VIIRS Binary Snow Cover and an Alternative Algorithm for Snow Fraction

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Outline

- Overview of VIIRS Snow Cover products
- Binary Snow Map

  - Examples, Accuracy, Existing problems
- Fractional Snow Cover

  - Current algorithm

  - Planned improvements & modifications

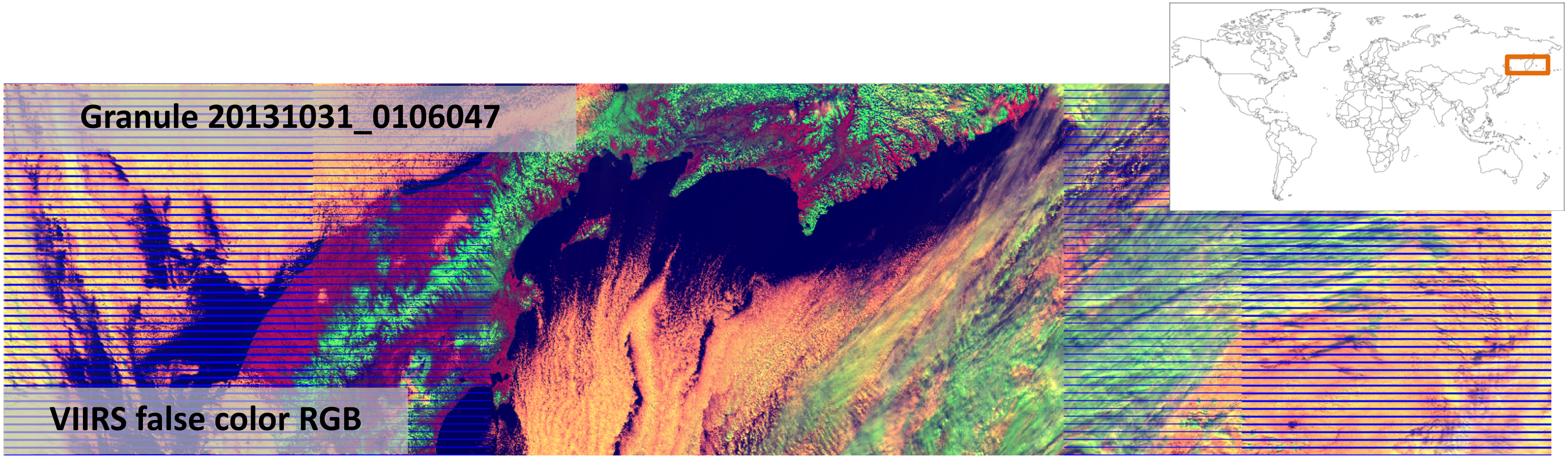
VIIRS Snow Cover Product

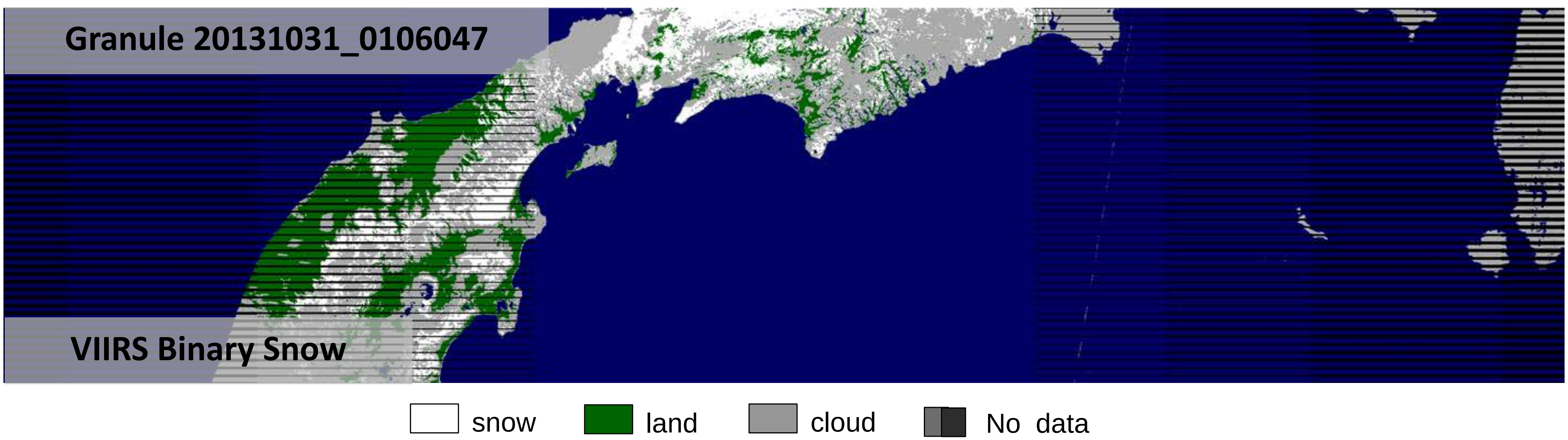
- Binary snow map:
  - Snow/no snow discrimination
  - Imagery (375m) resolution (better than MODIS @ 0.5 km)
- Snow fraction:
  - Fraction of snow cover in a horizontal cell
- Both snow products are critically dependent on the accuracy of the VIIRS cloud mask which is an upstream product.

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 clear sky pixels, requires daylight

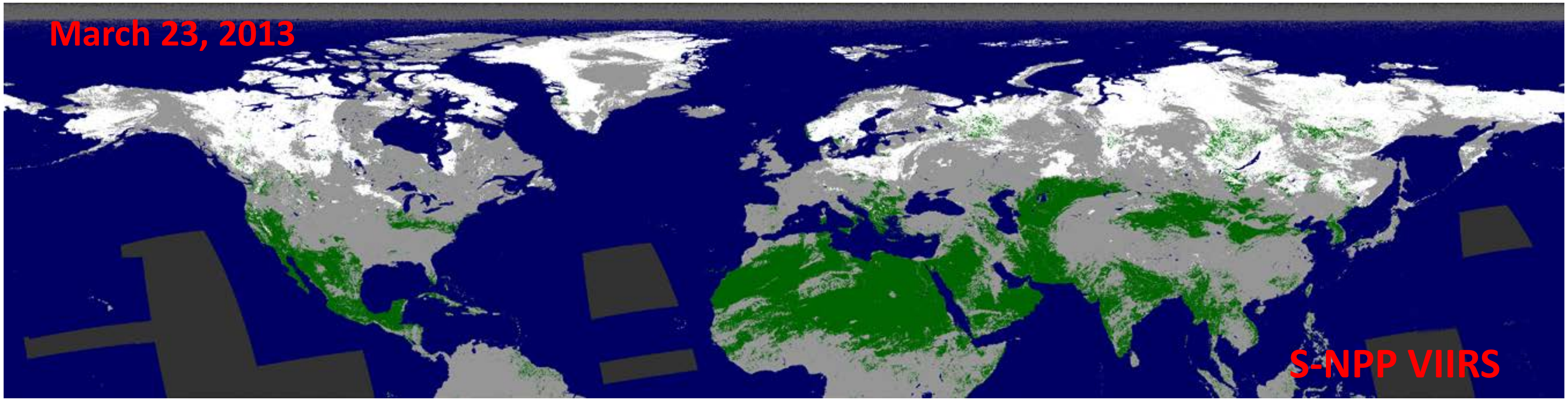
VIIRS Binary Snow Map at Granule Level



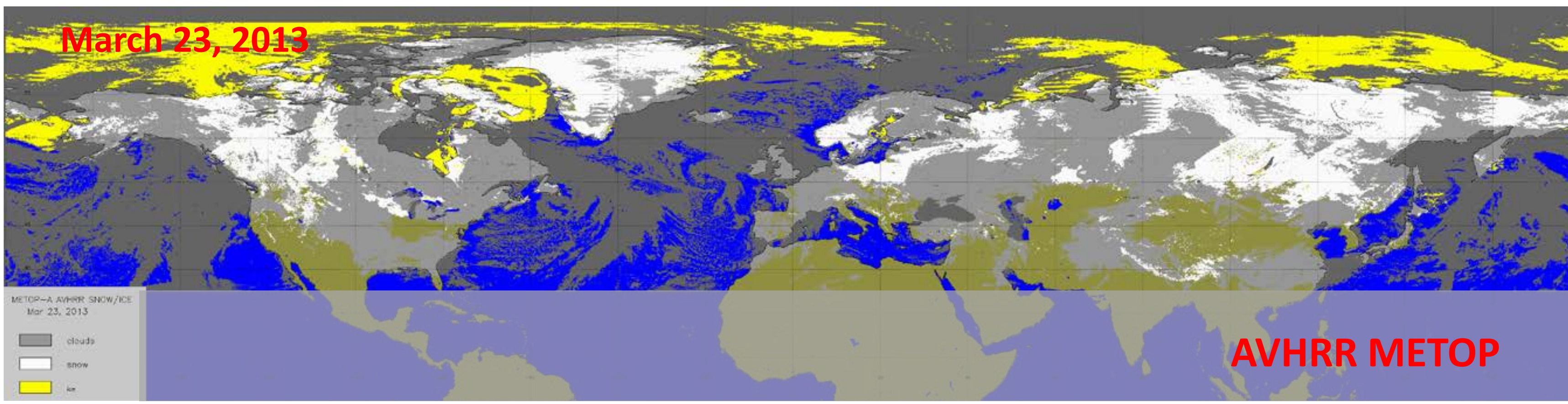


Good qualitative agreement between the snow cover seen in VIIRS false color images and mapped in the VIIRS binary snow cover product

VIIRS vs AVHRR Snow Map

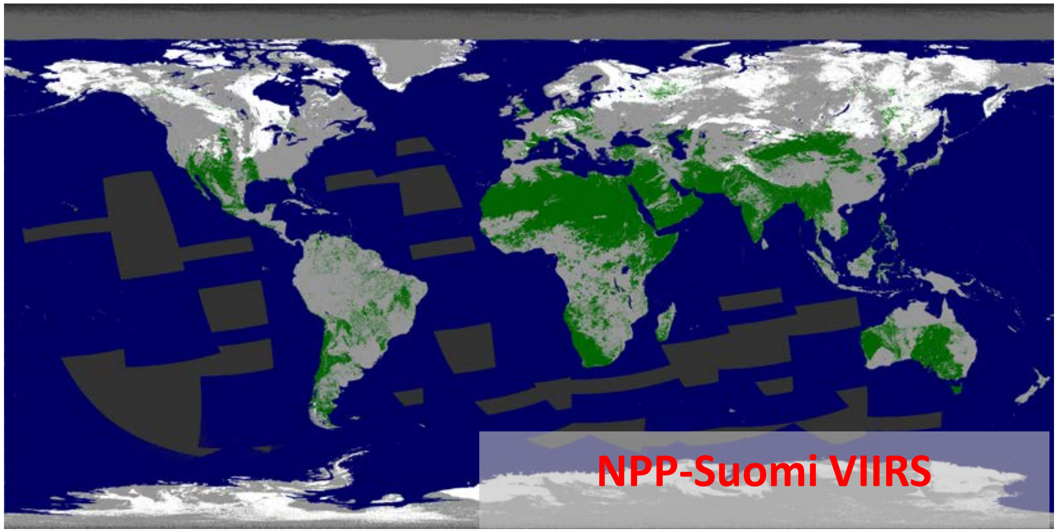


Snow Land Cloud No data

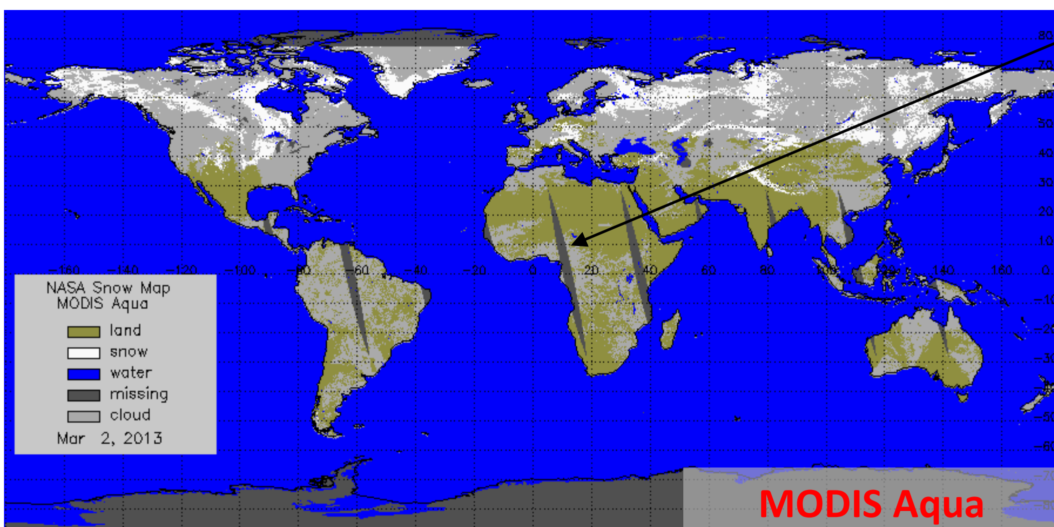


VIIRS Binary Snow Map agrees well to other similar satellite products (AVHRR, MODIS)

VIIRS vs MODIS Snow Map



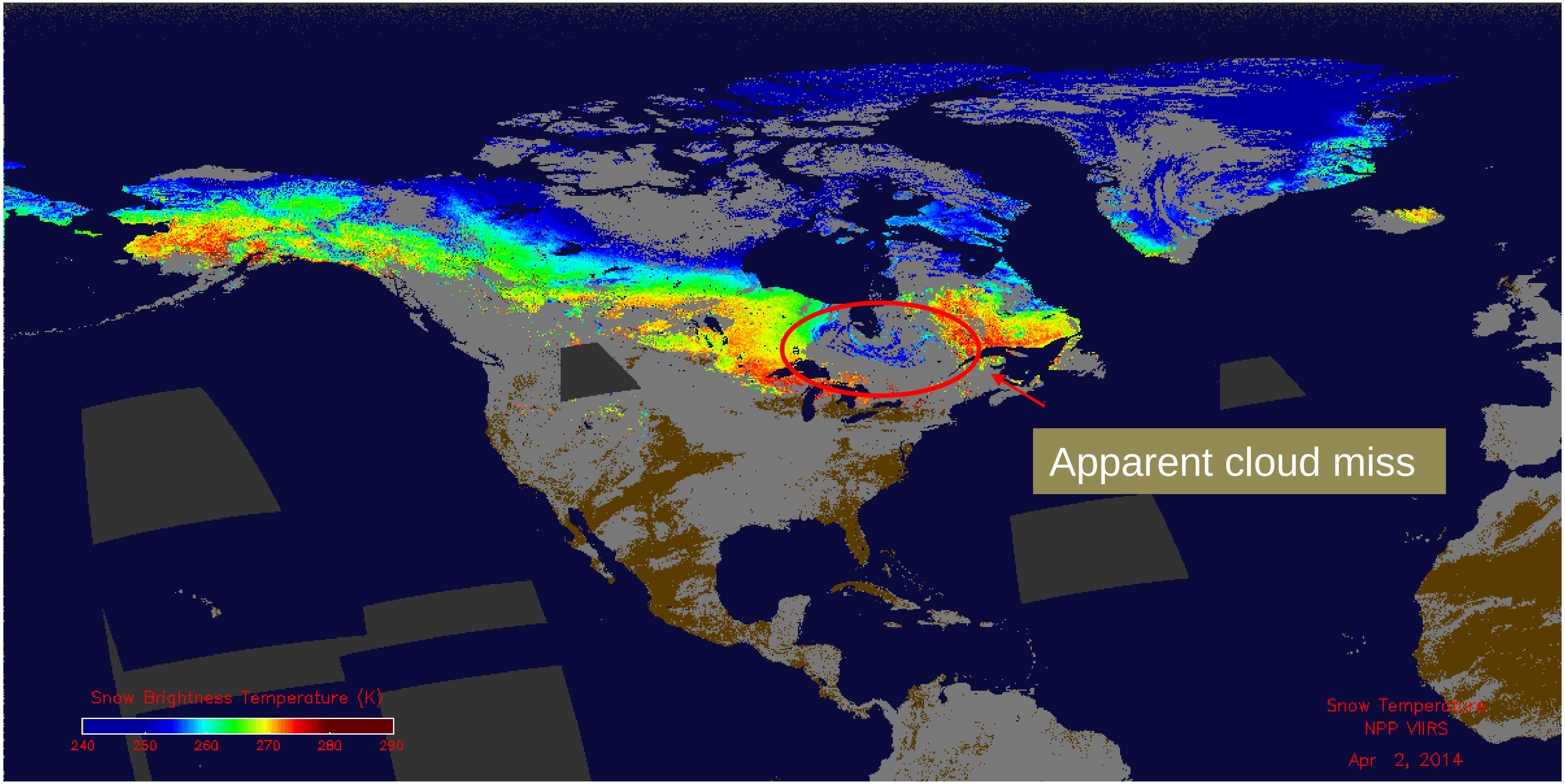
snow | land | cloud | No data



VIIRS daily global snow map has no gaps between adjacent swaths inherent to the MODIS global daily snow product.

March 2, 2013
(day 2013061)

VIIRS Temperature of Snow-Covered Land



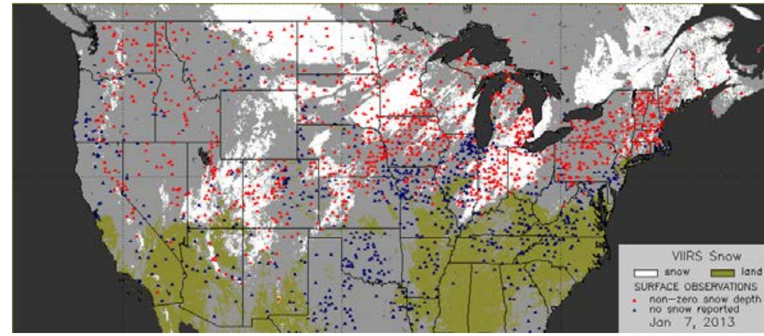
Maps of snow-covered land temperature reveal areas of snow melt and may also be used to identify cloud masking problems.

Accuracy Assessment Approach

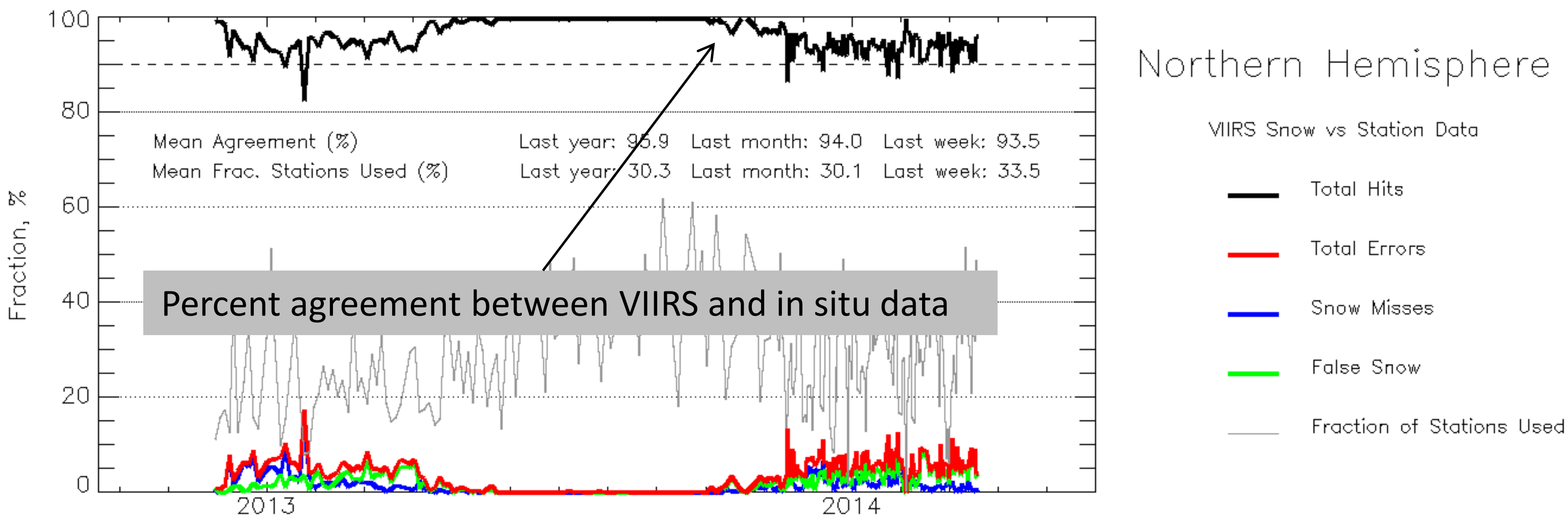
Quantitative accuracy assessment of VIIRS snow maps via

- Comparison with in situ snow cover observations
- Comparison with NOAA Interactive Snow/Ice product (IMS)

VIIRS Snow: Agreement to Station Data



Daily statistics of correspondence between VIIRS snow and in situ data



- **Several hundred station snow depth reports are used daily**
- **Agreement to station data is above 90% for most of the days**
- **Mean agreement in winter months is close to 94%.**

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

Somewhat better accuracy of VIIRS snow maps is attained at the expense of substantially reduced effective clear-sky coverage

Current Problems in the

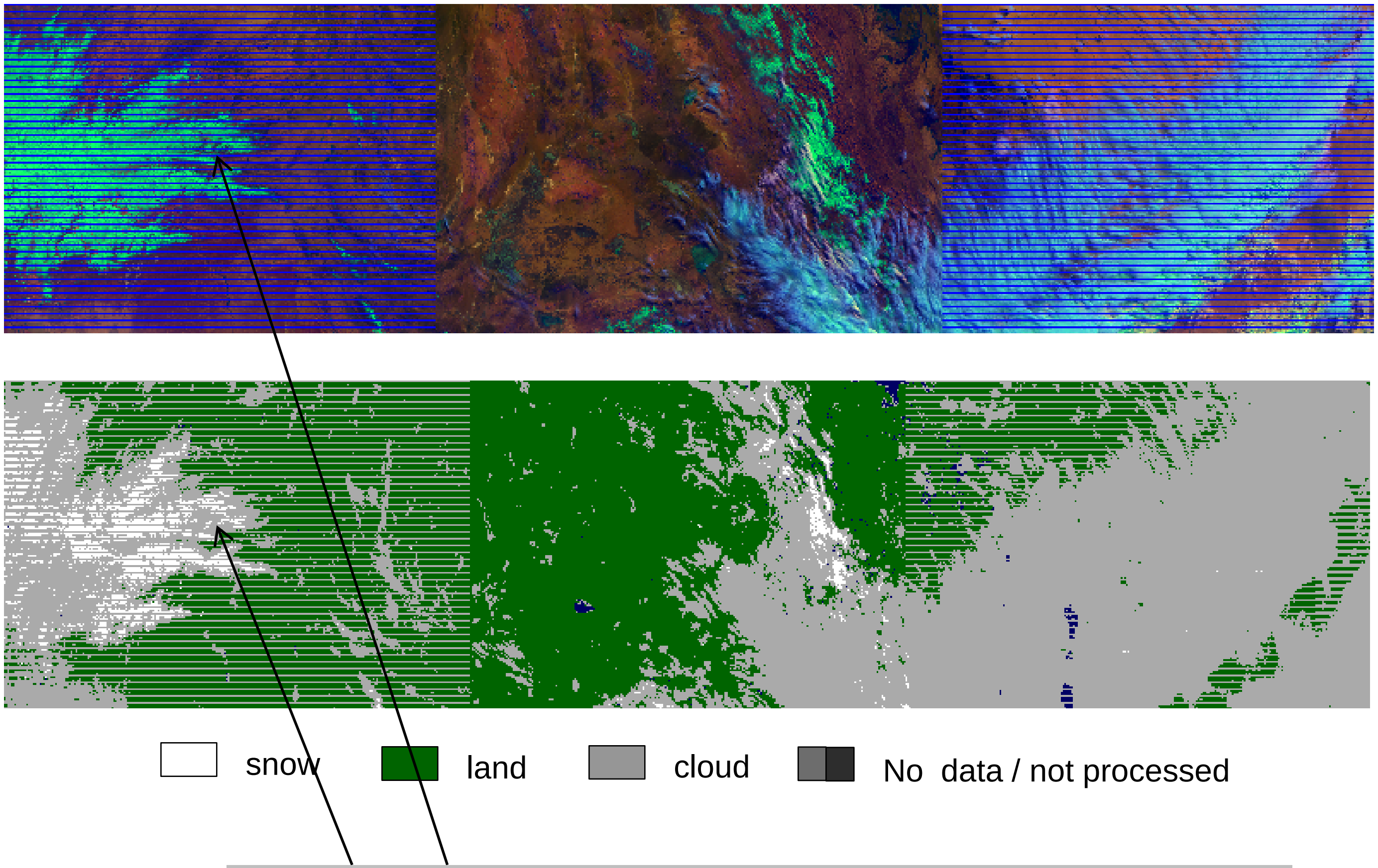
VIIRS Binary Snow Cover Map Product

- Caused by cloud mask issues
- Caused by snow algorithm limitations

Overestimated cloud extent

Partially snow-covered pixels are often interpreted as cloudy.

This hampers accurate delineation of the snow cover boundary



VIIRS RGB granule image

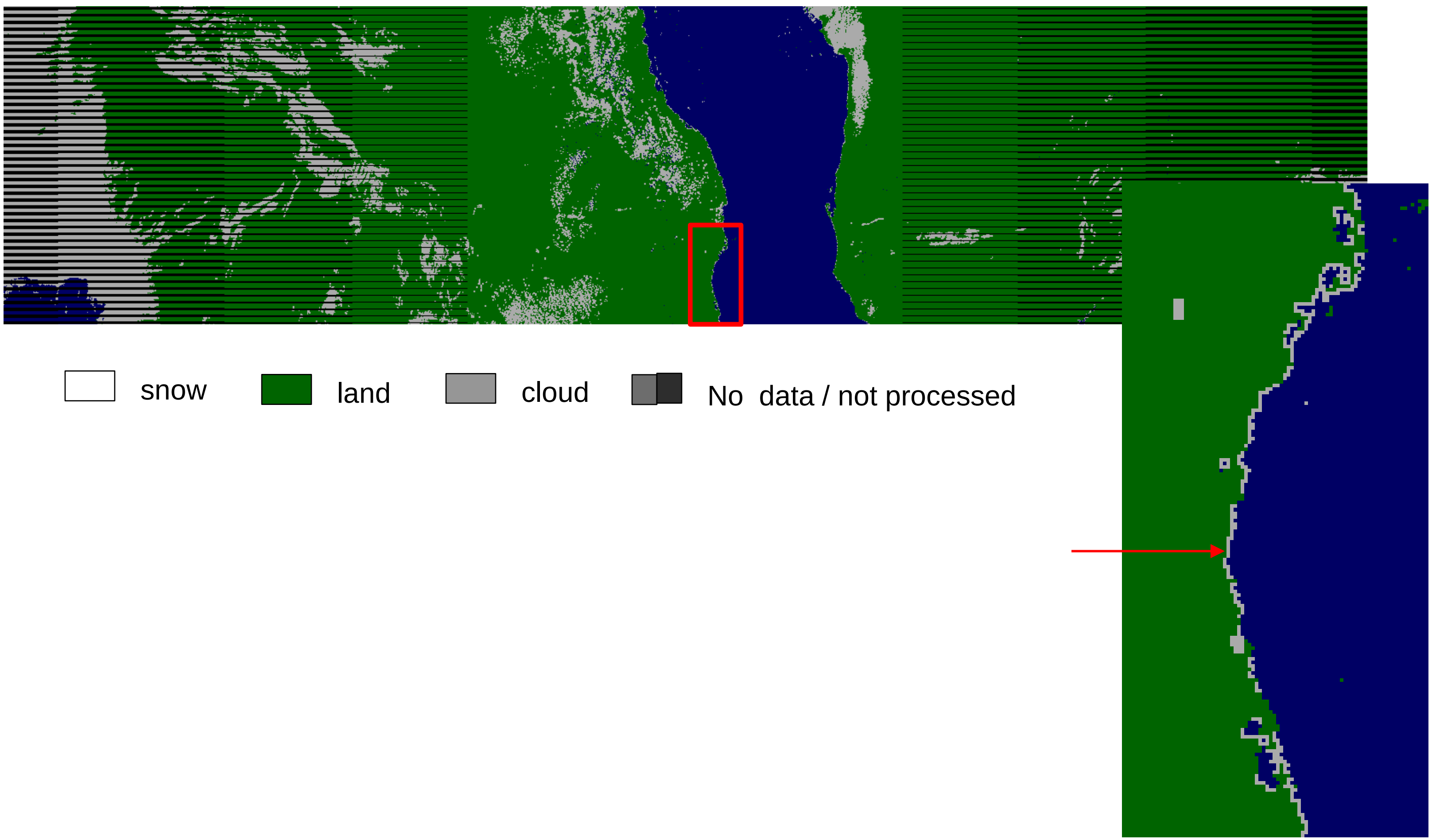
VIIRS granule snow product

False clouds over partially snow covered areas

Overestimated cloud extent

Coastal line pixels are always interpreted as "cloudy".

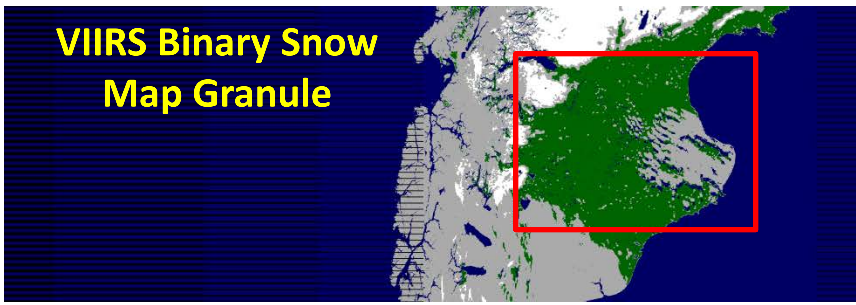
This prevent s from mapping snow cover in coastal areas



Corrupted Land/Water Mask

Land/water mask provided with the VIIRS snow product has inaccuracies

The problem occurs due to incorrect interpretation of cloud and topographical shadows as "water" by the VIIRS cloud mask algorithm. As a result, the land/water mask in the snow product gets corrupted.



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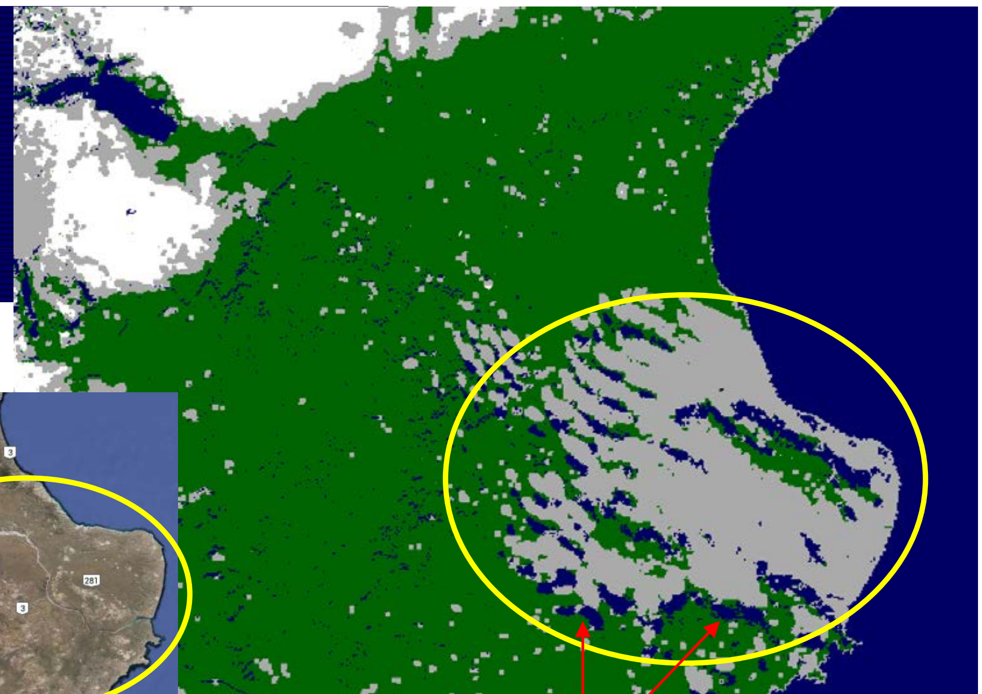
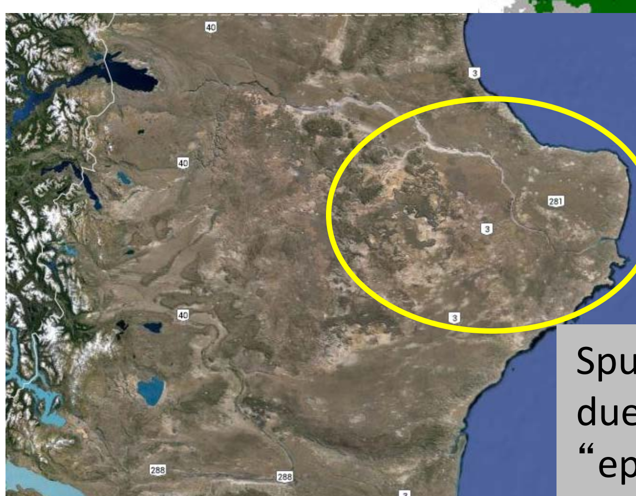


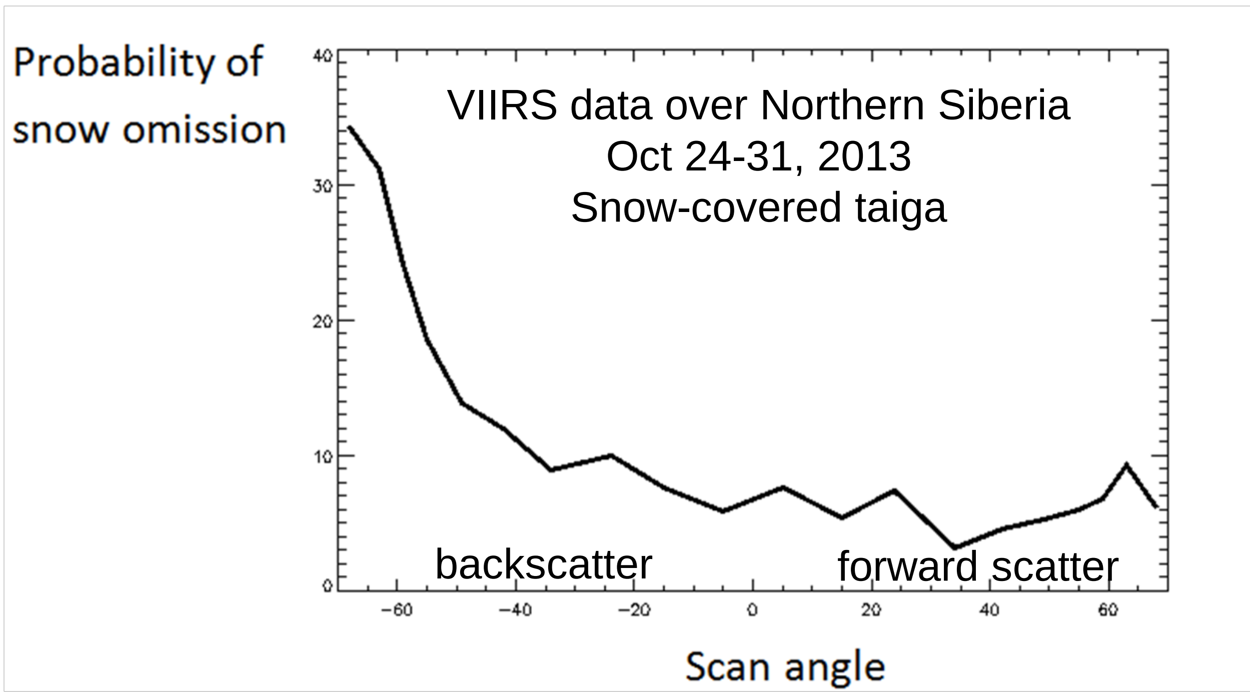


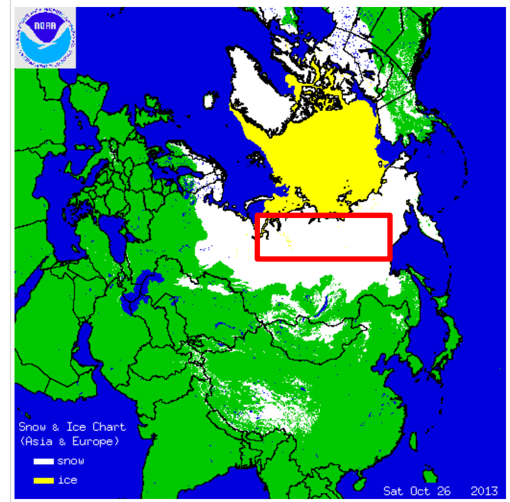
Spurious water bodies in the VIIRS snow product due to misinterpretation of cloud shadows as "ephemeral water" by the VIIRS cloud mask algorithm

Observation Geometry Effect

More missed snow at the edge of the scan, particularly in the backscatter

Observations in the backscatter portion of the scan are made at larger solar zenith angles.
Problem may be alleviated by introducing geometry-dependent thresholds in the algorithm.





Binary Snow Map: Summary

- VIIRS Binary Snow Product is consistent with existing satellite-based snow maps and with in situ data
- Over 90% agreement with other snow datasets
- Most issues are related to cloud masking
  - Somewhat overestimated cloud extent
  - Corrupted land/water mask needs immediate attention
- Some potential exist to improve the algorithm and the product
  - Geometry-dependent threshold values
- Introducing modifications to the algorithm makes more sense once VIIRS cloud mask is finalized.

Requirements to Snow Fraction Retrieval (uncertainty)

- Initially , the U.S. Government (USG) threshold requirements formulated by DoD and DOC in the Integrated Operational Requirements Document (IORD) included 10% measurement uncertainty under clear conditions for 1.3 km horizontal cell size

- The threshold requirements needed for Improved Freshwater Resource Management consider snow information for North America as Mission Critical data with measurement accuracy 10% and horizontal resolution 0.5 km

- It is logical that the requirement to measurement uncertainty for Fractional Snow Cover remained unchanged in the latest version of the Level 1 Requirements, Supplement

Significance of Snow Fraction

- Binary snow and snow fraction have quite different meaning. Under certain conditions, the binary data even in the case of perfect retrieval will systematically miss huge areas covered by snow (is illustrated in the presentation later)
- Snow fraction is an important component of land surface models and hydrological models using different spatial scales (down to 90 m cells)
- Not only does snow fraction describe snow cover properties, but it also modifies surface energy balance influencing processes in the atmosphere and on land
- Snow cover determines boundary conditions for numerous atmospheric processes
- Information on snow fraction improves downstream VIIRS products: vertical atmosphere profiles, soil moisture, etc.

Status of Snow Fraction Retrieval

- GOES-R program considers snow fraction as an option-one product. The requirements for Fractional Snow Cover (FSC), are well documented in the GOES-R Mission Requirements Document (MRD). The remotely senses fractional snow cover will be assimilated into the NOHRSC's snow model and used by more than a dozen of River Forecast Centers
- NASA provides users by fractional snow cover information and stopped retrieval of binary snow cover. Their estimates show that VIIRS could provide better snow fraction at finer resolution
- Snow fraction is a standard GOES product undergoing further improvements
- In Europe 'Snow Cover' data by default include information on snow fraction

Requirements to Snow Fraction Retrieval (Horizontal Cell Size)

- The NOAA Line Offices requirements to Horizontal Resolution (0.5 km) are more strict than initial USG requirements (1.3 km) or the latest Level 1 Requirements (1.6 km at the end of scan)

- However the difference between the resolutions is not very significant. The finer resolution is considered reasonable when applied to North America

- More important that for all variants of the Horizontal Cell Sizes the only possible approach to meet Snow Fraction uncertainty requirements is to retrieve sub-pixel information on snow cover

NPOESS Snow Fraction Retrieval

- Originally, an application of the Multiple Endmember Spectral Mixture Analysis (MESMA) was developed for VIIRS to retrieve the Snow Fraction product
- The spectral mixture analysis defines subpixel proportions of spectral endmembers related to mappable surface constituents
- It “unmixes” the mixed pixel, determining the fractions of each spectral endmember combined to produce the mixed pixel’s spectral signature
- The performance analysis indicated that the measurement uncertainty requirement can be achieved, except for scenes with forest canopy

MESMA Performance Analysis (1999)

Snow Fraction Measurement Uncertainty: Stratified Performance for Typical Case

Scan Angle	**Snow Fraction (Truth)**			
	0.0– 0.25	0.25 – 0.5	0.5 – 0.75	0.75 – 1.0
Nadir	.070	.072	.076	.081
Edge-of-Scan	.077	.079	.089	.102

Benefit and Opportunity of Using MESMA (*exceptional circumstances*)

Taken from Cryosphere Products Validation Team meeting, May 2, 2013

- MESMA was a part of all NPOESS algorithm and code developments for more than 10 years and delivered to IDPS
- The approach was considered, approved, and recommended to retrieve snow fraction at many meetings at all levels
- The code is still a part of a relatively recent version of software
- MESMA is currently a standard approach to such kind of tasks
- Existing experience of applying MESMA to retrieve snow fraction clearly demonstrates the advantages of the approach considered as one of the best for snow remote sensing
- There is no need for a lengthy process of approving a new approach since it has been already approved

Transformation of NPOESS Algorithm

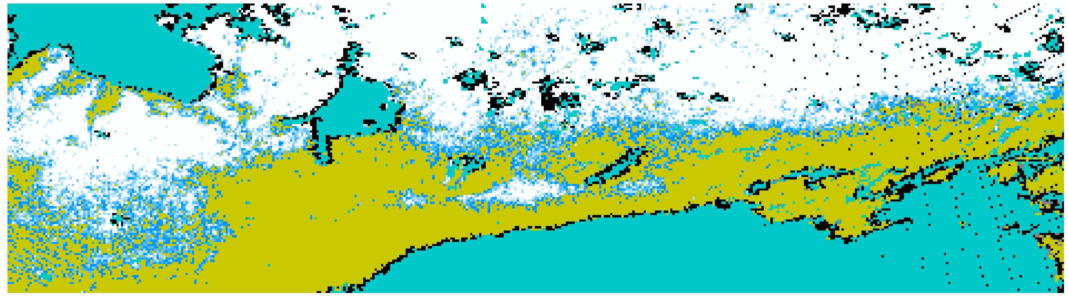
- In the current version of the VIIRS processing system, the MESMA was (temporarily?) replaced by the aggregation of the Binary Snow within 2x2 pixel blocks

- According to one of versions, Snow Fraction computed based on a 2x2 aggregation of the binary map replaced the originally proposed Multiple End Member Spectral Mixture Analysis (MESMA) approach due to uncertainty in the effort required to understand complex behavior in the initial results

- Snow fraction computed based on a 2x2 aggregation of the binary map is not a valid approach and provides no additional information beyond that already provided by the Snow Binary Map

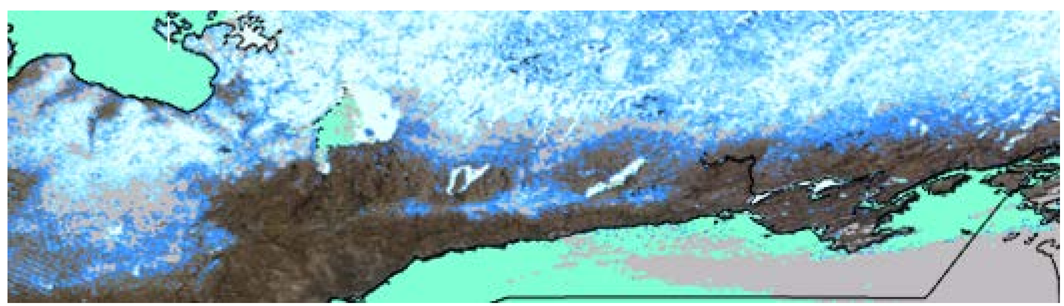
Transition Zones from Snow Covered Regions to Snow Free Areas are Very Narrow

VIIRS fraction



Image

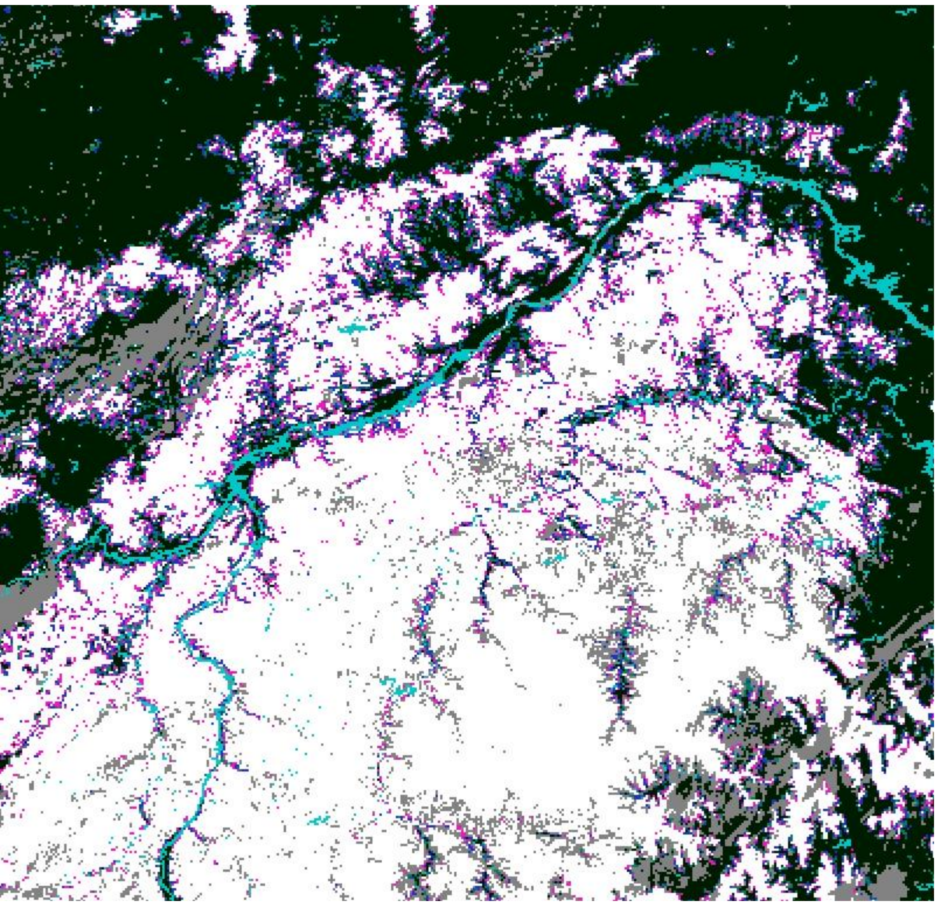
MODIS fraction

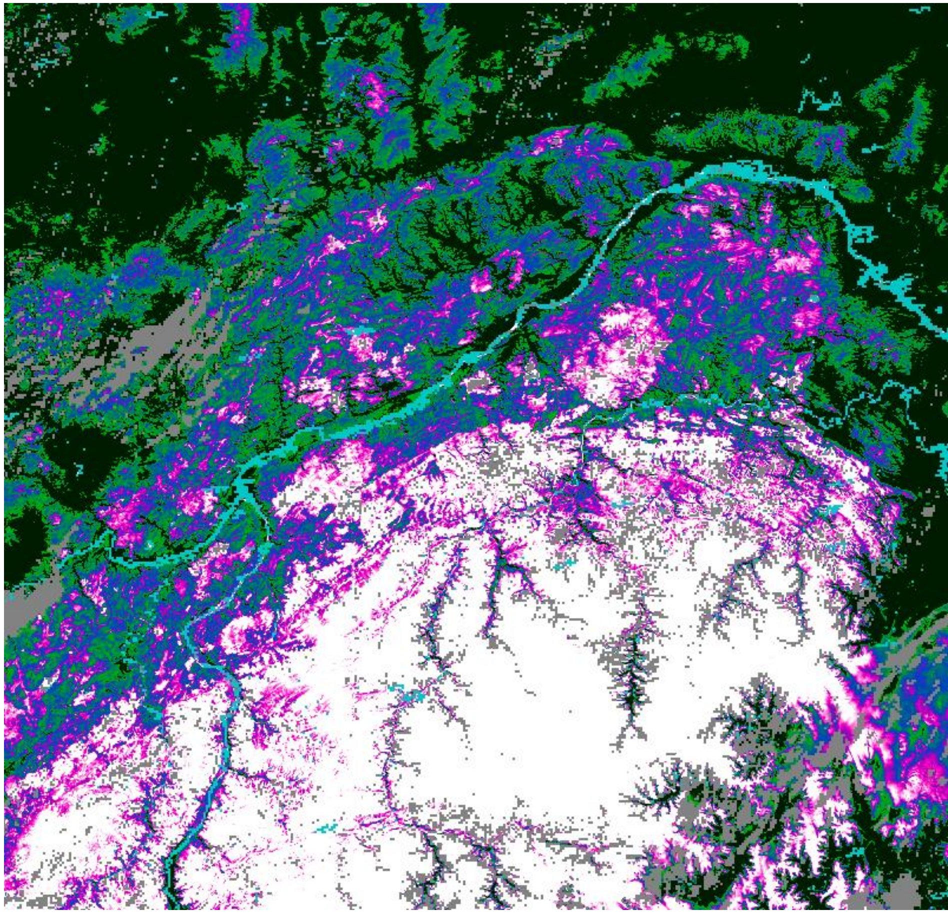


In 2x2 snow fraction (top) snow to no snow transition regions are unrealistically narrow compared to the MODIS based snow fractions

