STAR JPSS 2015 Science Team Meeting Land / Cryosphere Breakout Session

Ivan Csiszar, Jeff Key

August 27, 2015

Objectives

- NOAA operational land and cryosphere products
  - Current operational products
  - Ongoing algorithm improvement efforts
  - Relationship with other JPSS land production systems i.e. NASA
- Product validation
  - Ongoing validation resources and preparation for JPSS-1
  - Leveraging resources with other NOAA, US and international activities
  - Coordinated validation approach
- System development and new programmatic directions
  - NOAA Enterprise System and non-NOAA assets
- NOAA Operational Applications

Agenda (am)

<u>*Product overviews*</u>

- 8:45 Surface reflectance – Belen Franch
- 9:00 Vegetation index EDR and NDE Green Vegetation Fraction – Marco Vargas
- 9:15 Vegetation Health – Felix Kogan
- 9:30 Land surface albedo – Bob Yu
- 9:45 Land surface temperature – Bob Yu
- 10: 00 Active fire – Ivan Csiszar

10:15 Break

- 10:30 Surface type – Jerry Zhan
- 10:45 Sea ice characterization and thickness – Jeff Key
- 11:00 Sea ice concentration – Yinghui Liu
- 11:15 Sea ice surface temperature – Mark Tschudi
- 11:30 Binary snow cover – Peter Romanov
- 11:45 Snow fraction - Peter Romanov and Igor Appel
- 12:00 NASA SIPS Land Production and QA – Sadashiva Devadiga / Miguel Román

12:15 Lunch break

Agenda (pm)

<u>Product validation and long-term monitoring</u>

- 1:00 Validation datasets and interagency / international coordination - Miguel Román
- 1:30 JPSS 1 land validation plan overview – Ivan Csiszar
- 1:45 GOES-R land validation activities and coordination with JPSS – Bob Yu
- 2:00 Land product characterization system – Kevin Gallo
- 2:15 Land long-term monitoring system – Lori Brown / Tony Reale

<u>NOAA Enterprise system</u>

- 2:30 Land / cryosphere enterprise product assessment– Ivan Csiszar / Jeff Key
- 2:45 Non-NOAA data sources for operational land / cryosphere applications: mission status, data access and plans Marco Vargas / Bob Yu / Jeff Key / Ivan Csiszar

3:00 Break

<u>NOAA operational applications of JPSS land and cryosphere products</u>

- 3:15 NCEP – Mike Ek
- 3:30 National Ice Center– Sean Helfrich

<u>Open discussion and wrap-up</u>

- 3:45 - 5:00 *Overarching topics such as re-processing, gridding, CLASS RIP archives, Direct Broadcast, summary and action items*

NOAA Operational Product Status

- Evaluation and update of the heritage IDPS algorithms is practically complete
  - Products achieved validated stage 1 as defined by the NOAA JPSS program
  - Only remaining IDPS code change package is aerosol / SR (to implement validated algorithm in operations)
  - Reactive maintenance continues
  - Long-term monitoring in place / transitioning to systematic production
- NOAA ESPC (NDE) operational implementation
  - Additional / added-value products
    - Green Vegetation Fraction – fully operational
    - Vegetation Health – transition to operations
    - Active Fire – re-allocated to NDE – transition to operations
    - Snow Fraction – in development
    - Phenology (Risk Reduction) – in development
- JPSS Program Director's direction letter on algorithm development
- Program Level CCR to re-direct all Priority 3 and 4 products to ESPC

NOAA Operational Product Status

- NOAA Enterprise Algorithm Development
  - Common algorithms / ground system implementation options to leverage resources and ensure best algorithm solutions
    - Targets NOAA satellite assets i.e. JPSS and GOES-R
      - Often results in the implementation of GOES-R algorithms to process JPSS data
      - "Risk Reduction" algorithm package transitioning into operations
      - Land products not part of this effort, but assessment is ongoing
- Use of non-NOAA assets for critical NOAA missions
  - In some regards the extension of NOAA Enterprise development
- New directions and framework for the Science Team's activities
  - Reactive maintenance and long-term monitoring of operational products
  - Algorithm development towards ESPC implementation of enterprise solutions; testbeds, demonstration products, active user involvement
  - Different review / TTO process / documentation – follow SPSRB process
- Algorithm deliveries to STAR Algorithm Integration Team (AIT)

Moving forward

- JPSS-1 (-> to be renamed to NOAA-20 once operational) preparation
  - Suite of algorithms include significant improvements
    - TOC NDVI, full fire mask and FRP – implemented for Suomi NPP
    - JPSS-1 test datasets are becoming available
  - JPSS-1 validation plans
    - draft plans delivered; review / feedback ongoing
    - final plans due December 31
- NOAA – NASA ST coordination and collaboration
  - Algorithm development
    - keep algorithms in sync (i.e. SR, Active Fire)
    - seeking common algorithm solutions where possible (i.e. LST)
    - different algorithm solutions where necessary
    - NASA-unique features (SDR, output format etc.) to be addressed
  - Validation
    - leveraging approaches and resources
- JPSS-2 and beyond assessment

User involvement and added value products

- Close linkages between code cal/val and risk reduction activities
  - Risk reduction is also a platform for further algorithm changes
- Close collaboration with critical NOAA users
  - NOAA NCEP and other modeling groups – data assimilation
  - National Ice Center, Hazard Mapping System, CPC etc.
- Key Proving Ground Initiatives
  - e.g. Fire and Smoke, Land Data Assimilation
  - Joint Center for Satellite Data Assimilation as testbed
- Direct Broadcast CSPP and IPOPP and algorithm updates
- Development of new / level-3 and beyond products
  - GVF in operation
  - Gridded/composited LST, albedo etc.; LAI/fPAR
- Reprocessing
  - ongoing for select VIIRS bands / products (i.e. ocean)
  - planning / implementation for additional SDR and products

Surface Reflectance

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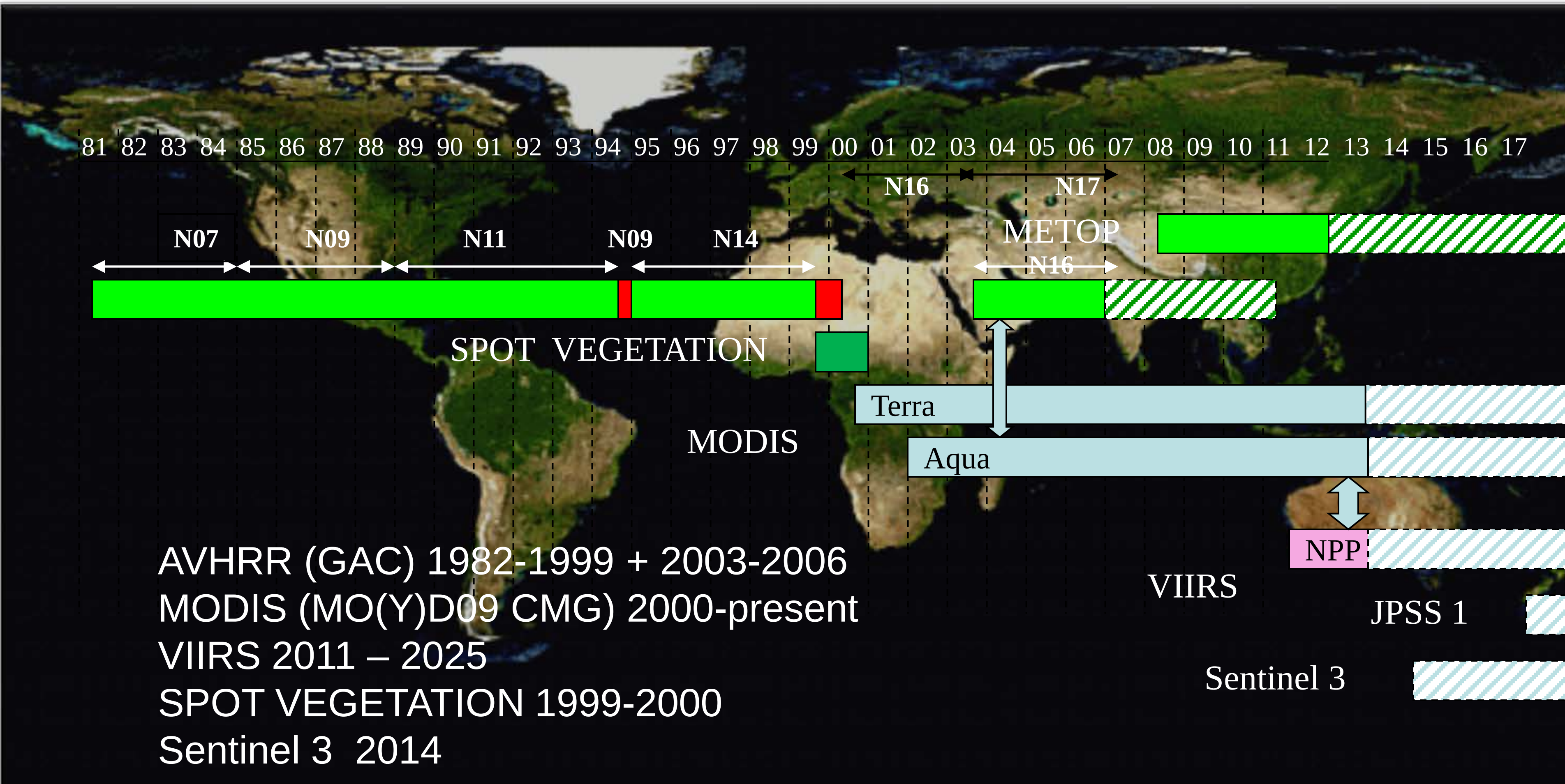
A Land Climate Data Record

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



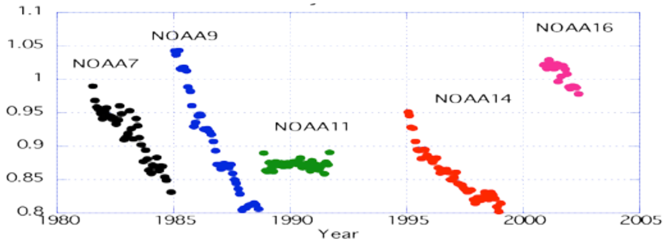
Emphasis on data consistency – characterization rather than degrading/smoothing the data

Land Climate Data Record (Approach)

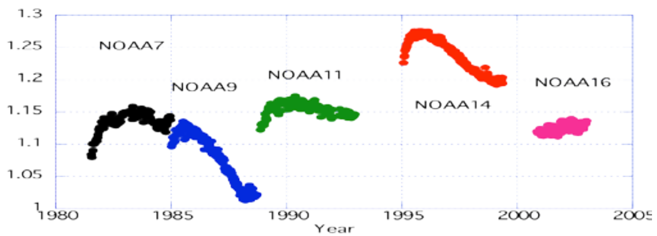
Needs to address geolocation,calibration, atmospheric/BRDF correction issues

CALIBRATION

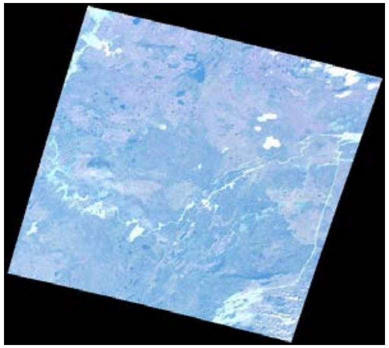
Degradation in channel 1
(from Ocean observations)

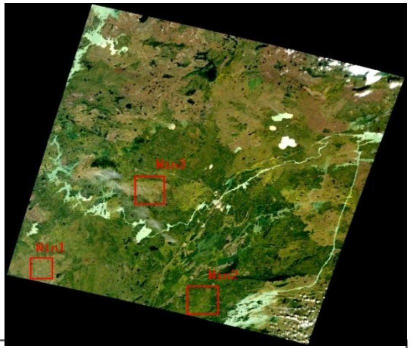


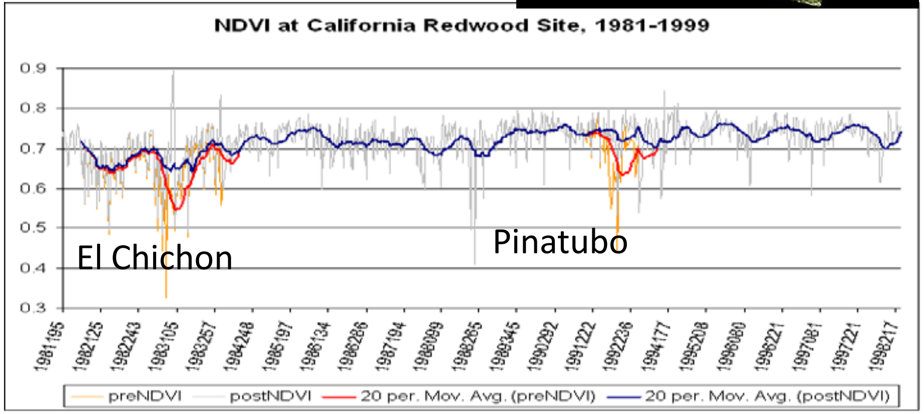
Channel1/Channel2 ratio
(from Clouds observations)



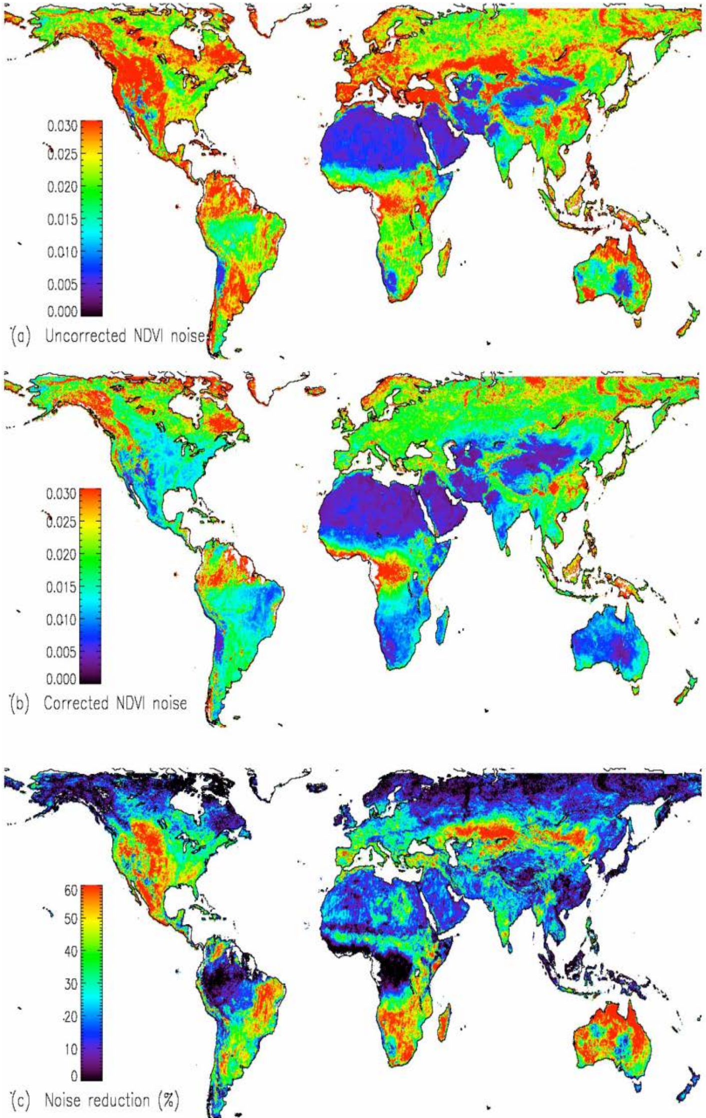
ATMOSPHERIC CORRECTION







BRDF CORRECTION



VIIRS Surface Reflectance based MODIS C5

The MODIS **Collection 5 AC 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

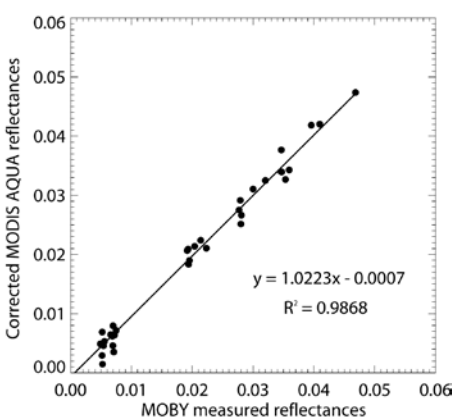
6SV Validation Effort

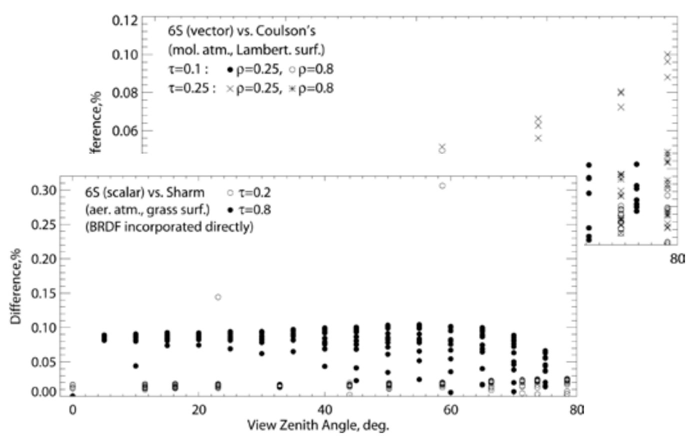
The complete 6SV validation effort is summarized in three manuscripts:

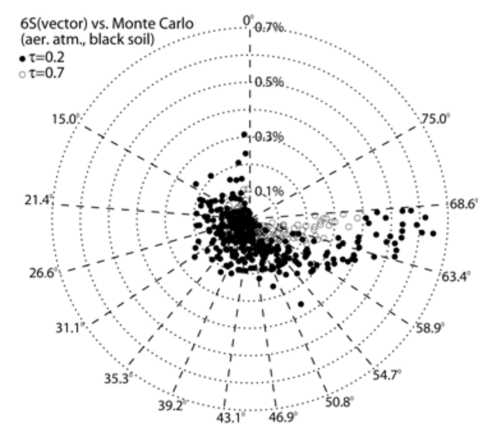
▪Kotchenova, S. Y., Vermote, E. F., Matarrese, R., & Klemm Jr, F. J. (2006). Validation of a vector version of the 6S radiative transfer code for atmospheric correction of satellite data. Part I: Path radiance. *Applied Optics*, *45*(26), 6762-6774.

▪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.







Methodology for evaluating the performance of VIIRS/MODIS

To first evaluate the performance of the MODIS Collection 5 SR algorithms, we analyzed 1 year of Terra data (2003) over **127** AERONET sites (**4988** cases in total).

Methodology:

Subsets of Level 1B data processed using the standard surface reflectance algorithm

comparison

Reference data set

Atmospherically corrected TOA reflectances derived from Level 1B subsets

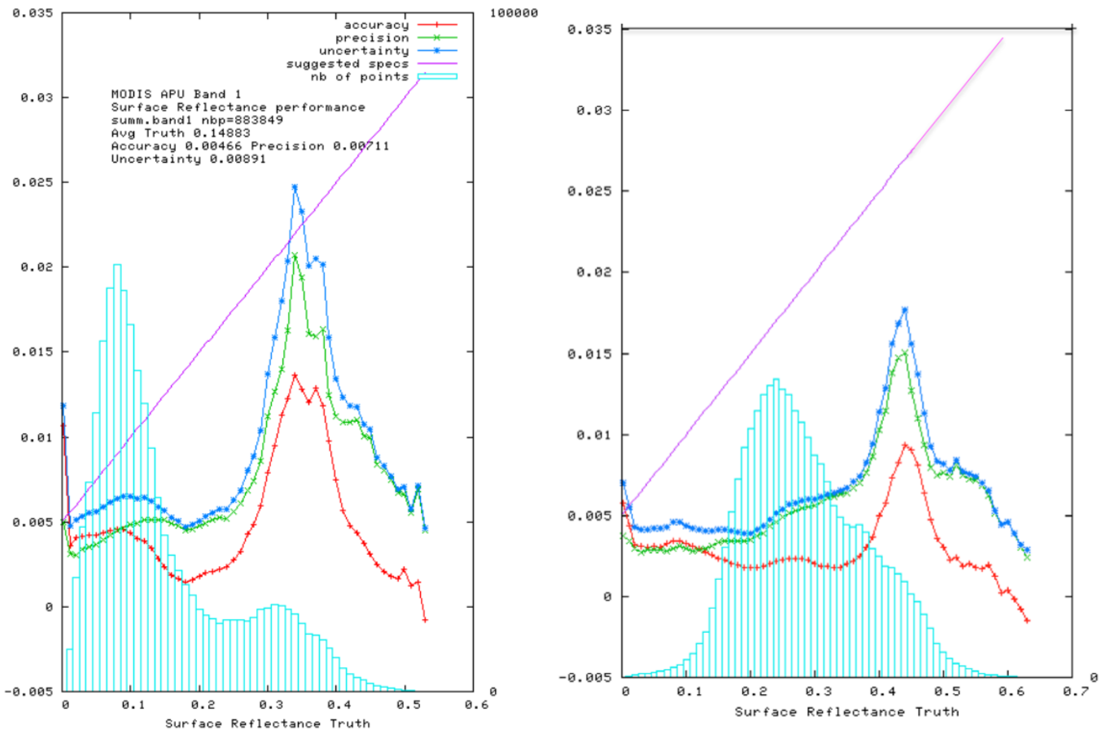
Vector 6S

AERONET measurements (τ_{aer}, H_2O, particle distribution Refractive indices,sphericityeri)

If the difference is within $\pm(0.005+0.05\rho)$, the observation is “good”.

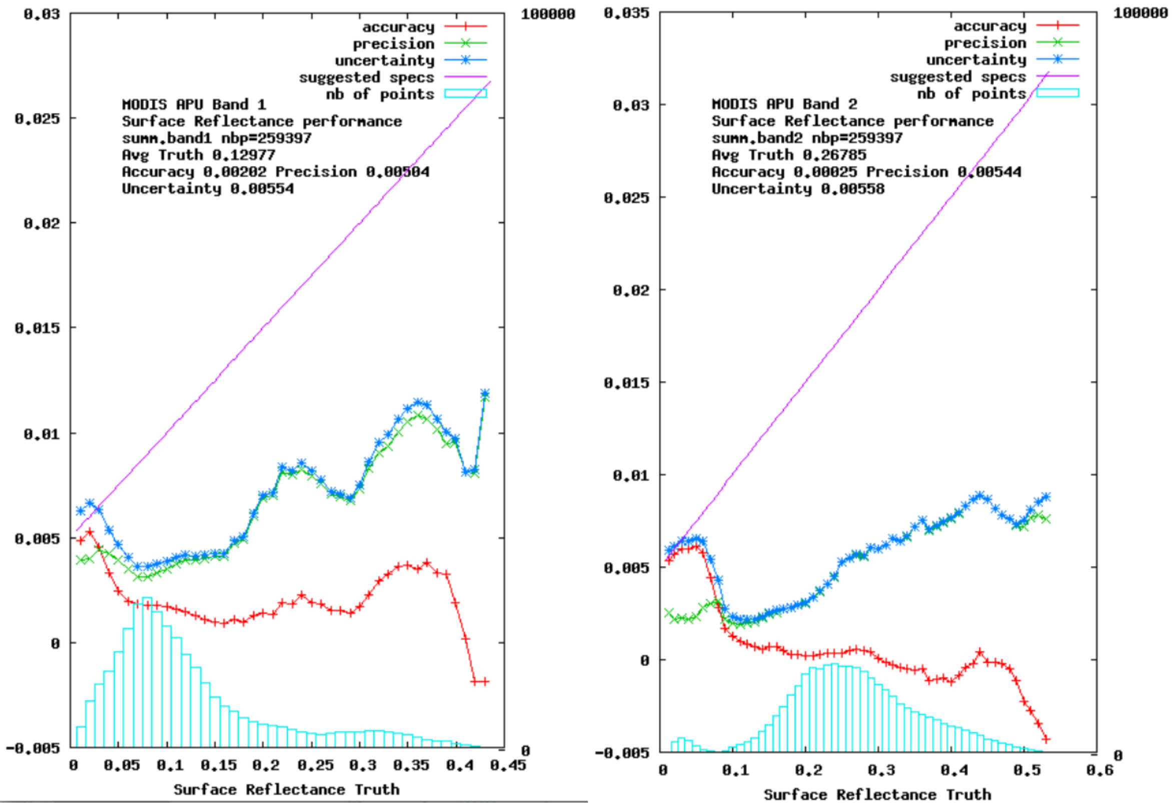
http://mod09val.ltdri.org/cgi-bin/mod09_c005_public_allsites_onecollection.cgi

quantitative assessment of performances (APU)

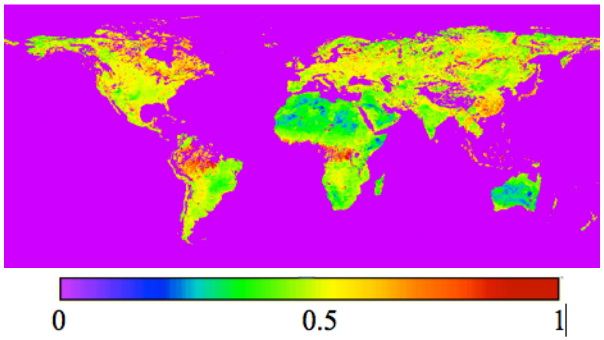


COLLECTION 5: accuracy or mean bias (red line), Precision or repeatability (green line) and Uncertainty or quadratic sum of Accuracy and Precision (blue line) of the surface reflectance in band 1 in the Red (top left), band 2 in the Near Infrared (top right also shown is the uncertainty specification (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



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.



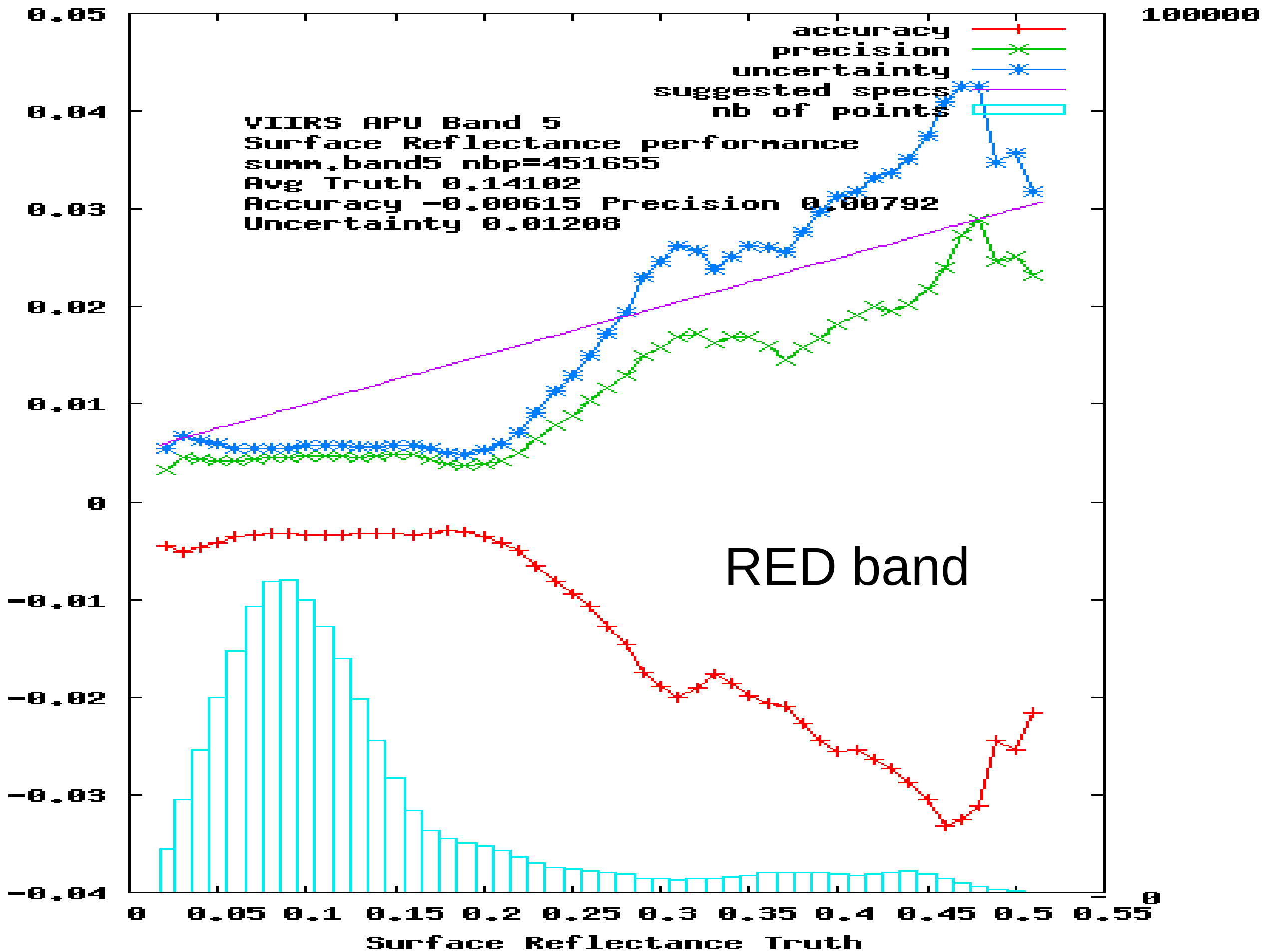
ratio band3/band1 derived using MODIS top of the atmosphere corrected with MISR aerosol optical depth

VIIRS Surface reflectance

- the VIIRS SR product is directly heritage from collection 5 MODIS and that it has been validated to stage 1 (Land PEATE adjusted version)
- MODIS algorithm refinements from Collection 6 will be integrated into the VIIRS algorithm and shared with the NOAA JPSS project for possible inclusion in future versions of the operational product .

Evaluation of Algorithm Performance

VIIRS C11 reprocessing



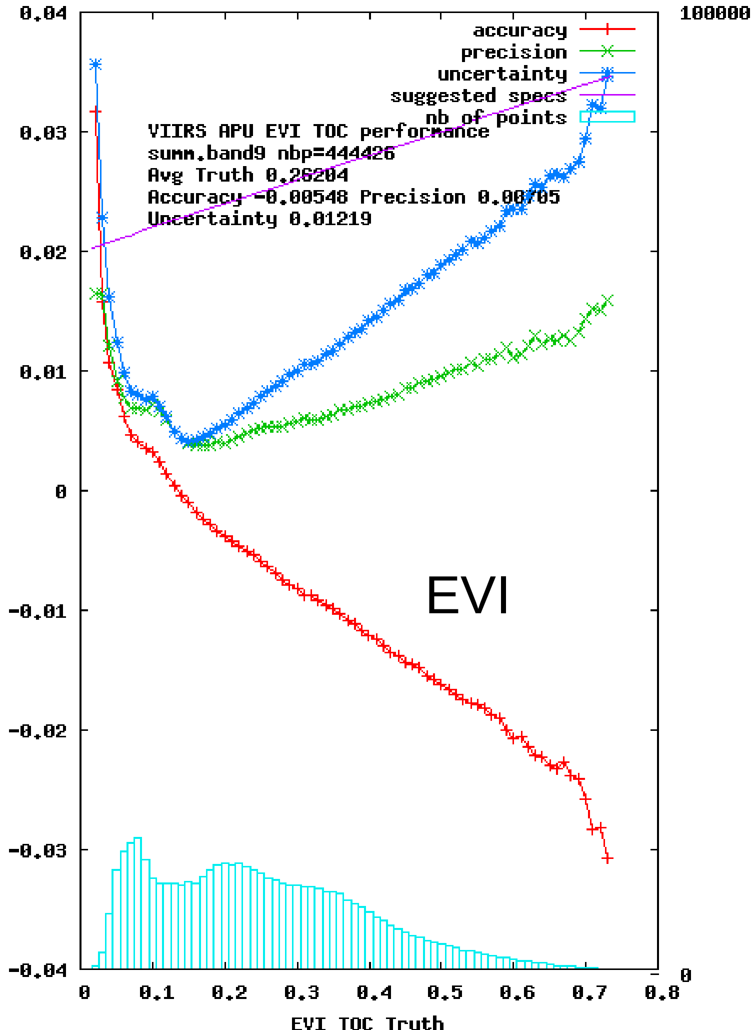
450000 pixels were analyzed for each band.

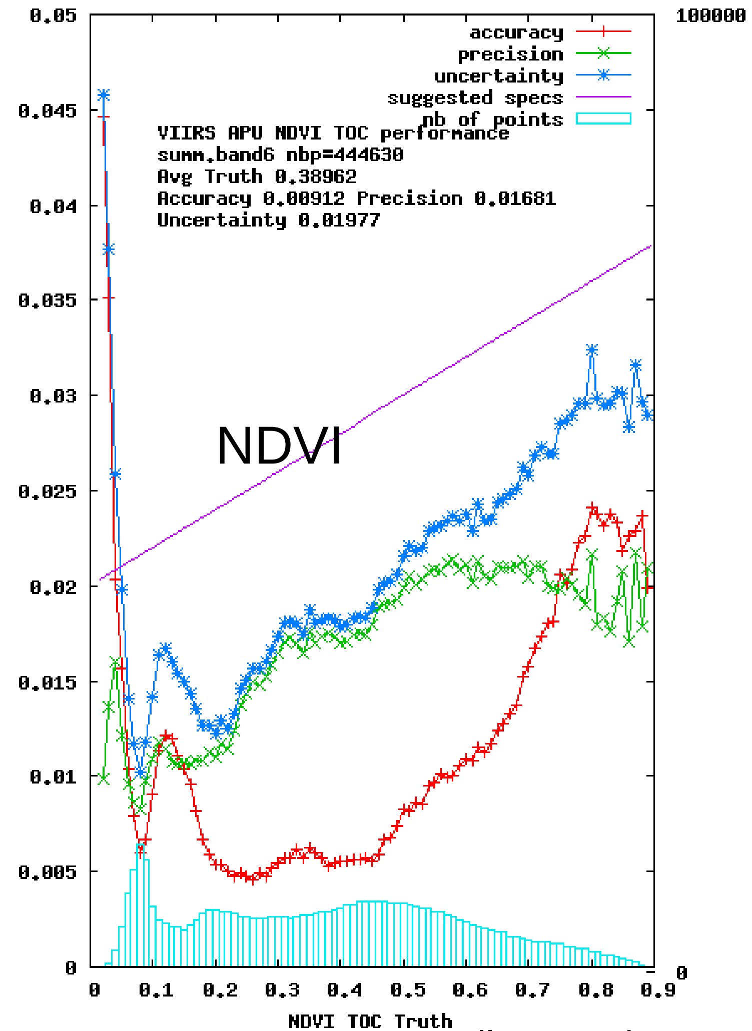
Red = Accuracy (mean bias)
Green = Precision (repeatability)
Blue = Uncertainty (quadatric sum of A and P)

On average well below magenta theoretical error bar

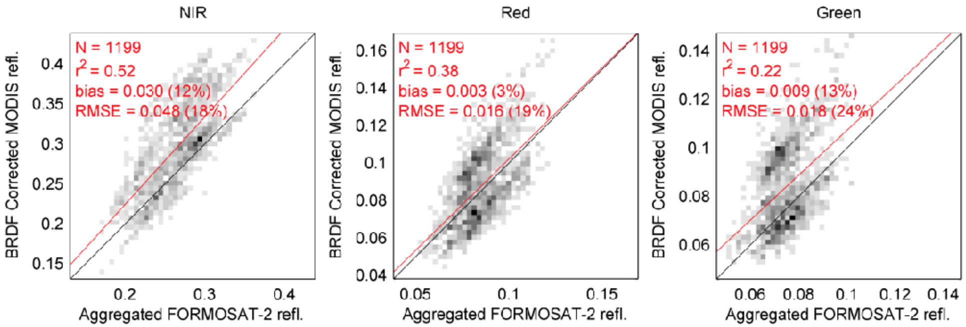
Evaluation of Algorithm Performance

VIIRS C11 reprocessing

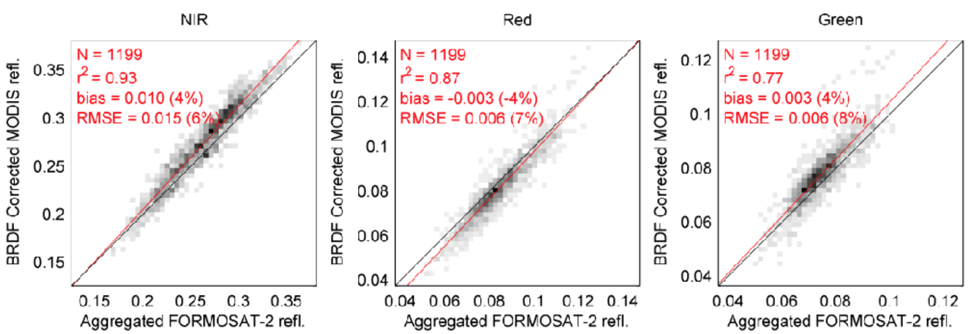




Use of BRDF correction for product cross-comparison



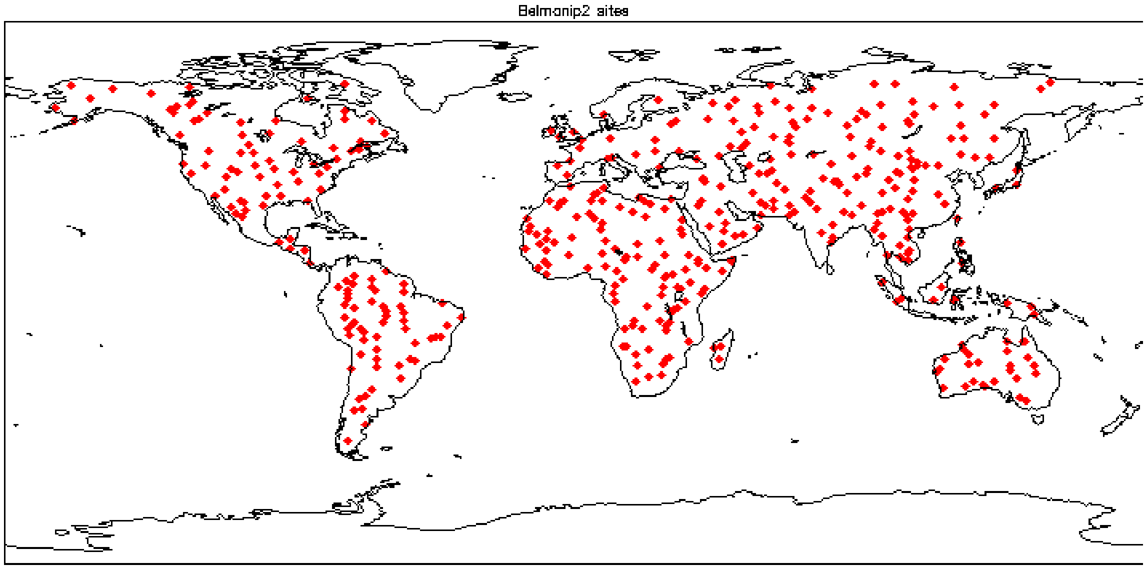
Comparison of aggregated FORMOSAT-2 reflectance and MODIS reflectance. No BRDF correction. Density function from light grey (minimum) to black (maximum); white = no data.

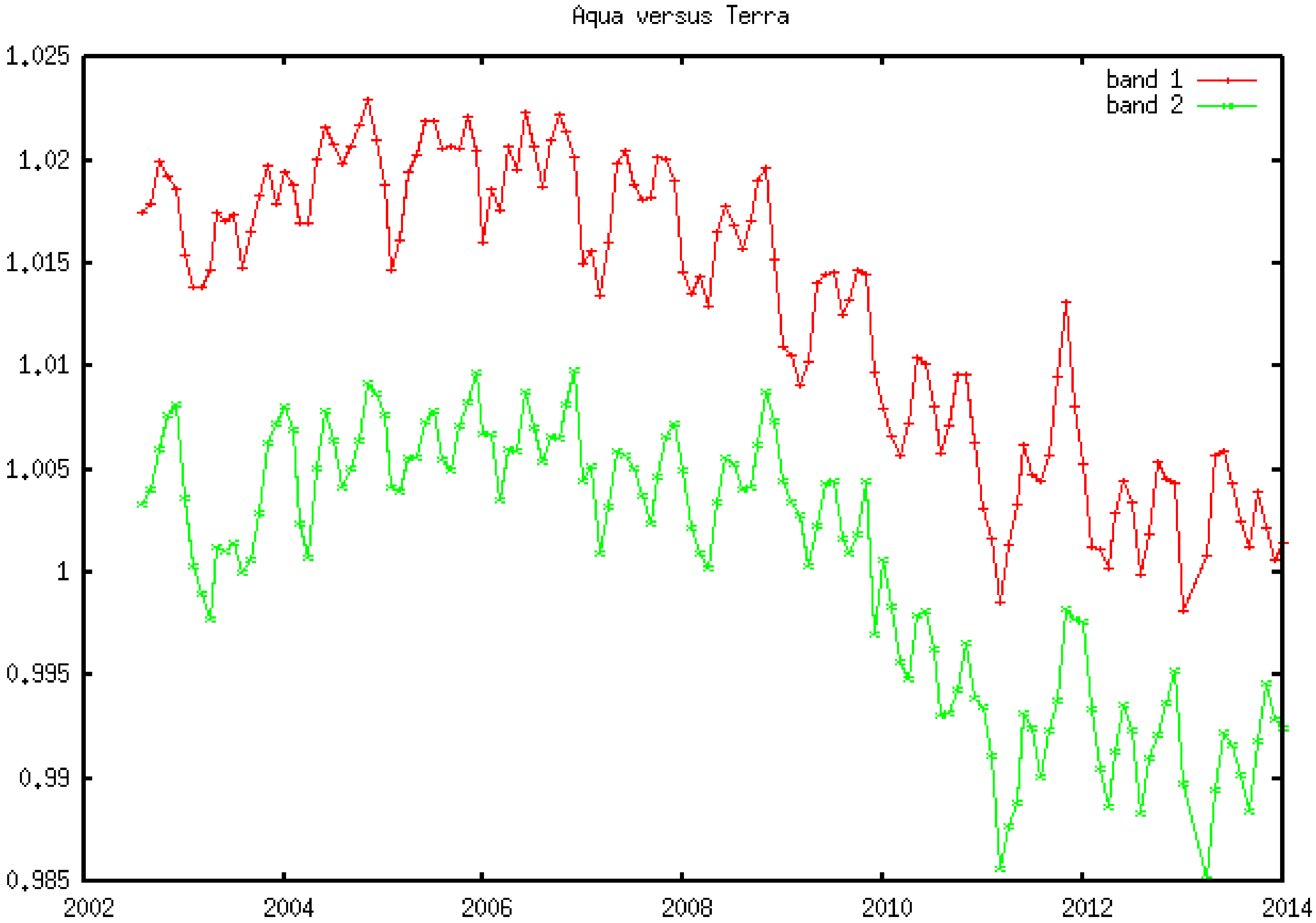


Comparison of aggregated FORMOSAT-2 reflectance and BRDF corrected MODIS reflectance. Corrections were performed with Vermote al. (2009) method using for each day of acquisition, the angular configuration of FORMOSAT-2 data.

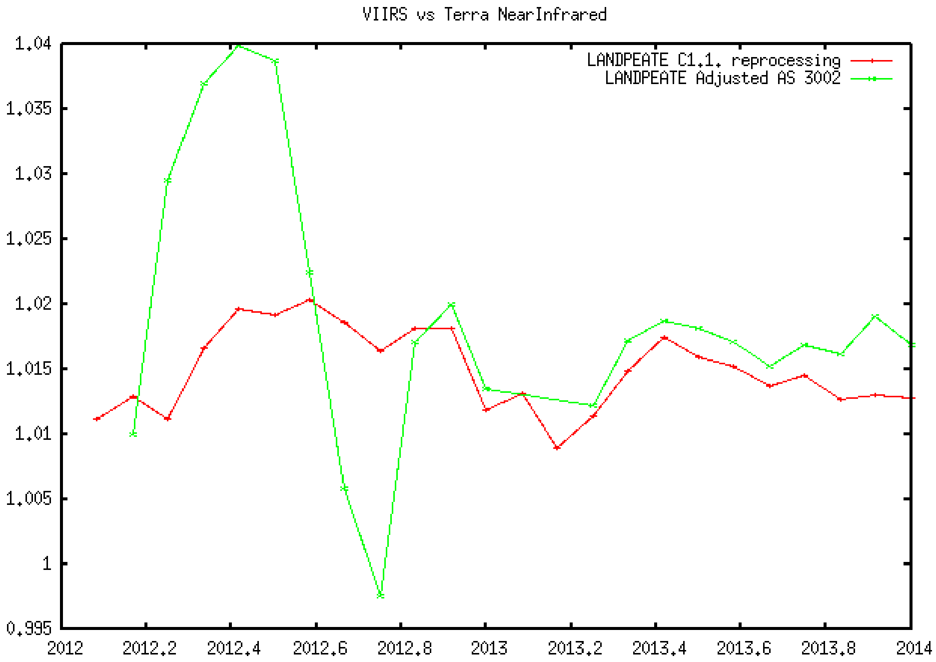
Cross comparison with MODIS over BELMANIP2

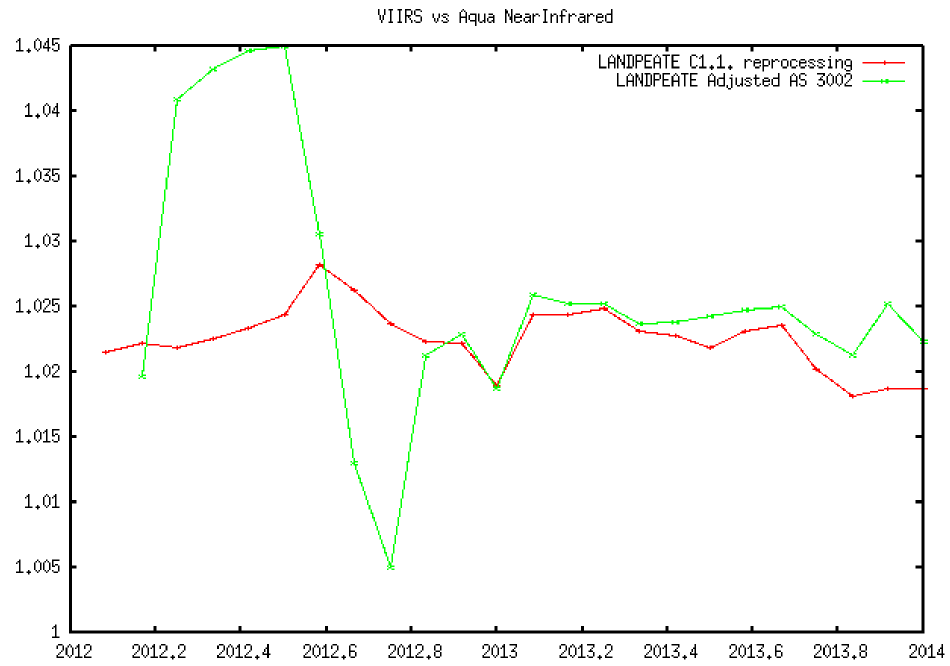
The VIIRS SR is now monitored at more than 400 sites (red losanges) through cross-comparison with MODIS.




Aqua versus Terra
band 1
band 2
1.025
1.02
1.015
1.01
1.005
1
0.995
0.99
0.985
2002
2004
2006
2008
2010
2012
2014

Results over BELMANIP2





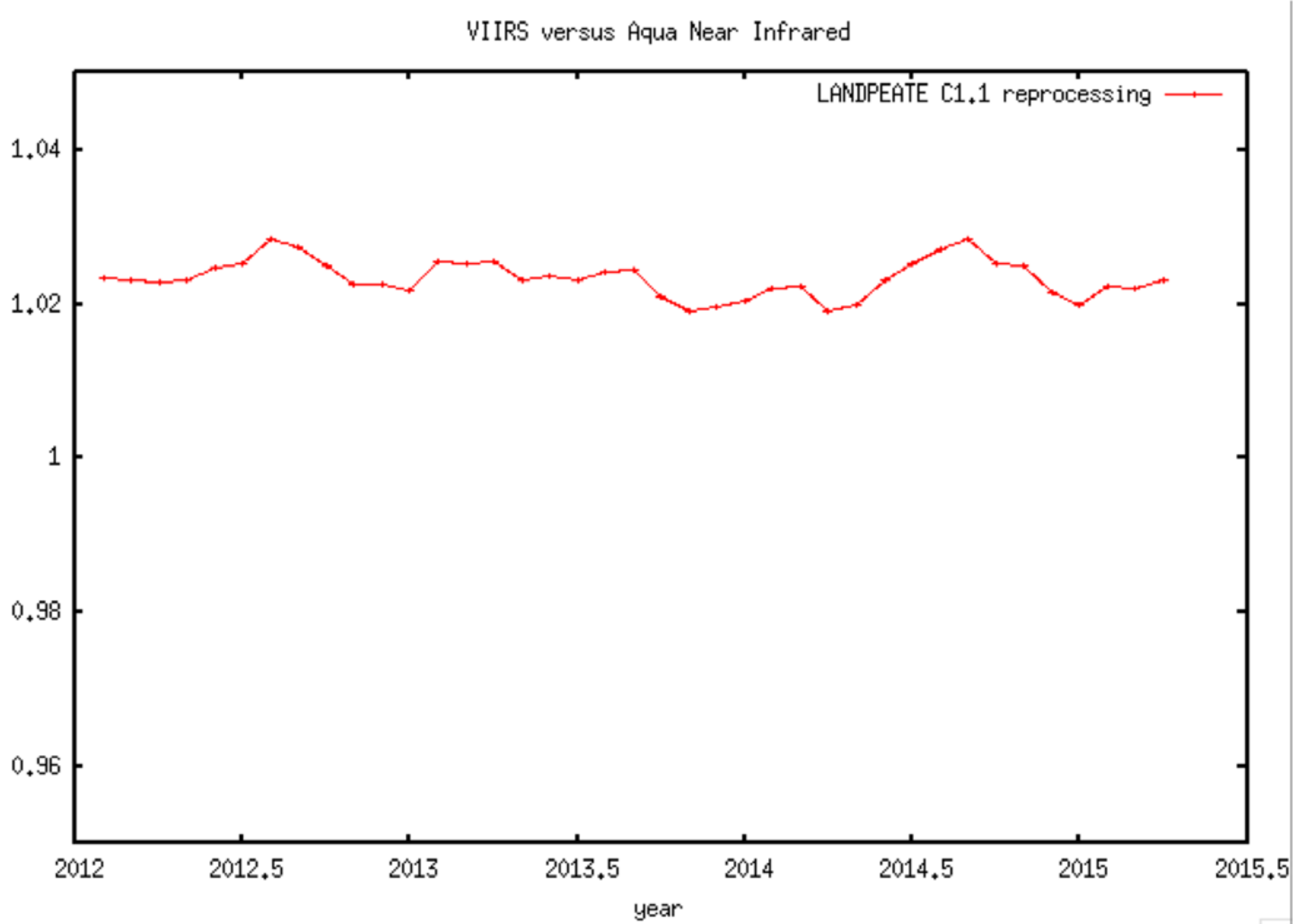


Figure 1: Cross comparison results of the VIIRS and MODIS-Aqua SR product on a monthly basis for the BELMANIP sites reprocessed version (C1.1) for the near infrared band (M7).

The need for a protocol to use of AERONET data

To correctly take into account the aerosols, we need the **aerosol microphysical properties** provided by the AERONET network including size-distribution ($\%C_f$, $\%C_c$, C_f, C_c, r_f, r_c, σ_r, σ_c), complex refractive indices and sphericity.

Over the 670 available AERONET sites, we selected **230 sites** with sufficient data.

To be useful for validation, the aerosol model should be readily available anytime, which is not usually the case.

Following *Dubovik et al.*, 2002, JAS,*[2] one can used regressions for each microphysical parameters using as parameter either τ_{550} (aot) or τ_{440} and α (*Angström* coeff.).

The protocol needs to be further agreed on and its uncertainties assessed (work in progress)

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 to be defined (CEOS CVWG initiative)

JPSS1 and SNPP VIIRS Vegetation Index Products and Algorithm Development

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[2]Department of Natural Resources & Environmental Management University of Hawaii at Manoa

August 27, 2015

Outline

- Overview
  - Team Members, Product Requirements, Accomplishments
- Algorithm Evaluation
  - Algorithm Description, Validation
- JPSS1 Cal/Val Plan
- Enterprise Vegetation Index Algorithm
- NASA SNPP VIIRS Vegetation Index Products
- Future Plans
- Summary

VI EDR Team Members

- Marco Vargas (NOAA/STAR) STAR VI EDR algorithm lead
- Tomoaki Miura (University of Hawaii) VI Cal/Val lead
- Anna Kato (University of Hawaii) Product monitoring and algorithm validation
- Mahany Lindquist (University of Hawaii) Product monitoring and algorithm validation
- Leslie Belsma (Aerospace) Land JAM
- Michael Ek (NOAA/NCEP) User readiness
- Walter Wolf (NOAA/STAR) AI&T Team Lead

JPSS VI EDR Product Requirements

Table 5.5.9 - Vegetation Indices (VIIRS)		
EDR Attribute	**Threshold**	**Objective**
Vegetation Indices Applicable Conditions: 1. Clear, land (not ocean),daytime only		
a. Horizontal Cell Size	0.4 km	0.25 km
b. Mapping Uncertainty, 3 Sigma	4 km	1 km
c. Measurement Range		
1. $NDVI_{TOA}$	-1 to +1	NS
2. EVI (1)	-1 to +1	NS
3. $NDVI_{TOC}$	-1 to +1	NS
d. Measurement Accuracy - $NDVI_{TOA}$ (2)	0.05 NDVI units	0.03 NDVI units
e. Measurement Precision - $NDVI_{TOA}$ (2)	0.04 NDVI units	0.02 NDVI units
f. Measurement Accuracy - EVI (2)	0.05 EVI units	NS
g. Measurement Precision - EVI (2)	0.04 EVI units	NS
h. Measurement Accuracy - $NDVI_{TOC}$ (2)	0.05 NDVI units	NS
i. Measurement Precision - $NDVI_{TOC}$ (2)	0.04 NDVI units	NS
j. Refresh	At least 90% coverage of the globe every 24 hours (monthly average)	24 hrs.
		v2.8, 4/19/13

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

Source: Level 1 Requirements Supplement – Final Version:2.10 June 25, 2014

VI EDR Accomplishments

- Validated Stage 1 Maturity approved by AERB in April 2015
- JPSS1 Algorithm Development (J1 Upper)
  - Completed the development of TOC NDVI
  - CCR-15-2382 approved by AERB in July 2015
- Delivered JPSS1 Cal/Val plan
- Started planning for Vegetation Index Enterprise Algorithm
- Started LTM activities
- New publication

Shabanov, N., M. Vargas, T. Miura, A. Sei, and A. Danial (2015), Evaluation of the performance of Suomi NPP VIIRS top of canopy vegetation indices over AERONET sites, Remote Sensing of Environment pp. 29-44, doi:10.1016/j.rse.2015.02.004.

SNPP/JPSS Vegetation Index EDR

- The Vegetation Index EDR consists of three vegetation indices:
  1. Normalized Difference Vegetation Index ($NDVI^{TOA}$) from top-of-atmosphere (TOA) reflectances
  2. Enhanced Vegetation Index (EVI^{TOC}) from top of canopy (TOC) reflectances.
  3. New for JPSS1 (J1 “Upper”) Normalized Difference Vegetation Index ($NDVI^{TOC}$) from top of canopy (TOC) reflectances
- These indices are produced at the VIIRS image channel resolution (375 m at nadir) over land in granule style (swath form)
- File format: HDF5

VI EDR Algorithm

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

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

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

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

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

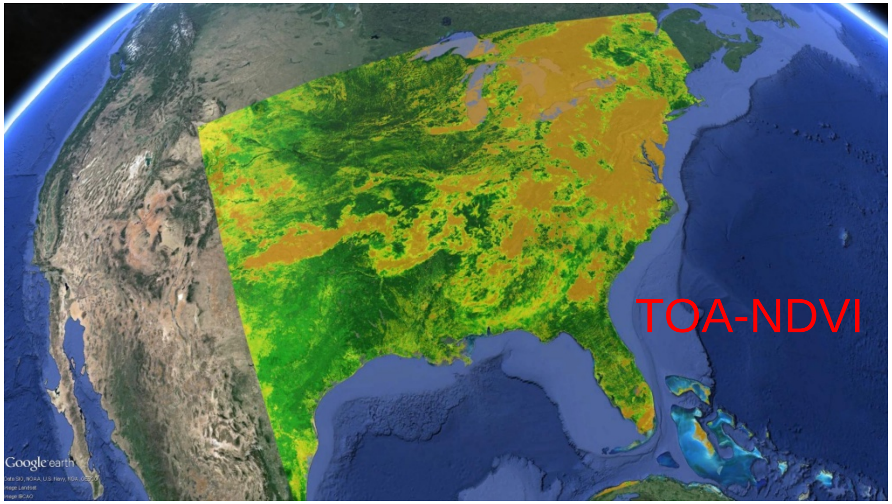
ρ_{I2}^{TOC} Surface reflectance band I2 (865 nm)

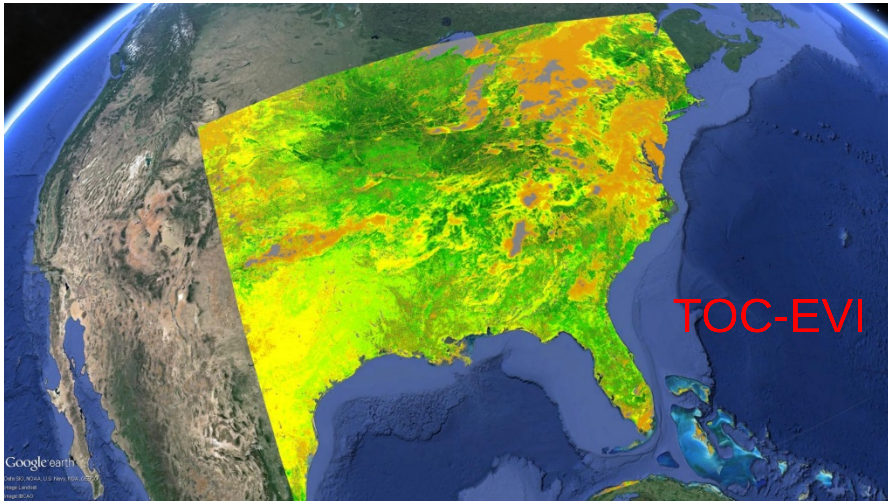
ρ_{I1}^{TOA} Top of the atmosphere reflectance band I1 (640 nm)

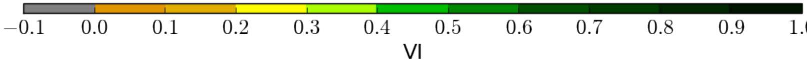
ρ_{I2}^{TOA} Top of the atmosphere reflectance band I2 (865 nm)

C_1, C_2 and L are constants

VI-EDR August 10, 2015

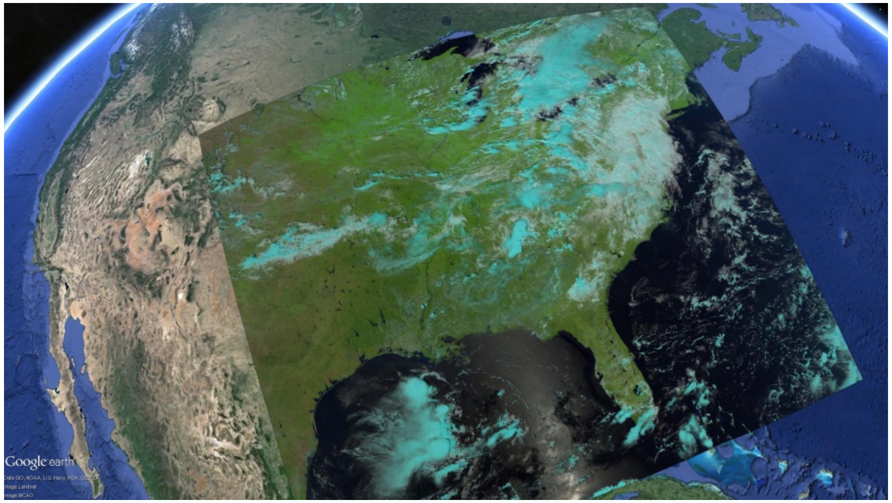






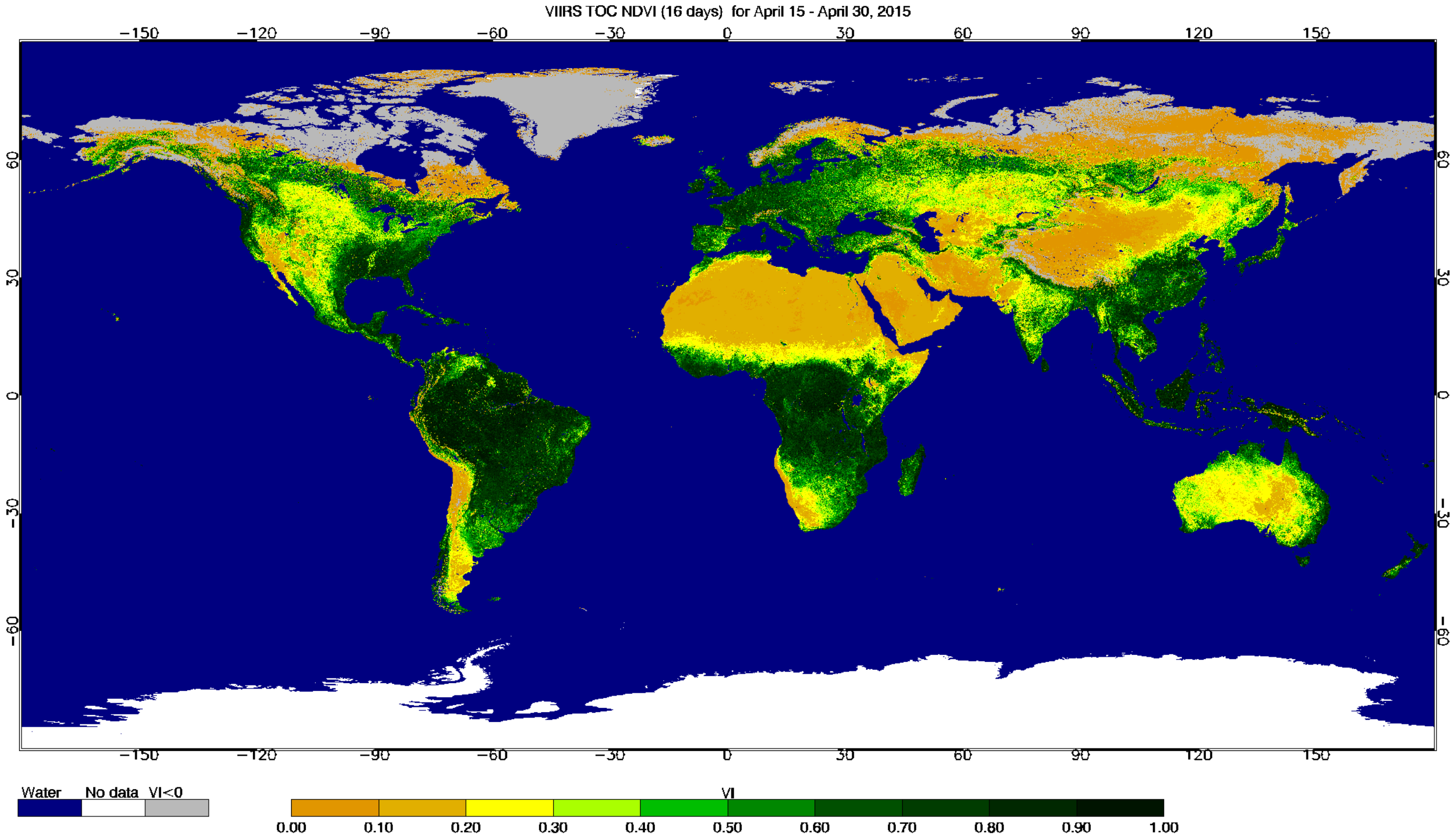
5 merged SNPP VIIRS VIVIO Granules

timestamp d20150810_t1844472
timestamp d20150810_t1846126
timestamp d20150810_t1847380
timestamp d20150810_t1849034
timestamp d20150810_t1850288



RGB (I1, I2 and I3 Imagery EDR bands)

TOC-NDVI
16-day composite



SNPP VIIRS Vegetation Index EDR Current Status

SNPP VI EDR Maturity: Validated Stage 1

Validation activities

1) Global comparisons with Aqua MODIS
2) Evaluation over AERONET sites
3) Time series validation over FLUXNET sites

Instrument/product quality

- High radiometric quality, meeting the L1RDS requirements

VI algorithm issues

- Unrealistic EVI for snow/ice or cloud-contaminated pixels

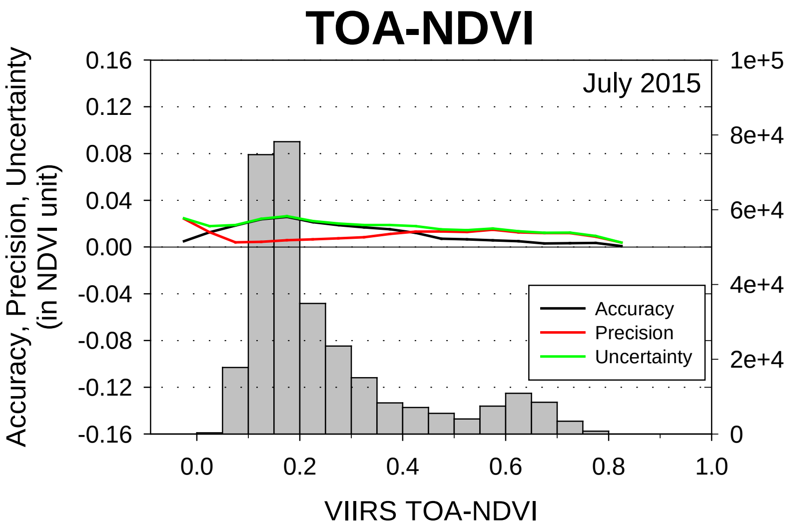
Long Term Monitoring (LTM)

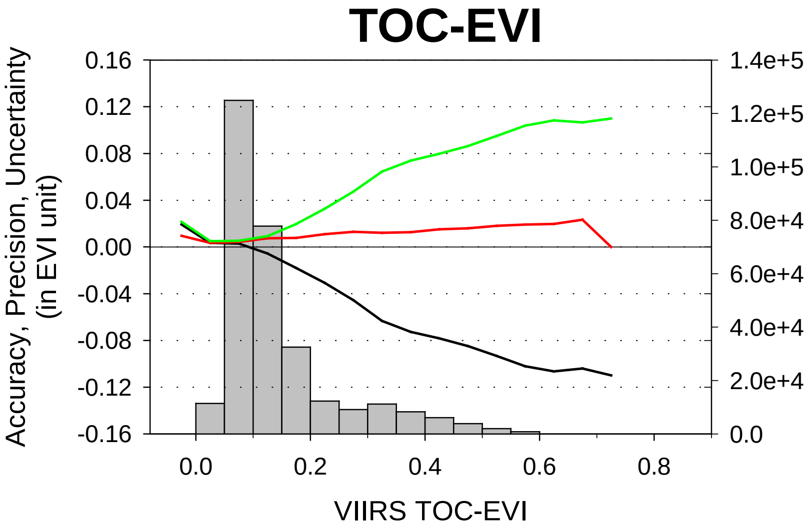
- Ongoing

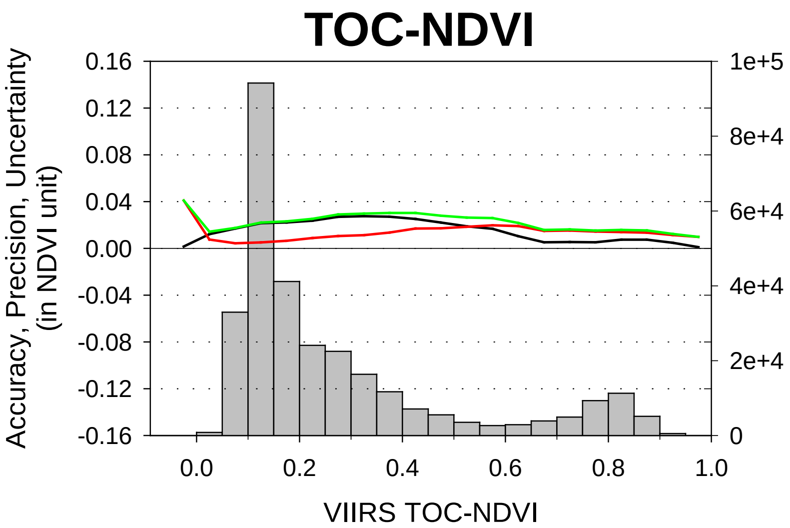
Global APU Estimates (2014 - 2015)

Attribute	L1RDS Threshold (VI units)	Validation Results
TOA NDVI Accuracy	0.05	0.005
TOA NDVI Precision	0.04	0.017
TOA NDVI Uncertainty	0.06	0.020
TOC EVI Accuracy	0.05	0.037
TOC EVI Precision	0.04	0.011
TOC EVI Uncertainty	0.06	0.039
TOC NDVI Accuracy	0.05	0.007
TOC NDVI Precision	0.04	0.023
TOC NDVI Uncertainty	0.06	0.025

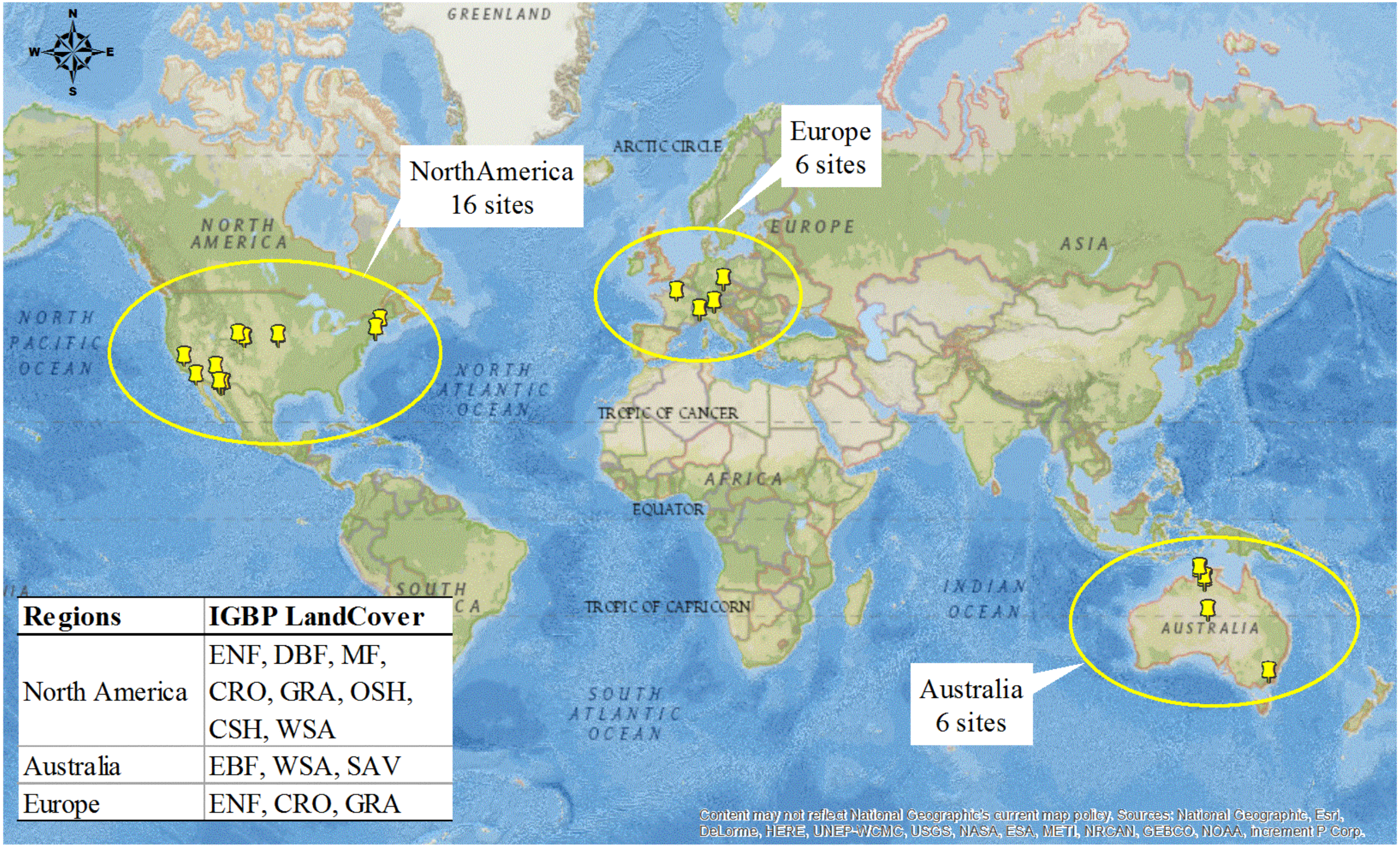
VIIRS Veg. Index EDR Global APU (Aqua MODIS as Reference) July 2015







VIIRS Vegetation Index EDR Temporal Profile Evaluation



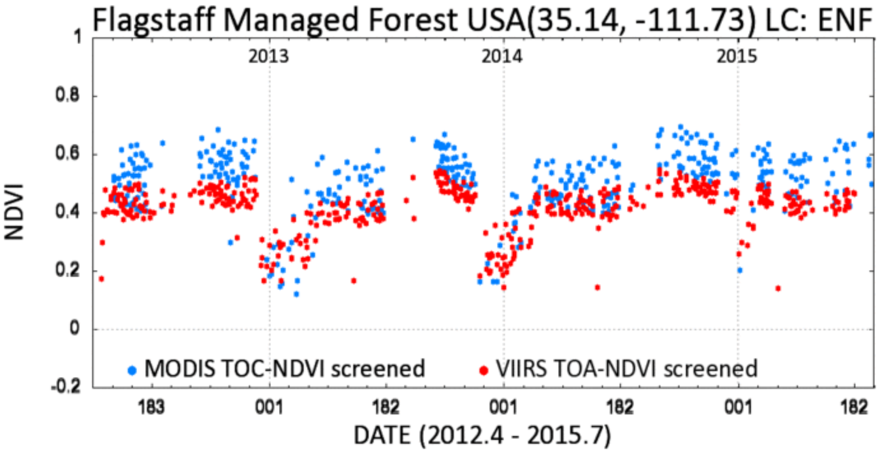
Regions	IGBP LandCover
North America	ENF, DBF, MF, CRO, GRA, OSH, CSH, WSA
Australia	EBF, WSA, SAV
Europe	ENF, CRO, GRA

Validation sites

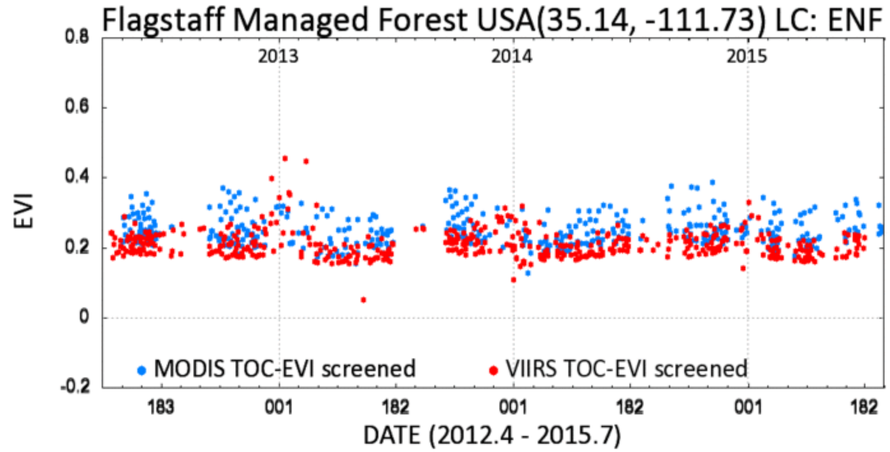
VIIRS Vegetation Index EDR Temporal Profile Evaluation

Red – VIIRS, Blue - MODIS

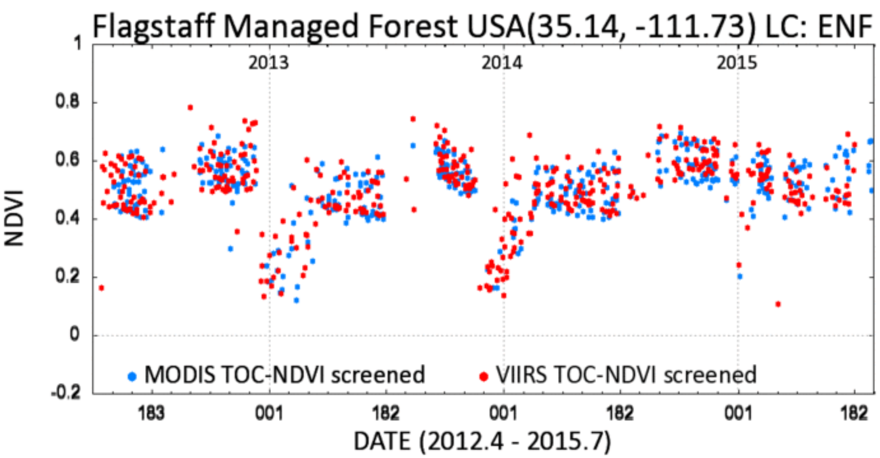
TOA NDVI



TOC EVI

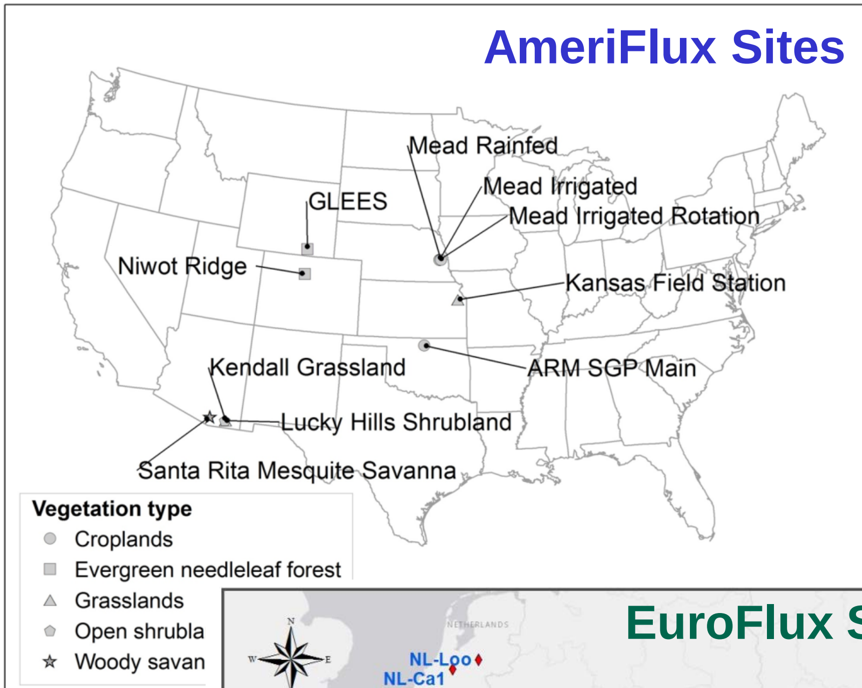


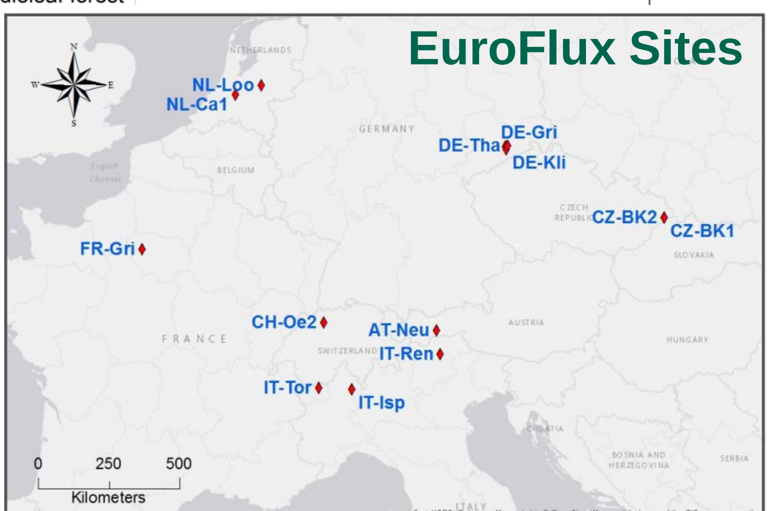
TOC NDVI



- VIIRS temporal profiles show matching seasonal changes with those of MODIS over CONUS, Europe, & Australia, e.g.,
  - Timing & length of peak growing period
  - Multiple growing periods
  - Interannual variations in seasonal changes
- VIIRS daily time series show secondary variations associated with variable Sun/view geometries among observations.

VIIRS Veg. Index Validation Using FLUXNET Radiation Flux Data



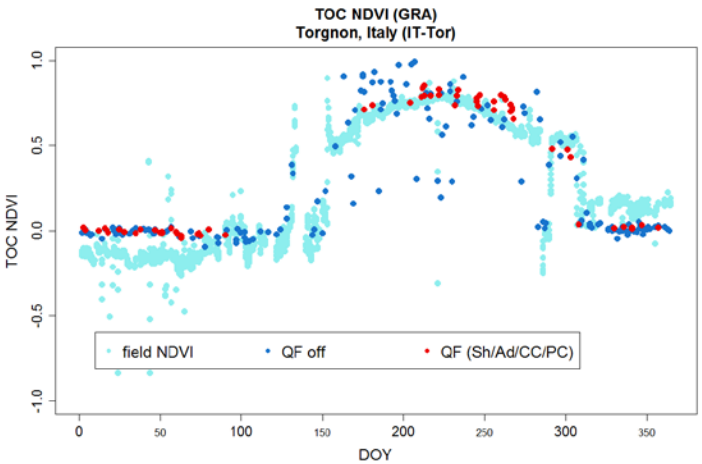


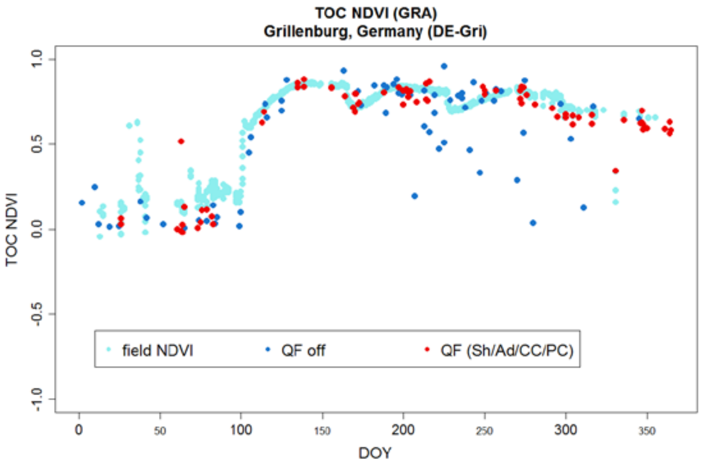
- FLUXNET sites
  - Spatial extent and homogeneity comparable to VIIRS pixels
  - Continuous PAR & global radiation measurements available
- High-temporal resolution NDVI and EVI2 (2-band EVI) time series
  - Computed from PAR & global radiation data (Wilson & Meyers 2007)
  - Cloudy observations removed (using precipitation and incoming global radiation data)

VIIRS Veg. Index Validation Using FLUXNET Radiation Flux Data

TOC NDVI: Sample Time Series

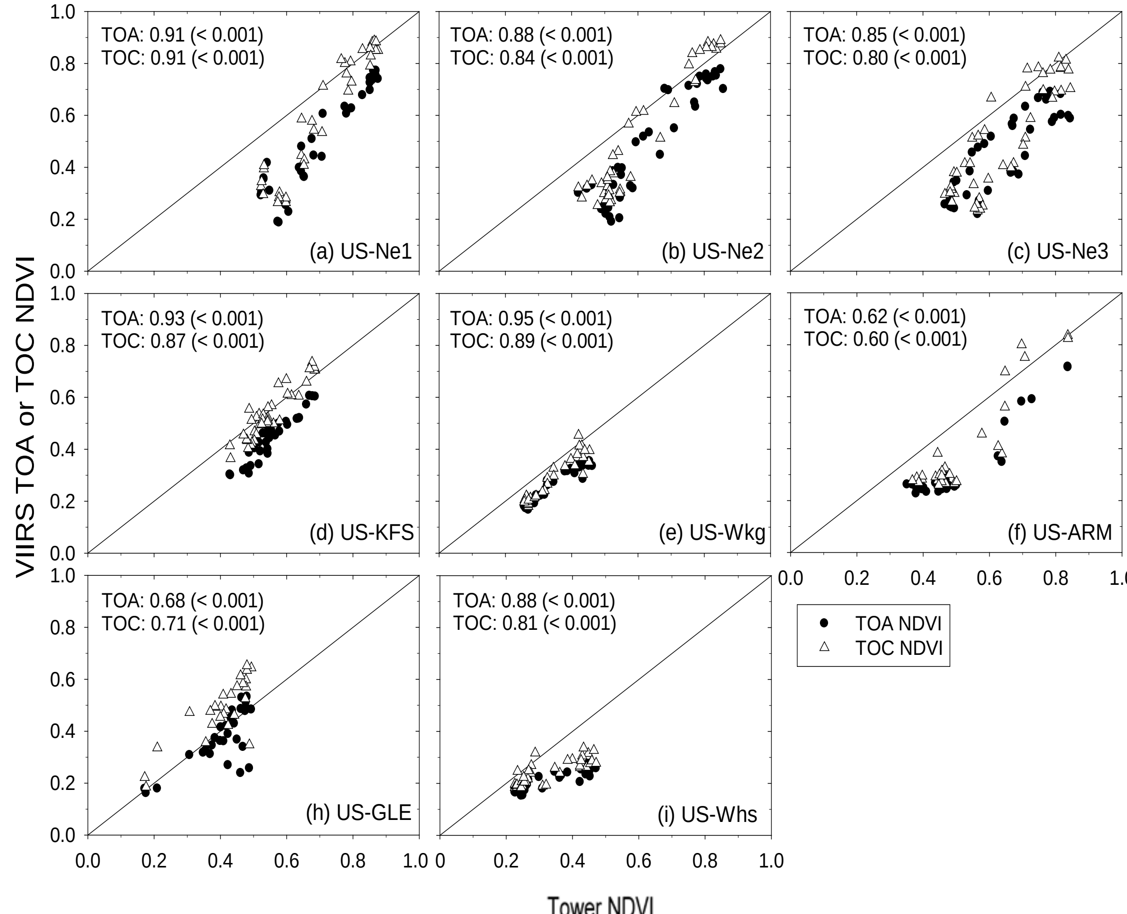
- *EuroFlux* -





VIIRS vs. Tower NDVI Cross-plots

- *AmeriFlux* -



JPSS1 VI EDR Cal/Val Plan

- **JPSS1 VI EDR will be validated by cross-comparisons with:**
  (1) data and products from other sensors (S-NPP VIIRS, MODIS, Landsat 8)
  (2) in situ data from observation networks (AERONET, FLUXNET)
  (3) independently-obtained climate datasets and analysis of process model results (FLUXNET)
- **APUs will be calculated periodically and plotted in time series to assure long-term consistency of the JPSS1 VI EDR**
- **Anticipated data needs for future validation**
  - MODIS, SNPP, FLUXNET, AERONET
- **VI EDR Cal/Val Tools**
  - VDDT, Time Series Analysis Tool, APU Tool, VIIRS Matchup Tool, VI Monitor, VI Phenological Metrics Tool, VI Cross-Comparison Tool
- **Schedule and Milestones** (based on availability of JPSS1 VIIRS VI products no later than March 2017)
  - Beta: October 2017 (VIIRS SDR Beta + 3 months)
  - Provisional: April 2018 (Beta + 6 months)
  - Validated: April 2019 (Provisional + 12 months)

NESDIS Enterprise Algorithms & NESDIS Ground Enterprise Architecture System (GEARS)

- NESDIS embarked in the Strengthening NESDIS initiative to reduce the cost of development, implementation, transition to operations, maintenance and sustainment of the NESDIS ground system
- NESDIS is transitioning to the Ground Enterprise Architecture System (GEARS)
- A new organization, the Office of Satellite Ground Services (OSGS), will consolidate the development and sustainment of all NESDIS ground systems

NESDIS Enterprise Algorithms

<u>Definition</u>: An Enterprise Algorithm is defined as an algorithm that uses the same scientific methodology and software base to create the same product from differing input data (satellite, in-situ or ancillary)

<u>Motivation</u>:

- Brings continuity of NOAA products between current and future NOAA operational satellites
- Cost effective processing for NOAA products
- Maintenance of fewer algorithms and systems within operations

<u>Benefits</u>: One set of algorithms will:

- Satisfy differing program requirements (latency, accuracy, resolution, etc)
- Reduce redundant software development and O&M costs
- Consistent science for data assimilation; fused products; enhanced products; and climate records

STAR Enterprise Algorithms

- <u>**VI EDR is a priority 4 product**</u>
- For JPSS Priority 3 and 4 products, JPSS STAR has been directed by NJO to:
  - Stop working on the NPOESS-heritage algorithms running in IDPS
  - Defer implementation of the algorithm change packages related to priority 3 and 4 products; only with exceptions with the changes that will impact the current operational users of those products
  - Continue work on enterprise science algorithms for all the JPSS Priority 3 and 4 EDR products

Enterprise Algorithm Assessment VI and GVF Products

Product	VIIRS	ABI	GOES	AVHRR	MODIS	Users
VI (NDVI, EVI)	O	F		O	O*	NWS
GVF	O	F				NWS

O – operational, F – future capability, *MODIS production at NASA

Path Forward for Enterprise Solution:

- TOA NDVI from AVHRR; VIIRS also has TOC EVI and TOC NDVI; AVHRR has a Level 3 (L3) product; No official L3 product for VIIRS NDVI or EVI
- GVF in NDE is a L3 product. Calculates its own EVI, same formula as JPSS EVI.
- A L3 suite of products for NDVI, TOC EVI, TOC NDVI and GVF are needed (GVF already in production)
- Need to align requirements across satellites, standardize the requirements
- LAI and FPAR products are also needed. (Users require composite products)
- GOES-R has NDVI and GVF but Option 2 and not operational
- Want GOES-R GVF to be like VIIRS GVF; NDVI is the same for both
- Need to have follow on meetings for VIIRS and GOES-R algorithm path
- Want all land products to use the same Grid and mapping tools. NCEP's stated requirement is 1km global grid
- Move towards NDE and SPSRB (Not use the IDPS deliveries and processes)
- Enterprise NDVI should be TOC NDVI
- NDVI is used for Vegetation Health product but it currently calculates NDVI separately from reflectance
- Possible addition of Sentinel-3 data (gap filler)

NASA SNPP VIIRS Vegetation Products

- NASA has funded a Science Team to produce Earth System Data Records From Suomi NPP (funded by NASA ROSES-13)
- NASA SNPP VI Team is generating Vegetation Index products from SNPP VIIRS extending the EOS-MODIS VI record
- NASA SNPP VIIRS VI Products: NDVI, EVI, EVI2 (Level 3 products for MODIS continuity at all resolutions)
- NASA is reprocessing the entire VIIRS SDR record
- NASA SNPP VIIRS VI products scheduled for archiving and distribution at the Land Processes Distributed Active Archive Center (LP DAAC) starting in April 2016
- STAR VI EDR Team Members Vargas and Miura have met with Kamel Didan (PI for the NASA VIIRS VI product suite) to coordinate efforts to make a successful Algorithm/Product suite for both science (NASA) and operations/applications (NASA/NOAA)

Future Plans

- Support JPSS1 Pre-launch and Post-launch Cal/Val activities
- Continue LTM, anomaly resolution, and reactive maintenance of the SNPP Vegetation index EDR
- Develop Level 3 Vegetation Index products
- Support the STAR/JPSS Enterprise Algorithm development effort

Summary

- The SNPP VIIRS Vegetation Index EDR operational product is stable and performing well
- VI Team ready to support JPSS1 pre-launch activities
- The SNPP VI EDR LTM phase is ongoing
- The JPSS1 VIIRS VI EDR algorithm development has been completed
- JPSS1 Cal/Val plan developed
- Vegetation Index Enterprise Algorithm in planning stage

For more information on VIIRS Vegetation Index EDR

- STAR JPSS

http://www.star.nesdis.noaa.gov/jpss/

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

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

- NOAA JPSS

http://www.jpss.noaa.gov/

- NOAA CLASS

http://www.nsof.class.noaa.gov/

- NASA

http://viirsland.gsfc.nasa.gov/Products/VIEDR.html

JPSS1 and SNPP VIIRS
Green Vegetation Fraction (GVF)

Marco Vargas[1], Zhangyan Jiang[2]

[1]NOAA Center for Satellite Applications and Research, College Park, MD,
[2]AER, College Park, MD

STAR JPSS 2015 Science Team Annual Meeting, August 24-28, NCWCP College Park, MD

GVF Team Members

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

GVF Users

- NCEP/EMC
- CLASS
- NASA/SPoRT

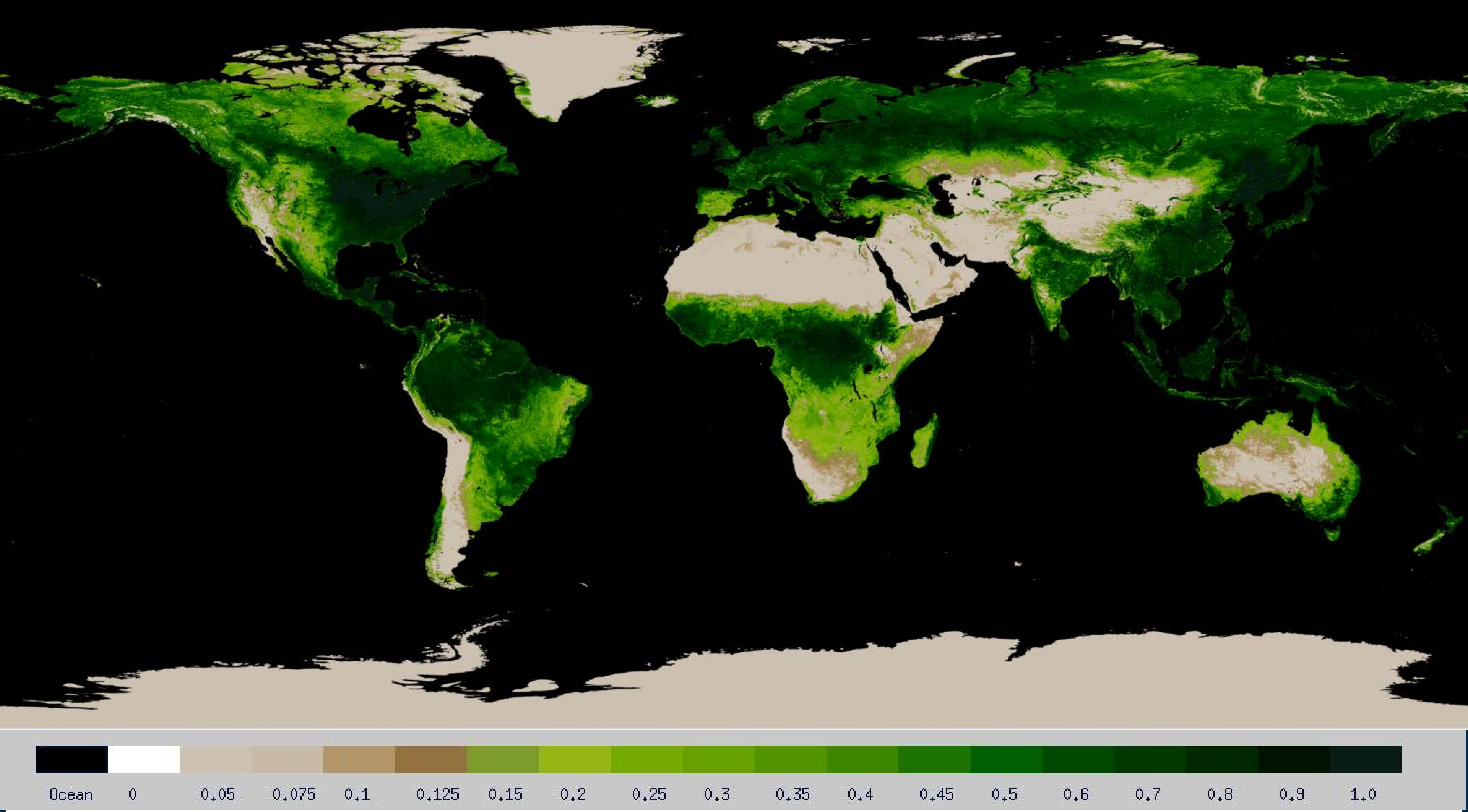
FY14-15 Accomplishments

- Delivered SNPP VIIRS GVF LINUX DAP to NDE (May 2014)
- Supported the NDE IPT team to during the integration, testing and pre-operational phase of the GVF system
- Briefed the VIIRS GVF product at the monthly SPSRB meeting for an operational decision in Sep, 2014
- The GVF product became operational within the Suomi NPP Data Exploitation (NDE) production facility in February 2015
- Started collaboration with NWS/NCEP to demonstrate that using the VIIRS GVF operational product instead of the AVHRR climatology will improve the performance of NOAA's environmental prediction suite

SNPP VIIRS GVF Product

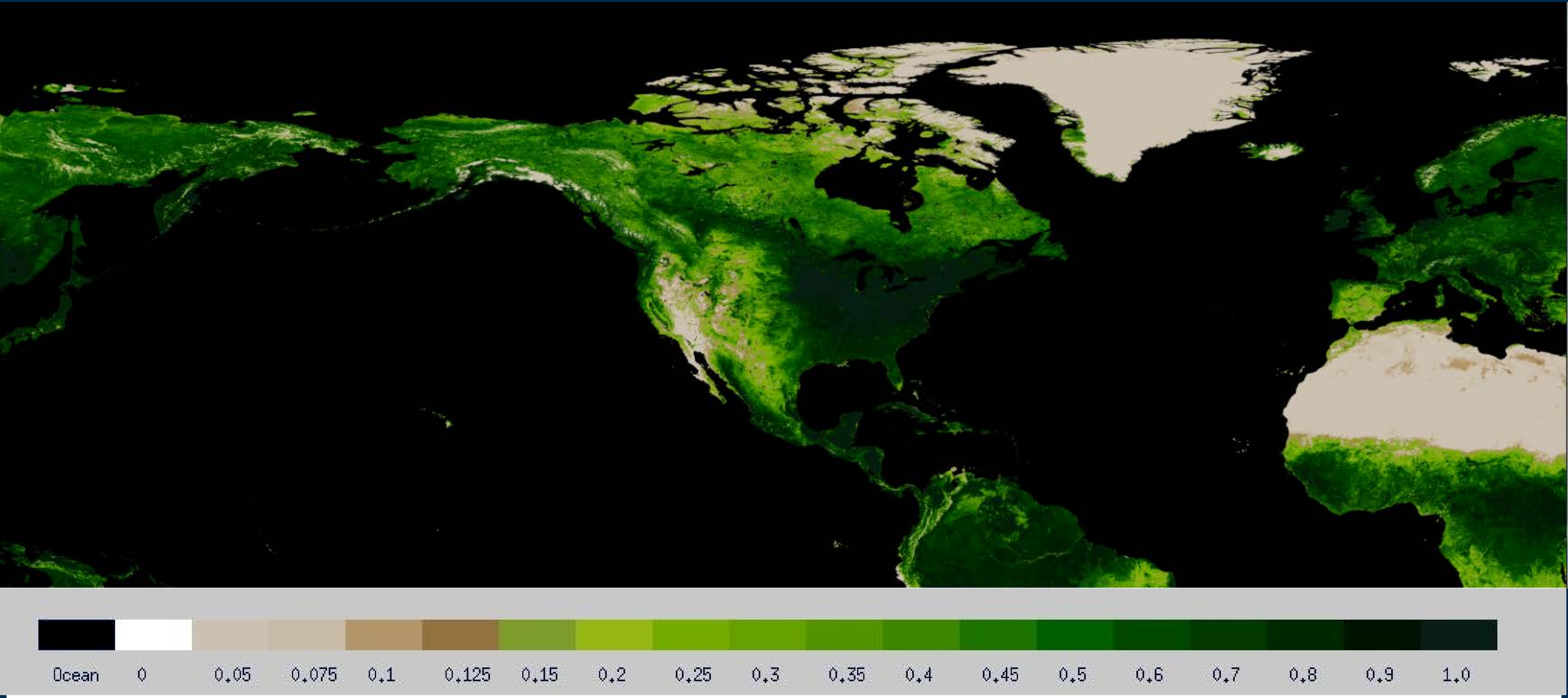
- The SNPP VIIRS GVF consists of two products:
  1) Daily Rolling Weekly GVF global (4-km resolution)
  2) Daily Rolling Weekly GVF regional (1-km resolution)
- SNPP VIIRS GVF products are derived from VIIRS surface reflectance data (Bands I1, I2 and M3)
- Surface reflectance data are gridded, composited and used for calculating the Enhanced Vegetation Index (EVI)
- GVF is derived from EVI

SNPP VIIRS GVF Global (4km res)



4km resolution weekly global GVF (August 18-24, 2015)

SNPP VIIRS GVF
Regional Product (1km res)

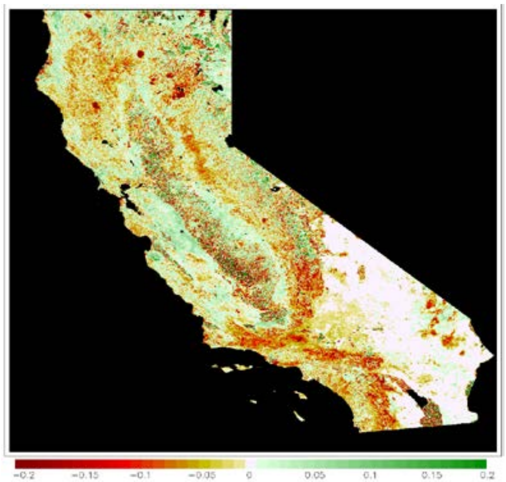


1km resolution weekly regional GVF (August 18-24, 2015). Coverage Lat 90°N - 7.5°S, Lon 130°E - 30°E

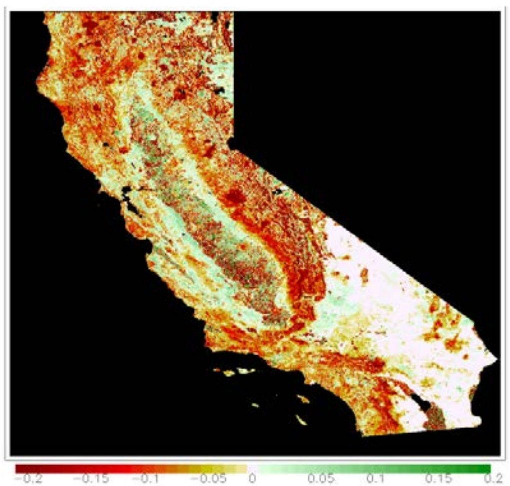
Monitoring Drought in California With SNPP VIIRS GVF

- California has been experiencing a severe drought since 2012
- Drought conditions develop gradually and they are often not identifiable immediately
- VIIRS Green Vegetation Fraction (GVF) can easily monitor <u>changes in vegetation density</u>

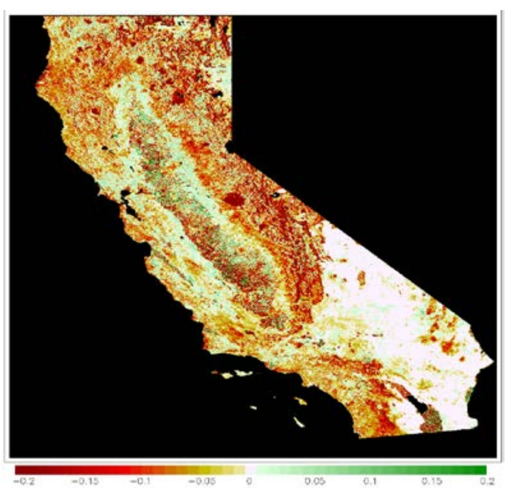
2013-08-15 minus 2012-08-15



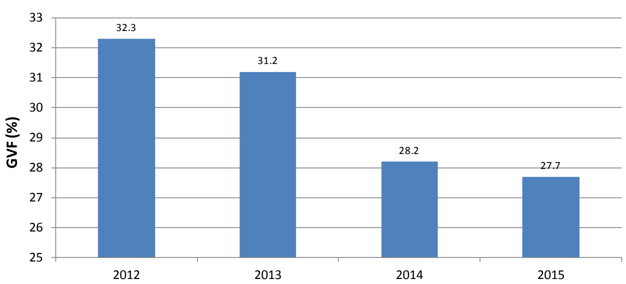
2015-08-15 minus 2012-08-15



2014-08-15 minus 2012-08-15



California mean GVF



California mean GVF in August decreased from 32.3% in 2012 to 27.7% in 2015

SNPP VIIRS GVF Validation

SNPP VIIRS GVF product Validation

- GVF product maturity: Provisional
- The SNPP VIIRS GVF pre-operational product was shown to meet the threshold performance attributes identified in the JPSS Level 1 Requirements Supplement
- SNPP VIIRS GVF pre-operational product was validated against Landsat derived GVF, and compared with AVHRR derived GVF
- Time series stability monitoring

Attribute Analyzed	L1RD Threshold	VIIRS GVF
Measurement accuracy		
1. Global	12%	7.9%
2. Regional	12%	6.5%
Measurement precision		
1. Global	15%	10.9%
2. Regional	15%	12.6%
Measurement uncertainty		
1. Global	17%	13.4%
2. Regional	17%	14.2%

Path Forward towards JPSS1

- Provide VIIRS GVF continuity and upgrades for JPSS1
  - Project Plan to produce the JPSS1 VIIRS GVF
  - GVF Algorithm update/development for JPSS1
  - SNPP/JPSS1 VIIRS GVF Compatibility assessment
- Anticipated data needs for future validation
  - SNPP VIIRS GVF, AVHRR GVF, Landsat GVF
- Product Validation
  - Deliver Cal/Val plan for the JPSS1 VIIRS GVF product

Future Plans

- Advance the SNPP VIIRS GVF to validated maturity
- Continue providing SNPP VIIRS GVF algorithm maintenance and product anomaly resolution
- Develop SNPP VIIRS GVF climatology
- JPSS1 VIIRS GVF algorithm development
- Develop GVF enterprise algorithm

Summary

- The SNPP VIIRS GVF operational product is stable and performing well
- Working with NCEP to improve the use of the operational GVF product in their land modeling suite
- JPSS1 VIIRS GVF Project Plan has been written
- GVF Enterprise Algorithm in planning stage
- SNPP VIIRS GVF product available from NOAA CLASS

http://www.nsof.class.noaa.gov/

- For more information on SNPP VIIRS GVF

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

http://viirsland.gsfc.nasa.gov/Products/GVF.html

http://www.star.nesdis.noaa.gov/jpss/

IMPROVEMENT in GLOBAL DROUGHT WATCH FROM S-NPP VEGETATION HEALTH (VH)

Felix Kogan
National Oceanic and Atmospheric Administration (NOAA)
National Environmental Satellite Data and Information Services (NESDIS)
Center for Satellite Applications and Research (STAR)

JPSS
August 27, 2015

Drought (D) as Natural Disaster

- D. affects the largest number of people
- D. is the most costly
- D. is a part of earth's climate
- D. occurs every year
- D. does not recognize borders, political & economic differences

World Population Affected by Natural Disasters 1967-1991

	%	
Disaster Type	Affected	Killed
	Weather	
Drought	**51**	**38**
Flood	38	9
Hurricane etc.	8	27
	Geological	
Earthquake	2	18
Volcano	<1	<1

Total People Affected: **2.8 billions**

Total People Killed: **3.5 millions**

Drought Disasters during 1980-2008

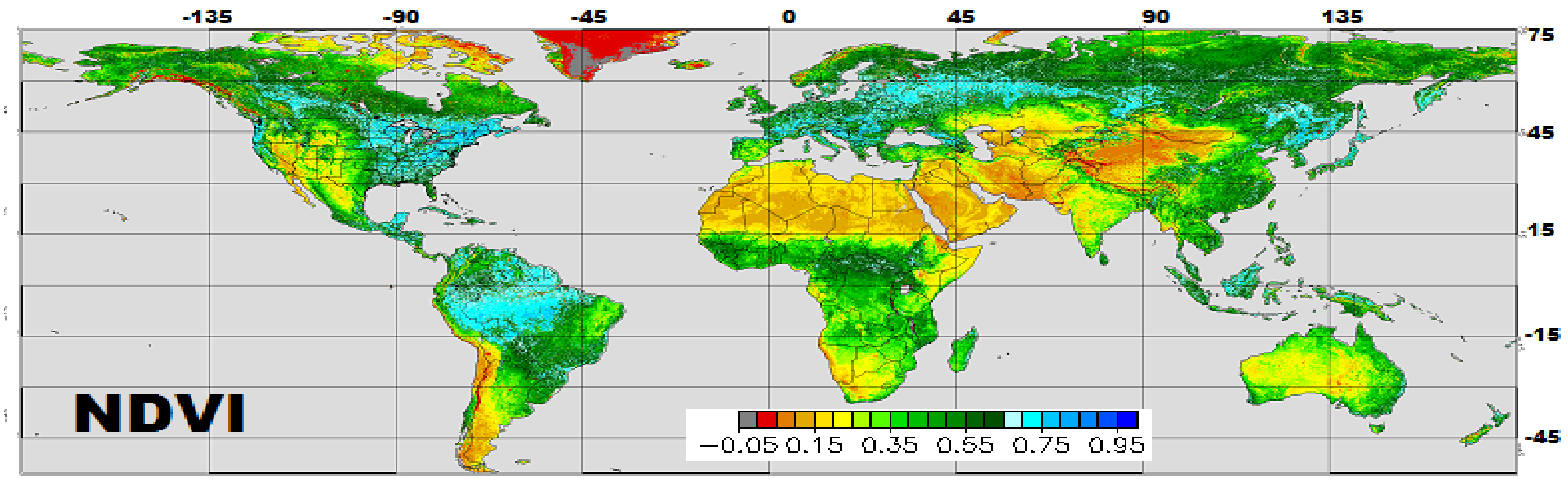
• No of people affected	1,551,455,112
India 2002 -	300,000,000
• No of people killed	558,565
Ethiopia 1983 -	300,000
• Economic damages	
China 1994	$ 13.8 bil
Australia 1981	$ 6.0 mil
USA 1988	$ 40-60 bil
USA 2006-2015 California	$ 2.7 bil (21,000 job loss)

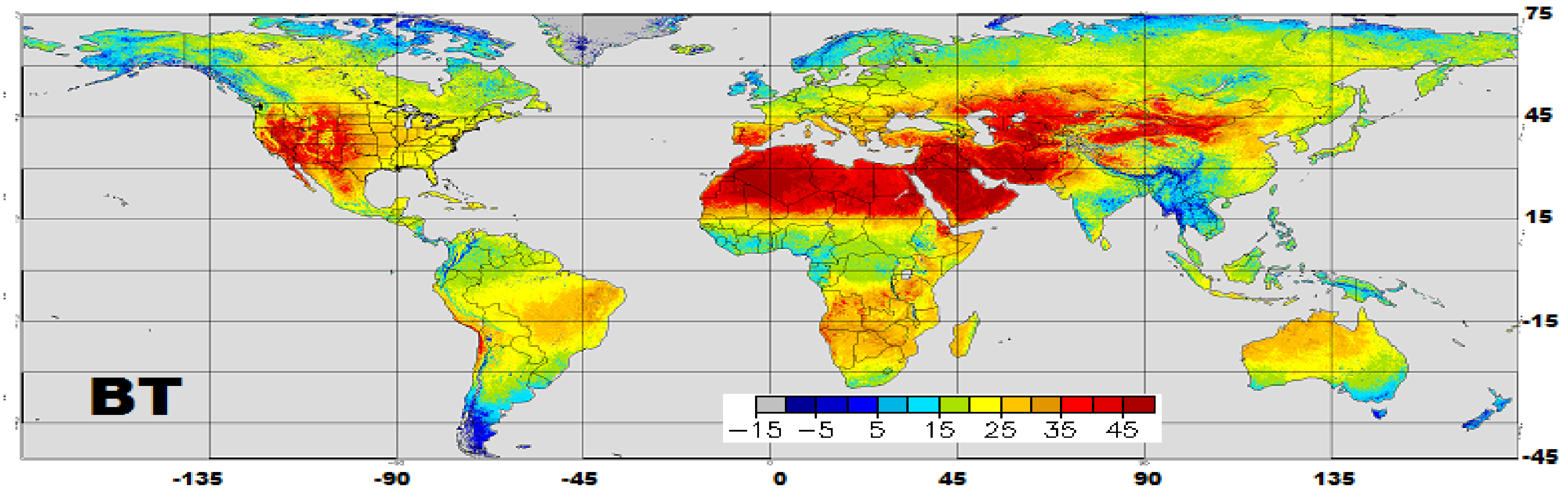
http://www.preventionweb.net/english/hazards/statistics/?hid=59

Drought Unique Features

- **Start** unnoticeably
- **Build-up** slowly
- **Develop** cumulatively
- **Impact** cumulative & not immediately observable
- **Mitigation:** When damage is evident it's too late to mitigate the consequences
- **Drought type:** Meteorological, Agricultural, Hydrological, Socio-Economic

Normalized Difference Vegetation Index & Brightness Temperature

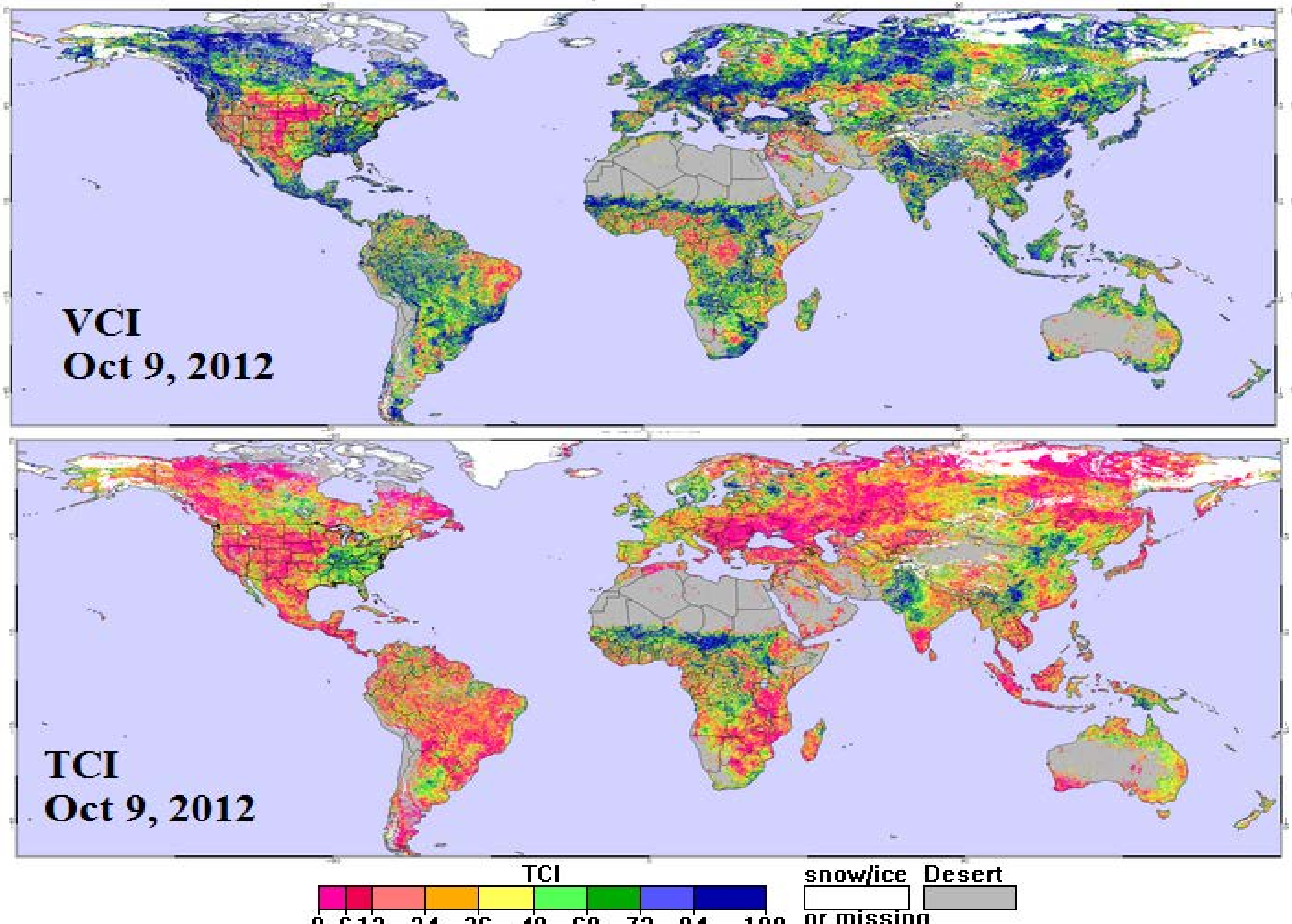




VH Requirements

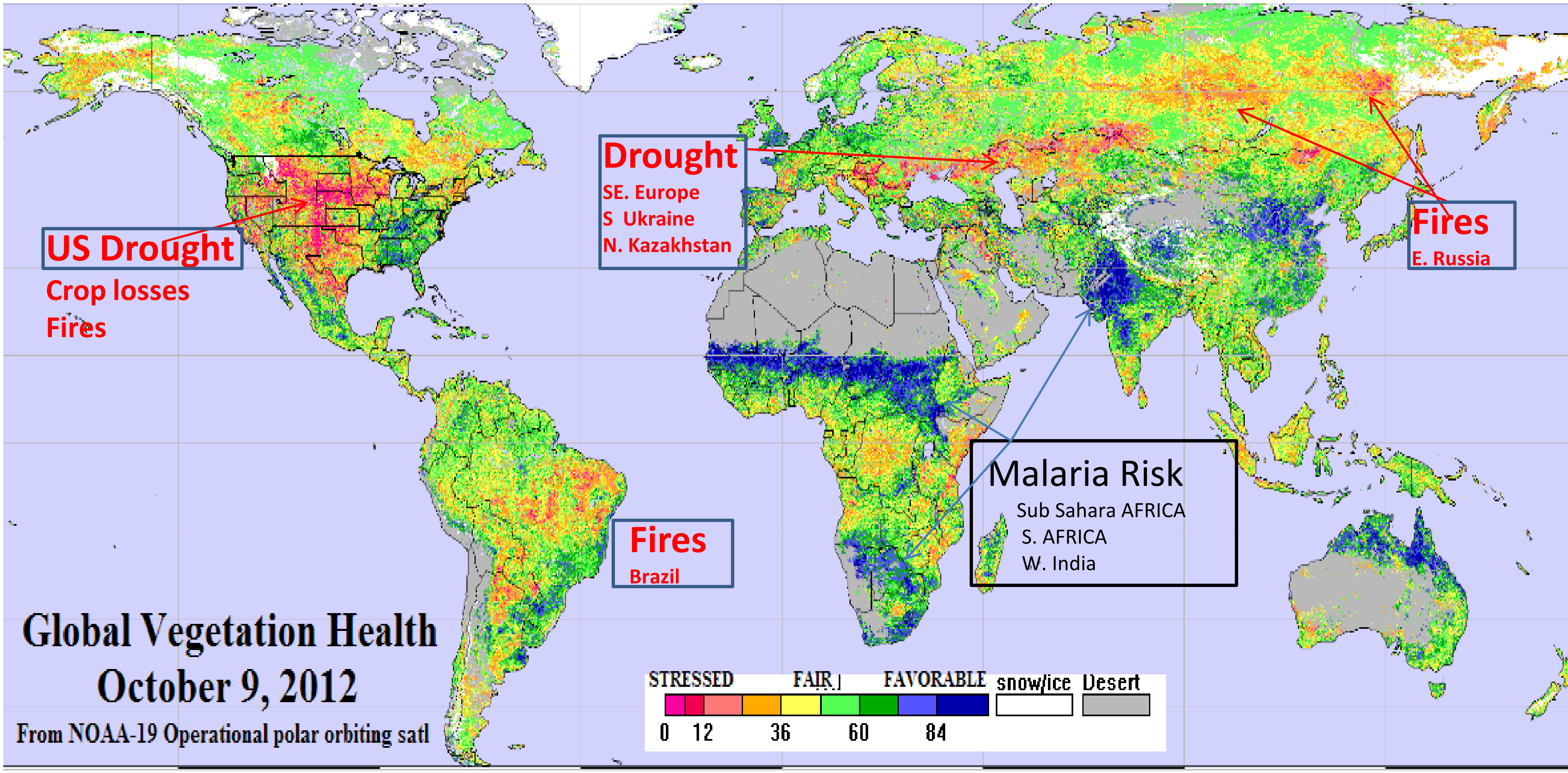
- **Real time NDVI and BT**
- **Climatology of NDVI and BT**

Vegetation Condition (VCI) and Themperature condition (TCI) indices



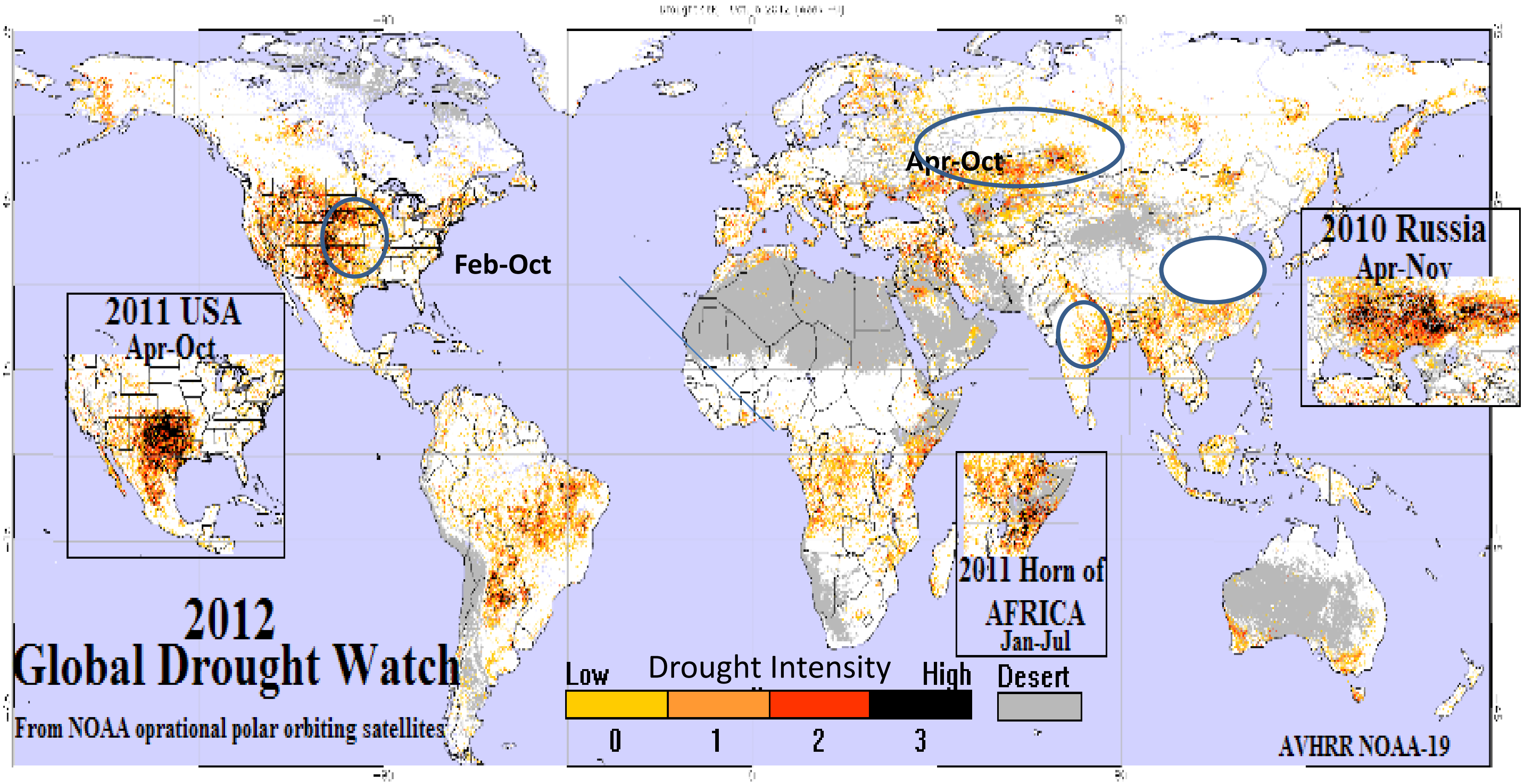
2012 Global Vegetation Health (VH)

From AVHRR/NOAA-19 Operational Polar Orbiting Satellite



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

Global Droughts from operational satellites



2012- Extreme drought in the USA, southern UKRAINE, northern KAZAKHSTAN,

- Severe drought in eastern INDIA, Kenya & South Americe

2011 – Exceptional drought in Texas (USA) and the Horn of AFRICA

2010 - Exceptional drought in RUSSIA and UKRAINE

USDA user (August 8, 2015)

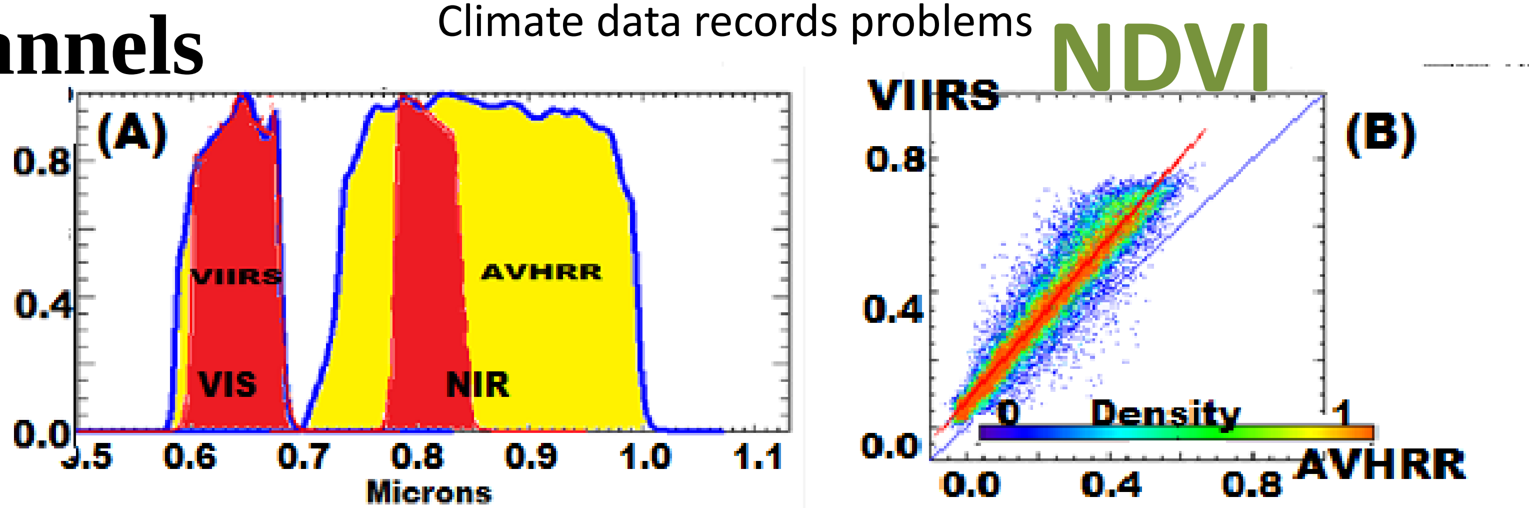
Eric Luebehusen, Analyst for FAS & WAOB (ELuebehusen@oce.usda.gov)

“the 4km VHI is a very big hit at USDA with senior level staff, economists, and meteorologists. I often get specialized requests for maps of the 4 km VHI “as soon as it’s available”, and the data is used to support our monthly crop yield and production estimates, particularly in the mid-latitudes”

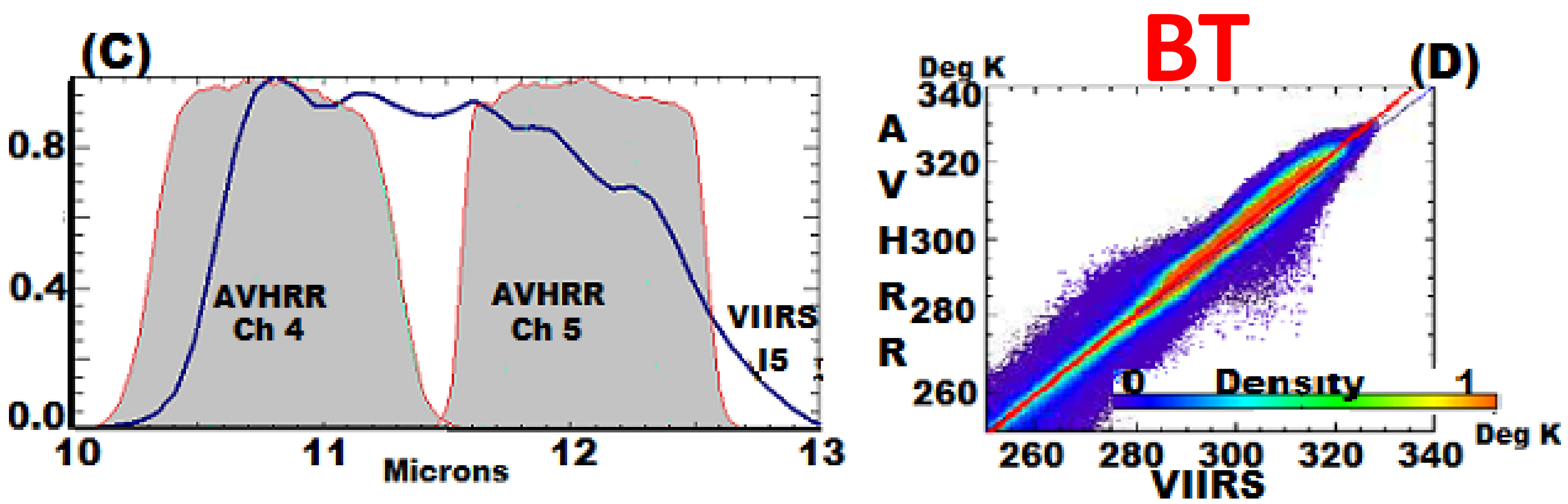
VIIRS versus AVHRR

Channels

Climate data records problems

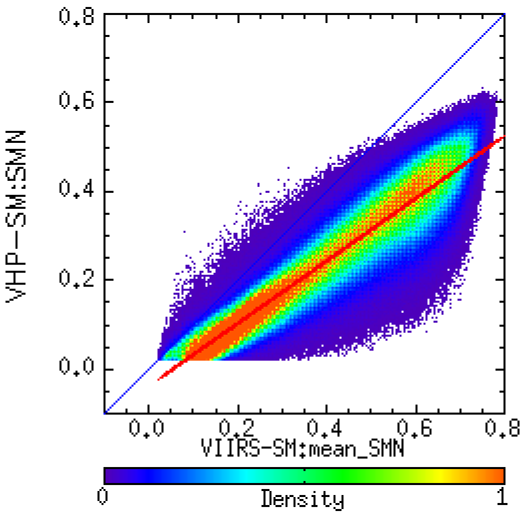


Normalized Difference Vegetation Index (NDVI)



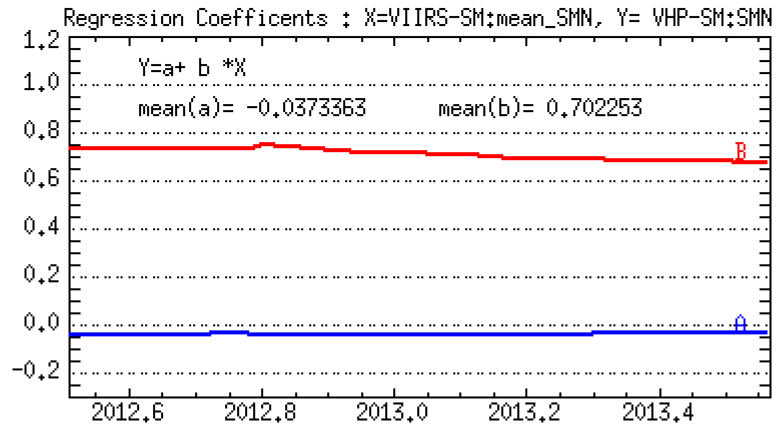
Brightness Teperature (BT)

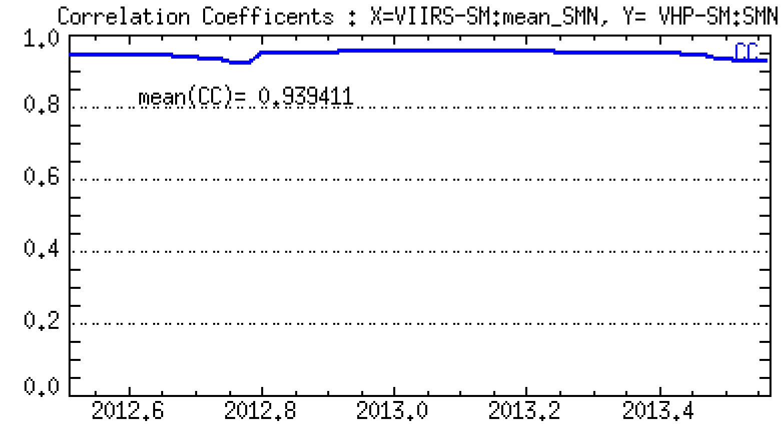
NDVI (SMN): AVHRR-VIIRS time series



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

Nsamples=4963003
CC = 0.9374
RMSE =0.0486750

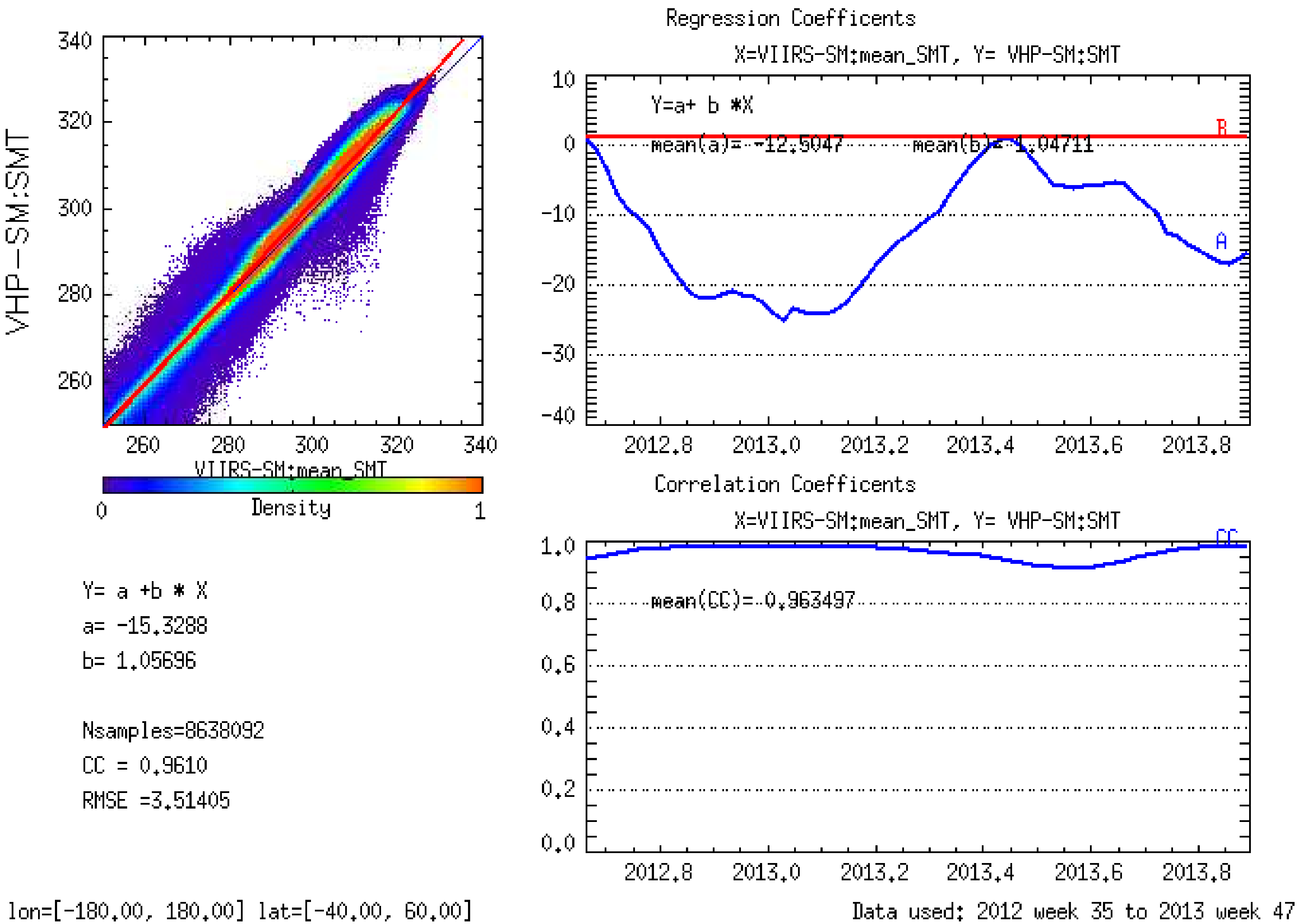




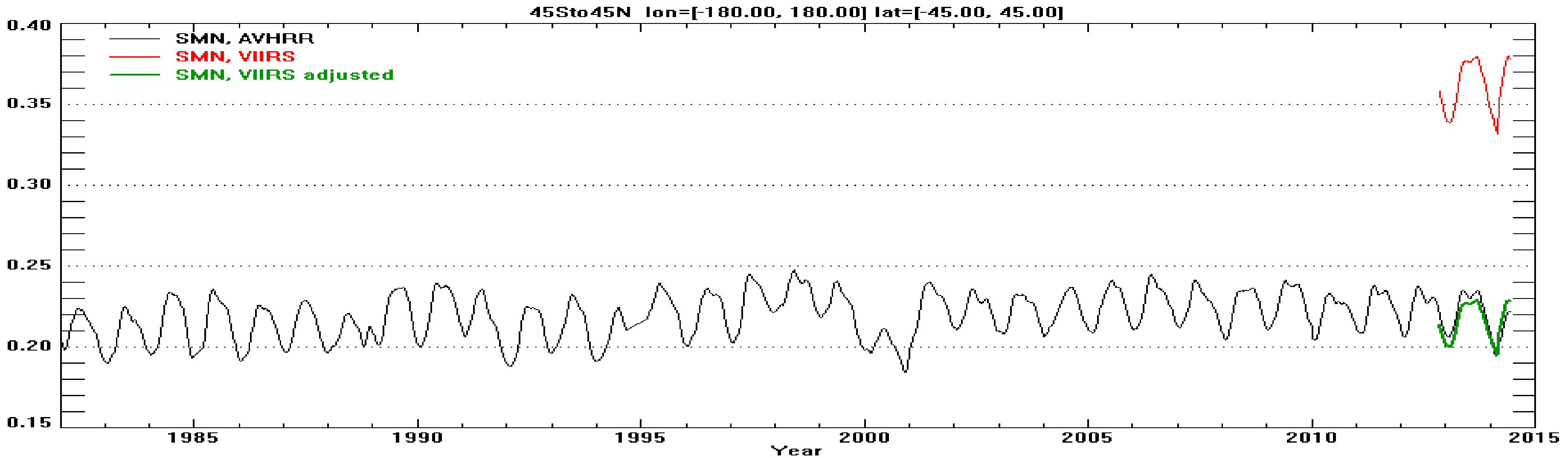
lon=[-180.00, 180.00] lat=[-40.00, 40.00]

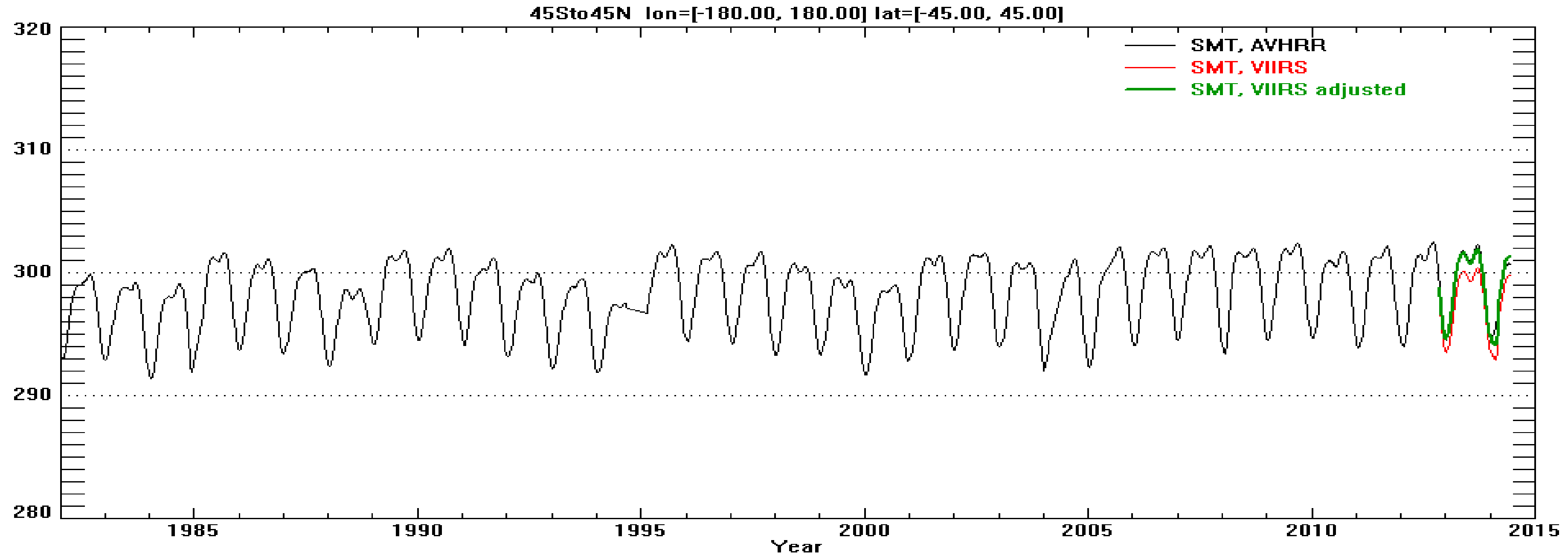
Data used: 2012 week 27 to 2013 week 30

BT (SMT): AVHRR-VIIRS COR and TSer

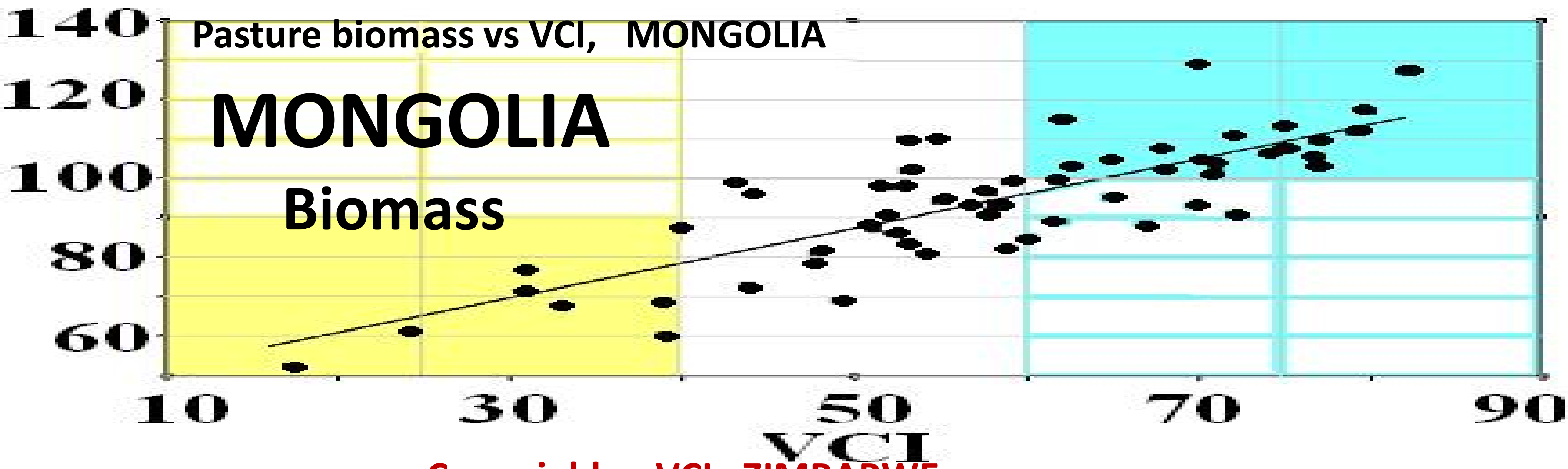


Towards NDVI & BT Climatology

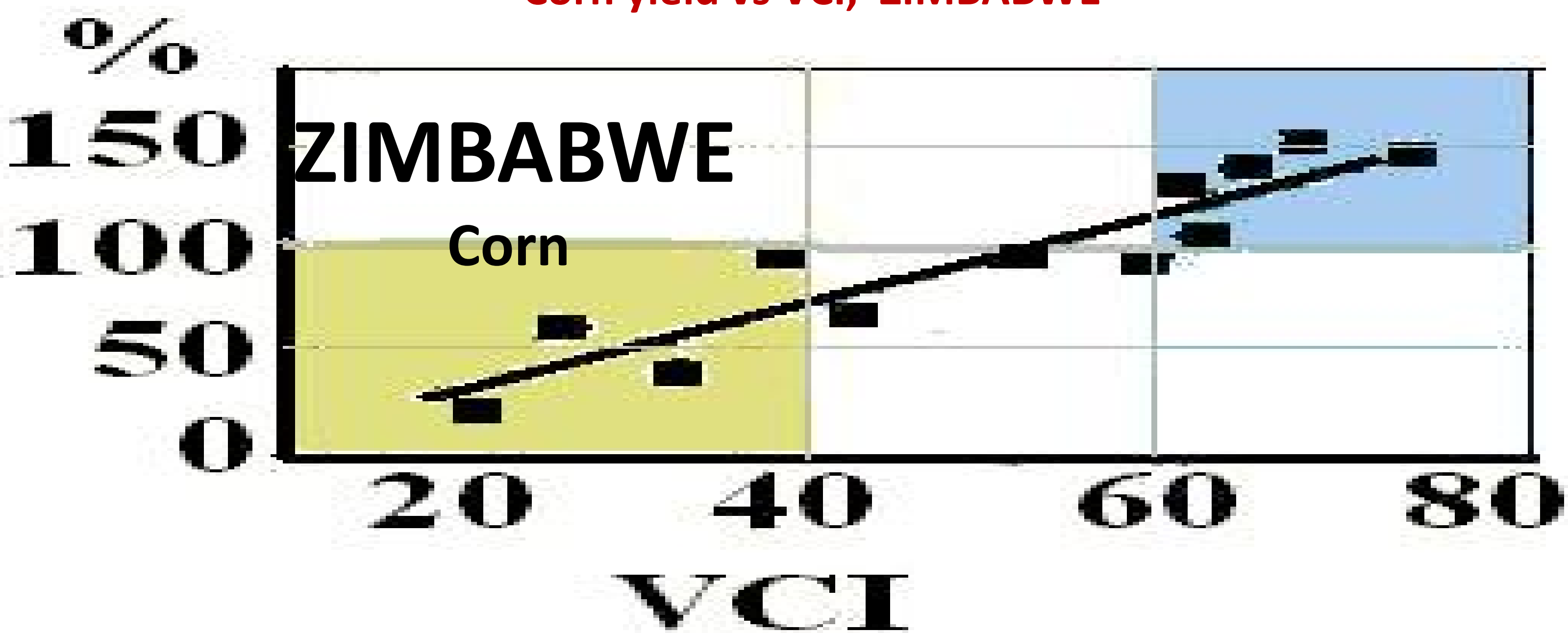




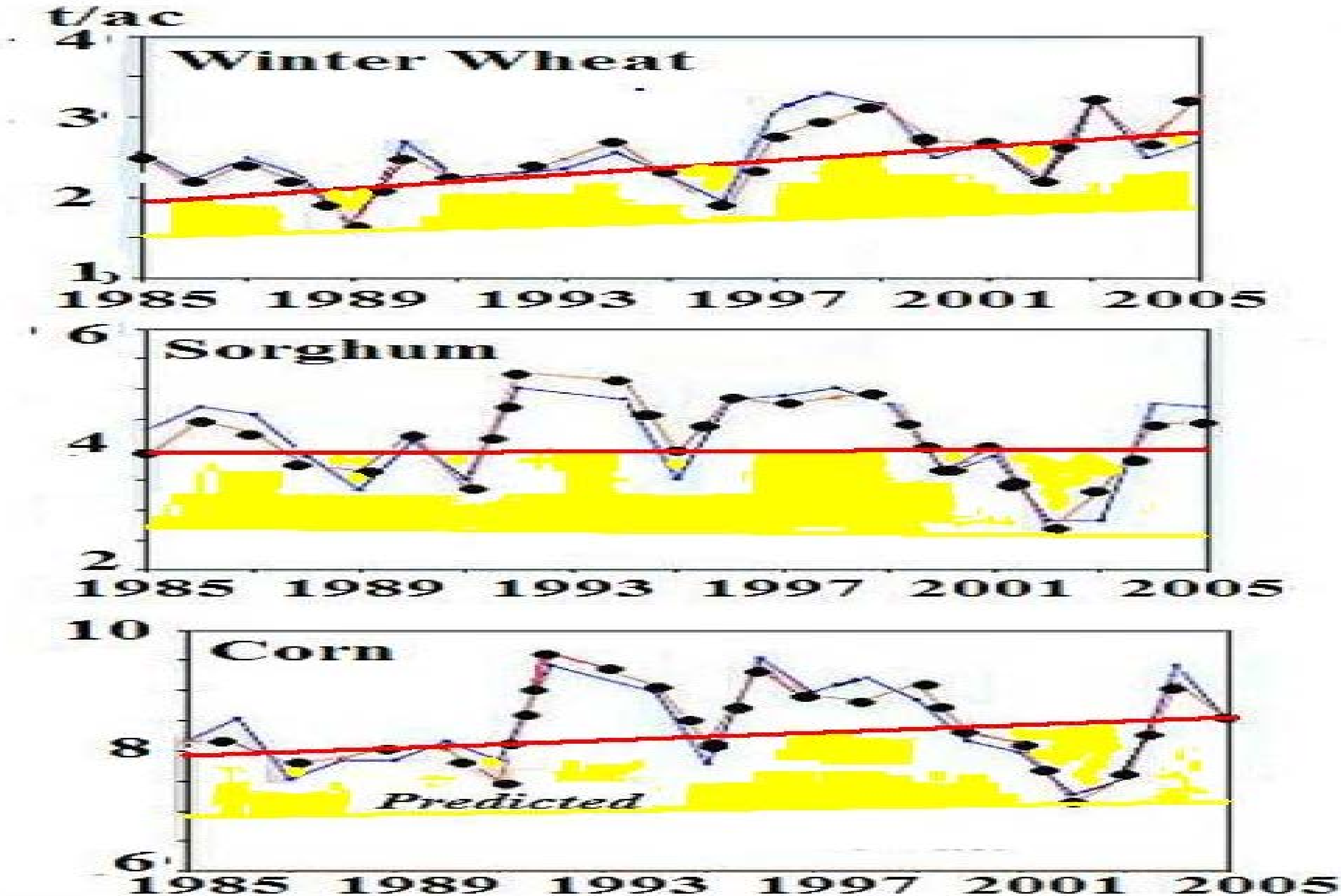
CAL/VAL: VH-Biomass & Corn Yield Modeling & Prediction



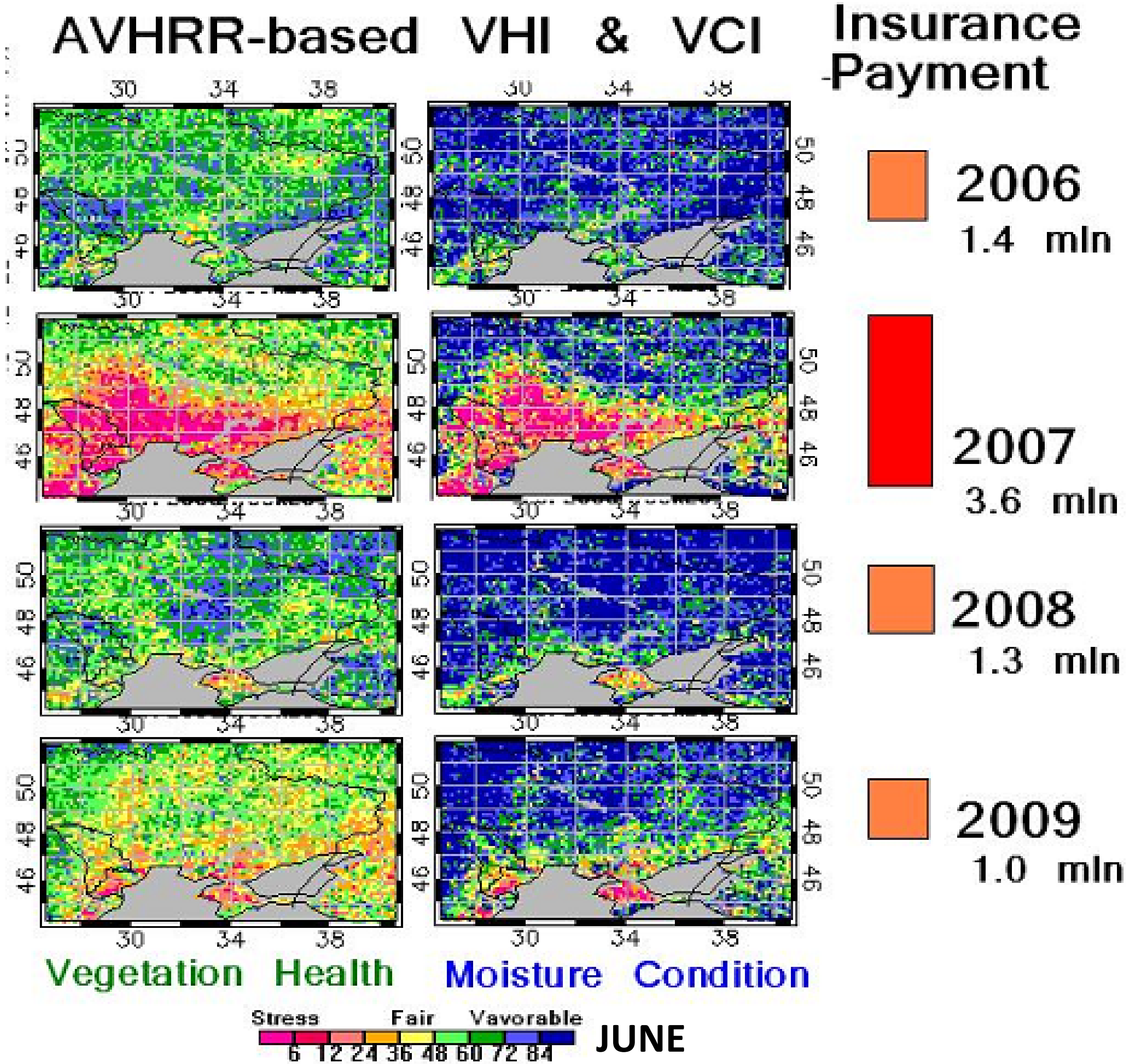
Corn yield vs VCI, ZIMBABWE



CAL/VAL: VH-Crop Losses Prediction: USA, Kansas



Observed & Predicted Yield, USA, Kansas

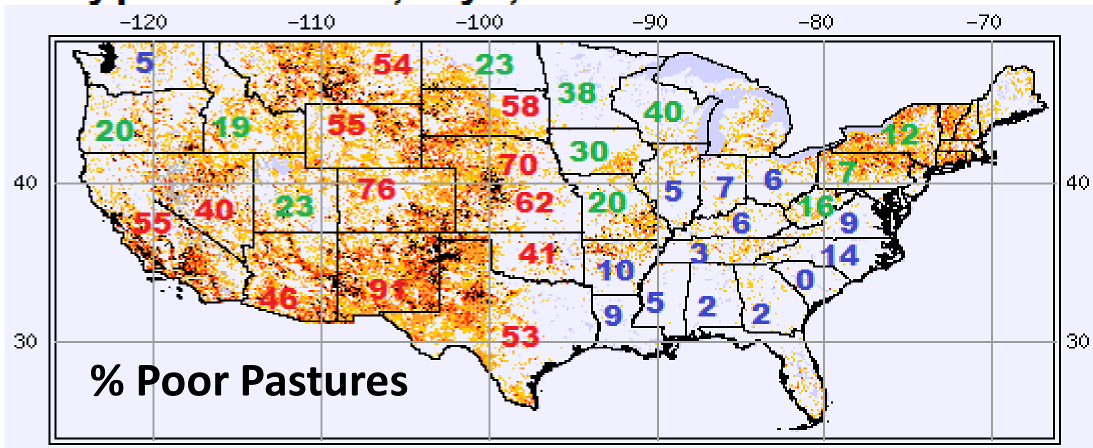


VH-based crop condition & Insurance payment (Grivna), UKRAINE

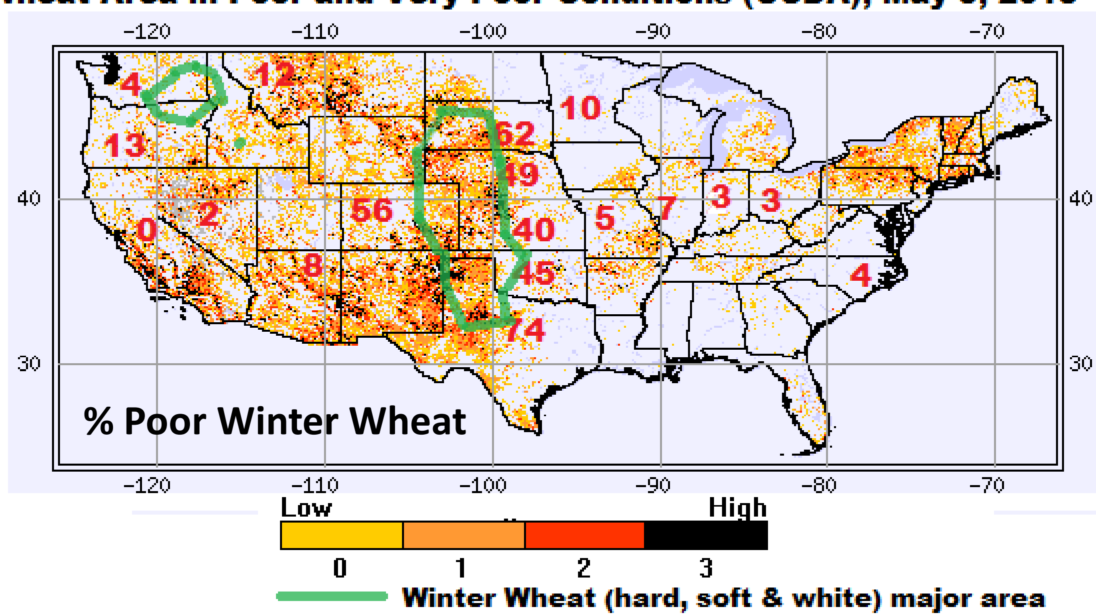
Source: NOAA and "Strahovaia Grupa TAC"

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

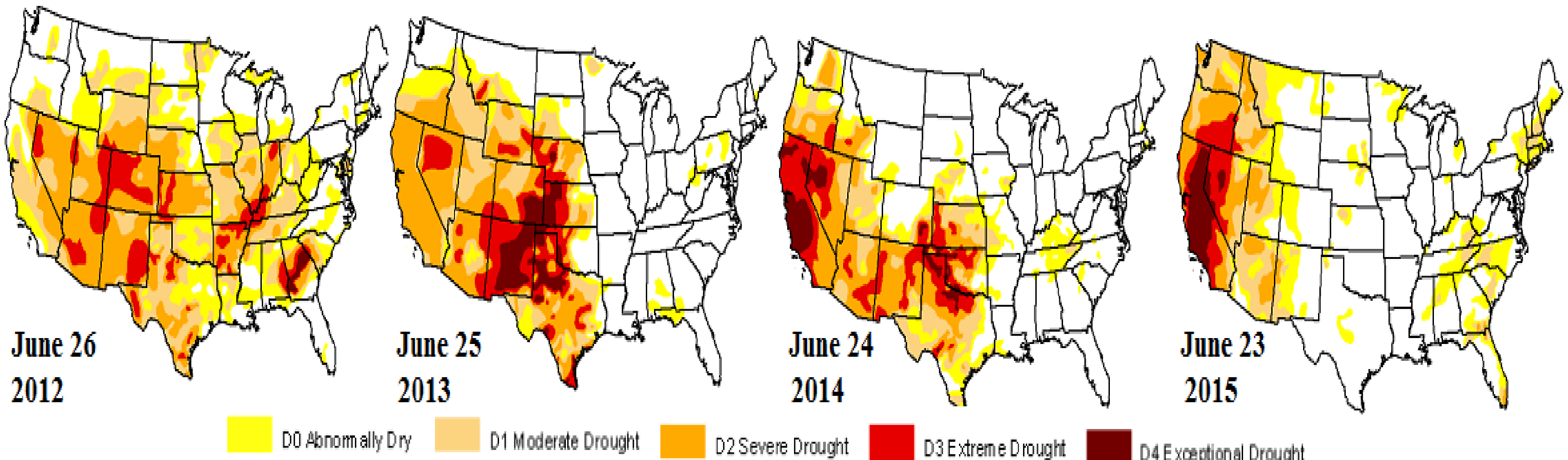
VH-based Drought Stress & % state with pasture & range land in poor & very poor coonditions, May 6, 2013



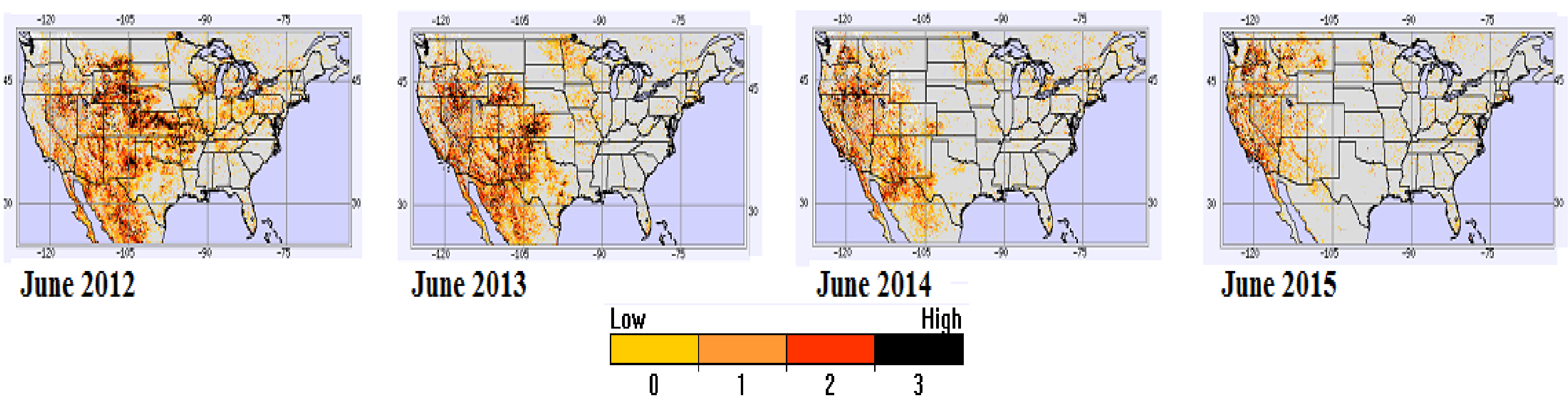
VH-based Drought Stress (NOAA), May 6, 2013 & Percent Whinter Wheat Area in Poor and Very Poor Conditions (USDA), May 5, 2013



USA Drought from USDM & VHI

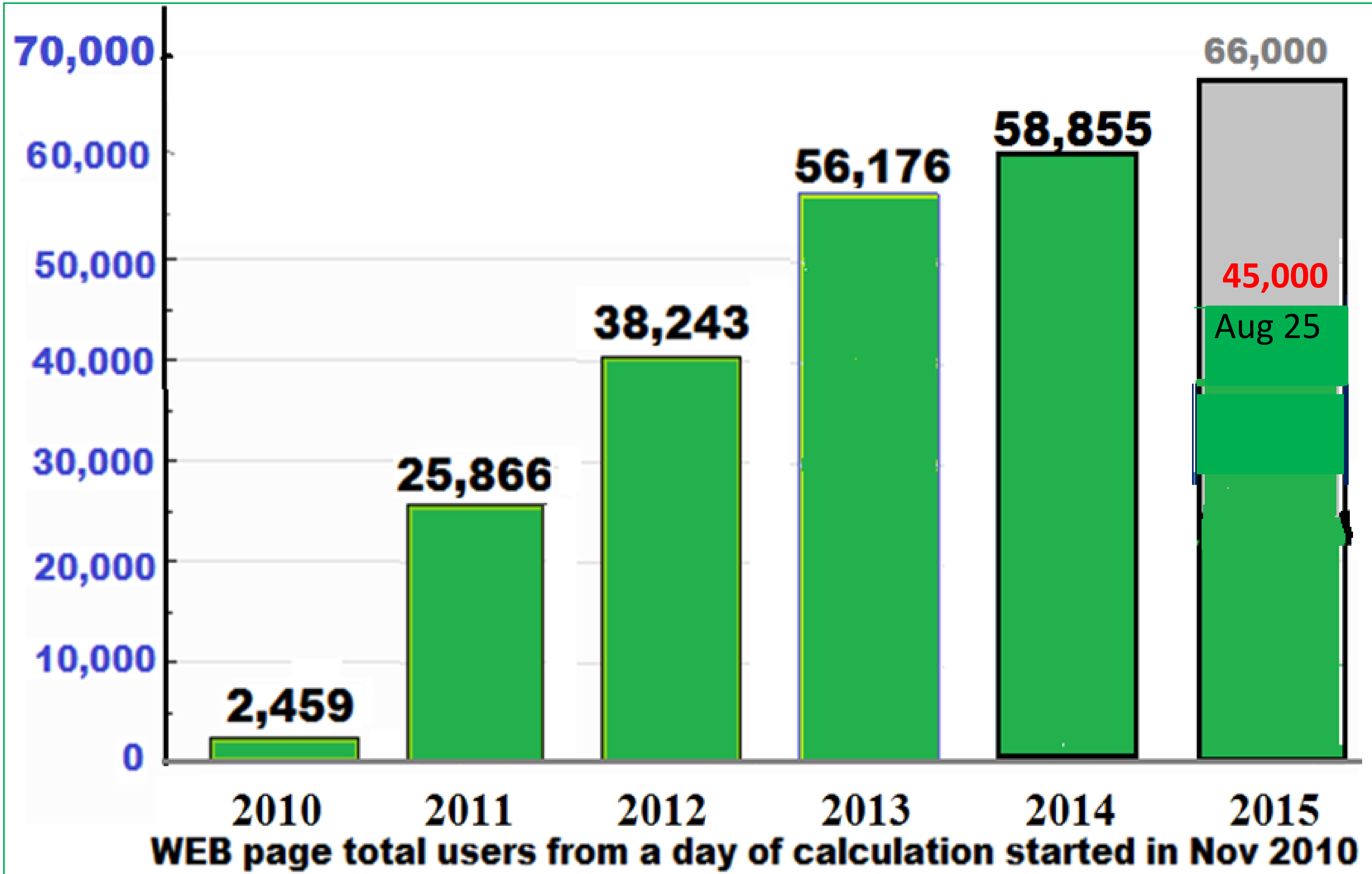


Drought from US Drought Monitor (USDM)



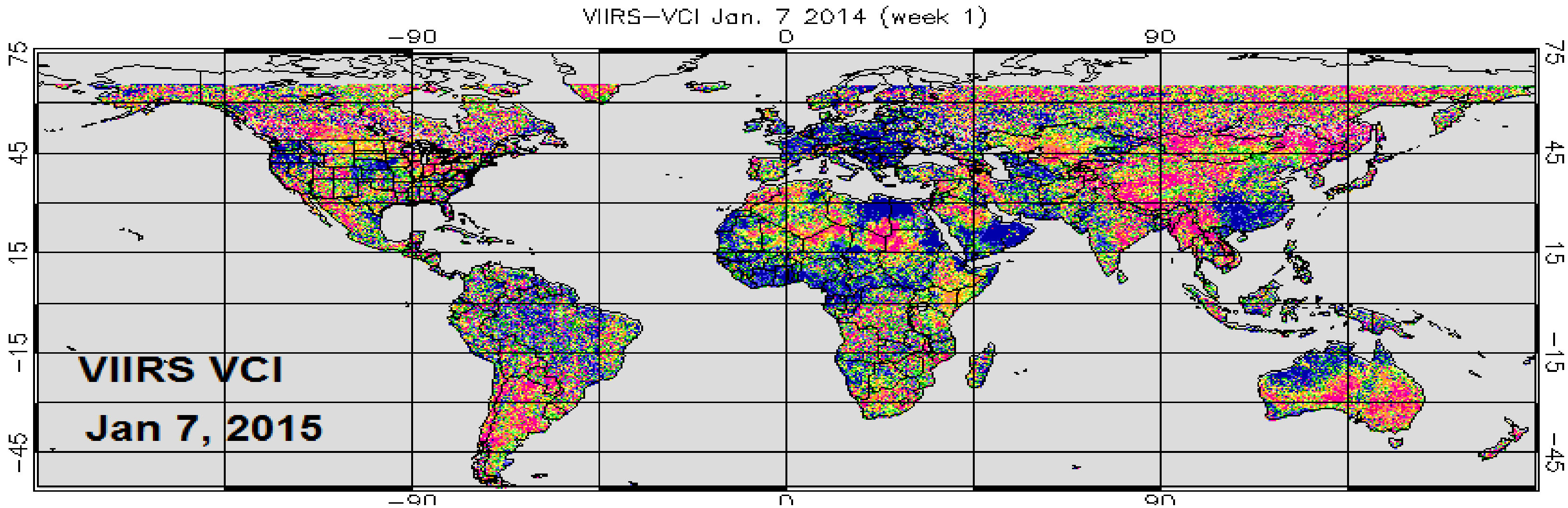
Drought from NOAA-19/AVHRR Vegetation health index (VHI)

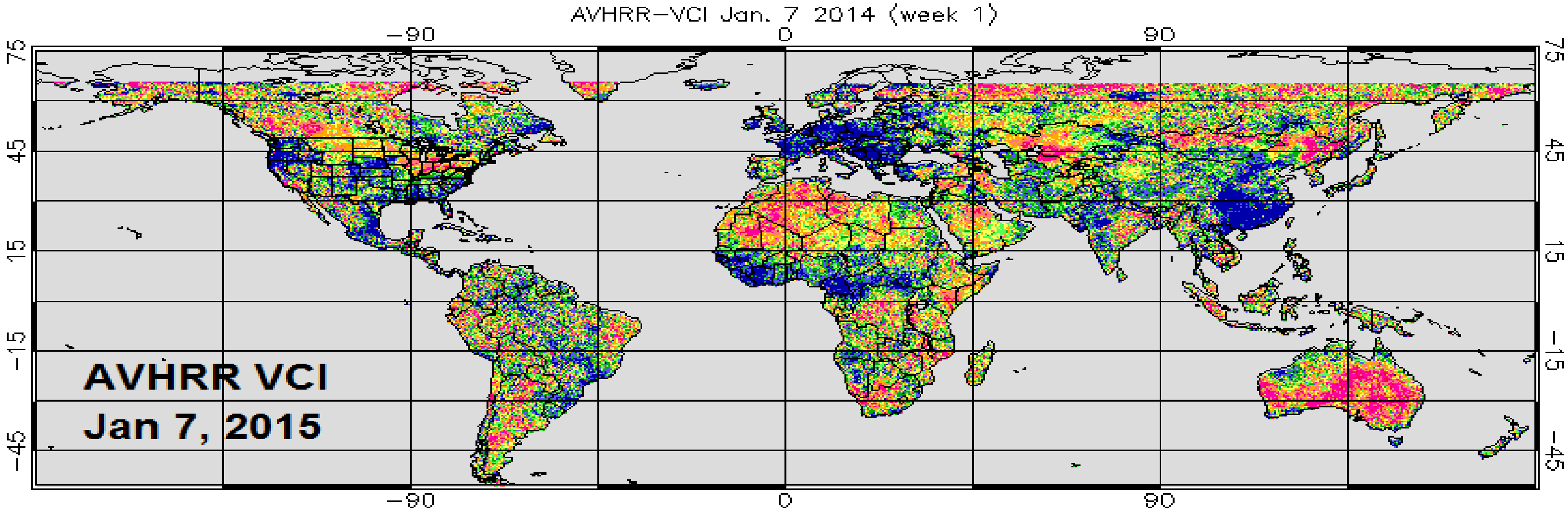
Users attending Vegetation Health WEB



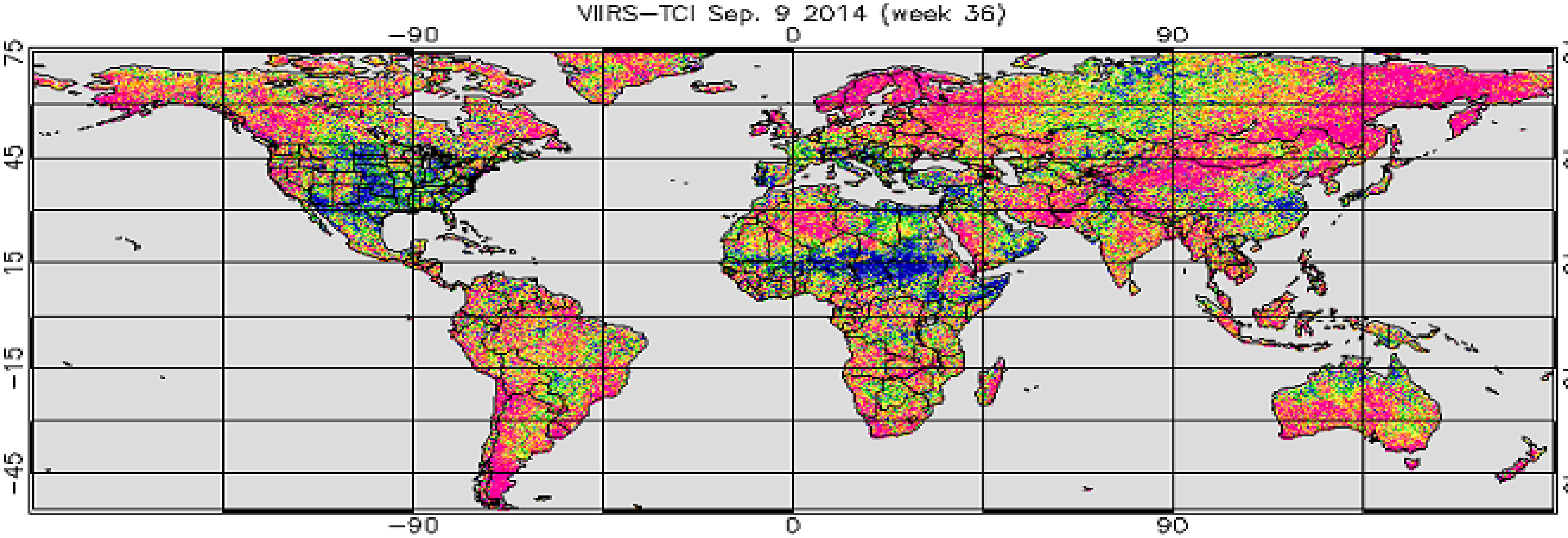
http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/index.php

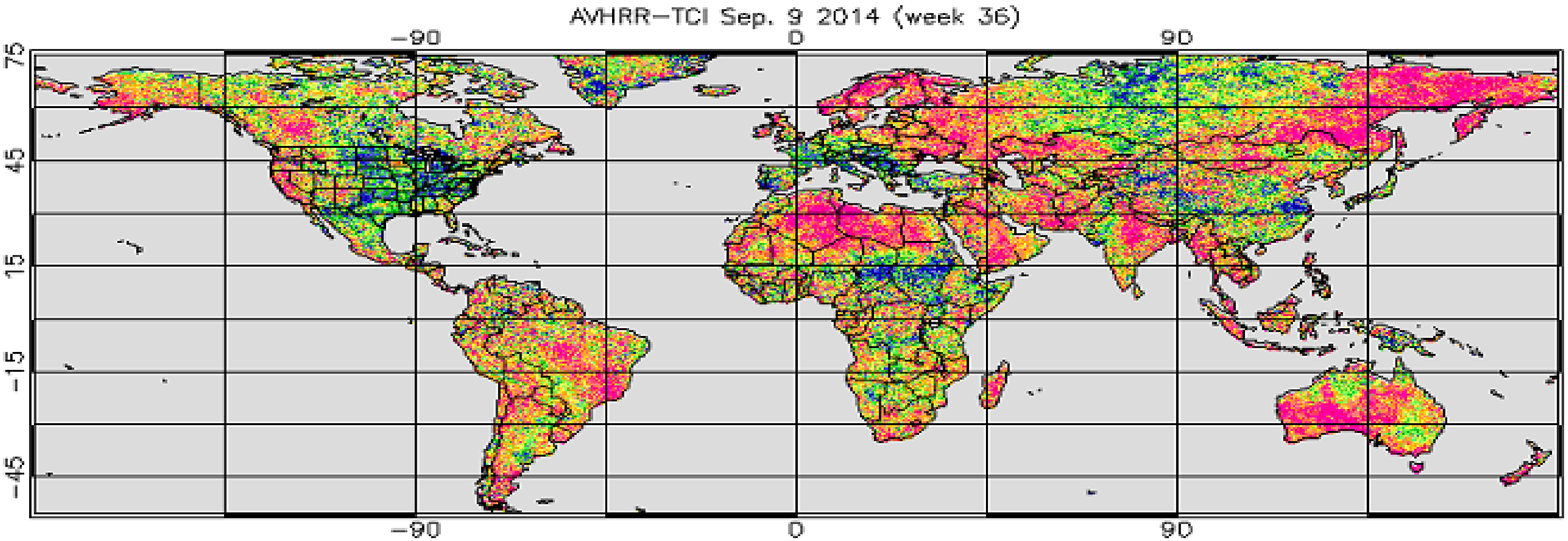
VALIDATION: VCI/VIIRS vs VCI/AVHRR



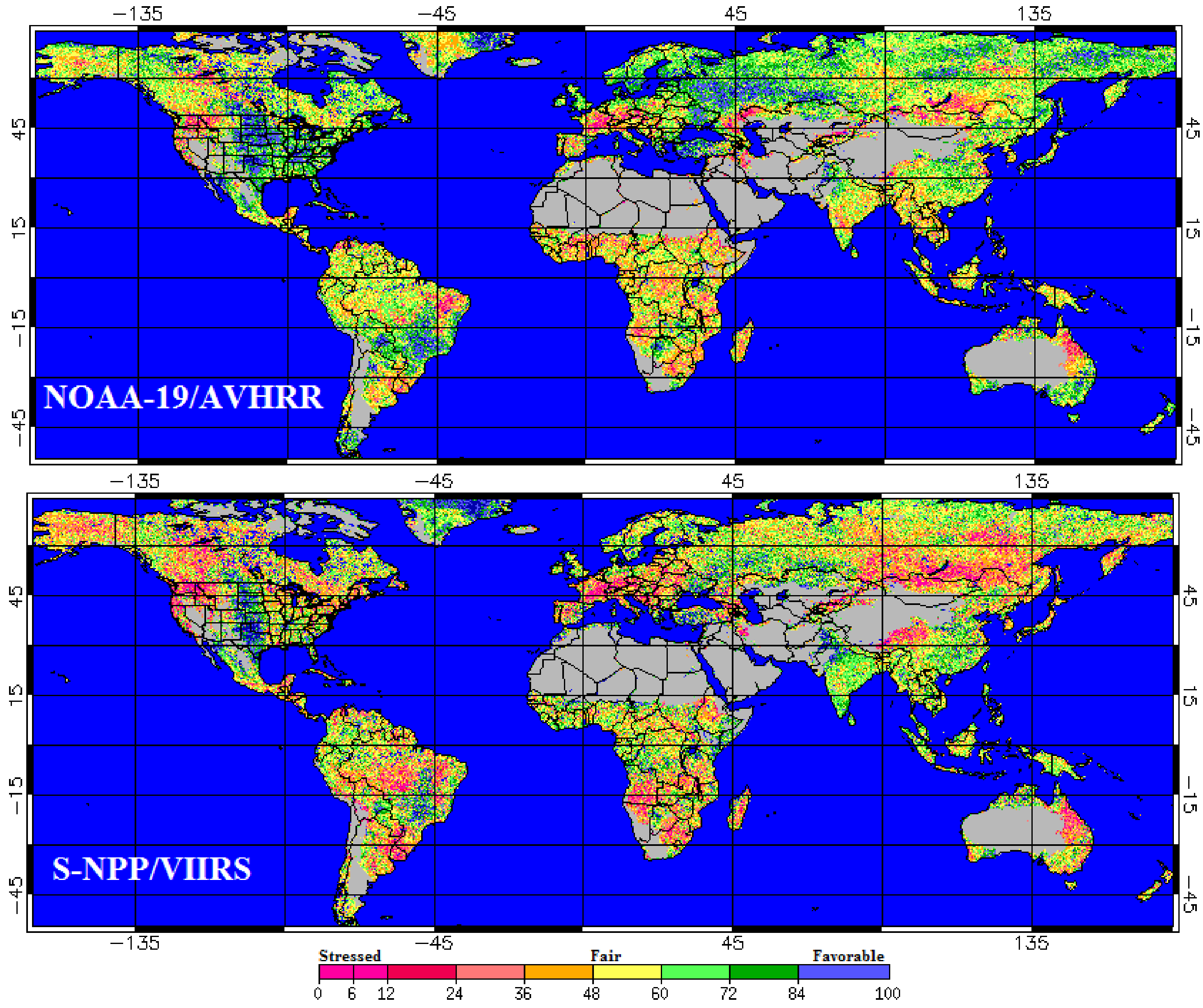


VALIDATION:
TCI VIIRS vs AVHRR
Sep 9, 2014





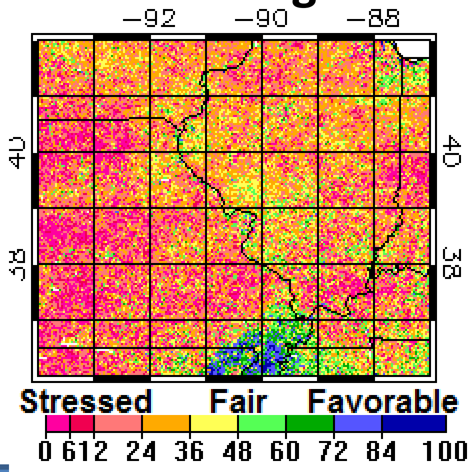
Vegetation health (VHI)



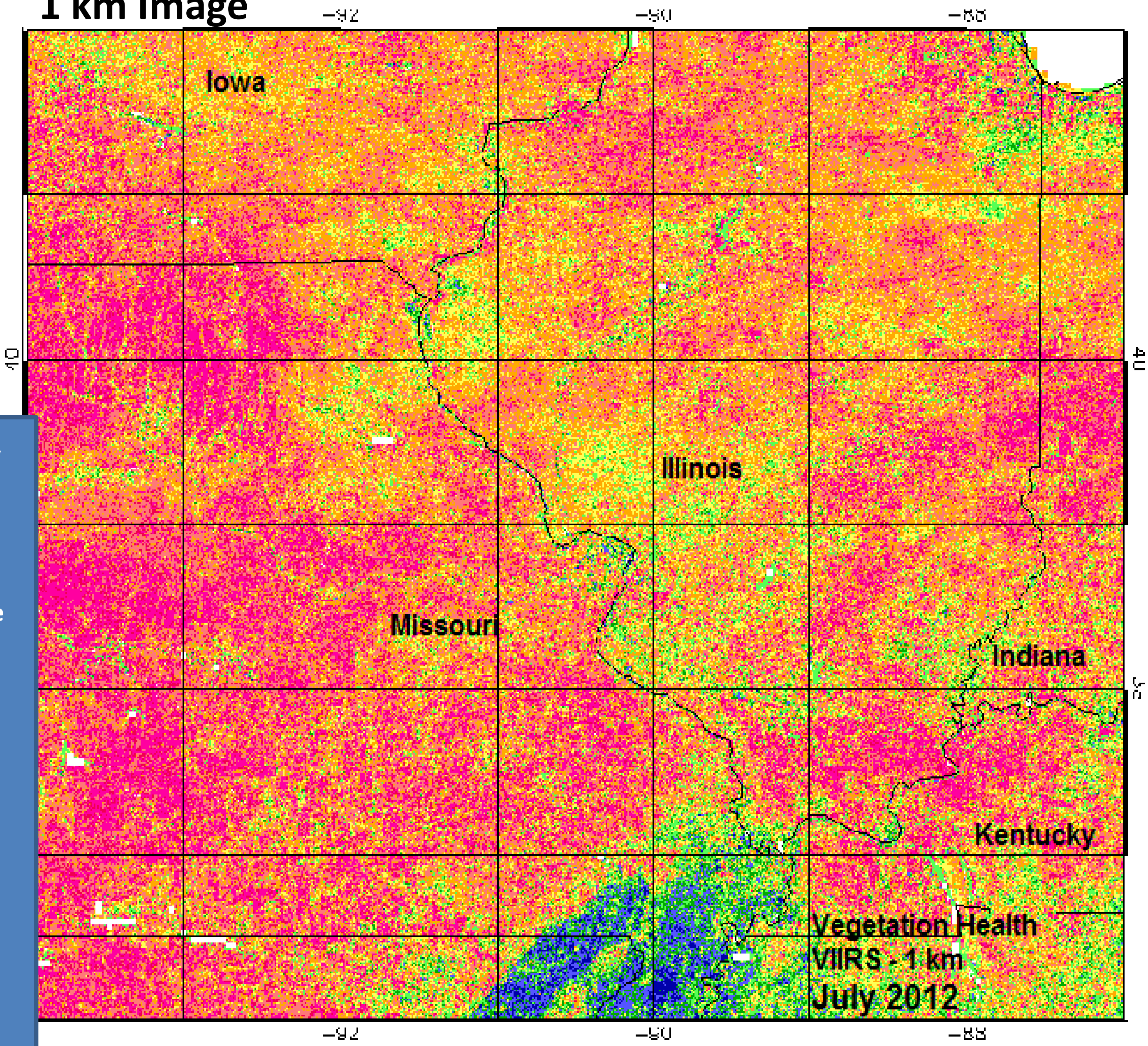
VEGETATION HEALTH, August 6, 2015

SNPP/VIIRS VHI & DROUGHT, USA Midwest, July 2012

4 km Image

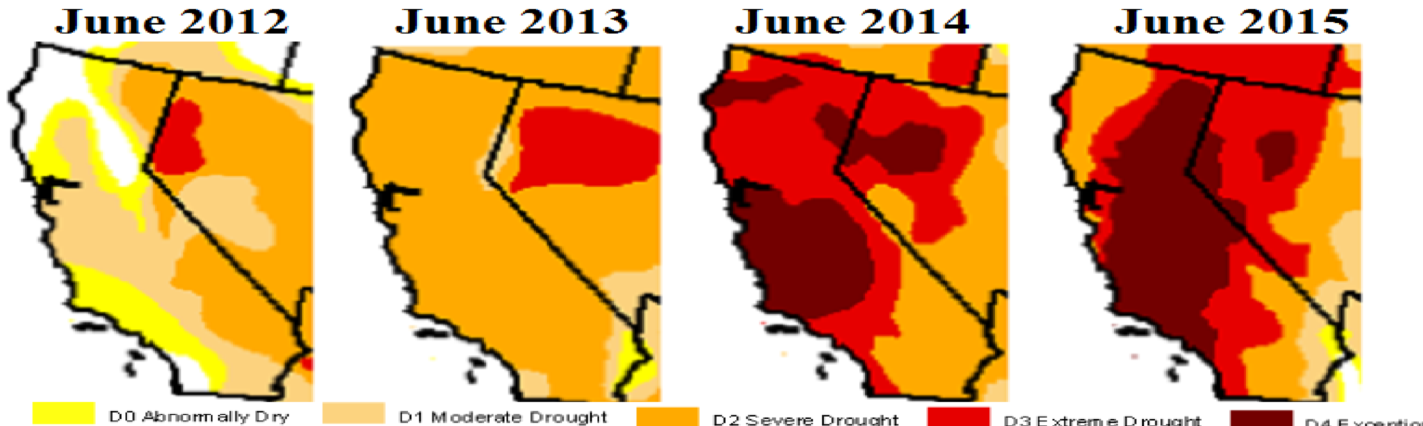


1 km Image

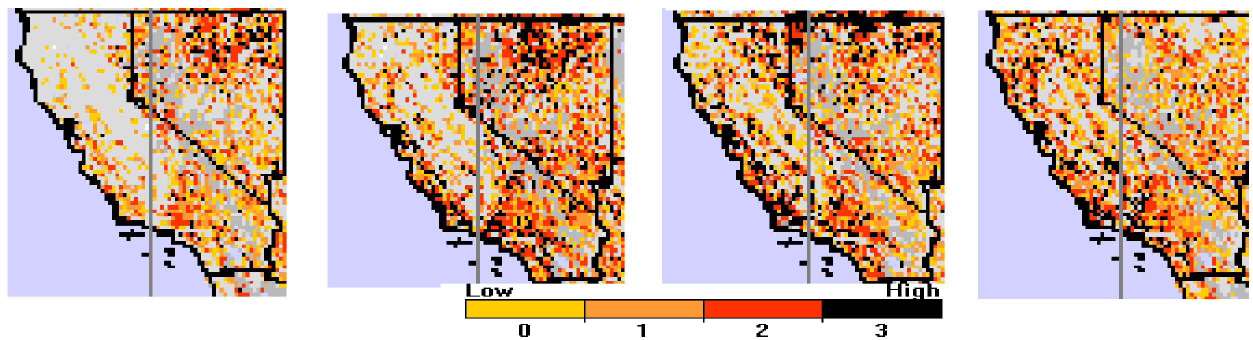


- Drought affects Global Food Security by reducing agricultural production below consumption.
- Since 2000, this occurred 8 years out of 13.
- Early drought detection and accurate monitoring its area, intensity, duration & impacts is important for mitigation drought consequences.
- Vegetation health(VH) method applied to SNPP/VIIRS data greatly improve drought watch & impact assessment.
- The two images showing similar patterns, indicate much more details of drought/no drought areas along the rivers: at the background of drought (red) no drought (yellow and green) is observed along the rivers (western part of 1 km image).

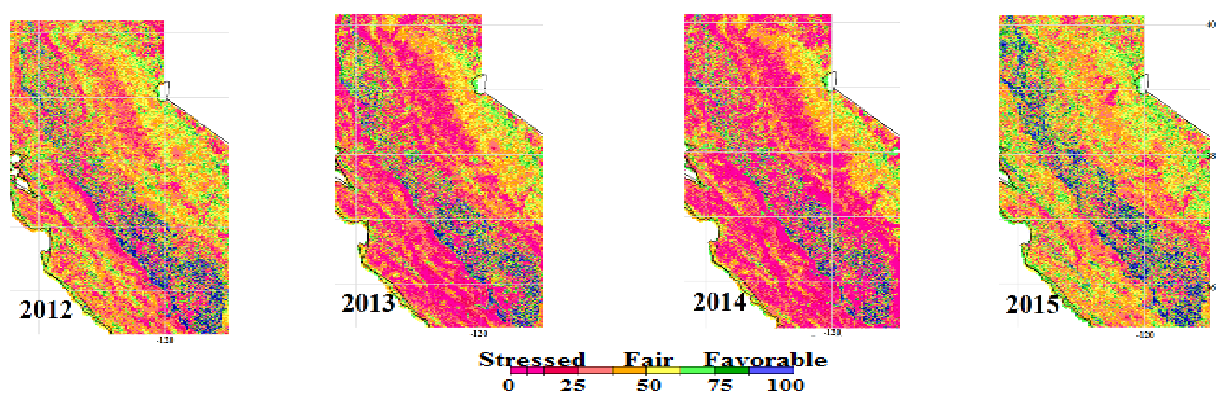
California Drought from USDM & VHI



California Drought from US Drought Monitor

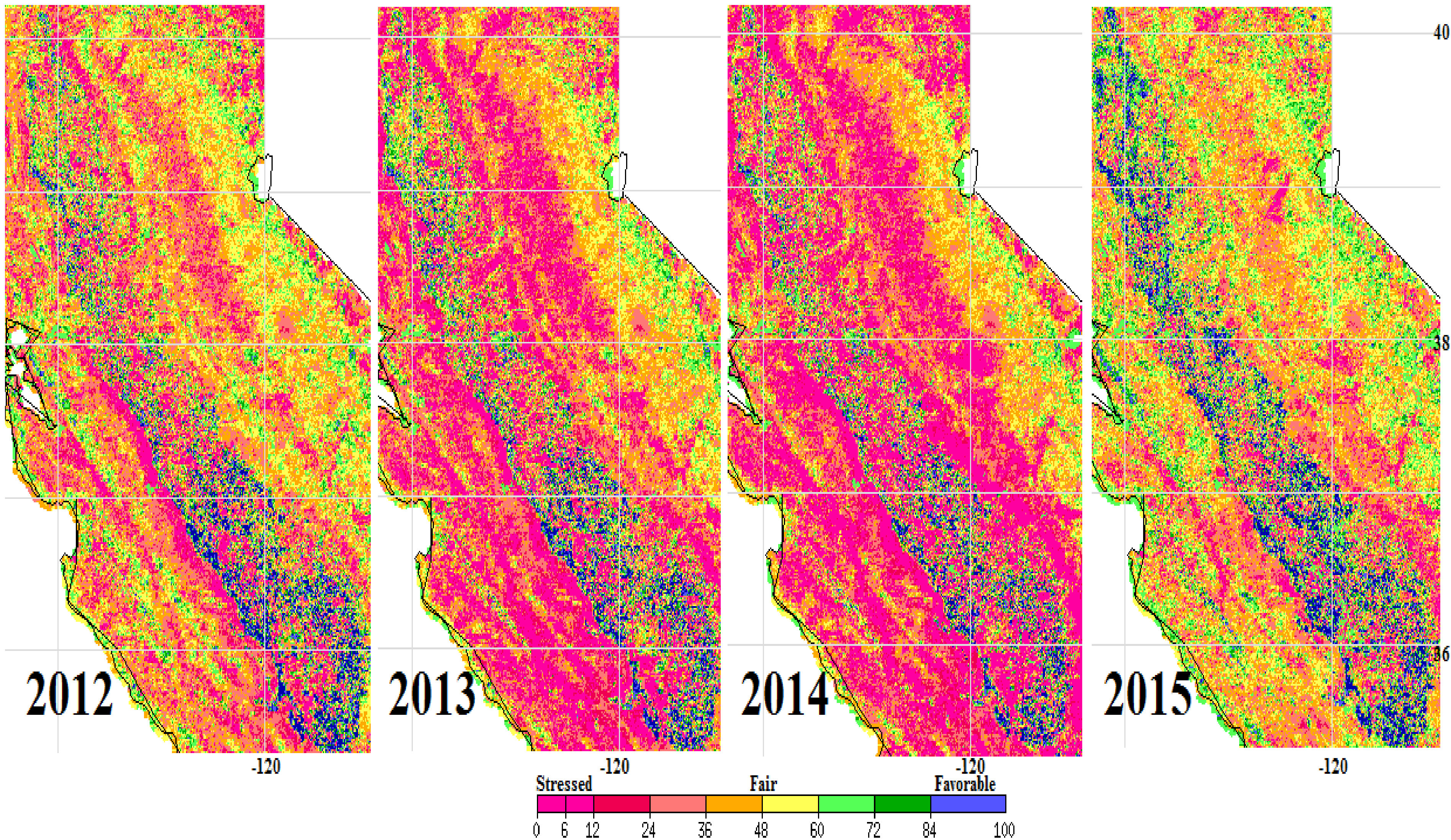


California Drought from 16 km NOAA-19 Vegetation health index (VHI)



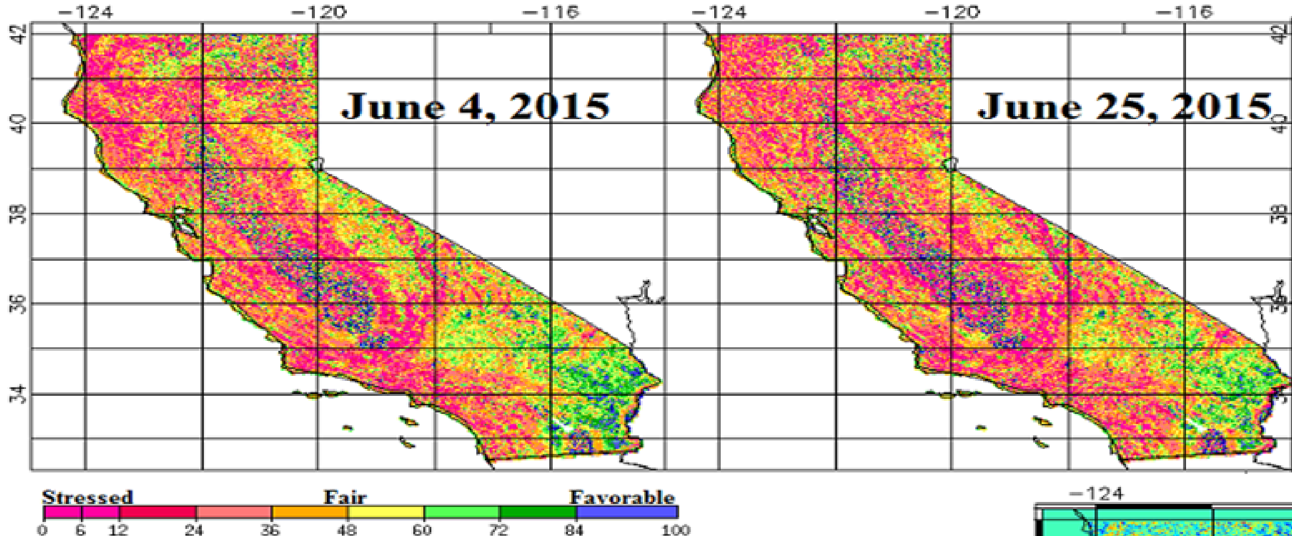
California Drought from 0.5 km S-NPP/VIIRS Vegetation health index

S-NPP/VIIRS Vegetation Health

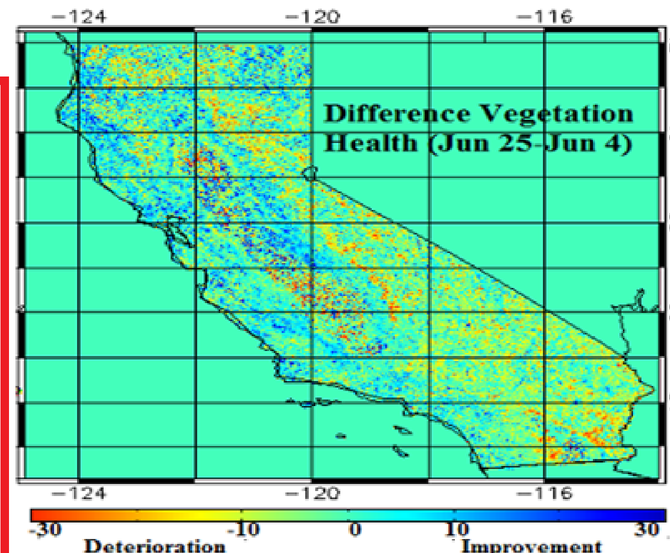


S-NPP/VIIRS-500m Vegetation health, June 12, USA, California, Central Valley

California Drought Dynamics & Economic Impacts in 2015

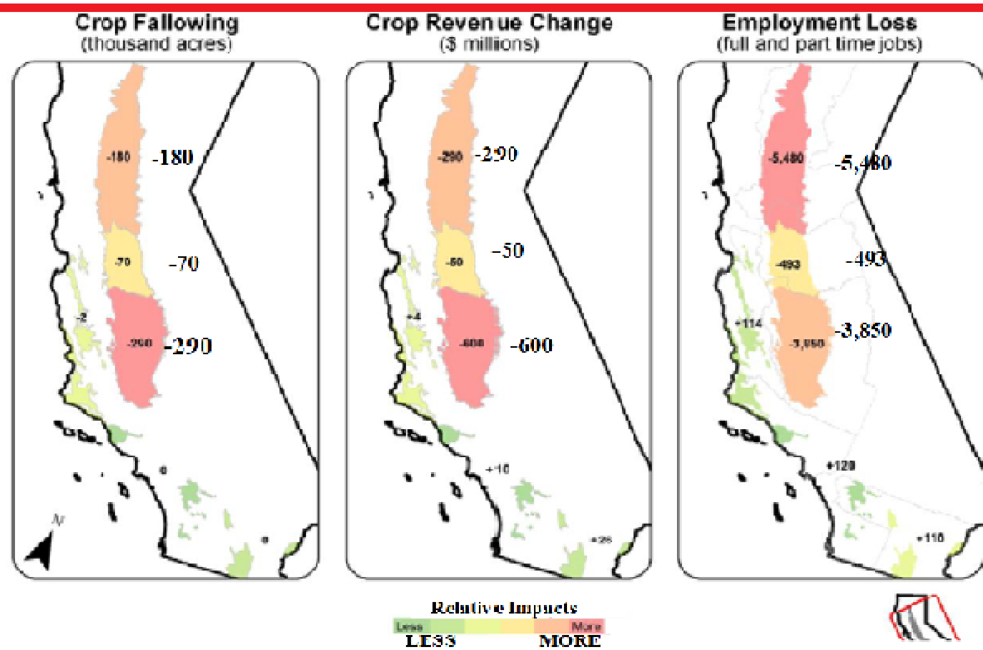


Vegetation Health from 500 m S-NPP/VIIRS



Difference Vegetation Health

June 25 - June 4



Economic Impacts of California Drought

Howitt R., D. MacEwan, J. Medellin-Azura, J. Lund & D. Sumner 2015. Economic Analysis of the 2015 Drought for California Agriculture. UC Davis Center for Watershed Science, University of California Davis, Davis, CA, 16 pp.

SUMMARY

- **VH algorithm requires NDVI & BT:**
  (a) Real time (from VIIRS)
  (b) Climatology (from AVHRR)
- **VIIRS/VH indices (VHI, VCI & TCI) are validated against AVHRR/VH because AVHRR's VH are validated against in situ data**
- **VIIRS/ NDVI & BT are different than AVHRR**
- **VIIRS/NDVI & BT are adjusted to AVHRR (in order to use climatology)**
- **The adjustments are stable over time and correlation is strong**
- **FURTHER Development:**

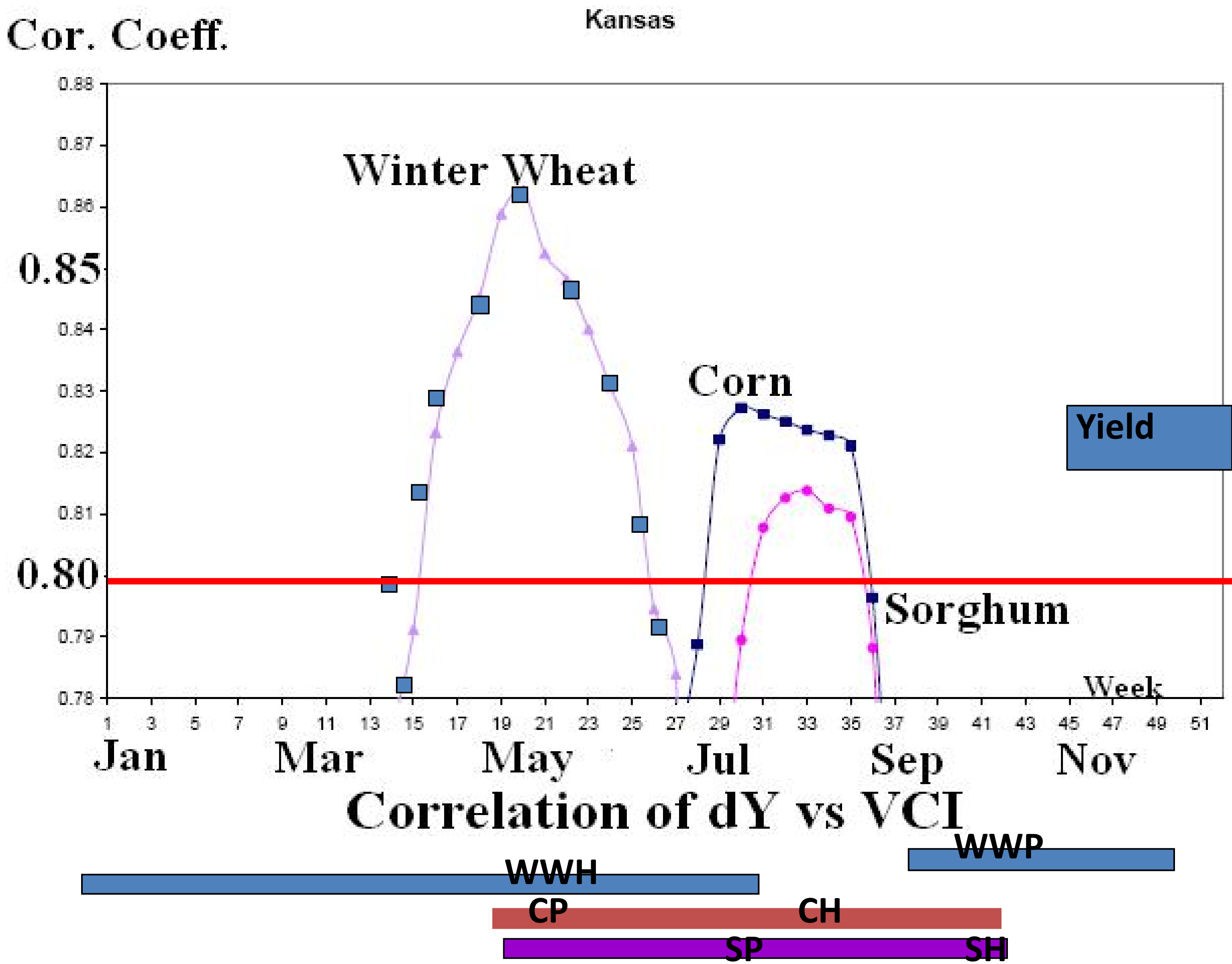
(a) New climatology from VIIRS

(b) High resolution VH

(c) New VH products

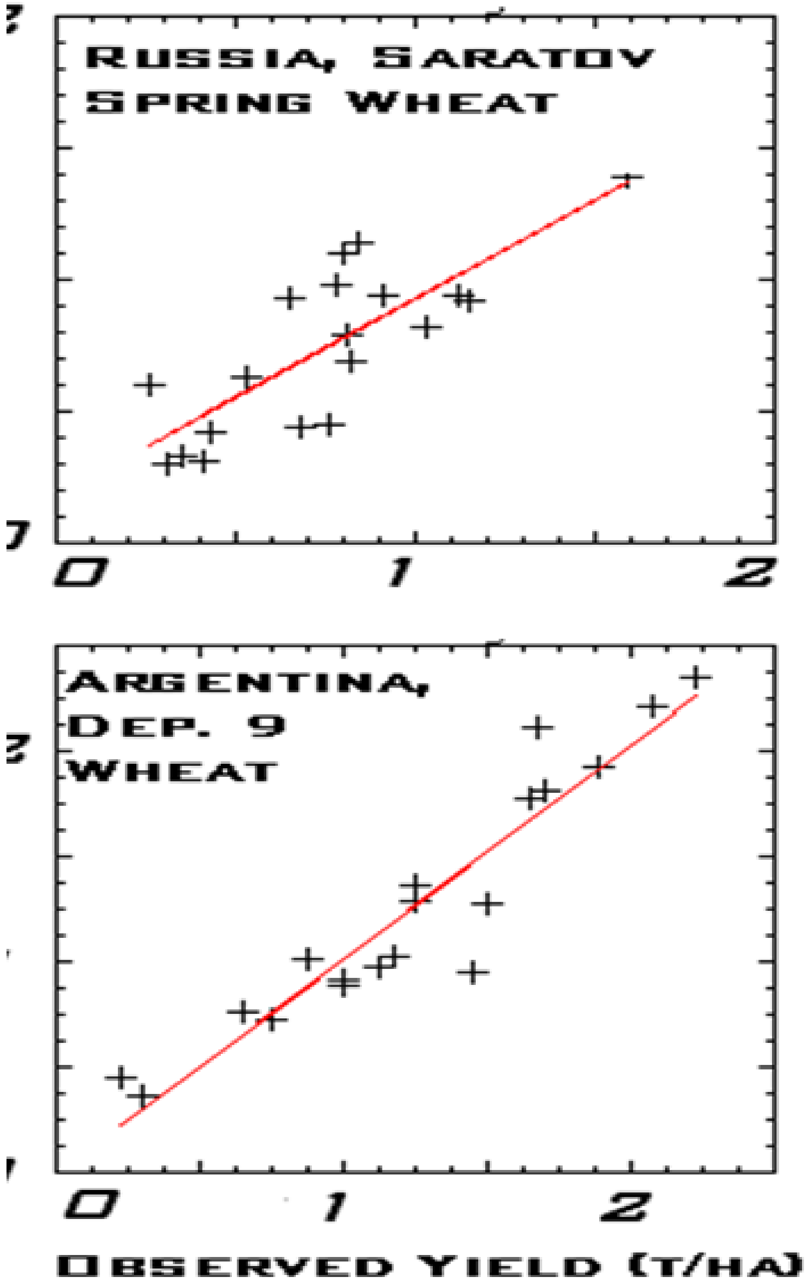
BACK UP

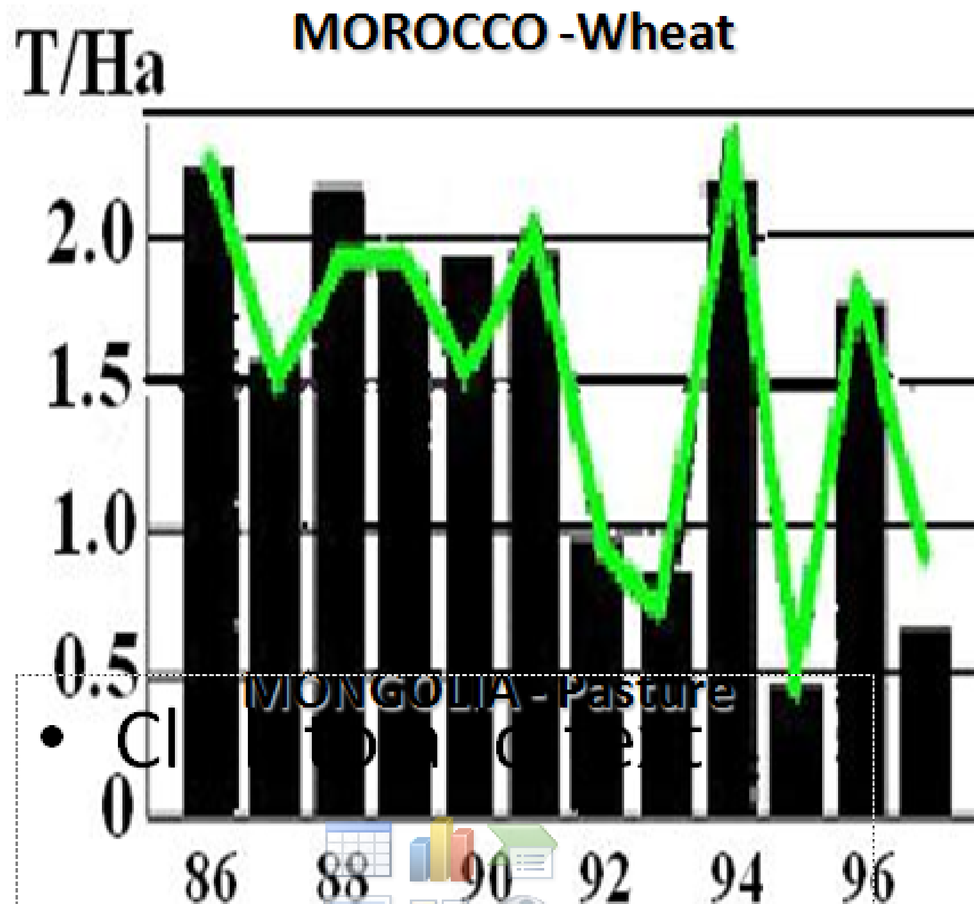
Correlation: Yield anomaly (dY) vs VCI, Kansas, USA



Growing season

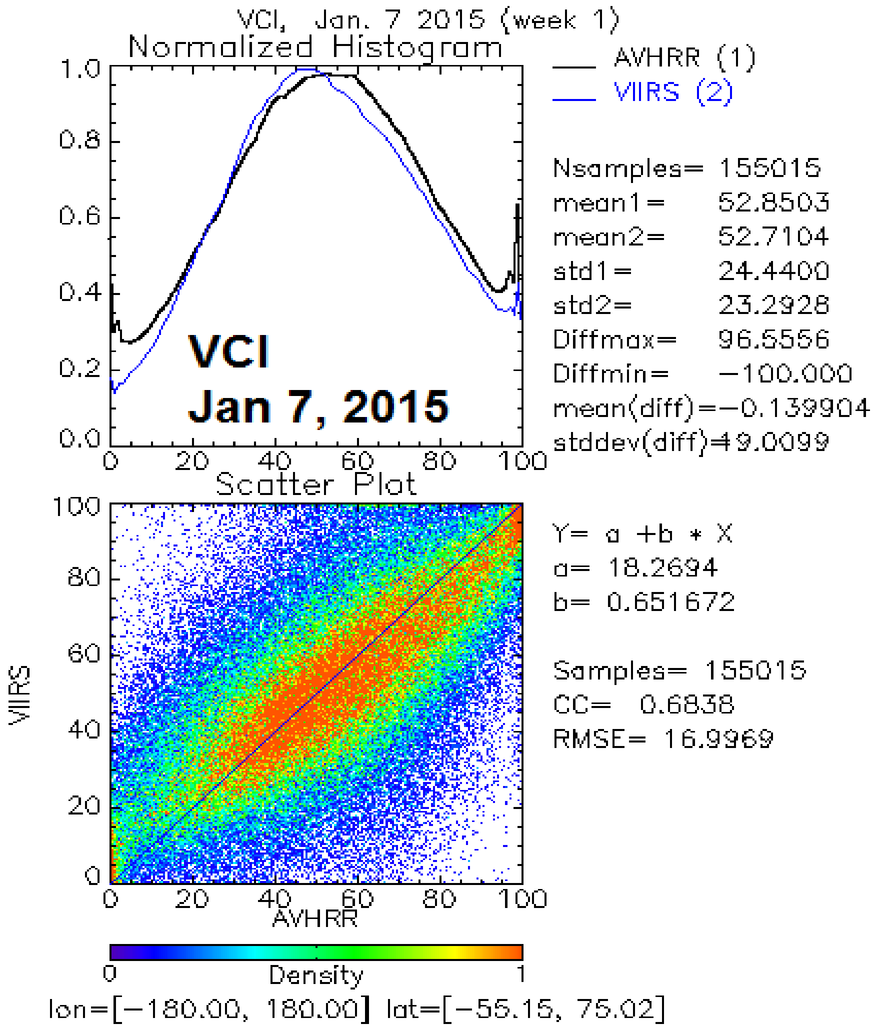
AVHRR/VH-Crop Yield Correlation

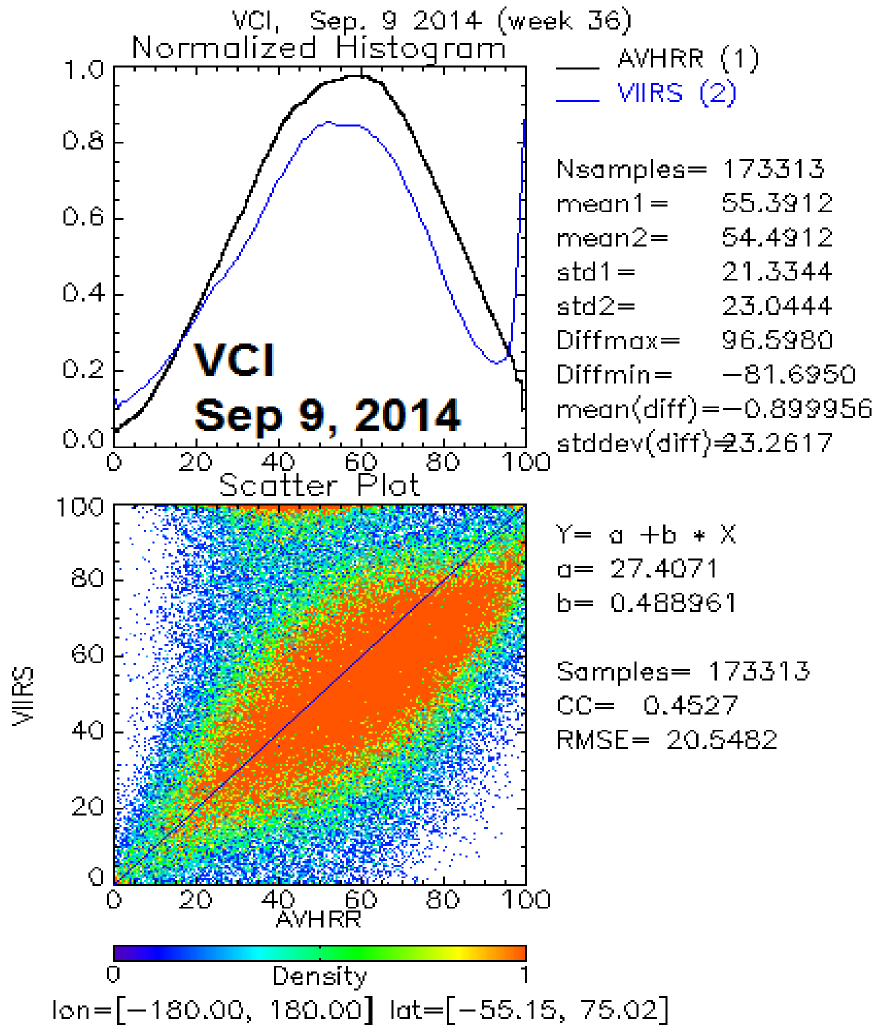




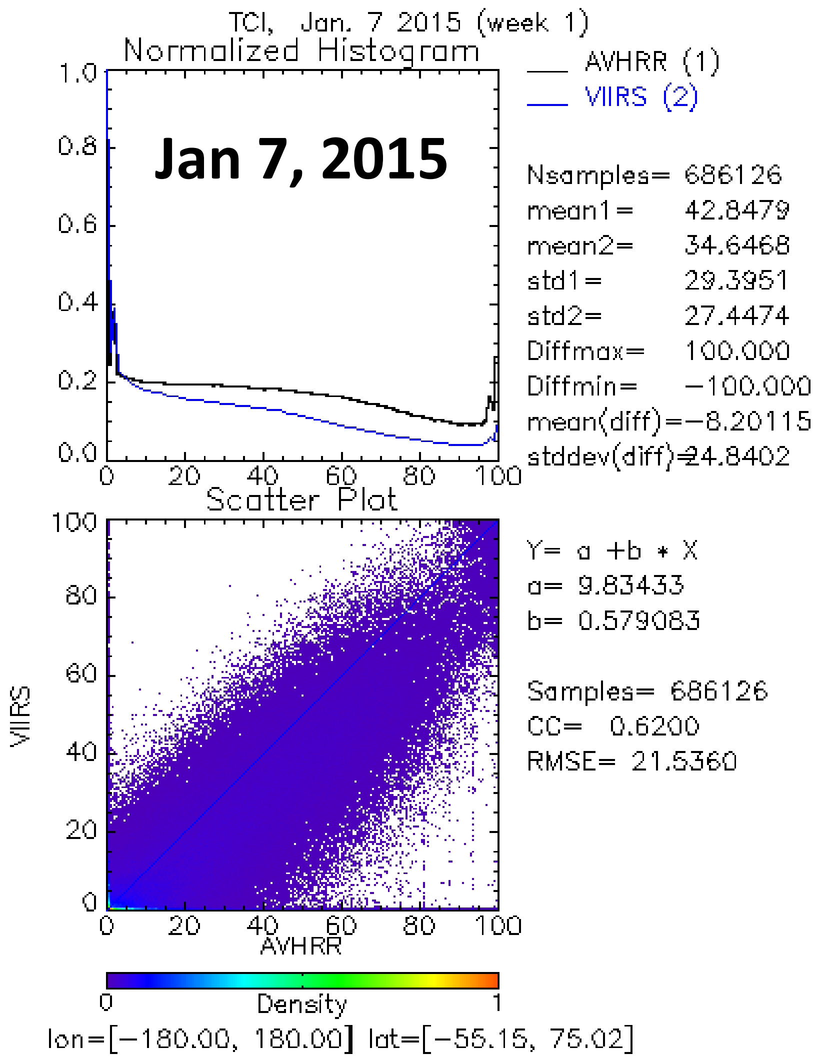
MONGOLIA - Pasture

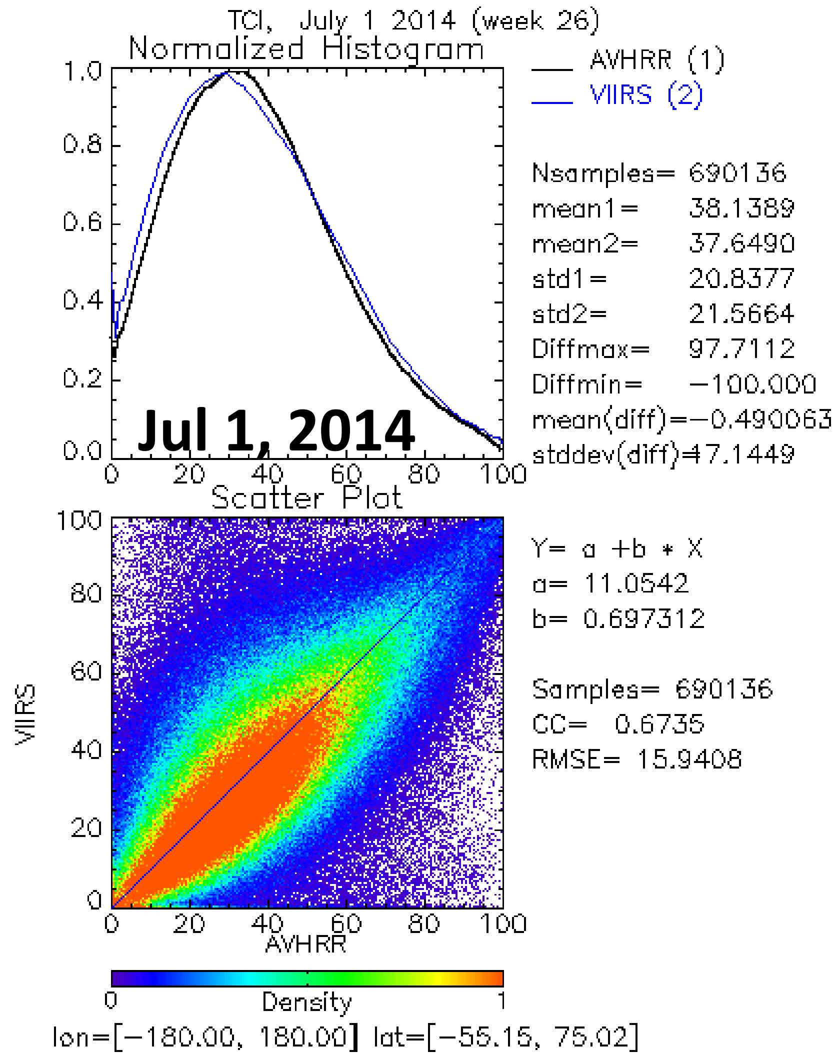
Validation: VCI
Correlation of VIIRS & AVHRR
Jan 7, 2015 & Sep 9, 2014



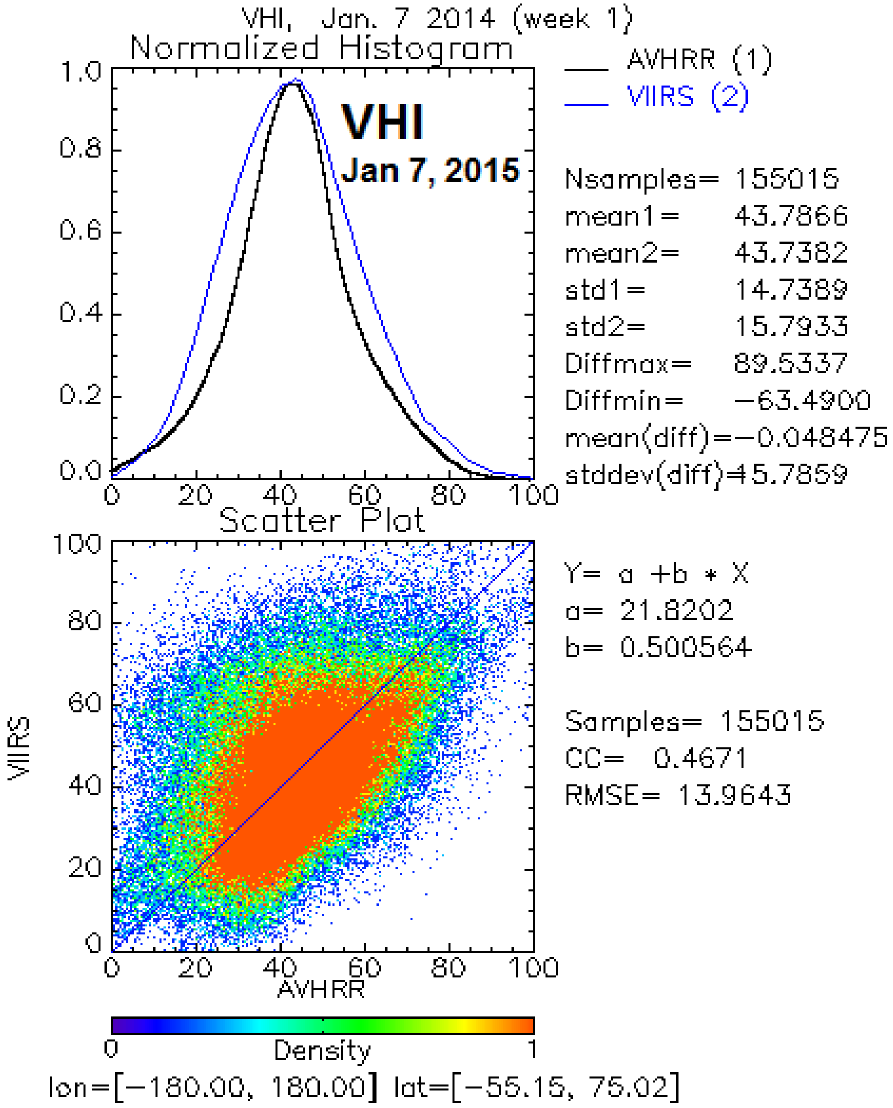


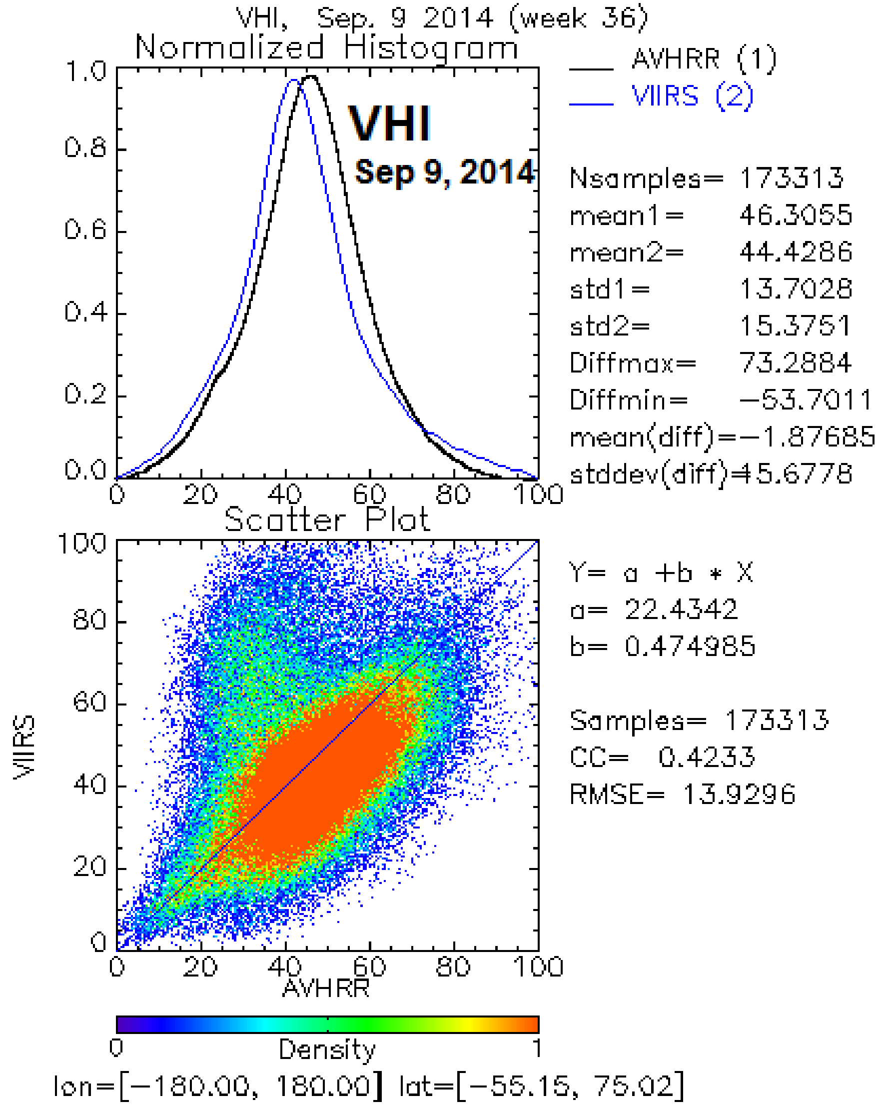
Validation: TCI
Correlation of VIIRS & AVHRR
Jan 7, 2015 & Jul 1, 2014



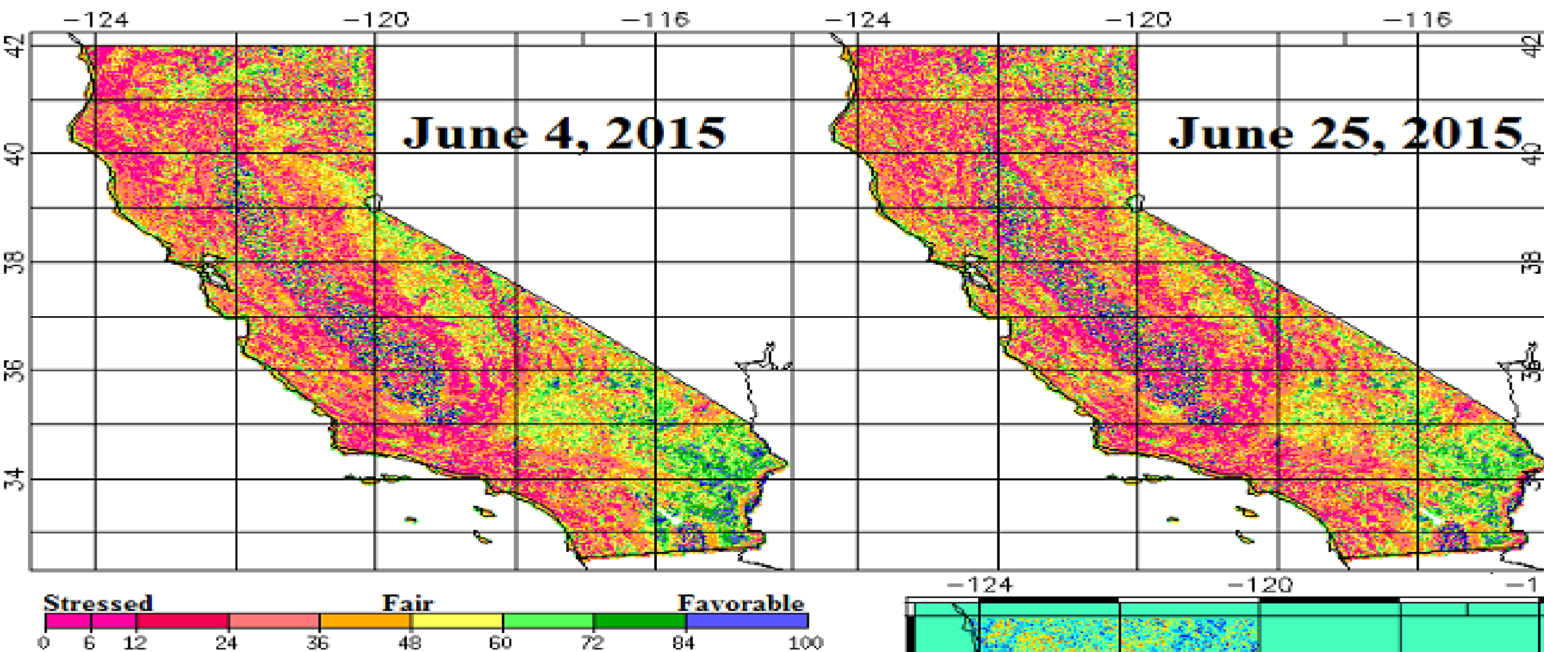


Validation: VHI
Correlation of VIIRS & AVHRR
Jan 7, 2015 & Sep 9, 2014

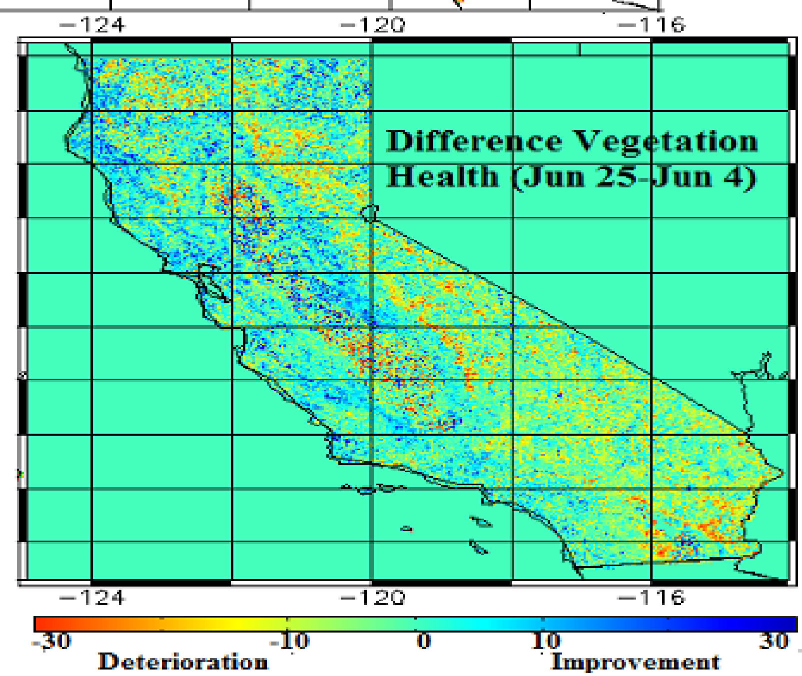




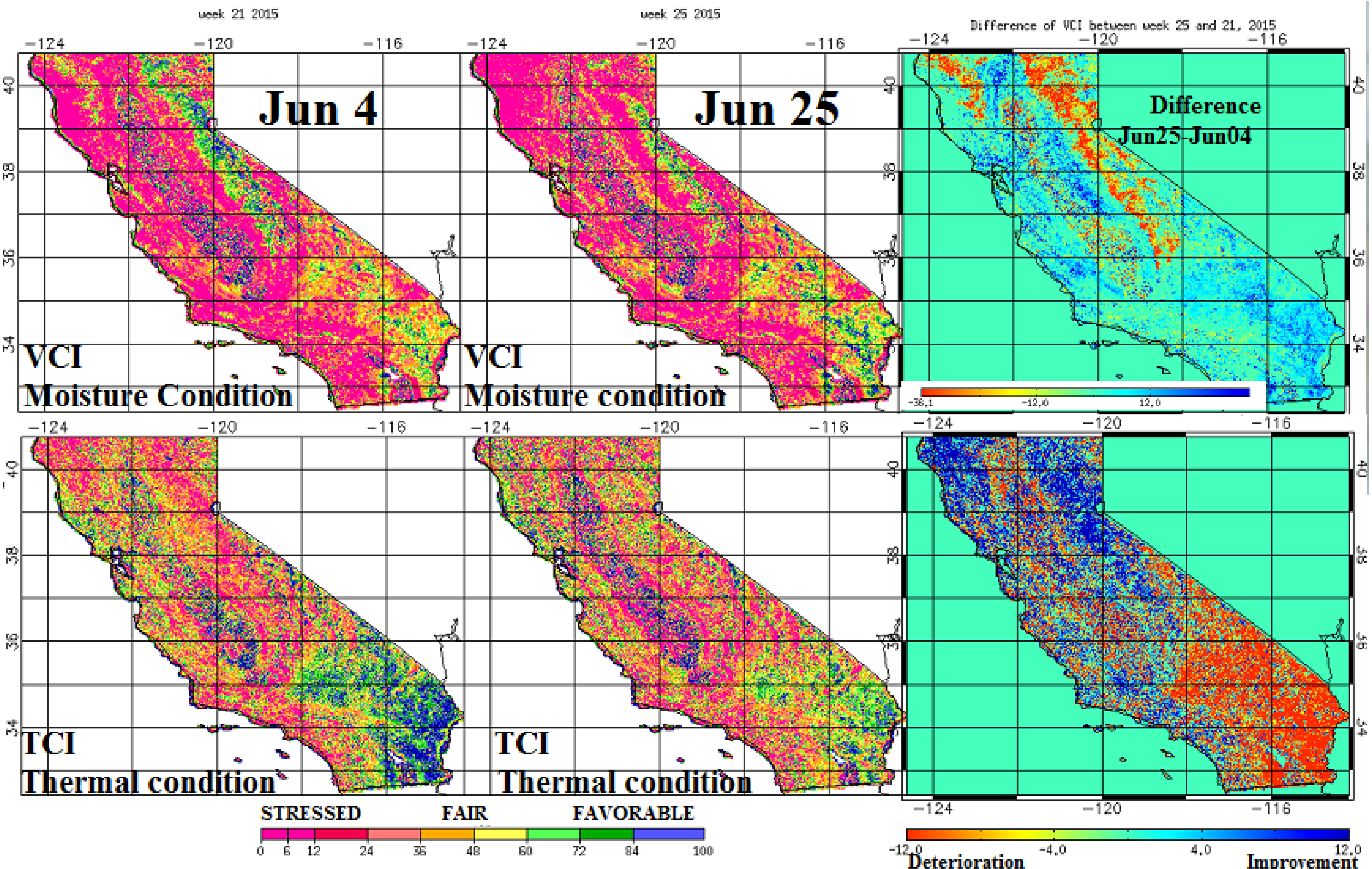
Vegetation Health (VHI) California June 2015



Vegetation Health
S-NPP/VIIRS 500 m
California

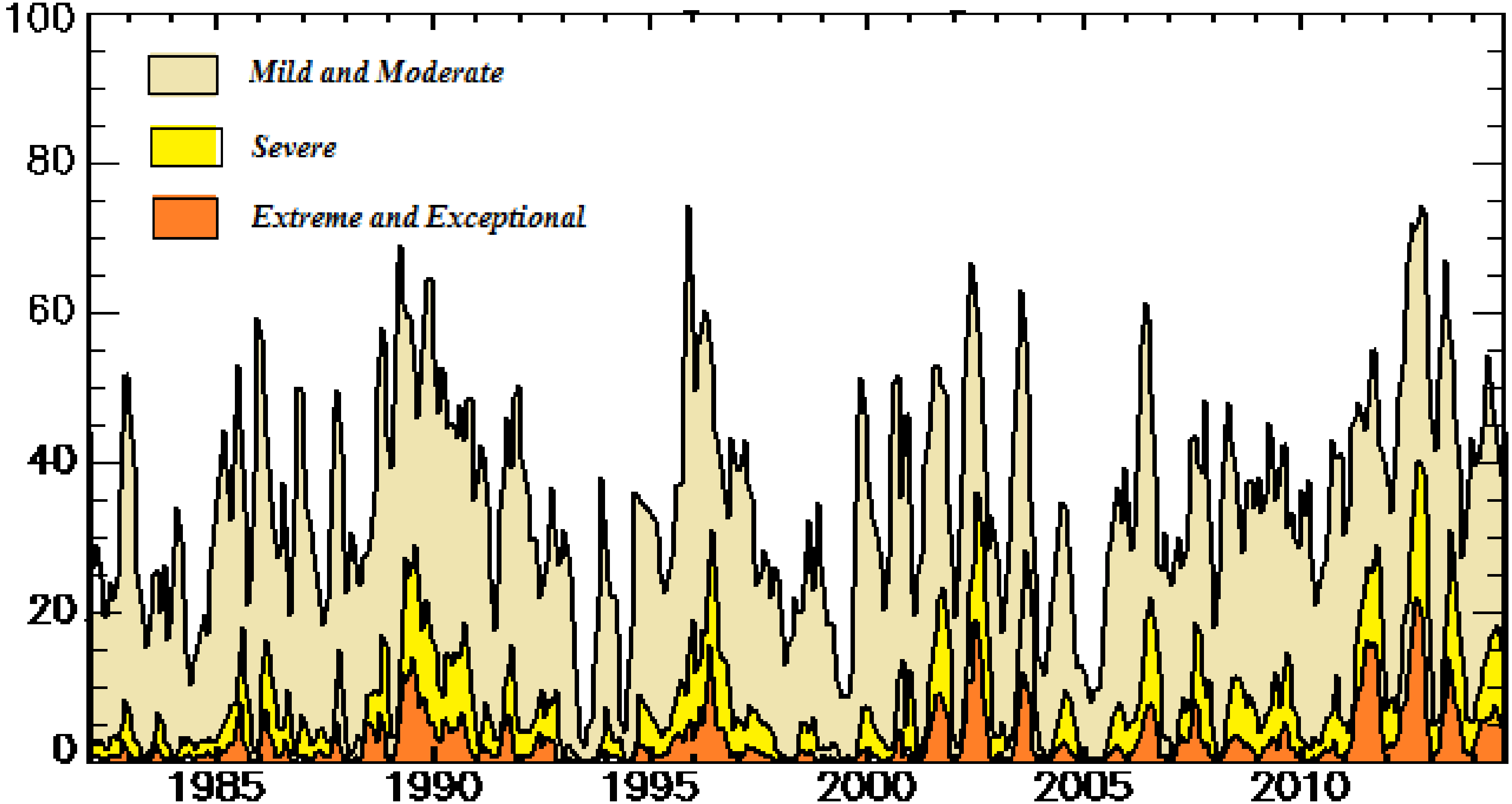


Moisture & Thermal Condition



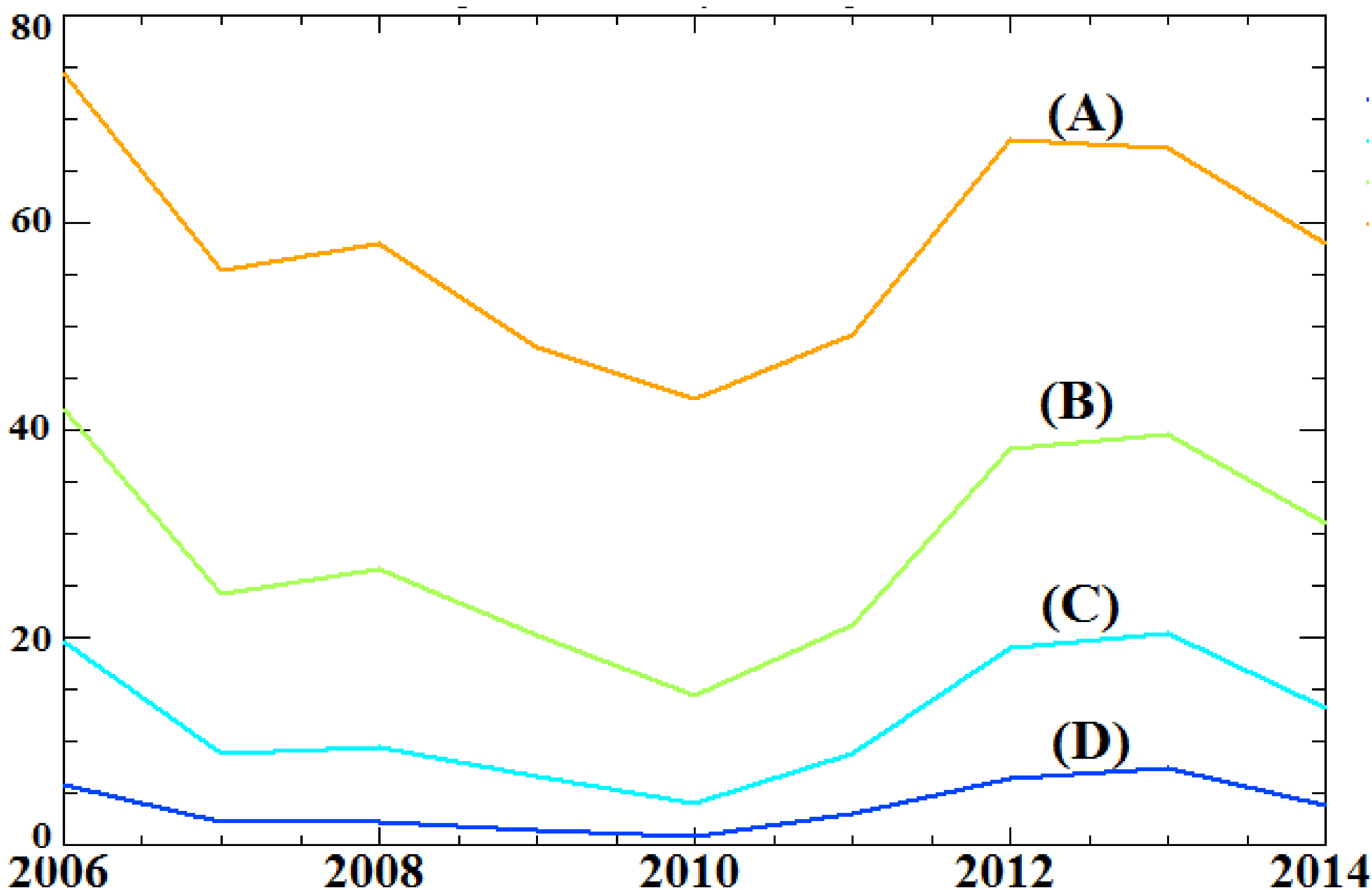
Vegetation Condition 2015, California (500 m)

Percent Western US under Drought

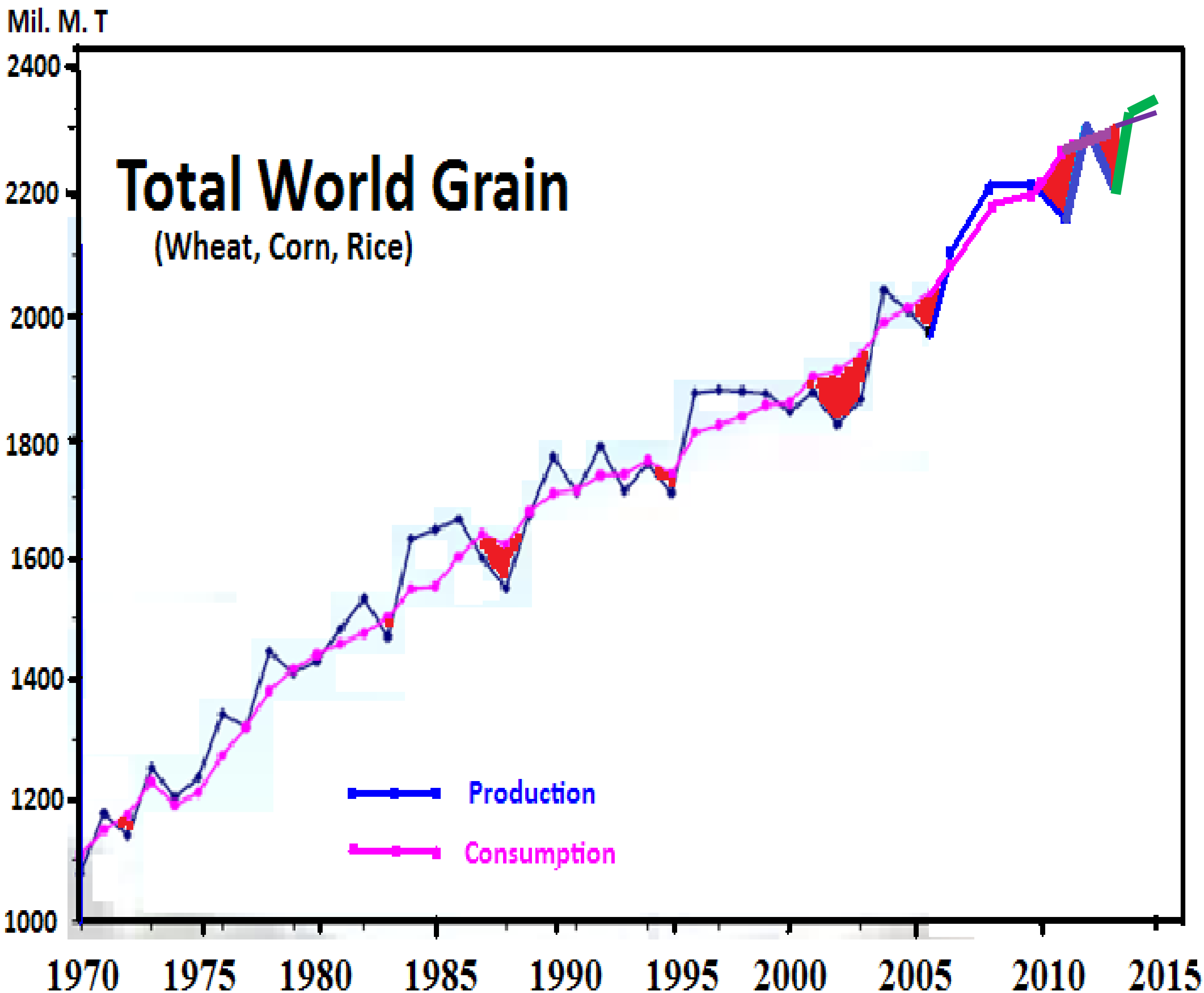


Drought Area & Intensity by weeks: Western United States, 1982-2014

Days with Drought



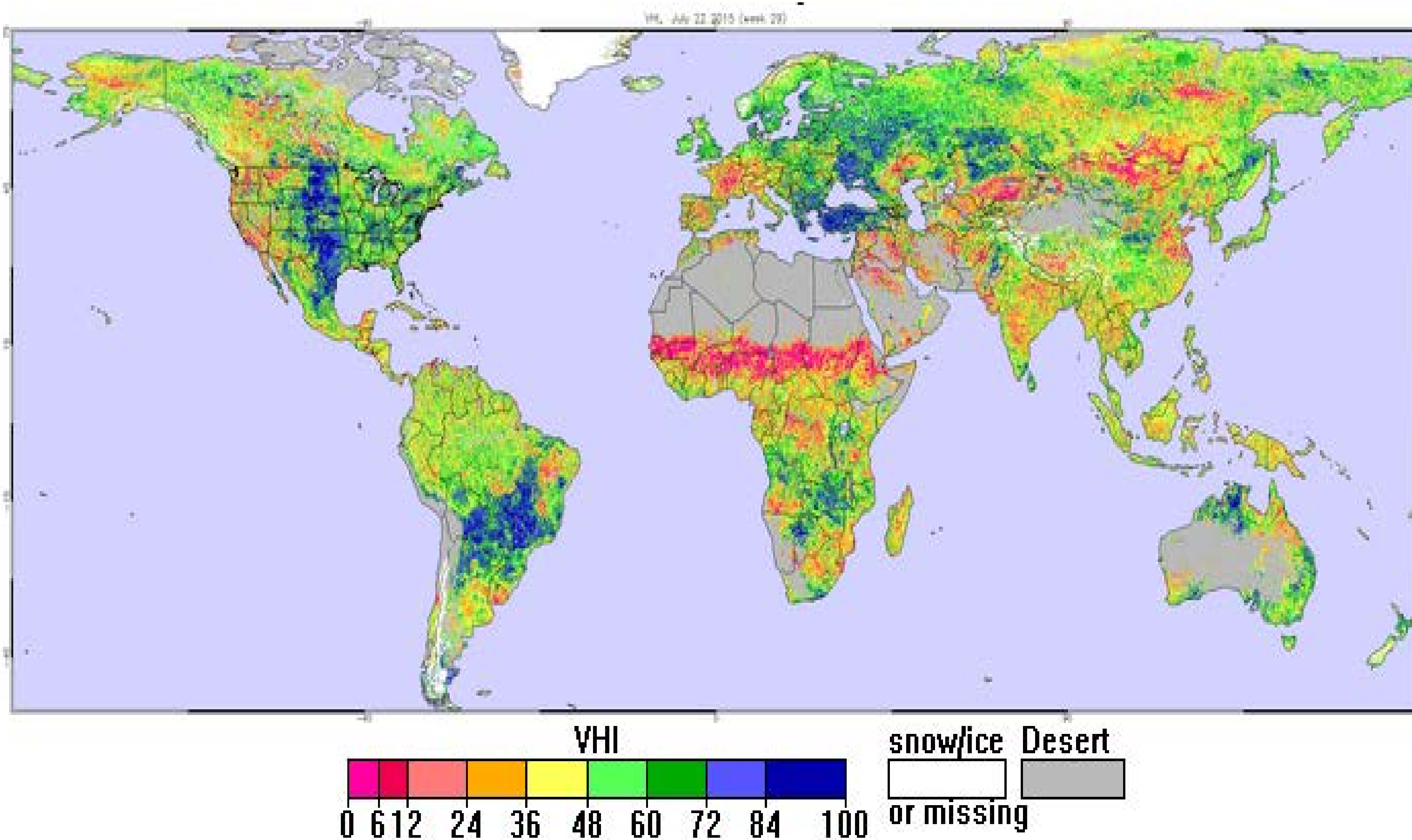
World Grain Production-Consumption, 1970-2013



Droughts

2013 - Argentina, Brazil, Australia, USA
2012 – USA
2011 – USA
2010 – Russia, Ukraine, Kazakhstan, Argentina
2007 – Australia, China, Argentina, Brazil
2003 – USA, Europe, Australia, India, China
2002 – USA, India, Australia, S. Africa
2001 - China
1996 – USA, Russia, Argentina, Kazakhstan Australia
1988 – USA

Vegetation Health July 22, 2015



Web

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

Every week on Thursday

2.5-day VH WEB view (May 4-6, 2015)

Page Views May 1-6, 2015

	Today May 6	Yesterday May 5	This Month May 1-6
STAR Vegetation Health Site	132	206	806

Countries used Vegetation Health WEB during May4-6, 2015

153 Hits	30.60%	United States
81 Hits	16.20%	South Africa
54 Hits	10.80%	Switzerland
41 Hits	8.20%	Australia
17 Hits	3.40%	Mexico
16 Hits	3.20%	India
16 Hits	3.20%	Armenia
11 Hits	2.20%	France
10 Hits	2.00%	Germany
9 Hits	1.80%	Dominican Republic
8 Hits	1.60%	United Kingdom
7 Hits	1.40%	Myanmar
7 Hits	1.40%	Korea, Republic Of
7 Hits	1.40%	Spain
6 Hits	1.20%	Ukraine
6 Hits	1.20%	Iran, Islamic Republic
5 Hits	1.00%	Kenya
5 Hits	1.00%	Japan
5 Hits	1.00%	China
4 Hits	0.80%	Romania

VH-Web Visitors

August 24, 2015, by 10 am

France	France Flag
Switzerland	Switzerland Flag
Canada	Canada Flag
Russian Federation	Russian

Countries during Aug 20-24

United States	United States Flag
Germany	Germany Flag
Mexico	Mexico Flag
United Kingdom	United Kingdom Flag
India	India Flag
South Africa	South Africa Flag
Brazil	Brazil Flag
Singapore	Singapore Flag
Japan	Japan Flag
China	China Flag
Australia	Australia Flag
Kenya	Kenya Flag
Vietnam	Vietnam Flag
Ukraine	Ukraine Flag

Conclusions

2014 World Population 7.3 bil. Increases with Accelerating Rate; World Grain Production Increases with Decelerating Rate

Grain supply drops below demands (in the 21st century 8 years out of 15)

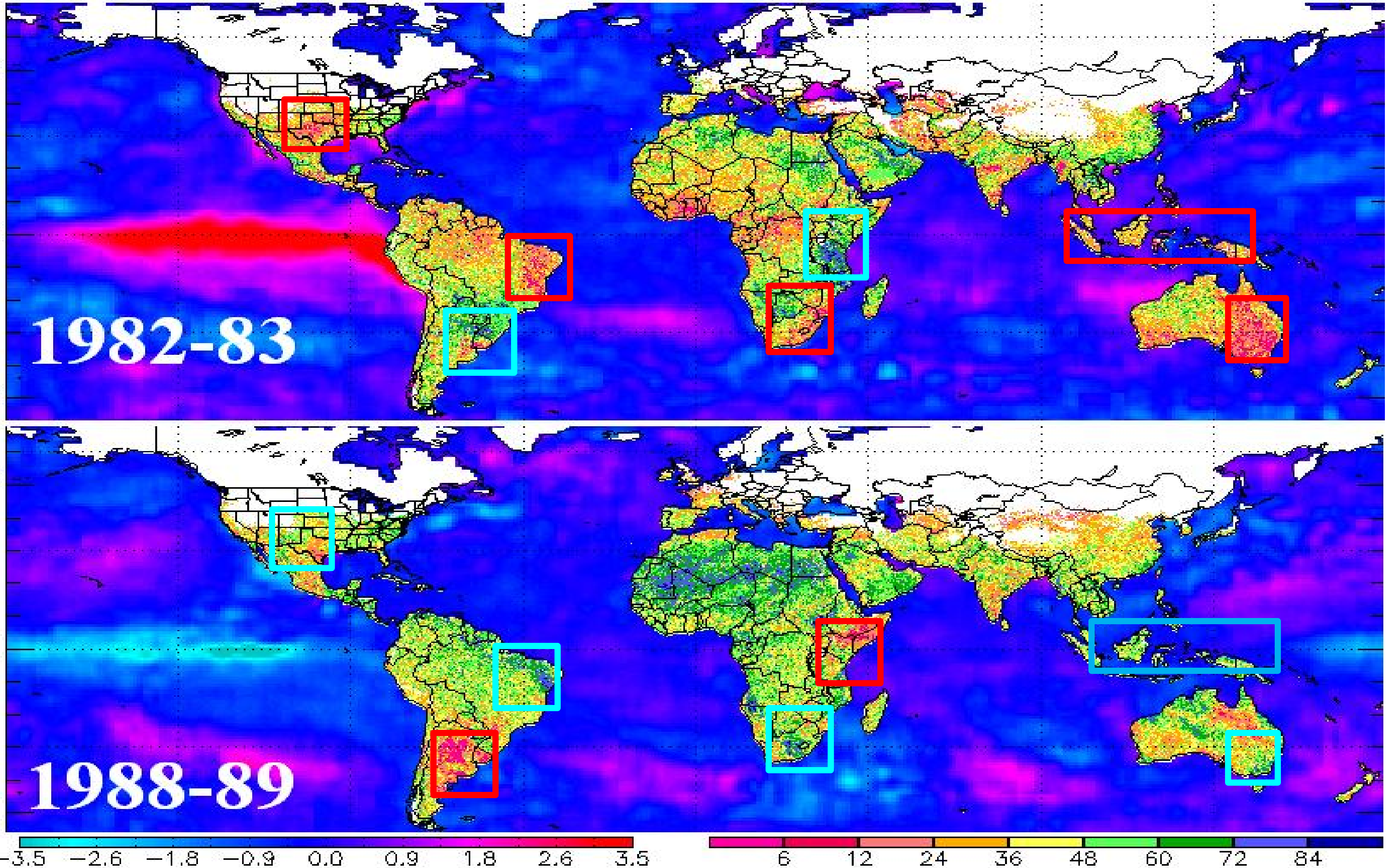
Severe Droughts - Reduces Global Grain Production 4-7% every 4-6 years; Moderate Drought – Reduces Grain 1-3% every 2-3 years

Satellite-based Vegetation Health (VH) Technology Provide Tools for Drought Monitoring & 1-2 Month Advanced Prediction of its Start/End, Area, Intensity, Duration and Impacts

VH Provide Prediction of Drought-related Crop & Pasture Losses: (a) 1-2 Months in Advance of Harvest, (b) During ENSO years 3-4 months prediction

Drought Area & Intensity has not Changed during the Period of Strong Global Warming

VH-Drought Prediction from ENSO (3-6 months)



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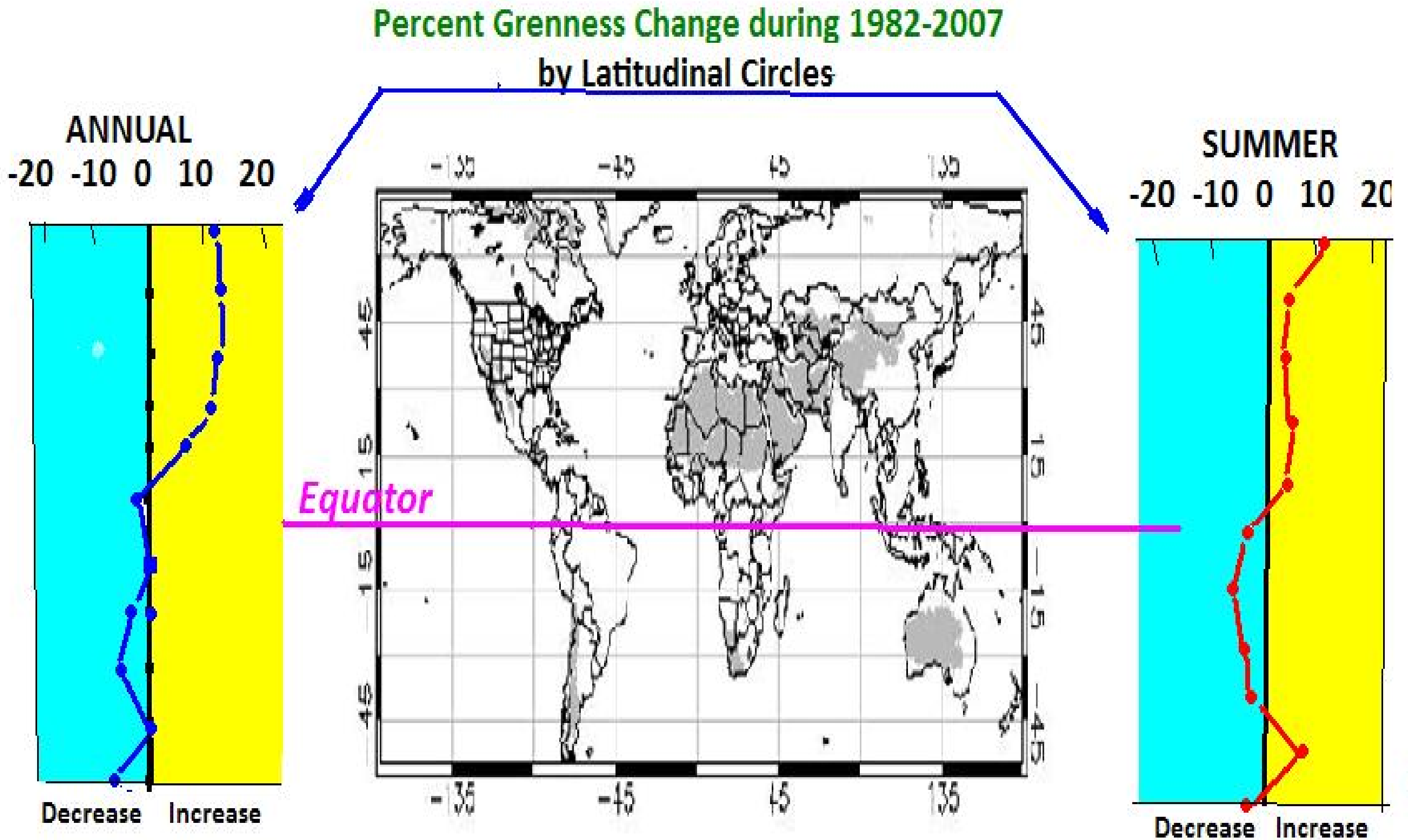
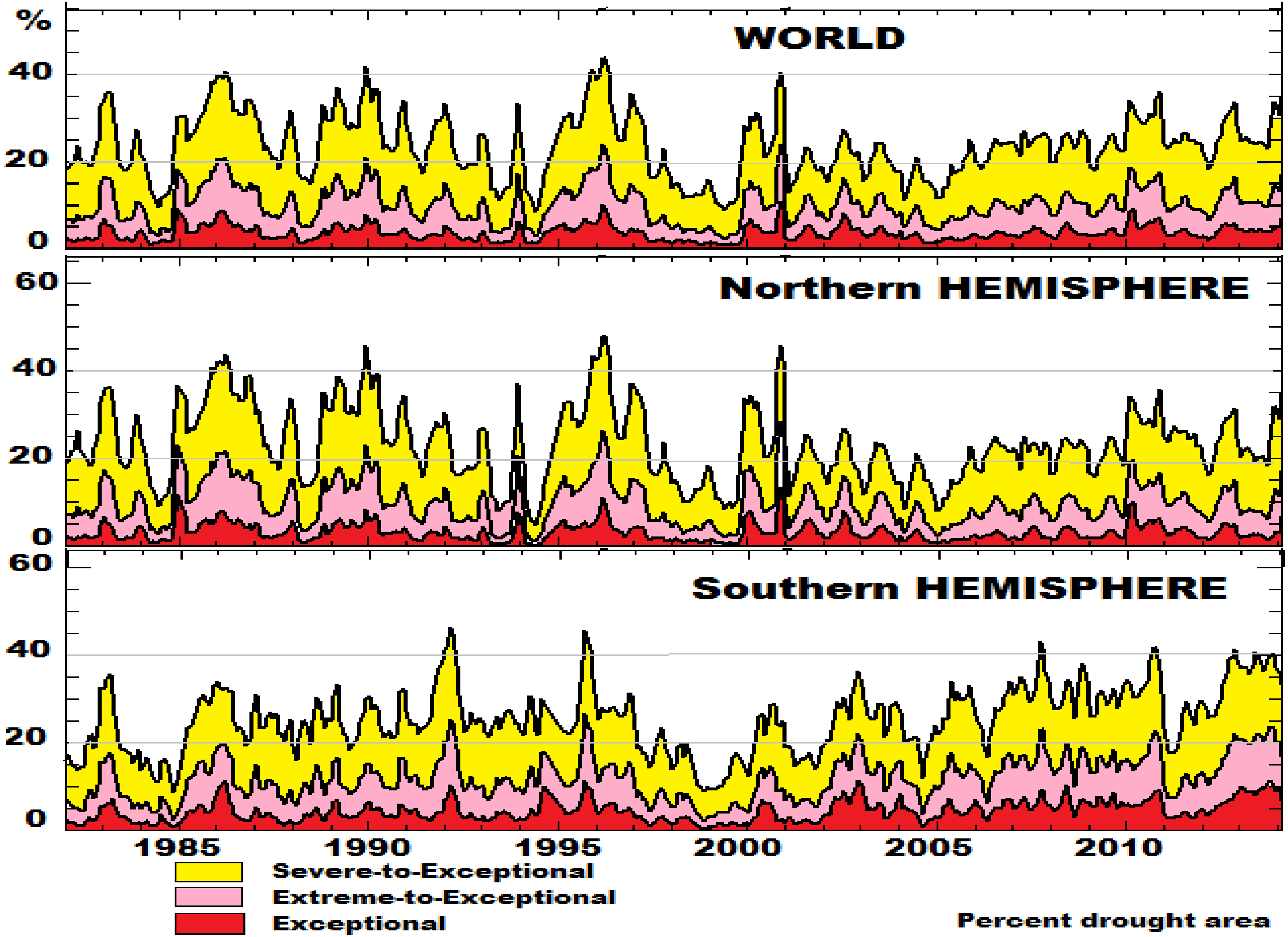
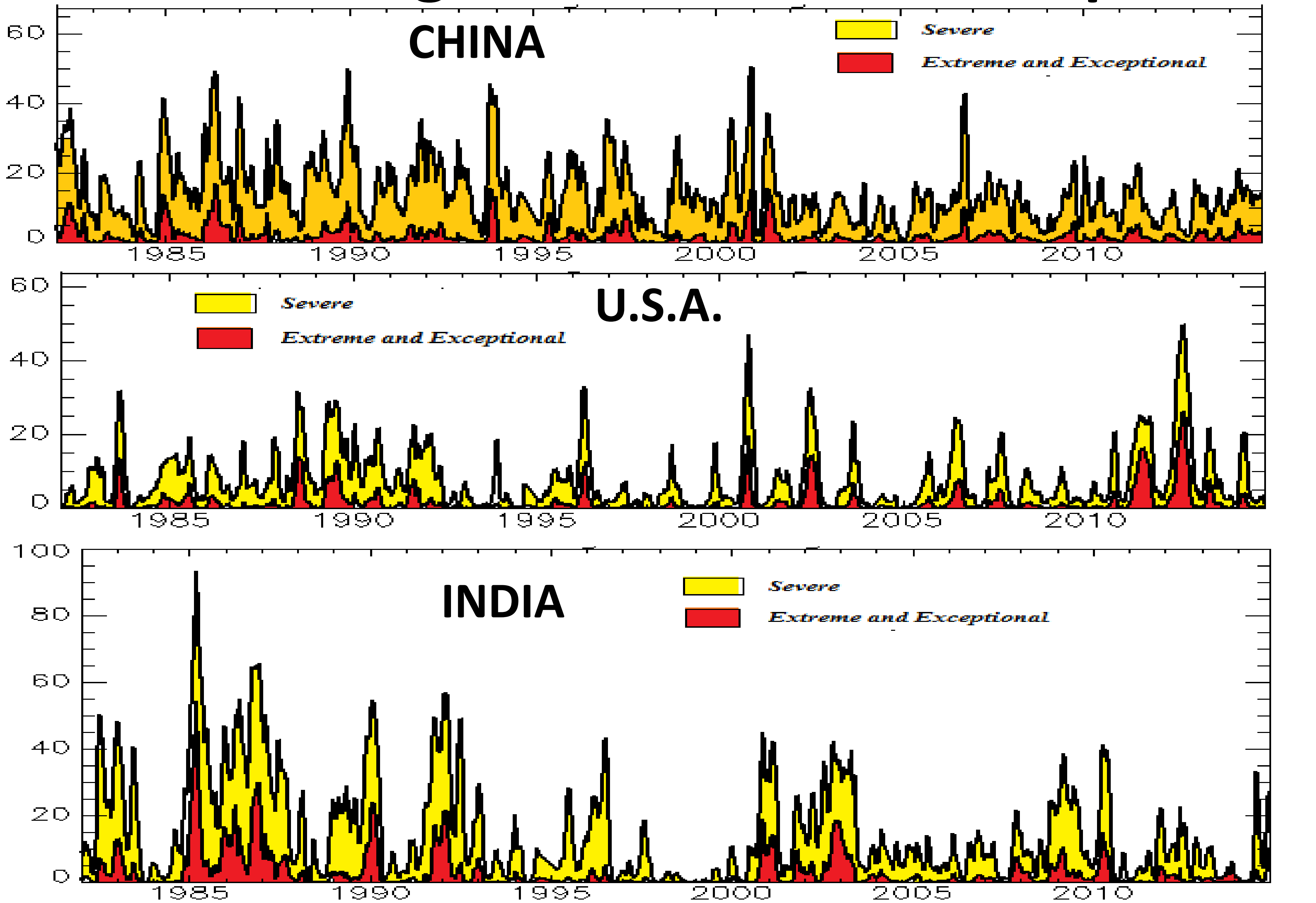
NDVI-based Land Cover Change trend, 1982-2007



Climate: Percent Land under Drought



Percent Drought-affected Grain Crop Area



AVHRR Data for Land Use

Sensors *Advanced Very High Resolution Radiometer (AVHRR)*

Visible Infrared Imaging Radiometer Suite (VIIRS)

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

S-NPP ➔ JPSS

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

Temporal - 7-day composite

Period 35-year (1981-2015)

3.5-year (2011-2015)

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

Channels VIS , NIR , Thermal

Mega-Drought in Western USA

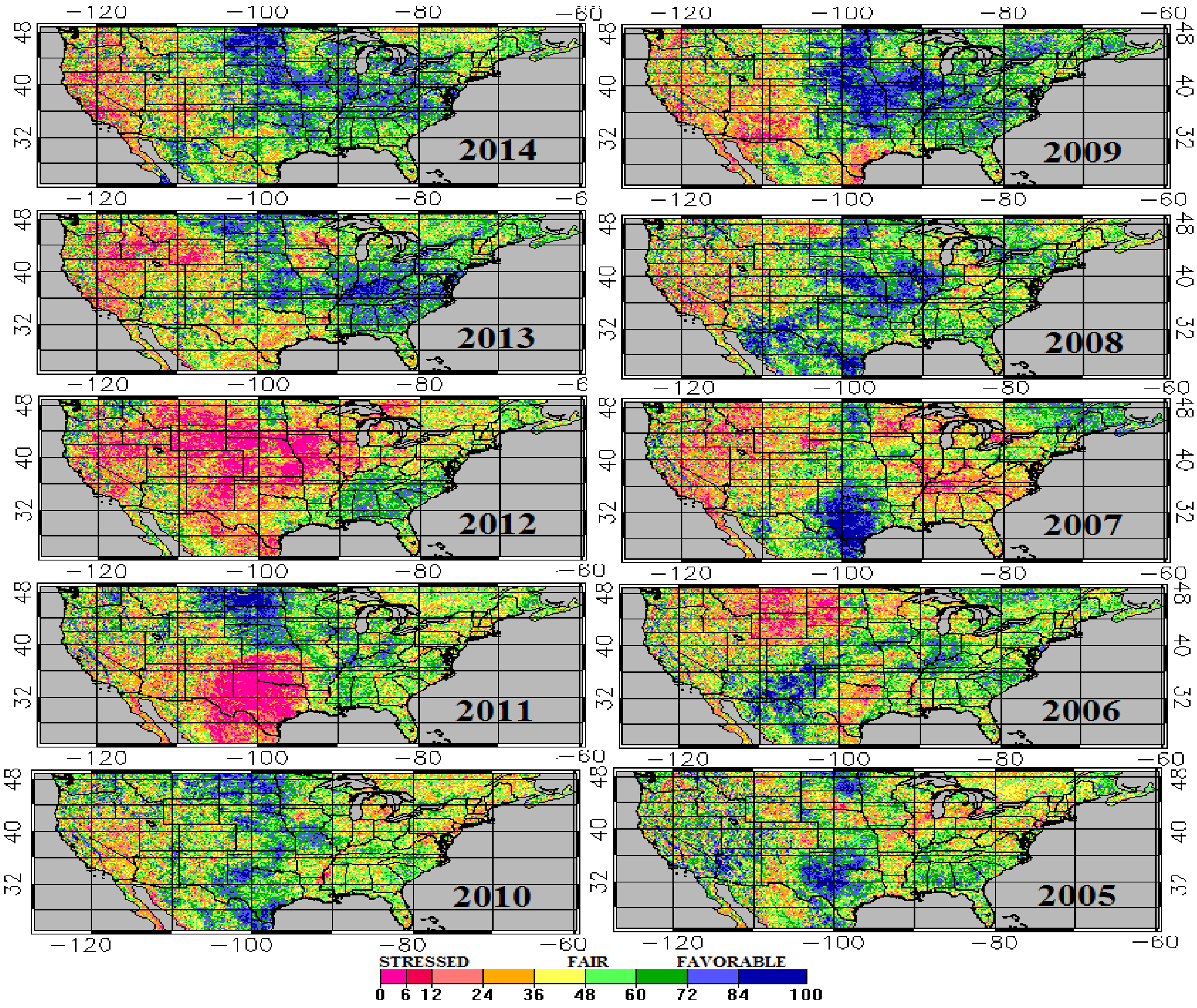
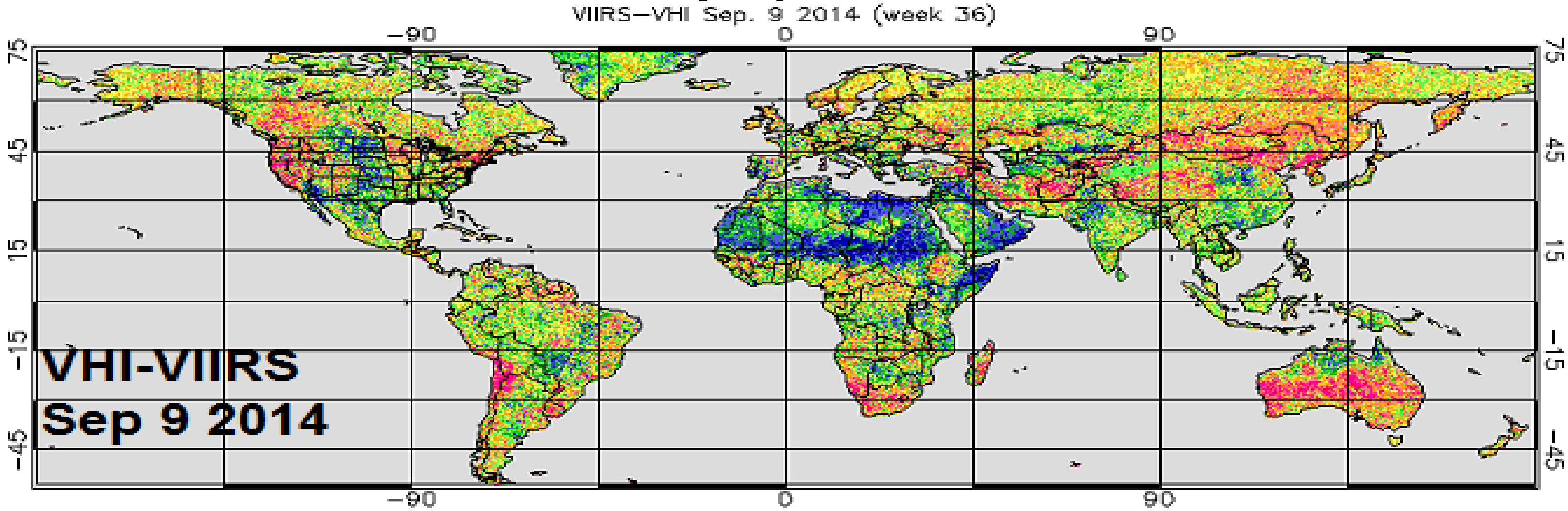
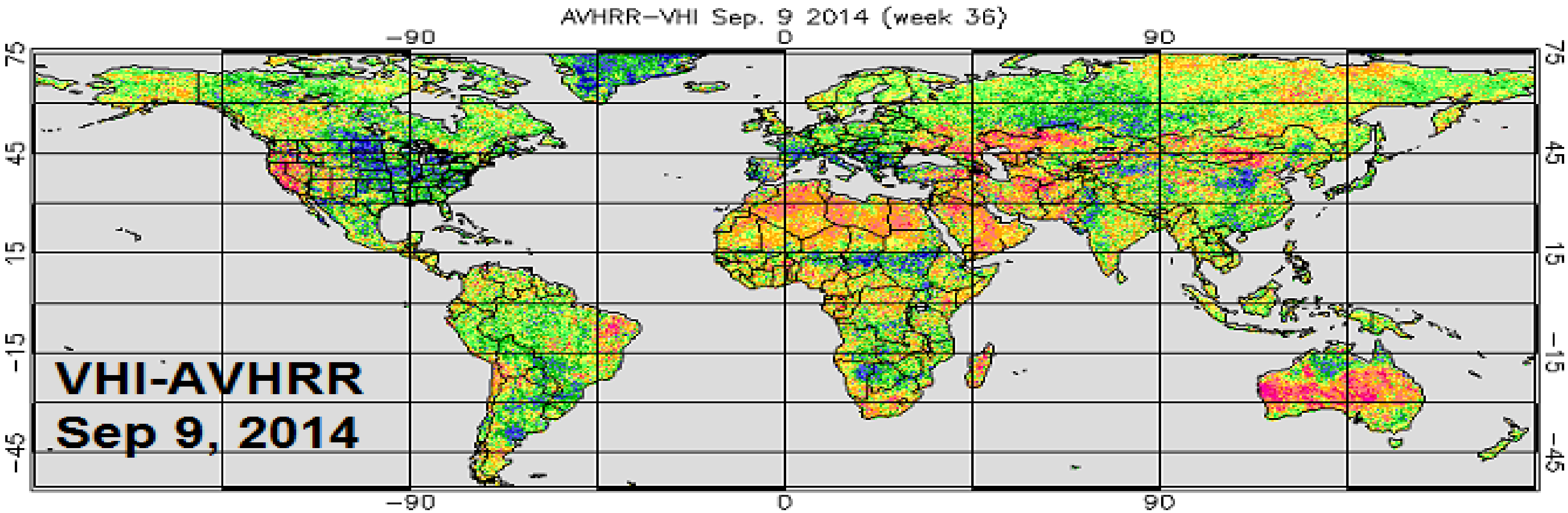


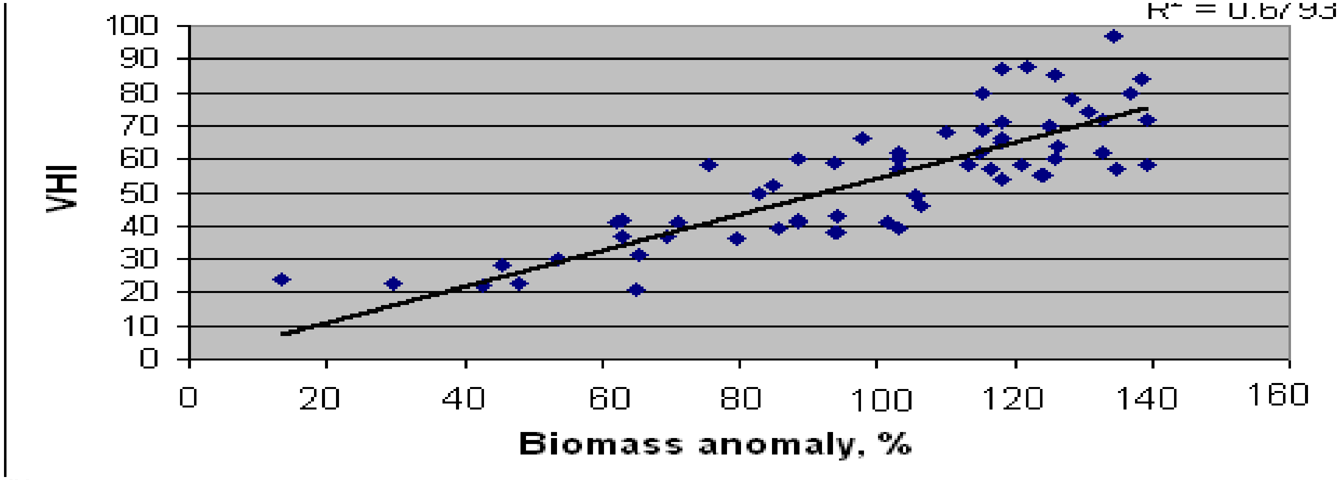
Figure 1. Vegetation health (from VHI) in August 2005 through 2014.

