Development and Evaluation of the Terrestrial Environmental Data Products from the Suomi NPP satellite

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and the SNPP/JPSS Land Product Team

Member Roles and Responsibilities

Role or Product Focus	Name	Affiliation
Product Lead, Fire	*Ivan Csiszar* / Wilfrid Schroeder	NOAA / UMD
Validation Lead, LST	Jeff Privette / Pierre Guillevic	NOAA / NCState
Surface Reflectance, Cloud Mask & Calibration Liaison	*Eric Vermote*	NASA
Surface Reflectance	Alex Lyapustin	NASA
Vegetation Index	*Marco Vargas*	NOAA
Vegetation Index	Tomoaki Miura/ Alfredo Huete	Univ. of Hawaii / Arizona
Albedo	*Yunyue (Bob) Yu* / Shunlin Liang	NOAA / UMD
Albedo	Crystal Schaaf	Univ. Mass.
Land Surface Temperature	*Bob Yu*	NOAA
Team Coordination, Fire	Chris Justice	UMD
NASA Coordination & Validation	Miguel Román	NASA
Surface Type	*Jerry Zhan*	NOAA
Surface Type	Mark Friedl	Boston Univ.

Italics indicates Product Lead. Otherwise: Validation Lead

SNPP Land Team Algorithm Development and Validation Strategy

- Leverage MODIS and other mature and validated "heritage" satellite systems
  - SNPP and EOS Aqua allow for near-simultaneous observations
  - but there are differences between VIIRS and MODIS (geometrical and spectral)

- Consider mission requirements for real-time applications and product specifications

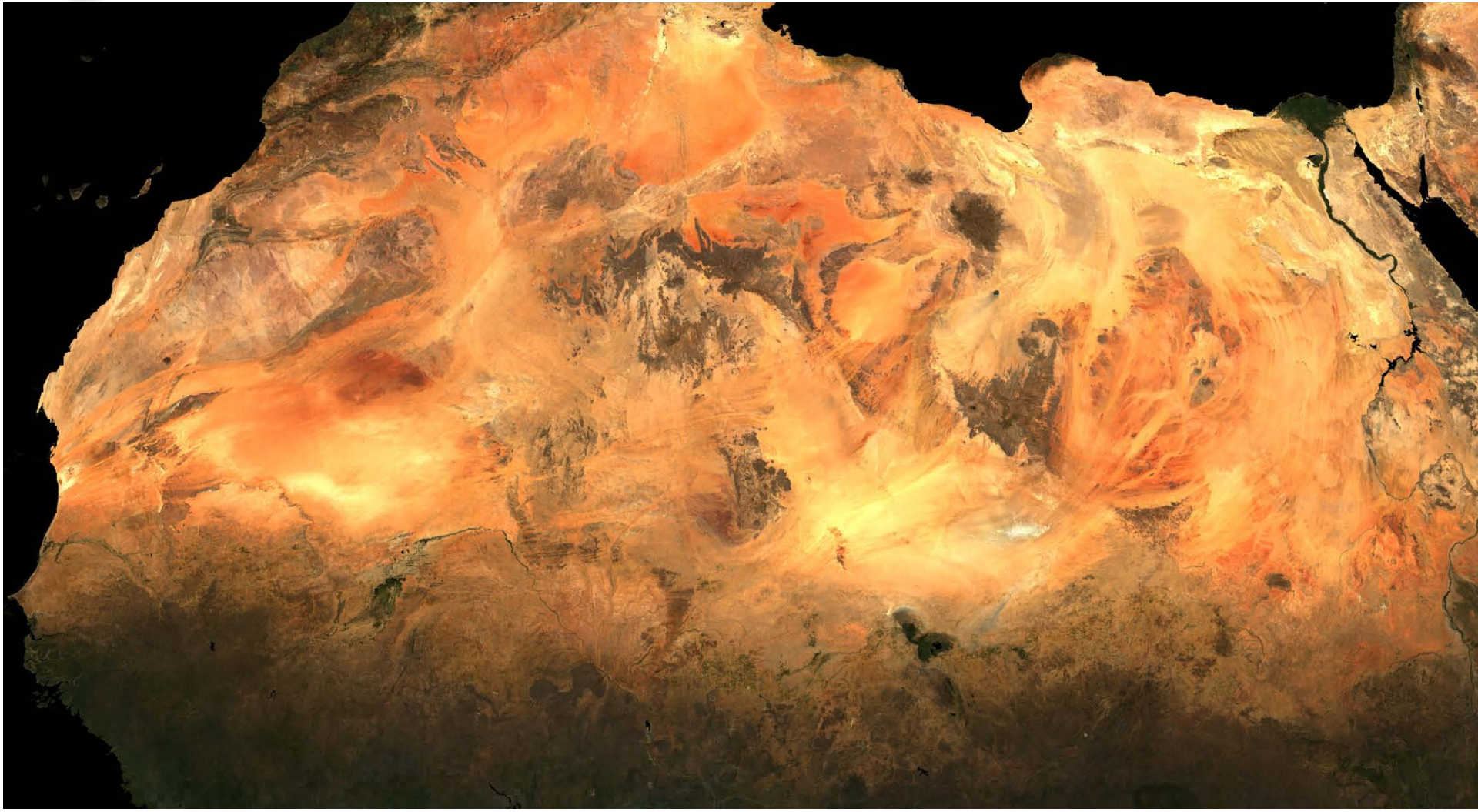
- Adapt proven validation methods (EOS, CEOS)
  - Must consider affordability over JPSS Program lifecycle (~2026)
  - Statistically-based assessments over long-term field networks (e.g., CRN, AERONET) are more economical than more precise field campaigns
  - Limited field campaigns as needed

- Close partnership with NASA Land PEATE and SNPP Science Team, the NOAA NDE program, Northrop Grumman and Raytheon

Major Land Team activities during the first year of on-orbit SNPP data

- Supported Early Orbit Check-out and phased into Intensive Calibration and Validation
- Continuing support of SDR evaluation and development
- Land EDR feedback on VIIRS Cloud Mask
- Continuing analysis of discrepancies and proposal/implementation of algorithm and code changes
- Moved forward with EDR maturity
  - Beta: Active Fires, Surface Reflectance, Vegetation Index, Land Surface Temperature
- Supported evaluation of seeded/granulated/intermediate data (NDVI, QST, LWM, LSA17Day, Snow-Ice-Cover Rolling)
- Quality flag evaluation and science support for QF testing
- Review and revision of JPSS Level 1 Requirements Supplement
  - High level product specifications, including major changes in some products
  - Promotion of Active Fires (done) and Surface Reflectance (in progress) to EDR status

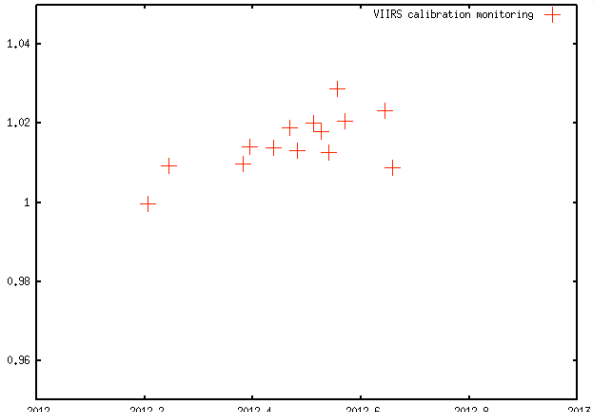
Surface Reflectance



Courtesy A. Lyapustin/NASA

Surface Reflectance

VIIRS Level 3 Global 0.05Deg Global Climate Modeling Grid (CMG) Surface Reflectance Intermediate Product (Land PEATE- adjusted version of the SR-IP IDPS algorithm) for 10/26/12



DR number	Short Description
DR 4488	Processing of surface reflectance under extended conditions (cloudy, high aerosol etc..) to enable an easier assessment of VCM and atmospheric correction

Continuous calibration monitoring

E. Vermote , UMD

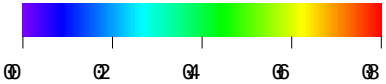
Surface Reflectance

Comparison of Operational VIIRS Products & "Truth"*

VIIRS Cloud Mask, Aerosol Optical Depth (AOT) & SR

East Coast USA (NY) on August 2 and 16.

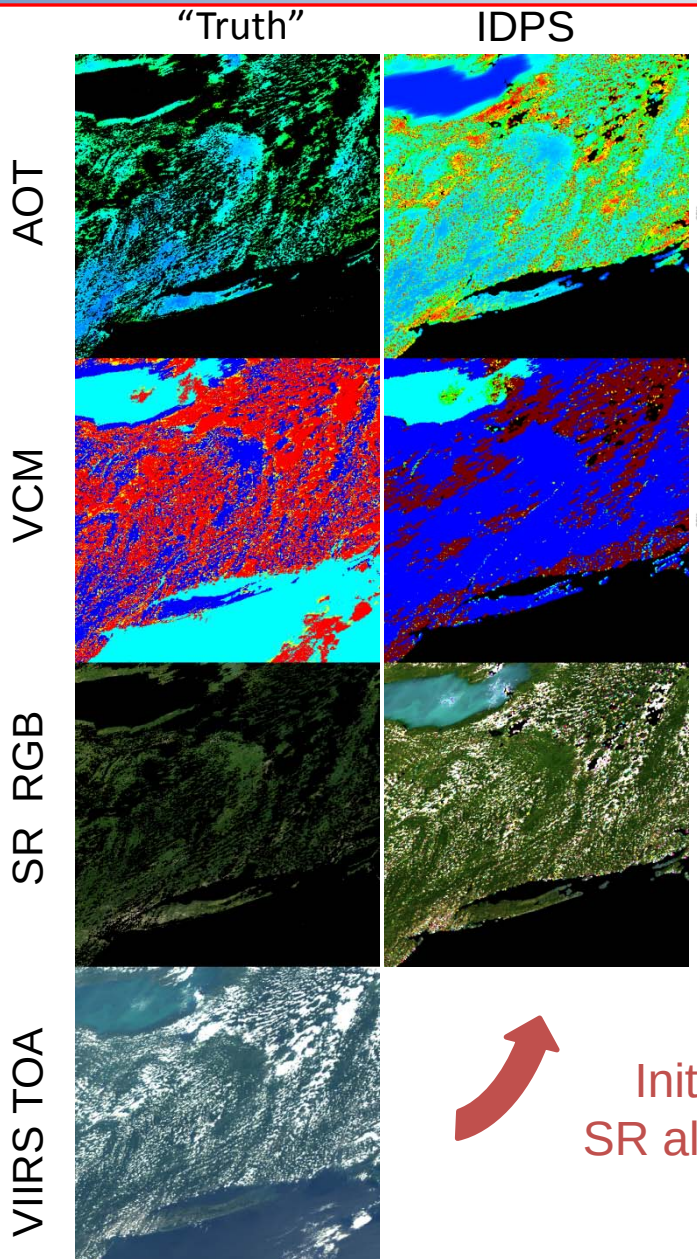
AOT scale

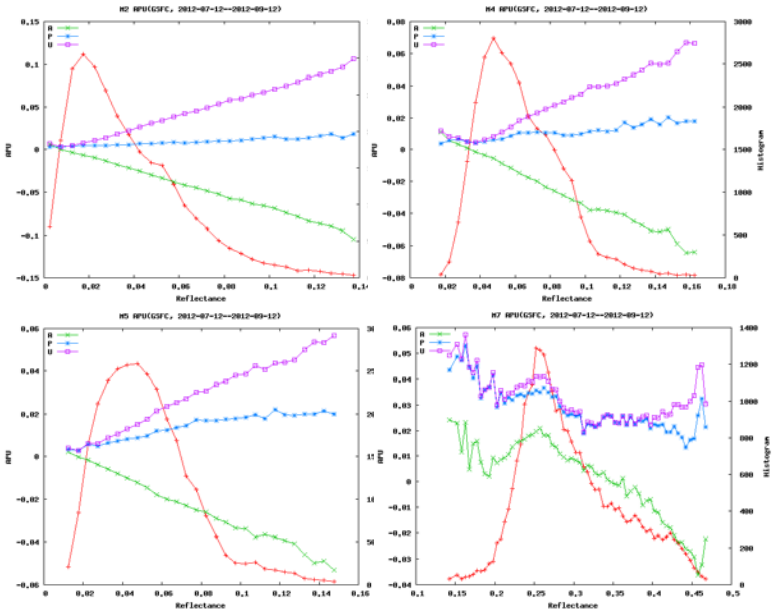


Cloud Mask Legend

Blue/Cyan (Clear Skies)
Red & Yellow (Cloudy),
Dark red (Cloud Shadow)

* "Truth" estimated via Multiangle implementation of atmospheric correction (MAIAC) system