Comparison of Snow Fractions

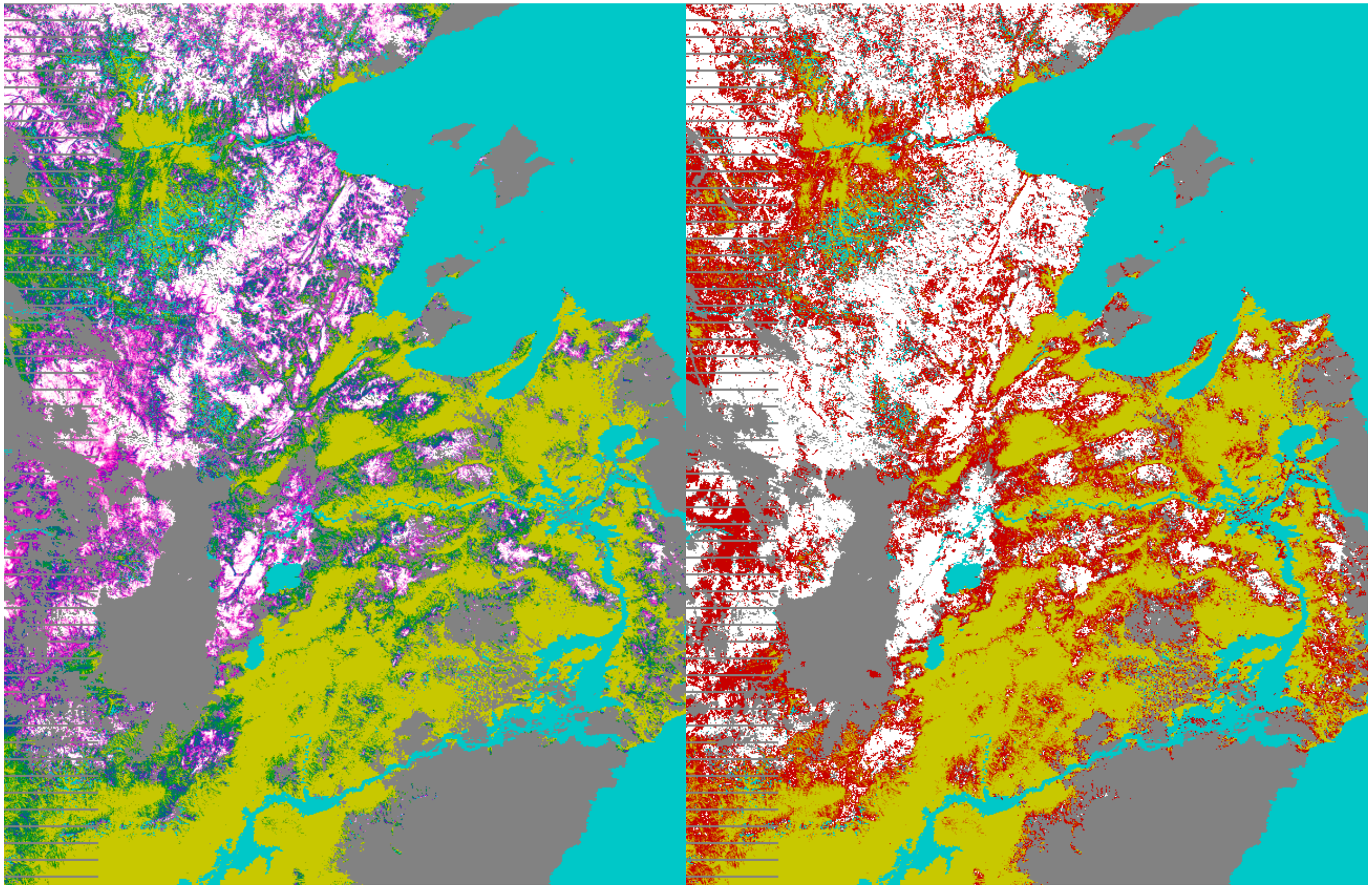
VIIRS Product 0% 100% Simulated Fraction





Current VIIRS 2x2 snow fraction will miss substantial amounts of snow with fraction greater than 0 and less than 100%

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



snow

confidently cloudy

fractional snow cover in areas of non-snow binary retrieval

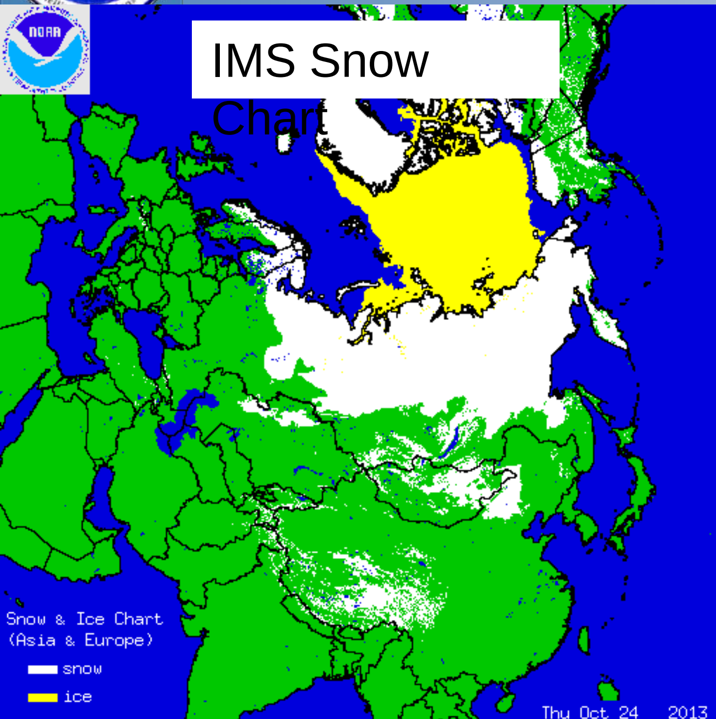
non-snow in binary and fractional retrievals

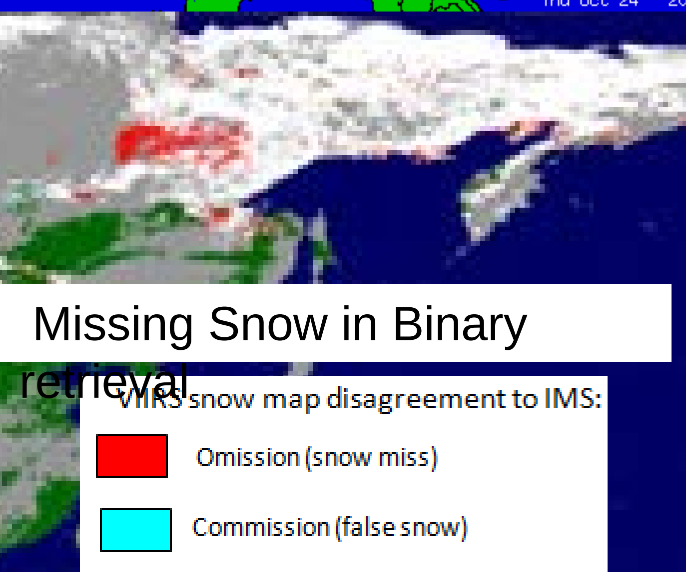
water

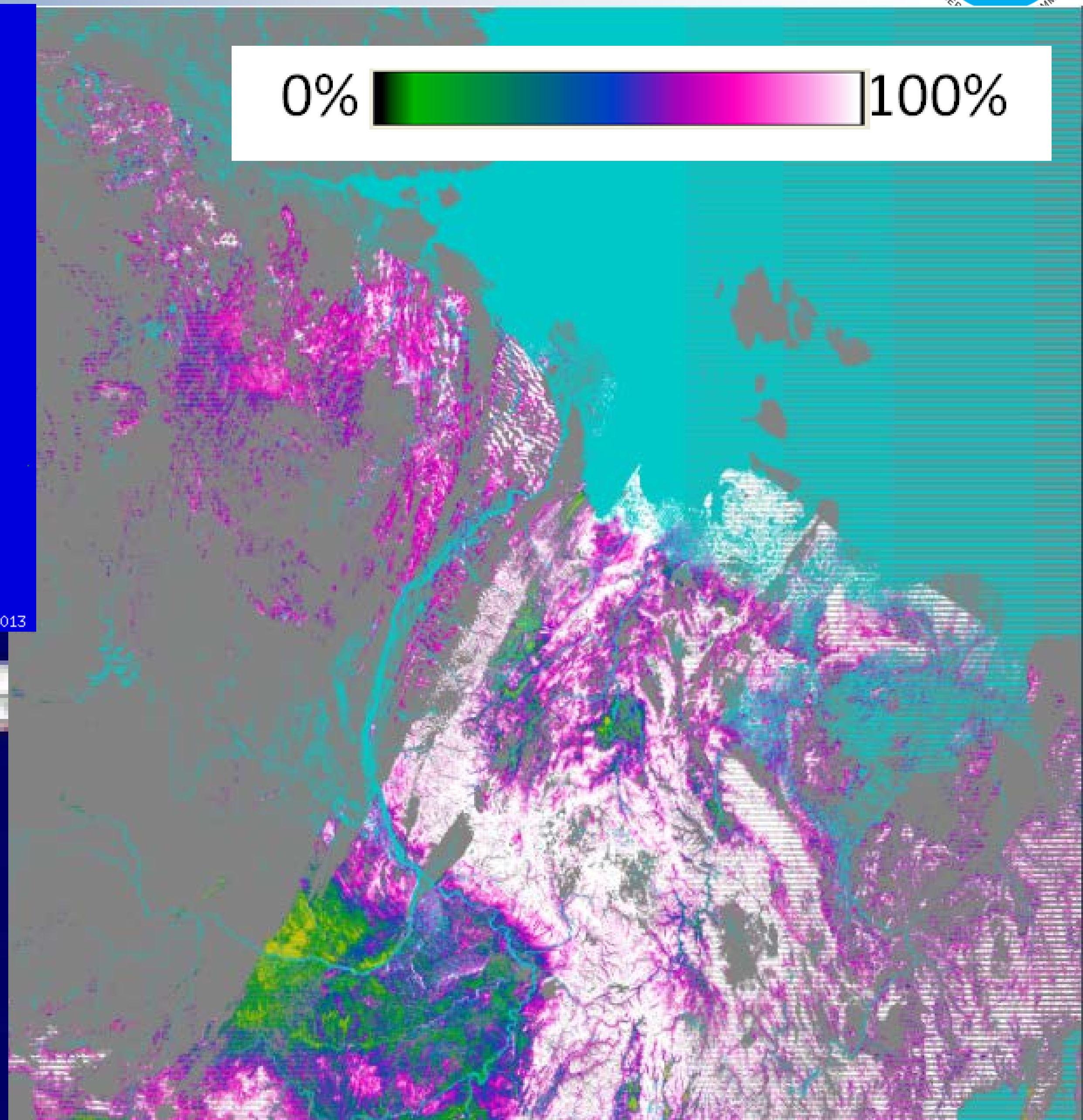
100 % 0%

Snow Fraction

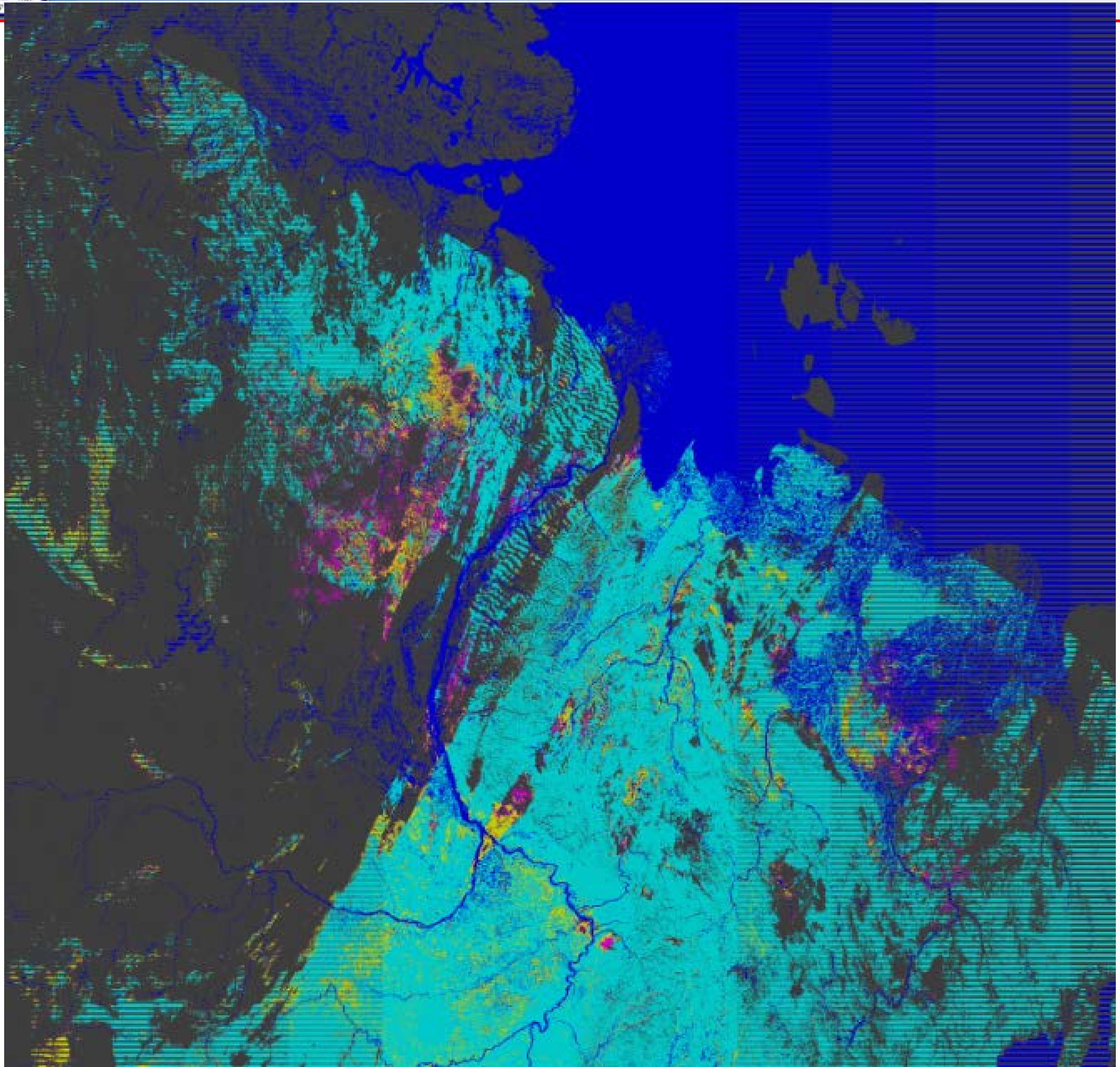
Snow Fraction on 10/24/13 (03:20)







Cloud Mask on 10/24/13 (03:20)



Confidently clear

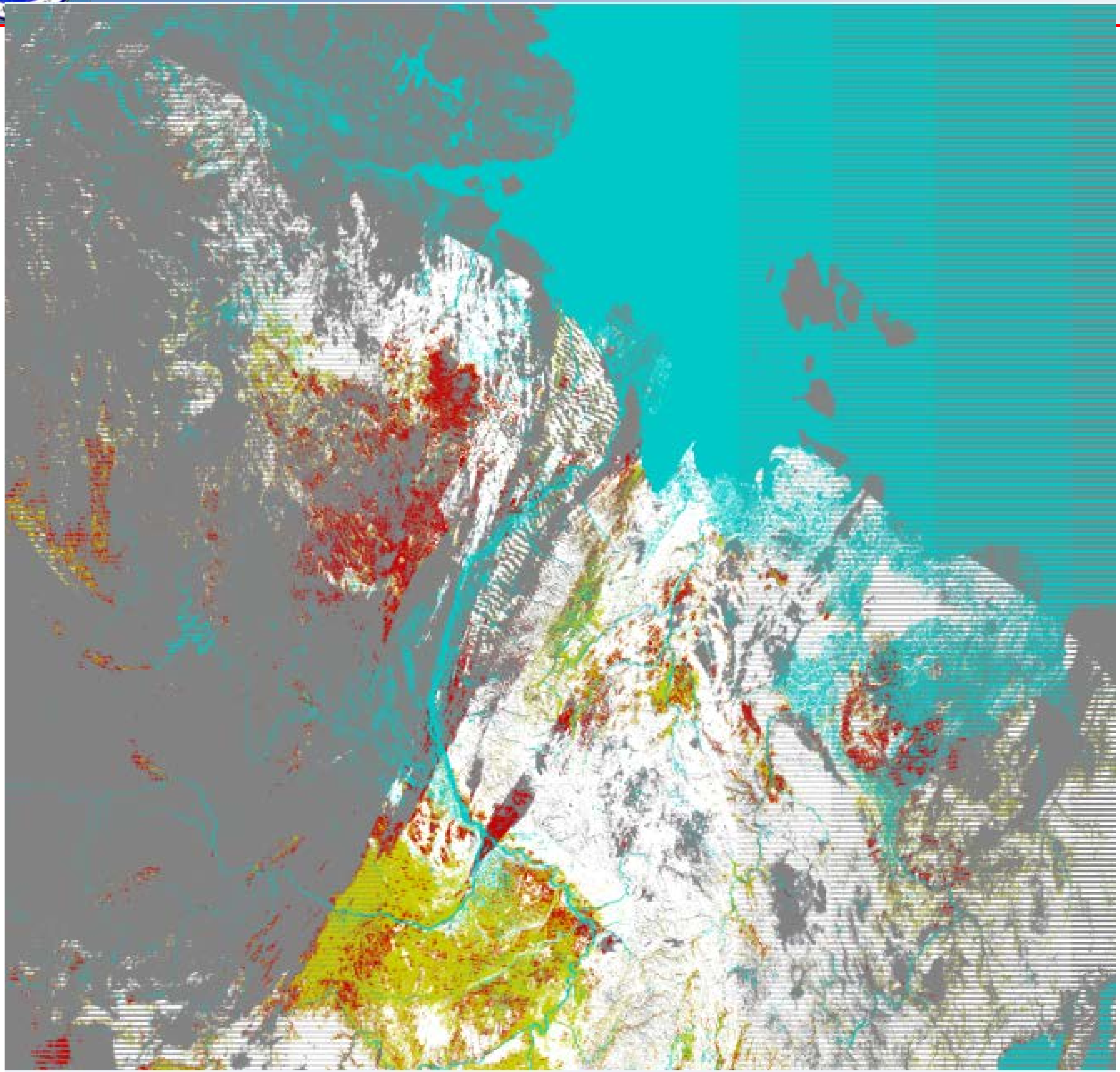
Probably clear

Probably cloudy

Confidently cloudy

Water

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



snow

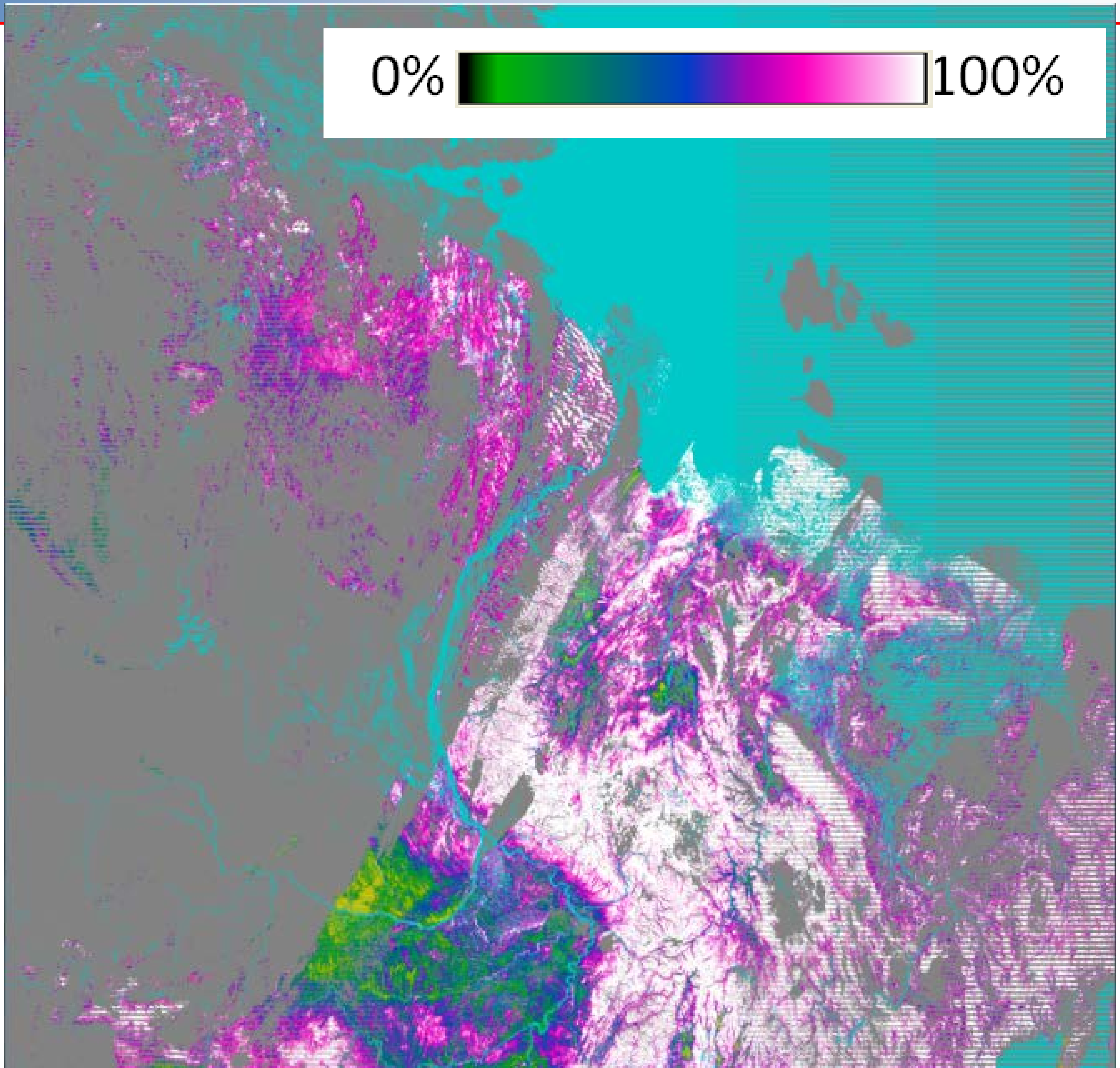
confidently cloudy

no snow retrieval in probably cloudy and probably clear areas

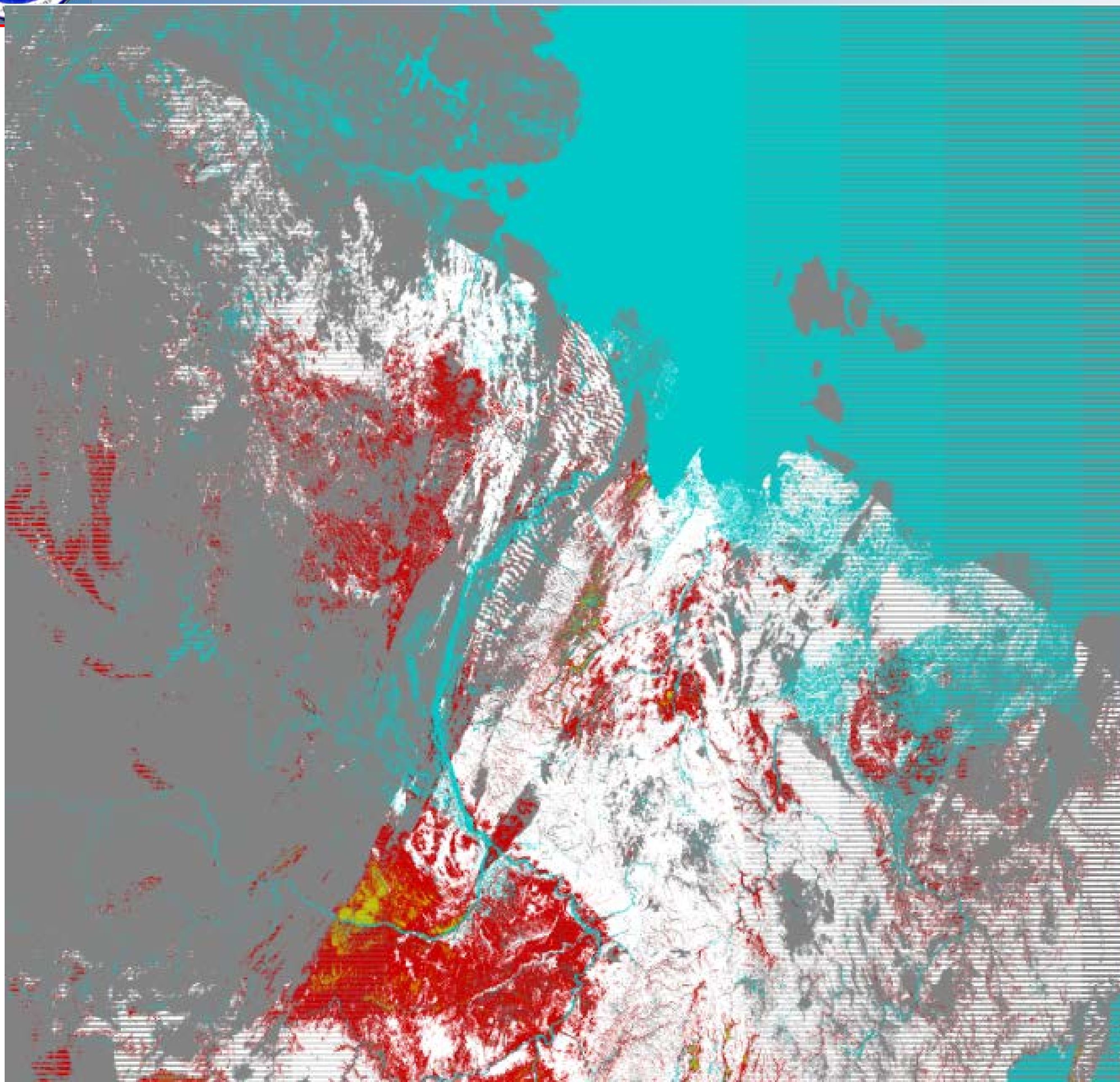
no snow retrieval in confidently clear areas

water

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



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

Alternative Algorithms

- There are three Approaches Alternative to 2x2 Aggregation under consideration:

  - Single visible band interpolation
  (used in NOAA for GOES)

  - Regression of snow fraction on NDSI
  (traditionally used in NASA)

  - Multiple Endmember Spectral Mixture Analysis
  (initially developed, approved, and coded for NPOESS; proposed later to GOES-R)

Similarity between Alternative Algorithms

- In a very general sense, one-band (a), NDSI (b), and MESMA (c) algorithms could be considered as different realizations of the interpolation between reflective characteristics corresponding to pure snow and non-snow

- It is possible to apply “endmember” term for all those algorithms meaning a reflectance (a), NDSI (b), and spectral signature (c)

- All the methods could provide comparable results if snow and non-snow properties are known to each pixel

- Endmembers depend on local conditions. Snow local endmembers could not be predetermined

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

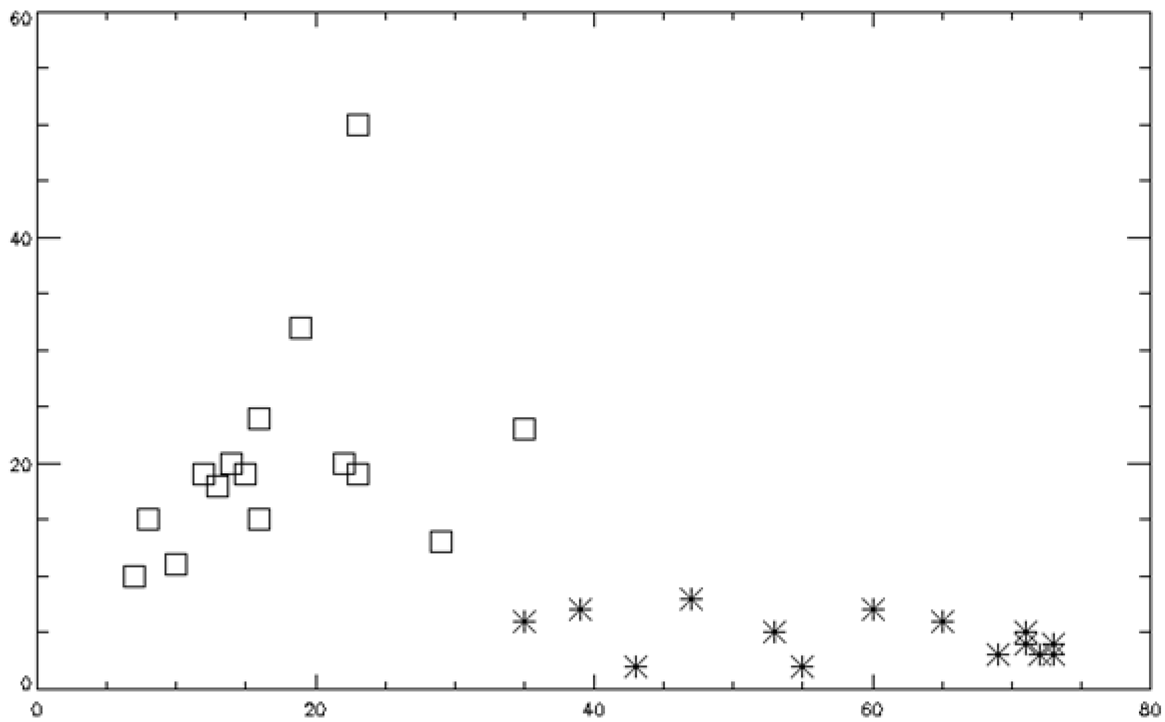
- Observed changes in pixel reflectances should not be ascribed exclusively to variable fraction, because they depends also on local variability in spectral signatures of the endmembers

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

Scene-specific Approach to Snow Retrieval

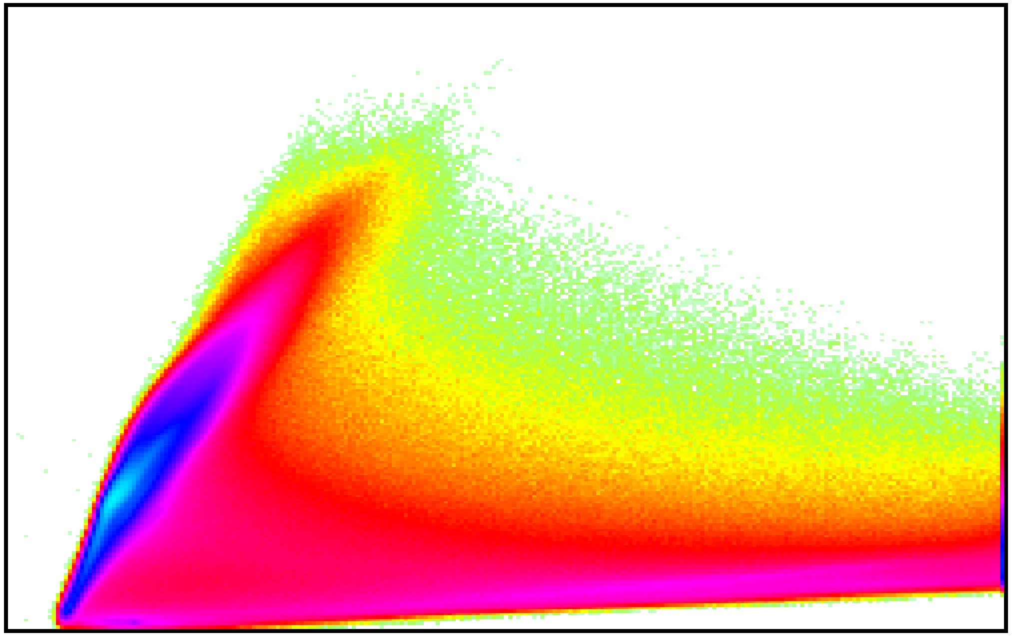
- The quality of snow retrieval could be improved if the variability of reflective properties characterizing different snow and underlying non-snow states is taken into account
- The one of possible approaches to better estimate the VIIRS snow fraction for varying local conditions is to use the scene-specific approach
- The adjustment of the parameters in snow algorithms to specific local conditions is a promising improvement leading to better quality of the VIIRS snow products
- The motivation for tuning snow retrieval in NDSI algorithm came from research of the optimized versions of algorithm for different conditions

Variability of snow & non-snow reflectances (from scene to scene)



The most probable snow (asterisks) and non-snow (squares) VIIRS reflectances (x axis – M5, y axis – M10) for 16 scenes with good illumination conditions within a narrow range of latitude and sun elevation (24˚ - 36˚)

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

Choice between Alternatives

- Different points of view were formulated during discussions regarding possible alternatives

  - the linear regression approach with NDSI would be the easiest and have the least impact on the system;

  - regarding a more simple, single (visible) band unmixing algorithm, the problems are much the same as in the multi- end member multispectral algorithm;

- There is no comprehensive quantitative comparison of alternatives results with ground truth
- Individual preference to one or other algorithm is not important
- Selection will be based on the quality of results that need to meet existing requirements (10% uncertainty)

Possible Approach to Replace Algorithm

To begin works doing the following

- Implement a simple algorithm making some enhancements to improve the retrieval quality
- Consider potential use of other alternative algorithms
- Make the emphasis on the comparative quantitative estimate of fractional snow product quality for global coverage

In the case if further improvements are needed

- It is very reasonable to assume that the uncertainty requirements could be met only if specific local conditions are taken into consideration
- Estimate applicability of scene specific approaches to modify the algorithms

Programmatic Recommendations

- Remove obsolete Algorithm Maturity schedule created for the snow fraction EDR that should be replaced

- Take into consideration that
  - snow fraction is just a half of Snow Cover EDR
  - less than 1 FTE is allocated per cryosphere EDR

- Available FTE per EDR is at at least twice less than for any other team even with a low people allocation

Discrepancy Report 4246

- Title: Snow algorithm inconsistent with … requirements
- Submitter: Neal Baker
- Program Officer Monitor: Paul Meade
- Description: … a 10% (uncertainty) value cannot be achieved. We will have to investigate sub pixel snow algorithms.
- Secondary comment of 20130416: … this algorithm … is of little value to a user and it really deserves to be delete and replaced by an alternate algorithm
- Secondary comment of 20131029: … Program Office Monitor set to … Cryospheres EDRs JAM to begin work looking at substitute fractional snow cover algorithms, per recommendation of Mitch Goldberg and Jim Gleason during data product Beta Maturity AERB and direction of Cryo Cal/Val Lead Jeff Key

Discrepancy Report 7270

- Title: JPSS-1 Algorithm improvements: mandated: Snow Cover Fraction EDR
- Submitter: Lance Williams
- Program Officer Monitor: Paul Meade
- Description: The cryosphere cal/val team has identified JPSS-1 algorithm improvements mandated in the Level 1 RD.

  - algorithm changes are required in the snow cover fraction EDR to meet the L1RD measurement uncertainty requirement of 10%

  - the aggregation approach must be revised for a new, pixel-by-pixel algorithm
- This DR serves as a tracking and development tool for those improvements

Conclusions

- VIIRS observations give the opportunity of daily snow fraction mapping at 375 m (or at least 800 m) at nadir, that is adequate for most applications

- A number of needed enhancements to algorithms are foreseen to improve the accuracy of snow retrievals to meet requirement to the uncertainty of the VIIRS snow fraction

- The optimal approach to improve moderate resolution remote sensing information on snow fraction will allow for the variability of snow and non-snow properties within a scene-specific snow algorithm

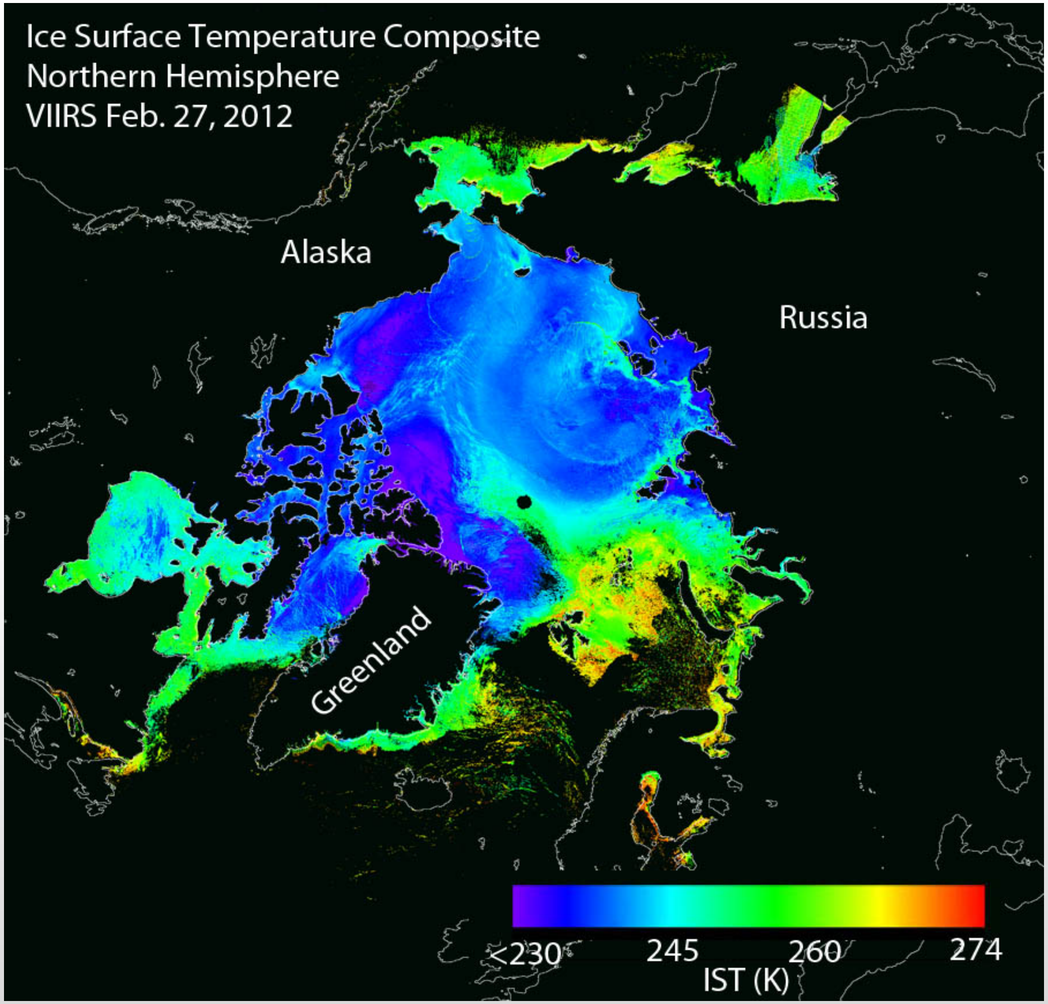
Suomi- NPP VIIRS Ice Surface Temperature EDR Status

Mark Tschudi (CU)*

Yinghui Liu (UWisc), Richard Dworak (UWisc), Dan Baldwin (CU), Robert Mahoney (NG)

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.

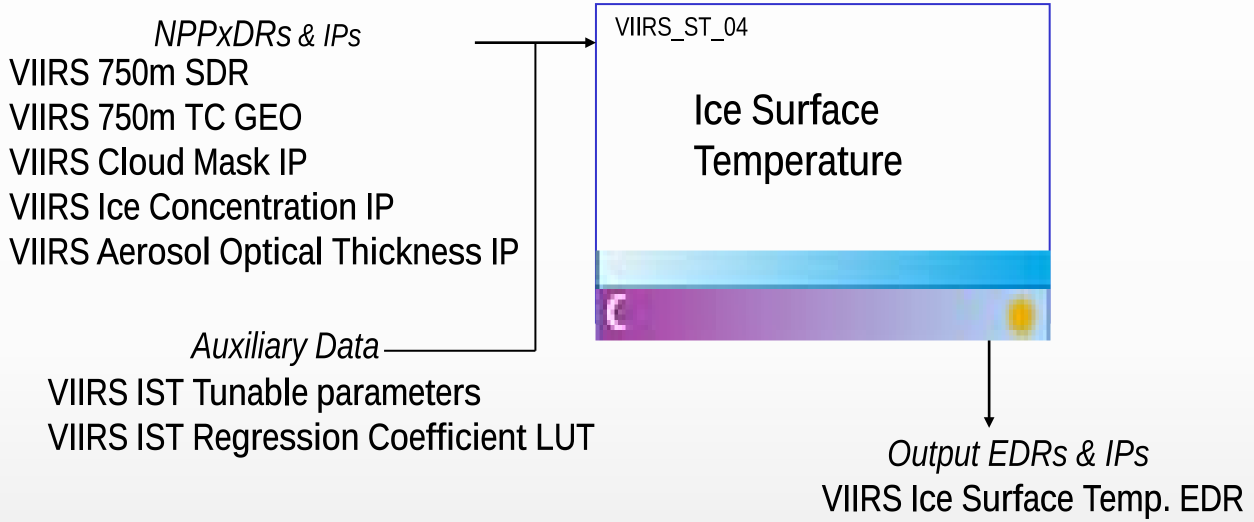


Summary of the VIIRS IST EDR

- The VIIRS Ice Surface Temperature (IST) EDR provides surface temperatures retrieved at VIIRS moderate resolution (750m), for snow/ice covered oceans for both day and night.
- The baseline split window algorithm statistical regression method uses two VIIRS Infrared bands, 10.76 µm (M15) and 12.01 µm (M16) for both day and night and is based on the AVHRR heritage IST algorithm (Yu *et al*., 1995).
- Threshold Measurement Uncertainty = **1K**

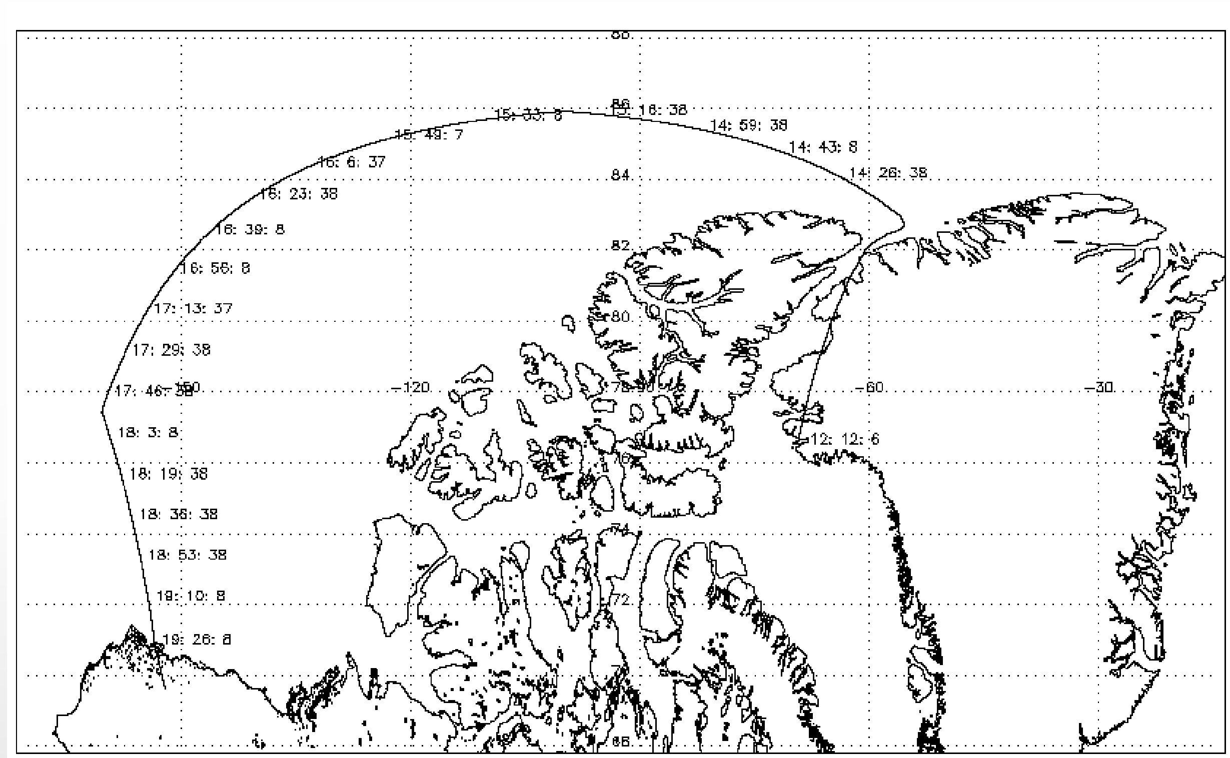
Yu,Y., D.A.Rothrock and R.W.Lindsay, 1995, Accuracy of sea ice temperature derived from the Advanced Very High Resolution Radiometer. J. Geophys. Res., 100(C3), 4525-4532

Summary of the VIIRS IST EDR Algorithm Inputs



VIIRS IST EDR and IceBridge Observations of IST

- Track of the NASA P-3 aircraft for the March 14, 2012 IceBridge flight.
- The P-3 carried a KT-19: a downward-pointing, IR pyrometer that measures the IST
- No atmospheric corrections applied
- Spot size of 15m



Icebridge KT-19 data:

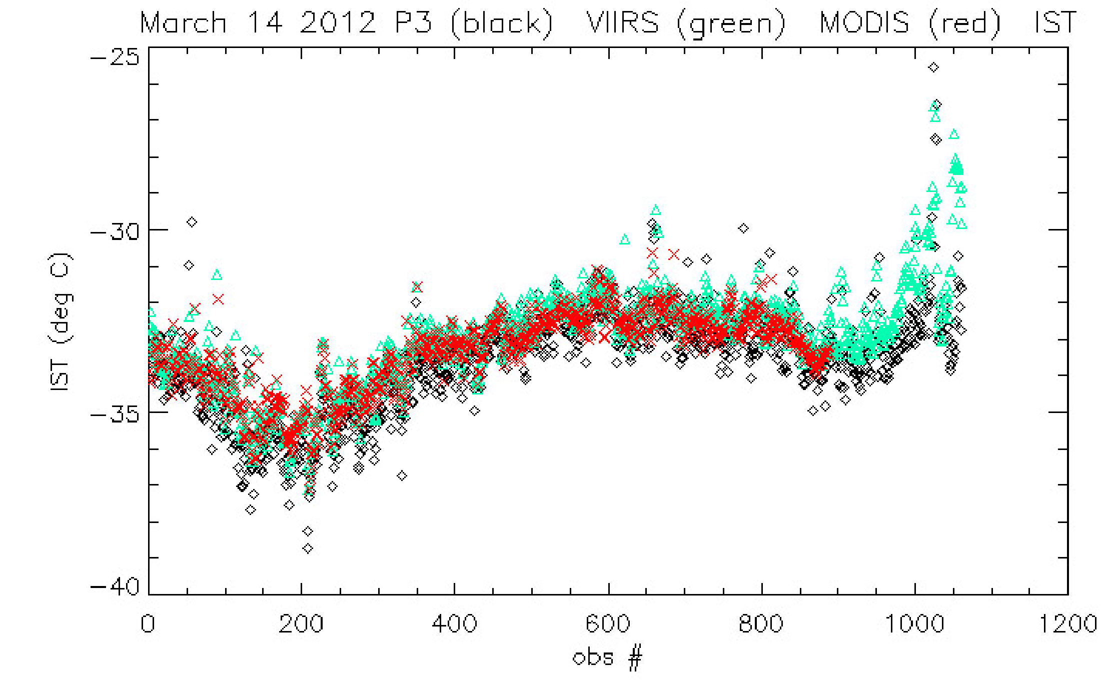
Krabill, W. B. and E. Buzay. 2012, updated 2014. *IceBridge KT19 IR Surface Temperature.* Boulder, Colorado USA: NASA DAAC at the National Snow and Ice Data Center.

VIIRS IST EDR and IceBridge Flight IST

NASA's Land PEATE re-processed portions of the VIIRS IST EDR that are co-incident with IceBridge flights over sea ice during March and April 2012.

mean VIIRS = -33.2 ˚C
mean KT-19 = -33.7 ˚C
mean MODIS = -33.4 ˚C
BIAS VIIRS-MODIS = +0.2˚C

RMS differences:
VIIRS - KT-19 = 0.6 ˚C
MODIS- KT-19 = 1.2 ˚C
VIIRS - MODIS = 1.1 ˚C

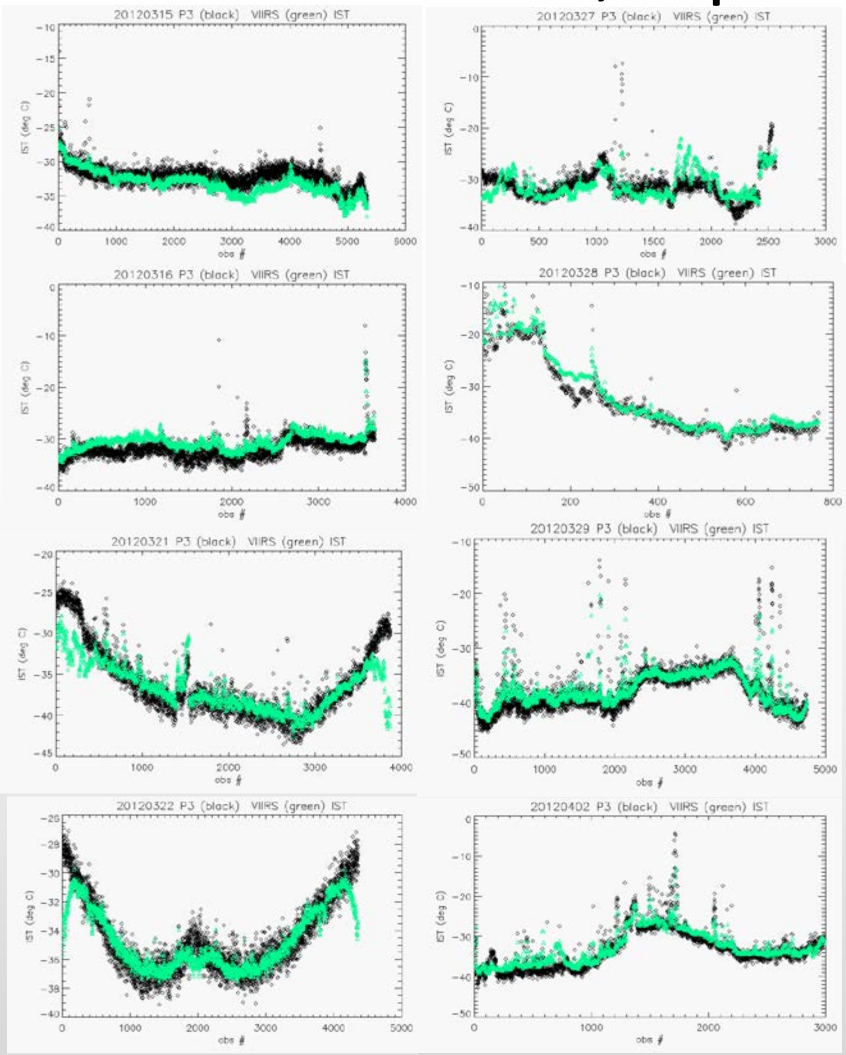


Comparison between the IST (in deg C) measured by the KT-19 (in black, smoothed over 100 points), the nearest VIIRS IST measurement (in green) and MODIS observation (red).