VALIDATION:
VHI VIIRS vs AVHRR
Sep 9, 2014

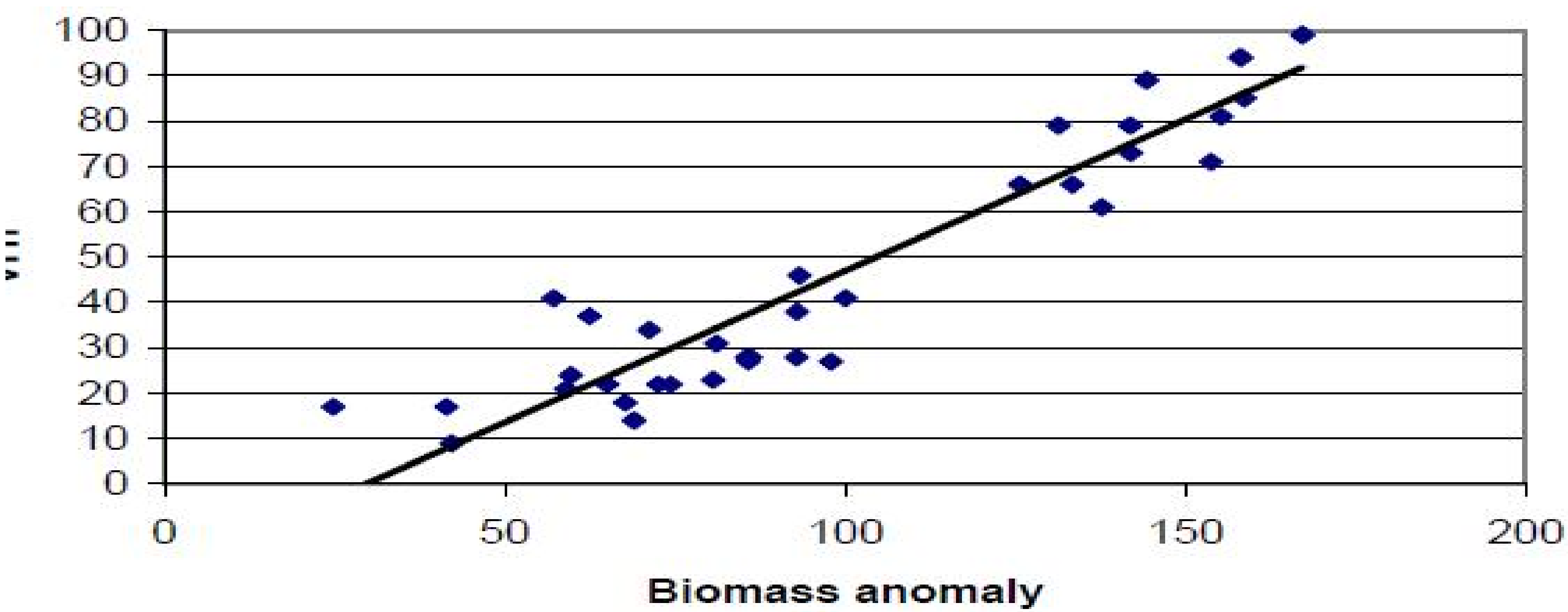




Biomass vs VHI, Turkmenistan

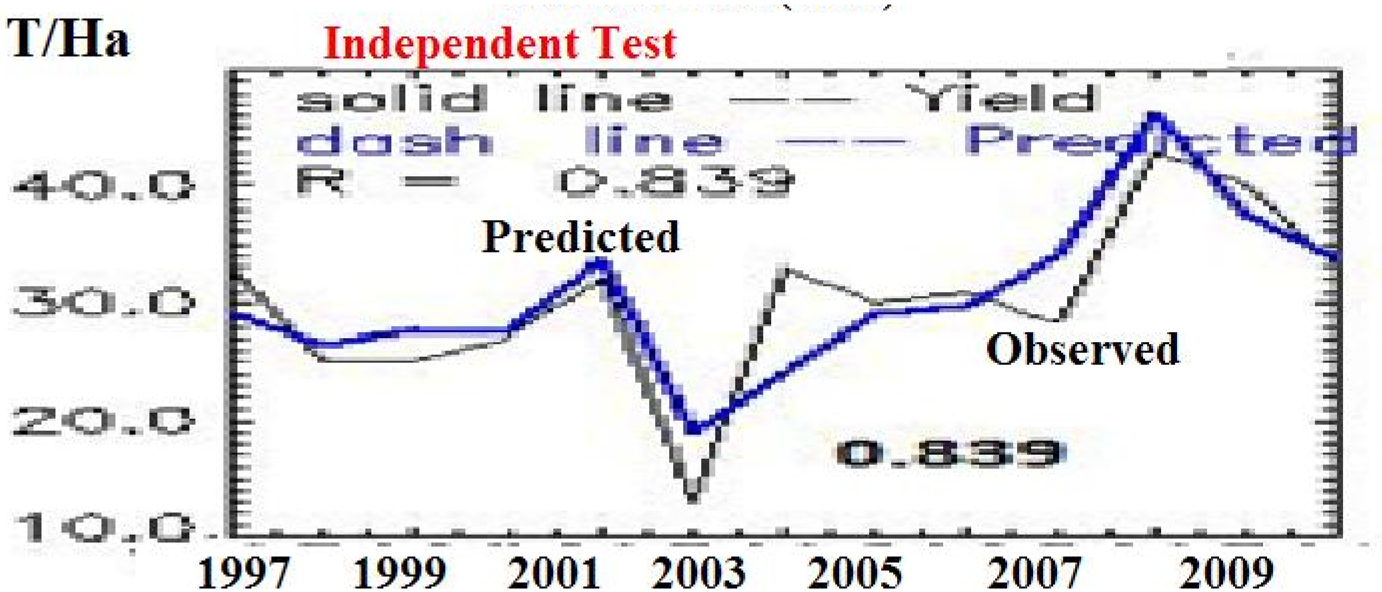


Erbent, Turkmenistan, 1982-2009 (Rsq=0.67)



Lekker monitoring site (36°16' N, 63°42'E) R^2=0.885, n=35 , 1982-2005
SoutheasternTurkmenistan.

Winter Wheat Yield
Vinnitsa Obl. UKRAINE

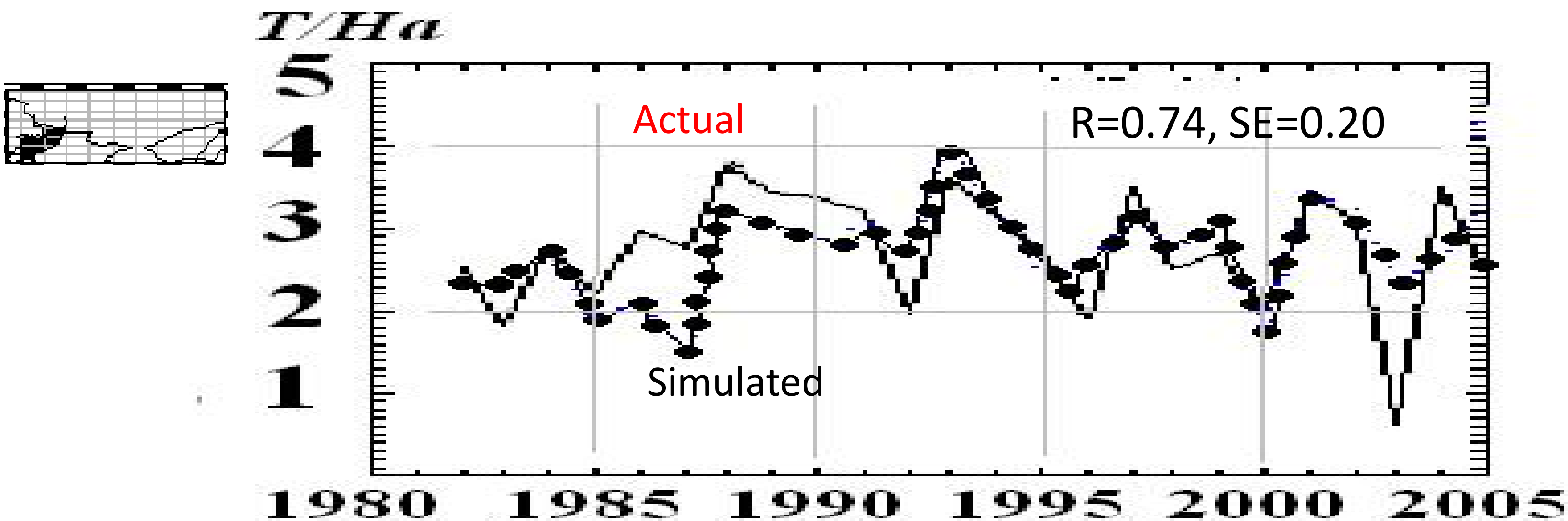


Winter Wheat yield Observed and VH-Predicted VINNITSA

Winter Wheat Yield
Odessa Obl. UKRAINE

Partial CC	*-0.57*	*0.58*	*-0.33*	*0.38*

$$dY = 0.286 - 0.057VH_5 + 0.067VH_6 - 0.041VH_{18} + 0.044VH_{19}$$



Actual vs Independently Simulated Winter Wheat Yield, Odessa Obl., UKRAINE

Vegetation Health data sources

Sensors *Advanced Very High Resolution Radiometer (AVHRR)*

Visible Infrared Imaging Radiometer Suite (VIIRS)

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

S-NPP → JPSS

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

Temporal - 7-day composite

Period 35-year (1981-2015)

3.5-year (2011-2015)

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

Channels VIS , NIR , IR

Indices NDVI & BT

Status of land surface albedo production from the JPSS Mission

Yunyue Yu

NOAA/NESDIS, Center for Satellite Applications and Research

Shunlin Liang, Dongdong Wang, Yuan Zhou

Department of Geographical Sciences, University of Maryland

Outline

- ✓ VIIRS LSA Basics
- ✓ Current Operational Products
- ✓ Validation Status
- ✓ Issues and improvement Needs
- ✓ International Cooperation
- ✓ Long-term Monitoring
- ✓ J1 CalVal Plan

VIIRS LSA Basics

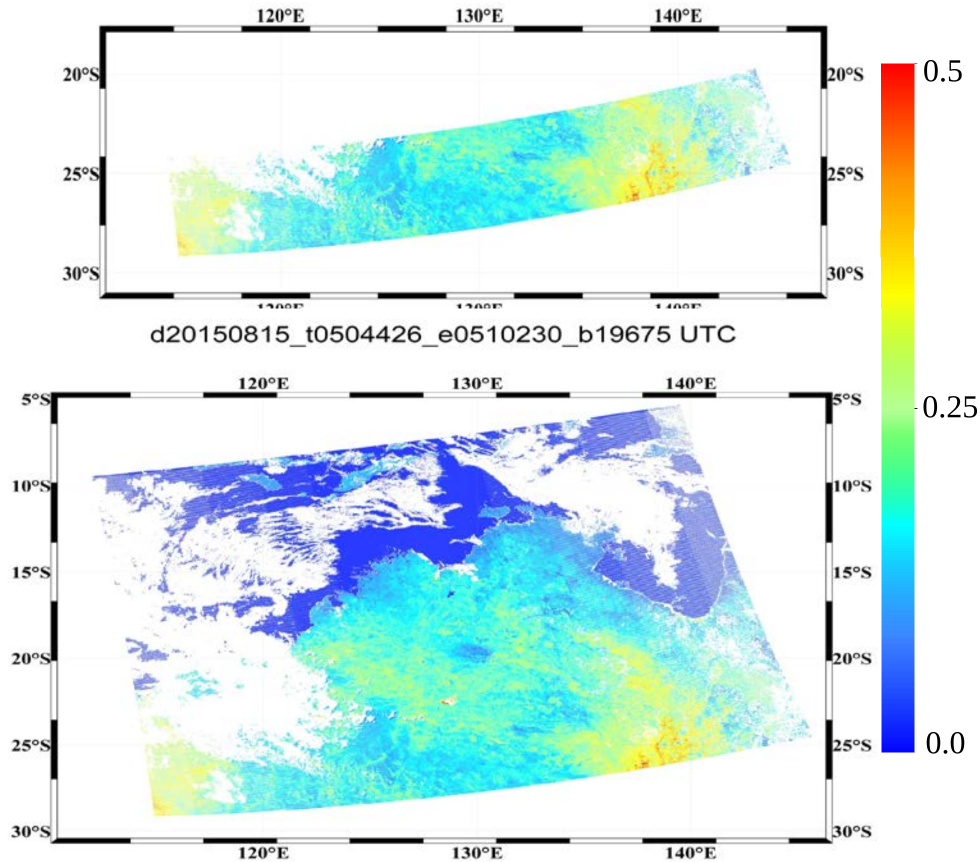
- Surface albedo is the ratio between outgoing and incoming shortwave radiation at the Earth surface. It is an essential component of the Earth's surface radiation budget.
- Surface albedo is produced from S-NPP VIIRS as Environmental Data Record (EDR). Surface albedo EDR has the global coverage, including land surface albedo (LSA) and sea ice surface albedo (ISA).
- Bright Pixel Sub-Algorithm (BPSA) is currently used to generate LSA and ISA from VIIRS data. Several improvements have been made since the S-NPP launch.
- Surface albedo EDR is a full resolution ***granule instantaneous*** product. LSA is only generated for ***clear-sky*** pixels.

Albedo EDR Cal/Val Team Membership

	Name	Institute	Function
JPSS-STAR	Land Lead: Ivan Csiszar	NOAA/NESDIS/SATR	Project Management
	EDR Lead: Yunyue YU	NOAA/NESDIS/SATR	Team management, algorithm development, validation
	Shunlin Liang	UMD/CICS –project PI	algorithm development, validation
	Dongdong Wang	UMD/CICS	algorithm development, validation, monitoring
	Yuan Zhou	UMD/CICS	algorithm development, validation, monitoring
	Marina Tsidulko	IMSG	STAR AIT support: product verification, testing
	Mike Ek' team	NOAA/NWS/NCEP	User readiness
	Weihong Zheng	NOAA/NWS/NCEP	User readiness
JPSS DPA			
	Leslie Belsma	JPSS/DPA	algorithm Manager (JAM) for Land
NASA S-NPP Science Team			
	Robert Wolf' team	NASA/GSFC	Cal/Val support
	Miguel Roman	NSAS/GSFC	algorithm (DPSA) development, product validation
	Crystal Schaaf	UMB	algorithm (DPSA) development, product validation

Basics: Current Operational Product

- Operational Product
  - 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



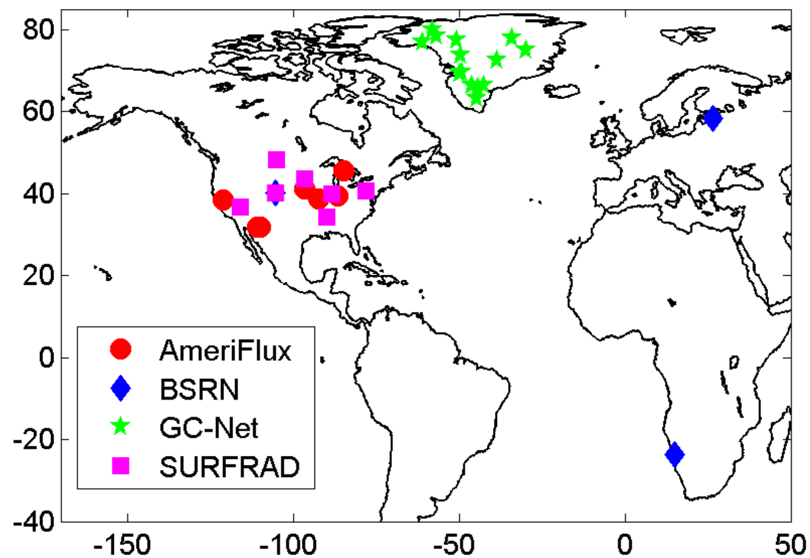
- Archive site
  - CLASS: http://www.nsof.class.noaa.gov/saa/products/welcome (search for JPSS VIIRS EDR)
  - Team site : http://www.star.nesdis.noaa.gov/jpss/albedo.php
  - NASA site: http://viirsland.gsfc.nasa.gov/Products/AlbedoEDR.html
- Monitoring: http://www.star.nesdis.noaa.gov/jpss/EDRs/products_LST.php

Validation status

Site	RMSE		Bias	
	VIIRS	MODIS	VIIRS	MODIS
AZ_Kendall_Grassland	0.042	0.062	-0.030	-0.057
AZ_Lucky_Hills_Shrubland	0.025	0.042	0.001	-0.039
AZ_Santa_Rita_Creosote	0.044	0.048	0.003	-0.035
AZ_Santa_Rita_Mesquite	0.026	0.033	0.007	-0.028
IN_Morgan_Monroe_State_Forest	0.043	0.063	-0.032	-0.058
MI_UMBS	0.200	0.028	0.136	-0.028
MI_UMBS_Disturbance	0.243	0.039	0.171	-0.032
MO_Missouri_Ozark_Site	0.025	0.041	-0.012	-0.035
NE_Mead_irrigated	0.032	0.141	0.007	-0.047
NE_Mead_Rainfed	0.209	0.184	0.088	0.096
Boulder	0.051	0.117	-0.017	-0.049
GITS	0.112	0.761	-0.057	-0.570
Humboldt	0.114	0.112	-0.071	-0.096
Summit	0.106	0.074	-0.028	-0.061
DYE-2	0.152	0.059	-0.009	0.027
Saddle	0.094	0.104	-0.028	-0.039
South-Dome	0.109	0.095	0.055	0.046
NASA-SE	0.142	0.241	-0.043	-0.086
Sioux_Falls	0.114	0.078	0.048	0.009
Table_Mountain	0.050	0.163	0.020	-0.019
Desert_Rock	0.038	0.011	0.029	-0.009
Fort_Peck	0.042	0.258	-0.006	-0.131
Penn_State	0.081	0.073	-0.066	-0.035
Goodwin_Creek	0.037	0.045	-0.031	-0.042

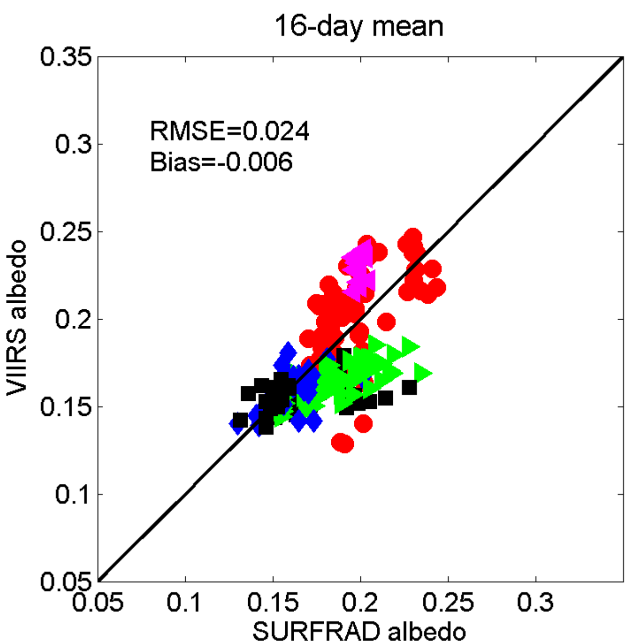
Validation data period: 2012 , 2013, 2014

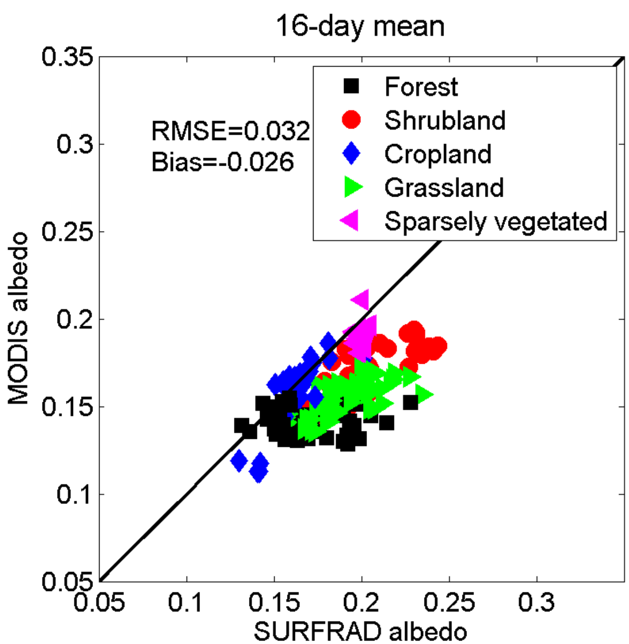
- Data of 35 stations are collected, which include measurements of recent three years.
- VIIRS data are generally better than MODIS products, with smaller RMSE and bias.
- Both data sets have high accuracy for snow-free cases.
- Large RMSE usually occurs at the cases of snow pixels and ephemeral snow.



Validation results for non-snow albedo

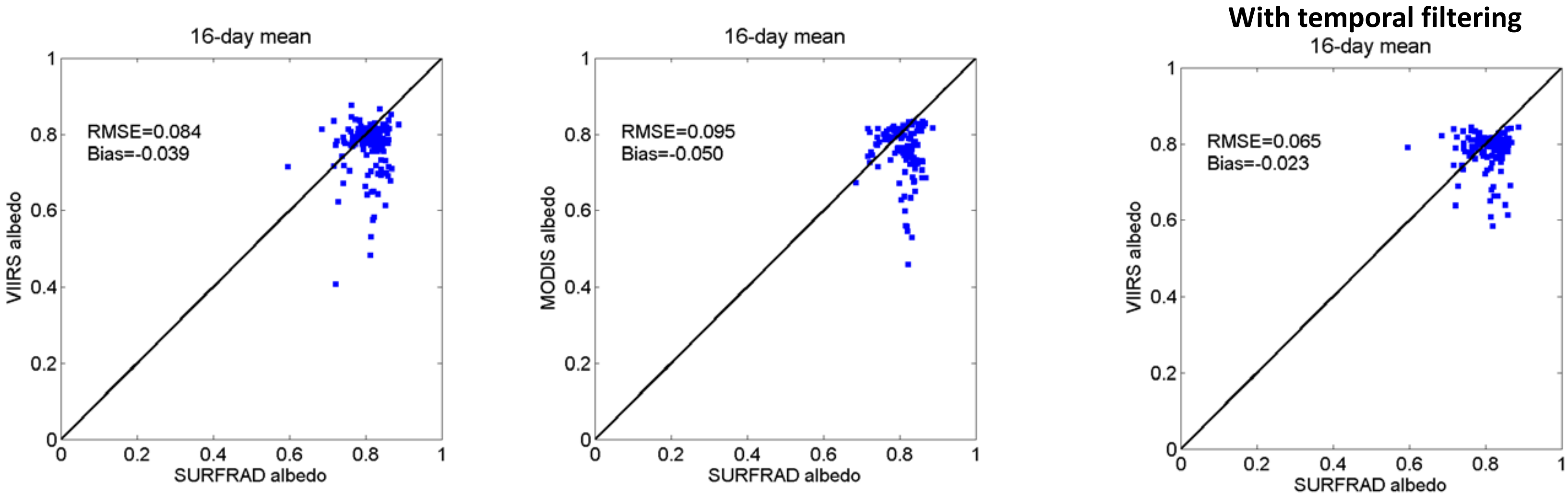
- Further analyzing accuracy of non-snow albedo
- Data over non-snow sites during non-snow seasons were used.
- 16-day mean was calculated to compare with MODIS data
- VIIRS data have smaller bias and RMSE, well below the product threshold.



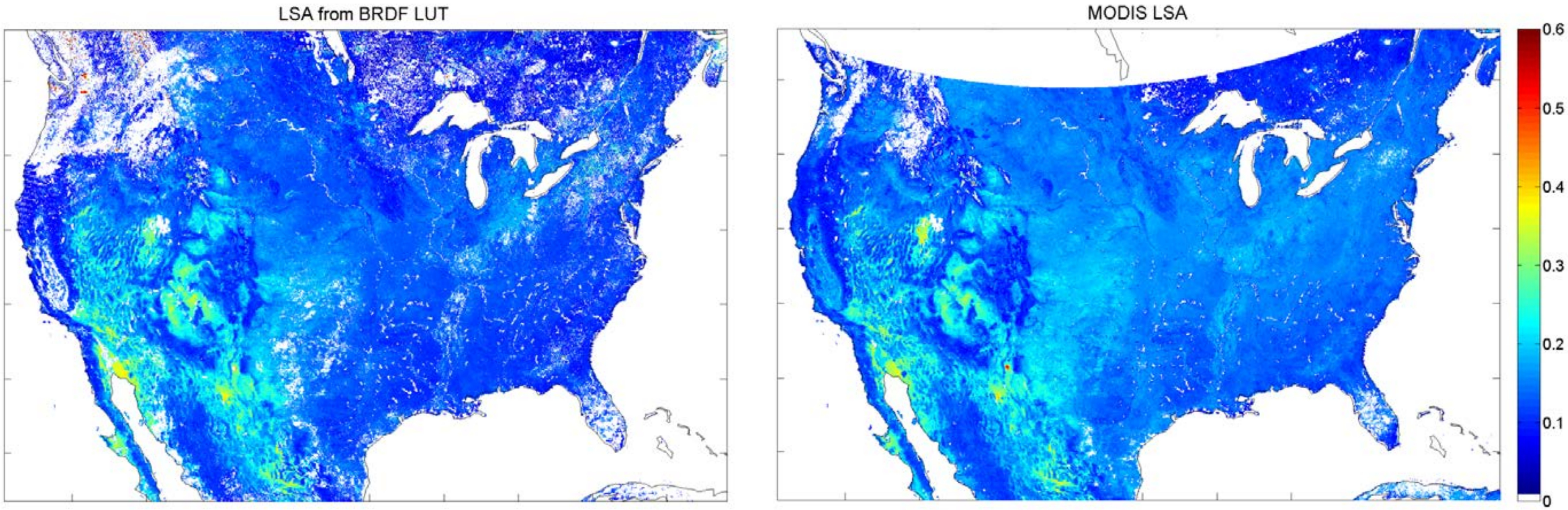


Validation results for snow albedo

- Accuracy of estimating snow albedo was evaluated at GC-Net stations.
- VIIRS generally has improved results.
- Retrieval accuracy is strongly dependent on quality of cloud detection.
- Temporal filtering can improve retrieval quality and data continuity.

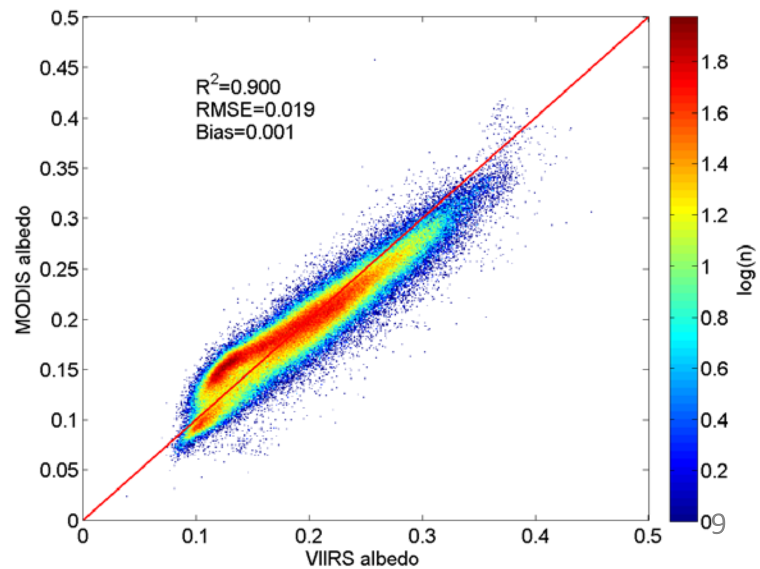


Inter-comparison with MODIS albedo



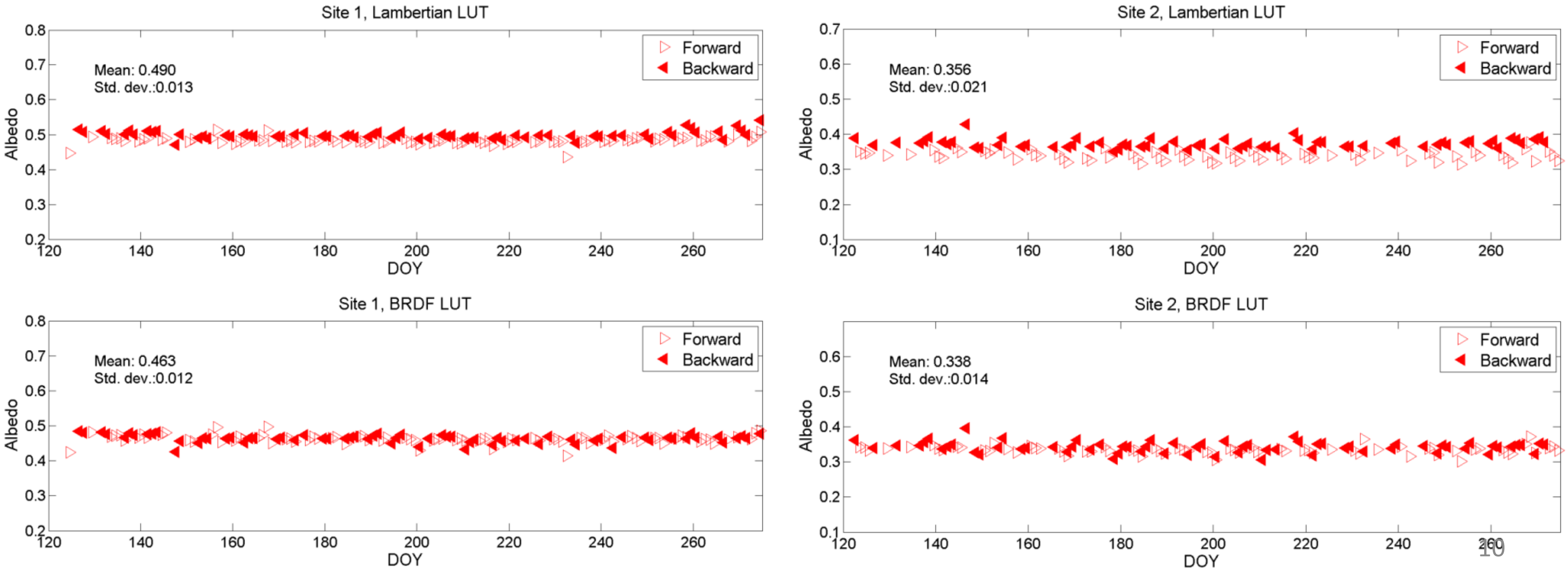
Contiguous US maps of 16-day mean LSA from VIIRS and MODIS, during DOY 145-160, 2012

Comparing 16-day mean VIIRS albedo from BRDF-impacted LUT with MODIS blue-sky albedo. Data are limited to those with at least 8 clear-day observations during the composite period of 16 days.



Temporal variability of LSA retrievals

- The VIIRS LSA algorithm uses one observation to estimate LSA. Angular dependency has been substantially reduced by incorporation of surface BRDF in model construction.
- Residual variations still exist after algorithm improvement, though they are comparable to results of other methods.
- The LSA retrievals over two Libya desert sites (Site 1: 24.42˚N 13.35˚E and Site 2: 26.45˚N, 14.08˚E) are used to illustrate the issue of temporal variability of LSA retrievals.

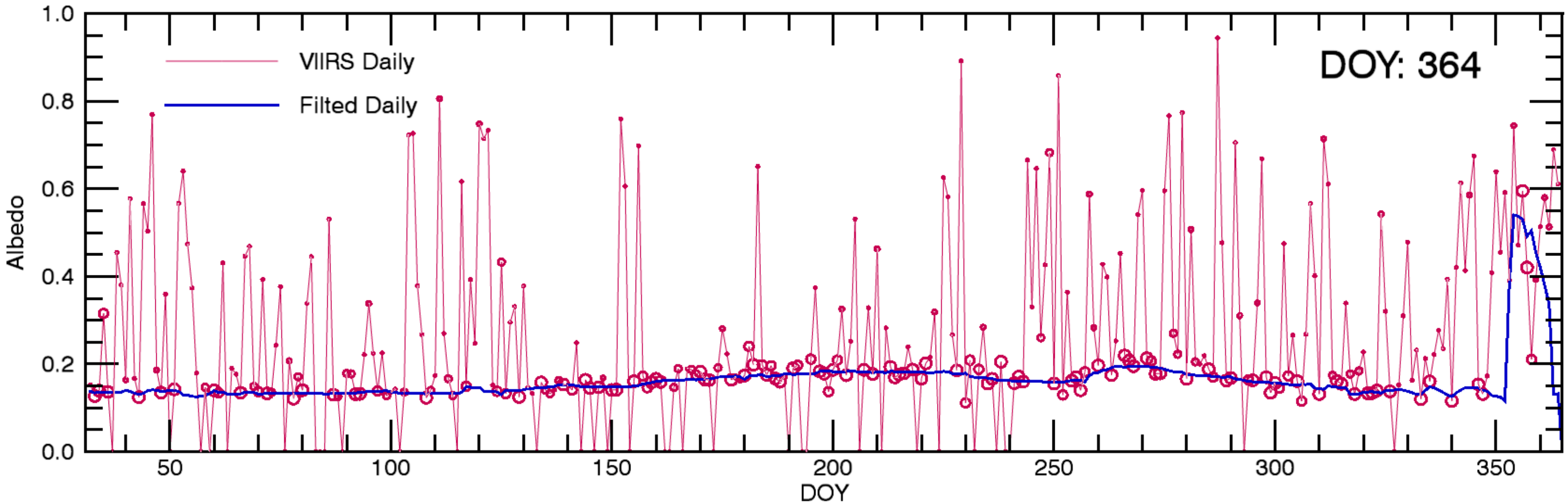


Issues and Improvement Needs

- **LUT of sea ice albedo** is out of date. Evaluation of current sea ice albedo data and development of a new LUT is greatly needed.
- The current BPSA algorithm estimates albedo from a single clear-sky observations. It is sensitive to errors in cloud mask and random effects. **Temporal filter** is proposed to generate smoother and gap-free albedo with improved accuracy.
- Land surface is currently divided into two categories (desert and non-desert). We plan to further separate surface types and develop a new version of **surface-specific LUTs**.
- **Comprehensive validation and intercomparison** is essential for both algorithm developers and end users. Limited validation has been done so far.

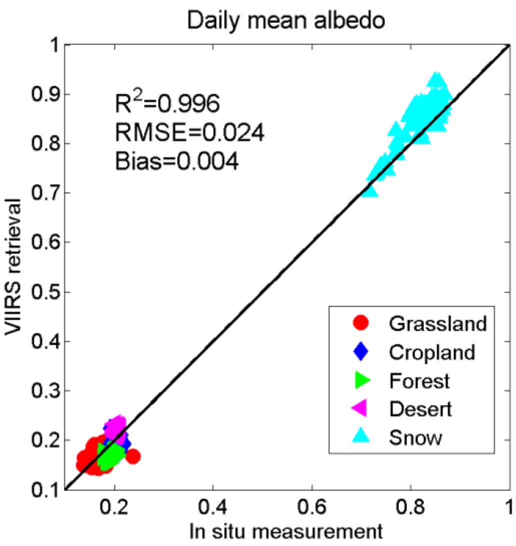
New development: temporal filter

- An algorithm based on temporal autocorrelation and climatology is developed.
- Objectives
  - Improve accuracy
    - Reduce temporal variations
    - Exclude undetected cloud and shadow
  - Fill data gaps
- Integrate multisource of information
  - VIIRS retrieval and its QF
  - Climatology (mean and variance)
  - Temporal correlation (historical observation)



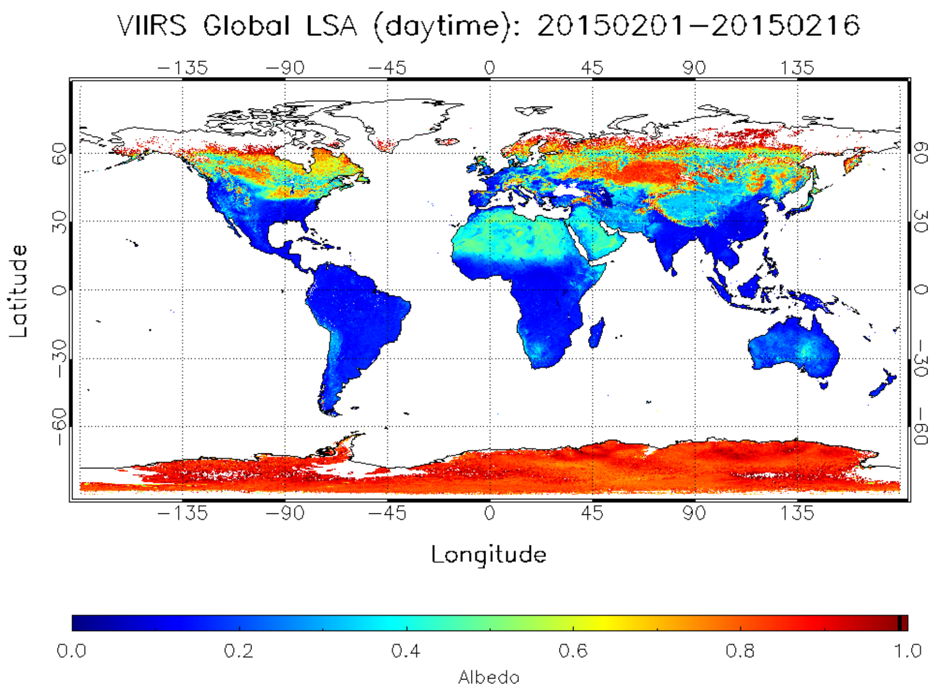
New development: gridded LSA product

- We proposed to develop a Level-3 LSA product on the basis of VIIRS SA EDR, which has the following features:
  - Gridded
  - Noise-reduced
  - Gap-filled
  - Diurnal variations being considered
- Use of instantaneous albedo to calculate daily surface radiation budget results in ~10% bias for snow-free conditions.
- We develop a new method to estimate daily mean albedo directly from VIIRS data.



Left: validation of daily mean albedo

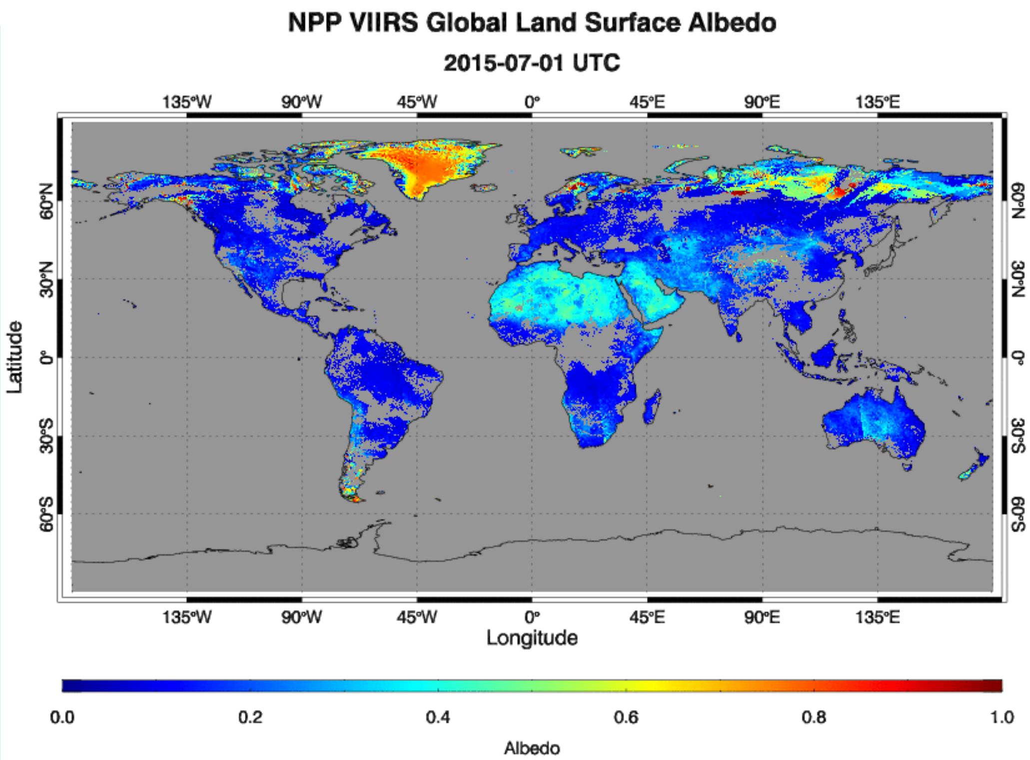
Right: gridded global albedo data



Long-term monitoring tool

Working on a long-term monitoring tool

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



Animation of global albedo map composed from the VIIRS albedo EDR, shown through the VIIRS Albedo production long-term monitoring website at STAR.

Data re-processing

- The S-NPP VIIRS LSA algorithm has gone through several updates for algorithm improvement and refinement.
- The updated algorithms were applied only for data acquired after the algorithm's effective dates.
- To generate consistent LSA product with highest quality possible, we need to re-process all the historical VIIRS data with the latest LSA algorithm.
- VIIRS TOA reflectance SDR and cloud mask IP are the major upstream inputs of the albedo algorithm. Such data with the latest version will be used during the data re-processing.

J1 Cal/Val plan

- Comprehensive evaluation of the J1 LSA product
  - Spatial scaling problem
  - Dependency of LSA retrievals on solar and view angles
  - Global accuracy of both snow-free and snow-covered data
  - Capability of capturing rapidly-changing surfaces
- Long-term monitoring
  - A web-based product monitoring interface
  - In-situ validation alerting/notification
- Correlative Data Sources
  - Ground stations
  - Airborne multiangular measurements
  - High resolution reference maps
  - Other albedo products
- Development of cal/val tool
  - Generating quality metrics commonly used by the international land community
  - Participating in the international cooperation on validation of satellite land products

Status of Land Surface Temperature production from the JPSS Mission

Yunyue Yu, Yuling Liu, Peng Yu, Heshun Wang

NOAA/NESDIS, Center for Satellite Applications and Research

Outline

- ✓ VIIRS LST Basics
- ✓ Current Operational Products
- ✓ Validation Status
- ✓ Issues and improvement Needs
- ✓ International Cooperation
- ✓ Long-term Monitoring
- ✓ J1 CalVal Plan

VIIRS LST Basics

Definition: Land Surface Temperature (LST) is the mean radiative skin temperature derived from thermal radiation of all objects comprising the surface, as measured by remote sensing ground-viewing or satellite instruments.

VIIRS LST EDR: Granule Product, moderate resolution, Split-window/Surface-type (17 IGBP) Dependent Regression Algorithm

Benefits:

- plays a key role in describing the physics of land-surface processes on regional and global scales
- provides a globally consistent record from satellite of clear-sky, radiative temperatures of the Earth's surface
- provides a crucial constraint on surface energy balances, particularly in moisture-limited states
- provides a metric of surface state when combined with vegetation parameters and soil moisture, and is related to the driving of vegetation phenology
- an important source of information for deriving surface air temperature in regions with sparse measurement stations

Target Requirement: Horizontal resolution – 1 km, Temporal resolution – 1 h, Accuracy – 1 K

Current VIIRS* : H = 1 km, T = Daily, A = 1.4 K, Uncertainty = 2.4 K

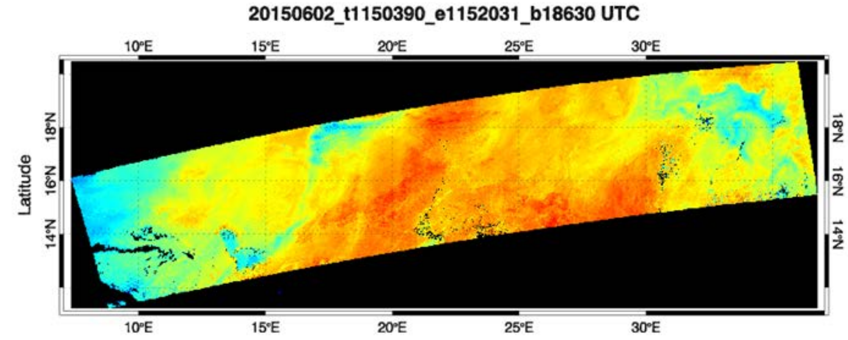
* with limited in-site estimates and cross-satellite validation

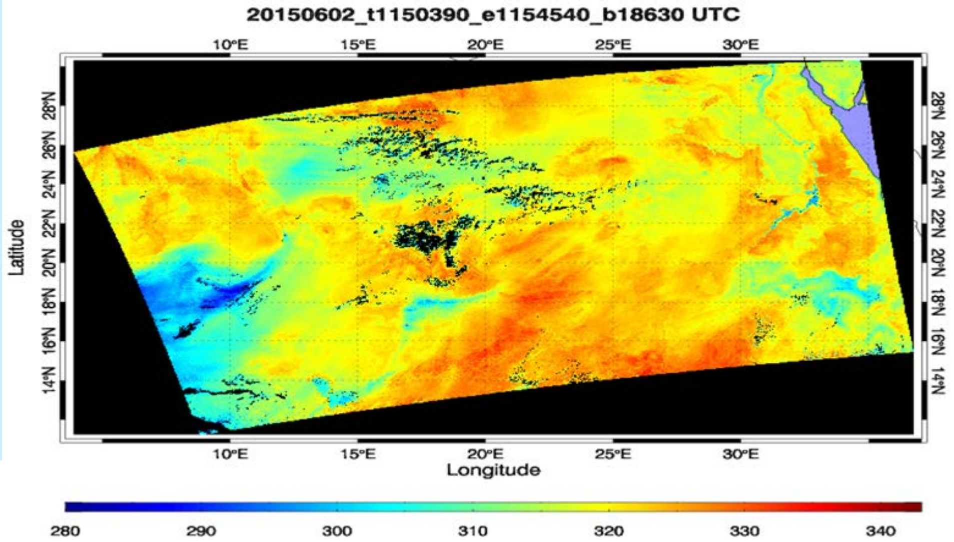
Basics: LST EDR and Cal/Val Team

	Name	Institute	Function
JPSS-STAR	Ivan Csiszar	NOAA/NESDIS/SATR	Land Lead, Project Management
	Yunyue YU	NOAA/NESDIS/SATR	EDR Lead, algorithm development/improvement, calibration/validation, team management
	Yuling Liu	*NOAA Affiliate, UMD/ESSIC*	*product monitoring and validation ; algorithm development/improvement*
	Heshun Wang	*NOAA Affiliate, UMD/ESSIC*	*algorithm improvement, product calibration/validation*
	Peng Yu	*NOAA Affiliate, UMD/ESSIC*	*product validation tool, monitoring, applications*
	Marina Tsidulko	*NOAA Affiliate, SciTech/IMSG*	*STAR AIT*
	Michael EK	NOAA/EMC/NCEP	user readiness ,
	Yihua Wu	NOAA/EMC/NCEP	user readiness
JPSS/DPA			
	Leslie Belsma	Aerospace Corp	algorithm Manager (JAM) for Land
NASA S-NPP Science Team			
	Miguel Roman	NSAS/GSFC	*Validation data support, product monitoring*
	Sadashiva Devadiga	NASA/GSFC Affiliate, SSC	*Validation data support, product monitoring*

Basics: Current Operational Product

- 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





- Archive site
  - CLASS: http://www.nsof.class.noaa.gov/saa/products/welcome (search for JPSS VIIRS EDR)
  - Team site : http://www.star.nesdis.noaa.gov/jpss/lst.php
  - NASA site: http://viirsland.gsfc.nasa.gov/Products/LSTEDR.html
- Monitoring: http://www.star.nesdis.noaa.gov/jpss/EDRs/products_LST.php

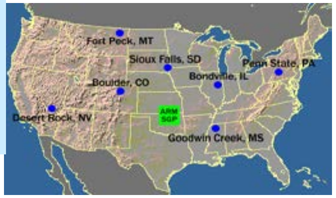
Validation Status

- **Provisional Review – May 2014**
- **Validated V1 review – December, 2014**

Validation summaries of the LST EDR are shown in Table (**right**); validated 1 maturity approval in Dec. 2014. Marginally meet the requirement with limited "in-situ" data

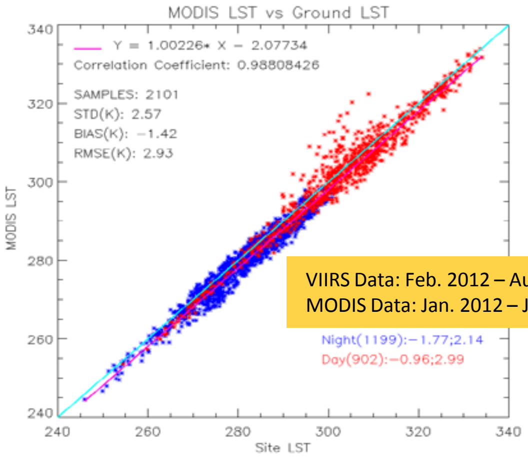
Validation details of the VIIRS LST comparisons against the SURFRAD station data are shown in the plots (**bottom-left**) and in the tables (**bottom-middle, bottom-right**).

Attribute Analyzed	L1RD Threshold	Validation Result	Description
In-situ Validation	1.4K (2.5K)	**-0.37 (2.35)**	Results are based on the VIIRS data over SURFRAD sites for over 2.5 years . The error budget estimation is limited by ground data quality control, cloud filtering procedure and upstream data error.
R-based Validation	1.4K (2.5K)	0.47(1.12)	A forward radiative transfer model is used, over 9 regions in globe, representing all 17-IGBP types over the seasons. The error budget estimation is limited by profile quality, cloud screening procedure and sampling procedure.
Cross satellite Comparison		0.59(1.93): daytime 0.99(2.02): nighttime	The results are based on comparisons to MODIS LST, over 100 scenes, over low latitude, polar area and CONUSThe error budget estimation is limited by the spatial and temporal difference, sensor difference, angle difference etc.

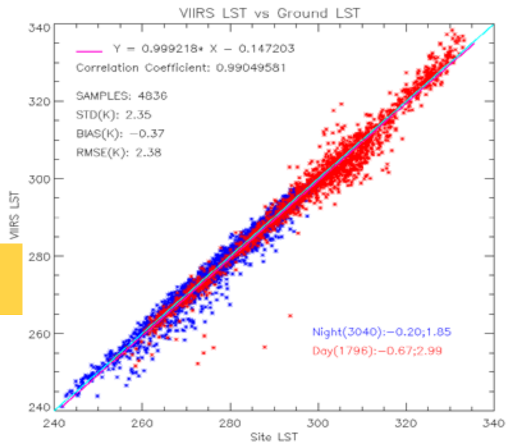


U.S. SURFRAD stations

Season	Samples	Overall		Day		Night	
		Bias	STD	Bias	STD	Bias	STD
Spring	1297	-0.54	2.78	-0.69	3.82	-0.46	1.97
Summer	1403	-0.1	2.43	-0.87	3.68	0.26	1.39
Fall	1160	-0.28	1.9	-0.32	2.04	-0.24	1.79
Winter	976	-0.65	2.01	-0.83	1.65	-0.53	2.21



VIIRS Data: Feb. 2012 – Aug. 2014
MODIS Data: Jan. 2012 – Jul. 2013

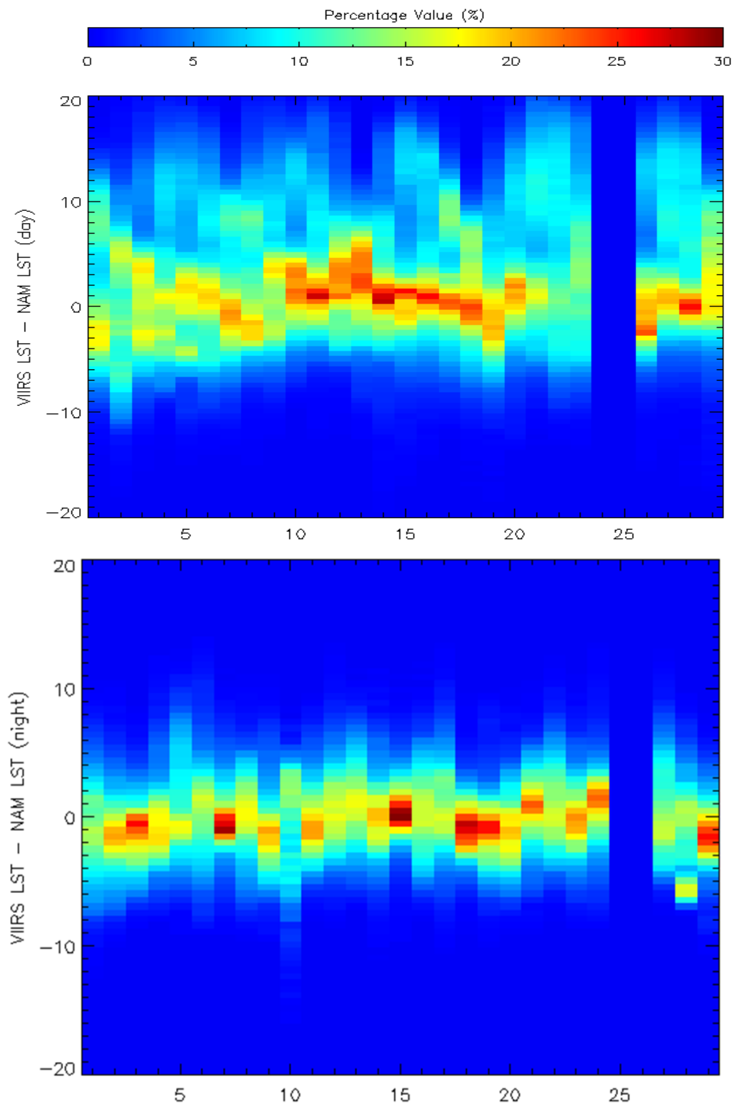


IGBP type	Samples	Overall		Day		Night	
		Bias	STD	Bias	STD	Bias	STD
4	18	-1.41	3.01	-1.82	2.66	-1.26	3.22
6	96	-0.98	1.41	-0.5	1.88	-1.32	0.84
7	955	-0.2	1.59	0.24	2.06	-0.61	0.79
8	286	0.19	2.56	-1.7	2.6	1.38	1.66
10	1048	-0.49	1.81	-0.85	2.3	-0.37	1.59
12	1238	-0.35	2.68	-0.63	3.8	-0.22	1.91
14	857	-0.28	2.54	-1.28	2.4	0.19	2.47
15*	189	-1.72	4.31	-1.72	4.31		
16	149	-0.23	1.55	0.87	1.67	-1.04	0.75

JPSS LST for EMC model validation

Project on-going: Incorporation of near-real-time S-NPP JPSS Land Surface Temperature data into the NCEP Land modeling suite

- Performed comparison of VIIRS Granule LST data and NAM model data
  - Period: March 2012
  - Resolution: 0.05 deg
- Results
  - ✓ VIIRS LST and NAM LST agree with each other better in nighttime.
  - ✓ The monthly mean biases are 0.47 and 3.76 during nighttime and daytime, respectively.
  - ✓ Granule level comparisons show that the VIIRS-NAM difference over west region is higher than that over east region.
- Current effort: new data format needed
  - Gridded 1 km data
  - Projection and data format matches to the EMC model run needs
  - Time label and QFs for each grid
  - Tools to convert a popular L3 LST data format into a rather specific EMC requested data format
  - Analysis of the JPSS and Model LST differences



Day and night, March 2012

Issues and Improvement Needs

Issues encountered through the Cal/Val activities

- *Lack of high quality validation data set.* The CalVal performed only with limited data, mostly with SURFRAD data. Global and seasonal representativeness of the validation is needed

- impacts of ST misclassification and cloud contamination are significant (will rely on annual ST data).

- *Cloud contamination impact is significant*

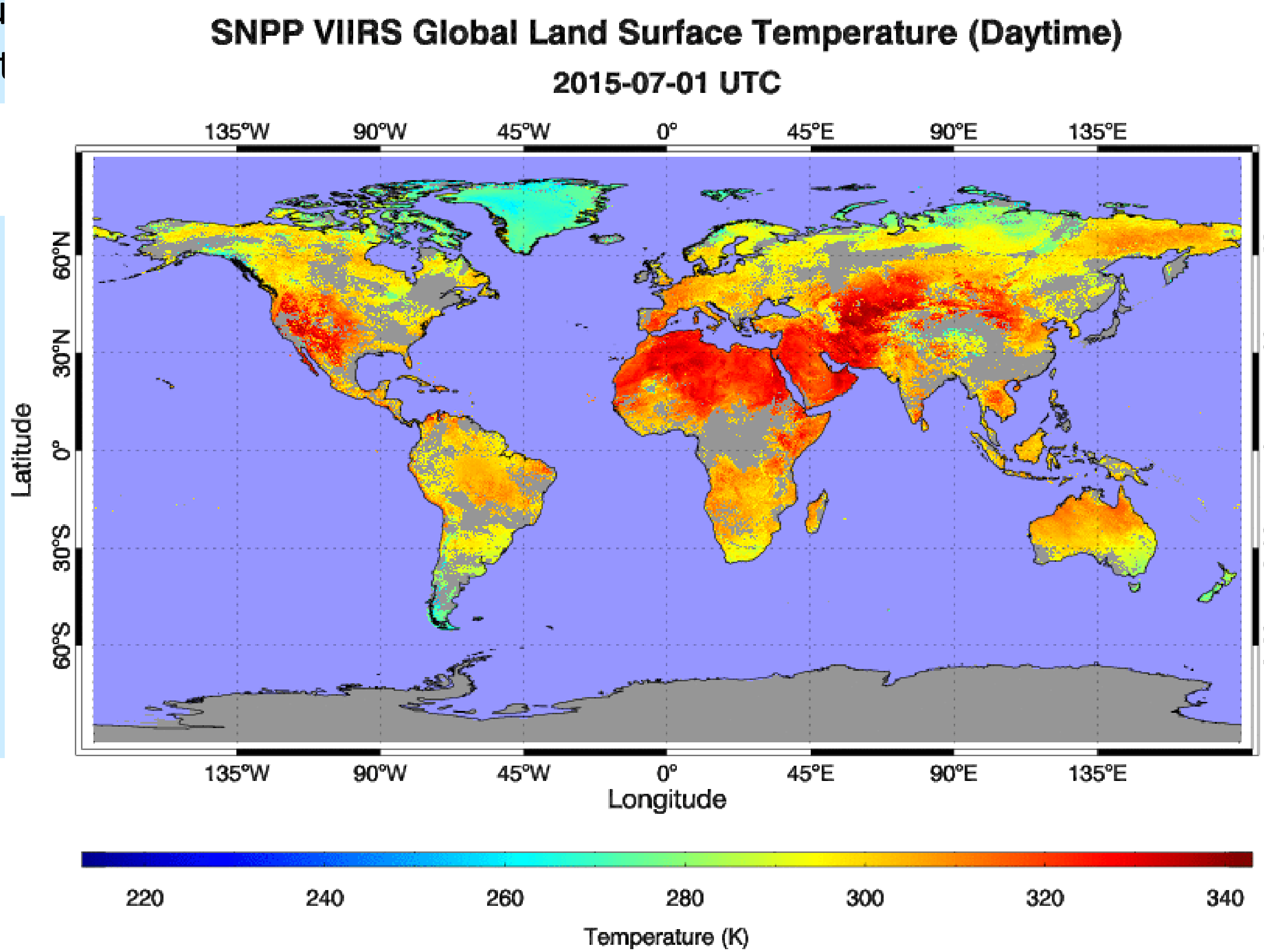
- over 50% error sources of the LST derivation can not be identified, due to quantitative and qualitative limitations of in-situ measurement.

- Practical uncertain is significantly larger than the theoretical analysis.

New Development (1)

Rational

User-friendly dataset needs
replacement of the ST-dependent algorithm
Enterprise System Requ
Emissivity Development



Example 1

L3 Global Gridded Daily LST

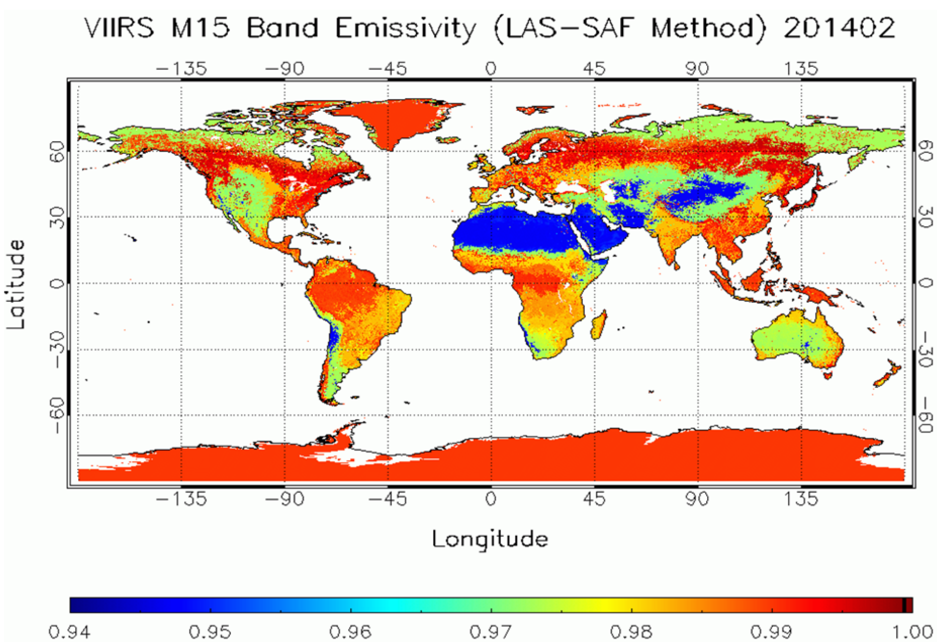
- 2 datasets each day (i.e. day and night)
- 1 km resolution
- Time label and QF for each grid

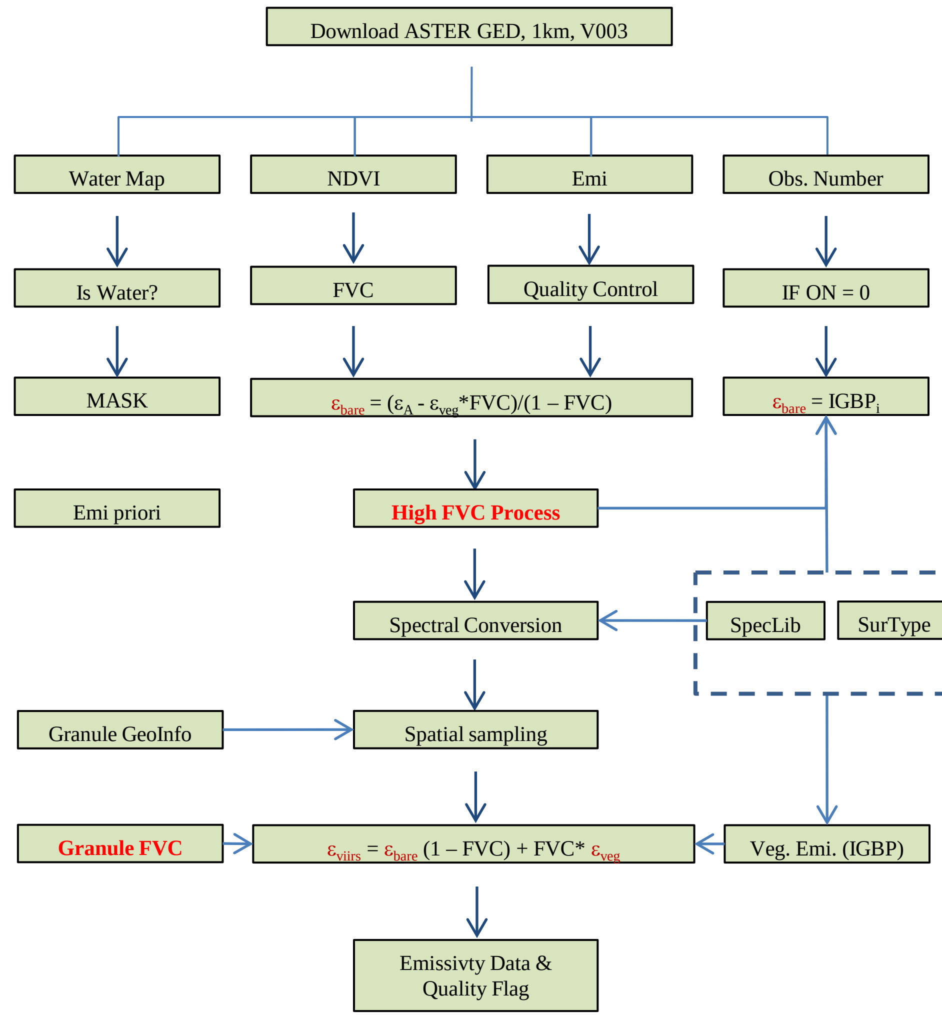
New Development (2)

Example 2

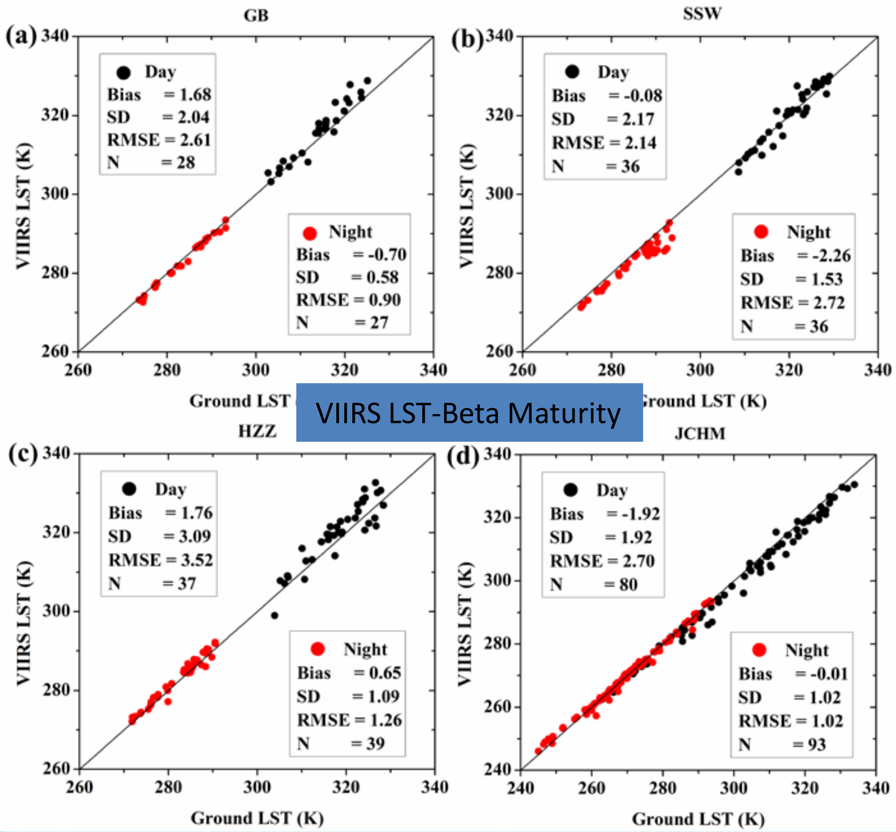
Land Surface Emissivity

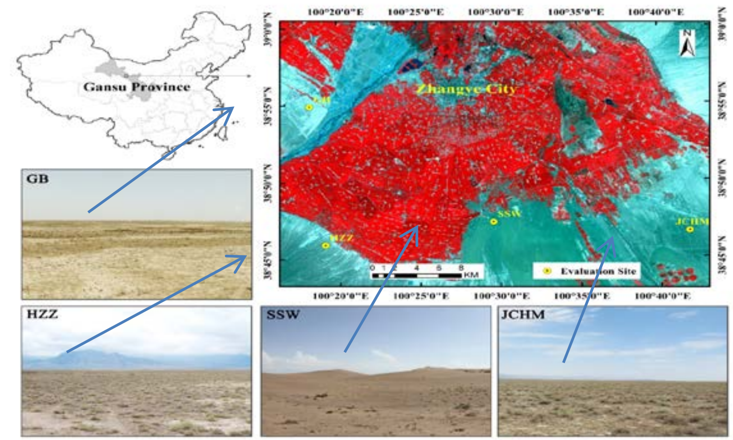
- Spectral emissivity at M15 (10.76 µm) and M16 (12.01 µm)
- Daily global gridded dataset
- 1 km resolution
- QF for each grid

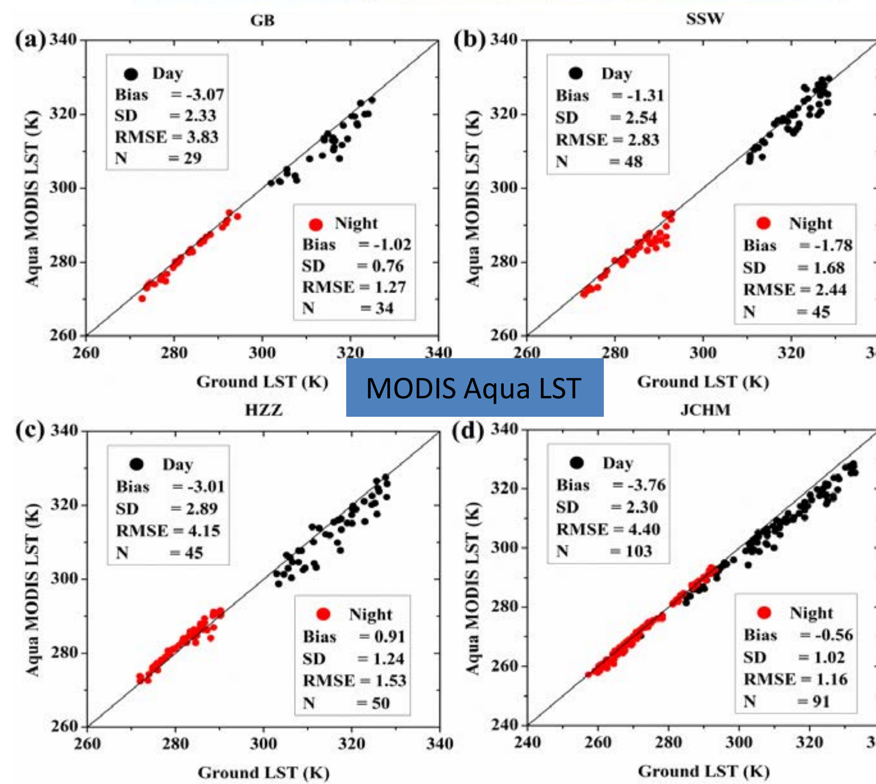




International cooperation
-- with CAS







Data collection: arid area of northwest China (Heihe Watershed Allied Telemetry Experimental Research), from June 2012 to April 2013. Four barren surface sites were chosen for the evaluation.

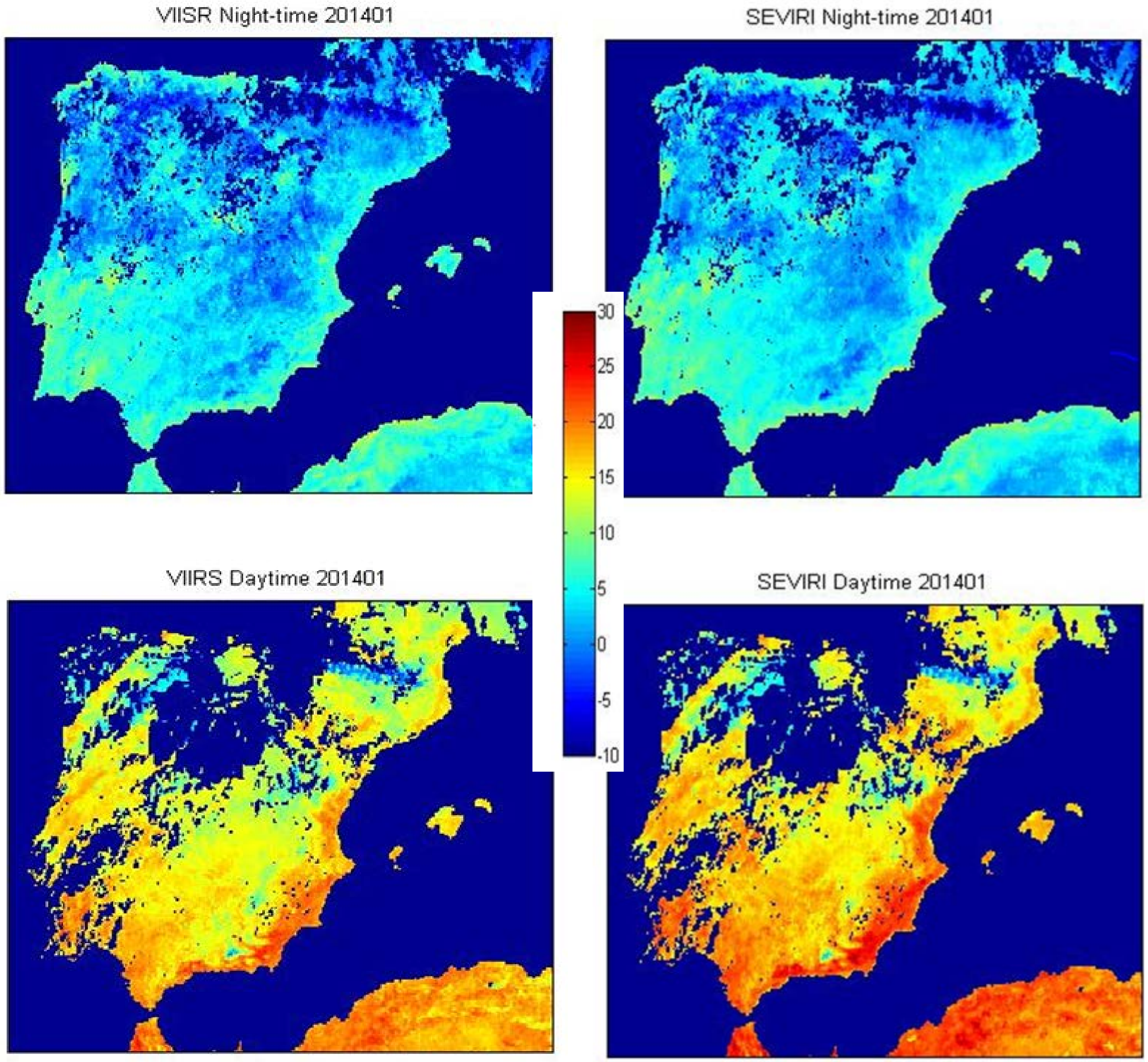
The result generally shows a better agreement for VIIRS LST than that for MODIS LST.

***China site data was obtained through a collaborative effort with Dr. Hua Li at Institute of Digital Earth and Remote Sensing, China Academy of Science**

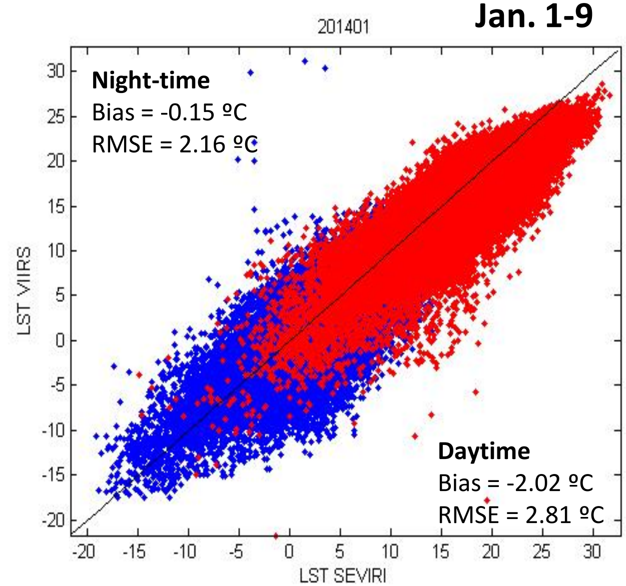
Reference: *H. Li, D. Sun, Y. Yu, H. Wang, Y. Liu, Q. Liu, Y. Du, H. Wang and B. Cao(2014), Evaluation of the VIIRS and MODIS LST products in an arid area of Northwest China Remote Sensing of Environment 02/2014; 142:111–121.*

International cooperation
-- with Land SAF

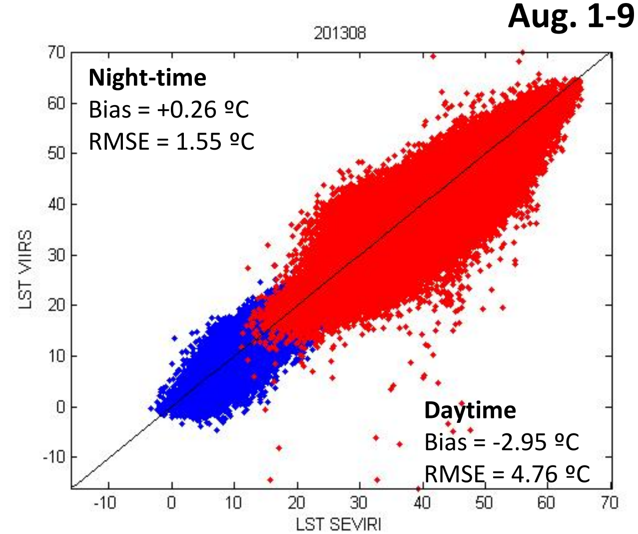
VIIRS **1-9 Jan 2014** **SEVIRI**



Jan. 1-9



Aug. 1-9



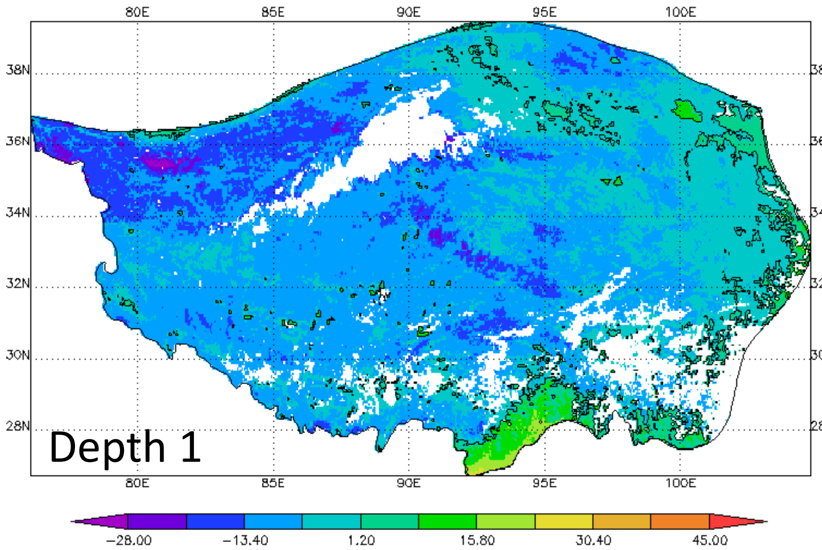
Courtesy of Isabel F. Trigo , through US-Portugal Bilateral cooperation program (on remote Sensing)

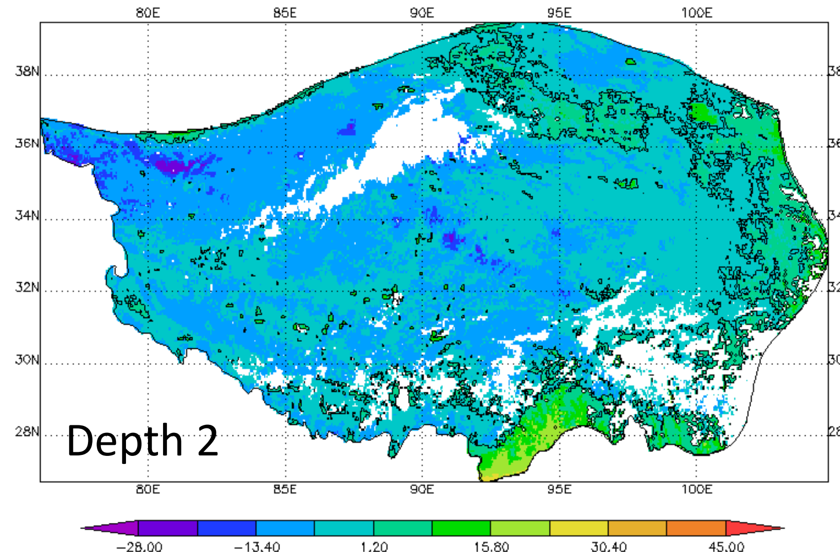
International cooperation

-- with CMA

VIIRS LST Application in Soil Freeze-Thaw in Tibet

- Monitoring spatial distribution of freeze-thaw in whole Tibet with high spatial resolution (1 km)
- Monitoring seasonal dynamics of freeze-thaw in Tibet (daily)
- Monitoring changes of freeze-thaw in different soil depth





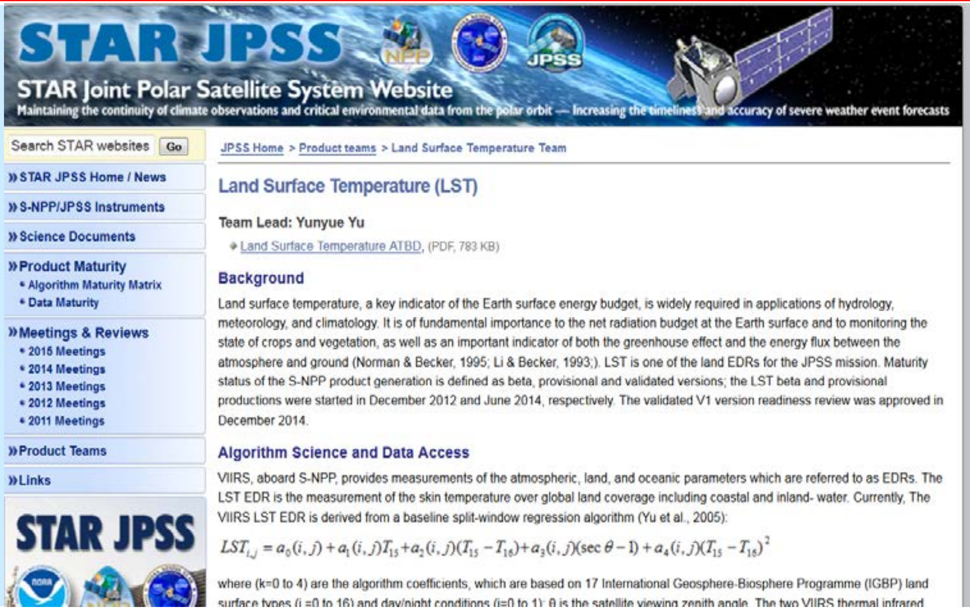
Long-term monitoring

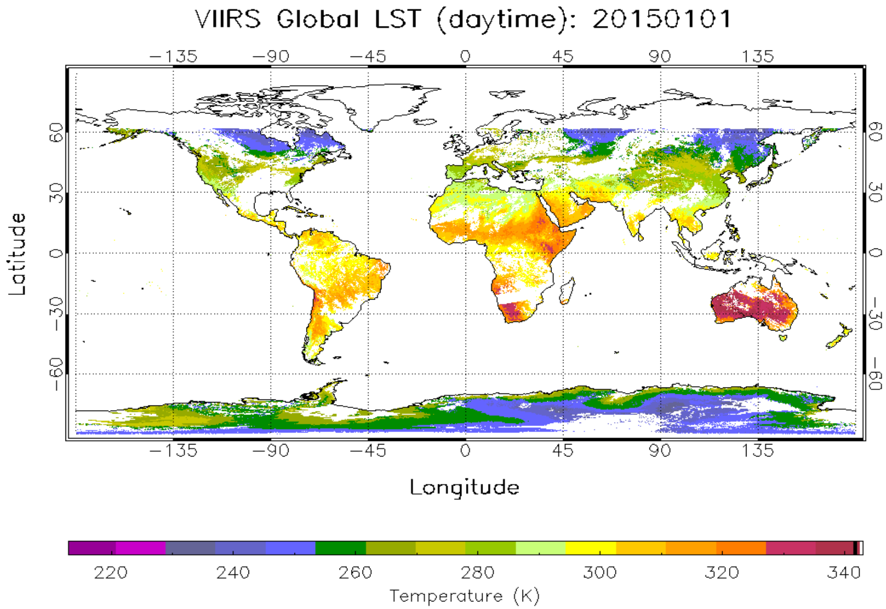
- **Monitoring/Validation tool drafted**
- **Webpage development**

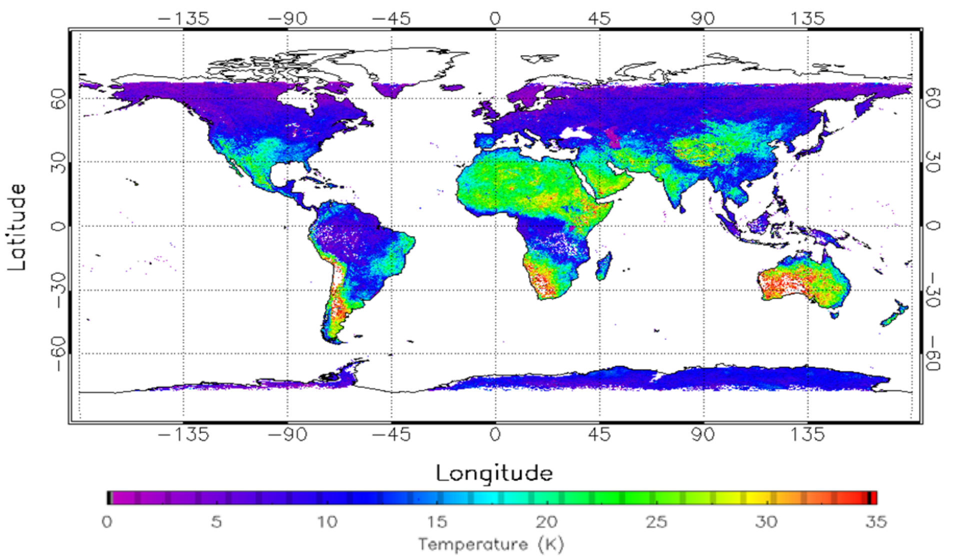
✓ A monitoring tool has been developed, which generates daily global VIIRS LST maps, and the diurnal temperature range (DTR) from the operational VIIRS LST EDR data and routinely validate with SURFRAD data.

✓ An ftp site and notification system has been setup for the monitoring, which runs the daily global LST, the monthly DTR, and the routine validation automatically. ftp://ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/VIIRS_monitoring/.

✓ A webpage development is on-going for public to review and download the global daily LST and the monthly DTR maps.







J1 Cal/Val plan

- Comprehensive Product Evaluation/validation
  - Pre-launch
    - Proxy and simulated datasets readiness
    - In-situ data readiness
    - Algorithm Evaluation and Characterization
    - Development of calibration and validation tools
  - Post-launch
    - Early orbit checkout
    - Intensive product evaluation and validation report
    - Algorithm/product calibration, coefficients update
    - Iterative in-situ data validation and calibration
    - Algorithm refinement
- Long-term monitoring
  - A web-based product monitoring interface
  - In-situ validation alerting/notification
- Correlative Data Sources
  - In-situ data collection
  - S-NPP LST data, and other satellite LST data
  - Field Campaign data (international cooperation)
- Development of CalVal tools

Active Fire product update

Presented by Ivan Csiszar (STAR)

Key contributors to results presented: Wilfrid Schroeder, Louis Giglio, Evan Ellicott, Will Walsh, Patricia Oliva (UMD) Marina Tsidulko, Valerie Mikles, Walter Wolf (STAR AIT)

August 27, 2015

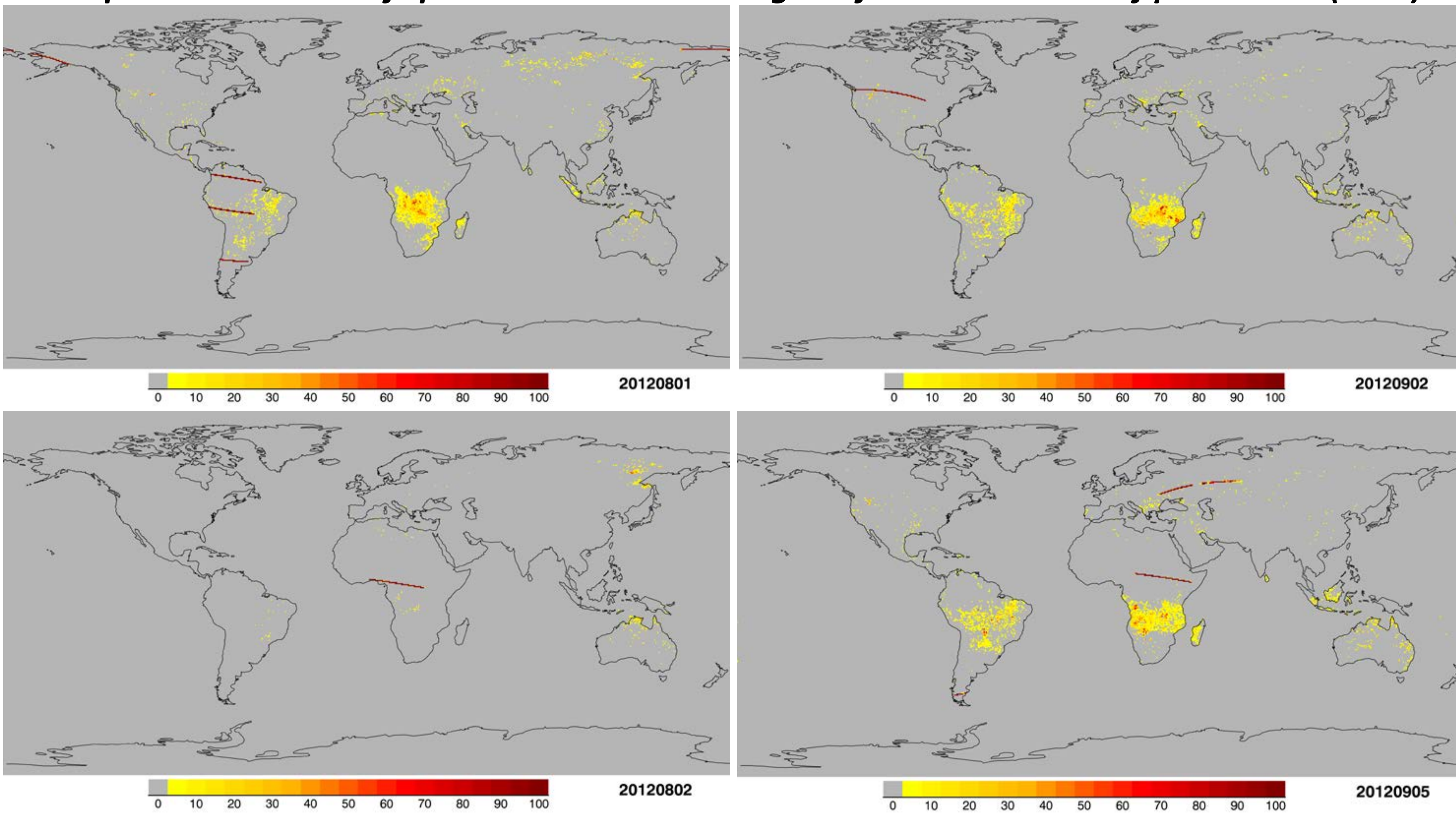
NOAA Operational Fire product status

- **Current 750m operational product** in IDPS*
  - delivers a list of fire pixels
  - reached **Validated 1 maturity status** with an effectivity date (i.e. IDPS implementation) of **August 13, 2014**.
  - **declared NOAA Operational** product in September 2014
  - **long-term monitoring** and maintenance continues
- **Upcoming 750 NOAA operational product** in NDE**
  - the product is developed at UMD and is **tailored subset of the NASA science product** for real-time NOAA operations
  - **global mask of thematic classes** including water, cloud, non-fire clear land and fire at three confidence levels
  - **fire radiative power** for each fire-affected pixel
  - **new algorithm elements** to improve detection performance
  - Code **delivered to STAR AIT** and tailored for NDE processing
  - **Algorithm Readiness Review** held on June 18 2015
  - Currently in **NDE testing and integration** – operational later this year

IDPS: Interface Data Processing Segment; **NDE: Suomi NPP Data Exploitation

Examples of early IDPS product

Frequent occurrence of spurious scanlines during the first ~10 months of production (Beta)



Examples of the operational real-time IDPS product as archived in NOAA CLASS.
Not reprocessed; not to be used for science analysis. Product history demonstration only.

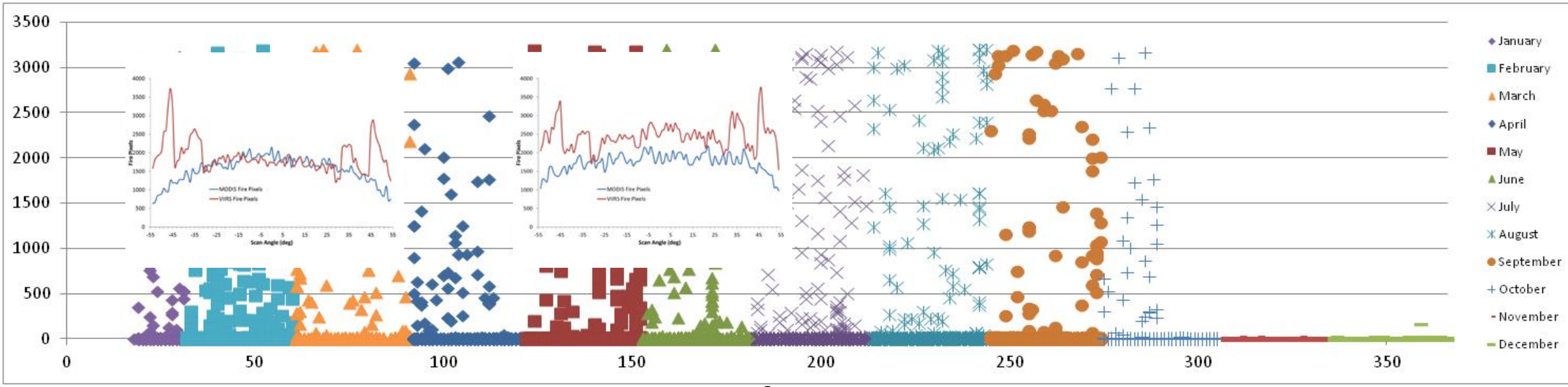
IDPS Suomi NPP Active Fire Product history: data anomalies and product maturity (2/1)

2012

April 3, 2012 IDPS Mx5.3 — October 16, 2012 IDPS Mx6.3

Pre-Beta → | ← *Beta* → | ← *Provisional* →

N_{max}

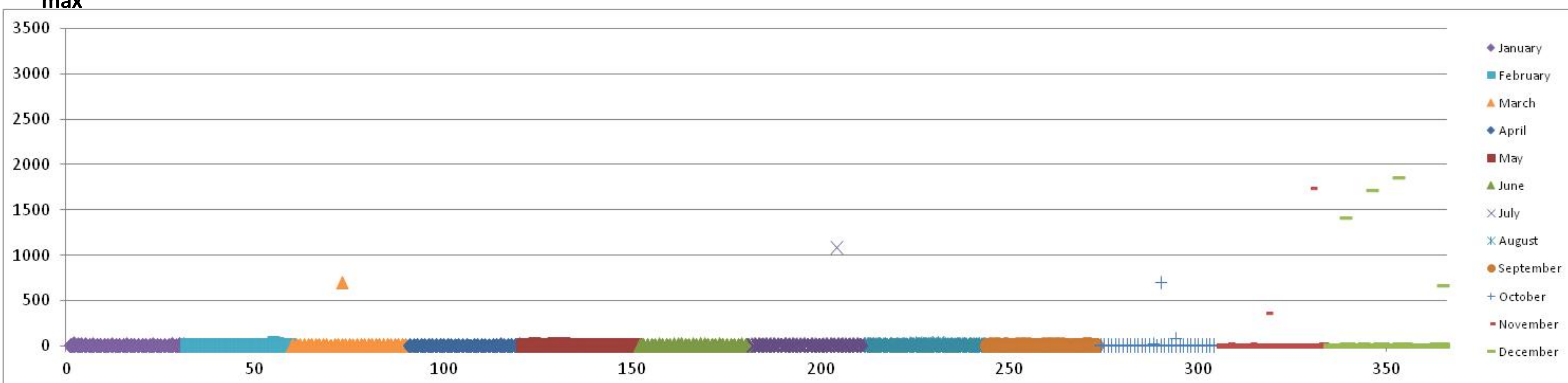


Day of Year

2013

← *Provisional* →

N_{max}



N_{max}: maximum number of detections within a scanline

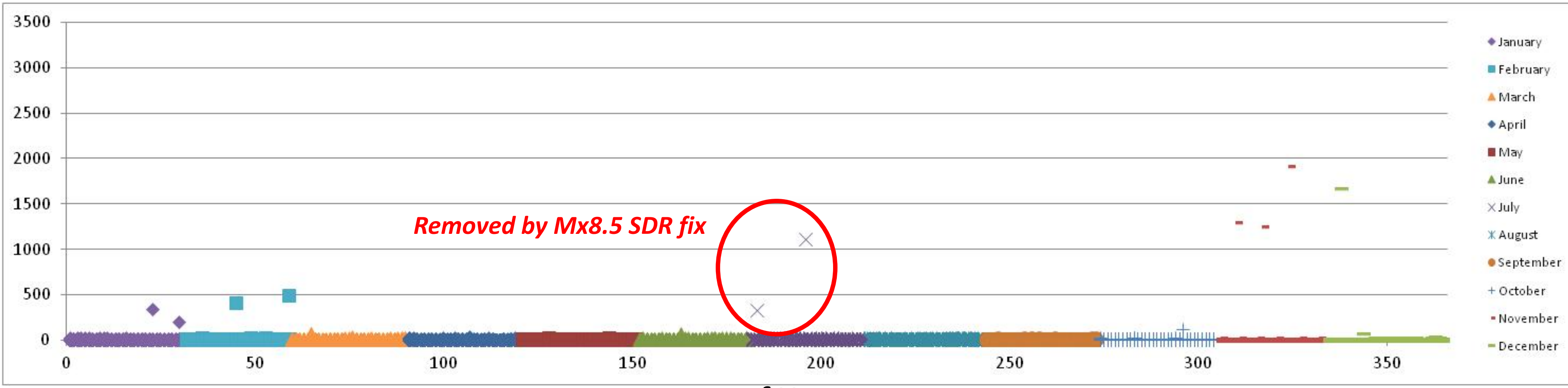
Day of Year

IDPS Suomi NPP Active Fire Product history: data anomalies and product maturity (2/2)

2014

August 13, 2014
IDPS Mx8.5

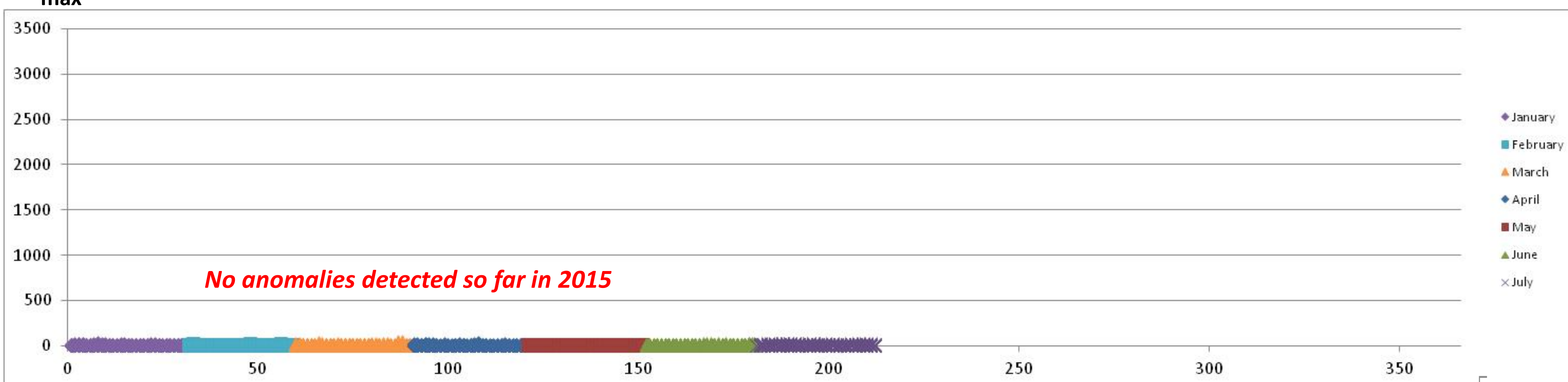
N_{max} ← *Provisional* → ← *Validated stage 1* →



Day of Year

2015

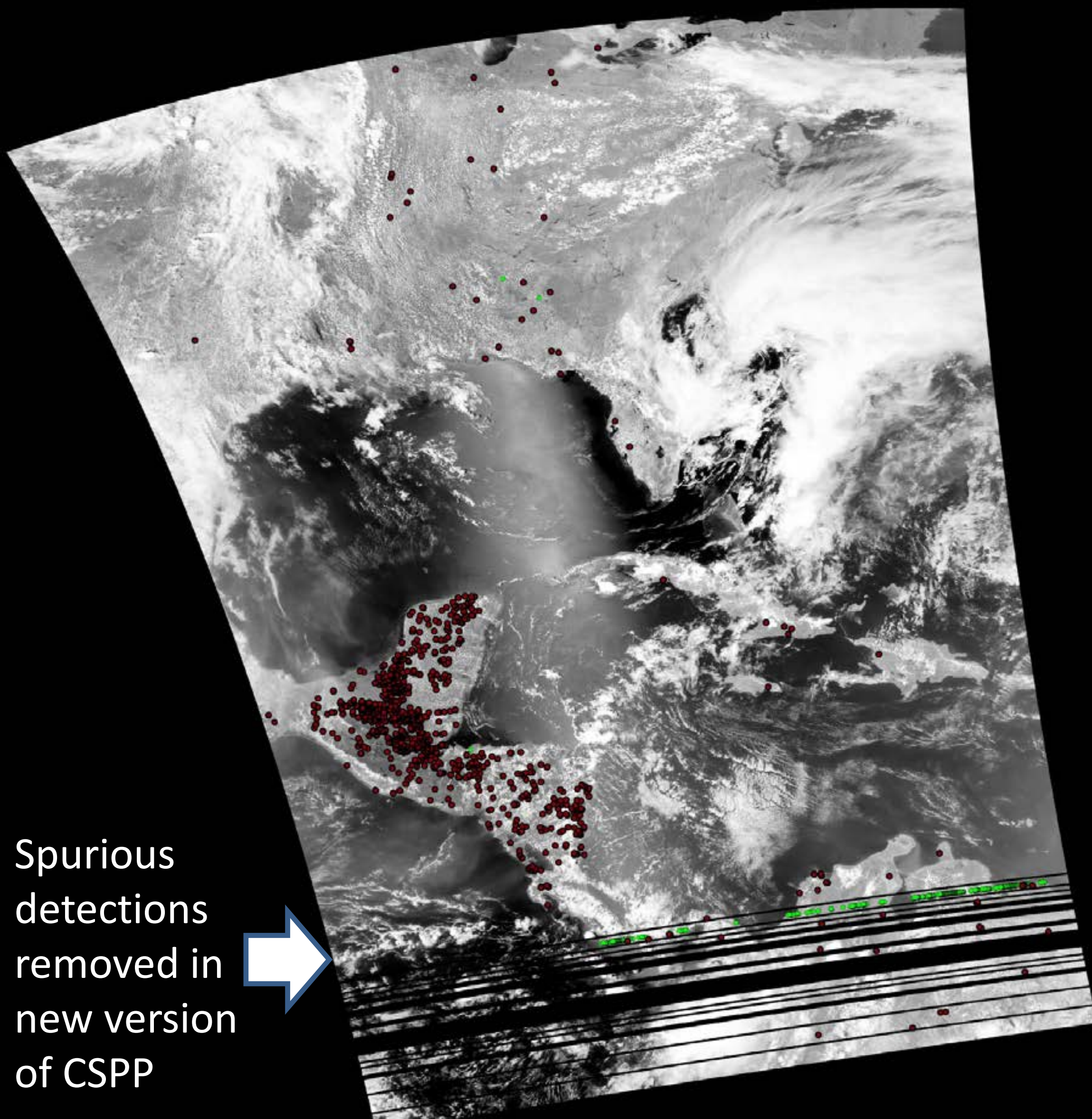
N_{max} ← *Validated stage 1* - - - - - - ->



Day of Year

N_{max}: maximum number of detections within a scanline

Direct broadcast support



Spurious detections removed in new version of CSPP

- *Missing / noisy data in Direct Broadcast transmission can result in incorrect SDR calibration and spurious detections.*
- *The frequency of DB data anomalies depend on the performance of the local DB processing system.*
- *Adjustments in the DB processing code are being implemented to improve SDR quality and spurious fire detections.*
- *Spurious detections can also be filtered by empirical techniques.*
- *Regular updates to include algorithm improvements is critical.*

CSPP V2.0 (SDR Mx8.4)

CSPP V2.1 (SDR Mx8.6)

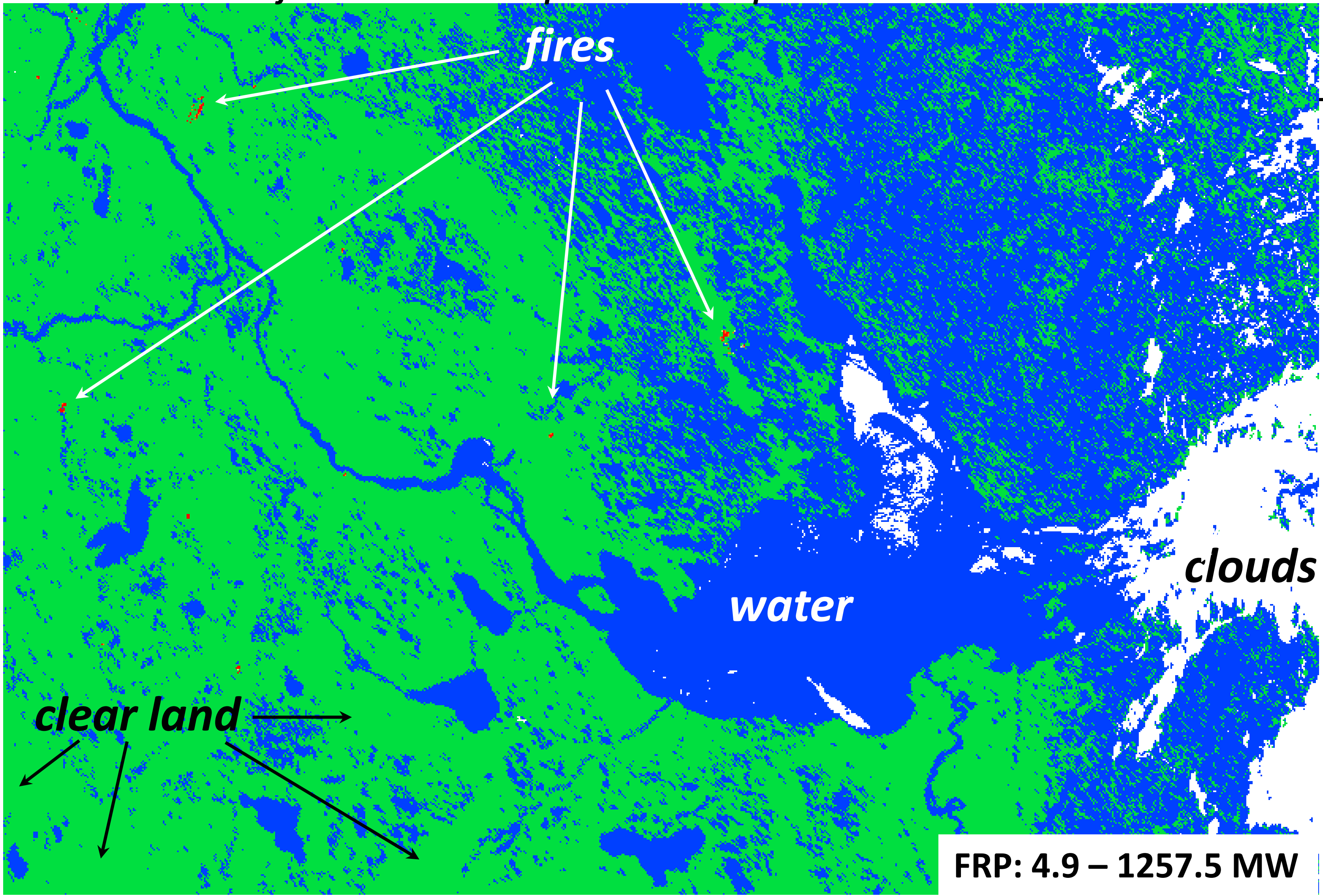
CSPP: Community Satellite Processing Package (UW-Madison)

Further fixes are needed to account for large data gaps – usually in DB – NASA DLR patch

Courtesy Isabel Cruz CONABIO, Mexico

NOAA NDE VIIRS Active Fire Product

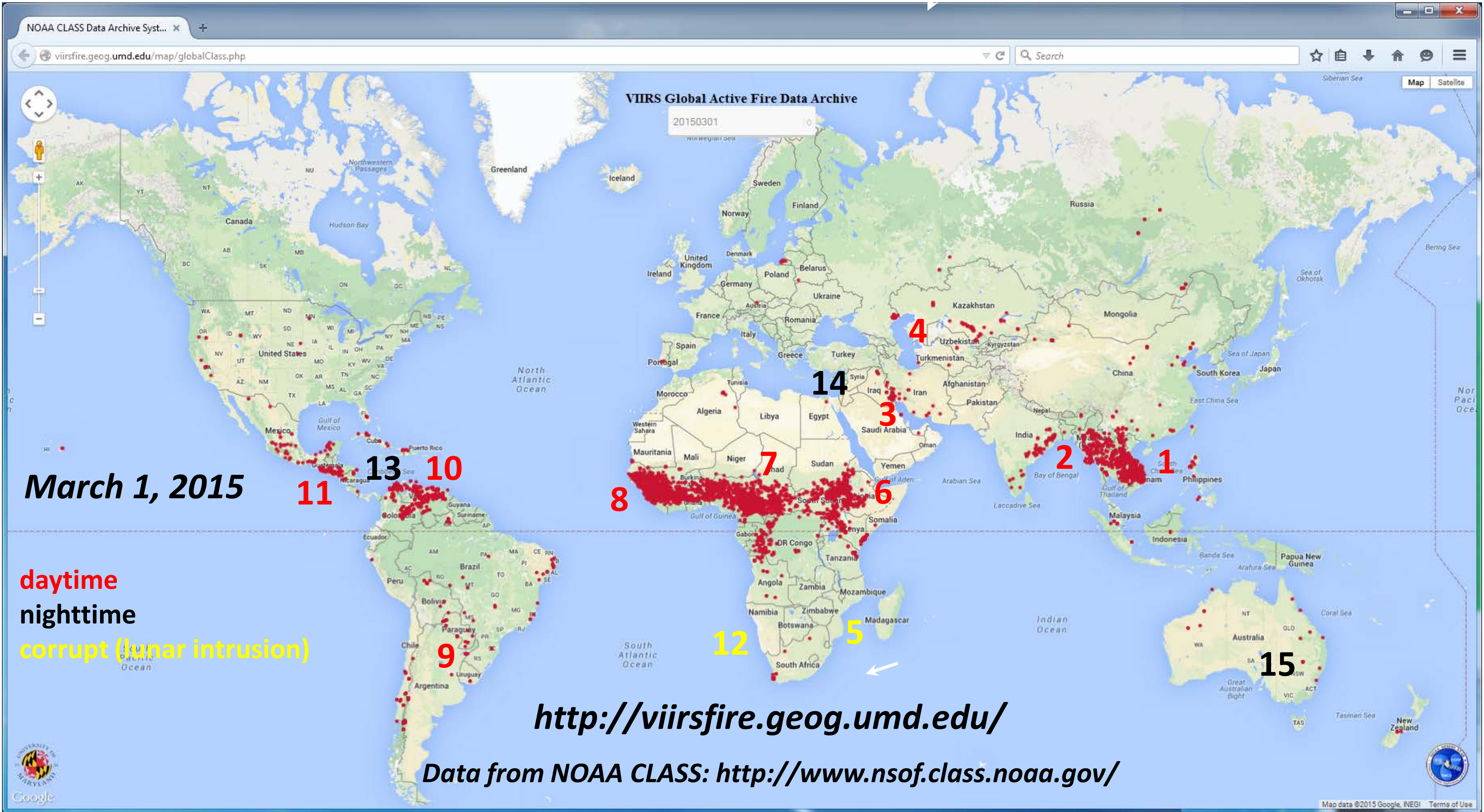
VIIRS fire mask generated at NOAA/NESDIS/STAR from IDPS input data. The NOAA Level-2 product is a tailored version of the NASA science product developed at UMD.



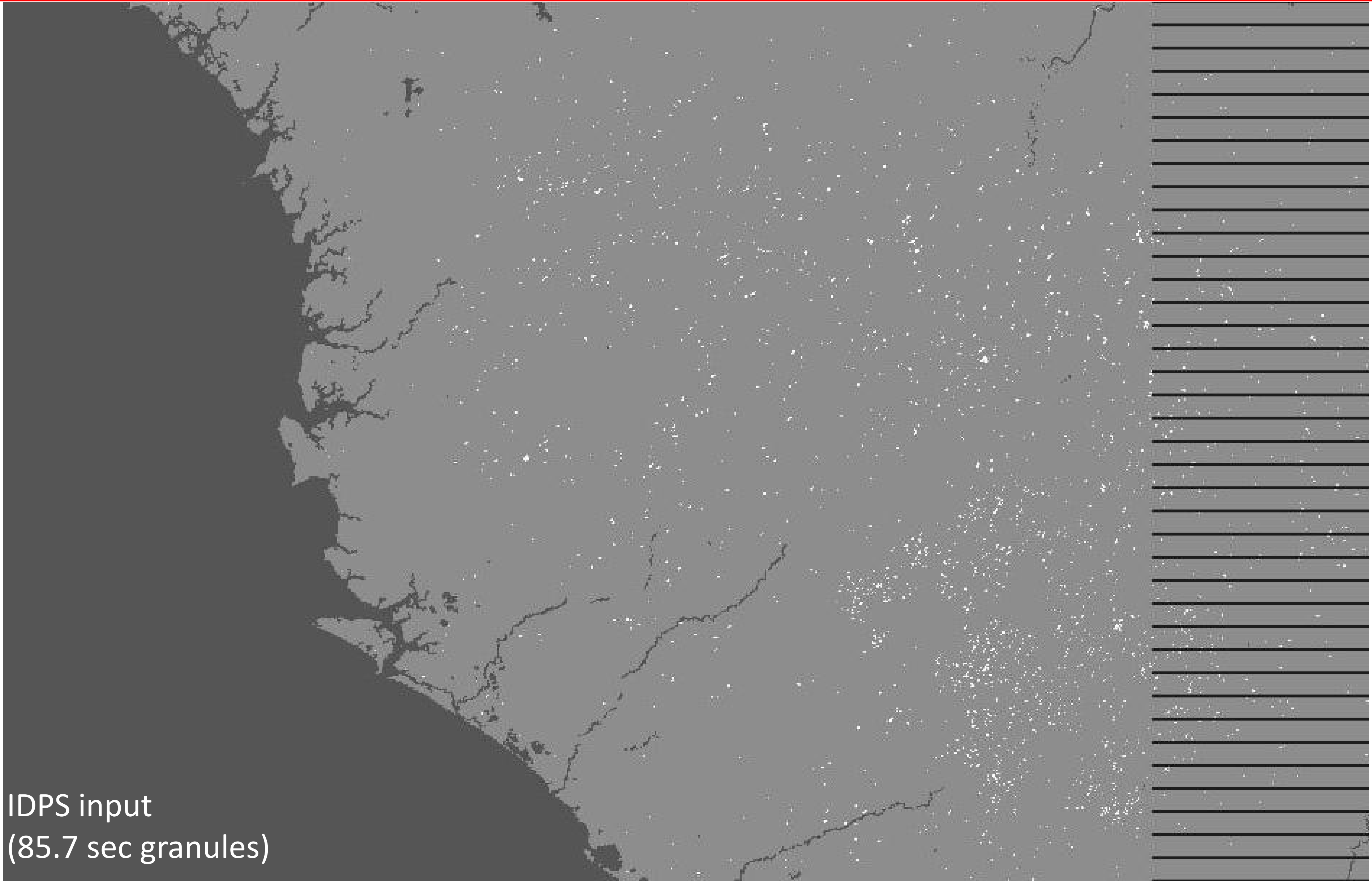
VIIRS fire mask over NW Canada 5/29/2015 20:06 UTC (daytime)

NOAA NDE VIIRS Active Fire Product testing

15 granules covering daytime (1-12), nighttime (13-15), land, water and corrupt (5,12) data were tested for overall performance and consistency between the NOAA and NASA output. The global map shown for reference is the current IDPS product.

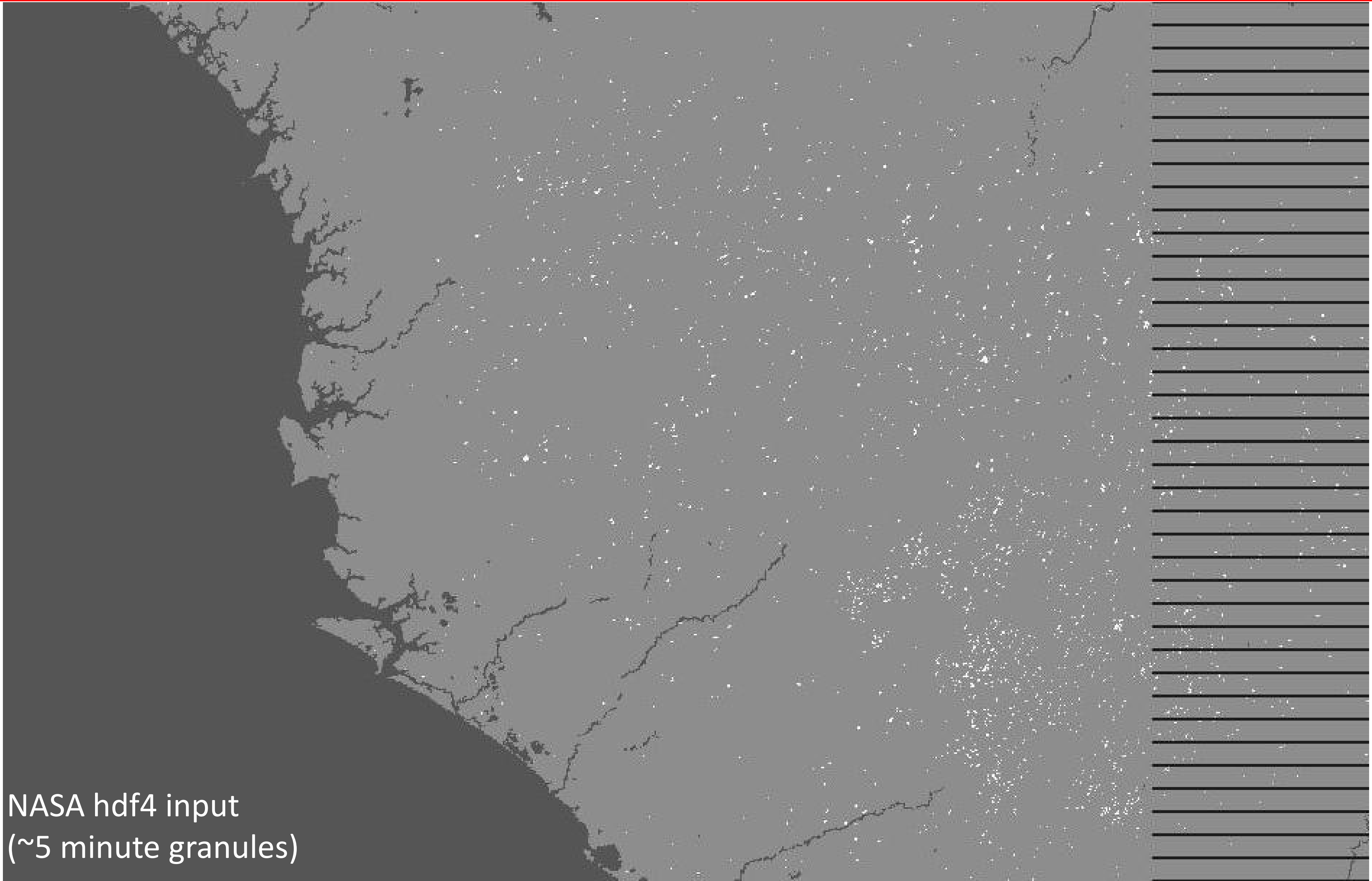


NOAA STAR AIT output



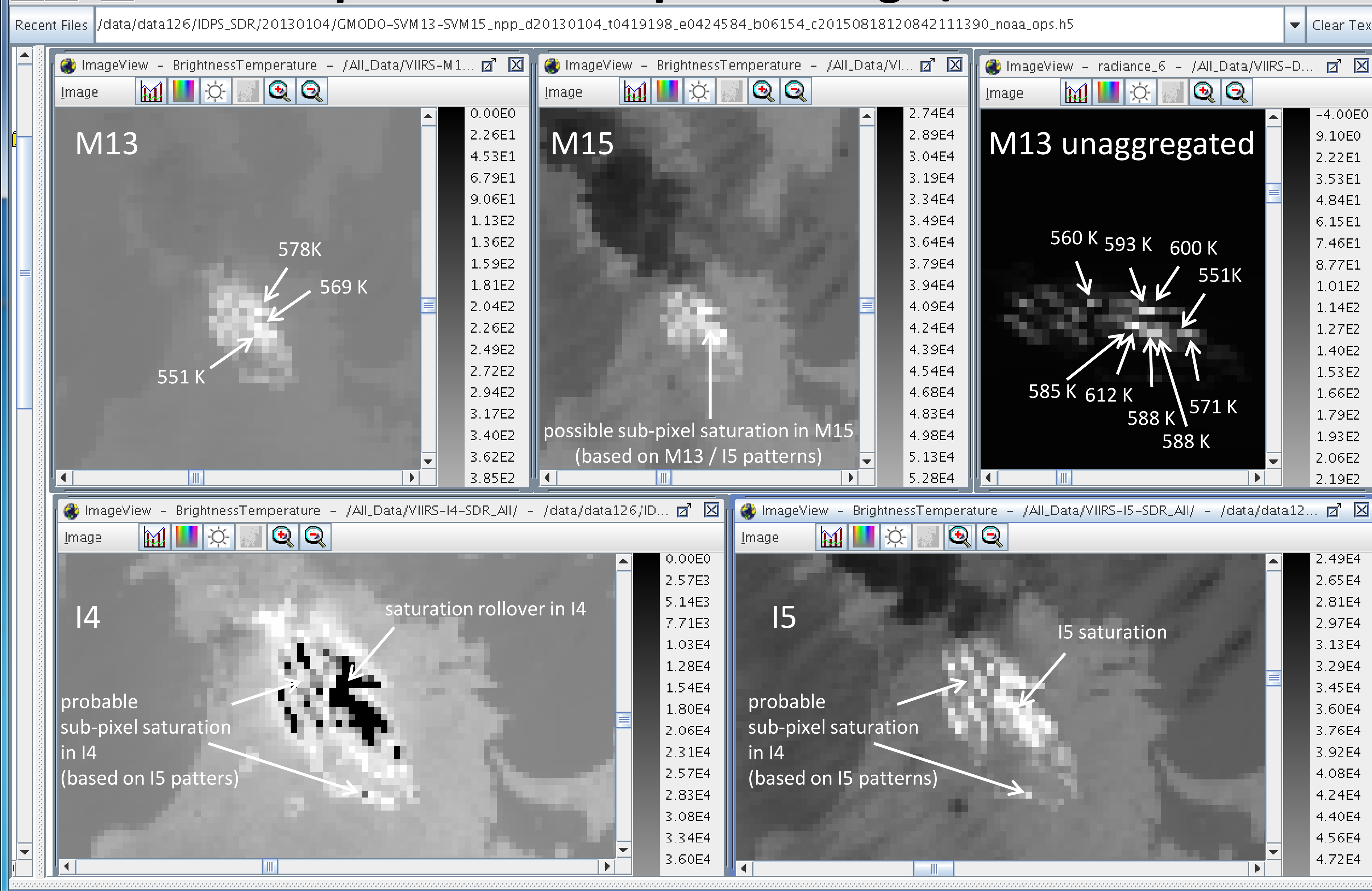
IDPS input
(85.7 sec granules)

NASA Science Code output



NASA hdf4 input
(~5 minute granules)

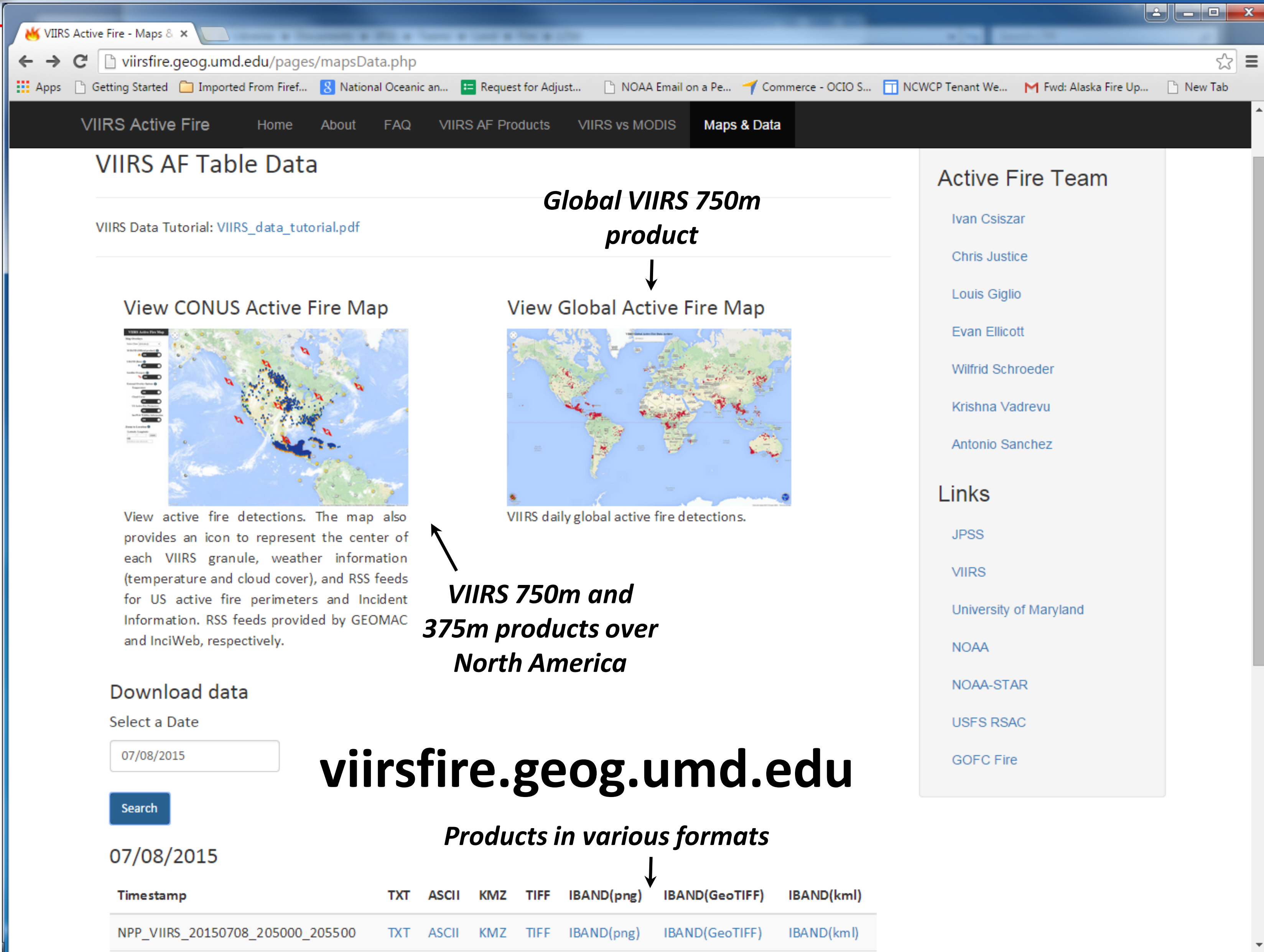
Example of SDR output for large / intense fires



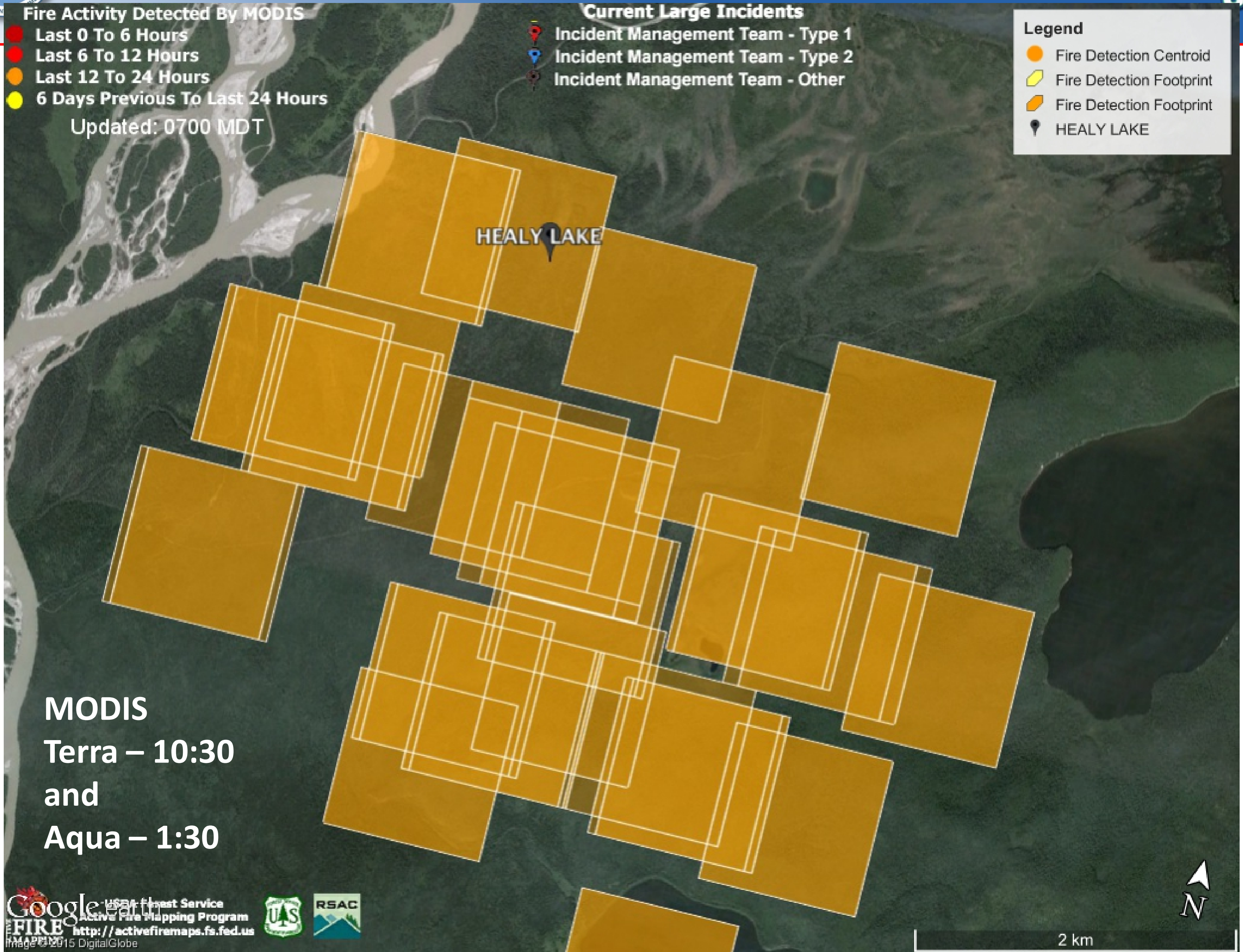
January 4 2013 4:22 UTC

greyscale images of scaled radiance or brightness temperature output for the purpose of displaying relative patterns of SDR output

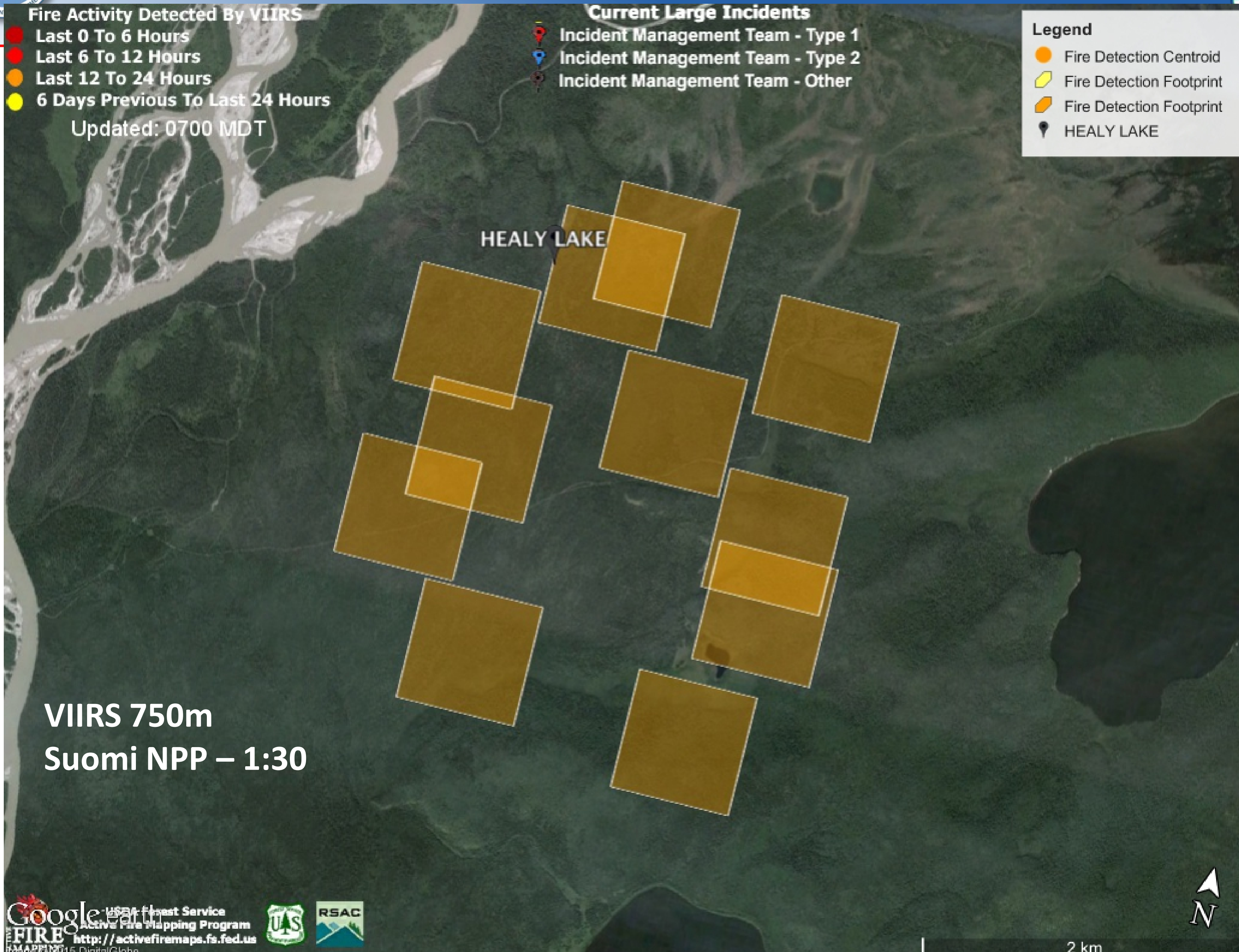
VIIRS Fire Data and Evaluation Portal



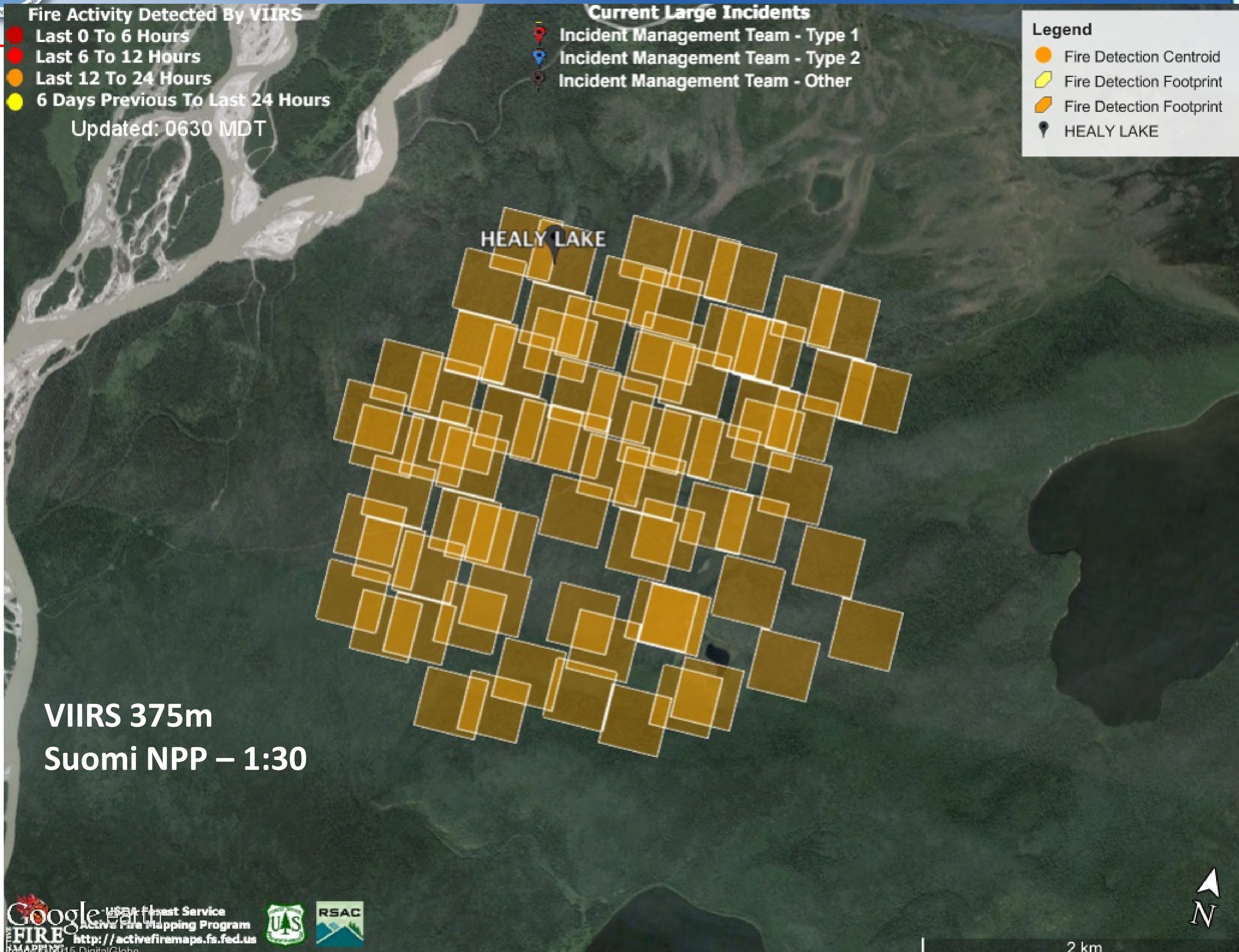
Healy Lake Fire (Alaska)



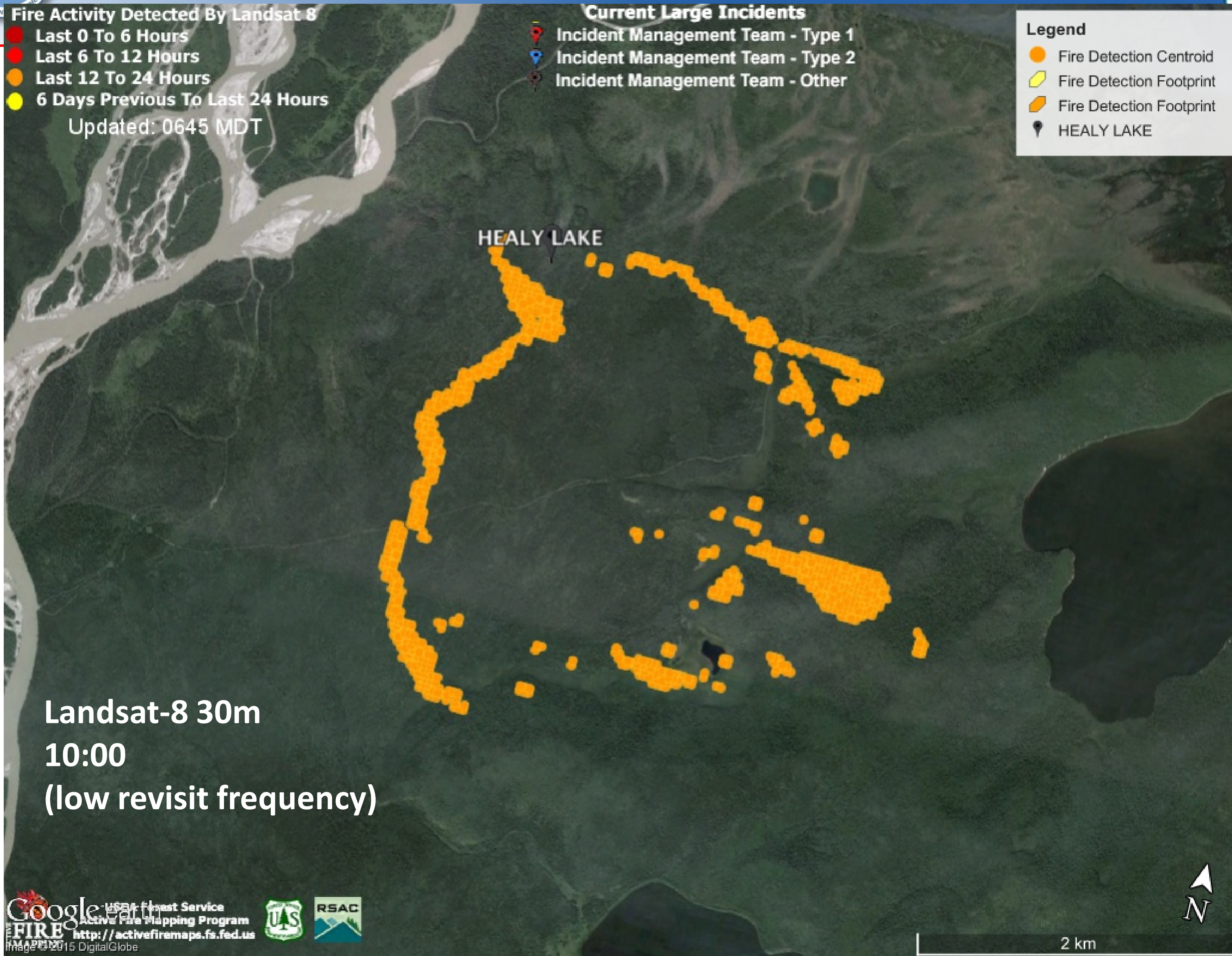
Healy Lake Fire (Alaska)



Healy Lake Fire (Alaska)



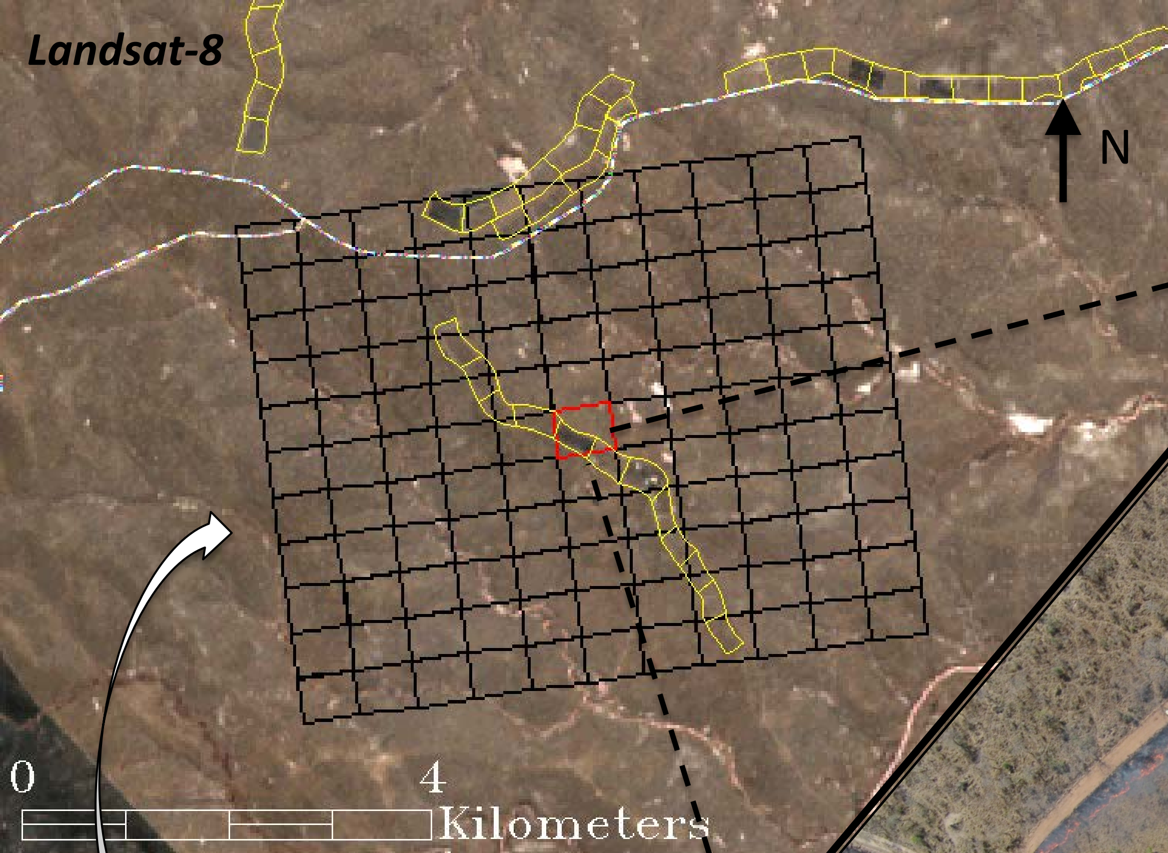
Healy Lake Fire (Alaska)



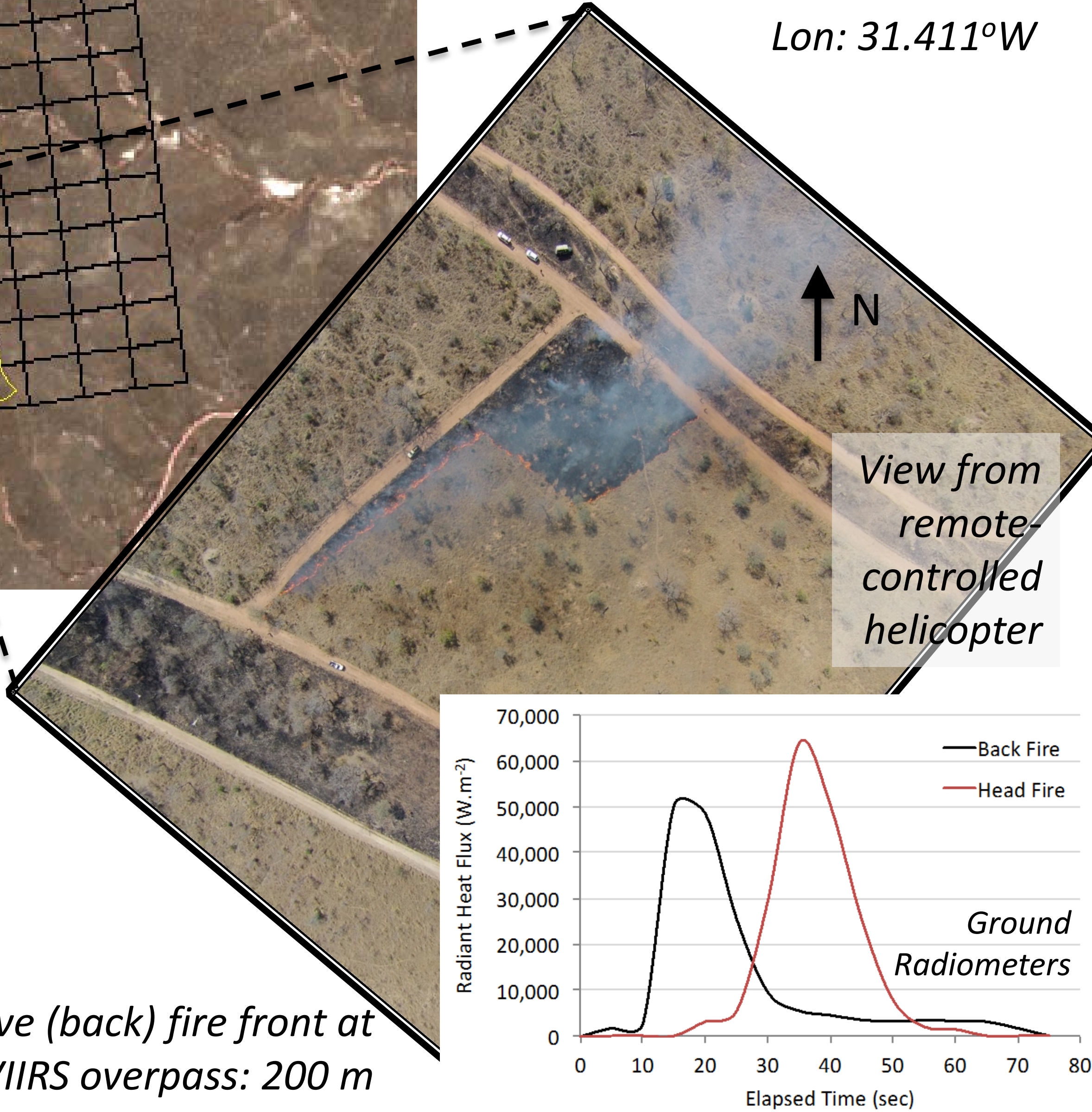
Active Fire Data Validation

- *Use of Landsat-class data to validate VIIRS is **not an option** due to prohibitively large time separation between same-day acquisitions*
  - *We won't match the MODIS validation status for VIIRS (≤ stage 2)*
- *Use of **prescribed fires** (easy/accessible)*
- ***Coincident** ground, airborne, spaceborne data acquisitions*
- ***Community-organized** (reduce spending, maximize output)*

Kruger National Park
19 August 2014
Lat: 25.131° S
Lon: 31.411°W



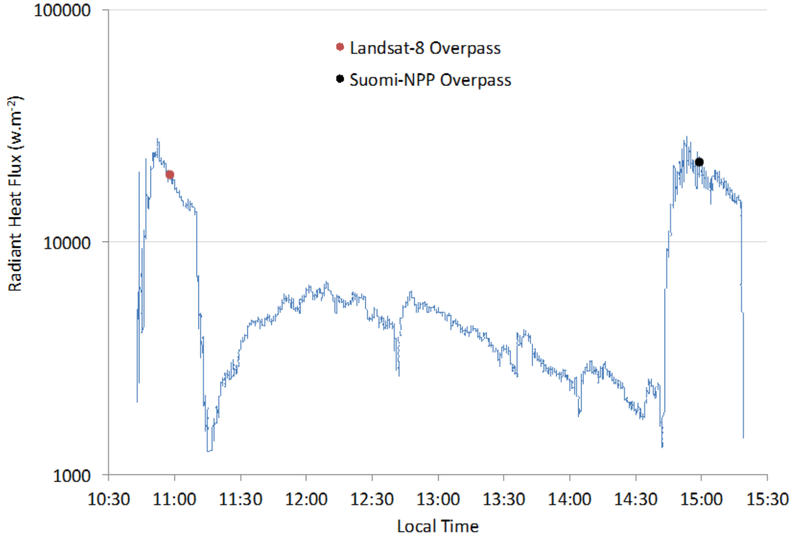
Subset of VIIRS 375 m pixel grid (fire detection in red)



Surface-leaving FRP (VIIRS):
4.4±0.2MW
@ 13:24:26 h local time

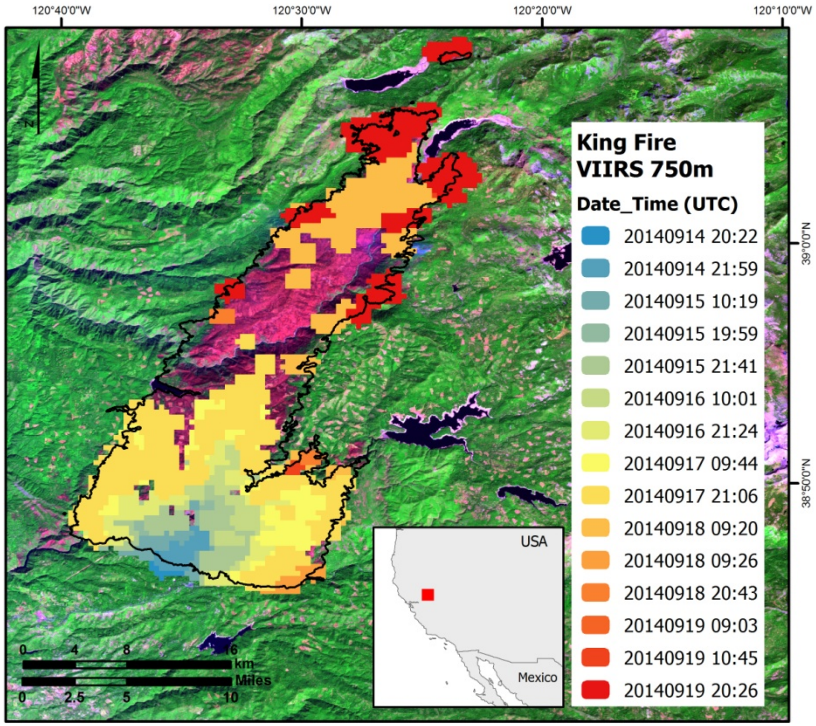
Length of active (back) fire front at time of VIIRS overpass: 200 m

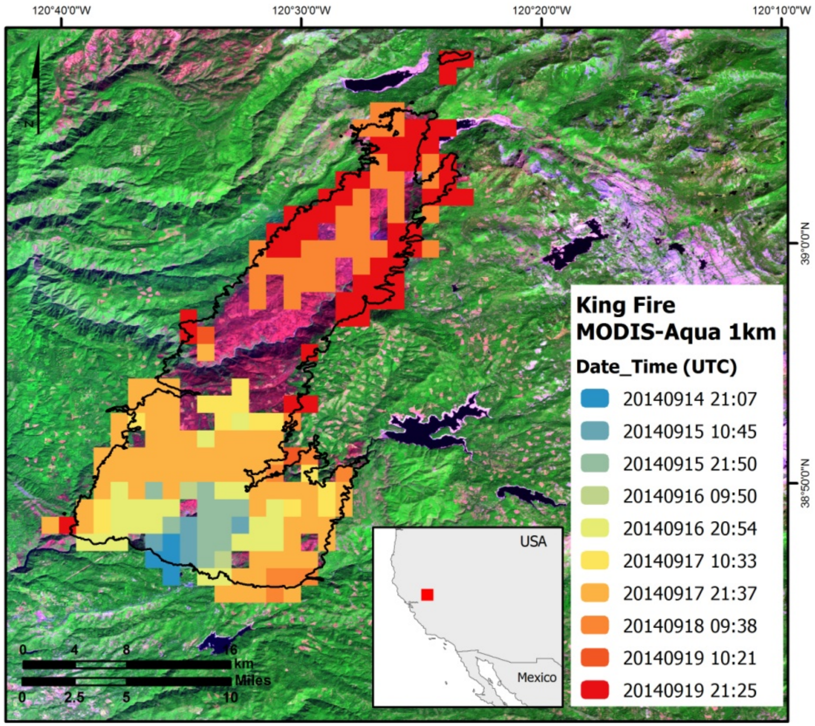
Active Fire Data Validation



Small experimental fire implemented for the validation of same-day Landsat-8 and Suomi-NPP/VIIRS fire detection data in Brazil, Jan/2015. Tower-mounted radiometers provided 1Hz fire radiant flux data coincident with satellite overpasses.

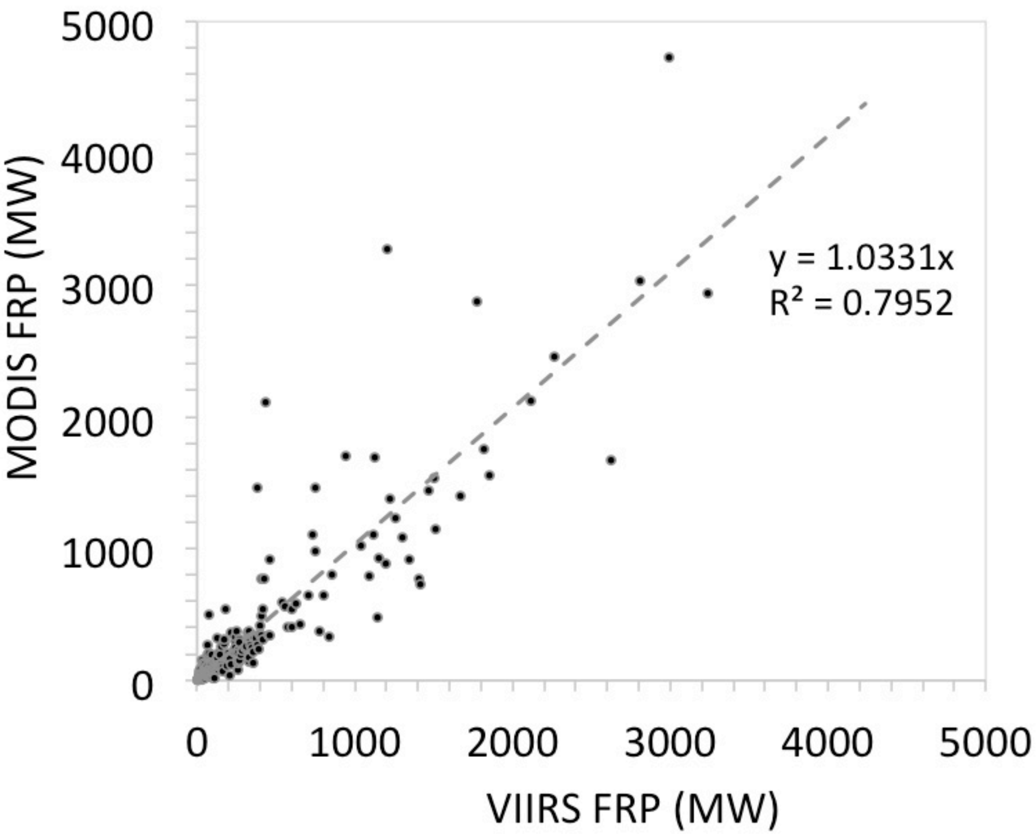
VIIRS vs. MODIS active fire





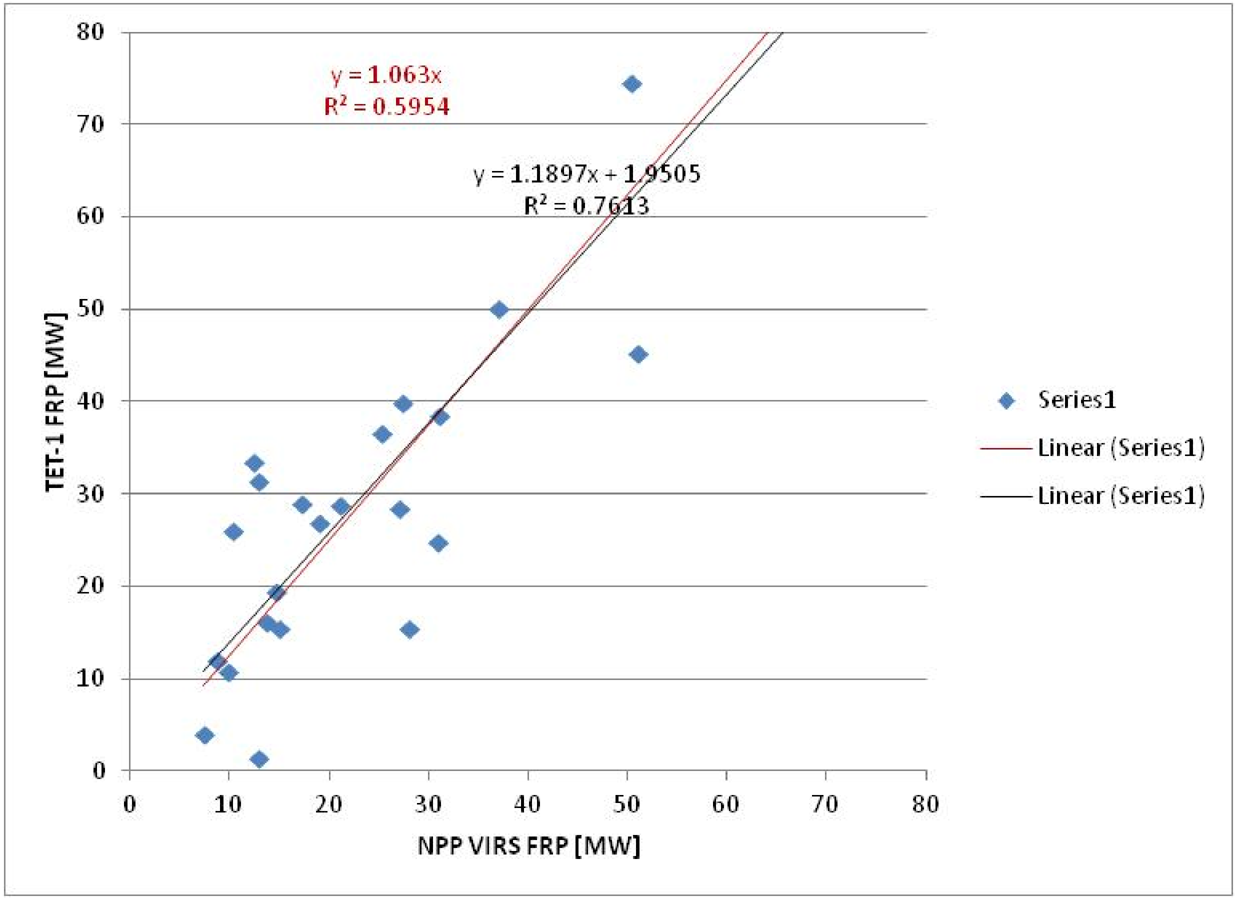
Suomi NPP/VIIRS AF and Aqua/MODIS MYD14 fire detection data produced for the King fire/California on 14-19 September 2014

FRP evaluation using MODIS



MODIS/VIIRS gridded data (0.5 degree) of near-coincident fires (<1km from each other) over different parts of the globe including atmospheric correction of both data sets.

FRP evaluation using DRL TET-1



Comparison of FRP retrievals of gas flares in the Middle East on May 9, 12, 15, 18, 24 2015

TET-1: Technology Experiment Carrier-1by German Aerospace Agency DRL; dedicated 185m unsaturated measurements for hotspot characterization

Summary

- 750m M-band product
  - the **IDPS Suomi NPP product** is stable
  - **new NDE product** that meets the **JPSS 1 requirements** is transitioning to NOAA operations
    - consistent NRT algorithm with NASA science product within Land SIPS
  - **long-term monitoring system** is set up at STAR
- 375m I-band product
  - **next generation** product towards operations
  - already in **systematic use** to support fire management and modeling
- Need thorough assessment of potential for **NOAA Enterprise and non-NOAA data processing**
- Continuing efforts towards rigorous **validation**
- Preparation for **JPSS-1** (and beyond) is ongoing
  - Calibration / validation plan
  - Sensor evaluation
  - Pre-launch algorithm testing
- Extensive **user outreach** and support
  - NOAA JPSS Proving Ground and Risk Reduction - Fire and Smoke Initiative
    - NOAA HRRR, HMS, NWS, IMETs, Alaska DB etc.
  - NASA Applied Sciences – Wildfires
    - USDA Forest Service RSAC, NCAR modeling, State of Colorado etc.

STAR JPSS EDR Overview

Name of the Product: Surface Type EDR

Contributors: ***Xiwu Zhan,***
Chengquan Huang,
Rui Zhang & Huiran Jin

Date: August 27, 2015

Outline

- Algorithm Cal/Val Team Members (1 slide)
- S-NPP Product Overview (2 slides)
- JPSS-1 Readiness (5 slides)
- Summary and Path Forward (2 slides)

Algorithm Cal/Val Team Members

PI	Organization	Team Members	Roles and Responsibilities
Xiwu Zhan	NOAA/STAR		Surface type EDR team lead, user outreach
	UMD/Geography	Chengquan Huang	Algorithm development lead
	UMD/Geography	Rui Zhang	Algorithm development, validation, user readiness
	UMD/Geography	Huiran Jin	Validation
	STAR/AIT	Marina Tsidulko	Product delivery

S-NPP Product Overview

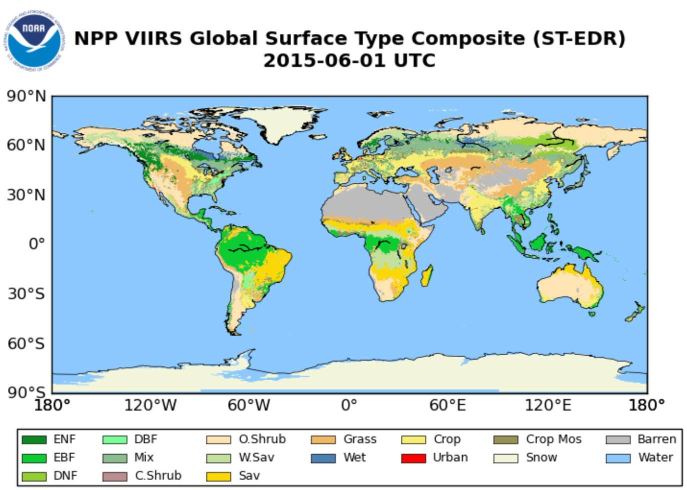
- List of Product(s) and L1RD Requirements Table(s)

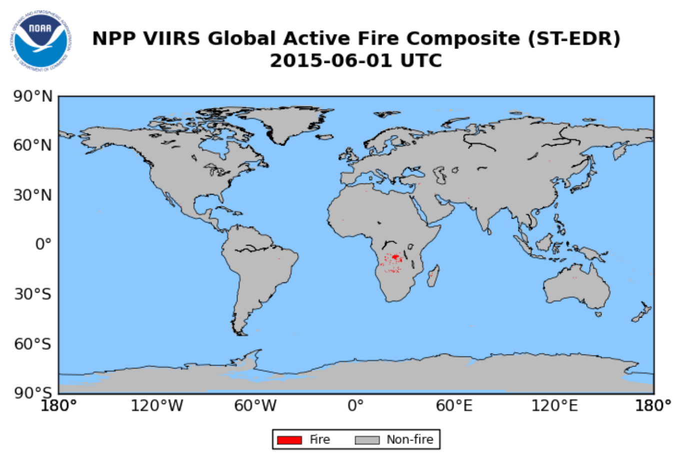
Attribute	Threshold	Objective
Geographic coverage	Global	Global
Vertical Coverage		
Vertical Cell Size	N/A	N/A
Horizontal Cell Size	1 km at nadir	1 km at edge of scan
Mapping Uncertainty	5 km	1 km
Measurement Range	17 IGBP classes	17 IGBP classes
Measurement Accuracy	70% correct for 17 types	70% correct for 17 types
Measurement Precision	10%	10%
Measurement Uncertainty		

- S-NPP Cal/Val Status
  - Reached validated 2 maturity stage
  - No known deficiencies

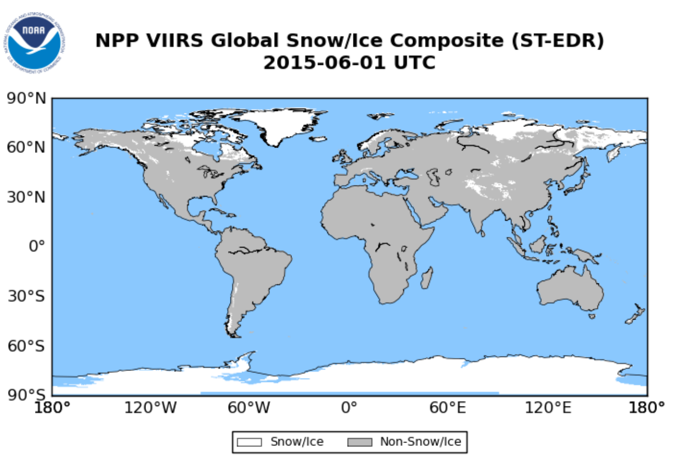
S-NPP Product Overview

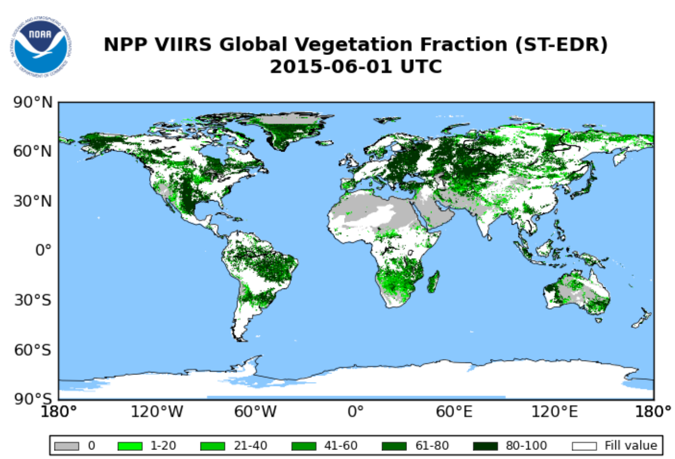
- LTM: Monitoring website links for the data product(s)
  - http://www.star.nesdis.noaa.gov/jpss/EDRs/products_surfacetype.php (in prep)





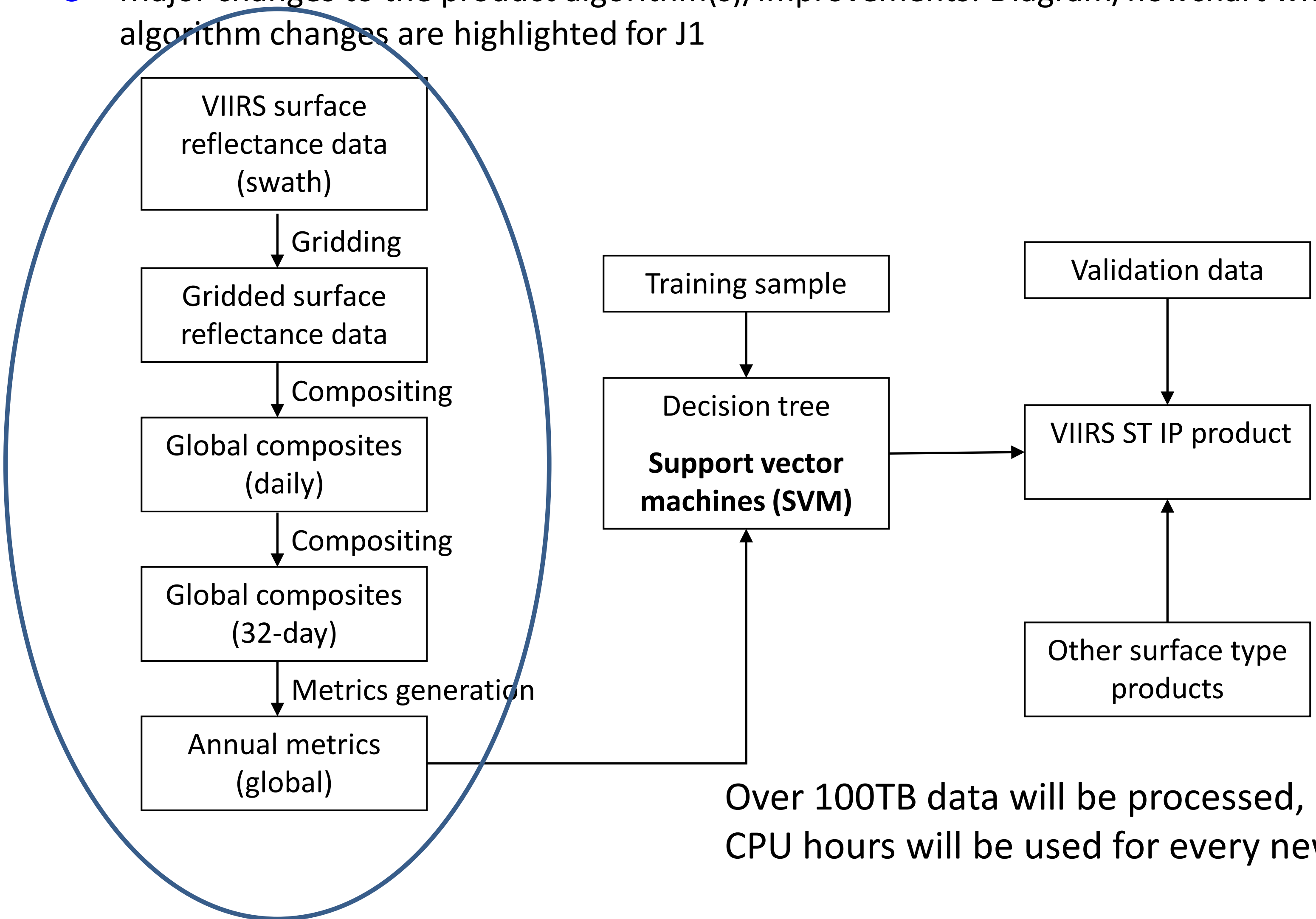
Daily global surface type, active fire, snow/ice and vegetation fraction maps are composited from the ST-EDR data for the long term monitoring





JPSS-1 Readiness

- J1 Algorithm Summary
  - Major changes to the product algorithm(s)/Improvements: Diagram/flowchart where major algorithm changes are highlighted for J1



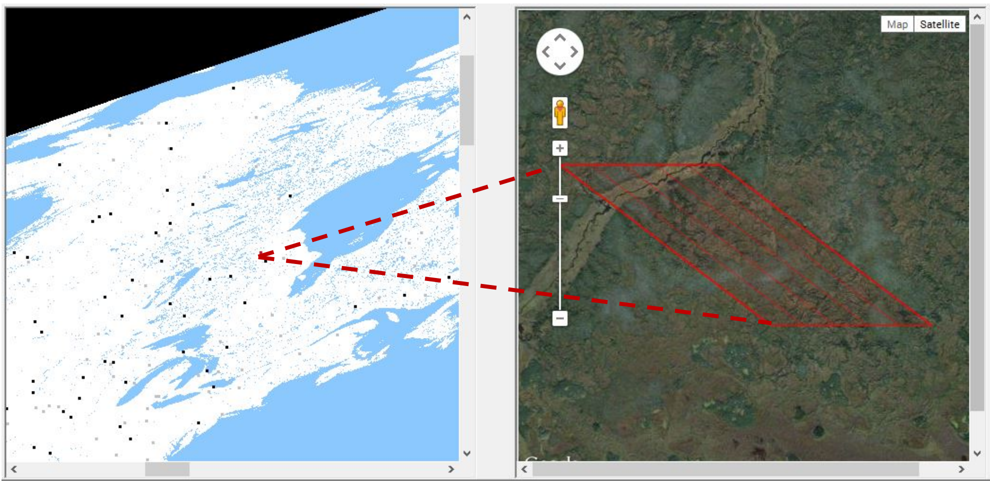
Over 100TB data will be processed, over 30,000 CPU hours will be used for every new map

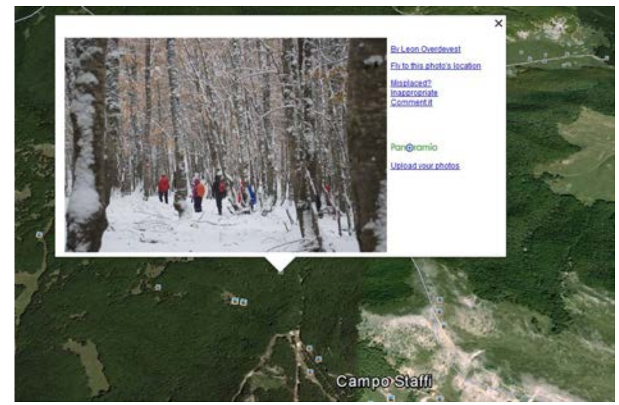
JPSS-1 Readiness

- J1 Cal/Val Overview
  - Timelines for Beta, Provisional and Validated Maturity
    - Beta: Launch (L) + 6 months (m) for ST-EDR with S-NPP proxy
      L+18months for GST using J-1 data
    - Provisional: L+9months for ST-EDR with S-NPP proxy
      L+21m for GST using J-1 data
    - Validated: L+12m for ST-EDR with S-NPP proxy
      L+24m for GST using J-1 data
  - Pre-Launch Calibration/Validation Plans
    - S-NPP and MODIS will be used as the proxy data in the pre-launch phase
    - Support Vector Machines (SVM) will replace C5.0 as the main classification algorithm. Evaluations and comparisons will be conducted.
    - Improve the validation tool, refine validation points sampling strategy
  - Post-Launch Calibration/Validation Plans
    - Earth orbit surface reflectance data will be checked.
    - Intensive validation using the interactive validation tool.
    - Collect more representative samples for product refinement
    - Long term monitoring

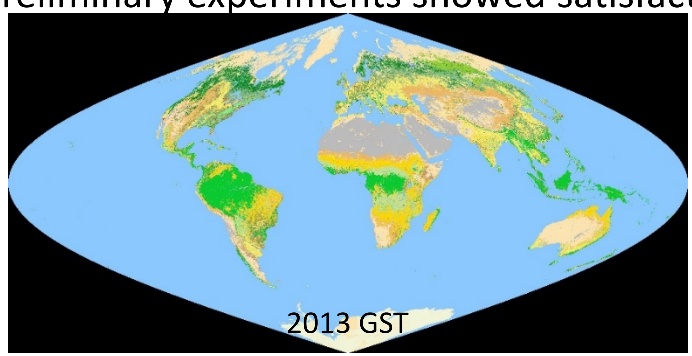
JPSS-1 Readiness

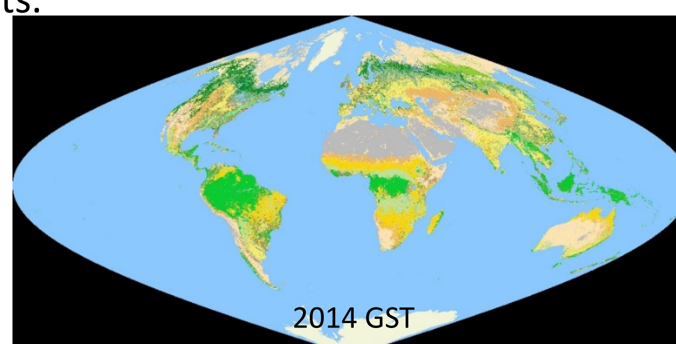
- Major Accomplishments and Highlights Moving Towards J1
  - Interactive validation tool has been developed, and a comprehensive validation has been conducted on the S-NPP GST. Error matrix and overall accuracy suggested the product accuracy exceeds the requirement of the J1RD. The ST-EDR reached the validated 1 maturity.





  - New SVM classification algorithm has been used in the production of 2013 and 2014 S-NPP GST. Preliminary experiments showed satisfactory results.


2013 GST


2014 GST

JPSS-1 Readiness

- Issues/Mitigation
  - No major issues.
  - Lack of computing resources for archiving gridded surface reflectance data is limiting the capability of the surface type science team to use multi-year data for the classification. Since the production of GST requires at least one full year global VIIRS surface reflectance data for the classification metrics, multi-terabytes have to be stored locally. Leveraging other teams' efforts on global daily VIIRS data processing is also limited the data downlinks between different team. Therefore, the surface type team computing resources may become a concern in the JPSS era.

JPSS-1 Readiness

- Stake Holder Interactions, Users and Impact Assessment Plans
  - Downstream product users:
    - Land surface temperature. LST check GST to determine proper ground type for accurate parameters in a LUT.
    - Cloud mask, aerosol products, other products require global land/water location information. General surface types separations are required by many algorithms and products.
    - National Center for Environmental Prediction (NCEP) in NOAA/NESDIS – point of contact: Dr. Mike Ek will be a major internal user for this product.
  - Production system user:
    - IDPS relies on Master Land Index (MLI) tiles to perform all Grid/Gran productions. The MLI tiles are created with the GST-Land/Water Mask, which is generated and maintained by the ST-EDR team. The GIP_GSTLWM_TILE update necessitates an update to the IDPS MLI tiles, which has high impact to the whole production system.
  - Science community users:
    - land surface parameterization (Feddema 2005, *Science* 310 (5754): 1674–78),
    - modeling of biogeochemical cycles (Cramer et al. 1999, *Global Change Biology* 5 (S1): 1–15),
    - carbon cycle studies (Friedlingstein et al. 2006, *Journal of Climate* 19 (14): 3337–53).

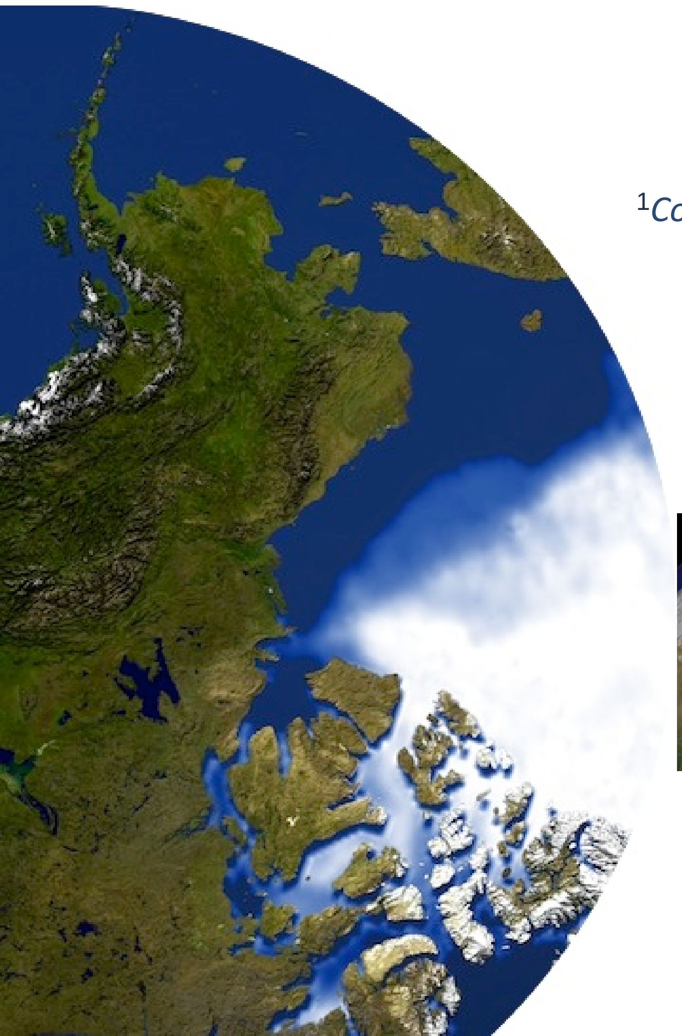
Summary & Path Forward

- Summary
  - S-NPP GST and ST-EDR have been successfully validated. The results suggested that the ST-EDR meets the accuracy requirement defined in the J1RD.
  - Validation protocol has been successfully established, including validation dataset, validation tool, and accuracy reporting approaches.
  - New classification algorithm SVM has been successfully tested, and preliminary results showed promising improvements. The SVM will replace the C5.0 decision tree in future data productions.
  - Long term monitoring for the ST-EDR has been created. Daily composited surface type, active fire (quality flag bit, provided by Active fire ARP), snow/ice (quality flag bit, provided by Snow EDR), and vegetation fraction (calculated from annual maximum minimum data and surface reflectance input) have been generated and posted into the LTM website.

Summary & Path Forward

- Path Forward
  - FY16 Milestones
    - Comparison of results from S-NPP VIIRS surface type EDR with other existing surface type products.
    - Improvement of the training samples and validation points, which are collected globally and incrementally.
    - delivery of a VIIRS global gridded surface type (GST) product based on 2012-2015 S-NPP VIIRS observations.
  - J2 and Beyond: Future Improvements
    - Better compositing algorithm to the data preparation, use multiple year data to stabilize the unnecessary annual variabilities.
    - Post-classification improvements, introduce more external data and product sources to improve the accuracy of the GST and ST-EDR
    - Different classification legend to better serve the users, such as Biome classification type.
    - More useful dataset or flags to be included into the ST-EDR, such as dynamic water information, which will be invaluable for flood monitoring.

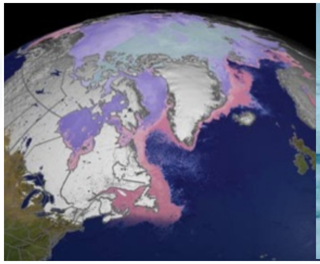
Sea Ice Thickness from Satellite

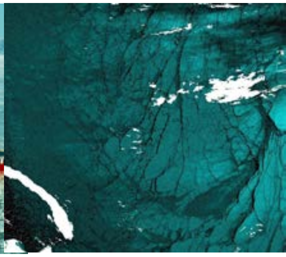


Xuanji Wang[1] and Jeff Key[2]

[1]Cooperative Institute for Meteorological Satellite Studies, U. Wisconsin-Madison
[2]NOAA Satellite and Information Services, Madison, Wisconsin

With input from Dan Baldwin and Mark Tschudi, CU-Boulder



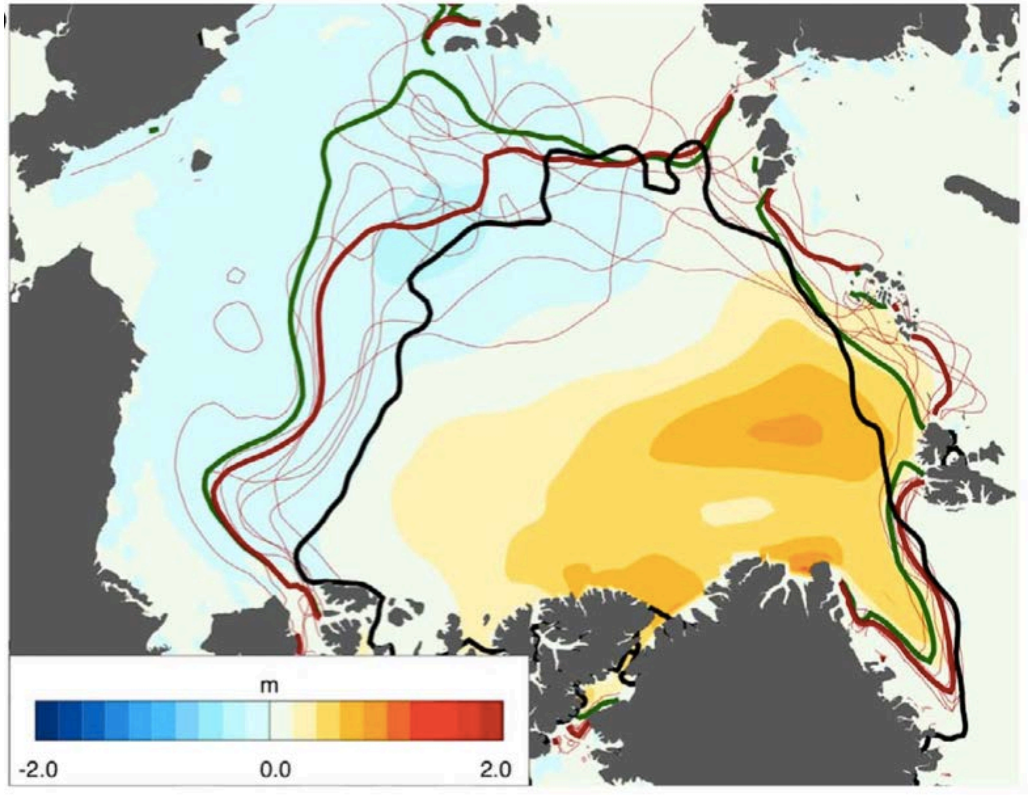



STAR JPSS 2015 Annual Science Team Meeting
24-28 August 2015, NCWCP, College Park, MD

Importance of Ice Thickness

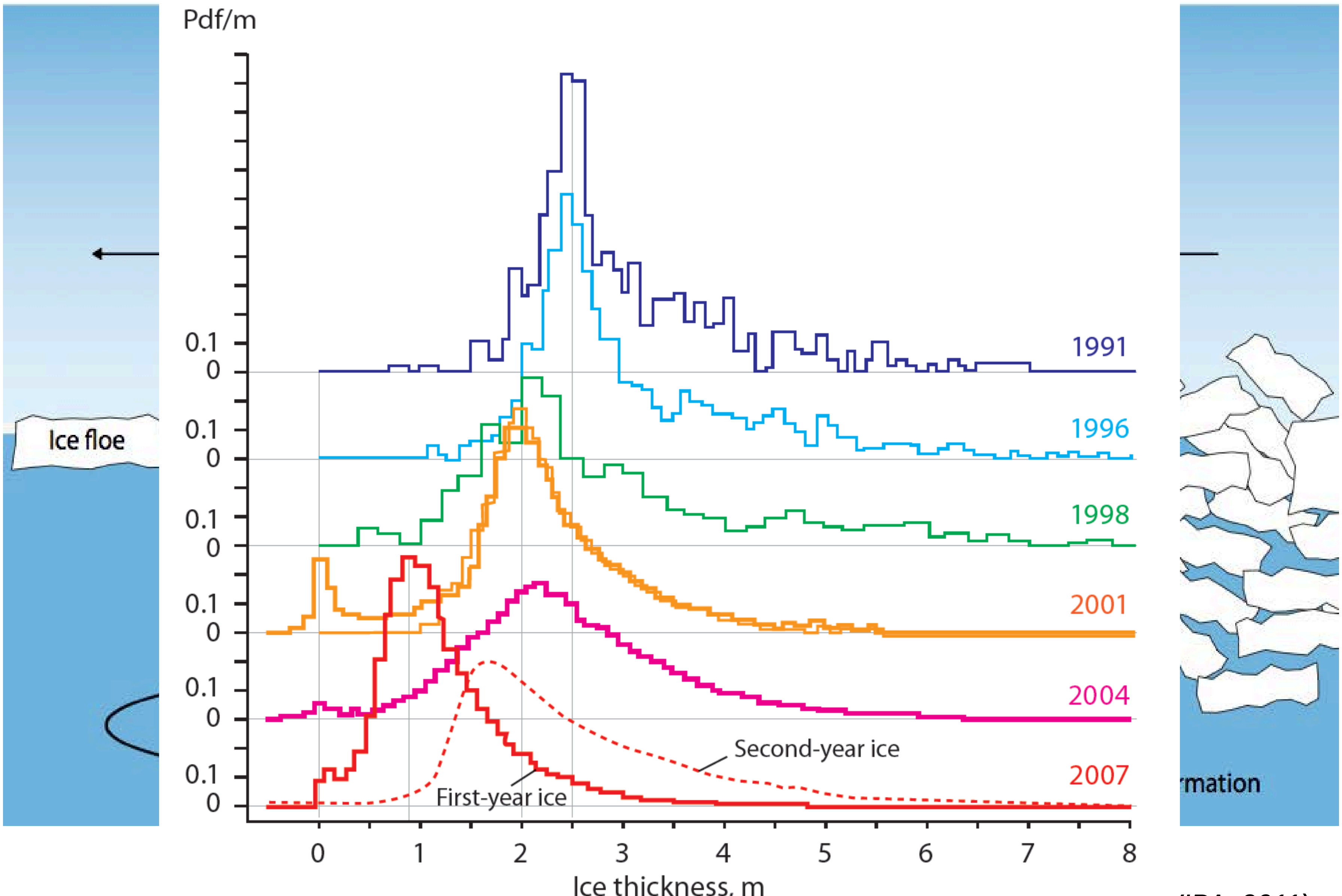
Thermodynamically and dynamically it is ice thickness, not ice extent, that is important. Thickness provides an integrated measure of changes in the energy balance. It is critical to navigation.

While little work has been done on assimilating ice thickness in models, indications are that doing so would improve ice forecasts.



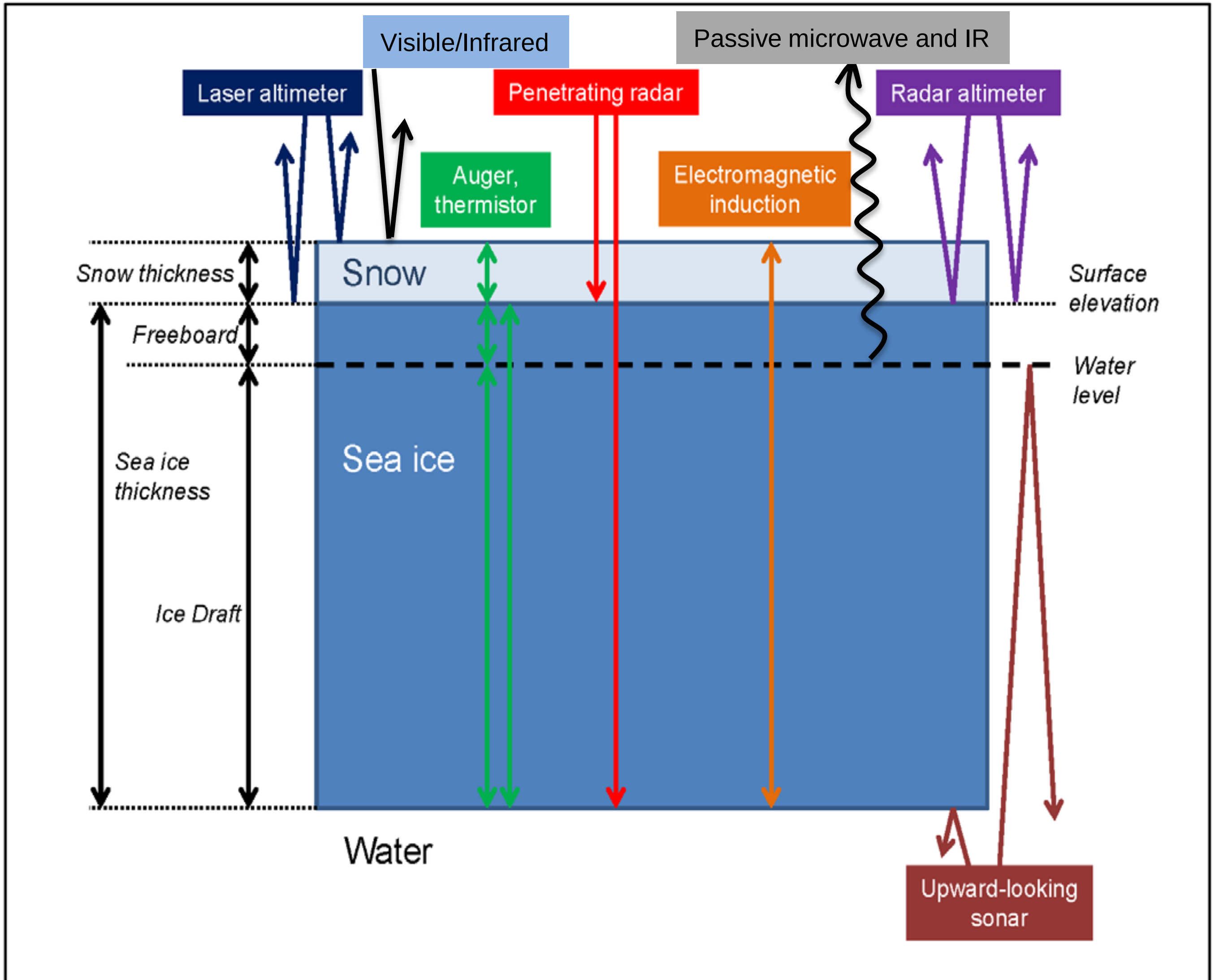
The difference in mean ice thickness for September between the corrected and the control runs of the PIOMAS model, where corrected runs use IceBridge and SIZONet ice thicknesses to correct the initial thickness field. The thin red lines are the ice extent (0.15 ice concentration) lines for each of the corrected ensemble members and the thick red line is the mean for the ensemble. The thick green line is the mean of the ensemble of control runs and the black line is the observed September mean ice extent. From Lindsay et al. (2012)

Processes That Affect Ice Thickness



'IPA, 2011)

Measuring Ice Thickness



(adapted from Meier et al., 2014)

Sea Ice Characterization EDR L1RD Requirements

Sea Ice Characterization Requirements from L1RD version 2.9

Note that because the percentage of N/Y ice is, on the annual average, very small, the 70% probability of correct typing of both classes together could be met by simply labeling all ice pixels as “Other Ice”!

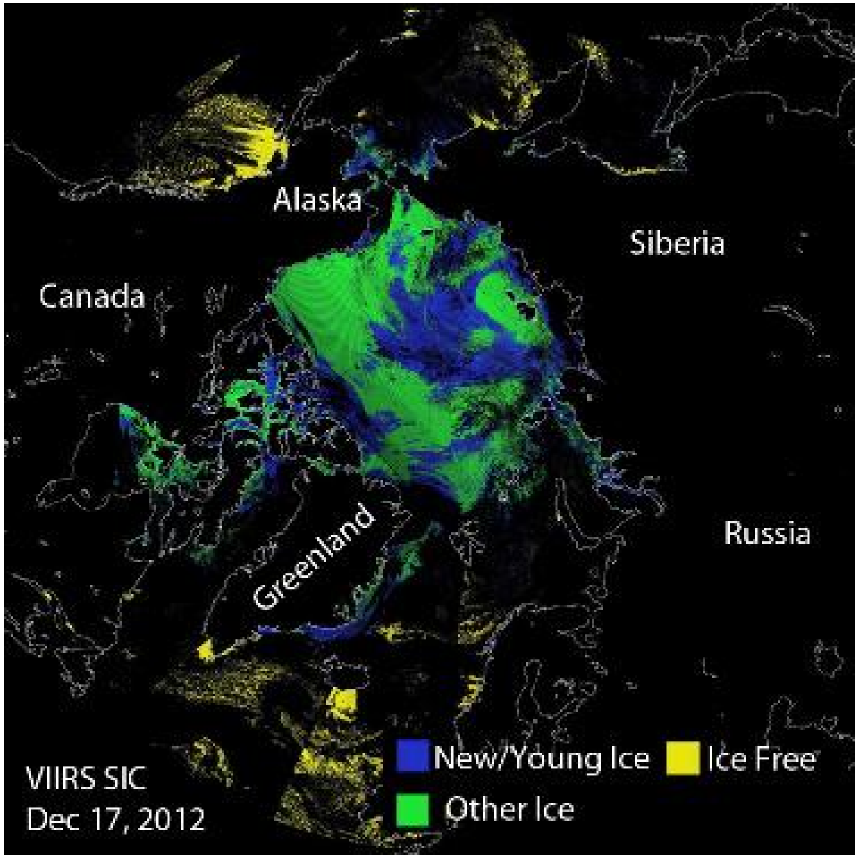
f. Refresh	24 hours (monthly average)	
g. Geographic coverage	All Ice-covered regions of the global ocean	All Ice-covered regions of the global ocean

Notes:
1. VIIRS produces a sea ice concentration IP in clear sky conditions, which is provided as an input to the ice surface temperature calculation

Summary of VIIRS Sea Ice Characterization EDR

- The VIIRS Sea Characterization EDR (Ice Age) consists of ice classifications for *Ice Free*, *New/Young* and *Other Ice* at VIIRS moderate spatial resolution (750m @ nadir), for both day and night, over oceans poleward of 36^{o}N and 50^{o}S latitude.

  - New or Young ice is discriminated from thicker ice (Other Ice) by a threshold ice thickness of 30 cm. Discrimination of New/Young ice from thicker ice is achieved by two algorithms: (1) Energy balance at night and (2) reflectance during the day.
  - Heritage: There is no operational visible/IR heritage. AVHRR research heritage (Comiso and Massom 1994, Yu and Rothrock 1996 and Wang et al. 2010).



Summary of VIIRS Sea Characterization EDR (Ice Age) Algorithm Overview

Reflectance Threshold Branch (Day Region Algorithm)

- Input ice tie point reflectance (I1, I2), VCM IP, AOT IP
- Input granulated NCEP gridded precipitable water, total ozone fields
- Obtain snow depth for each ice thickness bin obtained from climatology modeled snow depth/ice thickness LUT
- Retrieve ice thickness from sea ice reflectance LUT using ice tie point reflectances, modeled snow depth, AOT, precipitable water, and solar and satellite view geometry
- Classify by comparing retrieved ice thickness to 30 cm ice thickness threshold

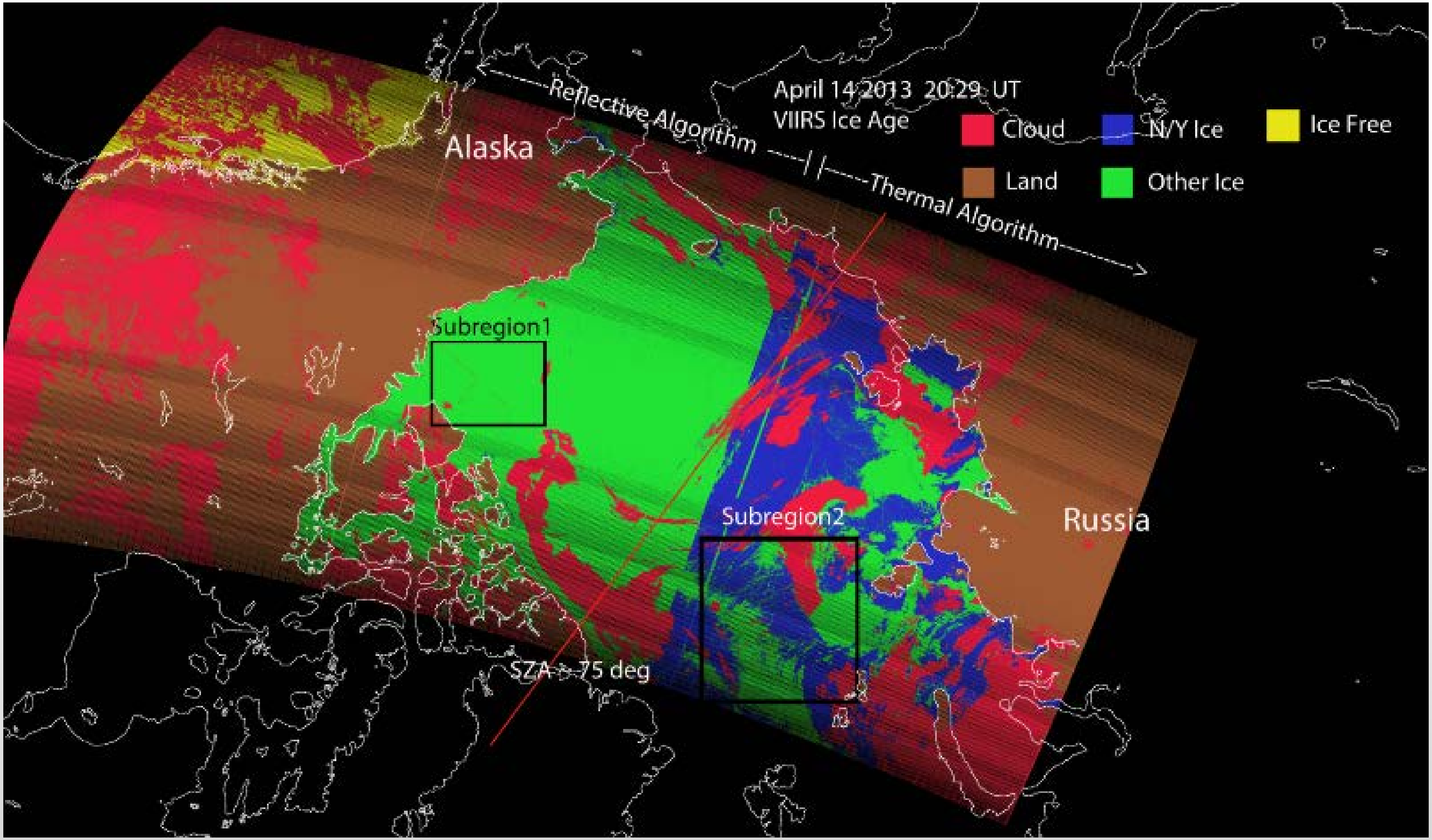
Energy Balance Branch (Terminator and Night Region Algorithm)

- Input Ice Temperature Tie Point IP
- Input granulated NCEP gridded surface fields (surface pressure, surface air temp, specific humidity, etc.)
- Compute snow depth for 30cm ice thickness threshold from heat/energy balance
- Classify by comparing computed and climatology LUT snow accumulation for a 30 cm ice thickness threshold

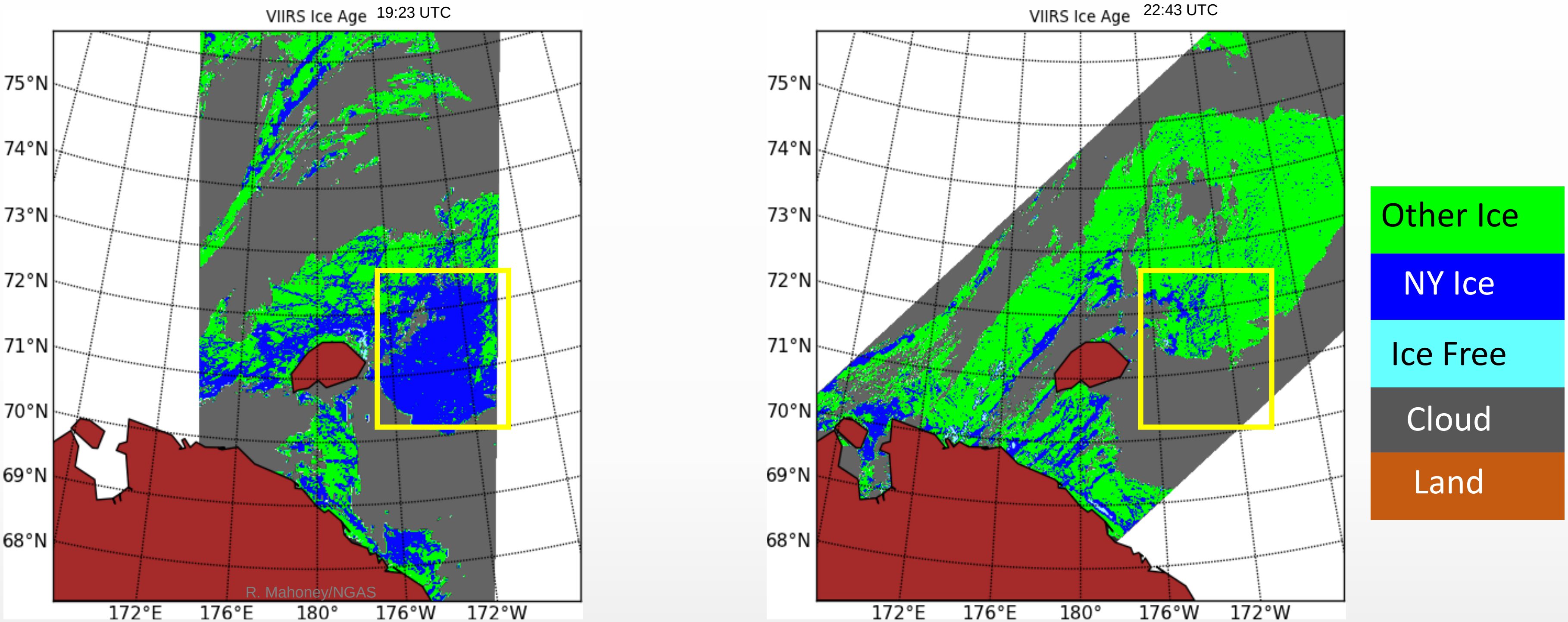
The Snow-Depth-Ice Thickness Climatology LUT contains:

- predicted snow accumulation depths for modeled ice thickness threshold growth times based on monthly climatology surface air temperatures and precipitation rates

Problem: Day-Night Differences



Problem: Orbit-to-Orbit Misclassification of NY and Other Ice



Region near Wrangle Island showed significant amounts of sea ice that were correctly classified as thicker “Other Ice” in 22:43 UTC orbit scene (right) being misclassified as NY in the 19:23 UTC orbit scene (left). The yellow boxed region shows a broad region of misclassified NY ice in the 19:23 scene.

SDR RGBs, ice tie point reflectance, modeled sea ice reflectance, modeled snow accumulation depth, internally computed ice thickness and other inputs were examined and compared in order to determine the cause for the misclassification.

Summary of VIIRS Sea Ice Characterization Status

The Sea Ice Characterization EDR has considerable performance challenges. Misclassification of ice was observed to occur for the following categories of conditions:

- Day regions:
  - bias towards misclassification of Other Ice as NY in regions with 1) large values of climatology snow depth, 2) high satellite view zenith angle and regions with 3) low reflectance due to melting ice and 4) cloud shadows
- Night regions
  - reversals of ice age classification
- Terminator regions
  - frequent, broad misclassification of Other Ice as NY and reversals of classification
  - Ice classification discontinuities are most evident and frequent where the algorithm transitions from the day reflectance based algorithm to the night energy balance based algorithm

Solutions to these problems are illusive, so another approach was pursued: the One-dimensional Thermodynamic Ice Model (OTIM) that was developed for GOES-R.

One-dimensional Thermodynamic Ice Model (OTIM) (Wang et al., 2010)

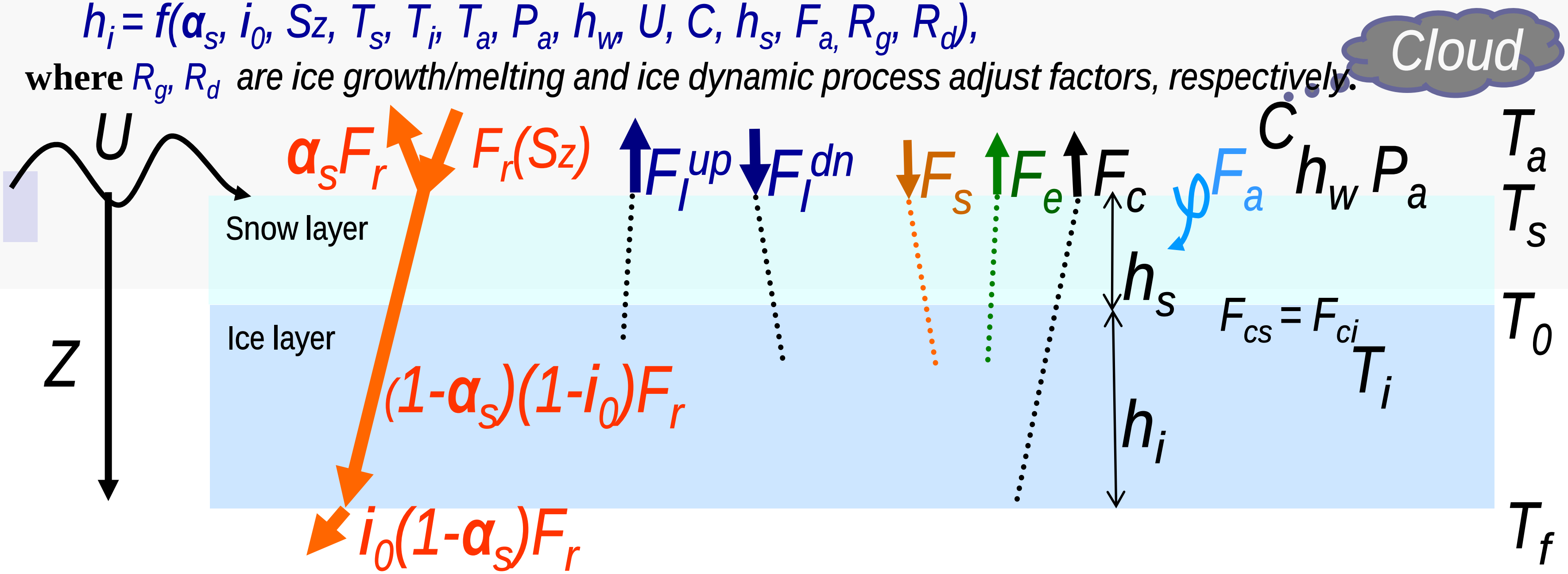
Based on the surface energy budget at thermo-equilibrium state, the fundamental equation is

$$(1-\alpha_s)(1-i_0)F_r - F_l^{up} + F_l^{dn} + F_s + F_e + F_c = F_a(\alpha_s, T_s, U, h_i, C, h_s, \ldots)$$

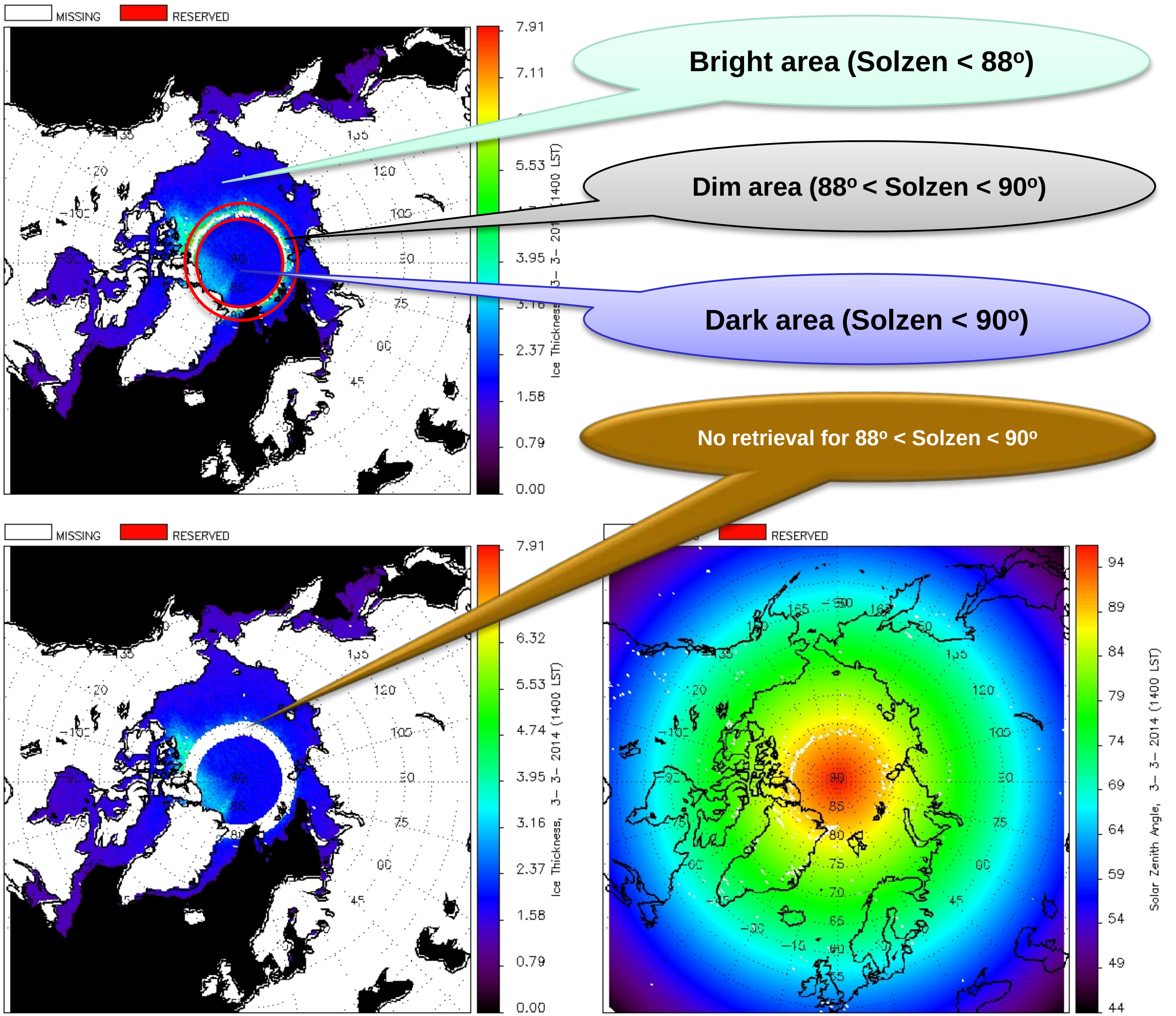
After parameterizations of thermal radiation (F_r, F_l^{up}, F_l^{dn}) and turbulent (sensible & latent) heat (F_s, F_e), ice thickness *hi* becomes a function of 11 model controlling variables plus two factors:

$$h_i = f(\alpha_s, i_0, Sz, T_s, T_i, T_a, P_a, h_w, U, C, h_s, F_a, R_g, R_d),$$

where R_g, R_d *are ice growth/melting and ice dynamic process adjust factors, respectively.*



Consistency - OTIM daytime and nighttime algorithms

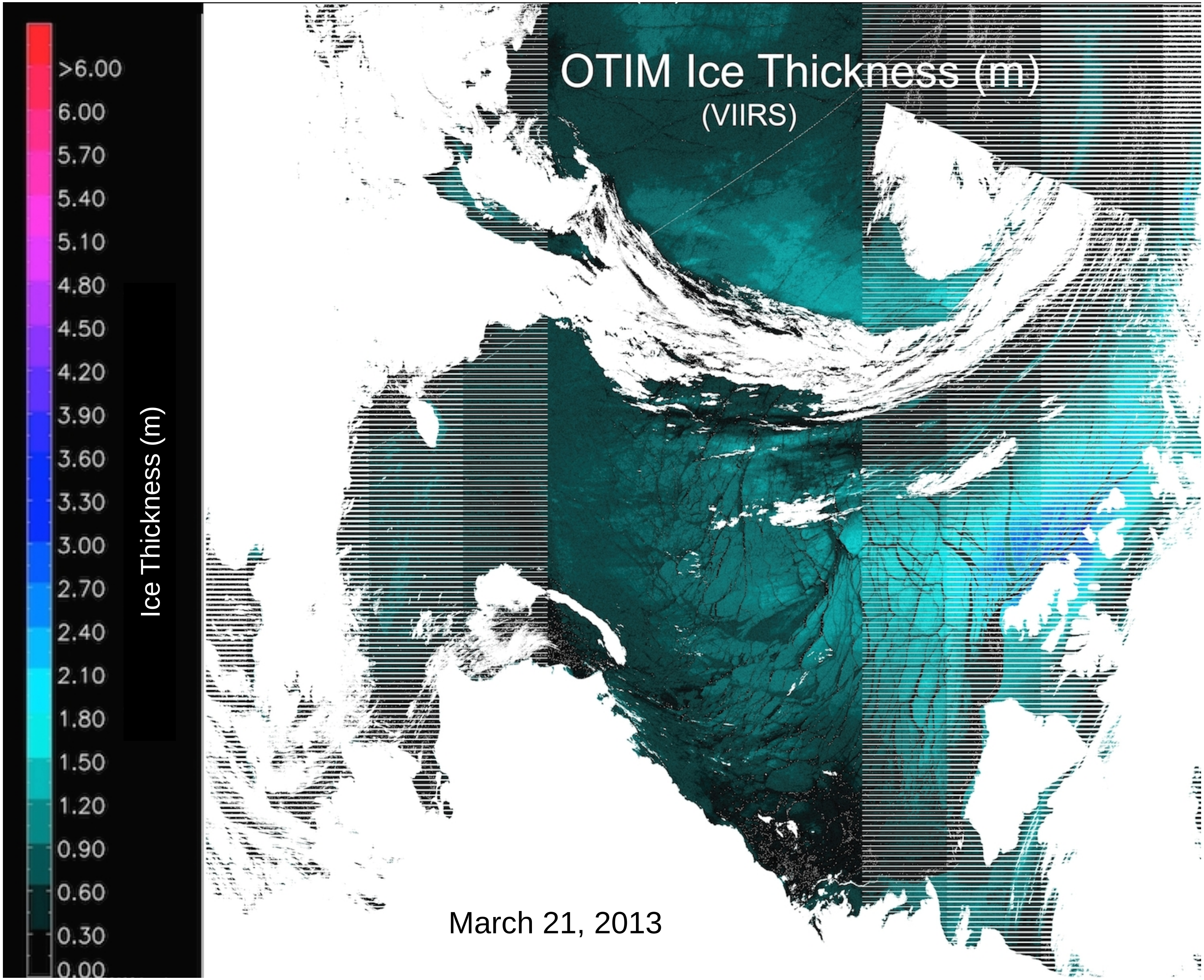


Sea ice thickness on March 3, 2014 at 14:00 LST (white solid ring indicating dim area with solar zenith angle between 88 and 90 degrees)

Solar zenith angle on March 3, 2014 at 14:00 LST

(APP-x 25 km data products)

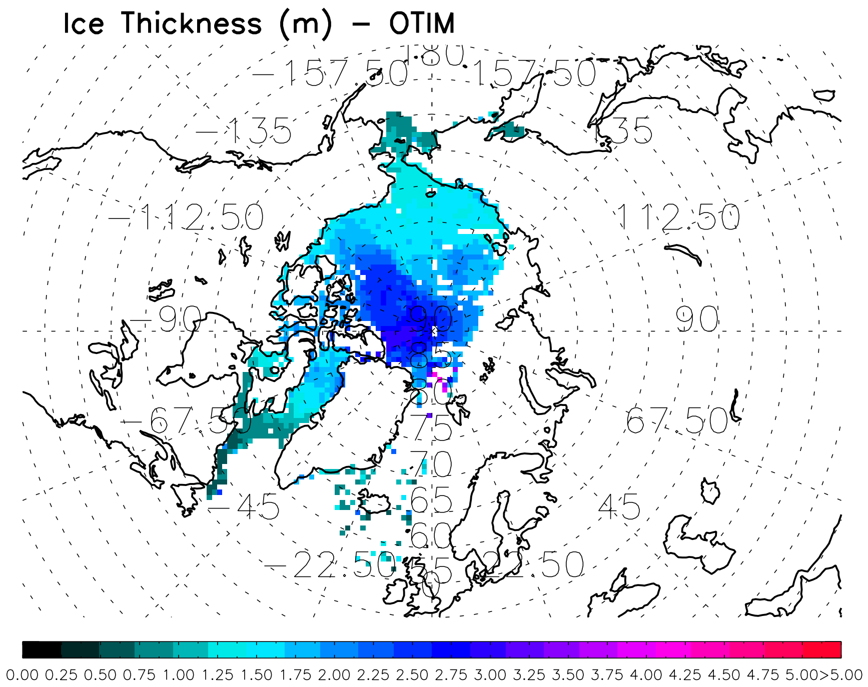
Though the algorithms in OTIM for retrieving daytime and nighttime ice thickness are different because of solar radiation involved in daytime retrieval, their retrieved ice thickness is very consistent in value except that dim area where solar zenith angle between 88 ~ 90 degrees has poor retrieved ice thickness because of poor cloud and surface albedo retrievals.



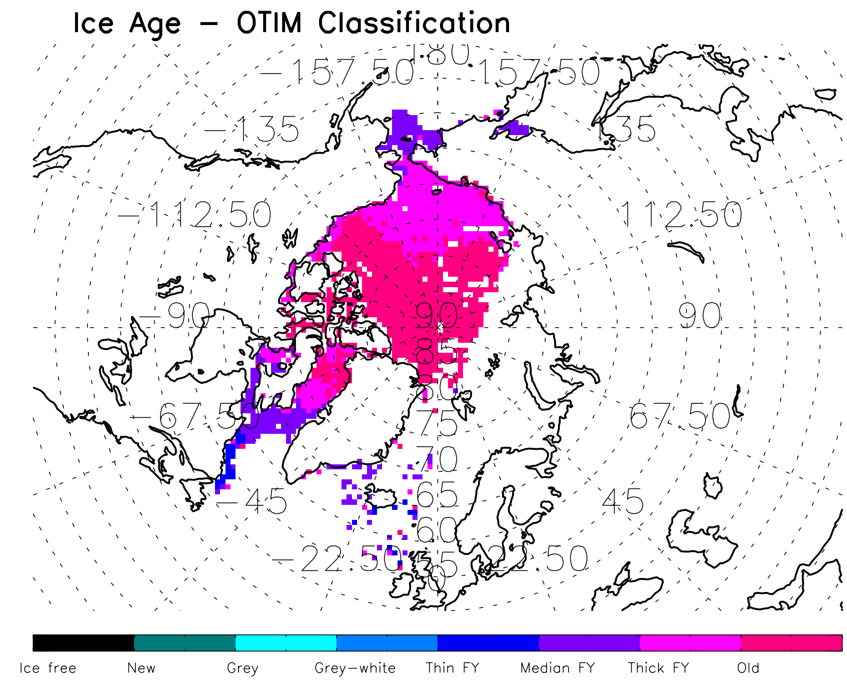
March 21, 2013

Large Scale VIIRS Ice Thickness

Ice Thickness

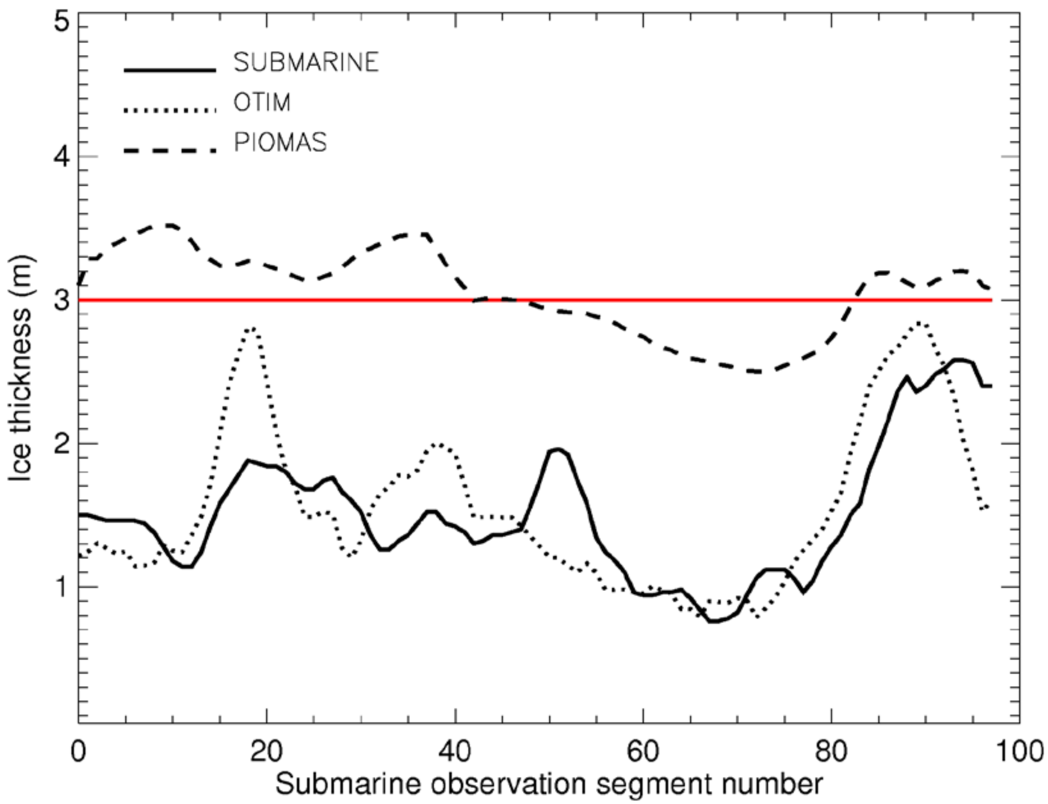


Ice Age



OTIM retrieved ice thickness (left) based on VIIRS ice surface temperature, and ice age (right) derived on March 4 ,2012 for the Arctic region.

Comparison of APP-x and Submarine ULS



Comparisons of ice thickness retrieved by OTIM with APP-x data, measured by submarine, and simulated by PIOMAS alone the submarine track segments.

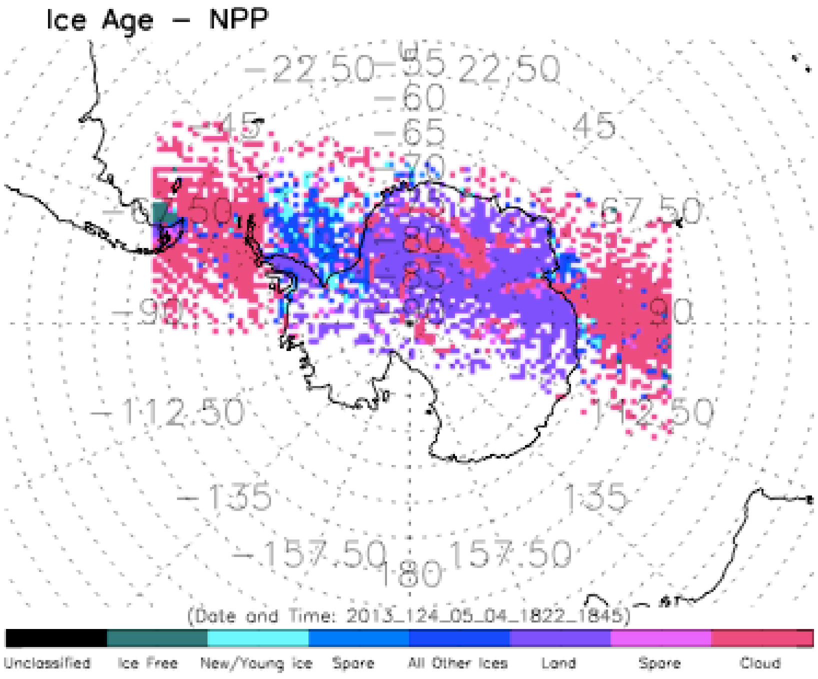
	OTIM	Submarine
Thickness Mean (m)	1.55	1.51
Bias (m)	0.04	
RMS difference (m)	0.52	

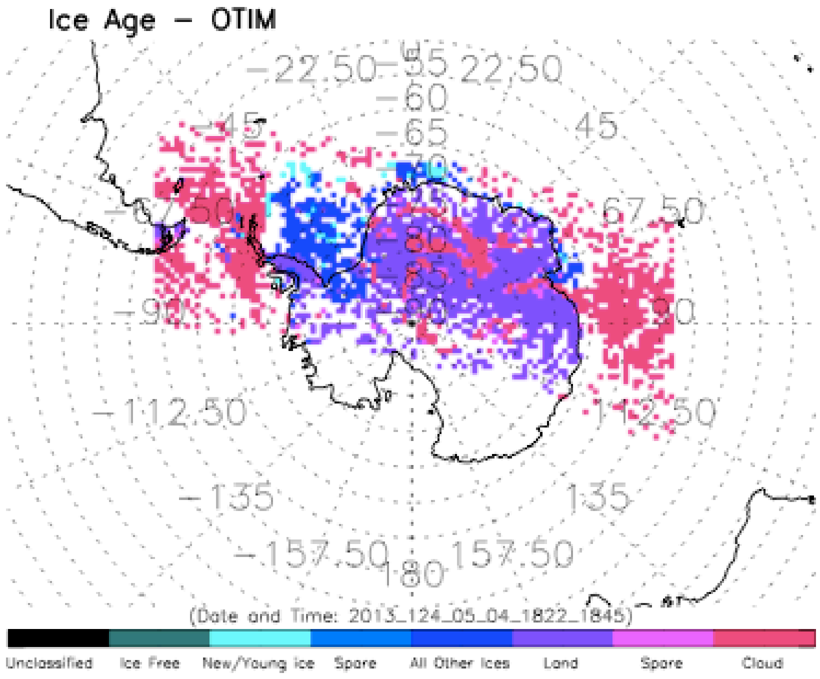
OTIM (w/AVHRR) and Surface Measurements

	OTIM ALERT LT1	OTIM ALERT YLT	OTIM CAMBRIDGE BAY YCB	OTIM CORAL HARBOUR YZS	OTIM EUREKA WEU	OTIM HALL BEACH YUX	OTIM RESOLUTE YRB	OTIM YELLOWKNIFE YZF
Thickness Mean (m)	1.52 1.09	1.59 1.09	1.51 1.44	1.04 1.20	1.59 1.22	1.18 1.41	1.63 1.38	0.95 0.98
Bias Mean (m)	0.43	0.50	0.07	-0.16	0.37	-0.23	0.25	-0.03
Bias Standard Deviation (m)	0.52	0.39	0.97	0.62	0.52	0.68	0.50	0.58
OTIM Ice Age	Ice free water, new/fresh, grey, grey-white, first year thin, first year medium, first year thick, and multi-year ice.							
EDR Requirements	Distinguish between ice free, new/fresh ice, and all other ice.							

Ice Thickness and Age
IDPS and NDE (OTIM) Comparison

Sea ice age categories from VIIRS sea ice age classification (left) and OTIM ice thickness converted to the same categories (right) on May 4, 2013 over the Arctic.





Ice Thickness and Age
IDPS and NDE (OTIM) Comparison

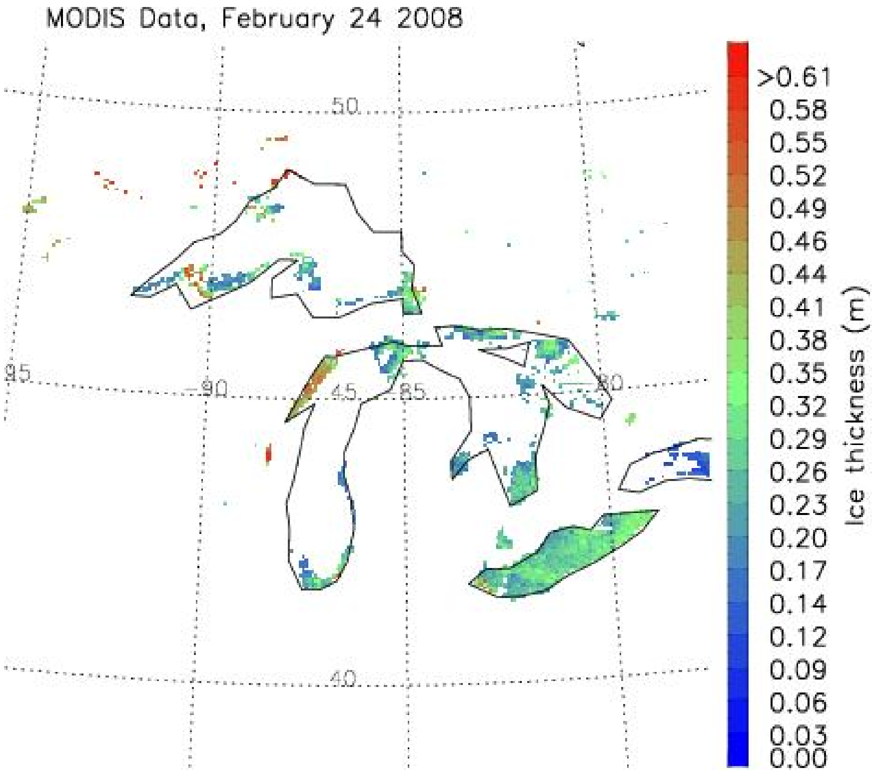
Statistics for figure on previous slide:

Percentage in each ice age category from VIIRS and OTIM for May 4, 2013 case.

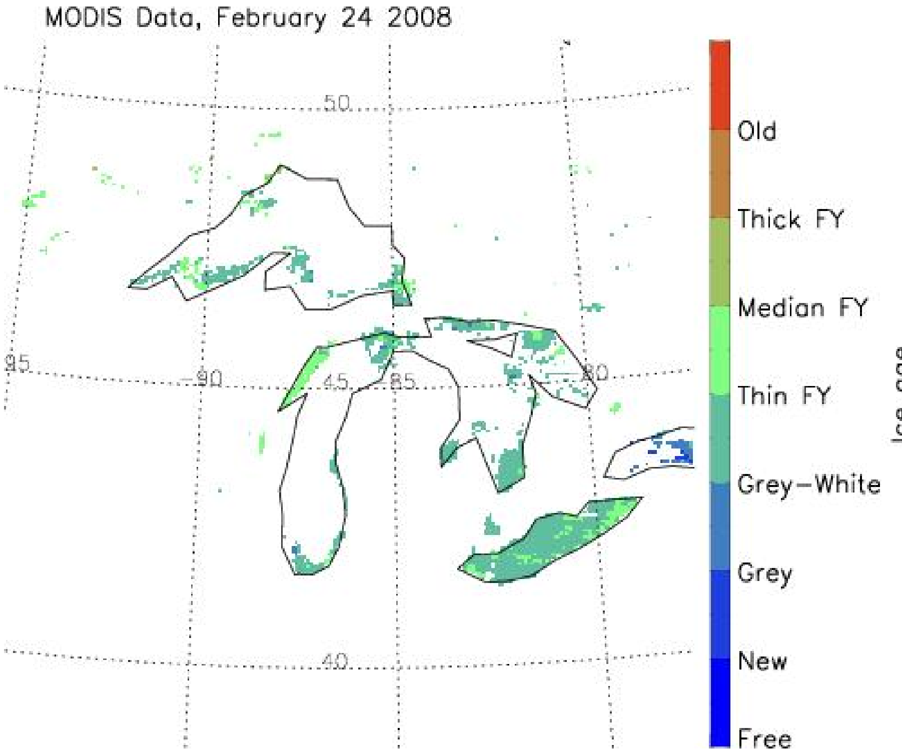
Categories	VIIRS ice age	OTIM ice age	Difference (VIIRS-OTIM)
Day and night time:			
Ice free	13	24	-11
New/Young ice	52	9	43
Other ice	35	67	-32
Daytime:			
Ice free	27	50	-23
New/Young ice	53	3	50
Other ice	20	47	-27
Nighttime:			
Ice free	10	20	-10
New/Young ice	52	10	42
Other ice	38	70	-32

Ice Thickness and Age: Great Lakes!

Ice Thickness



Ice Age



Estimated ice thickness (left) and ice age categories (right) based on MODIS data on February 24, 2008.

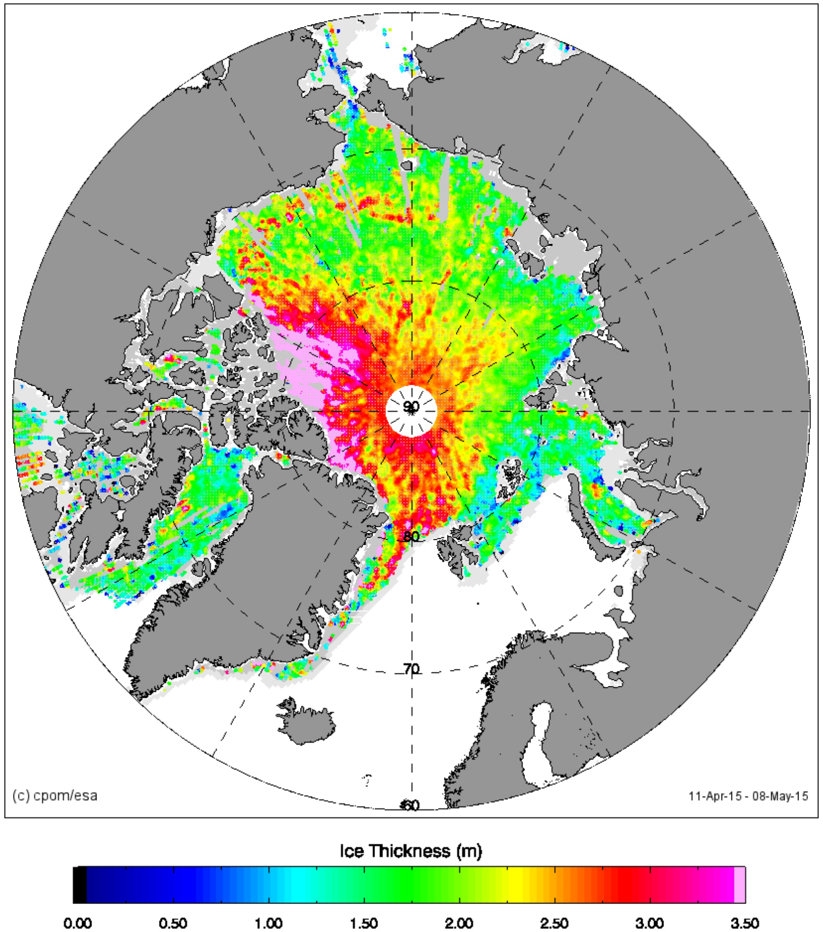
Satellite-Derived Ice Thickness Products

It is now possible to estimate ice thickness from space using a variety of techniques:

- **The One-dimensional Thermodynamic Ice Model (OTIM) is an energy budget approach for estimating sea and lake ice thickness with visible, near-infrared, and infrared satellite data from sensors such as the Advanced Very High Resolution Radiometer (AVHRR), the Moderate Resolution Imaging Spectroradiometer (MODIS), and the Visible Infrared Imaging Radiometer Suite (VIIRS) – APP-x and MPP-x (*Wang et al., 2010*).**
- **Laser and radar altimeter data from the ICESat and CryoSat-2 satellites estimate ice thickness from ice elevation (freeboard) – ICESat, CryoSat-2, and IceBridge (*Kwok et al., 2009; Laxon et al., 2013; Kurtz et al., 2013).***
- **Another method employs low-frequency passive microwave data from the Soil Moisture and Ocean Salinity (SMOS) mission (*Tian-Kunze et al., 2014*).**
- **Arctic sea ice thickness has also been modeled with Pan-Arctic Ice Ocean Modeling and Assimilation System (PIOMAS) (*Zhang and Rothrock, 2003*).**

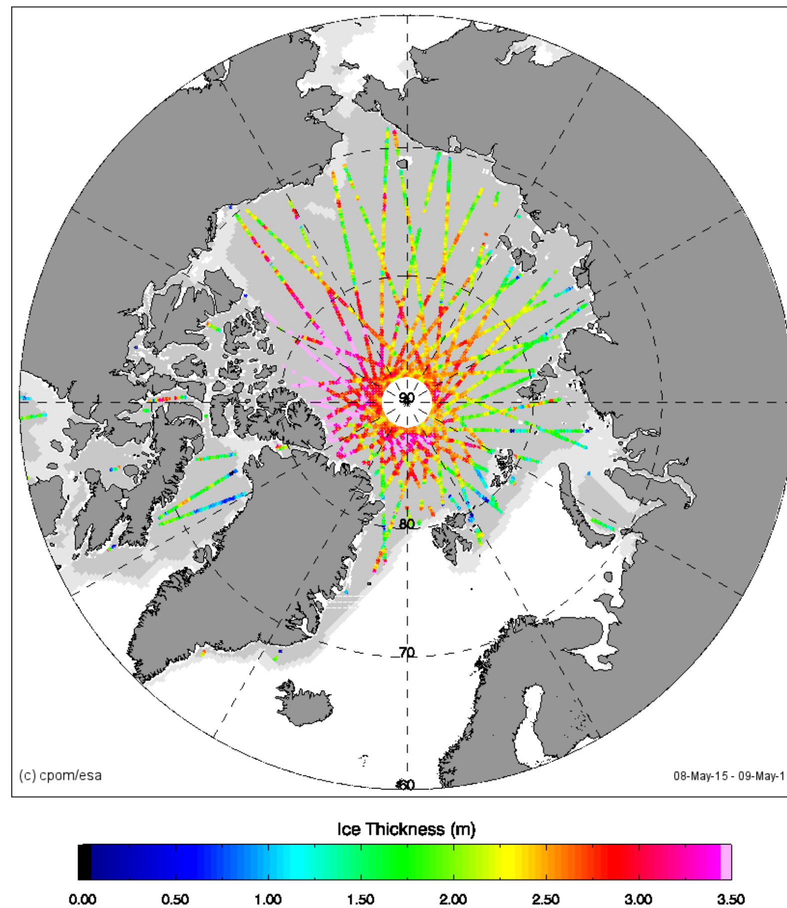
Thanks to: Ron Kwok, Jinlun Zhang, the National Snow and Ice Data Center (NSIDC), the Alfred Wegener Institute, and the University of Hamburg for providing sea ice thickness data from ICESat, PIOMAS, IceBridge, CryoSat-2, and SMOS.

CryoSat-2 Sea Ice Thickness (ESA)



Left: 28-day composite

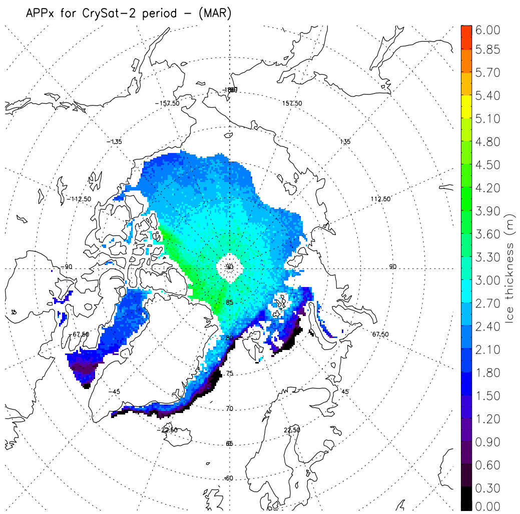
Below: 2-day composite



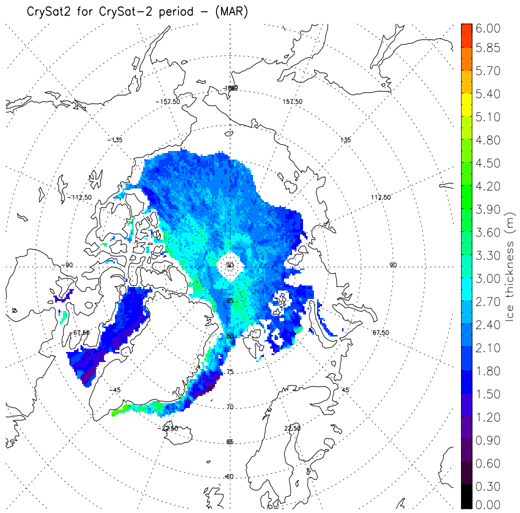
Intercomparison for CryoSat-2 Period

(01/2011 - 03/2013, March)

APP-x



CryoSat-2

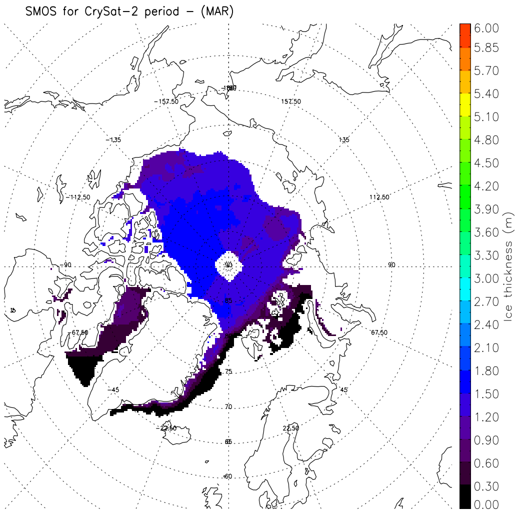


APP-x - PIOMAS: Bias=0.51 m

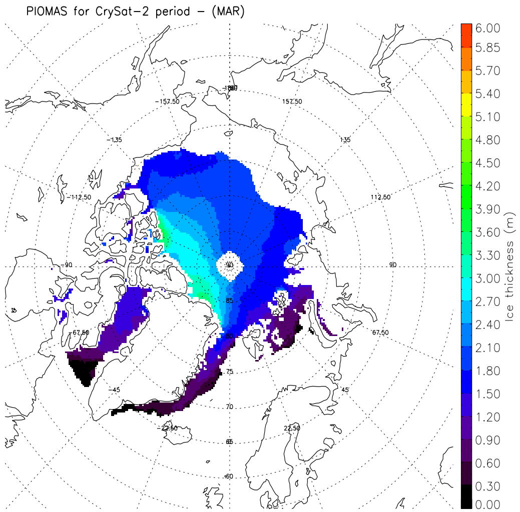
CryoSat-2 – PIOMAS: Bias=0.57 m

SMOS – PIOMAS: Bias=-0.43m

SMOS



PIOMAS



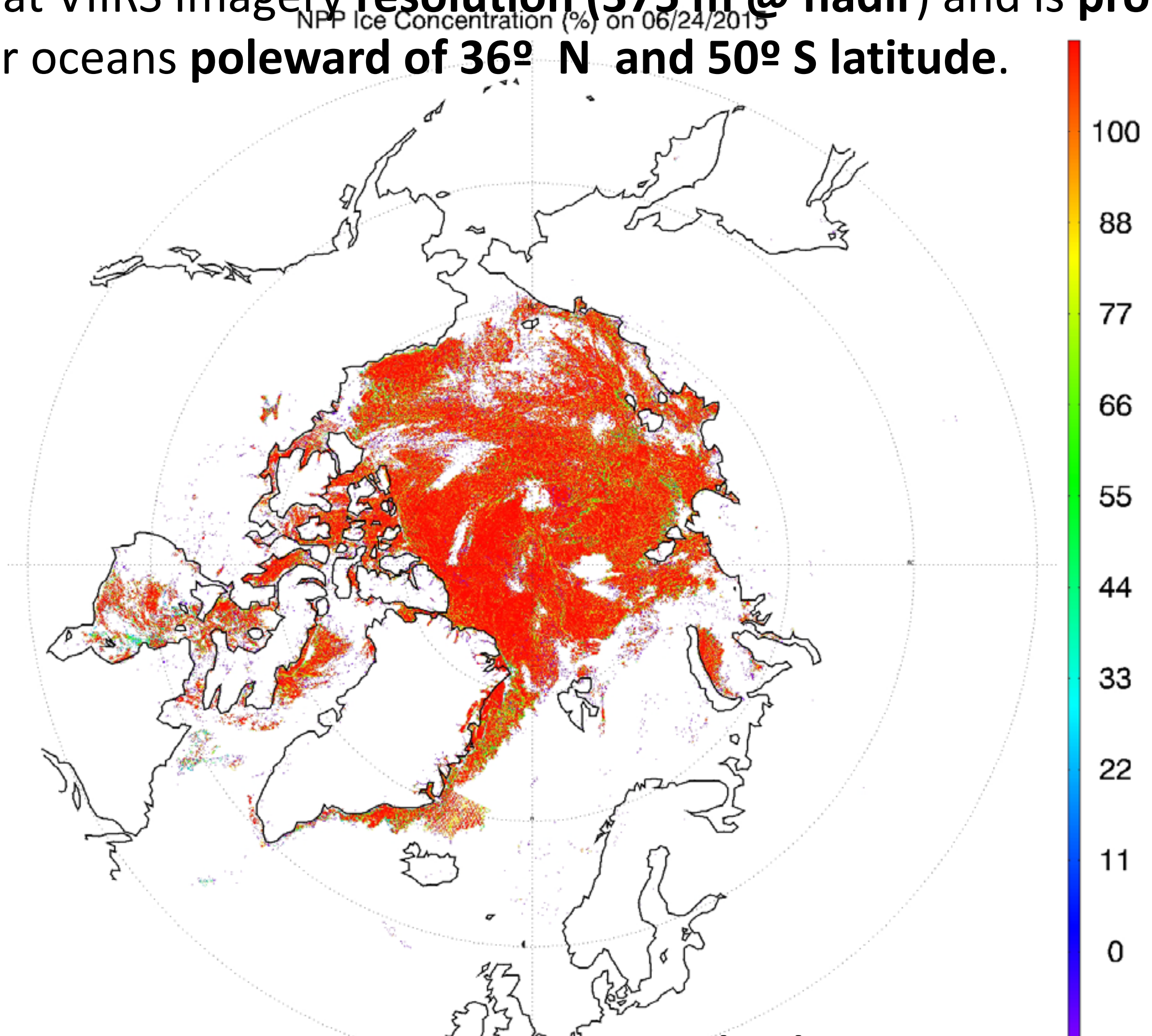
VIIRS Sea Ice Concentration IP Status

Yinghui Liu (CIMSS,UW-Madison)
Dan Baldwin (CU), Jeff Key (NOAA/NESDIS), Mark Tschudi (CU)

August 27, 2015

Sea Ice Concentration Product Description

•**Product Description:** The VIIRS Sea Ice Concentration IP consists of retrieved ice concentration at VIIRS Imagery **resolution (375 m @ nadir**) and is **produced both day and night**, over oceans **poleward of 36º N and 50º S latitude**.



NPP VIIRS Ice Concentration (%) on June 24 2015

Sea Ice Concentration IP Algorithm Description

•**Heritage:** No Vis/IR operational heritage. AVHRR research heritage (Comiso & Massom, 1994). Microwave heritage NASA Bootstrap and Team tie point based ice concentration retrieval algorithms.

• **Inputs:** TOA reflectances (VIIRS I1 and I2 bands) and Surface Temperature IP at imagery resolution, Ice Quality Flags IP, Ice Weights IP

• **Outputs:** Ice Reflectance/Temperature IP, Ice Concentration IP

•**Algorithm Description**

Tie point based retrieval of ice concentration at VIIRS imagery resolution (375 m @nadir). Ice and water tie points are determined for the visible TOA reflectance (VIIRS I1 band), near infrared TOA reflectance (VIIRS I2 band), and Surface Temperature.

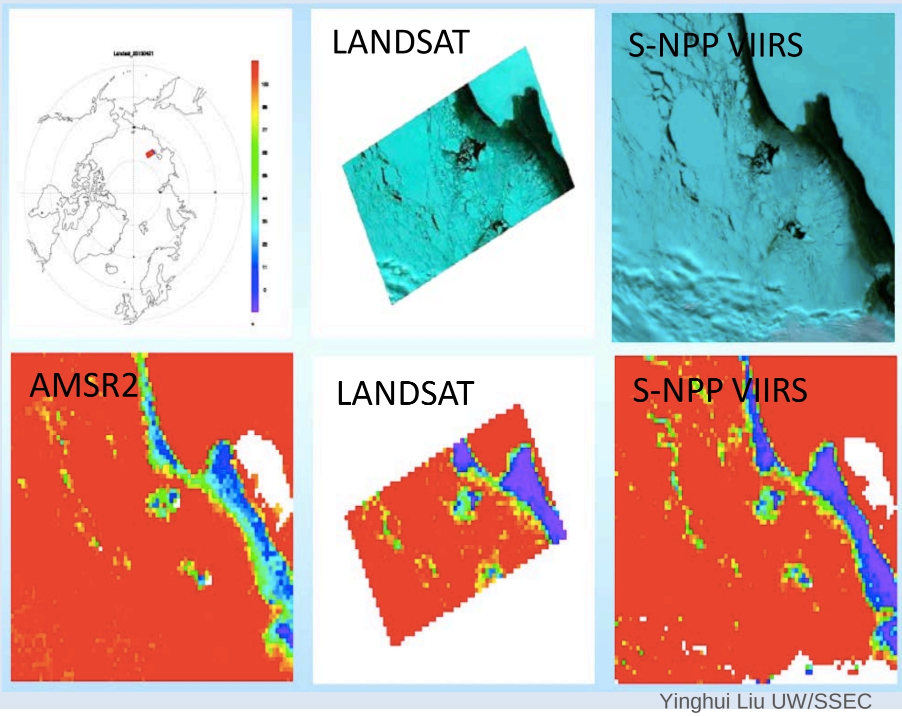
- –Tie points are established from the local distribution of reflectance and temperature within a sliding search window centered on each VIIRS Imagery resolution pixel.
- – Ice/water thresholds are derived from the local minimum of the distribution of reflectance and temperature. Derived tie points are specific to the local region contained within the search window.
- –Transition to Surface Temperature IP thermal tie points only for night is controlled by quality weights. De-weighted reflective quality weights for VCM cloud shadow flagged pixels favor thermal tie point based ice fraction retrievals
- – VIIRS Surface Temperature IP is determined using the VIIRS I5 (11.5 µm), M15 (10.8 µm) and M16 (12.0 µm) bands

Performance Evaluation

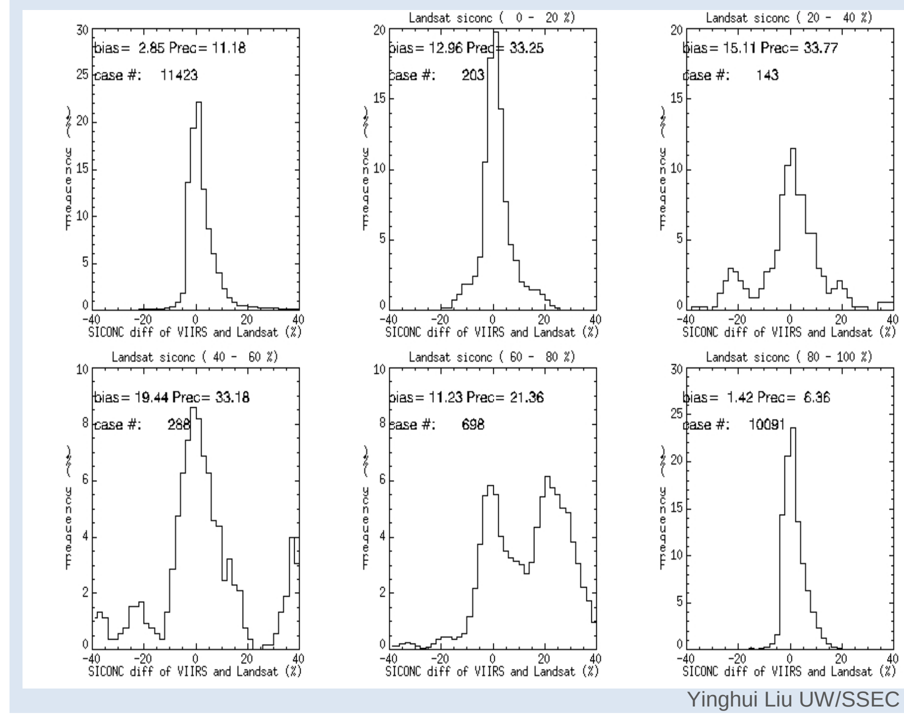
- Evaluation Approaches
  1. LANDSAT 8 derived ice concentration, quantitative comparisons to VIIRS SIC for 25 clear LANDSAT scenes(2014), for all available cases in 2013 and 2014
  2. Daily, global hemispheric VIIRS Sea Ice Concentration (SIC) and SSMIS passive microwave ice concentration visual and quantitative comparisons from 2012 to the present.
  3. Visual and quantitative comparisons with DigitalGlobe (DG) World View2 Multispectral reflectance images and derived SIC
  4. Visual comparison of NIC Weekly Ice Charts, VIIRS SDR false color reflectance imagery, MODIS Aqua MYD29 product for 30+ S-NPP/Aqua Simultaneous Nadir Overpass (SNO) scenes that span1 year and both hemispheres

(1) Comparison of VIIRS SIC to LANDSAT 8 (example)

Panel A



Panel B VIIRS vs. LANDSAT Ice Concentration

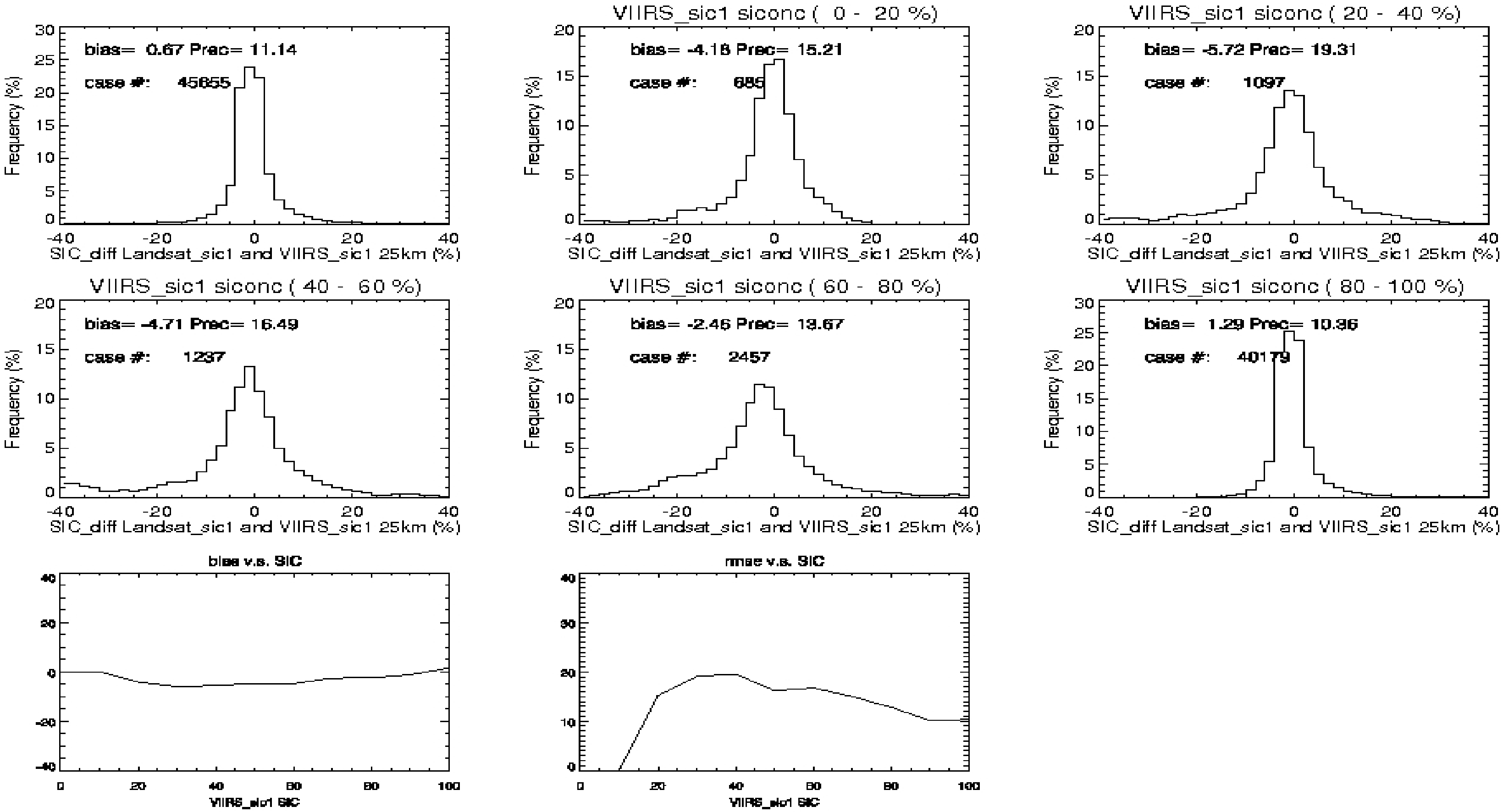


Panel A: upper image left to right: location of the scene, LANDSAT and VIIRS SDR false color image; Panel A, lower image left to right: Sea Ice Conc. from AMSR2, LANDSAT, and the Suomi NPP VIIRS on 4/21/2013 .

Ice Fraction Range	Total	0-20%	20-40%	40-60%	60-80%	80-100%
Bias	2.85	12.96	15.11	19.44	11.23	1.42
Precision	11.18	33.25	33.77	33.18	21.36	6.36

Panel B: Ice concentration differences between VIIRS and LANDSAT for all cases (top left) and cases with LANDSAT sea ice concentration in the ranges 0–20%, 20–40%, 40–60%, 60–80%, and 80–100%. Measurement accuracy (bias) and measurement precision (Prec) are indicated for each bin.

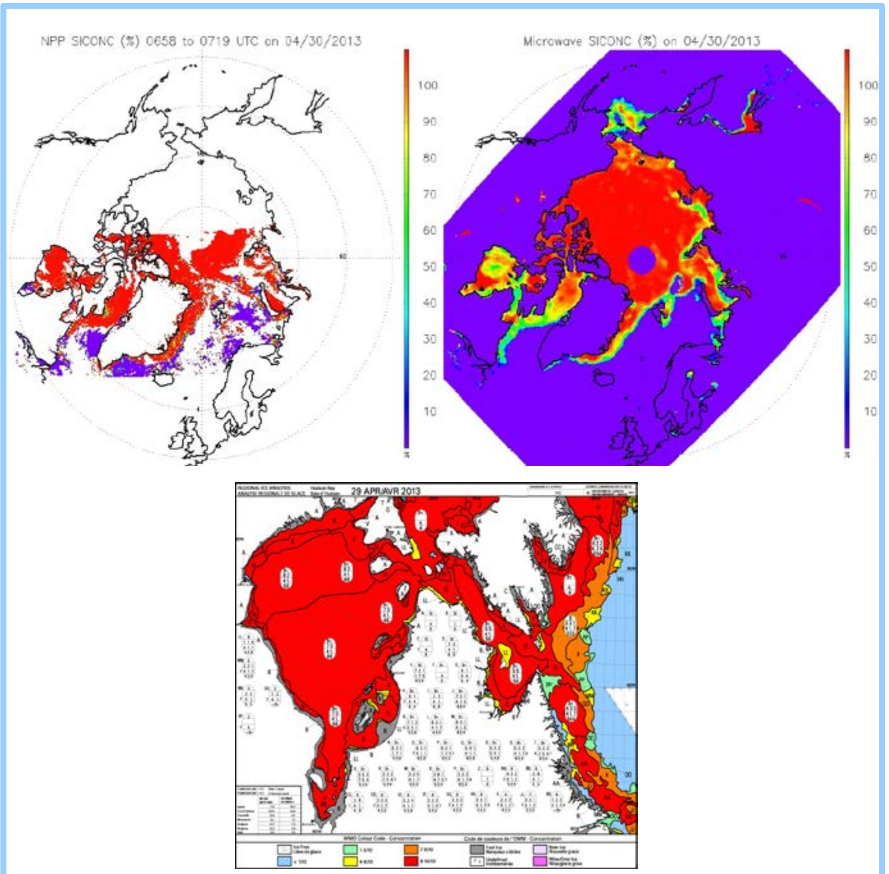
(1) Comparison of VIIRS SIC to LANDSAT (all cases from 2013 and 2014)



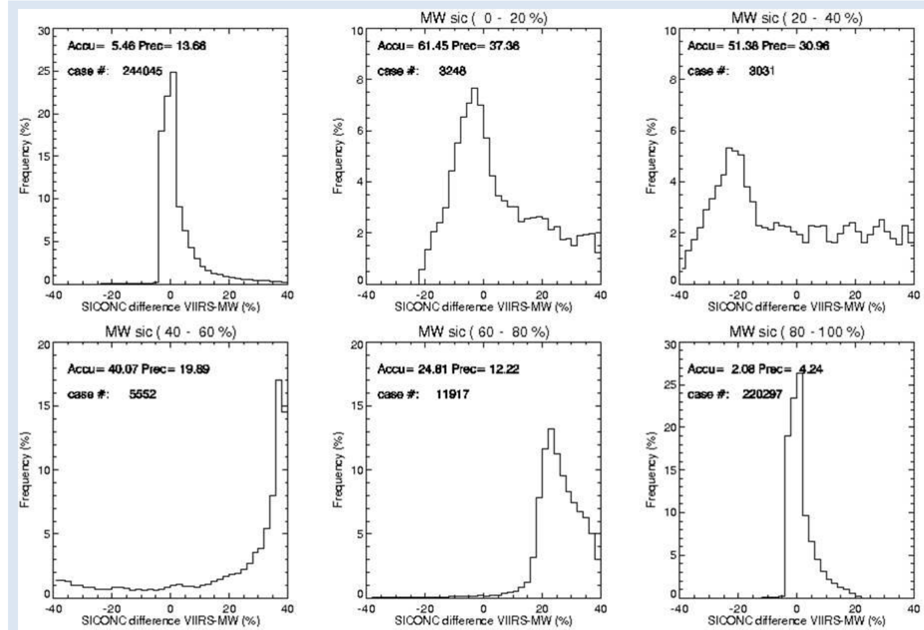
Ice Fraction Range	Total	0-20%	20-40%	40-60%	60-80%	80-100%
Bias	0.67	-4.18	-5.72	-4.71	-2.46	1.29
Precision	11.14	15.21	19.31	16.49	13.67	10.36

(2) Comparison of VIIRS SIC to Passive Microwave and Ice Chart (example)

Panel A



Panel B



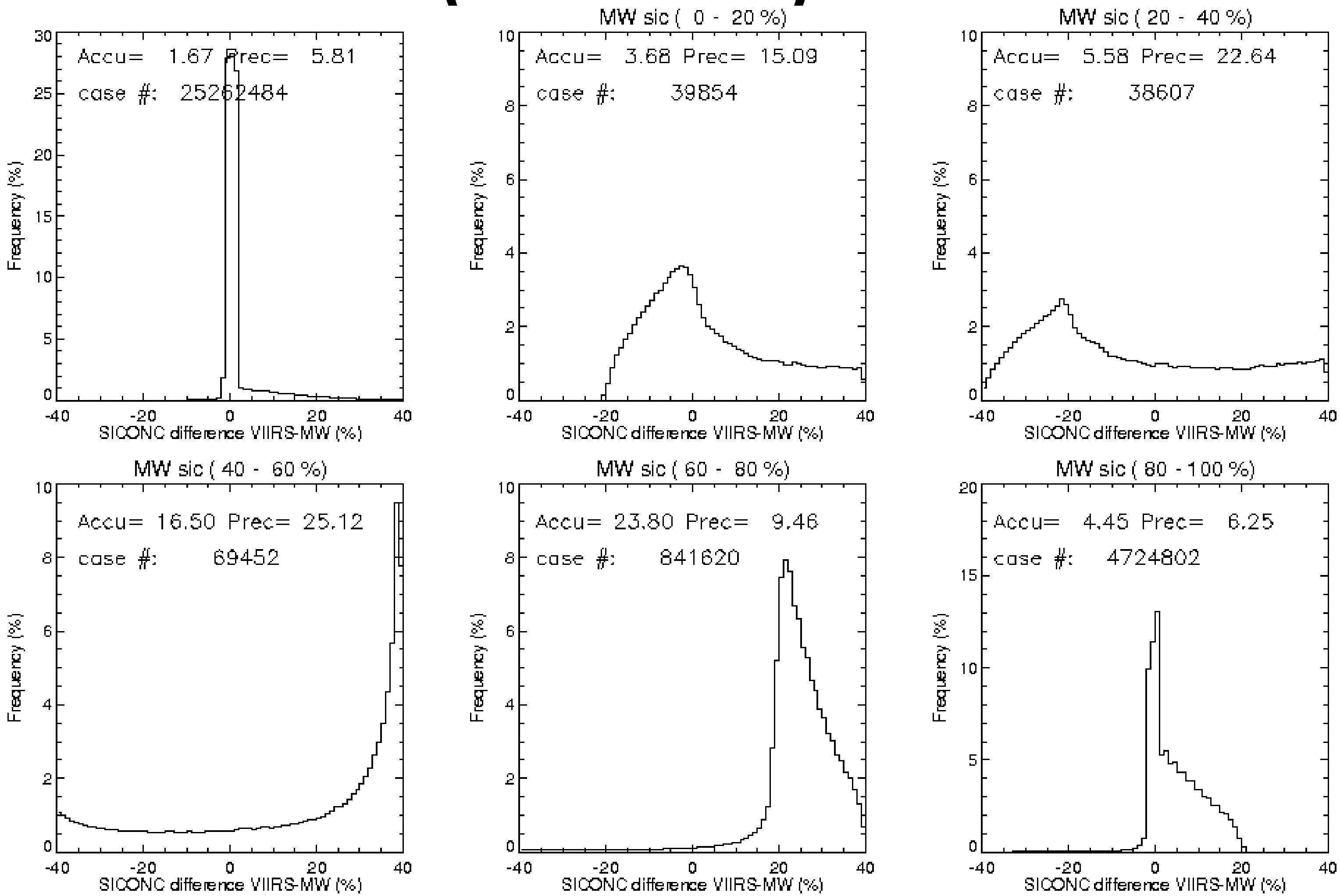
Yinghui Liu UW/SSEC

Ice Fraction Range	Total	0-20%	20-40%	40-60%	60-80%	80-100%
Accuracy	5.46	61.45	51.38	40.07	24.81	2.08
Precision	13.66	37.36	30.96	19.89	12.22	4.24

Panel A: Ice Concentration from S-NPP VIIRS Sea Ice Concentration IP (top left), SSMIS using NASA team algorithm (top right) on April 30, 2013, and from the weekly ice chart on April 29th 2013 from the Canadian Ice Service (bottom right).

Panel B: Accuracy and precision and ice concentration difference histograms for total, 0-20%, 20-40%, 40-50%, 0-80% and 80-100% ice fraction range.