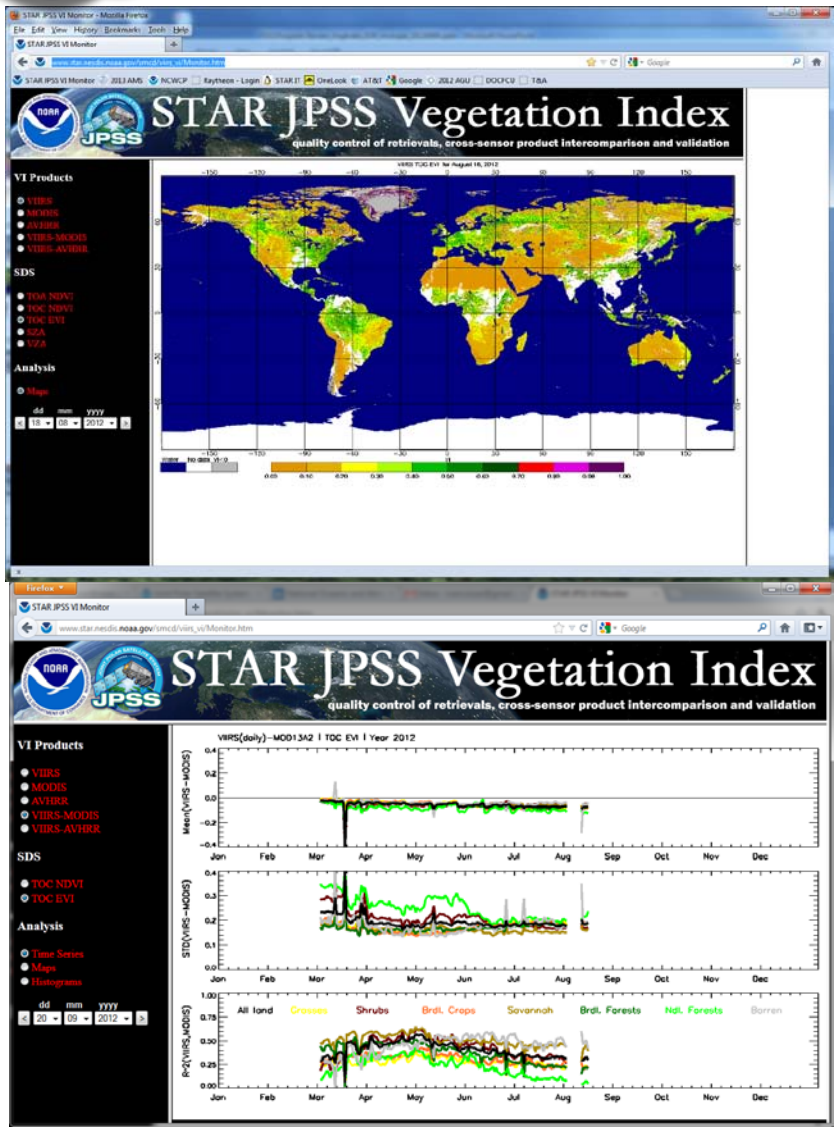


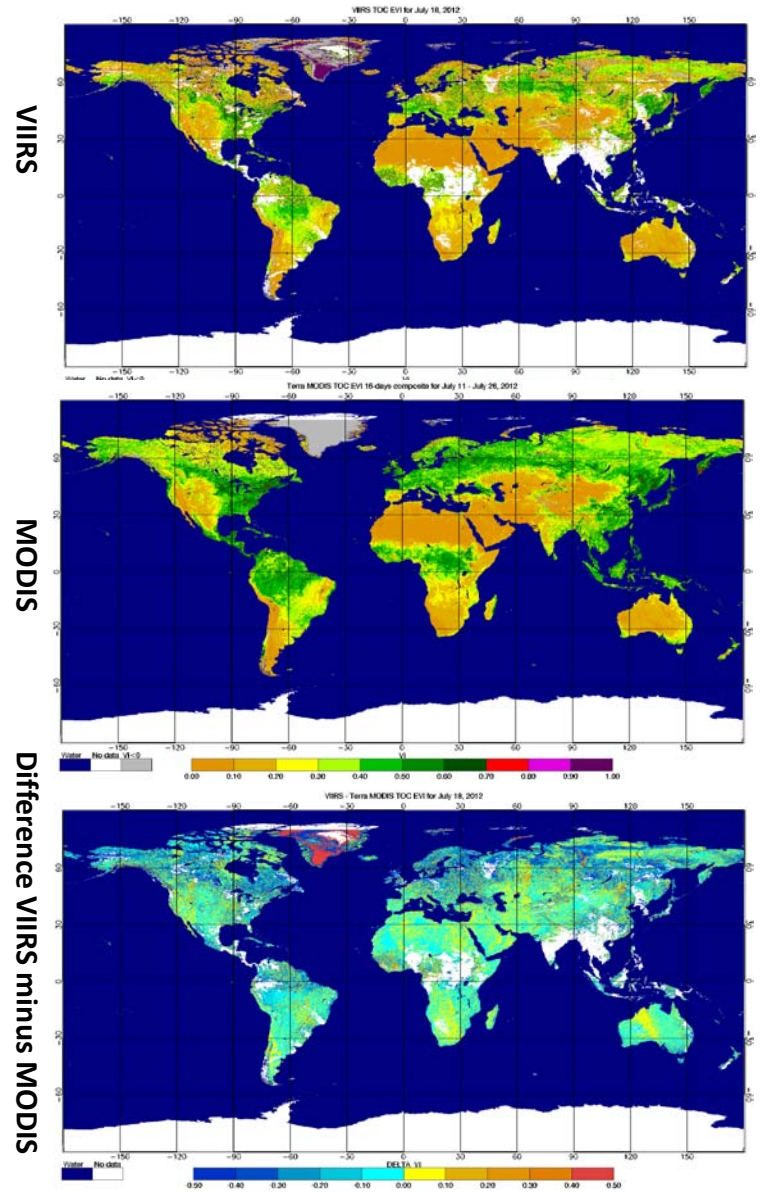
An example of APU plots in bands M2, M4, M5, M7 for the GSFC site.

Initial results suggest SR algorithm working well

Courtesy A. Lyapustin/NASA

VIIRS Vegetation Index





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

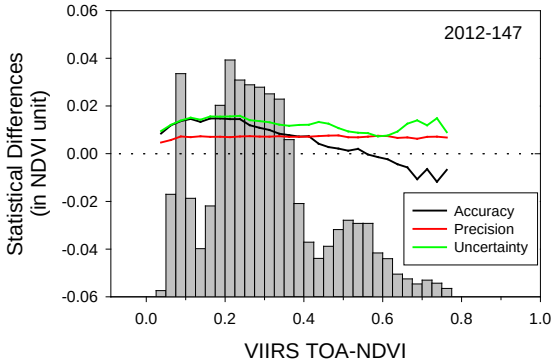
M.Vargas, N. Shabanov NOAA; T. Muira, Univ. Hawaii

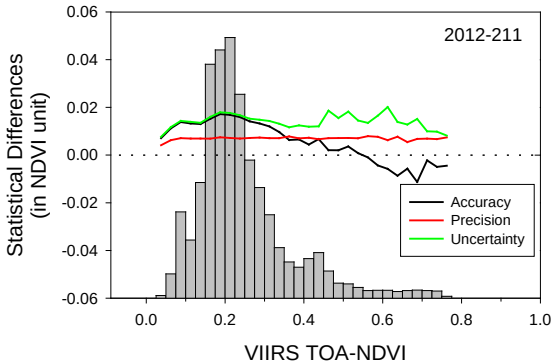
16-day TOC EVI composites for July 11-26 2012

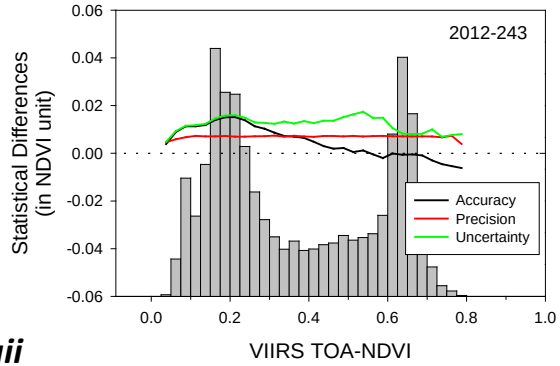
VIIRS Vegetation Index

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

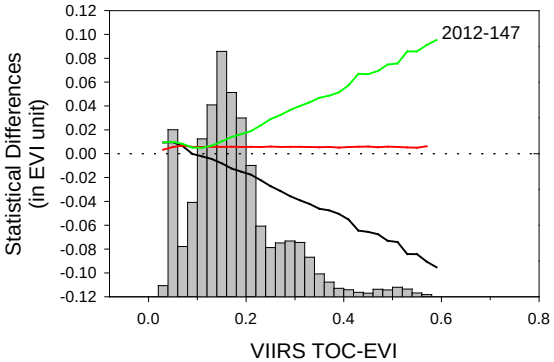
TOA-NDVI

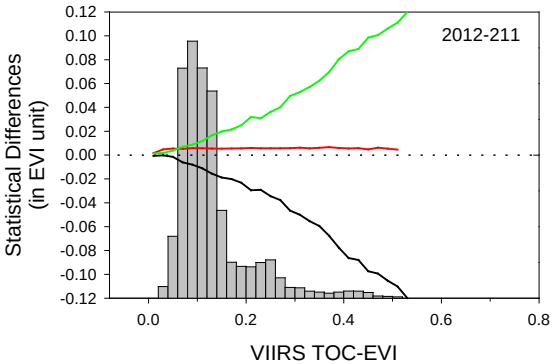


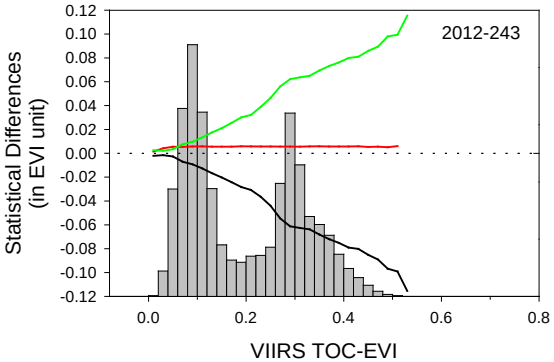




TOC-EVI







APU Summary Tables

2012-147

	TOA-NDVI	TOC-EVI
A	0.005	-0.04
P	0.007	0.005
U	0.012	0.05

2012-211

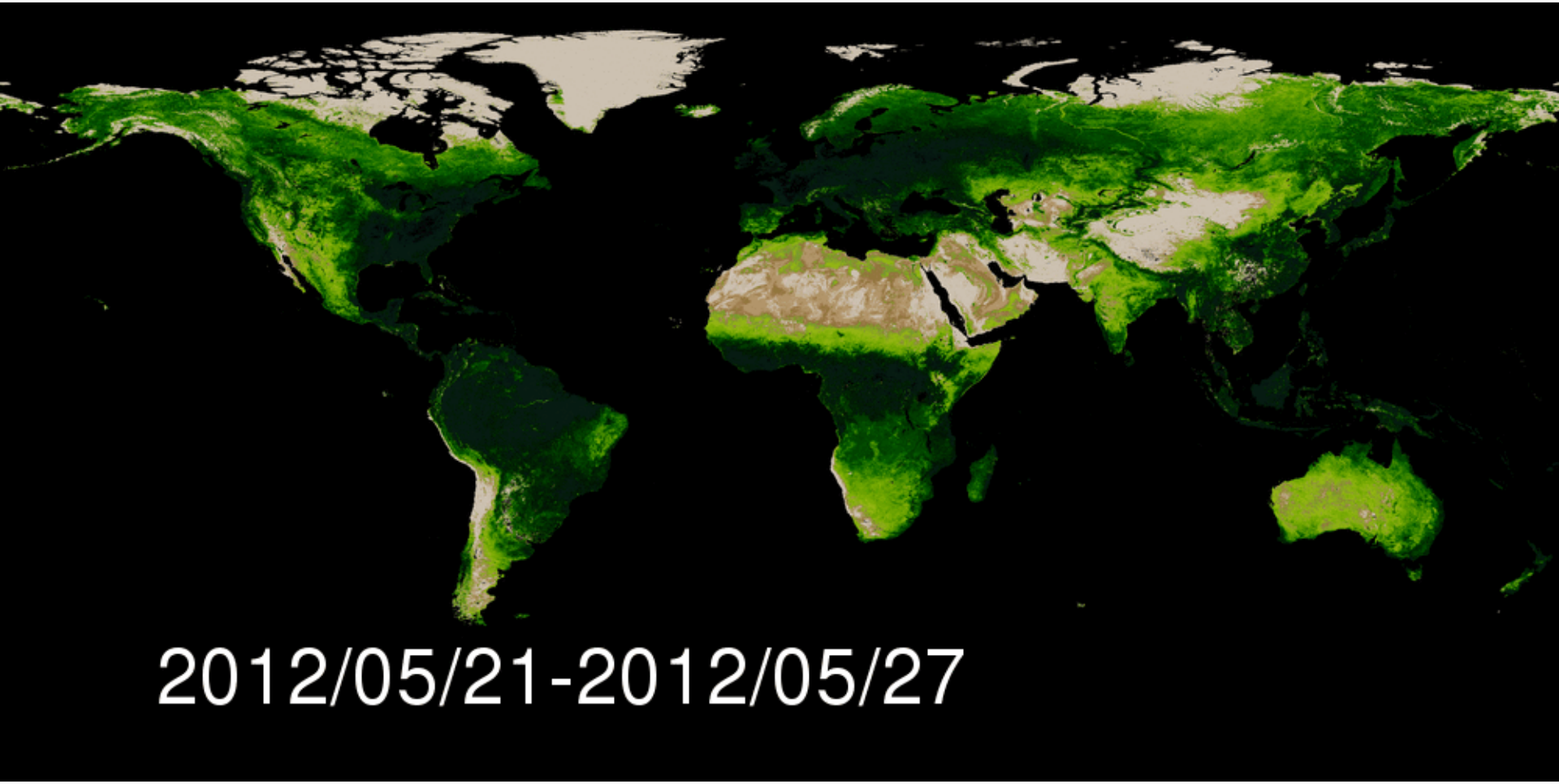
	TOA-NDVI	TOC-EVI
A	0.005	-0.05
P	0.007	0.006
U	0.014	0.06

