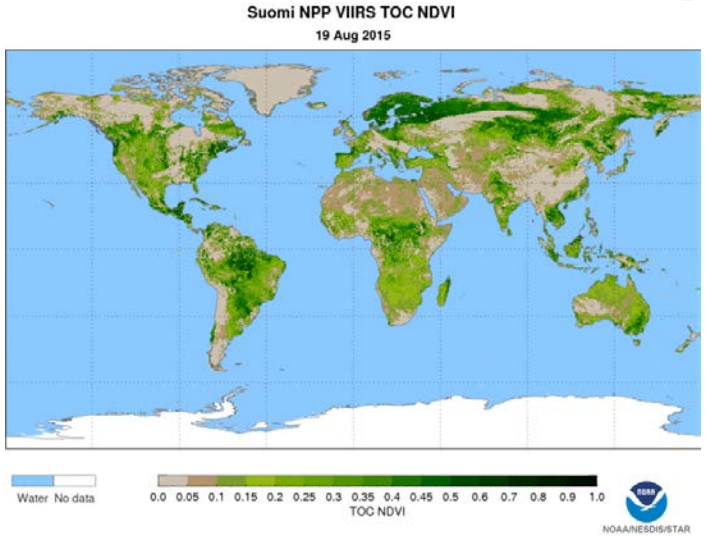
Prototype Global Daily VI Output File NetCDF4

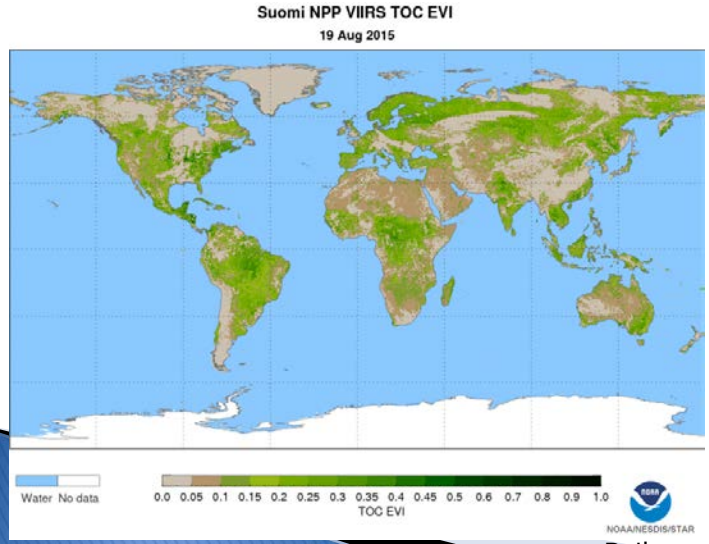


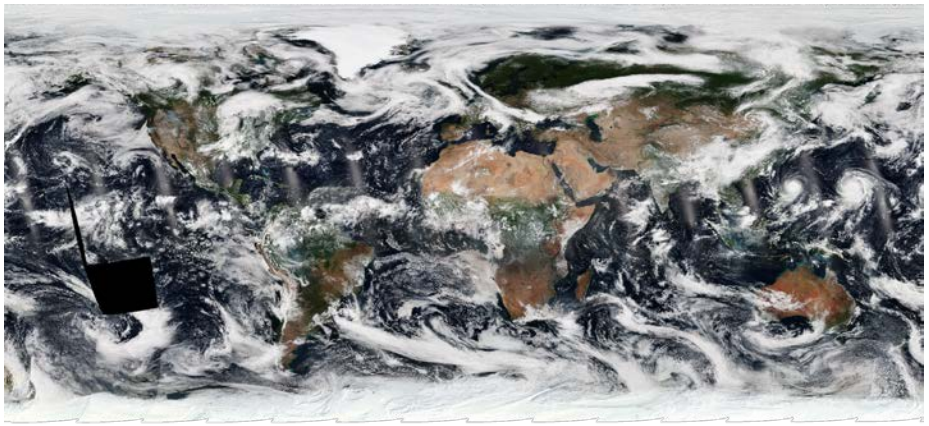
HDFView screen capture

Vegetation Index Daily Global Products (4 km res)





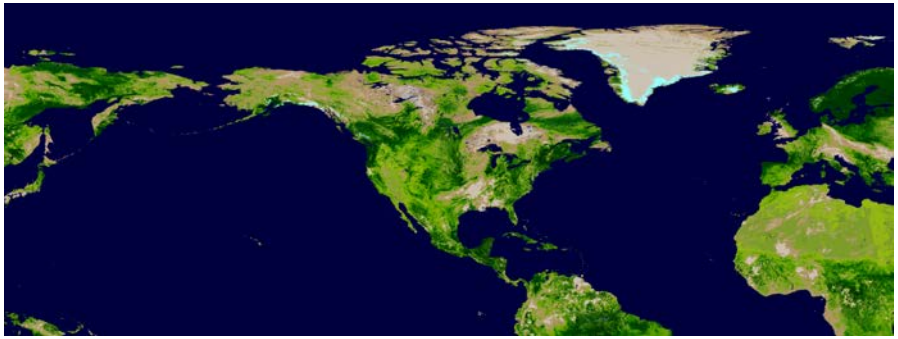




Daily products generated with the **Enterprise Surface Reflectance** granule data in NetCDF format

Vegetation Index Daily Regional Products

REGIONAL TOA NDVI 2015/08/19



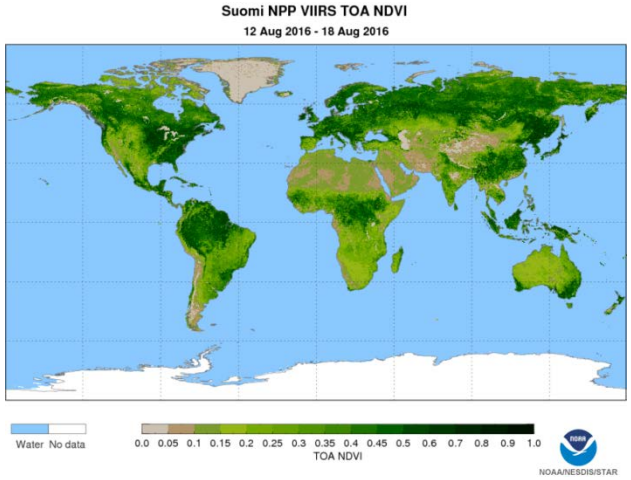
REGIONAL TOC NDVI 2015/08/19

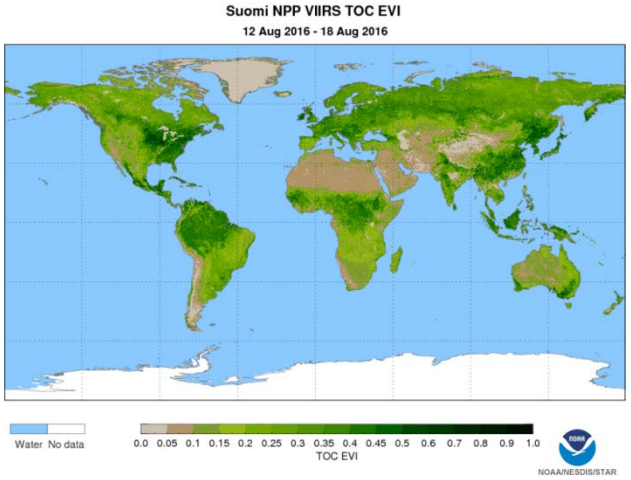


REGIONAL TOC EVI 2015/08/19

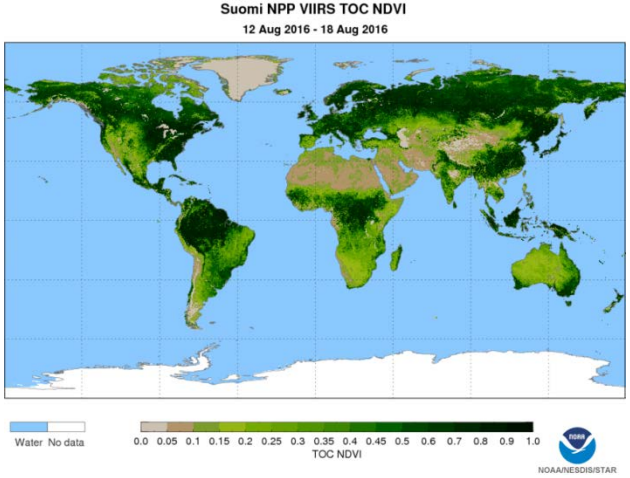


Vegetation Index Weekly Global Products

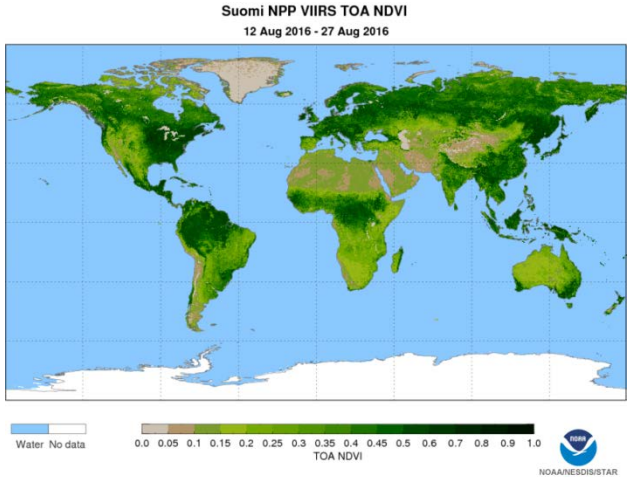


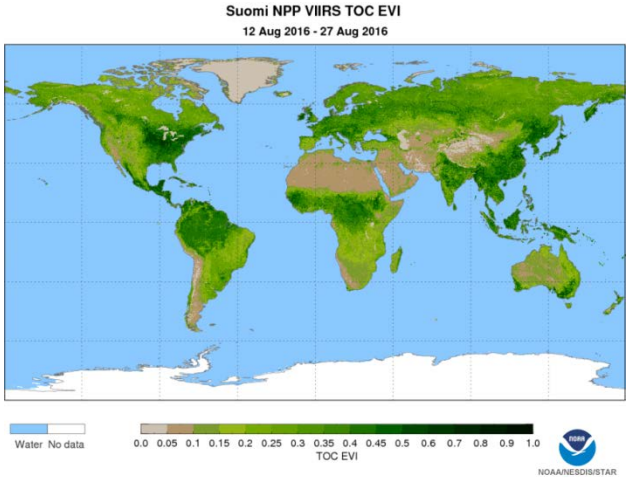


Global weekly products generated from Surface Reflectance granule Data in HDF5 format (from the IDPS)

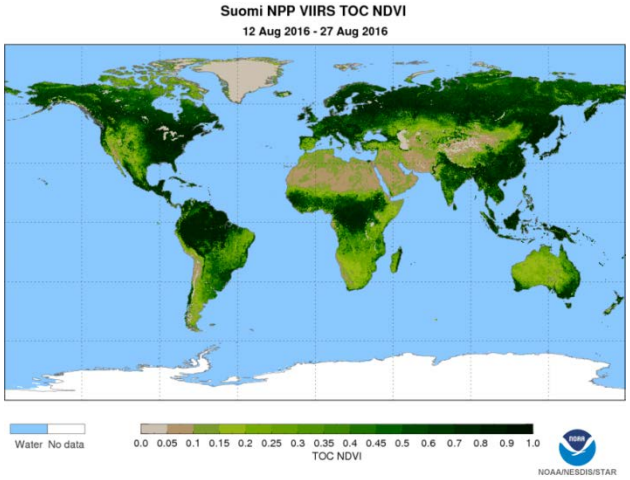


Vegetation Index Bi-Weekly Global Products



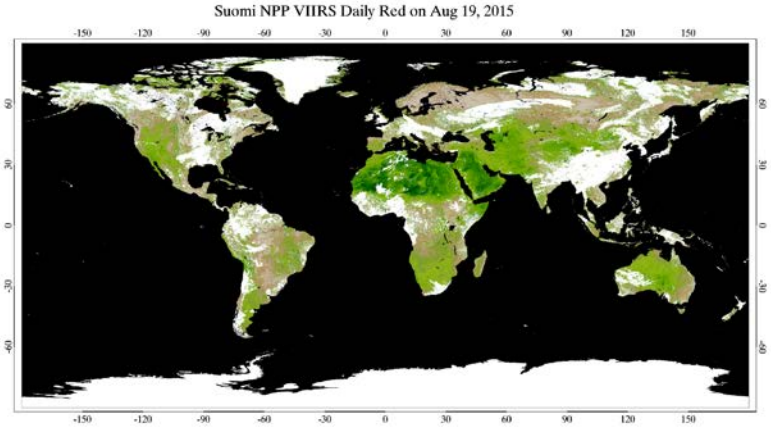


Global Bi-weekly products generated from Surface Reflectance granule Data in HDF5 format (from the IDPS)

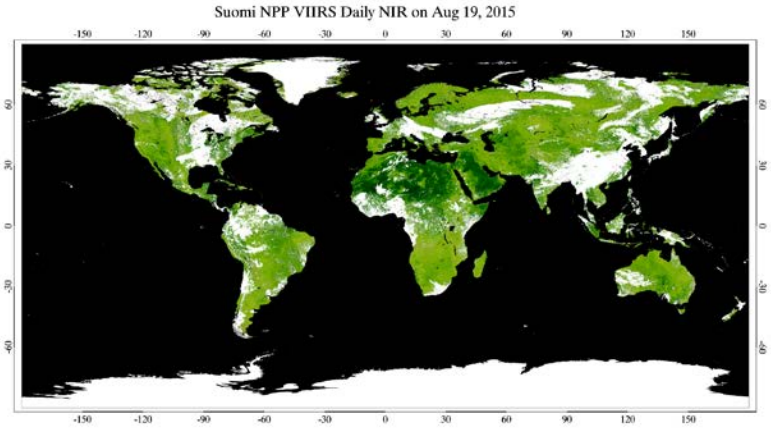


GVF System – Intermediate Files generated using Enterprise Surface Reflectance input granule data in NetCDF4 (2015-08-19)

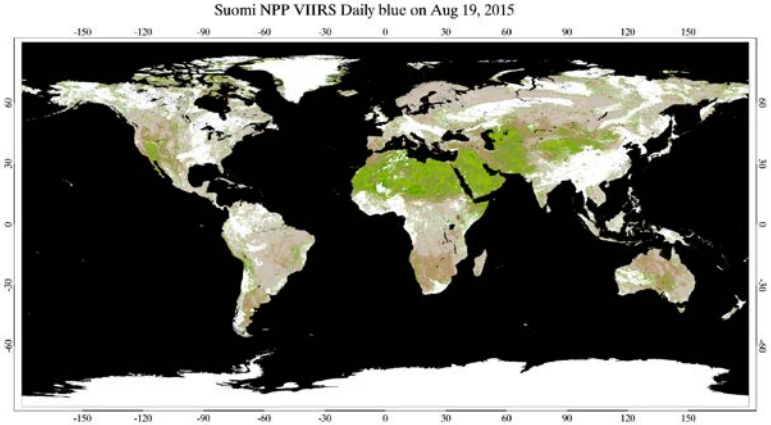
Daily VIIRS I1 ESR (Aug 19, 2015)



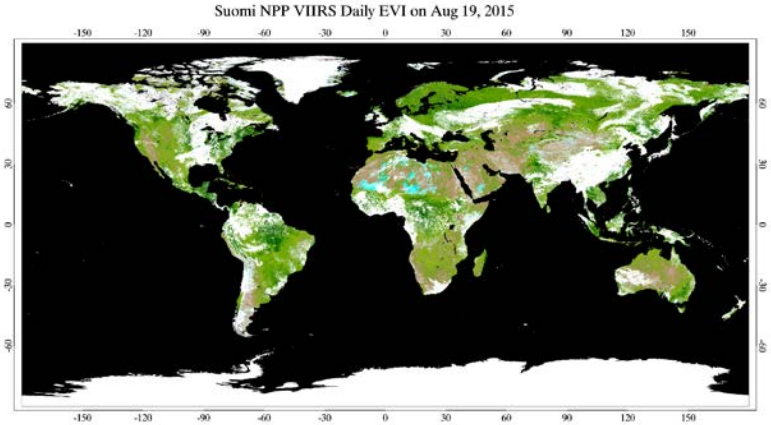
Daily VIIRS I2 ESR (Aug 19, 2015)



Daily VIIRS M3 ESR (Aug 19, 2015)

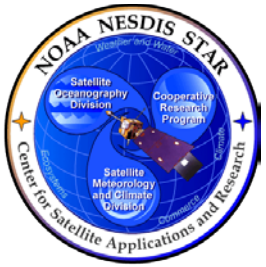


Daily EVI (Aug 19, 2015)



Intermediate files within the VIIRS GVF processing system

Validation Strategy

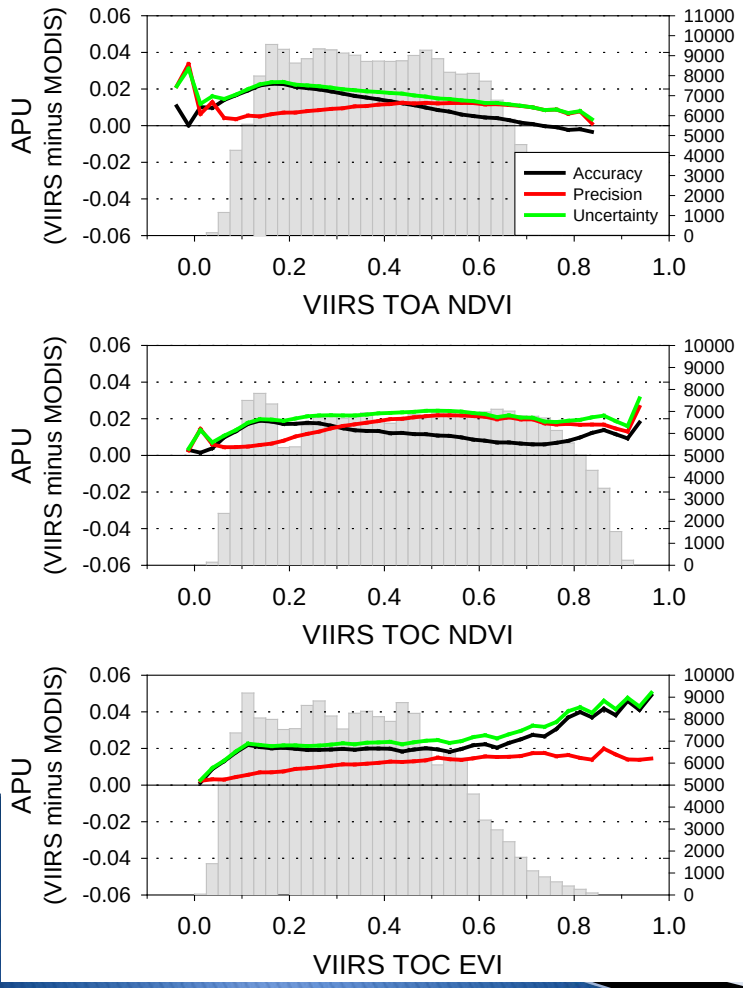


- NDE Vegetation Index (VI) products will be validated and evaluated by
  - Product inter-comparison with other satellites (e.g., MODIS, Sentinel, Landsat) over overlapping orbital tracks and over a globally-distributed set of sites
  - Time series comparison with *in situ* VI data and vegetation productivity (e.g., gross primary productivity) data over FLUXNET sites
  - Cross-comparison with AERONET-processed data

VIIRS VI EDR Global APU

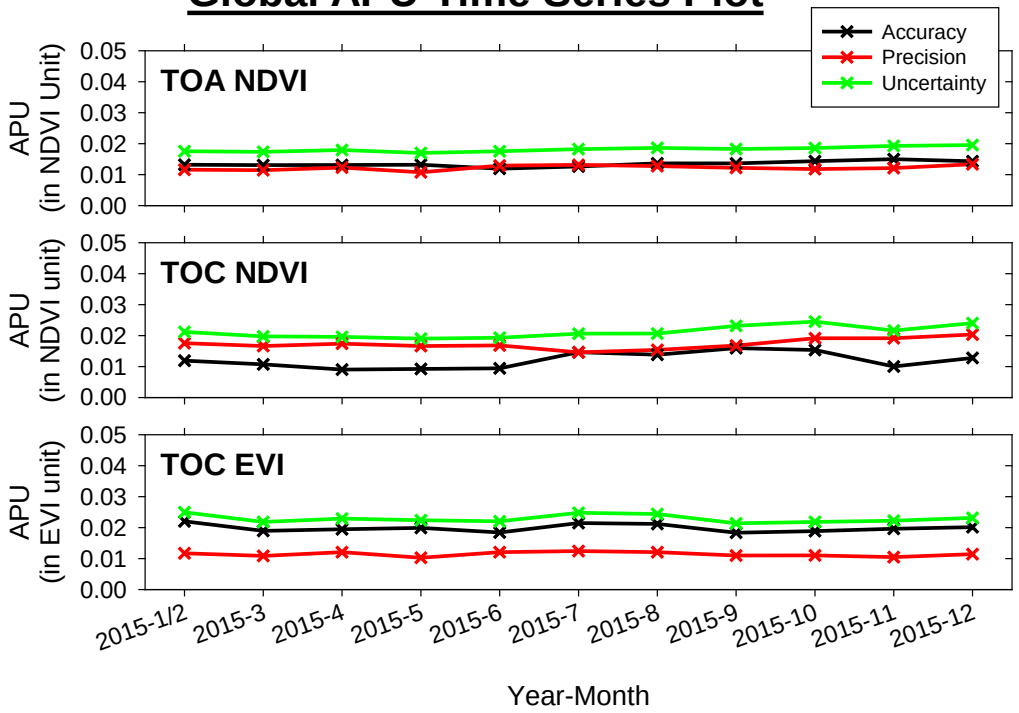
- VIIRS VI EDR meet the L1RDS requirements over time and across seasons
  - APU derived from global data using Aqua MODIS as a reference
  - VIIRS-MODIS observation pairs from matched orbital tracks used

Global APU Over Dynamic Range



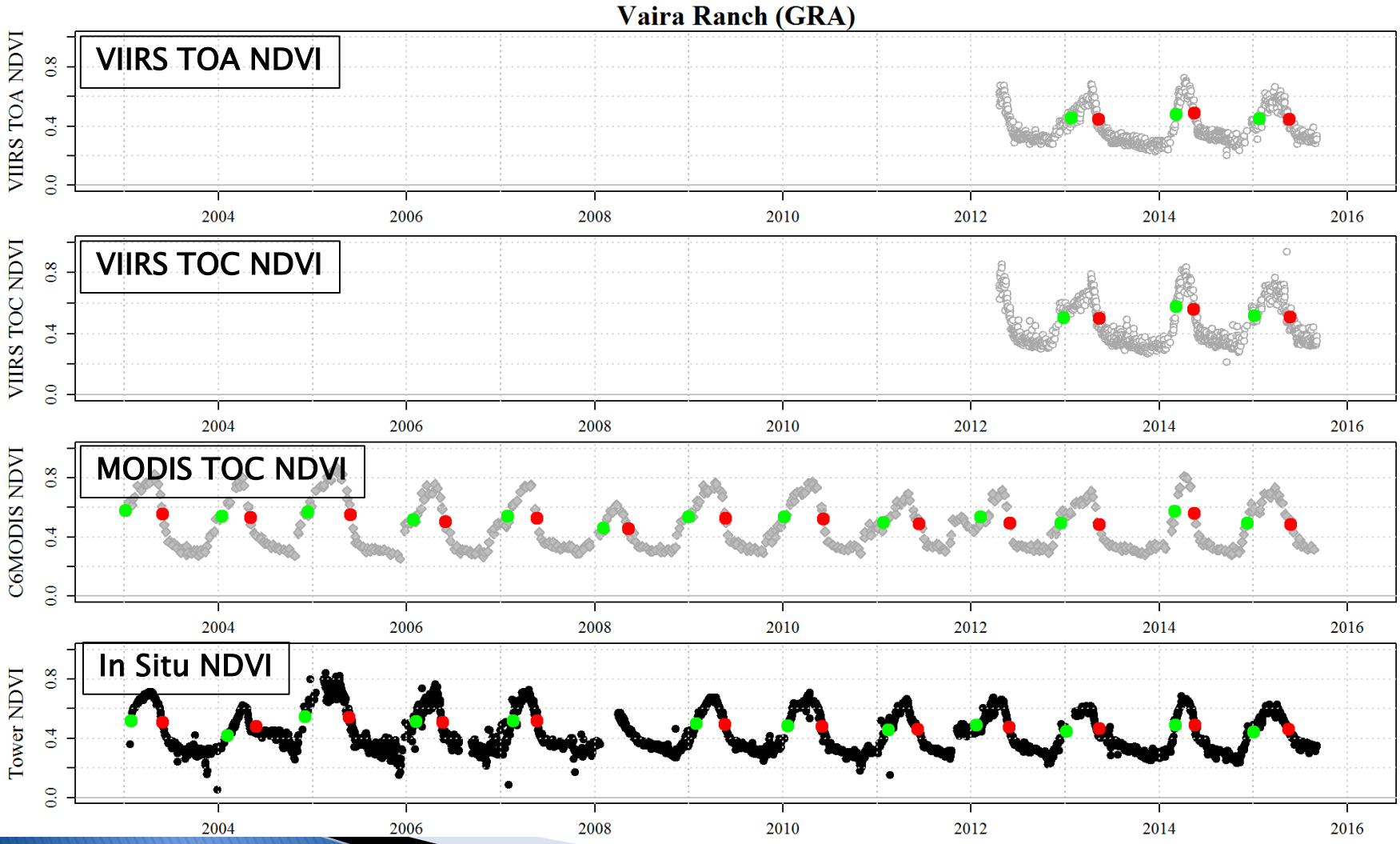
	TOA NDVI	TOC NDVI	TOC EVI
A	0.013	0.012	0.020
P	0.012	0.018	0.011
U	0.018	0.021	0.023

Global APU Time Series Plot



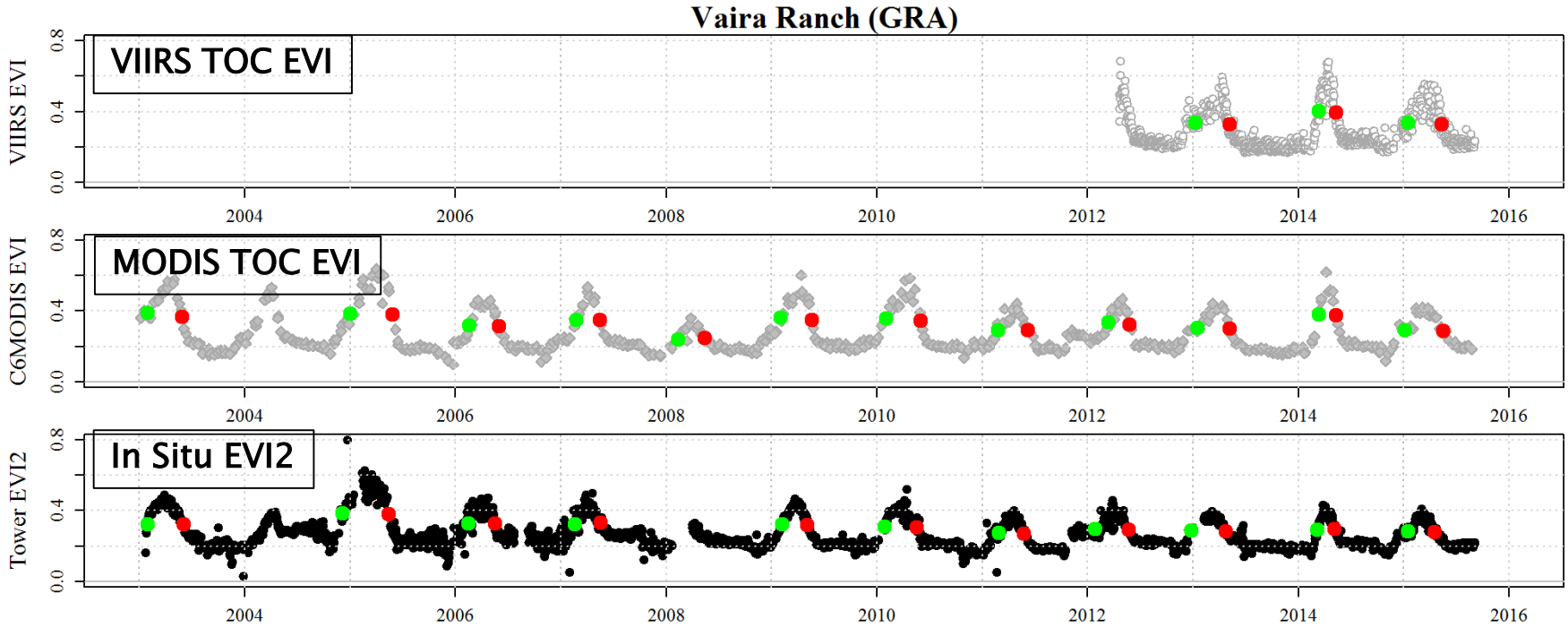
Product Inter-comparison Over a Distributed Set of Sites

- Quality of VIIRS VI EDR temporal profiles evaluated via visual inspection & comparison with Aqua MODIS and *in situ* data when available



Product Inter-comparison Over a Distributed Set of Sites

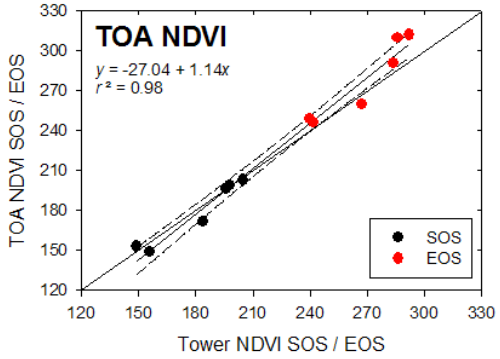
- Quality of VIIRS VI EDR temporal profiles evaluated via visual inspection & comparison with Aqua MODIS and *in situ* data when available

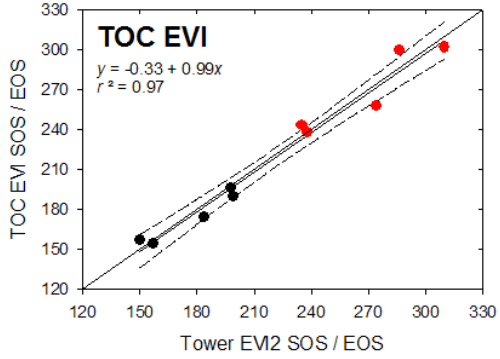


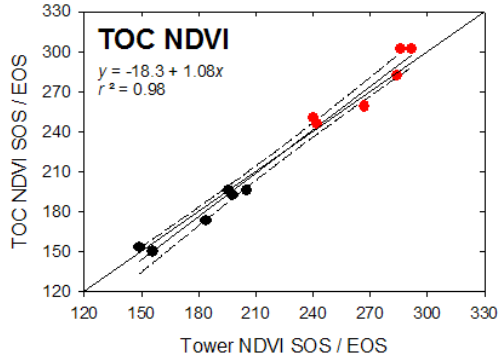
Time Series Validation Using *In Situ* Network (FLUXNET)

- High-quality time series measurements obtained through *in situ* tower networks will be used in time series validation of Phases 1 & 2 products (e.g., variables from FLUXNET: tower VIs, NPP, GPP, NEE)

VIIRS vs. In Situ: SOS & EOS



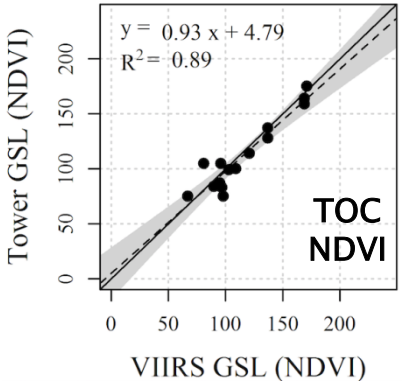


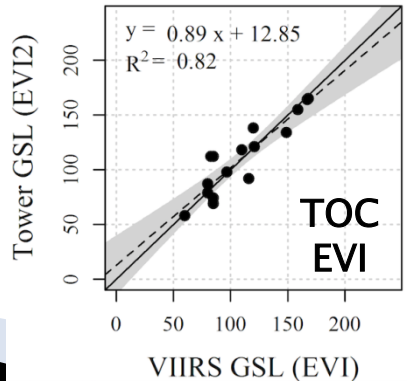


VIIRS vs. MODIS vs. In Situ Cross-Comparison of Phenological Metrics (SOS, EOS, & GSL)

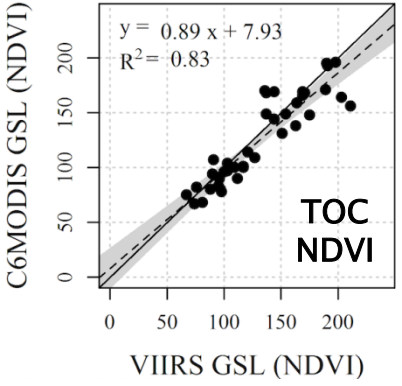
- VIIRS- & *In Situ*-derived phenological metrics corresponded well (e.g., SOS MD < 5 days; SOS RMSE < 7 days)

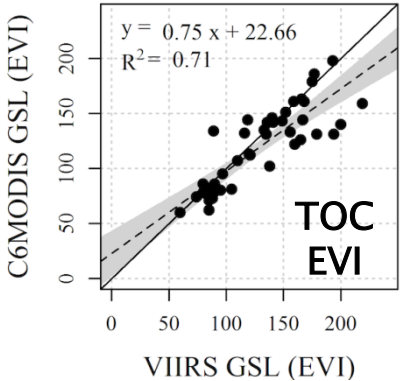
VIIRS vs. In Situ: GSL





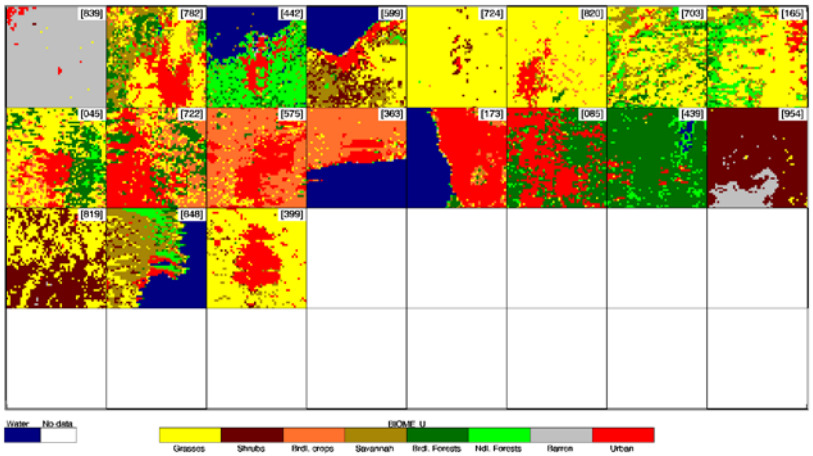
VIIRS vs. MODIS: GSL

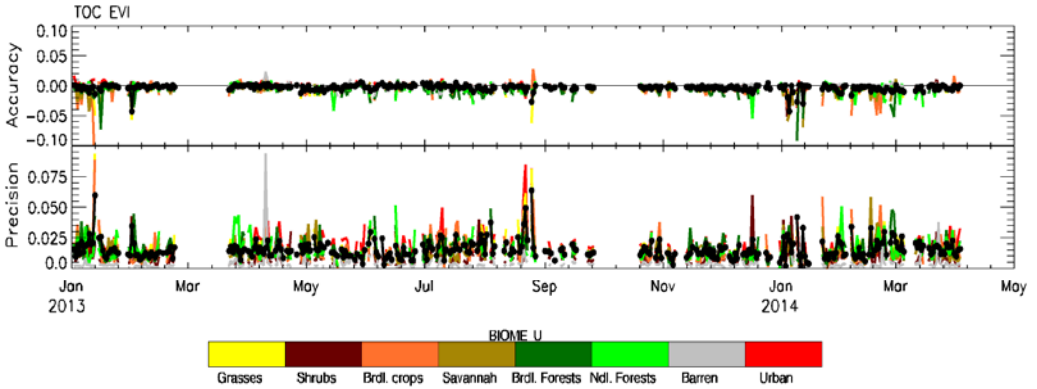


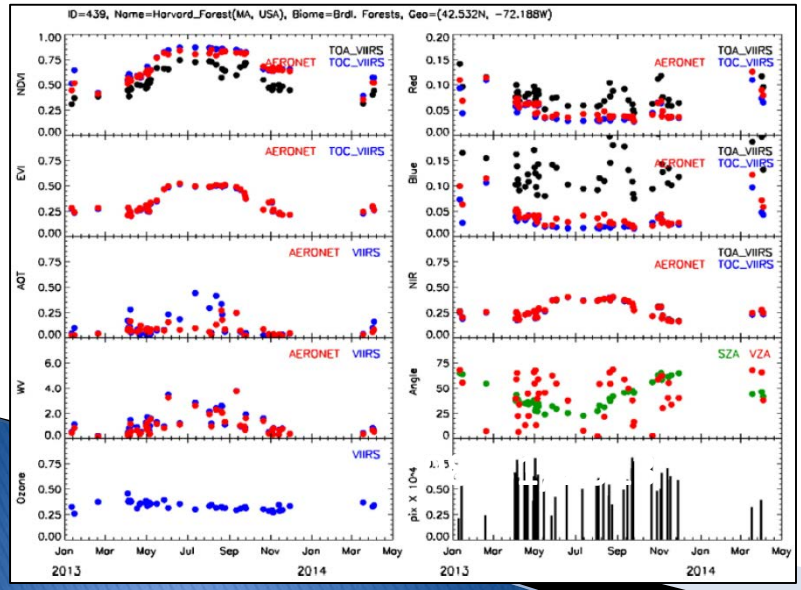


VIIRS Validation Over AERONET Sites (for TOC NDVI and TOC EVI)

- Globally-distributed match-up sites, covering different surface types and including urban areas, can be used to evaluate accuracy of atmospherically-corrected, TOC VIs. The protocol is applicable to Phase 1 products







Global APUs

(Jan 1, 2013 – Mar 31, 2014)

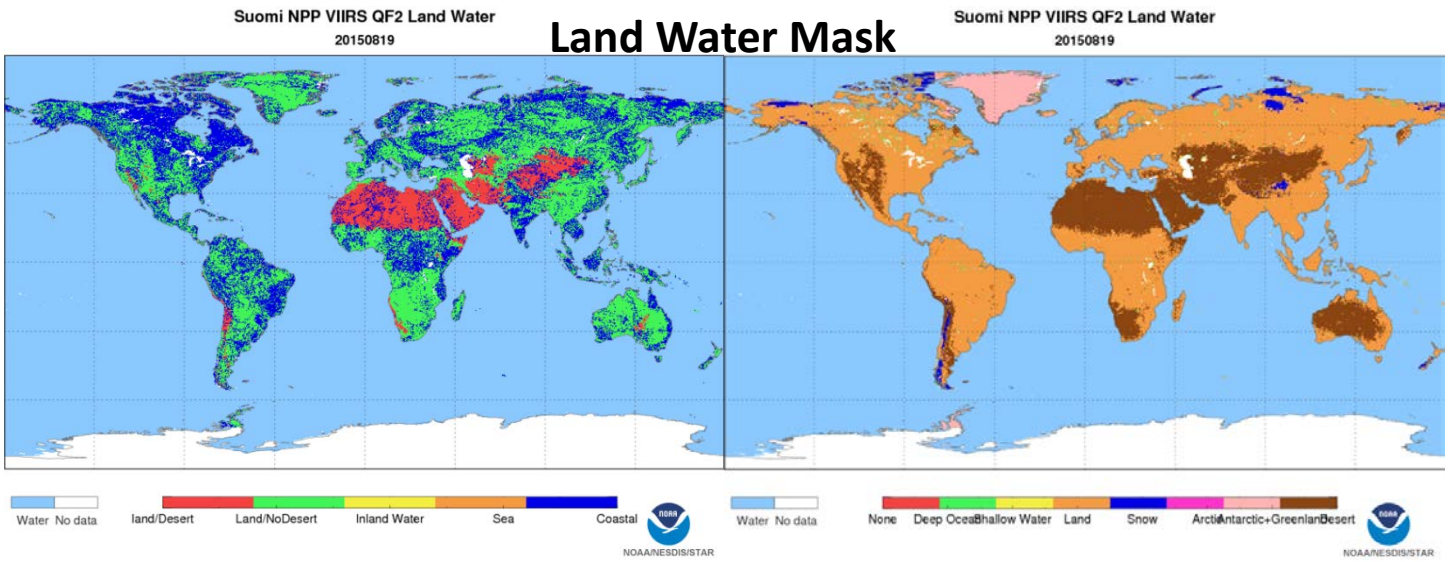
	TOC EVI	TOC NDVI
A	0.004	0.009
P	0.015	0.035
U	0.016	0.038

(Shabanov et al., 2015, RSE)

Evaluation using ECM v1r1 (i.e. current operational ECM product)

Issue #1: Attributable to ECM, as ESR only passes it on

IDPS



NDE

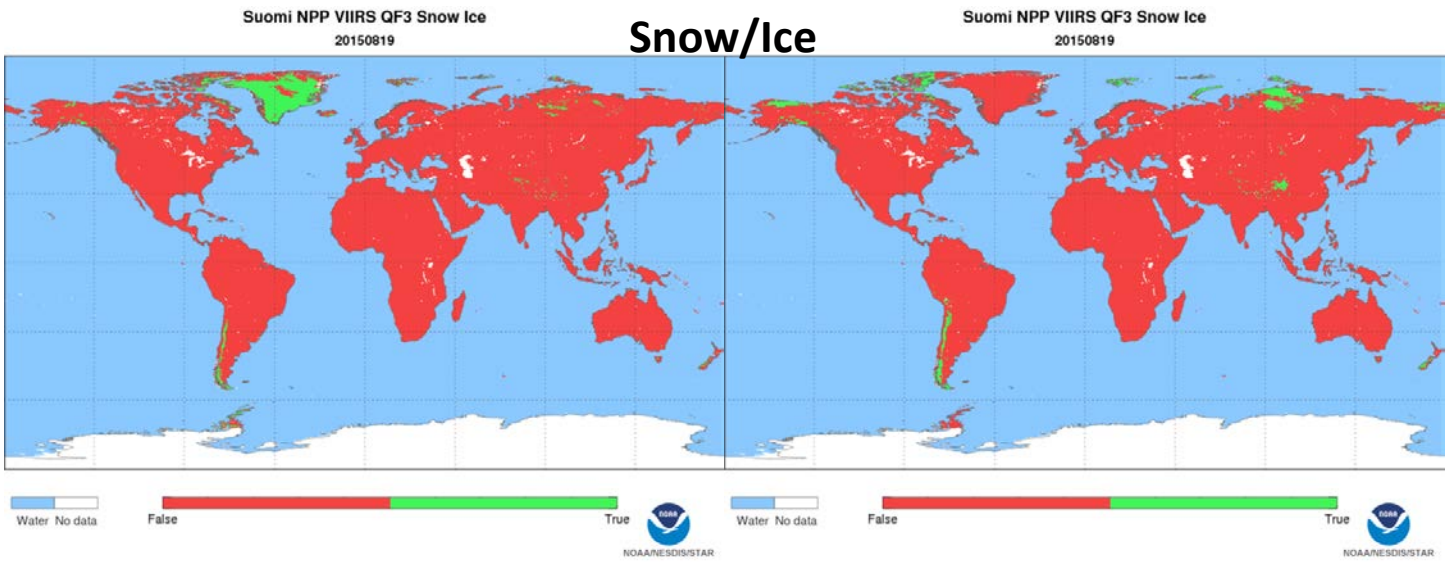
Land water mask:
The new LWM has snow in it, but Arctic and Antarctic+Greenlands are treated as separate categories.

Problem:
VI is degraded over snow/ice pixels. Over Antarctic and Greenland, we don't know whether there are snow/ice or not. We don't know how to treat Antarctic and Greenland overall (degrade them all?)

Evaluation using ECM v1r1 (i.e. current operational ECM product)

Issue #2: Attributable to ECM, as ESR only passes it on

IDPS



Snow/Ice

NDE

Snow/Ice:
There are no snow/ice information over Antarctic and Greenland. This is linked to the Land Water Mask issue.

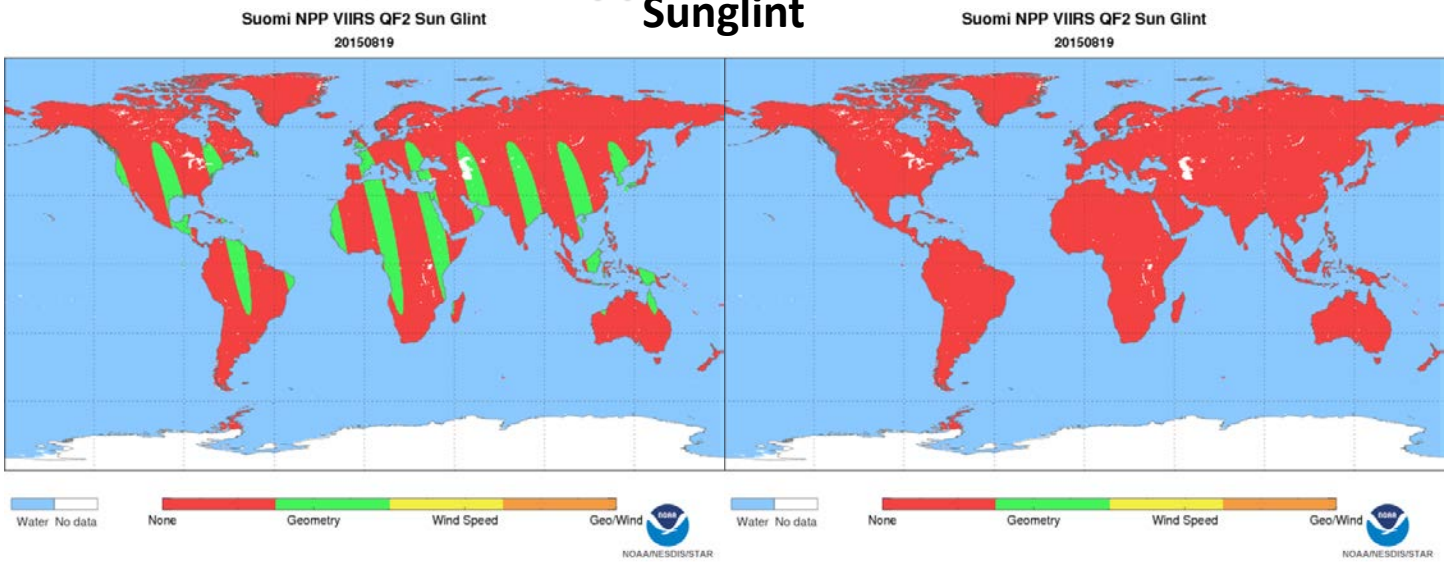
Problem:
VI is degraded over snow/ice pixels. Over Antarctic and Greenland, we don't know whether there are snow/ice or not. We don't know how to treat Antarctic and Greenland overall (degrade them all?)

Evaluation using ECM v1r1 (i.e. current operational ECM product)

Issue #3: Attributable to ECM, as ESR only passes it on

Sunglint

IDPS



NDE

Sunglint:

IDPS has two sunglint flags, one is geometry based (over land) and one based on wind speed (over water). NDE ECM only has the oceanic version, meaning there is no sun glint over land.

Problem:

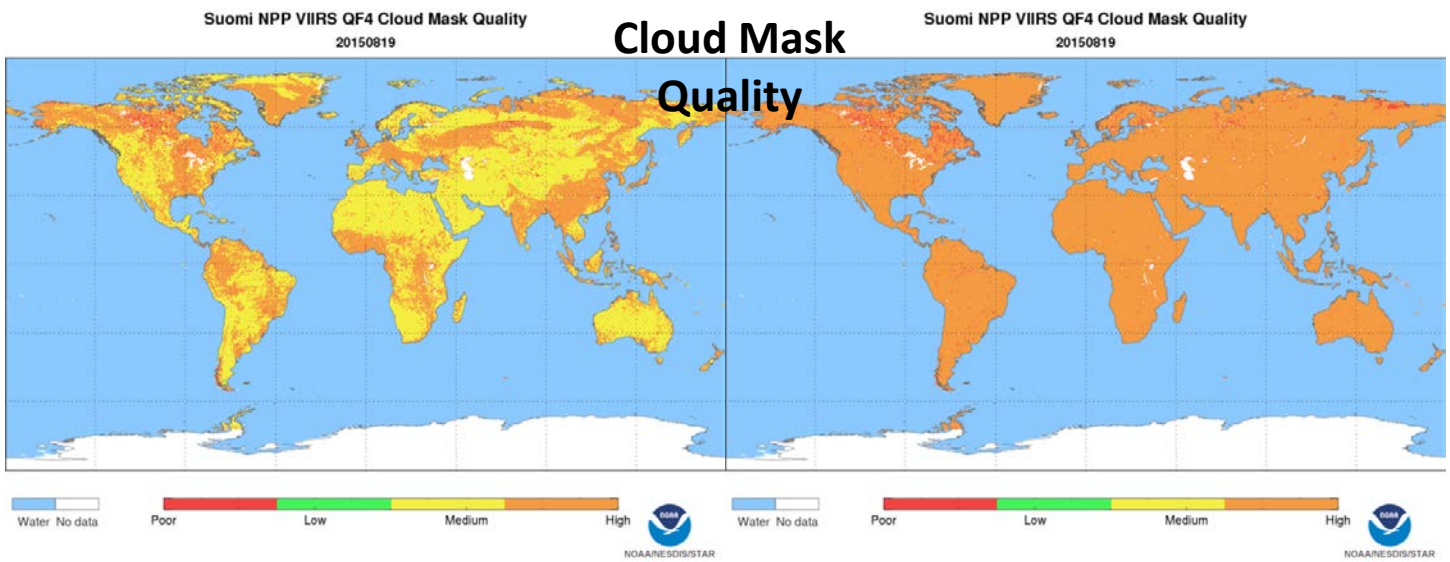
VI has known biases over pixels with sunglint over land. Without information of sun glint over land, we will have 'contaminated' VI product for the areas with sun glint over land. We hope we can get the ‘Geometry based sunglint QF’ back to ECM and ESR.

Sunglint over land is planned to be added to ECM revision 4

Evaluation using ECM v1r1 (i.e. current operational ECM product)

Issue #4: Attributable to ECM, as ESR only passes it on

IDPS



NDE

Cloud Mask Quality:

NDE cloud mask ECM has ‘cloudmaskqualflag’ but appears to be empty with fill value ‘-128’. So, ESR calls cloud mask high quality as long as there is a cloud mask. This is why ESR has high quality cloud mask almost everywhere.

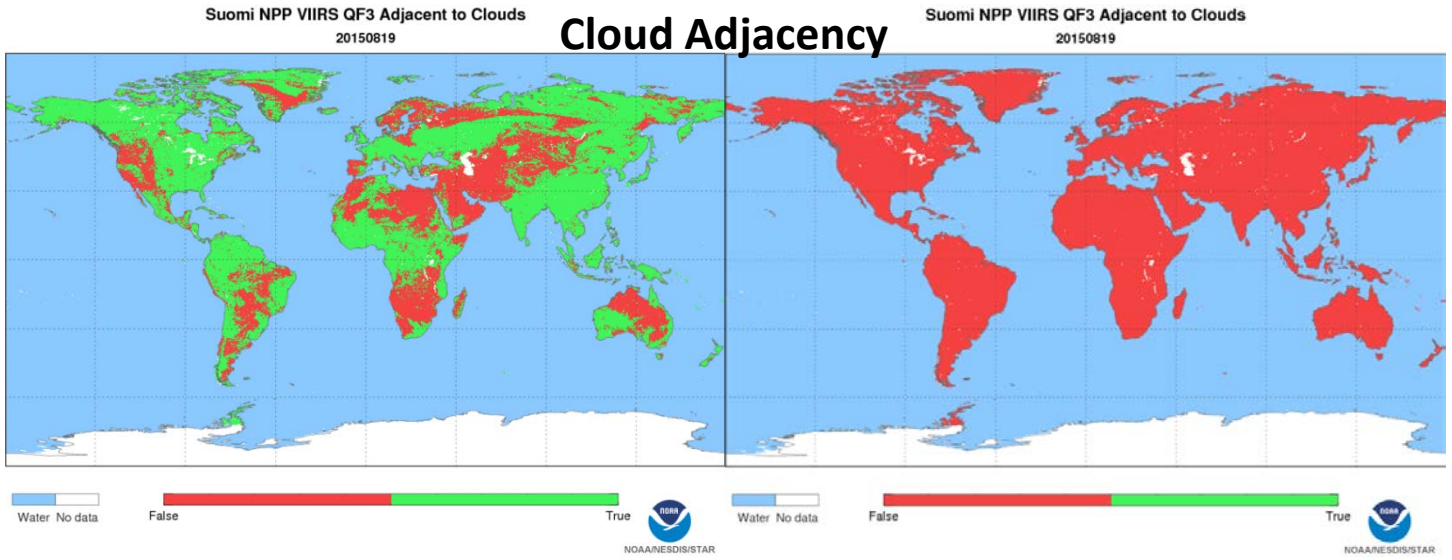
Problem:

VI does not have quality assurance criteria based on cloud mask quality yet. However, we do hope we can get a meaningful ‘cloudmaskqualflag’ in ECM.

Evaluation using ECM v1r1 (i.e. current operational ECM product)

Issue #5: Attributable to ECM, as ESR only passes it on

IDPS **Cloud Adjacency** **NDE**



Cloud Adjacency:
IDPS VCM has this QF, but NDE ECM does not.

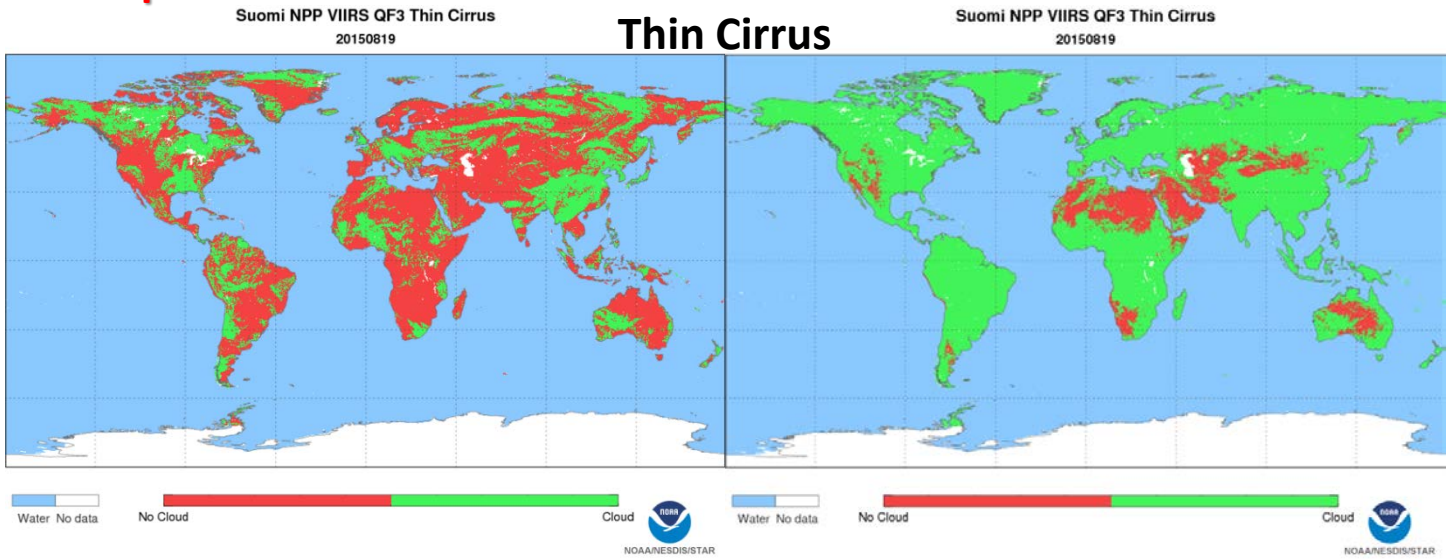
Problem:
'Cloud Adjacency' is an important parameter to avoid cloud contamination to ECM's downstream products. VI is degraded over pixels with 'cloud adjacency'. Without 'cloud adjacency' information, VI retrievals are likely 'contaminated' over pixels with cloud in adjacency.

Cloud Adjacency has been added to ECM

Evaluation using ECM v1r1 (i.e. current operational ECM product)

Issue #6: Need help from both ECM and ESR

IDPS **Thin Cirrus** **NDE**



Thin Cirrus Reflective:

VCM reports either no-cloud or cloud, but ECM reports a 4-category mask here: confident clear, probably clear, probably cloudy, and confident cloudy. ESR processes this as confident clear (no-cloud) versus everything else (cloud), so the thin cirrus reflective QF will potentially look very cloudy in ESR. ESR can change the sensitivity of this flag if needed, since surface reflectance only passes it on.

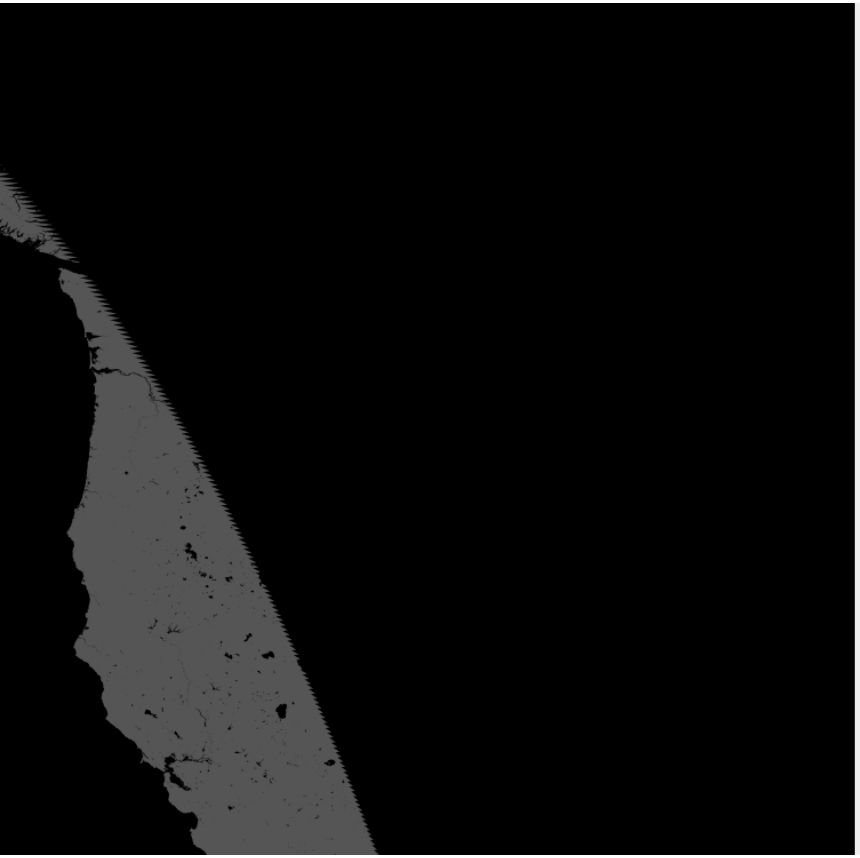
Problem:

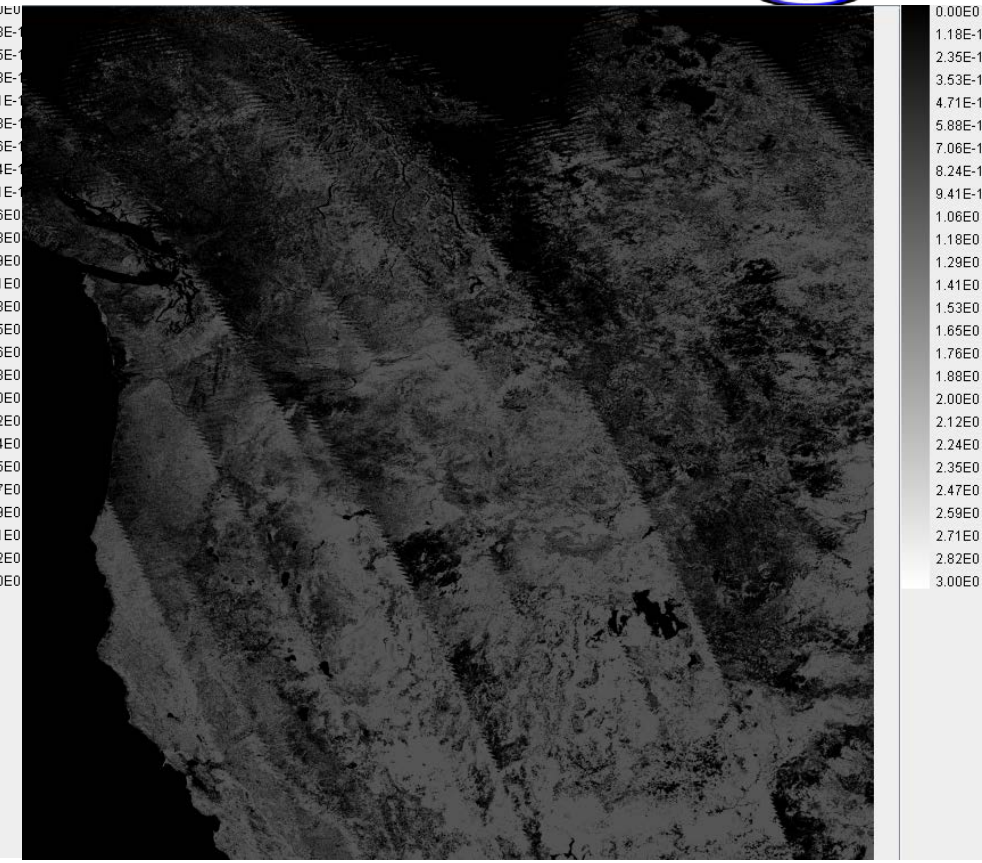
VI is degraded over pixels with ‘thin cirrus reflective’. We will appreciate ESR can change the sensitivity of this flag. Right now we have overwhelming thin cirrus reflective, which is one of the main reasons that we have ‘too many’ low quality VI.

Thin Cirrus has been added to ECM

20160819
H03V02
Sun Glint (QF2, Bit 6-7)

20160812-20160827
H03V02
Sun Glint (QF2, Bit 6-7)

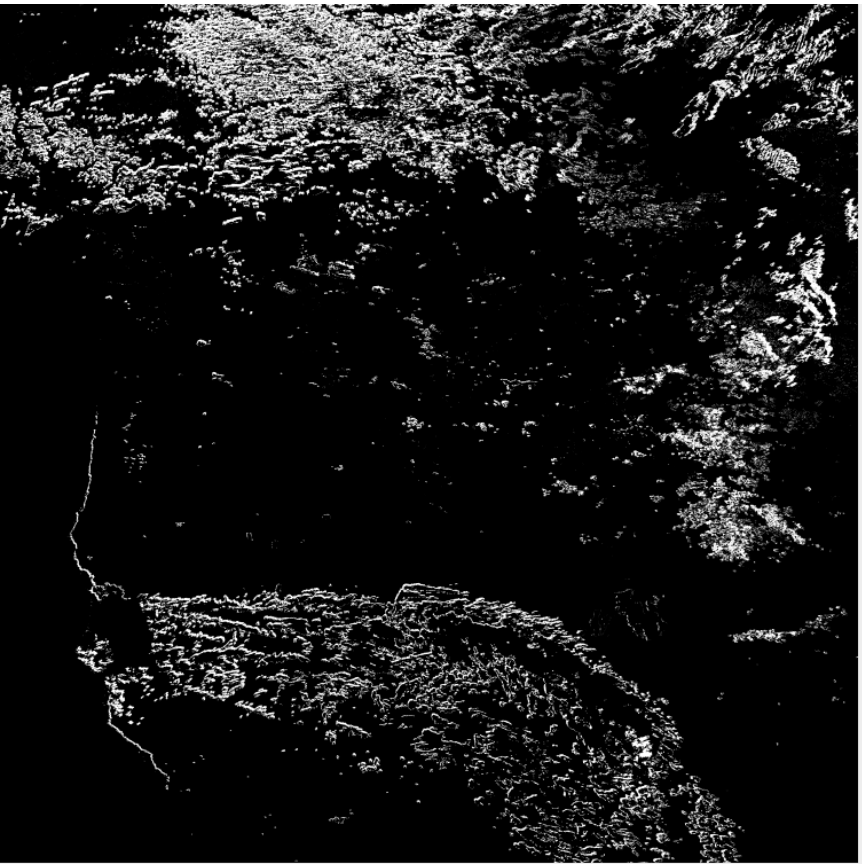


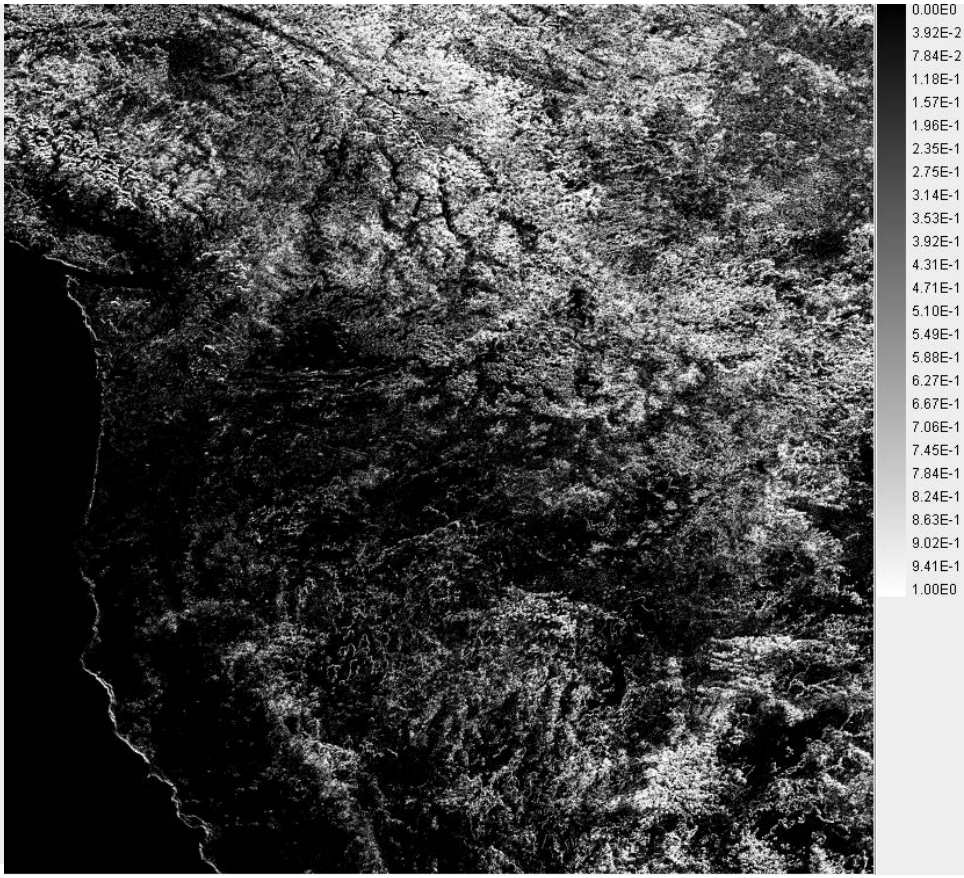


*Sun Glint	11 = Geometry & Wind 10 = Wind Speed Based 01 = Geometry Based 00 = None

20160819
H03V02
Cloud Shadow (QF4, Bit 0)

20160812-20160827
H03V02
Cloud Shadow (QF4, Bit 0)

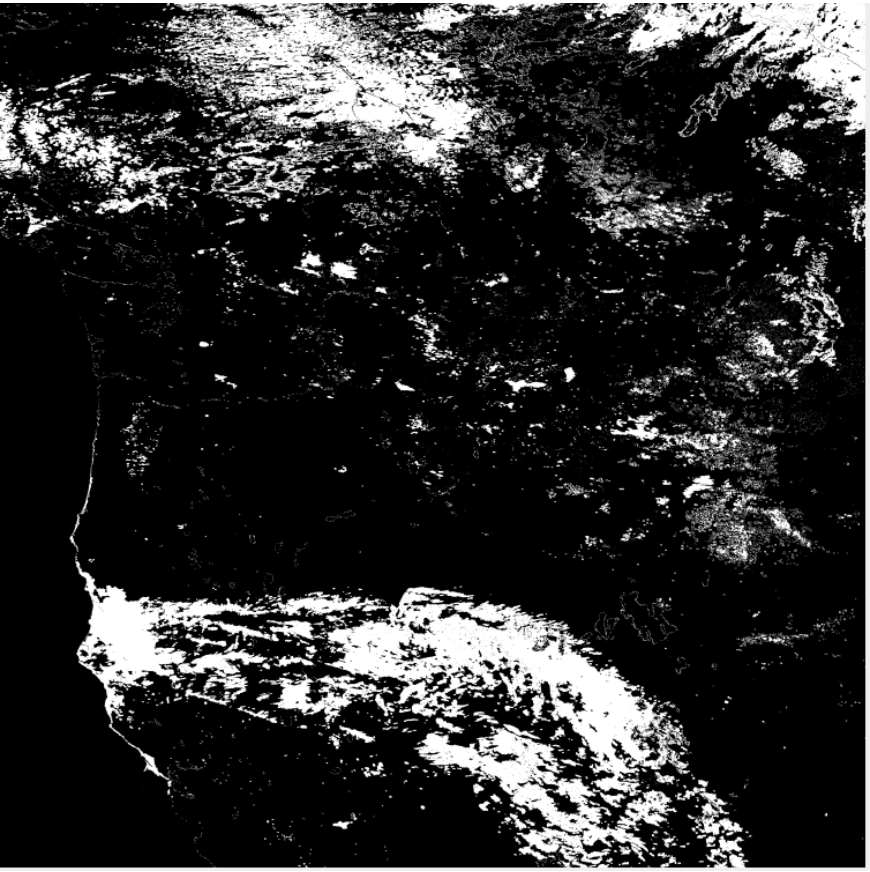


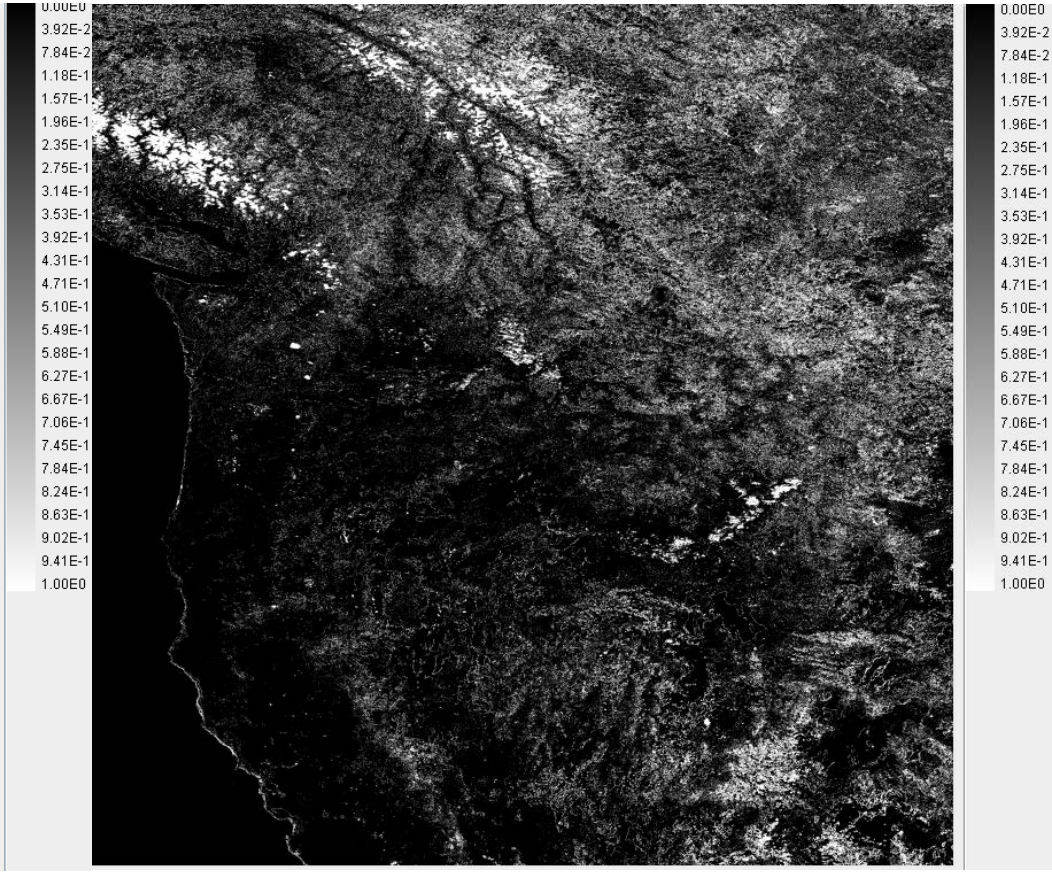


*Cloud Shadows	0 = False (no) 1 = True (yes)

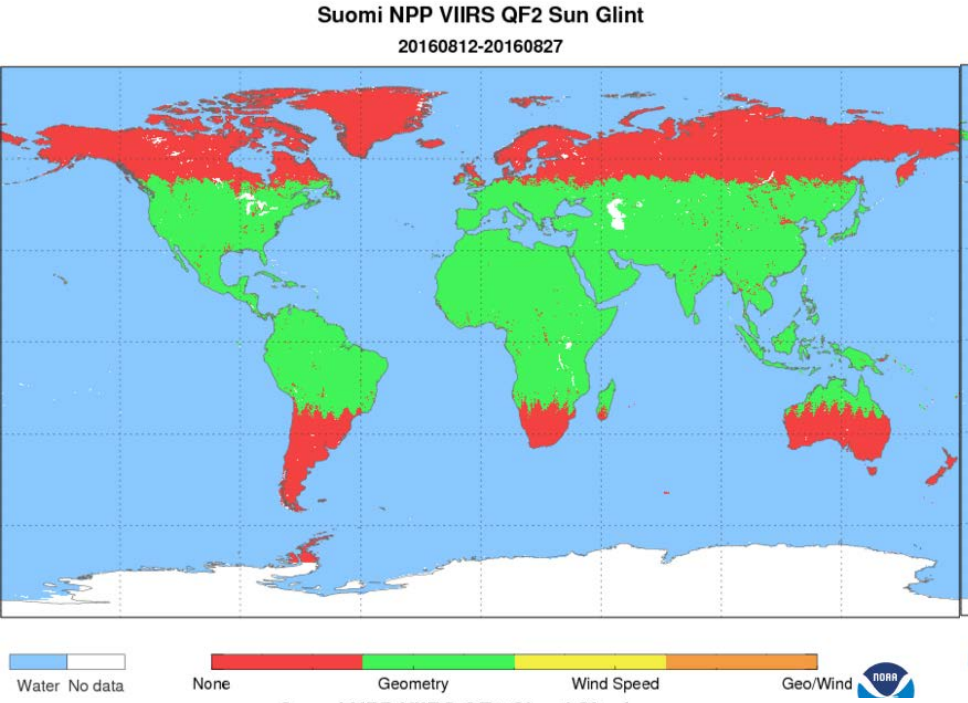
20160819
H03V02
Cloud Adjacency (QF3, Bit 5)

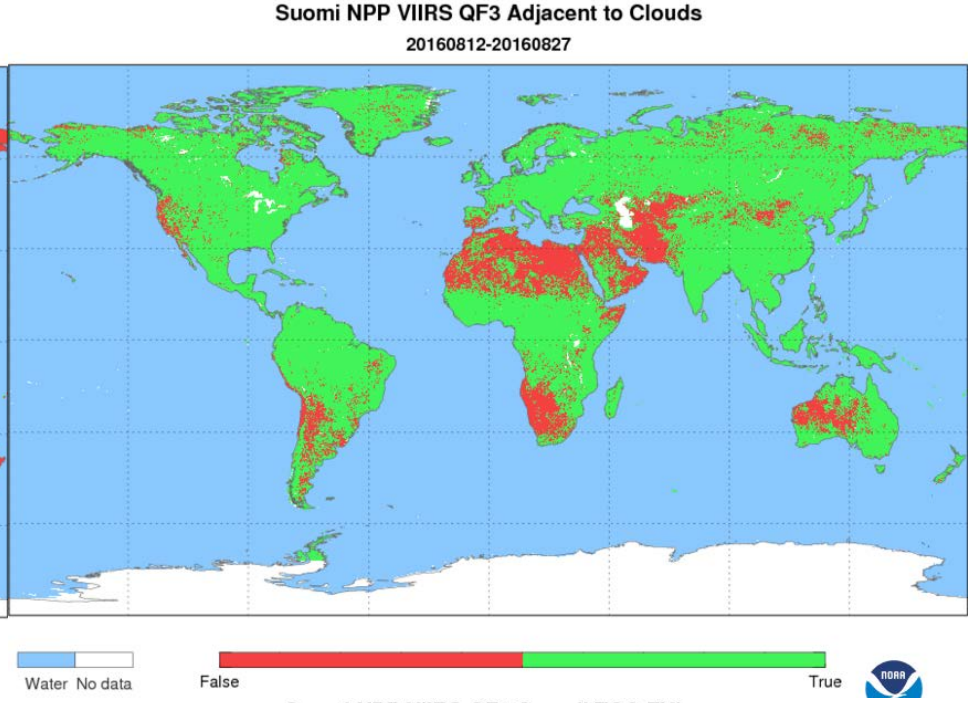
20160812-20160827
H03V02
Cloud Adjacency (QF3, Bit 5)

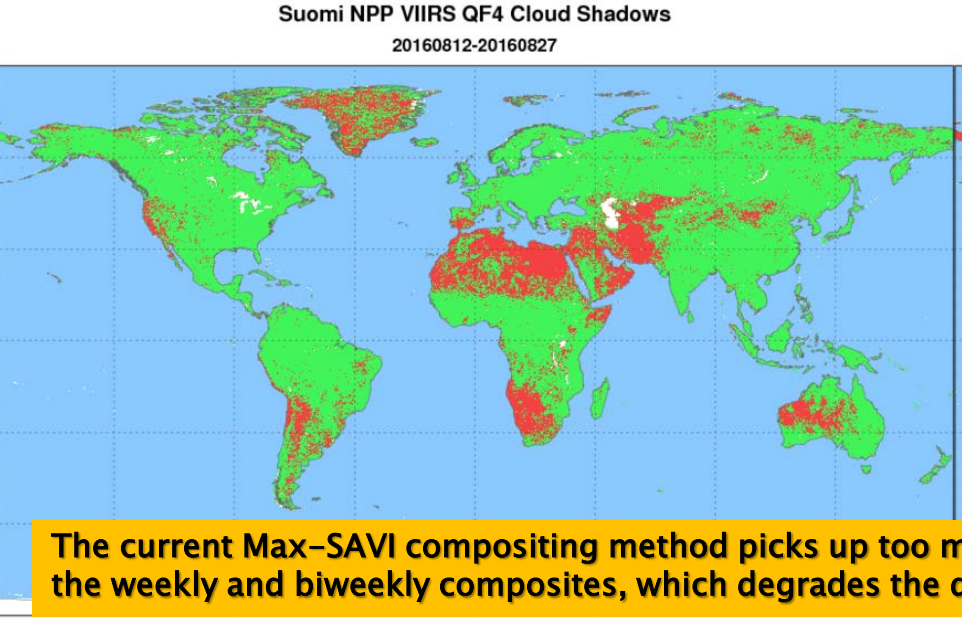


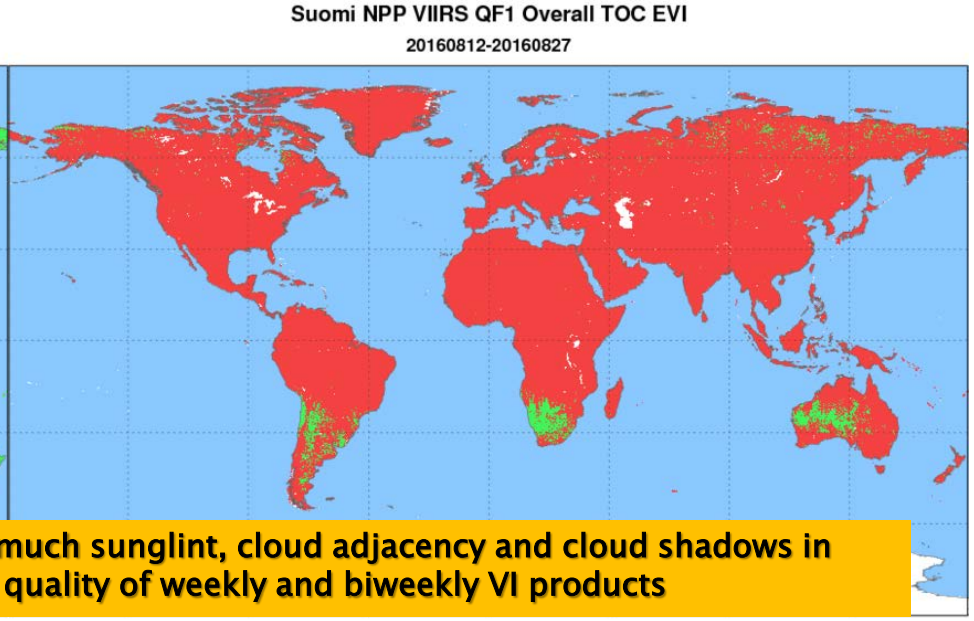


*Cloud Adjacency	0 = False (no) 1 = True (yes)









The current Max-SAVI compositing method picks up too much sunglint, cloud adjacency and cloud shadows in the weekly and biweekly composites, which degrades the quality of weekly and biweekly VI products

Summary and Conclusion

- Enterprise daily GVF and VI product were tested successfully with full day (20150819) run of Enterprise inputs.
- Enterprise weekly and bi-weekly product tested with IDPS inputs (20160812-20160827). Enterprise products started flowing on 8/15/17 for testing in preparation for the ARR in September.
- Two DAPs were delivered for code testing at NDE.
- Prepare for Algorithm Readiness Review in September 2017
- Improve the current Max-SAVI compositing method
- Improve the integration of VI and GVF systems within NVPS

JPSS LAND SURFACE ALBEDO EDR

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NOAA/NESDIS/STAR
Yunyue.Yu@noaa.gov

Shunlin Liang, Dongdong Wang,
Yuan Zhou, Jingjing Peng
UMD/CICS

Outline

- Cal/Val Team Members
- JPSS LSA Product Overview
- Validation and Monitoring
- Algorithm Improvement
  - Issues
  - New NDE Gridded LSA Product
  - Updates to Sea Ice Surface Albedo Algorithm
  - Validation
- User feedbacks
- Summary and Path Forward

Cal/Val Team Members

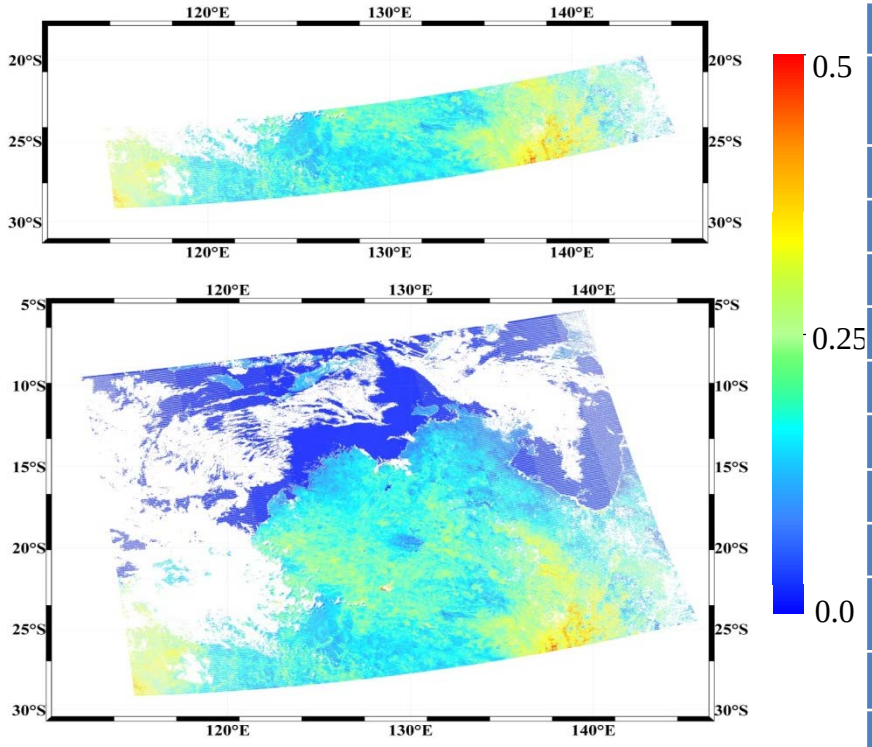
PI	Organization	Team Members	Roles and Responsibilities
Ivan Csiszar	NOAA/NESDIS/SATR		Land Lead, Project Management
Yunyue Yu	NOAA/NESDIS/SATR		EDR Lead, algorithm development, validation, team management
		Jingjing Peng	Algorithm development, validation, monitoring
Shunlin Liang	UMD/CICS		Algorithm development, validation
		Dongdong Wang	Algorithm development, validation, monitoring
		Yuan Zhou	Algorithm development, validation, monitoring
Walter Wolf	NOAA/NESDIS/SATR		System Integration, Transition
		Valerie Mikles	System Integration, Transition
		Marina Tsidulko	STAR IT support
Michael EK	NOAA/EMC/NCEP		User readiness
		Weizhong Zheng	User readiness : Model albedo application, verification
		Yihua Wu	User readiness : Model albedo application, verification
Miguel Roman	NSAS/GSFC		NASA Land Science Investigator-led Processing System Lead
		Sadashiva Devadiga	System support, product monitoring

Overview: Current VIIRS IDPS LSA Product

$$LSA = a_0 + \sum_i a_i r_i$$

i is VIIRS band number, including the channels 1,4,5,7,8,10 and11.

a_i is regression coefficient for Band *i*.

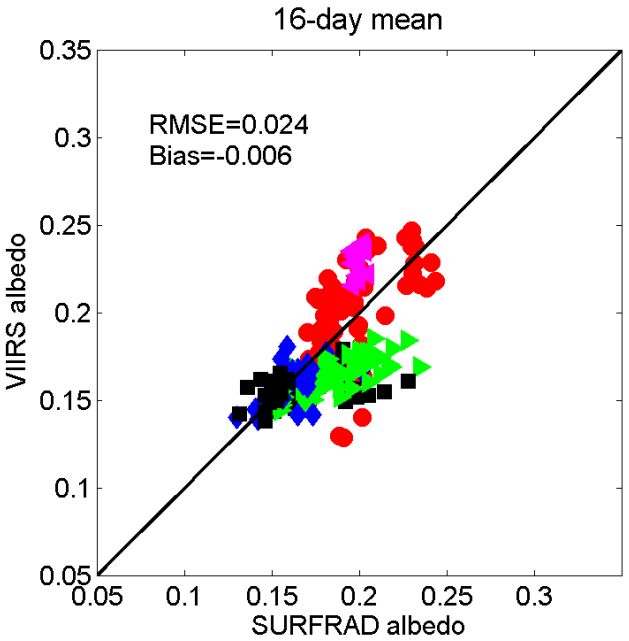


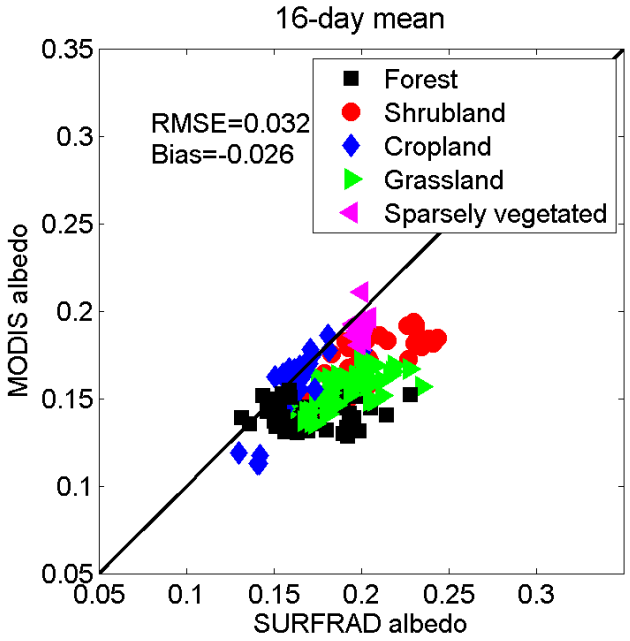
- Operational Products
  - Single 1.5 min granule data
  - Combined 4 x 1.5 min granule data
- Production team
  - STAR Science Team : Scientific development and validation
  - JPSS DPE (Data Product Engineering) : Production

Name	Type	Description	Dimension	Unit
Primary Sensor Data(SDR)				
Spectral reflectance	input	TOA spectral reflectance at M1, 4,5,7,8,10,11	grid (xsize, ysize)	unitless
Solar zenith	input	Solar zenith angles	grid (xsize, ysize)	Degree
View zenith	input	Satellite view zenith angle	grid (xsize, ysize)	Degree
Solar azimuth	input	Solar azimuth angles	grid (xsize, ysize)	Degree
View azimuth	input	Satellite view azimuth angle	grid (xsize, ysize)	Degree
SDR QC flags	Input	Level 1b data quality	grid (xsize, ysize)	unitless
Derived Sensor Data				
Cloud mask	Input	Cloud mask data	grid (xsize, ysize)	unitless
Snow mask	Input	Level 2 snow/ice mask data	grid (xsize, ysize)	unitless
Surface type	Input		grid (xsize, ysize)	unitless
LUT and Configuration File				
Coefficients LUT	Input	Regression coefficients for BPSA	2(two surface types)*18(sza) *18(vza)*23(raa)* 8(coef items)	Unitless
Output				
LSA	Output	LSA values	grid (xsize, ysize)	Unitless
QF	Output	Associated pixel quality flags	grid (xsize, ysize)	Unitless

Overview: Performance of VIIRS IDPS LSA Product

- Several algorithm improvements have been made since S-NPP was launched.
- A set of surface-specific LUTs with consideration of surface reflectance anisotropy are used.
- Validation results suggest the VIIRS direct estimation approach can generate albedo retrievals with accuracy similar (or superior) to existing products.

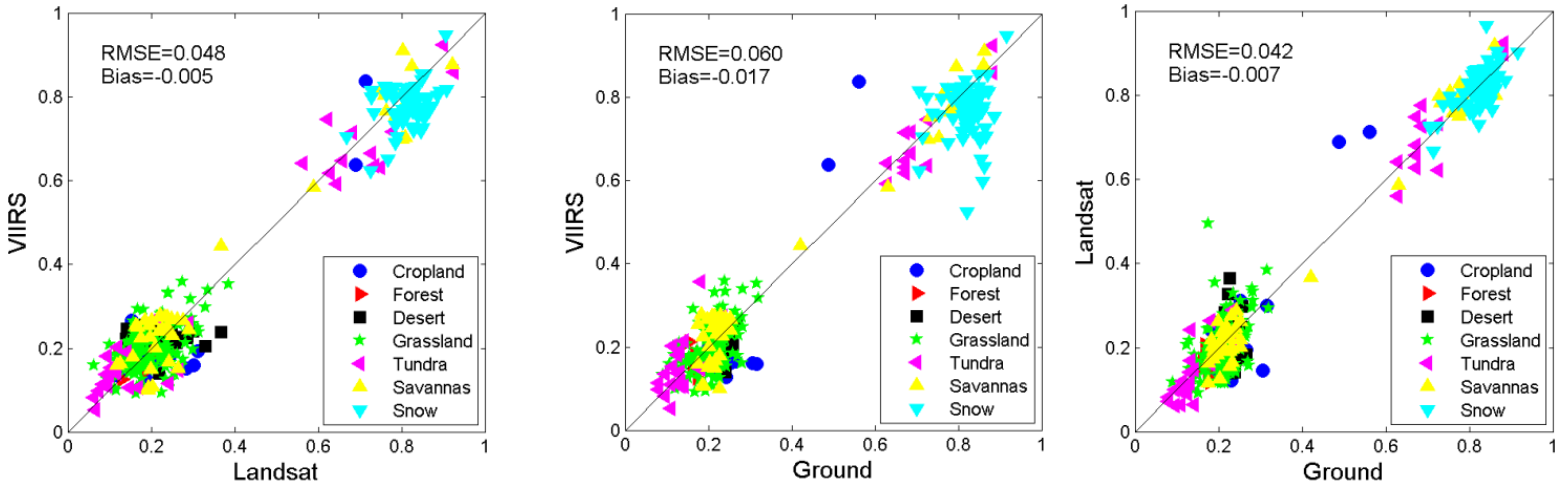




Wang, D., Liang, S., He, T., & Yu, Y. (2013). Direct Estimation of Land Surface Albedo from VIIRS Data: Algorithm Improvement and Preliminary Validation. *Journal of Geophysical Research, 118*, 12577-12586

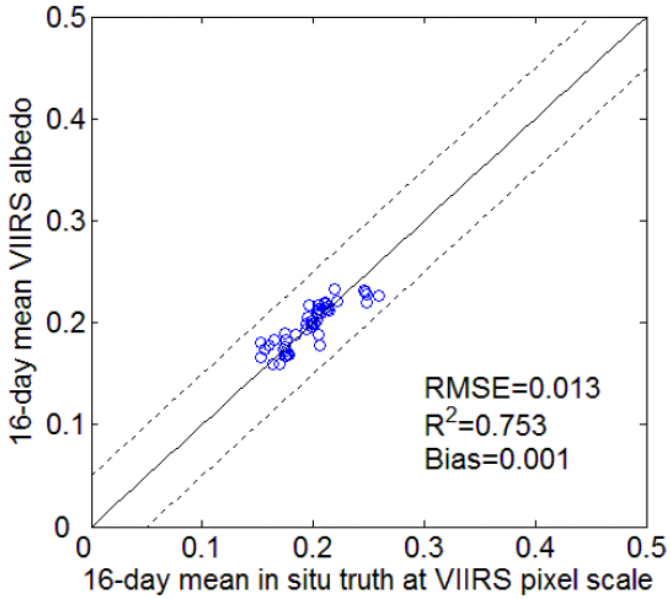
Comprehensive Assessment of VIIRS LSA

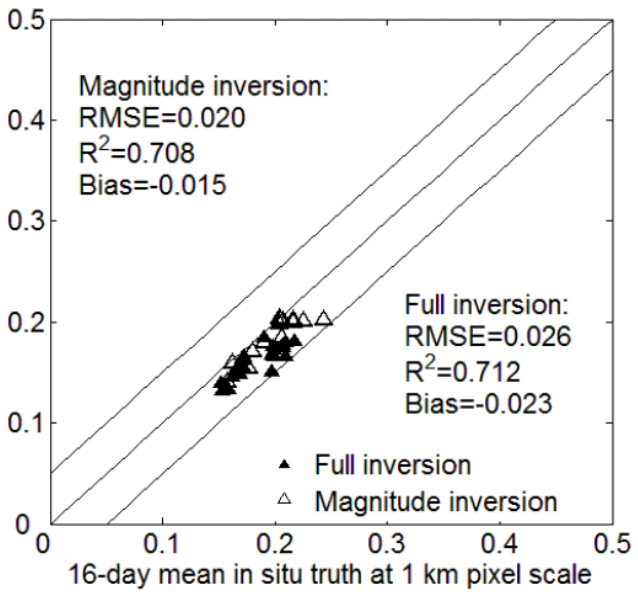
- Two years data over 23 sites
- Field measurements together with Landsat 7 ETM+ and Landsat 8 OLI maps (~3Tb)
- Intercomparison with MODIS product

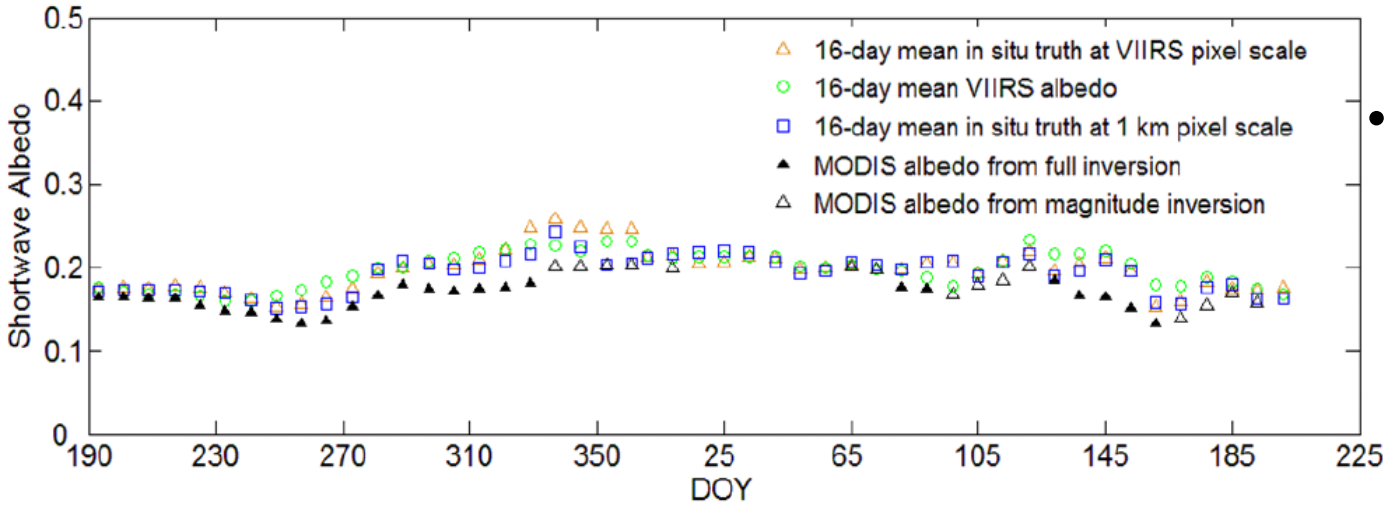


Zhou, Y., Wang, D., Liang, S., & He, T. (2016). Assessment of the Suomi NPP VIIRS land surface albedo data using station measurements and high-resolution albedo maps. *Remote Sensing*, 8, 137, doi: 10.3390/rs8020137.

Independent Validation Study





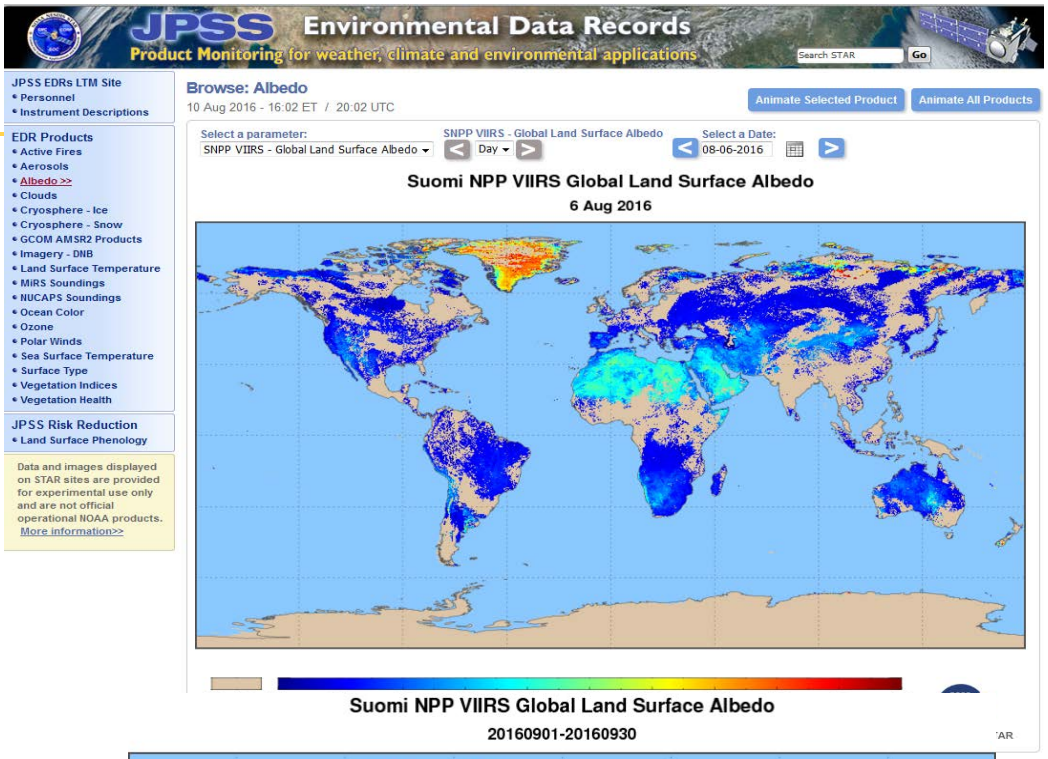


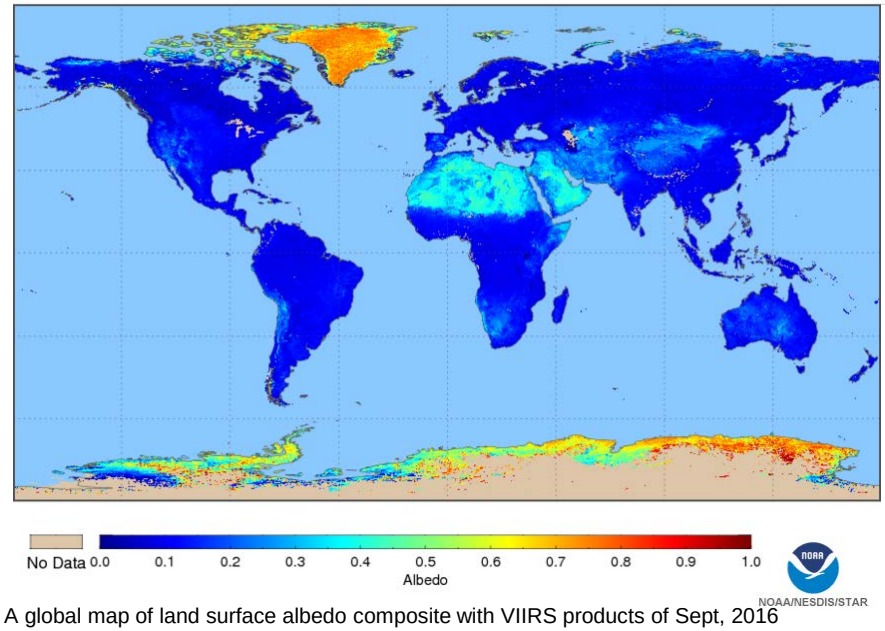
- Investigators from CAS used sophisticatedly-designed spatial sampling technique to address issues of spatial scaling in validating coarse spatial resolution LSA products
- Validation results suggested superior quality of VIIRS data.

VIIRS LSA Long-term Monitoring

Developed a long-term monitoring tool

- Automatically validate against field measurements;
- Generate global composite maps on a regular basis ;
- Send alerts when abnormal results occurs;
- Update maps through WWW
- http://www.star.nesdis.noaa.gov/jpss/EDRs/products_Albedo.php





A global map of land surface albedo composite with VIIRS products of Sept, 2016

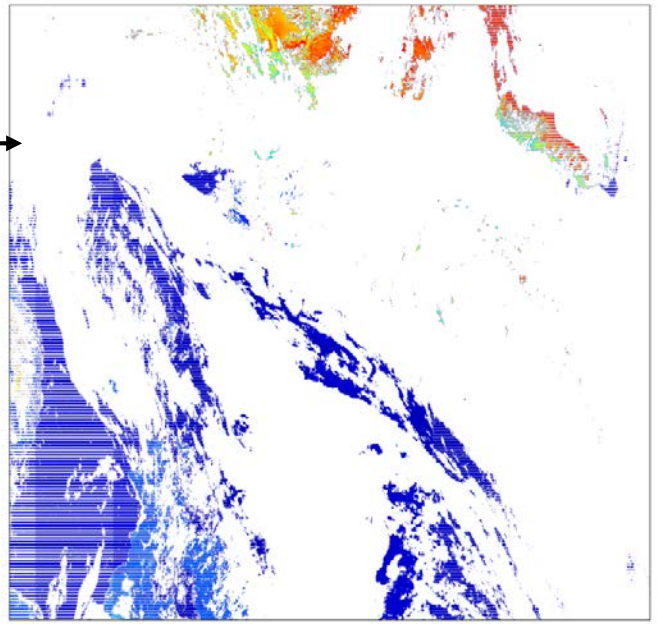
Issues of IDPS LSA Granule Product

- Issues of the current IDPS granule LSA algorithm:
  - Missing values
    - Current product: granule instantaneous, for clear-sky pixels only
  - Intraday residual variations
    - A direct estimation method is used for VIIRS to capture LSA variations of rapidly-changing surfaces.
    - Meanwhile, the albedo retrieved from a single observation may contain some levels of random noises.
  - Un-gridded product
    - End users need gridded product with common map projection.

Issues of IDPS LSA Granule Product: Illustration

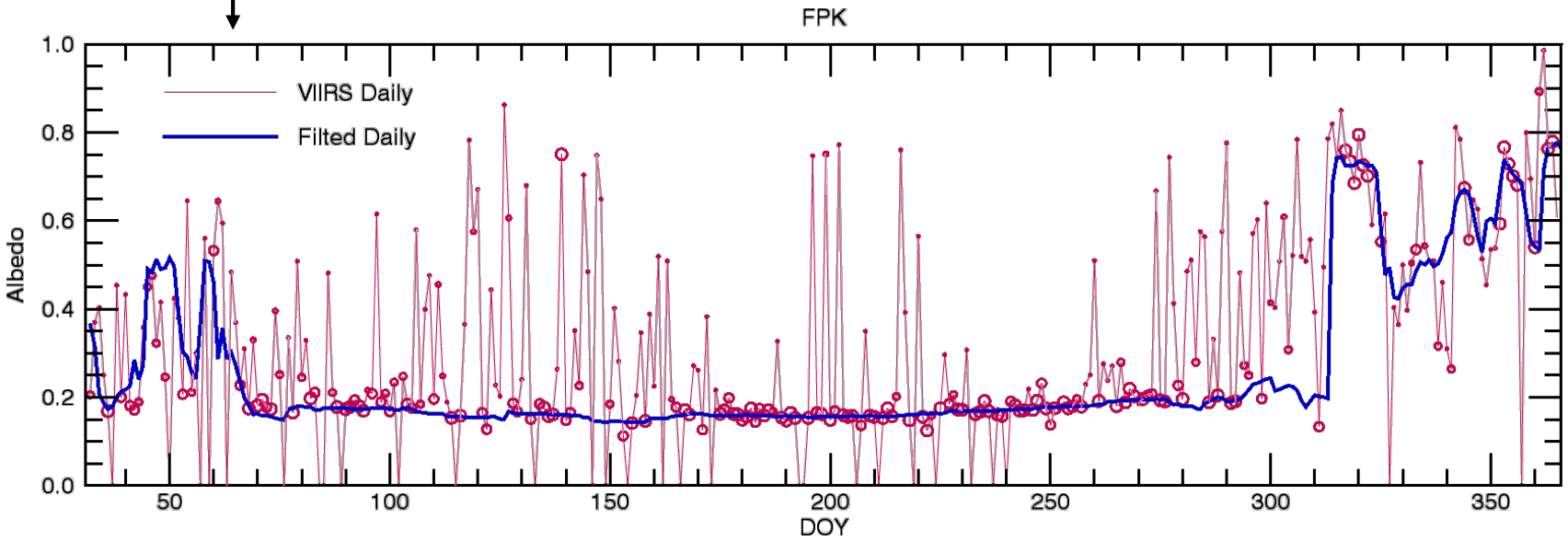
Features of current algorithm
- Using single overpass
- Needing clear-sky pixels

→ Data gaps →



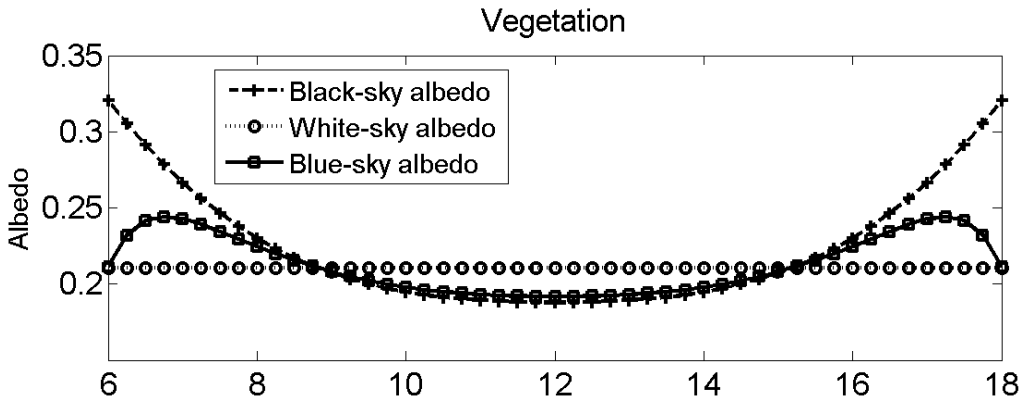
↓ Residual noise

↘ Possible multiple values for a day

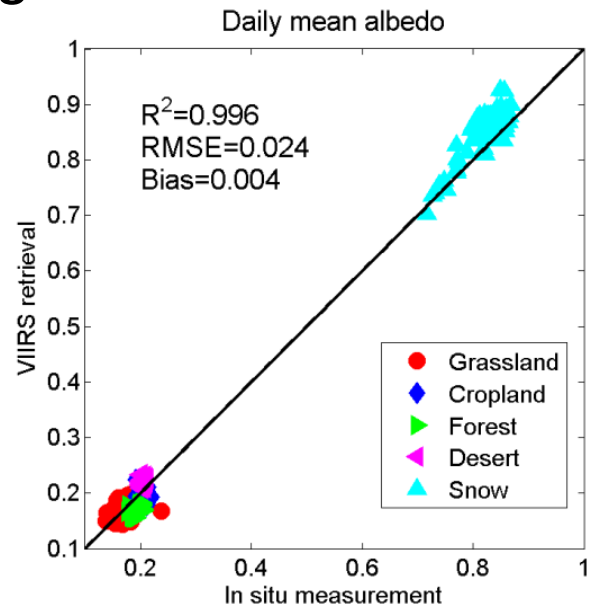


New Method for Daily Mean Albedo

- Use of instantaneous albedo to calculate daily surface radiation budget may result in ~10% bias.
- We developed a method to estimate daily mean albedo directly from VIIRS data.
- The new method uses similar LUTs of regression coefficients, but considers variations of albedo and diffuse radiation ratio with solar angles.