(2) Comparison of VIIRS SIC to Passive Microwave (2012-2015)



Ice Fraction Range	Total	0-20%	20-40%	40-60%	60-80%	80-100%
Accuracy	1.67	3.68	5.58	16.50	23.80	4.45
Precision	5.81	15.09	22.64	25.12	9.46	6.25

(3) Comparison of VIIRS SIC to DigitalGlobe (DG) derived SIC in melting season

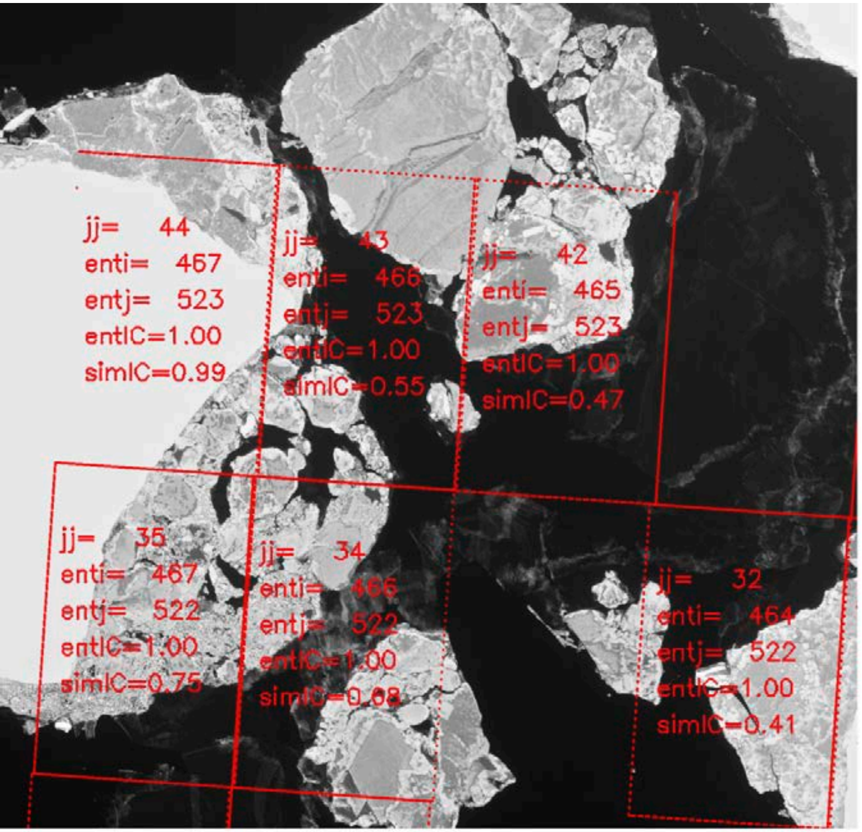


Figure 1 Example pixels of Enterprise IC vs Dig Glb Simulated IC
May 10, 2014 VIIRS Time: 18:29 UT Dig Glb Time: 18:15 UT
21 Enterprise FOVs with valid Ice Concs
Bias= -0.29 Stddev= 0.20 RMS= 0.35
Digital Globe WV2 Multispectral Band 1 Spatial Resolution ~ 2m
Red boxes are VIIRS Moderate band FOVs Spatial resolution ~800m
Values in boxes are: Box number, FOV column, FOV row, Enterprise Ice Conc, Simulated Ice Conc

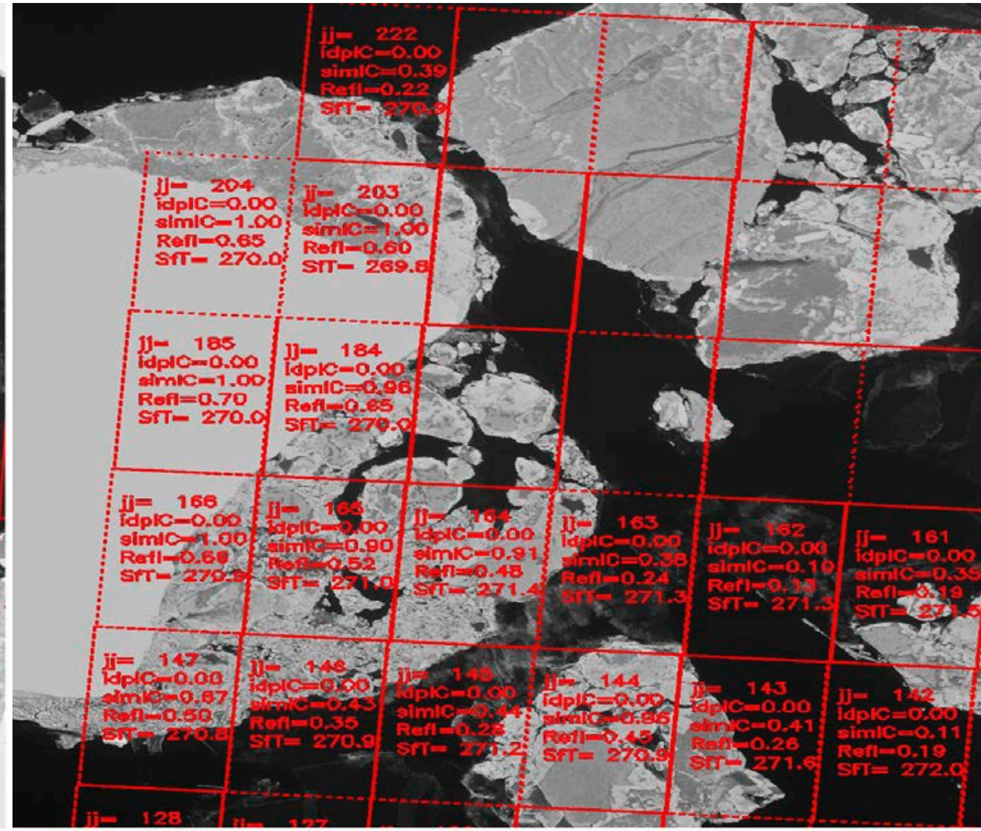
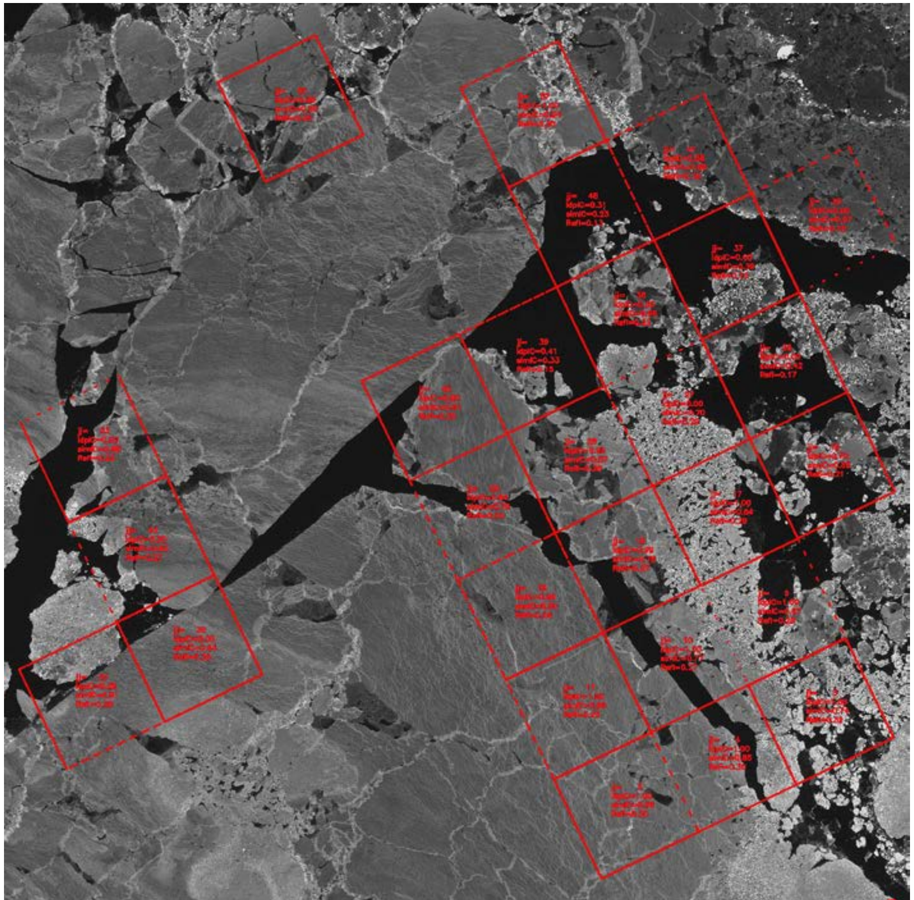


Figure 2 Example pixels of IDPS IC vs Dig Glb Simulated IC
May 10, 2014 VIIRS Time: 18:29 UT Dig Glb Time: 18:15 UT
71 IDPS FOVs with valid Ice Concs
Bias= 0.362 Stddev= 0.317 RMS= 0.48
Digital Globe WV2 Multispectral Band 1 Spatial Resolution ~ 2m
Red boxes are VIIRS Image band FOVs Spatial resolution ~400m
Values in boxes are: Box number, IDPS Ice Conc, Simulated Ice Conc, VIIRS I1 Band Reflectance and VIIRS Surface Temperature

Enterprise

IDPS

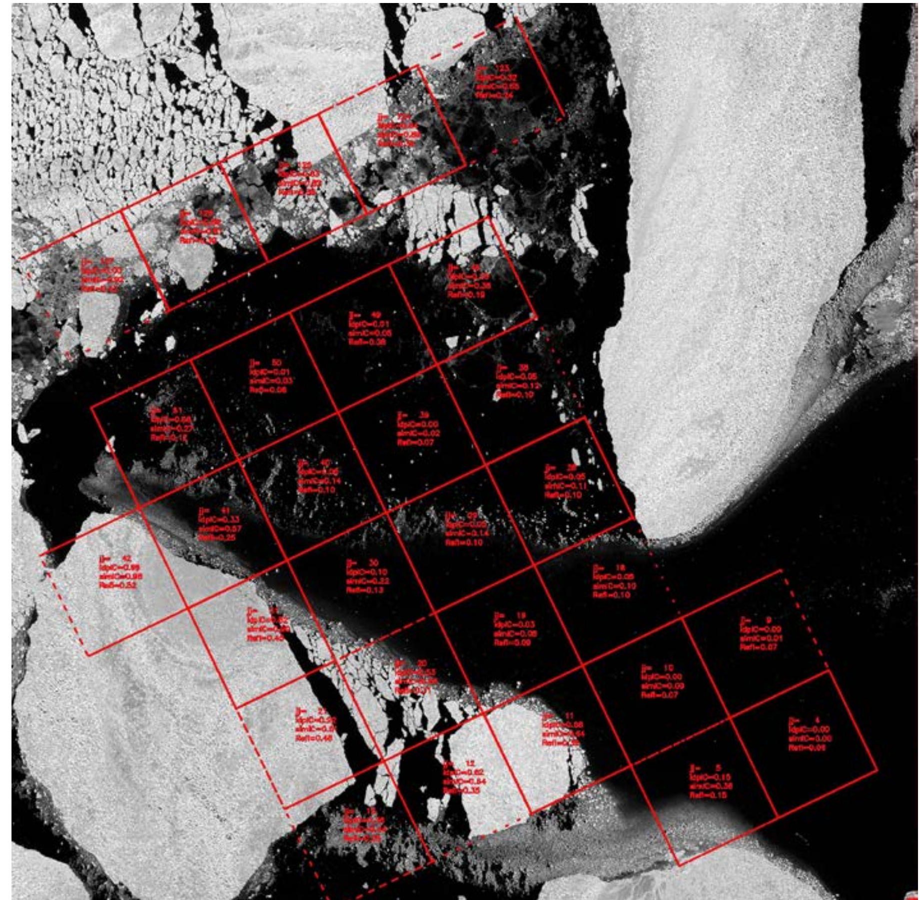
(3) Comparison of VIIRS SIC to DigitalGlobe (DG) derived SIC in non-melting season



March 21, 2014
VIIRS Time: 22:24 UT
Dig Glb Time: 22:25 UT
Row 2 Column 2

Statistics From this example:
27 VIIRS FOVs with valid Ice Concs
Bias= 0.151 Stddev= 0.393 RMS= 0.41

Digital Globe WV2 Multispectral Band 1 Spatial Resolution ~ 2m
Red boxes are VIIRS Image band FOVs Spatial resolution ~400m
Values in boxes are: Box number
VIIRS Ice Conc, Simulated Ice Conc,VIIRS I1 Band Reflectance



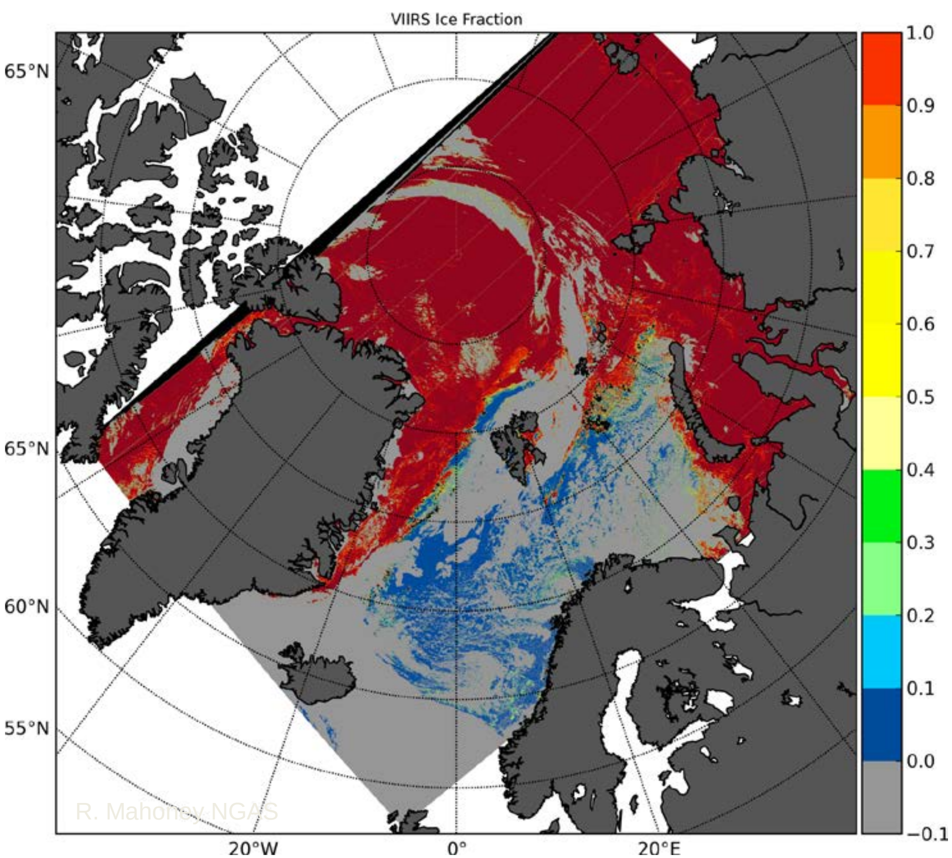
March 21, 2014
VIIRS Time: 22:24 UT
Dig Glb Time: 22:25 UT
Row 8 Column 2

Statistics From this example:
29 VIIRS FOVs with valid Ice Concs
Bias= 0.117 Stddev= 0.181 RMS= 0.21

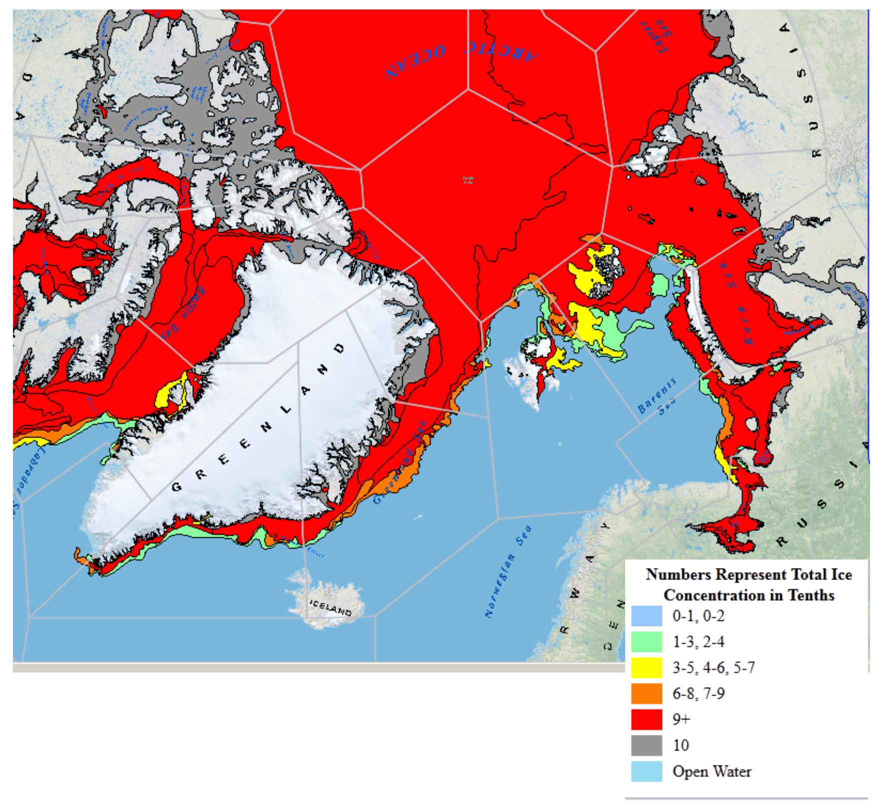
Digital Globe WV2 Multispectral Band 1 Spatial Resolution ~ 2m
Red boxes are VIIRS Image band FOVs Spatial resolution ~400m
Values in boxes are: Box number
VIIRS Ice Conc, Simulated Ice Conc,VIIRS I1 Band Reflectance

(4) Comparison of VIIRS SIC to National Ice Center Ice Charts (night scene example)

VIIRS Ice Concentration IP Feb. 20, 2014 (04:39-04:46 UTC)

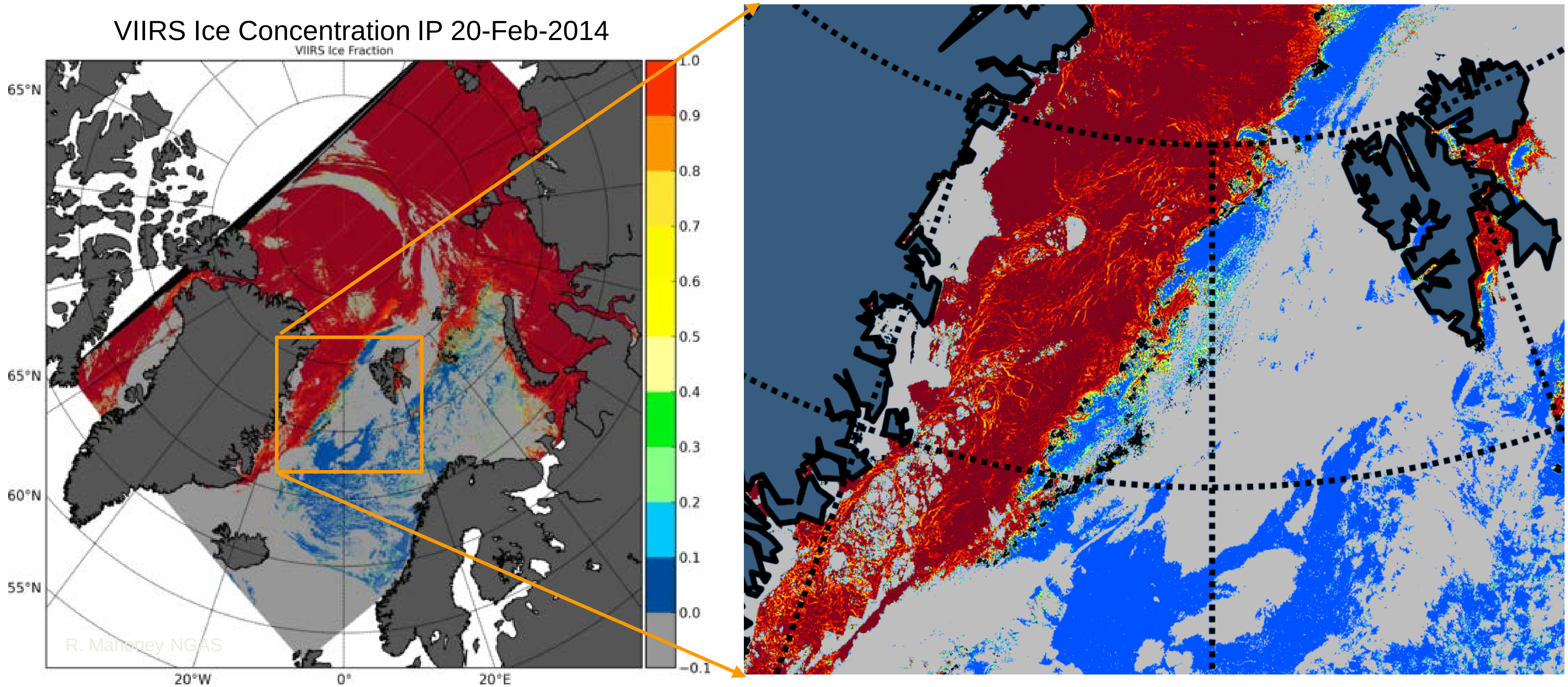


Reference: http://www.natice.noaa.gov/ps/javascriptproductviewer/index.html



VIIRS Ice Concentration IP for Feb. 20, 2014 night scene is consistent with that of the corresponding National Ice Center weekly ice chart for Feb. 20, 2014 and the ice extent matches extremely well

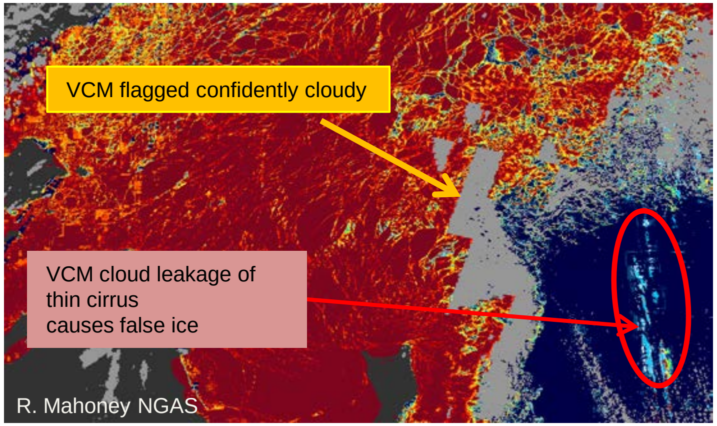
VIIRS SIC Shows Detailed Structure of Ice Edges and Leads

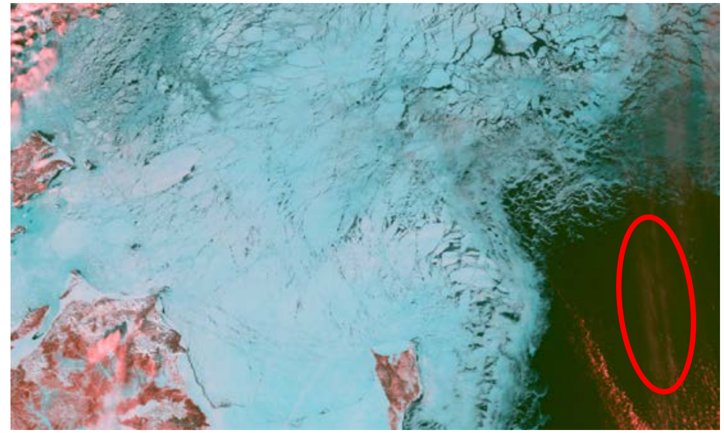


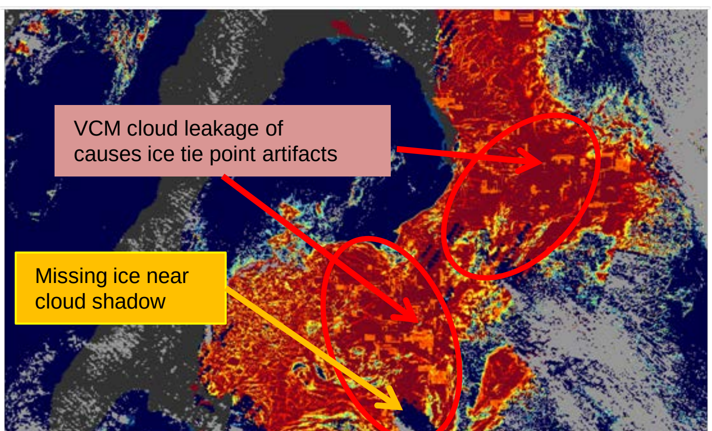
Zoom of boxed region. Note that the zoom is not at full resolution (zoom of sub-sampled, mapped image)

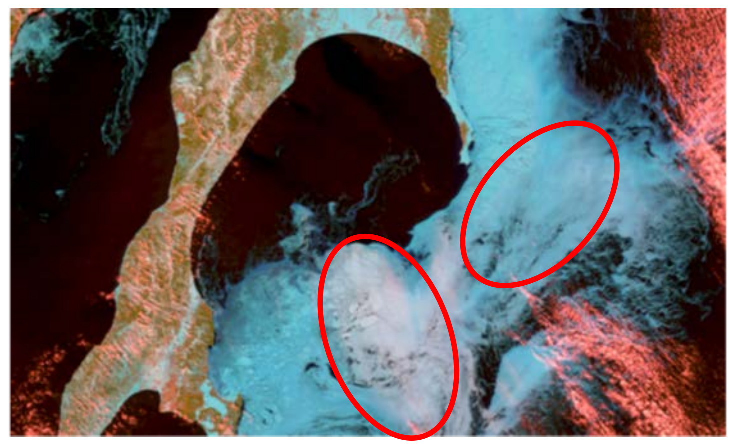
Detailed structure of the ice edge and leads can be seen in the Ice Concentration IP as shown in the zoomed subset region in the right figure. The current Ice Concentration IP if produced as a product should allow users to identify ice edges more accurately.

Comparison of VIIRS SIC to Zoomed VIIRS False Color SDR for Day Scenes – Issues



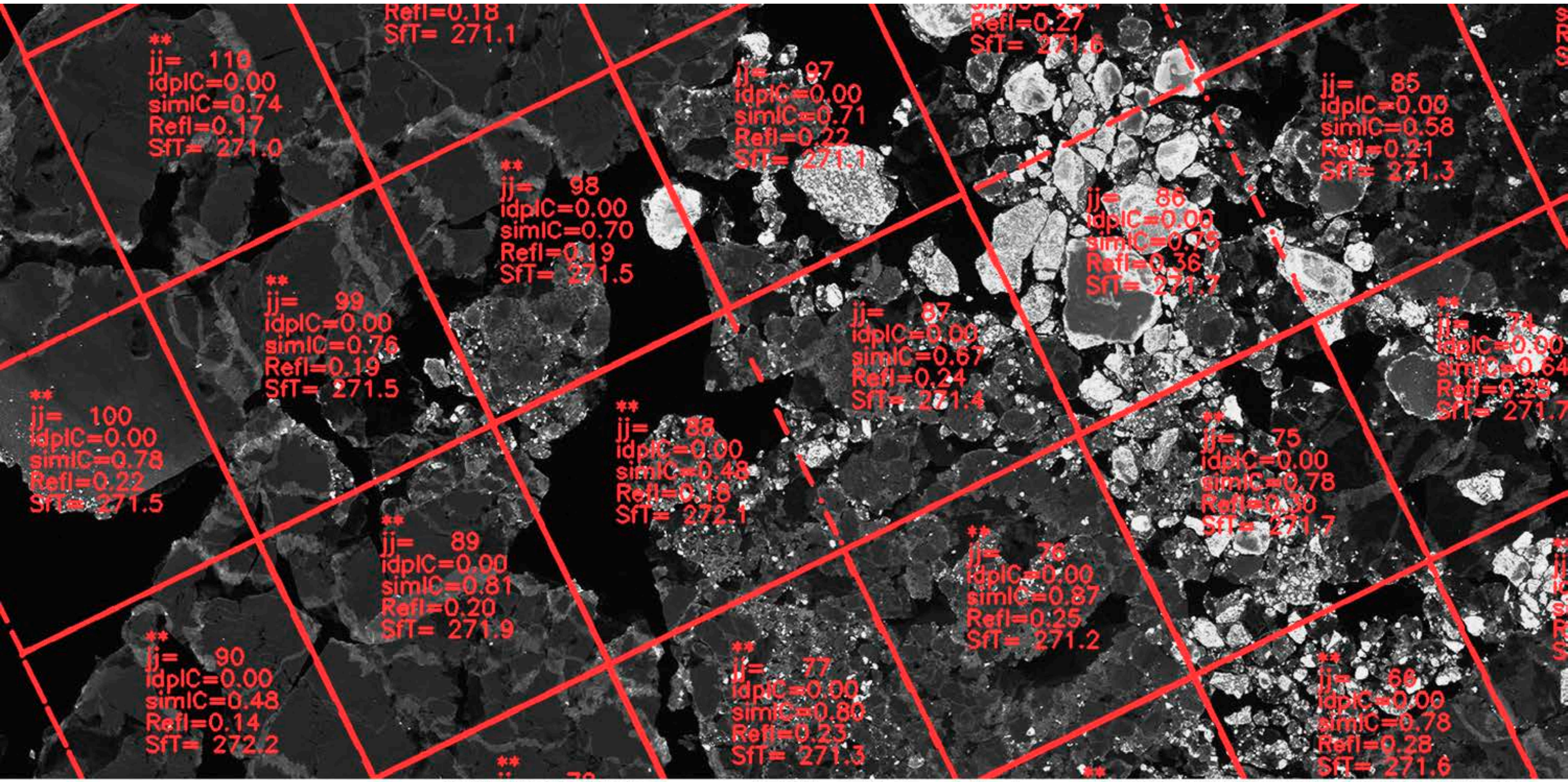






(1) Rectangular fill values are associated with VCM positive M7 and M1 threshold test triggered by out of date manually updated GMASI snow/ice (top left). (2) False ice is seen in the product (top left) corresponding undetected thin cirrus (red circle, top right). (3) Rectangular and linear artifacts seen within the circled regions in the VIIRS Ice Concentration IP (bottom left) are thought to be associated with ice tie point window fall back to default values. This often occurs over regions with ill defined ice tie point histogram peaks such as regions with undetected clouds as shown within the red circled regions in the false color SDR reflectance image (lower right). A possible fix is to fall back to a running mean ice tie point in instead of a global default.

Comparison of VIIRS SIC to DigitalGlobe (DG) derived SIC in non-melting season – Issues



Section of Dig Glb tile R1C2
IDPS IC vs Dig Glb Simulated IC
March 21, 2014 VIIRS Time: 22:24 UT Dig Glb Time: 22:25UT
Bering Sea off of SE coast of Alaska (lat= 58.7 N, lon= -161.9)

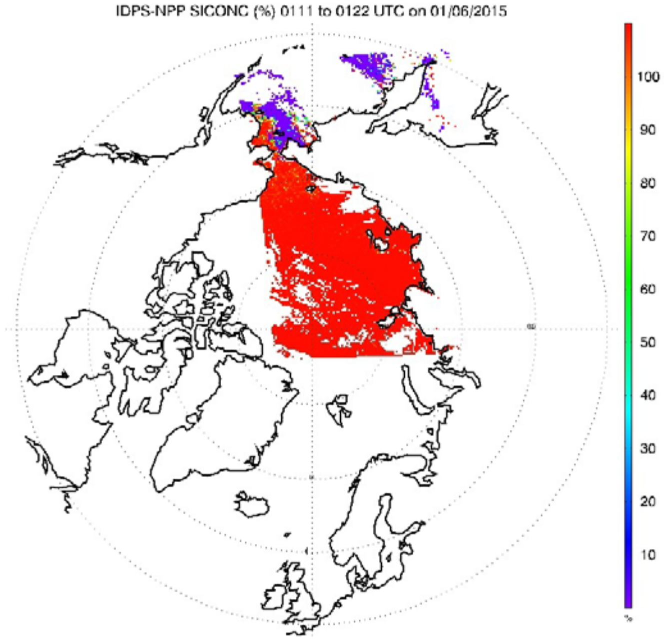
31 IDPS FOVs with valid Ice Concs
Bias= 0.69 Stddev= 0.18 RMS= 0.72
FOVs with ** were used in comparison
FOVs with no ** are cloud shadowed and not used in comparison statistics

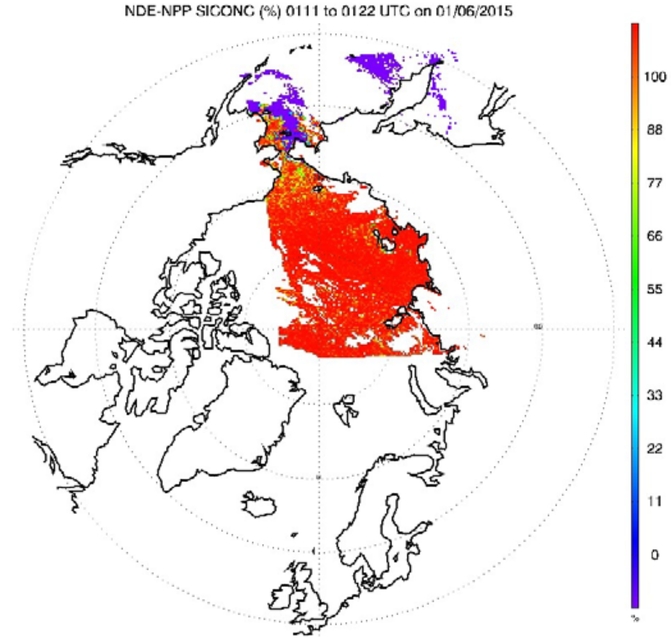
For this tile, 26 of the 31 non shadowed VIIRS FOVs had an IDPS IC=0.0 with the simulated IC > 0.4
All 26 of these FOVs had indeterminate reflective Ice Tie Points

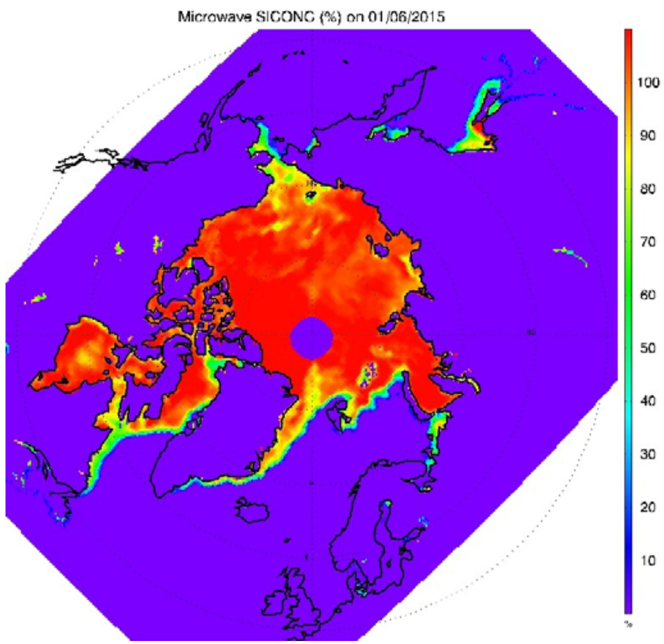
Digital Globe WV2 Multispectral Band 1 Spatial Resolution ~ 2m
Red boxes are VIIRS Image band FOVs Spatial resolution ~400m
Values in boxes are: Box number, IDPS Ice Conc, Simulated Ice Conc, VIIRS I1 Band Reflectance and VIIRS Surface Temperature

Enterprise SIC

IDPS, Enterprise SIC with MW SIC on January 6, 2015







VIIRS SICs to DG derived SIC in melting season

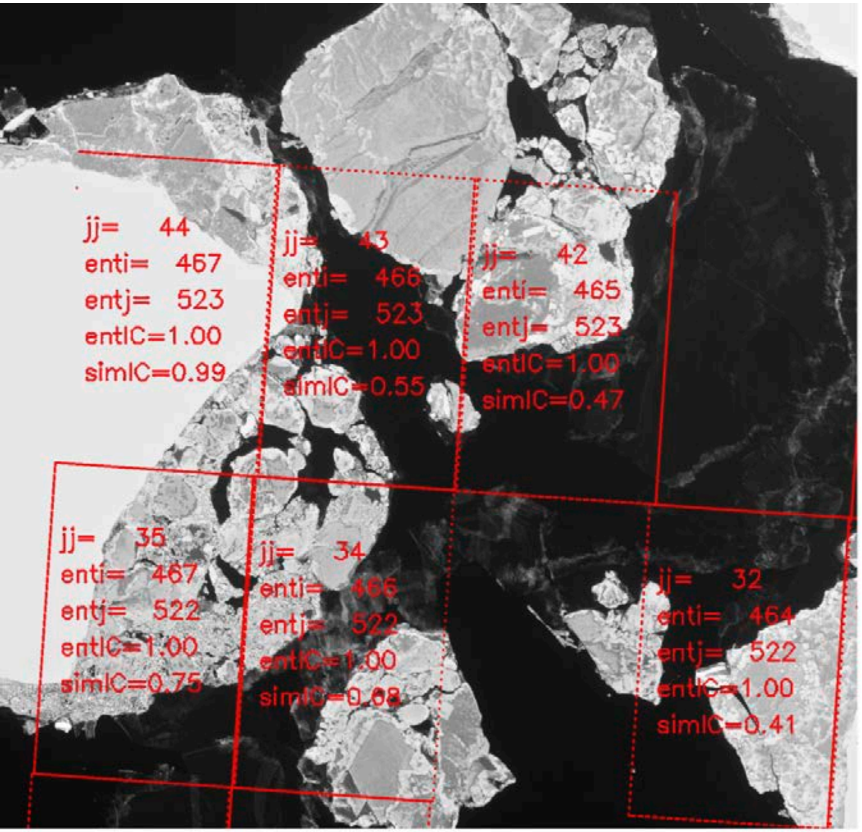


Figure 1 Example pixels of Enterprise IC vs Dig Glb Simulated IC
May 10, 2014 VIIRS Time: 18:29 UT Dig Glb Time: 18:15 UT
21 Enterprise FOVs with valid Ice Concs
Bias= -0.29 Stddev= 0.20 RMS= 0.35
Digital Globe WV2 Multispectral Band 1 Spatial Resolution ~ 2m
Red boxes are VIIRS Moderate band FOVs Spatial resolution ~800m
Values in boxes are: Box number, FOV column, FOV row, Enterprise Ice Conc, Simulated Ice Conc

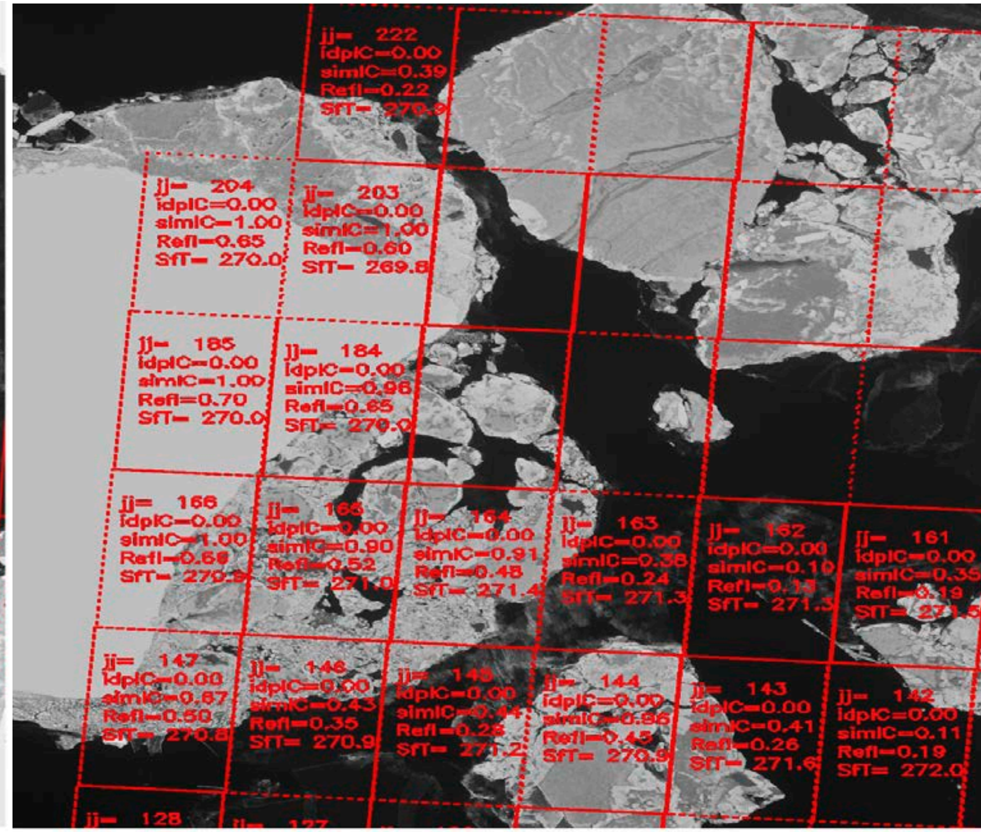


Figure 2 Example pixels of IDPS IC vs Dig Glb Simulated IC
May 10, 2014 VIIRS Time: 18:29 UT Dig Glb Time: 18:15 UT
71 IDPS FOVs with valid Ice Concs
Bias= 0.362 Stddev= 0.317 RMS= 0.48
Digital Globe WV2 Multispectral Band 1 Spatial Resolution ~ 2m
Red boxes are VIIRS Image band FOVs Spatial resolution ~400m
Values in boxes are: Box number, IDPS Ice Conc, Simulated Ice Conc, VIIRS I1 Band Reflectance and VIIRS Surface Temperature

Enterprise

IDPS

SIC EDR requirement

1. Clear	1.0 km	0.5 km
2. All Weather	No capability	1 km
c. Mapping Uncertainty, 3 Sigma		
1. Clear	1 km at Nadir	0.5 km
2. Cloudy	No capability	1 km
d. Measurement Range	0 - 100%	0 - 100%
e. Measurement Accuracy	10% (Notes 1, 2, 3)	5%
f. Measurement Uncertainty	25% (Notes 1, 2, 3)	10%
g. Refresh	At least 90% coverage of the globe every 24 hours (monthly average)	6 hrs.
h. Geographic coverage	All ice-covered regions of the global ocean	All ice-covered regions of the global ocean
		v3.0, 8/27/14

Notes:

1. VIIRS produces sea ice concentration in clear sky conditions only.
2. Performance Exclusion Conditions:
   a. VCM IP cloud confidence: confidently cloudy and probably cloudy.
   b. Sun glint regions

Summary

- **Detailed structure of Ice edges and ice leads are observable in the VIIRS Sea Ice Concentration IP** at VIIRS Imagery resolution for both day and night, out to edge of scan based on visual comparisons
  - Ice extent compares well with VIIRS SDR False color imagery, National Ice Center Ice Charts, MODIS Aqua/MYD29 (see backup slide) reference data and full resolution zoomed VIIRS SDR reflectance imagery

- Quantitative performance based on comparison with LANDSAT ice fractions show relatively small bias and good precision for the total (0.67% and 11%) and high ice fraction range (1.29% and 10.36%), with relatively reduced performance for mid range ice fractions (5% and 20% in bias and precision) based cases from 2013 and 2014

- Quantitative performance based on comparison with ice fractions from microwave products show small bias and good precision for the total (1.67% and 5.81%) and very high high ice fraction (4.45% and 6.25), but very high positive bias and relatively low precision for mid range ice fractions (23.8% and 9.46%) using collocated cases from 2012 to 2015.

- Quantitative performance based on comparison with ice fractions from DigitalGlobe show large bias and precision in the melting season, and relatively smaller bias and good precision in the non-melting season.

- Improvement in VCM will improve the VIIRS Ice Concentration IP performance. The VIIRS Ice Concentration IP performance in the melting season needs further improvement.

Conclusions

• Observed performance of the VIIRS Ice Concentration IP is such that this product has high potential to become an extremely useful JPSS product due to its high spatial resolution in both day and night.

• Performance evaluation indicates that the VIIRS Ice Concentration IP in its current state may already be an extremely useful product for identifying ice extent for both day and night for clear sky conditions

• The VIIRS Ice Concentration IP for NPP is a currently non-deliverable Retained Cal/Val IP. Promotion to a deliverable product will require minor level of effort for addition of product quality flags, implementation of extended cloud adjacency quality flagging and correction of minor defects

•The VIIRS Ice Concentration using Enterprise algorithm is expected to perform better than the IDPS product.

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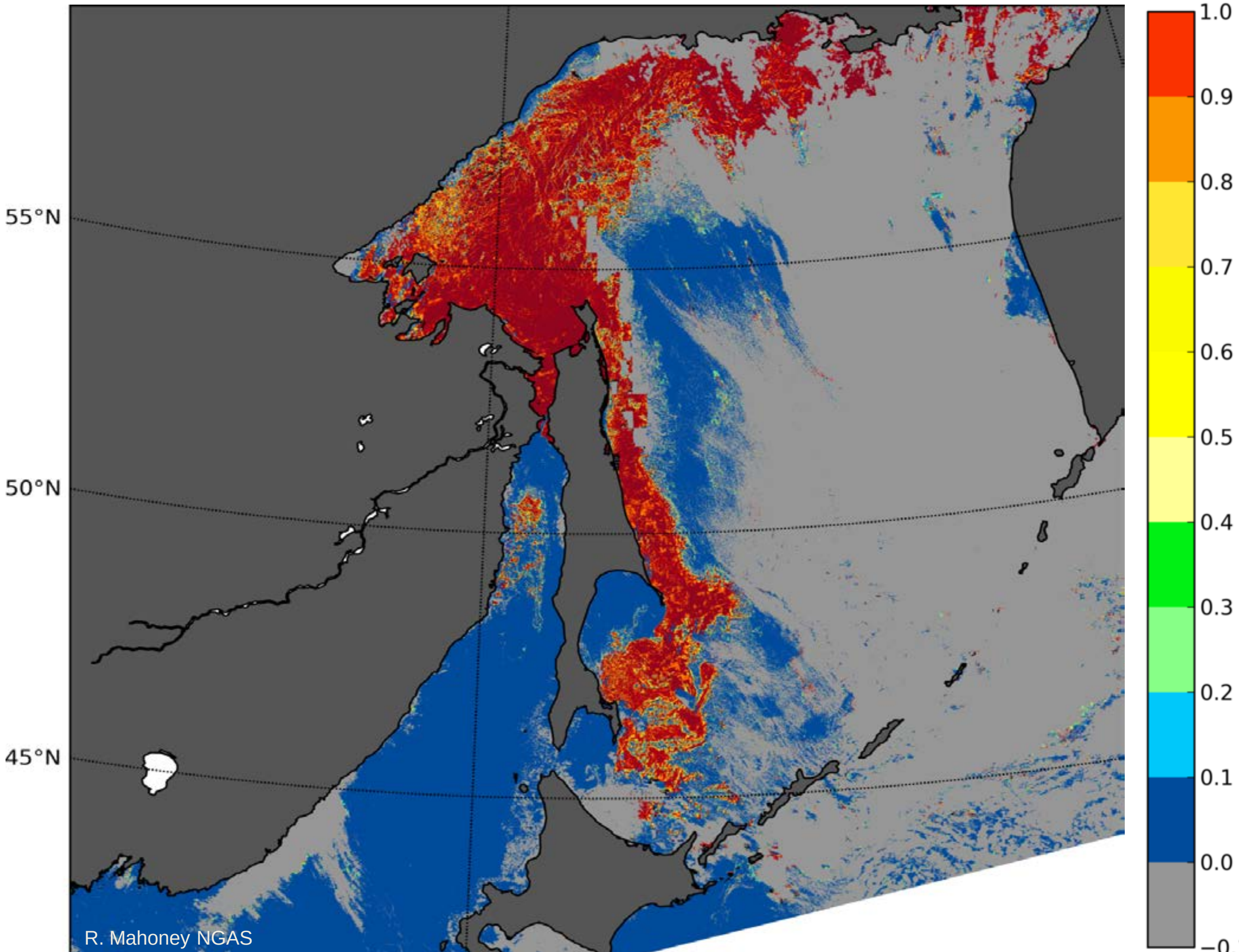
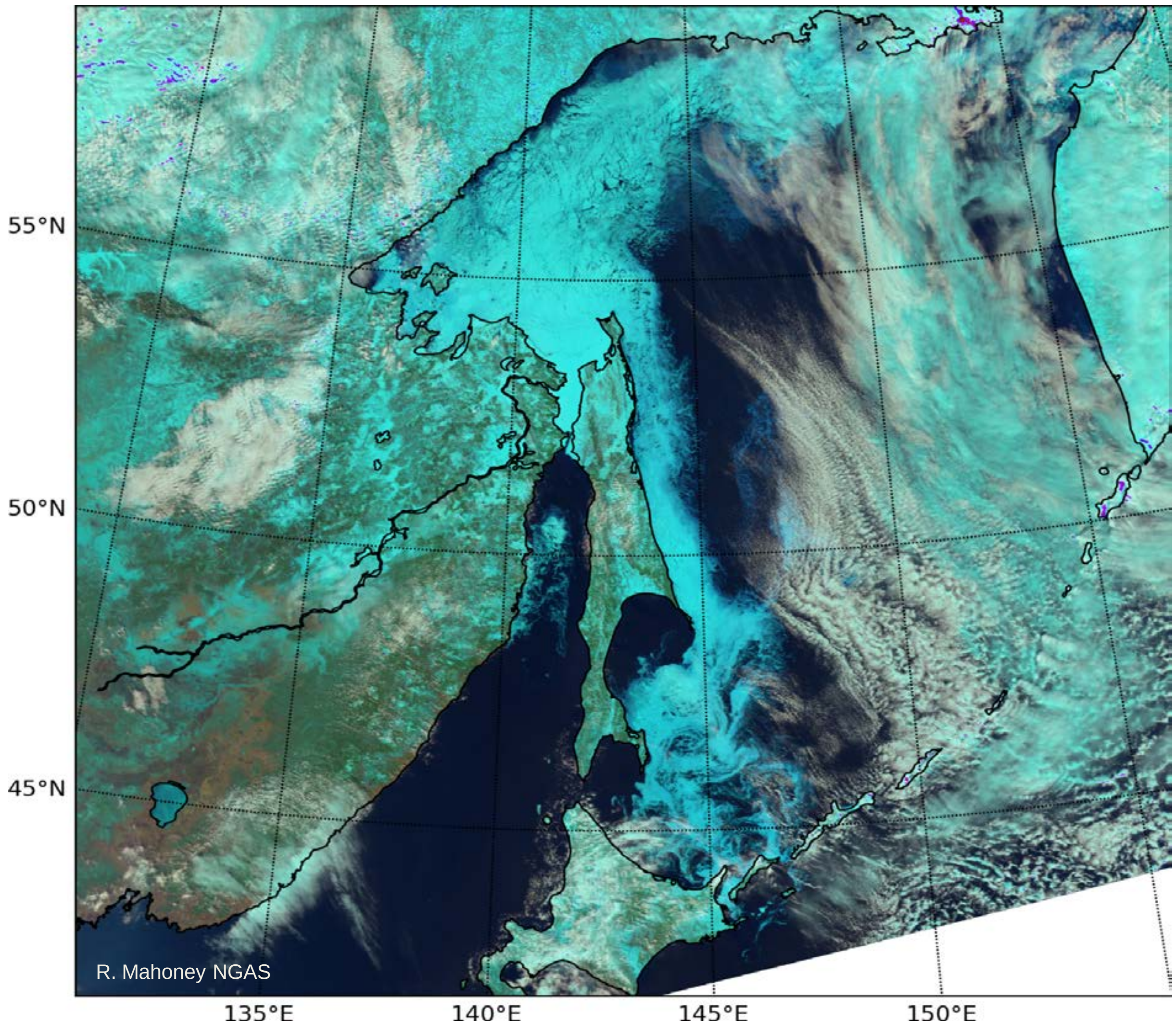
Backup slide

Comparison of VIIRS Ice Conc. to VIIRS False Color SDR for Day Scene



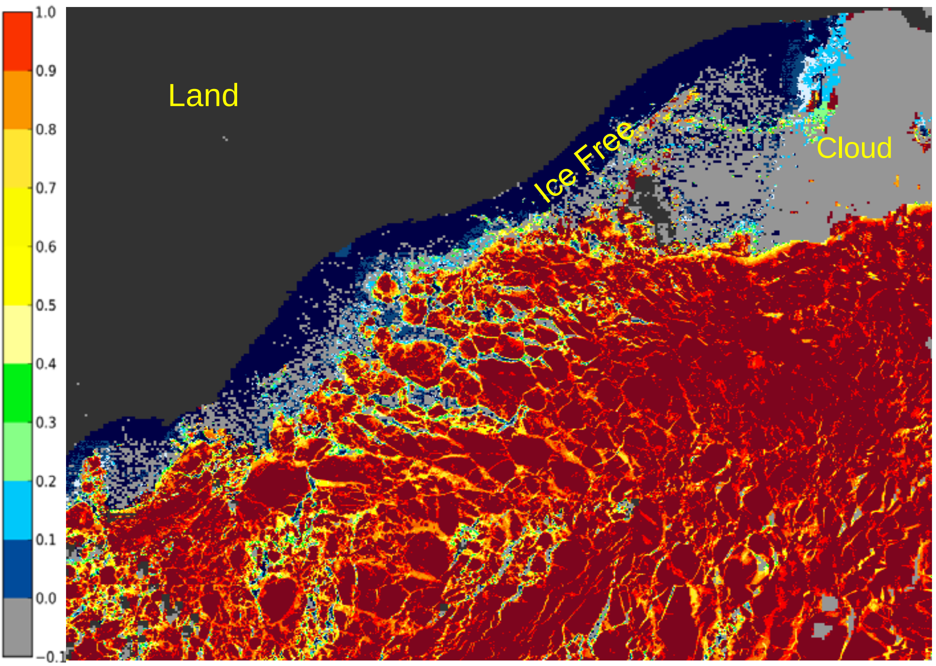
The ice edges seen in the VIIRS Ice Concentration IP typically closely match ice edges seen in false color SDR reflectance band imagery as in this day case of melting sea ice in the Sea of Okhotsk (March 23, 2014, 03:05-03:11 UTC)

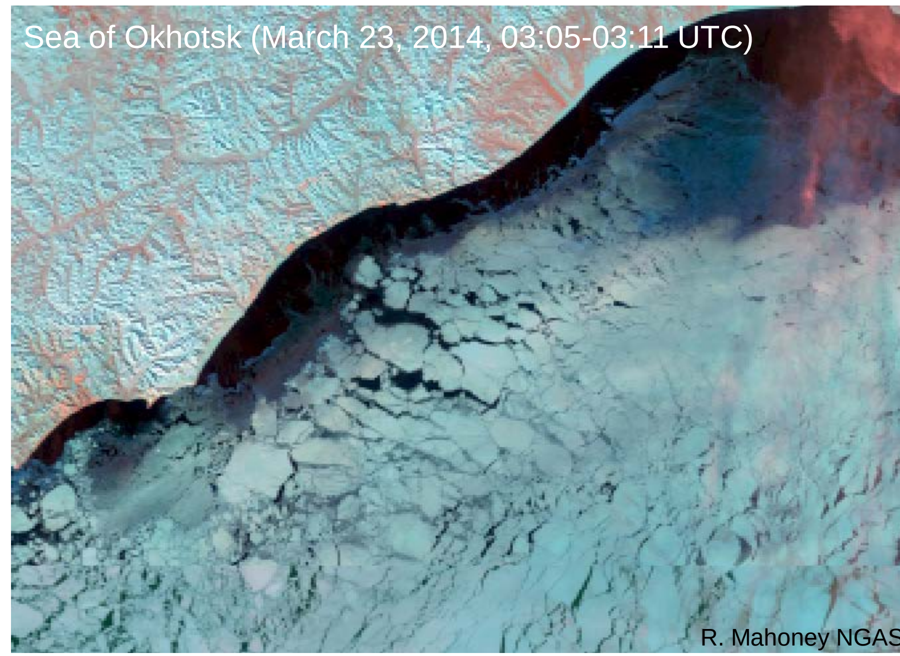
Comparison of VIIRS Ice Conc. to VIIRS False Color SDR for Day Scenes



Reference false color VIIRS SDR reflectance band imagery showing melting sea ice over the Sea of Okhostk for March 23, 2014.

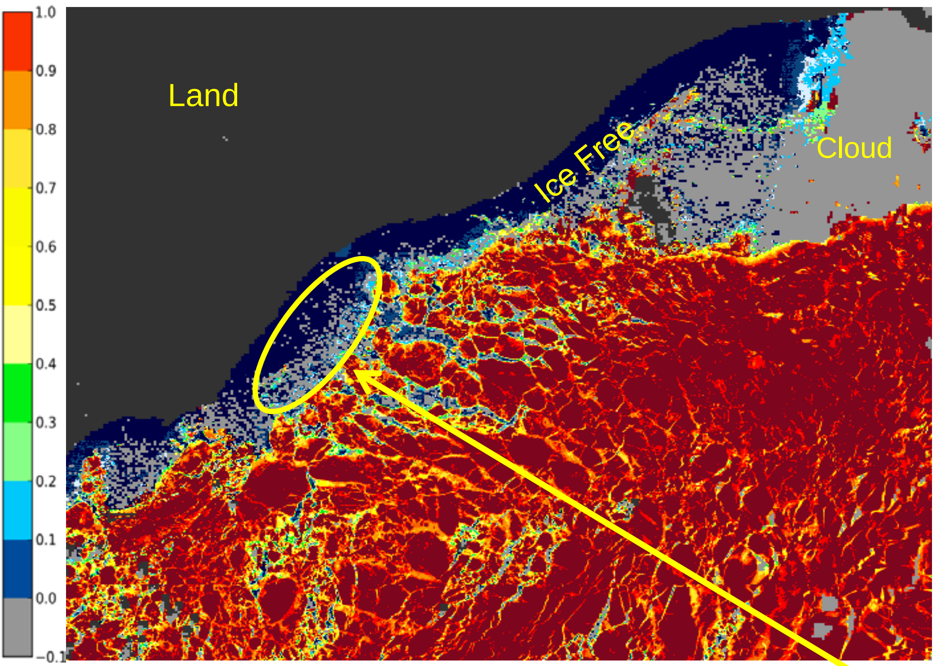
Comparison of VIIRS Ice Conc. to VIIRS False Color SDR for Day Scenes – Full Resolution Zoom

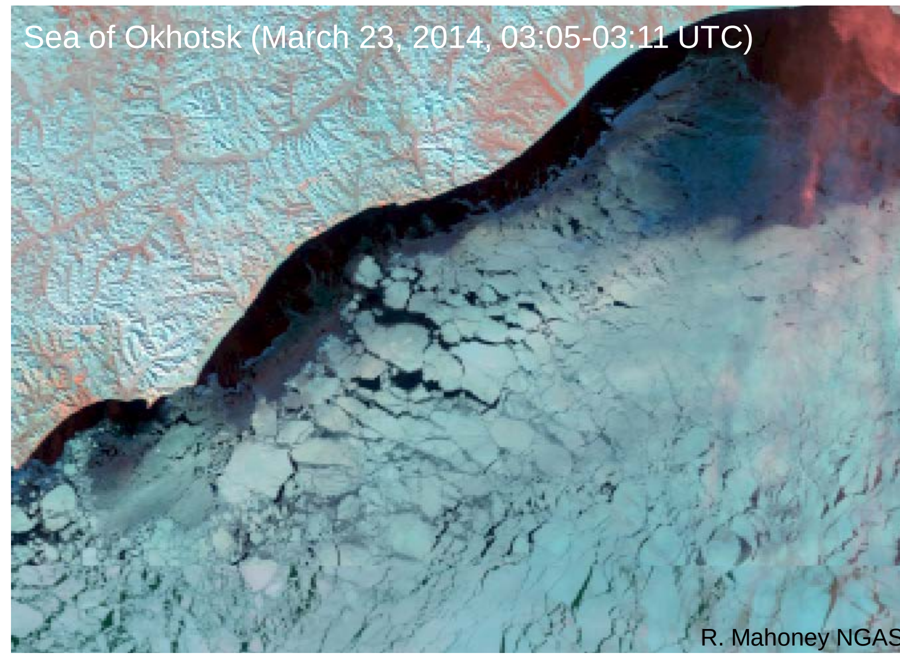




VIIRS Ice Concentration IP (left) shows fine detail of ice edge and lead features. An ice fraction threshold of 0.1 yields an ice extent that very closely matches the ice edges seen in the corresponding VIIRS SDR reflectance band imagery zoomed at full VIIRS imagery resolution (right).

Comparison of VIIRS SIC to VIIRS False Color SDR for Day Scenes – Issues





Many pixels near ice edges are flagged by VCM as confidently cloudy are clear in the corresponding false color SDR image

Many ice edge pixels however, are flagged as confidently cloudy by the VCM and are not retrieved by the ice concentration algorithm.

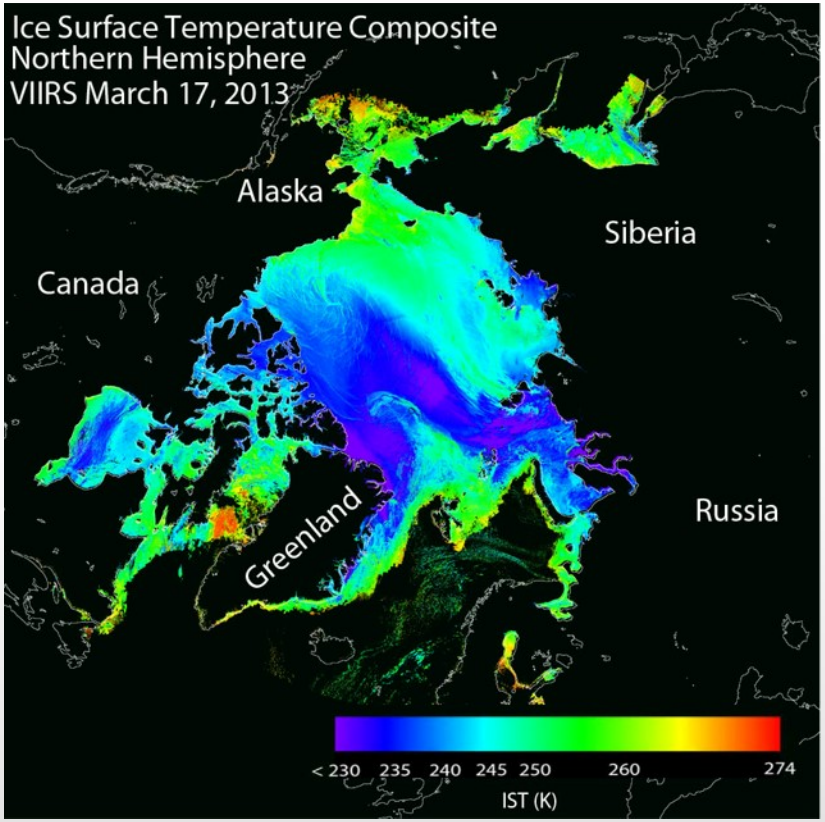
Suomi- NPP VIIRS
Ice Surface Temperature Status

Mark Tschudi (CU)*

Yinghui Liu (UWisc), Richard Dworak (UWisc), Dan Baldwin (CU), Jeff Key (NOAA)

VIIRS Ice Surface Temperature

IST is the radiating, or "skin", temperature at the ice surface. It includes the aggregate temperature of objects comprising the ice surface, including snow and melt water on the ice.



Summary of the VIIRS IST EDR

- The VIIRS Ice Surface Temperature (IST) EDR provides surface temperatures retrieved at VIIRS moderate resolution (750m), for Arctic and Antarctic sea ice for both day and night.
- The baseline split window algorithm statistical regression method is based on the AVHRR heritage IST algorithm *(Key and Haeflinger.,* 1992)

$$IST = a_o + a_1 T_{M15} + a_2(T_{M15} - T_{M16}) + a_3(\sec(z) - 1)$$

T_{M15} and T_{M16} : VIIRS TOA TB's for the VIIRS M15 and M16 bands

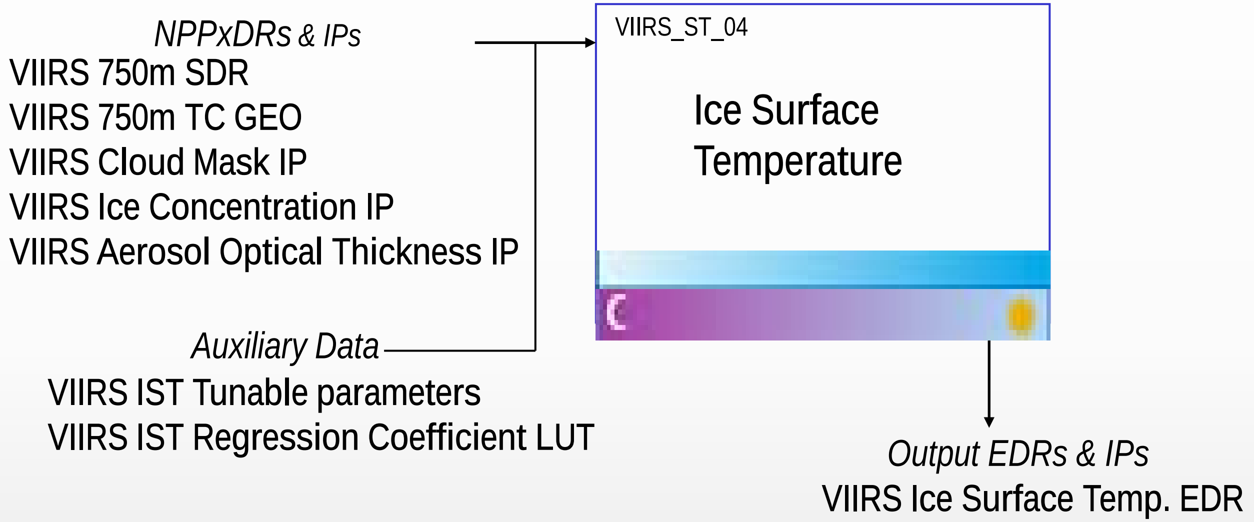
z: the satellite zenith angle

$a_{o,}$ $a_{1,}$ $a_{2,}$ a_3 : regression coefficients.

- Threshold Measurement Uncertainty = **1K** over a measurement range of 213–275 K.

Key, J., and M. Haefliger (1992), Arctic ice surface temperature retrieval from AVHRR thermal channels, J. Geophys. Res., 97(D5), 5885–5893.

Flow for the VIIRS Operational (IDPS) IST



VIIRS IST EDR Validation with IceBridge IST

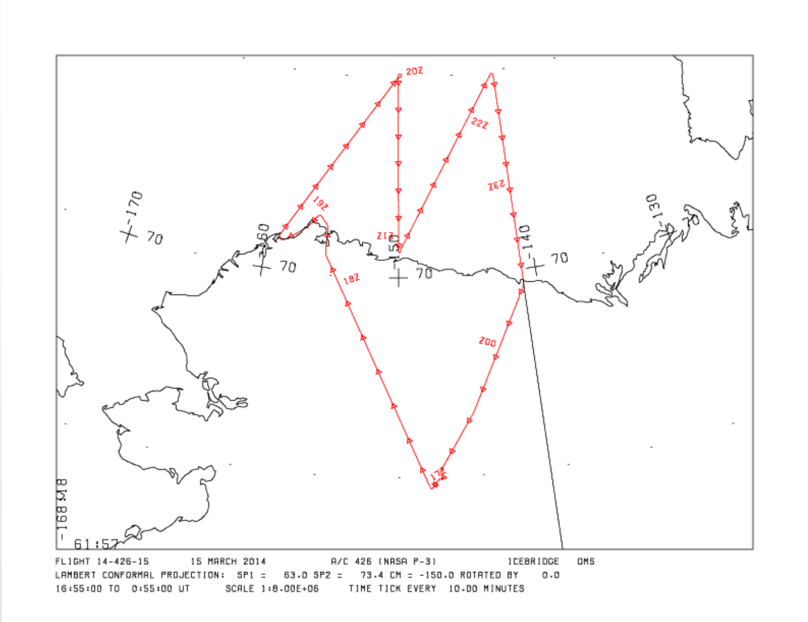
- IceBridge NASA P-3 aircraft carries a KT-19: a downward-pointing, IR pyrometer that measures IST
- No atmospheric corrections applied
- Spot size = 15m
- Resolution = 0.1° C
- Sampling = 10Hz

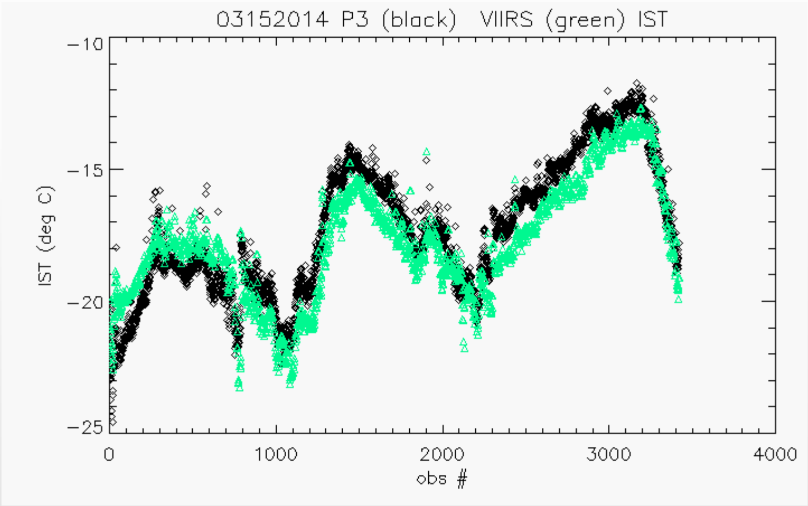
Krabill, W. B. and E. Buzay. 2012, updated 2014. IceBridge KT19 IR Surface Temperature. Boulder, Colorado USA: NASA DAAC at the National Snow and Ice Data Center.

VIIRS IST IceBridge Validation

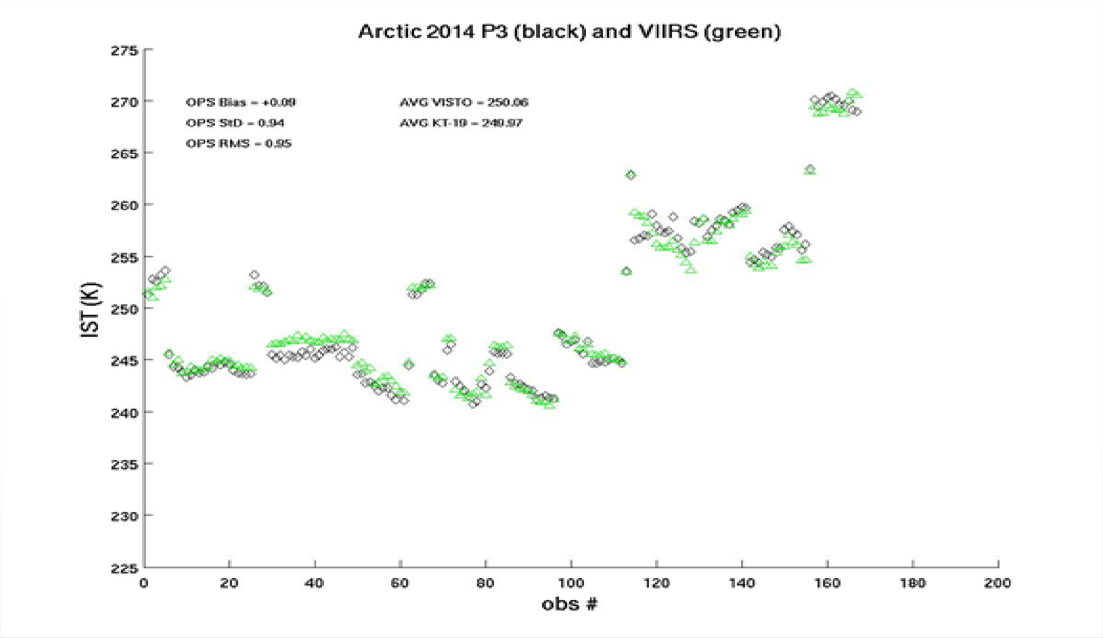
Flight track (left) and comparison (right) between the IST measured by the KT-19 (in black, smoothed over 100 points) and the nearest VIIRS Operational (IDPS) IST measurement (in green), March 15, 2014

mean KT-19 IST =-17.27°C, mean VIIRS IST = -17.75°C. RMS difference = 0.118



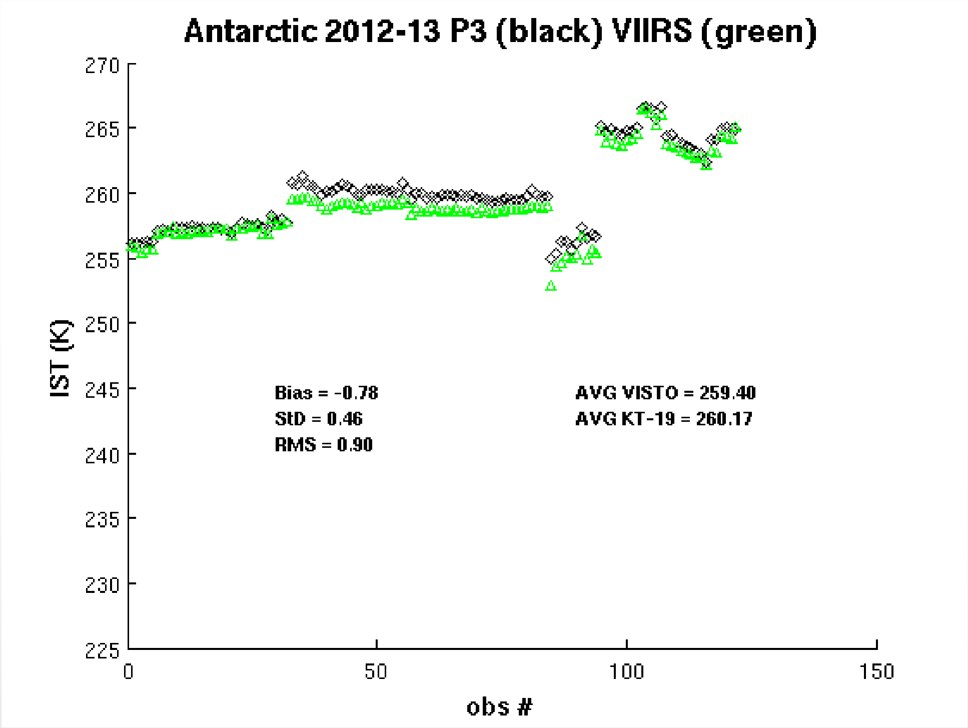


VIIRS IST IceBridge Validation



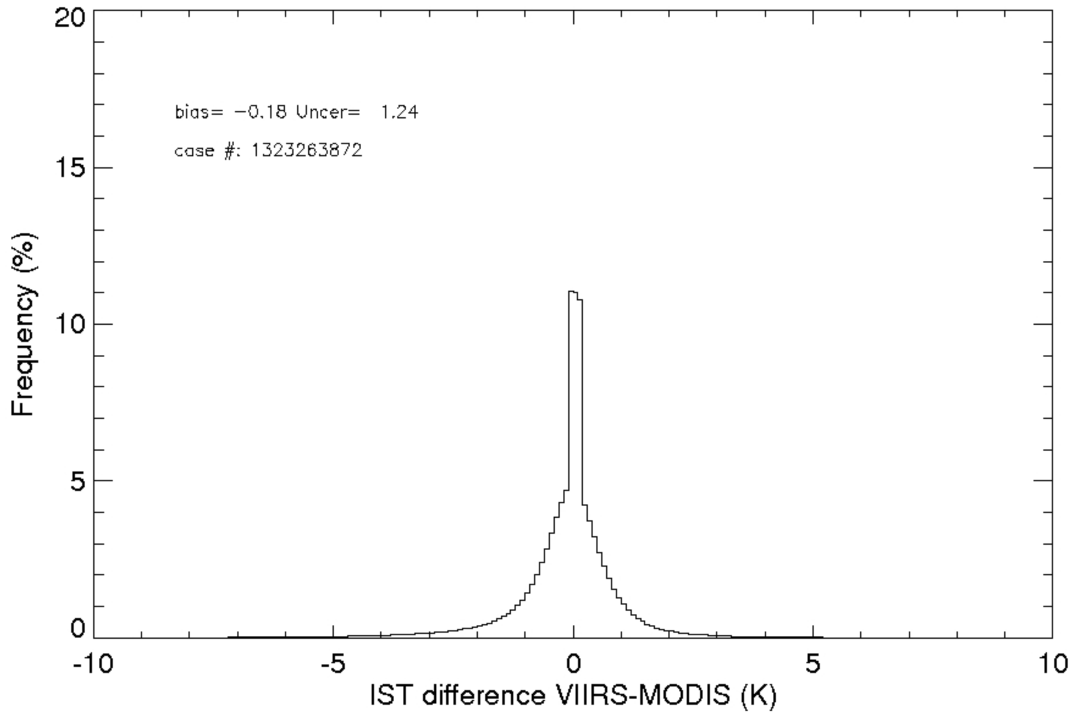
Operational S-NPP VIIRS IST (OPS) vs. airborne KT-19 IST for all coincident, cloud-free observations over the Arctic for all of the IceBridge Spring 2014 flights.

VIIRS IST IceBridge Validation



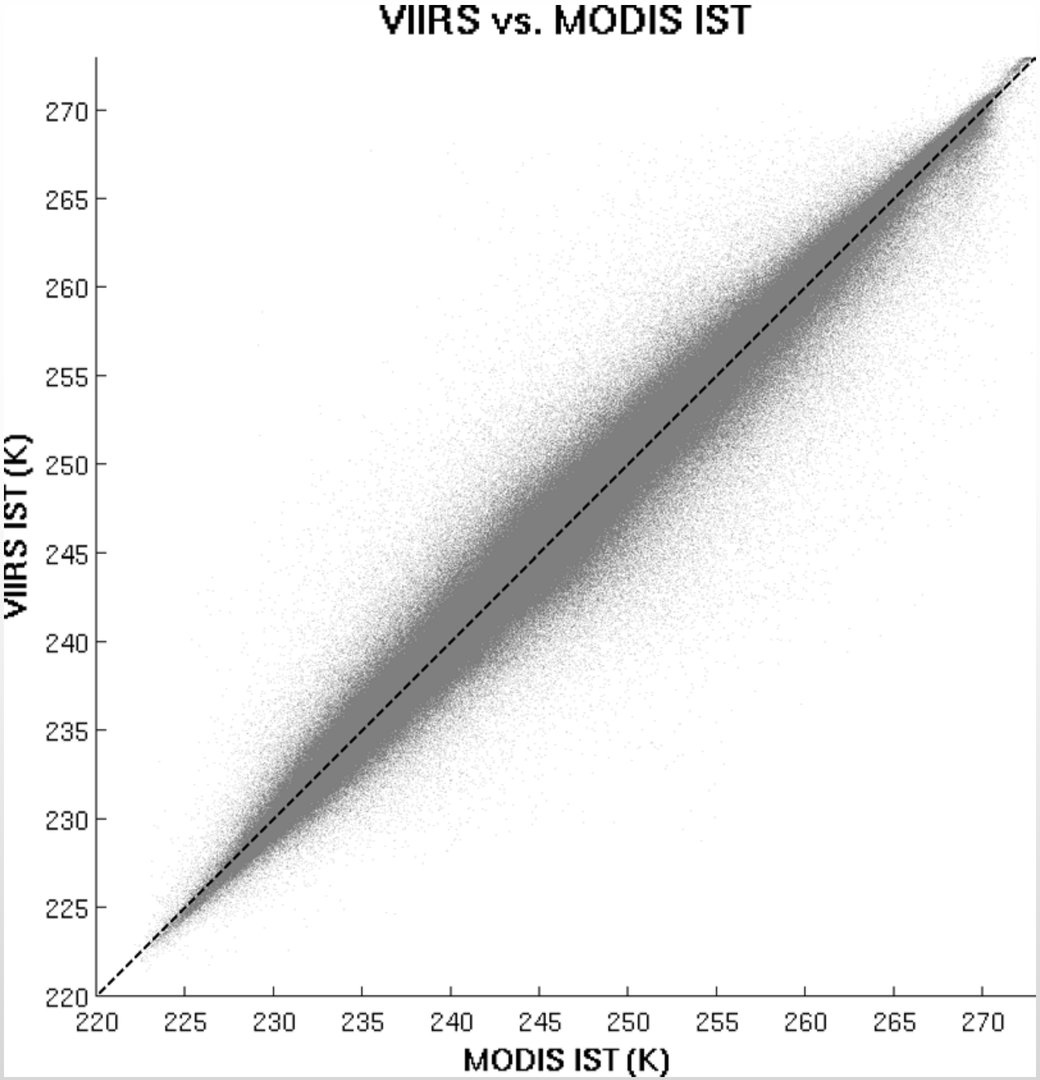
Operational S-NPP VIIRS IST (OPS) vs. airborne KT-19 IST for all coincident, cloud-free observations over the Antarctic for all of the IceBridge Fall 2012 & 2013 flights.

VIIRS / MODIS IST Intercomparison



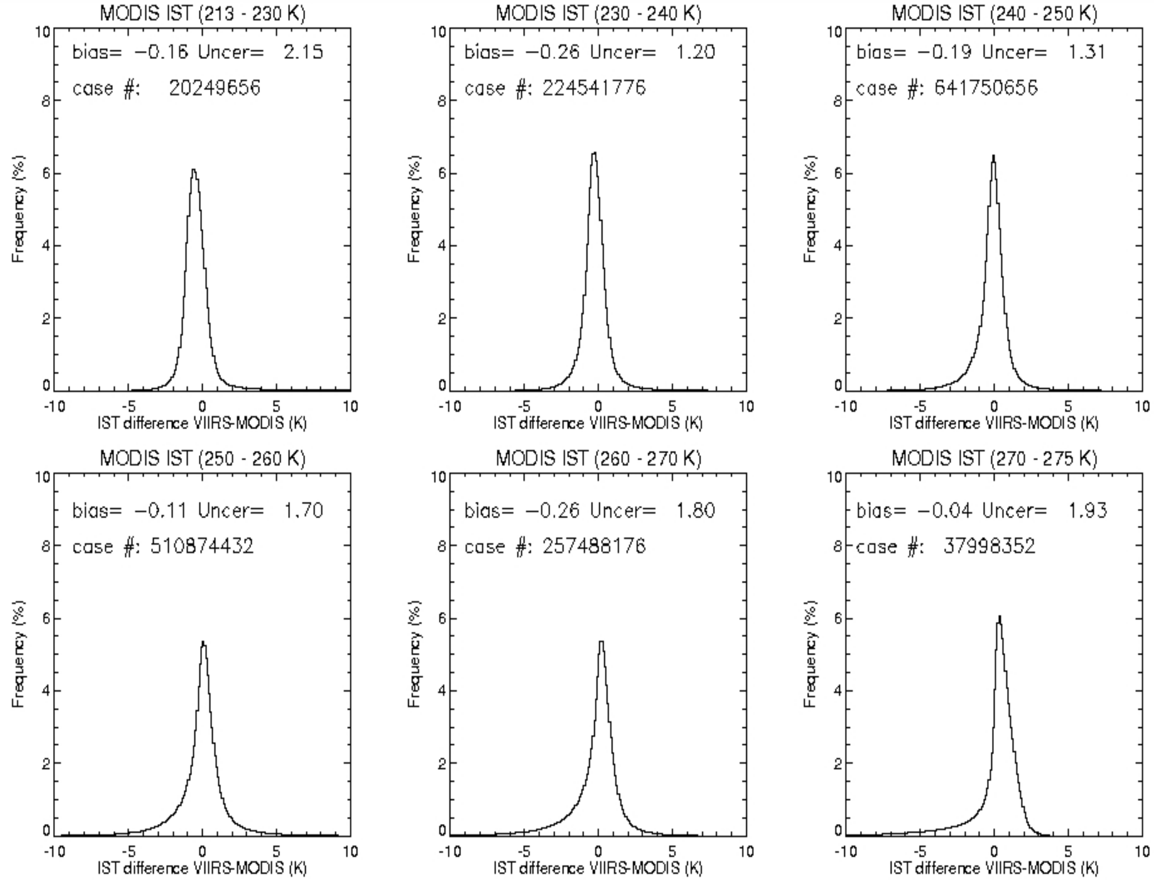
Differences between NPP VIIRS OPS and MODIS (Aqua and Terra) IST in the Arctic for all cases from August 2012 to July 2015.

VIIRS IST vs. MODIS IST



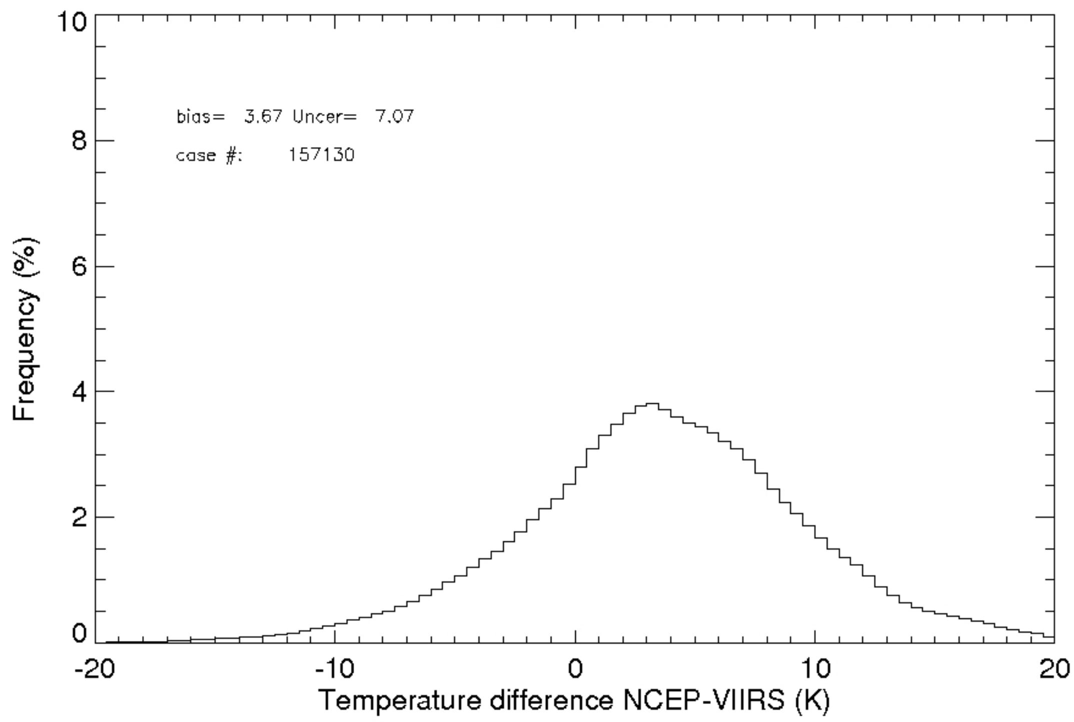
Scatterplot of OPS IST from 20 NPP VIIRS and MODIS Aqua simultaneous Nadir Overpass, with overall difference (VIIRS-MODIS) of 0.032 K and uncertainty (RMS)=1.187 K

VIIRS OPS IST vs. MODIS IST



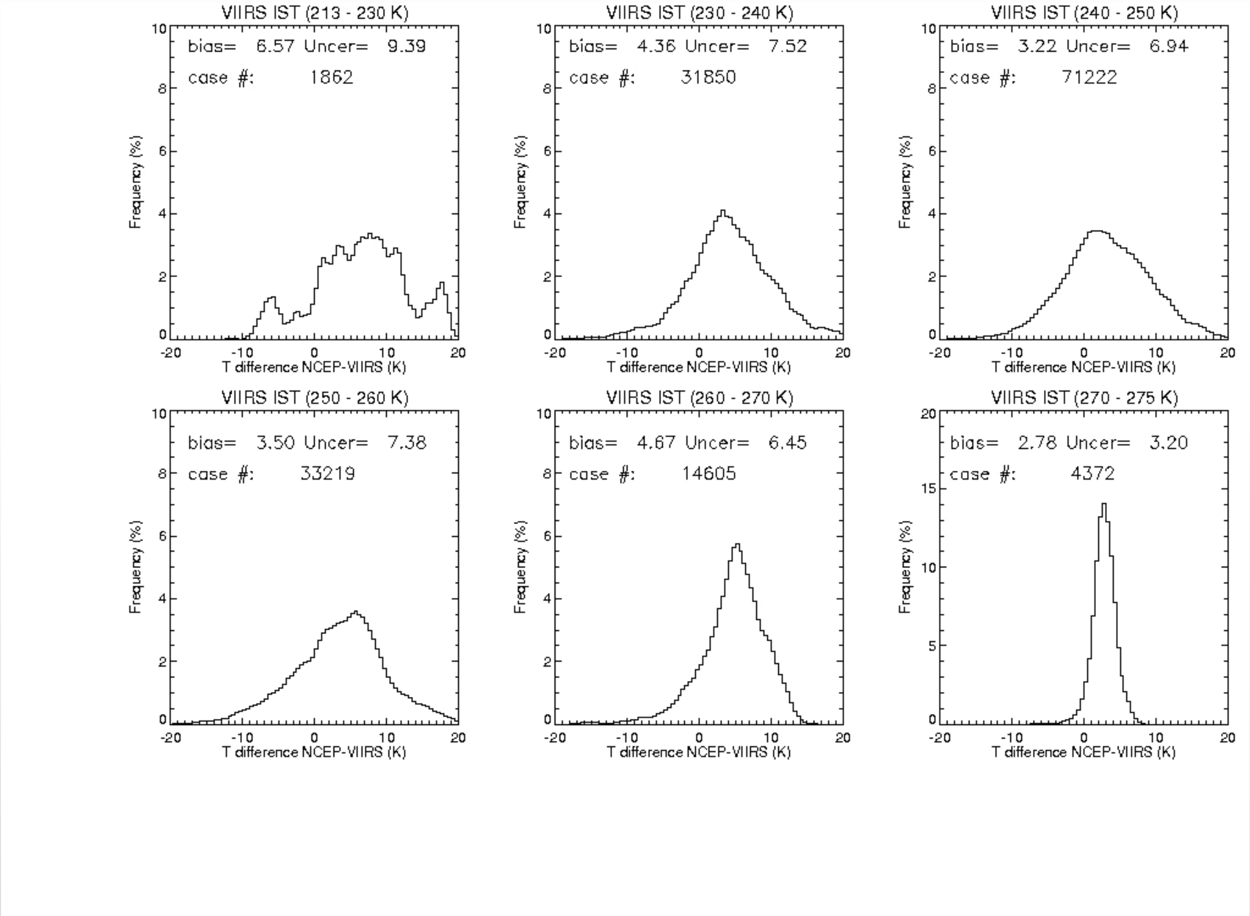
NPP VIIRS and MODIS (Aqua and Terra) IST differences in the Arctic and Antarctica from August 2012 to July 2015 for cases with MODIS ice surface temperature in range bins. Measurement bias and uncertainty (RMS) are indicated for each bin.

VIIRS OPS IST vs NCEP



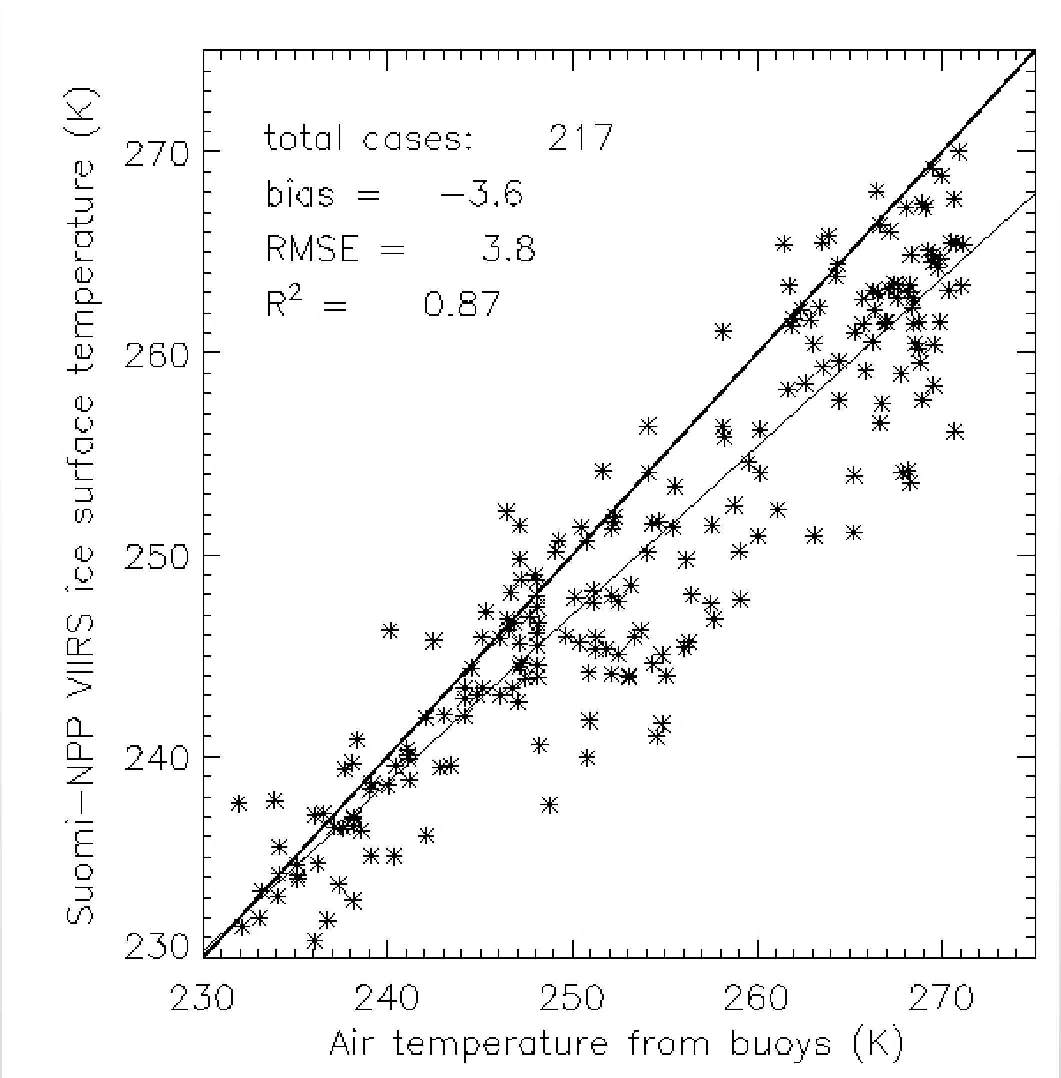
Differences between NCEP-NCAR surface air temperature and NPP VIIRS OPS IST in the Arctic for all cases from August 2012 to July 2015.

VIIRS OPS IST vs NCEP



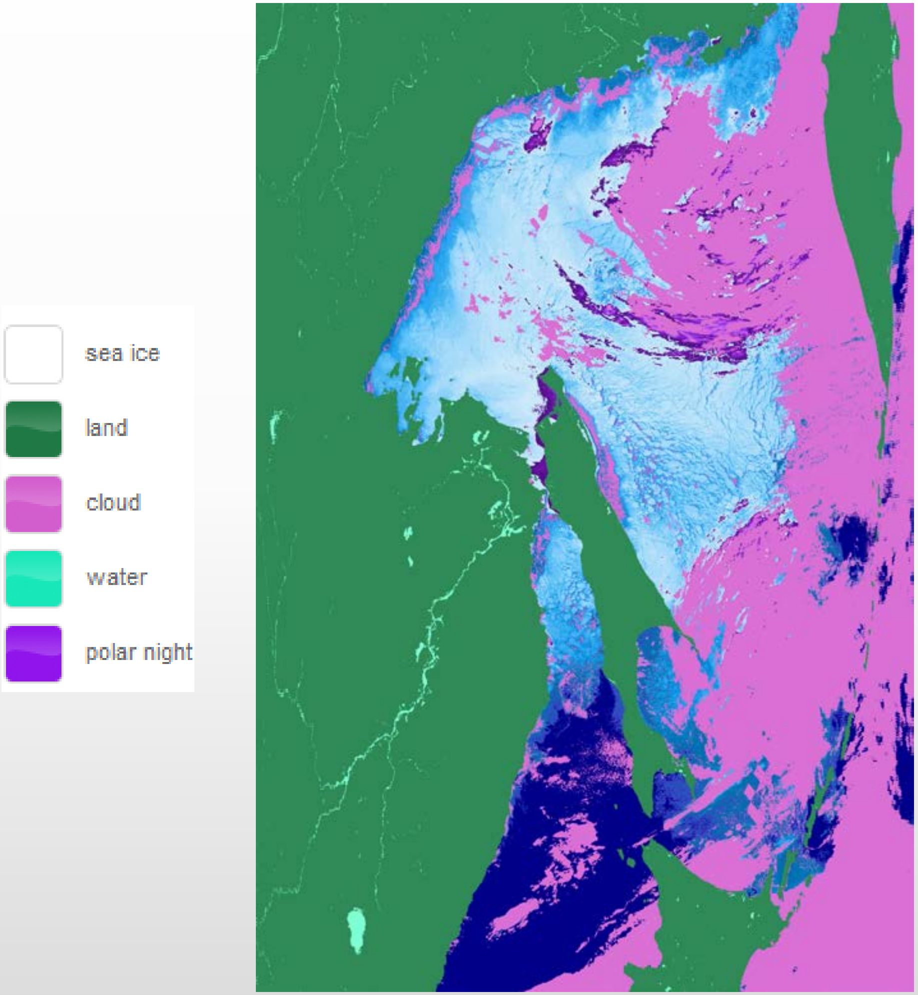
NCEP-NCAR surface air temperature and NPP VIIRS IST difference in the Arctic from August 2012 to July 2015 for cases with MODIS ice surface temperature in range bins. Measurement bias and uncertainty (RMS) are indicated for each bin.

VIIRS OPS IST vs. buoys



Scattering plot of surface air temperature from Arctic buoys and NPP VIIRS OPS IST from August 2012 to June 2014, with the thick line as the 1 to 1 ratio line, and thin line as the linear regression.

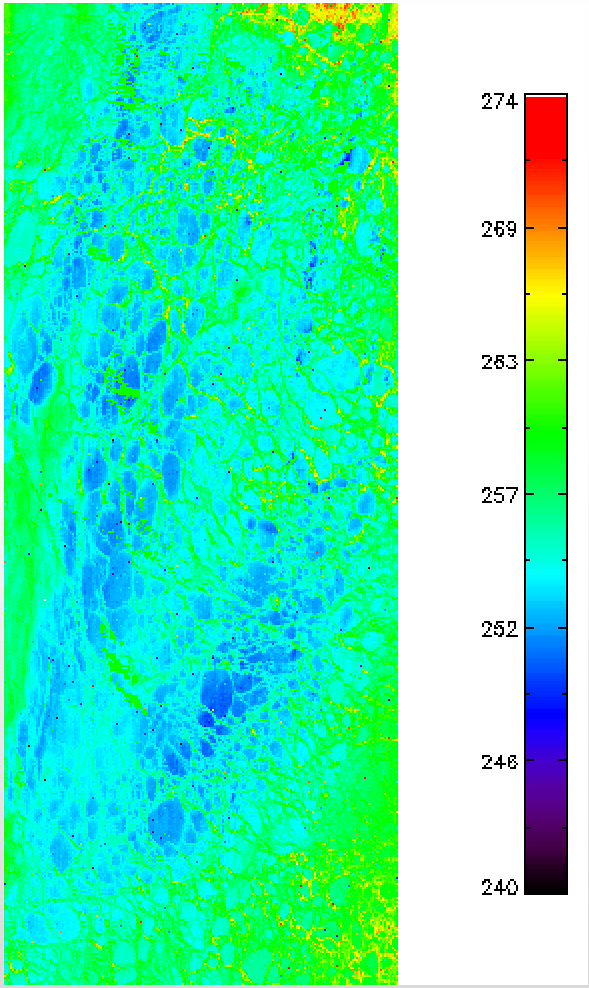
NASA VIIRS Sea Ice Extent Product



MODIS Sea ice, Sea of Okhotsk, March 17, 2002

- NASA VIIRS Sea Ice Cover by Reflectance
- Follow-on from MODIS (D. Hall & G. Riggs)
- Code generated by NASA SIPS
- In development by M. Tschudi (CU), George Riggs (SSAI)
- Reflectance-based during daytime, nighttime uses the IST product
- Sea ice by reflectance utilizes the NDSI:
  - NDSI = [R(I1) – R(I3)] / [R(I1) + R(I3)]
  - R=reflectance, VIIRS I1 (0.64um), VIIRS I3 (1.61um)
- Ice cover is mapped:
  - Snow-covered ice:
    - NDSI > thold and R(I1) > thold2
  - Thin ice (<10 cm, no snow cover)
    - IST – SST > thold
- Validation: IceBridge, Digital Globe, …
- Intercomparison: AMSR-2, IDPS Sea Ice Age, VIIRS Sea Ice Concentration, NDE Sea Ice Thickness

Suomi-NPP VIIRS IST – NASA product



- Utilizes enhanced split window:
  $IST = a_o + a_1 T_{M15} + a_2(T_{M15} - T_{M16}) + a_3(\boldsymbol{T_{M15} - T_{M16}})(\sec(z) - 1)$
- Initial code generated from MODIS code by NASA's Science Investigator-led Processing System (SIPS)
- Code being updated for VIIRS (calibration coefficients, etc.)
- New Quality Flags to be added
- Inter-comparison: MODIS, NCEP
- Validation: IceBridge, buoys

Left: VIIRS IST (K) from the NASA VIIRS IST product
Sept 12, 2014, 21:10 UTC
Beaufort Sea, AK

Conclusions

- Operational (OPS) VIIRS IST in several but not all cases meets the requirement of 1K measurement uncertainty
- OPS VIIRS IST shows a *cold* bias compared to MODIS and to several IceBridge KT-19 measurements, typically <1K
- Improvements in OPS IST EDR performance have been realized as the VIIRS Cloud Mask IP matures
- More VIIRS OPS IST improvement is expected as additional quality flags become available in the VIIRS Ice Concentration IP to avoid IST retrievals near clouds.
- NASA's Sea Ice Extent and IST product provide continuity from the MODIS product
  - No sea ice extent product is currently produced from VIIRS
  - Provides unique approach (NDSI) for sea ice identification

Future Plans and Issues

- No VIIRS IST code changes currently planned
- Update IST regression coefficients based on matchup with MODIS and airborne/other IST sources
- Additional quality checks in the VIIRS Ice Concentration IP (e.g. for cloud shadowing) will be passed to the VIIRS OPS IST
- NASA VIIRS IST
  - Add quality flags, based on MODIS product
  - Inter-comparison with MODIS, IDPS IST
  - validation with IceBridge IST, buoys
  - Complete ATBD

- NASA VIIRS Sea Ice Extent
  - Finalize code, add quality flags
  - inter-compare with MODIS, AMSR-2, VIIRS Ice Concentration, etc.
  - Validation with Digital Globe, IceBridge
  - Add quality flags , based on MODIS product
  - Complete ATBD
- Both IST products and NASA extent product: Improvements anticipated with continued upgrades to the VIIRS cloud mask

VIIRS Binary Snow Cover: Current Status and Plans

Peter Romanov, CREST/CUNY at NOAA/STAR

27 August 2015

Outline

- VIIRS Snow Cover products
- IDPS Binary Snow Map Product
  - Examples, Accuracy, Existing Problems
- NDE Algorithm
  - Modifications, Improvements, Examples
- Validation Plan
- Further Enhancements

Current VIIRS IDPS Snow Cover Product

- Binary snow map:
  - Snow/no snow discrimination
  - Imagery (375m) resolution (better than MODIS @ 0.5 km)

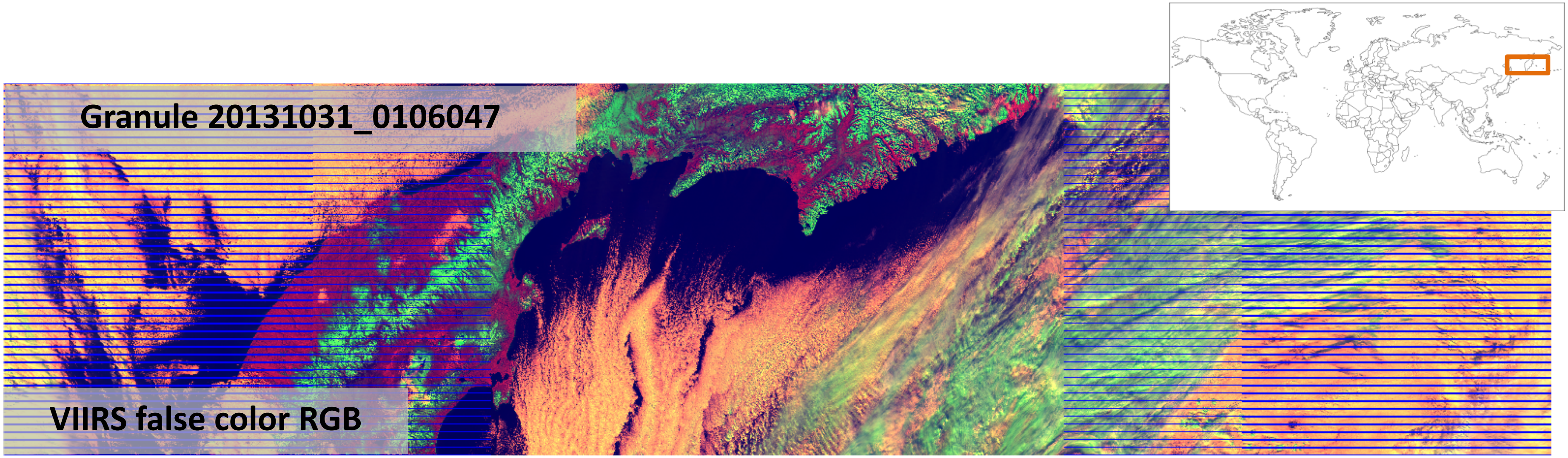
- Snow fraction:
  - Aggregation of the binary snow within 2x2 pixel blocks
  - 750 m spatial resolution

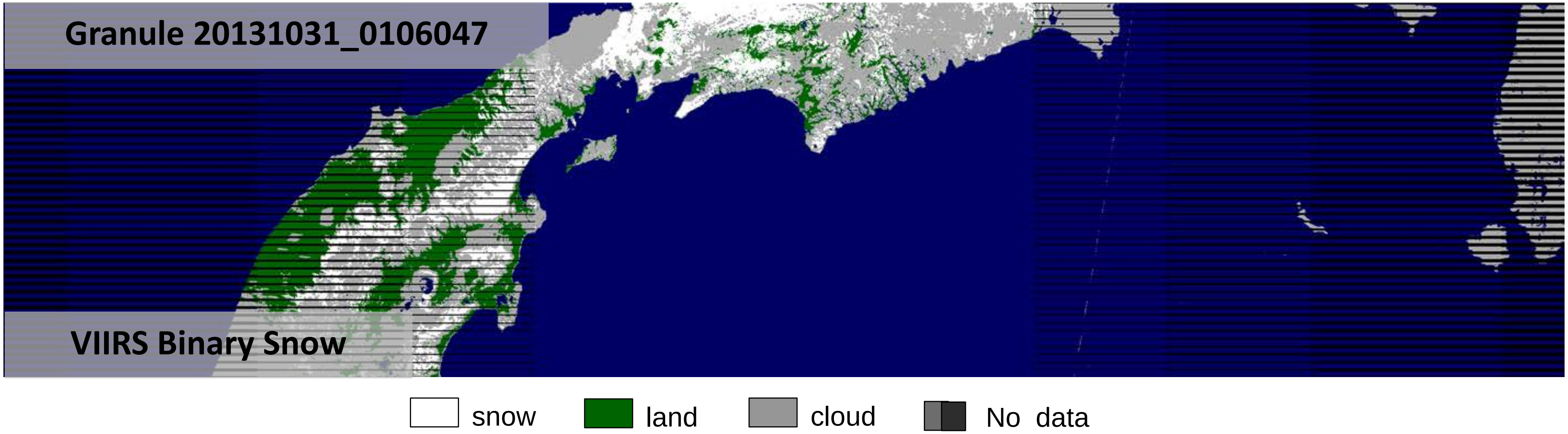
- <u>Both snow products are critically dependent on the accuracy of the VIIRS cloud mask which is an upstream product.</u>

IDPS Binary Snow Cover Algorithm

- Similar to MODIS SnowMap algorithm (Hall et.al 2001)
- Decision-tree threshold-based classification approach
- Uses Normalized Difference Snow Index (NDSI), reflectance, thermal and NDVI thresholds
- Applied to cloud-clear pixels, requires daylight

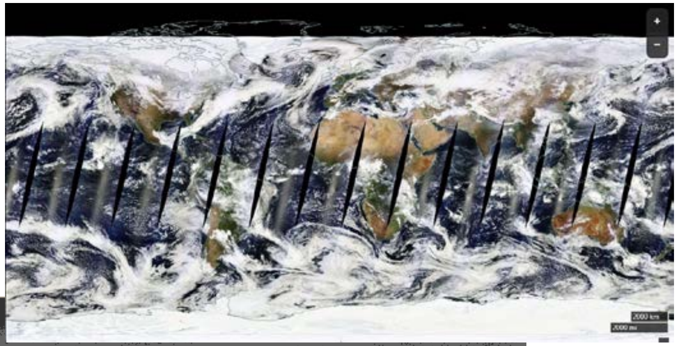
VIIRS Binary Snow Map at Granule Level

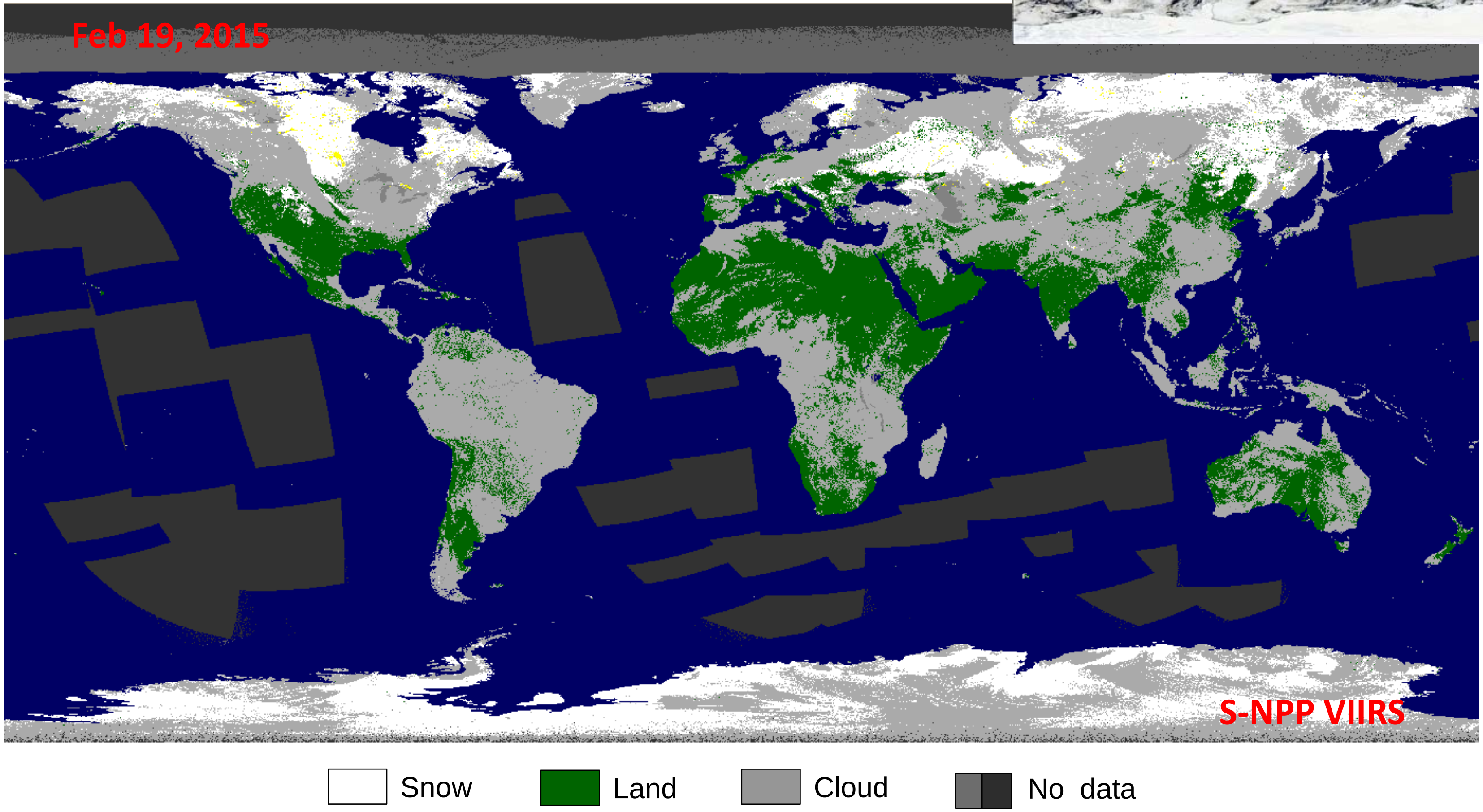




VIIRS Daily Gridded Snow Map

- Daily global gridded snow maps at 1 km resolution
- Have been produced since the beginning of 2013.
- Lat-lon projection is similar to NASA's CMG
- Granules with no land pixels are not processed





Product Evaluation Approach

- Visual qualitative assessment of global images
- Quantitative comparison with in situ snow cover observations
  - Mostly over CONUS area
- Comparison with NOAA Interactive Snow/Ice product (IMS)
  - Only over Northern Hemisphere

Accuracy Assessment

Daily rate of agreement of VIIRS IDPS binary snow maps

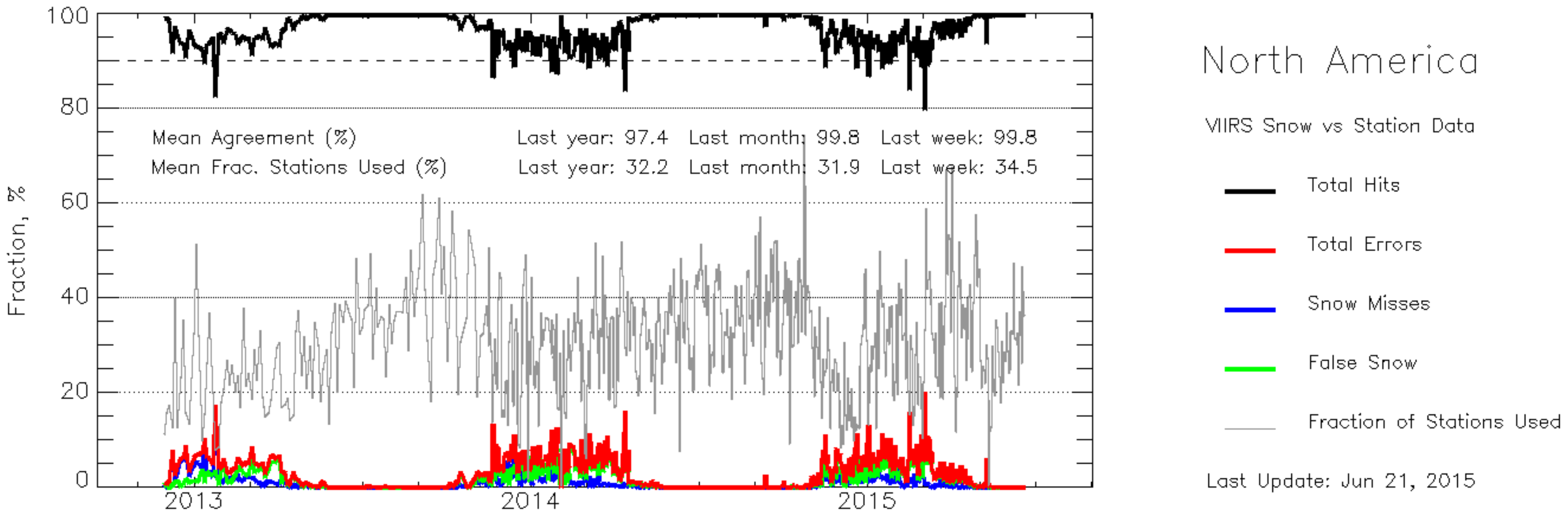
- To IMS, mean: 97%, range: 96-99%
- To in situ reports, mean: 92%, range: 85-96% (CONUS, November-April)
- 90% accuracy requirement is generally satisfied

Agreement decreases

- During transition seasons
- In forested areas
- At large solar/satellite zenith angles

VIIRS Snow vs In Situ Data

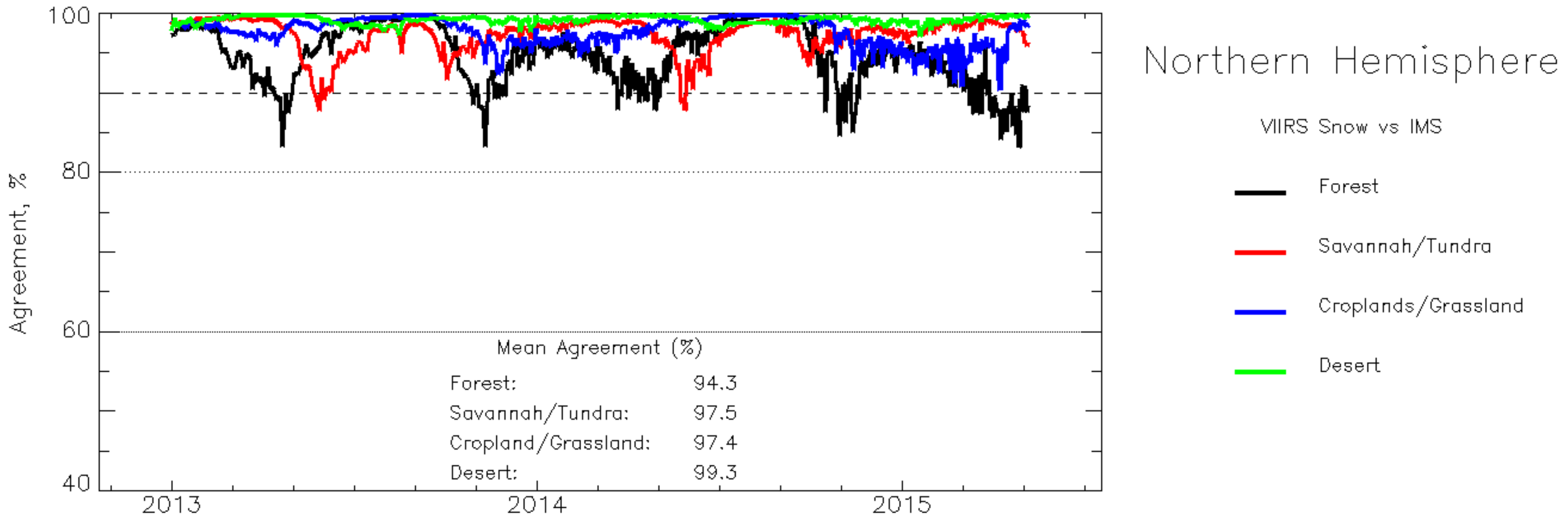
VIIRS vs In Situ Daily Comparison Statistics, 2013-2015



Most stations are in the CONUS area
Most daily agreement estimates are within 90-95% range

VIIRS Snow vs IMS

VIIRS daily agreement to IMS by surface cover type, 2013-2015



More frequent errors in forested areas
Some disagreement is due to finite accuracy of the IMS product

VIIRS, AVHRR, MODIS Snow vs IMS

Mean agreement to IMS and cloud-clear fraction of daily automated snow products in 2013

Northern Hemisphere

	Agreement to IMS (%)	*Cloud-clear(%)**
VIIRS	**98.0**	**38.6**
MODIS (T)	97.3	49.1
MODIS(A)	97.1	48.3
AVHRR	97.9	55.0

*Cloud-clear fraction is estimated in 25-60^{0}N latitude band

VIIRS: Better accuracy but smaller effective clear-sky coverage

2014-2015: VIIRS cloud-clear fraction increased to 40.7% while the rate of agreement to IMS dropped to 97.8%

Uncertainty in Accuracy Estimates

IDPS Snow Map agreement to IMS, Jan 7, 2015

	Agreement to IMS(%)
All Northern Hemisphere land	**98.4**
Snow climatologically possible	**95.3**
Within 200km of the snow cover boundary	**93.6**
Within 100km of the snow cover boundary	**91.0**
Within 50 km of the snow cover boundary	**87.2**
Within 20 km of the snow cover boundary	**81.3**

Mean agreement between products decreases with the region of comparison narrowing down onto the snow cover boundary

When evaluating the accuracy it is important to know exactly how it was obtained

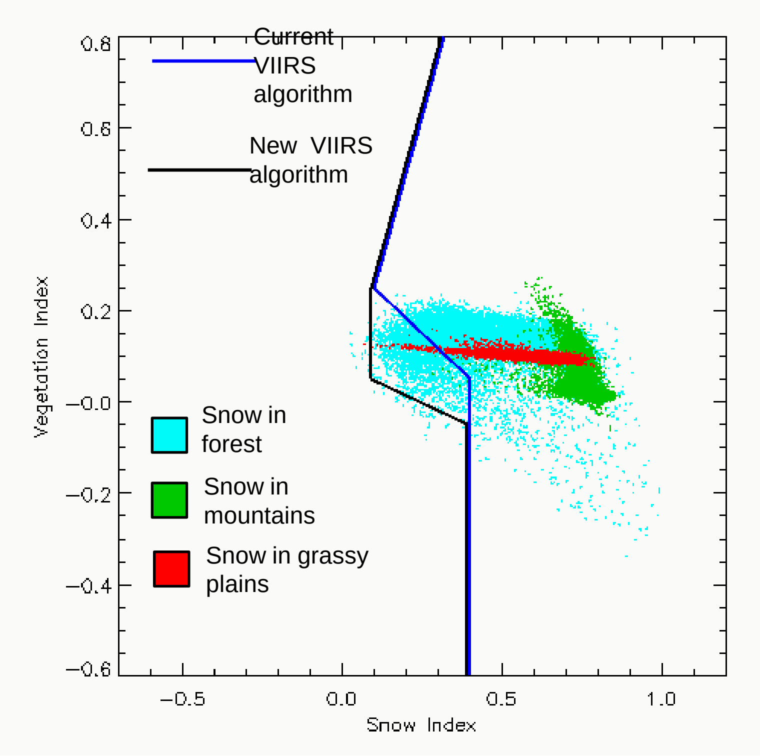
NDE Snow Algorithm

NDE Algorithm

- 2-stage procedure: spectral tests + consistency checks

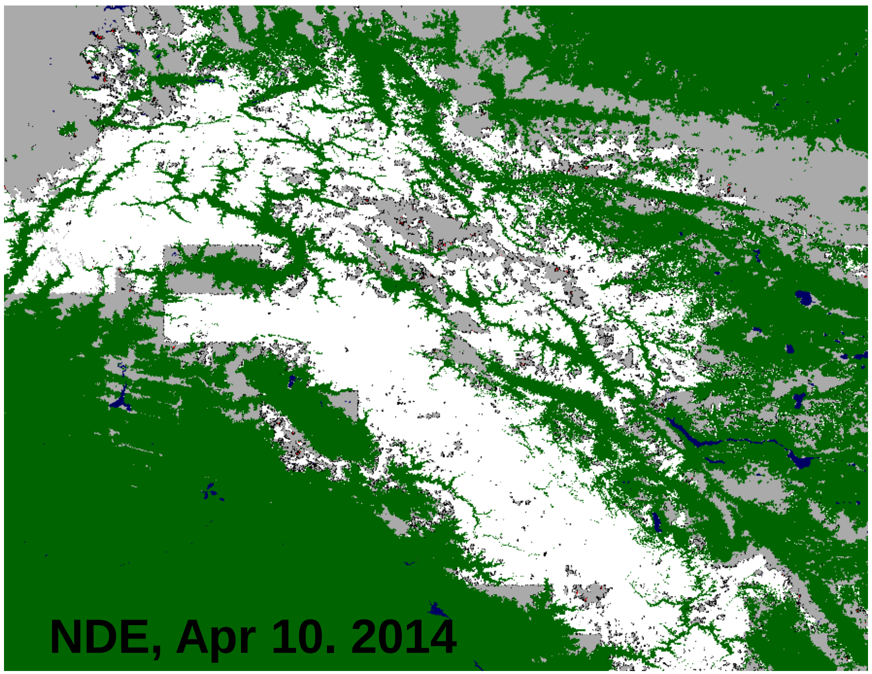
- Spectral tests: similar to IDPS but more relaxed
  - Intent: Improve snow identification in forests and in the transition zone

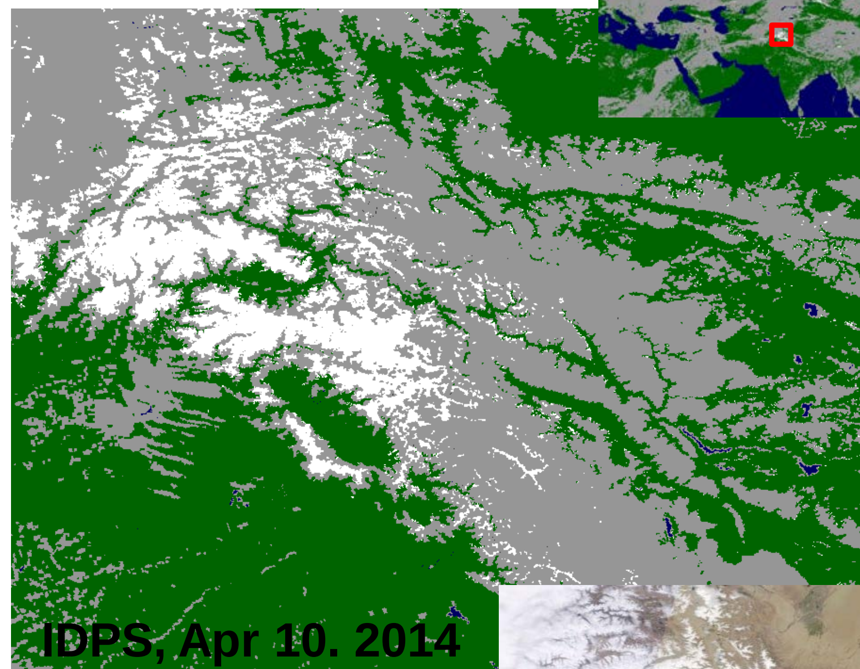
- Consistency tests (new, not in IDPS)
  - Snow climatology
  - Surface temperature climatology
  - Spatial consistency
  - Temperature spatial uniformity
  - Intent: Eliminate possible spurious snow

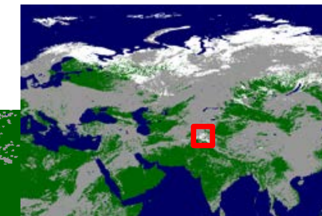


NDE vs IDPS Binary Snow Product

NDE: Better delineates the snow cover boundary due to less conservative cloud masking in the snow/no-snow transition zone







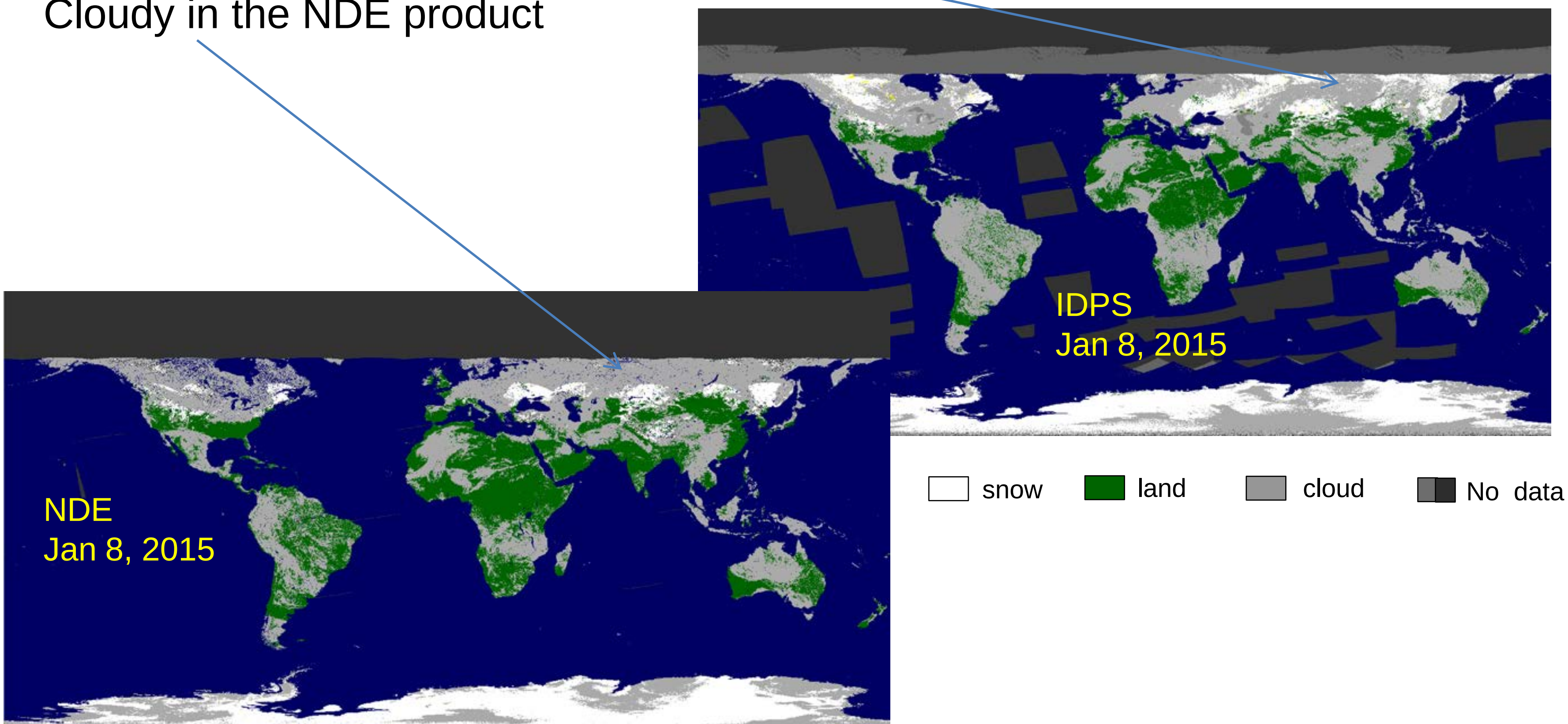
snow   land   cloud   No data

NDE vs IDPS Binary Snow Product

NDE: Less conservative cloud mask in low and midlatitudes, but much more conservative cloud mask at high solar zenith angles

Some cloud-clear scenes in the IDPS product

Cloudy in the NDE product



NDE Binary Snow Accuracy

Limited dataset processed: January 2015, 10 days in April, July and Oct 2014

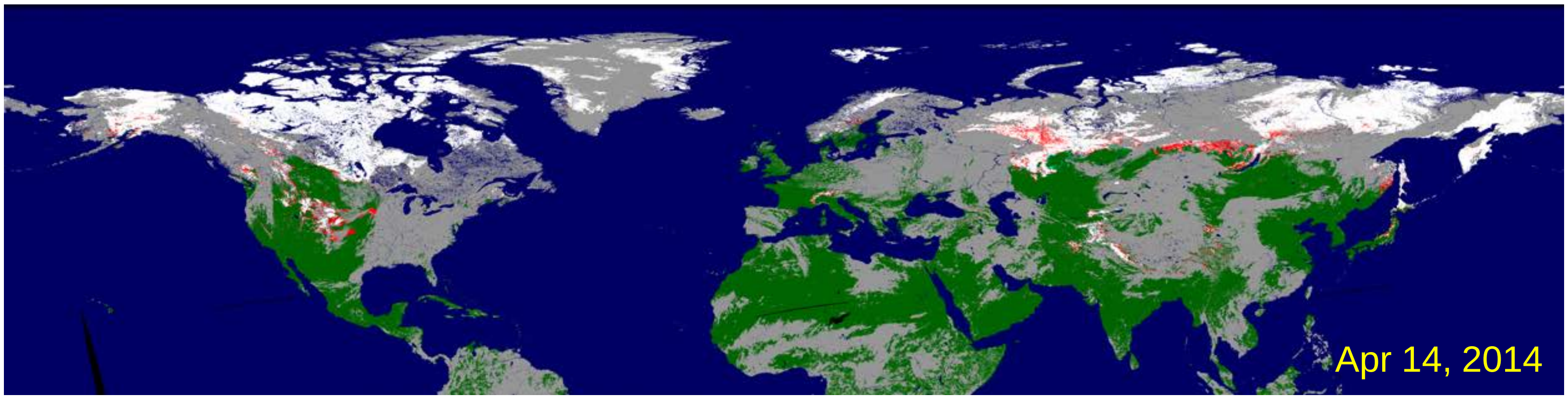
Daily rate of agreement,   January 2015

- To IMS: 96-99% (Northern Hemisphere)
- To in situ snow depth reports: 88-97% (CONUS)

NDE Binary Snow accuracy is similar to the IDPS accuracy

NDE Snow vs IMS

VIIRS NDE Binary Snow with IMS data overlaid



Both snow | Both land | Cloud | No data

VIIRS snow map errors: Omission (snow miss) | Commission (false snow)

Some VIIRS snow "omissions" may be due to overly aggressive snow mapping by IMS analysts

Further Enhancements

- Location-dependent threshold values

- Improved snow cover climatology

- Add ice identification on rivers and lakes

- Daily gridded products

NOAA vs NASA Approach

NASA:

- Discontinue producing binary snow maps
- Retain only Snow Fraction (NDSI-based)

NOAA:

- Binary Snow Cover is still needed. No plans to discontinue.

Reprocessing, Long-Term Monitoring

No plans for reprocessing so far

NDE long term product monitoring will be similar to IDPS

- Global gridded snow maps
- Visual examination
- Routine comparison with IMS and in –situ data
- Daily accuracy estimates

Summary

VIIRS Binary Snow validation approaches and tools

- Have been developed and are actively used

IDPS Binary Snow Cover product

- Provides consistent characterization of global snow cover
- Satisfies the 10% accuracy requirement but can be improved

New NDE algorithm will

- Improve snow detection/mapping in transition zones
- Reduce spurious snow identifications

Overall the quality of the new snow product is highly dependent on the performance of NDE cloud mask and its further improvement

VIIRS Fractional Snow Cover: Current Status and Plans

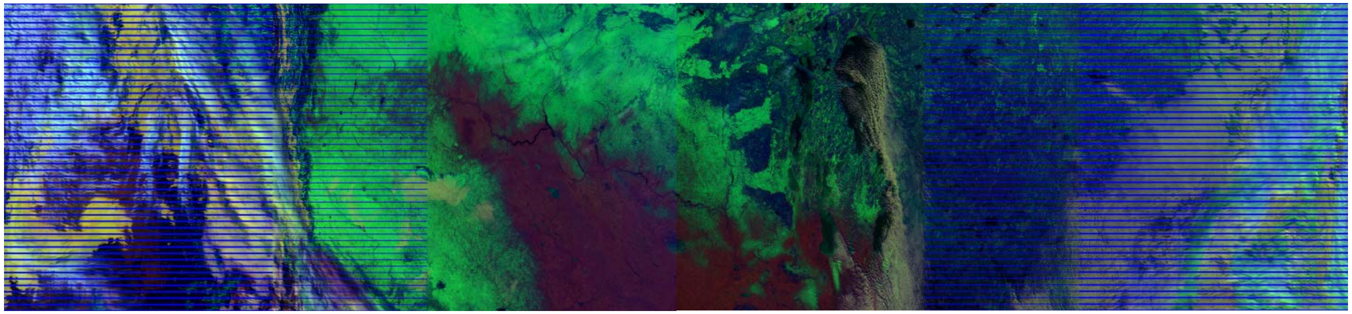
Peter Romanov, CREST/CUNY at NOAA/STAR
Igor Appel, IMSG at NOAA/STAR

27 August 2015

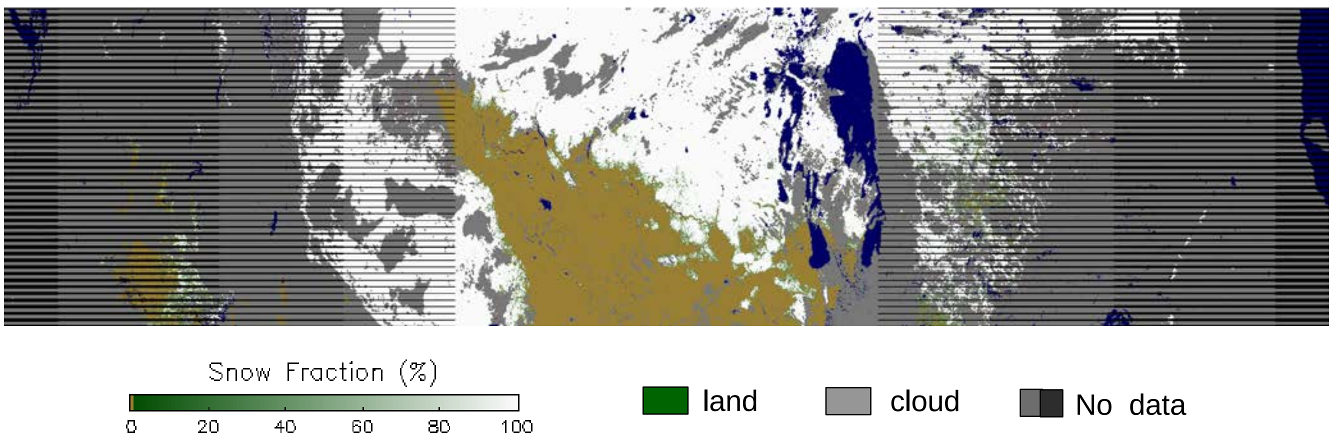
Current VIIRS IDPS Snow Fraction Product

- IDPS Snow Fraction:
  - Aggregation of the binary snow within 2x2 pixel blocks
  - 750 m spatial resolution
- Product depends on
  - Binary snow identification
  - VIIRS cloud mask

Aggregated Snow Fraction

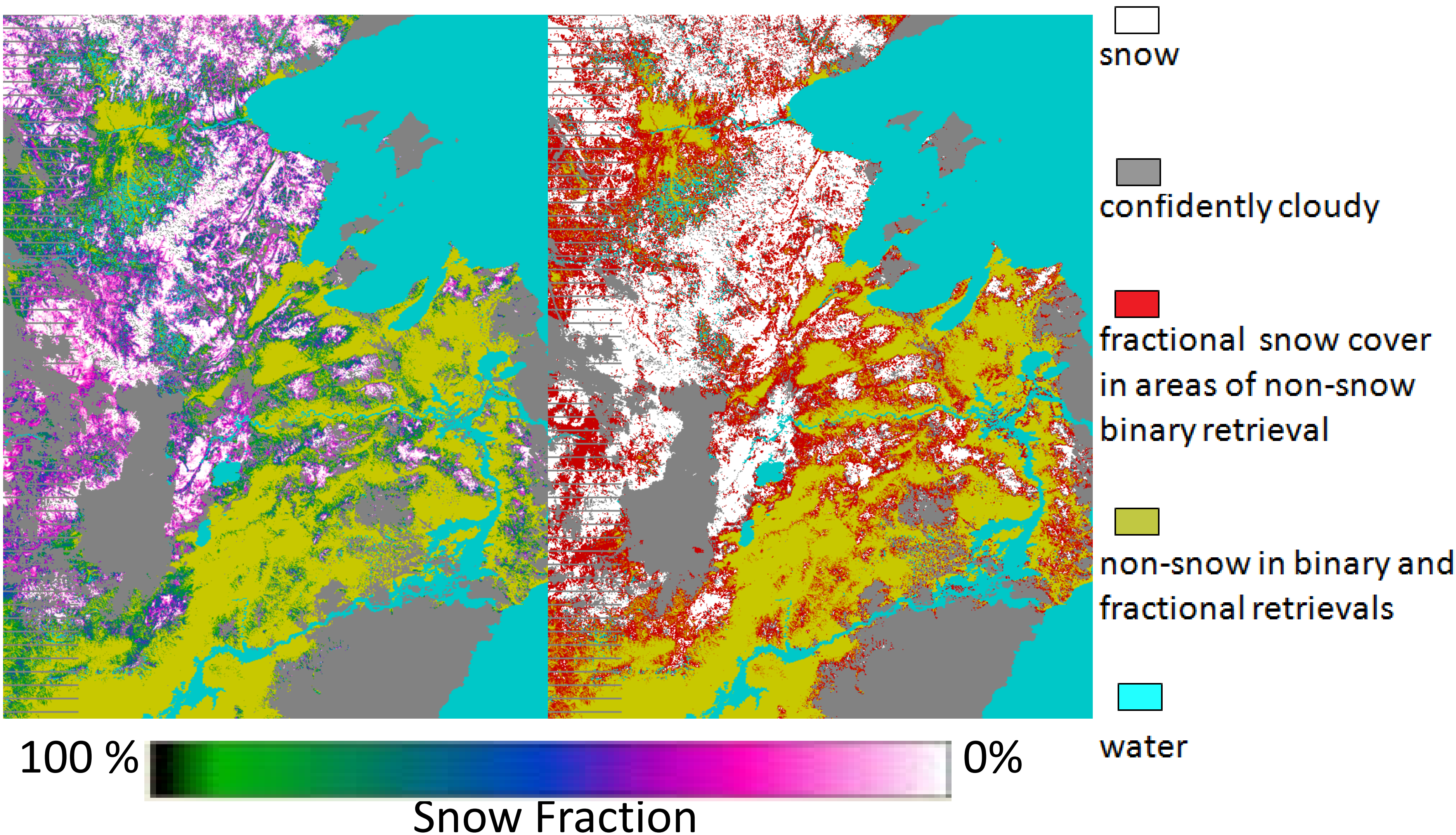


VIIRS IDPS snow fraction: derived through 2x2 binary snow pixel aggregation



- Product
  - Has little to none added value as compared to the binary snow
  - Can not and does not satisfy 10% accuracy requirements
  - Has to be replaced for sub-pixel snow fraction retrievals

Snow Fraction and Binary Snow (10/24/2013 at 03:15)



Comparison with false color imagery shows advantage of snow fraction

“Viewable” vs “True” Snow Fraction

Two Definitions/Perceptions of Sub-Pixel Snow Fraction

(1) Physical fraction of land surface covered with snow (“**true snow fraction**”).

- Characterizes patchiness of snow cover on the ground
- Use to calculate the snow area extent

(2) Snow fraction as “seen” from satellite (“**viewable snow fraction**”)

- Represents a combined effect of patchiness and snow masking by vegetation
- Directly related to the land surface albedo
- Can be converted to the true snow fraction if the forest gap function is known

In satellite remote sensing definition (2) of snow fraction is typically assumed

“Viewable” snow fraction will be derived from VIIRS data

Conclusions from high level fractional snow discussion (July 2014)

Overall Summary:

There are three algorithms:

a) Spectral unmixture (aka MODSCAG, GOESRSCAG, Painter algorithm),

b) NDSI-based, and

c) Single band approach.

Overall agreement that an enterprise algorithm approach is a good idea, but need to assess and compare the results of the three algorithms in order to make a recommendation on which to implement.

Panel recommendation from the maturity review (September 2014)

- **Snow Cover (Snow Fraction) EDR Algorithm**

- Scientific maturity seems sound for NDSI algorithm. Recommend to proceed with NDSI regression approach.

  - Study the inclusion of NDSI into the cryosphere products of the JPSS risk reduction project

  - Inter-comparisons with MODSCAG should be explored by a coordinated GOES-R JPSS effort

Two Snow Fraction Algorithms for NDE

Reflectance-based, modified from Romanov et al (2003)

$$\textbf{SnowFraction}=(\mathbf{R}-\mathbf{R}_{land})/(\mathbf{R}_{snow}-\mathbf{R}_{land})$$

- Uses band 1 (visible) reflectance
- $\mathbf{R}_{land}$ and $\mathbf{R}_{snow}$ are global and are determined empirically. They change with observation geometry
- Algorithm used with GOES Imager and AVHRR

NDSI-based, recent (2015) enhancement of Salomonson & Appel

$$\textbf{SnowFraction} = (\mathbf{NDSI} - \mathbf{NDSI}_{non\text{-}snow}) / (\mathbf{NDSI}_{snow} - \mathbf{NDSI}_{non\text{-}snow})$$

- Slope and Intercept are local and are established on the fly
- MODIS heritage algorithm
- Adopted as the primary algorithm for JPSS

Advantages of Reflectance-Based Snow Fraction

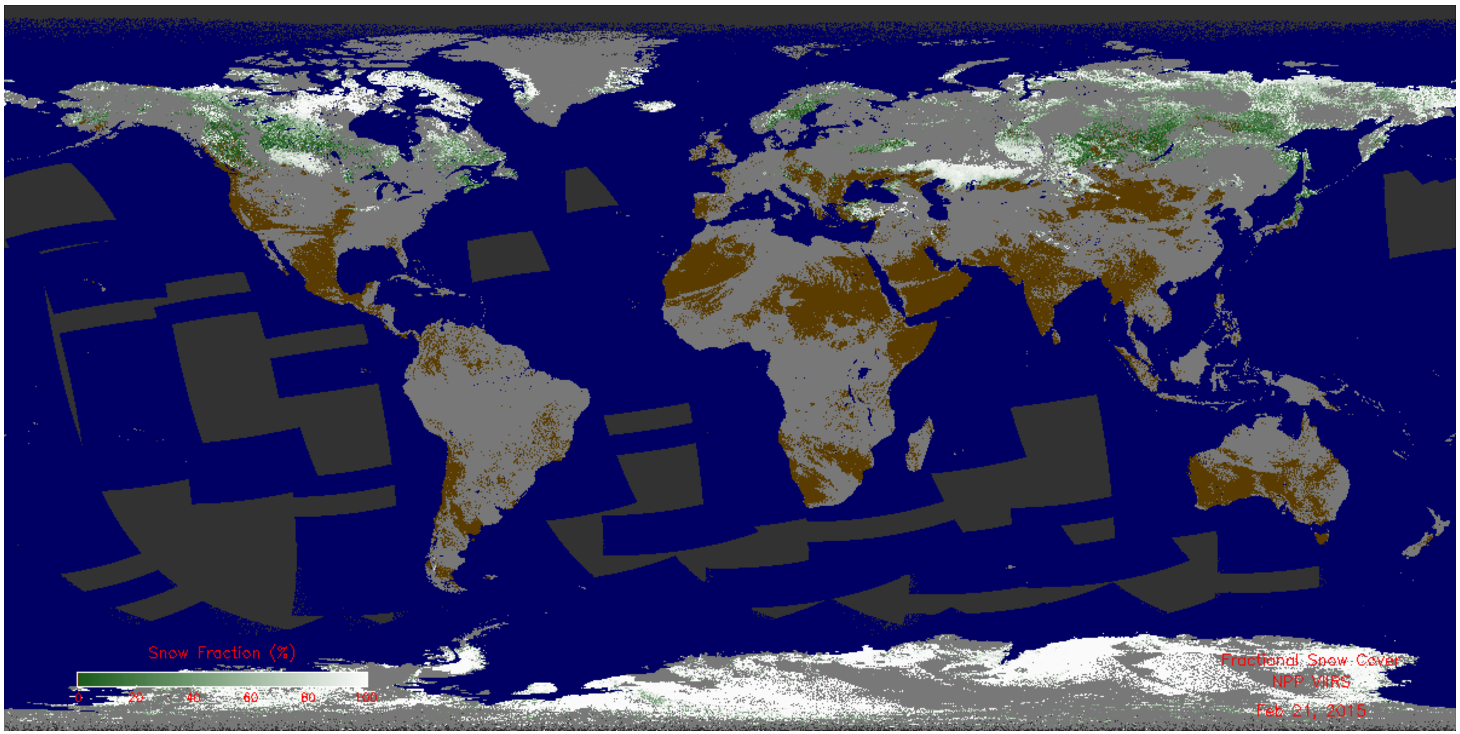
Linear relationship between snow fraction and surface reflectance

- Employed in land surface models
- Implicitly used when visually estimating the fractional snow cover (e.g. snow course measurements)

Theoretically estimated accuracy is 10-15%

- Mostly due to the end-members uncertainty

Global Daily Snow Fraction



land cloud No data

Daily gridded maps of reflectance-based snow fraction are generated daily since Jan 2014. See http://www.star.nesdis.noaa.gov/smcd/emb/snow/viirs/viirs-snow-fraction.html

Snow Fraction Evaluation Approach

Snow fraction is not observed in situ. Proper quantitative validation of the product accuracy is hardly feasible

General approach to the product verification

- Comparison with higher spatial resolution data

- Consistency testing
  - Self-consistency:
    - Lack of abnormal spatial patterns
    - Day-to-day repeatability of spatial patterns
  - Consistency with the forest cover distribution
  - Consistency with in situ snow depth data over open flat areas.

Comparison with Landsat

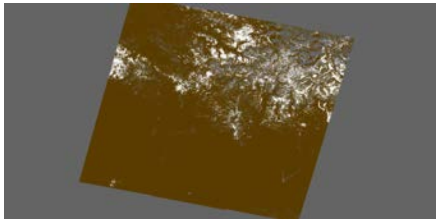
Landsat binary snow cover aggregated within VIIRS pixel is compared to VIIRS sub-pixel snow fraction

<u>Approach</u>

(1) Generate binary snow mask for a Landsat scene at 30 m resolution

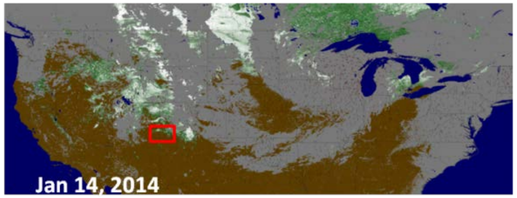
(2) Aggregate Landsat binary snow retrievals within VIIRS pixel

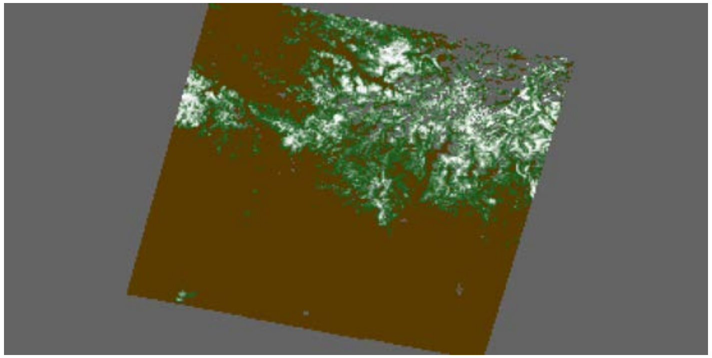
(3) Compare with VIIRS snow fraction estimate



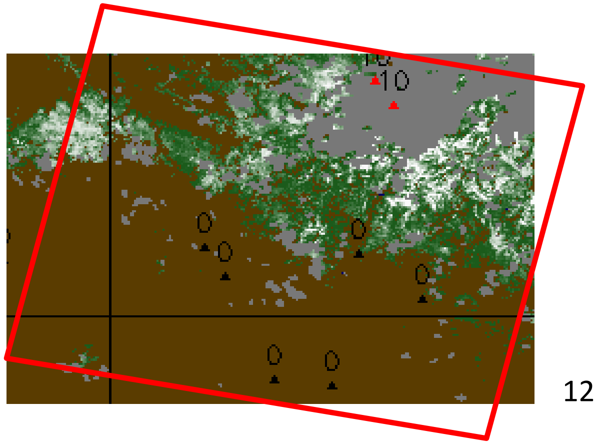
Landsat binary snow

VIIRS snow fraction





Landsat snow fraction



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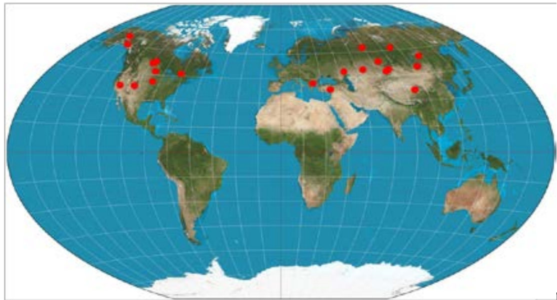
Comparison with Landsat



Location of Landsat scenes used

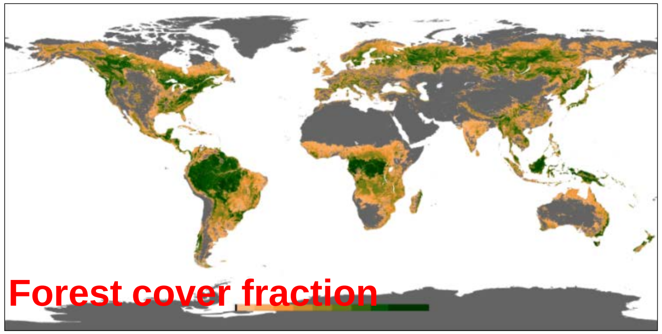
The overall agreement of Landsat aggregated and VIIRS subpixel snow fraction is about 12% for 1 km grid cells and about 8% for 5 km aggregation

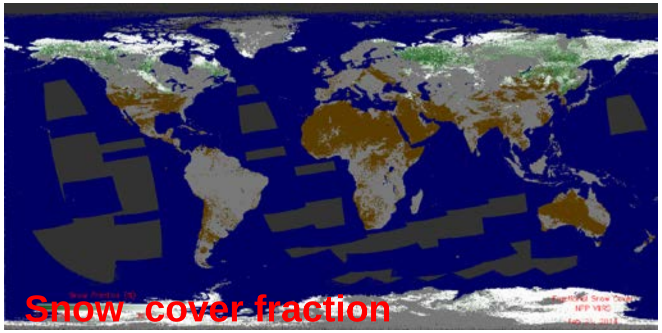
Date of year 2014	Path	Row	Sol Elev	Lat	Lon	Mean Fraction VIIRS	Mean Fraction Landsat	1 km		5 km	
								Correl	RMSE	Correl	RMSE
01/09	16	27	18	47.4	-75.5	0.21	0.23	0.71	0.173	0.87	0.112
01/09	32	28	20	46.0	-100.8	0.77	0.83	0.40	0.17	0.41	0.157
01/13	28	33	26	38.8	-96.9	0.19	0.06	0.67	0.106	0.92	0.078
01/14	35	24	14	51.7	-103.0	0.74	0.74	0.89	0.131	0.97	0.072
01/14	35	25	17	50.2	-103.6	0.89	0.90	0.72	0.098	0.84	0.054
01/14	35	34	28	37.5	-108.2	0.26	0.27	0.84	0.140	0.94	0.069
01/15	42	34	28	37.4	-119.0	0.11	0.10	0.82	0.112	0.92	0.061
01/15	131	26	18	48.8	107.4	0.42	0.47	0.84	0.157	0.83	0.142
01/15	147	26	18	48.8	82.7	0.67	0.70	0.89	0.101	0.95	0.069
01/15	147	27	19	47.4	82.1	0.66	0.68	0.91	0.051	0.96	0.031
03/14	169	26	36	48.4	48.6	0.42	0.47	0.95	0.094	0.99	0.068
03/14	185	31	41	41.7	21.3	0.34	0.31	0.91	0.145	0.97	0.094
03/15	160	26	36	48.8	62.5	0.86	0.90	0.72	0.070	0.80	0.055
03/15	128	20	29	57.3	116.0	0.59	0.53	0.69	0.203	0.80	0.125
03/24	159	15	27	64.1	72.9	0.74	0.77	0.89	0.111	0.98	0.049
03/24	175	34	48	36.5	35.49	0.72	0.70	0.79	0.146	0.94	0.114
03/25	134	35	50	36.0	98.4	0.56	0.56	0.90	0.132	0.97	0.070
03/25	150	23	37	53.1	79.8	0.43	0.44	0.90	0.078	0.98	0.040
04/23	72	14	37	65.5	-151.5	0.32	0.34	0.90	0.103	0.97	0.054
04/27	141	16	40	62.6	99.7	0.35	0.36	0.81	0.098	0.90	0.055
05/15	66	17	47	61.5	-145.2	0.67	0.65	0.80	0.131	0.94	0.069
Mean								**0.80**	**0.121**	**0.90**	**0.078**

Consistency Tests

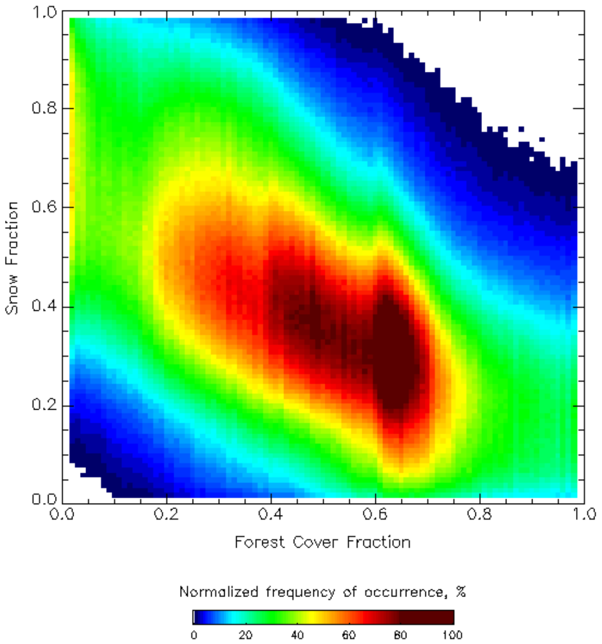
VIIRS reflectance based snow fraction satisfies all consistency tests
In particular it demonstrates:

- Strong negative correlation (-0.5 to -0.8) with forest fraction
- Positive correlation (0.2-0.6) with snow depth over non-forested areas
- Strong positive (0.7-0.9) day-to-day autocorrelation





Forest fraction vs snow fraction



Further Enhancements of Reflectance-based Approach

- Improved characterization of end-members
  - Location-dependent or surface-type-dependent values
  - Improved angular anisotropy parameterization of endmembers
- Testing multi-endmember multispectral approach
  - Add shadows as a separate land surface category besides snow and snow-free land
-

Advantages of NDSI-Based Snow Fraction

- The Normalized Snow Difference Index (NDSI) characterizes snow reflective properties: high snow reflectance in the visible wavelengths and low reflectance in the near infrared wavelengths

- NDSI is widely considered as an indicator of the presence of snow on the ground

- NDSI is sensitive enough to provide the snow fraction within a pixel of moderate resolution observations

- NDSI presenting relative ratio of reflectances to a large degree suppresses the influence of varying illumination conditions

Role of Changes in Endmembers

- The quality of snow cover information provided by remote sensing varies from region to region as well as from day to day depending on

  - snow and background surface types

  - the geometry of satellite observations

  - the state of the atmosphere

- Observed changes in pixel reflectances should not be ascribed exclusively to variable fraction, because they depends also on local variability in spectral signatures of the endmembers

- Allowing for local variability in spectral signatures of endmembers within a scene is a key requirement to snow algorithms

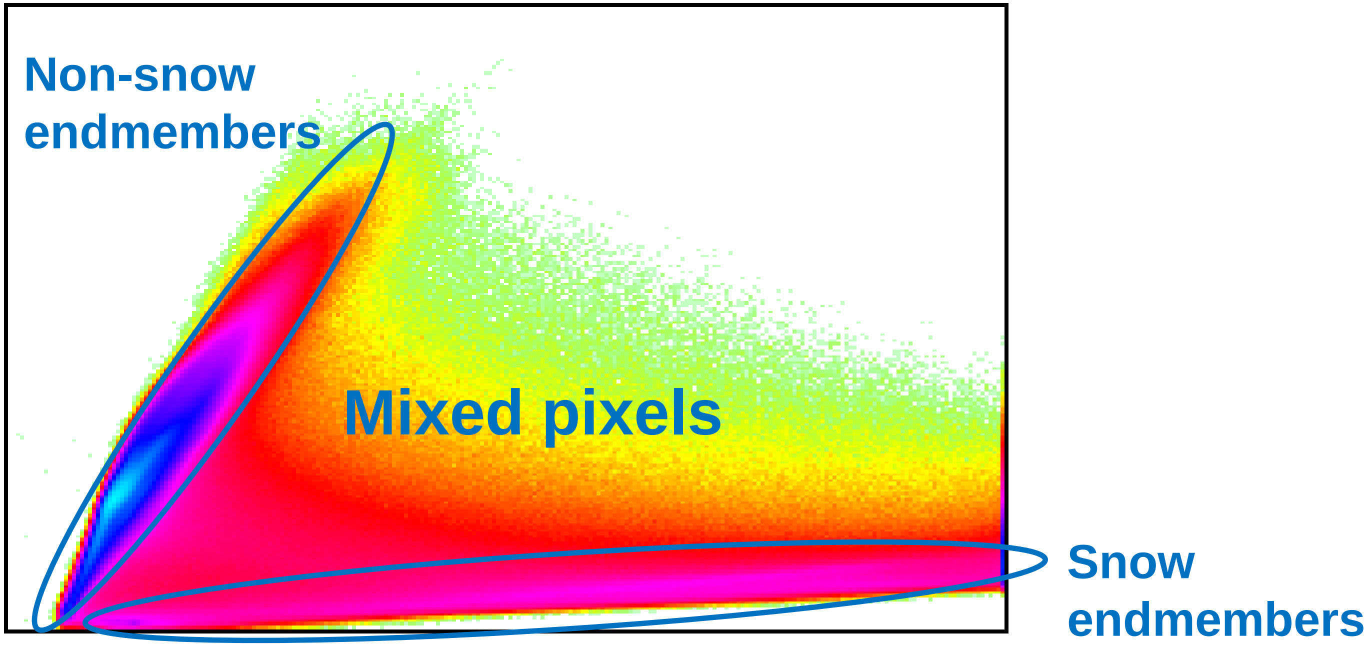
NDSI variability

VIIRS observations	NDSI		
Location	**Snow**	**Non-snow**	**50% fraction**
Beijing	0.70	-0.05	0.46
Altay	0.92	-0.12	0.59
Xinjiang 1	0.92	-0.20	0.52
Xinjiang 2	0.87	-0.25	0.42
Nevada	0.71	-0.23	0.31
Sierra	0.71	-0.18	0.31
Tian Shan	0.90	0.03	0.65
W Mongolia	0.92	0.10	0.61
Gobi	0.92	0.05	0.61
Pakistan	0.83	-0.37	0.16
S Mongolia	0.89	0.21	0.59
Dakotas	0.83	0.38	0.66
Spokane	0.93	-0.30	0.58
Oregon	0.91	-0.18	0.61
N Afghanistan	0.71	-0.23	0.37
C Afghanistan	0.79	-0.16	0.49
Average	0.84	-0.09	0.50

Reflectance variability

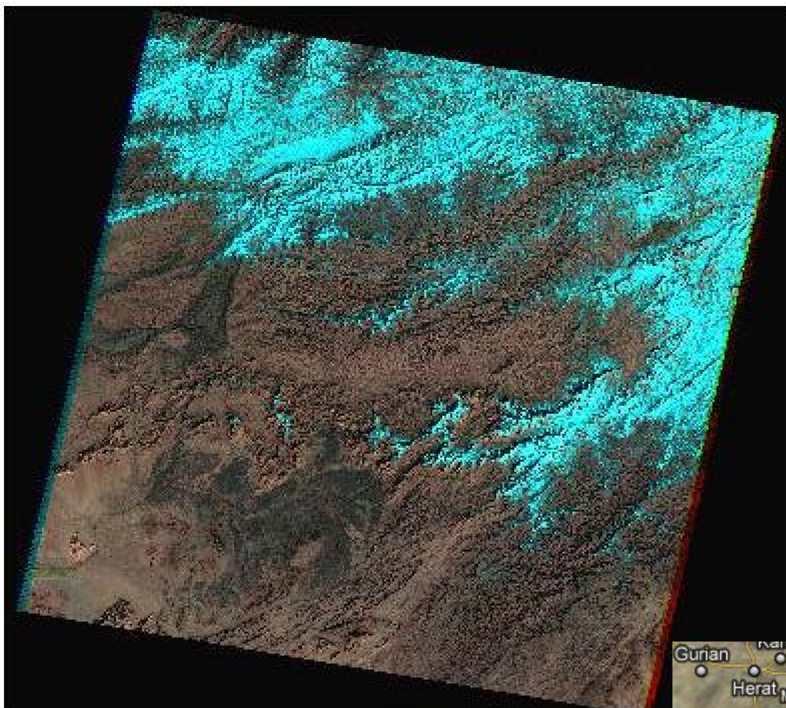
VIIRS observations	Snow reflectance (%)		Non-snow reflectance %	
Location	**Visible**	Near Infrared	**Visible**	Near Infrared
Beijing	39	7	10	11
Altay	72	3	15	19
Xinjiang 1	69	3	16	24
Xinjiang 2	71	5	19	32
Nevada	35	6	12	19
Sierra	35	6	14	20
Tian Shan	73	4	16	15
W Mongolia	69	3	23	19
Gobi	73	3	22	20
Pakistan	53	5	23	50
S Mongolia	71	4	35	23
Dakotas	65	6	29	13
Spokane	55	2	8	15
Oregon	43	2	7	10
N Afghanistan	47	8	12	19
C Afghanistan	60	7	13	18

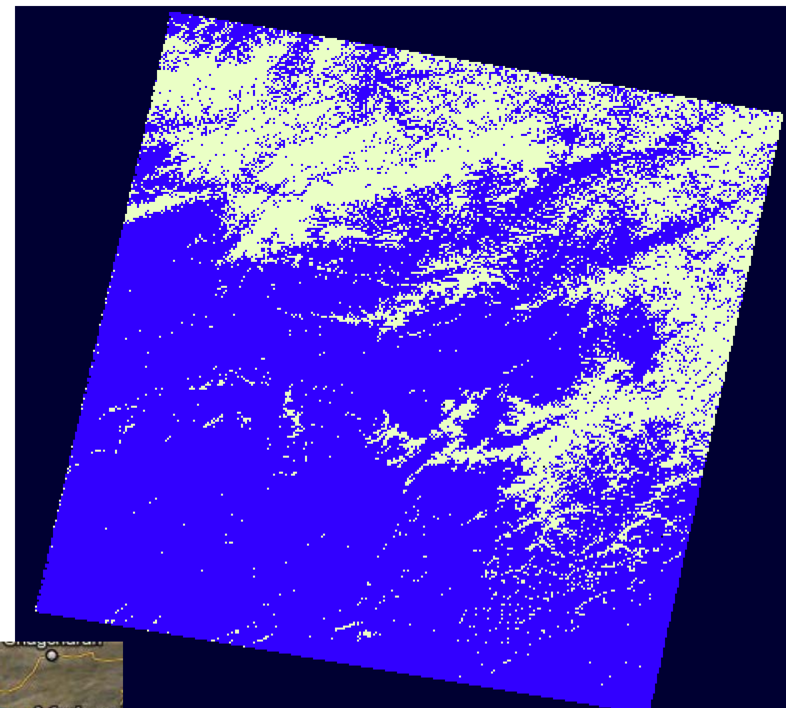
Variability of snow & non-snow reflectances (within a scene)



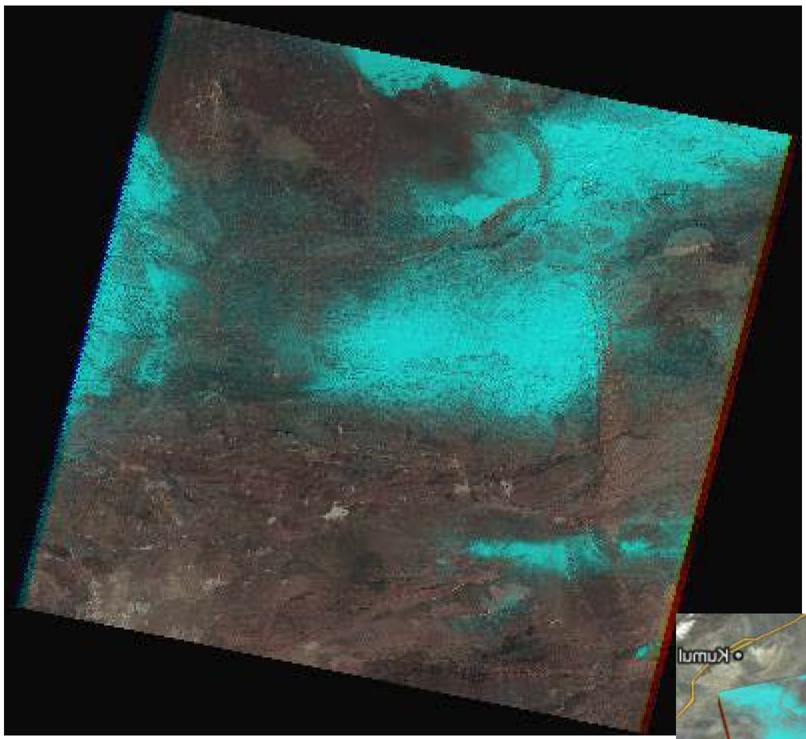
The simplest case of a two-dimensional histogram presenting the joint probability densities for Landsat band 2 (X axis) corresponding to VIIRS band M5 (0.64 µm) and Landsat 5 (Y axis) corresponding to VIIRS band M10 (1.61µm) illustrates significant variability in reflections characterizing snow and non-snow endmembers

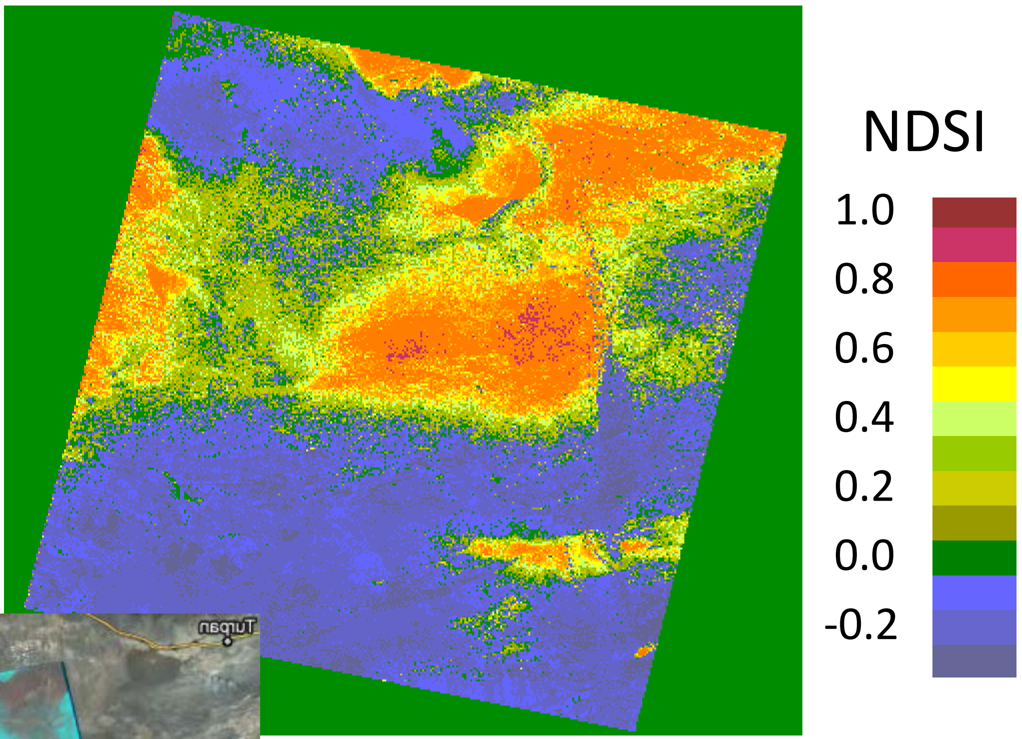
Landsas false color image and pixel classification (Afghanistan)

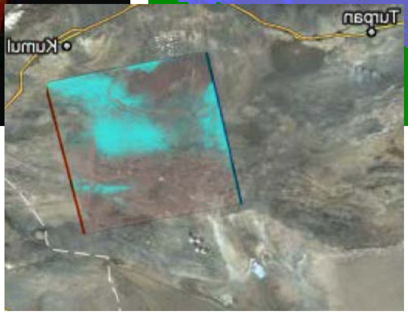




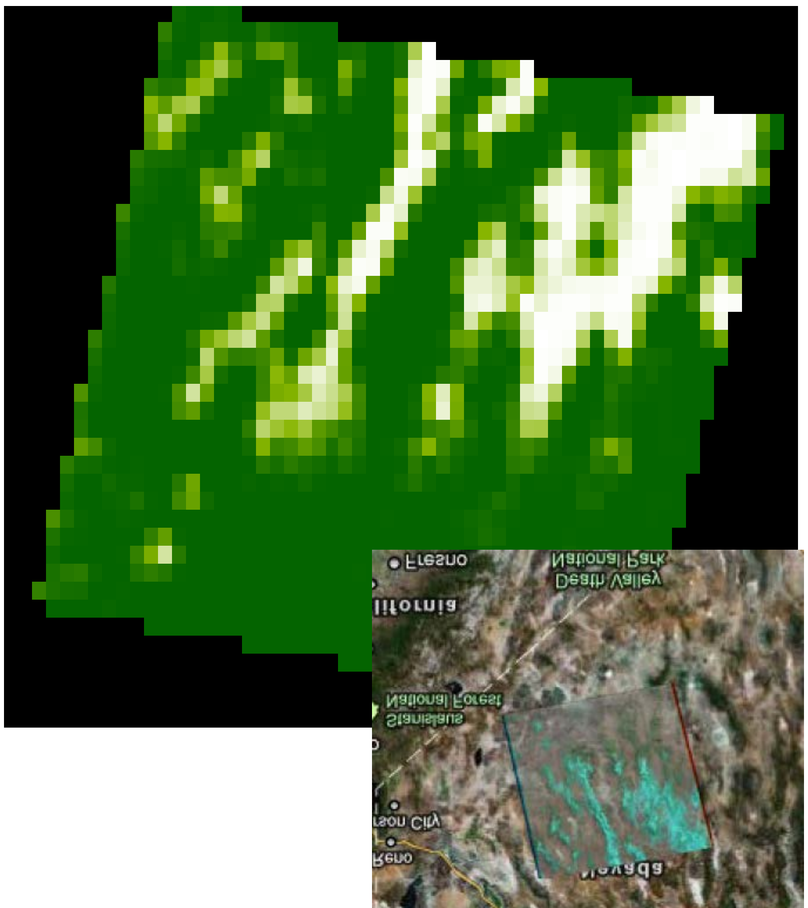
Landsat false color image and NDSI map (Xinjiang, W China)

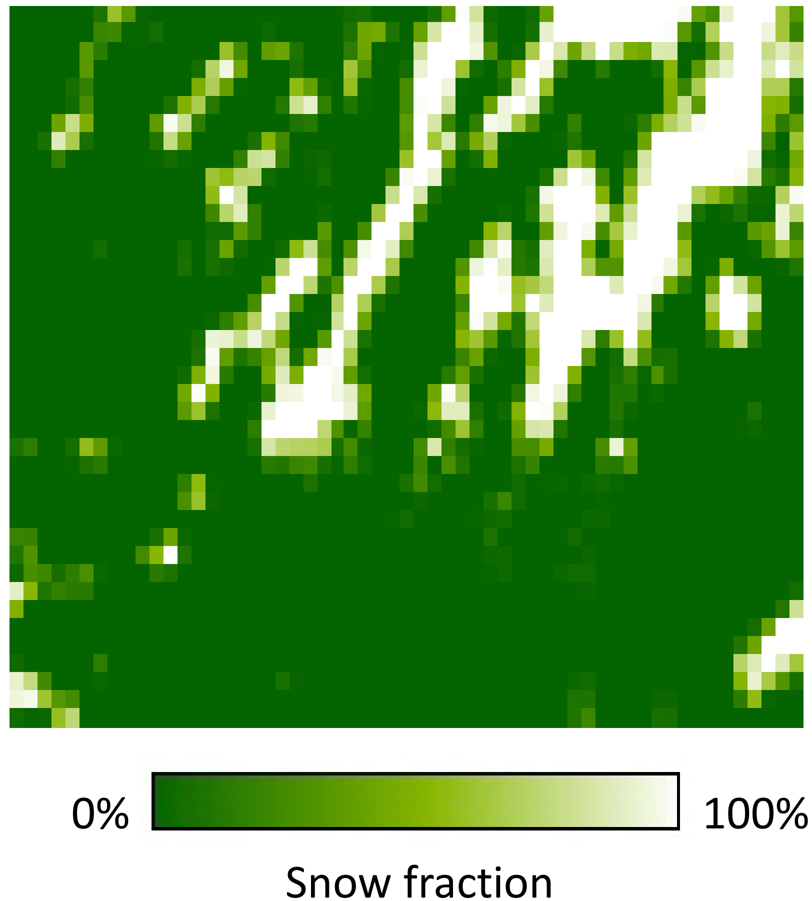






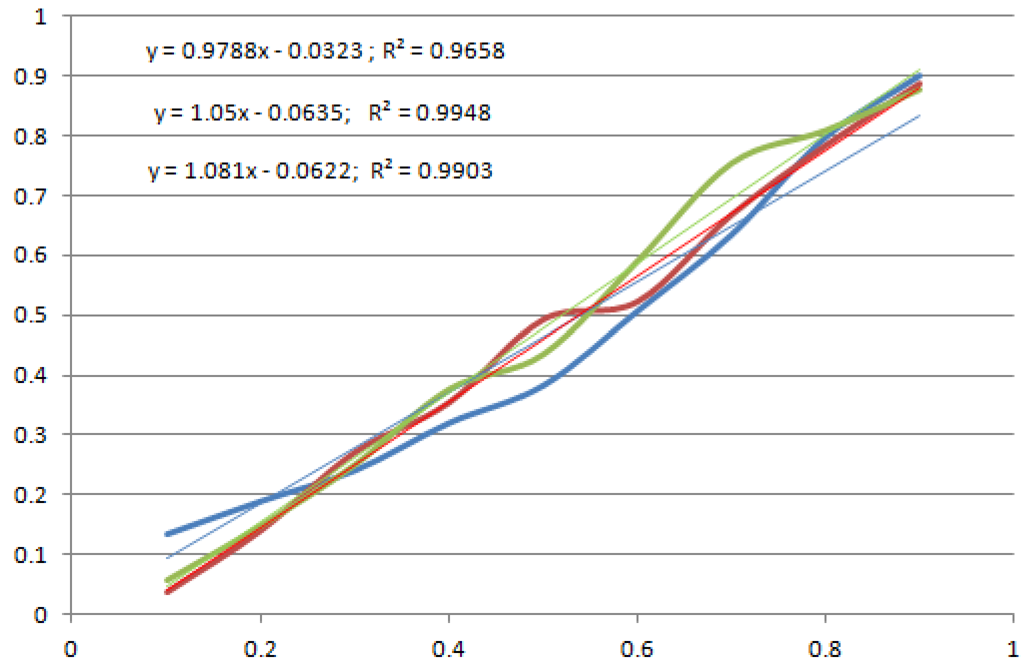
True and VIIRS snow fraction at 5 km resolution cells (Nevada)





Stratified Quantitative Assessment of NDSI-Based Algorithm Performance

Comparison of ground truth with NDSI algorithm results (thick lines) and trends (thin lines) for intermediate fractions demonstrates stratified performance for individual scenes



Validation of NDSI-based Snow Fraction

Corr. Coeff	Inter-cept	Slope	Mean true	Mean VIIRS	Location
0.84	-0.14	1.08	0.20	0.08	Beijing
0.89	-0.12	0.98	0.40	0.27	Altay
0.92	-0.14	1.10	0.61	0.53	Xinjiang 1
0.95	-0.03	1.00	0.20	0.17	Xinjiang 2
0.96	0.01	1.06	0.20	0.22	Nevada
0.96	-0.01	1.11	0.07	0.07	Sierra
0.92	-0.05	1.09	0.68	0.68	Tian Shan
0.91	-0.16	1.09	0.52	0.60	W Mongolia
0.89	-0.12	0.98	0.35	0.22	Gobi
0.74	-0.01	0.62	0.05	0.02	Pakistan
0.88	-0.07	1.09	0.92	0.93	S Mongolia
0.84	0.33	0.72	0.80	0.91	Dakotas
0.95	-0.00	1.07	0.19	0.20	Spokane
0.88	0.06	1.20	0.21	0.32	Oregon
0.95	-0.01	1.07	0.09	0.09	N Afghanistan
0.93	-0.06	1.17	0.27	0.25	C Afghanistan

NDSI-based Approach: Conclusions

- The optimal approach to improve moderate resolution remote sensing information on snow fraction allows the variability of local snow and non-snow properties
- Reliable evaluation of the VIIRS fractional snow algorithm quality is based on using Landsat scenes covering a wide variety of snow conditions, first of all, the areas including both snow and snow free surfaces
- Preliminary results of validation demonstrate that NDSI-based retrieval of snow fraction meets uncertainty requirements
- A scene-specific snow algorithm creates unbiased and consistent information on fractional snow cover distribution required for global studies, regional and local scale applications (including hydrological)

Further Enhancements of NDSI-based Approach

- It is necessary to explore and improve the quality of the following Look Up Tables
  - » NDSI LUT used to estimate scene-specific snow and non-snow NDSI (parameters of processed histograms)
  - » Cloud conditions LUT (cloud shadow, cloud confidence used for snow retrieval)
  - » Exclusion LUT defining conditions when snow fraction is not retrieved (dark pixels, climatic limitations)
- Investigate non-linear NDSI / snow fraction relationship
- Improve validation of the NDSI-based snow fraction for different scales, seasons, and conditions of observations
- Implement 250 m Land/Water mask
- Consider using cloud mask at imagery resolution

Reprocessing, Long-Term Monitoring

No plans for reprocessing so far

NDE long term product monitoring will include

- Generation global gridded snow fraction maps
- Visual examination of snow fraction estimates
- Comparison with Landsat
- Consistency testing

NOAA vs NASA Approach

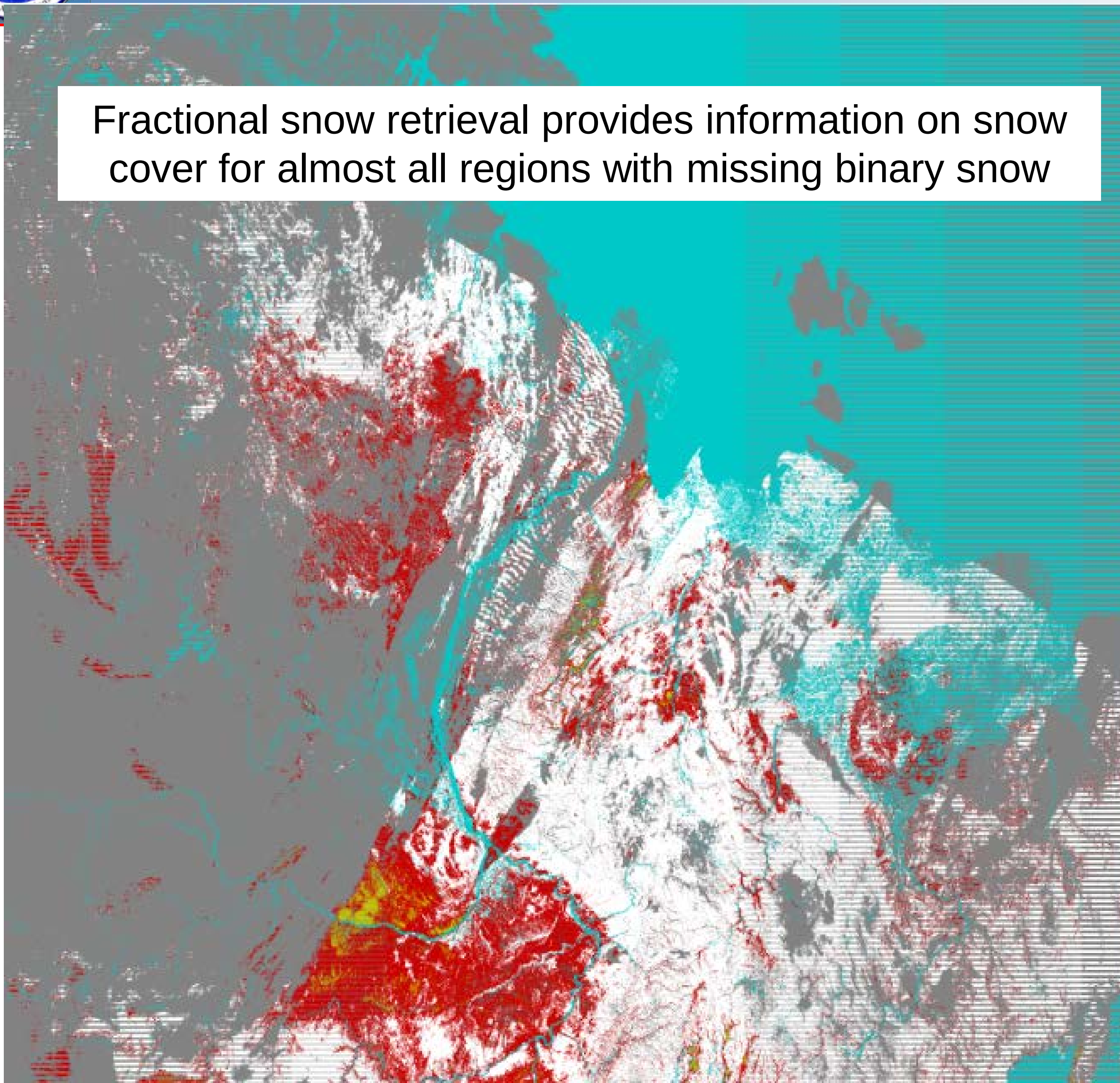
NASA:

- NDSI-based snow fraction

NOAA:

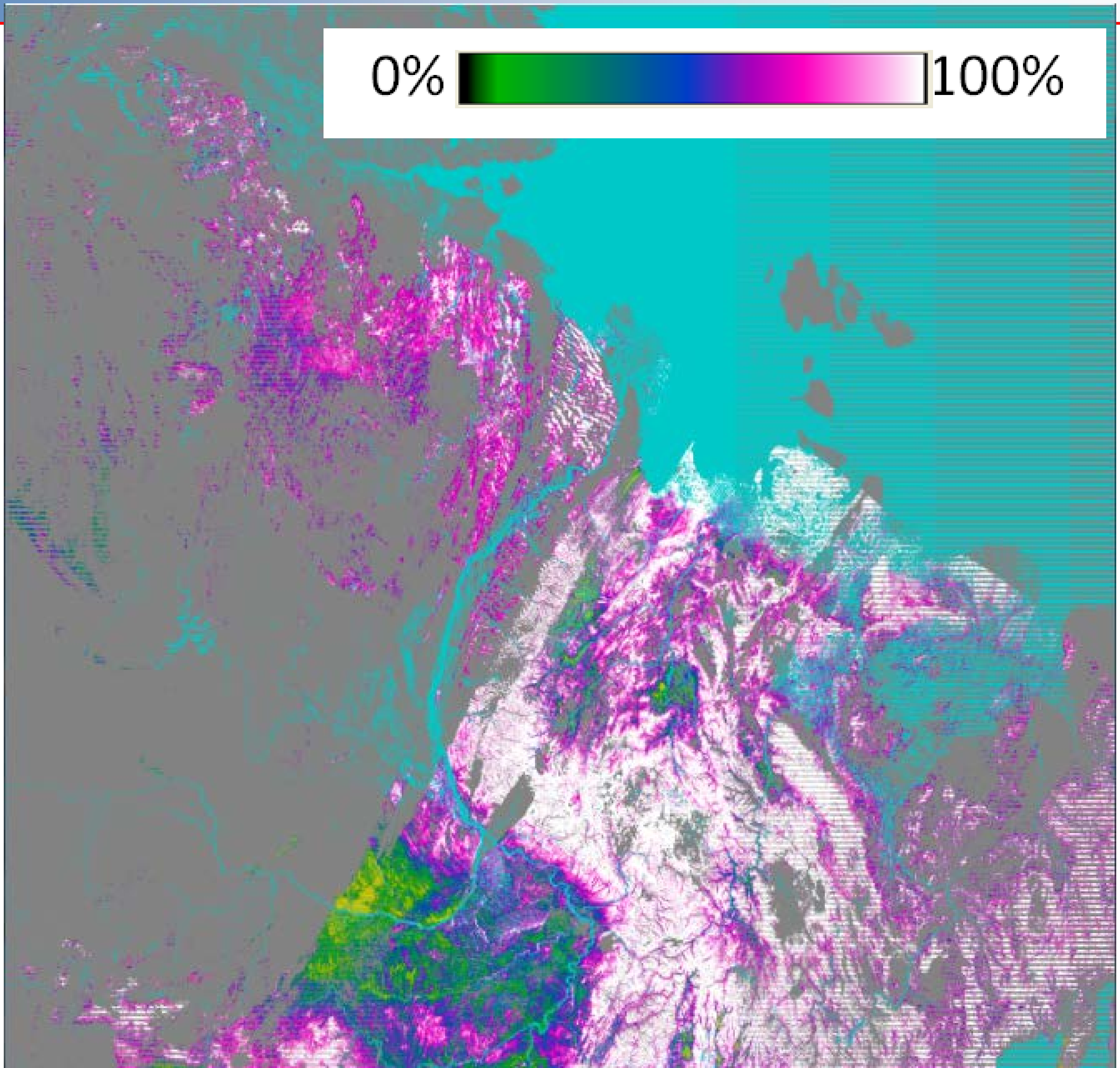
- Two snow fraction products

Snow Extent on 10/24/13 (03:20)

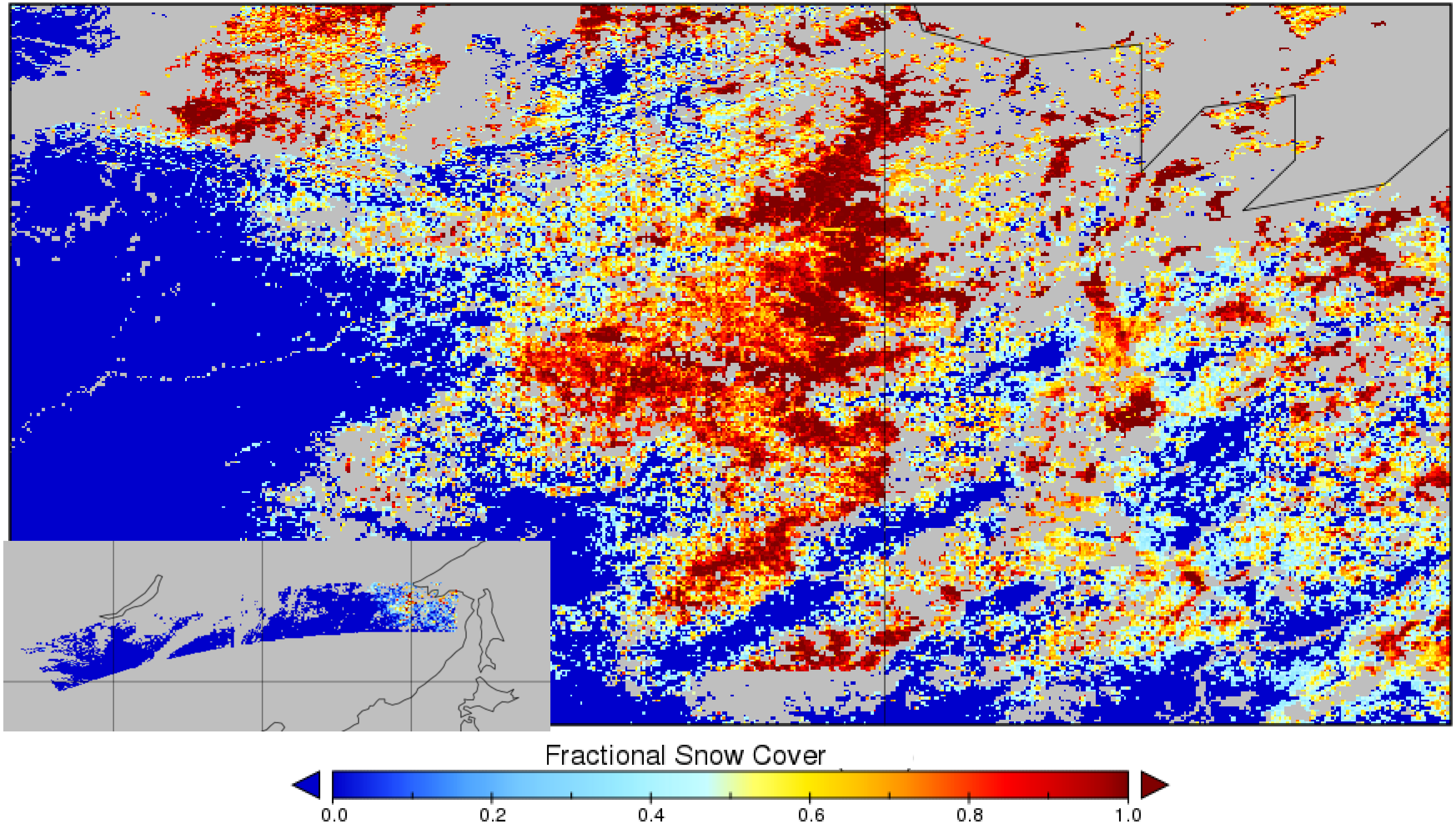


- snow
- confidently cloudy
- fractional snow cover in areas of non-snow binary retrieval
- non-snow in binary and fractional retrievals
- water

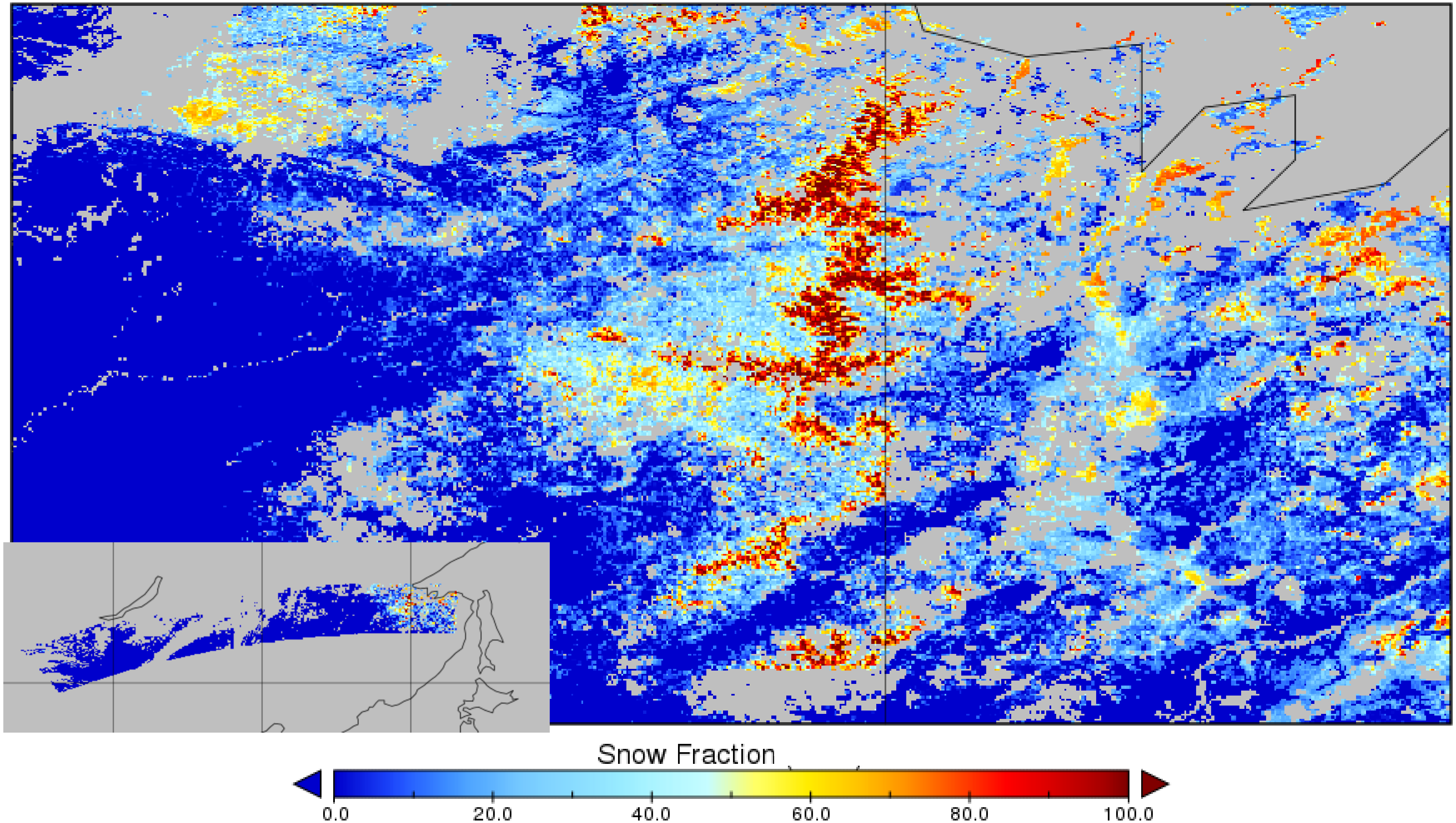
Snow Fraction on 10/24/13 (03:20)



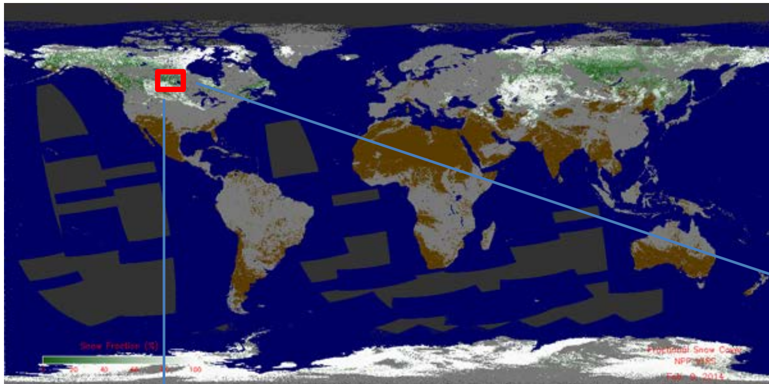
NDSI-based Snow Fraction (April 13, 2014)



Reflectance-based Fraction(April 13, 2014)

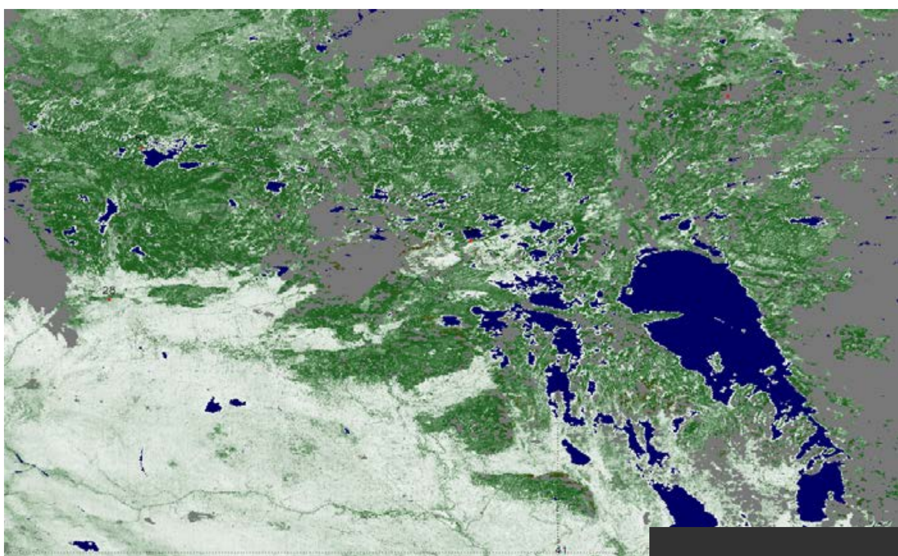


Reflectance-based vs NDSI-based Snow Fraction

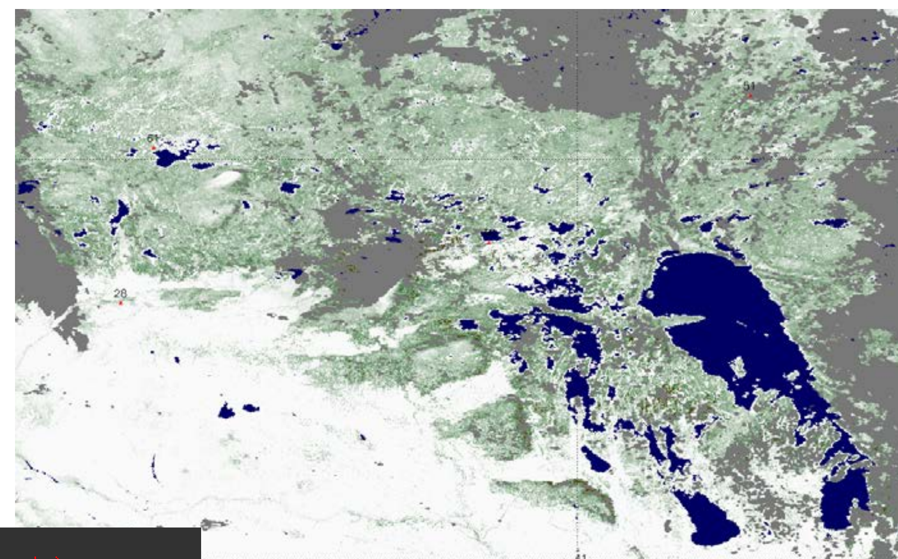


There is some similarity in the snow fraction patterns in the two products on the regional scale. NDSI-based snow fraction is much larger in the forest

Reflectance-based snow fraction

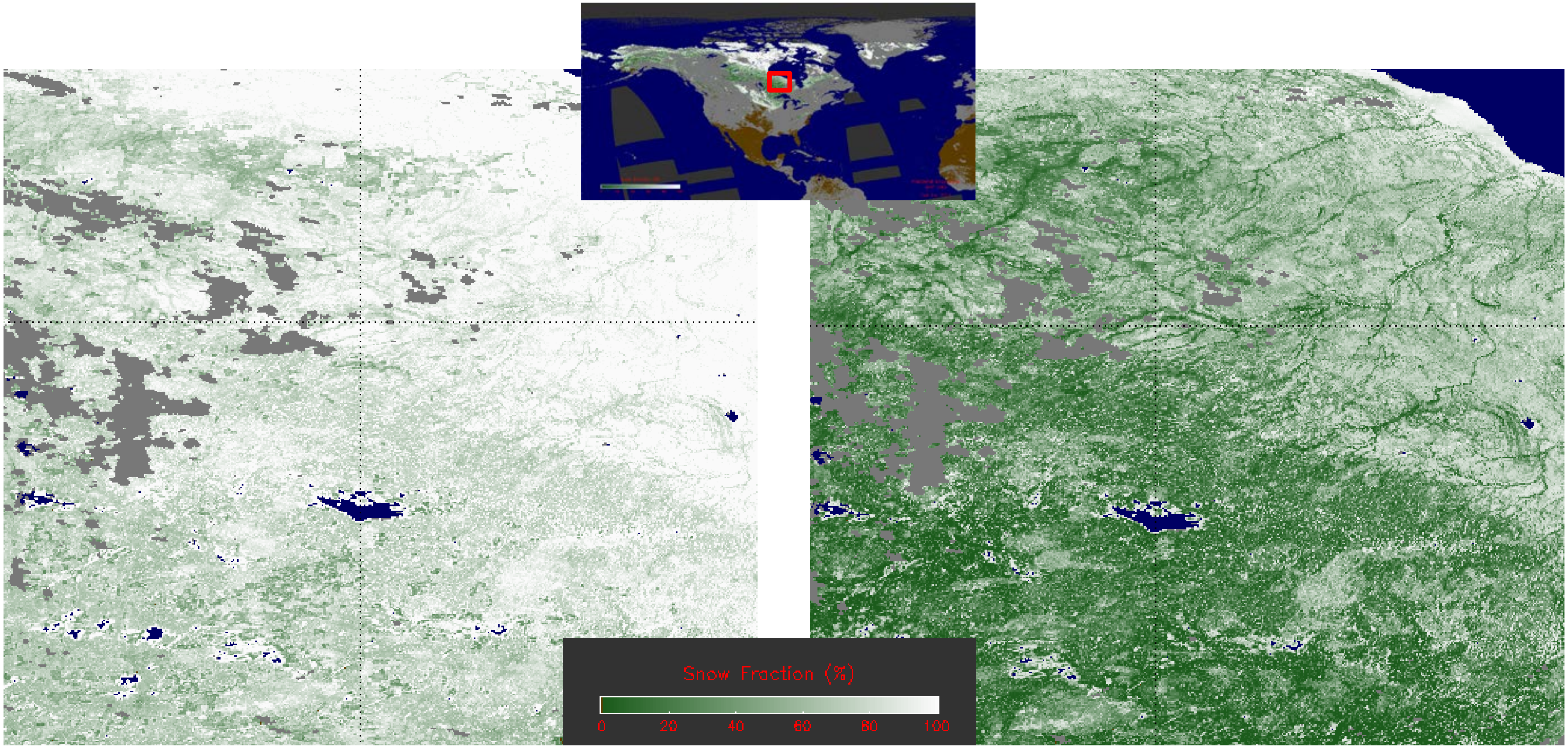


NDSI-based snow fraction



Clouds are shown in gray

Reflectance-based vs NDSI-based Snow Fraction



NDSI-based **Mean fraction: 83.4 %** **Reflectance-based** **Mean fraction: 36.8 %**

Questions Requiring Special Consideration

Consistency between algorithms retrieving binary snow mask and fractional snow cover

- comparable physical bases and algorithm realizations
- strict definition of binary snow product meaning
- excluding possible contradictions between binary and fractional products

Consistency between alternative algorithms of fractional snow cover retrieval

- Comparable outputs of fractional snow cover retrievals
- Explainable and acceptable differences between fractional snow cover products provided by two algorithms
- Estimated risk related to the difference between two retrievals

NASA Land SIPS: Production and QA

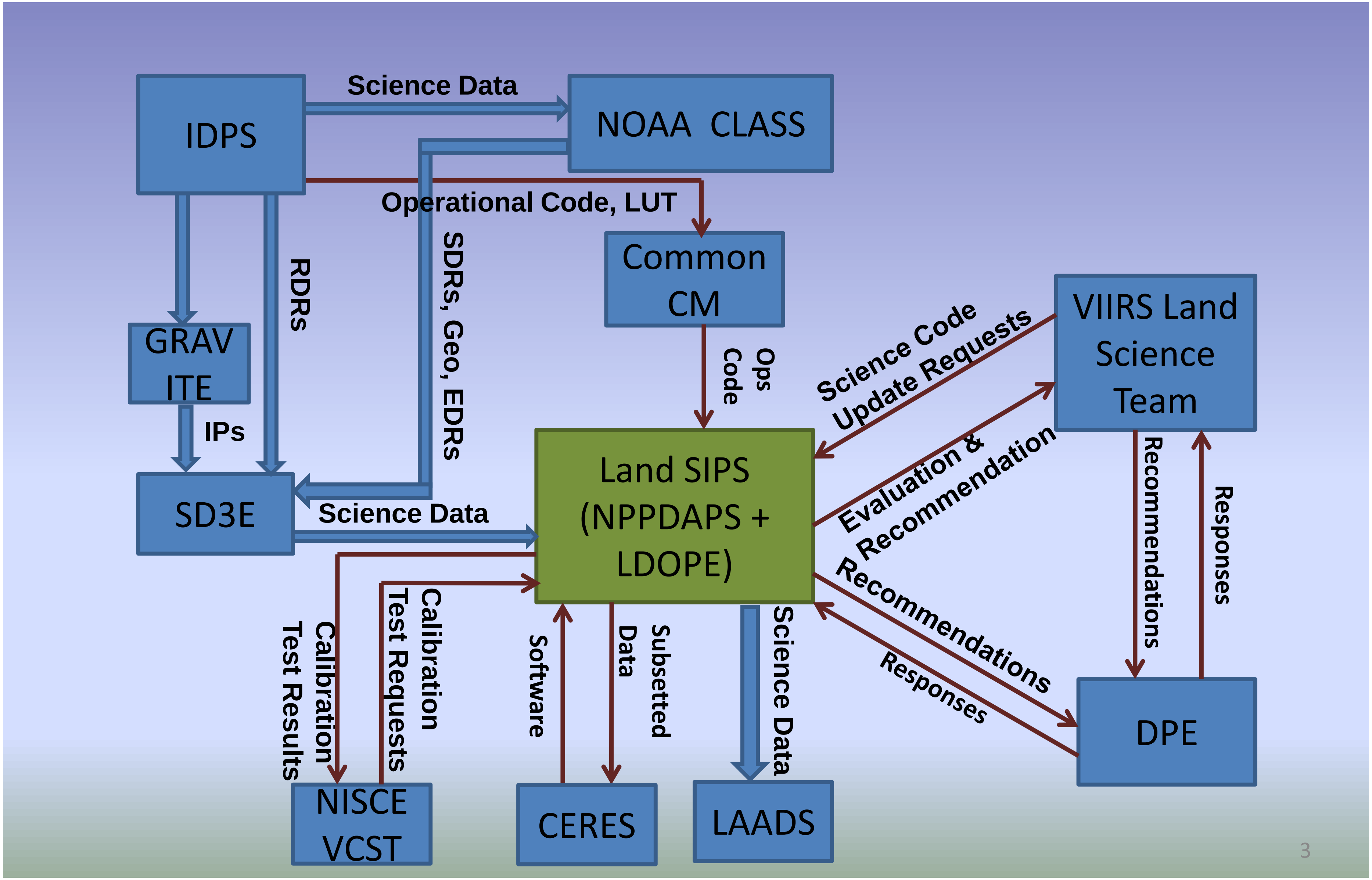
Sadashiva Devadiga[1,2], Carol Davidson[1,2], Gang Ye[1,2], Miguel Román[1], and Ed Masuoka[1]

[1]NASA Goddard Space Flight Center, [2]Science Systems and Applications Inc.

Land Science Investigator-led Processing System

- **Objective is to generate high quality land products from the VIIRS on-board S-NPP**
  - Extend the Earth System Data Records (ESDRs) developed from NASA's heritage Earth Observing System (EOS) Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the EOS Terra and Aqua satellites.
  - Generate land products using NASA science team delivered algorithms (beginning in December 2015) in combination with science algorithms currently in operation. Majority of NASA science algorithms will be in operation by December 2016.
  - Reprocess land data records from S-NPP mission as desired and recommended by the NASA science team using mature science algorithms provided by the NASA science team
  - Quality assessment performed at the Land Data Operational Product Evaluation (LDOPE) facility adopting the best-practices and tools used to assess the quality of heritage EOS-MODIS products generated at the MODIS Adaptive Processing System (MODAPS).

Land SIPS: Current Interface



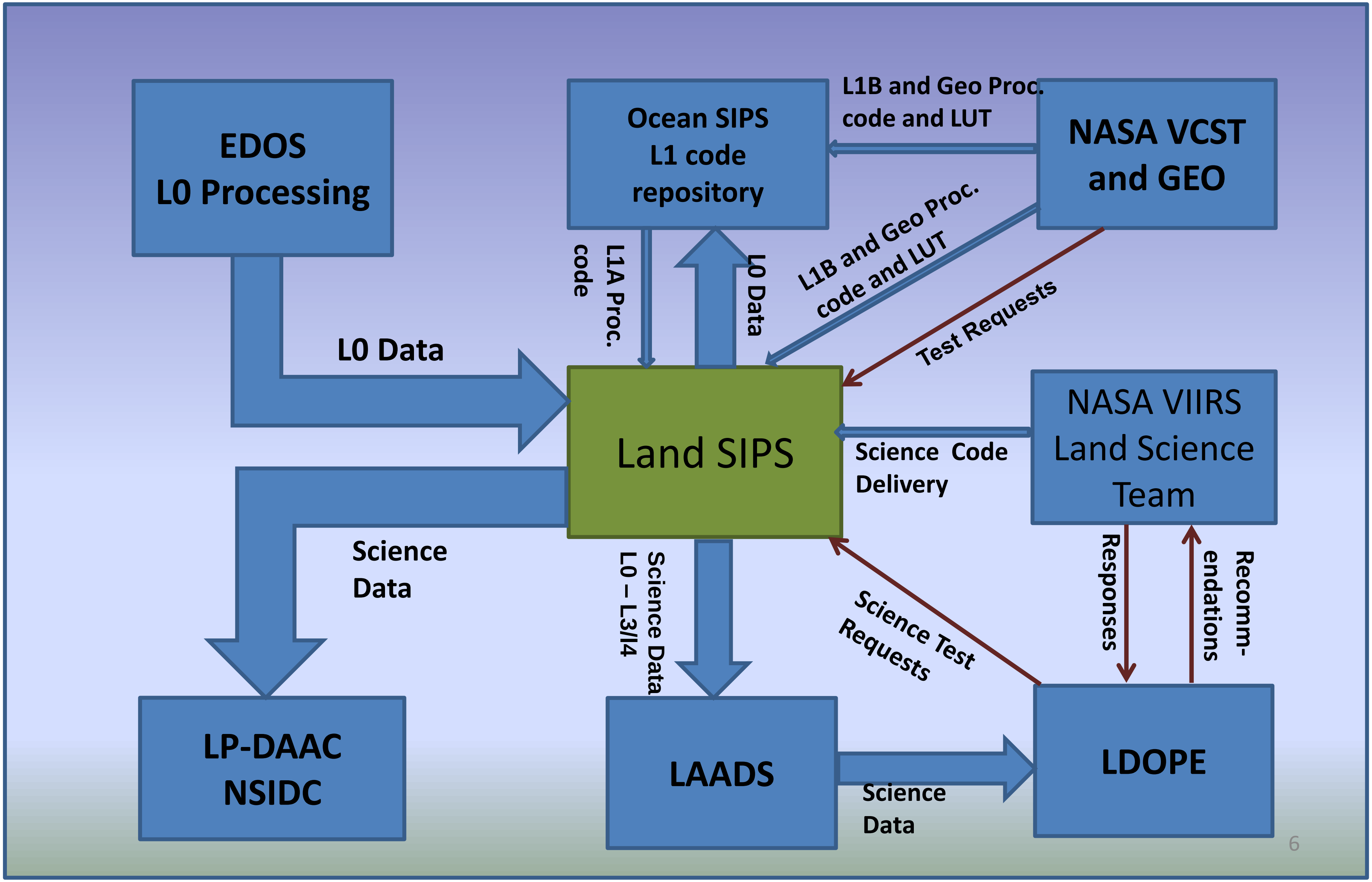
Land SIPS - Forward Processing Status

- **Land SIPS continues to receive and process VIIRS data. Data products are in HDF4 format, archived and distributed from LAADS** ***http://ladsweb.nascom.gov***
  - ***IDPS (LAADS AS 3000):*** Aggregate IDPS generated SDRs, Geolocation, EDRs and IPs from one global day (Saturday) every week. Data used to verify the accuracy of products produced in AS 3001. Build version in operation at IDPS is Mx8.10.
  - ***Land SIPS (LAADS AS 3001):*** Process RDRs using IDPS OPS PGEs integrated to Land SIPS processing system.
    - Leading edge is at current data day.
    - Cloud mask uses IDPS generated 17-day rolling tiles for RNDVI. GMASI based daily snow-ice tiles not ingested, instead tiles are generated in-house using daily NISE data.
    - Products match to aggregate IDPS products in AS 3000 except for minor differences in cloud mask and occasional differences from out of sync algorithm build versions and 17-day RNDVI roll up, ancillaries, and LUTs. Build version in operation is Mx8.10.
  - ***LPA (LAADS AS 3002):*** Process RDRs using Land SIPS adjusted version of IDPS OPS PGEs.
  - **Science team developed algorithms, Diagnostic Data Records (MODIS size gridded tiled products with VIIRS inputs) are generated from all three processing streams.**
- **Subsets are being generated from AS 3001 and 3002.**

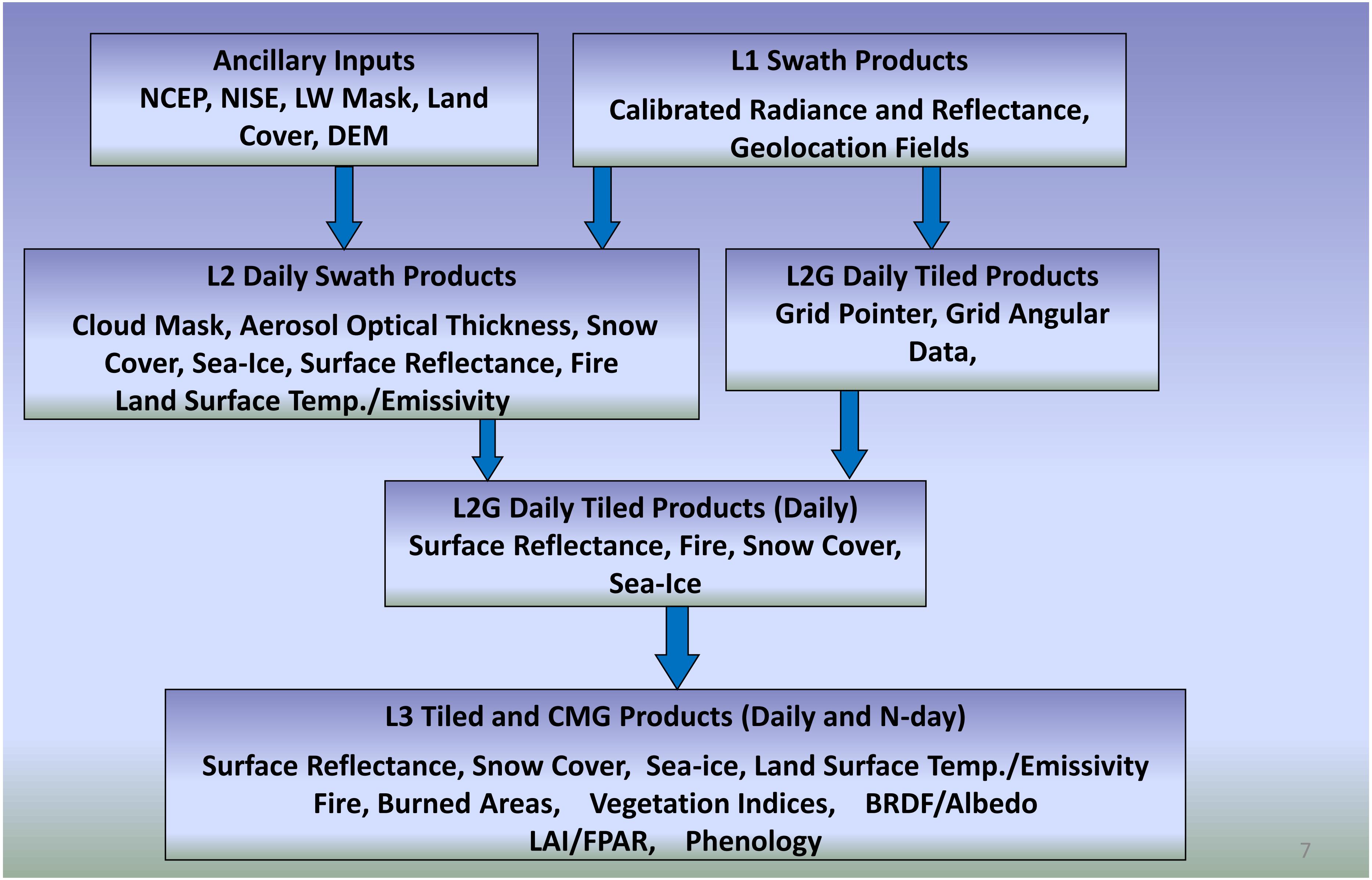
Land SIPS – C11 Reprocessing Status

- **C11 reprocessing in AS 3110 generates consistent records from the beginning of the mission using the best calibration LUT provided by NASA VCST and best of algorithms available.**
  - Reprocessing started on 2/26/2014 and completed on July 2014. Records start with the beginning data day 1/19/2012. Processing lags by one month waiting for delivery of LUT by VCST.
  - Cloud Mask uses the Climatology 16-day composite NDVI from the 4-years of Aqua MODIS observations and daily snow-ice from NISE data replacing the 17-day rolling tiles of NBAR-NDVI and the monthly/daily snow-ice rolling tiles used in the operational process at IDPS
  - DNBs are processed using the LUT for calibration and stray light correction provided by the NASA VCST.
  - Processing uses the Land SIPS Adjusted variations of OPS PGEs for TC DNB Geolocation (DNFT), L2 LSR (SR-IP), L2 VI (VRVI) and L2 Aerosols (AOTIP).
  - Land SIPS processes the Science DDRs using the latest version of the DDR algorithms based on MODIS C5 operational PGEs and the CERES subsetter.
  - This reprocessing does not generate the OPS L2 Land Albedo, Surface Albedo or any GIPs, and does not use rolling tiles.

Land SIPS: Operational Interface



Land SIPS - VIIRS Data Product Hierarchy



Land SIPS - VIIRS Data Production

- VIIRS L1 and L2 swath products are generated from processing of the VIIRS data acquired during 6 minutes of the satellite overpass.

- The L2G, L3 and L4 products are produced as adjacent non-overlapping tiles of approximately 10 degrees square, (at the equator)

- L2G product is a data structure storing the L2 observations intersecting the grid cell in a map projection. L2G heavy format stores all observations that meets the threshold criteria for the observation foot print coverage with the grid cell, L2G-lite format stores only one observation from an orbit. First observation is stored in a 2D array and the additional observations from all grid cells are stored in a 1-D array.

- The MODIS land gridded products are produced at 4 resolutions (500m, 1km, and 0.05 degree), and in 3 projections (Sinusoidal, Lambert Azimuthal Equal-Area, and Geographic). The simple Geographic lat/lon projection is only used for the coarsest resolution grid, produced at 0.05 km (~ 5.5 km), which is referred to as the Climate Modeling Grid (CMG). Most of the higher resolution VIIRS land products are produced in the Sinusoidal tile grid, except for the Sea Ice products, which are produced in the polar Lambert Azimuthal Equal-Area tile grids.

Land SIPS - Transition

- **The L0 dataflow from EDOS is currently under testing. The Operational Readiness Review (ORR) for EDOS is scheduled for Sept 14, 2015. Expected to be operational by early October.**
- **NASA L1A/L1B/Geo expected to be operational at Land SIPS by early October 2015.**
- **New Land SIPS Processing stream is currently in development. Expected to be operational in December 2015, generating land products using the NASA science team delivered algorithms and "best-of" science algorithms currently in operation.**
  - C11 reprocessing in AS 3110 will continue until NASA ST and SIPS is ready for the next collection reprocessing using the NASA L1B data and NASA Science Team delivered algorithms.
  - AS 3001 and 3002 will be replaced with a single forward processing stream in AS 300X containing best of the algorithms from the two processing streams, using IDPS delivered RDRs through SD3E.
  - In parallel to this forward processing in AS 300X, Land SIPS will develop the new SIPS processing stream (in AS 500x) that would generate the NASA VIIRS land products using the NASA ST delivered algorithms using the NASA L1B as input. This NASA processing stream, when fully functional could replace AS 300X.

Land SIPS – IDPS vs SIPS Products

- **L1B and Geo:** Aside from differences in format, when the same LUTs are configured and all data is converted to a common floating point radiance data type, there is no significant difference between the L1B and SDR products.
- **Upstream Products**
  - SIPS will use the **C11 approach to Cloud Mask**. Cloud Mask from Atmosphere SIPS could be also considered if available.
  - SIPS will use the Mx8.10 build of **IDPS for AOTIP** with recommended changes from the NASA SR science team.
- Science Processing algorithm for **Surface Reflectance and Fire** algorithm will be nearly the same as operational IDPS.
  - Code Changes to SR at Land SIPS will be delivered to STAR/AIT for implementation and testing in ADL and delivery to DPE for use in operational processing at IDPS.
- **Land Surface Temperature** will use the IDPS operational algorithm until an emissivity based algorithm is delivered by the NASA science team.

Land SIPS – VIIRS Land Products

Product Name	VIIRS (S-NPP) ESDTs	MODIS Heritage ESDTs	VIIRS (S-NPP) (Product release date: Tentative)
Land Surface Reflectance	VNP09	MxD09	DEC 2015
MAIAC Product Suite *	VNP19	MCD19	JUL 2016
BRDF/Albedo, NBAR	VNP43	MCD43	MAR 2016
Land Surface Temperature	VNP21	MxD21	DEC 2016
Vegetation Indices (VI)	VNP13	MxD13	JAN 2016
FPAR	VNP15	MxD15	JUN 2016
Fire and Thermal Anomalies	VNP14	MxD14	MAR 2016
Burned Area	VNP64A1	MCD64A1	DEC 2016
Snow Cover	VNP10	MxD10	MAR 2016
Sea Ice Cover	VNP29	MxD29	NOV 2016
Ice Surface Temperature	VNP30	MxD10	NOV 2016
Land Surface Phenology	VNP12Q2	MCD12Q2	APR 2017

** Includes surface reflectance, BRDF, snow fraction and aerosol retrievals over Land*

Land Product Quality Assessment and Algorithm Evaluation

- **Adopts the MODIS Land QA approach to assess quality of VIIRS products.**
  - Global browses, golden tiles browses, animation, time series
  - Visual inspection of browse images and analysis of selected sample data records
- **Verify reproducibility of IDPS products at Land SIPS.**
  - Through comparison of global browse images of Land SIPS generated products to IDPS aggregated products in AS 3000
  - Accuracy, Precision and Uncertainty estimate from comparison of full resolution data records from the two archive sets.
- **Assessment of VIIRS Land Algorithm Changes**
  - PGE specific science test and chain tests run generating global data
  - Baseline and Test data created for comparison of different algorithm versions, LUTs, Seed Files etc.
  - Comparison to heritage MODIS products
- **QA information posted on the QA web page**
  - Results from all QA processes (browses, time series, APU etc.)
  - Known issues from operational product evaluation
  - Algorithm test status and evaluation results
- **QA tools developed and maintained by LDOPE**
  - Generic and transparent to products from different instruments
  - All operational QA processes automated to process data in real time with production and populate result on the QA web page.

Land SIPS - QA Web Page

National Aeronautics and Space Administration
Goddard Space Flight Center

Suomi NPP - Land Science Investigator-led Processing System

VIIRS Land Product Quality Assessment

Visible Infrared Imaging Radiometer Suite

Home | Browse | Time Series | Land Products | QA Info | Alg Updates/Eval | Links | Early Images

Welcome to the NPP VIIRS Land Product Quality Assessment

The objective of the VIIRS (Visible Infrared Imaging Radiometer Suite) Land Product QA is to evaluate and document the science quality of products made from the remotely sensed data acquired using VIIRS. Results of quality assessment of samples of VIIRS Land products made at Land SIPS (Science Investigator Processing System) and IDPS (Interface Data Processing System) and results of evaluation of improvements to the VIIRS Land Science algorithms derived by analyzing the products made at Land SIPS using the new algorithms are placed on the web pages located at this site.

The Suomi NPP (National Polar-orbiting Partnership) satellite was launched on Oct. 28, 2011. Evaluation of products from the IDPS OPS (Operation System) algorithms, and the Land SIPS adjusted version of the IDPS OPS algorithms run at Land SIPS and of the science algorithm improvements are done at LDOPE (Land Data Operational Product Evaluation). Results from LDOPE's evaluation of the pre-launch version of the IDPS algorithms done using simulated or proxy MODIS data and the results from the science test of changes to algorithm done post-launch using on-orbit data are posted on the Algorithm Updates/Evaluation section of this web page. This web page is constantly evolving. For global browse images from immediate post-launch period please click on the Brows menu at the top of this page. Please direct your questions and comments to Sadashiva Devadiga.

For more information about the VIIRS Land products, validation, and product maturity status, visit: http://viirsland.gsfc.nasa.gov/index.html

What's New

- Mx8.10 is now in operation at Land SIPS starting day 08/08/2015 (2015126). Click here for NPP version history.
- VIIRS xDR from the operational processing of on-orbit data at Land SIPS using the same algorithm version as IDPS is available from AS 3001 of LAADS and products from science team improved version of algorithms is available from AS 3002. Please see the Land SIPS data production and retention policy to verify availability of data online.
- SNPP VIIRS Land Records from C1.1 reprocessing using best of Calibration LUTs and science algorithms available from AS 3110. C1.1 reprocessing started 2/26/14. Reprocessing of December, 2014 started 1/20/15 and completed 2/5/15. This reprocessing lags operational processing by a month.
- Data products from the early mission period were labeled as of BETA quality. Many products have now reached maturity stage of "provisional quality" or "Validation Stage 1".

http://landweb.nascom.nasa.gov/NPP_QA/

Goddard Space Flight Center

Responsible NASA Official : Edward Masuoka
Content Owner: Sadashiva Devadiga
Web Curator: Demi Feng

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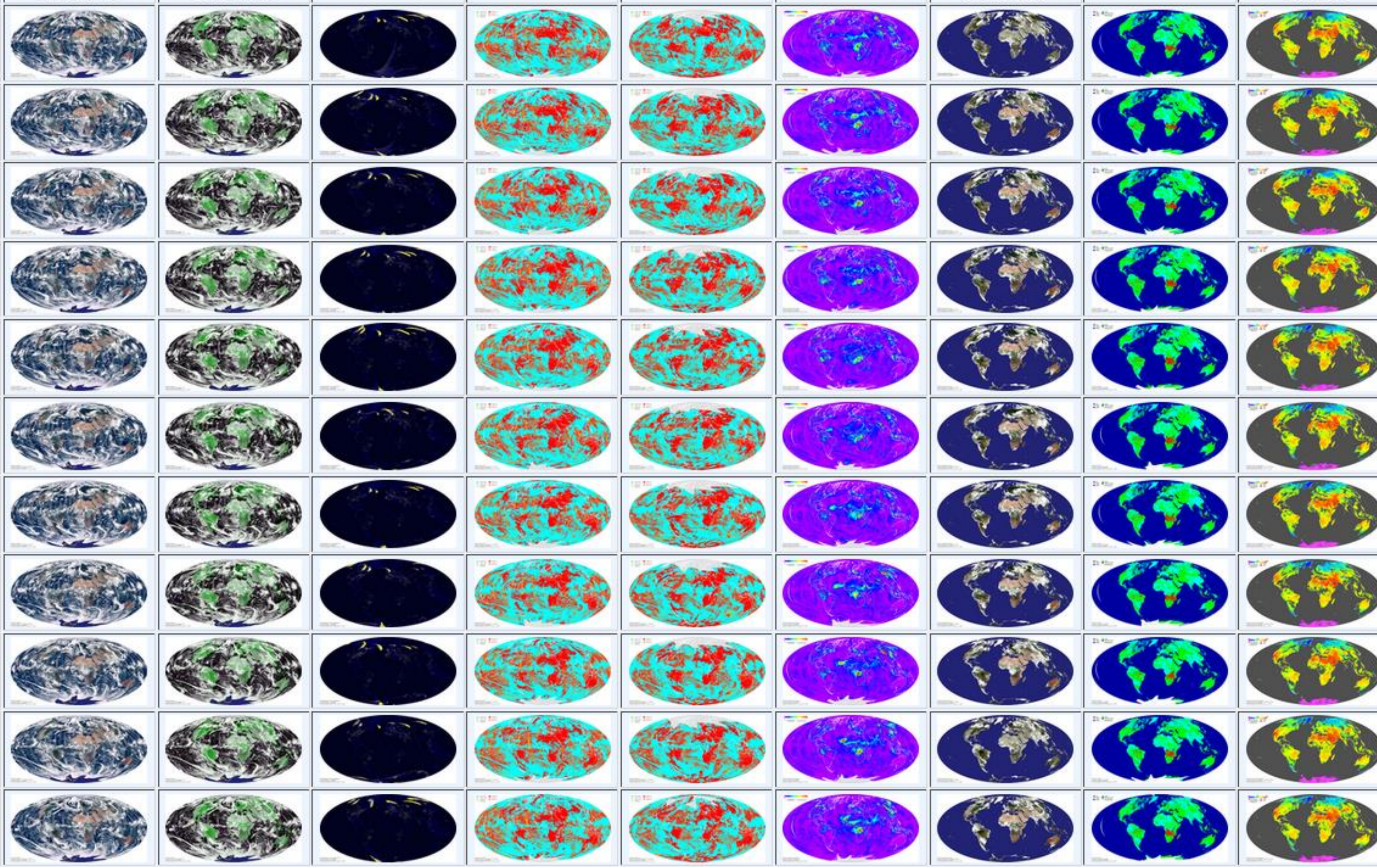
Contact Us

Land Product Quality Assessment
Global Browse Images of Operational Products

Julian day		NPP_VMAE_L1 L1B Moderate input, Day Band 5,4,3	NPP_VIAE_L1 L1B Imagery input, Day Band 1,2,1	NPP_VDNE_L1 Night Band	NPP_CMIP_L2 Cloud Mask IP Day	NPP_CMIP_L2 Cloud Mask IP Night	NPP_VAOTIP_L2 Aerosol Optical Thickness IP	NPP_SRFLMIP_L2 Surface Reflectance IP (Moderate)	NPP_VAFIP_L2 Active Fire IP	NPP_VLST_L2 Land Surface Temperature Daytime
2015 236 08/24	Orbits									
2015 235 08/23	Orbits									
2015 234 08/22	Orbits									
2015 233 08/21	Orbits									
2015 232 08/20	Orbits									
2015 231 08/19	Orbits									
2015 230 08/18	Orbits									
2015 229 08/17	Orbits									
2015 228 08/16	Orbits									
2015 227 08/15	Orbits									
2015 226 08/14	Orbits									



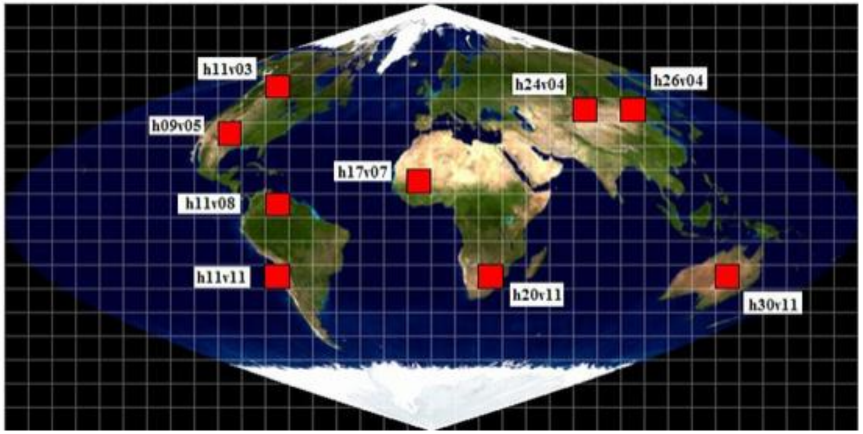
Land Product Quality Assessment Golden Tile Time Series

NPP Time Series

A time series of summary statistics derived from all the gridded NPP Land products at a number of xxed globally distributed locations is maintained and monitored by LDOPE personnel in order to enable synoptic quality assessment via the internet. Product time series analyses are important because they capture algorithm sensitivity to surface (e.g., vegetation phenology), atmospheric (e.g., aerosol loading) and remote sensing (e.g., sun-surface-sensor geometry) conditions that change temporally, and because they allow changes in the instrument characteristics and calibration to be examined. Time series statistics are extracted at nine NPP Land golden tiles selected over areas that are expected to be representative of the variability of the majority of the NPP Land products. Golden tile browse images are also available for the most recent month of production. Follow steps to examine time series plots. Click here for more information.

1.Select a data set: LPEATE 2.Select a product: NPP_D16VIHKM_L3D -16-day Vegetation Index

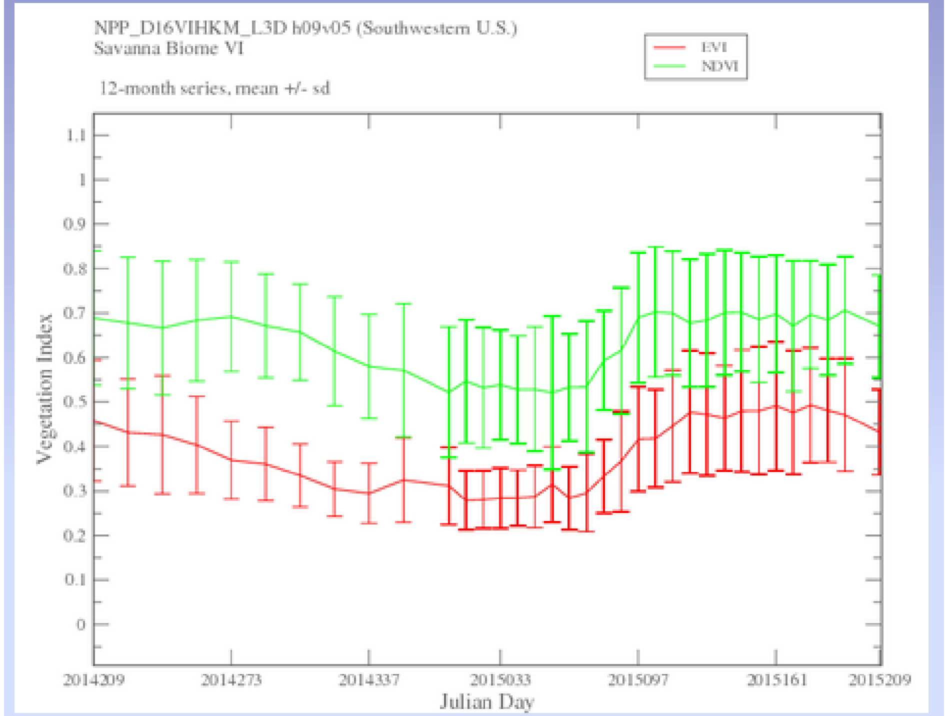
3.Click on a tile:

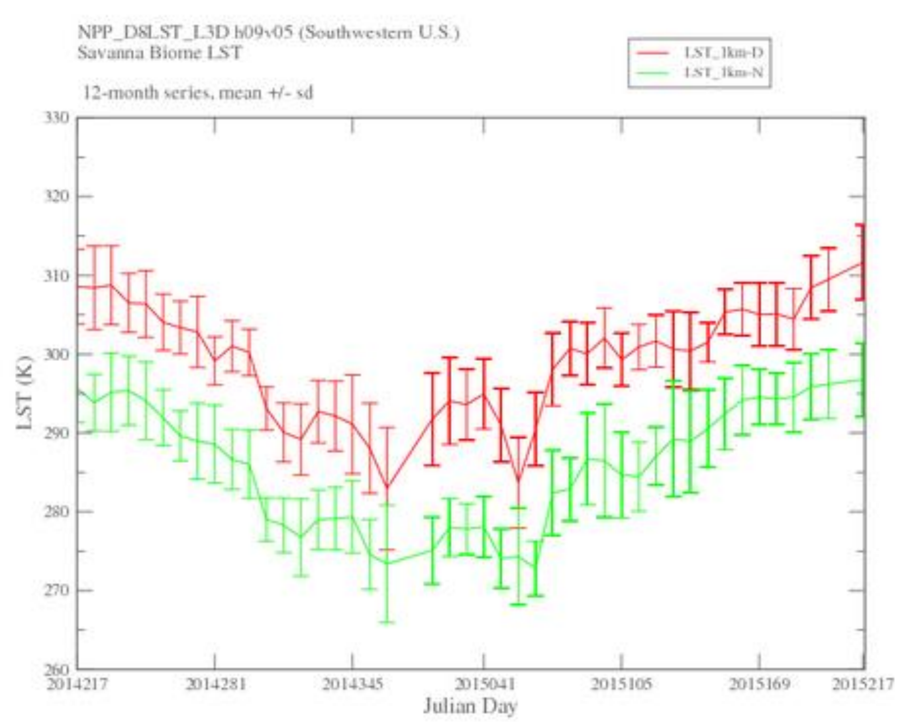


Plot Options: LPEATE, h09v05, NPP_D16VIHKM_L3D -16-day Vegetation Index

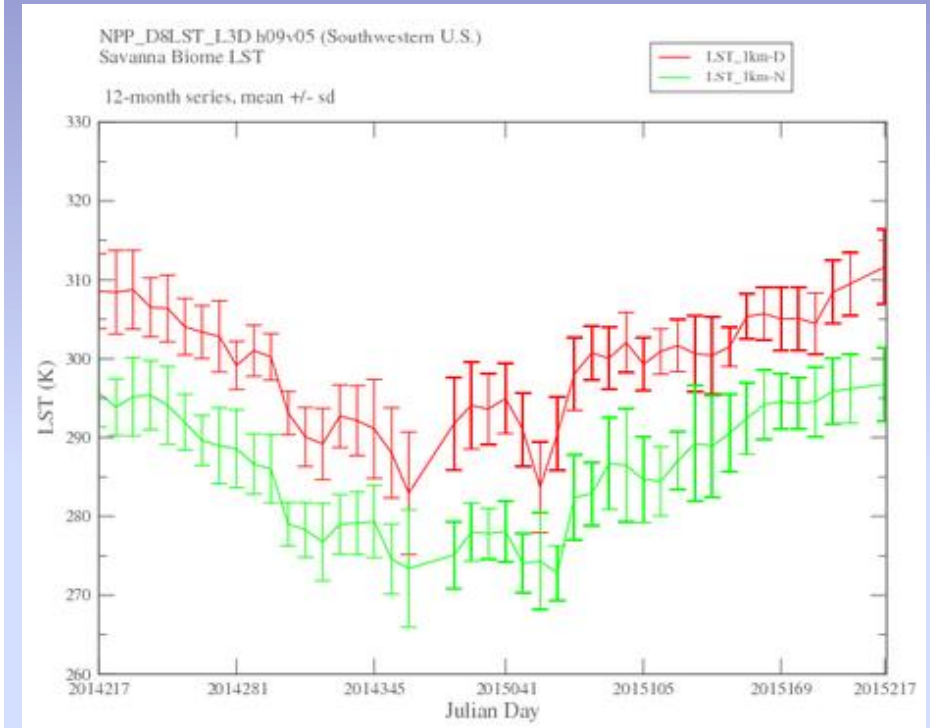
Biome	LandCover	Site
biome_1	land_cover_10	site_19 site_23
biome_2	land_cover_7	site_6 site_7 site_10
biome_3	land_cover_12	site_26 site_33
biome_4		site_18
biome_6	land_cover_1	
biome_7	land_cover_16	site_40 site_41 site_42

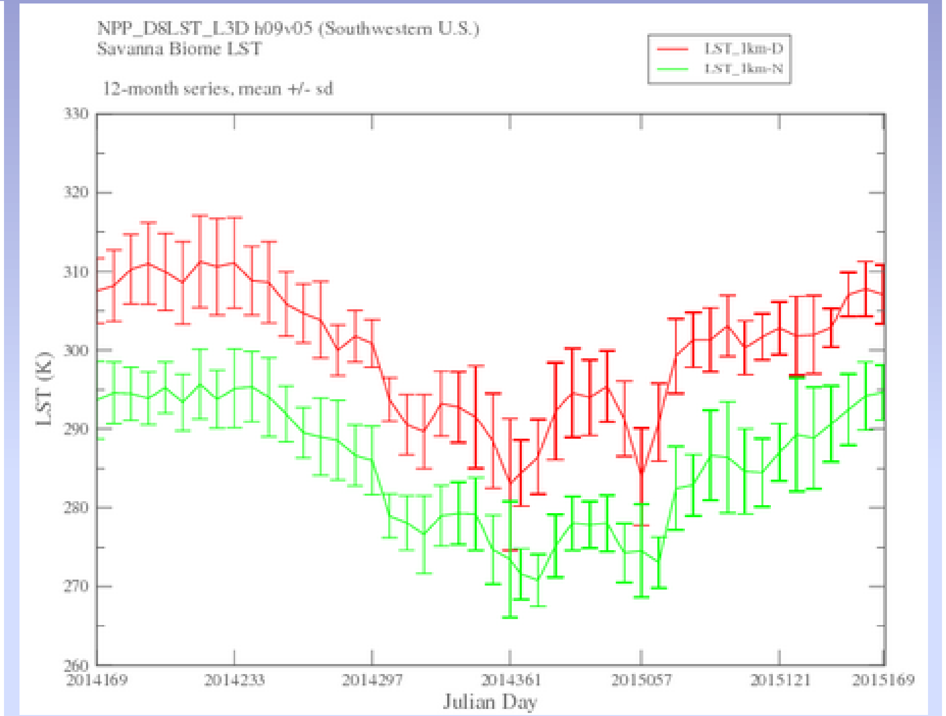
Land Product Quality Assessment Golden Tile Time Series: LST Day



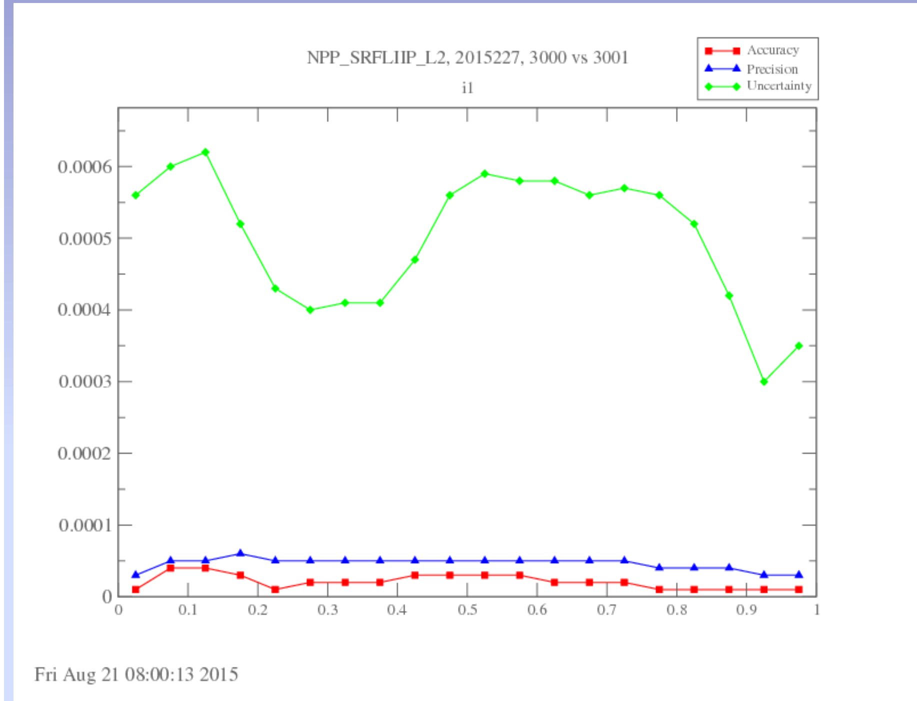


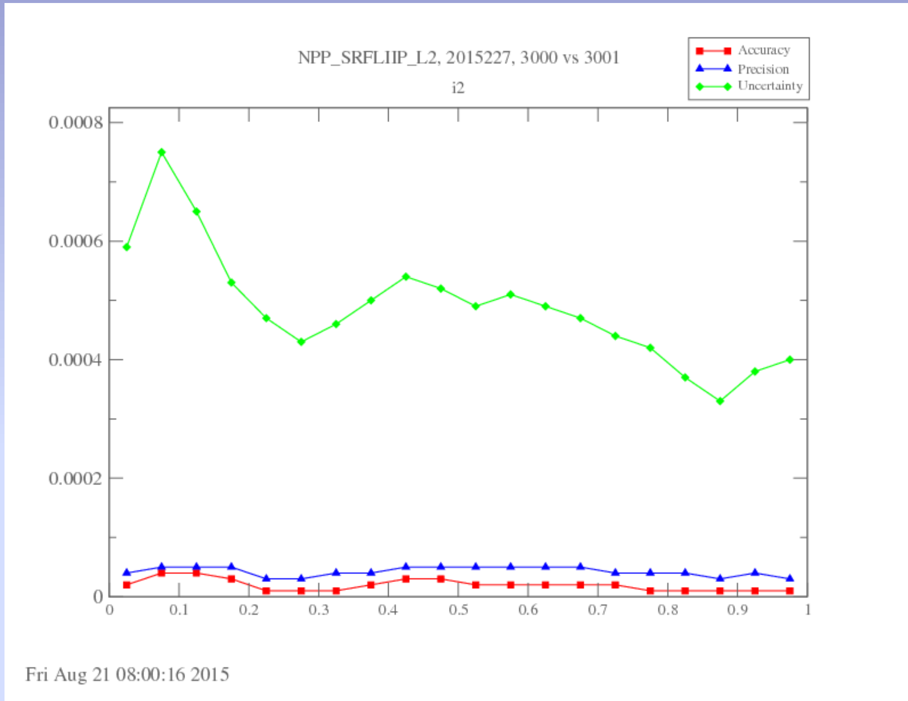
Land Product Quality Assessment
Golden Tile Time Series, LST: IDPS vs C11



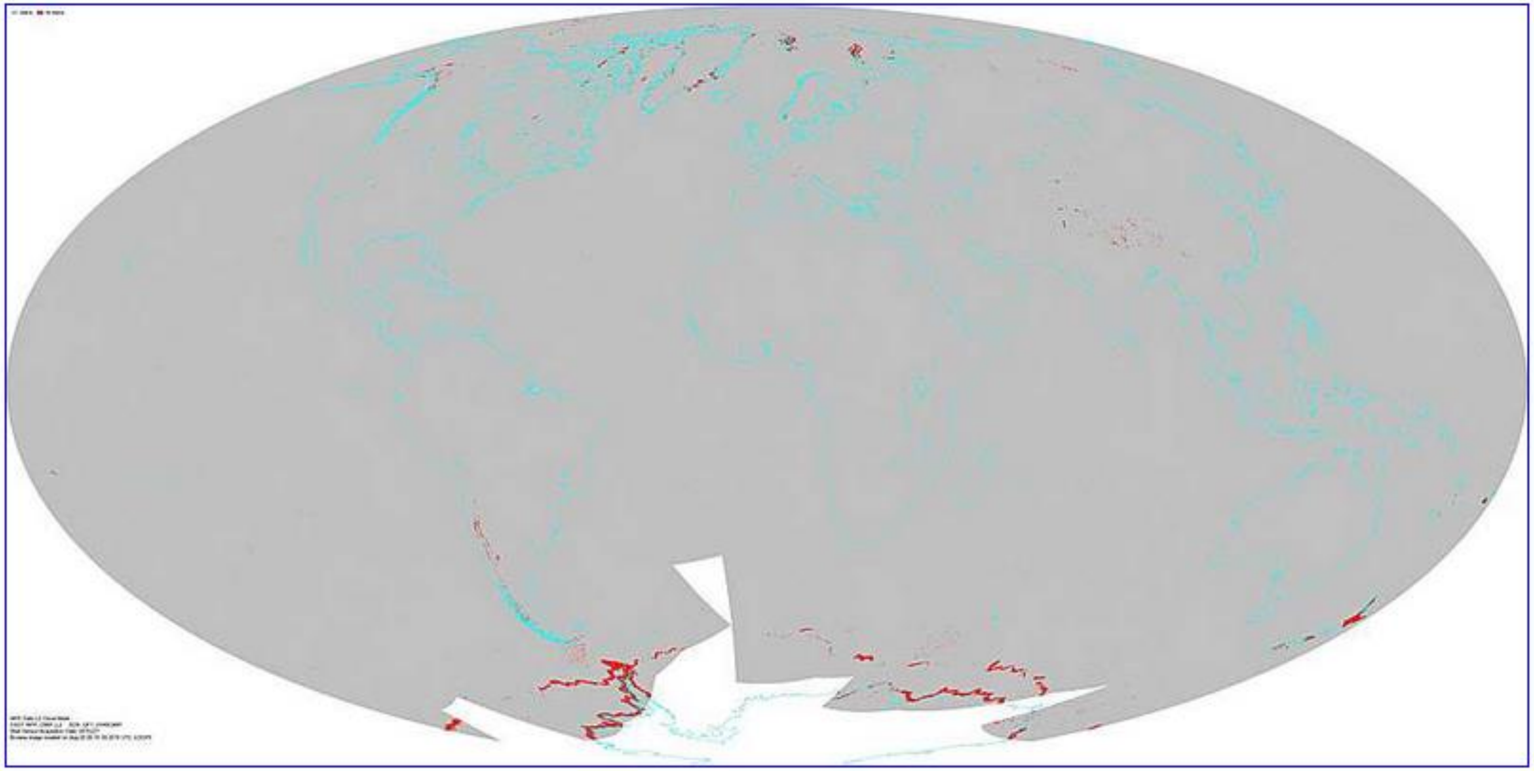


Land Product Quality Assessment
APU for Surface Reflectance : IDPS vs LSIPS





VCM QF1: IDPS diff LPEATE (Day 2015227)



Color Look Up: Match No Match

SDS	Total Match	Total Mismatch	Total Counts	Percent Match	Percent Mismatch
QF1_VIIRSCMIP	2410605463	25746301	2436351764	98.943244	1.056756
QF2_VIIRSCMIP	2430076970	6275030	2436352000	99.742442	0.257558
QF3_VIIRSCMIP	2423107005	13244995	2436352000	99.456360	0.543640
QF4_VIIRSCMIP	2426575211	9776789	2436352000	99.598712	0.401288
QF5_VIIRSCMIP	2436352000	0	2436352000	100.000000	0.000000
QF6_VIIRSCMIP	2427333469	9018531	2436352000	99.629835	0.370165

VCM: IDPS vs LPEATE (Day 2015227)

- **Statistics from comparison of cloud confidence in VCM_IP**

GranID		%Cloud	%Cloud_match	%Clear_Match	%Comm_Diff	%Omm_Diff
A2015227.0325	Australia - East	40.38	99.93	99.99	0.02	0.07
A2015227.0455	Antarctica	68.22	99.97	99.98	0.01	0.03
A2015227.0505	Australia - West	13.16	99.87	99.99	0.04	0.13
A2015227.0530	Northern Russia	60.56	99.88	99.84	0.10	0.12
A2015227.0535	Arctic	59.84	99.83	99.40	0.40	0.17
A2015227.0635	Antarctica	71.37	99.92	99.98	0.01	0.08
A2015227.0710	Northern Russia	63.70	99.99	99.98	0.01	0.01
A2015227.0715	Arctic	60.32	99.87	99.22	0.51	0.13
A2015227.1000	Antarctica	40.61	99.90	99.98	0.03	0.10
A2015227.1140	Antarctica	62.77	99.92	99.97	0.02	0.08
A2015227.1155	Africa - equitorial	40.71	99.99	100.00	0.00	0.01
A2015227.1200	Africa - Sahel	27.08	99.99	100.00	0.01	0.01
A2015227.1715	Canada - East	49.27	99.97	99.99	0.01	0.03
A2015227.1720	Canada - North	50.77	99.70	99.31	0.67	0.30
A2015227.1850	NA – Gulf of Mexico	38.26	99.96	99.99	0.02	0.04
A2015227.1855	Central NA	39.78	99.97	100.00	0.01	0.03
A2015227.1900	Canada - North	50.91	99.84	99.75	0.24	0.16

IDPS is used as reference
%Cloud = TotalCloudyPixels/TotalPixels
%CloudMatch = AllMatch/Total_Ref_Cloudy
%ClearMatch = AllClear/Total_Ref_Clear
%Comm = (TotalNumpixels where C1 is showing cloud and IDPS not)/TotalRefCloudy
%Omm = (TotalNumpixels where C1 is not showing cloud and IDPS is)/TotalRefCloudy

Conclusion

- **Land SIPS will soon generate VIIRS Land records using the NASA VIIRS L0 data.**
- **Land SIPS forward processing stream will generate high quality land products using NASA science team delivered algorithms or "best of" algorithms in current operations.**
- **C11 reprocessing will continue until Land SIPS is ready for another reprocessing.**
- **VIIRS L1 and L2 swath products are generated in 6 minute granules while the L2G, L3 and L4 products are produced as tiles of approximately 10 degrees square**
- **Products are distributed to public through assigned DAACs**

WORKING GROUP ON CALIBRATION & VALIDATION

CEOS/WGCV/LPV 2015 Report: Validation Datasets and Interagency/International Coordination

Miguel Román (NASA/GSFC/JPSS)
Jaime Nickeson (NASA/GSFC/SSAI)
Gabriela Schaepman-Strub (University of Zurich)

Committee on Earth Observation Satellites (CEOS)
Working Group on Calibration and Validation (WGCV)
Land Product Validation (LPV)

2015 JPSS Annual Science Team Meeting: August 24-28, 2015

CEOS > WGCV > LPV

CEOS - Committee on Earth Observation Satellites

31 CEOS Members

24 Associate Members (eg UNEP, GTOS, IGBP, WMO, GCOS)

CEOS coordinates civil space-based observations of the Earth

This is achieved through its working groups and virtual constellations. The **Working Group on Calibration and Validation (WGCV)** is one of 5 CEOS working groups.

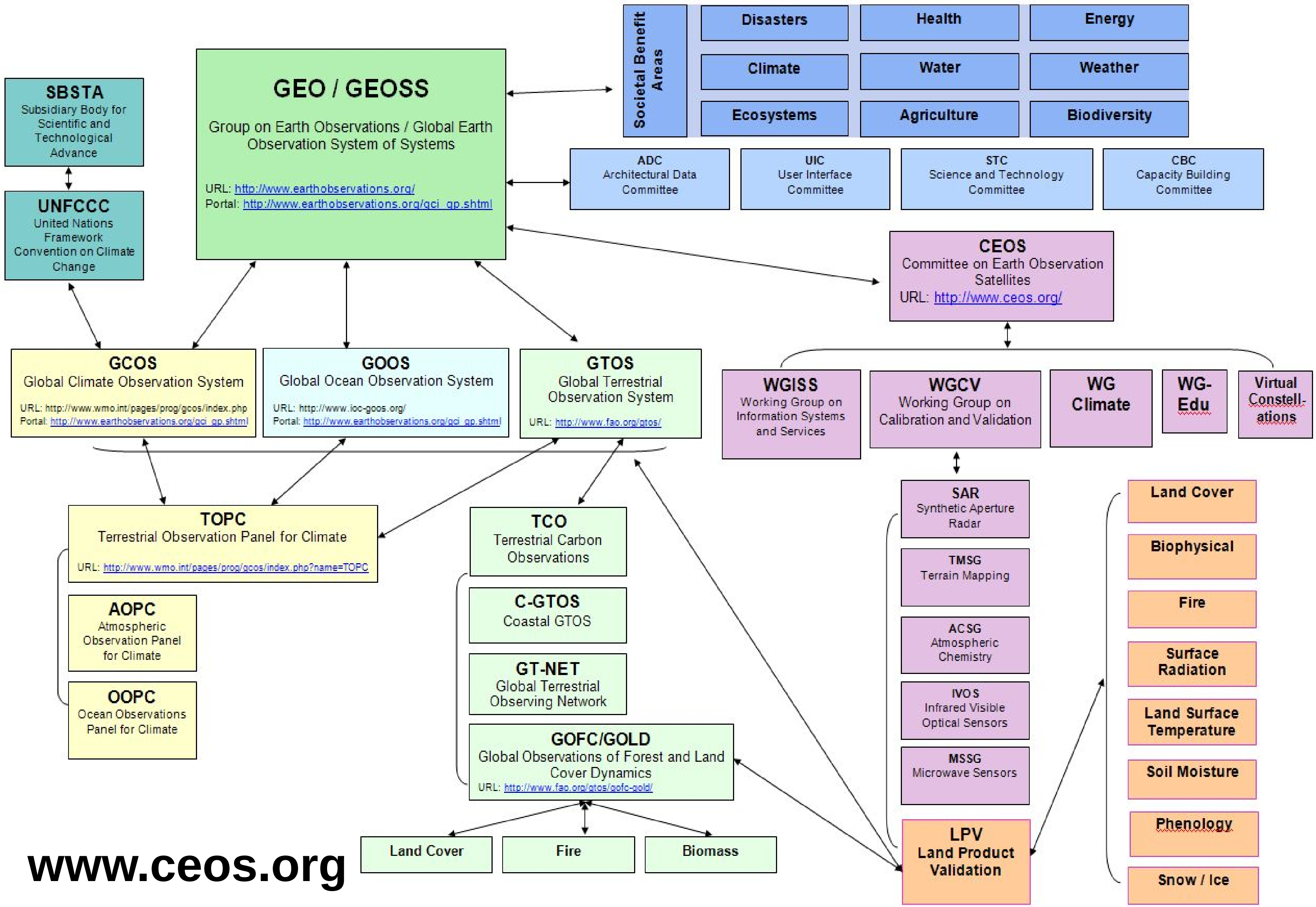
Land Product Validation (LPV) is one of 6 WGCV subgroups

Current LPV Officers

Chair	Gabriela Schaepman-Strub	University of Zurich
Vice-Chair	Miguel Román	NASA/GFSC/JPSS
LPV Support	Jaime Nickeson	NASA/GSFC/SSAI

9 Focus Areas with 2 co-leads each

Linkages between International Programs concerned with Terrestrial Earth Observation



www.ceos.org

Land Product Validation Subgroup Objectives

1. To **foster and coordinate quantitative validation** of higher level global land products derived from remotely sensed data, in a traceable way, and to relay results to users.

2. To increase the quality and efficiency of global satellite product validation by developing and promoting **international standards and protocols** for
   - **Field sampling**
   - **Scaling techniques**
   - **Accuracy reporting**
   - **Data and information exchange**

3. To provide **feedback to international structures** for
   - Requirements on product accuracy and quality assurance
   - Terrestrial ECV measurement standards
   - Definitions for future missions

Focus Areas and Co-leaders

* ECV

Product	North America	EU / China
Snow Cover (T5)*, **Sea Ice**	Thomas Nagler (ENVEO, Austria)	Tao Che (Chinese Academy of Sciences)
Surface Radiation (Reflectance, BRDF, Albedo [T8]*)	Crystal Schaaf (U. Massachusetts Boston)	Alessio Lattanzio (EUMETSAT)
Land Cover (T9)*	Pontus Olofsson (Boston University)	Martin Herold (Wageningen University, NL)
FAPAR (T10)*	Arturo Sanchez-Azofeifa (University of Alberta)	Nadine Gobron (JRC, IT)
Leaf Area Index (T11)*	Oliver Sonnentag (University of Montreal)	Stephen Plummer (Harwell, UK)
Fire (T13)* (Active Fire, Burned Area)	Luigi Boschetti (University of Idaho)	Kevin Tansey (University of Leicester, UK)
Land Surface Temperature (LST and Emissivity)	Pierre Guillevic (University of Maryland)	Jose Sobrino (University of Valencia, SP)
Soil Moisture*	Tom Jackson (USDA ARS)	Wolfgang Wagner (Vienna Univ of Technology, AT)
Land Surface Phenology	Matt Jones (University of Montana)	Jadu Dash (University of Southampton, UK)

JPSS Land Team: Drivers of Innovation

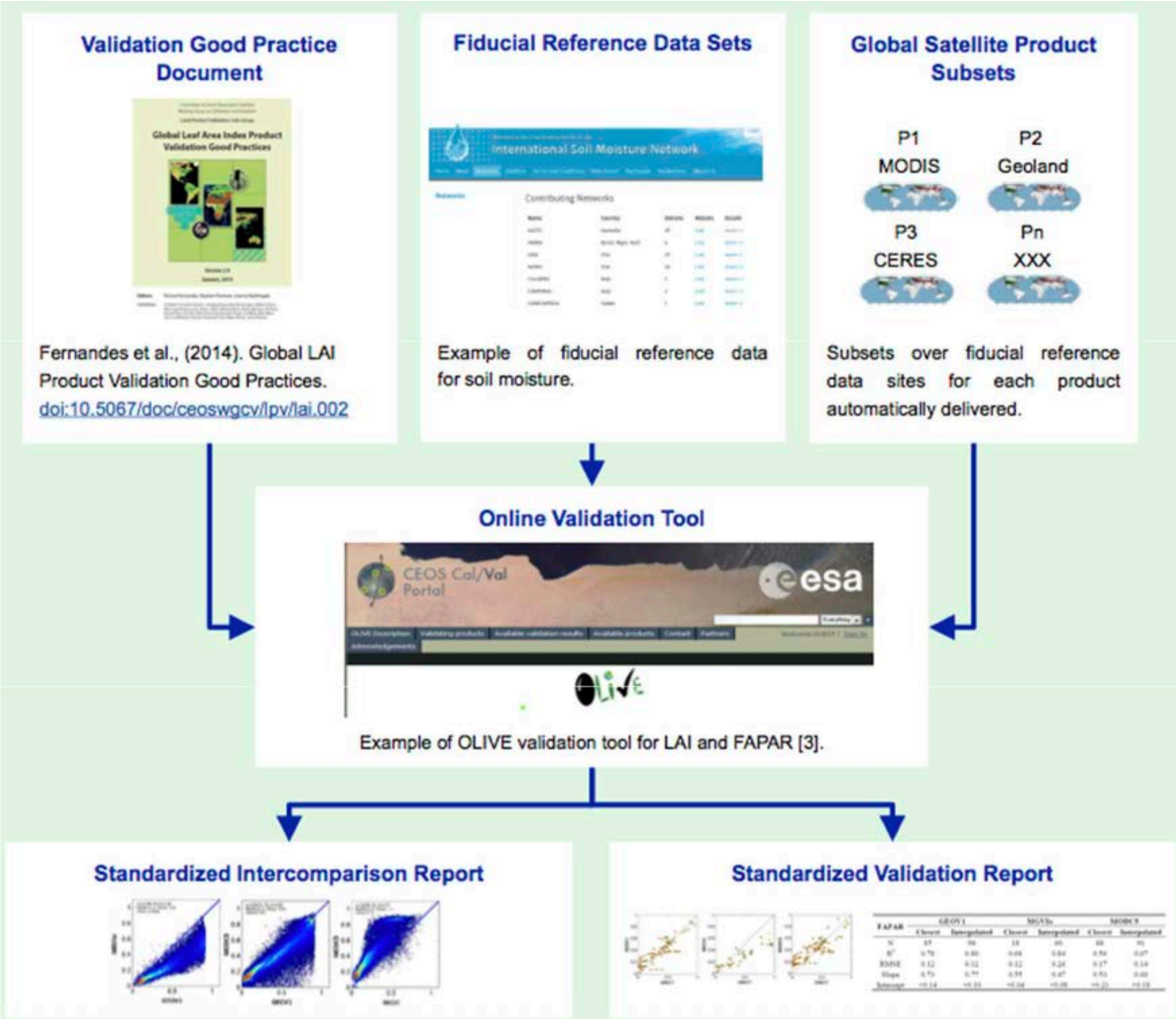
Innovation Driver	Impact to Product Utilization
Product Development and Cal/Val	~0 to 40%
Improved Access & Distribution	~40 to 75%
"Game Changing" Applications	~75 to ≥100%

PGRR Initiatives Integrate *across all drivers*

CEOS LPV Team: Drivers of Innovation

Innovation Driver	Impact to Land ECV
Validation Protocol Development	~0 to 40%
Access to and Distribution of Reference Data & Accuracy Reports	~40 to 75%
"Game Changing" Applications	~75 to ≥100%

JPSS Land Cal/Val Team Contributions to LPV



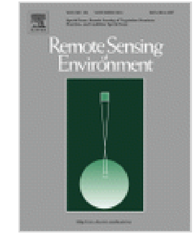
- ***JPSS Land cal/val team has adopted the CEOS/WGCV LPV framework & validation stages.***
- ***Key JPSS (FY16) contributions:***
  1. Tower-based reference data (CRN, BSRN-SURFRAD)
  2. Airborne-UAV reference data (MALIBU: Román et al.)
  3. Land Product Characterization System (LPCS: K. Gallo)
- ***Participating CEOS member agencies:*** *NOAA-STAR, NOAA-NCDC, USGS-EROS, NASA-GSFC, ESA-ESRIN.*

CEOS/WGCV/LPV subgroup has developed a framework for land product intercomparison and validation based on: **(1) a citable protocol, (2) fiducial reference data, and (3) automated subsetting**. These components are integrated into an **online platform** where quantitative tests are run, and standardized intercomparison and validation results reported.

ELSEVIER

Remote Sensing of Environment

Volume 154, November 2014, Pages 19–37



Validation of Land Surface Temperature products derived from the Visible Infrared Imaging Radiometer Suite (VIIRS) using ground-based and heritage satellite measurements

Pierre C. Guillevic[a], James C. Biard[b, c], Glynn C. Hulley[a], Jeffrey L. Privette[c], Simon J. Hook[a], Albert Olioso[d], Frank M. Göttsche[e], Robert Radocinski[a], Miguel O. Román[f], Yunyue Yu[g], Ivan Csiszar[g]

- V1 LST Protocol Published!
- Uses VIIIRS as case study
- Interagency Collaboration has been key to CEOS-LPV team's sucess. Major players:
- NOAA (STAR/NCDC)
- NASA (JPL/GSFC)
- INRA

Protocol for Validation of the Land Surface reflectance using AERONET (J.C. Roger, E. Vermote and B. Holben)

Validation of Land Surface Reflectance

The Problem: **A standard land surface reflectance protocol for using reference AERONET products needs to be agreed on by the MODIS/VIIRS science team.**

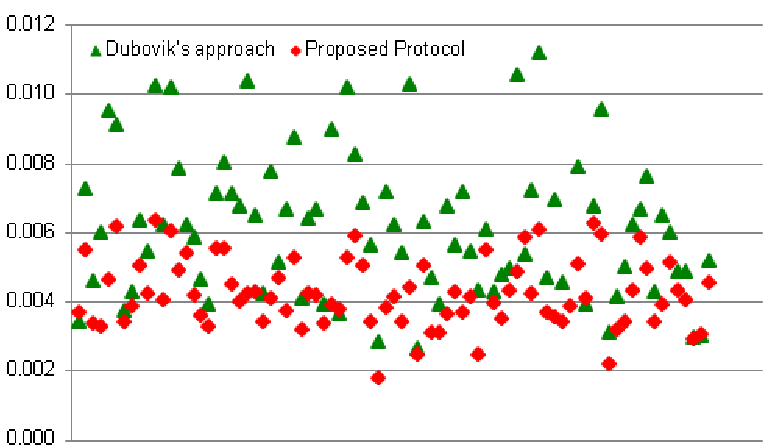
The Solution: **A validation protocol for MODIS/VIIRS Land surface reflectance that requires the aerosol model to be readily available.**

Description of Surface Reflectance Validation Protocol

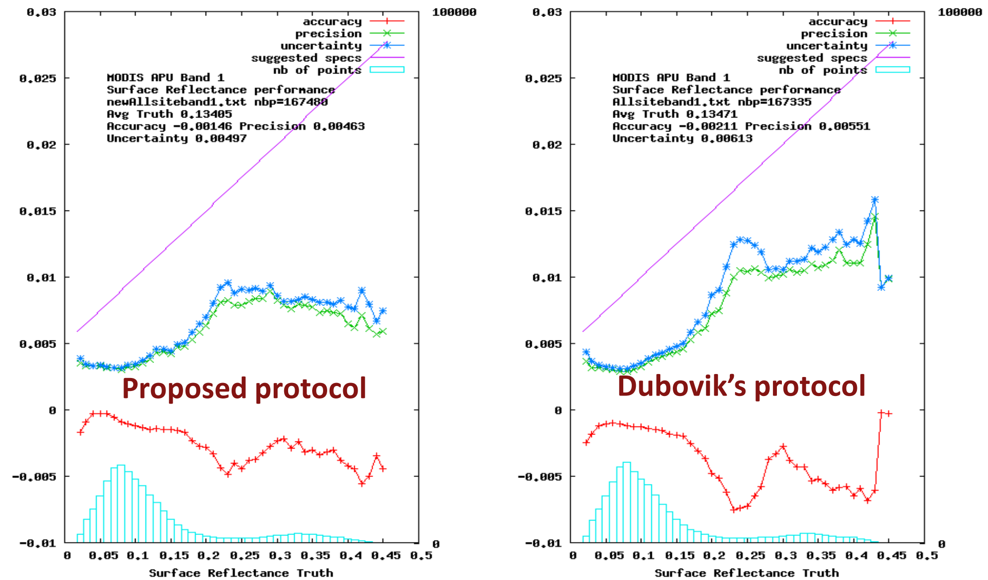
Aerosol models for each AERONET site can be defined using new regressions with optical properties (i.e., τ_{440} and α) as standardized parameters. For the aerosol models, the **aerosol microphysical properties** provisioned by AERONET, including size-distribution (%C_f, %C_c, r_f, r_c, σ_r, σ_c), complex refractive indices and sphericity, can also be used as standardized protocol measures.

Comparisons with AERONET indicate that parameter standardization produces Accuracy-Precision-Uncertainty (APU) metrics up to 20% lower than the current baseline (Dubovik et al., 2002).

Uncertainties on the retrieved surface reflectance for 40 AERONET sites MODIS band 1 (red) – synthetic input surface reflectance = 0.05

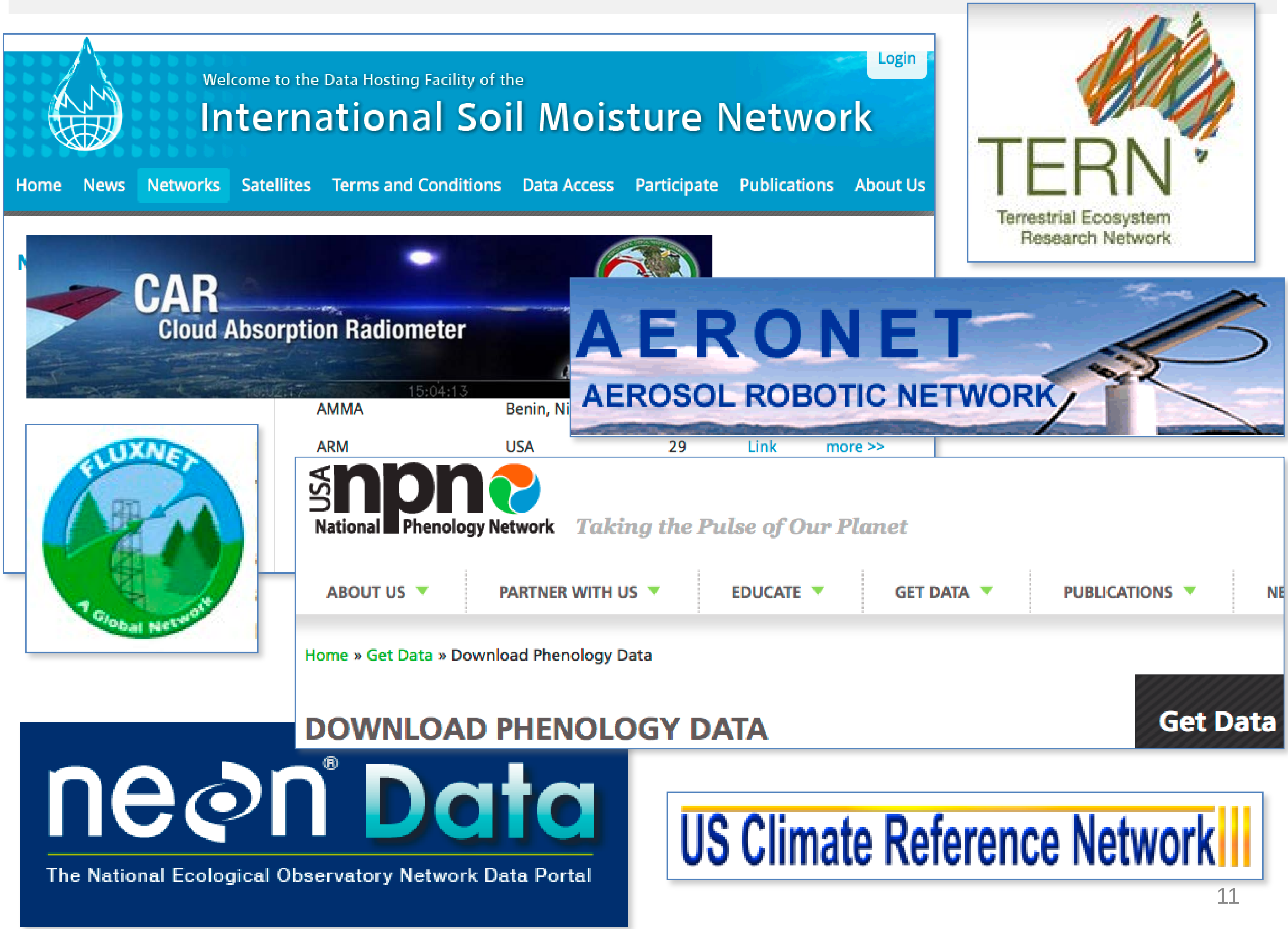


Example of APU for MODIS band 1 (red) for the whole 2003 year data set



Team Response: **Further classification of errors requires the adoption of consistent and agreeable protocols across MODIS/VIIRS land surface reflectance products. This is also crucial to enable objective assessment and characterization of downstream product impacts (e.g., NDVI/EVI, LAI/FPAR, BRDF/Albedo/NBAR).**

Fiducial Reference Data Sets



WORKING GROUP ON CALIBRATION & VALIDATION

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Relaying Validation Results to our Users

LPV Web Site
15 years and running..

Established in 2000

Subscribed member list has grown ***to nearly 700 members*** over the years.

Each focus area (ECV) has pull down menu of links to

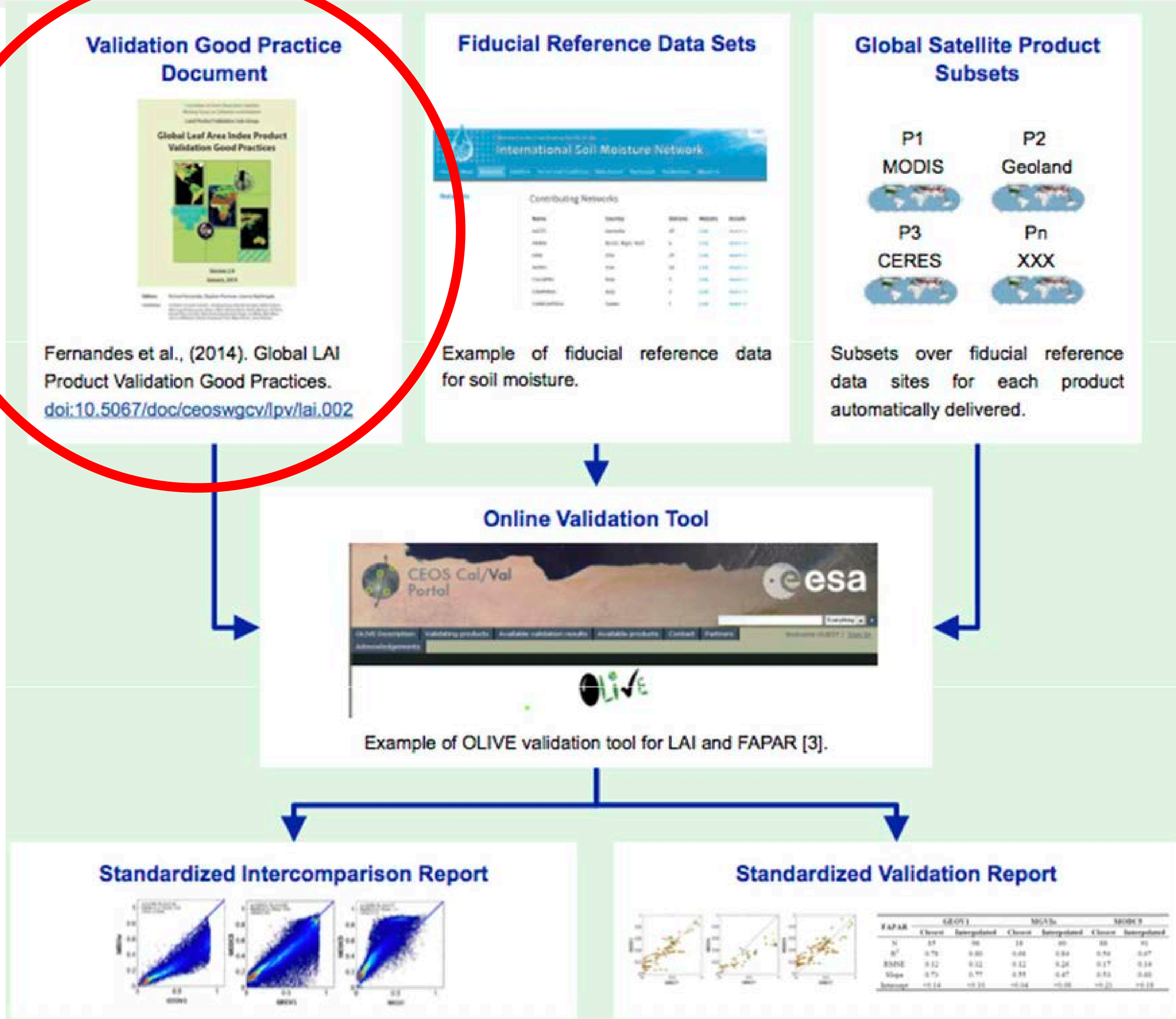
- Home page
- References
- Collaboration
- Products

http://lpvs.gsfc.nasa.gov

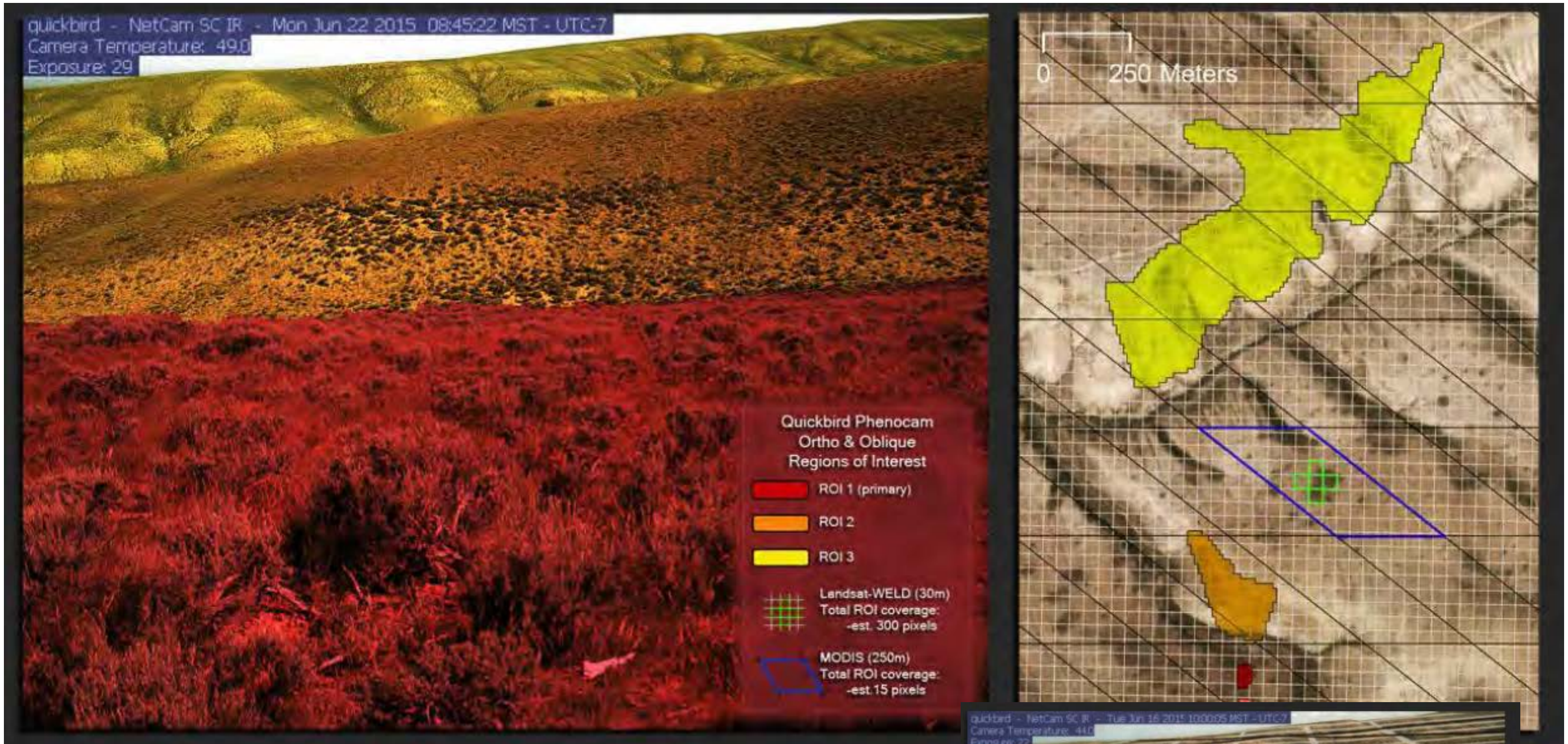
CEOS LPV Team: Drivers of Innovation Performance

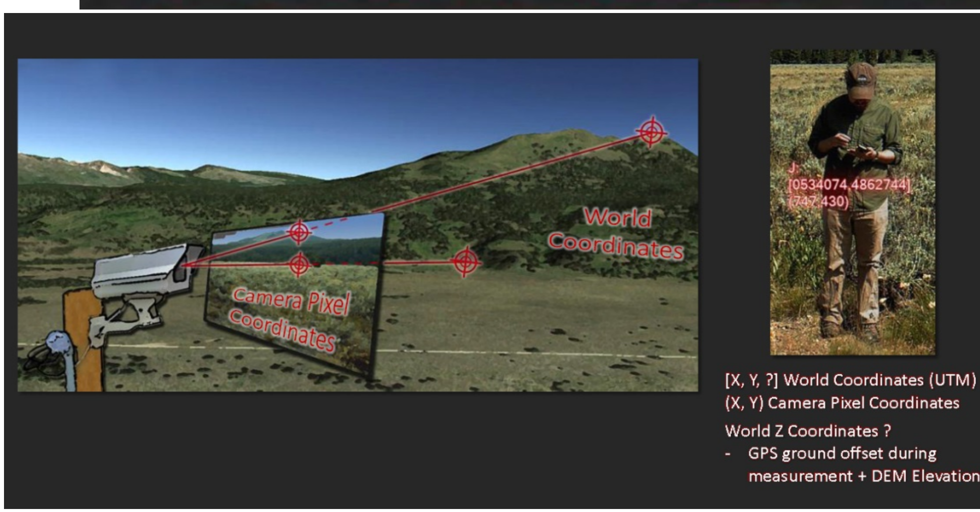
Innovation Driver	Impact to Land ECV
Validation Protocol Development	0 to 40%
Access to and Distribution of Reference Data & Accuracy Reports	40 to 75%
"Game Changing" Applications	75 to ≥100%
How About This Driver?	

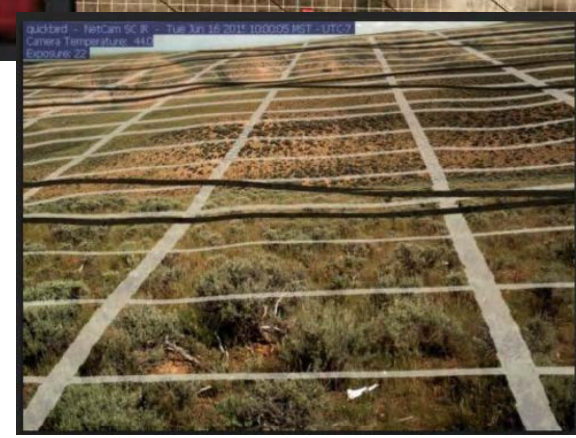
A Land Validation Framework



Scaling Phenology (USGS)







USGS/NCCSC PhenoCam Project
Credit: Joseph Krienert / Jeff Morisette

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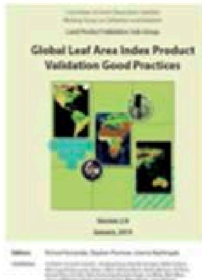
A Land Validation Framework

Validation Good Practice Document



Fernandes et al., (2014). Global LAI Product Validation Good Practices. doi:10.5067/doc/ceoswgcv/lpv/lai.002

Fiducial Reference Data Sets

Example of fiducial reference data for soil moisture.

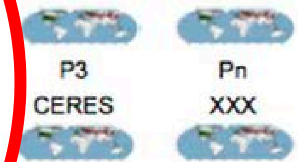
Global Satellite Product Subsets

P1 MODIS

P2 Geoland

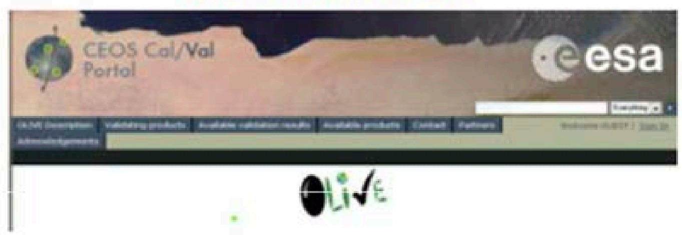
P3 CERES

Pn XXX



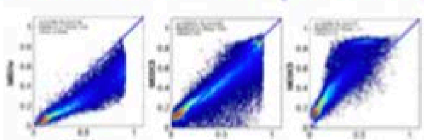
Subsets over fiducial reference data sites for each product automatically delivered.

Online Validation Tool



Example of OLIVE validation tool for LAI and FAPAR [3].

Standardized Intercomparison Report



Standardized Validation Report

Fiducial Reference Data Collection: Challenges

– *CEOS/WGCV/LPV Goal*: To characterize land product uncertainties in a statistically rigorous way (i.e., over multiple locations and time periods representing global conditions).

– *Our Challenge*: To work within the constrains of NOAA/ NASA missions, programs, and airborne assets (e.g., deployments costs on P3-B: ~$4000/flight hour).

– *Our Strategy to-date*: "Piggy-backing" has brought us some gains; but it requires a lot of:

1. Patience (work with lead PIs and identify common goals),
2. Good Luck (e.g., nominal operations + clear skies),
3. Hard Work (countless hours of mostly unfunded effort; esp. for post-processing and science data analysis).

FY15 GSFC IRAD

Multi AngLe Imaging Bidirectional Reflectance Distribution Function Unmanned Aerial System (MALIBU)

PI: Román/GSFC 619; Instrument PI: Pahlevan/Sigma Space 619

Goddard Space Flight Center

Description and Objectives:

- Design a low-cost imaging approach to validate critical land climate data records
- Radiometric/Spectral calibration of dual Tetracam cameras at GSFC calibration facility
- Platform integration and Field Deployment
- Subpixel (10 meter) land biogeophysical product retrieval (PRI, NDVI, BRDF/Albedo, Reflectance) and validation efforts (MODIS/MISR, VIIRS, Landsat/OLI, and GOES-R).

Key challenge(s)/Innovation:

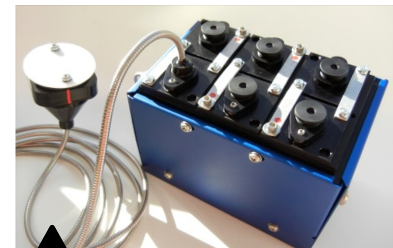
- Accurate earth gridding & geo-location of the collected images.

MALIBU Platform and Payload

Tempest Blackswift UAS

- Programmable flight path
- Endurance (~60-90 min)
- Altitude: 100-500 m
- Cruise speed: 50 km/h
- Weight: 3 kg

- Two six-channel cameras
- Irradiance sensor
- FOV ~ 50deg
- Weight 0.7kg (each)



Mini-MCA6 Equipped with Incident Light Sensor

Approach:

- Specify/Study camera specifications
- Work closely with the camera vendor during the fabrication
- In-house camera calibration
- Work closely with platform vendor during integration phase
- Test flights and geo-location tests
- Design flight plans and data collection procedure
- Data processing and product generation

Application / Mission:

- Develop international protocols for assessment of terrestrial essential climate variables.

Key Members: Geoff Bland (610W), Joel McCorkel (618), Zhuosen Wang (ORAU), Ed Masuoka (619), Robert Wolfe (619), Jack Elston (Black Swift), John Augustine (NOAA), and Ivan Csiszar (NOAA).

Milestones and Schedule:

Start of the project	10/2014
Camera procurement	11/2014
Camera characterization	12/2014
System Integration	03/2015
Test flights	04/2015
Data collection	06/2015
Post-deployment calibration	07/2015
Data processing	09/2015

TA-08; New Tools of Discovery; $TRL_{in} = 4$

Task Objective

- Objective: To deploy an Unmanned Aircraft System (UAS) that can enable high spatial and angular resolution mapping of terrestrial essential climate variables.
- MALIBU sensor suite performance metrics:
  - Two Tetracam optical units
  - Combined FOV ~ 100° (50° x camera)
  - GIFOV < 10 meters
  - Geolocation accuracy < 0.7 pixel*
  - Signal to Noise > 300
  - Radiometric uncertainty < 5% attained through frequent GSFC in-house calibration

*Challenges: All-of-the-Above Strategy: Onboard IMU (Uncertainty = 0.1^{deg}) + Onboard GPS (Uncertainty < 1 m) + Ground Control Points (image-based geolocation).