IceBridge KT19 vs VIIRS IST, Spring 2012

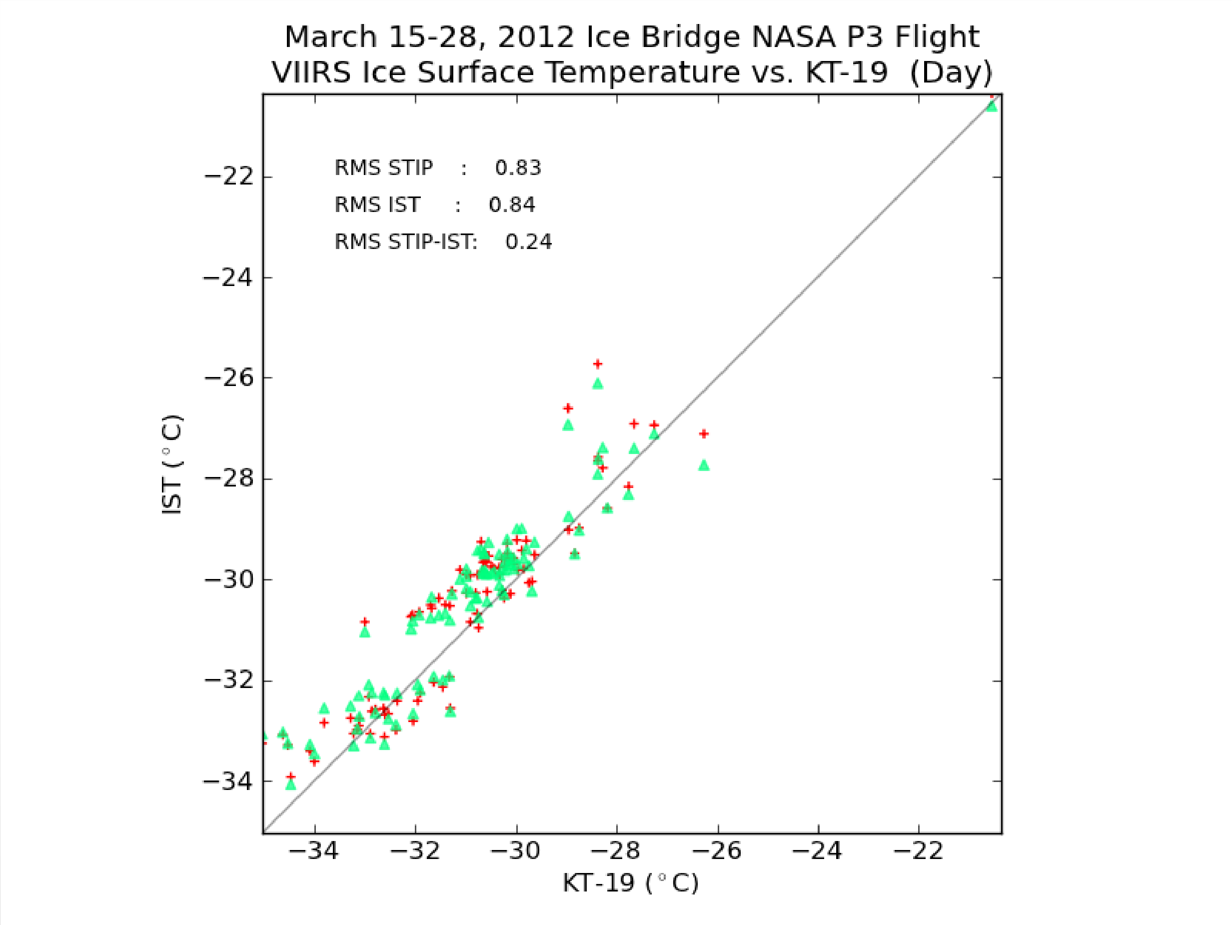
BIAS = VIIRS - KT19

DATE	KT19	VIIRS	BIAS	RMS
3/14	-33.71	-33.15	0.56	0.08
3/15	-32.22	-33.05	-0.84	0.63
3/16	-29.88	-28.87	1.01	0.71
3/21	-36.01	-36.56	-0.55	0.41
3/22	-34.45	-34.66	-0.21	0.14
3/27	-31.15	-31.02	0.12	0.21
3/28	-32.61	-31.49	1.12	0.53
3/29	-37.85	-37.39	0.46	0.10
4/02	-33.36	-32.70	0.66	0.19



Using data re-processed by NASA Land PEATE, Jan 2013

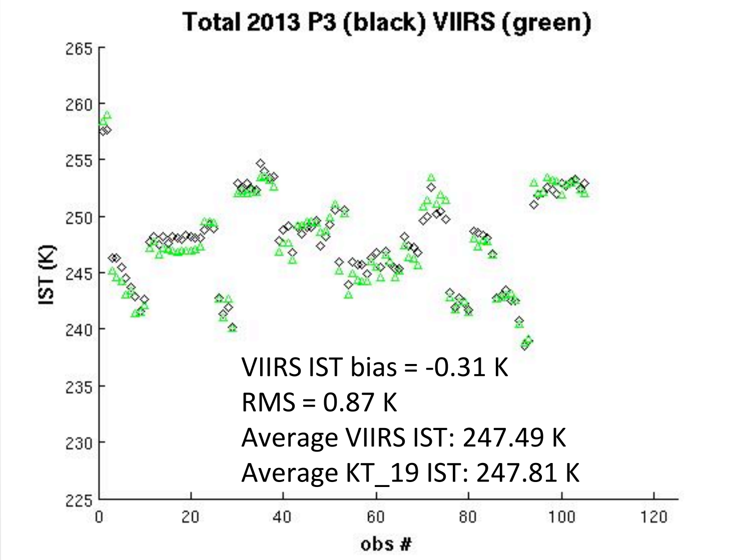
IST and ST IP Performance for Day Matchups (corrected ST IP coefficients)



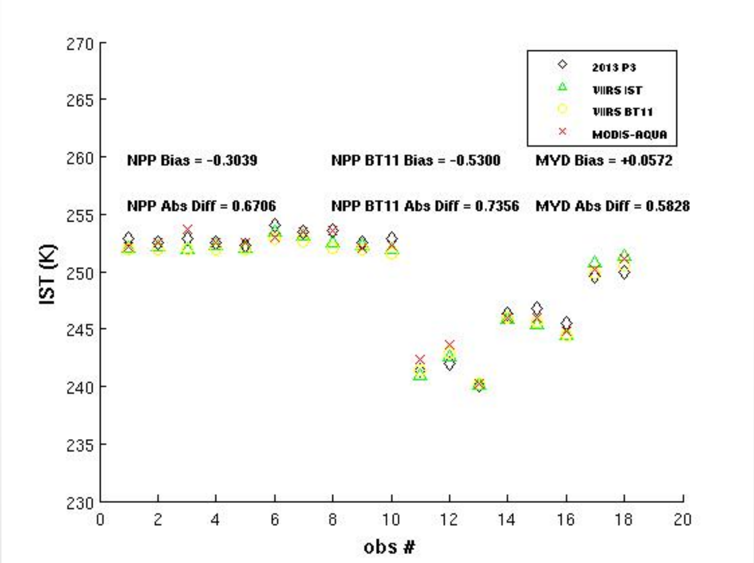
STIP-KT19 Bias = 0.48C
IST EDR-KT19 Bias = 0.47C

IST and ST IP performance for day matchups for ST IP computed using the corrected ST IP regression coefficients and reprocessed IST EDR to reflect current IDPS operational coefficients. A 15 minute matchup time window is used.

IceBridge KT-19, March/April 2013

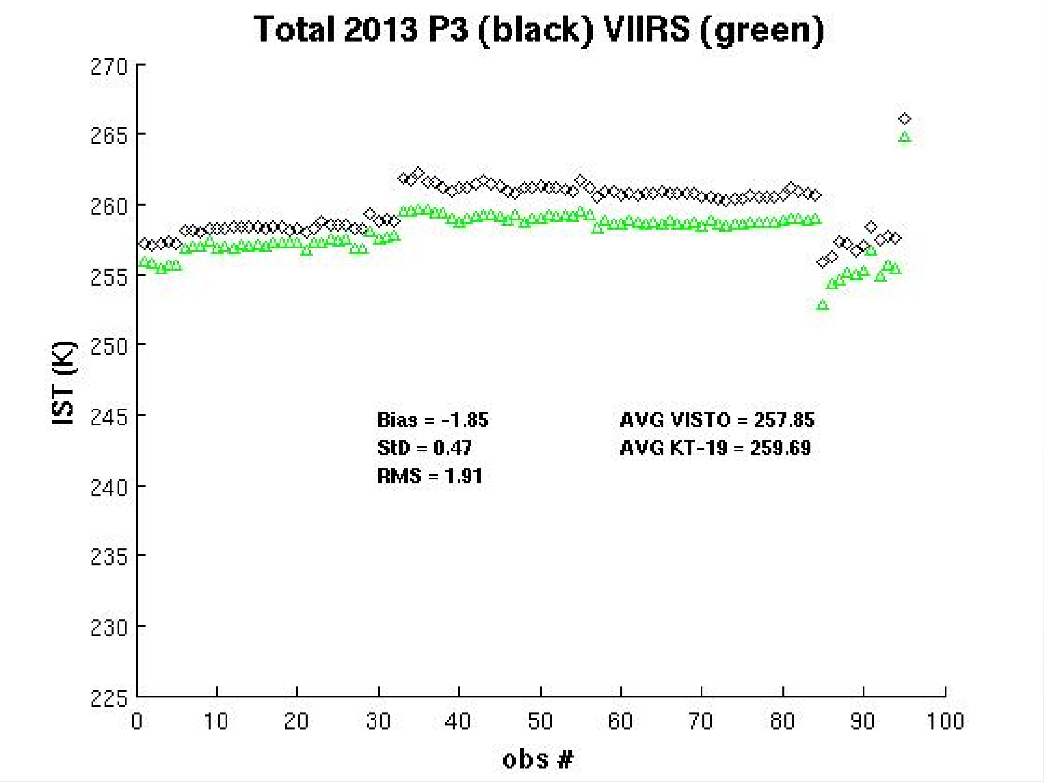


KT-19 vs VIIRS



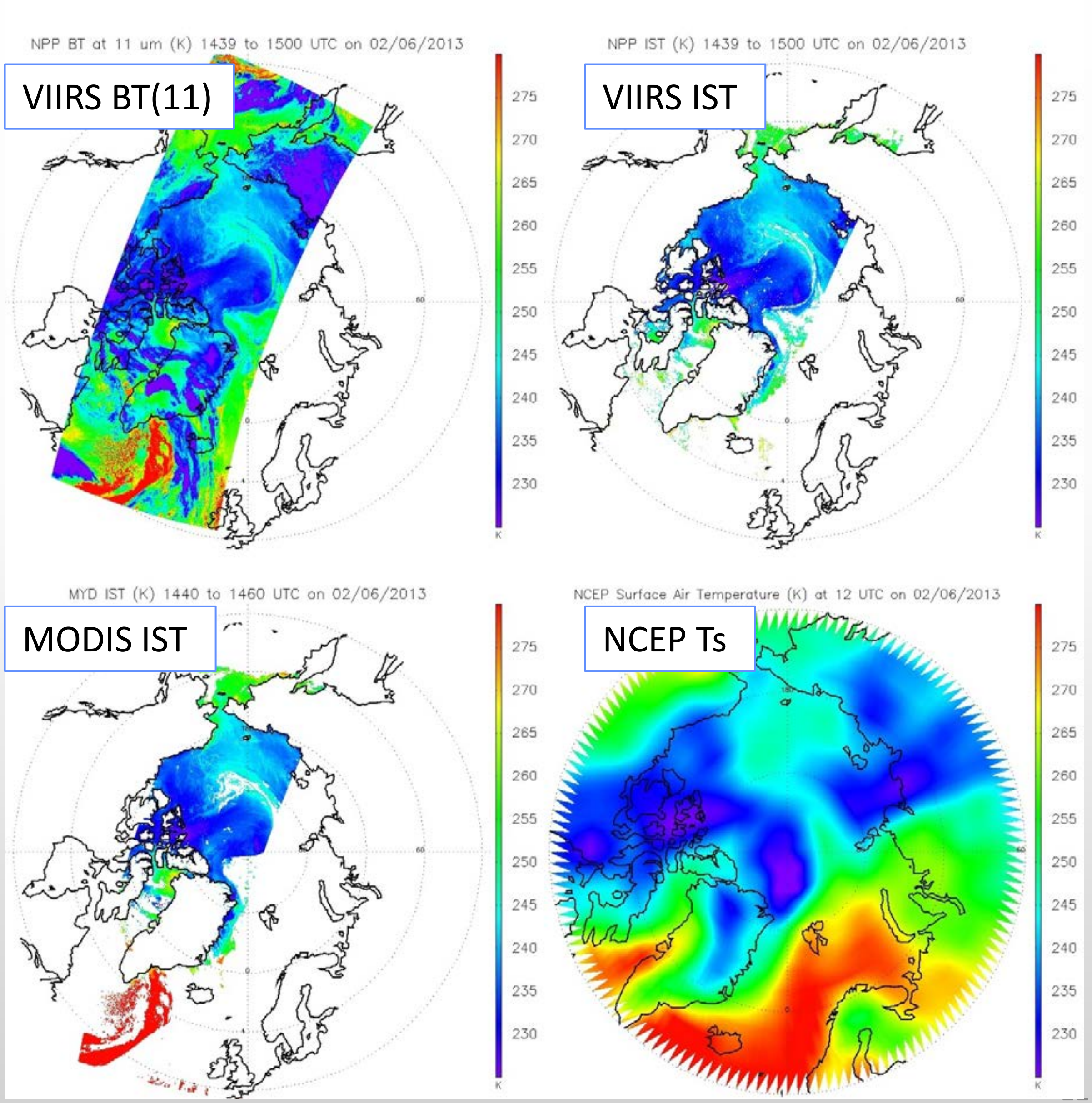
KT-19 vs VIIRS (BT & IST) vs MODIS

Antarctic, VIIRS vs KT-19

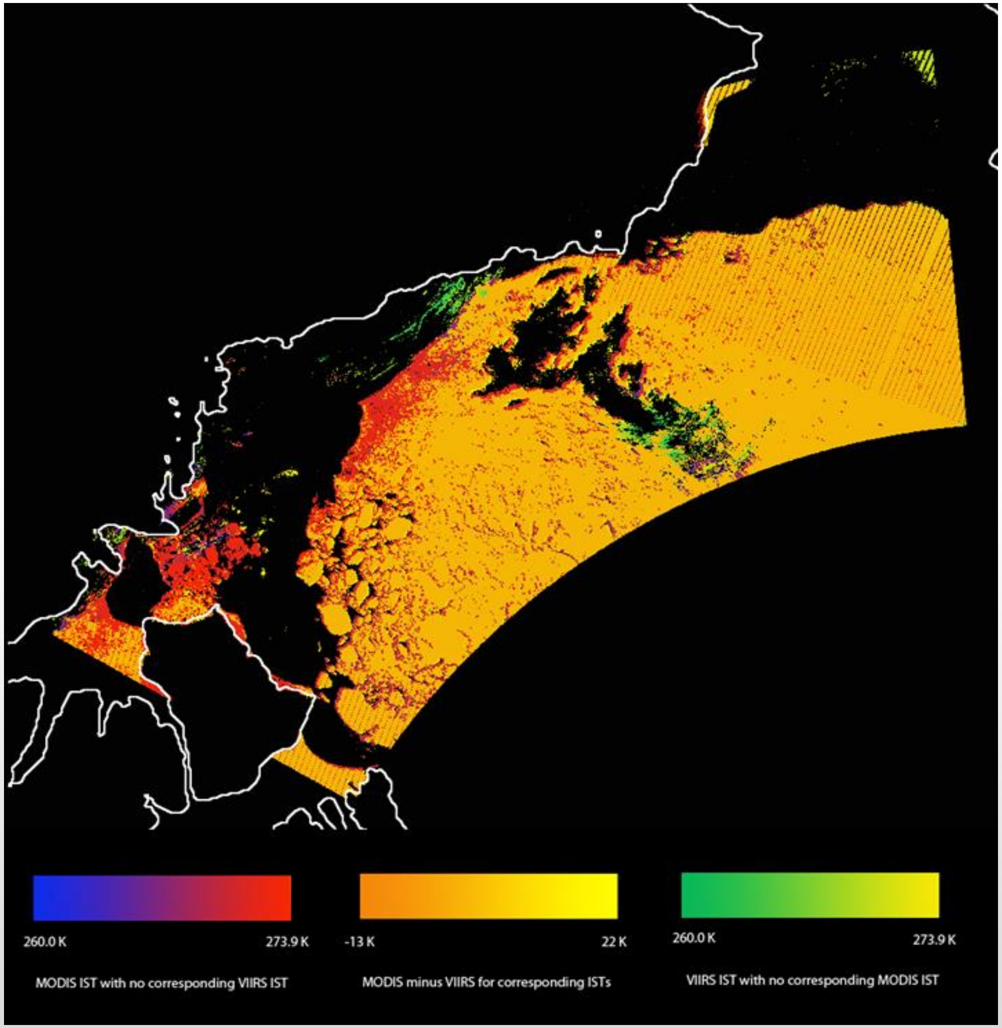


VIIRS IST, MODIS, and NCEP: 2/6/2013

- VIIRS IST has a 0.5-2 K *cold bias* relative to the MODIS Ice Surface Temperature product.
- Bias for VIIRS Land Surface Temperature vs MODIS over the ice sheet (not shown) is still cold but less than the sea ice IST.
- Comparisons to NCEP and IABP buoy air temperatures show a similar spatial pattern but yield a VIIRS *warm bias* of 1 K or more



MODIS/VIIRS IST comparison June 8, 2012



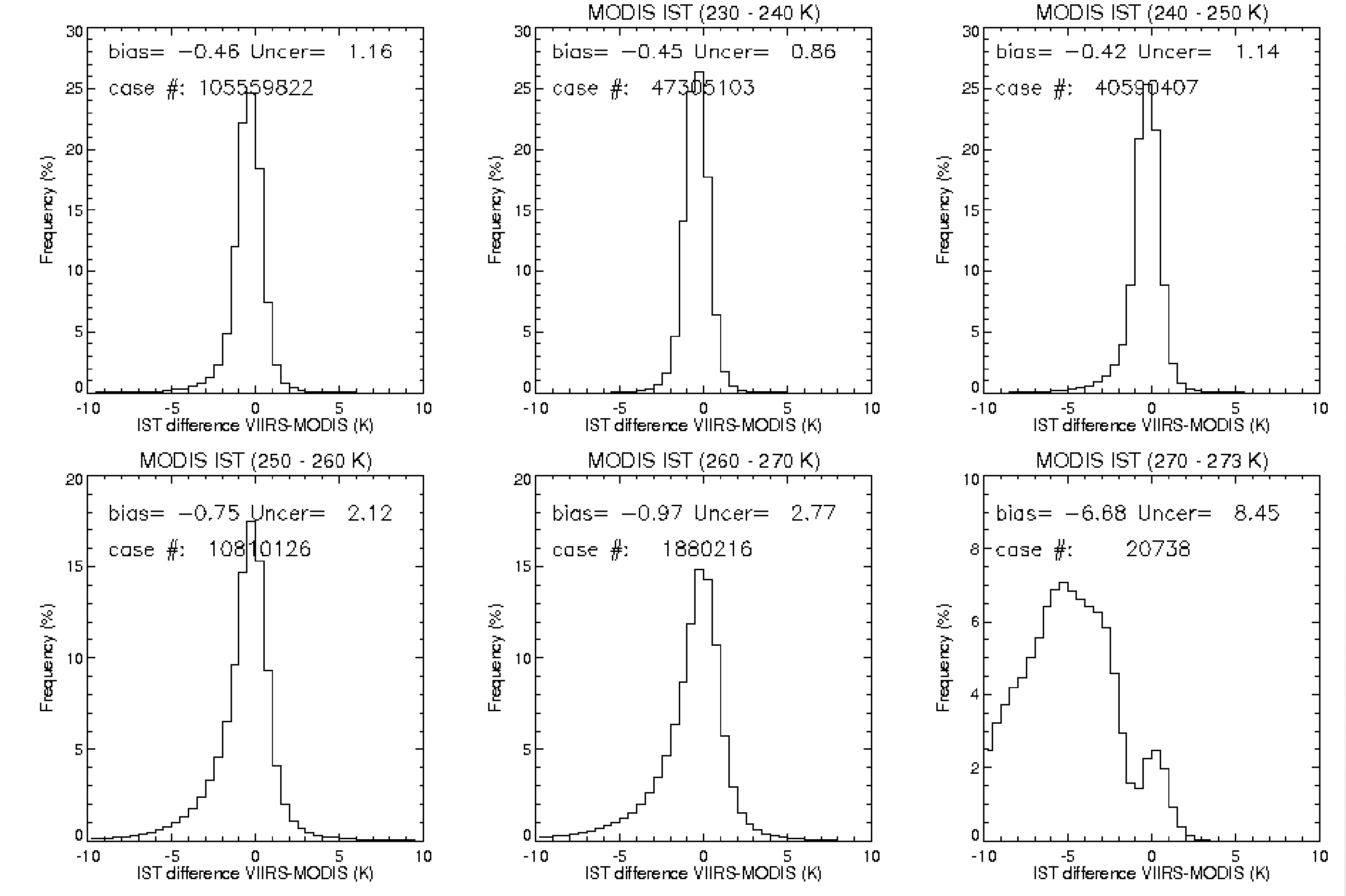
Bias (VIIRS-MODIS) = -0.181 K
(VIIRS cold bias)

Variance: 1.086 K

VIIRS IST vs MODIS IST

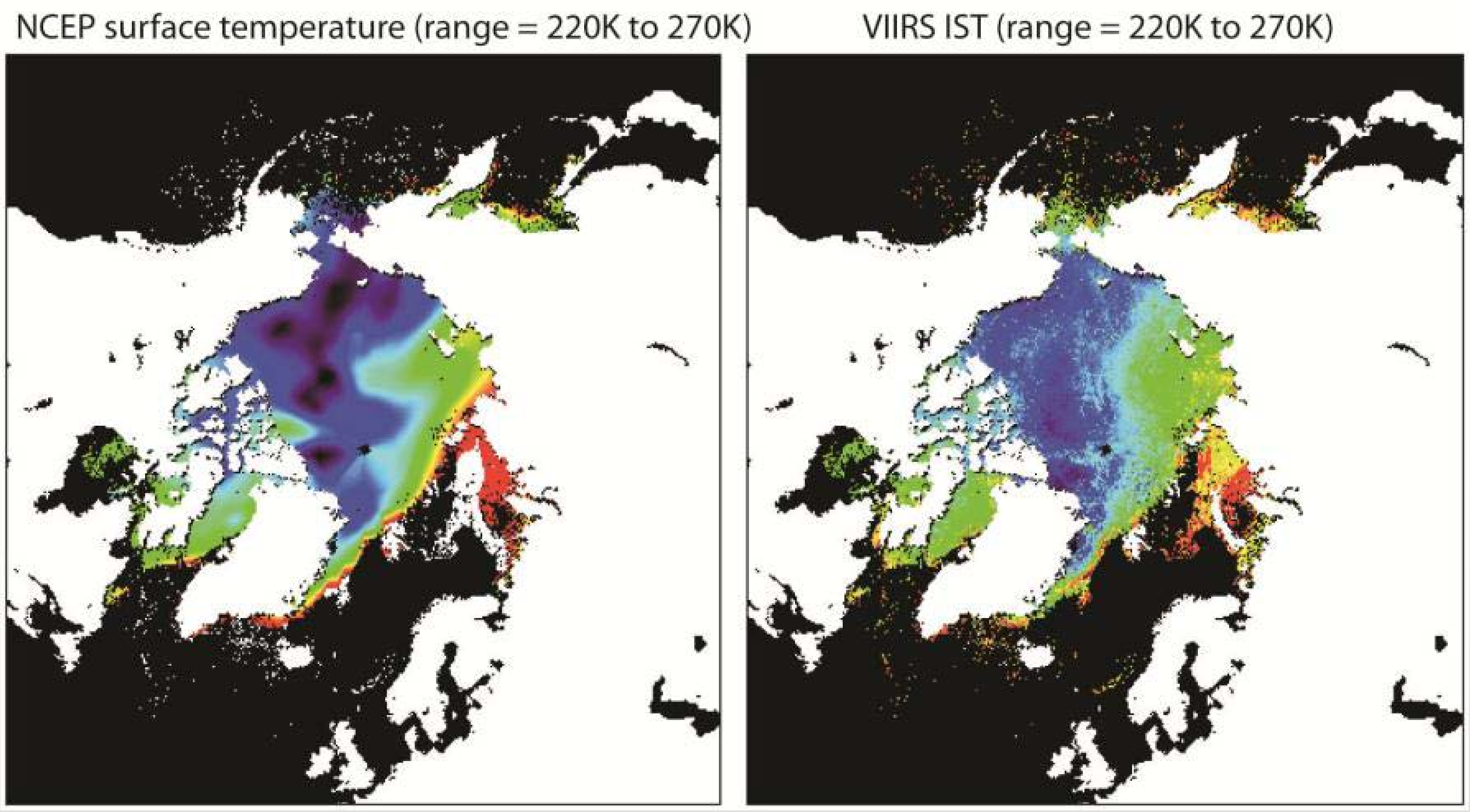
VIIRS is biased low (too cold) relative to MODIS, though the bias is relatively small for most of the temperature range.

Of greater concern is the uncertainty, which is large at higher temperatures.



Histogram of ice surface temperature differences of NPP VIIRS and MODIS (Aqua and Terra) in February 2013 in the Arctic for all cases (upper left), and for cases with MODIS ice surface temperature in the ranges 230-240 K, 240-250 K, 250-260 K, 260-270 K, and 270-273 K. Measurement bias and uncertainty are indicated for each bin.

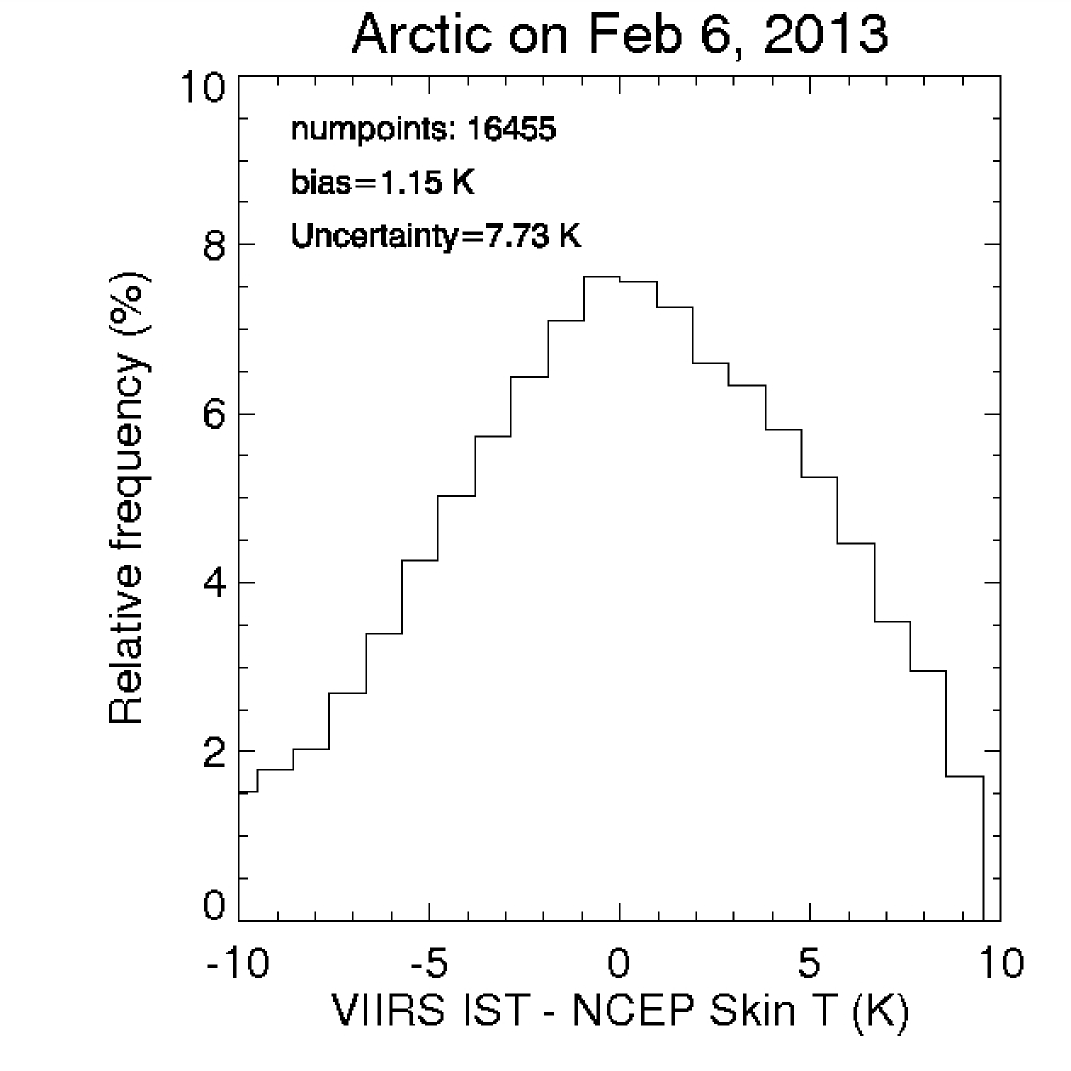
NCEP NH comparison



NCEP vs. VIIRS IST, Feb 27, 2012. Spatial patterns are similar.

Global comparison to NCEP

- **VIIRS is biased high (warm)** compared to NCEP reanalysis.
- Note that the NCEP skin temperature used in this analysis is a forecast, not an analysis
- Also note that the spatial resolution difference of NCEP and VIIRS is significant
- This result is the opposite of the MODIS & IceBridge results.



VIIRS IST EDR Conclusions

- VIIRS IST EDR in several but not all cases meets the requirement of 1K measurement uncertainty
- VIIRS IST EDR shows a *cold* bias compared to MODIS and to several IceBridge KT-19 measurements, typically <1K but higher for some comparisons
- Some issues, such as higher uncertainty for warmer temperatures, have been uncovered during validation and solutions are being evaluated.
- Improvements in IST EDR performance have been realized as the VIIRS Cloud Mask IP matures
- More IST improvement is expected as additional quality flags become available in the VIIRS Ice Concentration IP to avoid IST retrievals near clouds.

Future Plans and Issues

- No code changes currently planned
- Update IST regression coefficients based on matchup with MODIS and airborne/other IST sources
- Improvements anticipated with continued upgrades to the VIIRS cloud mask
- Additional quality checks in the VIIRS Ice Concentration IP (e.g. for cloud shadowing) will be passed to the IST IP & EDR

VIIRS Sea Ice Concentration IP Status

May 14, 2014

Robert Mahoney (NGAS)
Yinghui Liu (UW/SSEC)

THE VALUE OF PERFORMANCE.

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Outline

- Product Description, Inputs
- Status of Algorithm Changes/Updates
- Performance Evaluation of the VIIRS Sea Ice Concentration IP
- Summary
- Issues and Proposed Solutions
- Conclusion

Sea Ice Concentration IP Algorithm and Product - Description

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- **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

- **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

- **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**.
  – It is currently a retained Cal/Val IP (non-deliverable) product for NPP with quality flags provided separately in the Ice Quality Flags IP

Status of Algorithm changes/updates

Date	Update/DR#	Reason	Status
04-09-2013	7139	Correct Sea Ice Conc. OAD flow chart figure	Request closure with Beta Maturity 474-CCR-13-0945
12-13-2012	5017	RTN Sev2 PCR Ice IPs Maneuver	Closed (Raytheon PCR 032616)
11-27-2012	4987	Sea Ice Quality/Ice Concentration IP: Additional quality checks for identifying regions with potential VCM cloud leakage	Open
10-17-2012	4959	Sea Ice Conc. Tie Point Fill Fix	Open
01-19-2012	4524	OAD for VIIRS Sea Ice Concentration (SIC) Intermediate Product (IP) Mx6 Updates (ECR-ALG-0034) (CDRL A031)	Canceled (minor edits)
12-08-2010	4129	Ice concentration weights not initialized before final ice concentration calculation	Closed – Fix date unknown, verified by code inspection
07-17-2009	2863	Latency impact due to valid point count methodology	Deferred for re-evaluation
07-17-2009	2936	Ice Surface Temp and IST use different emissivities for ice	Closed CCR 474-CCR-14-1521 with delivery of updated Surface Temperature IP coefficients.

Performance Evaluation

- Evaluation Approaches
  1. LANDSAT 8 and AMSR2 derived ice concentration, quantitative comparisons to VIIRS SIC for 25 clear LANDSAT scenes
  2. Daily, global hemispheric VIIRS Sea Ice Concentration (SIC) and SSMIS passive microwave ice concentration visual and quantitative comparisons
  3. 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
  4. Visual comparison of NOAA AutoSnow product with global, hemispheric Snow/Ice gridding test results
- Notes:
  - Leveraging the 30+ S-NPP/MODIS Aqua SNO matchup scenes for IST EDR evaluation for Ice Concentration golden granules. (plan to extend the dataset)
  - Plan to extend the SSMIS comparisons performed for the Provisional Maturity to span golden granule scene dates
  - Leveraged the Snow/Ice gridding test results to identify occurrences of false and missing sea ice
  - Plan to use additional LANDSAT and AMSR2 ice concentration and other data sets as available

(1) Comparison of VIIRS Sea Ice Concentration to LANDSAT and AMSR2 (example)

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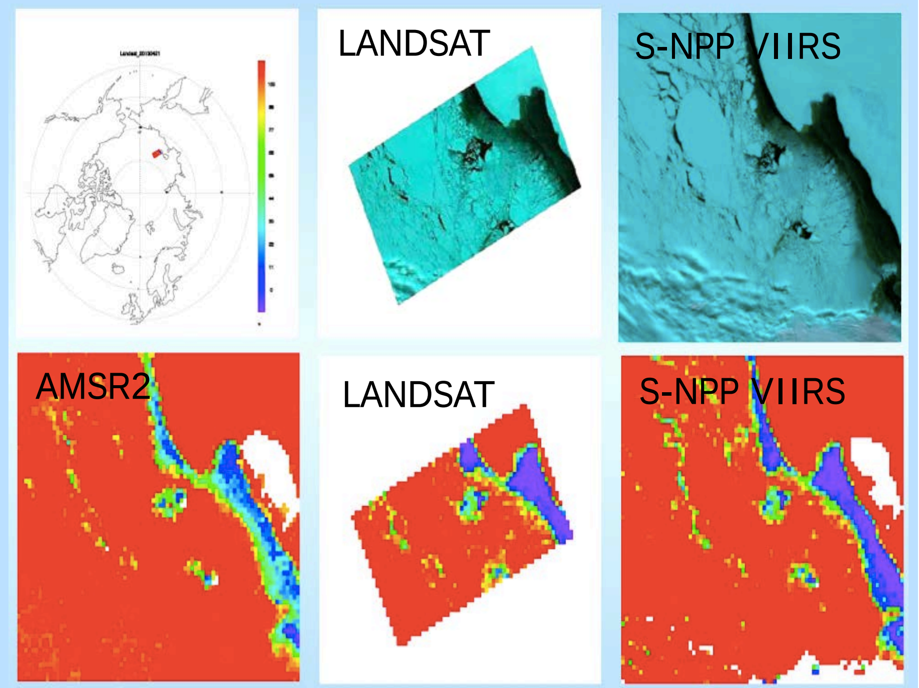
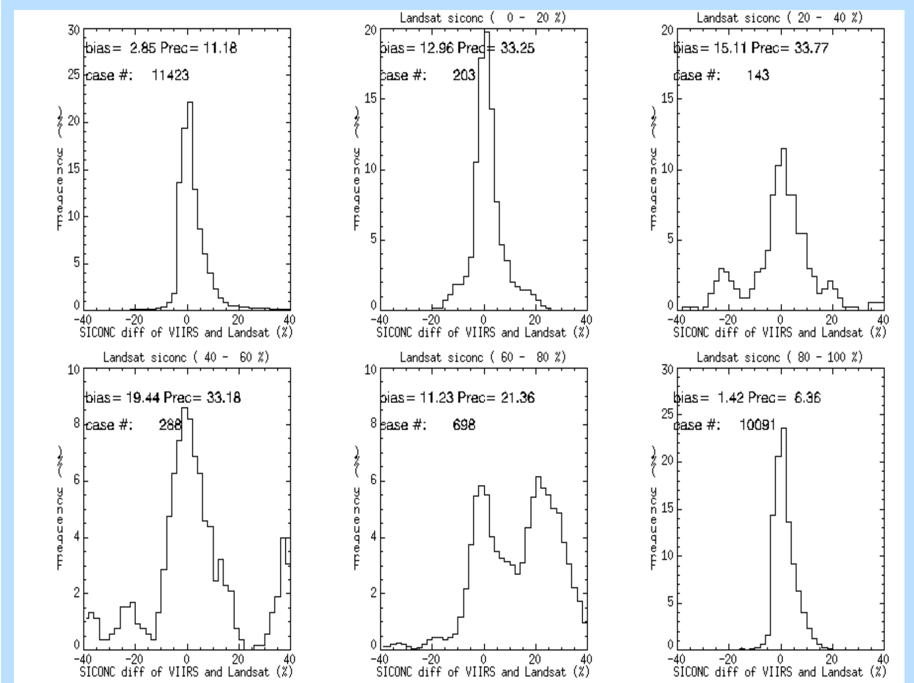
Panel A



Panel B VIIRS vs. LANDSAT Ice Concentration



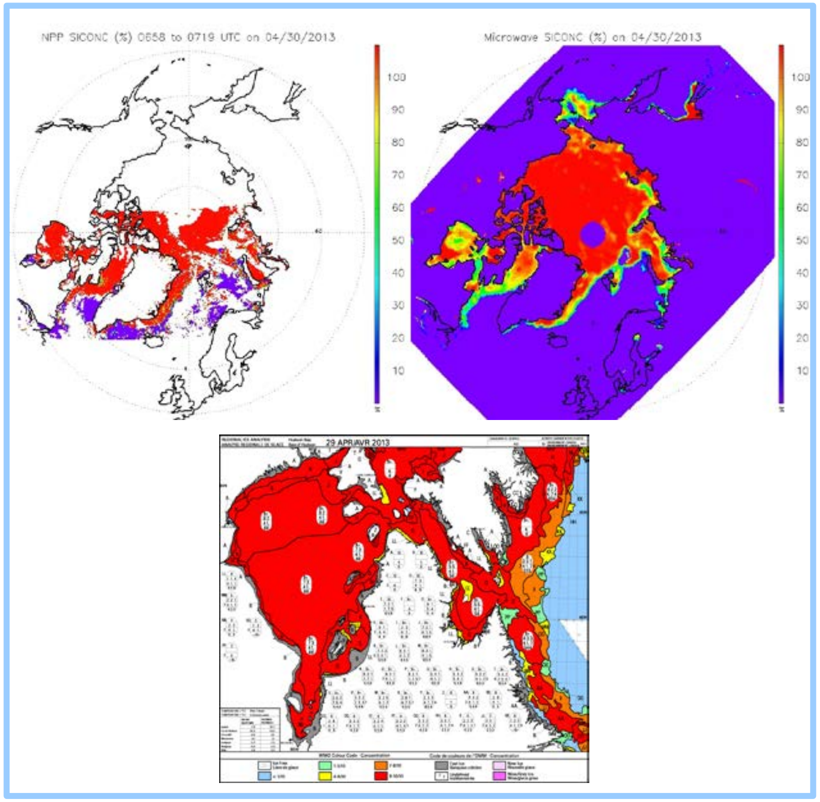
Panel A: upper image left to right: location of the scene, LANDSAT and VIIRS SDR false color image; Panel A, lower image left to right: Sea Ice Conc. from AMSR2, LANDSAT, and the Suomi NPP VIIRS on 4/21/2013 .

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

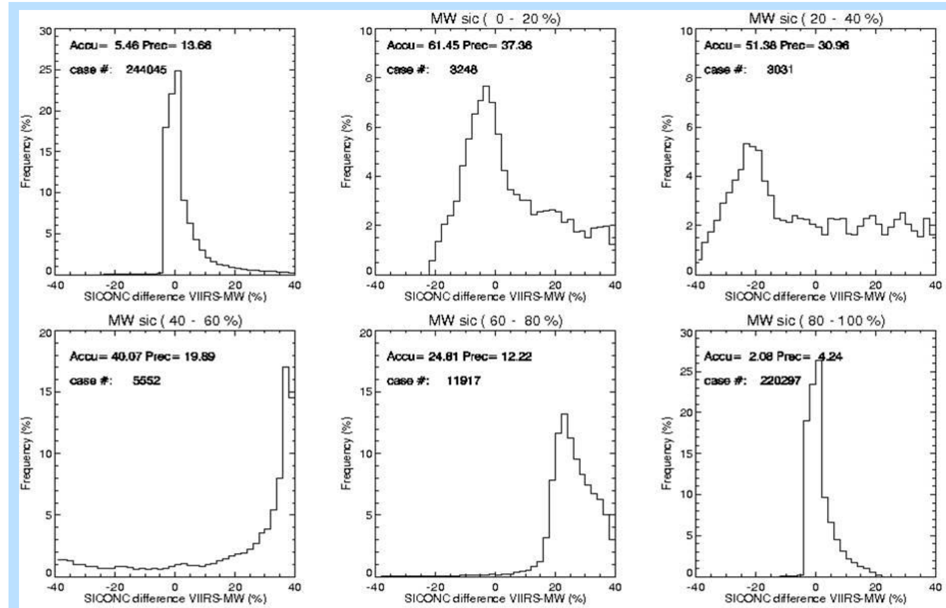
Panel B: Ice concentration differences between VIIRS and LANDSAT for all cases (top left) and cases with LANDSAT sea ice concentration in the ranges 0–20%, 20–40%, 40–60%, 60–80%, and 80–100%. Measurement accuracy (bias) and measurement precision (Prec) are indicated for each bin.

(2) Comparison of VIIRS Ice Conc. to Passive Microwave and NIC 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.