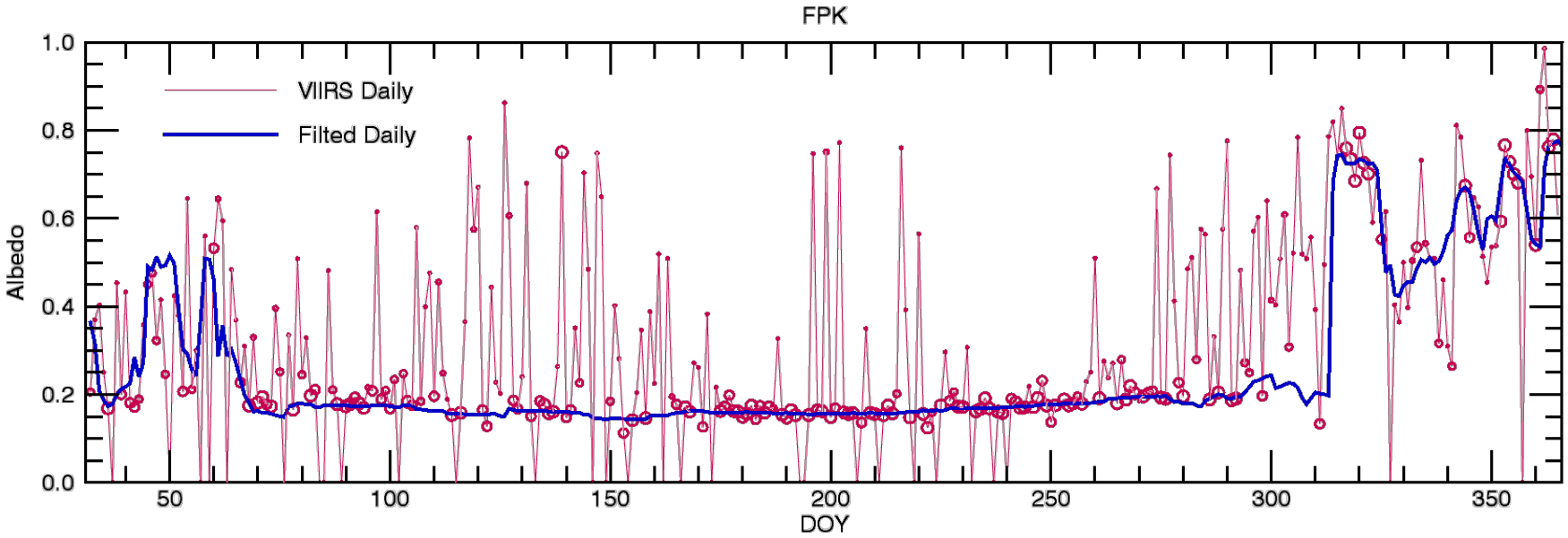


Wang et al. 2015, JGR;
Wang et al. 2017, TGRS



Advanced Statistics-based Temporal Filtering

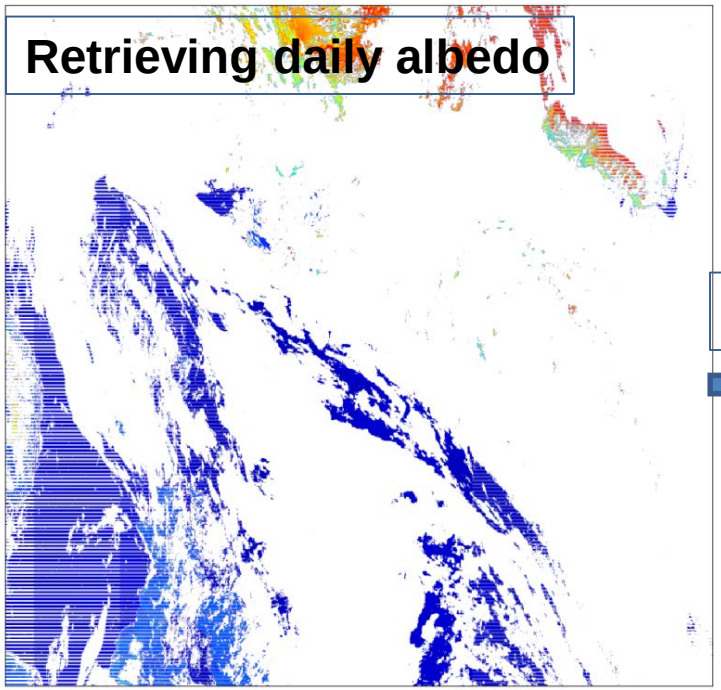
- Temporal filtering is a key step of the NDE LSA algorithm:
  - Improve accuracy
    - Reduce temporal variations
    - Exclude undetected cloud and shadow
  - Fill data gaps
- A sophisticated statistical based filtering approach was developed
- Capable of integrating multisource of information
  - VIIRS retrieval and its QF
  - Climatology (mean and variance)
  - Temporal correlation (historical observation)



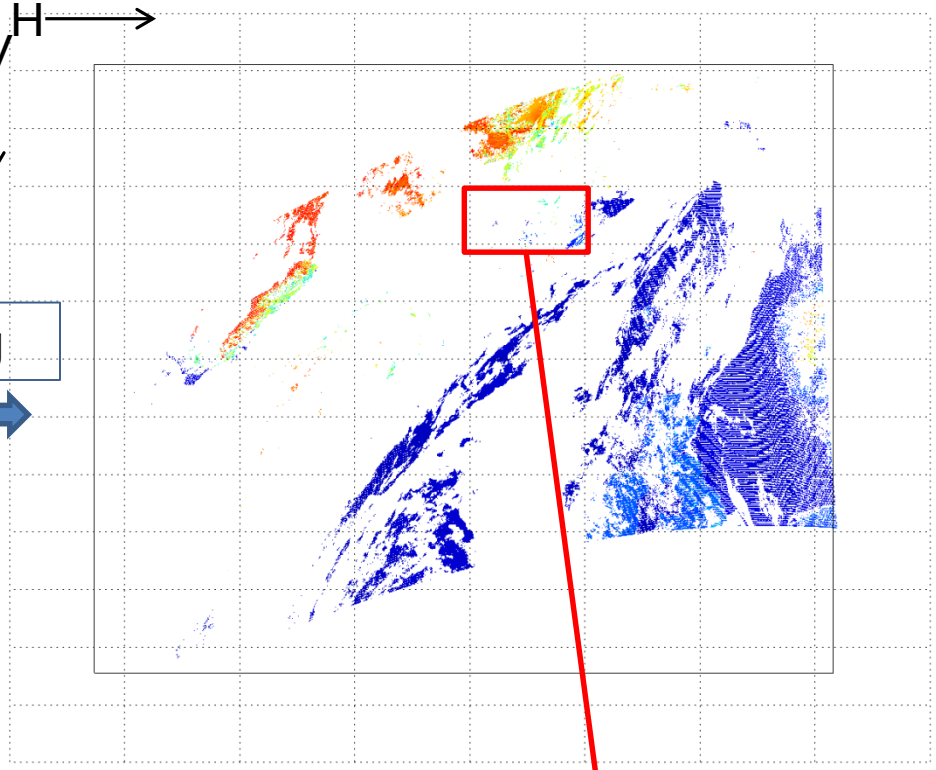
Developing Gridded NDE LSA Product

- We developed a new high-level LSA product on the basis of VIIRS SA EDR, which has the following features:
  - Gap-filled
  - Noise-reduced
  - Having potential of generating gridded product, which is desired by user community.
- The software package in C programming language has been delivered.
  - C source codes
  - LUTs
  - Climatology data
  - Documents
- Improved Granule LSA product in NDE
  - **Critical Design Review** was passed in **Sept. 2016**.
  - **Test Readiness Review** is scheduled for **August 2017**.

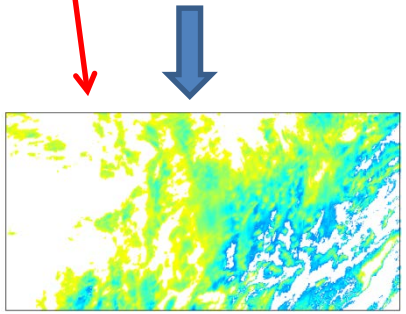
Major steps of generating NDE LSA



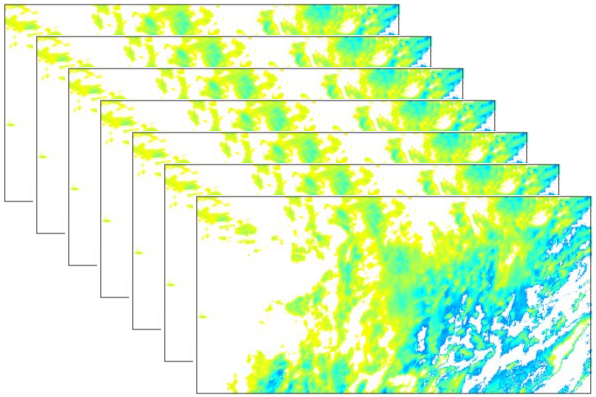
Gridding



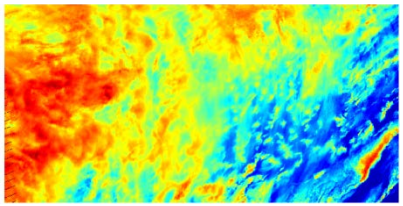
Cutting into tiles



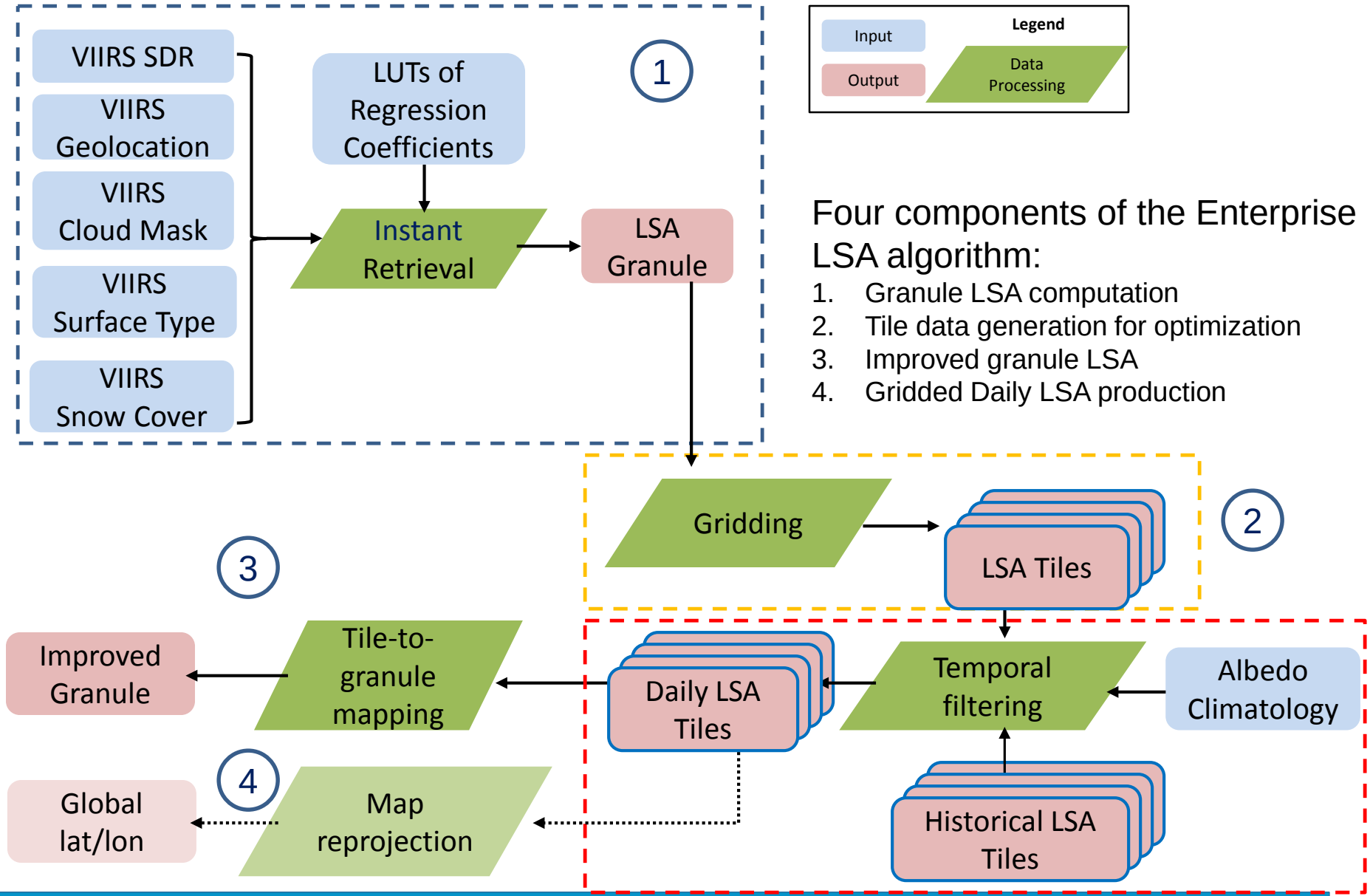
Preparing time series



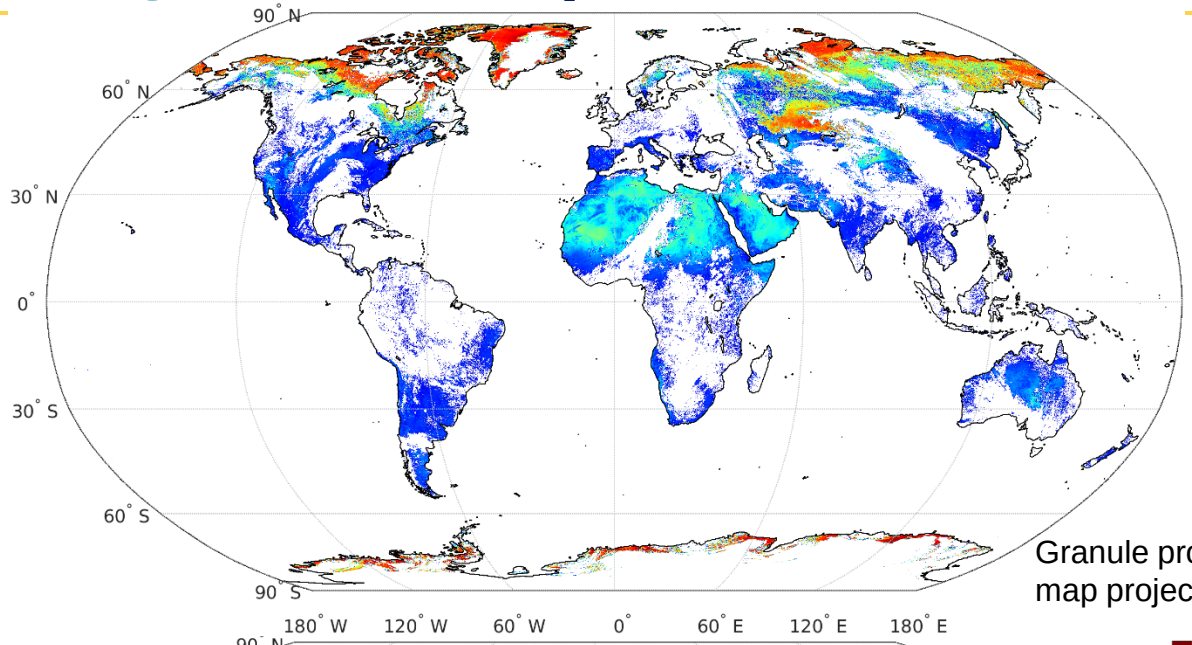
Temporal filtering



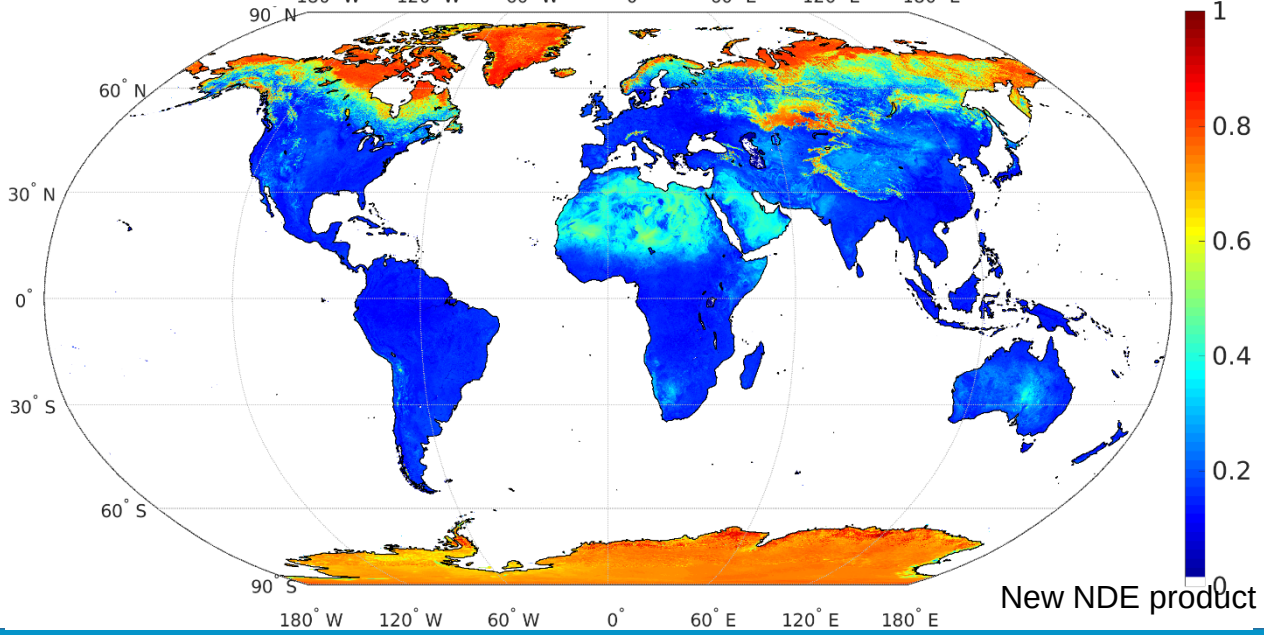
Enterprise Algorithm Development



Example of NDE Gridded LSA



Granule product after map projection

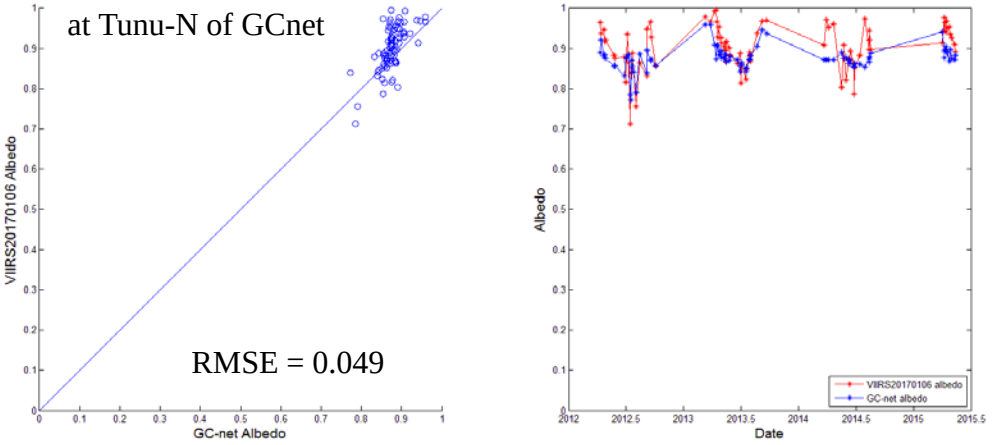


New NDE product

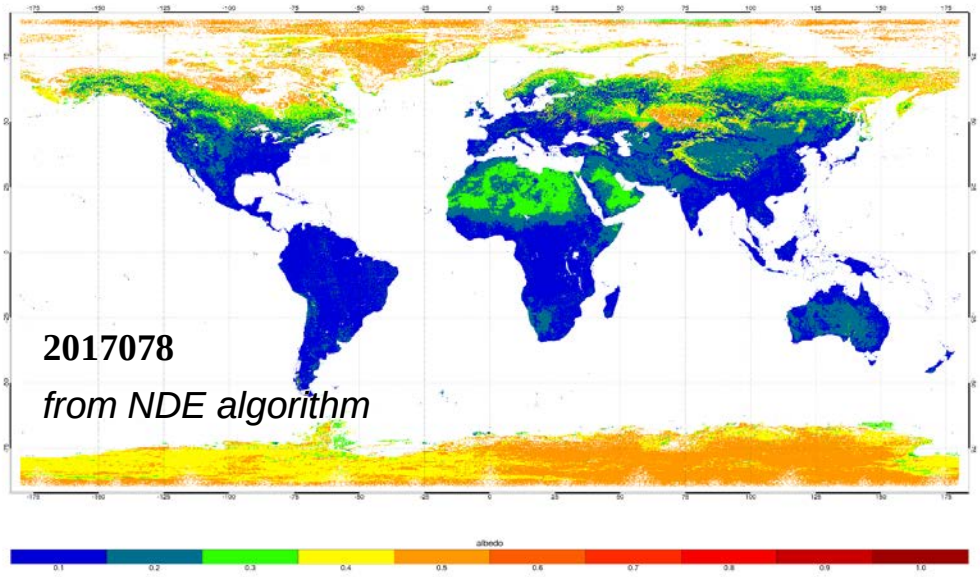
- Two global products of VIIRS LSA on April 1 2015 were shown here.
- Compared to the current granule product, the newly-developed NDE product represents several substantial major improvements:
  - Gap-filled: continuous map
  - Noise-reduced: higher accuracy
  - Gridded: ready to user

Update to Sea Ice Surface Albedo Algorithm

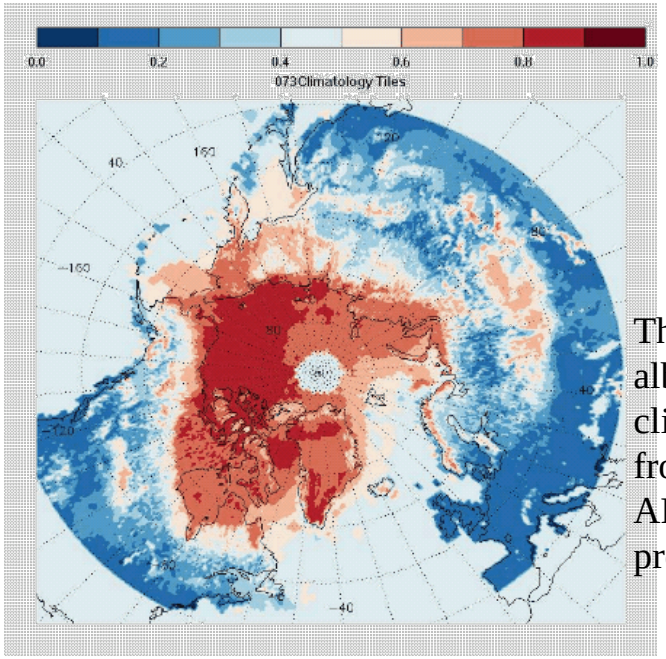
- We applied a new sea-ice albedo LUT in NPP VIIRS albedo calculation. The sea-ice albedo become available in the NDE LSA product. The coverage is consistent with the sea ice concentration product.
- We generated a 5-km daily sea-ice albedo climatology and used it as background information for temporal filtering of sea-ice albedo.



Comparison between VIIRS sea-ice albedo and GC-net albedo

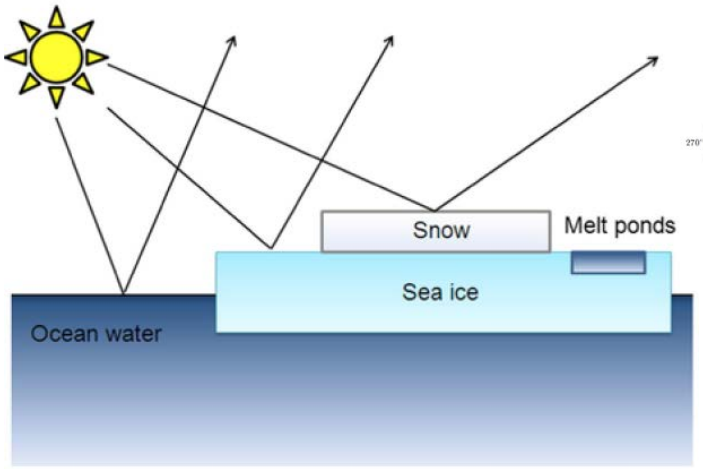


global albedo map (sea-ice included)



The sea-ice albedo climatology from AVHRR APP-x albedo product

Continued Improvement of Sea Ice Surface Albedo



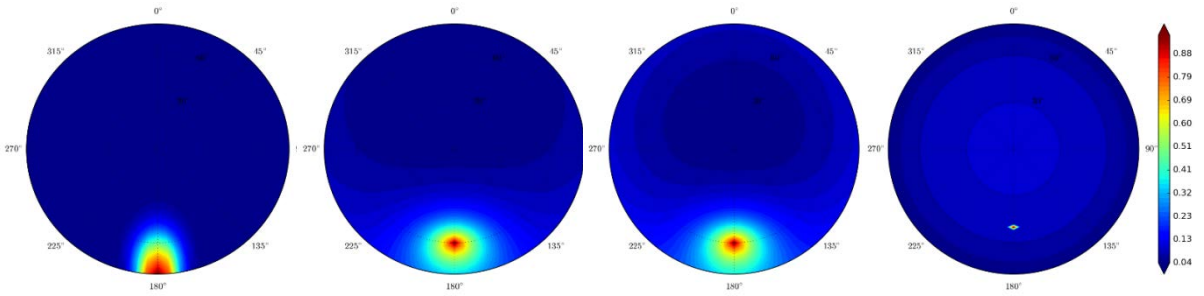
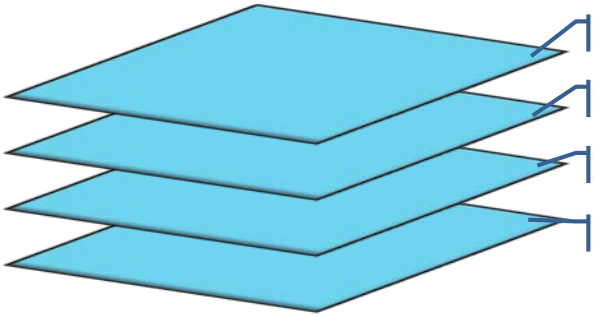


Figure Examples of BRDFs of sea water (a), snow (b), ice (c), pond (d) at 672nm (blue band) and 60˚ SZA.

component models

For further improvement the VIIRS sea-ice albedo LUT, we are working on enhancing the representativeness of the training data by building a spatio-temporal representative sea-ice BRDF database. The Ice concentration, Snow fraction and Snow parameters would be deployed as knowledge database for BRDF simulation and compositing.



parameters and compositing weight

Sea-ice BRDF database

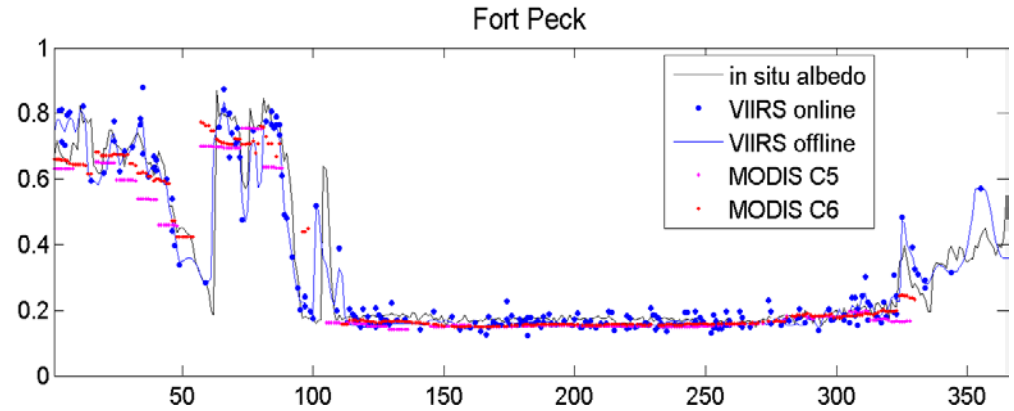
Atmospheric simulation

regression

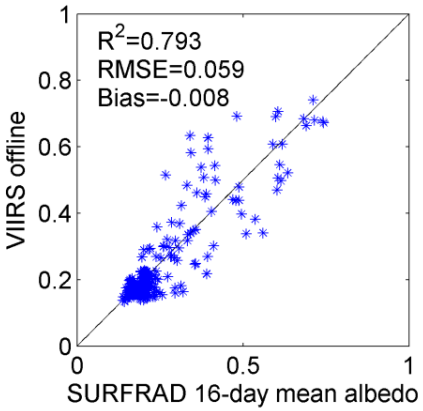
Improved sea-ice LUT

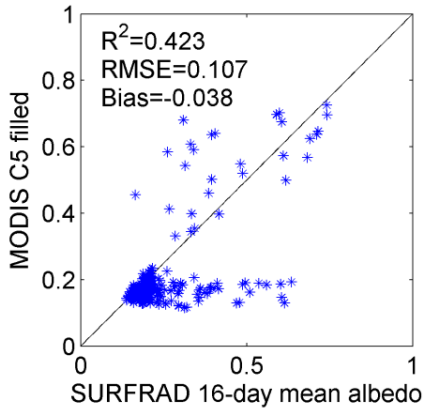
Validation of NDE LSA data

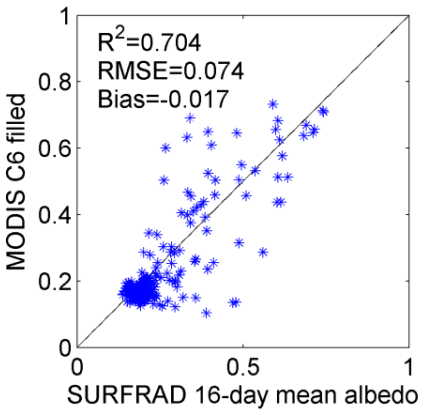
- The new NDE albedo was validated using field measurements and inter-compared with other albedo products.
- Preliminary assessment results suggested substantial improvement over existing datasets:
  - Gap-free continuous data
  - Higher accuracy:
    - Snow-covered and snow-free
    - Better prediction over ethereal snow cases

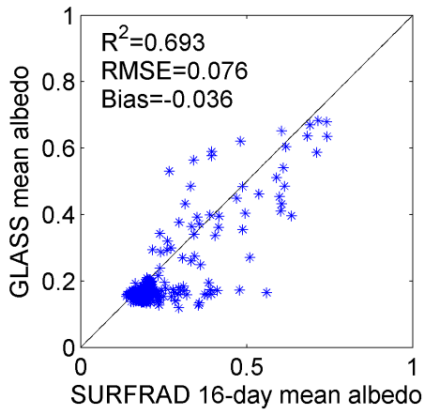


Example of time series of one year VIIRS NDE albedo at Fort Peck









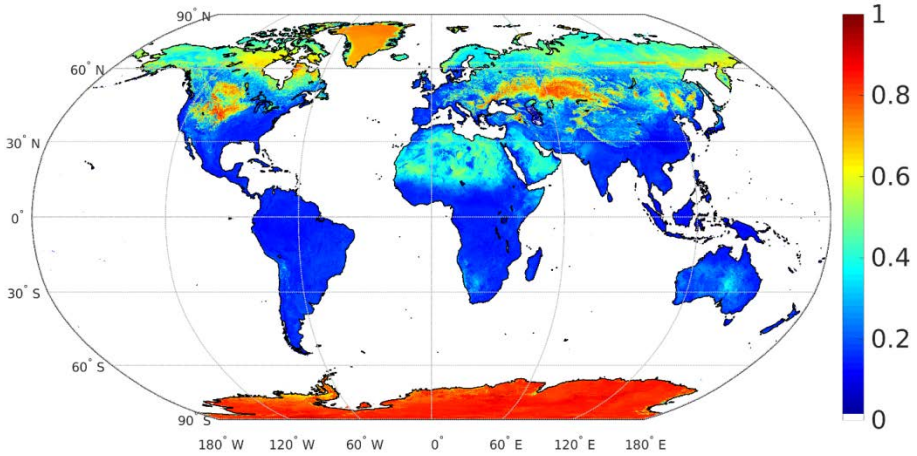
Comparison of snow-free and snow-covered VIIRS albedo with gap-filled MODIS C5 and C6 data, and GLASS albedo data

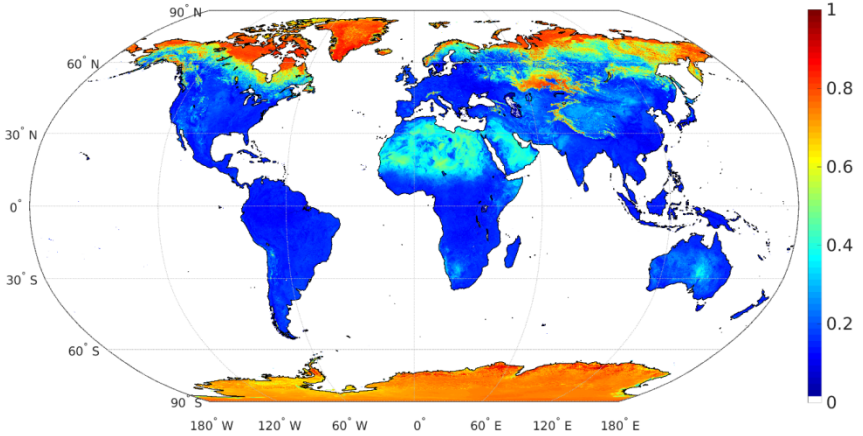
External Users of Albedo Product

- **U. S. Users:**
  - NOAA National Weather Service Environmental Modeling Center (Michael EK, Jesse Meng, Weizhong Zheng)
  - USDA Agricultural Research Services(Martha Anderson)
  - USDA Forest Service (Brad Quayle)
  - NOAA/NESDIS Center for Satellite Applications and Research (Jerry Zhan)
  - NOAA/NESDIS National Climate Data Center (Peter Thorne)
  - Academy -- University of Maryland (Konstantin Vinnikov, Shunlin Liang, Cezar Kongoli)
  - Army Research Lab (Kurt Preston)
- **Foreign Users**
  - EUMETSAT (Yves Govaerts)
  - Météo France (Jean-Louis Roujean)
  - Academy: Italy IASMA Research and Innovation Centre (Barbara Marcolla), Beijing Normal University (Qiang Liu)

Collaboration with EMC/NCEP Team

- The new gridded, gap-filled, noise-reduced product is developed to meet the requirements of modeling team and data analysis.
  - Working with the modeling team to test the application of new product
  - Customized the codes to generate tailored data sets.





Examples of albedo data customized for modeling team

Summary

- Accuracy of the current non-snow LSA retrievals are smaller than the L1RD threshold. The performance of snow LSA is also comparable (slightly better) than the existing albedo product, although RMSE of current snow retrievals are greater than the precision requirement.
- An improved NDE albedo product was developed.
- Initial evaluation suggested this new gridded, gap-filled, noise-reduced NDE product represent substantial improvements over previous granule product and other existing products.
- LUT of retrieving sea ice surface albedo was updated.
- Additional maintenance and further algorithm refinement is critical to assure the production of high-quality gridded LSA product.

Future Plans/Improvements

- Land-cover-specific LUT will further improve quality of albedo retrieval.
- Enterprise LSA development: TRR and ARR preparation
- Reprocessing LST data when the upstream data are ready.
- JPSS-1 LSA product evaluation and monitoring
- Level-3 gridded data production
- Further interactive with EMC/NCEP model team: intensive LSA model assimilation

JPSS LAND SUFACE TEMPERATURE EDR

Yunuye YU
NOAA/NESDIS/STAE
Yunyue.yu@noaa.gov

Yuling Liu, Peng Yu, Heshun Wang
UMD/CICS

Outline

- Cal/Val Team Members
- JPSS LST Production
  - Algorithm/Product Overview
  - Algorithm Improvement
- Validation and Monitoring
- S-NPP LST reprocessing
- JPSS-1 Readiness
- Gridding LST product development
- External Cooperation
- Summary and Path Forward

Cal/Val Team Members

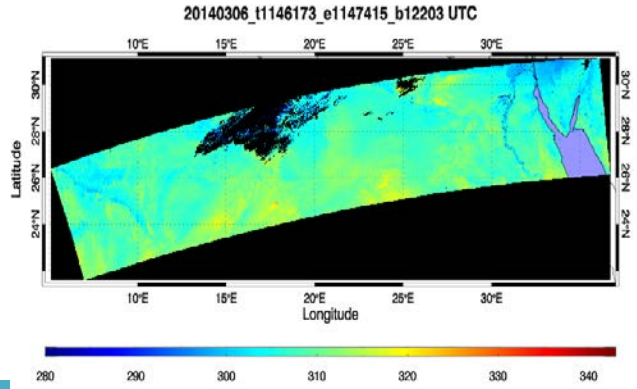
PI	Organization	Team Members	Roles and Responsibilities
Ivan Csiszar	NOAA/NESDIS/SATR		Land Lead, Project Management
Yunyue Yu	NOAA/NESDIS/SATR		LST Lead, algorithm development, validation, user promotion, team management
	NOAA Affiliate, UMD/CICS	Yuling Liu	product monitoring and validation ; algorithm development
	NOAA Affiliate, UMD/CICS	Heshun Wang	algorithm improvement, emissivity development
	NOAA Affiliate, UMD/CICS	Peng Yu	product validation, monitoring tool
Walter Wolf	NOAA/NESDIS/SATR		STAR ASSIST Lead, System Integration/transition
		Valerie Mikles	System Integration, Transition
Michael Ek	NOAA/NCEP/EMC		Model application Lead
		Weizhong Zheng	User readiness : Model albedo application, verification
		Yihua Wu	User readiness : Model albedo application, verification
Miguel Roman	NSAS/GSFC		NASA Land Science Investigator-led Processing System Lead
		Sadashiva Devadiga	System support, product monitoring

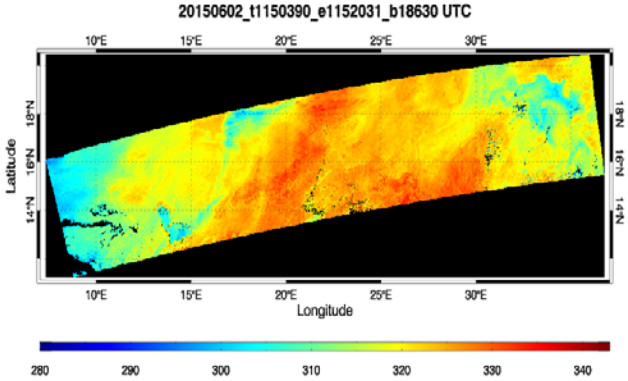
VIIRS LST Algorithm Overview

IDPS LST Algorithm

$$LST_{i,j} = a_0(i,j) + a_1(i,j)T_{11} + a_2(i,j)(T_{11} - T_{12}) + a_3(i,j)(\sec\theta - 1) + a_4(i,j)(T_{11} - T_{12})^2$$

Where a_k (with k=0 to 4) are coefficients depending on surface type (with i =0 to 16 for 17 IGBP surface types) and day/night condition (with j=0 to 1), and θ is satellite viewing zenith angle.

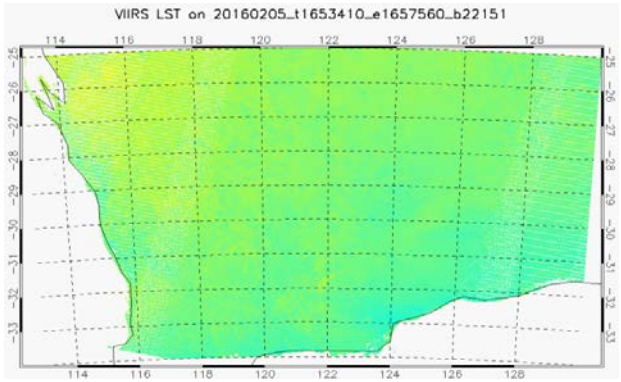


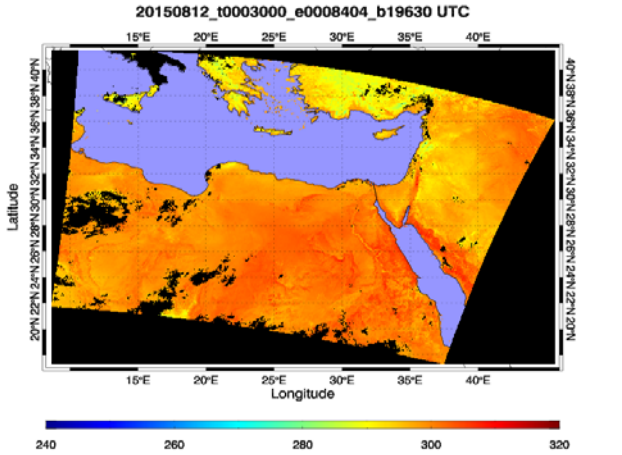


Enterprise LST Algorithm

$$T_s = A_0 + A_1T_{11} + A_2(T_{11} - T_{12}) + A_3\varepsilon + A_4\varepsilon(T_{11} - T_{12}) + A_5\Delta\varepsilon$$

Where A_k (with k=0 to 5) are coefficients stratified by day/night, viewing angle and precipitable water vapor. ε and Δε are the mean and difference of the spectral emissivity of the two split windows. T_{11} and T_{12} are brightness temperature at 11μm and 12 μm .





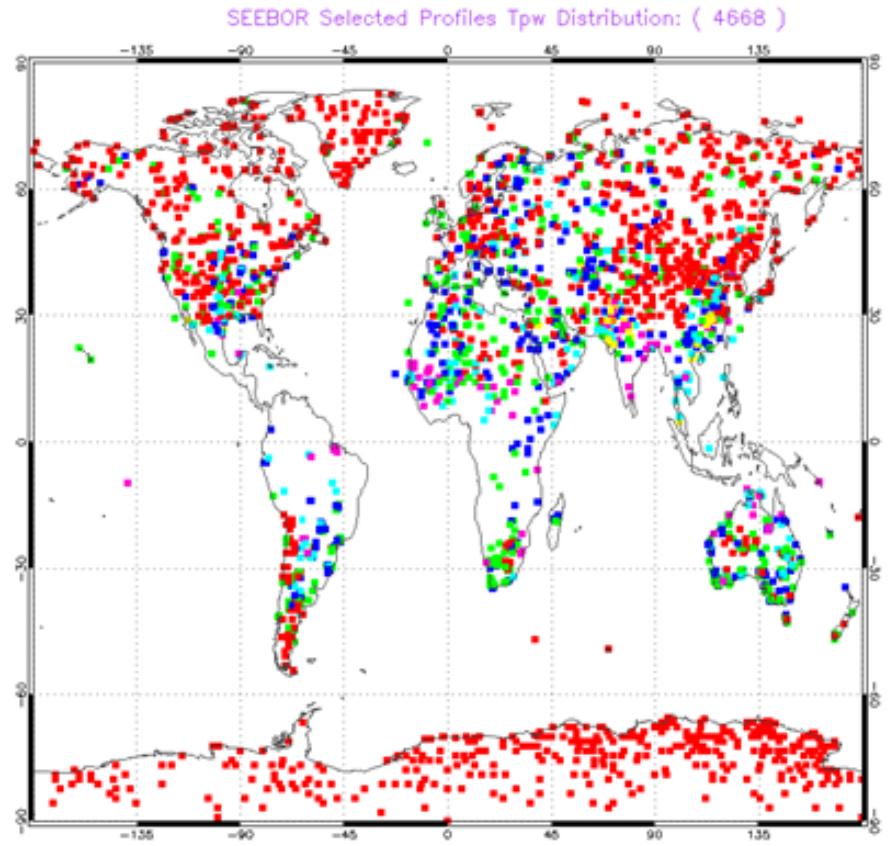
Improvement: Enterprise Algorithm Status

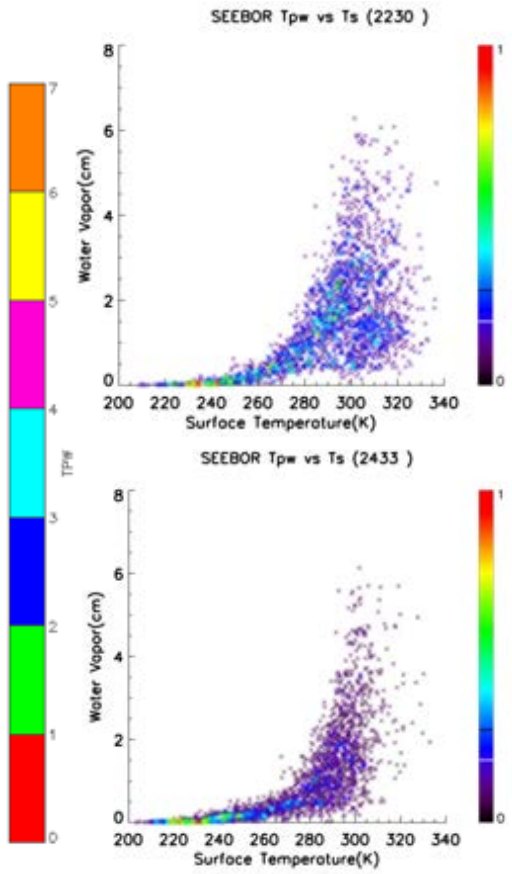
- Enterprise LST algorithm is ready for implementation
  - Algorithm test, uncertainty and sensitivity analysis has been performed
  - Consistent quality flags
  - Preliminary tests using real satellite data from multiple sensors including VIIRS, MODIS, AHI and SEVIRI have been conducted.
  - Preliminary validation with in-situ observations from SURFRAD, BSRN, ARM and GMD, and cross satellite comparisons using the above satellite data.
- The enterprise LST algorithm has gone through the critical design review; test readiness review will be conducted by Aug 24th.
- The DAP files are ready to deliver, which includes the science code, test data, LUT, configuration file, input and output I-O structure etc. The system integration is undergoing.
- The first version of the enterprise LST ATBD has been completed.

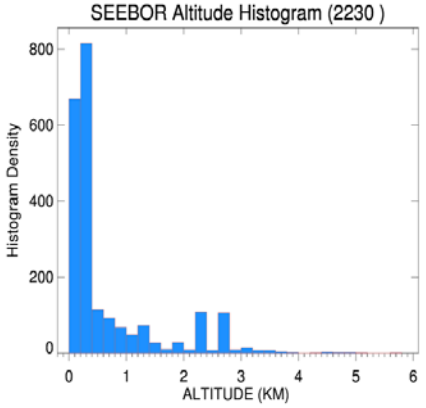
Improvement: Simulation Database

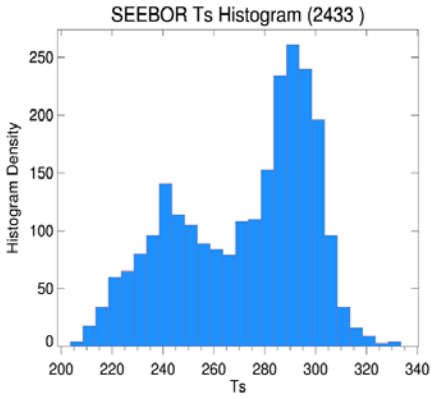
Improvements on the global representativeness of the simulation database with regard to the regional climate, water vapor range, elevation and seasonality etc.

- TIGR collection: v3.0, 2311 profiles in total
- SEEBOR collection: v5.0, 15704 profiles in total.



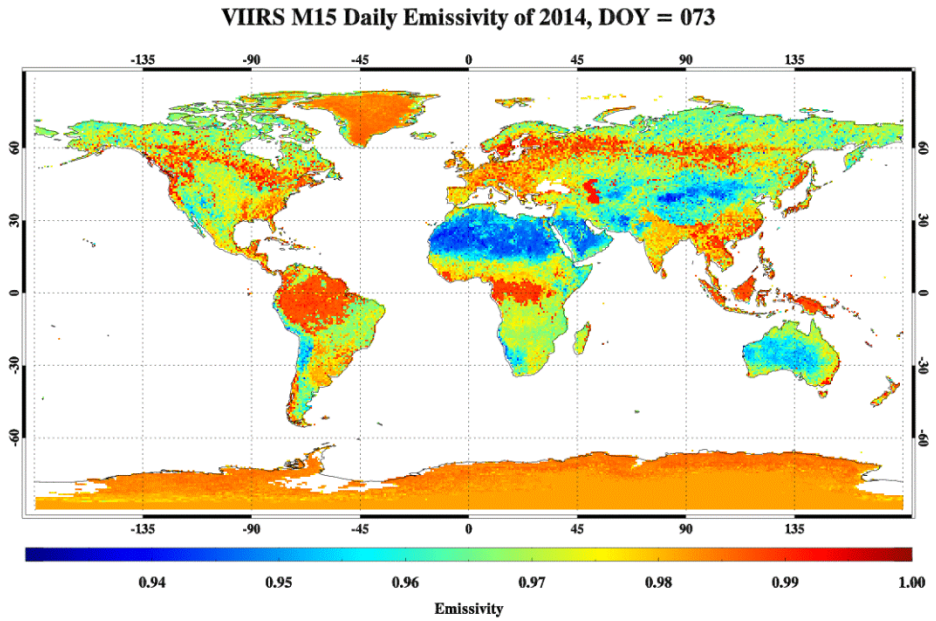


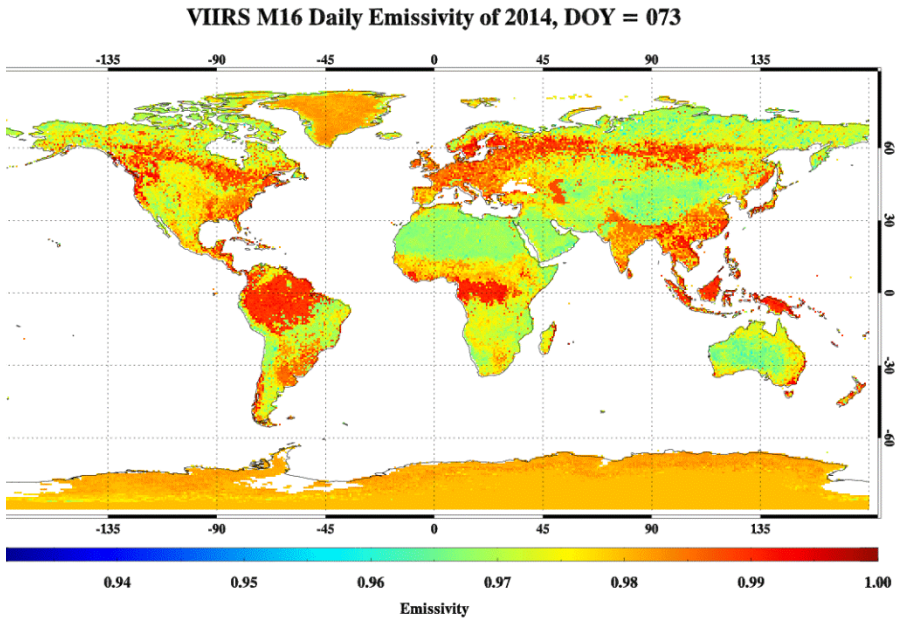




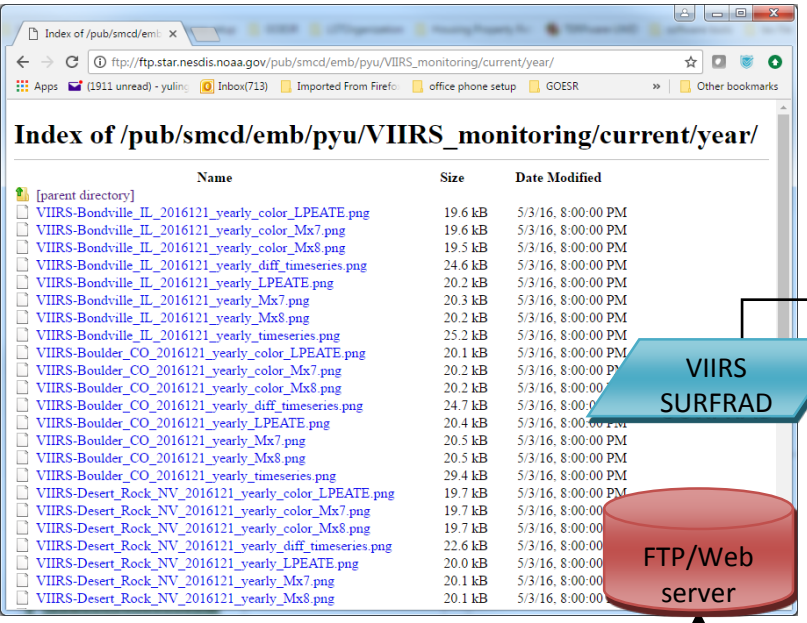
Improvement: Emissivity Data Development

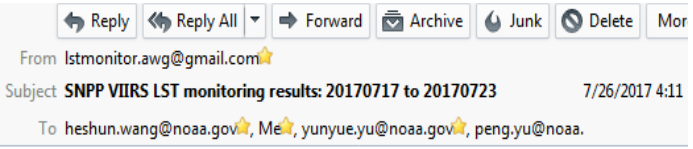
- **Emissivity algorithm is developed and implemented**
  - Using historical emissivity products to generate background emissivity climatology.
  - Employing a relationship between emissivity and GVF & Snow fraction to account for dynamic change.
  - Produce high resolution (0.009 degree) daily emissivity product for JPSS mission, and GOES-R mission as well.





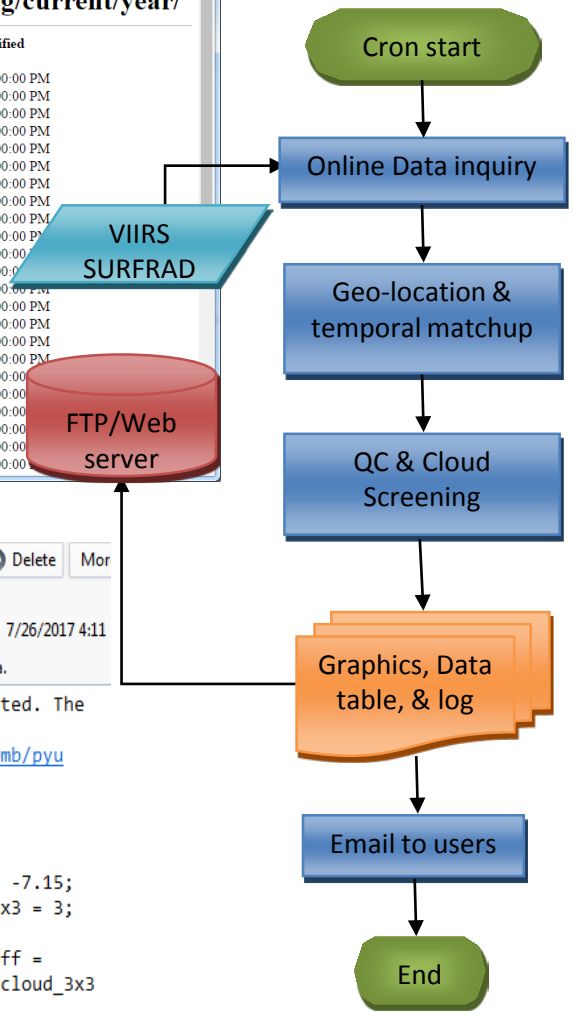
Long Term Monitoring: ftp links

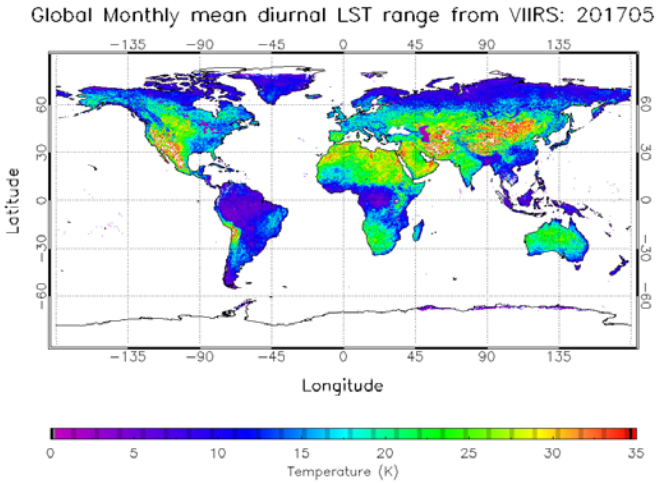


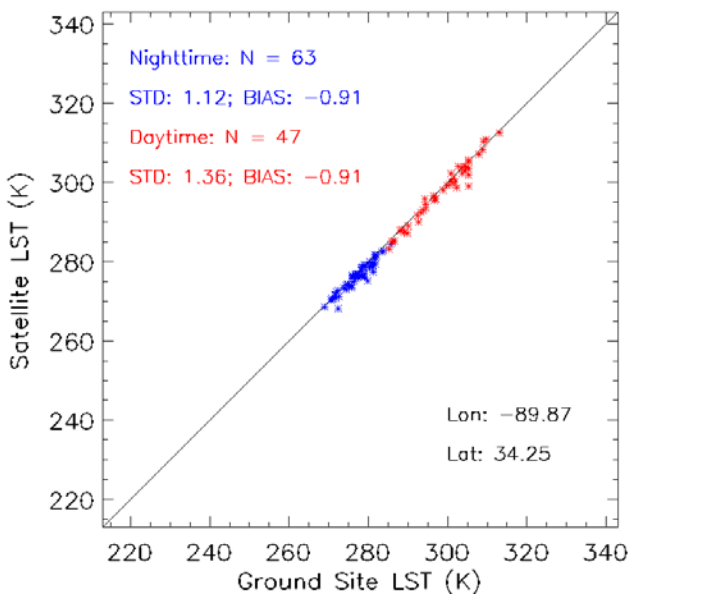


The LST monitroing task for SNPP VIIRS has been completed. The period for monitoring is 20170717 to 20170723.
Please visit ftp://ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/LTM/single/SNPP_VIIRS/site/ for detailed results.

44 valid data paris have been found.
Some problems have been found and listed as follow:
Bondville_IL: date = 20170717; time = 1929; lst_diff = -7.15; lst_sat = 298.72; lst_gnd = 305.87; cloud = 1; cloud_3x3 = 3; std_bt11_3x3 = 3.22; std_dwt_site = 4.00;
Goodwin_Creek_MS: date = 20170720; time = 1831; lst_diff = -6.80; lst_sat = 302.27; lst_gnd = 309.07; cloud = 0; cloud_3x3 = 3; std_bt11_3x3 = 3.21; std_dwt_site = 3.55;

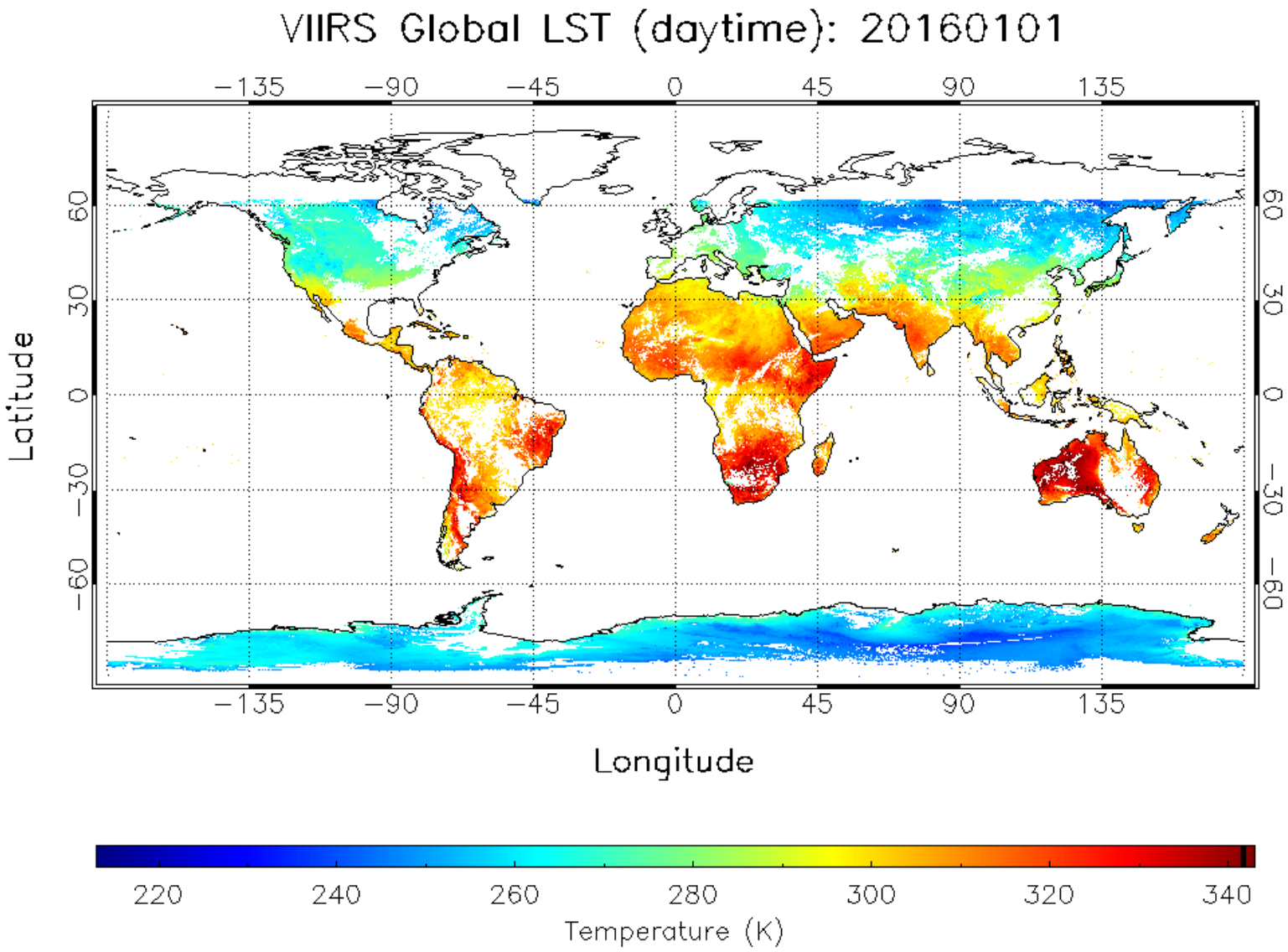




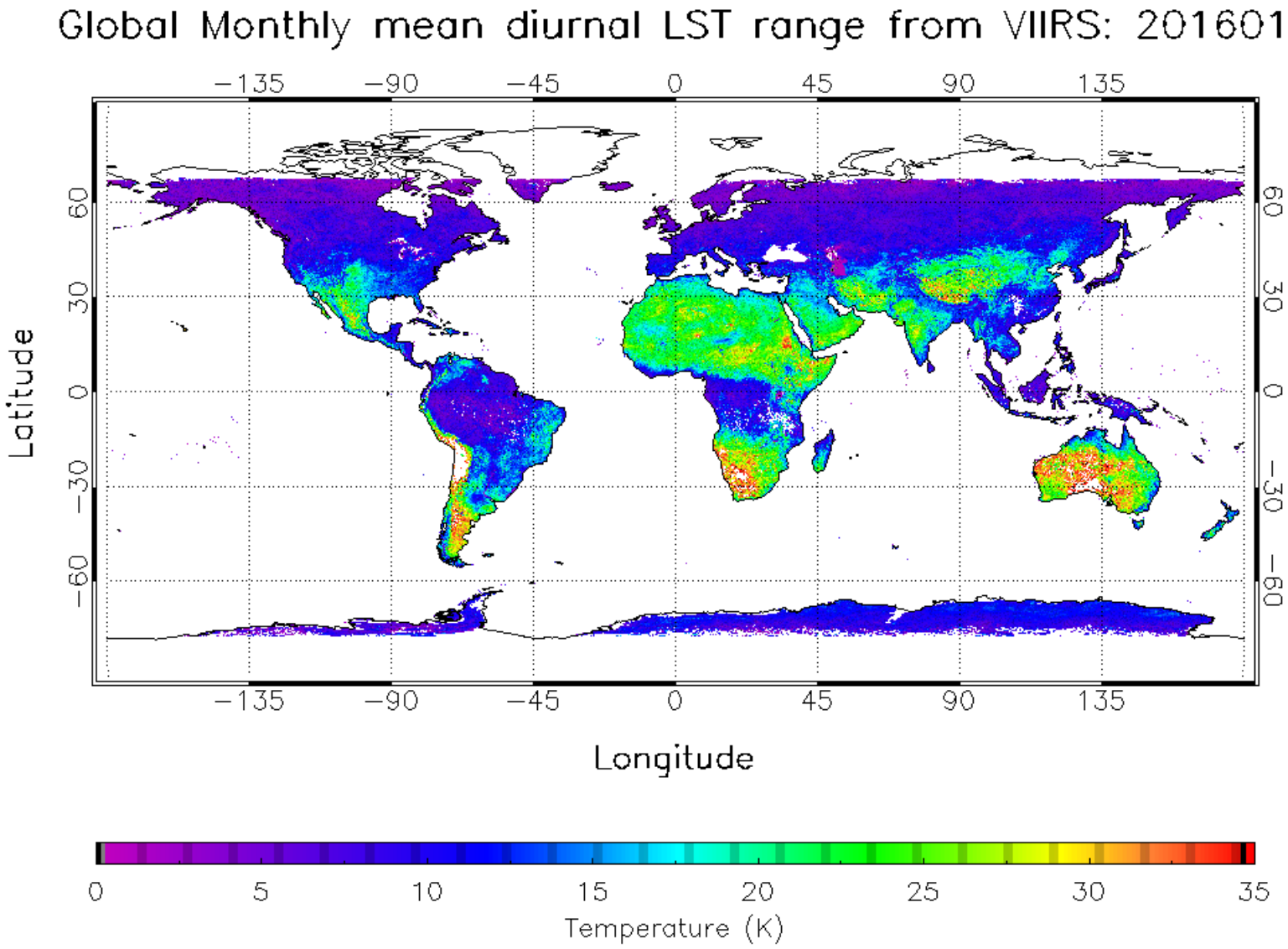


ftp://ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/VIIRS_monitoring/current/year/

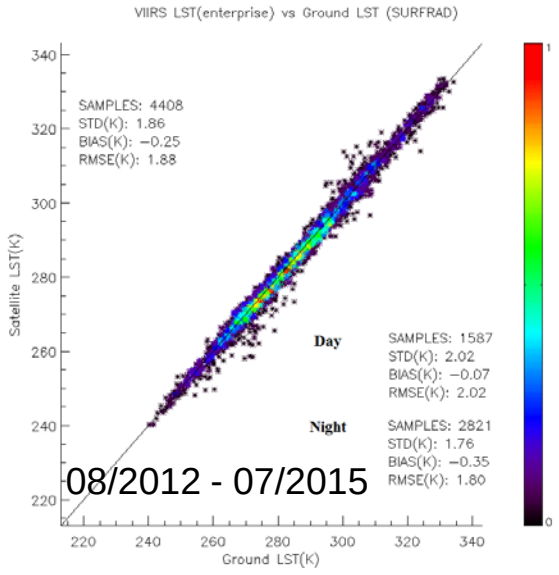
Long Term Monitoring : Global VIIRS LST

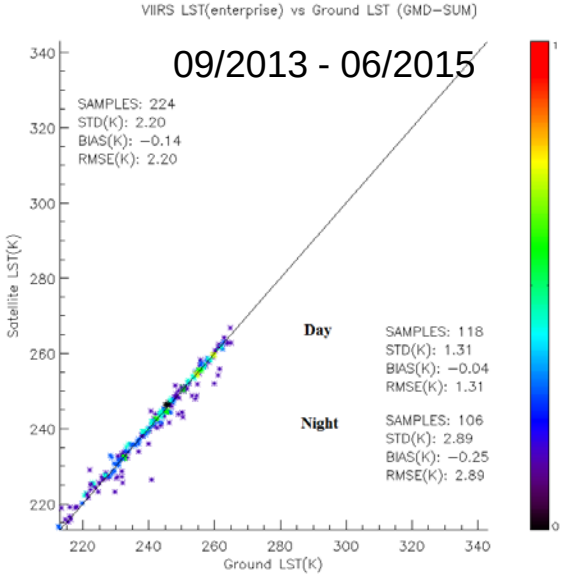


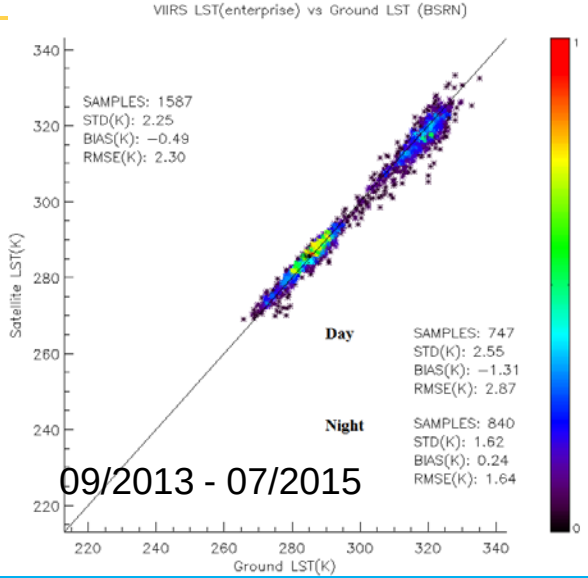
Long Term Monitoring : Monthly Diurnal LST Range



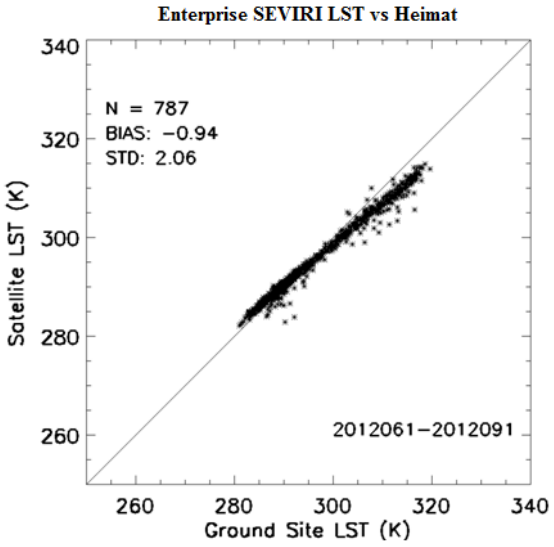
Validation and Evaluation

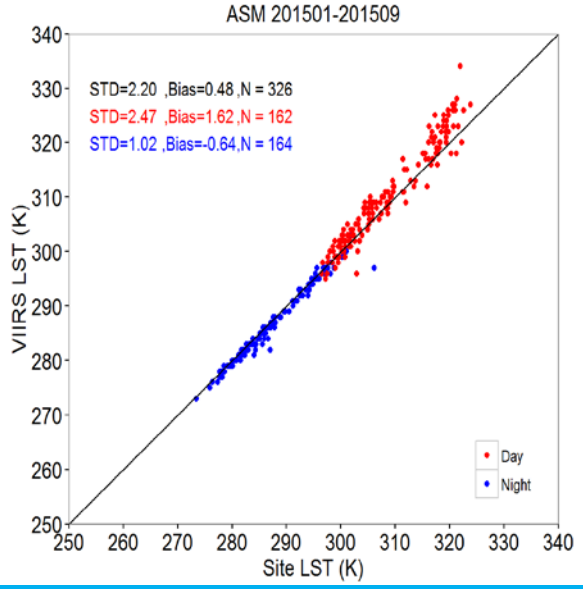


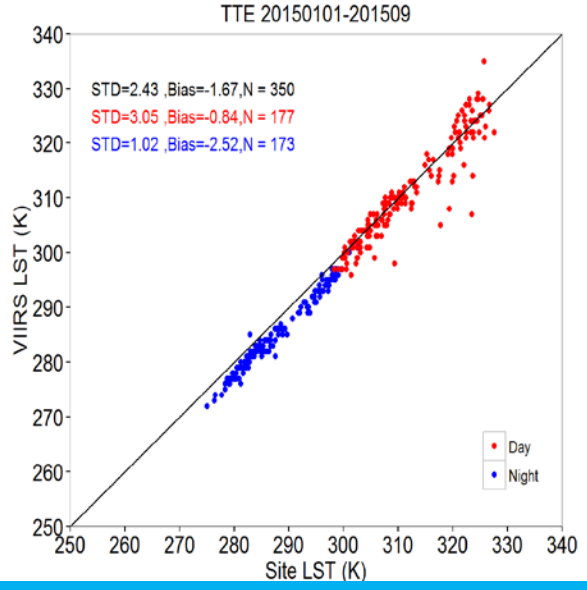




Enterprise VIIRS LST against ground data from SURFRAD, BSRN and GMD







Enterprise SEVIRI and VIIRS LST against ground data from KIT(left) and OZFlux(Middle and Right)

Reprocessing Status

- Investigated three weeks of reprocessed SDR data and its impact on LST product.
  - Investigation results have been presented in the reprocessing workshop
  - The brightness temperature of the band 15 and band 16 and geometry data are investigated and the statistics of the difference between the reprocessed SDR and the operational SDR are summarized.
  - It is found that the reprocessed sdr data in 2012 will cause a significant LST change at local scale under specific time span.
- Reprocessing is planned for LST derived from the enterprise algorithm for the time period from 11/19/2012 to present.
- Based on the reprocessing of the upstream data: SDR, enterprise cloud mask and AOD and the availability of the ancillary data such as total precipitable water and snow/ice information .

JPSS-1 Readiness (1)

- Enterprise LST algorithm will be run at NOAA NDE system to replace the IDPS LST algorithm
  - Emissivity explicit algorithm
  - Consistent QC flags
  - Detail LUT dimension
  - Comprehensive evaluation and calibration
- Pre-launch Characterization
  - SNPP data serves as proxy for JPSS-1.
  - Simulation software package and database are updated for J-1 LST LUT generation
  - Calibration/validation/monitoring tools developed for SNPP are applicable for J1 mission
- Post-Launch Cal/Val Plans
  - In-situ validation: existing + new site data; domestic + international
  - Cross comparisons: S-NPP, MODIS, +Sentinel-3
  - Schedules and Milestones: based on the mission requirement

JPSS-1 Readiness (2)

- Major Risks/Challenges/ and Mitigation
  - The enterprise algorithm may not be able to run by Sept. 2017, as scheduled

    Mitigation: Current IDPS LST algorithm will be kept running before then
  - Availability of full resolution GVF data for the emissivity data generation

    Mitigation: full resolution GVF product is in development
  - Available water vapor data is in coarse resolution and forecast accuracy is unknown

    Mitigation: theoretical analysis of the water vapor uncertainty on LST quality
  - Limitation on emissivity data evaluation and monitoring

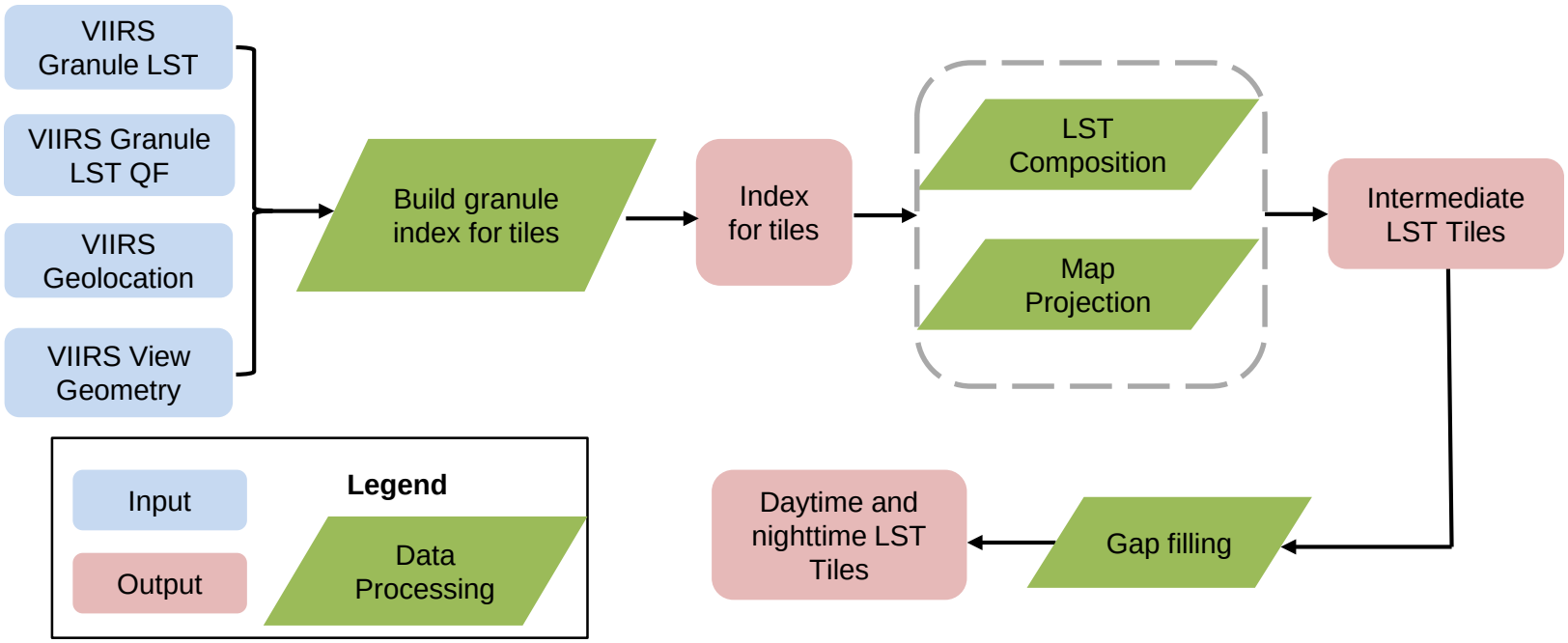
    Mitigation: limited in-situ validation; LST application ; LST monitoring tool for LSE
  - Lack of high quality, global validation data set.

    Mitigation: continue data collection through international cooperation;
  - Cloud contamination impact

    Mitigation: additional cloud filtering in deep-dive validation
- Collaboration with LST community and Stake Holders/User Agencies
  - Keep a close contact with ground data measurements providers for data quality issues and data stream anomalies
  - Provided technical support for user's questions in their applications.
  - Actively working with EMC/NCEP users and External Users

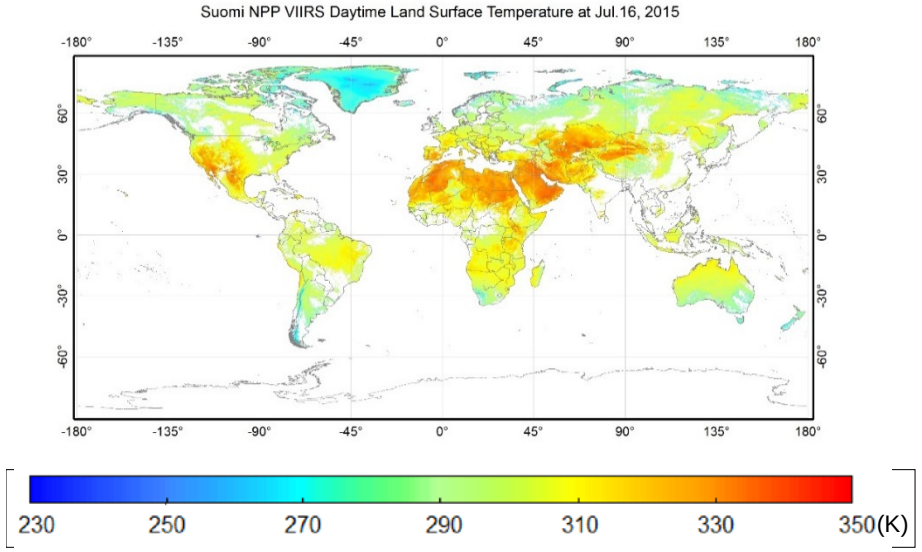
Gridded LST Development

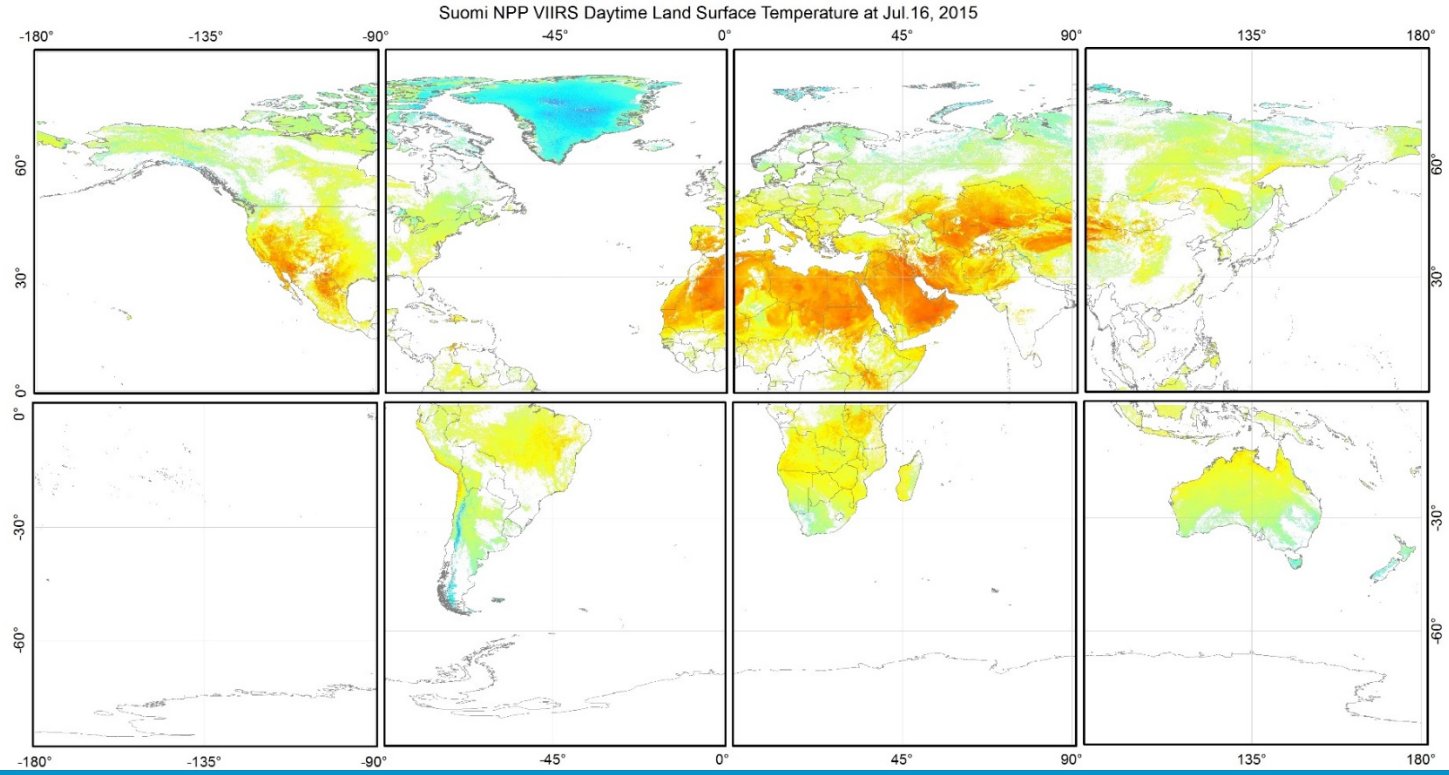
- From Users: a global continuous gridded LST product is required, in addition to the current granule LST data.
- An investigation was performed on developing a Level-3 VIIRS Gridded LST product, with intensive user interactions; major product features were determined:
  - Global coverage with two spatial resolutions: 0.009 degree and 0.036 degree
  - Gridded with tile system management
  - Gap-filled at invalid pixel (TBD)
  - Daytime and nighttime daily products.



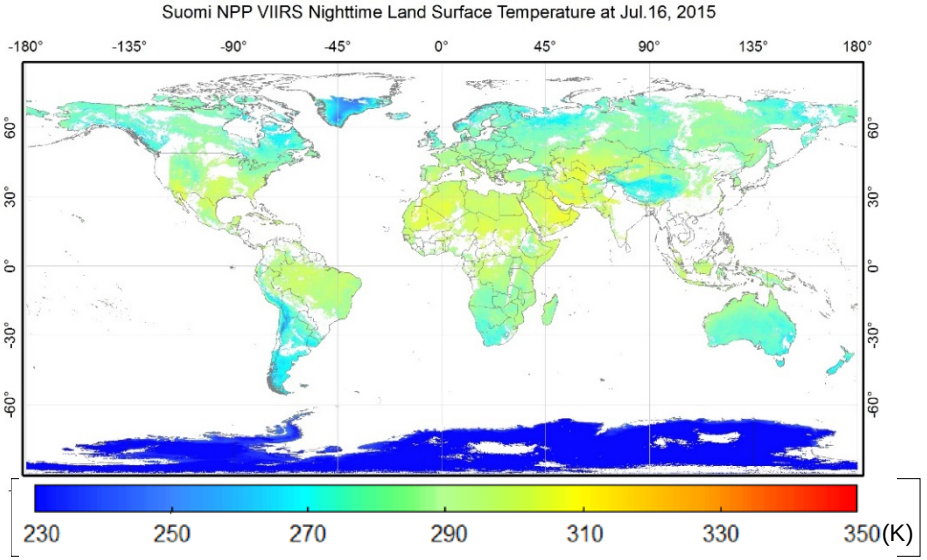
4km Gridded VIIRS Land Surface Temperature for daytime

1km Gridded VIIRS Land Surface Temperature for daytime
(4×2 tiles for globe)

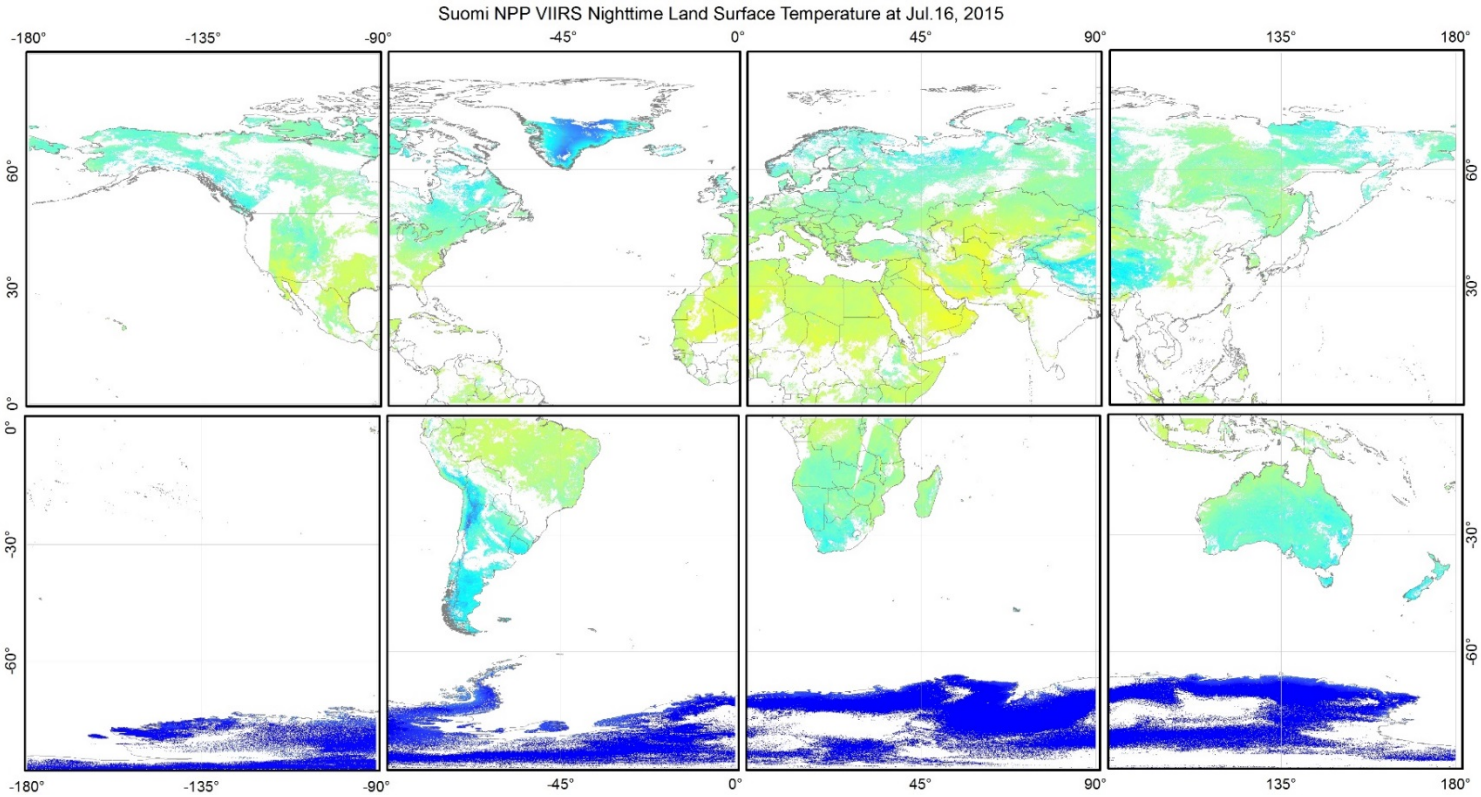




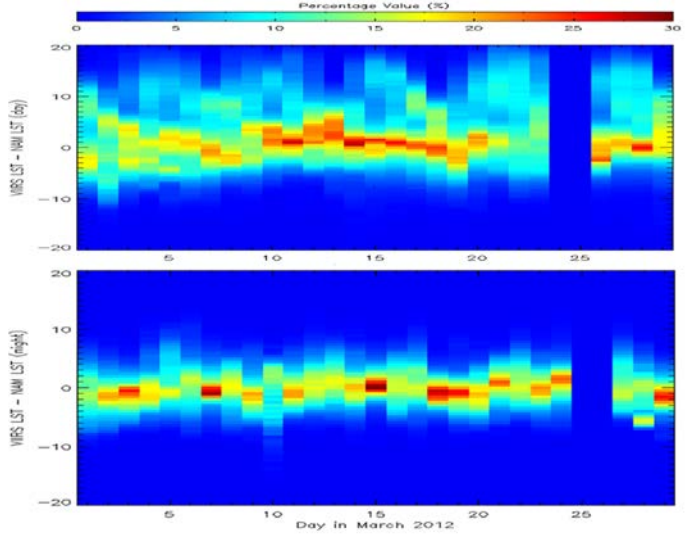
4km Gridded VIIRS Land Surface Temperature for nighttime



1km Gridded VIIRS Land Surface Temperature for nighttime
(4×2 tiles for globe)

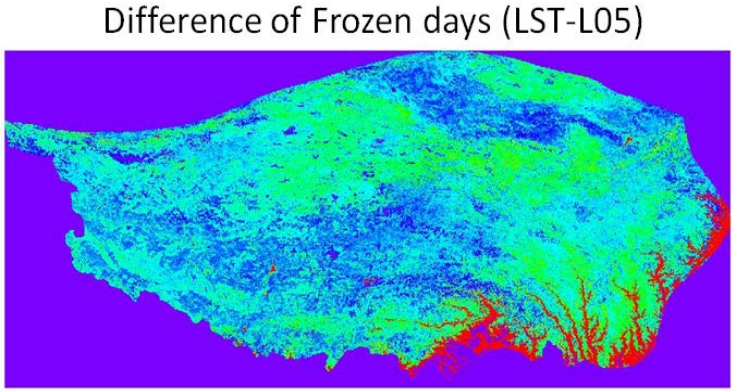


External Cooperation



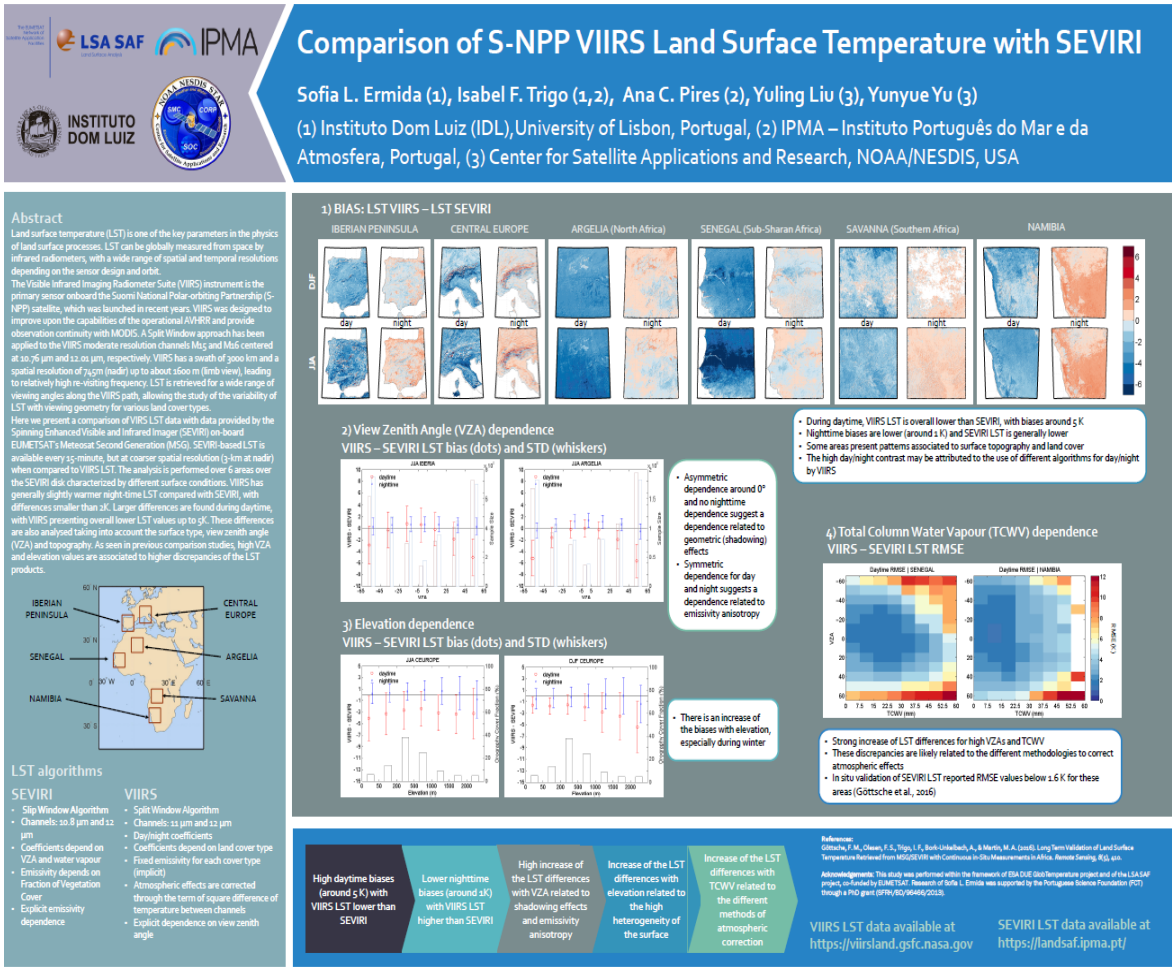
Above: Satellite LST is compared to the model LST output in time series

Bottom: VIIRS LST is used for the analysis of seasonal and diurnal cycle of freeze/thaw over Tibet Plateau area



Comprehensive VIIRS/LST vs SEVIRI/LST comparison

One year VIIRS subset data over 6 areas in Europe and Africa is used for the comprehensive cross comparison between VIIRS and SEVIRI LST. The result has been presented in EGU 2017.



Summary

- SNPP LST performance
  - The SNPP LST marginally meets the mission requirements based on the validation results
  - Validation tools are run regularly for routing monitoring and web info update
  - Working with EMC/NCEP for the model verification
  - International cooperation with ESA/EUMETSAT LST groups for the cross comparison to Sentinel-3 LSTs and SEVIRI LSTs
- Enterprise LST algorithm progress
  - The enterprise LST algorithm development went CDR in Sep. 2016, TRR in Aug 2017, ARR in Sept. 2017.
  - The DAP files are ready to deliver.
  - Land surface emissivity has been developed to support the enterprise LST.
  - The first version ATBD for the enterprise LST and LSE are ready.
- Reprocessing status
  - Sample reprocessed SDR data has been investigated and its impact on LST has been evaluated.
  - Enterprise algorithm will be used for the reprocessing for LST consistency
- JPSS-1 readiness
  - All the validation tools and simulation tools/database are ready for the J-1 mission
  - J-1 LST production in NDE will be based on the Enterprise Algorithm
  - J-1 Cal/Val plan has been reviewed
- Gridded LST development
  - Major features of the gridded LST product has been determined with major users
  - Software architecture and technical solutions have been investigated
  - A very preliminary code has been developed and tested; a simple version of the gridded LST production is running in a local server for current LST product monitoring purpose.
  - LST diurnal model and temporal interpolation has been studied.

Future Plans/Improvements

- Operational implementation of gridded LST data production
- Pre/post operational review and support
- Final version of the enterprise LST ATBD and related documentations
- Final DAP delivery
- Reprocessing LST data when the enterprise algorithm and upstream data is ready.
- JPSS-1 LST product evaluation, monitoring and maturity support
- Emissivity Data evaluation
- In-situ site upscaling model study
- LUT improvement : detail clarification of the LUT dimension
- Further interactive with EMC/NCEP model team: intensive LST model verification
- Resume international cooperation

VIIRS product status

Ivan Csiszar

NOAA NESDIS Center for Satellite Applications and Research

Marina Tsidulko

I.M. Systems Group, Inc.

Wilfrid Schroeder, Louis Giglio, Evan Ellicott

University of Maryland, Department of Geographical Sciences

Outline

- VIIRS active fire product status and data access
  - VIIRS baseline (MODIS heritage) fire product
  - Improved hybrid VIIRS fire product
- Ongoing science issues and product improvements
- Examples of key operational applications
- Reprocessing the Suomi NPP VIIRS data record
- Summary

NDE output file content

Name	Description	Type
fire mask	Fire mask 2D array (unit-less)	8 bit int
algorithm QA	Fire algorithm QA mask 2D array (unit-less)	32 bit Int
FP_line	Fire pixel line Sparse data array	16 bit Int
FP_sample	Fire pixel sample Sparse data array	16 bit Int
FP_latitude	Fire pixel latitude Sparse data array (deg)	32 bit Float
FP_longitude	Fire pixel longitude Sparse data array (deg)	32 bit Float
FP_power	Fire radiative power Sparse data array (MW)	32 bit Float
FP_confidence	Fire detection confidence Sparse data array (%)	8 bit Int
FP_land	Land pixel flag Sparse data array	8 bit Int

Total output for one granule: 11.7 Mb + number of fires * 79 bytes

Fire pixel information is also available in text files

Missing – 0	Brightness temperatures for M13 or M15 unavailable
Scan – 1	Not processed (trim)
Other – 2	Not processed (other reason)
Water – 3	Pixel classified as non fire water
Cloud – 4	Pixel classified as cloudy
No Fire – 5	Pixel classified as non fire land
Unknown – 6	Pixel with no valid background pixels
Fire Low – 7	Fire pixel with confidence strictly less than 20% fire
Fire Medium – 8	Fire pixel with confidence between 20% and 80%
Fire High – 9	Fire pixel with confidence greater than or equal to 80%

0-1	Surface Type (water=0, coastal=1, land=2)
2-3	Atmospheric correction (reserved for future use)
4	Day/Night (daytime = 1, nighttime = 0)
5	Potential fire (0/1)
6-10	Background window size parameter
11	Fire Test 1 valid (0 - No, 1 - Yes)
12	Fire Test 2 valid (0 - No, 1 - Yes)
13	Fire Test 3 valid (0 - No, 1 - Yes)
14	Fire Test 4 valid (0 - No, 1 - Yes)
15	Fire Test 5 valid (0 - No, 1 - Yes)
16	Fire Test 6 valid (0 - No, 1 - Yes)
17-19	N/A
20	Adjacent clouds (0/1)
21	Adjacent water (0/1)
22-23	Sun Glint Level (0-3)
24	Sun glint rejection
25	False Alarm 1 (excessive rejection of legitimate background pixels)
26	False Alarm 2 (water pixel contamination)
27	Amazon forest-clearing rejection test
28-31	N/A

NDE output file content

Name	Description	Type
fire mask	Fire mask 2D array (unit-less)	8 bit int
algorithm QA	Fire algorithm QA mask 2D array (unit-less)	32 bit Int
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Total output for one granule: 11.7 Mb + number of fires * 79 bytes

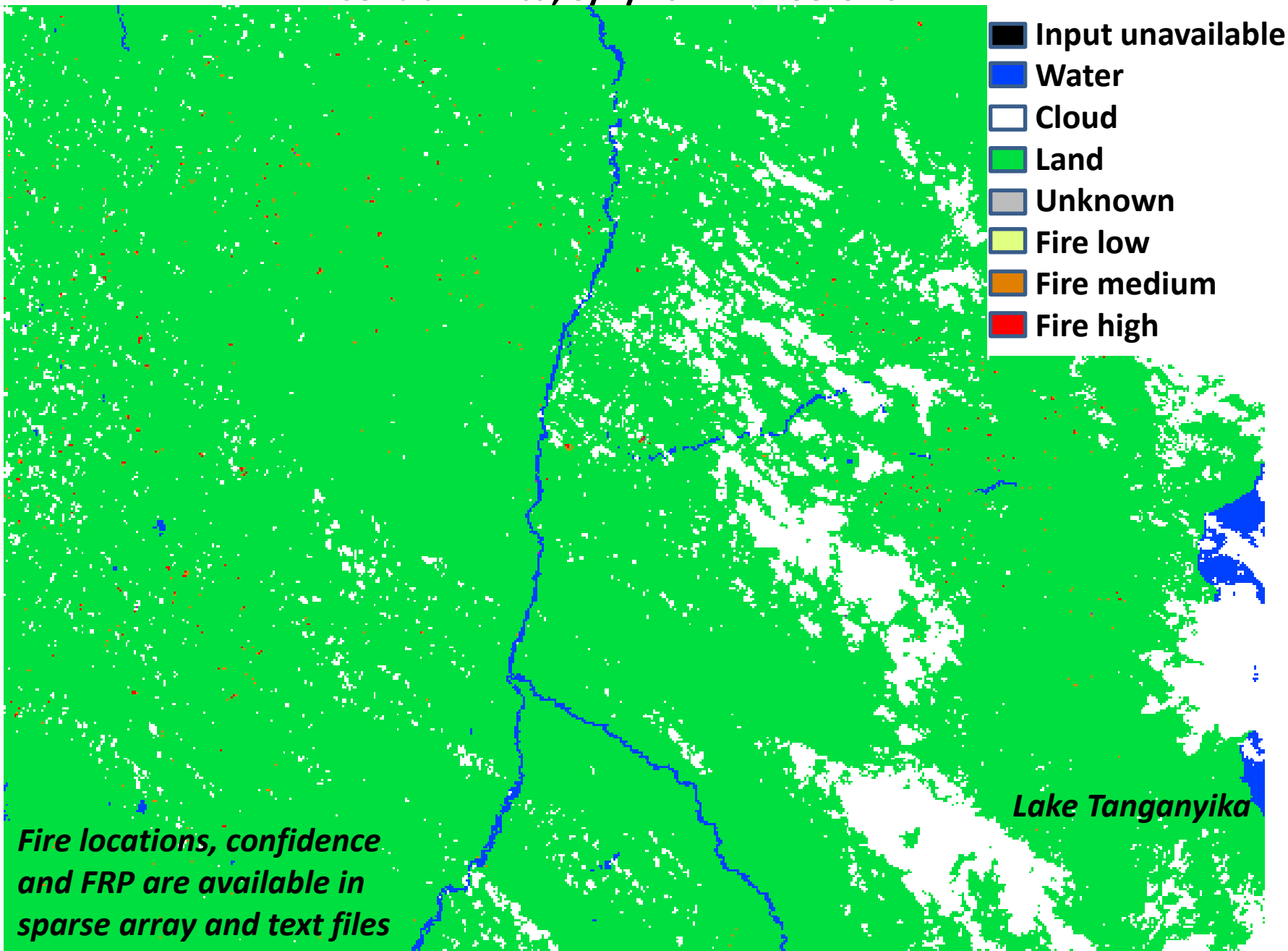
Fire pixel information is also available in text files

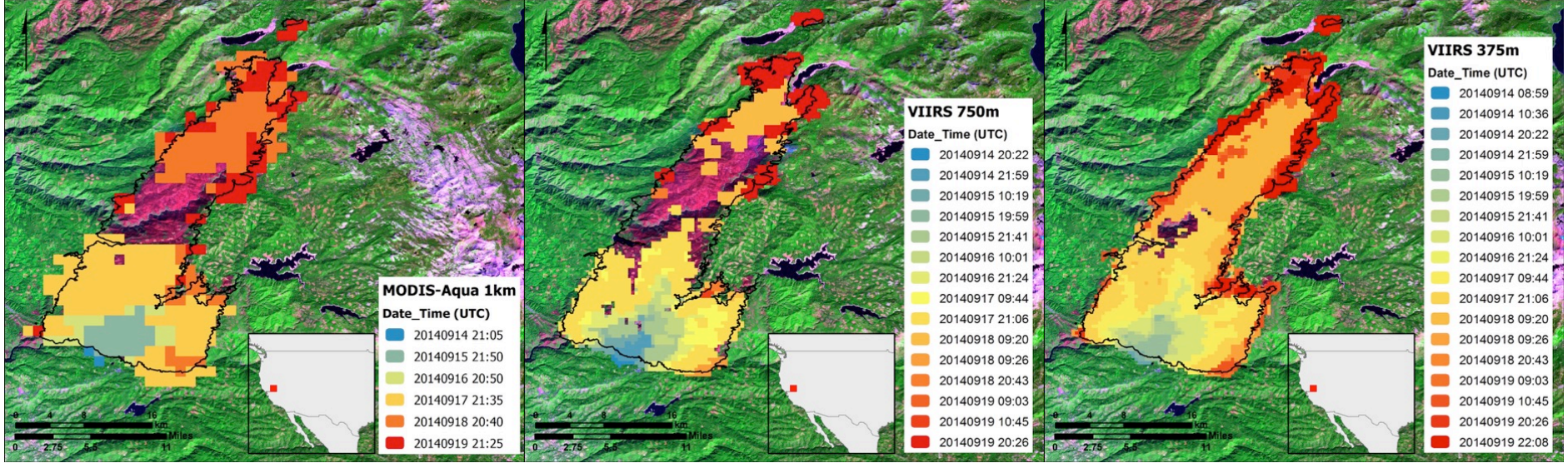
Missing – 0	Brightness temperatures for M13 or M15 unavailable
Scan – 1	Bowtie deletion
Other – 2	Not processed (other reason)
Water – 3	Pixel classified as non fire water
Cloud – 4	Pixel classified as cloudy
No Fire – 5	Pixel classified as non fire land
Unknown – 6	Pixel with no valid background pixels
Fire Low – 7	Fire pixel with confidence strictly less than 20% fire
Fire Medium – 8	Fire pixel with confidence between 20% and 80%
Fire High – 9	Fire pixel with confidence greater than or equal to 80%

0-1	Surface Type (water=0, coastal=1, land=2)
2	EDR trim zone (0=false, 1=true)
3	Atmospheric correction performed (0=false, 1=true)
4	Day/Night (daytime = 1, nighttime = 0)
5	Potential fire (0/1)
6	Spare (set to 0)
7-10	Background window size parameter
11	Fire Test 1 valid (0 - No, 1 - Yes)
12	Fire Test 2 valid (0 - No, 1 - Yes)
13	Fire Test 3 valid (0 - No, 1 - Yes)
14	Fire Test 4 valid (0 - No, 1 - Yes)
15	Fire Test 5 valid (0 - No, 1 - Yes)
16	Fire Test 6 valid (0 - No, 1 - Yes)
17-19	Spare (set to 0)
20	Adjacent clouds (0/1)
21	Adjacent water (0/1)
22-23	Sun Glint Level (0-3)
24-28	Individual rejection test flags (0=false, 1=true)
29-31	Spare (set to 0)

NOAA NDE VIIRS ACTIVE FIRE PRODUCT: FIRE MASK

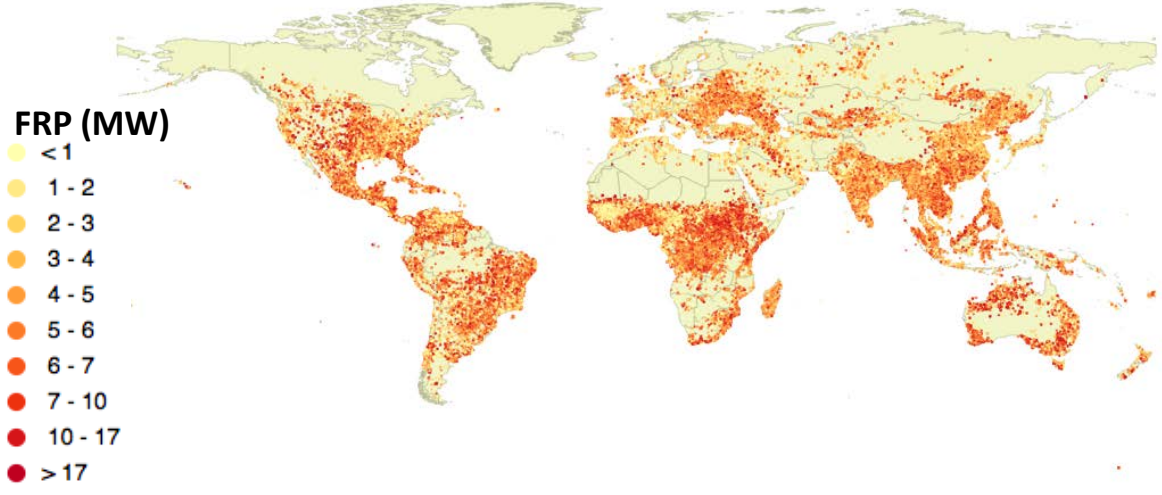
Central Africa, 5/1/2017 11:33 UTC

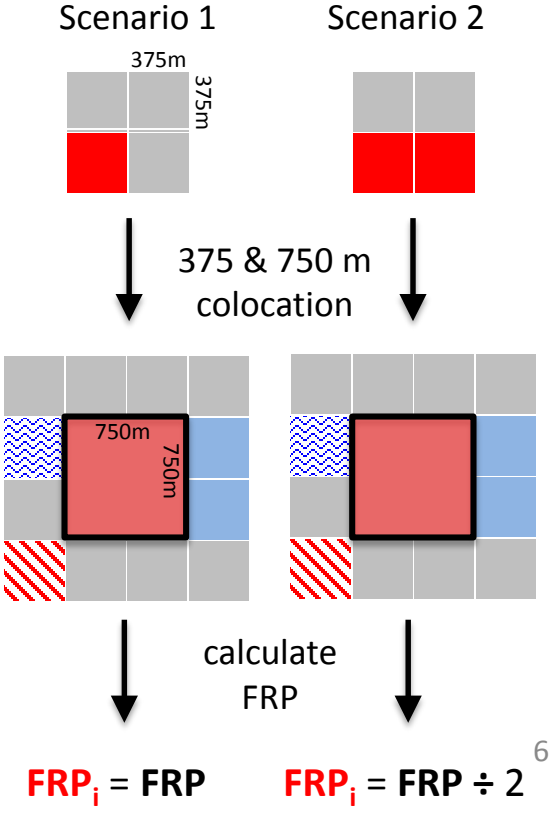




King Fire/CA, September 2014

Hybrid I/M-band product

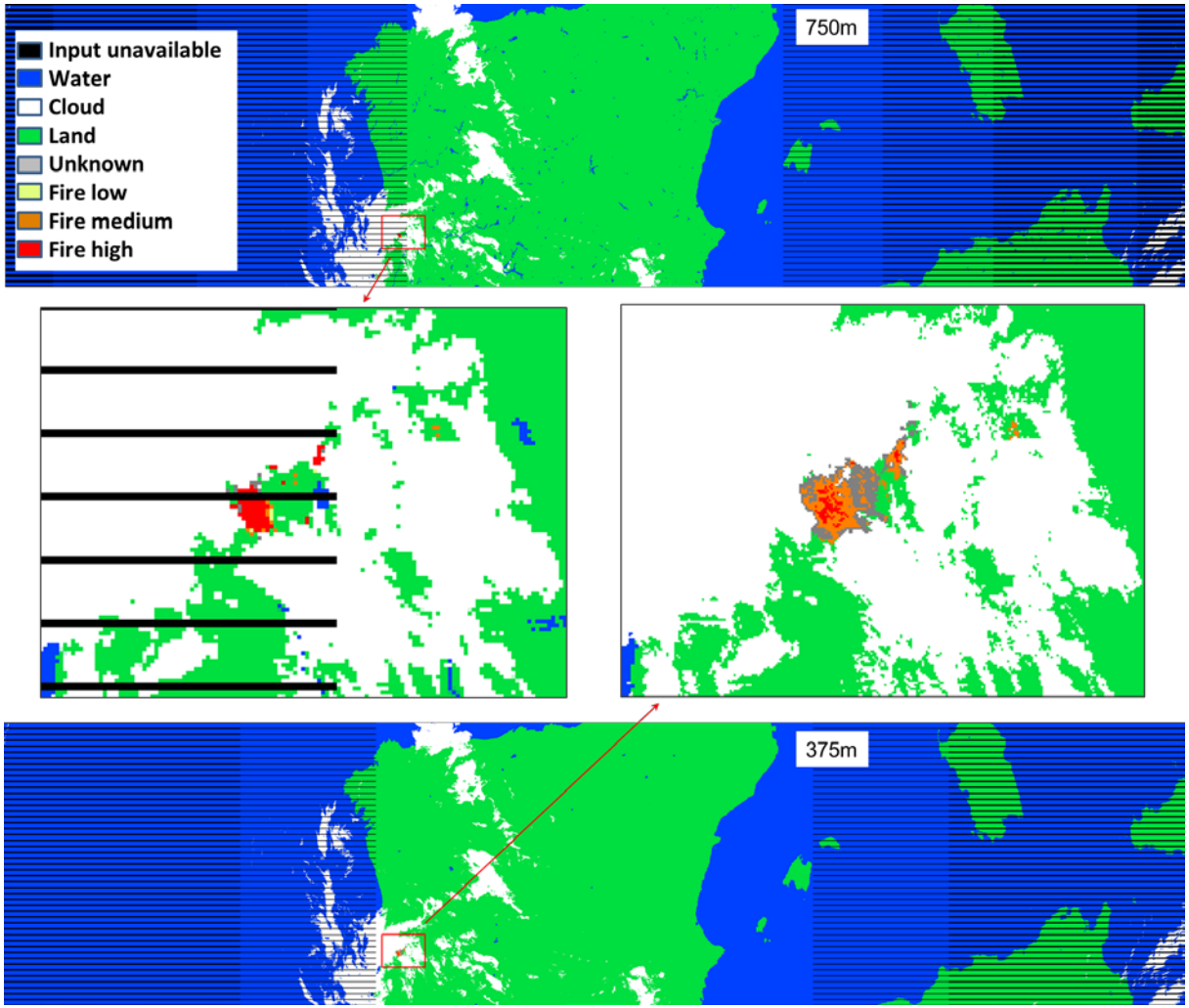




M-band vs. I-band

- The JPSS VIIRS active fire products provide high quality information
  - 750m M-band product in operations since March 15, 2016
  - 375m I-band algorithm evaluated for operational implementation
  - both products deliver fire mask and fire radiative power (FRP)
  - FRP used in air quality, and smoke analysis and prediction systems
  - FRP is incorporated into AWIPS-II

Updated M-band algorithm in delivery to NDE.