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Six types of drone concepts 'crazier' than MALIBU…

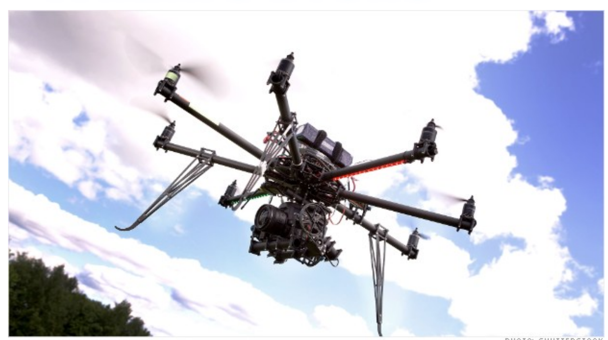
Package Delivery

IED Detection

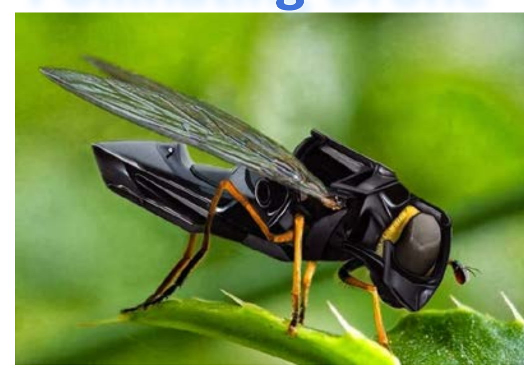
Hurricane Drone

Food Delivery

Wildfire Drone



Pollinating Drone



MALIBU Imaging Geometry

- **Camera mounts**

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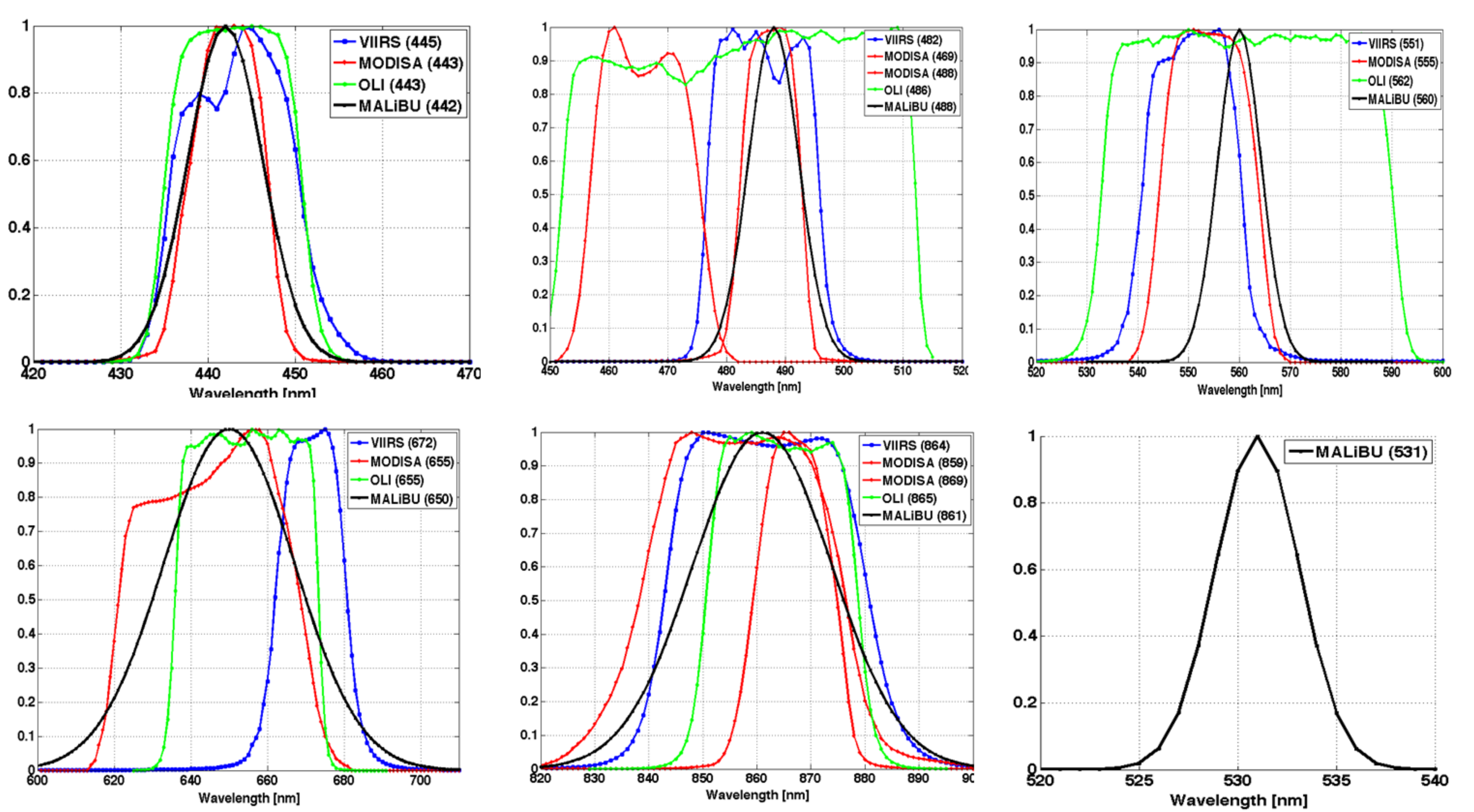
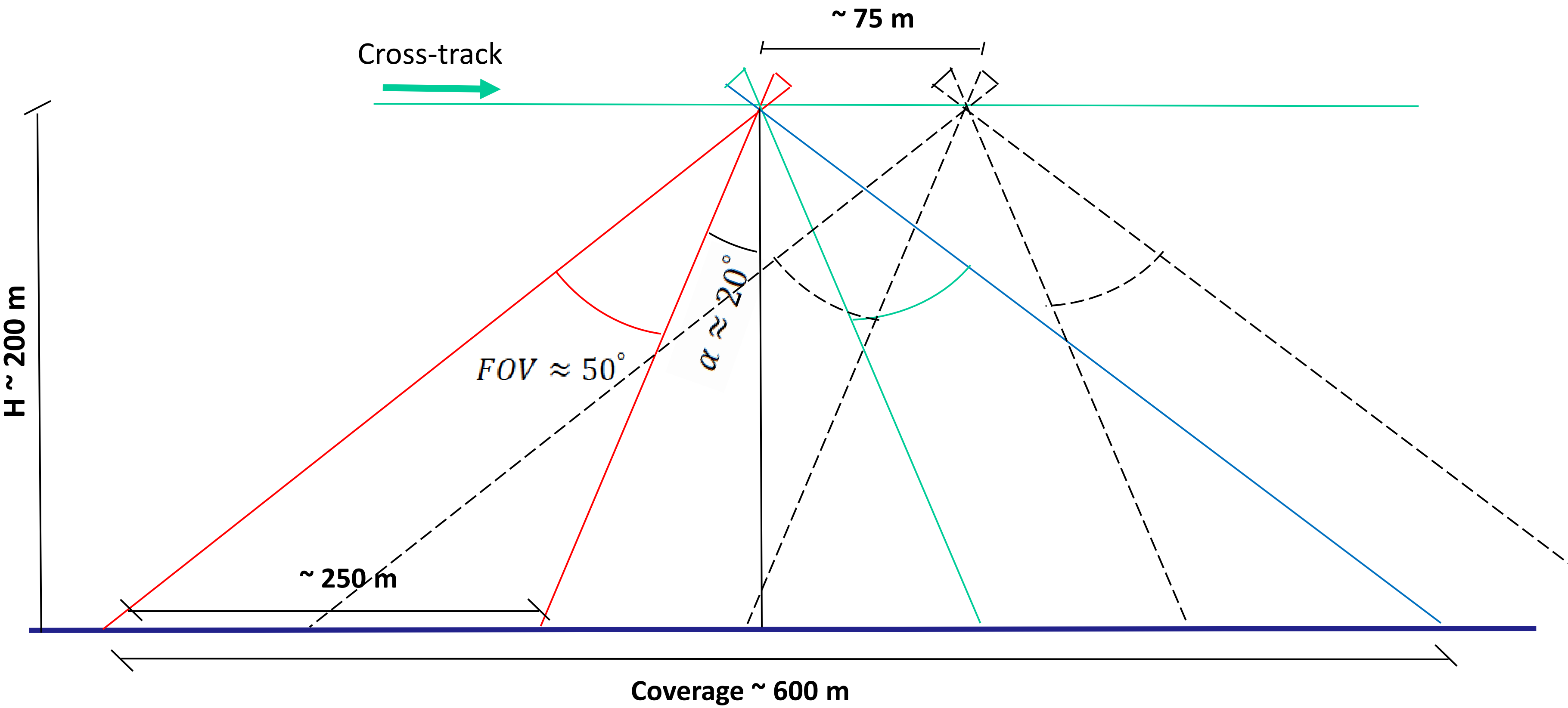
MALIBU Spectral Response



442, 488, 531, 560, 650, 861nm
+ Tetracam's Incident Light Sensor

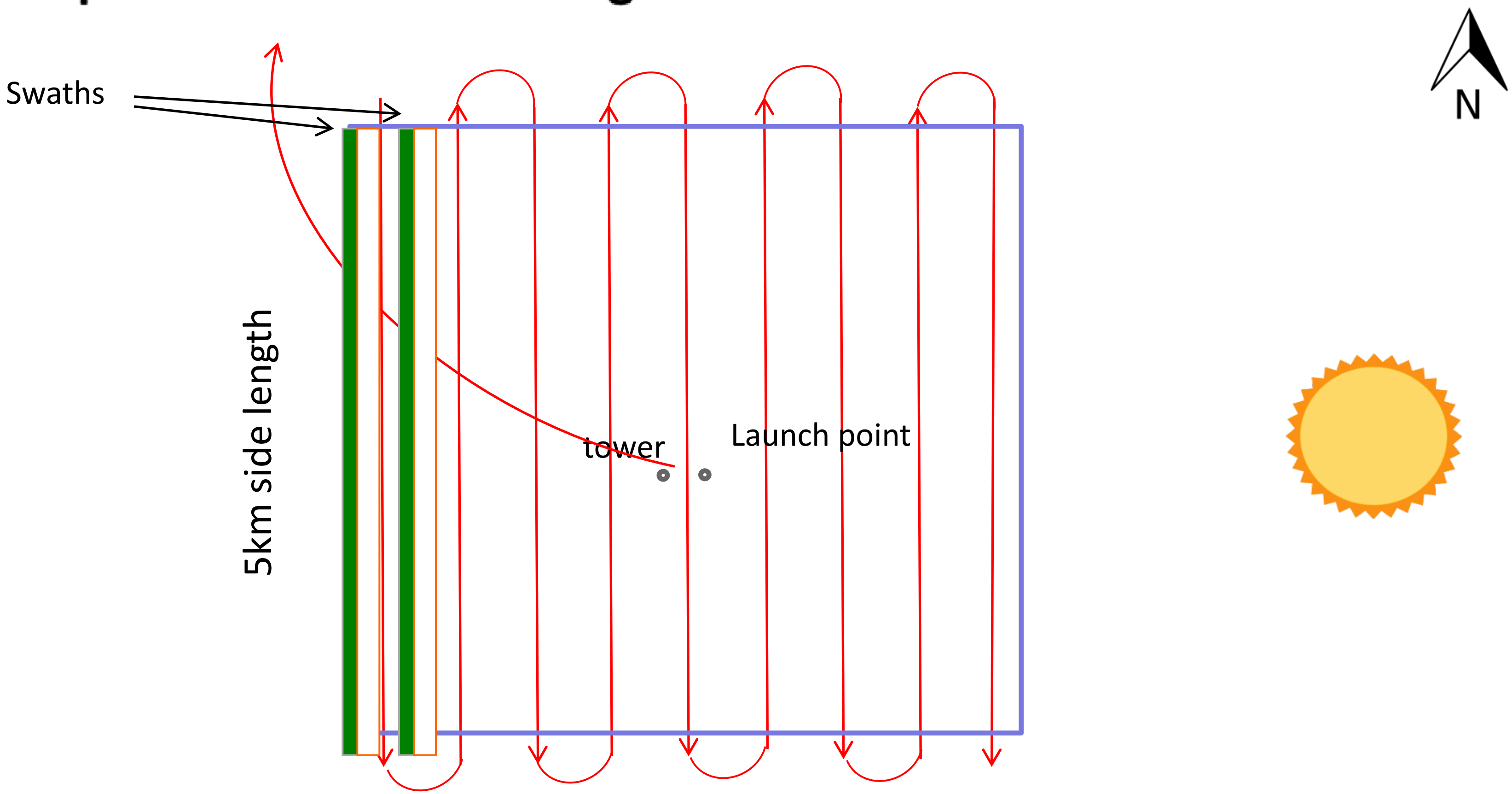
Viewing Geometry: Cross-track

- **Dual Tetracam cameras (with non-overlapping swaths) mounted on the platform across-track**



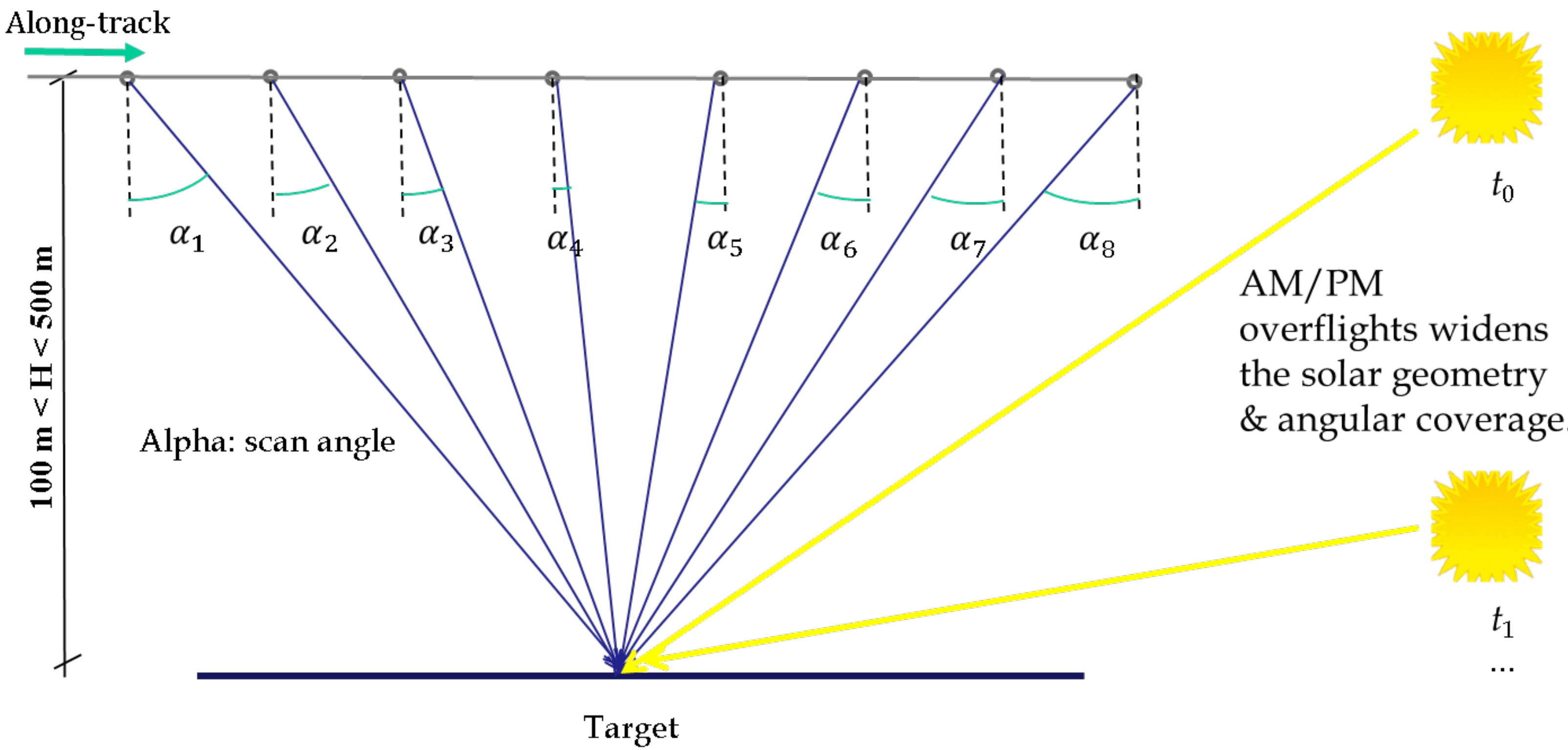
MALIBU Flight Path

- $5 \times 5\ km^2$ is covered during two-day deployment
- Requires visible line-of-sight less than 5 km

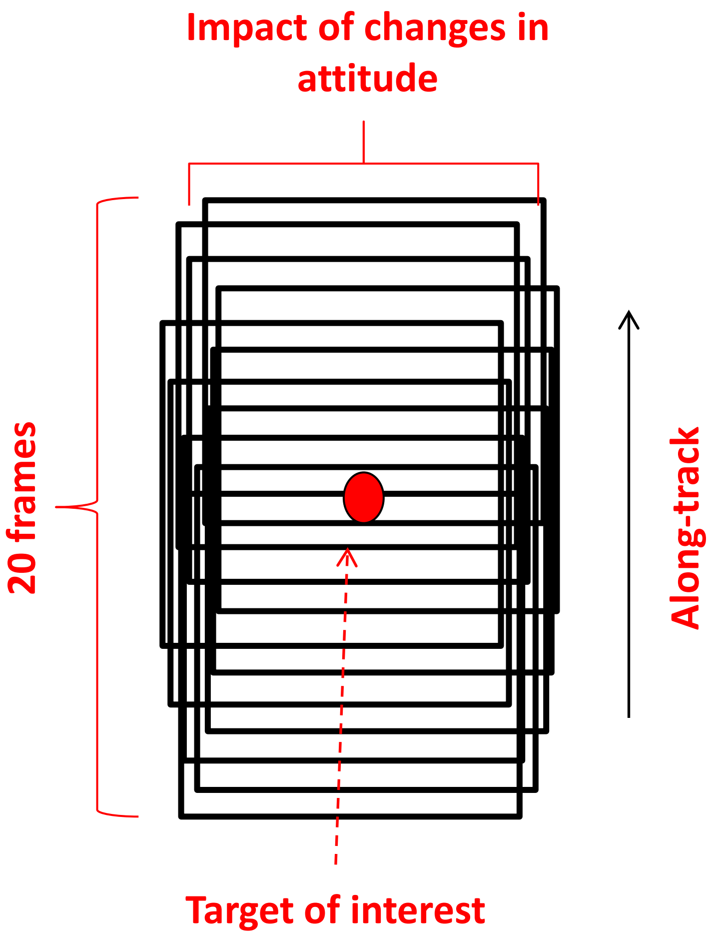


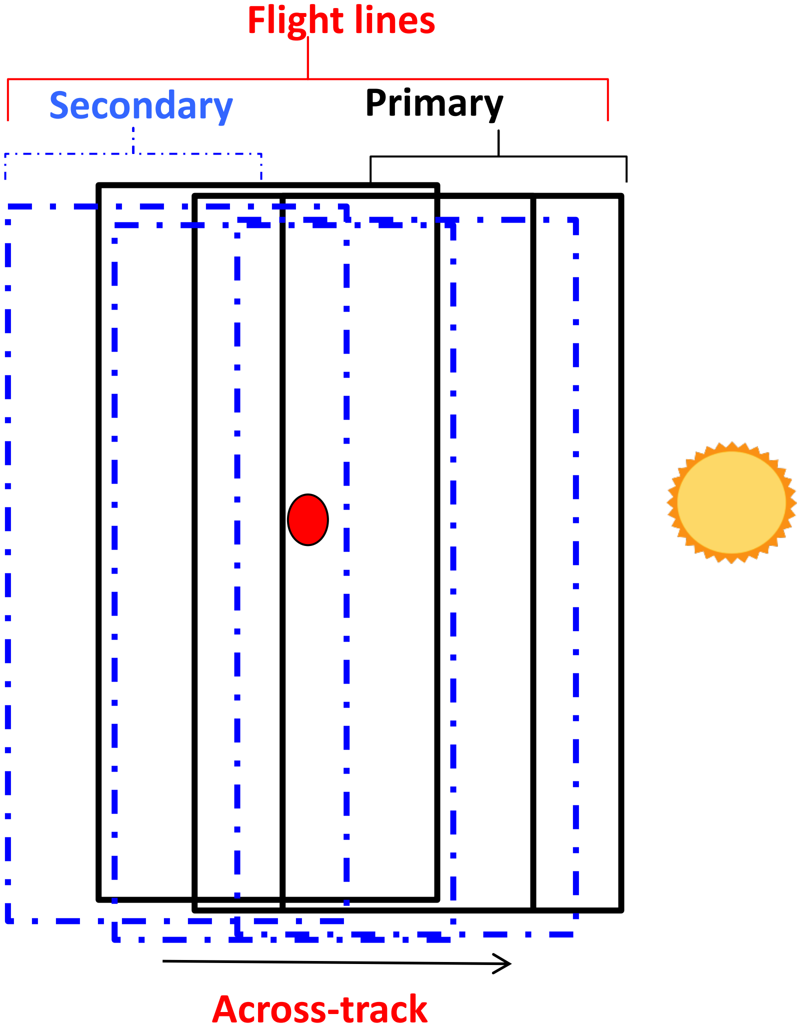
MALIBU Flight Path(cont.)

Overlapping scenes along-track provide multi-angular retrievals.



Overlapping Regions





First MALIBU Test Site: NOAA-Surfrad Table Mountain, CO

- Located ~8 miles north of Boulder, CO.
- Part of NOAA ESRL, US SURFRAD, and the international BSRN reference network .
- John Augustine (NOAA/ESRL, Site PI) is MALIBU team collaborator.

- In-situ measurements include: MFRSR, LI-COR PAR, Yankee UVB-1 Ultraviolet Pyranometer, ventilated Eppley pyrgeometer and ventilated Spectrosun pyranometers.
- Blackswift Tempest has been deployed extensively at this site (69 flights completed since 2010).

Latitude:	40.12498
Longitude:	-105.23680
Elevation:	1689 m
Installed:	July 1995

How About J2 Cal/Val??

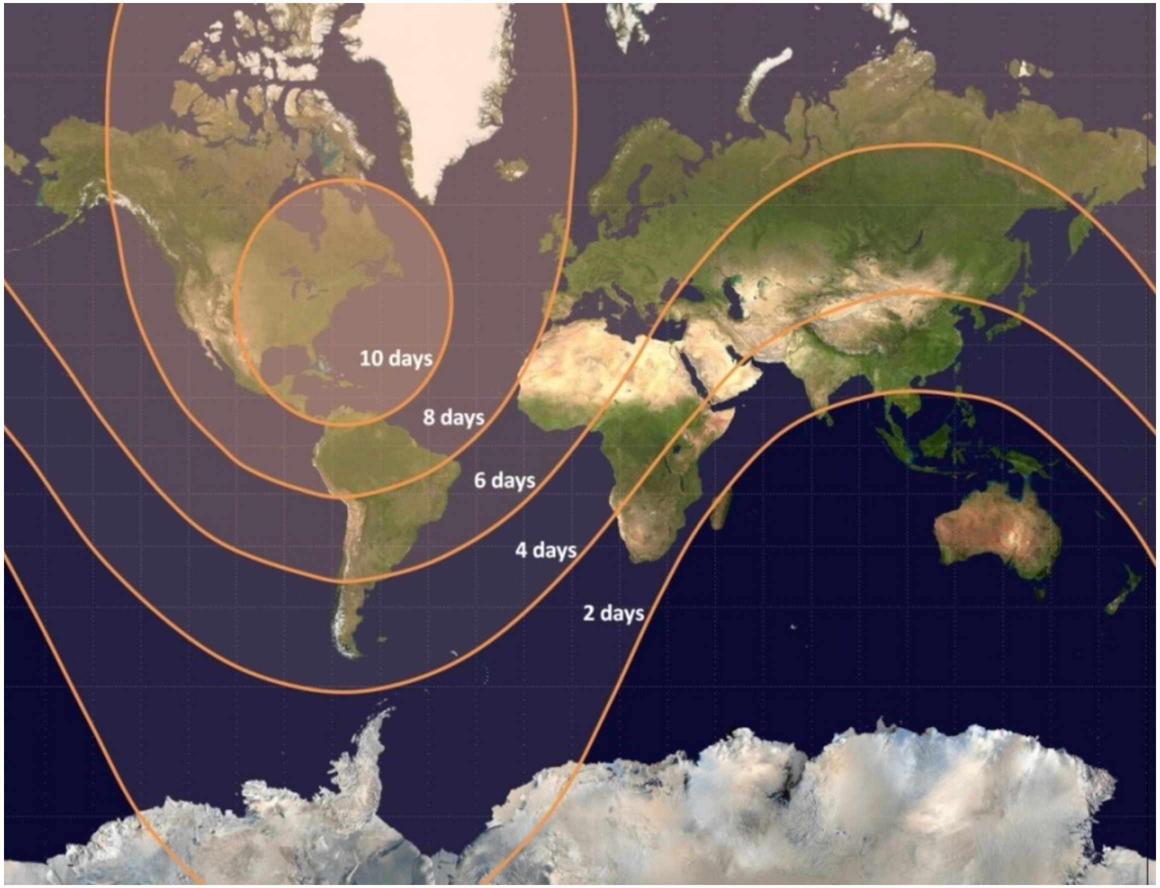
(2020 and beyond…)

VA001 Aircraft

Vanilla Aircraft, LLC

ConOps

- **18,500 nm** range, **10 day** endurance, with 30 pound payload
- 2 aircraft could keep a payload on-station indefinitely

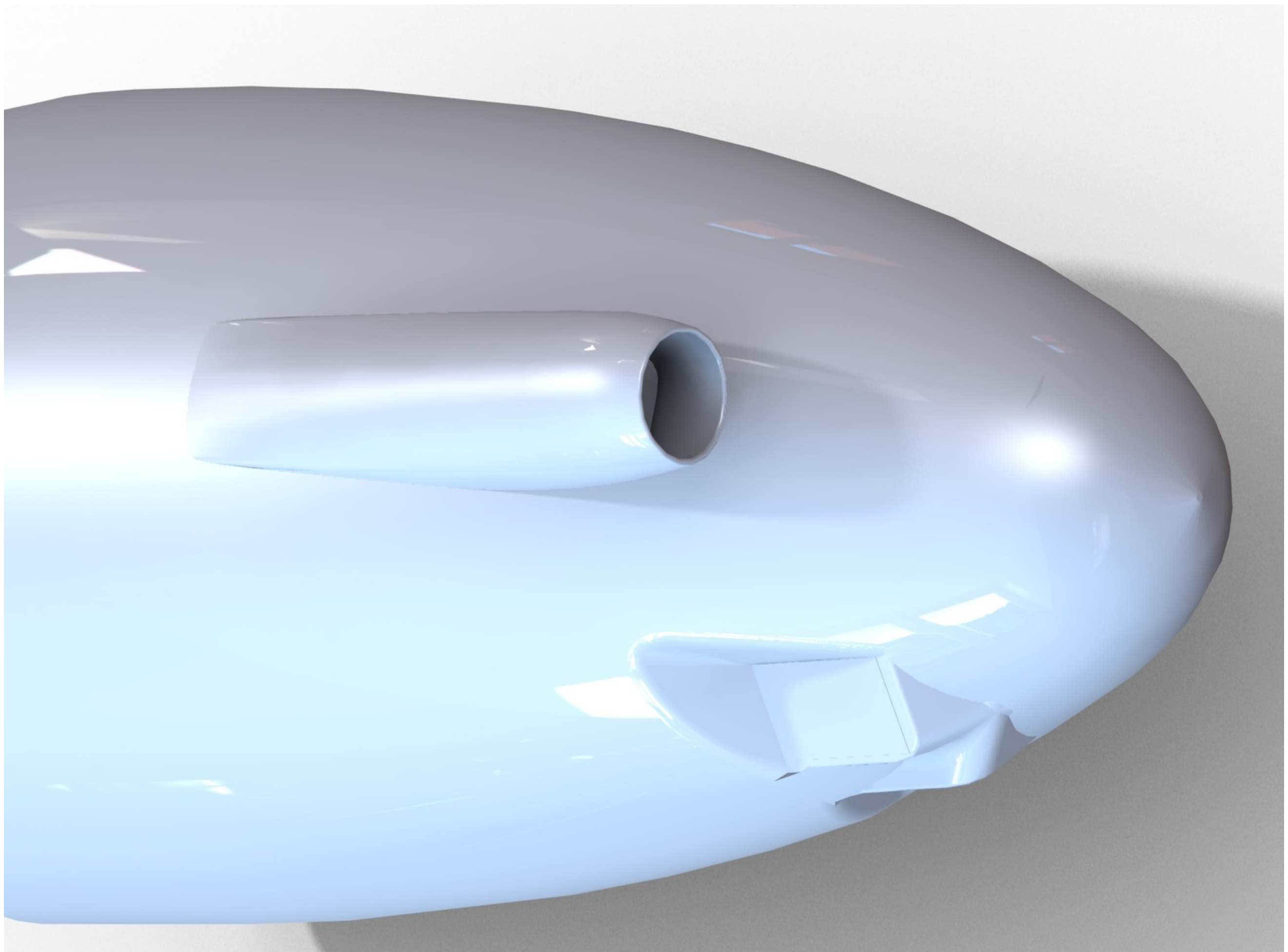


Contours of on-station endurance with launch and recovery from the eastern United States

Vanilla Aircraft, LLC

TetraCam Micro MCA-6

- Multi-spectral imaging, two systems each 45° from nadir



Vanilla Aircraft, LLC


If you want to go fast, go alone.
If you want to go far,
go together.
African Proverb
CEOS WGCV
Land Product Validation Subgroup
NASA
USGS
science for a changing world
NOAA
esa
EUMETSAT

GOES-R LST Validation Activities and Coordination with JPSS

Presented By: Yunyue Yu
NOAA/NESDIS/STAR

Team Members: Peng Yu, Yuling Lui, Heshun Wang, Yuhan Rao, Zhen Song
UMD/CICS

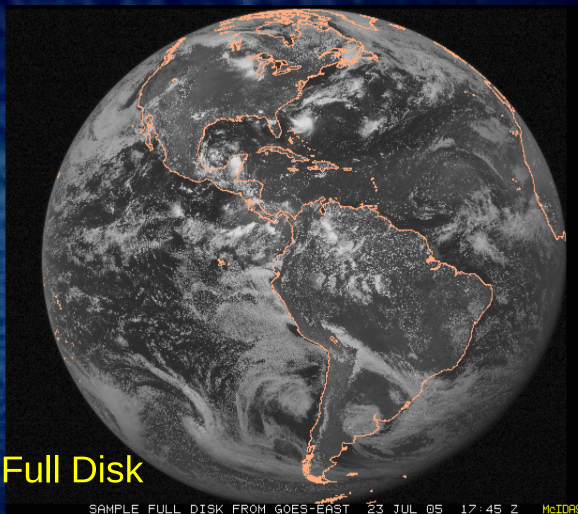
Funded by the GOES-R AWG, GOES-R Proving Ground (Field Campaign), and STAR JPSS

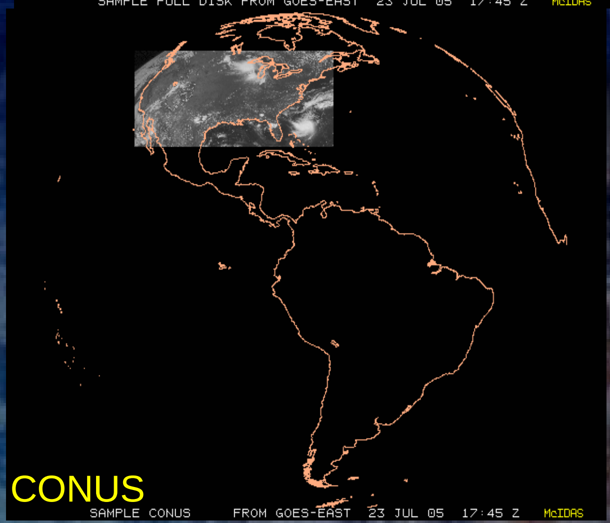
Outline

- GOES-R LST Products
- Development of GOES-R LST Validation Tool
- Coordination With JPSS
- Further Enhancement/Improvement

LST Products

- The ABI Land Surface Temperature (LST) algorithm generates the baseline products of land surface skin temperatures in three ABI scan modes: *Full Disk, CONUS, Mesoscale*;
- Has a good heritage; will add to the LST climate data record;





Products

Product	Accuracy	Precision	Range	Refresh Rate	Resolution
LST (CONUS)	2.5 K	2.3 K	213 ~ 330 K	60 min	2 km
LST (Full Disk)	2.5 K	2.3 K	213 ~ 330 K	60 min	*10 km*
LST (Mesoscale)	2.5 K	2.3 K	213 ~ 330 K	60 min	2 km

Qualifiers

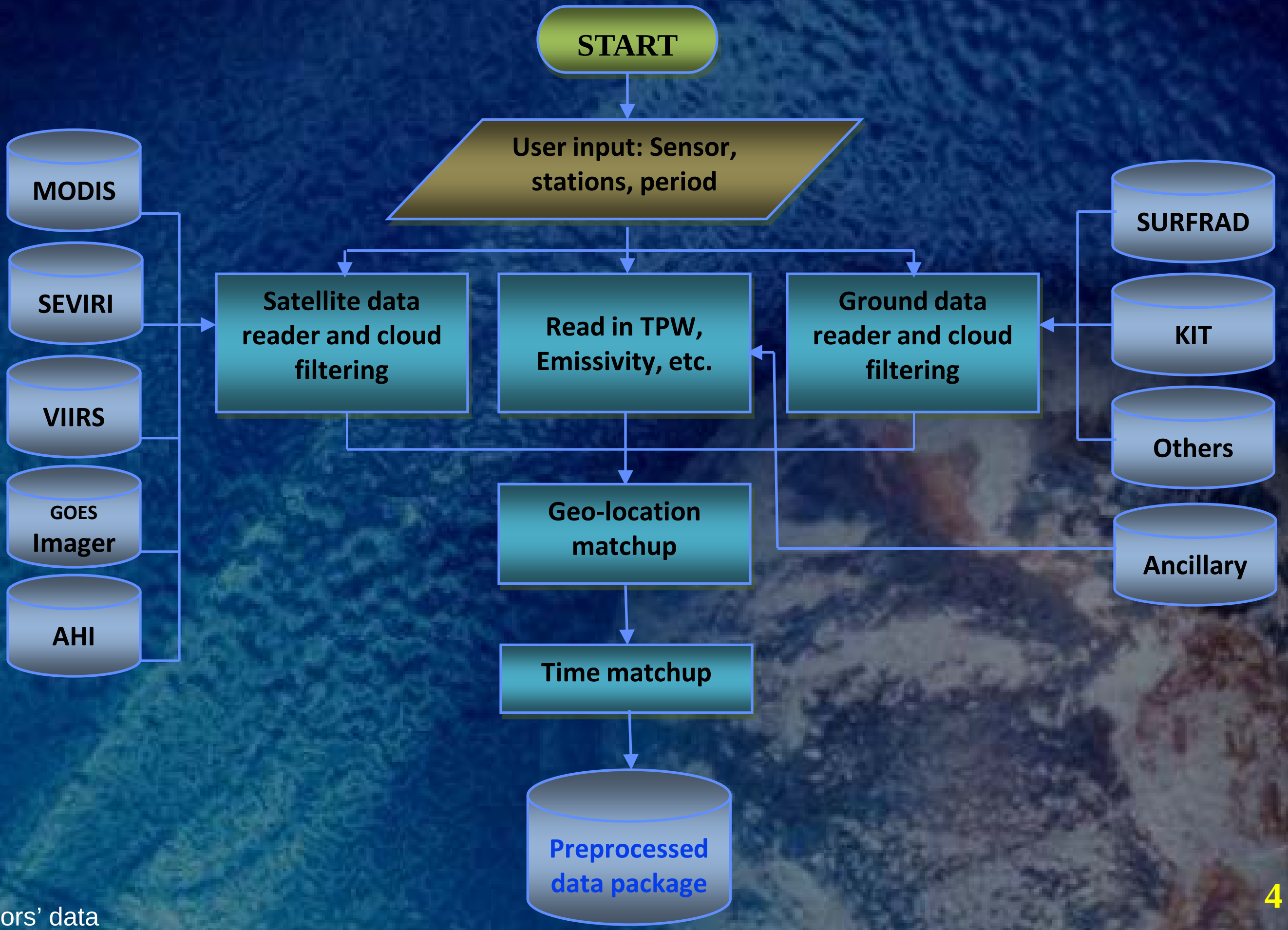
Product	Temporal Coverage	Product Extent	Cloud Cover Conditions	Product Statistics
LST (CONUS)	Day and Night	LZA < 70	Clear Conditions associated with threshold accuracy	Over specified geographic area
LST (Full Disk)	Day and Night	LZA < 70	Clear Conditions associated with threshold accuracy	Over specified geographic area
LST (Mesoscale)	Day and Night	LZA < 70	Clear Conditions associated with threshold accuracy	Over specified geographic area

Development of GOES-R LST Validation Tool

Preprocessing Module

Modulated processing of the validation dataset

- reader: Reads satellites, ground sites, and auxiliary data
- Spatial and temporal match-up: match the satellite obs to the ground sites' location and time
- Apply satellite cloud mask if available
- Satellite and ground site LST estimation/ extraction
- Preprocessed data set (relevant variables)



Note: this flow chart is for all proxy satellite sensors' data

Validation Tools Update

Preprocessed dataset

- 26 variables: enough for the current applications for GOES-R LST validation, *e.g.*, additional cloud filtering procedures
  - Temporal information: Year, Jday of the year, Hour, Minute
  - Data from the ground site: downwelling radiance and its std during the last 15 minutes (for additional cloud filter), upwelling radiance, LST, and broadband emissivity
  - Data from the satellite sensor: BT4 (~4 micrometer), BT11 (3x3 boxes centered at the matched pixel), BT12, and LST
  - Auxiliary data: zenith angle, emissivity, TPW, dry/wet, day/night
- Specific file naming convention: "*sat-gnd-sit-startday-endday.dat*"
- ASCII format
- Flexibility: allows user to validate satellite LST observations currently not included in the tool
- Output of the preprocessing module, input for the validation module
- Dramatically improve the performance of the validation work – generate outputs almost instantly

Routine LST Validation Interface

Interface to algorithm evaluation and product validation

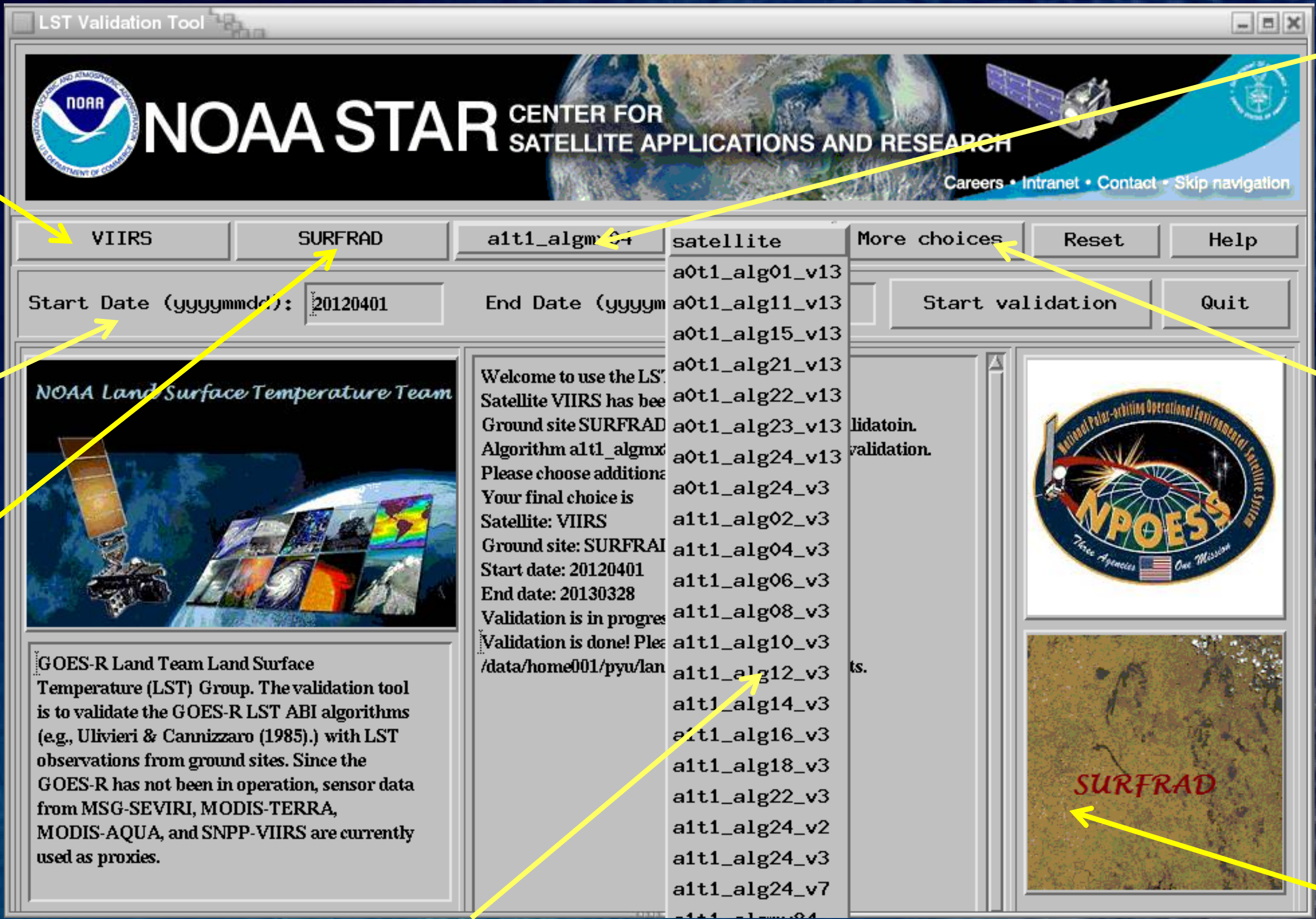
Selection of Multi-sensor proxy

Validation period

In-situ data selection

Algorithm selection

QC and cloud screening



Algorithm /product evaluation and improvement

User-friendly GUI

Validation Tools Update
-- A GUI interface

Satellite chooser

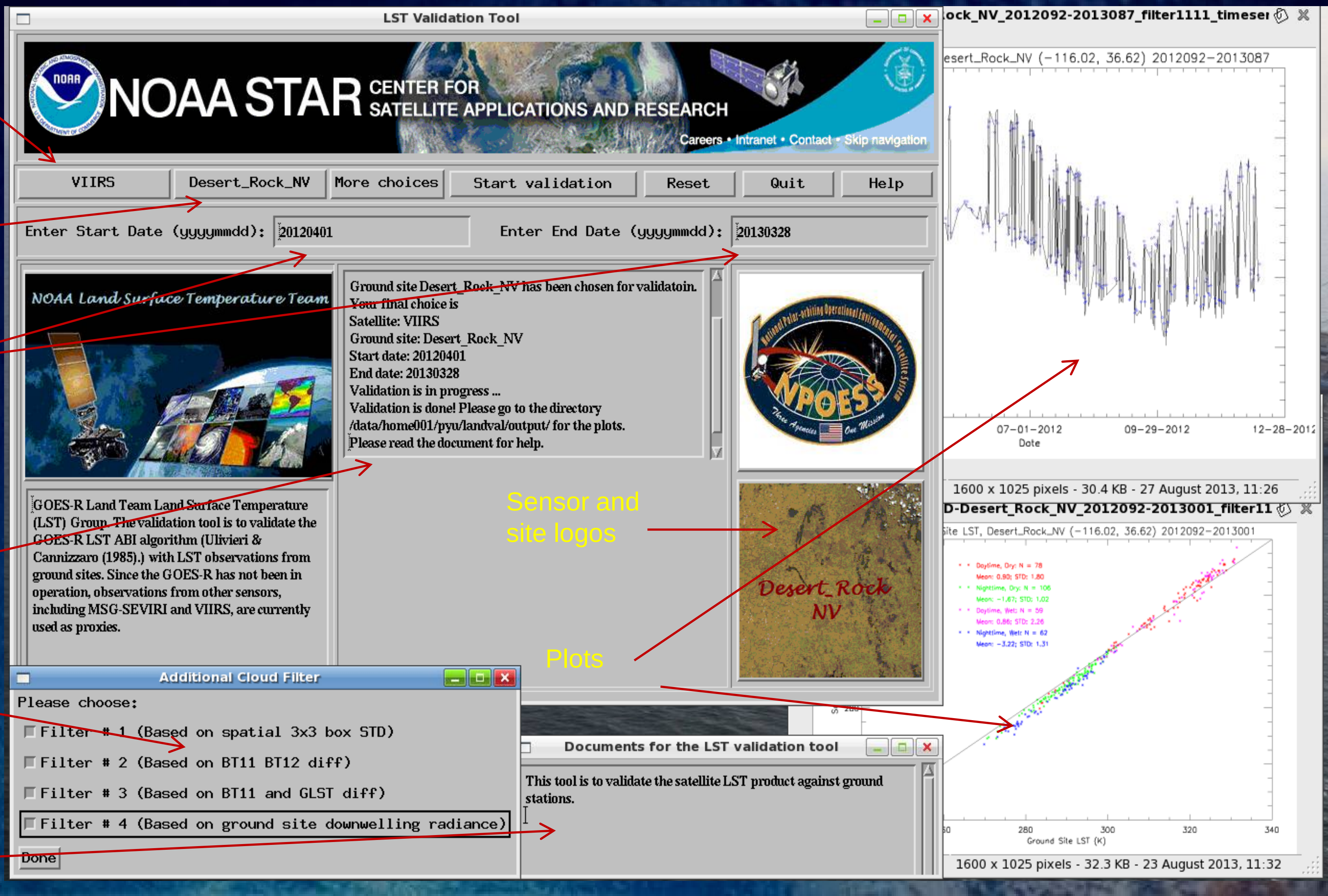
Ground site chooser

Start and end dates

Tool feedbacks

Additional cloud filter module

Tool documents



Towards Field Campaign for LST Validation

Components of LST Validation

- In-situ measurement comparisons and analyses
- Cross-satellite comparisons and analyses
- Successful applications –users promotion

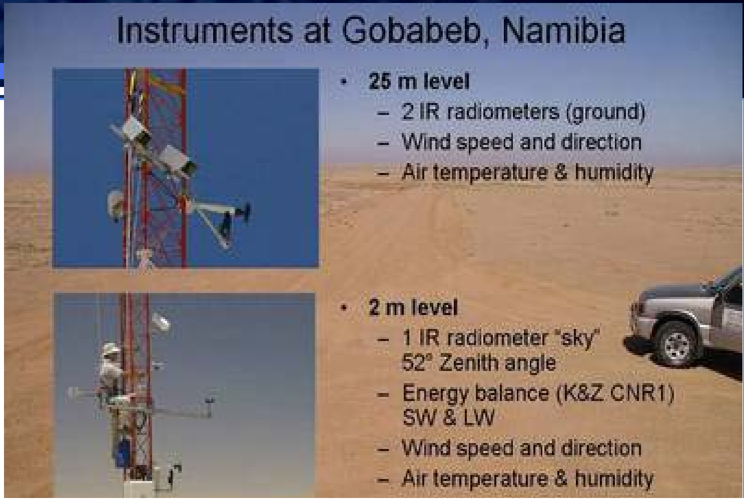
Strategy of In-situ measurement comparisons and analyses

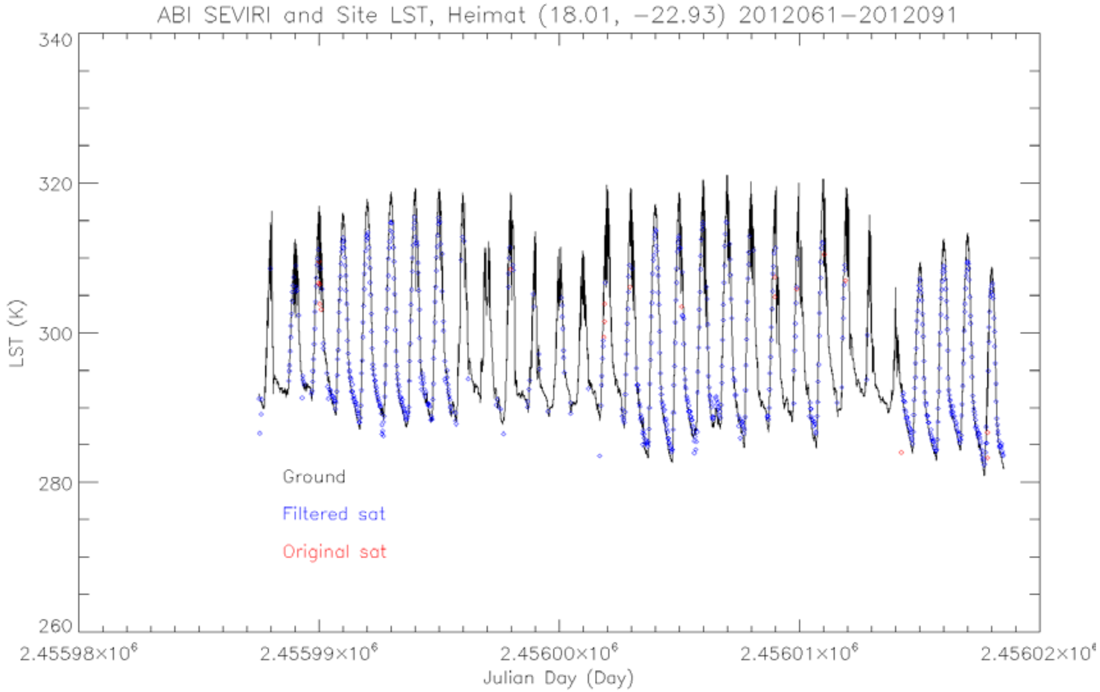
- Existing ground station observations (e.g. SURFRAD Network), as long-term data source
- Field campaign data plays three important roles
  - High quality observations for direct comparison and analysis
  - Calibrating co-site ground station observations
  - Characterizing heterogeneity feature of co-site ground station
- Towards the field campaign readiness
  - Platform: low altitude, small unmanned aerial vehicle (UVA)
  - Instrument readiness : accurate infrared radiometers covers ABI bands
  - Site selection: better to cover SURFRAD/CRN station
  - Data processing and algorithms: noise filtering, spatial characterization, calibration to station data, etc.
  - Coordination with the Field Campaign Team.

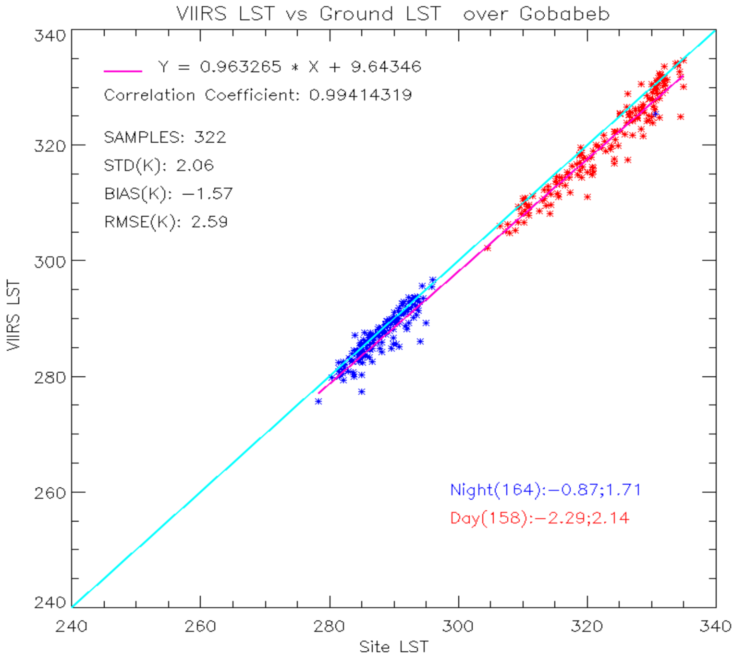
In-situ Data Validation

Case studies of in-situ data comparison in Africa (Gobabeb and Heimat, Namibia)

*the Africa site data provided by Frank Goettsche (KIT & EUMETSAT Land SAF), through LST validation collaboration



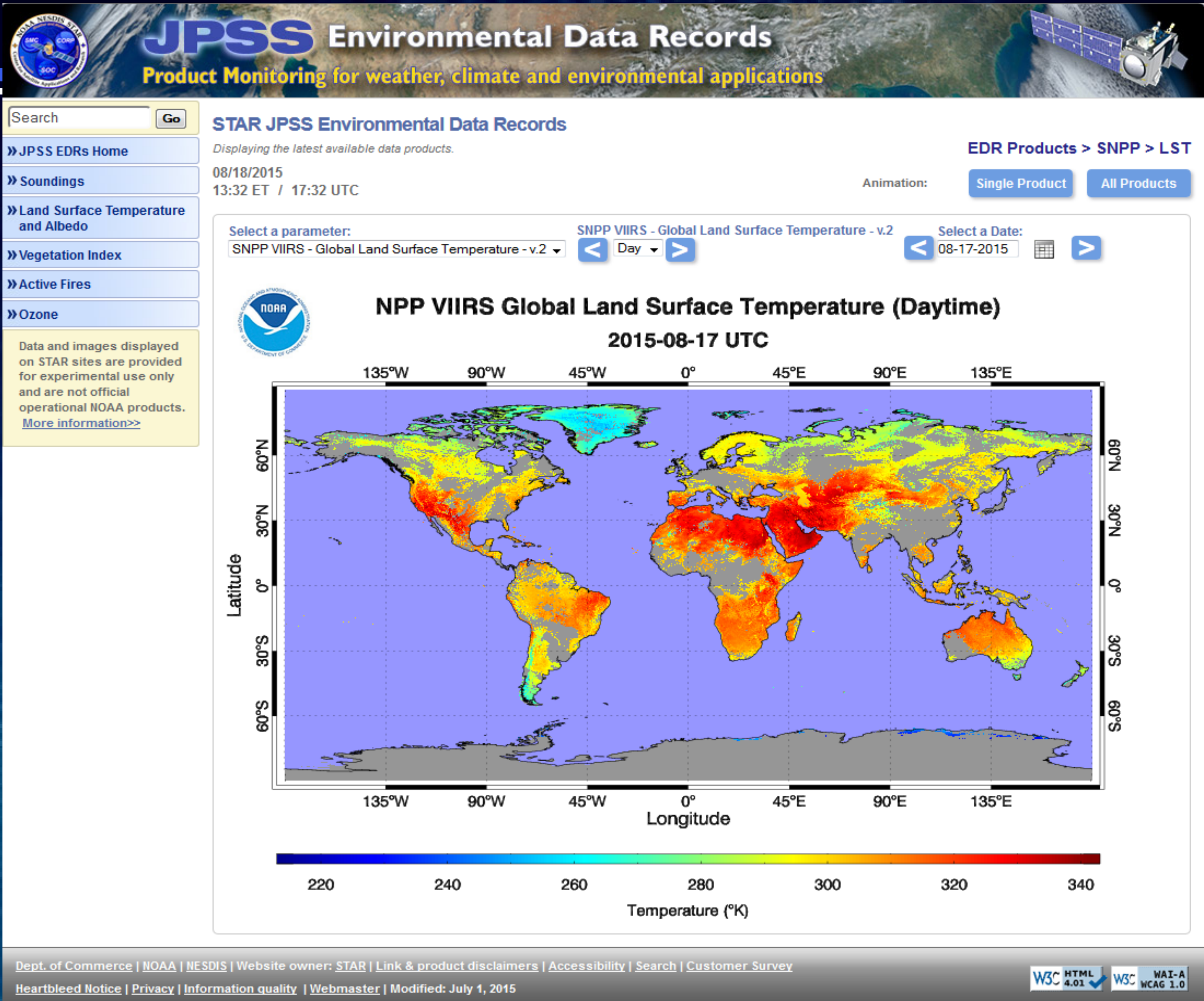




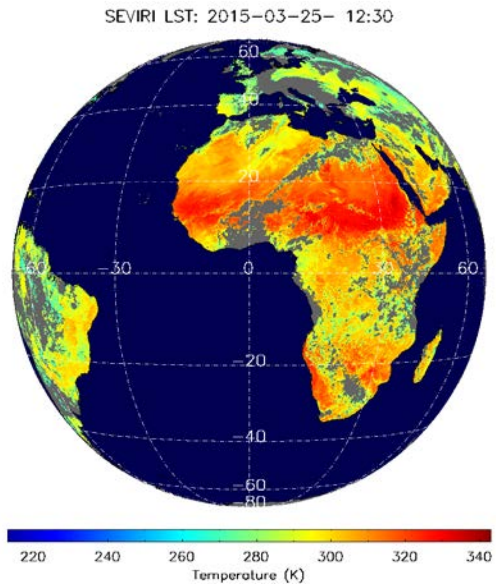
Routine Monitoring

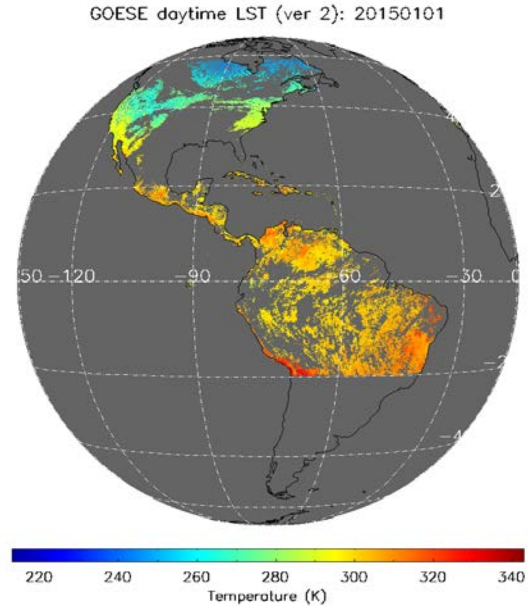
Route Monitoring through webpage

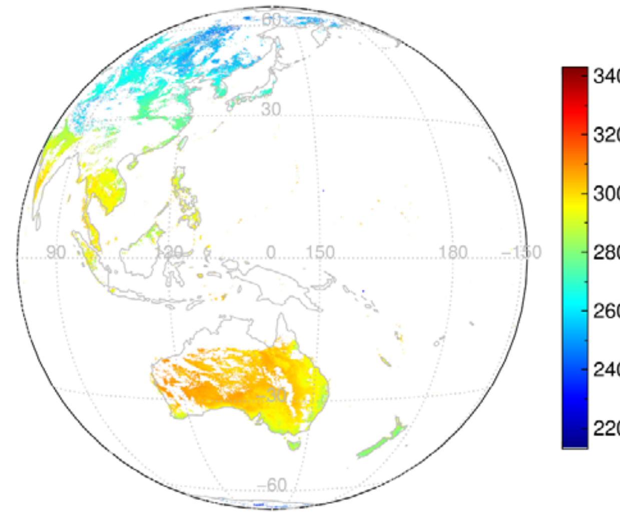
A STAR Webpage of LST routine monitoring has been set up for JPSS program. A similar webpage will be created for GOES-R mission after launch of the satellite (Mar 2016)



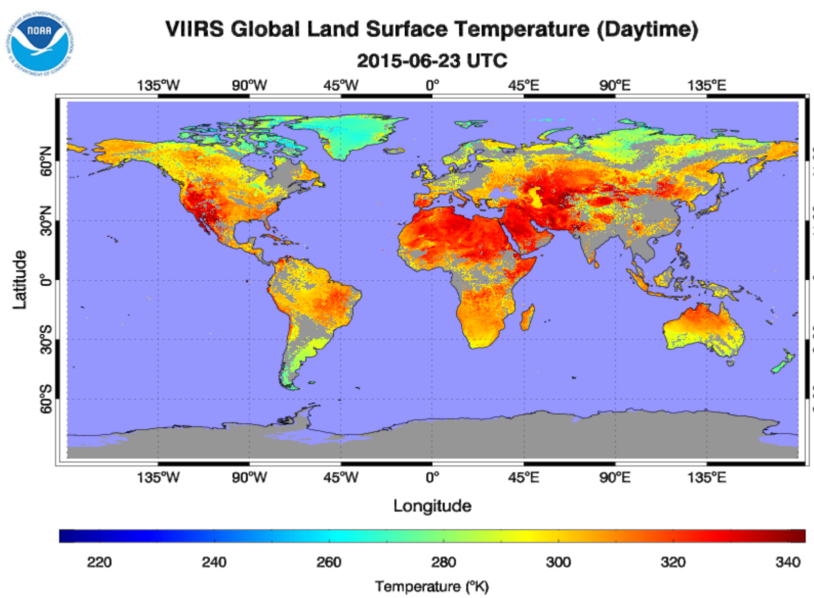
Monitoring -- LST images

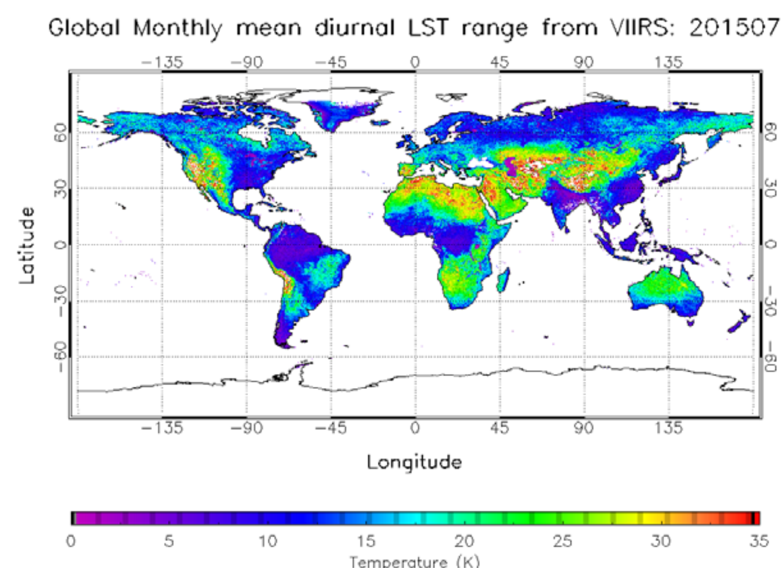




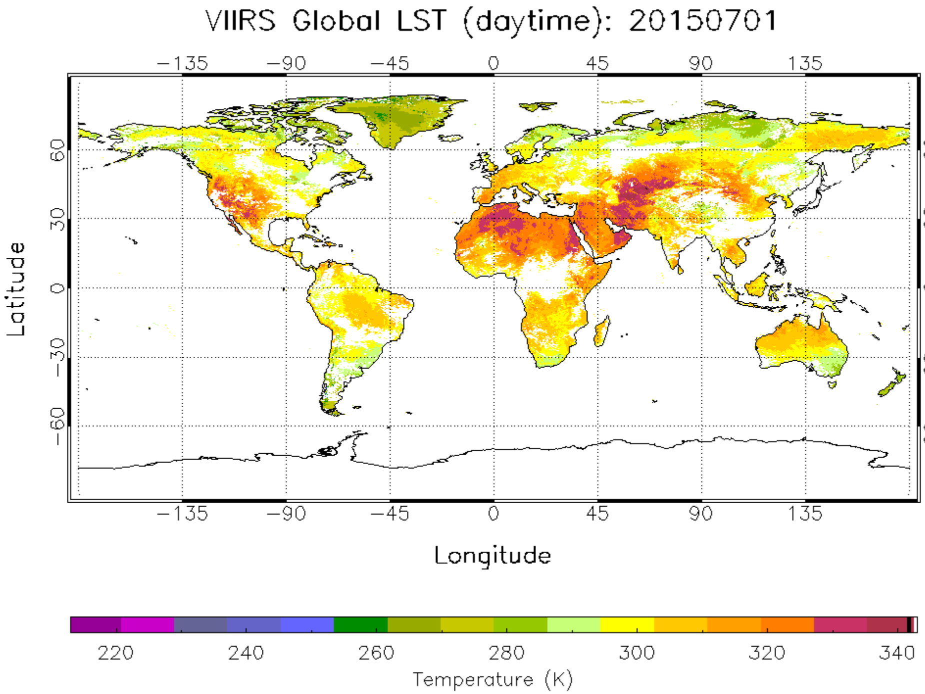


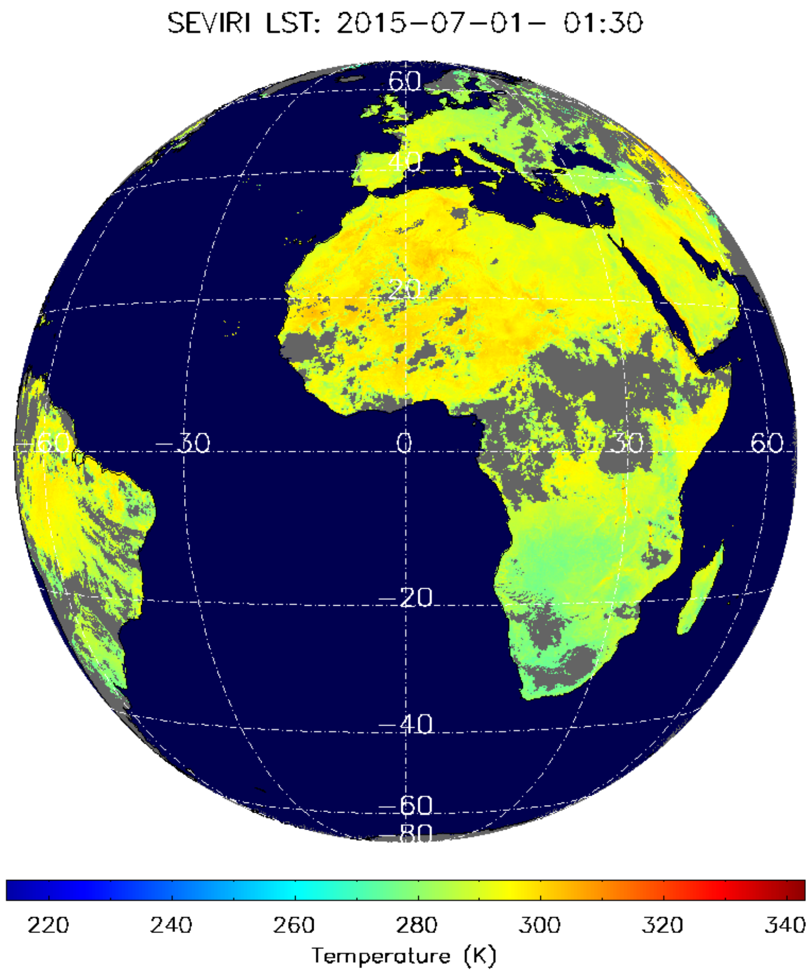
AHI LST2 Date: 20150210 UTC: 1200

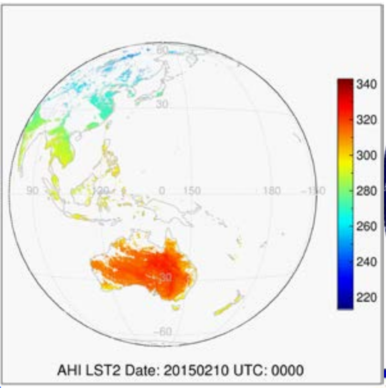


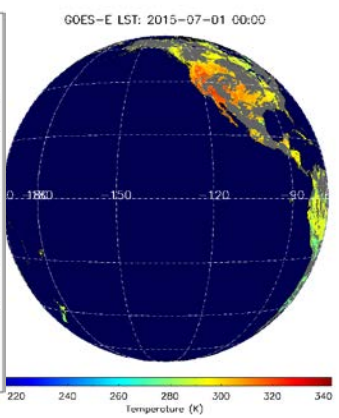


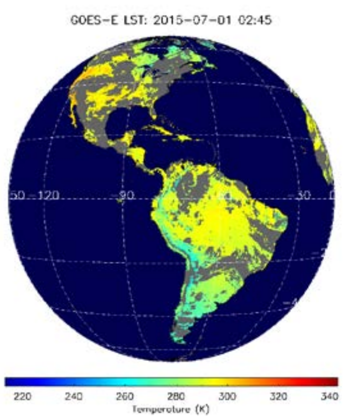
Monitoring -- Animation of Time Series



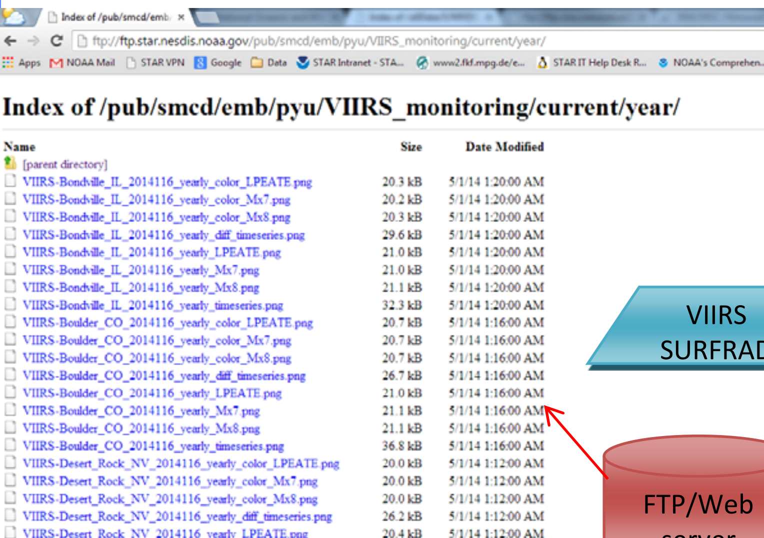








Alert System



Index of /pub/smcd/emb/pyu/VIIRS_monitoring/current/year/

Name	Size	Date Modified
[parent directory]		
VIIRS-Bondville_IL_2014116_yearly_color_LPEATE.png	20.3 kB	5/1/14 1:20:00 AM
VIIRS-Bondville_IL_2014116_yearly_color_Mx7.png	20.2 kB	5/1/14 1:20:00 AM
VIIRS-Bondville_IL_2014116_yearly_color_Mx8.png	20.3 kB	5/1/14 1:20:00 AM
VIIRS-Bondville_IL_2014116_yearly_diff_timeseries.png	29.6 kB	5/1/14 1:20:00 AM
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VIIRS-Bondville_IL_2014116_yearly_Mx7.png	21.0 kB	5/1/14 1:20:00 AM
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VIIRS-Desert_Rock_NV_2014116_yearly_diff_timeseries.png	26.2 kB	5/1/14 1:12:00 AM
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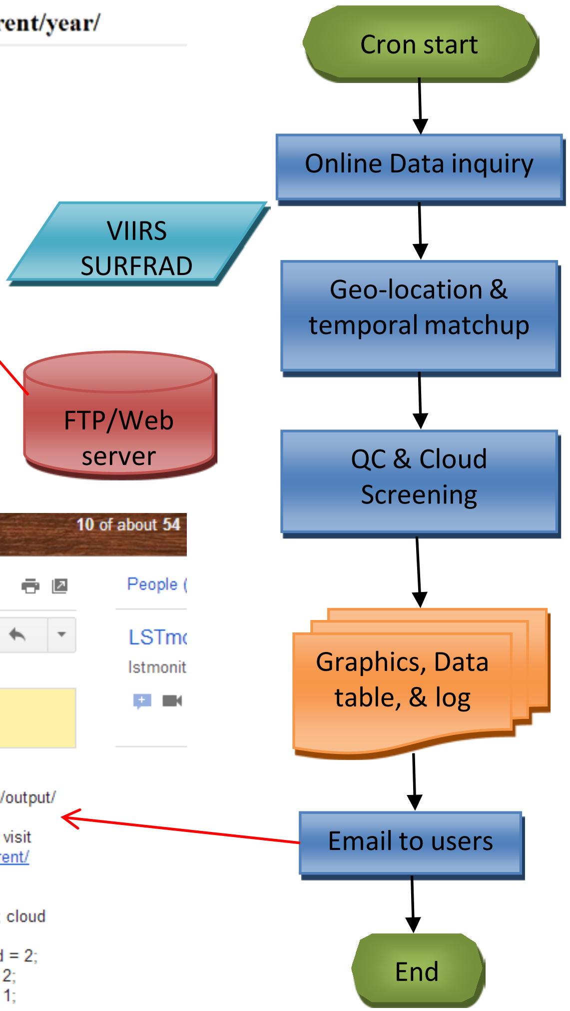
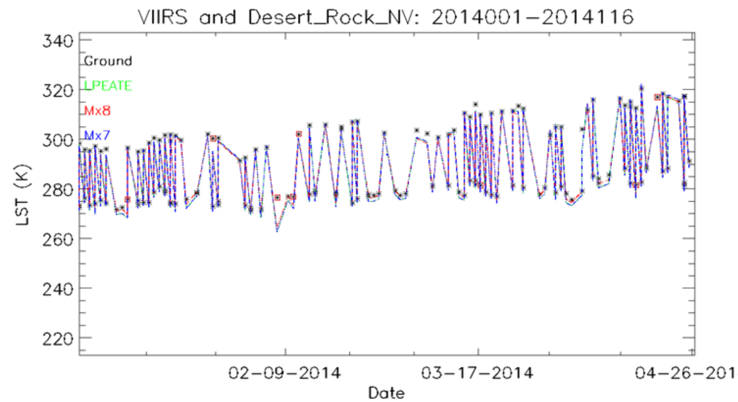
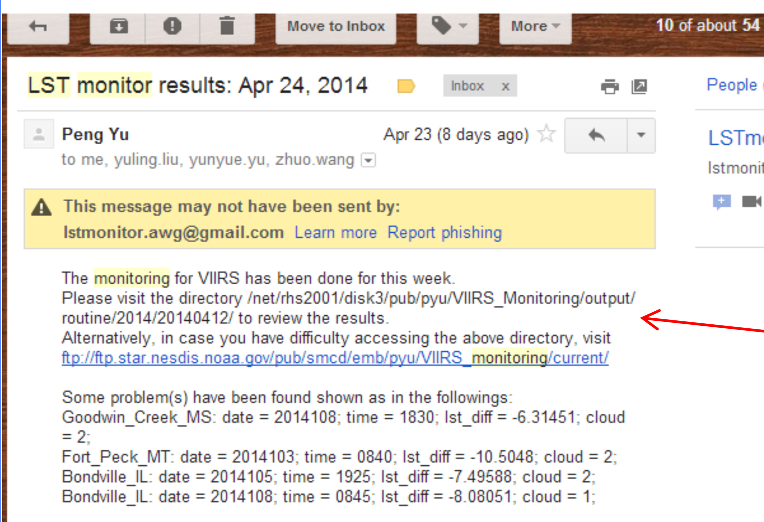






LST monitor results: Apr 24, 2014

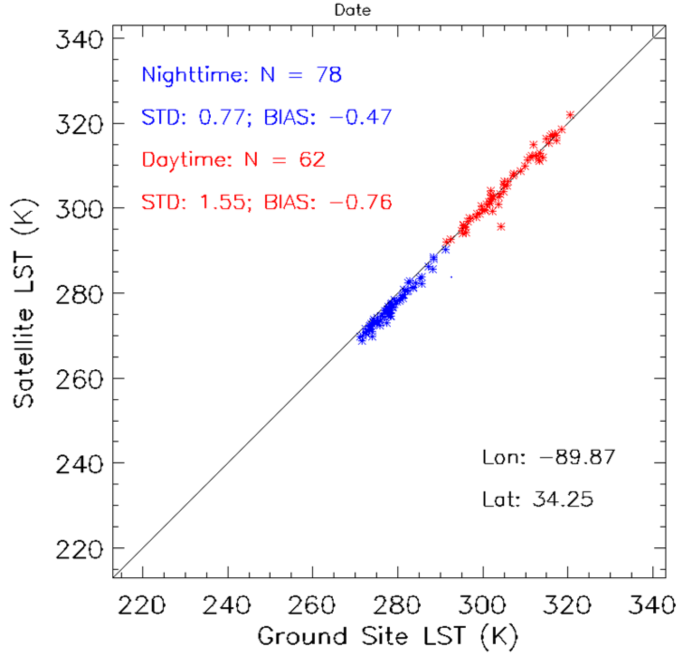
Peng Yu — Apr 23 (8 days ago)

to me, yuling.liu, yunyue.yu, zhuo.wang

This message may not have been sent by: lstmonitor.awg@gmail.com Learn more Report phishing

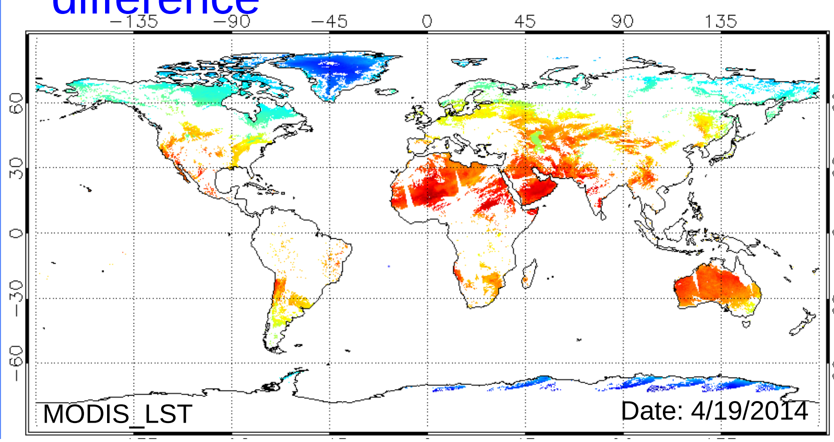
The monitoring for VIIRS has been done for this week.
Please visit the directory /net/rhs2001/disk3/pub/pyu/VIIRS_Monitoring/output/routine/2014/20140412/ to review the results.
Alternatively, in case you have difficulty accessing the above directory, visit
ftp://ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/VIIRS_monitoring/current/

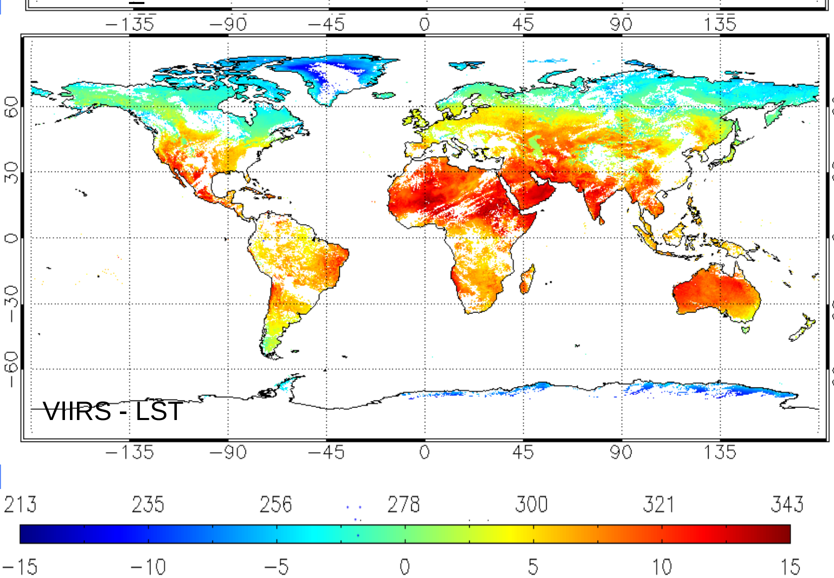
Some problem(s) have been found shown as in the followings:
Goodwin_Creek_MS: date = 2014108; time = 1830; lst_diff = -6.31451; cloud = 2;
Fort_Peck_MT: date = 2014103; time = 0840; lst_diff = -10.5048; cloud = 2;
Bondville_IL: date = 2014105; time = 1925; lst_diff = -7.49588; cloud = 2;
Bondville_IL: date = 2014108; time = 0845; lst_diff = -8.08051; cloud = 1;

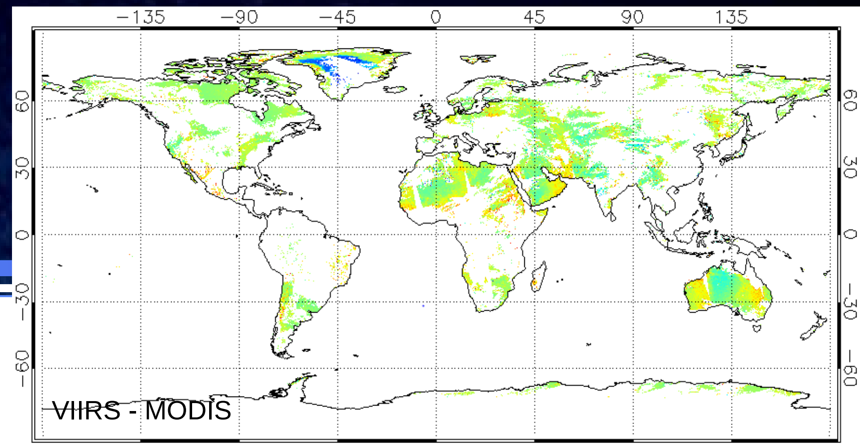


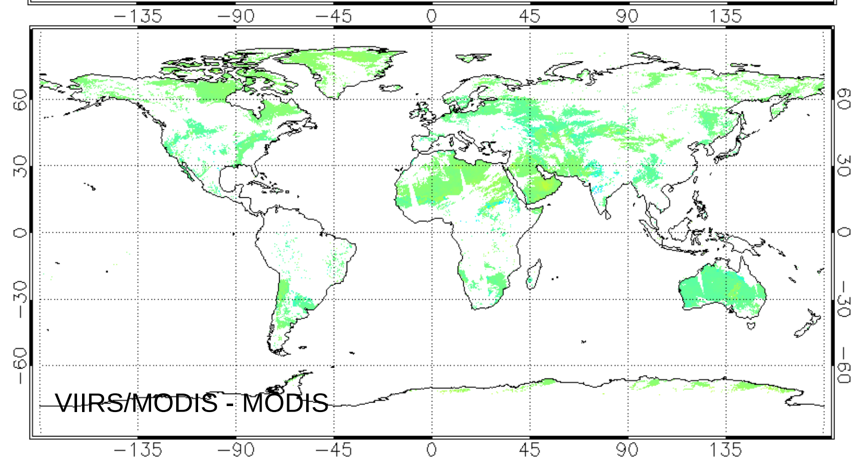
Cross-Satellite Comparison

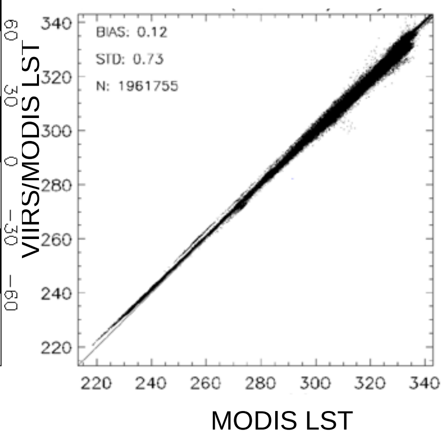
Cross-satellite Comparison: dataset difference







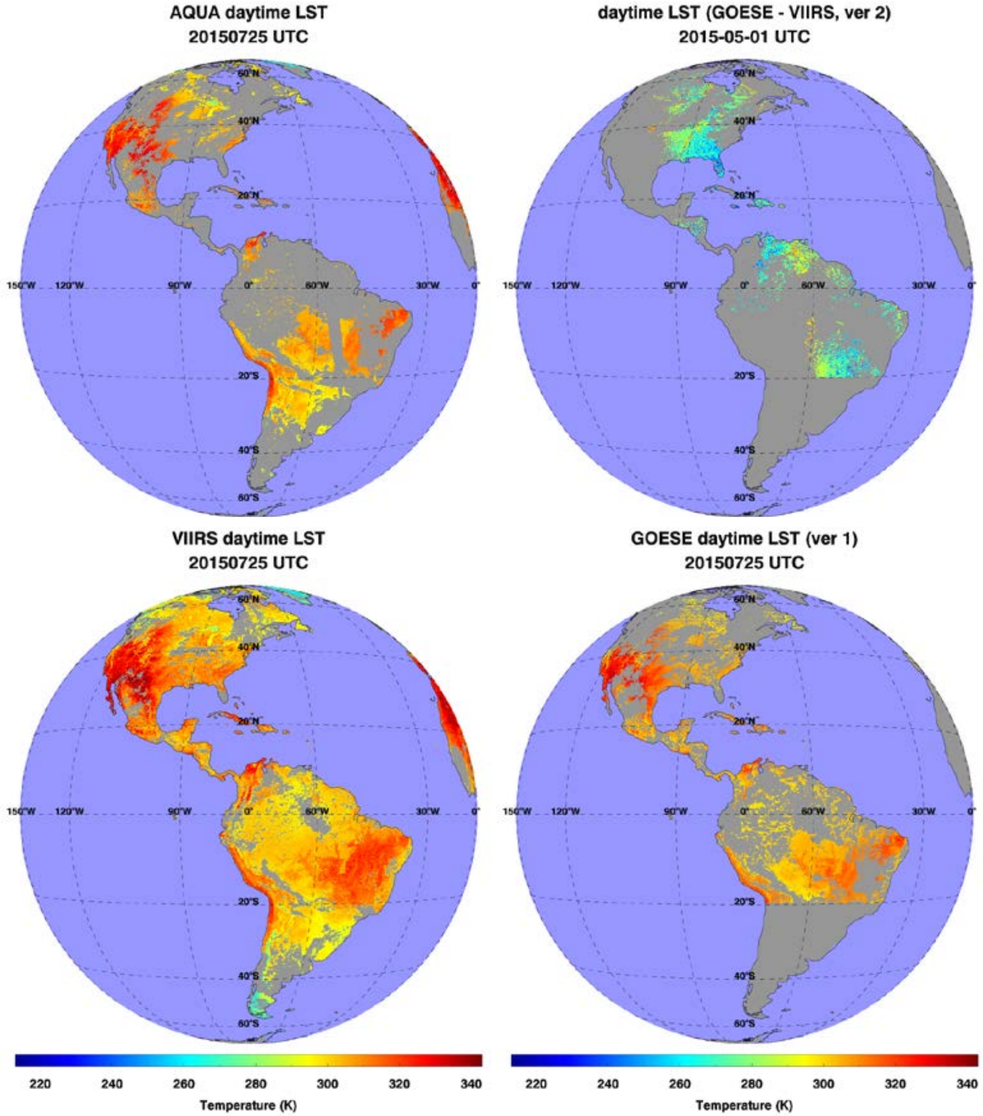




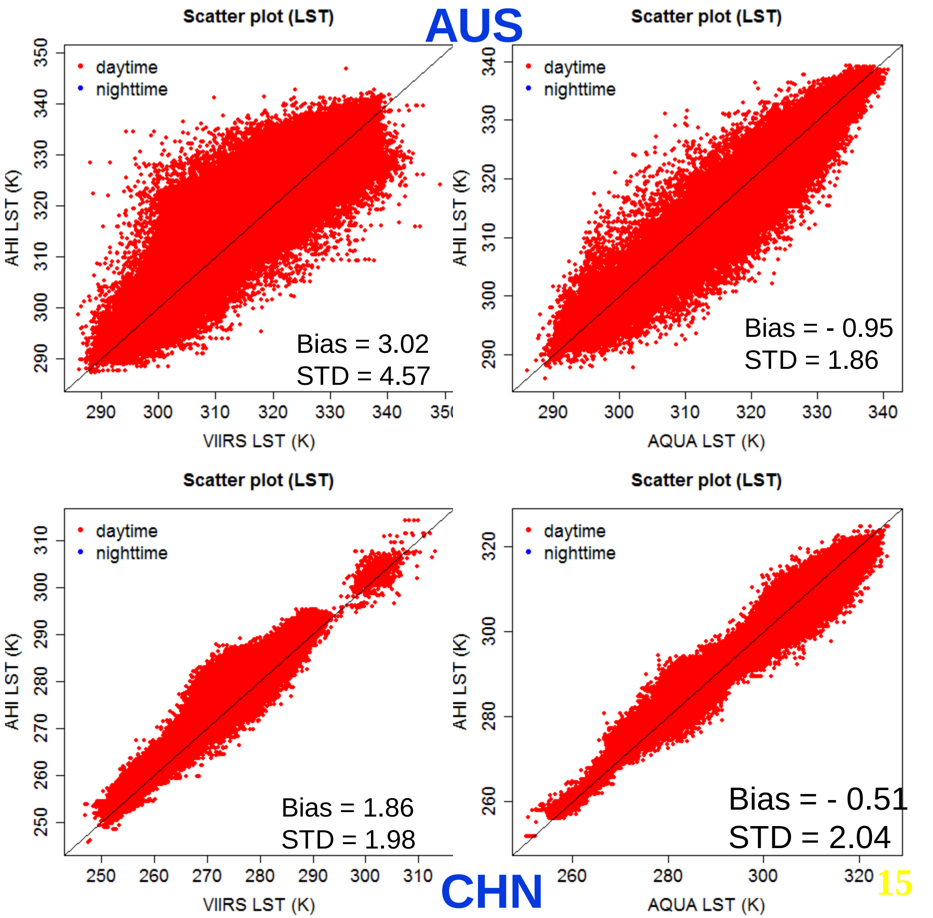
Cross-satellite LST comparison is used in VIIRS LST evaluation.

Caution: Time difference is a significant impact; granule level comparison is needed.

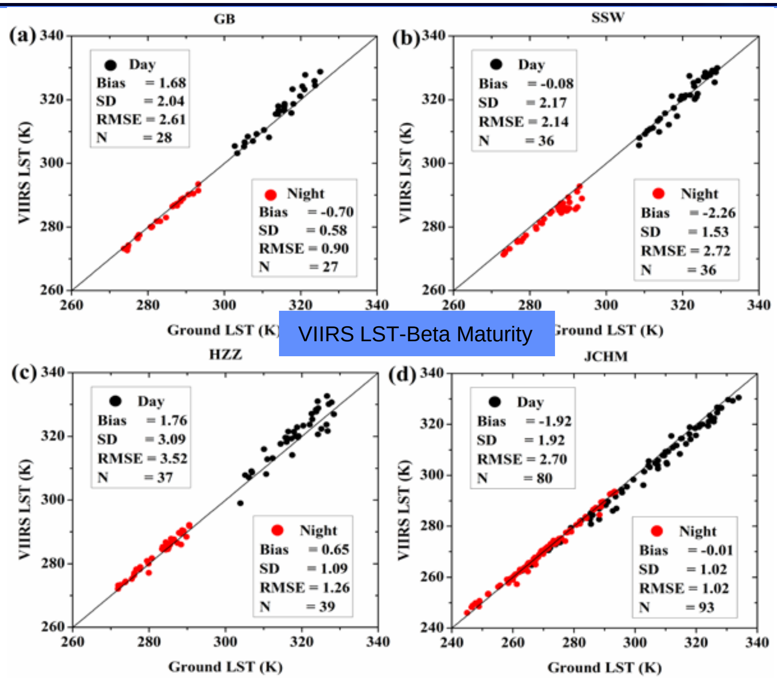
Cross-satellite comparisons

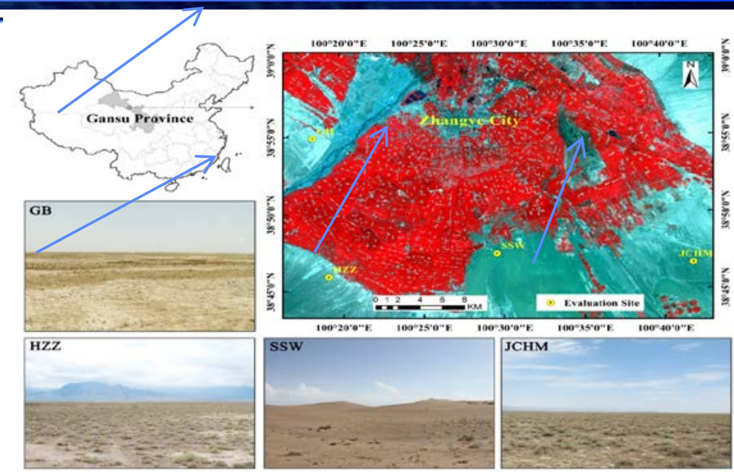


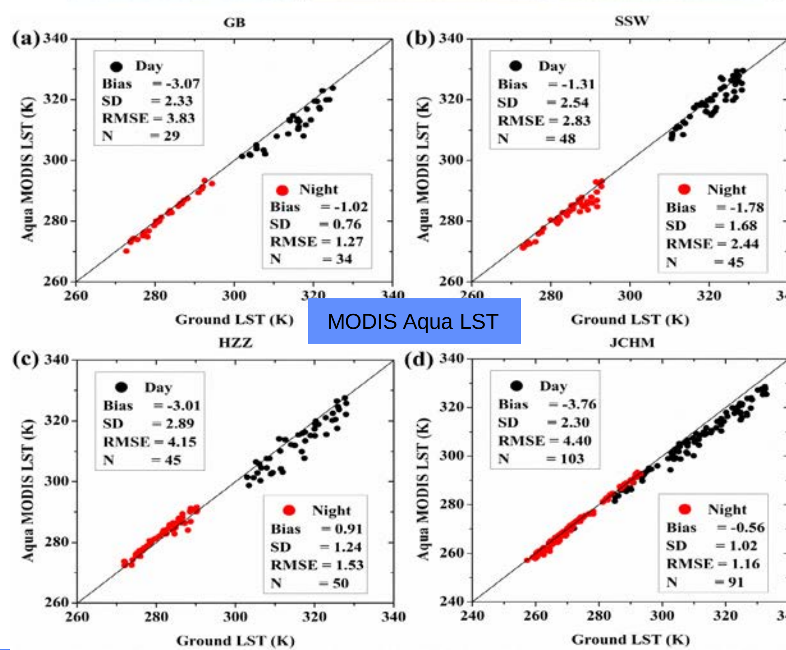
Geo-Leo LST comparisons



International cooperation







Data collection: arid area of northwest China (Heihe Watershed Allied Telemetry Experimental Research), from June 2012 to April 2013. Four barren surface sites were chosen for the evaluation.

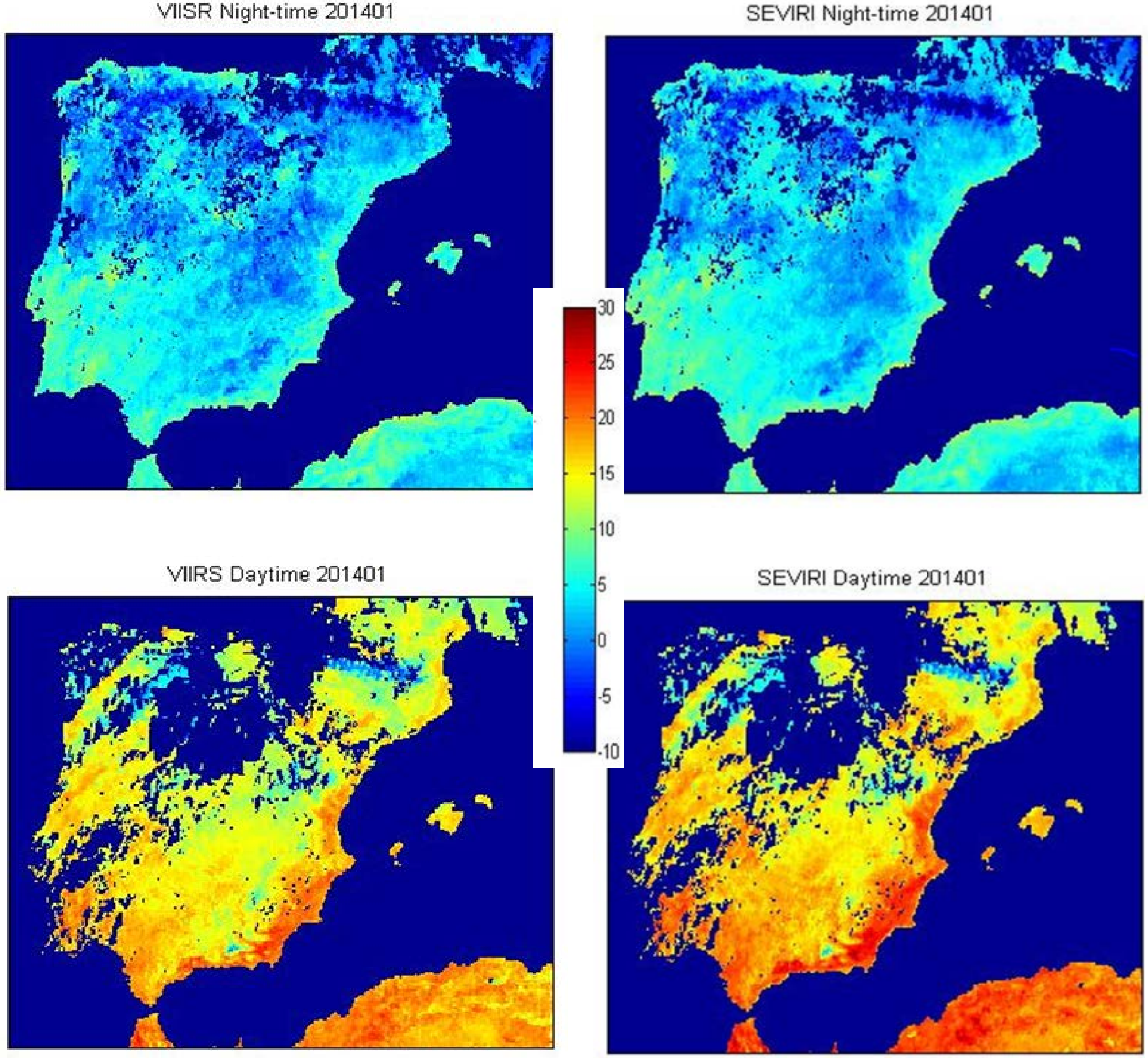
The result generally shows a better agreement for VIIRS LST than that for MODIS LST.

***China site data was obtained through a collaborative effort with Dr. Hua Li at Institute of Digital Earth and Remote Sensing, China Academy of Science**

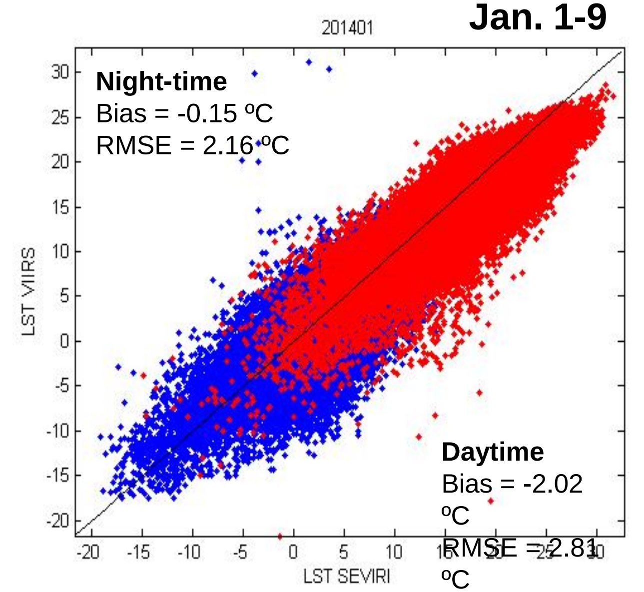
Reference: *H. Li, D. Sun, Y. Yu, H. Wang, Y. Liu, Q. Liu, Y. Du, H. Wang and B. Cao(2014) , Evaluation of the VIIRS and MODIS LST products in an arid area of Northwest China Remote Sensing of Environment 02/2014; 142:111–121*

International cooperation

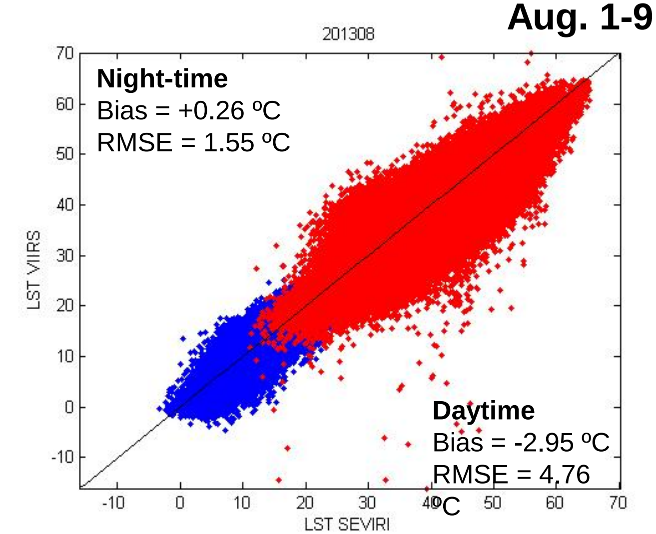
VIIRS **1-9 Jan 2014** **SEVIRI**



Jan. 1-9



Aug. 1-9



Courtesy of Isabel F. Trigo , through US-Portugal Bilateral cooperation program (on remote Sensing)

Further Enhancement /Improvement

- Validation tool improvement
  - » A web-based validation server
  - » practical use of the spot-to-pixel scaling method
  - » Field campaign participation (through national/international cooperation)
    - – High quality ground data is the key!
    - – Need the data over central and south of America
  - » Radiance-based LST validation method
  - » Cross-satellite comparison
    - – A visualization extension (comparisons with VIIRS, MODIS , Sentinel-3…)
  - » Three-measurement validation method
- Algorithm Enhancement /Improvement
  - » Emissivity data
  - » Additional cloud filtering for LST
  - » Water vapor correction
  - » Large angle correction
- Interactive with AIT, vender

NOAA-USGS Land Product Characterization System

STAR JPSS Science Team Meeting
27 August 2015

Kevin Gallo: NESDIS/STAR
John Dwyer: USGS/EROS
Steve Foga: SGT/EROS
Calli Jenkerson: SGT/EROS
Ryan Longhenry: USGS/EROS
Greg Stensaas: USGS/EROS

GOES-R
Geostationary Operational Environmental Satellite R-Series

JPSS
Joint Polar Satellite System

Land Product Characterization System (LPCS)

What is LPCS

Highlights/Status of LPCS

1. Inventory & Ordering
2. Analysis Tools

Path Forward

Summary

Land Product characterization System (LPCS)

What is LPCS

Highlights/Status of LPCS

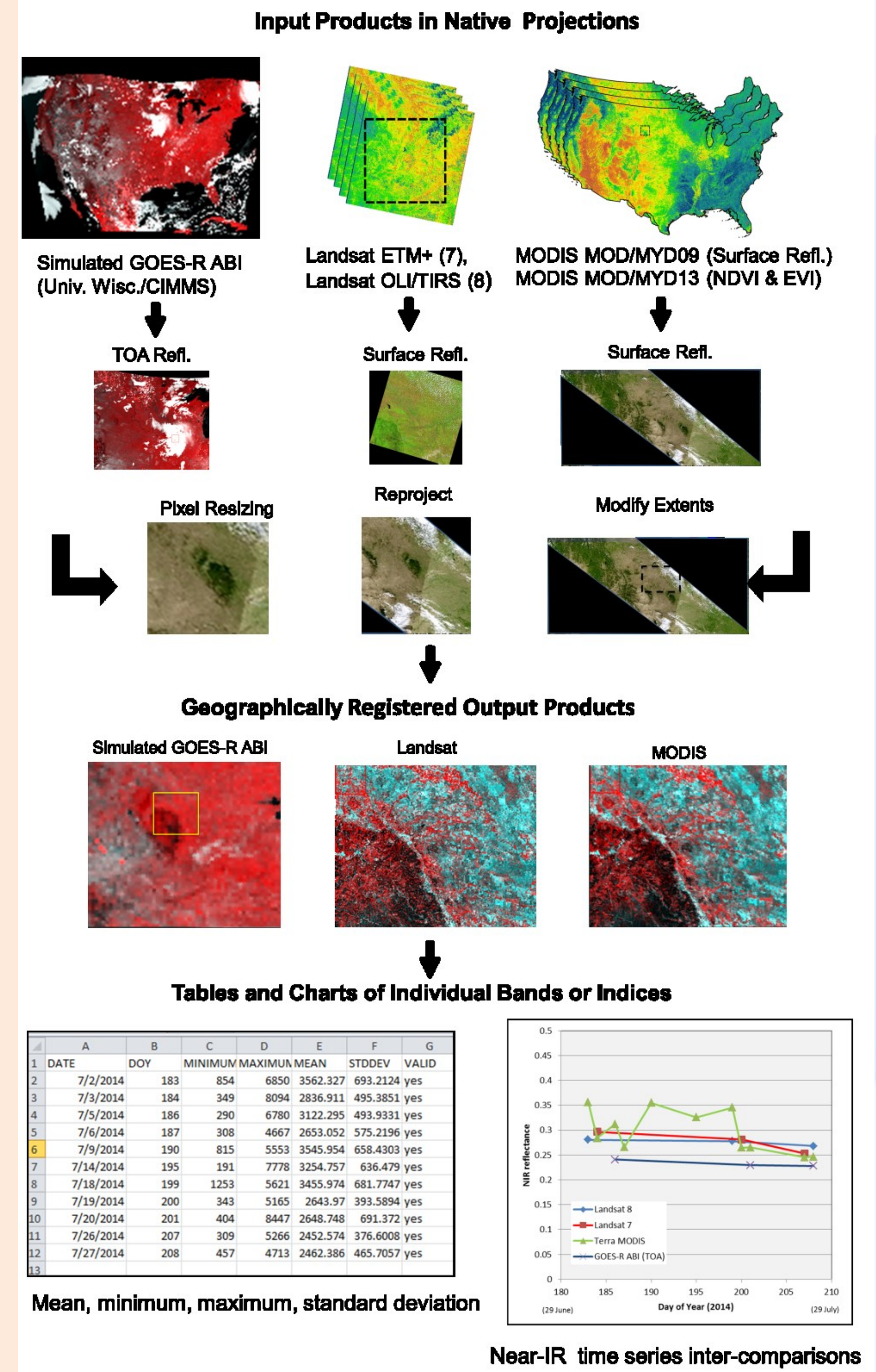
1. Inventory & Ordering
2. Analysis Tools

Path Forward

Summary

Land Product Characterization System

A web-based system designed to use moderate to high-resolution satellite data for characterization, and assist with validation, of GOES-R ABI and JPSS VIIRS products.

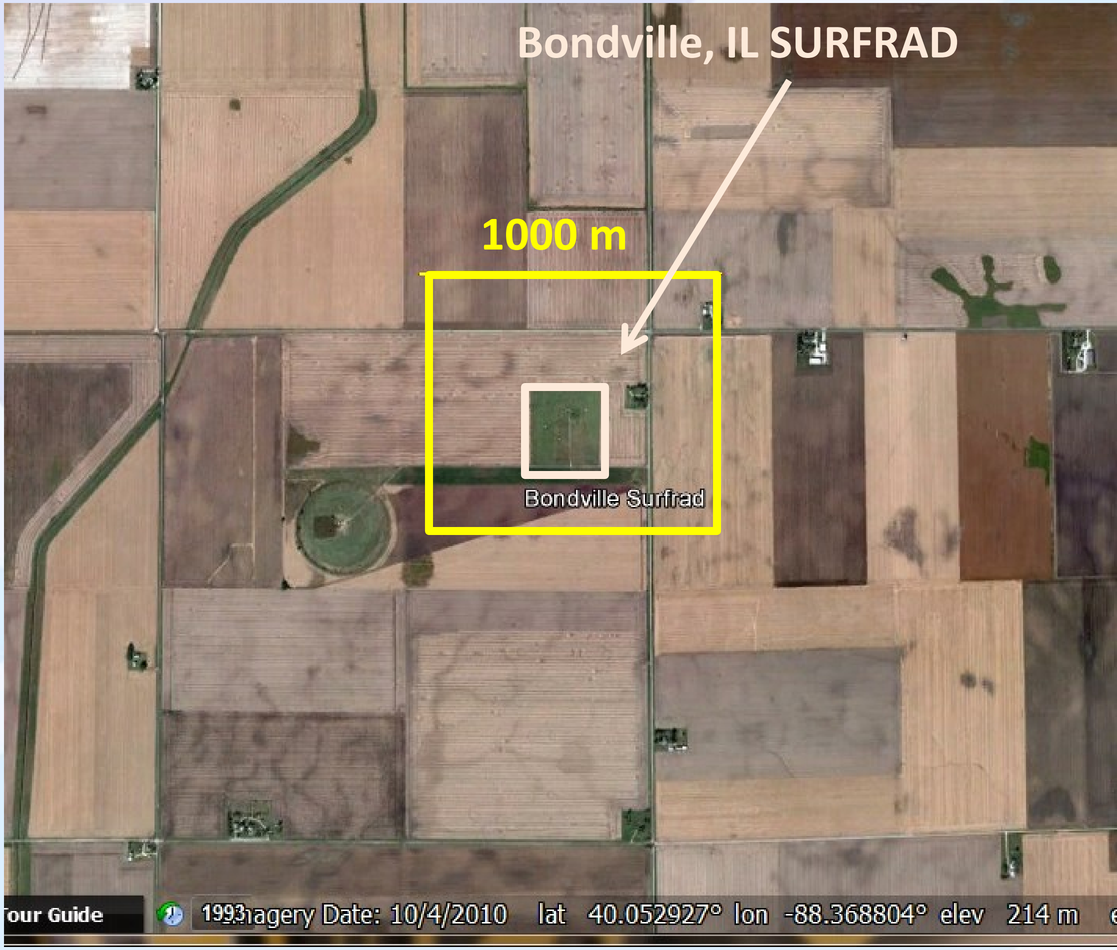


DATE	DOY	MINIMUM	MAXIMUM	MEAN	STDDEV	VALID
7/2/2014	183	854	6850	3562.327	693.2124	yes
7/3/2014	184	349	8094	2836.911	495.3851	yes
7/5/2014	186	290	6780	3122.295	493.9331	yes
7/6/2014	187	308	4667	2653.052	575.2196	yes
7/9/2014	190	815	5553	3545.954	658.4303	yes
7/14/2014	195	191	7778	3254.757	636.479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

What is LPCS

A web-based system designed to use **moderate to high-resolution** satellite data for validation of GOES-R ABI and JPSS VIIRS products.

Bondville, IL SURFRAD



What is LPCS

1. General characteristics
2. Desired functionality

Landsat 8 spatial resolution

vis/near IR 30 m

Thermal IR 100 m

Bondville, IL SURFRAD

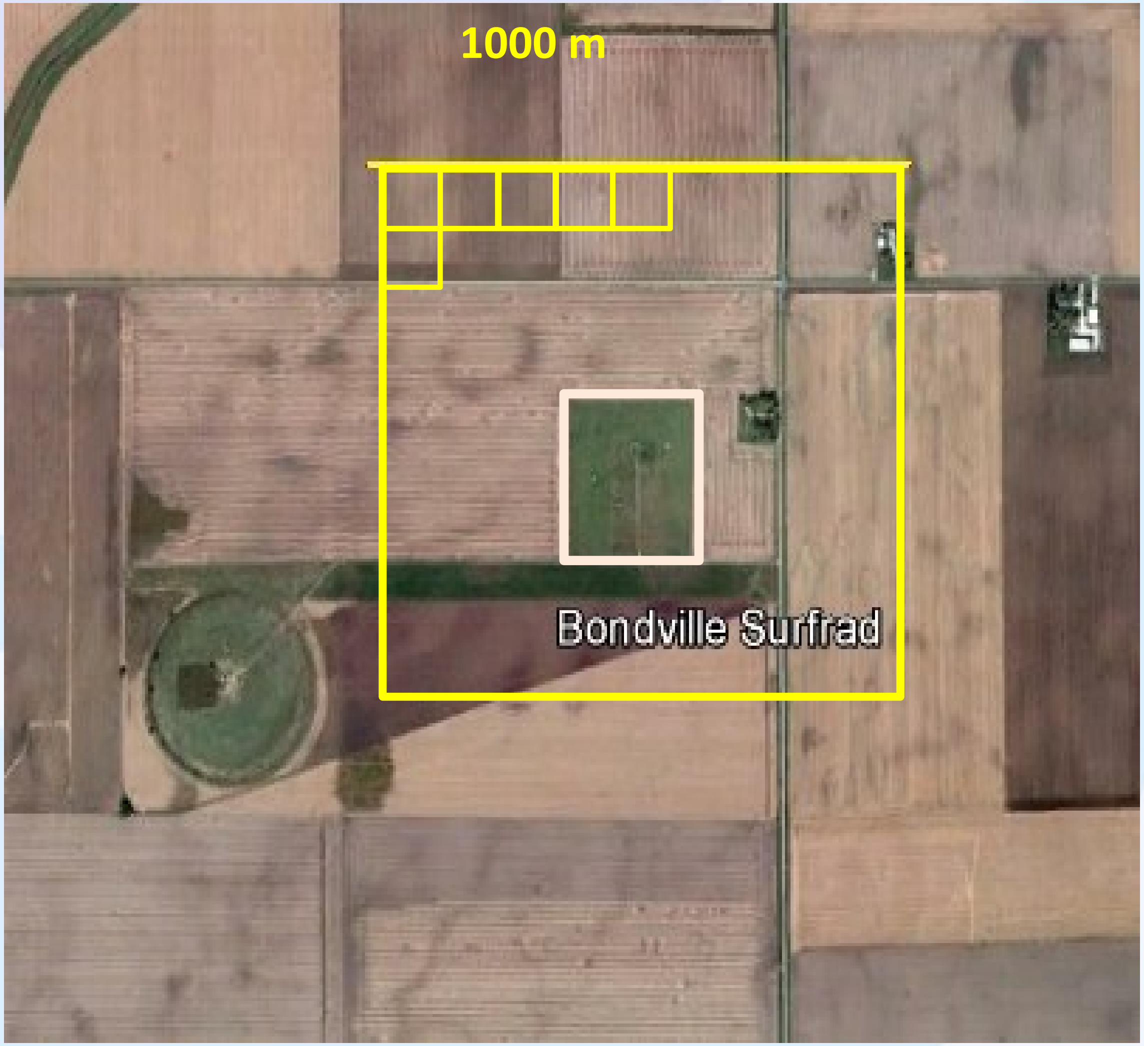
What is LPCS

1. General characteristics
2. Desired functionality

Landsat sampling for 1000 x 1000 m target:

- 1100 samples at 30 m resolution
- 100 samples at 100 m resolution

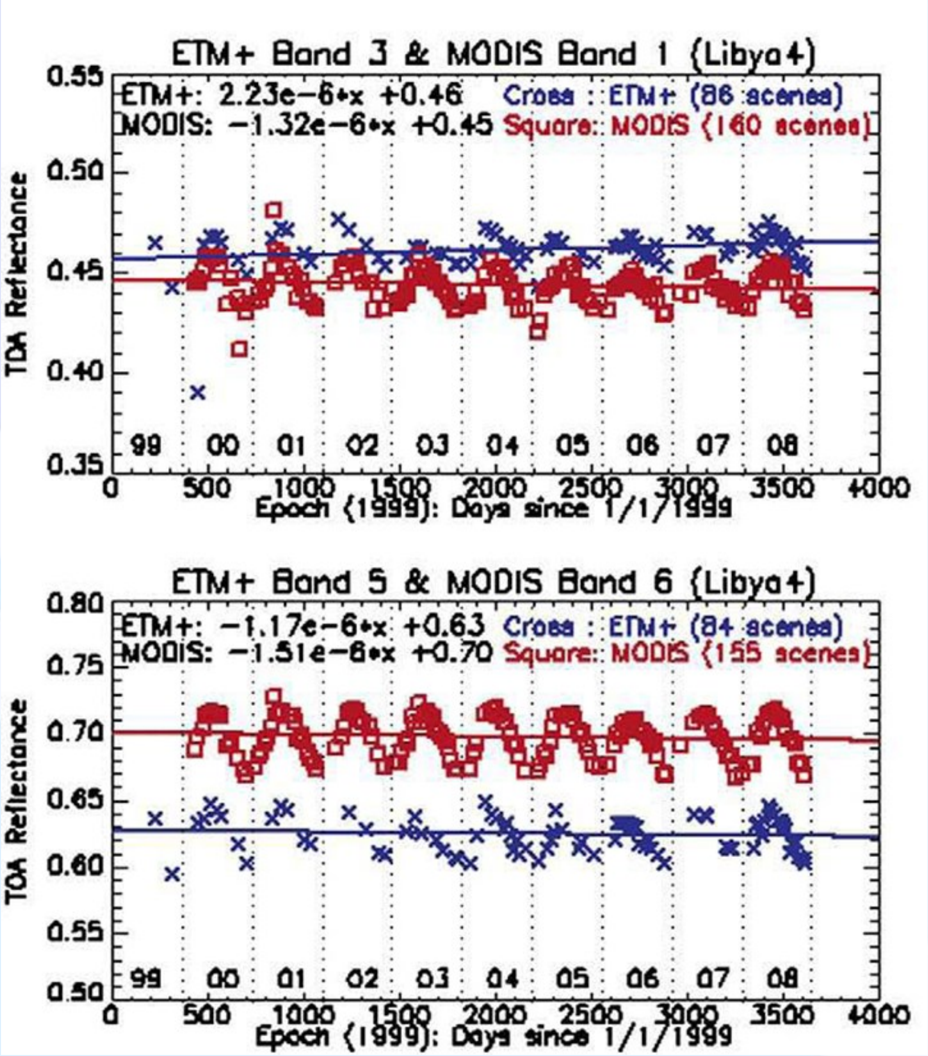
Bondville, IL SURFRAD



What is LPCS: General Characteristics
Potential Output examples

MODIS vs Landsat

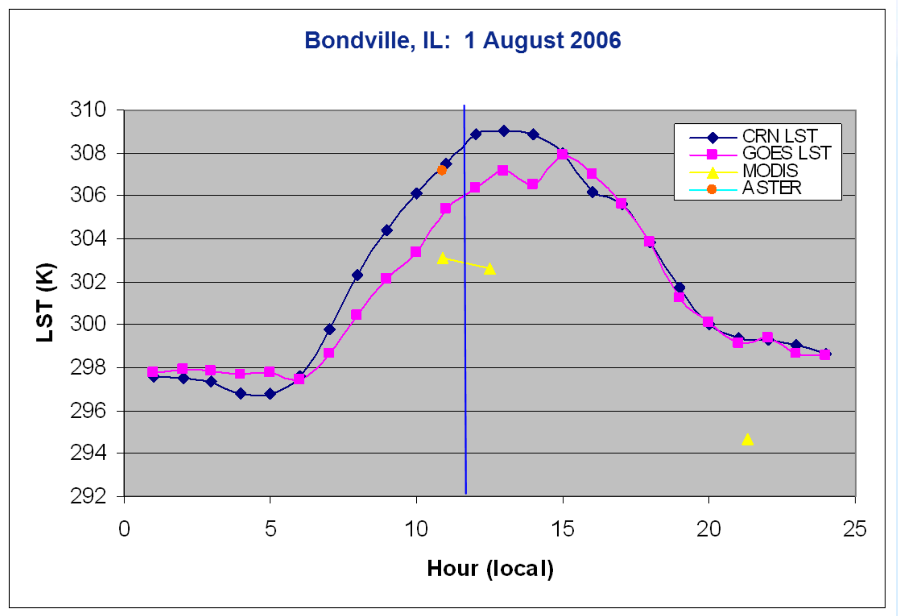
Trending of **similar bands** of data from **multiple sensors**.



What is LPCS: General Characteristics
Potential Output examples

Multiple sensor (satellite and in situ) comparisons for **single location** and **date.**

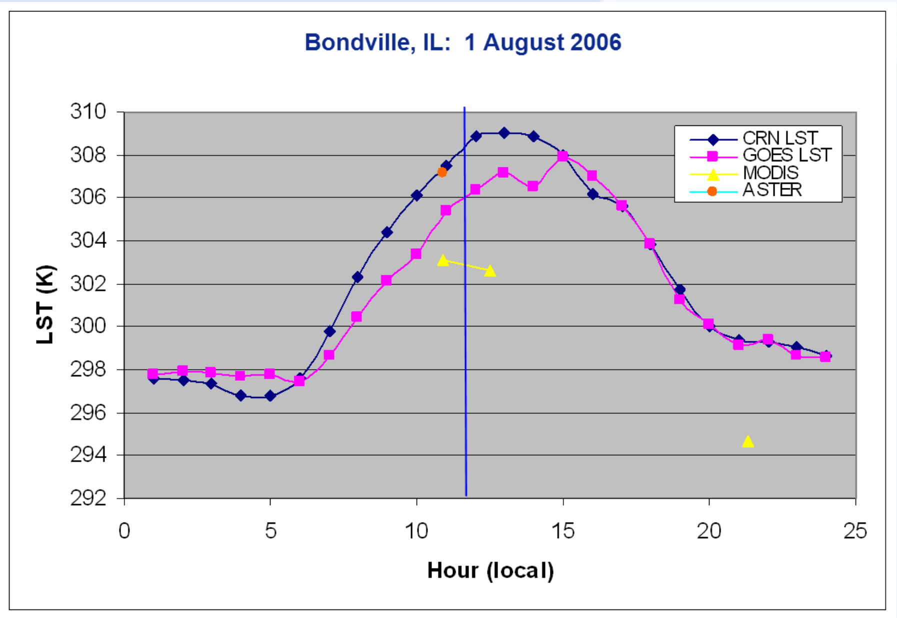
Land Surface Temp.



What is LPCS: General Characteristics
Potential Output examples

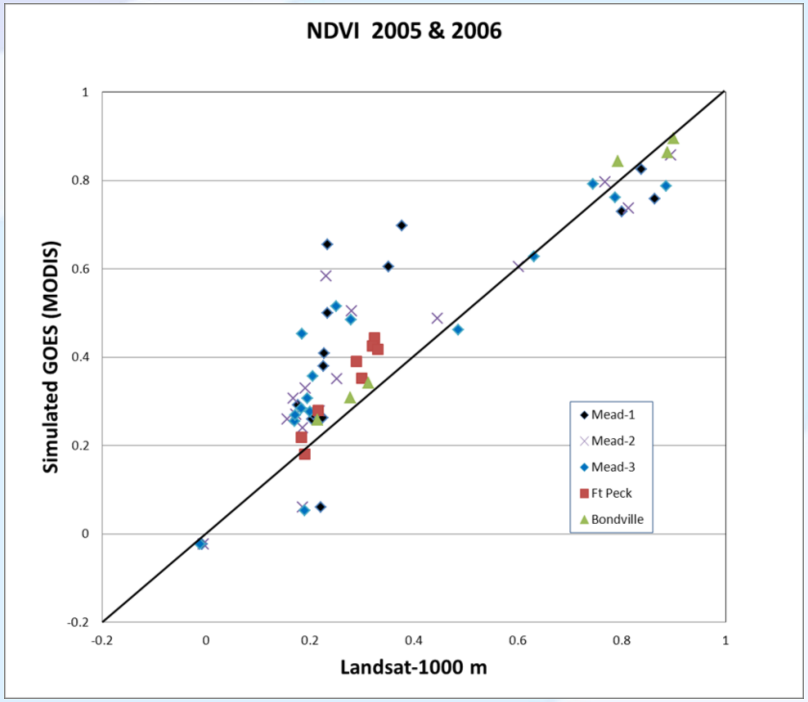
Multiple sensor (satellite and in situ) comparisons for single location and date.

Land Surface Temp.



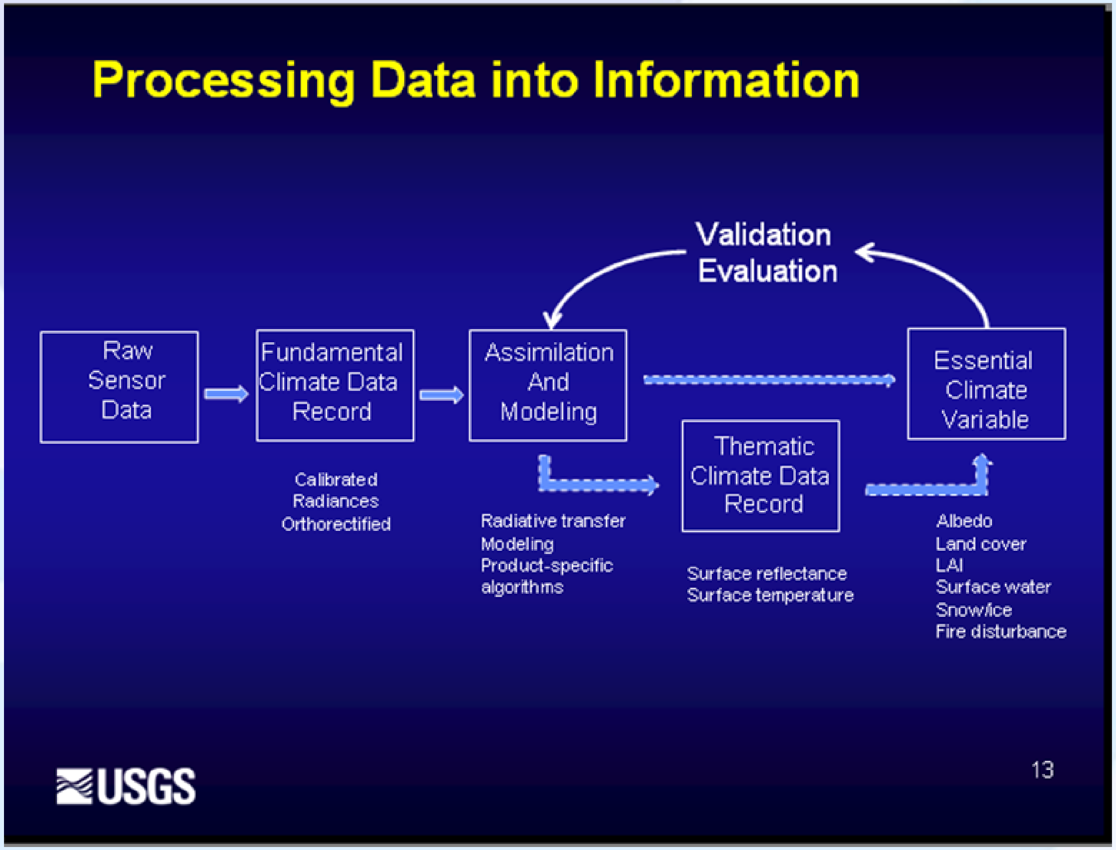
NDVI

Multiple sensor comparison for **multiple locations** and **multiple dates**.



Why LPCS utilization of Landsat?

Landsat Product Development

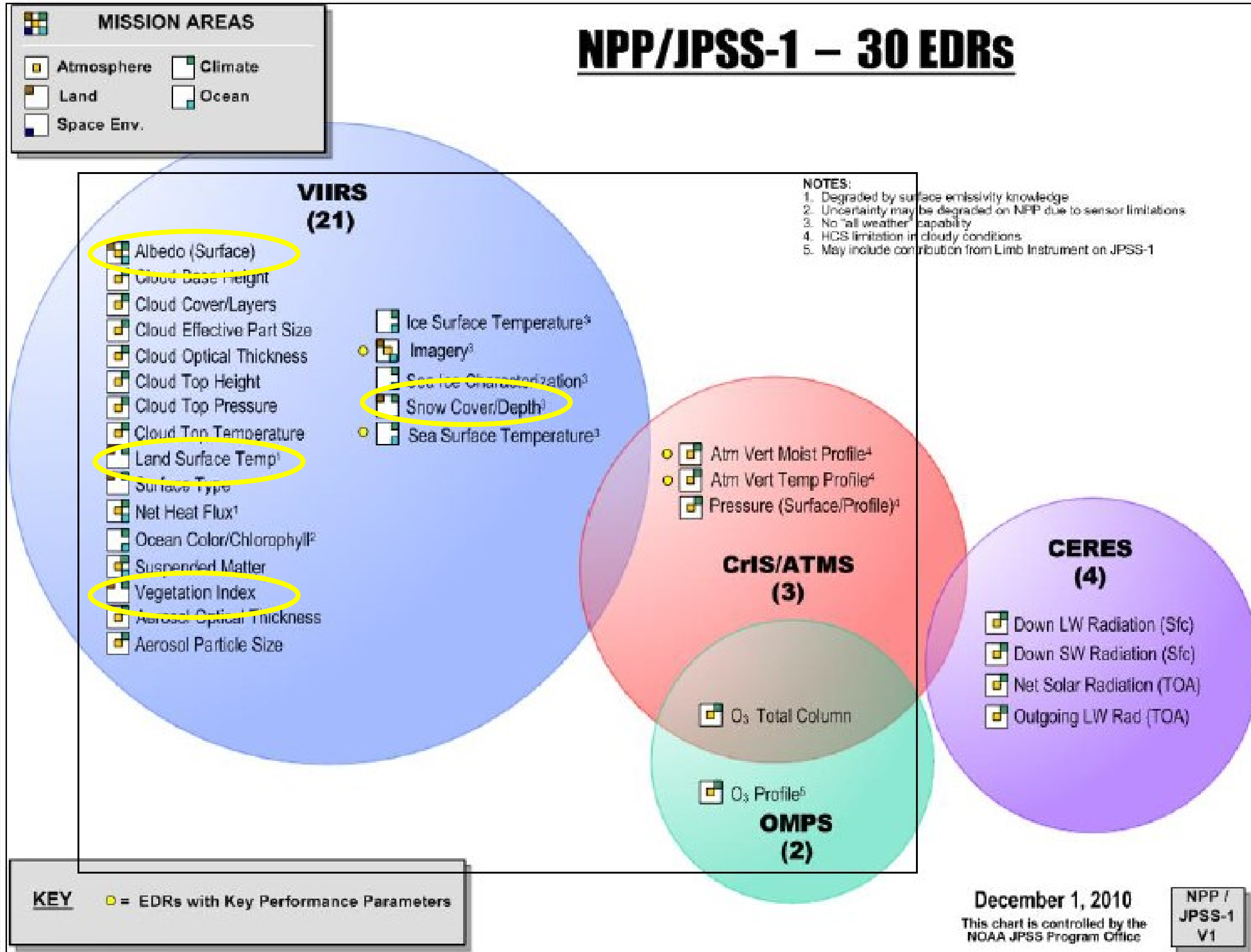


CDRs
Surface Reflectance (and NDVI),
Land Surface
Temperature/Emissivity

ECVs
Surface Water Extent,
Burned Area Extent,
Snow Covered Area

LPCS - VIIRS validation synergy

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



LPCS – GOES-R ABI 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

Land Product characterization System (LPCS)

What is LPCS

Why LPCS developed/hosted at EROS

Highlights of LPCS

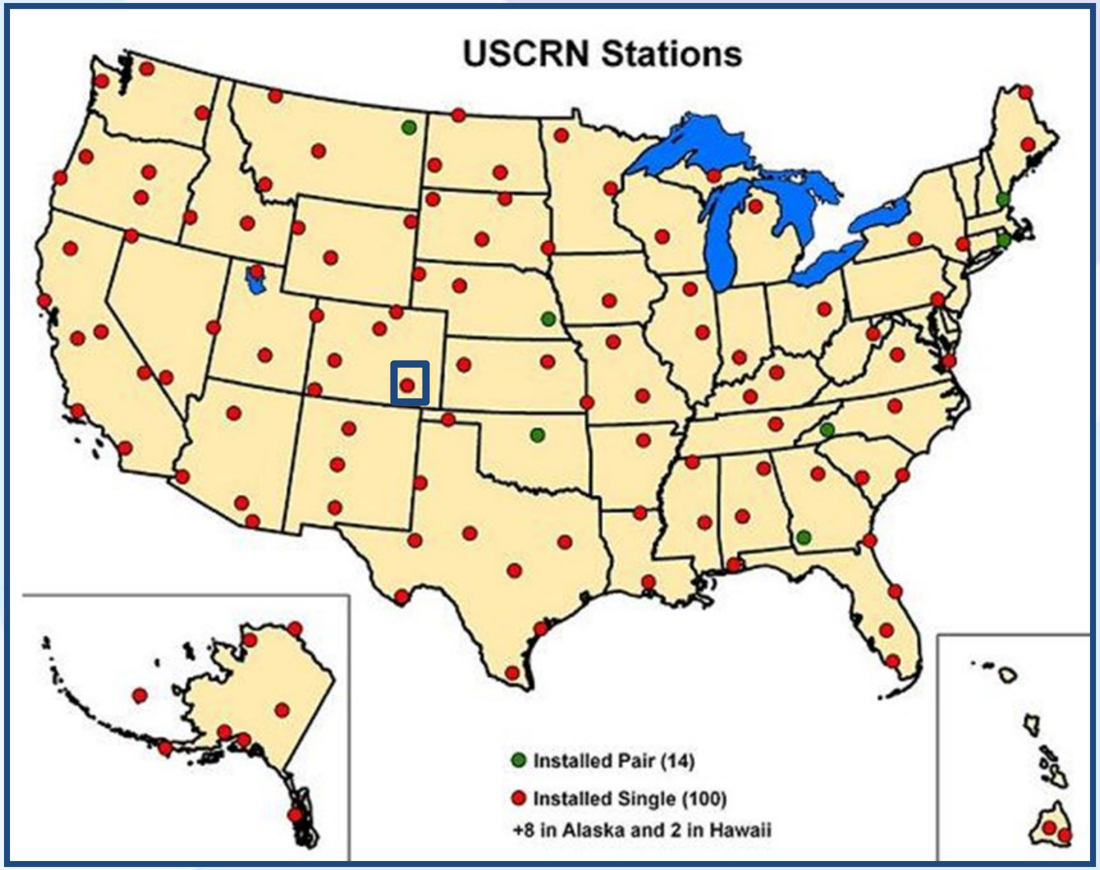
1. Inventory & Ordering
2. Analysis Tools

Path Forward

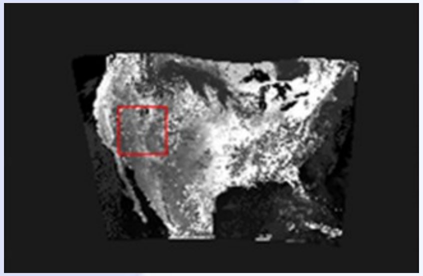
Summary

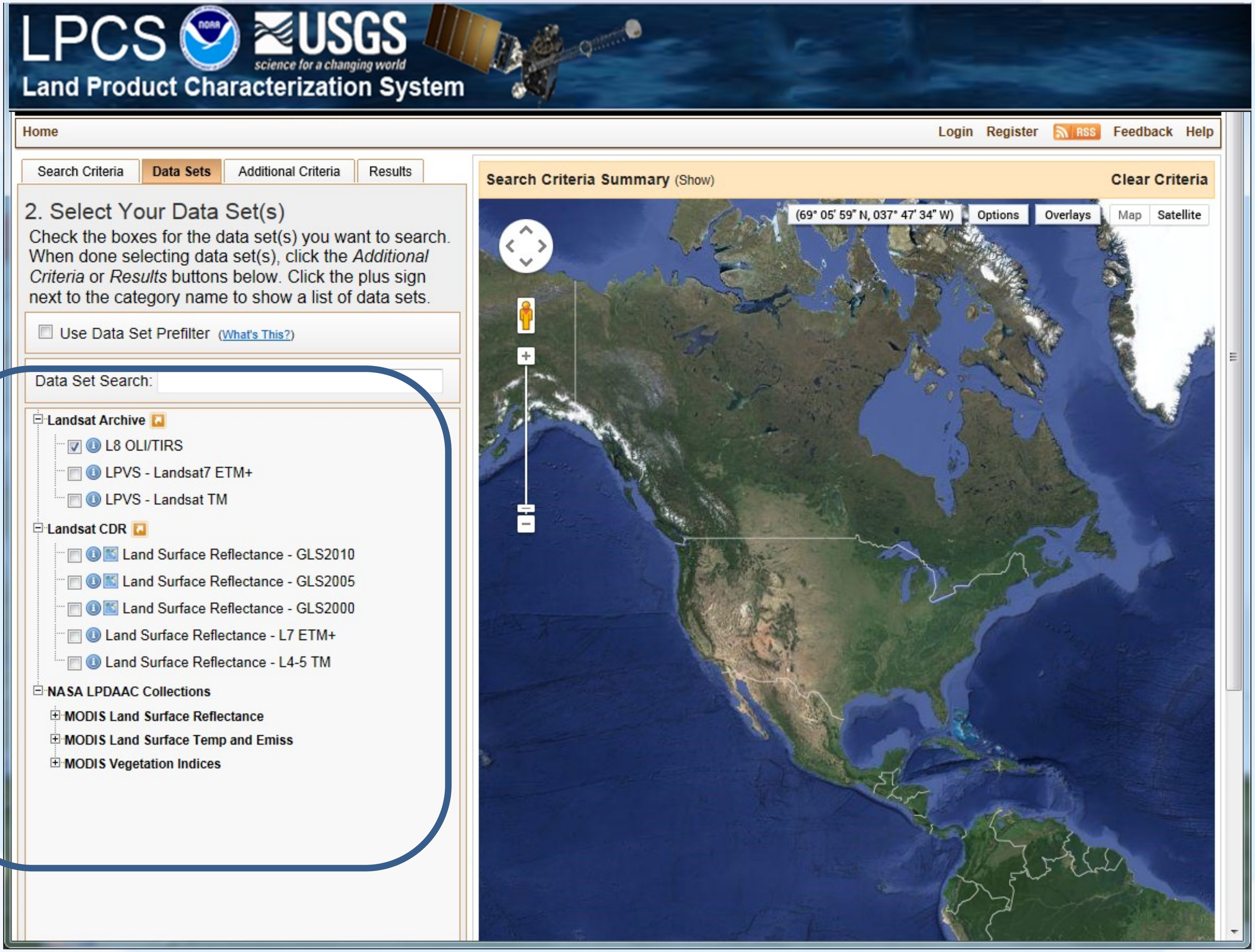
Example of LPCS Functionality

Data extracted for VIIRS (NOAA and NASA products), MODIS, Landsat 8, and simulated GOES-R ABI for the La Junta, CO, CRN station located within NASA golden tile (h09v05).

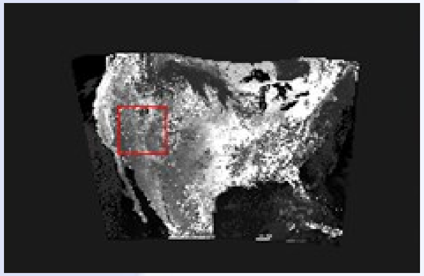


Search within LPCS for Landsat and MODIS data coincident with VIIRS and simulated GOES-R ABI data (provided by Univ. Wisc./CIMSS).

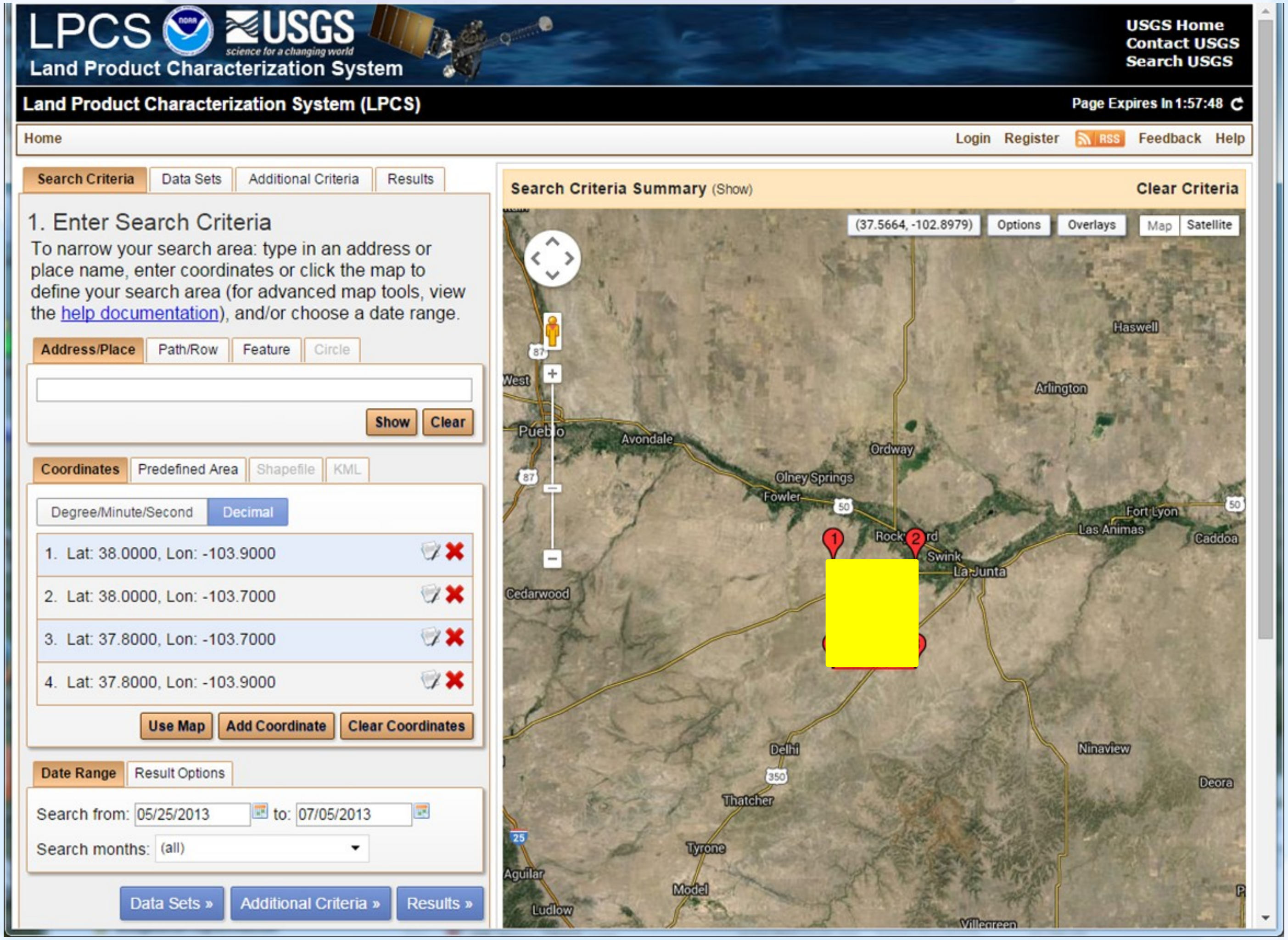




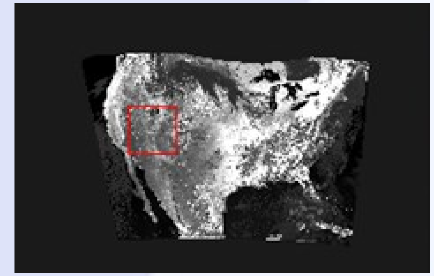
Search for Landsat and MODIS data coincident with VIIRS and simulated GOES-R ABI data (provided by Univ. Wisc./CIMSS).



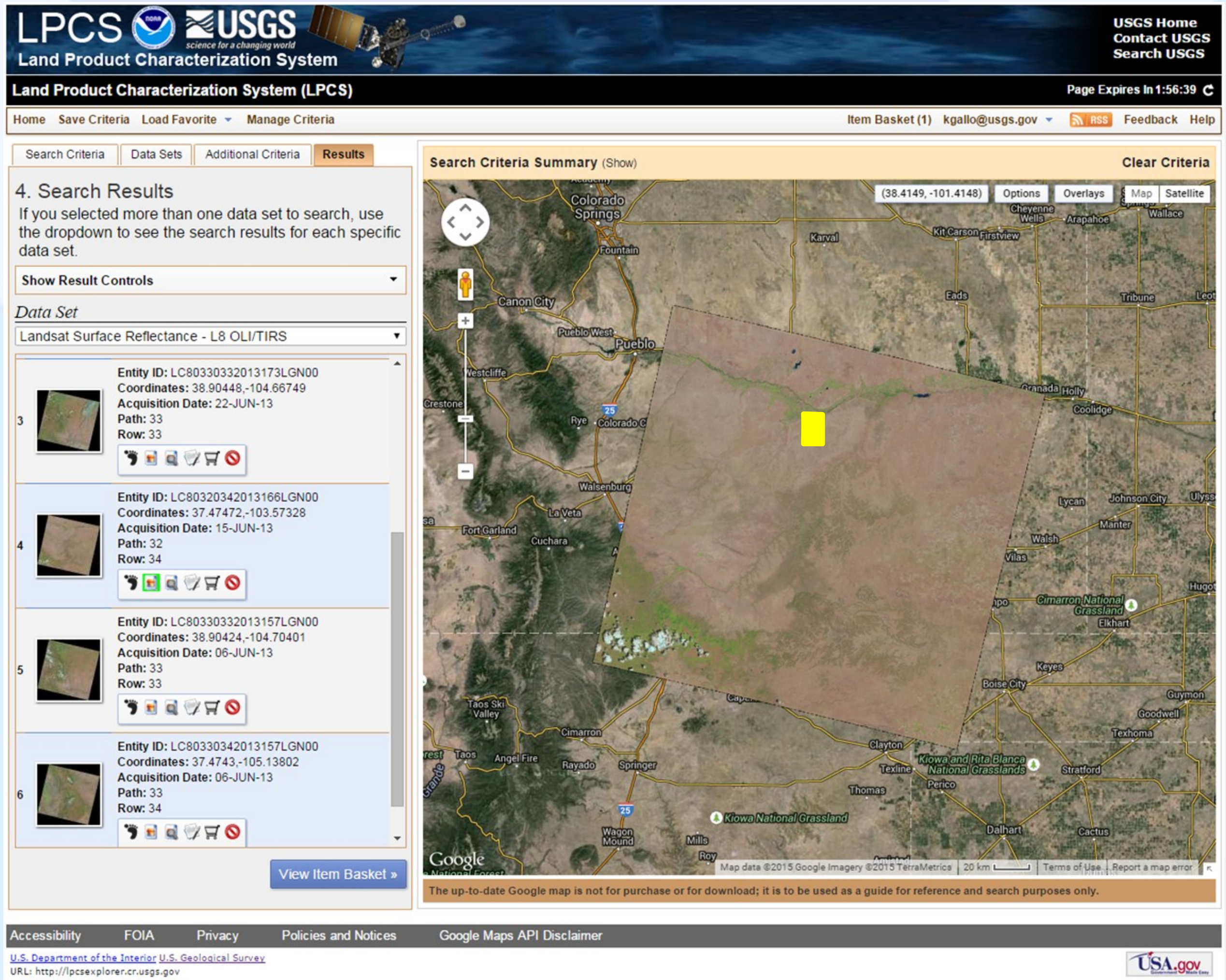
La Junta CO: Landsat 8 and MODIS data search criteria



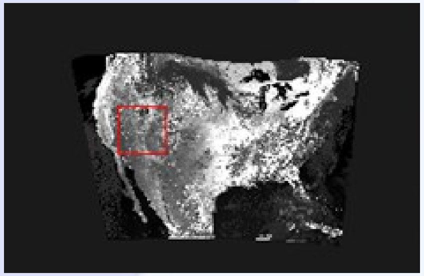
Search for Landsat and MODIS data coincident with VIIRS and simulated GOES-R ABI data (provided by Univ. Wisc./CIMSS).



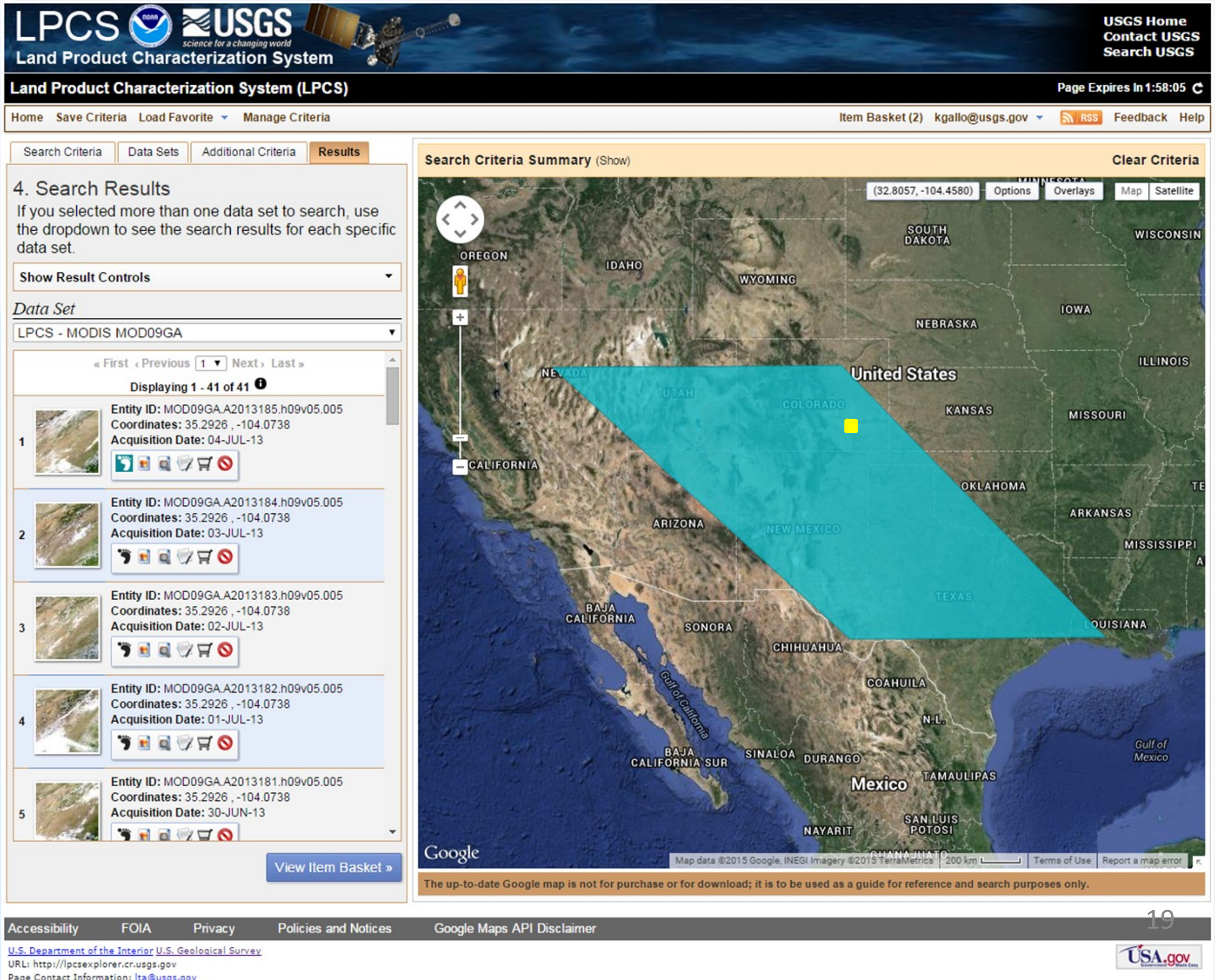
La Junta CO: Landsat 8 data results



Search for Landsat and MODIS data coincident with VIIRS and simulated GOES-R ABI data (provided by Univ. Wisc./CIMSS).



La Junta CO: MODIS-Terra data results



Enhanced Landsat Products

Additional ECVs and CDRs will be added to menu as available.

Select Product Contents

Source Products
☐ Source Products
☐ Source Metadata

Climate Data Records
☐ Top of Atmosphere Reflectance
☐ Surface Reflectance
☐ Band 6 Brightness Temperature

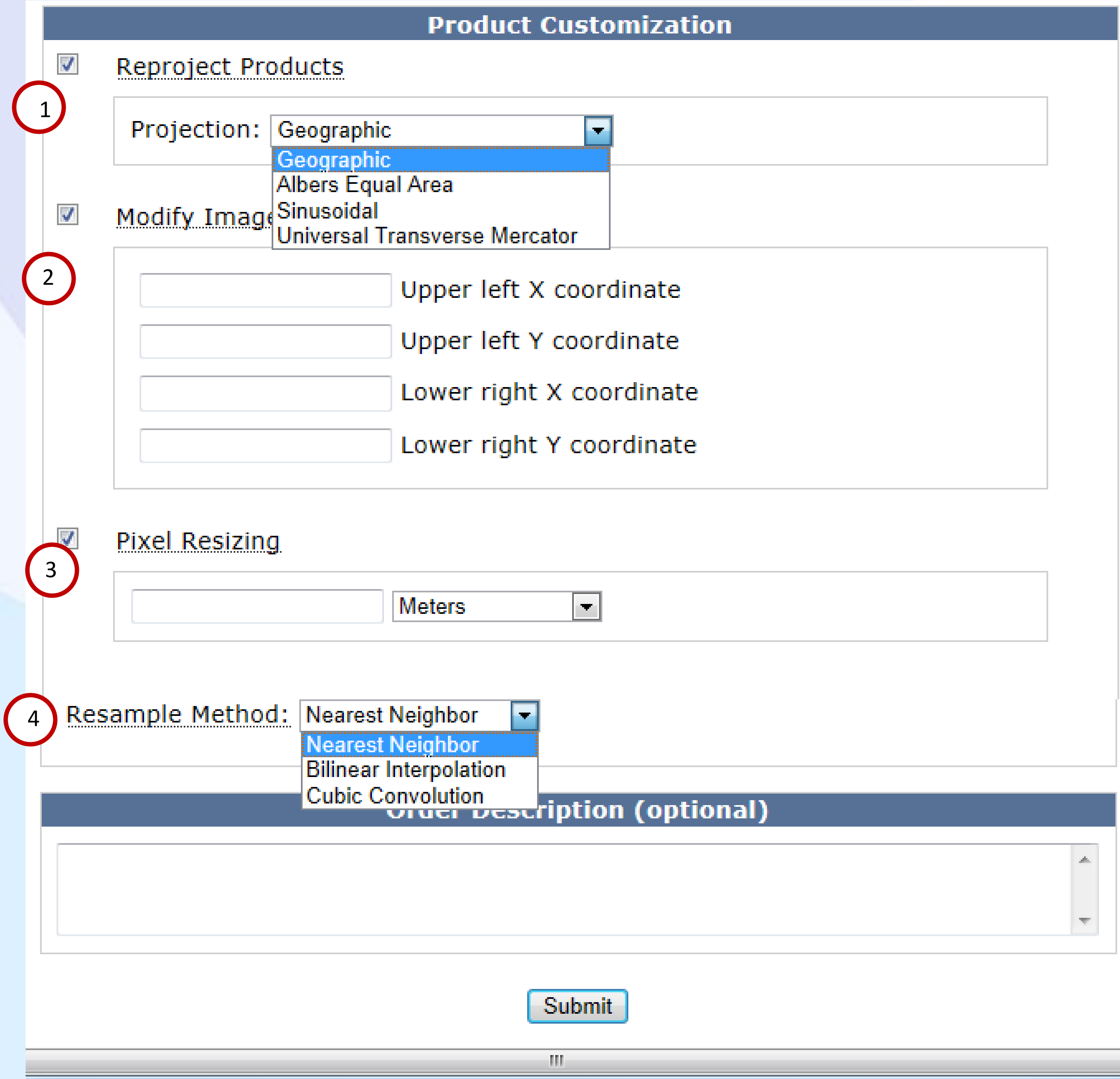
Spectral Indices
☐ Surface Reflectance NDVI
☐ Surface Reflectance NDMI
☐ Surface Reflectance NBR
☐ Surface Reflectance NBR2
☐ Surface Reflectance SAVI
☐ Surface Reflectance EVI

Other Products
☐ CFMask (standalone file)
☐ Solr Index

Product Customization

Enhanced Functionality

1. Auto-registration of data to common map projections for analysis.
2. User defines area of interest for analysis
3. Match pixel size for all images
4. Several resampling options



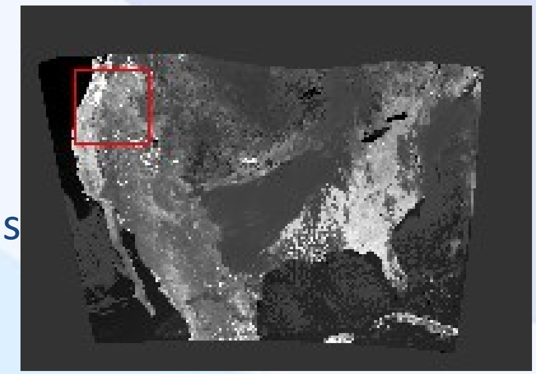
Example of LPCS Functionality

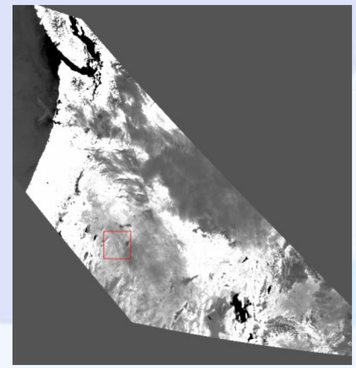
Example of georegistration of simulated ABI, VIIRS and Landsat data.

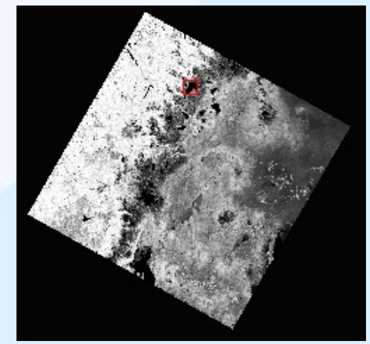
Simulated GOES-R ABI | VIIRS | Landsat

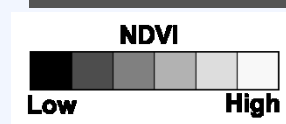
Input Data

Varied Pixel Sizes
Varied Map Projections



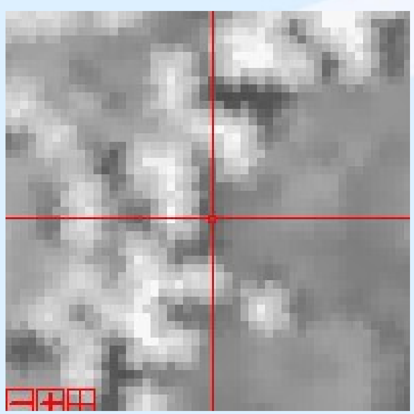


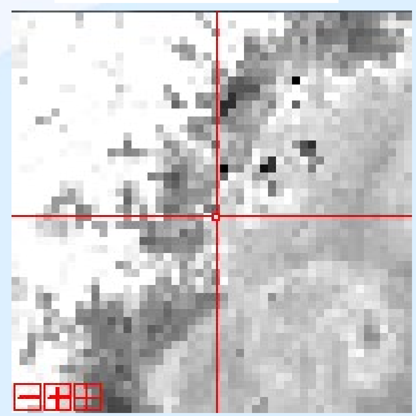


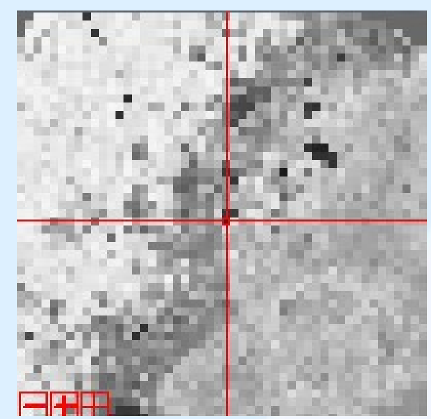


Georegistered Data

Same Pixel Size
Same Map Projection





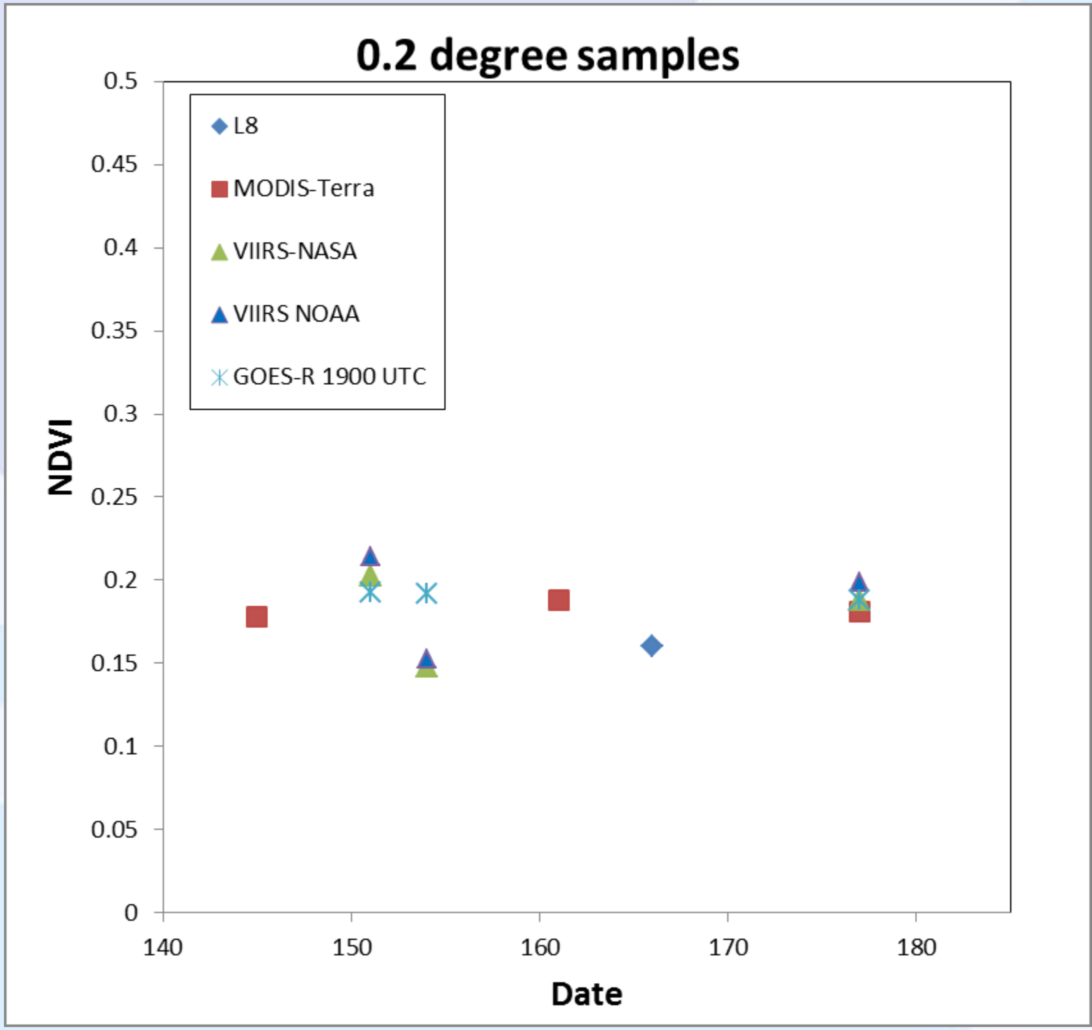


Example of Potential Analysis

Multisensor/multidate comparison for La Junta, CO, CRN station in 2013.

Data included in analysis:

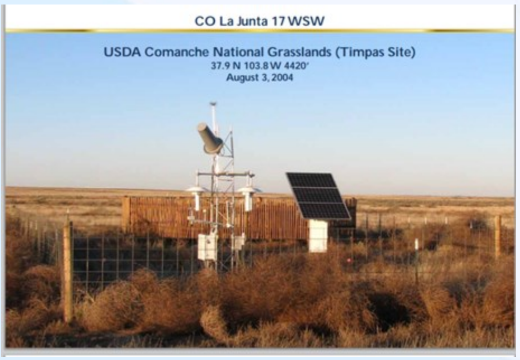
- Landsat 8: TOC NDVI
- NOAA-VIIRS: TOA NDVI
- NASA-VIIRS: TOC NDVI
- MODIS: TOC NDVI
- Simulated GOES-R: TOA NDVI

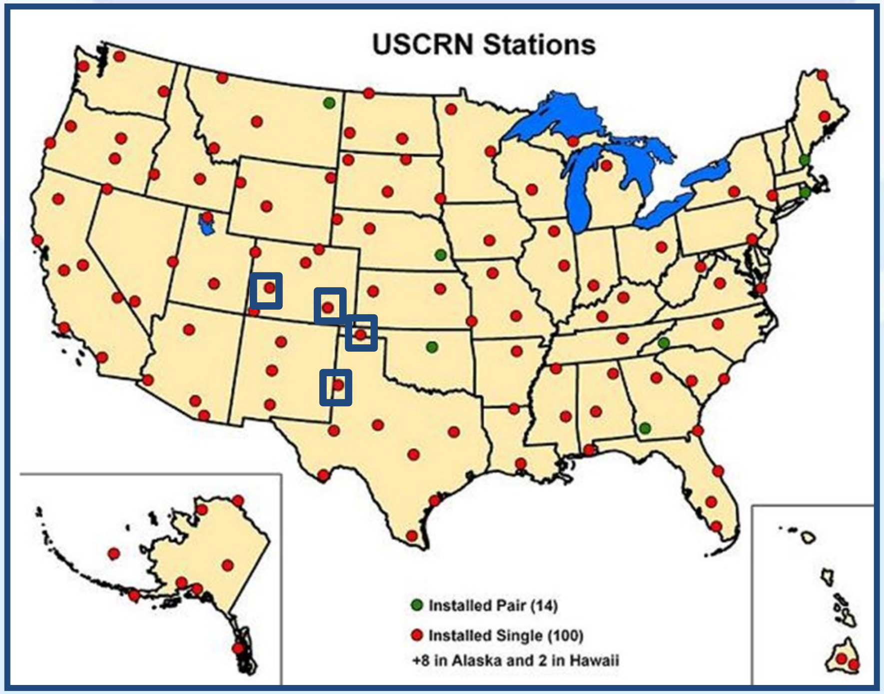


Each point within figures represents 0.2 x 0.2degree sample area.

Example of LPCS Functionality

Data extracted for VIIRS (NOAA and NASA products) and Landsat 8 for four CRN stations located within NASA golden tile (h09v05).

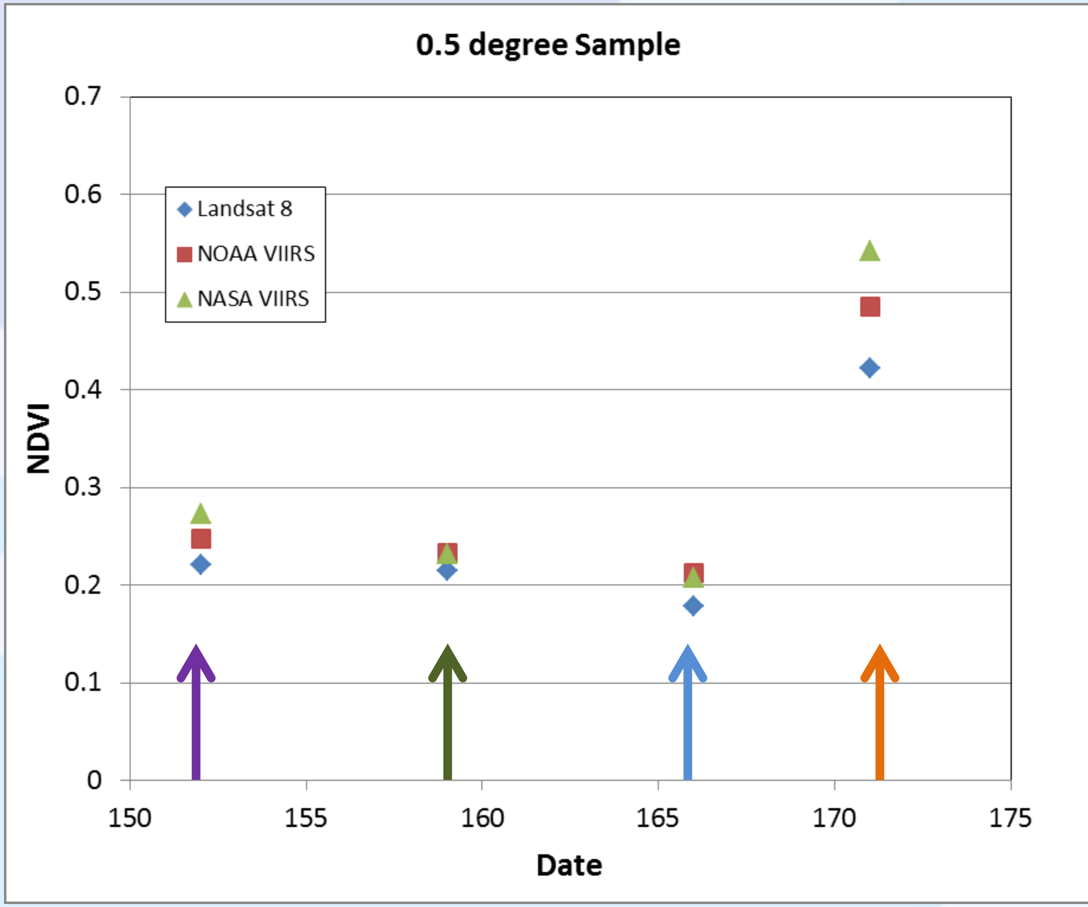




Example of Potential Analysis

Multisensor/multidate comparison for four CRN station locations in 2013.

- **Goodwell, OK, day 152**
- **Muleshoe, TX, day 159**
- **LaJunta, CO, day 166**
- **Montrose, CO day 171**



Data included in analysis:

- Landsat 8: TOA NDVI
- NOAA-VIIRS: TOA NDVI
- NASA-VIIRS: TOC NDVI

Each point within figures represents .5 x .5 degree sample area.

Land Product characterization System (LPCS)

What is LPCS

Why LPCS developed/hosted at EROS

Highlights of LPCS

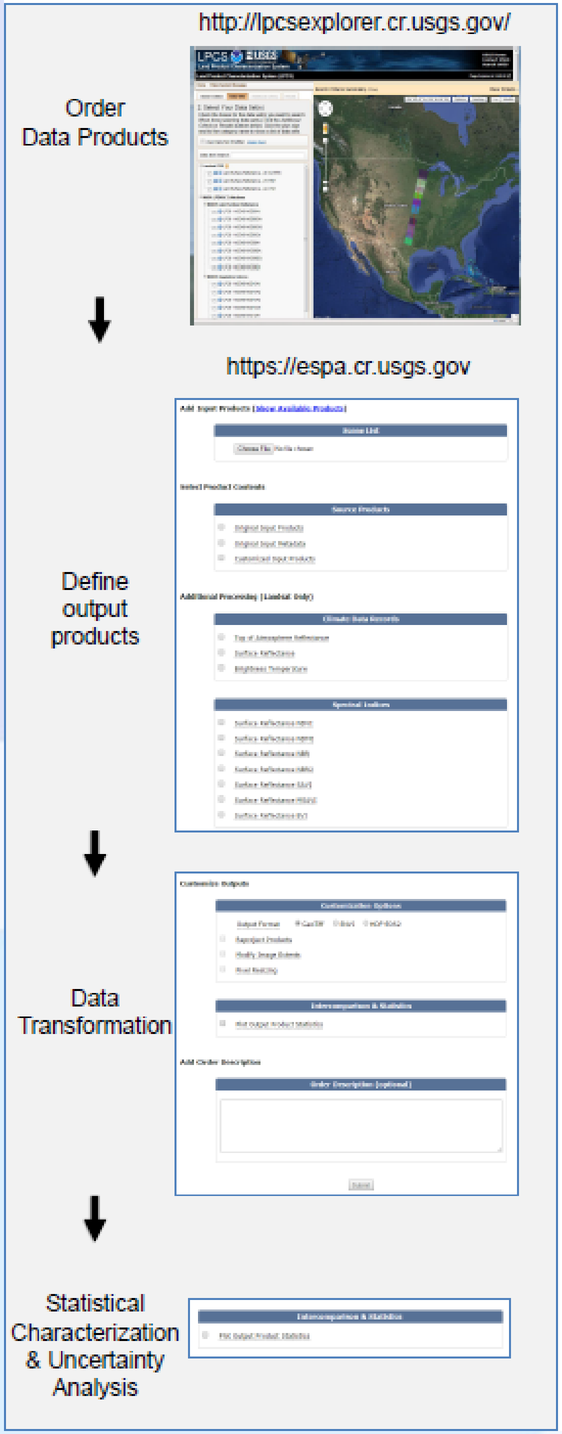
1. Inventory & Ordering
2. Analysis Tools

Path Forward

Summary

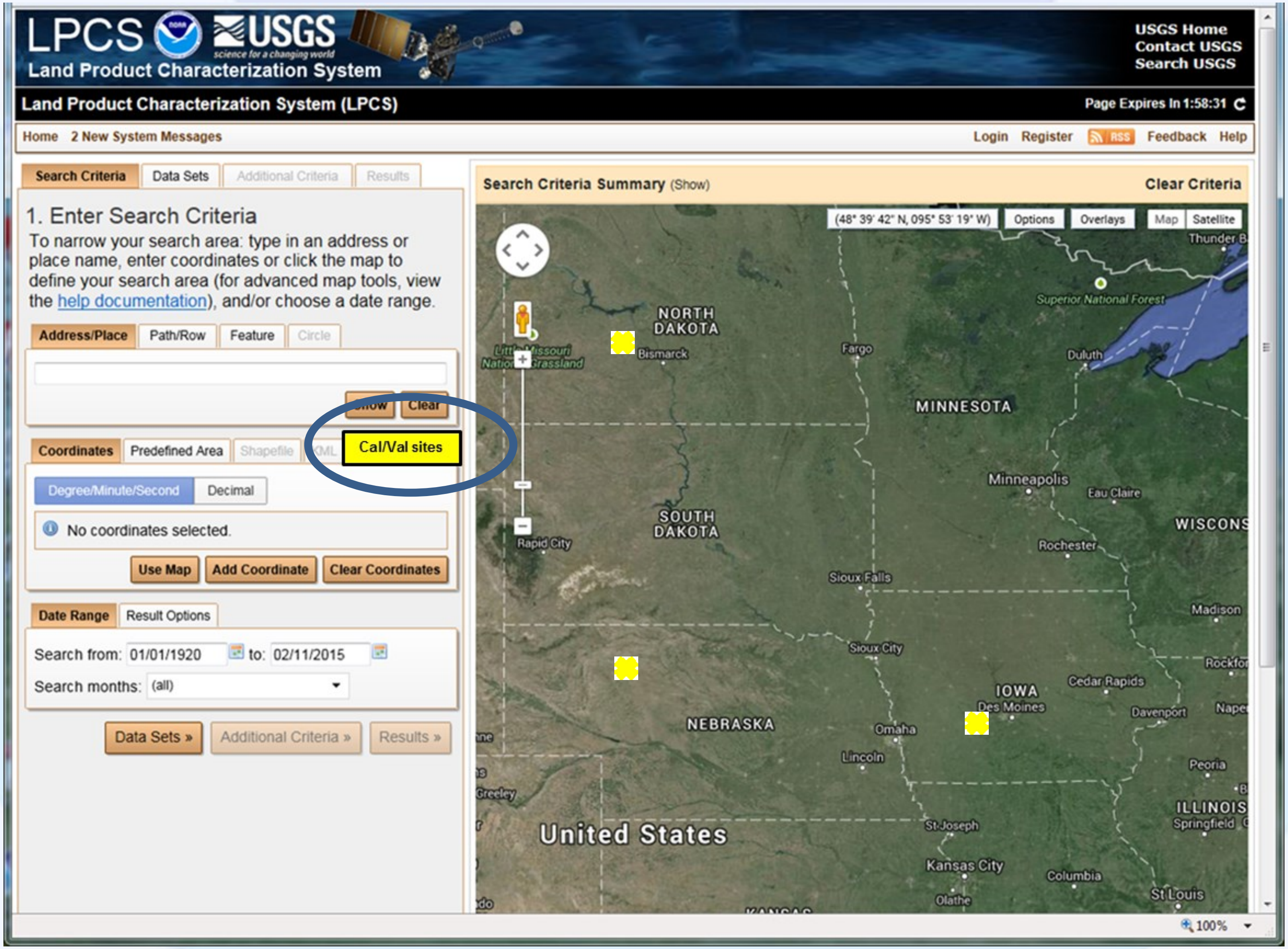
Path Forward

LPCS interface update:
Expected 30 Nov. 2015, one seamless system for LPCS data selection, ordering, and product processing requests.



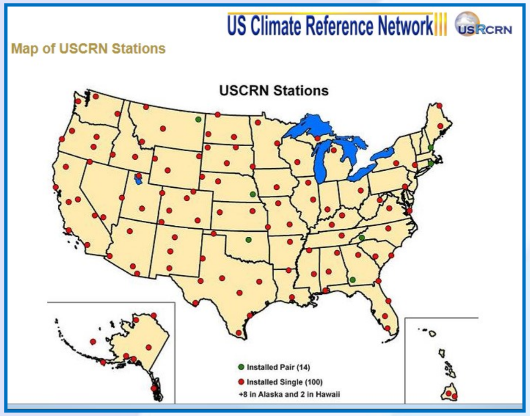
Path Forward

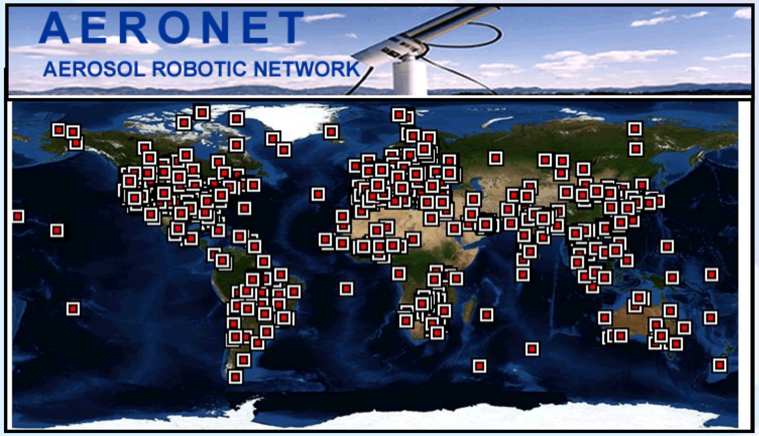
Predefined sample sites: user selectable for satellite (and potential in situ) inter-comparisons

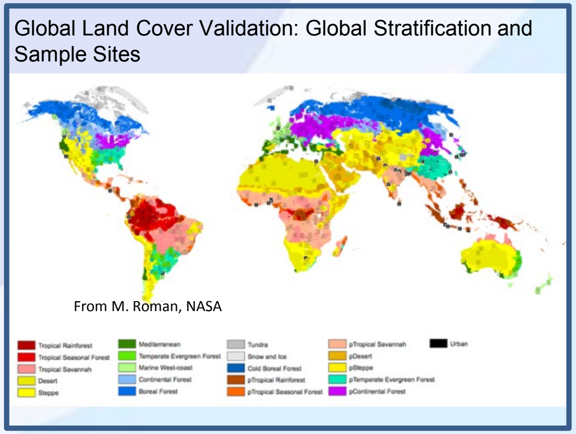


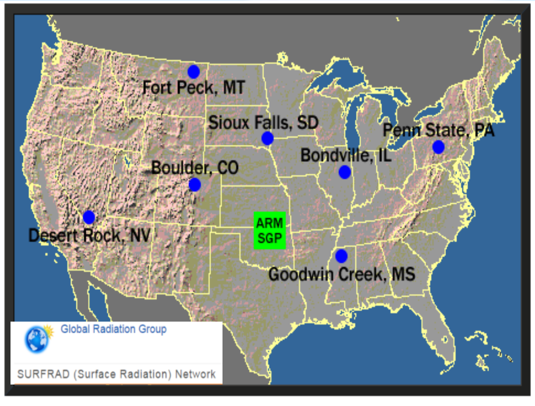
Path Forward

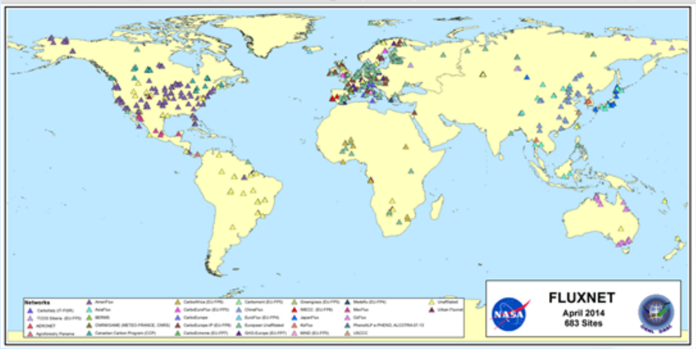
Predefined sample sites: user selectable for satellite (and potential in situ) inter-comparisons





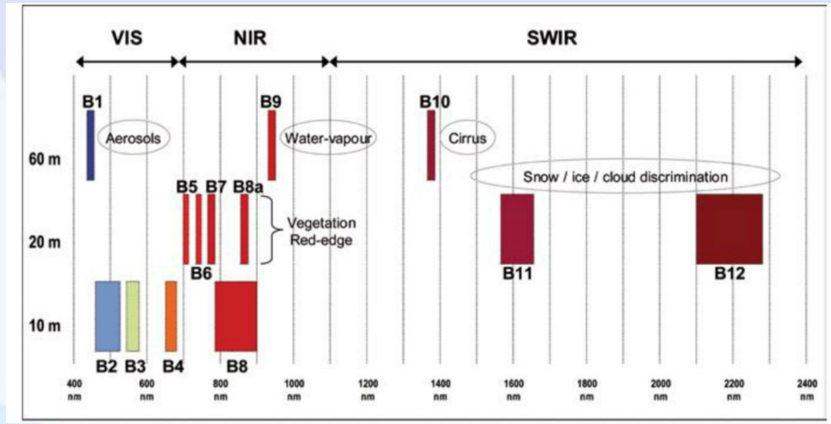






Path Forward

Sentinel-2 and Sentinel-3 data hosted at USGS/EROS



Sentinel-2
13 Bands
4 bands at 10 m resolution
6 bands at 20 m
3 bands at 60 m

Band	λ centre (nm)	Width (nm)	L_{min} ($W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$)	L_{ref} ($W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$)	L_{sat} ($W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$)	SNR @ L_{ref}
Oa1	400	15	21.60	62.95	413.5	2188
Oa2	412.50	10	25.93	74.14	501.3	2061
Oa3	442.50	10	23.96	65.61	466.1	1811
Oa4	490	10	19.78	51.21	483.3	1541
Oa5	510	10	17.45	44.39	449.6	1488
Oa6	560	10	12.73	31.49	524.5	1280
Oa7	620	10	8.86	21.14	397.9	997
Oa8	665	10	7.12	16.38	364.9	883
Oa9	673.75	7.5	6.87	15.70	443.1	707
Oa10	681.25	7.5	6.65	15.11	350.3	745
Oa11	708.75	10	5.66	12.73	332.4	785
Oa12	753.75	75	4.70	10.33	377.7	605
Oa13	761.25	2.5	2.53	6.09	369.5	232
Oa14	764.375	3.75	3.00	7.13	373.4	305
Oa15	767.50	2.5	3.27	7.58	250.0	330
Oa16	778.75	15	4.22	9.18	277.5	812
Oa17	865	20	2.88	6.17	229.5	666
Oa18	885	10	2.80	6.00	281.0	395
Oa19	900	10	2.05	4.73	237.6	308
Oa20	940	20	0.94	2.39	171.7	203
Oa21	1020	40	1.81	3.86	163.7	152

Ocean Land Color Instrument
21 Bands
300 m spatial resolution

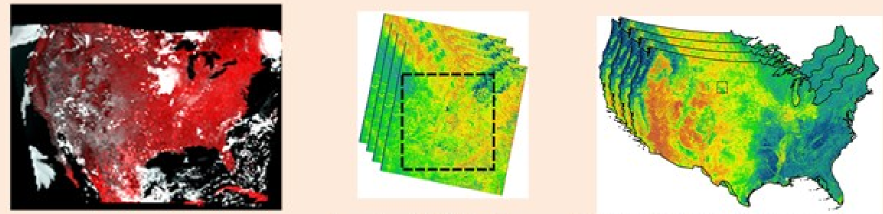
Land Product characterization System (LPCS)

What is LPCS
Why LPCS developed/hosted at EROS
Highlights of LPCS
1. Inventory & Ordering
2. Analysis Tools
Path Forward
Summary

Land Product Characterization System

A web-based system designed to use moderate to high-resolution satellite data for characterization, and assist with validation, of GOES-R ABI and JPSS VIIRS products.

Input Products in Native Projections

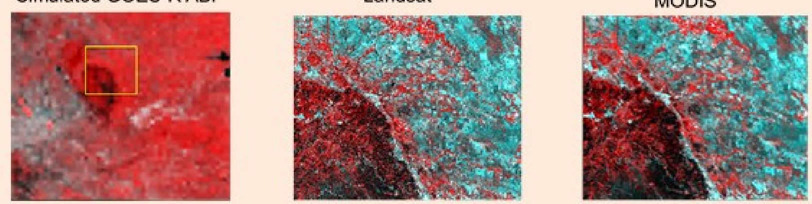


Simulated GOES-R ABI (Univ. Wisc./CIMMS)

Landsat ETM+ (7), Landsat OLI/TIRS (8)

MODIS MOD/MYD09 (Surface Refl.) MODIS MOD/MYD13 (NDVI & EVI)

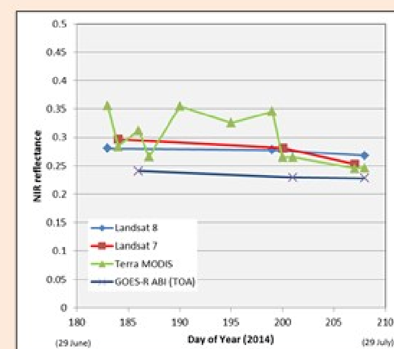
Geographically Registered Output Products



Tables and Charts of Individual Bands or Indices

	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							

Mean, minimum, maximum, standard deviation



Near-IR time series inter-comparisons

JPSS EDR

Long Term Monitoring & Product Repository

Lori K. Brown
JPSS-LTM Web Development Lead
Tom Atkins, Frank Tilley, Charlie Brown, Xingpin Liu, Lihang Zhou

Presented at the 2015 STAR JPSS Science Meeting

NOAA Center for Weather and Climate Prediction
College Park, MD
25 August 2015

JPSS EDR Product Repository Early Discussions

- At meetings in Fall 2014, the idea to develop a STAR JPSS program wide repository to house and share JPSS EDR product images was suggested.

- At this point, STAR ICVS had been implemented for 2 years; it seemed an ideal web interface and browsing framework for daily product information.

ICVS as an EDR Repository Platform

- Advantages of ICVS as interface for presenting EDR content:
  - Constructed and organized for browsing content that is updated daily;
  - Easy to update and edit;
  - Extensible to additional products without additional web programming;
  - Familiar to many of the prospective user groups;
  - Compliant with Section 508 and other government directives regarding web presentation and architecture;
  - Thoroughly tested and reliable across all modern browsers;
  - Interface can accommodate different content types: images, maps, charts, text, zip files, and eventually vector-based charts;
  - No surprises!

Prototype Now Online with 7 Product Groups

- Spring 2015 initiated prototyping;
- Contacted first product groups to start developing and acquiring images;
- Prototype currently houses product images from the following teams as of 8/24/2015:

Product Team	Product Images Daily	Product Dates Available	Production Stream
Soundings	598	1/1/2015 to present	automated
Land Surface Temperature	3	1/1/2015 to present	automated
Albedo	1	1/1/2015 to present	automated
Vegetation Index	3	6/20/2015 to present	automated
Active Fires	1	1/1/2015 to present	batch
Ozone	3	1/1/2015 to 7/15/2015	batch
Surface Type	4	5/1/2015 to present	automated

JPSS EDR Product Monitoring Demo

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

- Key features:
  - Navigate by product;
  - Navigate through products by date;
  - 'About' popup;
  - Animation:
    - Across all metrics in each product group;
    - **NEW!** Animate a selected timespan for a single product;

EDRs Are Not Quite the Same as Cal/Val Metrics

- Heavy on the maps; less emphasis on other types of 'charts'.
- Lower volume of images in most cases;

- So, we have made a few key updates to the ICVS interface to better support EDRs' presentational needs:
  - New Animation of a single product across a user-configurable time span (***Coming soon: download the animation file***)
  - Stricter standardization of product layout, typography, labelling, and underlying map conventions
    - The less variation in presentation, the more what users will see and focus on is the data being presented.
  - Goal: developing a shareable piece of code to generate product maps for all product teams who generate in IDL;
    - *Your mileage may vary – not all ways of producing data work well with all IDL mapping commands.*

JPSS EDR Site vs. Team Sites

- Producing content for the JPSS EDR site doesn't change what you do or don't produce for your own team or product area websites.

- There may or may not be content overlap between the JPSS EDR site and other sites;

- The goal of the EDR Repository is ONE STOP SHOPPING; a little redundancy is no cause for concern.

Steps to Produce & Publish EDR Products - 1

- Product Teams: figure out what you want to include on your page. Suitable content may include:
  - EDR deliverable products (at a minimum, we need these for the site);
  - Comparison products from other satellite instruments;
  - Quality measure charts, like NEΔN.
  - Usually images (.jpg, .gif, .png, but can also include .txt, .zip)
  - Please note: content for the page is ideally content that is refreshed daily.
    - Land Surface Temperature for Global Surface – 8/22/2015 – **YES**!
    - 10 day composite of anything – probably not.

- Meet with JPSS EDR to go over style guide, layout of maps, formatting preferences;
- Product Team develops a 'test set' of product images, JPSS EDR team reviews, revises, and approves.

Steps to Produce & Publish EDR Products - 2

- JPSS EDR team:
  - Establishes a directory structure on the webserver to house Team's products;
  - Develops the CSV file that lists product file descriptions and locations;
  - Add the new Product page;
  - To add or remove content, we edit the CSV file to reflect additions / changes / deletions from the product set.

- Product Teams
  - Run charts as far back as you can (we are aiming for EDRs back to Jan. 1, 2015), and write them to the specified location on STAR webserver;
  - Set the product generation script on a cron job;
  - No website to maintain, no HTML to write, just generate your products

Next Steps To Complete The EDR Repository

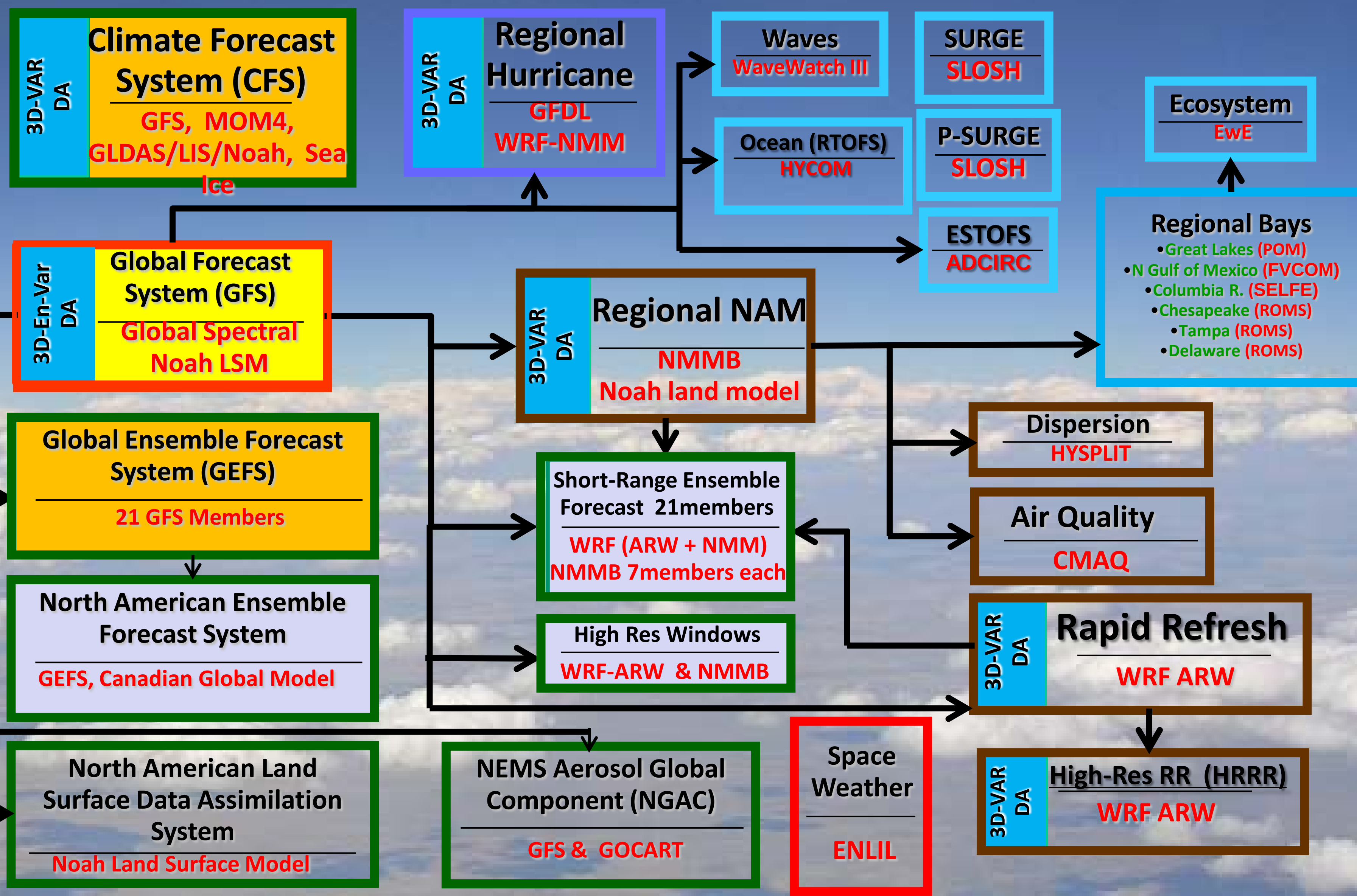
- Reach out to remaining product teams to start generating products;
- Work with existing teams to refine and improve product presentation, standardization, re-usable IDL script block;
- Integrate new features like new single product animation back into the STAR ICVS.

NCEP Operational Use of Satellite Land Products

Michael Ek and the EMC Land-Hydrology Team
Environmental Modeling Center (EMC)
National Centers for Environmental Prediction (NCEP)
NOAA/NWS

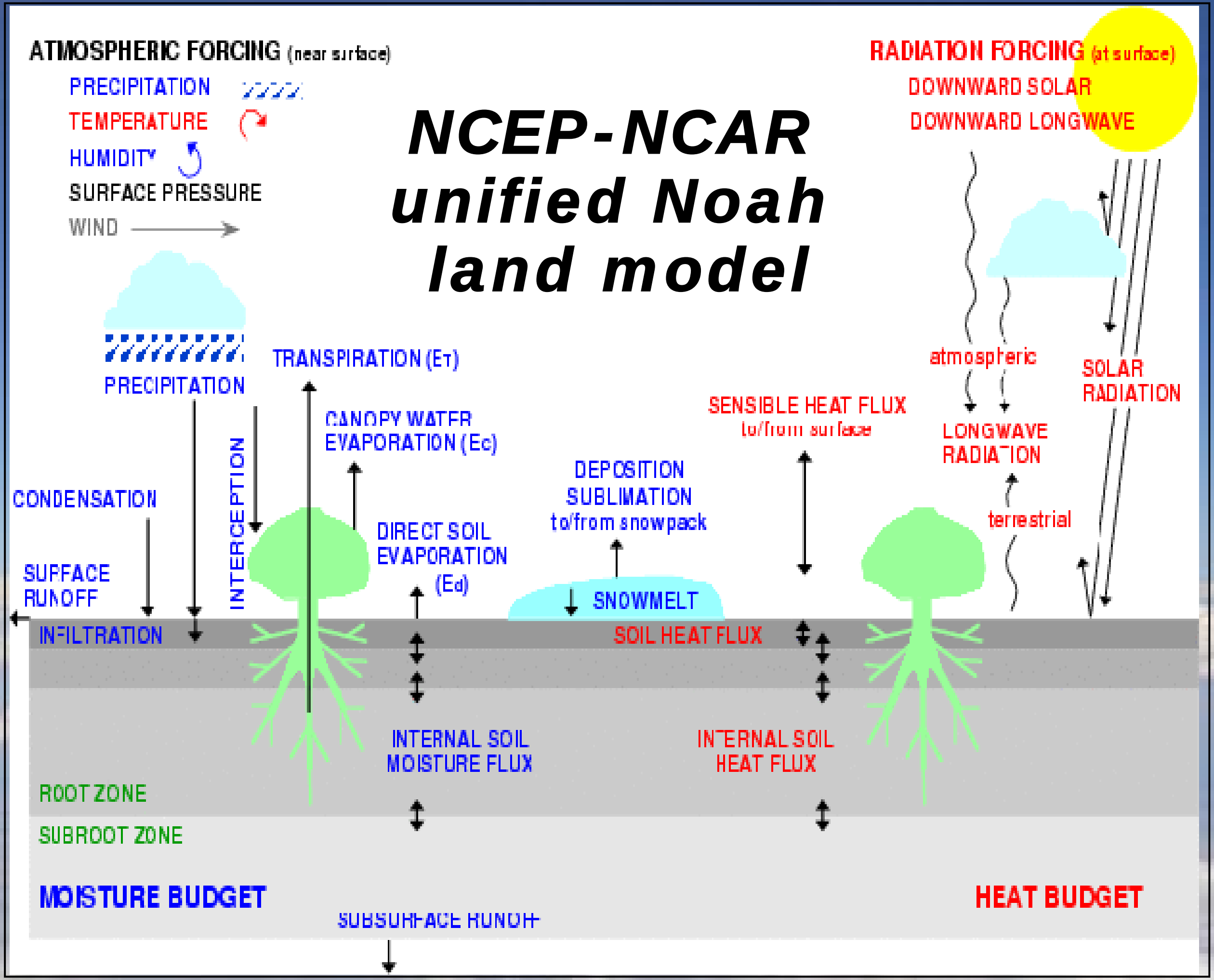
STAR JPSS Annual Meeting – 24-28 August 2015
NCWCP, College Park, Maryland

NOAA's Operational Numerical Guidance Suite (Feb 2015)



Role of Land-Surface Models

- Close surface energy & water budgets,
- Determine **heat**, **moisture**, and **momentum** exchange between surface & atmosphere,



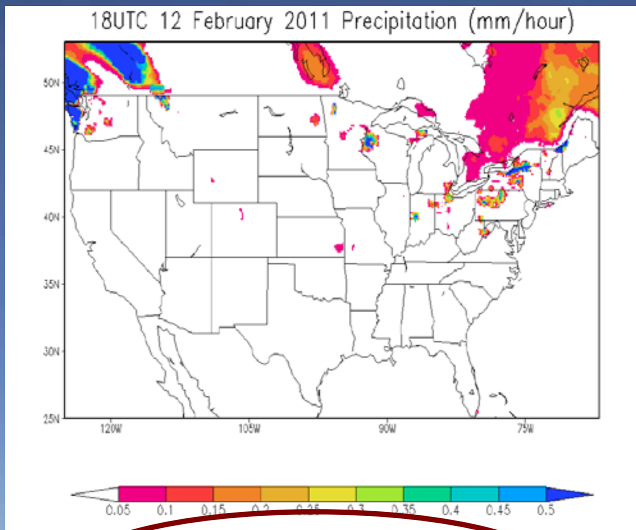
- Noah land model then provides surface boundary conditions to parent atmospheric model, e.g. meso-NAM, medium-range GFS, seasonal CFS.

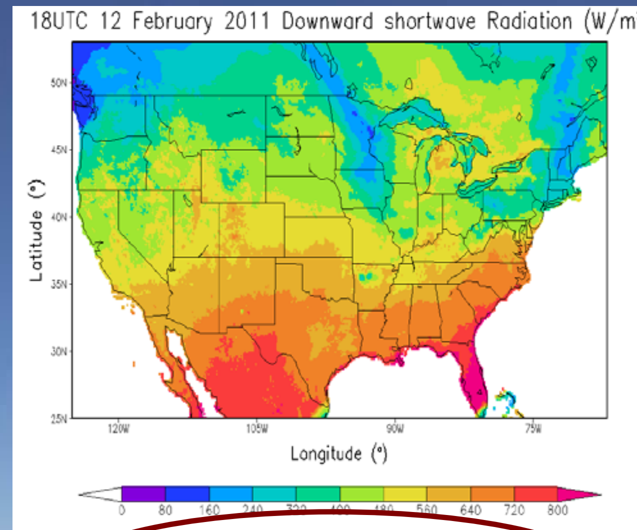
Land Model Requirements

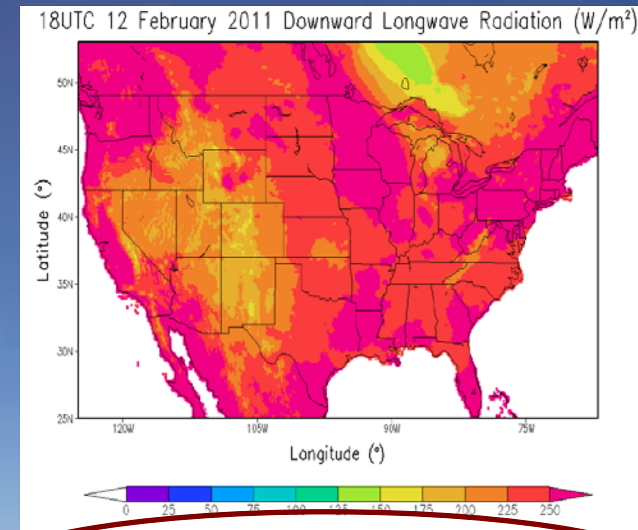
To provide these proper boundary conditions, land model must have:

- **Atmospheric forcing** to drive land model, such as *precipitation and incoming solar radiation*.
- Appropriate **physics** to represent land processes,
- Proper **initial land states**, such *as snow & soil moisture* (analogous to initial atmospheric conditions, though land states may carry more “memory”, especially deep soil moisture, similar to ocean SSTs),
- **Land data sets** e.g. *land use/land cover (vegetation type), green vegetation fraction (GVF), leaf-area-index (LAI), soil type, surface albedo & emissivity*, & associated parameters, e.g. surface roughness, soil and vegetation properties.

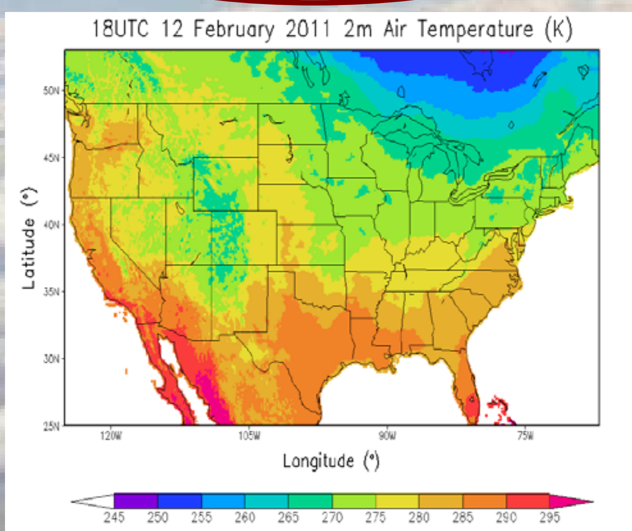
Atmospheric Forcing to Land Model

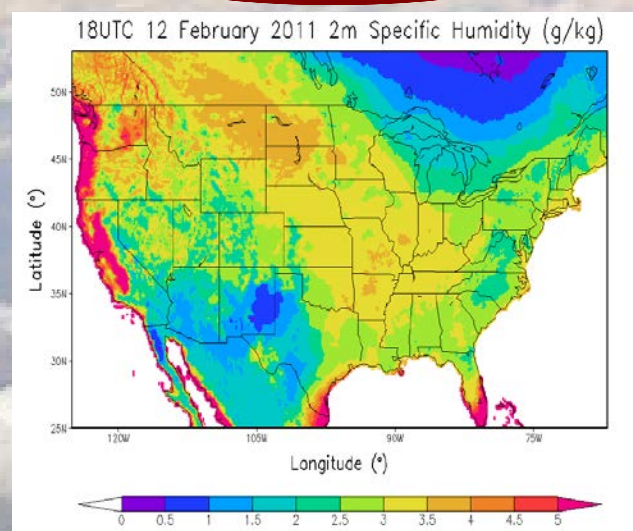


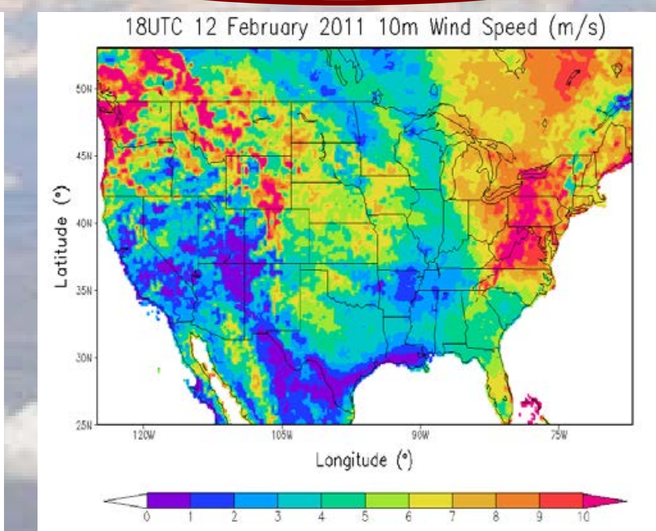




Precipitation **Incoming solar** **Incoming Longwave**





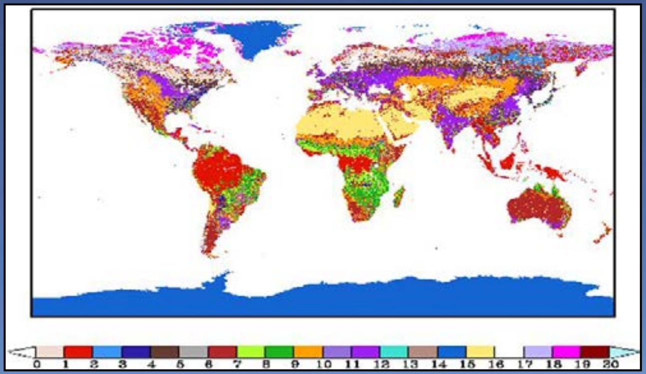


Air temperature **Specific humidity** **Wind speed**

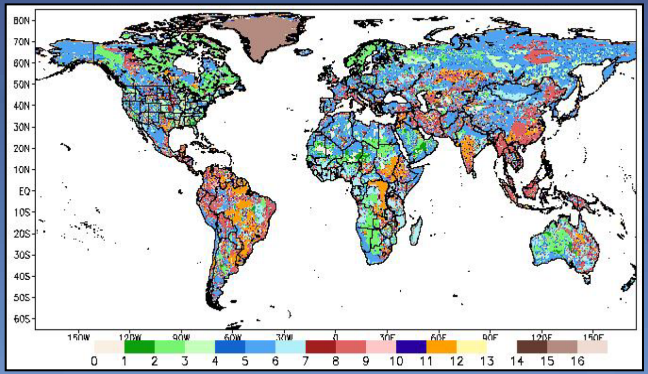
+ Atmospheric Pressure

Example from 18 UTC, 12 Feb 2011

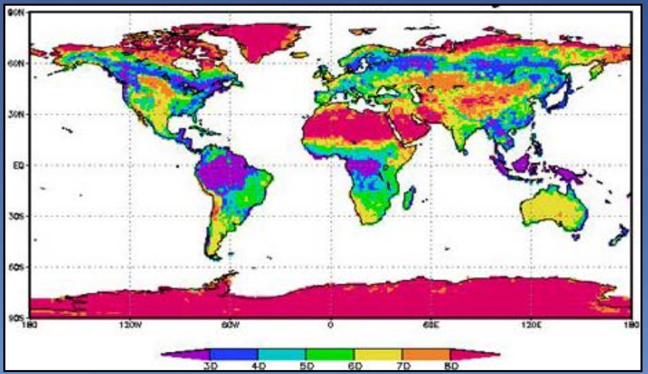
Land Data Sets



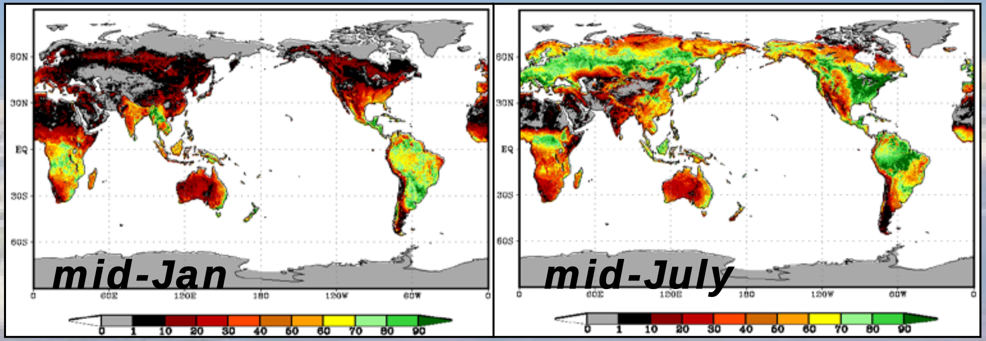
Land-Use Type
(1-km, IGBP-MODIS)



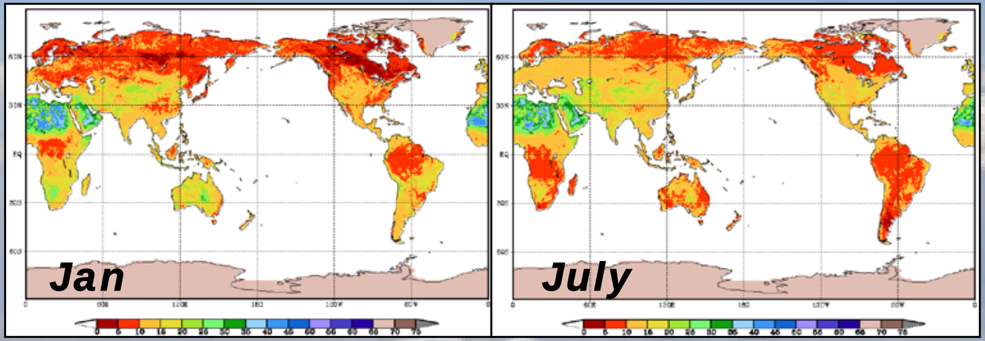
Soil Type
(1-km, STATSGO-FAO)



Max.-Snow Albedo
(1-km, UAz-MODIS)



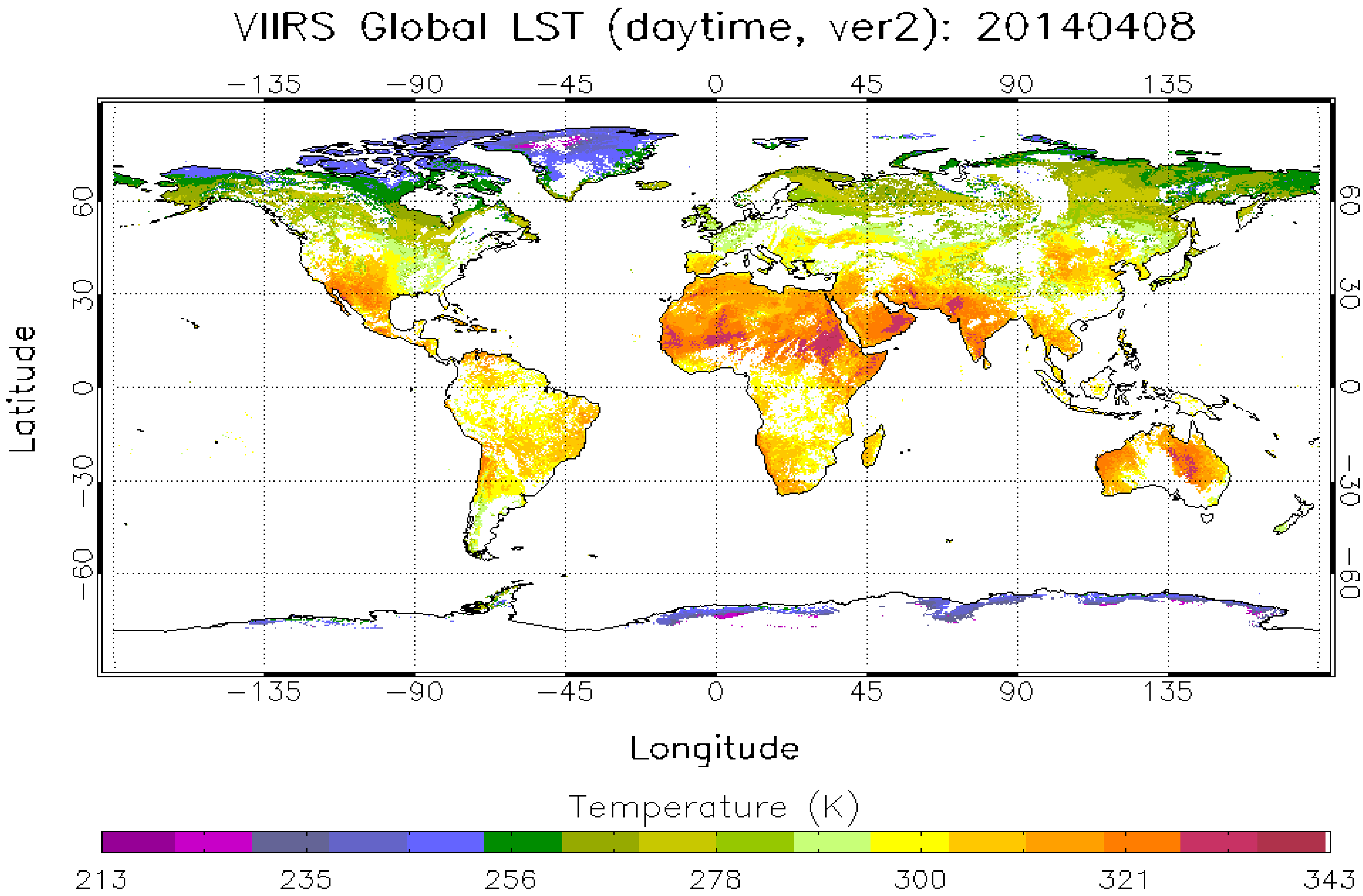
Green Vegetation Fraction
(weekly, 1/8-deg,
new NESDIS/AVHRR)



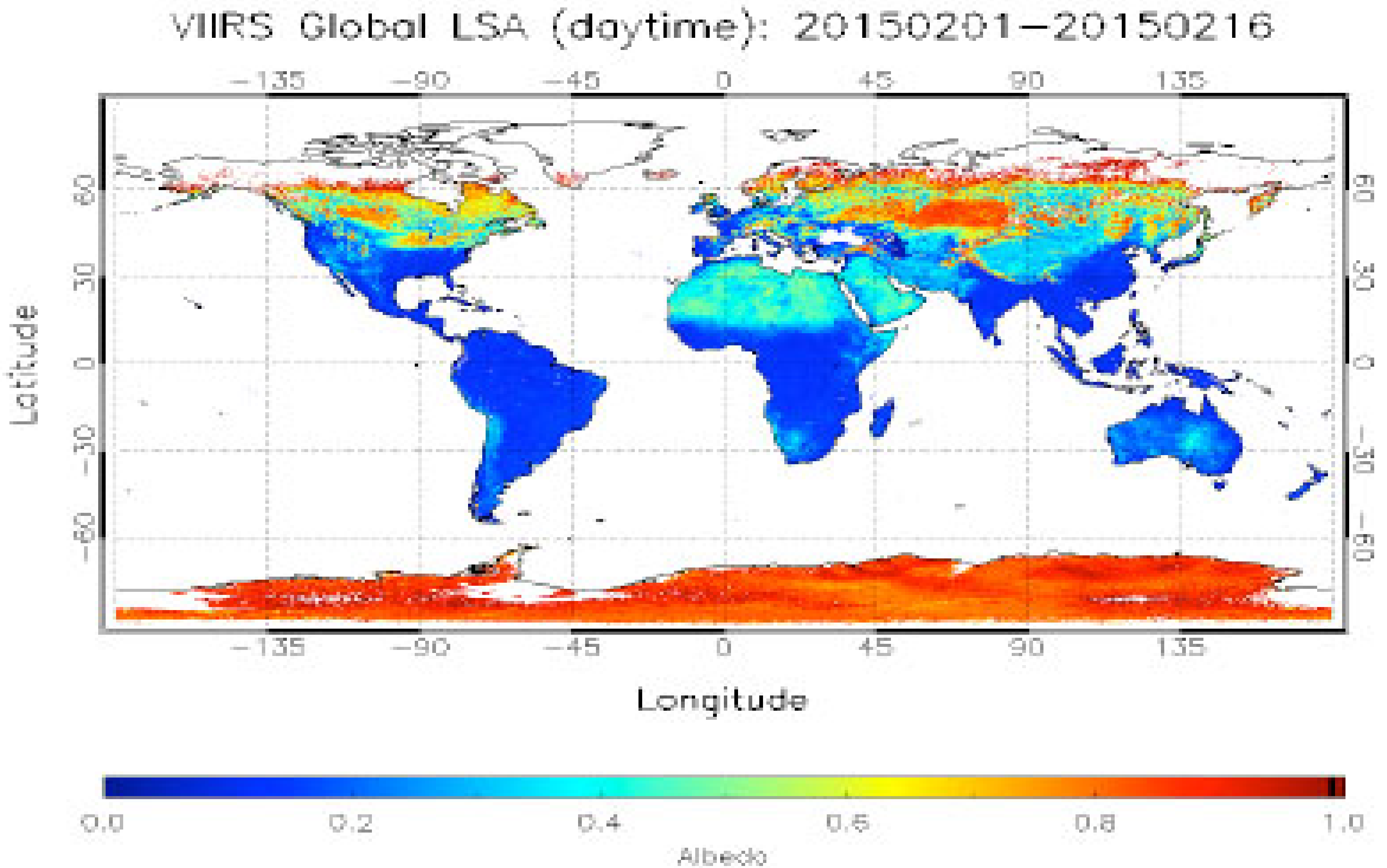
Snow-Free Albedo
(monthly, 1-km,
BU-MODIS)

- Fixed annual/monthly/weekly climatology, or near real-time observations; some quantities may be assimilated (e.g. soil moist., snow) into Noah.

Land Data Set: VIIRS Land Surface Temperature Used in NAM and GFS validation

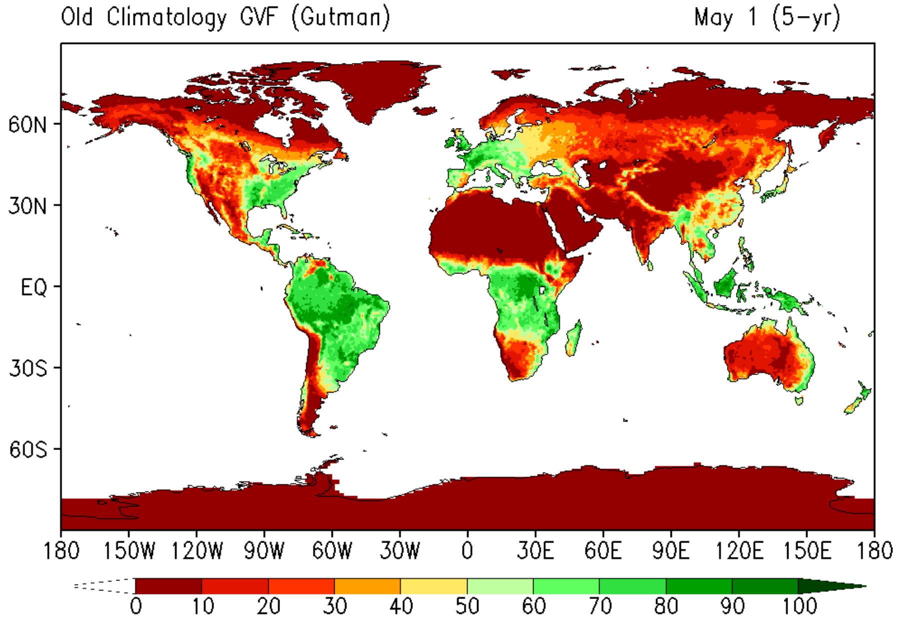


Land Data Set: VIIRS Land Surface Albdeo. Replace Albedo climatologies?

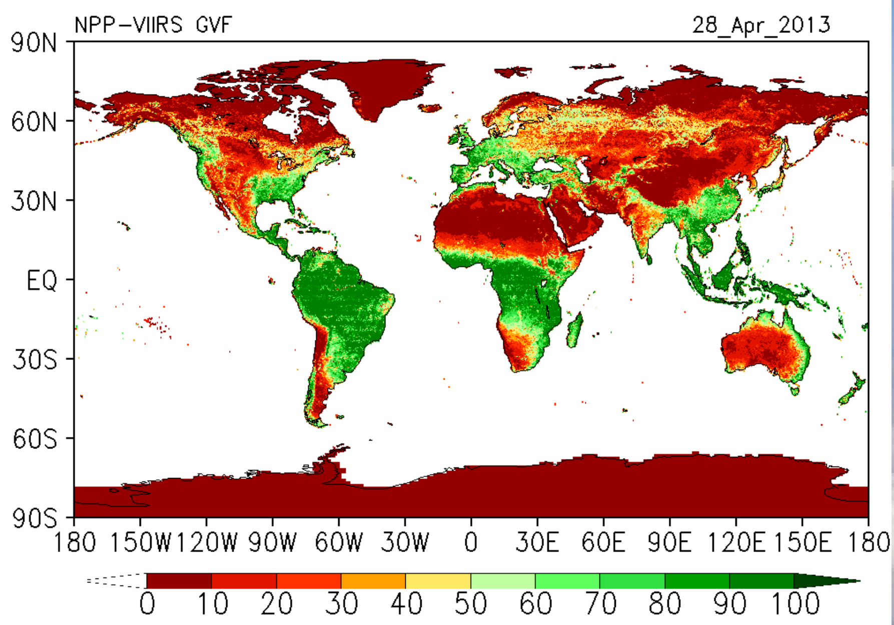


Green Vegetation Fraction

- **Climatology vs. near real-time GVF**
- **Ingested into NCEP models** where near real-time GVF leads to better partition between surface heating & evaporation --> impacts surface energy budget, PBL evolution, clouds & convection.



AVHRR 5-year Climatology

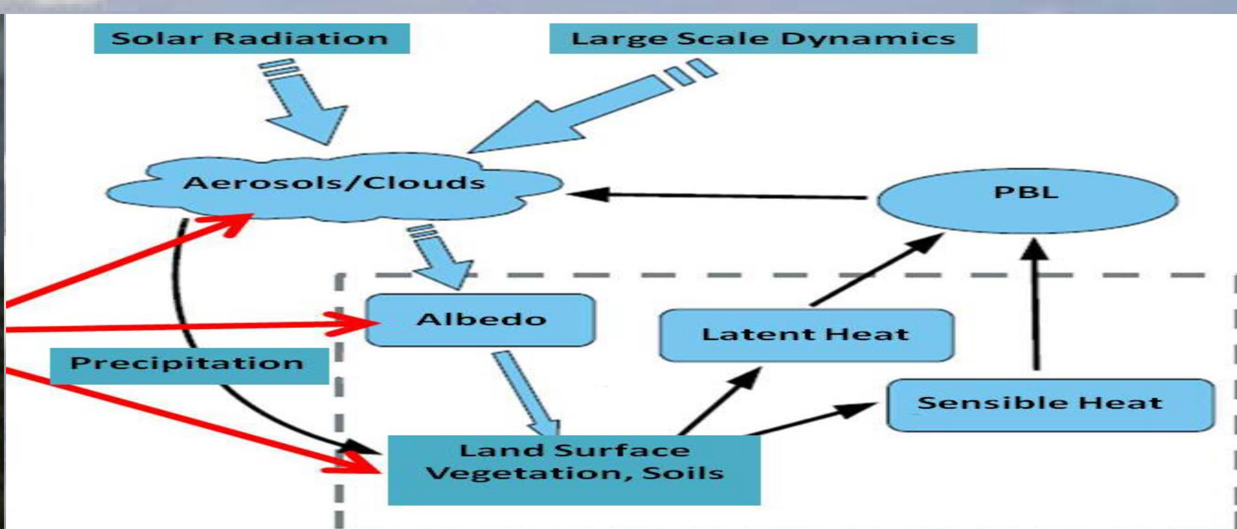


Near-realtime VIIRS

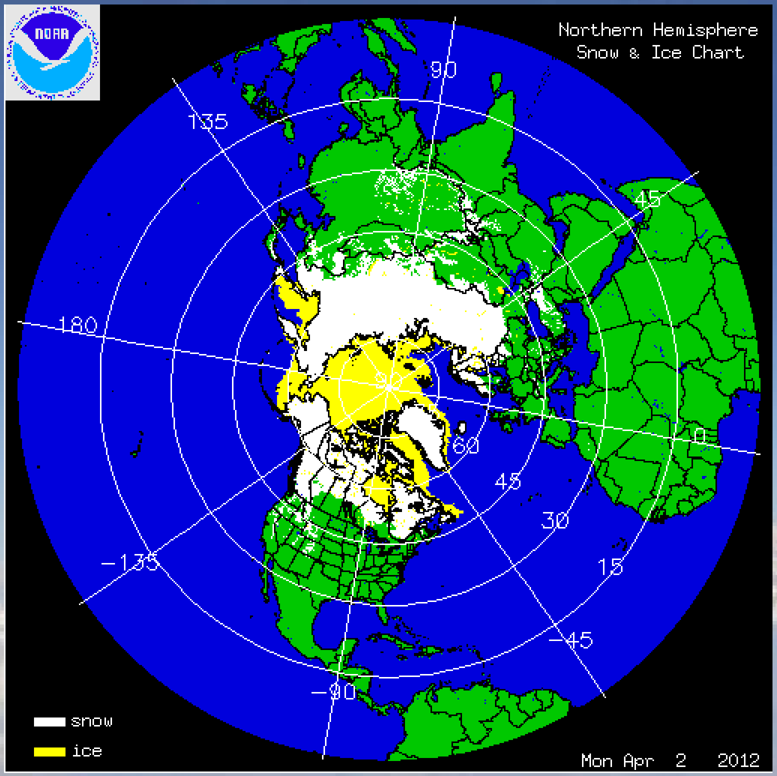
- Note: *VIIRS GVF in Midwestern US much lower than AVHRR GVF Climatology.*

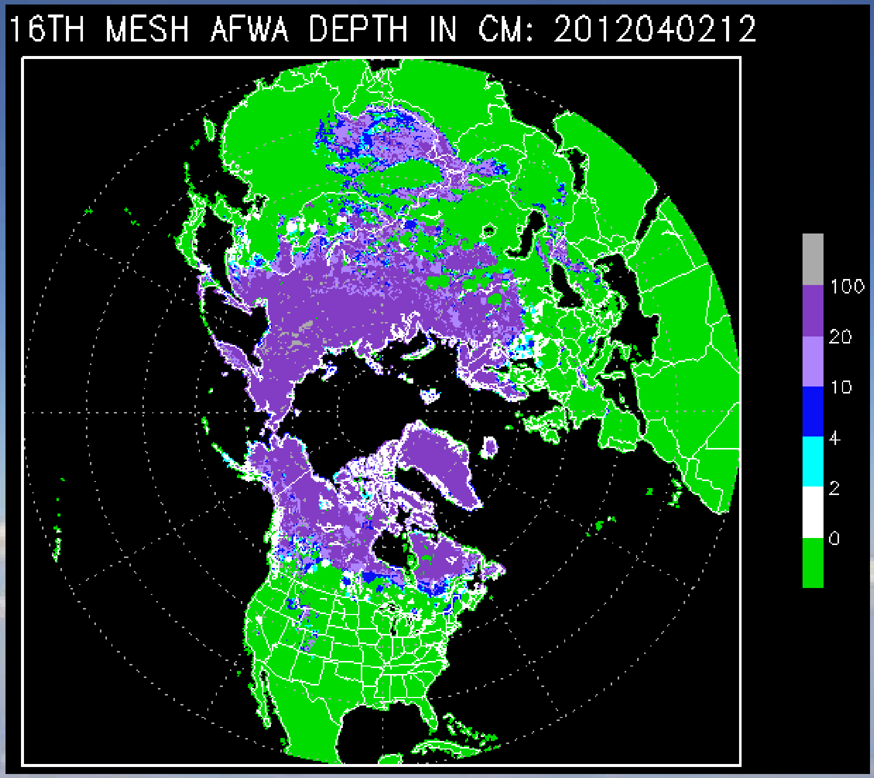
Wildfire Effects

- **Wildfires affect weather/climate systems**: (1) atmospheric circulations, (2) aerosols and clouds, (3) **land surface states** (GVF. albedo & surface temperature, etc.) --> impact on sfc energy budget, ABL, clouds & convection.
- **Surface Reflectance** used to derive **Burned Area Product** (NESDIS/STAR).
- **Two** fire burned area **products**:
  - 1 km resolution, 2x/day, 20N-70N
  - 12 km resolution, 4x/day, Equator-NP
- **Ingested into mesoscale NAM**, adjustments surface characteristics:
  - reduced: albedo, GVF, roughness, soil moisture
  - increase: surface & soil temperatures
- **Future**: consistency with remotely-sensed near-real time GVF/LAI, albedo, soil moisture, LST, etc.



Land Data Sets: *Daily Snow Products*





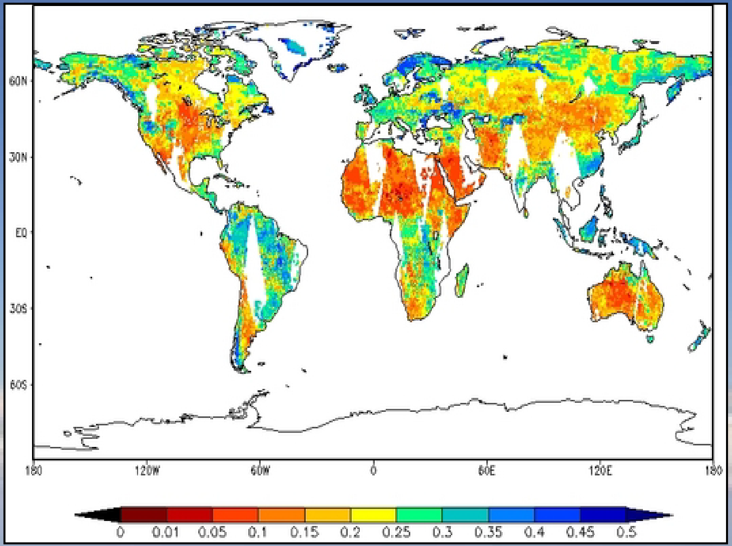
4-km *02 April 2012* ***24-km***

Snow Cover
(daily integrated
NIC IMS product)

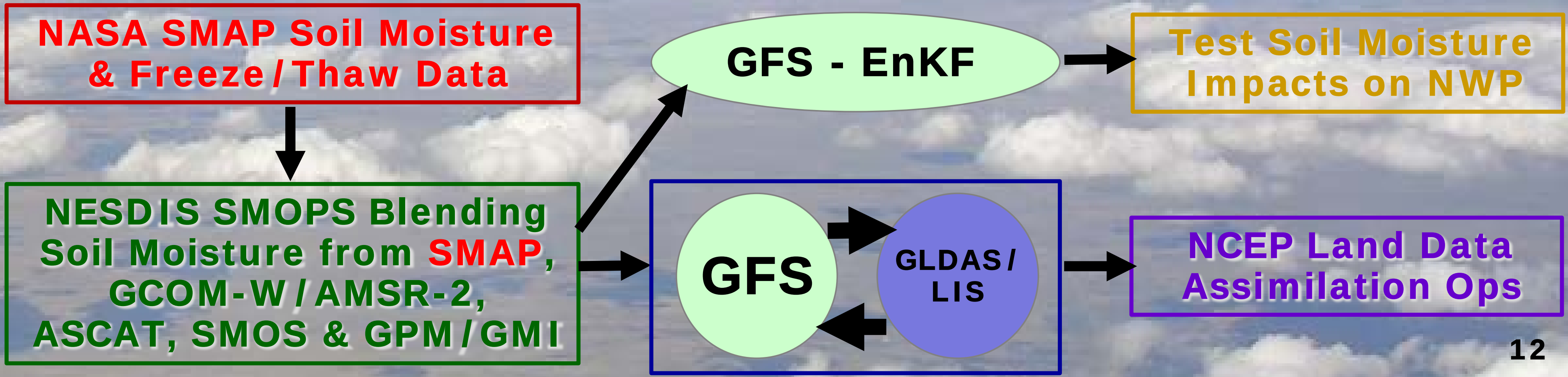
Snow Depth
(daily integrated
AFWA product)

Applications of NASA SMAP Data

- Two NOAA SMAP Early Adopters will ingest and assimilation SMAP soil moisture and freeze/thaw data products to improve forecasts of daily rainfall, air temperature, humidity, root-zone soil moisture, skin temperature, runoff and in turn drought and river floods.
- NESDIS will ingest SMAP data through Soil Moisture Operational Product System (SMOPS) into NWS-NCEP models.
- NWS-NCEP has tested a GFS-EnKF coupled system to test impact of assimilating satellite soil moisture data in GFS forecasts.
- NWS-NCEP and NESDIS-STAR will collaborate on the development of a GFS-GLDAS/LIS semi-coupled system for operational land data assimilation.



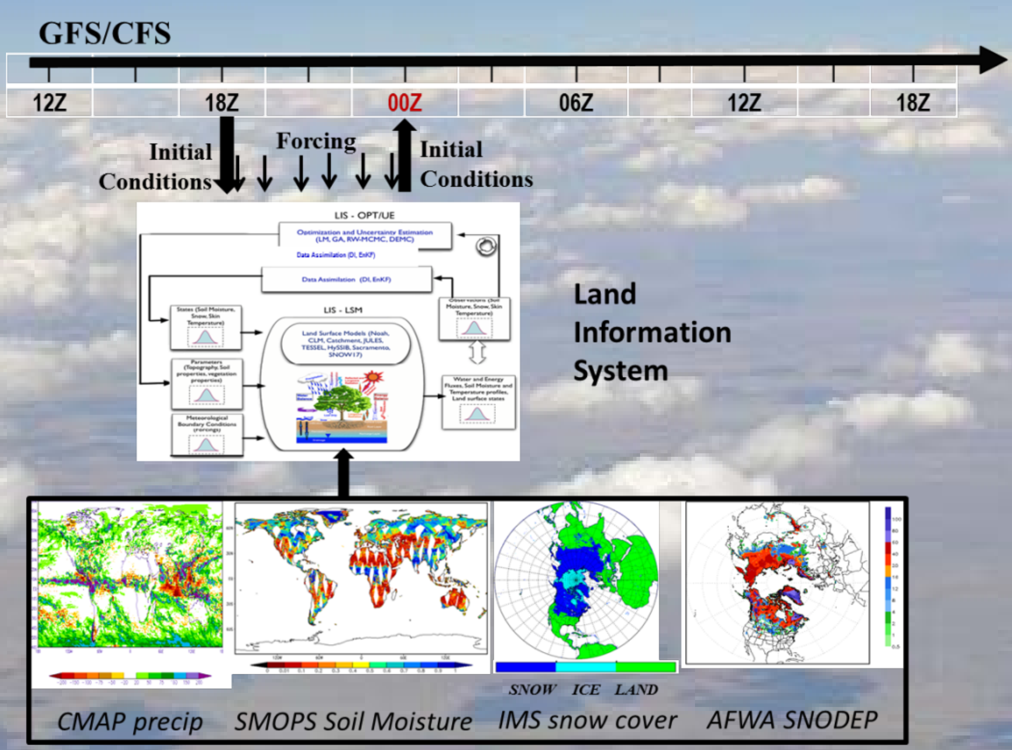
NOAA SMOPS Blended Soil Moisture: Daily - 20140304



Satellite-based Land Data Assimilation Tests in NWS GFS/CFS Operational Systems

NWS NGGPS PI: Michael Ek (NOAA/NCEP/EMC)
Co-Is: Jiarui Dong and Weizhong Zheng (IMSG at NOAA/NCEP/EMC)
Christa Peters-Lidard (NASA/GSFC) and Grey Nearing (SAIC at NASA/GSFC)

- Enable the existing NASA Land Information System (LIS) to serve as a global Land Data Assimilation System (LDAS) for both GFS and CFS.
- LIS integrates NOAA/NCEP operational land surface model (Noah), high-resolution satellite & observational data, and land data assimilation (DA) tools.



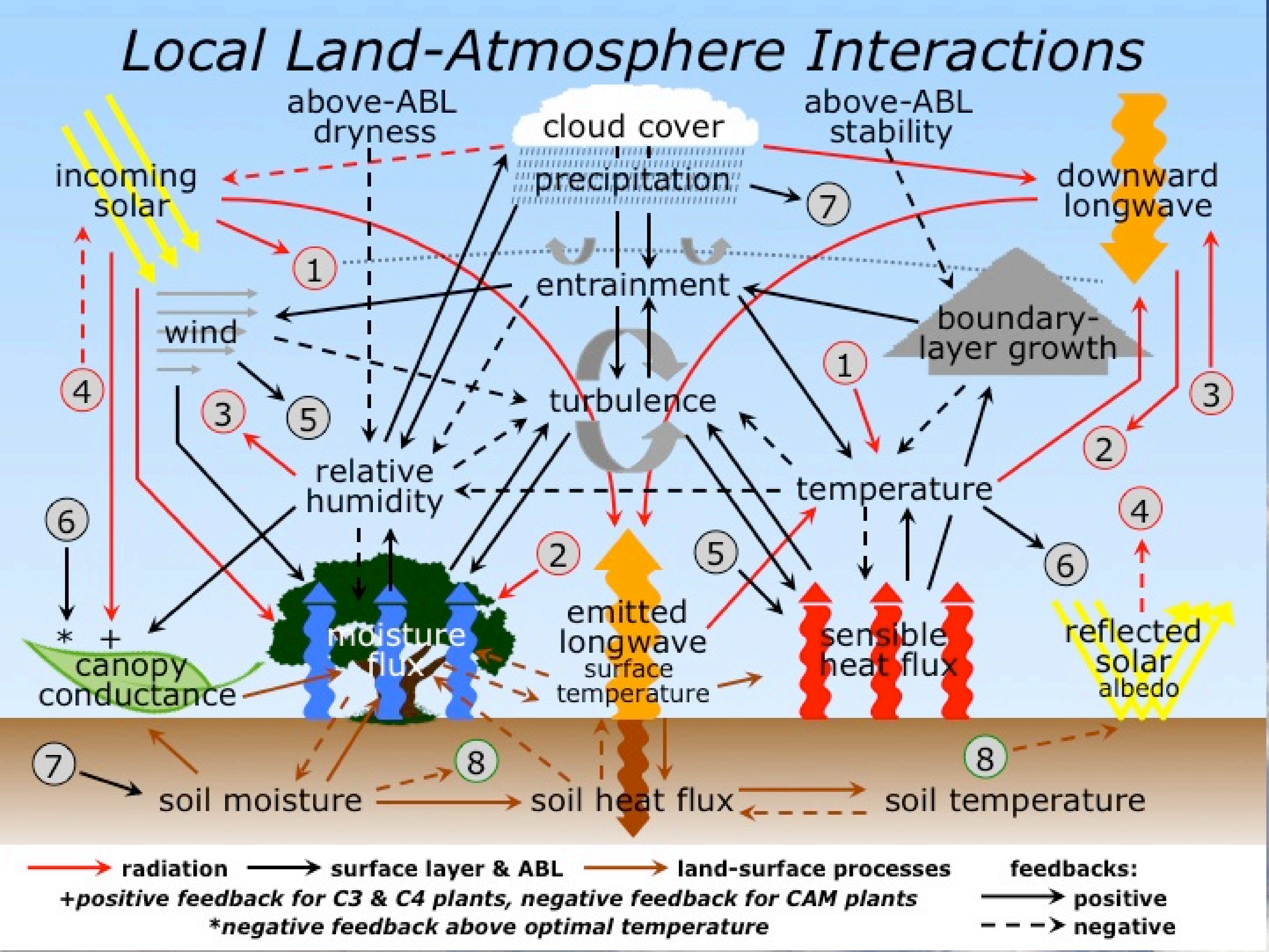
LIS EnKF-based land Data Assimilation tool used to assimilate soil moisture from the NESDIS global Soil Moisture Operational Product System (SMOPS), snow cover area (SCA) from operational NESDIS Interactive Multisensor Snow and Ice Mapping System (IMS) and AFWA snow depth (SNODEP) products.

Courtesy Jiarui Dong

Summary

Land models provide proper boundary conditions to atmospheric models, and rely on remote sensing for:

- **Atmospheric forcing**, e.g. *Precipitation & incoming solar radiation*.
- **Initial land states, e.g.** *Snow & soil moisture, land skin temperature for validation*.
- **Land data sets** e.g. *Land use/land cover (vegetation type), green vegetation fraction (GVF), leaf-area-index (LAI), surface albedo & emissivity*, (fixed annual/monthly/weekly climatologies, or near real-time observations, where some quantities may be assimilated (e.g. soil moist., snow) into the Noah land model.



Local Land-Atmosphere Interactions
above-ABL dryness
cloud cover
precipitation
above-ABL stability
incoming solar
downward longwave
entrainment
wind
boundary-layer growth
turbulence
relative humidity
temperature
emitted longwave
surface temperature
moisture flux
sensible heat flux
reflected solar
albedo
canopy conductance
soil moisture
soil heat flux
soil temperature
radiation
surface layer & ABL
land-surface processes
feedbacks:
positive
negative
+positive feedback for C3 & C4 plants, negative feedback for CAM plants
*negative feedback above optimal temperature

U.S. National Ice Center

U.S. National Ice Center Use of Satellite Cryosphere Products

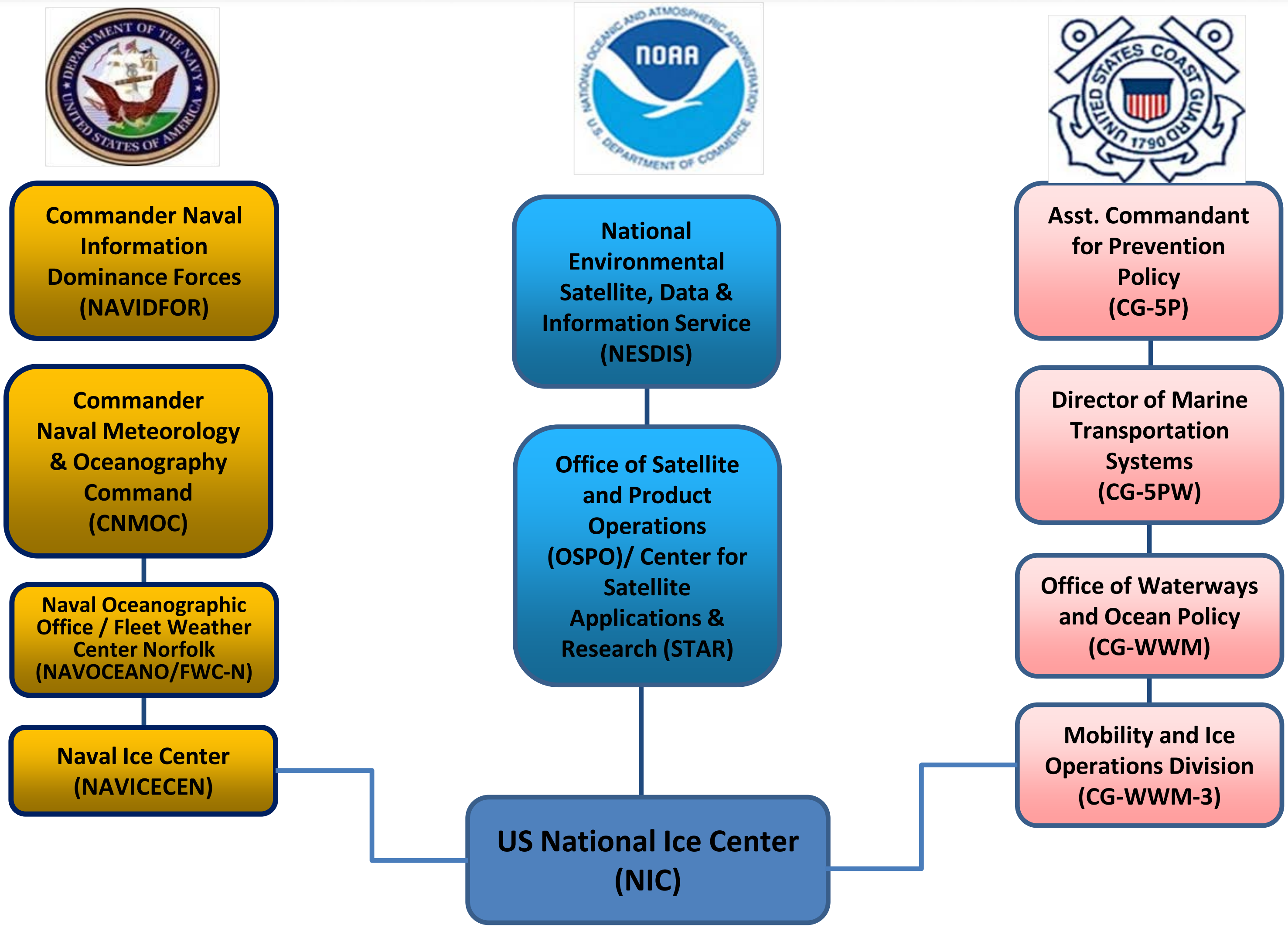
2015 JPSS Annual Science Team Meeting - August 24-28, 2015
Speaker: Sean R. Helfrich

CDR Kelly Taylor
Director / Commanding Officer

Mr. Sean R. Helfrich
Acting Deputy Director

LCDR Robert Atkinson
Naval Ice Center Executive Officer

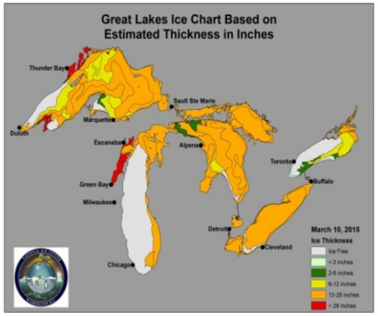
USNIC Organization



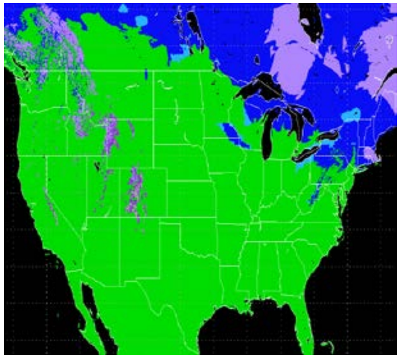
Total manpower: 37 personnel; 65% Navy, 33% NOAA, 2% USGC

NOAA Requirements

- **Great Lakes Ice Monitoring (Dec-May)**
  - Daily Ice Conc/thickness. 5 km res ,GRIB and ASCII
  - Weekly Ice Thickness & Form
  - 1-7 day forecast
  - NAVTEXT message (Dec-Mar)

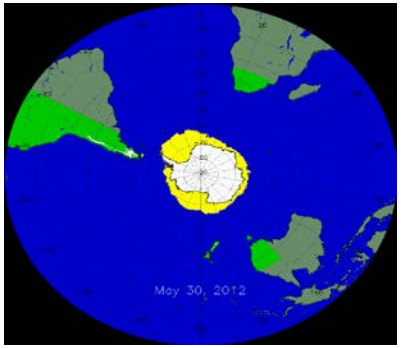


- **CONUS Ice Monitoring (Dec-May)**
  - Weekly or bi Weekly - Chesapeake and Delaware Bays



- **Alaska Ice Monitoring**
  - Twice weekly ice charting
  - SAR Imagery support for NWS Alaska
  - Ice edge and GRIB format

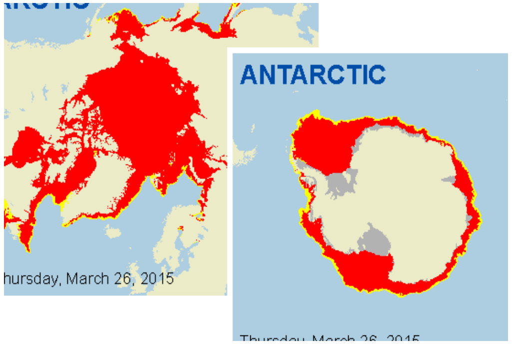
- **Global Snow and Ice Monitoring**
  - 2x Daily Gridded Ice/Snow Extent for North America, 1km
  - Global Daily Snow Depth, 4km res
  - Northern Hemisphere Daily Ice Concentration, 4km res
  - Northern Hemisphere Daily Ice Thickness, 4km res
  - Days since last observation for Snow and Ice Analysis Data



- **Special Support of NOAA Vessels**

USN Requirements

- **Submarine Force (SUBFOR) Requirements (USN)**
  - Daily ice edge within 3NM
  - Daily MIZ within 3NM
  - 48HR ice edge forecast within 3NM
  - Sea ice routing/FLAP - as required (up to 2X daily) within 4NM
  - Estimated ice thickness bi-weekly or as required within 10cm
  - Iceberg location within 3NM (Arctic/Antarctica)
  - Climatological outlooks as required



- **Fleet Weather Center (FWC) Requirements (USN)**
  - Ice edge information (generic), 25 km res, daily.
  - Ice coverage (analysis and 24 hour forecast) 0.5km res, daily or as required in ports/waterways
  - Ice thickness information, 0.5 m red, or as required for tactical ops
  - Route specific at 0.5 km
  - OTSR ice annotated imagery

USCG Requirements

Arctic / Antarctic

Daily Sea Ice Edge – Daily during operations, 2x month off season.
Arctic – w/i 50m of edge; Antarctic w/i 2nm

Daily Sea Ice Concentration – Daily during operations, 2x month off season.
Arctic – w/i 50m and 2/10ths coverage

FLAP - As requested - daily during operations, 2x month off season.
Features >200m in length

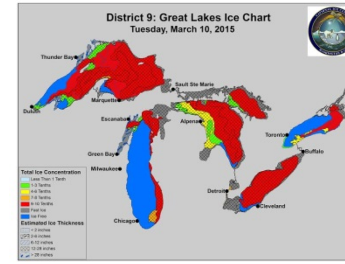
Daily Estimated Sea Ice Thickness - Daily during operations, 2x month off season

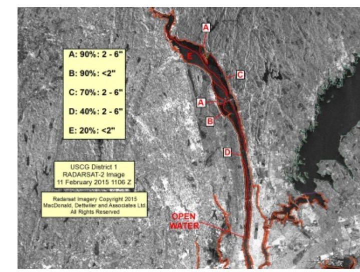
Daily Iceberg Location – Daily during operations, 2x month off season. w/i 2 km of actual; Imagery w/I 3 hrs of receipt

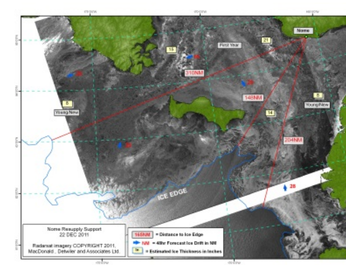
Daily Imagery Analysis/Forecast – As requested for operations/environmental awareness w/i 100nm radius of vessel

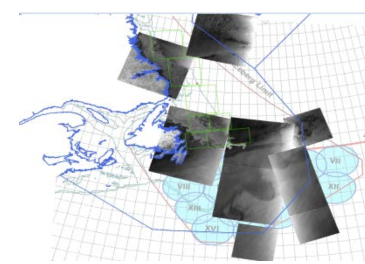
Climatological Outlooks - as requested
Arctic w/I 25nm; Antarctic w/I 20nm

Icebreakers or Aerial Recon
Embarked ice analysts or Aerial Recon for real time ice observations and analysis as requested
Annotated imagery analysis/forecasts

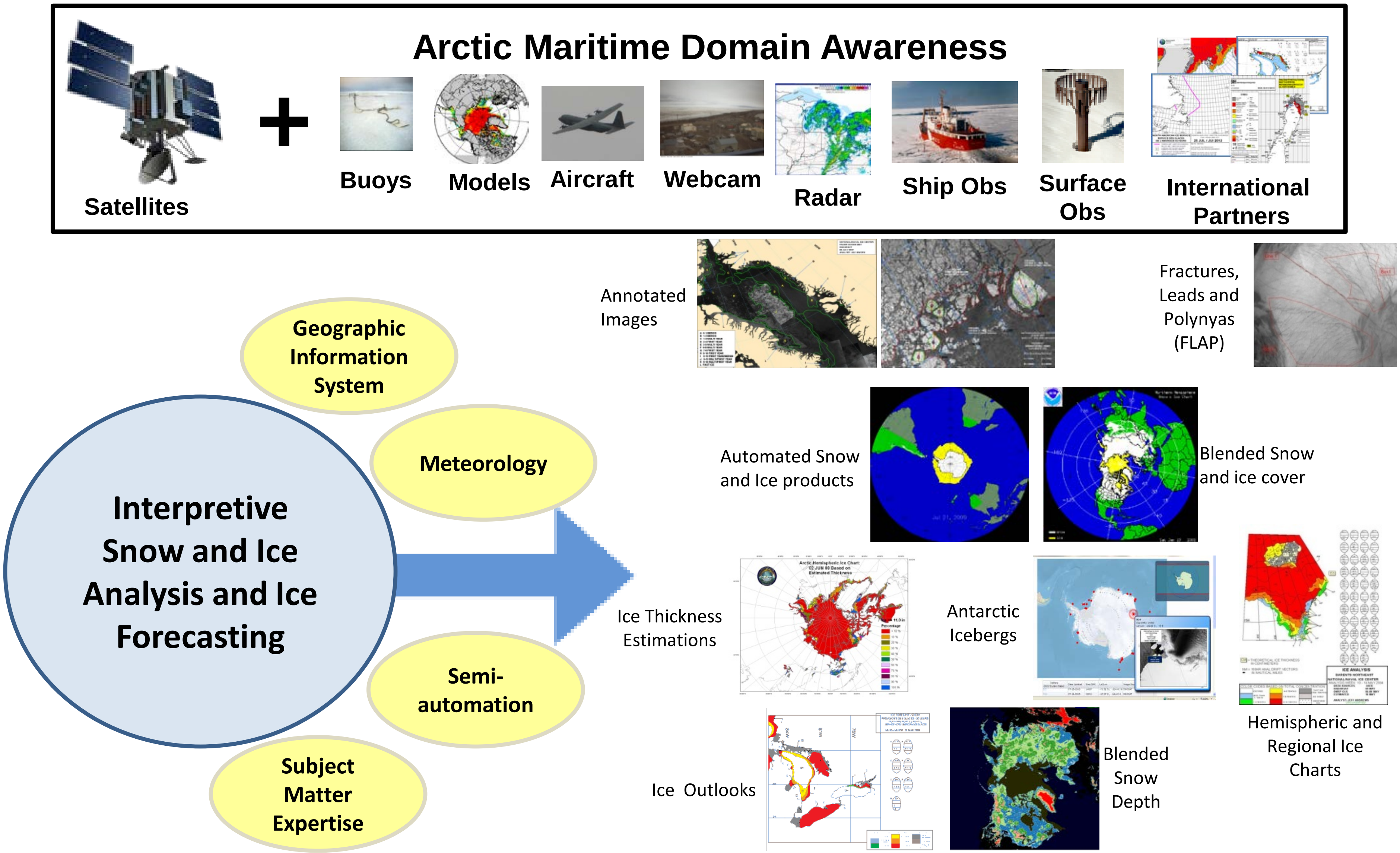








Product Generation



Current SNPP Utility in NIC Products

1. Imagery (I1, I2, I3, I5, DNB) (All)
2. VIIRS Sea ice characterization (IMS)

   Only used for Ice/No Ice (inaccurate ice typing), Cloud Mask issues

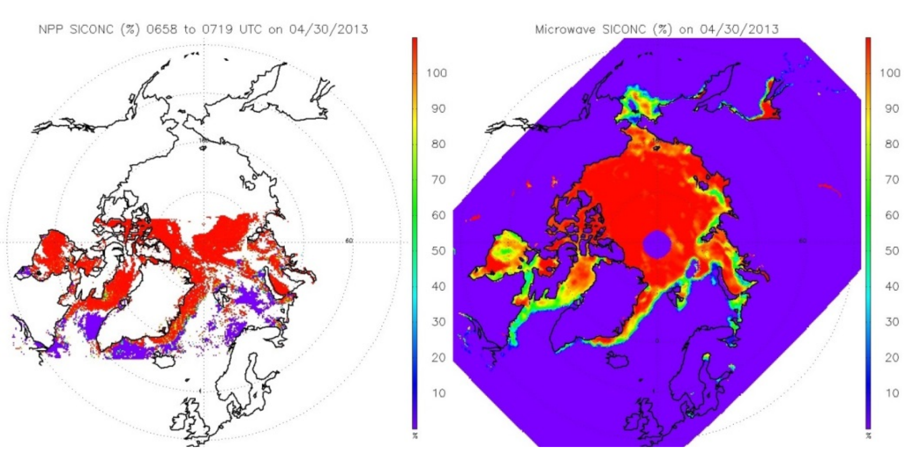
3. VIIRS Sea Ice concentration IP (Working on IMS, Hemi Ice Charts, & MIZ)

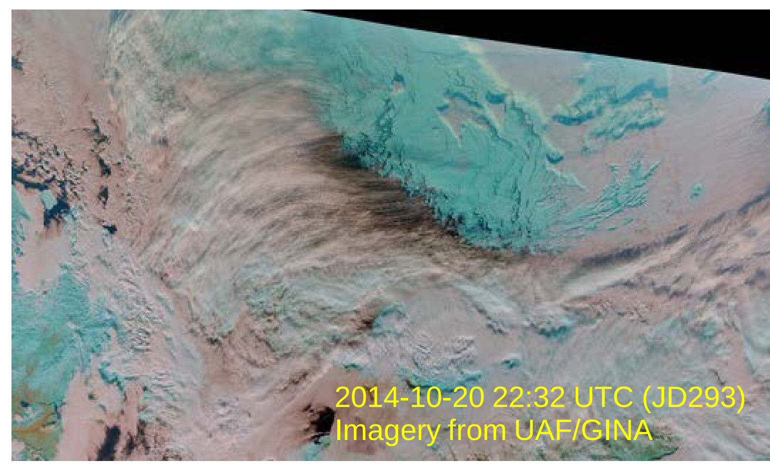
   Data format (HDF5 to Geotiff conversion being built)

   Will be helpful in IMS Blended Ice Con.

4. VIIRS Snow cover (IMS)

   OK, but conservative cloud mask





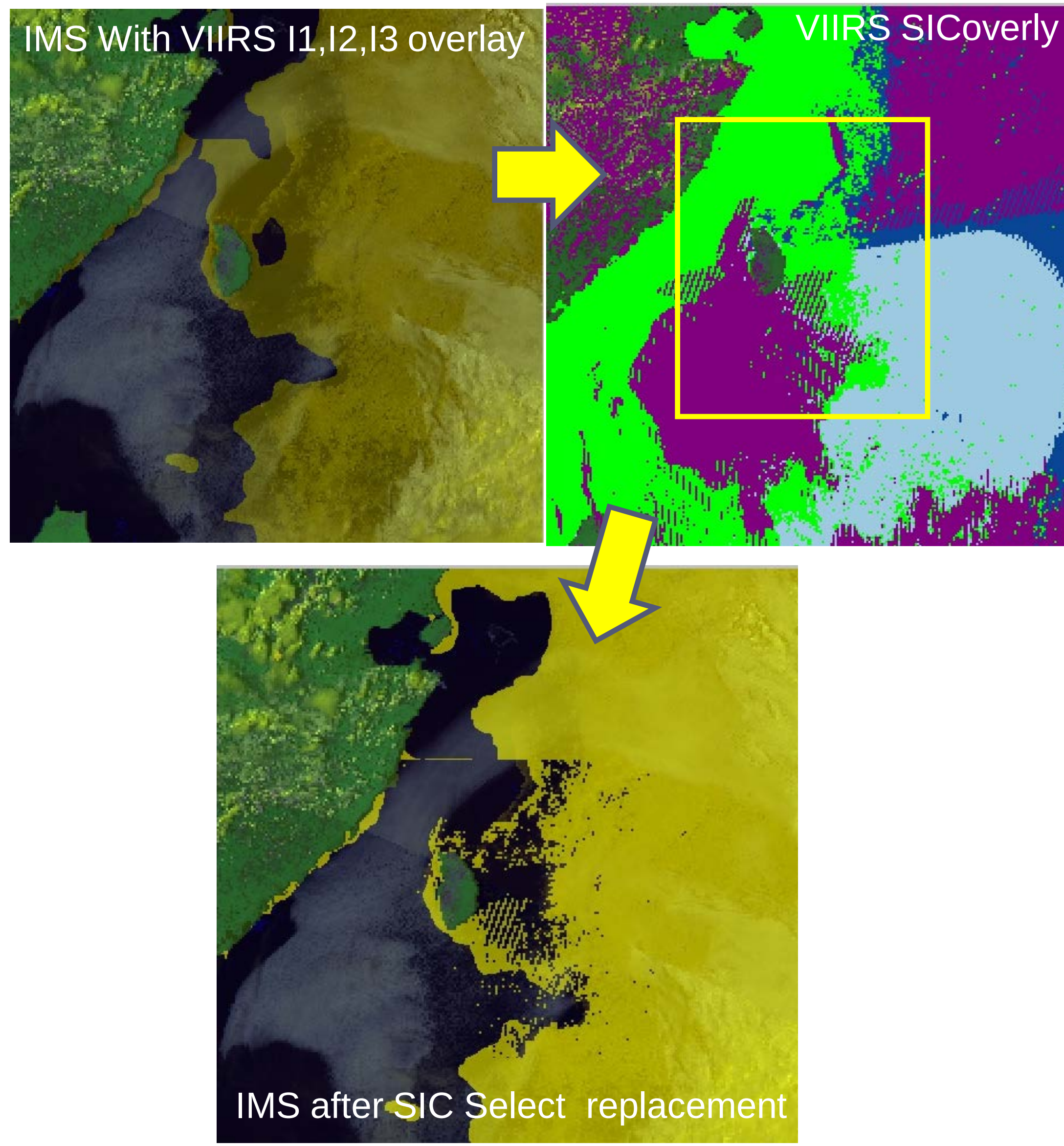
Direct Import of Automated Snow & Ice Cover

- Analysts will be able to selectively import the data from satellite derived products directly into the Blended Analysis

- Analysis will have selection box to select snow cover and ice cover from the VIIRS, NOHRSC, and NH AutoSnowIce.

- Human data selection to optimize product use based on expert knowledge and imagery interpretation

- Combines the speed and reliability of automated products with the QC and flexibility of Human Analysts



Current SNPP Utility in NIC Products

5. AMSR2 Ice Concentration (MIZ, Hemispheric Ice Charts)

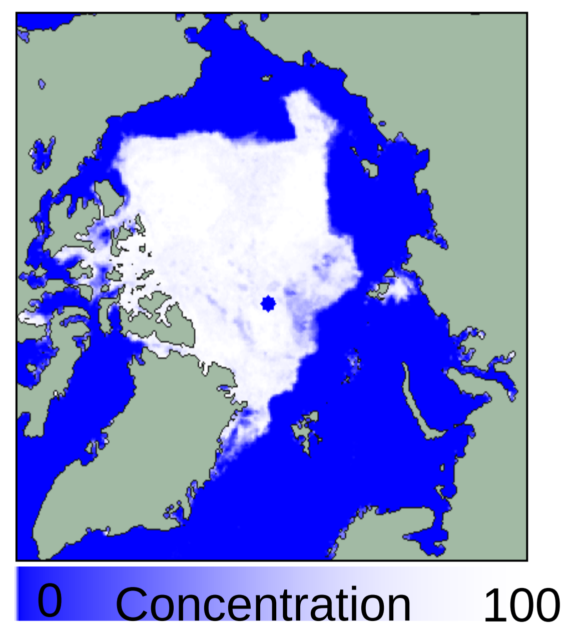
Applied in IMS Blended Ice Concentration

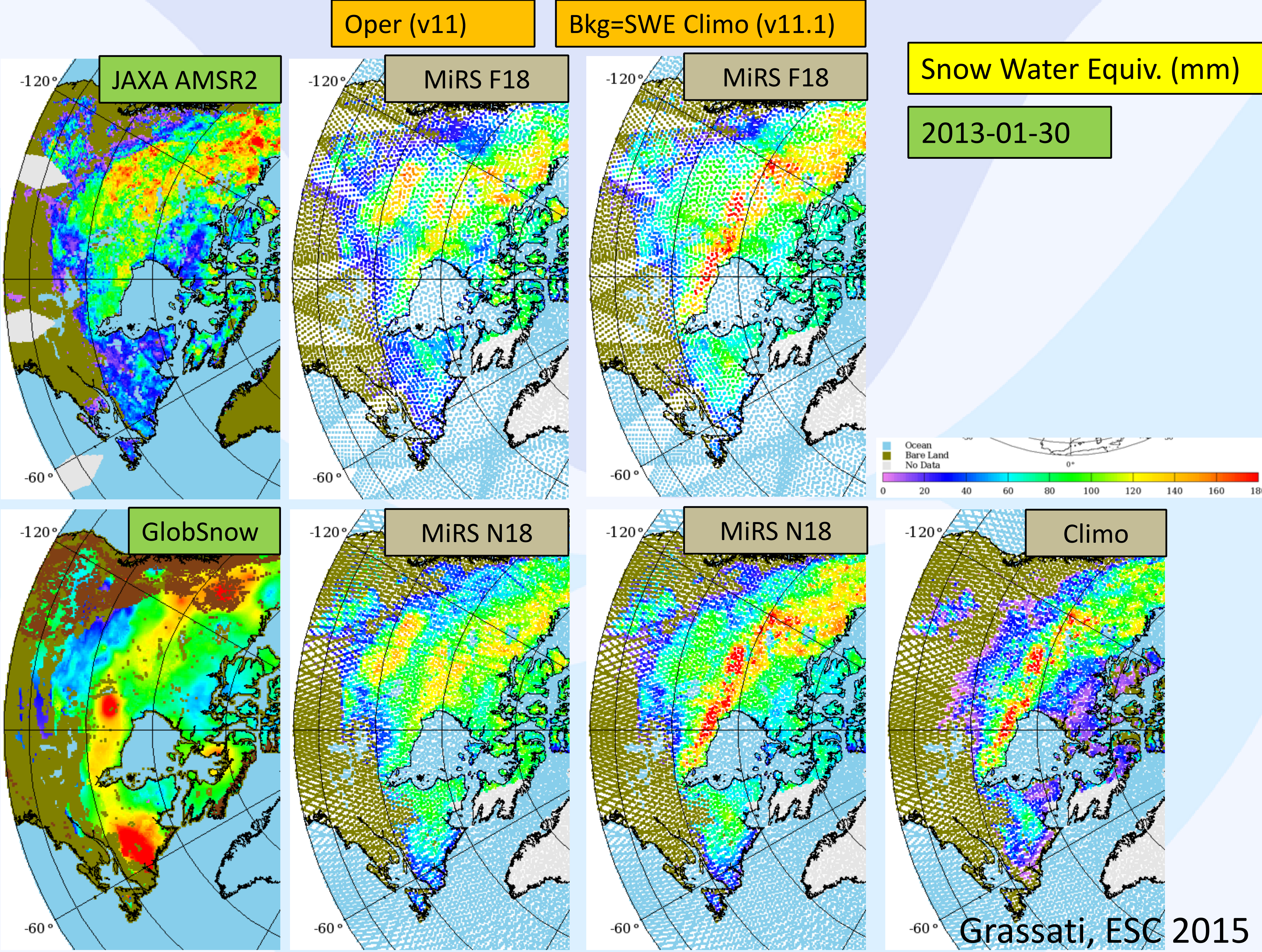
Using ASI (Univ Bremen), last resort data source,

6. ATMS Snow Water Equivalent (IMS)

Used to make IMS Snow Depth

Release of Version 11.1 – better agreement with AMSR 2 except in boreal forest areas




Oper (v11)
Bkg=SWE Climo (v11.1)
Snow Water Equiv. (mm)
2013-01-30
JAXA AMSR2
MiRS F18
MiRS F18
GlobSnow
MiRS N18
MiRS N18
Climo
-120°
-60°
Ocean
Bare Land
No Data
0 20 40 60 80 100 120 140 160 180
Grassati, ESC 2015

Potential JPSS Utility in NIC Products

7. ATMS Snow Grain Size (IMS)

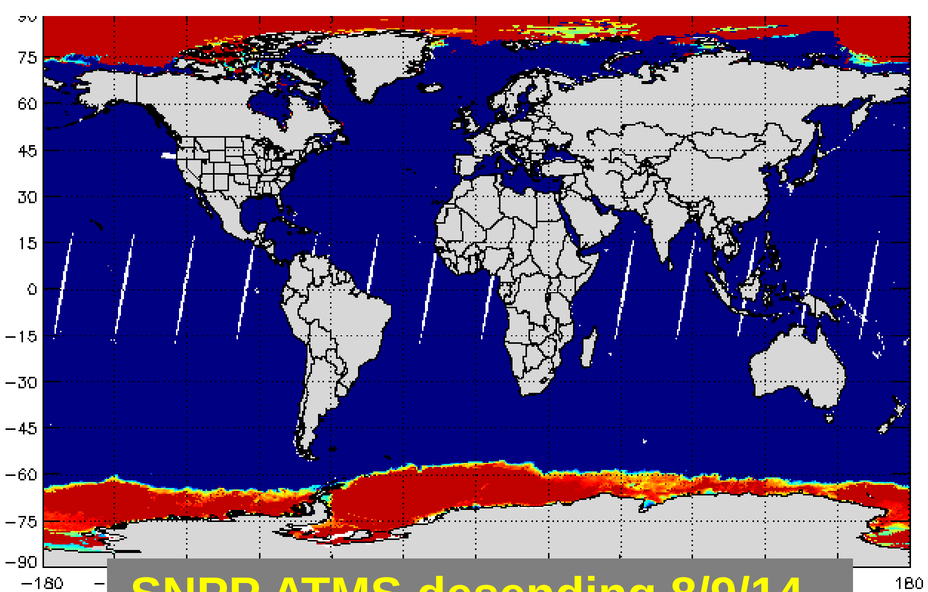
   Desired to adjust IMS Snow Depth

8. ATMS First Year Ice Concentration (IMS, Hemispheric Ice Charts)

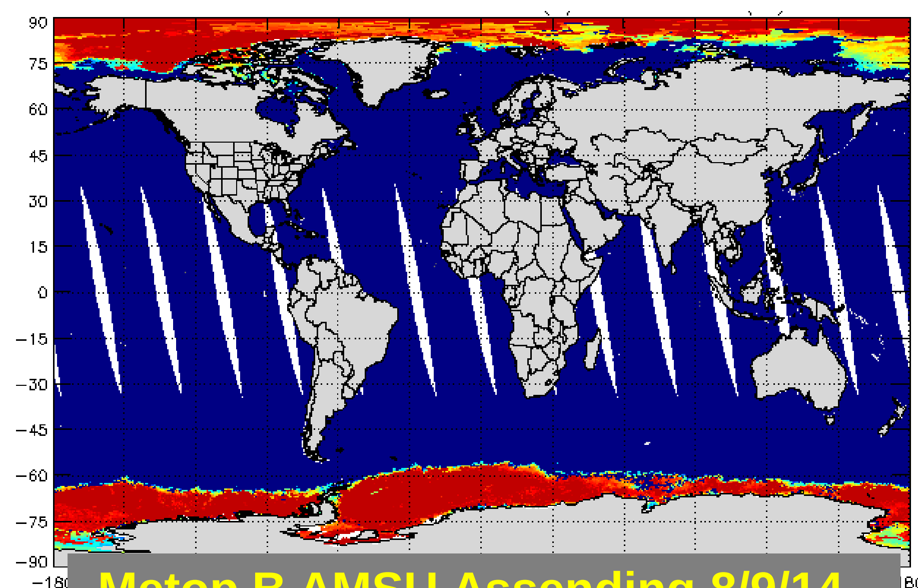
   Could be used in IMS Blended Ice Con

9. ATMS Multi-Year Ice Concentration (IMS, Hemi Ice Charts)

   Will be helpful in IMS Blended Ice Con



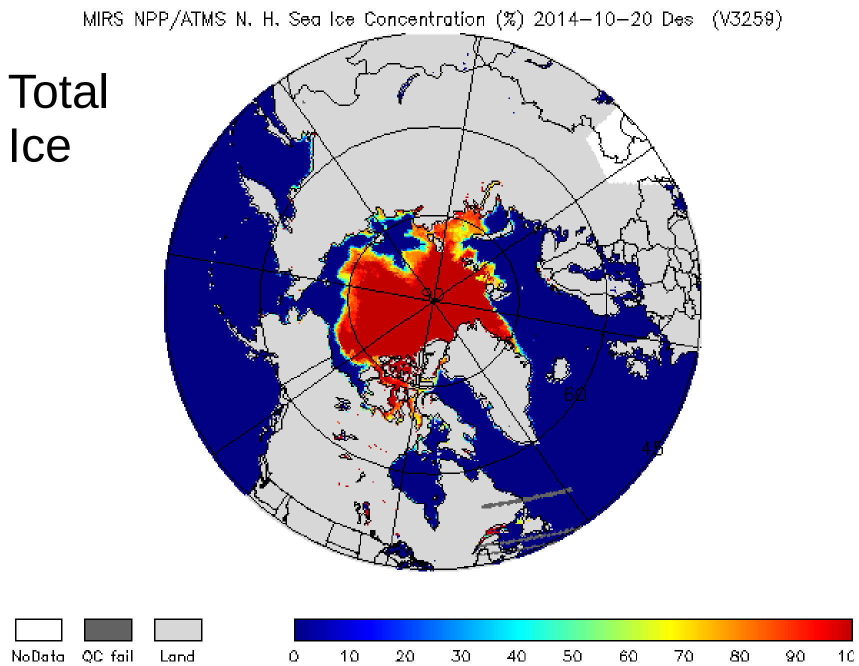
SNPP ATMS desending 8/9/14



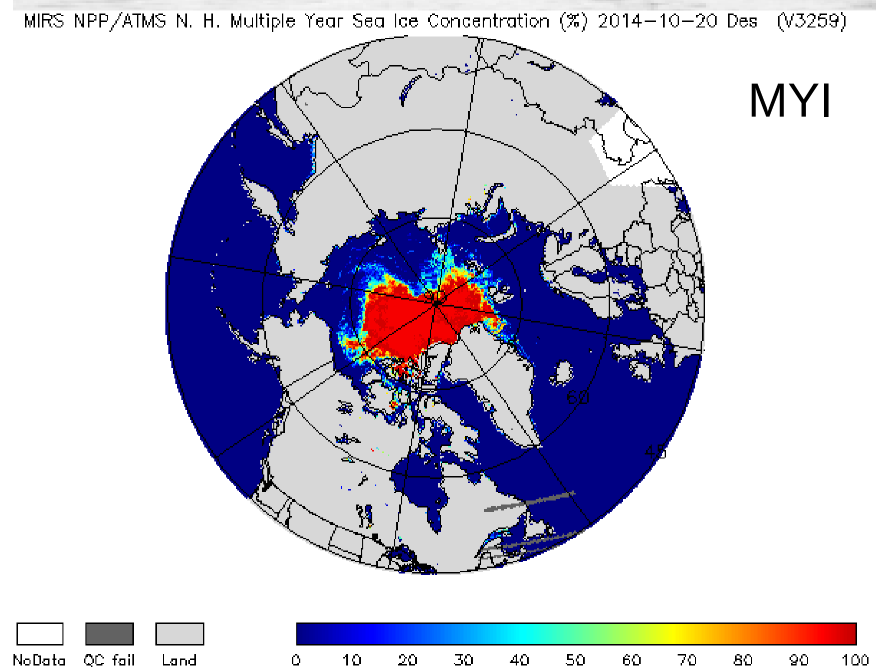
Metop B AMSU Assending 8/9/14

MIRS ATMS Sea Ice

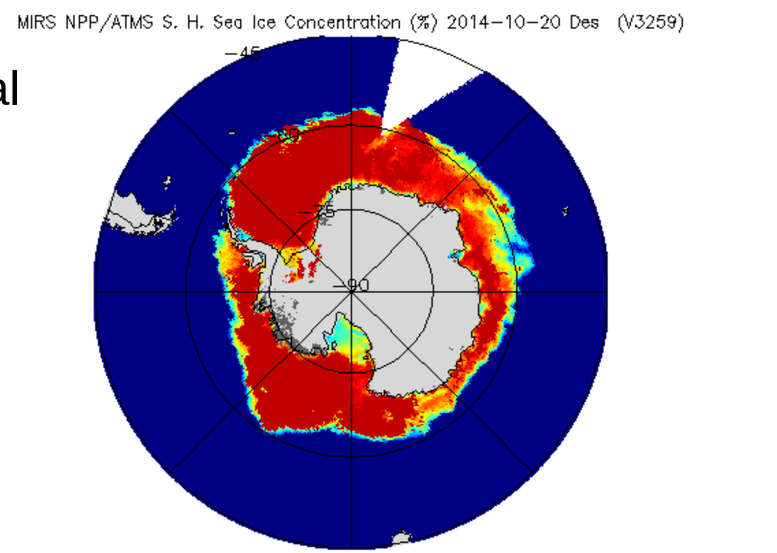
Total Ice



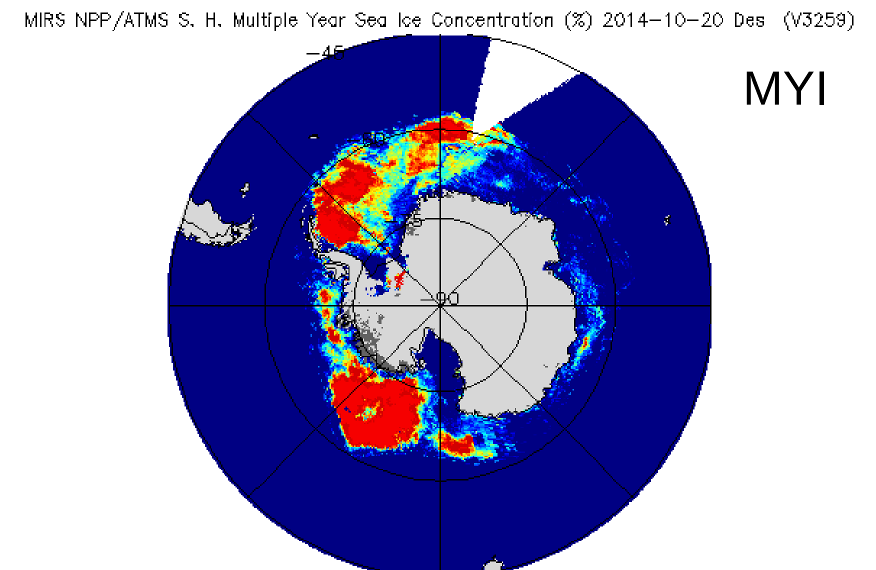
MYI



Total Ice



MYI



NIC JPSS Wish list for Future Work

(1) Geotiff formats (All)

NIC spends much of its infrastructure, bandwidth and processing on file conversion from HDF formats from VIIRS and MODIS leaving the majority of the content

(1) Include Lake ice in the Ice products (IMS, Great Lakes Analysis)

(2) Product Composites at 1km (IMS, Hemispheric Ice Charts)

Difficulty stitching multiple swath and resampling to lower resolution

(3) Ice Edge (Marginal Ice Zone)

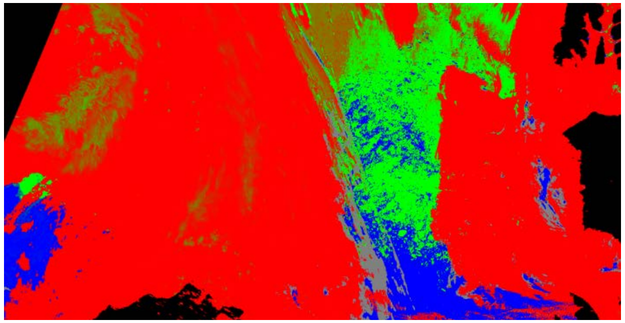
(4) Ice Drift (Ice Forecasting, IMS, annotated imagery)

(5) Ice Lead Detection (FLAP, Annotated Imagery)

(6) Snow Fraction (IMS, ASI)

(7) Blended products (All)

(8) Optional Cloud masks (All)



CREST experimental Ice Cover 7/31/13

IMS Blended Sea Ice Concentrations

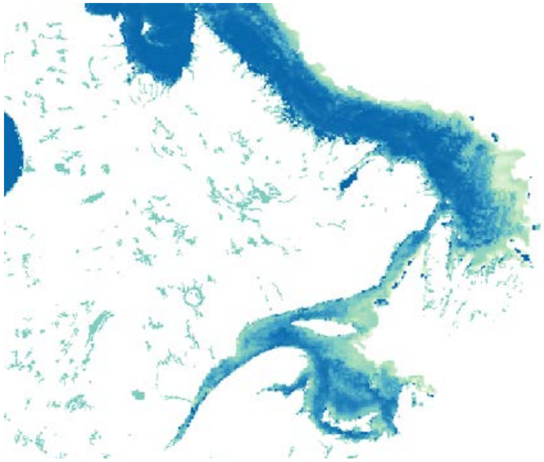
BLENDED ICE CONCENTRATIONS: STAR and NIC are developing a Blended Ice Concentration primarily for modeling

- Using Optimal Interpolation to blend ice concentrations
- New "replacement" using:
  - *SAR*
  - *Ice Charts*
  - *Other ice/no ice products (CREST, VIIRS RR, GOES R)*
- Date since last ob and source tracking
- Ice Concentrations determined from:
  - *IMS Ice Cover*
  - *AMSR 2*
  - *ATMS MIRS*
  - *VIIRS Ice Con*
  - *Ice Charts (NIC, CIS, DMI, MetNo, NWS Alaska, etc)*
  - *Analyst "tie Points"*
  - *NWP models*
- 2016 Release?

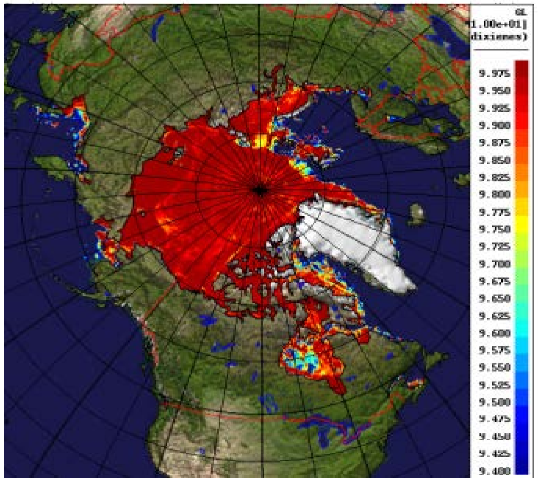
NIC & NOAA Arctic Action Plan (2012)

- **Improve ice, weather and water forecasts and warnings**
  - **Improve snow depth, snow cover, ice cover, and ice thickness analysis for operational model initialization or assimilation**
  - **Integrate new satellite-derived sea ice information into National Ice Center operations, such as ice thickness, ice concentration, and size of leads (fractures) in ice**
  - **Advance our sea ice services through the addition of more observational data sets to our analysis and forecasting techniques, evaluations of coupled model output from Environment Canada and the Naval Research Laboratory, and the expansion of product suites with new and more frequent services.**
  - **Establish foundational components of a Regional Operations Center and Arctic Test Bed to strengthen NOAA's ability to be responsive to emerging service requirements in the Arctic and leverage new science and technology capabilities.**

Blended IMS Ice Concentrations



GIOPS CMC Ice Concentrations



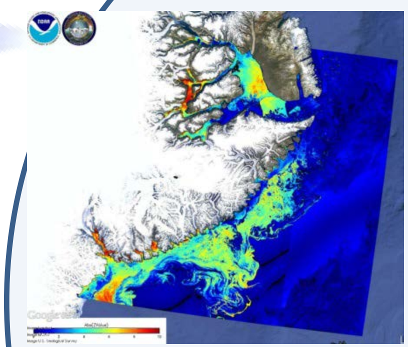
NIC & NOAA Arctic Action Plan (2012)

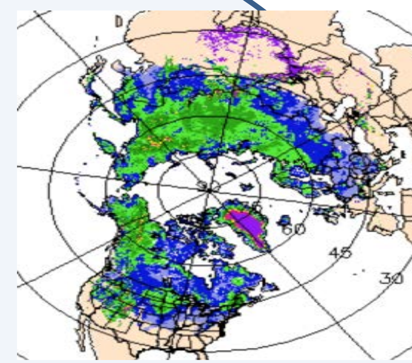
- **Strengthen foundational science to understand and detect Arctic climate and ecosystem changes**
  - **Conduct coordinated calibration and validation of satellite measurements of the cryosphere through in-situ and airborne missions in collaboration with national and international partners**
- **Enhance international and national partnerships**
  - **IICWG, NAIS, NASA, U of Washington, IABP, WMO Cryosphere Watch**
  - **Coordinating with national and international partners to broaden geographic coverage of Arctic sea ice analysis and forecasting**

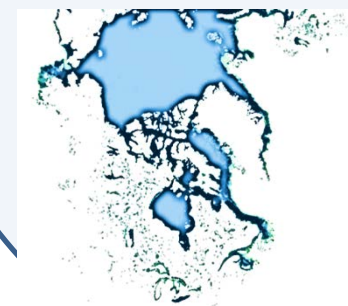
Integration with Models

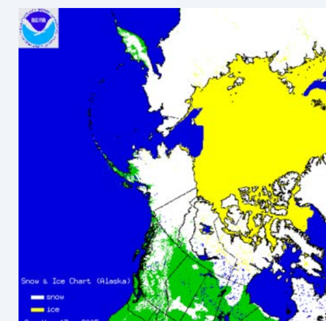
CUSTOMERS & PUBLIC

NIC Analysis

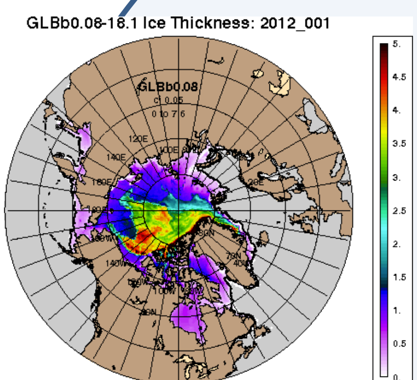


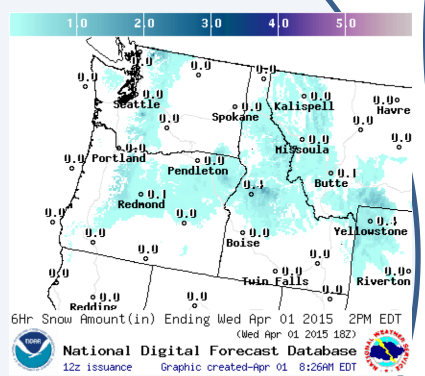


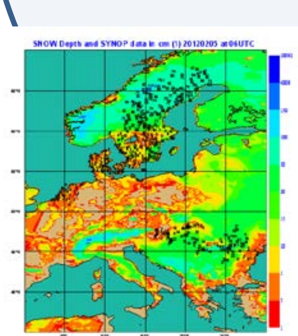


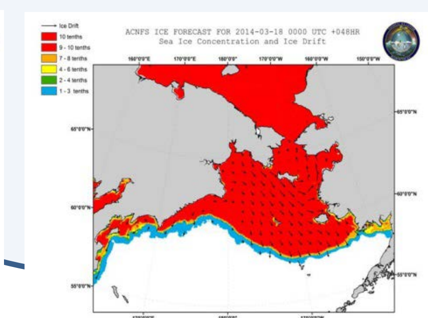


Navy and NOAA Models (and others)









Models provide forecasts for NIC forecasters which apply NIC analysis data.