Further VIIRS Ice Concentration IP comparisons to SSMIS Ice Concentrations for dates corresponding to the 30+ golden granule scenes are planned

(3) Comparison of VIIRS Ice Concentration IP to National Ice Center Ice Charts (night scene example)

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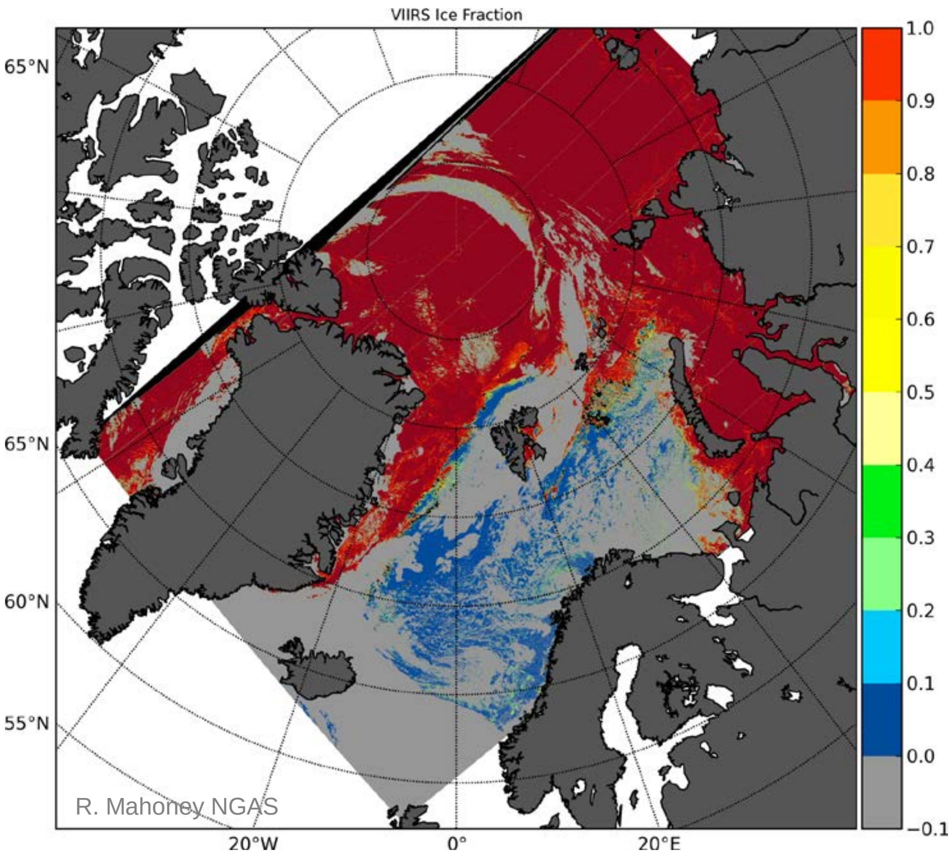
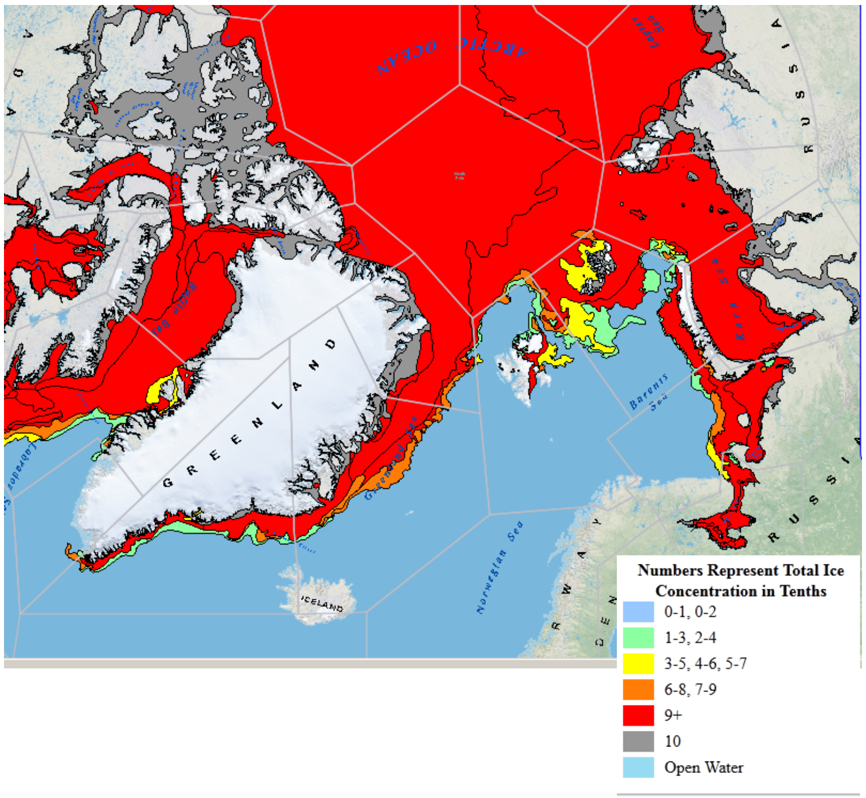
VIIRS Ice Concentration IP Feb. 20, 2014 (04:39-04:46 UTC)

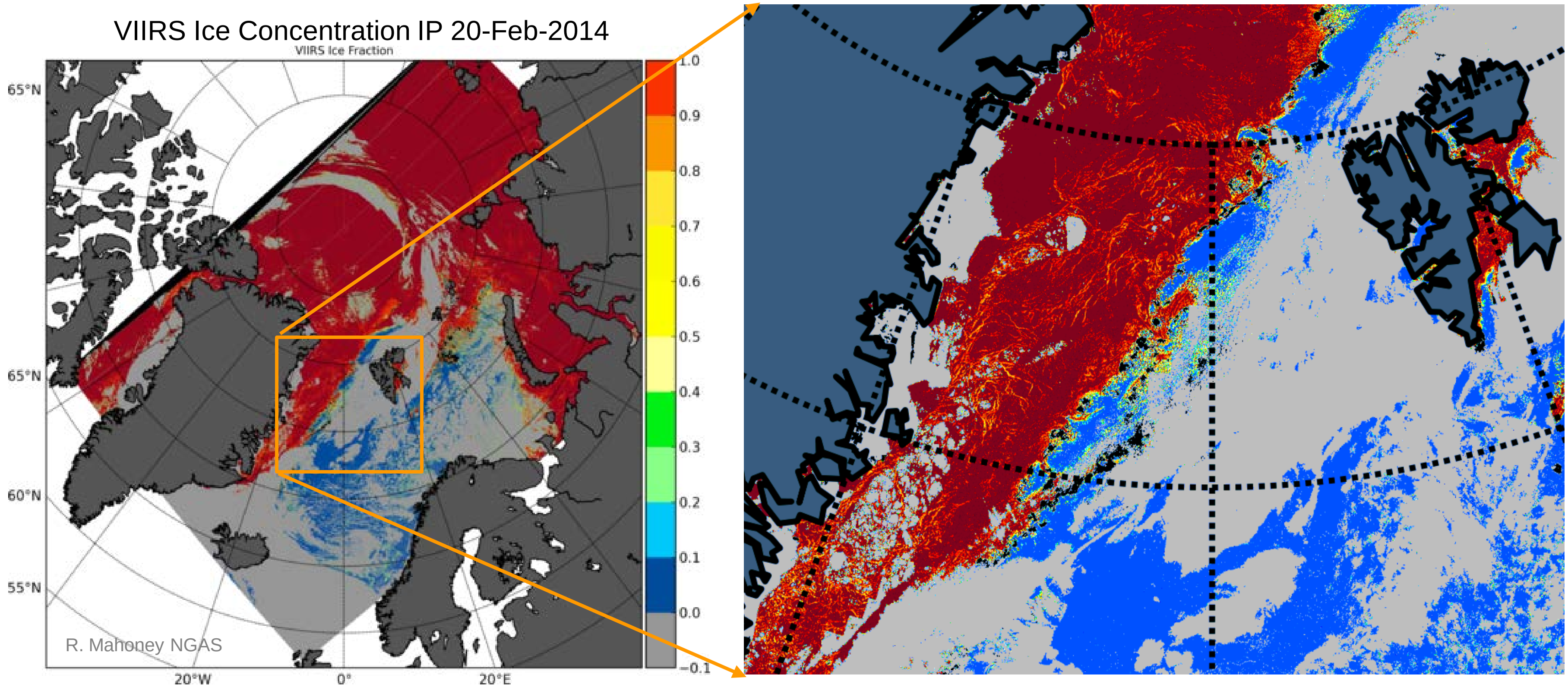


Reference: http://www.natice.noaa.gov/ps/javascriptproductviewer/index.html



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 Ice Concentration IP 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. The Ice Concentration IP is currently only a retained, non-deliverable Cal/Val IP

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

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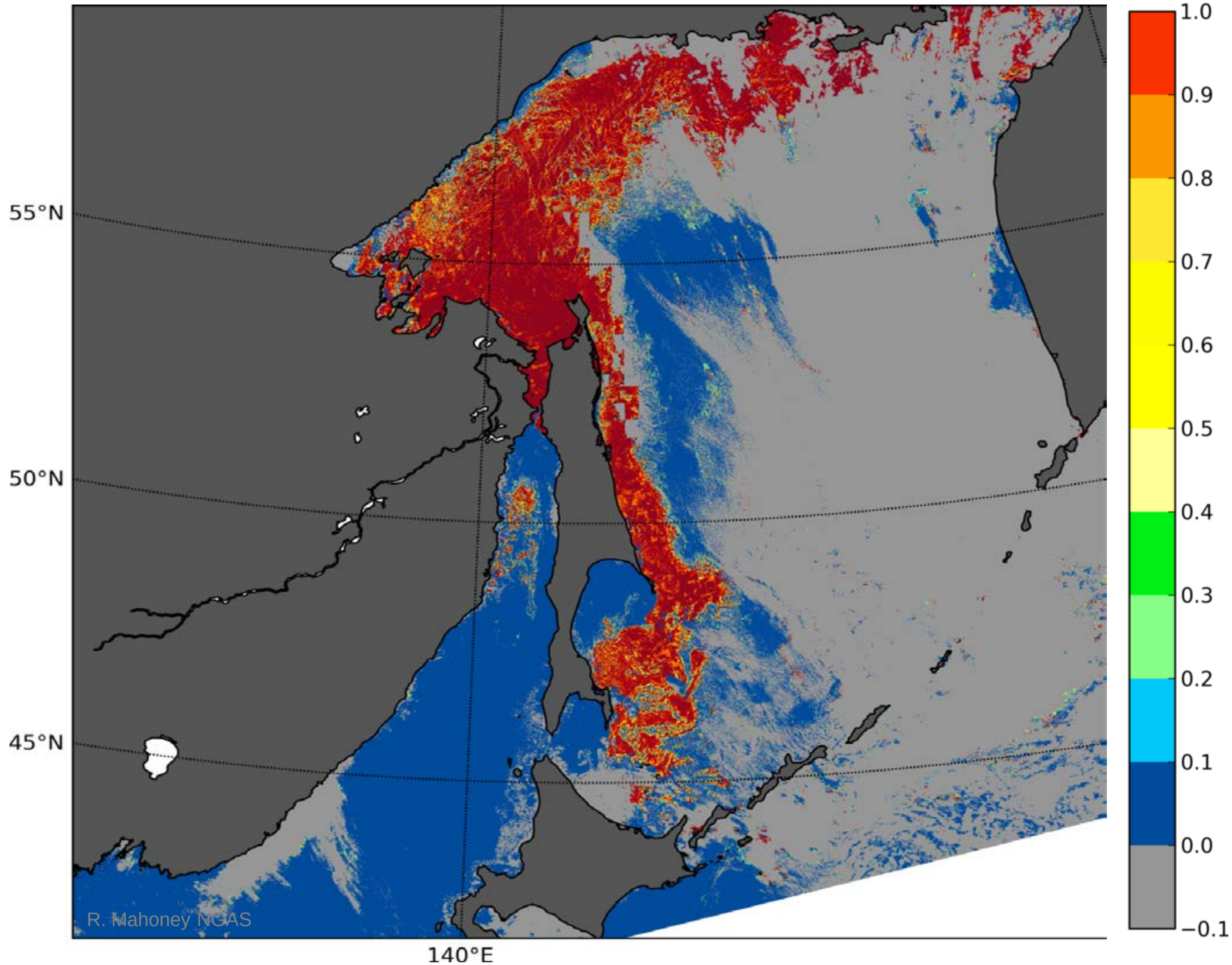
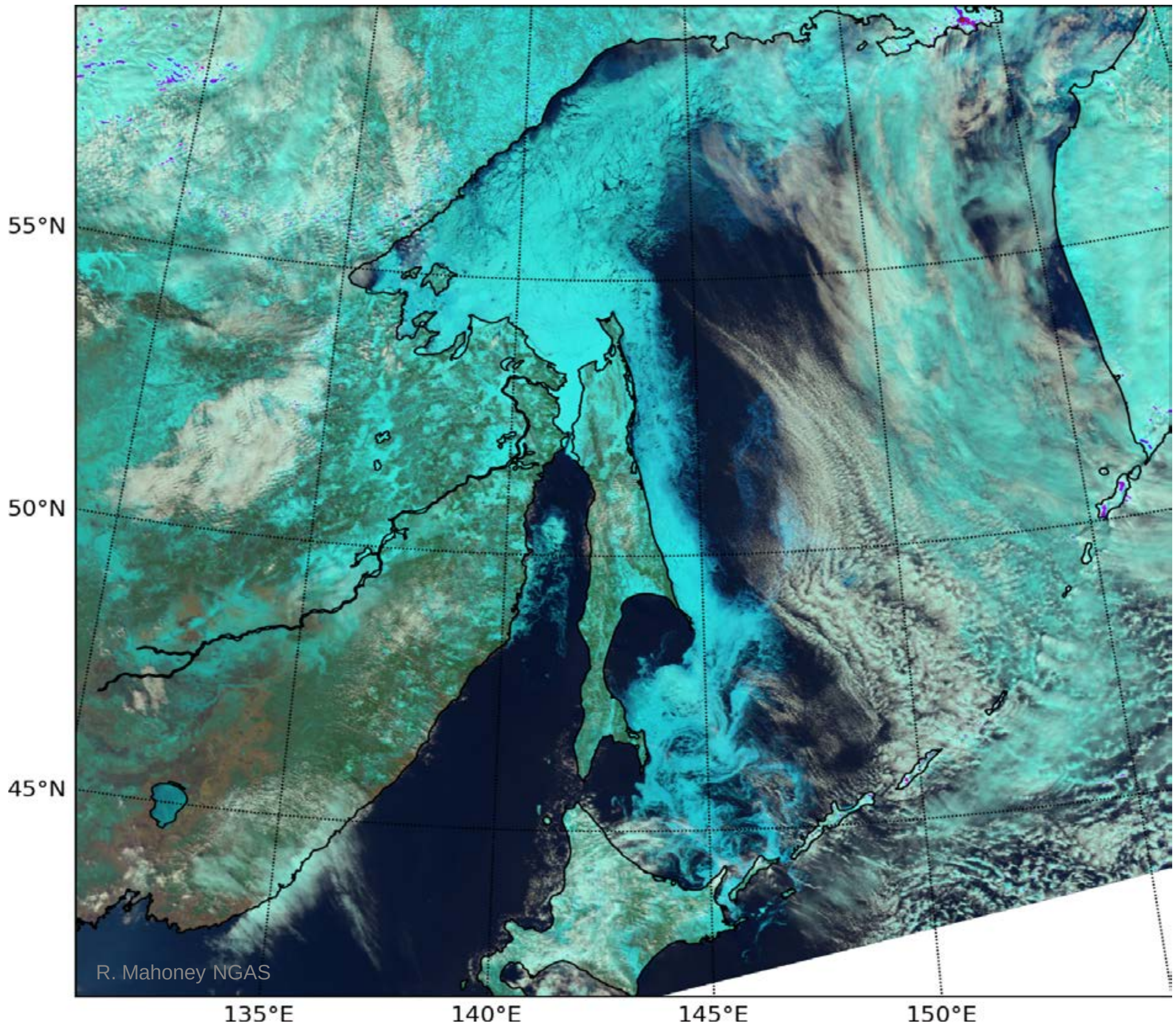


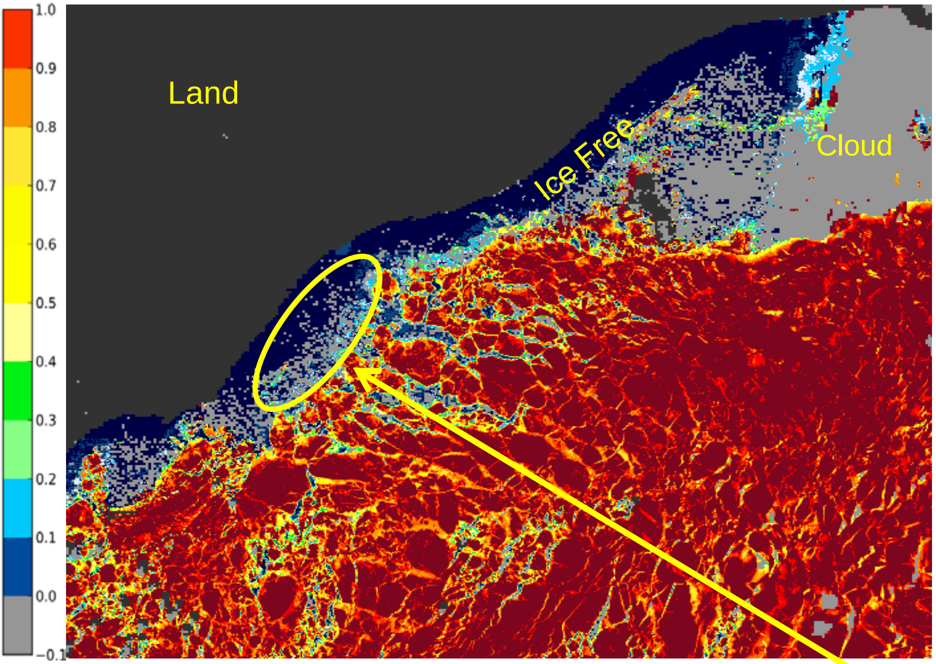
The ice edges seen in the VIIRS Ice Concentration IP typically closely match ice edges seen in false color SDR reflectance band imagery as in this day case of melting sea ice in the Sea of Okhotsk (March 23, 2014, 03:05-03:11 UTC)

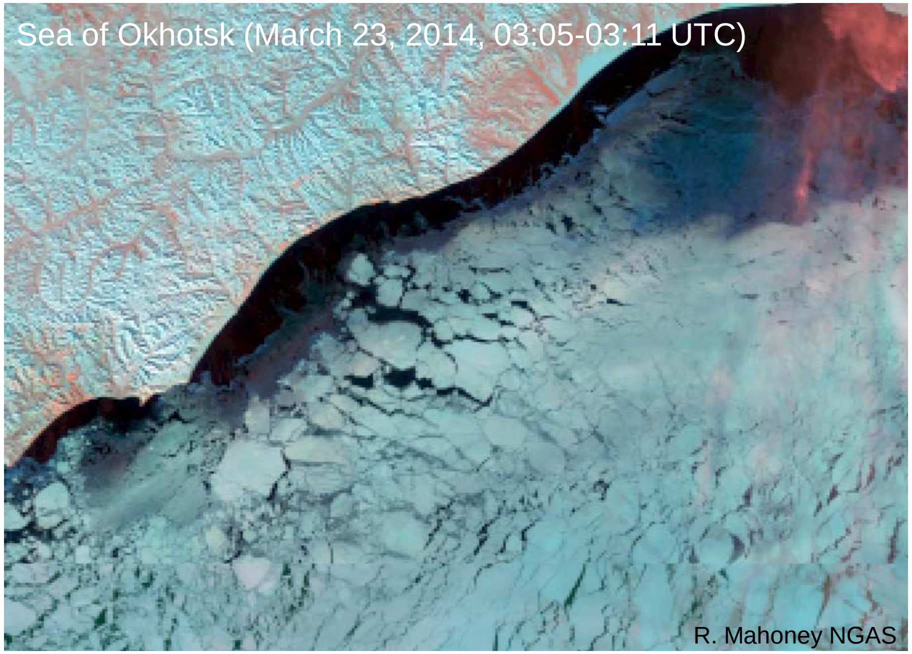
Comparison of VIIRS Ice Conc. to VIIRS False Color SDR for Day Scenes



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





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

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).

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

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

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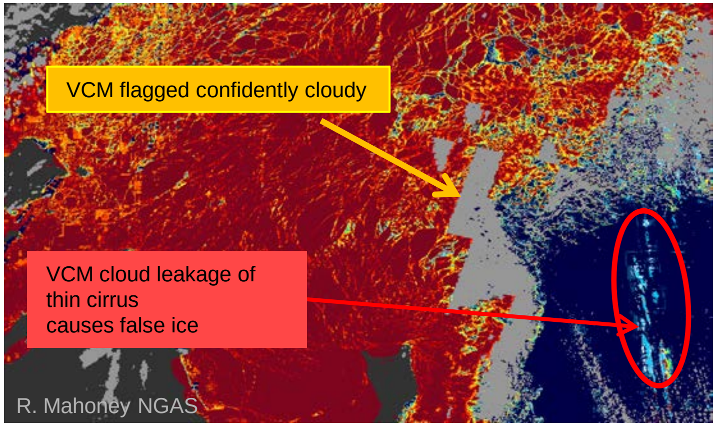

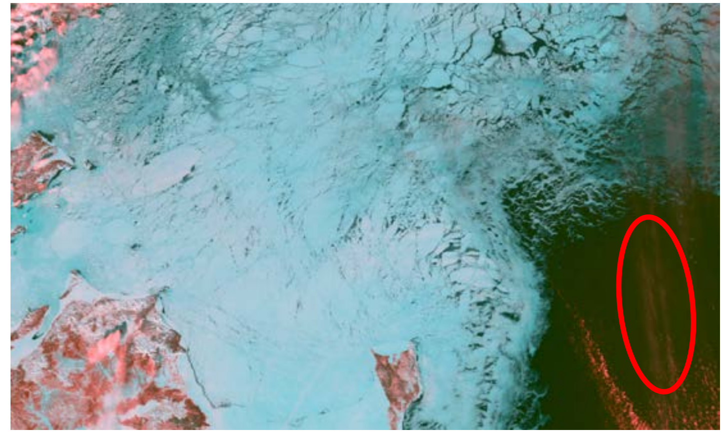

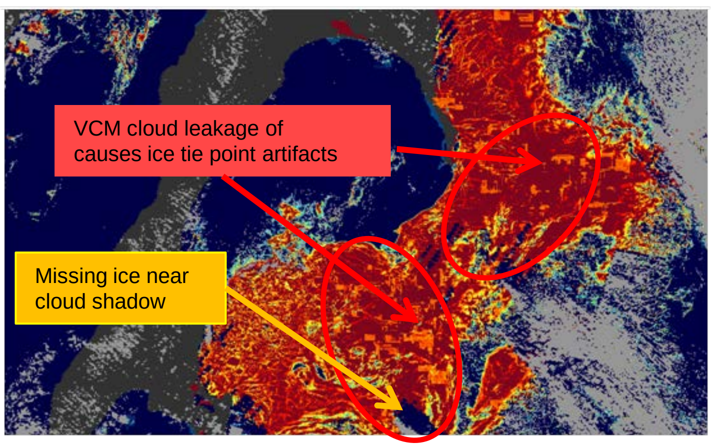

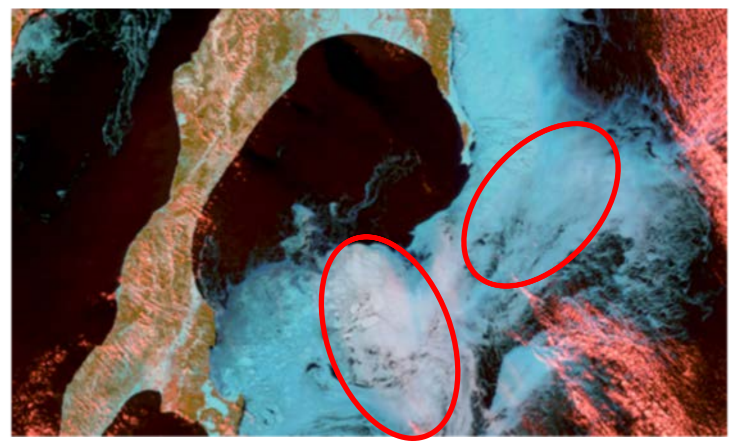

(1) Rectangular fill values are associated with VCM positive M7 and M1 threshold test triggered by out of date manually updated GMASI snow/ice (top left). (2) False ice is seen in the product (top left) corresponding undetected thin cirrus (red circle, top right). (3) Rectangular and linear artifacts 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.

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 (2.9% and 11%) and high ice fraction range (1.42% and 6.36%) but reduced performance for mid range ice fractions based a set of 25 scenes

• Some artifacts, rectangular lowered ice concentrations, were observed for regions associated with undetected thin clouds. ADR 4959 has been submitted and implementation running mean ice tie point will likely mitigate this problem

• Cloud shadows can result in missing ice. Tunable quality weight parameters may mitigate the problem for VCM cloud shadow flagged pixels.

• Ice edges under clear sky conditions are often flagged by VCM as confidently cloudy. Examples will be provided to the VCM team since ice edges are the regions of primary importance to users

• The VIIRS Ice Concentration IP is currently a non-deliverable retained cal/val IP. The JPSS system spec. defines a measurement range requirement but has no other performance spec.

VIIRS Sea Ice Concentration IP Issues & Proposed Solutions

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- In general, issues identified for the Ice Concentration IP are not severe in nature and most issues have technical solutions that can be tested. Some improvements however, depend on further improvements to VIIRS Cloud Mask cloud confidence and cloud shadow detection

Issue	Description	Proposed Solution
Ice Tie Point Fix		ADR 4959 to implement use of a running mean ice tie point as fall back for windows with ill conditioned and can water tie point distribution
False Ice Near Cloud Edges	False ice is frequently observed near cloud edges due to undetected clouds	ADR 4987 opened to implement additional quality check for extended cloud adjacency/ partly cloudy conditions within the ice tie point search window
Missing ice due to cloud shadow	Occasional occurrences of missing ice been observed to be associated with lowered reflectance due to cloud shadows.	1. Investigate algorithm tuning of quality weights for VCM cloud shadow flagged pixels (increase weight for thermal band retrieval) Need to submit ADR 2. Request VCM team to improve and extend the VCM cloud shadow algorithm
VCM false cloud detection near ice edges	Ice edges in clear sky conditions are often flagged by VCM as confidently cloudy thus obscuring the ice edge	Request VCM team to improve VCM cloud confidence performance near ice edges
Ice Concentration IP conversion to deliverable product	The VIIRS Sea Ice Concentration IP is currently a retained Cal/Val, non-deliverable IP. Quality flags are not provided with the product. Conversion to a deliverable product requires implementation of product quality flags	Define and implement a set of Ice Concentration IP product quality flags to Ice Concentration IP prior to being promoted to a deliverable product
Detection of low reflectance thin ice	Newly forming (dark) ice with low reflectance (<0.2) might not be detected by the current ice concentration algorithm day reflectance base retrieval algorithm branch	Investigate potential ice concentration algorithm failures to detect newly forming (dark) ice during day. Explore use of increasing thermal algorithm branch retrieval quality weight for ice temperatures over pixels with reflectance < 0.2

Conclusions

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• 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 ability to **provide detailed views of Ice edge and lead features at VIIRS Imagery resolution (375 m @ nadir) for both day and night out to VIIRS edge of scan**

• Performance evaluation based on visual comparisons indicate 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

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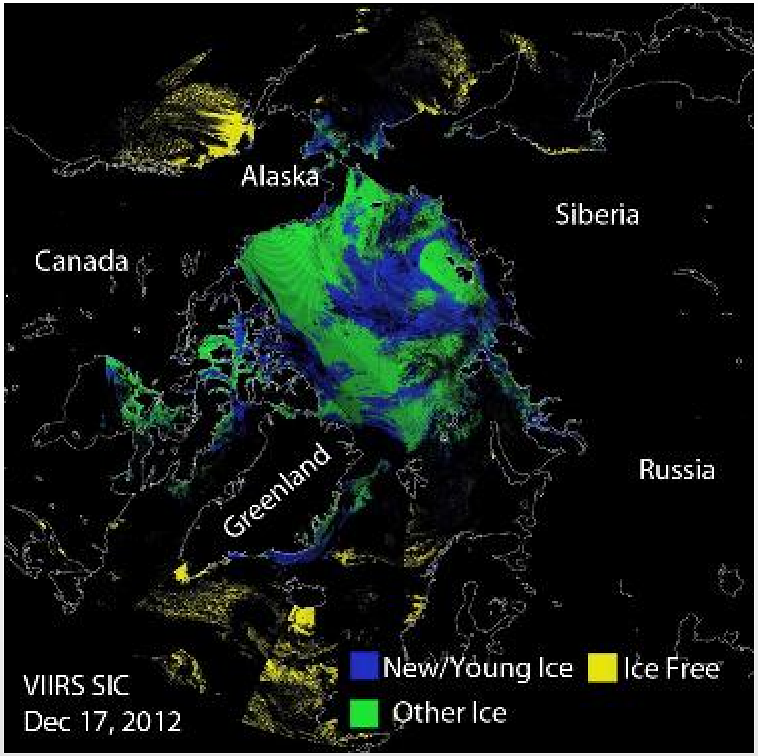
VIIRS Sea Ice Characterization EDR

Mark Tschudi (CU)*, Robert Mahoney (NG)*

Dan Baldwin(CU), Marina Tsidulko (NOAA)

Summary of VIIRS Sea Ice Characterization (Ice Age) EDR



- The VIIRS Sea Ice Characterization (Ice Age) EDR consists of ice classifications for *Ice Free*, *New/Young* and *Other Ice* at VIIRS moderate spatial resolution (750 m @ nadir), for both day and night, over oceans poleward of 36ºN and 50ºS 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 (heat) balance based retrieval for night and high solar zenith angles

    2. Reflectance/ice thickness retrieval using modeled Sea Ice Reflectance LUT for daytime

- Heritage: No operational Visible/IR heritage. AVHRR research heritage (Comiso and Massom 1994, Yu and Rothrock 1996 and Wang et al. 2010).

Summary of the VIIRS Characterization EDR (Ice Age) Algorithm Inputs

NPOESS xDRs & IPs

VIIRS 375m TC GEO
VIIRS 750m TC GEO
VIIRS Ice Quality Flags IP
VIIRS Ice Weights IP
VIIRS Ice Concentration IP
VIIRS Ice Refl./Temp. IP
VIIRS Surface Temperature IP
OMPS Tot. Col. Ozone 1st gues IP

Auxiliary Data

VIIRS Ice Age Tunable Parameter File
Sea Ice Modeled Refl. and Shortwave BB Albedo LUT
Snow-Depth-Ice-Thickness Climatology LUT
Atmos. Broadband Transmittance LUT

Ancillary Data

NCEP Gran. Anc. Sfc. Air Temp.
NCEP Gran. Anc. Sfc. Air Pressure
NCEP Gran. Anc. Sfc. Wind Speed
NCEP Gran. Anc. Sfc. Specific Humidity
NCEP Gran. Anc. Precipitable Water

Sea Ice Characterization (Ice Age) EDR

Output EDRs & IPs

VIIRS Sea Ice Age EDR

Summary of VIIRS Sea Ice 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, precip. 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 (sfc.P, sfc air temp, specific hum. 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

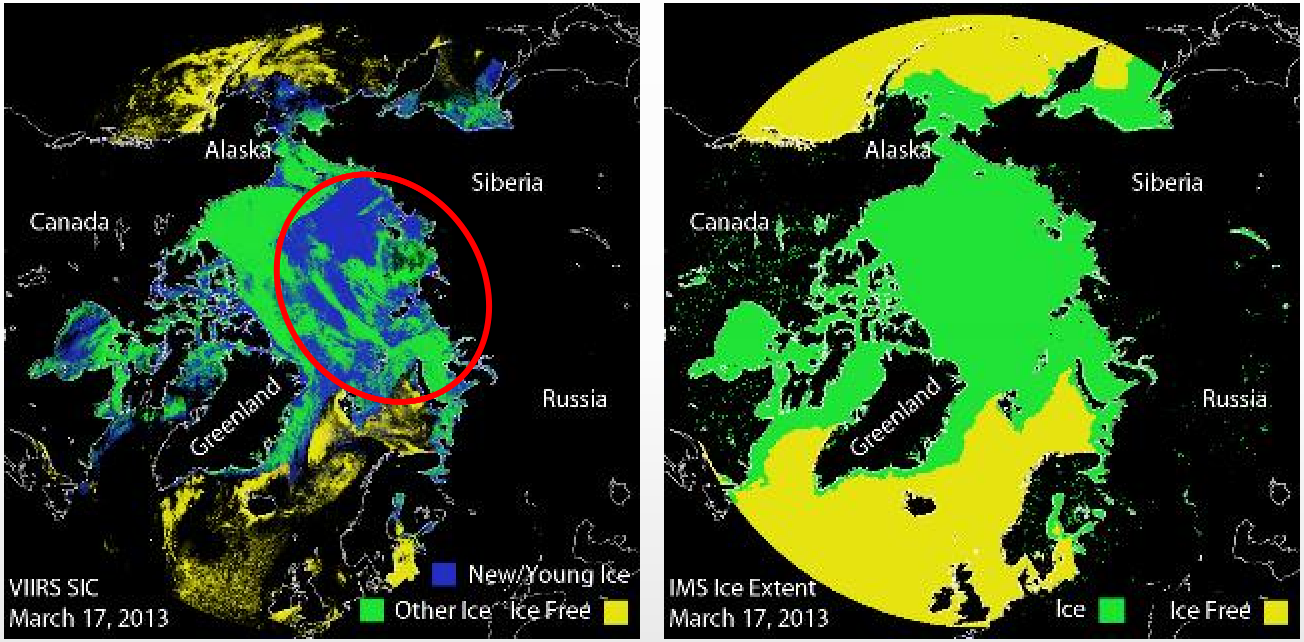
The Snow-Depth-Ice Thickness Climatology LUT contains:

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

Performance Evaluation of the VIIRS Sea Ice Characterization EDR (Ice Age) Algorithm

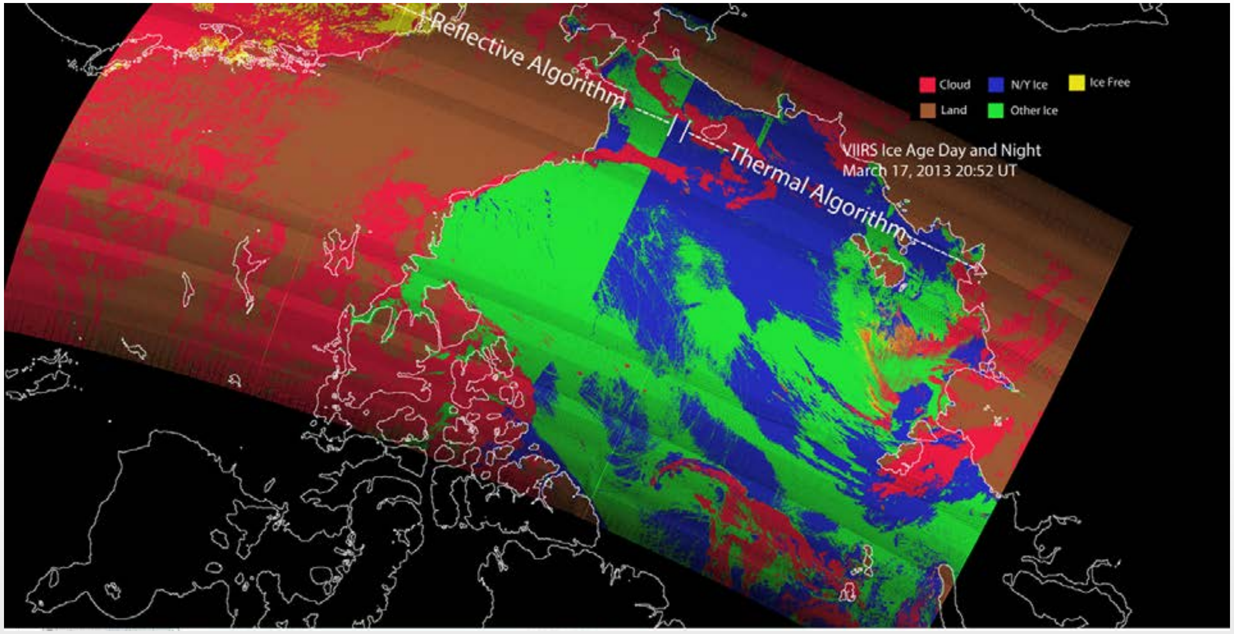
- Detailed analysis of 20 Arctic scenes including four seasons: April 5, 2012 – Dec 4, 2013
- Golden granule: March 17, 2013
  - Examined performance of daytime, nighttime and terminator (transition) areas
- Comparisons to other products:
  - VIIRS SDR reflectance
  - NOAA IMS ice extent
  - CU ice age
  - Airborne ice thickness
    - IceBridge ice thickness
    - Airborne EM & Lidar

VIIRS Sea Ice Characterization EDR
Extent of Misclassified New Young Ice on March 17, 2013



VIIRS Sea Ice Characterization (SIC) EDR (left) vs. NOAA IMS Ice Extent (right). Ice coverage is similar, but new/young ice is too extensive (as seen by manual interpretation).

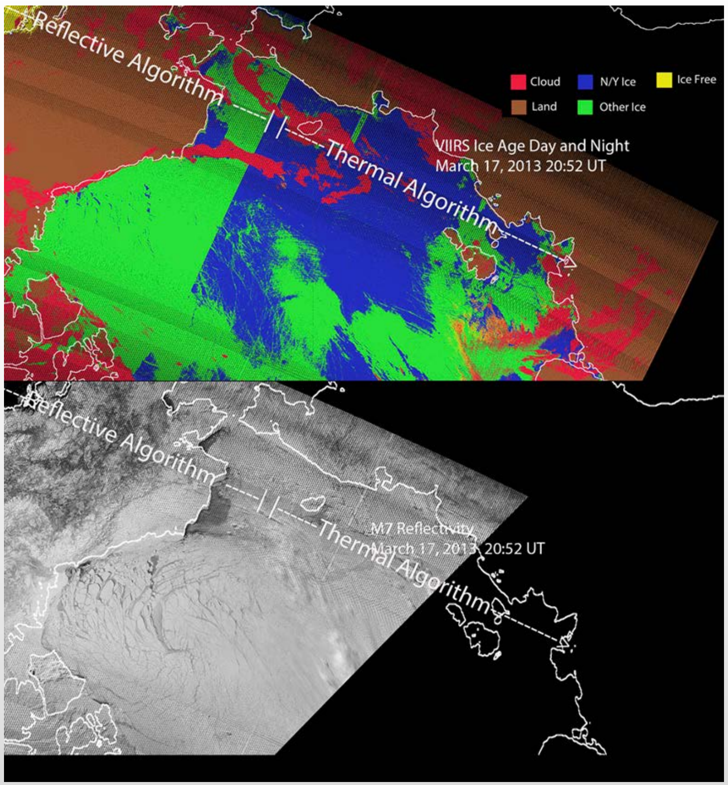
Sea Ice Characterization EDR – March 17, 2013
Misclassified Ice



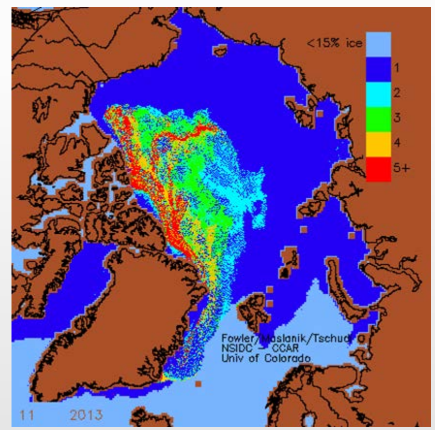
Dan Baldwin/CU, Mark Tschudi/CU

March 17, 2013 20:52 UTC scene (above) shows a broad region of Other Ice (green) misclassified as New Young ice (blue) in the terminator region where the algorithm transitioned from the reflective algorithm (left half) to the thermal heat balance branch (right half)

Details of Ice Misclassification - March 17, 2013

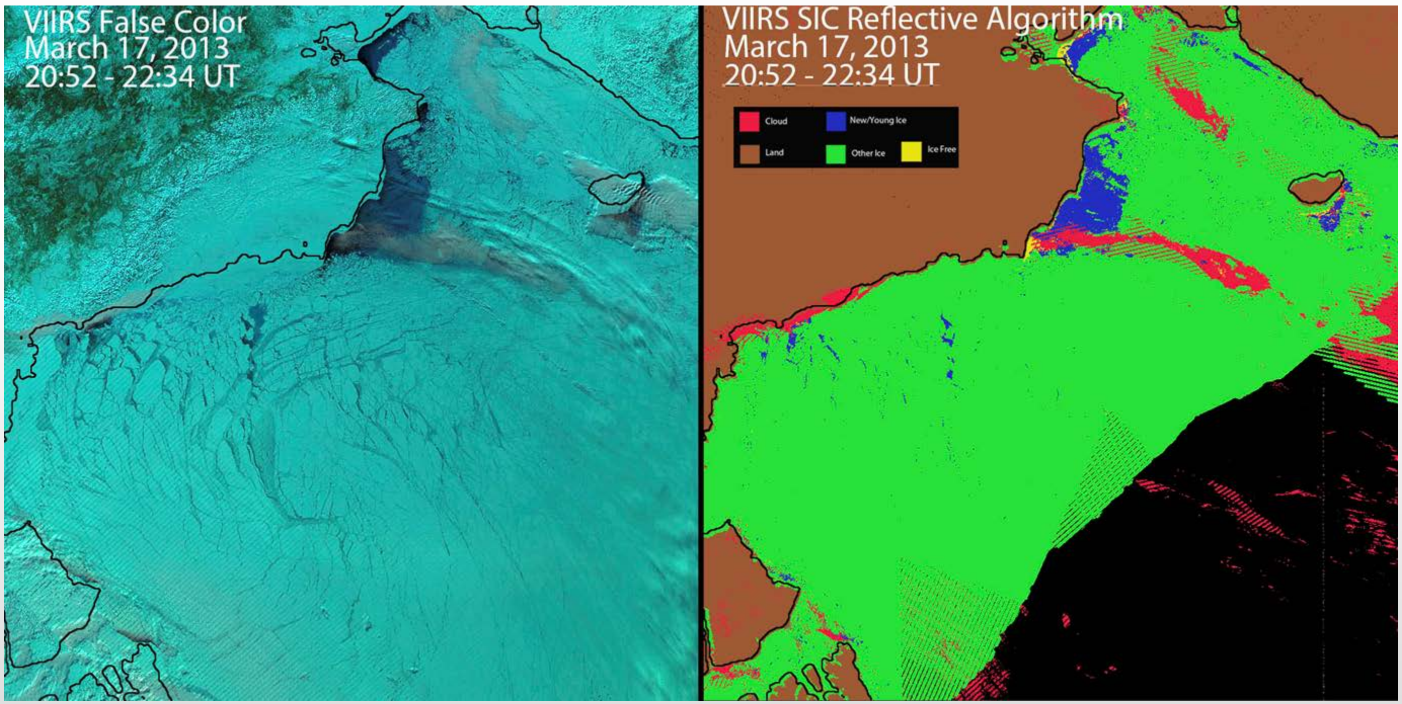


- In this case, the daytime (reflective) algorithm identifies other ice, but misses many leads likely containing N/Y ice
- Nighttime (thermal) algorithm overestimating N/Y ice
- Discontinuity at the transition zone



- CU's ice age product
- Dark blue is FYI, *not necessarily N/Y ice*
- Shows that multiyear ice exists in areas that Thermal Algorithm classifies as "new/young"

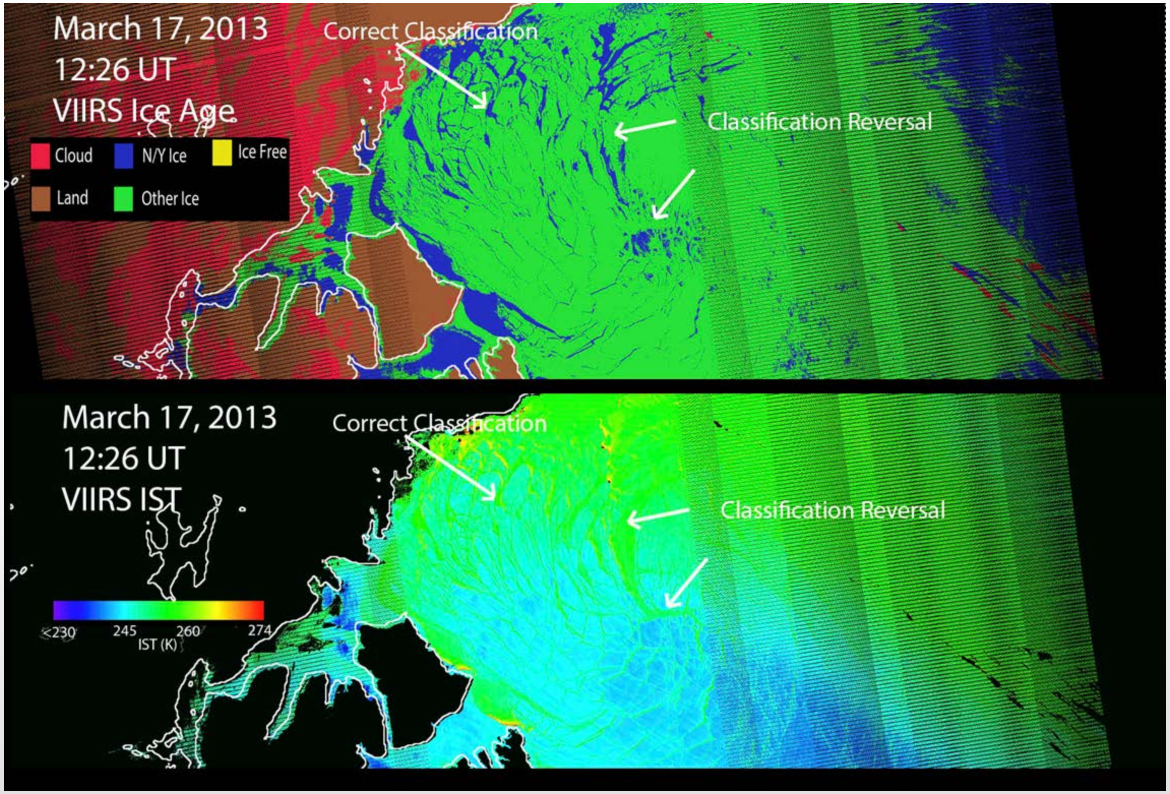
March 17, 2013 Day Reflectance Algorithm: Ice Age Compared with False Color VIIRS SDR Reflectance Image



Many leads, likely containing thin ice, seen in the VIIRS false color reflectance imagey (left) are not detected in the Ice Age EDR (right)

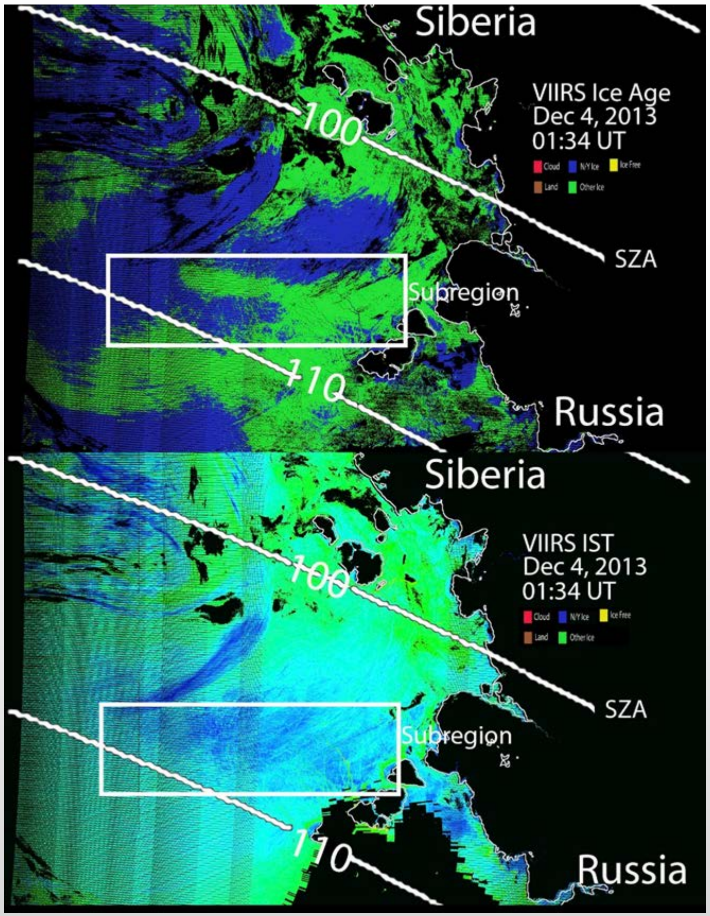
This may be due to use of ice tie point reflectance instead of the remotely sensed reflectance at each pixel

March 17, 2013 Nighttime Algorithm Ice Age Classification Reverse Classification

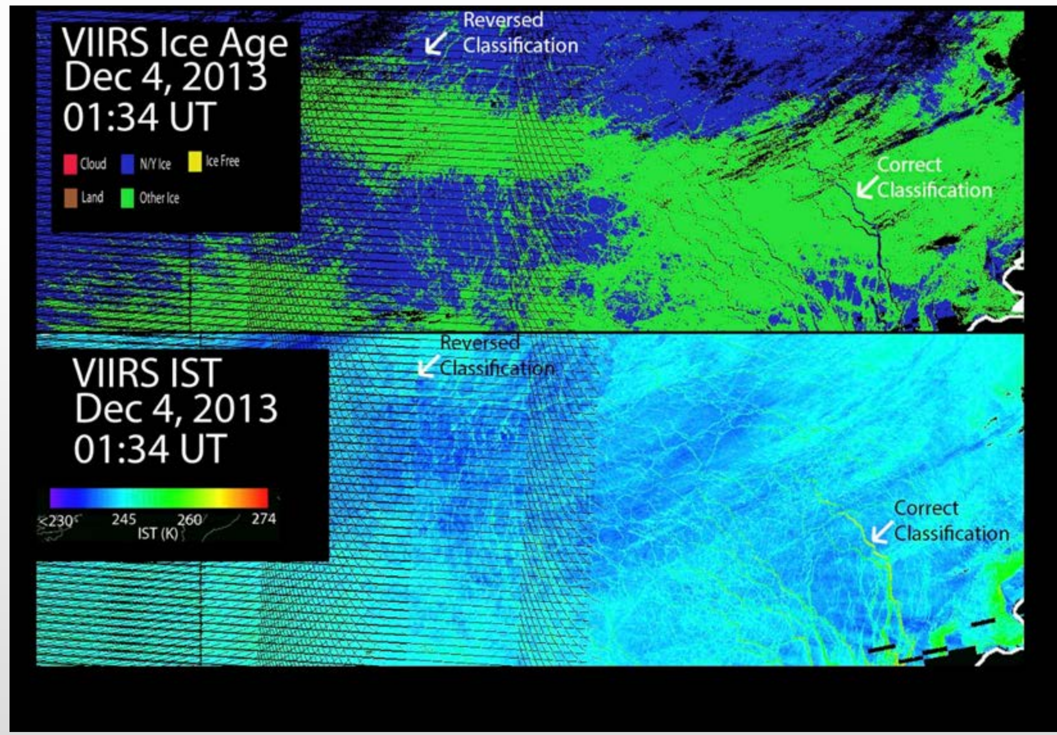


- Most ice classification is reasonable – many leads with thin ice are identified
- Misclassification suspected in area of warmer ice

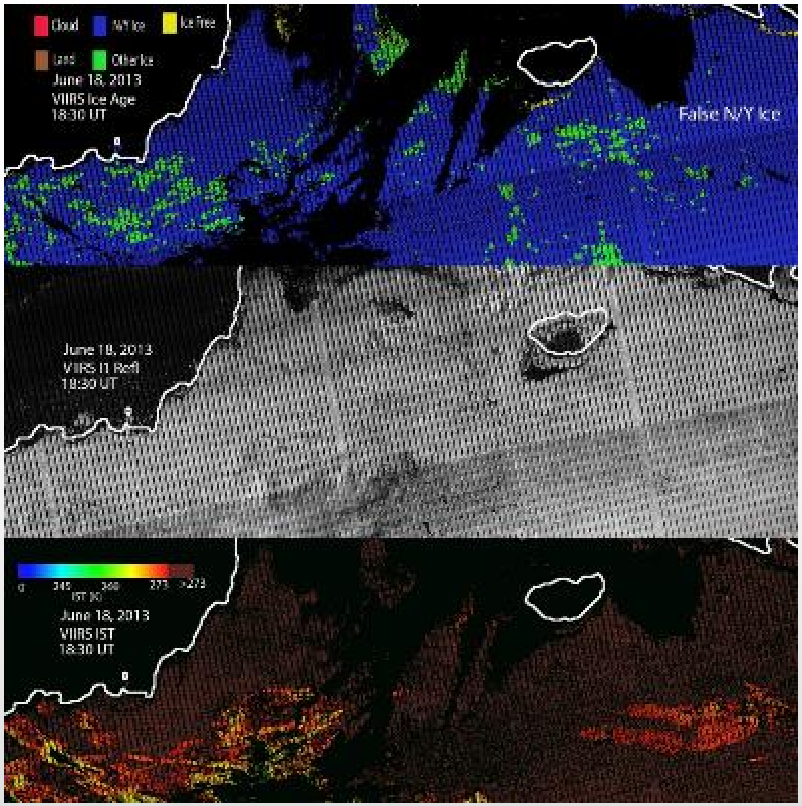
Classification Reversals Identified by Comparison to IST EDR for Dec. 4, 2013 Night Scene



- Occurs in several nighttime images
- Many other leads classified correctly, however