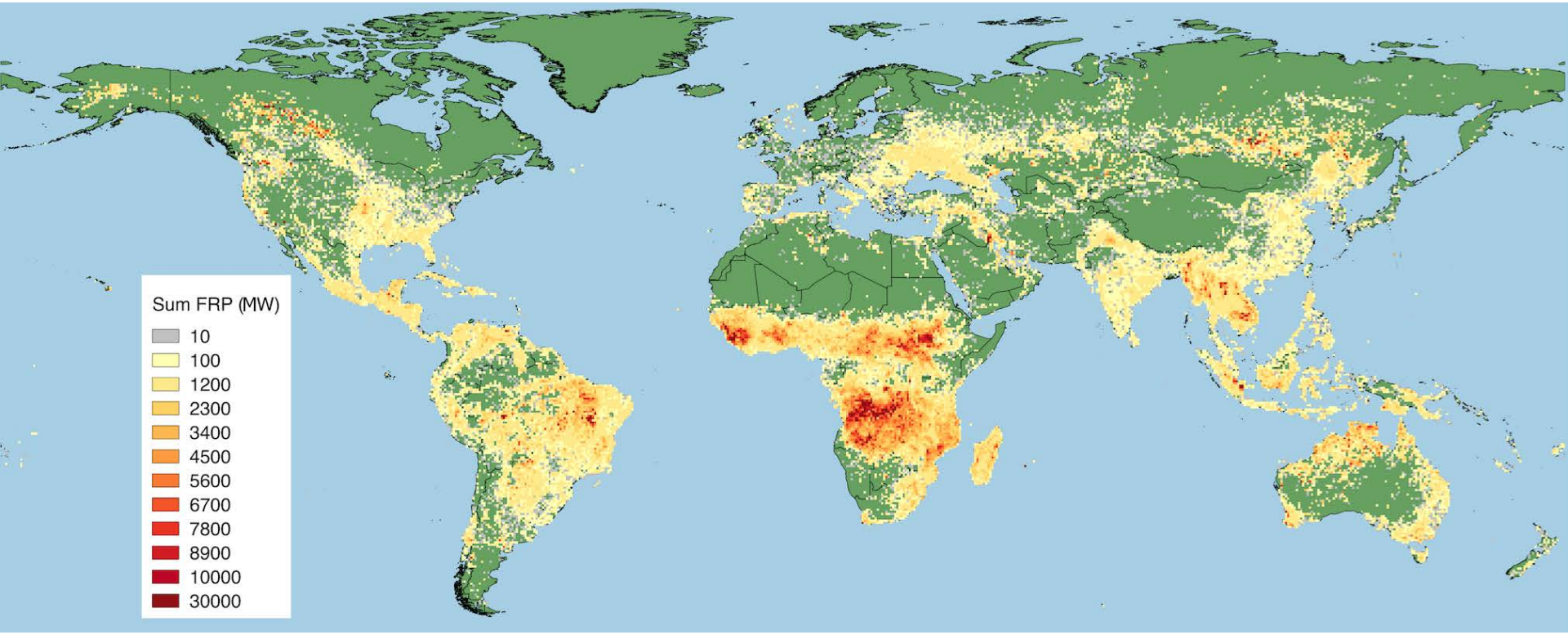
Fire masks from the M-band (top and left) and I-band (bottom and right) algorithms on 6/18/2017 02:04 UTC.

I. Csiszar, STAR; M. Tsidulko, IMSG@STAR, W. Schroeder, UMD

VIIRS 375 m Fire Radiative Power

Jan-Dec 2015 (Julian days 1,10,20,…,360)

Sum of top-of-atmosphere (TOA) FRP over sampling period using 0.5^{o} grid



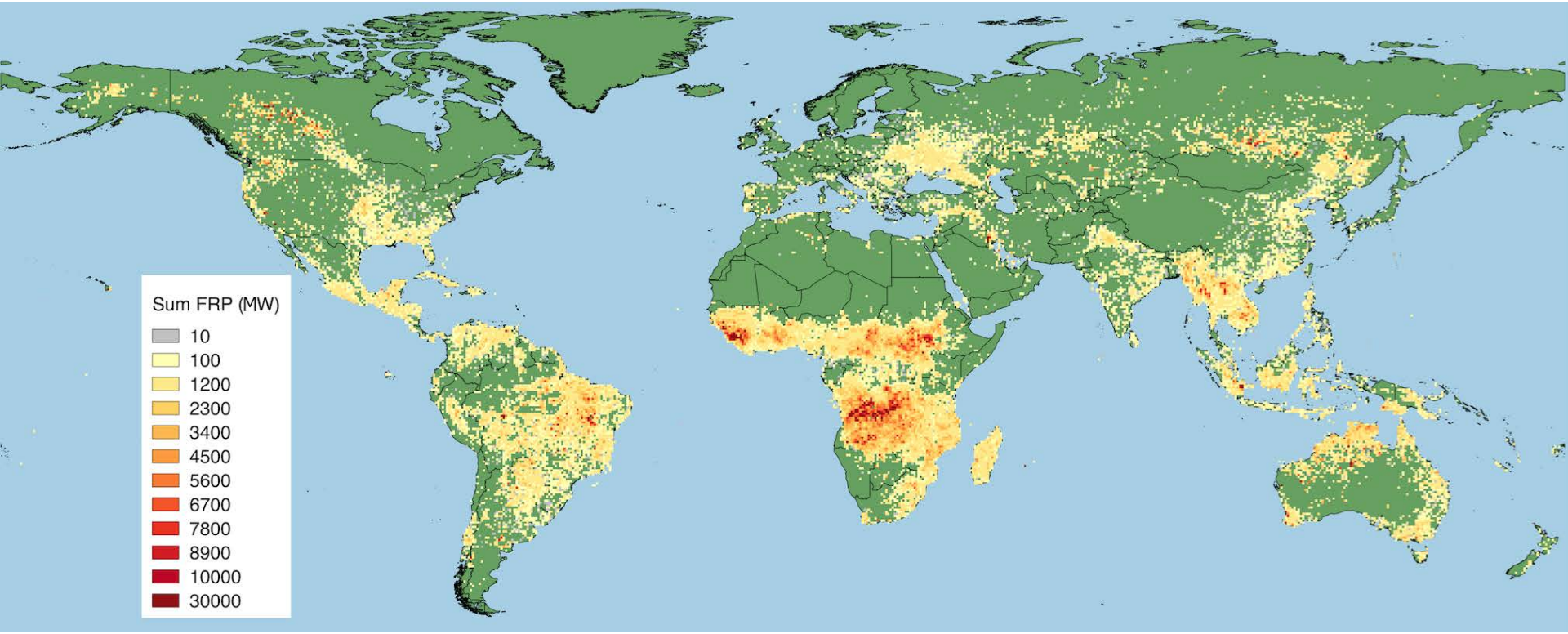
Frequent saturation prevents FRP retrieval using 375 m mid-IR data

Alternative calculation implemented using co-located 750 m mid-IR unsaturated data

MYD14 1km Collection 6 Fire Radiative Power

Jan-Dec 2015 (Julian days 1,10,20,…,360)

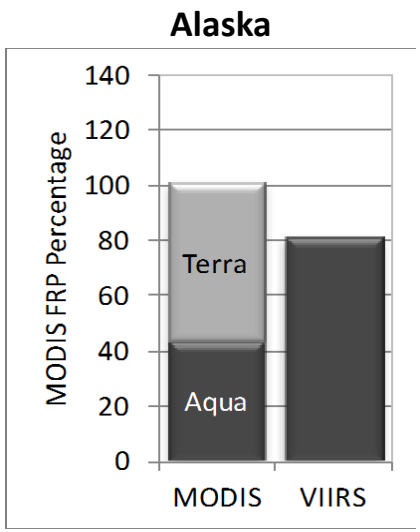
Sum of top-of-atmosphere (TOA) FRP over sampling period using 0.5^{o} grid

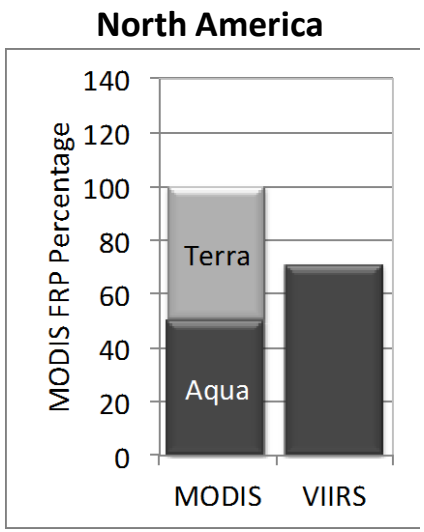


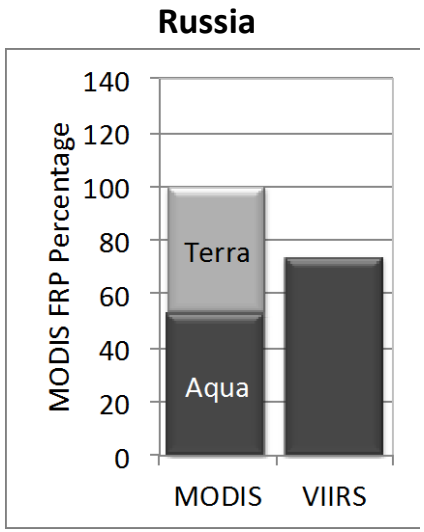
Higher VIIRS spatial resolution means:
3-4 more daytime fire pixels
20-25 more nighttime fire pixels
Compared to Aqua/MODIS

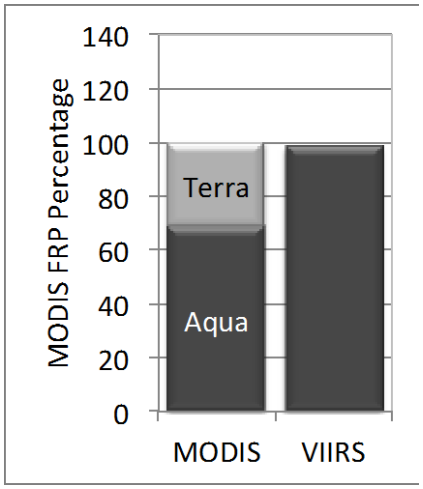
Global TOA FRP totals:
Terra/MODIS: 6.1×10^{6} MW
Aqua/MODIS: 13.4×10^{6} MW
S-NPP/VIIRS: 19.6×10^{6} MW

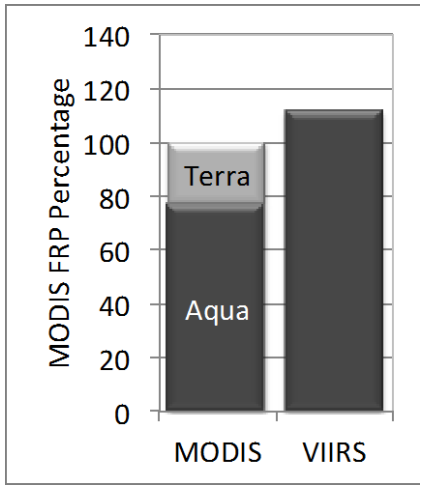
VIIRS 375 m x MODIS 1km
TOA Fire Radiative Power (FRP)

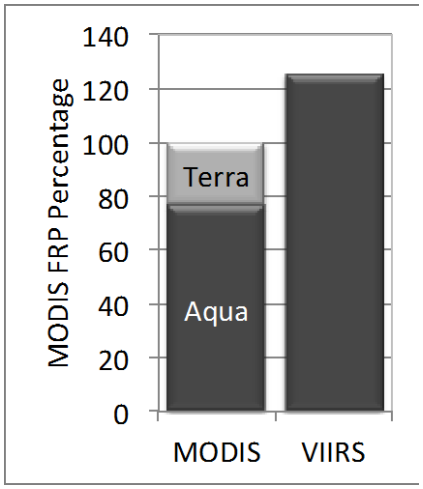








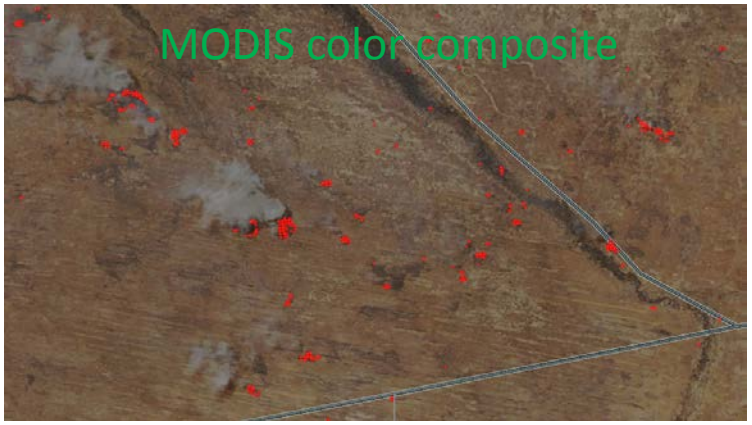


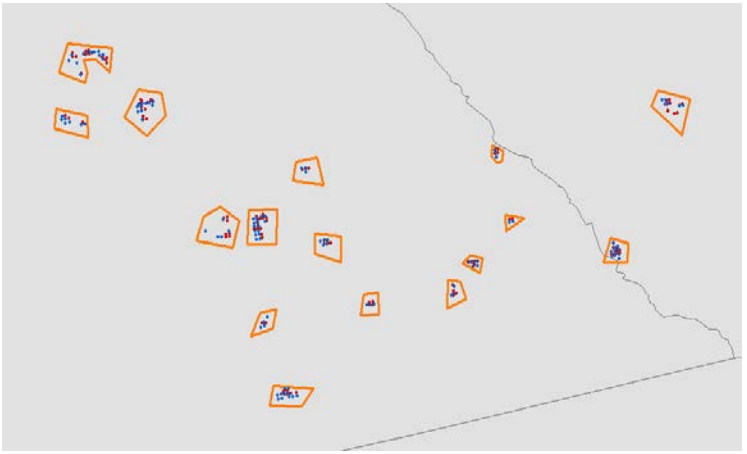


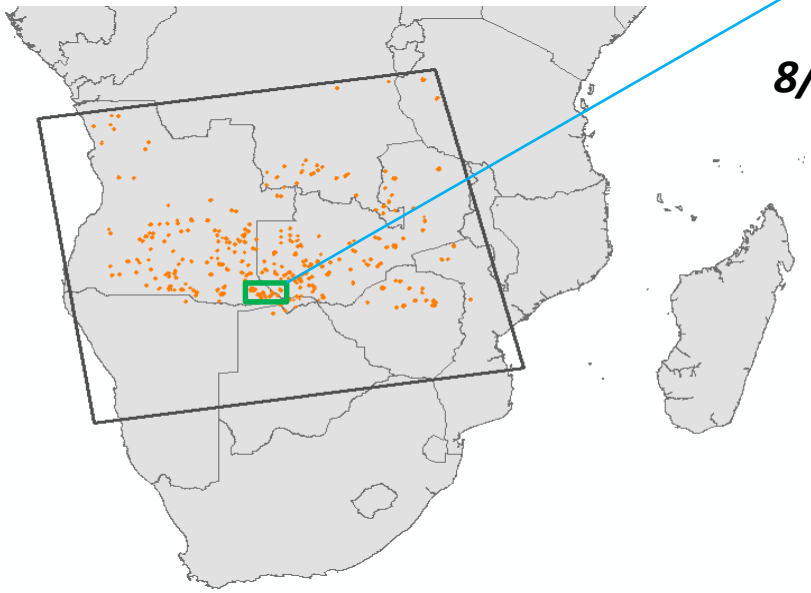
45% of daytime and 80% of nighttime VIIRS 375m fire pixels have no match in Aqua/MODIS fire data

VIIRS 375m systematically detecting more fires than same-day MODIS (Terra & Aqua) in areas dominated by small/low-intensity fires

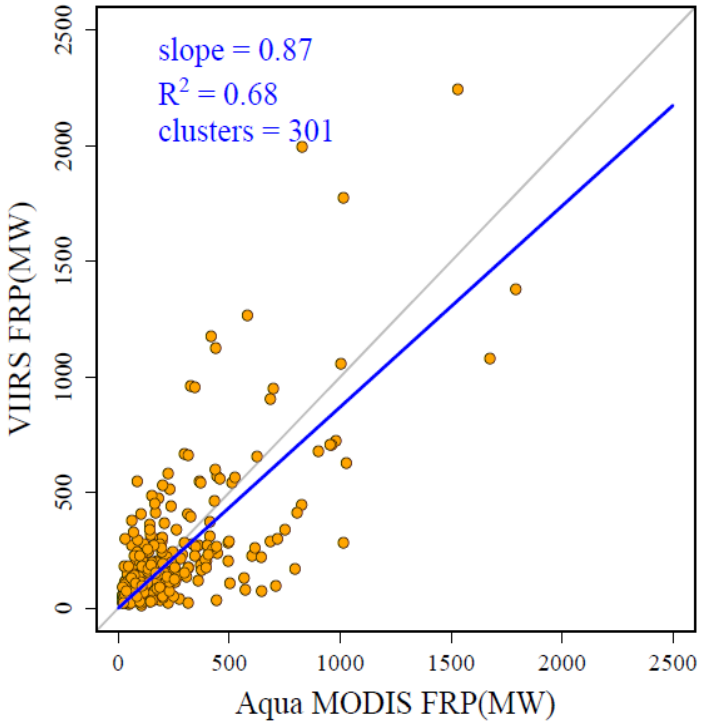
Aqua MODIS vs. VIIRS 750m FRP







8/22/2016

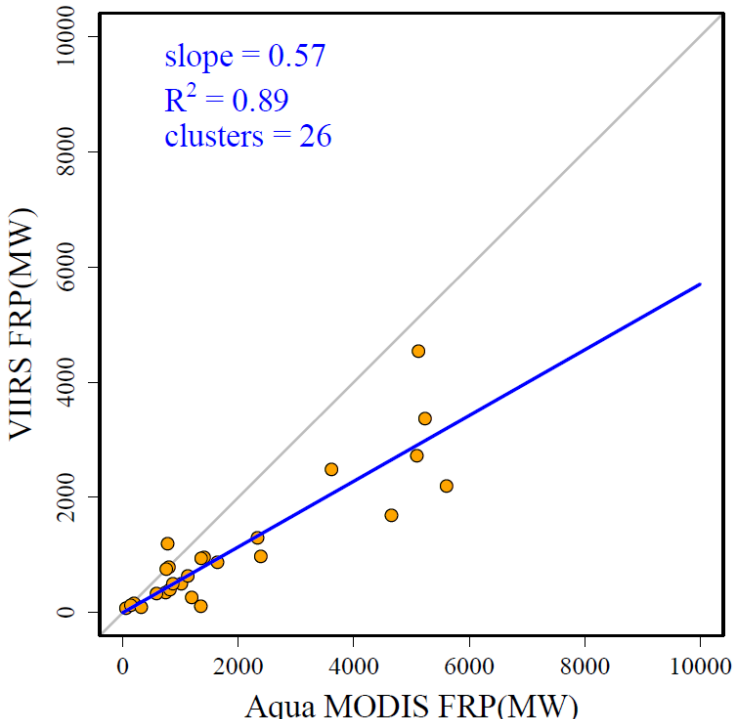


Fires from MODIS and VIIRS matched in individual fire events. Each fire event is considered as a cluster (total 301 fire events were selected)

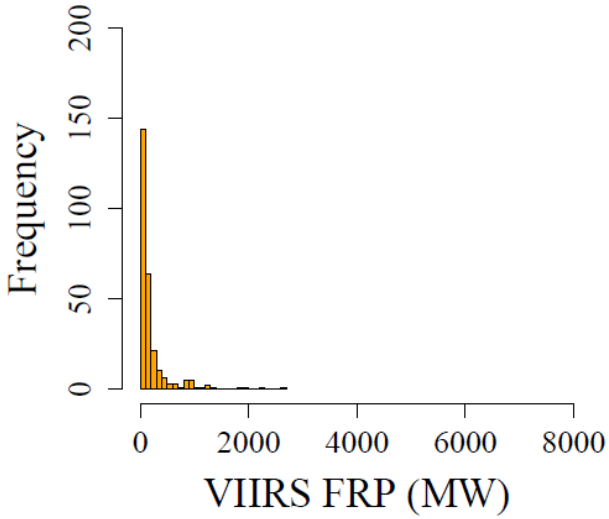
Aqua MODIS vs. VIIRS 750m FRP

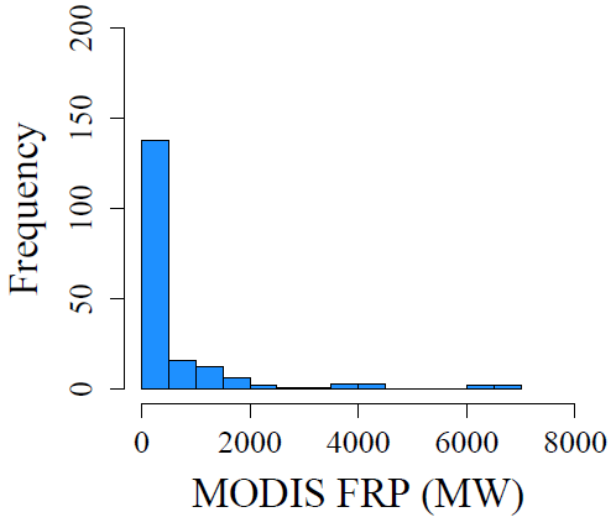


1/21/2017



Comparison of current Operational / systematically generated products

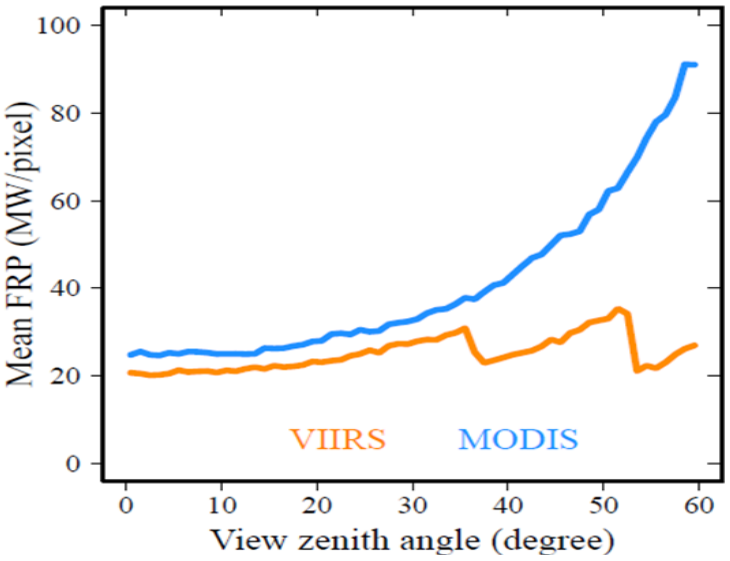


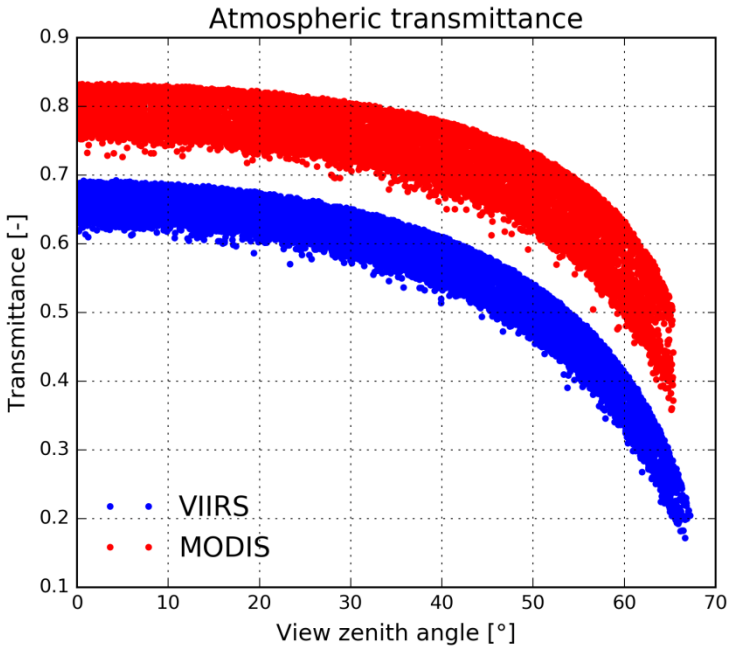


MODIS vs. VIIRS FRP considerations

- Differences in
  - Scanning geometry
    - Pixel size distribution
  - Handling of bow-tie effects
    - Duplicate detections
  - Pixel aggregation
    - Relative signal within pixel
  - Atmospheric transmittance
    - More CO_2 absorption in VIIRS M13

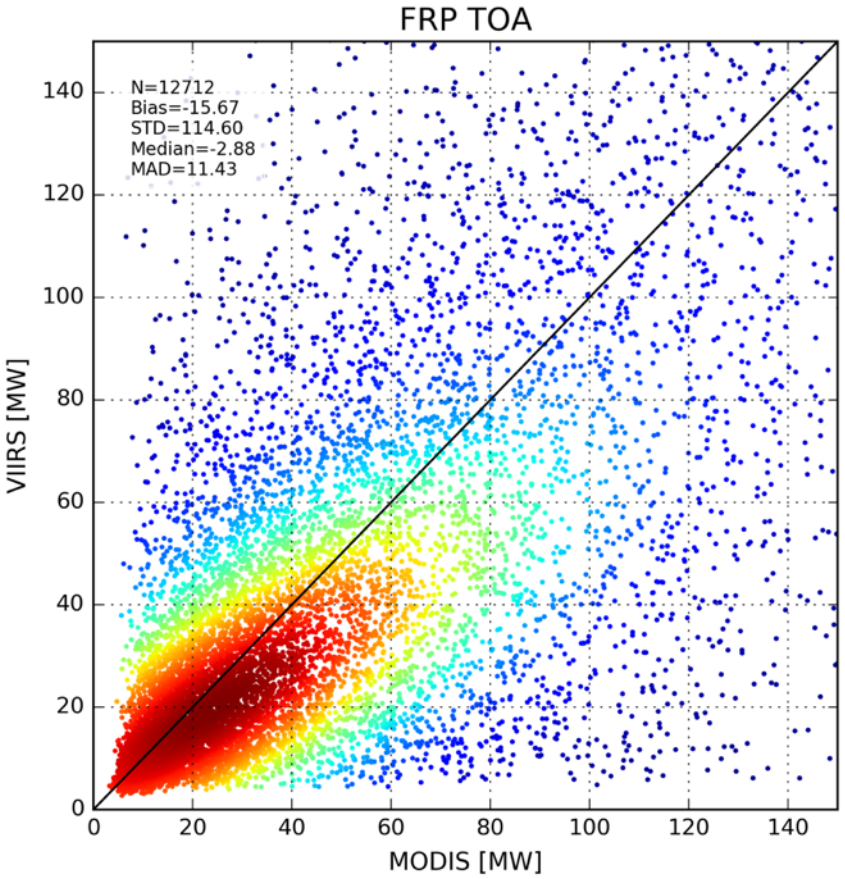
FRP is critical input for emission estimates!



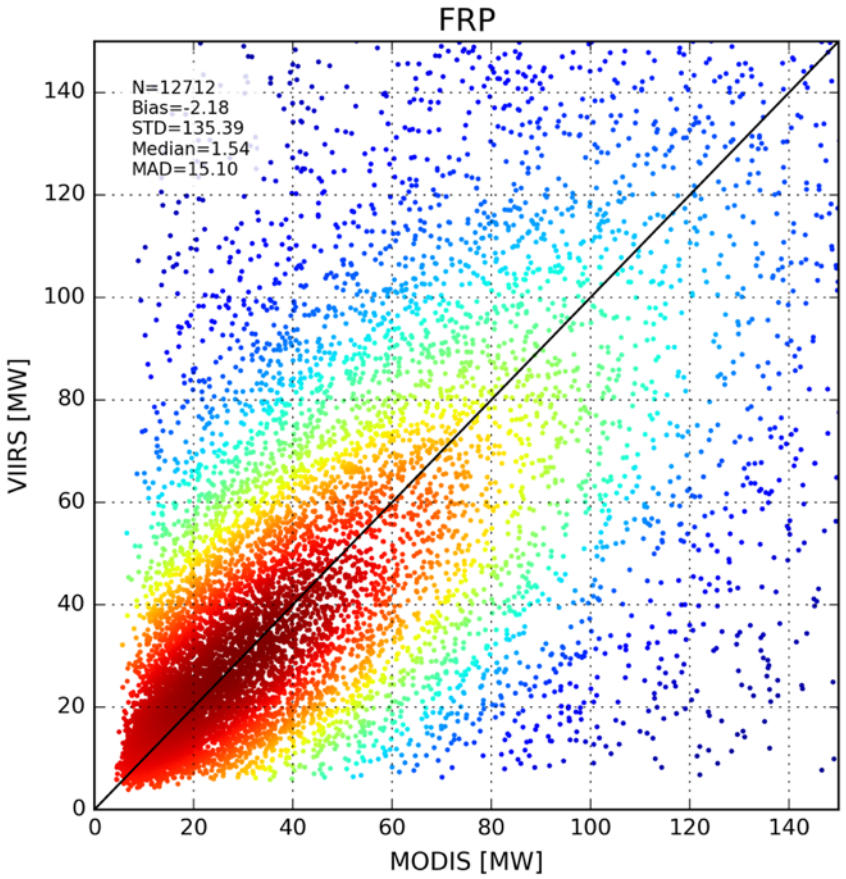


Cross-comparison of atmospherically corrected MODIS x VIIRS FRP Data

FRP retrievals corrected for atmospheric attenuation using MODTRAN + MERRA-2 (0.625º x 0.5º)

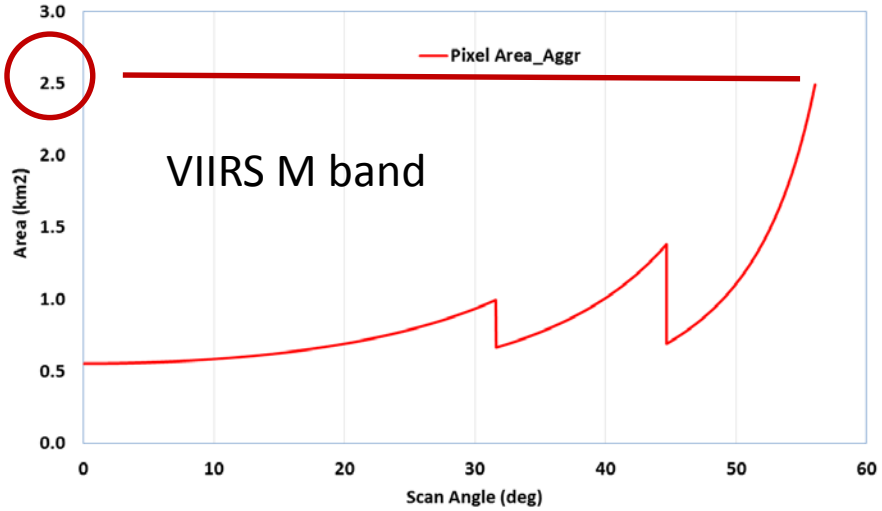


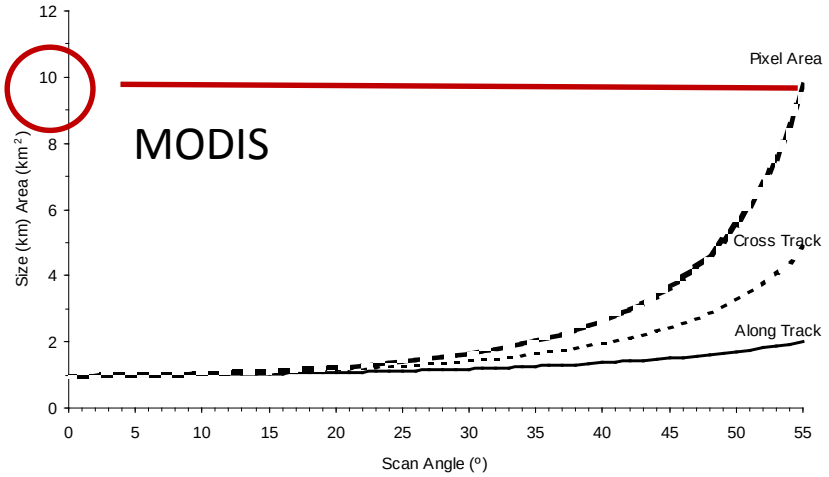
Before atmospheric correction



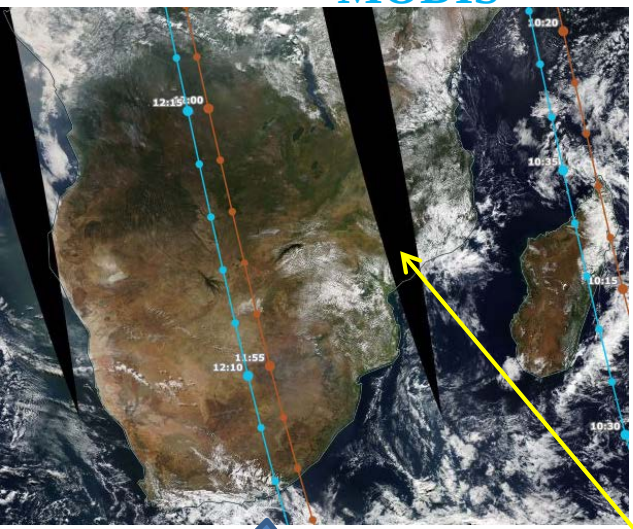
After atmospheric correction

VIIRS vs. MODIS pixel area and swath width

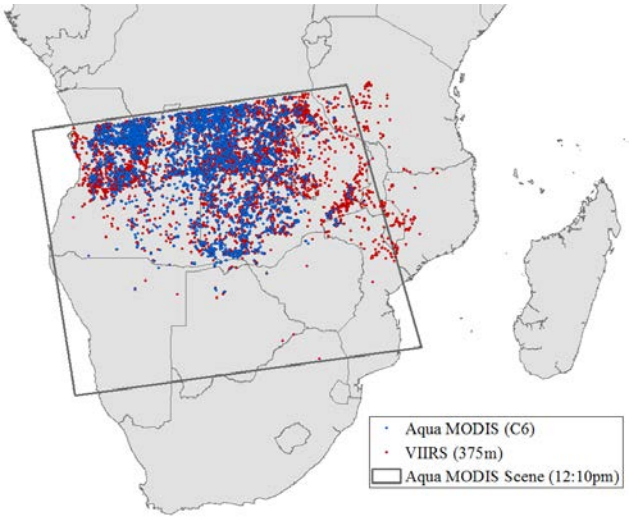




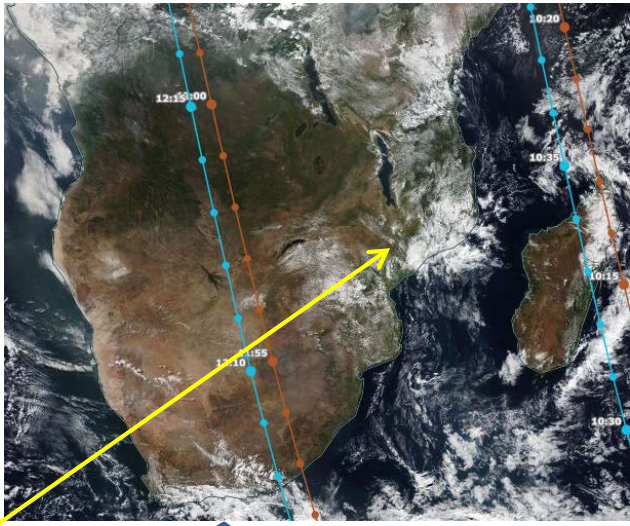
MODIS



June 3, 2016



VIIRS



1 km to 4 km

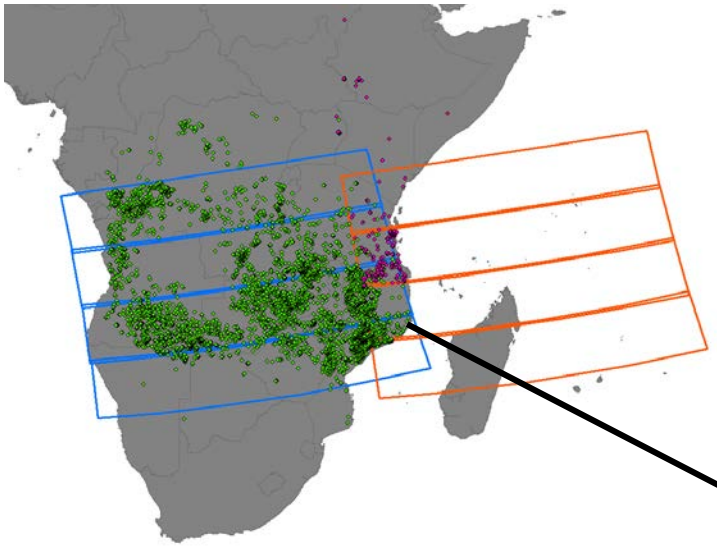
No VIIRS gaps at low latitudes!

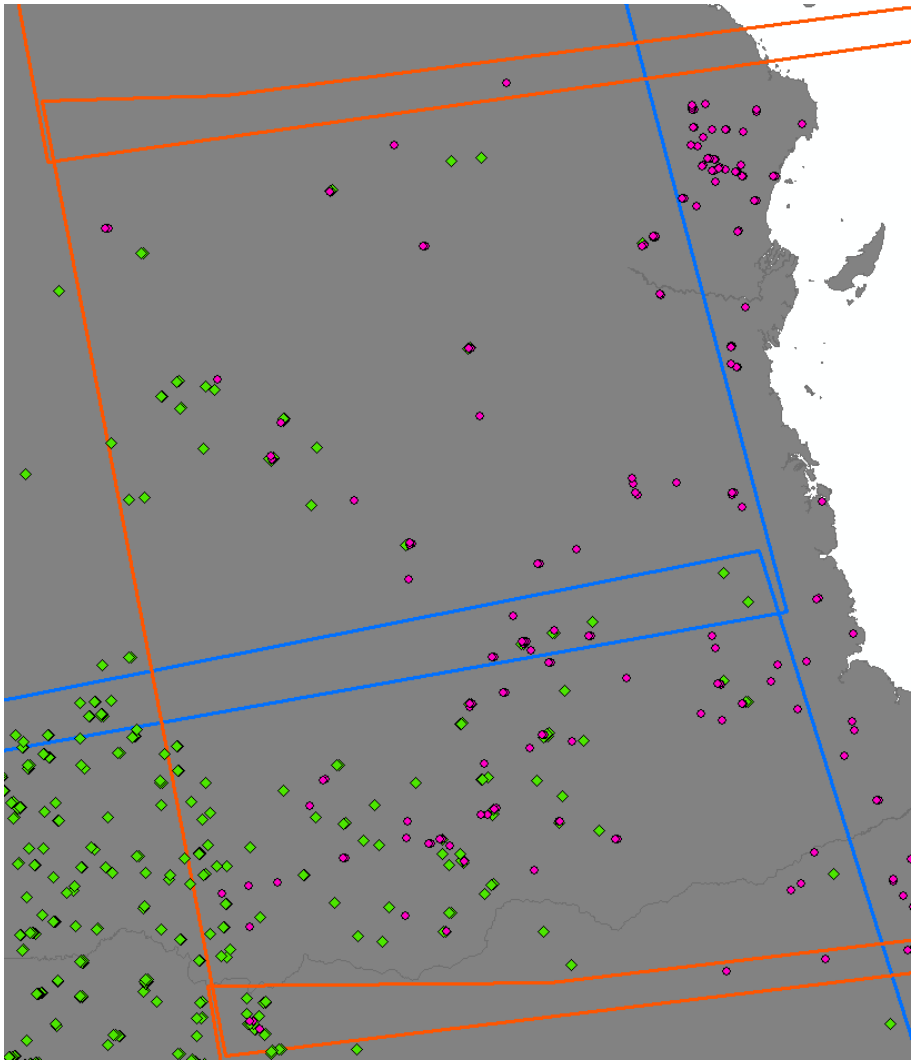
750 m to 1.2 km (M-band)

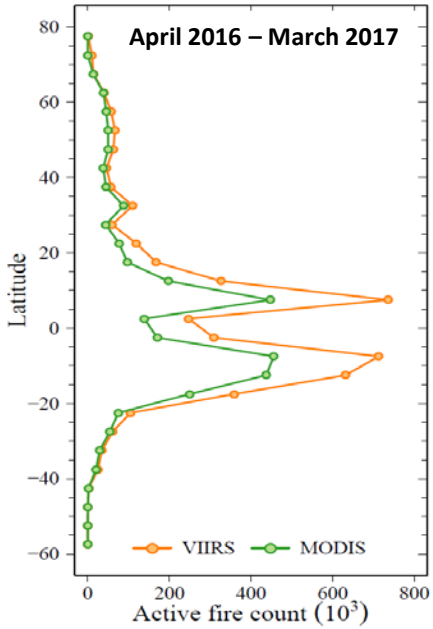
VIIRS vs. MODIS pixel area and swath width

Granules of two neighboring orbit tracks

(blue: 11:48-11:53am, orange: 10:09-10:12am)





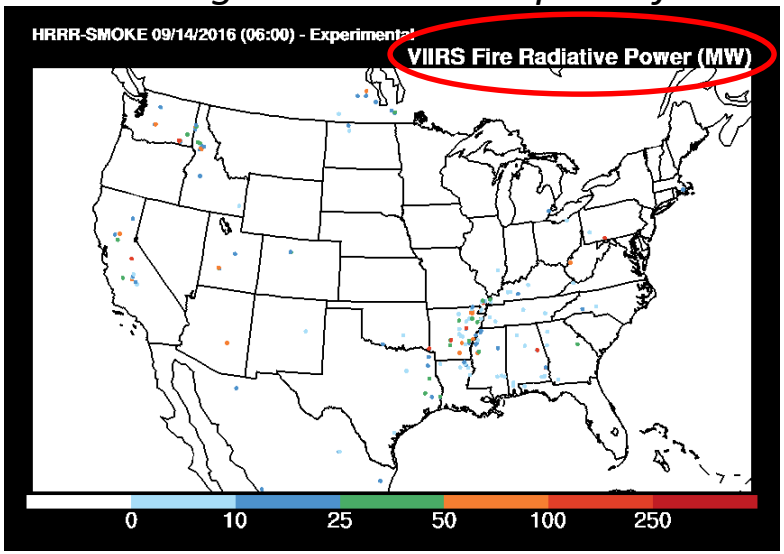


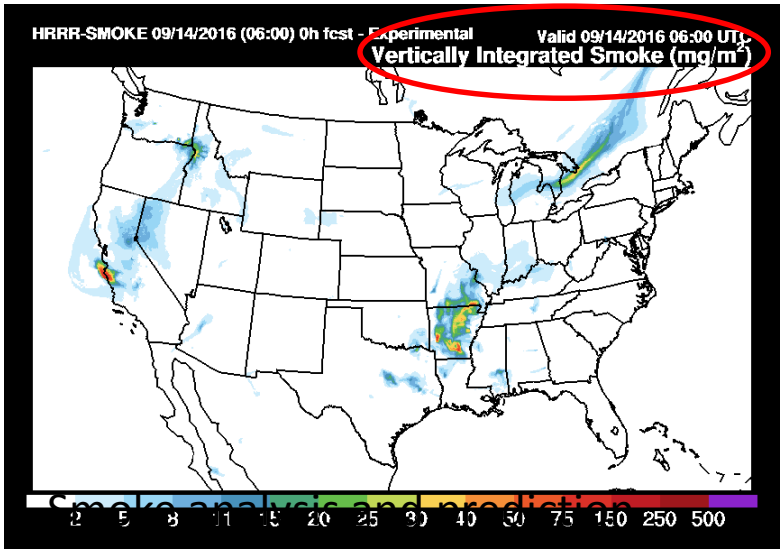
Significantly more VIIRS 750m detections at low latitudes

Good quality VIIRS observations at low latitudes from consecutive orbits!

Examples of real-time fire and smoke monitoring systems using VIIRS active fire data

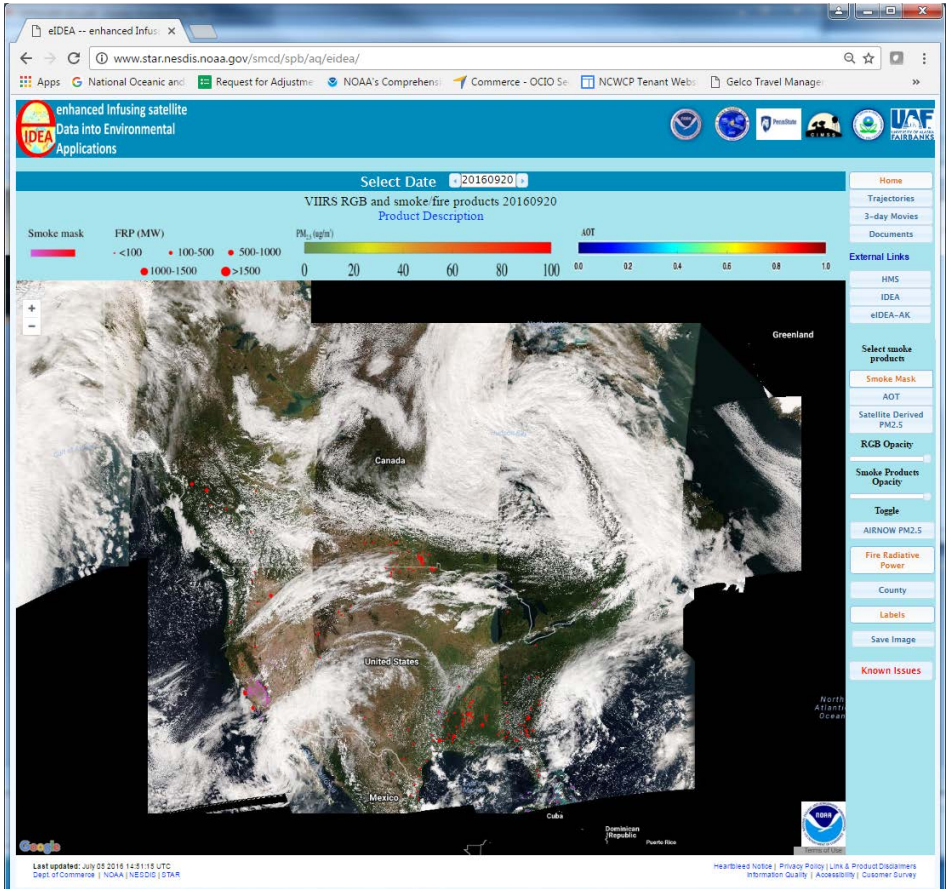
HRRR: High Resolution Rapid Refresh





https://rapidrefresh.noaa.gov/HRRRsmoke

eIDEA: enhanced Infusing satellite Data into Environmental Applications



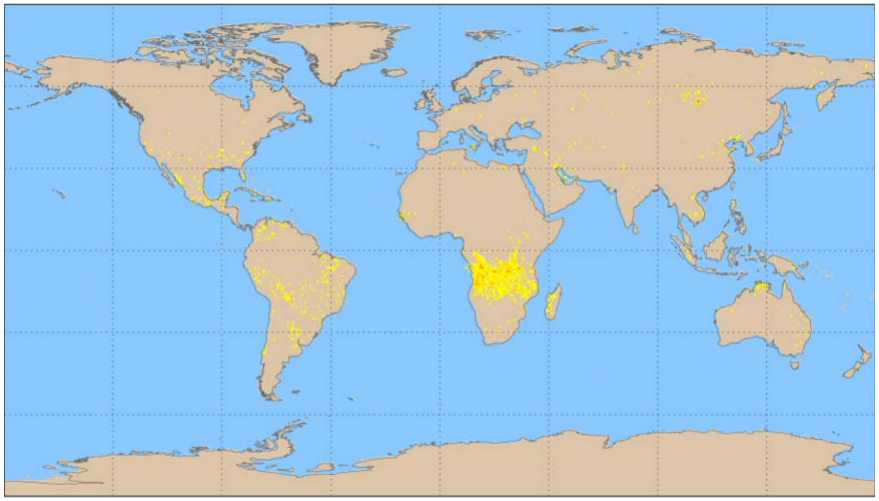
https://www.star.nesdis.noaa.gov/smcd/spb/aq/eidea/
https://www.star.nesdis.noaa.gov/smcd/spb/aq/eidea-ak/

VIIRS Active Fire Long-term Monitoring

http://www.star.nesdis.noaa.gov/jpss/EDRs/products_activeFires.php

Suomi NPP - VIIRS - NDE - Active Fires

16 Jun 2016



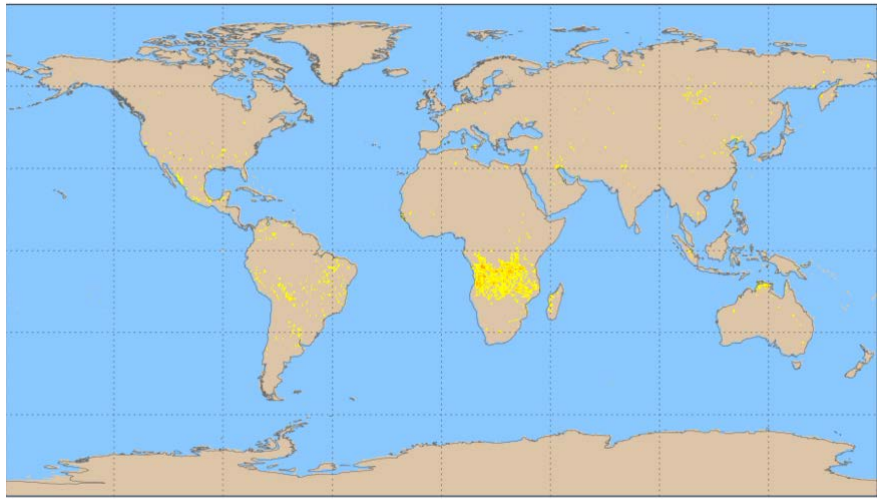
0 10 20 30 40 50 60 70 80 90 100

Fire Frequency

NOAA/NESDIS/STAR

Suomi NPP - VIIRS - IDPS - Active Fires

16 Jun 2016



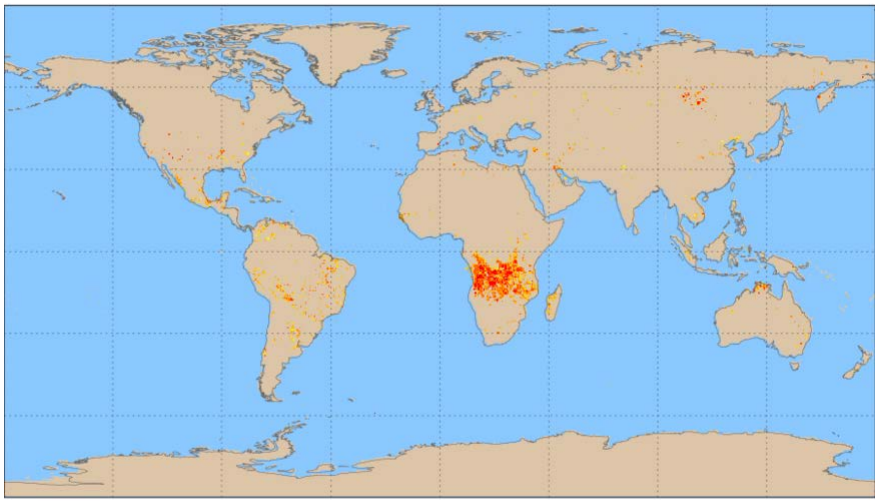
0 10 20 30 40 50 60 70 80 90 100

Fire Frequency

NOAA/NESDIS/STAR

Suomi NPP - VIIRS - NDE - Fire Radiative Power - Total

16 Jun 2016



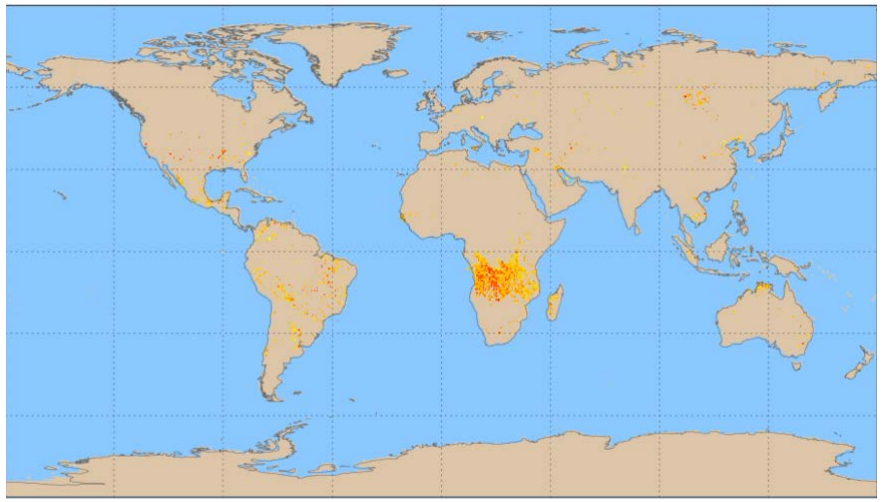
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5

$\log_{10}$ (Megawatts)

NOAA/NESDIS/STAR

Suomi NPP - VIIRS - NDE - Fire Radiative Power - Mean

16 Jun 2016

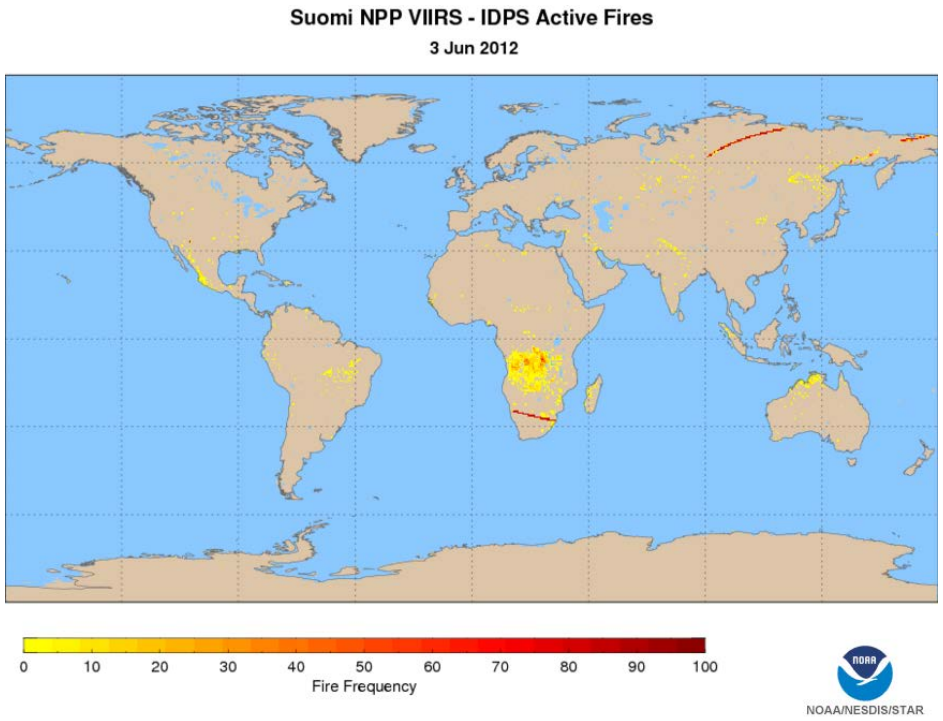


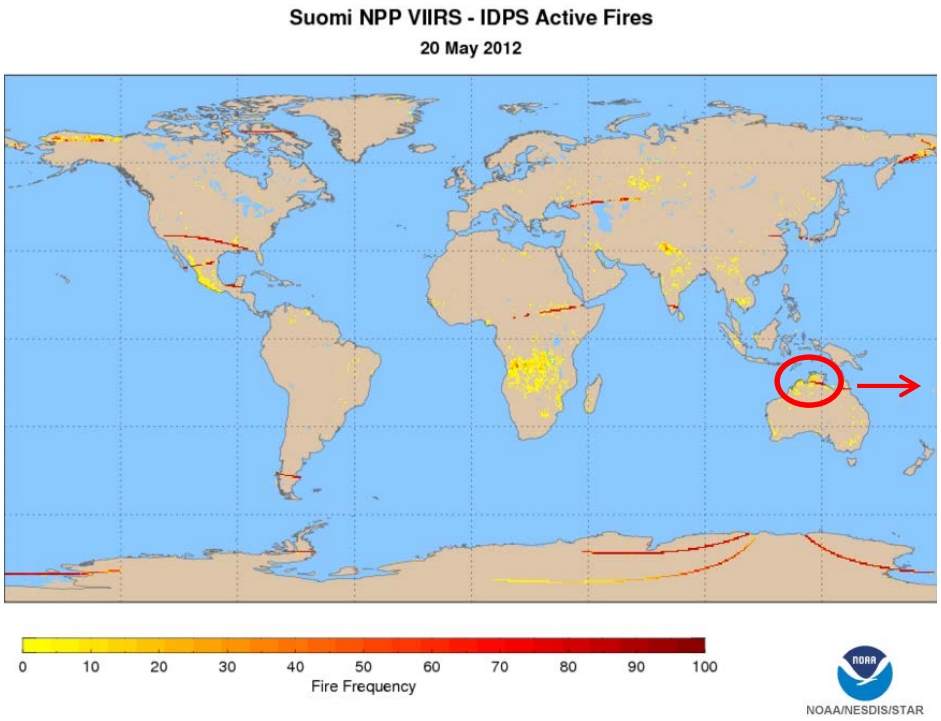
0.0 0.50 1.0 1.5 2.0 2.5

$\log_{10}$ (Megawatts)

NOAA/NESDIS/STAR

Active fire data anomalies during the early period of the Suomi NPP data record



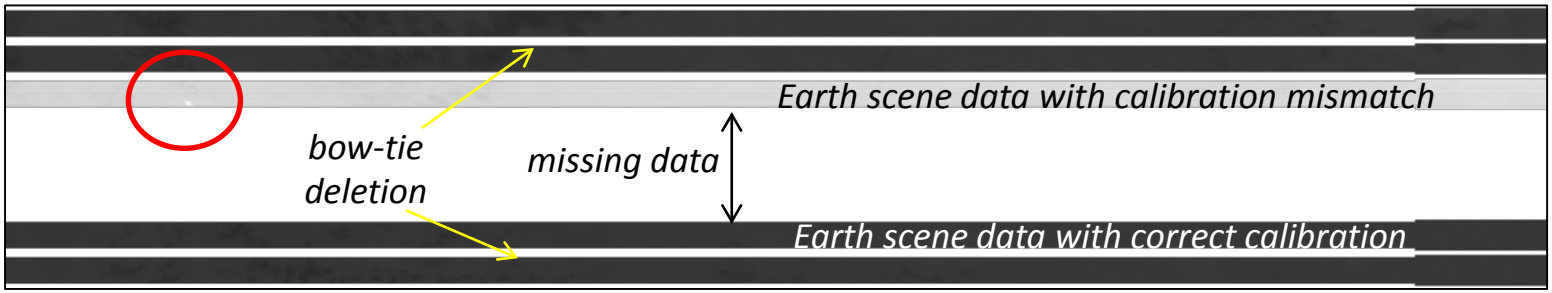


Examples of the first operational real-time IDPS product as archived in NOAA CLASS (http://www.class.ncdc.noaa.gov/).

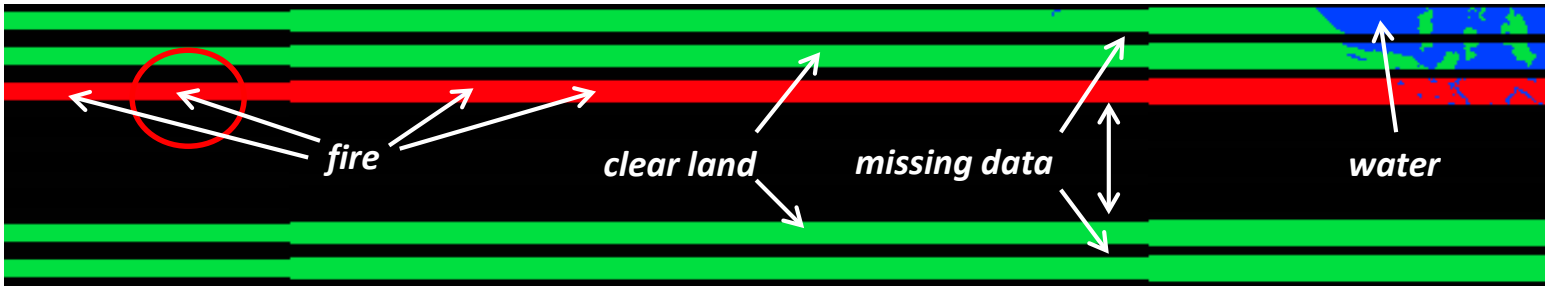
Not reprocessed; not to be used for science analysis. Reprocessing is ongoing.

Missing data packets / calibration mismatch

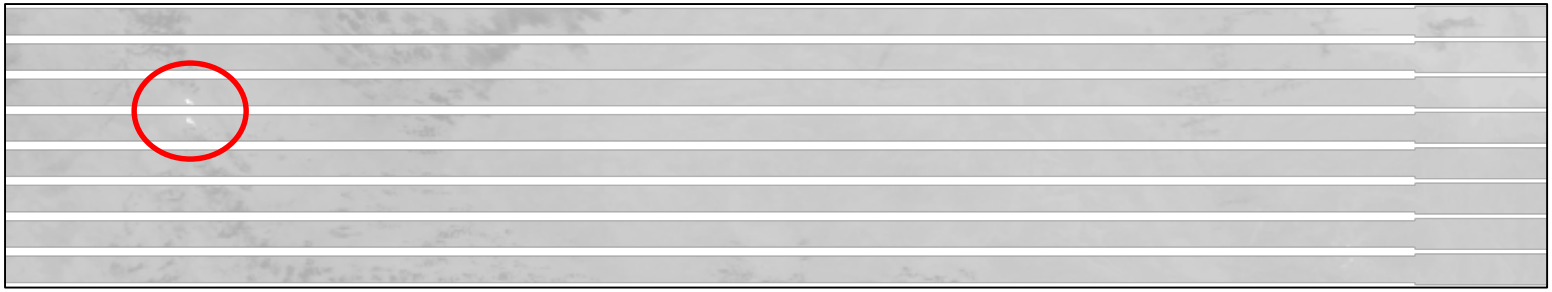
npp_d20120520_t1533555_e1535197



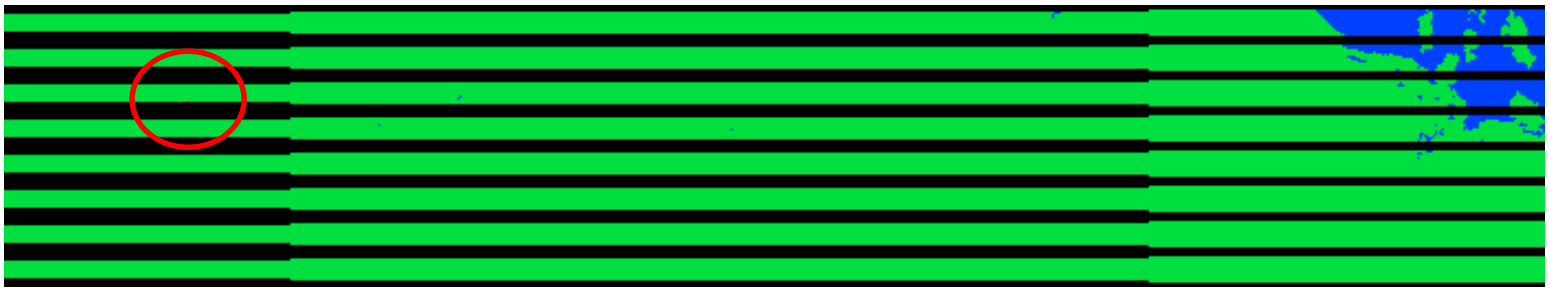
original
real-time
IDPS M13 SDR



NDE fire mask*



reprocessed
M13 SDR



NDE fire mask *

*including on ground bow-tie deletion

Summary

- Operational NDE production with a mature 750m algorithms is now ongoing
  - Some changes forthcoming
- Near-real-time product and distribution enables regional applications
- Algorithms incorporated into major direct broadcast packages
  - IPOPP and CSPP
- Extensive outreach, resulting in critical operational applications
  - e.g. coupled with air quality / smoke monitoring and modeling
  - Weather / fire
- Reprocessing of the data record with highest quality input and most mature algorithms is ongoing
  - Not only eliminates spurious detections, but also enables the detection of previously missed fires

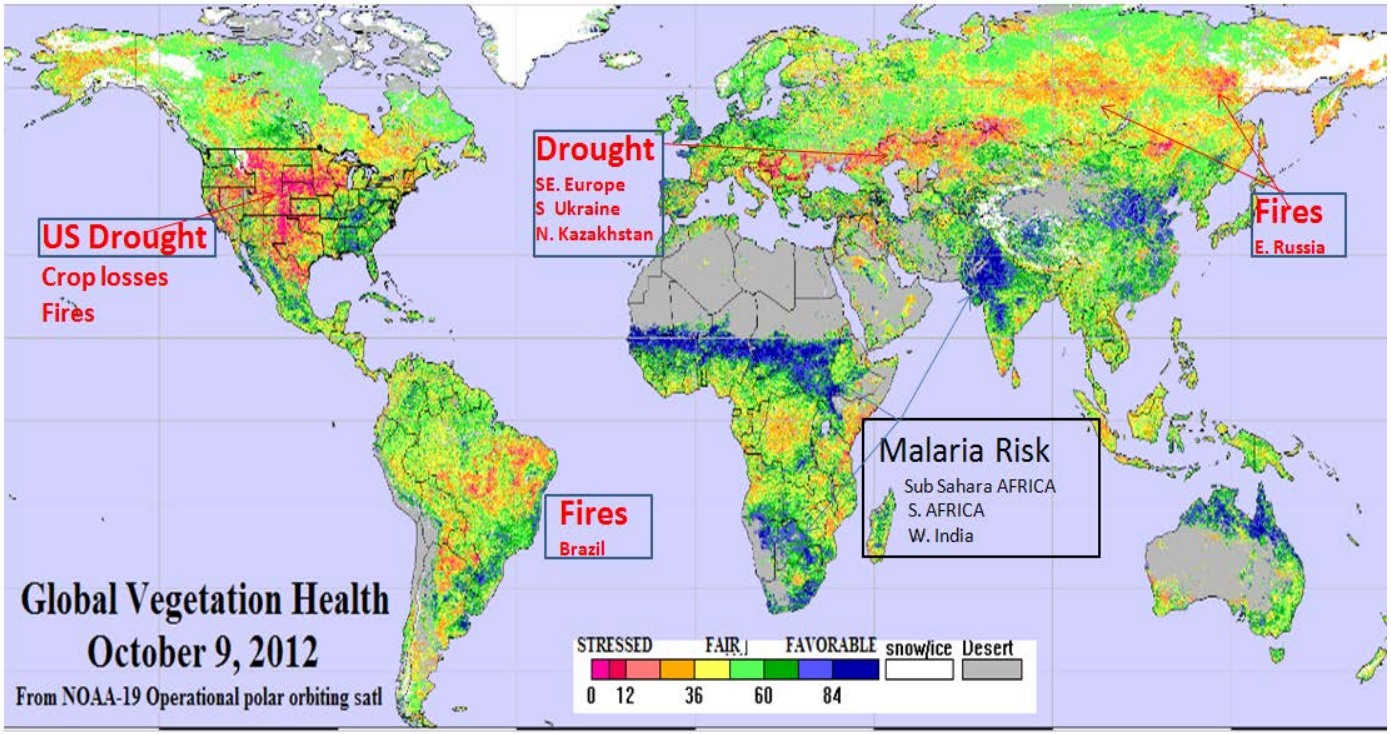
Vegetation Health Development and Applications Transition from AVHRR to JPSS

Presenters:
Felix Kogan, Wei Guo & Wenze Yang

Vegetation Health Index & Applications, Aug, 2017

Vegetation Health (VH) is an indicator of satellite-based vegetation response to weather (mostly P and T)

From AVHRR/NOAA-19 Operational Polar Orbiting Satellite



http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/index.php

- Vegetation Health
- Drought
  - Area
  - Intensity
  - Duration
  - Start/End
  - Impacts
- Moisture Stress
- Thermal Stress
- Healthy Vegetation
- Crop/pasture Prod.
- Fire Risk
- Soil Saturation
- Mosquitoes Diseases
- Land Greenness
- Landslides
- Food security
- Climate Change
- Land Change

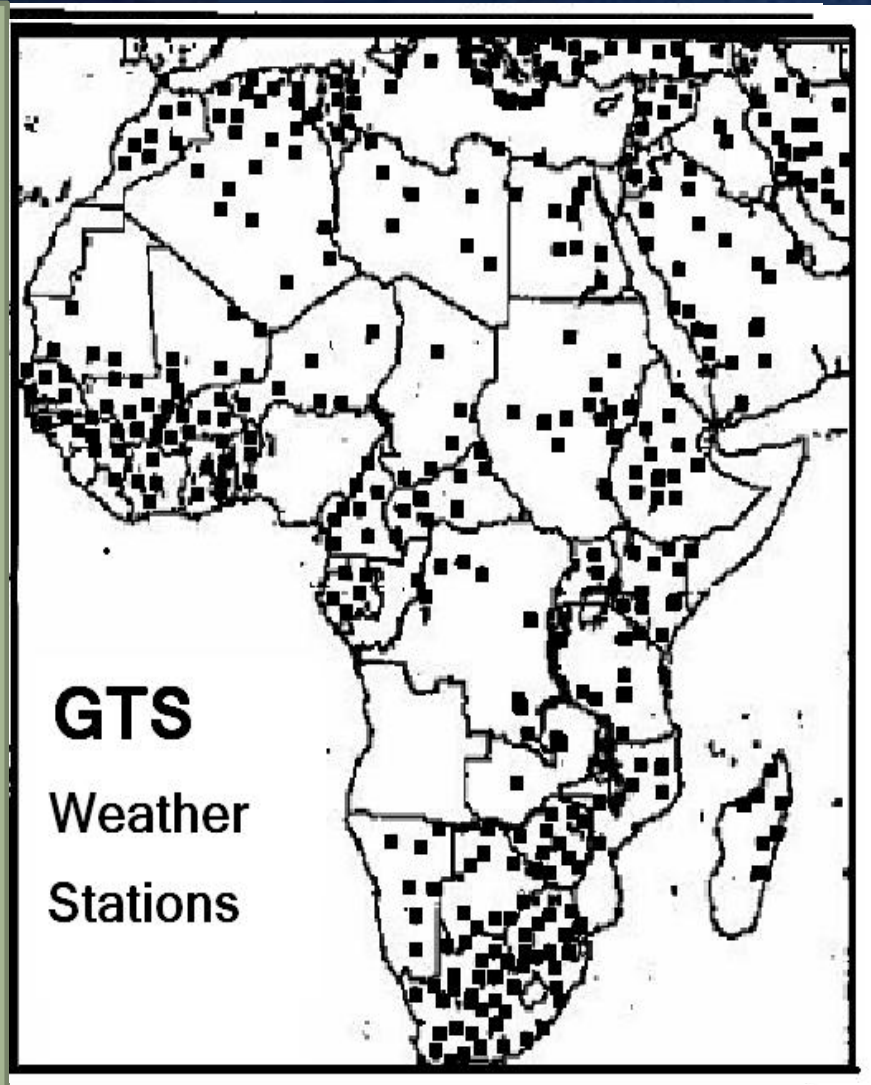
GTS (WMO-based) weather station network

One weather station covers

GLOBAL -10,000 sq. km
Africa - 31,000 sq. km

NOAA satellites cover

AVHRR: 4 & 16 km²
VIIRS: 0.5, 1 & 4 km²



Vegetation Health

(1) Normalized Difference Vegetation Index (NDVI)

VIS (Ch1) and NIR (CH2)

Brightness Temperature (BT)

IR (CH4)

(2) NDVI & BT Climatology

Vegetation Health (VH) Indices

Vegetation condition index (VCI), **values 0 - 100**

VCI=(NDVI-NDVImin)/(NDVImax-NDVImin)

NDVImax, and NDVImin – climatology (1981-2000 maximum and minimum NDVI for a pixel;

MOISTURE

Temperature condition index (TCI), **values 0 - 100**

TCI=(BTmax-BTmin)/(BTmax-BTmin)

NDVImax, and NDVImin – climatology (1981-2000 maximum and minimum NDVI for a pixel

THERMAL

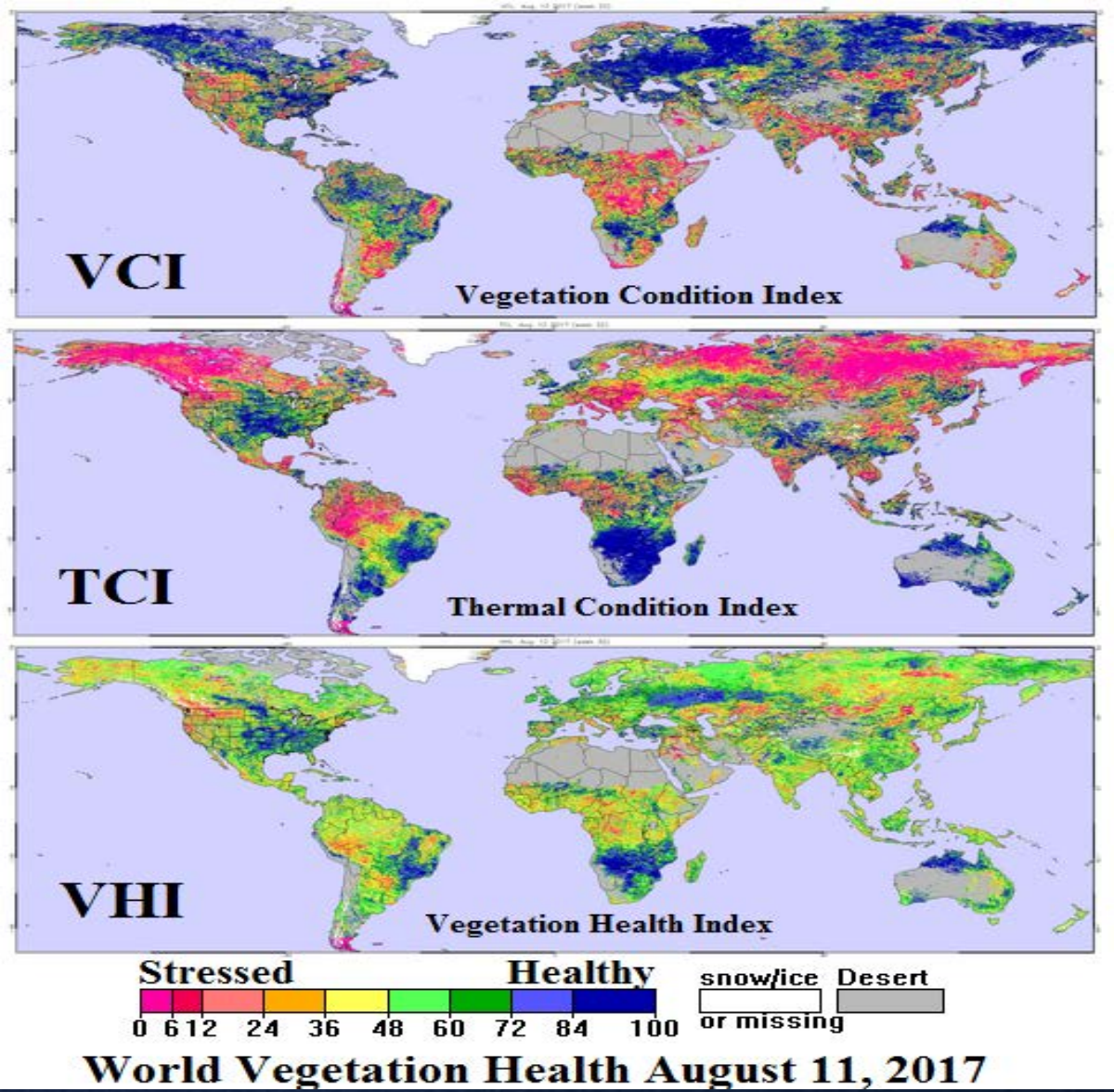
Vegetation Health Index (VHI), **values 0 – 100**

VHI=a*VCI+(1-a)*TCI

VEG. HEALTH

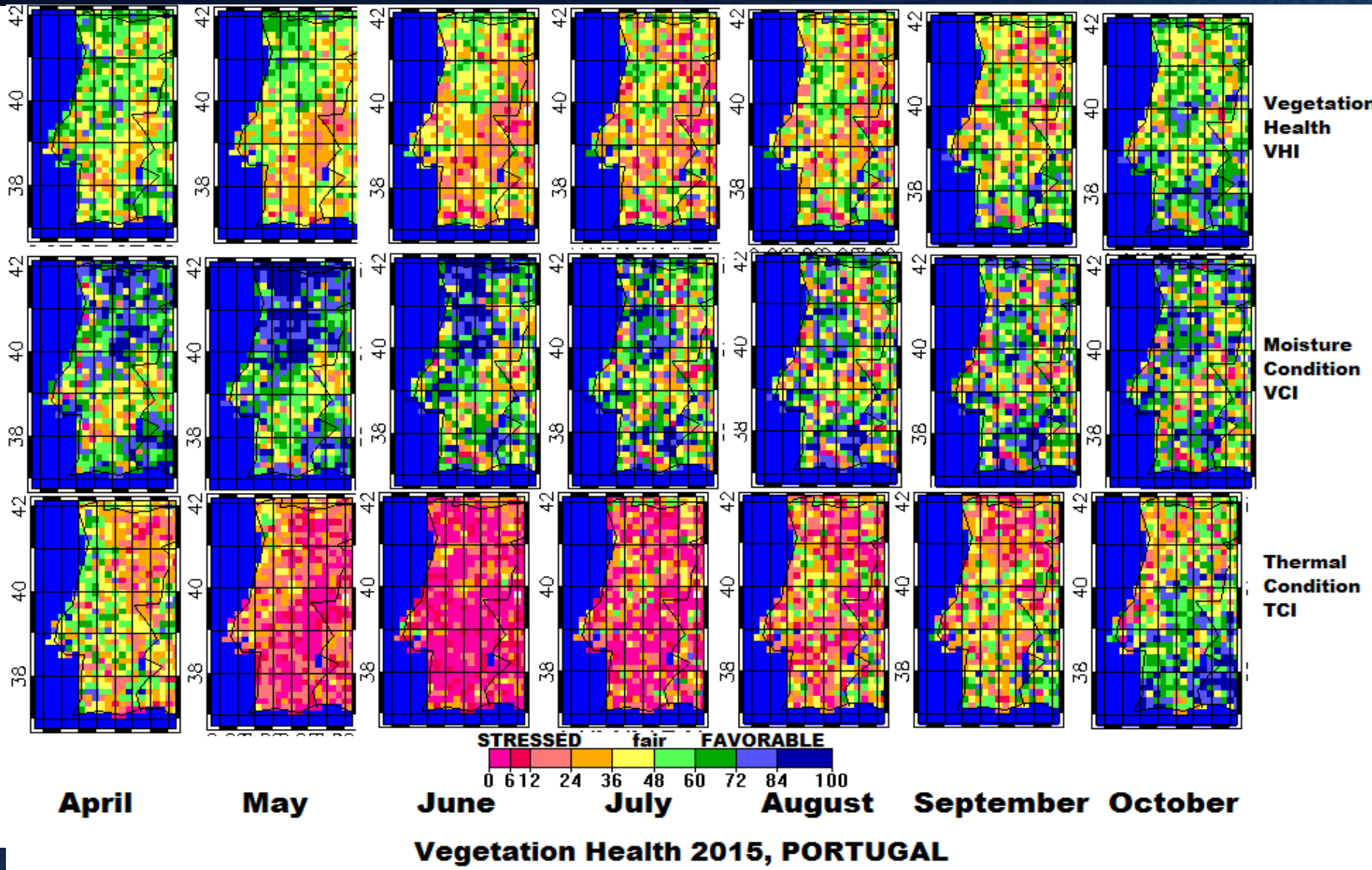
0 – indicates extreme stress; 100 – indicates favorable conditions

VCI, TCI & VHI Aug 11, 2017



2015 PORTUGAL

Vegetation health

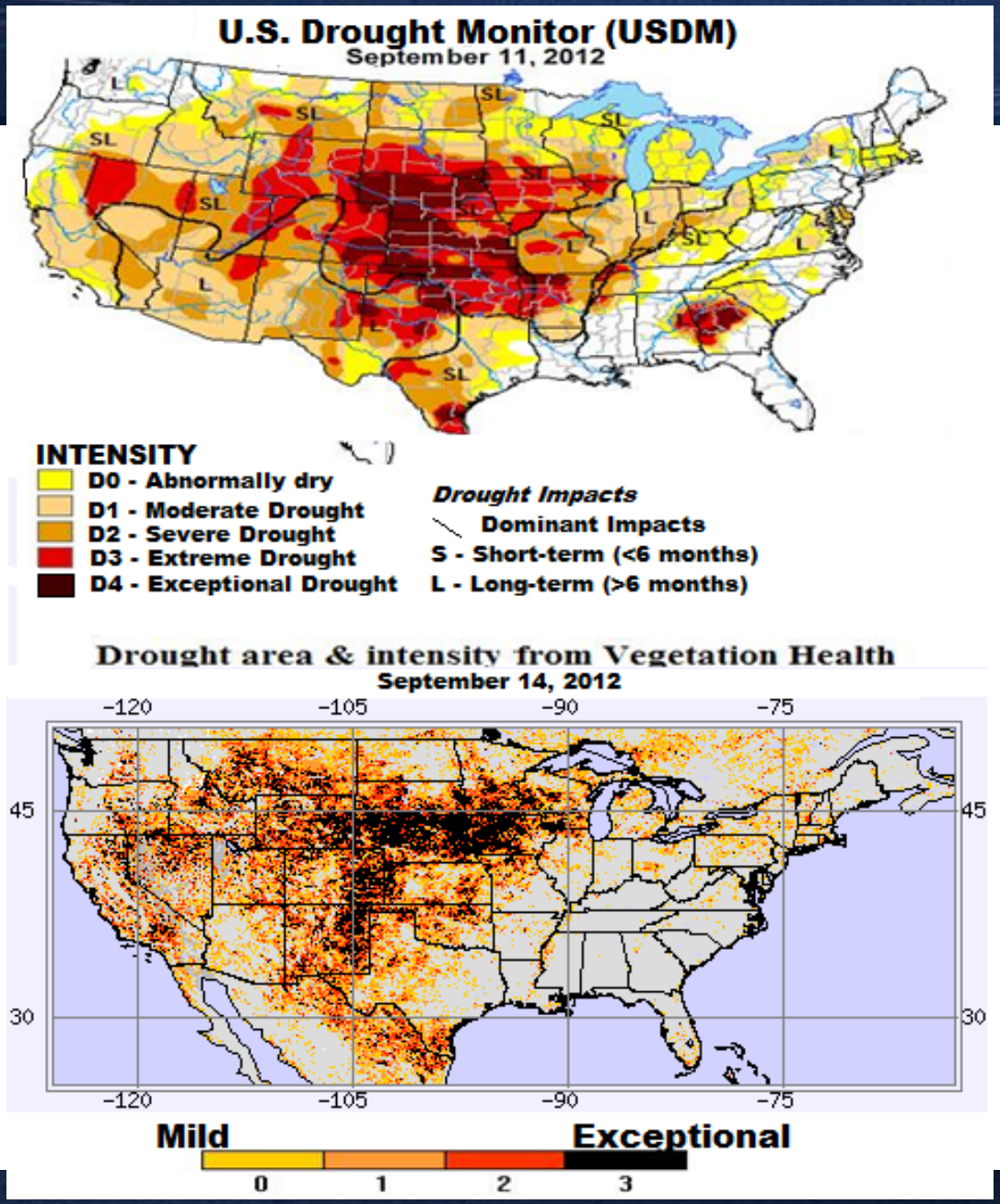


Vegetation Health (VH) Data

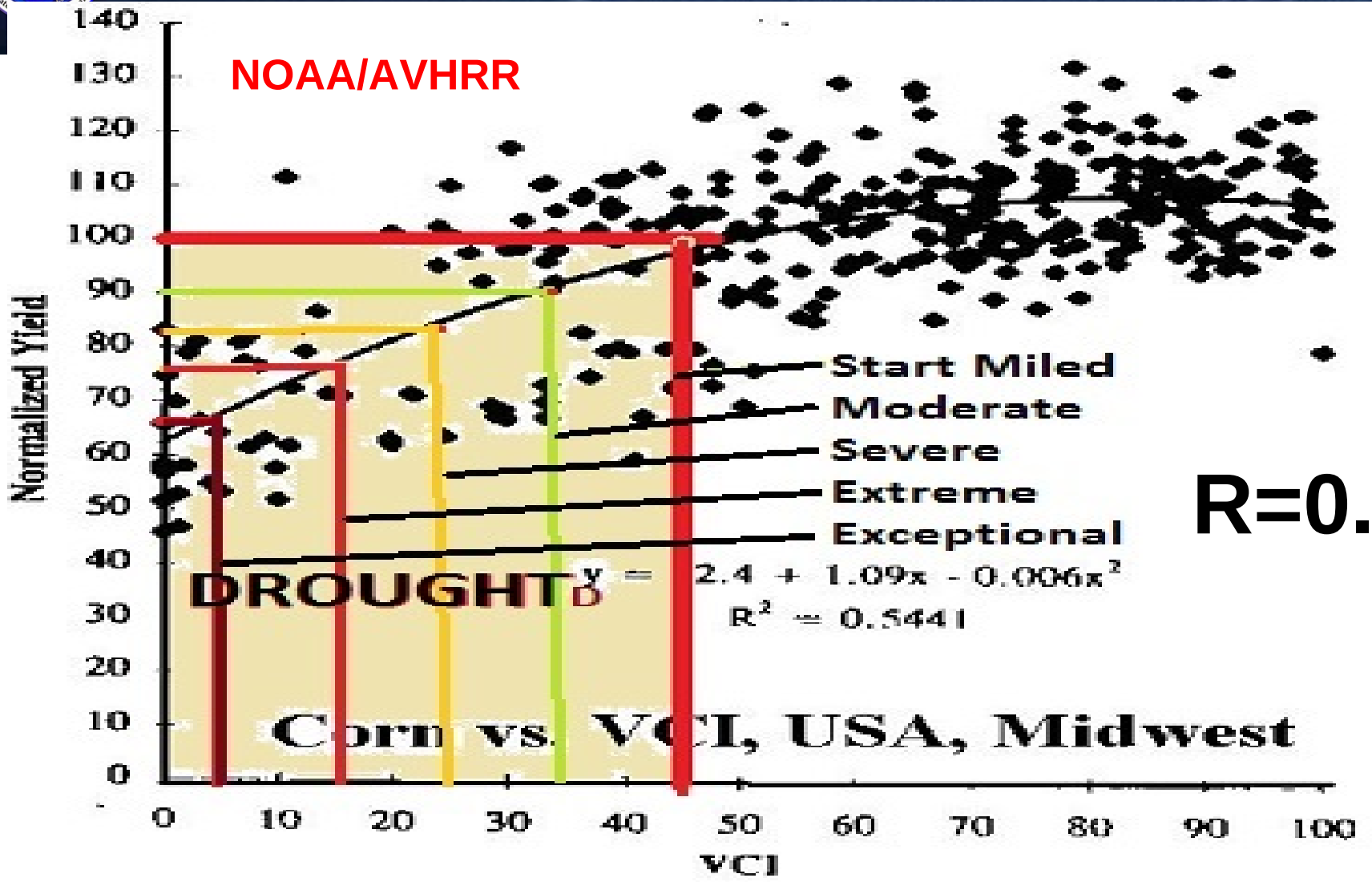
- NOAA/AVHRR (37y) 16 sq. km
  4 sq. km

- SNPP/VIIRS (6 y) 4 sq. km
  1 sq. km
  0.5 sq. km

Drought USDM & VH



Corn Yield vs AVHRR-based Vegetation health indicator (VCI) Midwest, USA

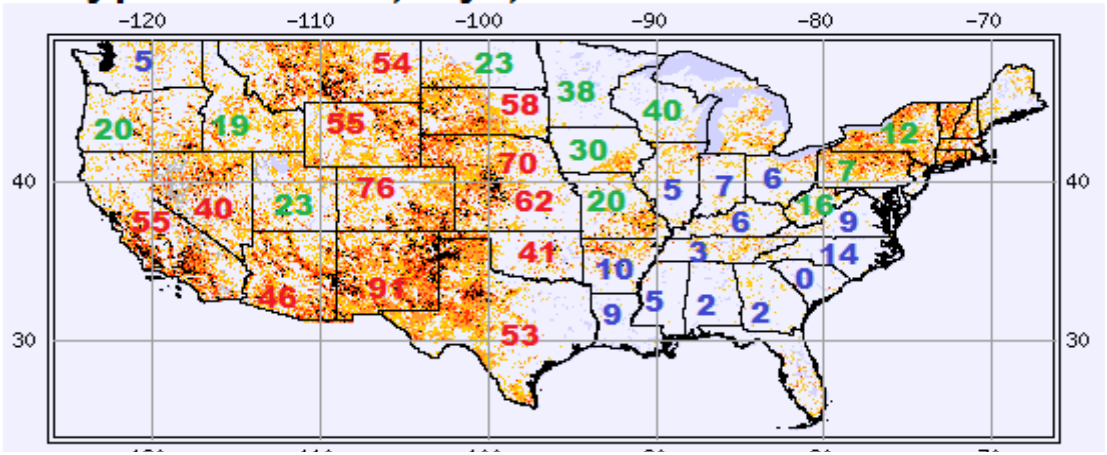


R=0.75

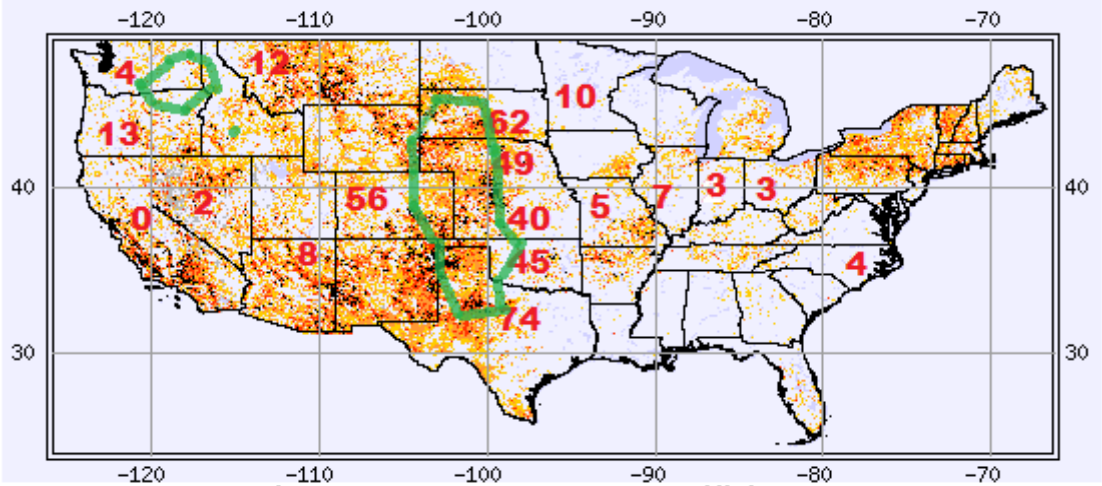
Correlation of Corn Yield Anomaly with VCI and Drought Classification

VHP-drought stress & USDA pasture & winter wheat condition, May 6, 2013

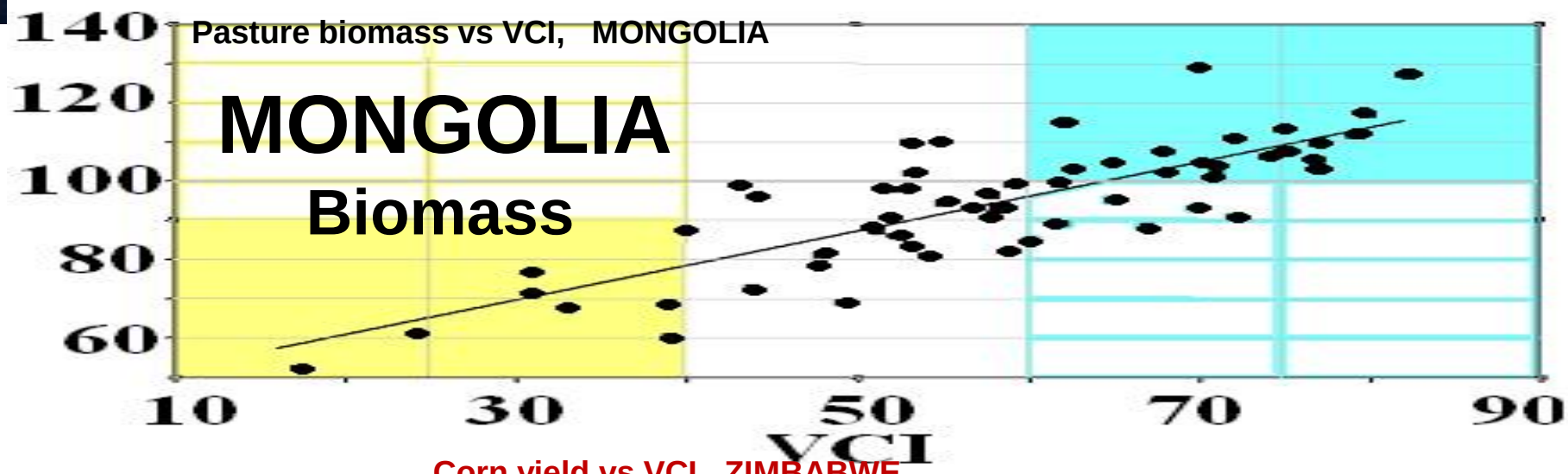
VH-based Drought Stress & % state with pasture & range land in poor & very poor coonditions, May 6, 2013



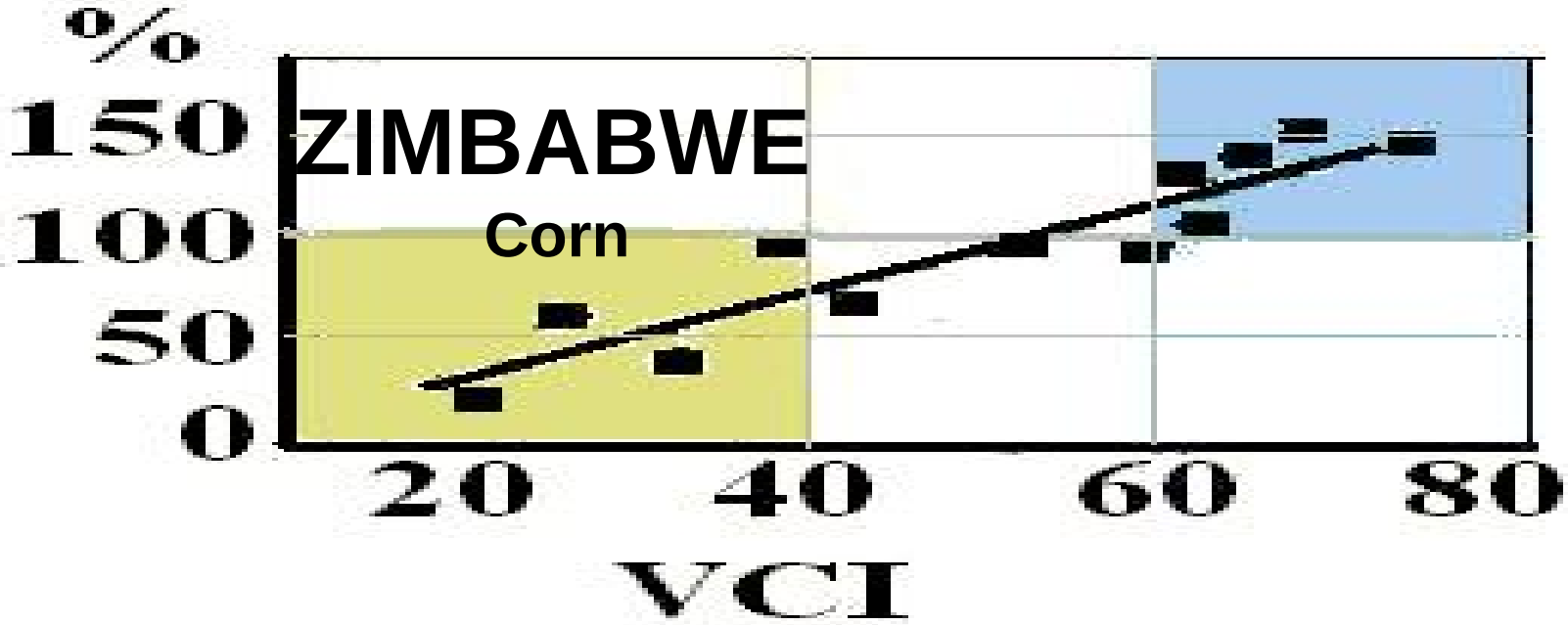
VH-based Drought Stress (NOAA), May 6, 2013 & Percent Whinter Wheat Area in Poor and Very Poor Conditions (USDA), May 5, 2013



VH-Biomass & Corn Yield Modeling & Prediction

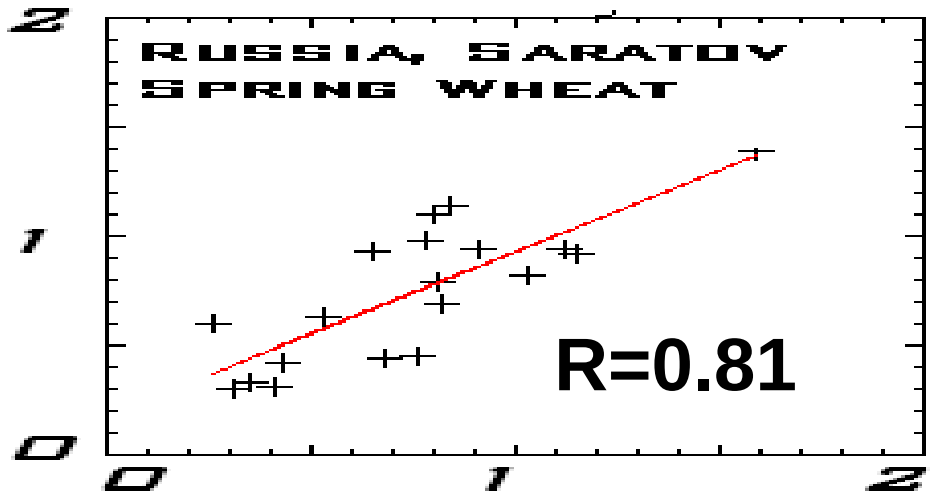


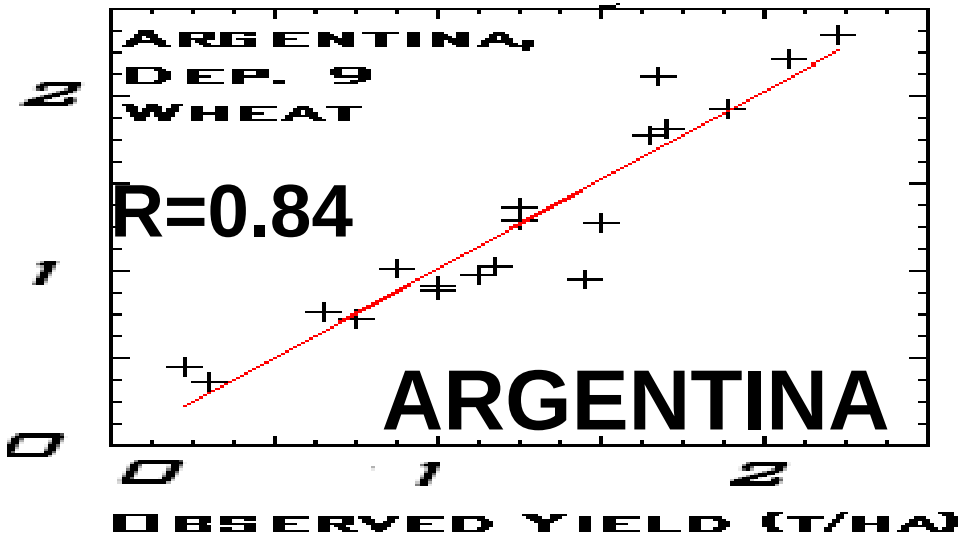
Corn yield vs VCI, ZIMBABWE



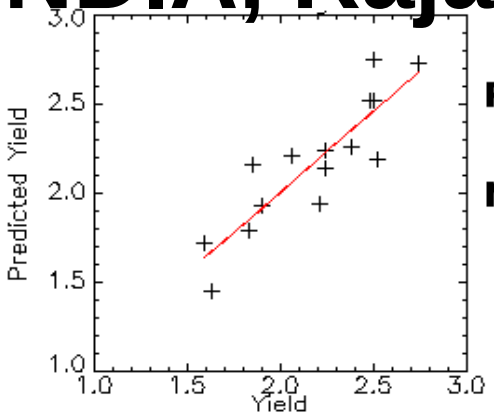
VH Predicted vs Observed Wheat Yield R=0.81