Thank You!

STAR JPSS 2015 Science Team Meeting Land / Cryosphere Breakout Session

Ivan Csiszar, Jeff Key

August 27, 2015

Objectives

- NOAA operational land and cryosphere products
  - Current operational products
  - Ongoing algorithm improvement efforts
  - Relationship with other JPSS land production systems i.e. NASA
- Product validation
  - Ongoing validation resources and preparation for JPSS-1
  - Leveraging resources with other NOAA, US and international activities
  - Coordinated validation approach
- System development and new programmatic directions
  - NOAA Enterprise System and non-NOAA assets
- NOAA Operational Applications

Agenda (am)

Product overviews

- 8:45 Surface reflectance – Belen Franch
- 9:00 Vegetation index EDR and NDE Green Vegetation Fraction – Marco Vargas
- 9:15 Vegetation Health – Felix Kogan
- 9:30 Land surface albedo – Bob Yu
- 9:45 Land surface temperature – Bob Yu
- 10: 00 Active fire – Ivan Csiszar

10:15 Break

- 10:30 Surface type – Jerry Zhan
- 10:45 Sea ice characterization and thickness – Jeff Key
- 11:00 Sea ice concentration – Yinghui Liu
- 11:15 Sea ice surface temperature – Mark Tschudi
- 11:30 Binary snow cover – Peter Romanov
- 11:45 Snow fraction - Peter Romanov and Igor Appel
- 12:00 NASA SIPS Land Production and QA – Sadashiva Devadiga / Miguel Román

12:15 Lunch break

Agenda (pm)

Product validation and long-term monitoring

- 1:00 Validation datasets and interagency / international coordination - Miguel Román
- 1:30 JPSS 1 land validation plan overview – Ivan Csiszar
- 1:45 GOES-R land validation activities and coordination with JPSS – Bob Yu
- 2:00 Land product characterization system – Kevin Gallo
- 2:15 Land long-term monitoring system – Lori Brown / Tony Reale

NOAA Enterprise system

- 2:30 Land / cryosphere enterprise product assessment– Ivan Csiszar / Jeff Key
- 2:45 Non-NOAA data sources for operational land / cryosphere applications: mission status, data access and plans Marco Vargas / Bob Yu / Jeff Key / Ivan Csiszar

3:00 Break

NOAA operational applications of JPSS land and cryosphere products

- 3:15 NCEP – Mike Ek
- 3:30 National Ice Center– Sean Helfrich

Open discussion and wrap-up

- 3:45 - 5:00 *Overarching topics such as re-processing, gridding, CLASS RIP archives, Direct Broadcast, summary and action items*

NOAA Operational Product Status

- Evaluation and update of the heritage IDPS algorithms is practically complete
  - Products achieved validated stage 1 as defined by the NOAA JPSS program
  - Only remaining IDPS code change package is aerosol / SR (to implement validated algorithm in operations)
  - Reactive maintenance continues
  - Long-term monitoring in place / transitioning to systematic production
- NOAA ESPC (NDE) operational implementation
  - Additional / added-value products
    - Green Vegetation Fraction – fully operational
    - Vegetation Health – transition to operations
    - Active Fire – re-allocated to NDE – transition to operations
    - Snow Fraction – in development
    - Phenology (Risk Reduction) – in development
- JPSS Program Director's direction letter on algorithm development
- Program Level CCR to re-direct all Priority 3 and 4 products to ESPC

NOAA Operational Product Status

- NOAA Enterprise Algorithm Development
  - Common algorithms / ground system implementation options to leverage resources and ensure best algorithm solutions
    - Targets NOAA satellite assets i.e. JPSS and GOES-R
      - Often results in the implementation of GOES-R algorithms to process JPSS data
      - “Risk Reduction” algorithm package transitioning into operations
      - Land products not part of this effort, but assessment is ongoing
- Use of non-NOAA assets for critical NOAA missions
  - In some regards the extension of NOAA Enterprise development
- New directions and framework for the Science Team’s activities
  - Reactive maintenance and long-term monitoring of operational products
  - Algorithm development towards ESPC implementation of enterprise solutions; testbeds, demonstration products, active user involvement
  - Different review / TTO process / documentation – follow SPSRB process
- Algorithm deliveries to STAR Algorithm Integration Team (AIT)

Moving forward

- JPSS-1 (-> to be renamed to NOAA-20 once operational) preparation
  - Suite of algorithms include significant improvements
    - TOC NDVI, full fire mask and FRP – implemented for Suomi NPP
    - JPSS-1 test datasets are becoming available
  - JPSS-1 validation plans
    - draft plans delivered; review / feedback ongoing
    - final plans due December 31
- NOAA – NASA ST coordination and collaboration
  - Algorithm development
    - keep algorithms in sync (i.e. SR, Active Fire)
    - seeking common algorithm solutions where possible (i.e. LST)
    - different algorithm solutions where necessary
    - NASA-unique features (SDR, output format etc.) to be addressed
  - Validation
    - leveraging approaches and resources
- JPSS-2 and beyond assessment

User involvement and added value products

- Close linkages between code cal/val and risk reduction activities
  - Risk reduction is also a platform for further algorithm changes
- Close collaboration with critical NOAA users
  - NOAA NCEP and other modeling groups – data assimilation
  - National Ice Center, Hazard Mapping System, CPC etc.
- Key Proving Ground Initiatives
  - e.g. Fire and Smoke, Land Data Assimilation
  - Joint Center for Satellite Data Assimilation as testbed
- Direct Broadcast CSPP and IPOPP and algorithm updates
- Development of new / level-3 and beyond products
  - GVF in operation
  - Gridded/composited LST, albedo etc.; LAI/fPAR
- Reprocessing
  - ongoing for select VIIRS bands / products (i.e. ocean)
  - planning / implementation for additional SDR and products

Surface Reflectance

Belen Franch, Eric Vermote
NASA GSFC Code 619
belen.franchgras@nasa.gov

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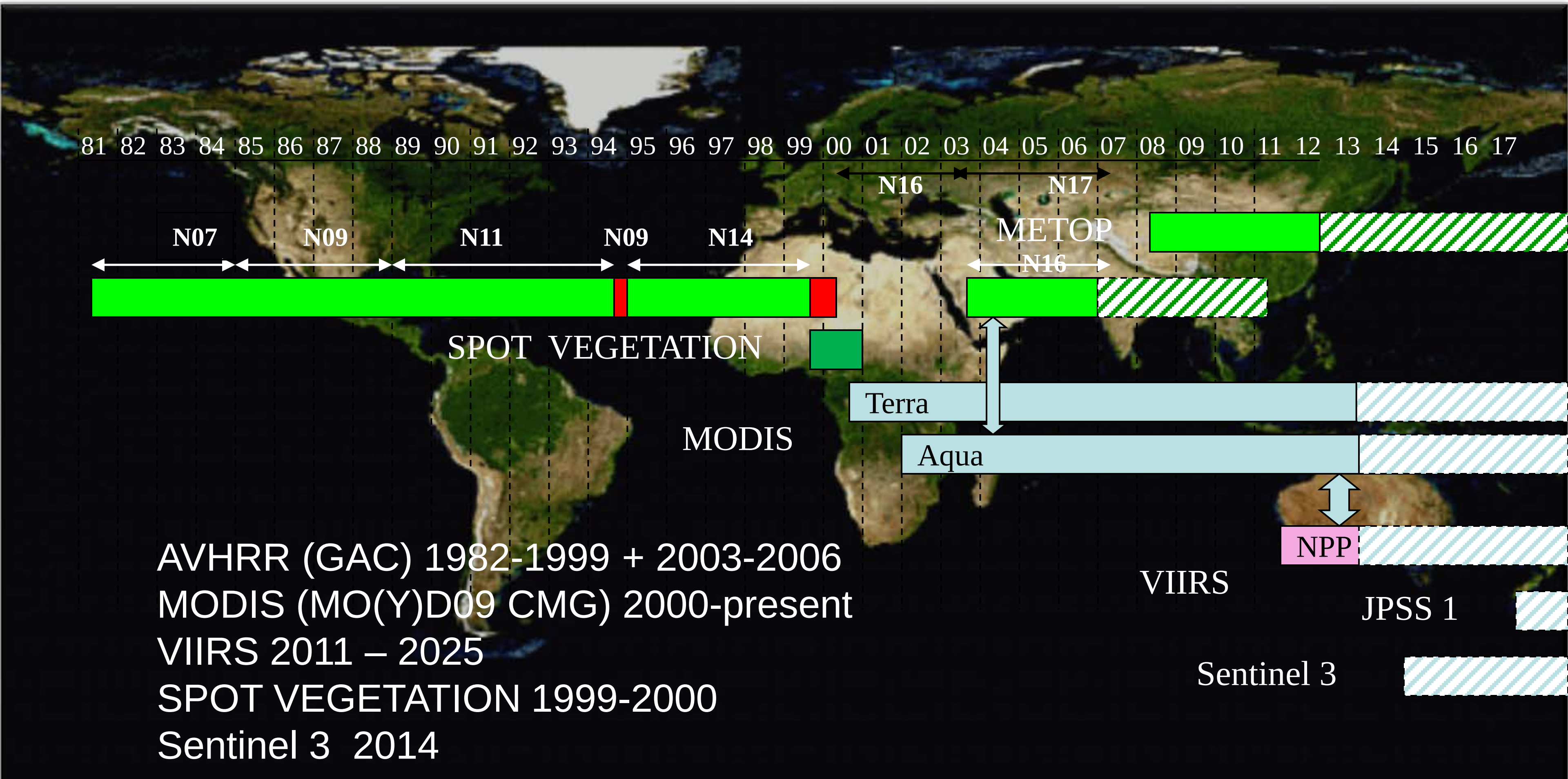
A Land Climate Data Record

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



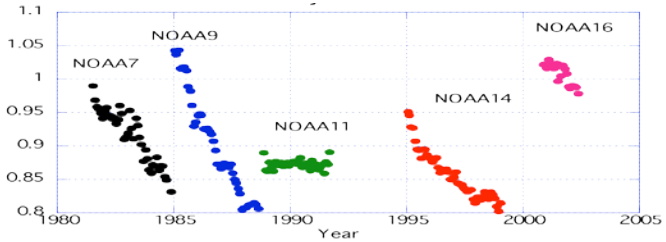
Emphasis on data consistency – characterization rather than degrading/smoothing the data

Land Climate Data Record (Approach)

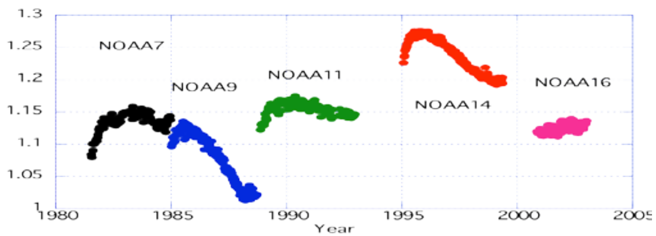
Needs to address geolocation,calibration, atmospheric/BRDF correction issues

CALIBRATION

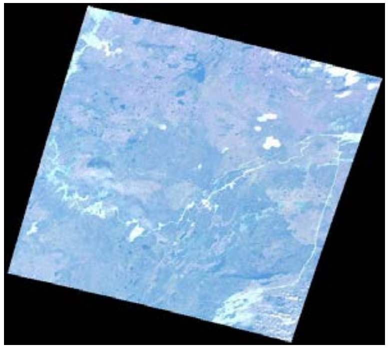
Degradation in channel 1
(from Ocean observations)

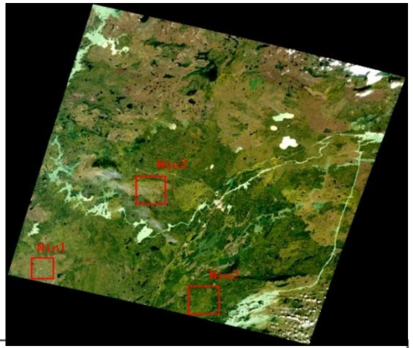


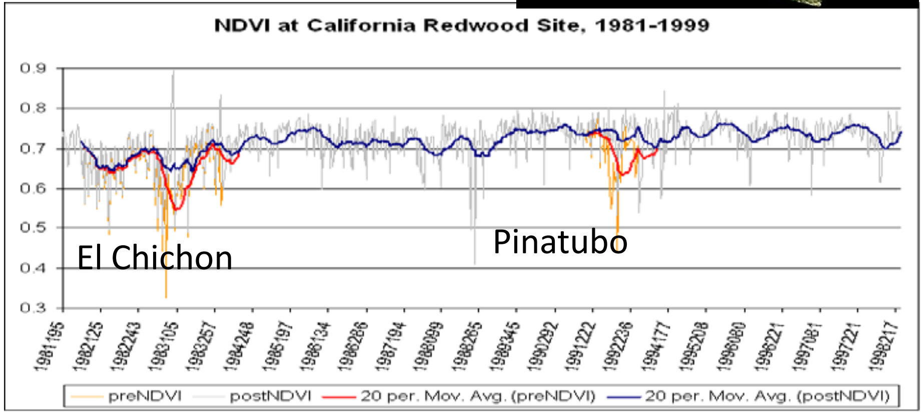
Channel1/Channel2 ratio
(from Clouds observations)



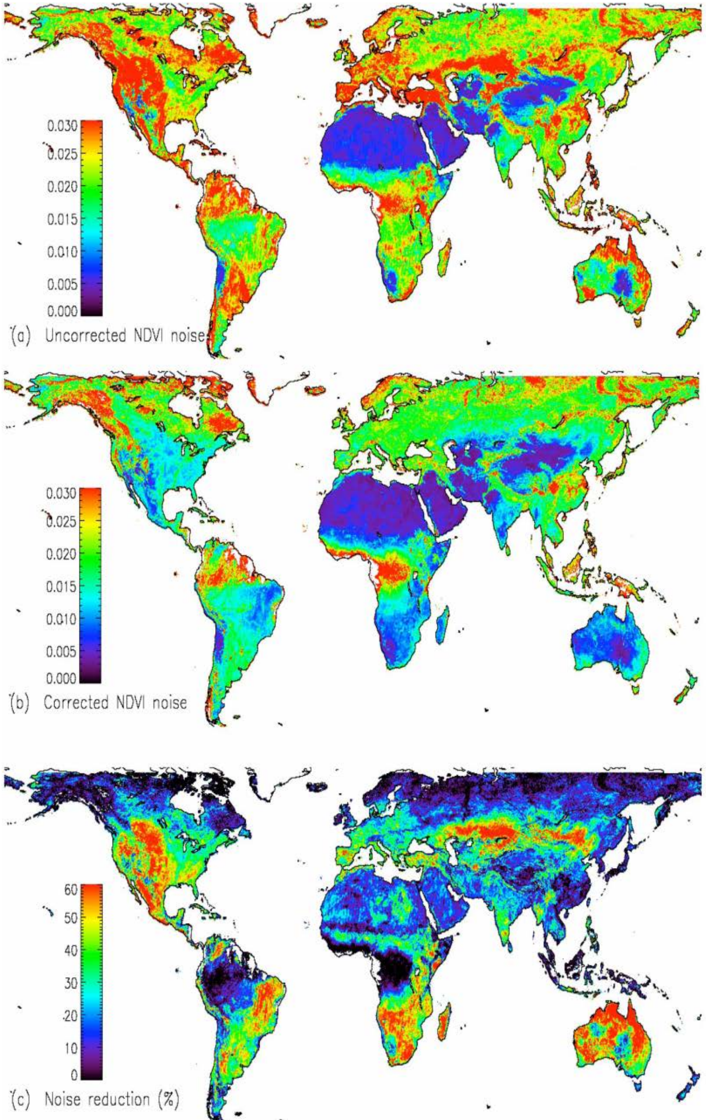
ATMOSPHERIC CORRECTION







BRDF CORRECTION



VIIRS Surface Reflectance based MODIS C5

The MODIS **Collection 5 AC algorithm** relies on

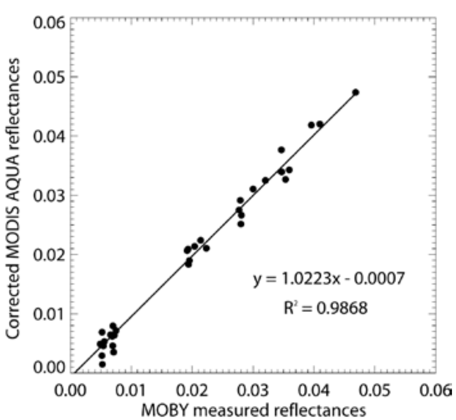
- the use of very accurate (better than 1%) vector radiative transfer modeling of the coupled atmosphere-surface system
- the inversion of key atmospheric parameters (aerosol, water vapor)

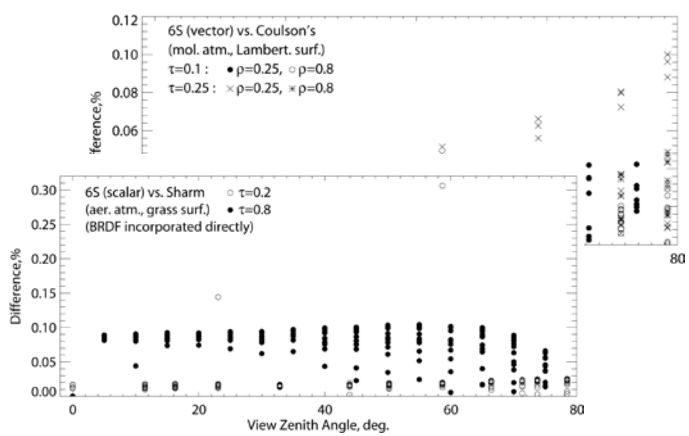
Home page: http://modis-sr.ltdri.org

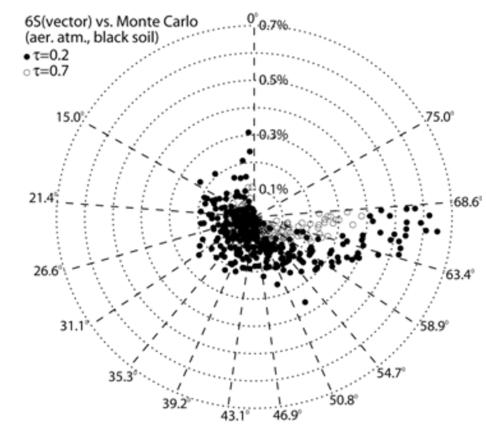
6SV Validation Effort

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.







Methodology for evaluating the performance of VIIRS/MODIS

To first evaluate the performance of the MODIS Collection 5 SR algorithms, we analyzed 1 year of Terra data (2003) over **127** AERONET sites (**4988** cases in total).

Methodology:

Subsets of Level 1B data processed using the standard surface reflectance algorithm

comparison

Reference data set

Atmospherically corrected TOA reflectances derived from Level 1B subsets

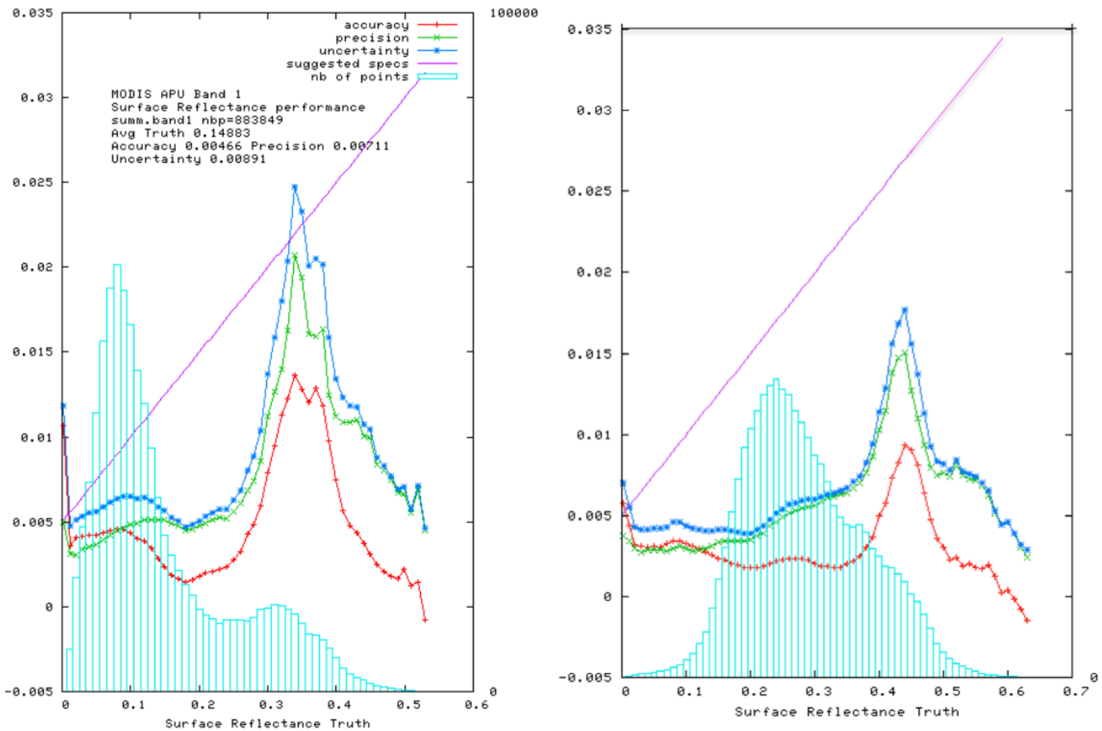
Vector 6S

AERONET measurements (τ_{aer}, H_2O, particle distribution Refractive indices,sphericityeri)

If the difference is within ±(0.005+0.05ρ), the observation is "good".

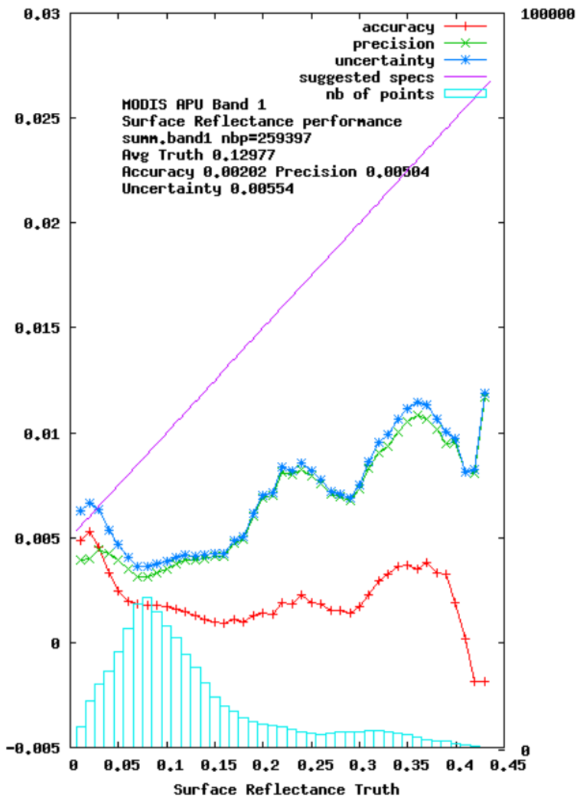
http://mod09val.ltdri.org/cgi-bin/mod09_c005_public_allsites_onecollection.cgi

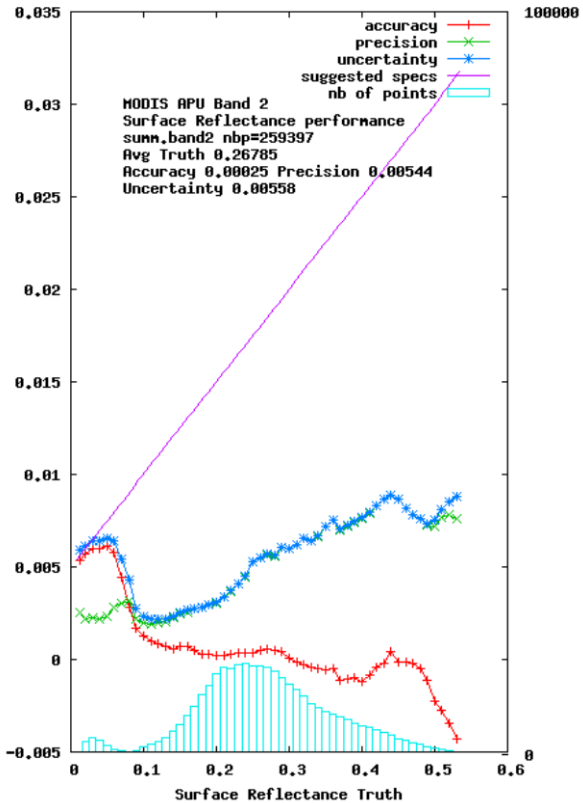
quantitative assessment of performances (APU)

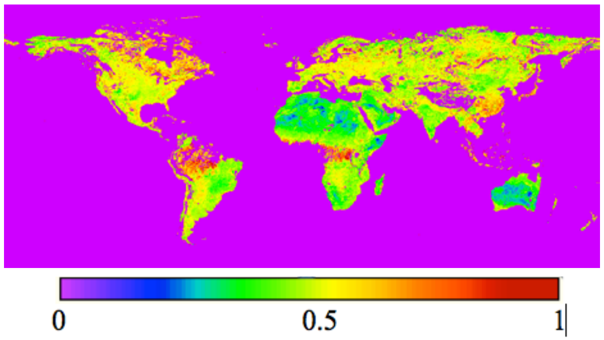


COLLECTION 5: accuracy or mean bias (red line), Precision or repeatability (green line) and Uncertainty or quadratic sum of Accuracy and Precision (blue line) of the surface reflectance in band 1 in the Red (top left), band 2 in the Near Infrared (top right also shown is the uncertainty specification (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

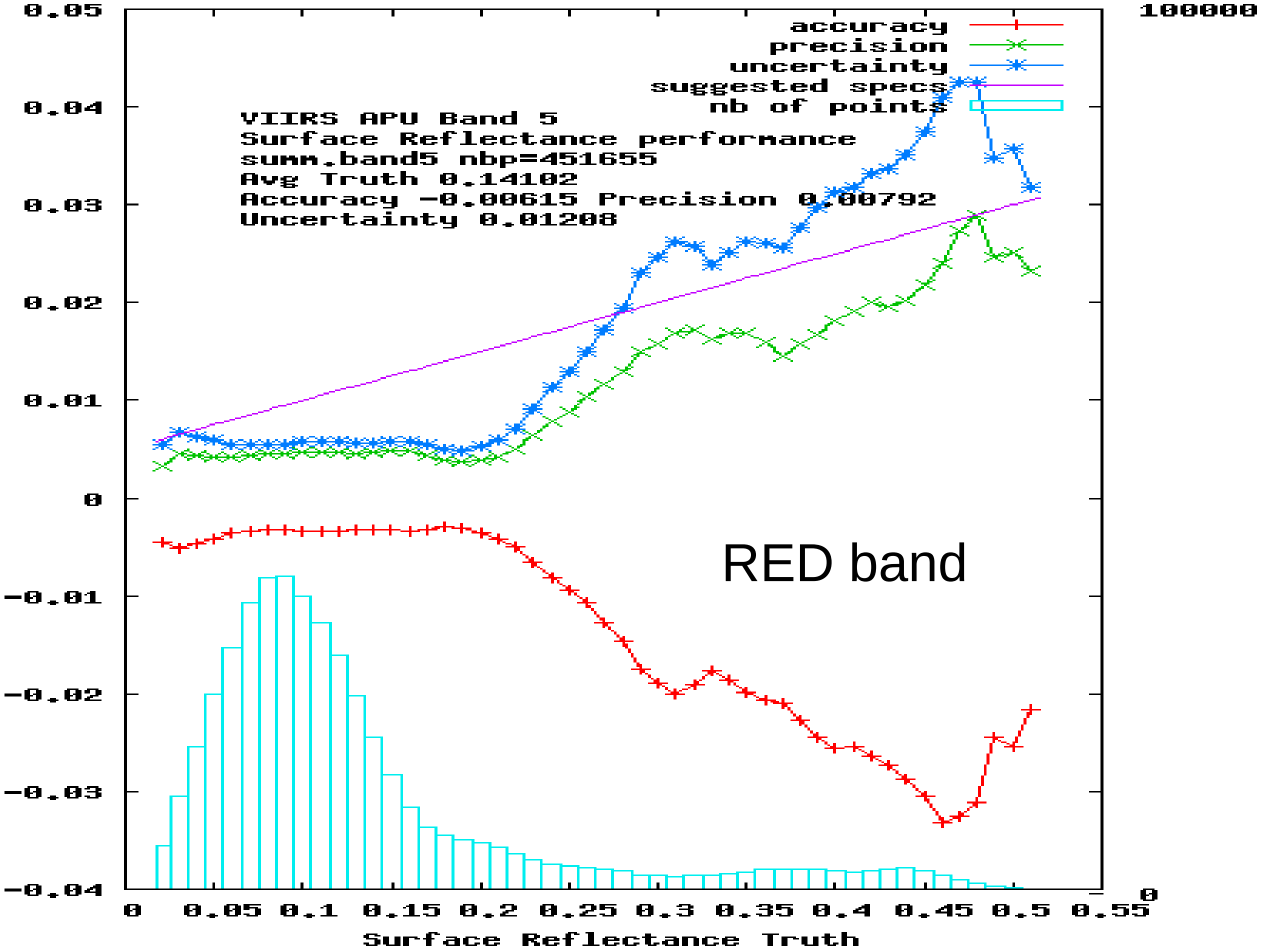
COLLECTION 6: accuracy or mean bias (red line), Precision or repeatability (green line) and Uncertainty or quadratic sum of Accuracy and Precision (blue line) of the surface reflectance in band 1 in the Red (top left), band 2 in the Near Infrared (top right also shown is the uncertainty specification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

VIIRS Surface reflectance

- the VIIRS SR product is directly heritage from collection 5 MODIS and that it has been validated to stage 1 (Land PEATE adjusted version)
- MODIS algorithm refinements from Collection 6 will be integrated into the VIIRS algorithm and shared with the NOAA JPSS project for possible inclusion in future versions of the operational product .

Evaluation of Algorithm Performance

VIIRS C11 reprocessing



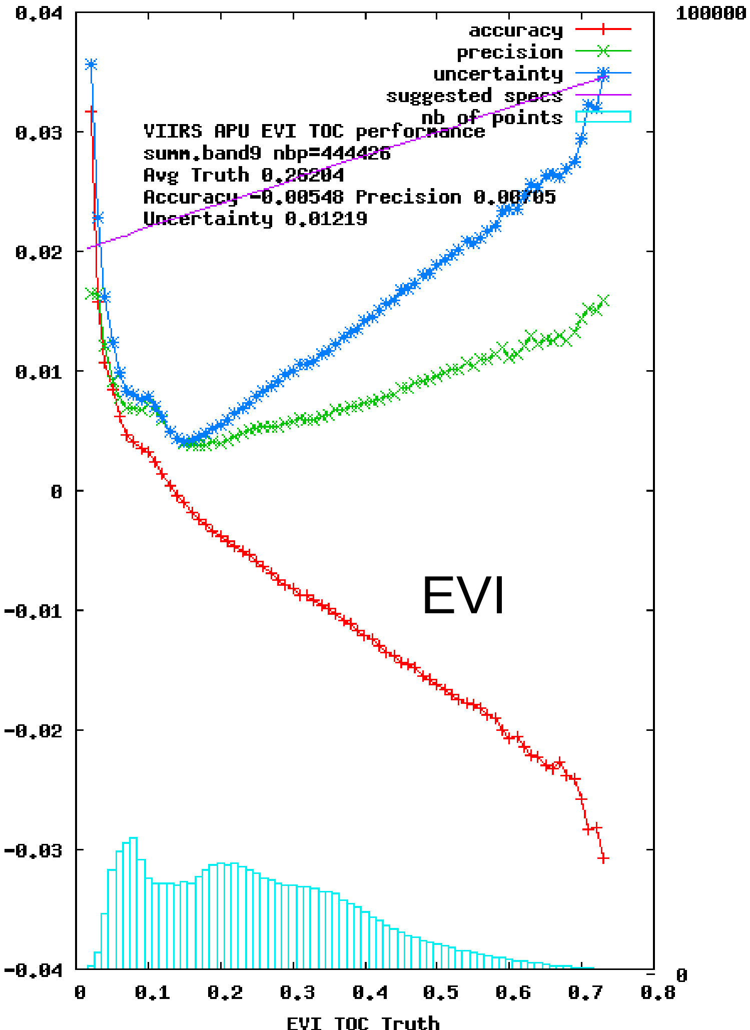
450000 pixels were analyzed for each band.

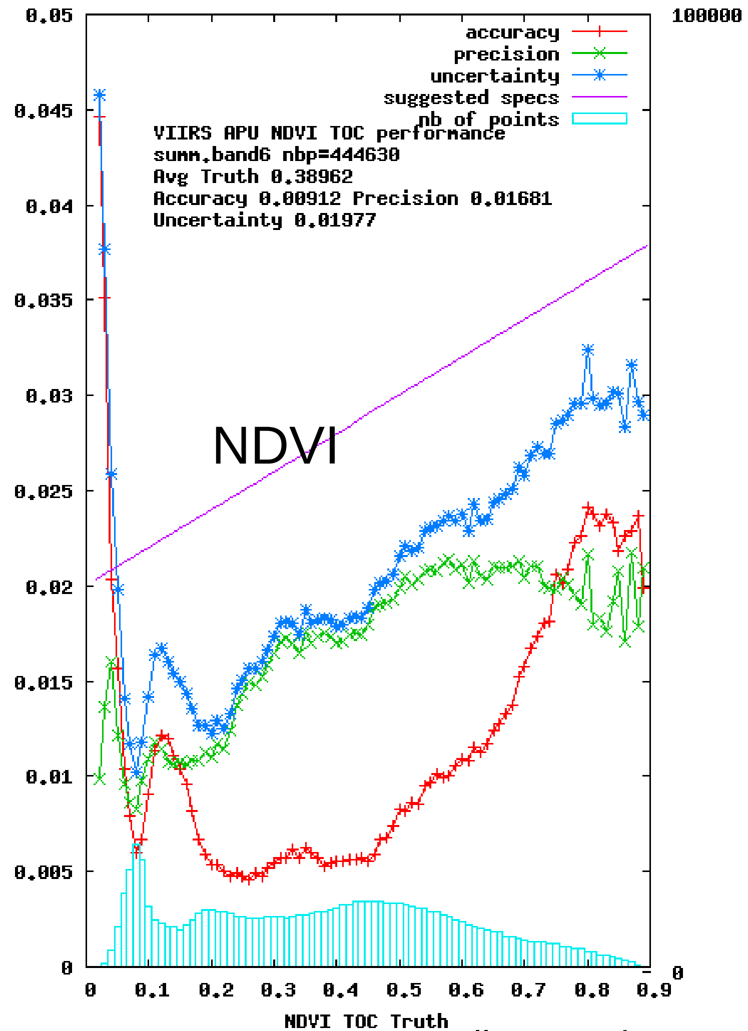
Red = Accuracy (mean bias)
Green = Precision (repeatability)
Blue = Uncertainty (quadatric sum of A and P)

On average well below magenta theoretical error bar

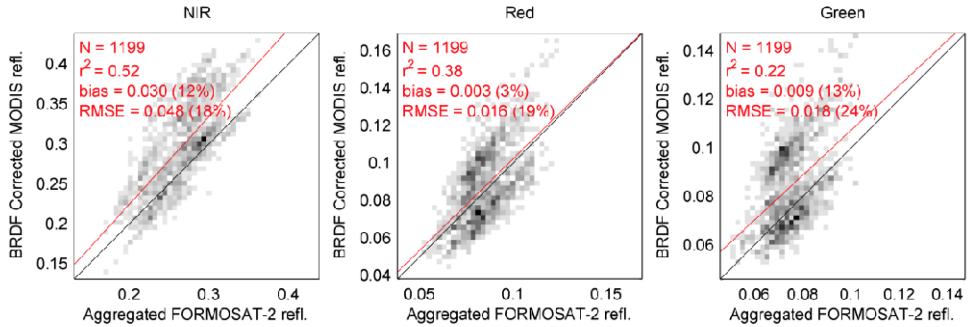
Evaluation of Algorithm Performance

VIIRS C11 reprocessing

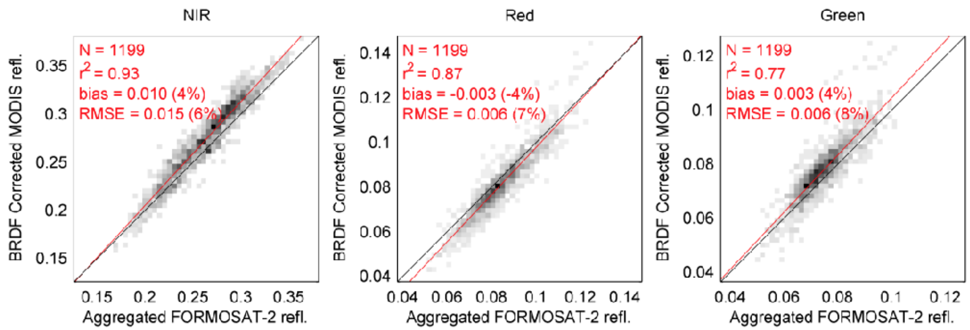




Use of BRDF correction for product cross-comparison



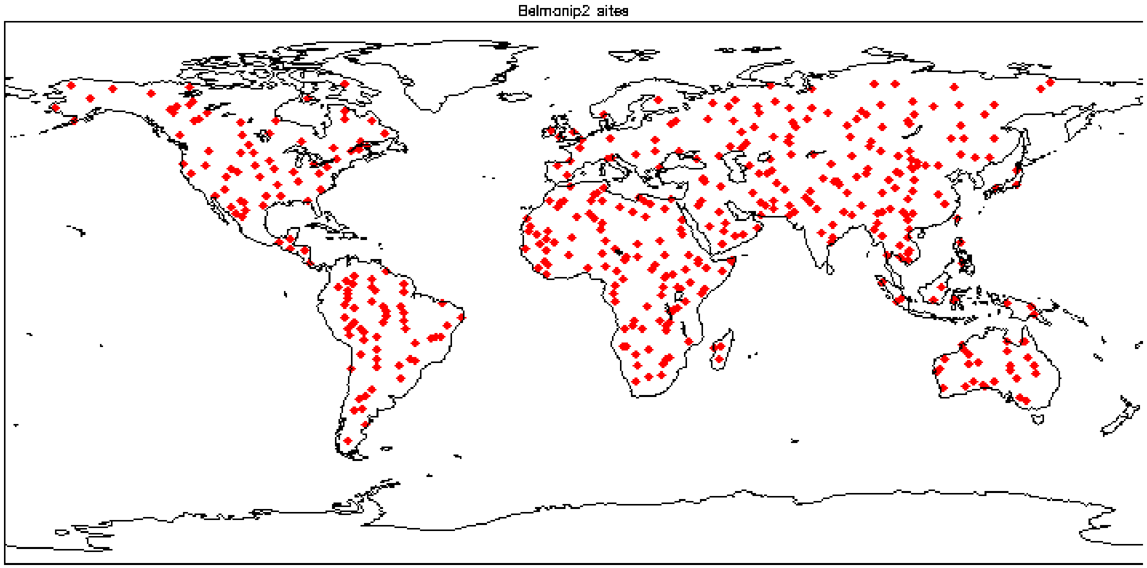
Comparison of aggregated FORMOSAT-2 reflectance and MODIS reflectance. No BRDF correction. Density function from light grey (minimum) to black (maximum); white = no data.

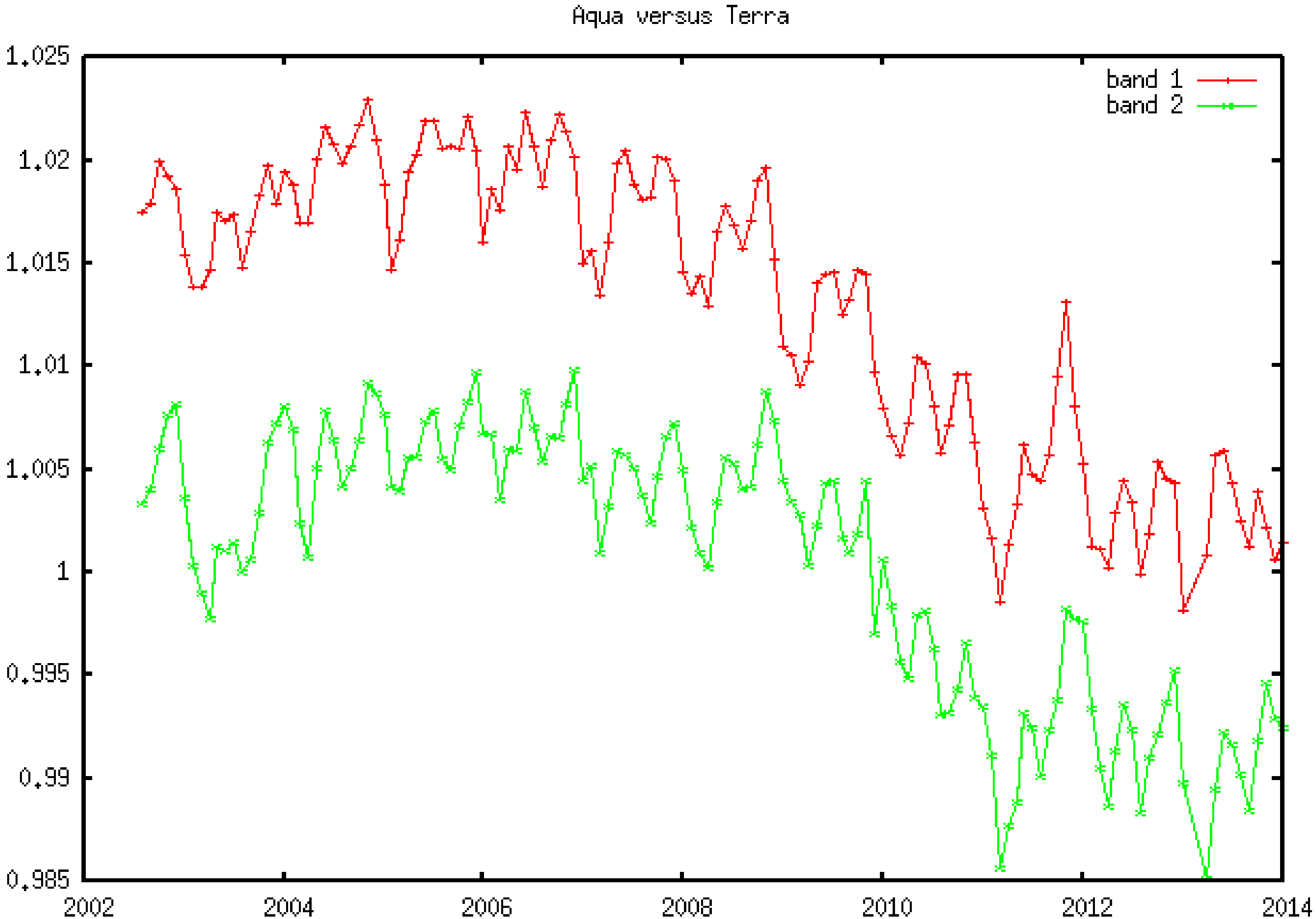


Comparison of aggregated FORMOSAT-2 reflectance and BRDF corrected MODIS reflectance. Corrections were performed with Vermote al. (2009) method using for each day of acquisition, the angular configuration of FORMOSAT-2 data.

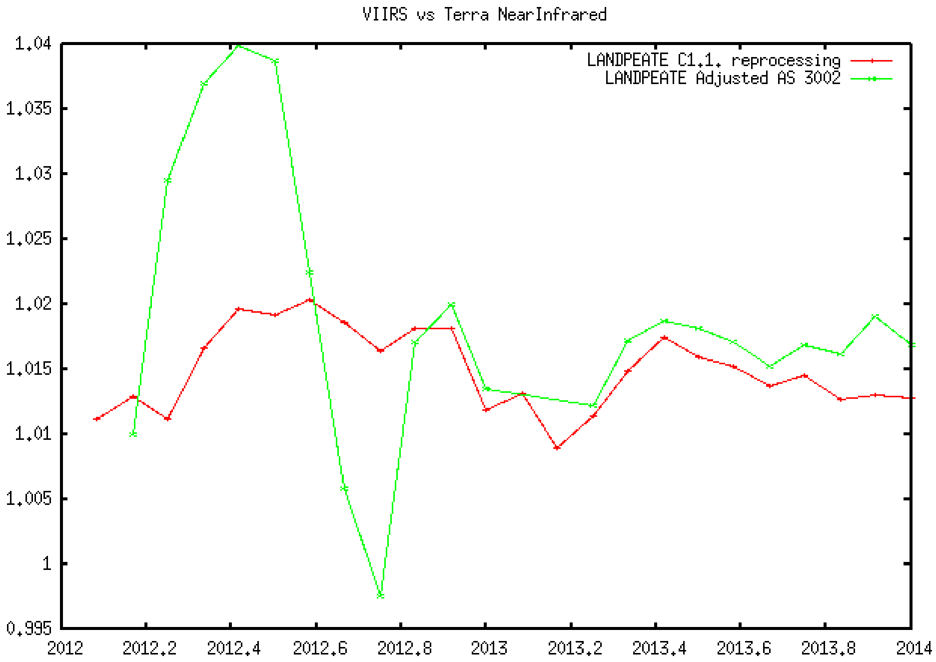
Cross comparison with MODIS over BELMANIP2

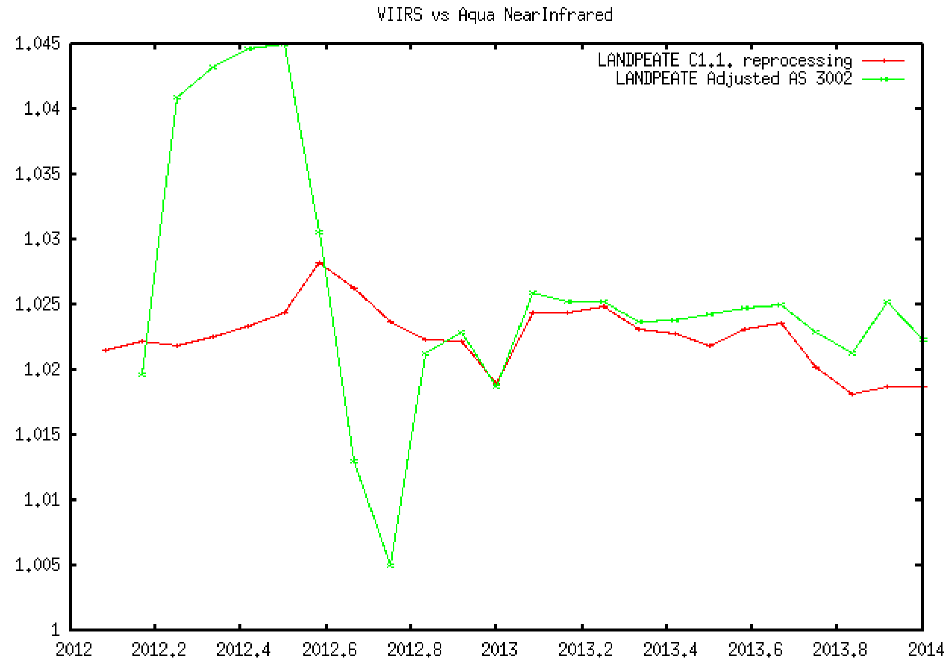
The VIIRS SR is now monitored at more than 400 sites (red losanges) through cross-comparison with MODIS.




Aqua versus Terra
band 1
band 2
1.025
1.02
1.015
1.01
1.005
1
0.995
0.99
0.985
2002
2004
2006
2008
2010
2012
2014

Results over BELMANIP2





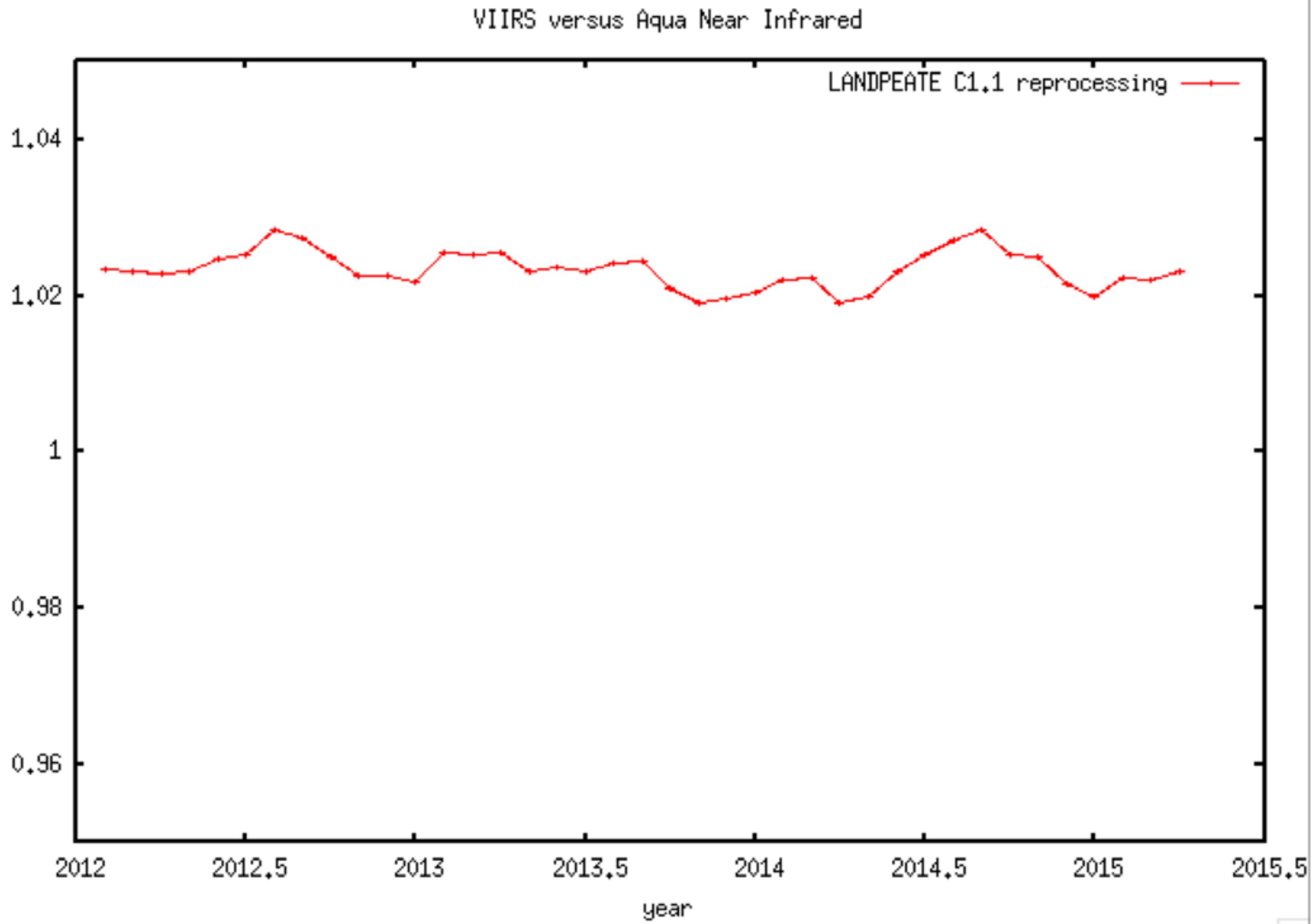


Figure 1: Cross comparison results of the VIIRS and MODIS-Aqua SR product on a monthly basis for the BELMANIP sites reprocessed version (C1.1) for the near infrared band (M7).

The need for a protocol to use of AERONET data

To correctly take into account the aerosols, we need the **aerosol microphysical properties** provided by the AERONET network including size-distribution ($\%C_f$, $\%C_c$, C_f, C_c, r_f, r_c, σ_r, σ_c), complex refractive indices and sphericity.

Over the 670 available AERONET sites, we selected **230 sites** with sufficient data.

To be useful for validation, the aerosol model should be readily available anytime, which is not usually the case.

Following *Dubovik et al.*, 2002, JAS,*[2] one can used regressions for each microphysical parameters using as parameter either τ_{550} (aot) or τ_{440} and α (*Angström* coeff.).

The protocol needs to be further agreed on and its uncertainties assessed (work in progress)

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 to be defined (CEOS CVWG initiative)

JPSS1 and SNPP VIIRS Vegetation Index Products and Algorithm Development

Marco Vargas[1], Tomoaki Miura[2]

[1]NOAA Center for Satellite Applications and Research, College Park, MD,
[2]Department of Natural Resources & Environmental Management University of Hawaii at Manoa

August 27, 2015

Outline

- Overview
  - Team Members, Product Requirements, Accomplishments
- Algorithm Evaluation
  - Algorithm Description, Validation
- JPSS1 Cal/Val Plan
- Enterprise Vegetation Index Algorithm
- NASA SNPP VIIRS Vegetation Index Products
- Future Plans
- Summary

VI EDR Team Members

- Marco Vargas (NOAA/STAR) STAR VI EDR algorithm lead
- Tomoaki Miura (University of Hawaii) VI Cal/Val lead
- Anna Kato (University of Hawaii) Product monitoring and algorithm validation
- Mahany Lindquist (University of Hawaii) Product monitoring and algorithm validation
- Leslie Belsma (Aerospace) Land JAM
- Michael Ek (NOAA/NCEP) User readiness
- Walter Wolf (NOAA/STAR) AI&T Team Lead

JPSS VI EDR Product Requirements

Table 5.5.9 - Vegetation Indices (VIIRS)		
EDR Attribute	**Threshold**	**Objective**
Vegetation Indices Applicable Conditions: 1. Clear, land (not ocean),daytime only		
a. Horizontal Cell Size	0.4 km	0.25 km
b. Mapping Uncertainty, 3 Sigma	4 km	1 km
c. Measurement Range		
1. $NDVI_{TOA}$	-1 to +1	NS
2. EVI (1)	-1 to +1	NS
3. $NDVI_{TOC}$	-1 to +1	NS
d. Measurement Accuracy - $NDVI_{TOA}$ (2)	0.05 NDVI units	0.03 NDVI units
e. Measurement Precision - $NDVI_{TOA}$ (2)	0.04 NDVI units	0.02 NDVI units
f. Measurement Accuracy - EVI (2)	0.05 EVI units	NS
g. Measurement Precision - EVI (2)	0.04 EVI units	NS
h. Measurement Accuracy - $NDVI_{TOC}$ (2)	0.05 NDVI units	NS
i. Measurement Precision - $NDVI_{TOC}$ (2)	0.04 NDVI units	NS
j. Refresh	At least 90% coverage of the globe every 24 hours (monthly average)	24 hrs.
		v2.8, 4/19/13

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

Source: Level 1 Requirements Supplement – Final Version:2.10 June 25, 2014

VI EDR Accomplishments

- Validated Stage 1 Maturity approved by AERB in April 2015
- JPSS1 Algorithm Development (J1 Upper)
  - Completed the development of TOC NDVI
  - CCR-15-2382 approved by AERB in July 2015
- Delivered JPSS1 Cal/Val plan
- Started planning for Vegetation Index Enterprise Algorithm
- Started LTM activities
- New publication

Shabanov, N., M. Vargas, T. Miura, A. Sei, and A. Danial (2015), Evaluation of the performance of Suomi NPP VIIRS top of canopy vegetation indices over AERONET sites, Remote Sensing of Environment pp. 29-44, doi:10.1016/j.rse.2015.02.004.

SNPP/JPSS Vegetation Index EDR

- The Vegetation Index EDR consists of three vegetation indices:
  1. Normalized Difference Vegetation Index ($NDVI^{TOA}$) from top-of-atmosphere (TOA) reflectances
  2. Enhanced Vegetation Index (EVI^{TOC}) from top of canopy (TOC) reflectances.
  3. New for JPSS1 (J1 "Upper") Normalized Difference Vegetation Index ($NDVI^{TOC}$) from top of canopy (TOC) reflectances
- These indices are produced at the VIIRS image channel resolution (375 m at nadir) over land in granule style (swath form)
- File format: HDF5

VI EDR Algorithm

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

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

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

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

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

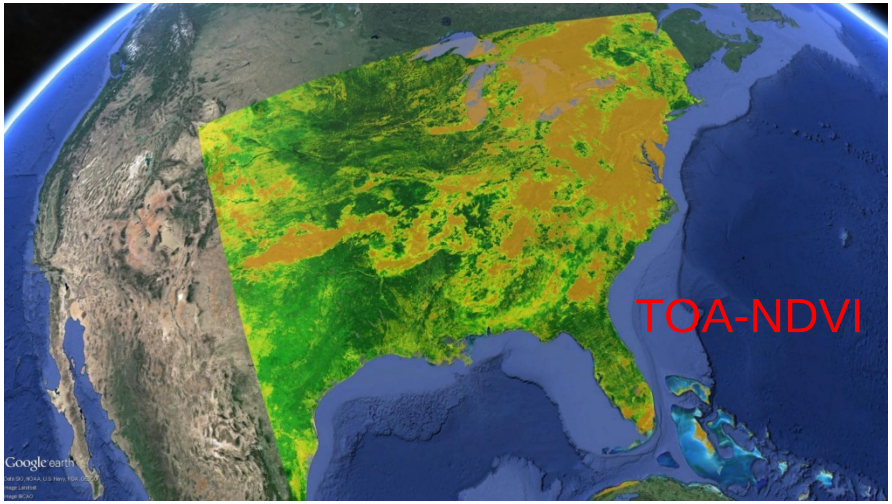
ρ_{I2}^{TOC} Surface reflectance band I2 (865 nm)

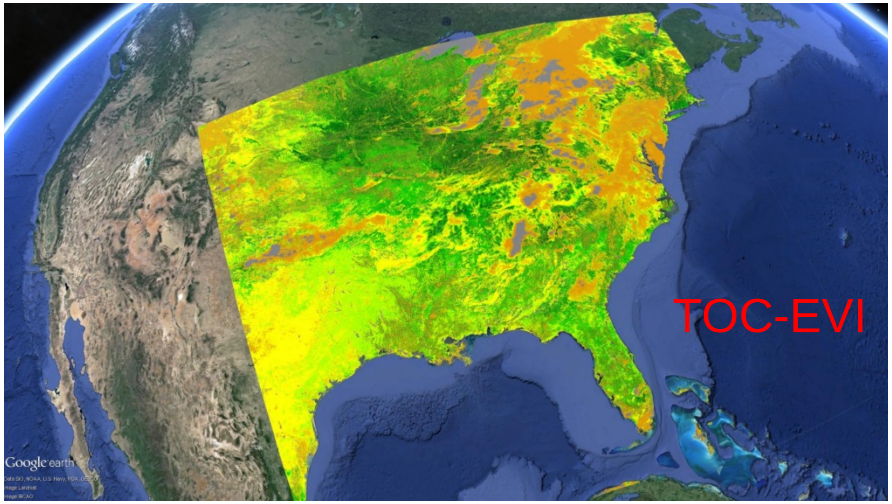
ρ_{I1}^{TOA} Top of the atmosphere reflectance band I1 (640 nm)

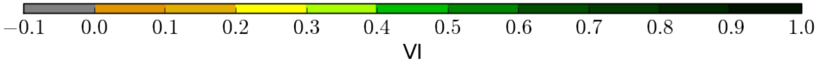
ρ_{I2}^{TOA} Top of the atmosphere reflectance band I2 (865 nm)

C_1, C_2 and L are constants

VI-EDR August 10, 2015

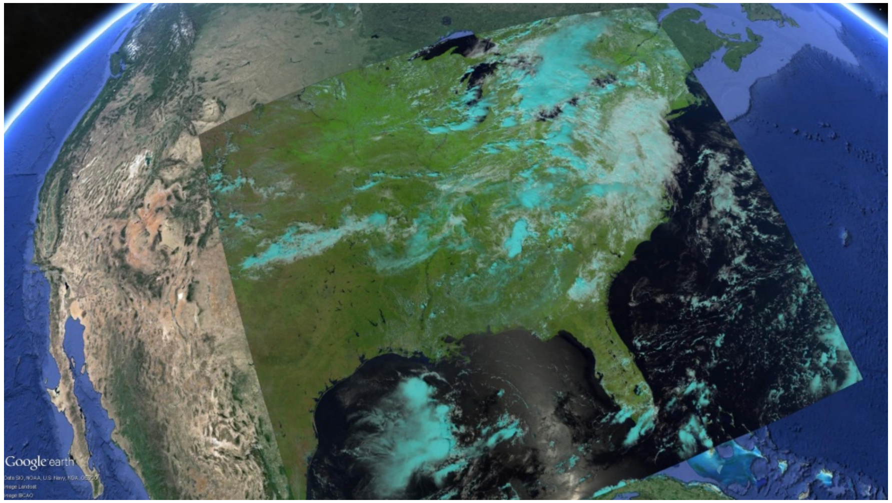






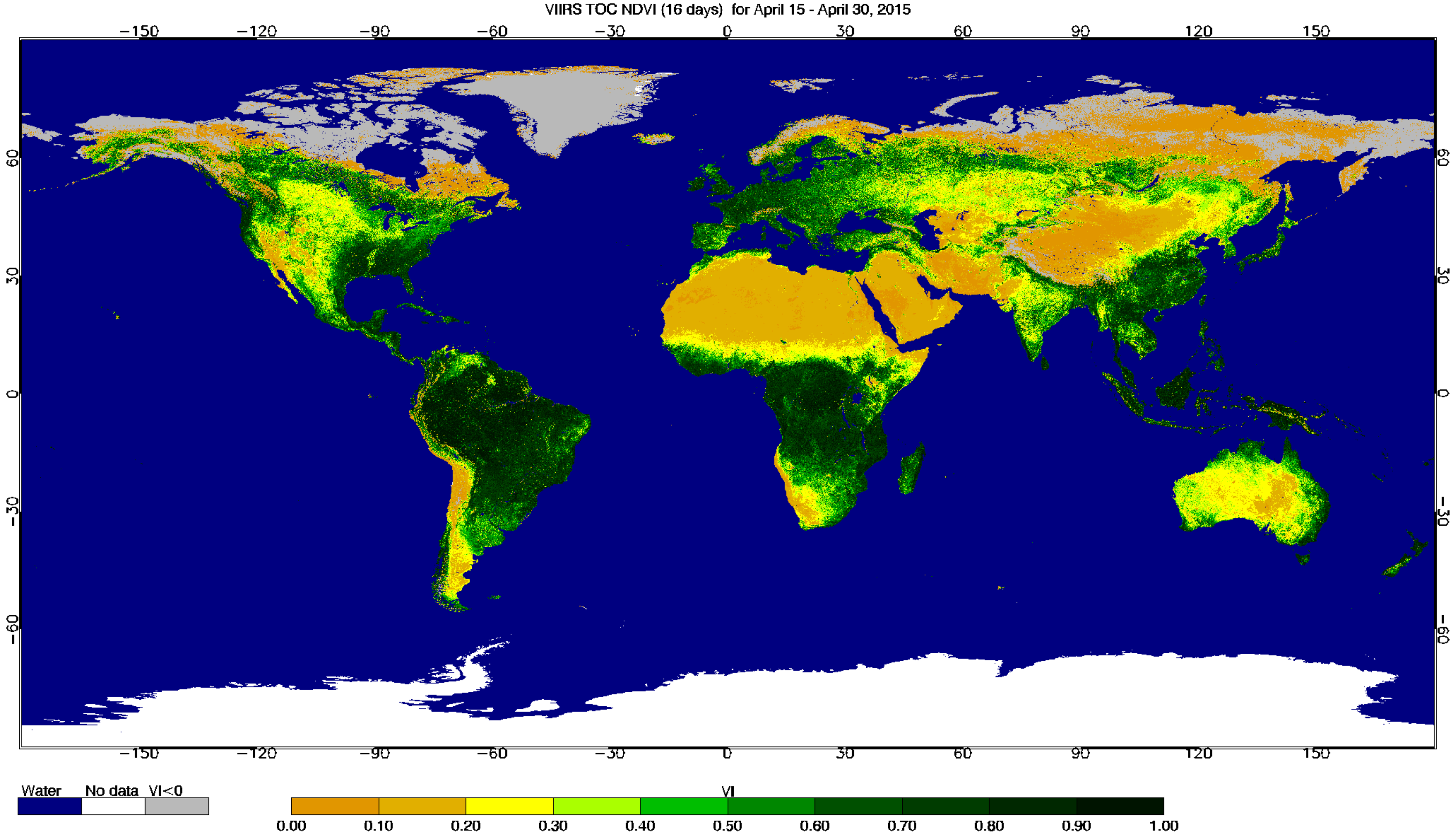
5 merged SNPP VIIRS VIVIO Granules

timestamp d20150810_t1844472
timestamp d20150810_t1846126
timestamp d20150810_t1847380
timestamp d20150810_t1849034
timestamp d20150810_t1850288



RGB (I1, I2 and I3 Imagery EDR bands)

TOC-NDVI
16-day composite



SNPP VIIRS Vegetation Index EDR Current Status

SNPP VI EDR Maturity: Validated Stage 1

Validation activities

1) Global comparisons with Aqua MODIS
2) Evaluation over AERONET sites
3) Time series validation over FLUXNET sites

Instrument/product quality

- High radiometric quality, meeting the L1RDS requirements

VI algorithm issues

- Unrealistic EVI for snow/ice or cloud-contaminated pixels

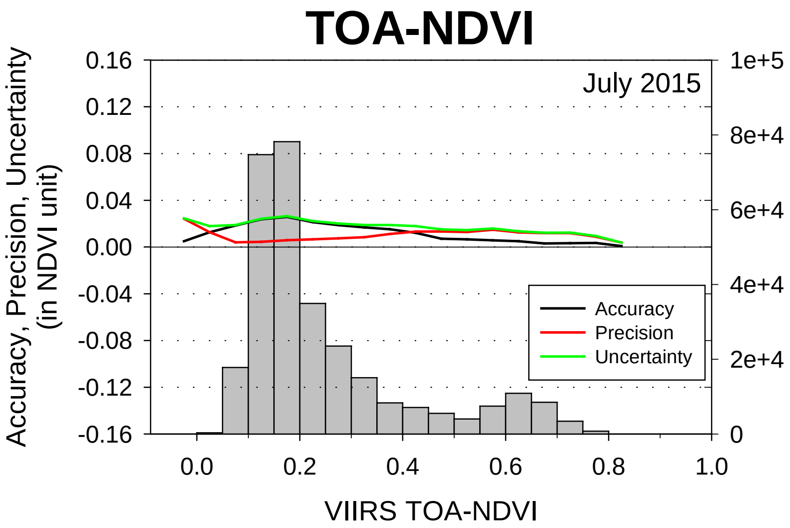
Long Term Monitoring (LTM)

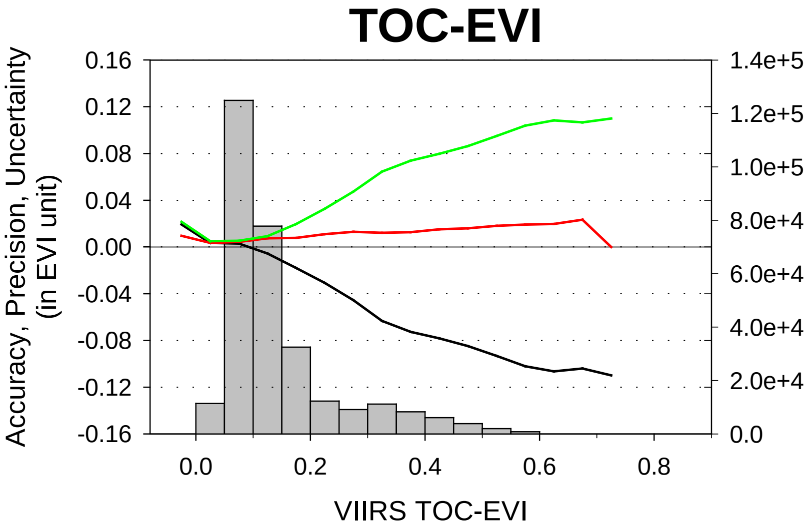
- Ongoing

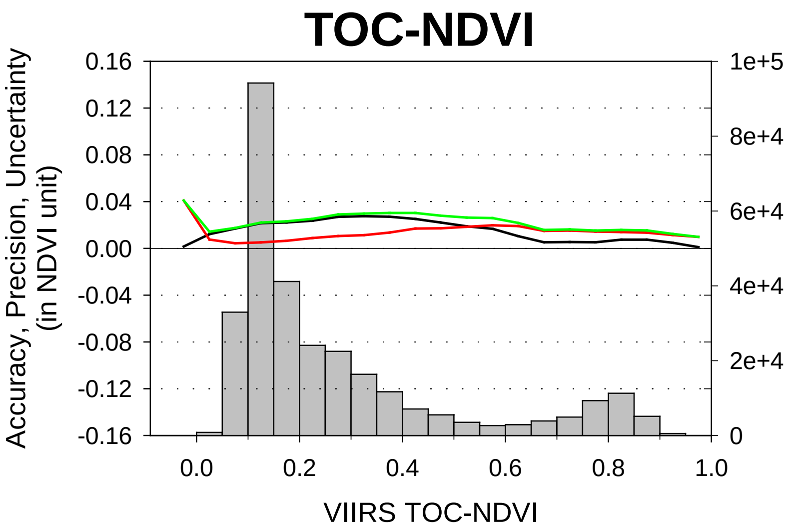
Global APU Estimates (2014 - 2015)

Attribute	L1RDS Threshold (VI units)	Validation Results
TOA NDVI Accuracy	0.05	0.005
TOA NDVI Precision	0.04	0.017
TOA NDVI Uncertainty	0.06	0.020
TOC EVI Accuracy	0.05	0.037
TOC EVI Precision	0.04	0.011
TOC EVI Uncertainty	0.06	0.039
TOC NDVI Accuracy	0.05	0.007
TOC NDVI Precision	0.04	0.023
TOC NDVI Uncertainty	0.06	0.025

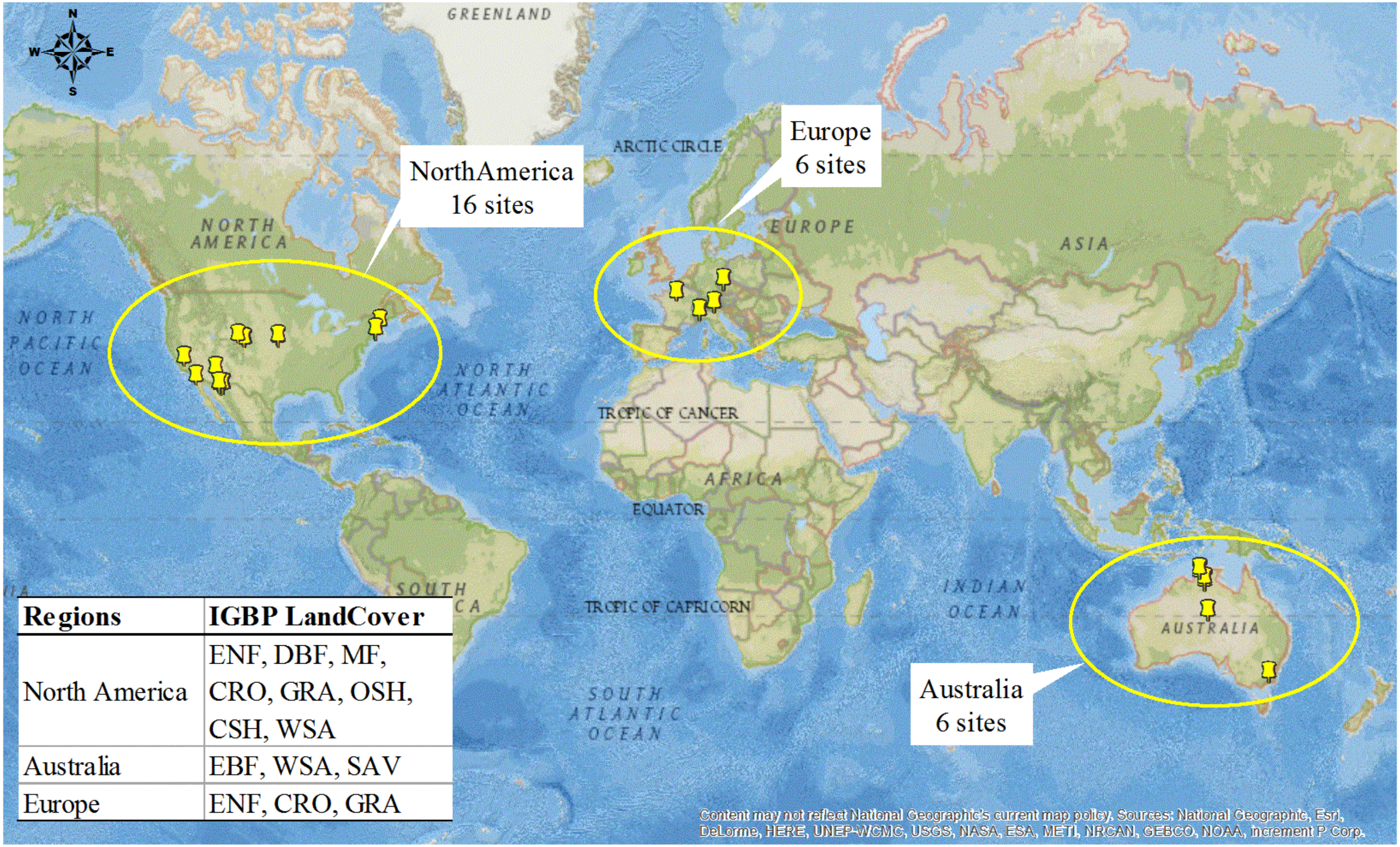
VIIRS Veg. Index EDR Global APU (Aqua MODIS as Reference) July 2015







VIIRS Vegetation Index EDR Temporal Profile Evaluation



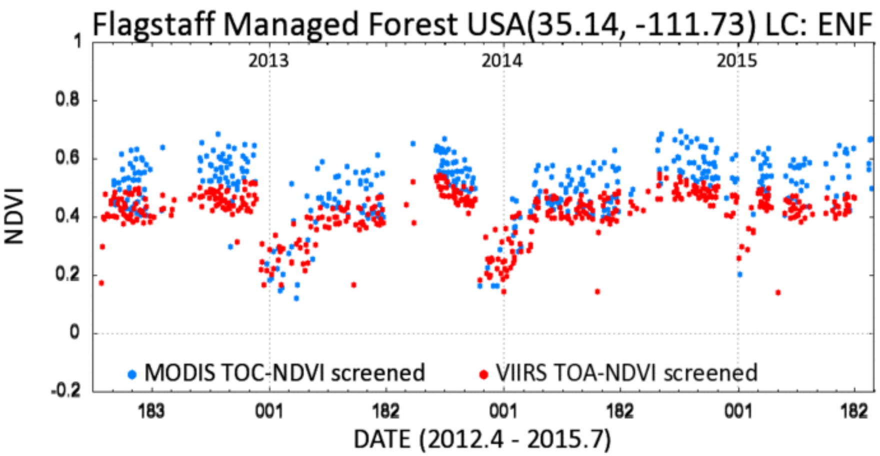
Regions	IGBP LandCover
North America	ENF, DBF, MF, CRO, GRA, OSH, CSH, WSA
Australia	EBF, WSA, SAV
Europe	ENF, CRO, GRA

Validation sites

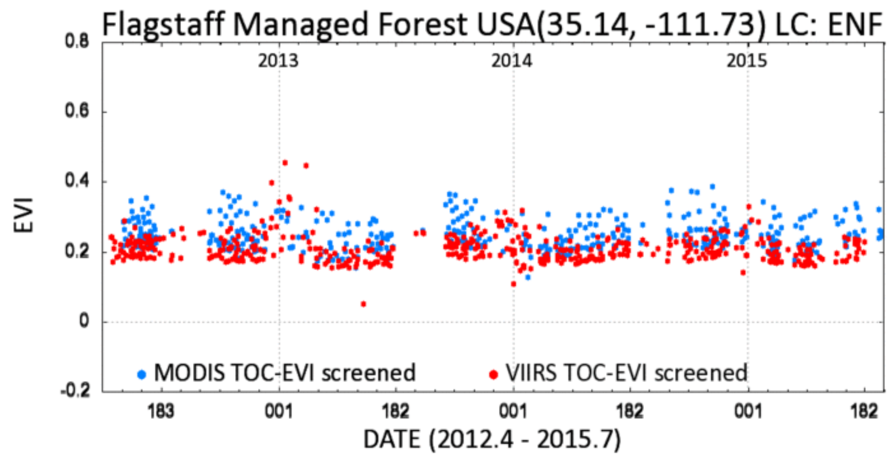
VIIRS Vegetation Index EDR Temporal Profile Evaluation

Red – VIIRS, Blue - MODIS

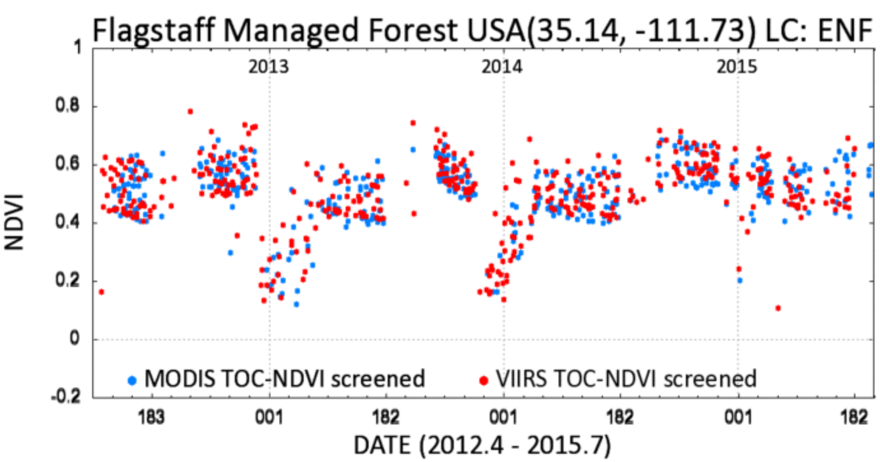
TOA NDVI



TOC EVI

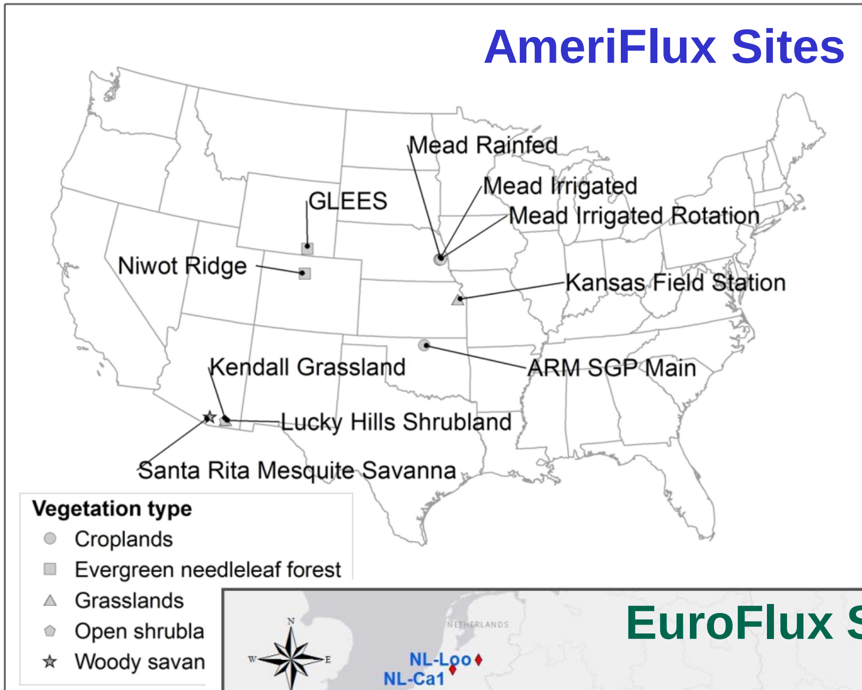


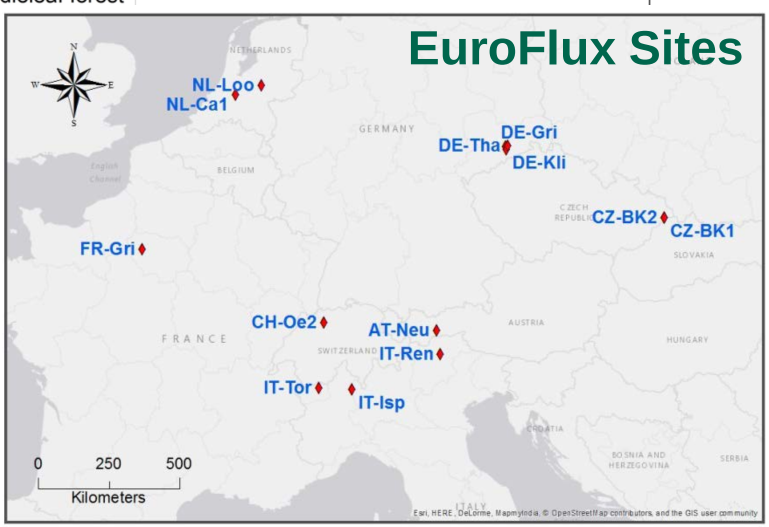
TOC NDVI



- VIIRS temporal profiles show matching seasonal changes with those of MODIS over CONUS, Europe, & Australia, e.g.,
  - Timing & length of peak growing period
  - Multiple growing periods
  - Interannual variations in seasonal changes
- VIIRS daily time series show secondary variations associated with variable Sun/view geometries among observations.

VIIRS Veg. Index Validation Using FLUXNET Radiation Flux Data

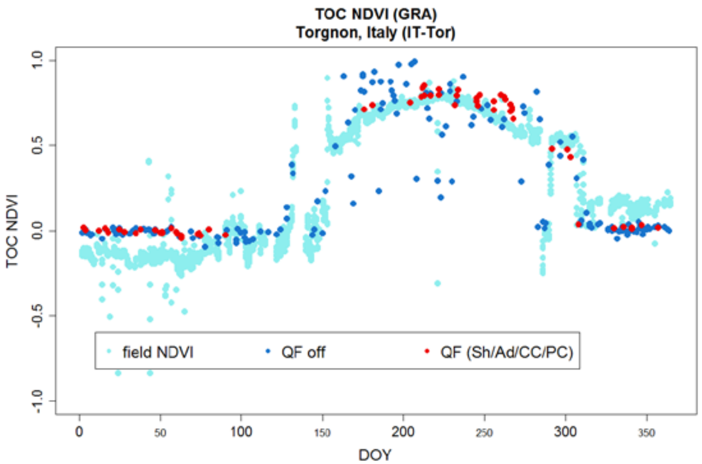


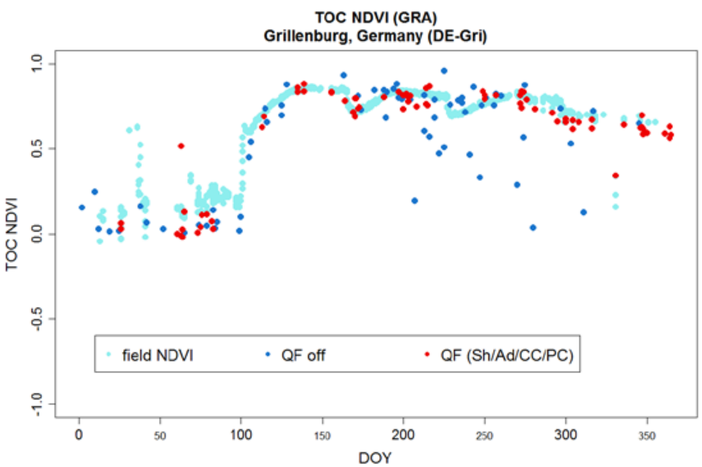


- FLUXNET sites
  - Spatial extent and homogeneity comparable to VIIRS pixels
  - Continuous PAR & global radiation measurements available
- High-temporal resolution NDVI and EVI2 (2-band EVI) time series
  - Computed from PAR & global radiation data (Wilson & Meyers 2007)
  - Cloudy observations removed (using precipitation and incoming global radiation data)

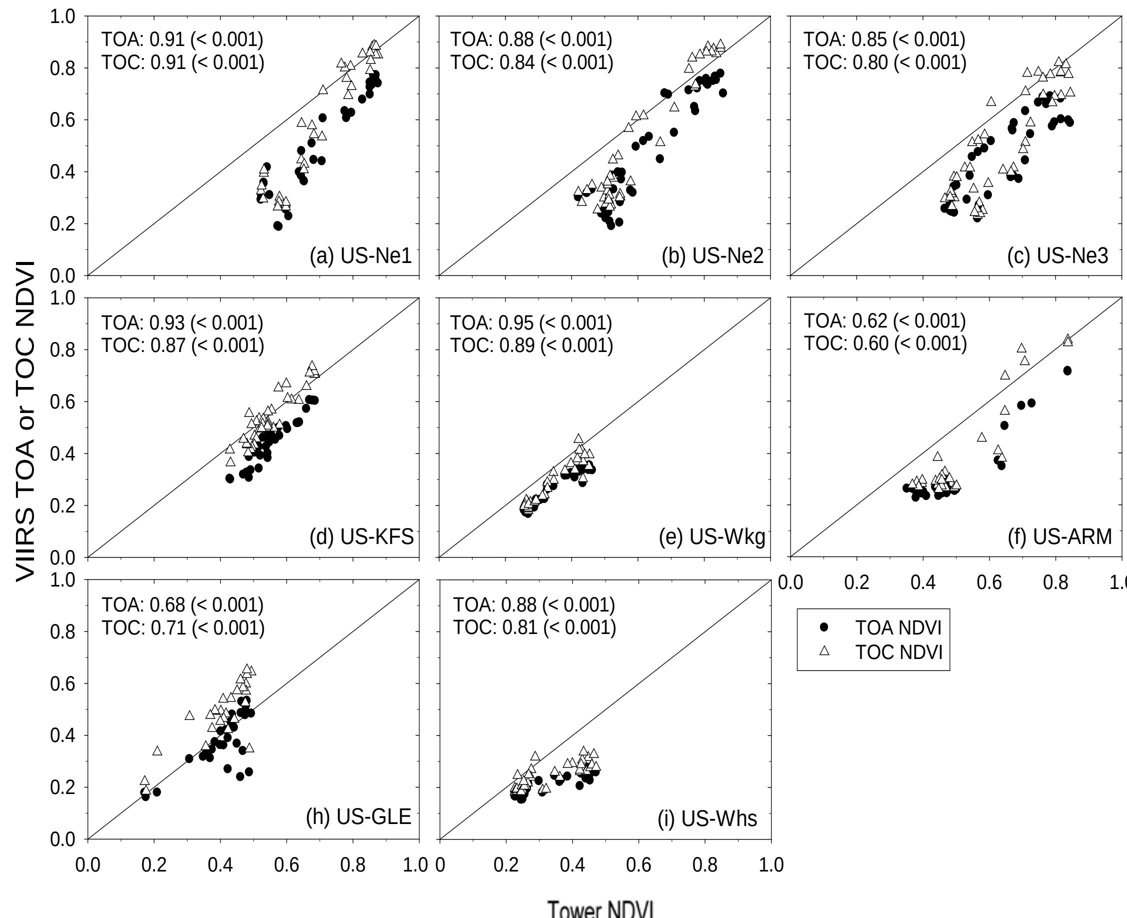
VIIRS Veg. Index Validation Using FLUXNET Radiation Flux Data

TOC NDVI: Sample Time Series
- *EuroFlux* -





VIIRS vs. Tower NDVI Cross-plots
- *AmeriFlux* -



JPSS1 VI EDR Cal/Val Plan

- **JPSS1 VI EDR will be validated by cross-comparisons with:**
  (1) data and products from other sensors (S-NPP VIIRS, MODIS, Landsat 8)
  (2) in situ data from observation networks (AERONET, FLUXNET)
  (3) independently-obtained climate datasets and analysis of process model results (FLUXNET)
- **APUs will be calculated periodically and plotted in time series to assure long-term consistency of the JPSS1 VI EDR**
- **Anticipated data needs for future validation**
  - MODIS, SNPP, FLUXNET, AERONET
- **VI EDR Cal/Val Tools**
  - VDDT, Time Series Analysis Tool, APU Tool, VIIRS Matchup Tool, VI Monitor, VI Phenological Metrics Tool, VI Cross-Comparison Tool
- **Schedule and Milestones** (based on availability of JPSS1 VIIRS VI products no later than March 2017)
  - Beta: October 2017 (VIIRS SDR Beta + 3 months)
  - Provisional: April 2018 (Beta + 6 months)
  - Validated: April 2019 (Provisional + 12 months)

NESDIS Enterprise Algorithms & NESDIS Ground Enterprise Architecture System (GEARS)

- NESDIS embarked in the Strengthening NESDIS initiative to reduce the cost of development, implementation, transition to operations, maintenance and sustainment of the NESDIS ground system
- NESDIS is transitioning to the Ground Enterprise Architecture System (GEARS)
- A new organization, the Office of Satellite Ground Services (OSGS), will consolidate the development and sustainment of all NESDIS ground systems

NESDIS Enterprise Algorithms

Definition: An Enterprise Algorithm is defined as an algorithm that uses the same scientific methodology and software base to create the same product from differing input data (satellite, in-situ or ancillary)

Motivation:

- Brings continuity of NOAA products between current and future NOAA operational satellites
- Cost effective processing for NOAA products
- Maintenance of fewer algorithms and systems within operations

Benefits: One set of algorithms will:

- Satisfy differing program requirements (latency, accuracy, resolution, etc)
- Reduce redundant software development and O&M costs
- Consistent science for data assimilation; fused products; enhanced products; and climate records

STAR Enterprise Algorithms

- **<u>VI EDR is a priority 4 product</u>**
- For JPSS Priority 3 and 4 products, JPSS STAR has been directed by NJO to:
  - Stop working on the NPOESS-heritage algorithms running in IDPS
  - Defer implementation of the algorithm change packages related to priority 3 and 4 products; only with exceptions with the changes that will impact the current operational users of those products
  - Continue work on enterprise science algorithms for all the JPSS Priority 3 and 4 EDR products

Enterprise Algorithm Assessment VI and GVF Products

Product	VIIRS	ABI	GOES	AVHRR	MODIS	Users
VI (NDVI, EVI)	O	F		O	O*	NWS
GVF	O	F				NWS

O – operational, F – future capability, *MODIS production at NASA

Path Forward for Enterprise Solution:

- TOA NDVI from AVHRR; VIIRS also has TOC EVI and TOC NDVI; AVHRR has a Level 3 (L3) product; No official L3 product for VIIRS NDVI or EVI
- GVF in NDE is a L3 product. Calculates its own EVI, same formula as JPSS EVI.
- A L3 suite of products for NDVI, TOC EVI, TOC NDVI and GVF are needed (GVF already in production)
- Need to align requirements across satellites, standardize the requirements
- LAI and FPAR products are also needed. (Users require composite products)
- GOES-R has NDVI and GVF but Option 2 and not operational
- Want GOES-R GVF to be like VIIRS GVF; NDVI is the same for both
- Need to have follow on meetings for VIIRS and GOES-R algorithm path
- Want all land products to use the same Grid and mapping tools. NCEP's stated requirement is 1km global grid
- Move towards NDE and SPSRB (Not use the IDPS deliveries and processes)
- Enterprise NDVI should be TOC NDVI
- NDVI is used for Vegetation Health product but it currently calculates NDVI separately from reflectance
- Possible addition of Sentinel-3 data (gap filler)

NASA SNPP VIIRS Vegetation Products

- NASA has funded a Science Team to produce Earth System Data Records From Suomi NPP (funded by NASA ROSES-13)
- NASA SNPP VI Team is generating Vegetation Index products from SNPP VIIRS extending the EOS-MODIS VI record
- NASA SNPP VIIRS VI Products: NDVI, EVI, EVI2 (Level 3 products for MODIS continuity at all resolutions)
- NASA is reprocessing the entire VIIRS SDR record
- NASA SNPP VIIRS VI products scheduled for archiving and distribution at the Land Processes Distributed Active Archive Center (LP DAAC) starting in April 2016
- STAR VI EDR Team Members Vargas and Miura have met with Kamel Didan (PI for the NASA VIIRS VI product suite) to coordinate efforts to make a successful Algorithm/Product suite for both science (NASA) and operations/applications (NASA/NOAA)

Future Plans

- Support JPSS1 Pre-launch and Post-launch Cal/Val activities
- Continue LTM, anomaly resolution, and reactive maintenance of the SNPP Vegetation index EDR
- Develop Level 3 Vegetation Index products
- Support the STAR/JPSS Enterprise Algorithm development effort

Summary

- The SNPP VIIRS Vegetation Index EDR operational product is stable and performing well
- VI Team ready to support JPSS1 pre-launch activities
- The SNPP VI EDR LTM phase is ongoing
- The JPSS1 VIIRS VI EDR algorithm development has been completed
- JPSS1 Cal/Val plan developed
- Vegetation Index Enterprise Algorithm in planning stage

For more information on VIIRS Vegetation Index EDR

- STAR JPSS

http://www.star.nesdis.noaa.gov/jpss/

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

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

- NOAA JPSS

http://www.jpss.noaa.gov/

- NOAA CLASS

http://www.nsof.class.noaa.gov/

- NASA

http://viirsland.gsfc.nasa.gov/Products/VIEDR.html

JPSS1 and SNPP VIIRS
Green Vegetation Fraction (GVF)

Marco Vargas[1], Zhangyan Jiang[2]

[1]NOAA Center for Satellite Applications and Research, College Park, MD,
[2]AER, College Park, MD

GVF Team Members

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

GVF Users

- NCEP/EMC
- CLASS
- NASA/SPoRT

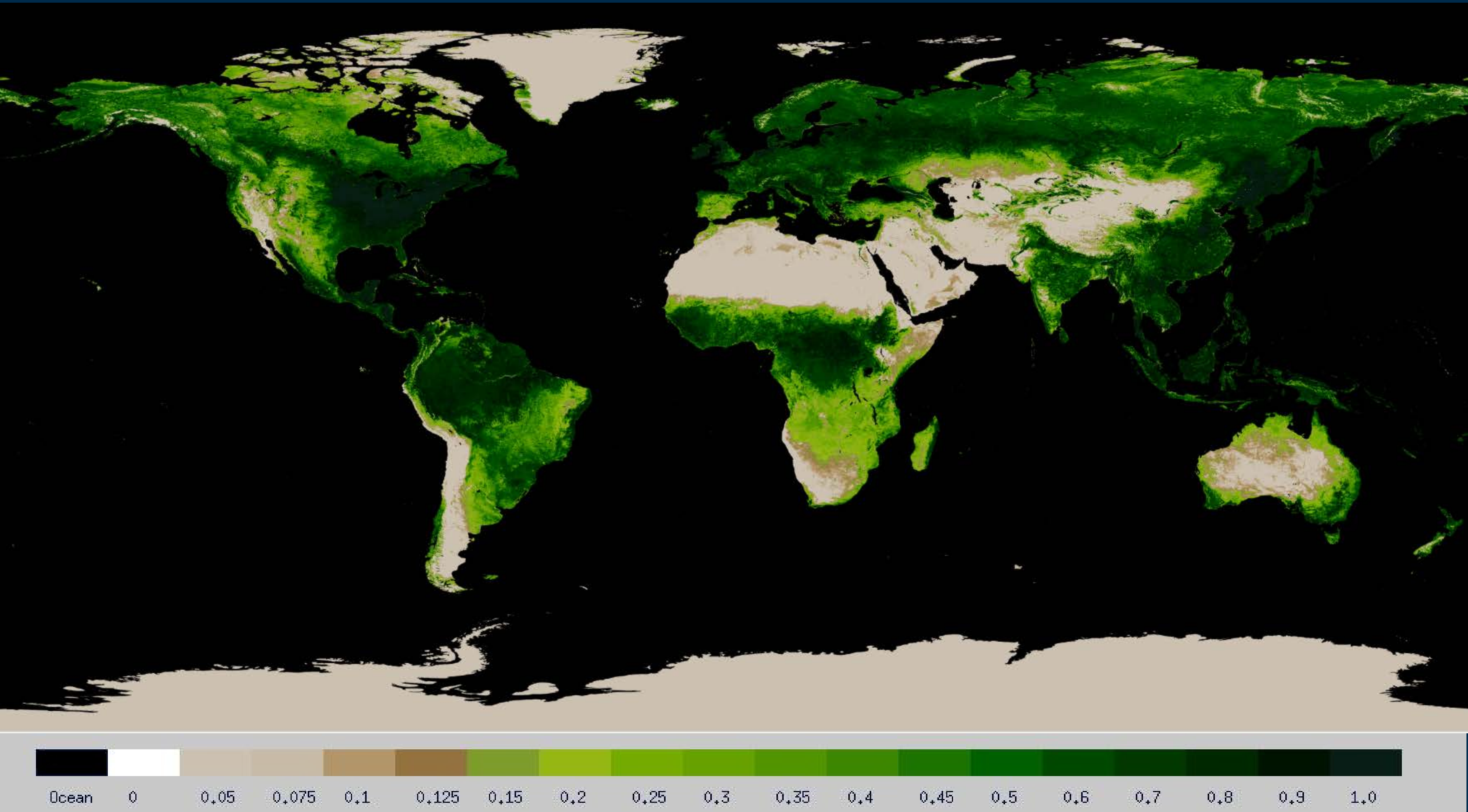
FY14-15 Accomplishments

- Delivered SNPP VIIRS GVF LINUX DAP to NDE (May 2014)
- Supported the NDE IPT team to during the integration, testing and pre-operational phase of the GVF system
- Briefed the VIIRS GVF product at the monthly SPSRB meeting for an operational decision in Sep, 2014
- The GVF product became operational within the Suomi NPP Data Exploitation (NDE) production facility in February 2015
- Started collaboration with NWS/NCEP to demonstrate that using the VIIRS GVF operational product instead of the AVHRR climatology will improve the performance of NOAA's environmental prediction suite

SNPP VIIRS GVF Product

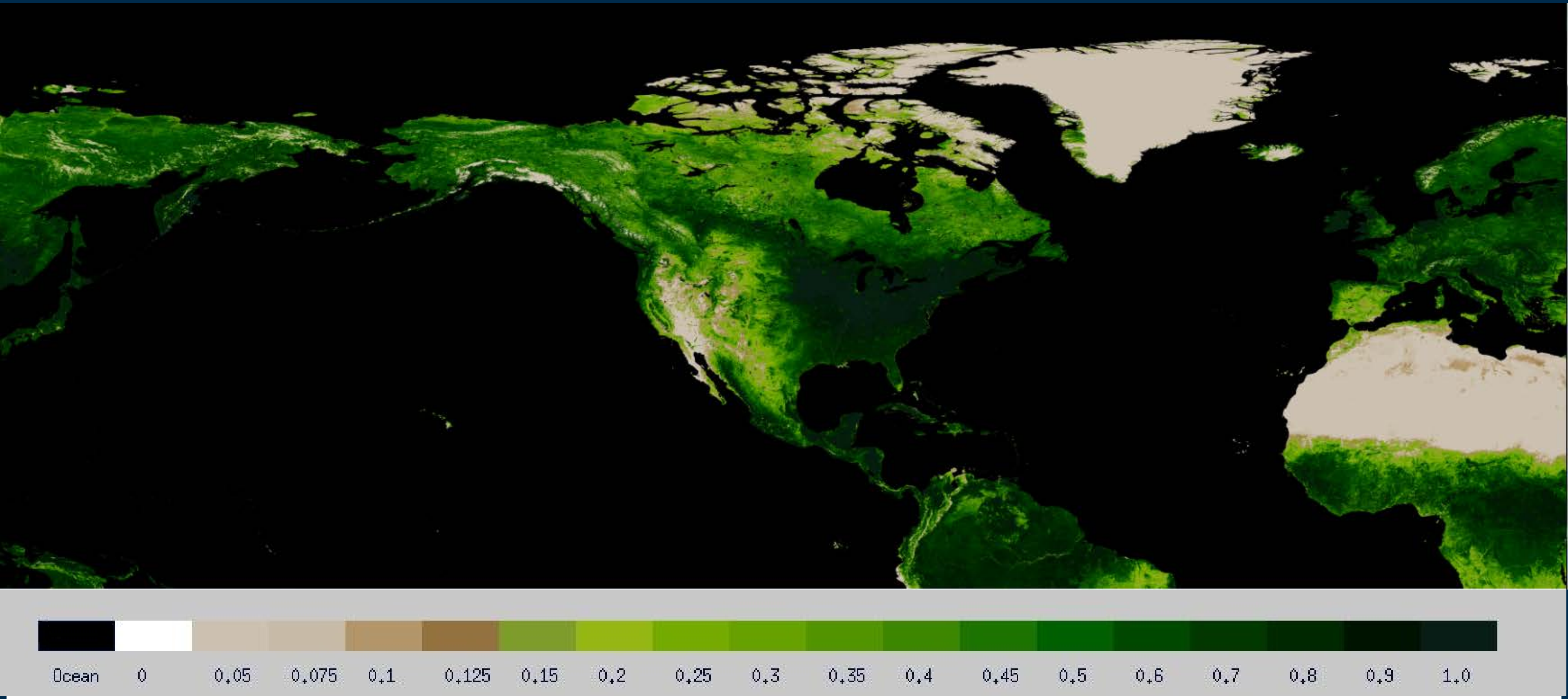
- The SNPP VIIRS GVF consists of two products:
  1) Daily Rolling Weekly GVF global (4-km resolution)
  2) Daily Rolling Weekly GVF regional (1-km resolution)
- SNPP VIIRS GVF products are derived from VIIRS surface reflectance data (Bands I1, I2 and M3)
- Surface reflectance data are gridded, composited and used for calculating the Enhanced Vegetation Index (EVI)
- GVF is derived from EVI

SNPP VIIRS GVF Global (4km res)



4km resolution weekly global GVF (August 18-24, 2015)

SNPP VIIRS GVF
Regional Product (1km res)

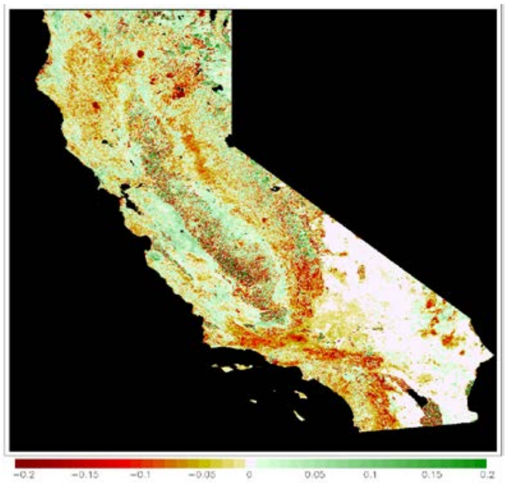


1km resolution weekly regional GVF (August 18-24, 2015). Coverage Lat 90°N - 7.5°S, Lon 130°E - 30°E

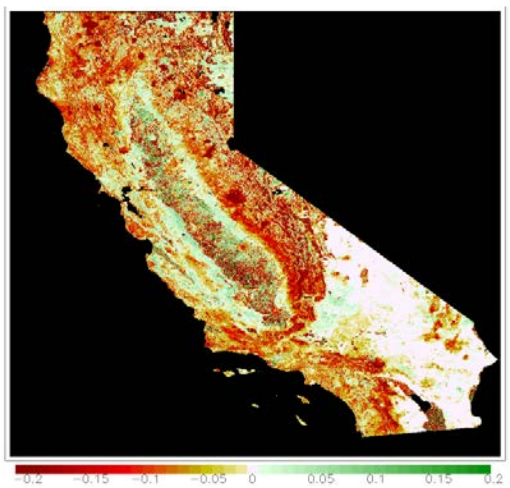
Monitoring Drought in California With SNPP VIIRS GVF

- California has been experiencing a severe drought since 2012
- Drought conditions develop gradually and they are often not identifiable immediately
- VIIRS Green Vegetation Fraction (GVF) can easily monitor changes in vegetation density

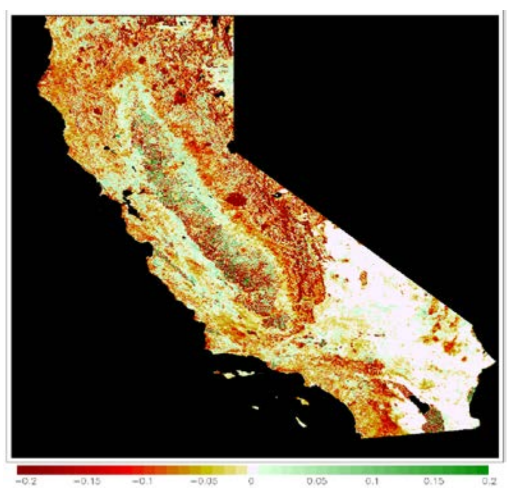
2013-08-15 minus 2012-08-15



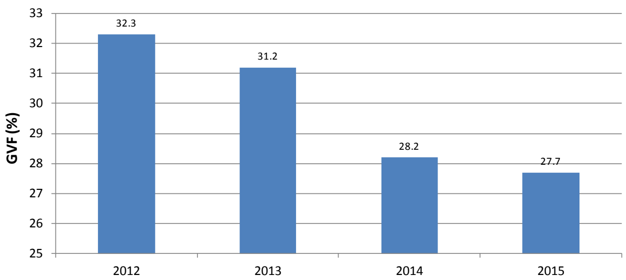
2015-08-15 minus 2012-08-15



2014-08-15 minus 2012-08-15



California mean GVF



California mean GVF in August decreased from 32.3% in 2012 to 27.7% in 2015

SNPP VIIRS GVF Validation

SNPP VIIRS GVF product Validation

- GVF product maturity: Provisional
- The SNPP VIIRS GVF pre-operational product was shown to meet the threshold performance attributes identified in the JPSS Level 1 Requirements Supplement
- SNPP VIIRS GVF pre-operational product was validated against Landsat derived GVF, and compared with AVHRR derived GVF
- Time series stability monitoring

Attribute Analyzed	L1RD Threshold	VIIRS GVF
Measurement accuracy		
1. Global	12%	7.9%
2. Regional	12%	6.5%
Measurement precision		
1. Global	15%	10.9%
2. Regional	15%	12.6%
Measurement uncertainty		
1. Global	17%	13.4%
2. Regional	17%	14.2%

Path Forward towards JPSS1

- Provide VIIRS GVF continuity and upgrades for JPSS1
  - Project Plan to produce the JPSS1 VIIRS GVF
  - GVF Algorithm update/development for JPSS1
  - SNPP/JPSS1 VIIRS GVF Compatibility assessment
- Anticipated data needs for future validation
  - SNPP VIIRS GVF, AVHRR GVF, Landsat GVF
- Product Validation
  - Deliver Cal/Val plan for the JPSS1 VIIRS GVF product

Future Plans

- Advance the SNPP VIIRS GVF to validated maturity
- Continue providing SNPP VIIRS GVF algorithm maintenance and product anomaly resolution
- Develop SNPP VIIRS GVF climatology
- JPSS1 VIIRS GVF algorithm development
- Develop GVF enterprise algorithm

Summary

- The SNPP VIIRS GVF operational product is stable and performing well
- Working with NCEP to improve the use of the operational GVF product in their land modeling suite
- JPSS1 VIIRS GVF Project Plan has been written
- GVF Enterprise Algorithm in planning stage
- SNPP VIIRS GVF product available from NOAA CLASS

http://www.nsof.class.noaa.gov/

- For more information on SNPP VIIRS GVF

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

http://viirsland.gsfc.nasa.gov/Products/GVF.html

http://www.star.nesdis.noaa.gov/jpss/

IMPROVEMENT in GLOBAL DROUGHT WATCH FROM S-NPP VEGETATION HEALTH (VH)

Felix Kogan
National Oceanic and Atmospheric Administration (NOAA)
National Environmental Satellite Data and Information Services (NESDIS)
Center for Satellite Applications and Research (STAR)

JPSS
August 27, 2015

Drought (D) as Natural Disaster

- D. affects the largest number of people
- D. is the most costly
- D. is a part of earth's climate
- D. occurs every year
- D. does not recognize borders, political & economic differences

World Population Affected by Natural Disasters 1967-1991

	%	
Disaster Type	Affected	Killed
	Weather	
Drought	**51**	**38**
Flood	38	9
Hurricane etc.	8	27
	Geological	
Earthquake	2	18
Volcano	<1	<1

Total People Affected: **2.8 billions**

Total People Killed: **3.5 millions**

Drought Disasters during 1980-2008

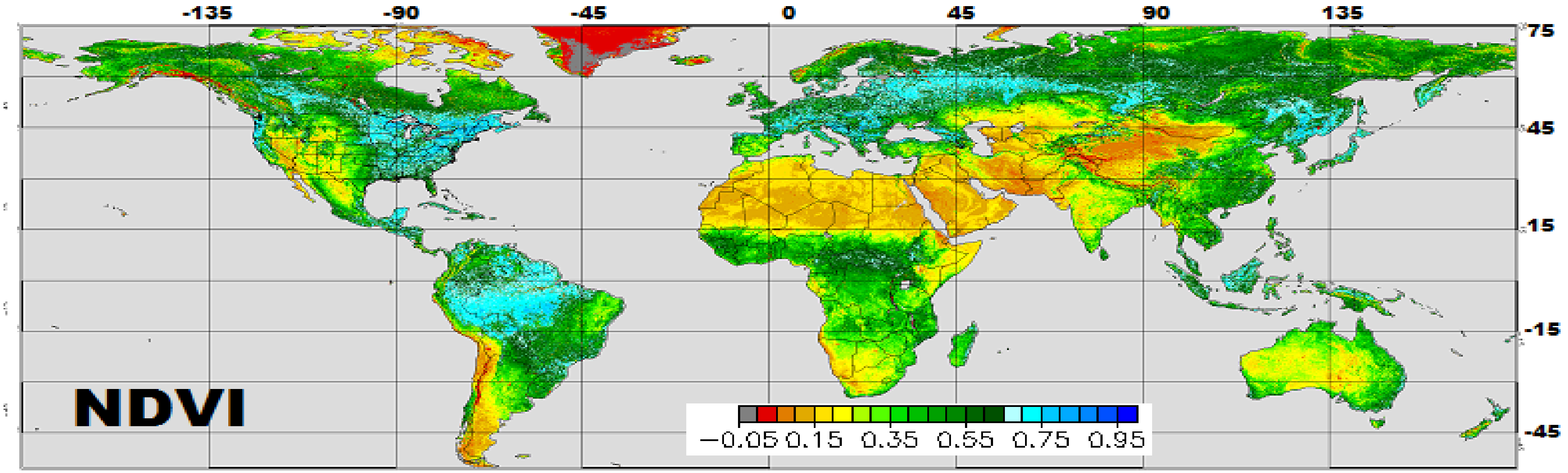
• No of people affected	1,551,455,112
India 2002 -	300,000,000
• No of people killed	558,565
Ethiopia 1983 -	300,000
• Economic damages	
China 1994	$ 13.8 bil
Australia 1981	$ 6.0 mil
USA 1988	$ 40-60 bil
USA 2006-2015 California	$ 2.7 bil (21,000 job loss)

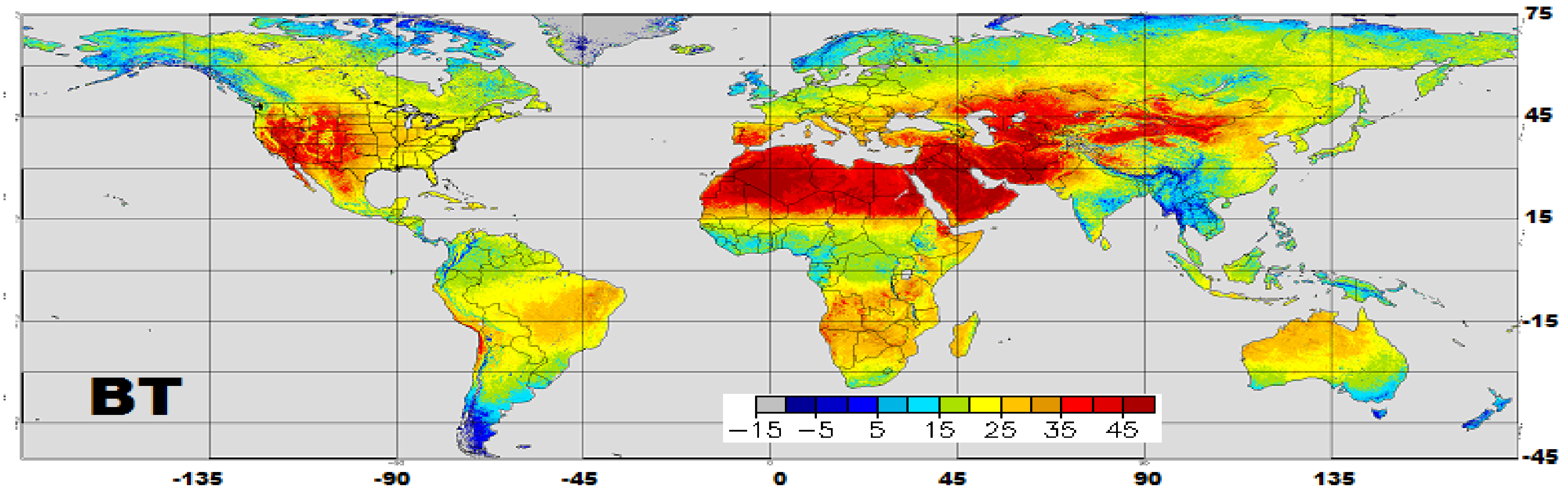
http://www.preventionweb.net/english/hazards/statistics/?hid=59

Drought Unique Features

- **Start** unnoticeably
- **Build-up** slowly
- **Develop** cumulatively
- **Impact** cumulative & not immediately observable
- **Mitigation:** When damage is evident it's too late to mitigate the consequences
- **Drought type:** Meteorological, Agricultural, Hydrological, Socio-Economic

Normalized Difference Vegetation Index & Brightness Temperature

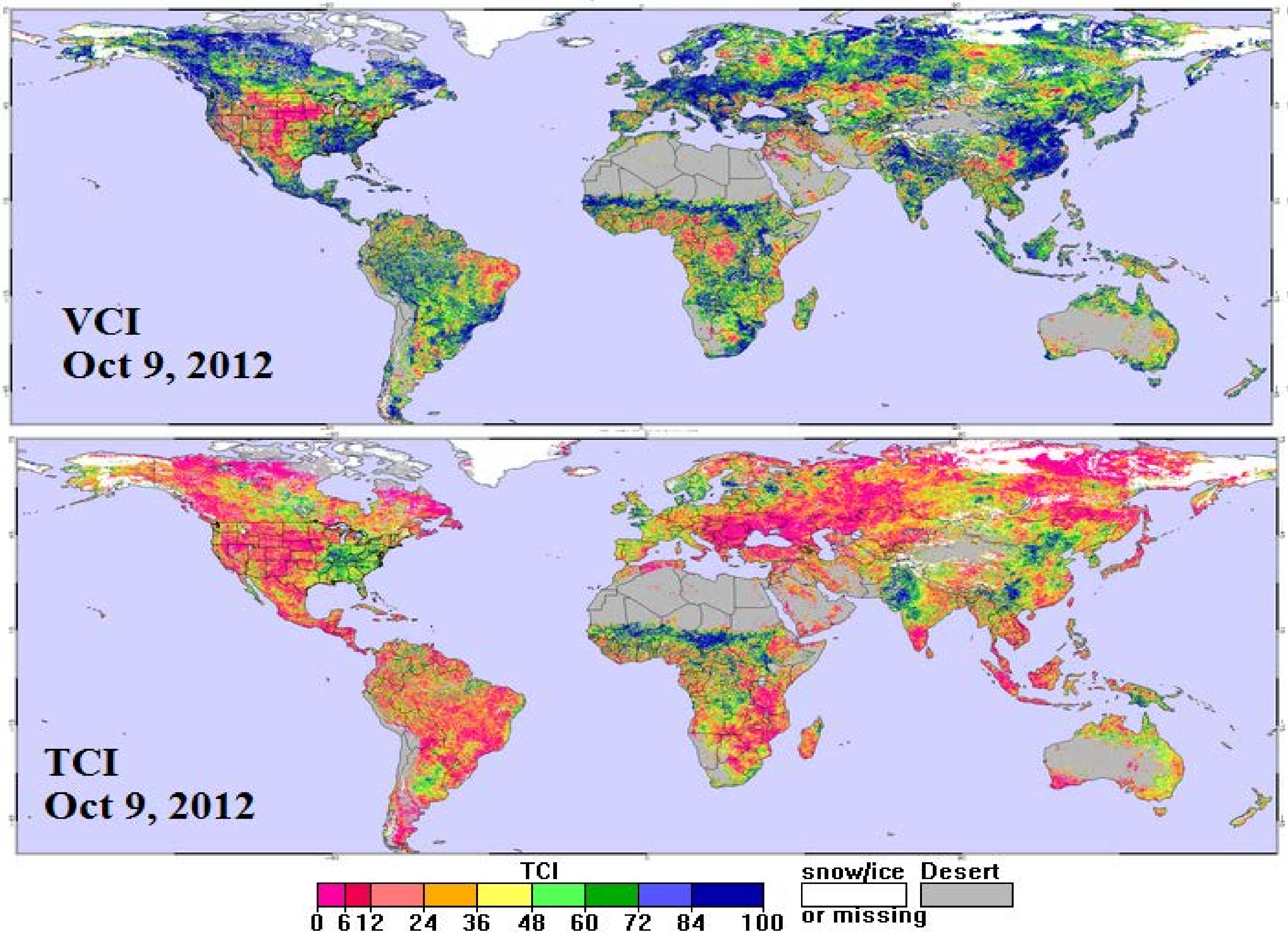




VH Requirements

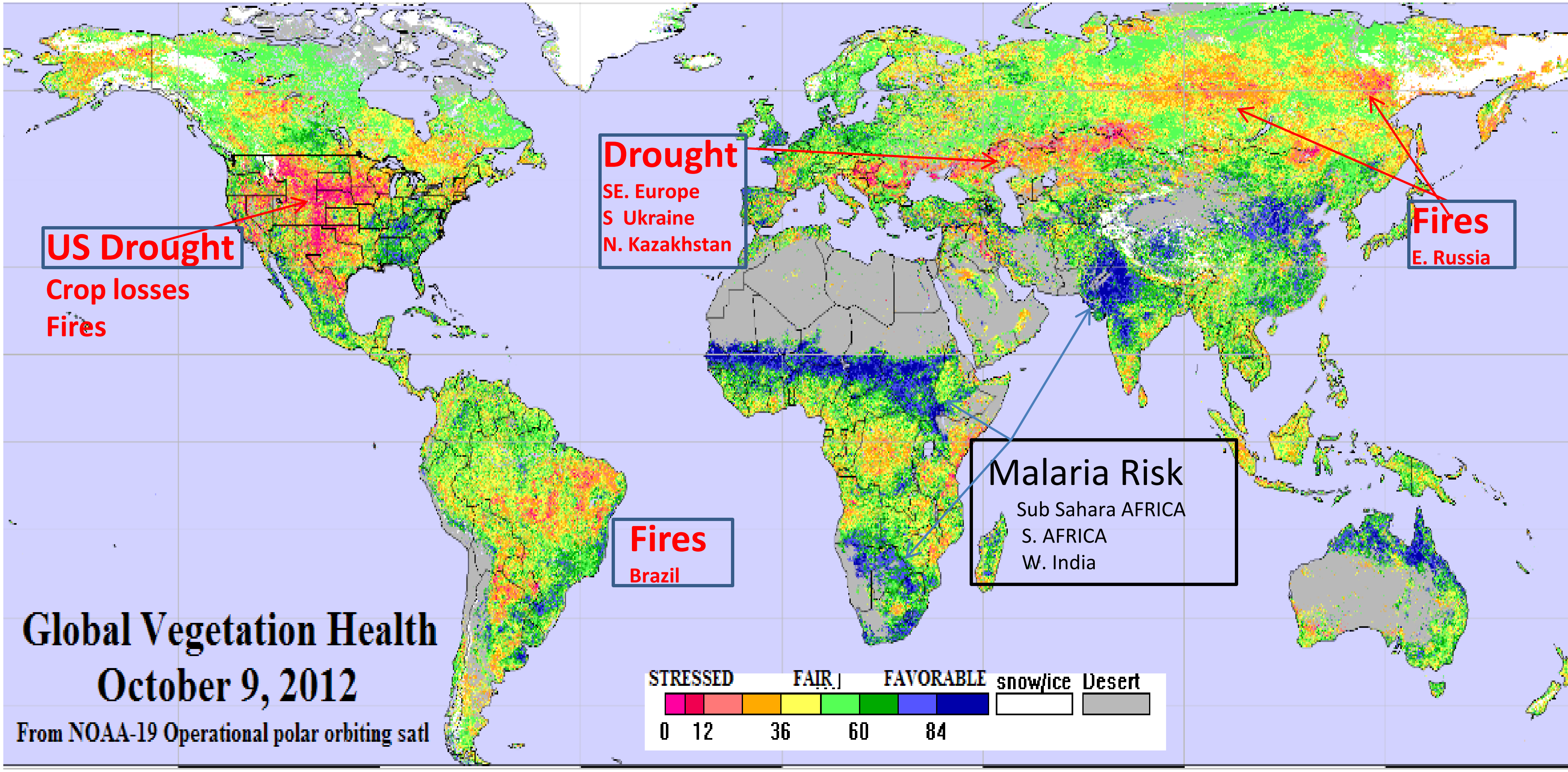
- **Real time NDVI and BT**
- **Climatology of NDVI and BT**

Vegetation Condition (VCI) and Themperature condition (TCI) indices



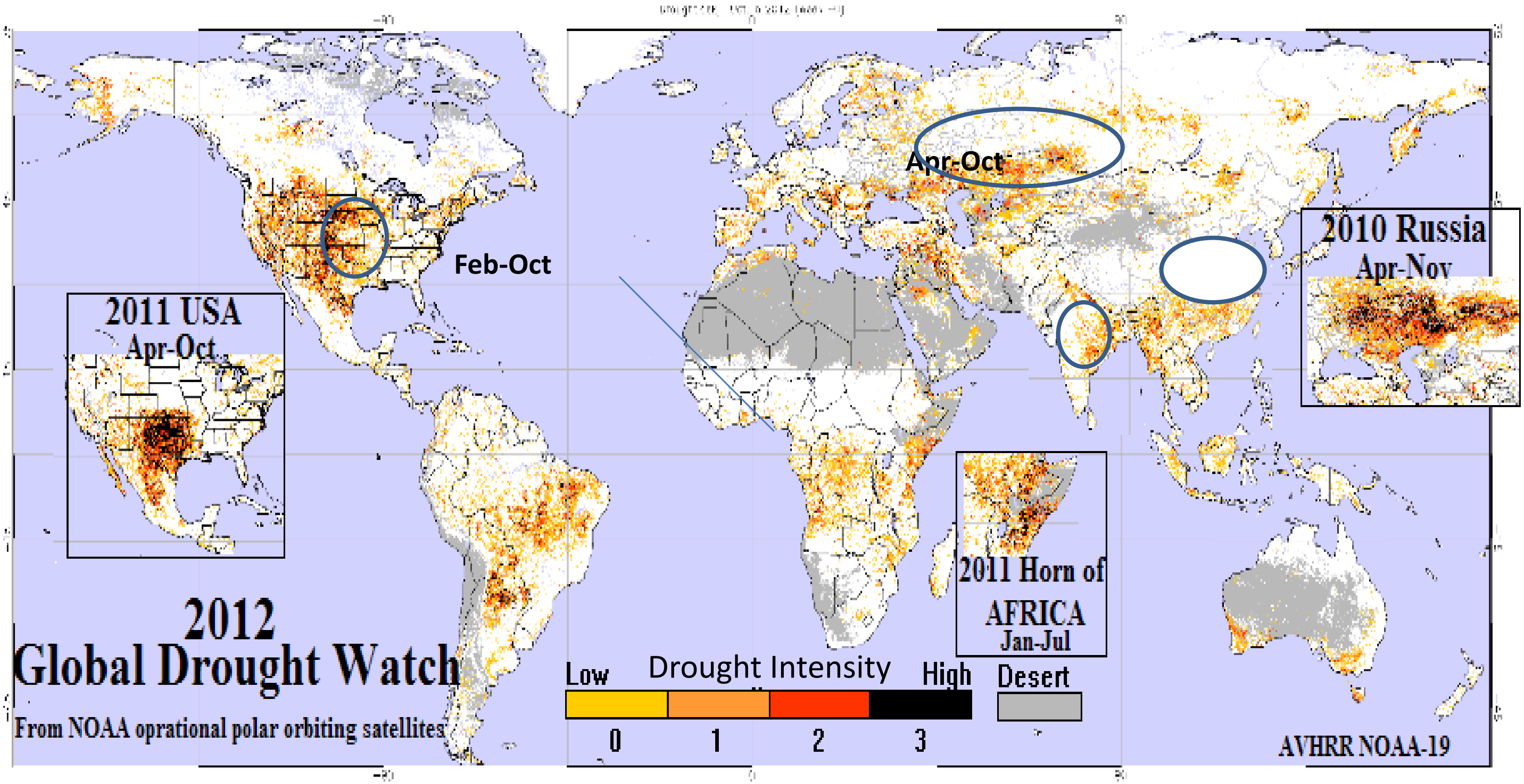
2012 Global Vegetation Health (VH)

From AVHRR/NOAA-19 Operational Polar Orbiting Satellite



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

Global Droughts from operational satellites



2012- Extreme drought in the USA, southern UKRAINE, northern KAZAKHSTAN,

- Severe drought in eastern INDIA, Kenya & South Americe

2011 – Exceptional drought in Texas (USA) and the Horn of AFRICA

2010 - Exceptional drought in RUSSIA and UKRAINE

USDA user (August 8, 2015)

Eric Luebehusen, Analyst for FAS & WAOB (ELuebehusen@oce.usda.gov)

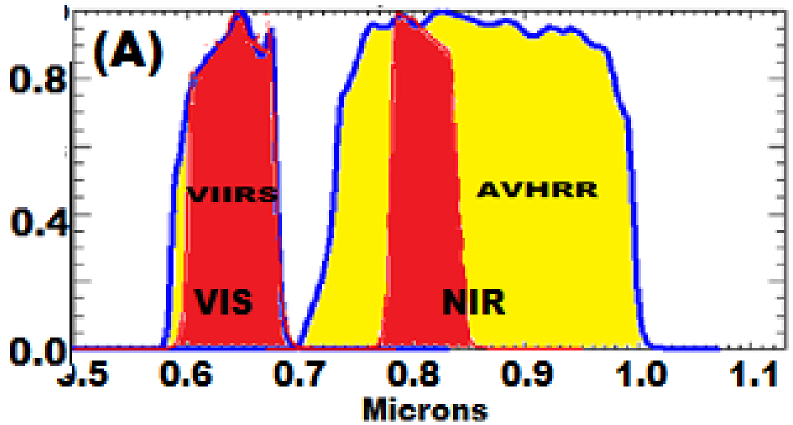
"the 4km VHI is a very big hit at USDA with senior level staff, economists, and meteorologists. I often get specialized requests for maps of the 4 km VHI "as soon as it's available", and the data is used to support our monthly crop yield and production estimates, particularly in the mid-latitudes"

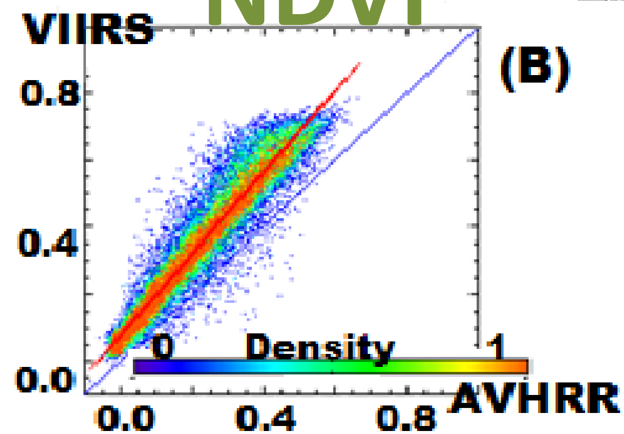
VIIRS versus AVHRR

Climate data records problems

Channels

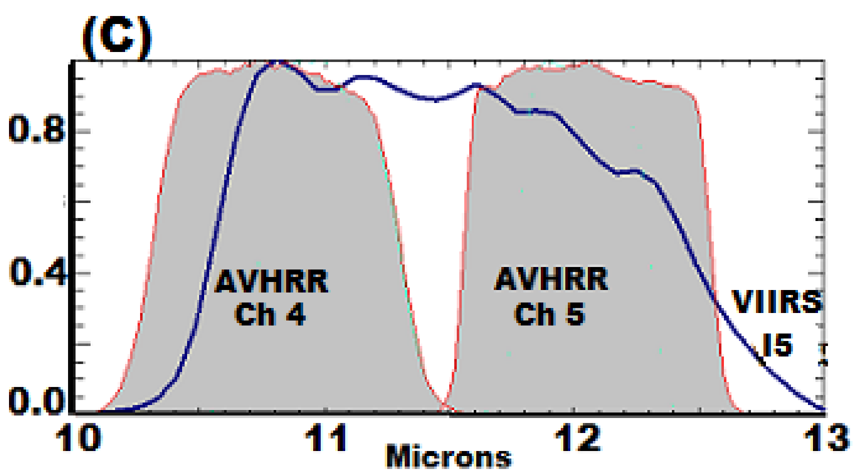
NDVI

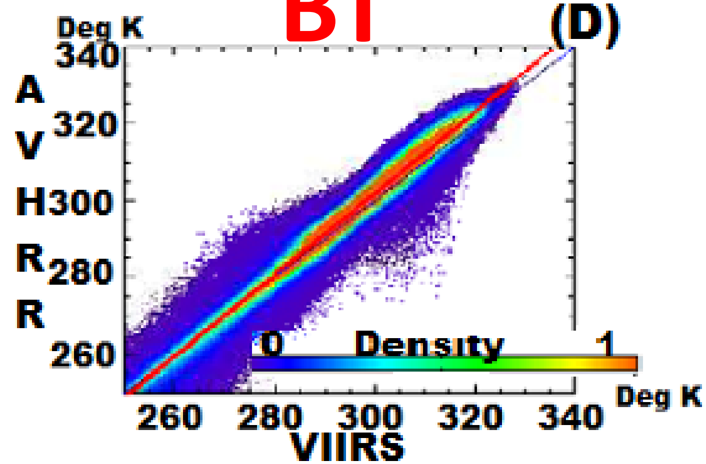




Normalized Difference Vegetation Index (NDVI)

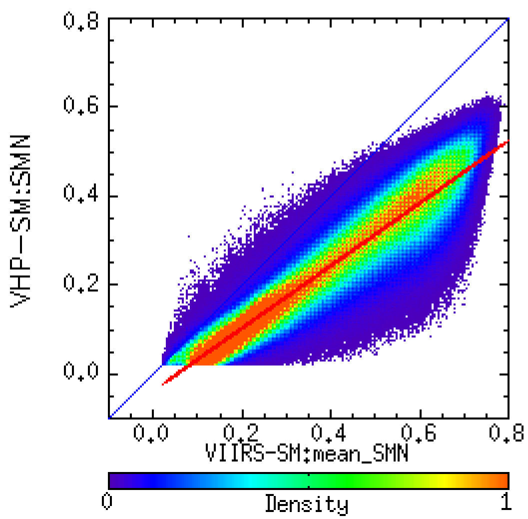
BT

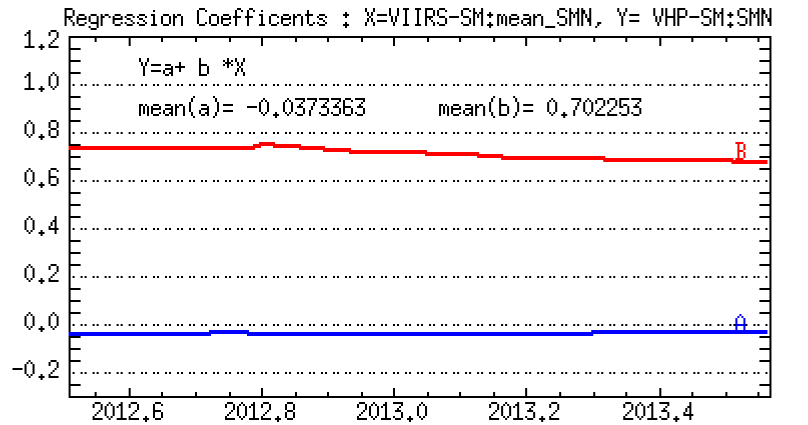


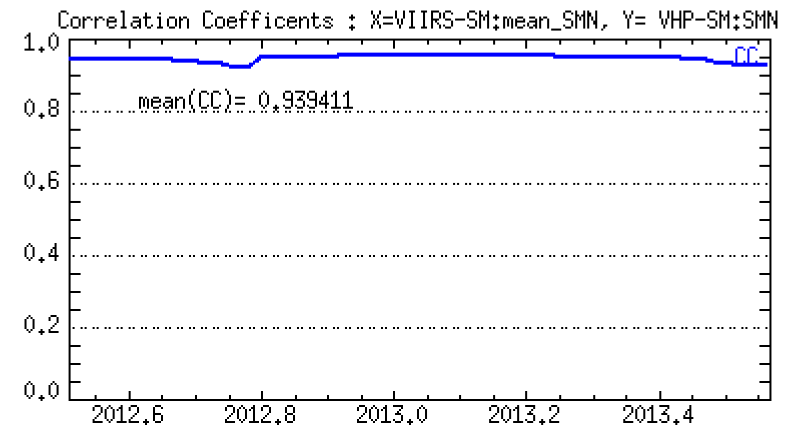


Brightness Teperature (BT)

NDVI (SMN): AVHRR-VIIRS time series







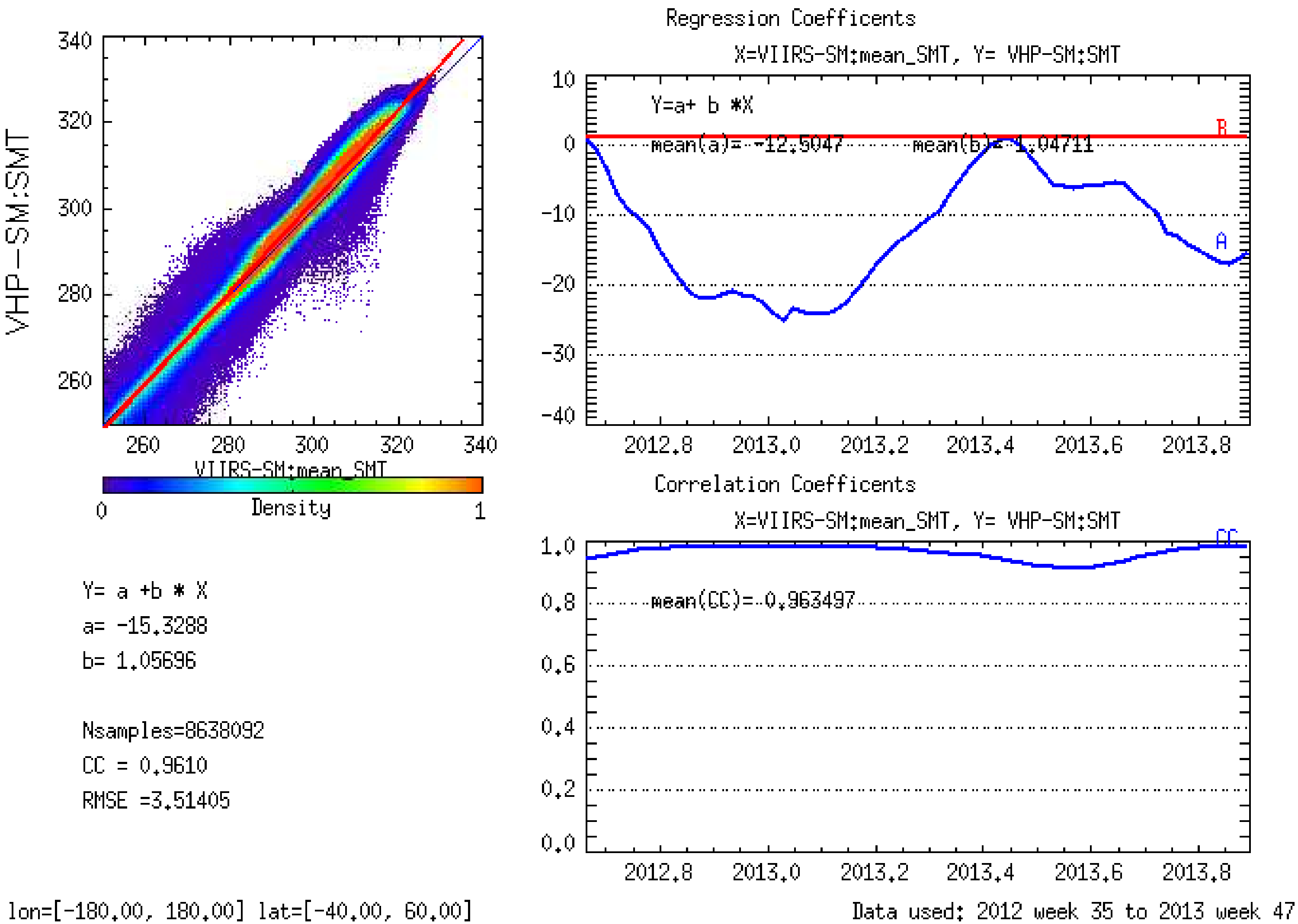
Y= a +b * X
a= -0.0374925
b= 0.703031

Nsamples=4963003
CC = 0.9374
RMSE =0.0486750

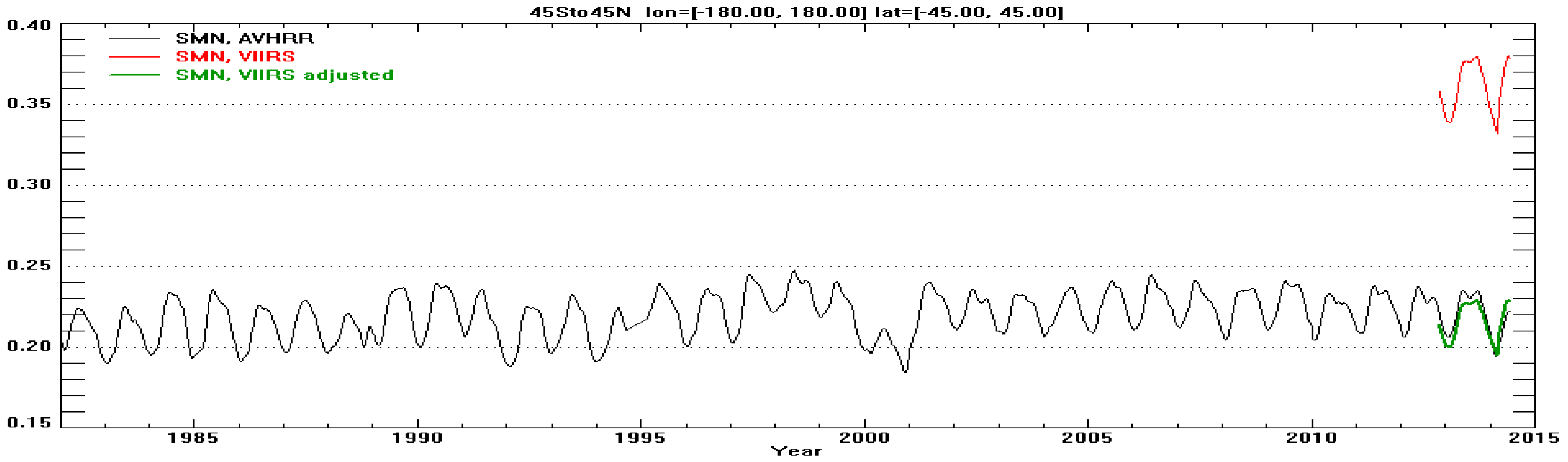
lon=[-180.00, 180.00] lat=[-40.00, 40.00]

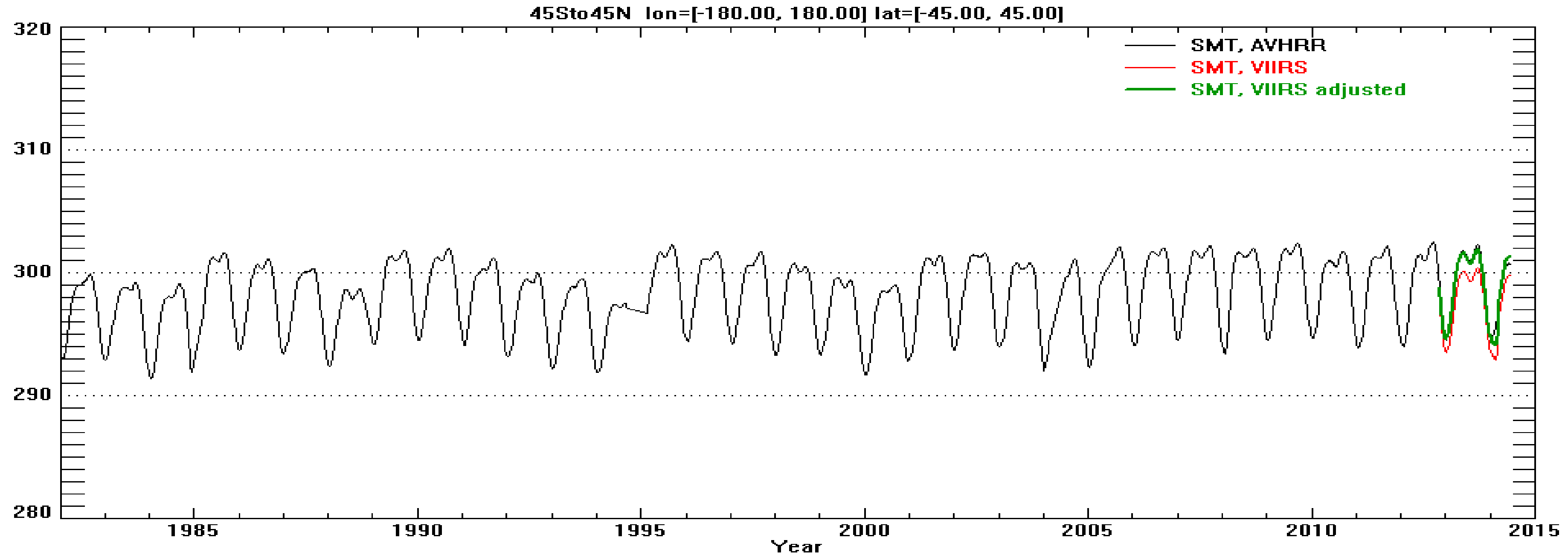
Data used: 2012 week 27 to 2013 week 30

BT (SMT): AVHRR-VIIRS COR and TSer

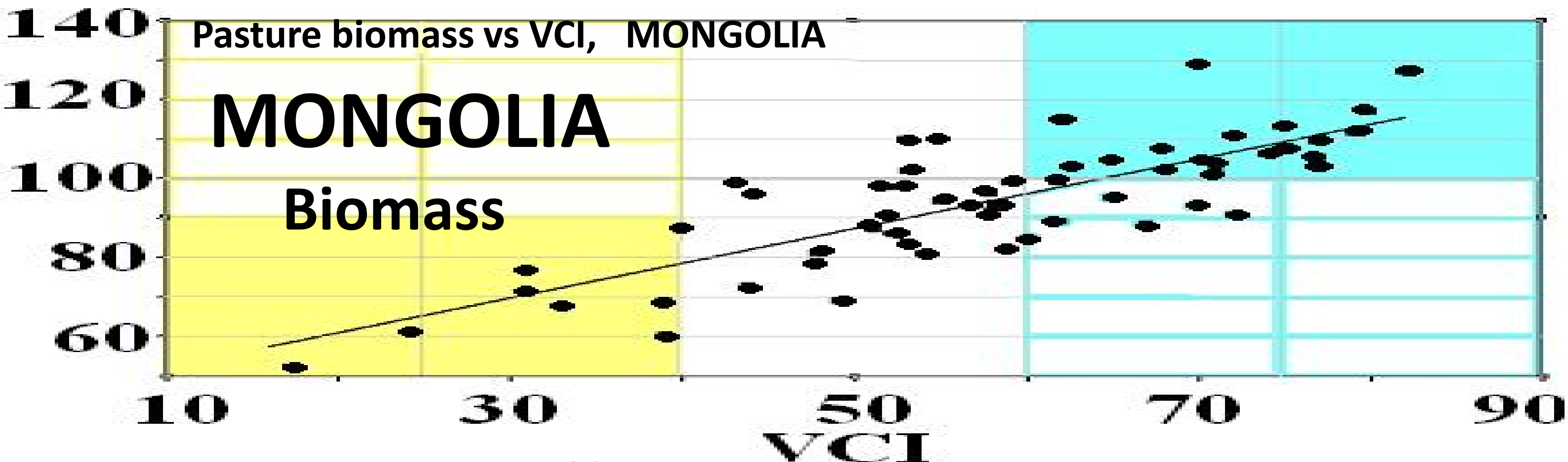


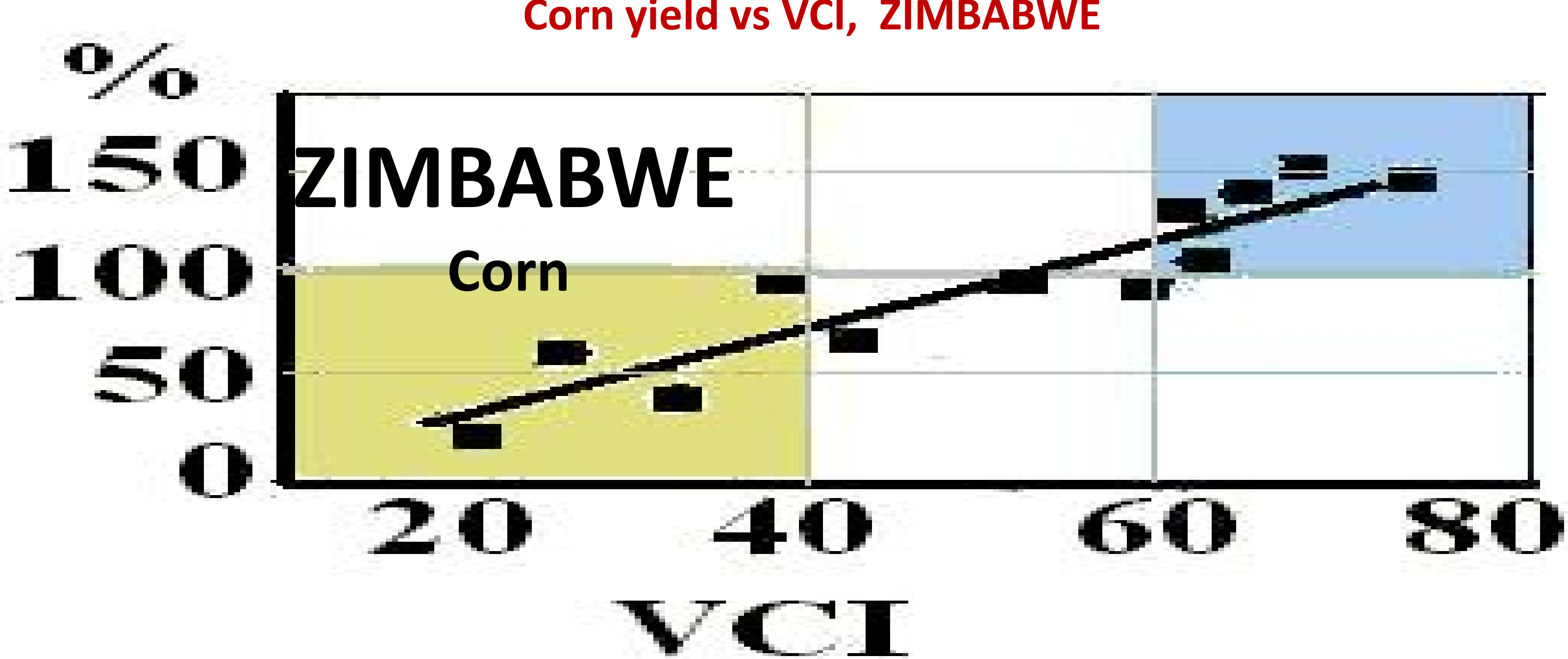
Towards NDVI & BT Climatology



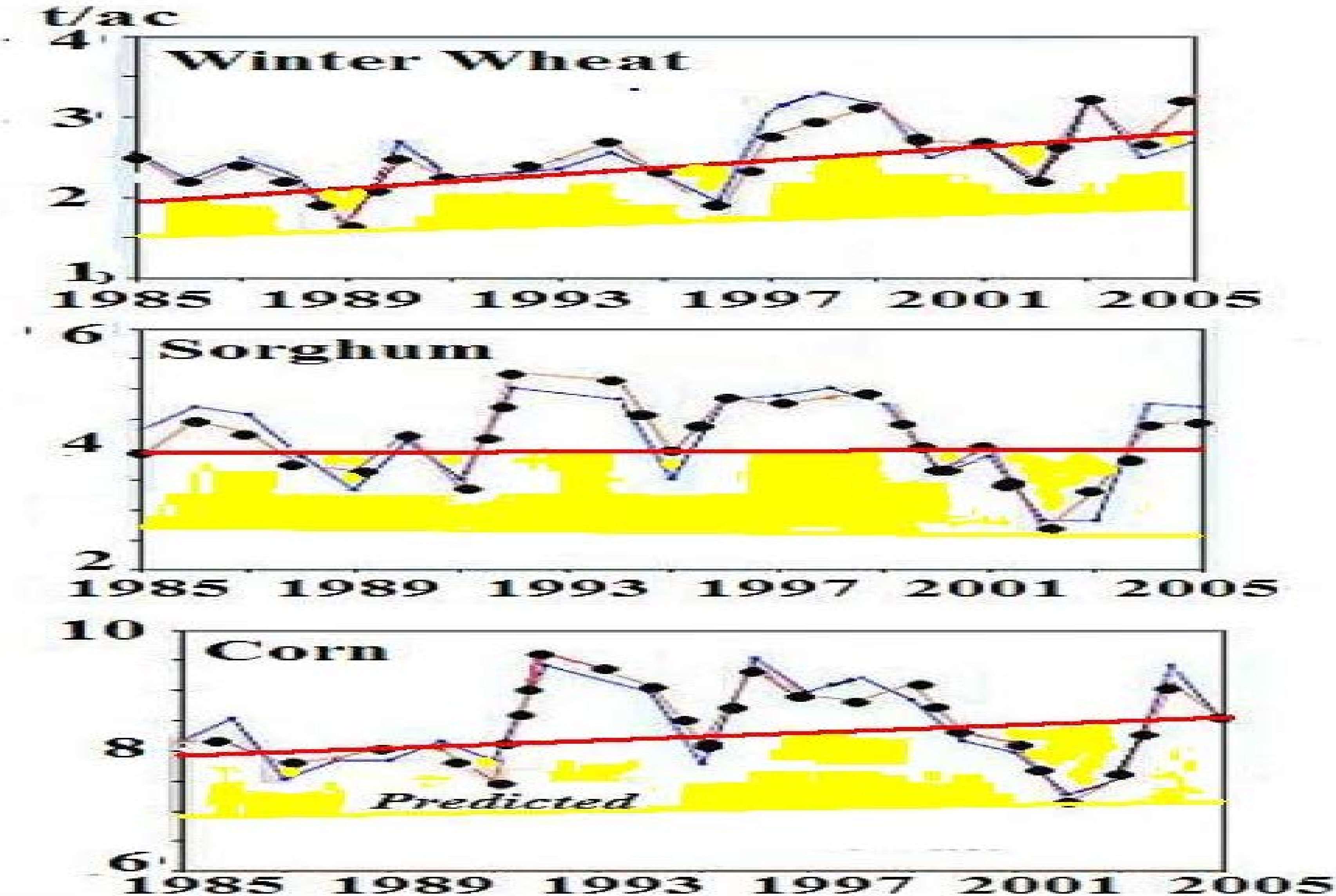


CAL/VAL: VH-Biomass & Corn Yield Modeling & Prediction



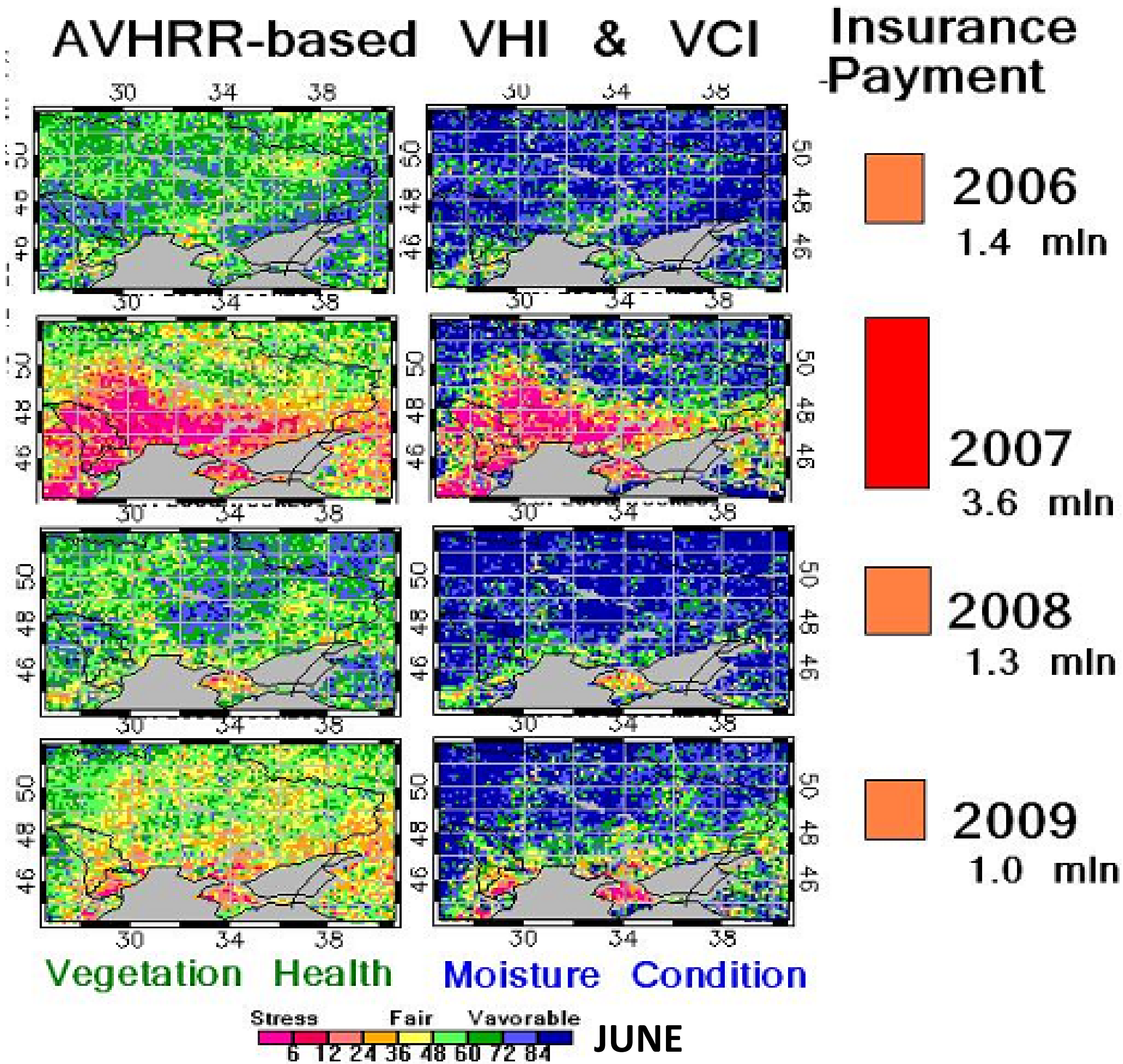


CAL/VAL: VH-Crop Losses Prediction: USA, Kansas



Observed & Predicted Yield, USA, Kansas

AVHRR-based VHI & VCI

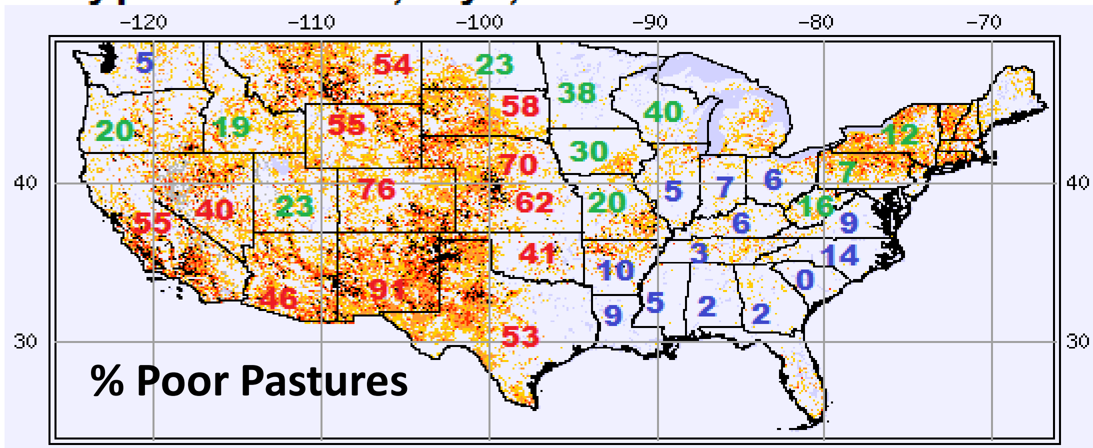


VH-based crop condition & Insurance payment (Grivna), UKRAINE

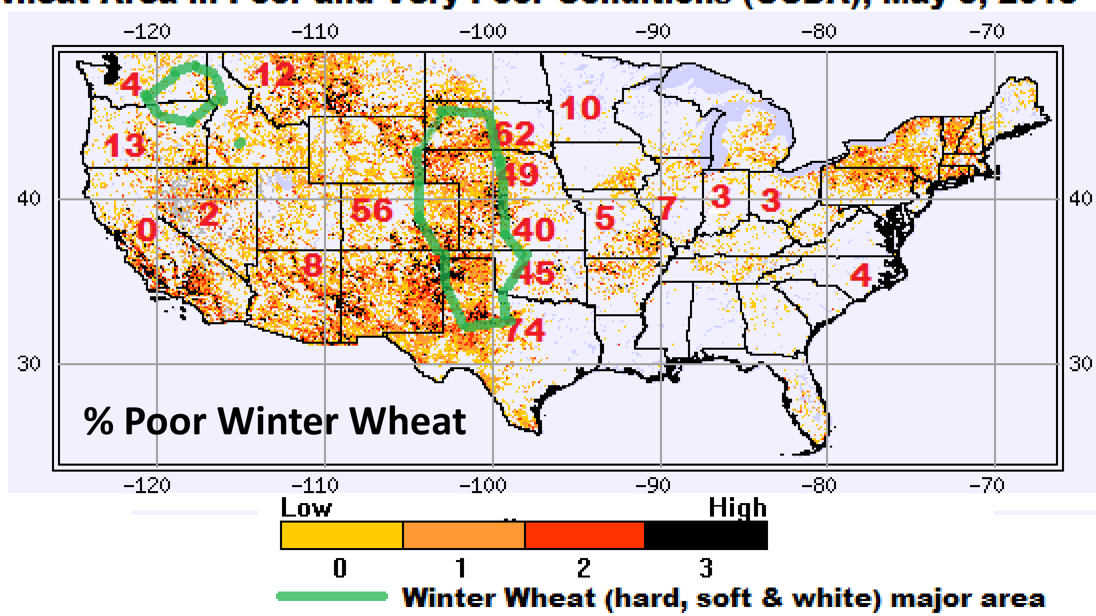
Source: NOAA and "Strahovaia Grupa TAC"

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

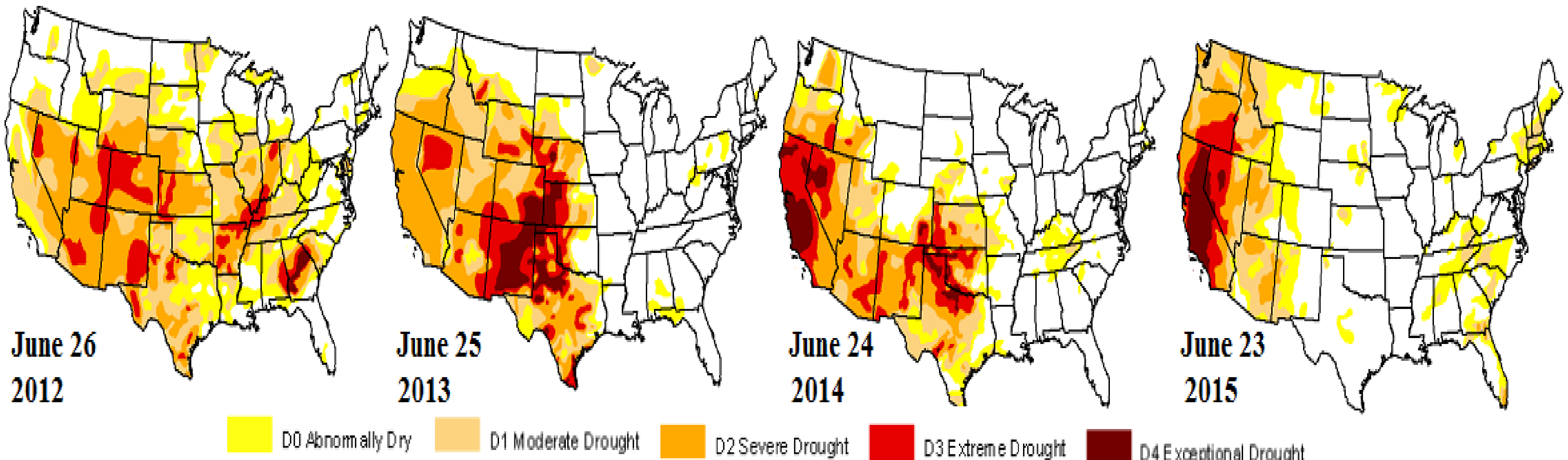
VH-based Drought Stress & % state with pasture & range land in poor & very poor coonditions, May 6, 2013



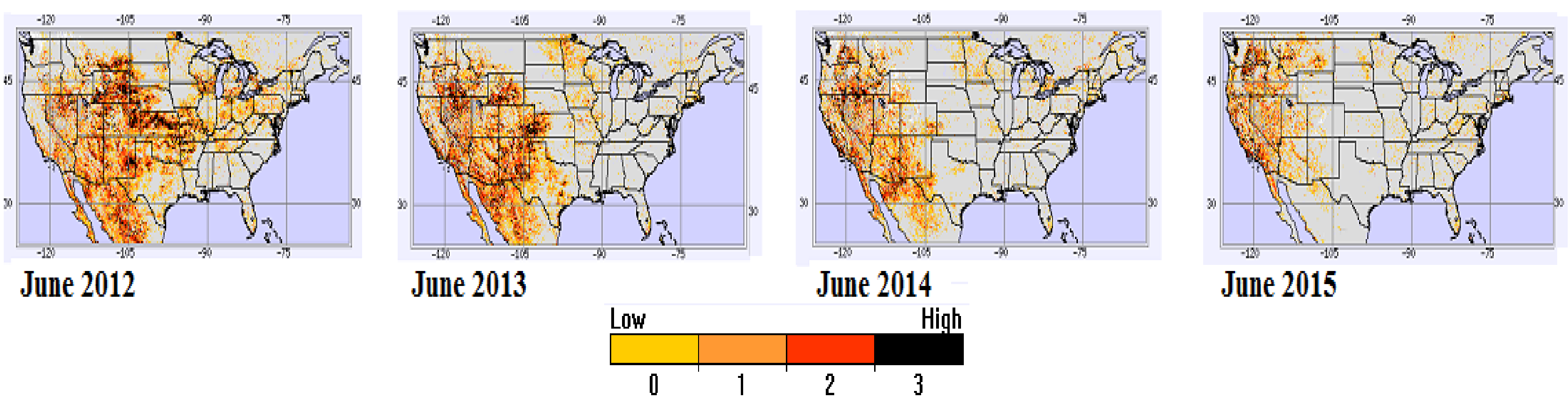
VH-based Drought Stress (NOAA), May 6, 2013 & Percent Whinter Wheat Area in Poor and Very Poor Conditions (USDA), May 5, 2013



USA Drought from USDM & VHI

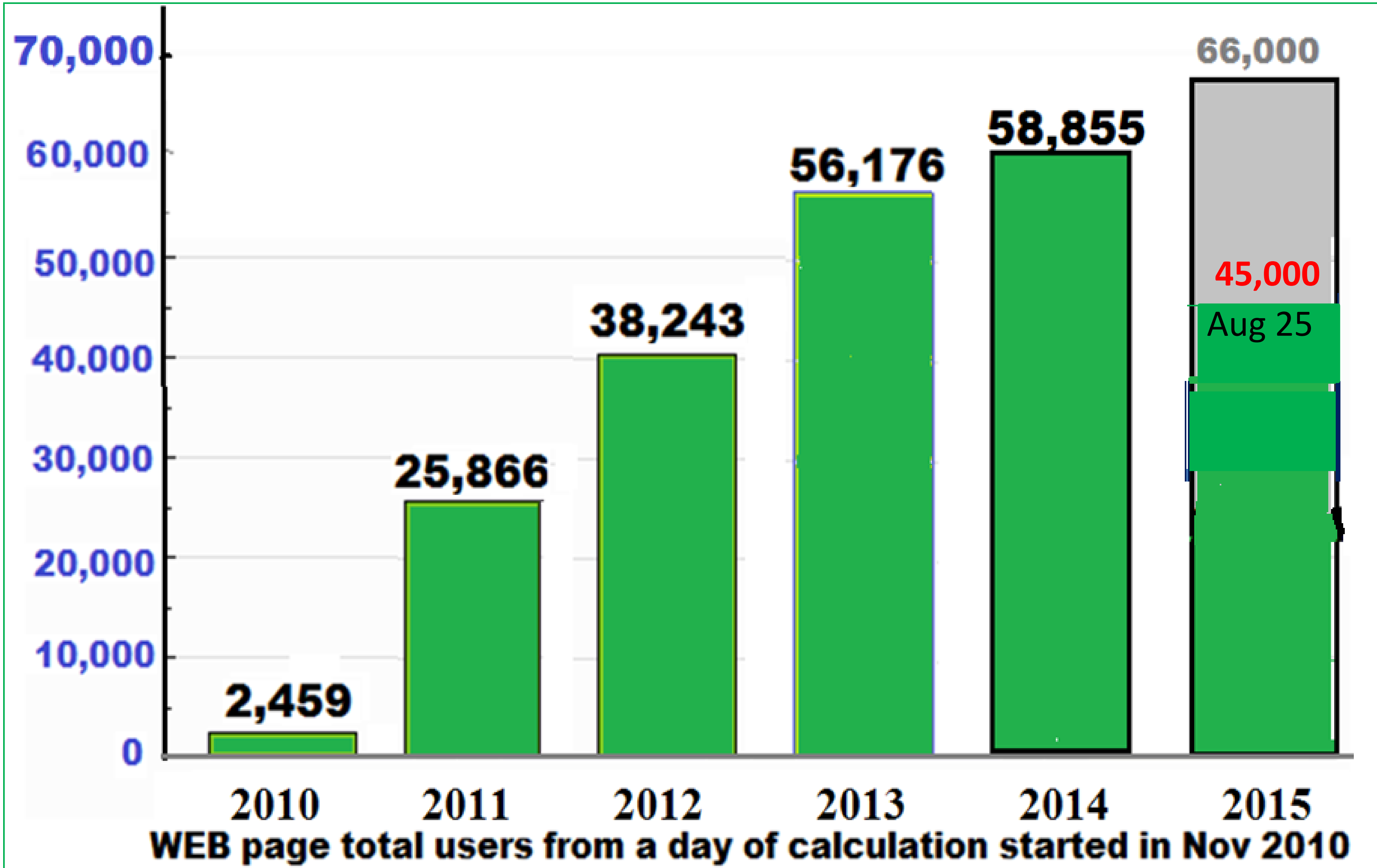


Drought from US Drought Monitor (USDM)



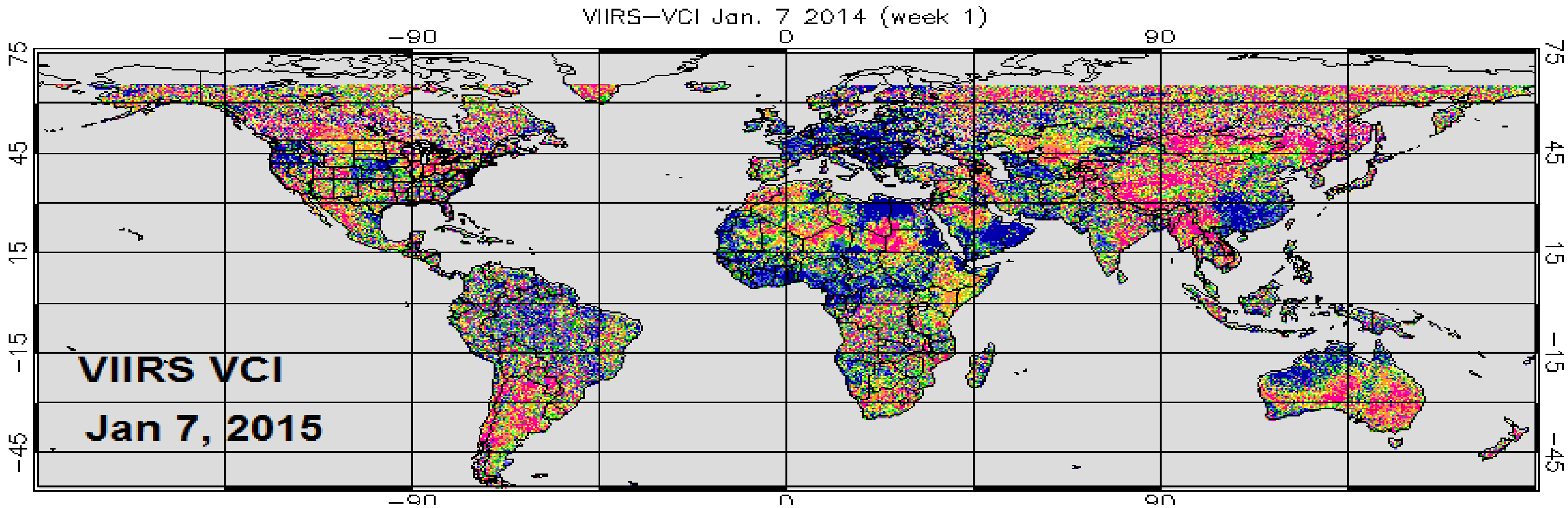
Drought from NOAA-19/AVHRR Vegetation health index (VHI)

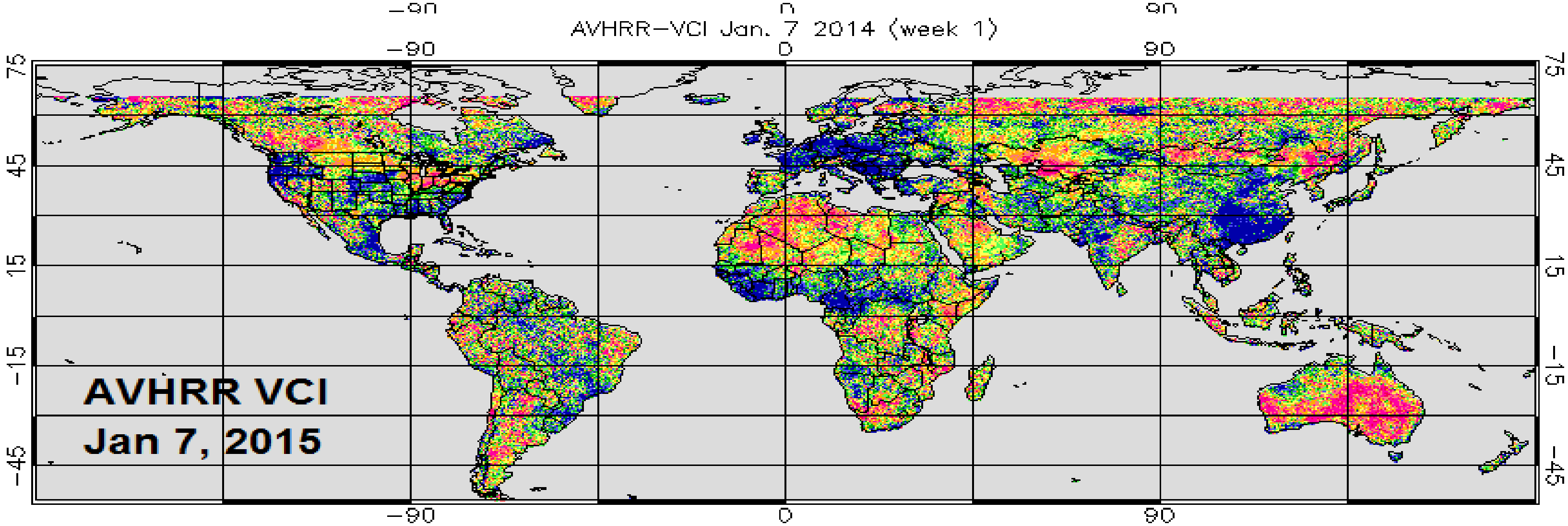
Users attending Vegetation Health WEB



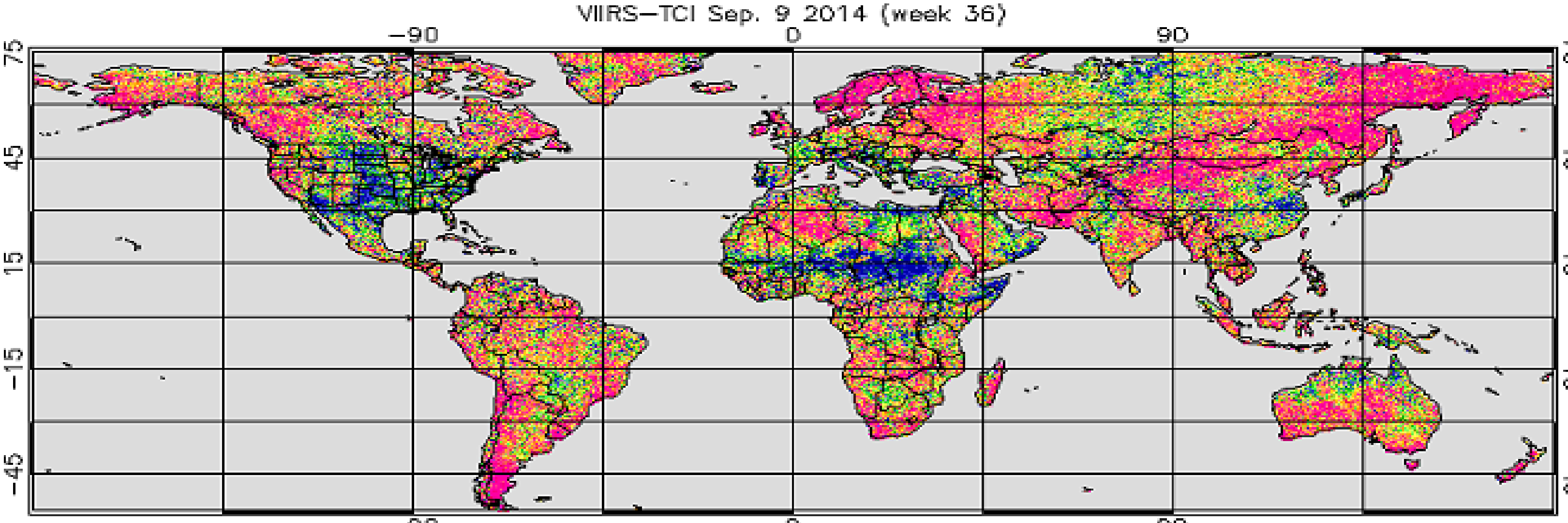
http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/index.php

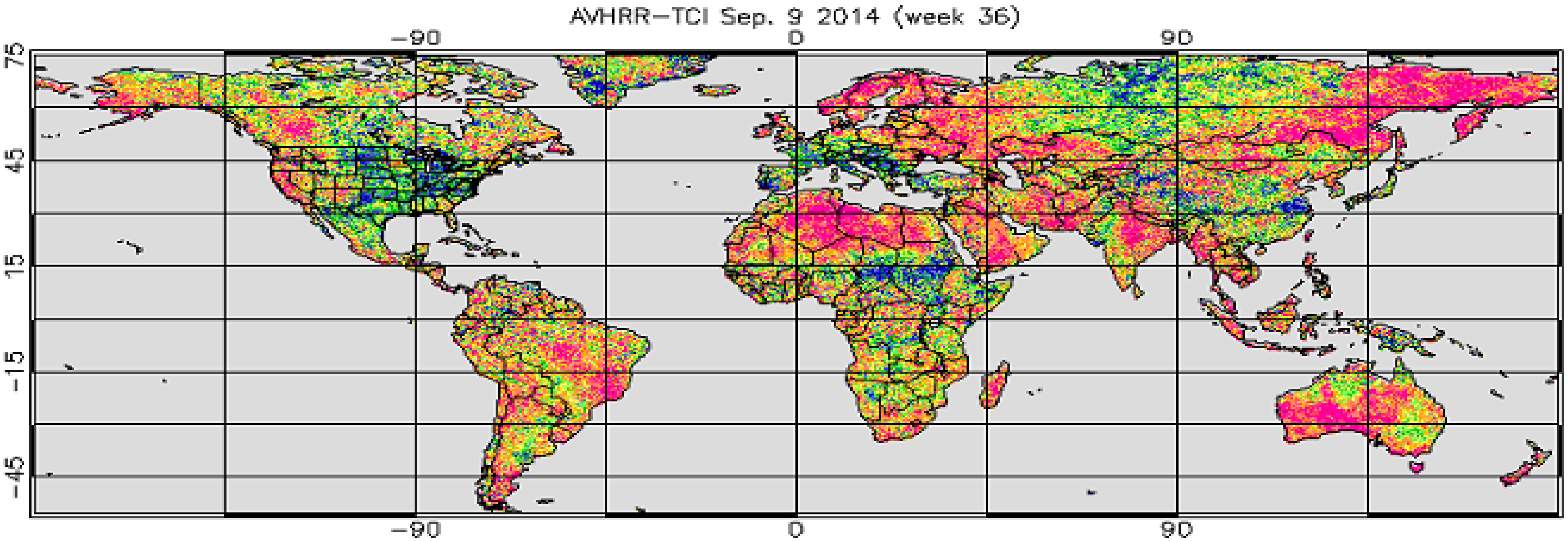
VALIDATION: VCI/VIIRS vs VCI/AVHRR



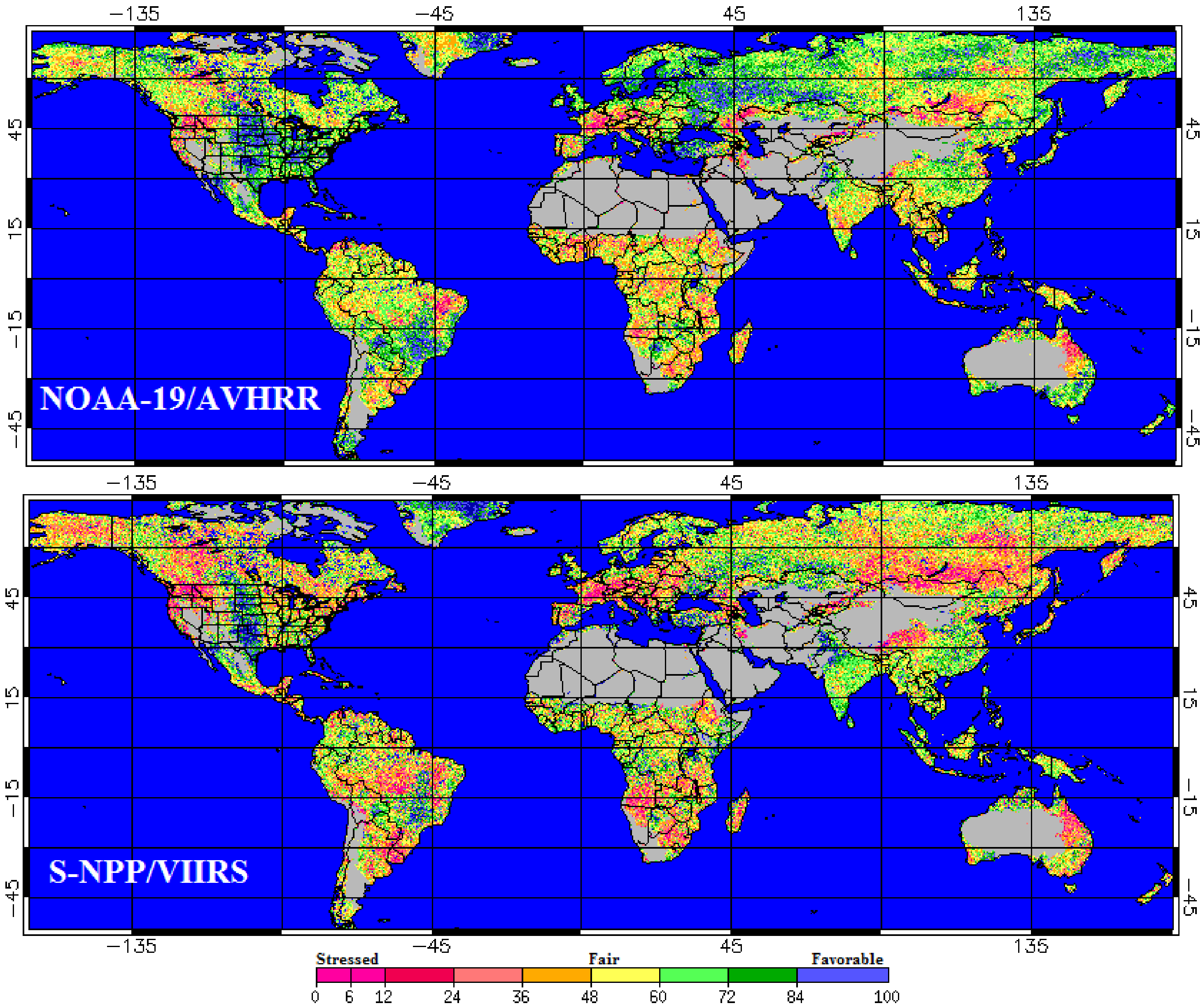


VALIDATION:
TCI VIIRS vs AVHRR
Sep 9, 2014





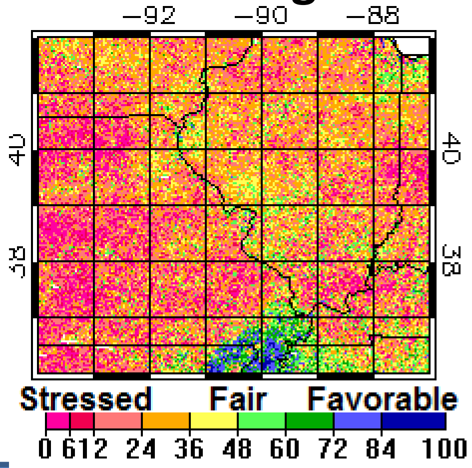
Vegetation health (VHI)



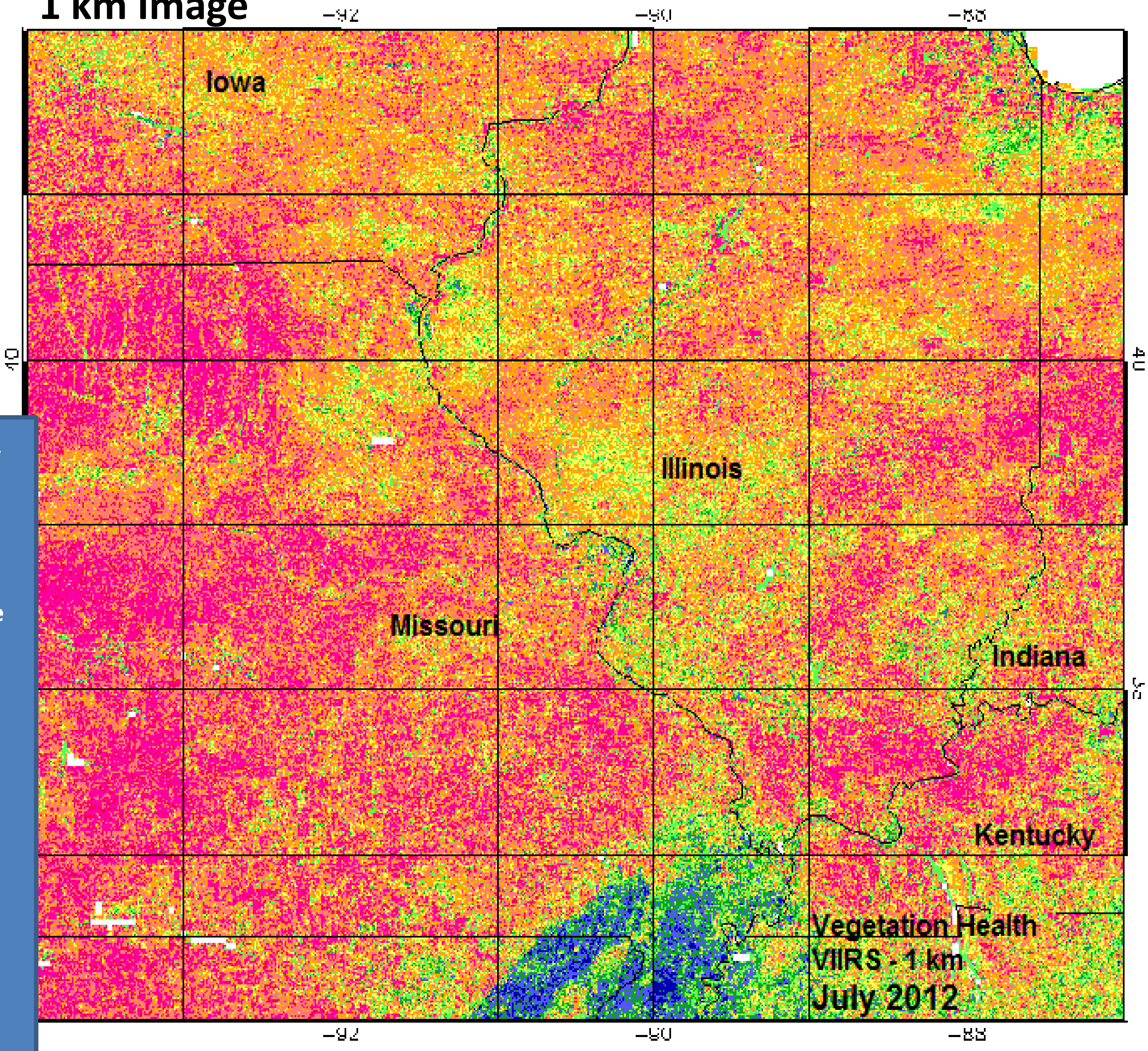
VEGETATION HEALTH, August 6, 2015

SNPP/VIIRS VHI & DROUGHT, USA Midwest, July 2012

4 km Image

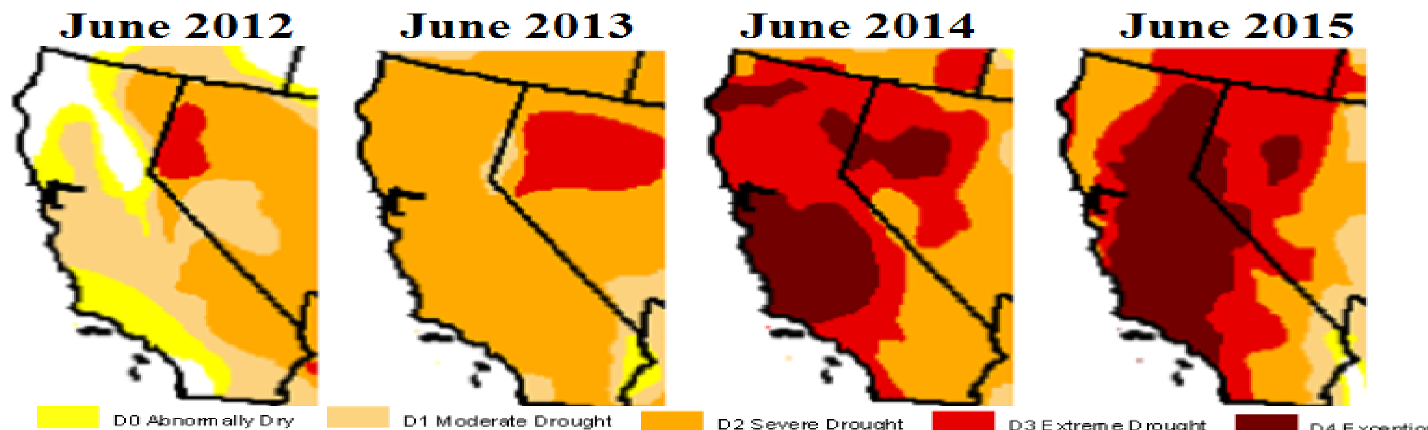


1 km Image

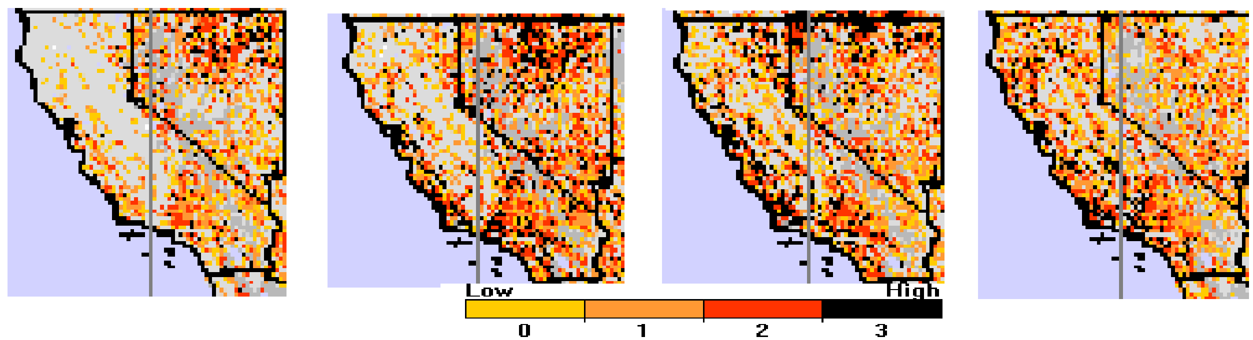


- Drought affects Global Food Security by reducing agricultural production below consumption.
- Since 2000, this occurred 8 years out of 13.
- Early drought detection and accurate monitoring its area, intensity, duration & impacts is important for mitigation drought consequences.
- Vegetation health(VH) method applied to SNPP/VIIRS data greatly improve drought watch & impact assessment.
- The two images showing similar patterns, indicate much more details of drought/no drought areas along the rivers: at the background of drought (red) no drought (yellow and green) is observed along the rivers (western part of 1 km image).

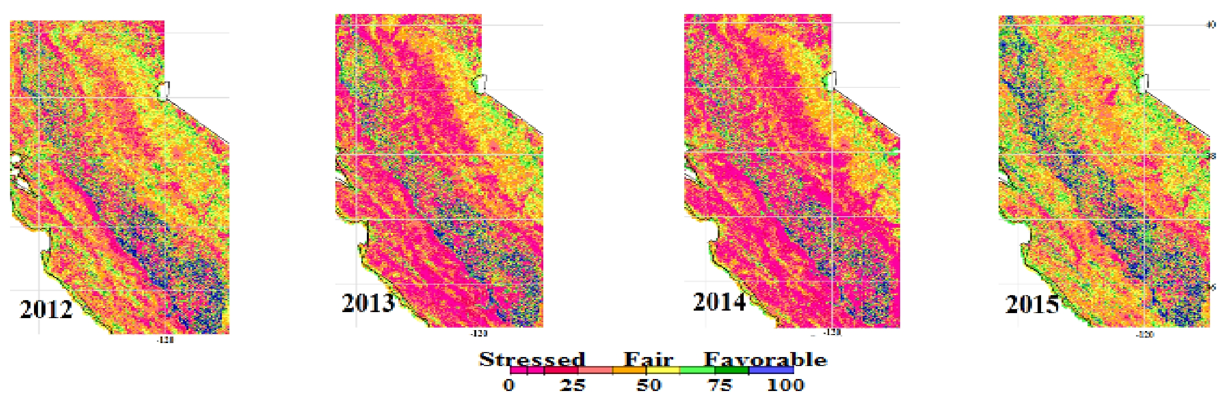
California Drought from USDM & VHI



California Drought from US Drought Monitor

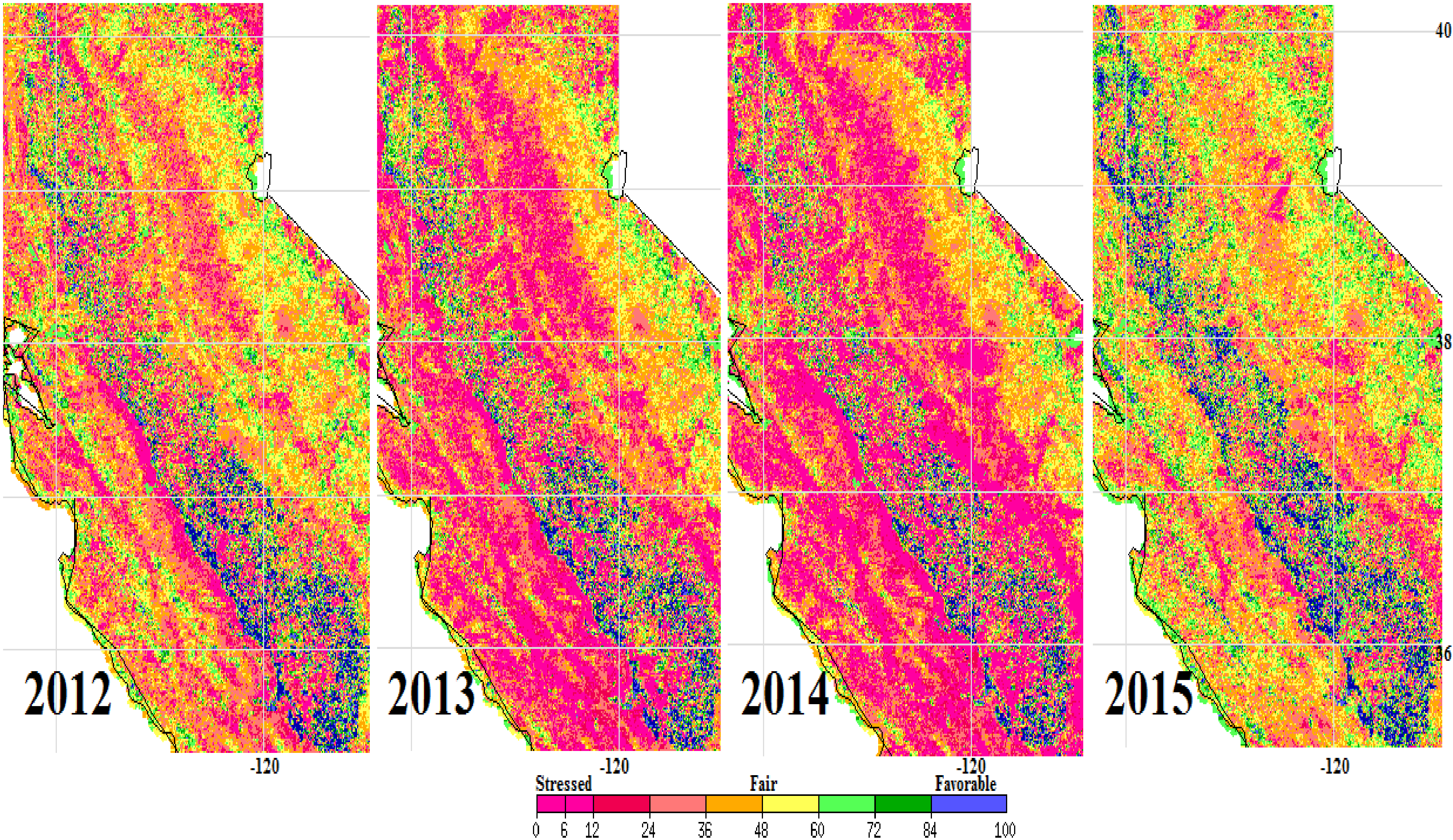


California Drought from 16 km NOAA-19 Vegetation health index (VHI)



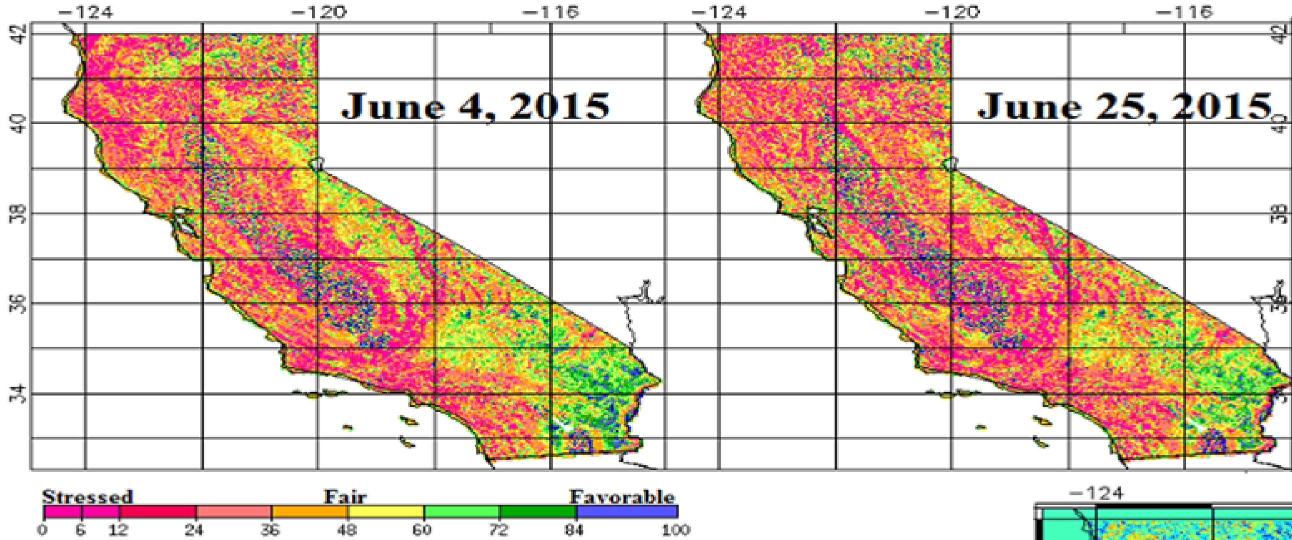
California Drought from 0.5 km S-NPP/VIIRS Vegetation health index

S-NPP/VIIRS Vegetation Health

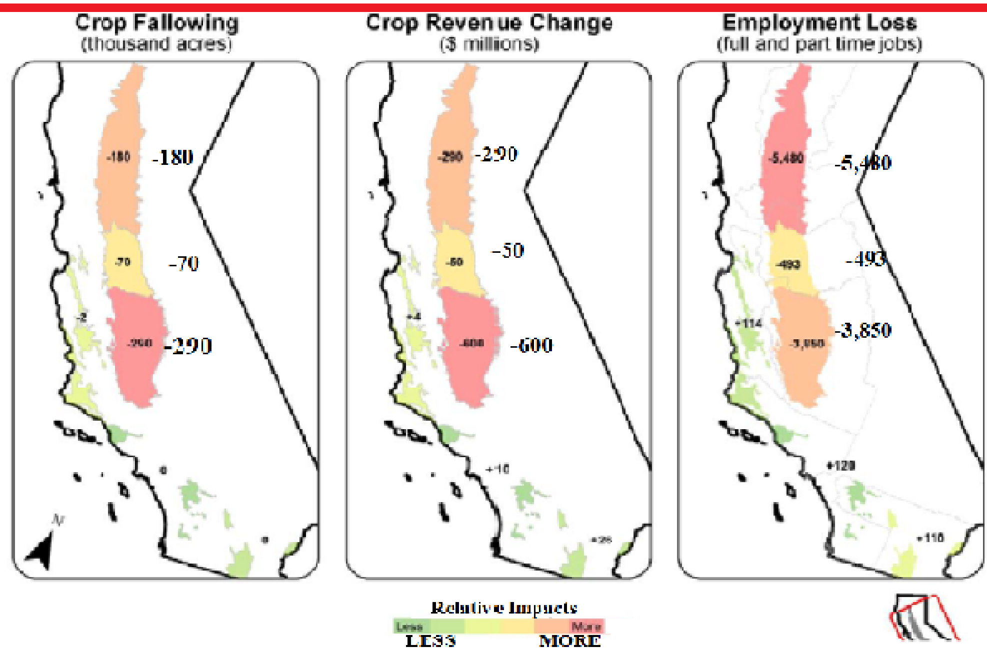


S-NPP/VIIRS-500m Vegetation health, June 12, USA, California, Central Valley

California Drought Dynamics & Economic Impacts in 2015

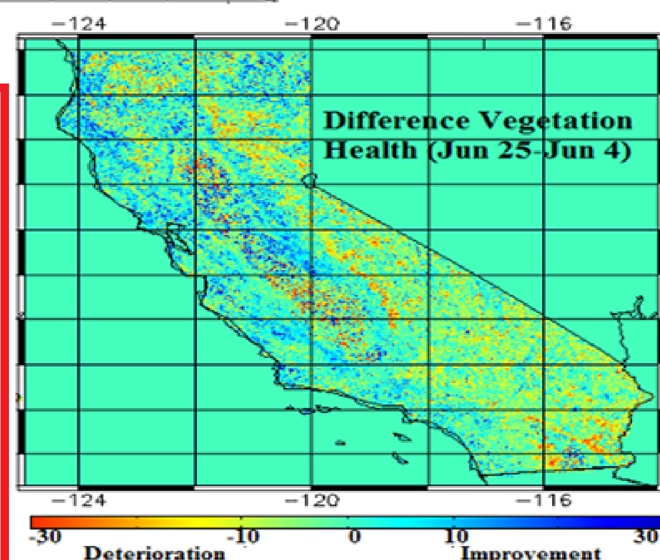


Vegetation Health from 500 m S-NPP/VIIRS



Economic Impacts of California Drought

Howitt R., D. MacEwan, J. Medellín-Azura, J. Lund & D. Sumner 2015. Economic Analysis of the 2015 Drought for California Agriculture. UC Davis Center for Watershed Science, University of California Davis, Davis, CA, 16 pp.



Difference Vegetation Health

June 25 - June 4

SUMMARY

- **VH algorithm requires NDVI & BT:**
  (a) Real time (from VIIRS)
  (b) Climatology (from AVHRR)
- **VIIRS/VH indices (VHI, VCI & TCI) are validated against AVHRR/VH because AVHRR's VH are validated against in situ data**
- **VIIRS/ NDVI & BT are different than AVHRR**
- **VIIRS/NDVI & BT are adjusted to AVHRR (in order to use climatology)**
- **The adjustments are stable over time and correlation is strong**
- **FURTHER Development:**

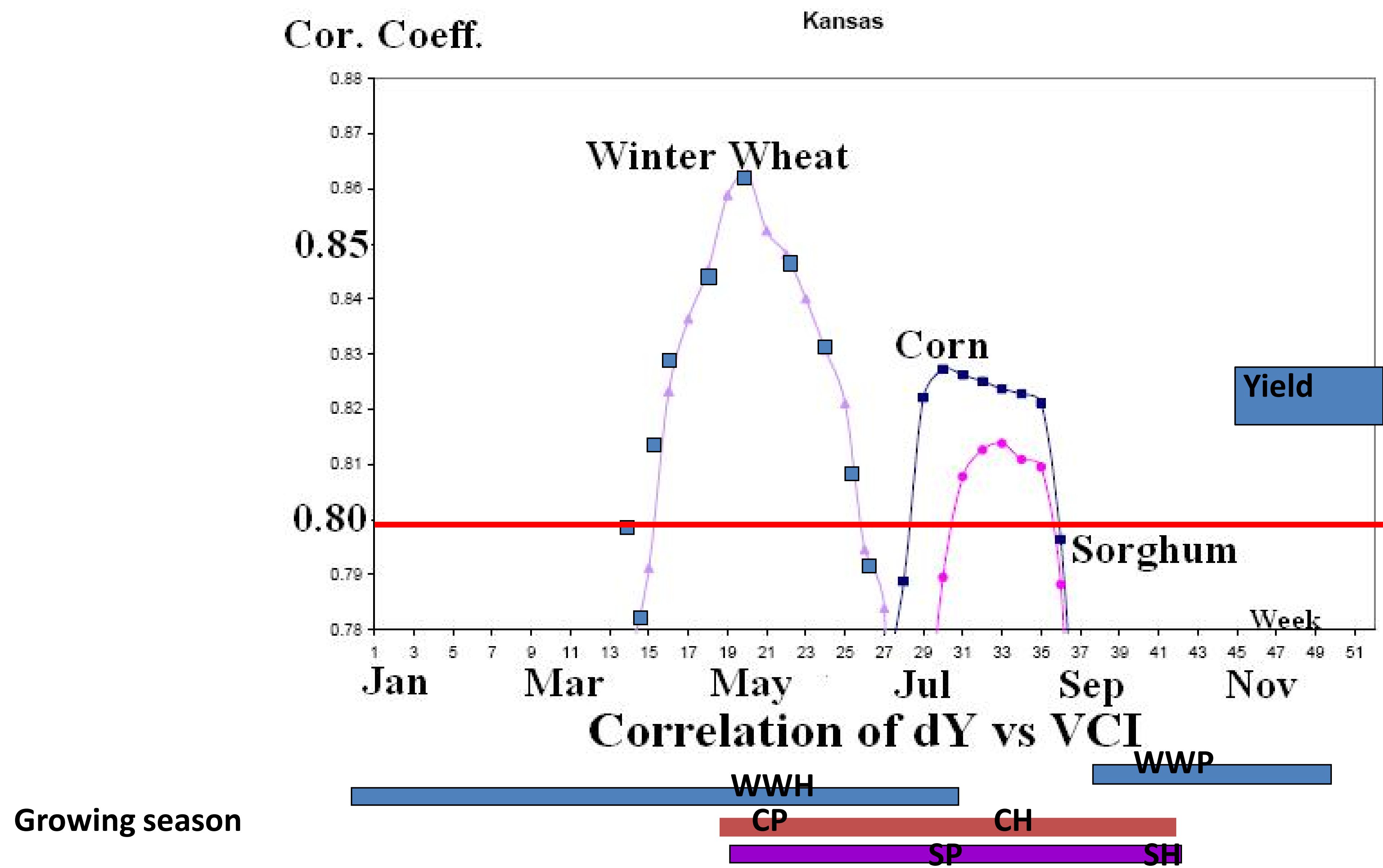
(a) New climatology from VIIRS

(b) High resolution VH

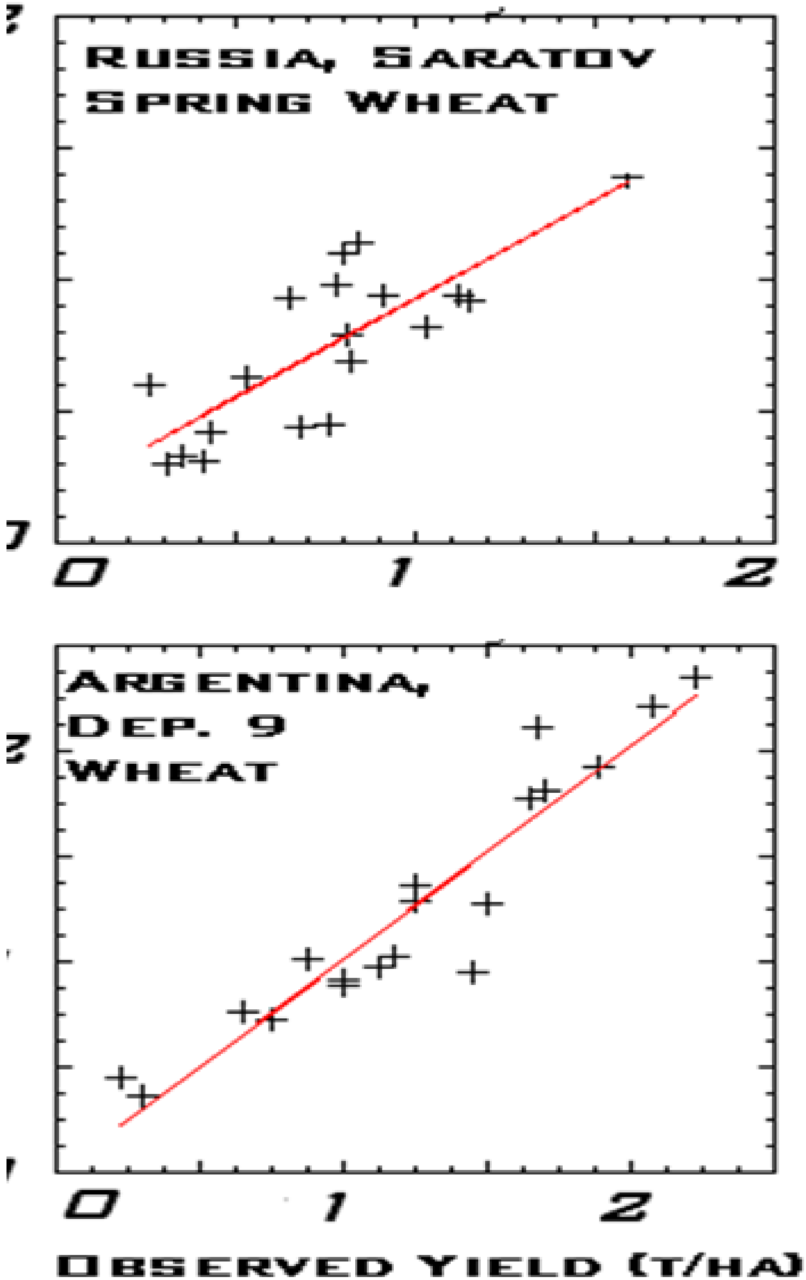
(c) New VH products

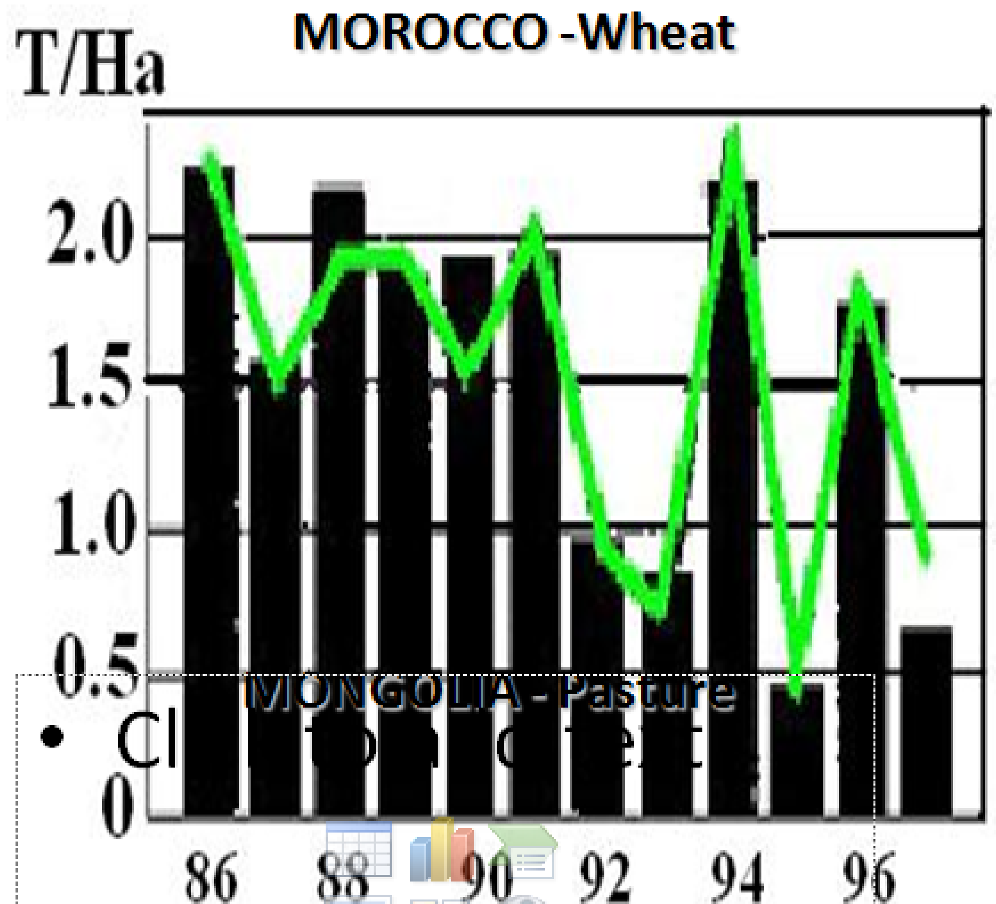
BACK UP

Correlation: Yield anomaly (dY) vs VCI, Kansas, USA



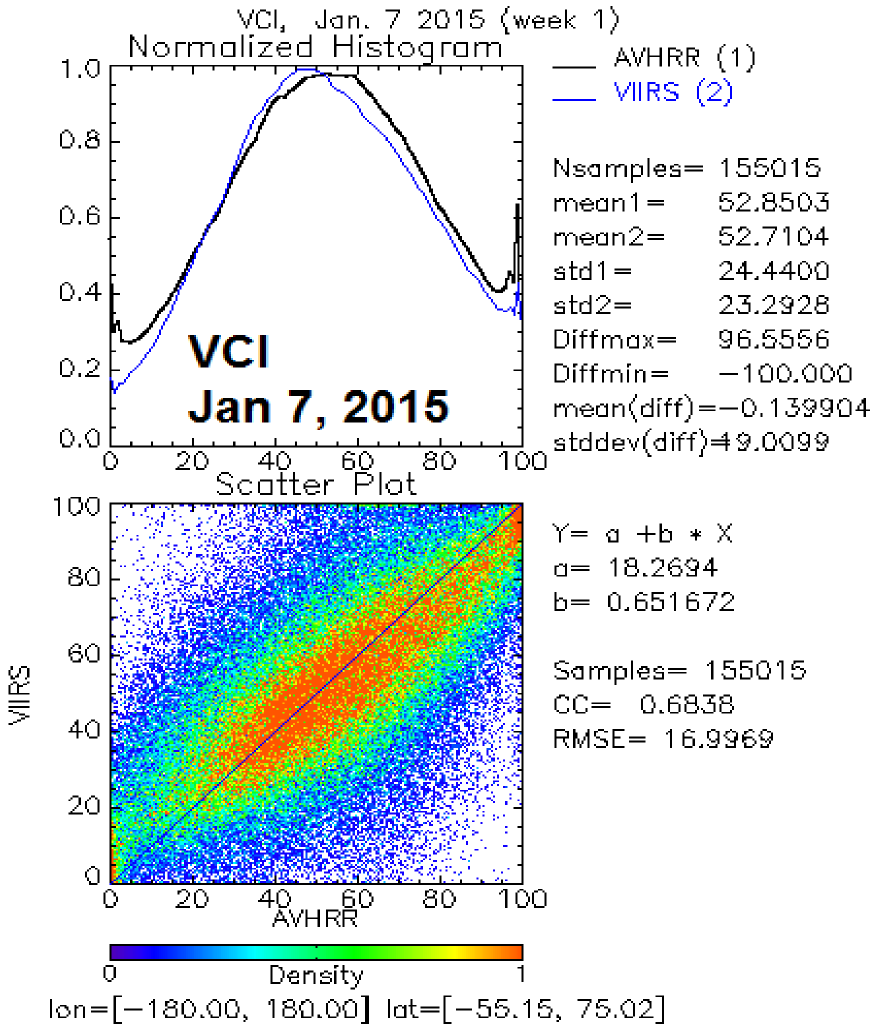
AVHRR/VH-Crop Yield Correlation

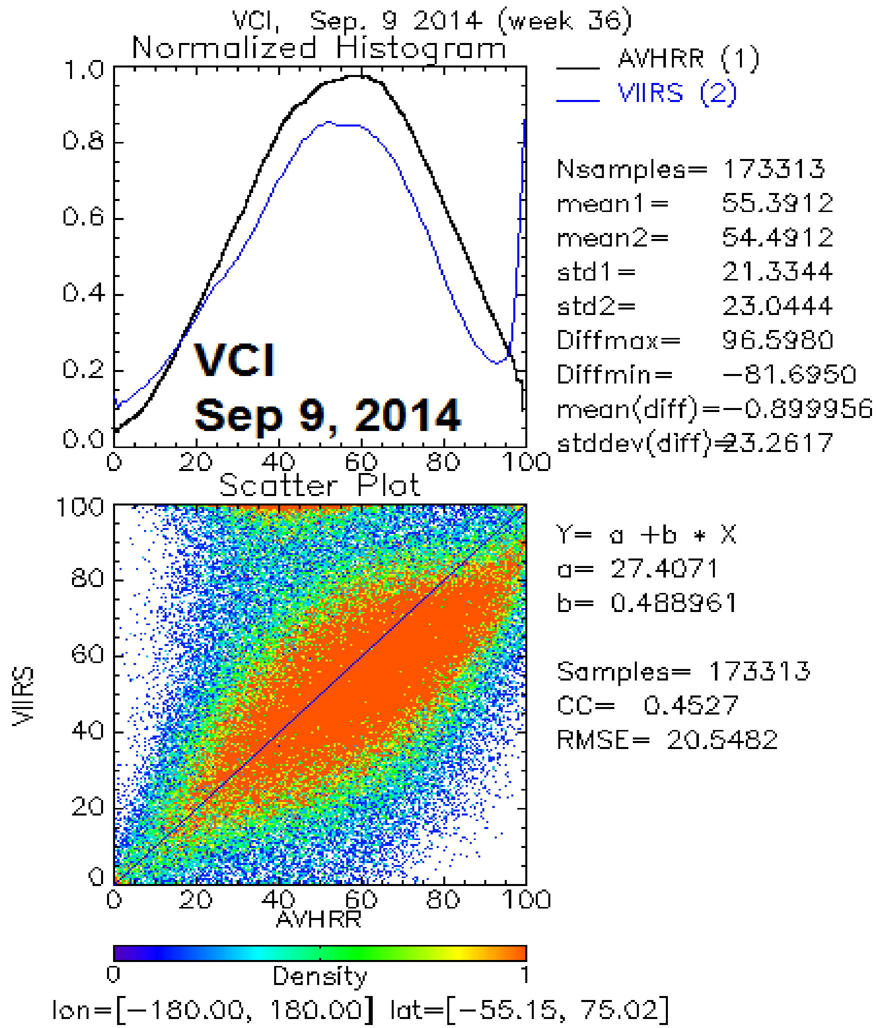




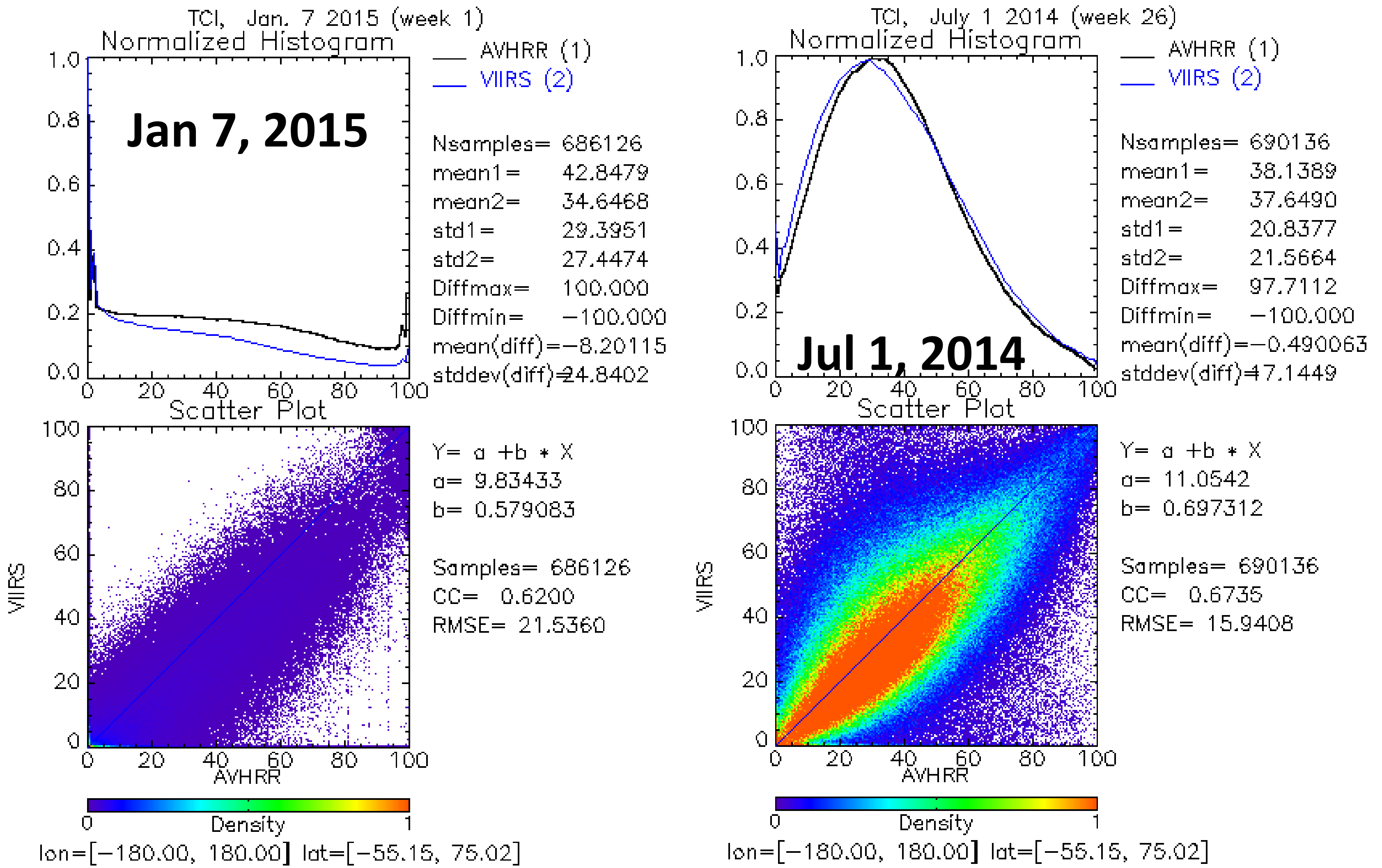
- Cl to text

Validation: VCI
Correlation of VIIRS & AVHRR
Jan 7, 2015 & Sep 9, 2014

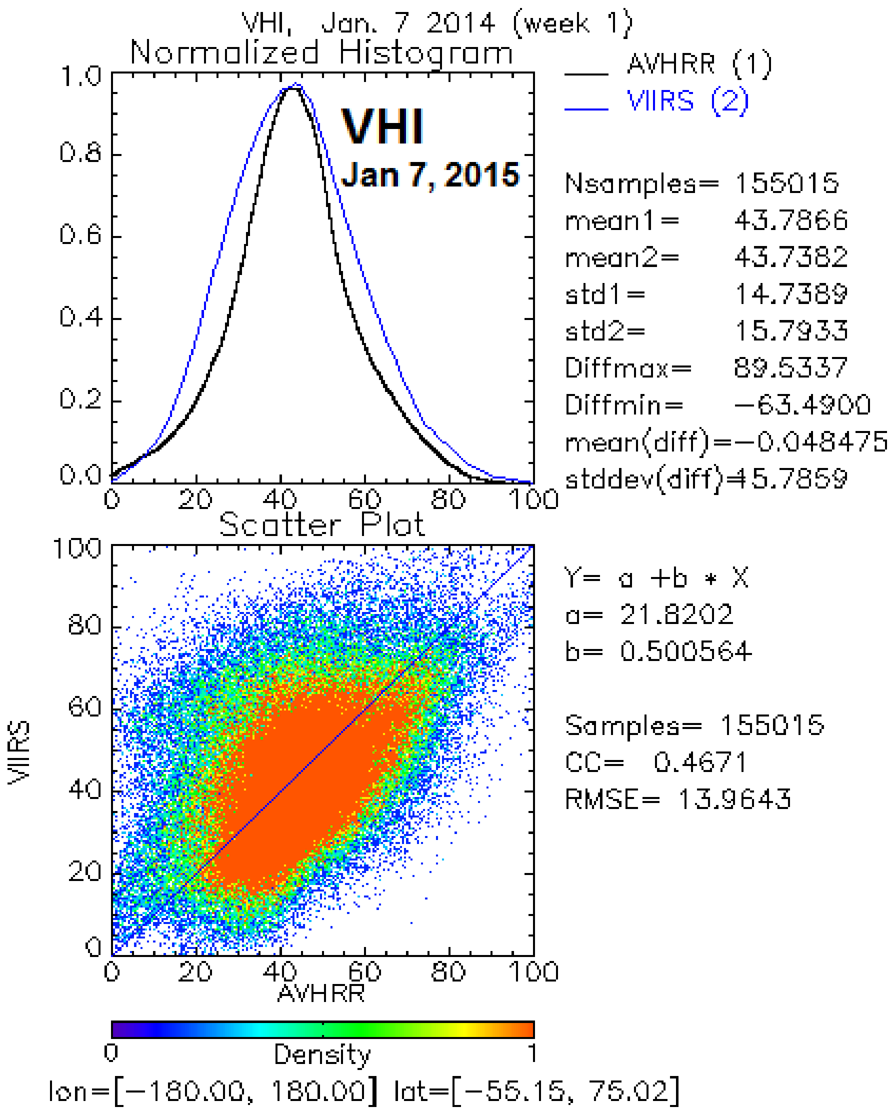


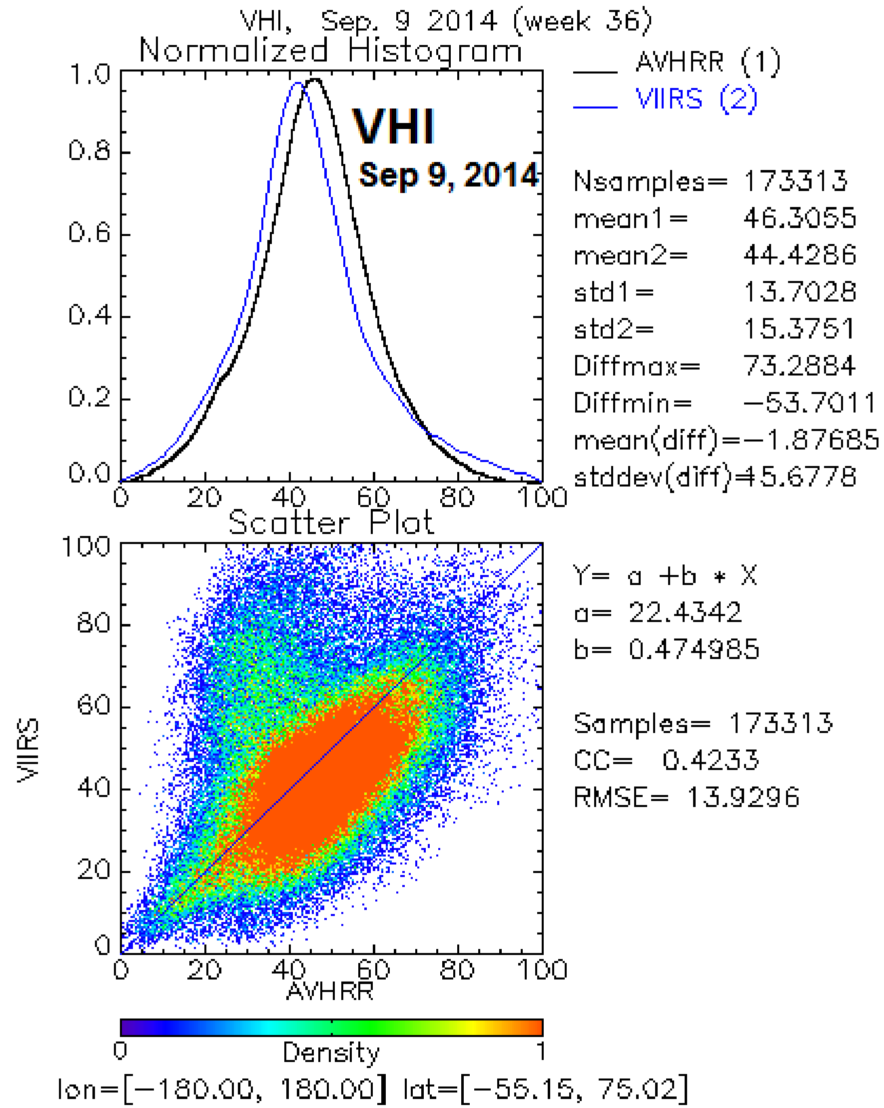


Validation: TCI
Correlation of VIIRS & AVHRR
Jan 7, 2015 & Jul 1, 2014

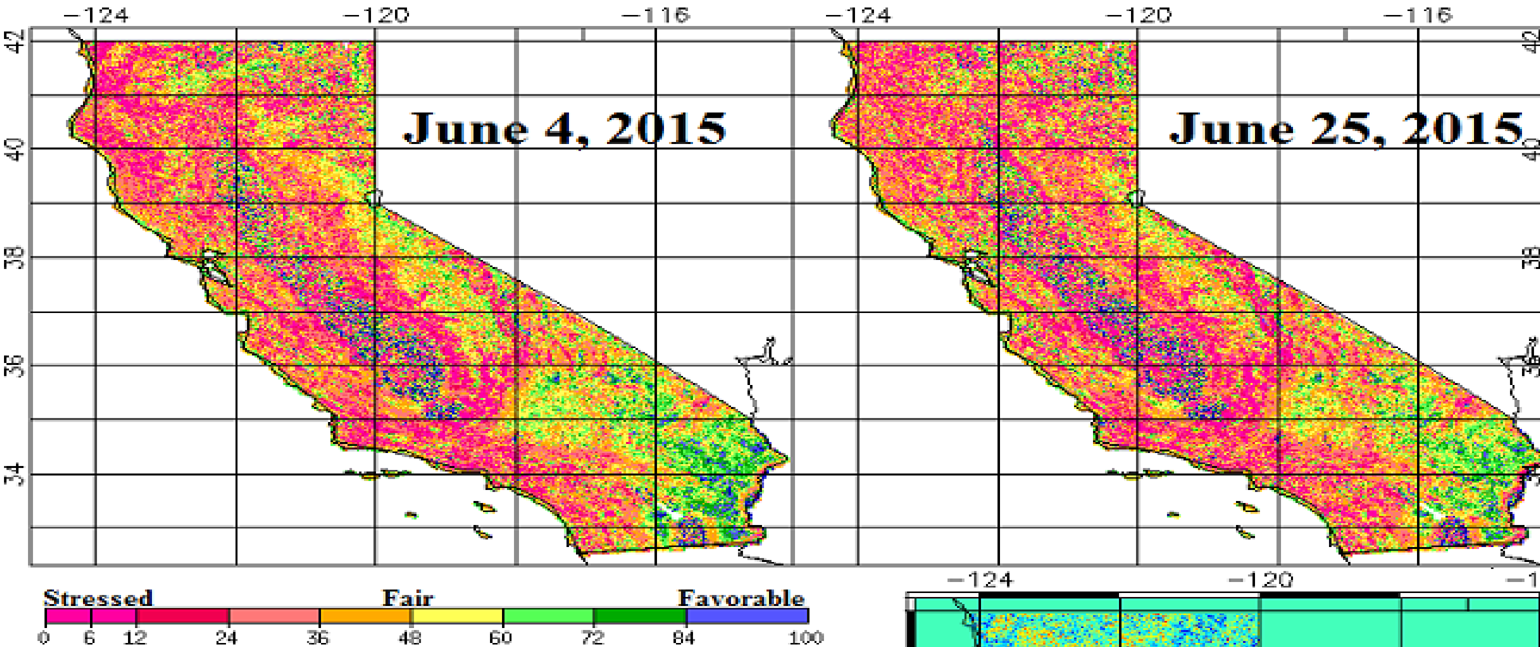


Validation: VHI
Correlation of VIIRS & AVHRR
Jan 7, 2015 & Sep 9, 2014

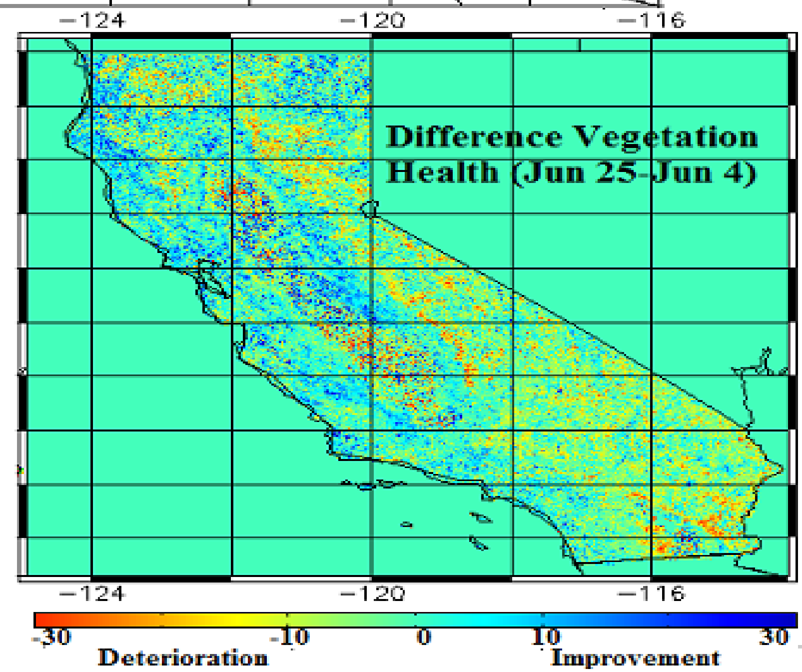




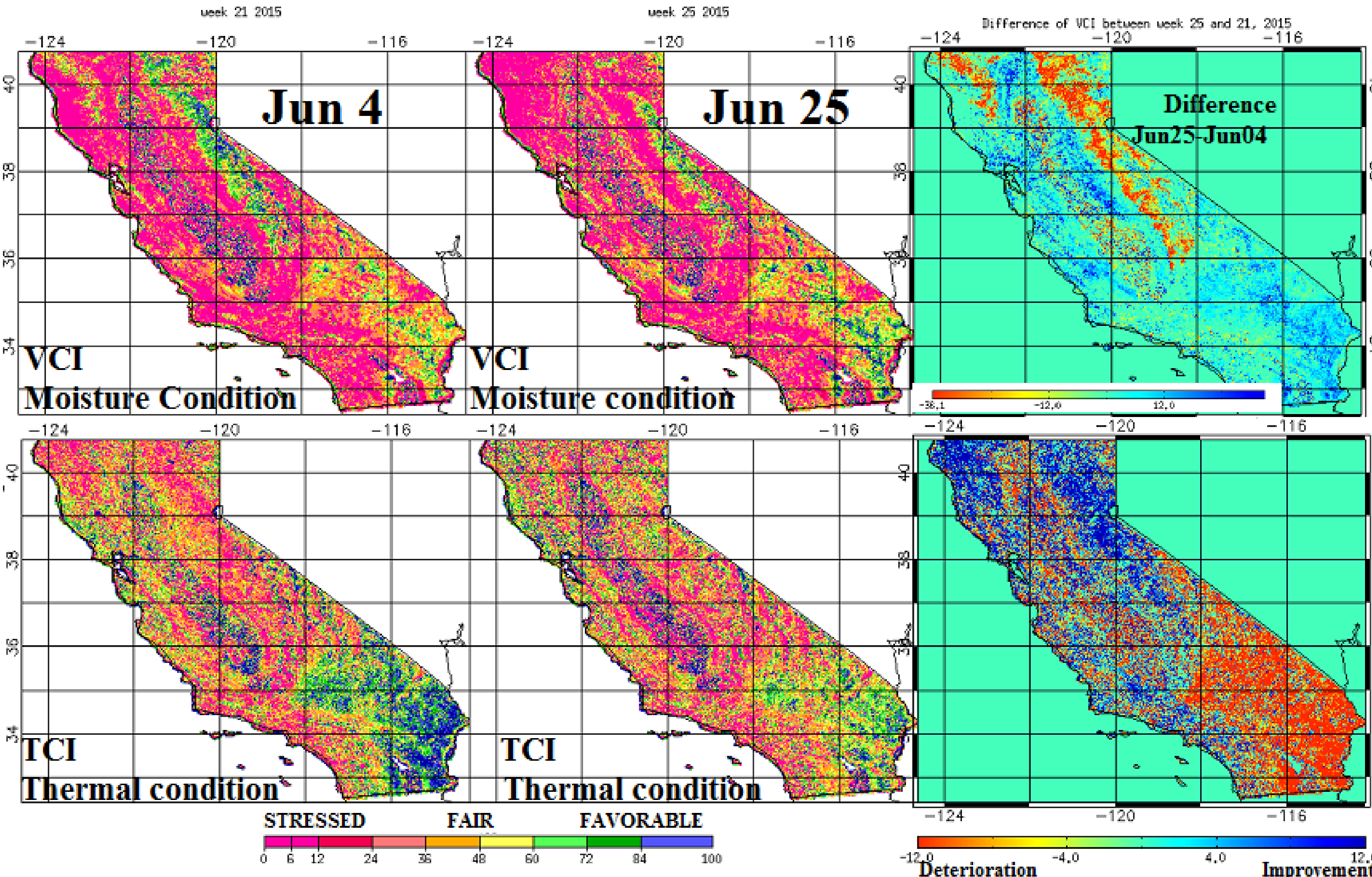
Vegetation Health (VHI) California June 2015



Vegetation Health
S-NPP/VIIRS 500 m
California

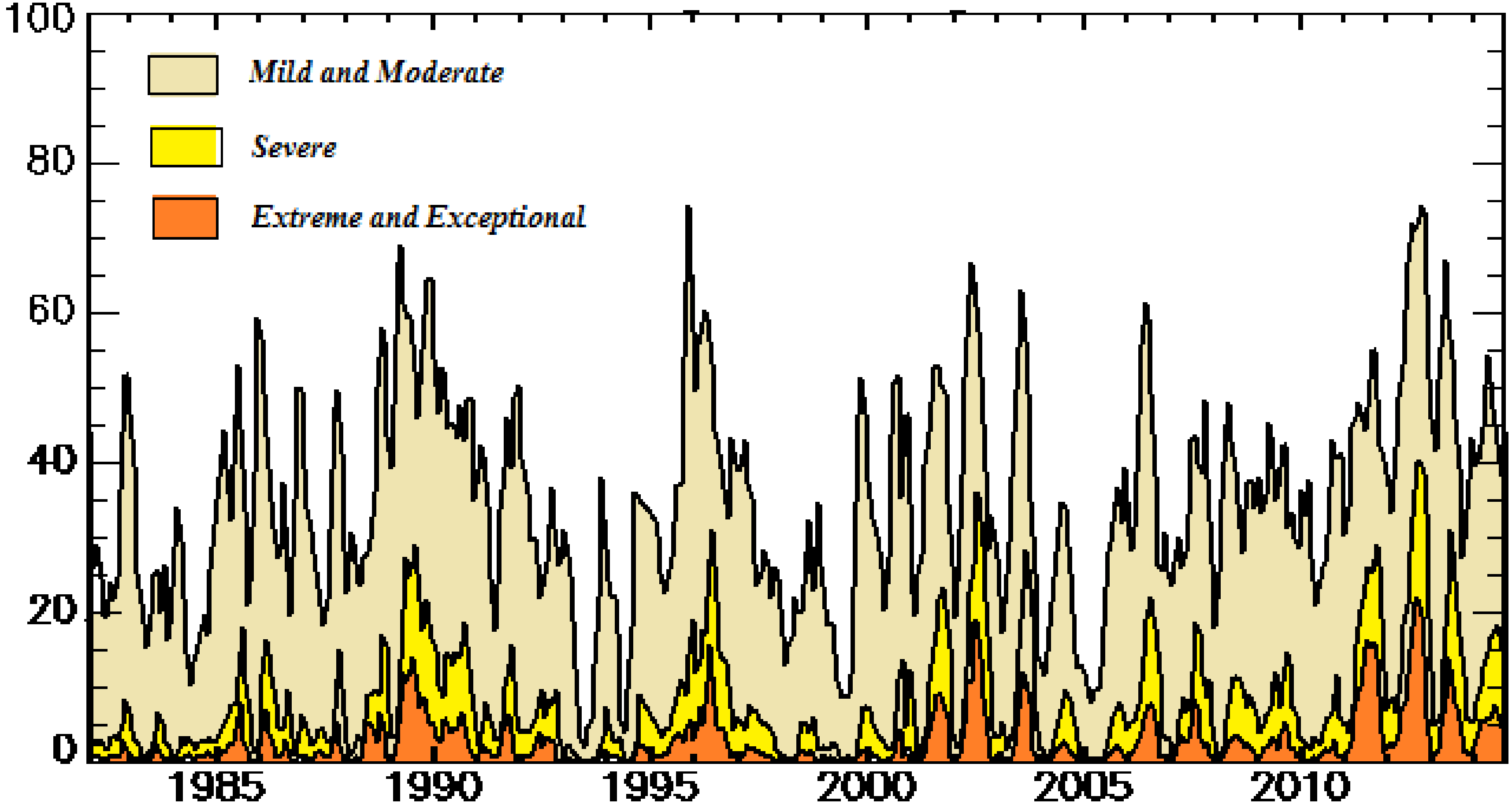


Moisture & Thermal Condition



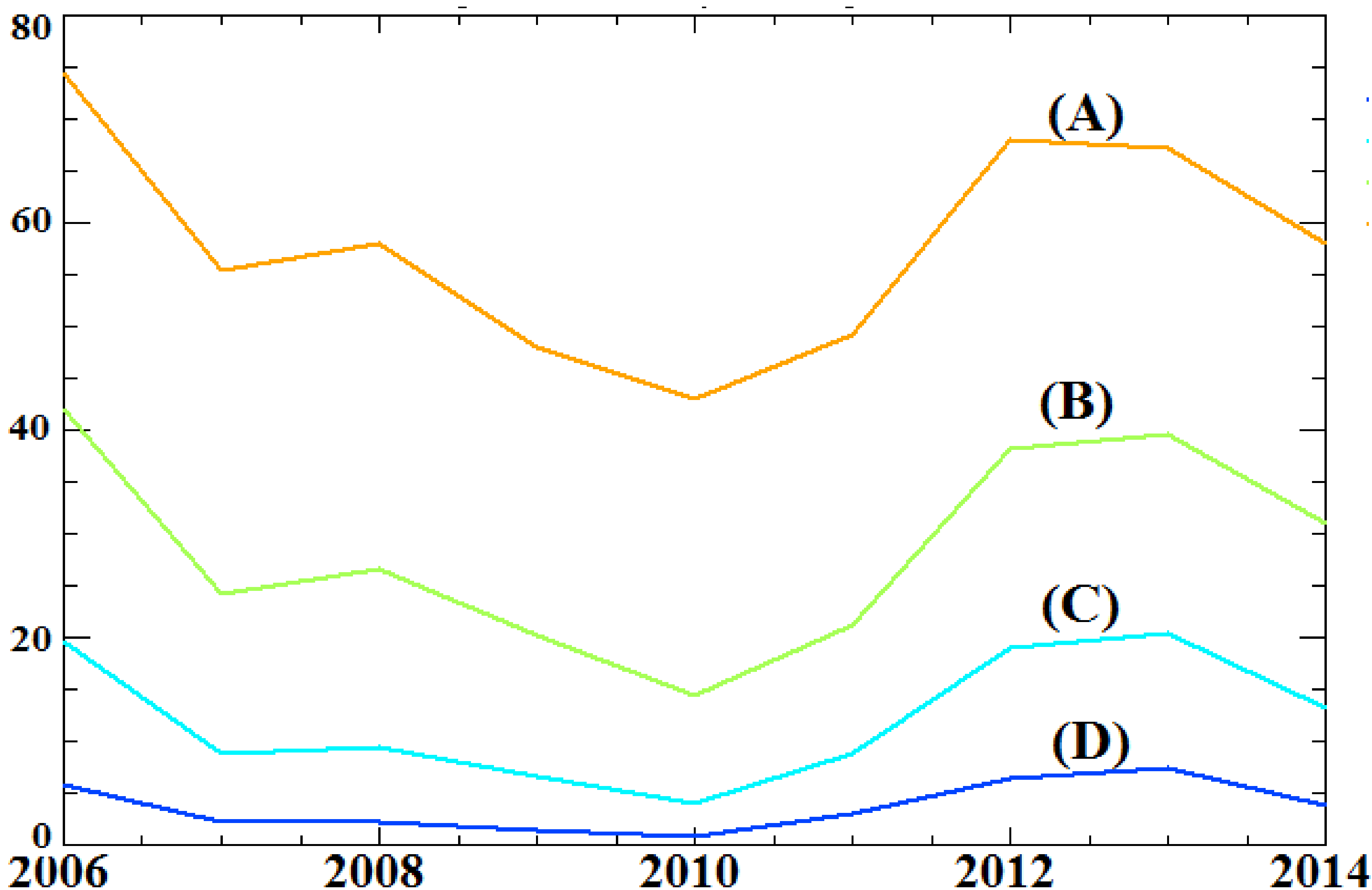
Vegetation Condition 2015, California (500 m)

Percent Western US under Drought

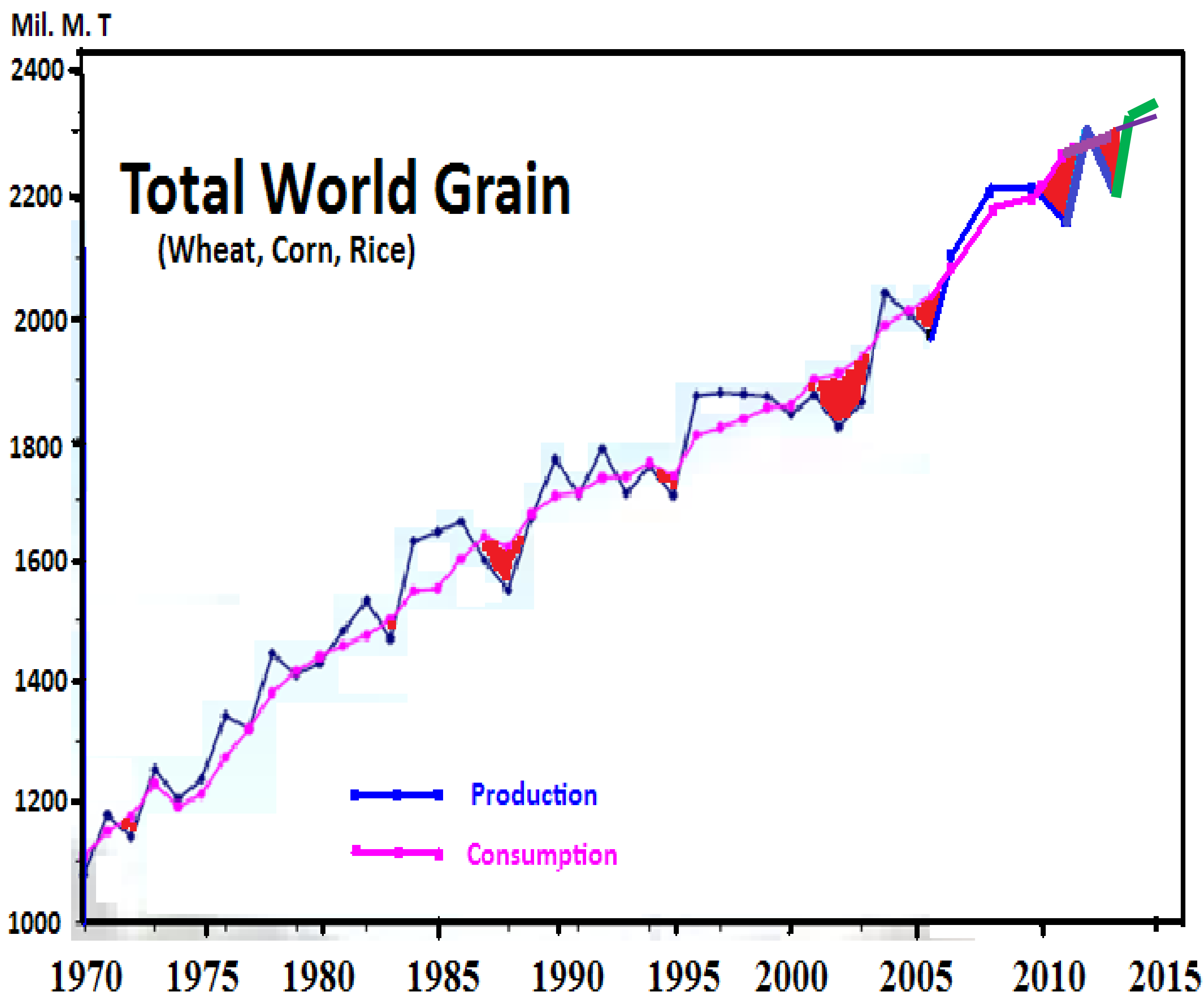


Drought Area & Intensity by weeks: Western United States, 1982-2014

Days with Drought



World Grain Production-Consumption, 1970-2013



Droughts

2013 - Argentina, Brazil, Australia, USA

2012 – USA

2011 – USA

2010 – Russia, Ukraine, Kazakhstan, Argentina

2007 – Australia, China, Argentina, Brazil

2003 – USA, Europe, Australia, India, China

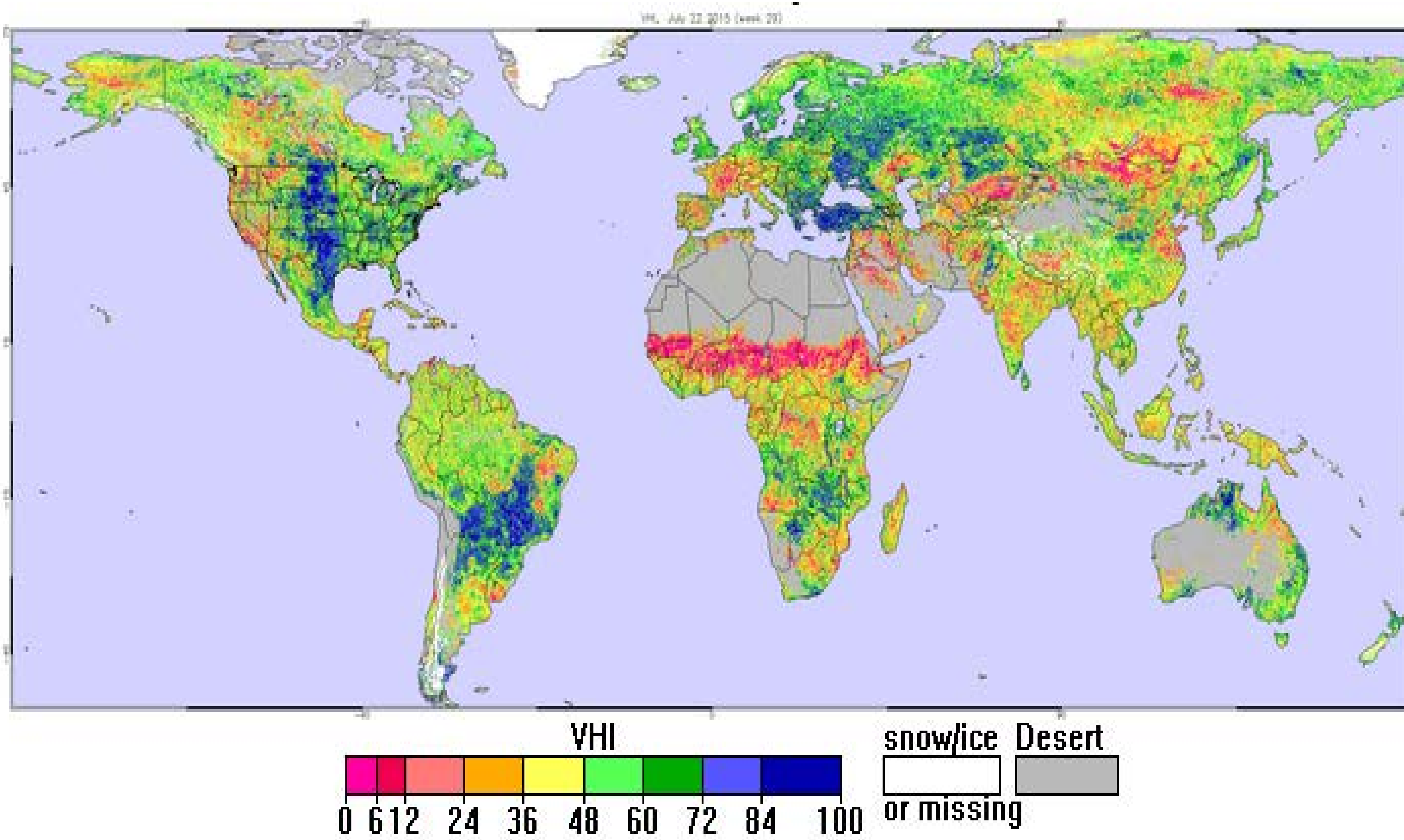
2002 – USA, India, Australia, S. Africa

2001 - China

1996 – USA, Russia, Argentina, Kazakhstan Australia

1988 – USA

Vegetation Health July 22, 2015



Web

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

Every week on Thursday

2.5-day VH WEB view (May 4-6, 2015)

Page Views May 1-6, 2015

	Today May 6	Yesterday May 5	This Month May 1-6
STAR Vegetation Health Site	132	206	806

Countries used Vegetation Health WEB during May4-6, 2015

153 Hits	30.60%	United States
81 Hits	16.20%	South Africa
54 Hits	10.80%	Switzerland
41 Hits	8.20%	Australia
17 Hits	3.40%	Mexico
16 Hits	3.20%	India
16 Hits	3.20%	Armenia
11 Hits	2.20%	France
10 Hits	2.00%	Germany
9 Hits	1.80%	Dominican Republic
8 Hits	1.60%	United Kingdom
7 Hits	1.40%	Myanmar
7 Hits	1.40%	Korea, Republic Of
7 Hits	1.40%	Spain
6 Hits	1.20%	Ukraine
6 Hits	1.20%	Iran, Islamic Republic
5 Hits	1.00%	Kenya
5 Hits	1.00%	Japan
5 Hits	1.00%	China
4 Hits	0.80%	Romania

VH-Web Visitors

August 24, 2015, by 10 am

France	France Flag
Switzerland	Switzerland Flag
Canada	Canada Flag
Russian Federation	Russian Federation

Countries during Aug 20-24

United States	United States Flag
Germany	Germany Flag
Mexico	Mexico Flag
United Kingdom	United Kingdom Flag
India	India Flag
South Africa	South Africa Flag
Brazil	Brazil Flag
Singapore	Singapore Flag
Japan	Japan Flag
China	China Flag
Australia	Australia Flag
Kenya	Kenya Flag
Vietnam	Vietnam Flag
Ukraine	Ukraine Flag

Conclusions

2014 World Population 7.3 bil. Increases with Accelerating Rate; World Grain Production Increases with Decelerating Rate

Grain supply drops below demands (in the 21st century 8 years out of 15)

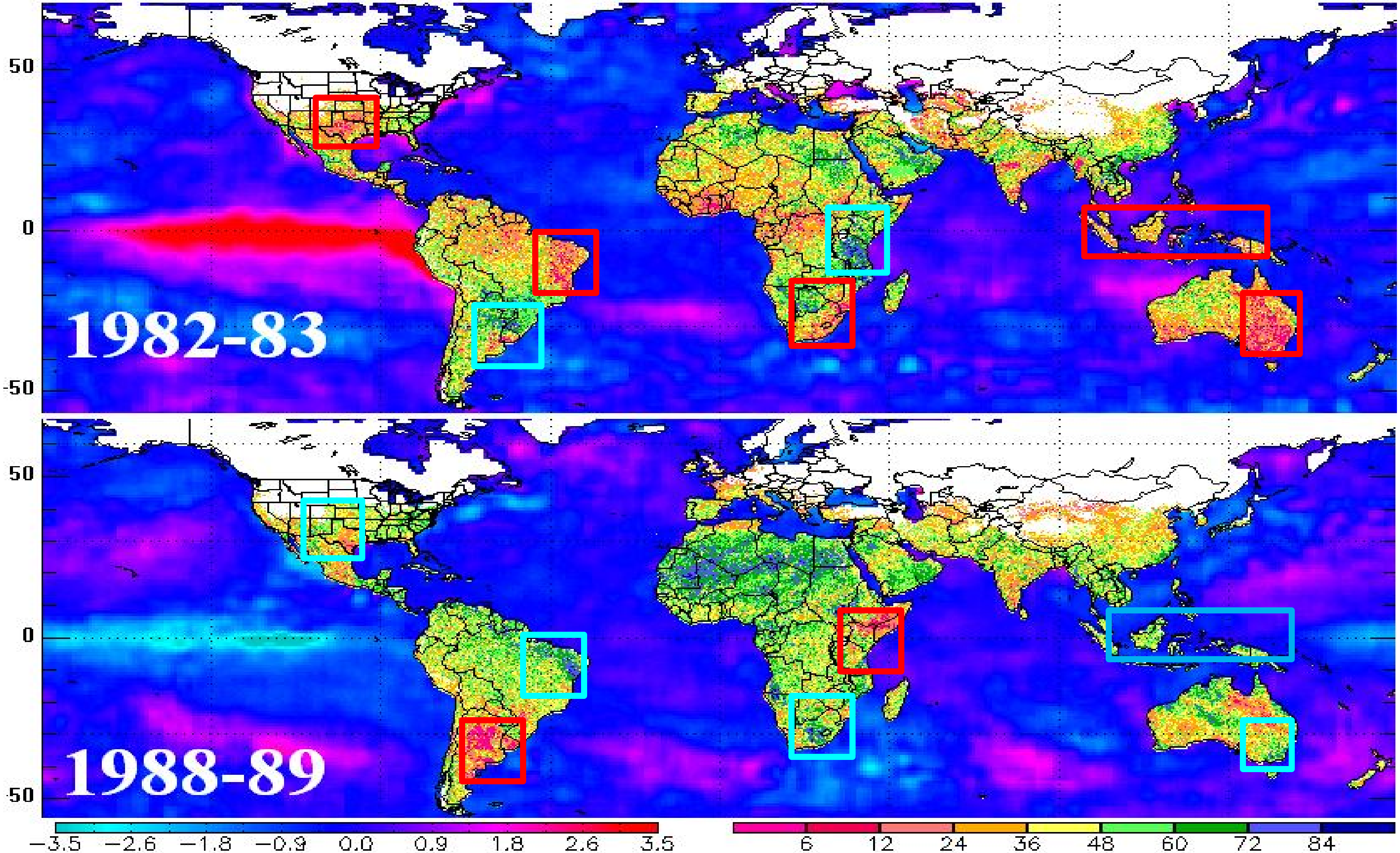
Severe Droughts - Reduces Global Grain Production 4-7% every 4-6 years; Moderate Drought – Reduces Grain 1-3% every 2-3 years

Satellite-based Vegetation Health (VH) Technology Provide Tools for Drought Monitoring & 1-2 Month Advanced Prediction of its Start/End, Area, Intensity, Duration and Impacts

VH Provide Prediction of Drought-related Crop & Pasture Losses: (a) 1-2 Months in Advance of Harvest, (b) During ENSO years 3-4 months prediction

Drought Area & Intensity has not Changed during the Period of Strong Global Warming

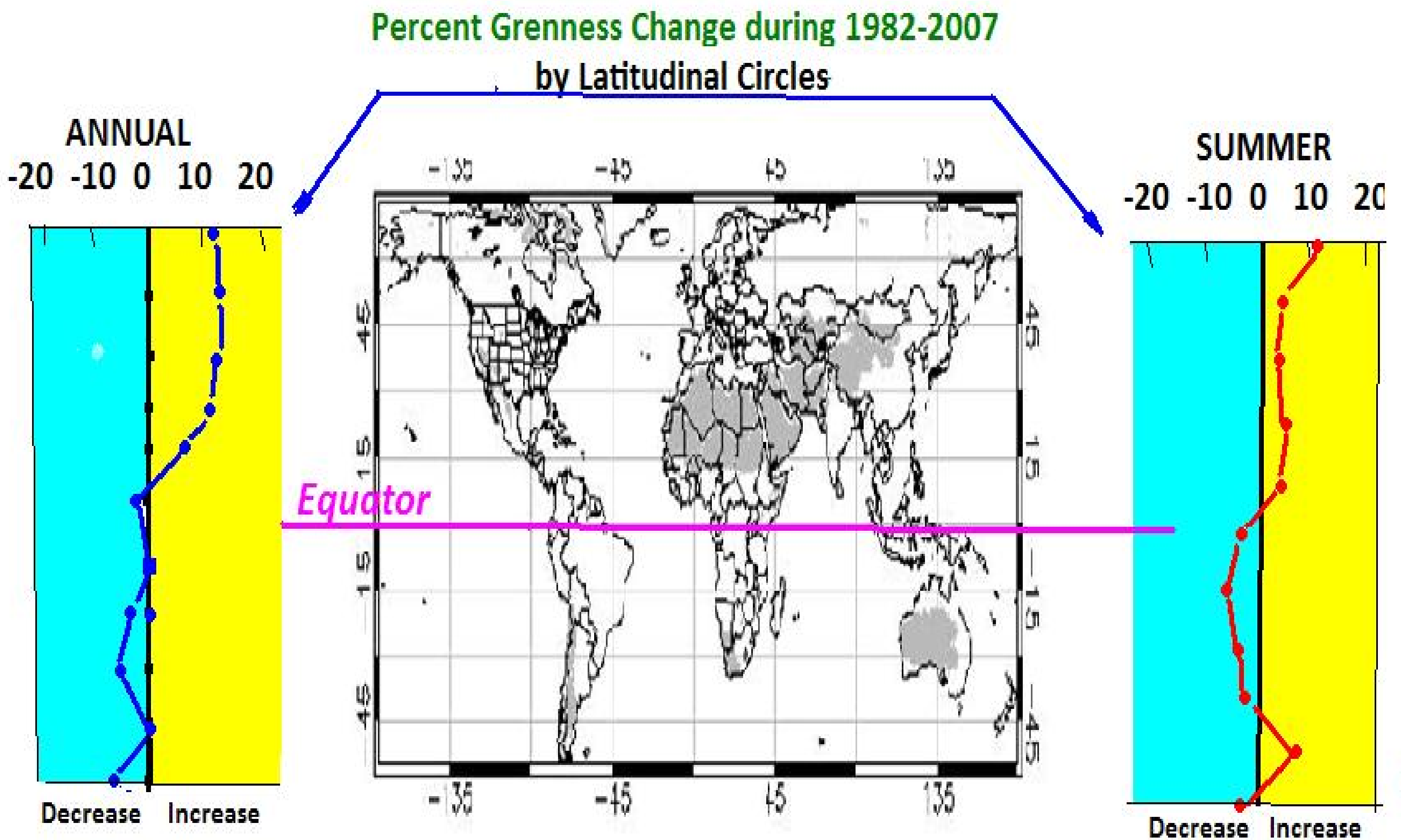
VH-Drought Prediction from ENSO (3-6 months)



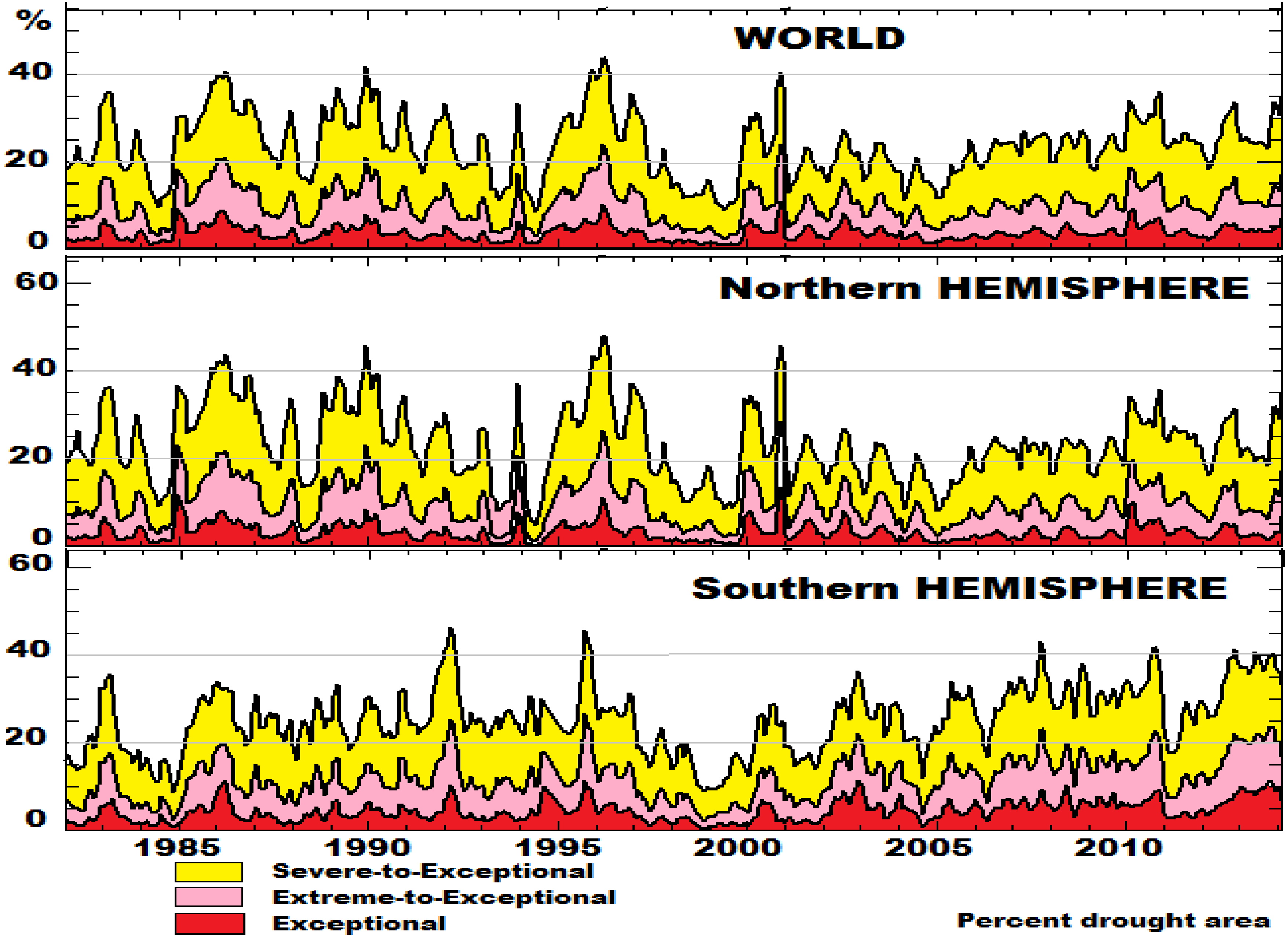
EN ... as ... od ve ... e

affected regions using VH information, time enough for planners to take action to mitigate seasonal changes. Courtesy of F. Kogan.

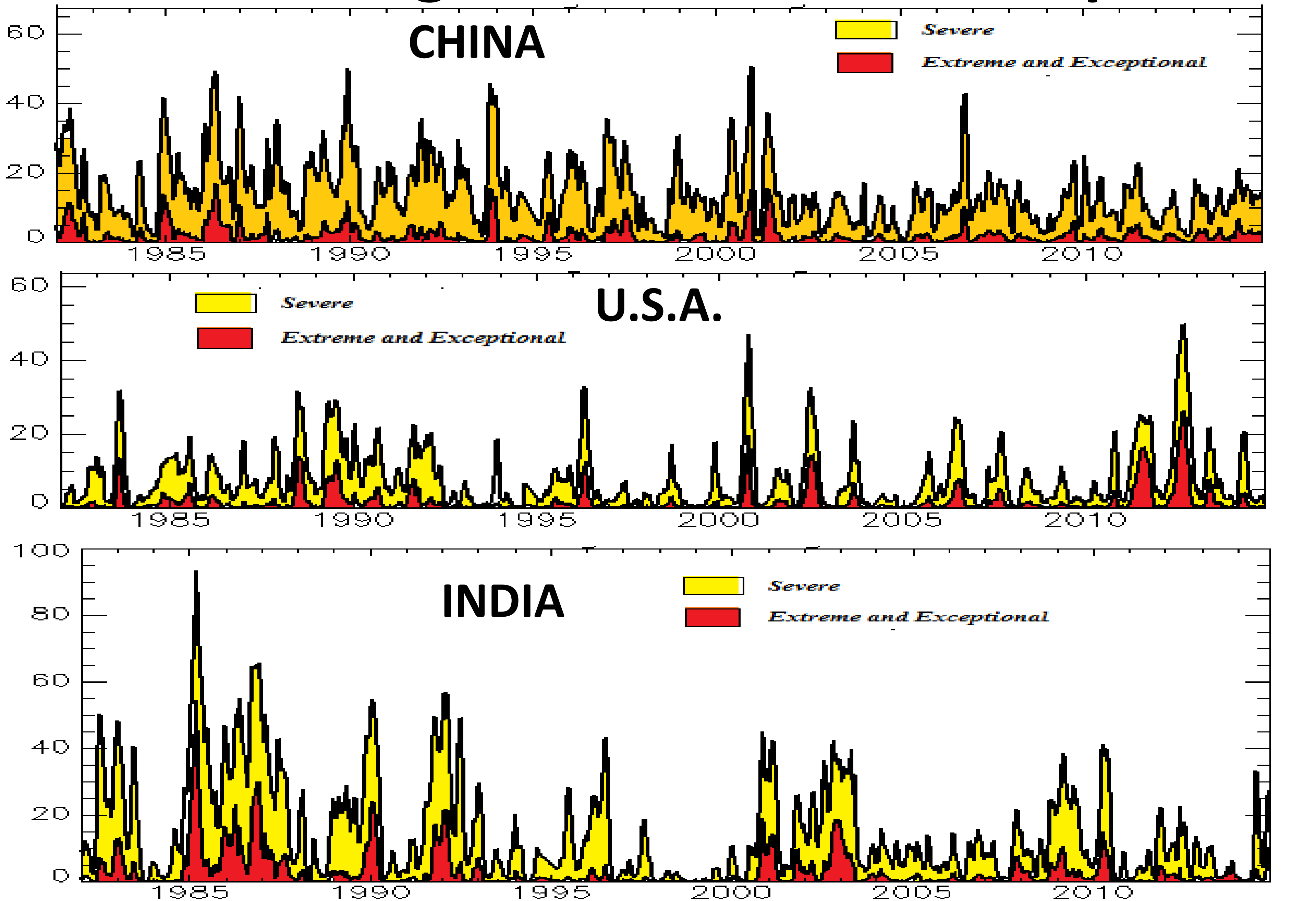
NDVI-based Land Cover Change trend, 1982-2007



Climate: Percent Land under Drought



Percent Drought-affected Grain Crop Area



AVHRR Data for Land Use

Sensors *Advanced Very High Resolution Radiometer (AVHRR)*

Visible Infrared Imaging Radiometer Suite (VIIRS)

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

S-NPP → JPSS

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

Temporal - 7-day composite

Period **35-year (1981-2015)**

3.5-year (2011-2015)

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

Channels **VIS , NIR , Thermal**

Mega-Drought in Western USA

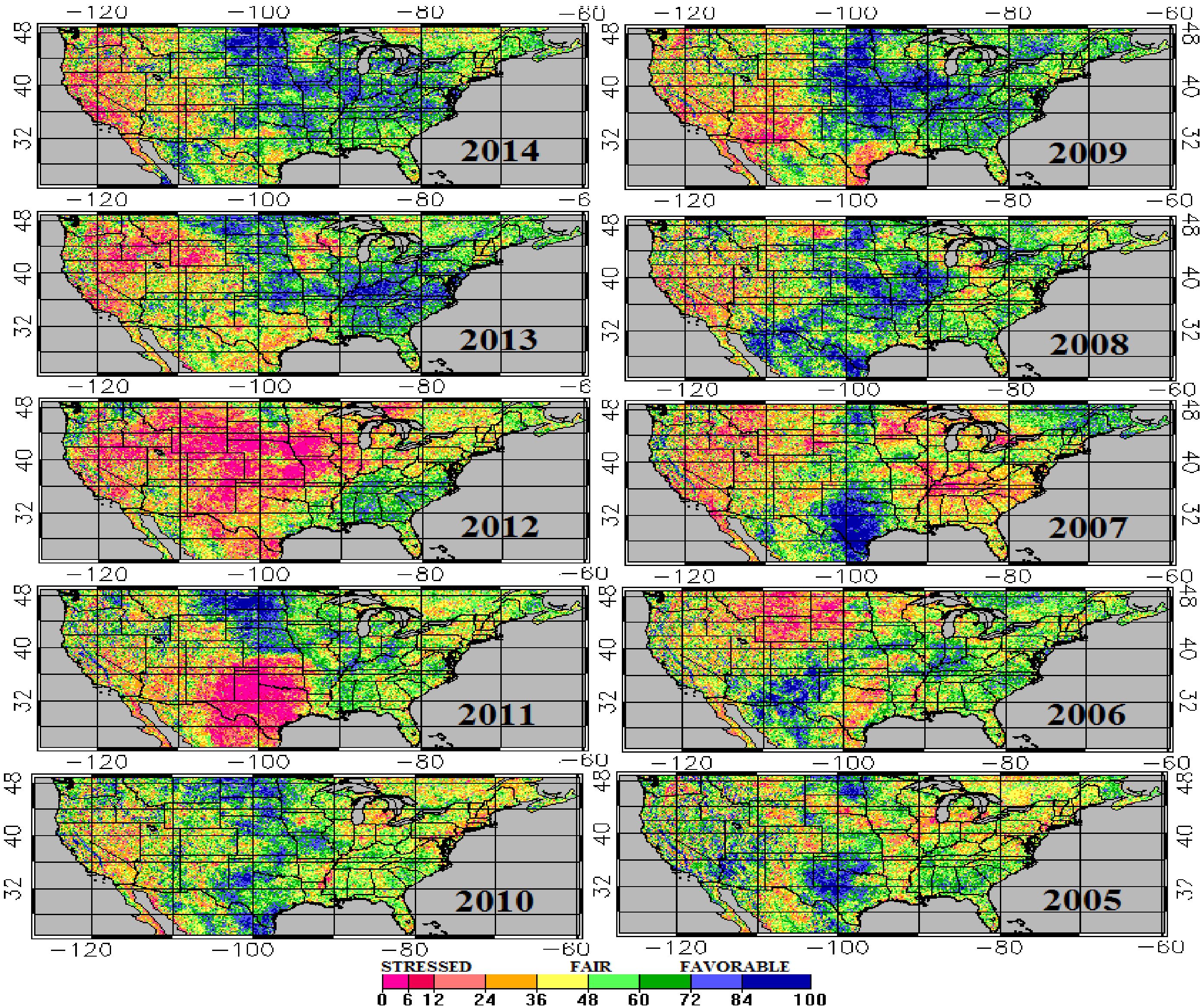
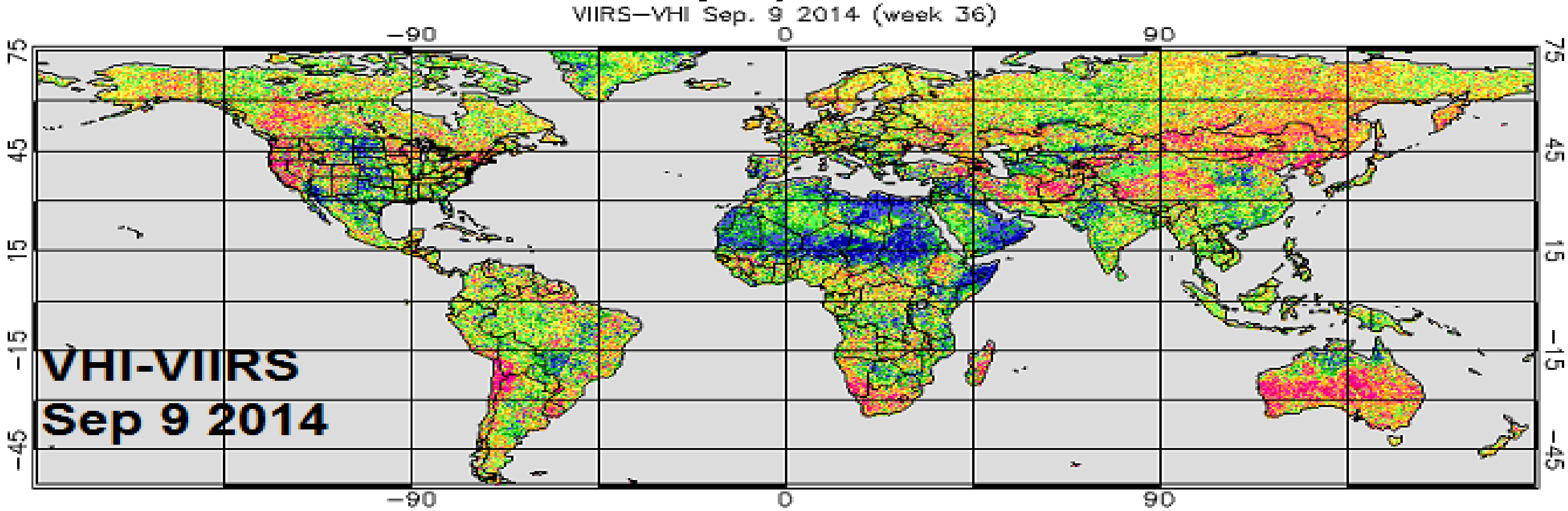
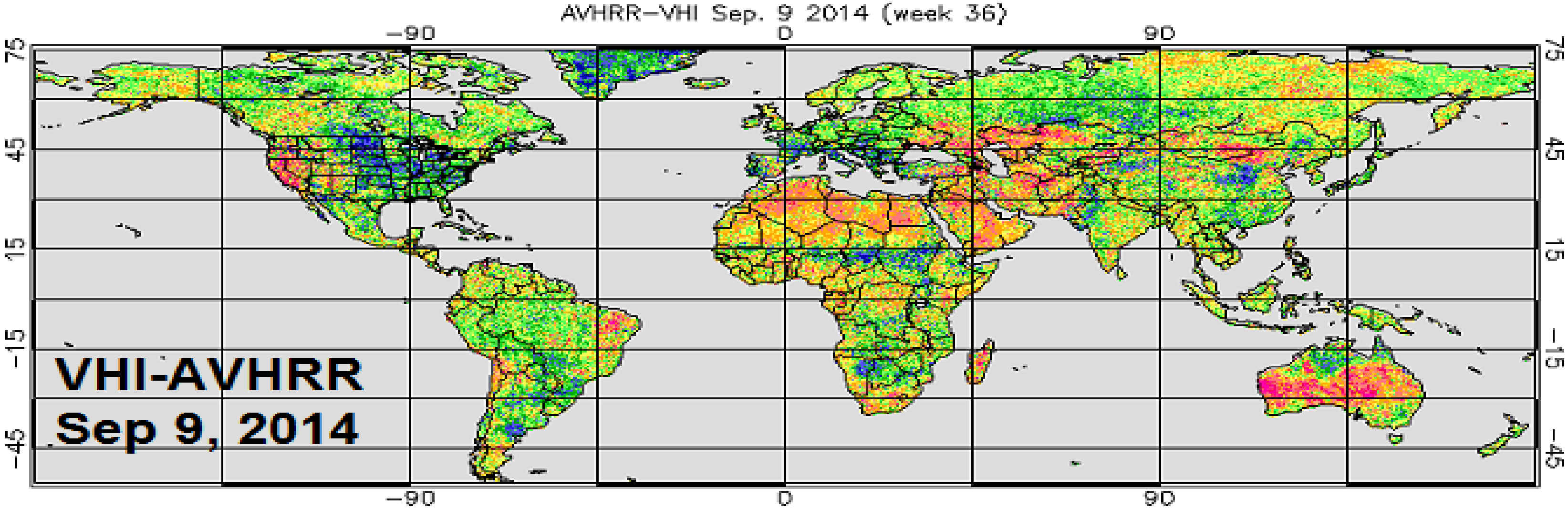


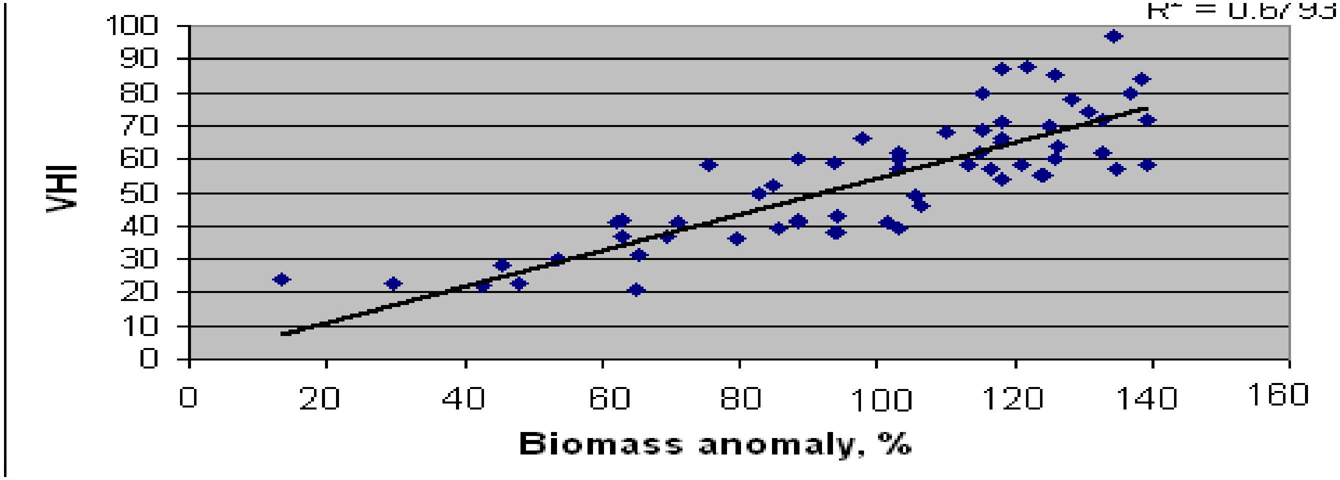
Figure 1. Vegetation health (from VHI) in August 2005 through 2014.