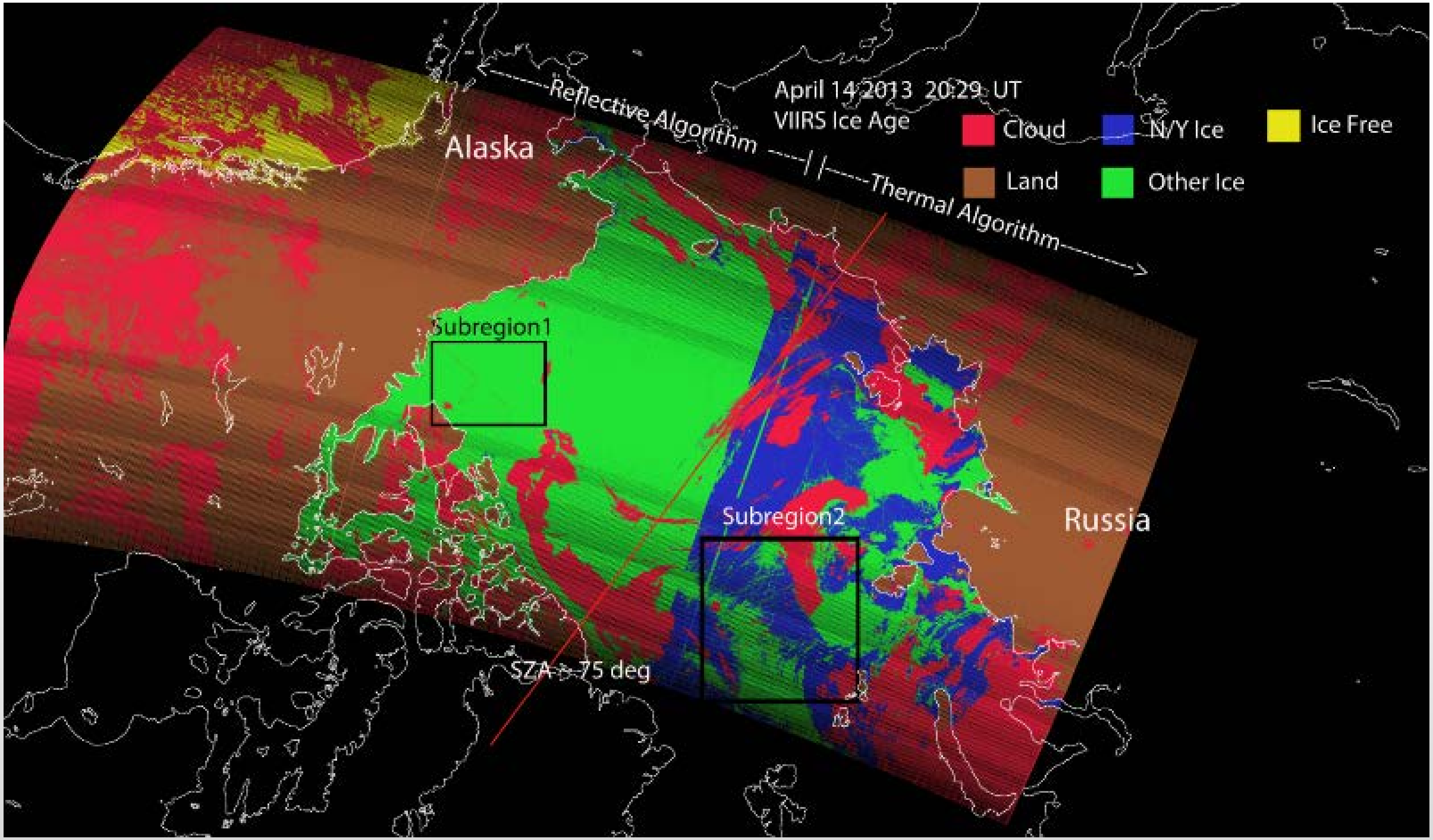


SIC EDR Daytime Misclassification Due to Melting Ice

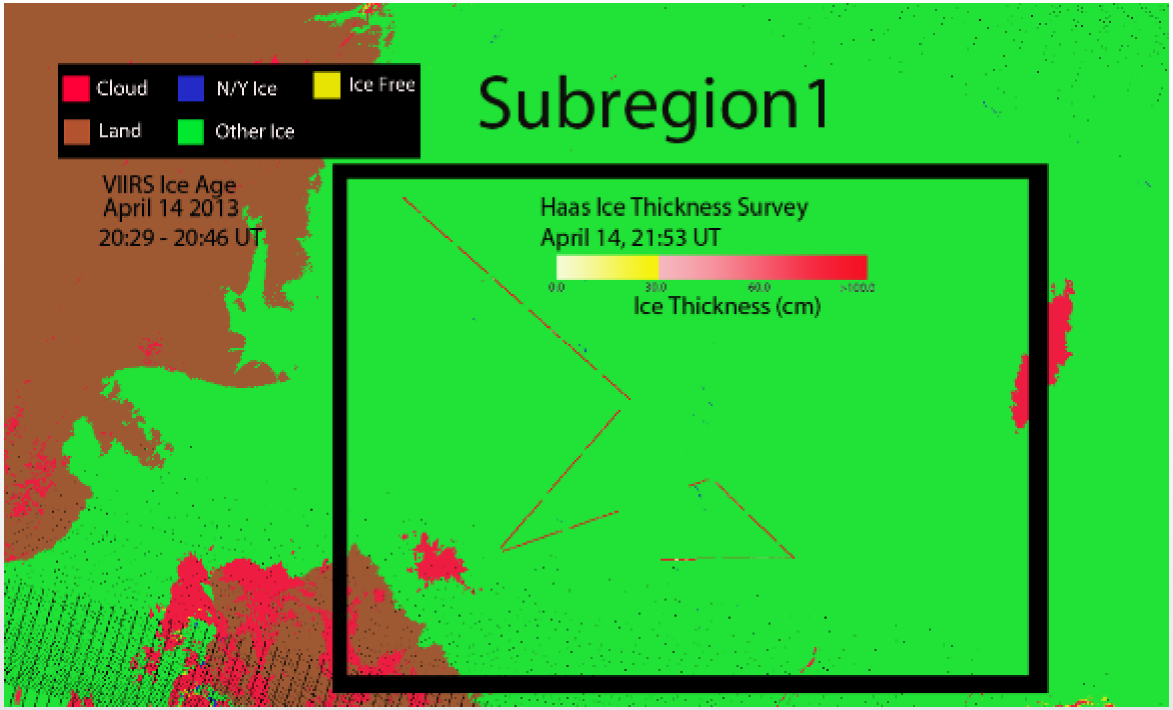


- Ice/snow melt (note IST is at melting temp) lowers reflectance
- Lower reflectance (<0.53) causes daytime algorithm to misclassify ice as N/Y, instead of other
- Melting ice may need to be included in the “other ice” category, as thickness may not be obtainable

Airborne Ice Thickness Data: Verification of Daytime Ice Age Classification for "Other Ice" in Subregion1



Airborne Ice Thickness Data:
Verification of Ice Age Classification for "Other Ice" in Subregion1



Thickness (cm) courtesy of C. Haas: Airborne EM & Lidar

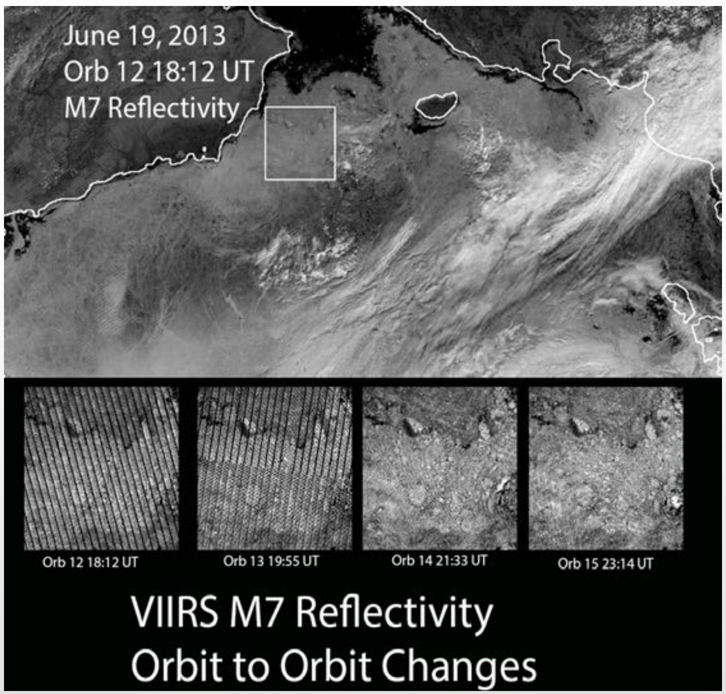
- **All ice for VIIRS SIC EDR is "other ice" (> 30 cm)**
- **1004 airborne data points: 99% > 30 cm (in agreement with VIIRS SIC EDR)**

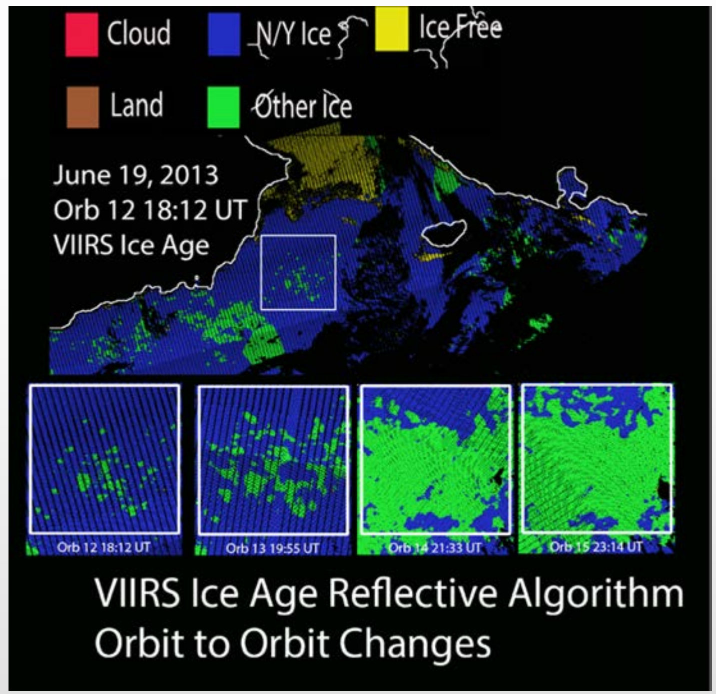
Airborne Ice Bridge Ice Thickness: Verification of Ice Age Classification for "Other Ice"

- SIC EDR, daytime algorithm
- Classification accuracy for 1155 pixels = 76%

IceBridge Ice Thickness [*Kurtz et al,* 2012]

Orbit to Orbit Classification Variability over Same Geographic Region



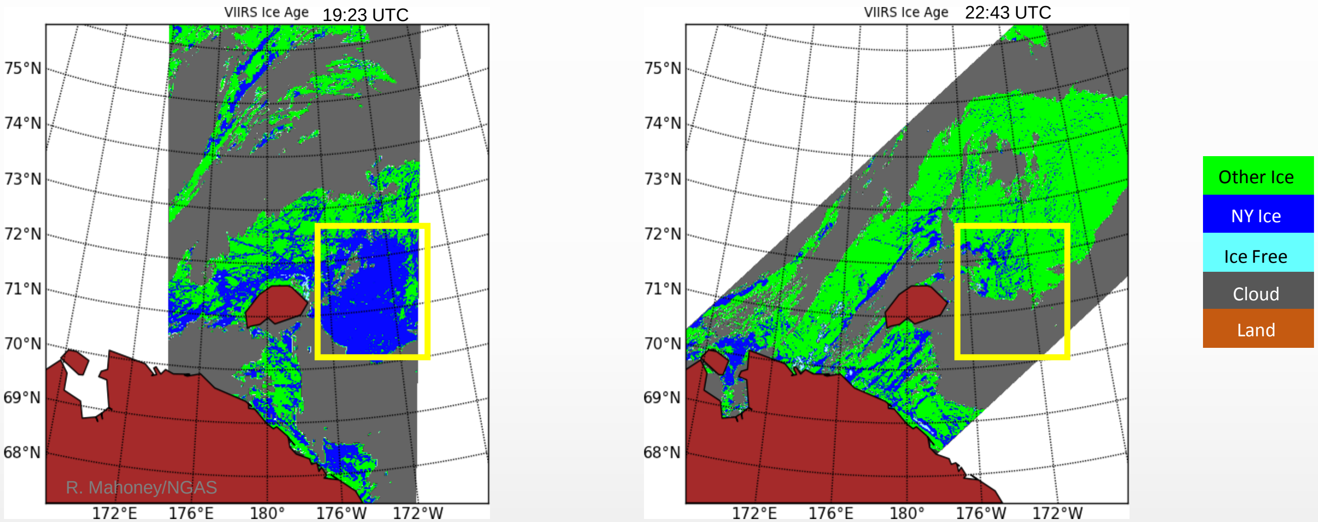


- daytime algorithm
- observed on multiple days

Performance Evaluation of the VIIRS Sea Characterization EDR (Ice Age) Algorithm

- Deep dive analysis performed for May 20, 2013 day scene ice for misclassification of thicker “Other Ice” as “New Young”
  - reflectance branch algorithm inputs and internal computed fields dumped from ADL were visually inspected:
    1. Modeled Sea Ice Reflectance from LUT
    2. Climatology Modeled Snow Accumulation/Ice Thickness LUT snow depths
    3. Ancillary input fields, internally computed ice thicknesses
    4. Ice tie point reflectance

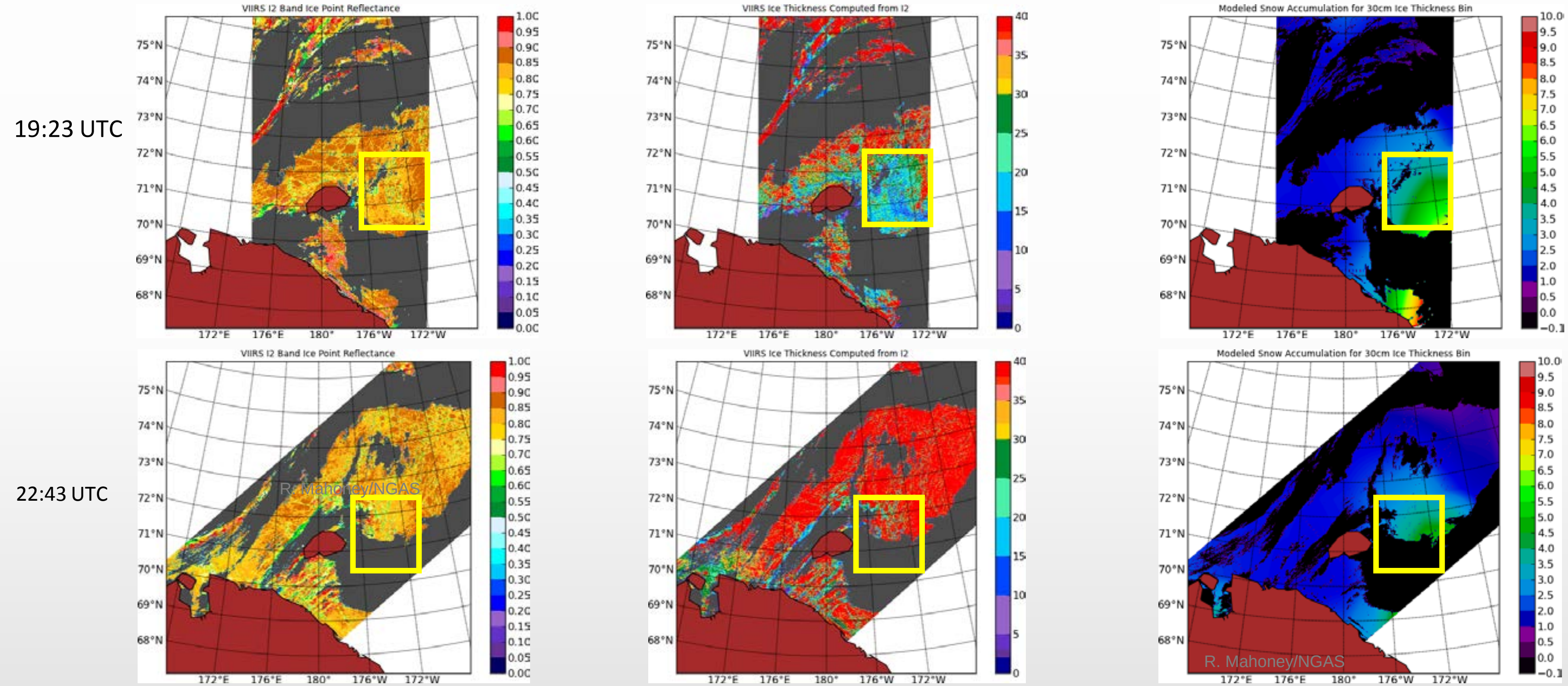
Detailed Analysis for Orbit to Orbit Misclassification of NY/Other Ice (May 20, 2013 19:23 and 22:43 UTC orbits)



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.

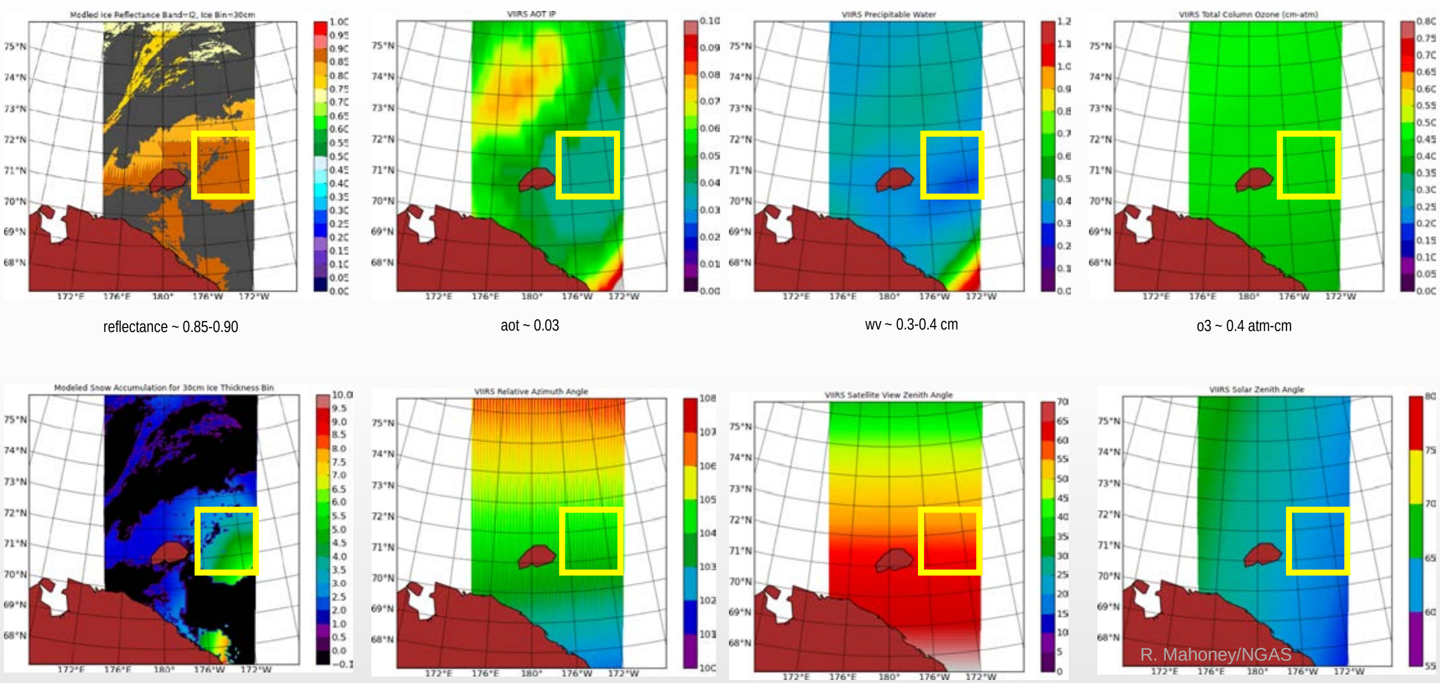
SDR RGBs, ice tie point reflectance, modeled sea ice reflectance, modeled snow accumulation depth, internally computed ice thickness and other inputs were examined and compared in order to determine the cause for the misclassification

Ice Tie Point Refl. (I2), Internally Computed Ice Thickness, and Climatology Modeled Snow Accumulation



Values of the **I2 ice tie point reflectance** (left), **and modeled snow depth** (right) examined for the misclassification region (box) have **similar values for both orbits**. However, computed ice thicknesses (center) are different. Lower values of ice thickness in the 19:23 UTC orbit have a pattern similar to that of the higher values of modeled snow depth in the boxed region (upper right).

VIIRS I2 Modeled TOA Sea Ice Reflectance and Inputs to Extract the Modeled Reflectance from the LUT



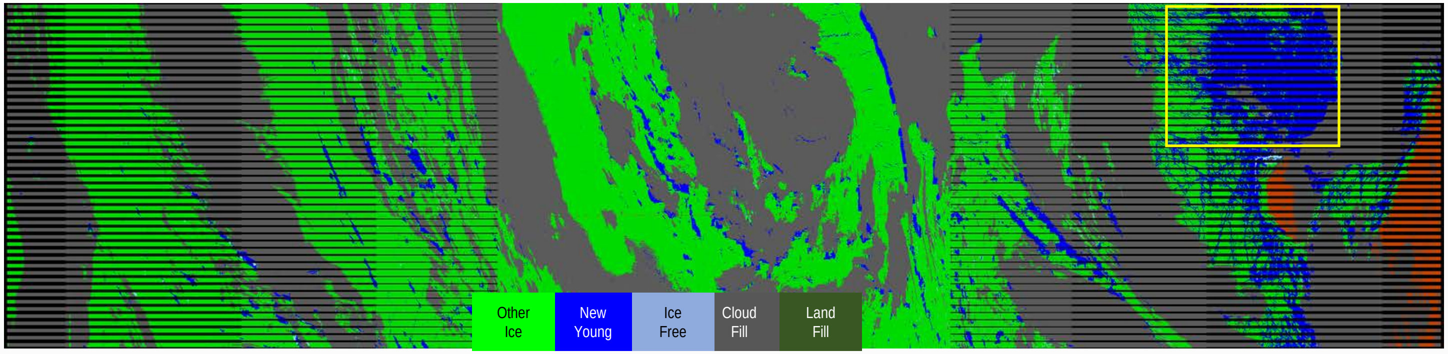
reflectance ~ 0.85-0.90 | aot ~ 0.03 | wv ~ 0.3-0.4 cm | o3 ~ 0.4 atm-cm

climatology modeled snow accumulation ~ 3-4 cm | relative azimuth angle ~ 105° | satellite view zenith angle ~ 56° | solar zenith angle ~ 62°

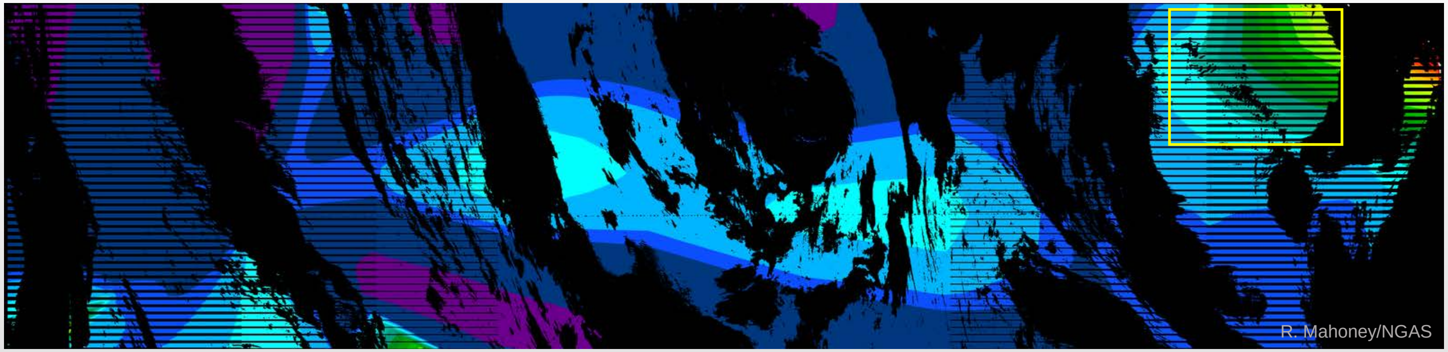
Modeled Sea Ice reflectance for I2 are between 0.85 and 0.9 in the boxed region. The input **parameter in the 19:23 UTC orbit that has the most difference** from that of the corresponding 22:43 UTC orbit (not shown here) is **the satellite view zenith angle**.

Ice Age EDR Compared with Input Modeled Snow Accumulation/Ice Thickness LUT Snow Depth

Sea Ice Age EDR



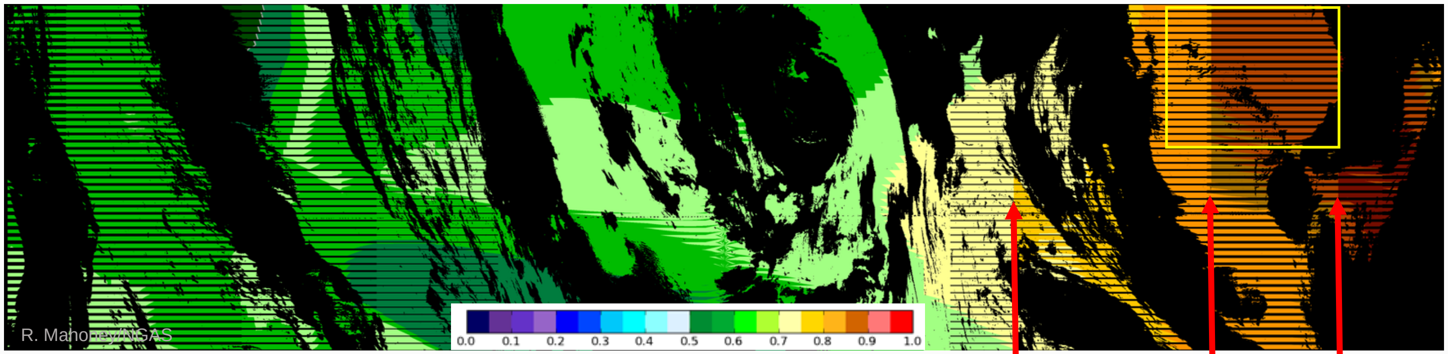
Modeled Climatology Snow Depth (30 cm ice thickness bin)



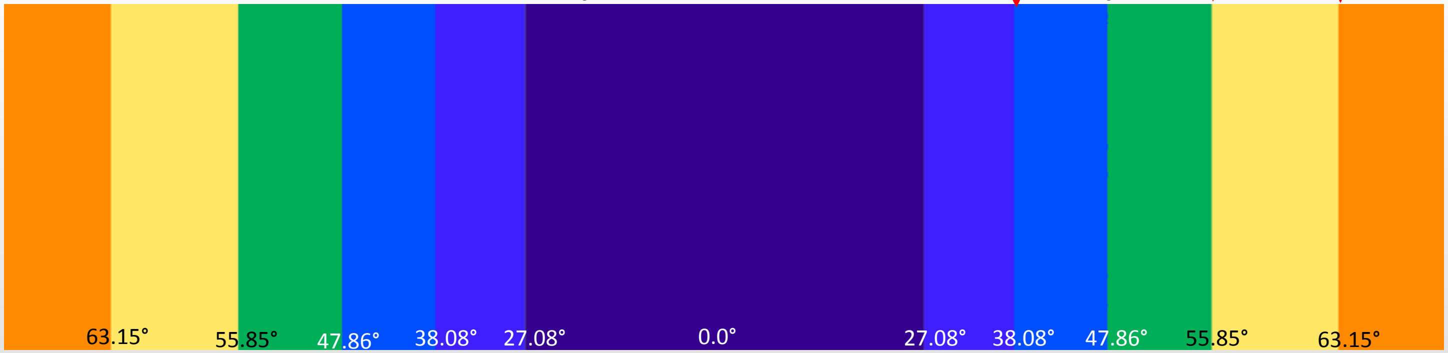
Misclassified New Young ice in the 19:23 UTC Sea Ice Age EDR orbit (upper figure, box region) correlates with the pattern high values of climatology modeled snow accumulation depth (lower figure, boxed region).

Granule Comparison of Modeled TOA Reflectance to Sat. View Zenith Angle May 20, 2013 19:23 UTC

I2 Modeled Sea Ice Reflectance (30 cm ice thickness bin)



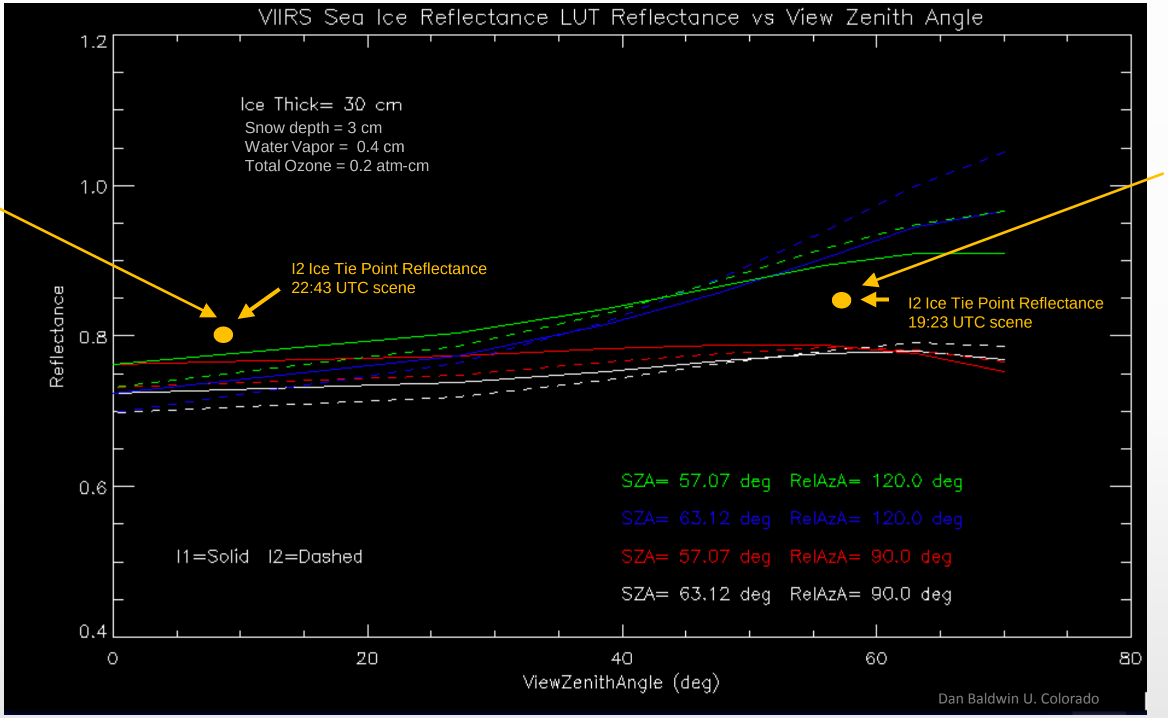
Satellite View Zenith Angle for Modeled Sea Ice TOA Reflectance VZA bin value ranges



Abrupt increases in the Modeled TOA Sea Ice Reflectance with increased view zenith angle (upper figure) correlate to the values (lower figure) of the modeled sea ice reflectance LUT's view zenith angle bin boundaries.

Examination of the Modeled Sea Ice TOA Reflectance LUT

I2 ice tie point reflectance for 22:43 UTC orbit for low value of sensor zenith is above that of the corresponding modeled Sea Ice Reflectance LUT.



I2 ice tie point reflectance for 19:23 UTC orbit for high value of sensor zenith is below that of the corresponding modeled Sea Ice Reflectance LUT.

VIIRS I1 (640 nm) and I2 (865 nm) band reflectances extracted from the Modeled Sea Ice Reflectance LUT are shown as function of satellite view zenith angle for two solar zenith angle and relative azimuth bins that bound the scene conditions. The fact that the I2 band modeled reflectances are greater than that of the I1 band reflectances is unexpected since the spectral albedo of snow decreases with increasing wavelength beyond about 0.5 µm.

Summary

• Evaluation of Sea Ice Characterization EDR (Ice Age) performance based on visual comparison of a set of golden granules consisting of day, terminator and night scenes indicates that the Sea Ice Age EDR has considerable performance challenges but particularly for terminator scenes

• Misclassification of ice age 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

• Detailed analysis performed for May 20, 2013 day, orbit to orbit variations over Wrangle Island

- Ice misclassified as NY due to high Modeled TOA Sea Ice Reflectance LUT values corresponding to regions with large climatology modeled snow depths and satellite view zenith angles
- Detailed analysis for night and terminator scenes has not been performed yet

VIIRS Sea Ice Characterization EDR Known Issues & Proposed Solutions

- In general, significant discontinuities in ice classification between New Young and Other Ice have been observed in the granule level mapped composite data.

Issue	Description	Proposed Solution
Day Region Ice Age Misclassifications	Daytime algorithm shows a bias towards N/Y ice for higher scattering angles	Update Modeled TOA Sea Ice Reflectance LUT to eliminate bias (reconstruct LUT based on CASIO/DISORT Snow/Ice BRDFs and coupled sea/ice/atmosphere RTM)
Night Region Ice Age Classification Reversals	Nighttime algorithm shows numerous classification reversals	Investigate tie point calculation in area of misclassification Investigate energy balance
Terminator Region Ice Age Misclassifications	Frequent misclassification of ice for broad regions, major discontinuities where algorithm transitions from day reflectance based to night energy balance algorithm, frequent reversal of ice classification	Update Night algorithm to use a local sliding IST window Investigate energy balance and solar flux term
Climatology Modeled Snow Accumulation/Ice Thickness LUT	Snow depth thresholds based on the monthly, climatology based snow/depth ice thickness LUT are problematic	Investigate use of ancillary precipitation to derive snow depth and compute an ice thickness based on that snow depth. Dependence on the problematic SnowDepth/IceThickness Climatology LUT can then be eliminated.
False ice is frequently observed near cloud edges	False ice is frequently observed near cloud edges due to undetected clouds	Implement additional quality checks for extended cloud adjacency and partly cloudy conditions within the ice tie point search window in the Sea Ice Concentration IP

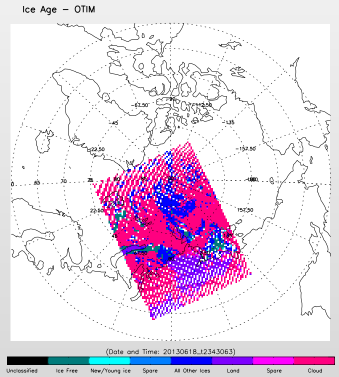
VIIRS Sea Ice Characterization EDR Known Issues & Proposed Solutions (continued)

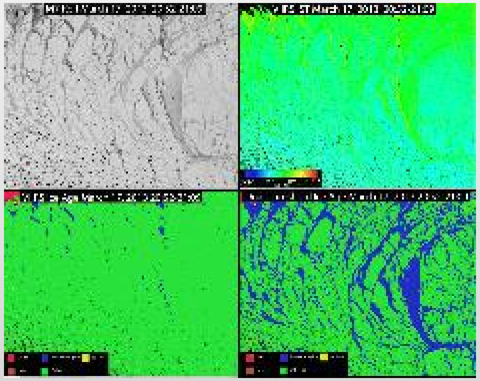
Issue	Description	Proposed Solution
Ice Age Misclassification due to low opacity clouds	Ice misclassifications occur due to low opacity clouds or ice fog, particularly during nighttime	Continued improvement of VCM to facilitate cloud vs. ice detection
Ice Age Misclassification due to melting ice	Lower reflectance of melting sea ice appears to cause the SIC EDR to indicate New/Young Ice, although this type of ice cannot be present this time of year.	Define and utilize melt season period where New/Young ice cannot exist. Could do this by date/latitude or possibly with IST or NCEP air temp input. During this time, ALL ice would be classified as "other ice."
Ice Age Misclassification due Cloud Shadows	Lower reflectance of cloud shadow regions cause SIC EDR to indicate New/Young even though surrounding ice is Other Ice	Continued improvement of VCM to extend cloud shadow algorithm and flagging. Add logic to Ice Age algorithm to check VCM cloud shadow flag cloud and set quality flag to indicate degraded Ice Age retrieval quality

VIIRS Sea Ice Characterization EDR Known Issues & Proposed Solutions – Alternate Algorithms

- Alternate Algorithms to Replace Current day and/or Night Ice Age Algorithms
  - It is not known if the proposed solutions above will be sufficient. It is therefore be necessary to identify and test alternate algorithms
    1. OTIM
       - One-dimensional Thermodynamic Ice Model (OTIM) of Wang et al. (2010) - Night Regions
    2. Temperature/Reflectance threshold algorithm – Day, Terminator and Night Regions
       - A simpler approach using a temperature/reflectance threshold (daytime) is also being investigated. This technique could also be implemented using without use of reflectance (nighttime).

OTIM Ice Model





Threshold algorithm

Snow and Ice Gridding Status and Recommendations

May 14, 2014

Robert Mahoney (NGAS)
Rich Dworak (UW/SSEC)
Paul Meade JPSS Cryosphere JAM
Marina Tsidulko (NOAA STAR/AIT)

THE VALUE OF PERFORMANCE.
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Overview

- Current Status – Monthly Manual Updating of Gridded Snow/Ice Rolling Tiles with NOAA Global Automated Multi-sensor Snow/Ice (GMASI)
- Near Term Plan – Daily Automated Updating of Gridded Snow/Ice Rolling Tiles with GMASI
- Gridding Tests Performed using VIIRS Snow/Ice with GMASI as Fallback
- Recommendations

(1) Current Status – Monthly Manual Updating of Gridded Snow/Ice Rolling Tiles with NOAA Global Automated Multi-sensor Snow/Ice (GMASI)

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Current Status – Monthly Manual Update of the Gridded Snow/Ice Rolling Tiles (IVGSC)

- **Monthly Fast Track** updating of the Snow/Ice Cover Rolling Tiles is currently being performed
  - Based on the "NOAA AutoSnow" 4 km, Global Multisensor Automated Snow/Ice cover (GMASI) product
  - Based on NOAA AutoSnow for 15th of each month
  - Manual processing to generate IDPS Sinusoidal Gridded Snow/Ice Rolling tiles (IVGSC)
  - Delay of 1 to 2 weeks after the 15th of each month for the update to become operational
    - time required for manual tile generation, AERB FastTrack process and IDPS implementation
  - Operational Snow/Ice Rolling tiles are 5 to 6 weeks old by the time of the next update
  - Need more frequent (daily) updates for downstream product quality

(2) Near Term Plan – Daily Automated Updating of Gridded Snow/Ice Rolling Tiles with GMASI

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Near Term Plan - Daily Automated Updating of IVGSC Tiles with NOAA GMASI Data

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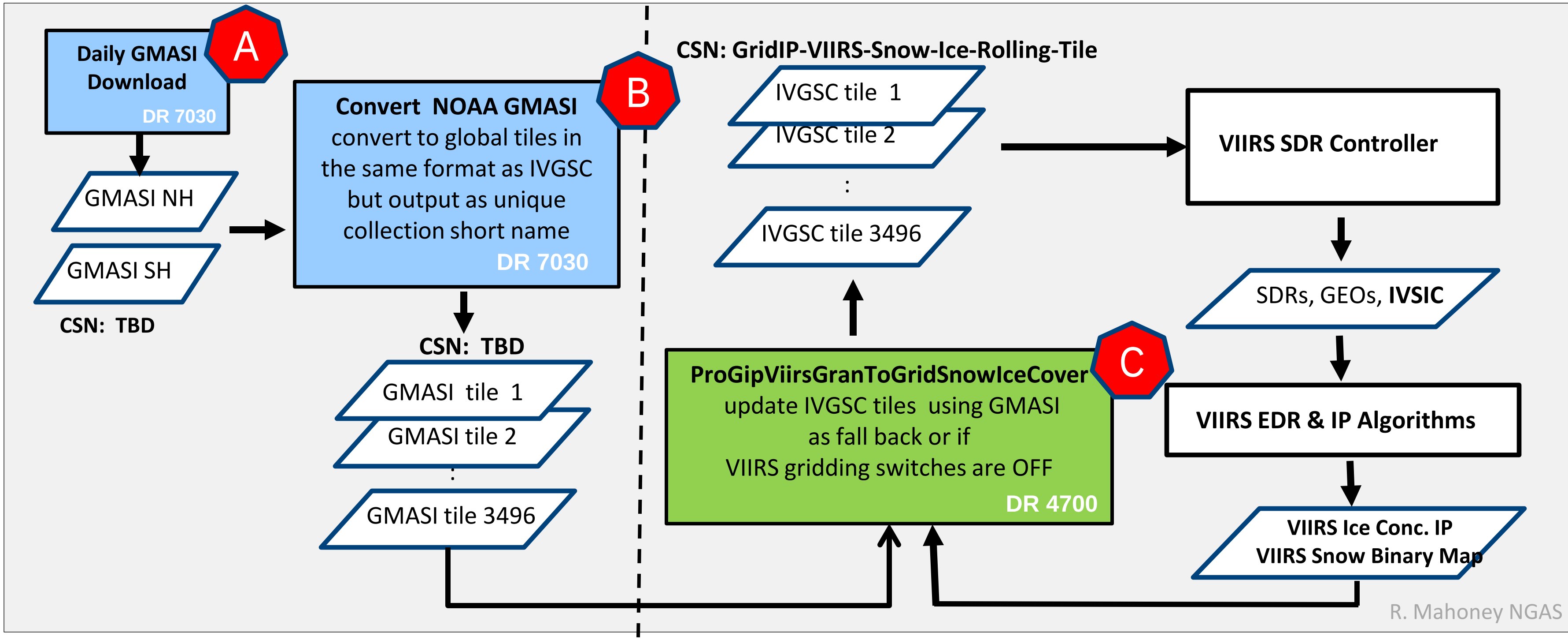

- **Stage A: CCR 13-1082 (ADR 7030**) implements daily automated acquisition of North and South Hemi. NOAA Global Multi-sensor Automated Snow/Ice (GMASI NH and SH) data files
- **Stage B: CCR 13-1082 (ADR 7030**) implements IDPS conversion of GMASI NH and SH files to global sinusoidal tiles in the same format as the NPP IVGSC tiles as a new collection short name entity
- **Stage C: CCR 13-1043 (ADR 4700**) implements code changes to the ProGipViirsGranToGridSnowIceCover routine to allow updating of IVGSC tiles using VIIRS Snow/Ice with GMASI as fall back **or** to **perform daily updating with only GMASI data if VIIRS snow/ice gridding switches are set to OFF**

GMASI Implementation Stage A

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- NOAA OSPO Produces Daily Snow/Ice Data
  - NH: 4 km IMS (Interactive Multisensor Snow product)
  - SH: 2 km AutoSnowIce
- NOAA OSPO delivers Daily Snow/Ice Data to NOAA TOC
  - 2 Files: NH, SH
- File Transfer from NOAA TOC to IDPS
  - Same as for other ODAD

GMASI Implementation Stage B

- IDPS Conversion: IMS/AutoSnowIce to GMASI
  - GMASI Format / Data Values Homologous to IVGSC (Snow/Ice Rolling Tiles)
  - 3436 Tiles, Sinusoidal Projection

- *Example* Conversion Scripts Provided by VIIRS Cryosphere Cal/Val Team (CCR 13-1082)
  - ~ 800 MatLab SLOC (including I/O and whitespace)
  - Technical Guidance Memo titled "NG_TechMemo_Conversion of_NOAA_IMS_and_AutoSnow_to_SinGrid.doc" (R. Mahoney/NGAS)

GMASI Implementation Stage C

- Modified IDPS & Algorithm Code Provided by Cryosphere Cal/Val Team (CCR 13-1043)
  - M. Tsidulko (NOAA STAR AIT) / R. Mahoney (NGAS)/P. Meade (Cryospshere JAM)
  - C++ Source:
    - 11 Modified Files, ~340 SLOC modified
    - 2 New Files, ~400 SLOC total
  - XML Source (configuration):
    - 2 Modified Files, ~140 SLOC modified
    - 1 New File, ~200 SLOC total
  - Approved by AERB

Near Term Plan for Daily Updating of the Snow/Ice Rolling Tiles with GMASI– Key Points

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- Modified Snow/Ice GranToGrid code (ADR 4700) introduces **two gridding switches** (VIIRS Snow and Ice gridding switches) that allow activation of the Snow/Ice GranToGrid in four possible states:

  1. Gridding Switches for VIIRS Snow and Ice both set to **OFF** results in:
     - Snow/Ice Rolling Tiles updated daily, globally with GMASI
  2. Gridding switches for VIIRS Snow and Ice both set to **ON** results in:
     - Snow/Ice Rolling Tiles updated using VIIRS Snow and Sea Ice and GMASI as fallback
  3. Gridding switches for VIIRS Snow set to **ON** and VIIRS Ice to **OFF** results in
     - Snow/Ice Rolling Tiles updated based on VIIRS Snow Cover EDR and GMASI as fallback over land and GMASI only over oceans
  4. Gridding switch for VIIRS Snow set to **OFF** and VIIRS Ice set to **ON** results in
     - Snow/Ice Rolling Tiles updated based on VIIRS Sea Ice Concentration and GMASI as fallback over oceans and GMASI only over land

- VIIRS Cryosphere Cal/Val Team recommends daily updating *initially* with GMASI data ONLY (VIIRS snow and ice gridding switch both set to “OFF”)

Note: Algorithm switches allows for testing of VIIRS Snow and Ice gridding separately

(3) Gridding Tests Performed using VIIRS Snow/Ice with GMASI as Fallback

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Gridding Tests for Updating Snow/Ice Rolling with VIIRS Snow/Ice + GMASI

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- Gridding Tests Performed to Determine Additional Quality Controls Required for Activation of VIIRS Snow/Ice Gridding (with GMASI as Fallback)
  - Goal to determine whether a set of VIIRS based quality criteria, shown below, can allow VIIRS Snow/Ice Gridding to be activated or whether additional climatology based quality control measures such as used in the production of the NOAA AutoSnow product are required
- Gridding Tests Performed for Two 1 Week Periods in Aug, 2013
  - Aug 11-18, 2013 (Pre-MX 7.2) and Aug 21-27, 2013 (Post- MX7.2) periods
  - Stand alone Ice Concentration IP and Snow Cover EDR off-line gridding test implemented by Rich Dworak UW/SSEC for more flexible and efficient prototyping of gridding tests
- Quality Control Criteria Applied for Gridding Tests (VIIRS Based Q/C Tests)

	Quality Control Criteria	Comment
1	VCM confidently clear	Cloud confidence from IVIQF for Sea Ice Concentration IP Cloud confidence from VSCMO cloud confidence quality flag
2	No thin cirrus	Based on VCM thin cirrus flag
3	Solar Zenith angle threshold to mitigate cloud shadows	SZA < 85° Pre MX7.2 gridded SZA < 80° Post MX7.2 gridded
4	Standard VCM cloud adjacency (no cloud adjacency)	**Applied to Snow Cover EDR** (VSCMO) and Ice Concentration IP (IVIIC) based on the VCM cloud adjacency flag
6	Extended cloud adjacency filter	**Applied to Sea Ice Concentration IP** (pixels with more than 15% clouds in a 31x31 sliding window screened)
6	**ForceDayThreshold**	Fallback to GMASI if no good quality VIIRS Snow/Ice after 5 days (changed "**forceDayThreshold**" from 10day threshold)

VIIRS Snow/Ice Gridding Test – Post MX 7.2
No Extended Cloud Adjacency Filter

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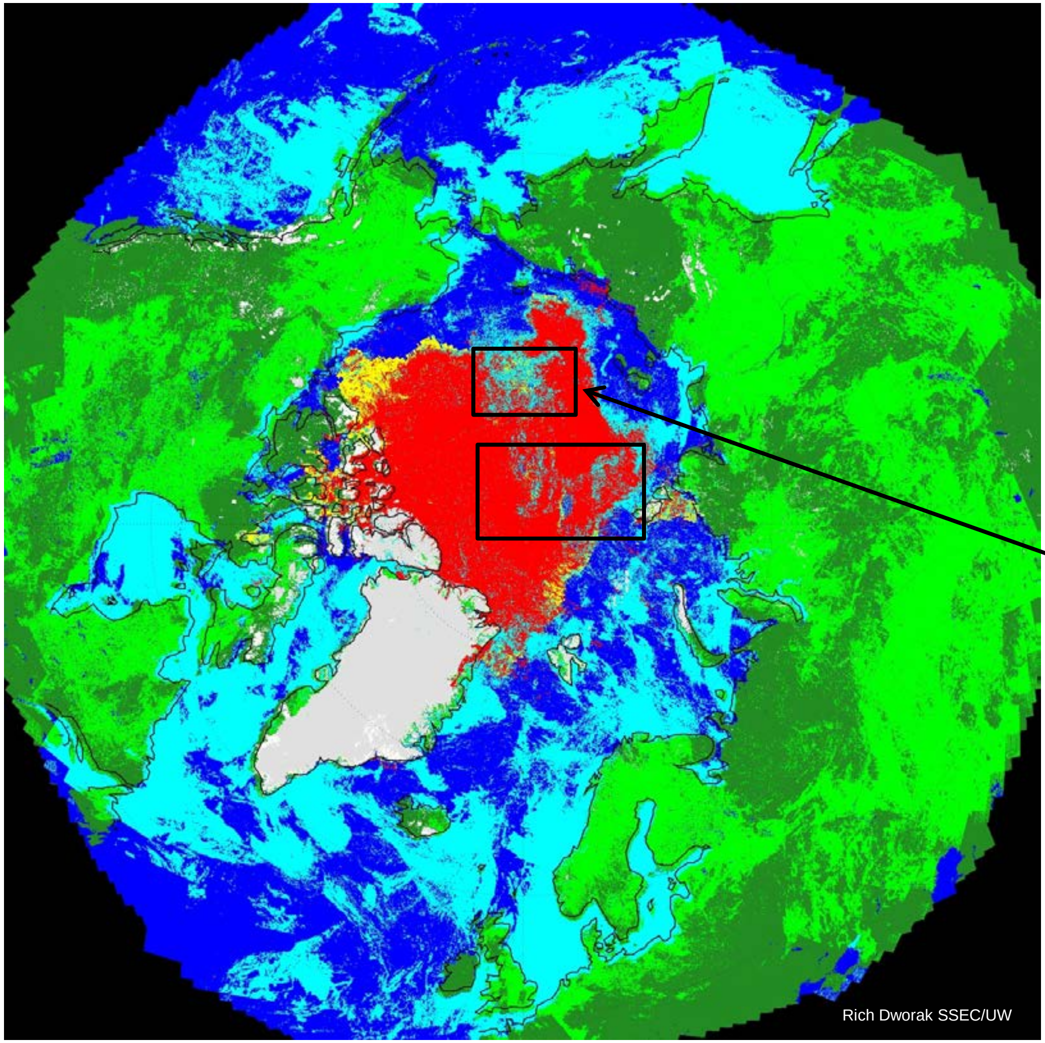