RUSSIA





INDIA, Rajasthan

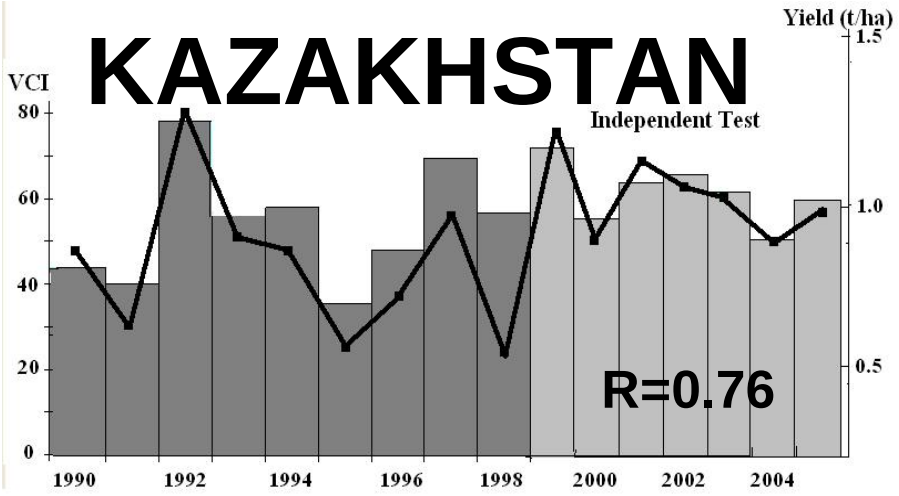


RSQ= 0.78

MSE=0.0291
SE= 3%
UE= 97%

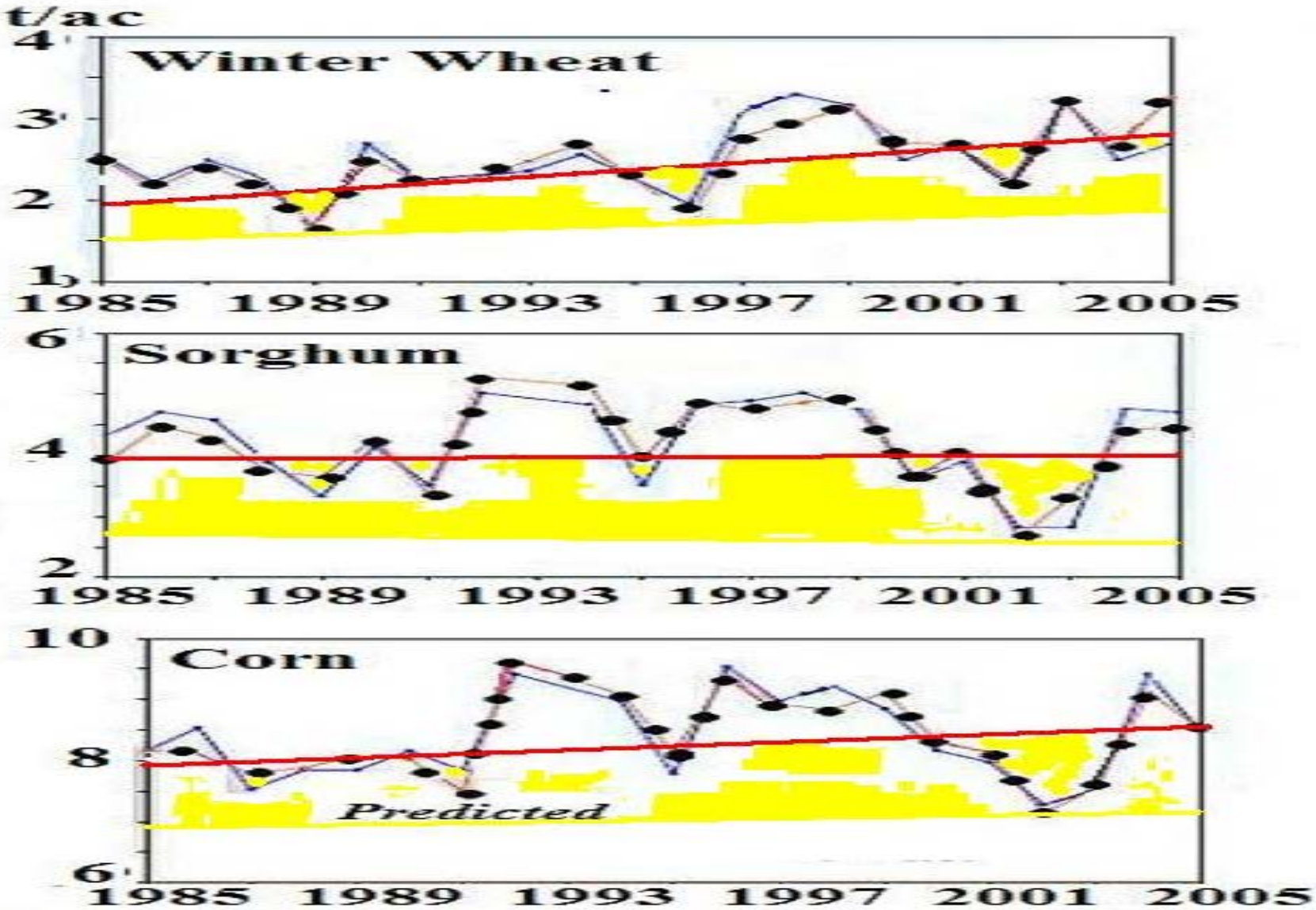
DY= 1.139 - 0.0022*VCI47-49 - 0.0029*TCI50-2
+ 0.0015*VCI14 + 0.0015*TCI14
R= 0.76; SER= 0.066

KAZAKHSTAN



Mean Yield (bars) and VCI, Kazakhstan, Spring Wheat

VH-Crop Losses Prediction: USA, Kansas

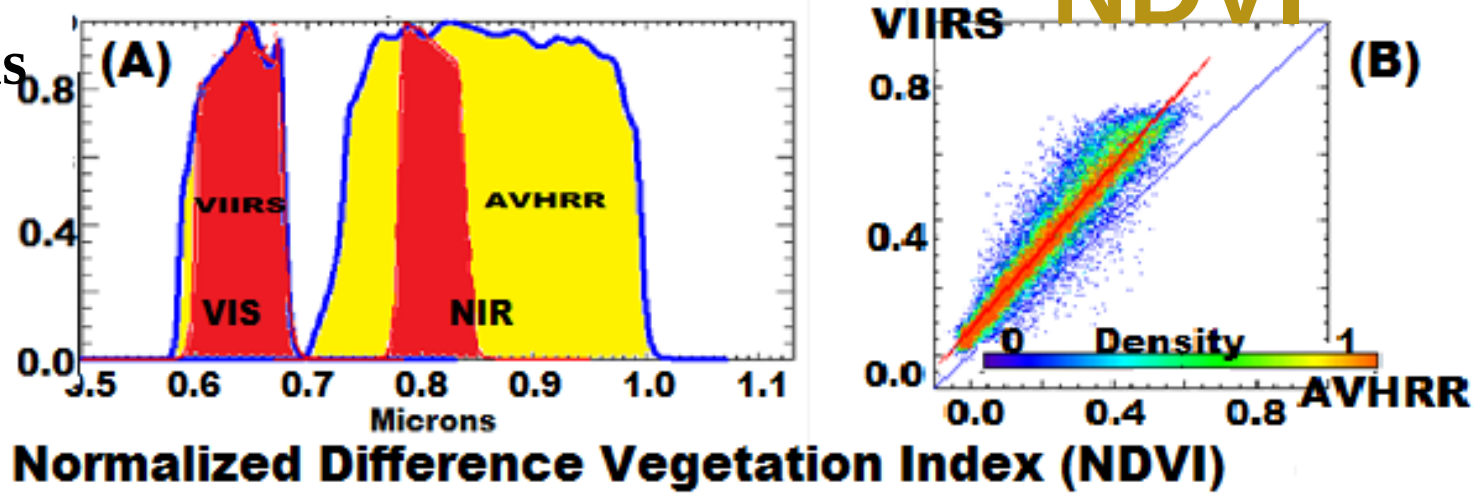


Observed & Predicted Yield, USA, Kansas

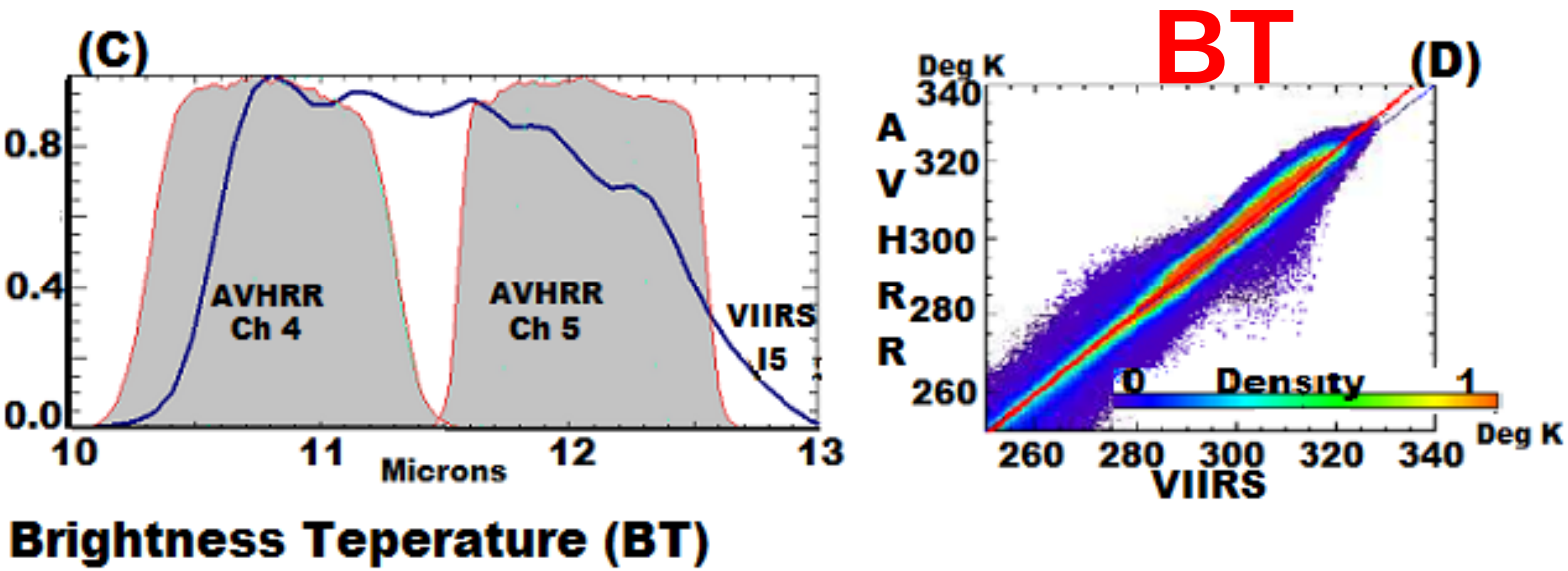
Channels:VIIRS versus AVHRR

Climate data records problems

Channels



Normalized Difference Vegetation Index (NDVI)



Brightness Teperature (BT)

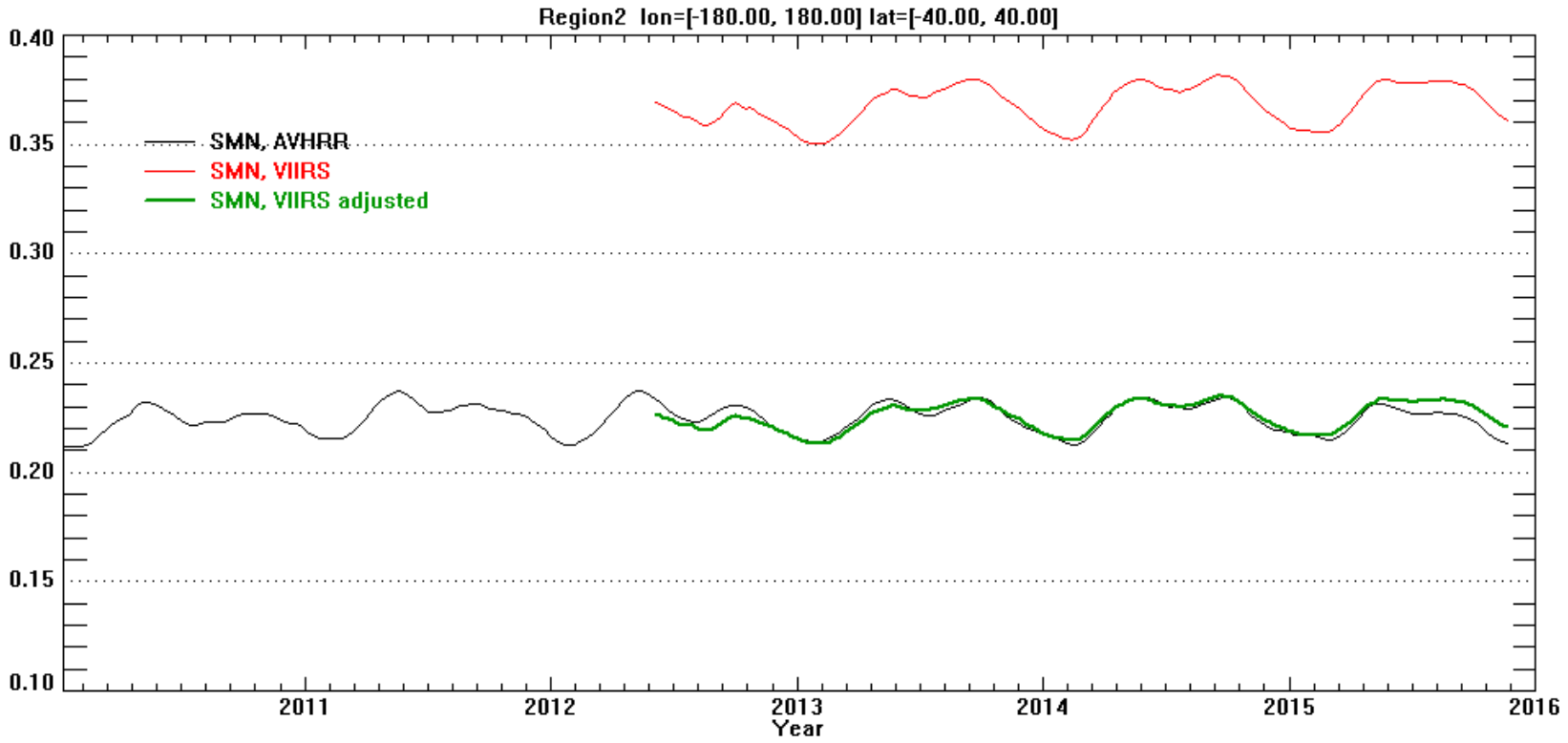
Transition to SNPP/VIIRS & J-1

- TWO methods:

1. Adjust SNPP/VIIRS weekly NDVI & BT to weekly NOAA/AVHRR

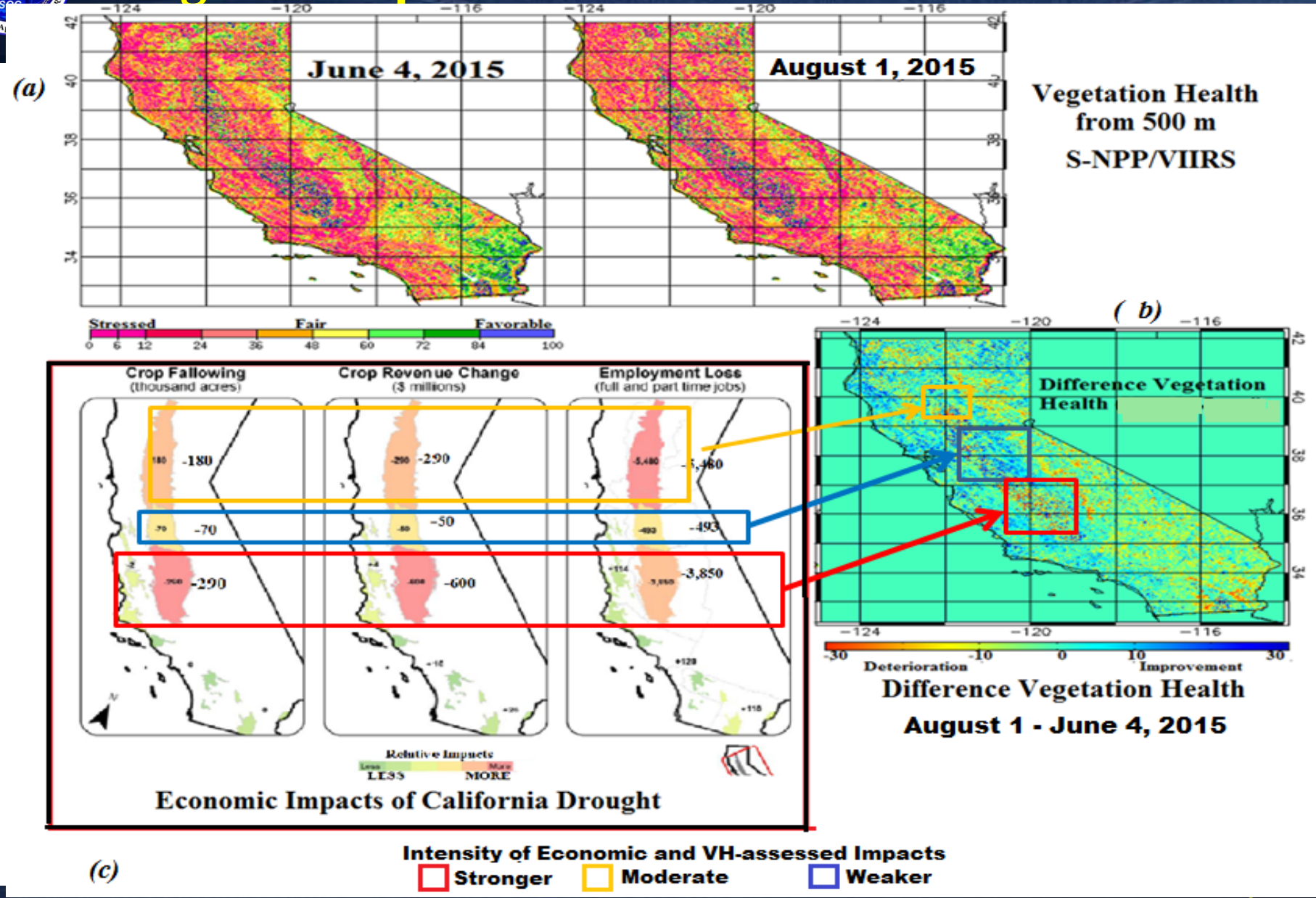
2. Adjust SNPP/VIIRS **5-year** weekly NDVI & BT **climatology** to NOAA/AVHRR **36-year climatology**

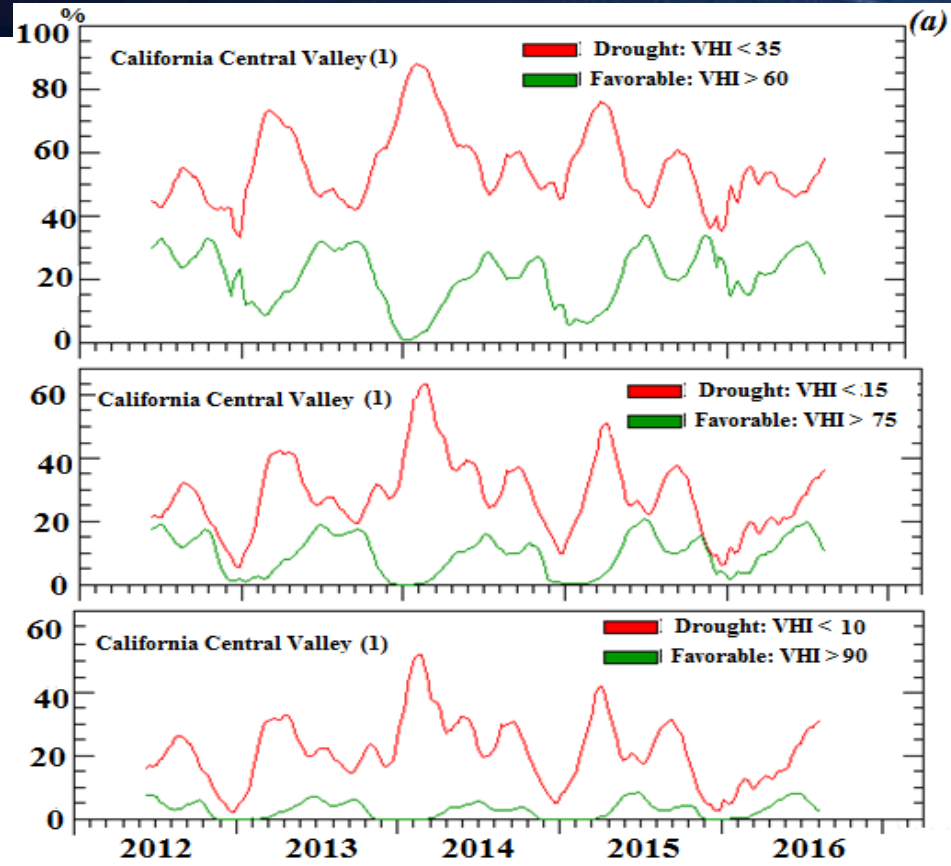
Time series of SMN from VIIRS and AVHRR

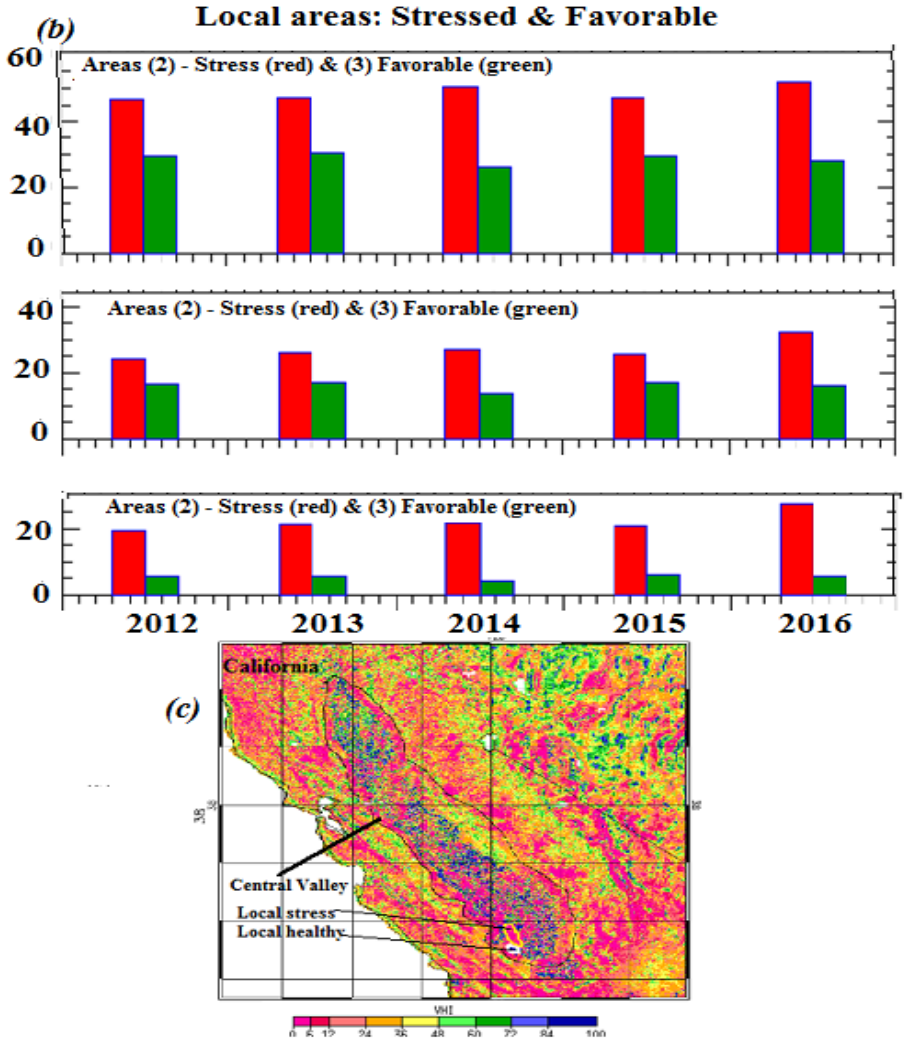


The SMN from VIIRS and AVHRR are not on the same level. Adjustment is required to make the long term time series aligned.

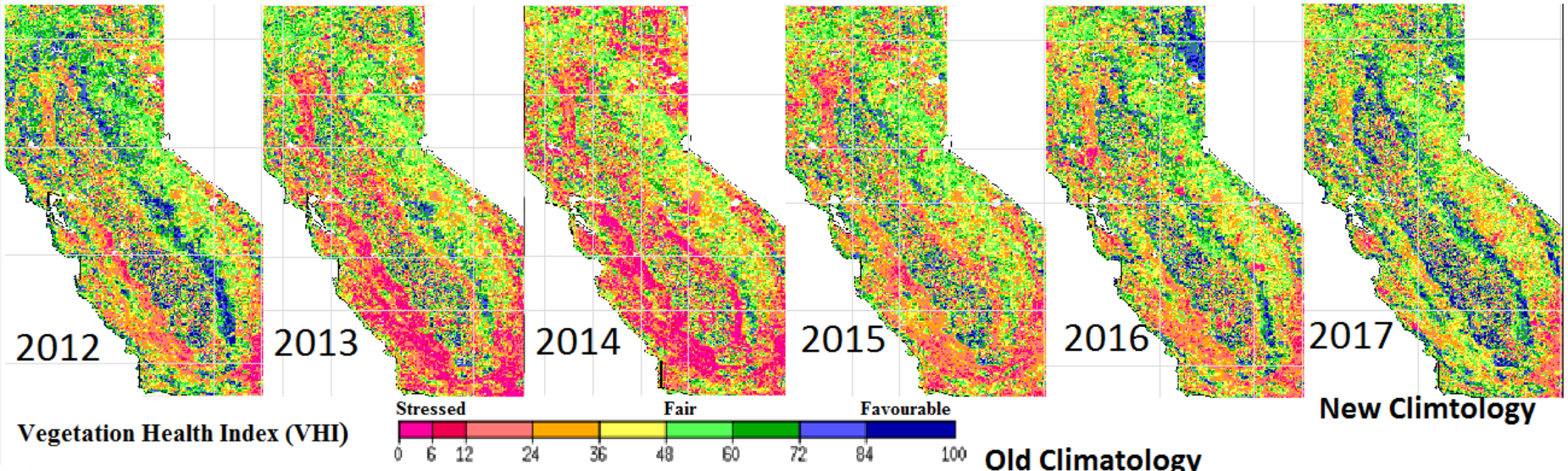
Drought & Impacts from VIIRS 0.5 km California

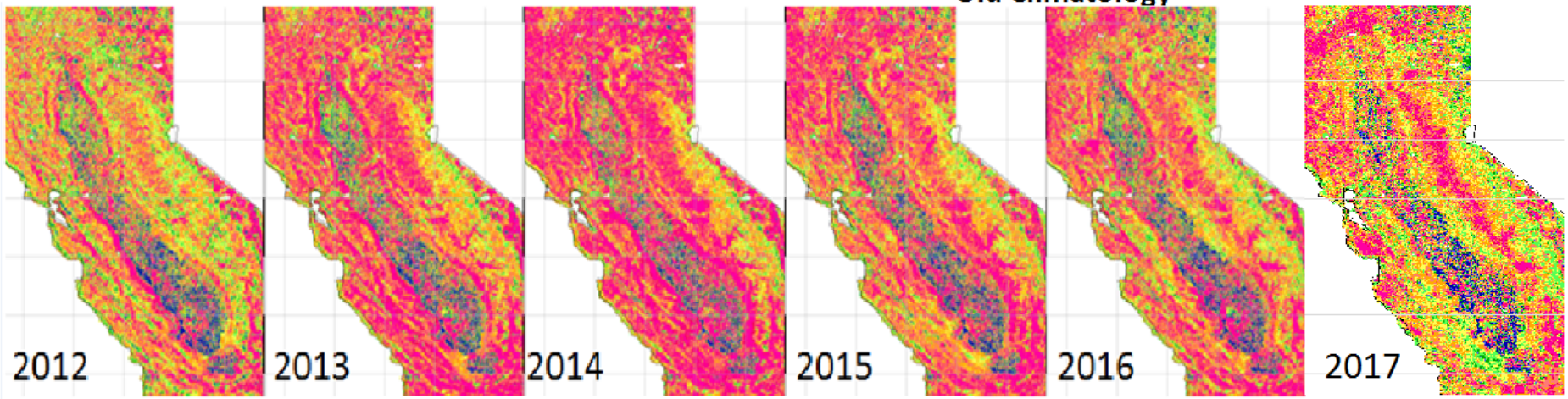



(a)
%
California Central Valley (1)
Drought: VHI < 35
Favorable: VHI > 60
California Central Valley (1)
Drought: VHI < 15
Favorable: VHI > 75
California Central Valley (1)
Drought: VHI < 10
Favorable: VHI > 90
2012
2013
2014
2015
2016


Local areas: Stressed & Favorable
(b)
Areas (2) - Stress (red) & (3) Favorable (green)
Areas (2) - Stress (red) & (3) Favorable (green)
Areas (2) - Stress (red) & (3) Favorable (green)
2012
2013
2014
2015
2016
(c)
California
Central Valley
Local stress
Local healthy
VHI

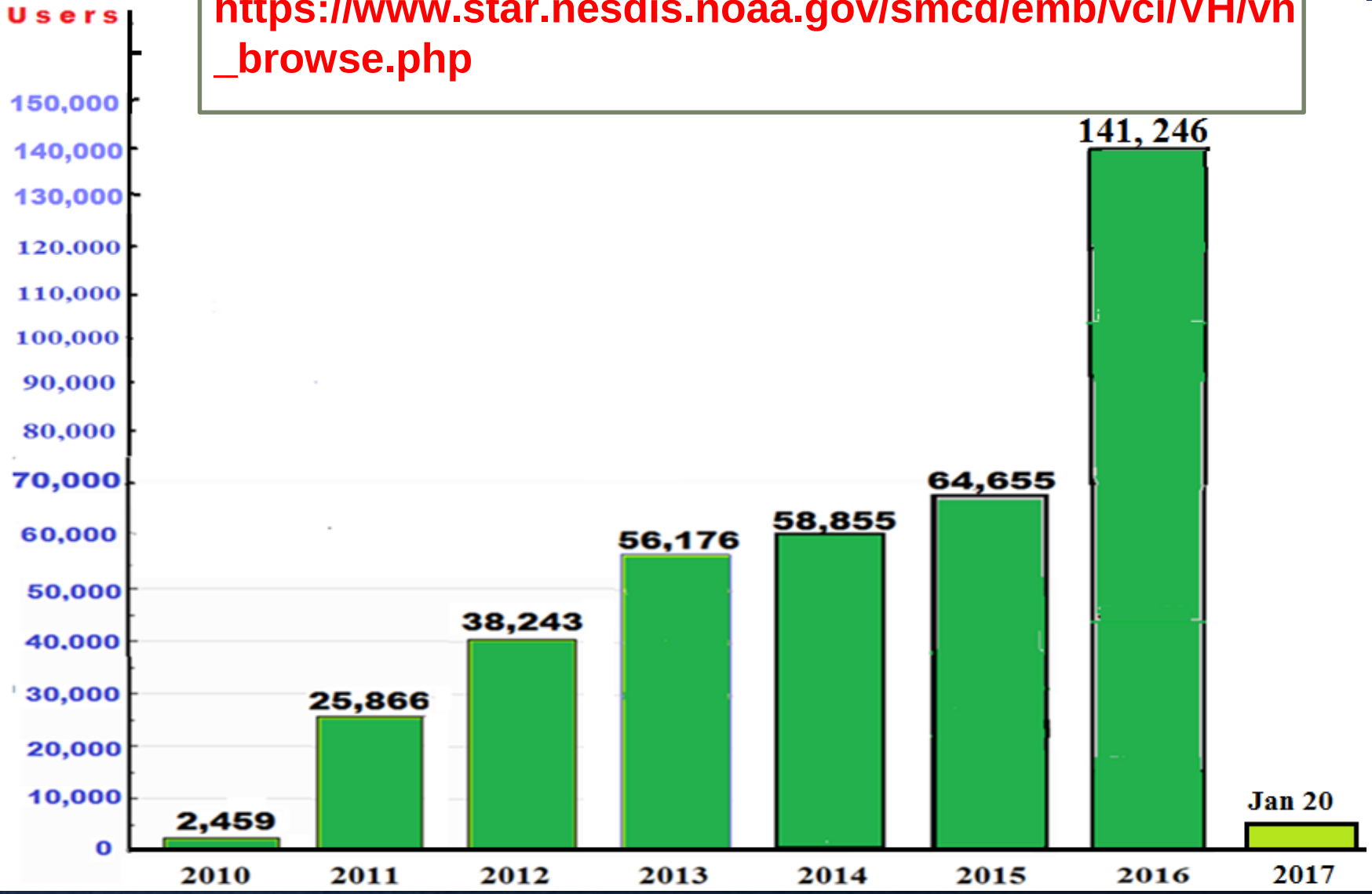
Vegetation Health 0.5 sq.km: New & old Climatology





Users attending Vegetation Health WEB

https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/vh_browse.php



Publication since the early 1980s

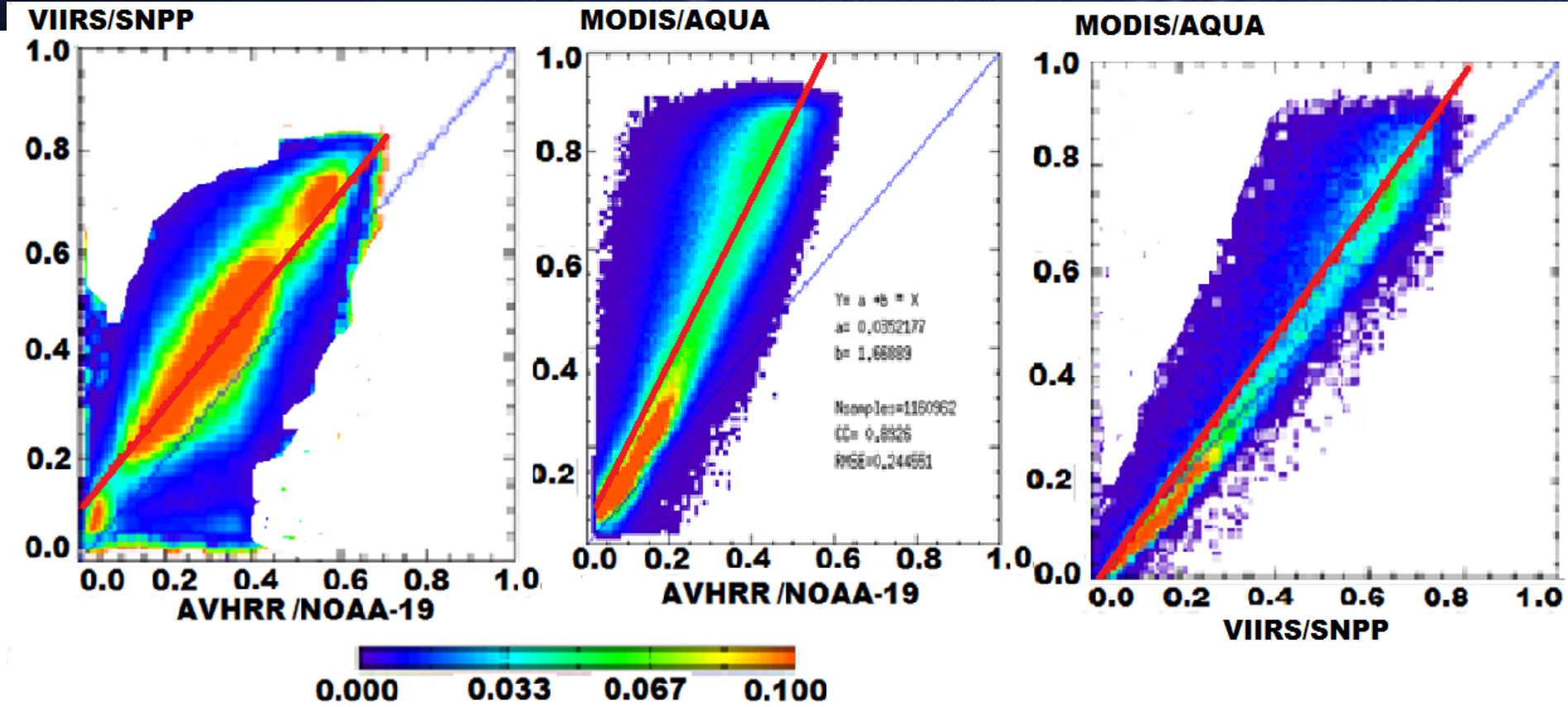
- **Camara N.E. and F.N. Kogan 2017. Monitoring landslides conditions in Madeira Island from NOAA operational satellites.**
- **Kogan F, W. Guo & W. Ysang 2017. SNPP/VIIRS vegetation health to assess 500 California drought, Geomatics, Natural Hazards and Risk, DOI:10.1080/19475705.2017.1337654 (http://dx.doi.org/10.1080/19475705.2017.1337654)**
- **C. Bhuiyan, A. K. Saha, N. Bandyopadhyay & F. N. Kogan 2017. Analyzing the impact of thermal stress on vegetation health and agricultural drought – a case study from Gujarat, India. *GIScience & Remote Sensing,* http://dx.doi.org/10.1080/15481603.2017.1309737**
- **Kogan F & W. Guo 2016. Strong 2015–2016 El Niño and implication to global ecosystems from space data. *International Journal of Remote Sensing,* 38:1, 161-178, DOI: 10.1080/01431161.2016.1259679**
- **Kogan F., Z. Popova and P. Alexandrov 2016. Early forecasting corn yield using field experiment dataset and Vegetation health indices in Pleven region, north Bulgaria. *Ecologia i Industria (Ecology and Industry)* Vol. 9, No 1, 76-80.**
- **Kogan F. and Guo W. 2015. 2006-2015 mega-drought in the western USA and its monitoring from space data. *Geomatic, Natural Hazards and Risk*, DOI:10/1080/19475705.2015.1079265. http://dx.doi.org/10/1080/19475705.2015.1079265.**
- **Kogan F., M.Goldberg, T.Schott and W.Guo 2015. SUOMI NPP/VIIRS: improve drought watch, crop losses prediction and food security. *International Journal Remote Sensing*, DOI: 10.1080/01431161.2015.1095370. http://dx.doi.org/10.1080/01431161.2015.1095370.**
- **Kogan F., W. Guo, A. Strashnaia, A. Kleshenko, O. Chub and O. Virchenko 2015. Modelling and prediction of crop losses from NOAA polar-orbiting operational satellites. *Geomatics, Natural Hazards and Risk.* http://dx.doi.org/10.1080/19475705.2015.1009178**
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- Kogan F.N. 1998. A typical pattern of vegetation condition in southern Africa during El Nino years detected from AVHRR data using three-channel numerical index. *International Journal Remote Sensing,* Vol. 19, No. 18, 3689-3695.
- Kogan FN. 1997. Global drought watch from space. *Bulletin of the American Meteorological Society* **78**: 621-636.
- *Kogan, F.N.J.T. Sullivan and Pu Bu Ciren, 1996.Testing post-launch calibration for the AVHRR sensor on world desert targets during 1985-1993. *Advancement in Space Research.* Vol.17, No. 1, 47-50.
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- Kogan F., J. Sullivan, R. Carey and D. Tarpley 1994. Post-Pinatubo vegetation index in central Africa. *GEOCARTO International.* Vol. 9 (3), 63-66.
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- Kogan F. 1993a. Development of global drought-watch system using NOAA/.AVHRR data. *Advancement in Space Research.* Vol.13, No. 5, 219-222.
- Kogan F. 1993b. Global drought detection and impact assessment from space. *DROUGHT: A Global Assessment* (Ed. Wilhite, D.A.), Vol. 1. Routledge, London and New York, 196-209.
- Kogan F. 1993c. Drought monitoring from NOAA polar orbiting satellites: Principles, development and verification. *Issledovaniya Zemli is Kosmosa (Land Studies from Space)*, No 4 (535.243.1:632.2), 12-22.
- Kogan F. 1989. Remote sensing of weather impacts on vegetation in non-homogeneous areas. *International Journal Remote Sensing,* Vol. 11, No. 8, 1405-1419.
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- Kogan F. 1985a. Sun Won't Keep Shine on Soviet Agriculture. *The Wall Street Journal.* August 29, p12.
- Kogan F. 1985b. Look for Soviet buying of grain to drop this year. *The Des Moines Register.* August 13.
- Kogan F. 1983a. Perspectives for grain production in the USSR. *Agricultural Meteorology,* 28, 213-227.
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- **BACK UP**

Mean NDVI (40N-40S)
VIIRS vs MODIS vs AVHRR: 2012 July



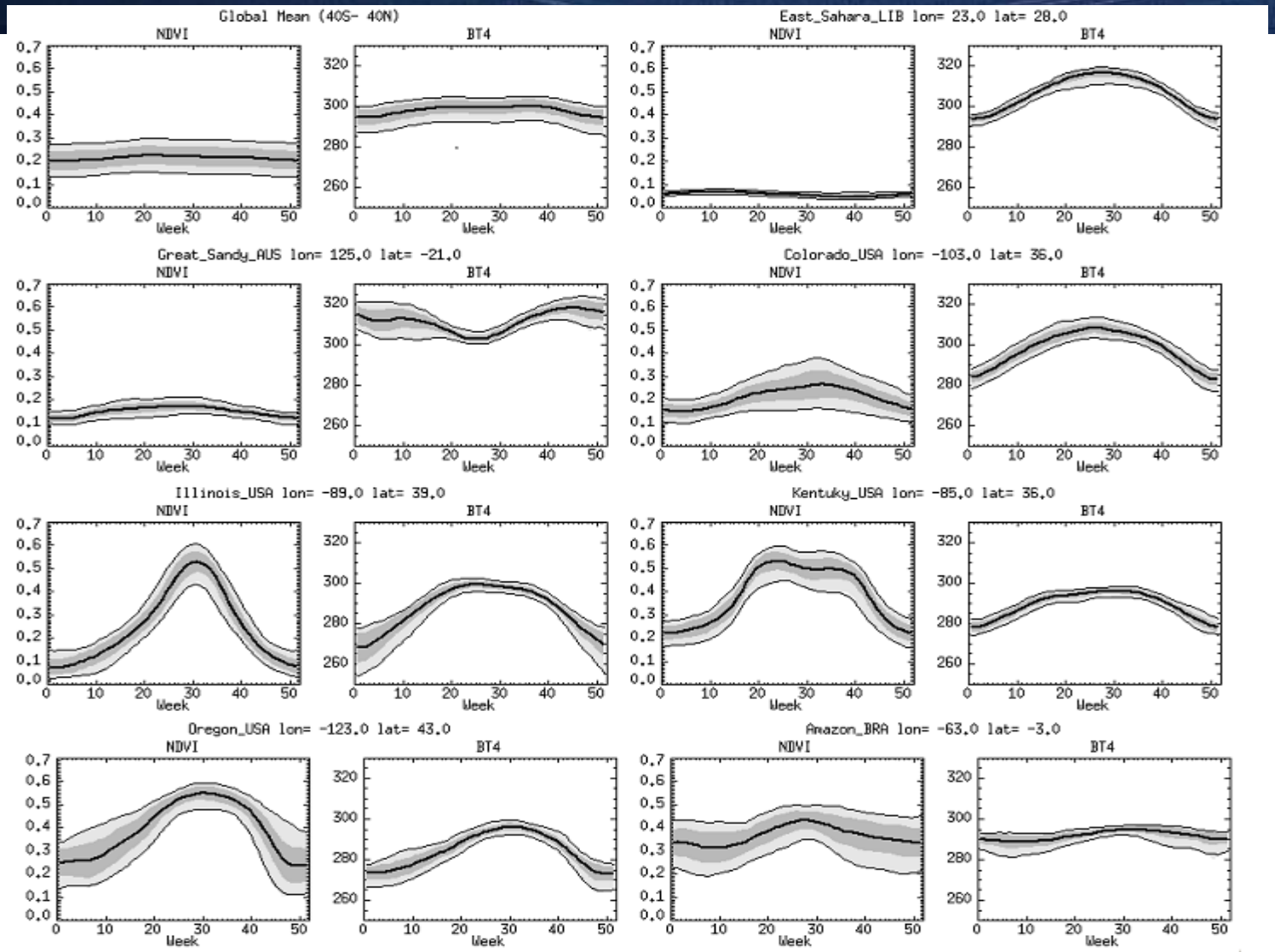
ACCOMPLISHMENTS

- Data collection from SNPP/VIIRS, AVHRR/NOAA-18 & 19, MODIS/AQUA
- Algorithm Development (data sampling, gap filling, reflectance calculation, noise removal)
- Data processing (NDVI, BT, no noise NDVI & BT)
- Data Stability tests

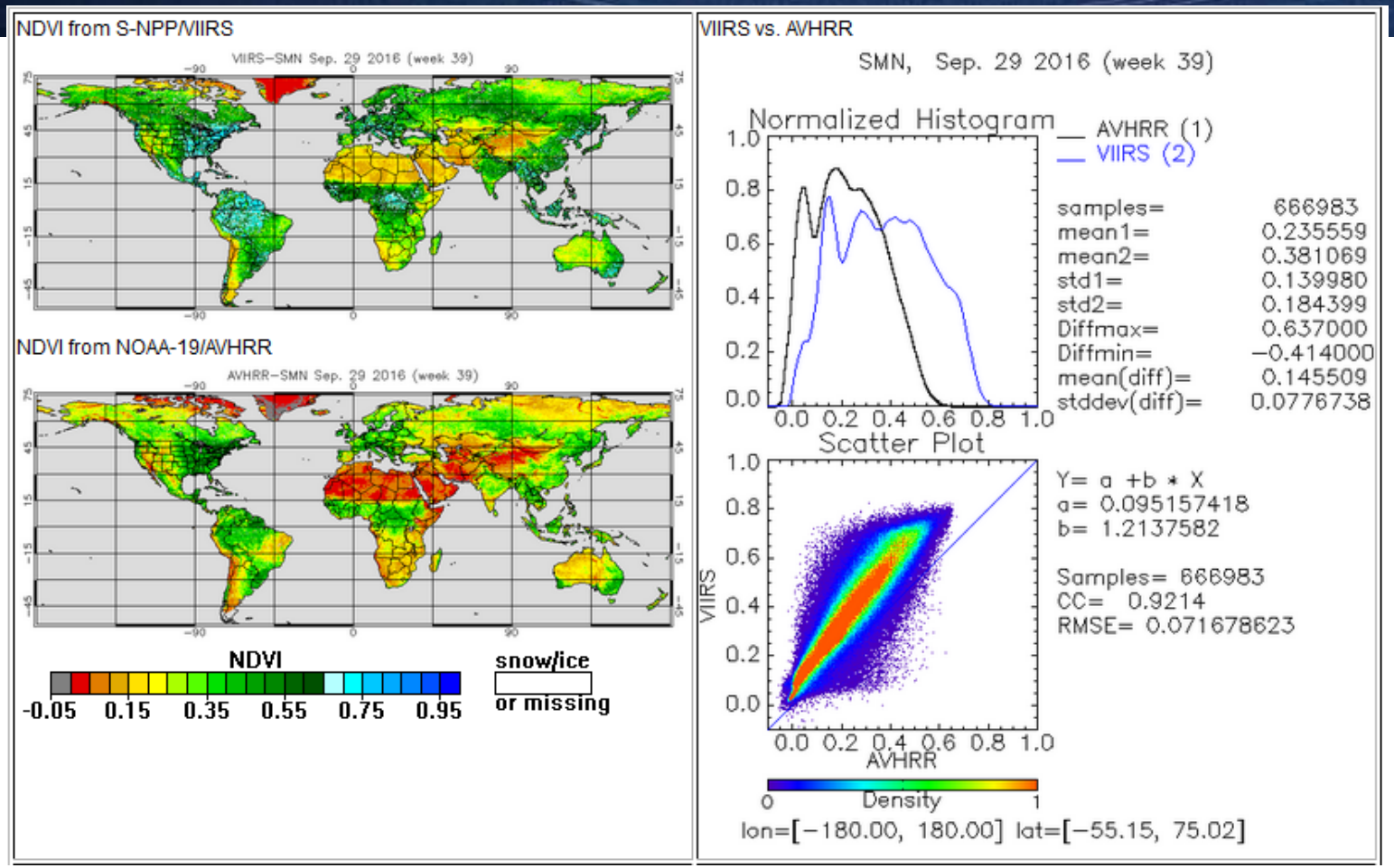
Algorithm Background

- **The SNPP & J1/VIIRS Vegetation Health (VH) Indices from EDR**
- **VIIRS/VH-1 is global weekly composite products with 1 km² resolution**
- **The VH-EDR consists of three indices, Vegetation Condition Index (VCI), Thermal Condition Index (TCI) and Vegetation Health Index (VHI)**
- **The algorithm is based on three bio-physical laws: Liebig's Law-of-Minimum, Shelford's Law-of-Tolerance & Carrying Capacity**
- Daily **SNPP/VIIRS-1** is derived from the TOA radiances: VIS, NIR - image bands: & Thermal bands
- The radiances are pre-launch & post-launch calibrated, checked for accuracy
- Weekly composite raw Normalized Difference Vegetation Index (NDVI) and raw Brightness temperature (BT) are calculated after adjustment for sun angle, observation time & atmospheric effects
- Noise removal from weekly raw NDVI & BT and converting them to no noise NDVI (SMN) and BT (SMT)
- Climatology derivation from multi-year SMN and SMT weekly data, using three Bio-physical Laws
- Two SNPP/VIIRS & J1/VIIRS climatology conversions to longer data sets & tests:
  - NDVI & BT real-time weekly from 5-year SNPP/VIIRS to 36-year NOAA/AVHRR
  - NDVI & BT climatology weekly from 5-year SNPP/VIIRS to 36-year NOAA/AVHRR
- Modeling SNPP/VIIRS-1 Vegetation condition index (VCI), Temperature condition index (TCI) & Vegetation health index (VHI)
- Derivation of VH-EDR's per-pixel quality flags (e.g., land/water snow, desert, cloud mask and random noise)
- Test SNPP VIIRS/VH-1 performance with in situ data

36-year Climatology: Max, Min, Mean



Expl: NDVI/SMN – VIIRS vs AVHRR



The SMN from VIIRS and AVHRR are not on the same level. Adjustment is required to make the long term time series aligned.

Vegetation Health Milestones Update June 10, 2017

- Calculate 5 year climatology (max and min) from S-NPP VIIRS (Apr, 2017)
- Calculate same 5 year climatology from AVHRR (Apr 2017)
- Similar/dissimilar for the two climatology (May, 2017)
- Similar/dissimilar for 5-year & 36-year climatology
- Calculate VIIRS/VH (VCI, TCI, VHI) (Jun, 2017)
- Compare VIIRS/VH to AVHRR/VH for 2012-2017 (Jan, 2018)
  - If there are issues with the VIIRS climatology re-calculate it each year with J1 data.

Algorithm Improvements

Algorithm Improvements

- 4 km Climatology from AVHRR
- 4 and 1 km Climatology from VIIRS
- Cal/Val Climatology for evaluating algorithm performance
    a. Comparison with AVHRR algorithms
    b. Comparison with *in situ* data

SNPP/VIIRS-1 Climatology

- Directly generate 5-year VIIRS 1km climatology (V5);

- Generate pseudo 36-year VIIRS 1km climatology (V36) based on VIIRS 4km V36 climatology and 1km V5 climatology:

- Get mean value over 4km grid cell for climatology mean:

  From V5 1km MEAN at specific week ($MEAN_{virrs1km}$), calculate mean values over 4km grid ($MEAN_{viirs4km}$).

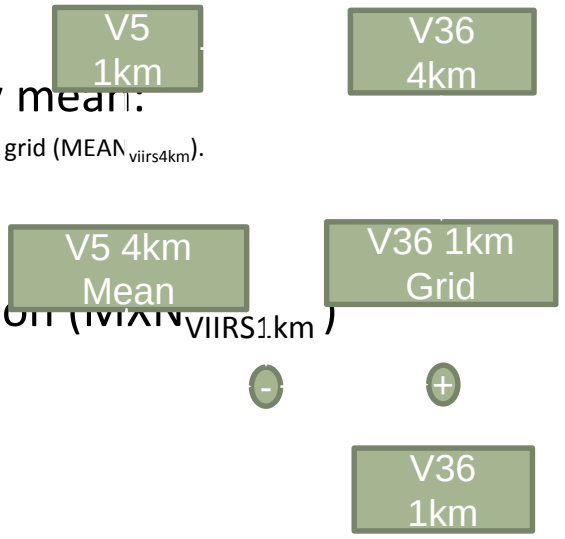
- Calculate adjustment:

  $Adjustment = MEAN_{viirs1km} - MEAN_{viirs4km}$

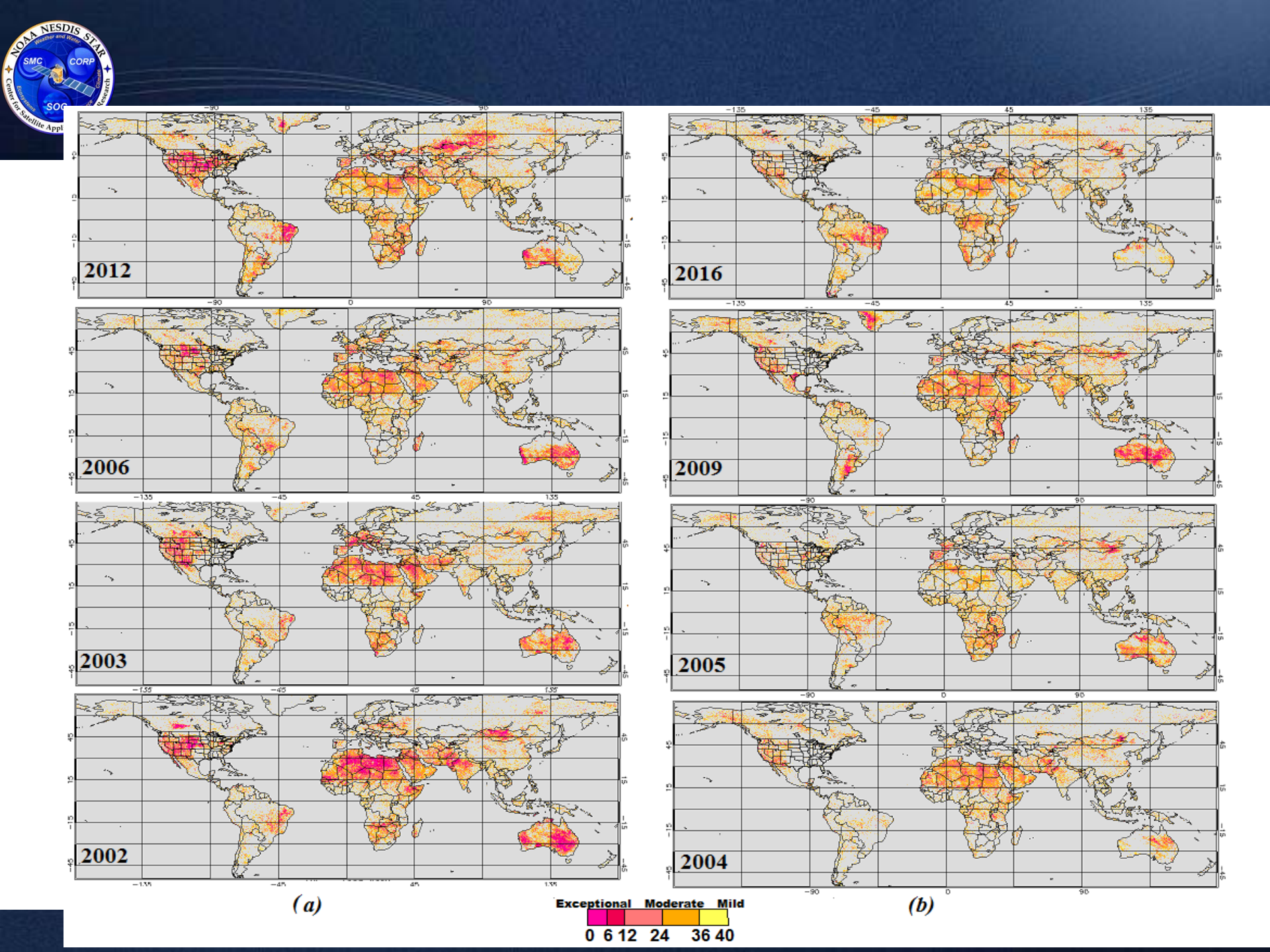
- Interpolate 4km VIIRS climatology to 1km resolution ($MXN_{VIIRS1km}$)

  $MXN_{viirs4km} \rightarrow MXN_{viirs1km}$

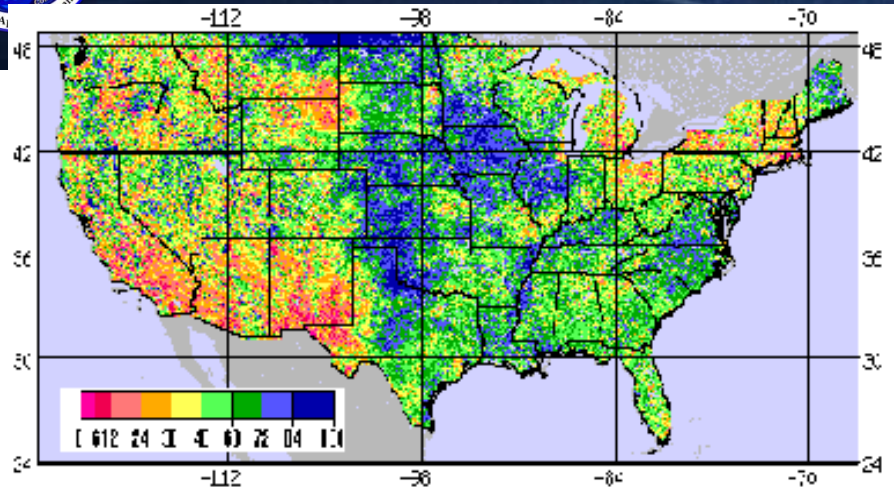
- $MXN_{new} = MXN_{viirs1km} + Adjustment$

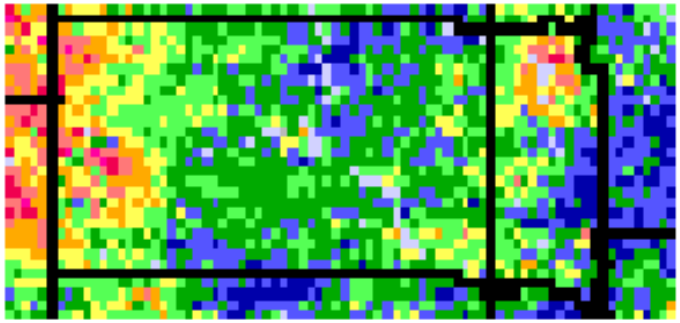


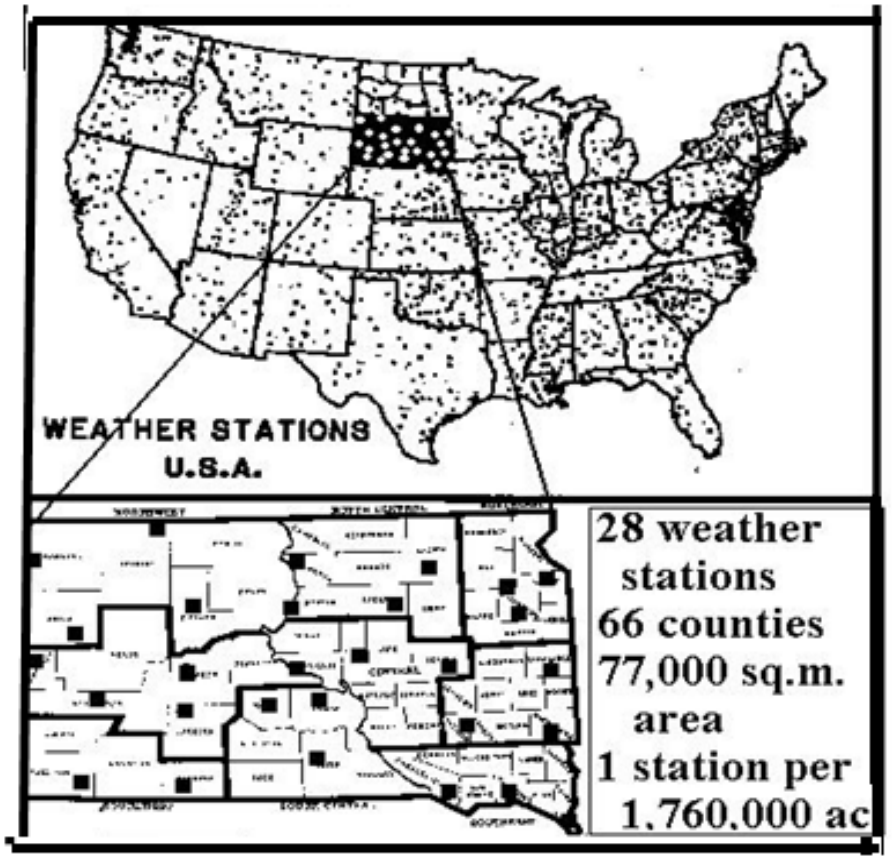
Back Up


2012
2006
2003
2002
2016
2009
2005
2004
(a)
(b)
Exceptional
Moderate
Mild
0 6 12 24 36 40

Weather Stations & Satellite Data Coverage







LAND COVERAGE

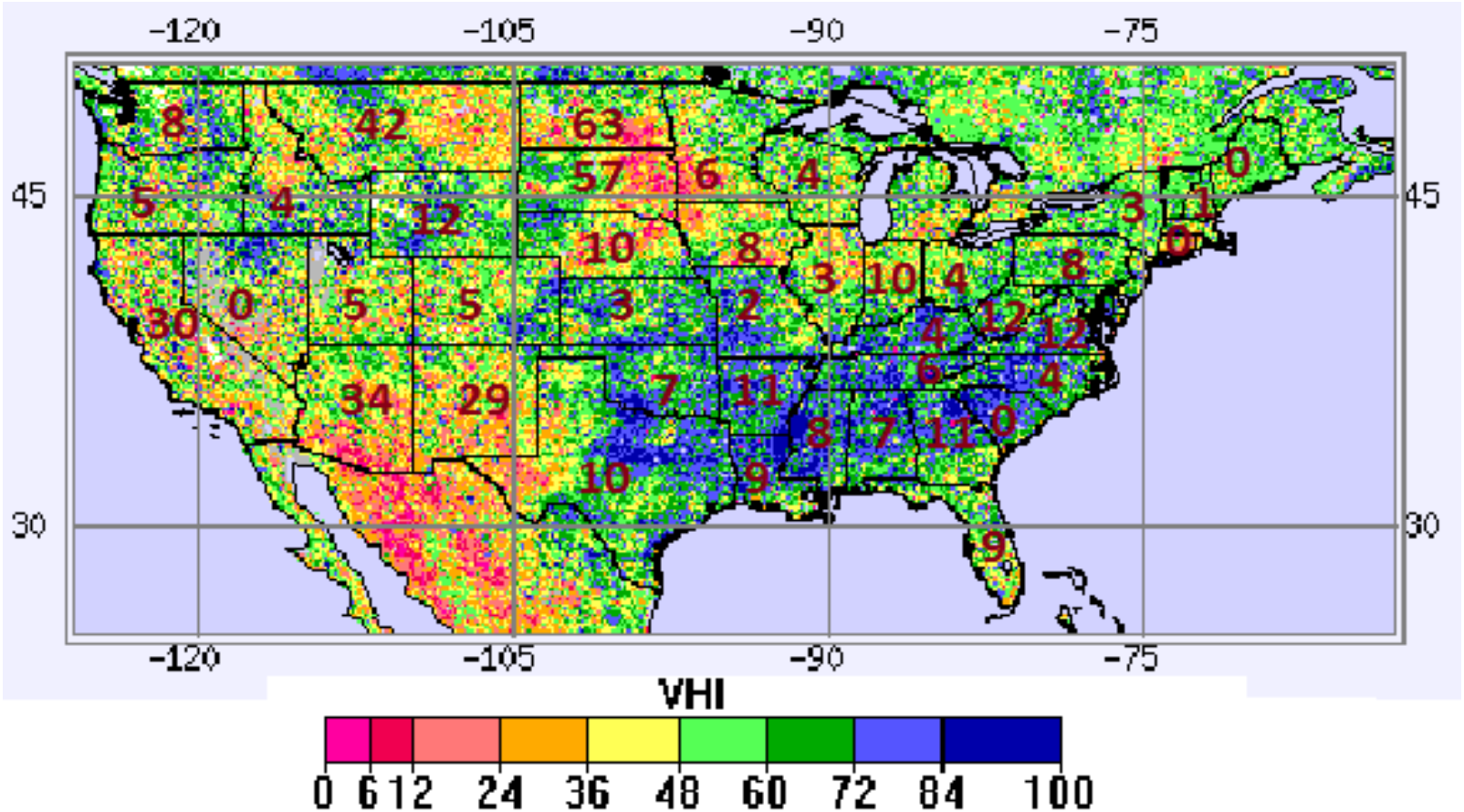
Satellite:

Every 4, 1 and 0.25 sq.km

Weather: One Station

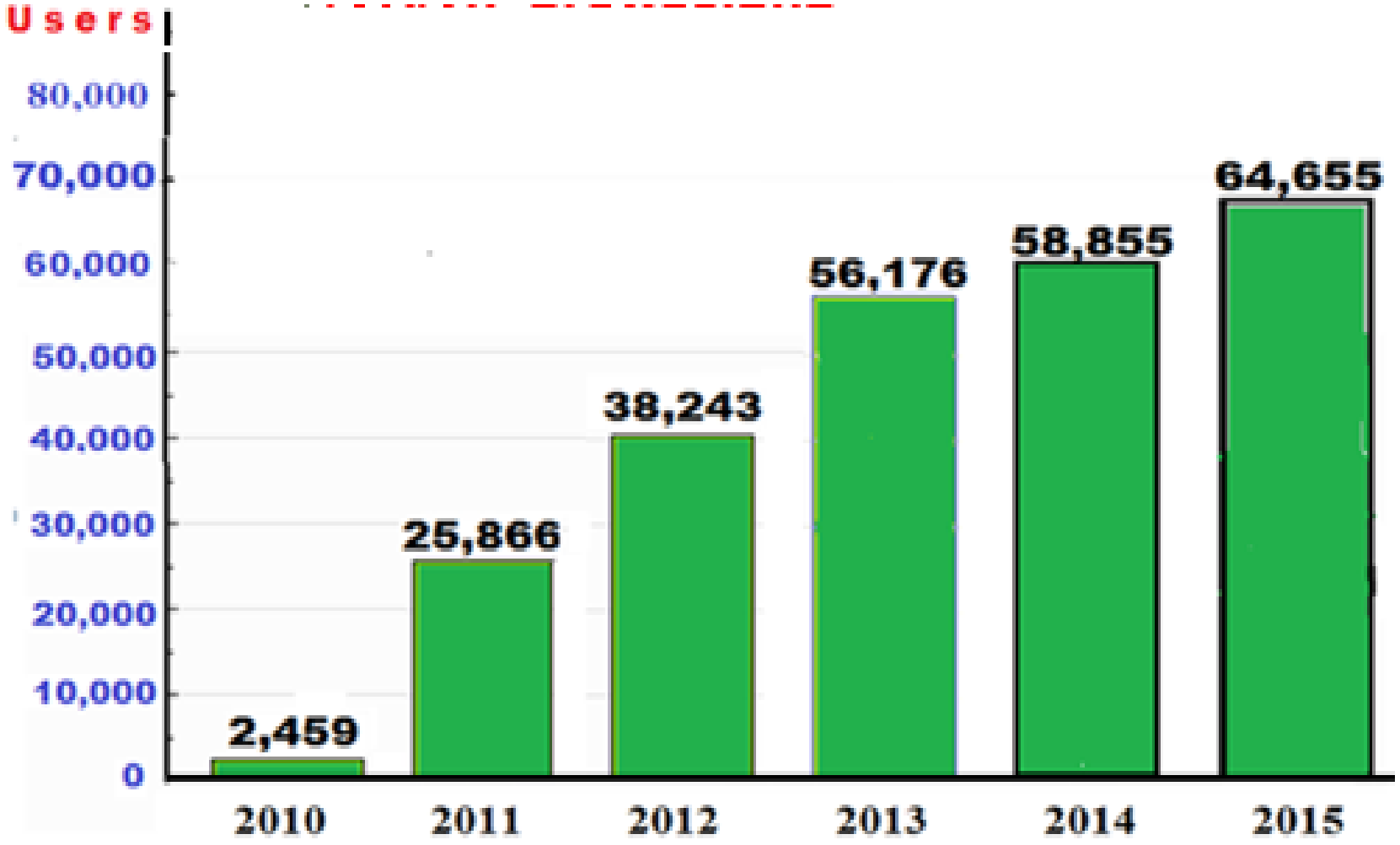
Every 7,140 sq.km (1,760,000 acres)

2017 Jul 8 VH & Jul 2, Pasture Conditions



Vegetation Health Jul 8, 2017 and % Pasture/Range Land in POOR & Very POOR Conditions, Jul 2, 2017 (USDA)

Number of VH Users per Year



Vegetation Health data sources

Sensors *Advanced Very High Resolution Radiometer (AVHRR)*

Visible Infrared Imaging Radiometer Suite (VIIRS)

Satellites NOAA/AVHRR: *NOAA-7, 9, 11, 14, 16, 18, 19*

S-NPP/VIIRS, J-1 (JPSS)/VIIRS

Data Resolution *Spatial* *0.5, 1, 4 (GAC), 8 & 16 (GVI) km;*

Temporal *7-day composite*

Period **37-year (1981-2017), future?**

5-year (2012-2016) currently

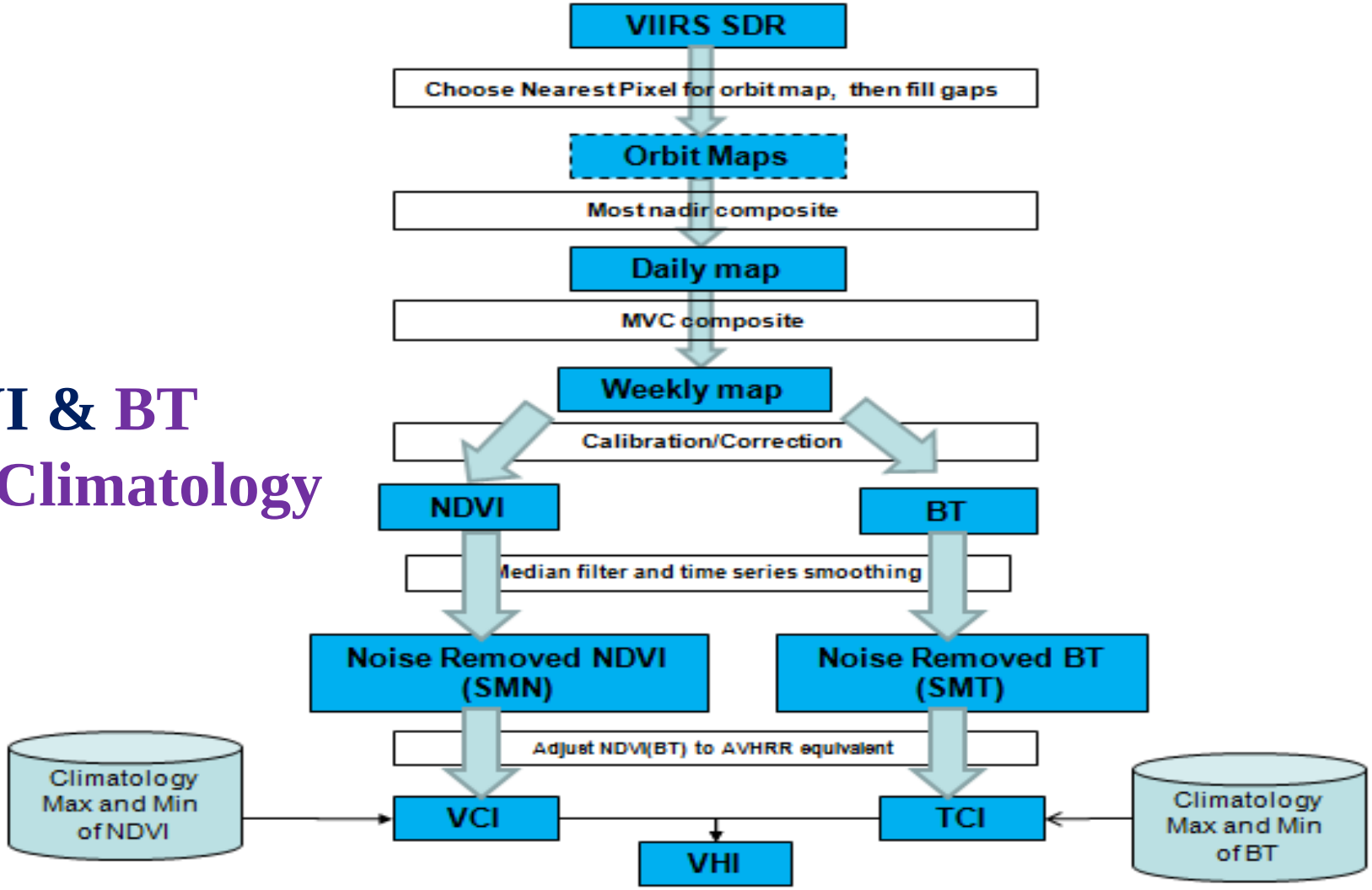
(2017 – 2030) future

Coverage **World** *(75 N to 55 S)*

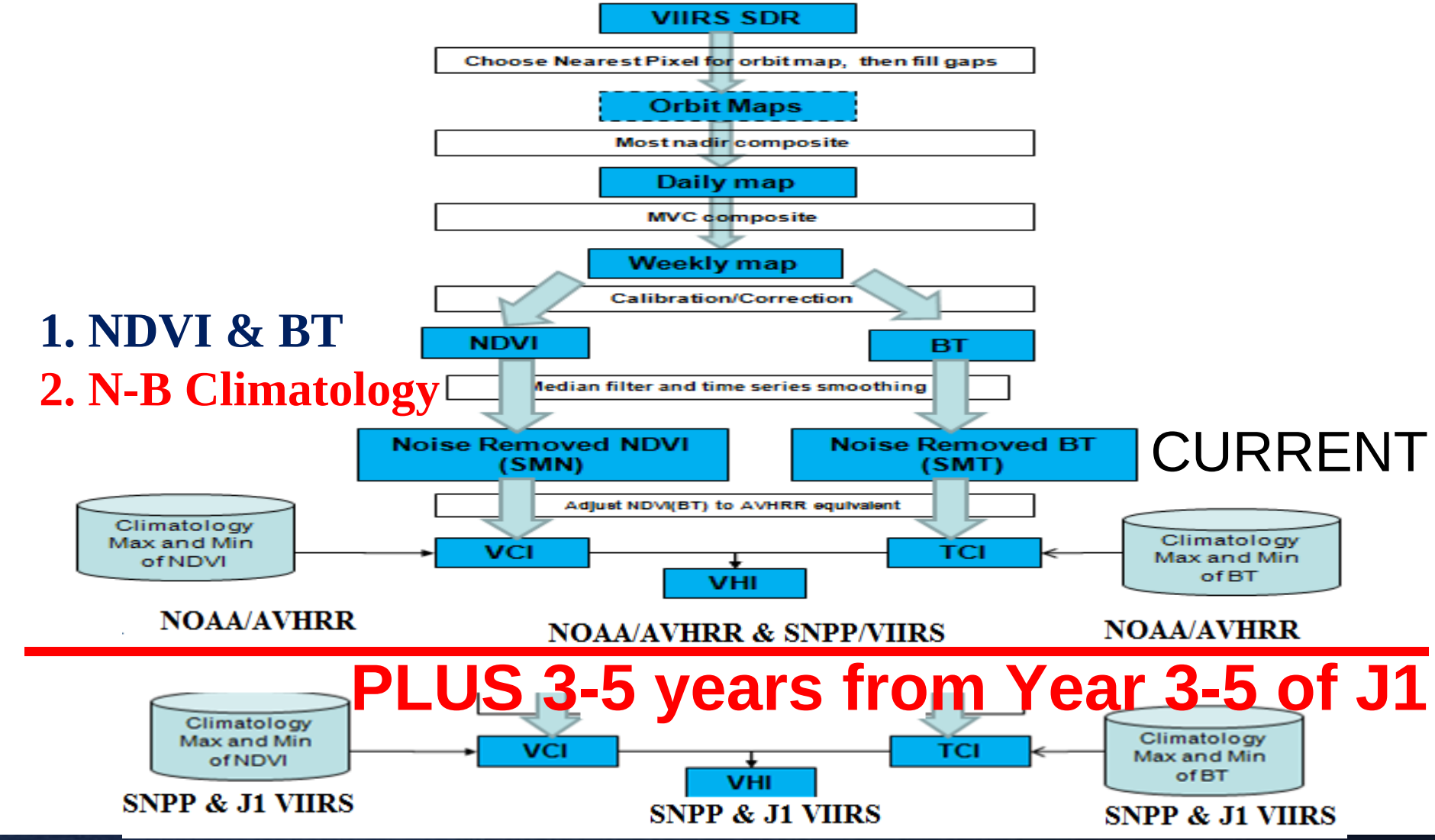
Channels: VIS , NIR , IR ; *Indices:* NDVI & BT

AVHRR Algorithm Architecture (SA)

1. NDVI & BT
2. N-B Climatology



Transition to SNPP/VIIRS & J1/VIIRS



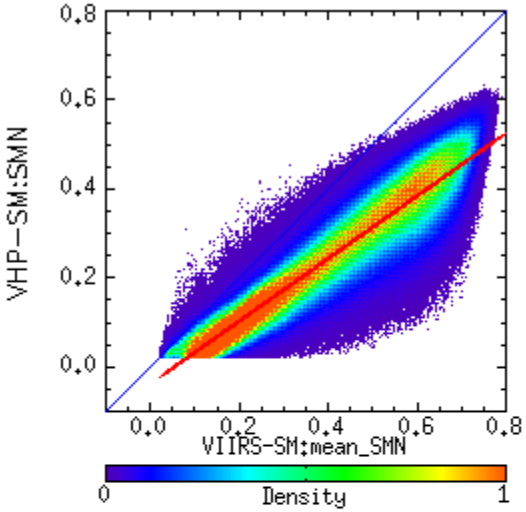
1. NDVI & BT
2. N-B Climatology

Transition to SNPP/VIIRS & J-1

- From the TWO methods the **first** one is used:

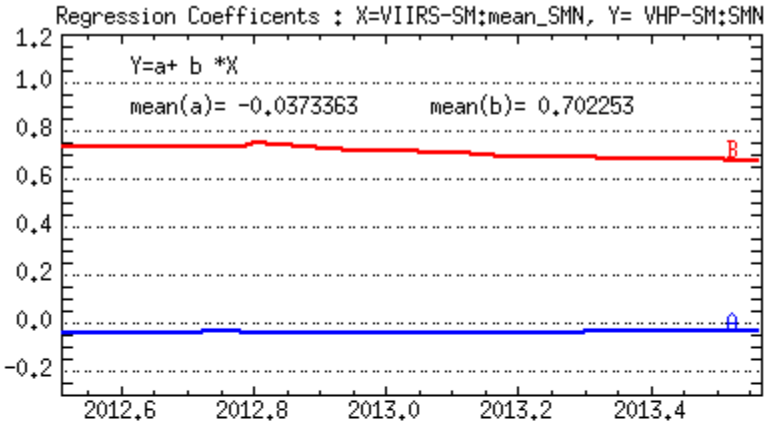
1. Adjust SNPP/VIIRS weekly NDVI & BT to weekly NOAA/AVHRR

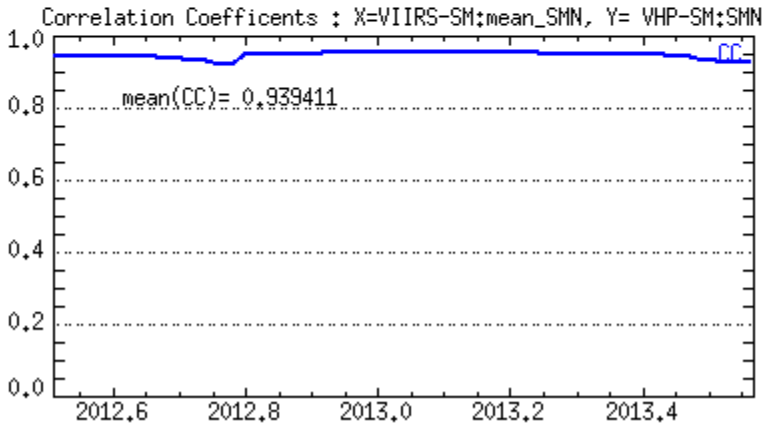
Expl: NDVI (SMN): AVHRR-VIIRS time series



Y= a +b * X
a= -0.0374925
b= 0.703031

Nsamples=4963003
CC = 0.9374
RMSE =0.0486750

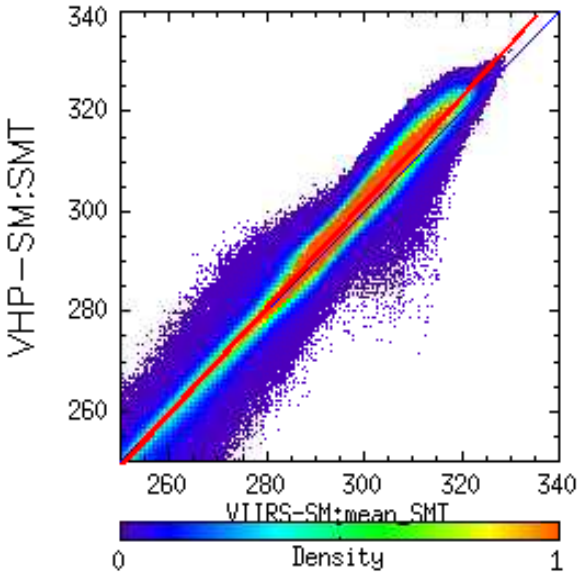




lon=[-180.00, 180.00] lat=[-40.00, 40.00]

Data used: 2012 week 27 to 2013 week 30

Expl: BT (SMT) AVHRR-VIIRS COR



Y= a +b * X

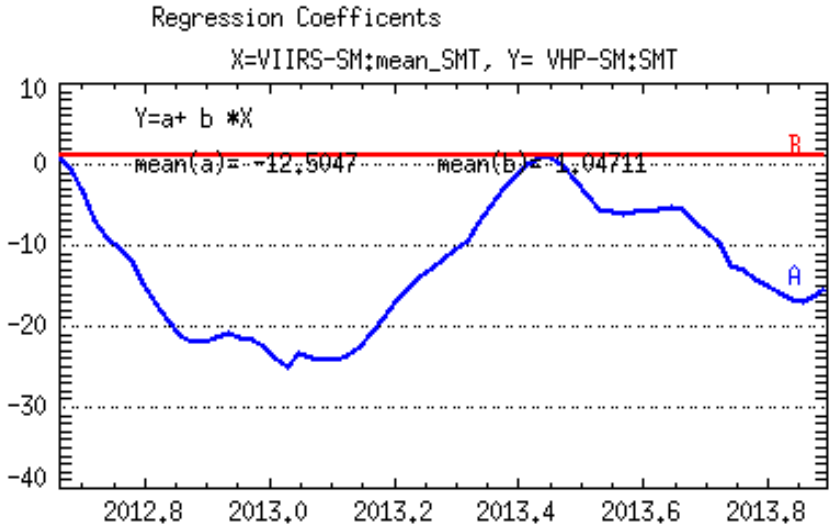
a= -15.3288

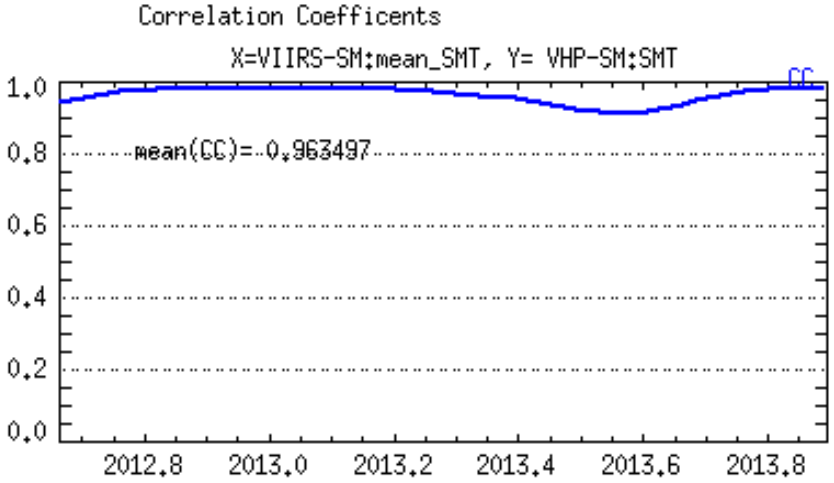
b= 1.05696

Nsamples=8638092

CC = 0.9610

RMSE =3.51405

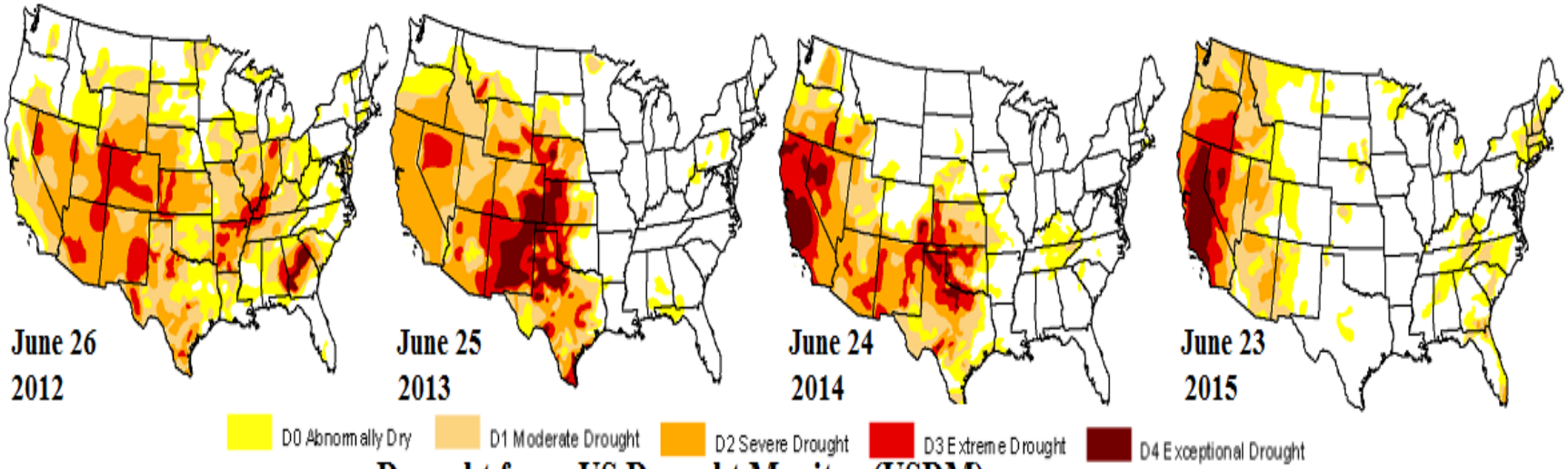




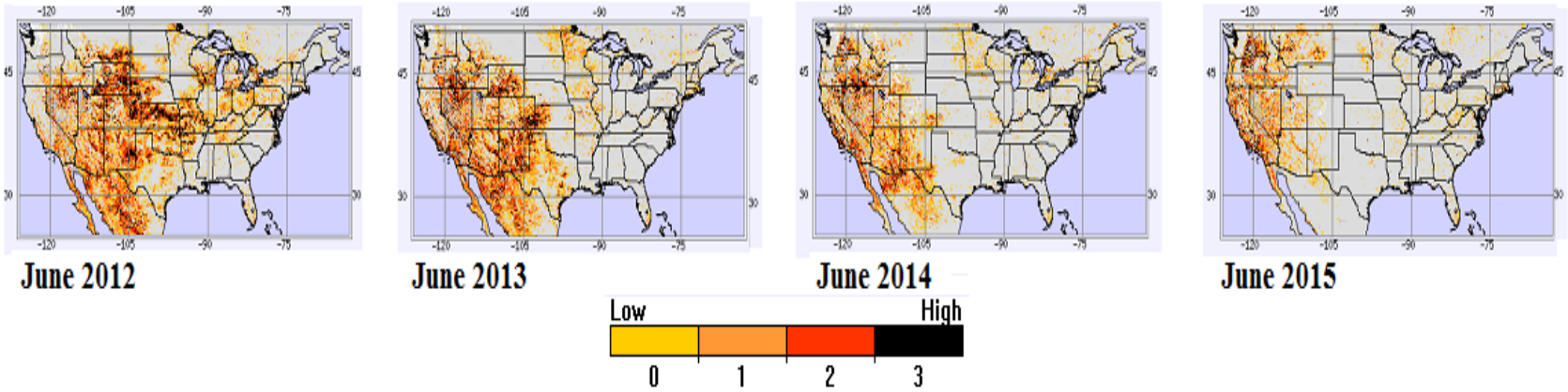
lon=[-180.00, 180.00] lat=[-40.00, 60.00]

Data used: 2012 week 35 to 2013 week 47

USA Drought from USDM & VHI



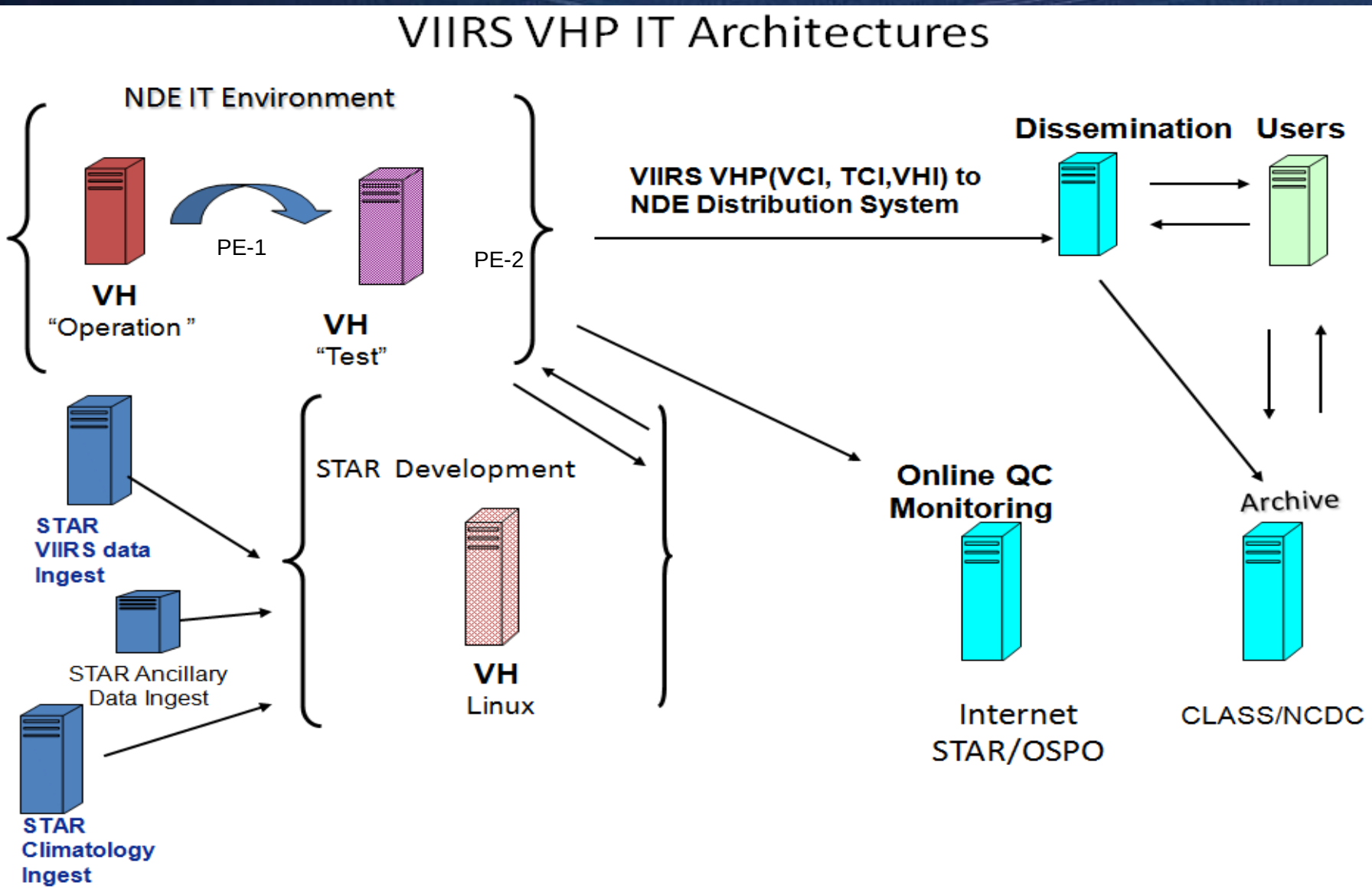
Drought from US Drought Monitor (USDM)



Drought from NOAA-19/AVHRR Vegetation health index (VHI)

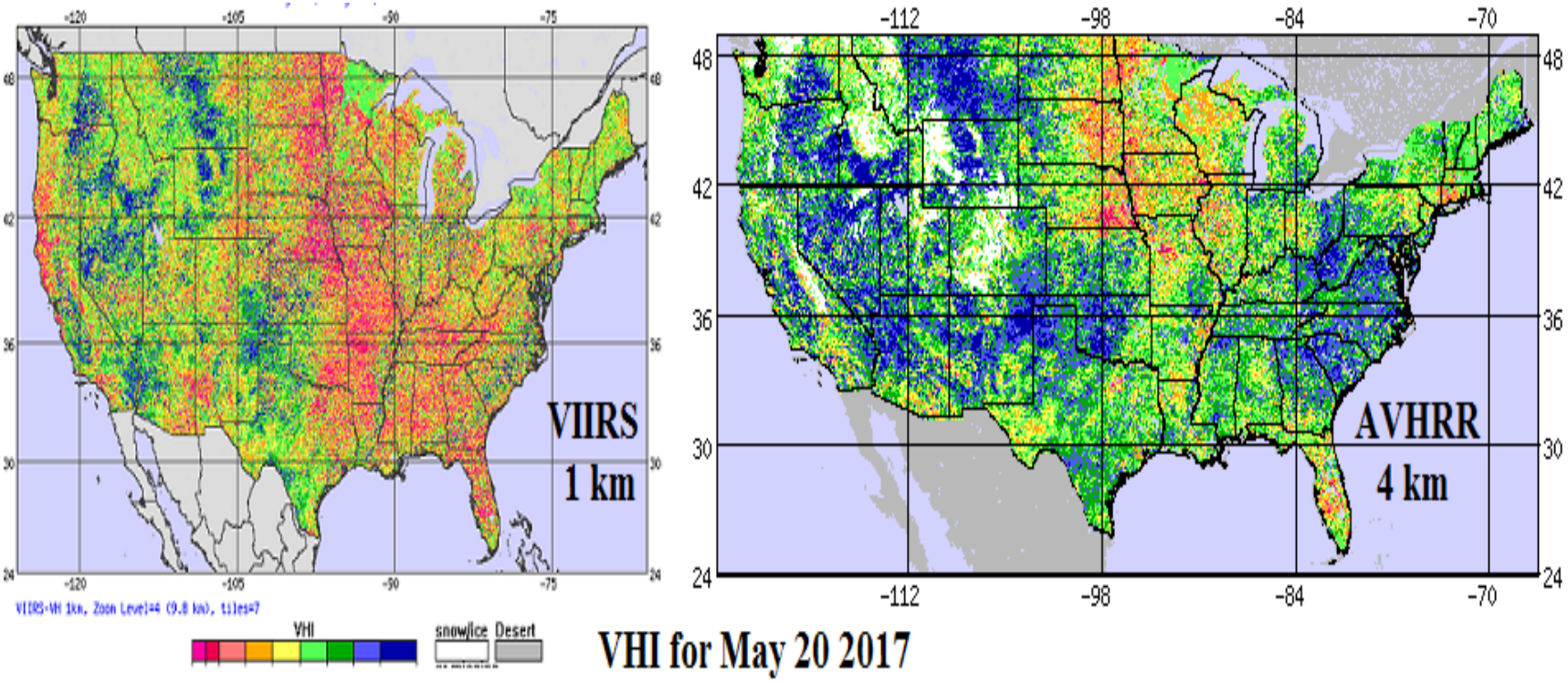
VIIRS VHP IT Architectures: Apply #1

Adjust SNPP/VIIRS weekly NDVI & BT to weekly NOAA/AVHRR



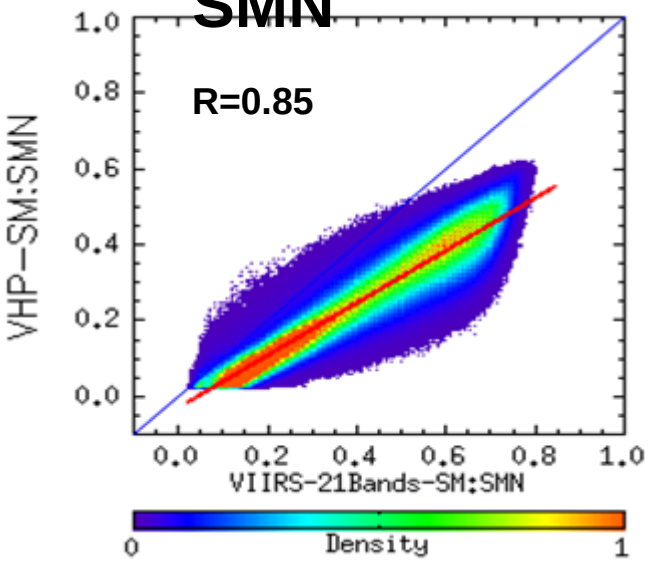
VHI: VIIRS-1km vs AVHRR-4 km May 20, 2017

- SNPP/VIIRS-1 NOAA/AVHRR-4

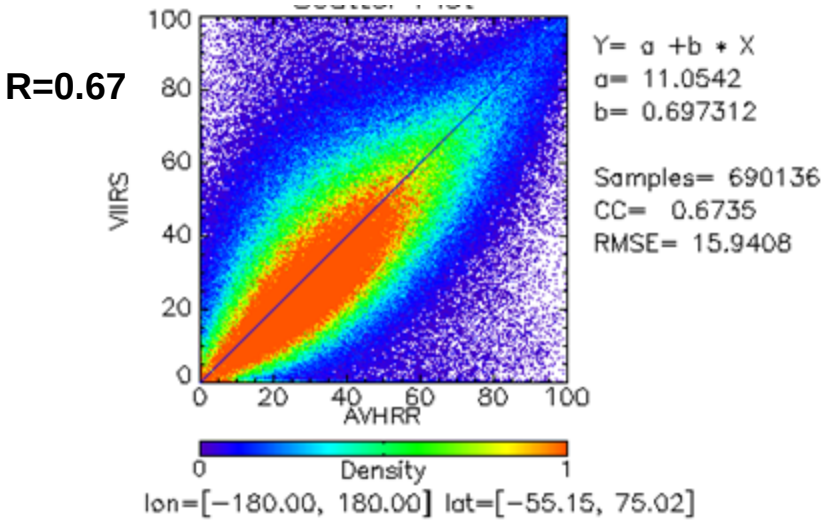


Expl: Error reduction is required

SMN



VCI



1. Raw data collection — problem
2. VIS, NIR & IR — problem
3. Climatology — problem

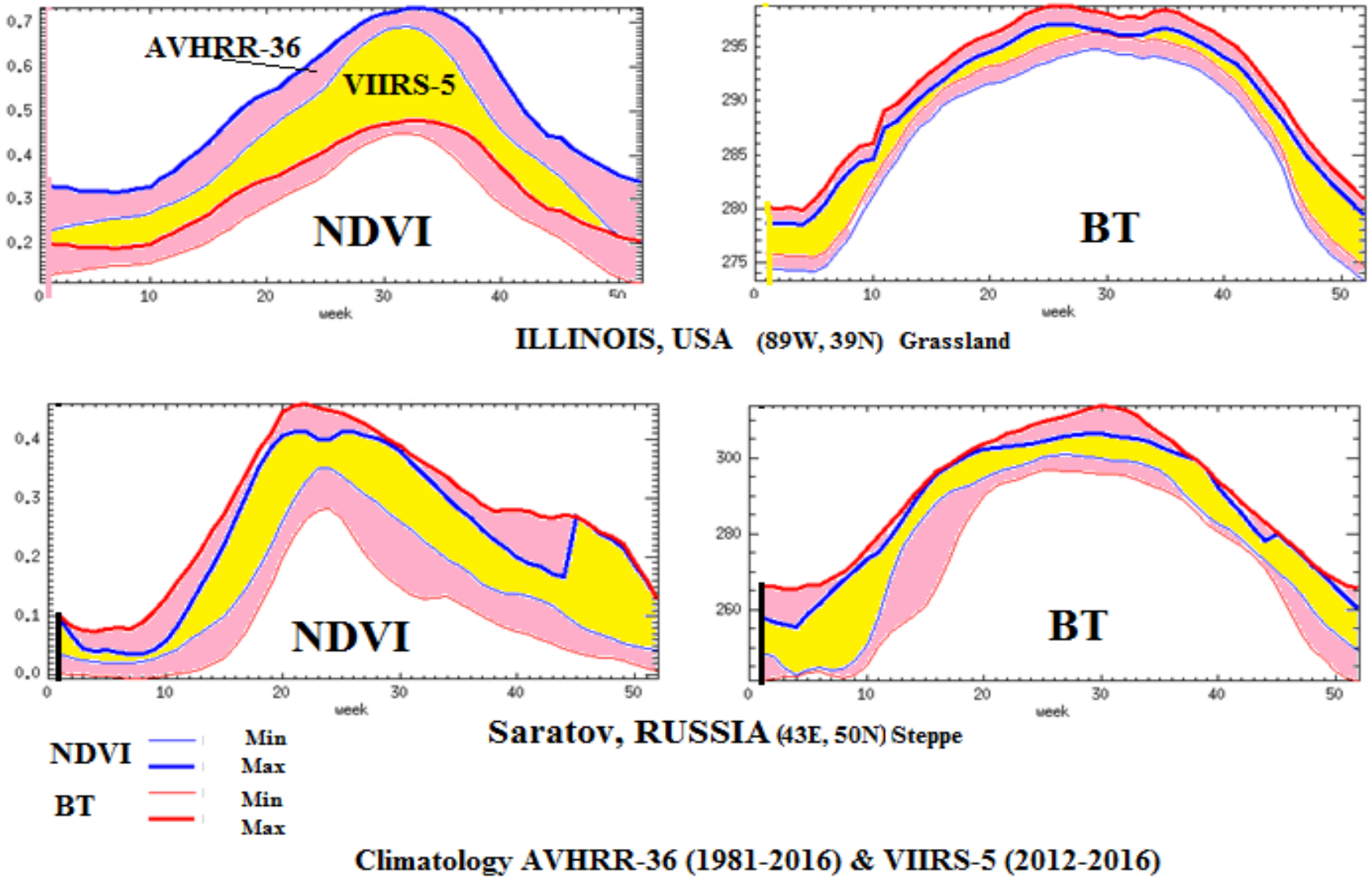
TRUE ????