2012-243

	TOA-NDVI	TOC-EVI
A	0.005	-0.05
P	0.007	0.006
U	0.012	0.06

T. Muira, Univ. Hawaii

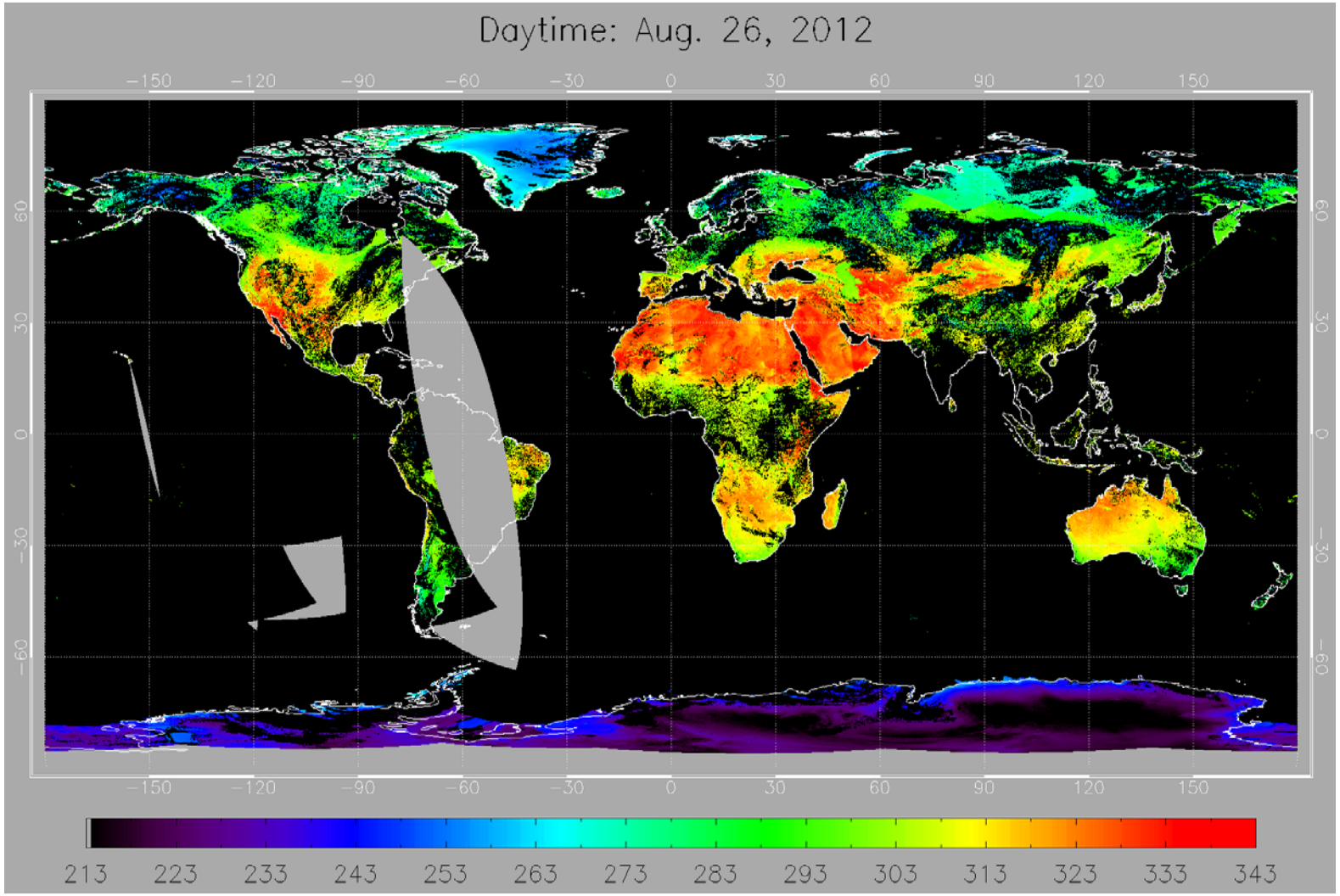
NDE VIIRS Green Vegetation Fraction



Global Daily Rolling Weekly VIIRS Green Vegetation Fraction Product developed within the NOAA NDE program.

M. Vargas/NDE GVF Team

VIIRS Land Surface Temperature



Daytime VIIRS LST Global Composite. 26 August 2012

Y. Yu (STAR)

VIIRS Land Surface Temperature

MODIS LST *vs.* ADL-SWLST over 17 IGBP surface types

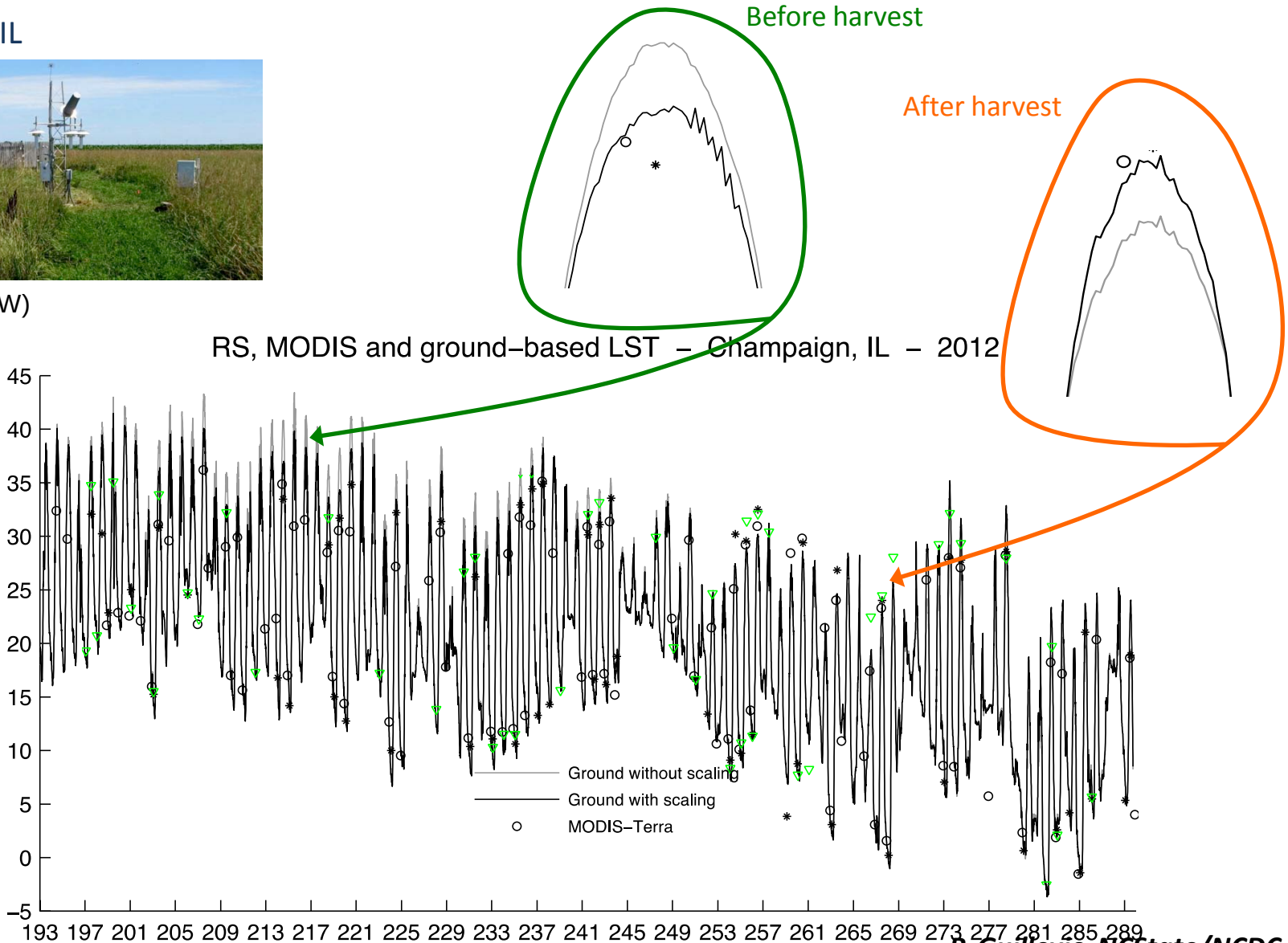
IGBP Land Type	Sample Size		STD(K)		BIAS(K)	
	Day	Night	Day	Night	Day	Night
Evergreen Needle Leaf Forests	78576	169041	3.869	2.53	-0.353	0.263
Evergreen Broadleaf Forests	42370	53237	2.466	1.737	0.749	0.241
Deciduous Needle leaf Forests	136	850	4.018	2.392	-0.396	0.152
Deciduous Broadleaf Forests	419490	319971	1.938	1.68	-0.22	-0.293
Mixed Forests	235425	321087	2.559	1.986	-0.184	-0.226
Closed Shrub Lands	101179	71349	3.415	2.353	0.021	-0.116
Open Shrub Lands	1142242	752619	3.03	2.224	-0.346	-0.868
Woody Savannahs	346408	354723	2.661	1.868	0.106	-0.643
Savannahs	93405	99398	2.517	1.773	0.419	0.047
Grasslands	833455	891019	2.712	1.662	0.206	-0.356
Permanent Wetlands	5029	5247	3.82	3.254	0.351	0.901
Croplands	413472	480492	2.497	1.631	0.157	-0.125
Urban Built-Up	76174	79016	2.833	1.823	-0.237	-0.75
Natural Vegetation Mosaics	395406	410113	2.122	1.562	0.245	-0.175
Snow ice	447385	11	2.389	2.7432	-0.287	-2.116
Barren	135049	89471	3.644	2.663	-0.147	-0.202
Water Bodies	55646	127271	3.993	2.977	-1.484	0.151

Y. Yu (STAR)

VIIRS Land Surface Temperature

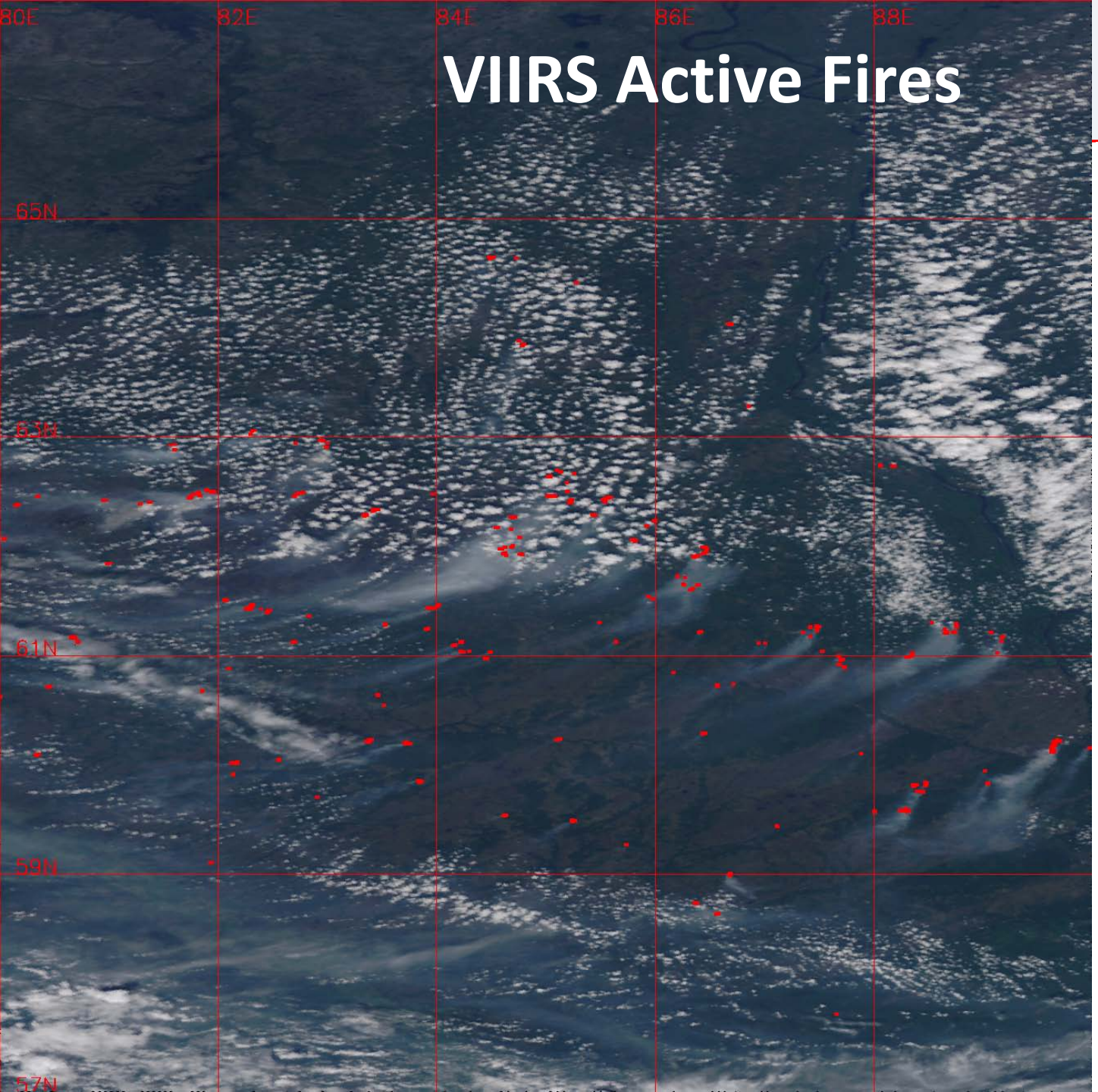
Champaign, IL

(40.05N, 88.37W)