GMASI

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

VIIIRS Updated

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

Missing Ice regions

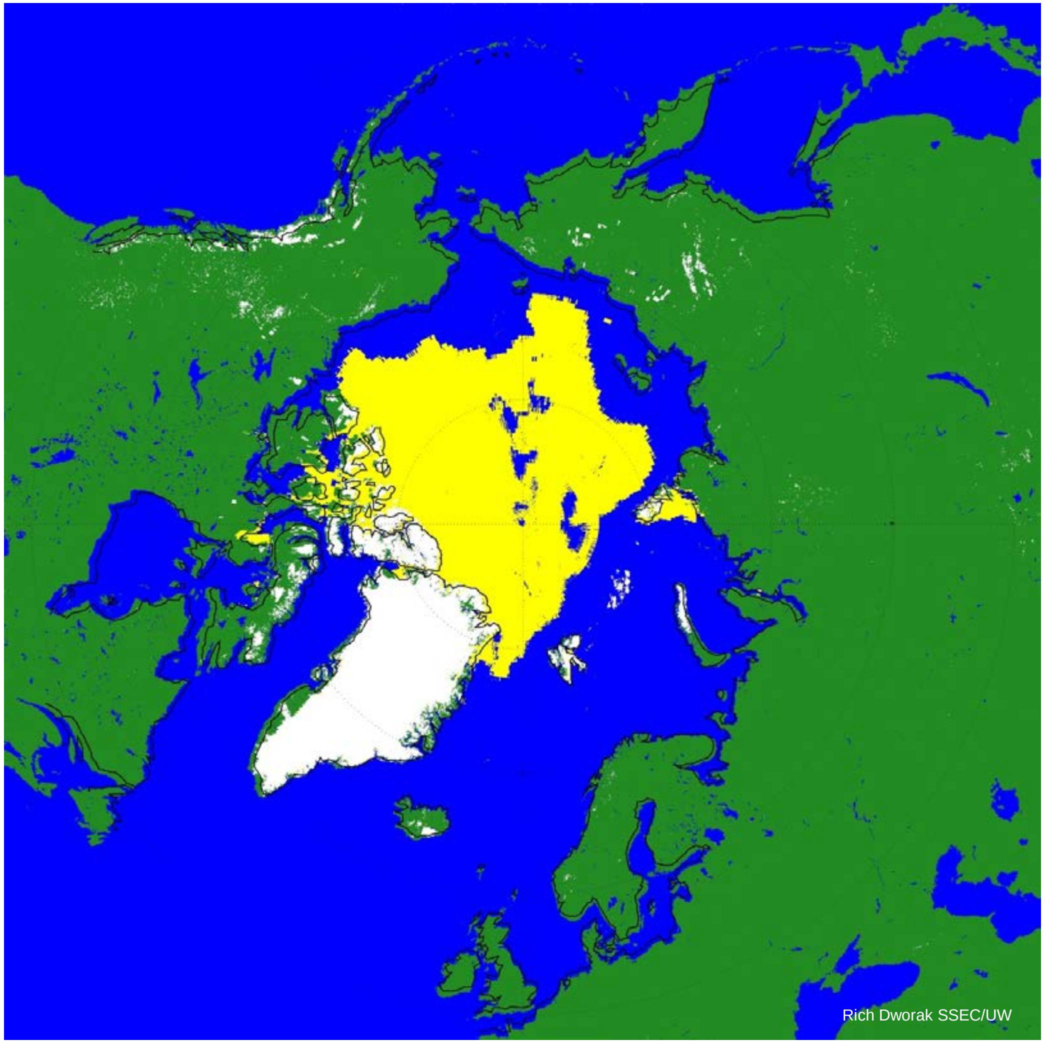
Gridding Quality Criteria

1. **No Extended Cloud Adjacency**:
2. **Only SZA < 80°** gridded
3. **Cloud Confidence**

- confidently clear only
- no thin cirrus
- no VCM cloud adjacency

Gridding test results after a one week gridding period (Aug. 21-27, 2013). Regions of missing ice still appear in the grid (boxed regions) based on gridding using the standard VCM cloud adjacency quality control

NOAA AutoSnow Used as Reference VIIRS Snow/Ice Gridding Test – August 27, 2013



Yellow	Ice over water
White	Snow over land
Green	No Snow over land
Blue	No Ice over water

NOAA AutoSnow reference for the end of day of Aug 27 for the one week gridding period August 21-27, 2013

VIIRS Snow/Ice Gridding Test – Post MX 7.2 VCM Extended Cloud Adjacency Filter

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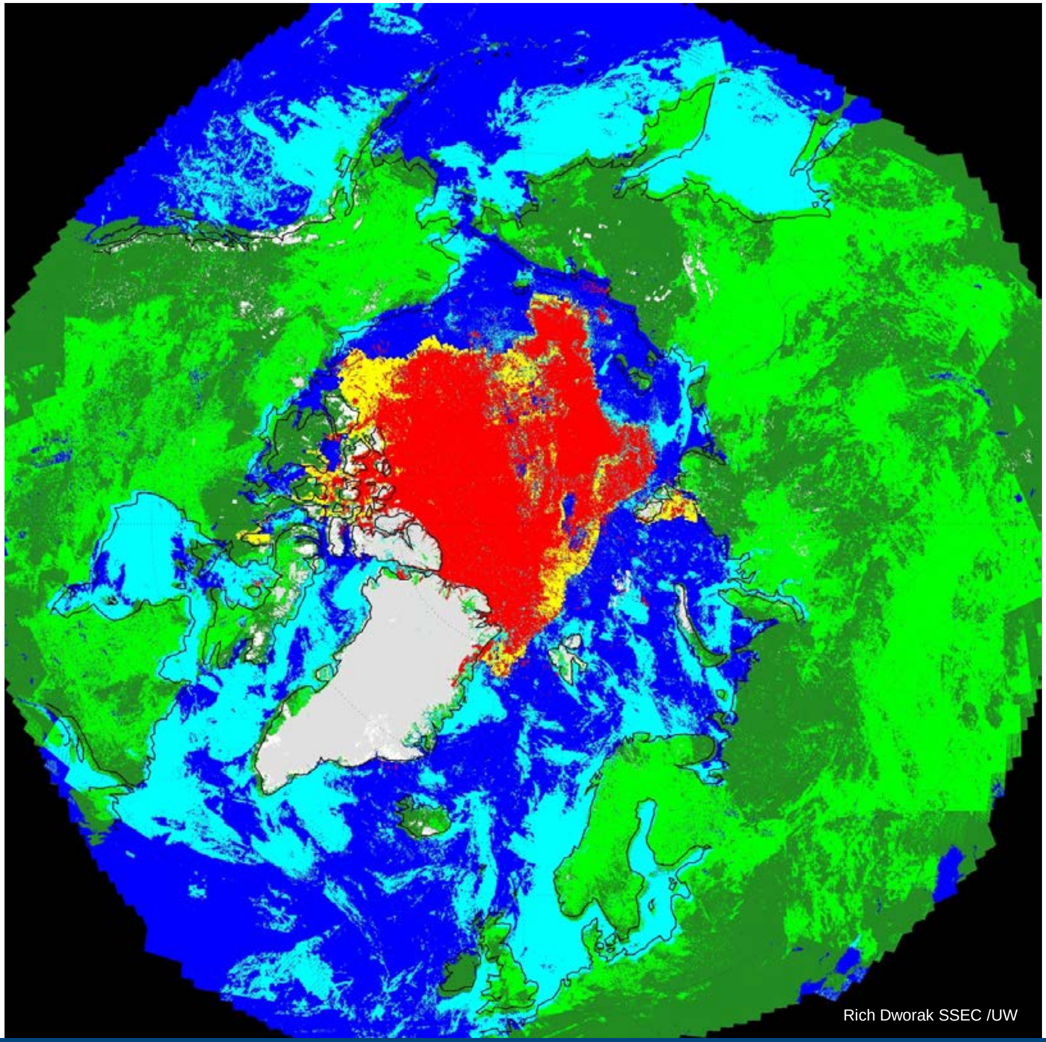


GMASI

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

VIIRS Updated

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

Gridding Quality Criteria

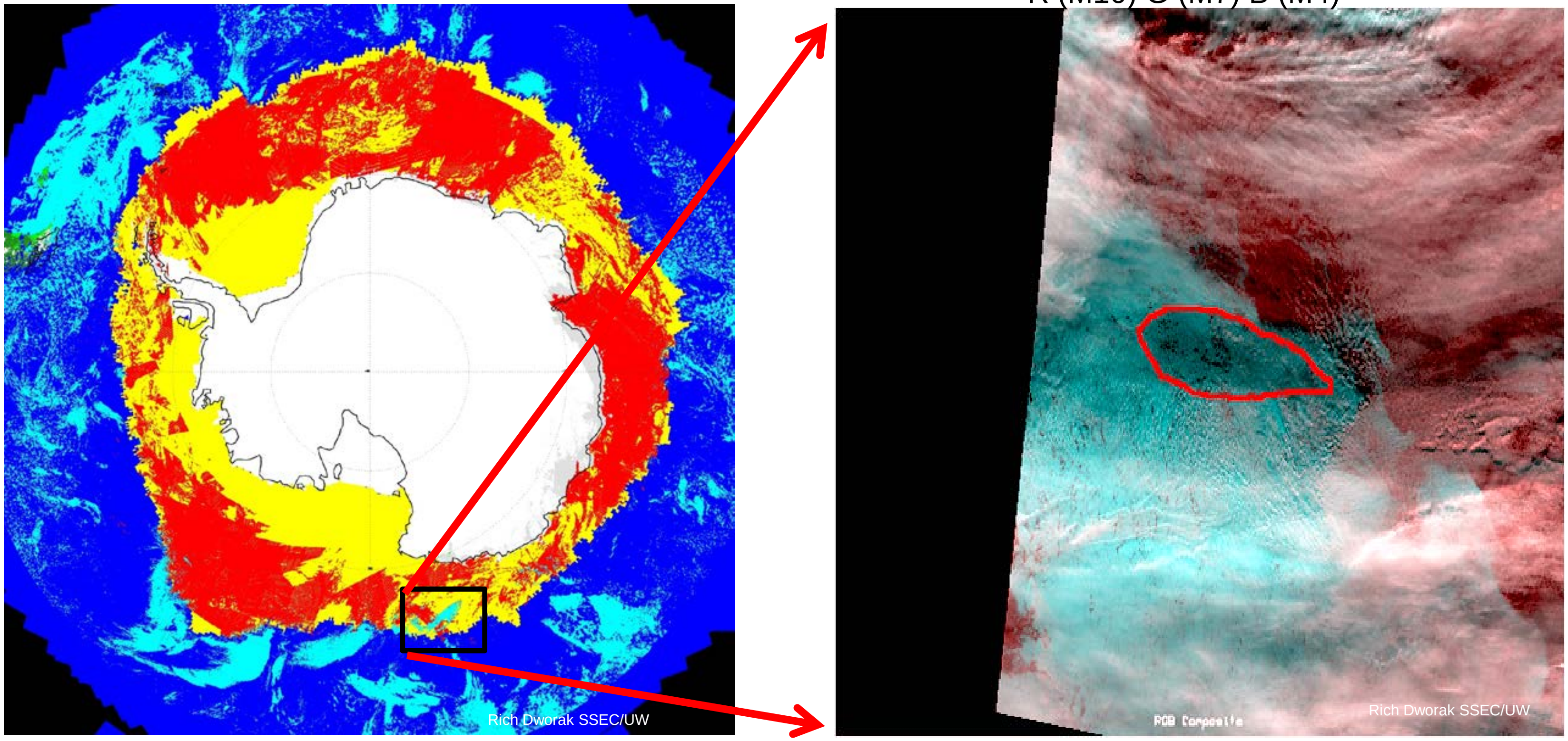
1. **Extended Cloud Adjacency**:
   - flag pixels with more than 15% clouds in a 31x31 sliding window
2. **SZA < 80°** gridded
3. **Cloud Confidence**
   - confidently clear only
   - no thin cirrus
   - no VCM cloud adjacency

After application of an extended cloud adjacency filter to the Sea Ice Concentration IP, the gridded Snow/Ice at the end of the Aug. 21-27 gridding period is consistent with the NOAA AutoSnow reference for Aug. 27 but significant regions were not updated by VIIRS data even after the 7 day gridding test period . Standard VCM cloud adjacency is applied to Snow Cover EDR

Example of Missing Ice Due to Cloud Shadows

Antarctic August 18, 2013 Pre-MX 7.2

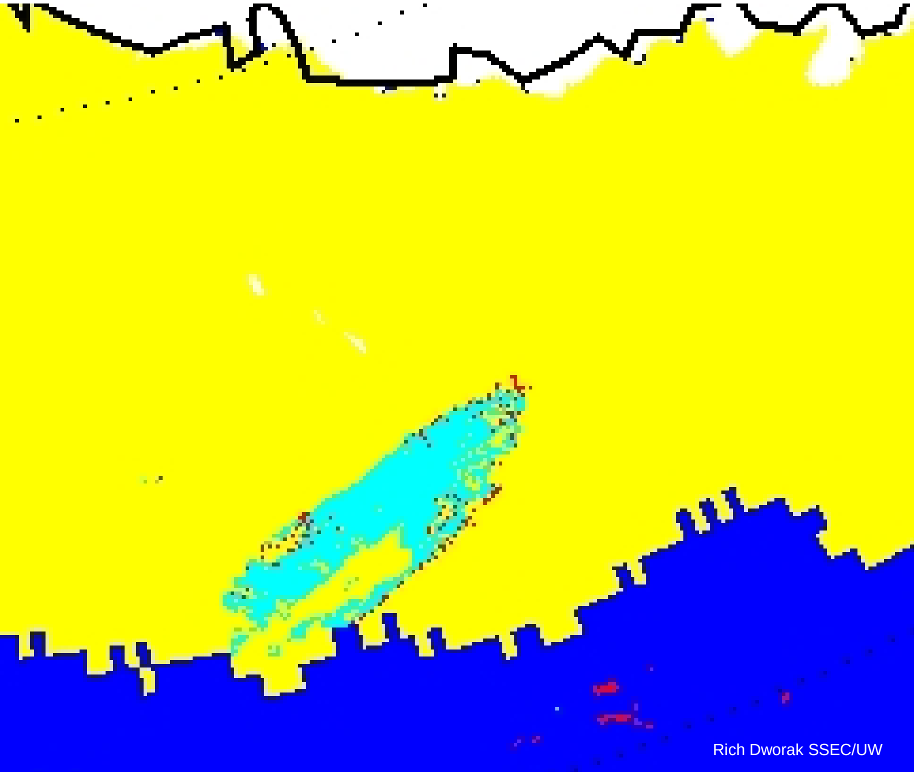
False Color SDR Reflectance for Region of Interest
R (M10) G (M7) B (M4)



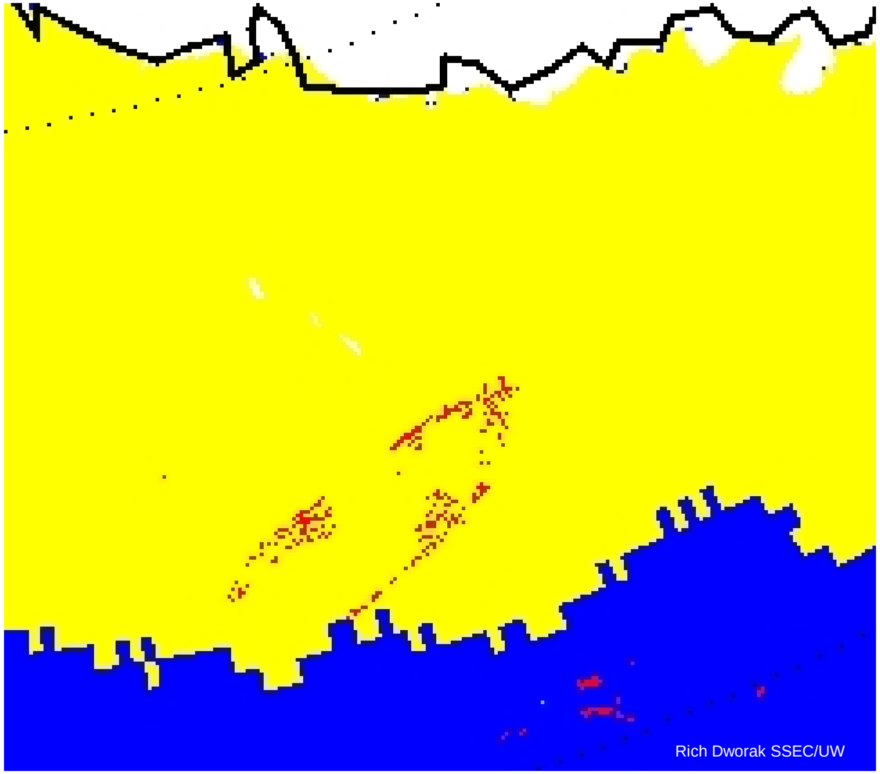
A region of missing sea ice was detected in the gridding test for Aug. 11-18, 2013. Cloud shadow seen in the enhanced false color image. The missing ice in the box region over the Antarctic (left) is due to the Ice Concentration algorithm erroneously retrieving "No Ice" in the region of lower reflectance due to undetected cloud shadows.

Antarctic Missing Ice Traced to 08/18/13 Orbit

Before



After



Missing Ice (light blue region) appears in the gridding test result for gridding for day only VIIRS data (Sol. Zen < 85°)

All missing ice detects removed with Sol. Zen. > 80 removed

Application of solar zenith angle threshold of 80° removed the missing ice associated with the cloud shadow. Although a solar zenith angle of 80° has been used for this gridding test it is recommended that the solar zenith angle threshold for gridding be tied to the VCM Cloud Shadow max solar zenith angle threshold (currently 75°) if VIIRS Snow/Ice Gridding is activated

Quantitative Comparison with GMASI Reference (NOAA AutoSnow) Snow/Ice Grid

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	Probability of Detection For VIIRS Updated Pixels		False Alarm Rate For VIIRS Updated Pixels	
	Sea Ice	Snow	Sea Ice	Snow
Northern H.	87.2 % (78.4%)	(87.8%)	6.6% (8.7%)	(10.0%)
Southern H.	94.4 % (92.8%)	(96.5%)	4.9% (5.6%)	(3.2%)

PoD = 100 x nSnowIceMatch/(nSnowIceMatch + nSnowIceMissing + nSnowIceFalse)

FAR = 100 x (nSnowIceFalse)/(nSnowIceFalse + nSnowIceMatch)

- Probability of detection and false alarm rate are shown for VIIRS updated pixels with all additional QC criteria applied
- Values shown in parenthesis have had No extended cloud adjacency filter applied
- PoD and FAR as defined here are relative to the NOAA AutoSnow product which used as the reference or derived truth

Probability of Detection (PoD) and False Alarm Rates (FAR) , shown above. Even after application of an Extended Cloud Adjacency filter, gridding only day pixels with Sol. Zen < 80° and all cloud mask elements confidently clear errors remain for VIIRS gridded sea ice.

Gridding Test Summary

- Improvement in VIIRS gridded Snow/Ice due to MX 7.2 VCM update and application of additional quality control criteria which included:
    1. Extended cloud adjacency applied to Sea Ice Concentration IP
    2. Standard cloud adjacency applied to Snow Cover EDR
    3. Confidently clear pixels only
    4. No thin cirrus
    5. Solar zenith angle limited to angles less than 80°
    6. Fallback to GMASI if no good quality VIIRS Snow/Ice after 5 days
- Sea Ice PoD and FAR relative to NOAA AutoSnow for VIIRS gridded Sea Ice are approximately 87% and 7% respectively after testing with the proposed quality control criteria
- Significant regions were not updated by VIIRS Snow/Ice even after a 7 day gridding test period
- Cloud shadows result in missing snow/ice in the Snow/Ice Rolling Tile grid. A solar zenith angle threshold of 80° used in the gridding tests appeared to mitigate cloud shadow errors.
- Gridding tests did not include Northern Hemi. Winter which is important for testing snow cover gridding
- Further reduction in Snow/Ice gridding errors will require significant effort to implement climatology based quality control criteria used for the production of the NOAA AutoSnow and additional quality control criteria

(4) Recommendations

THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN

Recommendations

NORTHROP GRUMMAN

- Implement Near Term Plan to Update the Snow/Ice Rolling Tiles Daily with GMASI
  - Activate Snow/Ice GranToGrid with VIIRS Snow and Ice Gridding Switches OFF
- Daily updating with GMASI is most likely adequate for downstream product quality
  - After daily GMASI updating becomes operational downstream products should be evaluated to determine whether further improvements are needed
  - Activation of VIIRS Snow or Ice gridding requires additional quality controls such as those used in the production of the NOAA AutoSnow product and should be tested only after being determined as necessary due to the significant level of effort associated with implementing such controls

Backup Slides

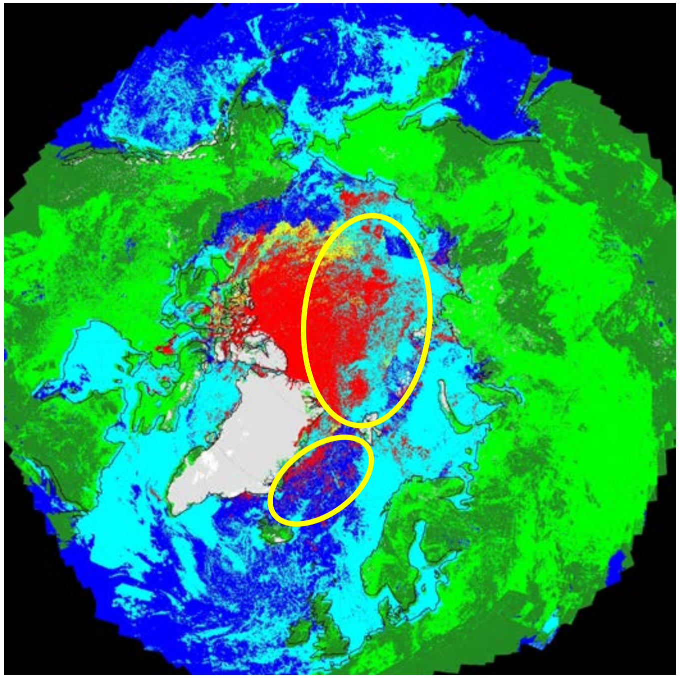
THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN

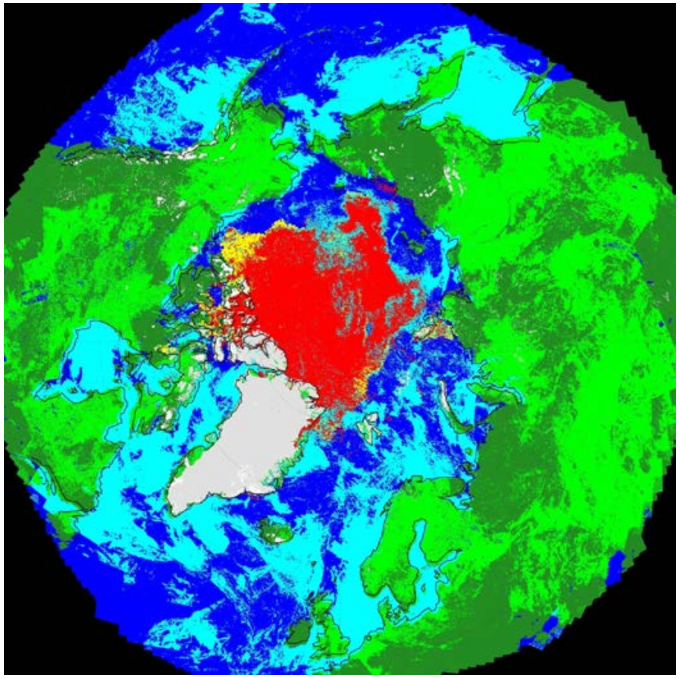
Gridding Tests Based on Post MX 7.2 Improved VCM

- MX 7.2 VCM Updates – Implemented at IDPS on Aug. 20, 2013
  - –Significant improvement to snow/ice/cloud differentiation in daytime scene (ADR 7018)
  - – Added thresholds for the gross nighttime Infrared (IR) and Mid-Wave IR difference cloud detection test (ADR 7018). Also corrected logic for cloud shadows (ADR 7028)

VIIRS Gridded Snow/Ice – Pre MX 7.2
End of 1 Week Gridding Test August 18, 2013



VIIRS Gridded Snow/Ice – Post MX 7.2
End of 1 Week Gridding Test August 27, 2013



GMASI

- Ice over water (yellow)
- Snow over land (white)
- No Snow over land (dark green)
- No Ice over water (blue)

VIIIRS Updated

- Ice over water (red)
- Snow over land (grey)
- No Snow over land (green)
- No Ice over water (cyan)

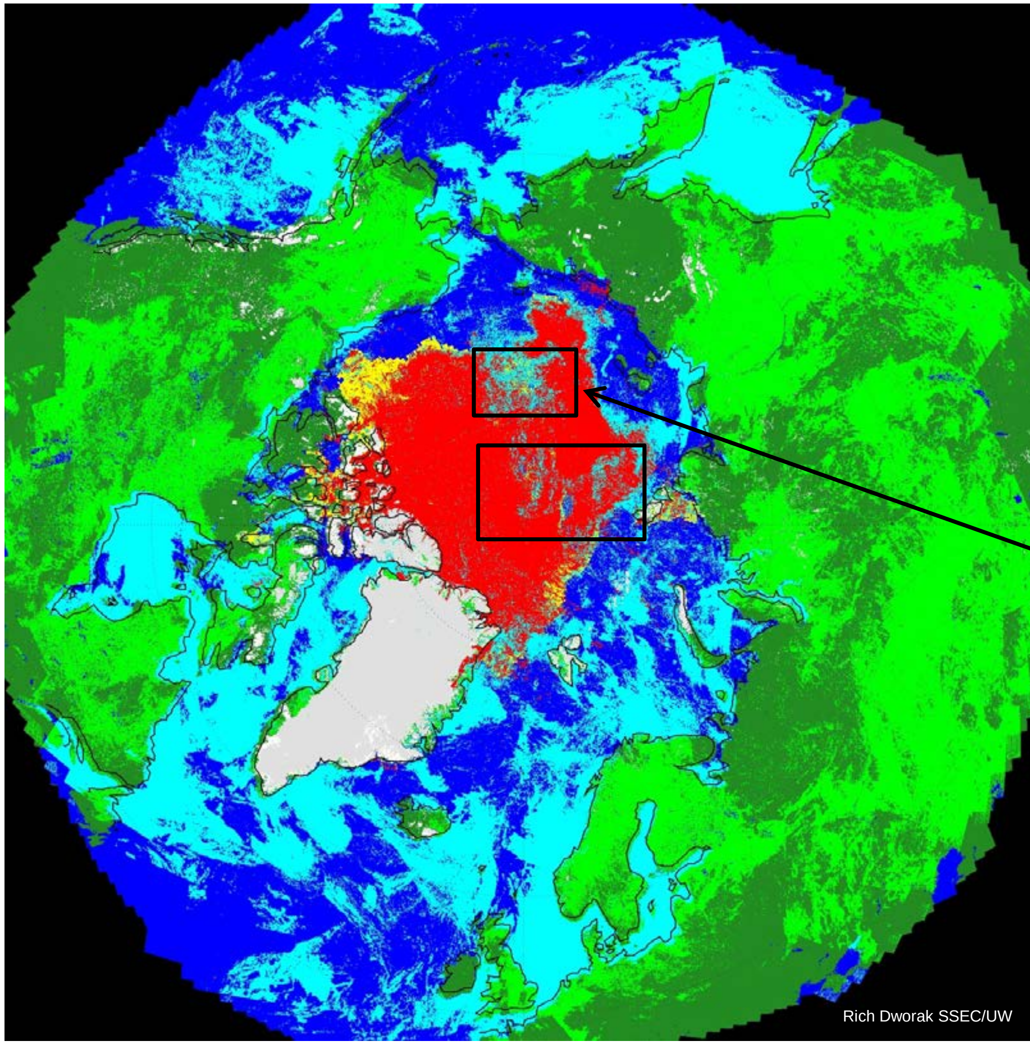
Gridding Quality Criteria

1. **No Extended Cloud Adjacency**:
2. **Only SZA < 80°** gridded
3. **Cloud Confidence**
   - confidently clear only
   - no thin cirrus
   - no VCM cloud adjacency

Gridding tests performed with Post MX 7.2 data (right) showed significantly less missing ice and false ice over the Northern Hemisphere. Circled regions in the Pre-MX 7.2 gridding test result show large regions of false ice and missing ice (left).

VIIRS Snow/Ice Gridding Test – Post MX 7.2
No Extended Cloud Adjacency Filter

NORTHROP GRUMMAN



GMASI

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

VIIRS Updated

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

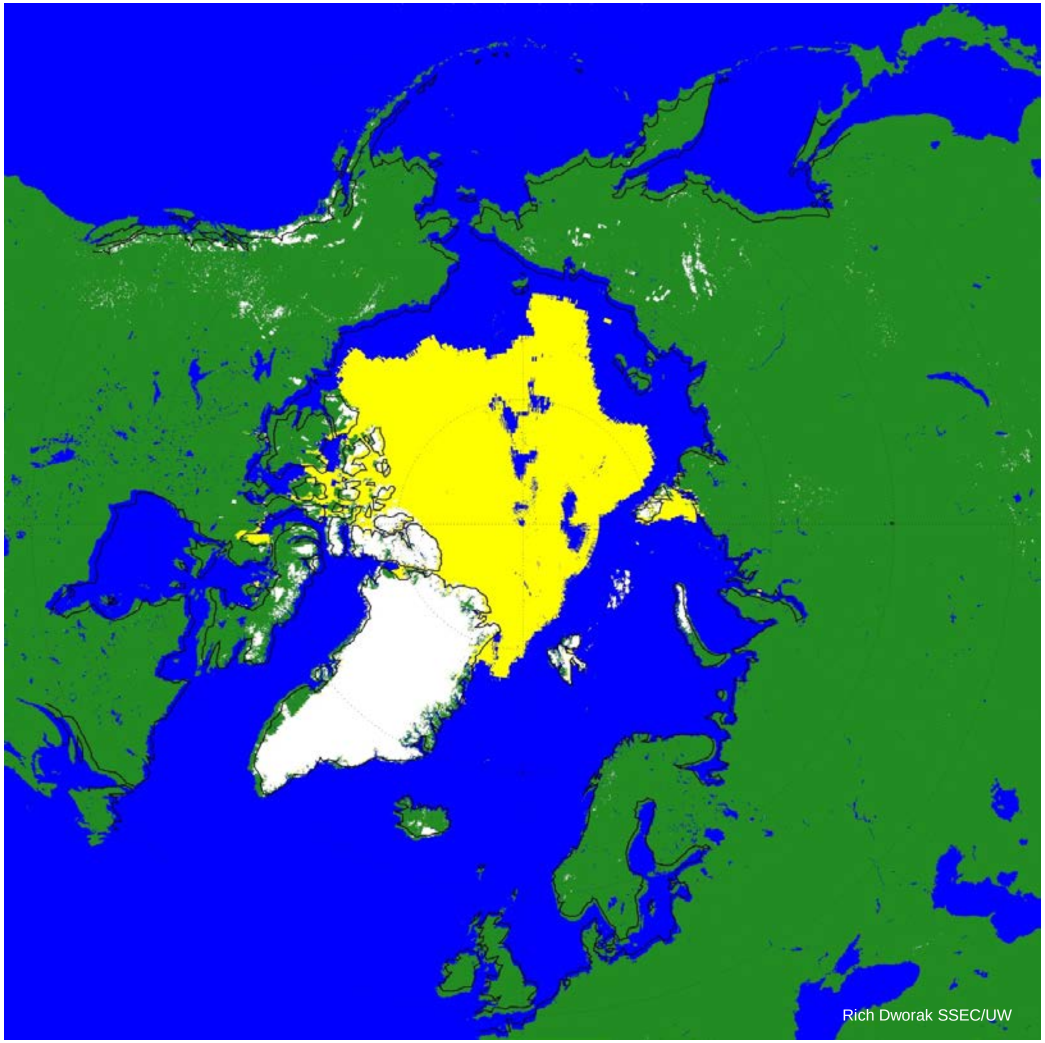
Missing Ice regions

Gridding Quality Criteria

1. **No Extended Cloud Adjacency**:
2. **Only SZA < 80°** gridded
3. **Cloud Confidence**
   - confidently clear only
   - no thin cirrus
   - no VCM cloud adjacency

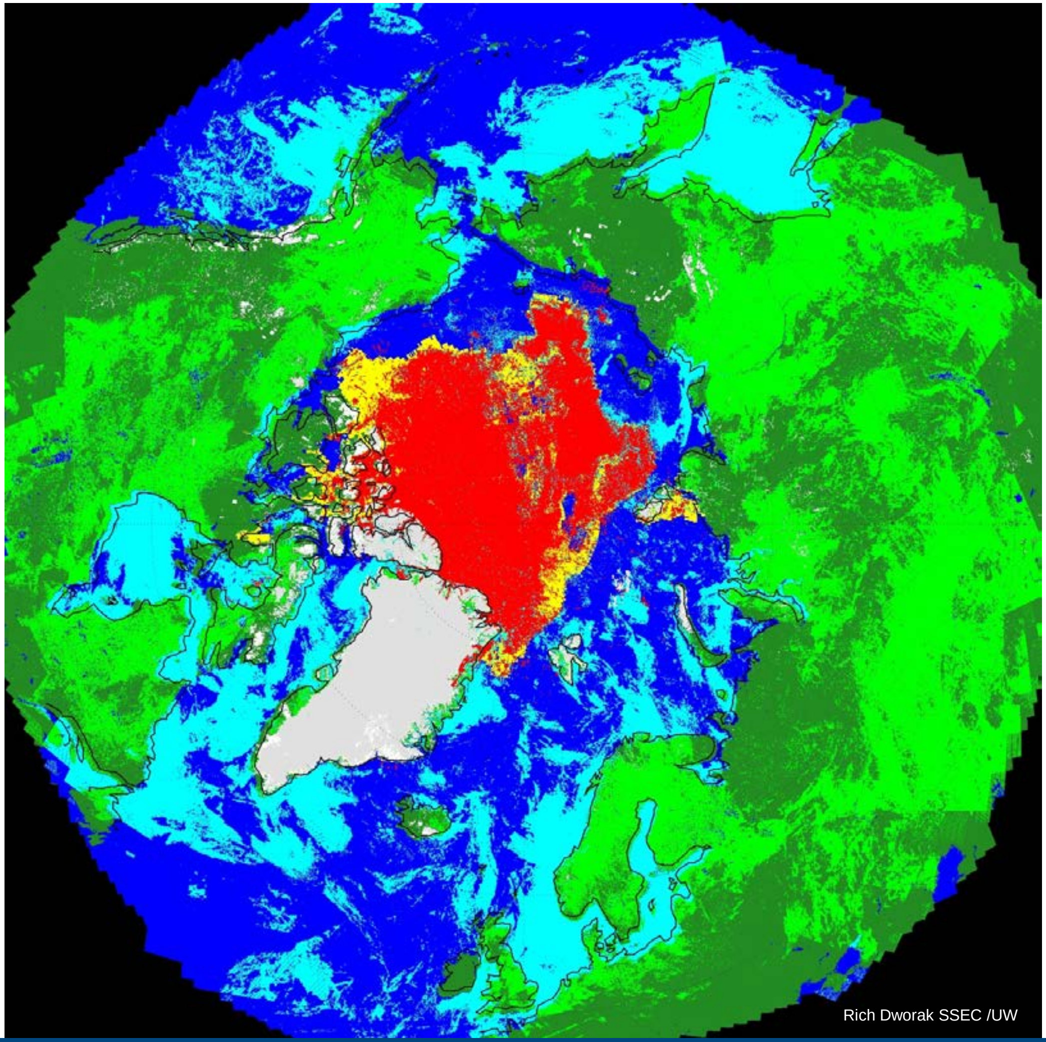
Gridding test results after a one week gridding period (Aug. 21-27, 2013). Regions of missing ice still appear in the grid (boxed regions) based on gridding using the standard VCM cloud adjacency quality control

NOAA AutoSnow Used as Reference VIIRS Snow/Ice Gridding Test – August 27, 2013



NOAA AutoSnow reference for the end of day of Aug 27 for the one week gridding period August 21-27, 2013

VIIRS Snow/Ice Gridding Test – Post MX 7.2 VCM Extended Cloud Adjacency Filter



GMASI

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

VIIRS Updated

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

Gridding Quality Criteria

1. Extended Cloud Adjacency:
- flag pixels with more than 15% clouds in a 31x31 sliding window

2. SZA < 80° gridded

3. Cloud Confidence
- confidently clear only
- no thin cirrus
- no VCM cloud adjacency

After application of an extended cloud adjacency filter to the Sea Ice Concentration IP, the gridded Snow/Ice at the end of the Aug. 21-27 gridding period is consistent with the NOAA AutoSnow reference for Aug. 27 but significant regions were not updated by VIIRS data even after the 7 day gridding test period . Standard VCM cloud adjacency is applied to Snow Cover EDR

VIIRS Gridded Snow/Ice Test – Post MX 7.2 VCM Extended Cloud Adjacency Filter Applied

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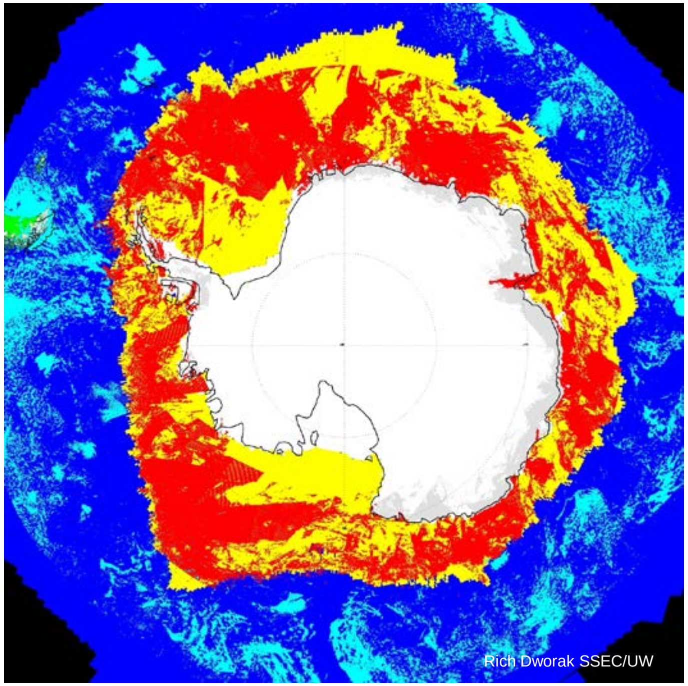
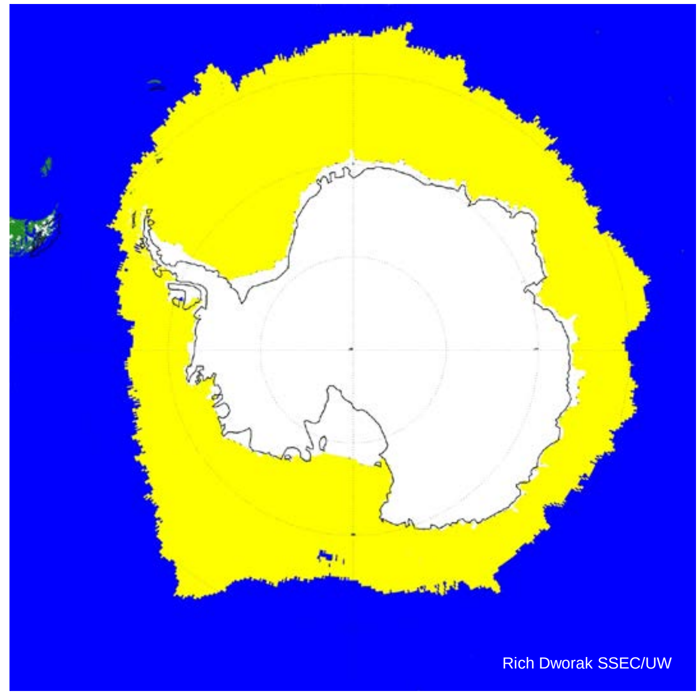
Gridded Snow/Ice Antarctic Aug. 27, 2013



NOAA AutoSnow Antarctic Aug. 27, 2013



GMASI

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

VIIRS Updated

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

Gridding Quality Criteria

1. Extended Cloud Adjacency:
- flag pixels with more than 15% clouds in a 31x31 sliding window

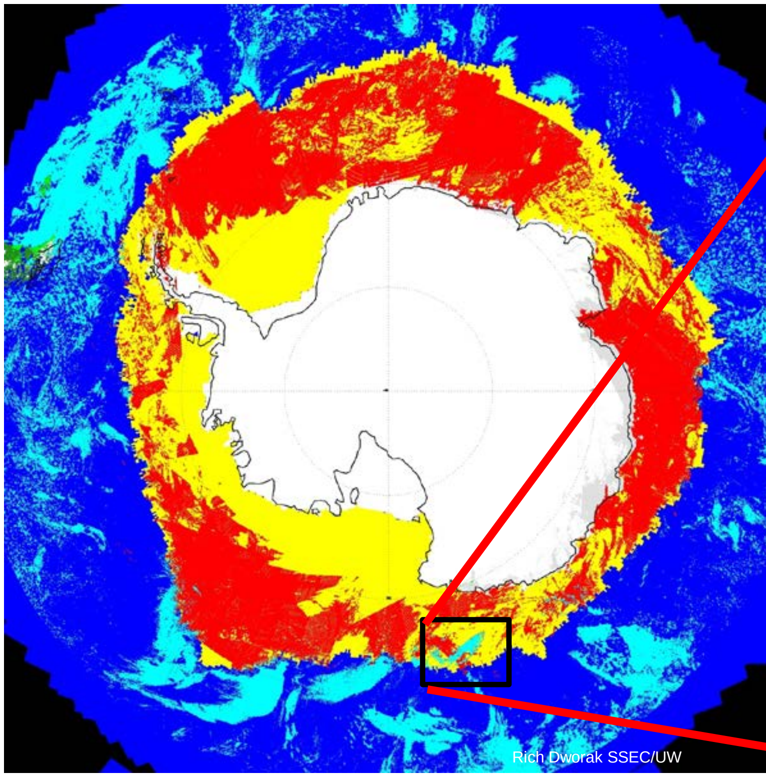
2. SZA < 80° gridded

3. Cloud Confidence
- confidently clear only
- no thin cirrus
- no VCM cloud adjacency

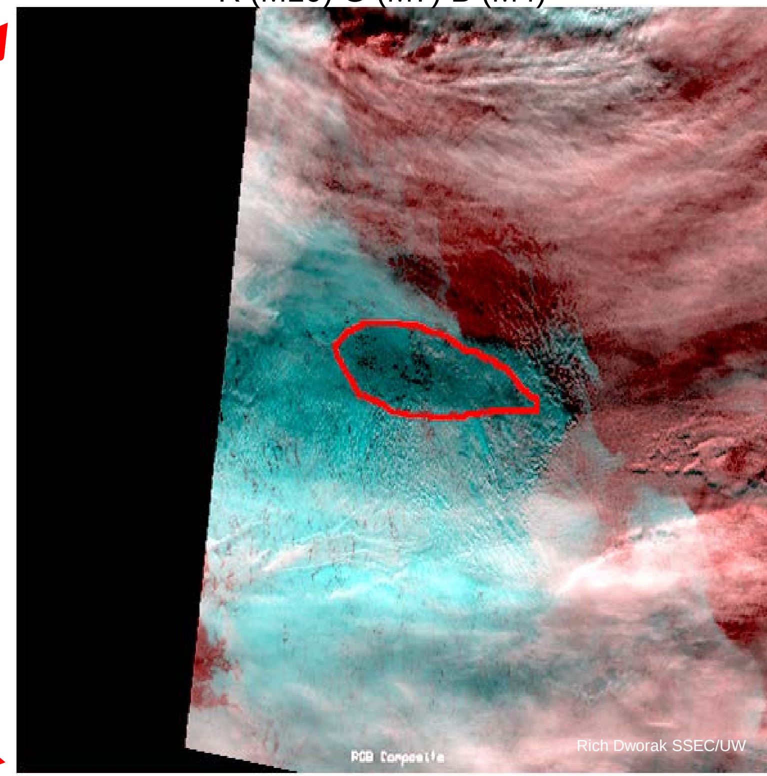
After one week gridding test period (Aug. 21-27) Snow/Ice in the VIIRS Snow/Ice gridding test grid (left) is consistent the GMASI (NOAA AutoSnow) but significant regions were not updated by VIIRS data even after the 7 day gridding test period.

Example of Missing Ice Due to Cloud Shadows

Antarctic August 18, 2013 Pre-MX 7.2



False Color SDR Reflectance for Region of Interest
R (M10) G (M7) B (M4)



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Antarctic Missing Ice Traced to 08/18/13 Orbit

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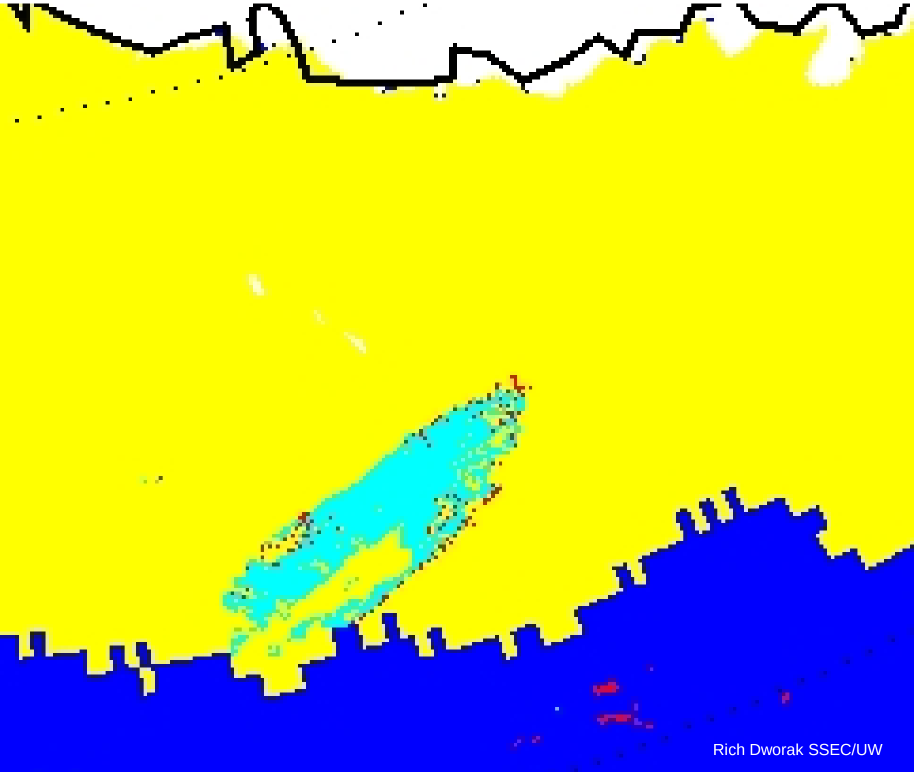
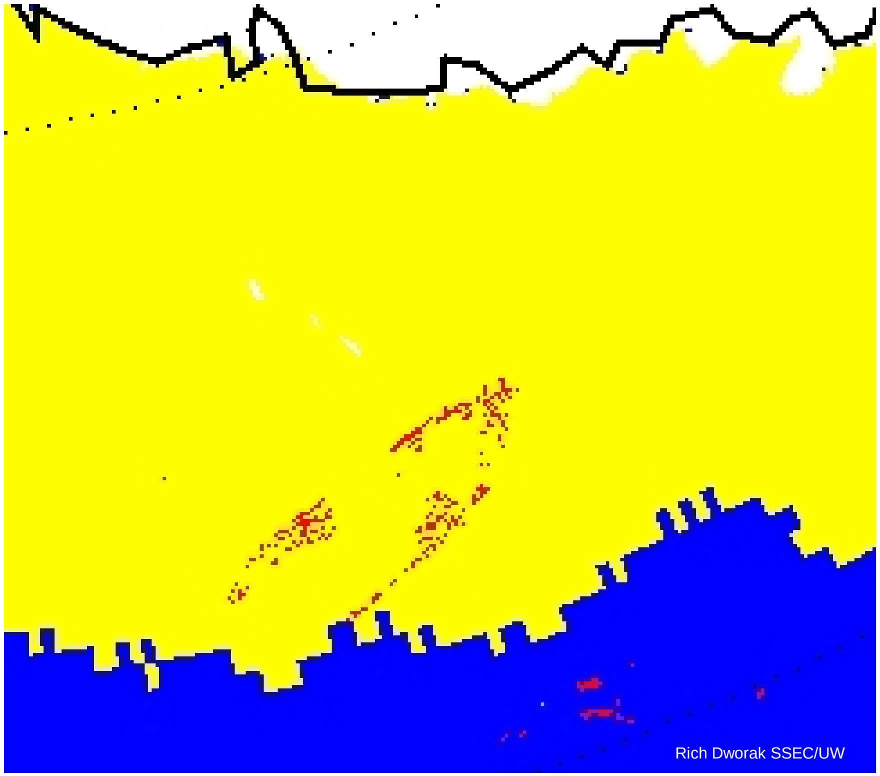


Missing Ice (light blue region) appears in the gridding test result for gridding for day only VIIRS data (Sol. Zen < 85°)

After



All missing ice detects removed with Sol. Zen. > 80 removed

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Long Term Plan – Step 3: Activation of VIIRS Snow and Sea Ice Gridding with Climatology Based and Other Checks

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- Duplicate all NOAA AutoSnow Q/C criteria checks
- Substantial level of effort that requires new climatology ancillary data and updates to the GranToGrid SnowIceCover, Snow Cover and Sea Ice Concentration IP routines.