Transition to SNPP/VIIRS & J-1

- From the TWO methods the **second** one is used:

Adjust SNPP/VIIRS **5-year** weekly NDVI & BT **climatology** to NOAA/AVHRR **36-year** **climatology**

Climatology A-36 vs V-5



Climatology AVHRR-36 (1981-2016) & VIIRS-5 (2012-2016)

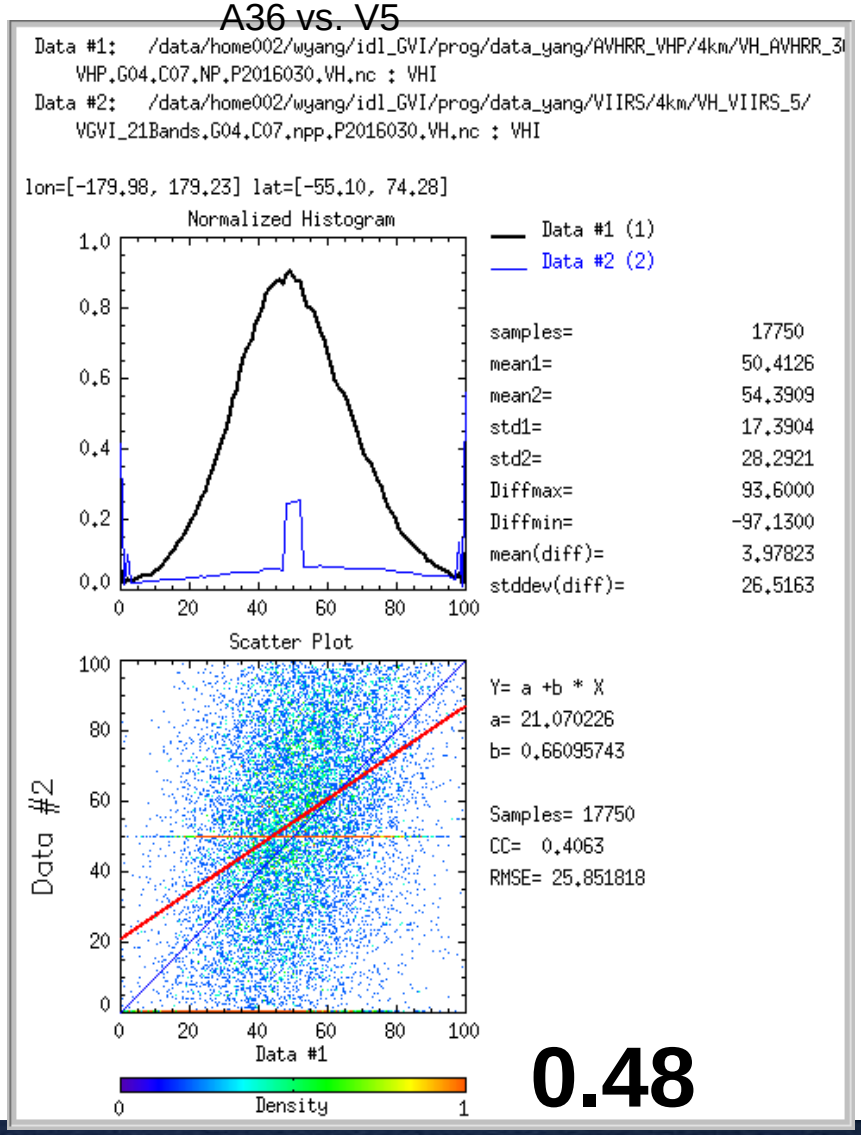
SNPP/VIIRS & NOAA/AVHRR 4km Climatology (Wz)

- Directly generate 5-year VIIRS 4km climatology (V5);
- Directly generate 5-year AVHRR 4km climatology (A5) at the same period with V5;
- Directly generate 36-year AVHRR 4km climatology (A36);
- Generate pseudo 36-year VIIRS 4km climatology (V36) based on the calculation from V5, A5 and A36 climatology:

$$V36 = V5 \times \frac{A36}{A5}$$

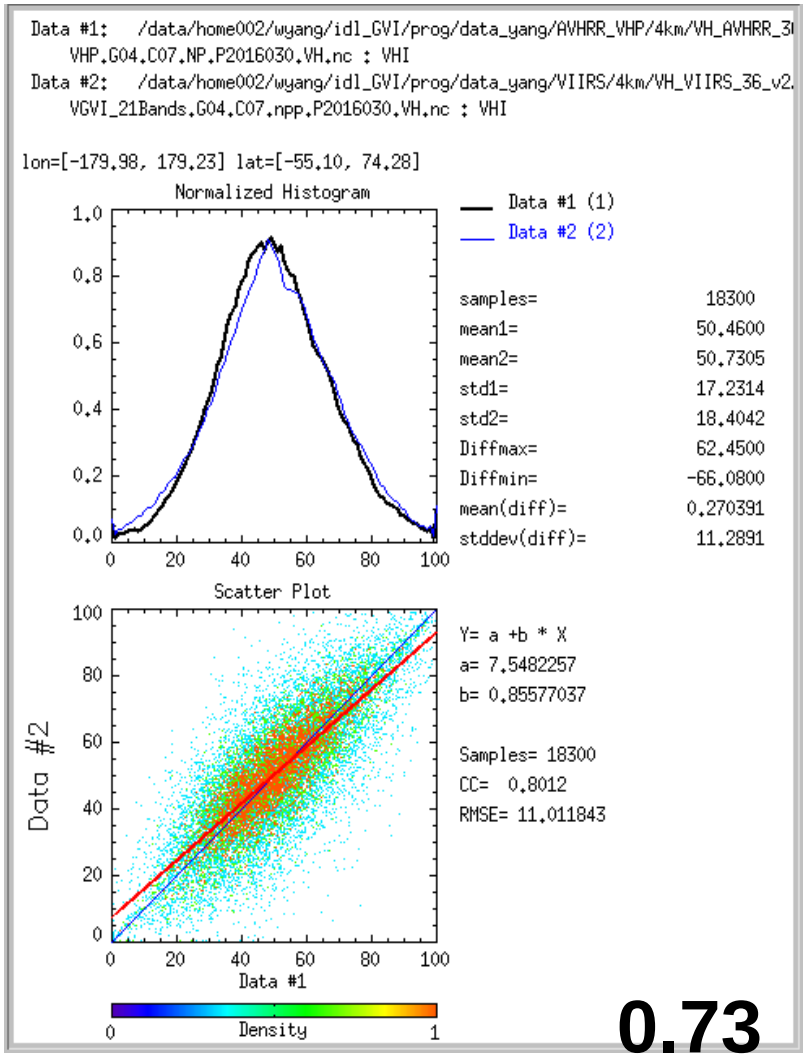
Test: VHI 4 km Product (Wz)

A36 vs. V5



0.48

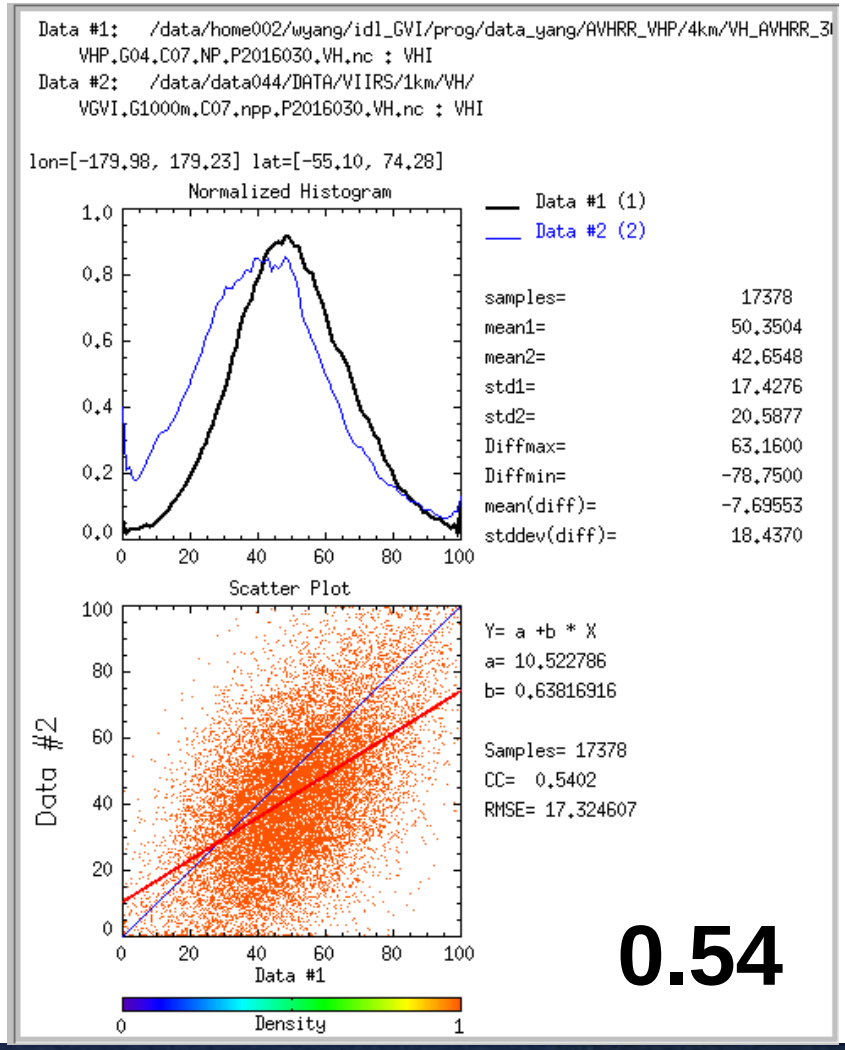
A36 vs. V36



0.73

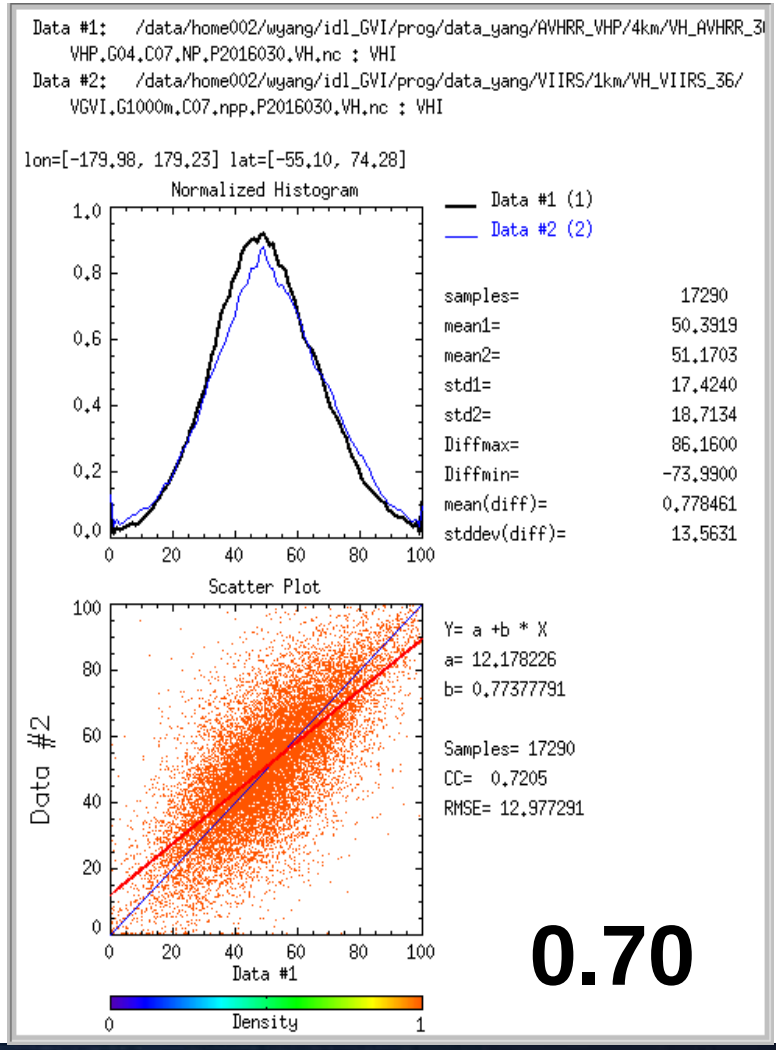
Test: VHI 1km Product

A36 vs. Former Scheme



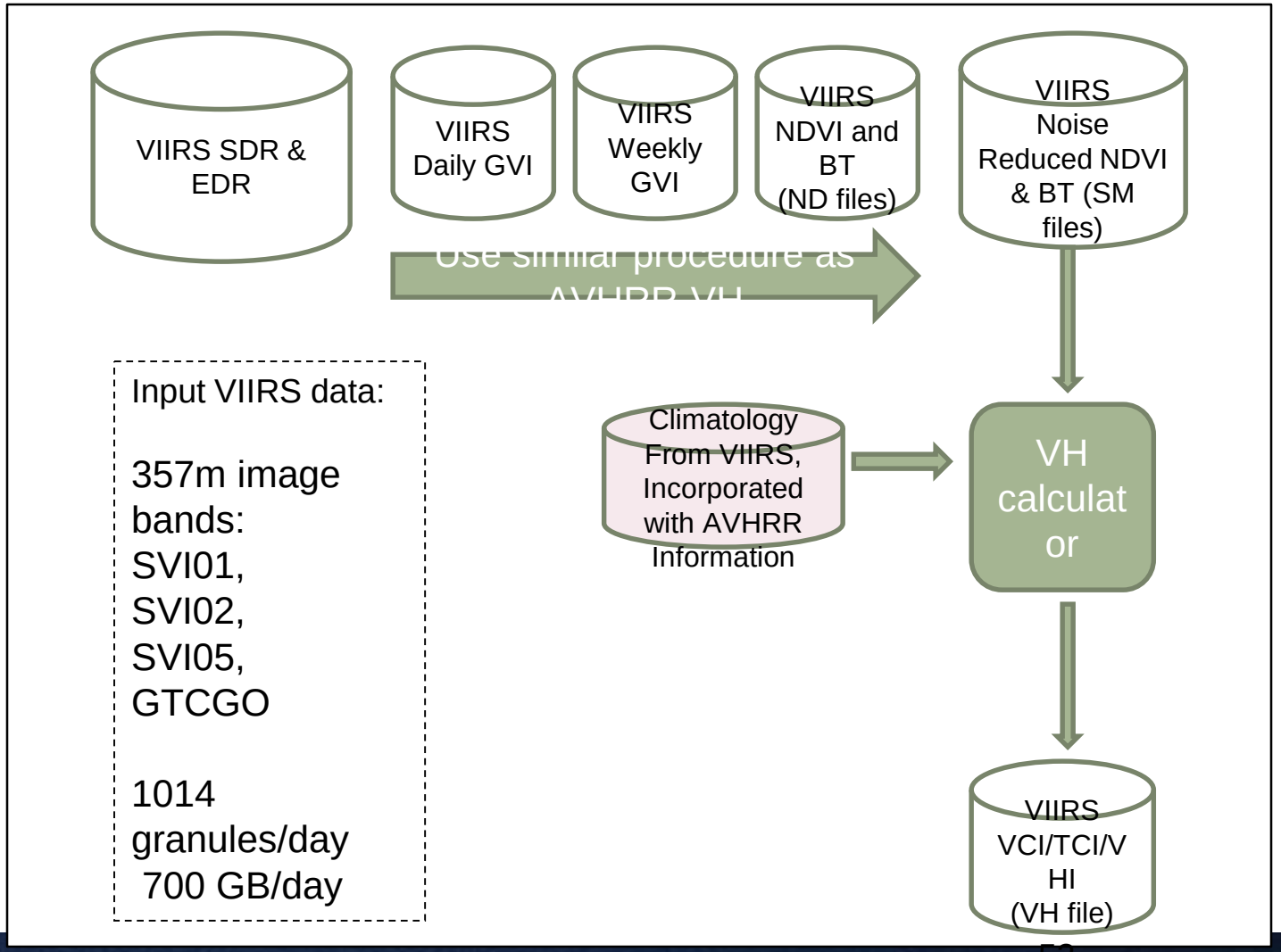
0.54

A36 vs. V36

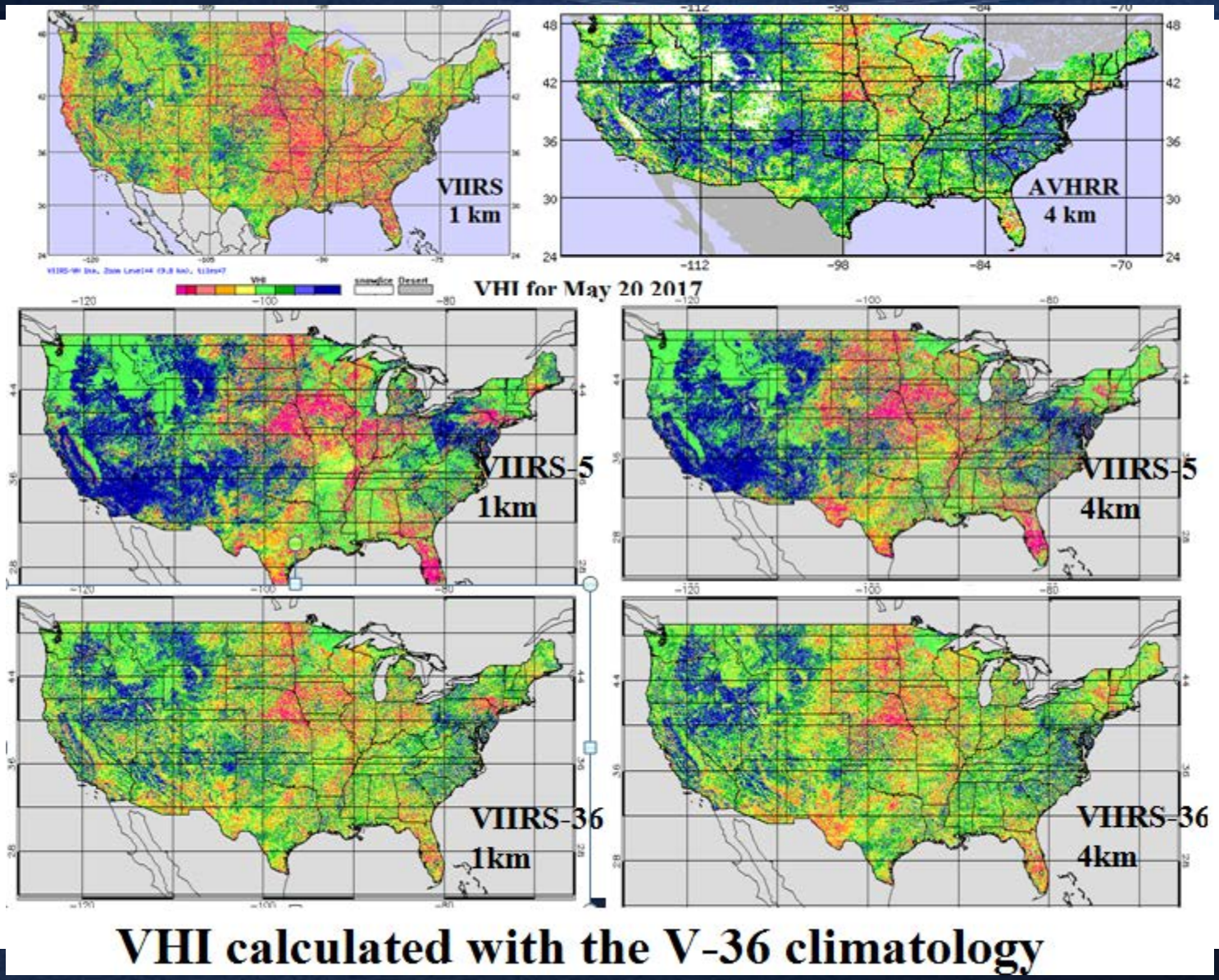


0.70

New VIIRS-VH system: Data Flow (Wz)

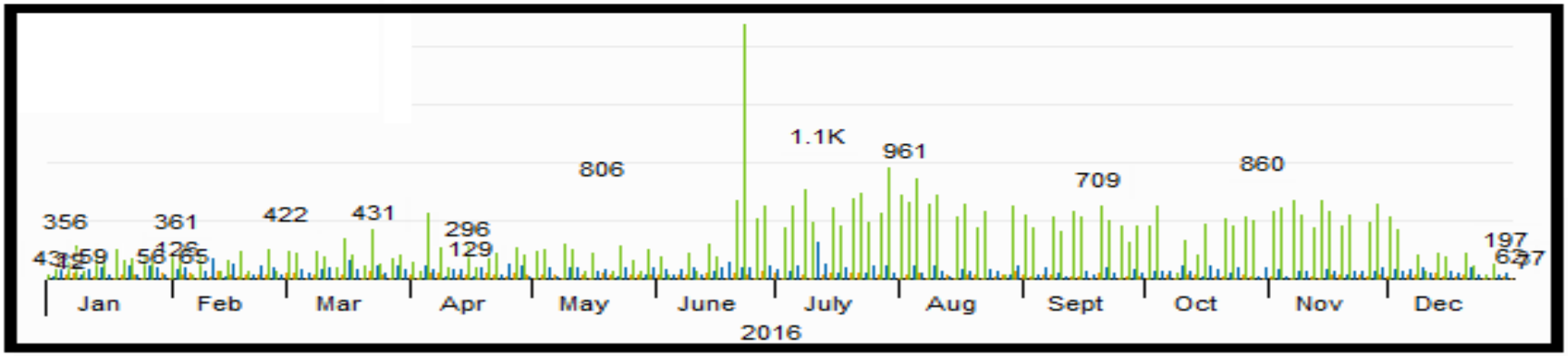


VHI from V-36, V-5 & A-36 climatology



VHI calculated with the V-36 climatology

VH-WEB Users in 2016



	Page Views	Unique Visits	First Time Visits	Returning Visits
Total	140,163	30,868	17,849	13,019
Daily Average	383	85	49	36

Vegetation Health (VH) Total Users in 2016 and Daily

VIIRS SURFACE TYPE

NOAA NESDIS STAR
301-683-3599; Xiwu.Zhan@noaa.gov
X. Zhan, C. Huang, R. Zhang, P. Wang, I. Csiszar

Outline

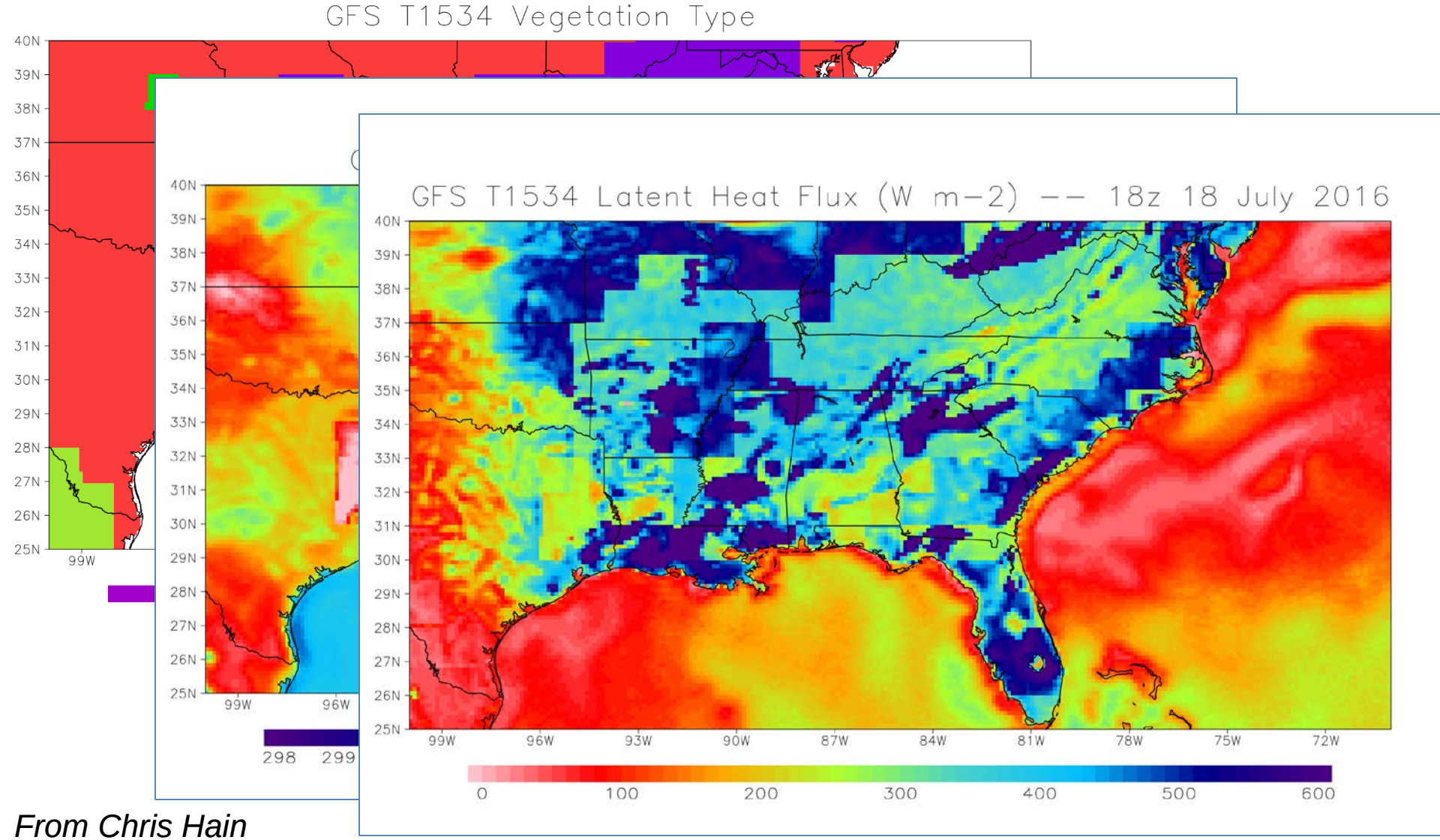
- VIIRS Surface Type Product Team Members
- Surface type algorithm overview
- S-NPP Surface Type Product Overview
- JPSS-1 Readiness for Surface Type products
- Summary and Path Forward

VIIRS Surface Type Team Members

Team Member	Organization	Roles and Responsibilities
Xiwu Zhan	NESDIS-STAR	PI of VIIRS Surface Type Team
Chengquan Huang	UMD Geography	Lead of UMD team members
Rui Zhang	UMD Geography	Algorithm, validation and production lead
Panshi Wang	UMD Geography	Algorithm, validation
Ivan Csiszar	NESDIS-STAR	VIIRS Land Team Lead

Surface Type Products Overview

- Impact of Surface Type to NWP model performance:



From Chris Hain

Surface Type Products Overview

ST-EDR/AST Requirements from JPSS L1RD

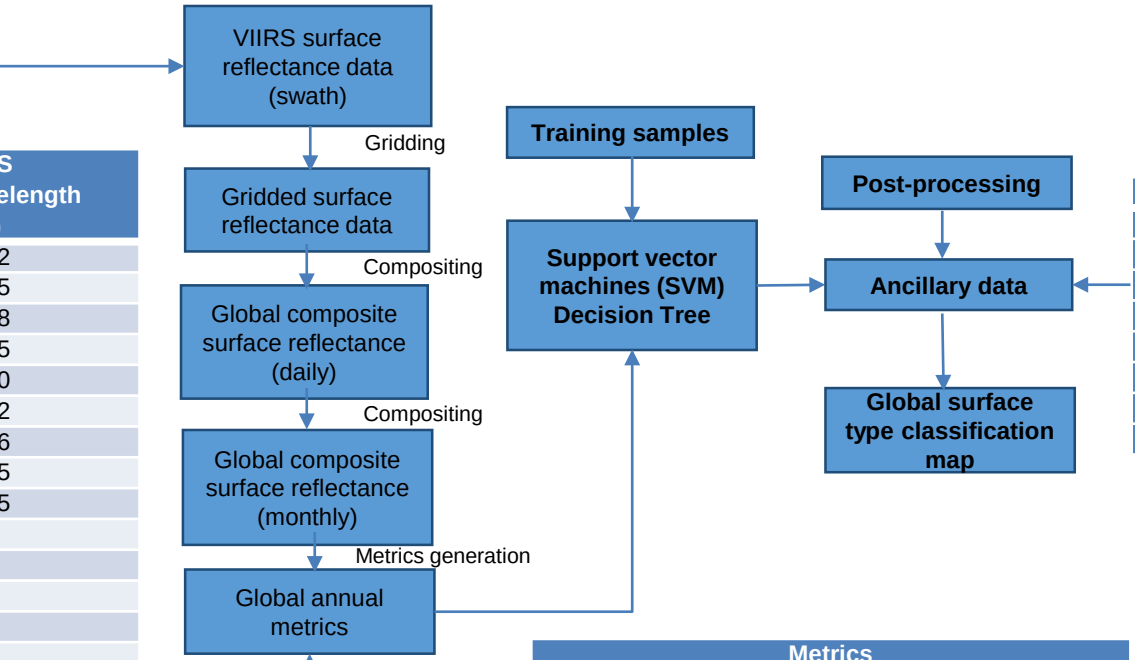
Attribute	Threshold	Performance
Geographic coverage	Global	Global
Vertical Coverage		
Vertical Cell Size	N/A	N/A
Horizontal Cell Size	1 km at nadir	1 km at edge of scan
Mapping Uncertainty	5 km	1 km
Measurement Range	17 IGBP classes	17 IGBP classes
Measurement Accuracy	70% correct for 17 types	~78% for 17 types
Measurement Precision		
Measurement Uncertainty		

Surface Type Products Overview

- Surface Type products include Surface Type EDR (ST EDR) and Global Annual Surface Type Maps (AST)
- Global Annual Surface Type Maps provide static labels for each 1km land grid for NWP models and other users
- Surface Type EDR is to provide current day surface type status for LST EDR and other users
- AST offline generation is the main task of the VIIRS ST team
- AST is generated using Support Vector Machine algorithm based on global training polygons database and dozens of classification metrics that are computed from daily surface reflectance observations from VIIRS
- A series of ancillary data are used in the post-classification processes to improve the initial classification result.

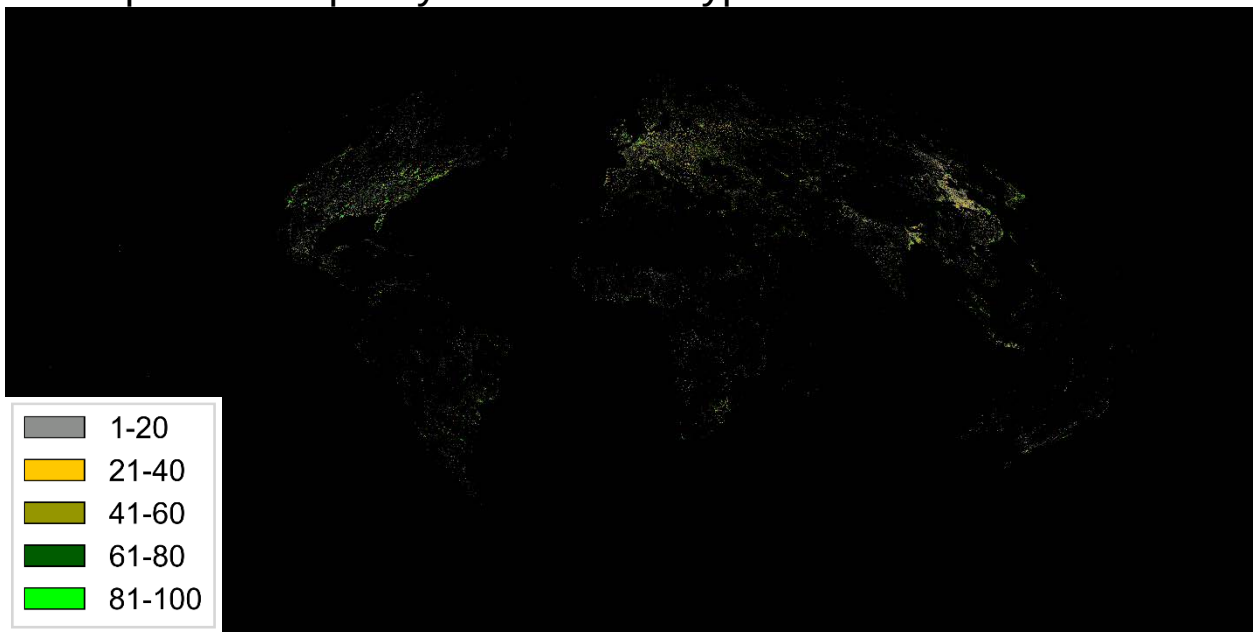
Surface Type Algorithm Overview

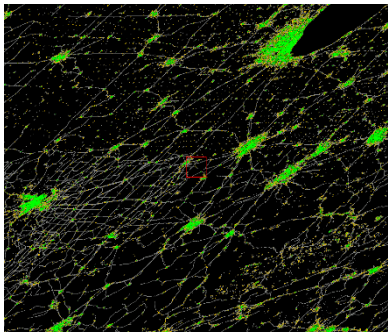
Band number (comparable in MODIS)	VIIRS wavelength (μm)
M1 (8)	0.412
M2 (9)	0.445
M3 (3 or 10)	0.488
M4 (4 or 12)	0.555
I1 (1)	0.640
M5 (13 or 14)	0.672
M6 (15)	0.746
I2 (2)	0.865
M7 (16 or 2)	0.865
DNB	0.7
M8 (5)	1.24
M9 (26)	1.38
M10 (6)	1.61
I3 (6)	1.61
M11 (7)	2.25
M12 (20)	3.70
I4 (20)	3.74
M13 (21 or 22)	4.05
M14 (29)	8.55
M15 (31)	10.76
I5 (31 or 32)	11.45
M16 (32)	12.01



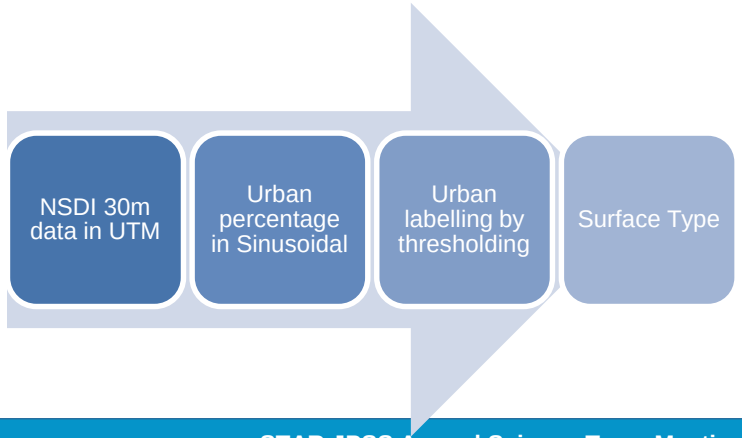
Surface Type Products Overview

- In the new 2016 AST production, a new urban percentage mask is created from the 30m NSDI land cover map, which has been used in the post-classification processes to improve the quality of the urban type.





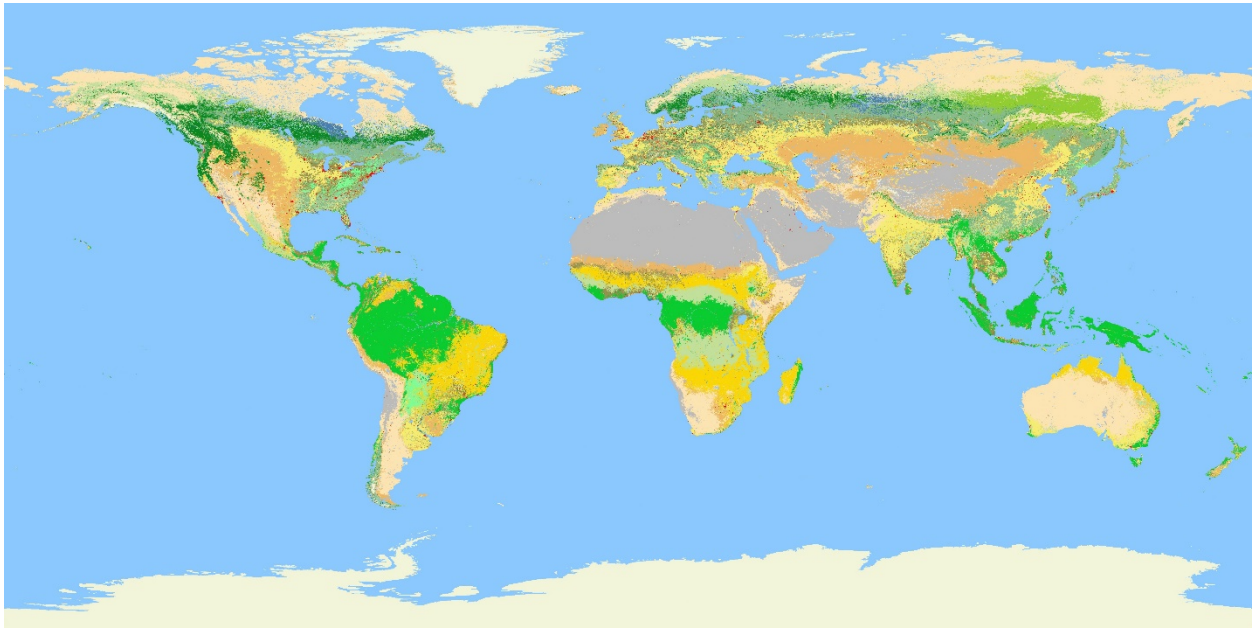
Zoom in
view for NW US

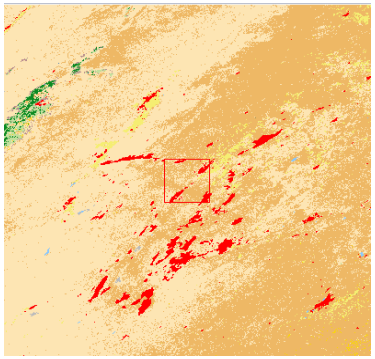


By integrating high-resolution based urban mask, more detailed residential regions could be identified. Additionally, other artificial surfaces, such as industrial lands, could also be separated.

Surface Type Products Overview

- New global surface type map using 2016 VIIRS data was generated.







Oil drilling land in TX, US in 2016 map

While the overall classification accuracy (~78%) of the new map is similar to 2015 delivery, some accuracy improvements are observed, such as urban/built-up lands. The images shown left demonstrate an examples of the newly labeled oil drilling land in Texas, US, which is considered built-up lands, where the old version presented wrong type labels. Google images verified the mapping results.

Surface Type Products Overview

		Reference																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total (%)	User's accuracy (%)	Producer's accuracy (%)
Map	1	0.0188	0	0.0006	0.0004	0.0028	0.0001	0	0.0021	0.0002	0.0004	0.0001	0	0	0.0001	0	0	0.0002	0.0259	**72.53±2.93**	**72±3.48**
	2	0	0.0856	0	0.0008	0.0009	0	0	0.0041	0.0011	0.0003	0	0.0003	0	0.0006	0	0	0	0.0938	**91.3±1.15**	**93.02±1.08**
	3	0.0007	0	0.01	0	0.001	0	0.0002	0.001	0	0.0001	0.0005	0	0	0	0	0	0	0.0135	**74.17±4.01**	**66.96±4.75**
	4	0	0	0.0001	0.0078	0.0004	0	0.0001	0.0009	0.0002	0	0	0	0	0.0001	0	0	0	0.0095	**82.32±2.99**	**36.07±3.18**
	5	0.0016	0.0011	0.0029	0.0074	0.0362	0.0002	0	0.0064	0.0011	0.0002	0.0002	0.0002	0.0002	0.0033	0	0	0.0002	0.061	**59.25±2.55**	**77.32±2.53**
	6	0	0	0	0	0	0.0004	0	0	0	0	0	0	0	0	0	0	0	0.0006	**72.41±5.92**	**2.74±0.58**
	7	0.002	0	0.0002	0.0005	0.0022	0.0066	0.1191	0.0051	0.0032	0.0137	0.0015	0.0037	0	0.0017	0	0.0056	0.0002	0.1653	**72.04±1.73**	**84.29±1.77**
	8	0.0027	0.0018	0.0005	0.003	0.0014	0.0007	0.0022	0.0505	0.006	0.0009	0.0006	0.0007	0.0001	0.0037	0	0	0.0002	0.0751	**67.24±1.86**	**58.12±2.18**
	9	0	0.0021	0.0003	0.0003	0.0003	0.004	0.0032	0.0097	0.0469	0.0024	0.0003	0.0021	0	0.004	0	0	0	0.0757	**62.06±2.89**	**68.64±2.64**
	10	0.0001	0	0.0002	0.0002	0.0006	0.0026	0.0069	0.0022	0.0028	0.0632	0	0.0066	0.0001	0.0023	0	0.002	0	0.09	**70.26±1.69**	**68.81±2.44**
	11	0.0001	0.0002	0	0	0.0001	0	0.0006	0.0004	0.0006	0.0002	0.005	0.0002	0	0	0	0	0	0.0076	**65.57±6.13**	**61.45±7.46**
	12	0.0001	0.0001	0	0.0001	0.0003	0.0002	0.0008	0.0005	0.002	0.0042	0.0001	0.069	0.0006	0.0058	0	0	0.0002	0.0841	**82.11±1.24**	**78.47±1.66**
	13	0	0	0	0	0	0	0.0001	0.0003	0	0.0001	0	0.0007	0.0052	0.0004	0	0	0	0.0069	**75±3.62**	**82.46±4.75**
	14	0	0.001	0.0002	0.0011	0.0006	0.0001	0.0007	0.0037	0.0041	0.0018	0	0.004	0.0001	0.0278	0	0.0001	0	0.0451	**61.61±2.08**	**54.62±2.68**
	15	0	0	0	0	0	0	0.0017	0	0	0.0017	0	0	0	0	0.1006	0	0	0.104	**96.72±2.3**	**100±0**
	16	0	0	0	0	0	0	0.0057	0	0	0.0022	0	0.0004	0	0.0009	0	0.1216	0	0.1308	**92.98±1.48**	**94.03±0.98**
	17	0	0	0	0	0	0	0	0	0	0.0002	0	0	0	0	0	0	0.0111	0.0113	**98.33±1.67**	**91.41±3.14**
	Total	0.0261	0.092	0.015	0.0216	0.0468	0.0148	0.1413	0.0868	0.0684	0.0919	0.0081	0.088	0.0063	0.0508	0.1006	0.1293	0.0121	100		

Error matrix of estimated area proportions (in percentage). Overall accuracy is **77.9 ± 0.6**%.



Note: the error matrix was created using area proportion of each class in the classification map, which could avoid estimation bias observed in simple pixel count based error matrices, in which the estimated overall classification accuracy is 74.5%

By incorporating new urban mask, the producer's accuracy (omission) for urban/built-up increased approximately 23.5%.

Reprocessing Plan

- The generation of surface type map depends on data availability of surface reflectance data. If surface reflectance reprocessing data is produced, the surface type products could benefit from improved data quality of the surface reflectance data.

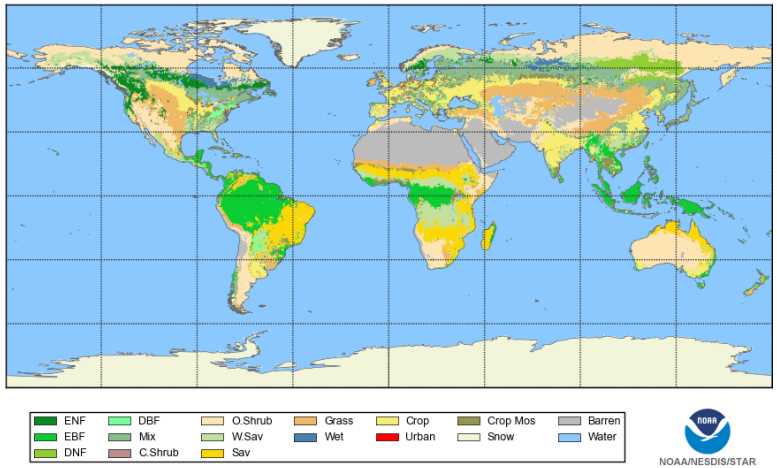
- The generation of surface type requires at least one whole year multiple bands surface reflectance data inputs, and the sophisticated classification algorithm usually takes significant amount of time to classify composited metrics, so extra computing resources are needed if reprocessing is planned.

Long Term Monitoring

- http://www.star.nesdis.noaa.gov/jpss/EDRs/products_surfacetype.php

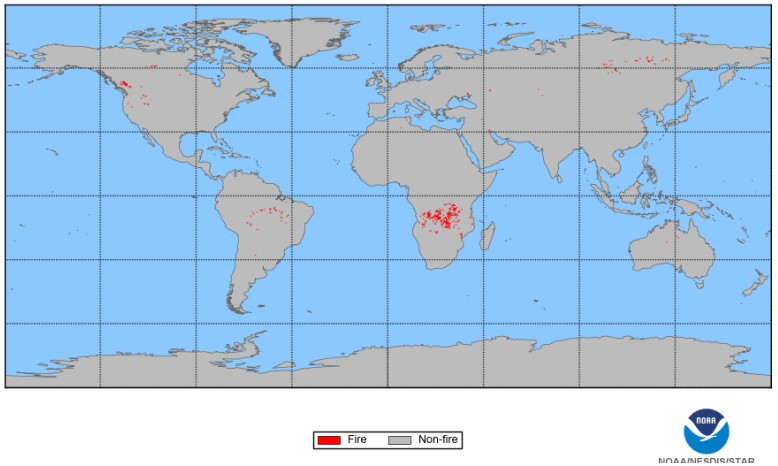
Suomi NPP VIIRS Global Surface Type Composite (ST-EDR)

5 Aug 2017



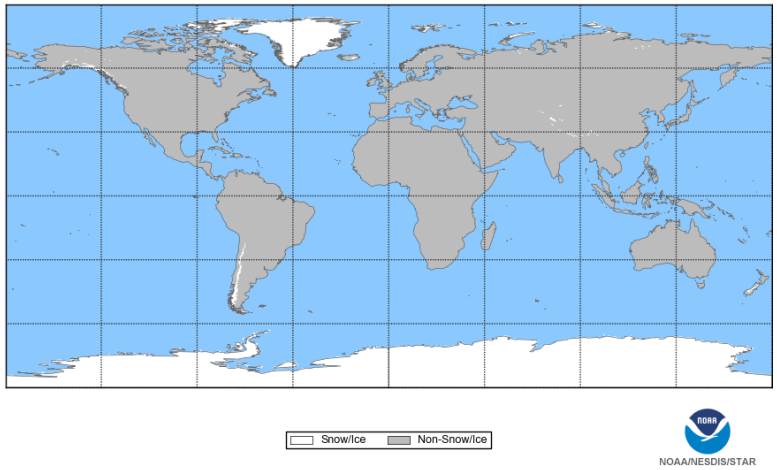
Suomi NPP VIIRS Global Active Fire Composite (ST-EDR)

5 Aug 2017



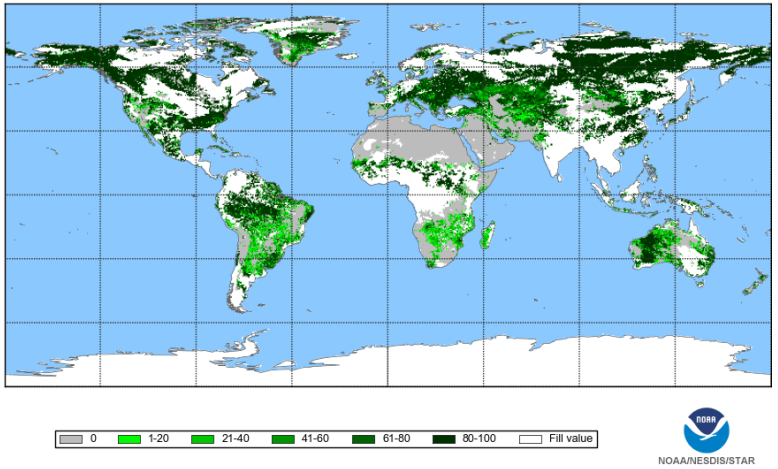
Suomi NPP VIIRS Global Snow/Ice Composite (ST-EDR)

5 Aug 2017



Suomi NPP VIIRS Global Vegetation Fraction (ST-EDR)

5 Aug 2017



Enterprise Algorithm Status

- Annual surface type map is produced offline, but it required VIIRS surface reflectance data input, which could be produced by the enterprise environment.

- Because surface type team needs a whole year observation to start processes, the production schedule for ST is at least one year delayed. For example, 2017 annual ST map will be delivered at the Sep. of 2018.

- The surface type team has coordinated with other enterprise algorithm teams about all aspects of technical details of the enterprise data products, such as data format, and output projections.

User Feedback

- User list
  - Modeling studies
    - Land surface parameterization for GCMs
    - Biogeochemical cycles
    - Hydrological processes
  - Carbon and ecosystem studies
    - Carbon stock, fluxes
    - Biodiversity
- Feedback from users (*Primary user: NCEP land team led by M. Ek*)
  - 2014 annual surface type map with three tundra types was delivered to NCEP earlier this year.
- Downstream product list
  - Land surface temperature (direct, could change)
  - Cloud mask, aerosol products, other products require global land/water location information (indirect)

Daily Surface Type Product

- Rapid surface changes can be caused by many events:
  - Flooding, severe drought, snow storm, fire, large scale deforestation
- These changes cannot be captured by the annual GST product
- A suite of daily products or change indicator products are needed to capture such rapid changes
  - Can build on the original ST-EDR concept
  - Where available, use existing VIIRS products (e.g., Snow, Fire, vegetation cover)
    - Better temporal consistency needed to allow change detection
    - For fire, post fire surface type information needs to be derived
  - Some changes require new products, e.g.:
    - Daily surface inundation needed to capture surface changes due to flooding and flood receding
    - Sub-annual tree cover data needed to capture deforestation

JPSS-1 Readiness

- Significant Algorithm changes from S-NPP to JPSS-1
  - Metrics and post-processing could be improved. No significant algorithm changes planed for J-1.
- Pre-launch Characterization: None.
- Post-Launch Cal/Val Plans
  - Dataset: Validation sites database. Collecting new sites. No field campaigns planned.
  - Schedule and Milestones: First J-1 based surface type map with validation should be generated in 18 months after JPSS-1 launch (Need one year to collect J-1 data, and 6 months for processes). **2017 J-1 surface type map will be delivered in year 2018**.
- Risks/issues/challenges: None.
- Collaboration with stake holders/users : In progress.

Summary

- 2016 VIIRS annual surface type (AST) classification map was generated, validated and in preparation of delivery through STAR-JPSS and other websites.
- High resolution land cover map (30 m NSDI) has been used to generate urban/built-up lands percentage for improving the quality of urban type. This data could also be used to improve other types, such as cropland, and current land/water mask.
- Validation results on 2016 surface type map suggest the new product meets the JPSS L1RD.
- Global surface type map with tundra types has been delivered to NCEP for evaluation.

Path Forward

- 2018 Milestones:
  - Delivery 2017 Global Annual Surface Type (AST) classification map
  - Develop new land/water mask for science and other users from collection of high resolution land cover map.
- Alternate algorithms and future improvements:
  - Keep using SVM, improve metrics and post-processing steps
  - Keep collecting new training and validation datasets
- J2 and Beyond:
  - Refine the algorithm details while keeping the overall data processing framework and continue the offline production of the AST product

Thanks!

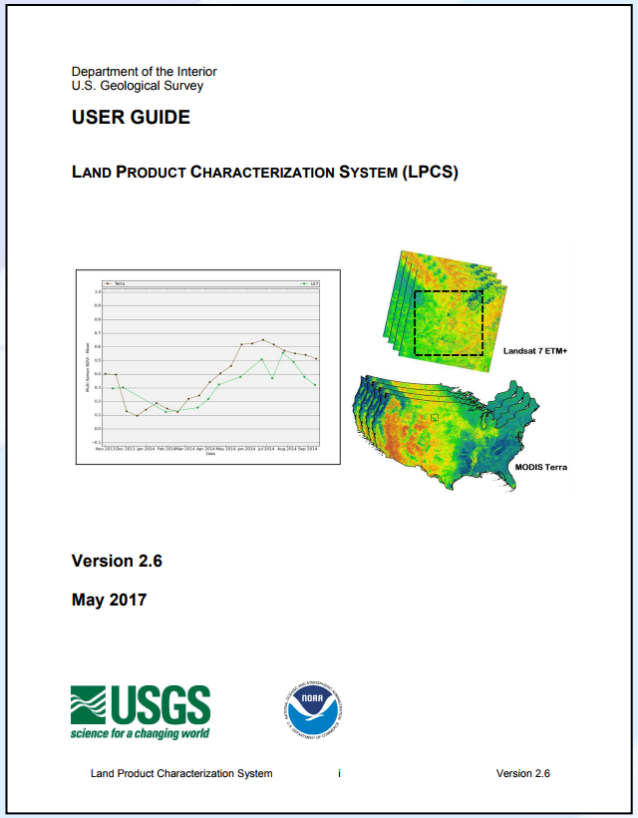
Land Product Characterization System

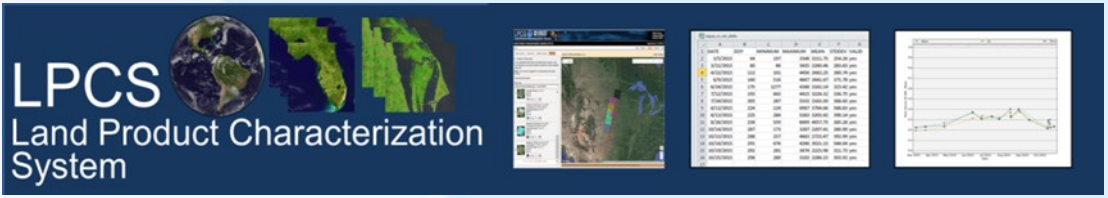
STAR JPSS Science Team Meeting
17 August 2017

Kevin Gallo: NOAA/NESDIS/STAR

collaborators

Greg Stensaas: USGS/EROS
John Dwyer: USGS/EROS
Ryan Longhenry: USGS/EROS





Land Product Characterization System (LPCS)

What is LPCS

Highlights of LPCS

1. Search, Inventory & Ordering
2. Analysis Tools

Path Forward

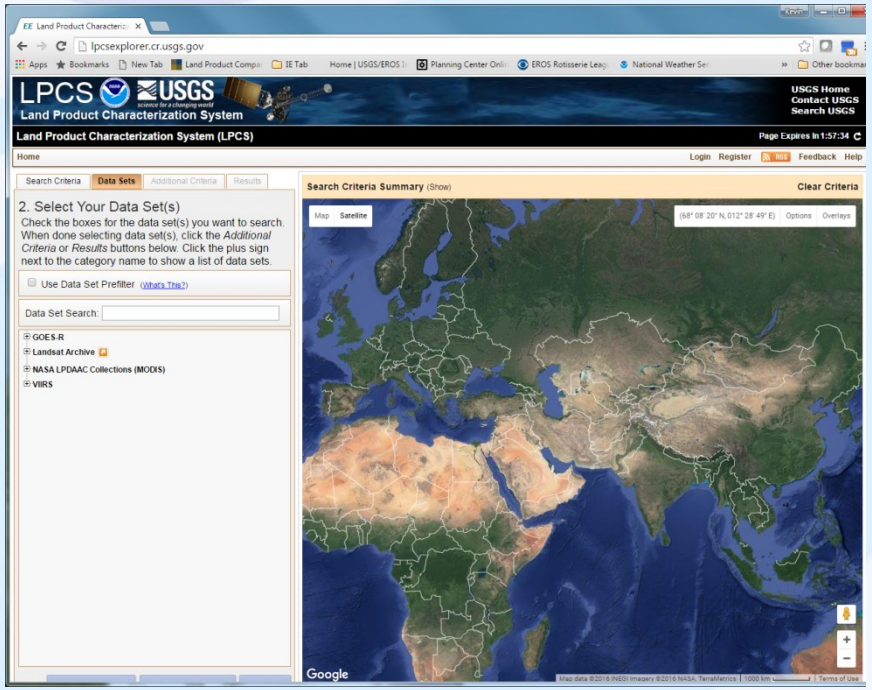
1. Status and Readiness
2. CEOS LPV collaboration

Summary

What is LPCS

A web-based system designed for comparative analysis of **global** satellite higher-level land products.

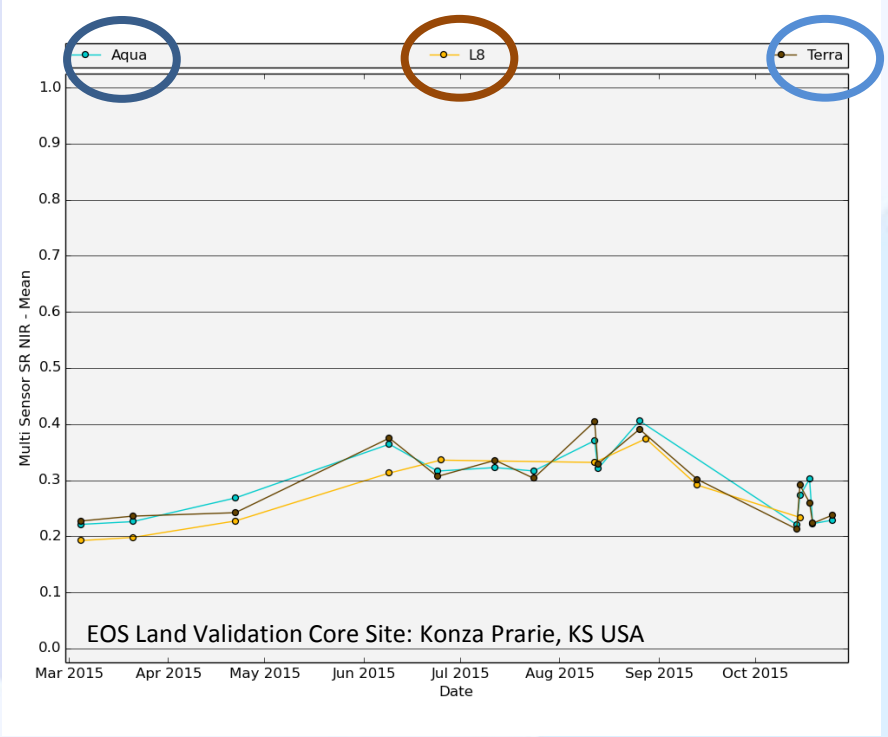




What is LPCS:
Output example

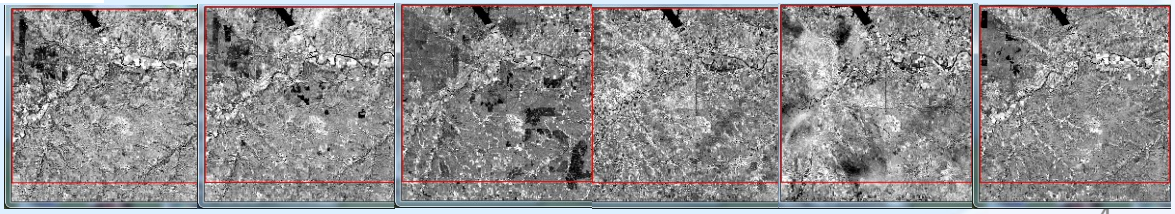
Trending of similar bands of data from multiple sensors.

Near-IR Surface Reflectance



DATE	DOY	MINIMUM	MAXIMUM	MEAN	STDDEV	VALID
3/5/2015	64	197	3348	2211.75	254.2622	yes
3/21/2015	80	86	3435	2260.46	283.6276	yes
4/22/2015	112	101	4456	2682.246	360.7378	yes
6/9/2015	160	516	4847	3641.673	371.7797	yes
6/24/2015	175	1277	4368	3162.141	323.418	yes
7/12/2015	193	663	4415	3224.323	336.7476	yes
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10/18/2015	291	676	4266	3021.147	584.0373	yes
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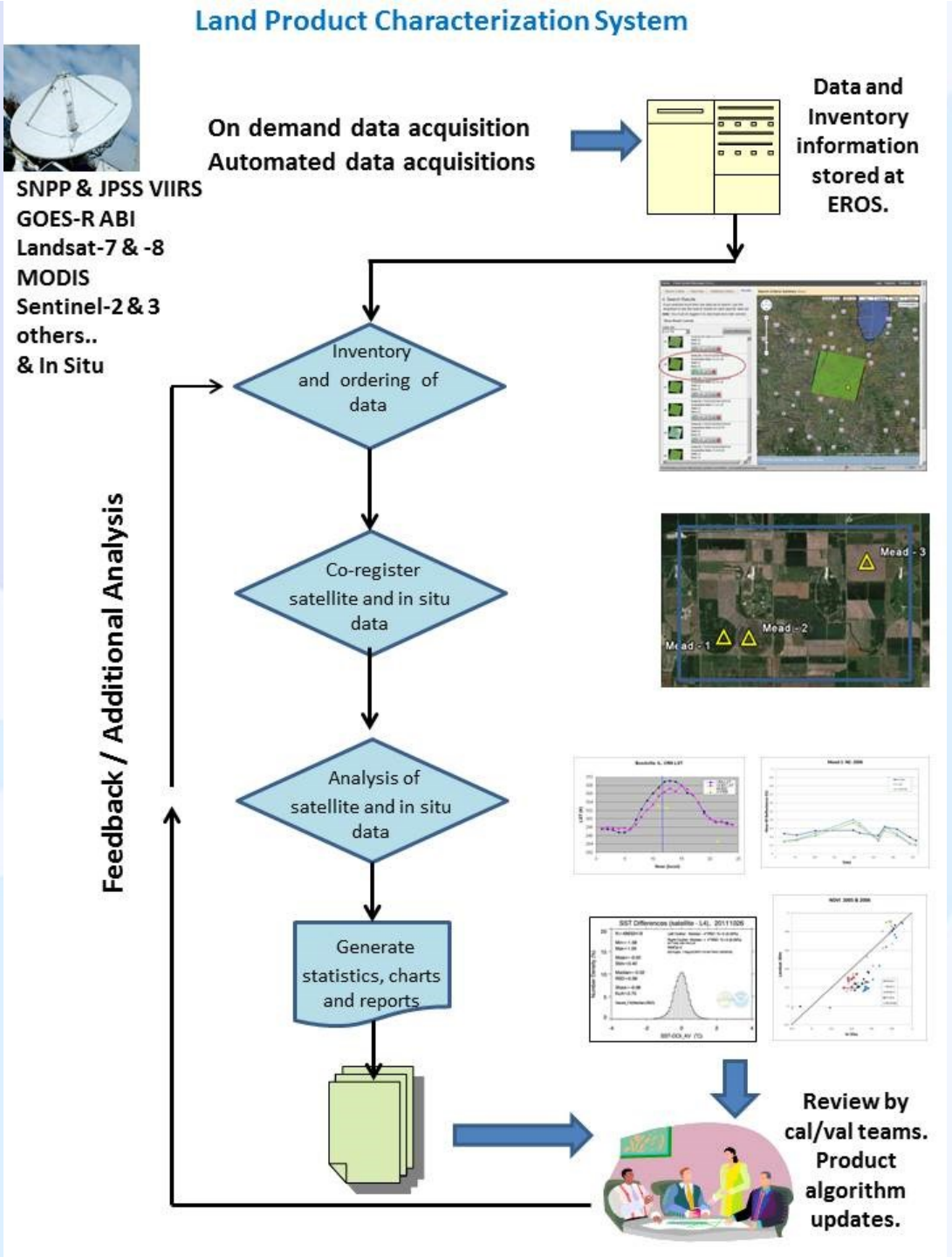
Tables and images provided for more intensive analyses.



What is LPCS

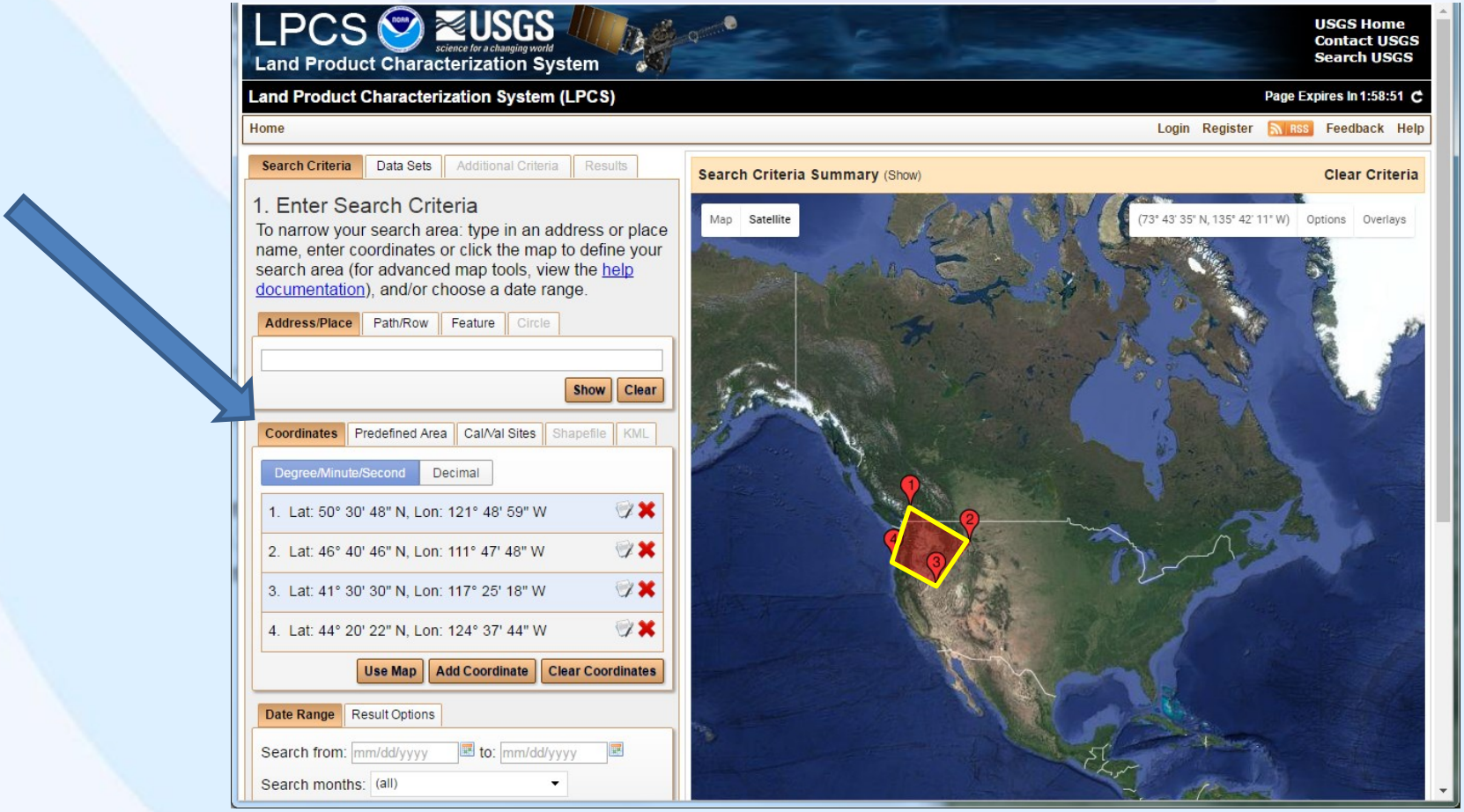
A web-based system designed for comparative analysis of global satellite higher-level land products.

- Search, inventory & order data
- Advanced processing
- Basic analysis options
- Output charts, images, & tables



Search, Inventory and Ordering

Several options to search and order data. Can search by entering latitude and longitude information or interactively drawing area of interest .



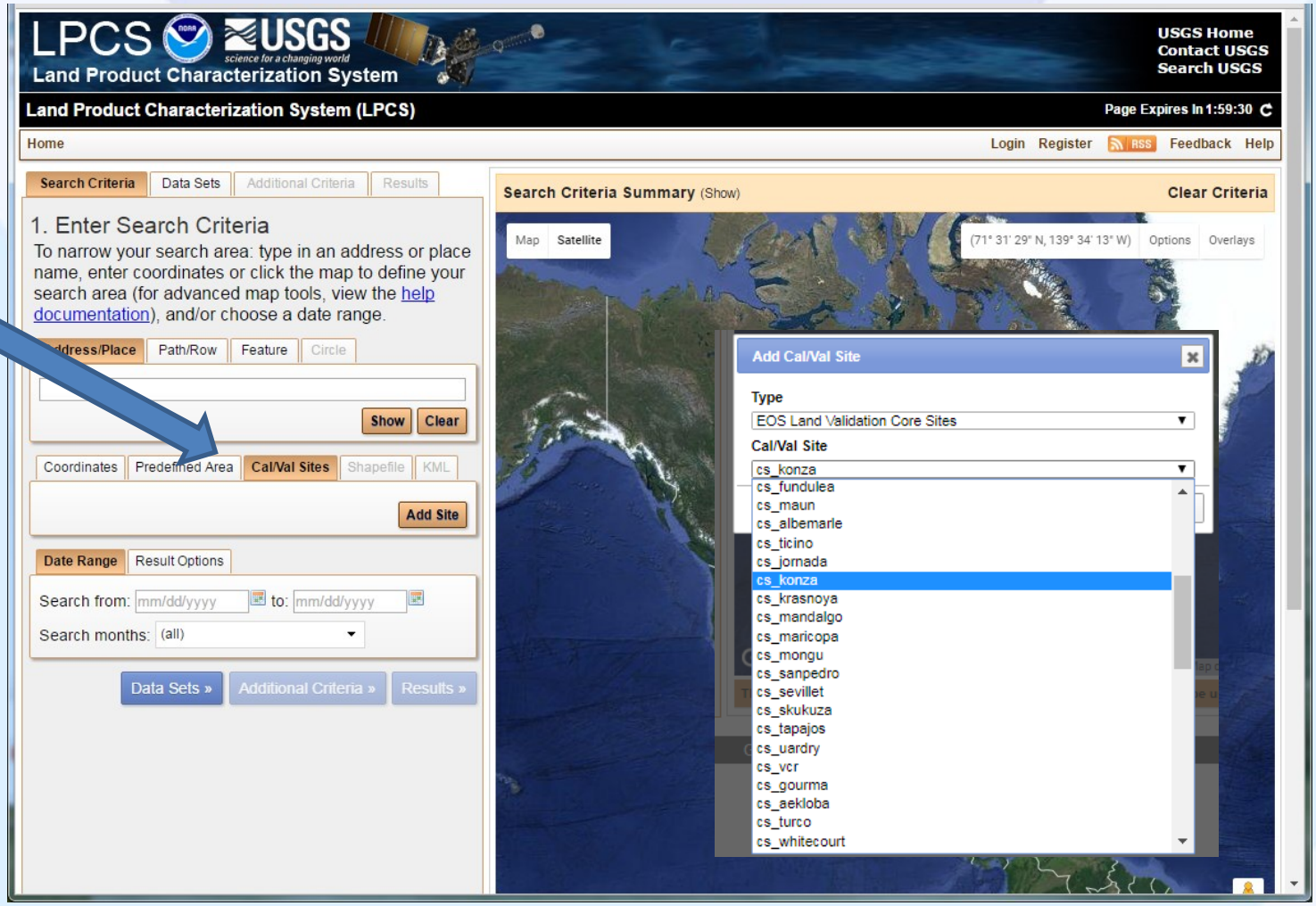
Search, Inventory and Ordering

NEW: Can search by location of several in situ networks.



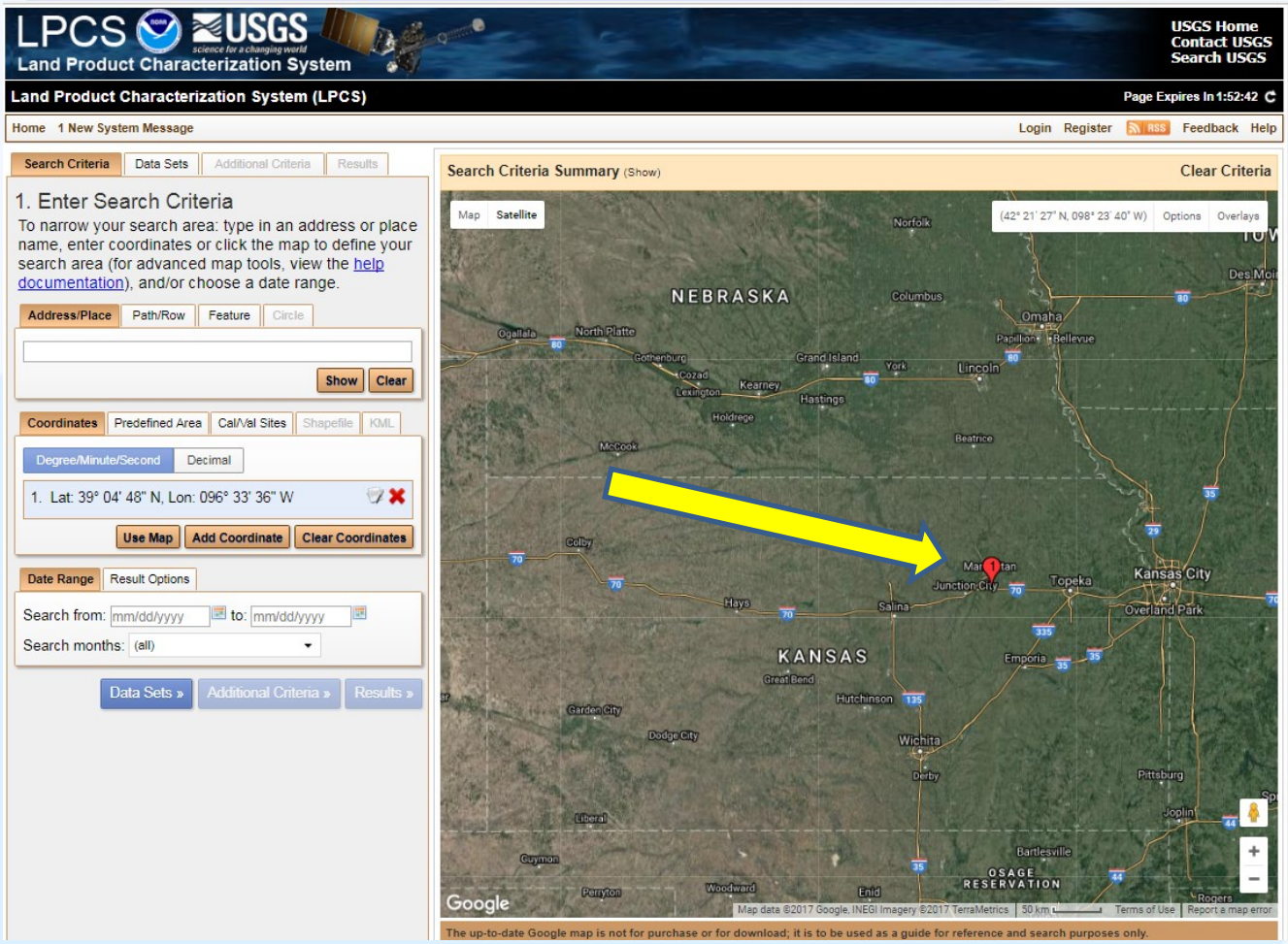
Search, Inventory and Ordering

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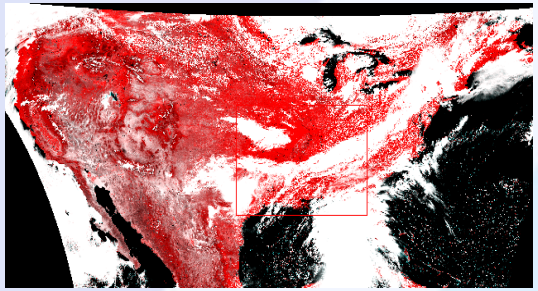
Search, Inventory and Ordering

NEW: Can search by location of several in situ networks (e.g., Konza Prairie, KS) .

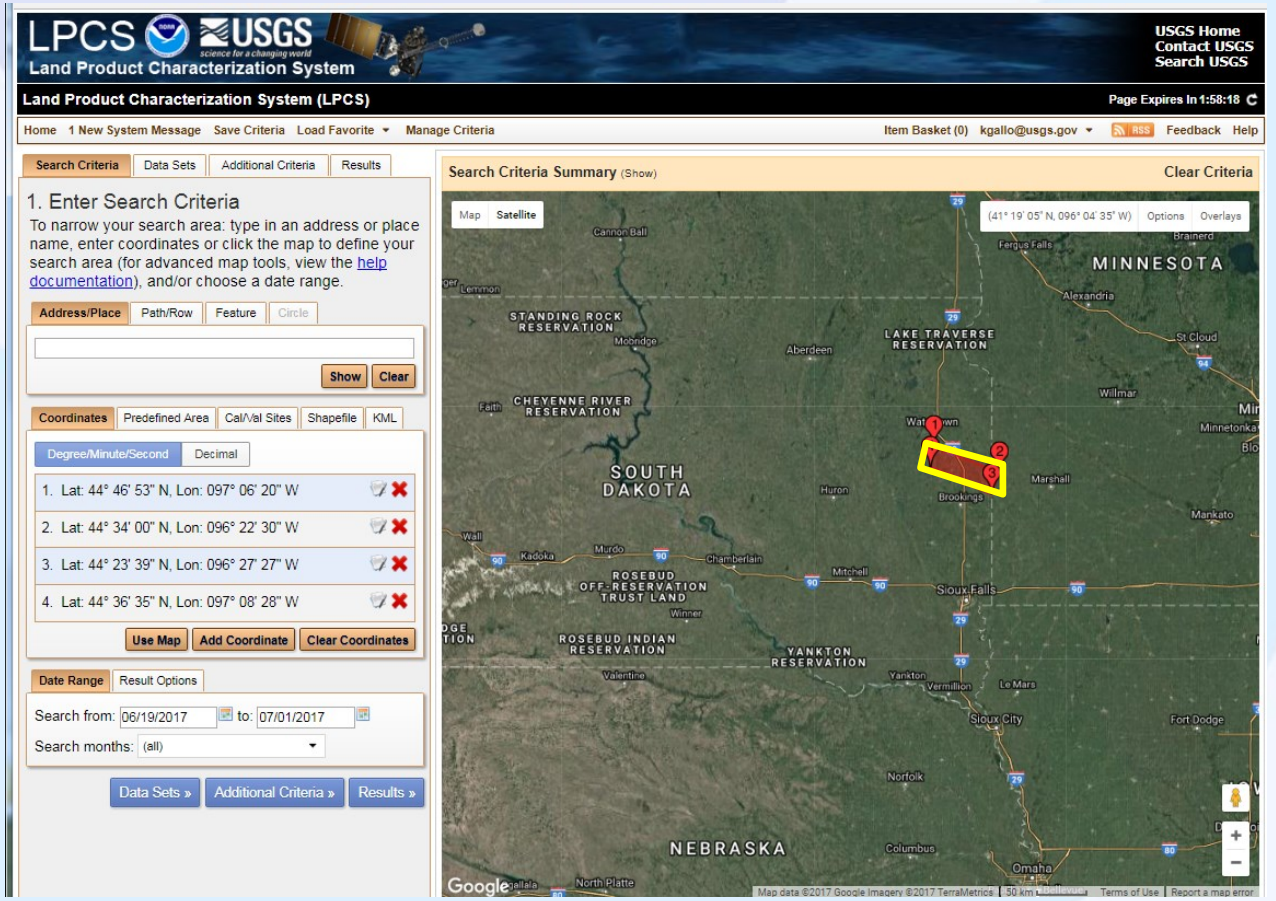


Search, Inventory and Ordering

Search for Landsat 8 data for comparison with GOES-16 ABI data for severe hail event in S. Dakota (June 2017).

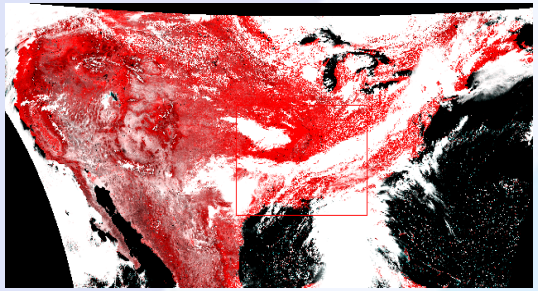


Users can search for data from multiple sensors over selected range of dates.

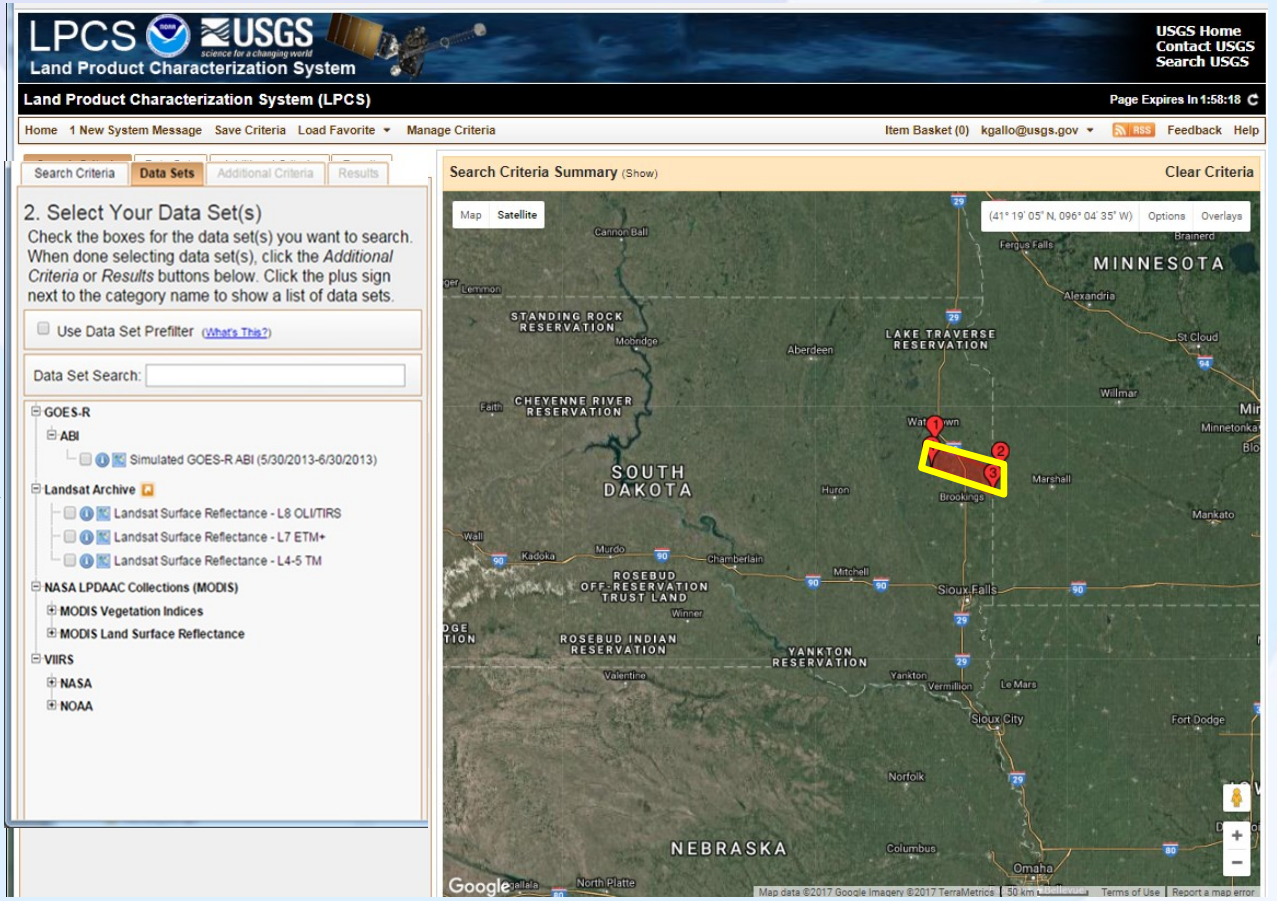


Search, Inventory and Ordering

Search for Landsat 8 data for comparison with GOES-16 ABI data for severe hail event in S. Dakota (June 2017).



Selected Landsat 8 data (other data options available and planned)



Search, Inventory and Ordering

Current

- 3 Landsat SR products
- 16 MODIS SR and NDVI
- Sample VIIRS
- Simulated GOES-R ABI

Future

- VIIRS
- GOES-R ABI
- Sentinel 2
- Sentinel 3
- in situ

Included data sets not arbitrary.

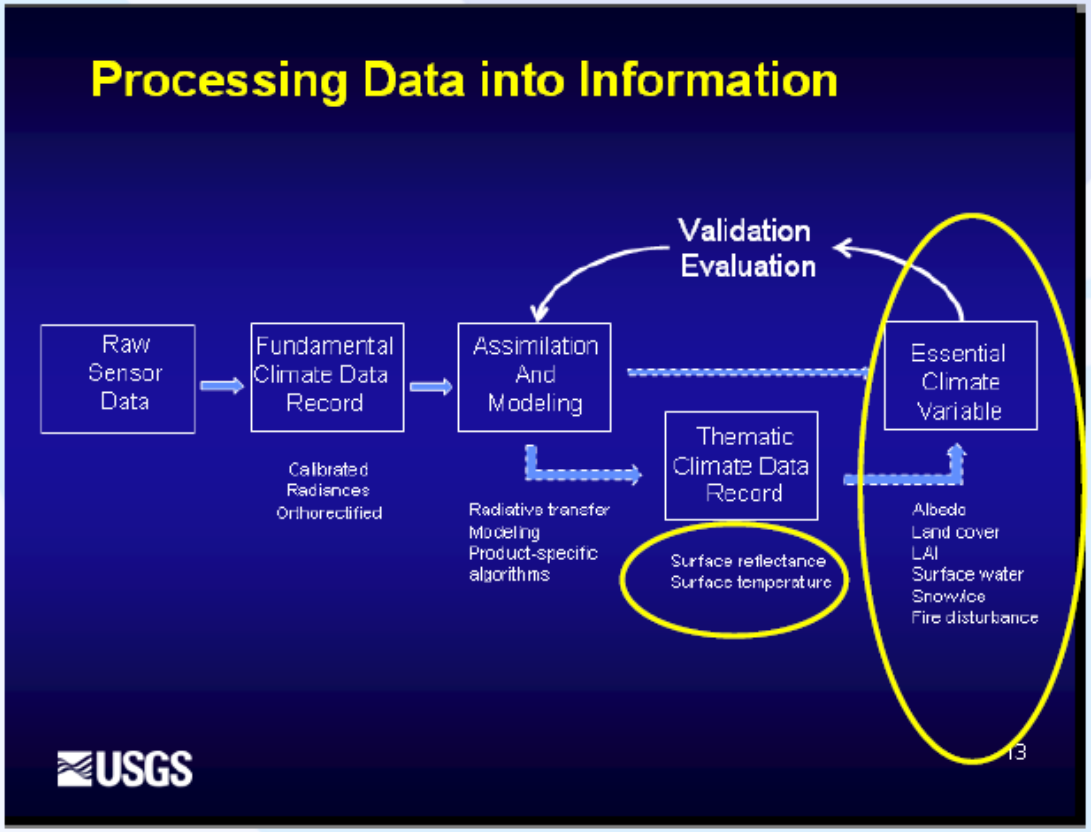
LPCS User Requirements Database

Organization	Mission	Instrument	Variable	Product Name	Spatial Coverage	Spatial Scale	Temporal Coverage	Temporal Scale	Validation Sites List
USGS/NASA	Landsat	Landsat 4-5	SR	Landsat Surface Reflectance L4-5 TM	Global	30 m		Daily (AM local time)	
USGS/NASA	Landsat	Landsat 7	SR	Landsat Surface Reflectance L7 ETM+	Global	30 m		Daily (AM local time)	
USGS/NASA	Landsat	Landsat 8	SR	Landsat Surface Reflectance L8 OLI/TIRS	Global	30 m		Daily (AM local time)	
NASA	EOS	MODIS	NDVI/EVI	MOD13A1 Vegetation Indices 16-Day L3 Global 500m	Global	500 m		Daily (AM local time)	
NASA	EOS	MODIS	NDVI/EVI	MOD13A2 Vegetation Indices 16-Day L3 Global 1km	Global	1000 m		Daily (AM local time)	
NASA	EOS	MODIS	NDVI/EVI	MOD13A3 Vegetation Indices Monthly L3 Global 1km	Global	1000 m		Daily (AM local time)	
NASA	EOS	MODIS	NDVI/EVI	MOD13Q1 Vegetation Indices 16-Day L3 Global 250m	Global	250 m		Daily (AM local time)	
NASA	EOS	MODIS	NDVI/EVI	MYD13A1 Vegetation Indices 16-Day L3 Global 500m	Global	500 m		Daily (PM local time)	
NASA	EOS	MODIS	NDVI/EVI	MYD13A2 Vegetation Indices 16-Day L3 Global 1km	Global	1000 m		Daily (PM local time)	
NASA	EOS	MODIS	NDVI/EVI	MYD13A3 Vegetation Indices Monthly L3 Global 1km	Global	1000 m		Daily (PM local time)	
NASA	EOS	MODIS	NDVI/EVI	MYD13Q1 Vegetation Indices 16-Day L3 Global 250m	Global	250 m		Daily (PM local time)	
NASA	EOS	MODIS	SR	MOD09A1 Surface Reflectance 8-Day L3 Global 500m	Global	500 m		Daily (AM local time)	
NASA	EOS	MODIS	SR	MOD09GA Surface Reflectance Daily L2G Global 1km and 500m	Global	500 m		Daily (AM local time)	
NASA	EOS	MODIS	SR	MOD09GQ Surface Reflectance Daily L2G Global 250m	Global	250 m		Daily (AM local time)	
NASA	EOS	MODIS	SR	MOD09Q1 Surface Reflectance 8-Day L3 Global 250m	Global	250 m		Daily (AM local time)	
NASA	EOS	MODIS	SR	MYD09A1 Surface Reflectance 8-Day L3 Global 500m	Global	500 m		Daily (PM local time)	
NASA	EOS	MODIS	SR	MYD09GA Surface Reflectance Daily L2G Global 1km and 500m	Global	500 m		Daily (PM local time)	
NASA	EOS	MODIS	SR	MYD09GQ Surface Reflectance Daily L2G Global 250m	Global	250 m		Daily (PM local time)	
NASA	EOS	MODIS	SR	MYD09Q1 Surface Reflectance 8-Day L3 Global 250m	Global	250 m		Daily (PM local time)	
NOAA	GOES-R	ABI	NDVI	Simulated TOA NDVI	CONUS	2222 m	31 May, 3 June, 26 Jun	1800, 1900, 2000 UTC	
NOAA	S-NPP	VIIRS	NDVI	Sample VIIRS Vegetation Index	SW CONUS	500 m	30 May - 29 June 2013	Daily (PM local time)	
NASA	S-NPP	VIIRS	NDVI	Sample VIIRS Vegetation Index	SW CONUS	488 m	31 May, 3 June, 26 Jun	Daily (PM local time)	
NASA	EOS	MODIS	land cover	MCD12Q1 Land Cover Type Yearly L3 Global 500 m SIN Grid	Global	500 m		Annual	
NASA	EOS	MODIS	LST	MOD11A1 LST and Emissivity Daily L3 Global 1 km Grid SIN	Global	1000 m		Daily (AM local time)	
NASA	EOS	MODIS	LST	MYD11A1 LST and Emissivity Daily L3 Global 1 km Grid SIN	Global	1000 m		Daily (PM local time)	
USGS/NASA	Landsat	Landsat 8	Albedo	TBD					
USGS/NASA	Landsat	Landsat 8	LST	TBD					
NOAA	GOES-R	ABI	TBD	TBD					
NOAA	GOES-R	ABI	TBD	TBD					
NOAA	GOES-R	ABI	TBD	TBD					
NOAA	GOES-R	ABI	TBD	TBD					
NOAA	S-NPP	VIIRS	TBD	TBD					
NOAA	S-NPP	VIIRS	TBD	TBD					
NOAA	S-NPP	VIIRS	TBD	TBD					
NOAA	S-NPP	VIIRS	TBD	TBD					
NASA	S-NPP	VIIRS	TBD	TBD					
NASA	S-NPP	VIIRS	TBD	TBD					
NASA	S-NPP	VIIRS	TBD	TBD					
NASA	S-NPP	VIIRS	TBD	TBD					
ESA	Sentinel-2	MSI	TBD	TBD					
	CRN	in situ	TBD	TBD					
	SURFRAD	in situ	TBD	TBD					
	AERONET	in situ	TBD	TBD					
	EOS Land Core	in situ	TBD	TBD					
				Currently available in LPCS					
				Soon to be avialble					
				Planned to be available					

USGS-NOAA validation synergy

USGS Requirements

- Landsat ECVs



USGS ECVs

- Albedo
- Land Cover
- LAI
- Surface Water
- Snow/Ice
- Fire disturbance
- LST

USGS-NOAA validation synergy

Several products of mutual interest (**e.g. GOES-R ABI**)

KEY

ABI	SUVI	EXIS
GLM	SEISS	MAG

ABI: Advanced Baseline Imager

SUVI: Solar Ultraviolet Imager

EXIS: Extreme Ultraviolet and X-ray Irradiance Suite

GLM: Geostationary Lightning Mapper

SEISS: Space Environment In-Situ Suite

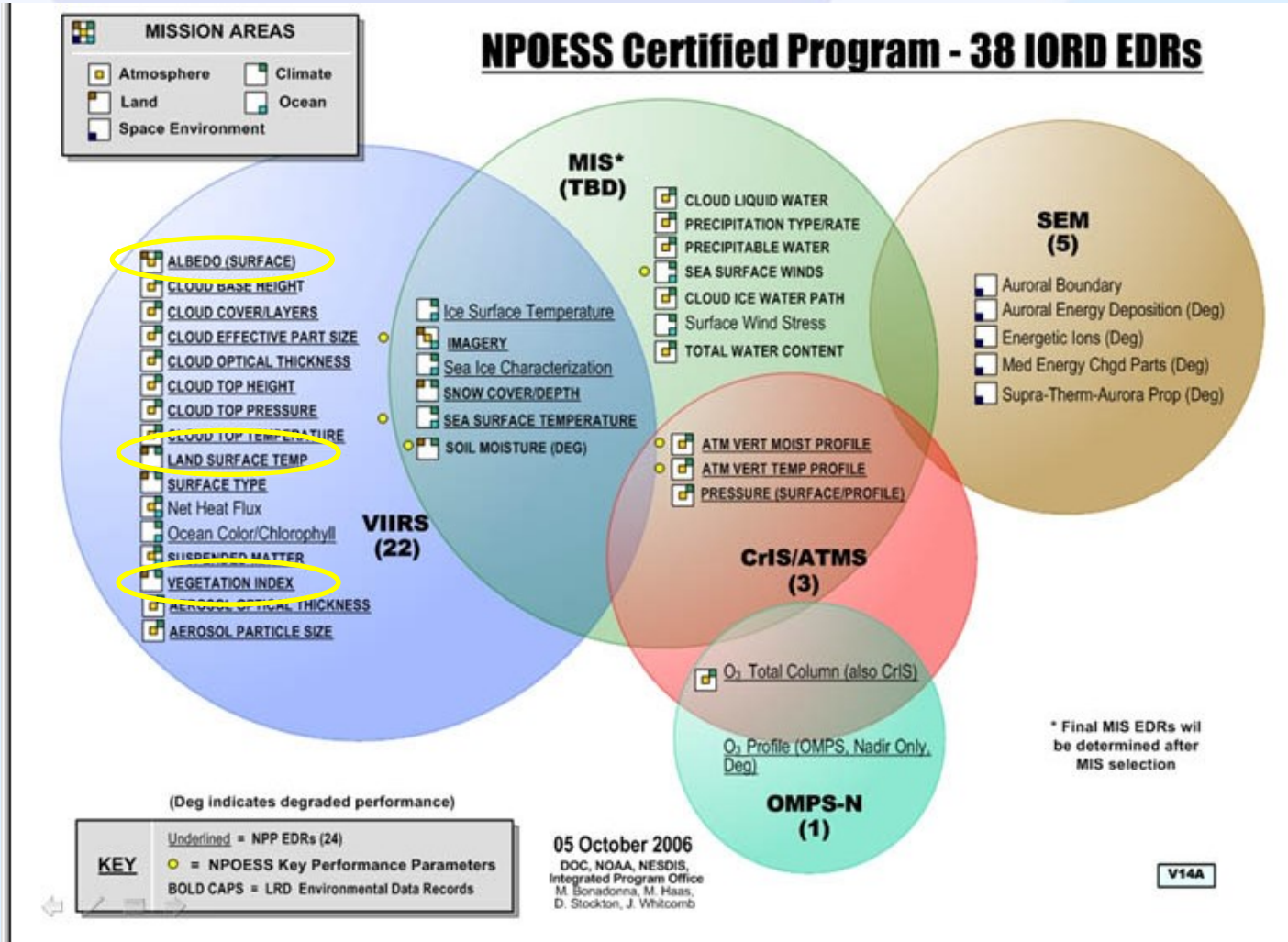
MAG: Magnetometer

BASELINE PRODUCTS
Aerosol Detection (Including Smoke and Dust)
Aerosol Optical Depth (AOD)
Volcanic Ash: Detection and Height
Cloud and Moisture Imagery
Cloud Optical Depth
Cloud Particle Size Distribution
Cloud Top Phase
Cloud Top Height
Cloud Top Pressure
Cloud Top Temperature
Hurricane Intensity
Lightning Detection: Events, Groups & Flashes
Rainfall Rate / QPE
Legacy Vertical Moisture Profile
Legacy Vertical Temperature Profile
Derived Stability Indices
Total Precipitable Water
Clear Sky Masks
Radiances
Downward Shortwave Radiation: Surface
Reflected Shortwave Radiation: TOA
Derived Motion Winds
Fire/Hot Spot Characterization
Land Surface Temperature (Skin)
Snow Cover
Sea Surface Temperature (Skin)
Energetic Heavy Ions
Mag. Electrons & Protons: Low Energy
Mag. Electrons & Protons: Med & High Energy
Solar & Galactic Protons
Geomagnetic Field
Solar Flux: EUV
Solar Flux: X-Ray
Solar Imagery: X-Ray

OPTION 2 PRODUCTS
Aerosol Partical Size
Aircraft Icing Threat
Cloud Ice Water Path
Cloud Layers/Heights
Cloud Liquid Water
Cloud Type
Convective Initiation
Enhanced "V" / Overshooting Top Detection
Low Cloud and Fog
Tropopause Folding Turbulence Prediction
Visibility
Probability of Rainfall
Rainfall Potential
Absorbed Shortwave Radiation: Surface
Downward Longwave Radiation: Surface
Upward Longwave Radiation: Surface
Upward Longwave Radiation: TOA
Ozone Total
SO2 Detection
Flood/Standing Water
Ice Cover
Snow Depth (Over Plains)
Surface Albedo
Surface Emissivity
Vegetation Fraction: Green
Vegetation Index
Currents
Currents: Offshore
Sea and Lake Ice: Age
Sea and Lake Ice: Concentration
Sea and Lake Ice: Motion

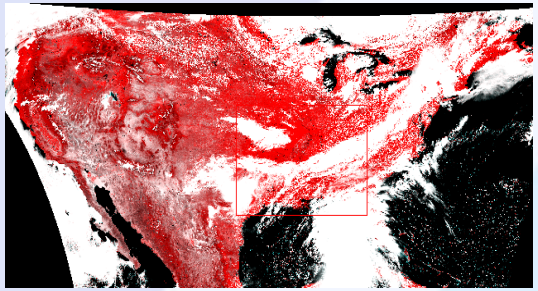
USGS-NOAA validation synergy

Several products of mutual interest (**e.g. VIIRS**)

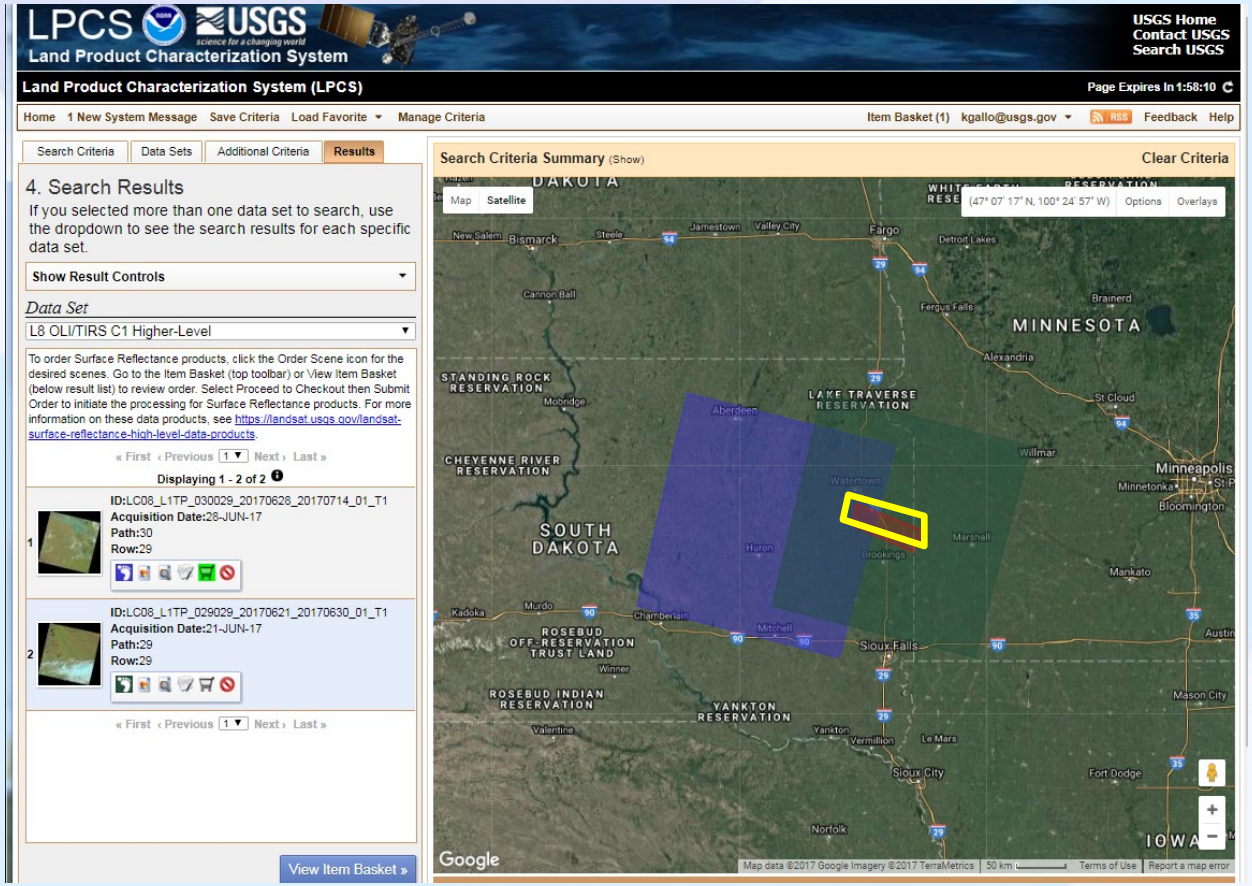


Search, Inventory and Ordering

Search for Landsat 8 data for comparison with GOES-16 ABI data for severe hail event in S. Dakota (June 2017).

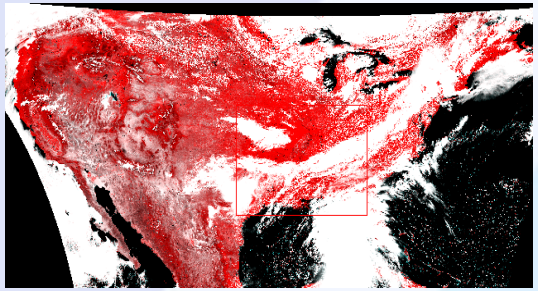


Once inventory of images provided, users can view browse images and…

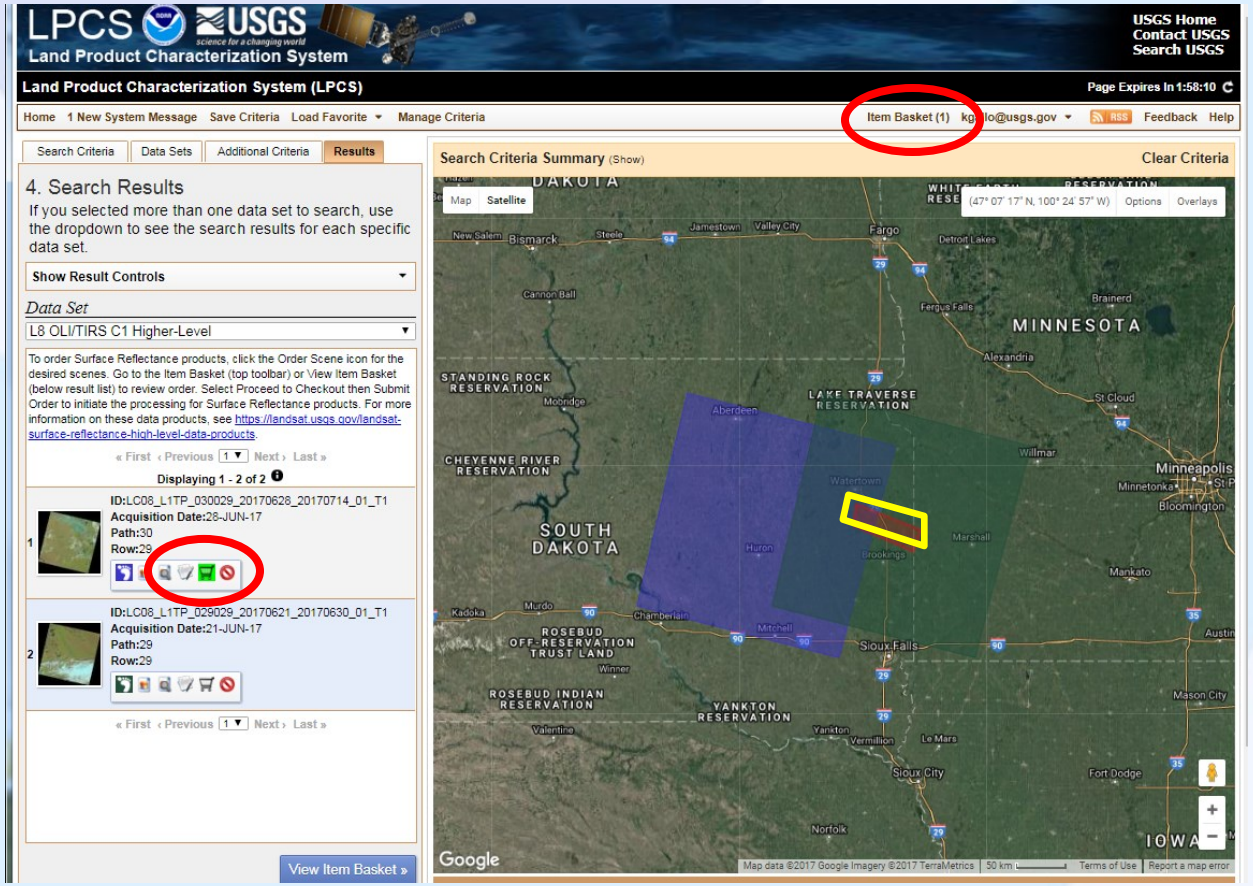


Search, Inventory and Ordering

Search for Landsat 8 data for comparison with GOES-16 ABI data for severe hail event in S. Dakota (June 2017).

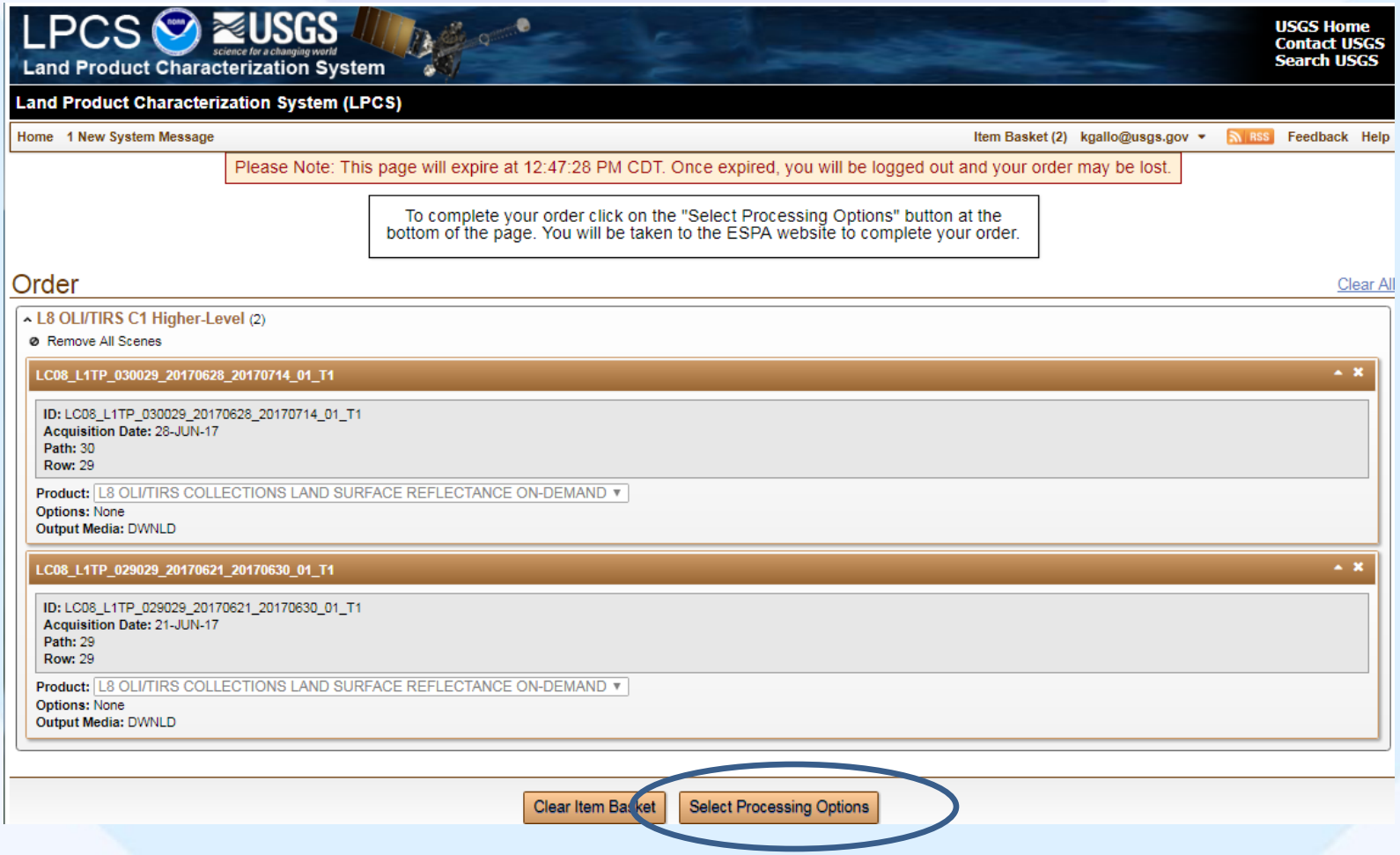


…. select scenes for further processing.



Search, Inventory and Ordering

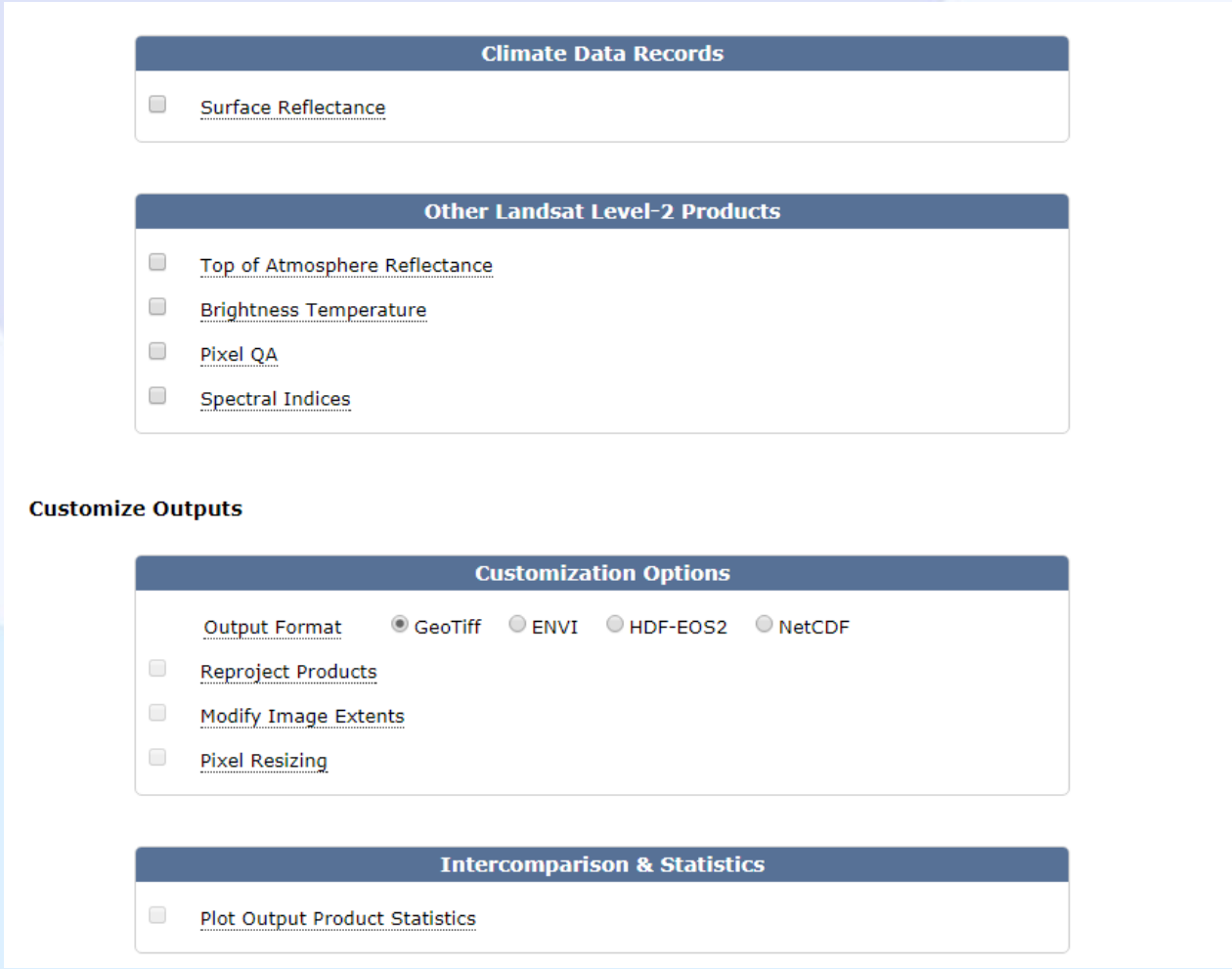
2017 Highlight…. seamless handoff of data from inventory/ordering to processing system.