P. Guillevic, NCState/NCDC

VIIRS Active Fires

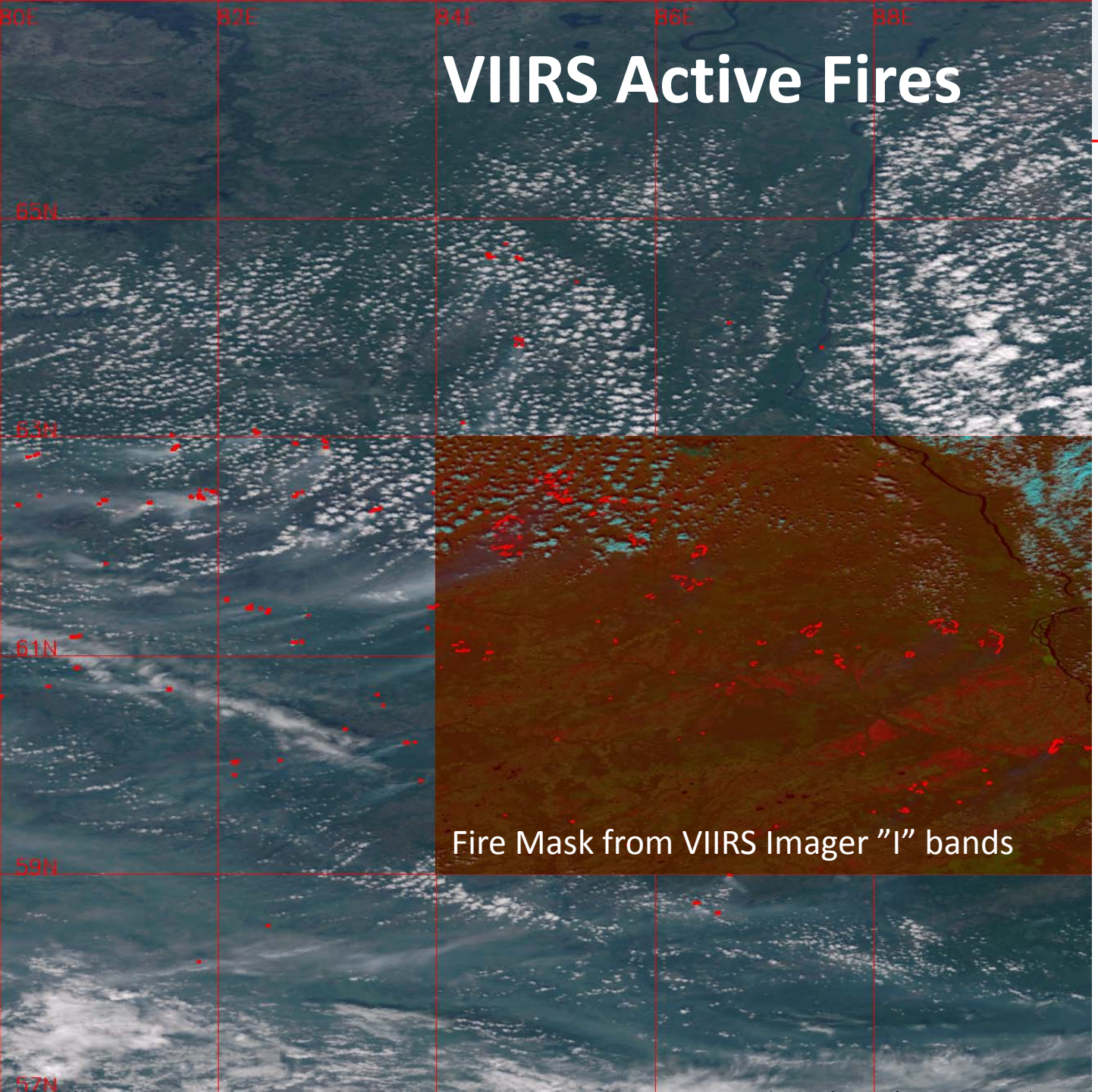


Aqua MODIS Western Siberia June 16 2012 6:42 UTC

Band 1-4-3 RGB, MYD14

I. Csiszar/JPSS Active Fire Team

VIIRS Active Fires

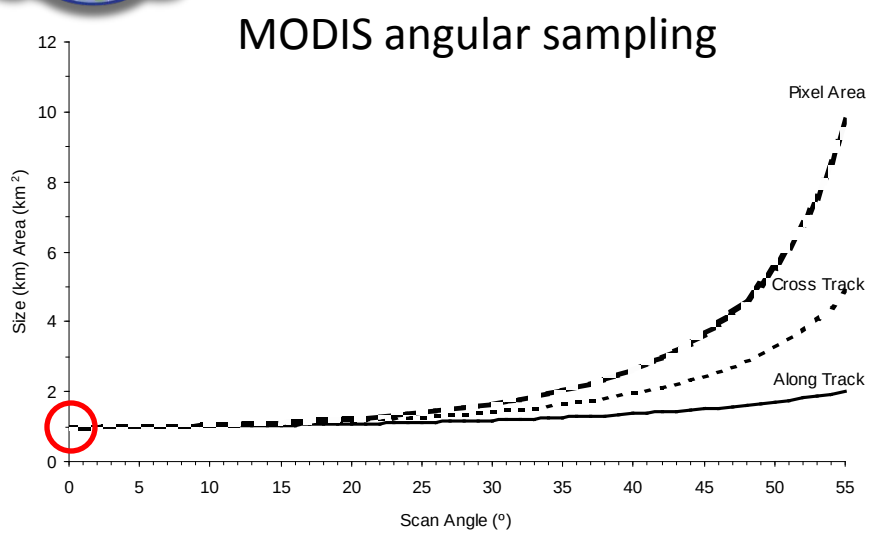


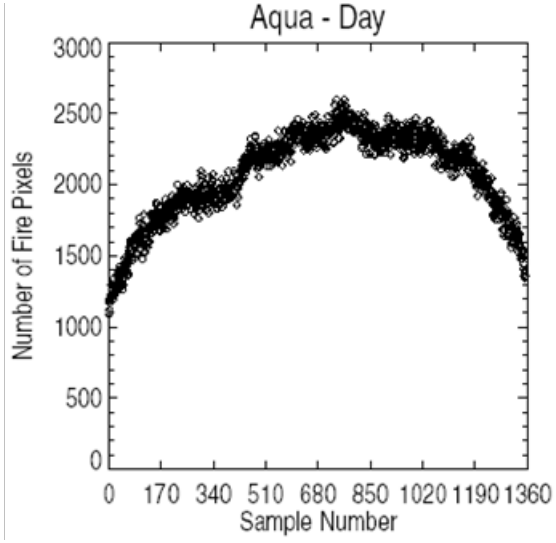
SNPP VIIRS Western Siberia June 16 2012 6:15 UTC

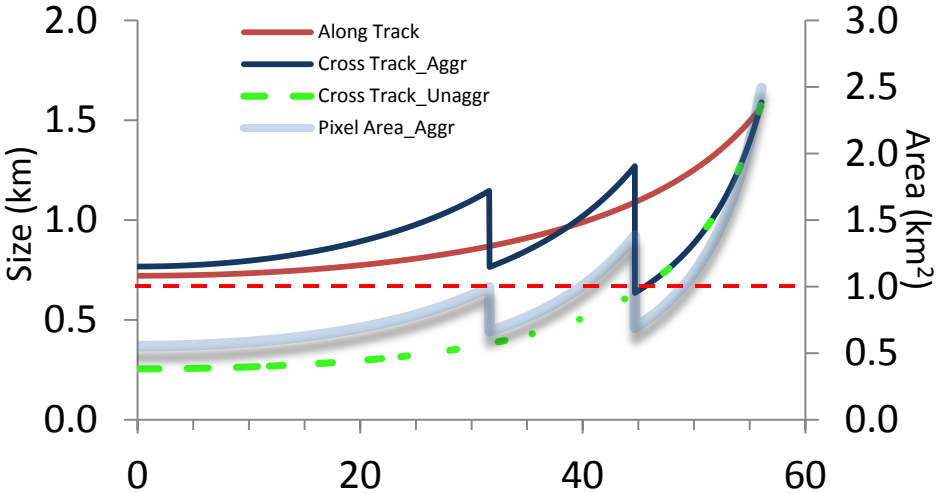
M5-M4-M3 RGB, IDPS AF ARP

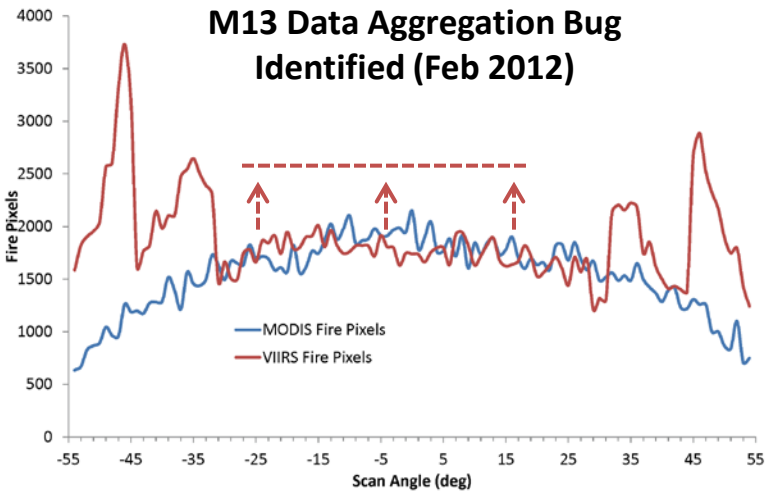
I. Csiszar/JPSS Active Fire Team

VIIRS Active Fires





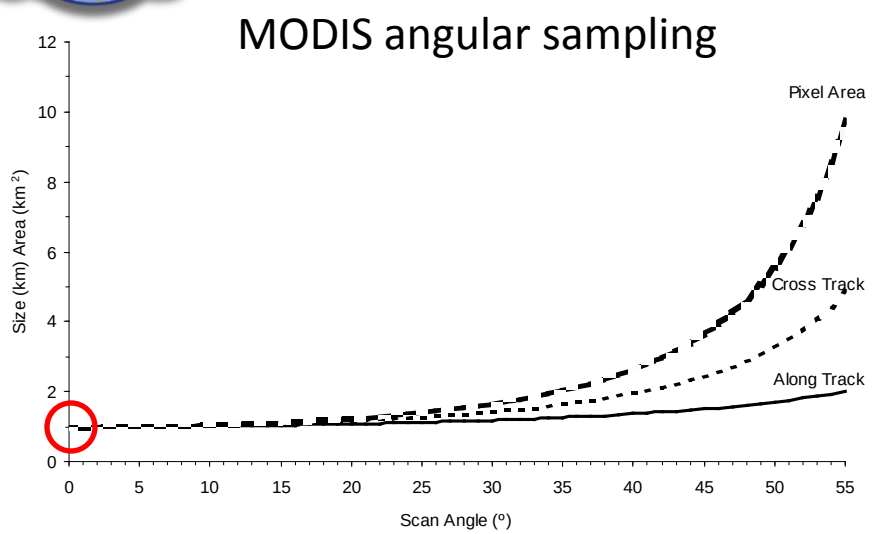


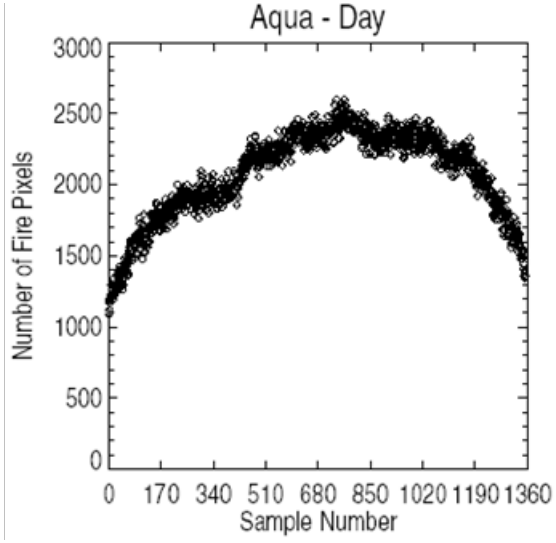


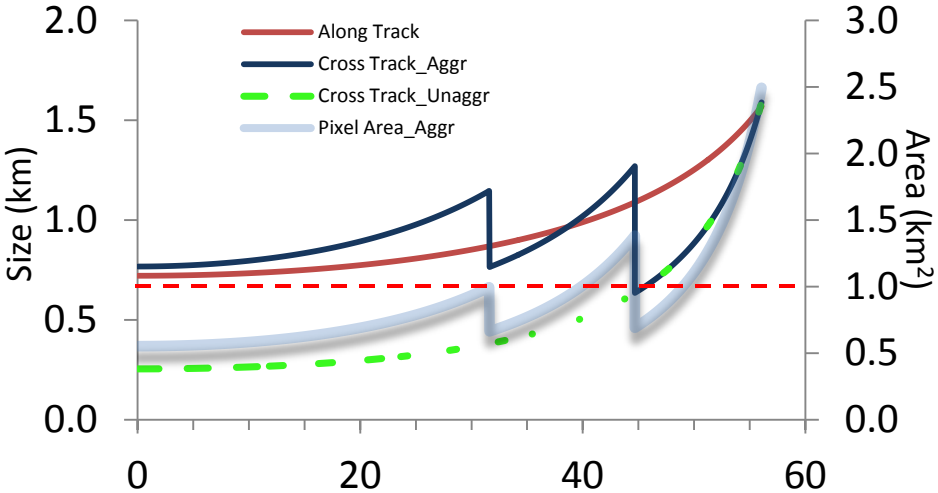
Compatible orbital segments are determined by pixel sizes