Long Term Plan – Higher Impact: Activate VIIRS Snow/Ice Gridding after implementation of Additional Quality Climatology Based Quality Control Criteria			
ADR	ADR Title	Description	Action
Not yet	Sea Ice Concentration IP Additional Quality Control Criteria	Apply additional surface temperature and climatology based surface temperature checks	•Identify NOAA AutoSnow tests and climatology data • Relative Azimuth test for high solar zenith angles •Prototype proposed tests, format conversion for new ancillary data Identify/submit ADRs
Not Yet	Snow Cover EDR Additional Quality Control Criteria to prevent false snow	Apply additional surface temperature, climatology and terrain height tests to screen false snow	•Identify NOAA AutoSnow tests and climatology data •Relative Azimuth test for high solar zenith angles • Extended Cloud Adjacency added to Snow Cover •Prototype proposed tests, format conversion for new ancillary data Identify/submit ADRs

Suomi-NPP VIIRS Land Product Quality Assessment Approach and Collection V1.1 Reprocessing

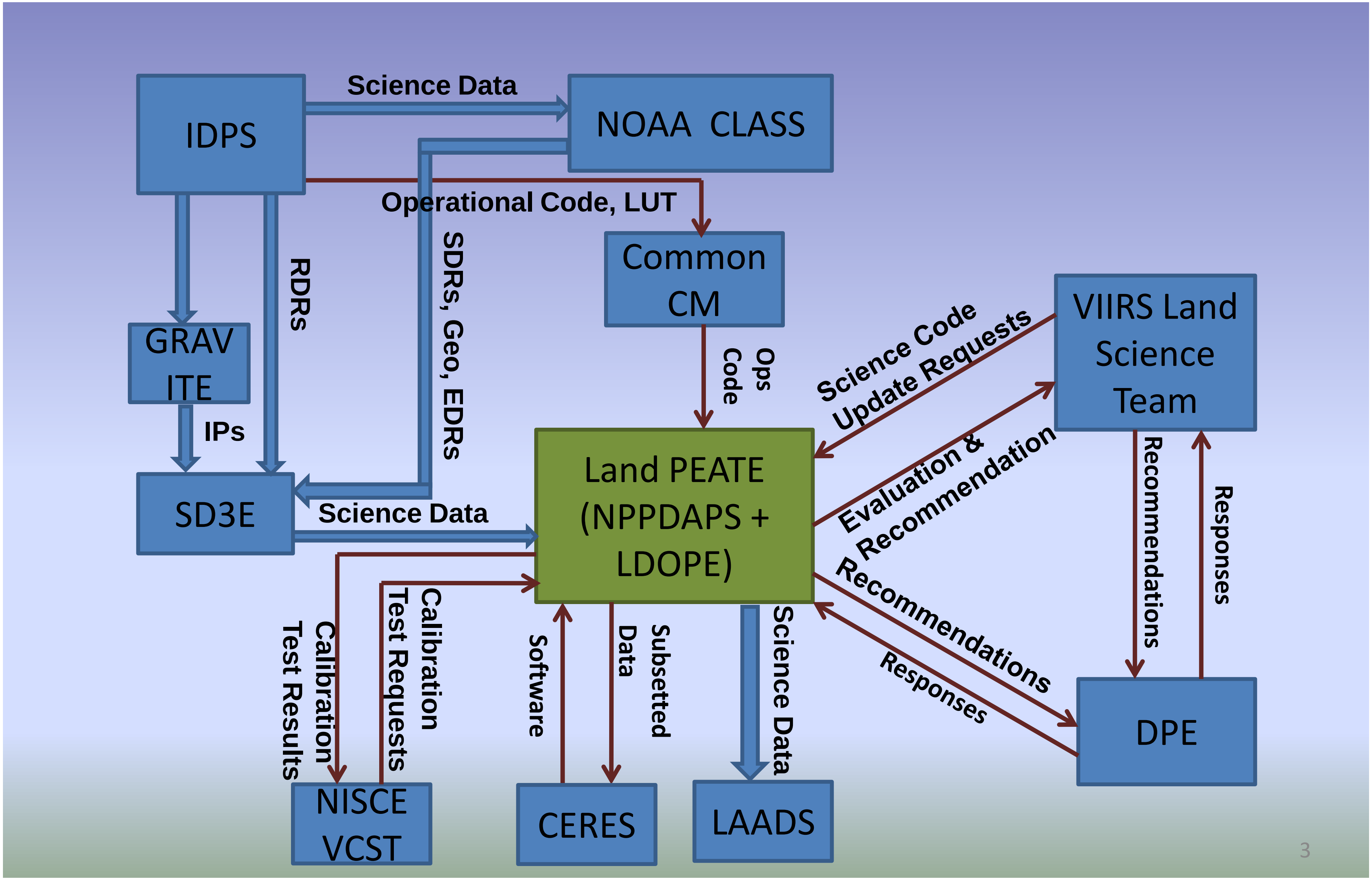
Sadashiva Devadiga[1,2], Carol Davidson[1,2], Sudipta Sarkar[1,2], Gang Ye[1,2], Maki Hattori[1,2], Cid Praderas[1,2], Virginia Kalb[1], Anhquan Nguyen[1,2], Cynthia Hamilton[1,2], James Kuyper[1,2], Miguel Román[1,2], and Ed Masuoka[1,2]

[1]NASA Goddard Space Flight Center, [2]Sigma Space Corporation

Land Product Evaluation and Analysis Tool Element

- **Component of NASA's Science Data Segment (SDS) of the Suomi NPP**
  - Assess the quality of the Visible Infrared Imaging Radiometer Suite (VIIRS) Land Products made by the Interface Data Processing System (IDPS)
  - Recommend improvements to the VIIRS Land science algorithms.
- **Uses NPP Data Processing System (NPPDAPS) for production of data and Land Data Operational Product Evaluation (LDOPE) for evaluation of the data products.**
  - NPPDAPS is a version of the MODIS Adaptive Processing System (MODAPS) modified to make products from the IDPS operational code and software provided by the science teams.
  - LDOPE Team adopts the MODIS Land QA approach to evaluate the quality of the VIIRS Land Products.

Interface of Land PEATE with SDS Elements and External Segments



Land PEATE Data Ingest & Production

- **Land PEATE has been receiving VIIRS data and processing 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. *(LAADS Archive Set 3000).* Downsized to 1 global day per week. Data used to verify the accuracy of products produced in AS 3001. Build version in operation at IDPS is Mx83.
  - ***LPEATE (LAADS AS 3001):*** Process RDRs using IDPS OPS PGEs integrated to Land PEATE processing system. Products match to aggregate IDPS products in AS 3000 except for minor difference from out of sync algorithm build versions, 17-day RNDVI roll up, and monthly snow-ice GIP rolling tiles, Ancillaries, and LUTs. Build version in operation is Mx73.
  - ***LPA (LAADS AS 3002):*** Process RDRs using Land PEATE 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 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 PEATE by processing RDRs using the IDPS operational algorithms in AS 3001.**
  - Through comparison of global browse images of Land PEATE 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 Product QA Web Page

National Aeronautics and Space Administration
Goddard Space Flight Center

Suomi NPP - Land Product Evaluation and Analysis Tool Element

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 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 PEATE (Product Evaluation and Analysis Tool Element) 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 PEATE adjusted version of the IDPS OPS algorithms run at Land PEATE 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

- C11 Reprocessing Underway
- C1 Reprocessing in progress: Reprocessing of L1B SDRs completed for the period 01/19/12 - 07/09/2013. Reprocessing of Land xDRS expected to start in Oct 2013. Data products from the reprocessing available in AS 3100 of LAADS
- Land PEATE is currently using IDPS Mx6.3/6.7 build versions of the algorithm in the forward processing. Mx7.2 build, put in operation on 8/20 at IDPS, is currently under testing and is expected to be in operation by end of Sept 2013
- VIIRS xDR from the processing of on-orbit data at Land PEATE using the same algorithm version as IDPS is available from AS 3001 of LAADS. Data products from IDPS processing aggregated 5min granule is available from AS 3000 and products from science team improved version of algorithm available from AS 3002. Please see the Land LPEATE data production and retention policy to verify availability of data online.
- Data products from the early mission period were labeled as of **BETA** quality. Many products have now reached maturity stage of "provisional quality".

Goddard Space Flight Center

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

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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_CMIP_L2 Cloud Mask IP Day	NPP_CMIP_L2 Cloud Mask IP Night	NPP_VAMIIP_L2 Aerosol Model IP	NPP_VAOTIP_L2 Aerosol Optical Thickness IP	NPP_VCOPIP_L2 Cloud Optical Properties COT	NPP_VCOPIP_L2 Cloud Optical Properties EPS	NPP_VISA_L2 Surface Albedo
2014 128 05/8	Orbits									
2014 127 05/7	Orbits									
2014 126 05/6	Orbits									
2014 125 05/5	Orbits									
2014 124 05/4	Orbits									
2014 123 05/3	Orbits									
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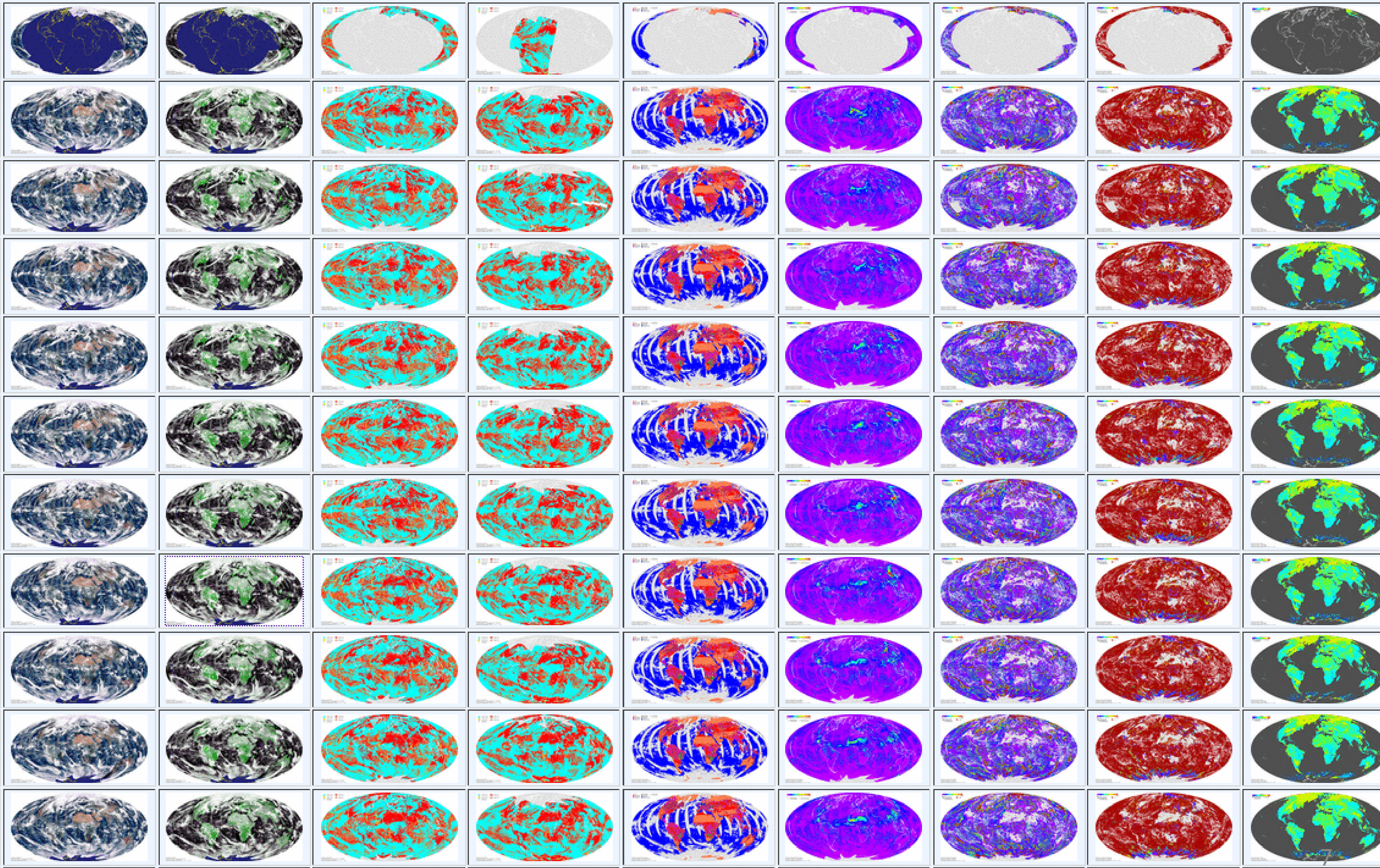
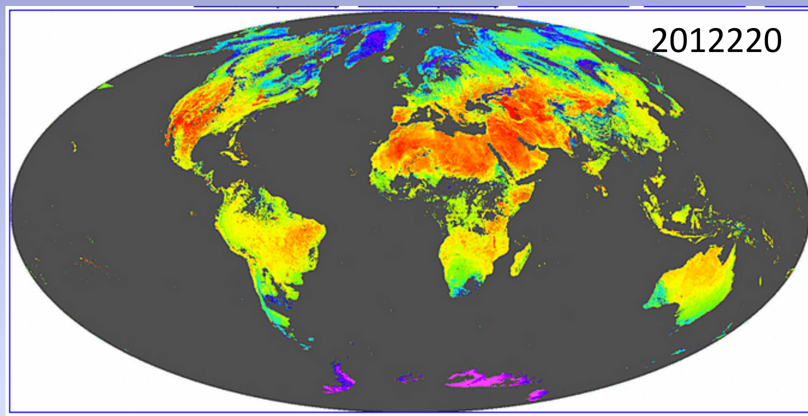
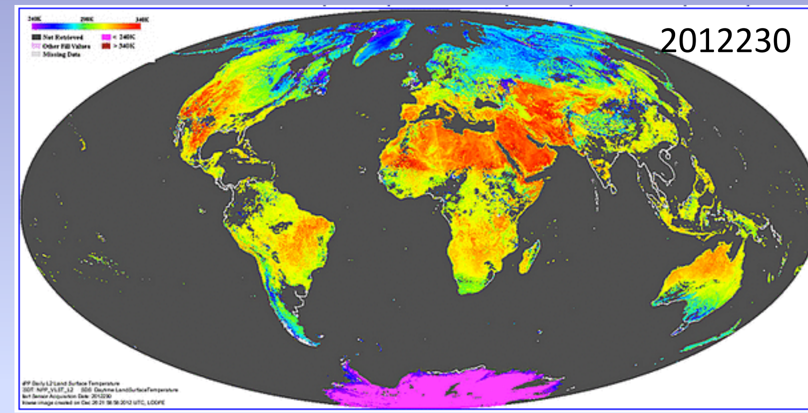
2014 121 05/1	Orbits									
2014 120 04/30	Orbits									
2014 119 04/29	Orbits									
2014 118 04/28	Orbits									

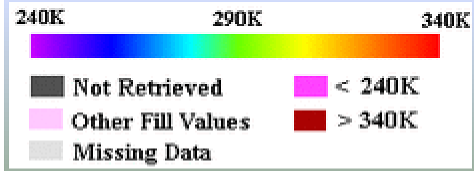


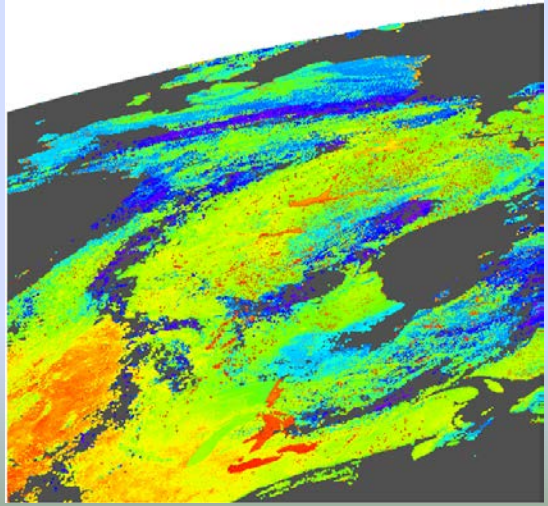
Land Product Quality Assessment
Product Issue – LST EDR

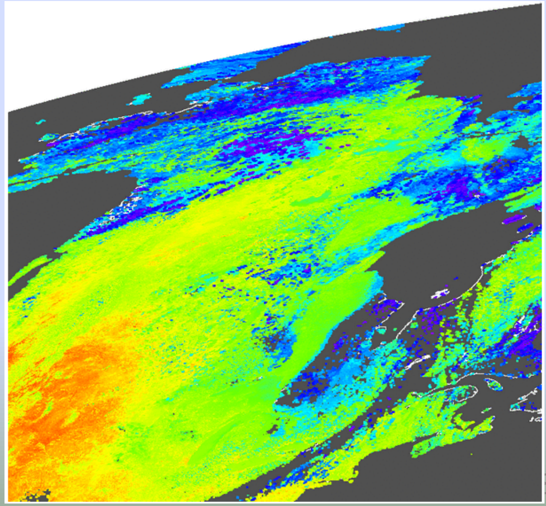
- **The VIIRS Land Surface Temperature EDR reported incorrect high temperatures over inland water bodies. This was fixed in Mx6.2 build version put in operation on 2012223 (08/10/2012)**





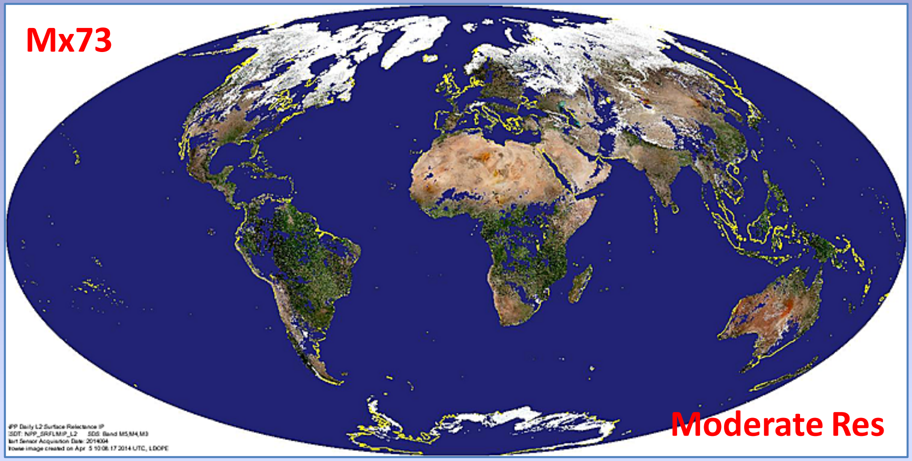


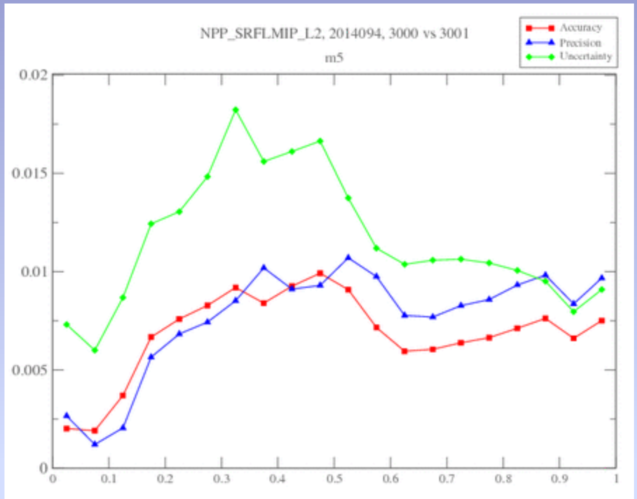


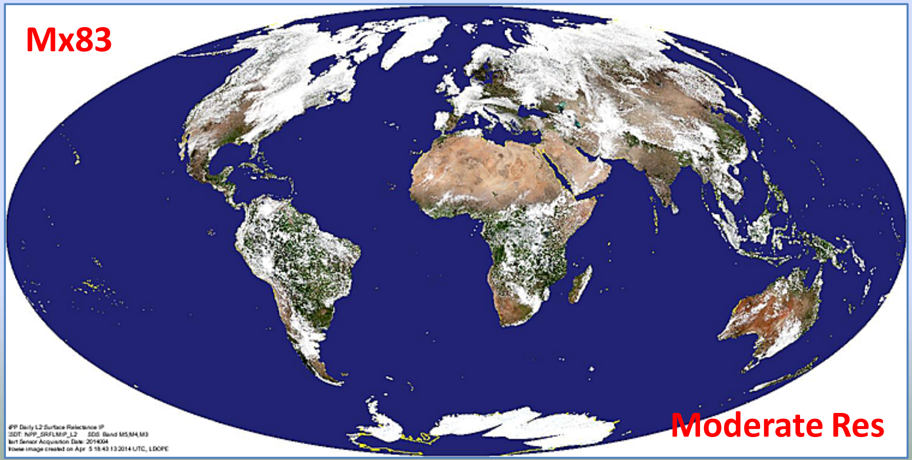


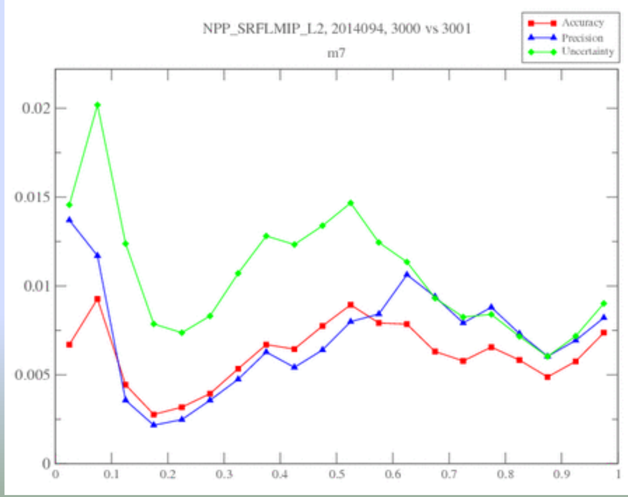
Land Product Quality Assessment Algorithm Change/Improvement – SR IP

- **The VIIRS Surface Reflectance IP algorithm was changed to retrieve reflectance all atmospheric conditions in Mx8.3 put in operation on 03/18/2014. Uses MODIS Climatology instead of the NAAPS/Climatology when AOTIP is not retrieved. Mean difference in reflectance < 0.005.**









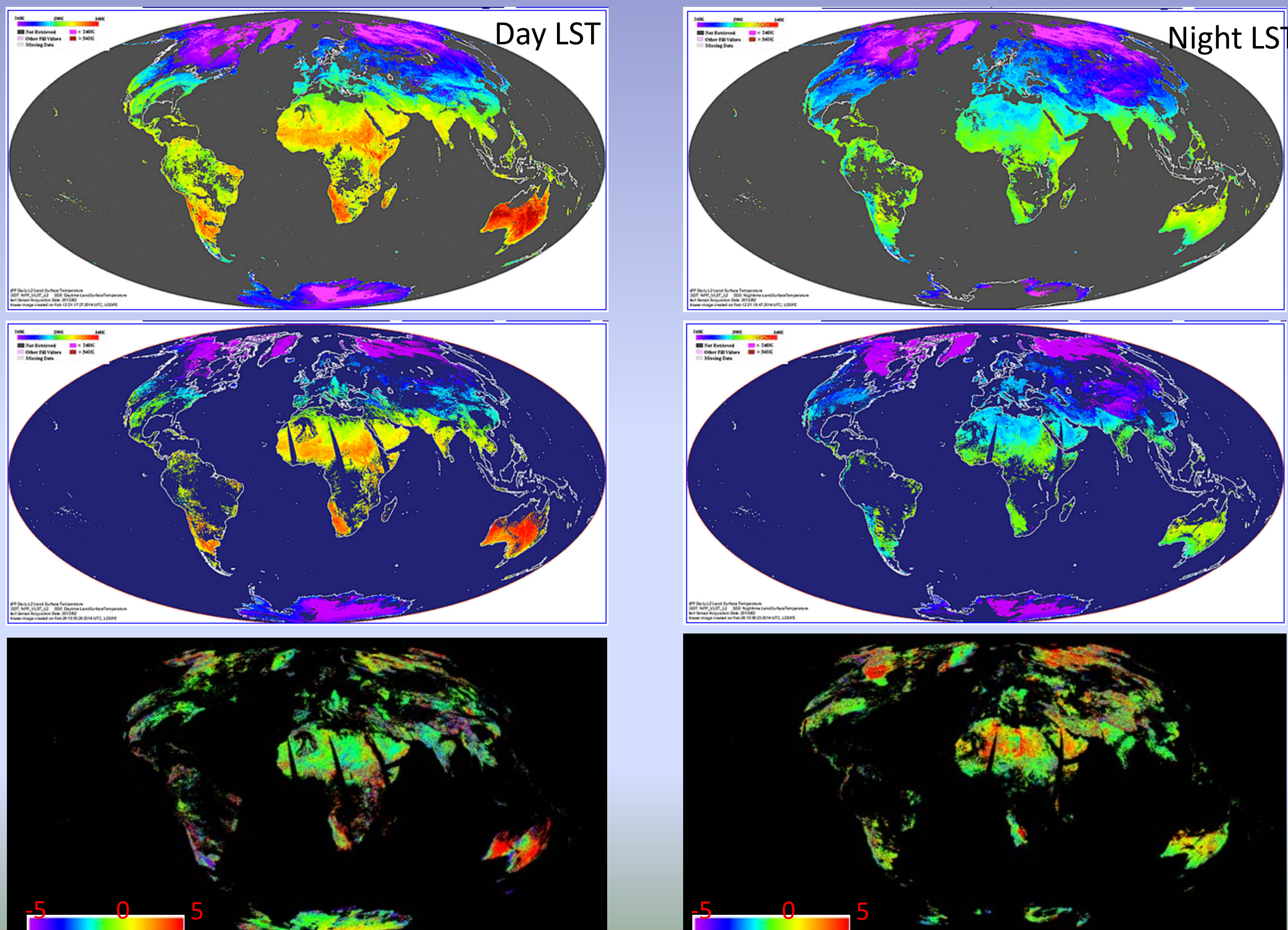
Land Product Quality Assessment Science Test – Coefficient LUT Update

- **Land PEATE ran science test of Mx8 LST Algorithm with the new Land Cover based Coefficient LUT for a data day (2013362) where nearly all observations from Aqua are within 30 minutes of NPP acquisition. Compared LST from VIIRS to operational MODIS C5 LST.**

VIIRS – Mx8

MODIS – C5

VIIRS – MODIS



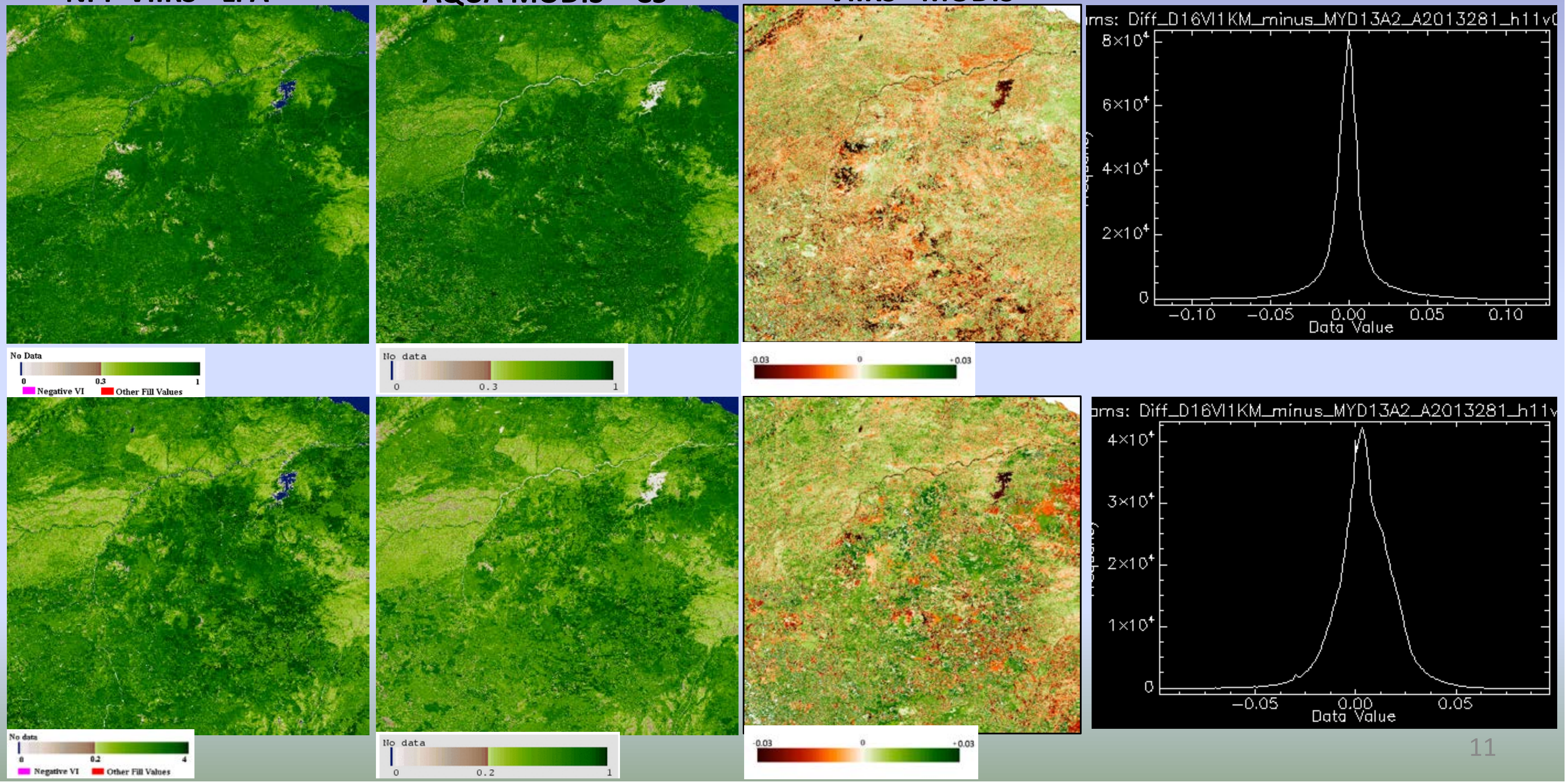
Land Product Quality Assessment Diagnostic Data Records (DDR)

- **VIIRS Level 3 daily and n-day composite gridded products generated by modifying the MODIS C5 operational algorithms to read the VIIRS xDRs and IPs with spectral remapping of corresponding VIIRS bands and associated QA flags. DDRs are of MODIS tile size and resolution.**

NPP VIIRS - LPA | **AQUA MODIS – C5** | **VIIRS - MODIS** | **Difference Histogram**

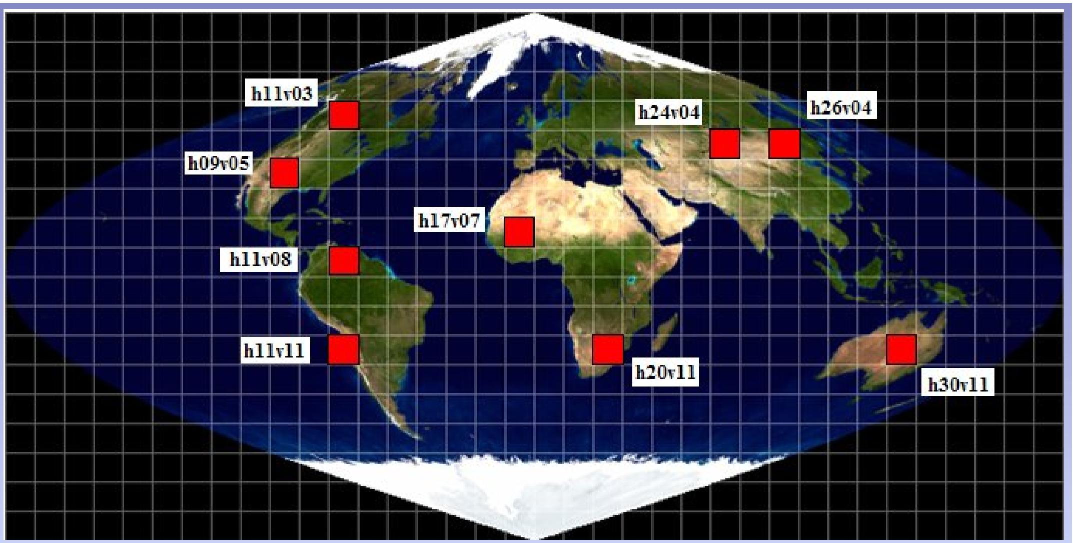
TOC NDVI

TOC EVI

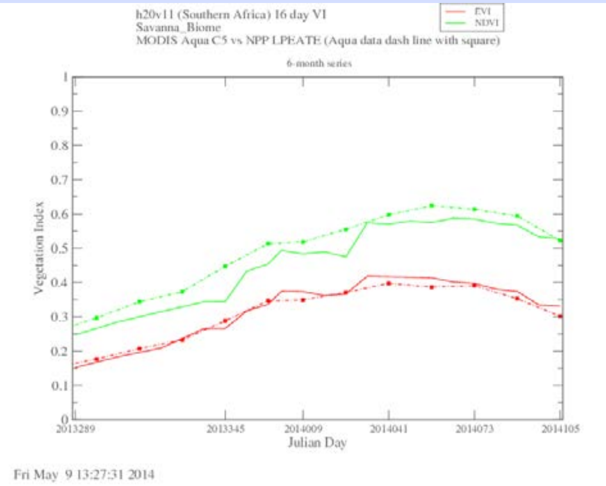


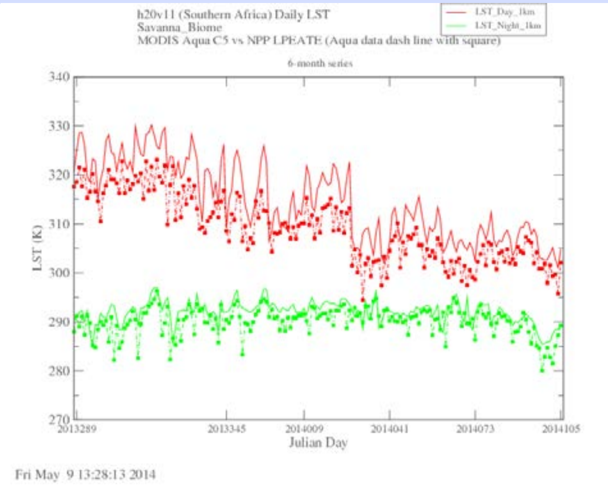
Land Product Quality Assessment Golden Tile Time Series

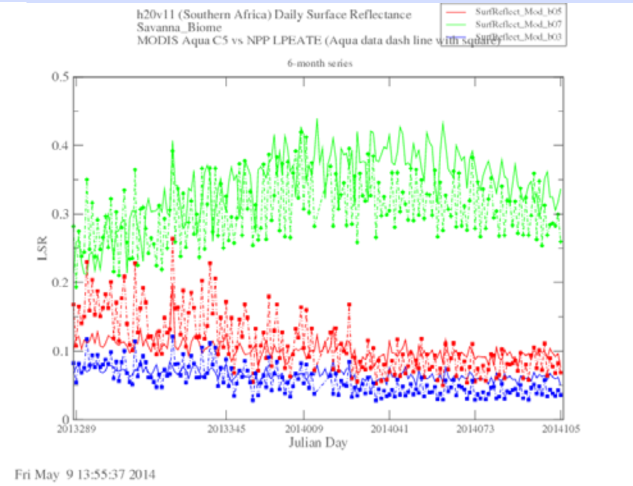
- A time series of summary statistics derived from the NPP Land DDRs at a number of fixed globally distributed locations is maintained and monitored.
- Geographical locations are of size 10 deg x 10 deg known as golden tiles.
- Summary statistics include mean, standard deviation, min, max, and number of observations of good quality observations in the tile.



- Following examples show product time series comparing products from VIIRS-LPEATE and MODIS-C5. Trending shown for observations from Savana biome from golden tile h20v11.







V1.1 Reprocessing of Suomi NPP Land Records

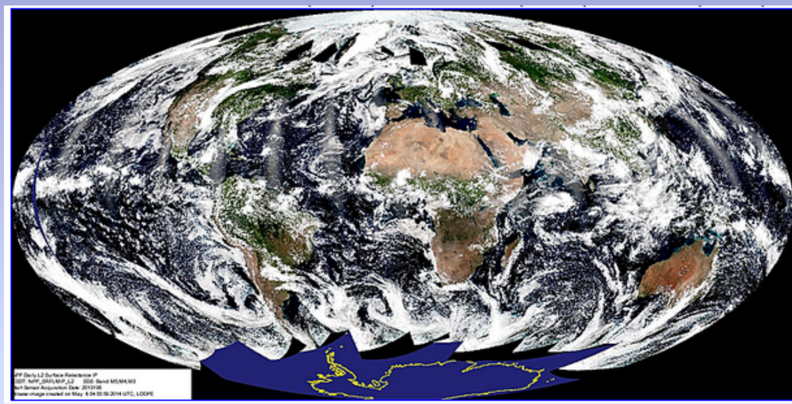
- **Generate consistent records from the beginning of the mission using the best calibration LUT and best of algorithms available.**
- **Reprocessing started on 2/26/2014 with beginning data day 1/19/2012 will go through to the present.**
- **At the current rate of 8x the reprocessing is expected to complete in July 2014.**
- **Data products are available from AS 3110**

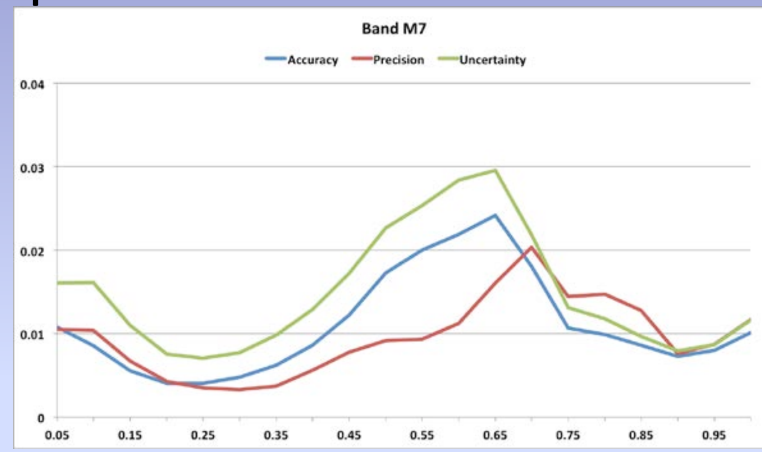
V1.1 Reprocessing of Suomi NPP Land Records

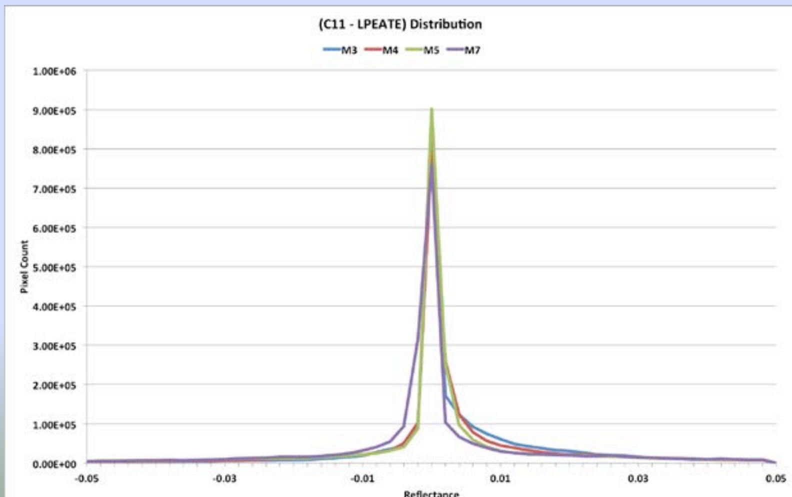
- **This reprocessing uses the calibration LUTs provided by the NASA VCST for the L1B SDR.**
- **DNBs are processed using the LUT for calibration and stray light correction provided by the NASA VCST.**
- **Processing uses the LPEATE Adjusted variations of OPS PGEs for TC DNB Geolocation (DNFT), L2 LSR (SR-IP), L2 VI (VRVI) and L2 Aerosols (AOTIP).**
- **Land PEATE processes the LPEATE Science DDRs using the most recent 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.**
- **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 snow-ice rolling tiles used in the operational process at IDPS.**

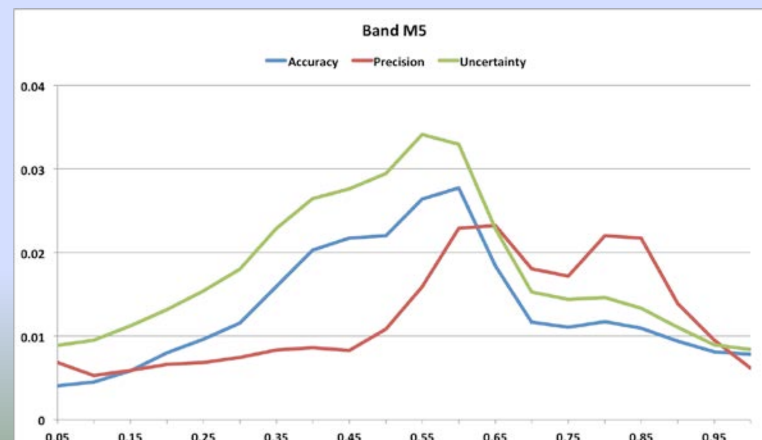
V1.1 Reprocessing – Evaluation in progress
Surface Reflectance IP - 2013195

- **C11 Surface Reflectance algorithm in addition to the Mx83 changes, ignores dual gain anomaly flag, retrieves reflectance over ocean. Some of the difference may be from change to the AOTIP outside of min-max range. APU and difference images comparing C11 and LPEATE are derived as (C11 –LPEATE). LPEATE version of SRIP was produced by the Mx7.1 IDPS algorithm. This analysis didn't do any quality filtering of observations except for removal of confident cloud.**



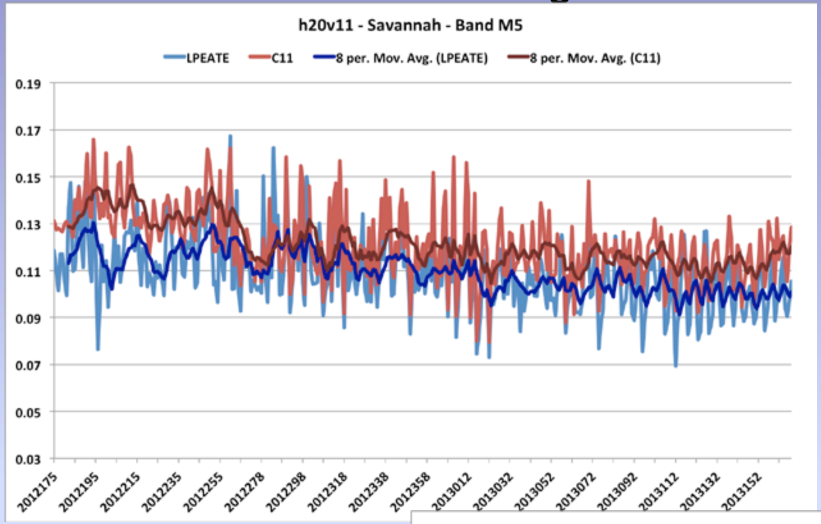


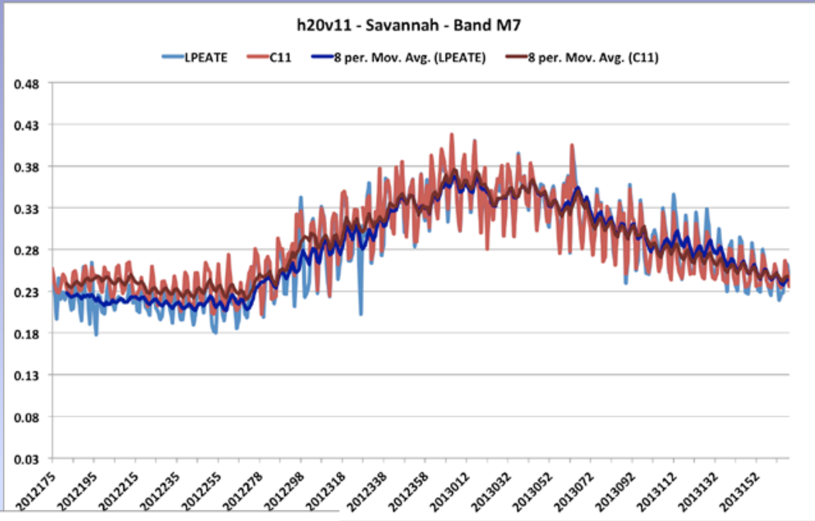


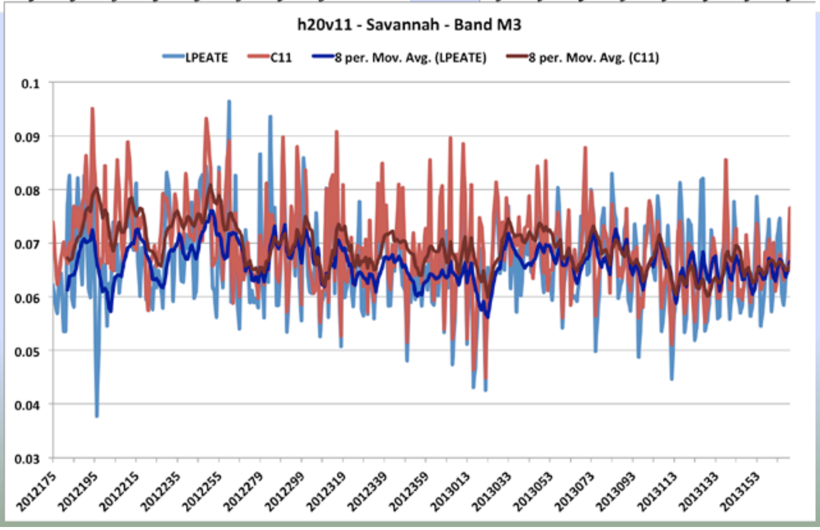


V1.1 Reprocessing – Evaluation in progress
Time Series of Daily Reflectance: C11 vs LPEATE

- **Time series comparing the daily gridded surface reflectance in the L2G 1km resolution product from C11 reprocessing and LPEATE. This times series used observation from the 1st layer i.e. maximum observation coverage.**





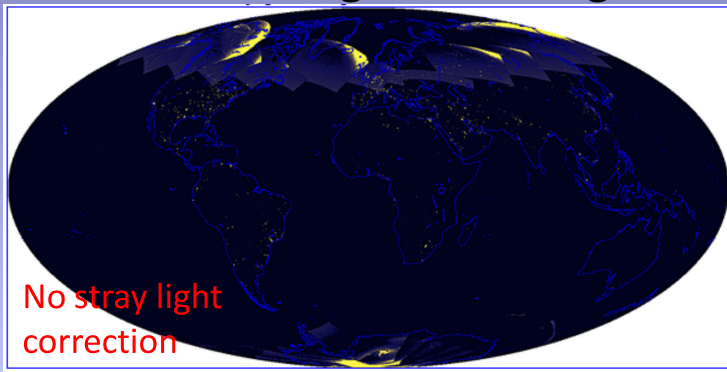


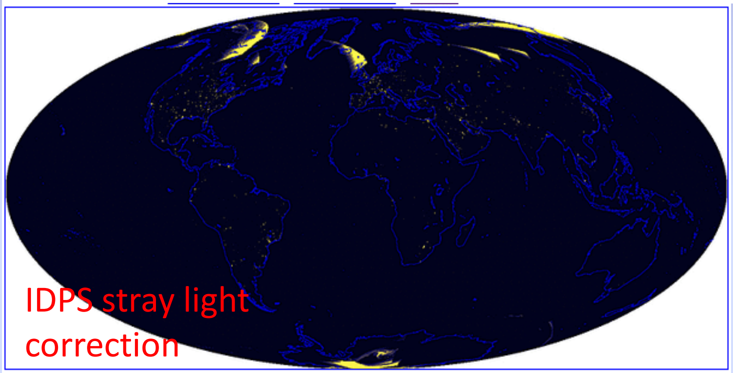
V1.1 Reprocessing – Evaluation in progress
DNB: IDPS vs C11

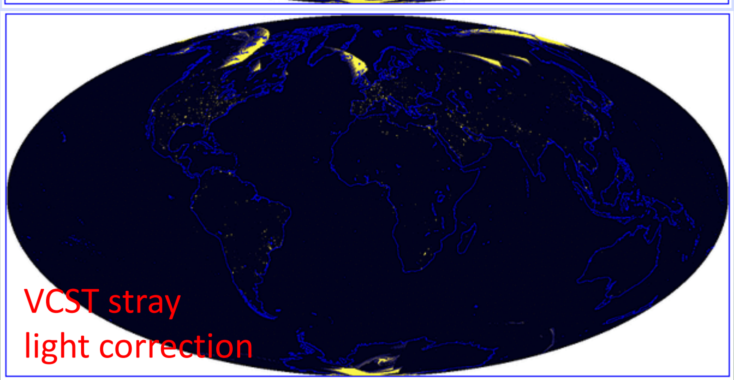
- **C11 reprocessing uses the calibration and stray light correction LUT provided by the NASA VCST and the product will have TC geolocation.**
- **Stray light correction in C11 reprocessing and the operational processing in AS 3001 and 3002 may have failed because of some software bug.**
- **The PGEs from all processing streams have been fixed, tested and verified.**
- **The product in AS 3110 (C11) will be reprocessed in a separate AS.**
- **NGSA provided LUT in operation at IDPS and the VCST LUT used in C11 both seems to fix the stray light issue, however there are differences in retrieved radiance at pixel level. The difference seems to be proportional to the radiance.**

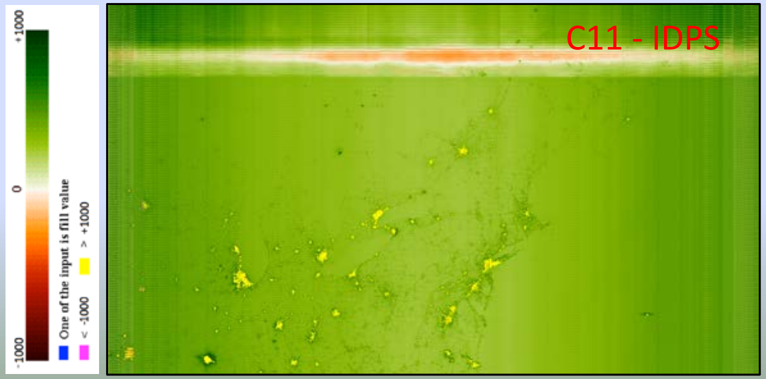
V1.1 Reprocessing – Evaluation in progress
DNB: IDPS vs C11 - 2013246