Custom Processing

Higher Level Products

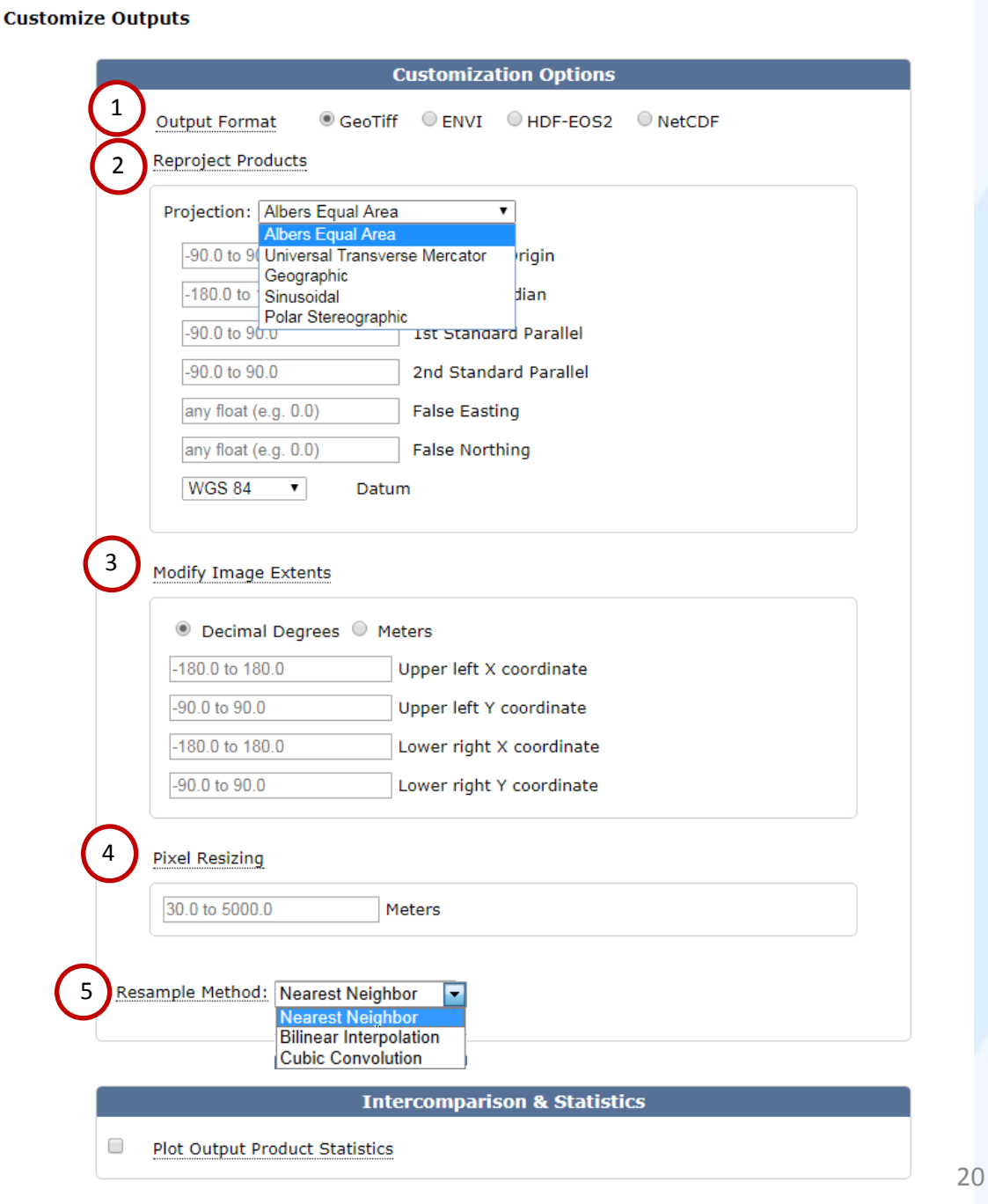
Choose higher level products from selected data. *Additional ECVs and CDRs will be added to menu as available.*



Custom Processing

Define Output Products
Product Customization

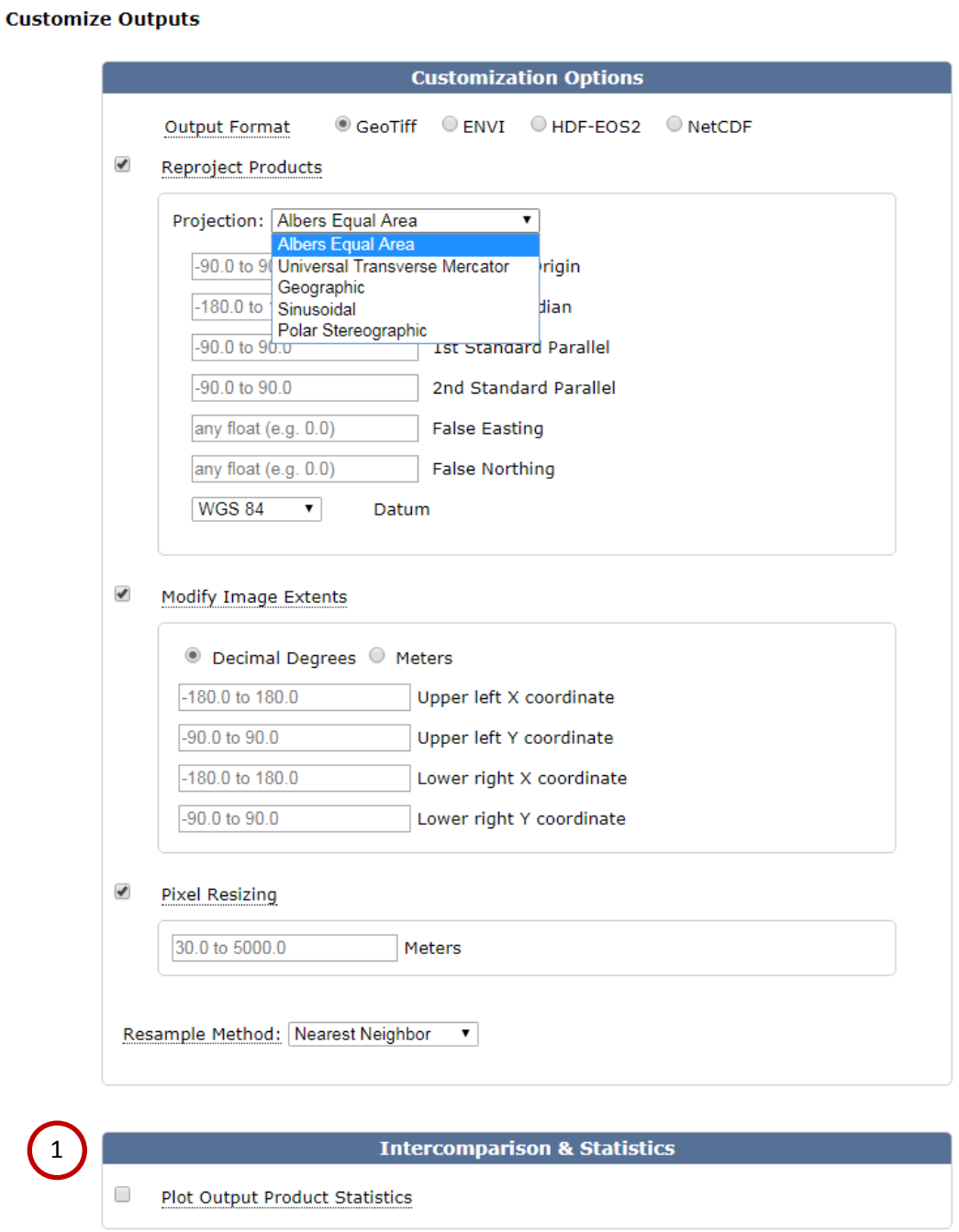
1. Several Output formats
2. Auto-registration of data to map projections
3. User defined area of interest
4. Defined pixel size for all images (30 – 5000 m)
5. Several resampling options



Custom Processing

Basic Analysis Tools

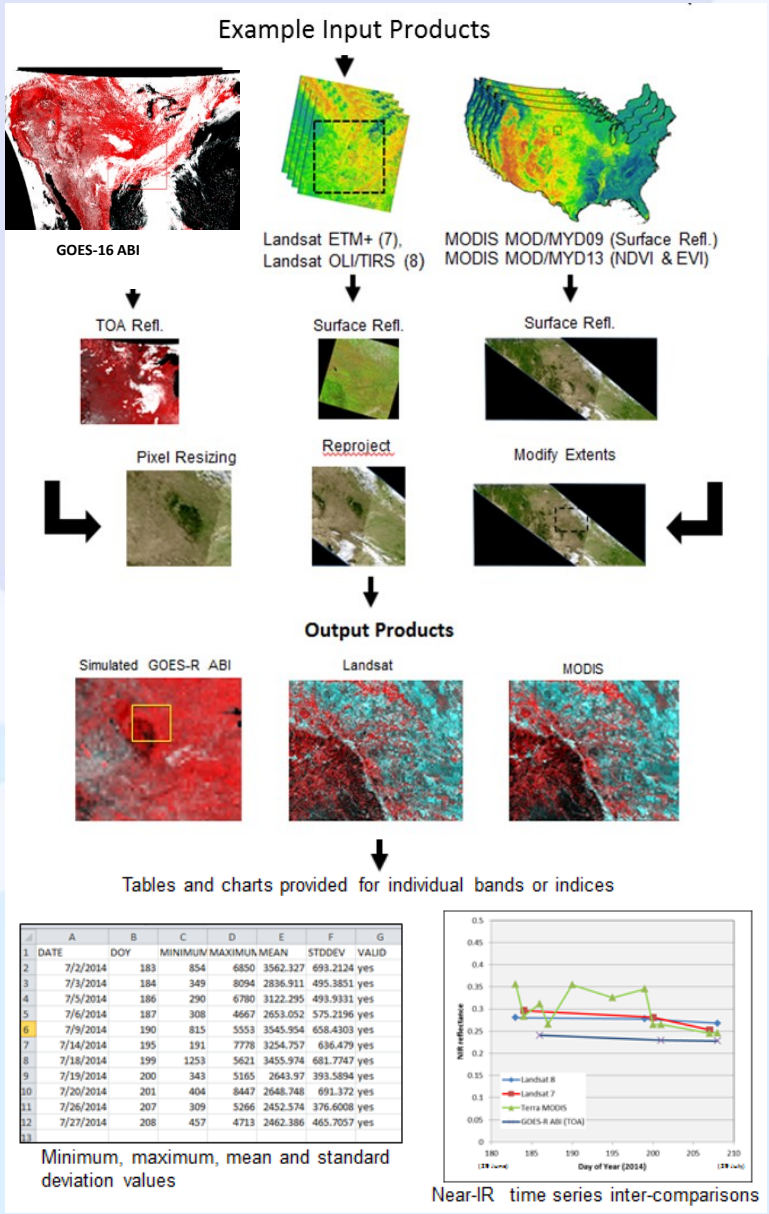
1. Product charts and tables



Custom Processing (summary)

Input products: *resized, remapped.*

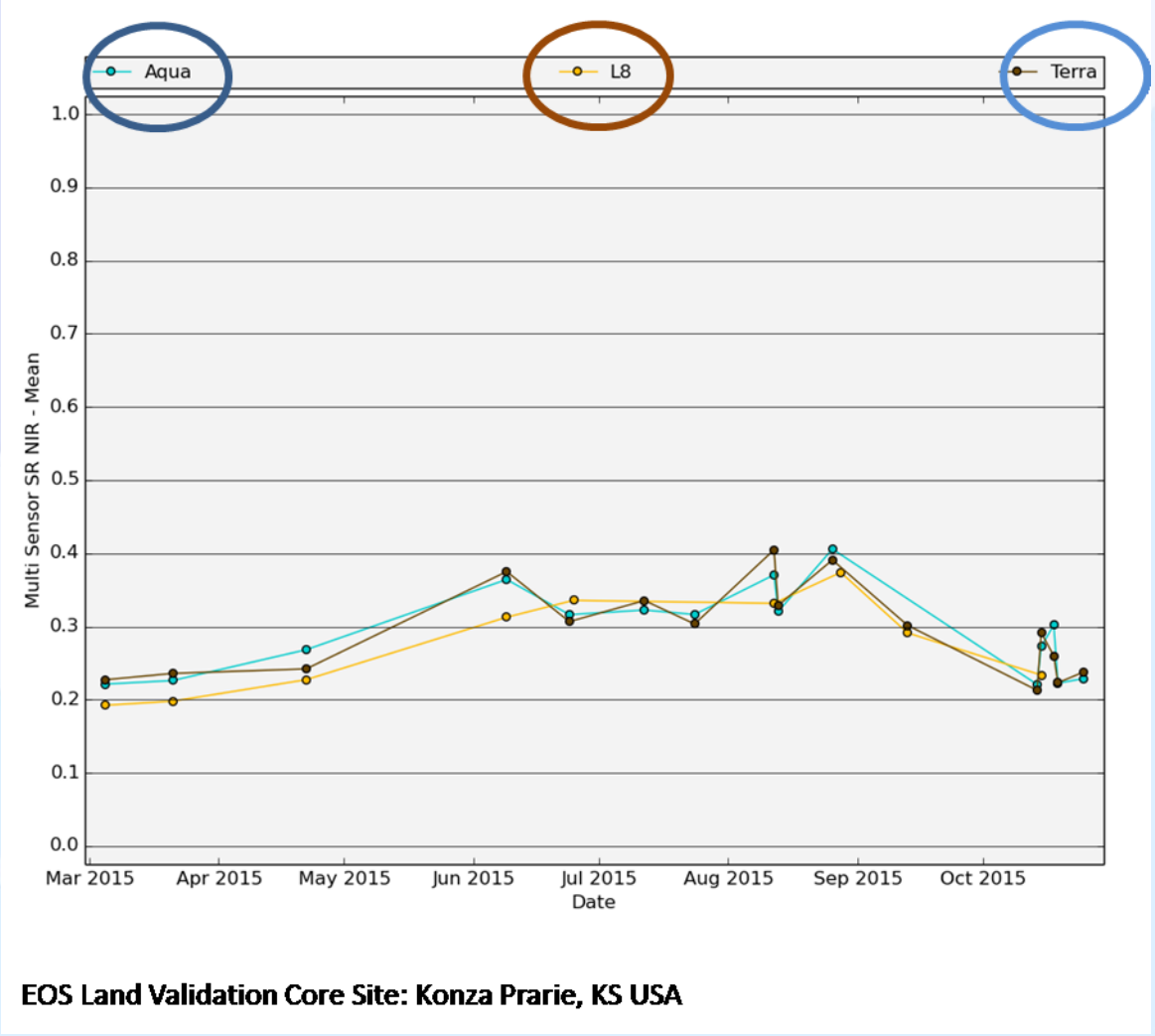
Output products*: images, charts, and tables.*



	A	B	C	D	E	F	G
1	DATE	DOY	MINIMUM	MAXIMUM	MEAN	STDDEV	VALID
2	7/2/2014	183	854	6850	3562.327	693.2124	yes
3	7/3/2014	184	349	8094	2836.911	495.3851	yes
4	7/5/2014	186	290	6780	3122.295	493.9331	yes
5	7/6/2014	187	308	4667	2653.052	575.2196	yes
6	7/9/2014	190	815	5553	3545.954	658.4303	yes
7	7/14/2014	195	191	7778	3254.757	636.479	yes
8	7/18/2014	199	1253	5621	3455.974	681.7747	yes
9	7/19/2014	200	343	5165	2643.97	393.5894	yes
10	7/20/2014	201	404	8447	2648.748	691.372	yes
11	7/26/2014	207	309	5266	2452.574	376.6008	yes
12	7/27/2014	208	457	4713	2462.386	465.7057	yes
13							

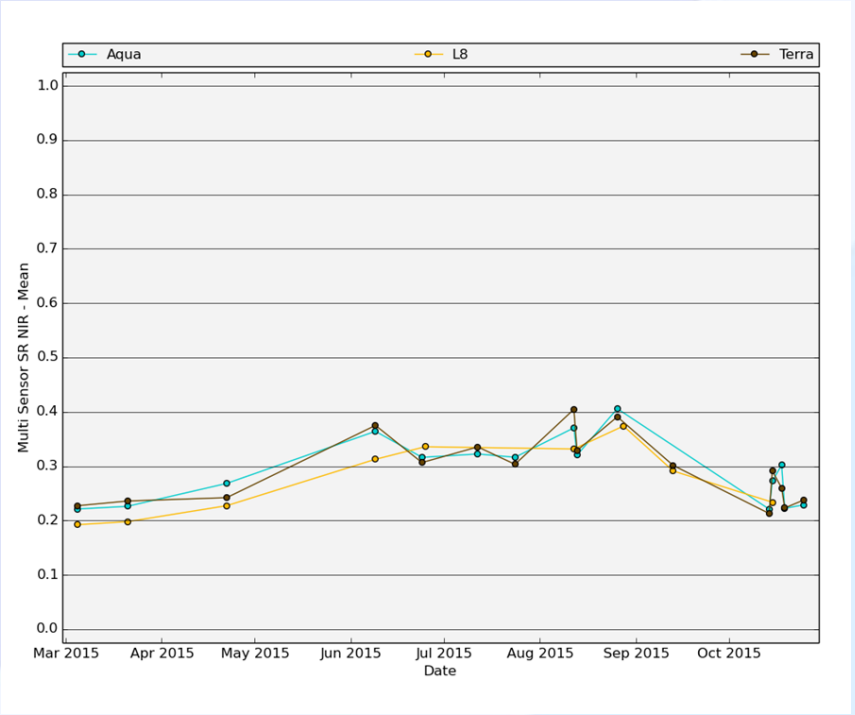
Analysis Tools

Output products include several charts, e.g., sensor values vs. time.



Near-IR Surface Reflectance (Aqua/MODIS, L8, and Terra/MODIS.

Analysis Tools



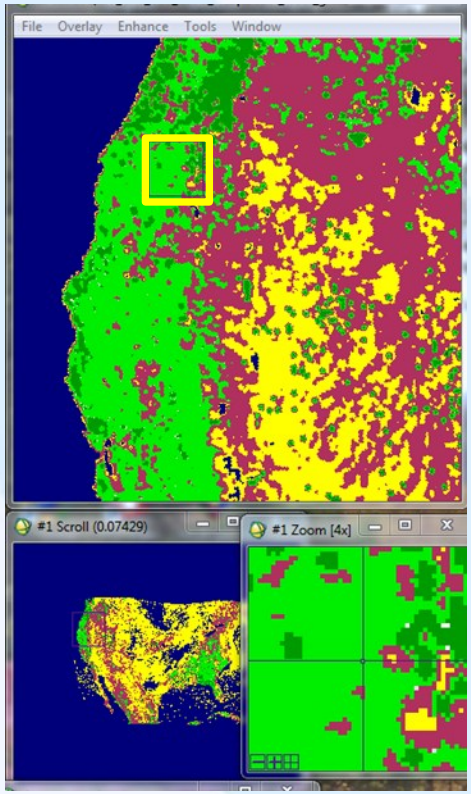
Tables provided with additional data for more intensive analyses.

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10/25/2015	298	280	3102	2286.152	303.9241	yes

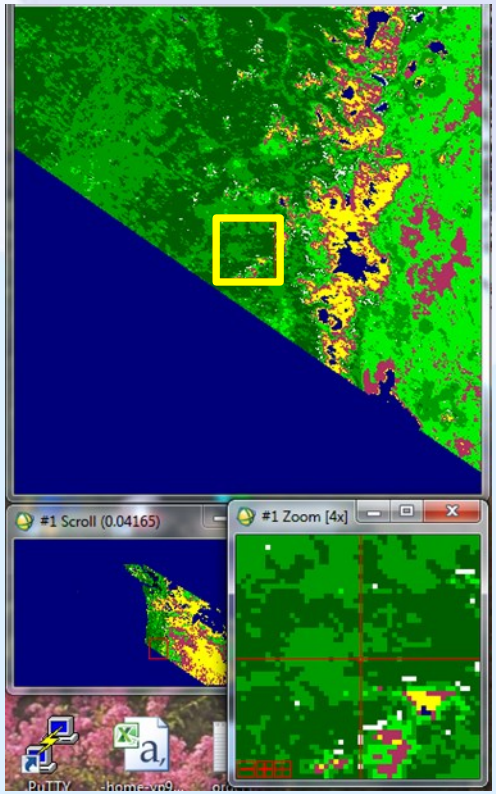
Analysis Tools

*LPCS also provides as output products **georegistered images** of input images for additional analysis (same map projection, cell size, etc., as defined within product customization).*

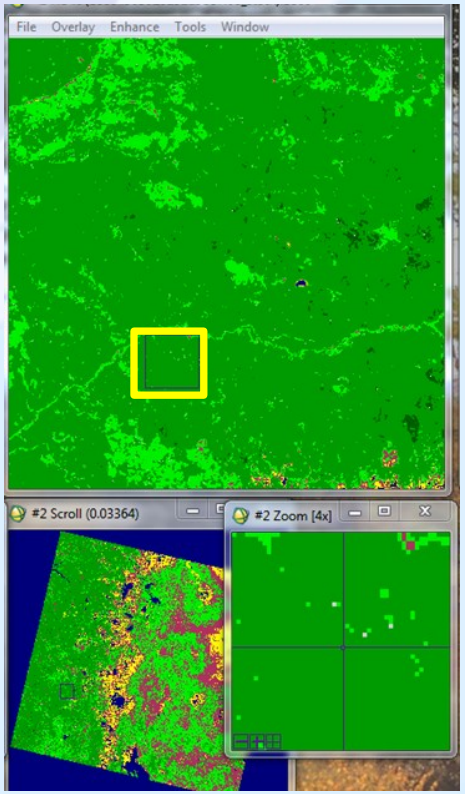
Simulated GOES-R ABI



VIIRS



Landsat 8



Land Product Characterization System (LPCS)

What is LPCS

Why LPCS developed/hosted at EROS

Highlights of LPCS

1. Inventory & Ordering
2. Analysis Tools

Path Forward

1. Status and Readiness
2. CEOS LPV collaboration

Summary

LPCS Status and Readiness

https://landsat.usgs.gov/lpcs

Public Release: February 2017

Includes a Landing Page and Tutorial



LPCS Status and Readiness

Introduction of future *data sets* and *analysis tools* within LPCS are planned, however, timing dependent on additional resources.

Current

MODIS

GSFC SBRC

Landsat 8



Under Development

Joint Polar Satellite System (JPSS) Visible Infrared Imaging Radiometer Suite (VIIRS)

NOAA-NASA Geostationary Operational Environmental Satellites - R Series (GOES-R)

Future

SENTINEL 2

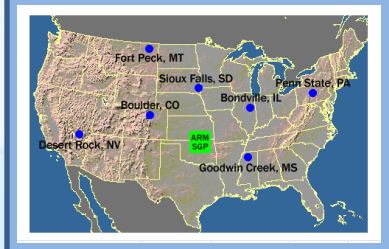
European Space Agency (ESA) Sentinel-2



sentinel-3

→ GMES MEDIUM RESOLUTION LAND AND OCEAN MISSION





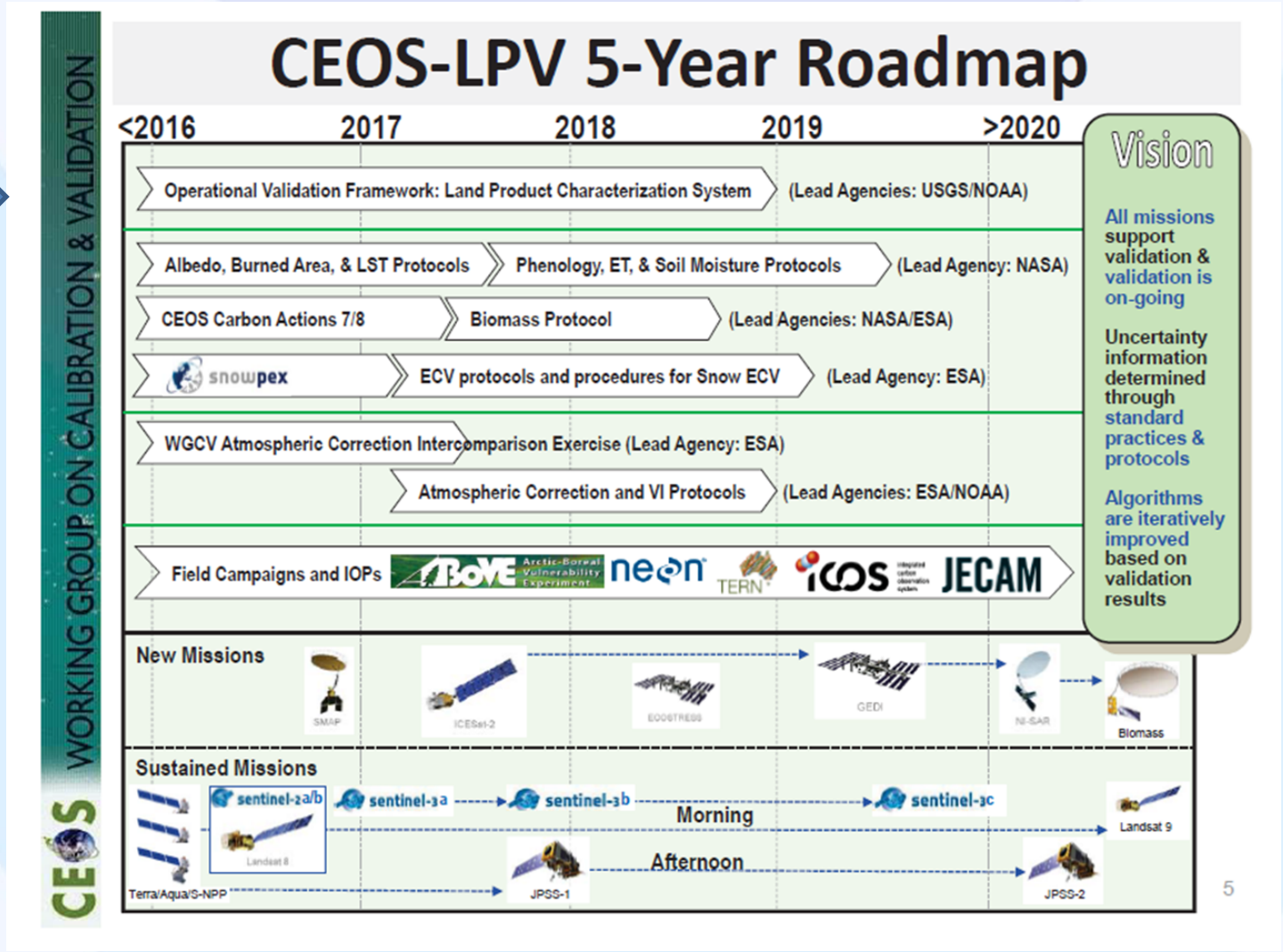
Surface Radiation Budget (SURFRAD) Network

The EOS Land Validation Core Sites



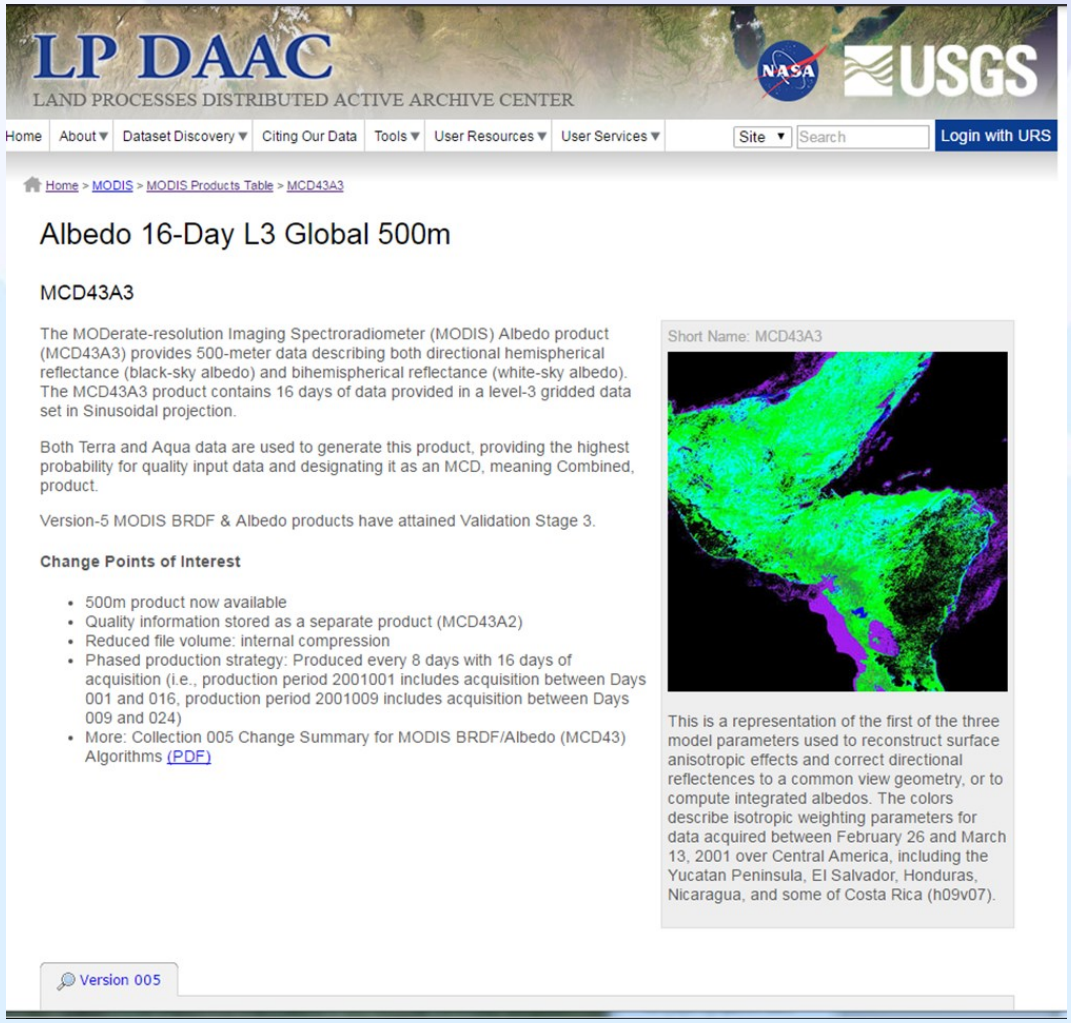
CEOS LPV collaboration

LPCS proposed/accepted as CEOS-LPV Online Validation Tool.



CEOS LPV collaboration

Albedo (MODIS MCD43A3) added to LPCS (limited capabilities) as requested by CEOS-LPV.



CEOS LPV collaboration

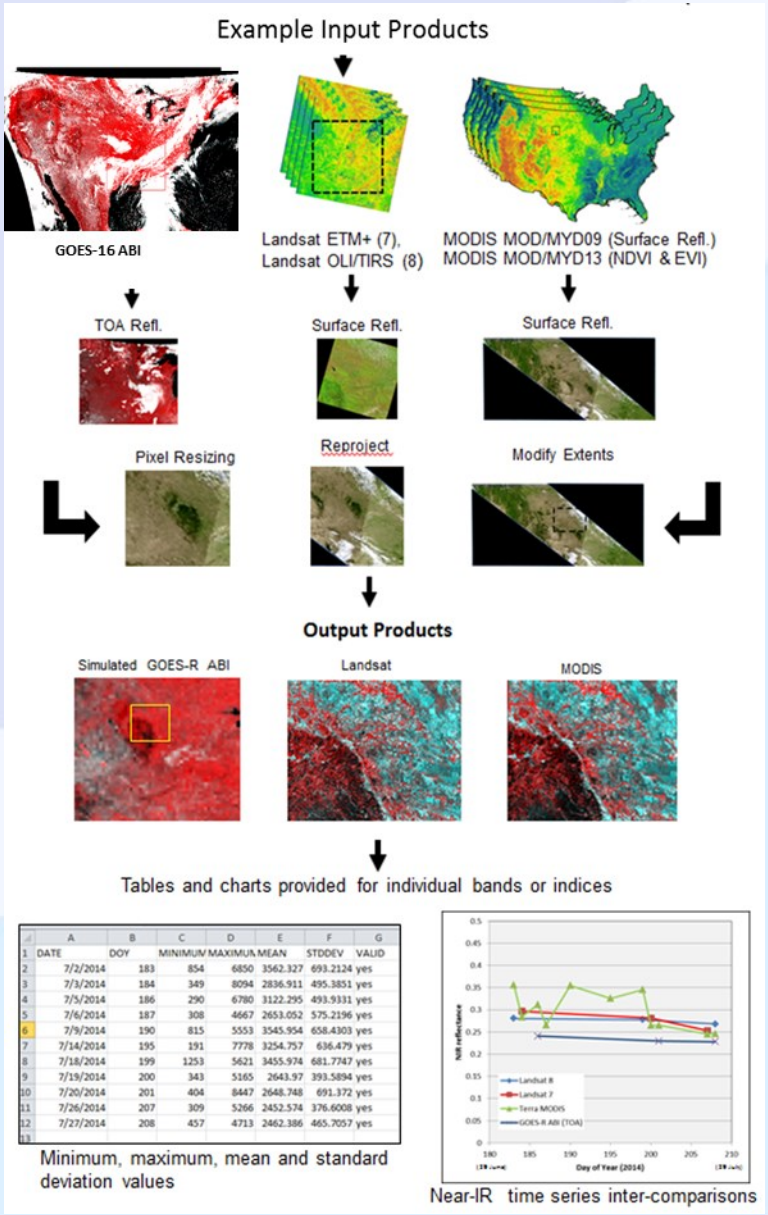
Additional analysis tools recommended by CEOS-LPV are under review for addition to LPCS.



Summary

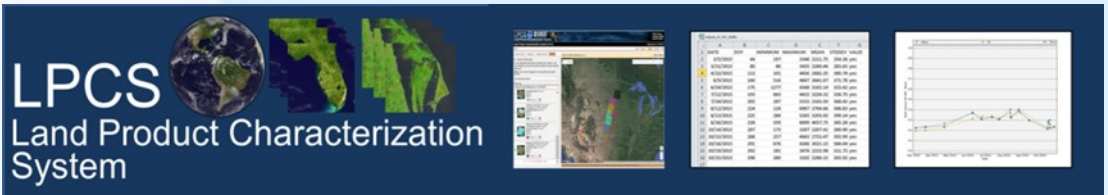
A web-based system designed for comparative analysis of global satellite higher-level land products.

- Search, Inventory & order data
- Advanced processing
- Basic analysis
- Output charts , images, & tables



LPCS Land Product Characterization System

Questions?



https://landsat.usgs.gov/lpcs

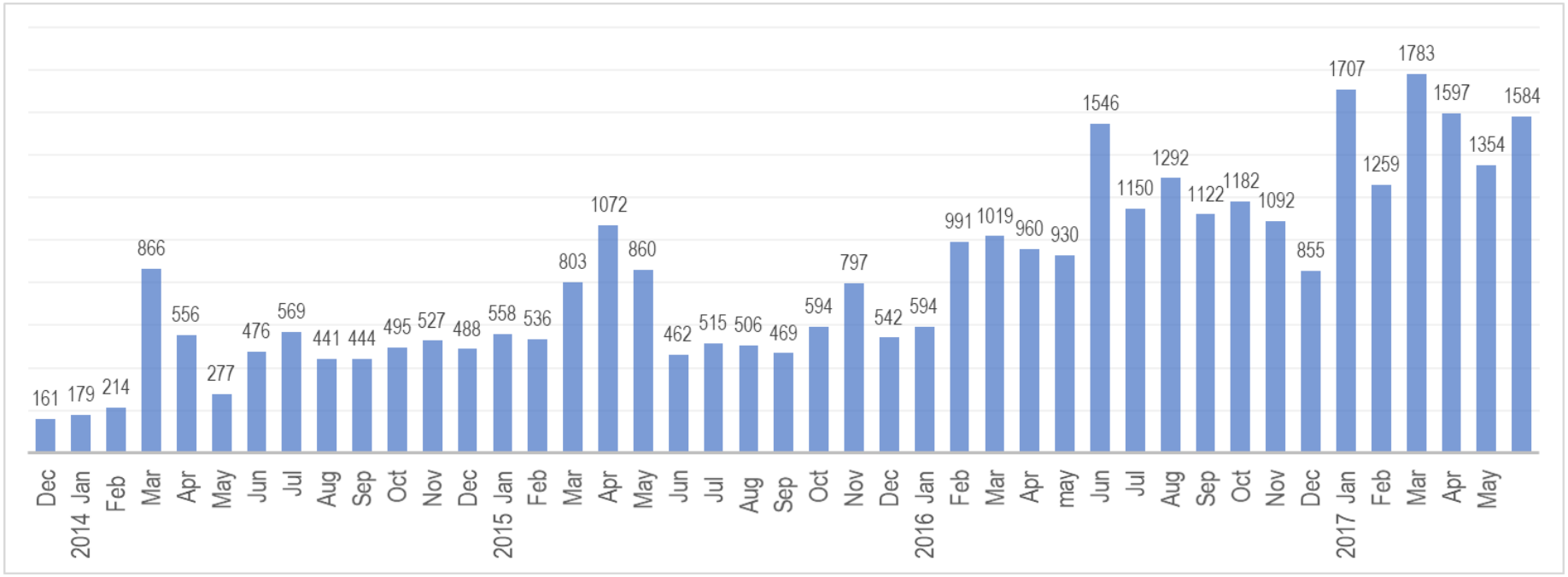
NASA Land Science Team Status

Miguel Román (NASA GSFC)
Chris Justice (UMCP)
with contributions from:
The Terra/Aqua/Suomi-NPP Land Discipline Team
NASA's Disasters Response Program

STAR JPSS NCWCP

8/17/2017 (13:55-14:15)





S-NPP VIIRS Land Discipline Website (http://viirsland.gsfc.nasa.gov/) and associated pageviews per month (since Dec, 2013).



EOS Products	Algorithms Delivered to Land SIPS	Product Integration and Testing	Draft ATBD Delivery	Delivery of User's Guide	Products Delivered to assigned DAAC
Surface Reflectance	✓	✓	✓	✓	✓
LAI/FPAR	✓	Underway	✓	✓	Summer, 2017
Snow Products	✓	✓	✓	✓	Summer, 2017
MAIAC	Pending	Pending	Summer, 2017	Summer, 2017	Summer, 2017
BRDF/Albedo	✓	Underway	✓	✓	Summer, 2017
Burned Area	Pending	Pending	Summer, 2017	Summer, 2017	Summer, 2017
Active Fires	✓	✓	✓	✓	✓
Vegetation Index	✓	Underway	Summer, 2017	Summer, 2017	Summer, 2017
LST&E	✓	Underway	✓	✓	Summer, 2017
Ice Surface Temp	✓	Underway	✓	✓	Summer, 2017
Sea Ice Cover	Summer, 2017	Underway	Summer, 2017	Summer, 2017	Summer, 2017
Phenology	✓	Underway	✓	✓	Summer, 2017
Black Marble	✓	Underway	Fall, 2017	Fall, 2017	Fall, 2017

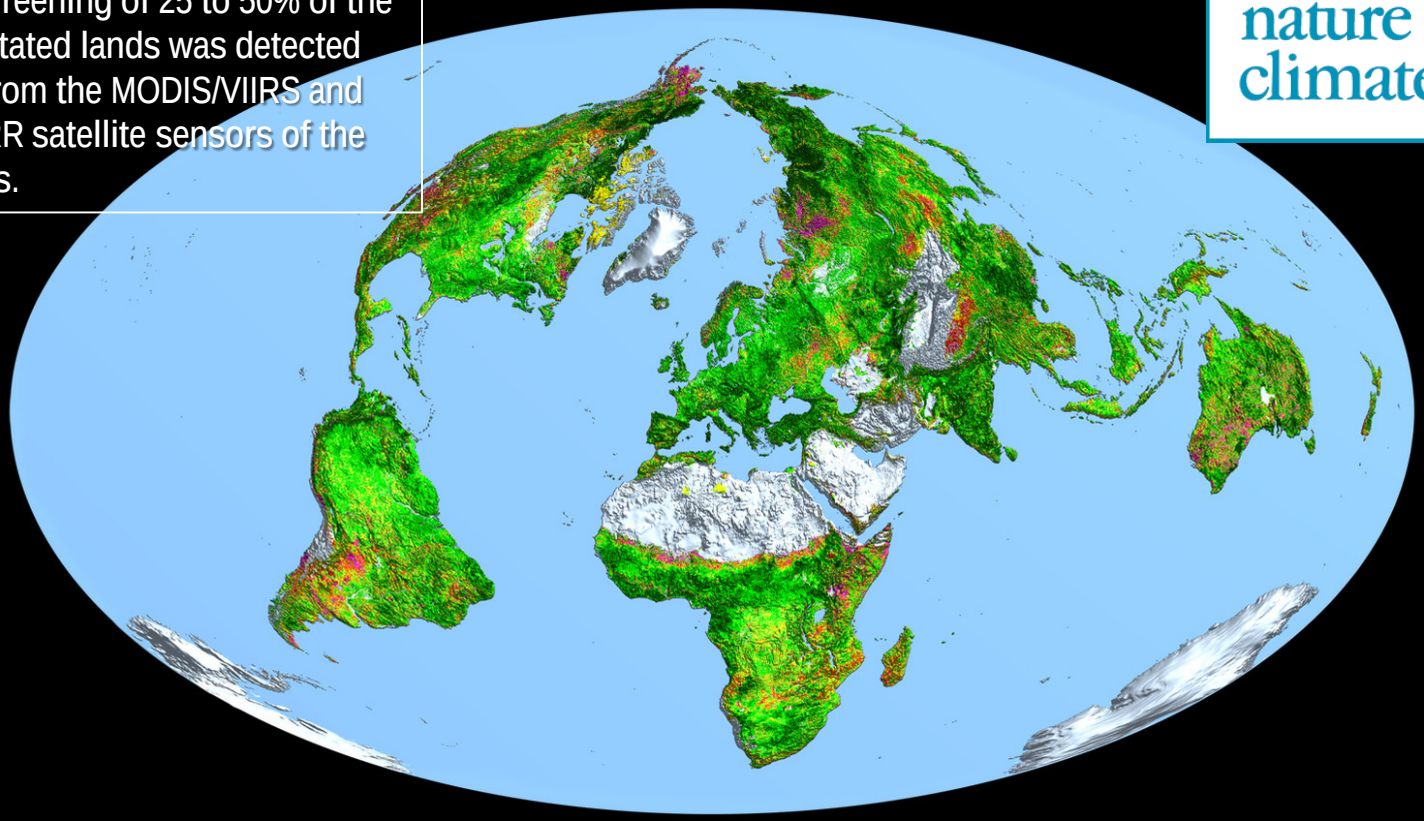
✓Completed Task;

S-NPP VIIRS Land Discipline Website (http://viirsland.gsfc.nasa.gov/) and current schedule including key milestones.

Carbon Dioxide Fertilization Greening the Earth

Significant greening of 25 to 50% of the Earth's vegetated lands was detected using data from the MODIS/VIIRS and NOAA-AVHRR satellite sensors of the past 34 years.

nature climate change



This represents an increase in leaves on plants and trees equivalent in twice the are of the Continental USA.

The increase was linked to the fertilization effect from increasing concentration of carbon dioxide in the atmosphere.

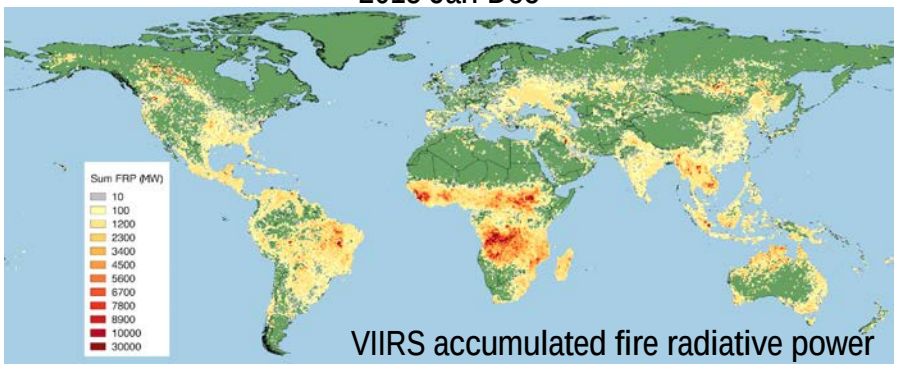
R. Myneni, BU

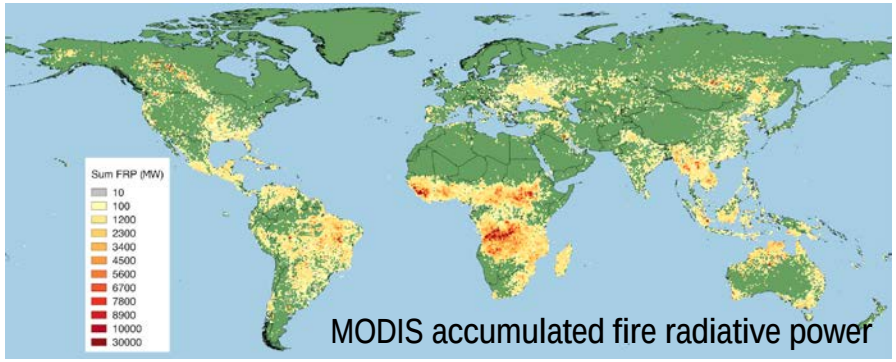
Zhu et al., Greening of the Earth and its Drivers. Nature Climate Change, doi:10.1038/nclimate3004.

VIIRS Active Fire Products Improve Global Estimates of Biomass Burning

VIIRS can detect significantly more fire activity compared to heritage MODIS fire products.

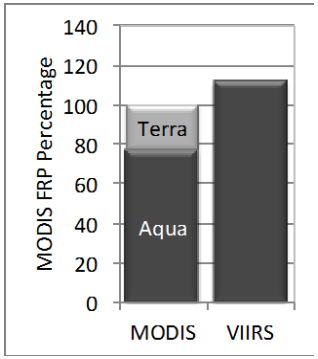
2015 Jan-Dec



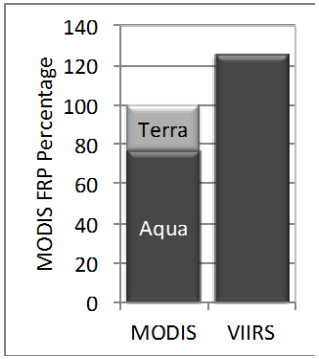


Global fire radiative power totals for 2015 showed that VIIRS can pick up as much fire activity as two heritage MODIS instruments: (Terra/MODIS: 6.1×10^6 MW; Aqua/MODIS; 13.4×10^6 MW; S-NPP/VIIRS: 19.6×10^6 MW)

As a result, regions dominated by small and low intensity fires (e.g., Southeast Asia) are now becoming ever more apparent – enhancing awareness of global hotspots and improving carbon emissions accounting.



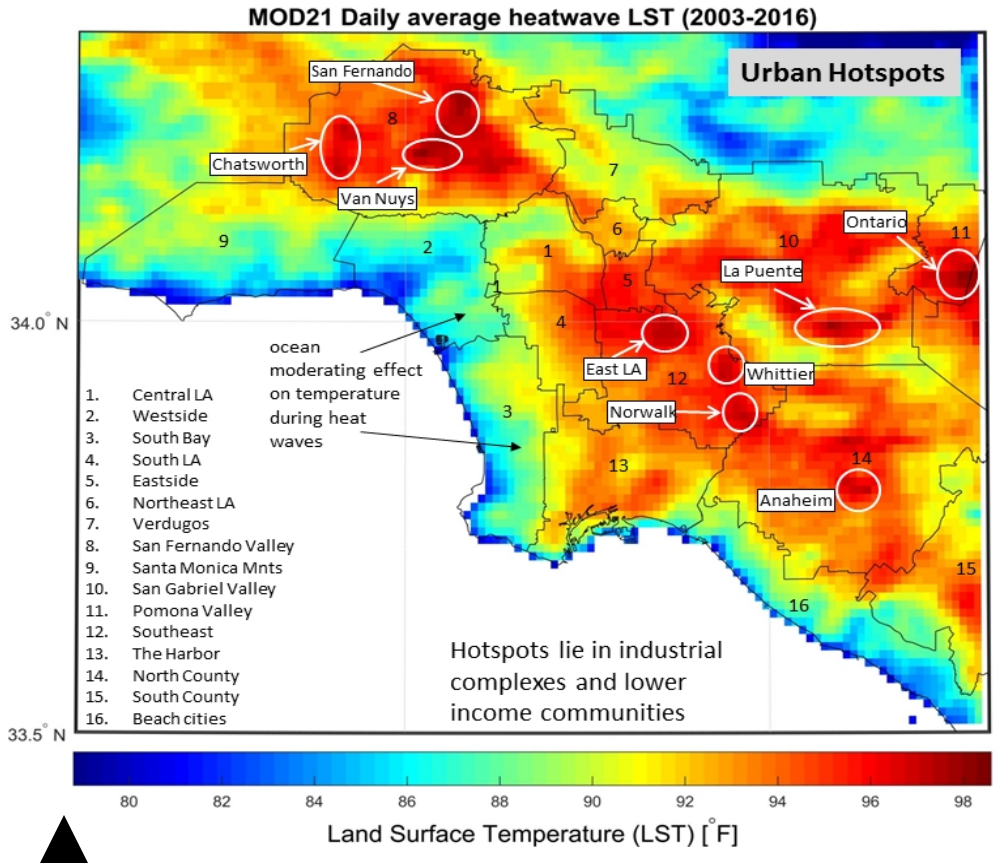
Africa



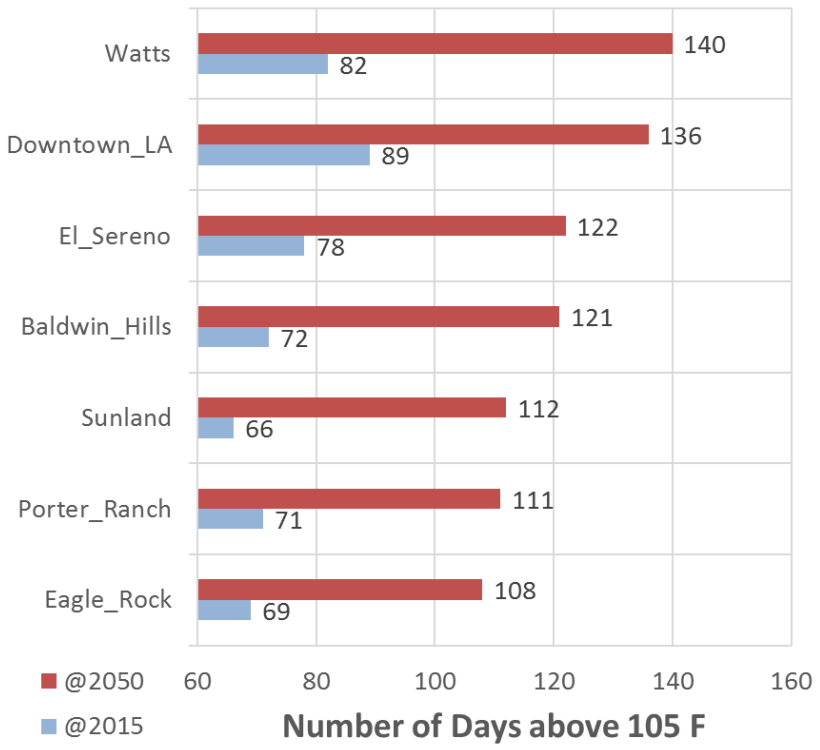
South East Asia

Credit: W. Schroeder & L. Giglio / UMD

MODIS Detects Rising Temperatures and Heat Wave Trends in Cities

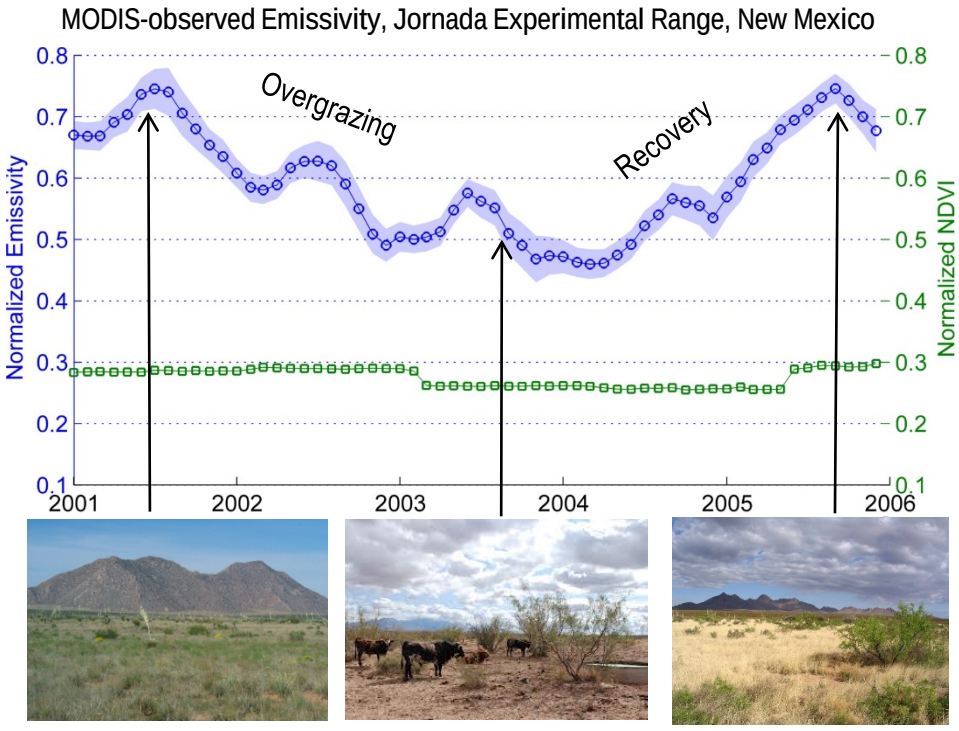


New MODIS surface temperature data can pinpoint current and future communities that are most vulnerable to the detrimental effects of heat waves. These satellite products are helping guide efforts to advise local governments on effective climate adaption and mitigation strategies.



Current and predicted days above 105° F in Los Angeles, CA based on the refined MODIS Land Surface Temperature product suite. All regions were predicted to warm, with inland areas warming faster than areas near the coast.

Desertification monitoring with a new MODIS/VIIRS thermal infrared emissivity product



MODIS emissivity and NDVI mean monthly time-series at the Jornada Experimental range from 2001-2006. MOD21 emissivity values show a distinct decreasing linear trend due to land degradation (increased soil exposure) from 2001-2004 followed by a recovery due to more controlled grazing from 2004-2006. Corresponding NDVI results show no seasonal cycle and insignificant linear trends.

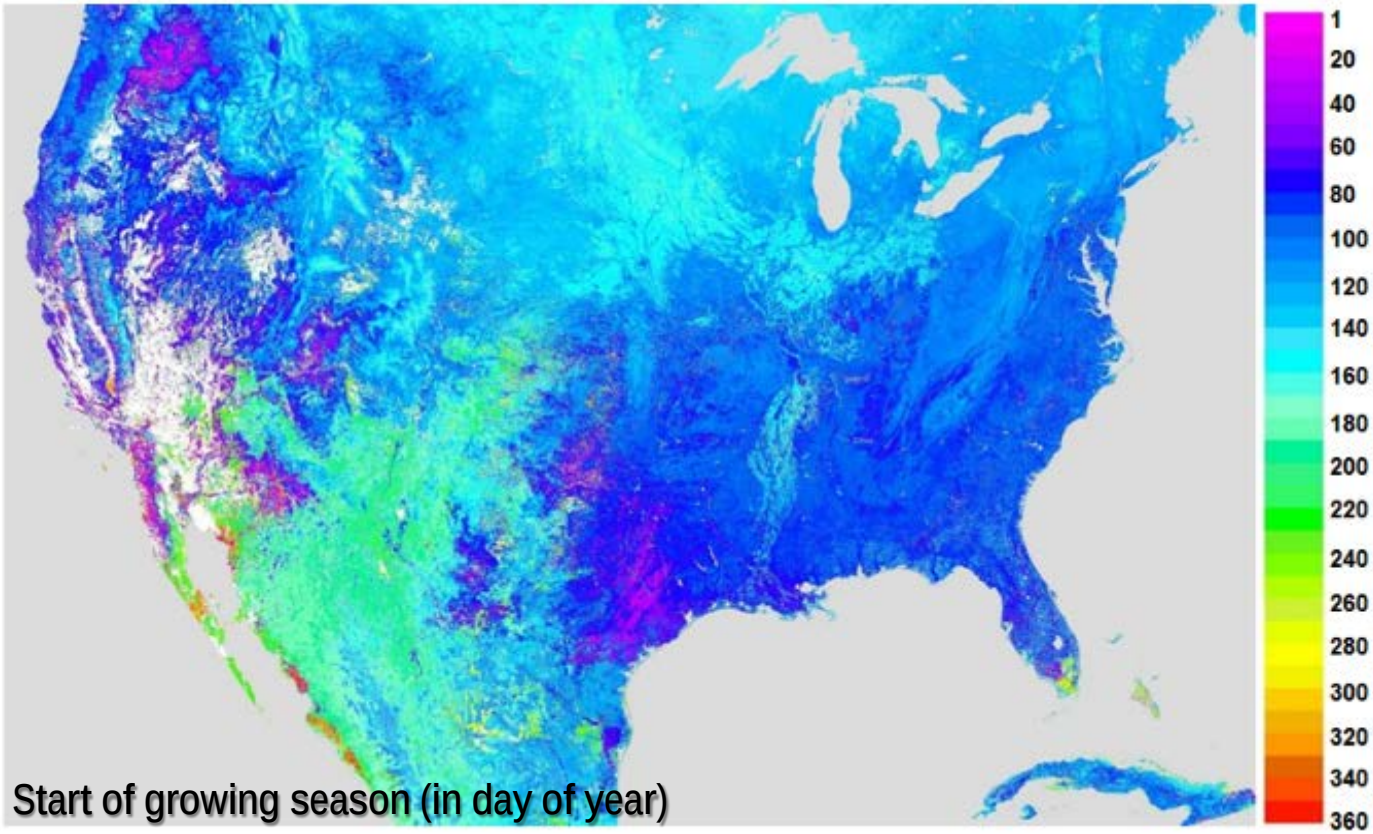
Objective: Develop a new land surface temperature and emissivity product using MODIS/VIIRS thermal infrared data that improves our ability to detect changes in land cover/use.

Finding: The new MOD21 emissivity product increased sensitivity to land cover changes from desertification (left image) in a more consistent manner to complement existing long-term time series of vegetation data.

Significance: Desertification in drylands at the fringes of the world's major deserts has been a prime environmental concern affecting the livelihoods of millions of people on Earth. The new MOD21 product will monitor desertification in these regions with much greater sensitivity than previously possible.

Hulley, G., Veraverbeke, S., & Hook, S. (2014). Thermal-based techniques for land cover change detection using a new dynamic MODIS multispectral emissivity product (MOD21). Remote Sensing of Environment, 140, 755-765

Tracking Nature's Calendar using Suomi-NPP VIIRS



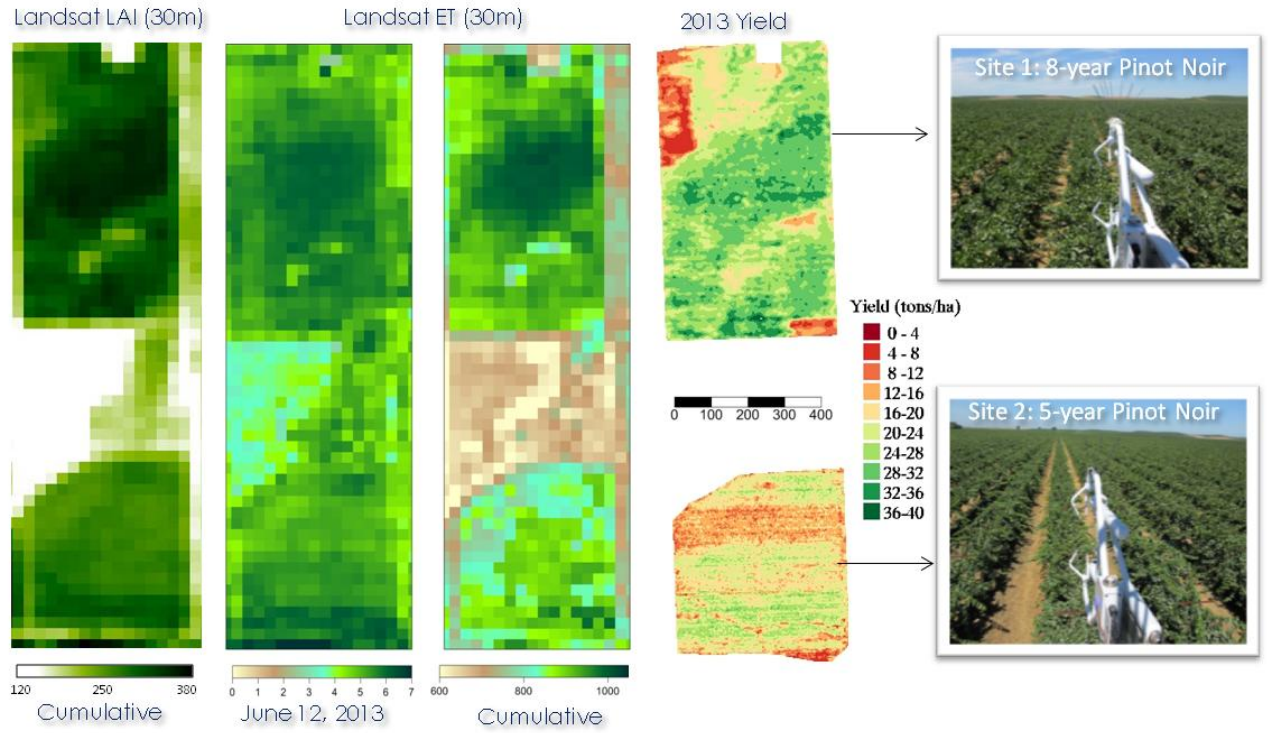
Start of growing season (in day of year)

Daily Global VIIRS observations enables scientists to track the timing and magnitude of plant growth.

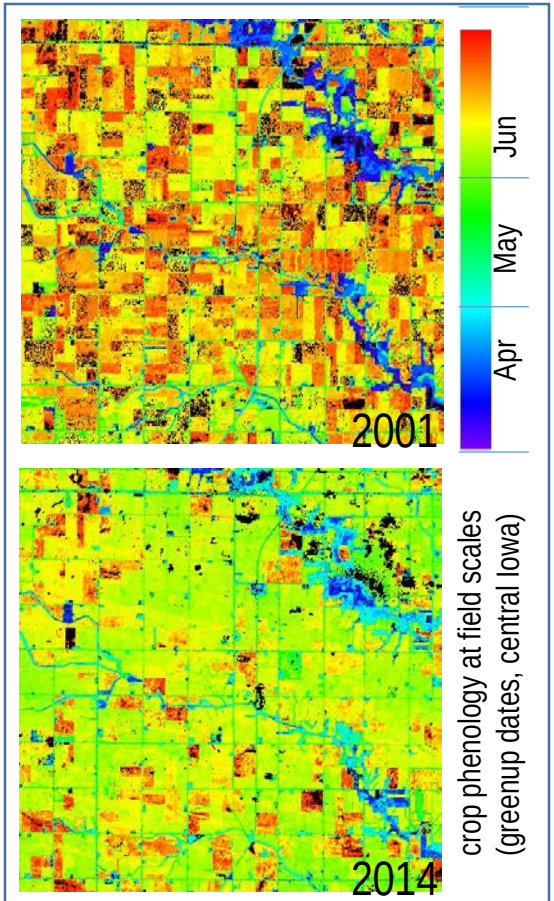
VIIRS also provides accurate information related to the timing of ecosystem properties, which is important for monitoring forests, croplands, grazing lands, and as input for modeling weather and biospheric processes.

Who uses MODIS phenology products? (1) Farmers, ranchers, and meteorologists that want to monitor drought extent and severity; (2) foresters that want to detect disturbances related to wind damage, pests and disease outbreaks, and invasion of exotic species; (3) public health officials looking for short-term forecasts of allergenic pollen; (4) scientists looking to improve weather and environmental models; and (5) tourists and the travel industry with information on the timing and location of spring wildflowers blooms or peak fall foliage.

MODIS/VIIRS, Landsat, and GOES Enable Daily Monitoring of Crop Condition and Water Use



Daily monitoring of vineyard water use and conditions for optimal grape management

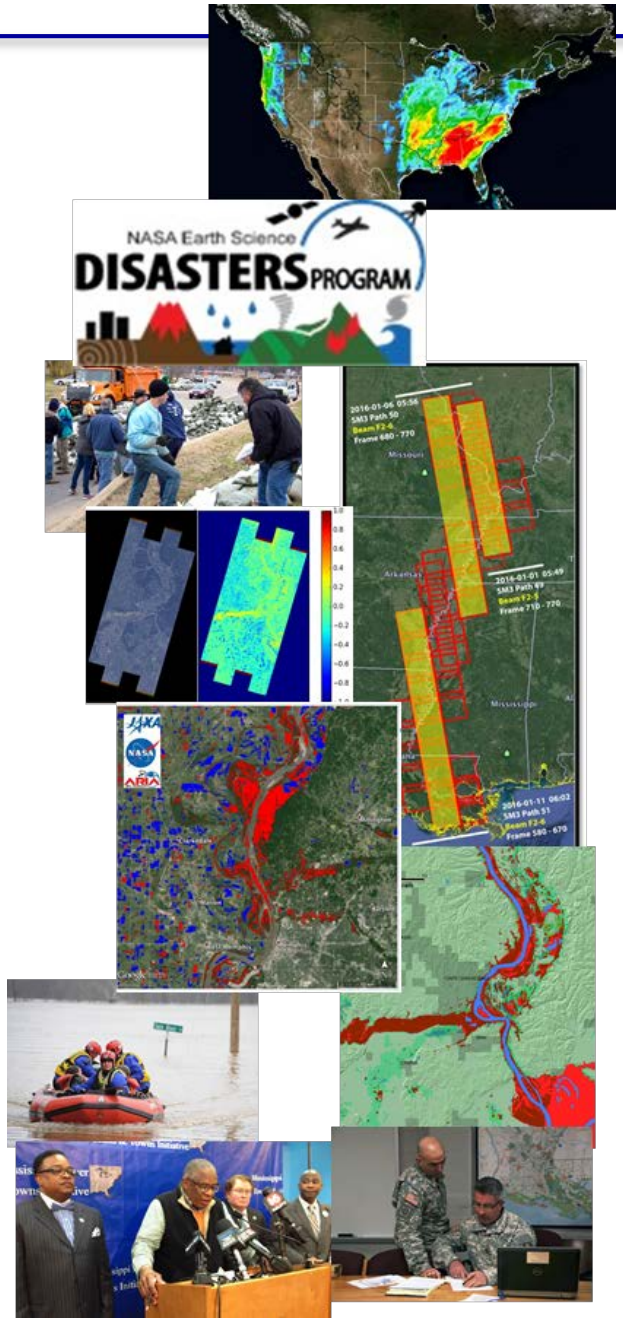


Frequent observations at the field level are necessary for effective precision agriculture, which benefit local farmers. Daily monitoring of crop condition and water use at fine scales has become possible by fusing MODIS/VIIRS, Landsat and Geostationary data. These measurements are critical for decision making in estimating crop yield, mitigating risks and ensuring food security.

Disaster Risk Reduction and Response from a NASA Perspective

- Engagement with Stakeholders and Partners
- Monitoring and Observation
- Data Acquisition, Processing, and Distribution
- Interpretive and Decision Support



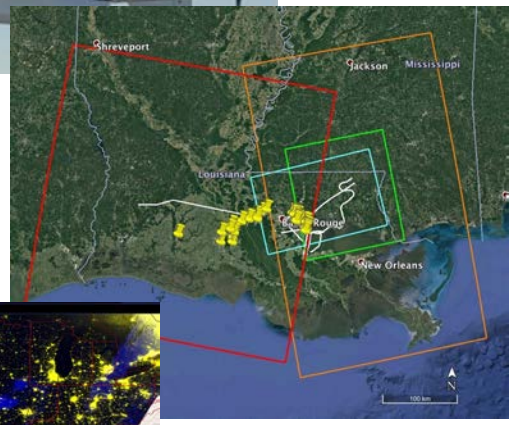


https://disasters.nasa.gov/
https://disasters.nasa.gov/argentina-summit-2017

Disaster Response Capacities

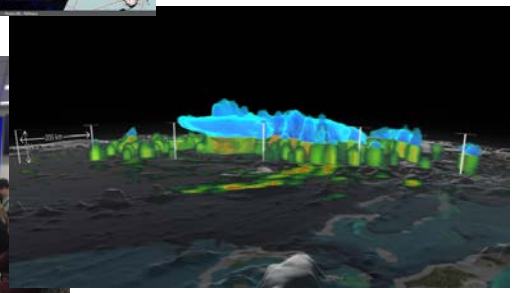
- *Airborne Instruments*
  - UAVSAR – Radar
  - LVIS – Lidar
  - AMS, MASTER – Thermal Infrared
  - HIWRAP, APR2, HAMSR, HIRAD, PALS
    MAPIR – Active and passive microwave
- *Data processing, analysis systems, Data Centers*
  - EOSDIS-ESDIS
  - LANCE/NRT/DB
- *Modeling and Analysis*
  - *Flood and Earthquake Models, Damage and infrastructure Maps, Day/Night and plum extent maps*
  - *Capacity Building*
  - *Response Exercises & Simulations*





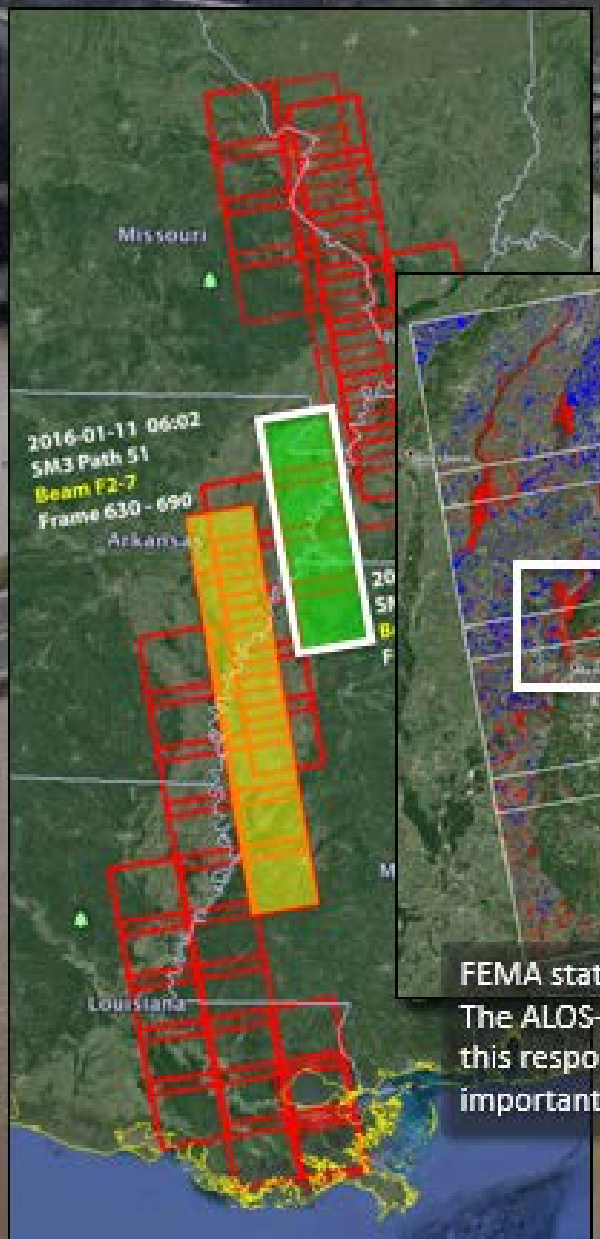


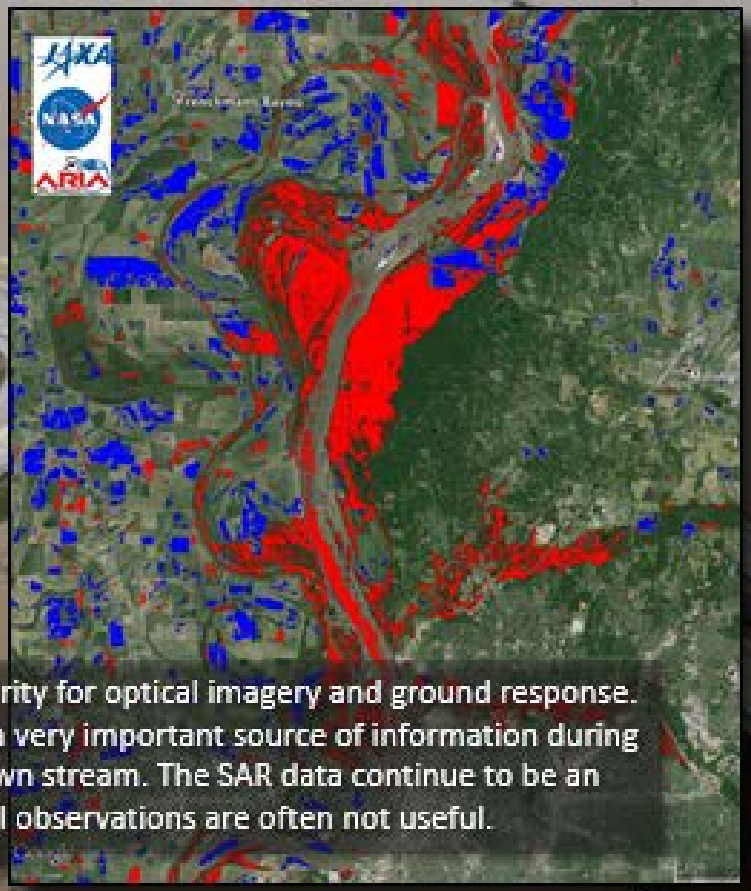




2016 Midwest Floods

Sensor: ALOS-2 SAR (JAXA)
Coverage: 70km x (240km + 420km)
Resolution: ~12m
Blue pixels: Open Land Floods
Red pixels: Vegetation Floods
Available online at
http://aria-share.jpl.nasa.gov/events/





FEMA stated that SAR provides inspection priority for optical imagery and ground response. The ALOS-2 data and the products have been a very important source of information during this response as the flood crest has moved down stream. The SAR data continue to be an important resources during times when optical observations are often not useful.

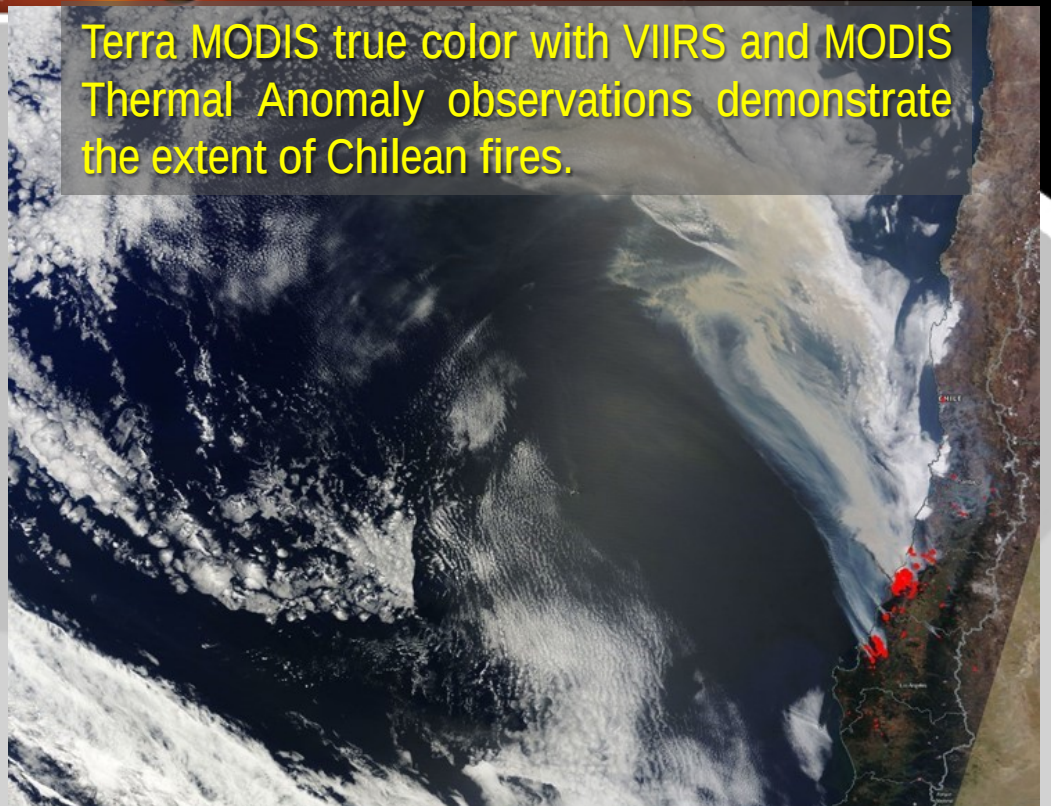
Jeff Roberson/AP Photo

Wildfire Extent Chile and Argentina 2017

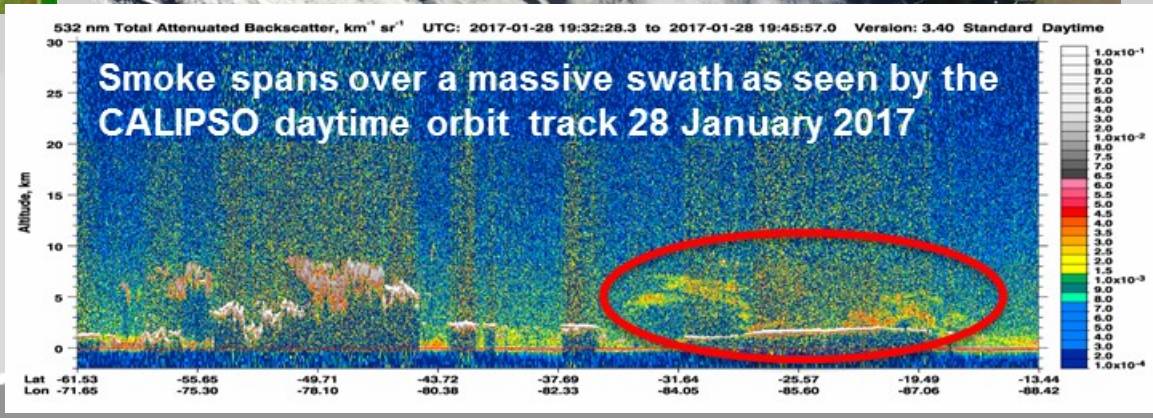
Landsat 8 Operational Land Imager (OLI) (January 24, 2017)



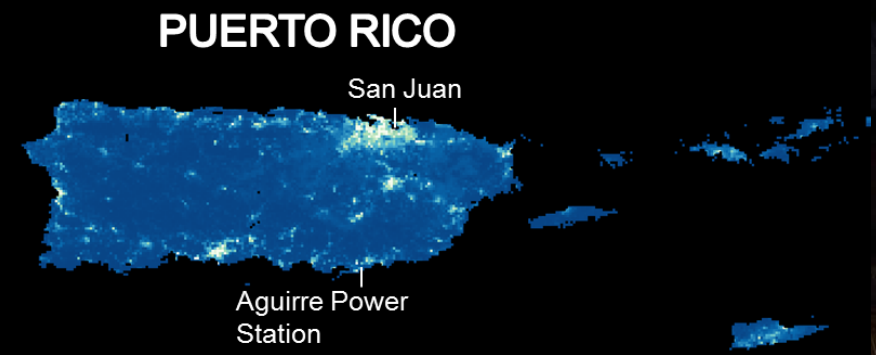
Terra MODIS true color with VIIRS and MODIS Thermal Anomaly observations demonstrate the extent of Chilean fires.



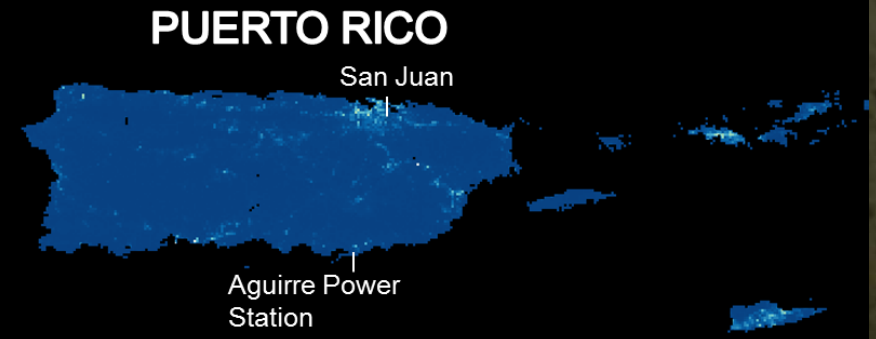
Massive fires extent over 100's of kilometers (km) in Chile, and the smoke pollution extends 1000s of km over the Pacific Ocean,



Puerto Rico Goes Dark



BEFORE (Sept 21, 2016; 02:00EDT)



AFTER (Sept 22, 2016; 02:10EDT)





https://earthobservatory.nasa.gov/NaturalHazards/view.php?id=88796


syria from space
BBC
عربي

Summary

- *At Year 5, the S-NPP Land Discipline team has met its mission success criteria – (1) Provide continuation of the EOS measurements for at least 3 years; (2) Provide risk reduction for JPSS 1/2 and beyond.*
- *The focus now is on transition of EOS continuity products into designated DAACs by Mid-to-Late 2017.*
- *Continued exploitation of unique S-NPP capabilities (e.g., 375m Fire, NASA Black Marble) into LANCE NRT and other decision support systems.*
- *Increased emphasis on multimission and multisensor innovative research that can be used to quantify change, characterize human-natural processes, and examine function within the Earth System over time.*

CEOS/WGCV/LPV Update

Miguel Román (NASA)
Miguel.O.Roman@nasa.gov

Tomoaki Miura (University of Hawaii at Manoa)
TomoakiM@hawaii.edu

CEOS-LPV Structure and Agency Programs



POC: Hank Margolis
(LPV Chair + 5 Focus Areas)

POC: Ferran Gascon
(WGCV-ACIX; 4 Focus Areas)

POC: Ivan Csiszar
(4 Focus Areas)

POC: Alessio Lattanzio
(3 Focus Areas)

POC: John Dwyer
(LSI-VC; WG-Climate;
1 Focus Area)

POC: Hongliang Fang
(1 Focus Area)

POC: Nadine Gobron
(GCOS-TOPC;
1 Focus Area)

Group	First Name	Surname	Country	Supporting Agency / Program	Institution
Chair	Miguel	Román	USA	NASA	NASA
Vice Chair	Fernando	Camacho	Spain	ESA	EOLab
Secretariat	Jaime	Nickeson	USA	NASA	GSFC
Land Use/Cover	Martin	Herold	The Netherlands	GOFC-GOLD/ESA	Wageningen University
	Pontus	Olofsson	USA	NASA	Boston University
LAI	Hongliang	Fang	China	CAS	CAS
	Oliver	Sonnentag	Canada	IAI/NSERC	University of Montreal
Fapar	Nadine	Gobron	Italy	JRC	Joint Research Centre
	Arturo	Sanchez	Canada	IAI/NSERC	Univ. of Alberta
Active Fire - Burn Area	Gareth	Roberts	UK	EUMETSAT	Univ. of Southampton
	Andrew	Edwards	Australia	DCBR/B&NHCRC	Charles Darwin University
	Luigi	Boschetti	USA	USGS/NASA	University of Idaho
BRDF/Albedo	Zhuosen	Wang	USA	NOAA/NASA	UMD/NASA GSFC
	Alessio	Lattanzio	Germany	EUMETSAT	EUMETSAT
Soil Moisture				VACANT	
	Michael	Cosh	USA	USDA	USDA ARS
LST & Emmisivity	Pierre	Guillevic	USA	NOAA/NASA	UMD/NASA GSFC
	Frank	Goettsche	Germany	EUMETSAT	KIT
Phenology	Jadu	Dash	UK	ESA	Univ. of Southampton
	Matt	Jones	USA	NASA	University of Montana
Vegetation Indices	Tomoaki	Miura	USA	NOAA	University of Hawai'i
	Swinnen	Else	Belgium	VITO	VITO
Snow Cover				VACANT	
	Thomas	Nagler	Austria	ESA	ENVEO
Biomass	Laura	Duncanson	USA	NASA	UMD/NASA GSFC
	John	Armston	USA	NASA	University of Maryland
	Mathias	Disney	UK	ESA	University College London

NOAA Contributions to LPV

- LPV focus area leads funded by NOAA – Vegetation Indices, Land Surface Temperature
- Creates operational NDVI, Fire, Snow products
- NOAA PIs on the VIIRS Land Science team are developing and validating VIIRS Environmental Data Records (EDRs)

EUMETSAT Contributions to LPV

- CEOS leadership – vice-chair of WG Climate
- Albedo focus area lead supported by EUMETSAT
- Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring – SCOPE-CM – retrieval of satellite albedo from geostationary satellites from various agencies

Area and accuracy estimation of land change

Pontus Olofsson (Boston University)

- Image classification errors can greatly biased mapped areas of land change – also, “pixel-counting” in maps is incompliant with IPCC criteria reporting of land change.
- CEOS-LPV is providing guidance to implement protocols for unbiased estimation of area and accuracy.
- NASA and other agencies support development and implementation of estimation protocols.

Remote Sensing of Environment 148 (2014) 42–57

Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

Review

Good practices for estimating area and assessing accuracy of land change

Pontus Olofsson [a,*], Giles M. Foody [b], Martin Herold [c], Stephen V. Stehman [d], Curtis E. Woodcock [a], Michael A. Wulder [e]

[a] Department of Earth and Environment, Boston University, 685 Commonwealth Avenue, Boston, MA 02215, USA
[b] School of Geography, University of Nottingham, University Park, Nottingham NG7 2RD, UK
[c] Laboratory of Geo-Information Science and Remote Sensing, Wageningen University, Droevendaalsesteeg 3, 6708 Wageningen, The Netherlands
[d] Department of Forest and Natural Resources Management, State University of New York, 1 Forestry Drive, Syracuse, NY 13210, USA
[e] Canadian Forest Service (Pacific Forestry Centre), Natural Resources Canada, Victoria, BC 12 V8Z 1M5, Canada

Remote Sensing of Environment 129 (2013) 122–131

Contents lists available at SciVerse ScienceDirect

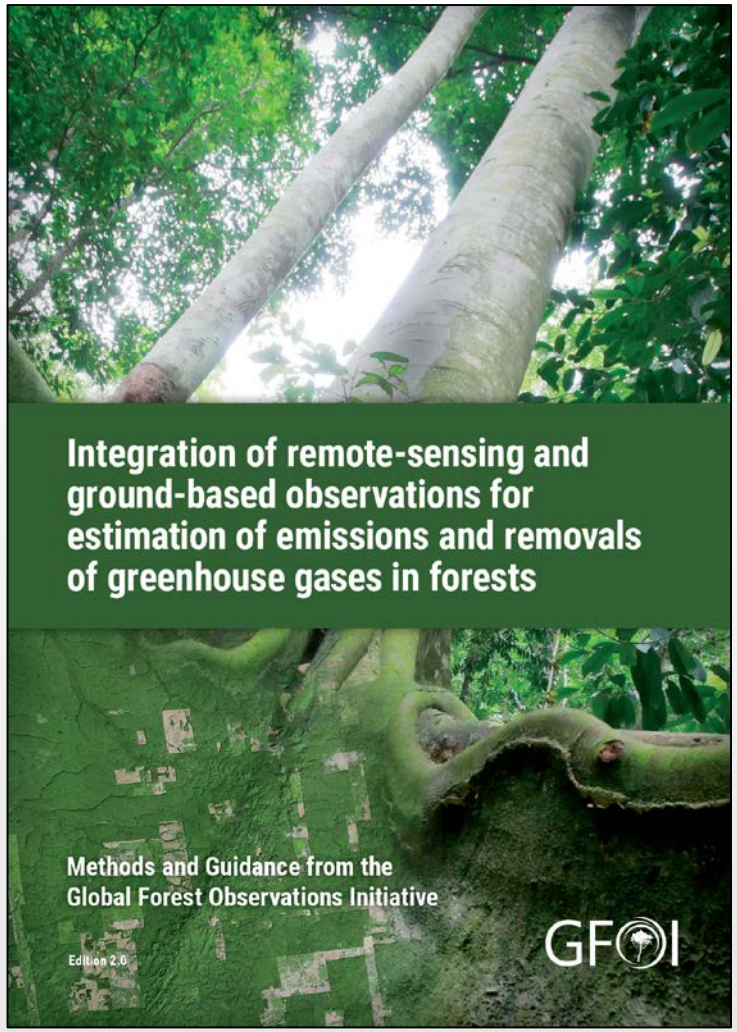
Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

Making better use of accuracy data in land change studies: Estimating accuracy and area and quantifying uncertainty using stratified estimation

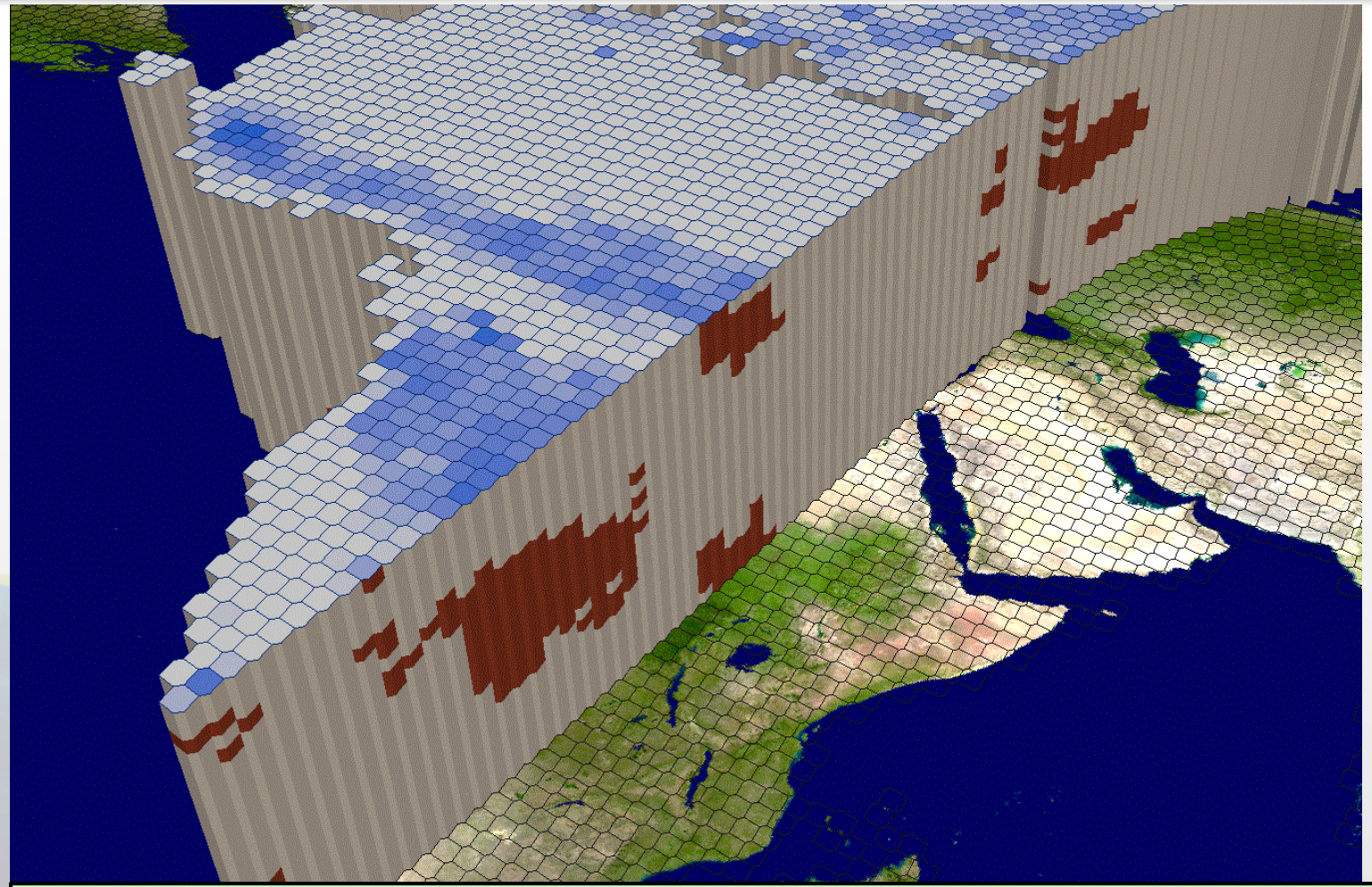
Pontus Olofsson [a,*], Giles M. Foody [b], Stephen V. Stehman [c], Curtis E. Woodcock [a]

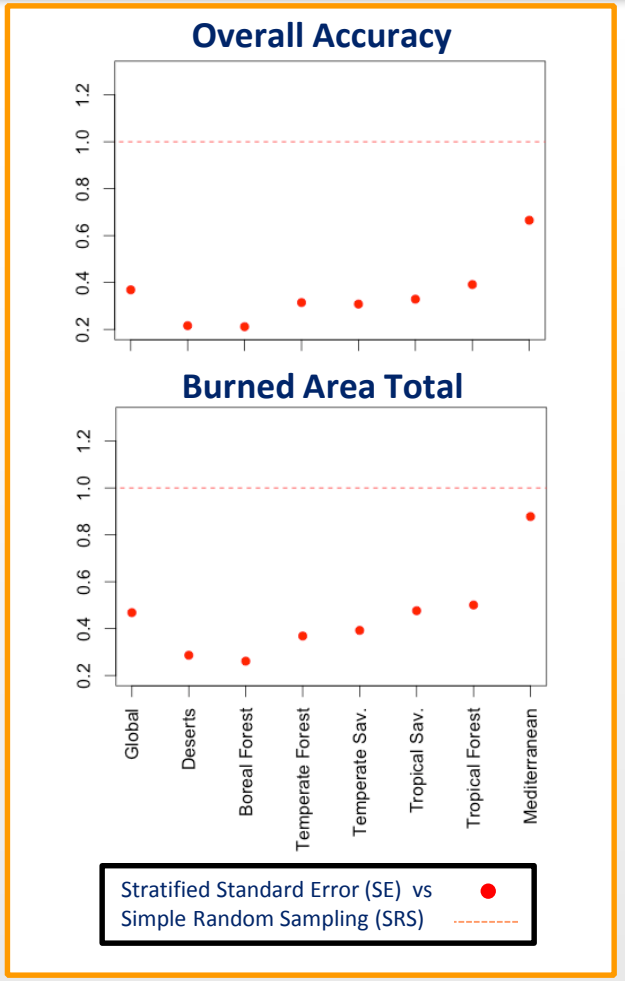
[a] Department of Earth and Environment, Boston University, 675 Commonwealth Avenue, Boston, MA 02215, USA
[b] School of Geography, University of Nottingham, University Park, Nottingham NG7 2RD, UK
[c] Department of Forest and Natural Resources Management, State University of New York, 1 Forestry Drive, Syracuse, NY 13210, USA



Spatial and temporal sampling for global burned area validation

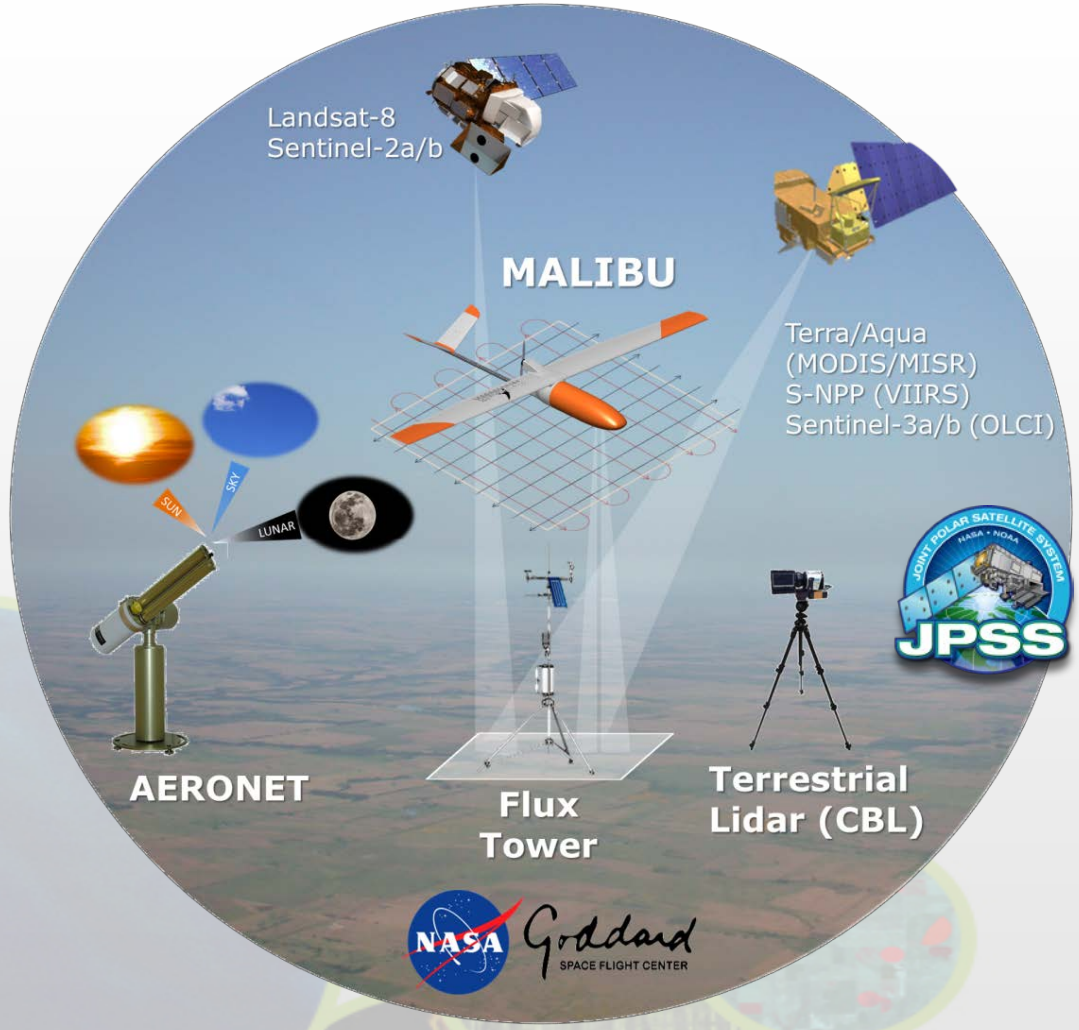
Luigi Boschetti (U Idaho, CEOS Land Product Validation Subgroup)
David P. Roy (South Dakota State)
Stephen V. Stehman (SUNY-ESF)

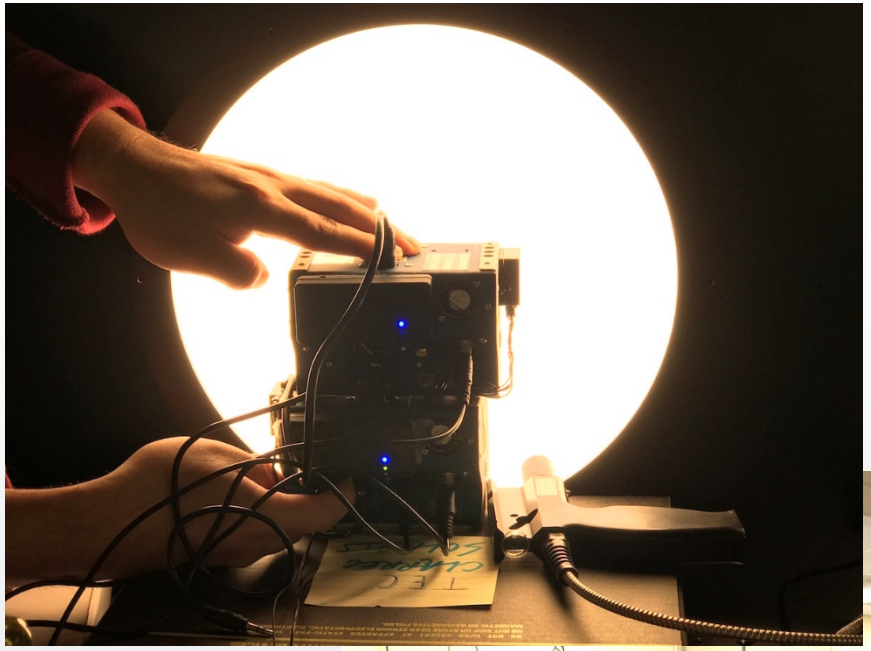


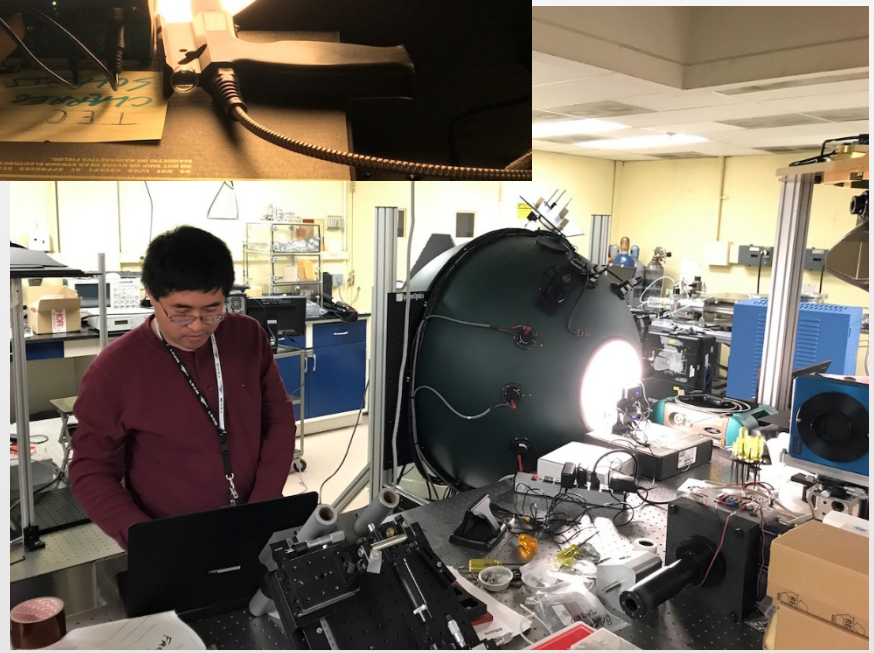


Rigorous design-based validation of global burned area products, in which reference data are selected via a probability sampling design, is effective in reducing the standard errors of accuracy and area estimators compared to simple random sampling.