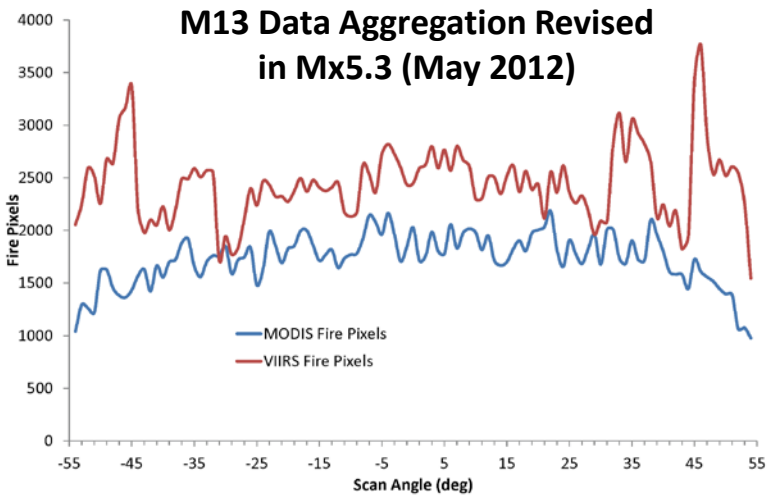
VIIRSxMYD14 Fire Detection Frequency (**19 Jan <> 13 Feb**)

VIIRS Active Fires





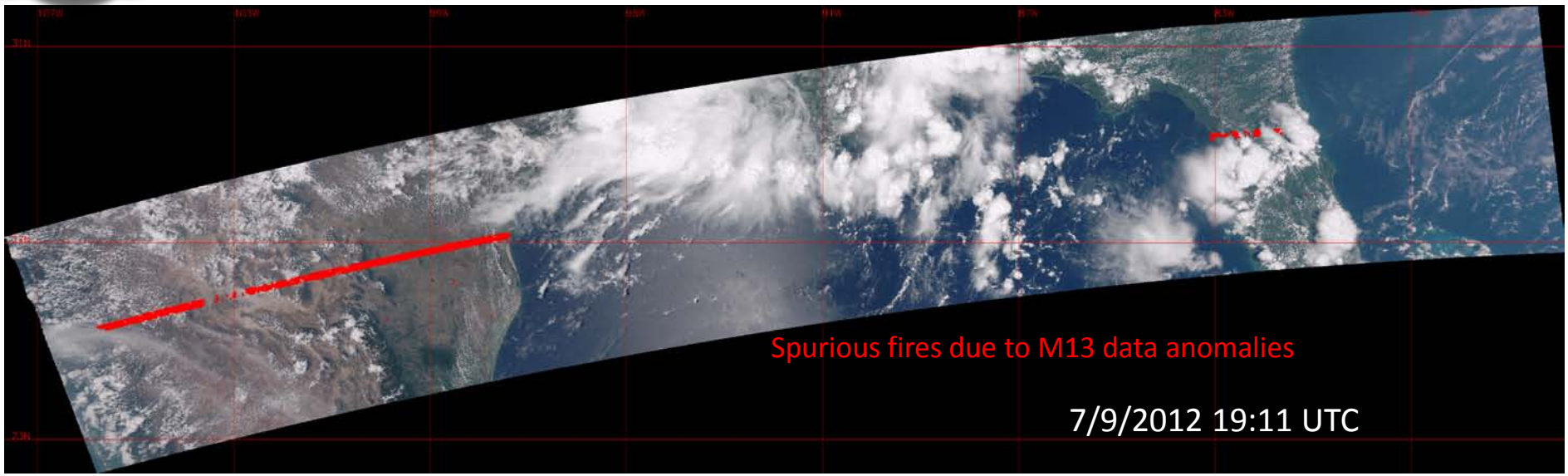


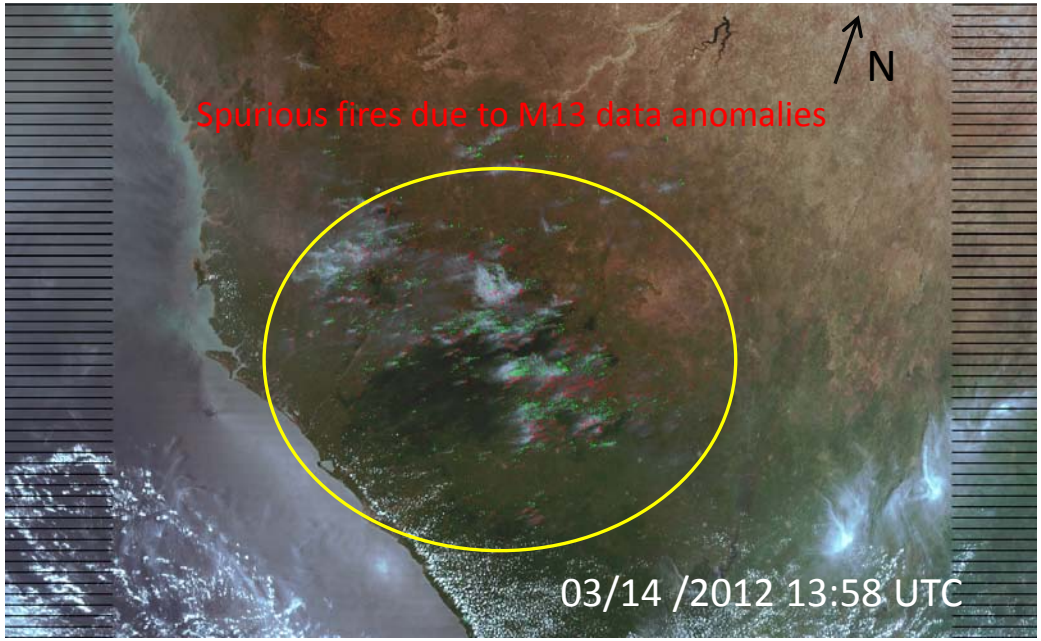


Compatible orbital segments are determined by pixel sizes

VIIRSxMYD14 Fire Detection Frequency (**11 May <> 10 Jun**)

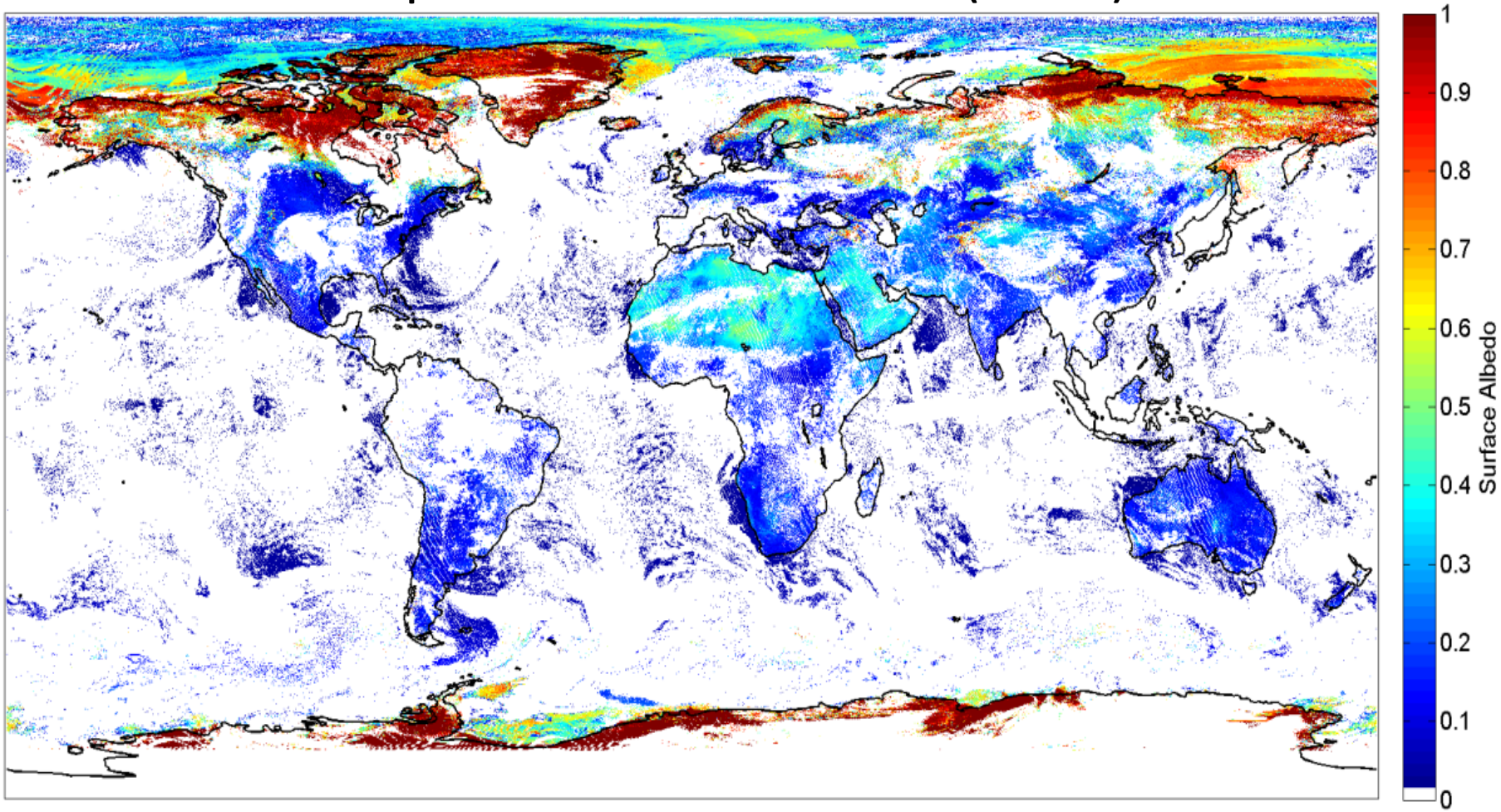
VIIRS Active Fires





VIIRS Surface Albedo

Global map of VIIRS albedo EDR (BPSA)

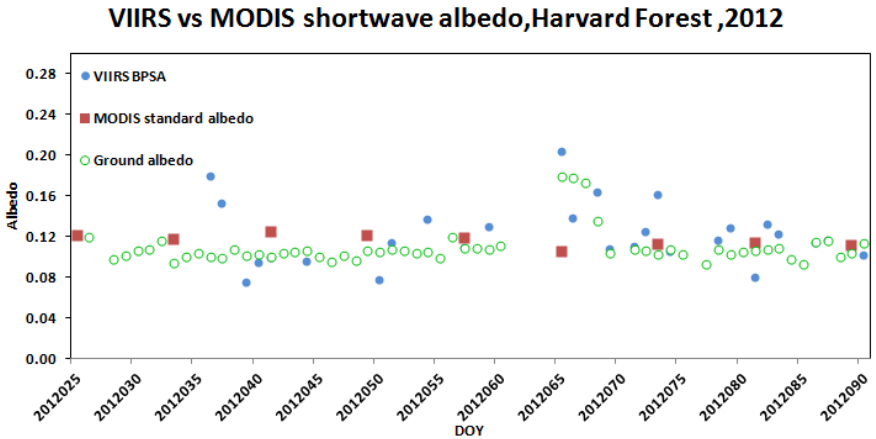


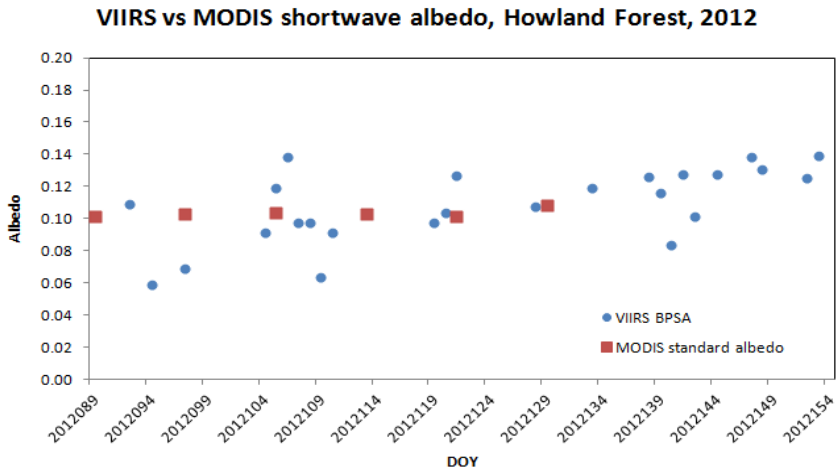
Date April 3, 2012.