VALIDATION:
VHI VIIRS vs AVHRR
Sep 9, 2014

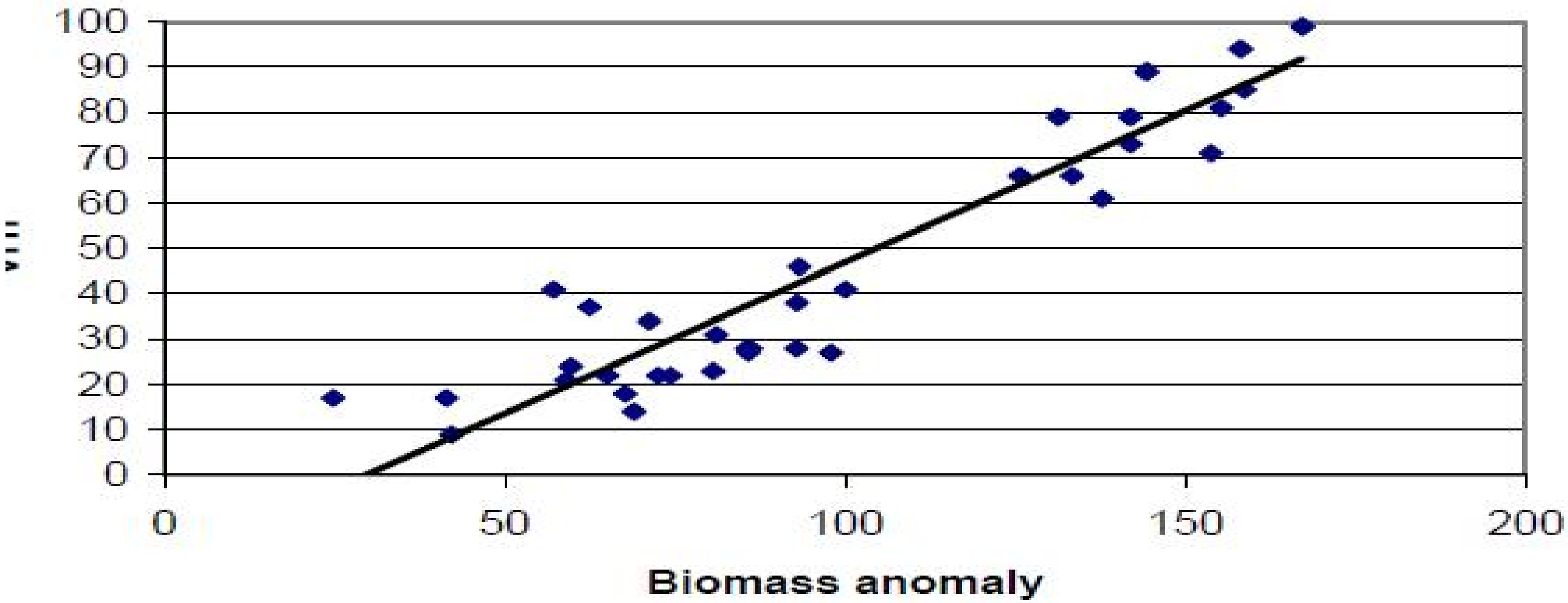




Biomass vs VHI, Turkmenistan

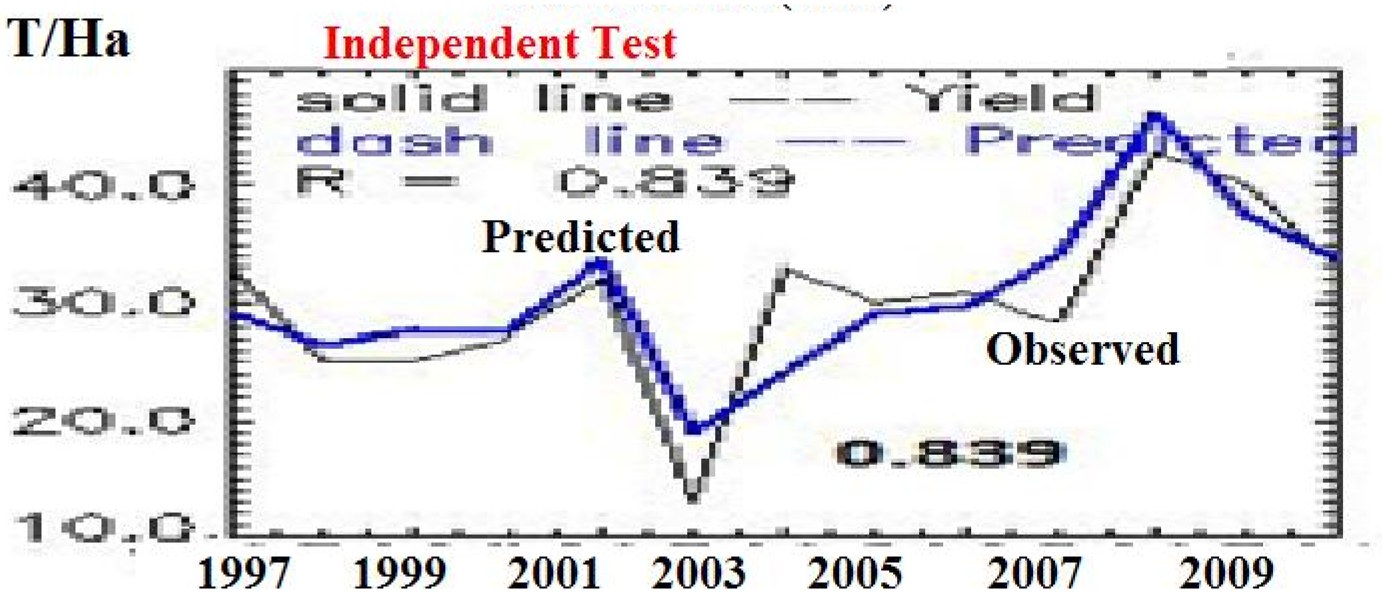


Erbent, Turkmenistan, 1982-2009 (Rsq=0.67)



Lekker monitoring site (36°16' N, 63°42'E) R^2=0.885, n=35 , 1982-2005
SoutheasternTurkmenistan.

Winter Wheat Yield
Vinnitsa Obl. UKRAINE

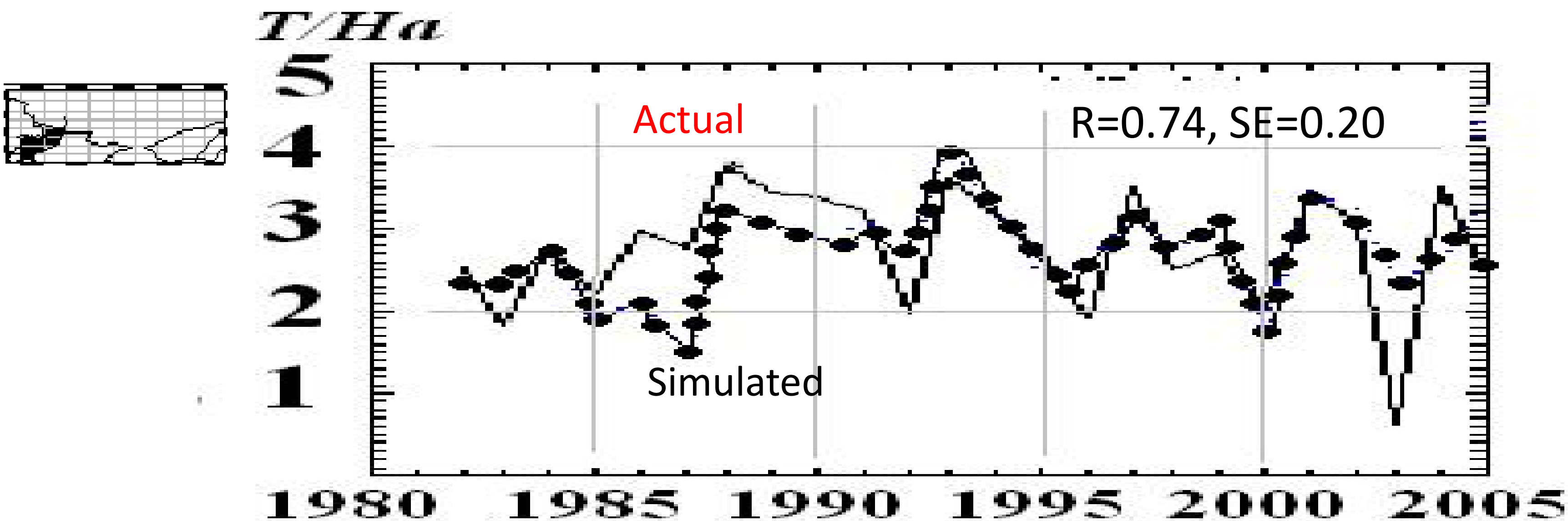


Winter Wheat yield Observed and VH-Predicted VINNITSA

Winter Wheat Yield
Odessa Obl. UKRAINE

Partial CC	*-0.57*	*0.58*	*-0.33*	*0.38*

$$dY=0.286-0.057VH_5+0.067VH_6-0.041VH_{18}+0.044VH_{19}$$



Actual vs Independently Simulated Winter Wheat Yield, Odessa Obl., UKRAINE

Vegetation Health data sources

Sensors *Advanced Very High Resolution Radiometer (AVHRR)*

Visible Infrared Imaging Radiometer Suite (VIIRS)

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

S-NPP → JPSS

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

Temporal - 7-day composite

Period **35-year (1981-2015)**

3.5-year (2011-2015)

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

Channels **VIS , NIR , IR**

Indices **NDVI & BT**

Status of land surface albedo production from the JPSS Mission

Yunyue Yu

NOAA/NESDIS, Center for Satellite Applications and Research

Shunlin Liang, Dongdong Wang, Yuan Zhou

Department of Geographical Sciences, University of Maryland

Outline

- ✓ VIIRS LSA Basics
- ✓ Current Operational Products
- ✓ Validation Status
- ✓ Issues and improvement Needs
- ✓ International Cooperation
- ✓ Long-term Monitoring
- ✓ J1 CalVal Plan

VIIRS LSA Basics

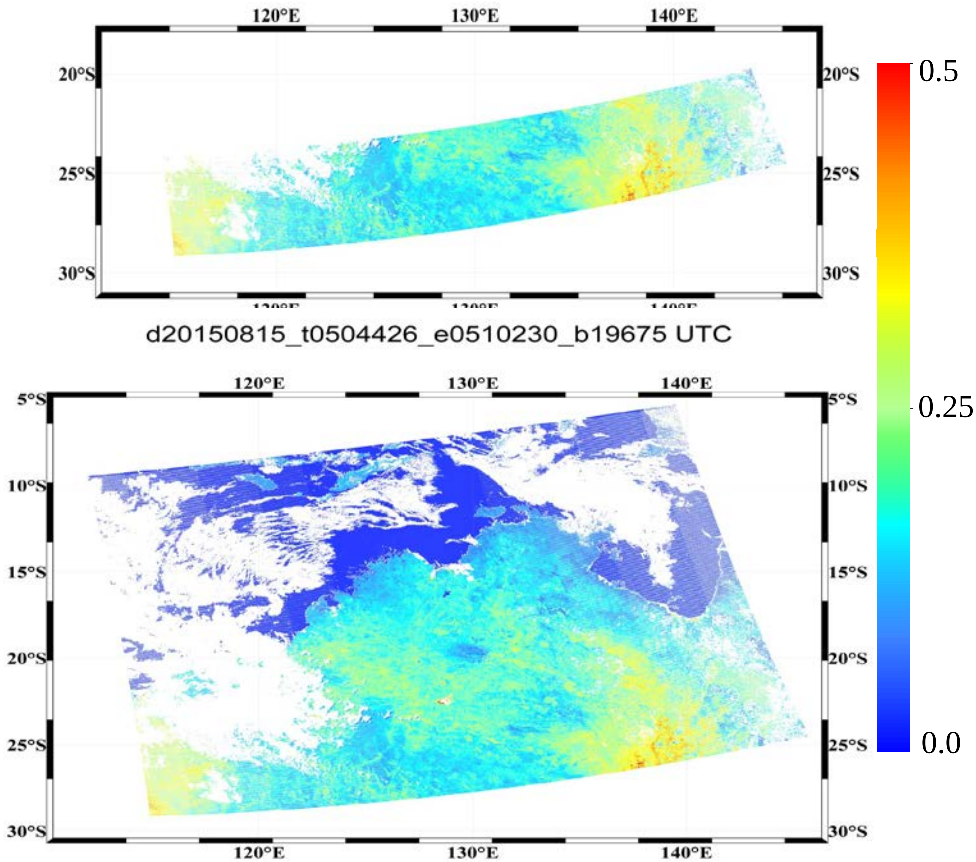
- Surface albedo is the ratio between outgoing and incoming shortwave radiation at the Earth surface. It is an essential component of the Earth's surface radiation budget.
- Surface albedo is produced from S-NPP VIIRS as Environmental Data Record (EDR). Surface albedo EDR has the global coverage, including land surface albedo (LSA) and sea ice surface albedo (ISA).
- Bright Pixel Sub-Algorithm (BPSA) is currently used to generate LSA and ISA from VIIRS data. Several improvements have been made since the S-NPP launch.
- Surface albedo EDR is a full resolution ***granule instantaneous*** product. LSA is only generated for ***clear-sky*** pixels.

Albedo EDR Cal/Val Team Membership

	Name	Institute	Function
JPSS-STAR	Land Lead: Ivan Csiszar	NOAA/NESDIS/SATR	Project Management
	EDR Lead: Yunyue YU	NOAA/NESDIS/SATR	Team management, algorithm development, validation
	Shunlin Liang	UMD/CICS –project PI	algorithm development, validation
	Dongdong Wang	UMD/CICS	algorithm development, validation, monitoring
	Yuan Zhou	UMD/CICS	algorithm development, validation, monitoring
	Marina Tsidulko	IMSG	STAR AIT support: product verification, testing
	Mike Ek' team	NOAA/NWS/NCEP	User readiness
	Weihong Zheng	NOAA/NWS/NCEP	User readiness
JPSS DPA			
	Leslie Belsma	JPSS/DPA	algorithm Manager (JAM) for Land
NASA S-NPP Science Team			
	Robert Wolf' team	NASA/GSFC	Cal/Val support
	Miguel Roman	NSAS/GSFC	algorithm (DPSA) development, product validation
	Crystal Schaaf	UMB	algorithm (DPSA) development, product validation

Basics: Current Operational Product

- Operational Product
  - 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



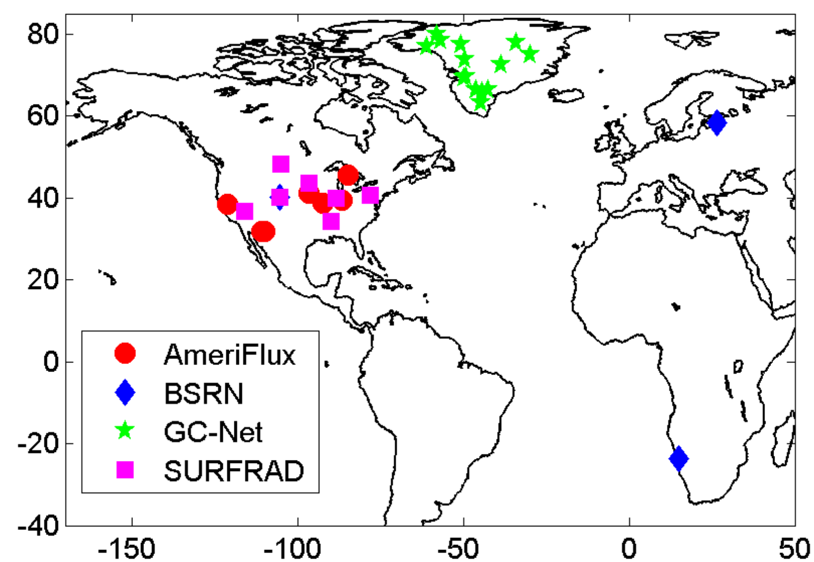
- Archive site
  - CLASS: http://www.nsof.class.noaa.gov/saa/products/welcome (search for JPSS VIIRS EDR)
  - Team site : http://www.star.nesdis.noaa.gov/jpss/albedo.php
  - NASA site: http://viirsland.gsfc.nasa.gov/Products/AlbedoEDR.html
- Monitoring: http://www.star.nesdis.noaa.gov/jpss/EDRs/products_LST.php

Validation status

Site	RMSE		Bias	
	VIIRS	MODIS	VIIRS	MODIS
AZ_Kendall_Grassland	0.042	0.062	-0.030	-0.057
AZ_Lucky_Hills_Shrubland	0.025	0.042	0.001	-0.039
AZ_Santa_Rita_Creosote	0.044	0.048	0.003	-0.035
AZ_Santa_Rita_Mesquite	0.026	0.033	0.007	-0.028
IN_Morgan_Monroe_State_Forest	0.043	0.063	-0.032	-0.058
MI_UMBS	0.200	0.028	0.136	-0.028
MI_UMBS_Disturbance	0.243	0.039	0.171	-0.032
MO_Missouri_Ozark_Site	0.025	0.041	-0.012	-0.035
NE_Mead_irrigated	0.032	0.141	0.007	-0.047
NE_Mead_Rainfed	0.209	0.184	0.088	0.096
Boulder	0.051	0.117	-0.017	-0.049
GITS	0.112	0.761	-0.057	-0.570
Humboldt	0.114	0.112	-0.071	-0.096
Summit	0.106	0.074	-0.028	-0.061
DYE-2	0.152	0.059	-0.009	0.027
Saddle	0.094	0.104	-0.028	-0.039
South-Dome	0.109	0.095	0.055	0.046
NASA-SE	0.142	0.241	-0.043	-0.086
Sioux_Falls	0.114	0.078	0.048	0.009
Table_Mountain	0.050	0.163	0.020	-0.019
Desert_Rock	0.038	0.011	0.029	-0.009
Fort_Peck	0.042	0.258	-0.006	-0.131
Penn_State	0.081	0.073	-0.066	-0.035
Goodwin_Creek	0.037	0.045	-0.031	-0.042

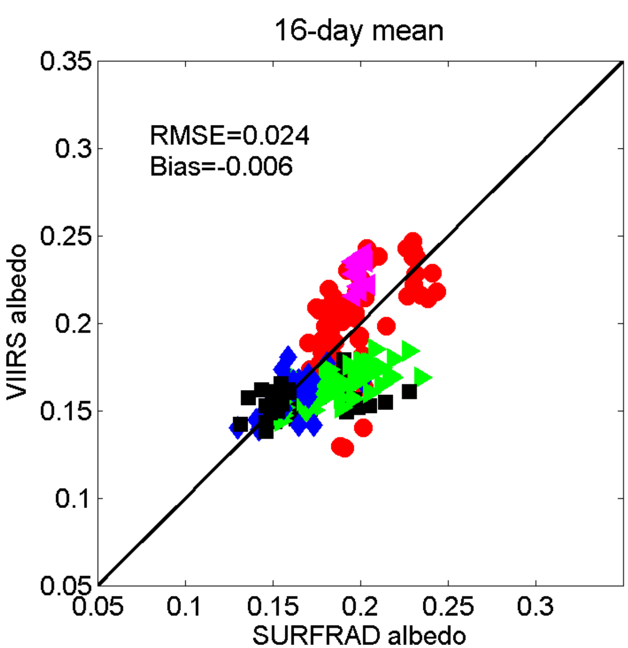
Validation data period: 2012 , 2013, 2014

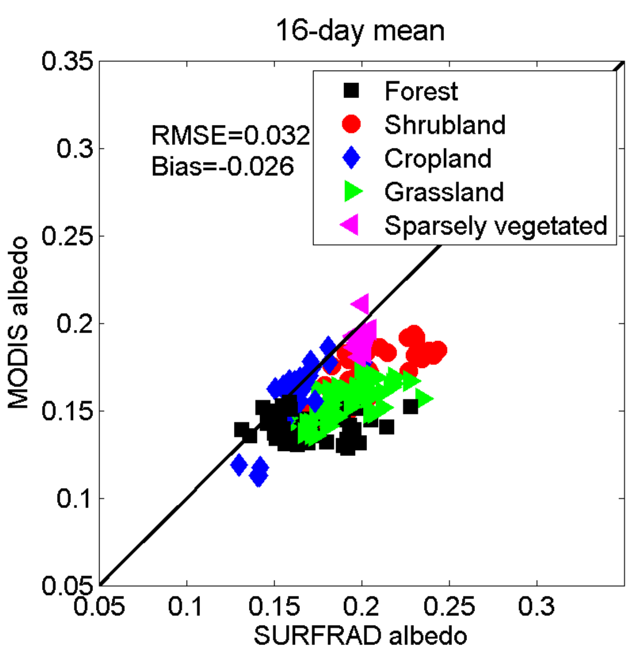
- Data of 35 stations are collected, which include measurements of recent three years.
- VIIRS data are generally better than MODIS products, with smaller RMSE and bias.
- Both data sets have high accuracy for snow-free cases.
- Large RMSE usually occurs at the cases of snow pixels and ephemeral snow.



Validation results for non-snow albedo

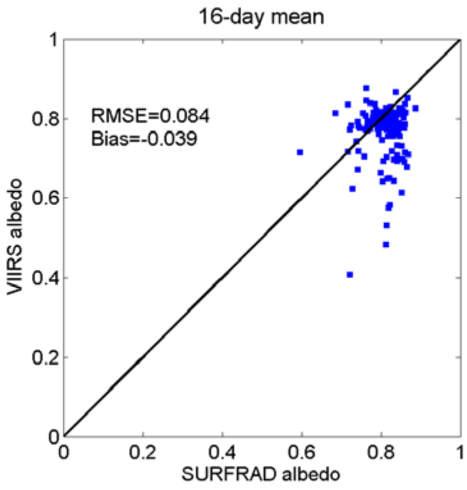
- Further analyzing accuracy of non-snow albedo
- Data over non-snow sites during non-snow seasons were used.
- 16-day mean was calculated to compare with MODIS data
- VIIRS data have smaller bias and RMSE, well below the product threshold.

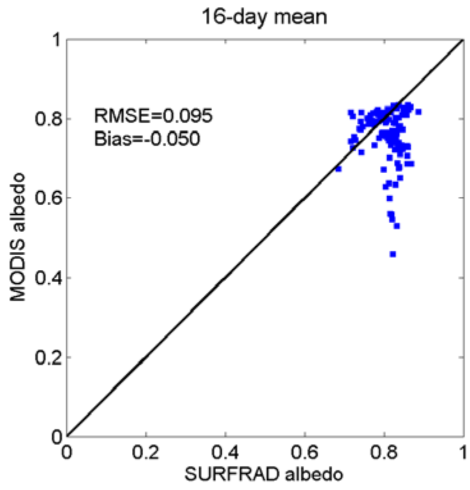




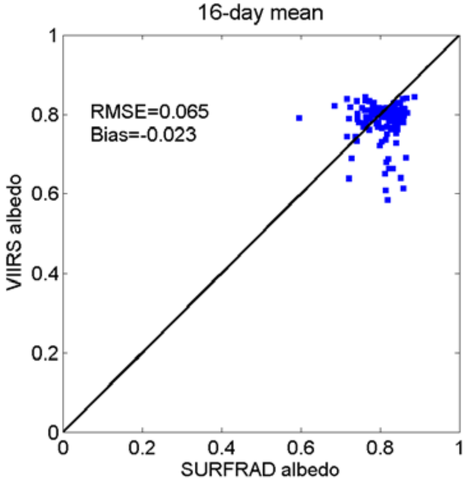
Validation results for snow albedo

- Accuracy of estimating snow albedo was evaluated at GC-Net stations.
- VIIRS generally has improved results.
- Retrieval accuracy is strongly dependent on quality of cloud detection.
- Temporal filtering can improve retrieval quality and data continuity.

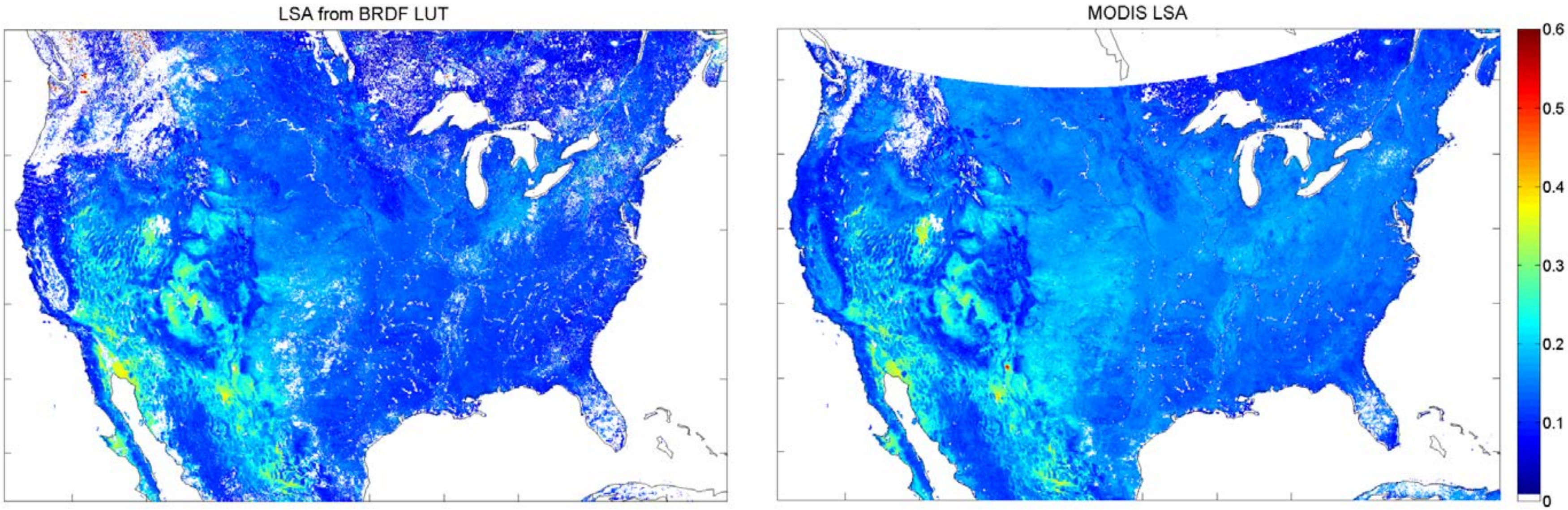




With temporal filtering

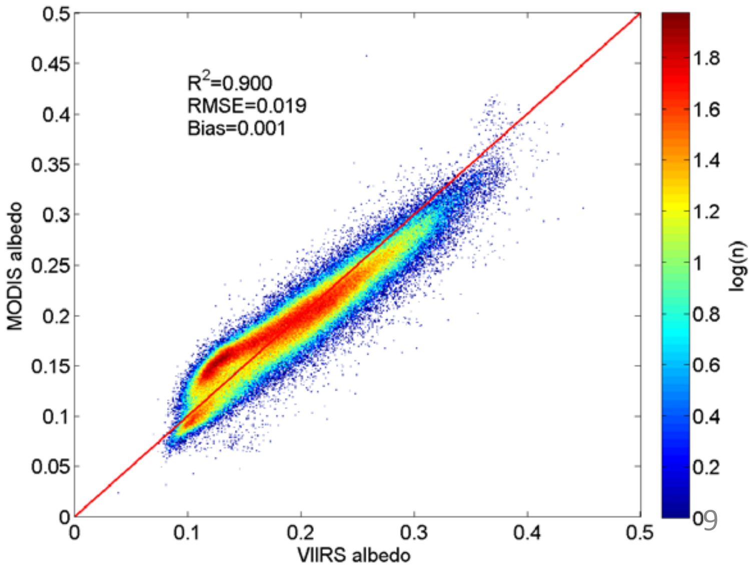


Inter-comparison with MODIS albedo



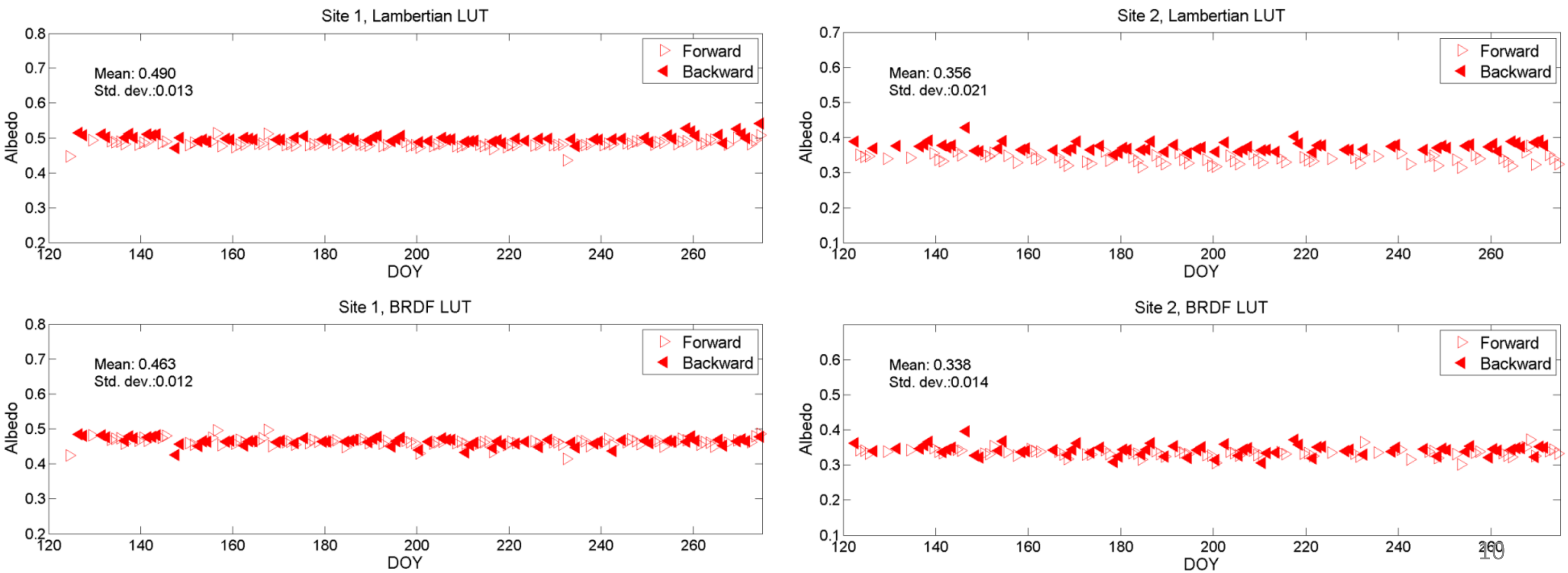
Contiguous US maps of 16-day mean LSA from VIIRS and MODIS, during DOY 145-160, 2012

Comparing 16-day mean VIIRS albedo from BRDF-impacted LUT with MODIS blue-sky albedo. Data are limited to those with at least 8 clear-day observations during the composite period of 16 days.



Temporal variability of LSA retrievals

- The VIIRS LSA algorithm uses one observation to estimate LSA. Angular dependency has been substantially reduced by incorporation of surface BRDF in model construction.
- Residual variations still exist after algorithm improvement, though they are comparable to results of other methods.
- The LSA retrievals over two Libya desert sites (Site 1: 24.42˚N 13.35˚E and Site 2: 26.45˚N, 14.08˚E) are used to illustrate the issue of temporal variability of LSA retrievals.

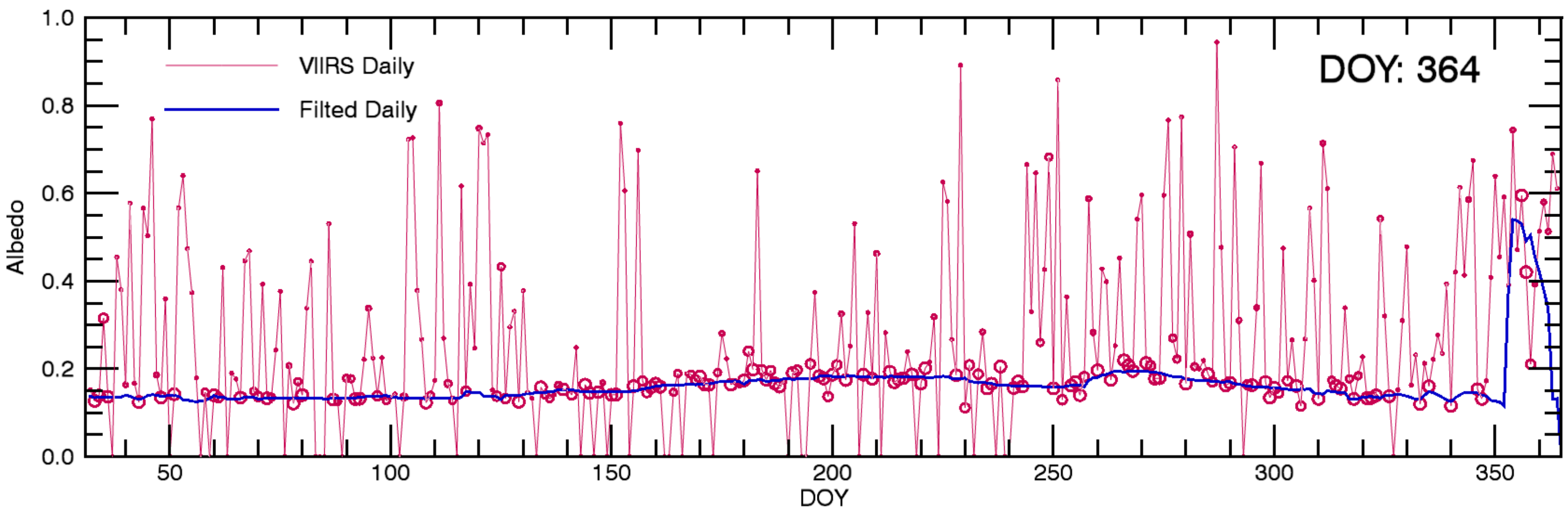


Issues and Improvement Needs

- **LUT of sea ice albedo** is out of date. Evaluation of current sea ice albedo data and development of a new LUT is greatly needed.
- The current BPSA algorithm estimates albedo from a single clear-sky observations. It is sensitive to errors in cloud mask and random effects. **Temporal filter** is proposed to generate smoother and gap-free albedo with improved accuracy.
- Land surface is currently divided into two categories (desert and non-desert). We plan to further separate surface types and develop a new version of **surface-specific LUTs**.
- **Comprehensive validation and intercomparison** is essential for both algorithm developers and end users. Limited validation has been done so far.

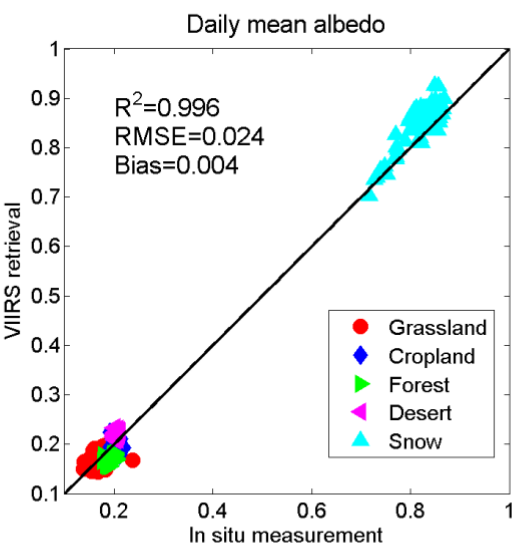
New development: temporal filter

- An algorithm based on temporal autocorrelation and climatology is developed.
- Objectives
  - Improve accuracy
    - Reduce temporal variations
    - Exclude undetected cloud and shadow
  - Fill data gaps
- Integrate multisource of information
  - VIIRS retrieval and its QF
  - Climatology (mean and variance)
  - Temporal correlation (historical observation)



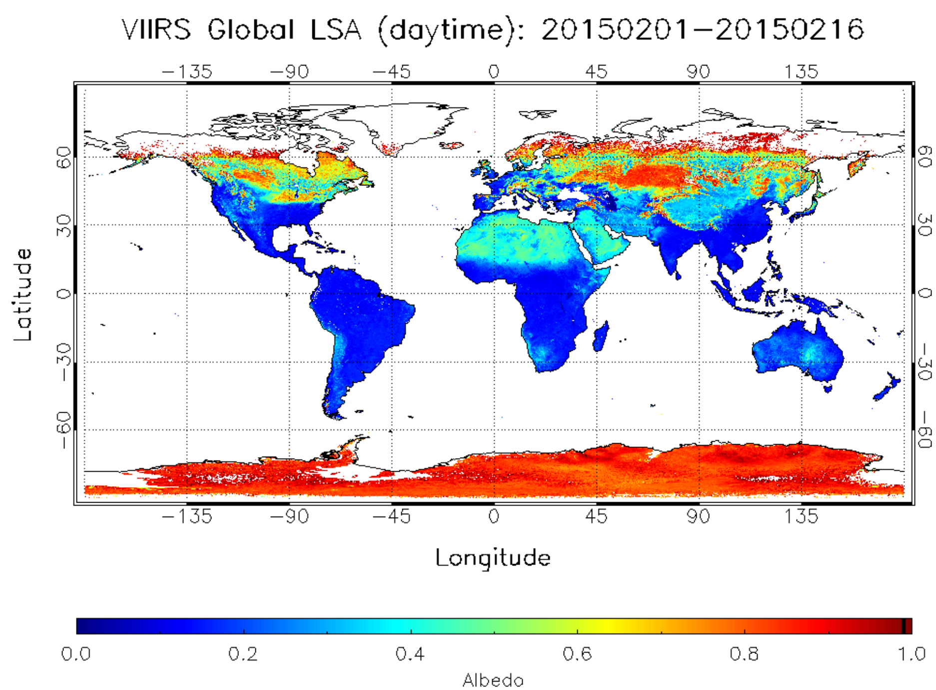
New development: gridded LSA product

- We proposed to develop a Level-3 LSA product on the basis of VIIRS SA EDR, which has the following features:
  - Gridded
  - Noise-reduced
  - Gap-filled
  - Diurnal variations being considered
- Use of instantaneous albedo to calculate daily surface radiation budget results in ~10% bias for snow-free conditions.
- We develop a new method to estimate daily mean albedo directly from VIIRS data.



Left: validation of daily mean albedo

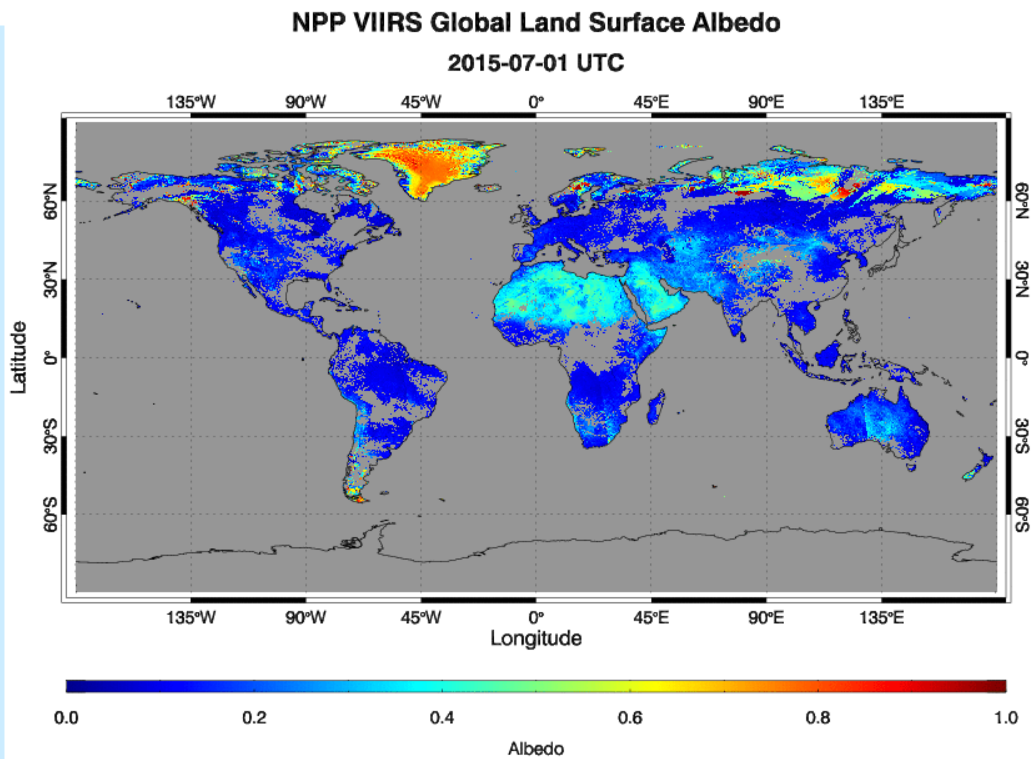
Right: gridded global albedo data



Long-term monitoring tool

Working on a long-term monitoring tool

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



Animation of global albedo map composed from the VIIRS albedo EDR, shown through the VIIRS Albedo production long-term monitoring website at STAR.

Data re-processing

- The S-NPP VIIRS LSA algorithm has gone through several updates for algorithm improvement and refinement.
- The updated algorithms were applied only for data acquired after the algorithm's effective dates.
- To generate consistent LSA product with highest quality possible, we need to re-process all the historical VIIRS data with the latest LSA algorithm.
- VIIRS TOA reflectance SDR and cloud mask IP are the major upstream inputs of the albedo algorithm. Such data with the latest version will be used during the data re-processing.

J1 Cal/Val plan

- Comprehensive evaluation of the J1 LSA product
  - Spatial scaling problem
  - Dependency of LSA retrievals on solar and view angles
  - Global accuracy of both snow-free and snow-covered data
  - Capability of capturing rapidly-changing surfaces
- Long-term monitoring
  - A web-based product monitoring interface
  - In-situ validation alerting/notification
- Correlative Data Sources
  - Ground stations
  - Airborne multiangular measurements
  - High resolution reference maps
  - Other albedo products
- Development of cal/val tool
  - Generating quality metrics commonly used by the international land community
  - Participating in the international cooperation on validation of satellite land products

Status of Land Surface Temperature production from the JPSS Mission

Yunyue Yu, Yuling Liu, Peng Yu, Heshun Wang

NOAA/NESDIS, Center for Satellite Applications and Research

Outline

- ✓ VIIRS LST Basics
- ✓ Current Operational Products
- ✓ Validation Status
- ✓ Issues and improvement Needs
- ✓ International Cooperation
- ✓ Long-term Monitoring
- ✓ J1 CalVal Plan

VIIRS LST Basics

Definition: Land Surface Temperature (LST) is the mean radiative skin temperature derived from thermal radiation of all objects comprising the surface, as measured by remote sensing ground-viewing or satellite instruments.

VIIRS LST EDR: Granule Product, moderate resolution, Split-window/Surface-type (17 IGBP) Dependent Regression Algorithm

Benefits:

- plays a key role in describing the physics of land-surface processes on regional and global scales
- provides a globally consistent record from satellite of clear-sky, radiative temperatures of the Earth's surface
- provides a crucial constraint on surface energy balances, particularly in moisture-limited states
- provides a metric of surface state when combined with vegetation parameters and soil moisture, and is related to the driving of vegetation phenology
- an important source of information for deriving surface air temperature in regions with sparse measurement stations

Target Requirement: Horizontal resolution – 1 km, Temporal resolution – 1 h, Accuracy – 1 K

Current VIIRS* : H = 1 km, T = Daily, A = 1.4 K, Uncertainty = 2.4 K

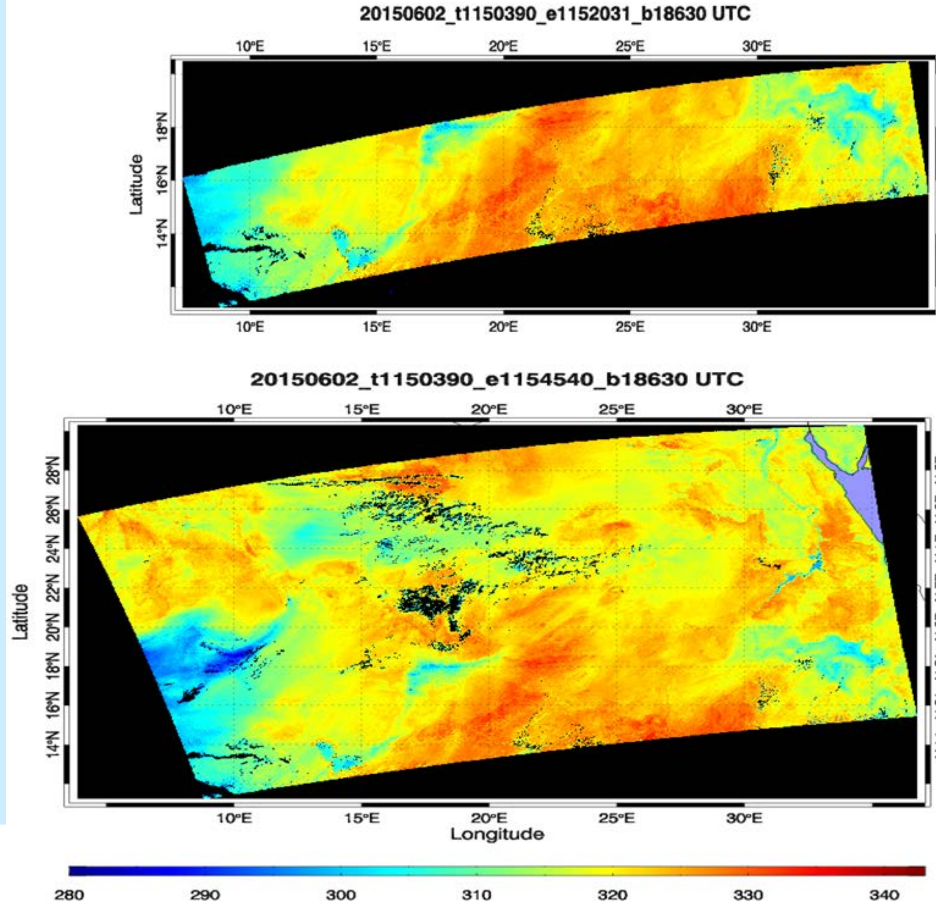
* with limited in-site estimates and cross-satellite validation

Basics: LST EDR and Cal/Val Team

	Name	Institute	Function
JPSS-STAR	Ivan Csiszar	NOAA/NESDIS/SATR	Land Lead, Project Management
	Yunyue YU	NOAA/NESDIS/SATR	EDR Lead, algorithm development/improvement, calibration/validation, team management
	Yuling Liu	*NOAA Affiliate, UMD/ESSIC*	*product monitoring and validation ; algorithm development/improvement*
	Heshun Wang	*NOAA Affiliate, UMD/ESSIC*	*algorithm improvement, product calibration/validation*
	Peng Yu	*NOAA Affiliate, UMD/ESSIC*	*product validation tool, monitoring, applications*
	Marina Tsidulko	*NOAA Affiliate, SciTech/IMSG*	*STAR AIT*
	Michael EK	NOAA/EMC/NCEP	user readiness ,
	Yihua Wu	NOAA/EMC/NCEP	user readiness
JPSS/DPA			
	Leslie Belsma	Aerospace Corp	algorithm Manager (JAM) for Land
NASA S-NPP Science Team			
	Miguel Roman	NSAS/GSFC	*Validation data support, product monitoring*
	Sadashiva Devadiga	NASA/GSFC Affiliate, SSC	*Validation data support, product monitoring*

Basics: Current Operational Product

- 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



- Archive site
  - CLASS: http://www.nsof.class.noaa.gov/saa/products/welcome (search for JPSS VIIRS EDR)
  - Team site : http://www.star.nesdis.noaa.gov/jpss/lst.php
  - NASA site: http://viirsland.gsfc.nasa.gov/Products/LSTEDR.html
- Monitoring: http://www.star.nesdis.noaa.gov/jpss/EDRs/products_LST.php

Validation Status

- **Provisional Review – May 2014**
- **Validated V1 review – December, 2014**

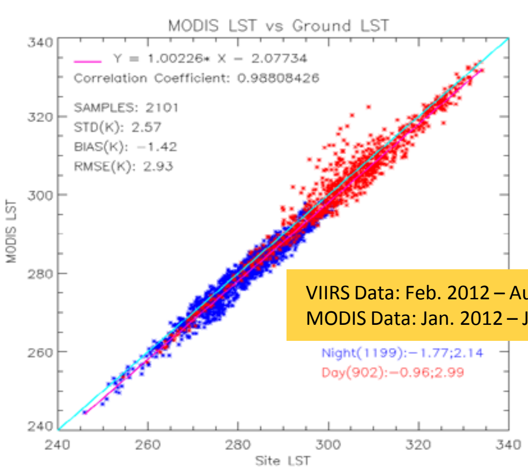
Validation summaries of the LST EDR are shown in Table (**right**); validated 1 maturity approval in Dec. 2014. Marginally meet the requirement with limited "in-situ" data

Validation details of the VIIRS LST comparisons against the SURFRAD station data are shown in the plots (**bottom-left**) and in the tables (**bottom-middle, bottom-right**).

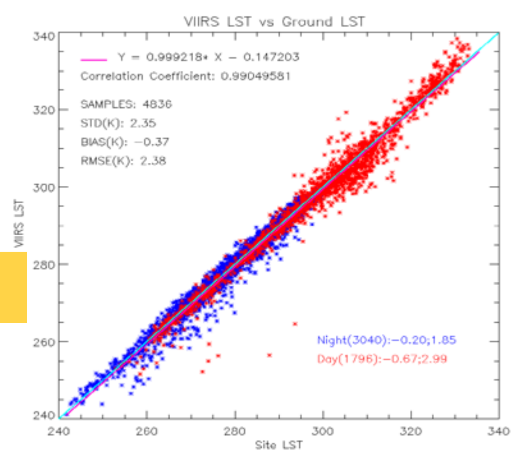
Attribute Analyzed	L1RD Threshold	Validation Result	Description
In-situ Validation	1.4K (2.5K)	**-0.37 (2.35)**	Results are based on the VIIRS data over SURFRAD sites for over 2.5 years . The error budget estimation is limited by ground data quality control, cloud filtering procedure and upstream data error.
R-based Validation	1.4K (2.5K)	0.47(1.12)	A forward radiative transfer model is used, over 9 regions in globe, representing all 17-IGBP types over the seasons. The error budget estimation is limited by profile quality, cloud screening procedure and sampling procedure.
Cross satellite Comparison		0.59(1.93): daytime 0.99(2.02): nighttime	The results are based on comparisons to MODIS LST, over 100 scenes, over low latitude, polar area and CONUSThe error budget estimation is limited by the spatial and temporal difference, sensor difference, angle difference etc.

U.S. SURFRAD stations

Season	Samples	Overall		Day		Night	
		Bias	STD	Bias	STD	Bias	STD
Spring	1297	-0.54	2.78	-0.69	3.82	-0.46	1.97
Summer	1403	-0.1	2.43	-0.87	3.68	0.26	1.39
Fall	1160	-0.28	1.9	-0.32	2.04	-0.24	1.79
Winter	976	-0.65	2.01	-0.83	1.65	-0.53	2.21



VIIRS Data: Feb. 2012 – Aug. 2014
MODIS Data: Jan. 2012 – Jul. 2013

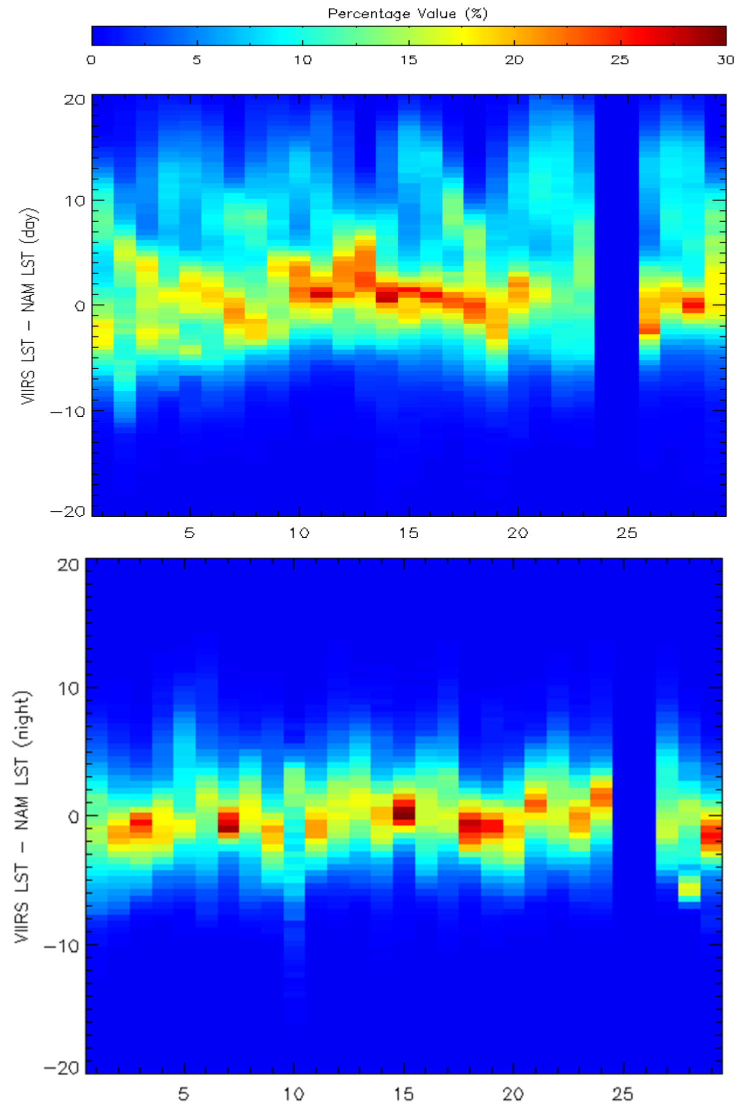


IGBP type	Samples	Overall		Day		Night	
		Bias	STD	Bias	STD	Bias	STD
4	18	-1.41	3.01	-1.82	2.66	-1.26	3.22
6	96	-0.98	1.41	-0.5	1.88	-1.32	0.84
7	955	-0.2	1.59	0.24	2.06	-0.61	0.79
8	286	0.19	2.56	-1.7	2.6	1.38	1.66
10	1048	-0.49	1.81	-0.85	2.3	-0.37	1.59
12	1238	-0.35	2.68	-0.63	3.8	-0.22	1.91
14	857	-0.28	2.54	-1.28	2.4	0.19	2.47
15*	189	-1.72	4.31	-1.72	4.31		
16	149	-0.23	1.55	0.87	1.67	-1.04	0.75

JPSS LST for EMC model validation

Project on-going: Incorporation of near-real-time S-NPP JPSS Land Surface Temperature data into the NCEP Land modeling suite

- Performed comparison of VIIRS Granule LST data and NAM model data
  - Period: March 2012
  - Resolution: 0.05 deg
- Results
  - ✓ VIIRS LST and NAM LST agree with each other better in nighttime.
  - ✓ The monthly mean biases are 0.47 and 3.76 during nighttime and daytime, respectively.
  - ✓ Granule level comparisons show that the VIIRS-NAM difference over west region is higher than that over east region.
- Current effort: new data format needed
  - Gridded 1 km data
  - Projection and data format matches to the EMC model run needs
  - Time label and QFs for each grid
  - Tools to convert a popular L3 LST data format into a rather specific EMC requested data format
  - Analysis of the JPSS and Model LST differences



Day and night, March 2012

Issues and Improvement Needs

Issues encountered through the Cal/Val activities

- *Lack of high quality validation data set.* The CalVal performed only with limited data, mostly with SURFRAD data. Global and seasonal representativeness of the validation is needed
- impacts of ST misclassification and cloud contamination are significant (will rely on annual ST data).
- *Cloud contamination impact is significant*
- over 50% error sources of the LST derivation can not be identified, due to quantitative and qualitative limitations of in-situ measurement.
- Practical uncertain is significantly larger than the theoretical analysis.

New Development (1)

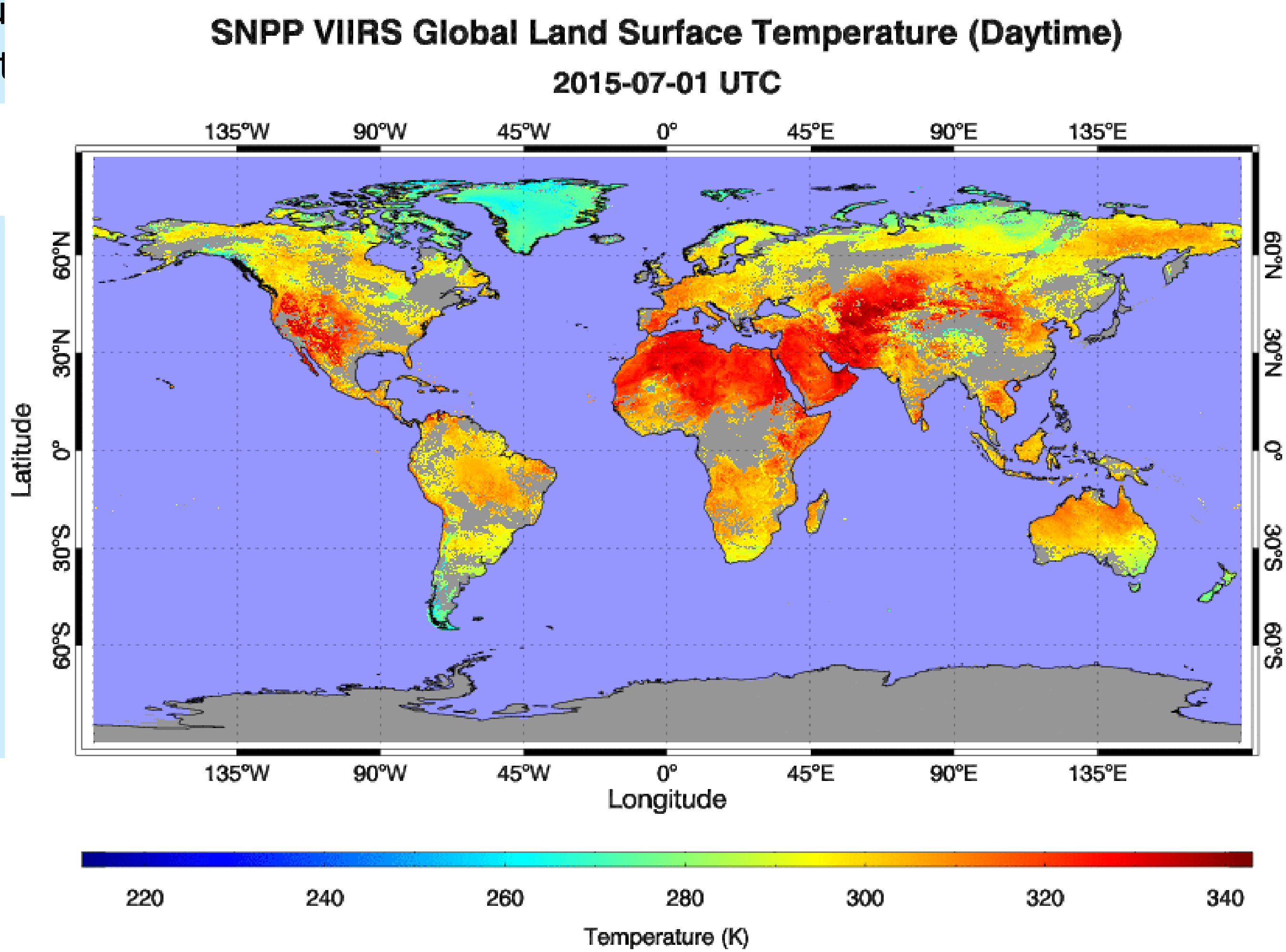
Rational

User-friendly dataset needs

replacement of the ST-dependent algorithm

Enterprise System Requ

Emissivity Development



Example 1

L3 Global Gridded Daily LST

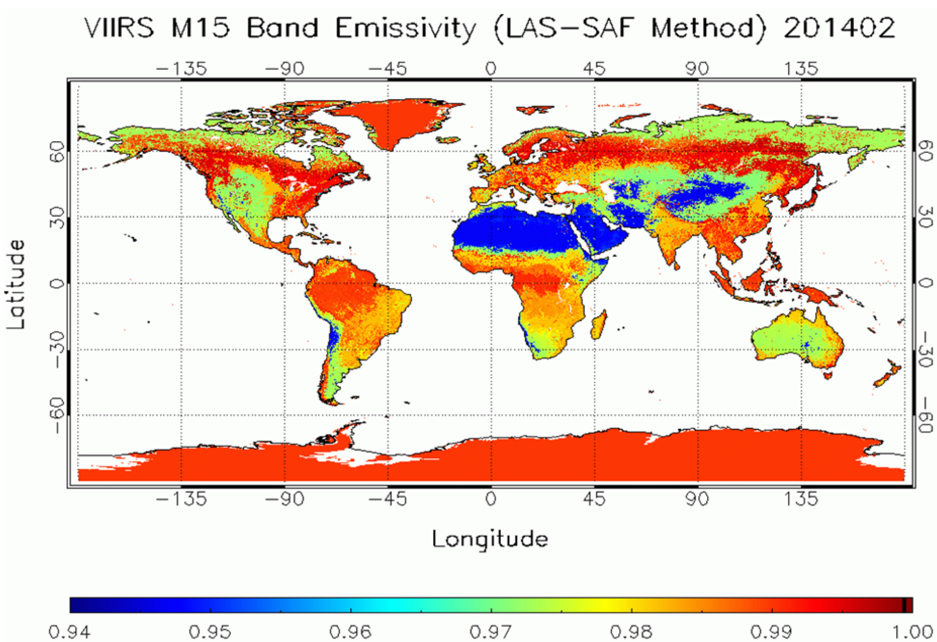
- 2 datasets each day (i.e. day and night)
- 1 km resolution
- Time label and QF for each grid

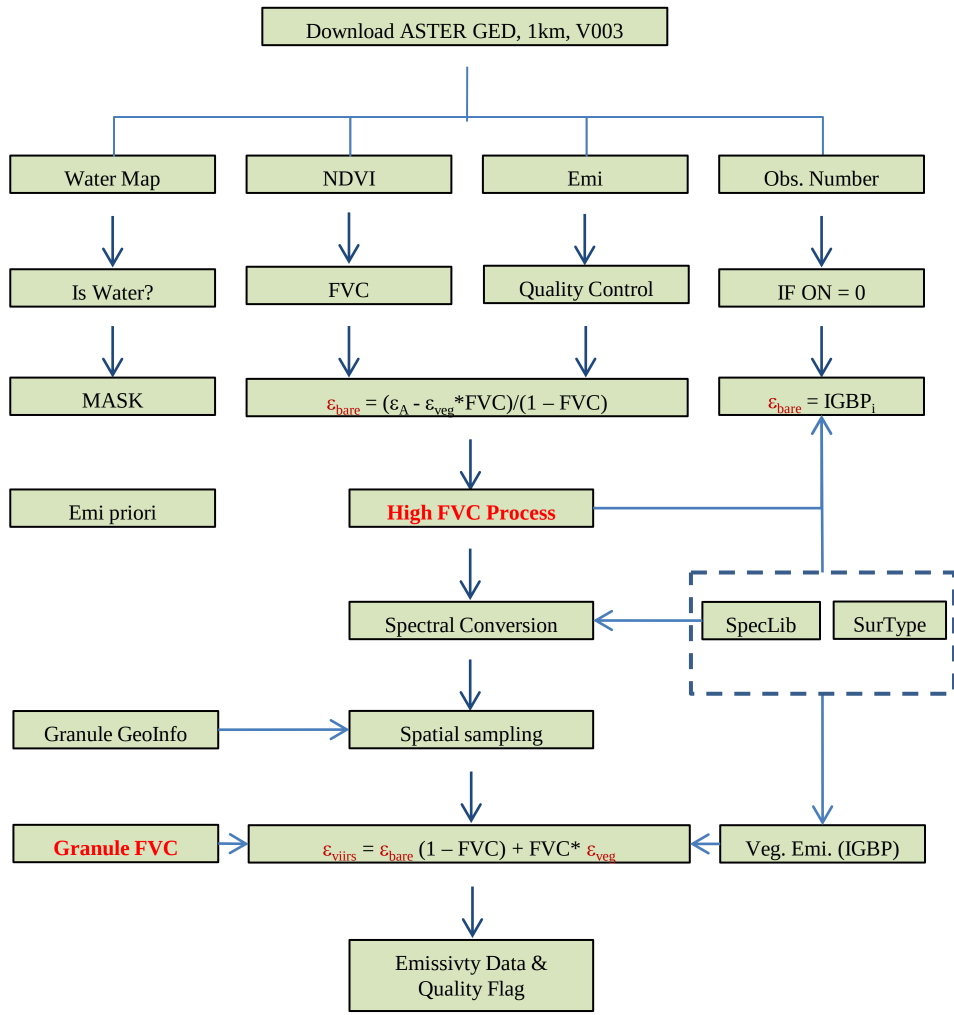
New Development (2)

Example 2

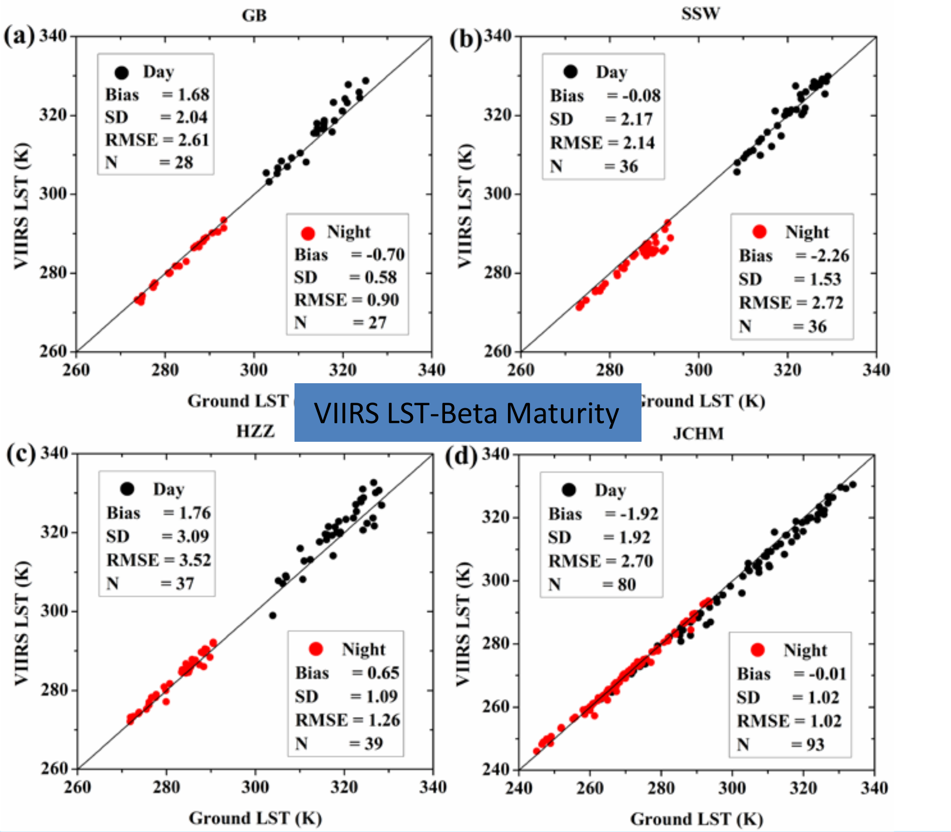
Land Surface Emissivity

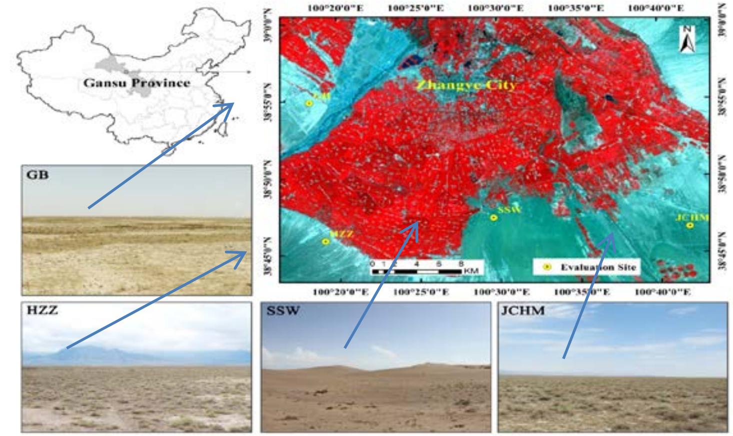
- Spectral emissivity at M15 (10.76 μm) and M16 (12.01 μm)
- Daily global gridded dataset
- 1 km resolution
- QF for each grid

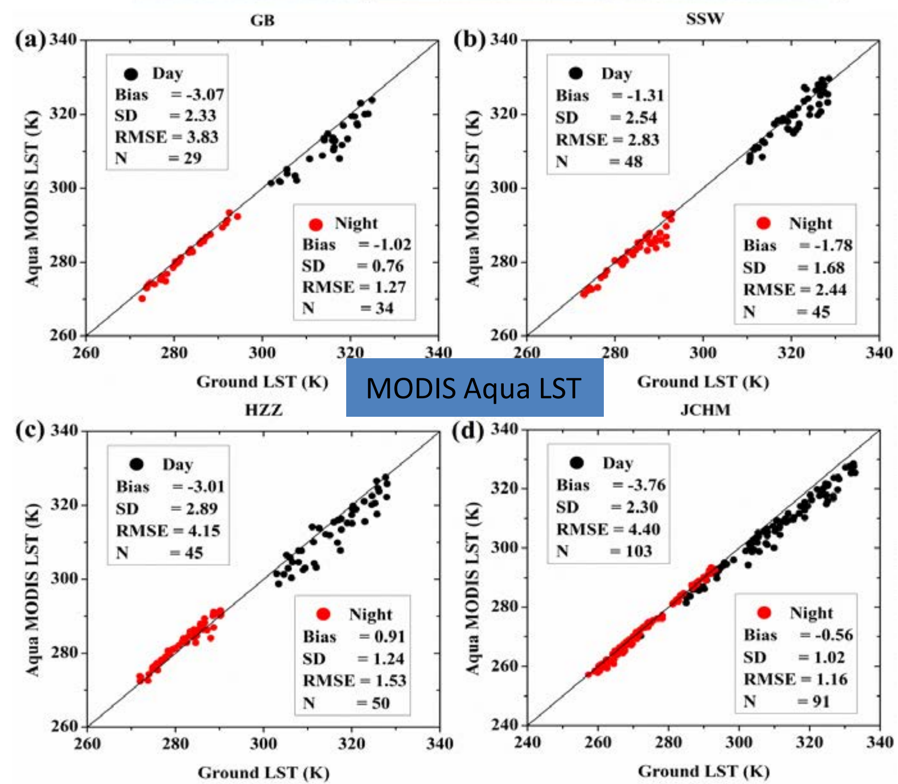




International cooperation
-- with CAS







Data collection: arid area of northwest China (Heihe Watershed Allied Telemetry Experimental Research), from June 2012 to April 2013. Four barren surface sites were chosen for the evaluation.

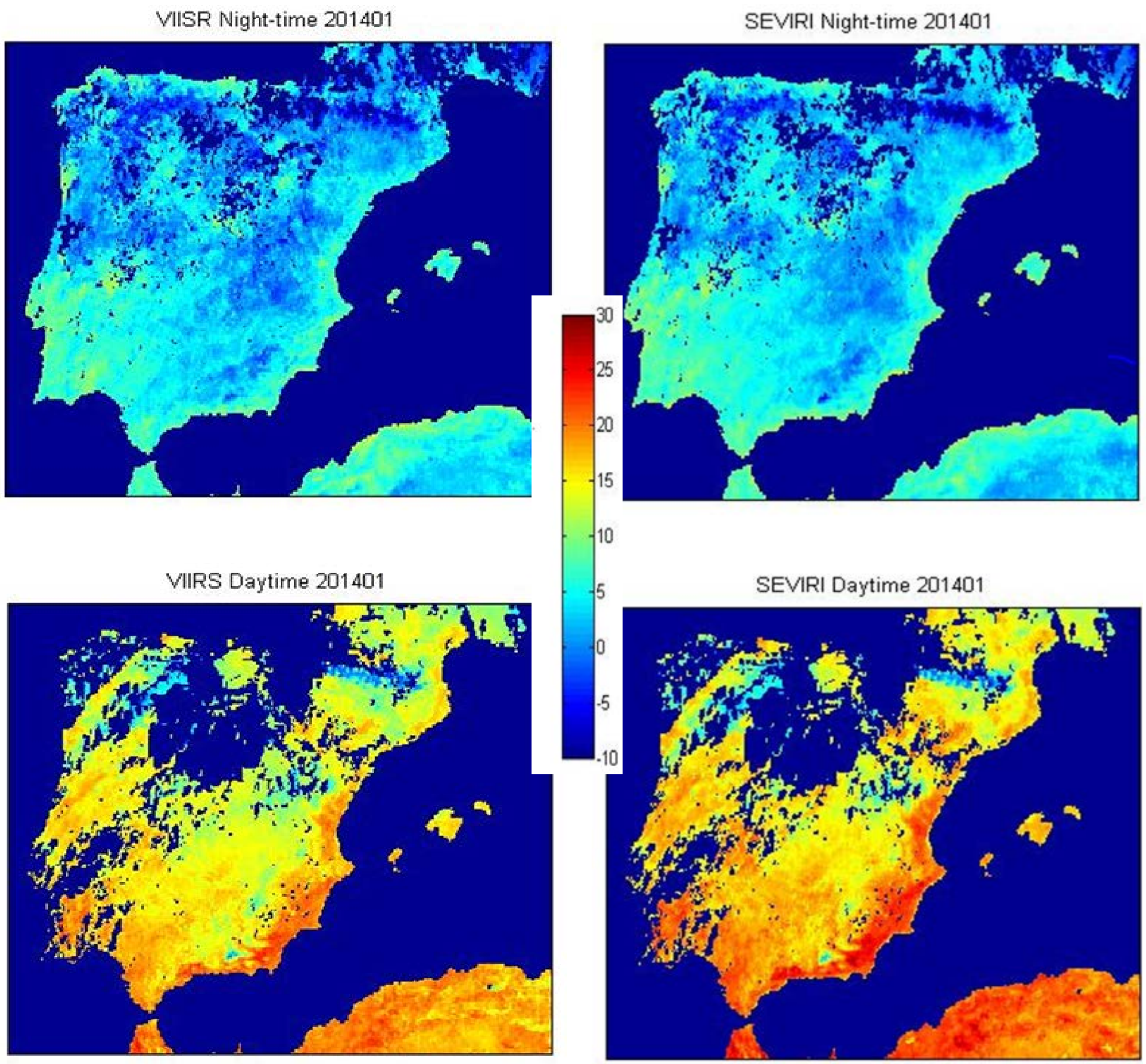
The result generally shows a better agreement for VIIRS LST than that for MODIS LST.

***China site data was obtained through a collaborative effort with Dr. Hua Li at Institute of Digital Earth and Remote Sensing, China Academy of Science**

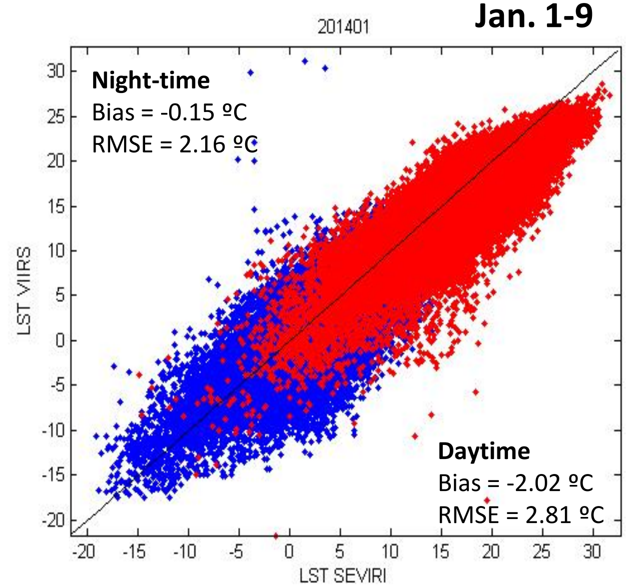
Reference: *H. Li, D. Sun, Y. Yu, H. Wang, Y. Liu, Q. Liu, Y. Du, H. Wang and B. Cao(2014), Evaluation of the VIIRS and MODIS LST products in an arid area of Northwest China Remote Sensing of Environment 02/2014; 142:111–121.*

International cooperation
-- with Land SAF

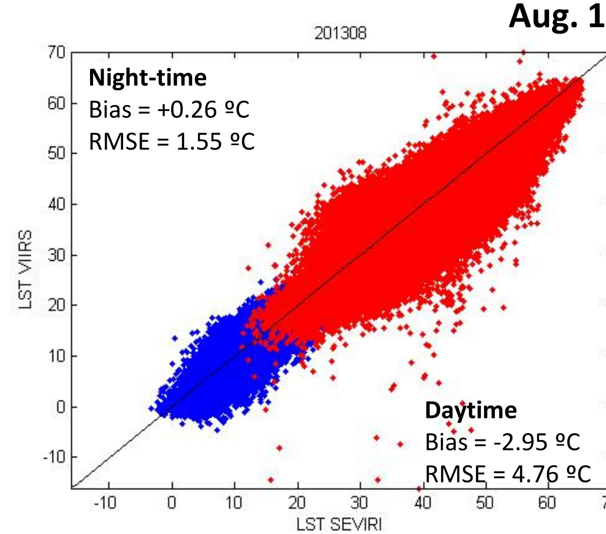
VIIRS **1-9 Jan 2014** **SEVIRI**



Jan. 1-9



Aug. 1-9



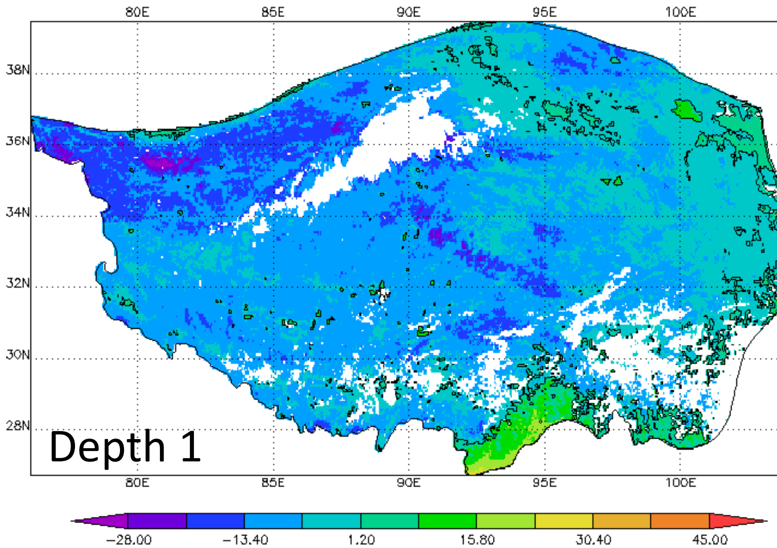
Courtesy of Isabel F. Trigo , through US-Portugal Bilateral cooperation program (on remote Sensing)

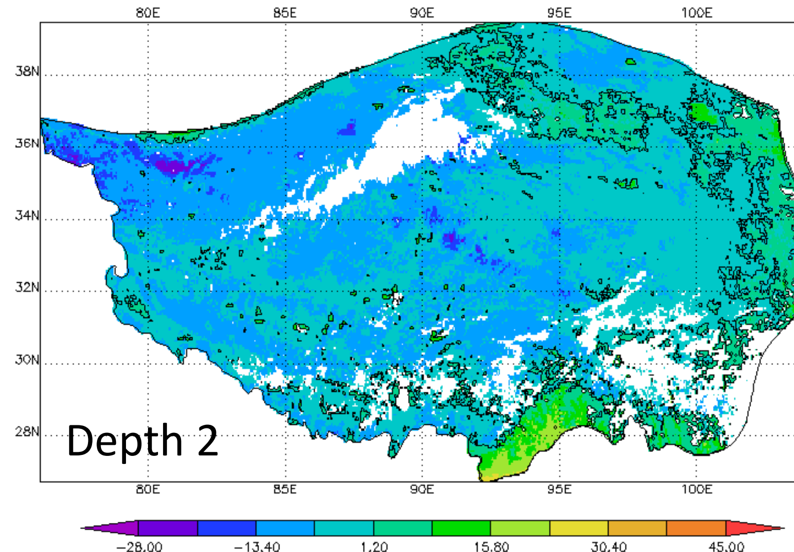
International cooperation

-- with CMA

VIIRS LST Application in Soil Freeze-Thaw in Tibet

- Monitoring spatial distribution of freeze-thaw in whole Tibet with high spatial resolution (1 km)
- Monitoring seasonal dynamics of freeze-thaw in Tibet (daily)
- Monitoring changes of freeze-thaw in different soil depth





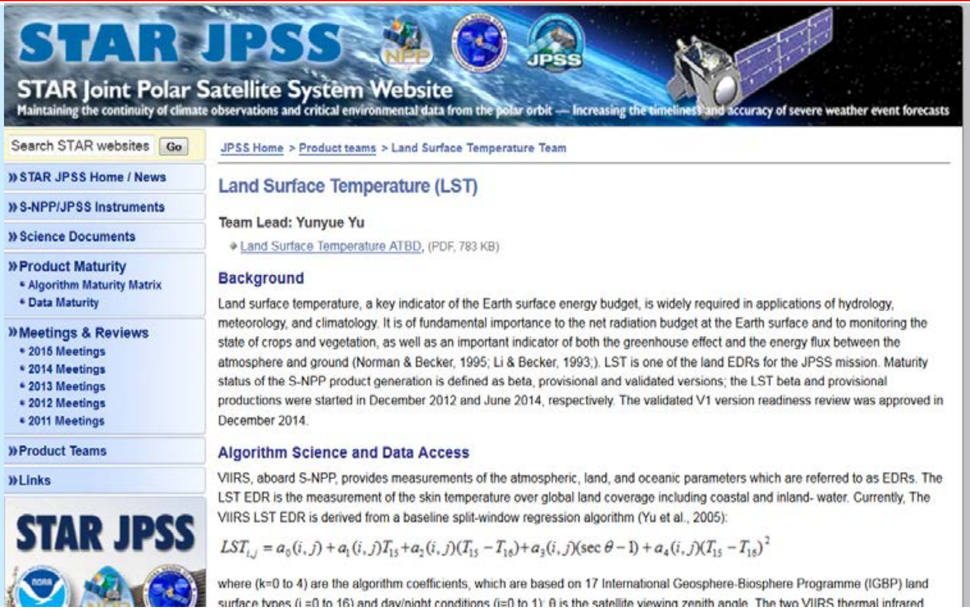
Long-term monitoring

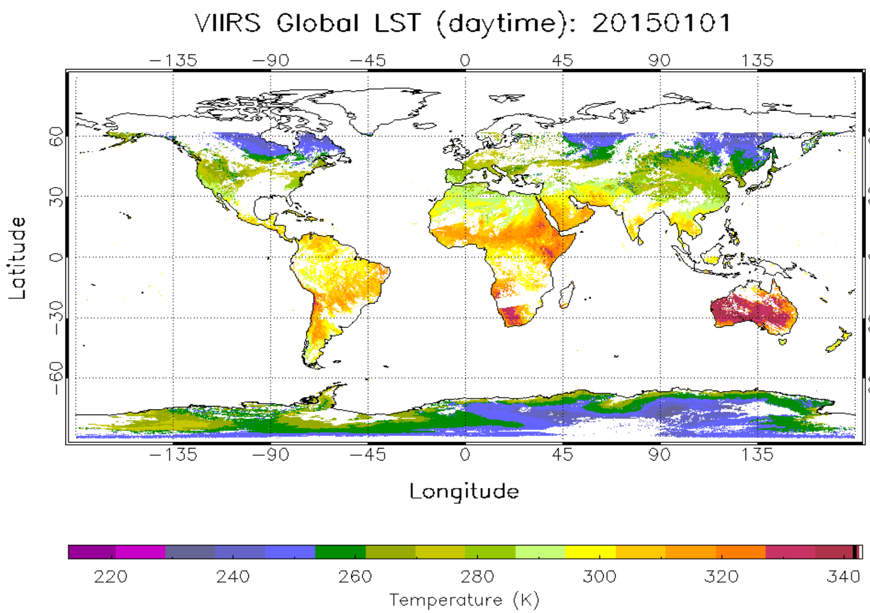
- **Monitoring/Validation tool drafted**
- **Webpage development**

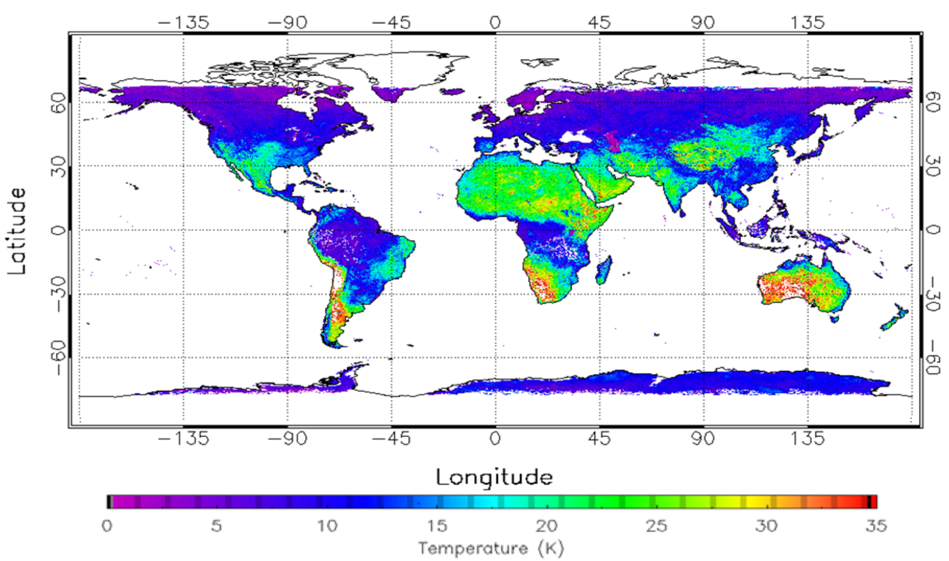
✓ A monitoring tool has been developed, which generates daily global VIIRS LST maps, and the diurnal temperature range (DTR) from the operational VIIRS LST EDR data and routinely validate with SURFRAD data.

✓ An ftp site and notification system has been setup for the monitoring, which runs the daily global LST, the monthly DTR, and the routine validation automatically. ftp://ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/VIIRS_monitoring/.

✓ A webpage development is on-going for public to review and download the global daily LST and the monthly DTR maps.







J1 Cal/Val plan

- Comprehensive Product Evaluation/validation
  - Pre-launch
    - Proxy and simulated datasets readiness
    - In-situ data readiness
    - Algorithm Evaluation and Characterization
    - Development of calibration and validation tools
  - Post-launch
    - Early orbit checkout
    - Intensive product evaluation and validation report
    - Algorithm/product calibration, coefficients update
    - Iterative in-situ data validation and calibration
    - Algorithm refinement
- Long-term monitoring
  - A web-based product monitoring interface
  - In-situ validation alerting/notification
- Correlative Data Sources
  - In-situ data collection
  - S-NPP LST data, and other satellite LST data
  - Field Campaign data (international cooperation)
- Development of CalVal tools

Active Fire product update

Presented by Ivan Csiszar (STAR)

Key contributors to results presented: Wilfrid Schroeder, Louis Giglio, Evan Ellicott, Will Walsh, Patricia Oliva (UMD) Marina Tsidulko, Valerie Mikles, Walter Wolf (STAR AIT)

August 27, 2015

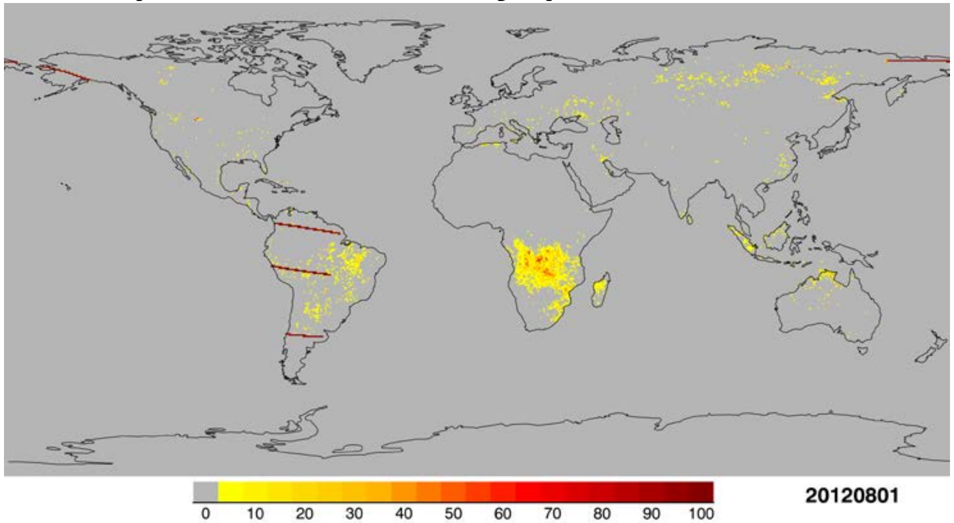
NOAA Operational Fire product status

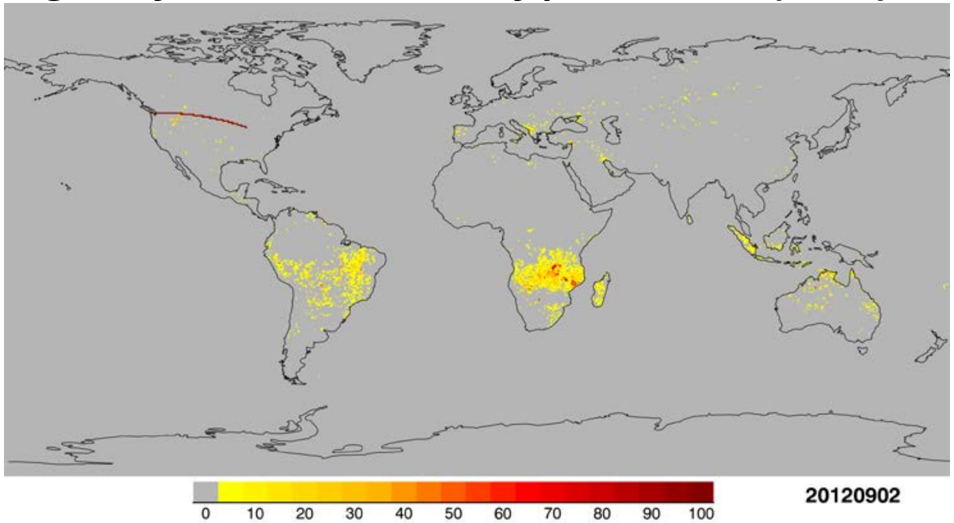
- **Current 750m operational product** in IDPS*
  - delivers a list of fire pixels
  - reached **Validated 1 maturity status** with an effectivity date (i.e. IDPS implementation) of **August 13, 2014**.
  - **declared NOAA Operational** product in September 2014
  - **long-term monitoring** and maintenance continues
- **Upcoming 750 NOAA operational product** in NDE**
  - the product is developed at UMD and is **tailored subset of the NASA science product** for real-time NOAA operations
  - **global mask of thematic classes** including water, cloud, non-fire clear land and fire at three confidence levels
  - **fire radiative power** for each fire-affected pixel
  - **new algorithm elements** to improve detection performance
  - Code **delivered to STAR AIT** and tailored for NDE processing
  - **Algorithm Readiness Review** held on June 18 2015
  - Currently in **NDE testing and integration** – operational later this year

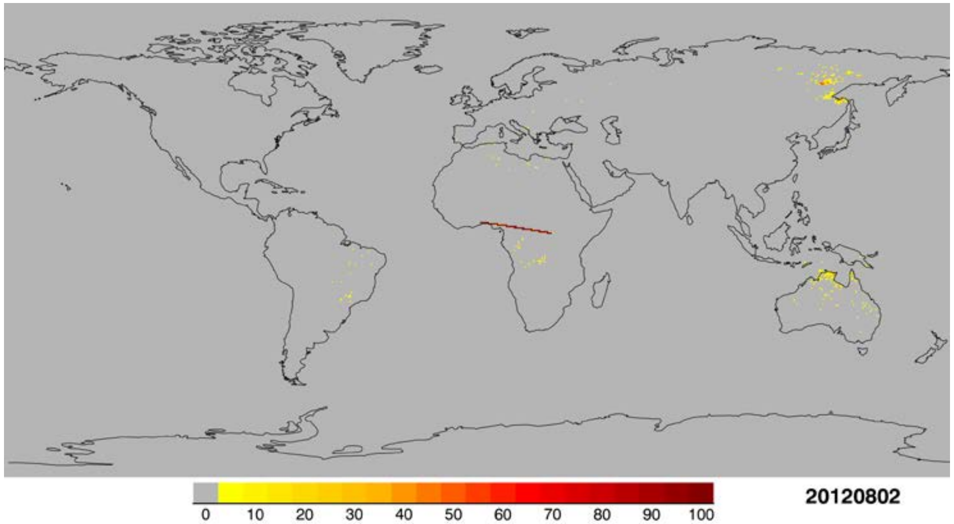
IDPS: Interface Data Processing Segment; **NDE: Suomi NPP Data Exploitation

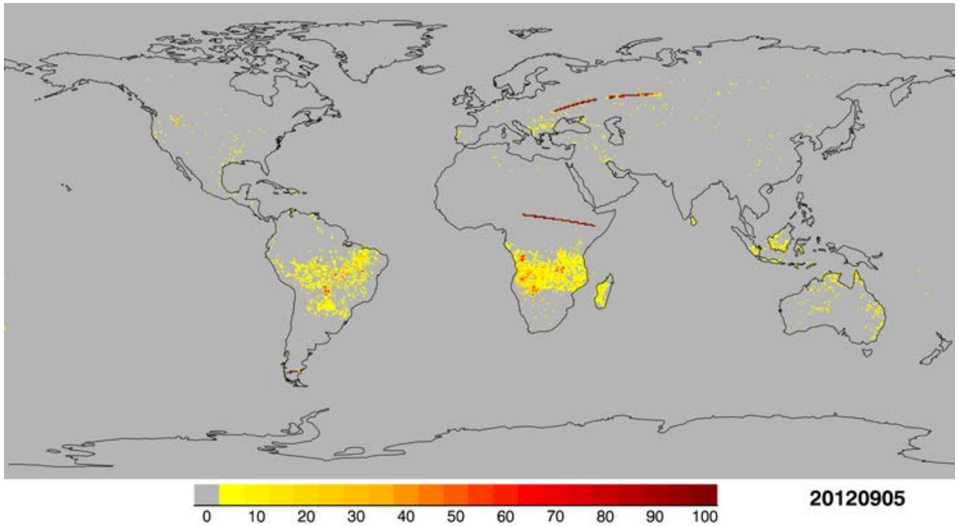
Examples of early IDPS product

Frequent occurrence of spurious scanlines during the first ~10 months of production (Beta)









Examples of the operational real-time IDPS product as archived in NOAA CLASS.
Not reprocessed; not to be used for science analysis. Product history demonstration only.

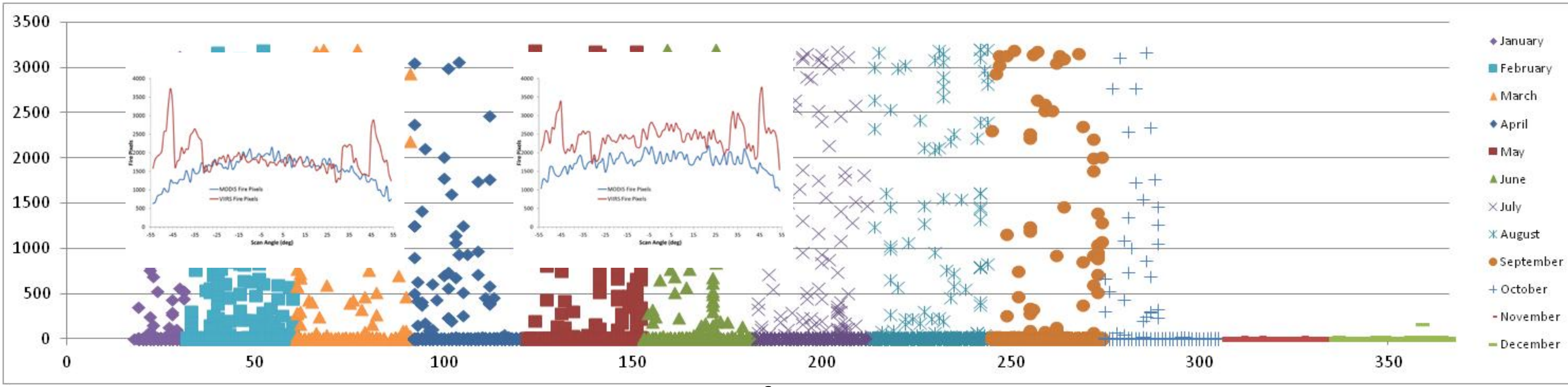
IDPS Suomi NPP Active Fire Product history: data anomalies and product maturity (2/1)

2012

April 3, 2012
IDPS Mx5.3

October 16, 2012
IDPS Mx6.3

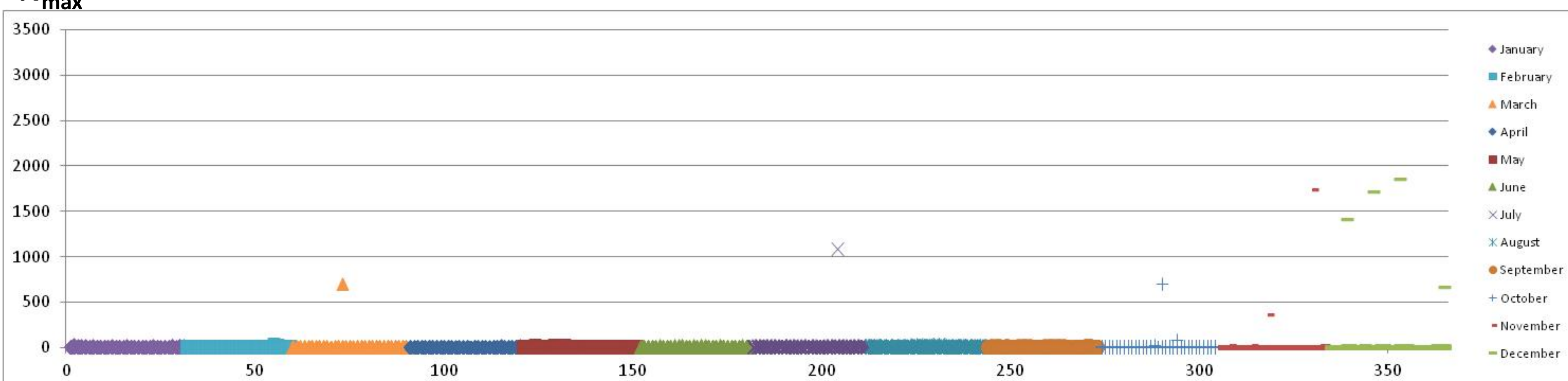
N_{max} | ← *Pre-Beta* → | ← *Beta* → | ← *Provisional* →



Day of Year

2013

N_{max} ← *Provisional* →



Day of Year

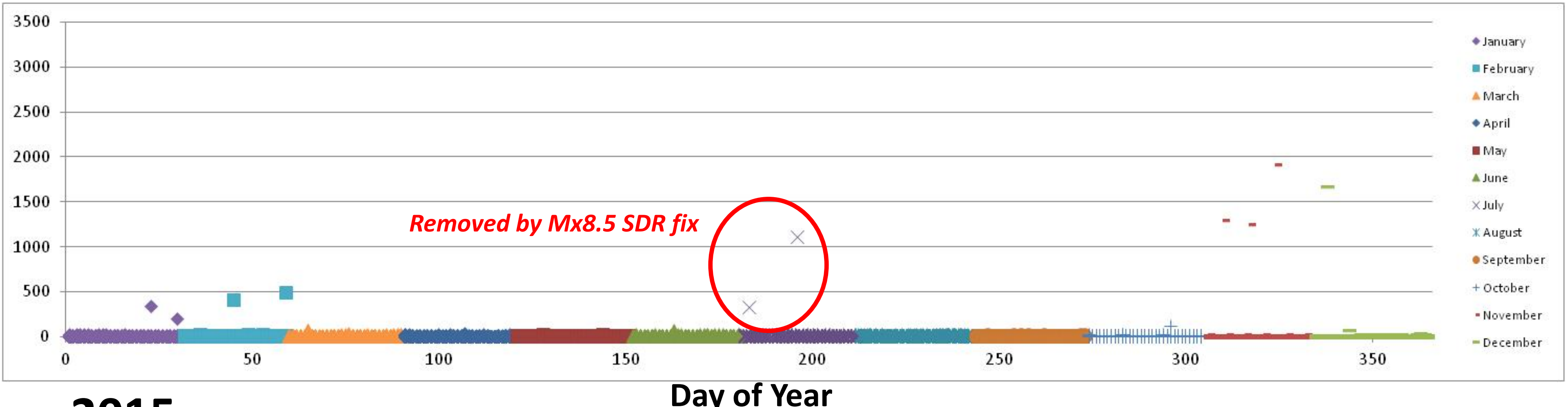
N_{max}: maximum number of detections within a scanline

IDPS Suomi NPP Active Fire Product history: data anomalies and product maturity (2/2)

2014

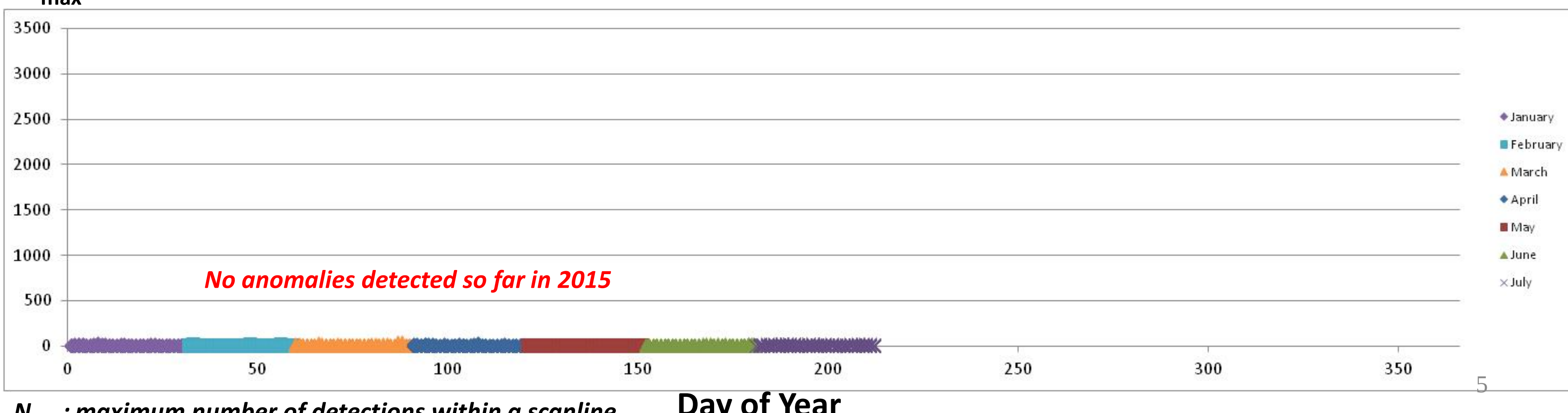
August 13, 2014
IDPS Mx8.5

N_{max} ← *Provisional* → ← *Validated stage 1* →



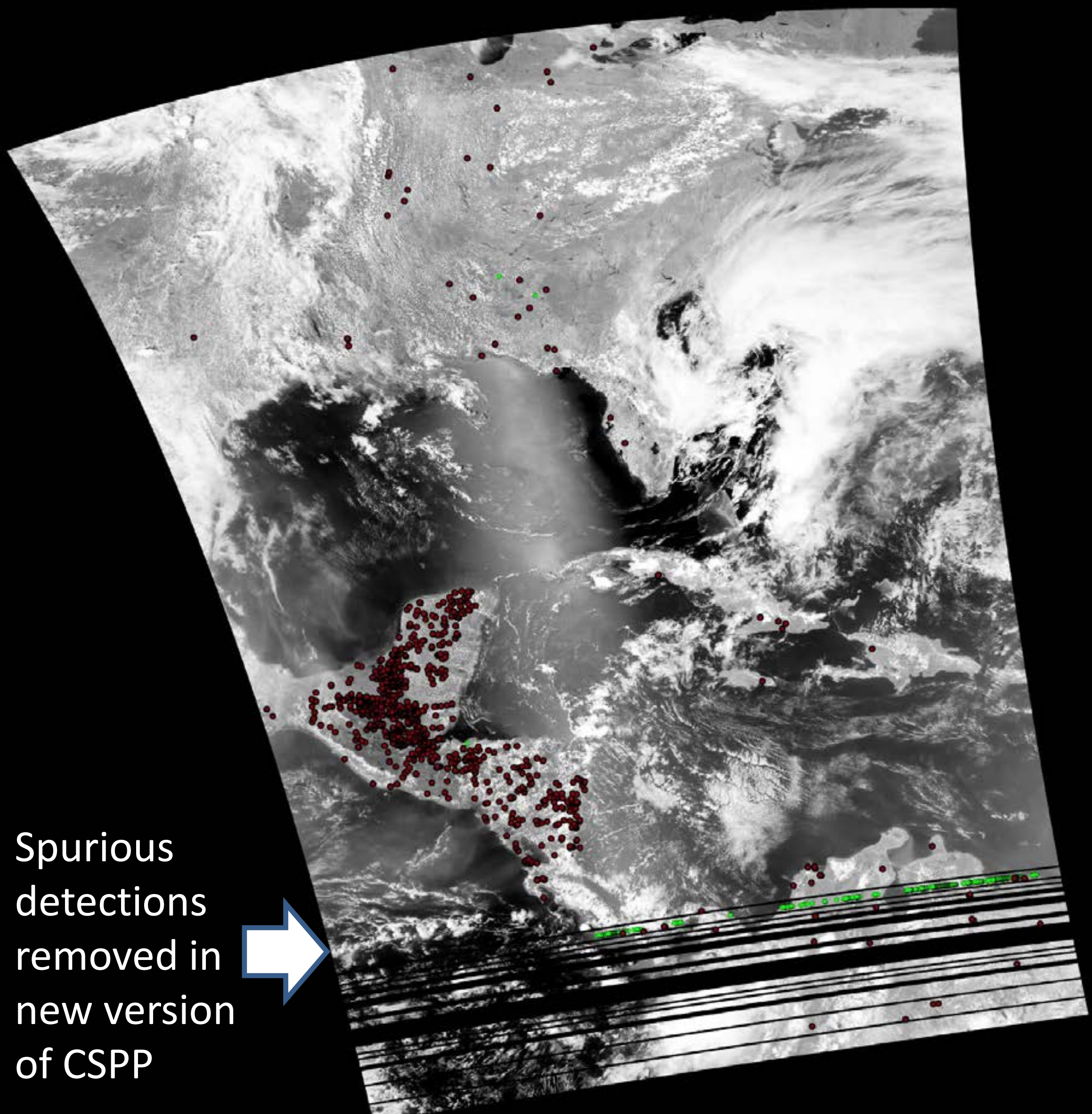
2015

N_{max} ← *Validated stage 1* ------->



N_{max}: maximum number of detections within a scanline

Direct broadcast support



Spurious detections removed in new version of CSPP

- *Missing / noisy data in Direct Broadcast transmission can result in incorrect SDR calibration and spurious detections.*
- *The frequency of DB data anomalies depend on the performance of the local DB processing system.*
- *Adjustments in the DB processing code are being implemented to improve SDR quality and spurious fire detections.*
- *Spurious detections can also be filtered by empirical techniques.*
- *Regular updates to include algorithm improvements is critical.*

CSPP V2.0 (SDR Mx8.4)

CSPP V2.1 (SDR Mx8.6)

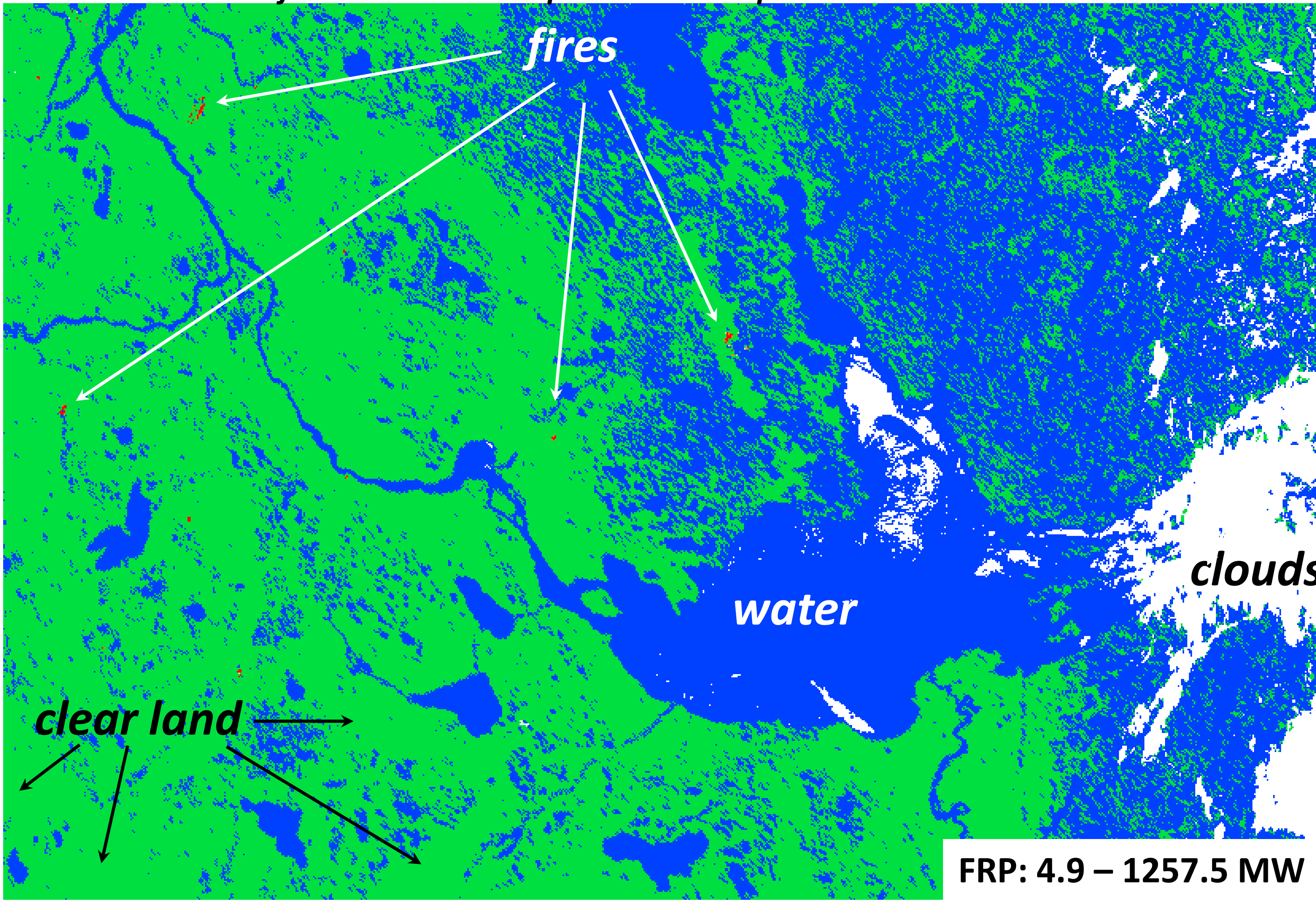
CSPP: Community Satellite Processing Package (UW-Madison)

Further fixes are needed to account for large data gaps – usually in DB – NASA DLR patch

Courtesy Isabel Cruz CONABIO, Mexico

NOAA NDE VIIRS Active Fire Product

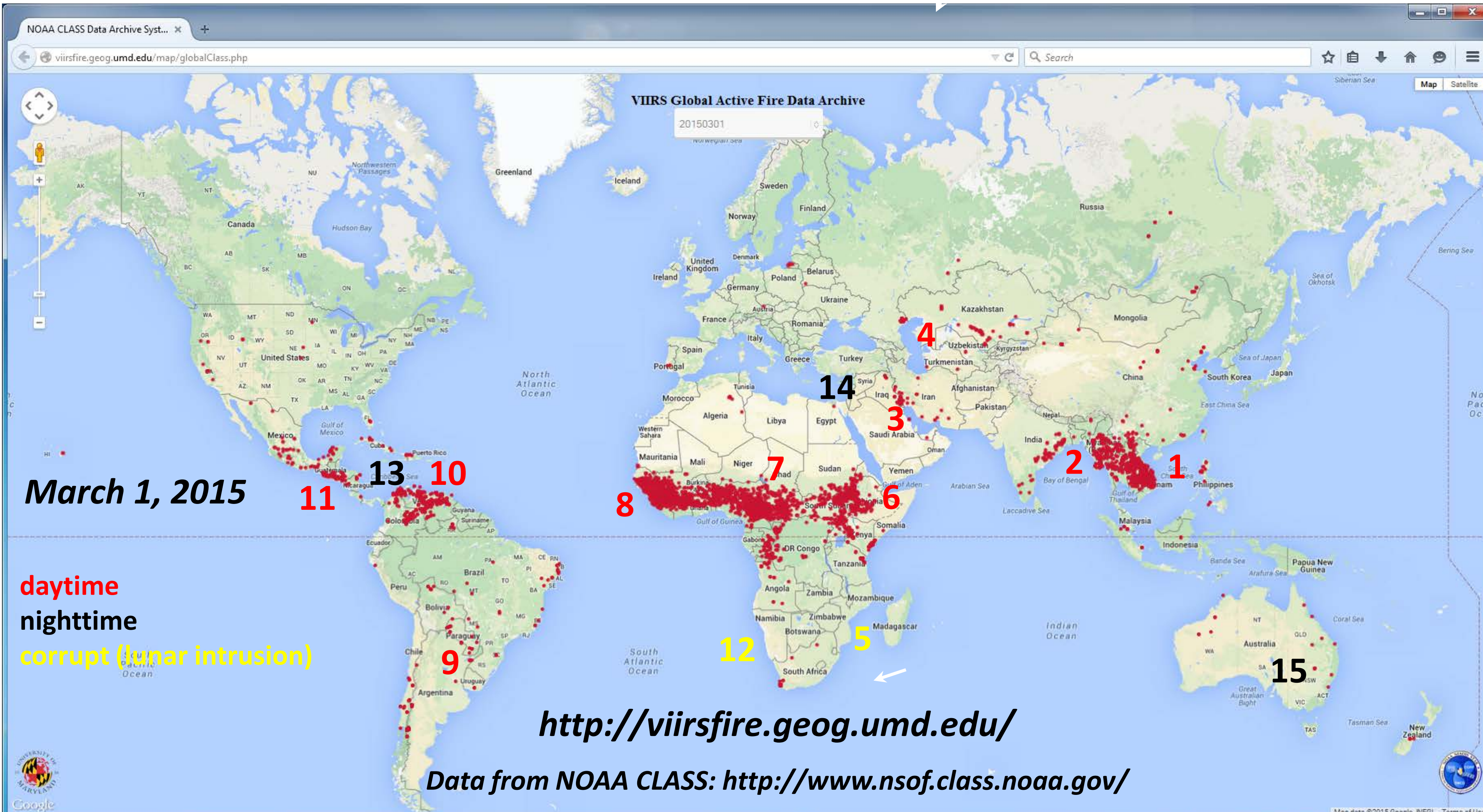
VIIRS fire mask generated at NOAA/NESDIS/STAR from IDPS input data. The NOAA Level-2 product is a tailored version of the NASA science product developed at UMD.



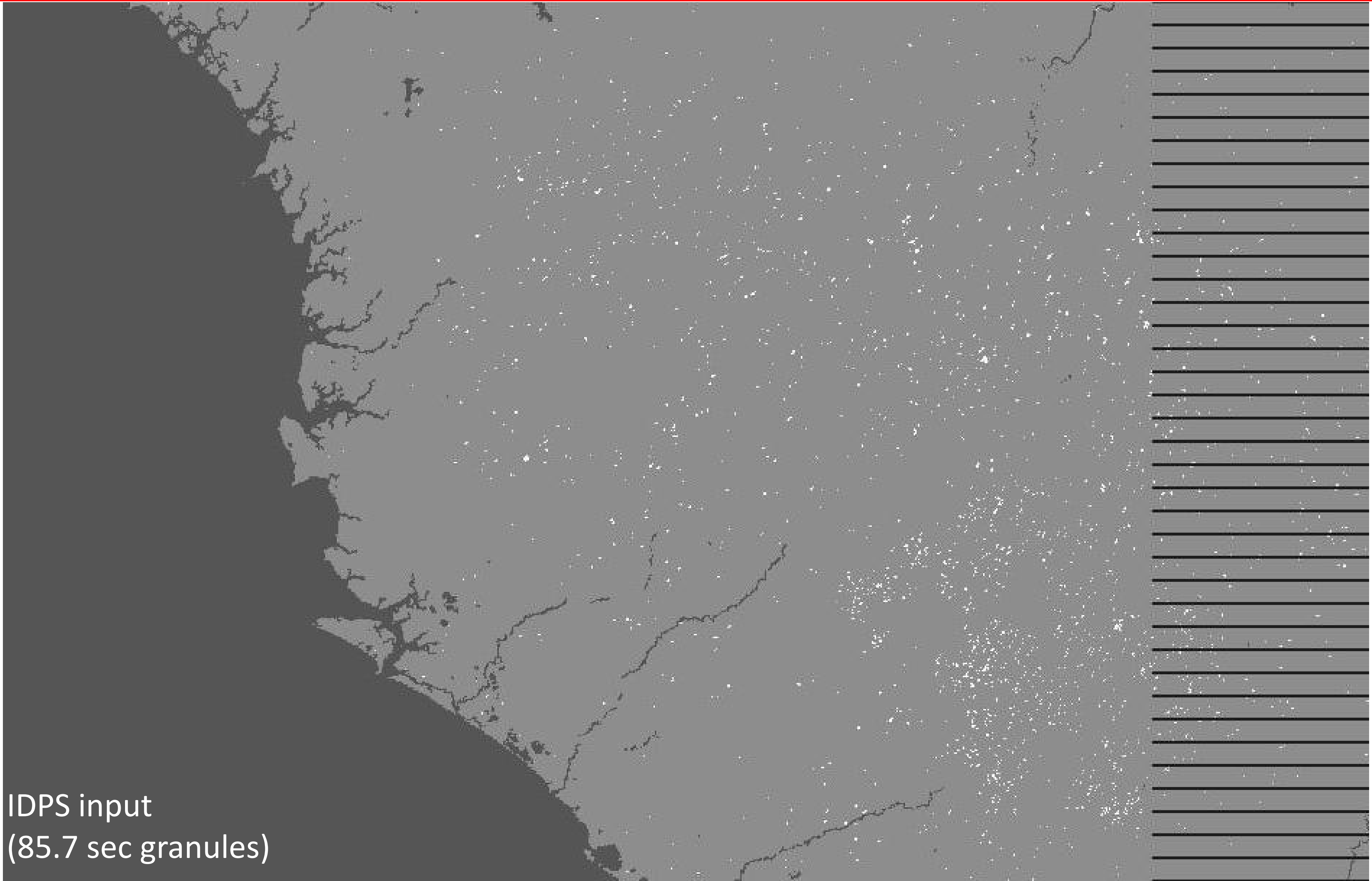
VIIRS fire mask over NW Canada 5/29/2015 20:06 UTC (daytime)

NOAA NDE VIIRS Active Fire Product testing

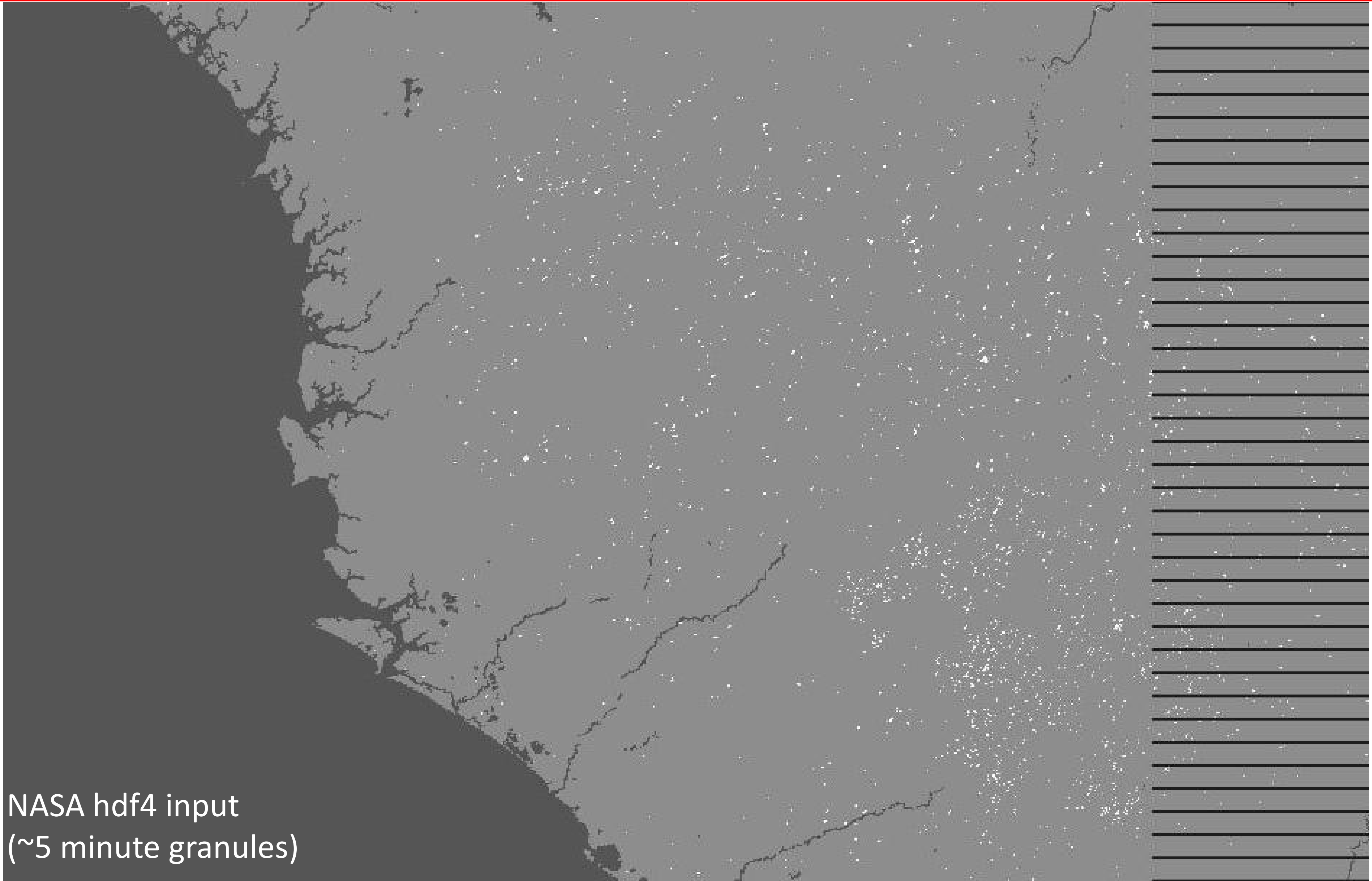
15 granules covering daytime (1-12), nighttime (13-15), land, water and corrupt (5,12) data were tested for overall performance and consistency between the NOAA and NASA output. The global map shown for reference is the current IDPS product.



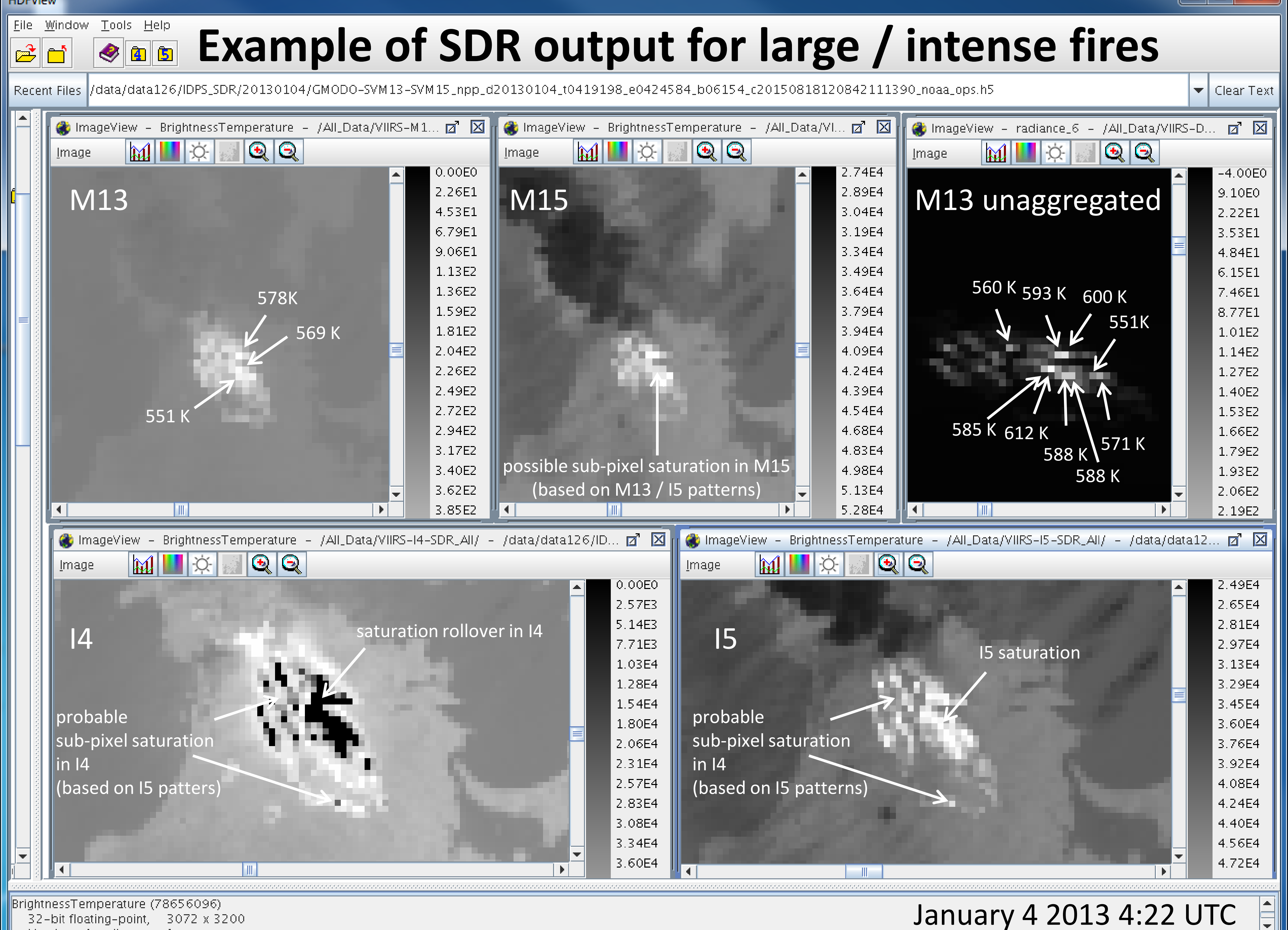
NOAA STAR AIT output



NASA Science Code output



Example of SDR output for large / intense fires



January 4 2013 4:22 UTC

greyscale images of scaled radiance or brightness temperature output for the purpose of displaying relative patterns of SDR output

VIIRS Fire Data and Evaluation Portal

VIIRS Active Fire - Maps &

viirsfire.geog.umd.edu/pages/mapsData.php

Apps | Getting Started | Imported From Firef... | National Oceanic an... | Request for Adjust... | NOAA Email on a Pe... | Commerce - OCIO S... | NCWCP Tenant We... | Fwd: Alaska Fire Up... | New Tab

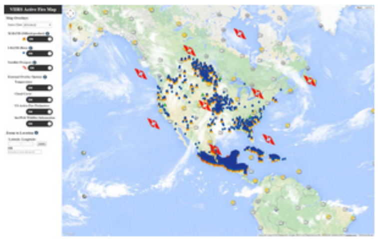
VIIRS Active Fire | Home | About | FAQ | VIIRS AF Products | VIIRS vs MODIS | Maps & Data

VIIRS AF Table Data

VIIRS Data Tutorial: VIIRS_data_tutorial.pdf

Global VIIRS 750m product

View CONUS Active Fire Map



View active fire detections. The map also provides an icon to represent the center of each VIIRS granule, weather information (temperature and cloud cover), and RSS feeds for US active fire perimeters and Incident Information. RSS feeds provided by GEOMAC and InciWeb, respectively.

View Global Active Fire Map

VIIRS daily global active fire detections.

VIIRS 750m and 375m products over North America

Download data

Select a Date

07/08/2015

Search

viirsfire.geog.umd.edu

Products in various formats

07/08/2015

Timestamp	TXT	ASCII	KMZ	TIFF	IBAND(png)	IBAND(GeoTIFF)	IBAND(kml)
NPP_VIIRS_20150708_205000_205500	TXT	ASCII	KMZ	TIFF	IBAND(png)	IBAND(GeoTIFF)	IBAND(kml)

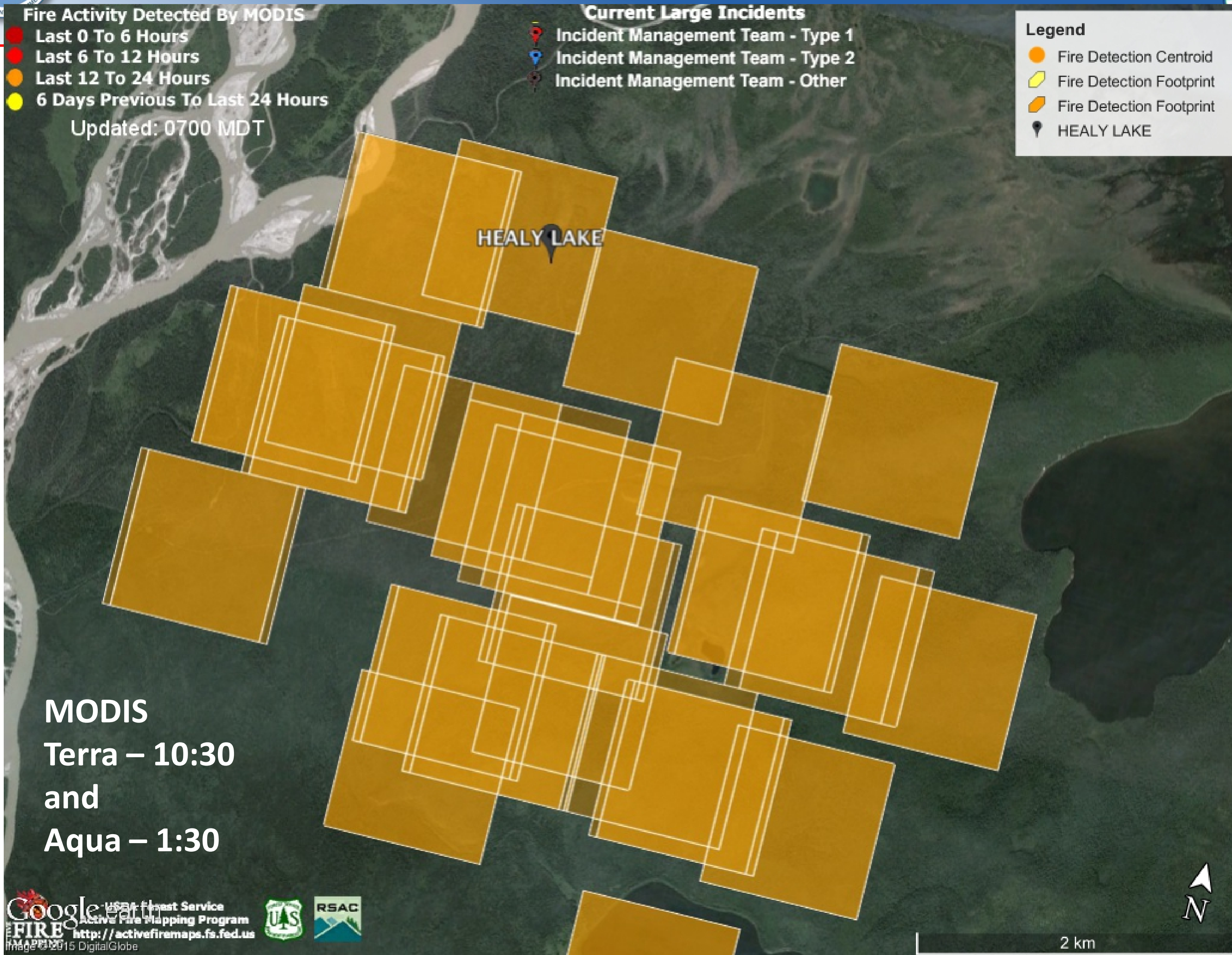
Active Fire Team

- Ivan Csiszar
- Chris Justice
- Louis Giglio
- Evan Ellicott
- Wilfrid Schroeder
- Krishna Vadrevu
- Antonio Sanchez

Links

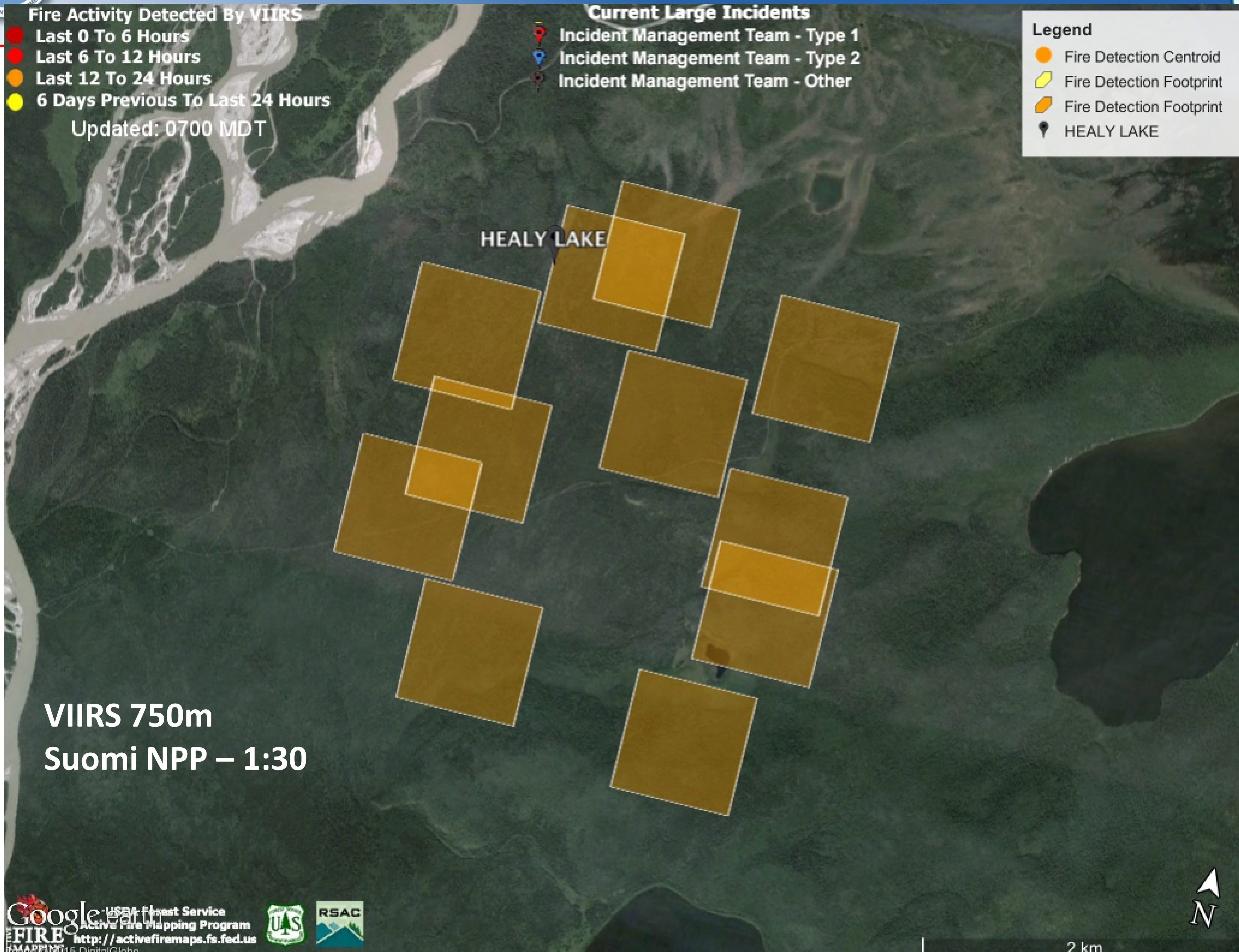
- JPSS
- VIIRS
- University of Maryland
- NOAA
- NOAA-STAR
- USFS RSAC
- GOFC Fire

Healy Lake Fire (Alaska)

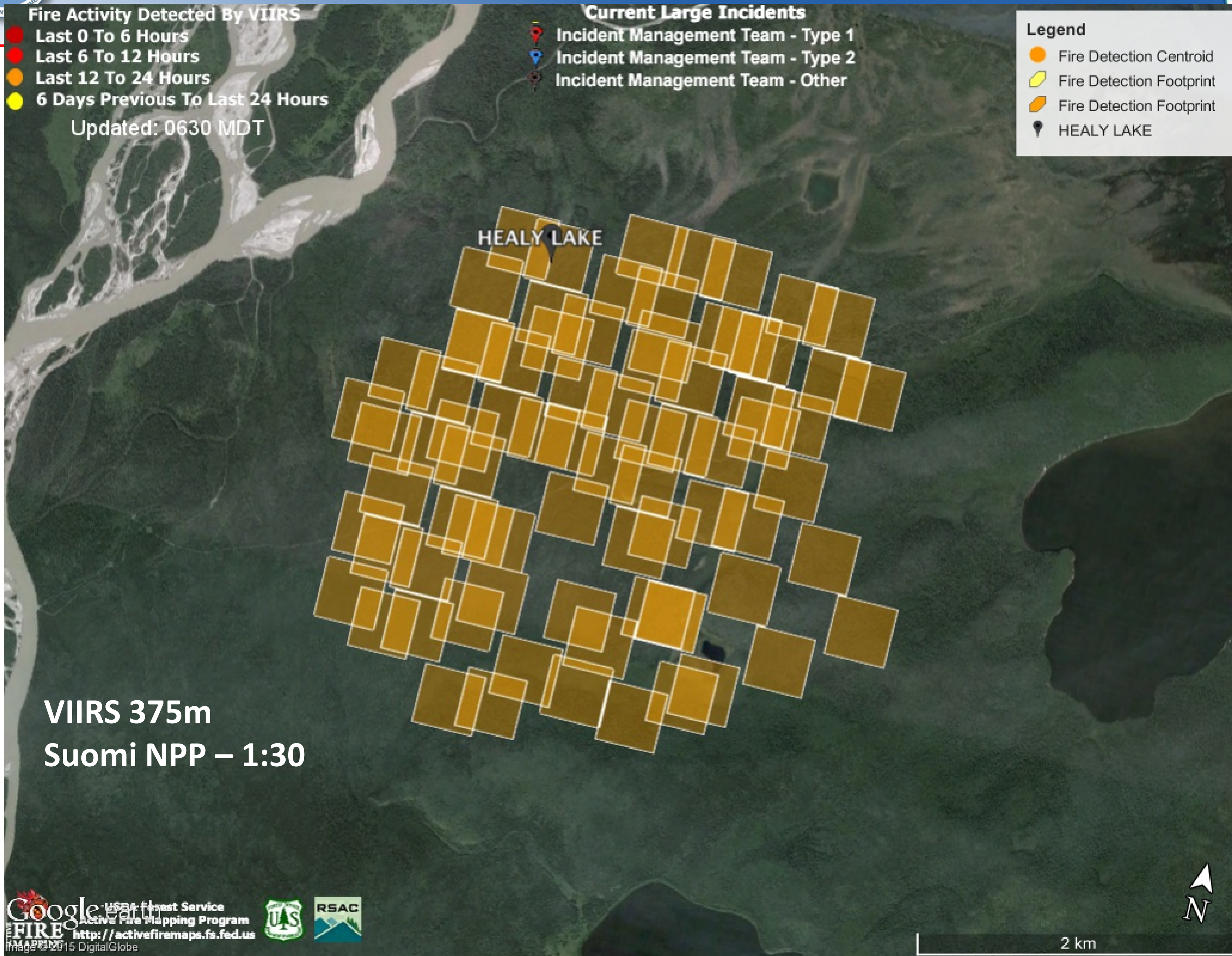


MODIS
Terra – 10:30
and
Aqua – 1:30

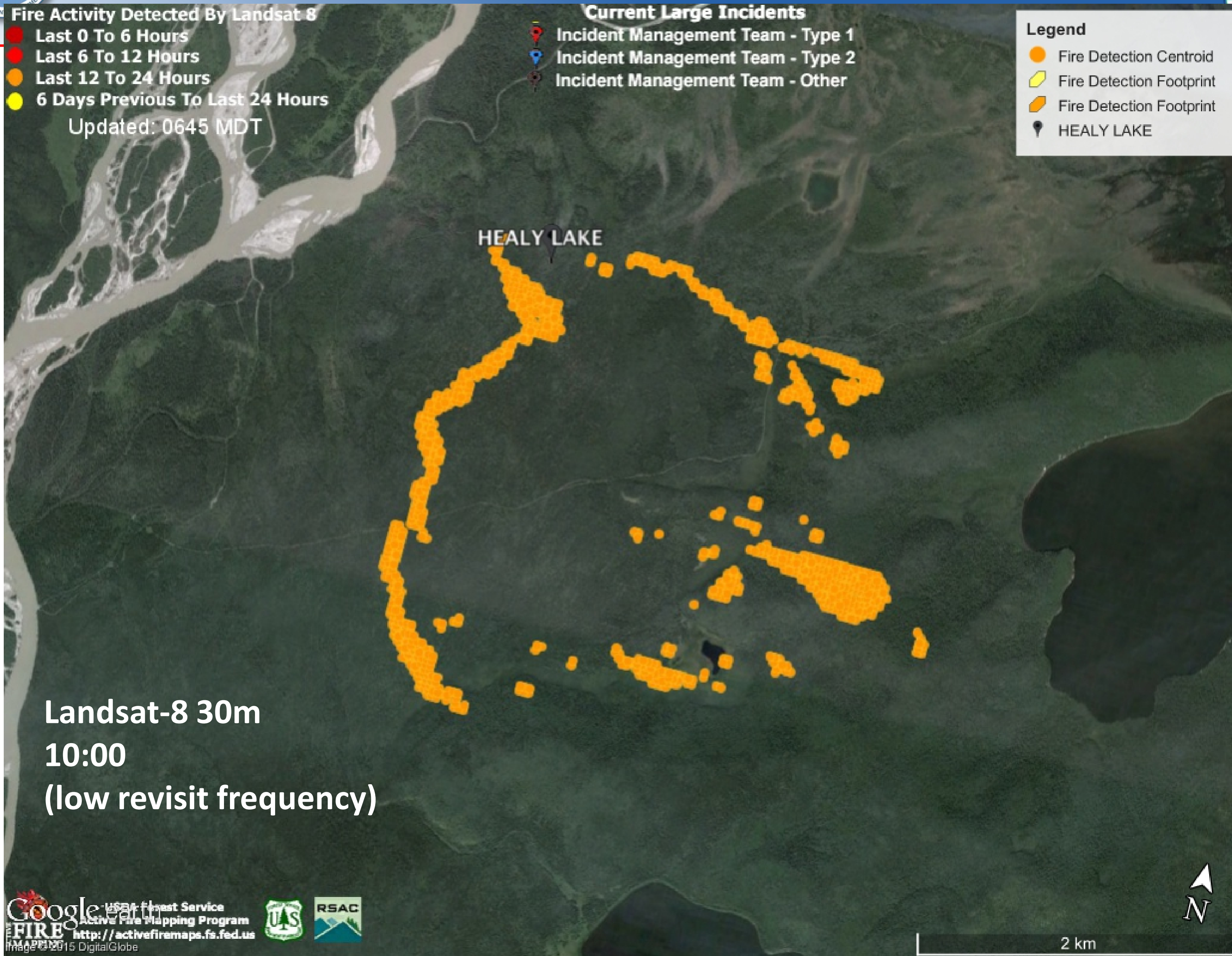
Healy Lake Fire (Alaska)



Healy Lake Fire (Alaska)

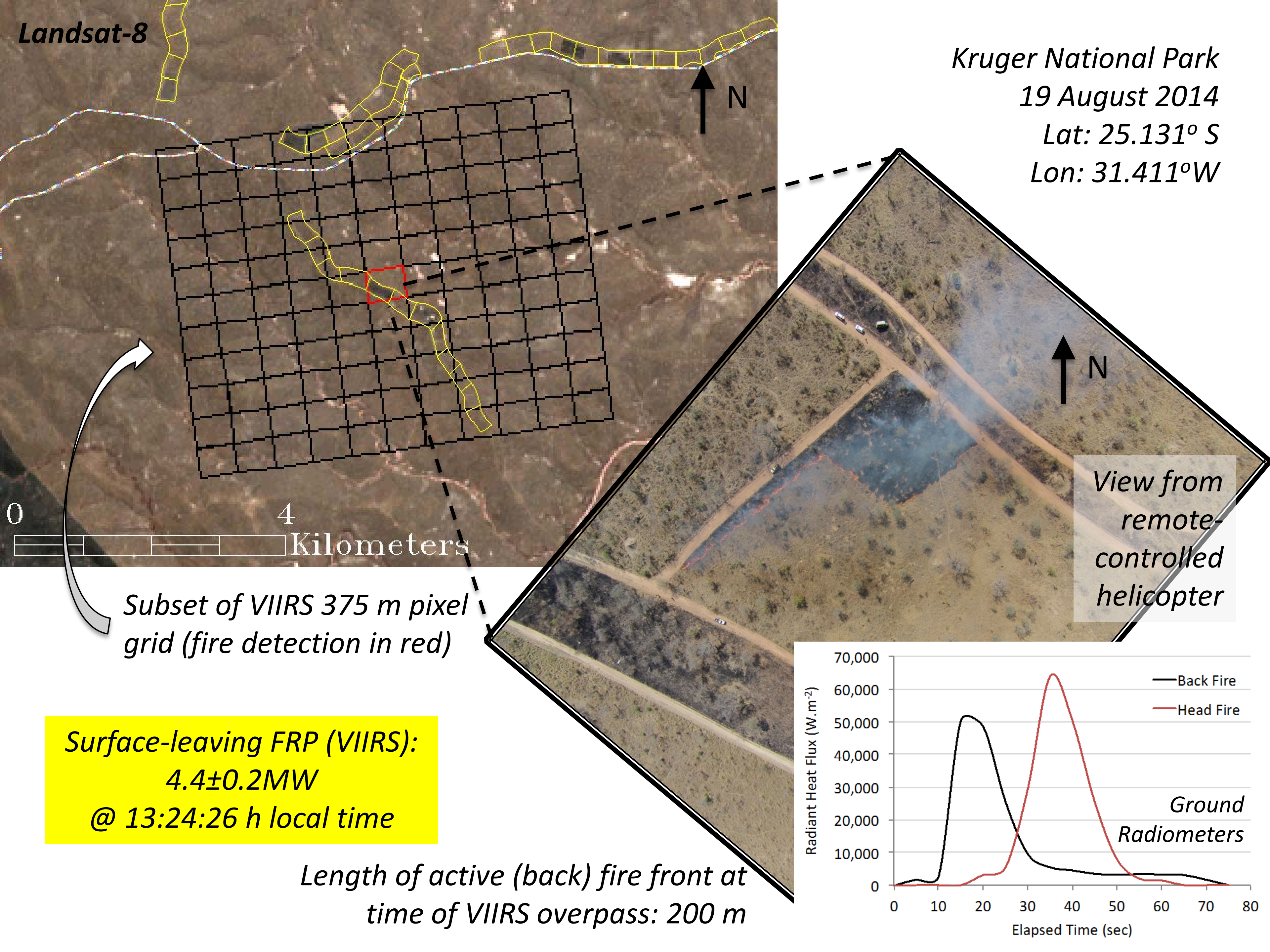


Healy Lake Fire (Alaska)



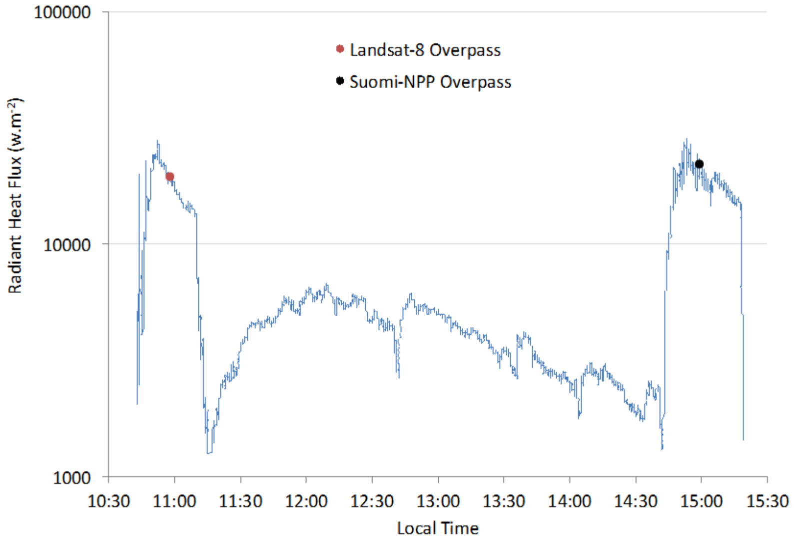
Active Fire Data Validation

- *Use of Landsat-class data to validate VIIRS is **not an option** due to prohibitively large time separation between same-day acquisitions*
  - *We won't match the MODIS validation status for VIIRS (≤ stage 2)*
- *Use of **prescribed fires** (easy/accessible)*
- ***Coincident** ground, airborne, spaceborne data acquisitions*
- ***Community-organized** (reduce spending, maximize output)*



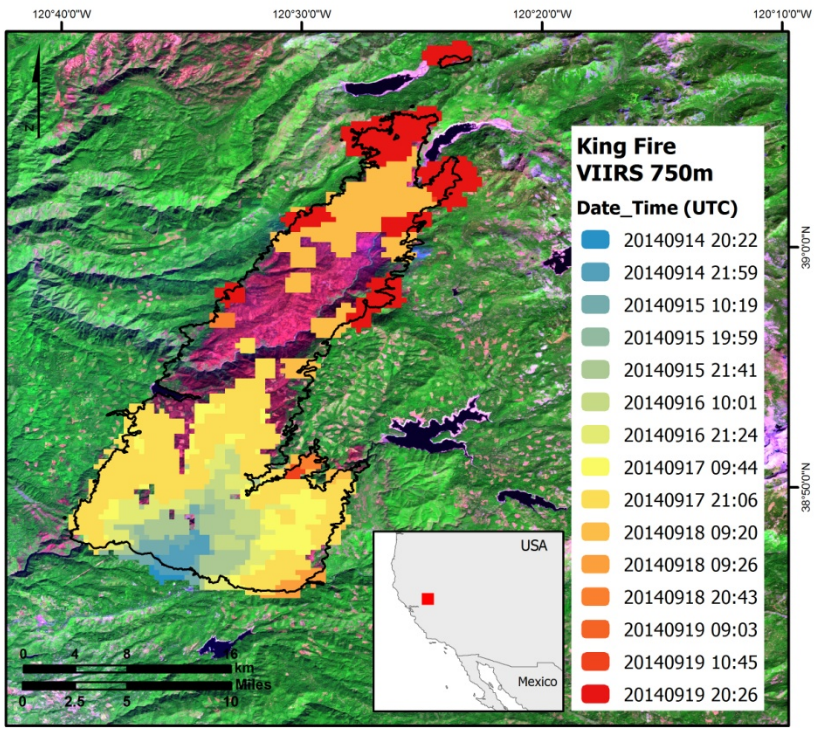
Landsat-8
N
0
4
Kilometers
Kruger National Park
19 August 2014
Lat: 25.131° S
Lon: 31.411°W
N
View from remote-controlled helicopter
Subset of VIIRS 375 m pixel grid (fire detection in red)
Surface-leaving FRP (VIIRS): 4.4±0.2MW @ 13:24:26 h local time
Length of active (back) fire front at time of VIIRS overpass: 200 m
Radiant Heat Flux (W.m⁻²)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0
10
20
30
40
50
60
70
80
Elapsed Time (sec)
Back Fire
Head Fire
Ground Radiometers

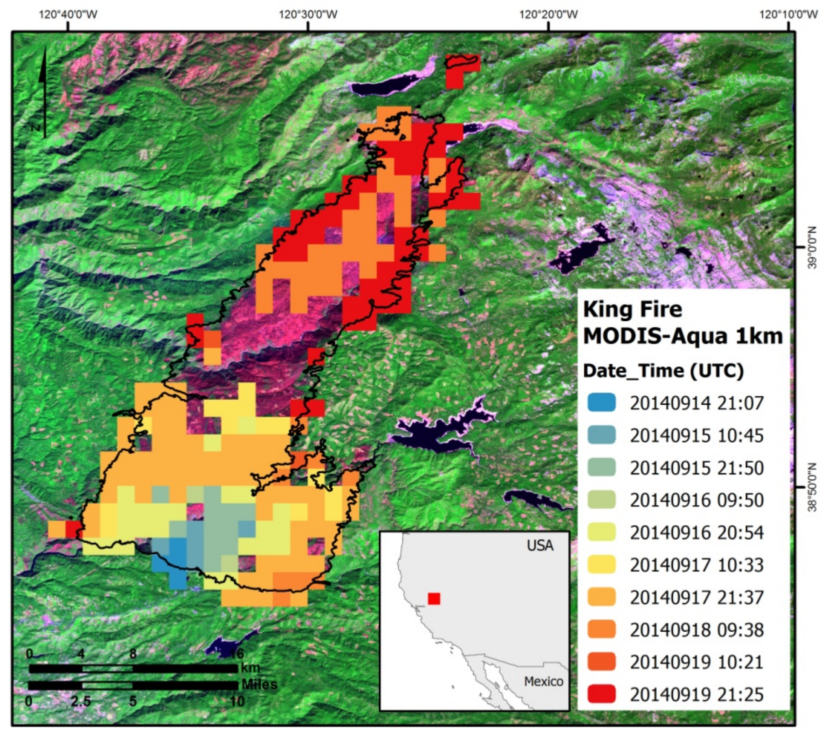
Active Fire Data Validation



Small experimental fire implemented for the validation of same-day Landsat-8 and Suomi-NPP/VIIRS fire detection data in Brazil, Jan/2015. Tower-mounted radiometers provided 1Hz fire radiant flux data coincident with satellite overpasses.

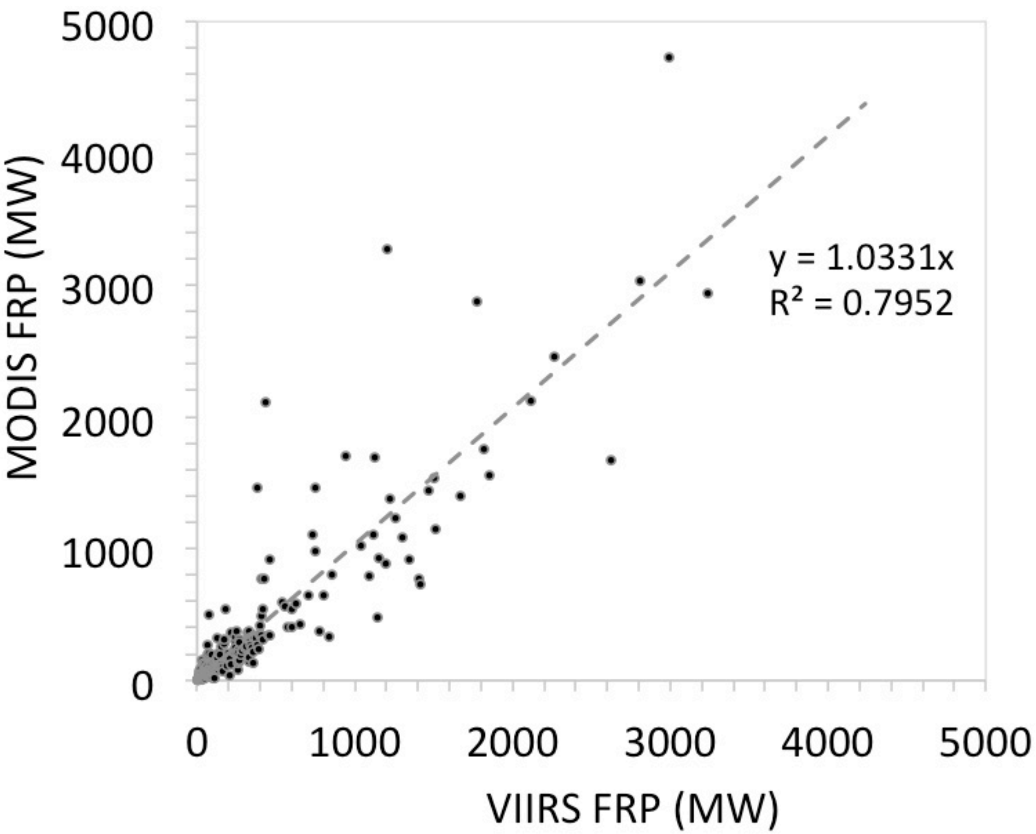
VIIRS vs. MODIS active fire





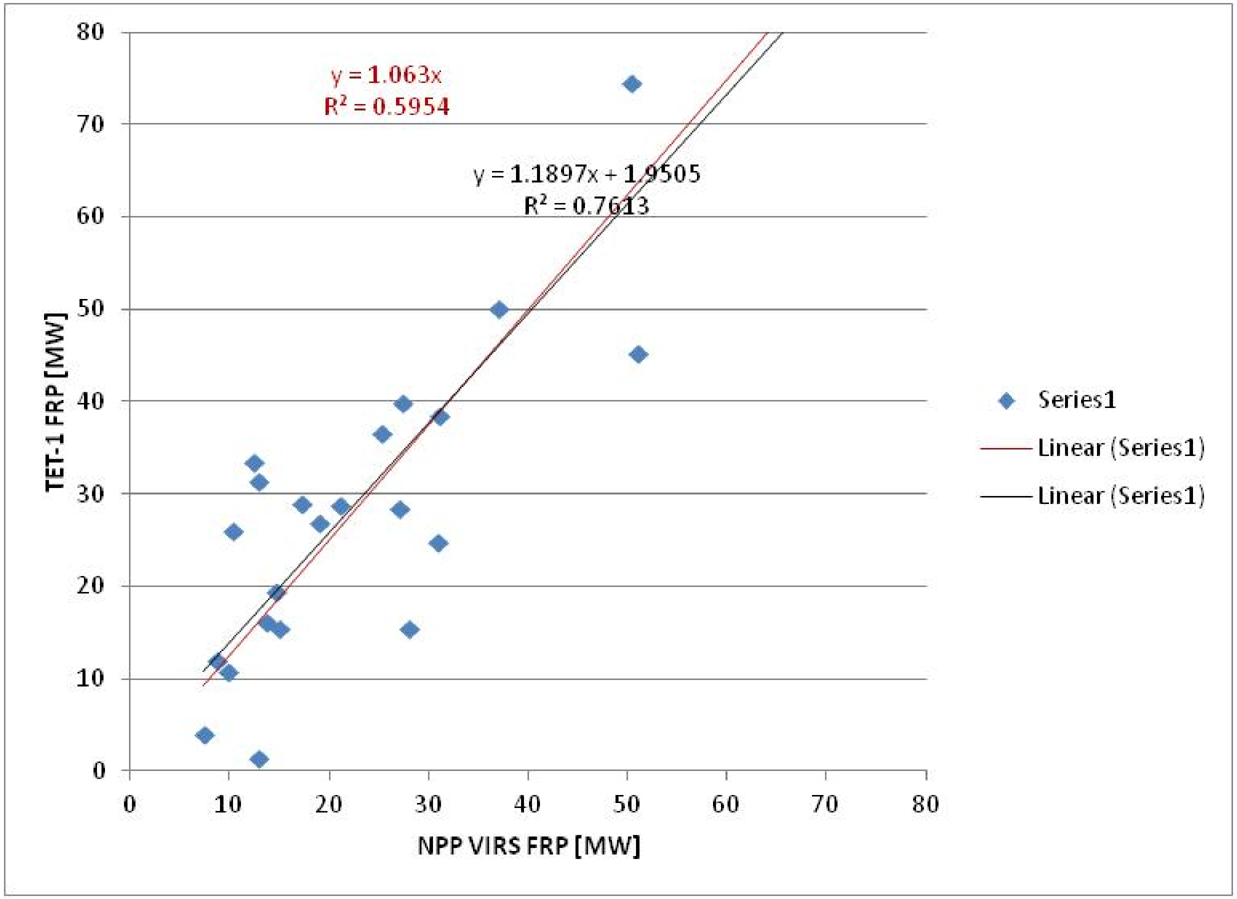
Suomi NPP/VIIRS AF and Aqua/MODIS MYD14 fire detection data produced for the King fire/California on 14-19 September 2014

FRP evaluation using MODIS



MODIS/VIIRS gridded data (0.5 degree) of near-coincident fires (<1km from each other) over different parts of the globe including atmospheric correction of both data sets.

FRP evaluation using DRL TET-1



Comparison of FRP retrievals of gas flares in the Middle East on May 9, 12, 15, 18, 24 2015

TET-1: Technology Experiment Carrier-1by German Aerospace Agency DRL; dedicated 185m unsaturated measurements for hotspot characterization

Summary

- 750m M-band product
  - the **IDPS Suomi NPP product** is stable
  - **new NDE product** that meets the **JPSS 1 requirements** is transitioning to NOAA operations
    - consistent NRT algorithm with NASA science product within Land SIPS
  - **long-term monitoring system** is set up at STAR
- 375m I-band product
  - **next generation** product towards operations
  - already in **systematic use** to support fire management and modeling
- Need thorough assessment of potential for **NOAA Enterprise and non-NOAA data processing**
- Continuing efforts towards rigorous **validation**
- Preparation for **JPSS-1** (and beyond) is ongoing
  - Calibration / validation plan
  - Sensor evaluation
  - Pre-launch algorithm testing
- Extensive **user outreach** and support
  - NOAA JPSS Proving Ground and Risk Reduction - Fire and Smoke Initiative
    - NOAA HRRR, HMS, NWS, IMETs, Alaska DB etc.
  - NASA Applied Sciences – Wildfires
    - USDA Forest Service RSAC, NCAR modeling, State of Colorado etc.

STAR JPSS EDR Overview

Name of the Product: Surface Type EDR

Contributors: ***Xiwu Zhan,***

Chengquan Huang,

Rui Zhang & Huiran Jin

Date: August 27, 2015

Outline

- Algorithm Cal/Val Team Members (1 slide)
- S-NPP Product Overview (2 slides)
- JPSS-1 Readiness (5 slides)
- Summary and Path Forward (2 slides)

Algorithm Cal/Val Team Members

PI	Organization	Team Members	Roles and Responsibilities
Xiwu Zhan	NOAA/STAR		Surface type EDR team lead, user outreach
	UMD/Geography	Chengquan Huang	Algorithm development lead
	UMD/Geography	Rui Zhang	Algorithm development, validation, user readiness
	UMD/Geography	Huiran Jin	Validation
	STAR/AIT	Marina Tsidulko	Product delivery

S-NPP Product Overview

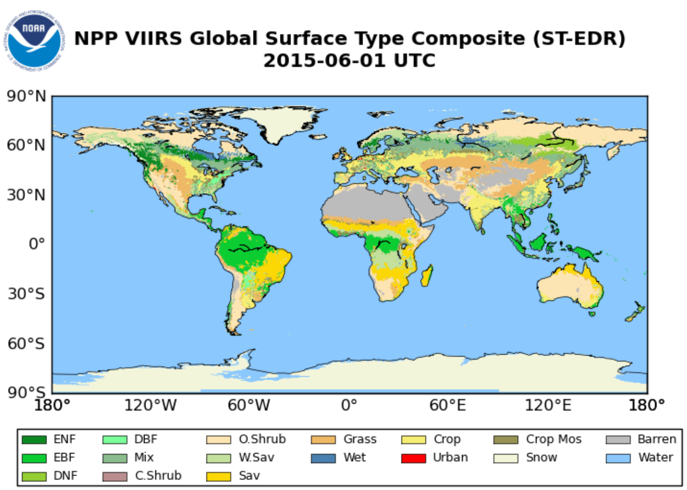
- List of Product(s) and L1RD Requirements Table(s)

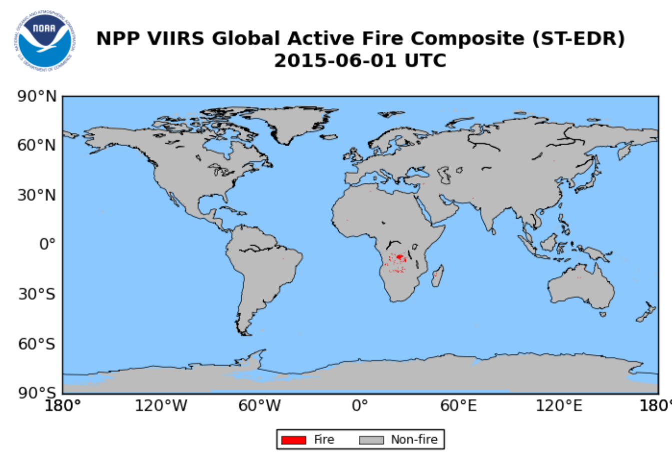
Attribute	Threshold	Objective
Geographic coverage	Global	Global
Vertical Coverage		
Vertical Cell Size	N/A	N/A
Horizontal Cell Size	1 km at nadir	1 km at edge of scan
Mapping Uncertainty	5 km	1 km
Measurement Range	17 IGBP classes	17 IGBP classes
Measurement Accuracy	70% correct for 17 types	70% correct for 17 types
Measurement Precision	10%	10%
Measurement Uncertainty		

- S-NPP Cal/Val Status
  - Reached validated 2 maturity stage
  - No known deficiencies

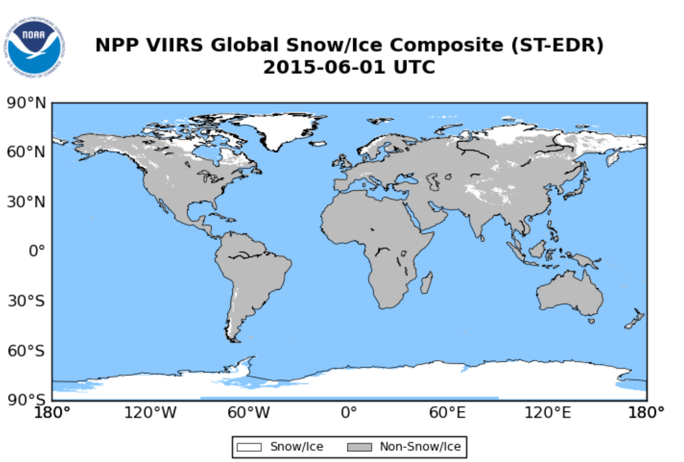
S-NPP Product Overview

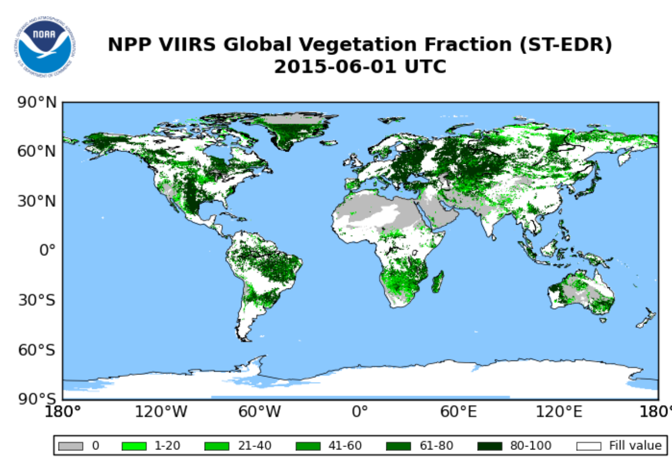
- LTM: Monitoring website links for the data product(s)
  - http://www.star.nesdis.noaa.gov/jpss/EDRs/products_surfacetype.php (in prep)





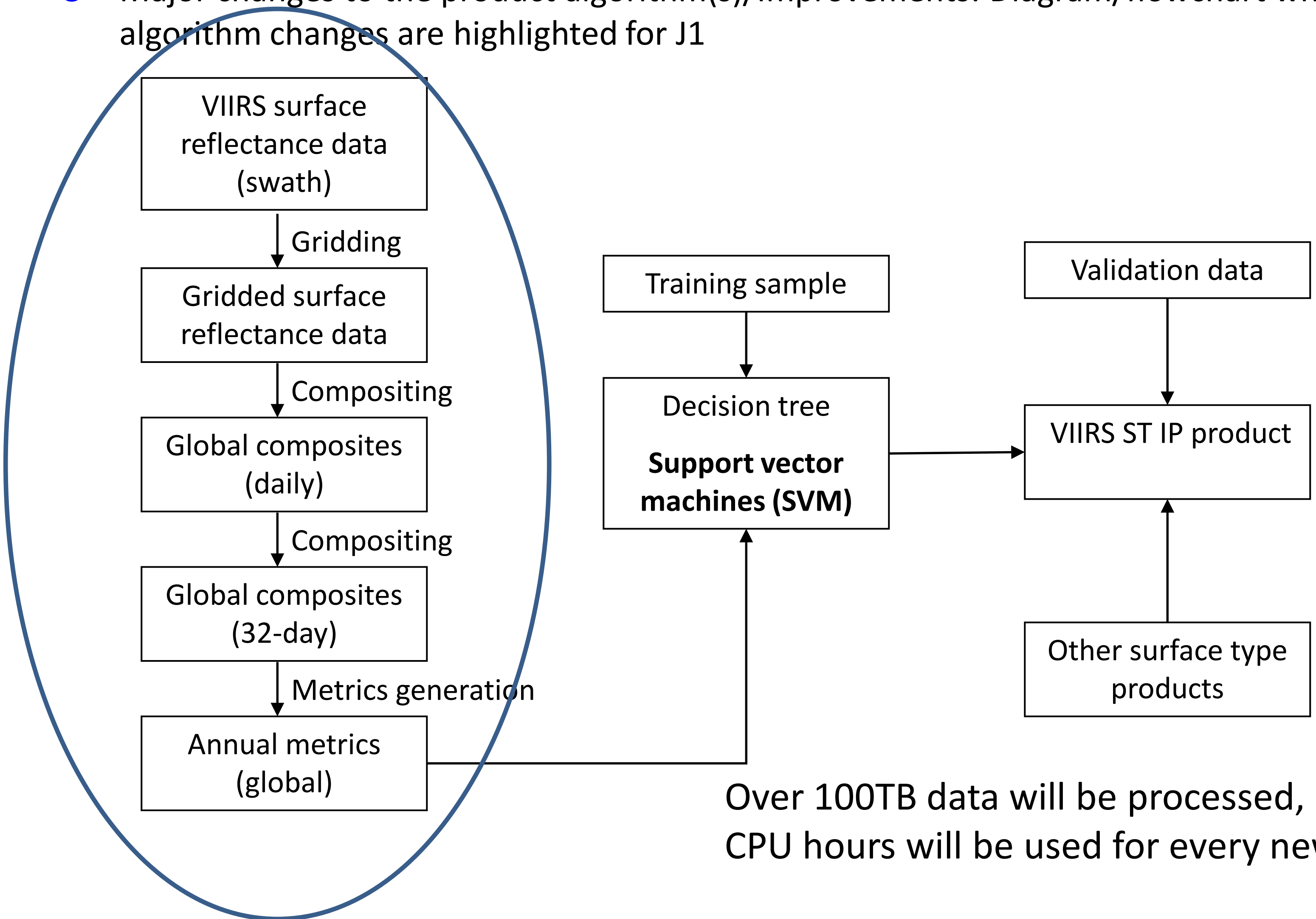
Daily global surface type, active fire, snow/ice and vegetation fraction maps are composited from the ST-EDR data for the long term monitoring





JPSS-1 Readiness

- J1 Algorithm Summary
  - Major changes to the product algorithm(s)/Improvements: Diagram/flowchart where major algorithm changes are highlighted for J1



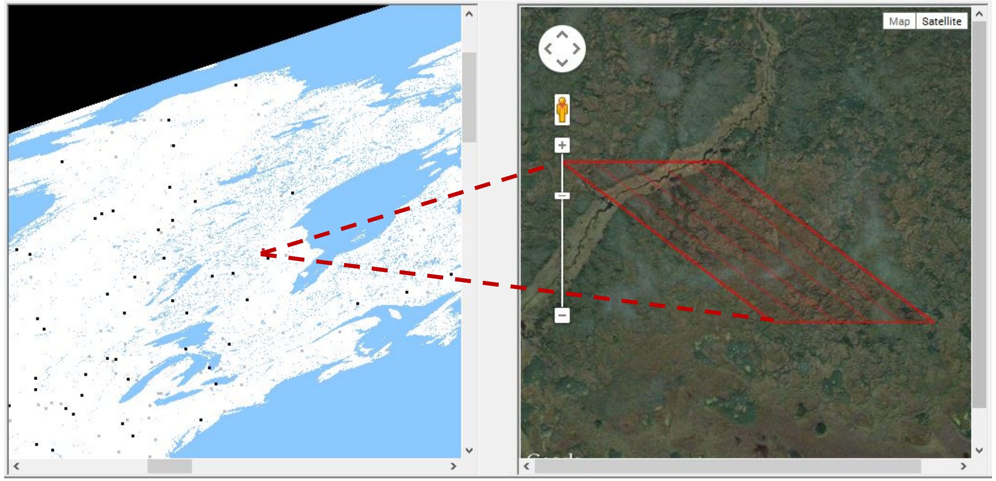
Over 100TB data will be processed, over 30,000 CPU hours will be used for every new map

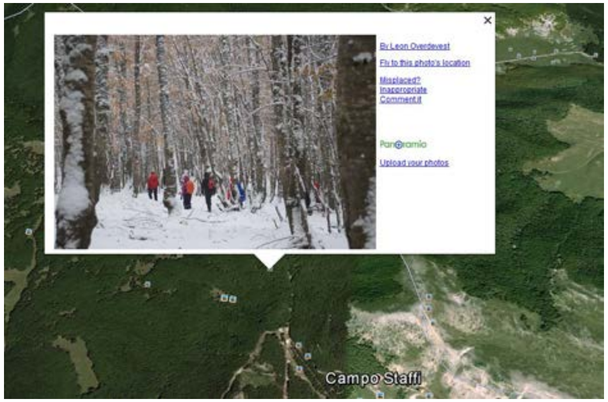
JPSS-1 Readiness

- J1 Cal/Val Overview
  - Timelines for Beta, Provisional and Validated Maturity
    - Beta: Launch (L) + 6 months (m) for ST-EDR with S-NPP proxy
      L+18months for GST using J-1 data
    - Provisional: L+9months for ST-EDR with S-NPP proxy
      L+21m for GST using J-1 data
    - Validated: L+12m for ST-EDR with S-NPP proxy
      L+24m for GST using J-1 data
  - Pre-Launch Calibration/Validation Plans
    - S-NPP and MODIS will be used as the proxy data in the pre-launch phase
    - Support Vector Machines (SVM) will replace C5.0 as the main classification algorithm. Evaluations and comparisons will be conducted.
    - Improve the validation tool, refine validation points sampling strategy
  - Post-Launch Calibration/Validation Plans
    - Earth orbit surface reflectance data will be checked.
    - Intensive validation using the interactive validation tool.
    - Collect more representative samples for product refinement
    - Long term monitoring

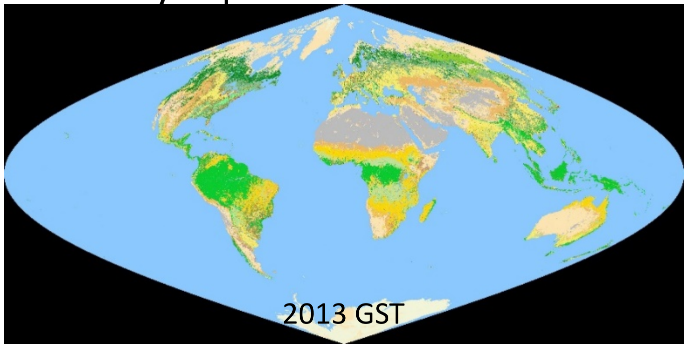
JPSS-1 Readiness

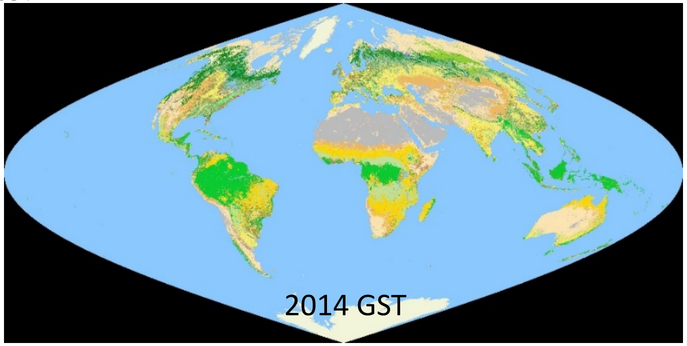
- Major Accomplishments and Highlights Moving Towards J1
  - Interactive validation tool has been developed, and a comprehensive validation has been conducted on the S-NPP GST. Error matrix and overall accuracy suggested the product accuracy exceeds the requirement of the J1RD. The ST-EDR reached the validated 1 maturity.





  - New SVM classification algorithm has been used in the production of 2013 and 2014 S-NPP GST. Preliminary experiments showed satisfactory results.





JPSS-1 Readiness

- Issues/Mitigation
  - No major issues.
  - Lack of computing resources for archiving gridded surface reflectance data is limiting the capability of the surface type science team to use multi-year data for the classification. Since the production of GST requires at least one full year global VIIRS surface reflectance data for the classification metrics, multi-terabytes have to be stored locally. Leveraging other teams' efforts on global daily VIIRS data processing is also limited the data downlinks between different team. Therefore, the surface type team computing resources may become a concern in the JPSS era.

JPSS-1 Readiness

- Stake Holder Interactions, Users and Impact Assessment Plans
  - Downstream product users:
    - Land surface temperature. LST check GST to determine proper ground type for accurate parameters in a LUT.
    - Cloud mask, aerosol products, other products require global land/water location information. General surface types separations are required by many algorithms and products.
    - National Center for Environmental Prediction (NCEP) in NOAA/NESDIS – point of contact: Dr. Mike Ek will be a major internal user for this product.
  - Production system user:
    - IDPS relies on Master Land Index (MLI) tiles to perform all Grid/Gran productions. The MLI tiles are created with the GST-Land/Water Mask, which is generated and maintained by the ST-EDR team. The GIP_GSTLWM_TILE update necessitates an update to the IDPS MLI tiles, which has high impact to the whole production system.
  - Science community users:
    - land surface parameterization (Feddema 2005, *Science* 310 (5754): 1674–78),
    - modeling of biogeochemical cycles (Cramer et al. 1999, *Global Change Biology* 5 (S1): 1–15),
    - carbon cycle studies (Friedlingstein et al. 2006, *Journal of Climate* 19 (14): 3337–53).

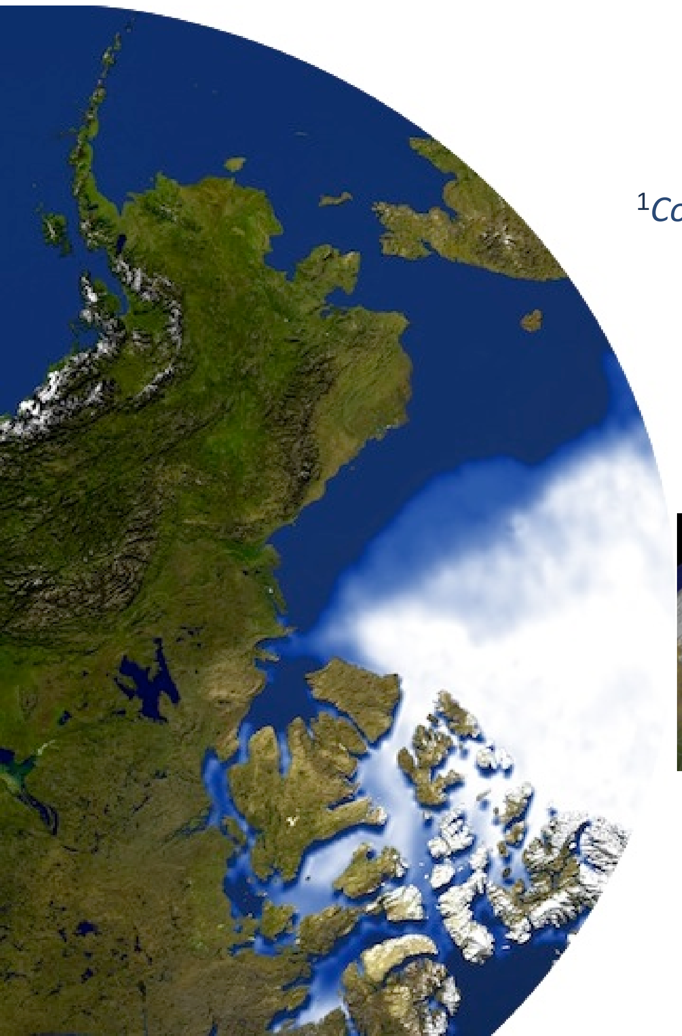
Summary & Path Forward

- Summary
  - S-NPP GST and ST-EDR have been successfully validated. The results suggested that the ST-EDR meets the accuracy requirement defined in the J1RD.
  - Validation protocol has been successfully established, including validation dataset, validation tool, and accuracy reporting approaches.
  - New classification algorithm SVM has been successfully tested, and preliminary results showed promising improvements. The SVM will replace the C5.0 decision tree in future data productions.
  - Long term monitoring for the ST-EDR has been created. Daily composited surface type, active fire (quality flag bit, provided by Active fire ARP), snow/ice (quality flag bit, provided by Snow EDR), and vegetation fraction (calculated from annual maximum minimum data and surface reflectance input) have been generated and posted into the LTM website.

Summary & Path Forward

- Path Forward
  - FY16 Milestones
    - Comparison of results from S-NPP VIIRS surface type EDR with other existing surface type products.
    - Improvement of the training samples and validation points, which are collected globally and incrementally.
    - delivery of a VIIRS global gridded surface type (GST) product based on 2012-2015 S-NPP VIIRS observations.
  - J2 and Beyond: Future Improvements
    - Better compositing algorithm to the data preparation, use multiple year data to stabilize the unnecessary annual variabilities.
    - Post-classification improvements, introduce more external data and product sources to improve the accuracy of the GST and ST-EDR
    - Different classification legend to better serve the users, such as Biome classification type.
    - More useful dataset or flags to be included into the ST-EDR, such as dynamic water information, which will be invaluable for flood monitoring.

Sea Ice Thickness from Satellite



Xuanji Wang[1] and Jeff Key[2]

[1]*Cooperative Institute for Meteorological Satellite Studies, U. Wisconsin-Madison*
[2]*NOAA Satellite and Information Services, Madison, Wisconsin*

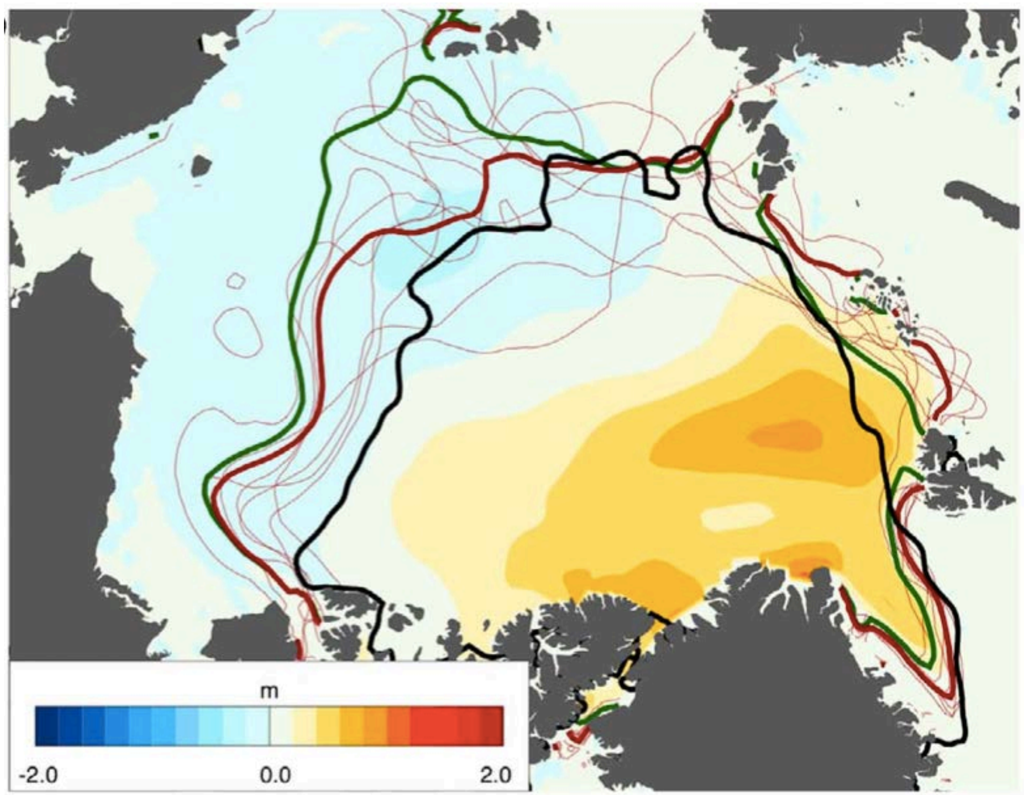
With input from Dan Baldwin and Mark Tschudi, CU-Boulder

STAR JPSS 2015 Annual Science Team Meeting
24-28 August 2015, NCWCP, College Park, MD

Importance of Ice Thickness

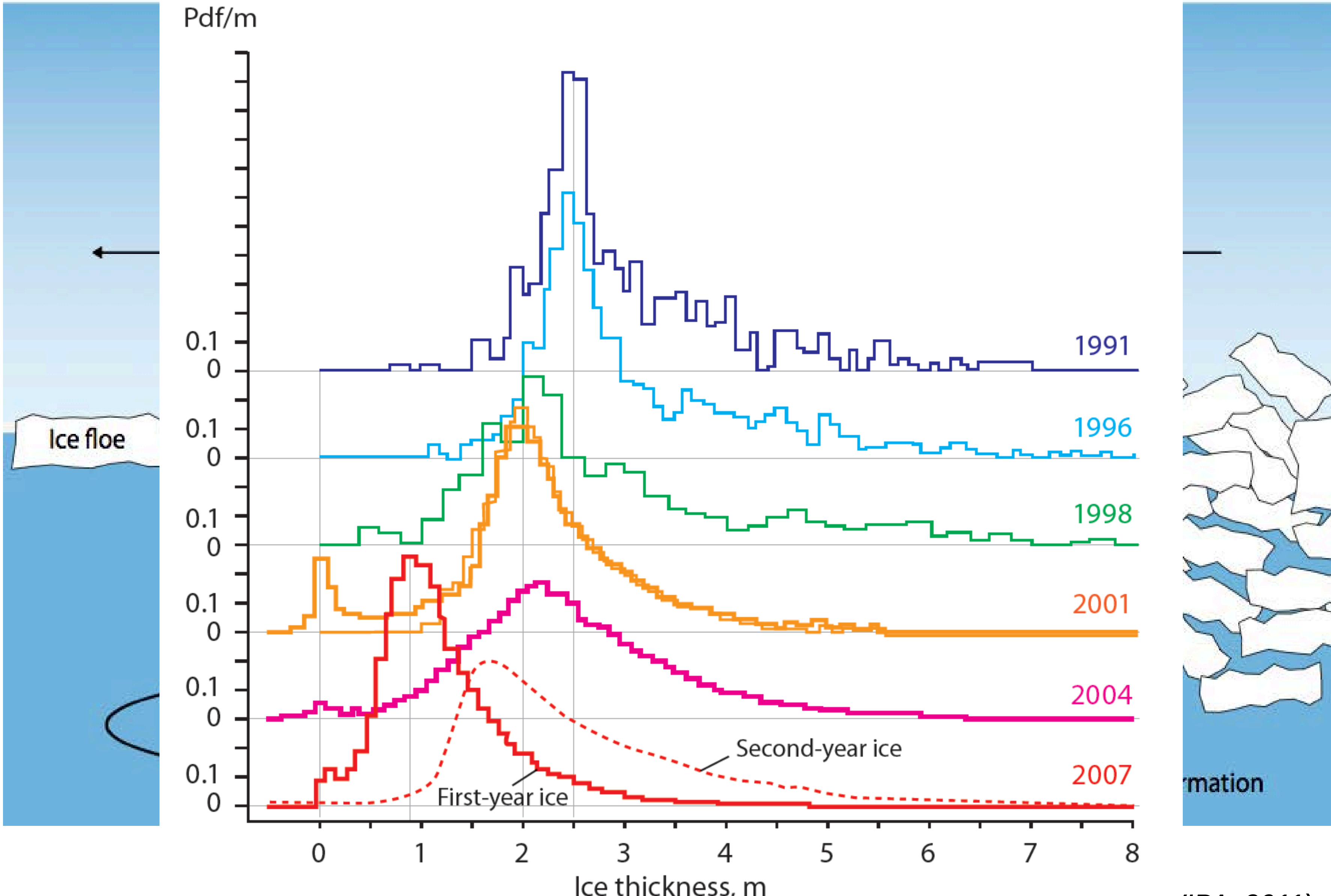
Thermodynamically and dynamically it is ice thickness, not ice extent, that is important. Thickness provides an integrated measure of changes in the energy balance. It is critical to navigation.

While little work has been done on assimilating ice thickness in models, indications are that doing so would improve ice forecasts.



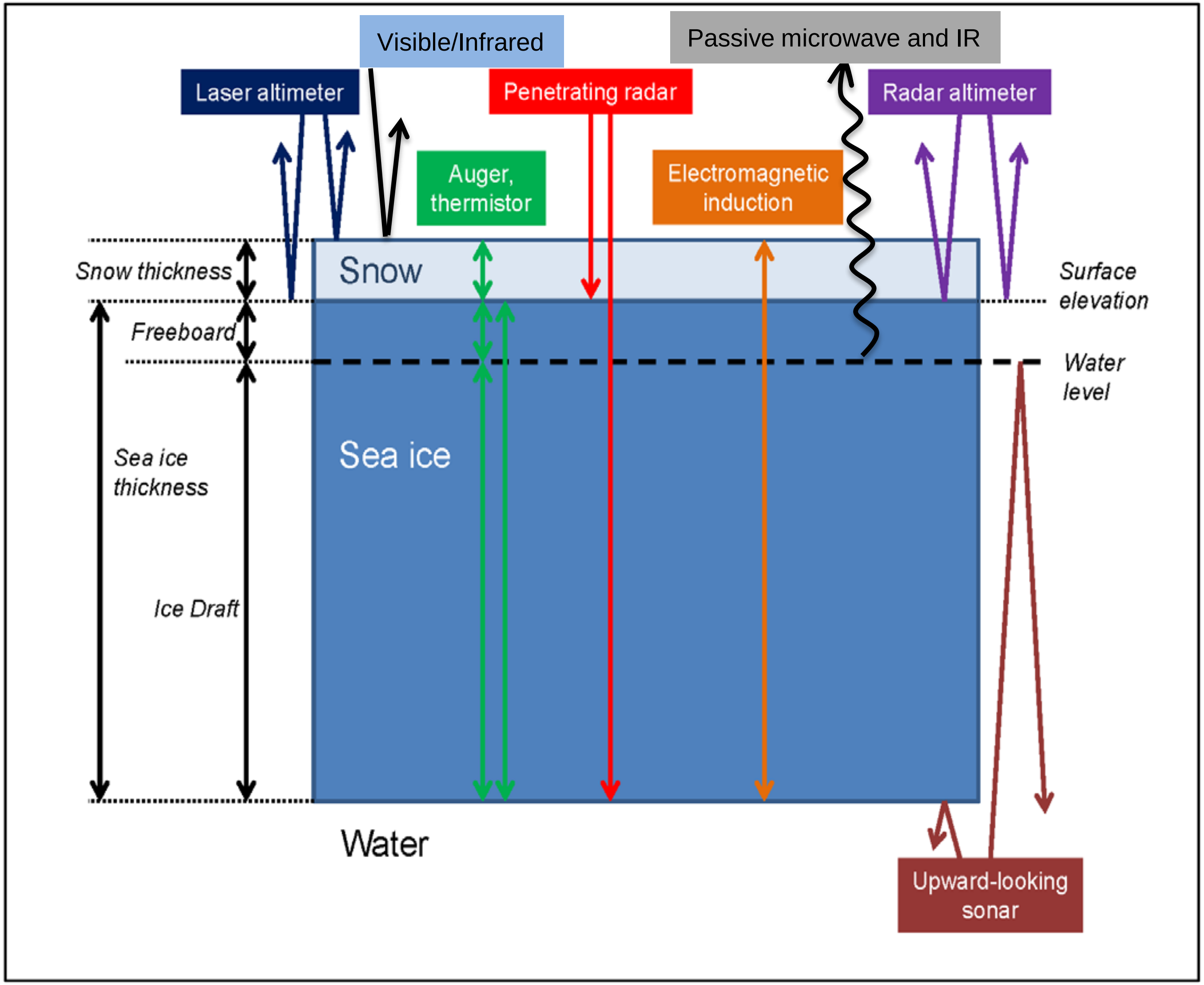
The difference in mean ice thickness for September between the corrected and the control runs of the PIOMAS model, where corrected runs use IceBridge and SIZONet ice thicknesses to correct the initial thickness field. The thin red lines are the ice extent (0.15 ice concentration) lines for each of the corrected ensemble members and the thick red line is the mean for the ensemble. The thick green line is the mean of the ensemble of control runs and the black line is the observed September mean ice extent. From Lindsay et al. (2012)

Processes That Affect Ice Thickness



'IPA, 2011)

Measuring Ice Thickness



(adapted from Meier et al., 2014)

Sea Ice Characterization EDR L1RD Requirements

Sea Ice Characterization Requirements from L1RD version 2.9

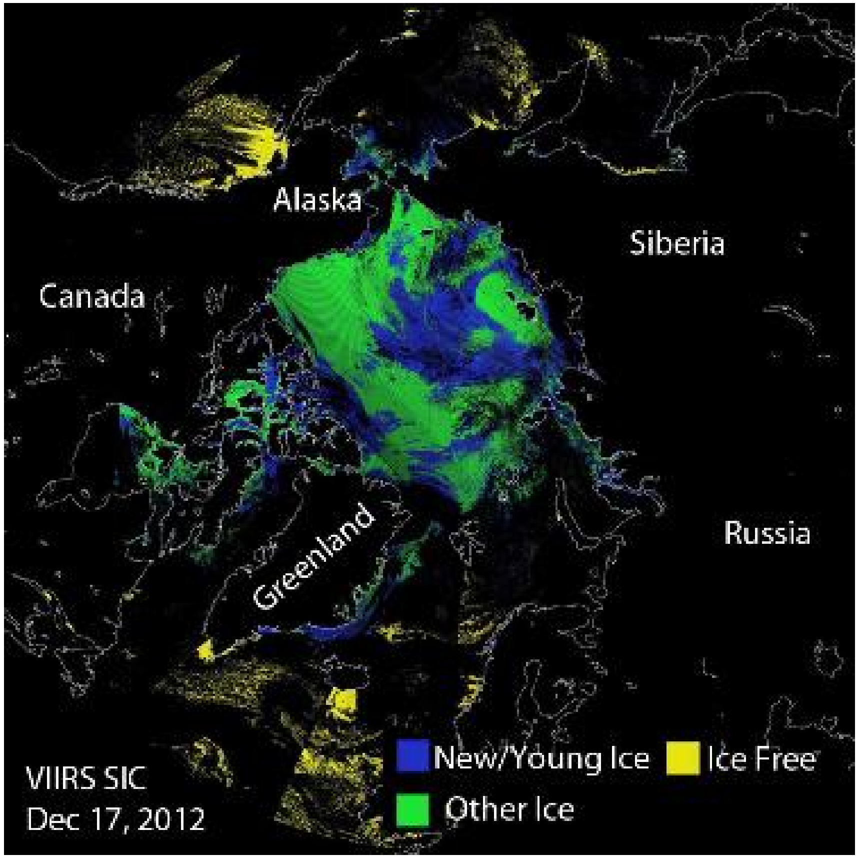
Note that because the percentage of N/Y ice is, on the annual average, very small, the 70% probability of correct typing of both classes together could be met by simply labeling all ice pixels as "Other Ice"!

f. Refresh	At least 90% coverage of the global every 24 hours (monthly average)	6 hrs
g. Geographic coverage	All Ice-covered regions of the global ocean	All Ice-covered regions of the global ocean
Notes: 1. VIIRS produces a sea ice concentration IP in clear sky conditions, which is provided as an input to the ice surface temperature calculation		

Summary of VIIRS Sea Ice Characterization EDR

- The VIIRS Sea Characterization EDR (Ice Age) consists of ice classifications for *Ice Free*, *New/Young* and *Other Ice* at VIIRS moderate spatial resolution (750m @ nadir), for both day and night, over oceans poleward of 36^{o}N and 50^{o}S latitude.

  - New or Young ice is discriminated from thicker ice (Other Ice) by a threshold ice thickness of 30 cm. Discrimination of New/Young ice from thicker ice is achieved by two algorithms: (1) Energy balance at night and (2) reflectance during the day.
  - Heritage: There is no operational visible/IR heritage. AVHRR research heritage (Comiso and Massom 1994, Yu and Rothrock 1996 and Wang et al. 2010).



Summary of VIIRS Sea Characterization EDR (Ice Age) Algorithm Overview

Reflectance Threshold Branch (Day Region Algorithm)

- Input ice tie point reflectance (I1, I2), VCM IP, AOT IP
- Input granulated NCEP gridded precipitable water, total ozone fields
- Obtain snow depth for each ice thickness bin obtained from climatology modeled snow depth/ice thickness LUT
- Retrieve ice thickness from sea ice reflectance LUT using ice tie point reflectances, modeled snow depth, AOT, precipitable water, and solar and satellite view geometry
- Classify by comparing retrieved ice thickness to 30 cm ice thickness threshold

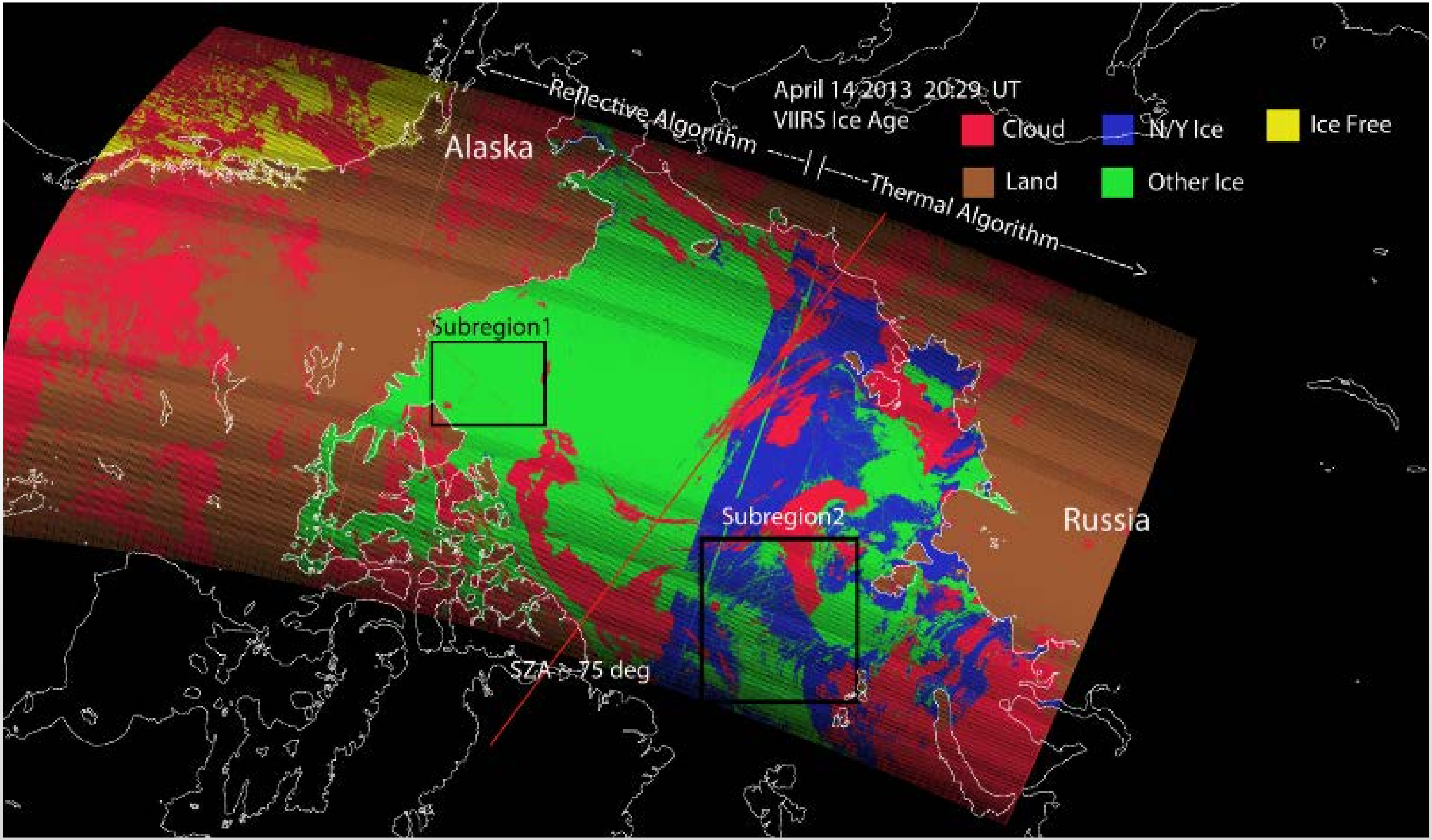
Energy Balance Branch (Terminator and Night Region Algorithm)

- Input Ice Temperature Tie Point IP
- Input granulated NCEP gridded surface fields (surface pressure, surface air temp, specific humidity, etc.)
- Compute snow depth for 30cm ice thickness threshold from heat/energy balance
- Classify by comparing computed and climatology LUT snow accumulation for a 30 cm ice thickness threshold

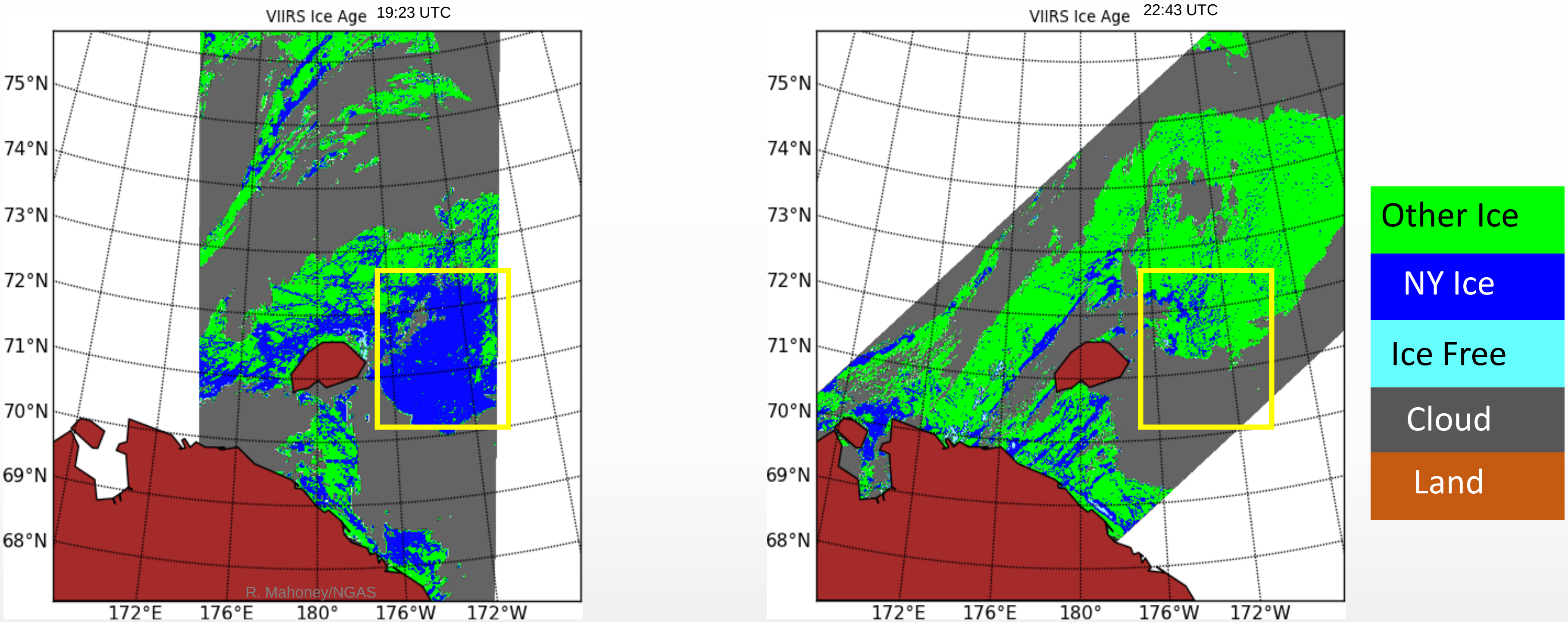
The Snow-Depth-Ice Thickness Climatology LUT contains:

- predicted snow accumulation depths for modeled ice thickness threshold growth times based on monthly climatology surface air temperatures and precipitation rates

Problem: Day-Night Differences



Problem: Orbit-to-Orbit Misclassification of NY and Other Ice



Region near Wrangle Island showed significant amounts of sea ice that were correctly classified as thicker "Other Ice" in 22:43 UTC orbit scene (right) being misclassified as NY in the 19:23 UTC orbit scene (left). The yellow boxed region shows a broad region of misclassified NY ice in the 19:23 scene.

SDR RGBs, ice tie point reflectance, modeled sea ice reflectance, modeled snow accumulation depth, internally computed ice thickness and other inputs were examined and compared in order to determine the cause for the misclassification.

Summary of VIIRS Sea Ice Characterization Status

The Sea Ice Characterization EDR has considerable performance challenges. Misclassification of ice was observed to occur for the following categories of conditions:

- Day regions:
  - bias towards misclassification of Other Ice as NY in regions with 1) large values of climatology snow depth, 2) high satellite view zenith angle and regions with 3) low reflectance due to melting ice and 4) cloud shadows
- Night regions
  - reversals of ice age classification
- Terminator regions
  - frequent, broad misclassification of Other Ice as NY and reversals of classification
  - Ice classification discontinuities are most evident and frequent where the algorithm transitions from the day reflectance based algorithm to the night energy balance based algorithm

Solutions to these problems are illusive, so another approach was pursued: the One-dimensional Thermodynamic Ice Model (OTIM) that was developed for GOES-R.

One-dimensional Thermodynamic Ice Model (OTIM) (Wang et al., 2010)

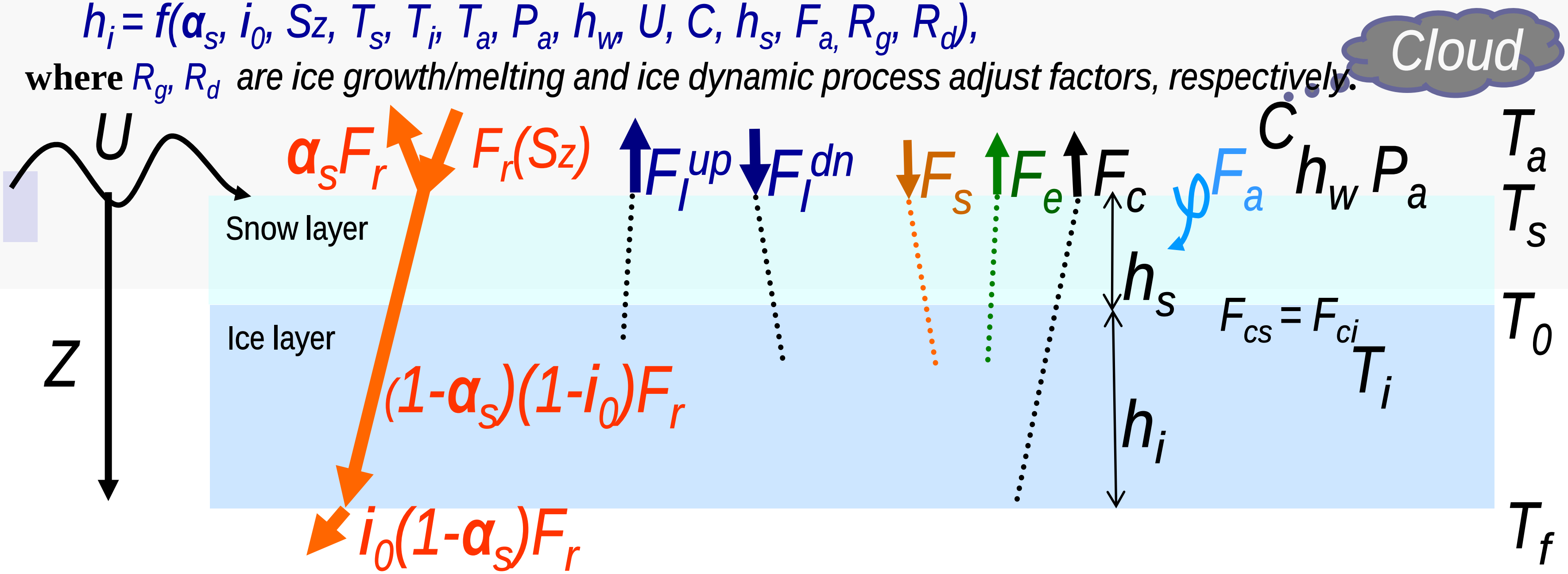
Based on the surface energy budget at thermo-equilibrium state, the fundamental equation is

$$(1-\alpha_s)(1-i_0)F_r - F_l^{up} + F_l^{dn} + F_s + F_e + F_c = F_a(\alpha_s, T_s, U, h_i, C, h_s, \ldots)$$

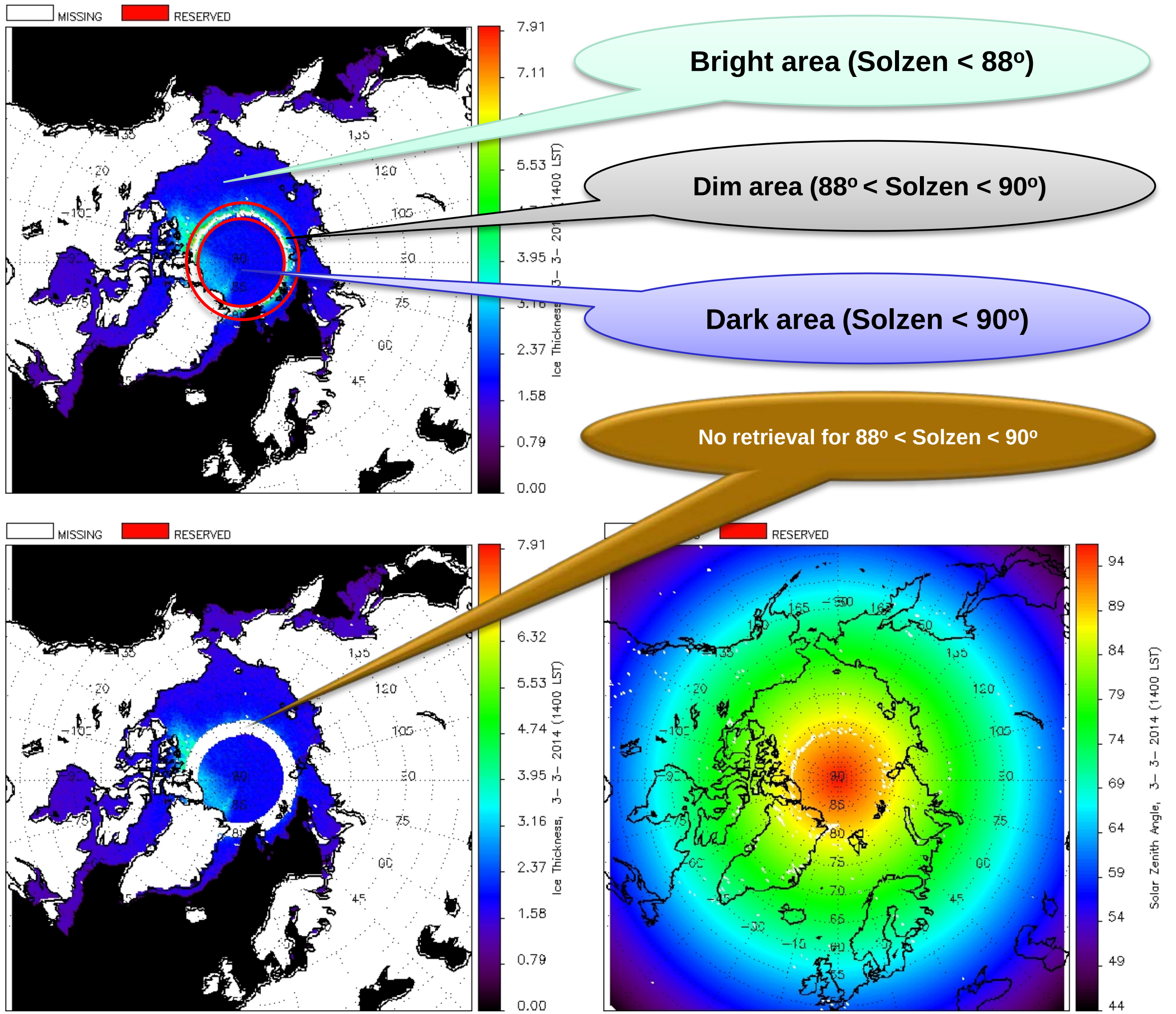
After parameterizations of thermal radiation (F_r, F_l^{up}, F_l^{dn}) and turbulent (sensible & latent) heat (F_s, F_e), ice thickness *hi* becomes a function of 11 model controlling variables plus two factors:

$$h_i = f(\alpha_s, i_0, Sz, T_s, T_i, T_a, P_a, h_w, U, C, h_s, F_a, R_g, R_d),$$

where R_g, R_d *are ice growth/melting and ice dynamic process adjust factors, respectively.*



Consistency - OTIM daytime and nighttime algorithms

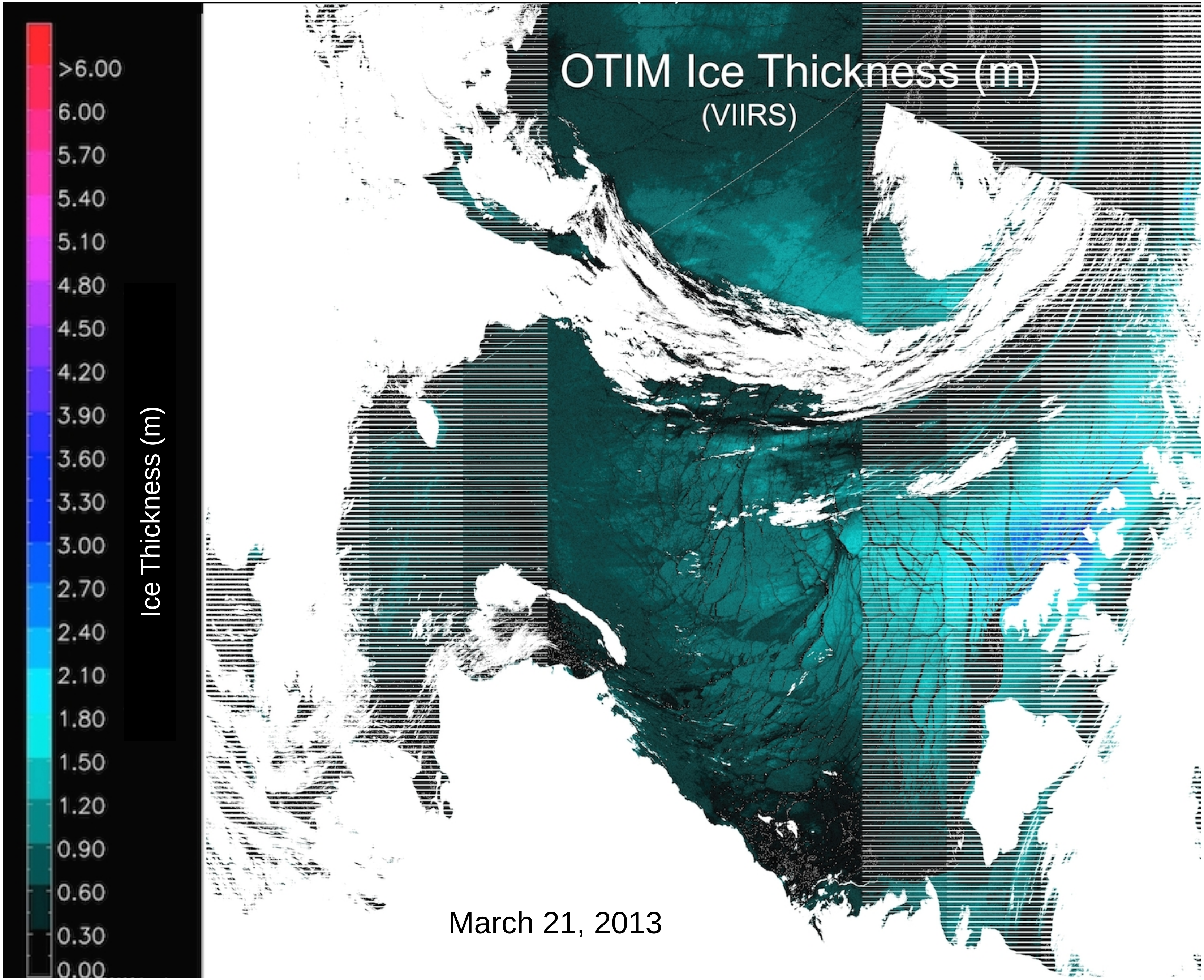


Sea ice thickness on March 3, 2014 at 14:00 LST (white solid ring indicating dim area with solar zenith angle between 88 and 90 degrees)

Solar zenith angle on March 3, 2014 at 14:00 LST

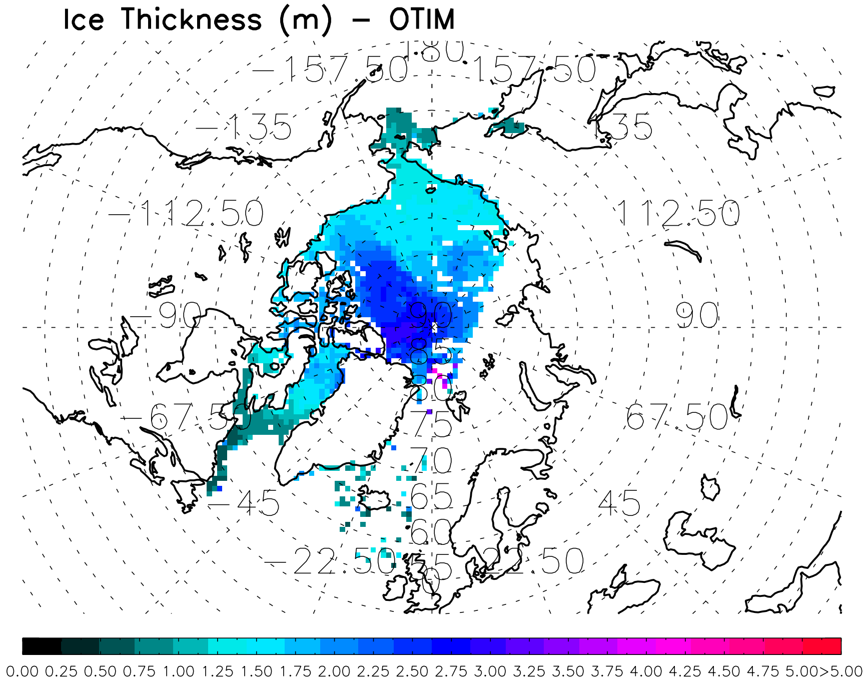
(APP-x 25 km data products)

Though the algorithms in OTIM for retrieving daytime and nighttime ice thickness are different because of solar radiation involved in daytime retrieval, their retrieved ice thickness is very consistent in value except that dim area where solar zenith angle between 88 ~ 90 degrees has poor retrieved ice thickness because of poor cloud and surface albedo retrievals.

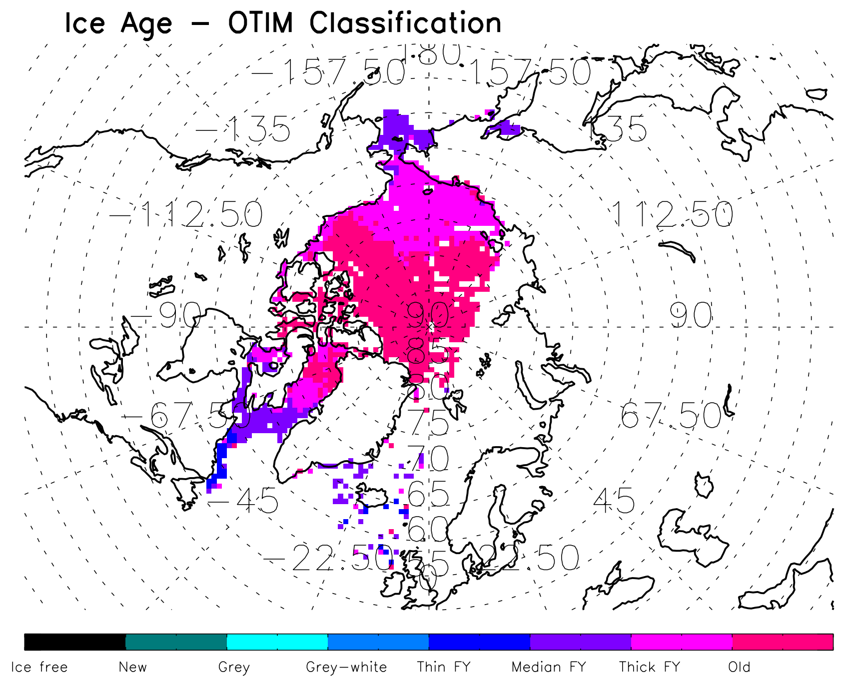

OTIM Ice Thickness (m)
(VIIRS)
>6.00
6.00
5.70
5.40
5.10
4.80
4.50
4.20
3.90
3.60
3.30
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Ice Thickness (m)
March 21, 2013

Large Scale VIIRS Ice Thickness

Ice Thickness

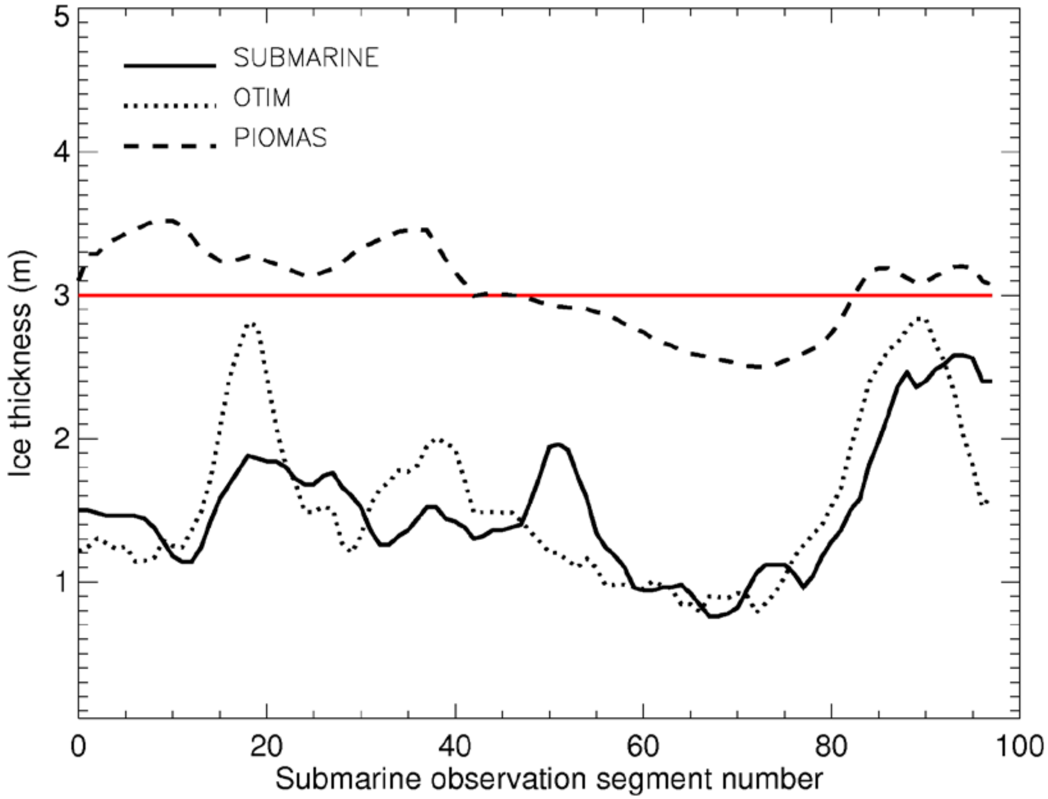


Ice Age



OTIM retrieved ice thickness (left) based on VIIRS ice surface temperature, and ice age (right) derived on March 4 ,2012 for the Arctic region.

Comparison of APP-x and Submarine ULS



Comparisons of ice thickness retrieved by OTIM with APP-x data, measured by submarine, and simulated by PIOMAS alone the submarine track segments.

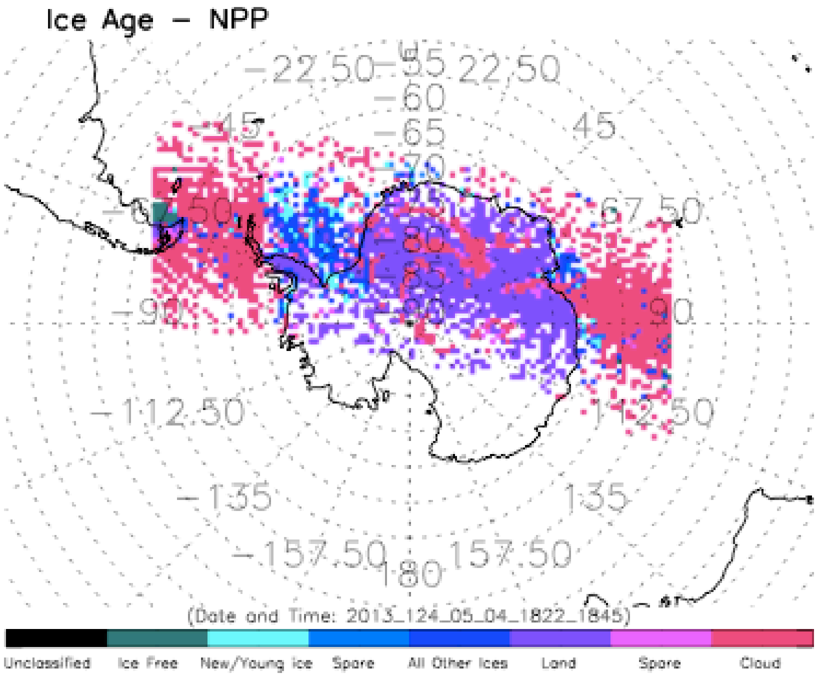
	OTIM	Submarine
Thickness Mean (m)	1.55	1.51
Bias (m)	0.04	
RMS difference (m)	0.52	

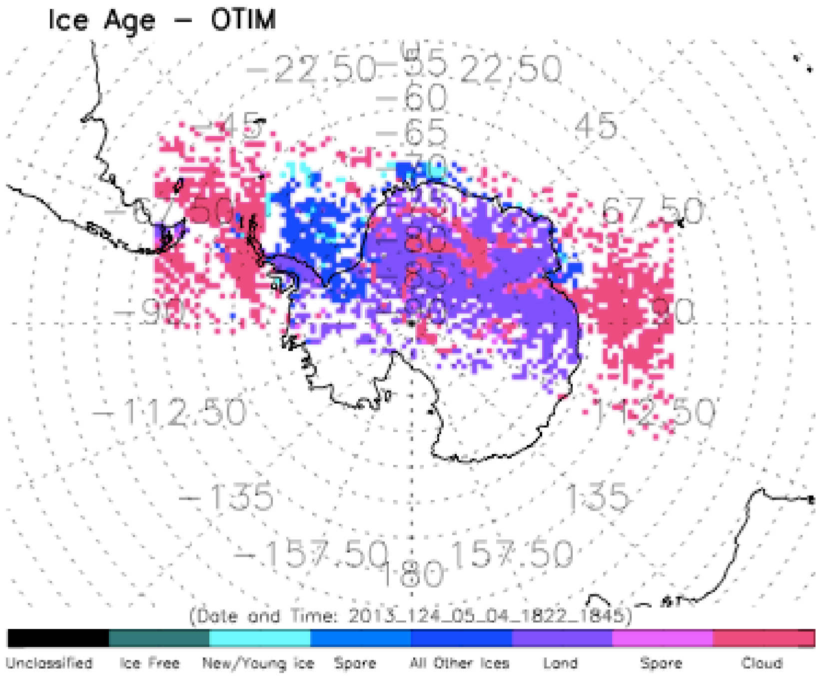
OTIM (w/AVHRR) and Surface Measurements

	OTIM ALERT LT1	OTIM ALERT YLT	OTIM CAMBRIDGE BAY YCB	OTIM CORAL HARBOUR YZS	OTIM EUREKA WEU	OTIM HALL BEACH YUX	OTIM RESOLUTE YRB	OTIM YELLOWKNIFE YZF
Thickness Mean (m)	1.52 1.09	1.59 1.09	1.51 1.44	1.04 1.20	1.59 1.22	1.18 1.41	1.63 1.38	0.95 0.98
Bias Mean (m)	0.43	0.50	0.07	-0.16	0.37	-0.23	0.25	-0.03
Bias Standard Deviation (m)	0.52	0.39	0.97	0.62	0.52	0.68	0.50	0.58
OTIM Ice Age	Ice free water, new/fresh, grey, grey-white, first year thin, first year medium, first year thick, and multi-year ice.							
EDR Requirements	Distinguish between ice free, new/fresh ice, and all other ice.							

Ice Thickness and Age
IDPS and NDE (OTIM) Comparison

Sea ice age categories from VIIRS sea ice age classification (left) and OTIM ice thickness converted to the same categories (right) on May 4, 2013 over the Arctic.





Ice Thickness and Age
IDPS and NDE (OTIM) Comparison

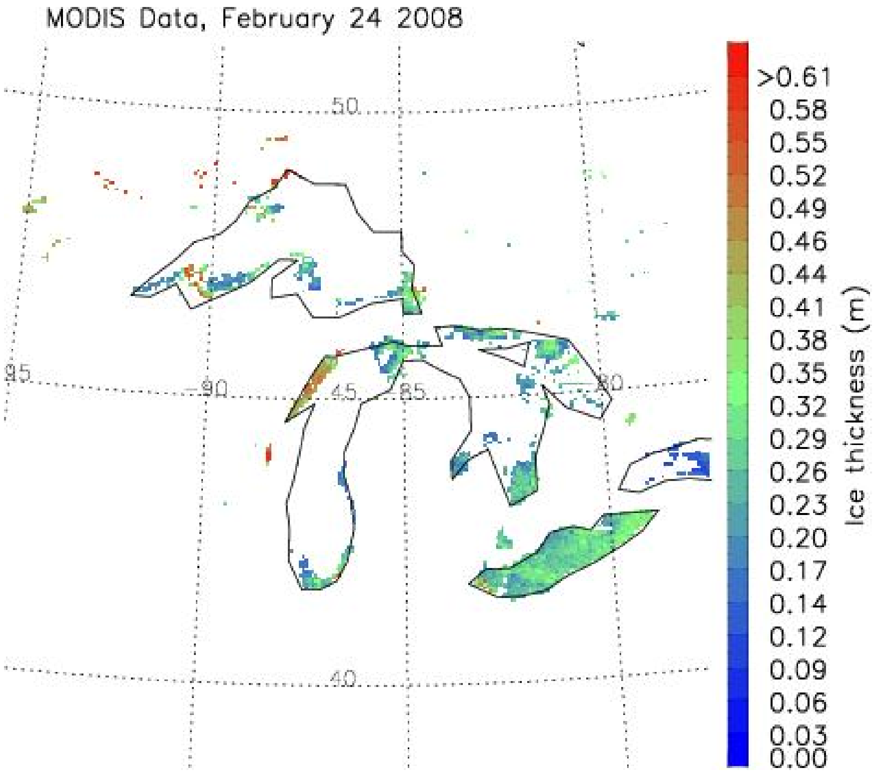
Statistics for figure on previous slide:

Percentage in each ice age category from VIIRS and OTIM for May 4, 2013 case.

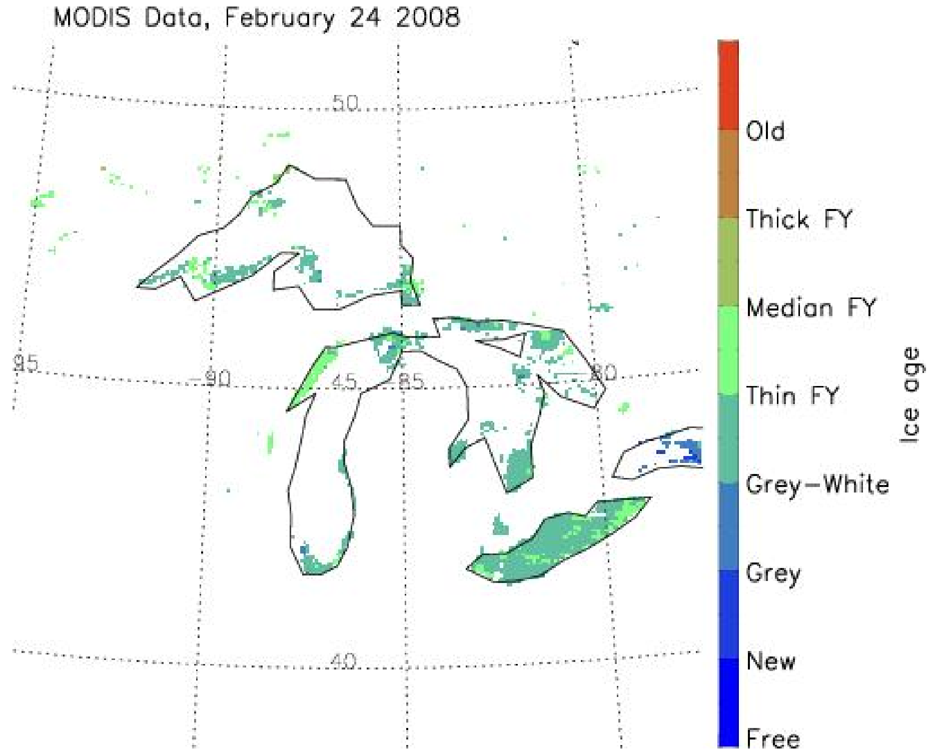
Categories	VIIRS ice age	OTIM ice age	Difference (VIIRS-OTIM)
Day and night time:			
Ice free	13	24	-11
New/Young ice	52	9	43
Other ice	35	67	-32
Daytime:			
Ice free	27	50	-23
New/Young ice	53	3	50
Other ice	20	47	-27
Nighttime:			
Ice free	10	20	-10
New/Young ice	52	10	42
Other ice	38	70	-32

Ice Thickness and Age: Great Lakes!

Ice Thickness



Ice Age



Estimated ice thickness (left) and ice age categories (right) based on MODIS data on February 24, 2008.

Satellite-Derived Ice Thickness Products

It is now possible to estimate ice thickness from space using a variety of techniques:

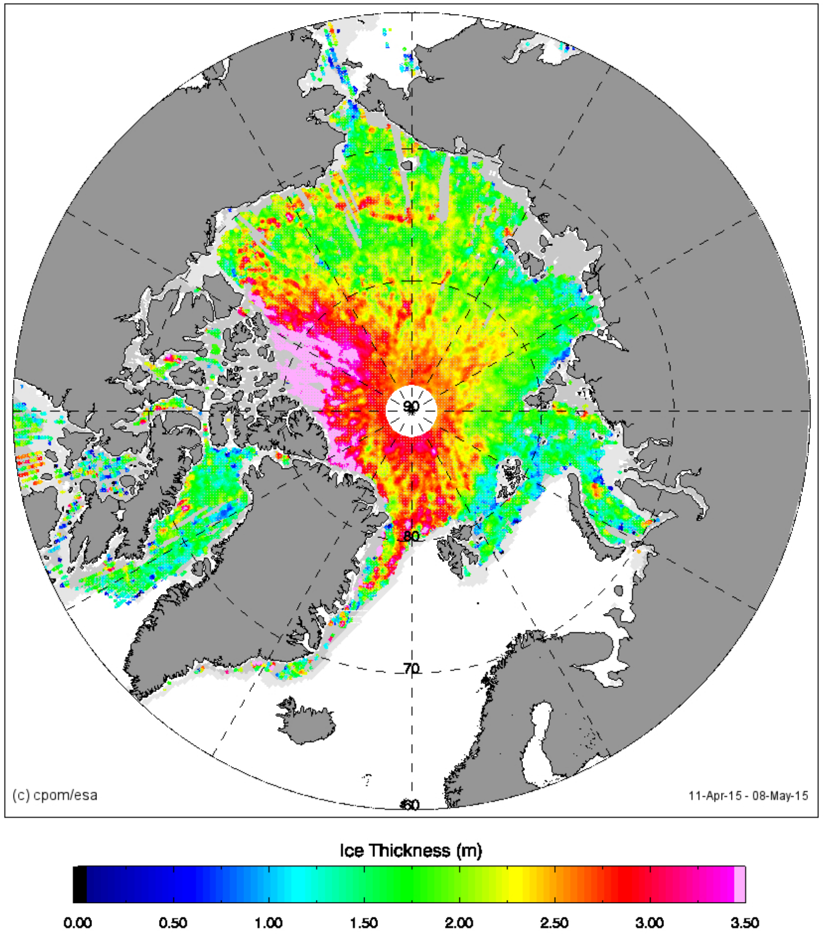
- The One-dimensional Thermodynamic Ice Model (OTIM) is an energy budget approach for estimating sea and lake ice thickness with visible, near-infrared, and infrared satellite data from sensors such as the Advanced Very High Resolution Radiometer (AVHRR), the Moderate Resolution Imaging Spectroradiometer (MODIS), and the Visible Infrared Imaging Radiometer Suite (VIIRS) – **APP-x** and **MPP-x** (*Wang et al., 2010*).
- Laser and radar altimeter data from the ICESat and CryoSat-2 satellites estimate ice thickness from ice elevation (freeboard) – **ICESat**, **CryoSat-2**, and **IceBridge** (*Kwok et al., 2009; Laxon et al., 2013; Kurtz et al., 2013).*
- Another method employs low-frequency passive microwave data from the Soil Moisture and Ocean Salinity (**SMOS**) mission (*Tian-Kunze et al., 2014*).
- Arctic sea ice thickness has also been modeled with Pan-Arctic Ice Ocean Modeling and Assimilation System (**PIOMAS**) (*Zhang and Rothrock, 2003*).

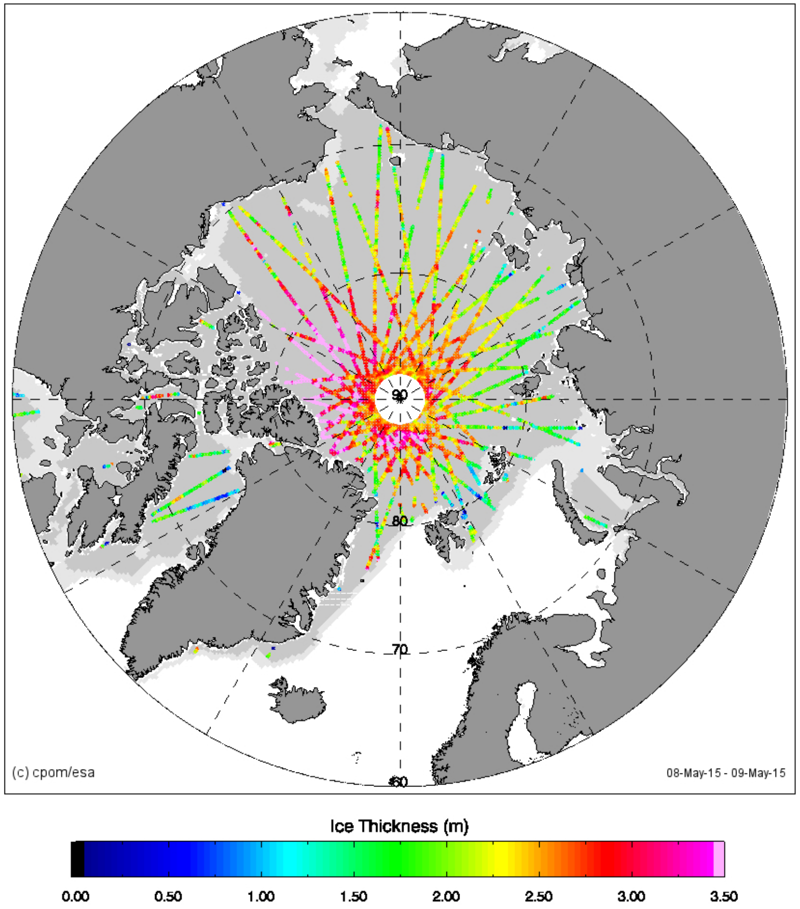
Thanks to: Ron Kwok, Jinlun Zhang, the National Snow and Ice Data Center (NSIDC), the Alfred Wegener Institute, and the University of Hamburg for providing sea ice thickness data from ICESat, PIOMAS, IceBridge, CryoSat-2, and SMOS.

CryoSat-2 Sea Ice Thickness (ESA)

Left: 28-day composite

Below: 2-day composite

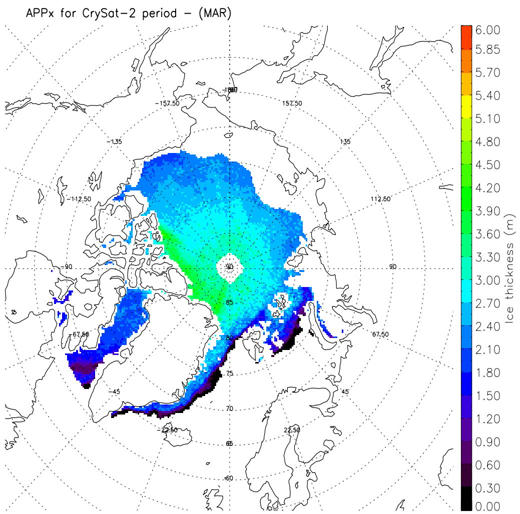




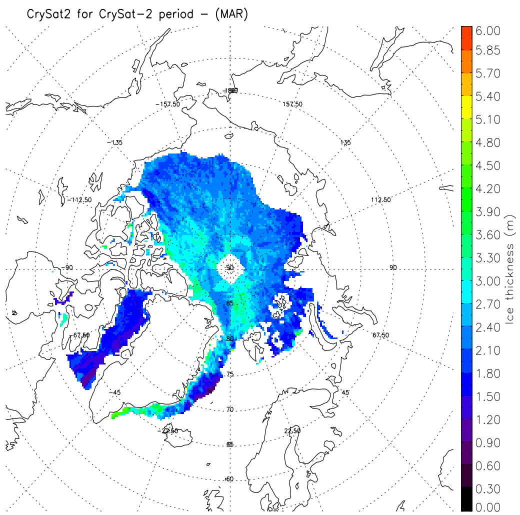
Intercomparison for CryoSat-2 Period

(01/2011 - 03/2013, March)

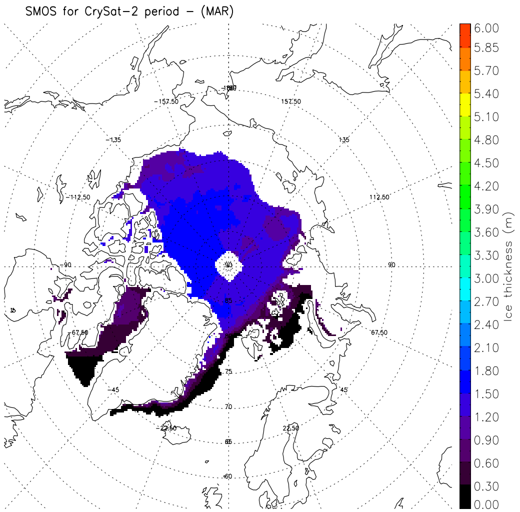
APP-x



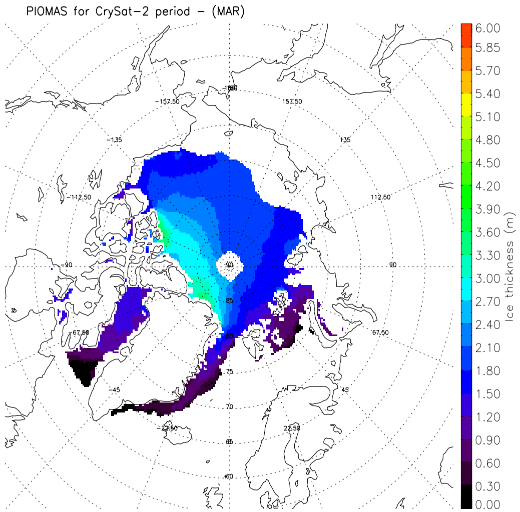
CryoSat-2



SMOS



PIOMAS



APP-x - PIOMAS: Bias=0.51 m

CryoSat-2 – PIOMAS: Bias=0.57 m

SMOS – PIOMAS: Bias=-0.43m

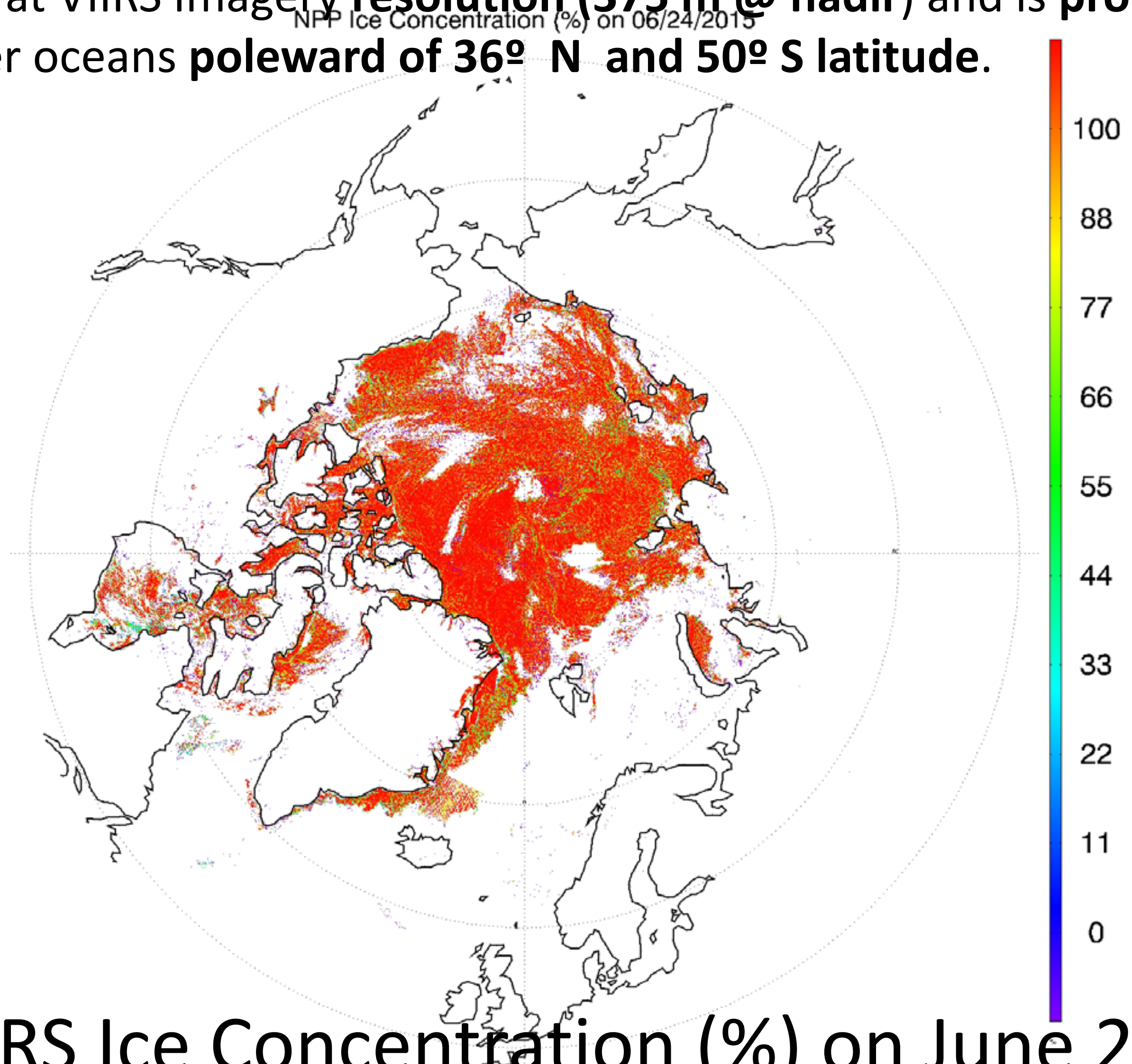
VIIRS Sea Ice Concentration IP Status

Yinghui Liu (CIMSS,UW-Madison)
Dan Baldwin (CU), Jeff Key (NOAA/NESDIS), Mark Tschudi (CU)

August 27, 2015

Sea Ice Concentration Product Description

•**Product Description:** The VIIRS Sea Ice Concentration IP consists of retrieved ice concentration at VIIRS Imagery **resolution (375 m @ nadir**) and is **produced both day and night**, over oceans **poleward of 36º N and 50º S latitude**.



NPP VIIRS Ice Concentration (%) on June 24 2015

Sea Ice Concentration IP Algorithm Description

•**Heritage:** No Vis/IR operational heritage. AVHRR research heritage (Comiso & Massom, 1994). Microwave heritage NASA Bootstrap and Team tie point based ice concentration retrieval algorithms.

• **Inputs:** TOA reflectances (VIIRS I1 and I2 bands) and Surface Temperature IP at imagery resolution, Ice Quality Flags IP, Ice Weights IP

• **Outputs:** Ice Reflectance/Temperature IP, Ice Concentration IP

•**Algorithm Description**

Tie point based retrieval of ice concentration at VIIRS imagery resolution (375 m @nadir). Ice and water tie points are determined for the visible TOA reflectance (VIIRS I1 band), near infrared TOA reflectance (VIIRS I2 band), and Surface Temperature.

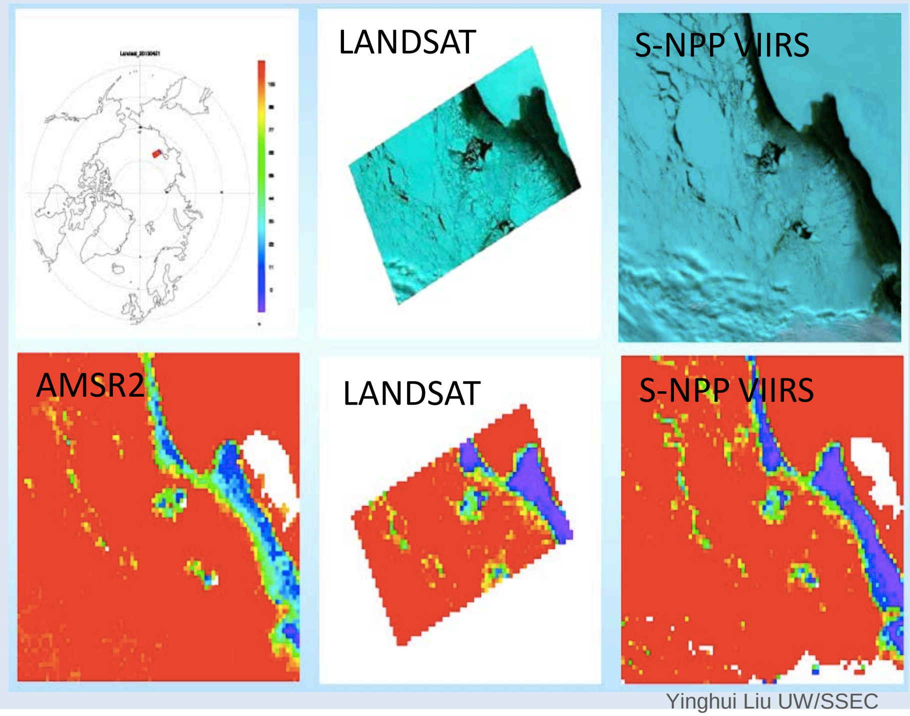
- Tie points are established from the local distribution of reflectance and temperature within a sliding search window centered on each VIIRS Imagery resolution pixel.
- Ice/water thresholds are derived from the local minimum of the distribution of reflectance and temperature. Derived tie points are specific to the local region contained within the search window.
- Transition to Surface Temperature IP thermal tie points only for night is controlled by quality weights. De-weighted reflective quality weights for VCM cloud shadow flagged pixels favor thermal tie point based ice fraction retrievals
- VIIRS Surface Temperature IP is determined using the VIIRS I5 (11.5 µm), M15 (10.8 µm) and M16 (12.0 µm) bands

Performance Evaluation

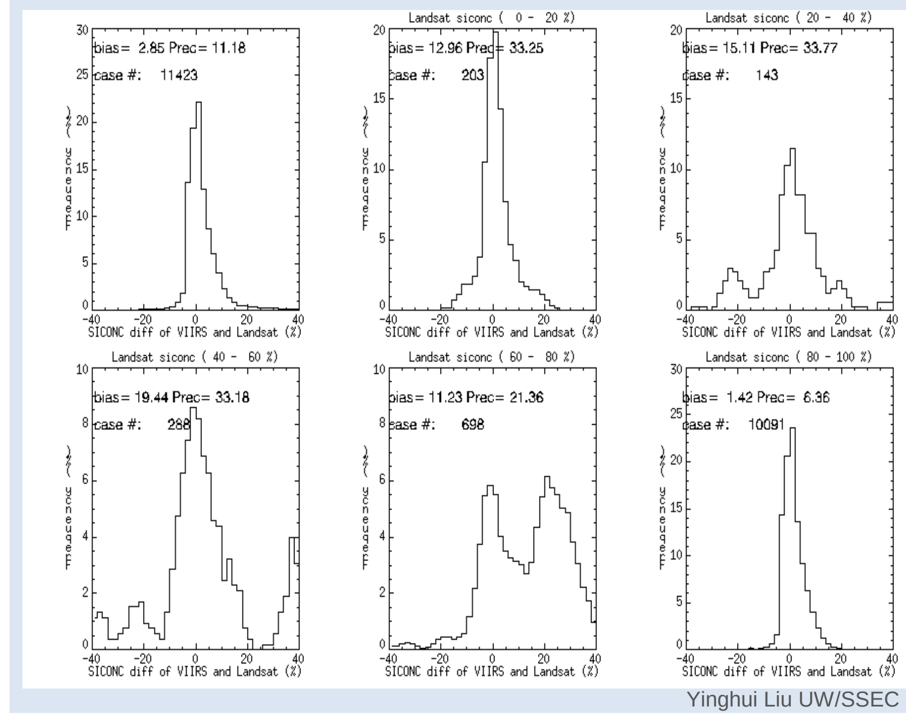
- Evaluation Approaches
  1. LANDSAT 8 derived ice concentration, quantitative comparisons to VIIRS SIC for 25 clear LANDSAT scenes(2014), for all available cases in 2013 and 2014
  2. Daily, global hemispheric VIIRS Sea Ice Concentration (SIC) and SSMIS passive microwave ice concentration visual and quantitative comparisons from 2012 to the present.
  3. Visual and quantitative comparisons with DigitalGlobe (DG) World View2 Multispectral reflectance images and derived SIC
  4. Visual comparison of NIC Weekly Ice Charts, VIIRS SDR false color reflectance imagery, MODIS Aqua MYD29 product for 30+ S-NPP/Aqua Simultaneous Nadir Overpass (SNO) scenes that span1 year and both hemispheres

(1) Comparison of VIIRS SIC to LANDSAT 8 (example)

Panel A



Panel B VIIRS vs. LANDSAT Ice Concentration

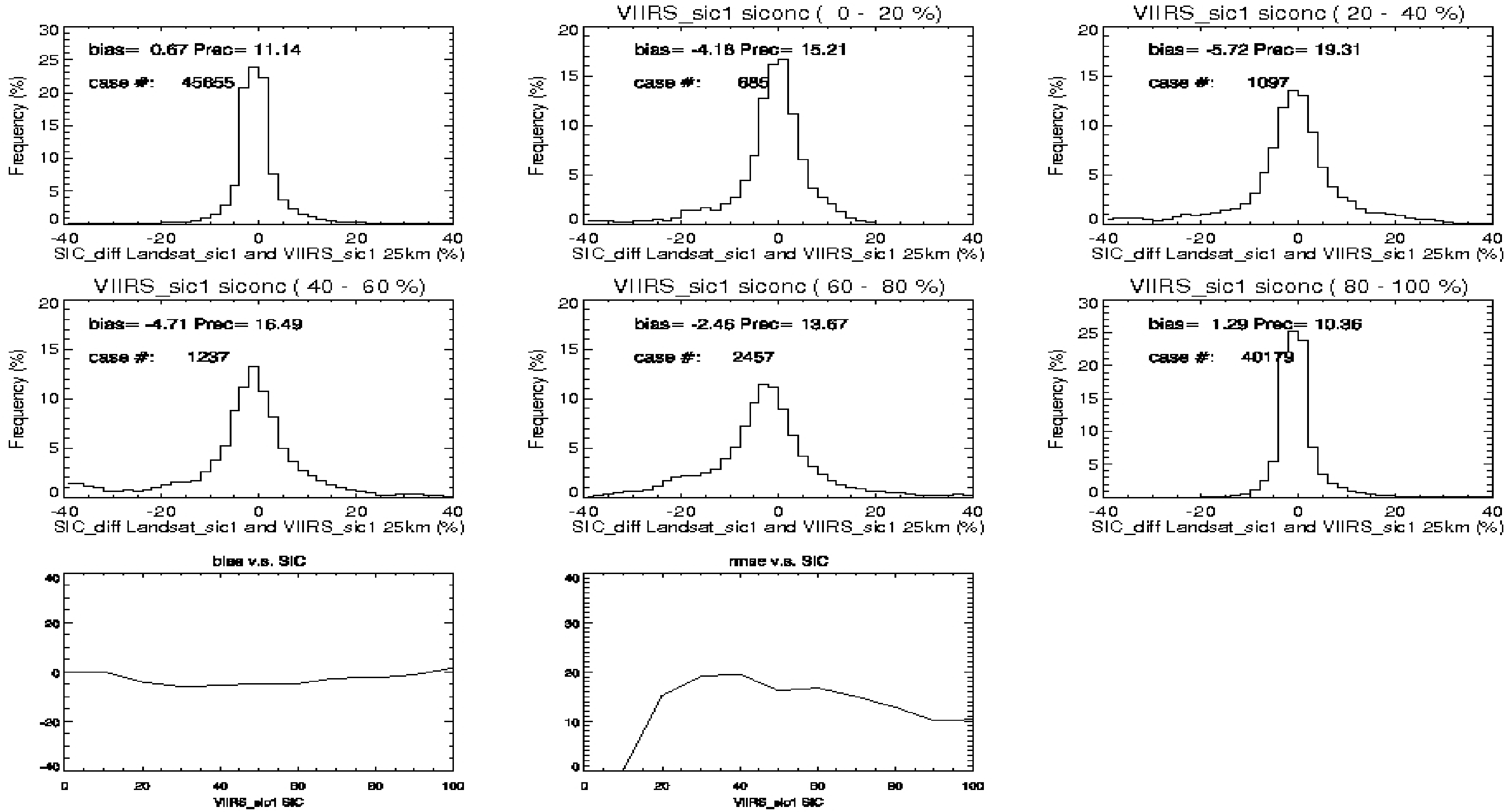


Panel A: upper image left to right: location of the scene, LANDSAT and VIIRS SDR false color image; Panel A, lower image left to right: Sea Ice Conc. from AMSR2, LANDSAT, and the Suomi NPP VIIRS on 4/21/2013 .

Ice Fraction Range	Total	0-20%	20-40%	40-60%	60-80%	80-100%
Bias	2.85	12.96	15.11	19.44	11.23	1.42
Precision	11.18	33.25	33.77	33.18	21.36	6.36

Panel B: Ice concentration differences between VIIRS and LANDSAT for all cases (top left) and cases with LANDSAT sea ice concentration in the ranges 0–20%, 20–40%, 40–60%, 60–80%, and 80–100%. Measurement accuracy (bias) and measurement precision (Prec) are indicated for each bin.

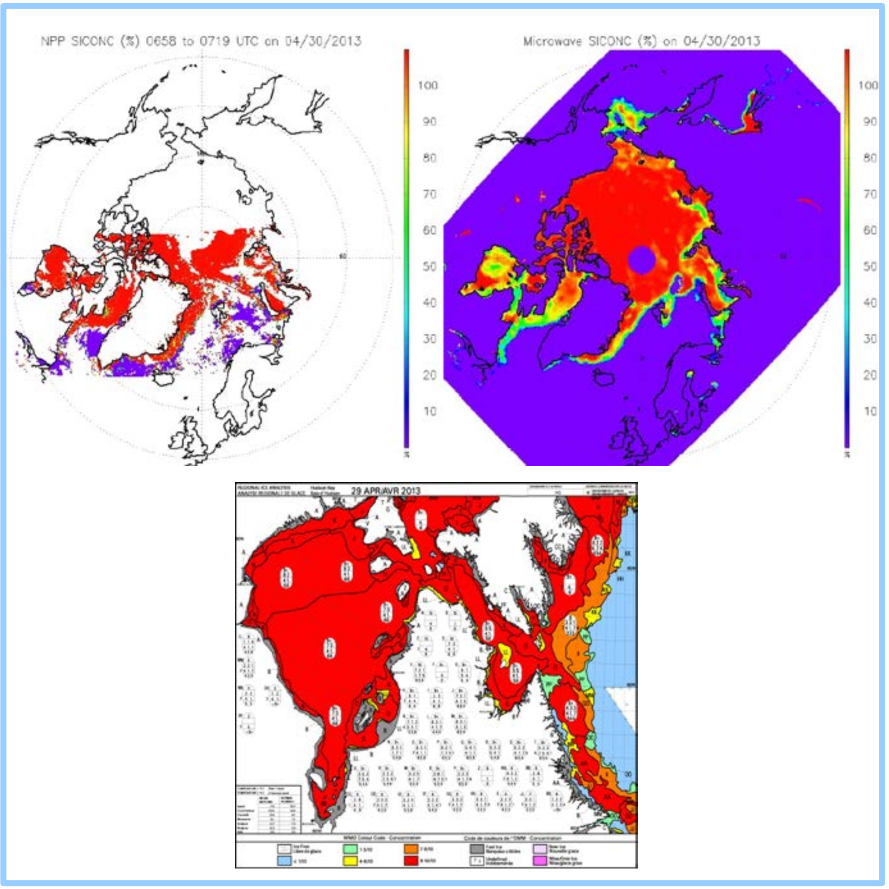
(1) Comparison of VIIRS SIC to LANDSAT (all cases from 2013 and 2014)



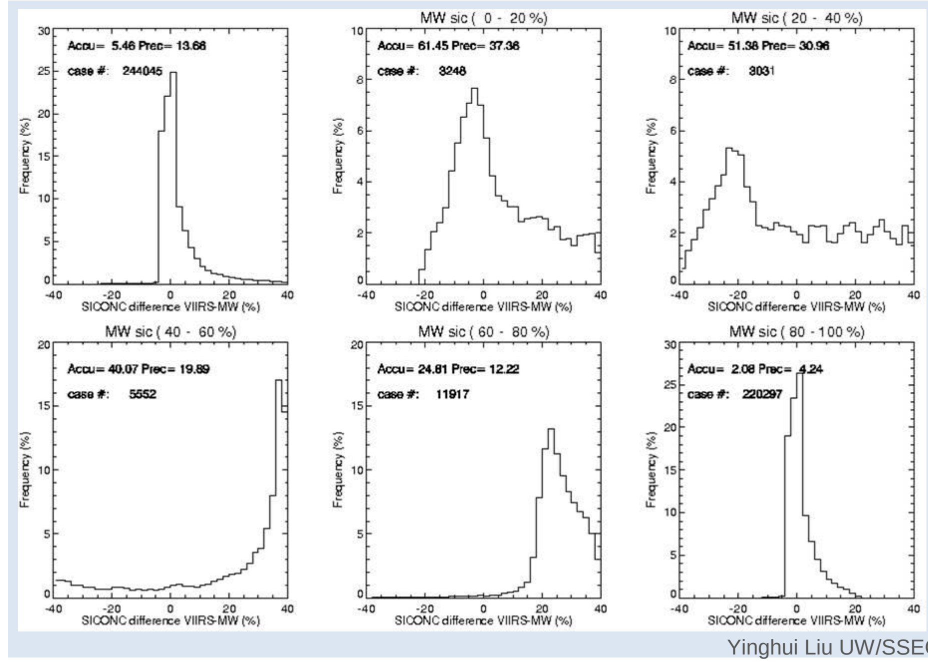
Ice Fraction Range	Total	0-20%	20-40%	40-60%	60-80%	80-100%
Bias	0.67	-4.18	-5.72	-4.71	-2.46	1.29
Precision	11.14	15.21	19.31	16.49	13.67	10.36

(2) Comparison of VIIRS SIC to Passive Microwave and Ice Chart (example)

Panel A



Panel B

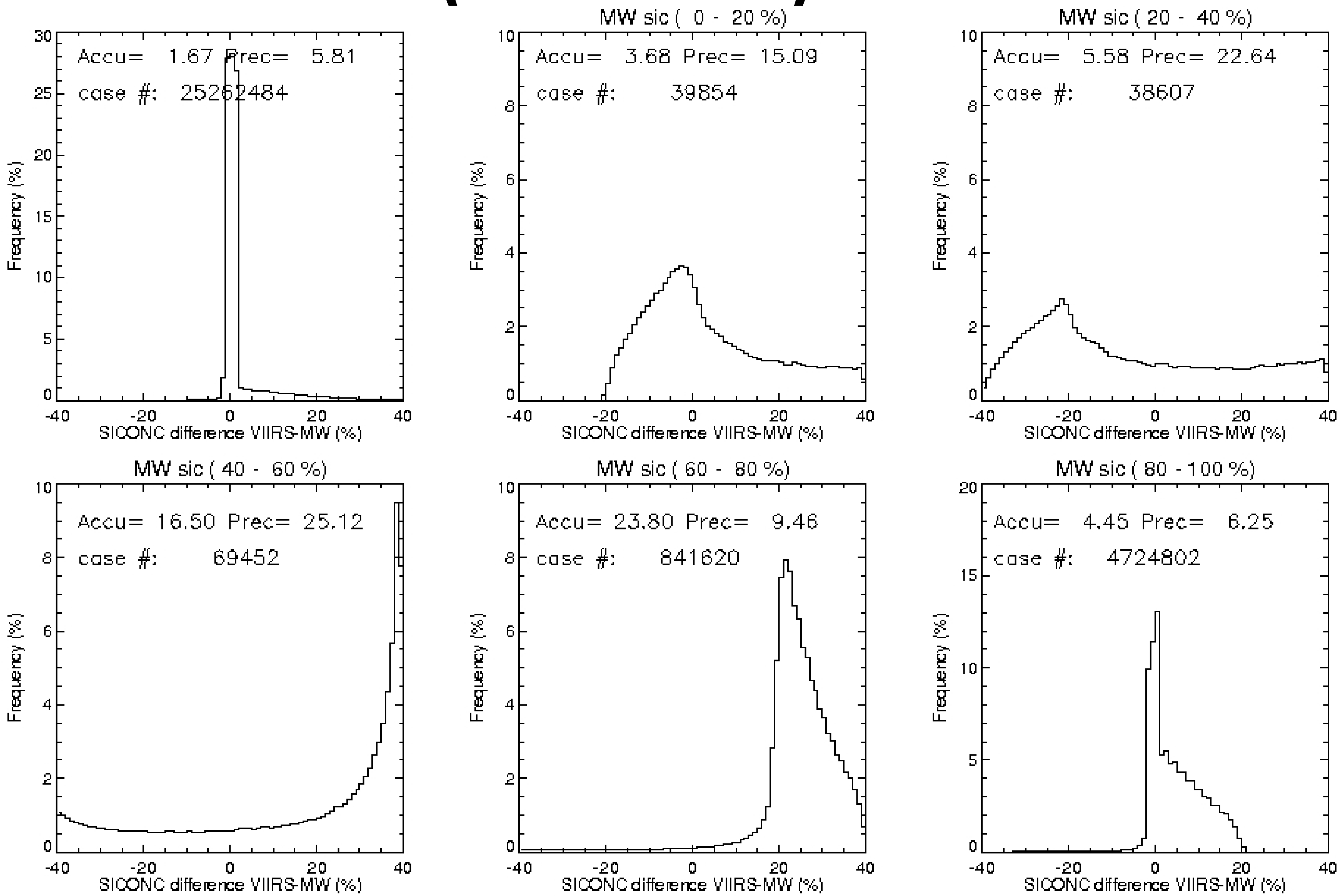


Ice Fraction Range	Total	0-20%	20-40%	40-60%	60-80%	80-100%
Accuracy	5.46	61.45	51.38	40.07	24.81	2.08
Precision	13.66	37.36	30.96	19.89	12.22	4.24

Panel A: Ice Concentration from S-NPP VIIRS Sea Ice Concentration IP (top left), SSMIS using NASA team algorithm (top right) on April 30, 2013, and from the weekly ice chart on April 29th 2013 from the Canadian Ice Service (bottom right).

Panel B: Accuracy and precision and ice concentration difference histograms for total, 0-20%, 20-40%, 40-50%, 0-80% and 80-100% ice fraction range.