Multi AngLe Imaging BRDF Unmanned aerial system

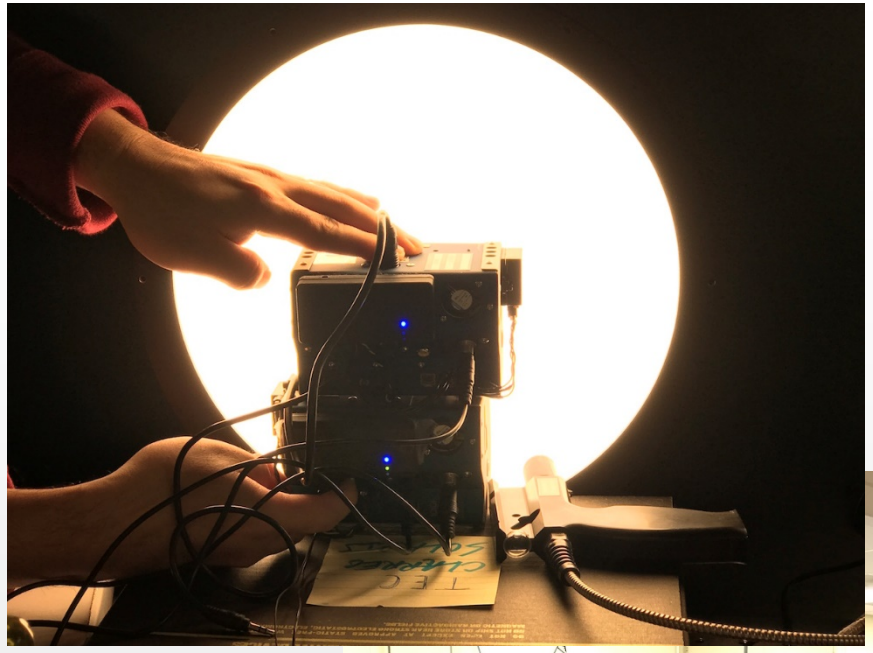


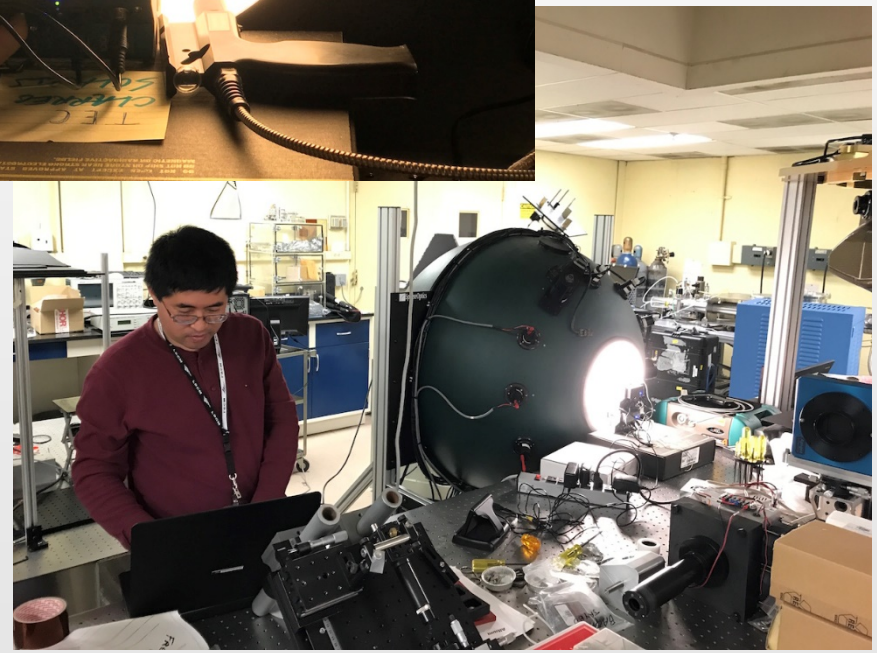




https://viirsland.gsfc.nasa.gov/Campaigns.html

Multi AngLe Imaging BRDF Unmanned aerial system

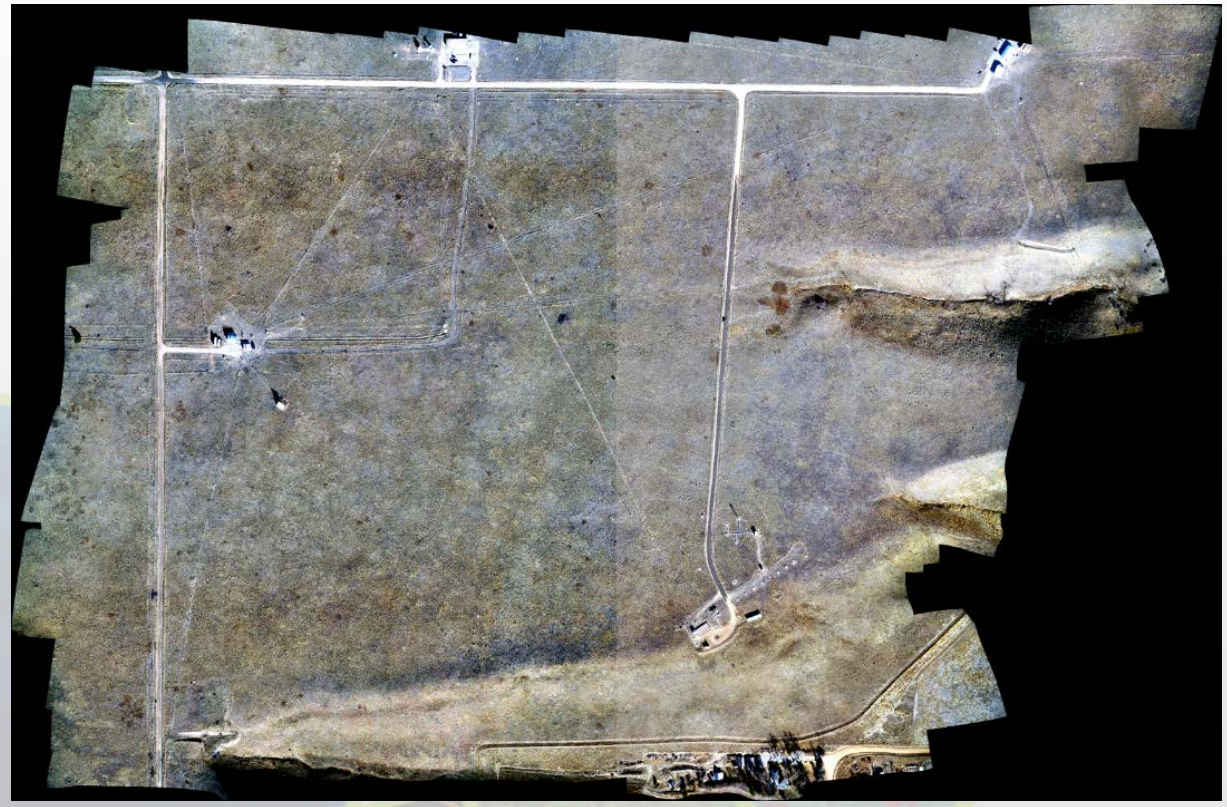




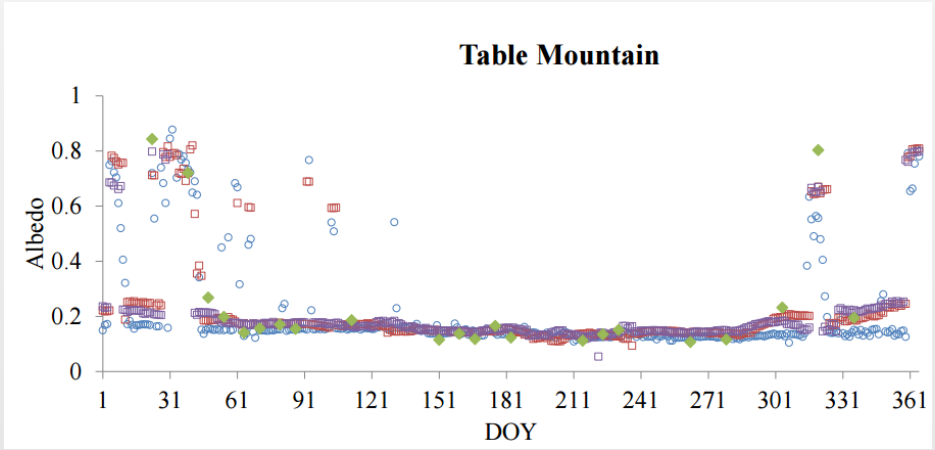
SuperSwift Platform with:
(1) Soil moisture radiometer,
(2) Volcano payload,
(3) MALIBU

MALIBU Campaign Status

- **Ortho-rectified imagery @ BSRN Table Mountain (Nov 30, 16.)**
- **FAA approvals went through without a hitch – from flight request, to approval, to deployment in < 2 weeks!**







Time Series plot from:
https://www.esrl.noaa.gov/gmd/grad/meetings/BSRN_talks/P2_3_Crystal_Schaaf_BSRN_validation_2016_v0.8.pdf

2017-2019 Work Plan

3.2 Progress on the implementation of the CEOS Strategy for Carbon Observations from Space

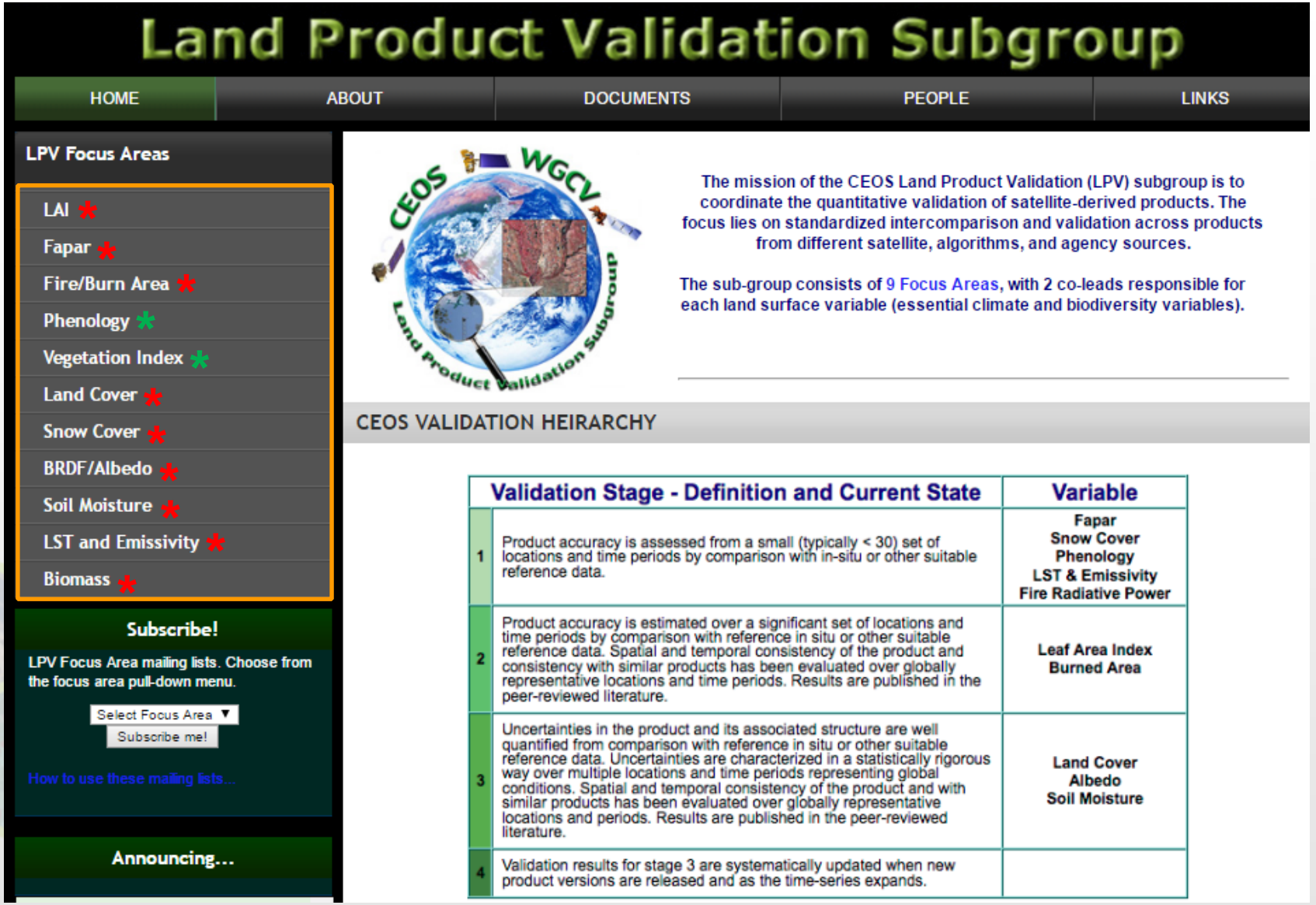
CARB-19: Land product validation listing and framework	Q4 2017	**Summarize current list of validated land data products relevant to Carbon Strategy.** Document validation framework and protocols Provide guidance for online platform for intercomparison of terrestrial carbon products.	WGCV

CARB-19: Land product validation listing

- CEOS/WGCV/LPV has completed listing of 11 carbon-focused variables, totaling 138 land products from 11 CEOS Agencies.

https://lpvs.gsfc.nasa.gov/

- 9 product categories are listed as GCOS Essential Climate Variables (ECVs*)
- 2 product categories are listed as GEOBON Essential Biodiversity Variables (EBVs*).

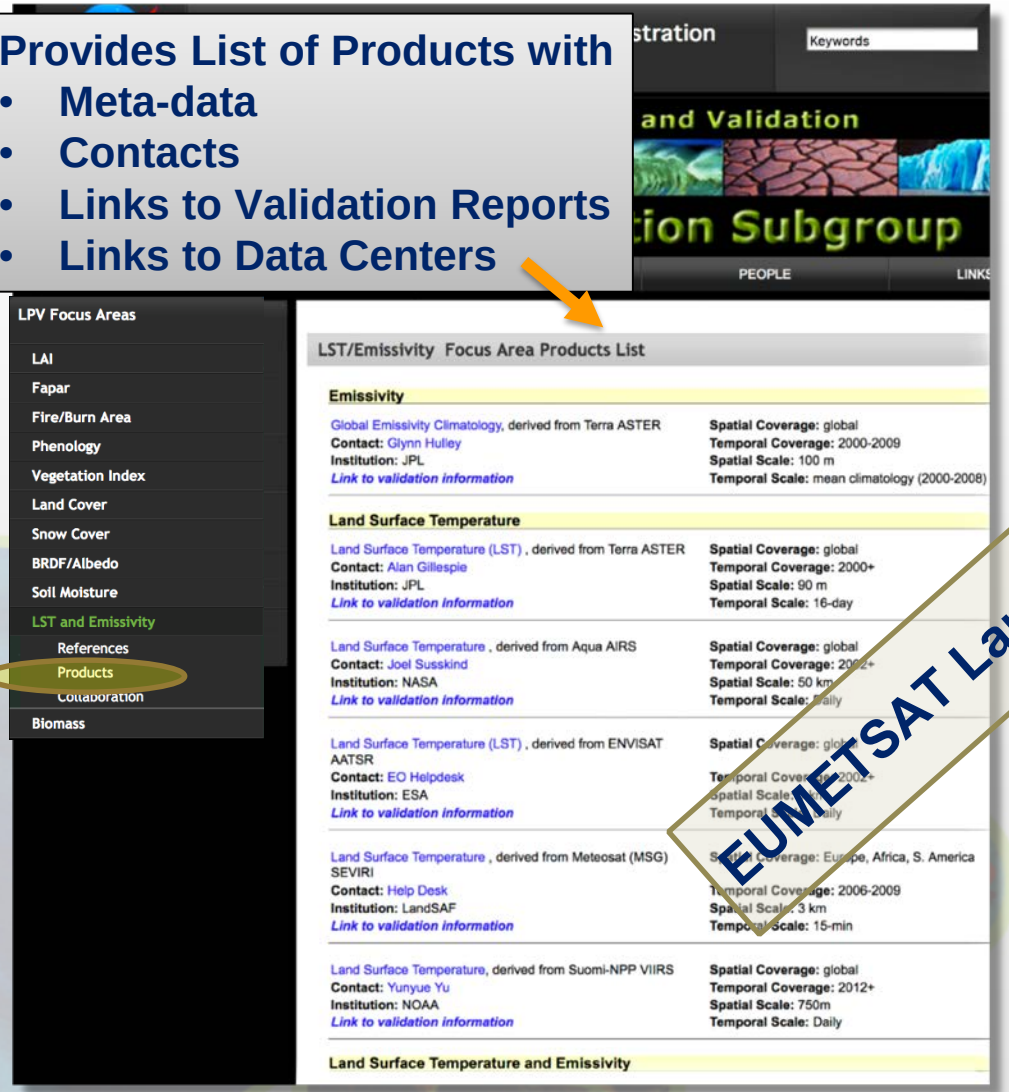


CARB-19: Land product validation listing (Example #3)

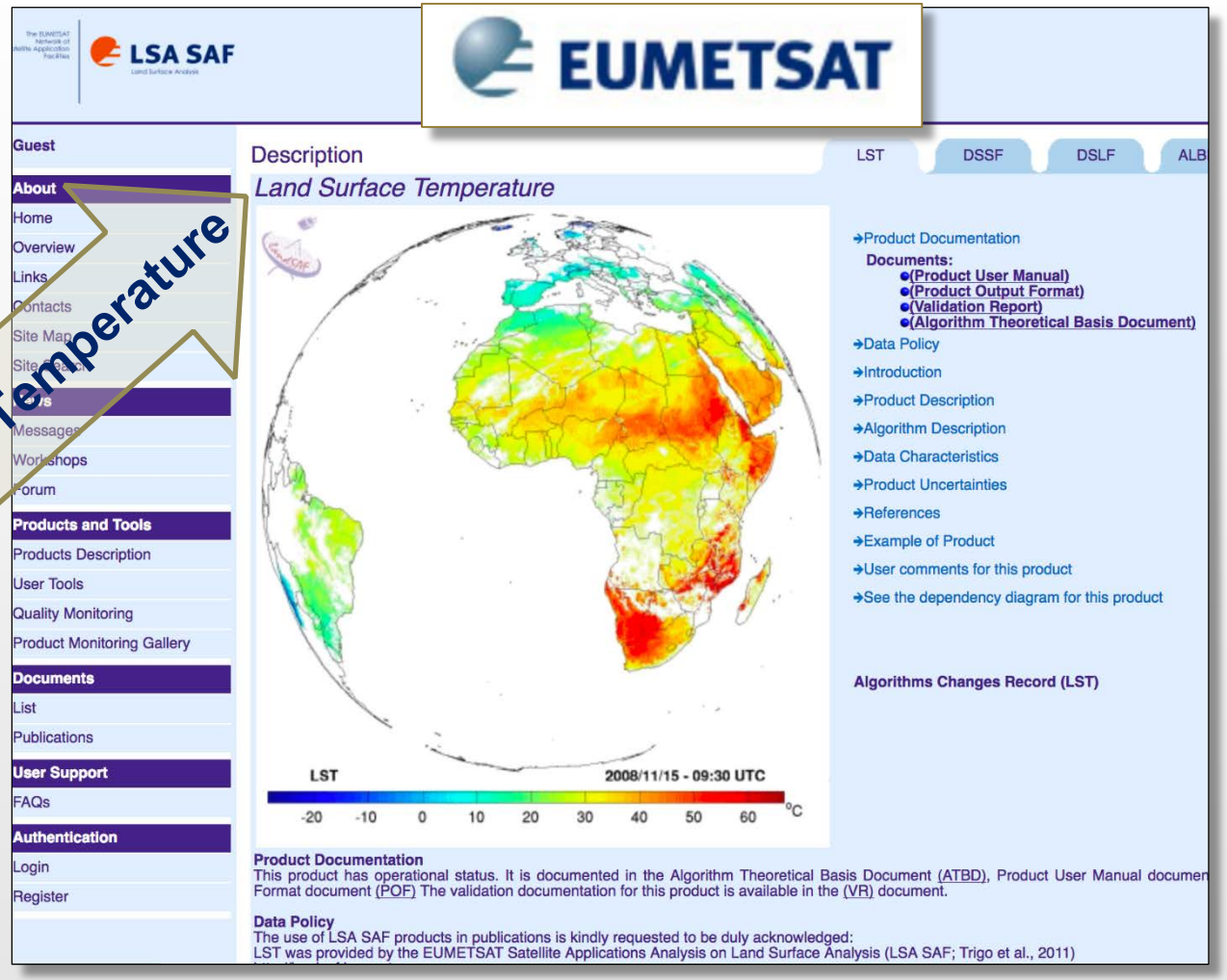
CEOS-LPV Validation Reports – Land Surface Temperature & Emissivity Focus Area

Provides List of Products with

- Meta-data
- Contacts
- Links to Validation Reports
- Links to Data Centers



EUMETSAT Land Surface Temperature



2017-2019 Work Plan

3.2 Progress on the implementation of the CEOS Strategy for Carbon Observations from Space

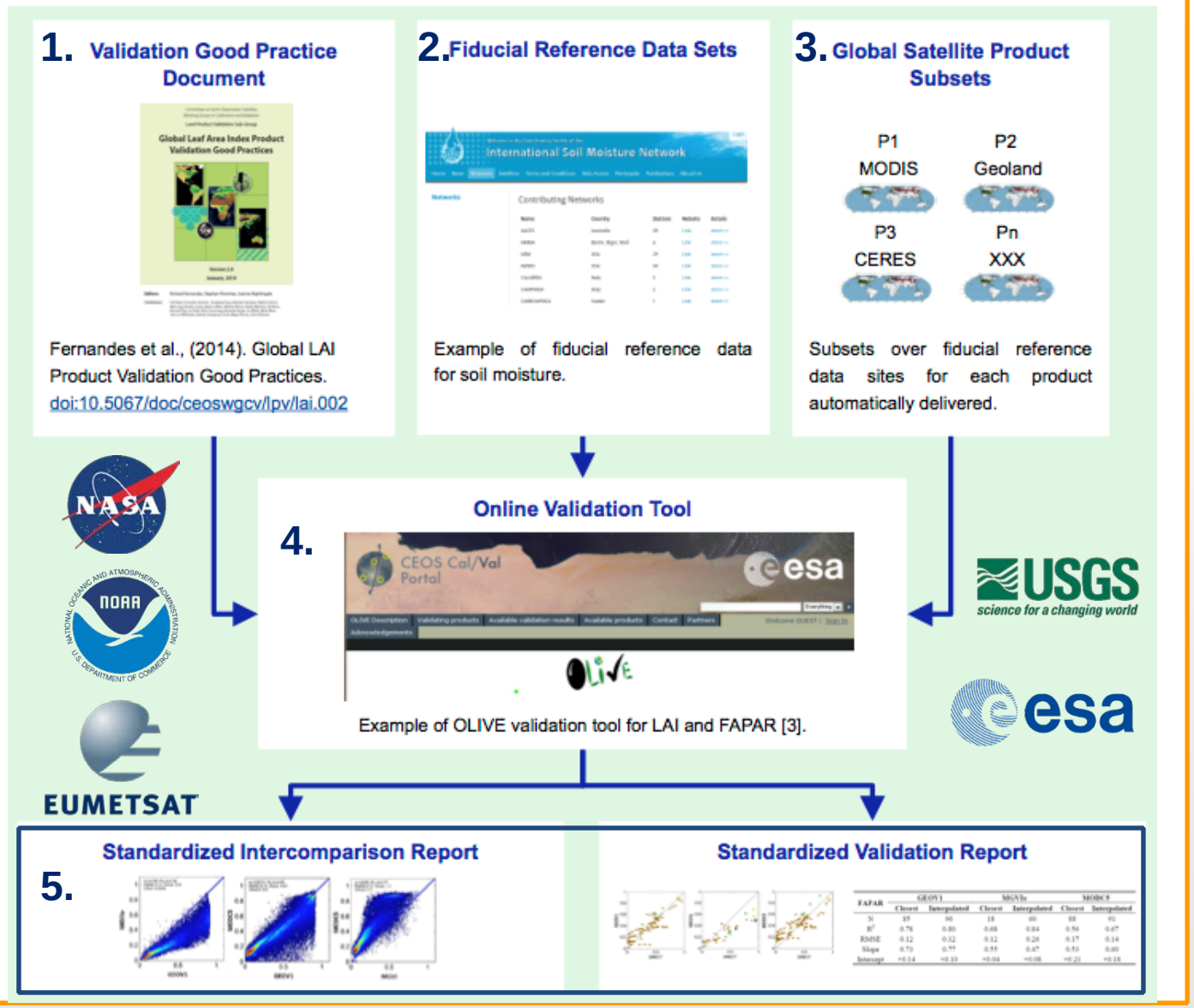
CARB-19: Land product validation listing and framework	Q4 2017	**Summarize current list of validated land data products relevant to Carbon Strategy.** **Document validation framework and protocols** **Provide guidance for online platform for intercomparison of terrestrial carbon products.**	WGCV

CARB-19: CEOS Land Validation Framework

- CEOS LPV has established a framework with the aim of independent validation and consistent uncertainty reporting across products as main output.
- Multiple agencies are coordinating five actionable tasks:

1. **[NASA]** Developing best practice validation protocols, where validation methods are sent through rigorous peer-review (Q4-2018).
2. **[NOAA/ESA/EUMETSAT]** Ensuring access to processed fiducial reference data (ongoing).
3. **[USGS/NOAA]** Supporting automated subsets of global satellite products (LPCS; Q2-2017.)
4. **[NASA]** Implementing data analysis tools (Q2-2018).
5. **[NASA/ESA]** Delivering standardized intercomparison and validation reports (Q4-2018)

Schaepman-Strub et al., (2017) submitted



CARB-19: Land Validation Protocol - Land Surface Temperature (LST) (Q4-2017)

Protocol Status: LST validation protocol document is complete and undergoing peer-review. The protocol will present recommendations on internationally accepted validation good practices.

Overarching Goal: To ensure thematic compatibility across products, reference datasets, and methods. CEOS agency deliverables include:

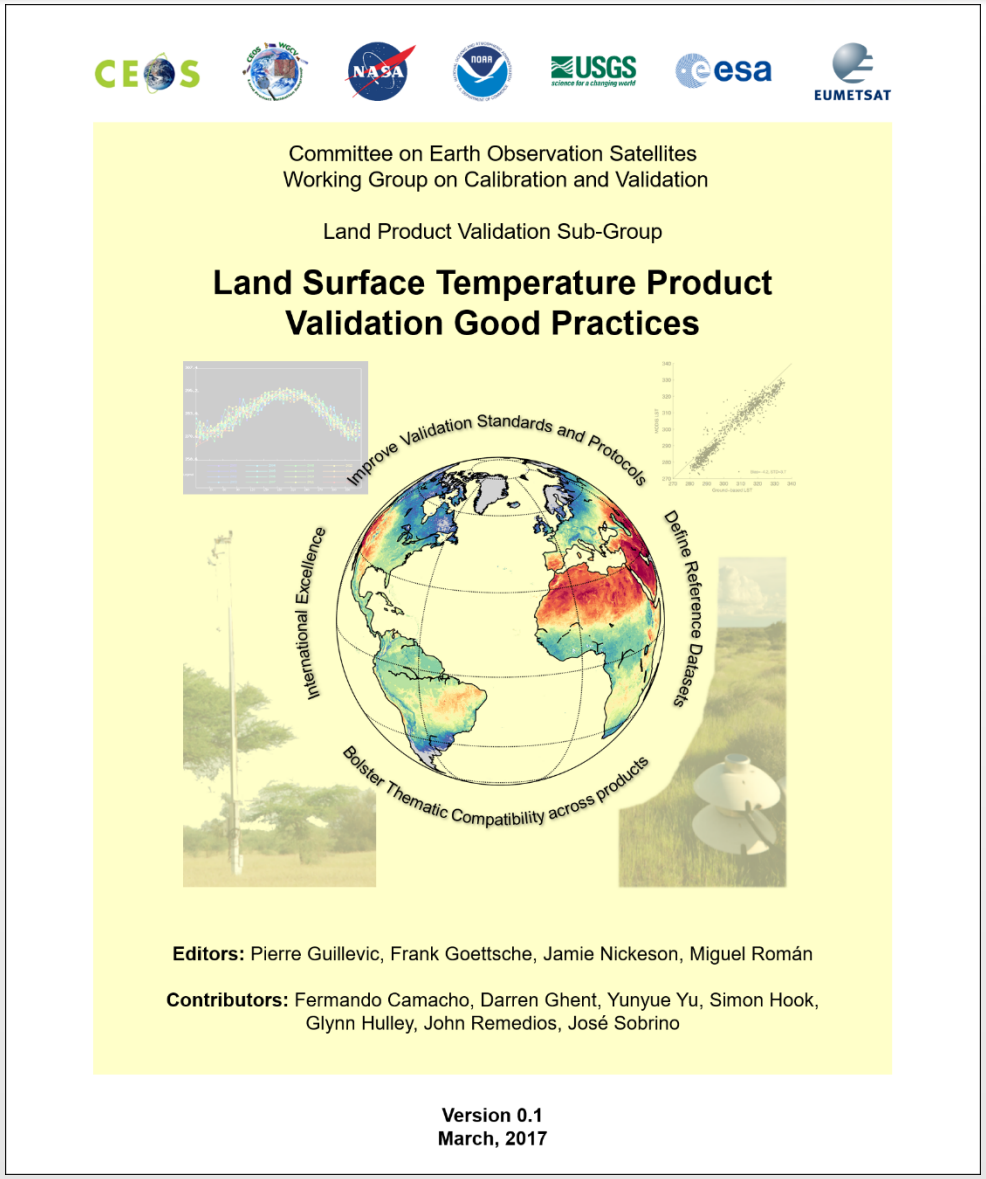
Support product development, validation, and interconsistency efforts (ROSES, MEaSUREs), maintain the On Line Interactive Validation Exercise (OLIVE) platform to assess global satellite products (LAI, Albedo, LST).

Maintain observational networks in the US (BSRN/SURFRAD, USCRN) used for routine validation of LST.

Develop and maintain the online Land Product Characterization System (https://landsat.usgs.gov/lpcs) to facilitate the characterization and validation of multi-satellite products using in-situ data .

Provide users with multi-mission LST data (**GlobTemperature**). Engage with the user community through the **International LST and Emissivity Working Group** (http://ilste-wg.org)

Maintain ground-based LST reference networks in Portugal and Africa for satellite land products validation (Satellite Application Facilities, http://landsaf.ipma.pt)



Committee on Earth Observation Satellites
Working Group on Calibration and Validation

Land Product Validation Sub-Group

Land Surface Temperature Product Validation Good Practices

Editors: Pierre Guillevic, Frank Goettsche, Jamie Nickeson, Miguel Román

Contributors: Fermando Camacho, Darren Ghent, Yunyue Yu, Simon Hook, Glynn Hulley, John Remedios, José Sobrino

Version 0.1
March, 2017

CEOS LPV Supersites

CV-12 WGCV action: Evaluation of validation supersites and new validation approaches

Evaluation of well-characterized supersites with data continuity prospects for validation purposes that allow for testing of products, algorithms, and validation strategies through radiative transfer modeling.

LPV Supersite Definition

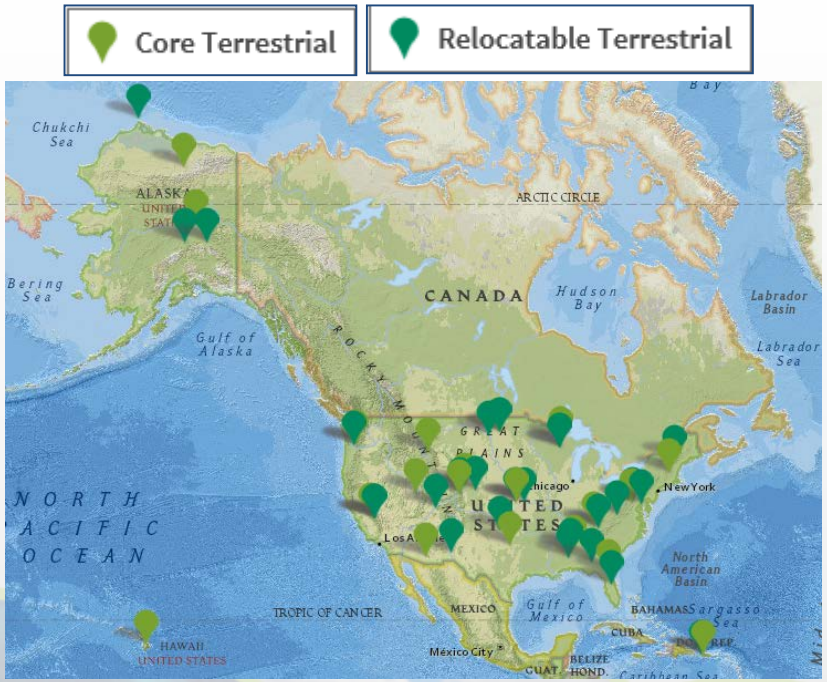
- A Supersite should be fully characterized (3D canopy structure, plus key land variables) to allow a RT model parameterization, whereas a core site refers typically to the same variable.

- A Supersite should be useful for the validation of several land products (> 3) .

Candidates Networks:

- TERN Australian Super Sites
- ICOS Ecosystem network
- NEON
- Sites proposed by LPV members

NEON Network



Contact:

- Shelley Petroy

National Ecological Observatory Network (NEON)

- Continental-scale ecological observation facility sponsored by the National Science Foundation to gather and synthesize data on the impacts of climate change, land use change and invasive species on natural resources and biodiversity
- Strategically locates sites across the U.S. to capture variability in ecological and climatological conditions (terrestrial and aquatic stations)
- Coordinates local measurements in the field with high-resolution airborne remote sensing.
- Provide resources for the ecological community to integrate observations and datasets independently, such as collection and processing protocols.
- NEON network includes core and relocatable terrestrial sites across the U.S. (including Alaska, Hawaii and Puerto Rico). ***Core sites (20)*** are fixed, collect data for a minimum of 30 years and are designed to represent and capture wildland conditions. ***Relocatable sites (27)*** move through time to capture environmental gradients not captured at core sites
- Open access to sites data is provided through the NEON data portal (http://data.neonscience.org/home).

source: http://www.neonscience.org/science-design/field-sites
http://www.neonscience.org/science-design/spatiotemporal-design

Candidates Selection Status

Overall, 61 Supersites selected out of:

- TERN : 18 nodes in 10 Supersites
- ICOS: 71 sites
- NEON: 47 sites
- LPV : 13 sites

➢ The networks referred previously have been investigated to select the candidate sites. Two major criteria were first applied:

❑ ***Availability of data***: the station is active.

❑***Spatial representativeness***: to guarantee the highest level of homogeneity and to minimize issues associated with spatial representativeness in the point-to-pixel comparison.

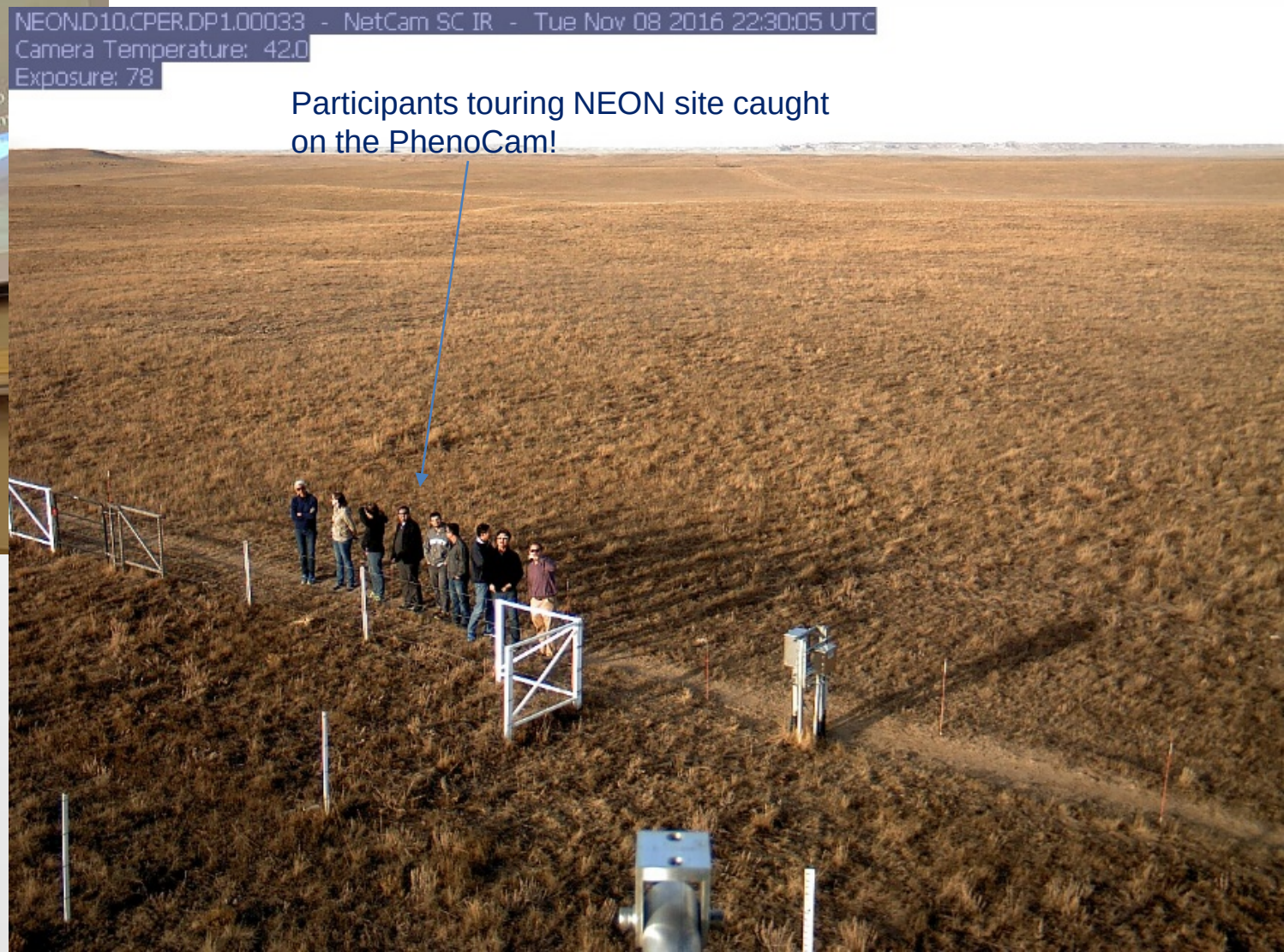
- Using high resolution satellite images (available via Google Earth™), to identify those matching the requirement of homogeneity in the area surrounding the measurement tower
- Only visually homogeneous sites at 3x3 km and 1x1 km are considered.

Vegetation Index Focus Area

- **May 2016: Proposed at CEOS WGCV LPV meeting**
- **Sep 2016: Officially established**
- **Nov 2016: Held a VI & LSP workshop (Fort Collins, CO)**
  1) **Initiate the development of validation protocols for Vegetation Indices and Land Surface Phenology products.**
  2) **Develop a strategy to advance the validation stage of one or more operational Land Surface Phenology Products and one or more Vegetation Index Products**
     - To learn the current validation status of VI products
     - To exchange validation methodologies used for VI products
     - To discuss and develop a list of action items and a strategic plan

LPV Vegetation Index & Land Surface Phenology Workshop





Participants touring NEON site caught on the PhenoCam!

Vegetation Index Focus Area

VI & LSP Workshop
Fort Collins, CO, USA, November 9-10, 2016

- **Three components of VI validation needed to define and characterize VI uncertainties and to satisfy the user needs:**
  1) **Uncertainty of VIs in their units (e.g., 👎NDVI)**
  2) **VI sensitivity to vegetation biophysical/physiological conditions**
  3) **Long-term stability of VI time series data**
- **Potential data sources for VI validation were identified:**
  - **NEON airborne hyperspectral data**
  - **AERONET-based surface reflectance data**
  - **Ground-/drone-observational reflectance data**
  - **FLUXNET data**

***Each participant volunteered to look into one or more of these datasets and to begin evaluating their VI products of interest**

Vegetation Index Focus Area

- **Mar 2017:**
  - **Else Swinnen (VITO) appointed as co-lead**
  - **Invitation to participate in the VI focus area was sent (127 potential participants)**

- **July 2017:the VI focus are website launched and completed (https://lpvs.gsfc.nasa.gov/NDVI/VI_home.html)**
  - **Updated VI product list**
  - **Updated VI validation references**

National Aeronautics and Space Administration
Goddard Space Flight Center

Keywords

CEOS Working Group on Calibration and Validation

Land Product Validation Subgroup

HOME | ABOUT | DOCUMENTS | PEOPLE | LINKS

LPV Focus Areas

- LAI
- Fapar
- Fire/Burn Area
- Phenology
- Vegetation Index
- Land Cover
- Snow Cover
- BRDF/Albedo
- Soil Moisture
- LST and Emissivity
- Biomass

Vegetation Index Focus Area Products

Gap-Filled, Smoothed Time Series

Gap-Filled, Smoothed NDVI , derived from MODIS TERRA
Contact: LAADS DAAC
Institution: NASA GSFC
Spatial Coverage:
Temporal Coverag
Spatial Scale: 500
Temporal Scale: 8

Gap-Filled, Smoothed EVI , derived from MODIS TERRA
Contact: LAADS DAAC
Institution: NASA GSFC
Spatial Coverage:
Temporal Coverag
Spatial Scale: 500
Temporal Scale: 8

Gap-Filled, Smoothed NDVI , derived from MODIS TERRA
Contact: LAADS DAAC
Institution: NASA GSFC
Spatial Coverage:
Temporal Coverag
Spatial Scale: 250
Temporal Scale: 8

Gap-Filled, Smoothed EVI , derived from MODIS TERRA
Contact: LAADS DAAC
Institution: NASA GSFC
Spatial Coverage:
Temporal Coverag
Spatial Scale: 250
Temporal Scale: 8

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- LAI
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  - Products
  - Collaboration
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- Snow Cover
- BRDF/Albedo
- Soil Moisture
- LST and Emissivity
- Biomass

Vegetation Index Focus Area Contributions to International Structures

Building International Structures

It is our aim to build international structures for the validaiton of this extensively utilized remote sensing variable.

Global Vegetation Index products are routinely used in crop monitoring and forecasting by the UN's FAO and the USDA's FAS to project yield and predict shortages. They also serve as key measurements in productivity, phenology, climate, hydrology, biogeochemical and biodiversity studies. Thus, a coordinated effort on the validation of global VI measurements is warranted, and the LPV VI focus area aims to lead such an effort.

Links to In Situ Networks for VI Validation

- The World Meteorological Organization
- The FLUXNET Project
- The National Ecological Observatory Network (NEON)
- The PhenoCam Network

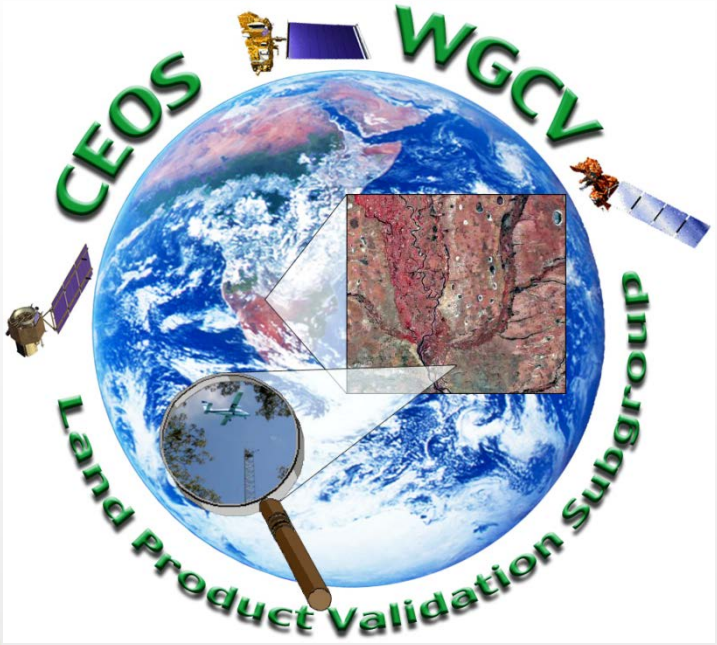
Vegetation Index Home | Vegetation Index References | Vegetation Index Products

Vegetation Index Focus Area

- **Action Items:**
  - **Preliminary validation exercises using the identified validation data sources**
  - **Selection of a globally representative set of sites for inter-comparison**
  - **Inter-comparison exercise**
  - **Reconvening in a year or 1.5 years**



CEOS/WGCV/LPV



Visit our web site, subscribe to the listserv!

lpvs.gsfc.nasa.gov

Incorporate Satellite GVF & LAI Products into NOAA NEMS System

Yihua Wu[1,2], Weizhong Zheng[1,2], Mike Ek[2], Yunyue Yu[3], Marco Vargas [3]

[1]IMSG at NOAA/NCEP/EMC, [2]NOAA/NCEP/EMC, [3]NOAA/NESDIS/STAR

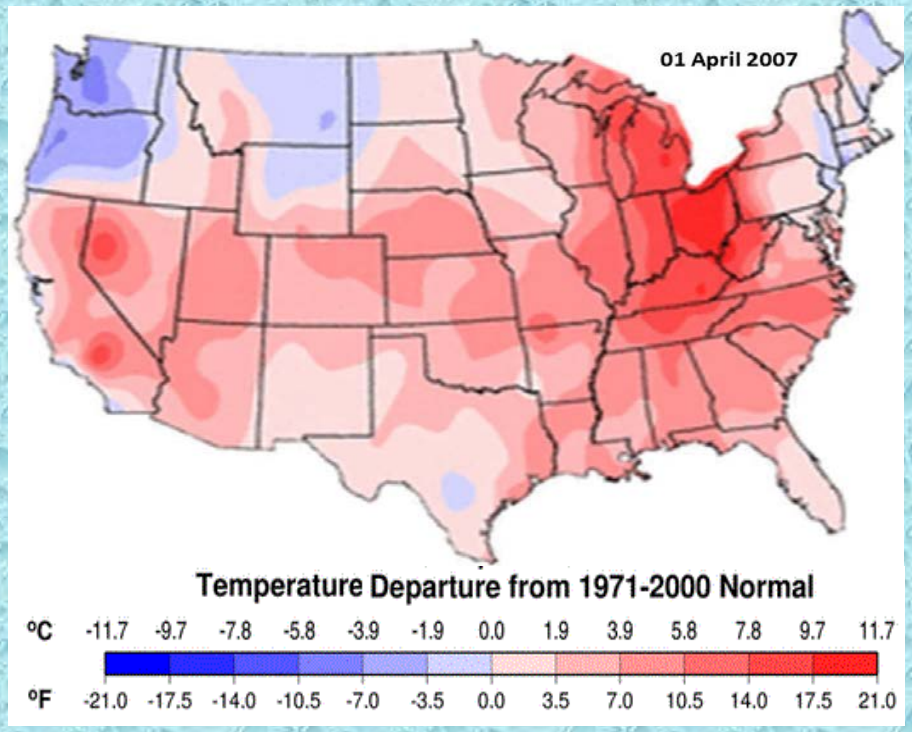
Outline

- Motivation
- Products of GVF & LAI
- Numerical Experiments
- Results
- Summary

Motivation

- Both GVF and LAI are very important parameters for representing the interactions between the land surface and the atmosphere in LSM. GVF is used to characterize land surface while LAI is used to characterize plant canopies in LSM.
- Both GVF and LAI have seasonal, spatial changes and annual variations; both can be affected by natural hazards, such as droughts, frosts and wild fires.
- The GVF currently used in NOAA Environmental Modeling System (NEMS) are monthly mean values from AVHRR data (from April 1985 to March 1991 with year 1988 excluded)
- The LAI used in the current model systems is an unrealistic constant value for all plant types.

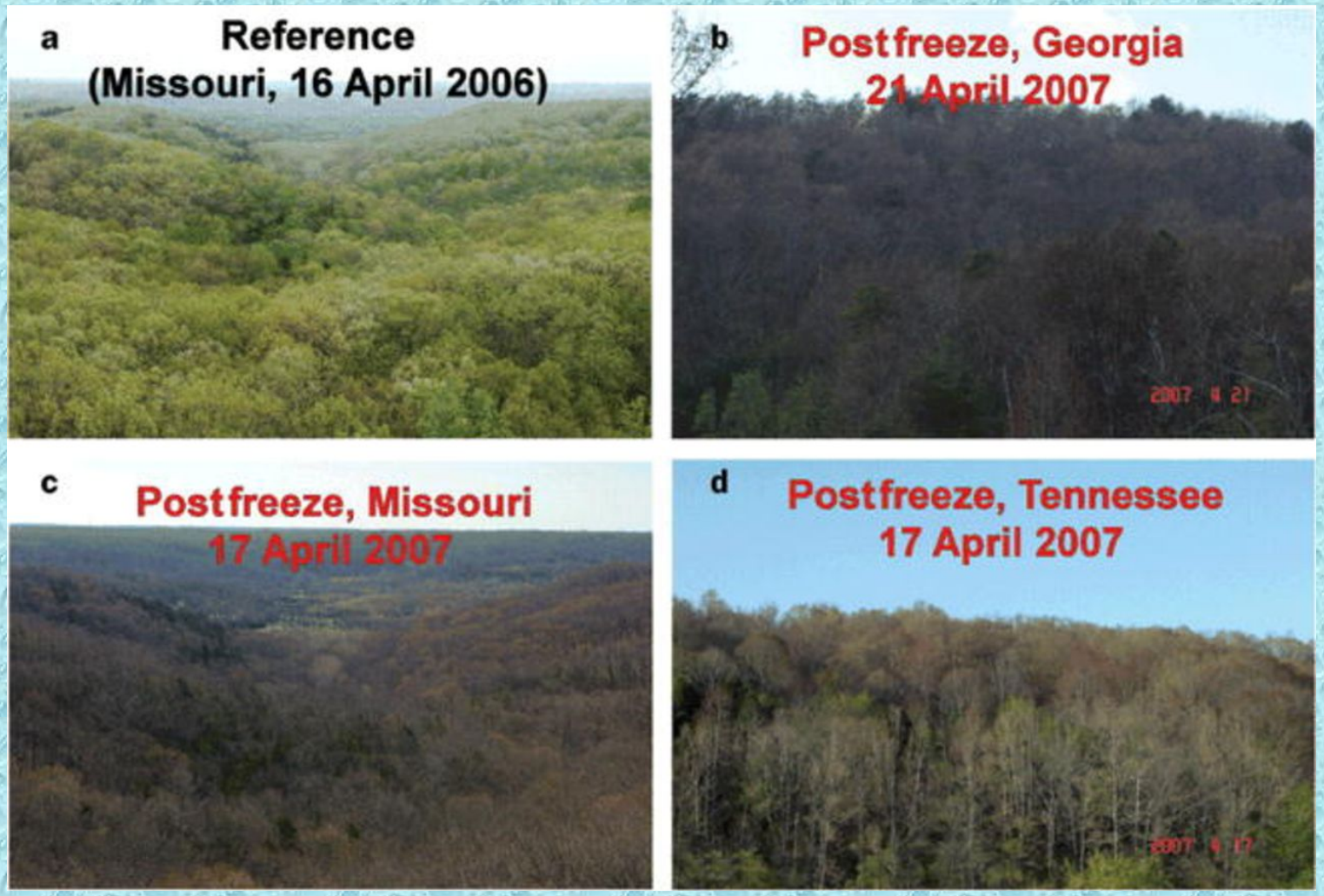
The Easter Freeze of April 2007





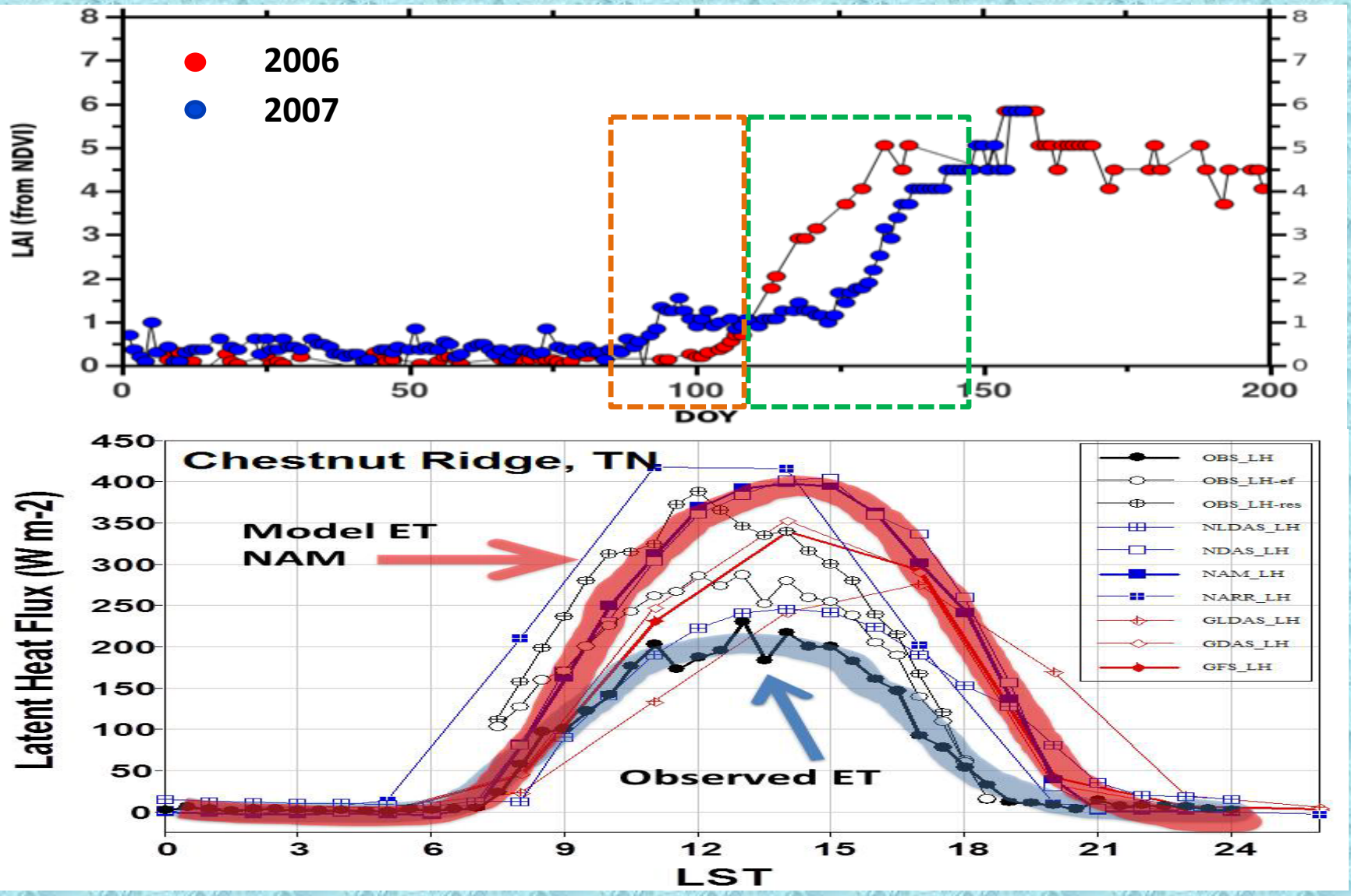
- In March 2007, unseasonably warm weather over the eastern half of the United States prompted early growth of many agricultural and horticultural crops.
- In early April (4-10), an arctic cold hit the same region. Air temperatures in many locations were well below 25°F and lasted almost a week in some areas.
- The widespread freeze extensively damaged agriculture in 18 states in the region, resulting in losses over $2 billion. Many farmers lost about 90% or nearly all of their crops.
- It also caused problems in NOAA weather forecast.

Canopy Damage from The Easter Freeze of April 2007



Gu, Lianhong, et al. The 2007 Eastern US spring freeze: increased cold damage in a warming world? *BioScience*, vol. 58, no. 3, 2008, p. 253+. *Academic OneFile*, Accessed 21 July 2017

LAI Reduced by The Easter Freeze of April 2007



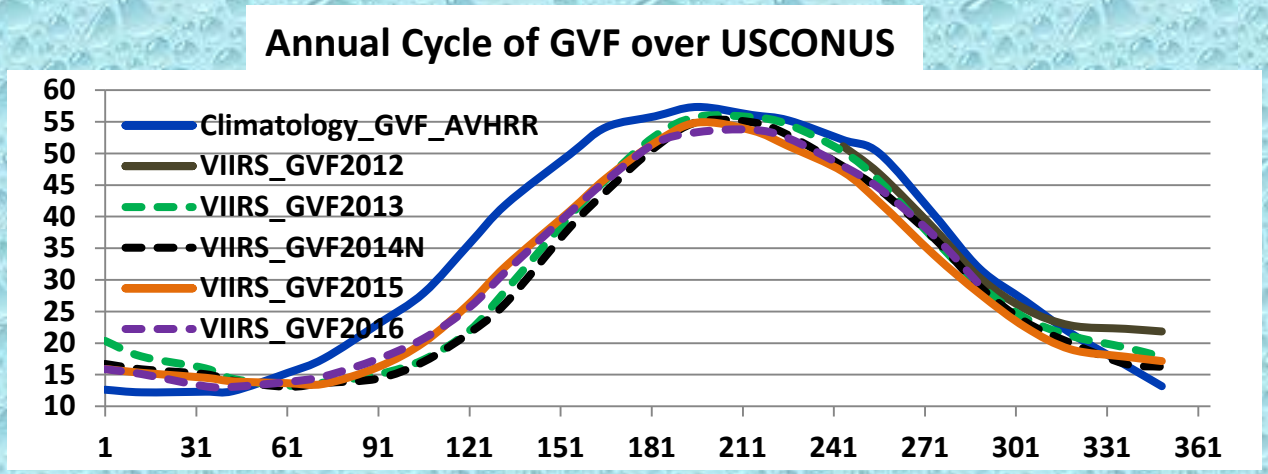
Courtesy: Tilden Meyers

Products of GVF & LAI

- Near real time satellite products for GVF starting from 2012 have been developed
- Near real time LAI products will be developed from VIIRS?
- These new products have weekly values and are updated daily.
- These new products have 4-km resolution at global scale and 1-km resolution at regional scale
- The products will be in lat/lon project and in GRIB2 data format

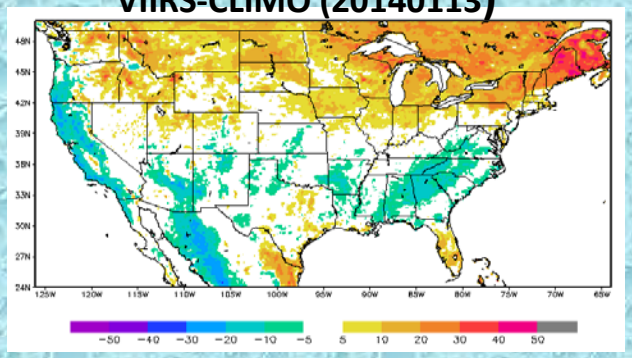
http://www.ospo.noaa.gov/Products/land/gvf/

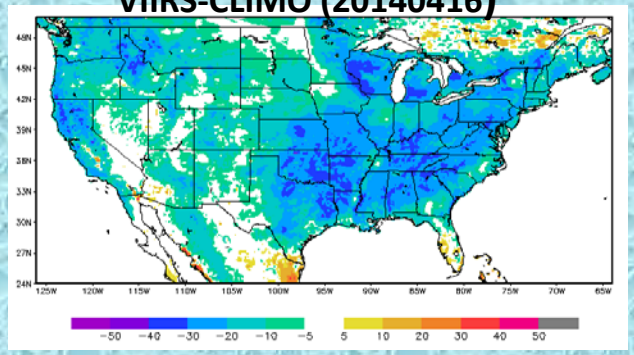
Comparison between VIIRS and Climatology GVF

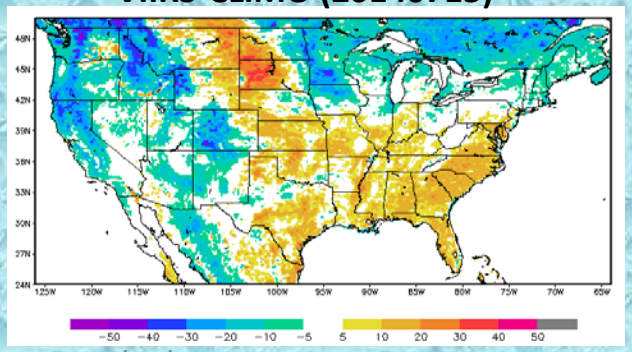


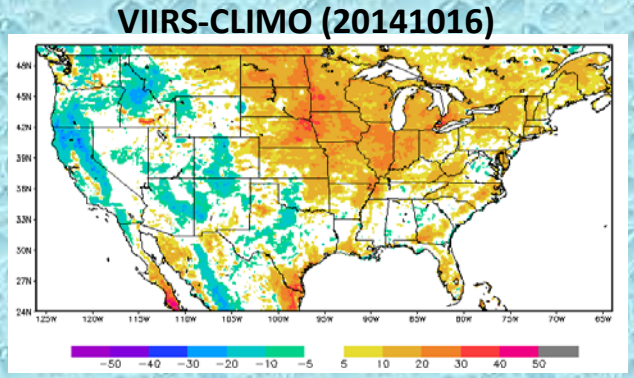
- Climatology GVF green up earlier
- Climatology GVF is higher most of a year

GVF difference in 2014 (VIIRS-AVHRR CLIMO)





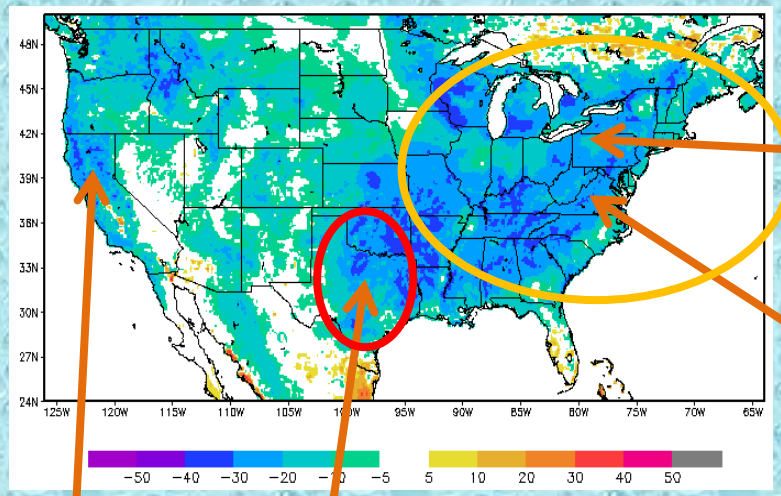




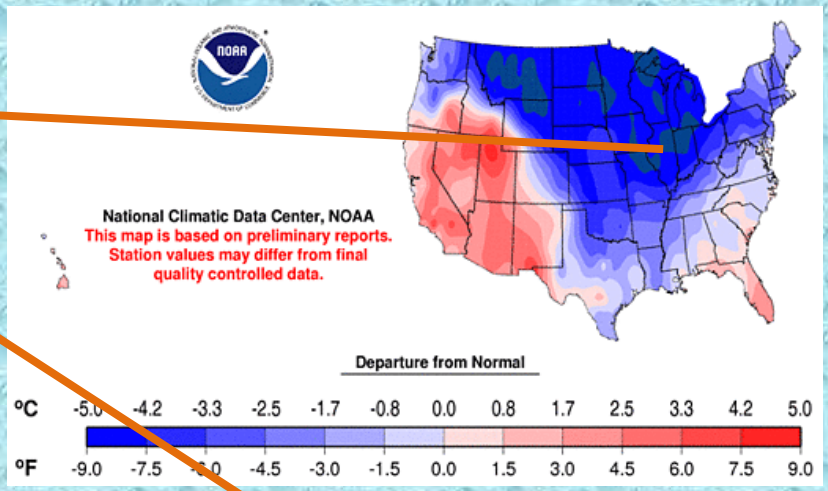
- VIIRS GVF is higher at high latitude in January
- VIIRS GVF is much lower over the entire USCONUS in April
- VIIRS GVF is higher in southeast US in July
- VIIRS GVF is higher over the eastern US

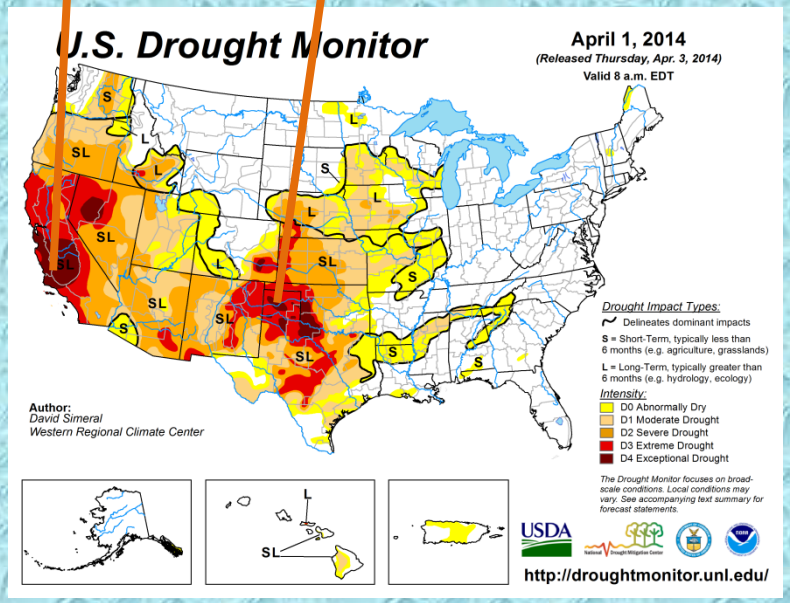
2014 Cold Spring & Drought Effects on GVF in US

GVF Difference (VIIRS-CLIMO) 20140416

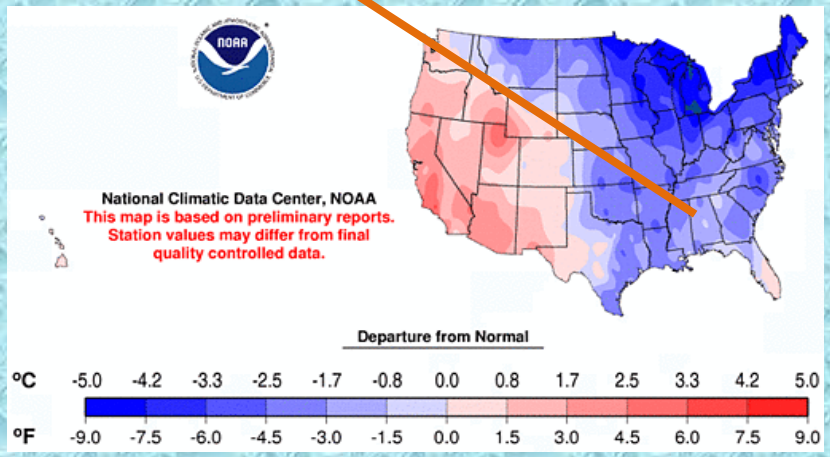


February 2014 Mean Temperature Departure from 1981-2010 Normal





March 2014 Mean Temperature Departure from 1981-2010 Normal

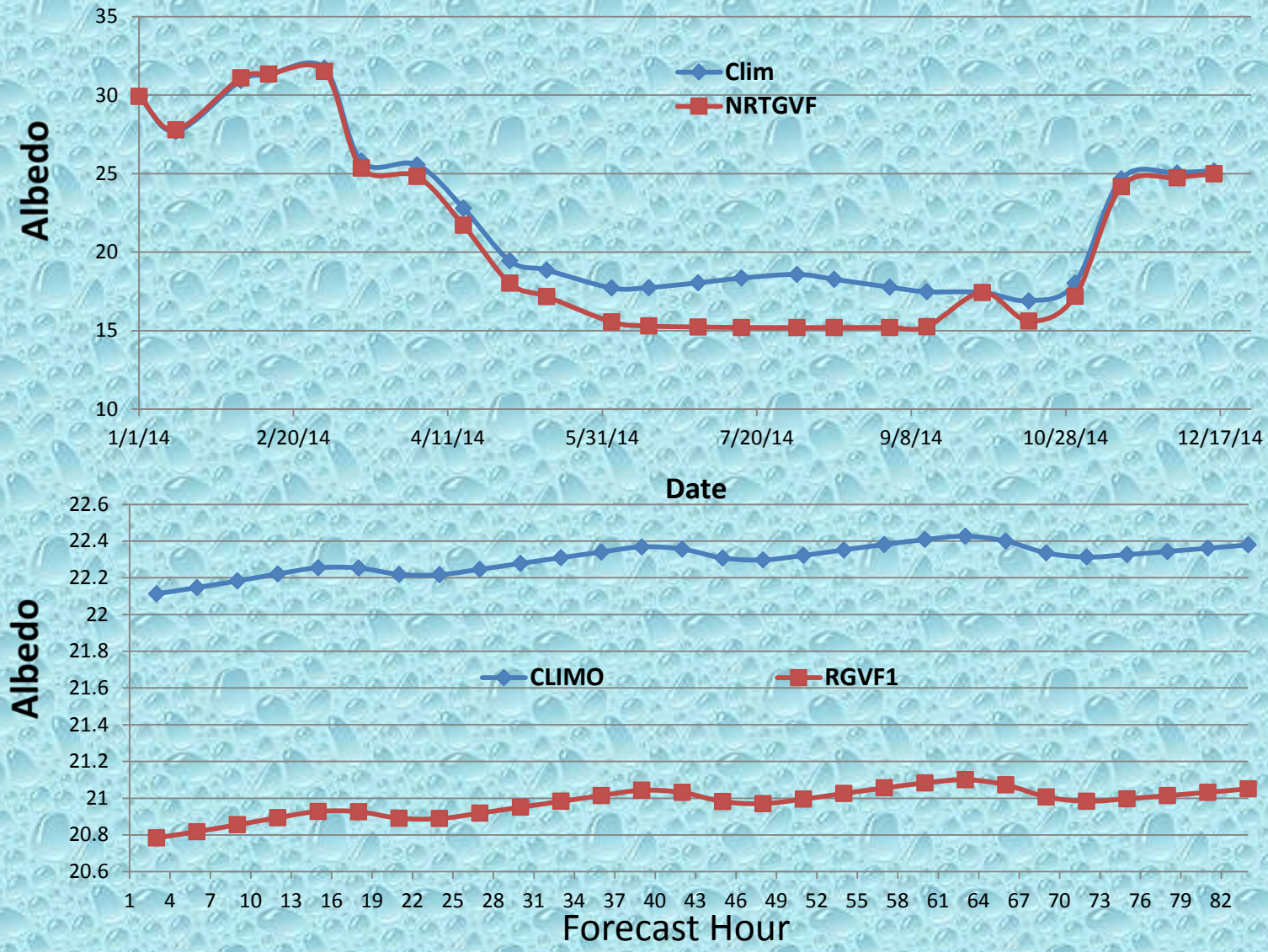


https://www.ncdc.noaa.gov/temp-and-precip/asos/avgtemp.dfn/dot/monthly/201405

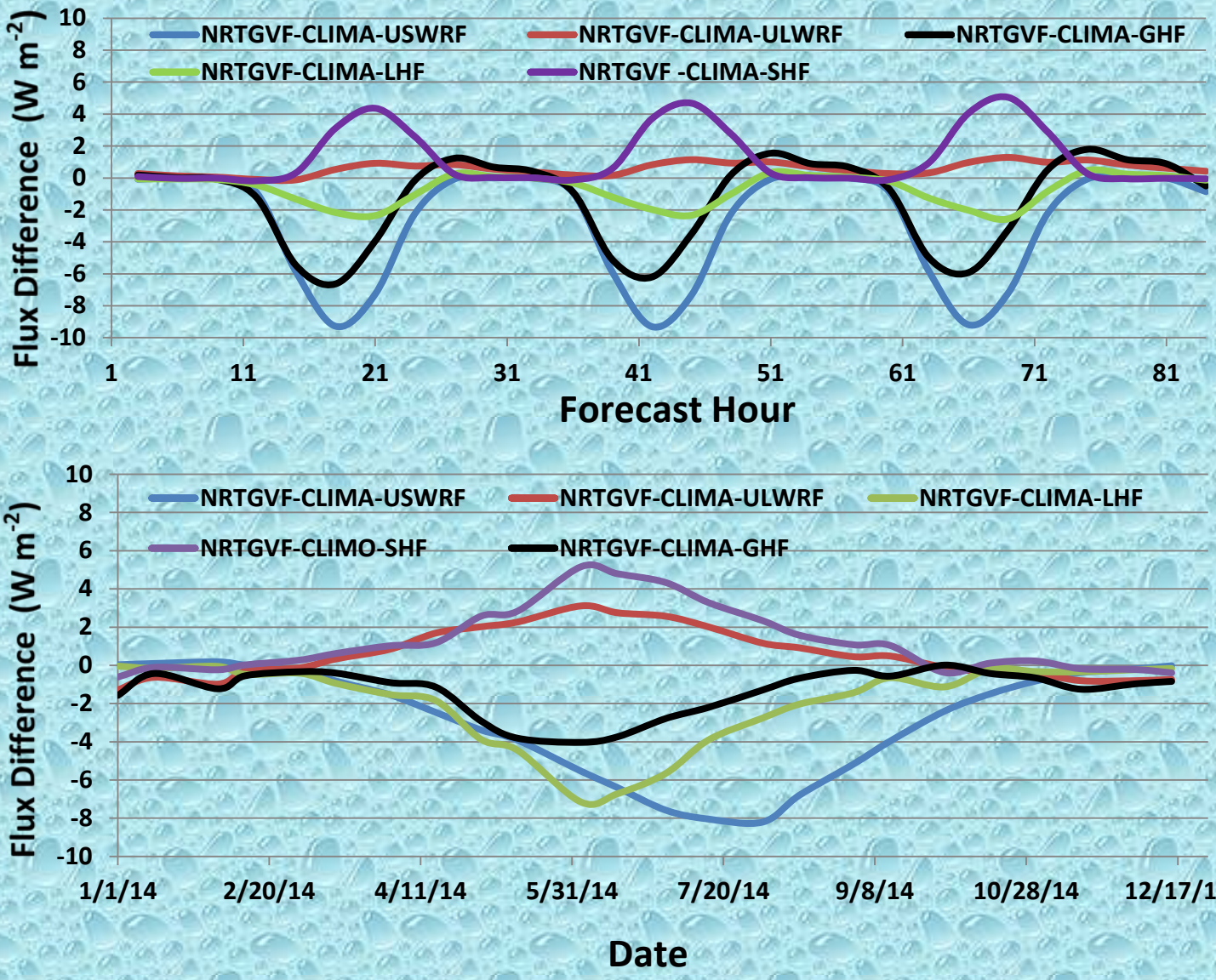
Numerical Experiments

- NAM was run with 2 GVF products for 2014: AVHRR climatology, the real time VIIRS GVF
- The BUDGET method was used to interpolate the products to the NAM domain (at least 25 points are chosen in one model grid box, then are weighted with area to get one value for the model grid box)
- Data on 24 days (two from each month, the beginning and middle day of each month) were used for tests. Total 48 runs were conducted with the 2 GVF products.
- 84 hour simulation was conducted for each run. Analysis was done for all land points over 218 grid domain.

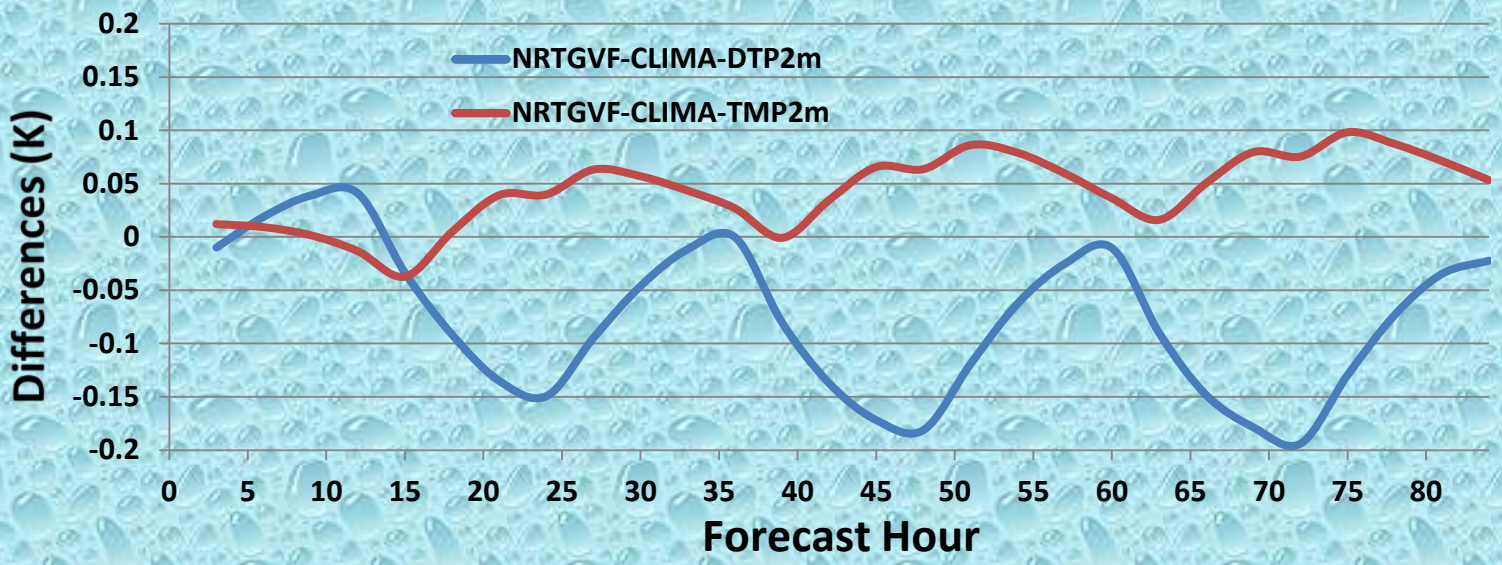
Land Surface Albedo in the Two Runs

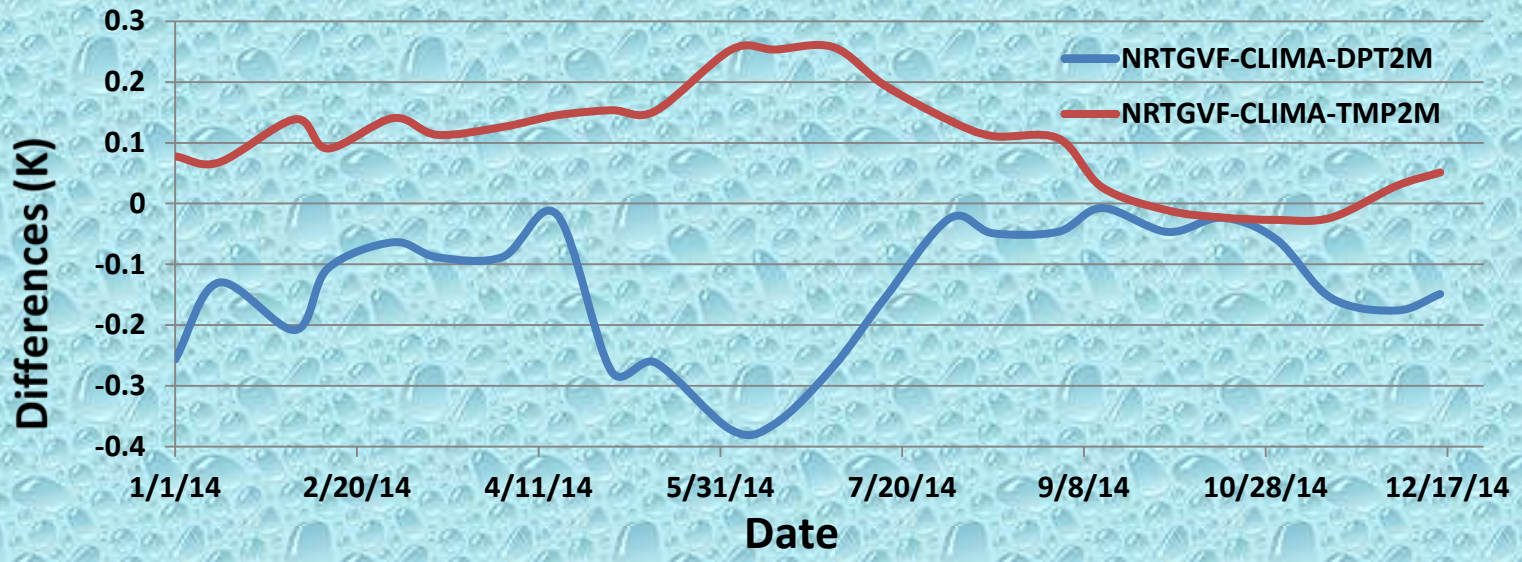


Flux Difference Between the Two Runs

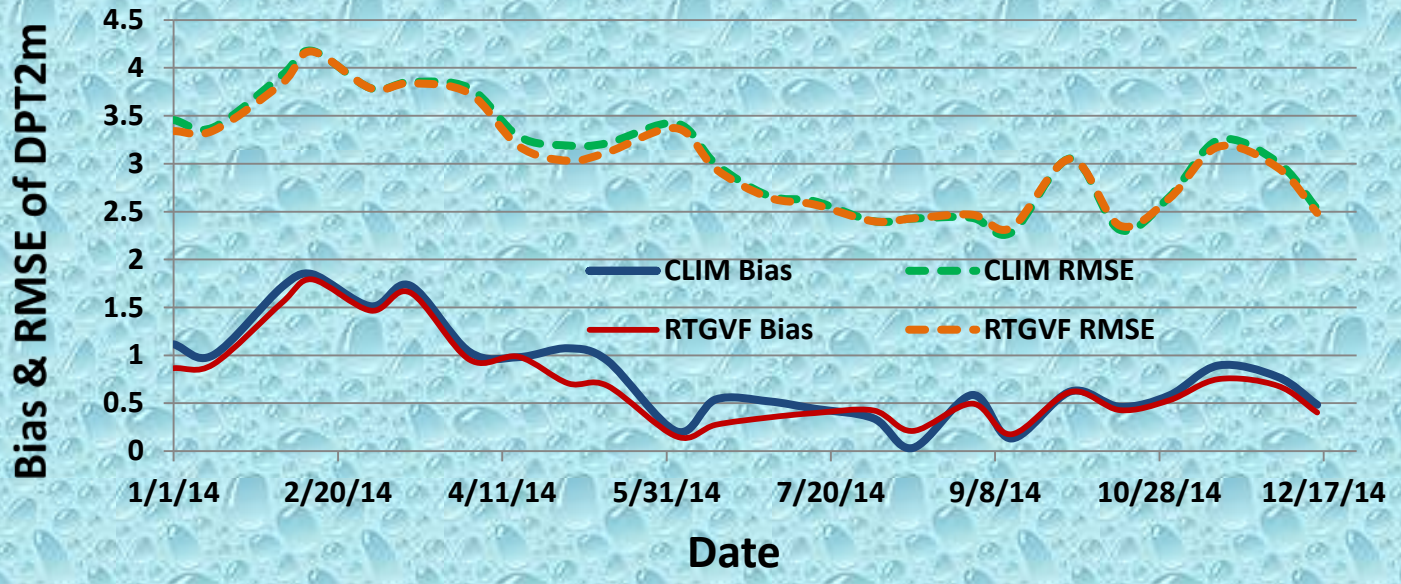


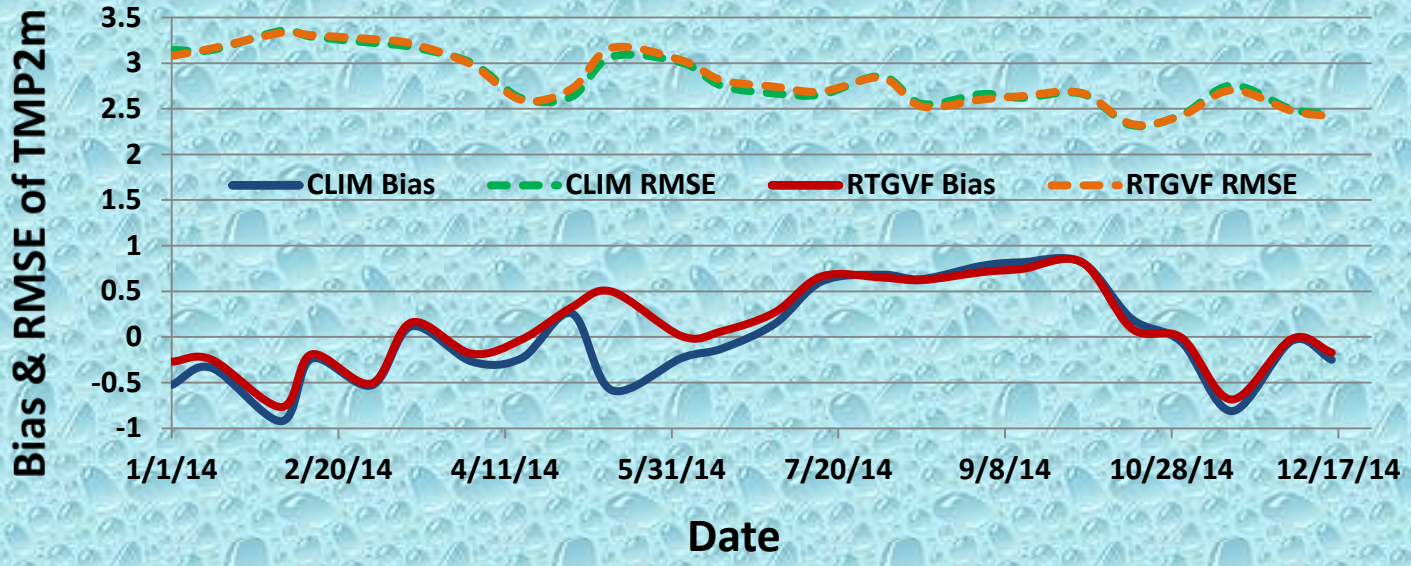
DPT2m & TMP2m Difference Between the Two Runs





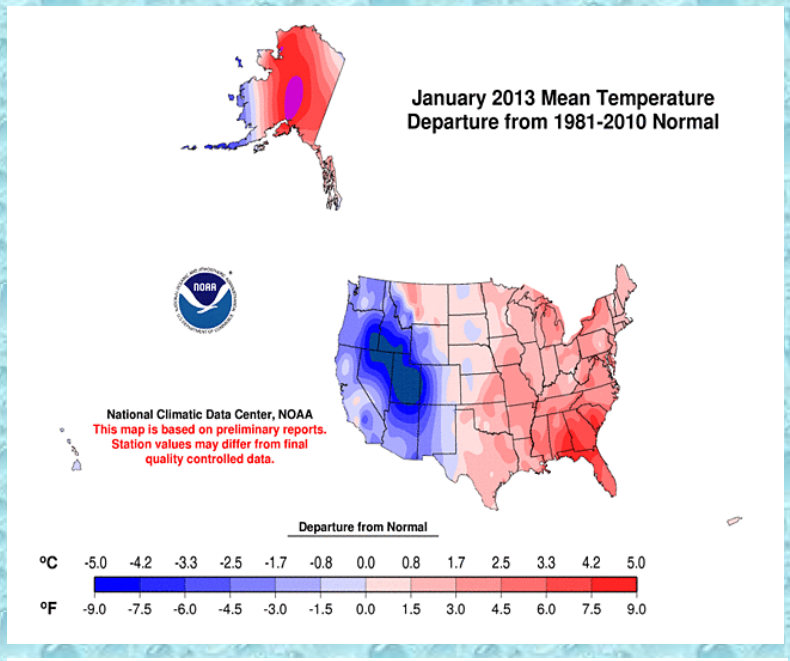
Bias & RMSE of DPT2m & TMP2m in the Two Runs

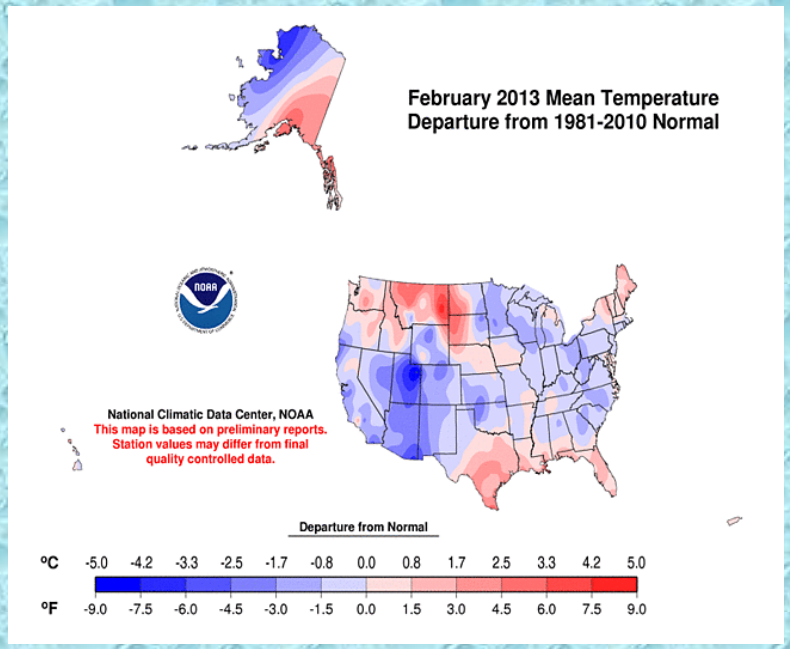


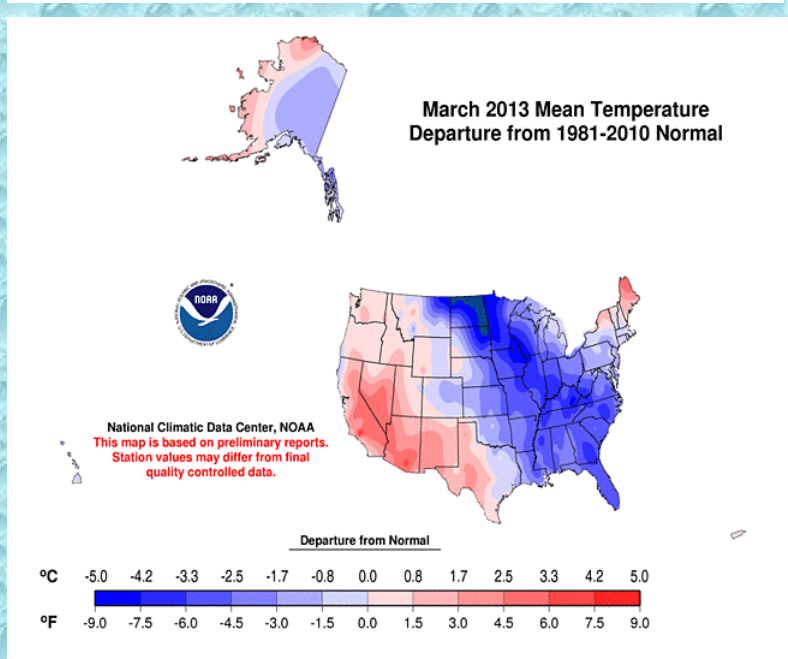


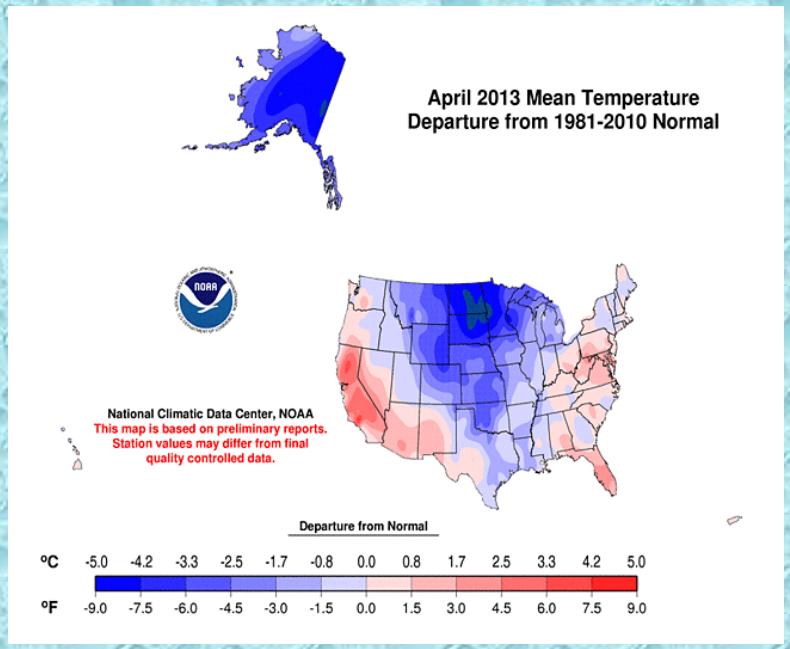
Summary

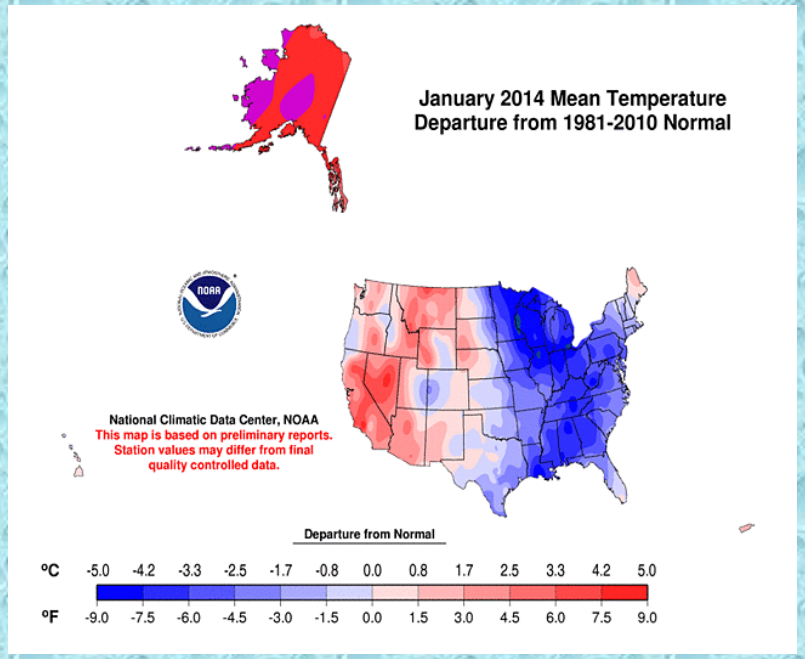
- Near real time VIIRS GVF products has been developed and tested with the North American Model system.
- Numerical sensitive tests were conducted with NAM for 2014
- Replacing Climatology GVF changes not only GVF, but also surface albedo in NAM.
- The near real time GVF has smaller values which reduced latent heat fluxes, increased sensible heat fluxes, and reduced the NAM wet bias of DPT2m and cold bias of T2m in 2014
- VIIRS GVF dataset have been produced to enable ingest into the NCEP NEMS system
- Near real time LAI will be developed soon, and be used in NCEP NEMS system ?

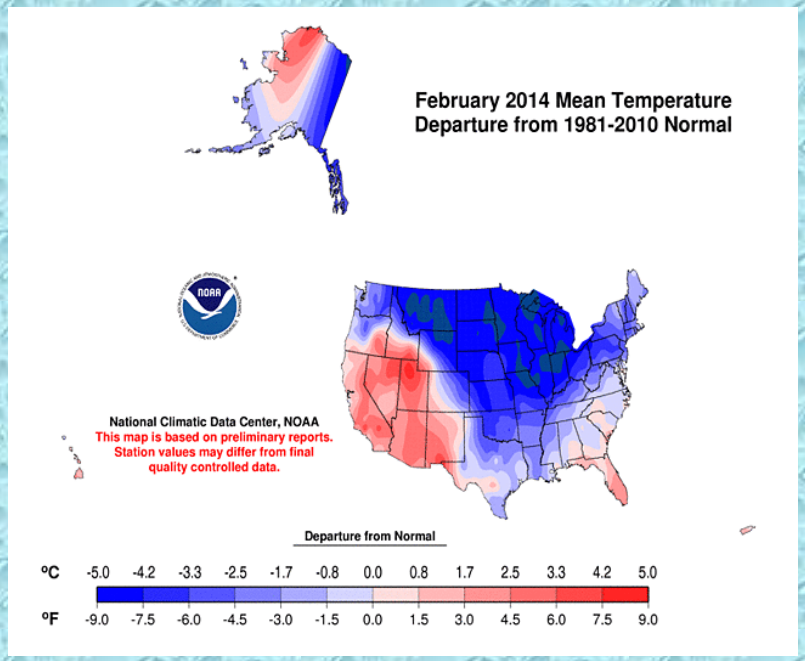

January 2013 Mean Temperature
Departure from 1981-2010 Normal
National Climatic Data Center, NOAA
This map is based on preliminary reports.
Station values may differ from final
quality controlled data.
Departure from Normal
°C -5.0 -4.2 -3.3 -2.5 -1.7 -0.8 0.0 0.8 1.7 2.5 3.3 4.2 5.0
°F -9.0 -7.5 -6.0 -4.5 -3.0 -1.5 0.0 1.5 3.0 4.5 6.0 7.5 9.0

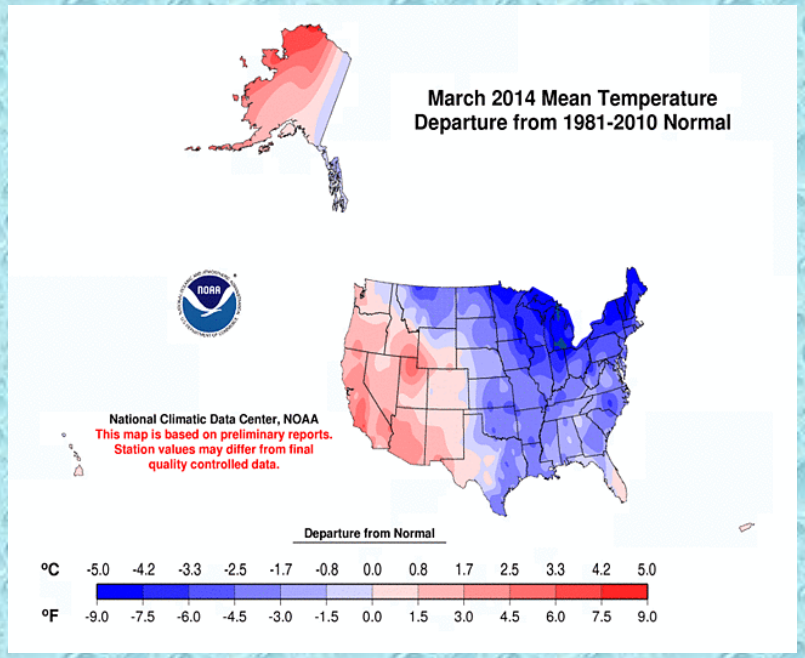

February 2013 Mean Temperature
Departure from 1981-2010 Normal
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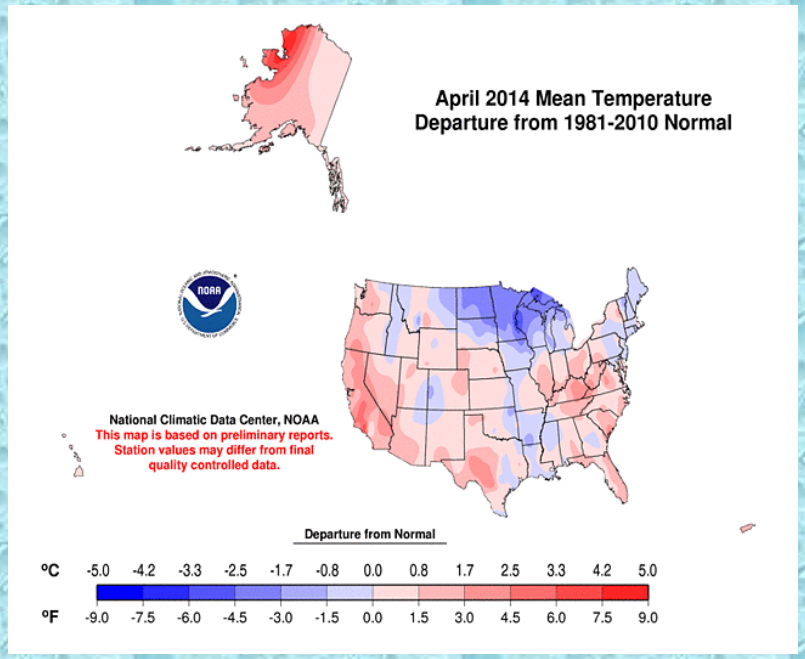

March 2013 Mean Temperature
Departure from 1981-2010 Normal
National Climatic Data Center, NOAA
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Departure from Normal
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°F -9.0 -7.5 -6.0 -4.5 -3.0 -1.5 0.0 1.5 3.0 4.5 6.0 7.5 9.0

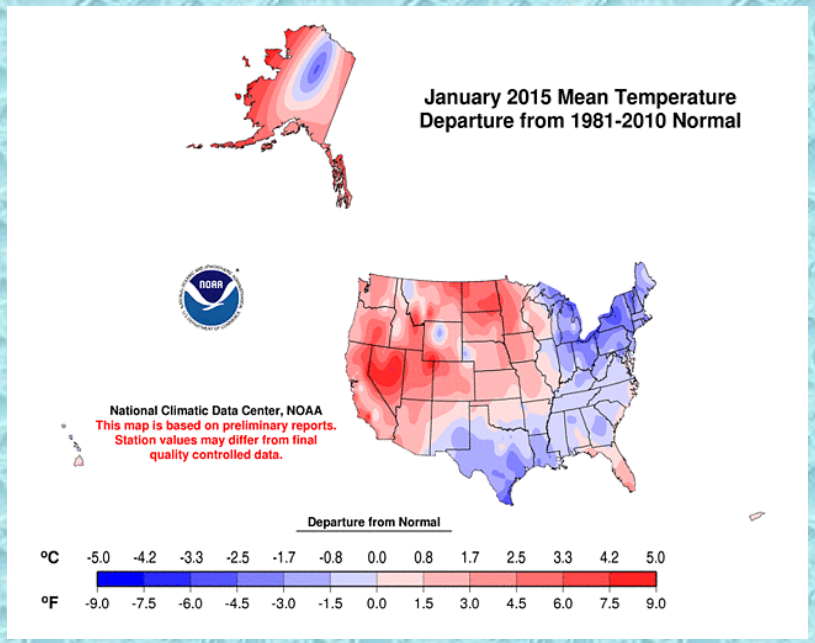

April 2013 Mean Temperature
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°F -9.0 -7.5 -6.0 -4.5 -3.0 -1.5 0.0 1.5 3.0 4.5 6.0 7.5 9.0

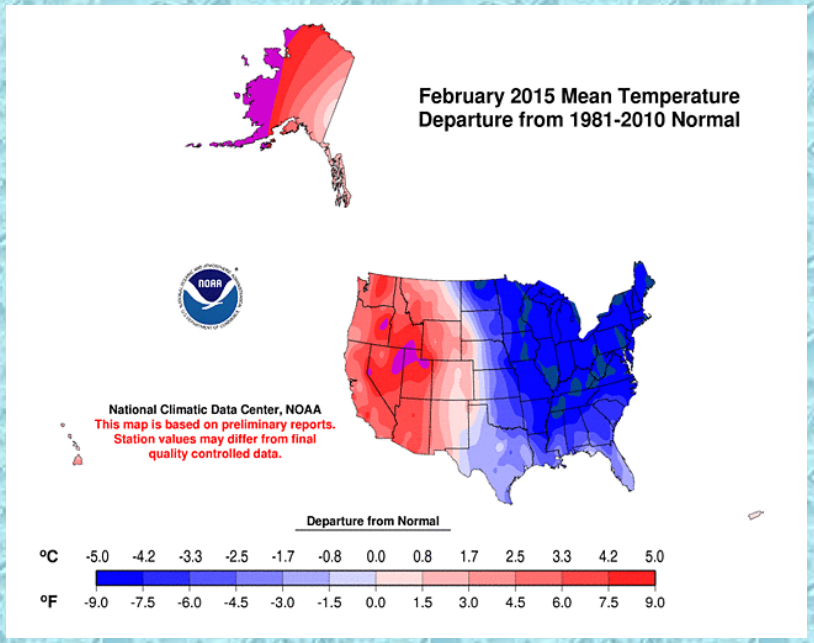

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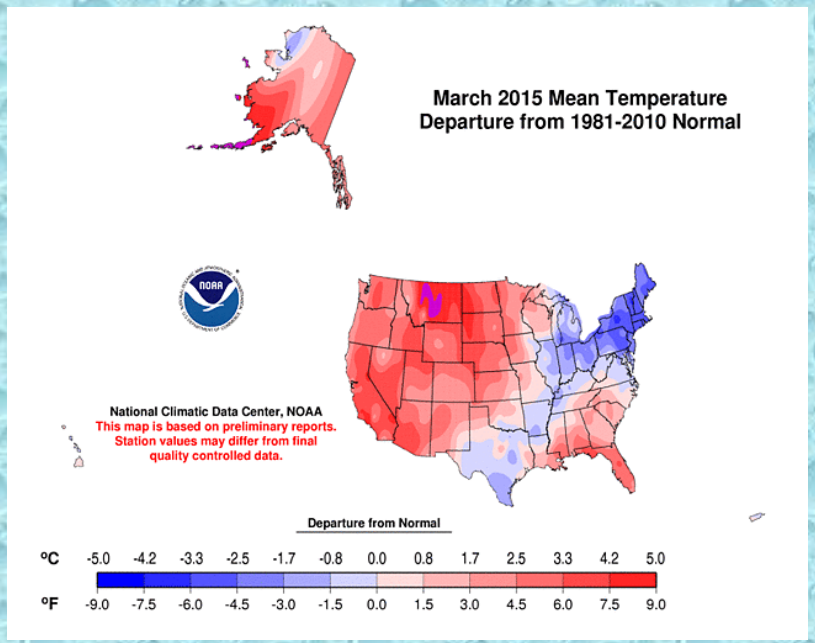

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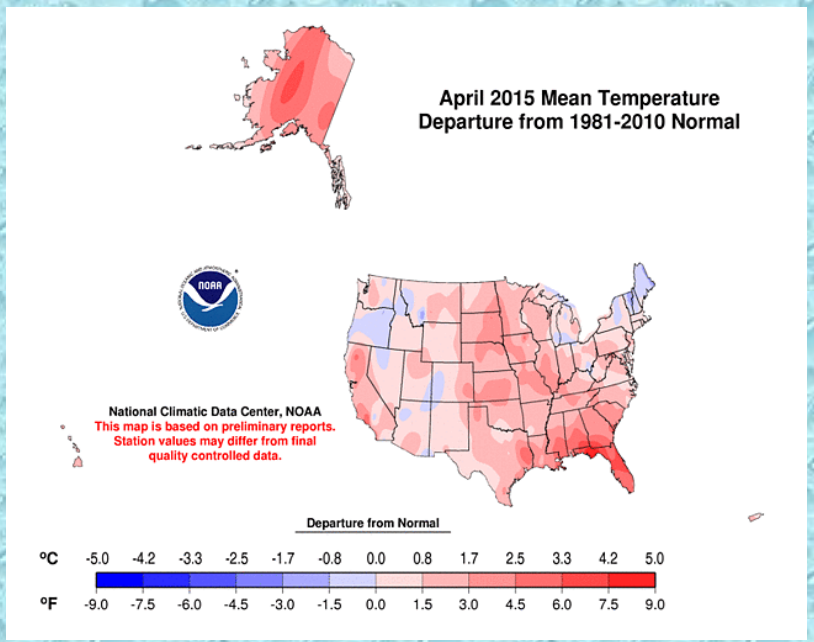

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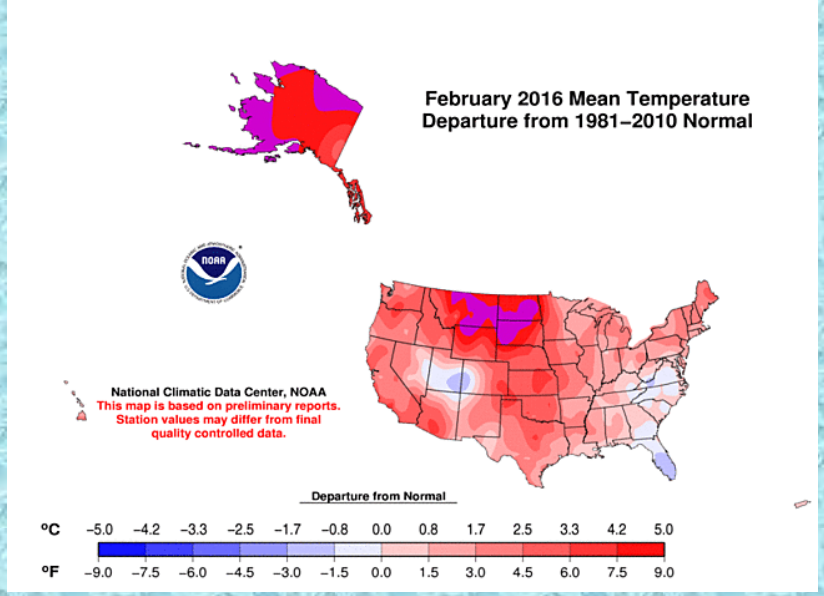

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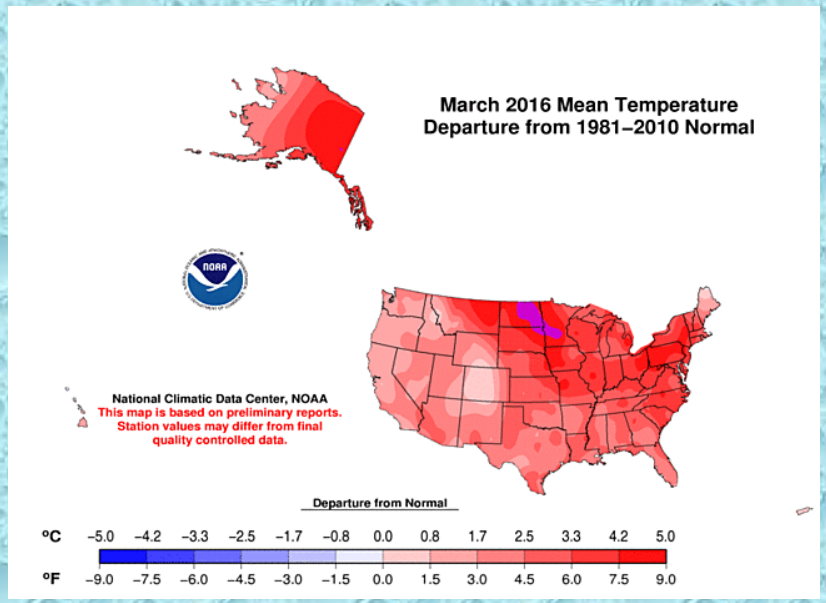

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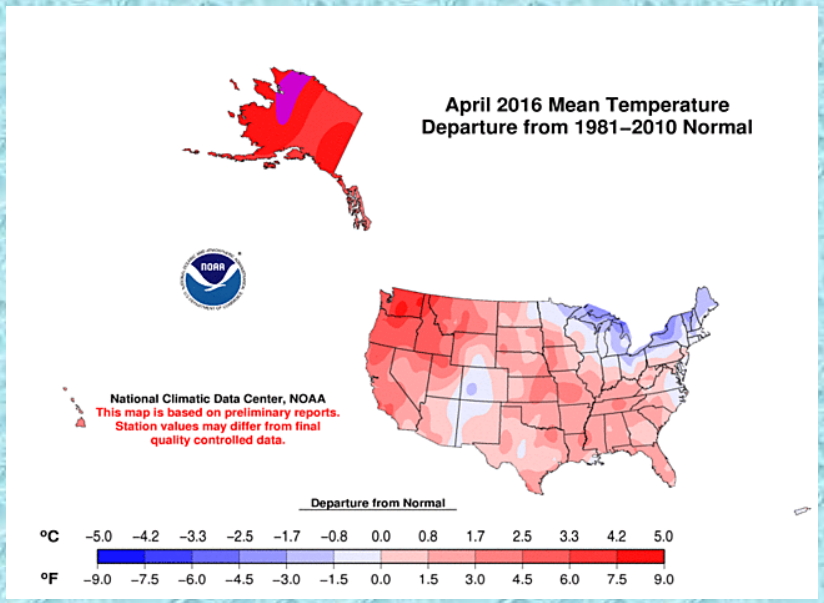

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February 2016 Mean Temperature
Departure from 1981–2010 Normal
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°C −5.0 −4.2 −3.3 −2.5 −1.7 −0.8 0.0 0.8 1.7 2.5 3.3 4.2 5.0
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Application of Satellite Land Surface Observations in NCEP Models: VIIRS GVF Data

Weizhong Zheng[1,2] and Mike Ek[1]

[1]*NOAA/NCEP/Environmental Modeling Center , College Park, MD*

[2]*IMSG @NOAA/NCEP/EMC, College Park, MD*

Contributions: Jiarui Dong, Yihua Wu, Helin Wei, Jesse Meng and Youlong Xia (NCEP/EMC); Marco Vargas, Zhagyan Jian, Xiwu Zhan, Jicheng Liu, Li Fang, Jifu Yin, Yunyue Yu and Ivan Csiszar (NESDIS/STAR); Zhen Song (UMD)

2017 STAR JPSS Annual Science Team Meeting, 14-18 August 2017

Motivation

➢ *Objective:*

To improve satellite data utilization over land in NCEP forecast models and data assimilation system and then improve the numerical weather prediction (NWP).