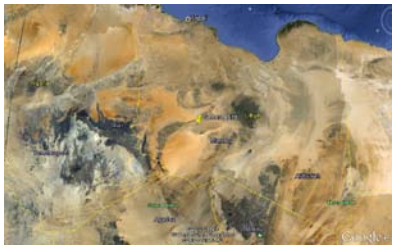
Y. Yu, C. Schaaf, U. Mass.

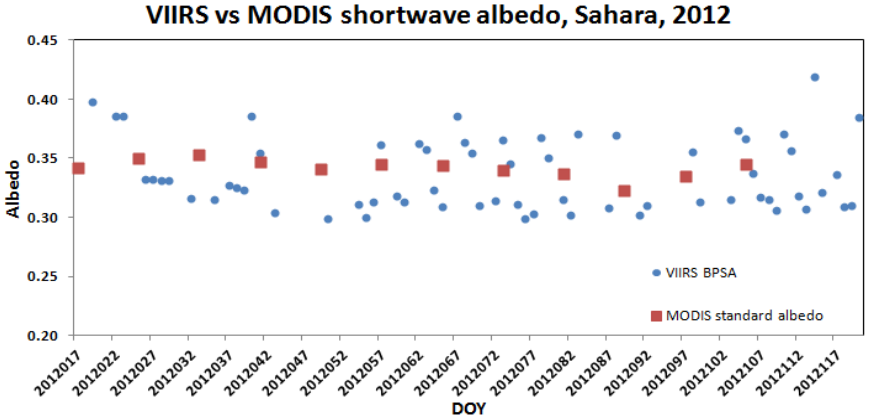
VIIRS Surface Albedo

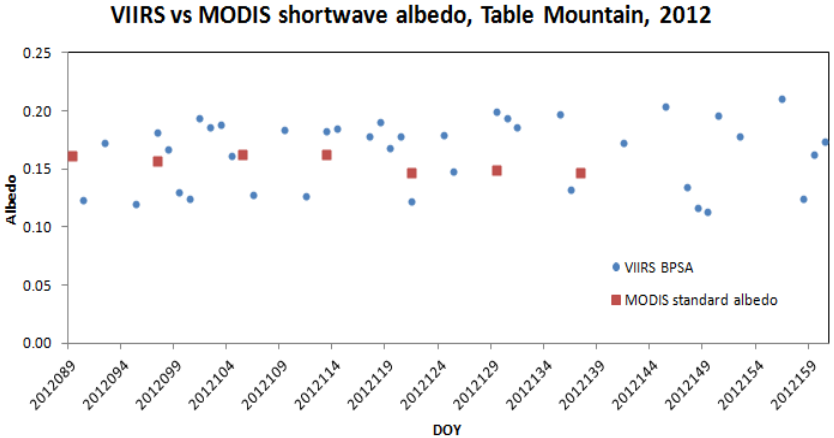
Comparison of VIIRS BPSA with MODIS albedo





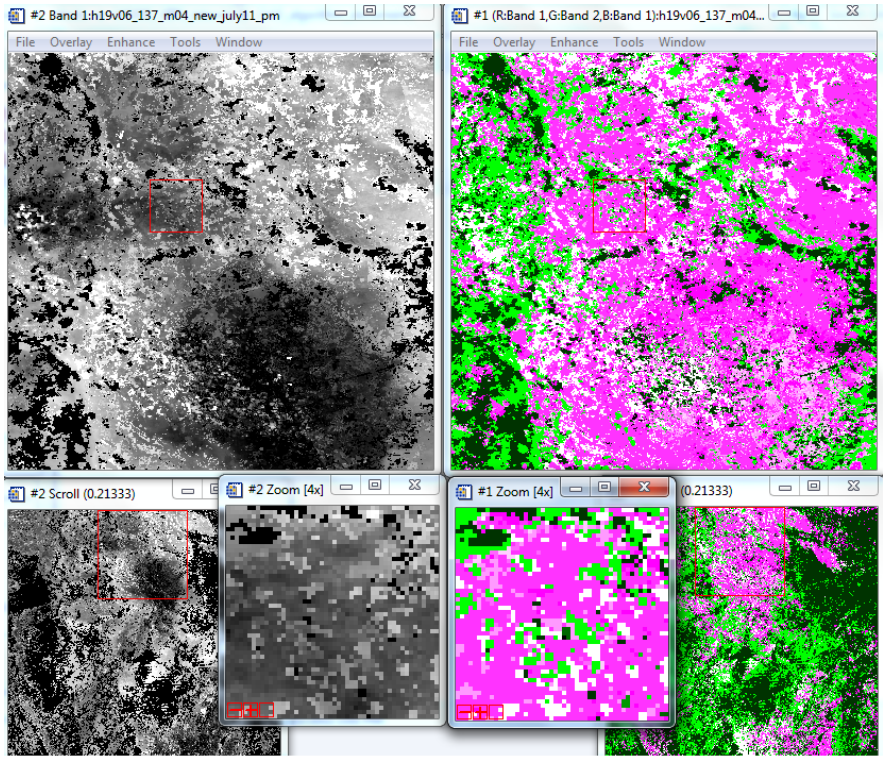




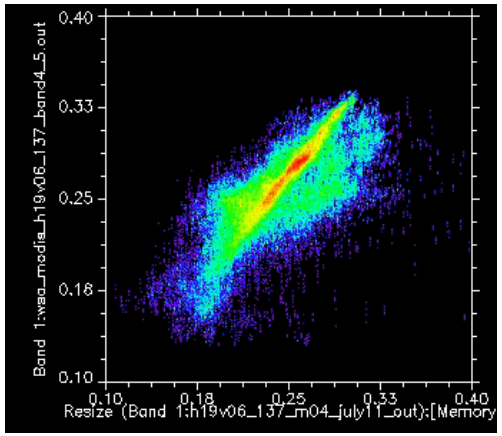


VIIRS Surface Albedo

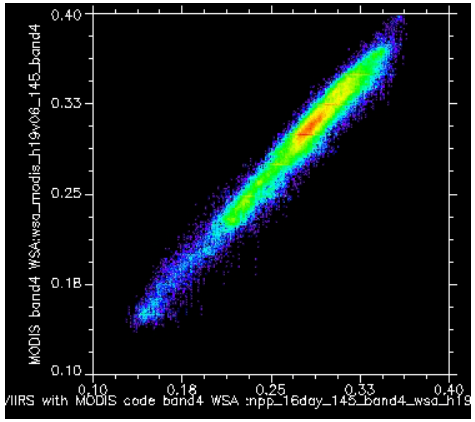
Study of multi-kernels vs single-kernel (RTLSR) for DPSA



VIIRS full inversion band 4 white sky albedo (left) and kernel combinations (right)



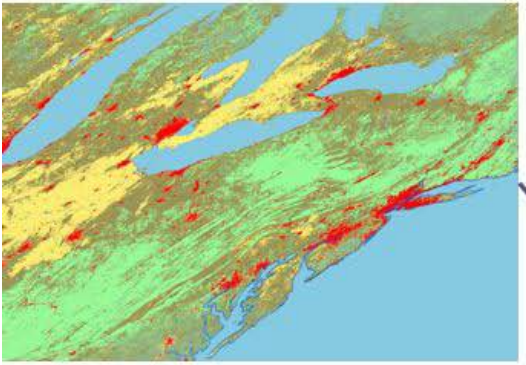
Scatter plot of band 4 MODIS white sky full inversion albedo and VIIRS full inversion white sky albedo for DOY 137



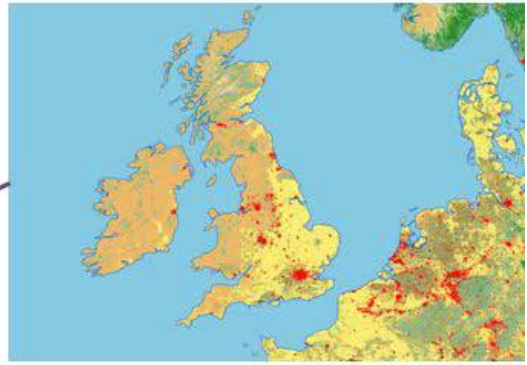
Scatter plot of MODIS Band 4 versus VIIRS through MODIS code Band 4 for DOY 145

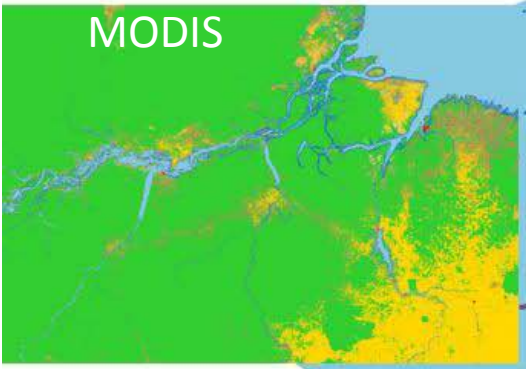
C. Schaaf, U. Mass.

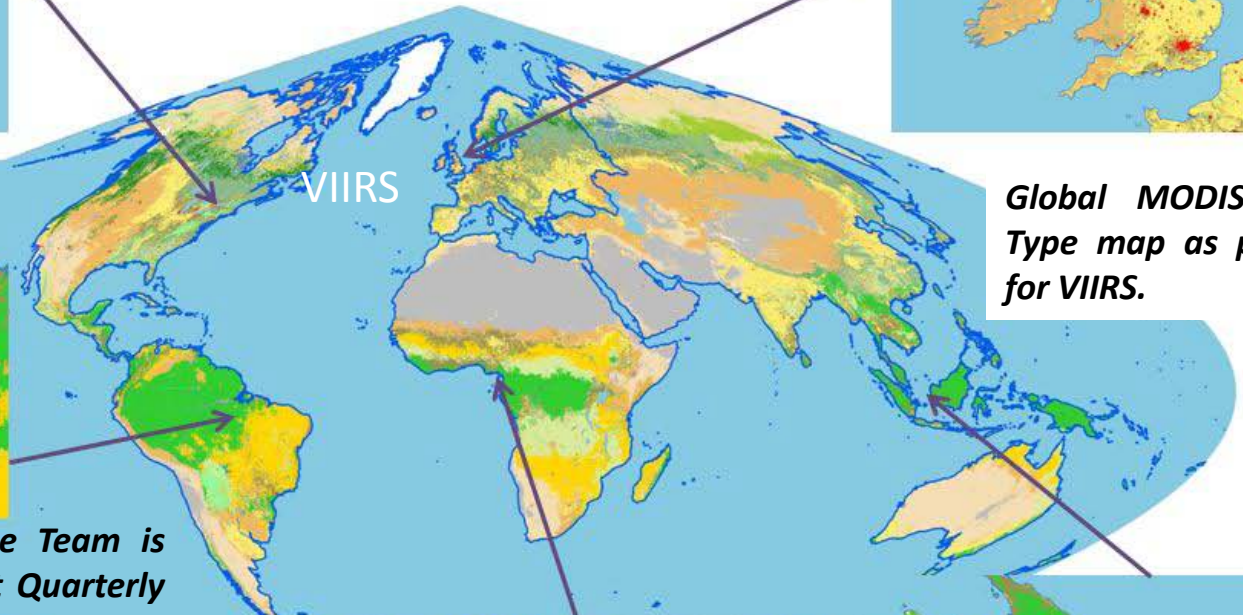
VIIRS Surface Type



VIIRS Surface Type is used in Land Surface Models, for global and large-scale ecosystem assessments, and for ecosystem change monitoring. It is also an auxiliary input for other data products.







Global MODIS Surface Type map as prototype for VIIRS.

The JPSS Surface Type Science Team is preparing to generate the first Quarterly Surface Type IP based on one full year VIIRS data.