(2) Comparison of VIIRS SIC to Passive Microwave (2012-2015)



Ice Fraction Range	Total	0-20%	20-40%	40-60%	60-80%	80-100%
Accuracy	1.67	3.68	5.58	16.50	23.80	4.45
Precision	5.81	15.09	22.64	25.12	9.46	6.25

(3) Comparison of VIIRS SIC to DigitalGlobe (DG) derived SIC in melting season

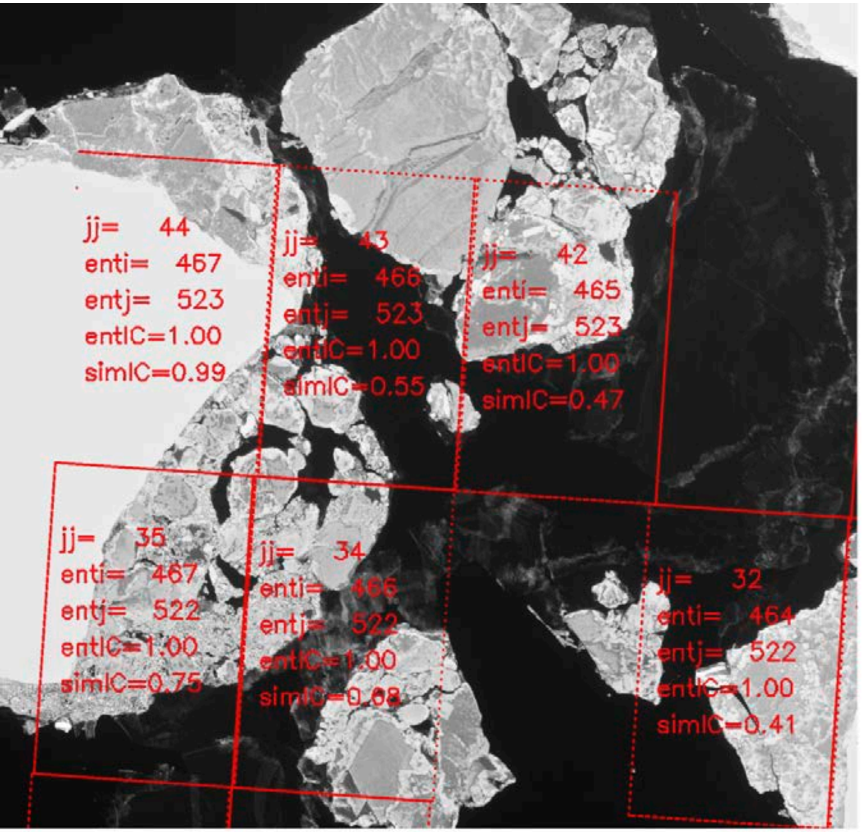


Figure 1 Example pixels of Enterprise IC vs Dig Glb Simulated IC
May 10, 2014 VIIRS Time: 18:29 UT Dig Glb Time: 18:15 UT
21 Enterprise FOVs with valid Ice Concs
Bias= -0.29 Stddev= 0.20 RMS= 0.35
Digital Globe WV2 Multispectral Band 1 Spatial Resolution ~ 2m
Red boxes are VIIRS Moderate band FOVs Spatial resolution ~800m
Values in boxes are: Box number, FOV column, FOV row, Enterprise Ice Conc, Simulated Ice Conc

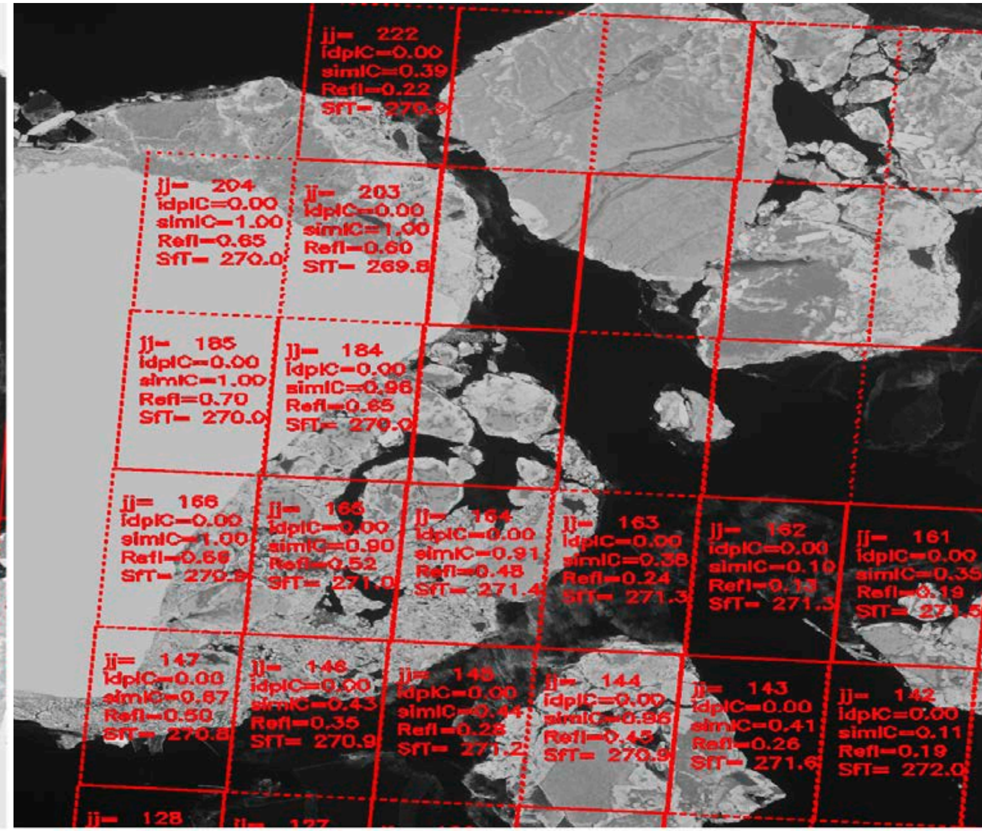
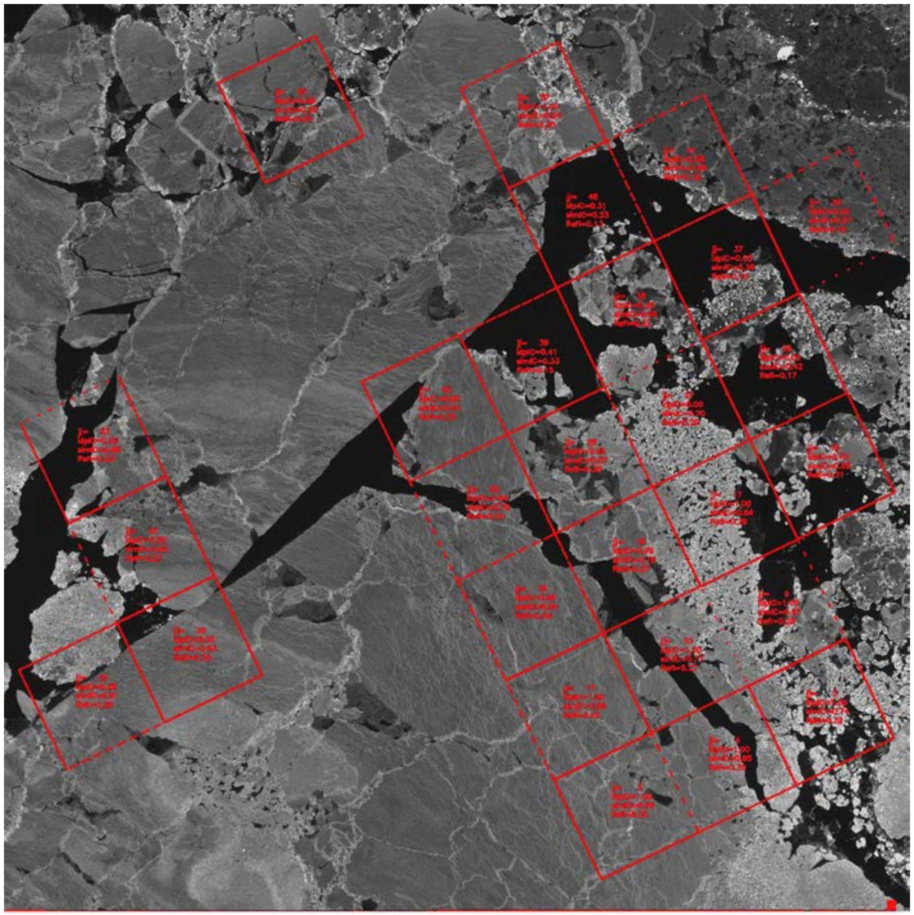


Figure 2 Example pixels of IDPS IC vs Dig Glb Simulated IC
May 10, 2014 VIIRS Time: 18:29 UT Dig Glb Time: 18:15 UT
71 IDPS FOVs with valid Ice Concs
Bias= 0.362 Stddev= 0.317 RMS= 0.48
Digital Globe WV2 Multispectral Band 1 Spatial Resolution ~ 2m
Red boxes are VIIRS Image band FOVs Spatial resolution ~400m
Values in boxes are: Box number, IDPS Ice Conc, Simulated Ice Conc, VIIRS I1 Band Reflectance and VIIRS Surface Temperature

Enterprise

IDPS

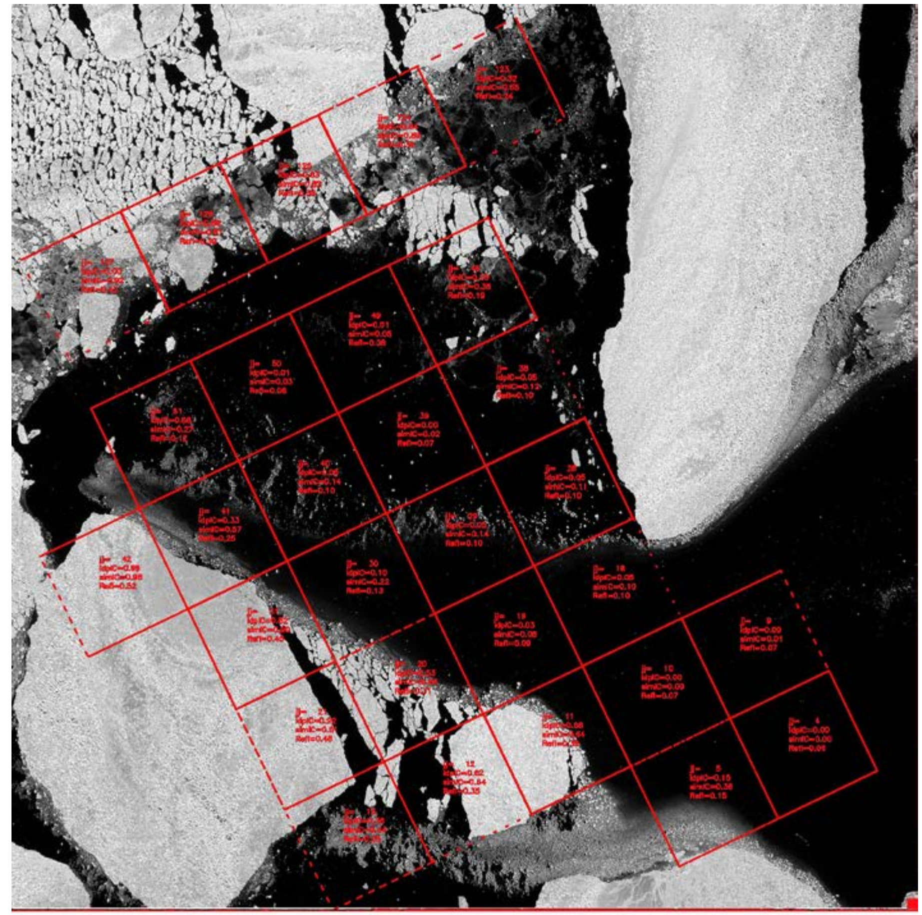
(3) Comparison of VIIRS SIC to DigitalGlobe (DG) derived SIC in non-melting season



March 21, 2014
VIIRS Time: 22:24 UT
Dig Glb Time: 22:25 UT
Row 2 Column 2

Statistics From this example:
27 VIIRS FOVs with valid Ice Concs
Bias= 0.151 Stddev= 0.393 RMS= 0.41

Digital Globe WV2 Multispectral Band 1 Spatial Resolution ~ 2m
Red boxes are VIIRS Image band FOVs Spatial resolution ~400m
Values in boxes are: Box number
VIIRS Ice Conc, Simulated Ice Conc,VIIRS I1 Band Reflectance



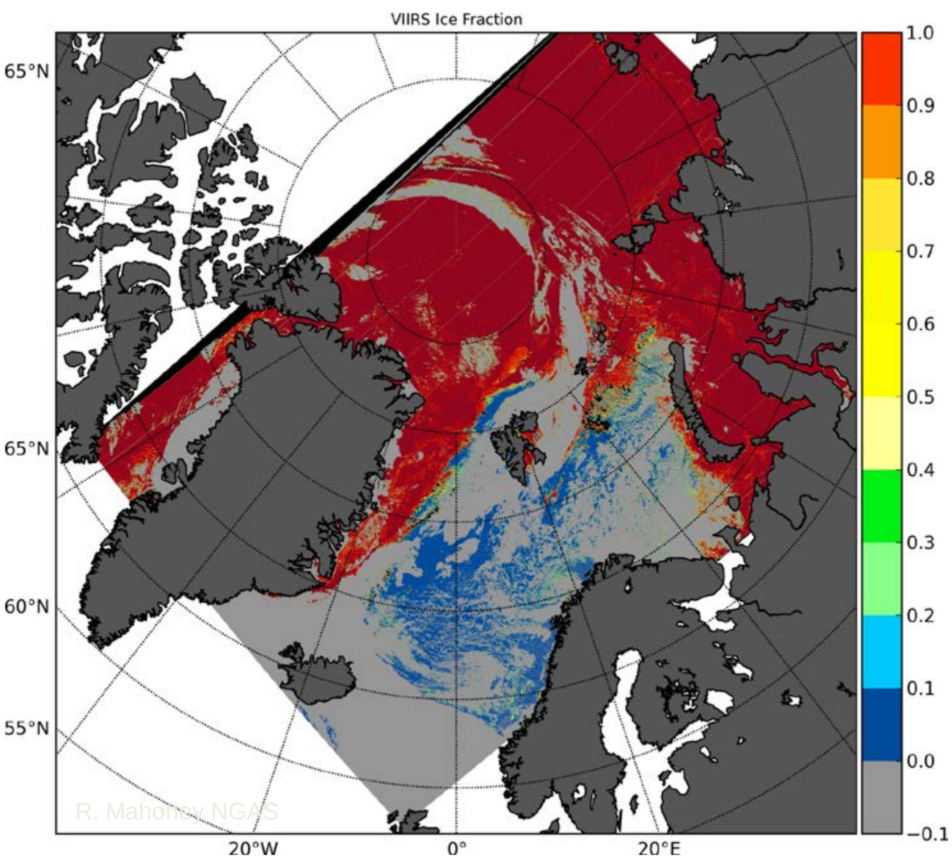
March 21, 2014
VIIRS Time: 22:24 UT
Dig Glb Time: 22:25 UT
Row 8 Column 2

Statistics From this example:
29 VIIRS FOVs with valid Ice Concs
Bias= 0.117 Stddev= 0.181 RMS= 0.21

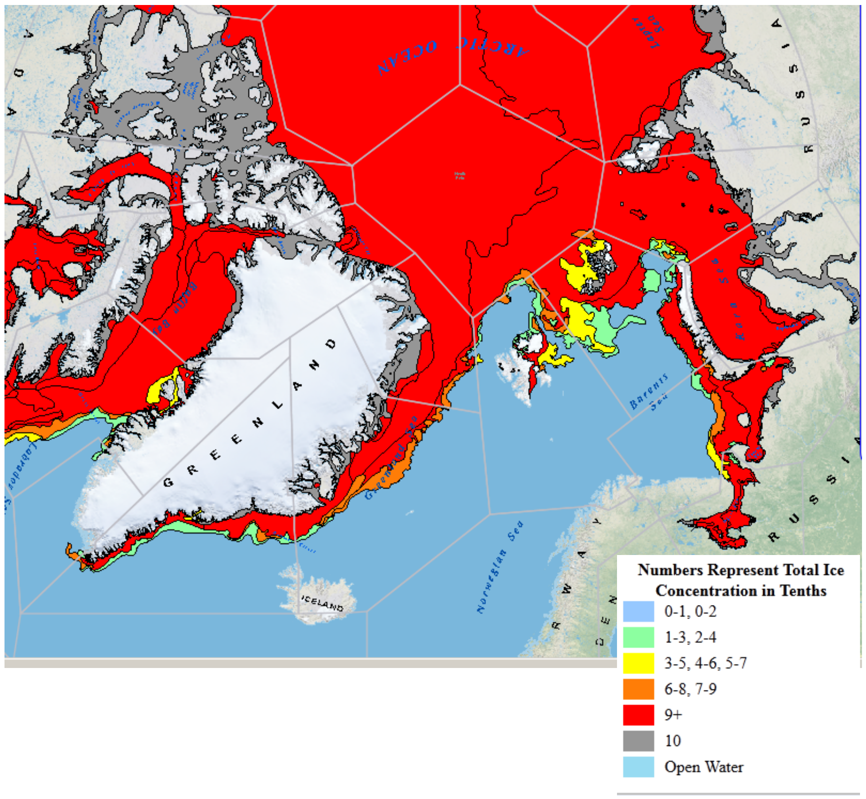
Digital Globe WV2 Multispectral Band 1 Spatial Resolution ~ 2m
Red boxes are VIIRS Image band FOVs Spatial resolution ~400m
Values in boxes are: Box number
VIIRS Ice Conc, Simulated Ice Conc,VIIRS I1 Band Reflectance

(4) Comparison of VIIRS SIC to National Ice Center Ice Charts (night scene example)

VIIRS Ice Concentration IP Feb. 20, 2014 (04:39-04:46 UTC)

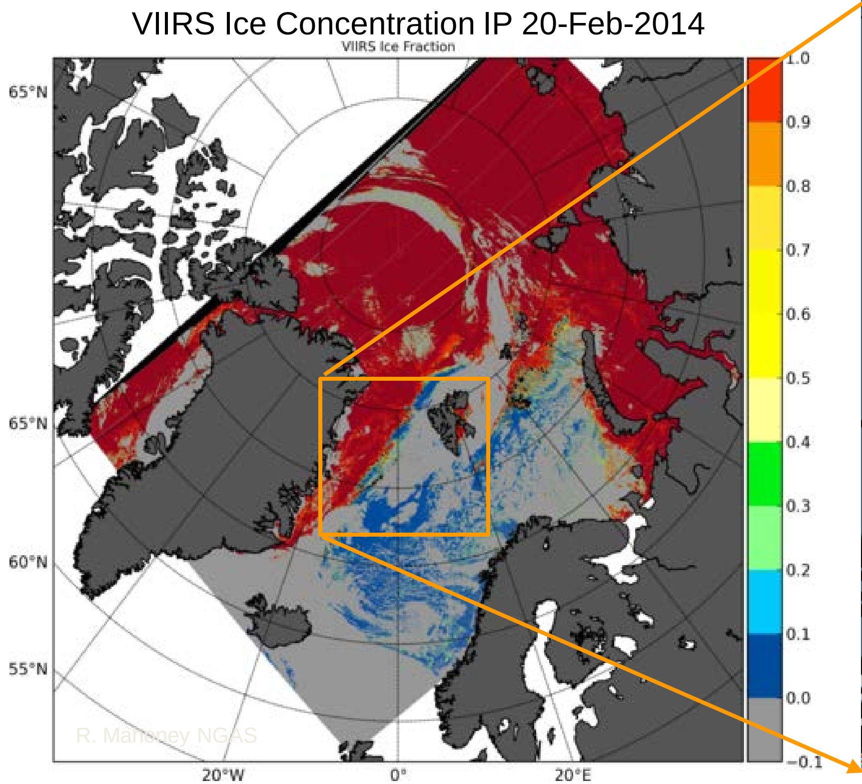


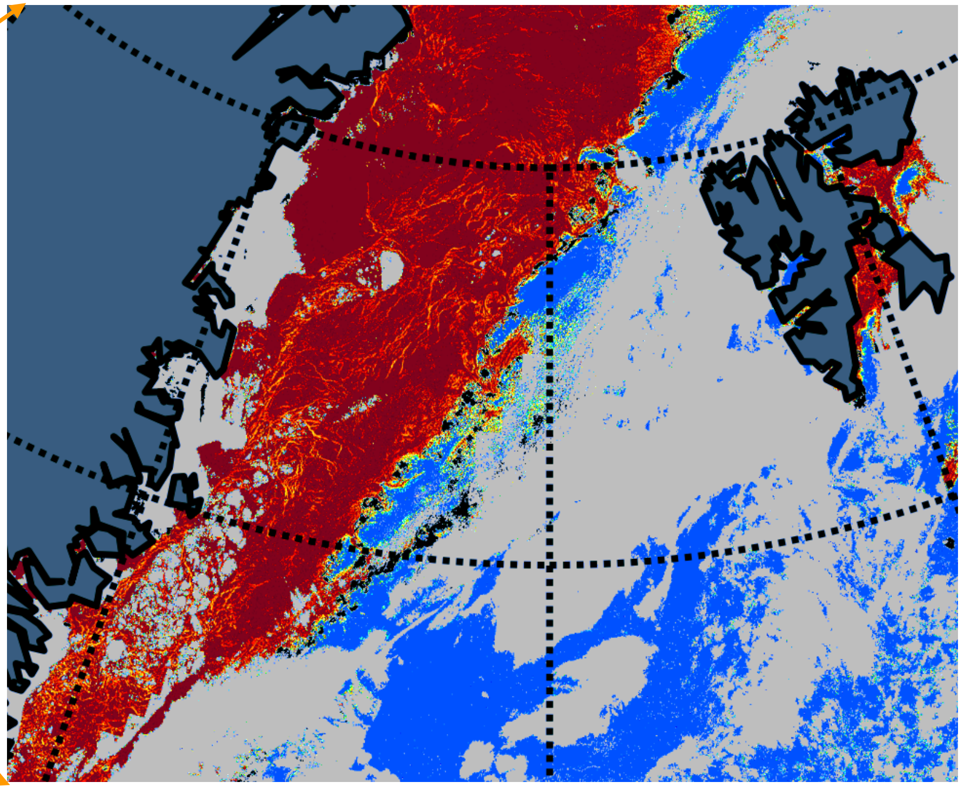
Reference: http://www.natice.noaa.gov/ps/javascriptproductviewer/index.html



VIIRS Ice Concentration IP for Feb. 20, 2014 night scene is consistent with that of the corresponding National Ice Center weekly ice chart for Feb. 20, 2014 and the ice extent matches extremely well

VIIRS SIC Shows Detailed Structure of Ice Edges and Leads

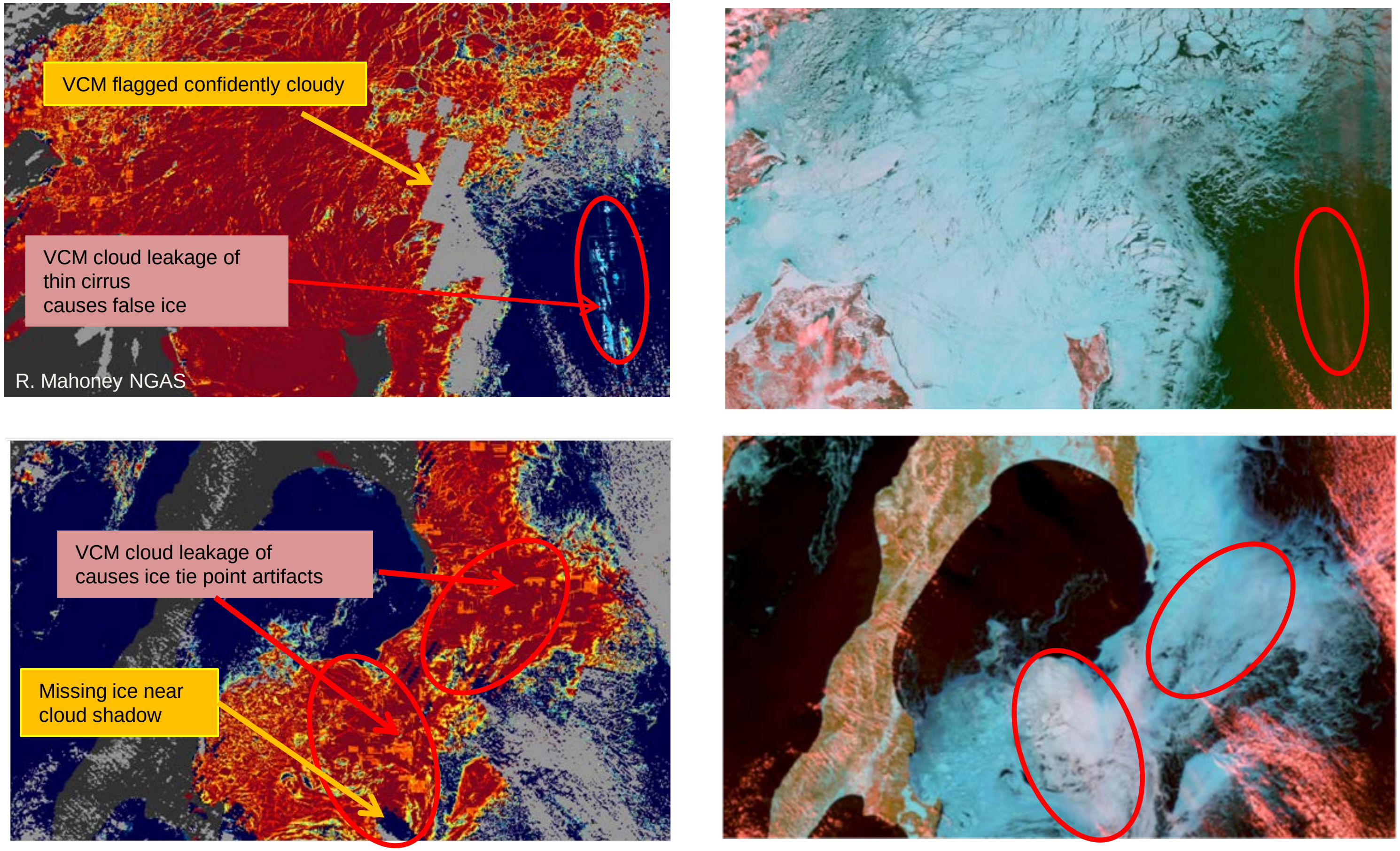




Zoom of boxed region. Note that the zoom is not at full resolution (zoom of sub-sampled, mapped image)

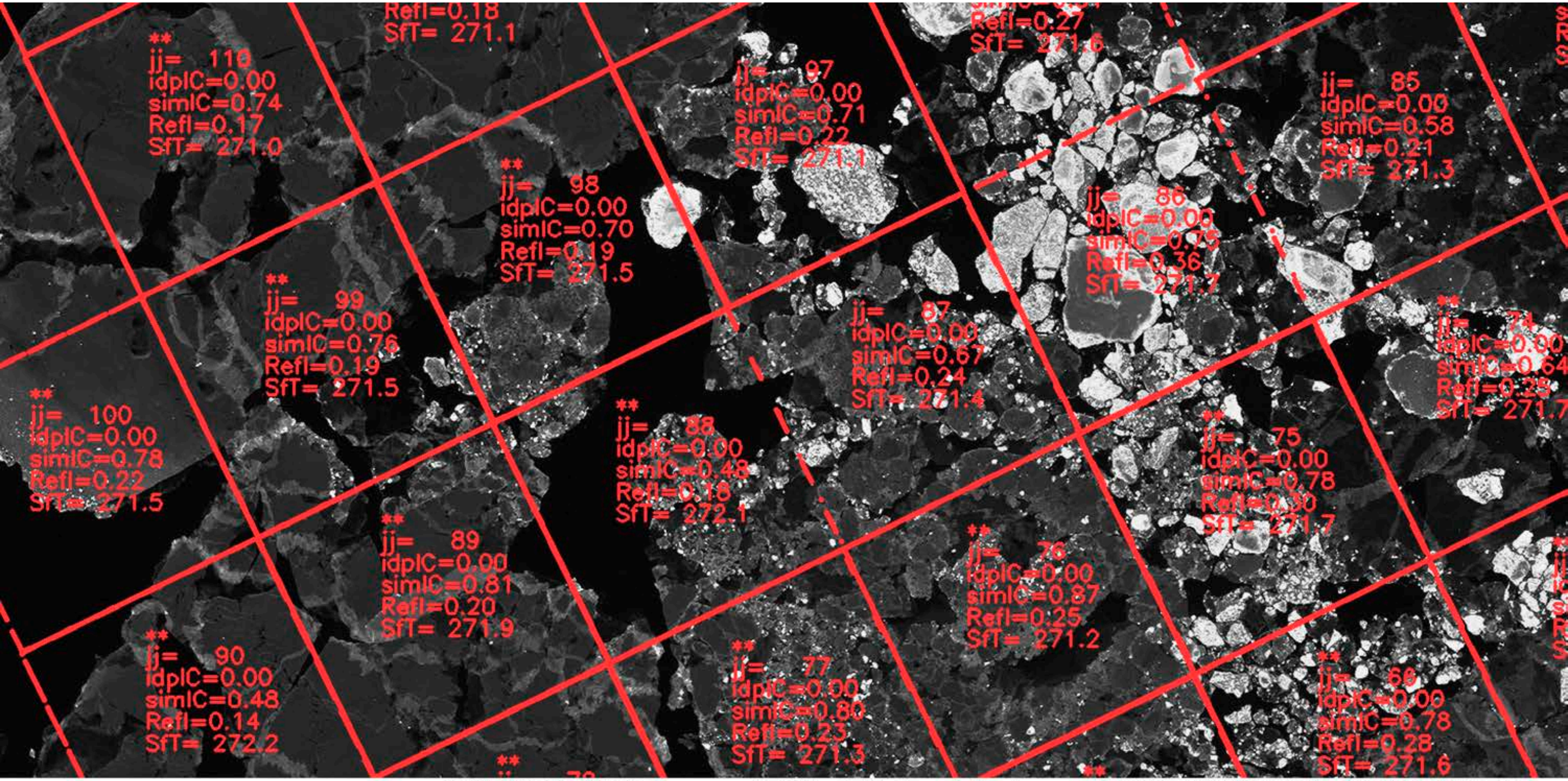
Detailed structure of the ice edge and leads can be seen in the Ice Concentration IP as shown in the zoomed subset region in the right figure. The current Ice Concentration IP if produced as a product should allow users to identify ice edges more accurately.

Comparison of VIIRS SIC to Zoomed VIIRS False Color SDR for Day Scenes – Issues



(1) Rectangular fill values are associated with VCM positive M7 and M1 threshold test triggered by out of date manually updated GMASI snow/ice (top left). (2) False ice is seen in the product (top left) corresponding undetected thin cirrus (red circle, top right). (3) Rectangular and linear artifacts seen within the circled regions in the VIIRS Ice Concentration IP (bottom left) are thought to be associated with ice tie point window fall back to default values. This often occurs over regions with ill defined ice tie point histogram peaks such as regions with undetected clouds as shown within the red circled regions in the false color SDR reflectance image (lower right). A possible fix is to fall back to a running mean ice tie point in instead of a global default.

Comparison of VIIRS SIC to DigitalGlobe (DG) derived SIC in non-melting season – Issues



Section of Dig Glb tile R1C2
IDPS IC vs Dig Glb Simulated IC
March 21, 2014 VIIRS Time: 22:24 UT Dig Glb Time: 22:25UT
Bering Sea off of SE coast of Alaska (lat= 58.7 N, lon= -161.9)

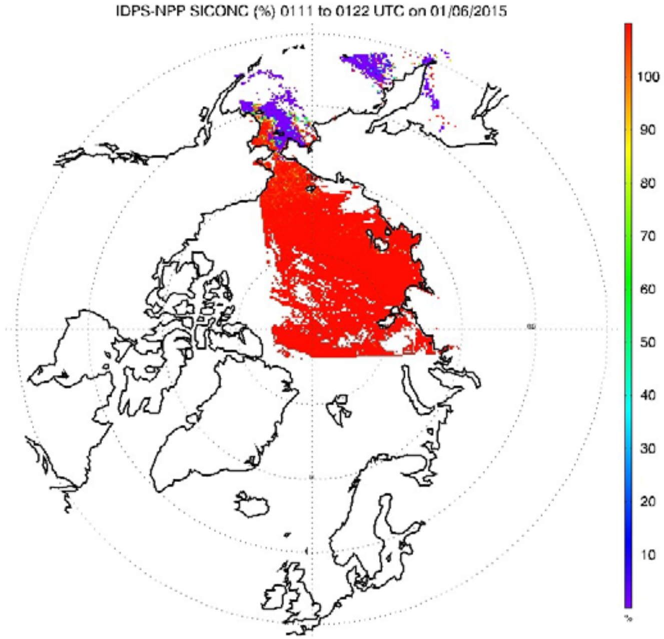
31 IDPS FOVs with valid Ice Concs
Bias= 0.69 Stddev= 0.18 RMS= 0.72
FOVs with ** were used in comparison
FOVs with no ** are cloud shadowed and not used in comparison statistics

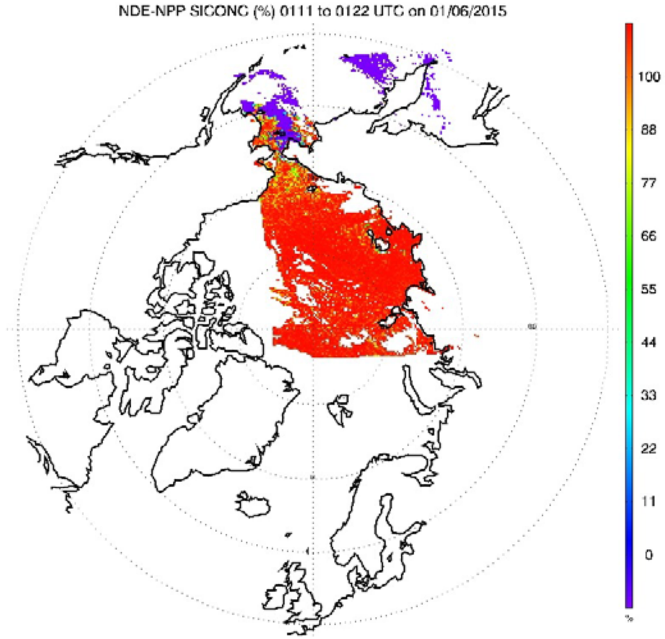
For this tile, 26 of the 31 non shadowed VIIRS FOVs had an IDPS IC=0.0 with the simulated IC > 0.4
All 26 of these FOVs had indeterminate reflective Ice Tie Points

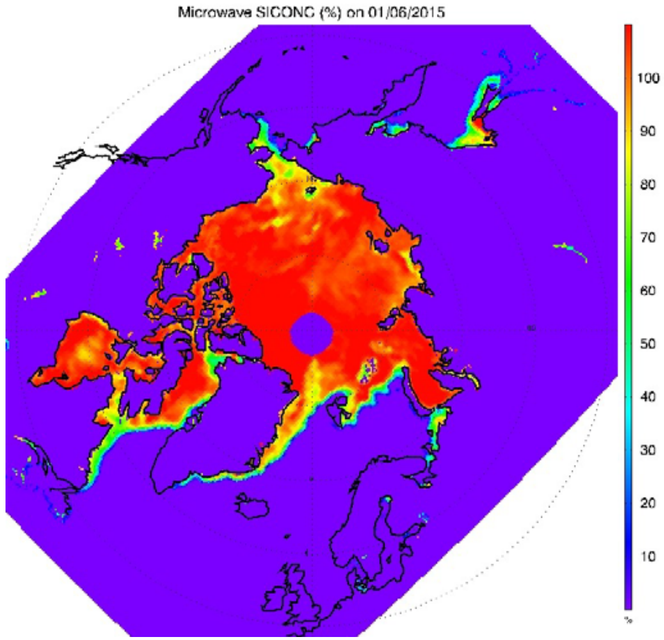
Digital Globe WV2 Multispectral Band 1 Spatial Resolution ~ 2m
Red boxes are VIIRS Image band FOVs Spatial resolution ~400m
Values in boxes are: Box number, IDPS Ice Conc, Simulated Ice Conc, VIIRS I1 Band Reflectance and VIIRS Surface Temperature

Enterprise SIC

IDPS, Enterprise SIC with MW SIC on January 6, 2015







VIIRS SICs to DG derived SIC in melting season

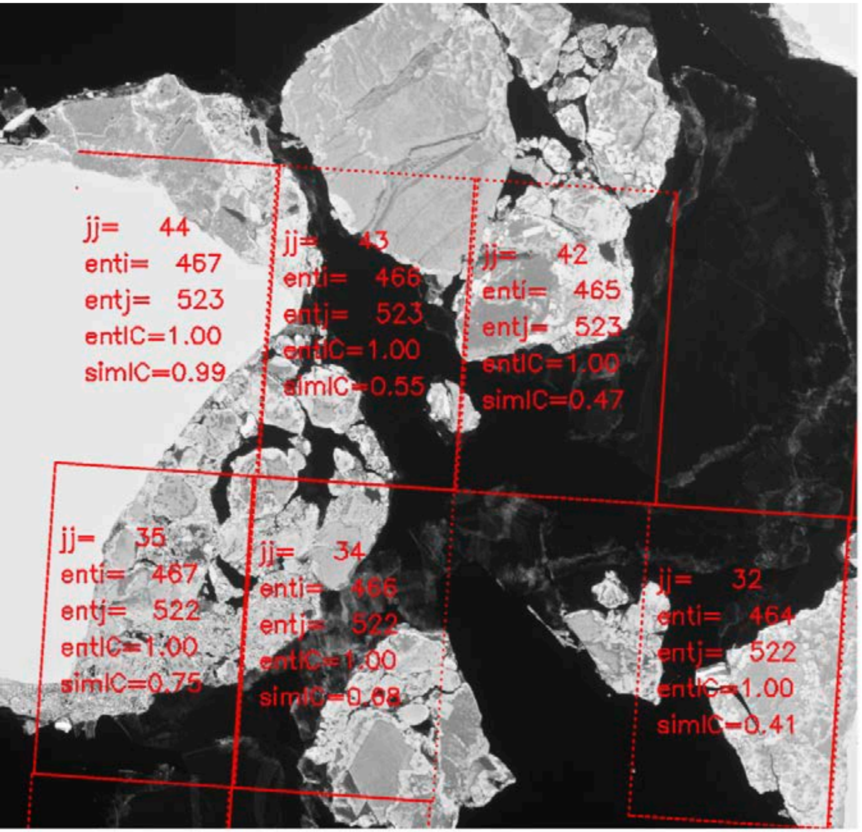


Figure 1 Example pixels of Enterprise IC vs Dig Glb Simulated IC
May 10, 2014 VIIRS Time: 18:29 UT Dig Glb Time: 18:15 UT
21 Enterprise FOVs with valid Ice Concs
Bias= -0.29 Stddev= 0.20 RMS= 0.35
Digital Globe WV2 Multispectral Band 1 Spatial Resolution ~ 2m
Red boxes are VIIRS Moderate band FOVs Spatial resolution ~800m
Values in boxes are: Box number, FOV column, FOV row, Enterprise Ice Conc, Simulated Ice Conc

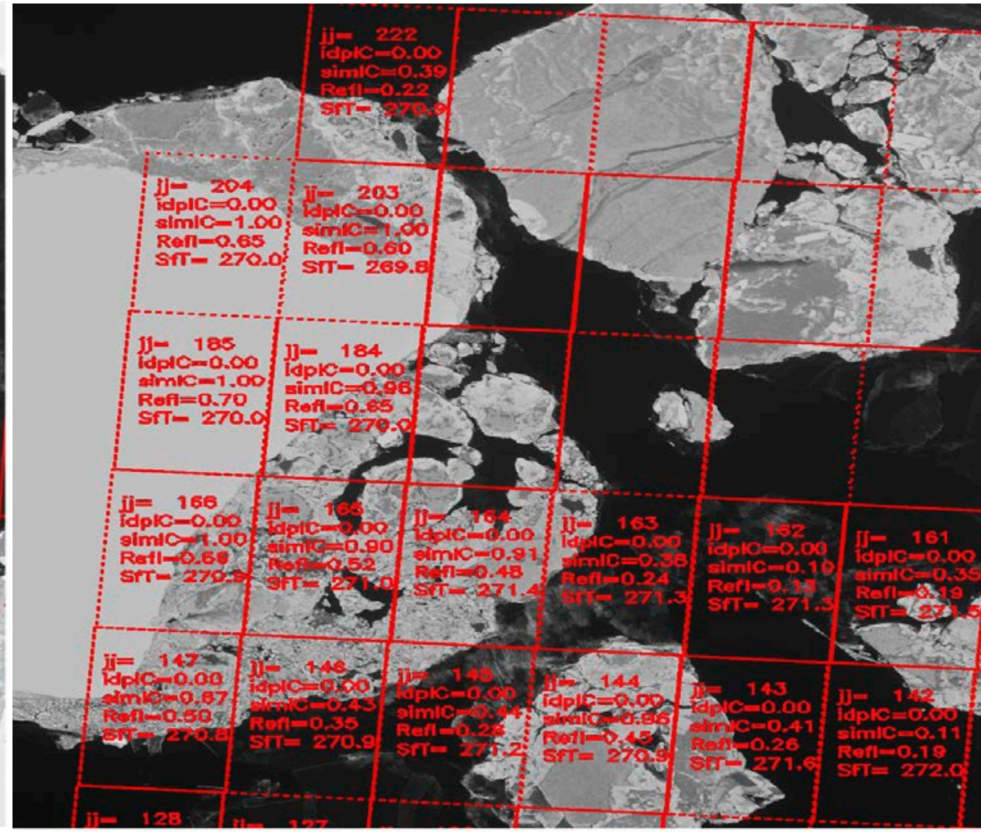


Figure 2 Example pixels of IDPS IC vs Dig Glb Simulated IC
May 10, 2014 VIIRS Time: 18:29 UT Dig Glb Time: 18:15 UT
71 IDPS FOVs with valid Ice Concs
Bias= 0.362 Stddev= 0.317 RMS= 0.48
Digital Globe WV2 Multispectral Band 1 Spatial Resolution ~ 2m
Red boxes are VIIRS Image band FOVs Spatial resolution ~400m
Values in boxes are: Box number, IDPS Ice Conc, Simulated Ice Conc, VIIRS I1 Band Reflectance and VIIRS Surface Temperature

Enterprise

IDPS

SIC EDR requirement

1. Clear	1.0 km	0.5 km
2. All Weather	No capability	1 km
c. Mapping Uncertainty, 3 Sigma		
1. Clear	1 km at Nadir	0.5 km
2. Cloudy	No capability	1 km
d. Measurement Range	0 - 100%	0 - 100%
e. Measurement Accuracy	10% (Notes 1, 2, 3)	5%
f. Measurement Uncertainty	25% (Notes 1, 2, 3)	10%
g. Refresh	At least 90% coverage of the globe every 24 hours (monthly average)	6 hrs.
h. Geographic coverage	All ice-covered regions of the global ocean	All ice-covered regions of the global ocean
		v3.0, 8/27/14

Notes:

1. VIIRS produces sea ice concentration in clear sky conditions only.
2. Performance Exclusion Conditions:
   a. VCM IP cloud confidence: confidently cloudy and probably cloudy.
   b. Sun glint regions

Summary

• **Detailed structure of Ice edges and ice leads are observable in the VIIRS Sea Ice Concentration IP** at VIIRS Imagery resolution for both day and night, out to edge of scan based on visual comparisons

– Ice extent compares well with VIIRS SDR False color imagery, National Ice Center Ice Charts, MODIS Aqua/MYD29 (see backup slide) reference data and full resolution zoomed VIIRS SDR reflectance imagery

• Quantitative performance based on comparison with LANDSAT ice fractions show relatively small bias and good precision for the total (0.67% and 11%) and high ice fraction range (1.29% and 10.36%), with relatively reduced performance for mid range ice fractions (5% and 20% in bias and precision) based cases from 2013 and 2014

•Quantitative performance based on comparison with ice fractions from microwave products show small bias and good precision for the total (1.67% and 5.81%) and very high high ice fraction (4.45% and 6.25), but very high positive bias and relatively low precision for mid range ice fractions (23.8% and 9.46%) using collocated cases from 2012 to 2015.

•Quantitative performance based on comparison with ice fractions from DigitalGlobe show large bias and precision in the melting season, and relatively smaller bias and good precision in the non-melting season.

• Improvement in VCM will improve the VIIRS Ice Concentration IP performance. The VIIRS Ice Concentration IP performance in the melting season needs further improvement.

Conclusions

• Observed performance of the VIIRS Ice Concentration IP is such that this product has high potential to become an extremely useful JPSS product due to its high spatial resolution in both day and night.

• Performance evaluation indicates that the VIIRS Ice Concentration IP in its current state may already be an extremely useful product for identifying ice extent for both day and night for clear sky conditions

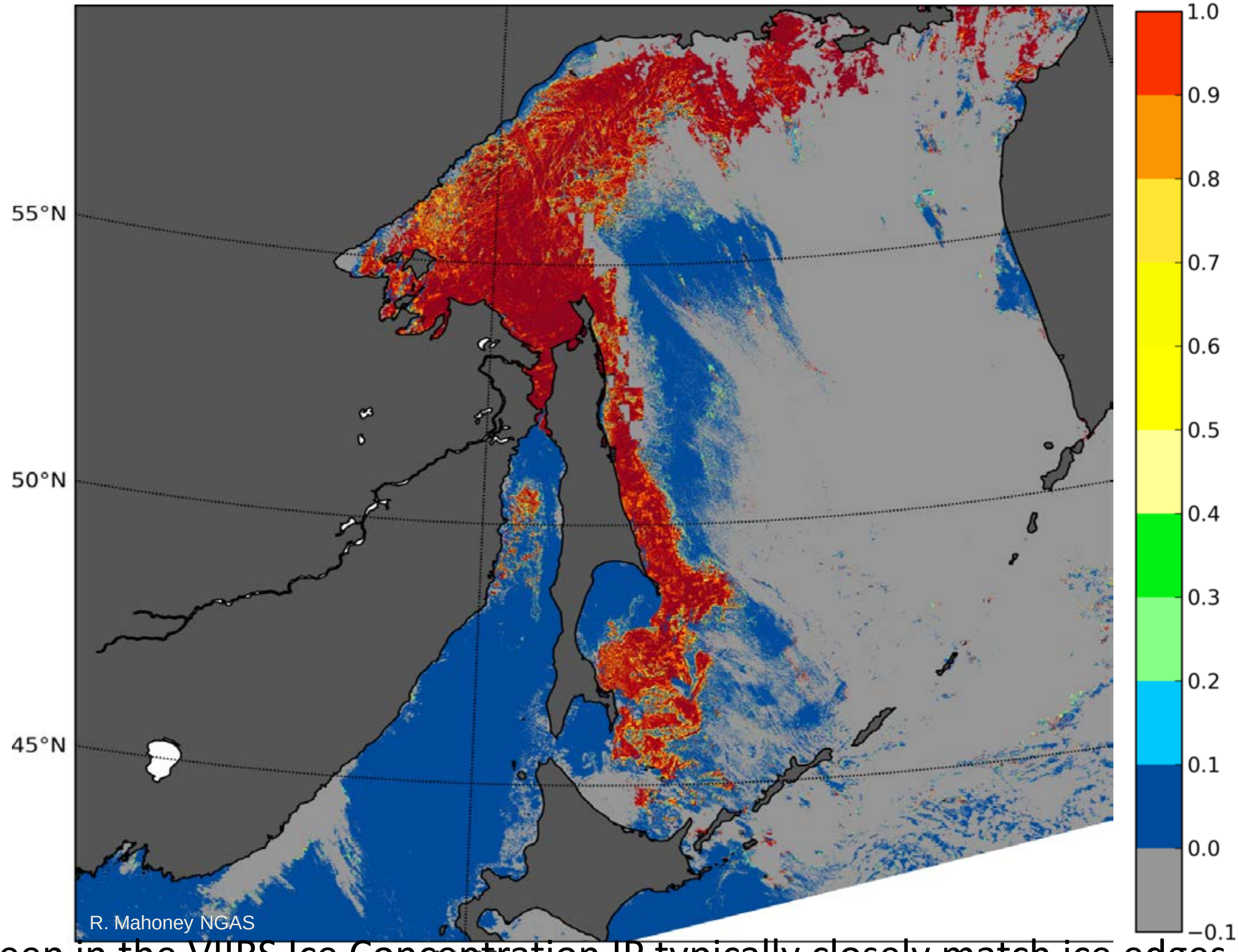
• The VIIRS Ice Concentration IP for NPP is a currently non-deliverable Retained Cal/Val IP. Promotion to a deliverable product will require minor level of effort for addition of product quality flags, implementation of extended cloud adjacency quality flagging and correction of minor defects

•The VIIRS Ice Concentration using Enterprise algorithm is expected to perform better than the IDPS product.

20

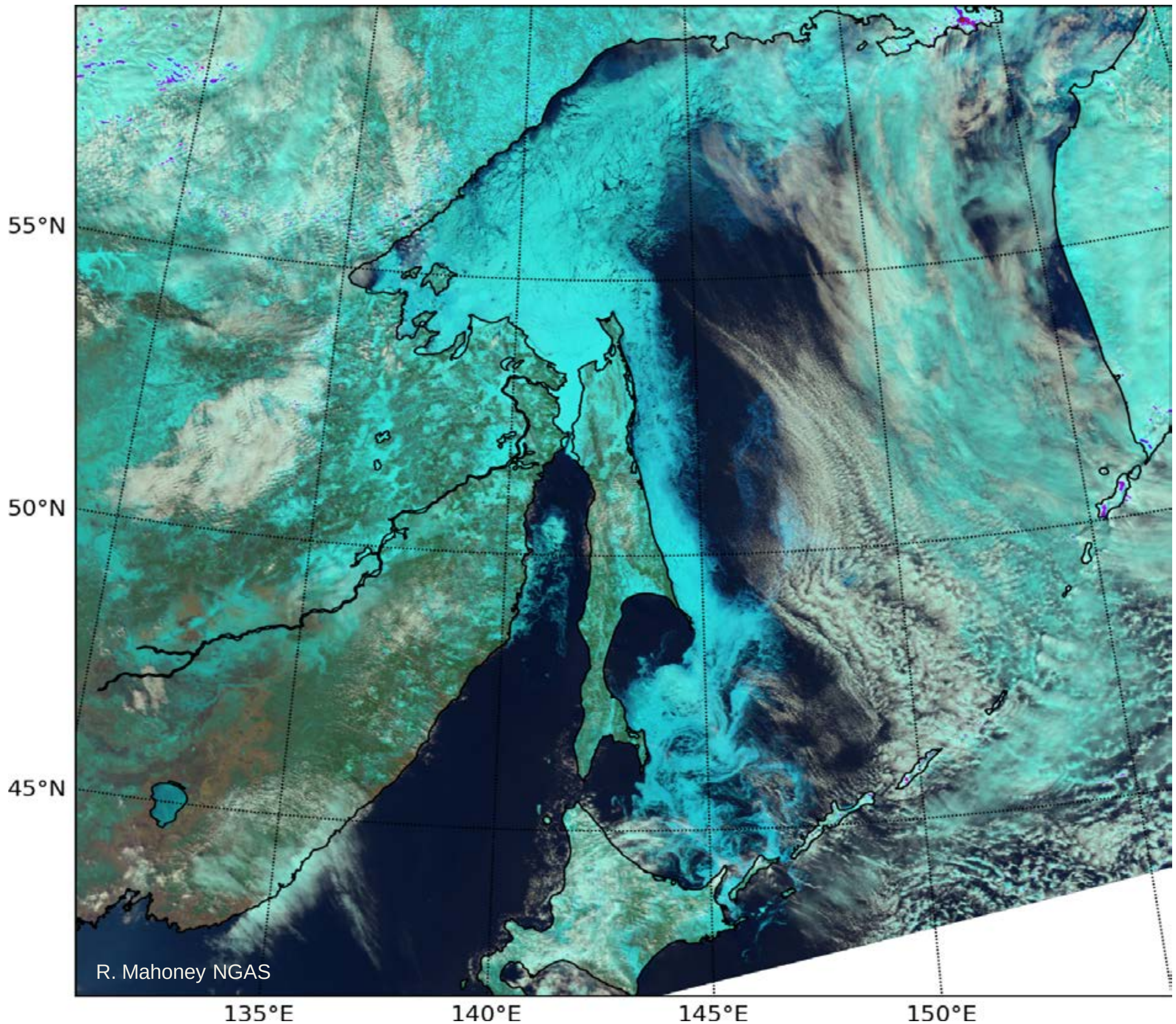
Backup slide

Comparison of VIIRS Ice Conc. to VIIRS False Color SDR for Day Scene



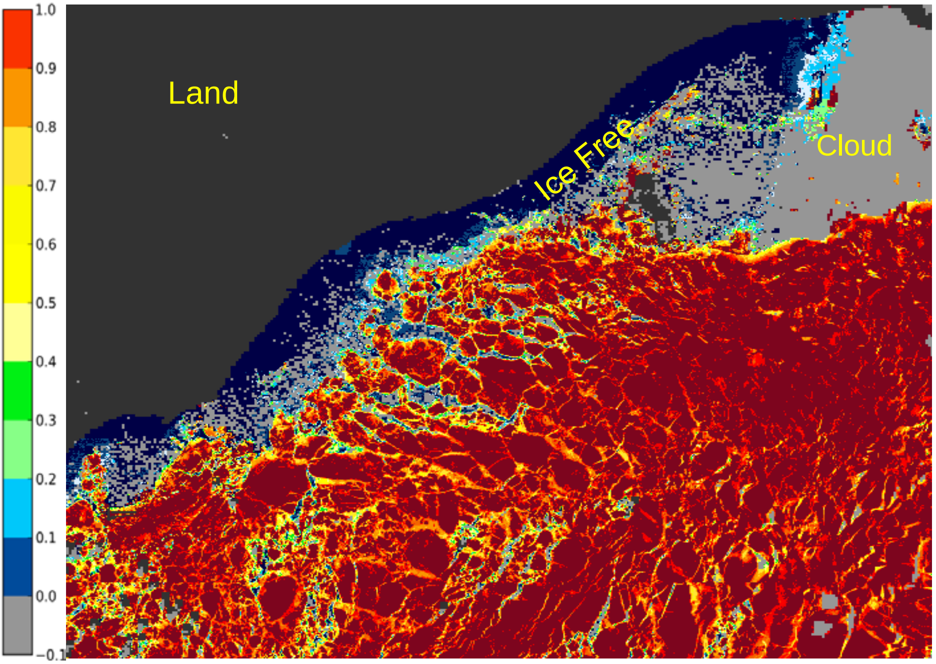
The ice edges seen in the VIIRS Ice Concentration IP typically closely match ice edges seen in false color SDR reflectance band imagery as in this day case of melting sea ice in the Sea of Okhotsk (March 23, 2014, 03:05-03:11 UTC)

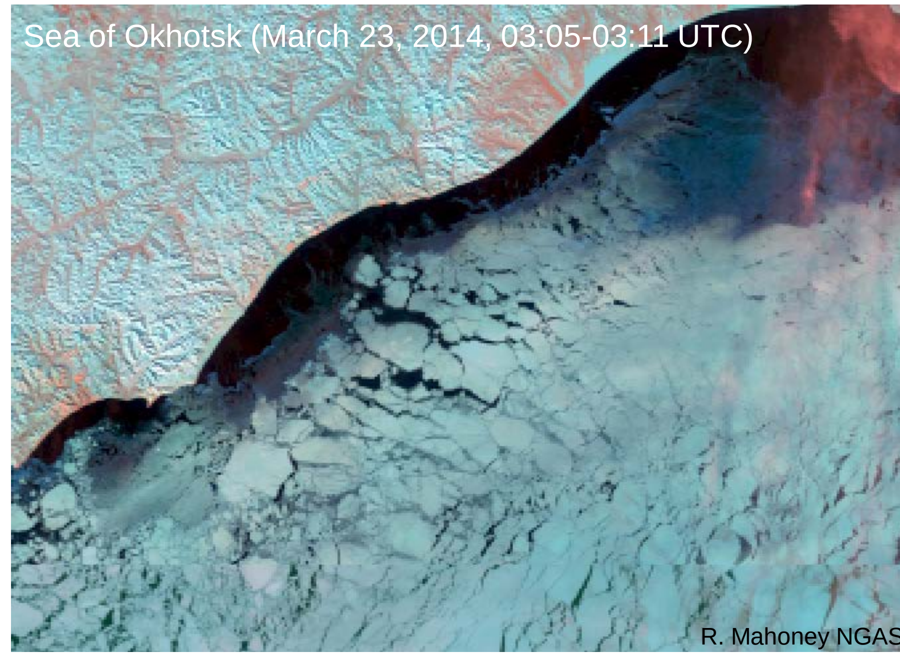
Comparison of VIIRS Ice Conc. to VIIRS False Color SDR for Day Scenes



Reference false color VIIRS SDR reflectance band imagery showing melting sea ice over the Sea of Okhostk for March 23, 2014.

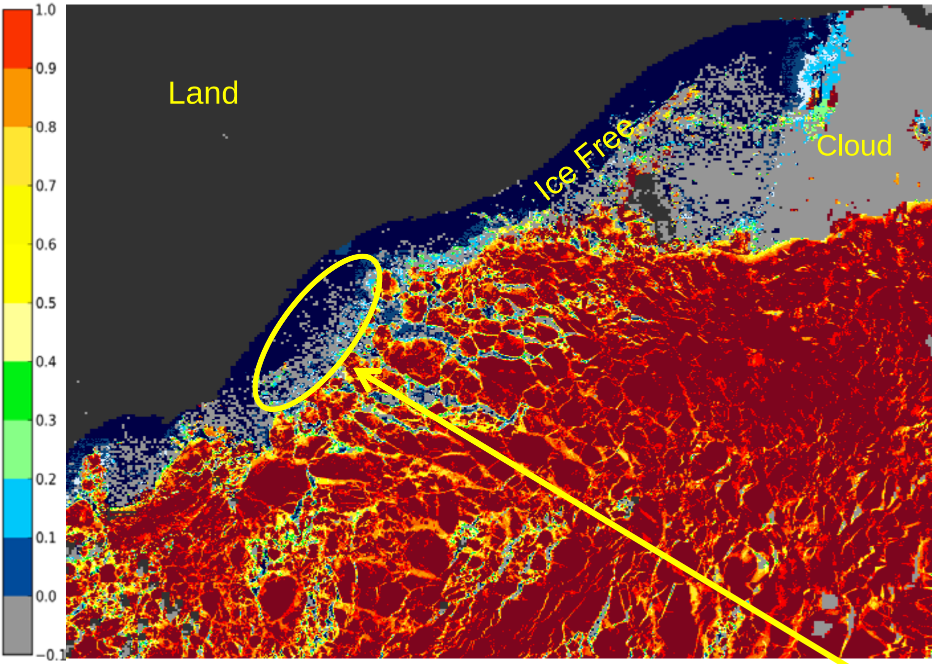
Comparison of VIIRS Ice Conc. to VIIRS False Color SDR for Day Scenes – Full Resolution Zoom

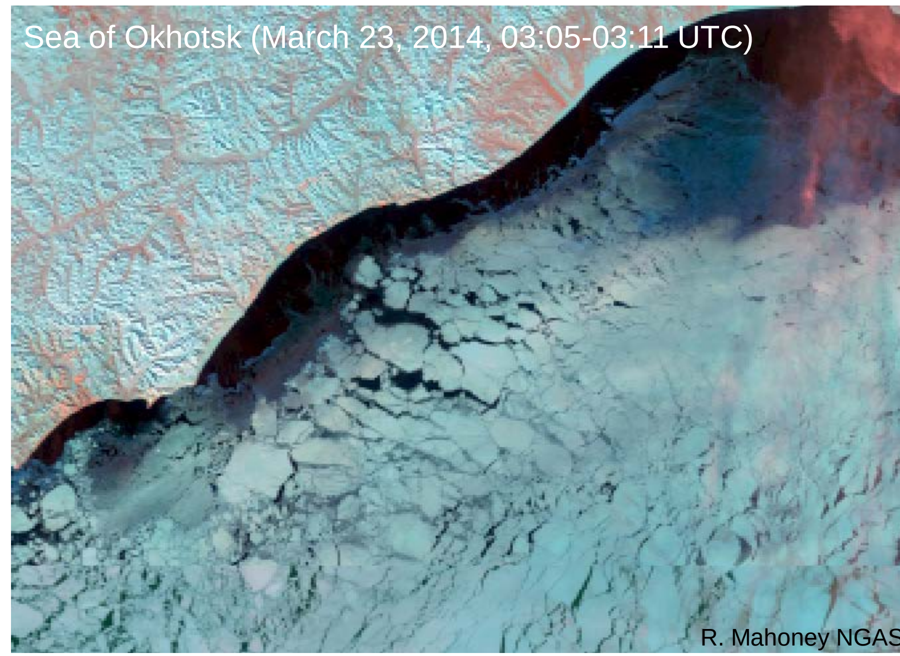




VIIRS Ice Concentration IP (left) shows fine detail of ice edge and lead features. An ice fraction threshold of 0.1 yields an ice extent that very closely matches the ice edges seen in the corresponding VIIRS SDR reflectance band imagery zoomed at full VIIRS imagery resolution (right).

Comparison of VIIRS SIC to VIIRS False Color SDR for Day Scenes – Issues





Many pixels near ice edges are flagged by VCM as confidently cloudy are clear in the corresponding false color SDR image

Many ice edge pixels however, are flagged as confidently cloudy by the VCM and are not retrieved by the ice concentration algorithm.

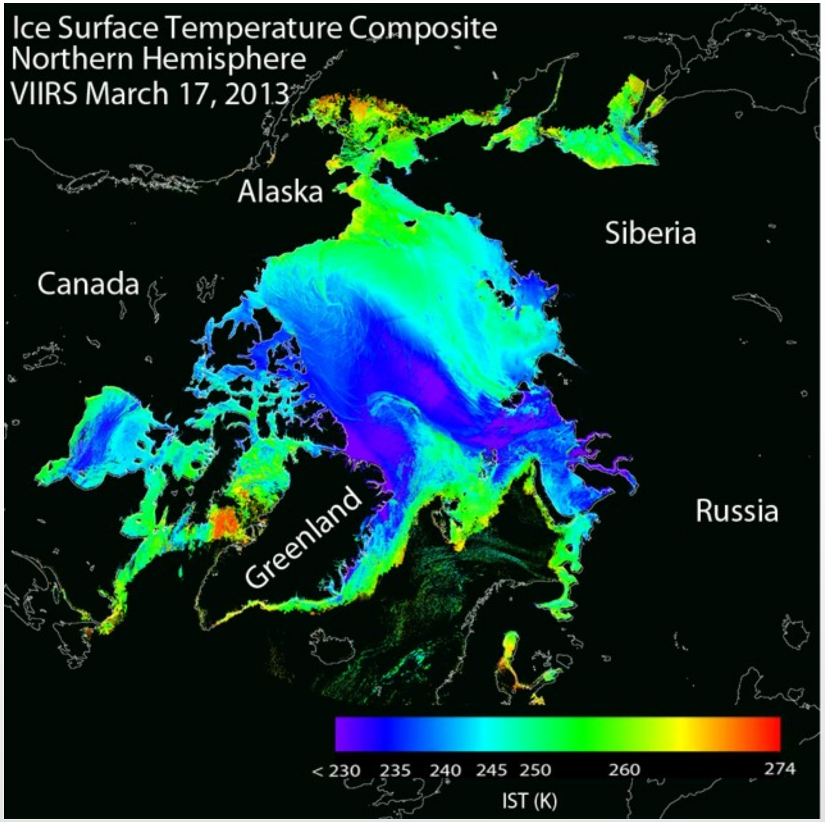
Suomi- NPP VIIRS Ice Surface Temperature Status

Mark Tschudi (CU)*

Yinghui Liu (UWisc), Richard Dworak (UWisc), Dan Baldwin (CU), Jeff Key (NOAA)

VIIRS Ice Surface Temperature

IST is the radiating, or "skin", temperature at the ice surface. It includes the aggregate temperature of objects comprising the ice surface, including snow and melt water on the ice.



Summary of the VIIRS IST EDR

- The VIIRS Ice Surface Temperature (IST) EDR provides surface temperatures retrieved at VIIRS moderate resolution (750m), for Arctic and Antarctic sea ice for both day and night.
- The baseline split window algorithm statistical regression method is based on the AVHRR heritage IST algorithm *(Key and Haeflinger.,* 1992)

$$IST= a_o + a_1 T_{M15} + a_2(T_{M15}-T_{M16}) + a_3(\sec(z)-1)$$

T_{M15} and T_{M16} : VIIRS TOA TB's for the VIIRS M15 and M16 bands

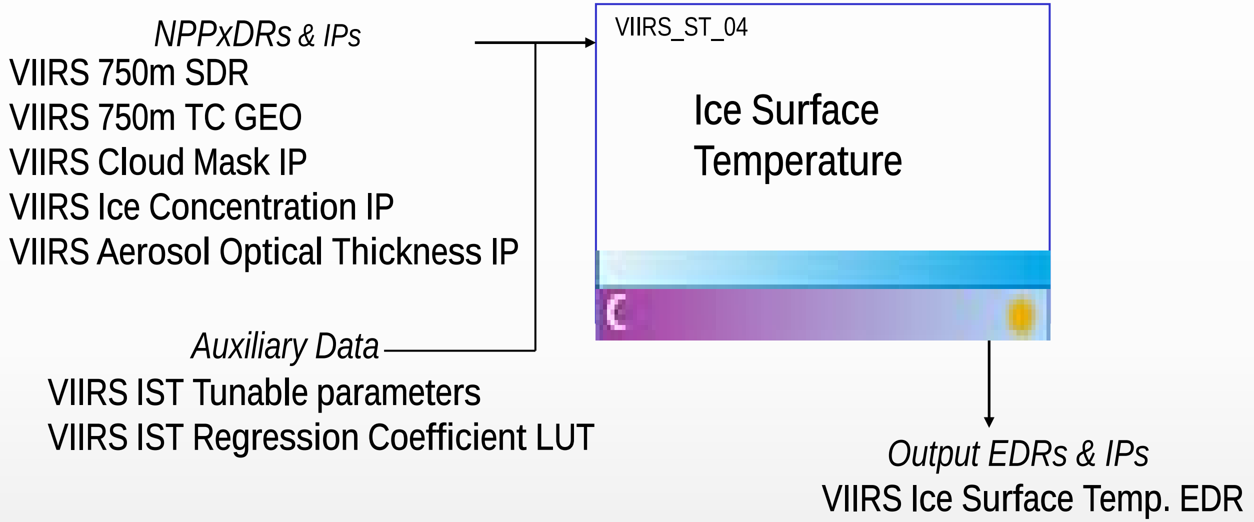
z: the satellite zenith angle

$a_{o,}$ $a_{1,}$ $a_{2,}$ a_3 : regression coefficients.

- Threshold Measurement Uncertainty = **1K** over a measurement range of 213–275 K.

Key, J., and M. Haefliger (1992), Arctic ice surface temperature retrieval from AVHRR thermal channels, J. Geophys. Res., 97(D5), 5885–5893.

Flow for the VIIRS Operational (IDPS) IST



VIIRS IST EDR Validation with IceBridge IST

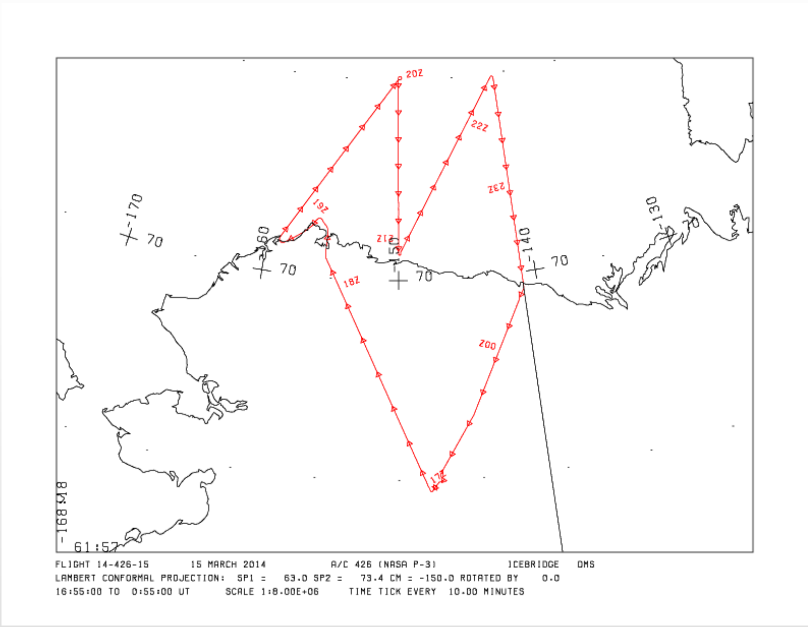
- IceBridge NASA P-3 aircraft carries a KT-19: a downward-pointing, IR pyrometer that measures IST
- No atmospheric corrections applied
- Spot size = 15m
- Resolution = 0.1° C
- Sampling = 10Hz

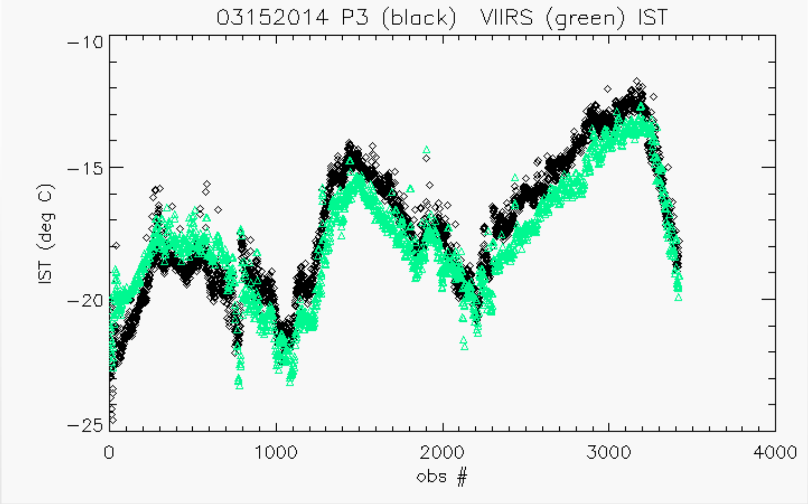
Krabill, W. B. and E. Buzay. 2012, updated 2014. IceBridge KT19 IR Surface Temperature. Boulder, Colorado USA: NASA DAAC at the National Snow and Ice Data Center.

VIIRS IST IceBridge Validation

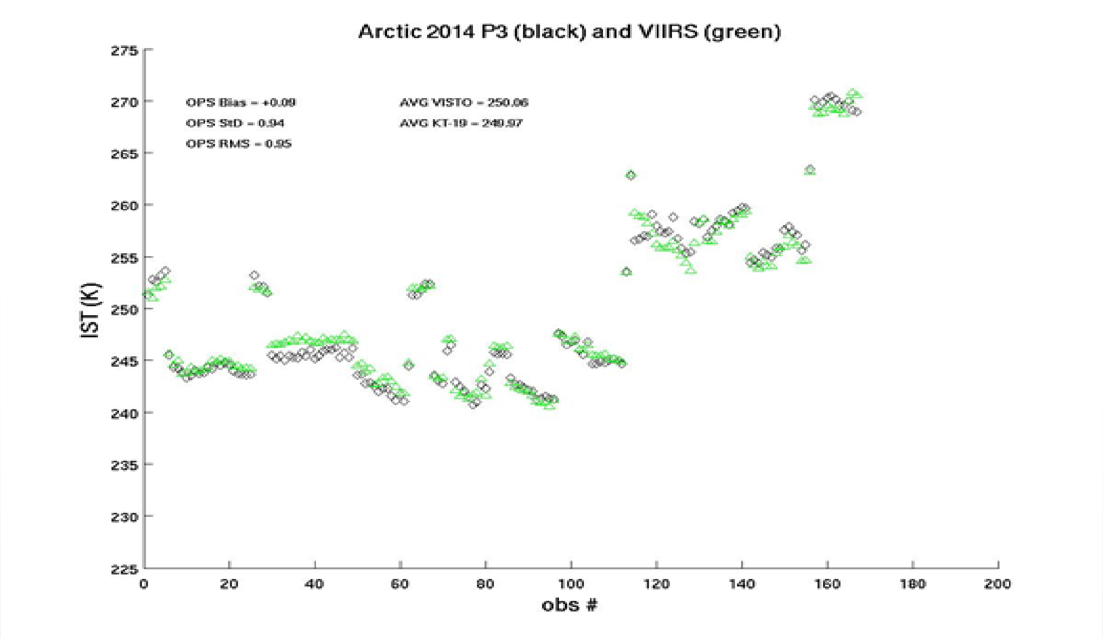
Flight track (left) and comparison (right) between the IST measured by the KT-19 (in black, smoothed over 100 points) and the nearest VIIRS Operational (IDPS) IST measurement (in green), March 15, 2014

mean KT-19 IST =-17.27°C, mean VIIRS IST = -17.75°C. RMS difference = 0.118



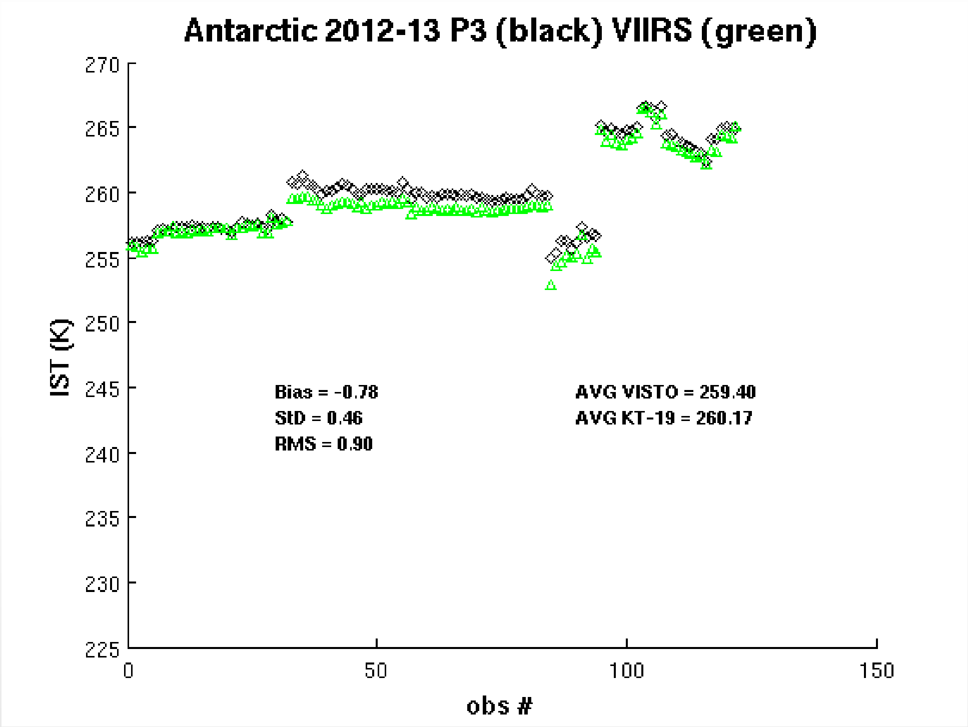


VIIRS IST IceBridge Validation



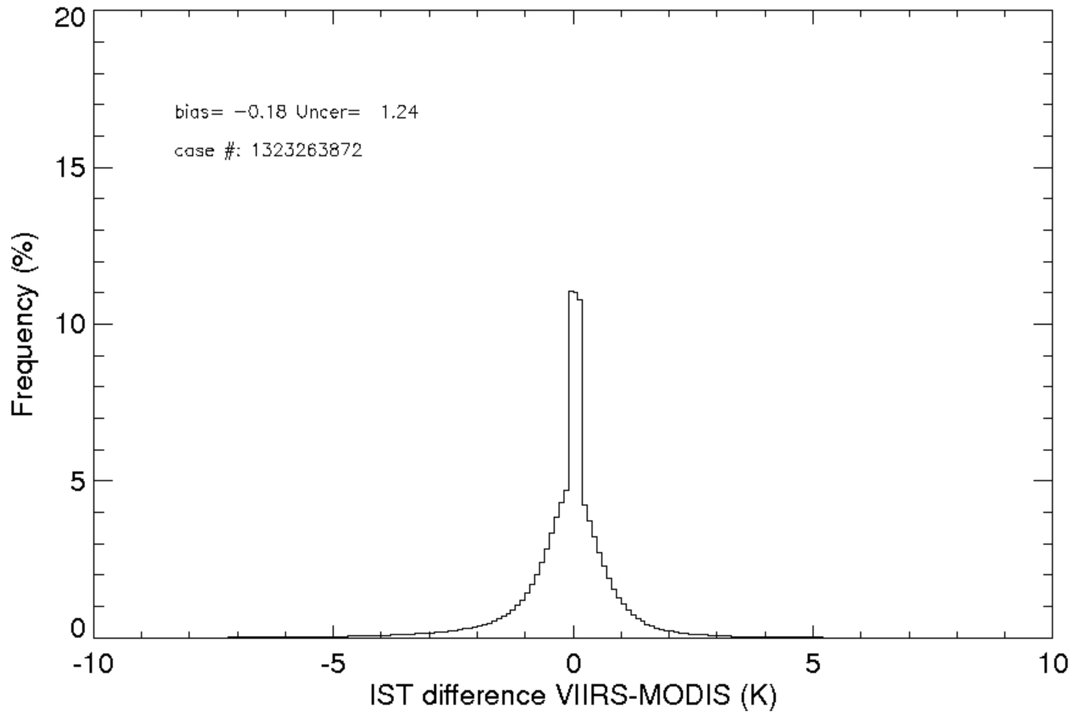
Operational S-NPP VIIRS IST (OPS) vs. airborne KT-19 IST for all coincident, cloud-free observations over the Arctic for all of the IceBridge Spring 2014 flights.

VIIRS IST IceBridge Validation



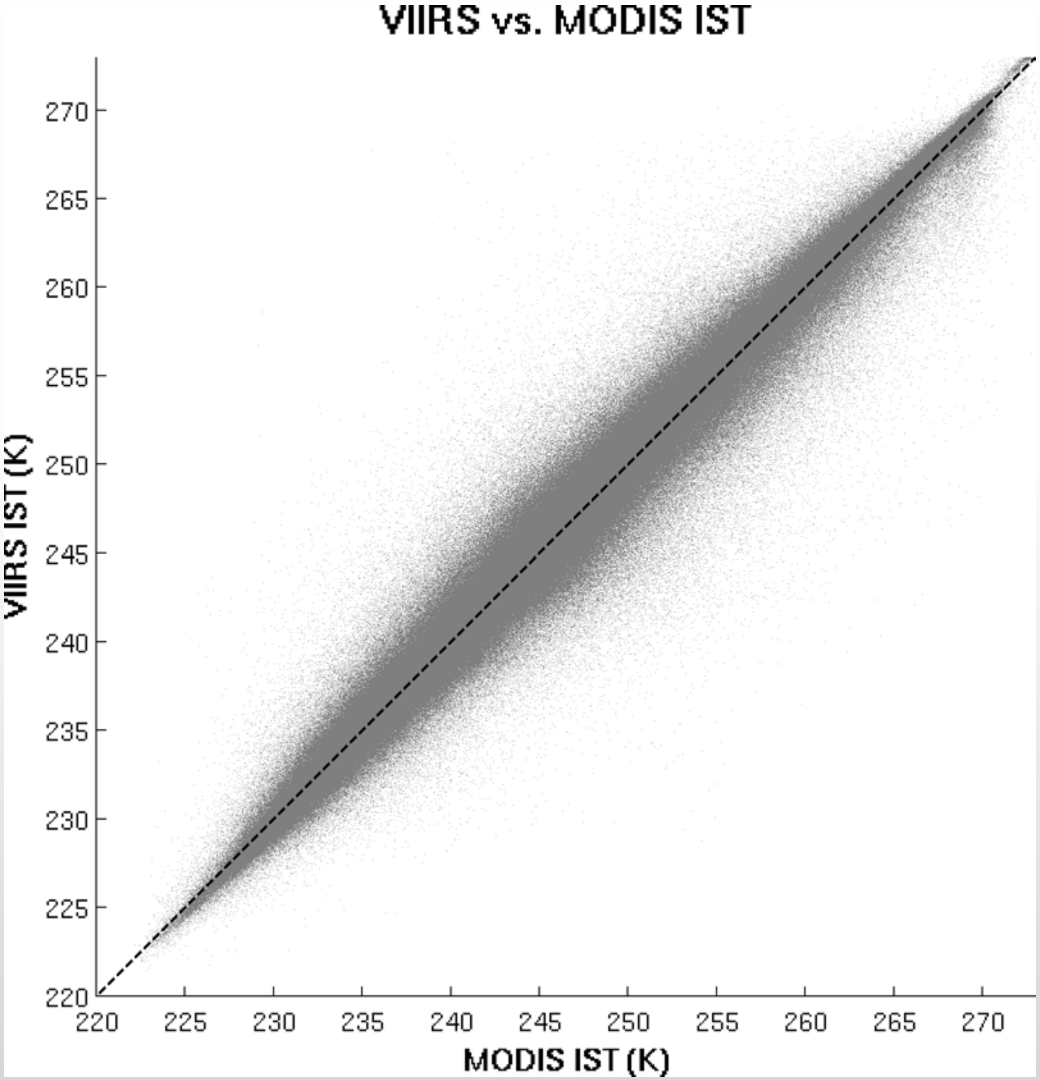
Operational S-NPP VIIRS IST (OPS) vs. airborne KT-19 IST for all coincident, cloud-free observations over the Antarctic for all of the IceBridge Fall 2012 & 2013 flights.

VIIRS / MODIS IST Intercomparison



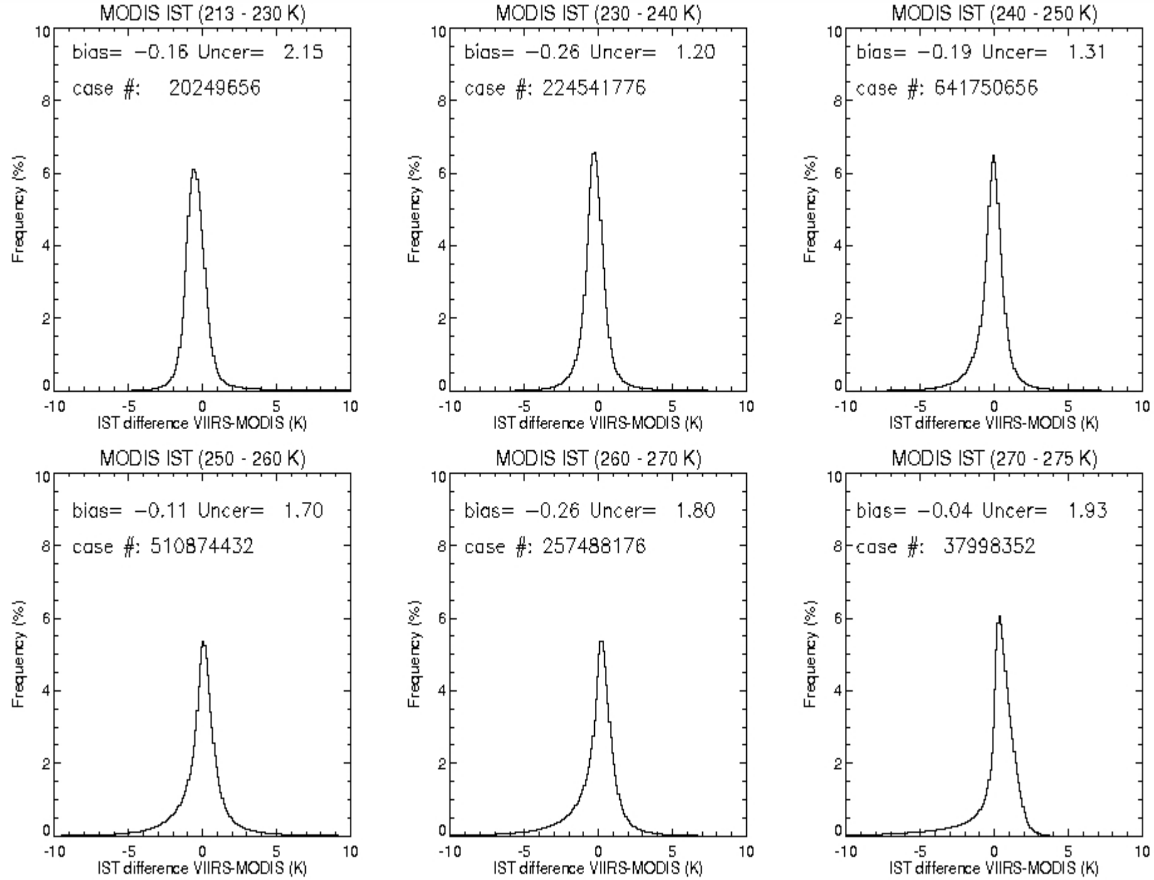
Differences between NPP VIIRS OPS and MODIS (Aqua and Terra) IST in the Arctic for all cases from August 2012 to July 2015.

VIIRS IST vs. MODIS IST



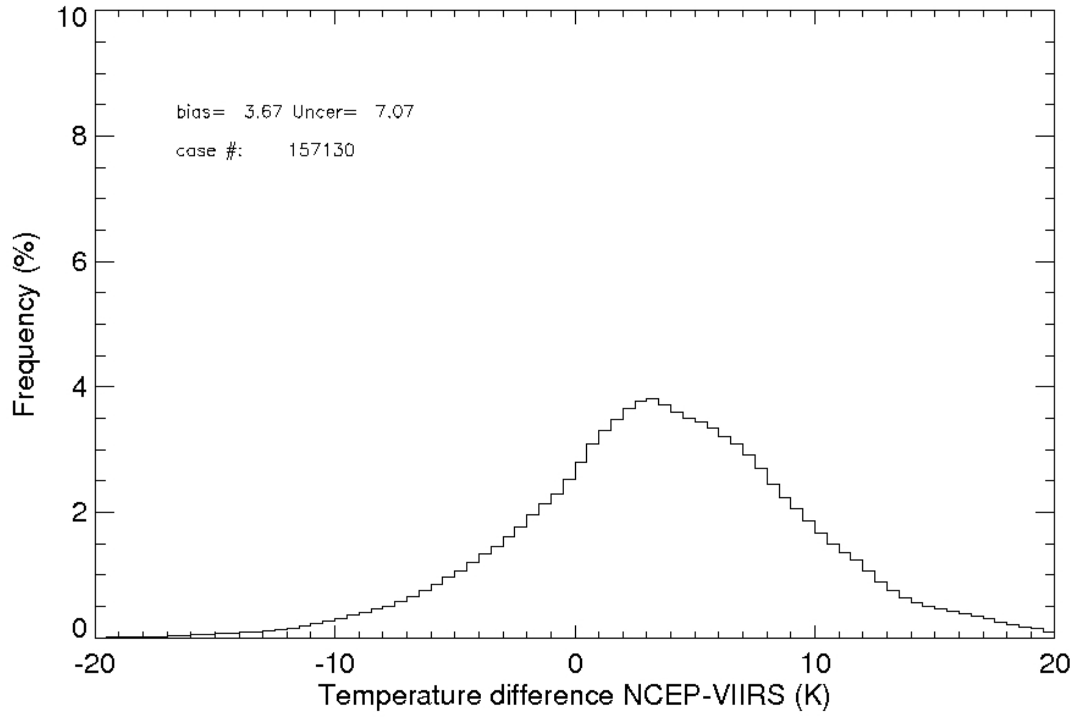
Scatterplot of OPS IST from 20 NPP VIIRS and MODIS Aqua simultaneous Nadir Overpass, with overall difference (VIIRS-MODIS) of 0.032 K and uncertainty (RMS)=1.187 K

VIIRS OPS IST vs. MODIS IST



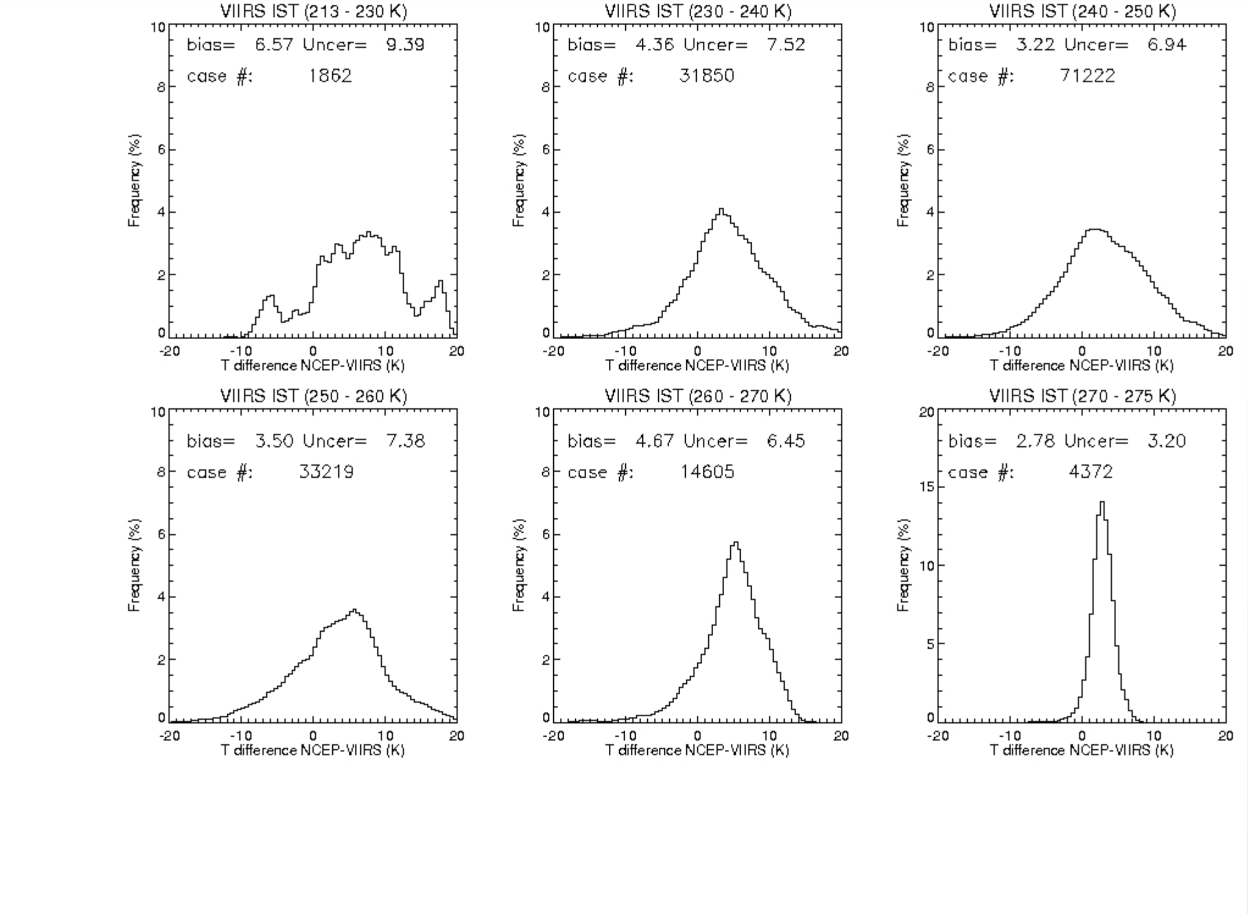
NPP VIIRS and MODIS (Aqua and Terra) IST differences in the Arctic and Antarctica from August 2012 to July 2015 for cases with MODIS ice surface temperature in range bins. Measurement bias and uncertainty (RMS) are indicated for each bin.

VIIRS OPS IST vs NCEP



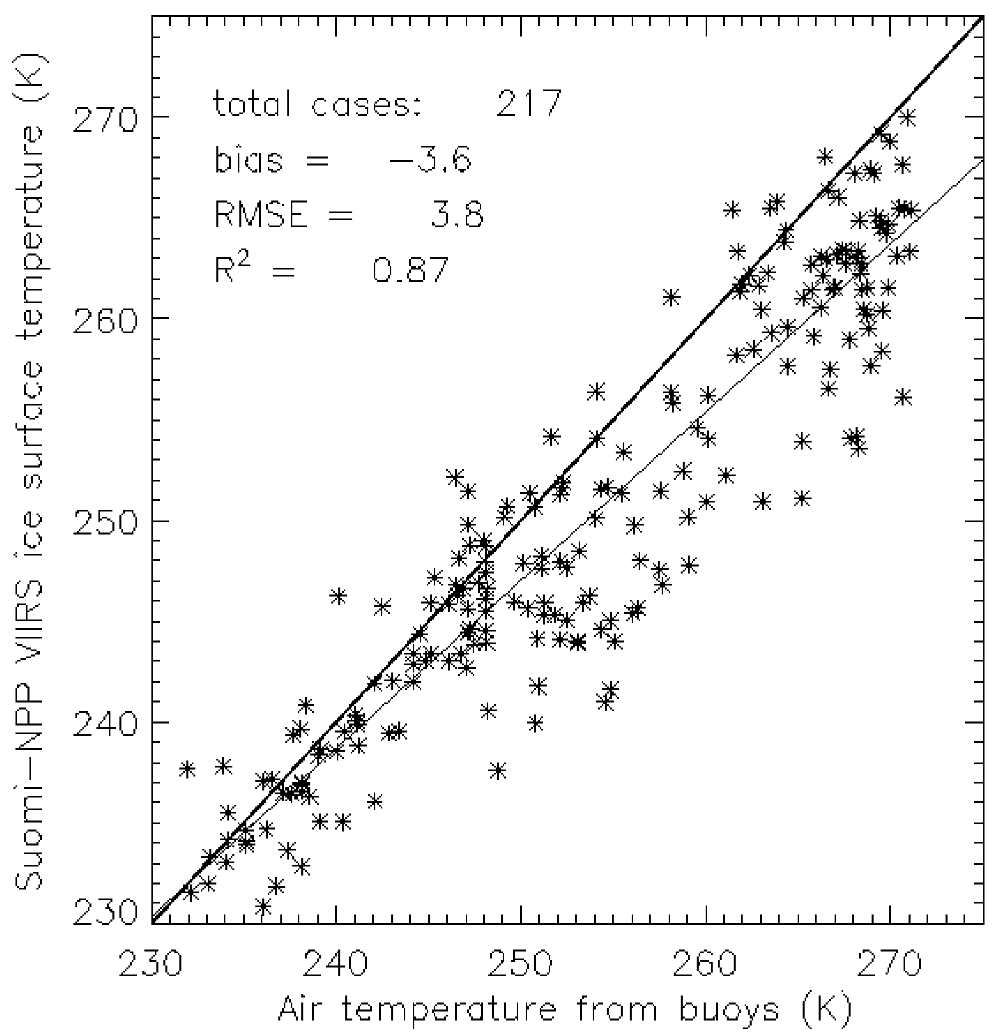
Differences between NCEP-NCAR surface air temperature and NPP VIIRS OPS IST in the Arctic for all cases from August 2012 to July 2015.

VIIRS OPS IST vs NCEP



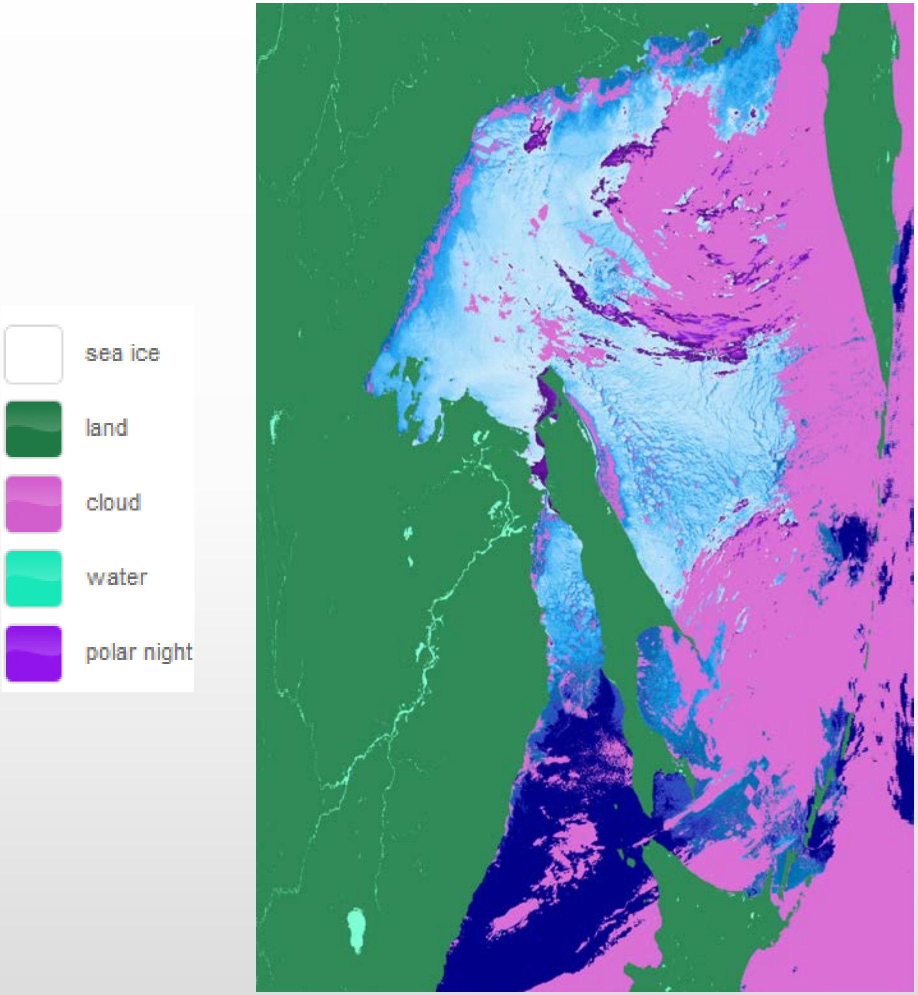
NCEP-NCAR surface air temperature and NPP VIIRS IST difference in the Arctic from August 2012 to July 2015 for cases with MODIS ice surface temperature in range bins. Measurement bias and uncertainty (RMS) are indicated for each bin.

VIIRS OPS IST vs. buoys



Scattering plot of surface air temperature from Arctic buoys and NPP VIIRS OPS IST from August 2012 to June 2014, with the thick line as the 1 to 1 ratio line, and thin line as the linear regression.

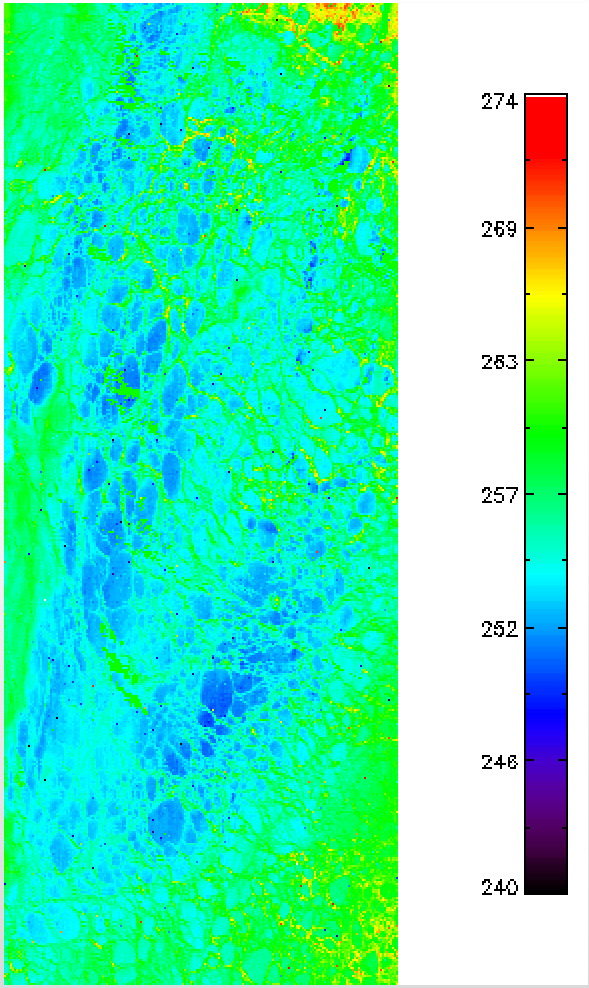
NASA VIIRS Sea Ice Extent Product



MODIS Sea ice, Sea of Okhotsk, March 17, 2002

- NASA VIIRS Sea Ice Cover by Reflectance
- Follow-on from MODIS (D. Hall & G. Riggs)
- Code generated by NASA SIPS
- In development by M. Tschudi (CU), George Riggs (SSAI)
- Reflectance-based during daytime, nighttime uses the IST product
- Sea ice by reflectance utilizes the NDSI:
  - NDSI = [R(I1) – R(I3)] / [R(I1) + R(I3)]
  - R=reflectance, VIIRS I1 (0.64um), VIIRS I3 (1.61um)
- Ice cover is mapped:
  - Snow-covered ice:
    - NDSI > thold and R(I1) > thold2
  - Thin ice (<10 cm, no snow cover)
    - IST – SST > thold
- Validation: IceBridge, Digital Globe, …
- Intercomparison: AMSR-2, IDPS Sea Ice Age, VIIRS Sea Ice Concentration, NDE Sea Ice Thickness

Suomi-NPP VIIRS IST – NASA product



- Utilizes enhanced split window:
  $IST = a_o + a_1 T_{M15} + a_2(T_{M15} - T_{M16}) + a_3(\boldsymbol{T_{M15} - T_{M16}})(\sec(z) - 1)$

- Initial code generated from MODIS code by NASA's Science Investigator-led Processing System (SIPS)
- Code being updated for VIIRS (calibration coefficients, etc.)
- New Quality Flags to be added
- Inter-comparison: MODIS, NCEP
- Validation: IceBridge, buoys

Left: VIIRS IST (K) from the NASA VIIRS IST product
Sept 12, 2014, 21:10 UTC
Beaufort Sea, AK

Conclusions

- Operational (OPS) VIIRS IST in several but not all cases meets the requirement of 1K measurement uncertainty
- OPS VIIRS IST shows a *cold* bias compared to MODIS and to several IceBridge KT-19 measurements, typically <1K
- Improvements in OPS IST EDR performance have been realized as the VIIRS Cloud Mask IP matures
- More VIIRS OPS IST improvement is expected as additional quality flags become available in the VIIRS Ice Concentration IP to avoid IST retrievals near clouds.
- NASA's Sea Ice Extent and IST product provide continuity from the MODIS product
  - No sea ice extent product is currently produced from VIIRS
  - Provides unique approach (NDSI) for sea ice identification

Future Plans and Issues

- No VIIRS IST code changes currently planned
- Update IST regression coefficients based on matchup with MODIS and airborne/other IST sources
- Additional quality checks in the VIIRS Ice Concentration IP (e.g. for cloud shadowing) will be passed to the VIIRS OPS IST
- NASA VIIRS IST
  - Add quality flags, based on MODIS product
  - Inter-comparison with MODIS, IDPS IST
  - validation with IceBridge IST, buoys
  - Complete ATBD
- NASA VIIRS Sea Ice Extent
  - Finalize code, add quality flags
  - inter-compare with MODIS, AMSR-2, VIIRS Ice Concentration, etc.
  - Validation with Digital Globe, IceBridge
  - Add quality flags , based on MODIS product
  - Complete ATBD
- Both IST products and NASA extent product: Improvements anticipated with continued upgrades to the VIIRS cloud mask

VIIRS Binary Snow Cover: Current Status and Plans

Peter Romanov, CREST/CUNY at NOAA/STAR

27 August 2015

Outline

- VIIRS Snow Cover products
- IDPS Binary Snow Map Product
  - Examples, Accuracy, Existing Problems
- NDE Algorithm
  - Modifications, Improvements, Examples
- Validation Plan
- Further Enhancements

Current VIIRS IDPS Snow Cover Product

- Binary snow map:
  - Snow/no snow discrimination
  - Imagery (375m) resolution (better than MODIS @ 0.5 km)

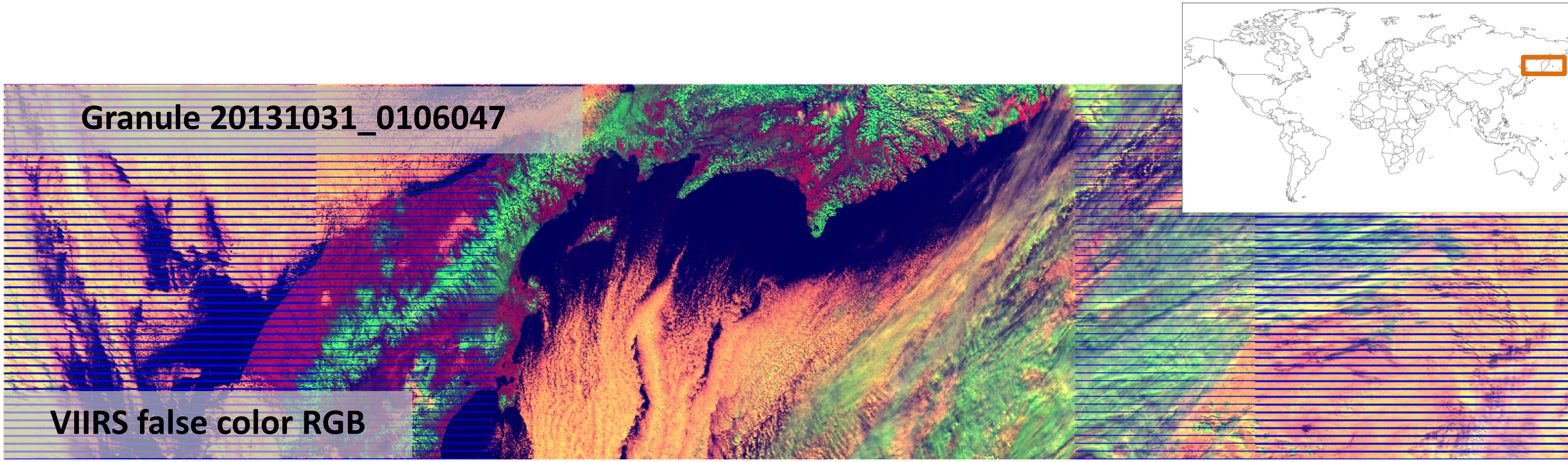
- Snow fraction:
  - Aggregation of the binary snow within 2x2 pixel blocks
  - 750 m spatial resolution

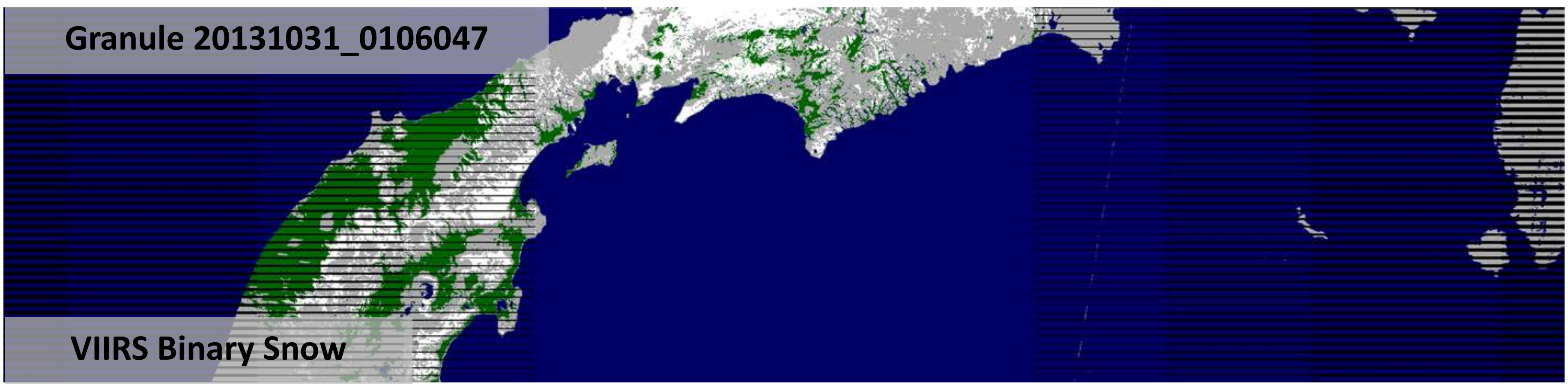
- Both snow products are critically dependent on the accuracy of the VIIRS cloud mask which is an upstream product.

IDPS Binary Snow Cover Algorithm

- Similar to MODIS SnowMap algorithm (Hall et.al 2001)
- Decision-tree threshold-based classification approach
- Uses Normalized Difference Snow Index (NDSI), reflectance, thermal and NDVI thresholds
- Applied to cloud-clear pixels, requires daylight

VIIRS Binary Snow Map at Granule Level

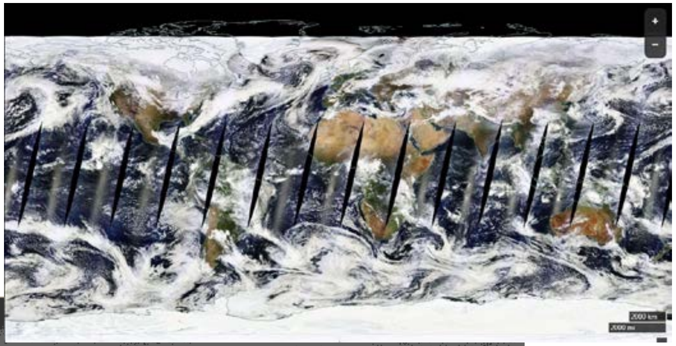


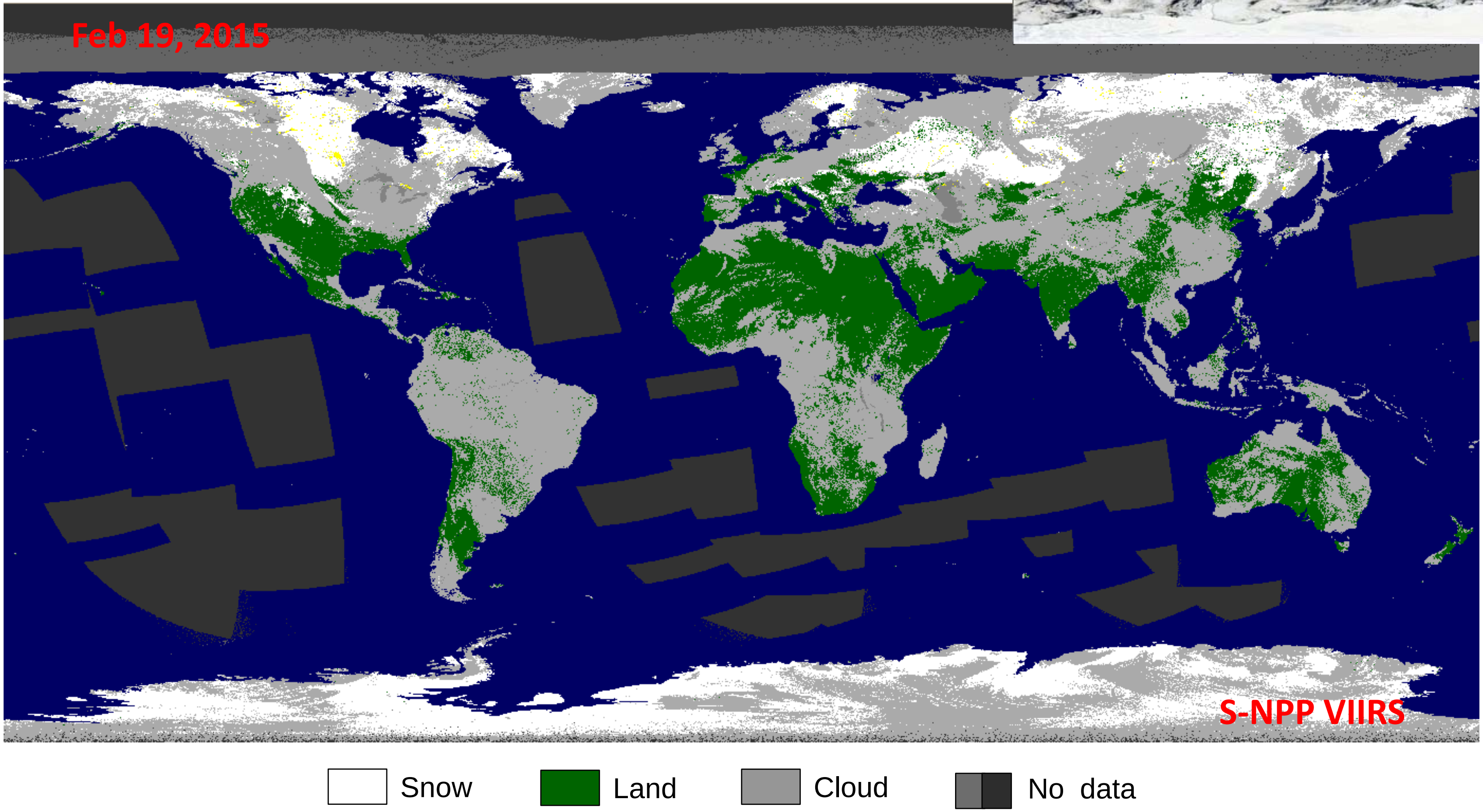


snow   land   cloud   No data

VIIRS Daily Gridded Snow Map

- Daily global gridded snow maps at 1 km resolution
- Have been produced since the beginning of 2013.
- Lat-lon projection is similar to NASA's CMG
- Granules with no land pixels are not processed





Product Evaluation Approach

- Visual qualitative assessment of global images
- Quantitative comparison with in situ snow cover observations
  - Mostly over CONUS area
- Comparison with NOAA Interactive Snow/Ice product (IMS)
  - Only over Northern Hemisphere

Accuracy Assessment

Daily rate of agreement of VIIRS IDPS binary snow maps

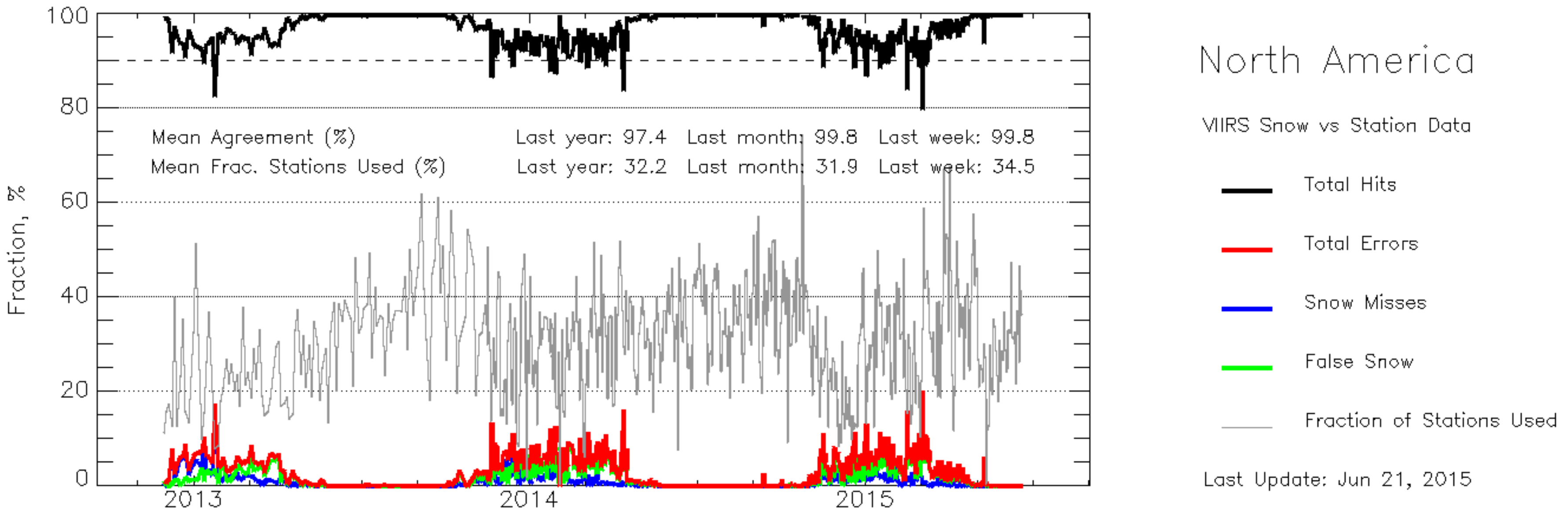
- To IMS, mean: 97%, range: 96-99%
- To in situ reports, mean: 92%, range: 85-96% (CONUS, November-April)
- 90% accuracy requirement is generally satisfied

Agreement decreases

- During transition seasons
- In forested areas
- At large solar/satellite zenith angles

VIIRS Snow vs In Situ Data

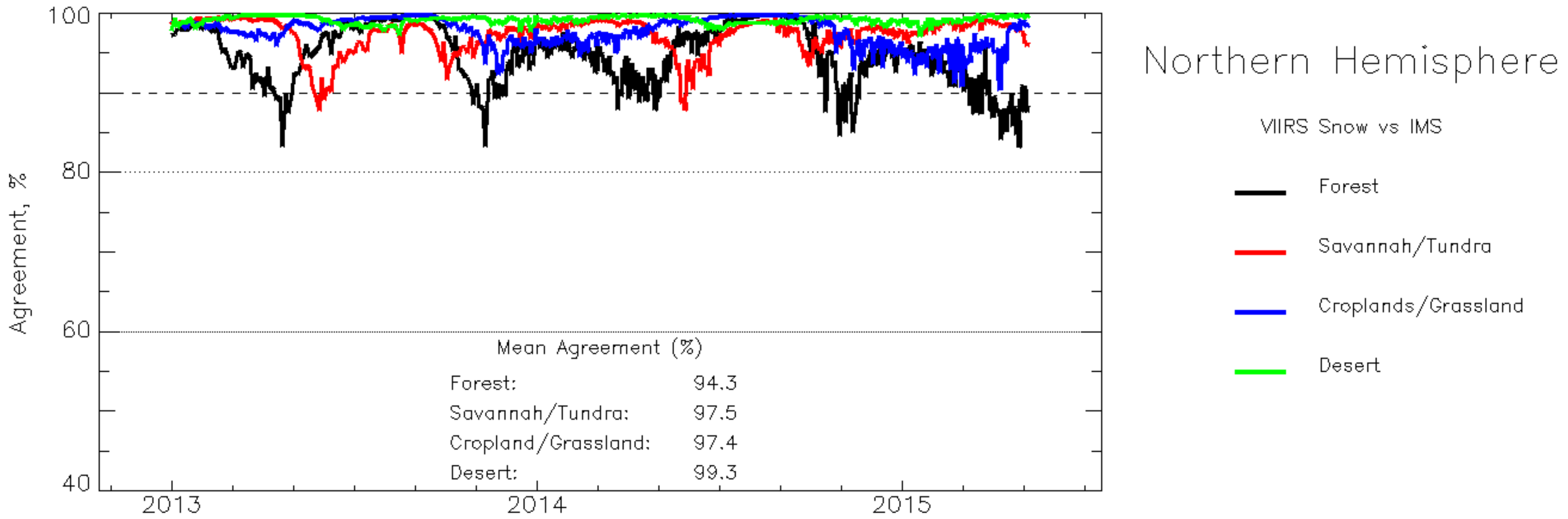
VIIRS vs In Situ Daily Comparison Statistics, 2013-2015



Most stations are in the CONUS area
Most daily agreement estimates are within 90-95% range

VIIRS Snow vs IMS

VIIRS daily agreement to IMS by surface cover type, 2013-2015



More frequent errors in forested areas
Some disagreement is due to finite accuracy of the IMS product

VIIRS, AVHRR, MODIS Snow vs IMS

Mean agreement to IMS and cloud-clear fraction
of daily automated snow products in 2013
Northern Hemisphere

	Agreement to IMS (%)	*Cloud-clear(%)**
VIIRS	**98.0**	**38.6**
MODIS (T)	97.3	49.1
MODIS(A)	97.1	48.3
AVHRR	97.9	55.0

*Cloud-clear fraction is estimated in 25-60^{0}N latitude band

VIIRS: Better accuracy but smaller effective clear-sky coverage

2014-2015: VIIRS cloud-clear fraction increased to 40.7% while the rate of agreement to IMS dropped to 97.8%

Uncertainty in Accuracy Estimates

IDPS Snow Map agreement to IMS, Jan 7, 2015

	Agreement to IMS(%)
All Northern Hemisphere land	**98.4**
Snow climatologically possible	**95.3**
Within 200km of the snow cover boundary	**93.6**
Within 100km of the snow cover boundary	**91.0**
Within 50 km of the snow cover boundary	**87.2**
Within 20 km of the snow cover boundary	**81.3**

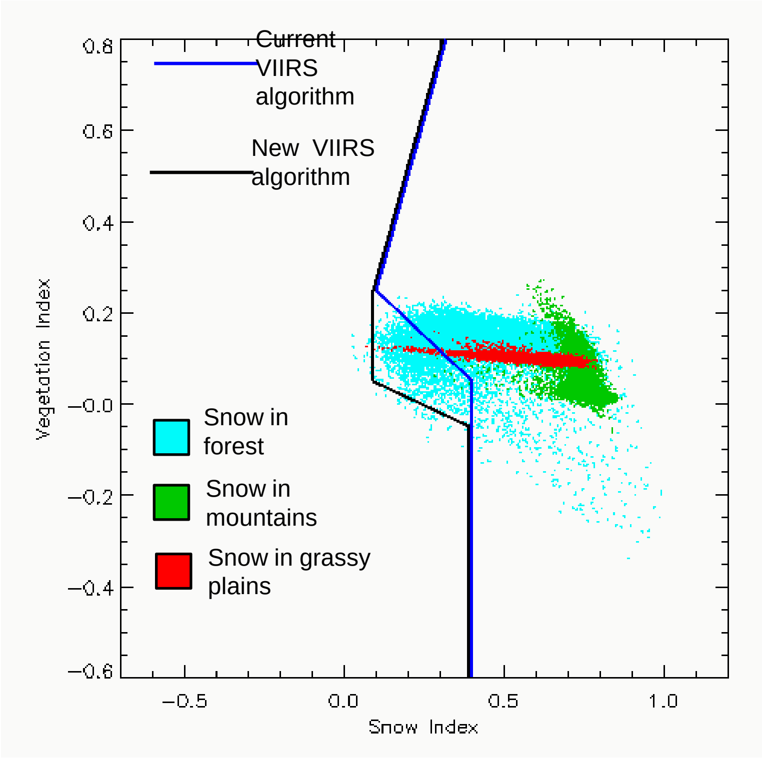
Mean agreement between products decreases with the region of comparison narrowing down onto the snow cover boundary

When evaluating the accuracy it is important to know exactly how it was obtained

NDE Snow Algorithm

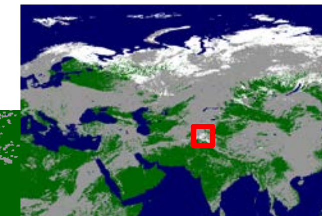
NDE Algorithm

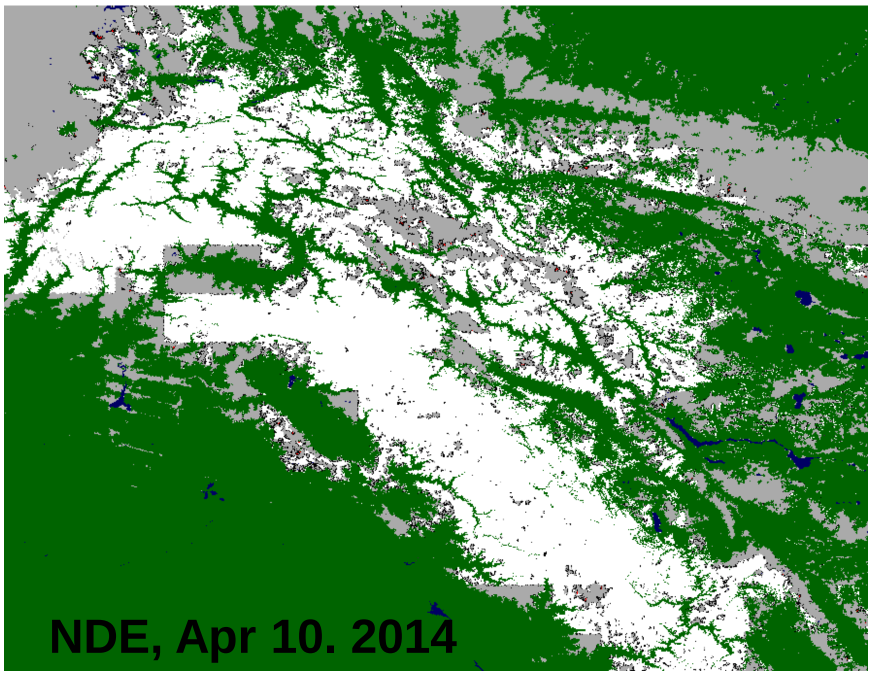
- 2-stage procedure: spectral tests + consistency checks
- Spectral tests: similar to IDPS but more relaxed
  - Intent: Improve snow identification in forests and in the transition zone
- Consistency tests (new, not in IDPS)
  - Snow climatology
  - Surface temperature climatology
  - Spatial consistency
  - Temperature spatial uniformity
  - Intent: Eliminate possible spurious snow

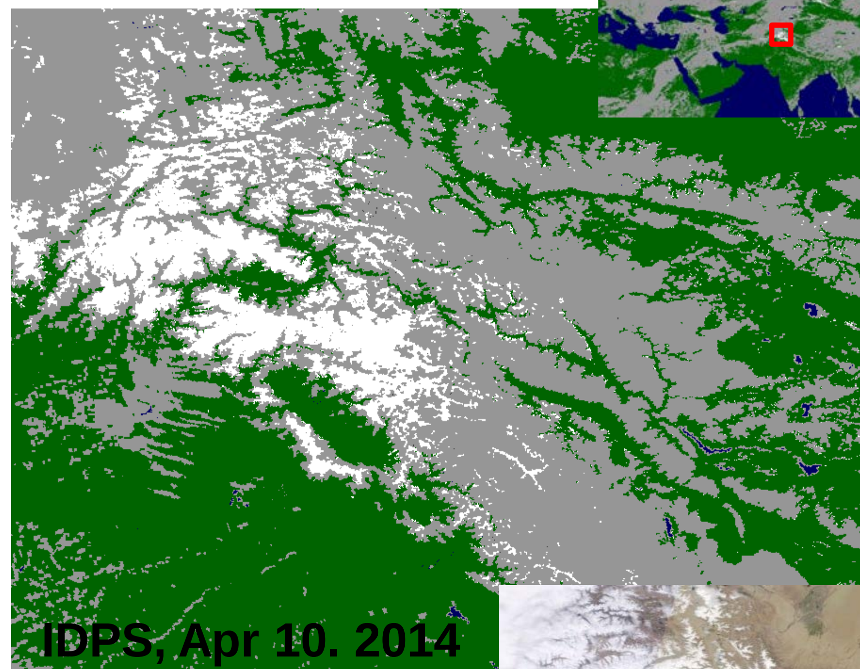


NDE vs IDPS Binary Snow Product

NDE: Better delineates the snow cover boundary due to less conservative cloud masking in the snow/no-snow transition zone



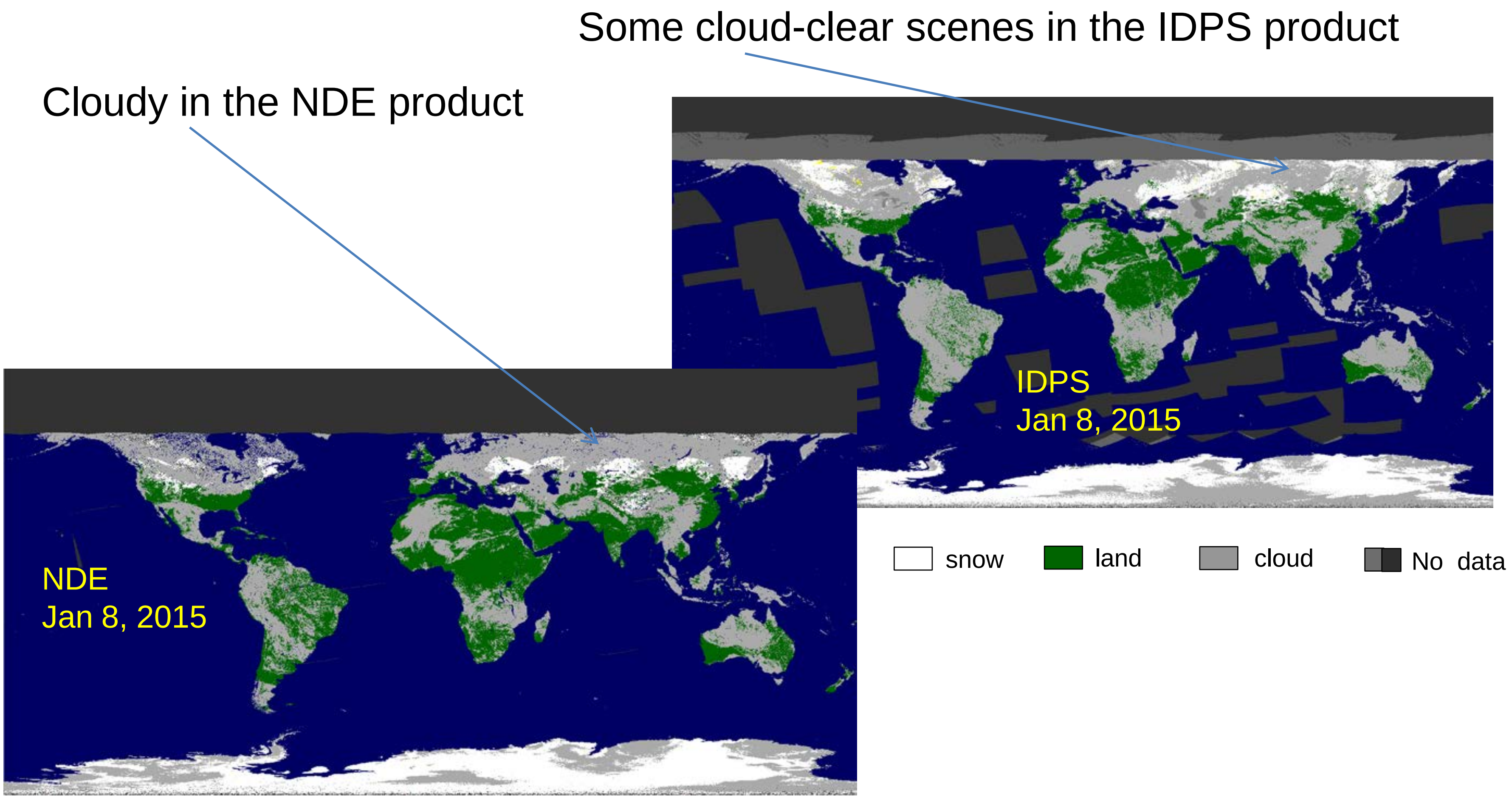




snow land cloud No data

NDE vs IDPS Binary Snow Product

NDE: Less conservative cloud mask in low and midlatitudes, but much more conservative cloud mask at high solar zenith angles



NDE Binary Snow Accuracy

Limited dataset processed: January 2015, 10 days in April, July and Oct 2014

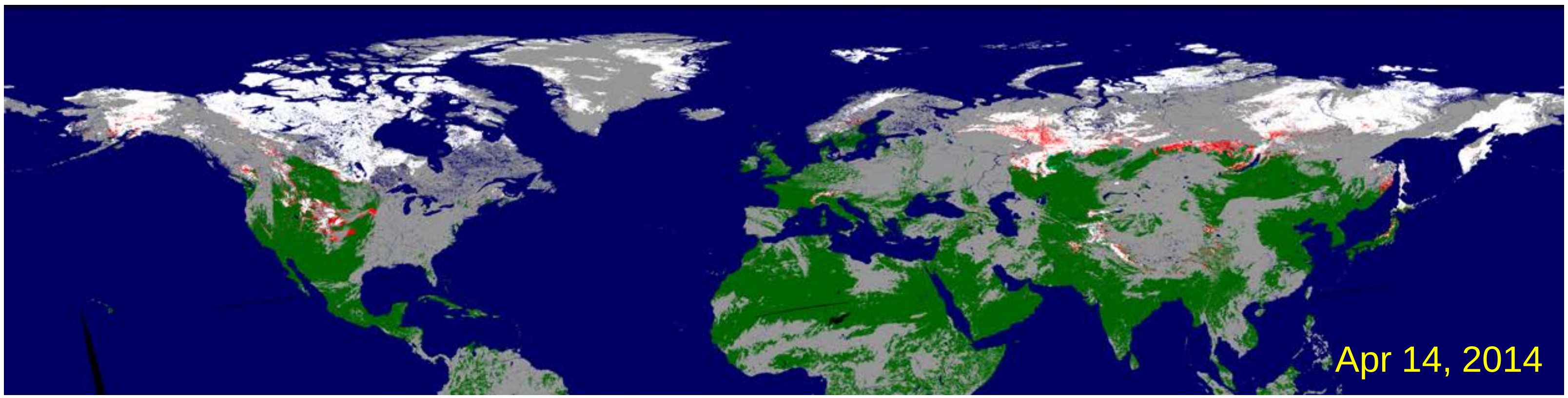
Daily rate of agreement,   January 2015

- To IMS: 96-99% (Northern Hemisphere)
- To in situ snow depth reports: 88-97% (CONUS)

NDE Binary Snow accuracy is similar to the IDPS accuracy

NDE Snow vs IMS

VIIRS NDE Binary Snow with IMS data overlaid



Both snow | Both land | Cloud | No data

VIIRS snow map errors: Omission (snow miss) | Commission (false snow)

Some VIIRS snow “omissions” may be due to overly aggressive snow mapping by IMS analysts

Further Enhancements

- Location-dependent threshold values

- Improved snow cover climatology

- Add ice identification on rivers and lakes

- Daily gridded products

NOAA vs NASA Approach

NASA:

- Discontinue producing binary snow maps
- Retain only Snow Fraction (NDSI-based)

NOAA:

- Binary Snow Cover is still needed. No plans to discontinue.

Reprocessing, Long-Term Monitoring

No plans for reprocessing so far

NDE long term product monitoring will be similar to IDPS

- Global gridded snow maps
- Visual examination
- Routine comparison with IMS and in –situ data
- Daily accuracy estimates

Summary

VIIRS Binary Snow validation approaches and tools

- Have been developed and are actively used

IDPS Binary Snow Cover product

- Provides consistent characterization of global snow cover
- Satisfies the 10% accuracy requirement but can be improved

New NDE algorithm will

- Improve snow detection/mapping in transition zones
- Reduce spurious snow identifications

Overall the quality of the new snow product is highly dependent on the performance of NDE cloud mask and its further improvement

VIIRS Fractional Snow Cover: Current Status and Plans

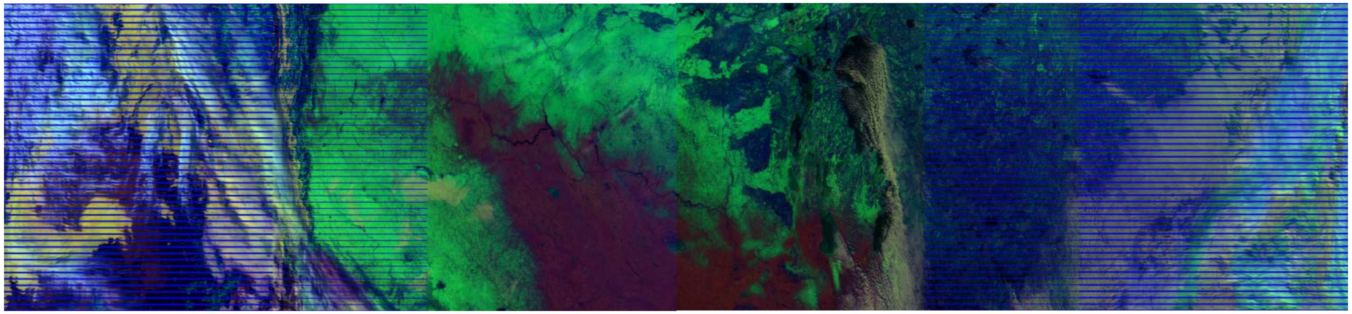
Peter Romanov, CREST/CUNY at NOAA/STAR
Igor Appel, IMSG at NOAA/STAR

27 August 2015

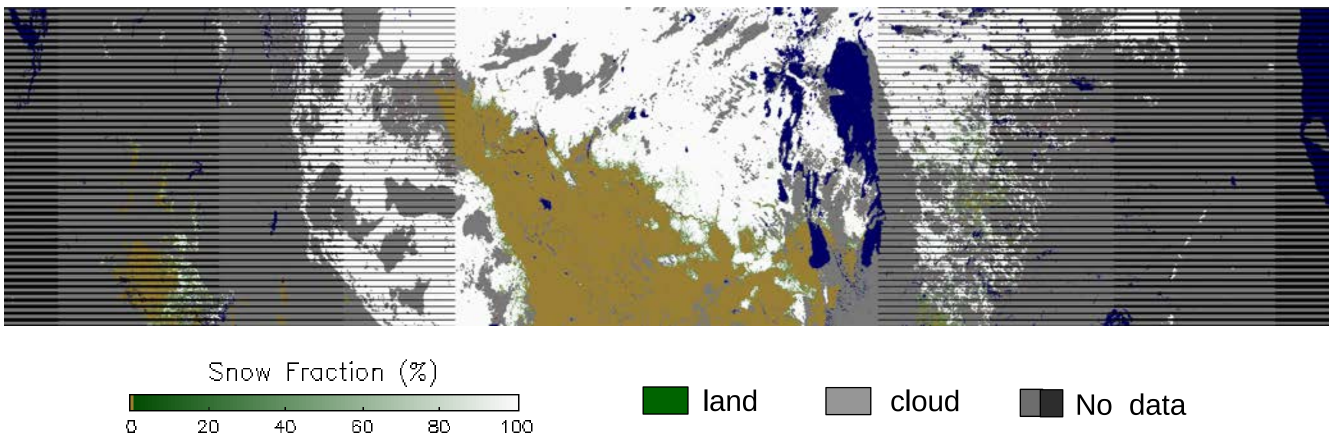
Current VIIRS IDPS Snow Fraction Product

- IDPS Snow Fraction:
  - Aggregation of the binary snow within 2x2 pixel blocks
  - 750 m spatial resolution
- Product depends on
  - Binary snow identification
  - VIIRS cloud mask

Aggregated Snow Fraction

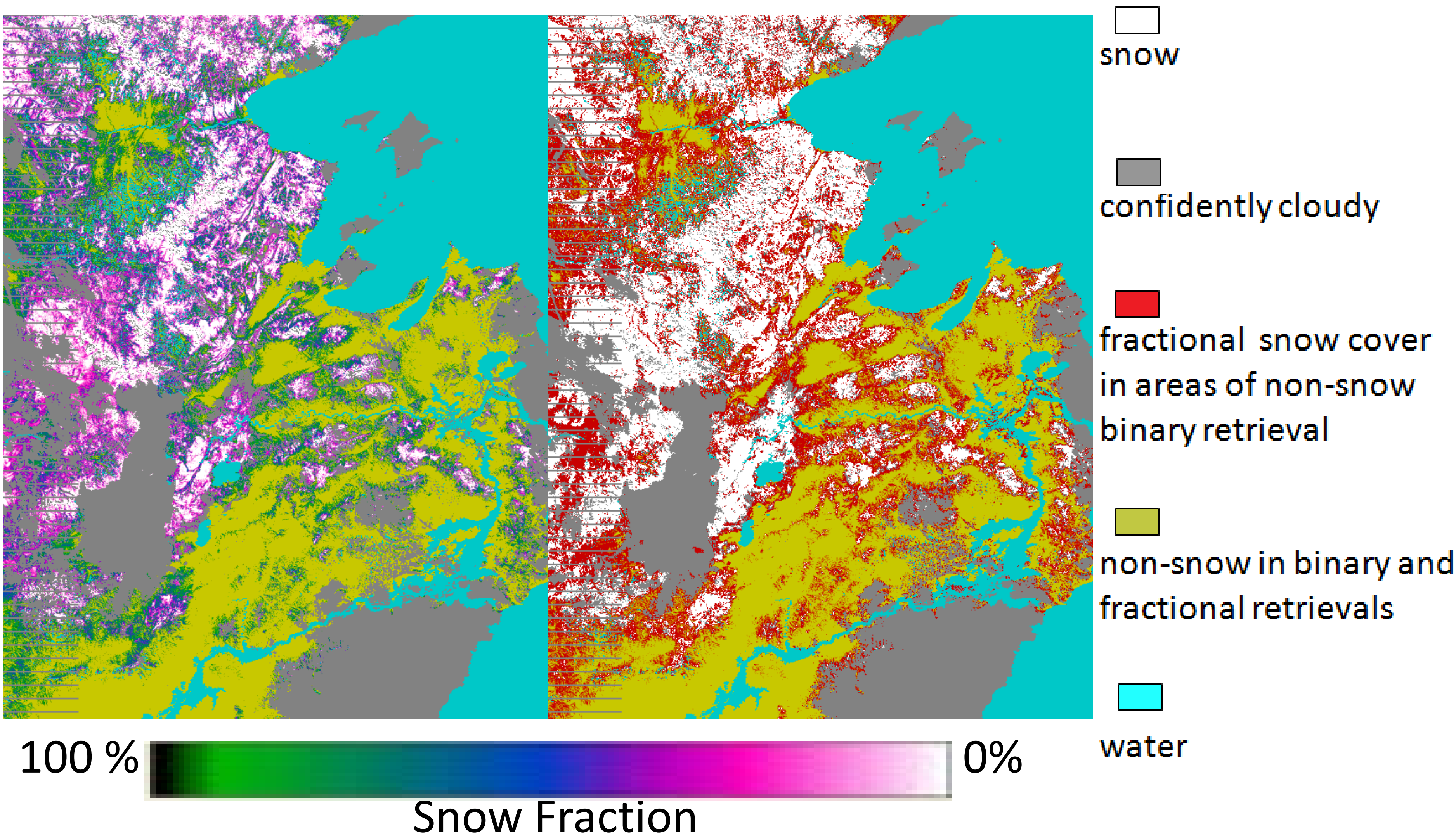


VIIRS IDPS snow fraction: derived through 2x2 binary snow pixel aggregation



- Product
  - Has little to none added value as compared to the binary snow
  - Can not and does not satisfy 10% accuracy requirements
  - Has to be replaced for sub-pixel snow fraction retrievals

Snow Fraction and Binary Snow (10/24/2013 at 03:15)



Comparison with false color imagery shows advantage of snow fraction

“Viewable” vs “True” Snow Fraction

Two Definitions/Perceptions of Sub-Pixel Snow Fraction

(1) Physical fraction of land surface covered with snow (“**true snow fraction**”).

- Characterizes patchiness of snow cover on the ground
- Use to calculate the snow area extent

(2) Snow fraction as “seen” from satellite (“**viewable snow fraction**”)

- Represents a combined effect of patchiness and snow masking by vegetation
- Directly related to the land surface albedo
- Can be converted to the true snow fraction if the forest gap function is known

In satellite remote sensing definition (2) of snow fraction is typically assumed

“Viewable” snow fraction will be derived from VIIRS data

Conclusions from high level fractional snow discussion (July 2014)

Overall Summary:

There are three algorithms:

a) Spectral unmixture (aka MODSCAG, GOESRSCAG, Painter algorithm),

b) NDSI-based, and

c) Single band approach.

Overall agreement that an enterprise algorithm approach is a good idea, but need to assess and compare the results of the three algorithms in order to make a recommendation on which to implement.

Panel recommendation from the maturity review (September 2014)

- **Snow Cover (Snow Fraction) EDR Algorithm**

- Scientific maturity seems sound for NDSI algorithm. Recommend to proceed with NDSI regression approach.

  - Study the inclusion of NDSI into the cryosphere products of the JPSS risk reduction project

  - Inter-comparisons with MODSCAG should be explored by a coordinated GOES-R JPSS effort

Two Snow Fraction Algorithms for NDE

Reflectance-based, modified from Romanov et al (2003)

$$\textbf{SnowFraction}=(\mathbf{R}-\mathbf{R}_{land})/(\mathbf{R}_{snow}-\mathbf{R}_{land})$$

- Uses band 1 (visible) reflectance
- $\mathbf{R}_{land}$ and $\mathbf{R}_{snow}$ are global and are determined empirically. They change with observation geometry
- Algorithm used with GOES Imager and AVHRR

NDSI-based, recent (2015) enhancement of Salomonson & Appel

$$\textbf{SnowFraction} = (\mathbf{NDSI} - \mathbf{NDSI}_{non\text{-}snow}) / (\mathbf{NDSI}_{snow} - \mathbf{NDSI}_{non\text{-}snow})$$

- Slope and Intercept are local and are established on the fly
- MODIS heritage algorithm
- Adopted as the primary algorithm for JPSS

Advantages of Reflectance-Based Snow Fraction

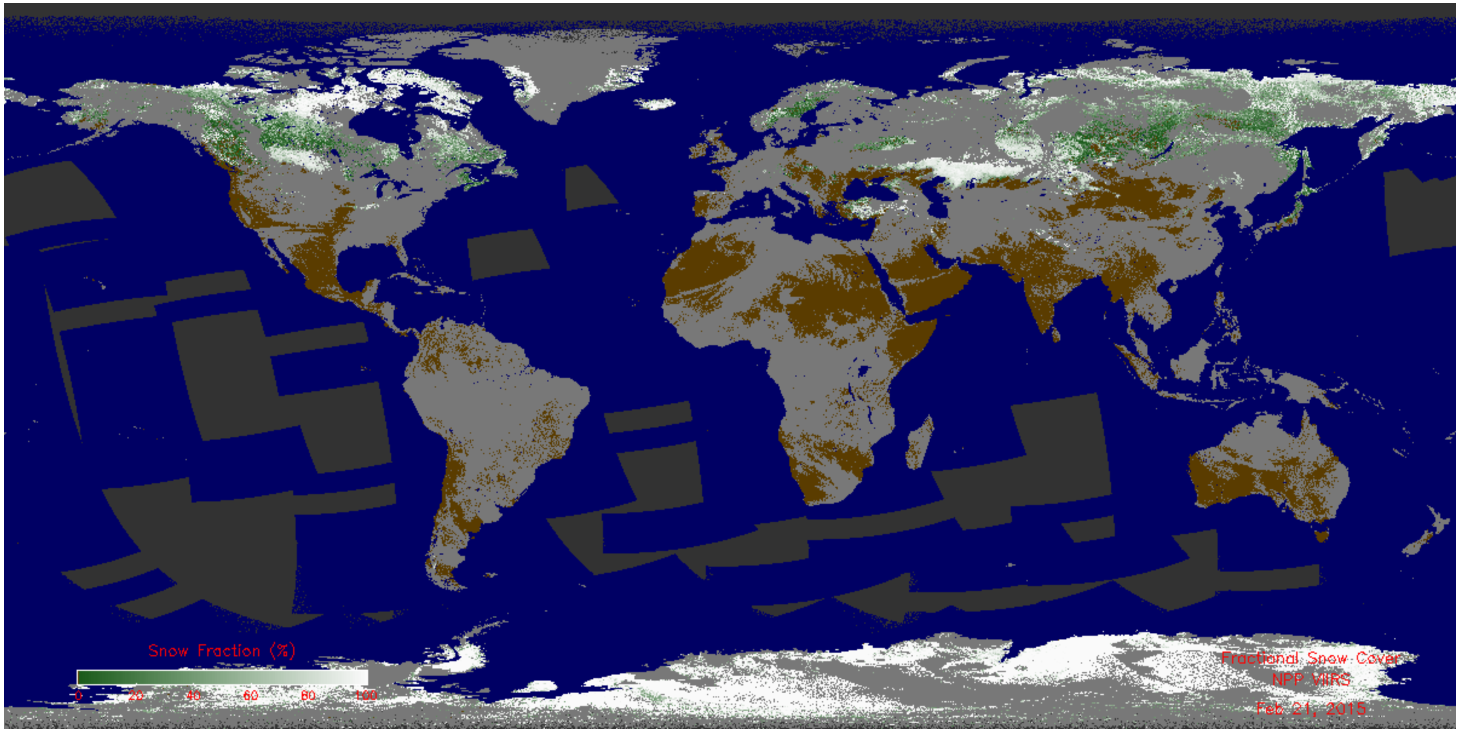
Linear relationship between snow fraction and surface reflectance

- Employed in land surface models
- Implicitly used when visually estimating the fractional snow cover (e.g. snow course measurements)

Theoretically estimated accuracy is 10-15%

- Mostly due to the end-members uncertainty

Global Daily Snow Fraction



land cloud No data

Daily gridded maps of reflectance-based snow fraction are generated daily since Jan 2014. See http://www.star.nesdis.noaa.gov/smcd/emb/snow/viirs/viirs-snow-fraction.html

Snow Fraction Evaluation Approach

Snow fraction is not observed in situ. Proper quantitative validation of the product accuracy is hardly feasible

General approach to the product verification

- Comparison with higher spatial resolution data

- Consistency testing
  - Self-consistency:
    - Lack of abnormal spatial patterns
    - Day-to-day repeatability of spatial patterns
  - Consistency with the forest cover distribution
  - Consistency with in situ snow depth data over open flat areas.

Comparison with Landsat

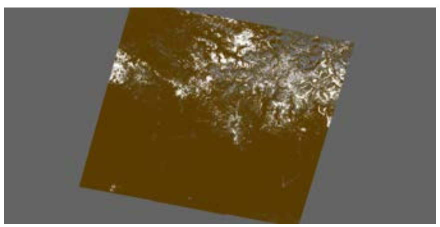
Landsat binary snow cover aggregated within VIIRS pixel is compared to VIIRS sub-pixel snow fraction

<u>Approach</u>

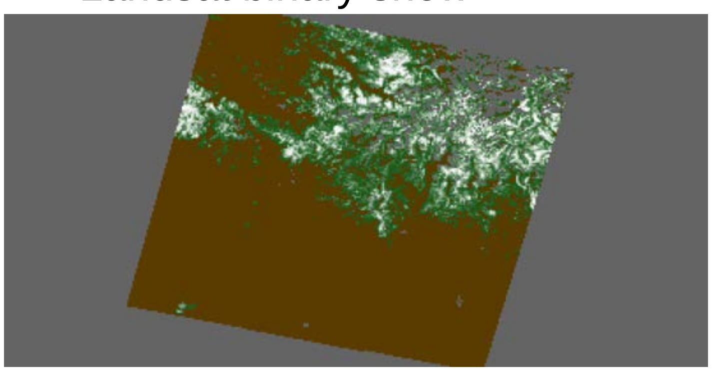
(1) Generate binary snow mask for a Landsat scene at 30 m resolution

(2) Aggregate Landsat binary snow retrievals within VIIRS pixel

(3) Compare with VIIRS snow fraction estimate

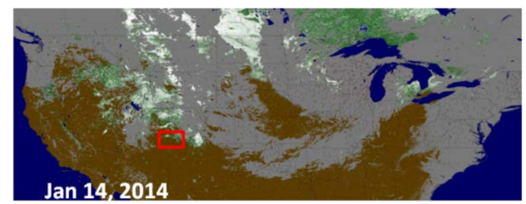


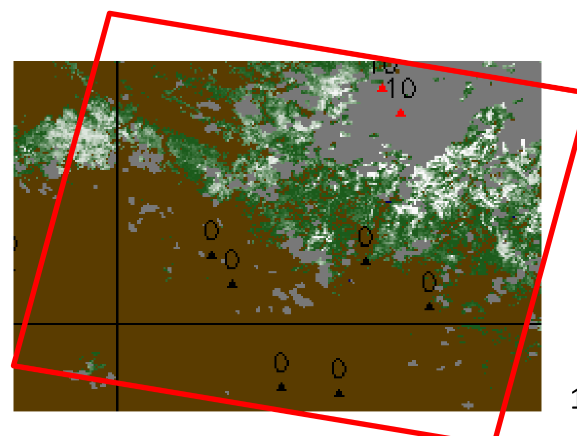
Landsat binary snow



Landsat snow fraction

VIIRS snow fraction





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Comparison with Landsat

Location of Landsat scenes used

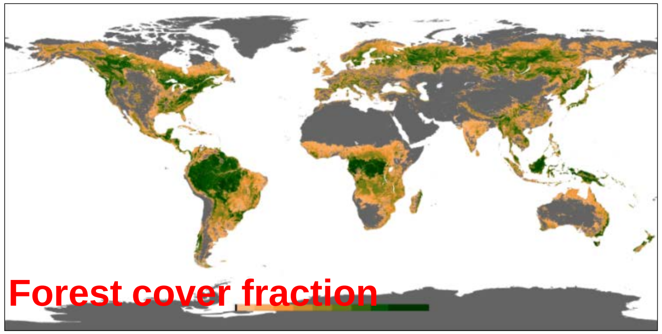
The overall agreement of Landsat aggregated and VIIRS subpixel snow fraction is about 12% for 1 km grid cells and about 8% for 5 km aggregation

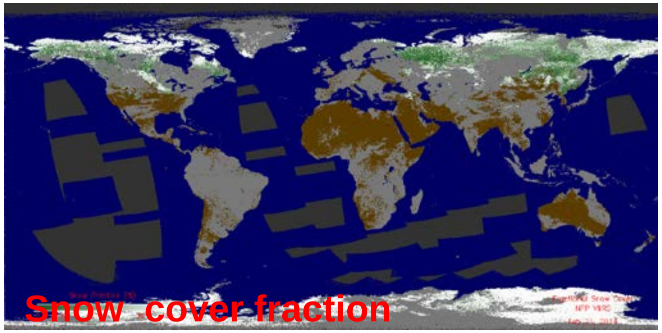
Date of year 2014	Path	Row	Sol Elev	Lat	Lon	Mean Fraction VIIRS	Mean Fraction Landsat	1 km		5 km	
								Correl	RMSE	Correl	RMSE
01/09	16	27	18	47.4	-75.5	0.21	0.23	0.71	0.173	0.87	0.112
01/09	32	28	20	46.0	-100.8	0.77	0.83	0.40	0.17	0.41	0.157
01/13	28	33	26	38.8	-96.9	0.19	0.06	0.67	0.106	0.92	0.078
01/14	35	24	14	51.7	-103.0	0.74	0.74	0.89	0.131	0.97	0.072
01/14	35	25	17	50.2	-103.6	0.89	0.90	0.72	0.098	0.84	0.054
01/14	35	34	28	37.5	-108.2	0.26	0.27	0.84	0.140	0.94	0.069
01/15	42	34	28	37.4	-119.0	0.11	0.10	0.82	0.112	0.92	0.061
01/15	131	26	18	48.8	107.4	0.42	0.47	0.84	0.157	0.83	0.142
01/15	147	26	18	48.8	82.7	0.67	0.70	0.89	0.101	0.95	0.069
01/15	147	27	19	47.4	82.1	0.66	0.68	0.91	0.051	0.96	0.031
03/14	169	26	36	48.4	48.6	0.42	0.47	0.95	0.094	0.99	0.068
03/14	185	31	41	41.7	21.3	0.34	0.31	0.91	0.145	0.97	0.094
03/15	160	26	36	48.8	62.5	0.86	0.90	0.72	0.070	0.80	0.055
03/15	128	20	29	57.3	116.0	0.59	0.53	0.69	0.203	0.80	0.125
03/24	159	15	27	64.1	72.9	0.74	0.77	0.89	0.111	0.98	0.049
03/24	175	34	48	36.5	35.49	0.72	0.70	0.79	0.146	0.94	0.114
03/25	134	35	50	36.0	98.4	0.56	0.56	0.90	0.132	0.97	0.070
03/25	150	23	37	53.1	79.8	0.43	0.44	0.90	0.078	0.98	0.040
04/23	72	14	37	65.5	-151.5	0.32	0.34	0.90	0.103	0.97	0.054
04/27	141	16	40	62.6	99.7	0.35	0.36	0.81	0.098	0.90	0.055
05/15	66	17	47	61.5	-145.2	0.67	0.65	0.80	0.131	0.94	0.069
Mean								**0.80**	**0.121**	**0.90**	**0.078**

Consistency Tests

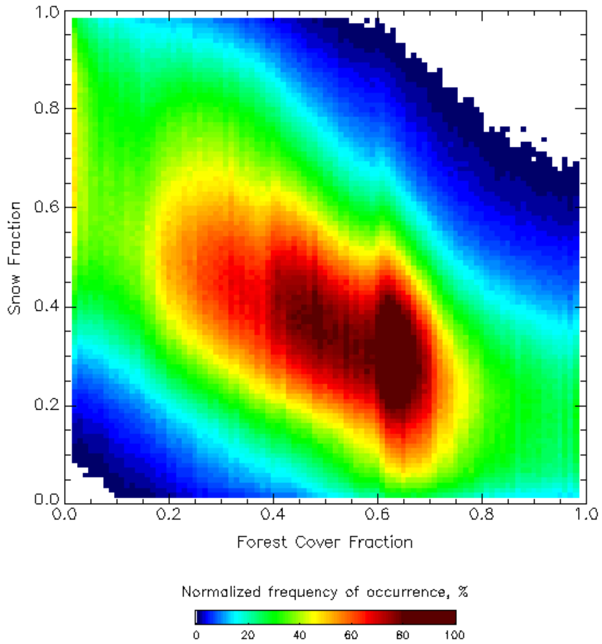
VIIRS reflectance based snow fraction satisfies all consistency tests
In particular it demonstrates:

- Strong negative correlation (-0.5 to -0.8) with forest fraction
- Positive correlation (0.2-0.6) with snow depth over non-forested areas
- Strong positive (0.7-0.9) day-to-day autocorrelation





Forest fraction vs snow fraction



Further Enhancements of Reflectance-based Approach

- Improved characterization of end-members
  - Location-dependent or surface-type-dependent values
  - Improved angular anisotropy parameterization of endmembers
- Testing multi-endmember multispectral approach
  - Add shadows as a separate land surface category besides snow and snow-free land
-

Advantages of NDSI-Based Snow Fraction

- The Normalized Snow Difference Index (NDSI) characterizes snow reflective properties: high snow reflectance in the visible wavelengths and low reflectance in the near infrared wavelengths
- NDSI is widely considered as an indicator of the presence of snow on the ground
- NDSI is sensitive enough to provide the snow fraction within a pixel of moderate resolution observations
- NDSI presenting relative ratio of reflectances to a large degree suppresses the influence of varying illumination conditions

Role of Changes in Endmembers

- The quality of snow cover information provided by remote sensing varies from region to region as well as from day to day depending on

  - snow and background surface types

  - the geometry of satellite observations

  - the state of the atmosphere

- Observed changes in pixel reflectances should not be ascribed exclusively to variable fraction, because they depends also on local variability in spectral signatures of the endmembers

- Allowing for local variability in spectral signatures of endmembers within a scene is a key requirement to snow algorithms

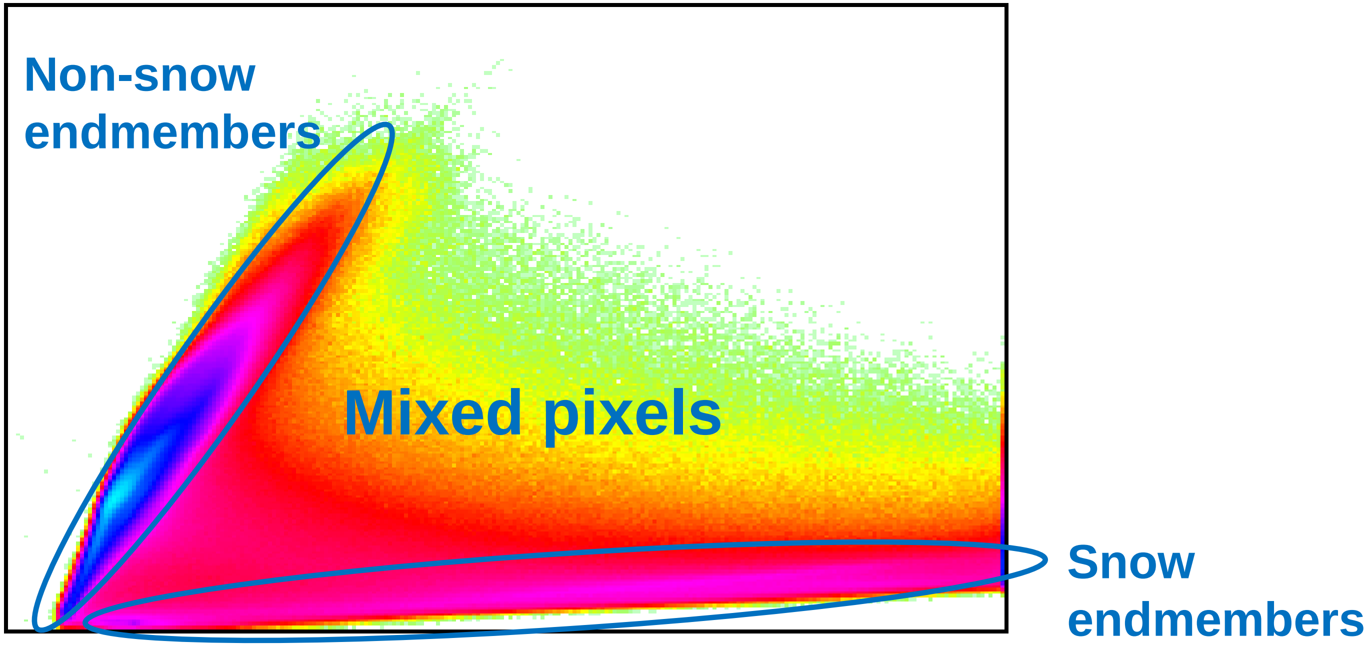
NDSI variability

VIIRS observations	NDSI		
Location	**Snow**	**Non-snow**	**50% fraction**
Beijing	0.70	-0.05	0.46
Altay	0.92	-0.12	0.59
Xinjiang 1	0.92	-0.20	0.52
Xinjiang 2	0.87	-0.25	0.42
Nevada	0.71	-0.23	0.31
Sierra	0.71	-0.18	0.31
Tian Shan	0.90	0.03	0.65
W Mongolia	0.92	0.10	0.61
Gobi	0.92	0.05	0.61
Pakistan	0.83	-0.37	0.16
S Mongolia	0.89	0.21	0.59
Dakotas	0.83	0.38	0.66
Spokane	0.93	-0.30	0.58
Oregon	0.91	-0.18	0.61
N Afghanistan	0.71	-0.23	0.37
C Afghanistan	0.79	-0.16	0.49
Average	0.84	-0.09	0.50

Reflectance variability

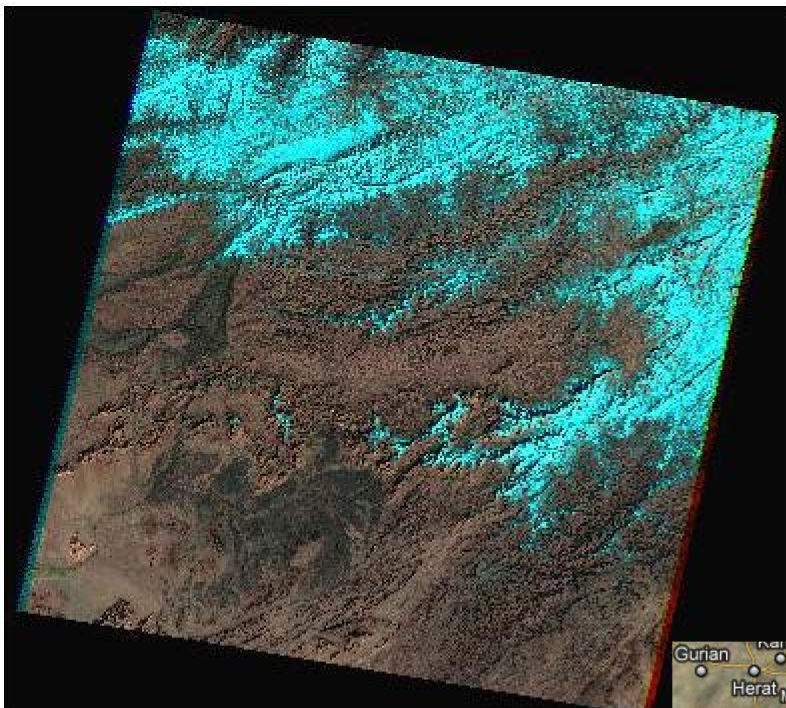
VIIRS observations	Snow reflectance (%)		Non-snow reflectance %	
Location	**Visible**	Near Infrared	**Visible**	Near Infrared
Beijing	39	7	10	11
Altay	72	3	15	19
Xinjiang 1	69	3	16	24
Xinjiang 2	71	5	19	32
Nevada	35	6	12	19
Sierra	35	6	14	20
Tian Shan	73	4	16	15
W Mongolia	69	3	23	19
Gobi	73	3	22	20
Pakistan	53	5	23	50
S Mongolia	71	4	35	23
Dakotas	65	6	29	13
Spokane	55	2	8	15
Oregon	43	2	7	10
N Afghanistan	47	8	12	19
C Afghanistan	60	7	13	18

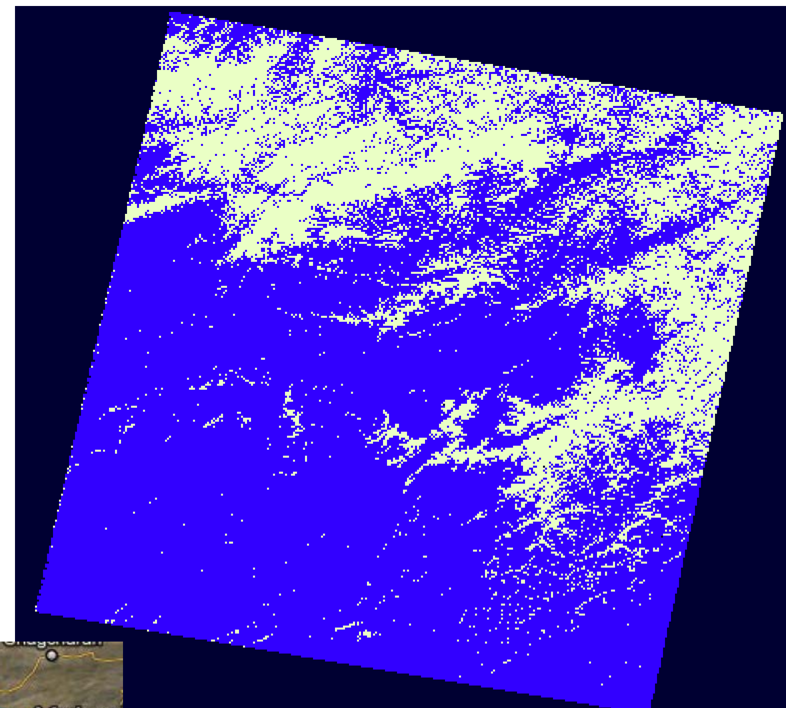
Variability of snow & non-snow reflectances (within a scene)



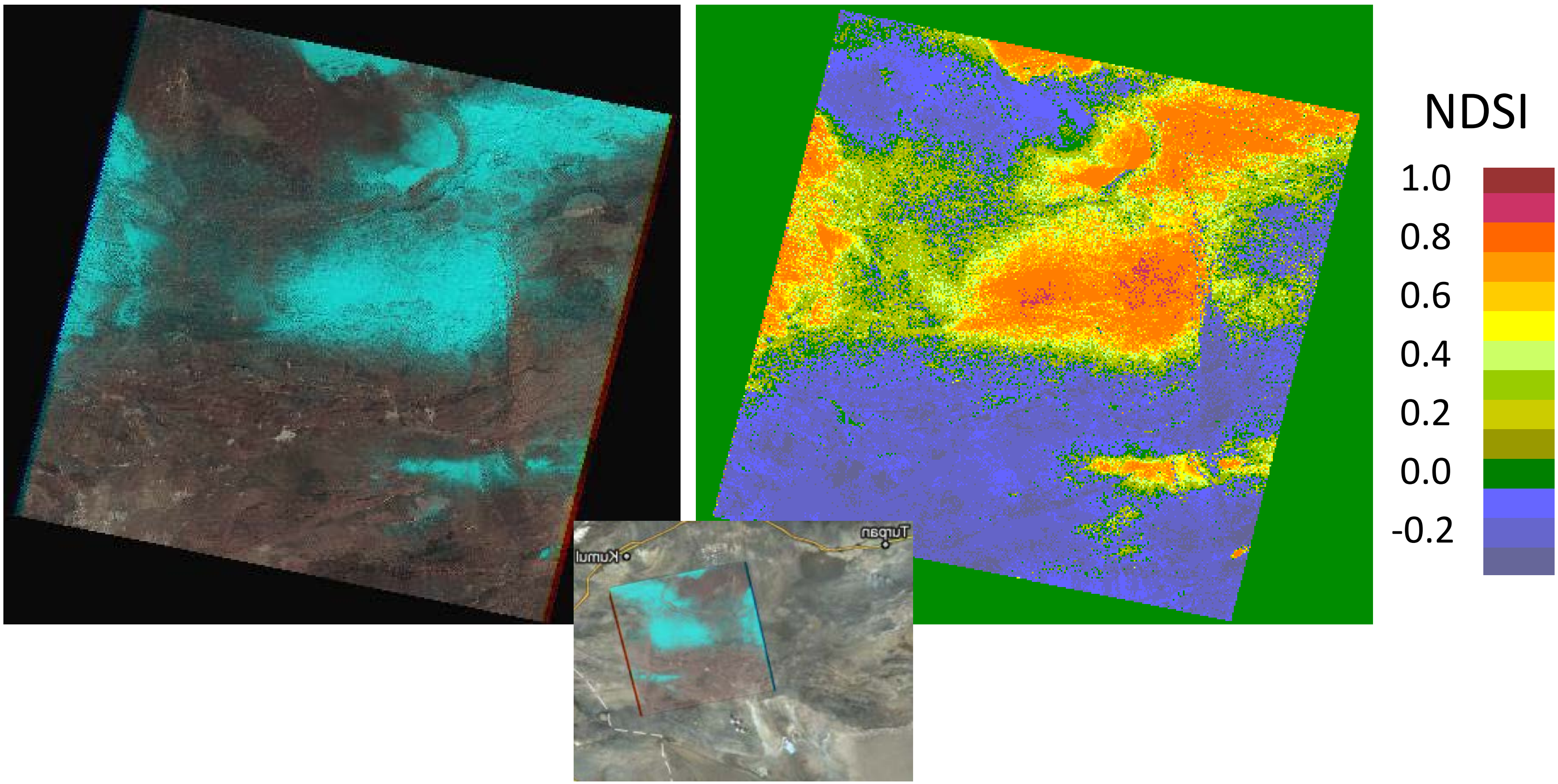
The simplest case of a two-dimensional histogram presenting the joint probability densities for Landsat band 2 (X axis) corresponding to VIIRS band M5 (0.64 µm) and Landsat 5 (Y axis) corresponding to VIIRS band M10 (1.61µm) illustrates significant variability in reflections characterizing snow and non-snow endmembers

Landsas false color image and pixel classification (Afghanistan)

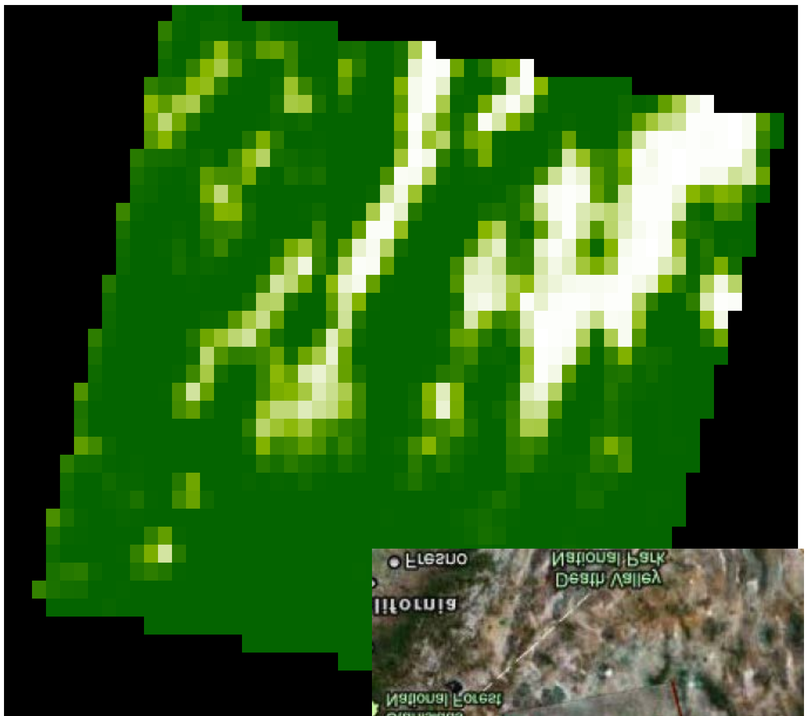


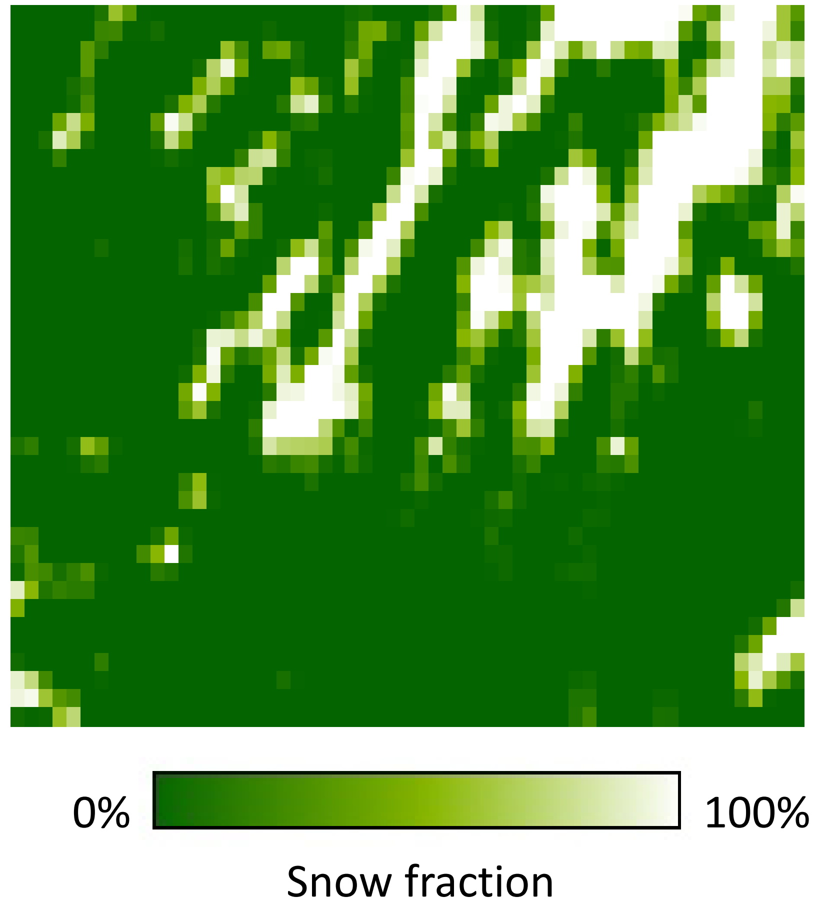


Landsat false color image and NDSI map (Xinjiang, W China)



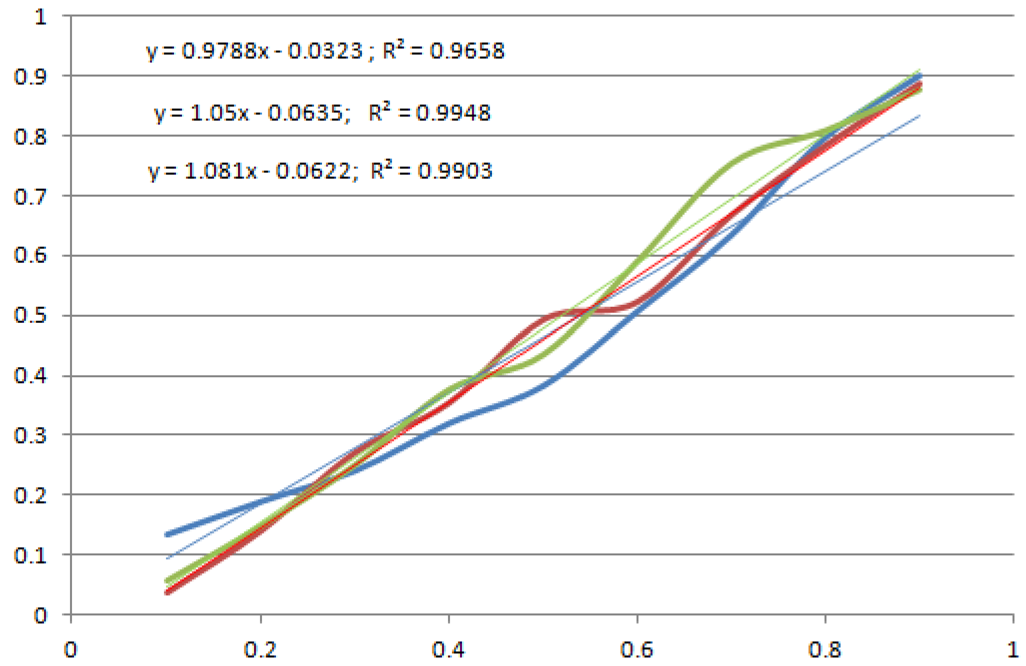
True and VIIRS snow fraction at 5 km resolution cells (Nevada)





Stratified Quantitative Assessment of NDSI-Based Algorithm Performance

Comparison of ground truth with NDSI algorithm results (thick lines) and trends (thin lines) for intermediate fractions demonstrates stratified performance for individual scenes



Validation of NDSI-based Snow Fraction

Corr. Coeff	Inter-cept	Slope	Mean true	Mean VIIRS	Location
0.84	-0.14	1.08	0.20	0.08	Beijing
0.89	-0.12	0.98	0.40	0.27	Altay
0.92	-0.14	1.10	0.61	0.53	Xinjiang 1
0.95	-0.03	1.00	0.20	0.17	Xinjiang 2
0.96	0.01	1.06	0.20	0.22	Nevada
0.96	-0.01	1.11	0.07	0.07	Sierra
0.92	-0.05	1.09	0.68	0.68	Tian Shan
0.91	-0.16	1.09	0.52	0.60	W Mongolia
0.89	-0.12	0.98	0.35	0.22	Gobi
0.74	-0.01	0.62	0.05	0.02	Pakistan
0.88	-0.07	1.09	0.92	0.93	S Mongolia
0.84	0.33	0.72	0.80	0.91	Dakotas
0.95	-0.00	1.07	0.19	0.20	Spokane
0.88	0.06	1.20	0.21	0.32	Oregon
0.95	-0.01	1.07	0.09	0.09	N Afghanistan
0.93	-0.06	1.17	0.27	0.25	C Afghanistan

NDSI-based Approach: Conclusions

- The optimal approach to improve moderate resolution remote sensing information on snow fraction allows the variability of local snow and non-snow properties
- Reliable evaluation of the VIIRS fractional snow algorithm quality is based on using Landsat scenes covering a wide variety of snow conditions, first of all, the areas including both snow and snow free surfaces
- Preliminary results of validation demonstrate that NDSI-based retrieval of snow fraction meets uncertainty requirements
- A scene-specific snow algorithm creates unbiased and consistent information on fractional snow cover distribution required for global studies, regional and local scale applications (including hydrological)

Further Enhancements of NDSI-based Approach

- It is necessary to explore and improve the quality of the following Look Up Tables
  - » NDSI LUT used to estimate scene-specific snow and non-snow NDSI (parameters of processed histograms)
  - » Cloud conditions LUT (cloud shadow, cloud confidence used for snow retrieval)
  - » Exclusion LUT defining conditions when snow fraction is not retrieved (dark pixels, climatic limitations)
- Investigate non-linear NDSI / snow fraction relationship
- Improve validation of the NDSI-based snow fraction for different scales, seasons, and conditions of observations
- Implement 250 m Land/Water mask
- Consider using cloud mask at imagery resolution

Reprocessing, Long-Term Monitoring

No plans for reprocessing so far

NDE long term product monitoring will include

- Generation global gridded snow fraction maps
- Visual examination of snow fraction estimates
- Comparison with Landsat
- Consistency testing

NOAA vs NASA Approach

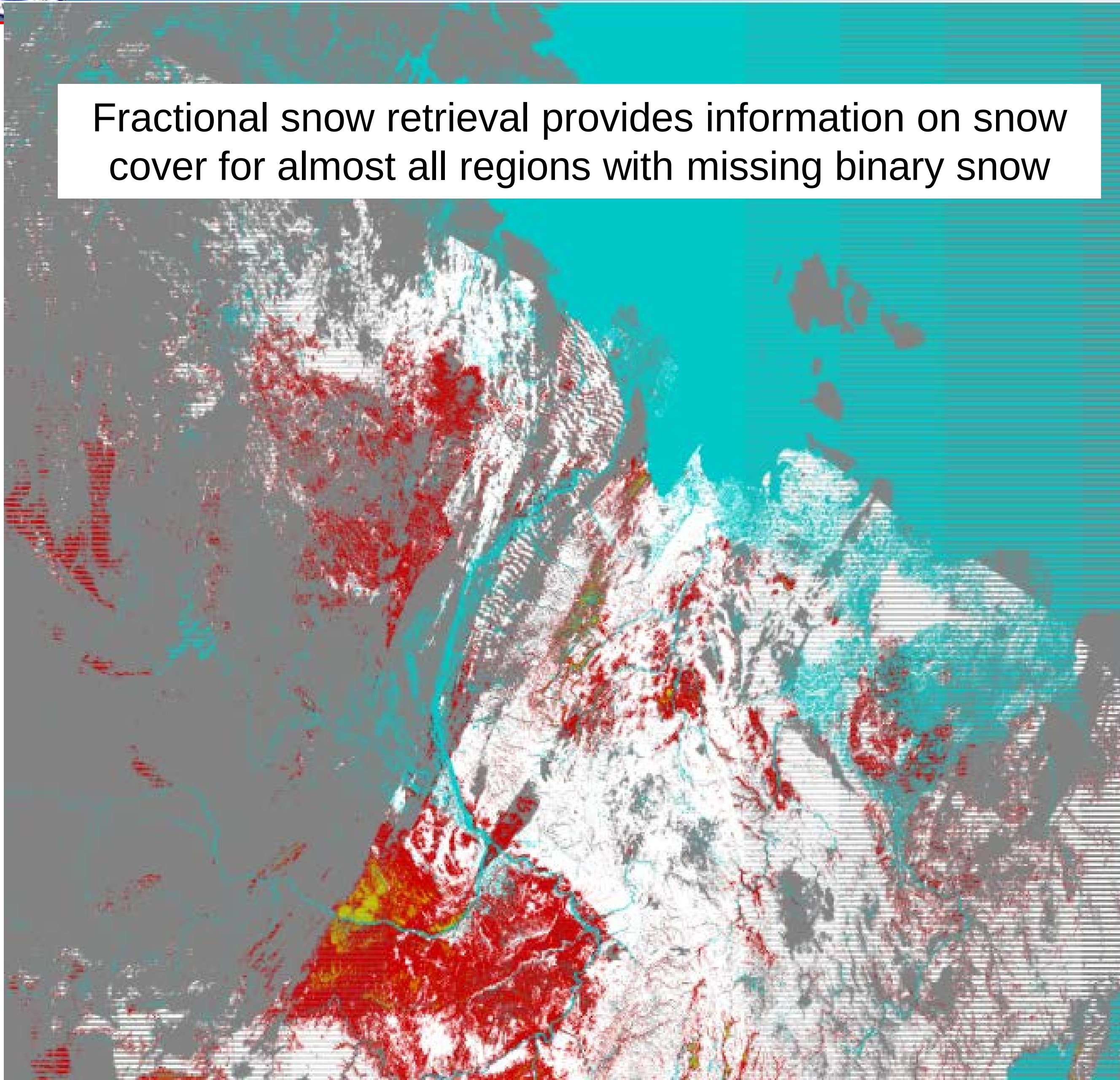
NASA:

- NDSI-based snow fraction

NOAA:

- Two snow fraction products

Snow Extent on 10/24/13 (03:20)



snow

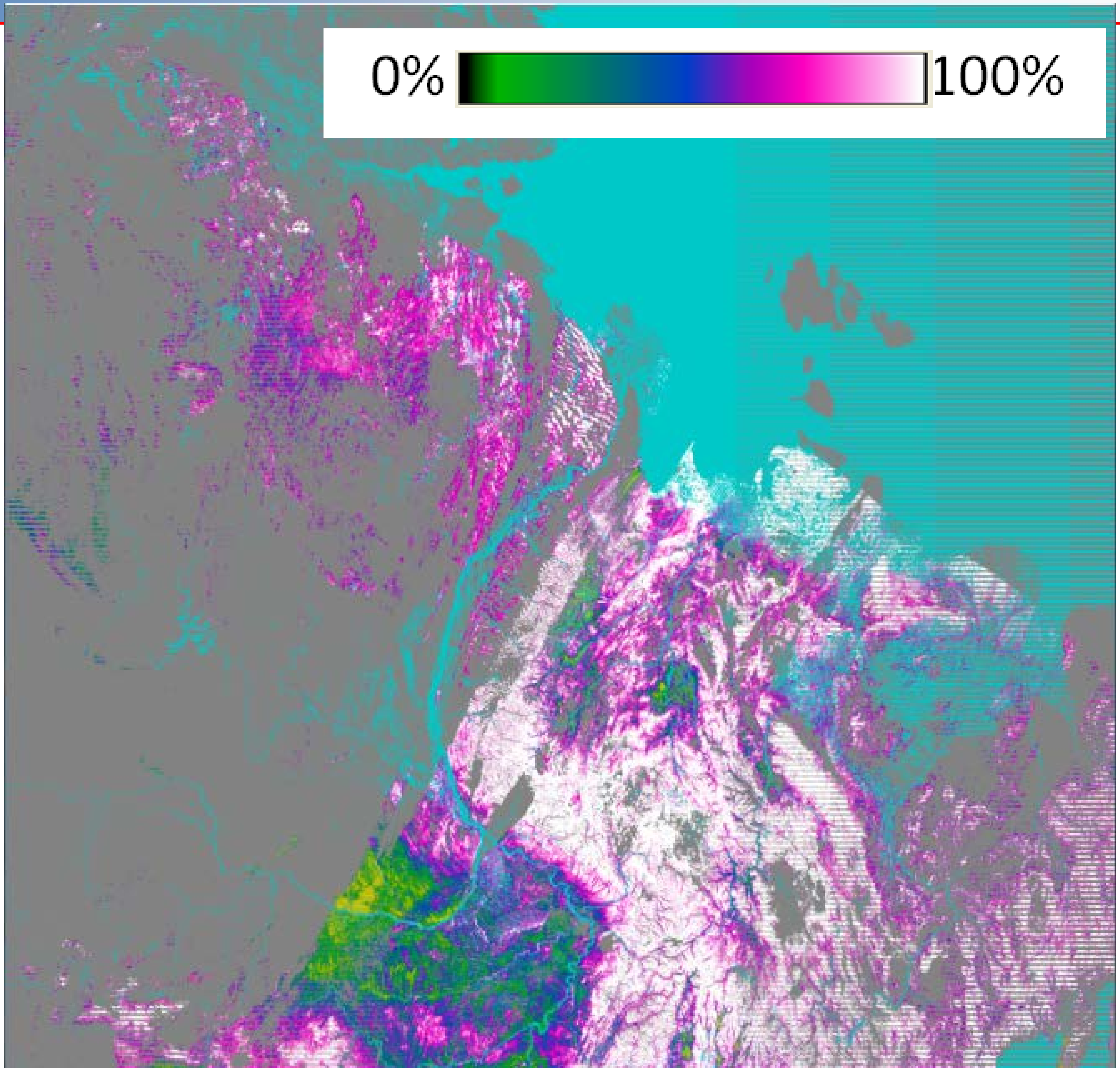
confidently cloudy

fractional snow cover in areas of non-snow binary retrieval

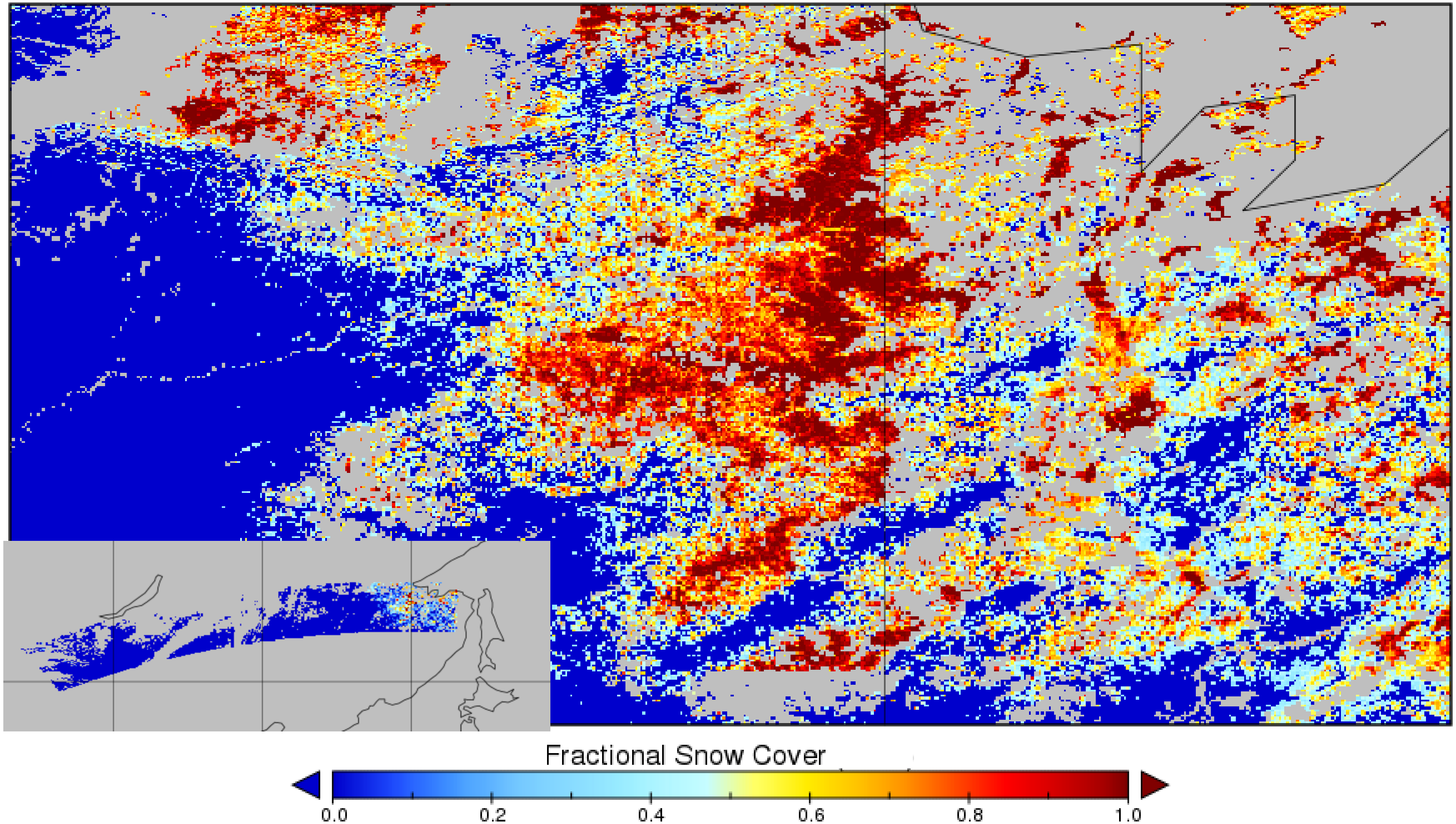
non-snow in binary and fractional retrievals

water

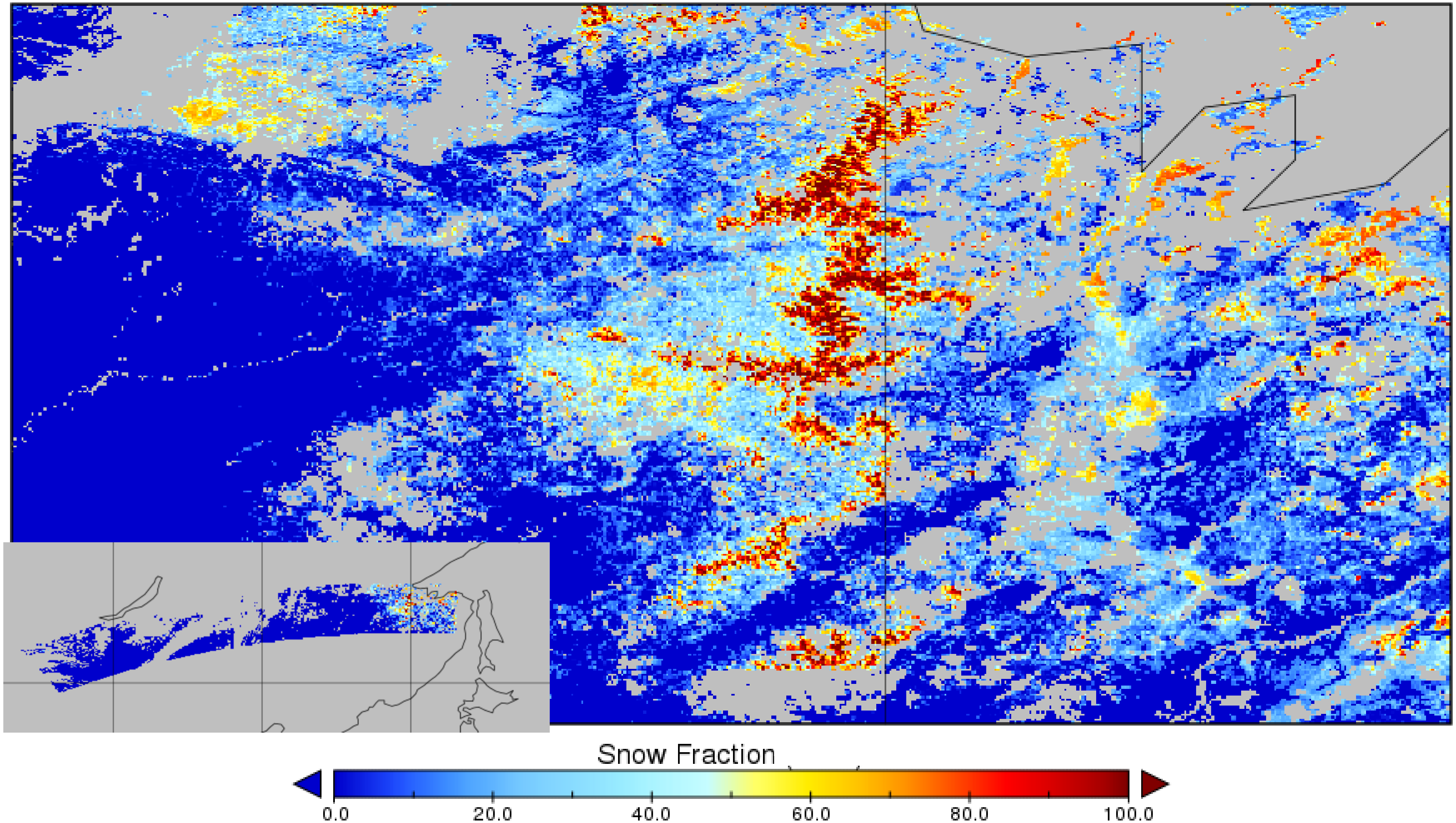
Snow Fraction on 10/24/13 (03:20)



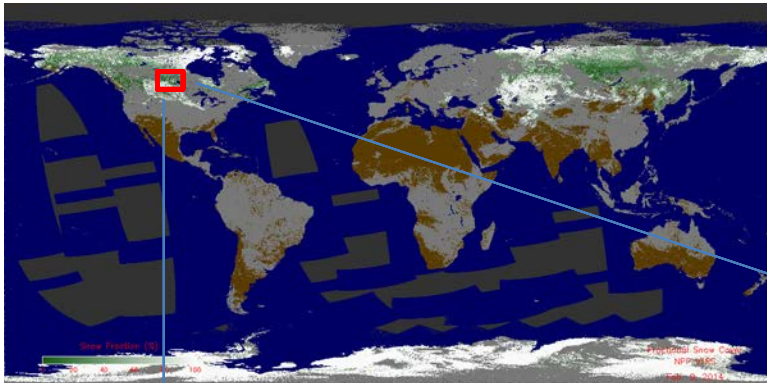
NDSI-based Snow Fraction (April 13, 2014)



Reflectance-based Fraction(April 13, 2014)

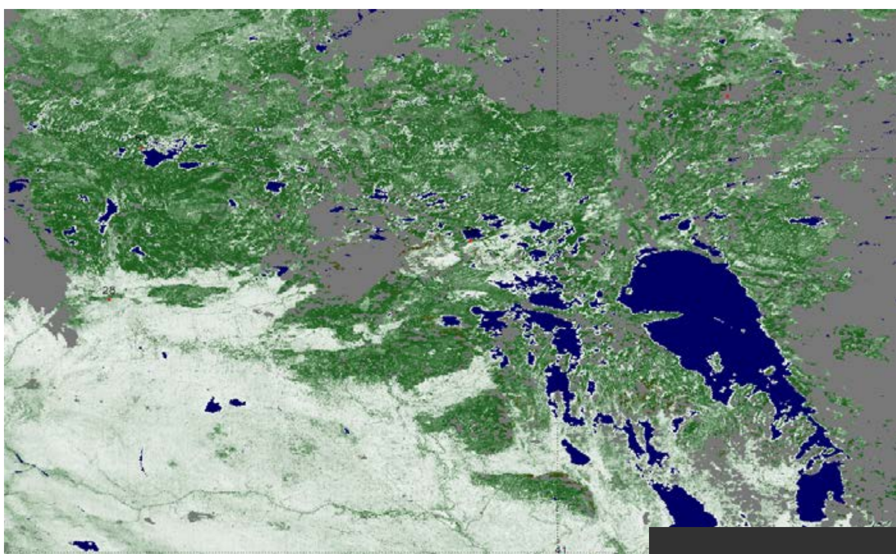


Reflectance-based vs NDSI-based Snow Fraction

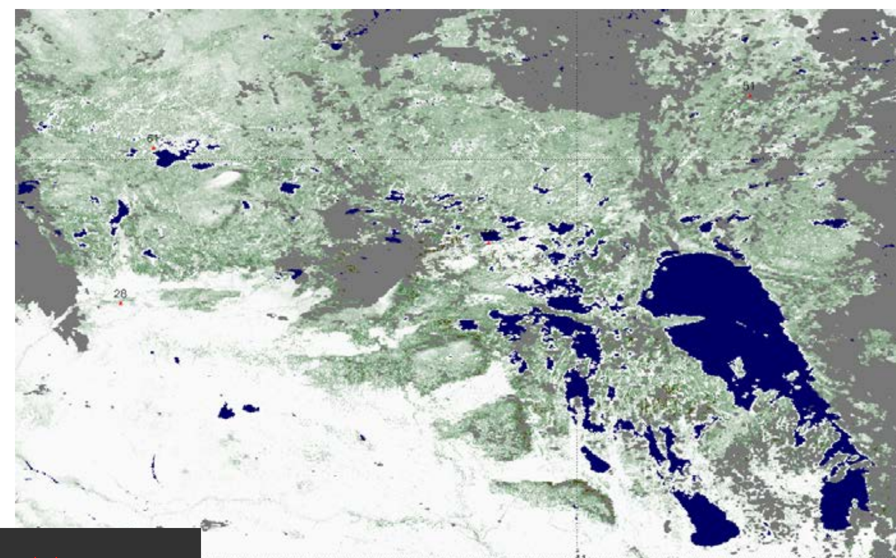


There is some similarity in the snow fraction patterns in the two products on the regional scale. NDSI-based snow fraction is much larger in the forest

Reflectance-based snow fraction

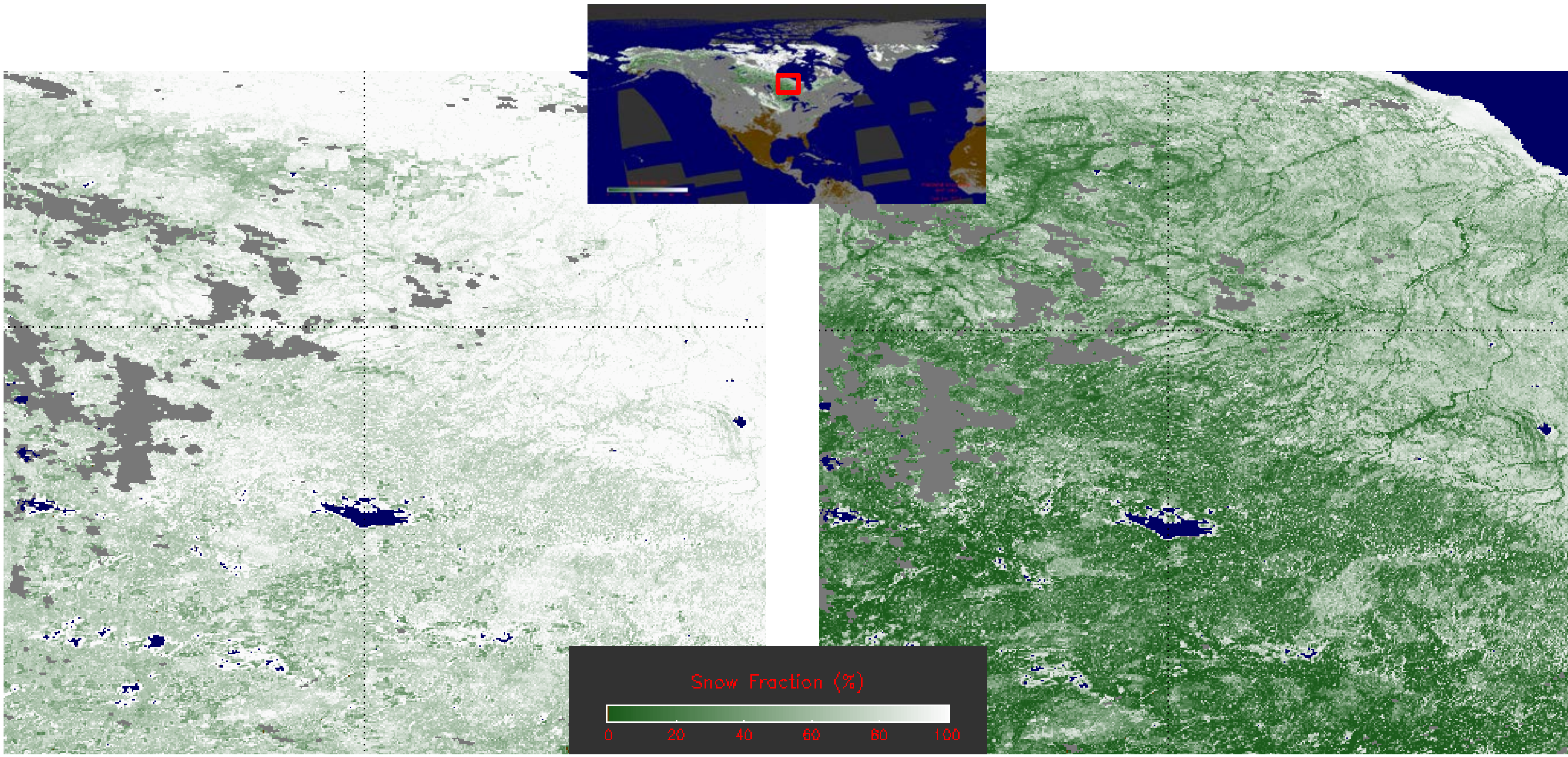


NDSI-based snow fraction



Clouds are shown in gray

Reflectance-based vs NDSI-based Snow Fraction



NDSI-based **Mean fraction: 83.4 %**

Reflectance-based **Mean fraction: 36.8 %**

Questions Requiring Special Consideration

Consistency between algorithms retrieving binary snow mask and fractional snow cover

- comparable physical bases and algorithm realizations
- strict definition of binary snow product meaning
- excluding possible contradictions between binary and fractional products

Consistency between alternative algorithms of fractional snow cover retrieval

- Comparable outputs of fractional snow cover retrievals
- Explainable and acceptable differences between fractional snow cover products provided by two algorithms
- Estimated risk related to the difference between two retrievals

NASA Land SIPS: Production and QA

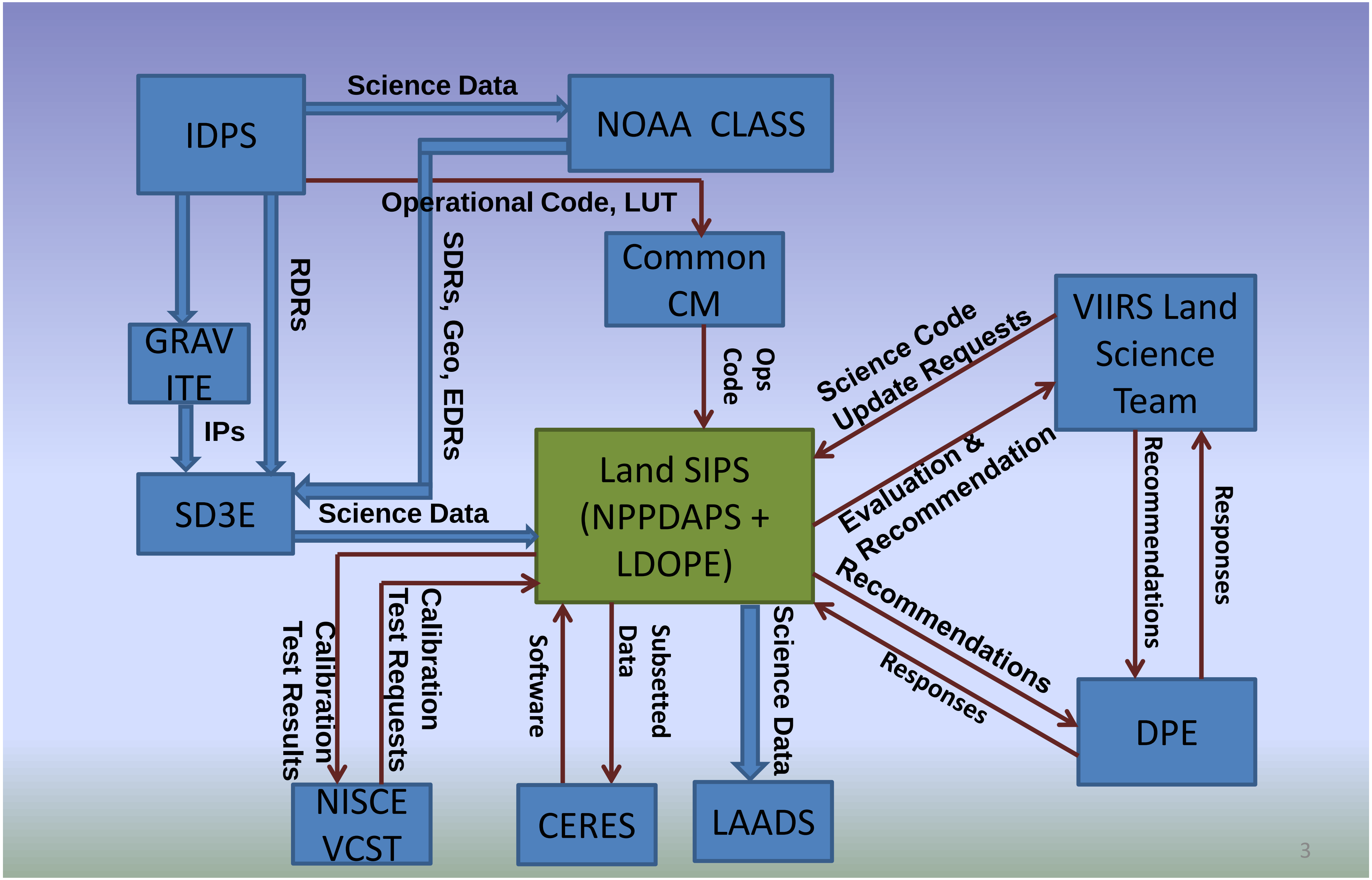
Sadashiva Devadiga[1,2], Carol Davidson[1,2], Gang Ye[1,2], Miguel Román[1], and Ed Masuoka[1]

[1]NASA Goddard Space Flight Center, [2]Science Systems and Applications Inc.

Land Science Investigator-led Processing System

- **Objective is to generate high quality land products from the VIIRS on-board S-NPP**
  - Extend the Earth System Data Records (ESDRs) developed from NASA's heritage Earth Observing System (EOS) Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the EOS Terra and Aqua satellites.
  - Generate land products using NASA science team delivered algorithms (beginning in December 2015) in combination with science algorithms currently in operation. Majority of NASA science algorithms will be in operation by December 2016.
  - Reprocess land data records from S-NPP mission as desired and recommended by the NASA science team using mature science algorithms provided by the NASA science team
  - Quality assessment performed at the Land Data Operational Product Evaluation (LDOPE) facility adopting the best-practices and tools used to assess the quality of heritage EOS-MODIS products generated at the MODIS Adaptive Processing System (MODAPS).

Land SIPS: Current Interface



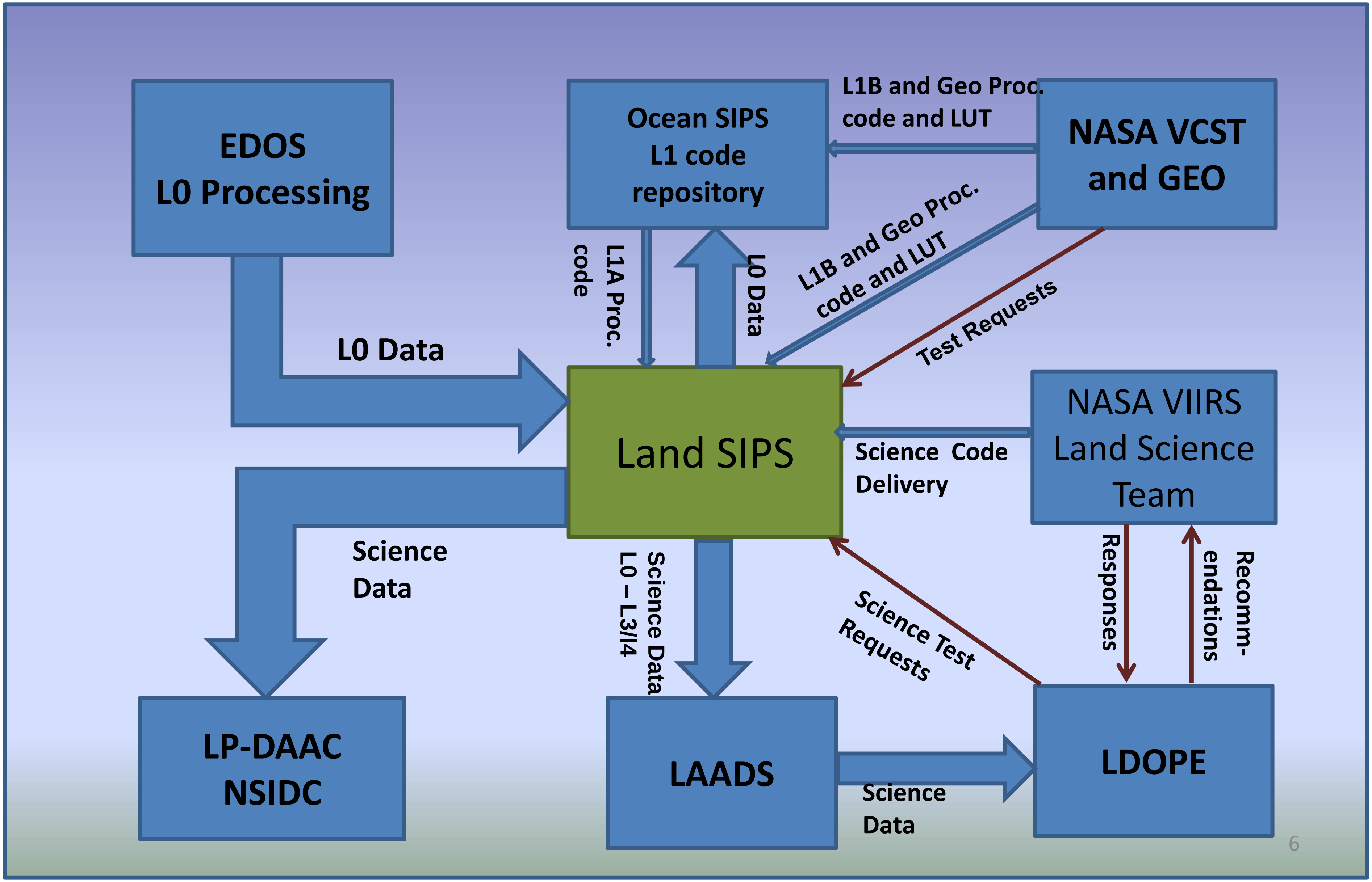
Land SIPS - Forward Processing Status

- **Land SIPS continues to receive and process VIIRS data. Data products are in HDF4 format, archived and distributed from LAADS** ***http://ladsweb.nascom.nasa.gov***
  - ***IDPS (LAADS AS 3000):*** Aggregate IDPS generated SDRs, Geolocation, EDRs and IPs from one global day (Saturday) every week. Data used to verify the accuracy of products produced in AS 3001. Build version in operation at IDPS is Mx8.10.
  - ***Land SIPS (LAADS AS 3001):*** Process RDRs using IDPS OPS PGEs integrated to Land SIPS processing system.
    - Leading edge is at current data day.
    - Cloud mask uses IDPS generated 17-day rolling tiles for RNDVI. GMASI based daily snow-ice tiles not ingested, instead tiles are generated in-house using daily NISE data.
    - Products match to aggregate IDPS products in AS 3000 except for minor differences in cloud mask and occasional differences from out of sync algorithm build versions and 17-day RNDVI roll up, ancillaries, and LUTs. Build version in operation is Mx8.10.
  - ***LPA (LAADS AS 3002):*** Process RDRs using Land SIPS adjusted version of IDPS OPS PGEs.
  - **Science team developed algorithms, Diagnostic Data Records (MODIS size gridded tiled products with VIIRS inputs) are generated from all three processing streams.**
- **Subsets are being generated from AS 3001 and 3002.**

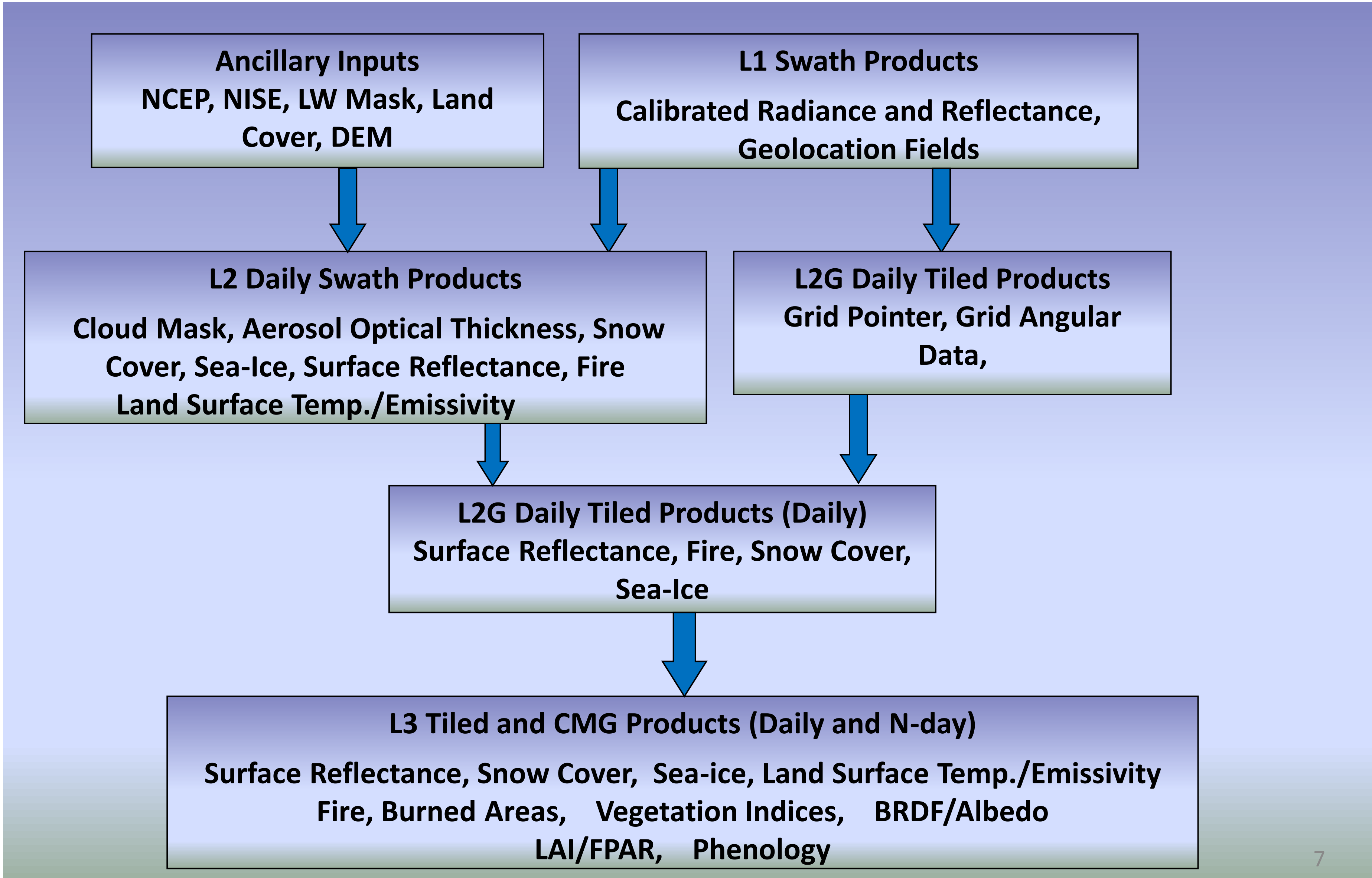
Land SIPS – C11 Reprocessing Status

- **C11 reprocessing in AS 3110 generates consistent records from the beginning of the mission using the best calibration LUT provided by NASA VCST and best of algorithms available.**
  - Reprocessing started on 2/26/2014 and completed on July 2014. Records start with the beginning data day 1/19/2012. Processing lags by one month waiting for delivery of LUT by VCST.
  - Cloud Mask uses the Climatology 16-day composite NDVI from the 4-years of Aqua MODIS observations and daily snow-ice from NISE data replacing the 17-day rolling tiles of NBAR-NDVI and the monthly/daily snow-ice rolling tiles used in the operational process at IDPS
  - DNBs are processed using the LUT for calibration and stray light correction provided by the NASA VCST.
  - Processing uses the Land SIPS Adjusted variations of OPS PGEs for TC DNB Geolocation (DNFT), L2 LSR (SR-IP), L2 VI (VRVI) and L2 Aerosols (AOTIP).
  - Land SIPS processes the Science DDRs using the latest version of the DDR algorithms based on MODIS C5 operational PGEs and the CERES subsetter.
  - This reprocessing does not generate the OPS L2 Land Albedo, Surface Albedo or any GIPs, and does not use rolling tiles.

Land SIPS: Operational Interface



Land SIPS - VIIRS Data Product Hierarchy



Land SIPS - VIIRS Data Production

- VIIRS L1 and L2 swath products are generated from processing of the VIIRS data acquired during 6 minutes of the satellite overpass.

- The L2G, L3 and L4 products are produced as adjacent non-overlapping tiles of approximately 10 degrees square, (at the equator)

- L2G product is a data structure storing the L2 observations intersecting the grid cell in a map projection. L2G heavy format stores all observations that meets the threshold criteria for the observation foot print coverage with the grid cell, L2G-lite format stores only one observation from an orbit. First observation is stored in a 2D array and the additional observations from all grid cells are stored in a 1-D array.

- The MODIS land gridded products are produced at 4 resolutions (500m, 1km, and 0.05 degree), and in 3 projections (Sinusoidal, Lambert Azimuthal Equal-Area, and Geographic). The simple Geographic lat/lon projection is only used for the coarsest resolution grid, produced at 0.05 km (~ 5.5 km), which is referred to as the Climate Modeling Grid (CMG). Most of the higher resolution VIIRS land products are produced in the Sinusoidal tile grid, except for the Sea Ice products, which are produced in the polar Lambert Azimuthal Equal-Area tile grids.

Land SIPS - Transition

- **The L0 dataflow from EDOS is currently under testing. The Operational Readiness Review (ORR) for EDOS is scheduled for Sept 14, 2015. Expected to be operational by early October.**
- **NASA L1A/L1B/Geo expected to be operational at Land SIPS by early October 2015.**
- **New Land SIPS Processing stream is currently in development. Expected to be operational in December 2015, generating land products using the NASA science team delivered algorithms and "best-of" science algorithms currently in operation.**
  - C11 reprocessing in AS 3110 will continue until NASA ST and SIPS is ready for the next collection reprocessing using the NASA L1B data and NASA Science Team delivered algorithms.
  - AS 3001 and 3002 will be replaced with a single forward processing stream in AS 300X containing best of the algorithms from the two processing streams, using IDPS delivered RDRs through SD3E.
  - In parallel to this forward processing in AS 300X, Land SIPS will develop the new SIPS processing stream (in AS 500x) that would generate the NASA VIIRS land products using the NASA ST delivered algorithms using the NASA L1B as input. This NASA processing stream, when fully functional could replace AS 300X.

Land SIPS – IDPS vs SIPS Products

- **L1B and Geo:** Aside from differences in format, when the same LUTs are configured and all data is converted to a common floating point radiance data type, there is no significant difference between the L1B and SDR products.
- **Upstream Products**
  - SIPS will use the **C11 approach to Cloud Mask**. Cloud Mask from Atmosphere SIPS could be also considered if available.
  - SIPS will use the Mx8.10 build of **IDPS for AOTIP** with recommended changes from the NASA SR science team.
- Science Processing algorithm for **Surface Reflectance and Fire** algorithm will be nearly the same as operational IDPS.
  - Code Changes to SR at Land SIPS will be delivered to STAR/AIT for implementation and testing in ADL and delivery to DPE for use in operational processing at IDPS.
- **Land Surface Temperature** will use the IDPS operational algorithm until an emissivity based algorithm is delivered by the NASA science team.

Land SIPS – VIIRS Land Products

Product Name	VIIRS (S-NPP) ESDTs	MODIS Heritage ESDTs	VIIRS (S-NPP) (Product release date: Tentative)
Land Surface Reflectance	VNP09	MxD09	DEC 2015
MAIAC Product Suite *	VNP19	MCD19	JUL 2016
BRDF/Albedo, NBAR	VNP43	MCD43	MAR 2016
Land Surface Temperature	VNP21	MxD21	DEC 2016
Vegetation Indices (VI)	VNP13	MxD13	JAN 2016
FPAR	VNP15	MxD15	JUN 2016
Fire and Thermal Anomalies	VNP14	MxD14	MAR 2016
Burned Area	VNP64A1	MCD64A1	DEC 2016
Snow Cover	VNP10	MxD10	MAR 2016
Sea Ice Cover	VNP29	MxD29	NOV 2016
Ice Surface Temperature	VNP30	MxD10	NOV 2016
Land Surface Phenology	VNP12Q2	MCD12Q2	APR 2017

** Includes surface reflectance, BRDF, snow fraction and aerosol retrievals over Land*

Land Product Quality Assessment and Algorithm Evaluation

- **Adopts the MODIS Land QA approach to assess quality of VIIRS products.**
  - Global browses, golden tiles browses, animation, time series
  - Visual inspection of browse images and analysis of selected sample data records
- **Verify reproducibility of IDPS products at Land SIPS.**
  - Through comparison of global browse images of Land SIPS generated products to IDPS aggregated products in AS 3000
  - Accuracy, Precision and Uncertainty estimate from comparison of full resolution data records from the two archive sets.
- **Assessment of VIIRS Land Algorithm Changes**
  - PGE specific science test and chain tests run generating global data
  - Baseline and Test data created for comparison of different algorithm versions, LUTs, Seed Files etc.
  - Comparison to heritage MODIS products
- **QA information posted on the QA web page**
  - Results from all QA processes (browses, time series, APU etc.)
  - Known issues from operational product evaluation
  - Algorithm test status and evaluation results
- **QA tools developed and maintained by LDOPE**
  - Generic and transparent to products from different instruments
  - All operational QA processes automated to process data in real time with production and populate result on the QA web page.

Land SIPS - QA Web Page

National Aeronautics and Space Administration
Goddard Space Flight Center

Suomi NPP - Land Science Investigator-led Processing System
VIIRS Land Product Quality Assessment
Visible Infrared Imaging Radiometer Suite

Home | Browse | Time Series | Land Products | QA Info | Alg Updates/Eval | Links | Early Images

Welcome to the NPP VIIRS Land Product Quality Assessment

The objective of the VIIRS (Visible Infrared Imaging Radiometer Suite) Land Product QA is to evaluate and document the science quality of products made from the remotely sensed data acquired using VIIRS. Results of quality assessment of samples of VIIRS Land products made at Land SIPS (Science Investigator Processing System) and IDPS (Interface Data Processing System) and results of evaluation of improvements to the VIIRS Land Science algorithms derived by analyzing the products made at Land SIPS using the new algorithms are placed on the web pages located at this site.

The Suomi NPP (National Polar-orbiting Partnership) satellite was launched on Oct. 28, 2011. Evaluation of products from the IDPS OPS (Operation System) algorithms, and the Land SIPS adjusted version of the IDPS OPS algorithms run at Land SIPS and of the science algorithm improvements are done at LDOPE (Land Data Operational Product Evaluation). Results from LDOPE's evaluation of the pre-launch version of the IDPS algorithms done using simulated or proxy MODIS data and the results from the science test of changes to algorithm done post-launch using on-orbit data are posted on the Algorithm Updates/Evaluation section of this web page. This web page is constantly evolving. For global browse images from immediate post-launch period please click on the Brows menu at the top of this page. Please direct your questions and comments to Sadashiva Devadiga.

For more information about the VIIRS Land products, validation, and product maturity status, visit: http://viirsland.gsfc.nasa.gov/index.html

What's New

- Mx8.10 is now in operation at Land SIPS starting day 08/08/2015 (2015126). Click here for NPP version history.
- VIIRS xDR from the operational processing of on-orbit data at Land SIPS using the same algorithm version as IDPS is available from AS 3001 of LAADS and products from science team improved version of algorithms is available from AS 3002. Please see the Land SIPS data production and retention policy to verify availability of data online.
- SNPP VIIRS Land Records from C1.1 reprocessing using best of Calibration LUTs and science algorithms available from AS 3110. C1.1 reprocessing started 2/26/14. Reprocessing of December, 2014 started 1/20/15 and completed 2/5/15. This reprocessing lags operational processing by a month.
- Data products from the early mission period were labeled as of BETA quality. Many products have now reached maturity stage of "provisional quality" or "Validation Stage 1".

Goddard Space Flight Center

Responsible NASA Official : Edward Masuoka
Content Owner: Sadashiva Devadiga
Web Curator: Demi Feng

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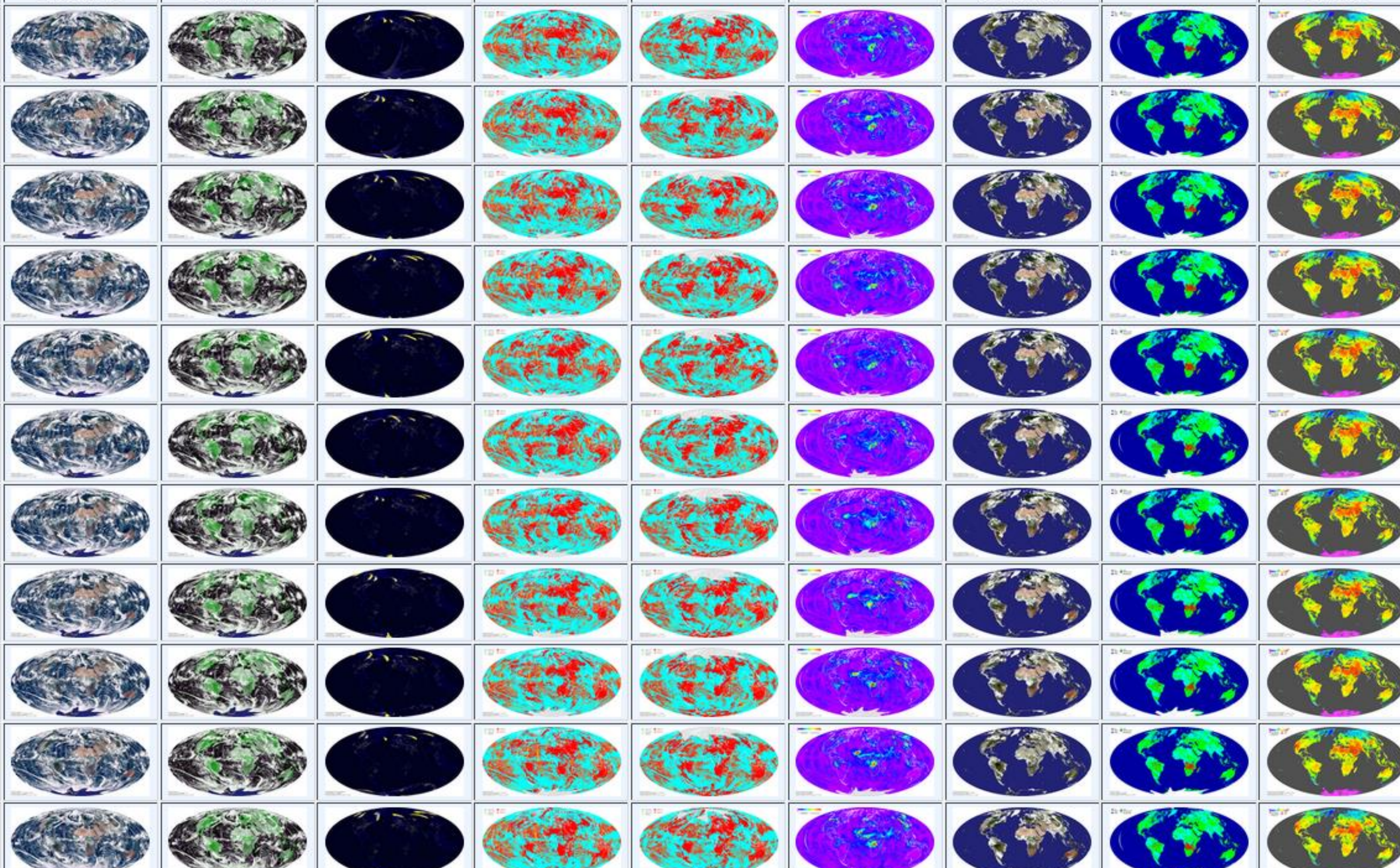
Contact Us

http://landweb.nascom.nasa.gov/NPP_QA/

Land Product Quality Assessment
Global Browse Images of Operational Products

Julian day		NPP_VMAE_L1 L1B Moderate input, Day Band 5,4,3	NPP_VIAE_L1 L1B Imagery input, Day Band 1,2,1	NPP_VDNE_L1 Night Band	NPP_CMIP_L2 Cloud Mask IP Day	NPP_CMIP_L2 Cloud Mask IP Night	NPP_VAOTIP_L2 Aerosol Optical Thickness IP	NPP_SRFLMIP_L2 Surface Re×ectance IP (Moderate)	NPP_VAFIP_L2 Active Fire IP	NPP_VLST_L2 Land Surface Temperature Daytime
2015 236 08/24	Orbits									
2015 235 08/23	Orbits									
2015 234 08/22	Orbits									
2015 233 08/21	Orbits									
2015 232 08/20	Orbits									
2015 231 08/19	Orbits									
2015 230 08/18	Orbits									
2015 229 08/17	Orbits									
2015 228 08/16	Orbits									
2015 227 08/15	Orbits									
2015 226 08/14	Orbits									



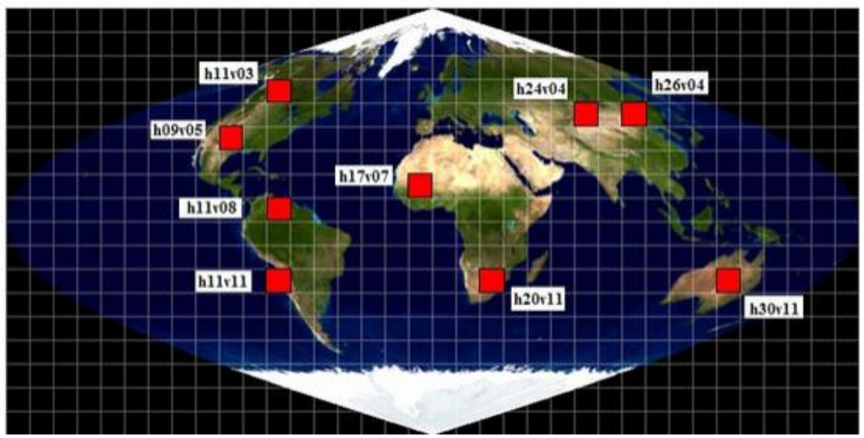
Land Product Quality Assessment
Golden Tile Time Series

NPP Time Series

A time series of summary statistics derived from all the gridded NPP Land products at a number of ×xed globally distributed locations is maintained and monitored by LDOPE personnel in order to enable synoptic quality assessment via the internet. Product time series analyses are important because they capture algorithm sensitivity to surface (e.g., vegetation phenology), atmospheric (e.g., aerosol loading) and remote sensing (e.g., sun-surface-sensor geometry) conditions that change temporally, and because they allow changes in the instrument characteristics and calibration to be examined. Time series statistics are extracted at nine NPP Land golden tiles selected over areas that are expected to be representative of the variability of the majority of the NPP Land products. Golden tile browse images are also available for the most recent month of production. Follow steps to examine time series plots. Click here for more information.

1.Select a data set: LPEATE 2.Select a product: NPP_D16VIHKM_L3D -16-day Vegetation Index

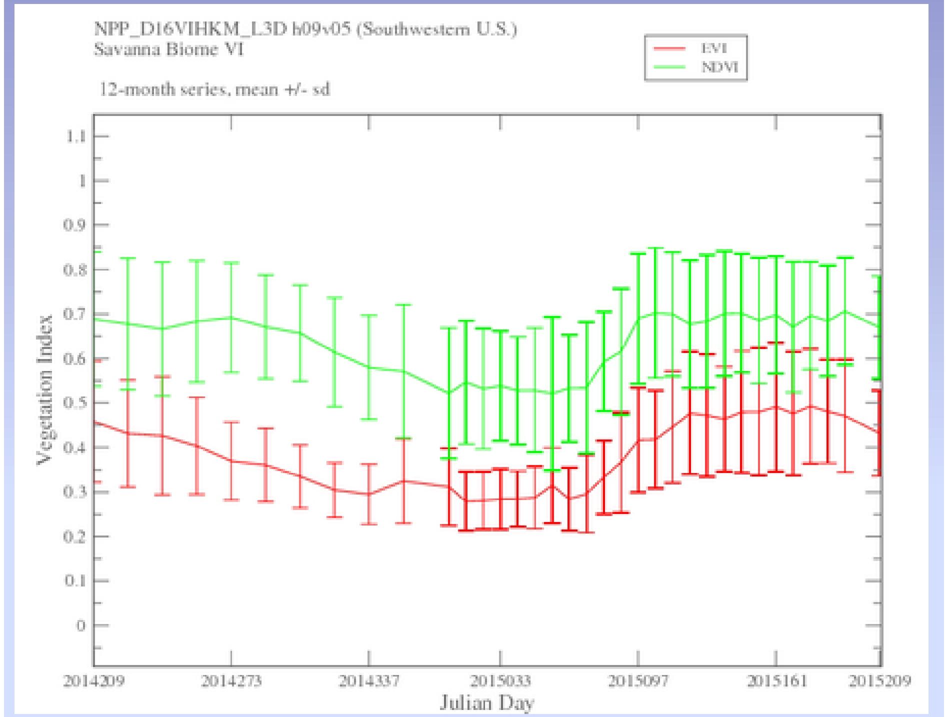
3.Click on a tile:

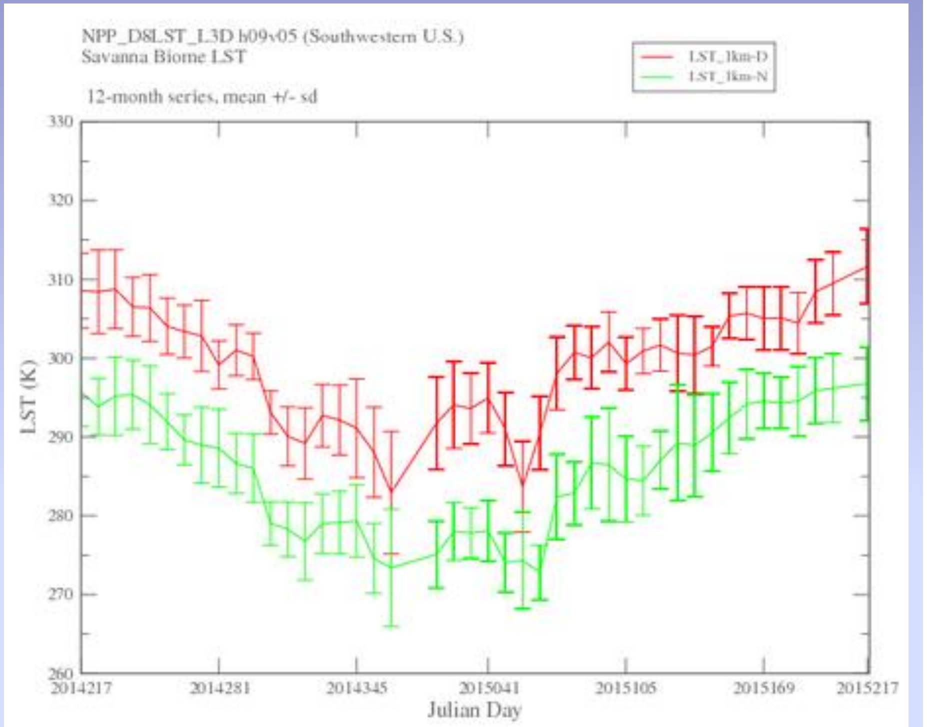


Plot Options: LPEATE, h09v05, NPP_D16VIHKM_L3D -16-day Vegetation Index

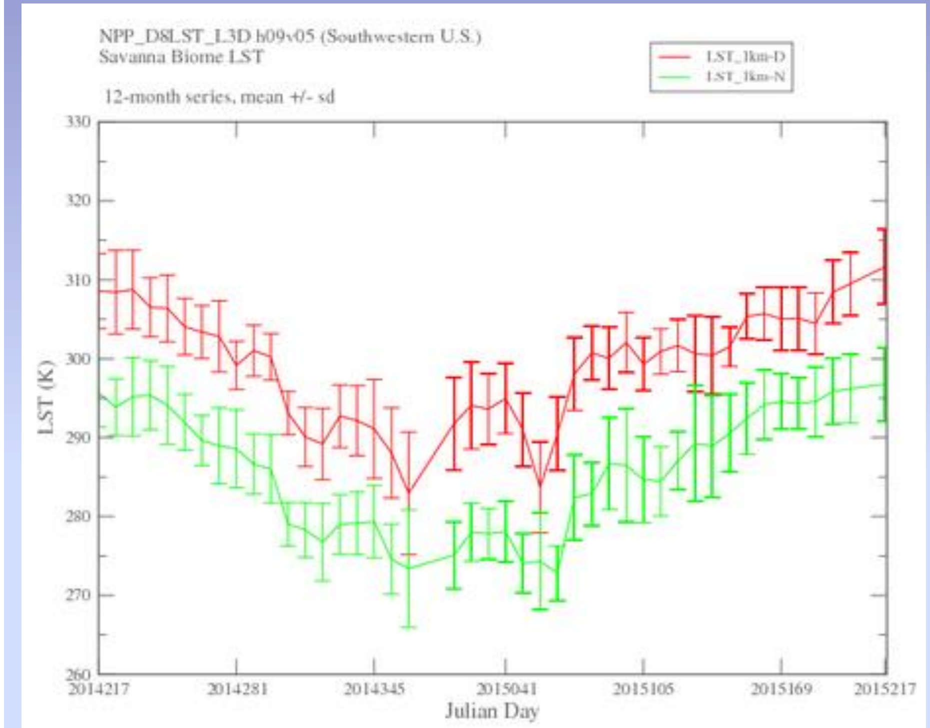
Biome	LandCover	Site
biome_1	land_cover_10	site_19 site_23
biome_2	land_cover_7	site_6 site_7 site_10
biome_3	land_cover_12	site_26 site_33
biome_4		site_18
biome_6	land_cover_1	
biome_7	land_cover_16	site_40 site_41 site_42

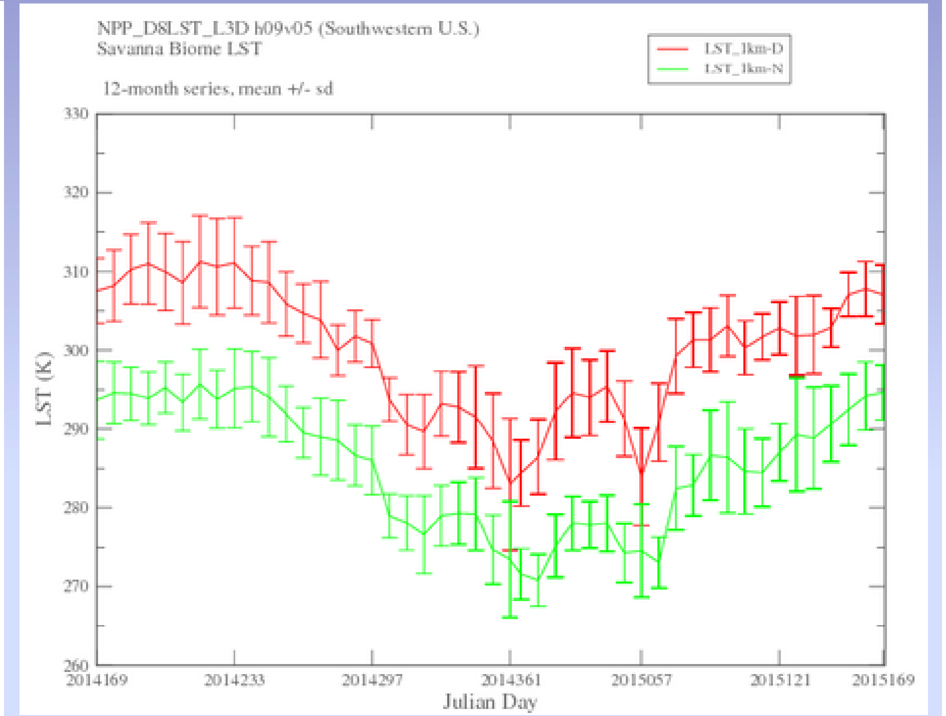
Land Product Quality Assessment
Golden Tile Time Series: LST Day



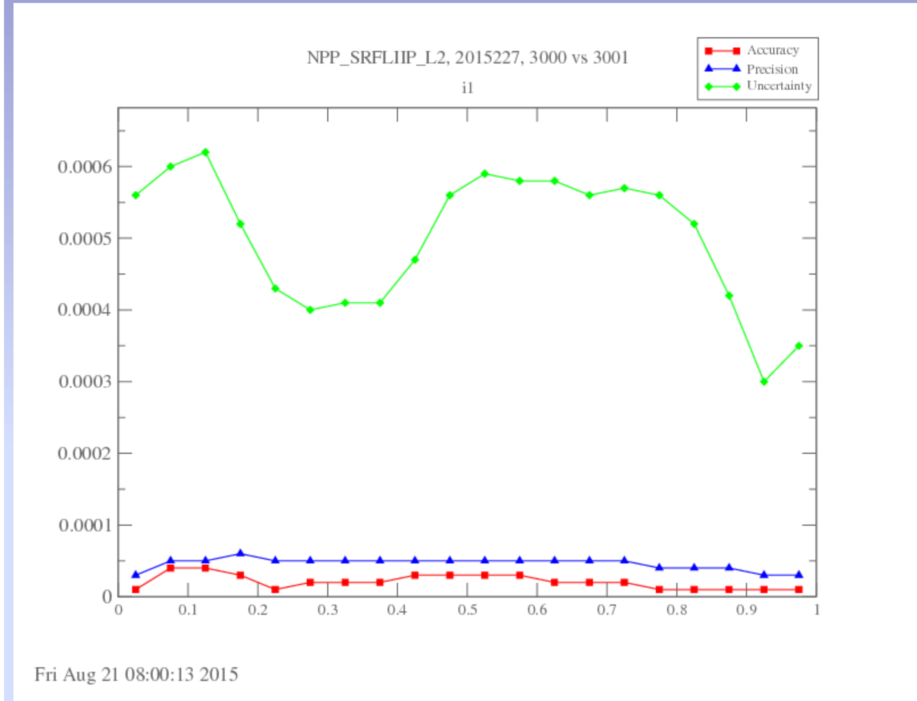


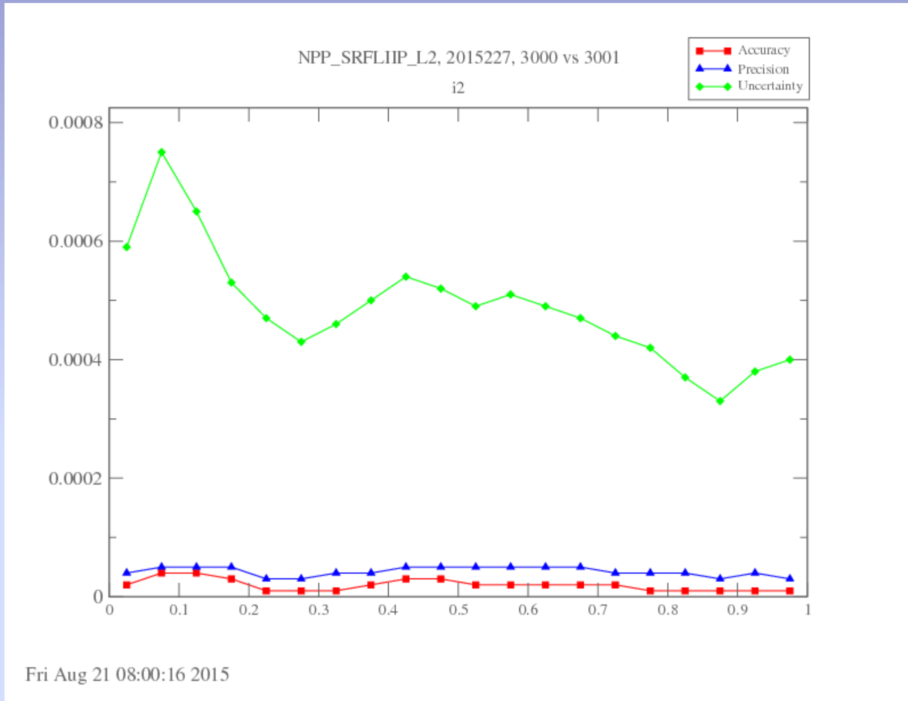
Land Product Quality Assessment
Golden Tile Time Series, LST: IDPS vs C11



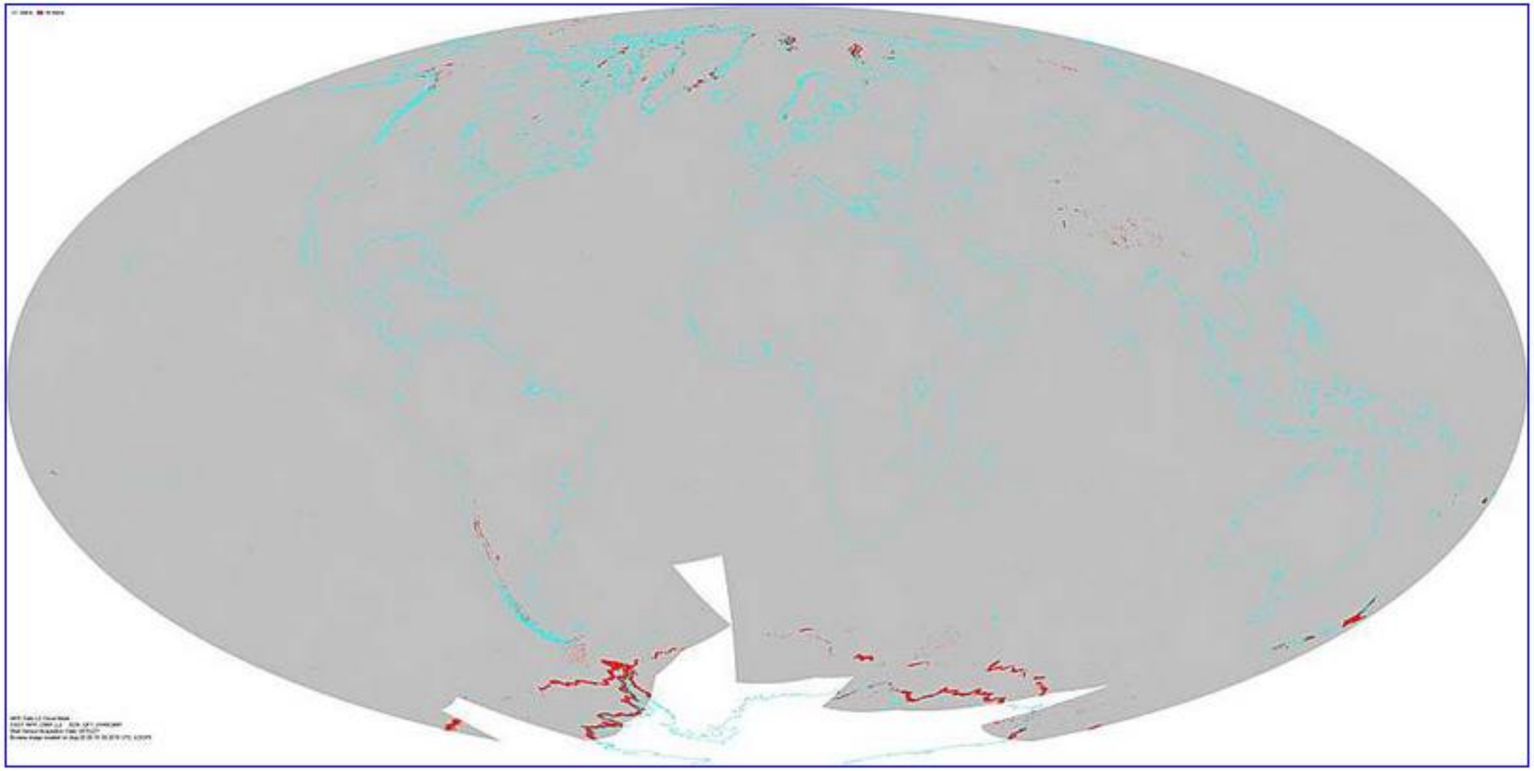


Land Product Quality Assessment
APU for Surface Reflectance : IDPS vs LSIPS





VCM QF1: IDPS diff LPEATE (Day 2015227)



Color Look Up: Match No Match

SDS	Total Match	Total Mismatch	Total Counts	Percent Match	Percent Mismatch
QF1_VIIRSCMIP	2410605463	25746301	2436351764	98.943244	1.056756
QF2_VIIRSCMIP	2430076970	6275030	2436352000	99.742442	0.257558
QF3_VIIRSCMIP	2423107005	13244995	2436352000	99.456360	0.543640
QF4_VIIRSCMIP	2426575211	9776789	2436352000	99.598712	0.401288
QF5_VIIRSCMIP	2436352000	0	2436352000	100.000000	0.000000
QF6_VIIRSCMIP	2427333469	9018531	2436352000	99.629835	0.370165

VCM: IDPS vs LPEATE (Day 2015227)

- **Statistics from comparison of cloud confidence in VCM_IP**

GranID		%Cloud	%Cloud_match	%Clear_Match	%Comm_Diff	%Omm_Diff
A2015227.0325	Australia - East	40.38	99.93	99.99	0.02	0.07
A2015227.0455	Antarctica	68.22	99.97	99.98	0.01	0.03
A2015227.0505	Australia - West	13.16	99.87	99.99	0.04	0.13
A2015227.0530	Northern Russia	60.56	99.88	99.84	0.10	0.12
A2015227.0535	Arctic	59.84	99.83	99.40	0.40	0.17
A2015227.0635	Antarctica	71.37	99.92	99.98	0.01	0.08
A2015227.0710	Northern Russia	63.70	99.99	99.98	0.01	0.01
A2015227.0715	Arctic	60.32	99.87	99.22	0.51	0.13
A2015227.1000	Antarctica	40.61	99.90	99.98	0.03	0.10
A2015227.1140	Antarctica	62.77	99.92	99.97	0.02	0.08
A2015227.1155	Africa - equitorial	40.71	99.99	100.00	0.00	0.01
A2015227.1200	Africa - Sahel	27.08	99.99	100.00	0.01	0.01
A2015227.1715	Canada - East	49.27	99.97	99.99	0.01	0.03
A2015227.1720	Canada - North	50.77	99.70	99.31	0.67	0.30
A2015227.1850	NA – Gulf of Mexico	38.26	99.96	99.99	0.02	0.04
A2015227.1855	Central NA	39.78	99.97	100.00	0.01	0.03
A2015227.1900	Canada - North	50.91	99.84	99.75	0.24	0.16

IDPS is used as reference
%Cloud = TotalCloudyPixels/TotalPixels
%CloudMatch = AllMatch/Total_Ref_Cloudy
%ClearMatch = AllClear/Total_Ref_Clear
%Comm = (TotalNumpixels where C1 is showing cloud and IDPS not)/TotalRefCloudy
%Omm = (TotalNumpixels where C1 is not showing cloud and IDPS is)/TotalRefCloudy

Conclusion

- **Land SIPS will soon generate VIIRS Land records using the NASA VIIRS L0 data.**
- **Land SIPS forward processing stream will generate high quality land products using NASA science team delivered algorithms or "best of" algorithms in current operations.**
- **C11 reprocessing will continue until Land SIPS is ready for another reprocessing.**
- **VIIRS L1 and L2 swath products are generated in 6 minute granules while the L2G, L3 and L4 products are produced as tiles of approximately 10 degrees square**
- **Products are distributed to public through assigned DAACs**

CEOS/WGCV/LPV 2015 Report: Validation Datasets and Interagency/International Coordination

Miguel Román (NASA/GSFC/JPSS)
Jaime Nickeson (NASA/GSFC/SSAI)
Gabriela Schaepman-Strub (University of Zurich)

Committee on Earth Observation Satellites (CEOS)
Working Group on Calibration and Validation (WGCV)
Land Product Validation (LPV)

2015 JPSS Annual Science Team Meeting: August 24-28, 2015

CEOS > WGCV > LPV

CEOS - Committee on Earth Observation Satellites

31 CEOS Members

24 Associate Members (eg UNEP, GTOS, IGBP, WMO, GCOS)

CEOS coordinates civil space-based observations of the Earth

This is achieved through its working groups and virtual constellations. The **Working Group on Calibration and Validation (WGCV)** is one of 5 CEOS working groups.

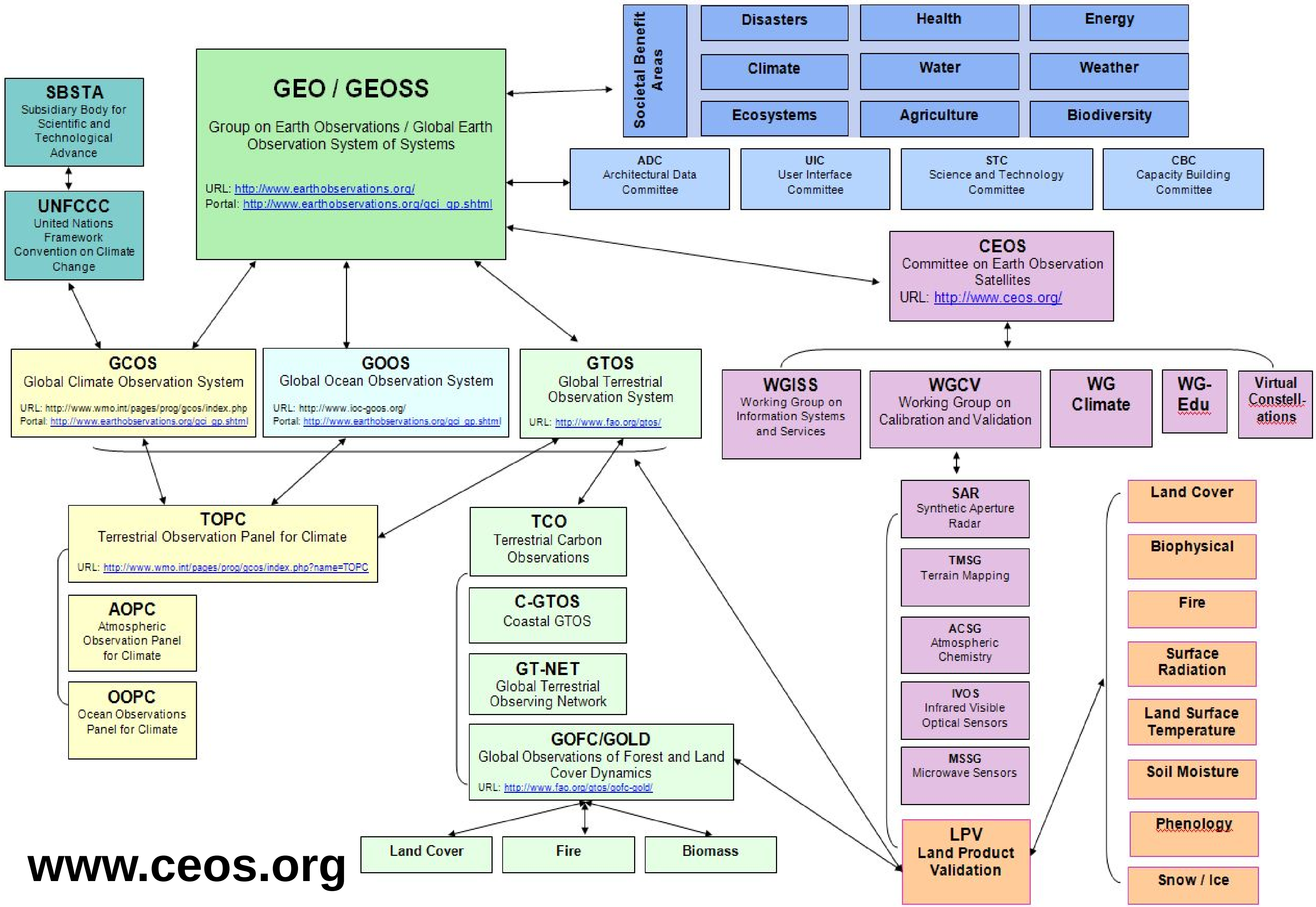
Land Product Validation (LPV) is one of 6 WGCV subgroups

Current LPV Officers

Chair	Gabriela Schaepman-Strub	University of Zurich
Vice-Chair	Miguel Román	NASA/GFSC/JPSS
LPV Support	Jaime Nickeson	NASA/GSFC/SSAI

9 Focus Areas with 2 co-leads each

Linkages between International Programs concerned with Terrestrial Earth Observation



www.ceos.org

CEOS WORKING GROUP ON CALIBRATION & VALIDATION

Land Product Validation Subgroup Objectives

1. To **foster and coordinate quantitative validation** of higher level global land products derived from remotely sensed data, in a traceable way, and to relay results to users.

2. To increase the quality and efficiency of global satellite product validation by developing and promoting **international standards and protocols** for
    - **Field sampling**
    - **Scaling techniques**
    - **Accuracy reporting**
    - **Data and information exchange**

3. To provide **feedback to international structures** for
    - Requirements on product accuracy and quality assurance
    - Terrestrial ECV measurement standards
    - Definitions for future missions

Focus Areas and Co-leaders

* ECV

Product	North America	EU / China
Snow Cover (T5)*, **Sea Ice**	Thomas Nagler (ENVEO, Austria)	Tao Che (Chinese Academy of Sciences)
Surface Radiation (Reflectance, BRDF, Albedo [T8]*)	Crystal Schaaf (U. Massachusetts Boston)	Alessio Lattanzio (EUMETSAT)
Land Cover (T9)*	Pontus Olofsson (Boston University)	Martin Herold (Wageningen University, NL)
FAPAR (T10)*	Arturo Sanchez-Azofeifa (University of Alberta)	Nadine Gobron (JRC, IT)
Leaf Area Index (T11)*	Oliver Sonnentag (University of Montreal)	Stephen Plummer (Harwell, UK)
Fire (T13)* (Active Fire, Burned Area)	Luigi Boschetti (University of Idaho)	Kevin Tansey (University of Leicester, UK)
Land Surface Temperature (LST and Emissivity)	Pierre Guillevic (University of Maryland)	Jose Sobrino (University of Valencia, SP)
Soil Moisture*	Tom Jackson (USDA ARS)	Wolfgang Wagner (Vienna Univ of Technology, AT)
Land Surface Phenology	Matt Jones (University of Montana)	Jadu Dash (University of Southampton, UK)

JPSS Land Team: Drivers of Innovation

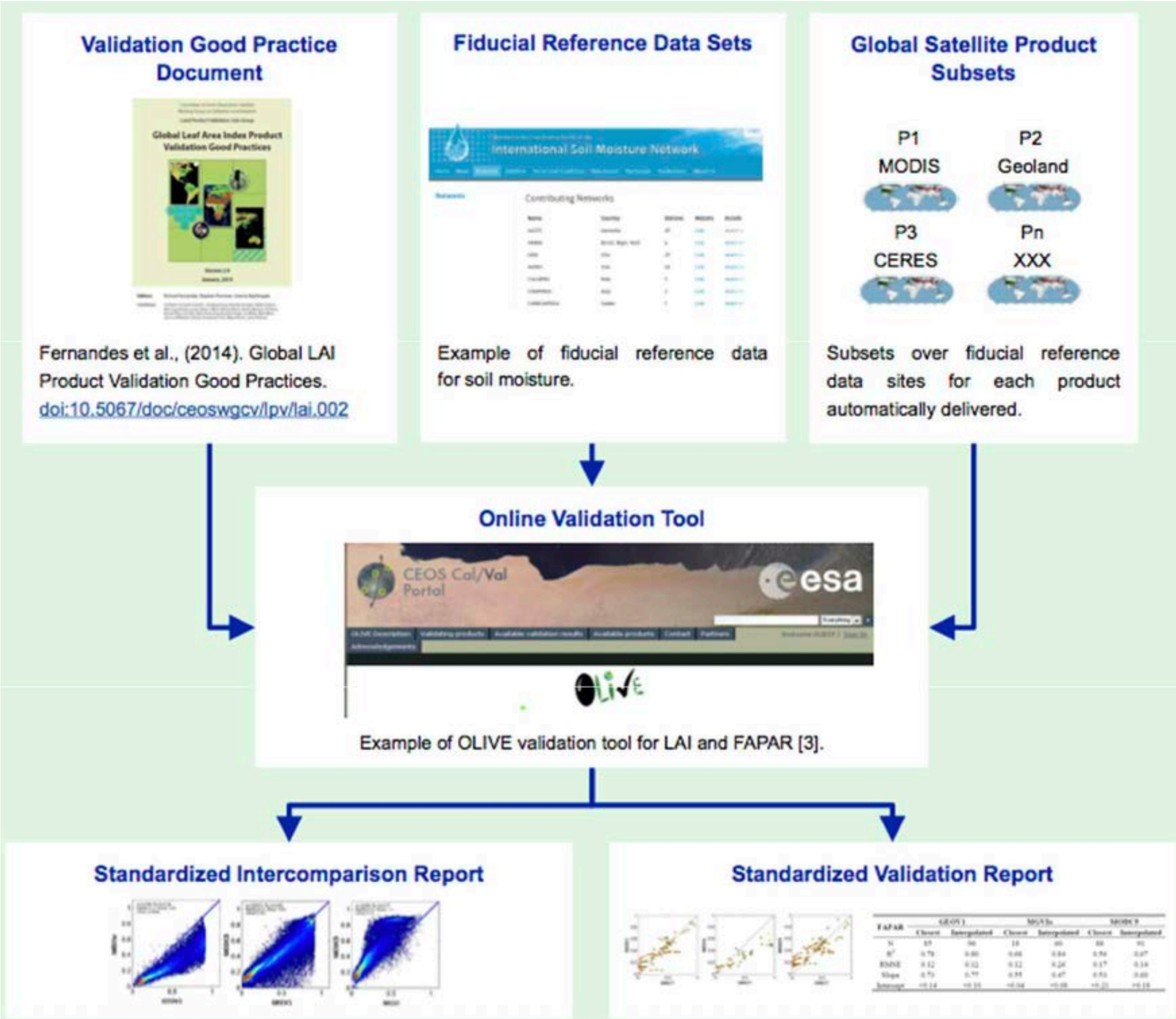
Innovation Driver	Impact to Product Utilization
Product Development and Cal/Val	~0 to 40%
Improved Access & Distribution	~40 to 75%
"Game Changing" Applications	~75 to ≥100%

PGRR Initiatives Integrate *across all drivers*

CEOS LPV Team: Drivers of Innovation

Innovation Driver	Impact to Land ECV
Validation Protocol Development	~0 to 40%
Access to and Distribution of Reference Data & Accuracy Reports	~40 to 75%
“Game Changing” Applications	~75 to ≥100%

JPSS Land Cal/Val Team Contributions to LPV



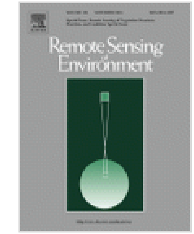
- ***JPSS Land cal/val team has adopted the CEOS/WGCV LPV framework & validation stages.***
- ***Key JPSS (FY16) contributions:***
  1. Tower-based reference data (CRN, BSRN-SURFRAD)
  2. Airborne-UAV reference data (MALIBU: Román et al.)
  3. Land Product Characterization System (LPCS: K. Gallo)
- ***Participating CEOS member agencies:*** *NOAA-STAR, NOAA-NCDC, USGS-EROS, NASA-GSFC, ESA-ESRIN.*

CEOS/WGCV/LPV subgroup has developed a framework for land product intercomparison and validation based on: **(1) a citable protocol, (2) fiducial reference data, and (3) automated subsetting**. These components are integrated into an **online platform** where quantitative tests are run, and standardized intercomparison and validation results reported.

ELSEVIER

Remote Sensing of Environment

Volume 154, November 2014, Pages 19–37



Validation of Land Surface Temperature products derived from the Visible Infrared Imaging Radiometer Suite (VIIRS) using ground-based and heritage satellite measurements

Pierre C. Guillevic[a], James C. Biard[b, c], Glynn C. Hulley[a], Jeffrey L. Privette[c], Simon J. Hook[a], Albert Olioso[d], Frank M. Göttsche[e], Robert Radocinski[a], Miguel O. Román[f], Yunyue Yu[g], Ivan Csiszar[g]

- **V1 LST Protocol Published!**
- **Uses VIIIRS as case study**
- **Interagency Collaboration has been key to CEOS-LPV team’s sucess. Major players:**
- **NOAA (STAR/NCDC)**
- **NASA (JPL/GSFC)**
- **INRA**

Protocol for Validation of the Land Surface reflectance using AERONET (J.C. Roger, E. Vermote and B. Holben)

Validation of Land Surface Reflectance

The Problem: **A standard land surface reflectance protocol for using reference AERONET products needs to be agreed on by the MODIS/VIIRS science team.**

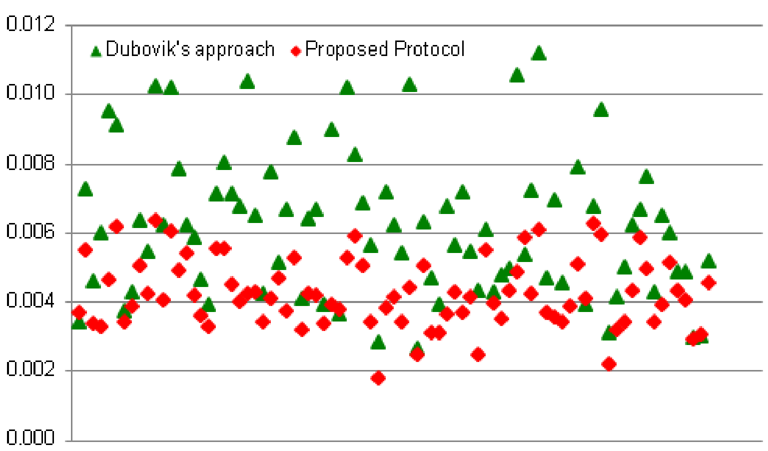
The Solution: **A validation protocol for MODIS/VIIRS Land surface reflectance that requires the aerosol model to be readily available.**

Description of Surface Reflectance Validation Protocol

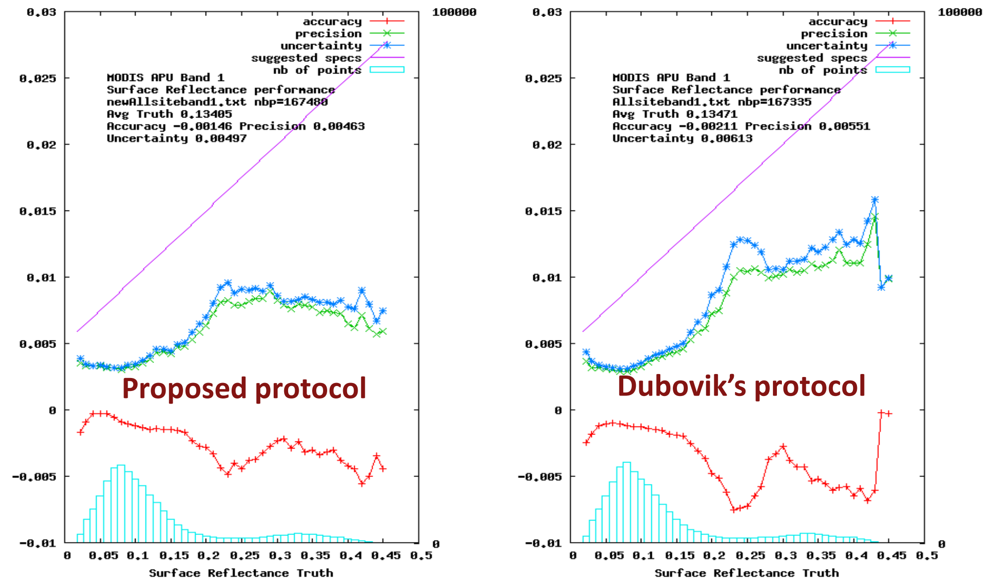
Aerosol models for each AERONET site can be defined using new regressions with optical properties (i.e., τ_{440} and α) as standardized parameters. For the aerosol models, the **aerosol microphysical properties** provisioned by AERONET, including size-distribution (%C_f, %C_c, r_f, r_c, σ_r, σ_c), complex refractive indices and sphericity, can also be used as standardized protocol measures.

Comparisons with AERONET indicate that parameter standardization produces Accuracy-Precision-Uncertainty (APU) metrics up to 20% lower than the current baseline (Dubovik et al., 2002).

Uncertainties on the retrieved surface reflectance for 40 AERONET sites MODIS band 1 (red) – synthetic input surface reflectance = 0.05

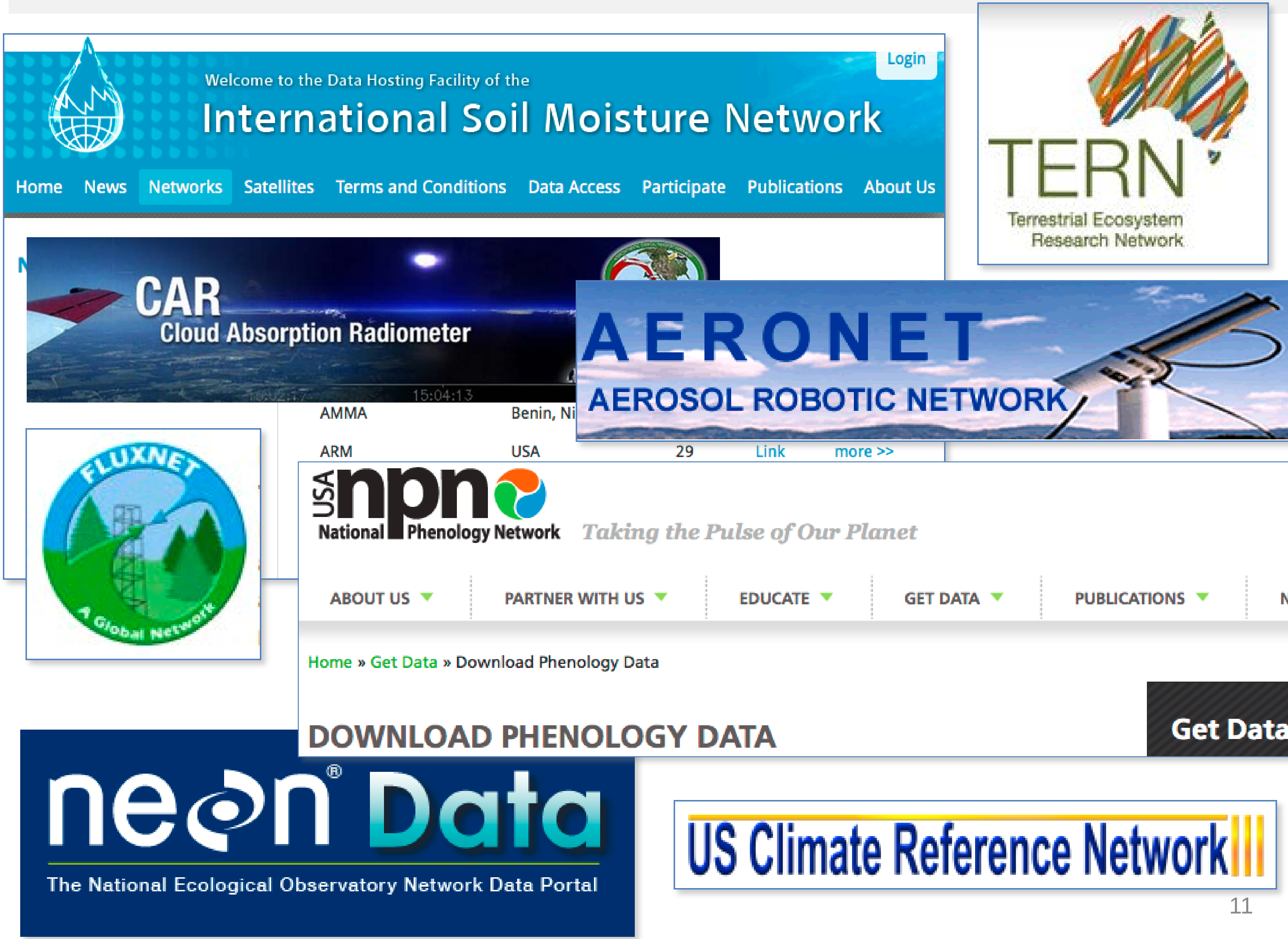


Example of APU for MODIS band 1 (red) for the whole 2003 year data set



Team Response: **Further classification of errors requires the adoption of consistent and agreeable protocols across MODIS/VIIRS land surface reflectance products. This is also crucial to enable objective assessment and characterization of downstream product impacts (e.g., NDVI/EVI, LAI/FPAR, BRDF/Albedo/NBAR).**

Fiducial Reference Data Sets



Relaying Validation Results to our Users

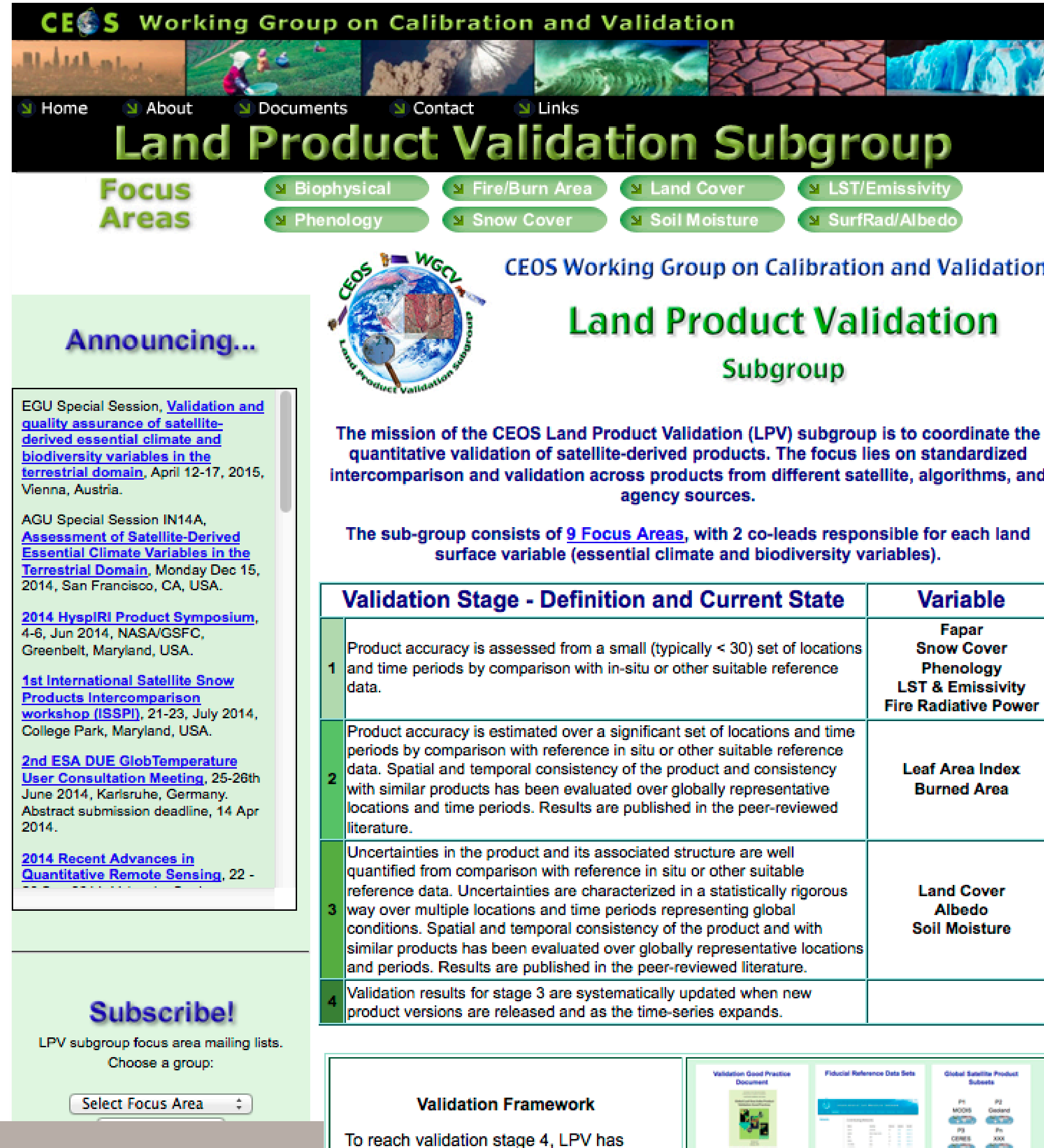
LPV Web Site
15 years and running..

Established in 2000

Subscribed member list has grown ***to nearly 700 members*** over the years.

Each focus area (ECV) has pull down menu of links to

- Home page
- References
- Collaboration
- Products



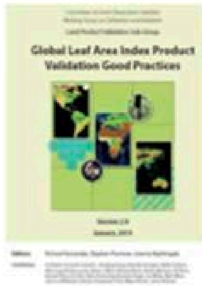
http://lpvs.gsfc.nasa.gov

CEOS LPV Team: Drivers of Innovation Performance

Innovation Driver	Impact to Land ECV
Validation Protocol Development	0 to 40%
Access to and Distribution of Reference Data & Accuracy Reports	40 to 75%
“Game Changing” Applications	75 to ≥100%
How About This Driver?	

A Land Validation Framework

Validation Good Practice Document



Fernandes et al., (2014). Global LAI Product Validation Good Practices. doi:10.5067/doc/ceoswgcv/lpv/lai.002

Fiducial Reference Data Sets

Example of fiducial reference data for soil moisture.

Global Satellite Product Subsets

P1 MODIS

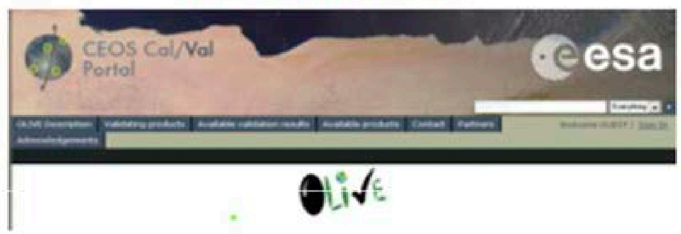
P2 Geoland

P3 CERES

Pn XXX

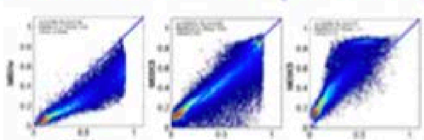
Subsets over fiducial reference data sites for each product automatically delivered.

Online Validation Tool



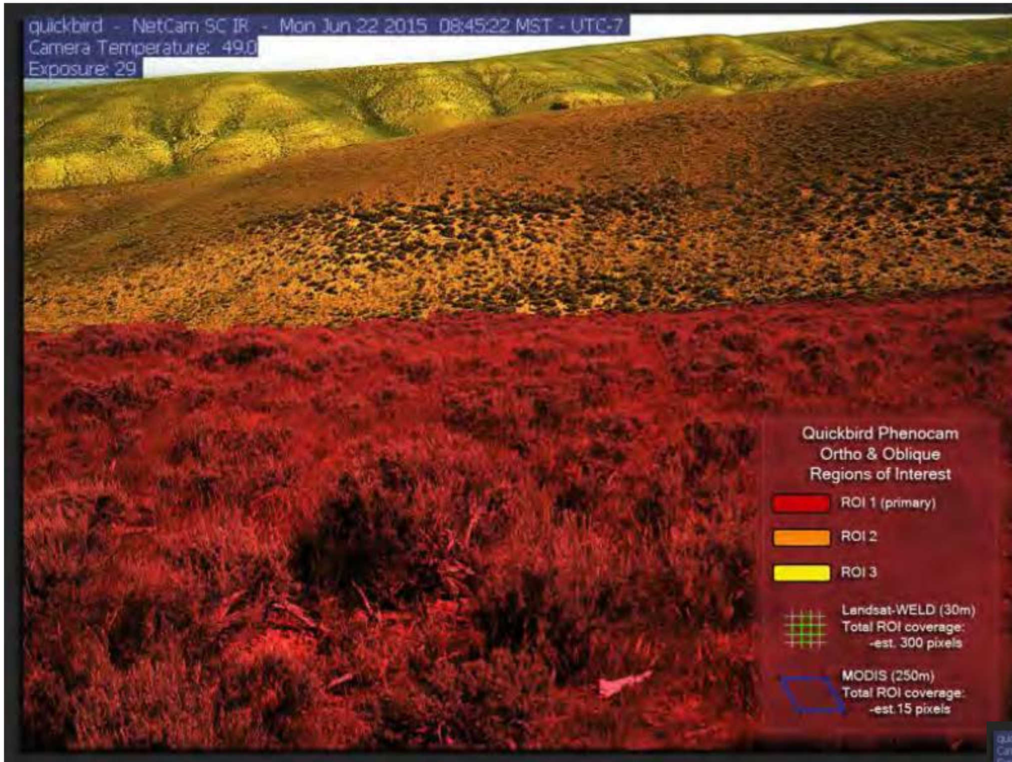
Example of OLIVE validation tool for LAI and FAPAR [3].

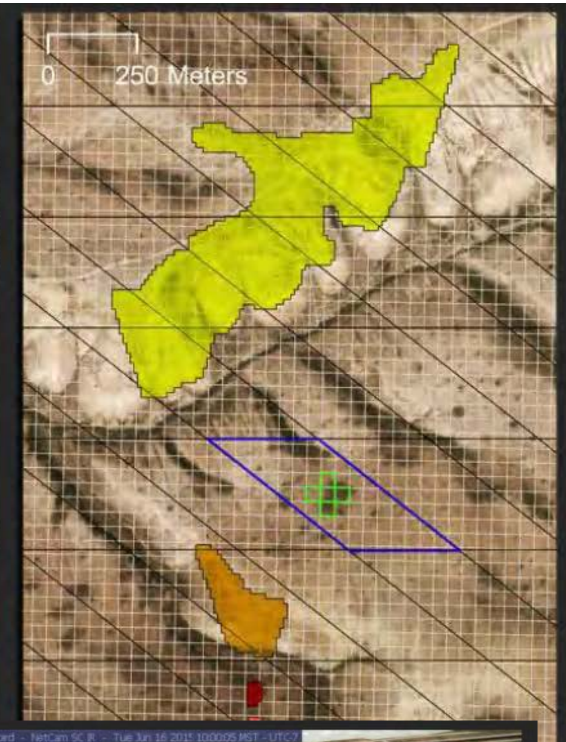
Standardized Intercomparison Report

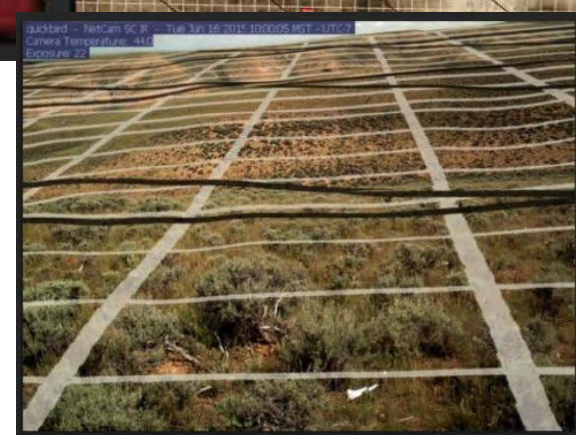


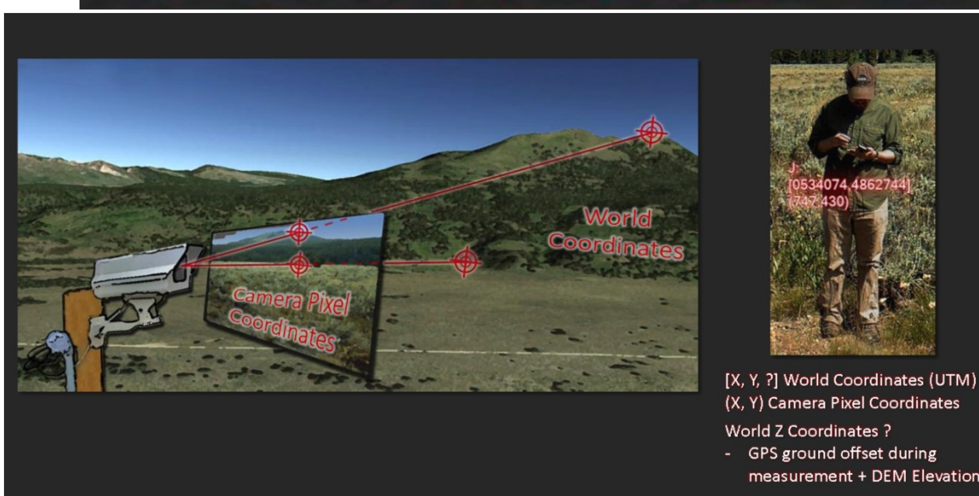
Standardized Validation Report

Scaling Phenology (USGS)





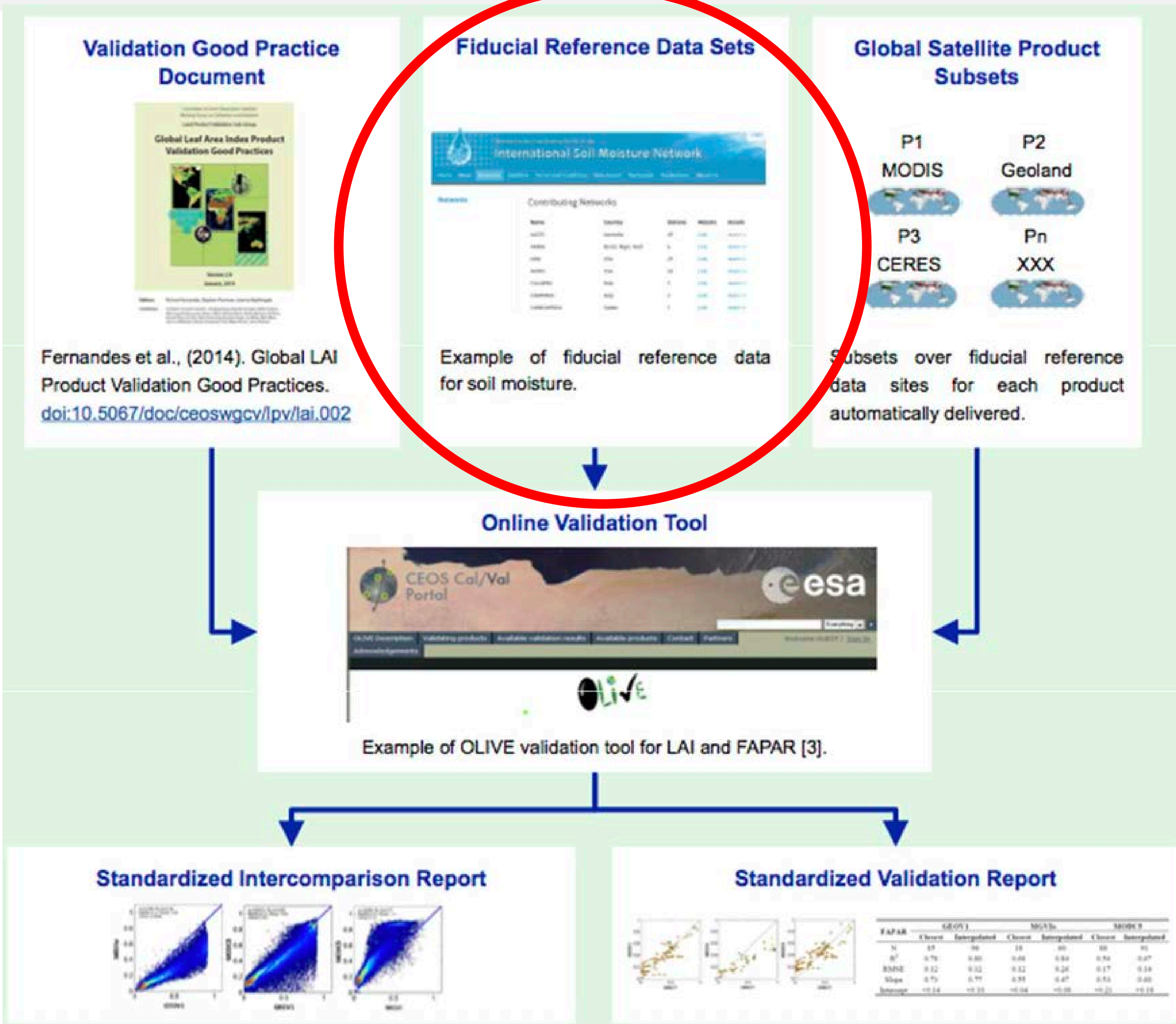




USGS/NCCSC PhenoCam Project
Credit: Joseph Krienert / Jeff Morisette

CEOS WORKING GROUP ON CALIBRATION & VALIDATION

A Land Validation Framework



Fiducial Reference Data Collection: Challenges

– *CEOS/WGCV/LPV Goal*: To characterize land product uncertainties in a statistically rigorous way (i.e., over multiple locations and time periods representing global conditions).

– *Our Challenge*: To work within the constrains of NOAA/ NASA missions, programs, and airborne assets (e.g., deployments costs on P3-B: ~$4000/flight hour).

– *Our Strategy to-date*: "Piggy-backing" has brought us some gains; but it requires a lot of:

1. Patience (work with lead PIs and identify common goals),
2. Good Luck (e.g., nominal operations + clear skies),
3. Hard Work (countless hours of mostly unfunded effort; esp. for post-processing and science data analysis).

Multi AngLe Imaging Bidirectional Reflectance Distribution Function Unmanned Aerial System (MALIBU)

PI: Román/GSFC 619; Instrument PI: Pahlevan/Sigma Space 619

Goddard Space Flight Center

Description and Objectives:

- Design a low-cost imaging approach to validate critical land climate data records
- Radiometric/Spectral calibration of dual Tetracam cameras at GSFC calibration facility
- Platform integration and Field Deployment
- Subpixel (10 meter) land biogeophysical product retrieval (PRI, NDVI, BRDF/Albedo, Reflectance) and validation efforts (MODIS/MISR, VIIRS, Landsat/OLI, and GOES-R).

Key challenge(s)/Innovation:

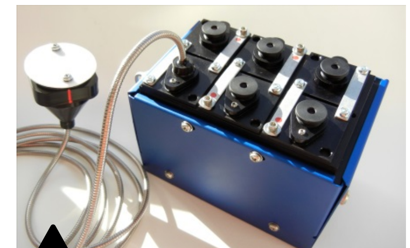
- Accurate earth gridding & geo-location of the collected images.

MALIBU Platform and Payload

Tempest Blackswift UAS

- Programmable flight path
- Endurance (~60-90 min)
- Altitude: 100-500 m
- Cruise speed: 50 km/h
- Weight: 3 kg

- Two six-channel cameras
- Irradiance sensor
- FOV ~ 50deg
- Weight 0.7kg (each)



Mini-MCA6 Equipped with Incident Light Sensor

Approach:

- Specify/Study camera specifications
- Work closely with the camera vendor during the fabrication
- In-house camera calibration
- Work closely with platform vendor during integration phase
- Test flights and geo-location tests
- Design flight plans and data collection procedure
- Data processing and product generation

Application / Mission:

- Develop international protocols for assessment of terrestrial essential climate variables.

Key Members: Geoff Bland (610W), Joel McCorkel (618), Zhuosen Wang (ORAU), Ed Masuoka (619), Robert Wolfe (619), Jack Elston (Black Swift), John Augustine (NOAA), and Ivan Csiszar (NOAA).

Milestones and Schedule:

Start of the project	10/2014
Camera procurement	11/2014
Camera characterization	12/2014
System Integration	03/2015
Test flights	04/2015
Data collection	06/2015
Post-deployment calibration	07/2015
Data processing	09/2015

TA-08; New Tools of Discovery; $TRL_{in} = 4$

WORKING GROUP ON CALIBRATION & VALIDATION

CEOS

Task Objective

- Objective: To deploy an Unmanned Aircraft System (UAS) that can enable high spatial and angular resolution mapping of terrestrial essential climate variables.
- MALIBU sensor suite performance metrics:
  - Two Tetracam optical units
  - Combined FOV ~ 100° (50° x camera)
  - GIFOV < 10 meters
  - Geolocation accuracy < 0.7 pixel*
  - Signal to Noise > 300
  - Radiometric uncertainty < 5% attained through frequent GSFC in-house calibration

*Challenges: All-of-the-Above Strategy: Onboard IMU (Uncertainty = 0.1^{deg}) + Onboard GPS (Uncertainty < 1 m) + Ground Control Points (image-based geolocation).