➢*Land satellite data assimilation:*

– Utilization of satellite data sets in the models (e.g., *GVF, snow, burning area, albedo, emissivity, LST, radiation, vegetation and soil type, etc.*)

– Assimilation of satellite products (e.g, *Soil moisture (SMAP, SMOPS); snow*);

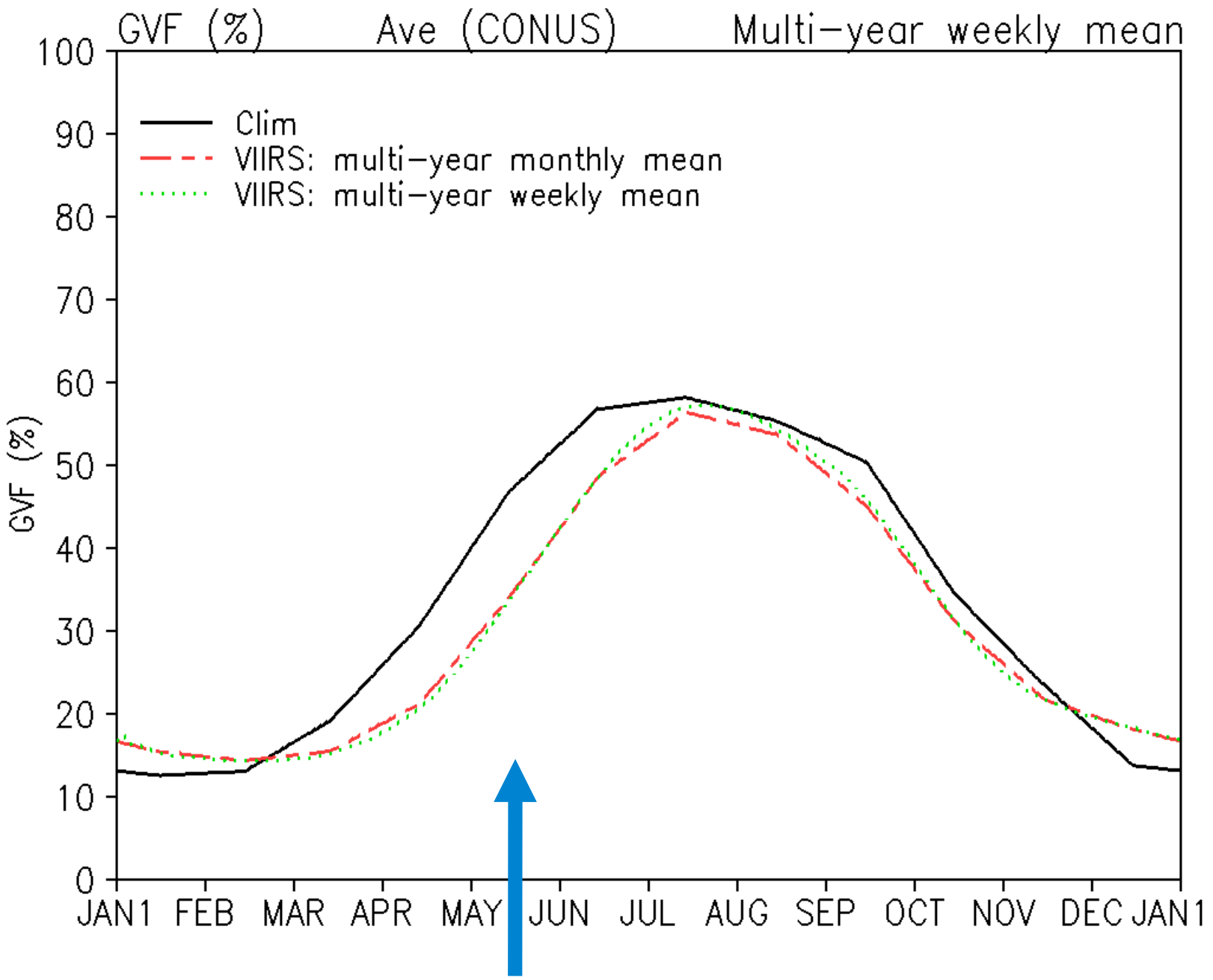
– Direct radiance assimilation (Tb)

Requiring a forward radiative transfer model (RTM) to calculate Tb with input of model atm profiles and sfc parameters. (sfc emissivity, sfc parameters). (Understand the interaction and feedback between land and atmosphere, and then improve NWP and DA)

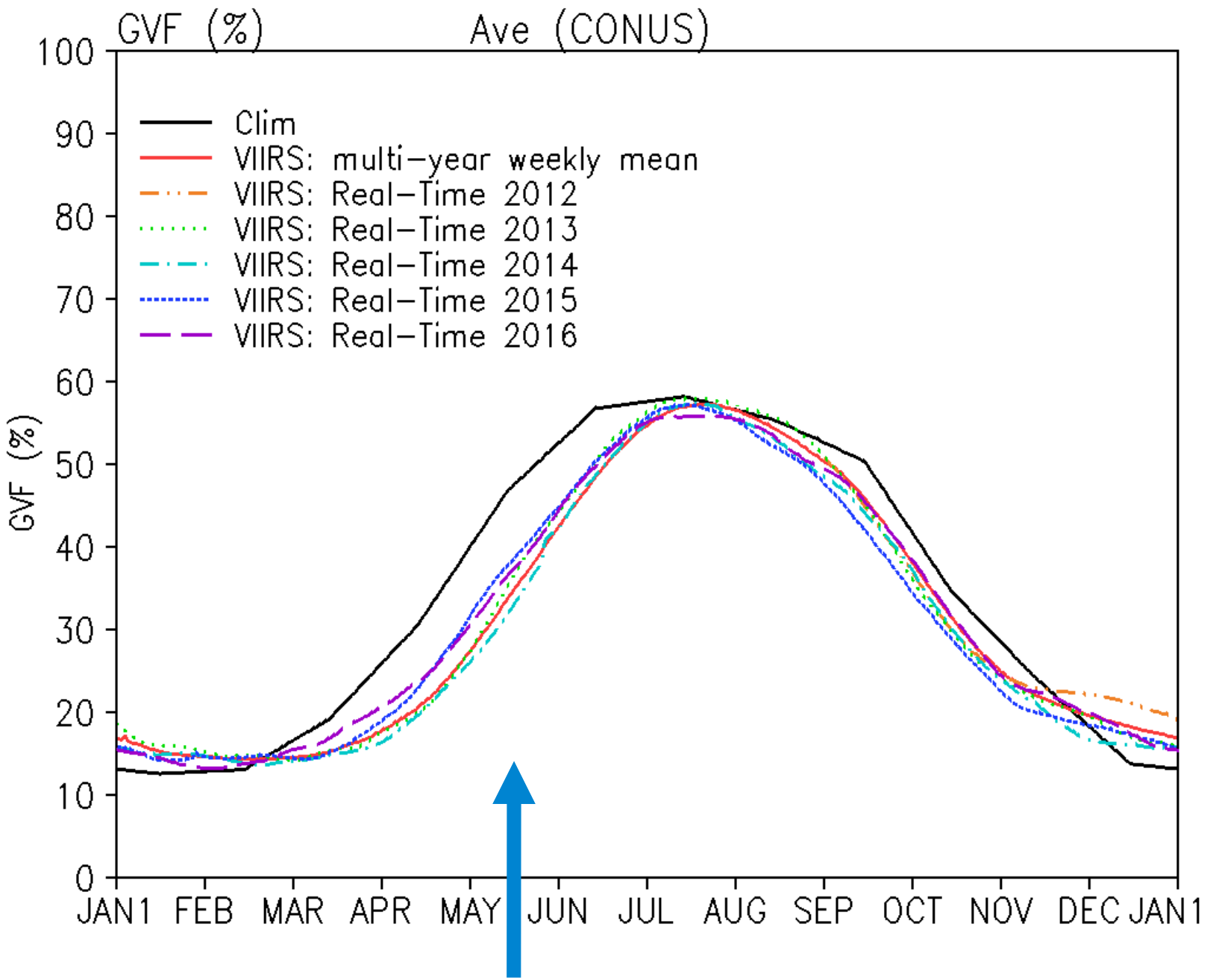
-time VIIRS GVF

- **NCEP Operations: Monthly 0.14-deg (16-km) global climatology of GVF**
- **Weekly GVF: VIIRS near real-time weekly global 0.036-deg (4-km) GV**
- **Three data sets: (a) Weekly climatology GVF;**
  (b) Monthly climatology GVF;
  (c) Near real-time weekly GVF
- **The other GVF data sets are also examined:**
  (a) Near real-time weekly AVHRR (Le Jiang et al., NESDIS);
  (b) Near real-time weekly MODIS (Xiaoyang Zhang, SD State U.).

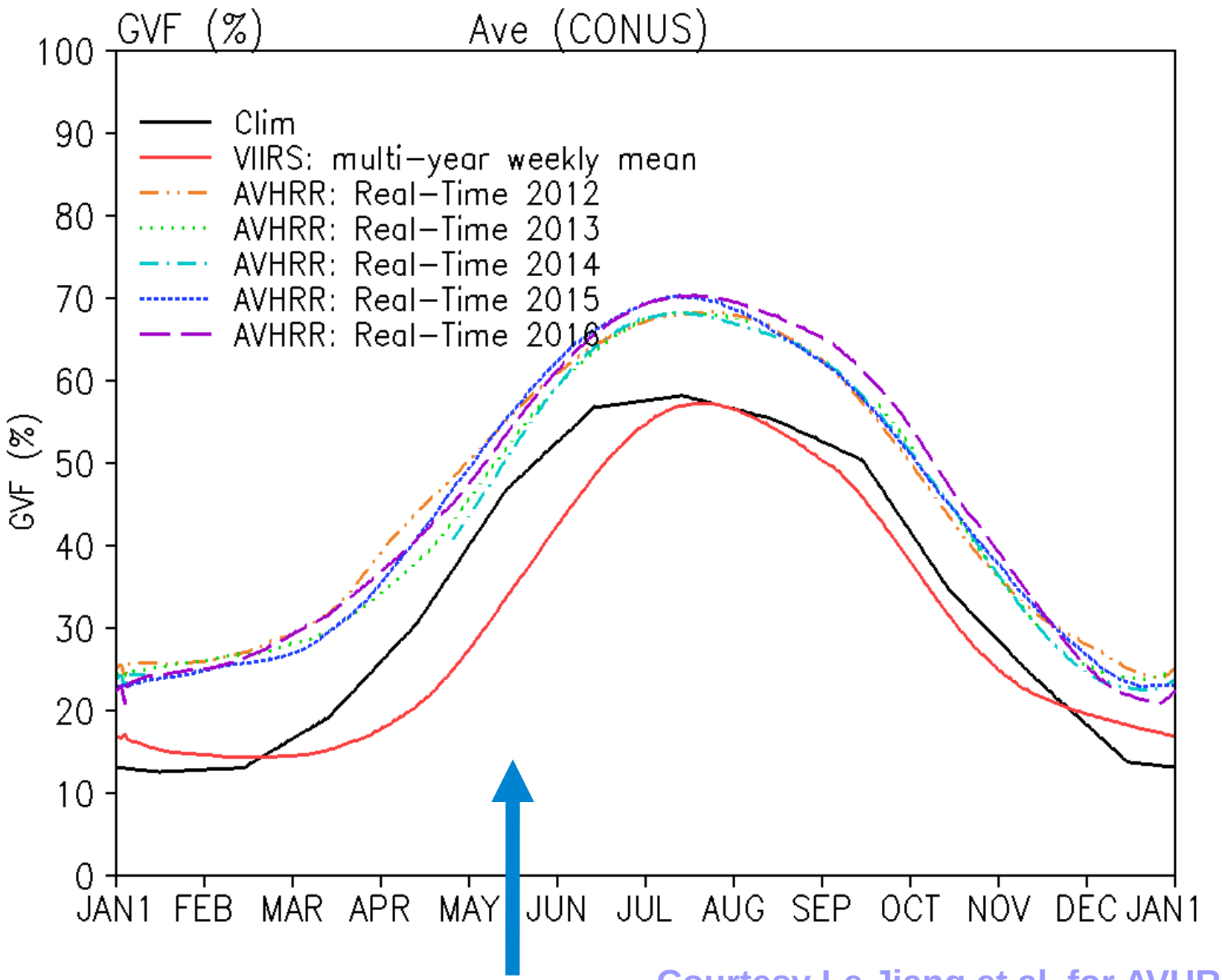
Multi-year mean VIIRS GVF over CONUS



Average VIIRS GVF over CONUS: Near Real-Time

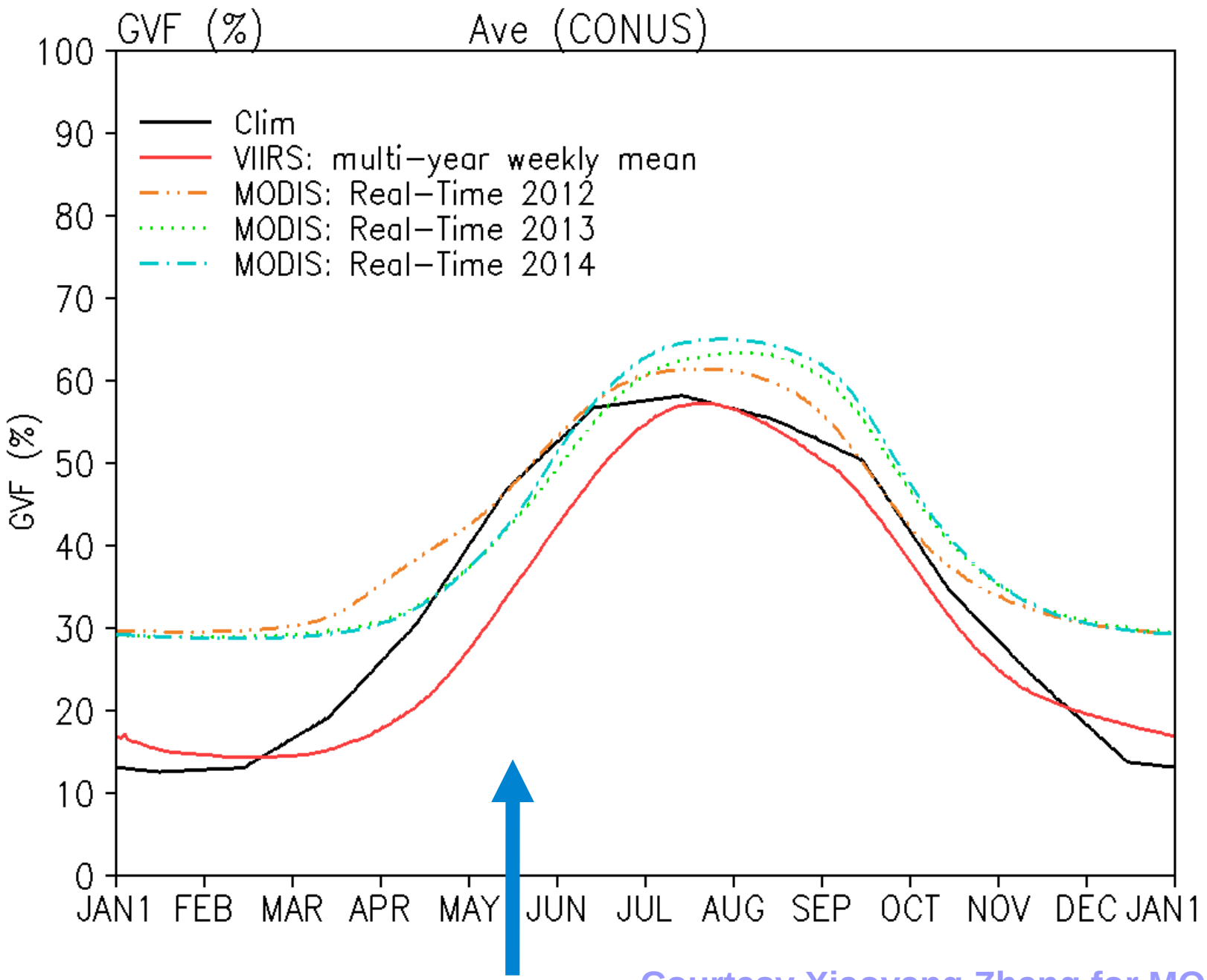


Average AVHRR GVF over CONUS: Near Real-Time



Courtesy Le Jiang et al. for AVHRR data

Average MODIS GVF over CONUS: Near Real-Time

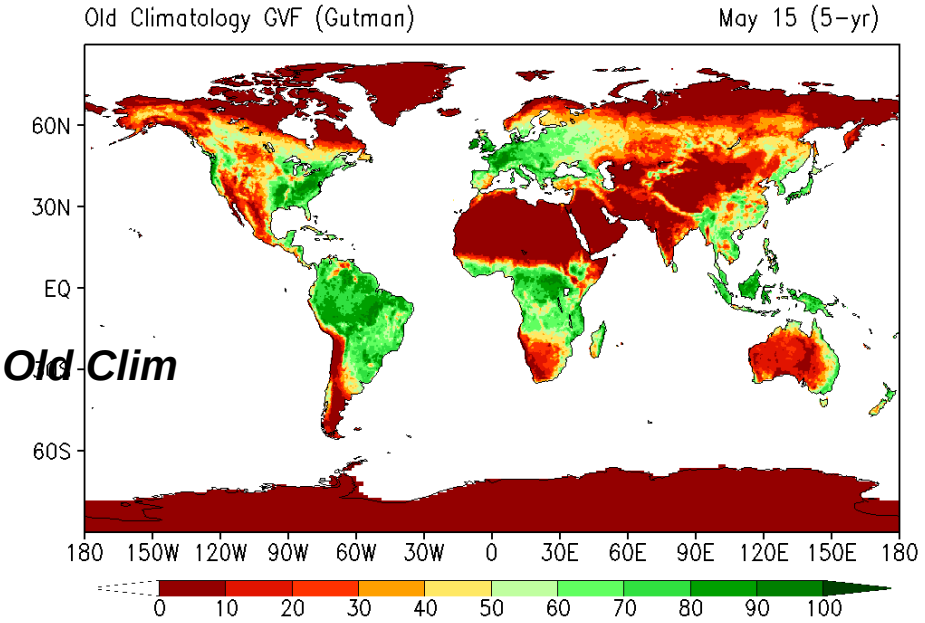


Courtesy Xiaoyang Zhang for MODIS data

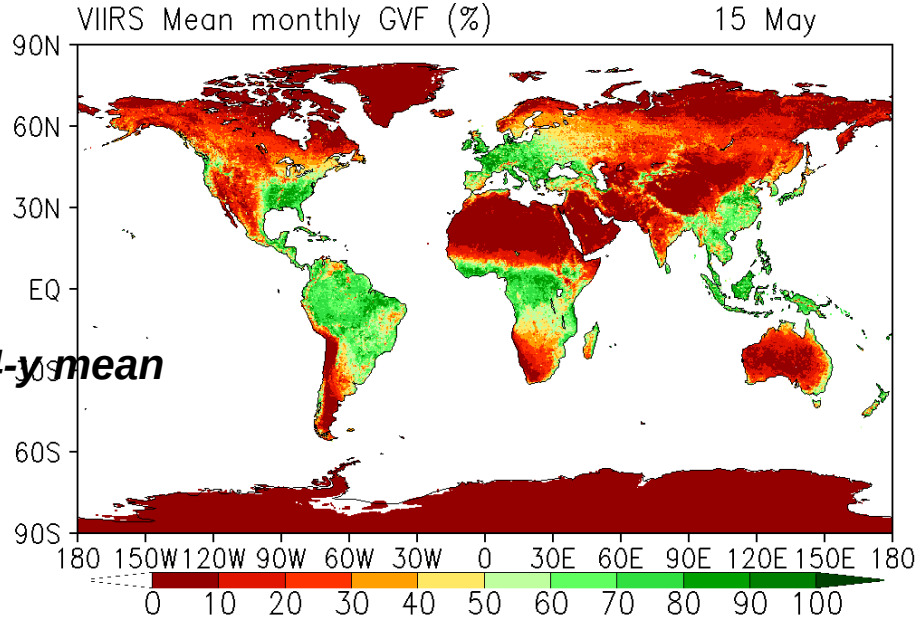
VIIRS GVF (4-y monthly mean) test:

5/02 – 6/02, 2016

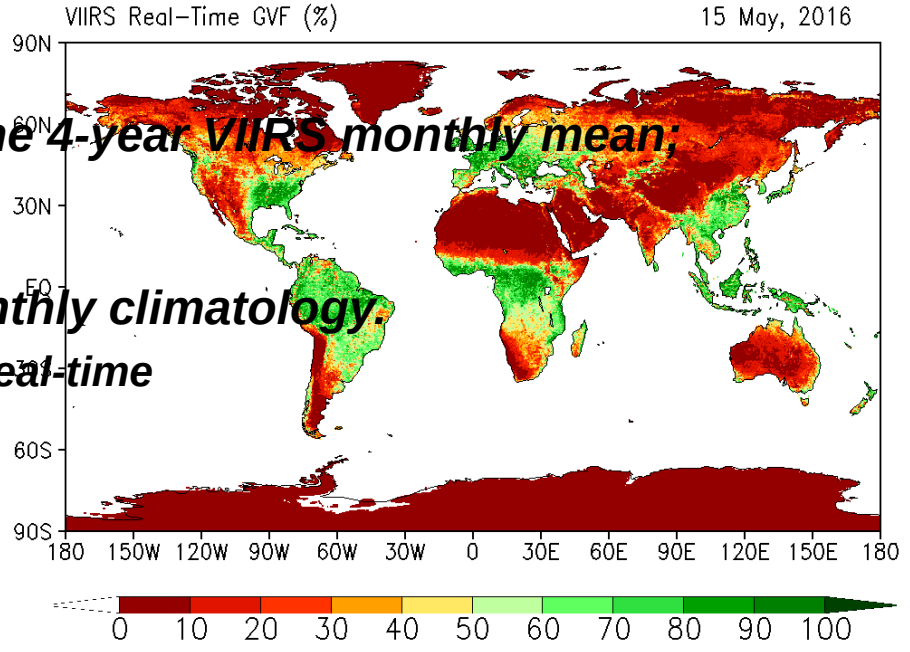
n and VIIRS data: 15 May 2016



Old Clim



4-y mean

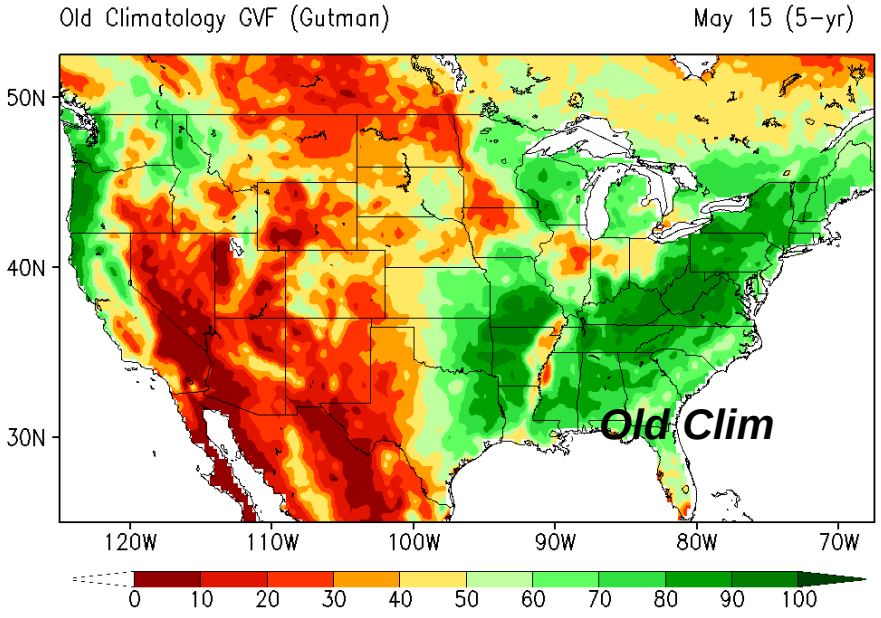


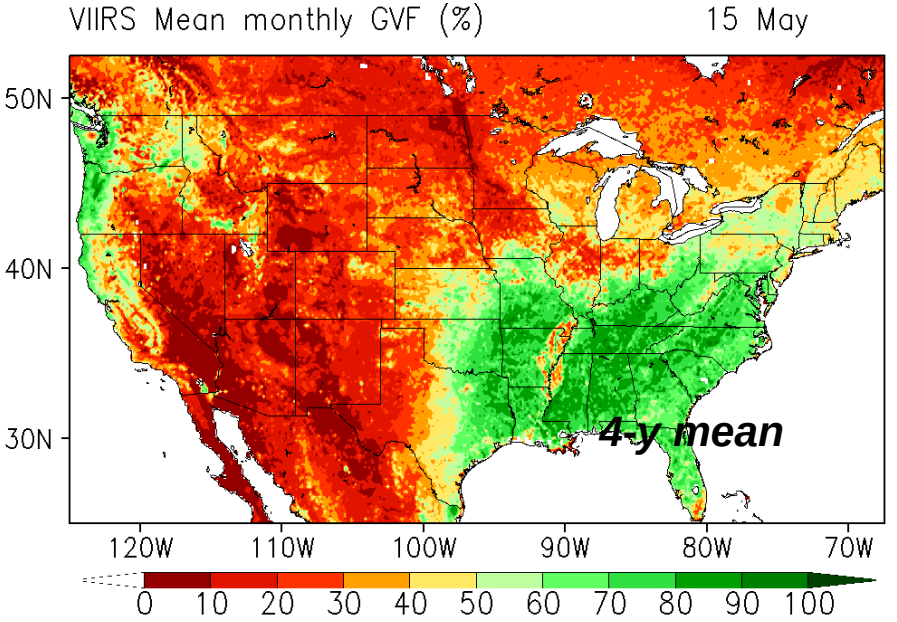
Real-time

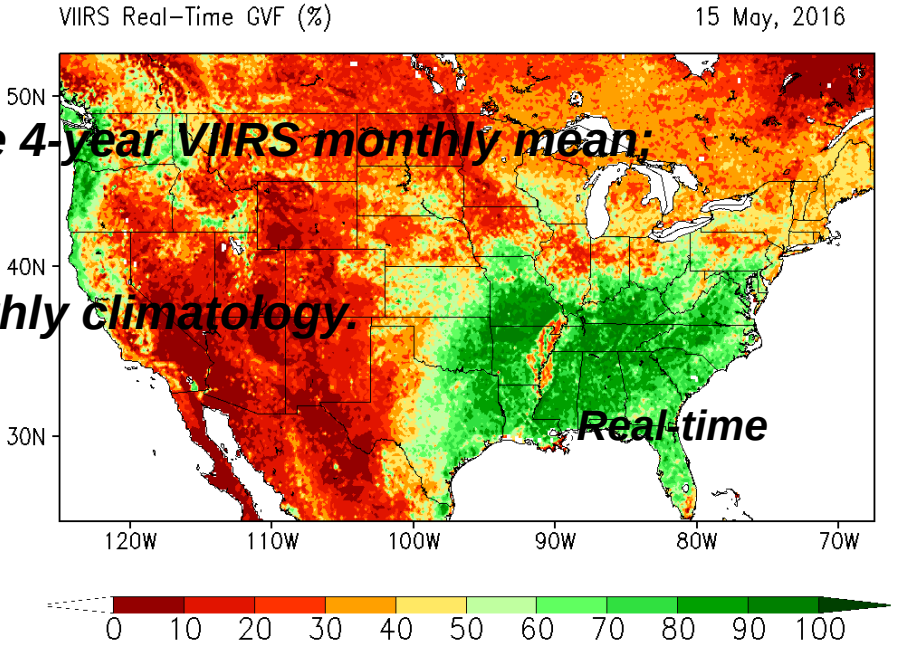
– Near real-time VIIRS GVF is similar to the 4-year VIIRS monthly mean;

– Both are lower than the old AVHRR monthly climatology.

m and VIIRS data: 15 May 2016



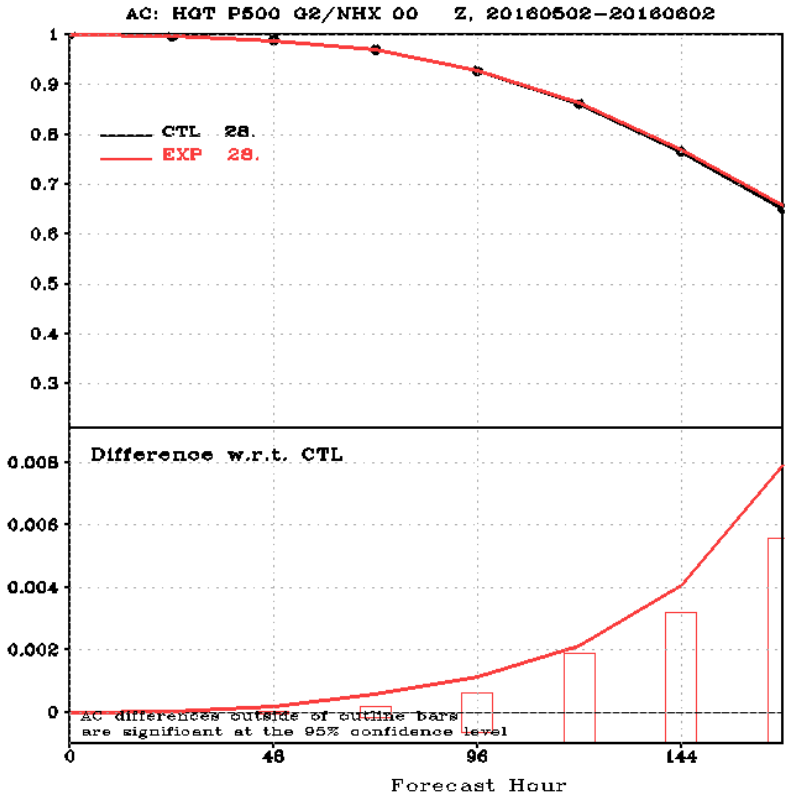




- ***Near real-time VIIRS GVF is similar to the 4-year VIIRS monthly mean;***
- ***Both are lower than the old AVHRR monthly climatology.***

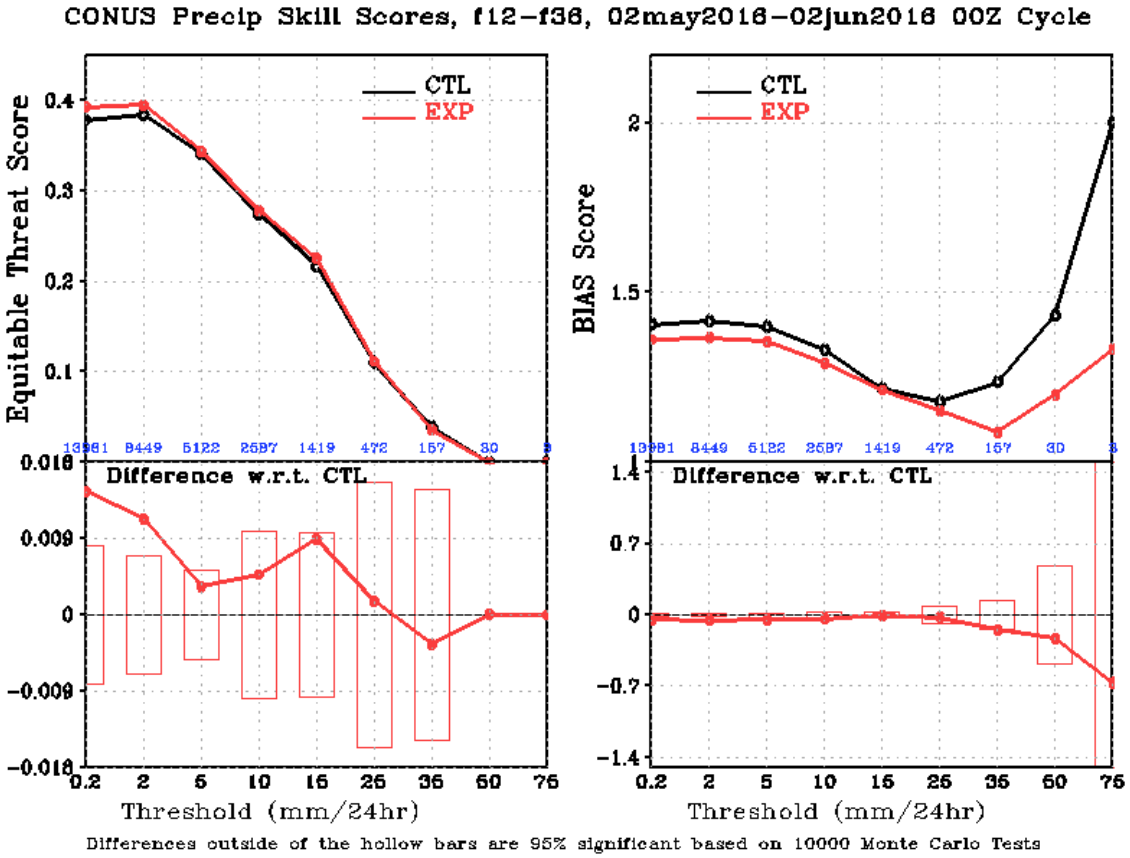
ean) test: 5/02 – 6/02, 2016

AC: HGT 500 hPa G2/NHX



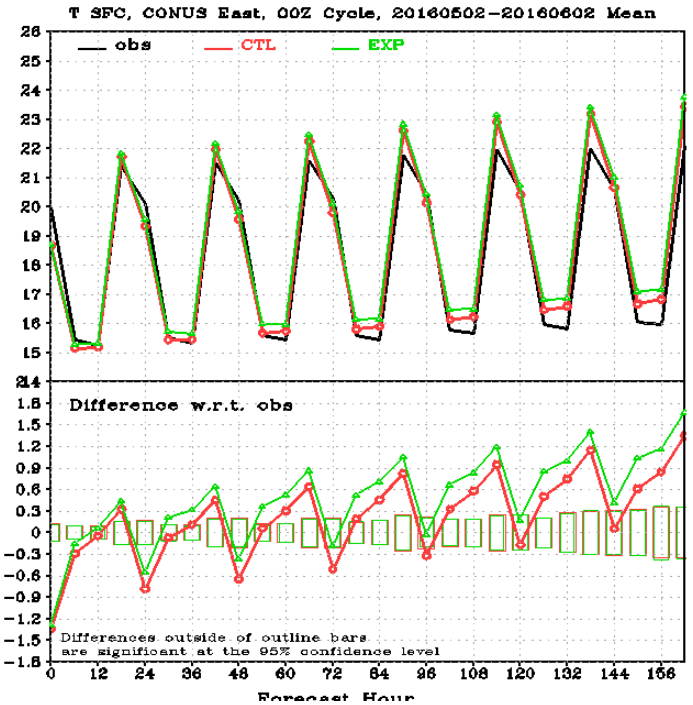
VIIRS test: Improve AC score @500 hPa.

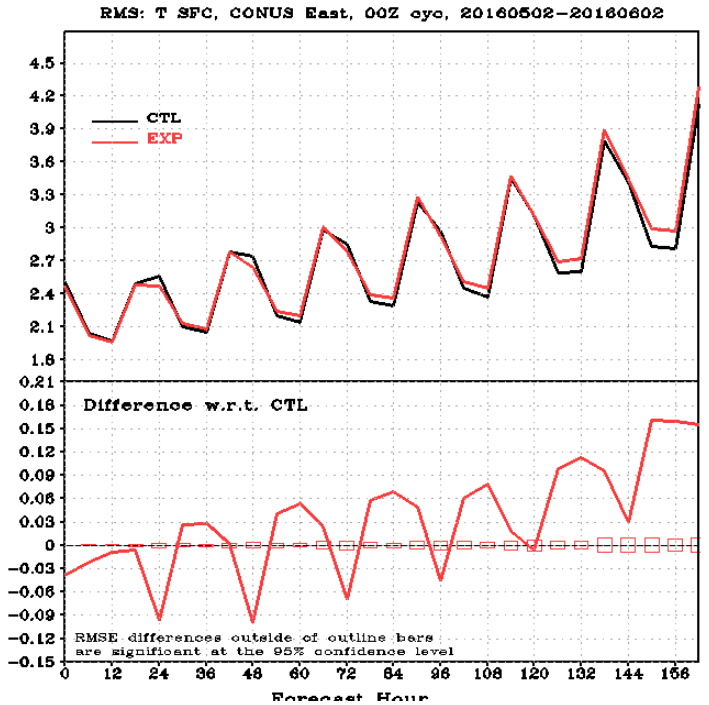
Precipitation Skill Scores over CONUS: f12-f36



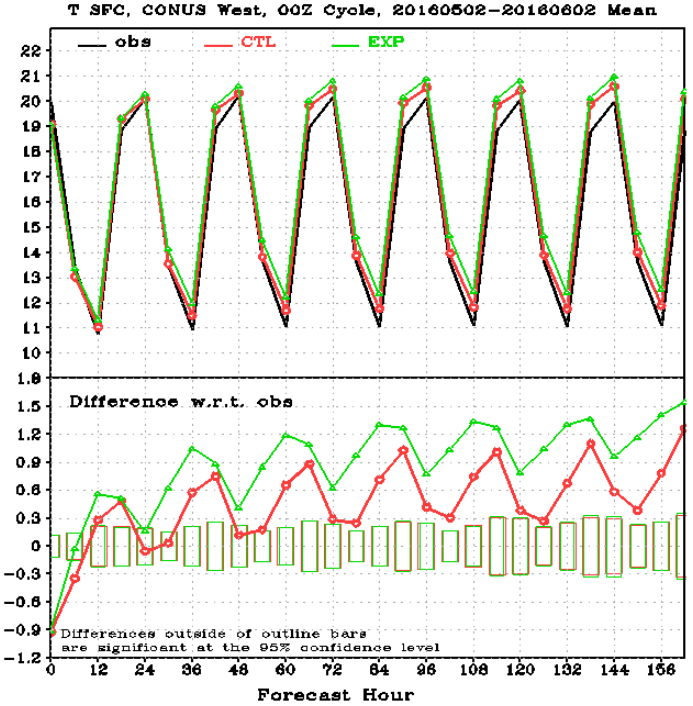
VIIRS test: positive impact for light precipitation

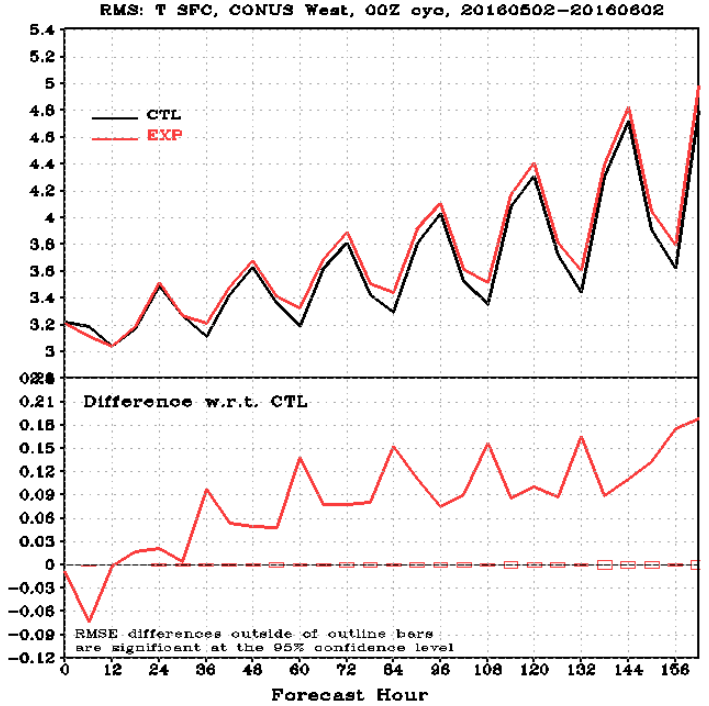
&W. CONUS 5/02-6/02, 2016





East CONUS



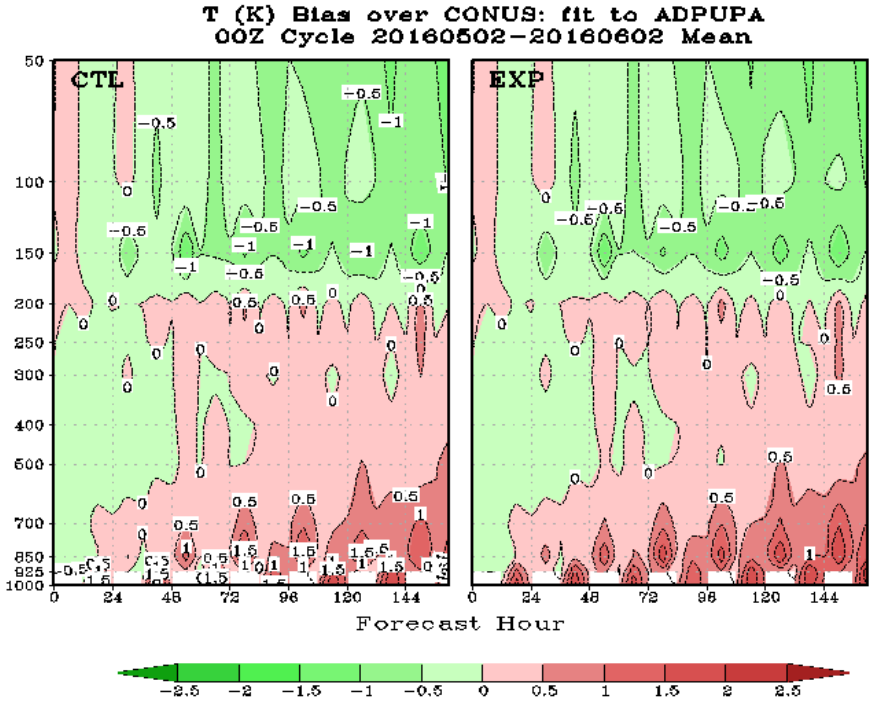


West CONUS

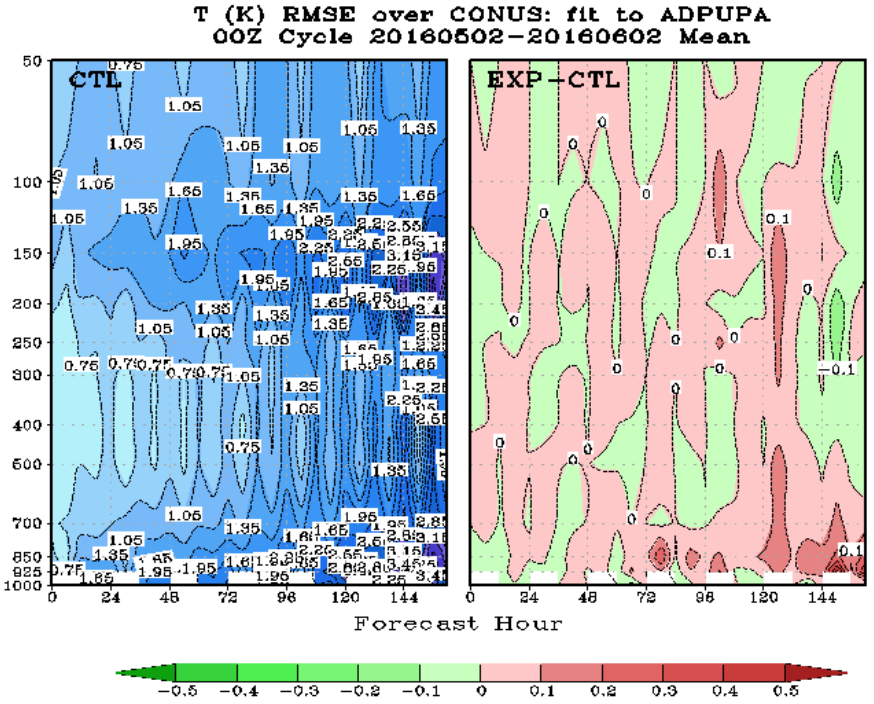
<u>VIIRS:</u>
Increase warm bias and RMSE!

er CONUS 5/02-6/02, 2016

Temp Bias

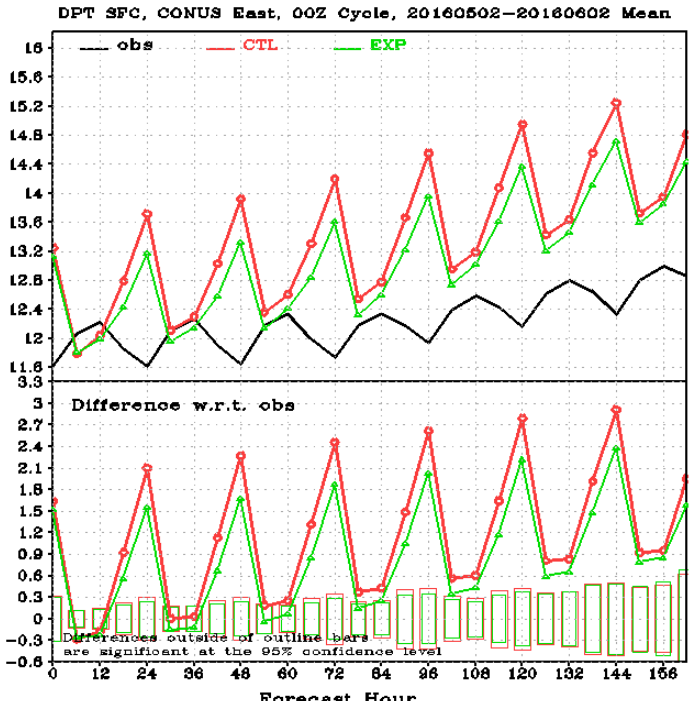


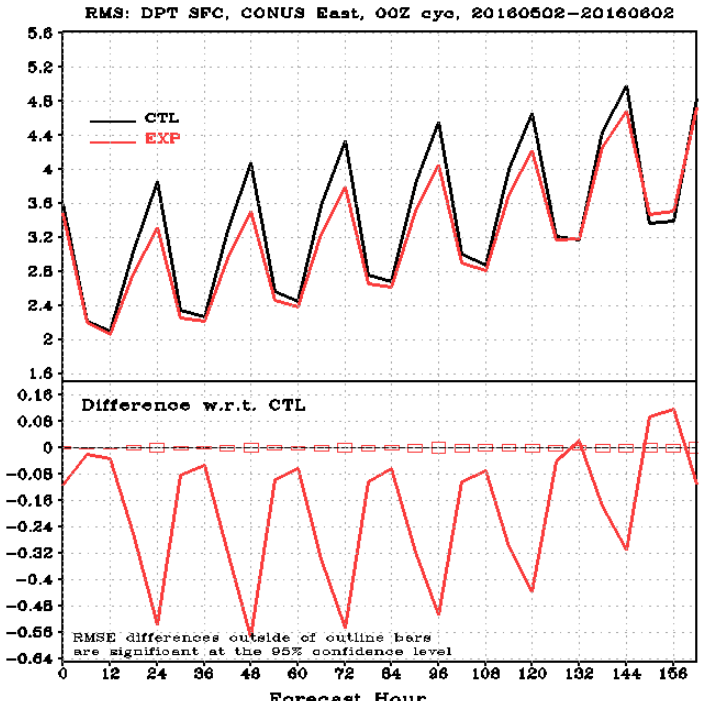
Temp RMSE



VIIRS: Increase warm bias and RMSE!

&W. CONUS 5/02-6/02, 2016



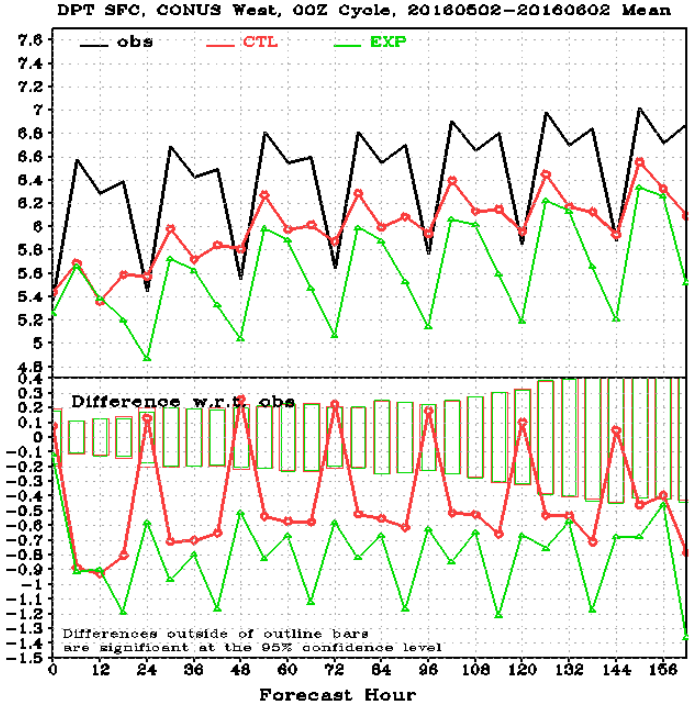


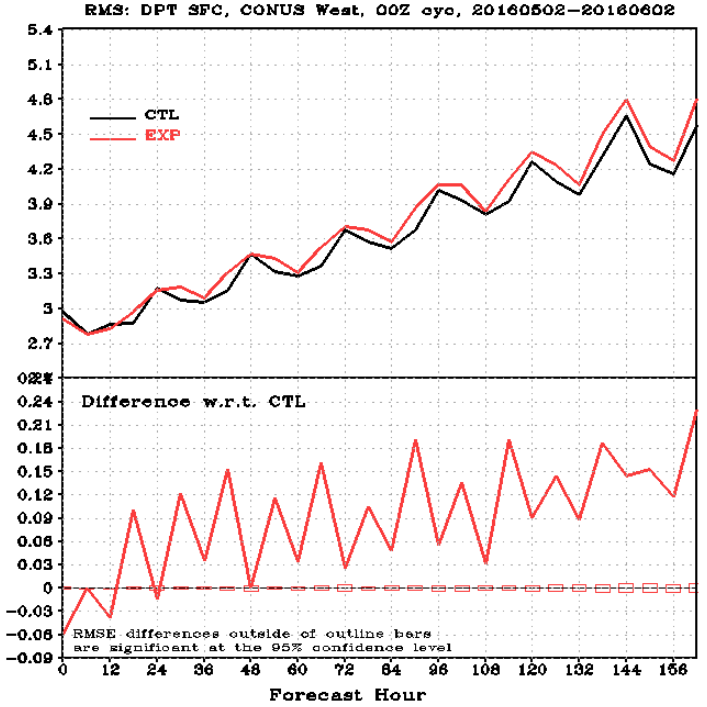
East CONUS

VIIRS:

East CONUS:
Reduce wet bias and RMSE.

West CONUS:
Increase dry bias and RMSE.



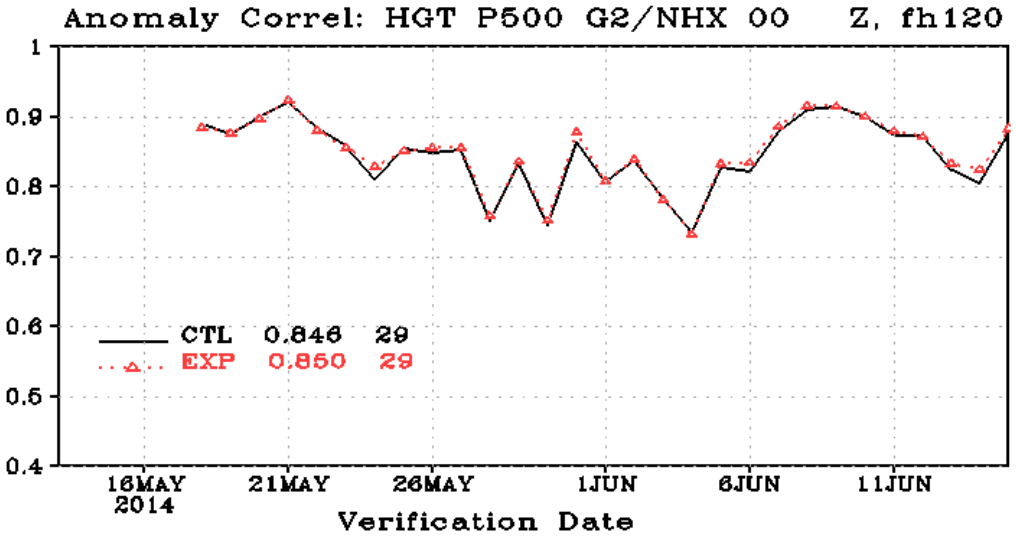


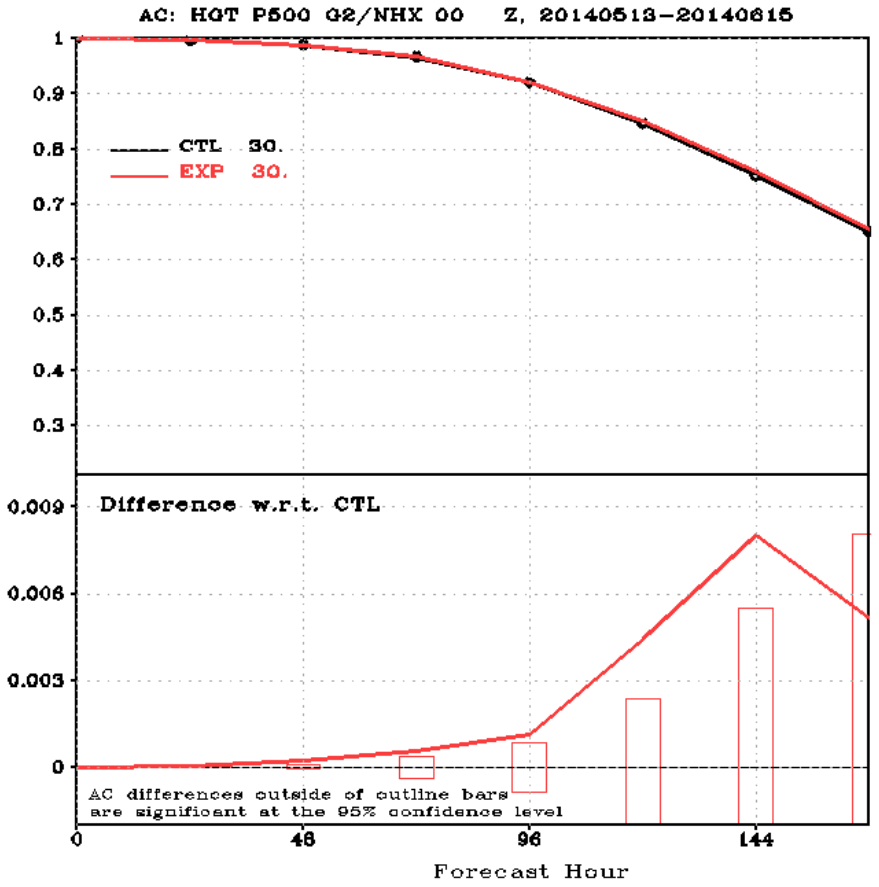
West CONUS

VIIRS GVF (4-y monthly mean) test:

5/13 – 6/15, 2014

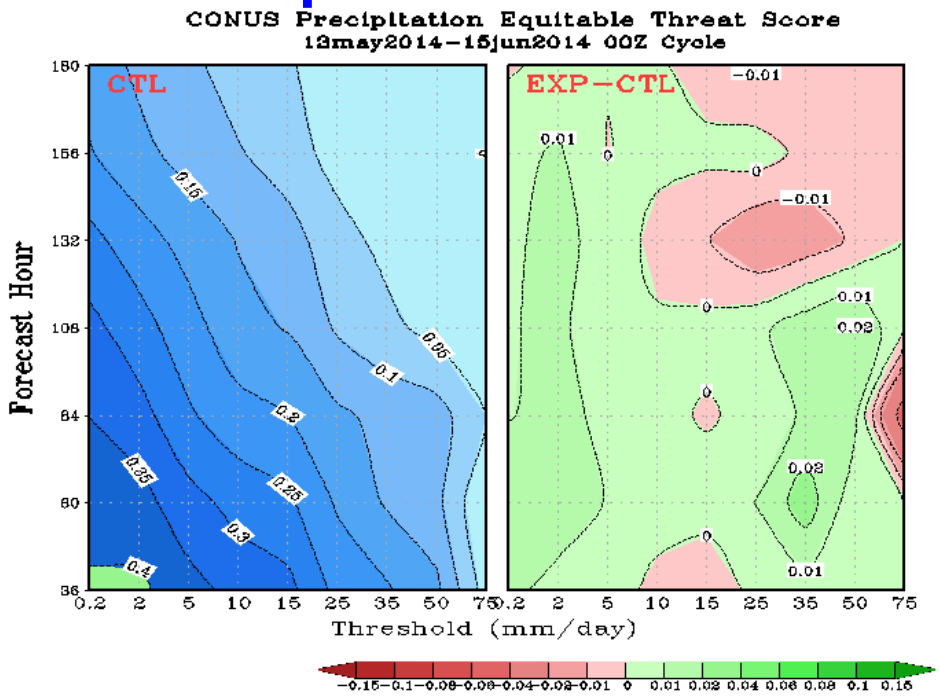
AC: HGT 500 hPa G2/NHX 5/13-6/15 2014

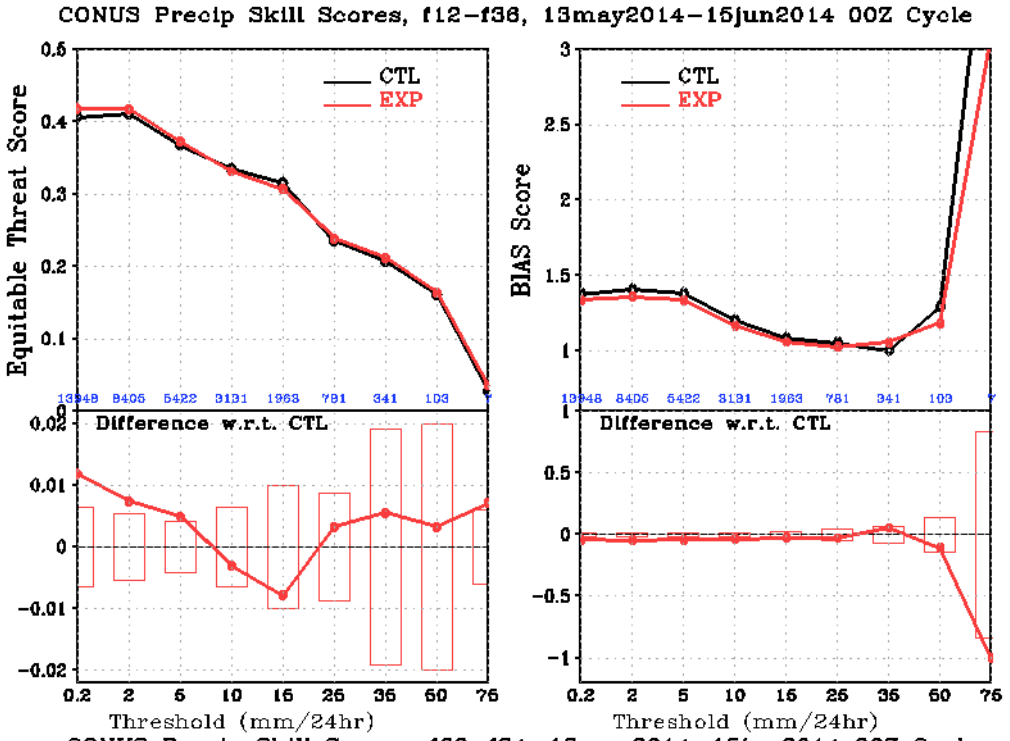


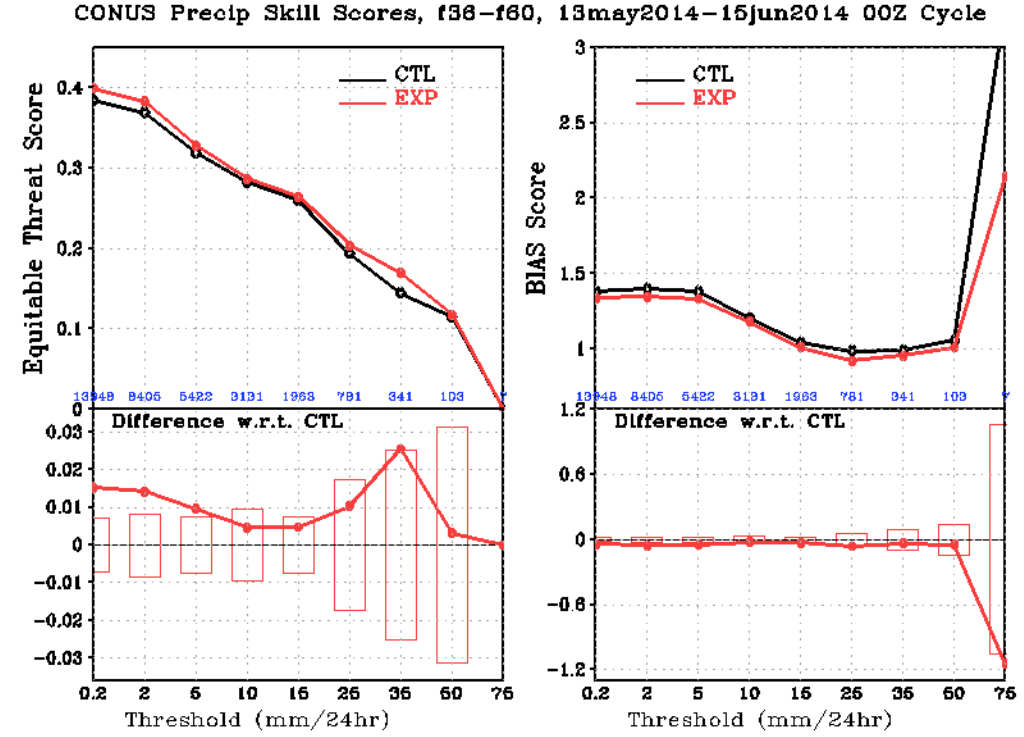


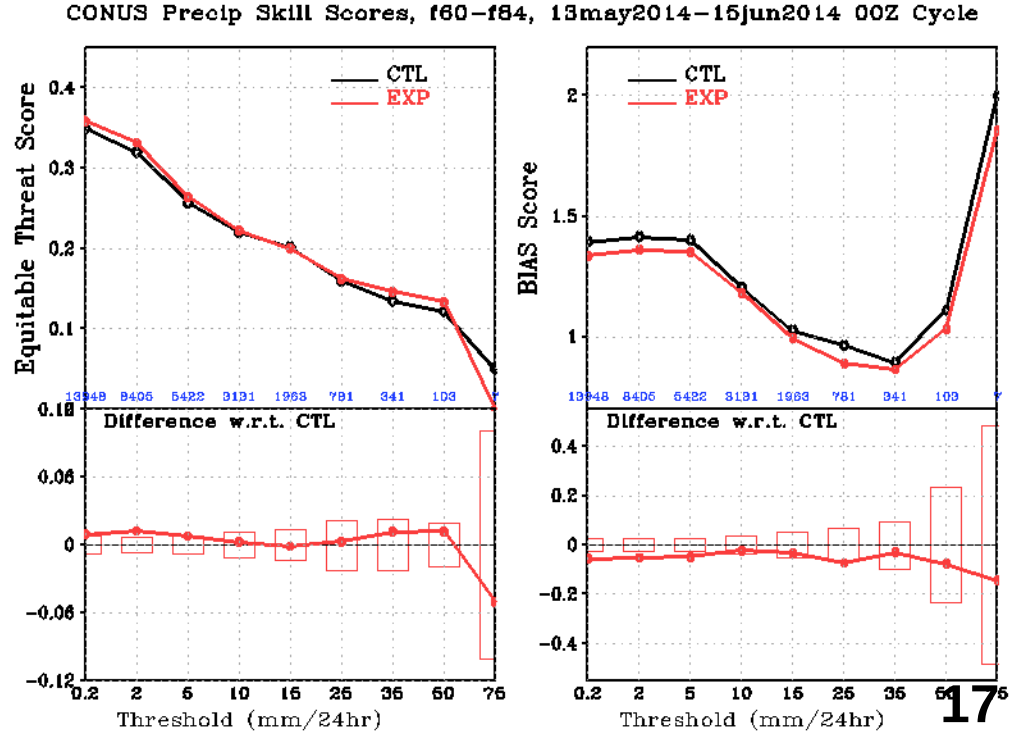
VIIRS test: Improve AC score @500 hPa.

Precipitation Skill Scores over CONUS: 5/13-6/15 2014

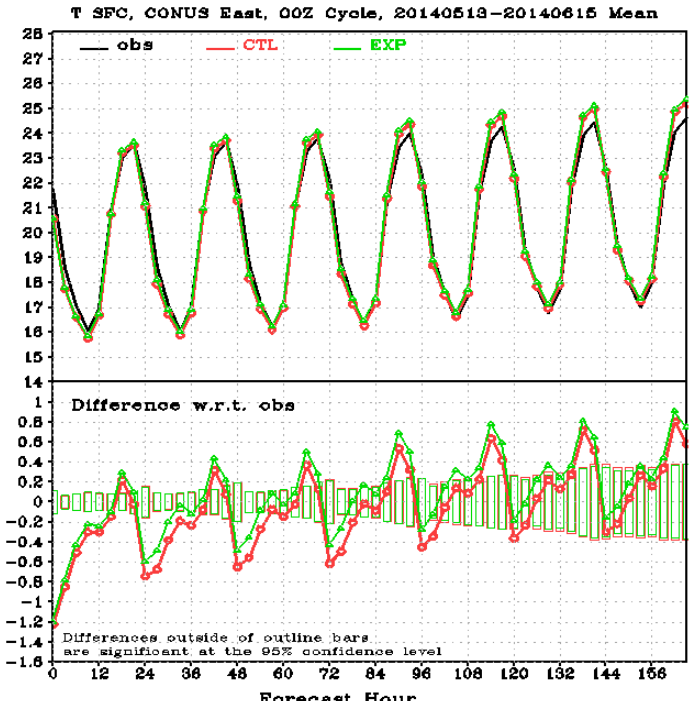


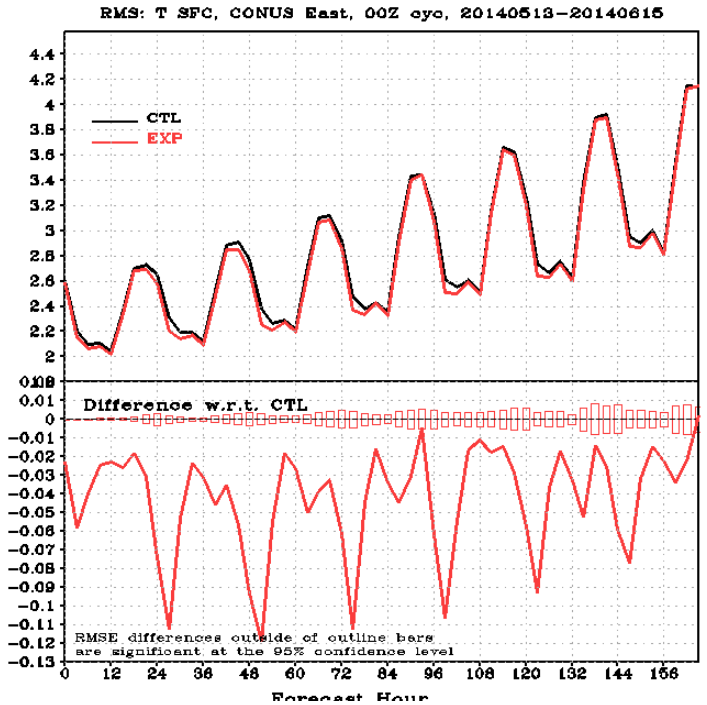






&W. CONUS 5/13-6/15, 2014

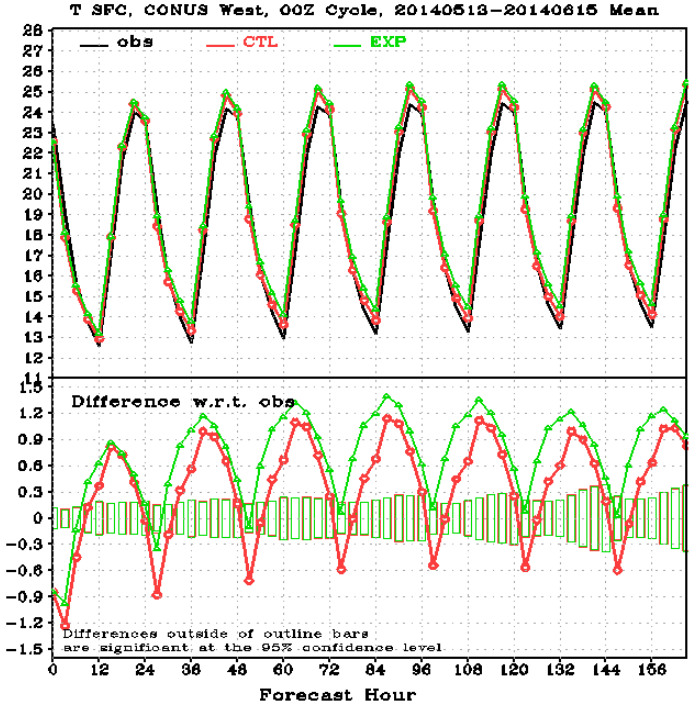


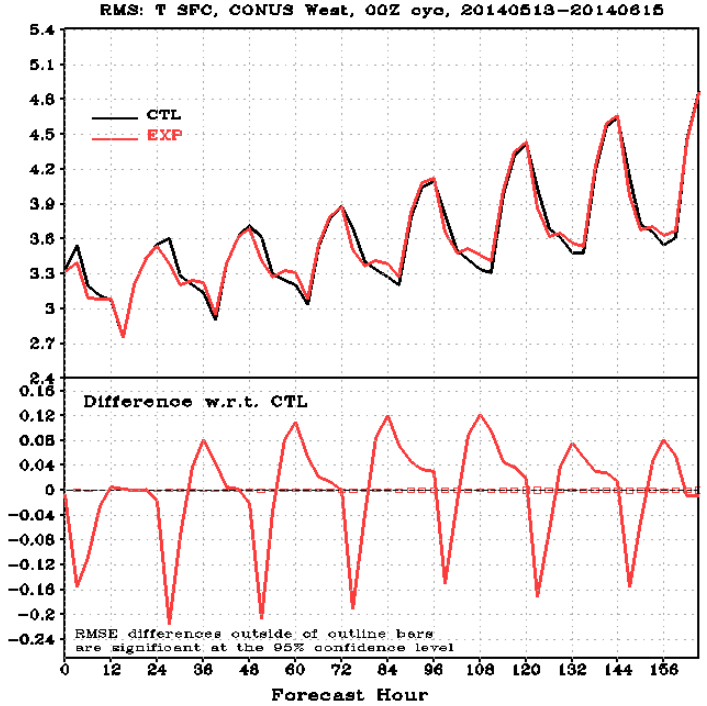


East CONUS

VIIRS:

East CONUS:
Reduce RMSE.

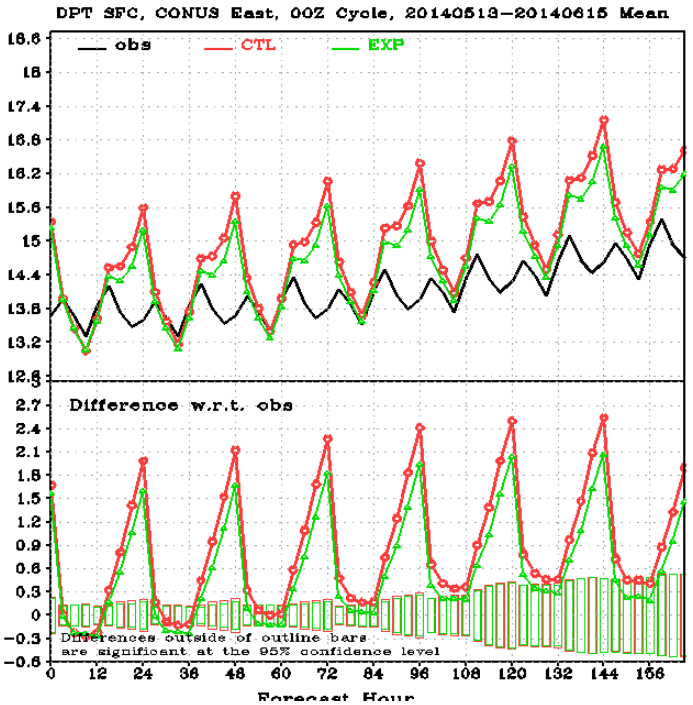


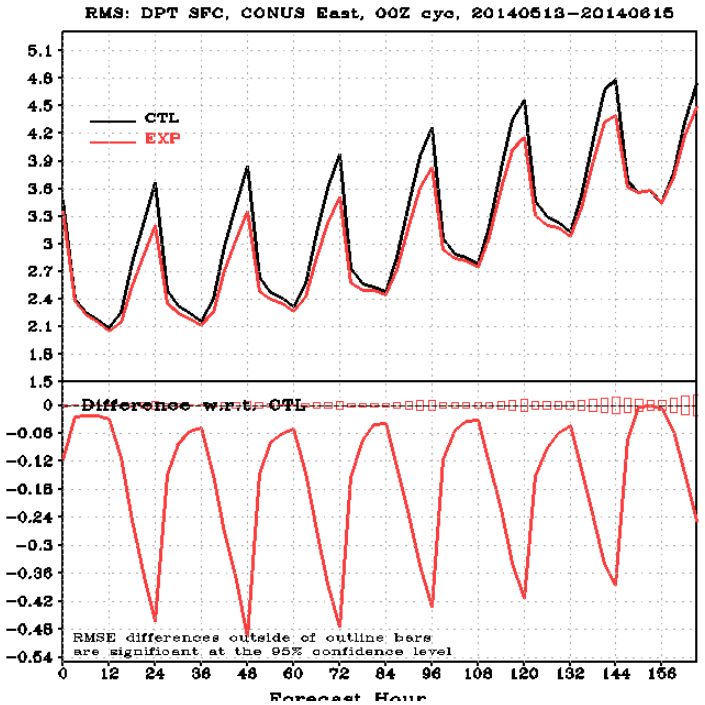


West CONUS:
Increase warm bias.

West CONUS

&W. CONUS 5/13-6/15, 2014



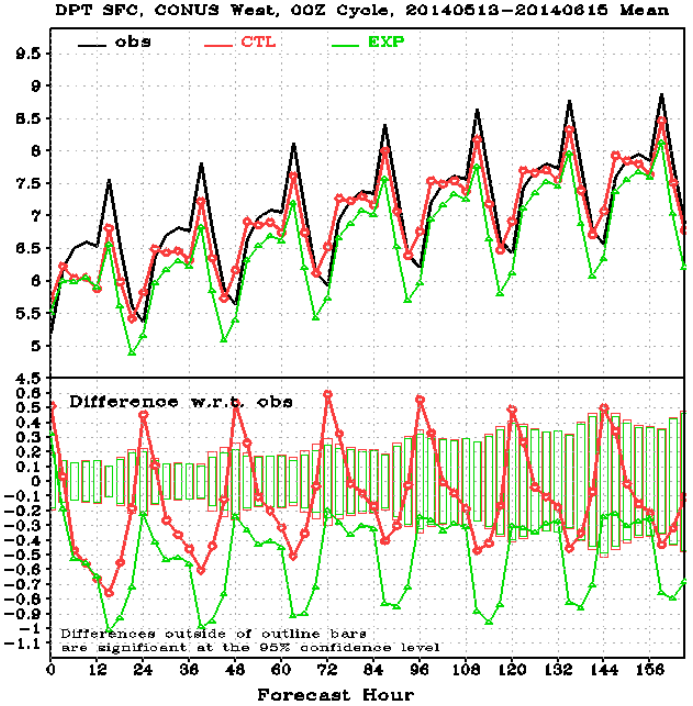


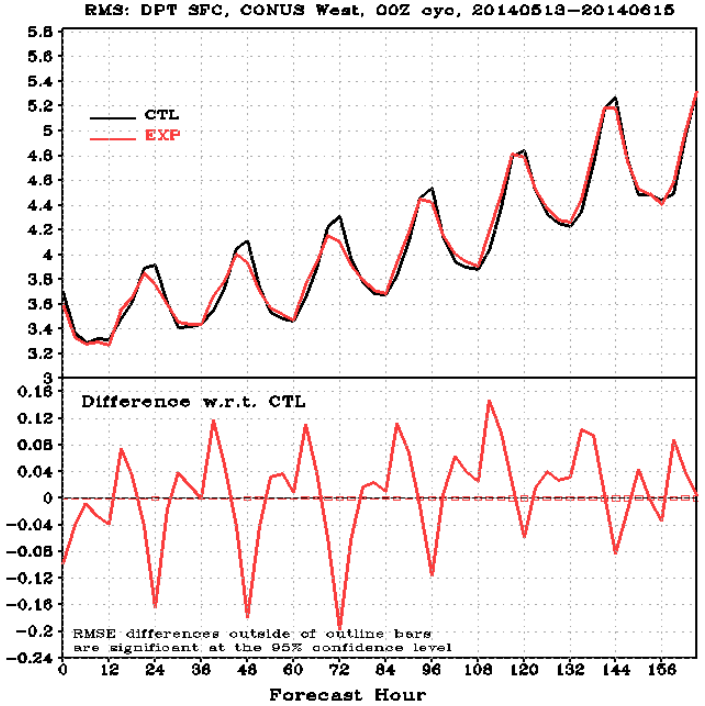
East CONUS

VIIRS:

East CONUS: Reduce wet bias and RMSE.

West CONUS: Increase dry bias.

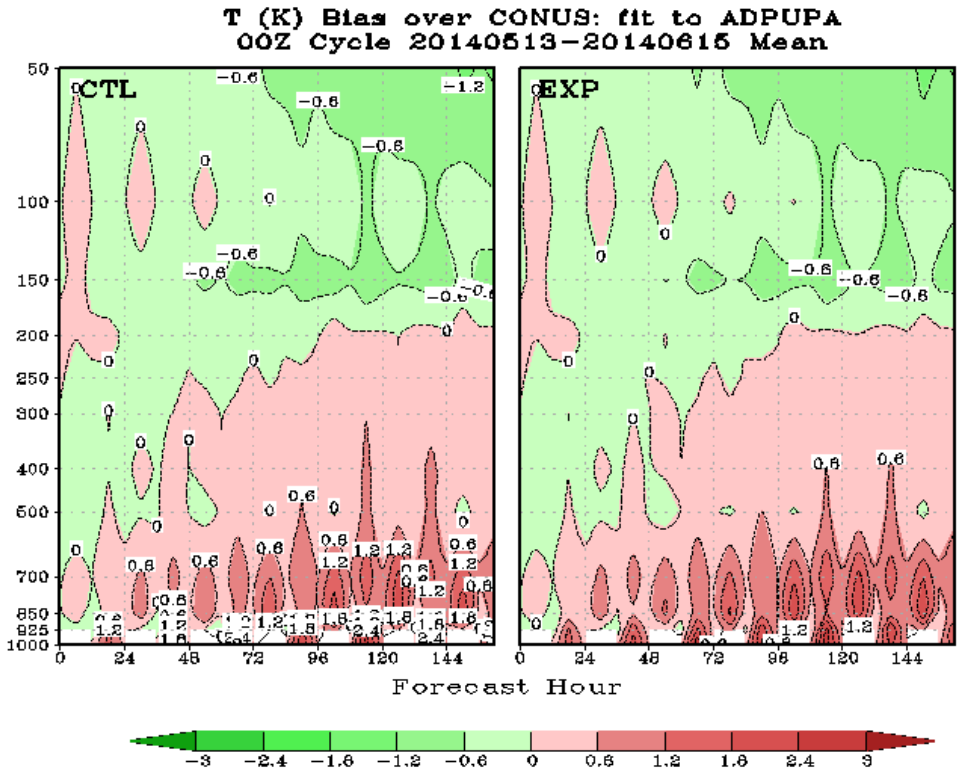




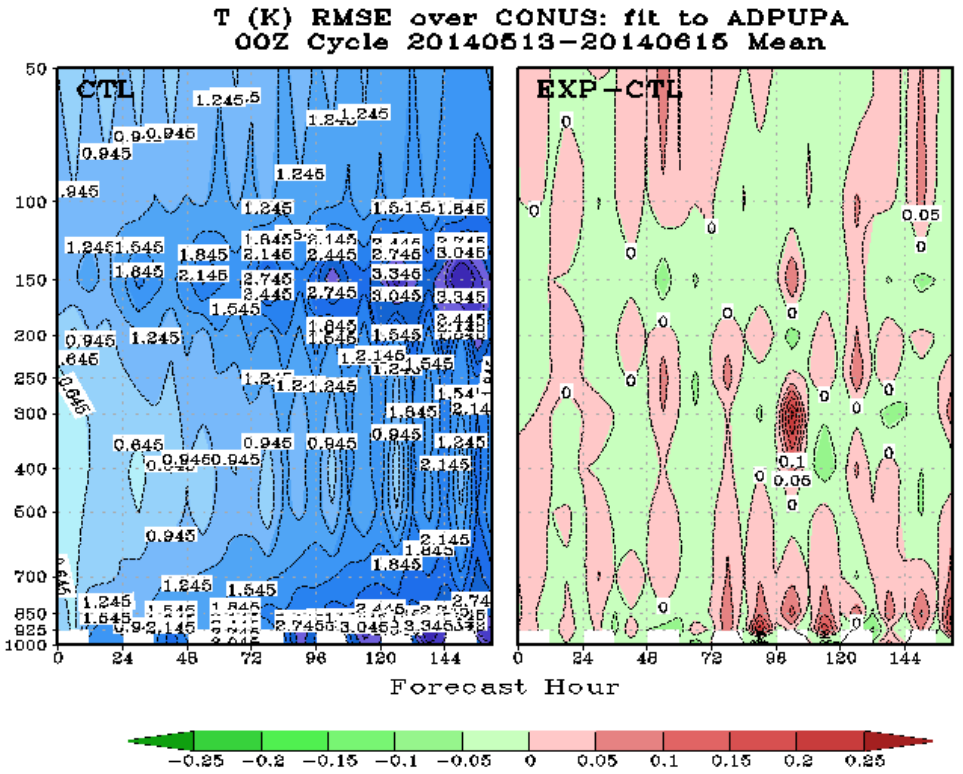
West CONUS

er CONUS 5/13-6/15, 2014

Temp Bias



Temp RMSE



VIIRS: Increase warm bias and RMSE!

Summary

- **Several satellite data sets developed recently (e.g., GVF, snow, burning area, albedo, radiation, soil and vegetation type) have been tested in the NCEP models. The results show good improvements, compared with the current data sets; However, some data sets need further validation with ground measurements, and consistence of all these data sets is required.**

- **VIIRS GVF data has lower values than other data sets, especially in growing seasons, which needs further investigation with ground measuements.**

- **We will continue our efforts and working together with several research teams including NESDIS to improve satellite data utilization and data assimilation and then improve NCEP NWP.**

Thank You !

Any questions/comments?

VIIRS VI Product Validation Methods

1. Global Inter-comparison with Aqua MODIS (or other sensors)
2. Validation using subsets
   a) Inter-comparison with Aqua MODIS
   b) Comparison with Aeronet-based surface reflectance
   c) Comparison with in situ reflectance (tower, UAV, airborne)
   d) Validation using FLUXNET productivity data

Global Comparison with Aqua MODIS

APU for the Month of July (DOY 192, 194, & 197) 2017

TOA NDVI

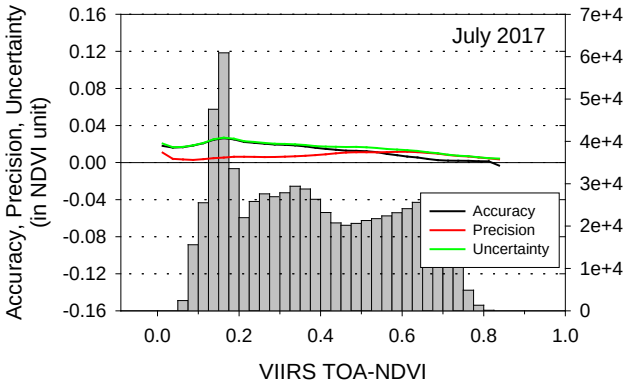
TOA-NDVI	Global APU	L1R
Accuracy	0.016	0.05
Precision	0.011	0.04
Uncertainty	0.019	0.06

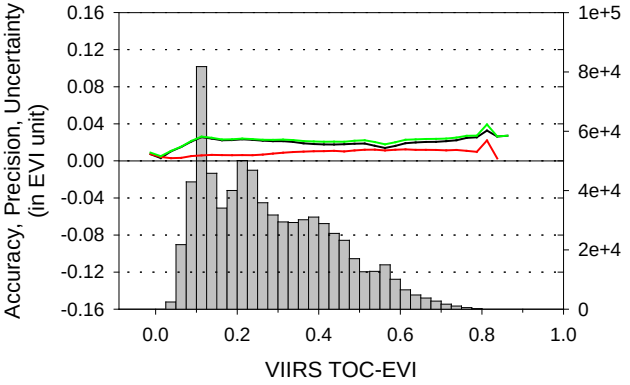
TOC EVI

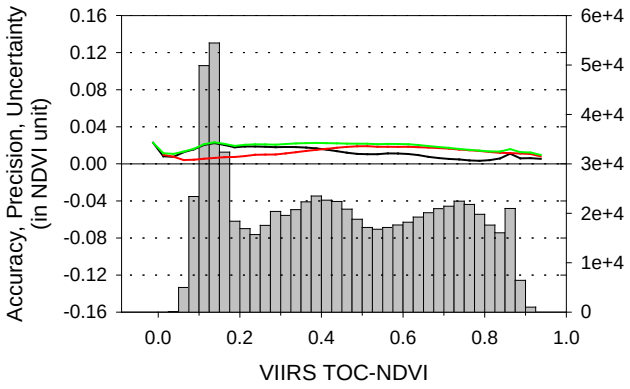
TOC-EVI	Global APU	L1R
Accuracy	0.020	0.05
Precision	0.009	0.04
Uncertainty	0.022	0.06

TOC NDVI

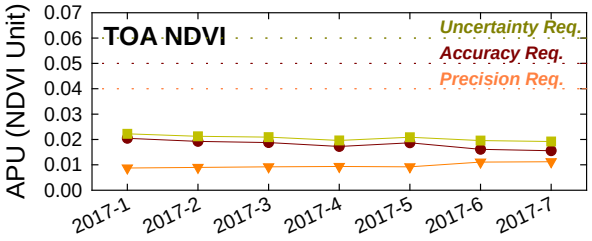
TOC-NDVI	Global APU	L1R
Accuracy	0.012	0.05
Precision	0.016	0.04
Uncertainty	0.020	0.06

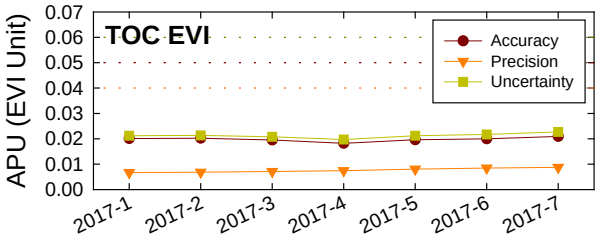


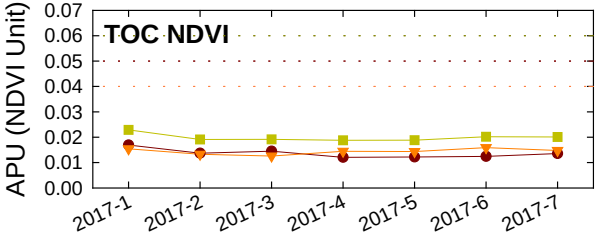




Global APU Time Series Plots for 2017



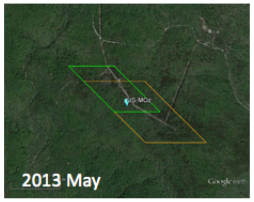


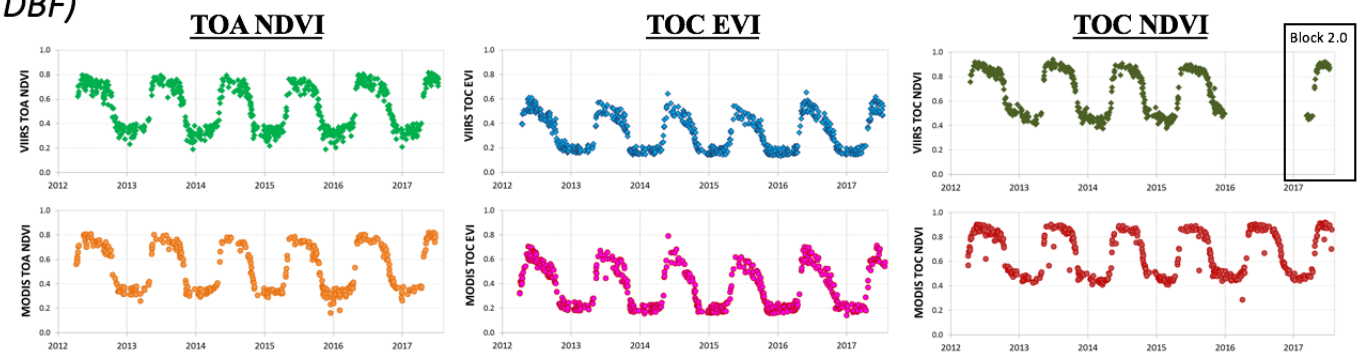


Inter-Comparison of VI Profiles

Missouri Ozark (DBF)

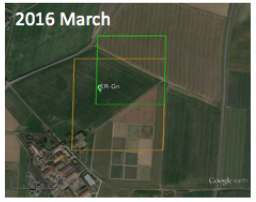


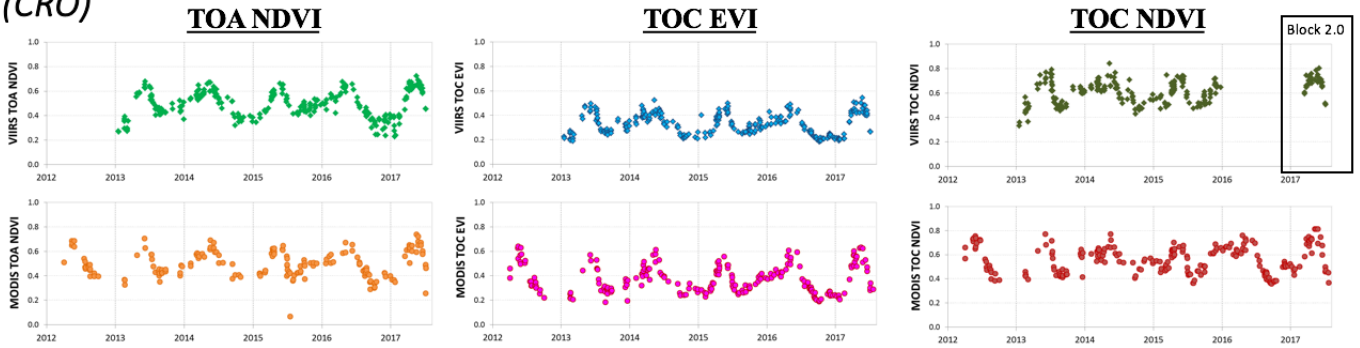




Grignon, France (CRO)

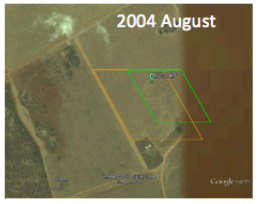


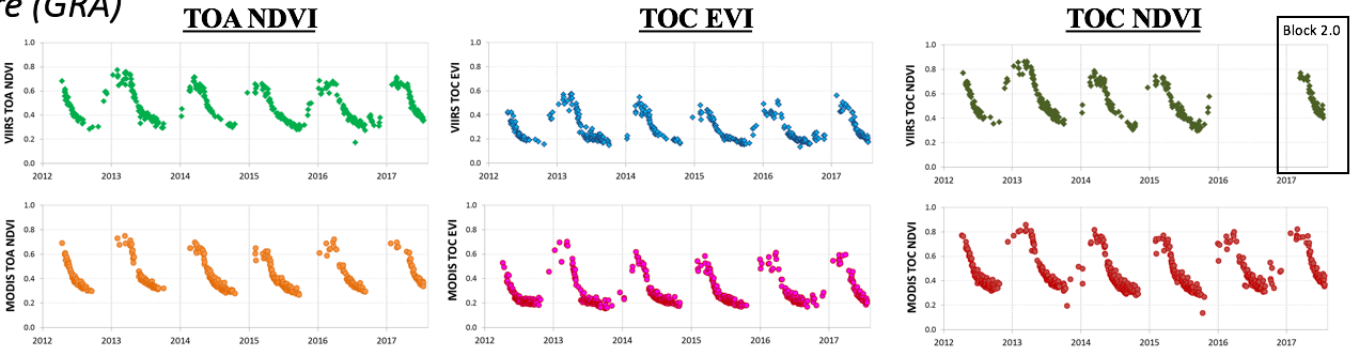




Daly River Pasture (GRA)

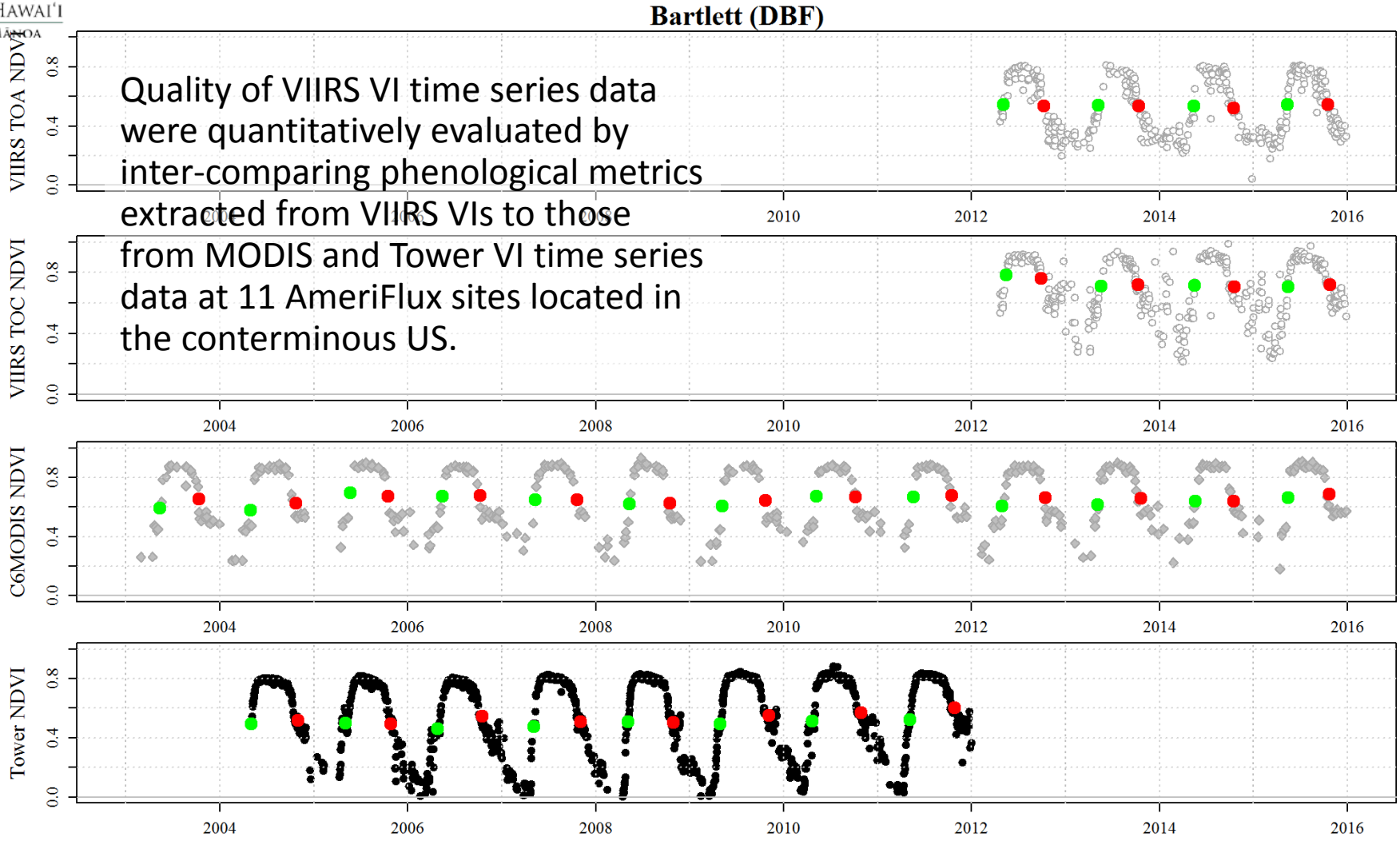






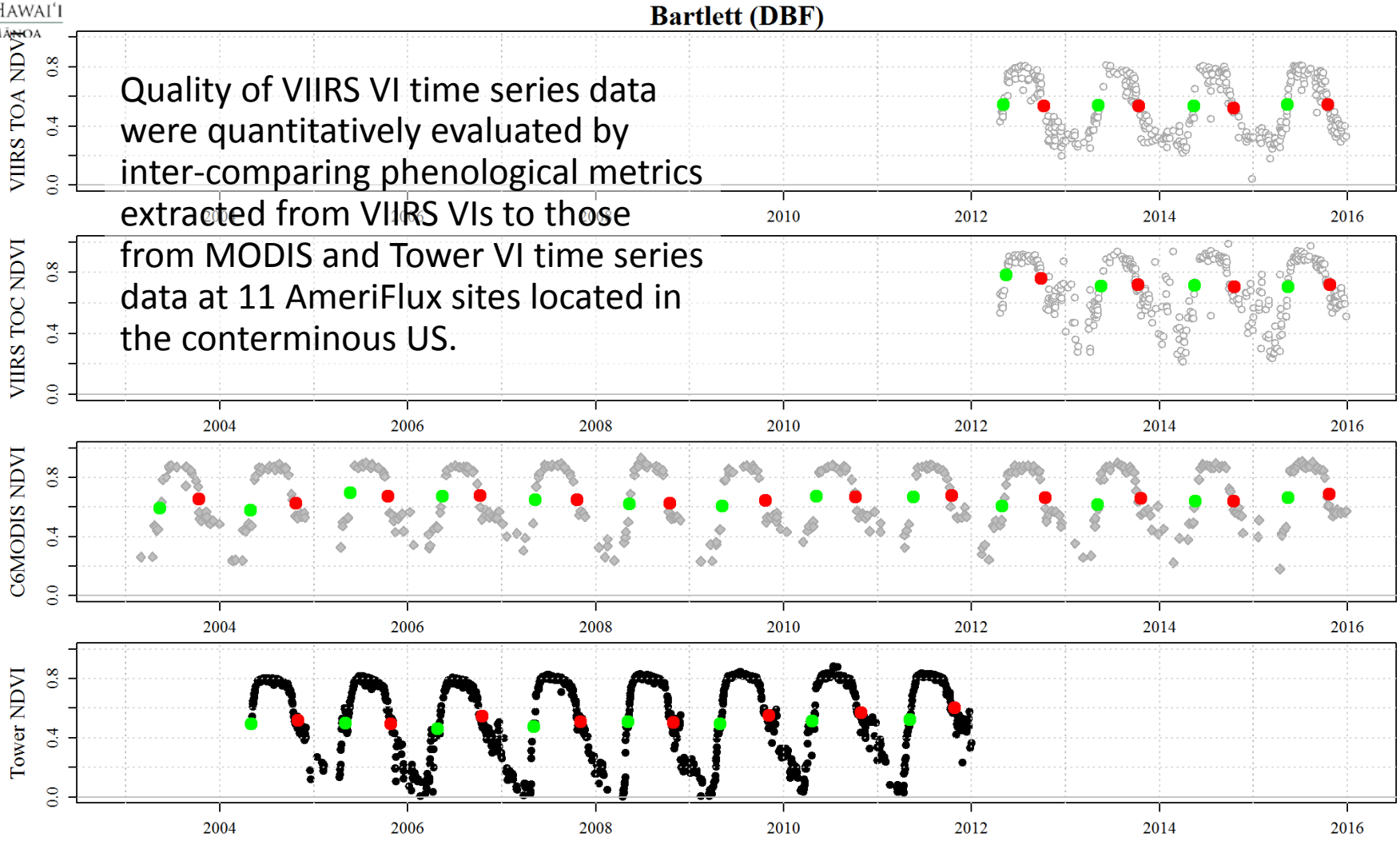
Comparison with *in situ* VIs

Quality of VIIRS VI time series data were quantitatively evaluated by inter-comparing phenological metrics extracted from VIIRS VIs to those from MODIS and Tower VI time series data at 11 AmeriFlux sites located in the conterminous US.



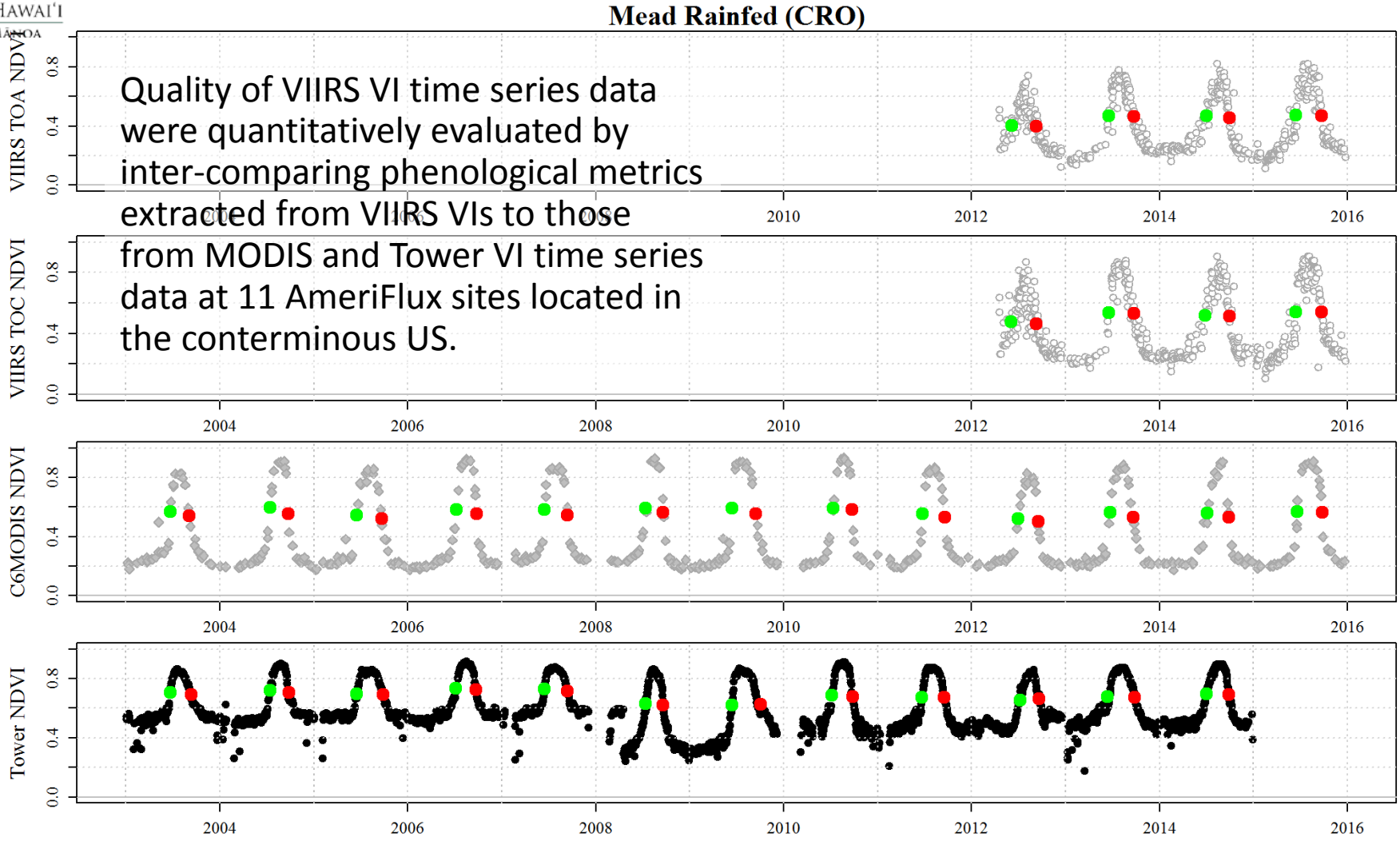
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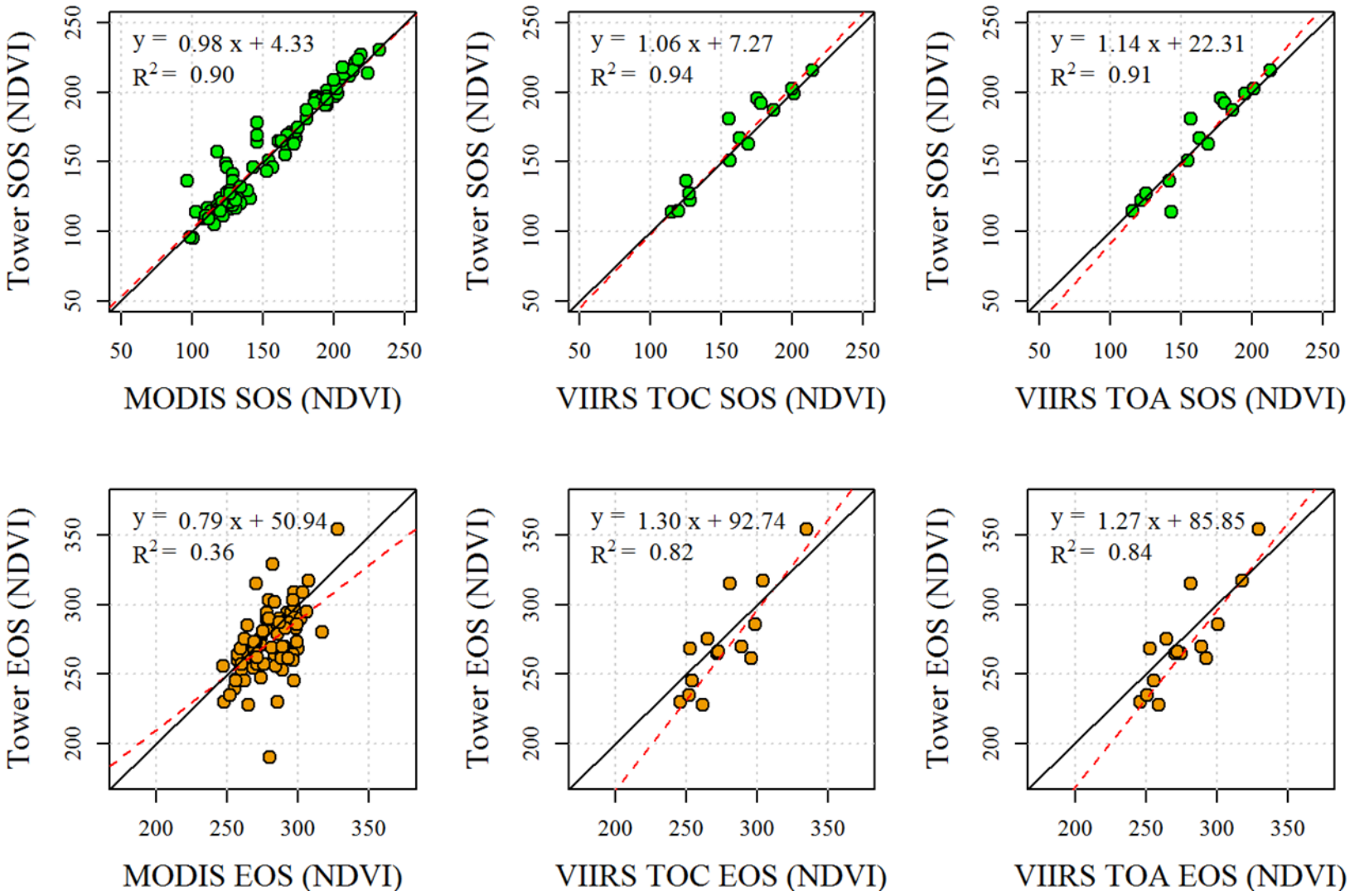


Comparison with *in situ* VIs

Quality of VIIRS VI time series data were quantitatively evaluated by inter-comparing phenological metrics extracted from VIIRS VIs to those from MODIS and Tower VI time series data at 11 AmeriFlux sites located in the conterminous US.



Inter-Comparison of Start and End of Growing Seasons (SOS & EOS) Derived from VIIRS, MODIS, and Tower NDVI



Inter-Comparison of Length of Growing Season Derived from VIIRS, MODIS, and Tower VIs

Tower vs. MODIS (C6) | **Tower vs. VIIRS** | **MODIS (C6) vs. VIIRS**