- Water Bodies
- Evergreen Needleleaf Forests
- Evergreen Broadleaf Forests
- Deciduous Needleleaf Forests
- Deciduous Broadleaf Forests
- Mixed Forests
- Closed Shrublands
- Open Shrublands
- Woody Savannas
- Savannas
- Grasslands
- Permanent Wetlands
- Croplands
- Urban and Built-up Lands
- Cropland/Natural Vegetation Mosaics
- Snow and Ice
- Barren

X. Zhan, NOAA

VIIRS Surface Type

Previous seed: MODIS MOD12Q1 collection 4

New seed: MODIS MOD12Q1 collection 5

Unchanged land cover class labels: 66.2% of global land area

		Collection 5															
		Class1	Class2	Class3	Class4	Class5	Class6	Class7	Class8	Class9	Class10	Class11	Class12	Class13	Class14	Class15	Class16
Collection 4	Class1	2.5	0.1	0.2	0	1.6	0	0.1	1.1	0.2	0.2	0.3	0	0	0.1	0	0
	Class2	0	14.1	0	0	0.3	0	0	0.8	0.3	0.1	0.2	0.1	0	0.9	0	0
	Class3	0	0	0.8	0	0.1	0	0.1	0.1	0	0	0	0	0	0	0	0
	Class4	0	0.1	0	0.8	0.5	0	0	0.6	0.2	0.1	0	0.1	0	0.3	0	0
	Class5	0.3	0.1	0.2	0.2	5.1	0	0.1	0.6	0.1	0.2	0.1	0.2	0	0.6	0	0
	Class6	0	0	0	0	0	0	0.3	0.1	0.1	0.2	0	0.1	0	0	0	0
	Class7	0.1	0	0.2	0.1	0.2	0	18.3	1	1	5.5	0.5	0.8	0	0.3	0.2	2.5
	Class8	0.2	0.3	0.3	0.2	0.7	0	0.9	5.3	2.2	0.7	0.2	0.4	0	1.2	0	0
	Class9	0	0.1	0	0.1	0.1	0	0.4	1.9	5.8	1	0.1	0.7	0	1.5	0	0
	Class10	0	0	0.1	0.1	0.1	0	2	0.4	0.9	9.8	0.1	0.8	0	1.1	0	0.2
	Class11	0	0.1	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0
	Class12	0	0	0	0	0.2	0	0.2	0.3	0.2	1.3	0	10	0.2	2.8	0	0
	Class13	0	0	0	0	0	0	0	0	0	0.1	0	0.2	0.4	0.1	0	0
	Class14	0	0.1	0	0.1	0.2	0	0	0.3	0.5	0.5	0	0.6	0	1.3	0	0
	Class15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.8	0
	Class16	0	0	0	0	0	0	1.5	0	0.1	1.6	0	0.1	0	0.1	0.3	19.5

The error confusion matrix between two QST IP seeds

The unit of this table is million square kilometer

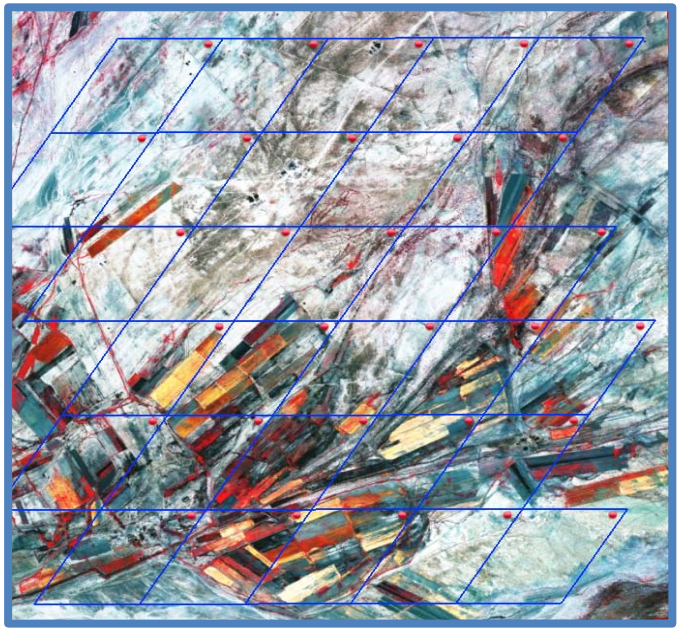
The green diagonal of the matrix indicates the amount of unchanged class labels

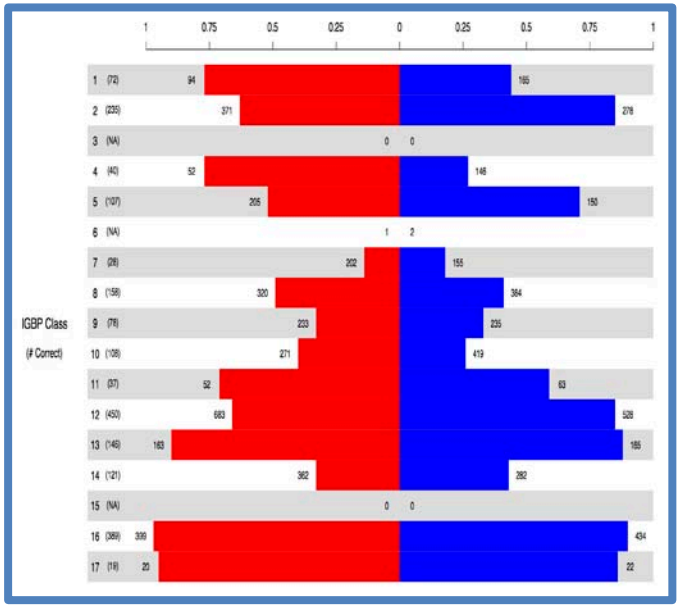
The red elements of the matrix indicate the amount of changed class labels

X. Zhan, NOAA

VIIRS Surface Type

- Current Validsation Status:
  - Site Database
    - ~150 sites completed (~3500 VIIRS QST pixels); currently being expanded.
    - Image at right shows dryland agriculture site from Chaacha, Turkmenistan. Blue lines show the VIIRS QST grid superimposed on high-res image.
  - Statistical Methods/Tools
    - Currently being tested and used to assess MODIS C4 Land cover and VIIRS QST seed based on MODIS C5.1
    - Graphic at left shows sample results (user, producer accuracies) for MODIS C4 product Each horizontal bar corresponds to one IGBP class; red="producer's" accuracy; blue = "user's" accuracy; overall accuracy ~50%).