Six types of drone concepts ‘crazier’ than MALIBU…

Package Delivery

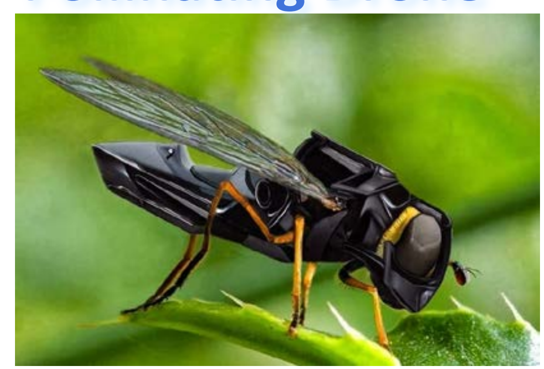
IED Detection

Hurricane Drone

Food Delivery

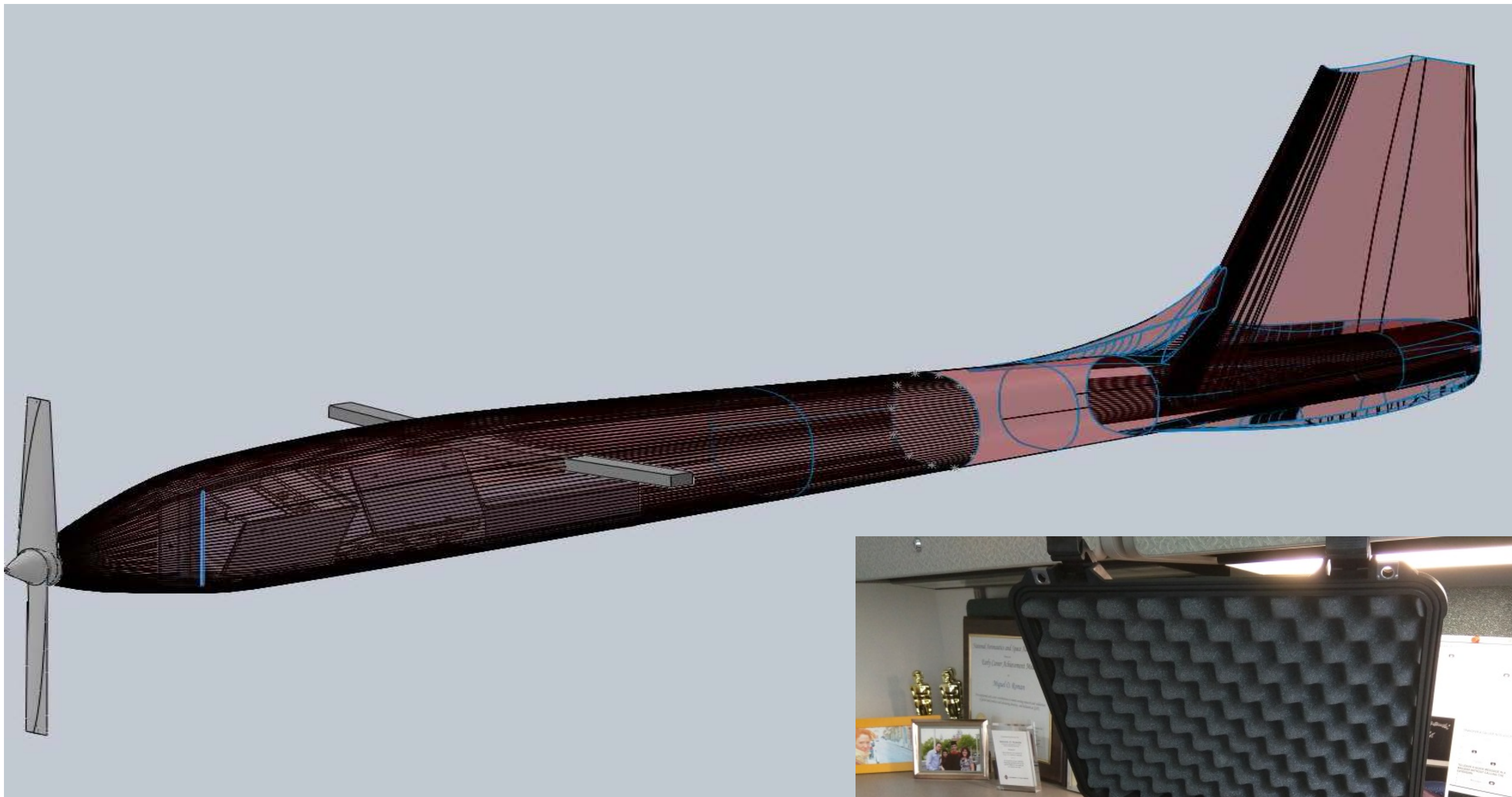
Wildfire Drone

Pollinating Drone

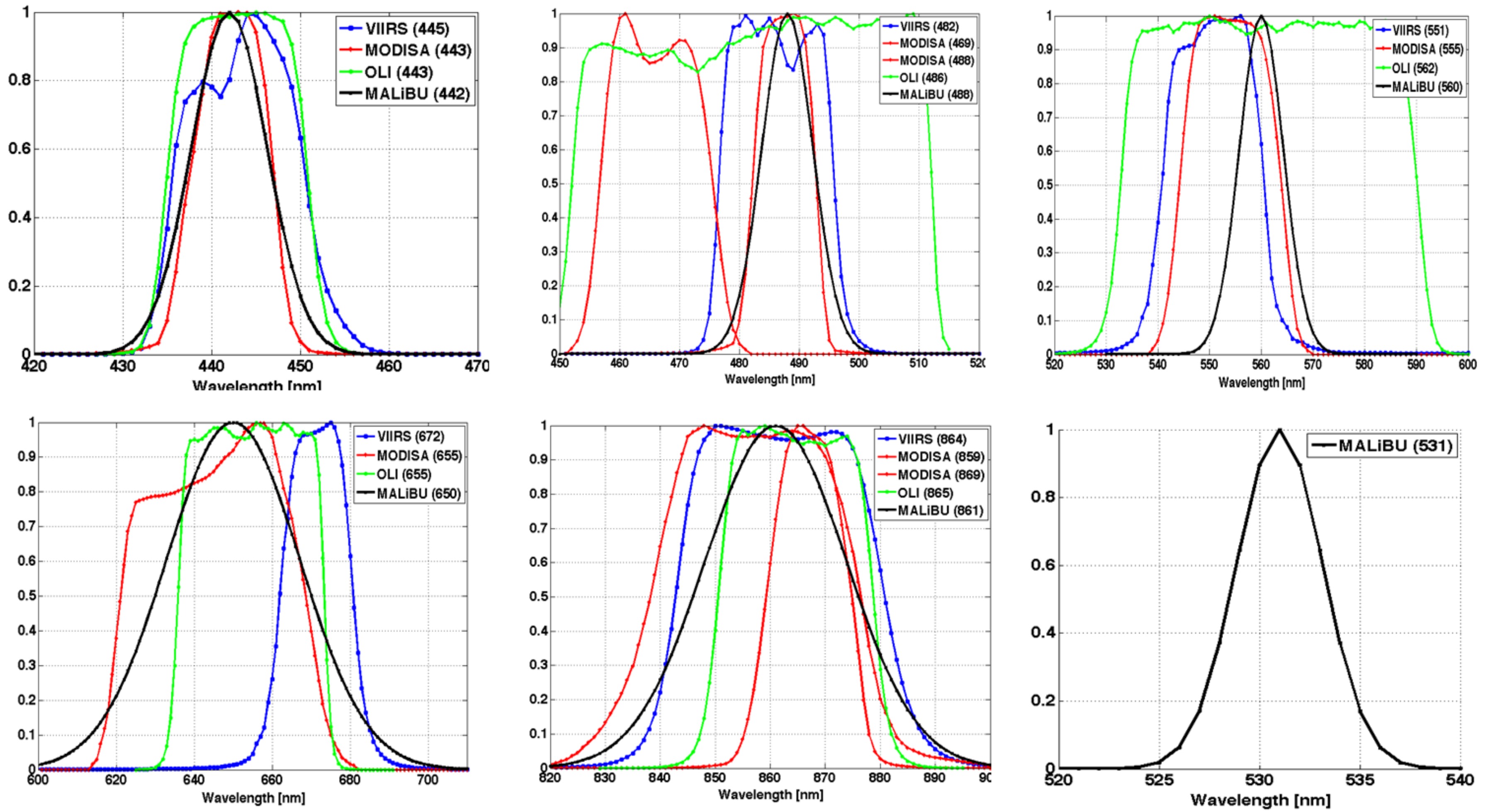


MALIBU Imaging Geometry

- **Camera mounts**



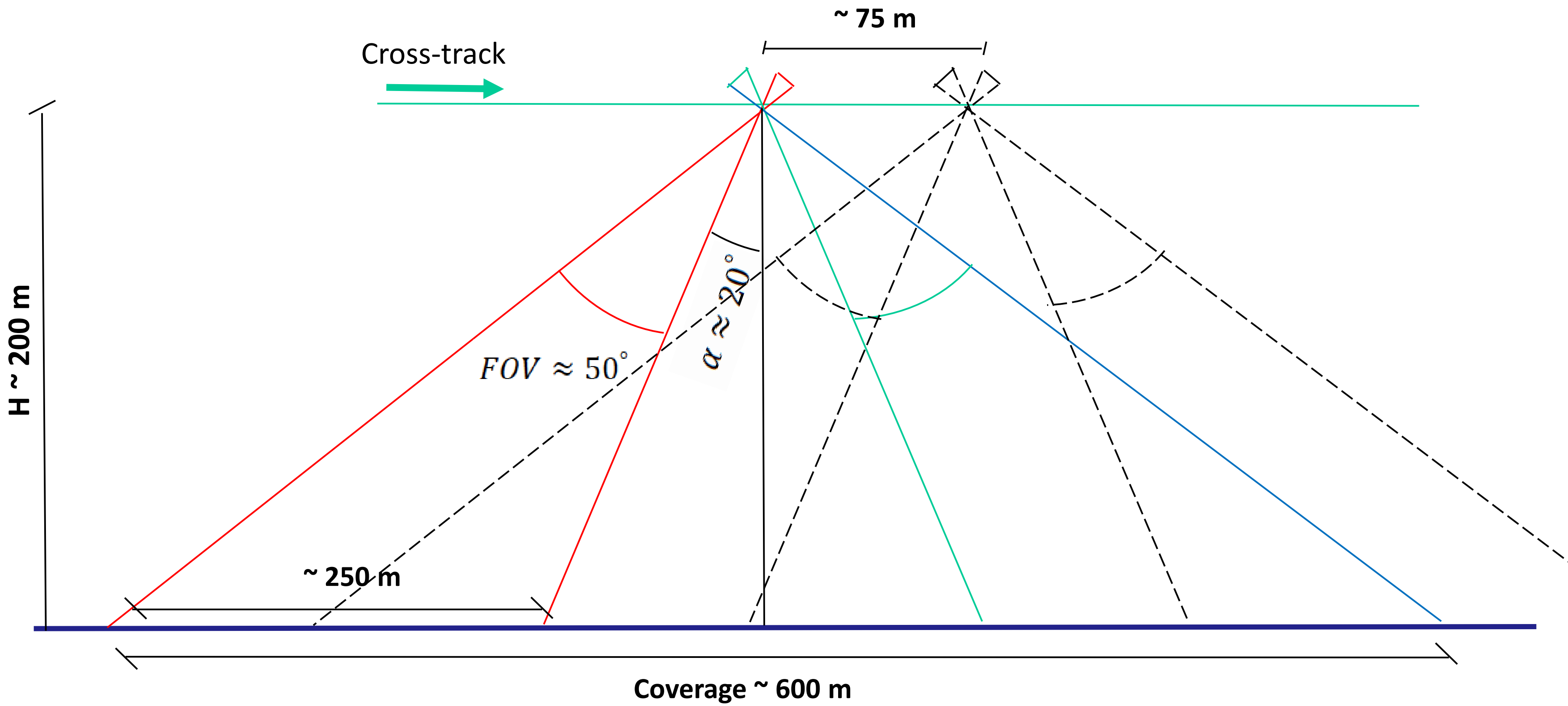
MALIBU Spectral Response



442, 488, 531, 560, 650, 861nm
+ Tetracam's Incident Light Sensor

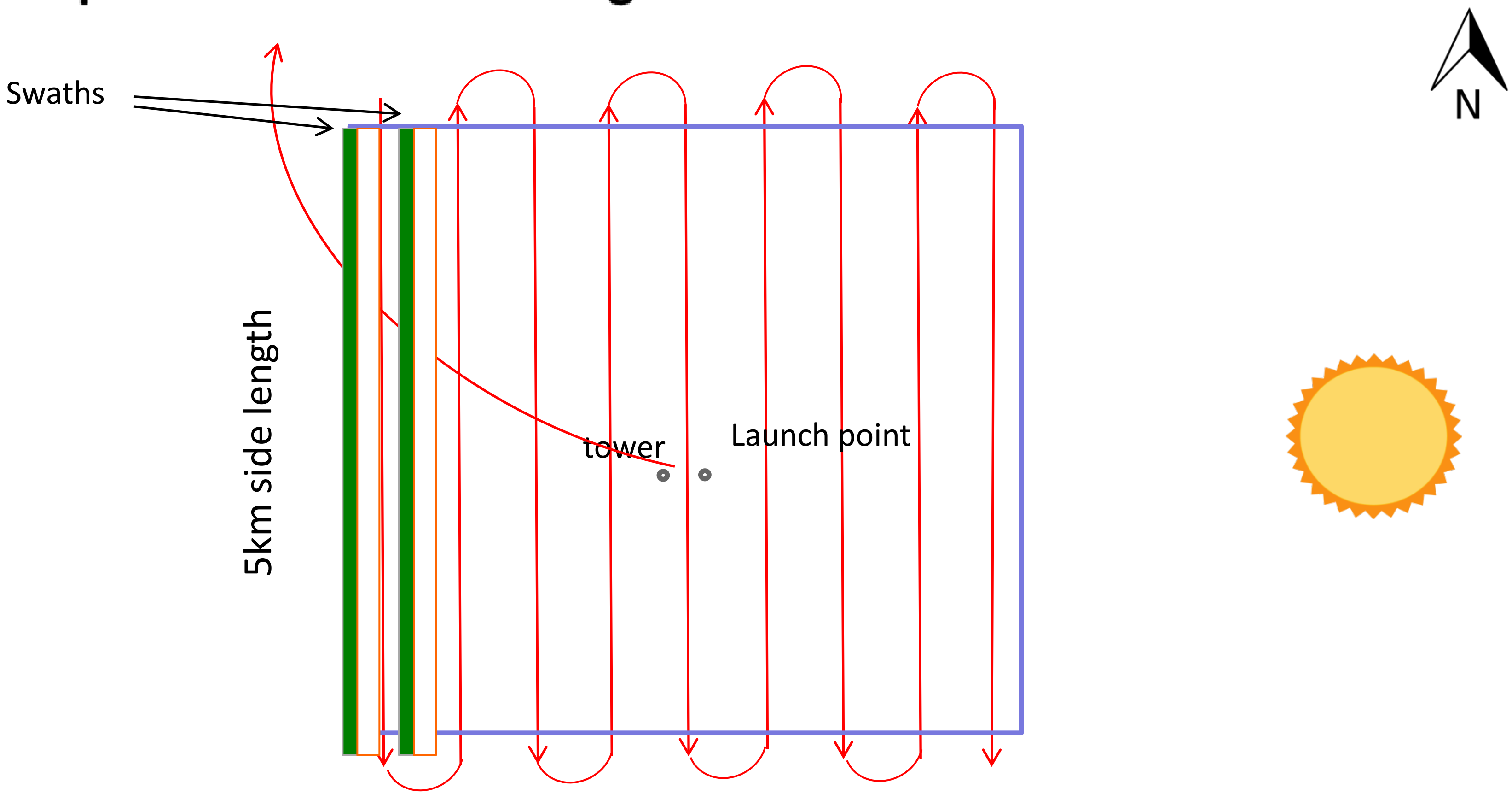
Viewing Geometry: Cross-track

- **Dual Tetracam cameras (with non-overlapping swaths) mounted on the platform across-track**



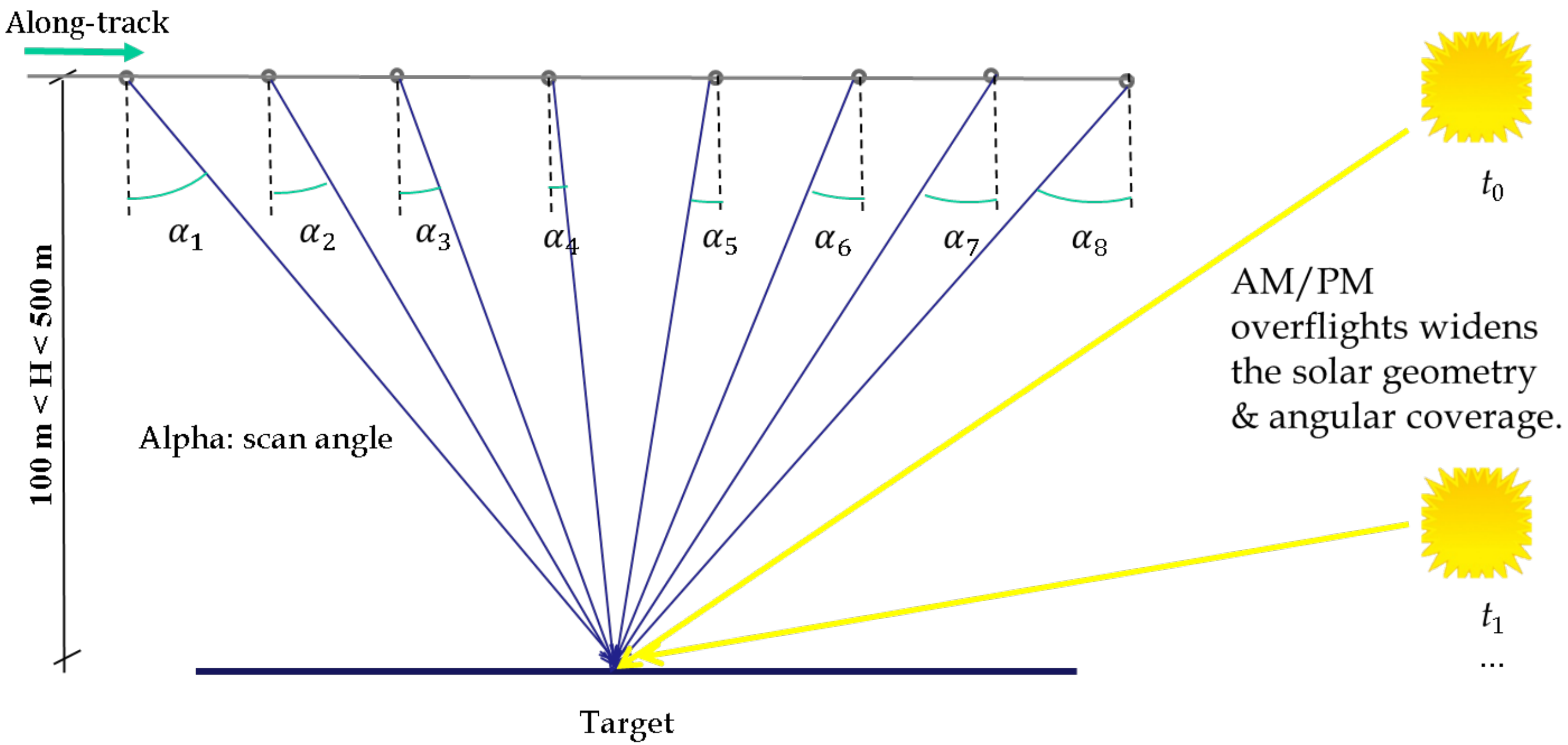
MALIBU Flight Path

- 5×5 km^2 is covered during two-day deployment
- Requires visible line-of-sight less than 5 km

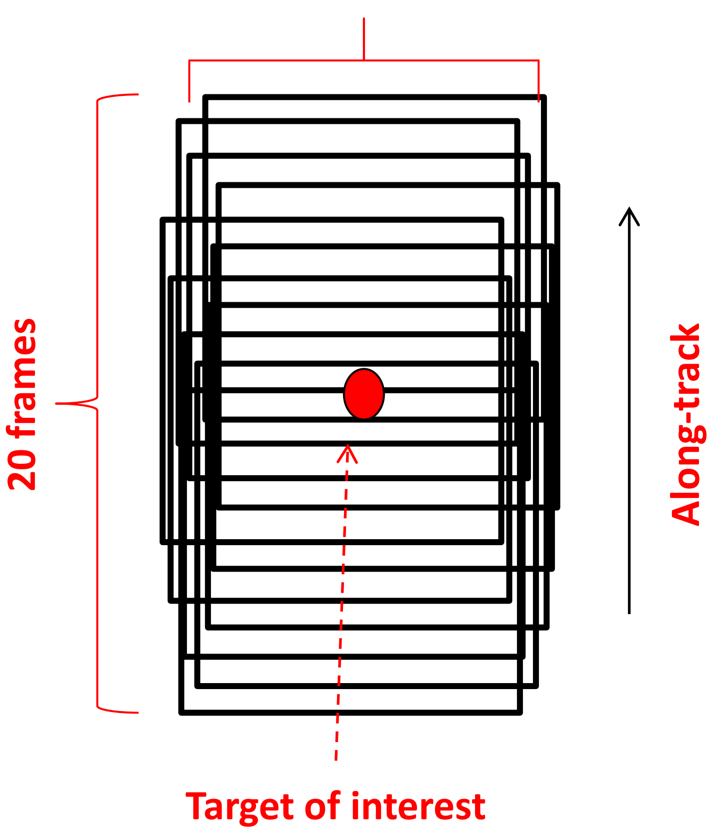


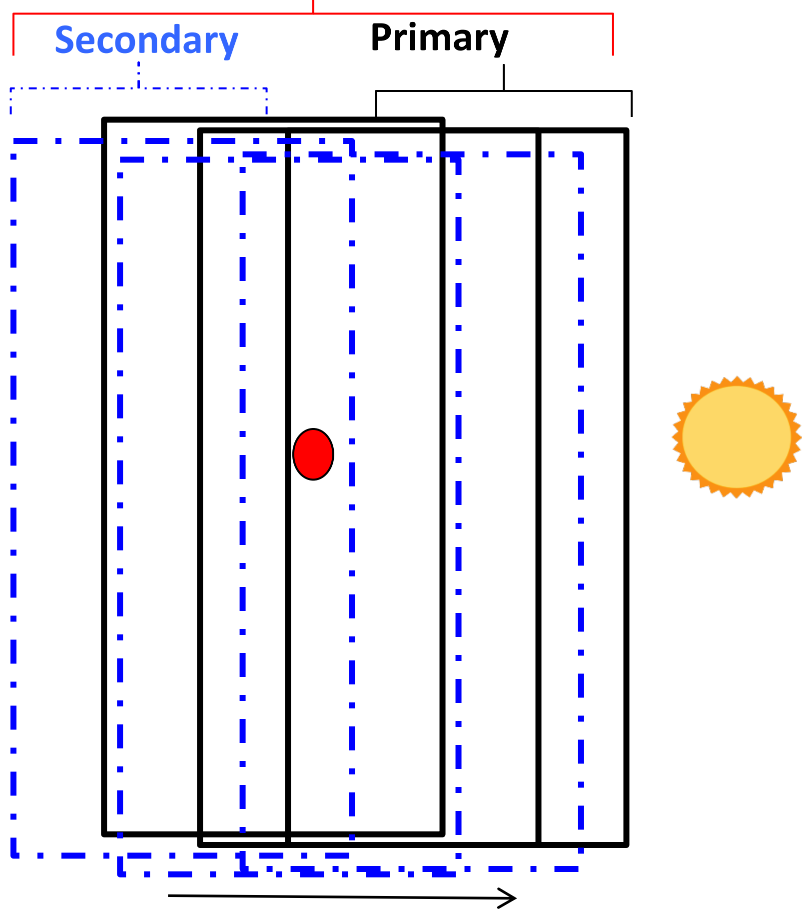
MALIBU Flight Path(cont.)

Overlapping scenes along-track provide multi-angular retrievals.



Overlapping Regions





First MALIBU Test Site: NOAA-Surfrad Table Mountain, CO

- Located ~8 miles north of Boulder, CO.
- Part of NOAA ESRL, US SURFRAD, and the international BSRN reference network .
- John Augustine (NOAA/ESRL, Site PI) is MALIBU team collaborator.

- In-situ measurements include: MFRSR, LI-COR PAR, Yankee UVB-1 Ultraviolet Pyranometer, ventilated Eppley pyrgeometer and ventilated Spectrosun pyranometers.
- Blackswift Tempest has been deployed extensively at this site (69 flights completed since 2010).

Latitude:	40.12498
Longitude:	-105.23680
Elevation:	1689 m
Installed:	July 1995

How About J2 Cal/Val??

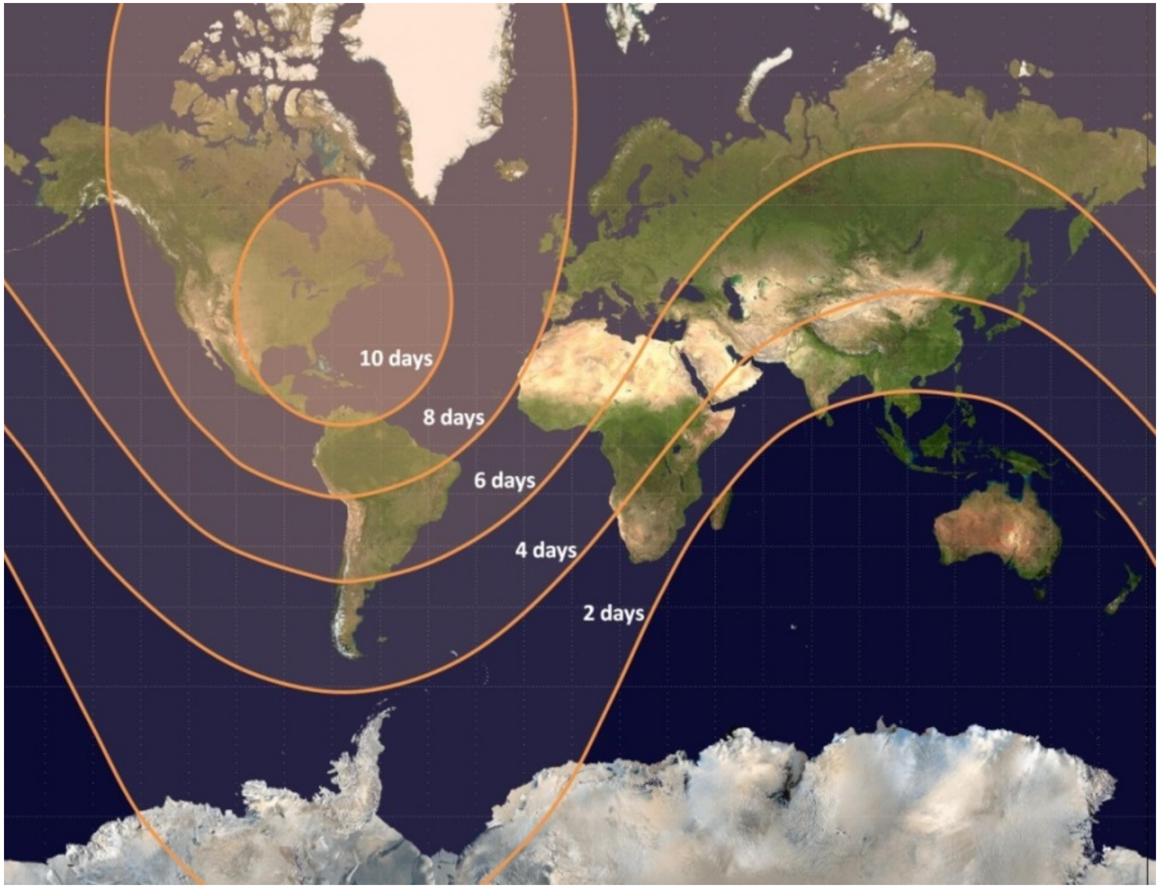
(2020 and beyond…)

VA001 Aircraft

Vanilla Aircraft, LLC

ConOps

- **18,500 nm** range, **10 day** endurance, with 30 pound payload
- 2 aircraft could keep a payload on-station indefinitely

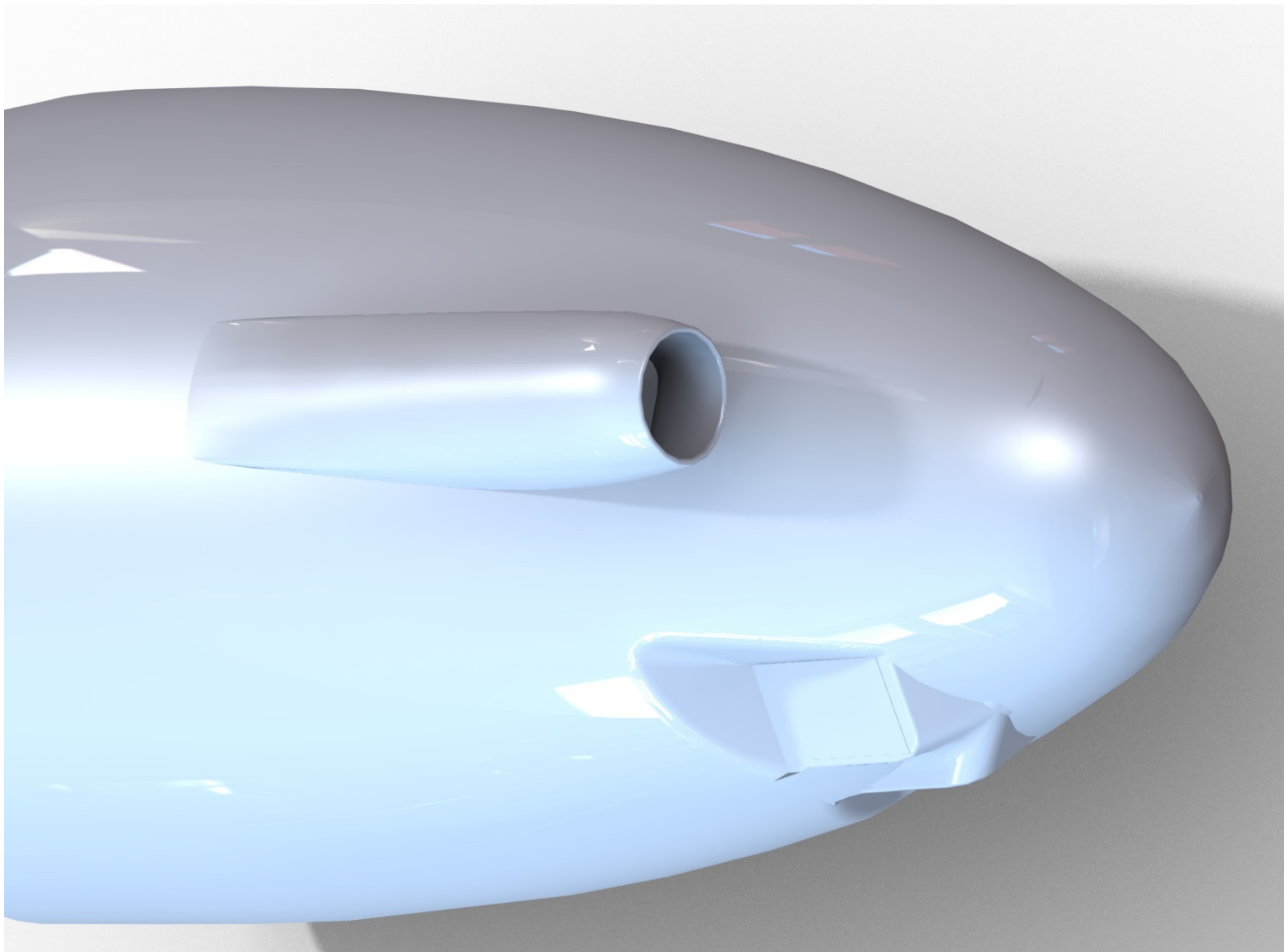


Contours of on-station endurance with launch and recovery from the eastern United States

Vanilla Aircraft, LLC

TetraCam Micro MCA-6

- Multi-spectral imaging, two systems each 45° from nadir



Vanilla Aircraft, LLC


If you want to go fast, go alone.
If you want to go far,
go together.
African Proverb
CEOS WGCV
Land Product Validation Subgroup
NASA
USGS
science for a changing world
NOAA
esa
EUMETSAT

GOES-R LST Validation Activities and Coordination with JPSS

Presented By: Yunyue Yu
NOAA/NESDIS/STAR

Team Members: Peng Yu, Yuling Lui, Heshun Wang, Yuhan Rao, Zhen Song
UMD/CICS

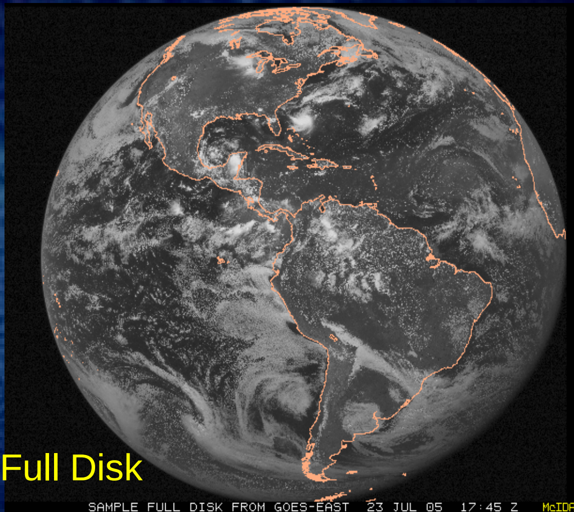
Funded by the GOES-R AWG, GOES-R Proving Ground (Field Campaign), and STAR JPSS

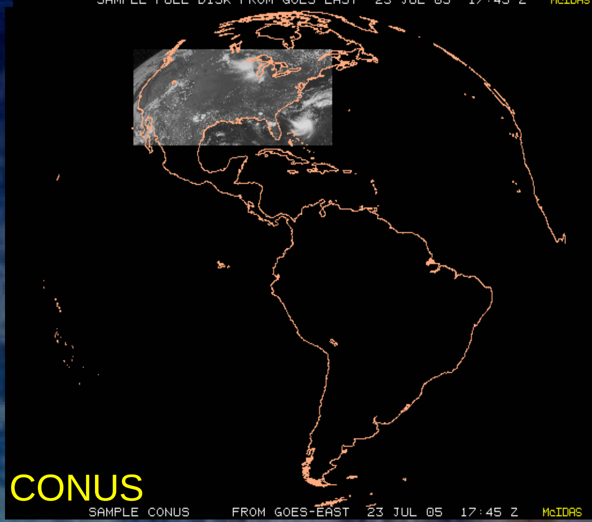
Outline

- GOES-R LST Products
- Development of GOES-R LST Validation Tool
- Coordination With JPSS
- Further Enhancement/Improvement

LST Products

- The ABI Land Surface Temperature (LST) algorithm generates the baseline products of land surface skin temperatures in three ABI scan modes: *Full Disk, CONUS, Mesoscale*;
- Has a good heritage; will add to the LST climate data record;





Products

Product	Accuracy	Precision	Range	Refresh Rate	Resolution
LST (CONUS)	2.5 K	2.3 K	213 ~ 330 K	60 min	2 km
LST (Full Disk)	2.5 K	2.3 K	213 ~ 330 K	60 min	*10 km*
LST (Mesoscale)	2.5 K	2.3 K	213 ~ 330 K	60 min	2 km

Qualifiers

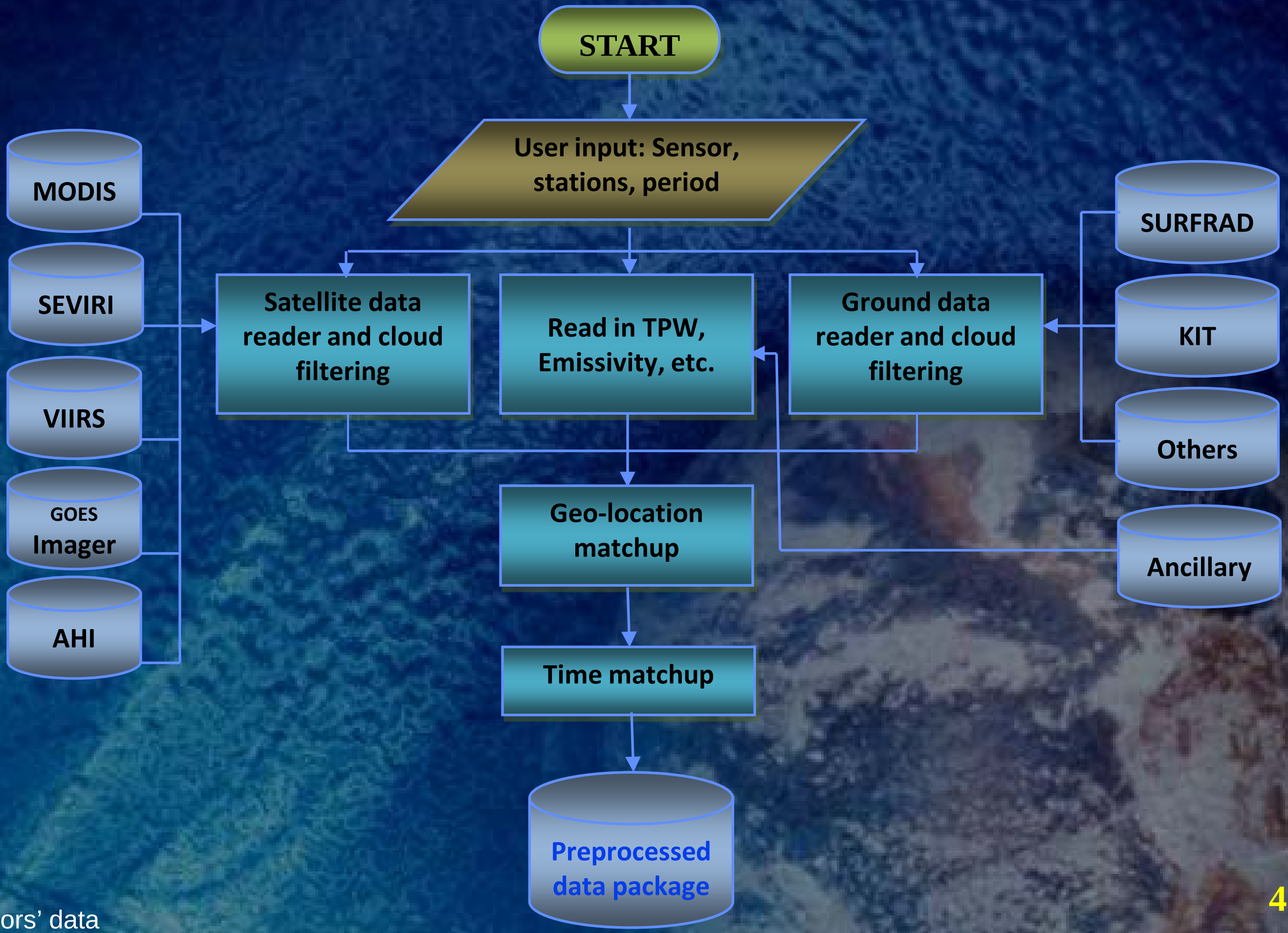
Product	Temporal Coverage	Product Extent	Cloud Cover Conditions	Product Statistics
LST (CONUS)	Day and Night	LZA < 70	Clear Conditions associated with threshold accuracy	Over specified geographic area
LST (Full Disk)	Day and Night	LZA < 70	Clear Conditions associated with threshold accuracy	Over specified geographic area
LST (Mesoscale)	Day and Night	LZA < 70	Clear Conditions associated with threshold accuracy	Over specified geographic area

Development of GOES-R LST Validation Tool

Preprocessing Module

Modulated processing of the validation dataset

- reader: Reads satellites, ground sites, and auxiliary data
- Spatial and temporal match-up: match the satellite obs to the ground sites' location and time
- Apply satellite cloud mask if available
- Satellite and ground site LST estimation/ extraction
- Preprocessed data set (relevant variables)



Note: this flow chart is for all proxy satellite sensors' data

Validation Tools Update

Preprocessed dataset

- 26 variables: enough for the current applications for GOES-R LST validation, *e.g.*, additional cloud filtering procedures
  - Temporal information: Year, Jday of the year, Hour, Minute
  - Data from the ground site: downwelling radiance and its std during the last 15 minutes (for additional cloud filter), upwelling radiance, LST, and broadband emissivity
  - Data from the satellite sensor: BT4 (~4 micrometer), BT11 (3x3 boxes centered at the matched pixel), BT12, and LST
  - Auxiliary data: zenith angle, emissivity, TPW, dry/wet, day/night
- Specific file naming convention: "*sat-gnd-sit-startday-endday.dat*"
- ASCII format
- Flexibility: allows user to validate satellite LST observations currently not included in the tool
- Output of the preprocessing module, input for the validation module
- Dramatically improve the performance of the validation work – generate outputs almost instantly

Routine LST Validation Interface

Interface to algorithm evaluation and product validation

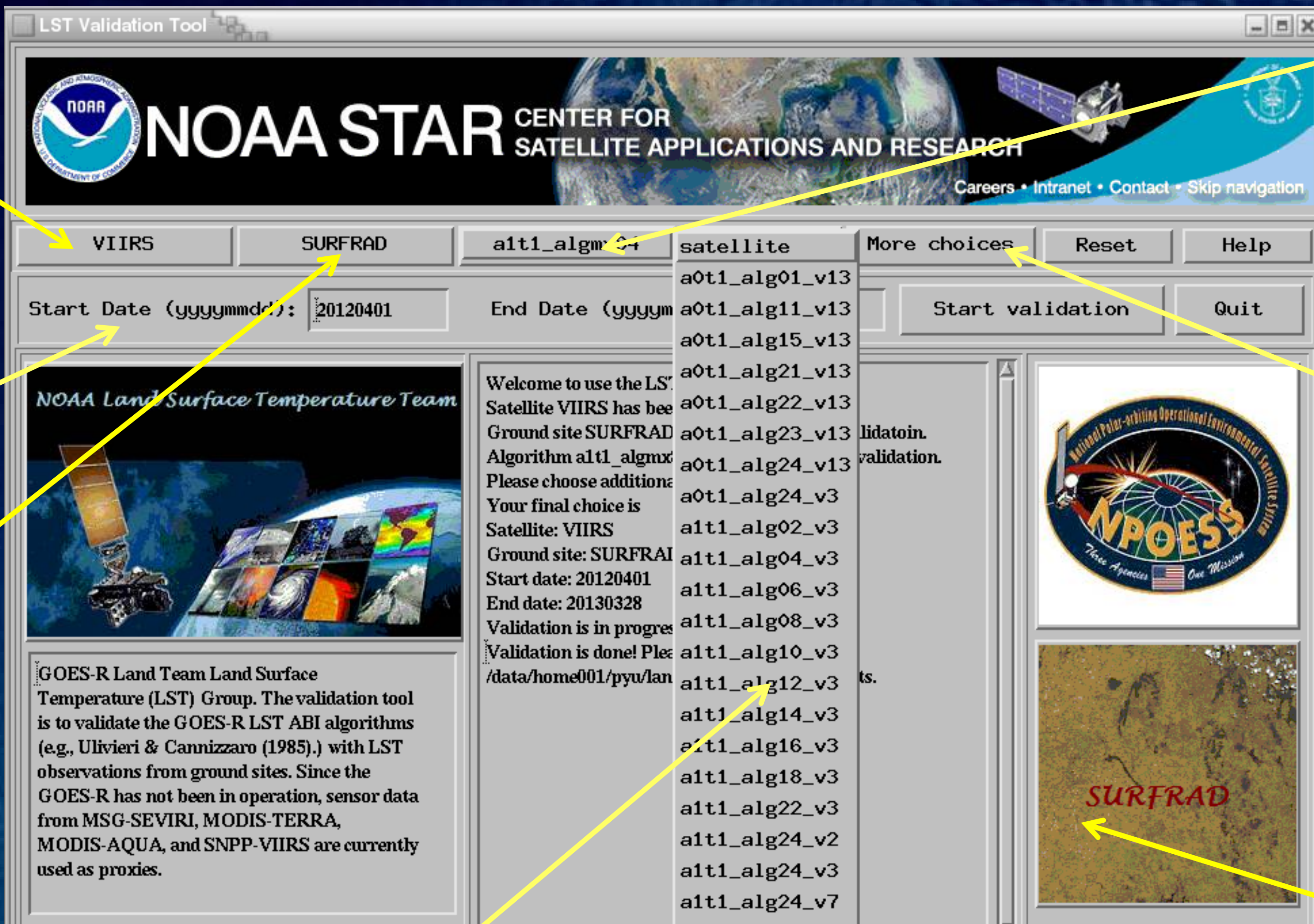
Selection of Multi-sensor proxy

Validation period

In-situ data selection

Algorithm selection

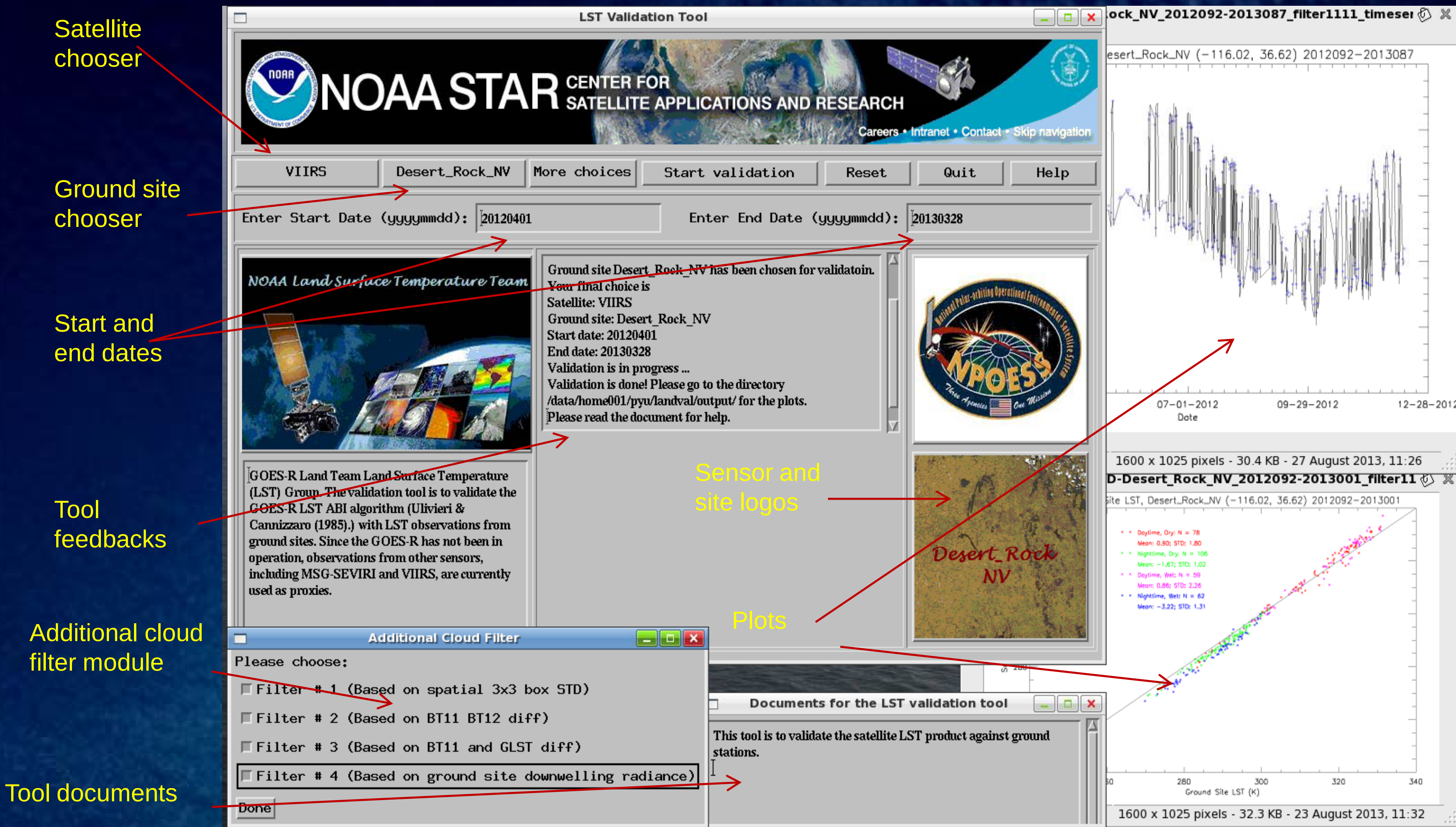
QC and cloud screening



Algorithm /product evaluation and improvement

User-friendly GUI

Validation Tools Update
-- A GUI interface



Towards Field Campaign for LST Validation

Components of LST Validation

- In-situ measurement comparisons and analyses
- Cross-satellite comparisons and analyses
- Successful applications –users promotion

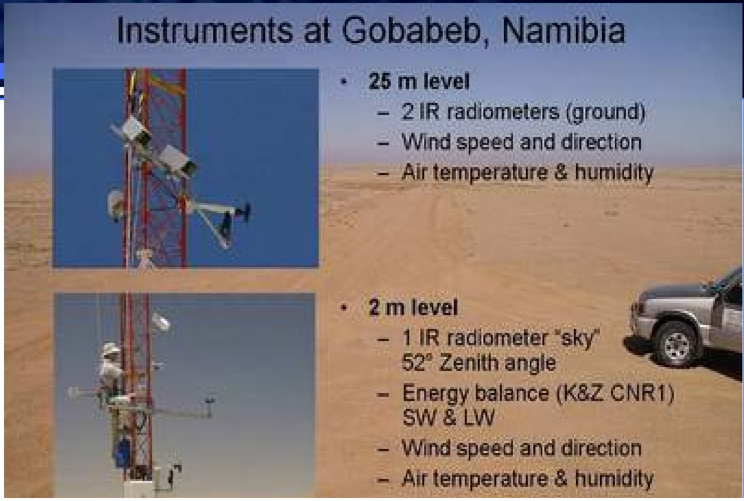
Strategy of In-situ measurement comparisons and analyses

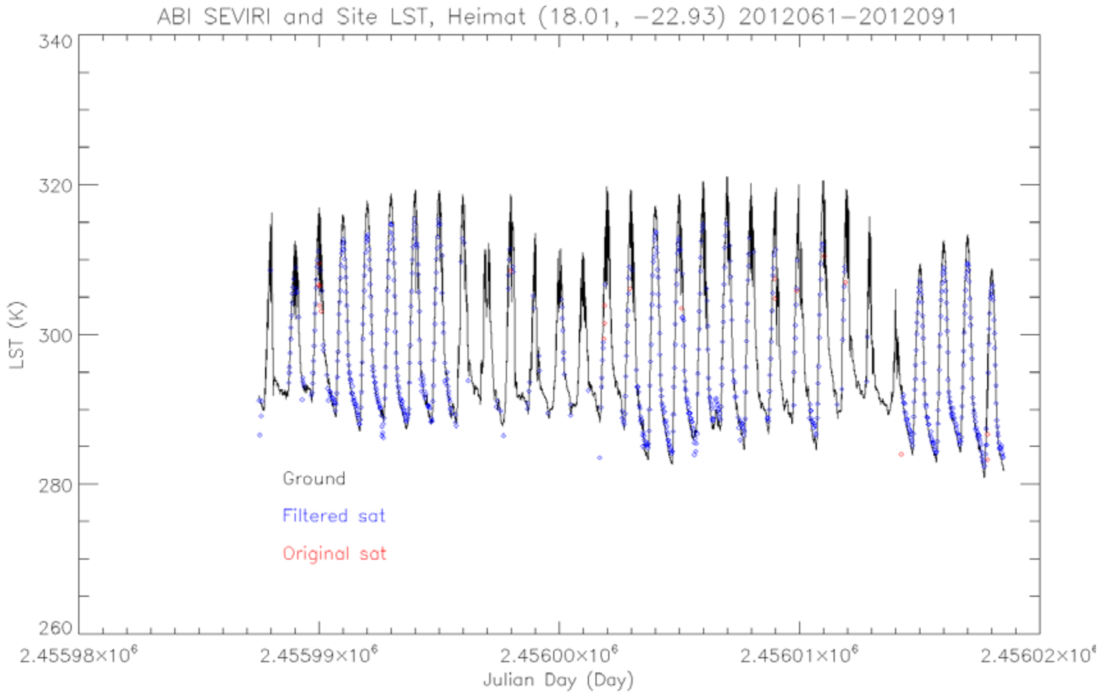
- Existing ground station observations (e.g. SURFRAD Network), as long-term data source
- Field campaign data plays three important roles
  - ❑ High quality observations for direct comparison and analysis
  - ❑ Calibrating co-site ground station observations
  - ❑ Characterizing heterogeneity feature of co-site ground station
- Towards the field campaign readiness
  - ❑ Platform: low altitude, small unmanned aerial vehicle (UVA)
  - ❑ Instrument readiness : accurate infrared radiometers covers ABI bands
  - ❑ Site selection: better to cover SURFRAD/CRN station
  - ❑ Data processing and algorithms: noise filtering, spatial characterization, calibration to station data, etc.
  - ❑ Coordination with the Field Campaign Team.

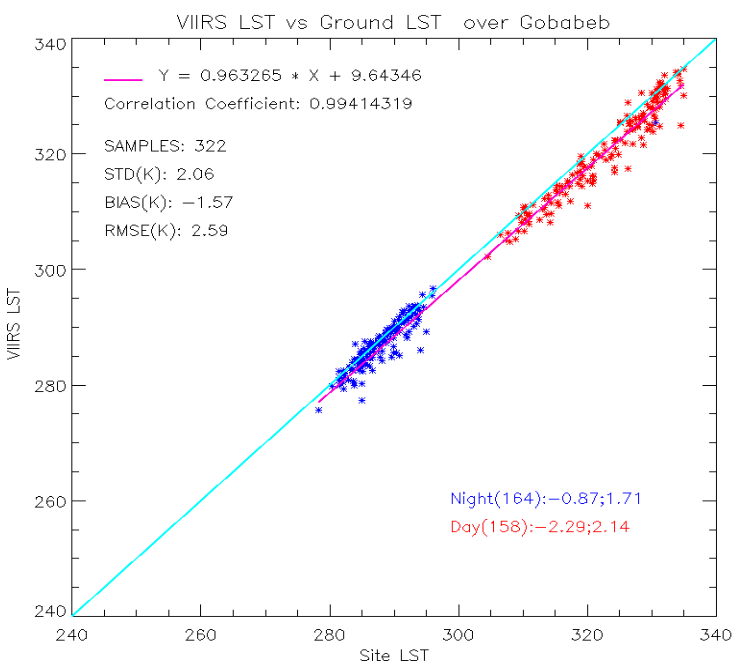
In-situ Data Validation

Case studies of in-situ data comparison in Africa (Gobabeb and Heimat, Namibia)

*the Africa site data provided by Frank Goettsche (KIT & EUMETSAT Land SAF), through LST validation collaboration



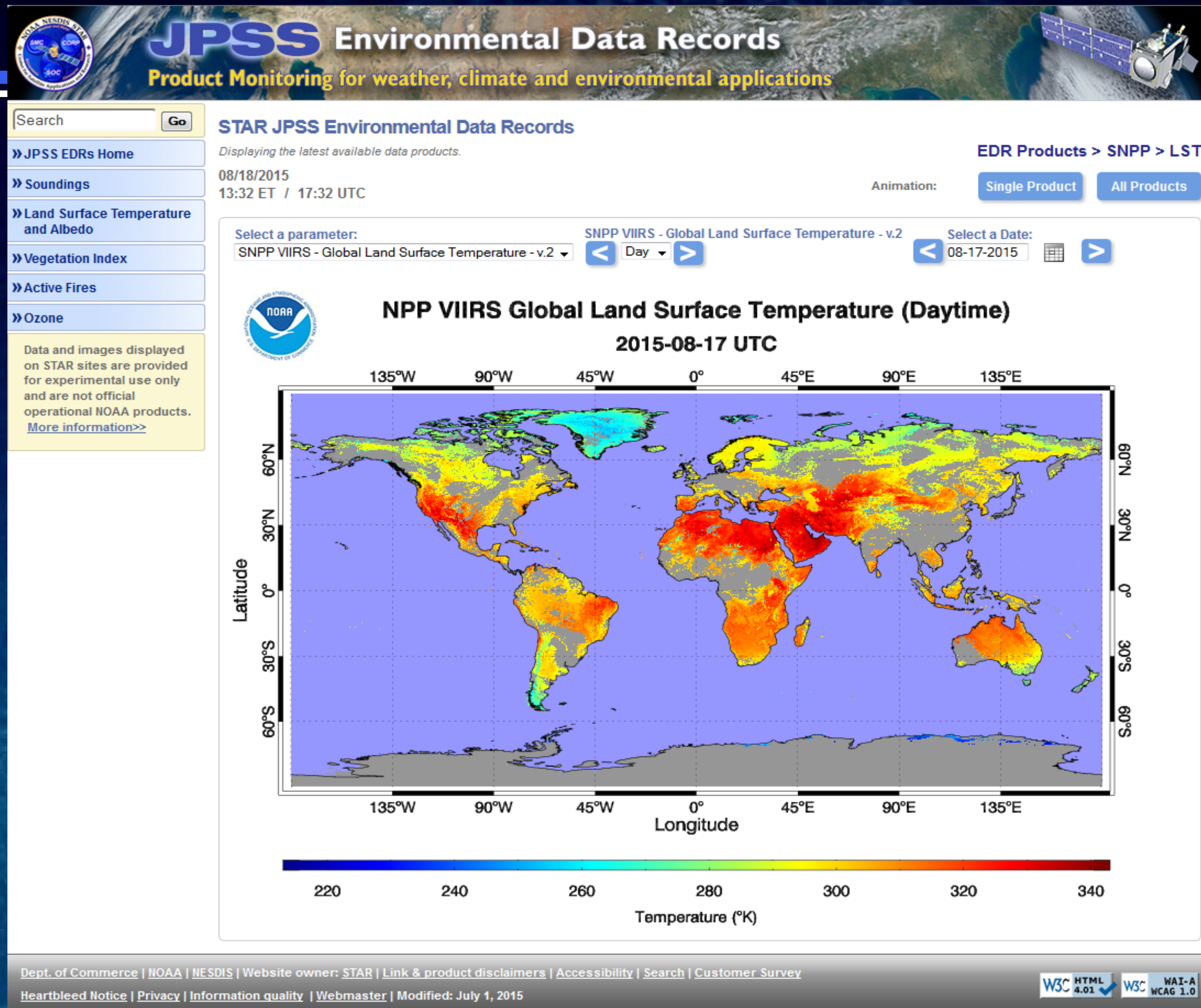




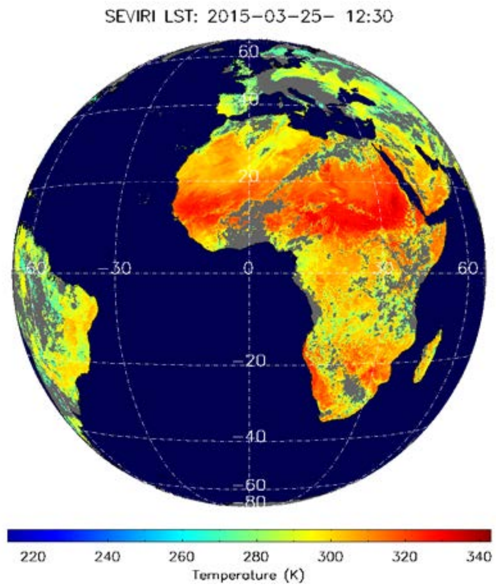
Routine Monitoring

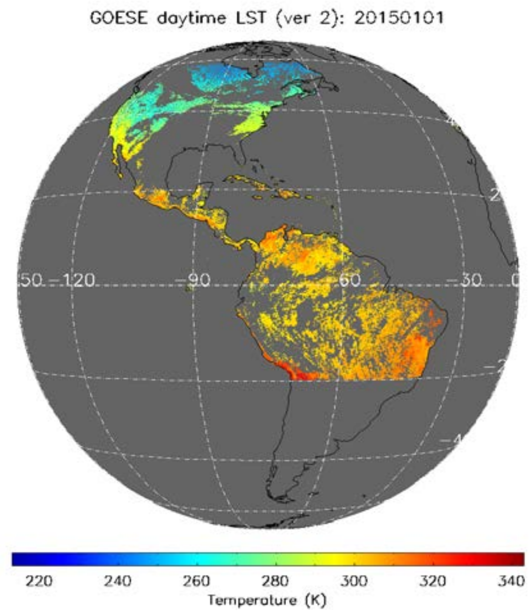
Route Monitoring through webpage

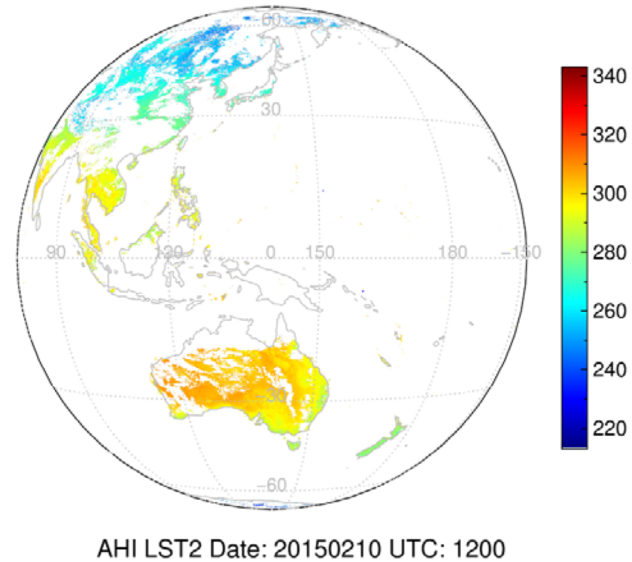
A STAR Webpage of LST routine monitoring has been set up for JPSS program. A similar webpage will be created for GOES-R mission after launch of the satellite (Mar 2016)

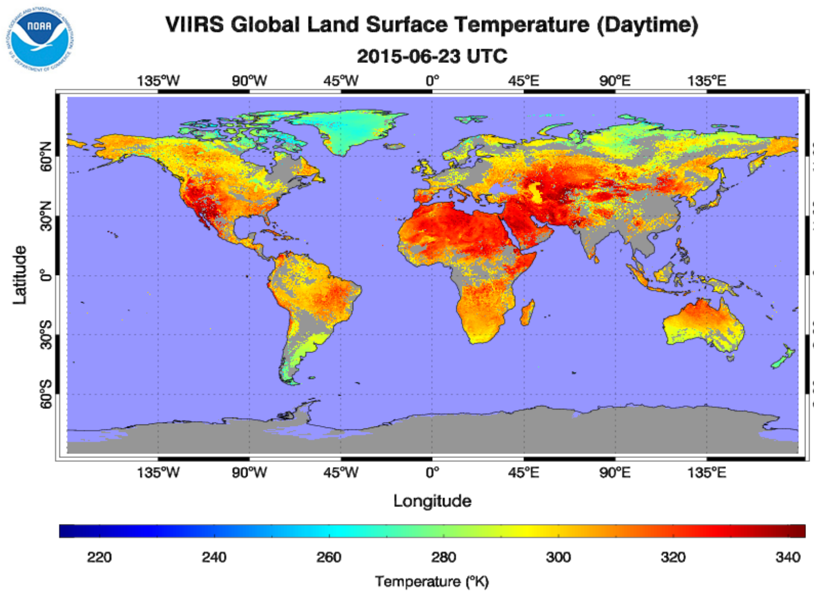


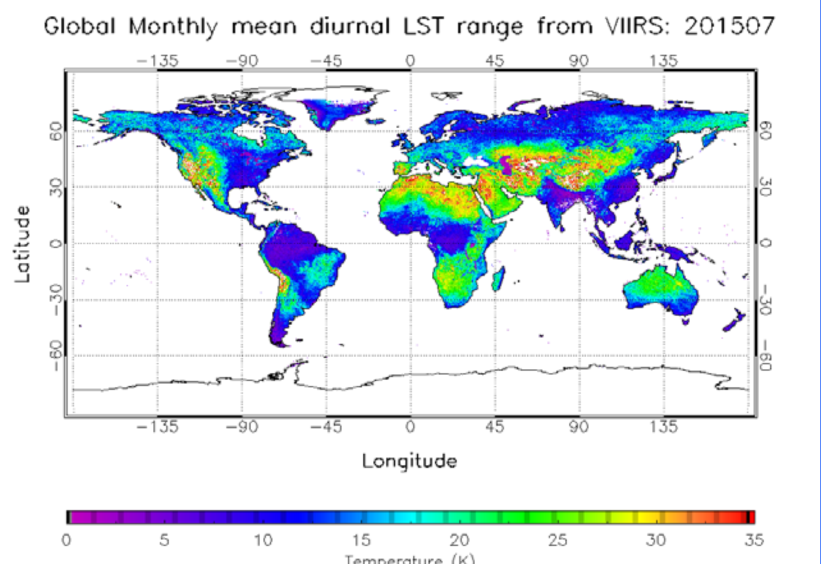
Monitoring -- LST images



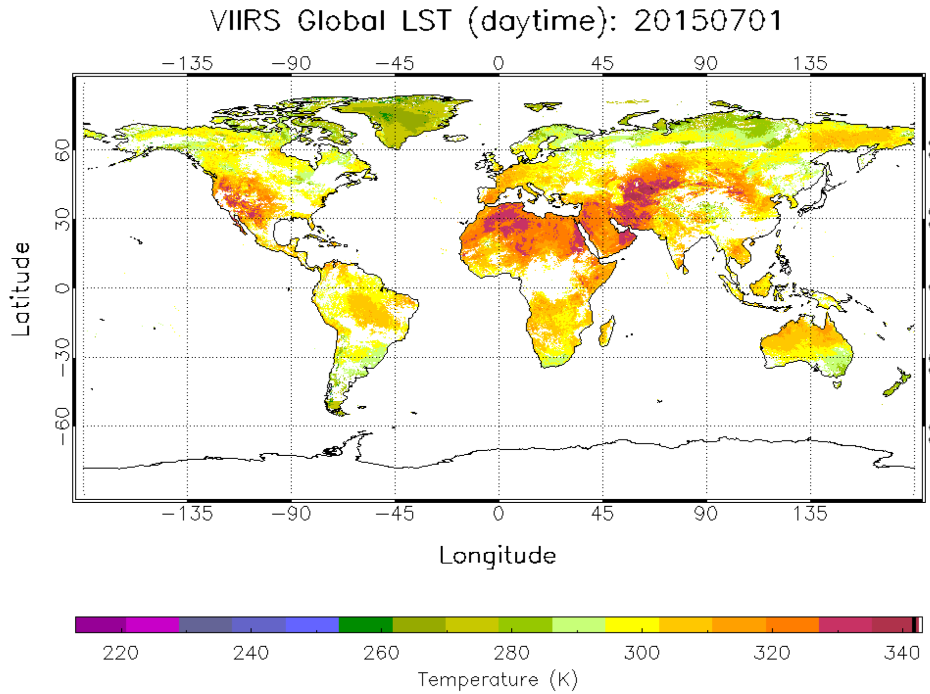


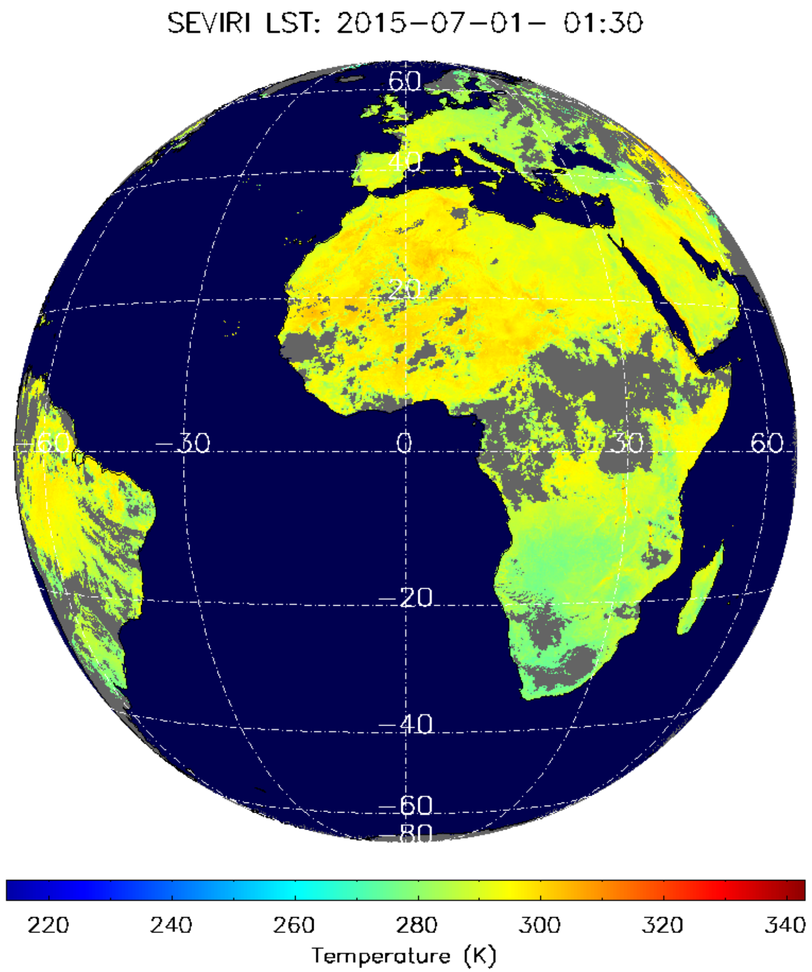


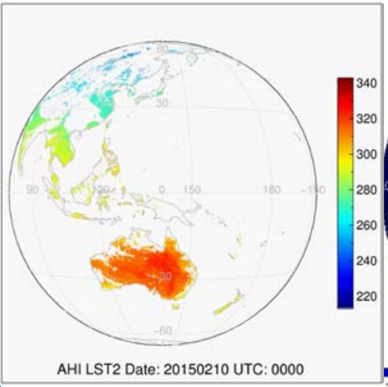


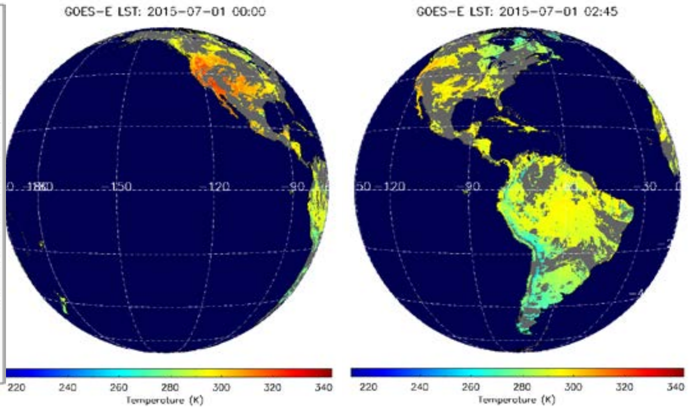


Monitoring -- Animation of Time Series

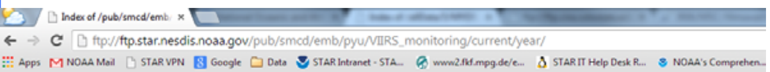








Alert System



Index of /pub/smcd/emb/pyu/VIIRS_monitoring/current/year/

Name	Size	Date Modified
[parent directory]		
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VIIRS-Bondville_IL_2014116_yearly_color_Mx7.png	20.2 kB	5/1/14 1:20:00 AM
VIIRS-Bondville_IL_2014116_yearly_color_Mx8.png	20.3 kB	5/1/14 1:20:00 AM
VIIRS-Bondville_IL_2014116_yearly_diff_timeseries.png	29.6 kB	5/1/14 1:20:00 AM
VIIRS-Bondville_IL_2014116_yearly_LPEATE.png	21.0 kB	5/1/14 1:20:00 AM
VIIRS-Bondville_IL_2014116_yearly_Mx7.png	21.0 kB	5/1/14 1:20:00 AM
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VIIRS-Boulder_CO_2014116_yearly_Mx8.png	21.1 kB	5/1/14 1:16:00 AM
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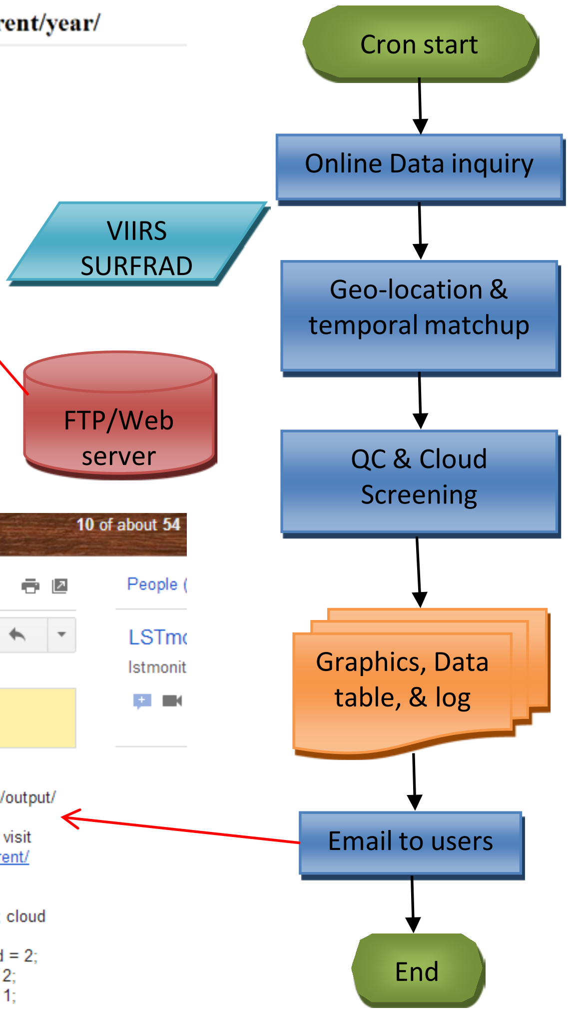
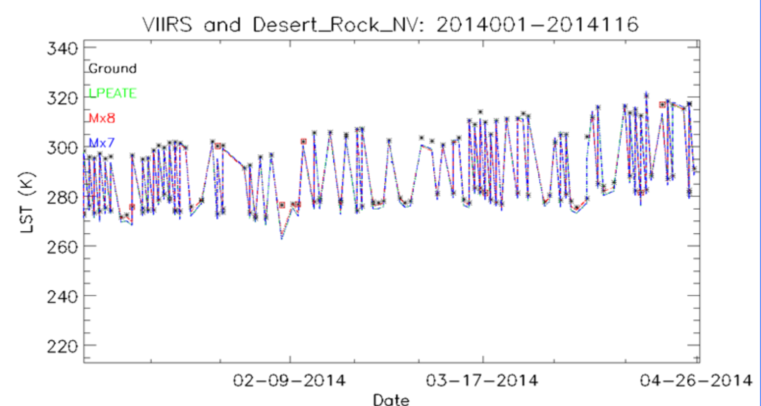
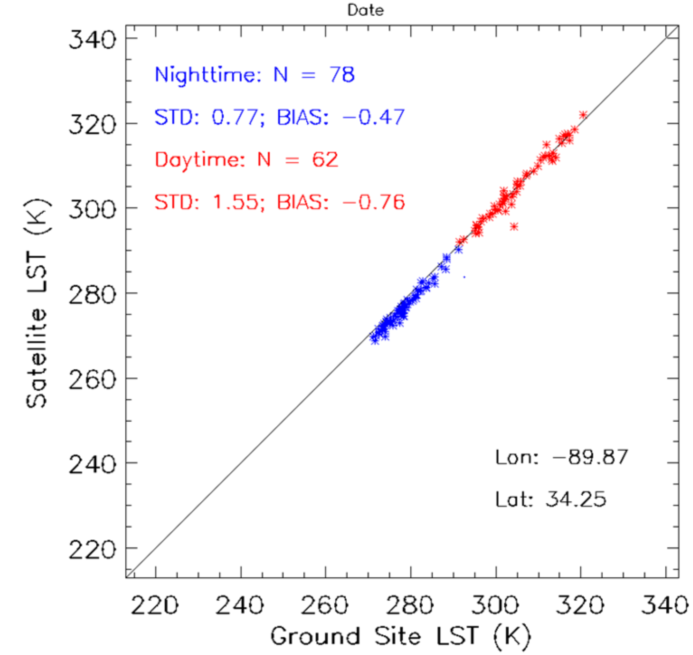
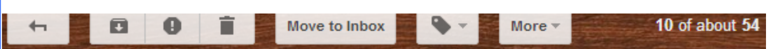
VIIRS-Desert_Rock_NV_2014116_yearly_color_Mx8.png	20.0 kB	5/1/14 1:12:00 AM
VIIRS-Desert_Rock_NV_2014116_yearly_diff_timeseries.png	26.2 kB	5/1/14 1:12:00 AM
VIIRS-Desert_Rock_NV_2014116_yearly_LPEATE.png	20.4 kB	5/1/14 1:12:00 AM









LST monitor results: Apr 24, 2014 Inbox

Peng Yu Apr 23 (8 days ago)
to me, yuling.liu, yunyue.yu, zhuo.wang

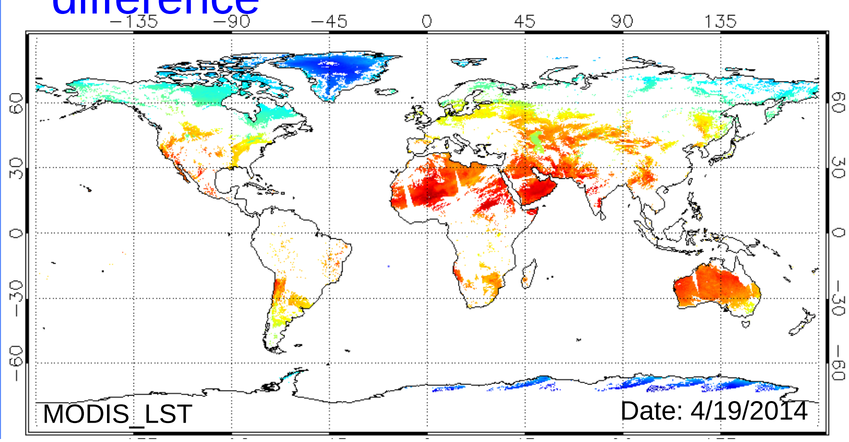
This message may not have been sent by: lstmonitor.awg@gmail.com Learn more Report phishing

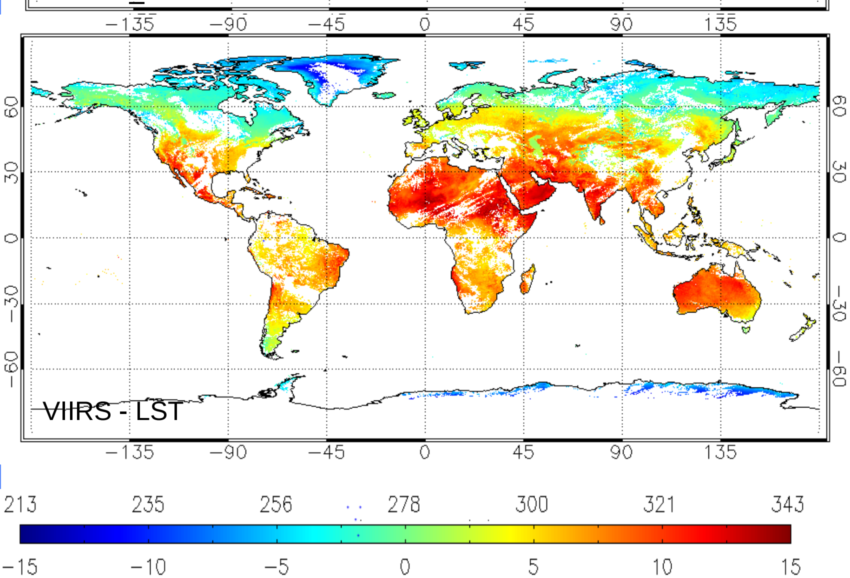
The monitoring for VIIRS has been done for this week.
Please visit the directory /net/rhs2001/disk3/pub/pyu/VIIRS_Monitoring/output/routine/2014/20140412/ to review the results.
Alternatively, in case you have difficulty accessing the above directory, visit ftp://ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/VIIRS_monitoring/current/

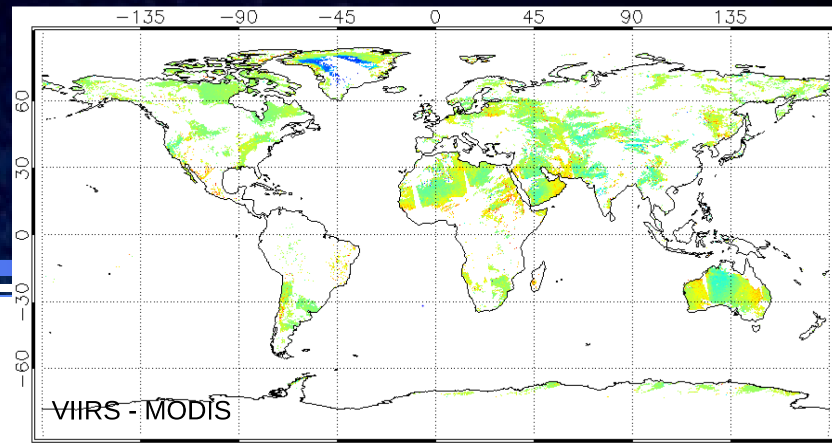
Some problem(s) have been found shown as in the followings:
Goodwin_Creek_MS: date = 2014108; time = 1830; lst_diff = -6.31451; cloud = 2;
Fort_Peck_MT: date = 2014103; time = 0840; lst_diff = -10.5048; cloud = 2;
Bondville_IL: date = 2014105; time = 1925; lst_diff = -7.49588; cloud = 2;
Bondville_IL: date = 2014108; time = 0845; lst_diff = -8.08051; cloud = 1;

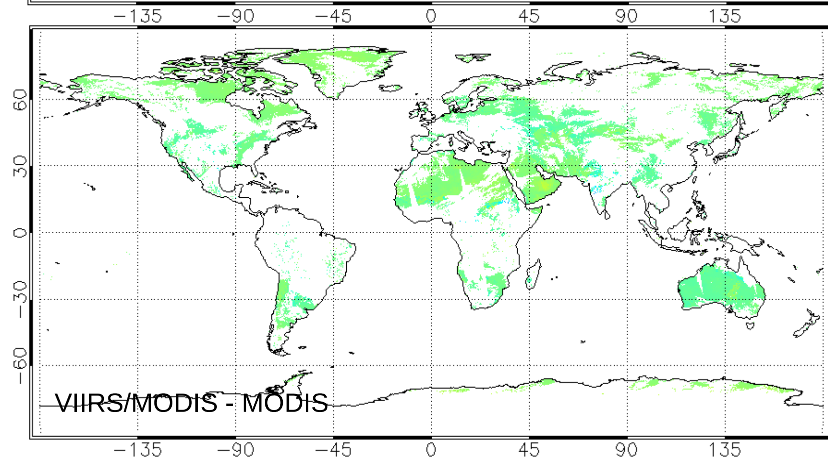
Cross-Satellite Comparison

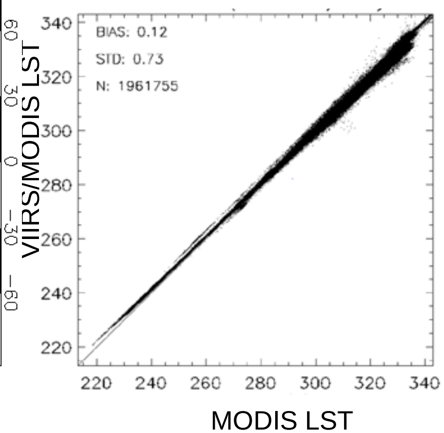
Cross-satellite Comparison: dataset difference







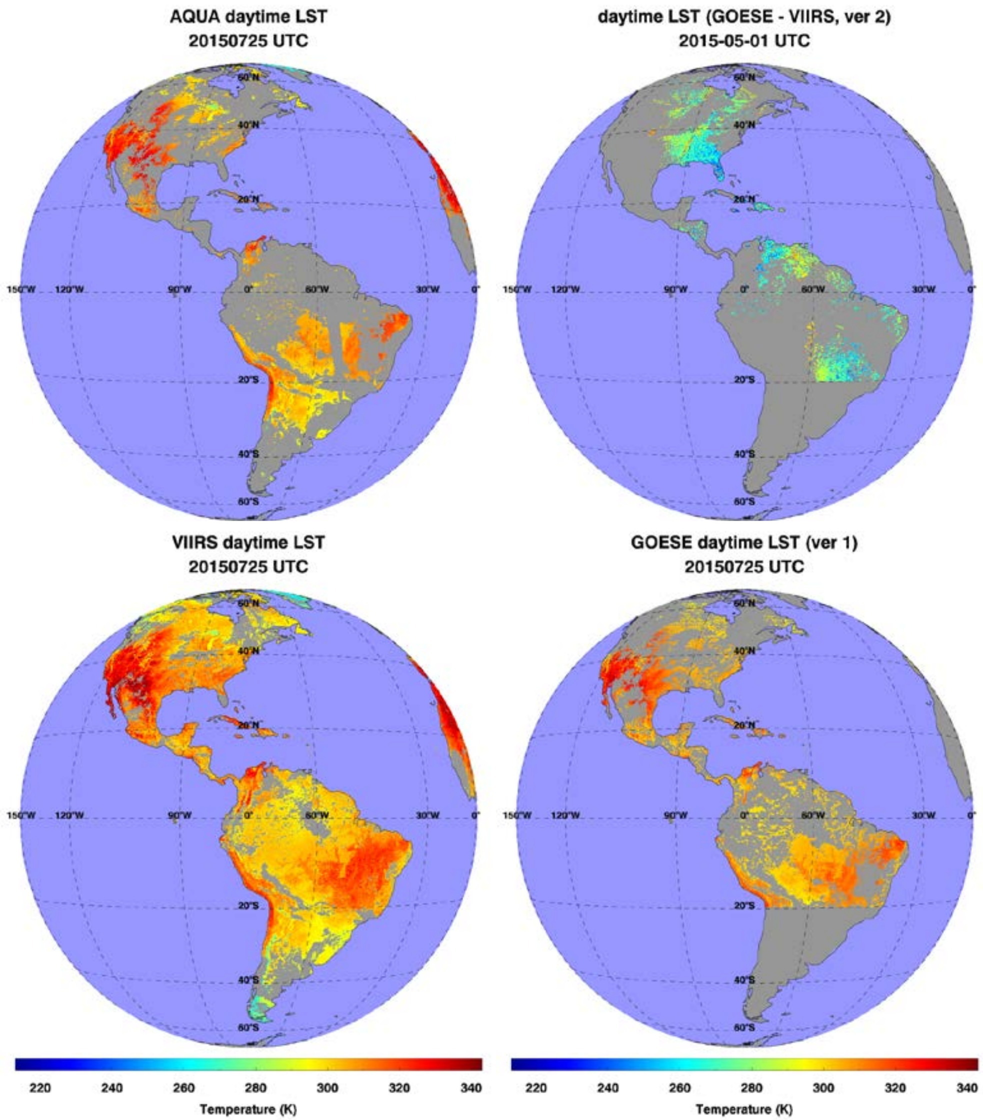




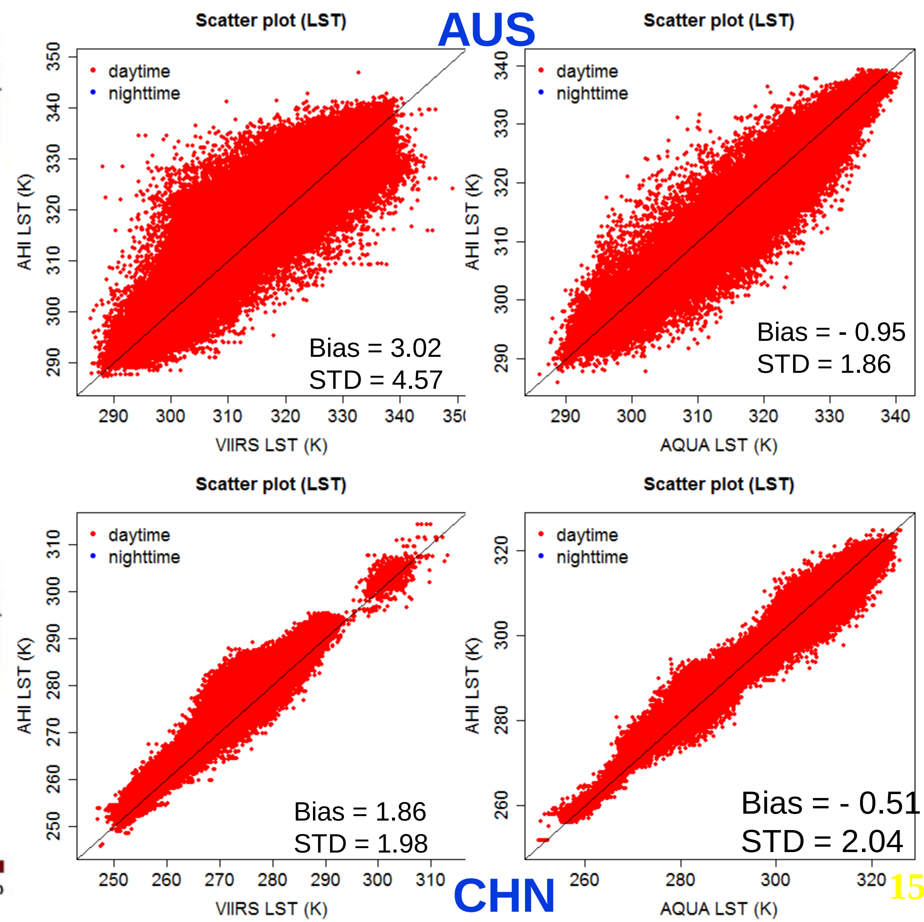
Cross-satellite LST comparison is used in VIIRS LST evaluation.

Caution: Time difference is a significant impact; granule level comparison is needed.

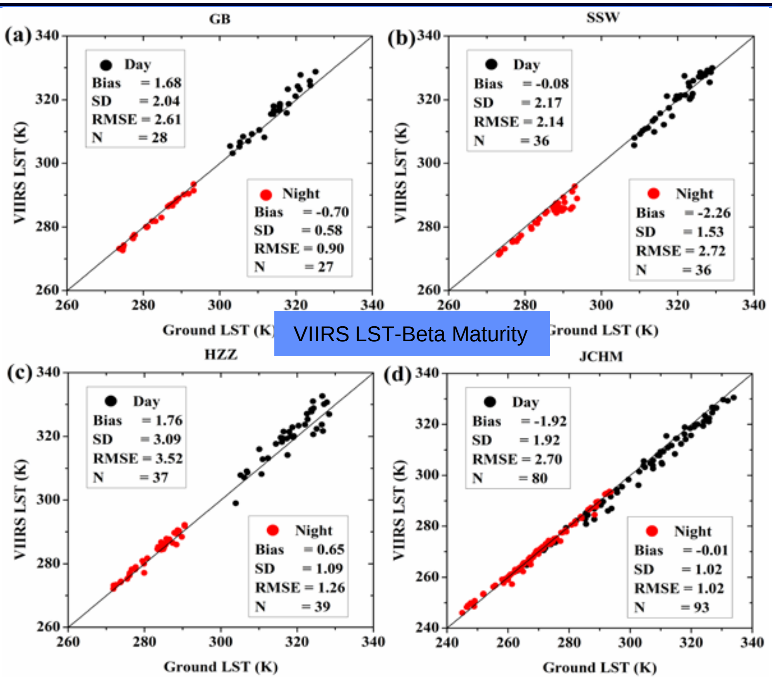
Cross-satellite comparisons

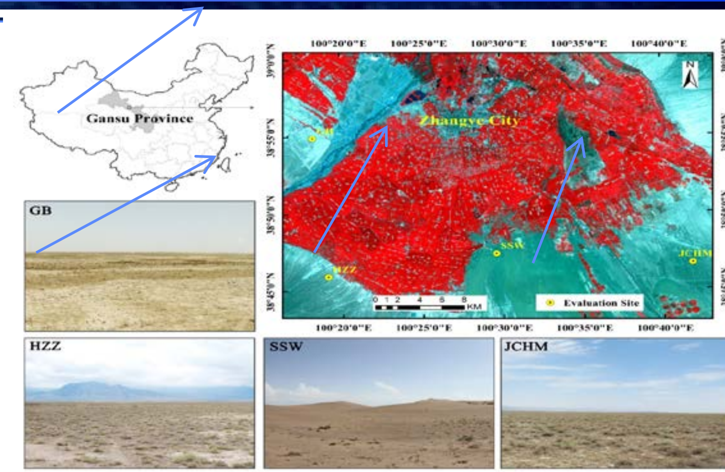


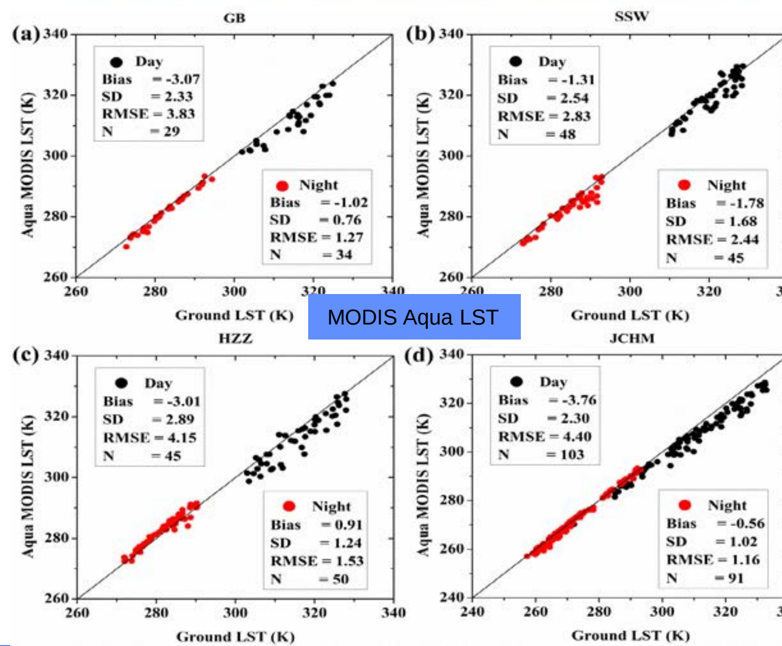
Geo-Leo LST comparisons



International cooperation







Data collection: arid area of northwest China (Heihe Watershed Allied Telemetry Experimental Research), from June 2012 to April 2013. Four barren surface sites were chosen for the evaluation.

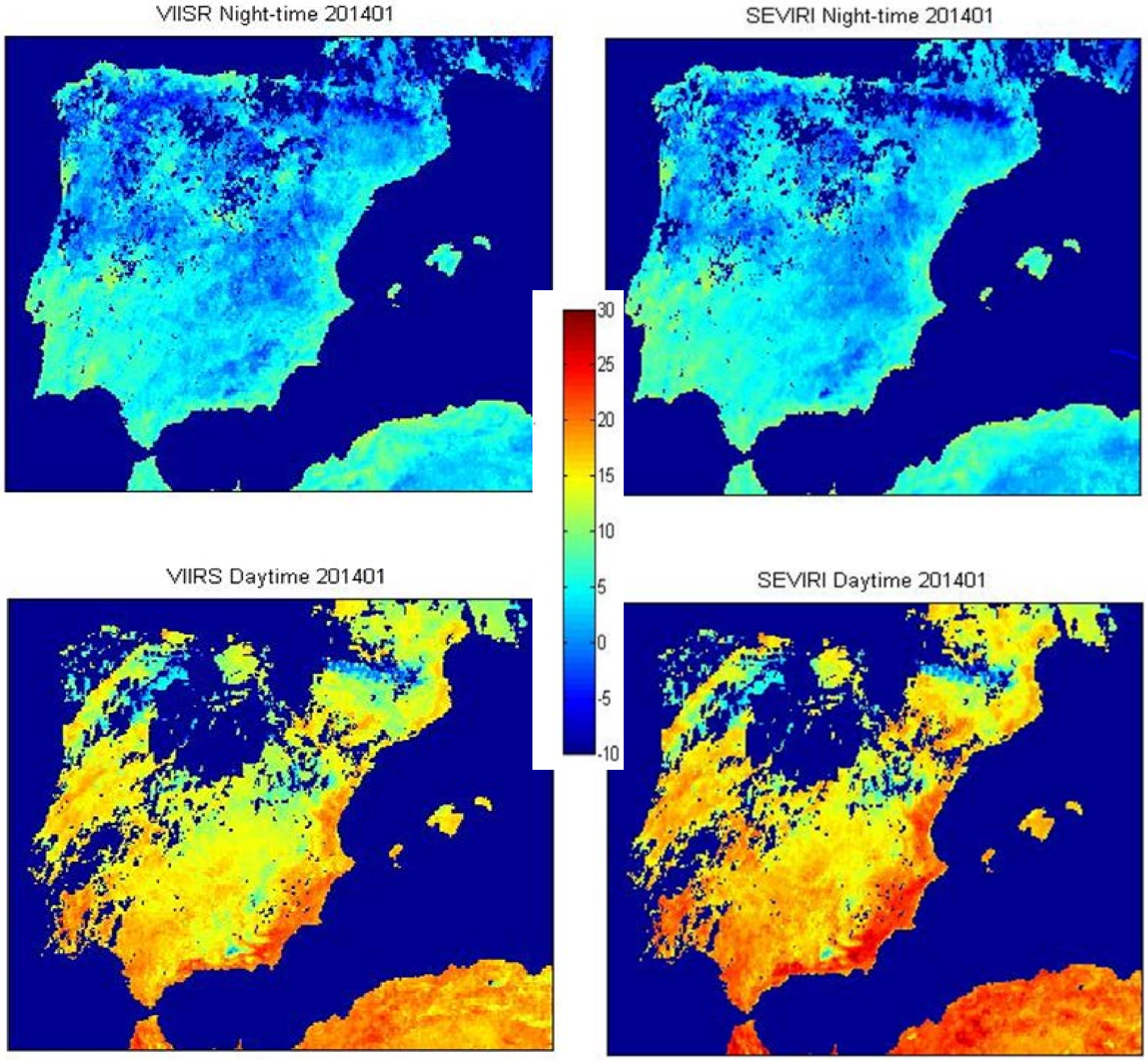
The result generally shows a better agreement for VIIRS LST than that for MODIS LST.

***China site data was obtained through a collaborative effort with Dr. Hua Li at Institute of Digital Earth and Remote Sensing, China Academy of Science**

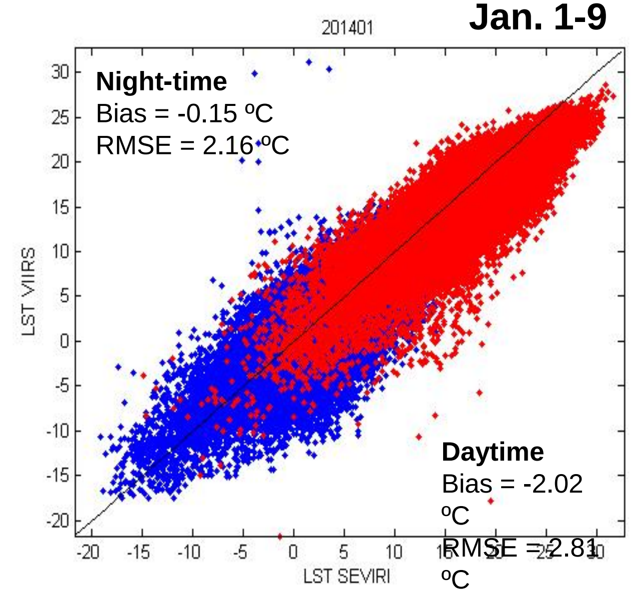
Reference: *H. Li, D. Sun, Y. Yu, H. Wang, Y. Liu, Q. Liu, Y. Du, H. Wang and B. Cao(2014) , Evaluation of the VIIRS and MODIS LST products in an arid area of Northwest China Remote Sensing of Environment 02/2014; 142:111–121*

International cooperation

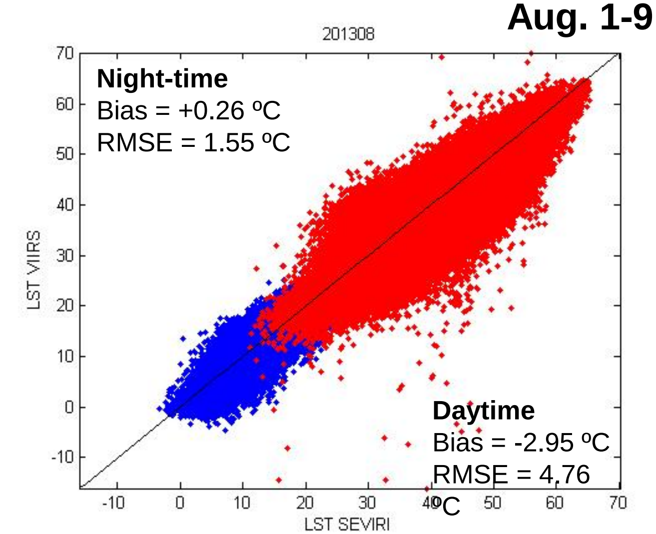
VIIRS **1-9 Jan 2014** **SEVIRI**



Jan. 1-9



Aug. 1-9



Courtesy of Isabel F. Trigo , through US-Portugal Bilateral cooperation program (on remote Sensing)

Further Enhancement /Improvement

- Validation tool improvement
  - » A web-based validation server
  - » practical use of the spot-to-pixel scaling method
  - » Field campaign participation (through national/international cooperation)
    - – High quality ground data is the key!
    - – Need the data over central and south of America
  - » Radiance-based LST validation method
  - » Cross-satellite comparison
    - – A visualization extension (comparisons with VIIRS, MODIS , Sentinel-3…)
  - » Three-measurement validation method
- Algorithm Enhancement /Improvement
  - » Emissivity data
  - » Additional cloud filtering for LST
  - » Water vapor correction
  - » Large angle correction
- Interactive with AIT, vender

NOAA-USGS Land Product Characterization System

STAR JPSS Science Team Meeting
27 August 2015

Kevin Gallo: NESDIS/STAR
John Dwyer: USGS/EROS
Steve Foga: SGT/EROS
Calli Jenkerson: SGT/EROS
Ryan Longhenry: USGS/EROS
Greg Stensaas: USGS/EROS

GOES-R
Geostationary Operational Environmental Satellite R-Series

JPSS
Joint Polar Satellite System

Land Product Characterization System (LPCS)

What is LPCS

Highlights/Status of LPCS

1. Inventory & Ordering
2. Analysis Tools

Path Forward

Summary

Land Product characterization System (LPCS)

What is LPCS

Highlights/Status of LPCS

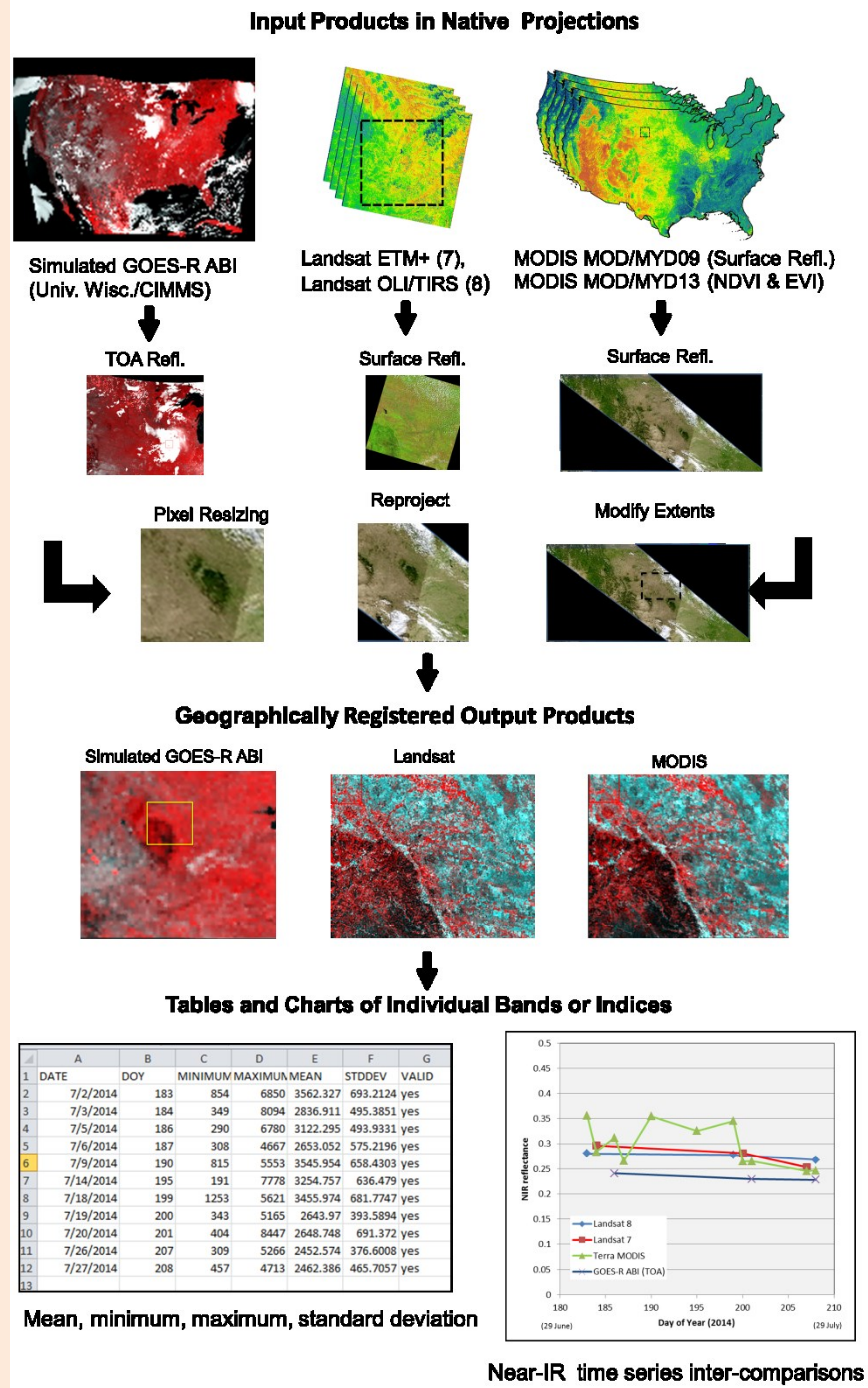
1. Inventory & Ordering
2. Analysis Tools

Path Forward

Summary

Land Product Characterization System

A web-based system designed to use moderate to high-resolution satellite data for characterization, and assist with validation, of GOES-R ABI and JPSS VIIRS products.



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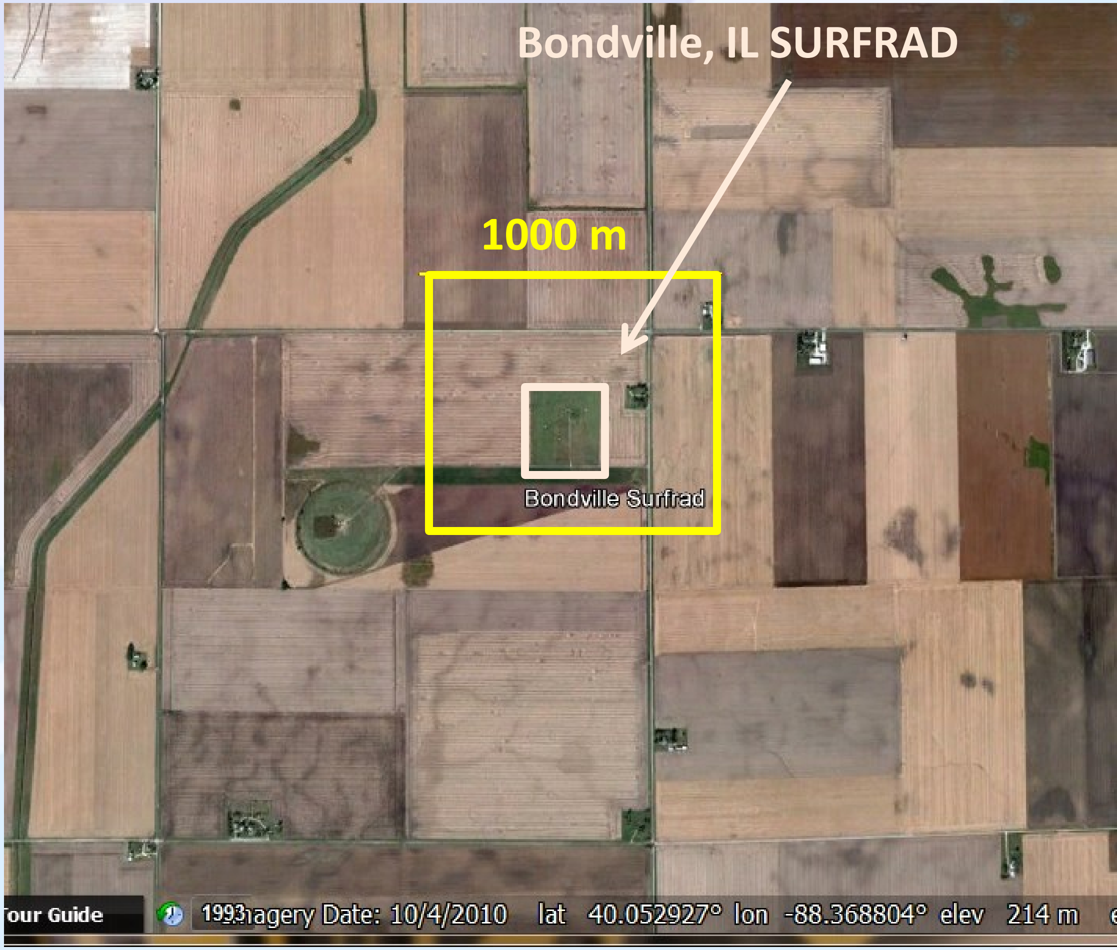
1	DATE	DOY	MINIMUM	MAXIMUM	MEAN	STDDEV	VALID
2	7/2/2014	183	854	6850	3562.327	693.2124	yes
3	7/3/2014	184	349	8094	2836.911	495.3851	yes
4	7/5/2014	186	290	6780	3122.295	493.9331	yes
5	7/6/2014	187	308	4667	2653.052	575.2196	yes
6	7/9/2014	190	815	5553	3545.954	658.4303	yes
7	7/14/2014	195	191	7778	3254.757	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							

Bondville, IL SURFRAD

What is LPCS

A web-based system designed to use **moderate to high-resolution** satellite data for validation of GOES-R ABI and JPSS VIIRS products.



What is LPCS

1. General characteristics
2. Desired functionality

Landsat 8 spatial resolution

vis/near IR 30 m

Thermal IR 100 m

Bondville, IL SURFRAD

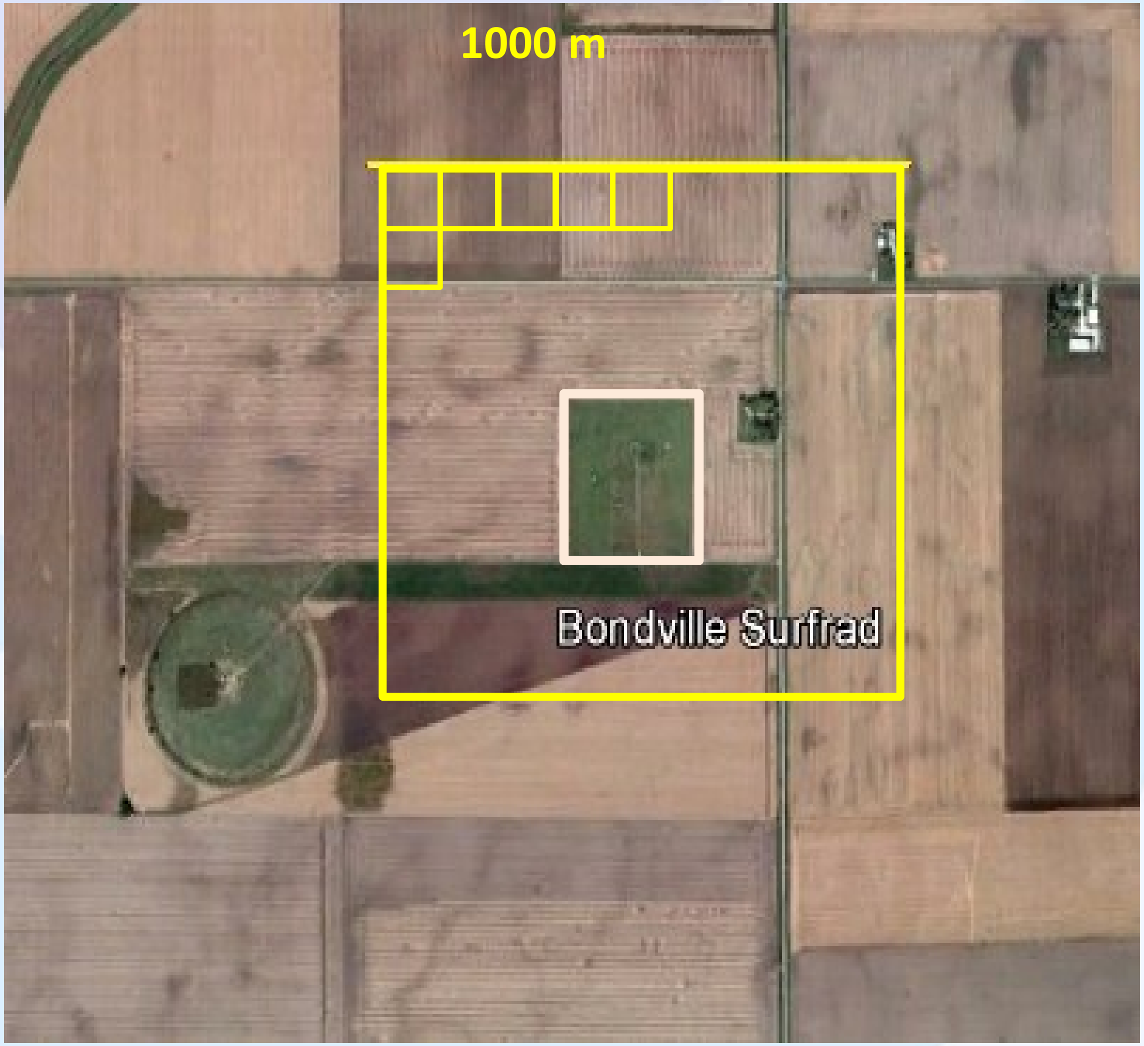
What is LPCS

1. General characteristics
2. Desired functionality

Landsat sampling for 1000 x 1000 m target:

- 1100 samples at 30 m resolution
- 100 samples at 100 m resolution

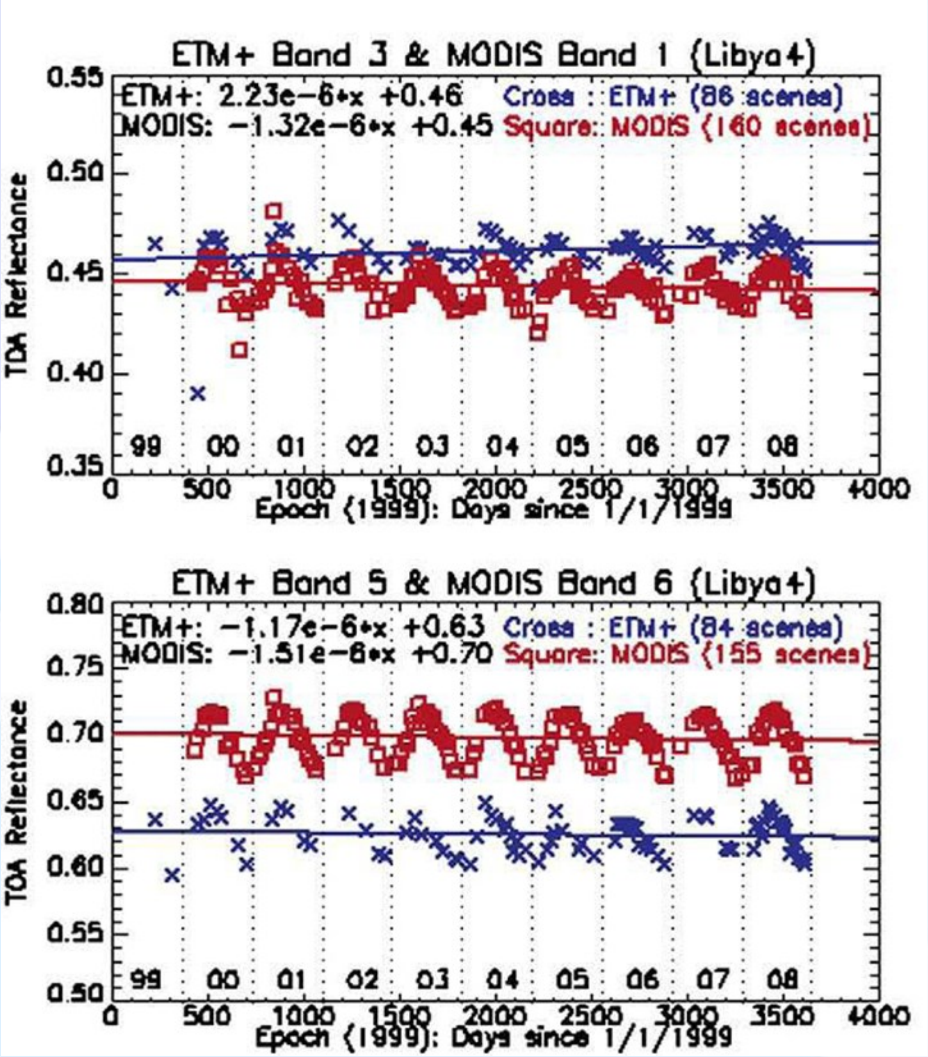
Bondville, IL SURFRAD



What is LPCS: General Characteristics
Potential Output examples

MODIS vs Landsat

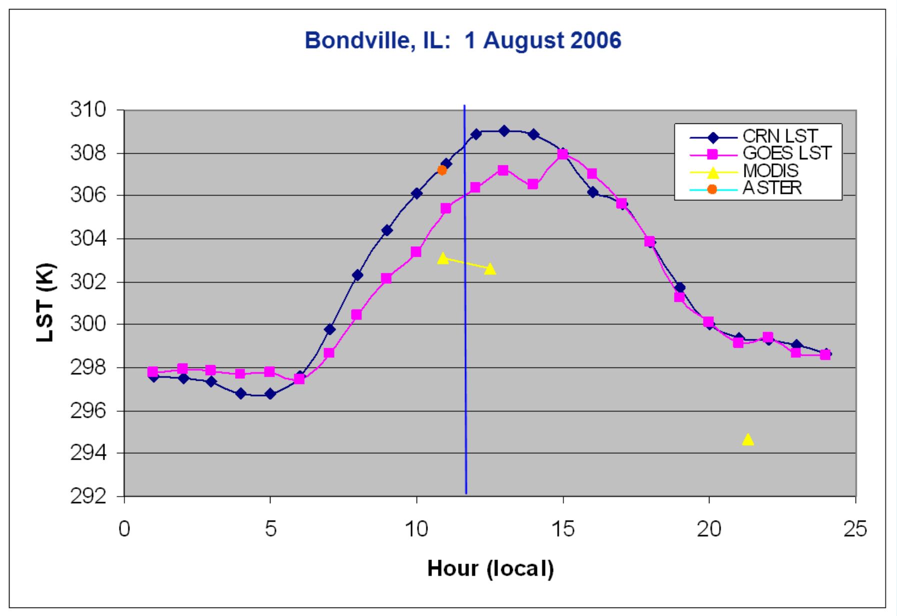
Trending of **similar bands** of data from **multiple sensors**.



What is LPCS: General Characteristics
Potential Output examples

Multiple sensor (satellite and in situ) comparisons for **single location** and **date.**

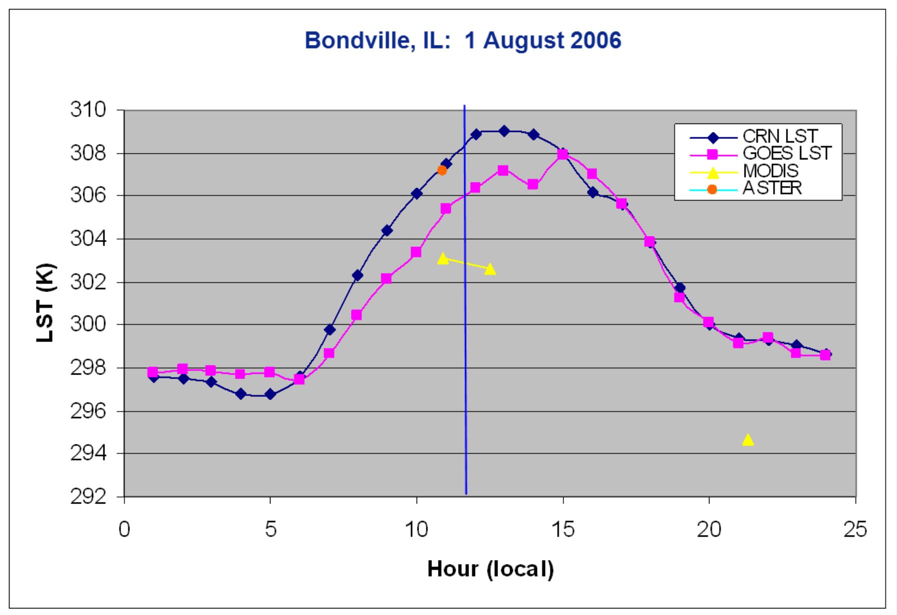
Land Surface Temp.



What is LPCS: General Characteristics
Potential Output examples

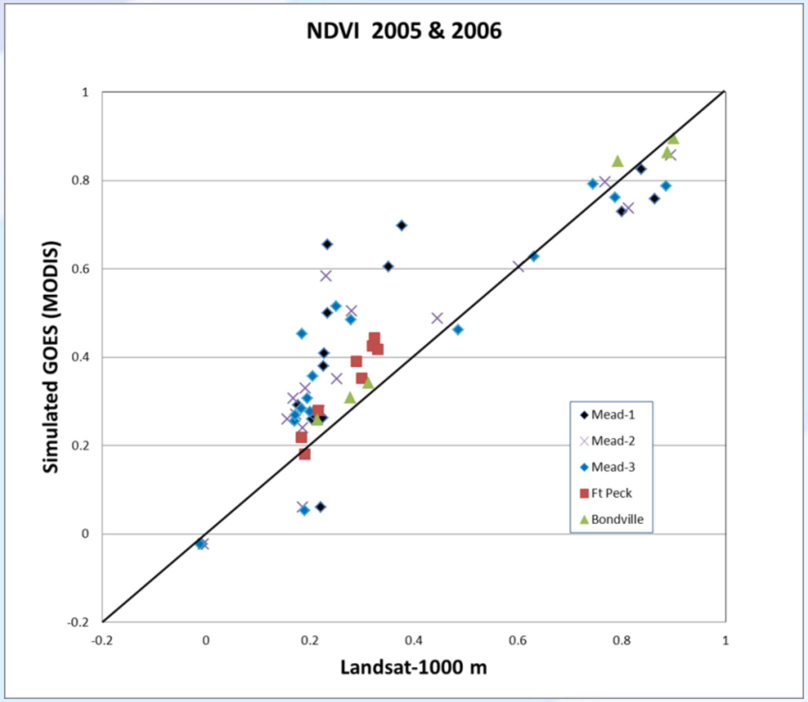
Land Surface Temp.

Multiple sensor (satellite and in situ) comparisons for single location and date.



NDVI

Multiple sensor comparison for **multiple locations** and **multiple dates**.

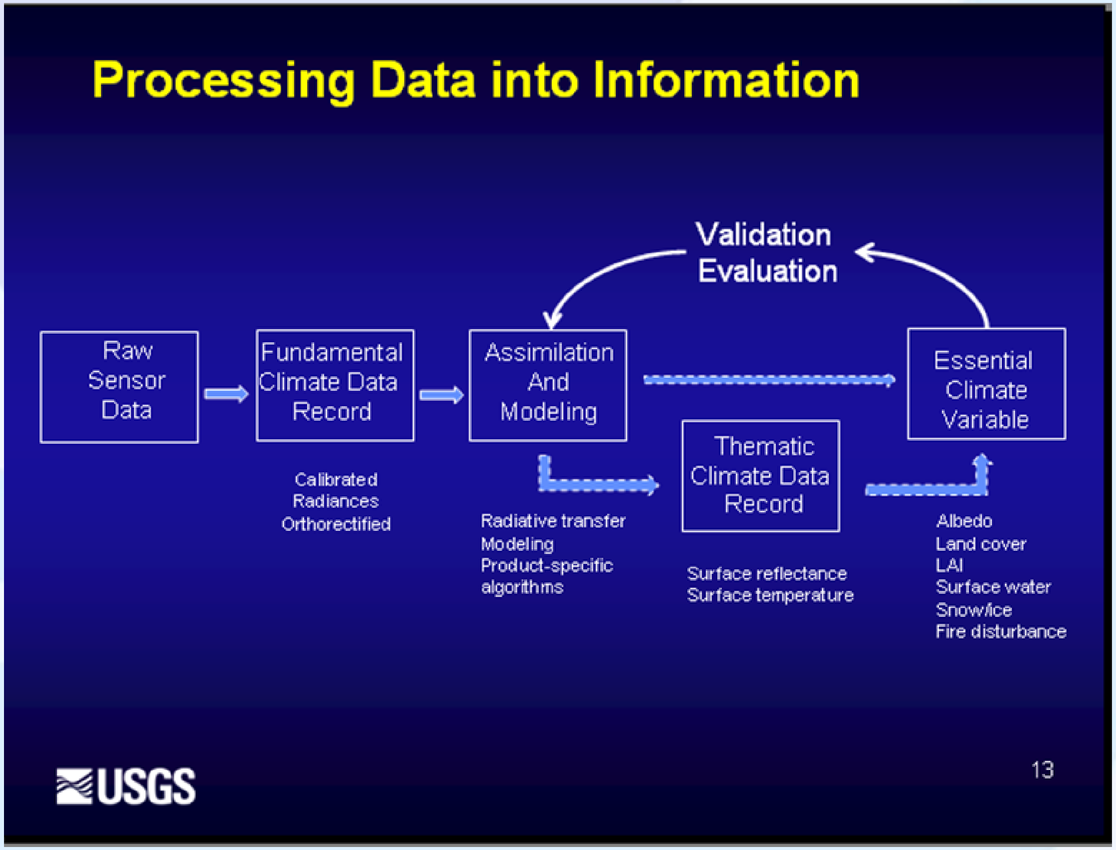


Why LPCS utilization of Landsat?

Landsat Product Development

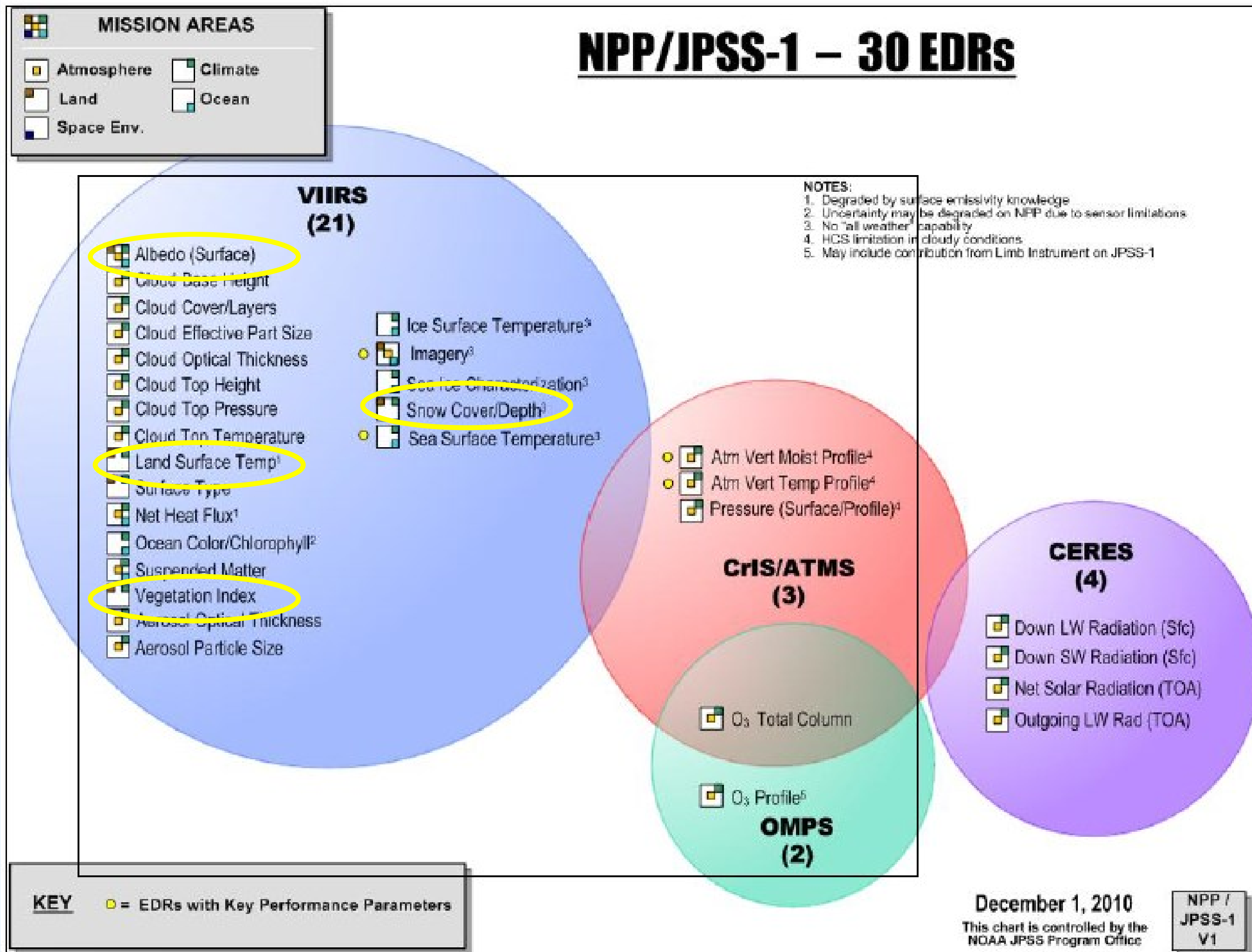
<ins>CDRs</ins>
Surface Reflectance (and NDVI), Land Surface Temperature/Emissivity

<ins>ECVs</ins>
Surface Water Extent, Burned Area Extent, Snow Covered Area



LPCS - VIIRS validation synergy

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



LPCS – GOES-R ABI 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

Land Product characterization System (LPCS)

What is LPCS

Why LPCS developed/hosted at EROS

Highlights of LPCS

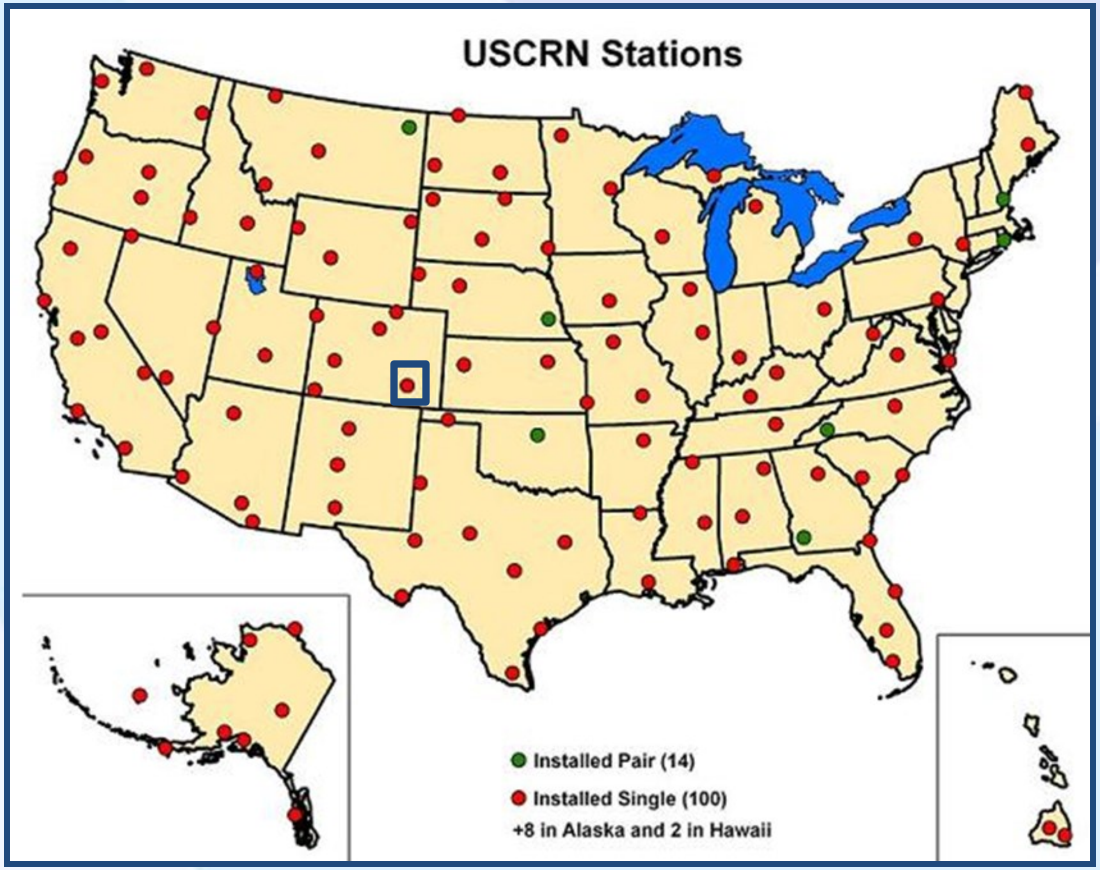
1. Inventory & Ordering
2. Analysis Tools

Path Forward

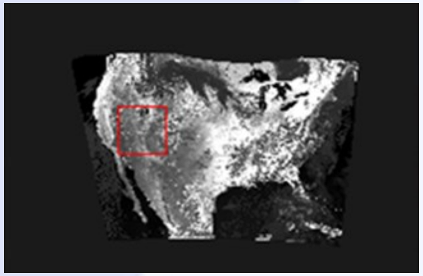
Summary

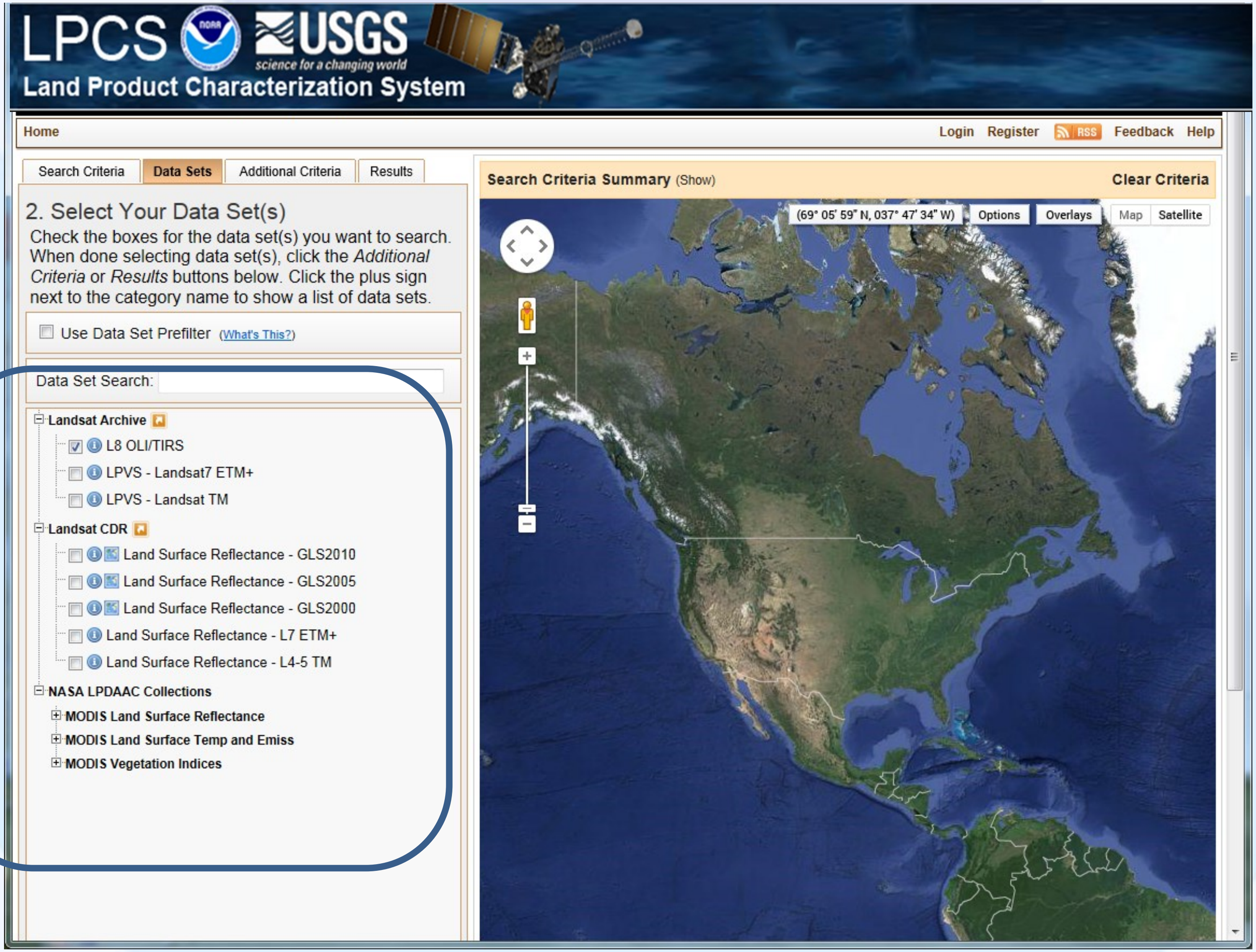
Example of LPCS Functionality

Data extracted for VIIRS (NOAA and NASA products), MODIS, Landsat 8, and simulated GOES-R ABI for the La Junta, CO, CRN station located within NASA golden tile (h09v05).

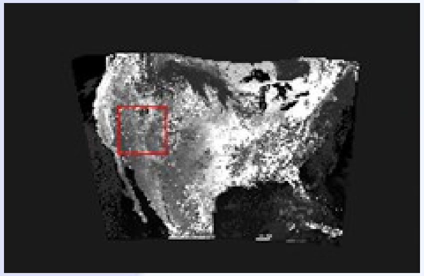


Search within LPCS for Landsat and MODIS data coincident with VIIRS and simulated GOES-R ABI data (provided by Univ. Wisc./CIMSS).

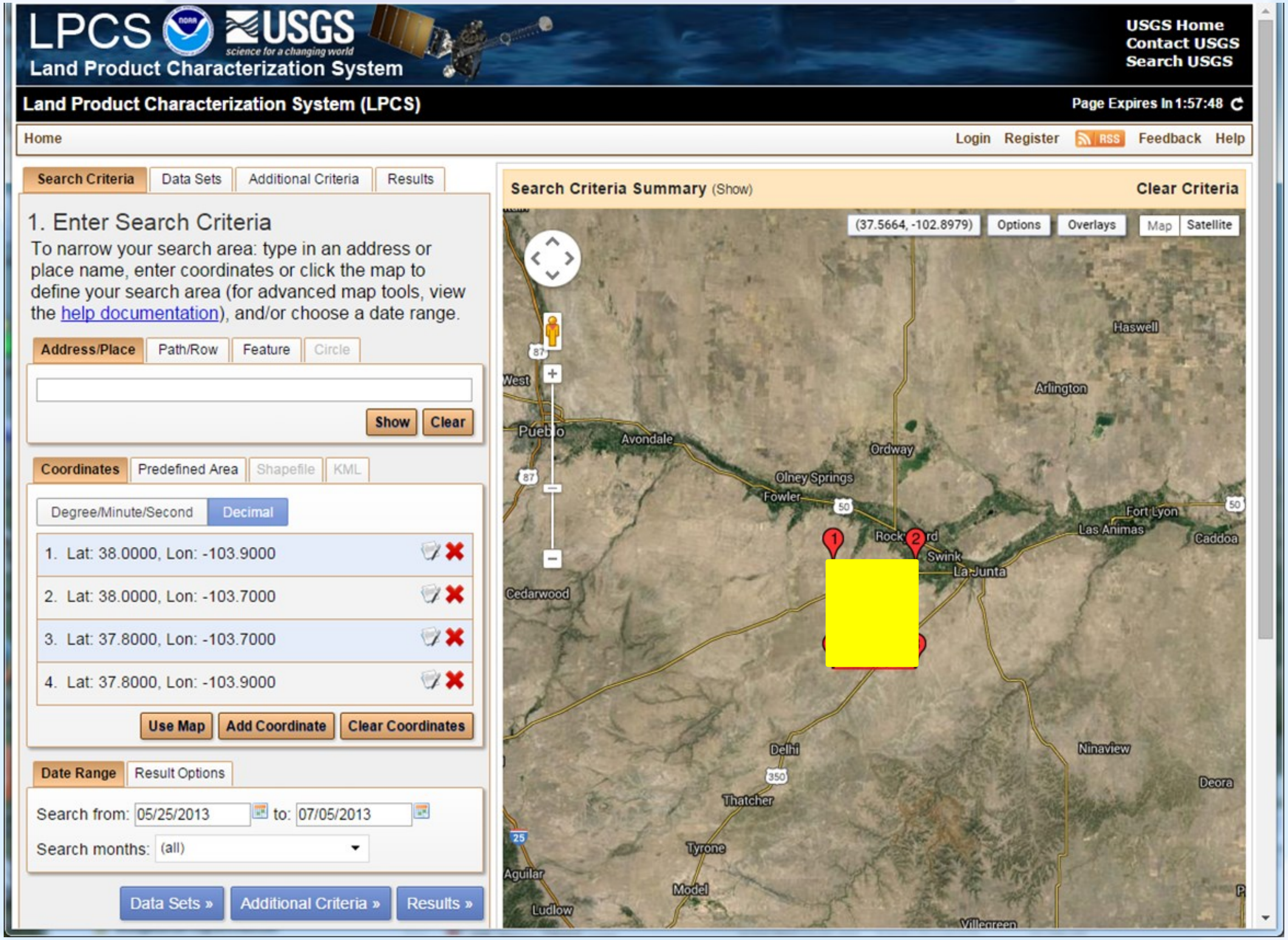




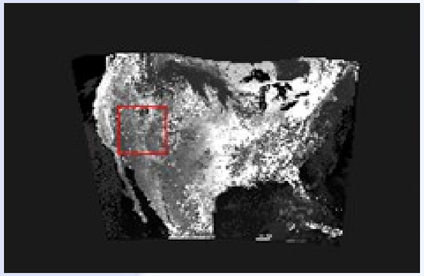
Search for Landsat and MODIS data coincident with VIIRS and simulated GOES-R ABI data (provided by Univ. Wisc./CIMSS).



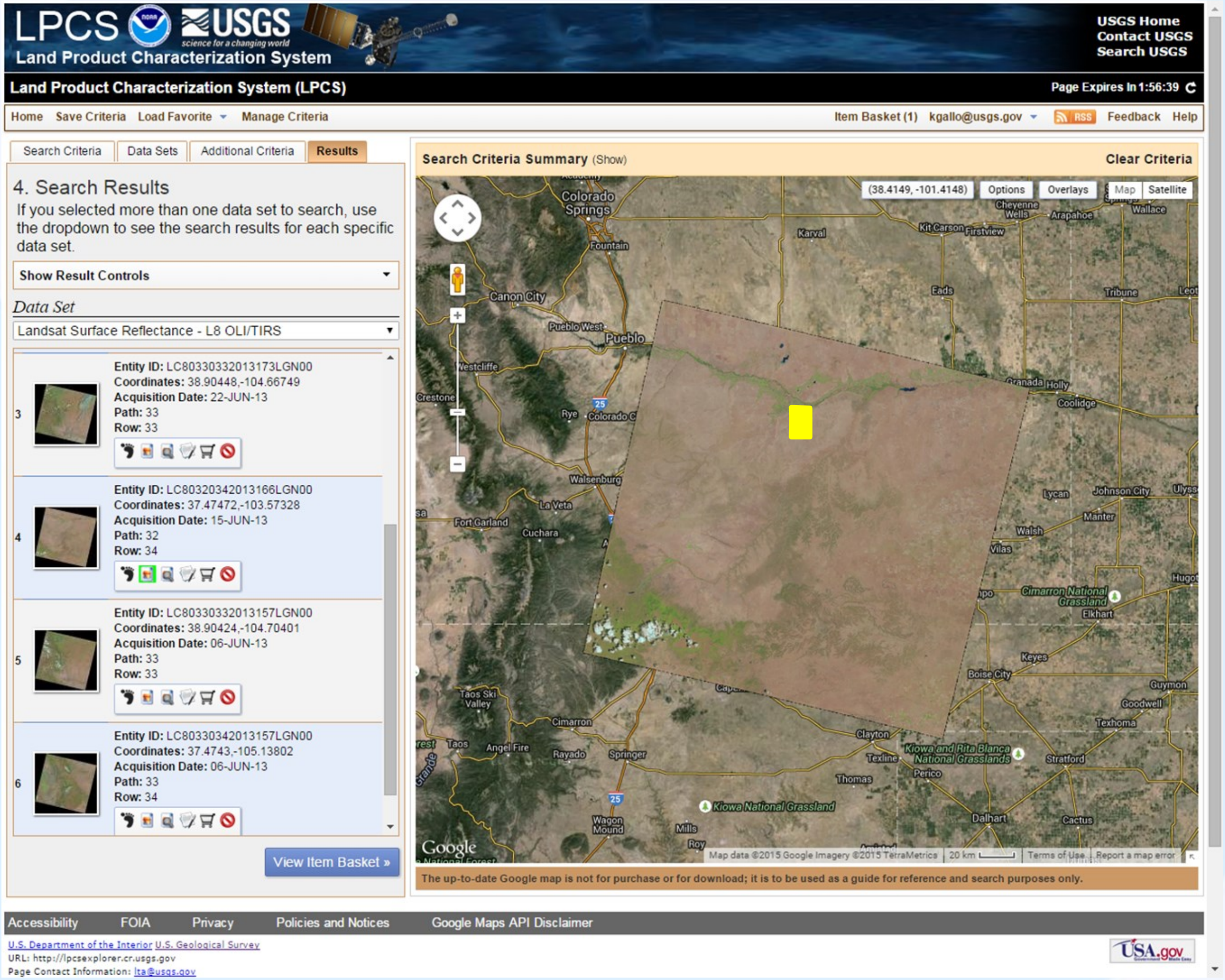
La Junta CO: Landsat 8 and MODIS data search criteria



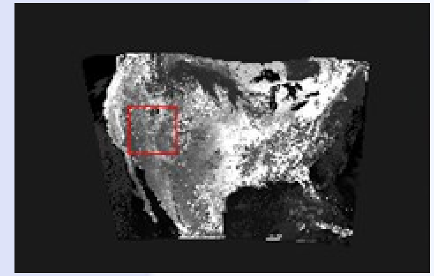
Search for Landsat and MODIS data coincident with VIIRS and simulated GOES-R ABI data (provided by Univ. Wisc./CIMSS).



La Junta CO: Landsat 8 data results



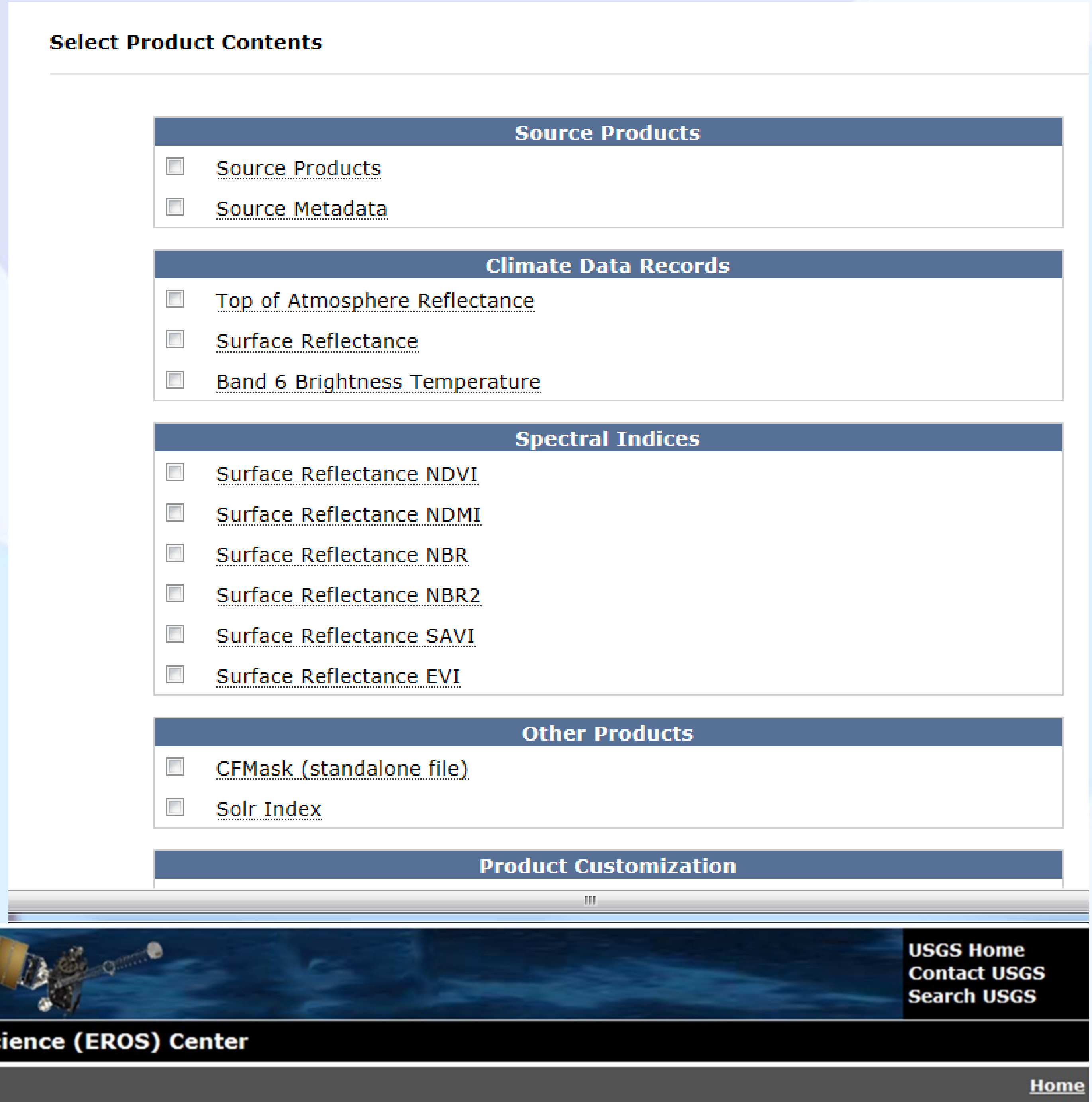
Search for Landsat and MODIS data coincident with VIIRS and simulated GOES-R ABI data (provided by Univ. Wisc./CIMSS).



La Junta CO: MODIS-Terra data results

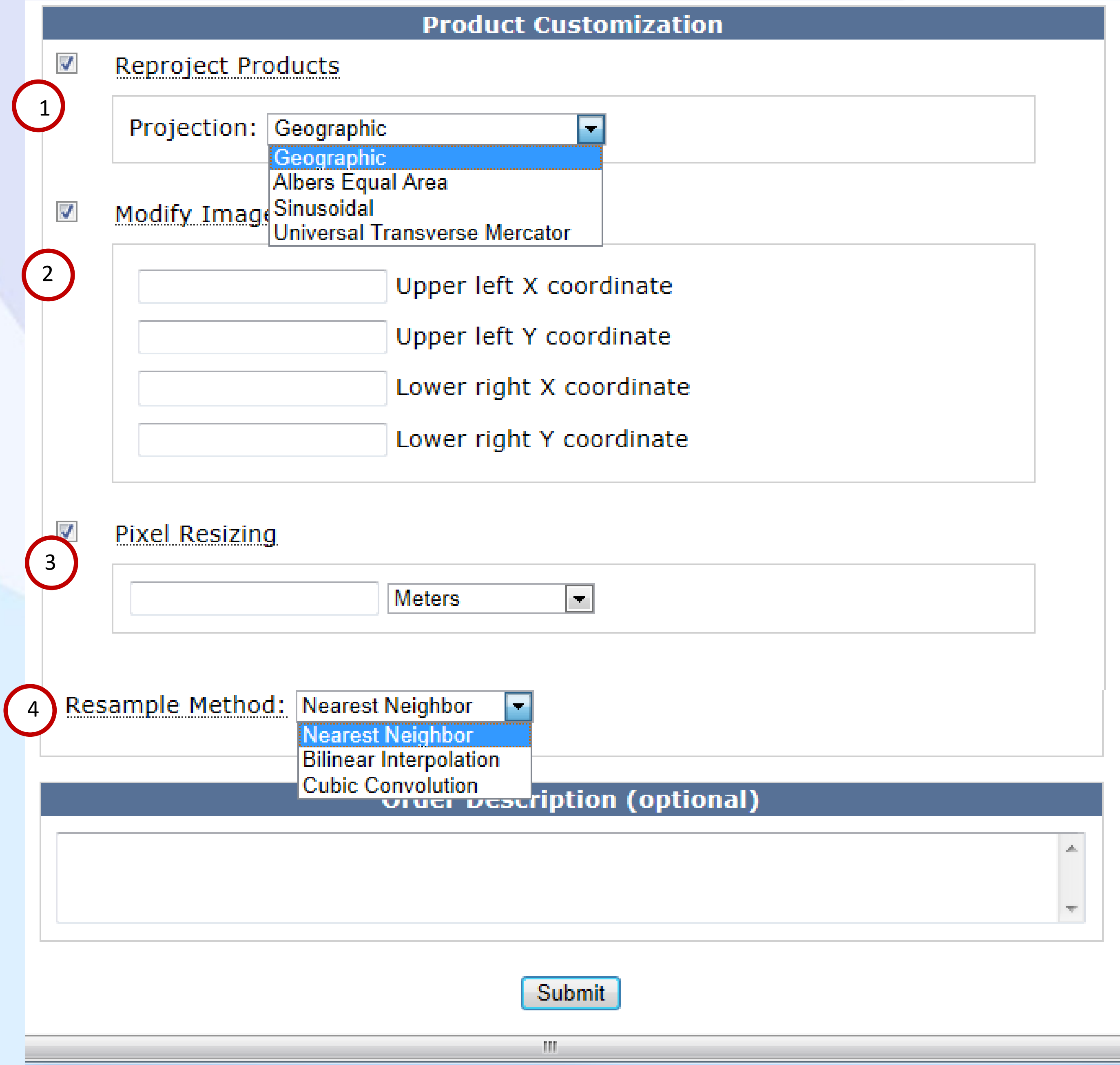
Enhanced Landsat Products

Additional ECVs and CDRs will be added to menu as available.



Enhanced Functionality

1. Auto-registration of data to common map projections for analysis.
2. User defines area of interest for analysis
3. Match pixel size for all images
4. Several resampling options



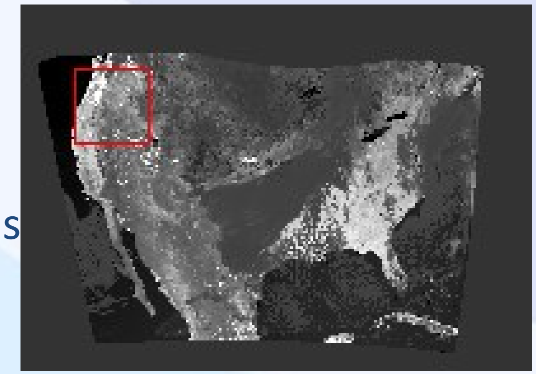
Example of LPCS Functionality

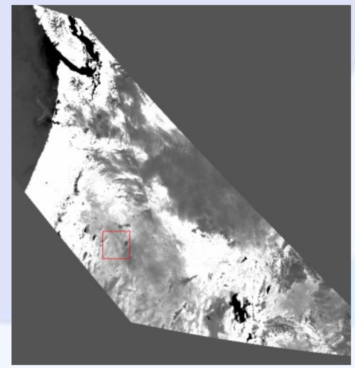
Example of georegistration of simulated ABI, VIIRS and Landsat data.

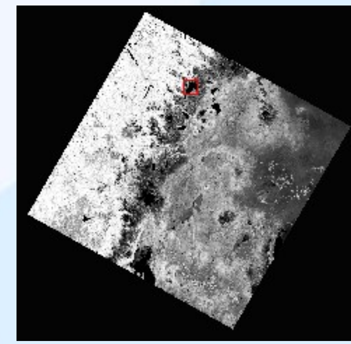
Simulated GOES-R ABI | VIIRS | Landsat

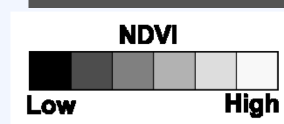
Input Data

Varied Pixel Sizes
Varied Map Projections



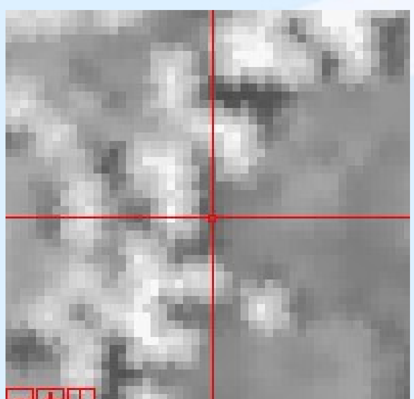


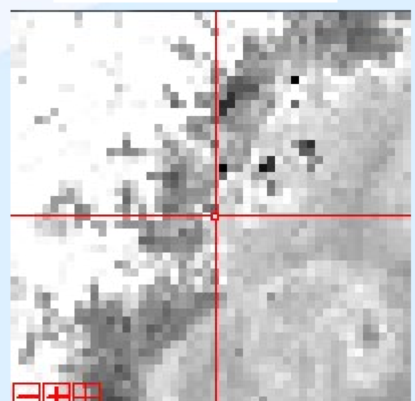


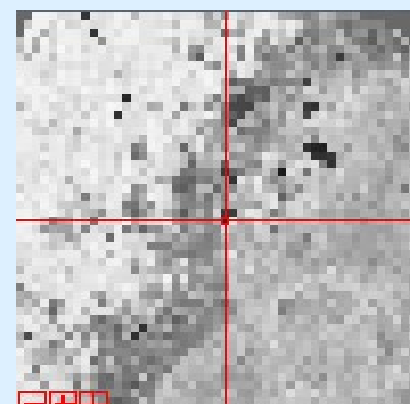


Georegistered Data

Same Pixel Size
Same Map Projection





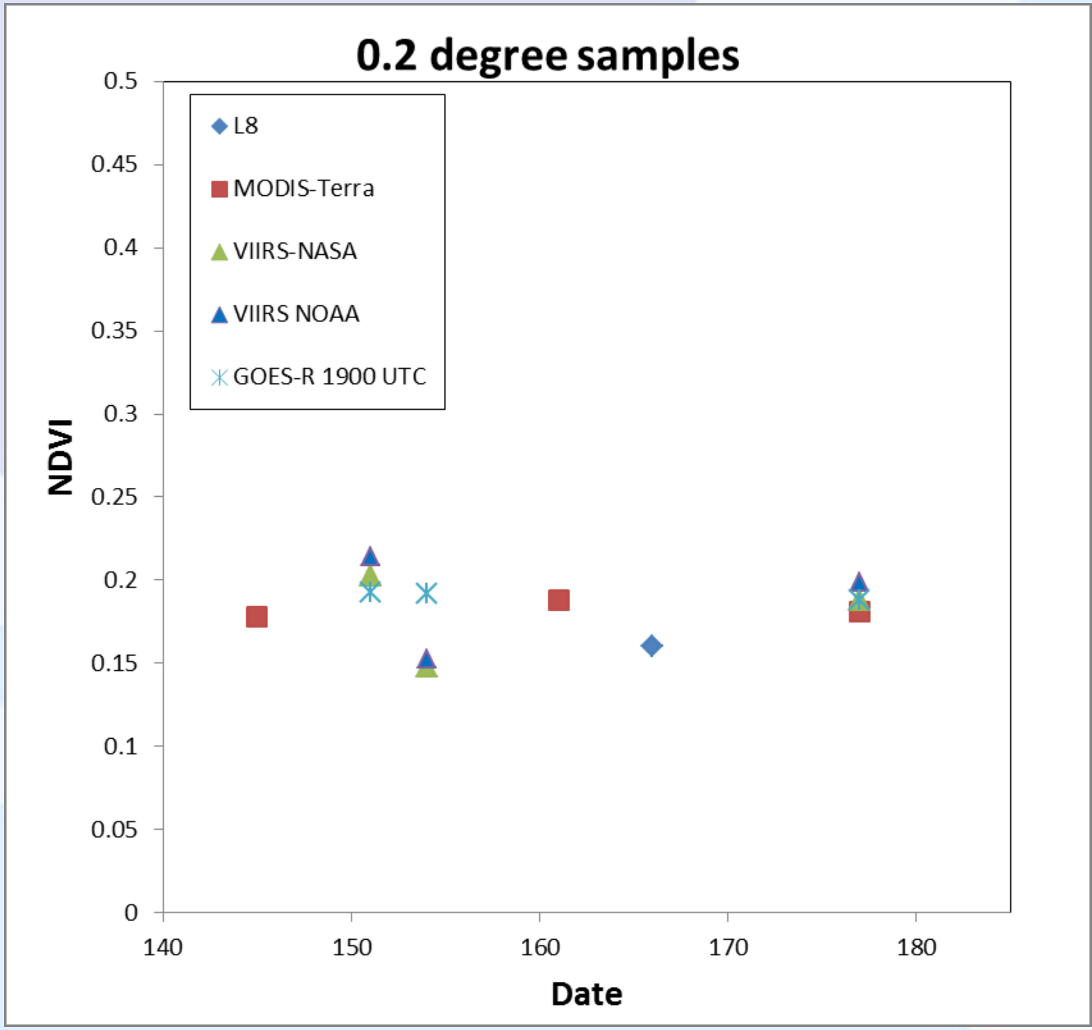


Example of Potential Analysis

Multisensor/multidate comparison for La Junta, CO, CRN station in 2013.

Data included in analysis:

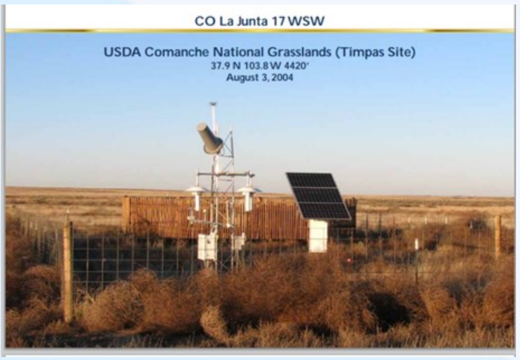
- Landsat 8: TOC NDVI
- NOAA-VIIRS: TOA NDVI
- NASA-VIIRS: TOC NDVI
- MODIS: TOC NDVI
- Simulated GOES-R: TOA NDVI

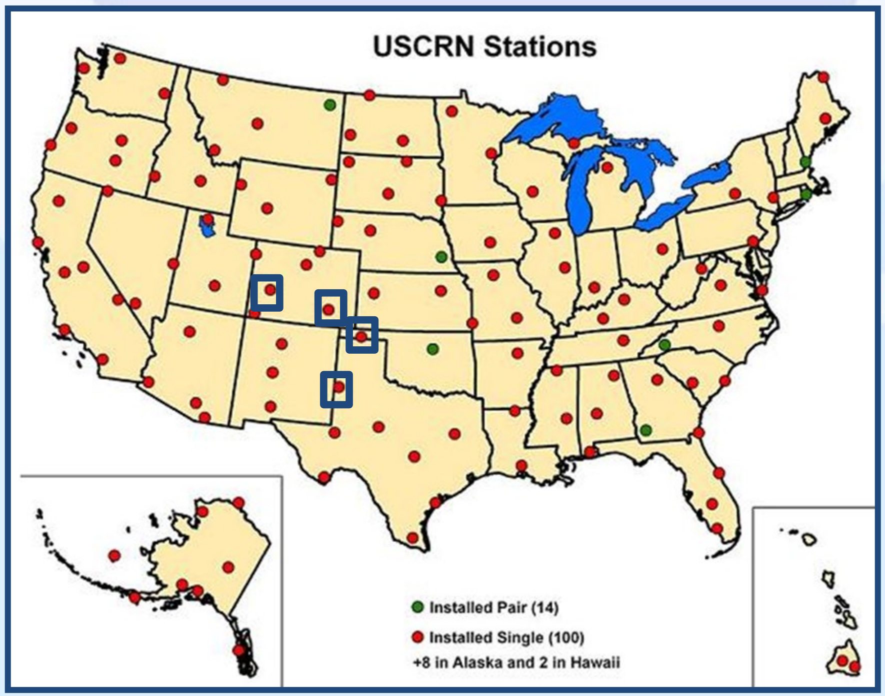


Each point within figures represents 0.2 x 0.2degree sample area.

Example of LPCS Functionality

Data extracted for VIIRS (NOAA and NASA products) and Landsat 8 for four CRN stations located within NASA golden tile (h09v05).

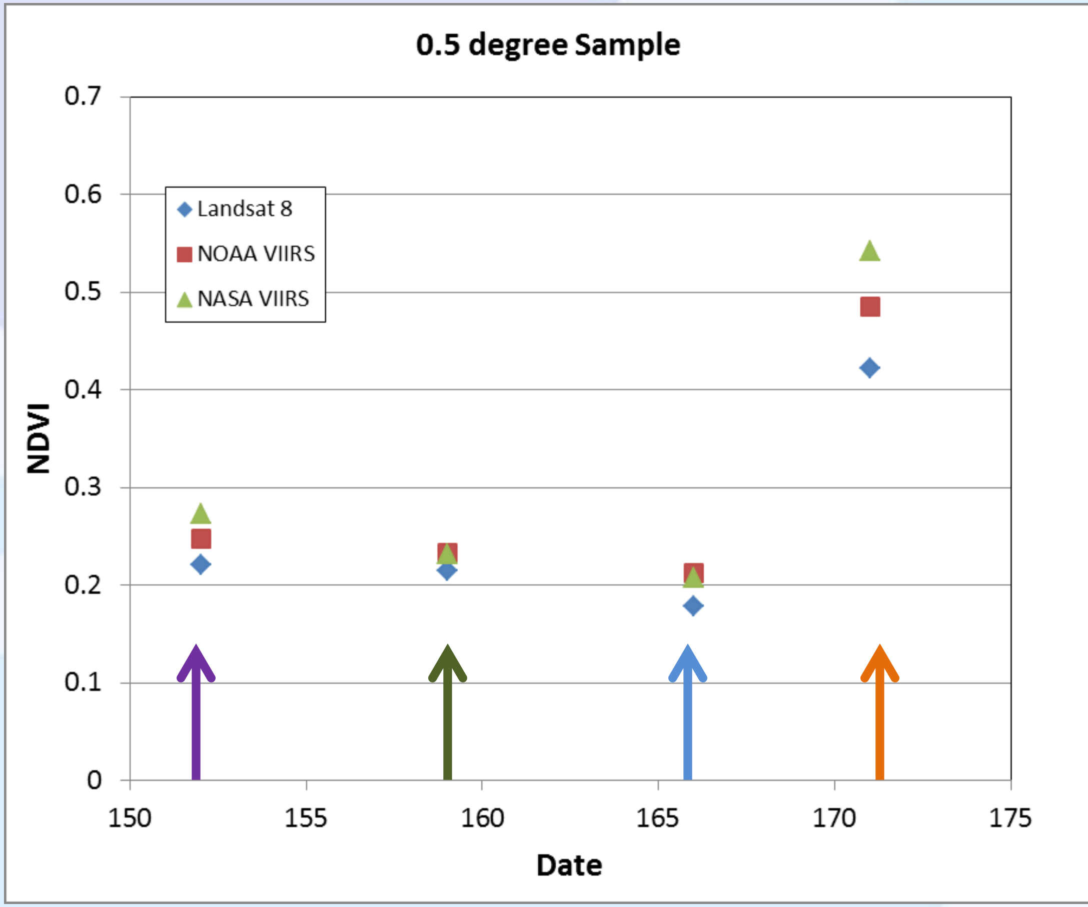




Example of Potential Analysis

Multisensor/multidate comparison for four CRN station locations in 2013.

- Goodwell, OK, day 152
- Muleshoe, TX, day 159
- LaJunta, CO, day 166
- Montrose, CO day 171



Data included in analysis:

- Landsat 8: TOA NDVI
- NOAA-VIIRS: TOA NDVI
- NASA-VIIRS: TOC NDVI

Each point within figures represents .5 x .5 degree sample area.

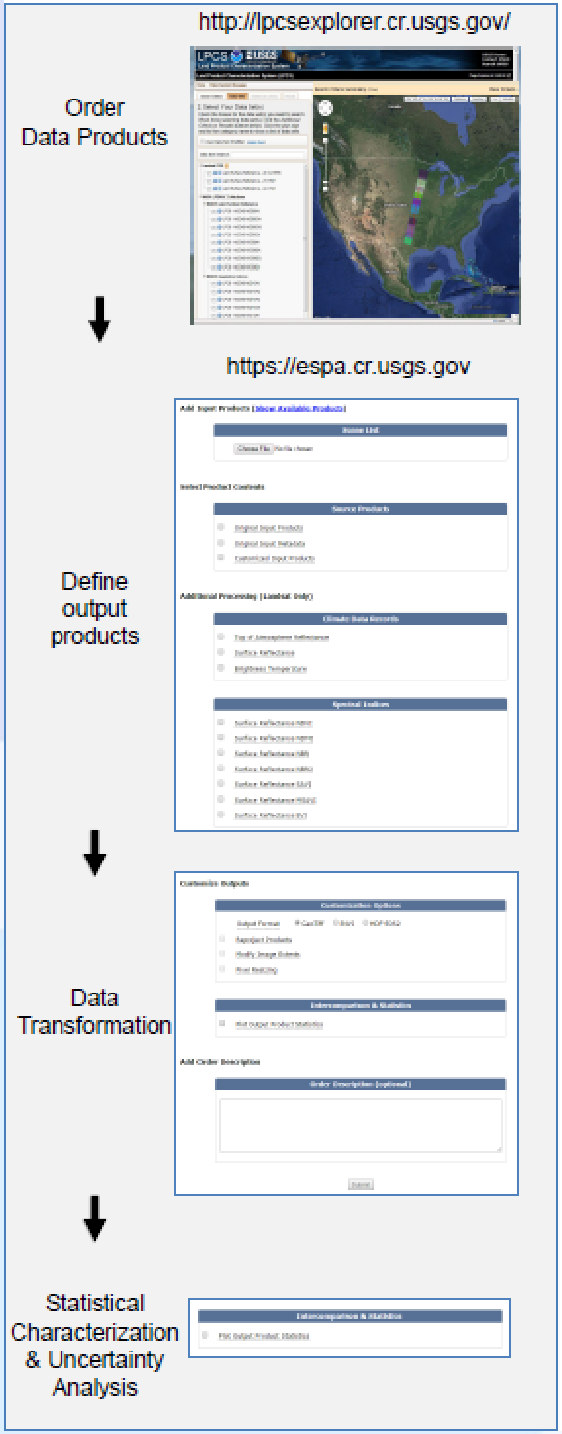
Land Product characterization System (LPCS)

What is LPCS
Why LPCS developed/hosted at EROS
Highlights of LPCS
1. Inventory & Ordering
2. Analysis Tools

Path Forward
Summary

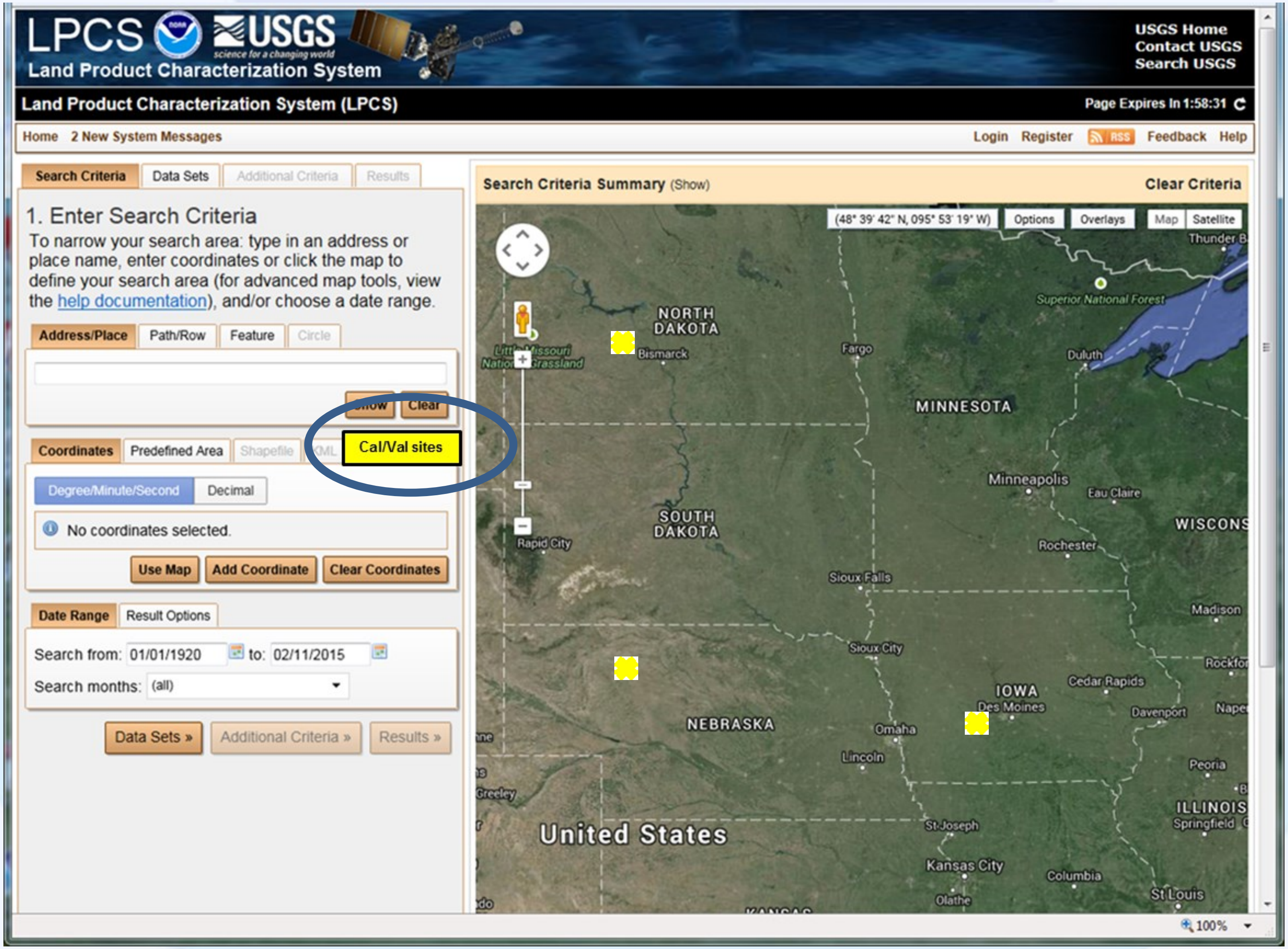
Path Forward

LPCS interface update:
Expected 30 Nov. 2015, one seamless system for LPCS data selection, ordering, and product processing requests.



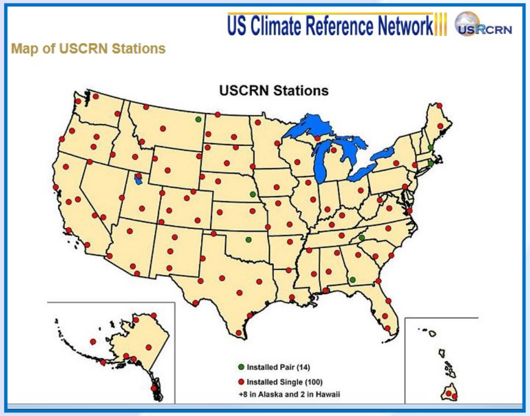
Path Forward

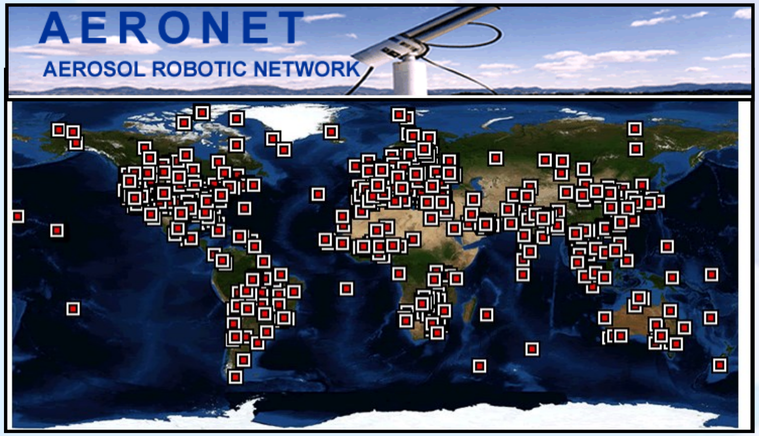
Predefined sample sites: user selectable for satellite (and potential in situ) inter-comparisons

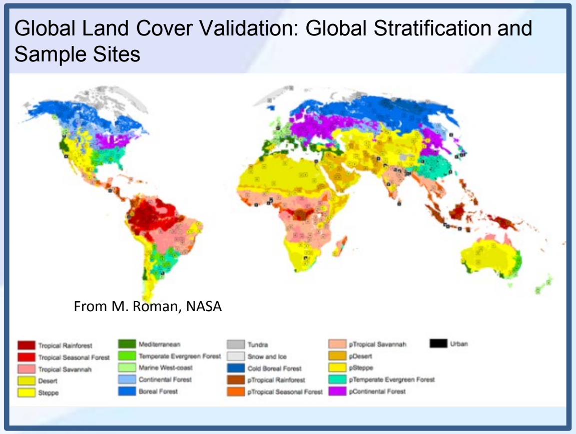


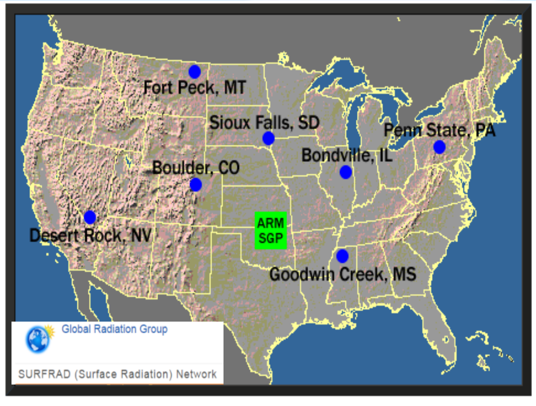
Path Forward

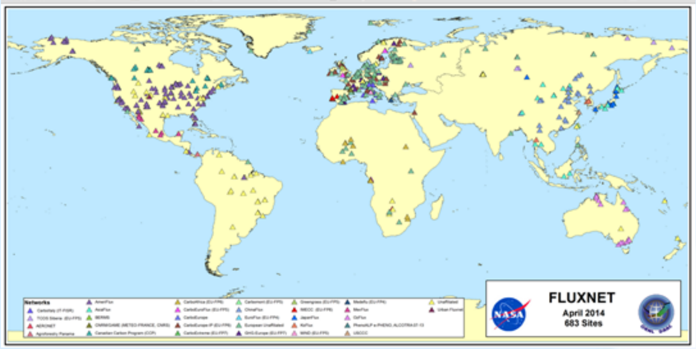
Predefined sample sites: user selectable for satellite (and potential in situ) inter-comparisons





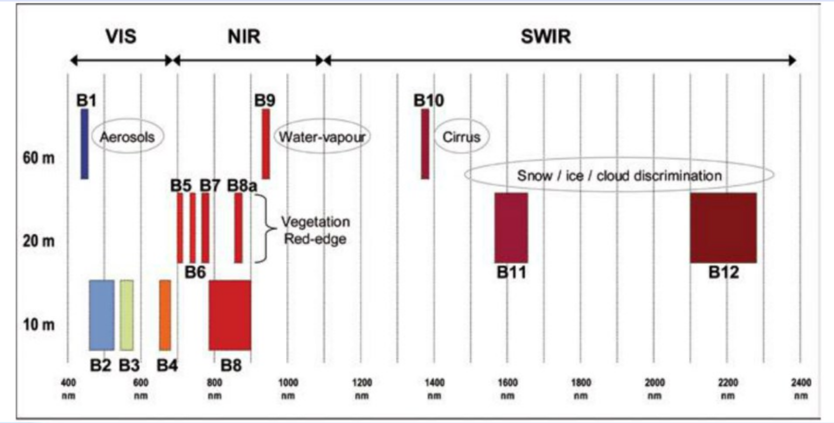






Path Forward

Sentinel-2 and Sentinel-3 data hosted at USGS/EROS



Sentinel-2
13 Bands
4 bands at 10 m resolution
6 bands at 20 m
3 bands at 60 m

Band	λ centre (nm)	Width (nm)	L_{min} (W m^{-2} sr^{-1} μm^{-1})	L_{ref} (W m^{-2} sr^{-1} μm^{-1})	L_{sat} (W m^{-2} sr^{-1} μm^{-1})	SNR @ L_{ref}
Oa1	400	15	21.60	62.95	413.5	2188
Oa2	412.50	10	25.93	74.14	501.3	2061
Oa3	442.50	10	23.96	65.61	466.1	1811
Oa4	490	10	19.78	51.21	483.3	1541
Oa5	510	10	17.45	44.39	449.6	1488
Oa6	560	10	12.73	31.49	524.5	1280
Oa7	620	10	8.86	21.14	397.9	997
Oa8	665	10	7.12	16.38	364.9	883
Oa9	673.75	7.5	6.87	15.70	443.1	707
Oa10	681.25	7.5	6.65	15.11	350.3	745
Oa11	708.75	10	5.66	12.73	332.4	785
Oa12	753.75	75	4.70	10.33	377.7	605
Oa13	761.25	2.5	2.53	6.09	369.5	232
Oa14	764.375	3.75	3.00	7.13	373.4	305
Oa15	767.50	2.5	3.27	7.58	250.0	330
Oa16	778.75	15	4.22	9.18	277.5	812
Oa17	865	20	2.88	6.17	229.5	666
Oa18	885	10	2.80	6.00	281.0	395
Oa19	900	10	2.05	4.73	237.6	308
Oa20	940	20	0.94	2.39	171.7	203
Oa21	1020	40	1.81	3.86	163.7	152

Ocean Land Color Instrument
21 Bands
300 m spatial resolution

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
Summary

LPCS

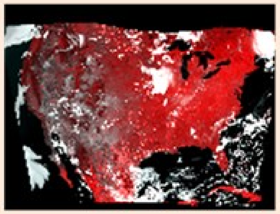
science for a changing world

Land Product Characterization System

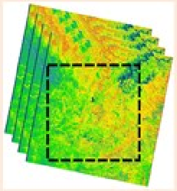
Land Product Characterization System

A web-based system designed to use moderate to high-resolution satellite data for characterization, and assist with validation, of GOES-R ABI and JPSS VIIRS products.

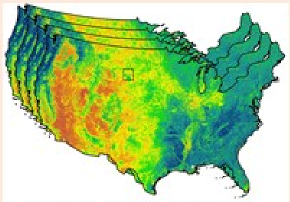
Input Products in Native Projections



Simulated GOES-R ABI (Univ. Wisc./CIMMS)



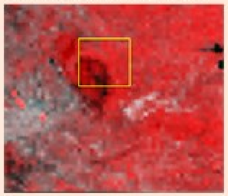
Landsat ETM+ (7), Landsat OLI/TIRS (8)



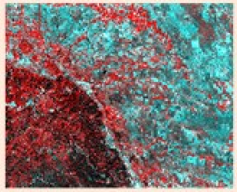
MODIS MOD/MYD09 (Surface Refl.) MODIS MOD/MYD13 (NDVI & EVI)

Geographically Registered Output Products

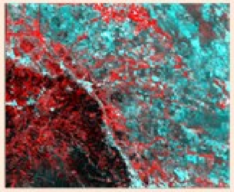
Simulated GOES-R ABI



Landsat



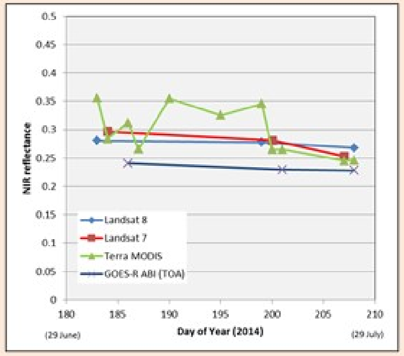
MODIS



Tables and Charts of Individual Bands or Indices

	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							

Mean, minimum, maximum, standard deviation



Near-IR time series inter-comparisons

JPSS EDR

Long Term Monitoring & Product Repository

Lori K. Brown

JPSS-LTM Web Development Lead

Tom Atkins, Frank Tilley, Charlie Brown, Xingpin Liu, Lihang Zhou

Presented at the 2015 STAR JPSS Science Meeting

NOAA Center for Weather and Climate Prediction

College Park, MD

25 August 2015

JPSS EDR Product Repository Early Discussions

- At meetings in Fall 2014, the idea to develop a STAR JPSS program wide repository to house and share JPSS EDR product images was suggested.

- At this point, STAR ICVS had been implemented for 2 years; it seemed an ideal web interface and browsing framework for daily product information.

ICVS as an EDR Repository Platform

- Advantages of ICVS as interface for presenting EDR content:
  - Constructed and organized for browsing content that is updated daily;
  - Easy to update and edit;
  - Extensible to additional products without additional web programming;
  - Familiar to many of the prospective user groups;
  - Compliant with Section 508 and other government directives regarding web presentation and architecture;
  - Thoroughly tested and reliable across all modern browsers;
  - Interface can accommodate different content types: images, maps, charts, text, zip files, and eventually vector-based charts;
  - No surprises!

Prototype Now Online with 7 Product Groups

- Spring 2015 initiated prototyping;
- Contacted first product groups to start developing and acquiring images;
- Prototype currently houses product images from the following teams as of 8/24/2015:

Product Team	Product Images Daily	Product Dates Available	Production Stream
Soundings	598	1/1/2015 to present	automated
Land Surface Temperature	3	1/1/2015 to present	automated
Albedo	1	1/1/2015 to present	automated
Vegetation Index	3	6/20/2015 to present	automated
Active Fires	1	1/1/2015 to present	batch
Ozone	3	1/1/2015 to 7/15/2015	batch
Surface Type	4	5/1/2015 to present	automated

JPSS EDR Product Monitoring Demo

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

- Key features:
  - Navigate by product;
  - Navigate through products by date;
  - 'About' popup;
  - Animation:
    - Across all metrics in each product group;
    - **NEW!** Animate a selected timespan for a single product;

EDRs Are Not Quite the Same as Cal/Val Metrics

- Heavy on the maps; less emphasis on other types of 'charts'.
- Lower volume of images in most cases;

- So, we have made a few key updates to the ICVS interface to better support EDRs' presentational needs:
  - New Animation of a single product across a user-configurable time span (***Coming soon: download the animation file***)
  - Stricter standardization of product layout, typography, labelling, and underlying map conventions
    - The less variation in presentation, the more what users will see and focus on is the data being presented.
  - Goal: developing a shareable piece of code to generate product maps for all product teams who generate in IDL;
    - *Your mileage may vary – not all ways of producing data work well with all IDL mapping commands.*

JPSS EDR Site vs. Team Sites

- Producing content for the JPSS EDR site doesn’t change what you do or don’t produce for your own team or product area websites.
- There may or may not be content overlap between the JPSS EDR site and other sites;
- The goal of the EDR Repository is ONE STOP SHOPPING; a little redundancy is no cause for concern.

Steps to Produce & Publish EDR Products - 1

- Product Teams: figure out what you want to include on your page. Suitable content may include:
  - EDR deliverable products (at a minimum, we need these for the site);
  - Comparison products from other satellite instruments;
  - Quality measure charts, like NEΔN.
  - Usually images (.jpg, .gif, .png, but can also include .txt, .zip)
  - Please note: content for the page is ideally content that is refreshed daily.
    - Land Surface Temperature for Global Surface – 8/22/2015 – **YES**!
    - 10 day composite of anything – probably not.
- Meet with JPSS EDR to go over style guide, layout of maps, formatting preferences;
- Product Team develops a 'test set' of product images, JPSS EDR team reviews, revises, and approves.

Steps to Produce & Publish EDR Products - 2

- JPSS EDR team:
  - Establishes a directory structure on the webserver to house Team's products;
  - Develops the CSV file that lists product file descriptions and locations;
  - Add the new Product page;
  - To add or remove content, we edit the CSV file to reflect additions / changes / deletions from the product set.

- Product Teams
  - Run charts as far back as you can (we are aiming for EDRs back to Jan. 1, 2015), and write them to the specified location on STAR webserver;
  - Set the product generation script on a cron job;
  - No website to maintain, no HTML to write, just generate your products

Next Steps To Complete The EDR Repository

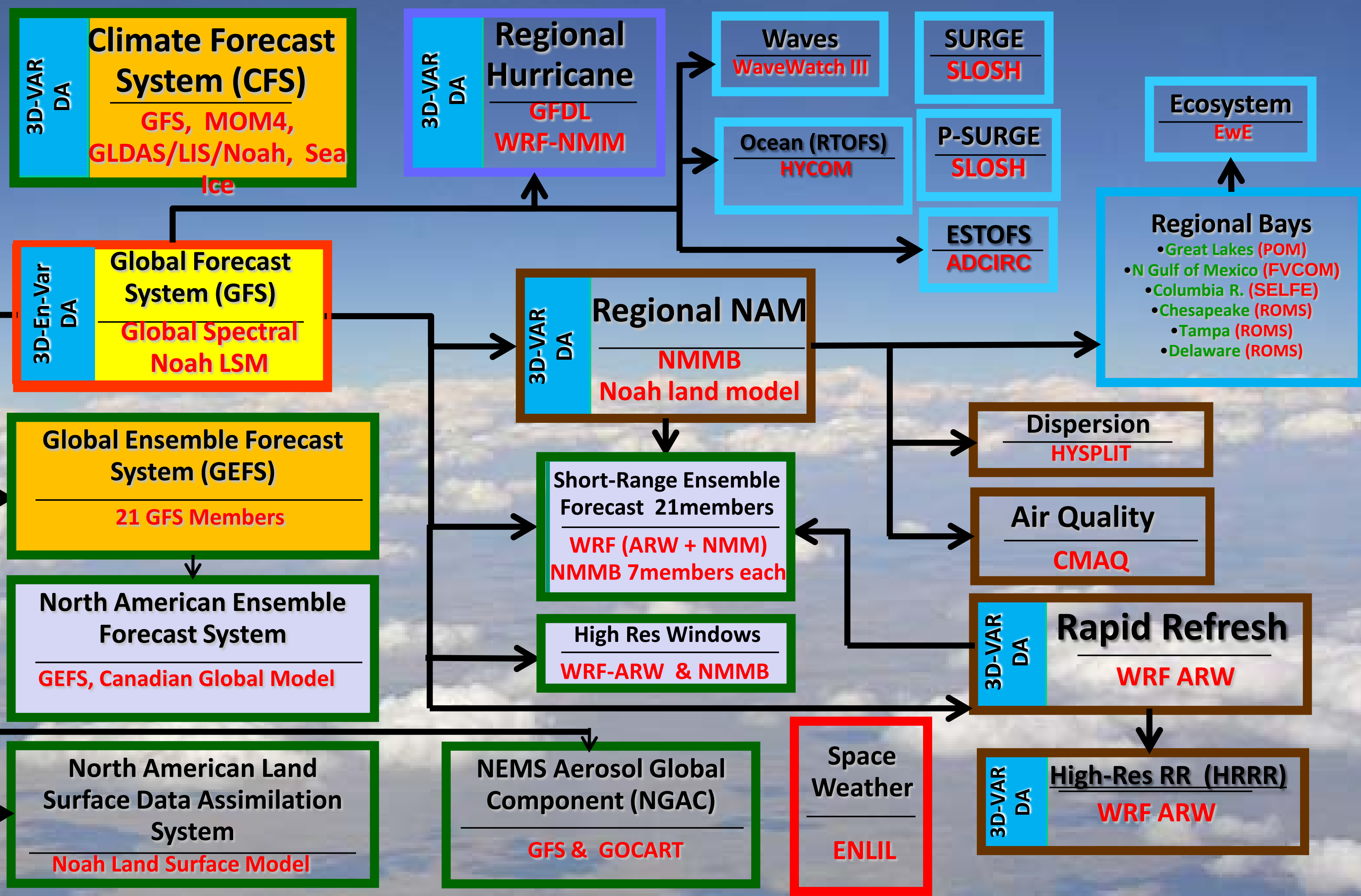
- Reach out to remaining product teams to start generating products;
- Work with existing teams to refine and improve product presentation, standardization, re-usable IDL script block;
- Integrate new features like new single product animation back into the STAR ICVS.

NCEP Operational Use of Satellite Land Products

Michael Ek and the EMC Land-Hydrology Team
Environmental Modeling Center (EMC)
National Centers for Environmental Prediction (NCEP)
NOAA/NWS

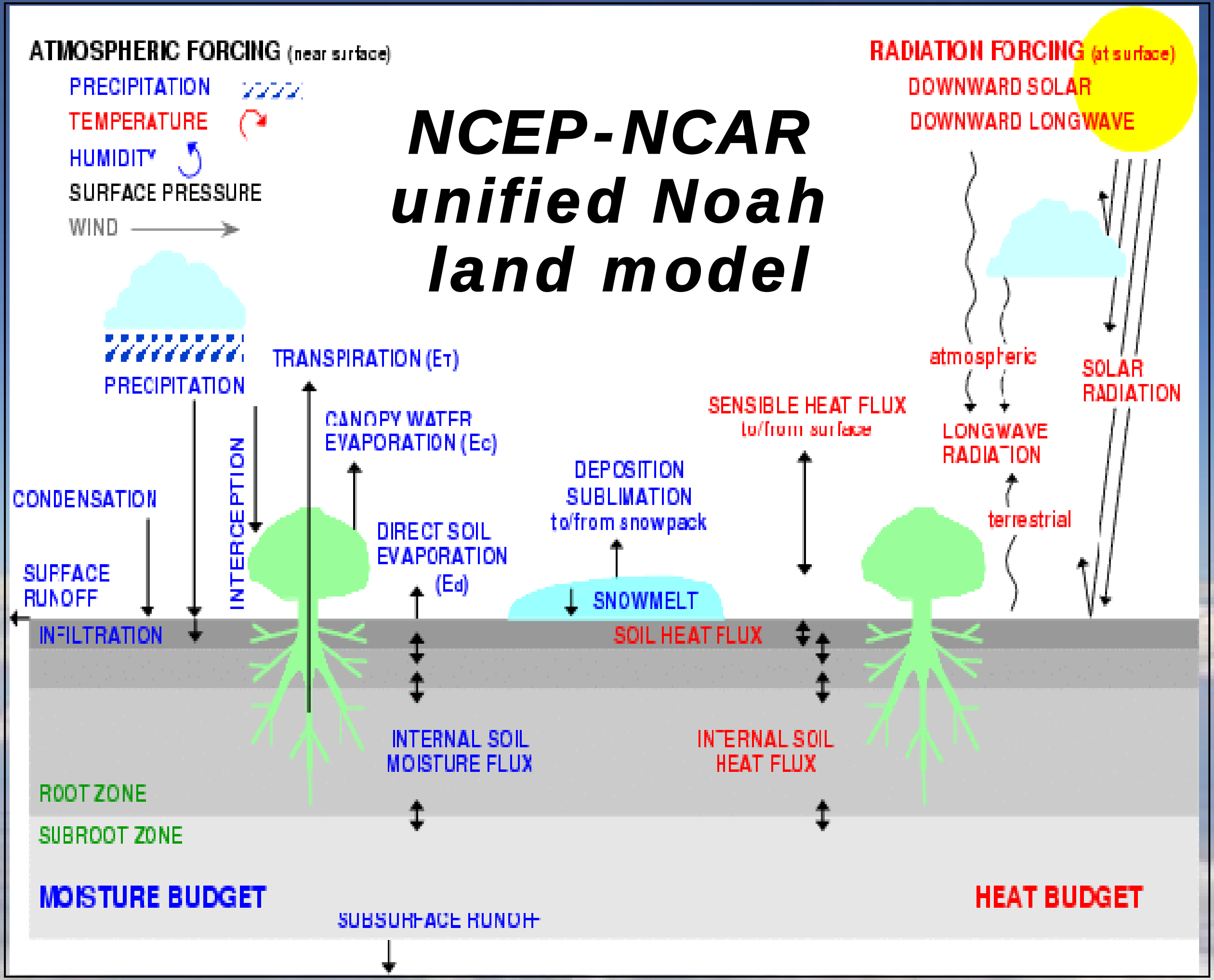
STAR JPSS Annual Meeting – 24-28 August 2015
NCWCP, College Park, Maryland

NOAA's Operational Numerical Guidance Suite (Feb 2015)



Role of Land-Surface Models

- Close surface energy & water budgets,
- Determine **heat**, **moisture**, and **momentum** exchange between surface & atmosphere,



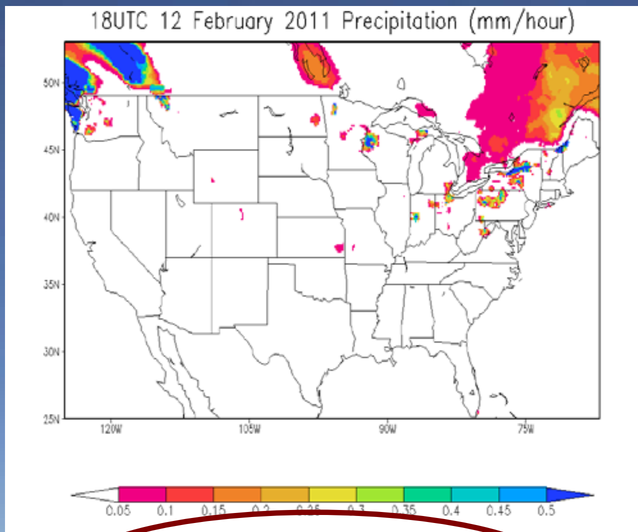
- Noah land model then provides surface boundary conditions to parent atmospheric model, e.g. meso-NAM, medium-range GFS, seasonal CFS.

Land Model Requirements

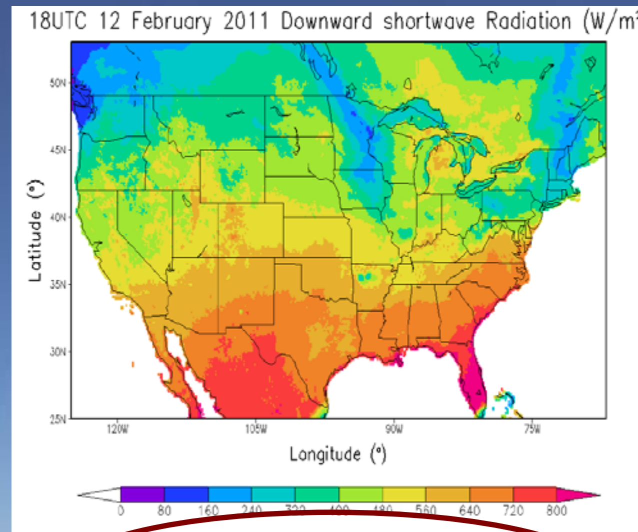
To provide these proper boundary conditions, land model must have:

- **Atmospheric forcing** to drive land model, such as *precipitation and incoming solar radiation*.
- Appropriate **physics** to represent land processes,
- Proper **initial land states**, such *as snow & soil moisture* (analogous to initial atmospheric conditions, though land states may carry more “memory”, especially deep soil moisture, similar to ocean SSTs),
- **Land data sets** e.g. *land use/land cover (vegetation type), green vegetation fraction (GVF), leaf-area-index (LAI), soil type, surface albedo & emissivity*, & associated parameters, e.g. surface roughness, soil and vegetation properties.

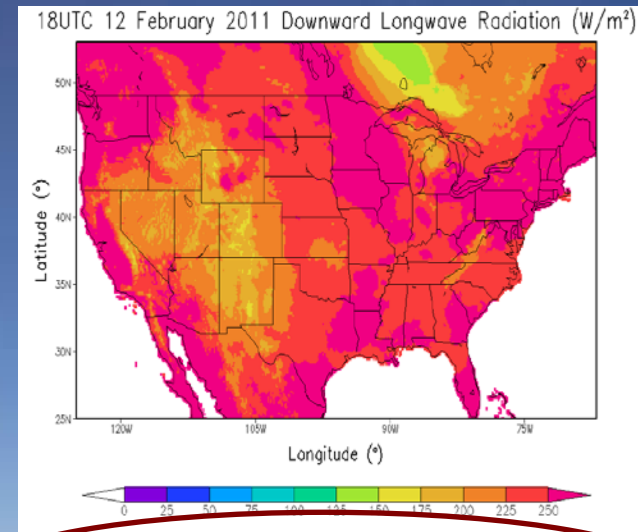
Atmospheric Forcing to Land Model



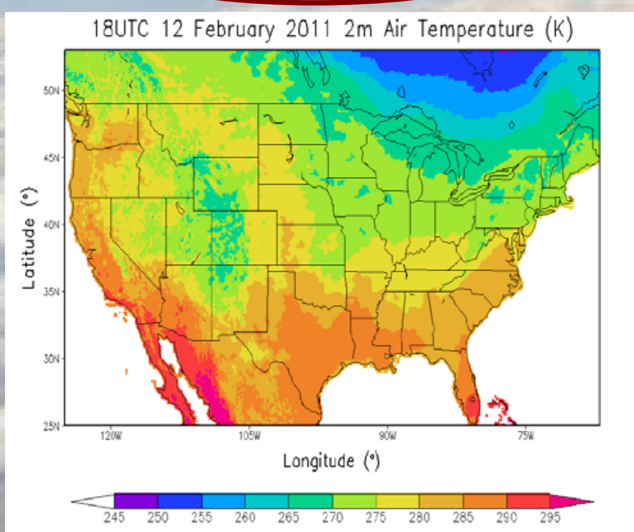
Precipitation



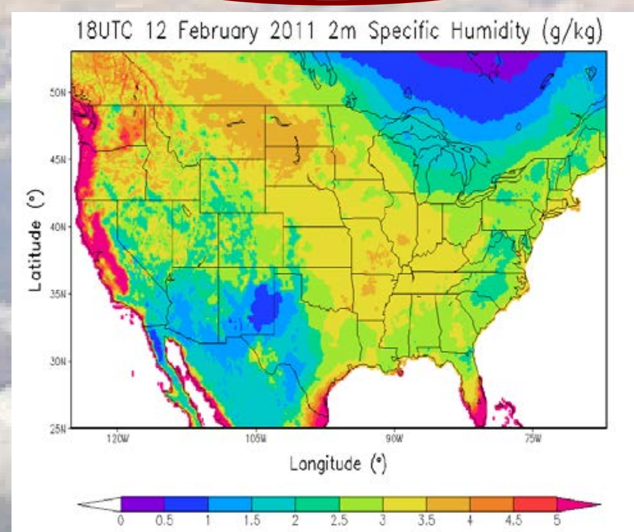
Incoming solar



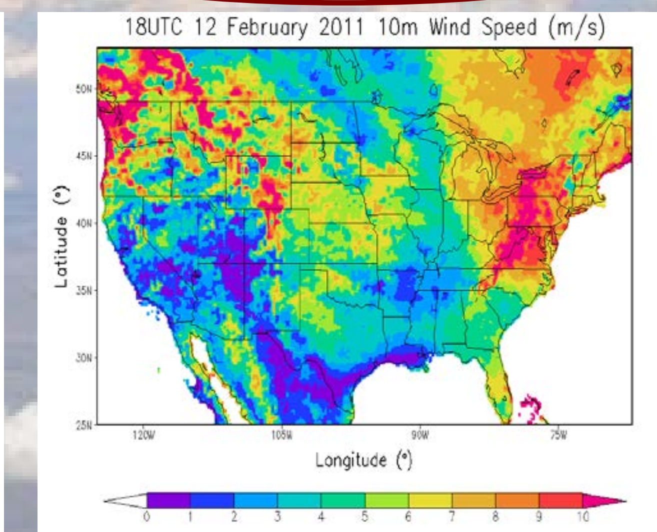
Incoming Longwave



Air temperature



Specific humidity

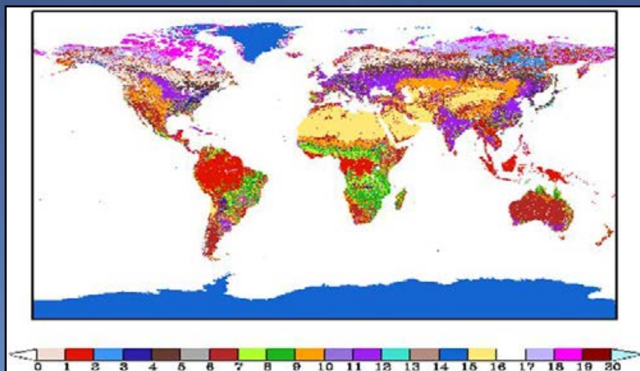


Wind speed

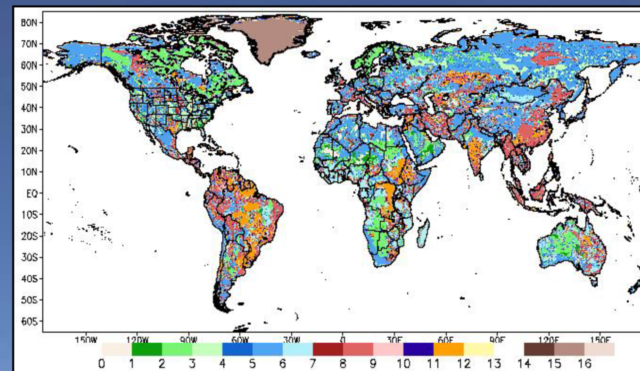
+ Atmospheric Pressure

Example from 18 UTC, 12 Feb 2011

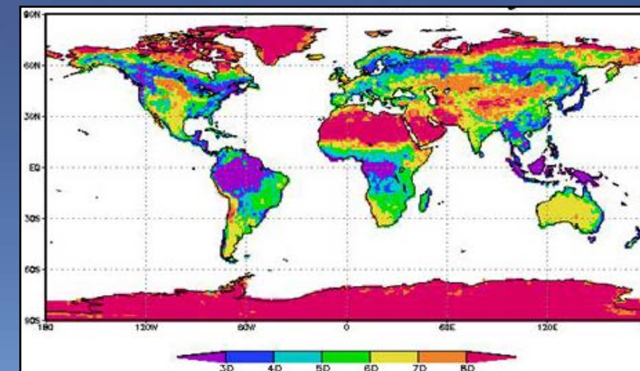
Land Data Sets



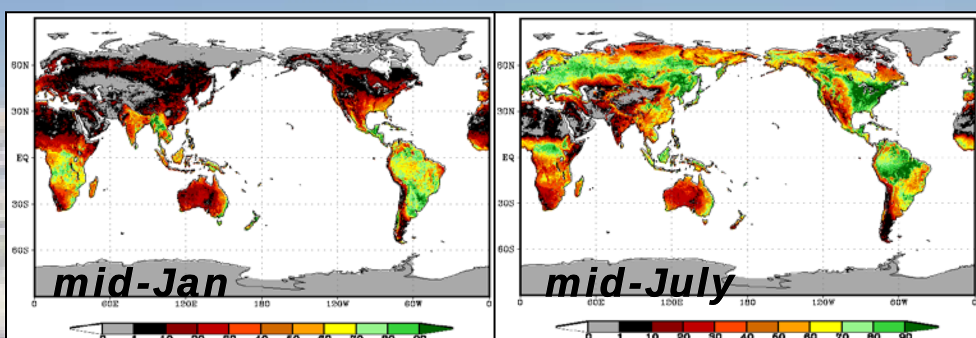
Land-Use Type
(1-km, IGBP-MODIS)



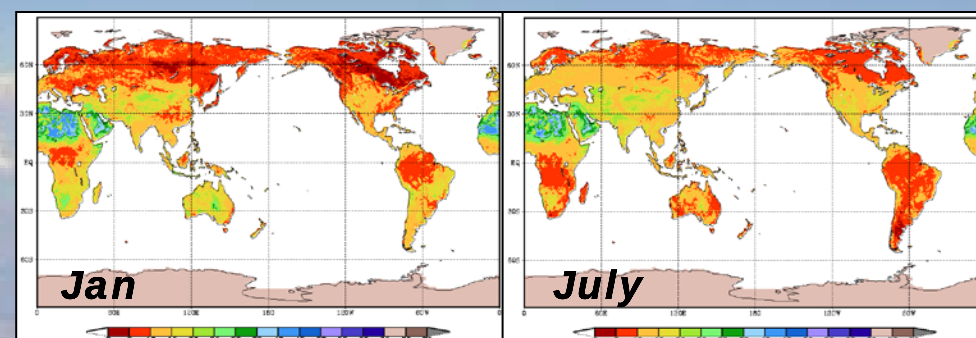
Soil Type
(1-km, STATSGO-FAO)



Max.-Snow Albedo
(1-km, UAz-MODIS)



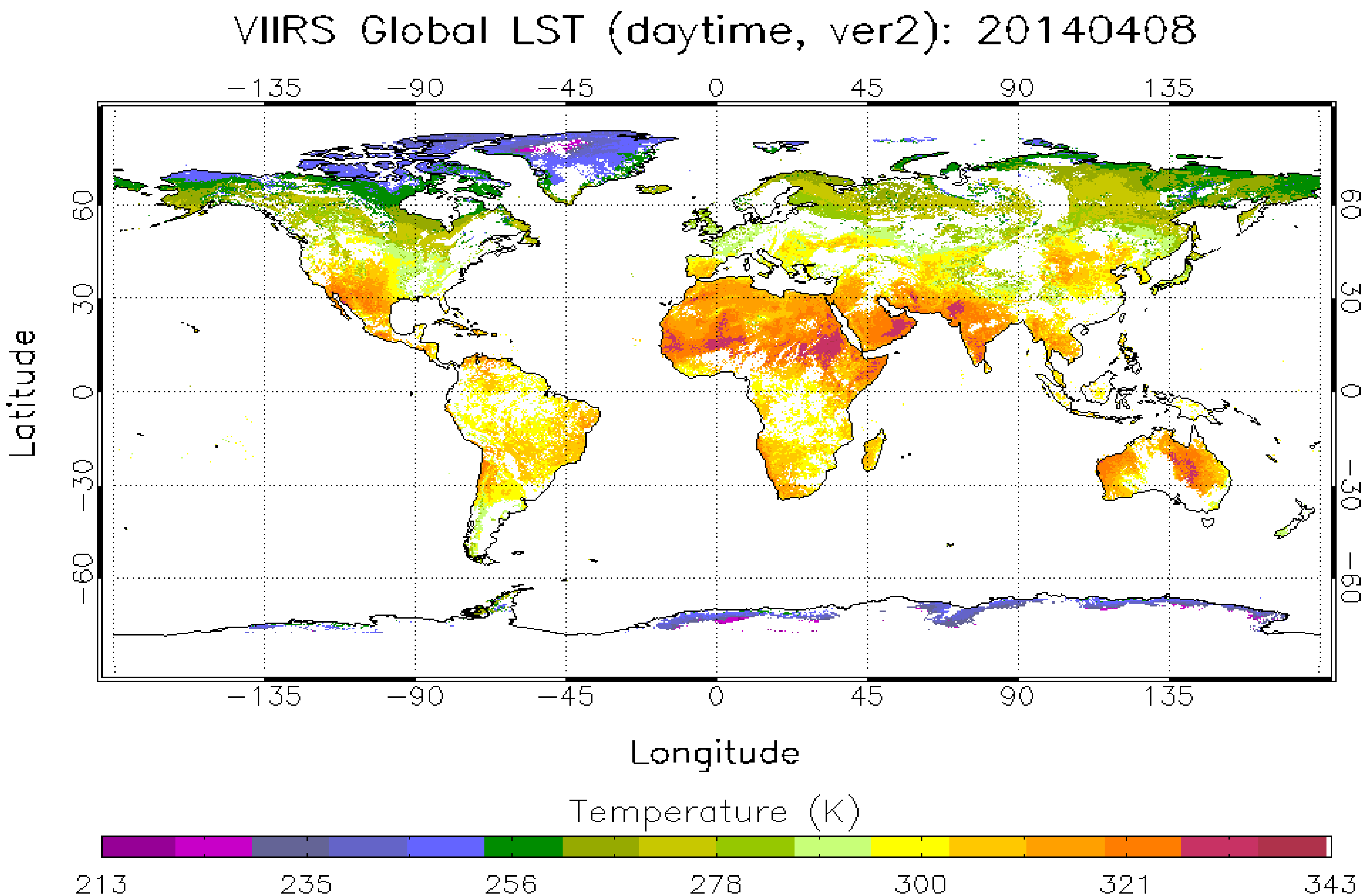
Green Vegetation Fraction
(weekly, 1/8-deg,
new NESDIS/AVHRR)



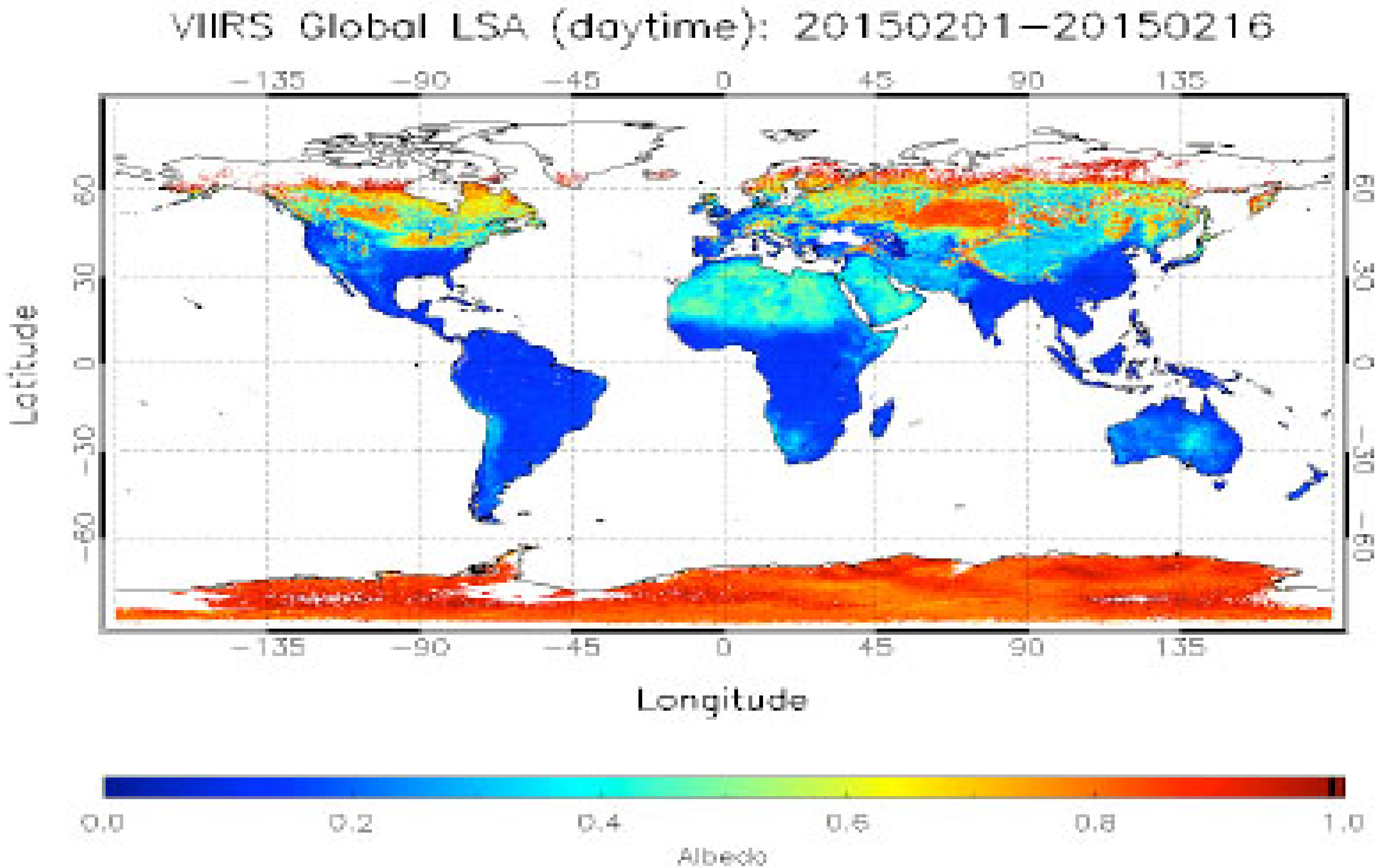
Snow-Free Albedo
(monthly, 1-km,
BU-MODIS)

- Fixed annual/monthly/weekly climatology, or near real-time observations; some quantities may be assimilated (e.g. soil moist., snow) into Noah.

Land Data Set: VIIRS Land Surface Temperature Used in NAM and GFS validation

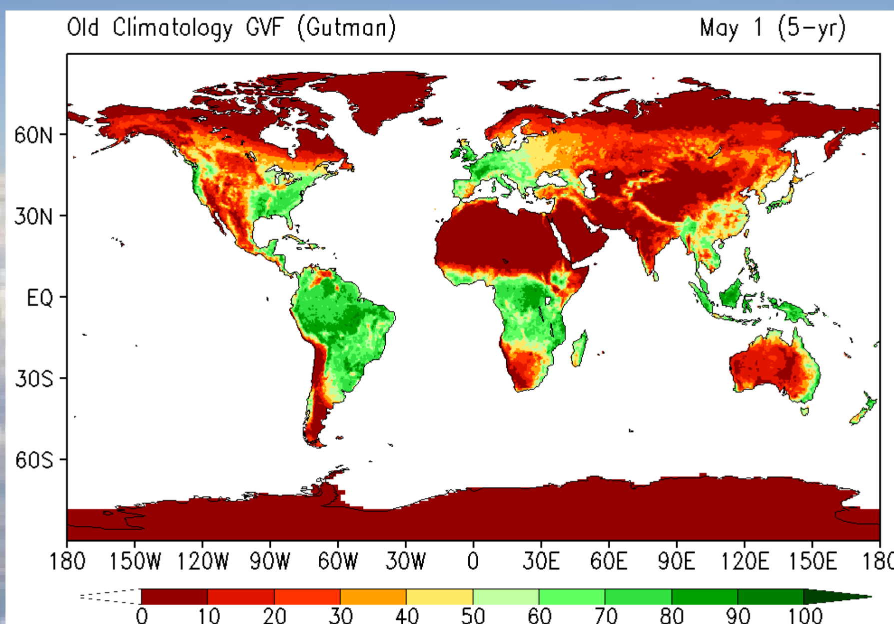


Land Data Set: VIIRS Land Surface Albdeo. Replace Albedo climatologies?

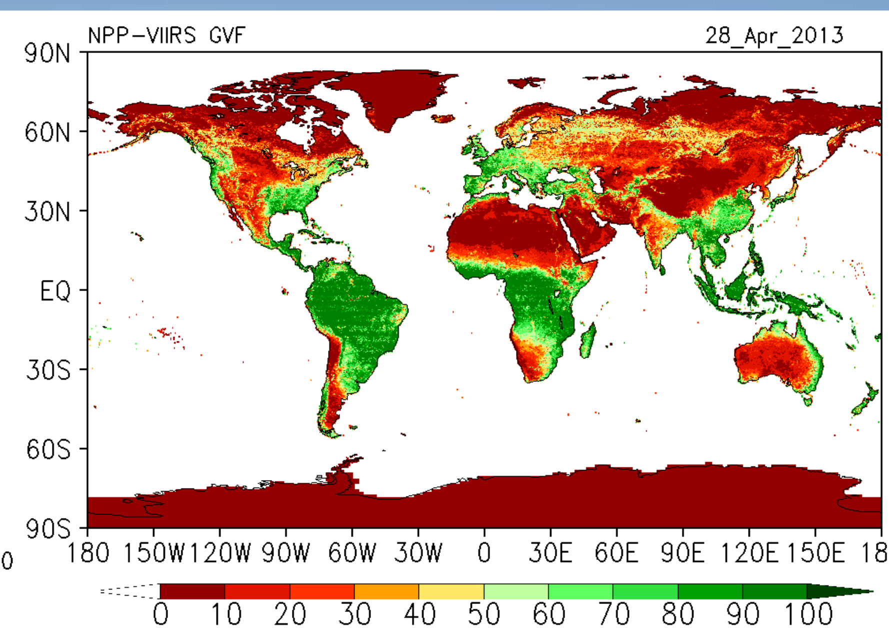


Green Vegetation Fraction

- **Climatology vs. near real-time GVF**
- **Ingested into NCEP models** where near real-time GVF leads to better partition between surface heating & evaporation --> impacts surface energy budget, PBL evolution, clouds & convection.



AVHRR 5-year Climatology

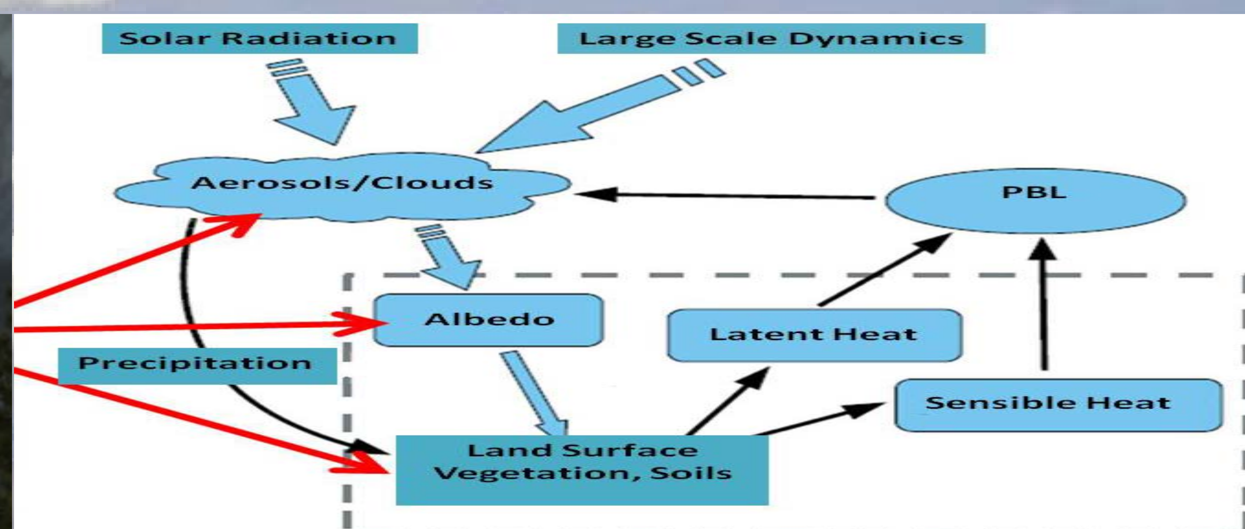


Near-realtime VIIRS

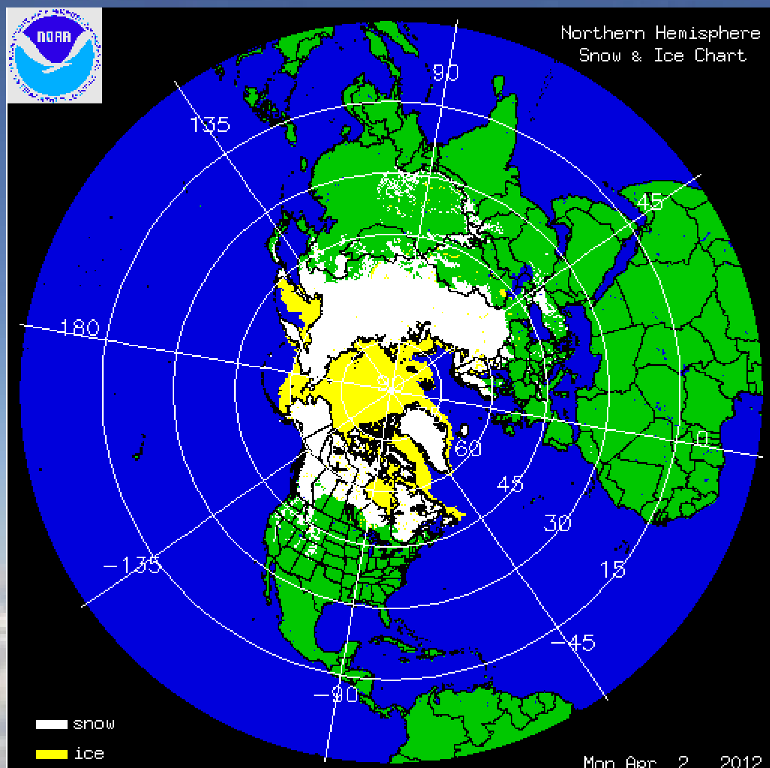
- Note: *VIIRS GVF in Midwestern US much lower than AVHRR GVF Climatology.*

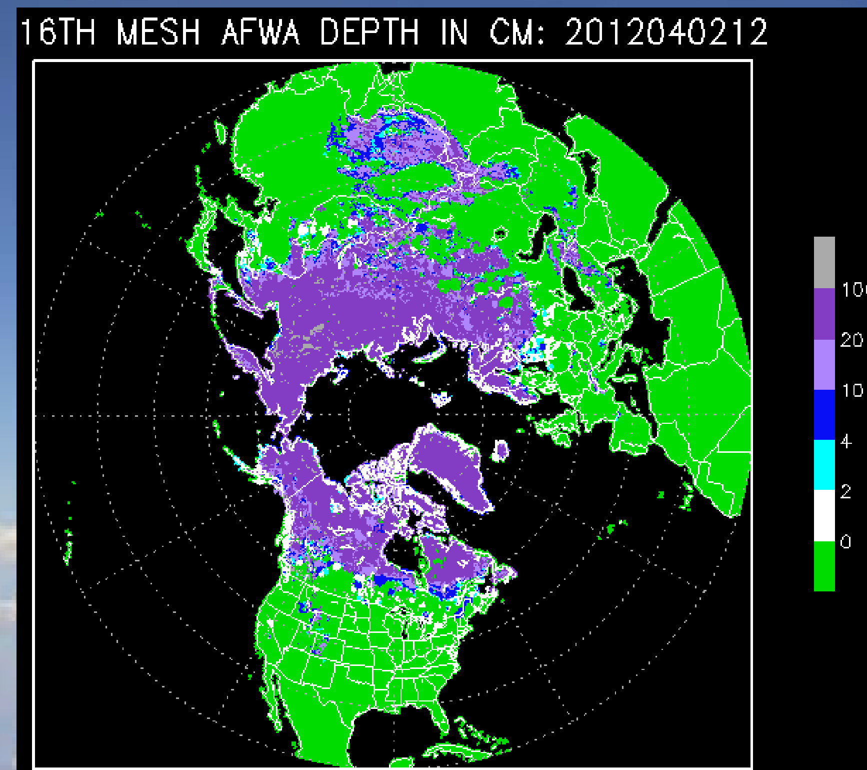
Wildfire Effects

- **Wildfires affect weather/climate systems**: (1) atmospheric circulations, (2) aerosols and clouds, (3) **land surface states** (GVF. albedo & surface temperature, etc.) --> impact on sfc energy budget, ABL, clouds & convection.
- **Surface Reflectance** used to derive **Burned Area Product** (NESDIS/STAR).
- **Two** fire burned area **products**:
  - 1 km resolution, 2x/day, 20N-70N
  - 12 km resolution, 4x/day, Equator-NP
- **Ingested into mesoscale NAM**, adjustments surface characteristics:
  - reduced: albedo, GVF, roughness, soil moisture
  - increase: surface & soil temperatures
- **<u>Future</u>**: consistency with remotely-sensed near-real time GVF/LAI, albedo, soil moisture, LST, etc.



Land Data Sets: *Daily Snow Products*





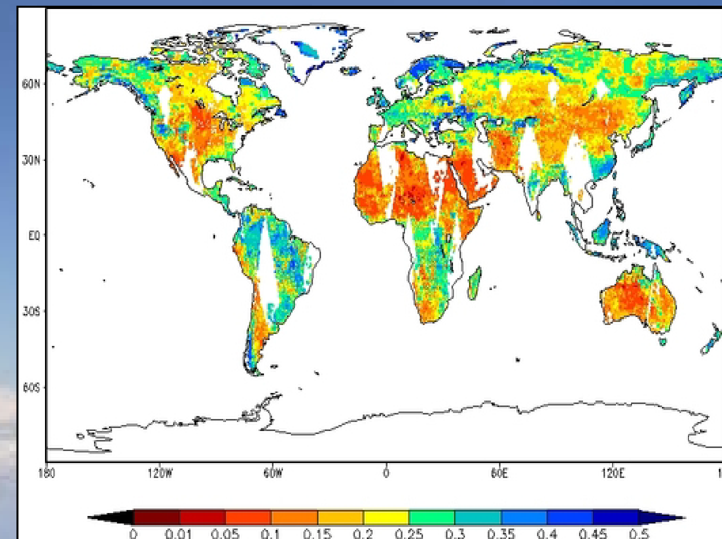
4-km *02 April 2012* ***24-km***

Snow Cover
(daily integrated
NIC IMS product)

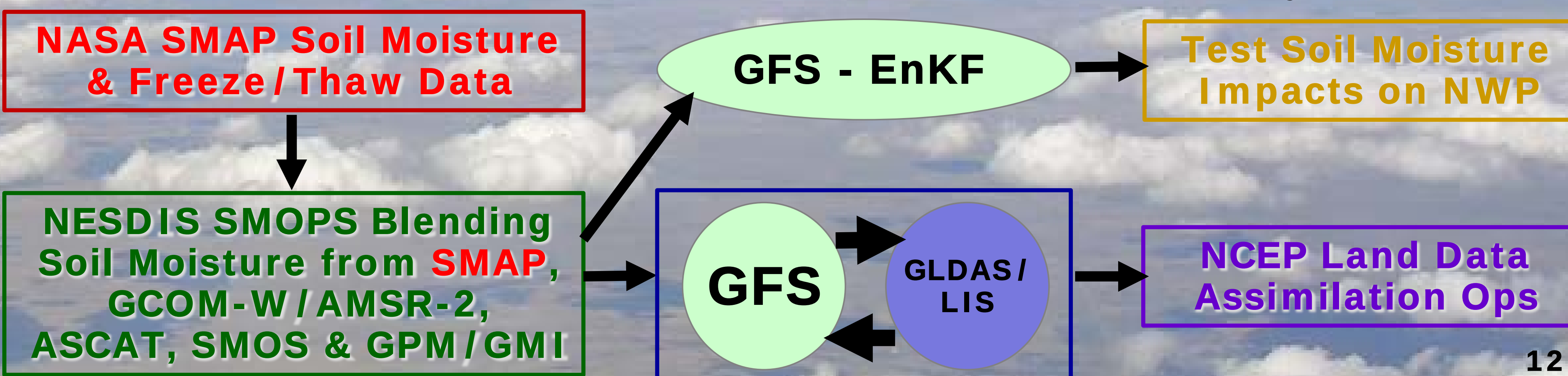
Snow Depth
(daily integrated
AFWA product)

Applications of NASA SMAP Data

- Two NOAA SMAP Early Adopters will ingest and assimilation SMAP soil moisture and freeze/thaw data products to improve forecasts of daily rainfall, air temperature, humidity, root-zone soil moisture, skin temperature, runoff and in turn drought and river floods.
- NESDIS will ingest SMAP data through Soil Moisture Operational Product System (SMOPS) into NWS-NCEP models.
- NWS-NCEP has tested a GFS-EnKF coupled system to test impact of assimilating satellite soil moisture data in GFS forecasts.
- NWS-NCEP and NESDIS-STAR will collaborate on the development of a GFS-GLDAS/LIS semi-coupled system for operational land data assimilation.



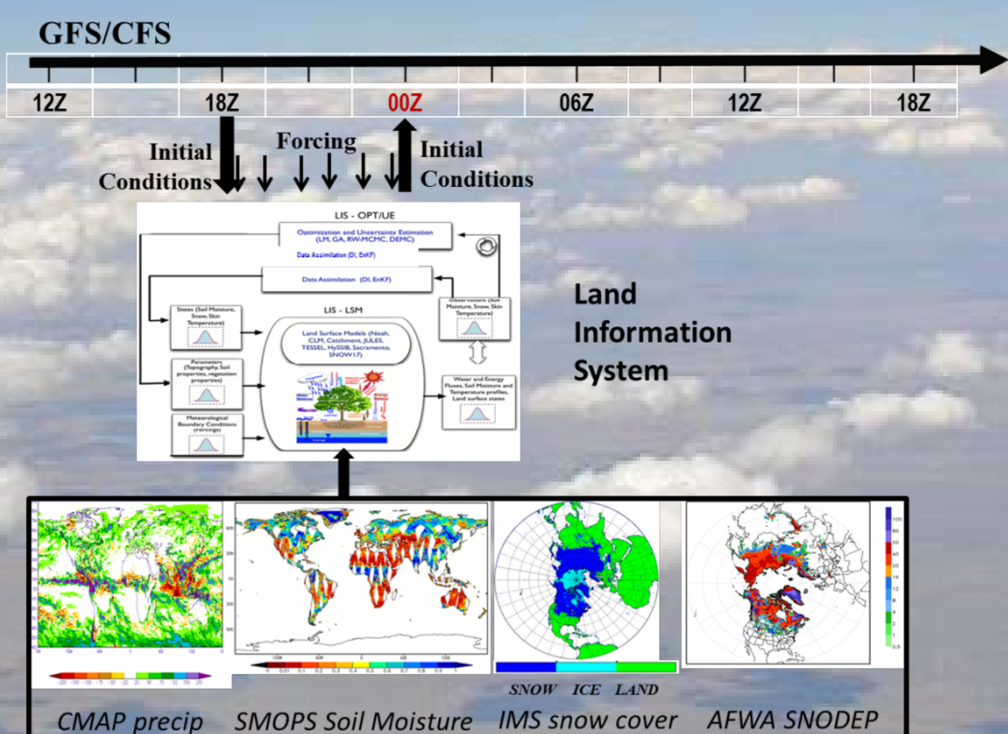
NOAA SMOPS Blended Soil Moisture: Daily - 20140304



Satellite-based Land Data Assimilation Tests in NWS GFS/CFS Operational Systems

NWS NGGPS PI: Michael Ek (NOAA/NCEP/EMC)
Co-Is: Jiarui Dong and Weizhong Zheng (IMSG at NOAA/NCEP/EMC)
Christa Peters-Lidard (NASA/GSFC) and Grey Nearing (SAIC at NASA/GSFC)

- Enable the existing NASA Land Information System (LIS) to serve as a global Land Data Assimilation System (LDAS) for both GFS and CFS.
- LIS integrates NOAA/NCEP operational land surface model (Noah), high-resolution satellite & observational data, and land data assimilation (DA) tools.



LIS EnKF-based land Data Assimilation tool used to assimilate soil moisture from the NESDIS global Soil Moisture Operational Product System (SMOPS), snow cover area (SCA) from operational NESDIS Interactive Multisensor Snow and Ice Mapping System (IMS) and AFWA snow depth (SNODEP) products.

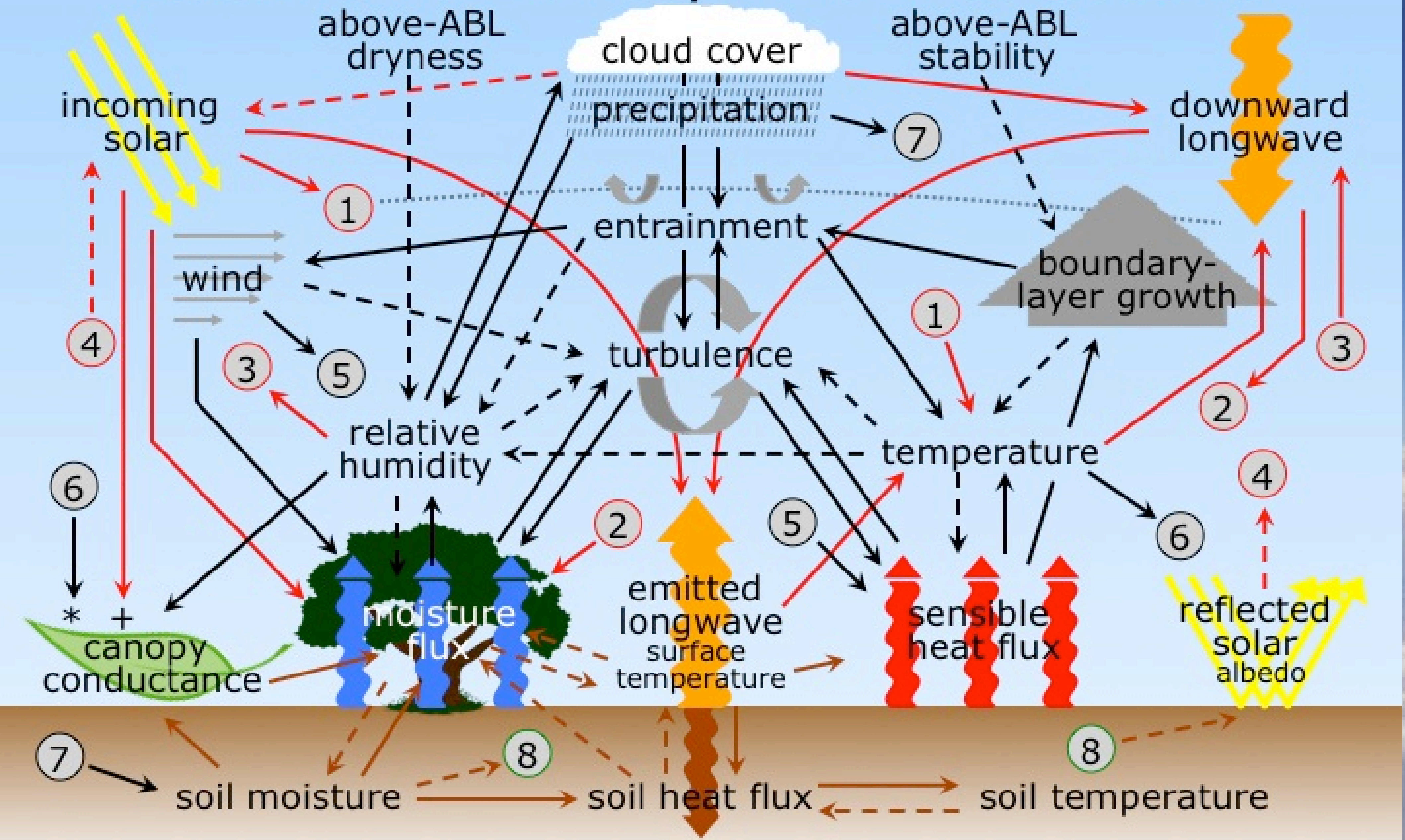
Courtesy Jiarui Dong

Summary

Land models provide proper boundary conditions to atmospheric models, and rely on remote sensing for:

- **Atmospheric forcing**, e.g. *Precipitation & incoming solar radiation*.
- **Initial land states, e.g.** *Snow & soil moisture, land skin temperature for validation*.
- **Land data sets** e.g. *Land use/land cover (vegetation type), green vegetation fraction (GVF), leaf-area-index (LAI), surface albedo & emissivity*, (fixed annual/monthly/weekly climatologies, or near real-time observations, where some quantities may be assimilated (e.g. soil moist., snow) into the Noah land model.

Local Land-Atmosphere Interactions



radiation **surface layer & ABL** **land-surface processes** **feedbacks:**

+positive feedback for C3 & C4 plants, negative feedback for CAM plants **positive**

****negative feedback above optimal temperature*** **negative**

U.S. National Ice Center

U.S. National Ice Center Use of Satellite Cryosphere Products

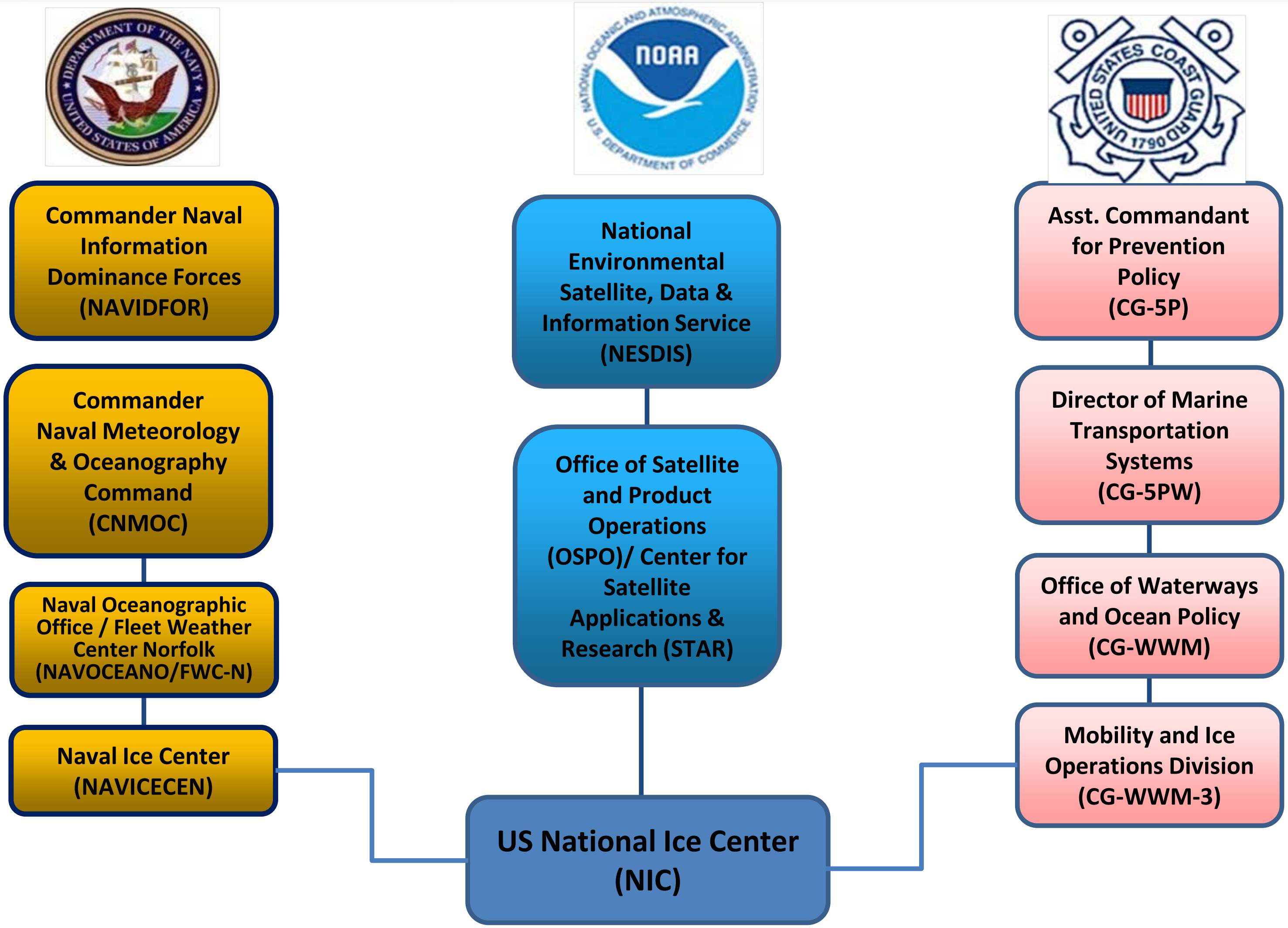
2015 JPSS Annual Science Team Meeting - August 24-28, 2015
Speaker: Sean R. Helfrich

CDR Kelly Taylor
Director / Commanding Officer

Mr. Sean R. Helfrich
Acting Deputy Director

LCDR Robert Atkinson
Naval Ice Center Executive Officer

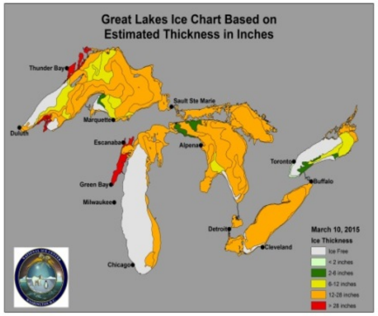
USNIC Organization

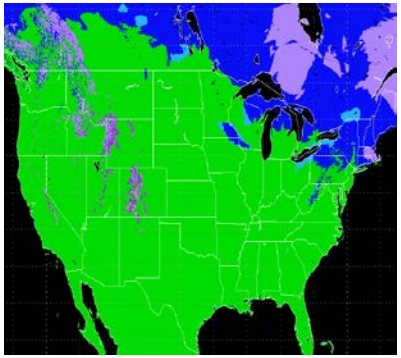


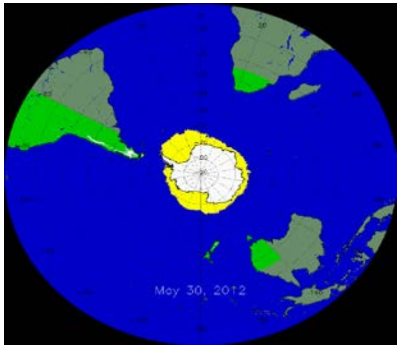
Total manpower: 37 personnel; 65% Navy, 33% NOAA, 2% USGC

NOAA Requirements

- **Great Lakes Ice Monitoring (Dec-May)**
  - Daily Ice Conc/thickness. 5 km res ,GRIB and ASCII
  - Weekly Ice Thickness & Form
  - 1-7 day forecast
  - NAVTEXT message (Dec-Mar)
- **CONUS Ice Monitoring (Dec-May)**
  - Weekly or bi Weekly - Chesapeake and Delaware Bays
- **Alaska Ice Monitoring**
  - Twice weekly ice charting
  - SAR Imagery support for NWS Alaska
  - Ice edge and GRIB format
- **Global Snow and Ice Monitoring**
  - 2x Daily Gridded Ice/Snow Extent for North America, 1km
  - Global Daily Snow Depth, 4km res
  - Northern Hemisphere Daily Ice Concentration, 4km res
  - Northern Hemisphere Daily Ice Thickness, 4km res
  - Days since last observation for Snow and Ice Analysis Data
- **Special Support of NOAA Vessels**

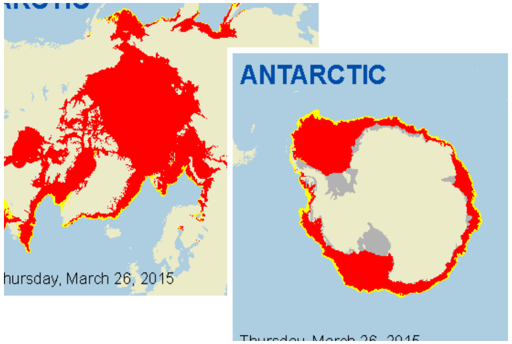






USN Requirements

- **Submarine Force (SUBFOR) Requirements (USN)**
  - Daily ice edge within 3NM
  - Daily MIZ within 3NM
  - 48HR ice edge forecast within 3NM
  - Sea ice routing/FLAP - as required (up to 2X daily) within 4NM
  - Estimated ice thickness bi-weekly or as required within 10cm
  - Iceberg location within 3NM (Arctic/Antarctica)
  - Climatological outlooks as required



- **Fleet Weather Center (FWC) Requirements (USN)**
  - Ice edge information (generic), 25 km res, daily.
  - Ice coverage (analysis and 24 hour forecast) 0.5km res, daily or as required in ports/waterways
  - Ice thickness information, 0.5 m red, or as required for tactical ops
  - Route specific at 0.5 km
  - OTSR ice annotated imagery

USCG Requirements

Arctic / Antarctic

Daily Sea Ice Edge – Daily during operations, 2x month off season.
Arctic – w/i 50m of edge; Antarctic w/i 2nm

Daily Sea Ice Concentration – Daily during operations, 2x month off season.
Arctic – w/i 50m and 2/10ths coverage

FLAP - As requested - daily during operations, 2x month off season.
Features >200m in length

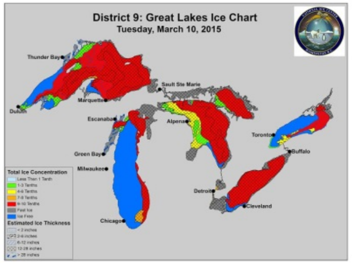
Daily Estimated Sea Ice Thickness - Daily during operations, 2x month off season

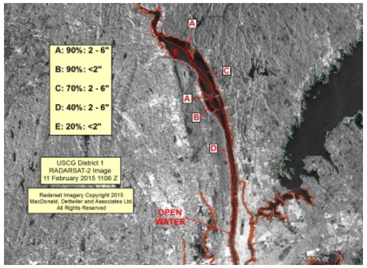
Daily Iceberg Location – Daily during operations, 2x month off season. w/i 2 km of actual; Imagery w/I 3 hrs of receipt

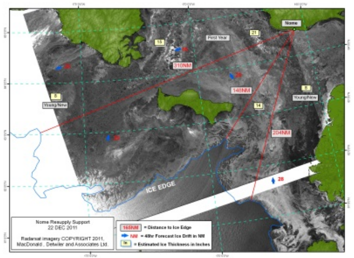
Daily Imagery Analysis/Forecast – As requested for operations/environmental awareness w/i 100nm radius of vessel

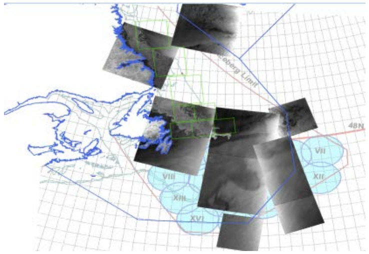
Climatological Outlooks - as requested
Arctic w/I 25nm; Antarctic w/I 20nm

Icebreakers or Aerial Recon
Embarked ice analysts or Aerial Recon for real time ice observations and analysis as requested
Annotated imagery analysis/forecasts

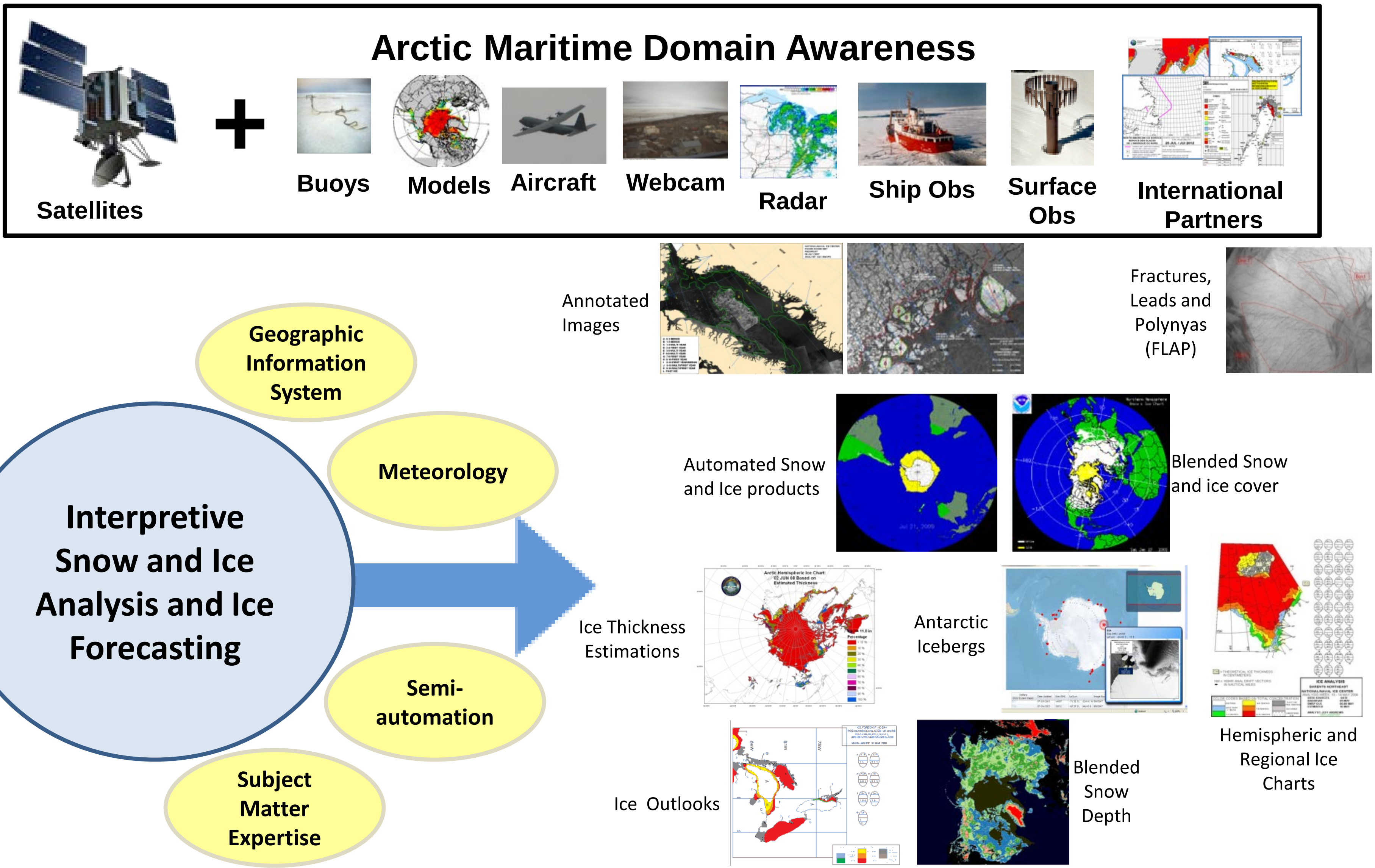








Product Generation



Current SNPP Utility in NIC Products

1. Imagery (I1, I2, I3, I5, DNB) (All)
2. VIIRS Sea ice characterization (IMS)

   Only used for Ice/No Ice (inaccurate ice typing), Cloud Mask issues

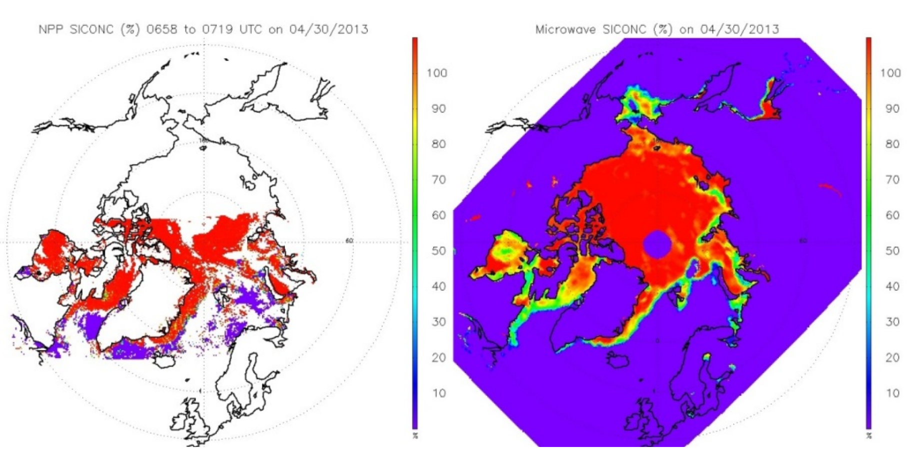
3. VIIRS Sea Ice concentration IP (Working on IMS, Hemi Ice Charts, & MIZ)

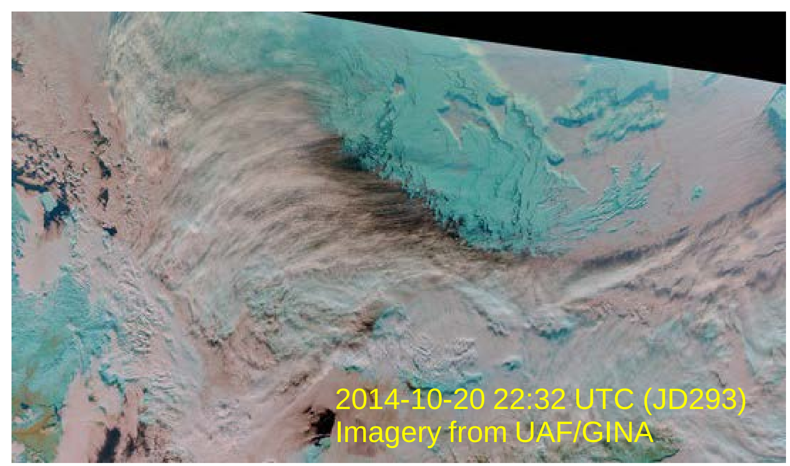
   Data format (HDF5 to Geotiff conversion being built)

   Will be helpful in IMS Blended Ice Con.

4. VIIRS Snow cover (IMS)

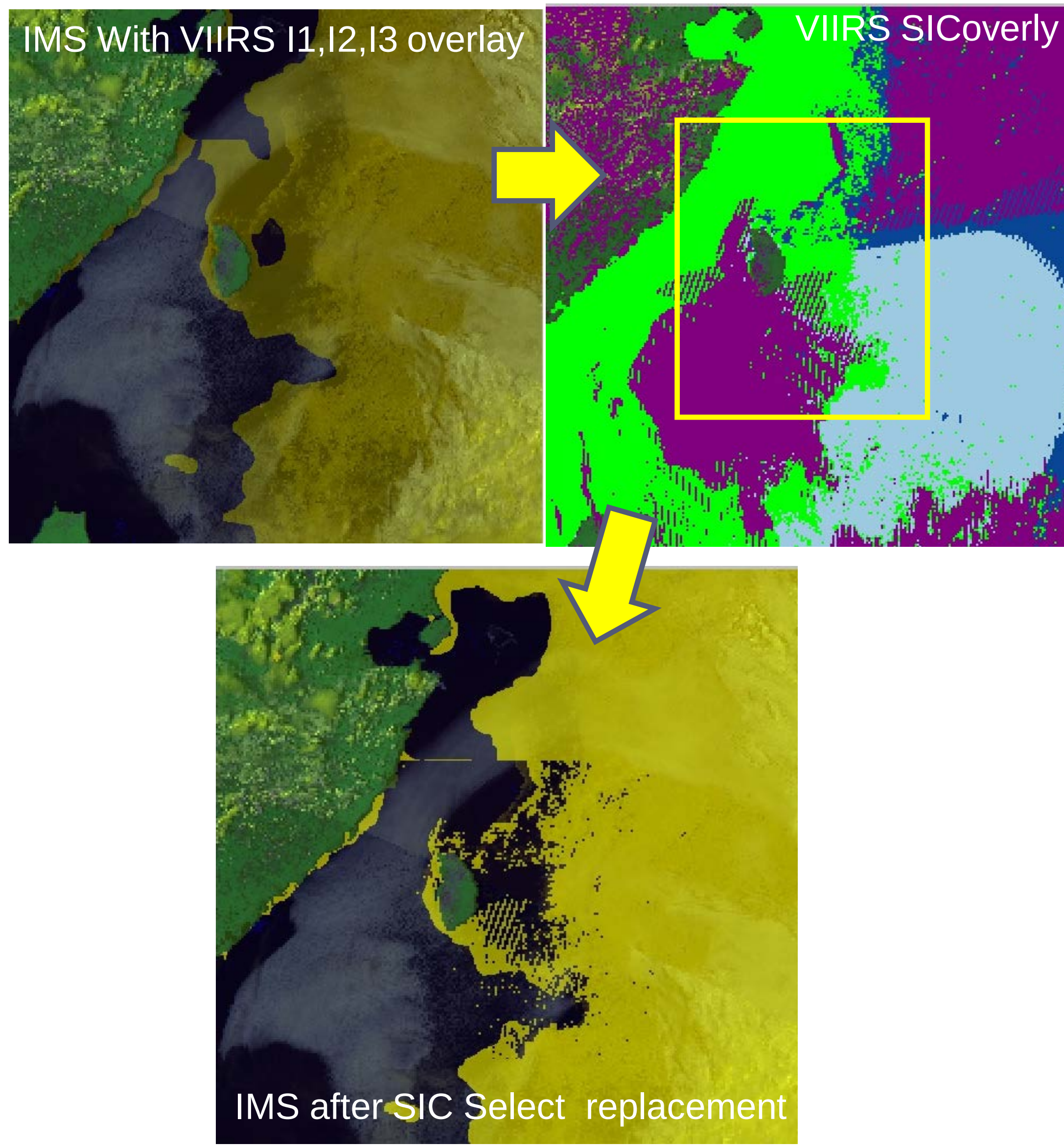
   OK, but conservative cloud mask





Direct Import of Automated Snow & Ice Cover

- **Analysts will be able to selectively import the data from satellite derived products directly into the Blended Analysis**
- **Analysis will have selection box to select snow cover and ice cover from the VIIRS, NOHRSC, and NH AutoSnowIce.**
- **Human data selection to optimize product use based on expert knowledge and imagery interpretation**
- **Combines the speed and reliability of automated products with the QC and flexibility of Human Analysts**



Current SNPP Utility in NIC Products

5. AMSR2 Ice Concentration (MIZ, Hemispheric Ice Charts)

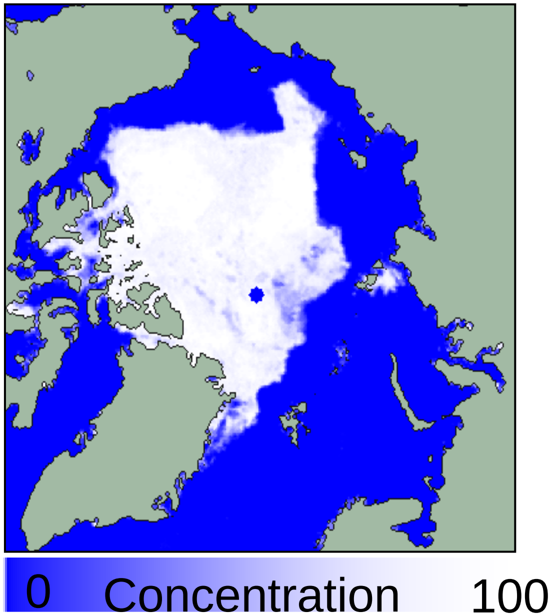
Applied in IMS Blended Ice Concentration

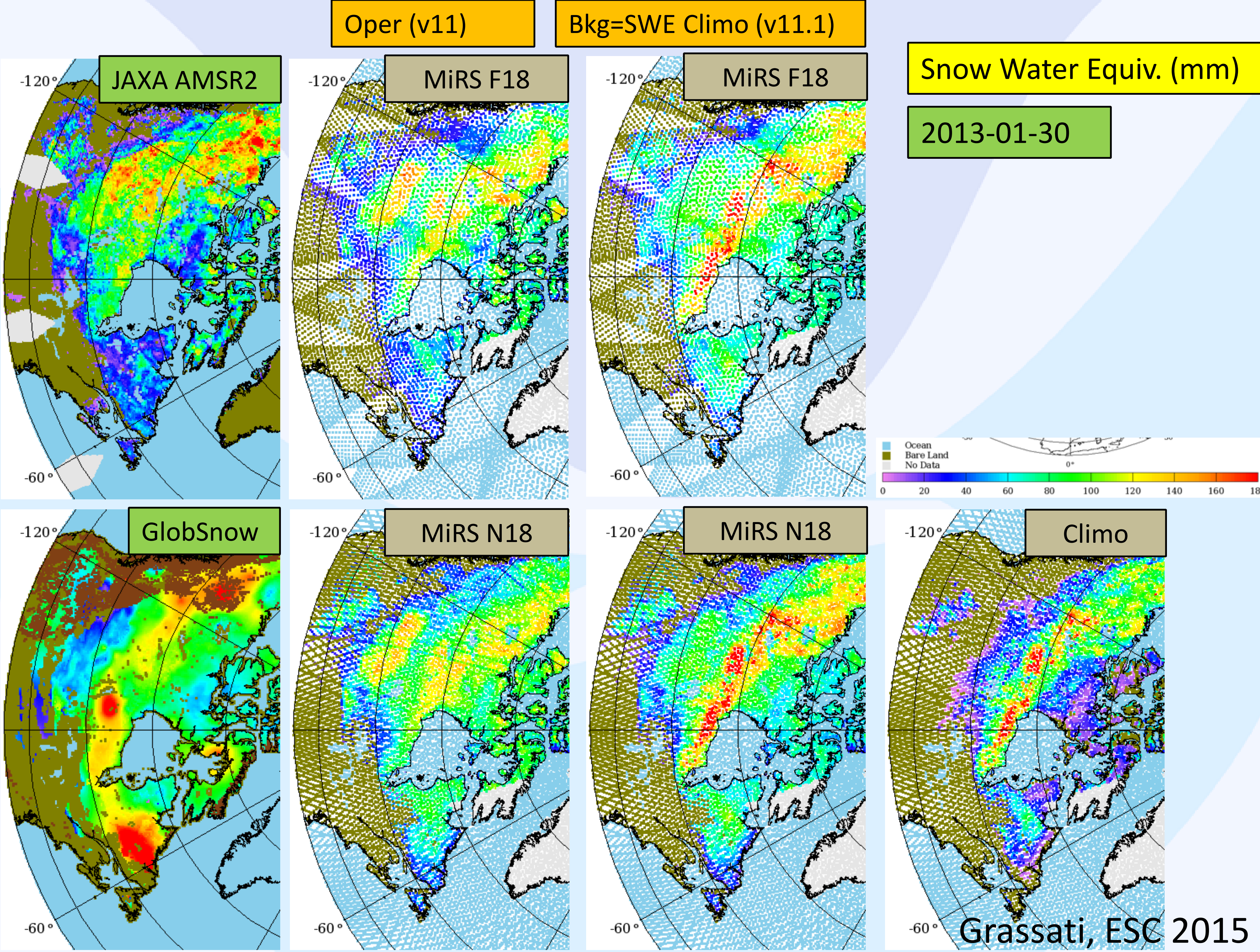
Using ASI (Univ Bremen), last resort data source,

6. ATMS Snow Water Equivalent (IMS)

Used to make IMS Snow Depth

Release of Version 11.1 – better agreement with AMSR 2 except in boreal forest areas




Oper (v11)
Bkg=SWE Climo (v11.1)
Snow Water Equiv. (mm)
2013-01-30
JAXA AMSR2
MiRS F18
MiRS F18
GlobSnow
MiRS N18
MiRS N18
Climo
-120°
-60°
Ocean
Bare Land
No Data
0 20 40 60 80 100 120 140 160 180
Grassati, ESC 2015

Potential JPSS Utility in NIC Products

7. ATMS Snow Grain Size (IMS)

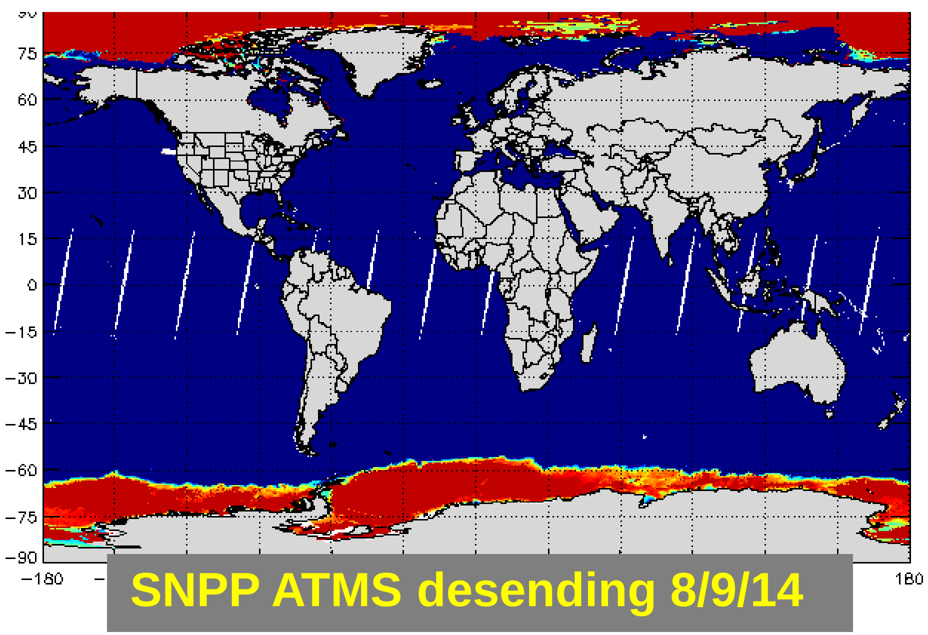
   Desired to adjust IMS Snow Depth

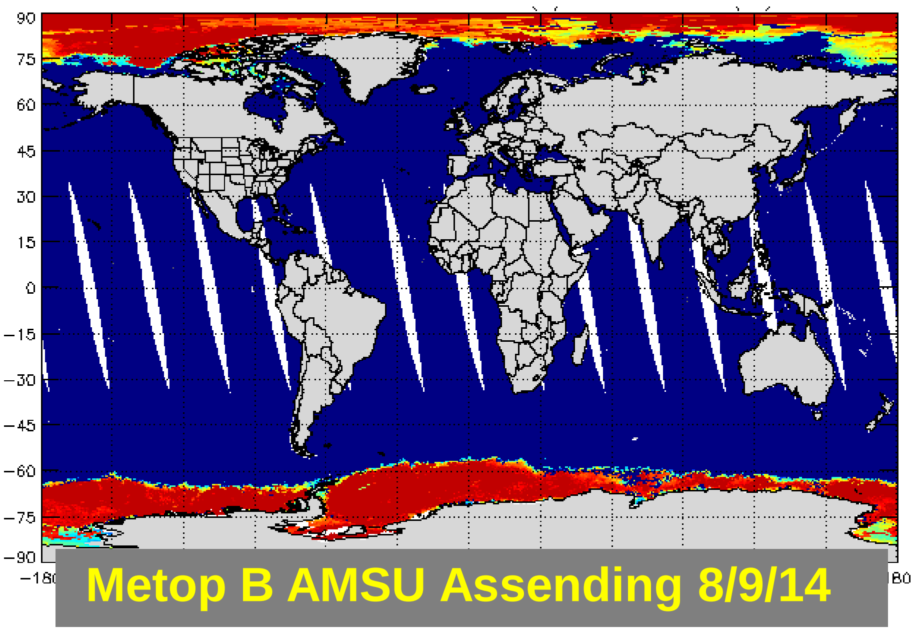
8. ATMS First Year Ice Concentration (IMS, Hemispheric Ice Charts)

   Could be used in IMS Blended Ice Con

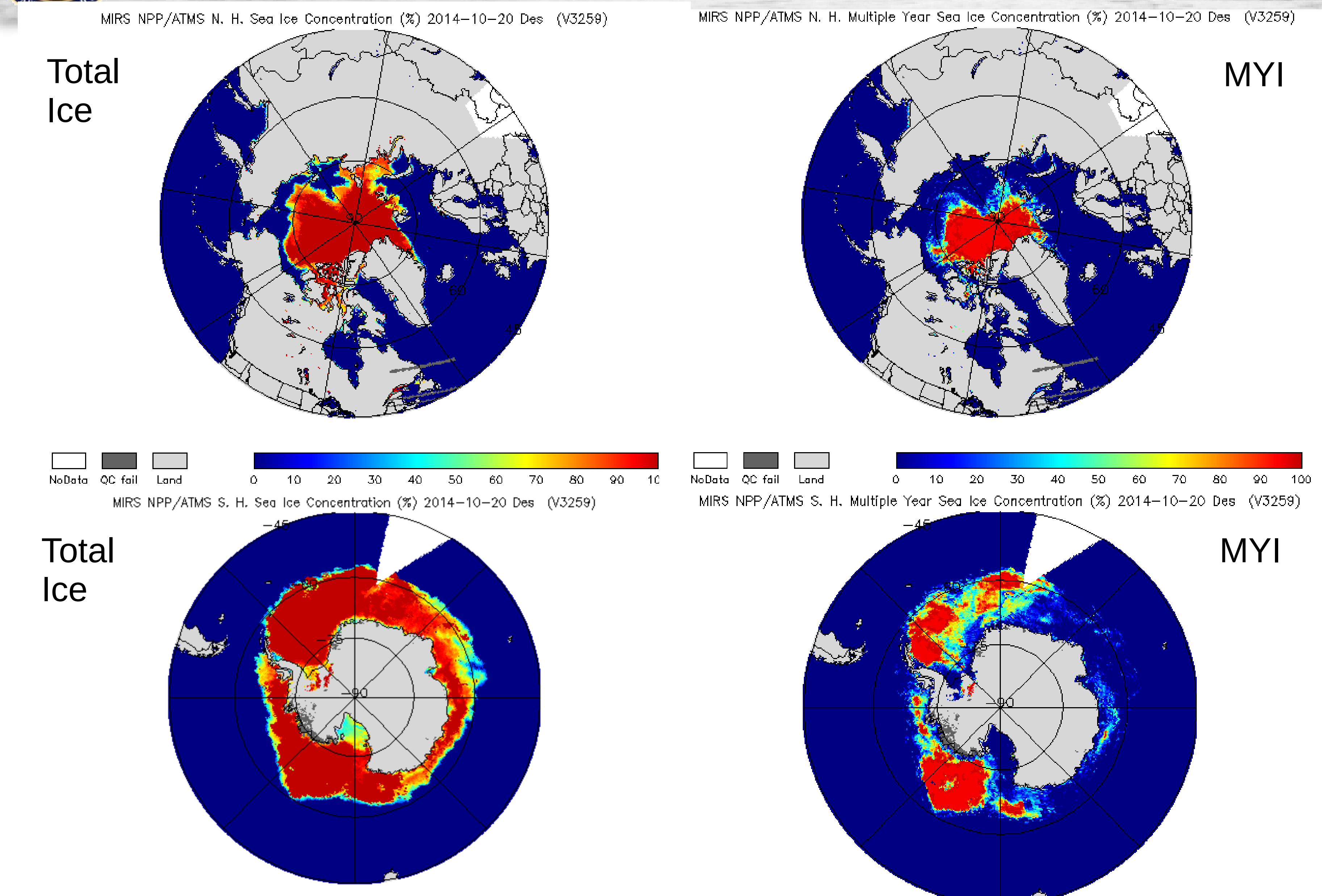
9. ATMS Multi-Year Ice Concentration (IMS, Hemi Ice Charts)

   Will be helpful in IMS Blended Ice Con





MIRS ATMS Sea Ice



NIC JPSS Wish list for Future Work

(1) Geotiff formats (All)

NIC spends much of its infrastructure, bandwidth and processing on file conversion from HDF formats from VIIRS and MODIS leaving the majority of the content

(1) Include Lake ice in the Ice products (IMS, Great Lakes Analysis)

(2) Product Composites at 1km (IMS, Hemispheric Ice Charts)

Difficulty stitching multiple swath and resampling to lower resolution

(3) Ice Edge (Marginal Ice Zone)

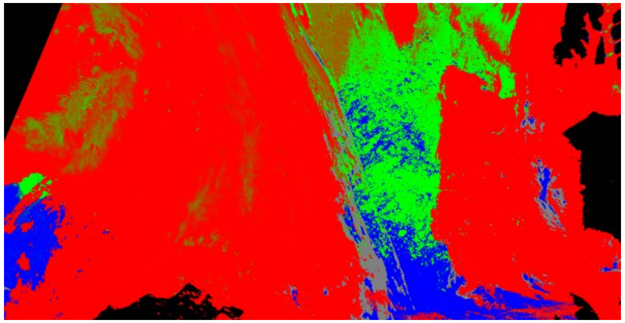
(4) Ice Drift (Ice Forecasting, IMS, annotated imagery)

(5) Ice Lead Detection (FLAP, Annotated Imagery)

(6) Snow Fraction (IMS, ASI)

(7) Blended products (All)

(8) Optional Cloud masks (All)



CREST experimental Ice Cover 7/31/13

IMS Blended Sea Ice Concentrations

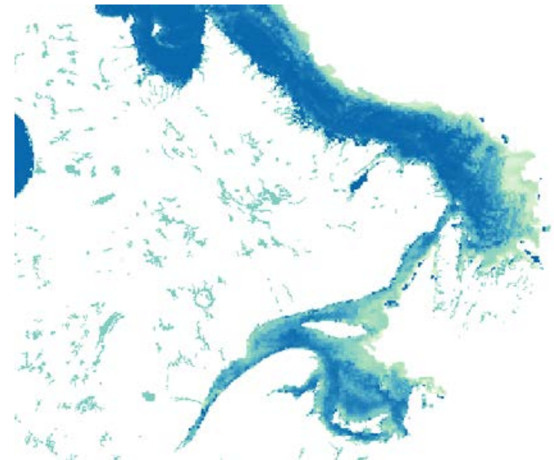
BLENDED ICE CONCENTRATIONS: STAR and NIC are developing a Blended Ice Concentration primarily for modeling

- **Using Optimal Interpolation to blend ice concentrations**
- **New "replacement" using:**
  - ***SAR***
  - ***Ice Charts***
  - ***Other ice/no ice products (CREST, VIIRS RR, GOES R)***
- **Date since last ob and source tracking**
- **Ice Concentrations determined from:**
  - ***IMS Ice Cover***
  - ***AMSR 2***
  - ***ATMS MIRS***
  - ***VIIRS Ice Con***
  - ***Ice Charts (NIC, CIS, DMI, MetNo, NWS Alaska, etc)***
  - ***Analyst "tie Points"***
  - ***NWP models***
- **2016 Release?**

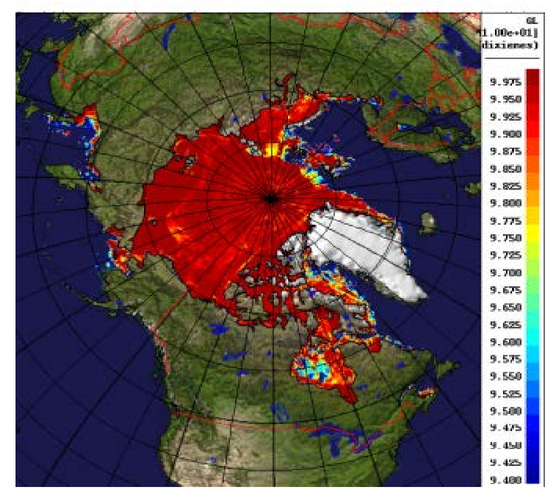
NIC & NOAA Arctic Action Plan (2012)

- **Improve ice, weather and water forecasts and warnings**
  - **Improve snow depth, snow cover, ice cover, and ice thickness analysis for operational model initialization or assimilation**
  - **Integrate new satellite-derived sea ice information into National Ice Center operations, such as ice thickness, ice concentration, and size of leads (fractures) in ice**
  - **Advance our sea ice services through the addition of more observational data sets to our analysis and forecasting techniques, evaluations of coupled model output from Environment Canada and the Naval Research Laboratory, and the expansion of product suites with new and more frequent services.**
  - **Establish foundational components of a Regional Operations Center and Arctic Test Bed to strengthen NOAA's ability to be responsive to emerging service requirements in the Arctic and leverage new science and technology capabilities.**

Blended IMS Ice Concentrations



GIOPS CMC Ice Concentrations



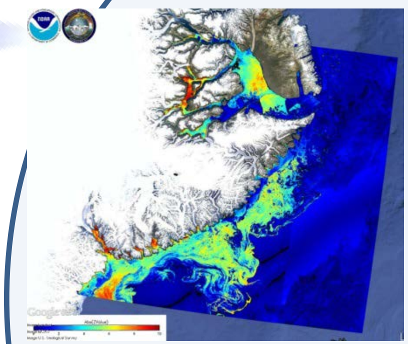
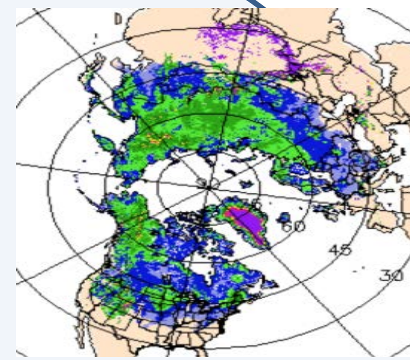
NIC & NOAA Arctic Action Plan (2012)

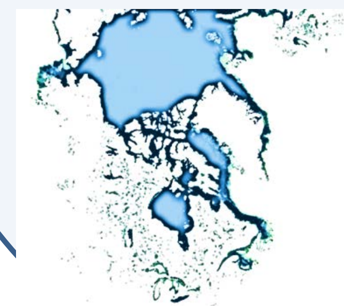
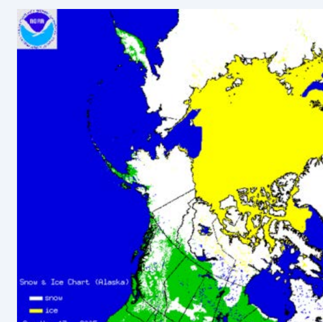
- **Strengthen foundational science to understand and detect Arctic climate and ecosystem changes**
  - **Conduct coordinated calibration and validation of satellite measurements of the cryosphere through in-situ and airborne missions in collaboration with national and international partners**
- **Enhance international and national partnerships**
  - **IICWG, NAIS, NASA, U of Washington, IABP, WMO Cryosphere Watch**
  - **Coordinating with national and international partners to broaden geographic coverage of Arctic sea ice analysis and forecasting**

Integration with Models

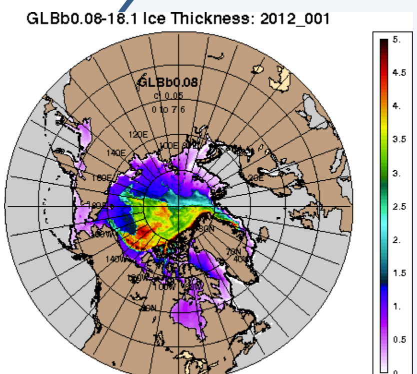
CUSTOMERS & PUBLIC

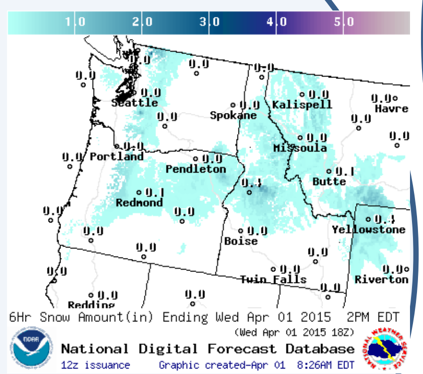
NIC Analysis

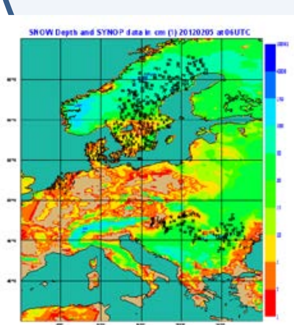
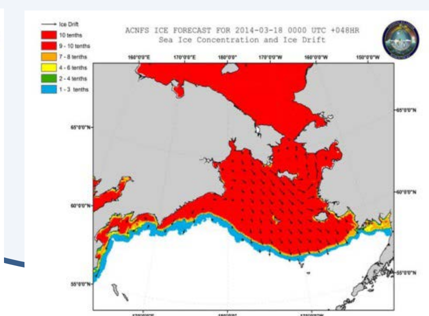



Navy and NOAA Models (and others)





Models provide forecasts for NIC forecasters which apply NIC analysis data.

Thank You!