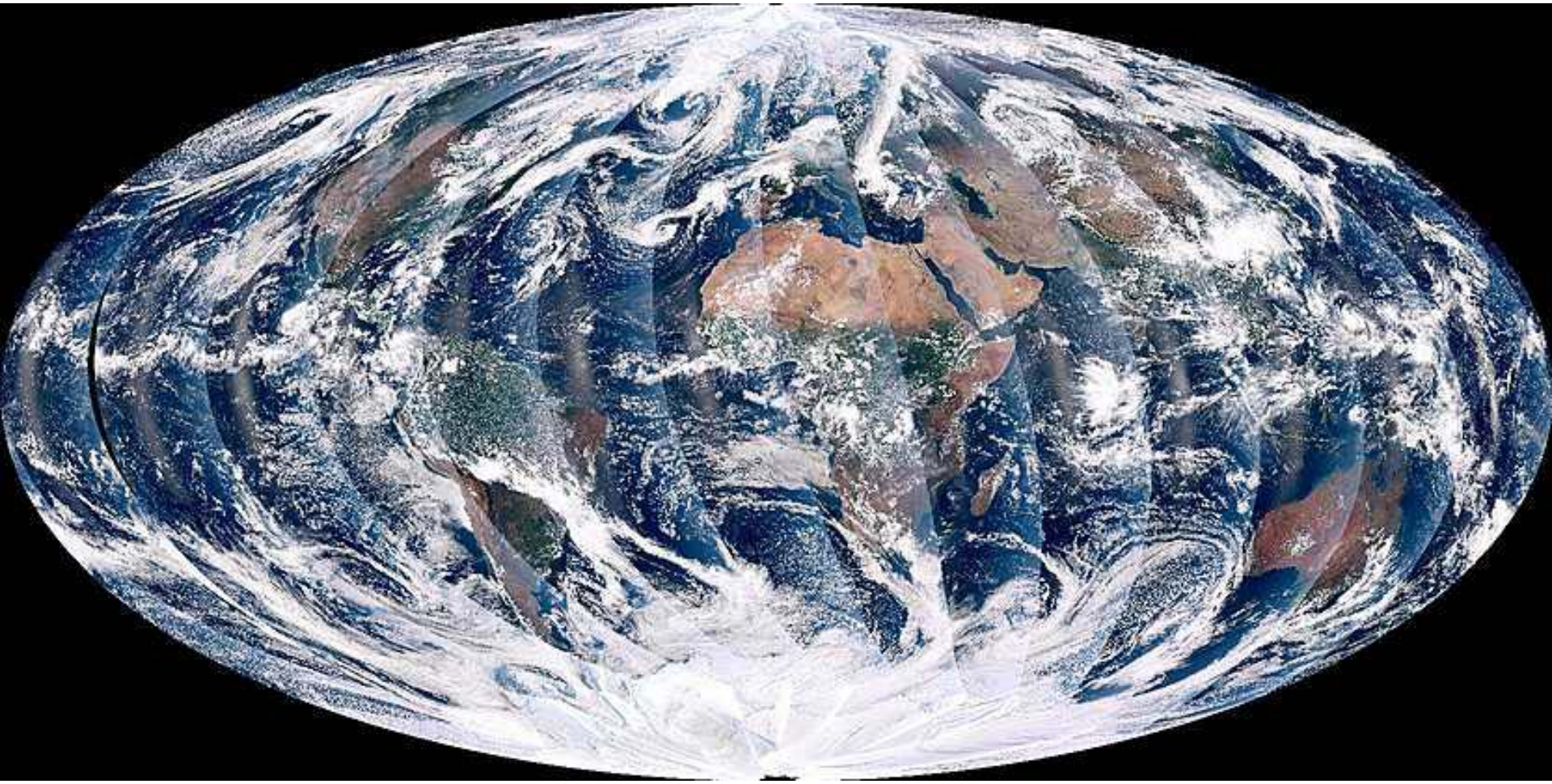




M. Friedl, BU

NASA's Land PEATE Activities

landweb.nascom.nasa.gov

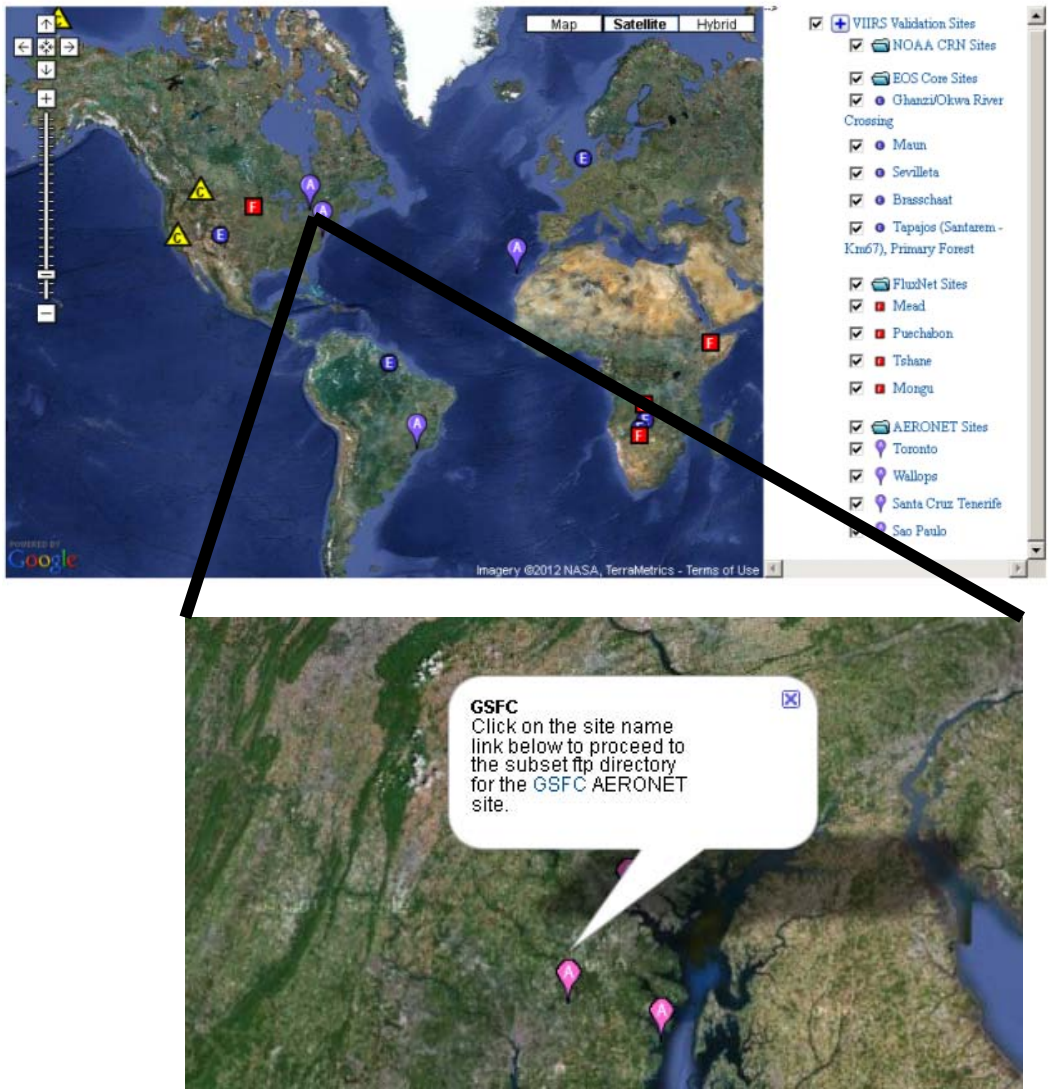


NPP_VMAE_L1 L1B Moderate input, Day Band 5,4,3

September 21, 2012

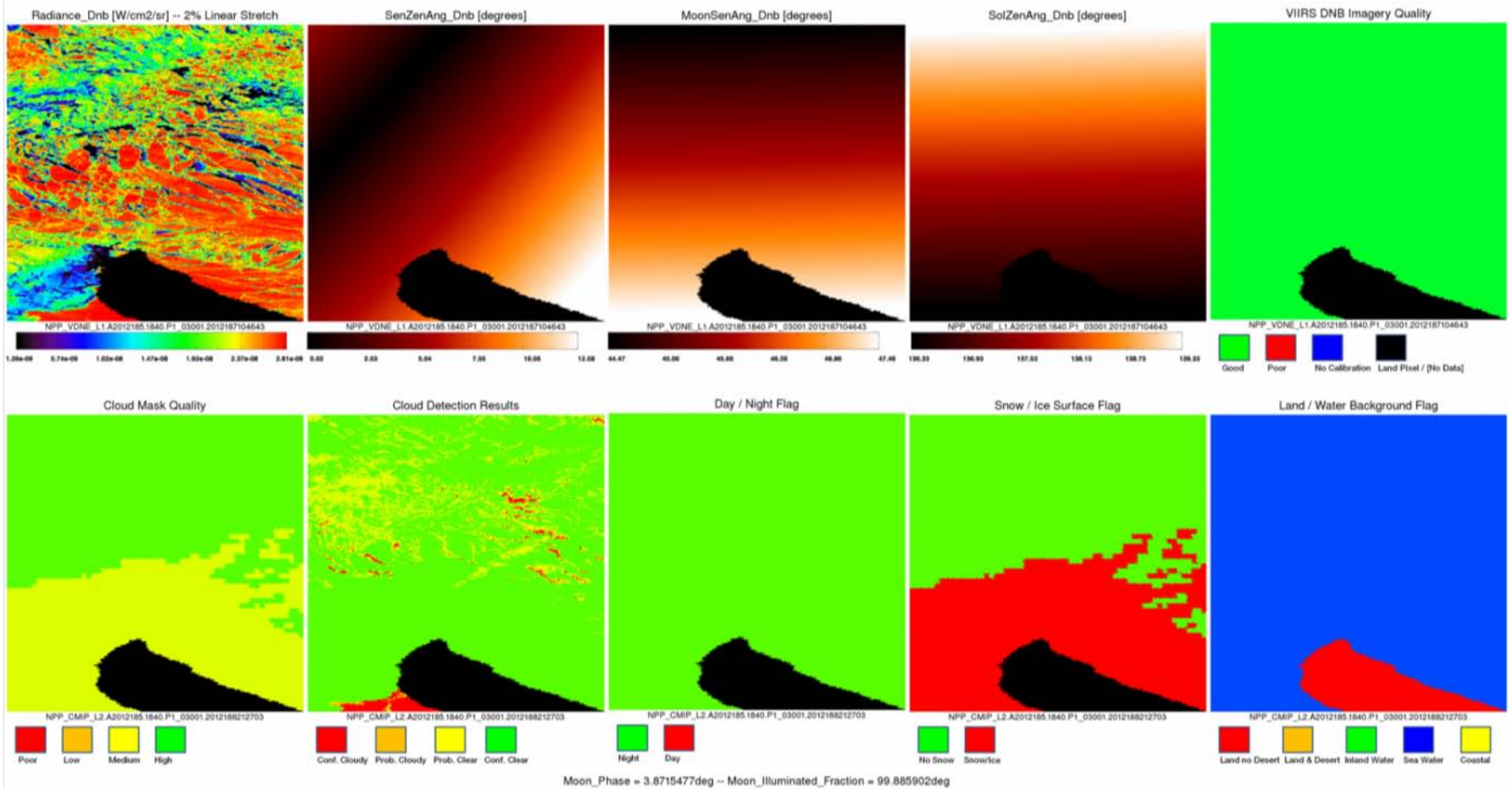
NASA LandPEATE

NASA's Land PEATE Activities



- **A web presence for the VIIRS Land Validation subsets was established to allow the science team to retain cutouts of all VIIRS Land EDR indefinetly .**
- **Focused on incorporating PI-requested products over established operational networks (e.g., NOAA-CRN, DOE-ARM, BSRN, ASVRN/AERONET).**
- **Performed site characterizations to evaluate the spatial heterogeneity of the operational network sites over an area of 50km^2 (cf., Román et al., 2009).**

NASA's Land PEATE Activities

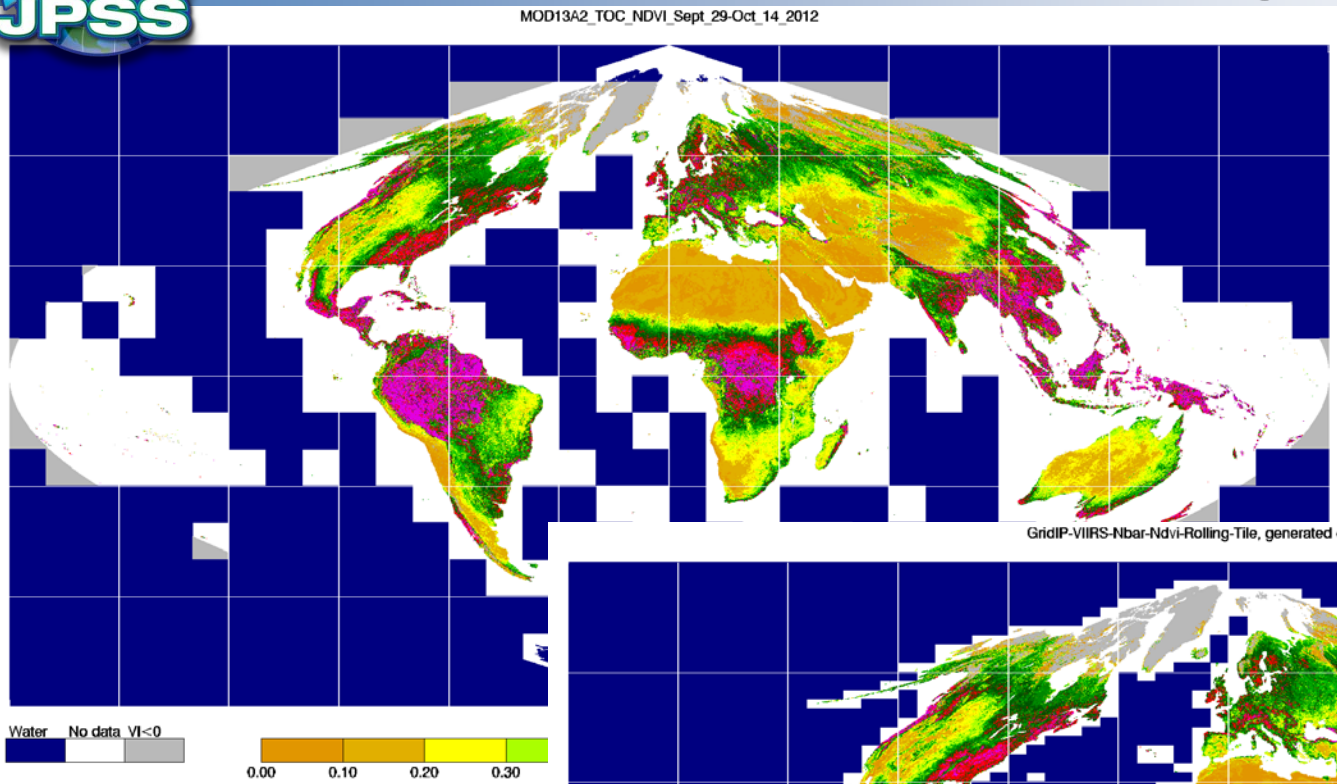


VIIRS Land EDR SwathToGrid tool has been progressively generalized so it incorporates SDR and VIIRS Day-Night-Band geometries (top images). Testing has focused on the tropics and high latitudes to characterize the effect of stray-light on VIIRS DNB and evaluate VIIRS Cloud Mask output quality flags (bottom images).

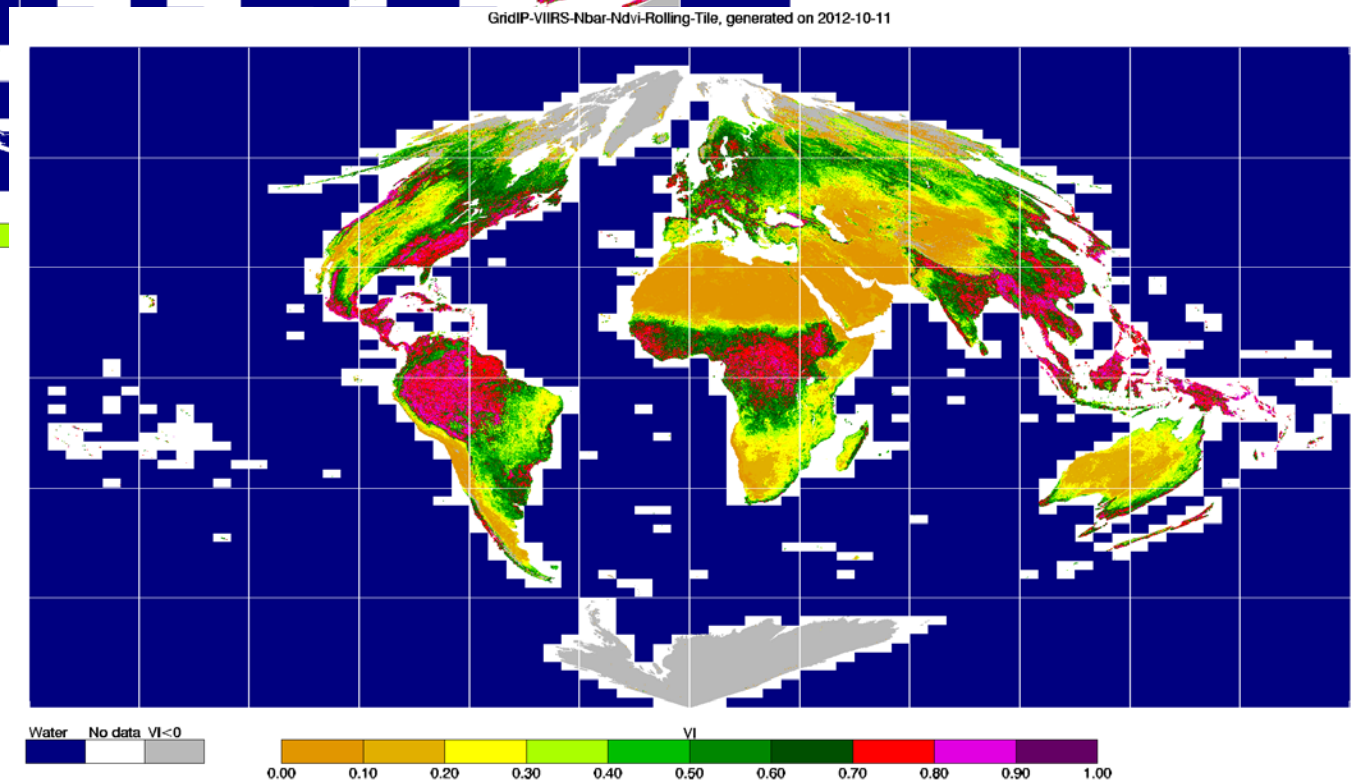
NASA LandPEATE

Evaluation of IDPS Gridding Processes

Evaluation of Rolling NBAR NDVI GIP



MODIS



VIIRS GIP

Land Product Maturity Schedule

Algorithm	Beta	Provisional	Val 1	Val 2	Val 3
Land Surface Reflectance IP	Dec-12 / Jan-13	Jul-13	Jul-14	Jan-15	Jan-16
Land Veg Index	Dec-12 / Jan-13	Sep-13	Jun-14	Jan-15	Jan-16
Land Surface Albedo	May-13	Nov-13	Jul-14	Jan-15	Jan-16
Surface Temps - LST	Dec-12	May-13	Dec-13	May-14	May-15
Land Active Fires	Oct-12	Aug-13	Sep-14	Sep-15	Dec-15
Land Surf Type	Dec-12 /Jan-13	Dec-13	Sep-14	Sep-15	Dec-15

Conclusions

- SNPP Land products are being **rigorously assessed and improved** by an experienced team

- The SNPP Land VIIRS products have **good overall quality** and potential for further improvement

- Much **better validation resources** are available now compared to the early MODIS period, e.g.,
  - MODIS (well validated and characterized)
  - Climate Reference Network
  - Physical models to properly scale up point field data

- Product **maturity and Beta release are progressing**, pending dependencies on upstream products