- **Global browse image of DNB night time radiance.**









C11 VCM: Using Climatology NDVI and NISE

- C11 reprocessing uses MODIS approach to generating Cloud Mask using Climatology NDVI and daily NISE data
- This approach uses
  - QST LWM (same as IDPS)
  - 16-day VI Seed File: Generated 4-year (2009-2012) climatology NDVI from the 16-day composite MODIS Aqua VI product, MYD13A2. Global product generated in MODIS tiles every 16-day at 1km and 5km resolution.
  - Daily Snow Ice Seed File: Generated by reprojecting the daily NISE data at 25 km resolution in the Lambert equal-area projection to the Sinusoidal projection at 1km resolution using nearest neighbor resampling. Global product generated in MODIS tiles.
  - Test result presented here used Mx72 build of IDPS L1B

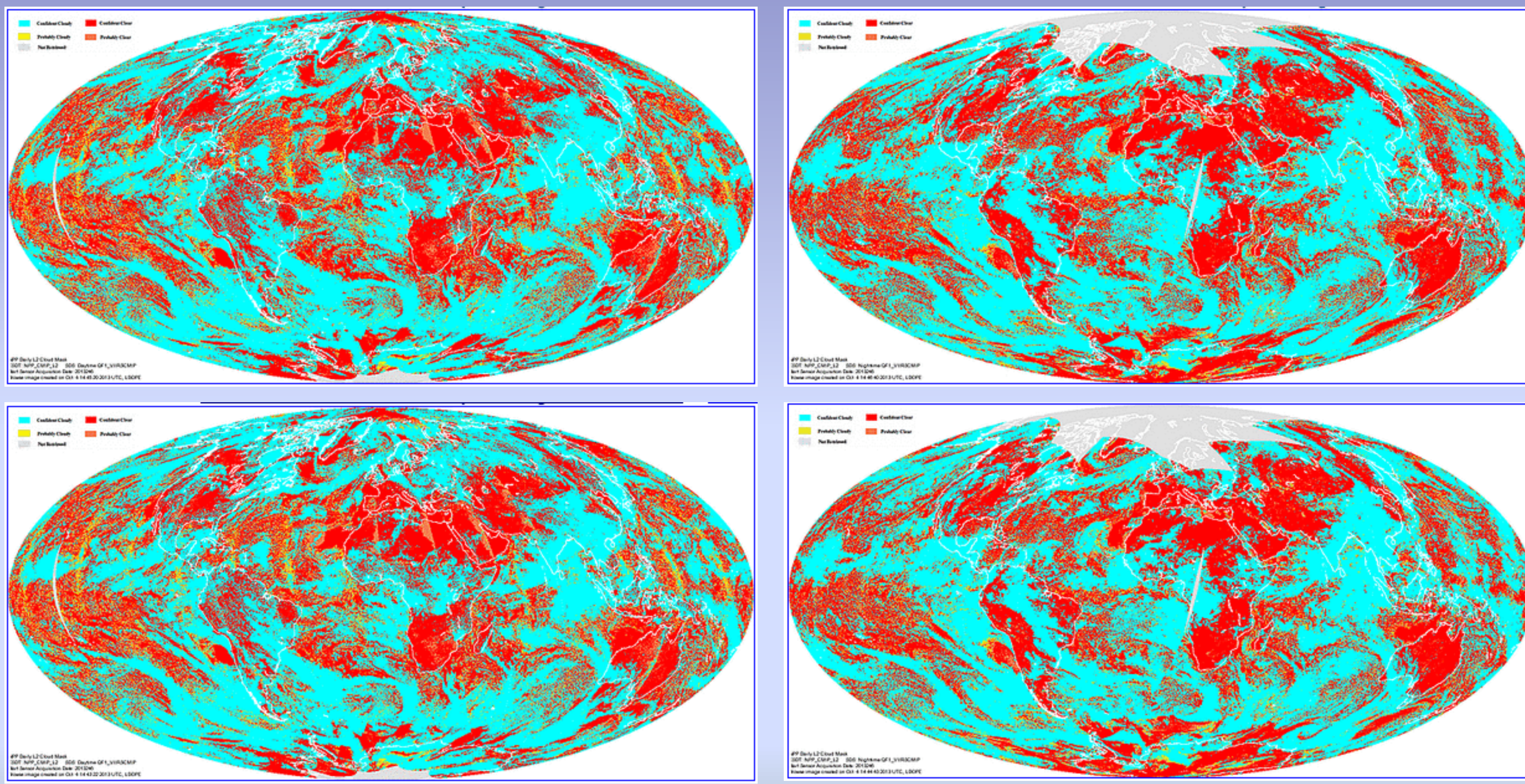
C11 VCM: C11 vs IDPS

- **Day Time Cloud Confidence from NPP_VCM_IP: Day 2013246**

Day time | Night time

IDPS

LPEATE- C1



Confident clear
Probable clear
Probable cloud
Confident cloud

C11 VCM: C11 vs IDPS

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

GranID		%Cloud	%Cloud_match	%Clear_Match	%Comm_Diff	%Omm_Diff
A2013246.0350	Australia - East	16.68	97.43	99.82	0.88	2.57
A2013246.0520	Antarctica	62.7	99.91	98.77	0.73	0.09
A2013246.0530	Australia - West	32.56	98.51	99.7	0.63	1.49
A2013246.0600	Northern Russia	64.3	99.52	99.49	0.28	0.48
A2013246.0605	Arctic	43.4	99.02	98.51	1.94	0.98
A2013246.0700	Antarctica	62.4	99.25	98.24	1.06	0.75
A2013246.0740	Northern Russia	60.82	99.54	99.64	0.23	0.46
A2013246.0745	Arctic	48.88	99.76	99.08	0.96	0.24
A2013246.1025	Antarctica	69.95	96.05	99.99	0	3.95
A2013246.1205	Antarctica	69.8	98.53	99.76	0.1	1.47
A2013246.1225	Africa - equitorial	52.64	99.8	98.25	1.57	0.2
A2013246.1230	Africa - Sahel	17.43	99.9	99.64	1.69	0.1
A2013246.1745	Canada - East	58.11	97.2	99.01	0.71	2.8
A2013246.1750	Canada - North	54.29	99.04	97.82	1.83	0.96
A2013246.1920	NA – Gulf of Mexico	19.23	99.39	99.19	3.41	0.61
A2013246.1925	Central NA	35.98	96.21	99.94	0.11	3.79
A2013246.1930	Canada - North	59.88	98.62	98.51	1	1.38

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

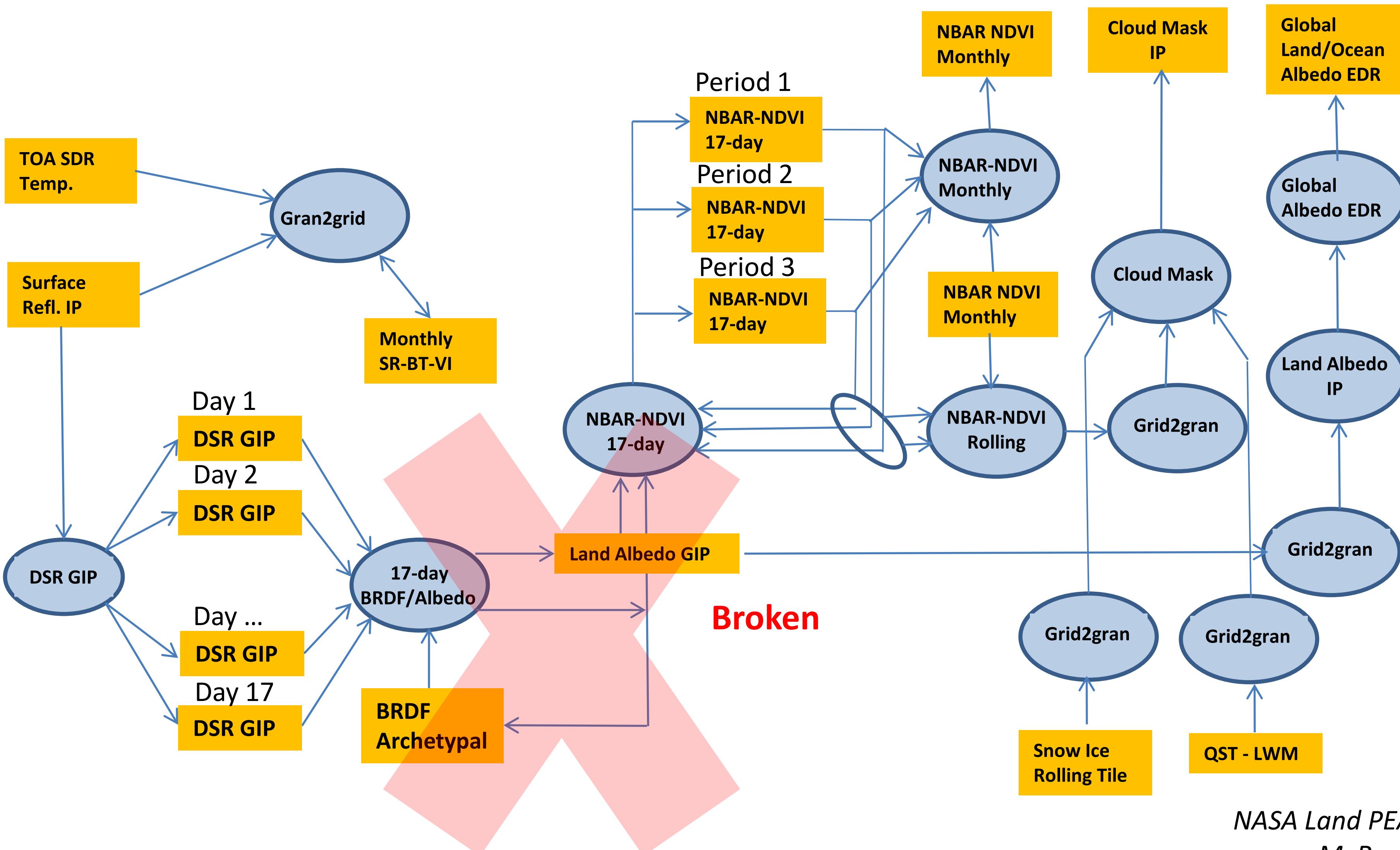
VCM and Gridding/Granulation

Land Gridded IPs and Consumer IPs/xDRs

Gridded IP	Generating Process	Consumer IP/xDR Process
Snow Ice Cover	Currently: Monthly seed file Original design: Rolling tile updated daily from ICIP and VSCD	Cloud Mask IP
Quarterly Surface Type	Delivered to IDPS by offline processing – uses Monthly SR/TB/VI. Not clear if this is annual or quarterly. Currently uses seed file – pre-launch, Sept 2012, Jan 2013.	Surface Type EDR Surface Temperature EDR
QST-LWM	Delivered to IDPS by offline processing – merges QST and LWM.	Cloud Mask IP Fire Mask IP
Annual Max/Min NDVI	Delivered to IDPS by offline Processing – Uses Monthly SR/TB/VI. Generated by the same process that generates QST.	Surface Type EDR to determine vegetation fraction
Daily Surface Reflectance (DSR) GIP	Gran2Grid - Uses SR-IP from one global day	BRDF/Land Surface Albedo GIP
Land Surface Albedo	Grid2Grid - Uses 17-days of DSR GIP	Land Surface Albedo IP NBAR-NDVI 17-day
BRDF Archetype	Grid2Grid - Uses 17-days of DSR GIP	NBAR-NDVI 17-day BRDF/Land Surface Albedo GIP
Monthly SR-BT-VI	Gran2Grid - Uses SR-IP and TOA SDR Brightness Temperature	Quarterly Surface Type
NBAR-NDVI 17 day*	Grid2Grid – Uses BRDF Archetype and Land Surface Albedo	NBAR-NDVI Rolling NBAR-NDVI Monthly
NBAR-NDVI Rolling*	Grid2Grid – Uses NBAR-NDVI 17-day (2 recent periods) and Monthly NDVI	Cloud Mask IP
NBAR-NDVI Monthly*	Grid2Grid – Uses NBAR-NDVI 17-day (3 periods)	NBAR-NDVI Rolling NBAR-NDVI Monthly

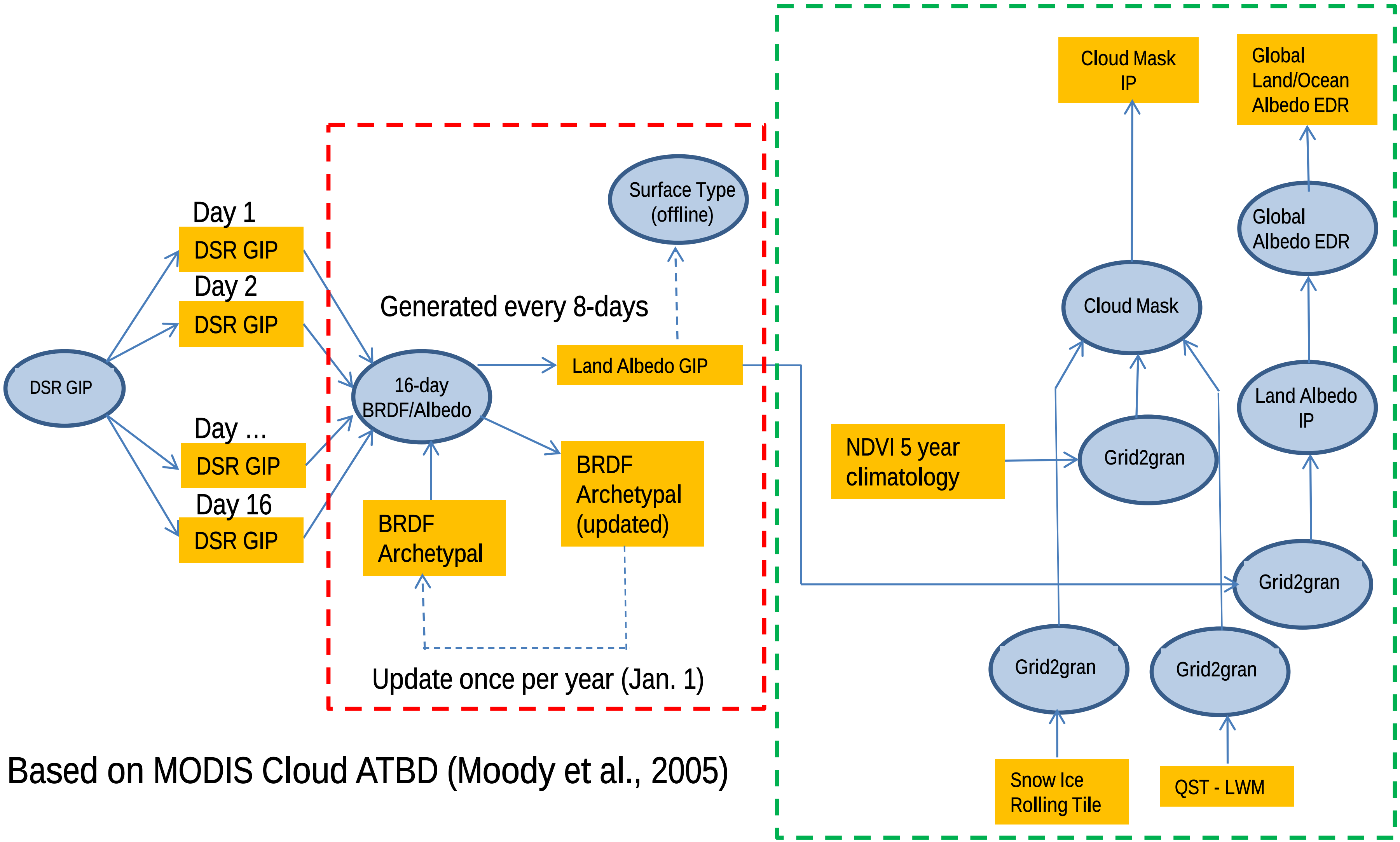
*5 km products

Gridding/Granulation - Current



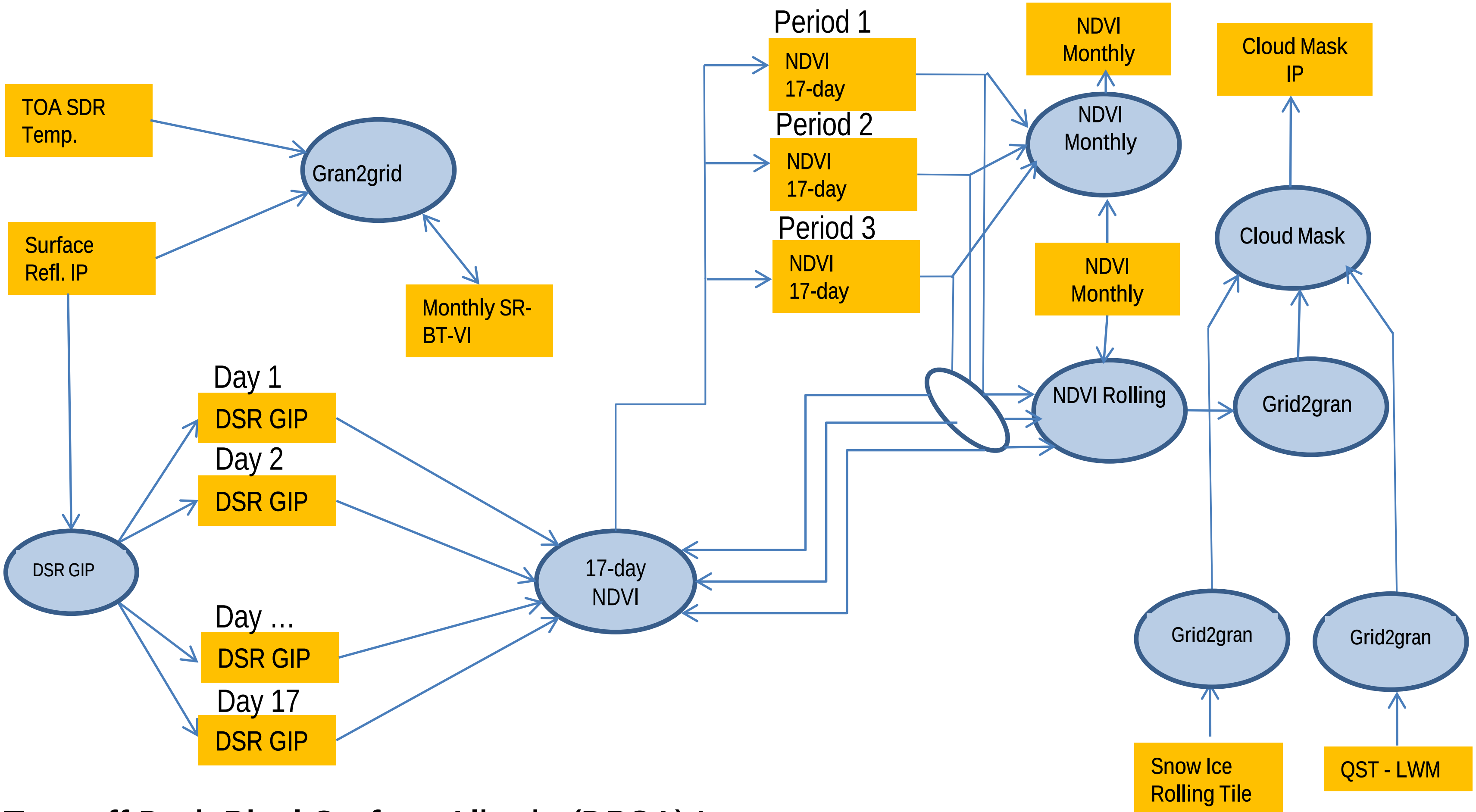
NASA Land PEATE
M. Román
S. Devadiga

Gridding/Granulation - NASA Approach



- Based on MODIS Cloud ATBD (Moody et al., 2005)

Gridding/Granulation - Land and VCM Compromise



- Turn off Dark Pixel Surface Albedo (DPSA) Loop.
- Retain DSR GIP 17-day updates
- Replace NBAR-NDVI chain with 17-day TOC NDVI (rationale: BRDF effect on NDVI should not impact the VCM's brightness change test. VCM tuning should account for possible increased biases (e.g., next slide).

NASA Land PEATE
M. Román
S. Devadiga

Conclusion

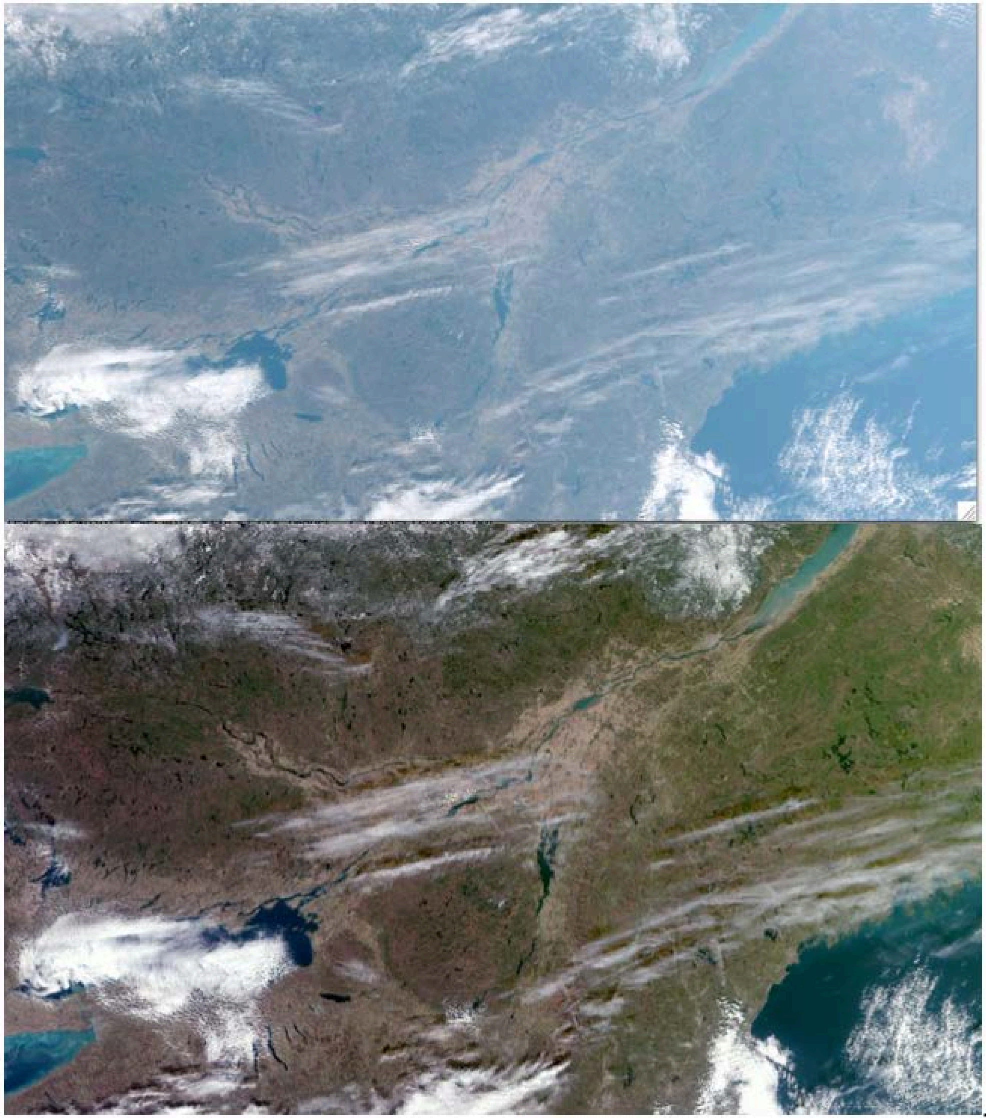
- **Land PEATE is processing RDRs using the operational IDPS algorithms and current LUTs generating the L1B SDRs, Geolocation, IPs and EDRs.**
- **DDRs generated from the MODIS L3 PGEs, and science PGEs delivered by the science teams.**
- **Land PEATE is conducting routine quality check of products from the processing at Land PEATE.**
- **Land PEATE is running multiday science tests generating global data to help science teams in algorithm evaluation and cal/val.**
- **C11 reprocessing of VIIRS land data records using the NASA VCST LUT and best of available science algorithms is in progress and is expected to finish soon. Product evaluation comparing to the heritage MODIS products has started.**
- **C11 reprocessing used the MODIS-based approach to using the Climatology NDVI and and NISE data for generating the Cloud Mask. Land/VCM team "compromise" could be a viable approach for use at IDPS**
  - **Simple to use.**
  - **VCM generated using this approach should have the same performance as 'corrected' NBAR-NDVI rollup.**
  - **Easy to run science tests to any length of the processing chain for verification of effect of algorithm changes on downstream products**

Surface Reflectance, SDR and VCM feedback

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

NOAA STAR JPSS Science Team Meeting,
May 12-16, 2014

Exciting times!

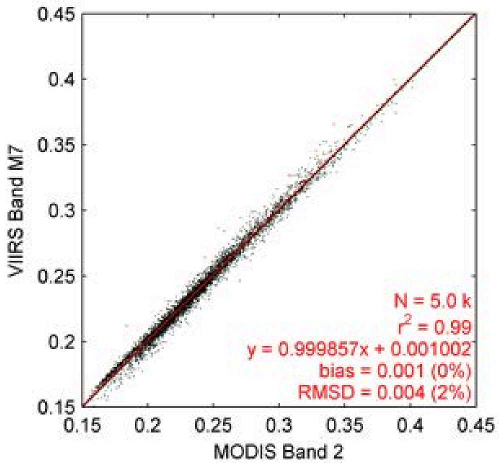


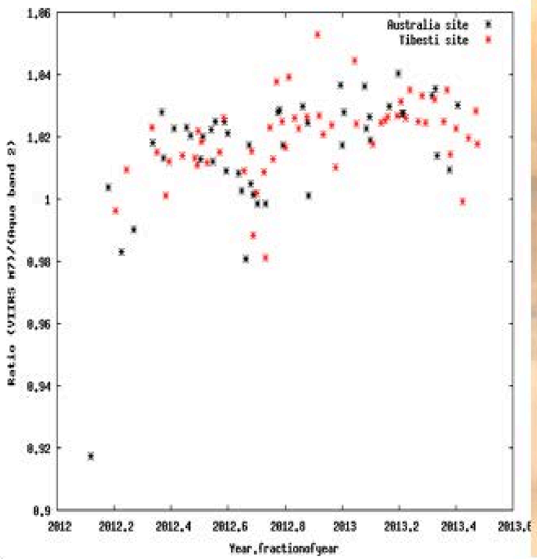
The VIIRS first light image acquired on November 21, 2011 in the visible bands, top is a the top of the atmosphere (RGB) image and bottom is the prototype VIIRS corrected surface reflectance product

Outline

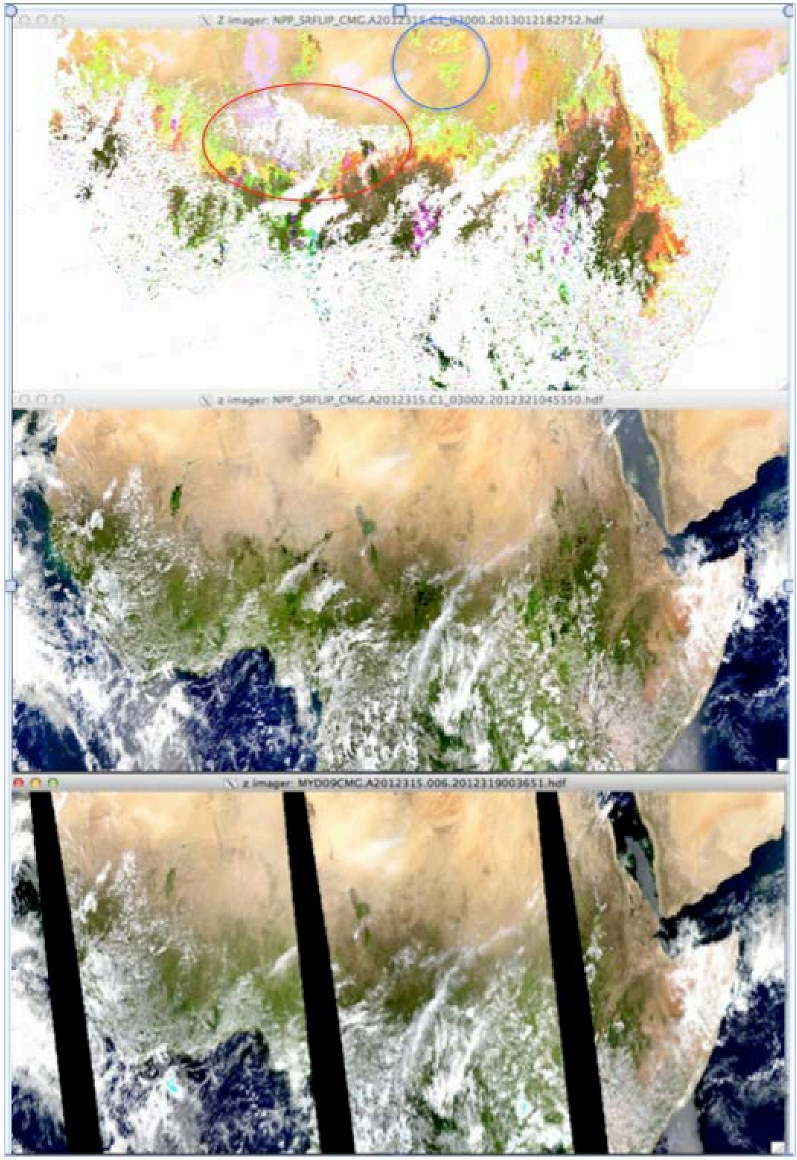
- SDR feedback
- VCM feedback
- SR status and future steps

VIIRS SDR quality is being monitoring through SR cross-comparison with MODIS Aqua SR on a continuous basis





VCM early evaluation

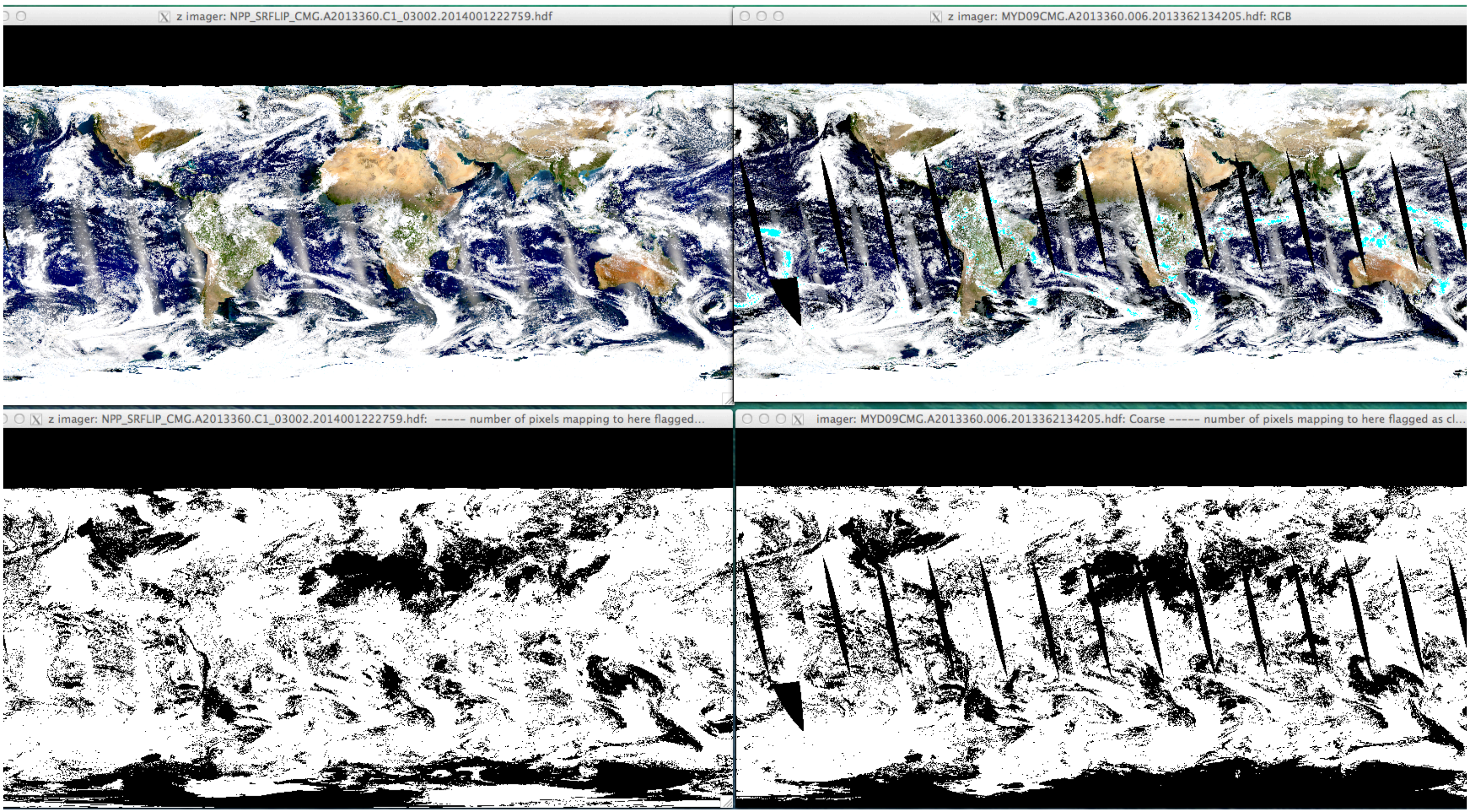


Issue with the VIIRS Cloud Mask (VCM) over Sahel on 11/10/2012 due to the seed file currently used. The top image is the VIIRS IDPS generated product (clouds are white filled value), the middle is the VIIRS Land PEATE adjusted product (which is the product generated by the Land PEATE using the NASA Land Science Team adjusted version of the IDPS software), where the cloud are not set to filled values, the bottom is the MODIS Aqua data. The red circle outlines the false cloud detection in VCM due to a problem in the seed file used, the blue circle outines an area of aerosol over-correction due to the use of the Navy Aerosol climatology

2013 December 26, VCM improved substantially

VIIRS CMG (Land Peate Adjusted)

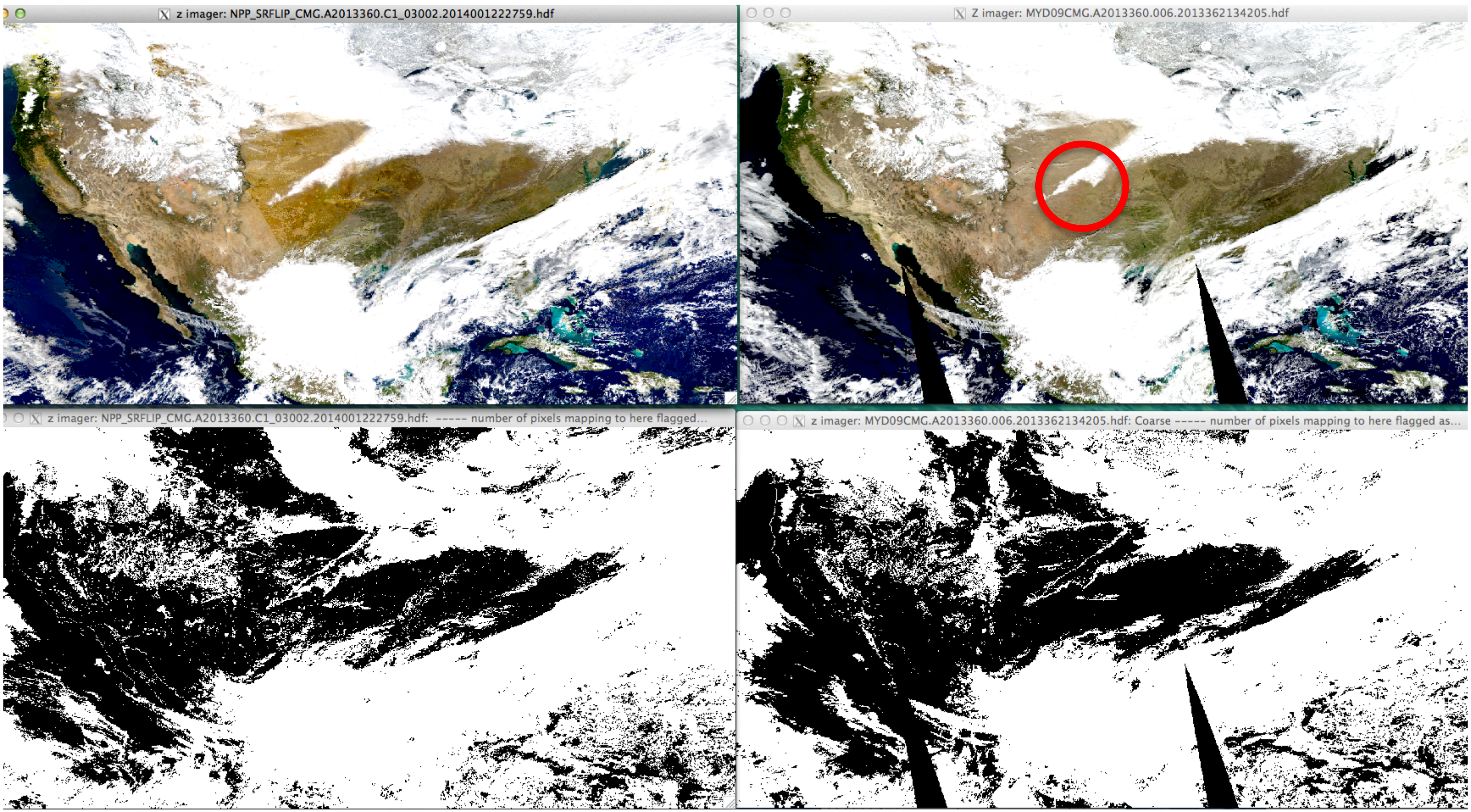
Aqua CMG



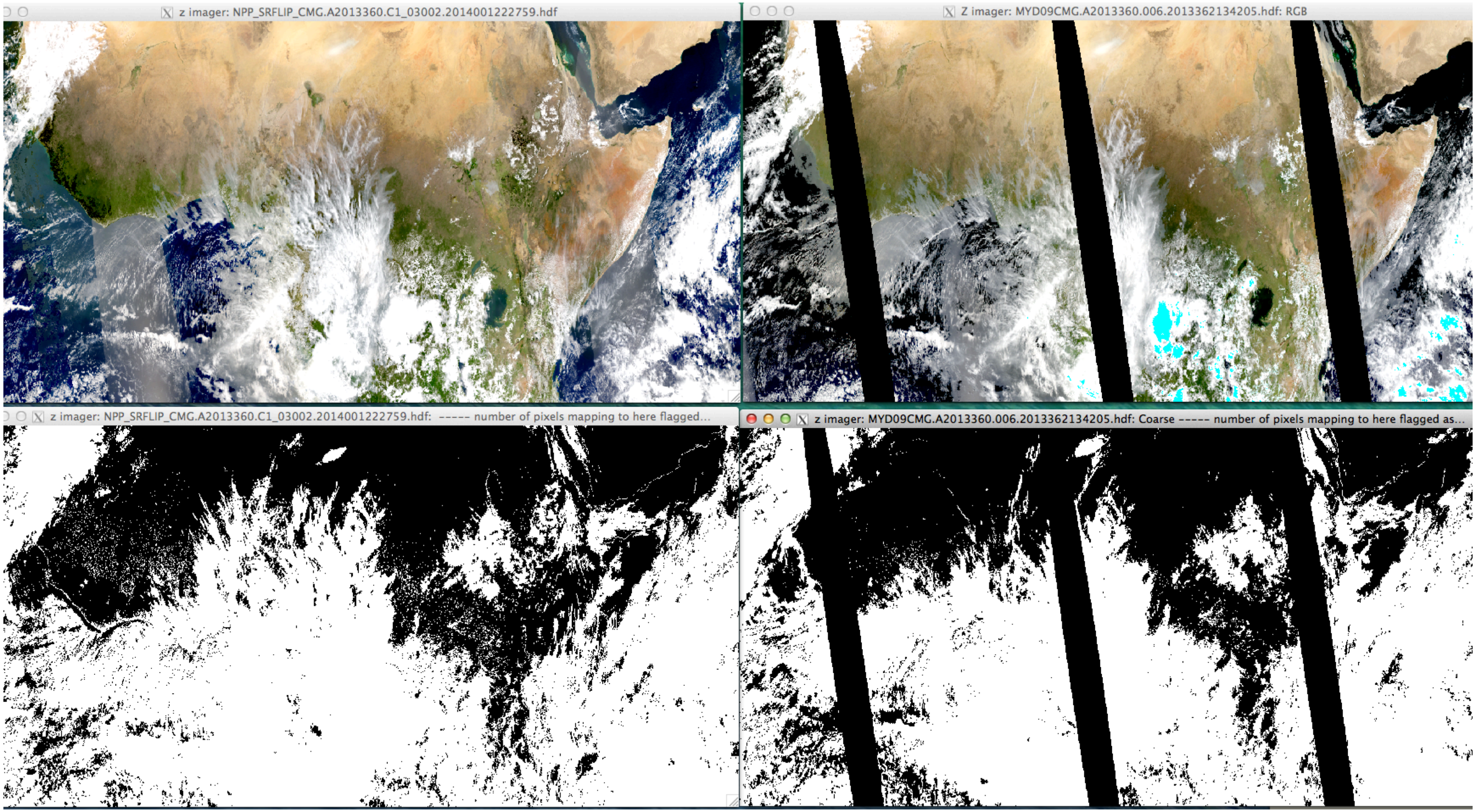
VIIRS Cloud Mask

Aqua Cloud Mask

VCMcompare well with some small difference in snow/cloud (not a concern to us)



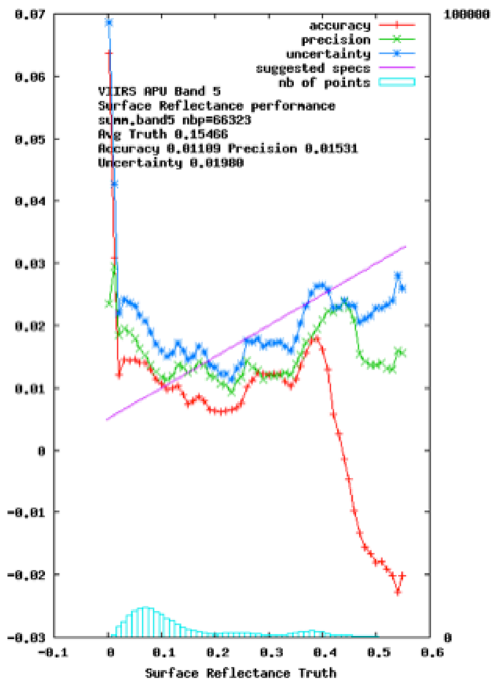
Good comparison over bright regions (Sahel)

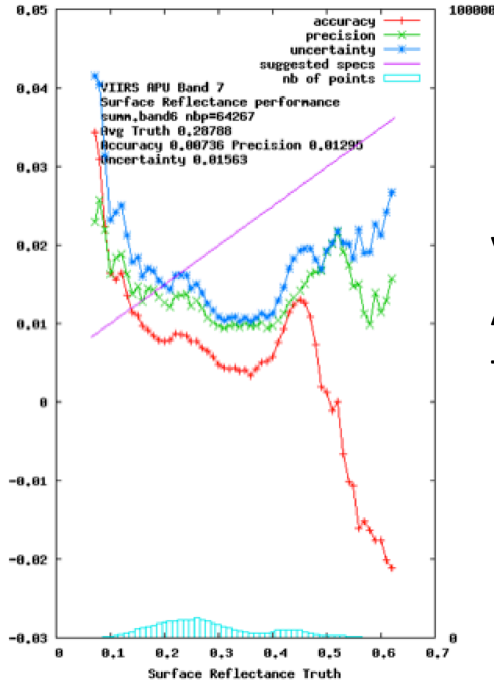


VCM

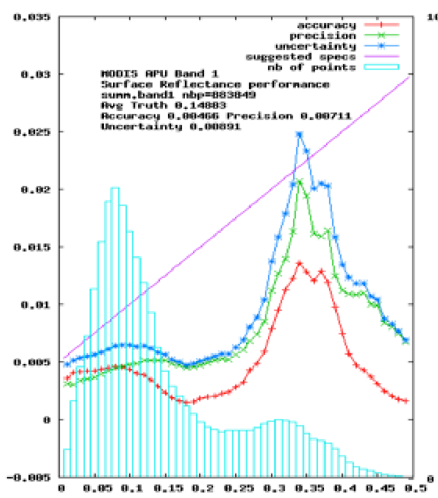
- VCM is performing well, all previous artifact (bright sites, high altitude) have been addressed
- VCM compares well with MODIS Aqua internal cloud mask
- VCM quantitative assessment with CALIPSO adopted to evaluate Aqua Internal cloud Mask

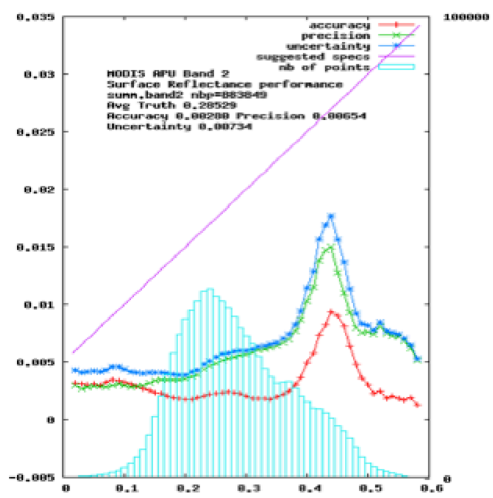
SR provisional as of 3/18/2014





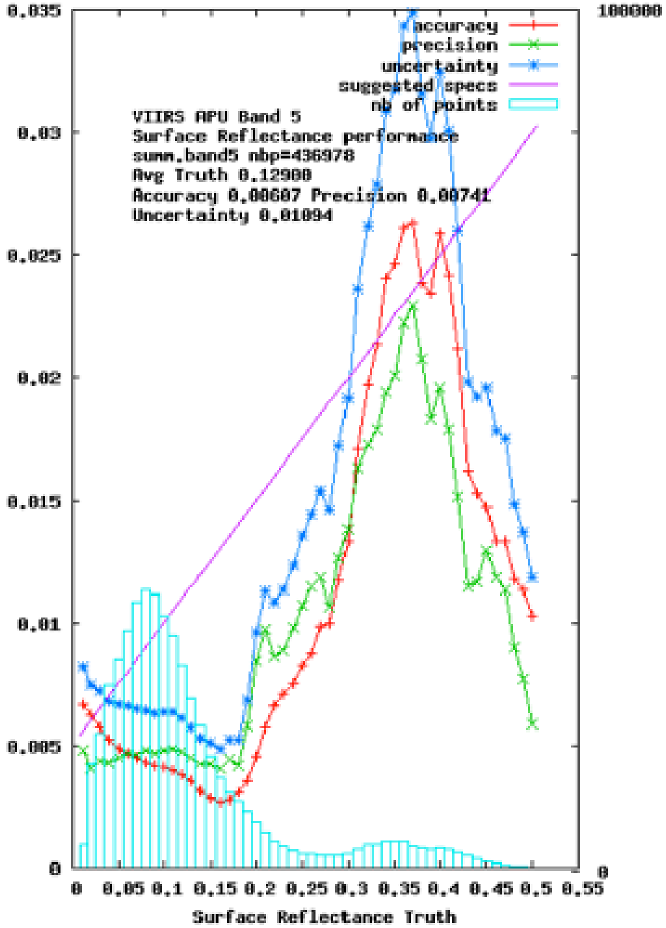
VIIRS Red (left) and NIR (Right) expected APU after provisional status (derived from LPEATE-SR analysis)

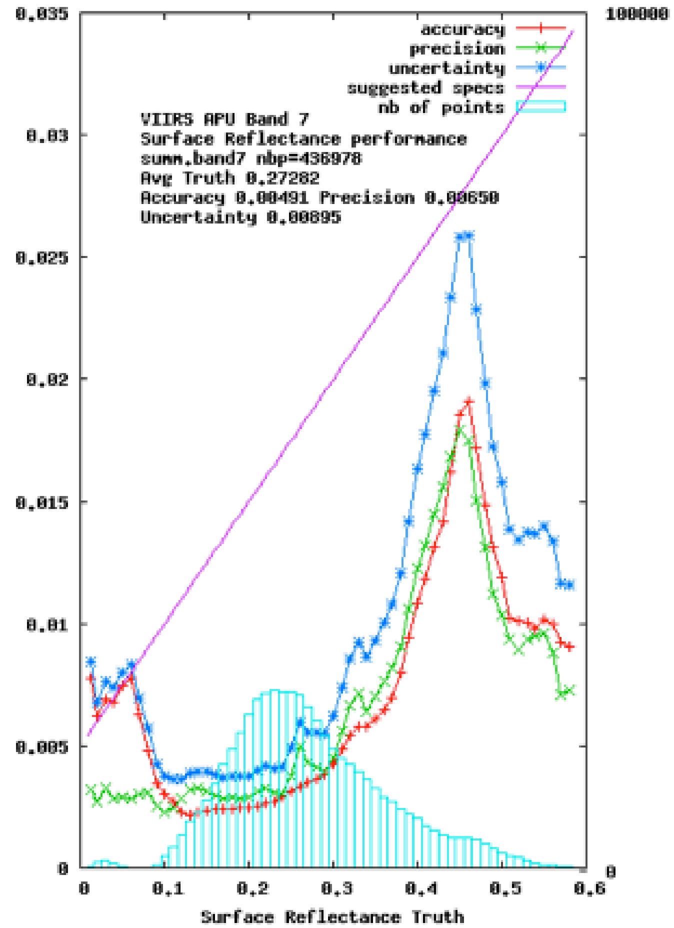




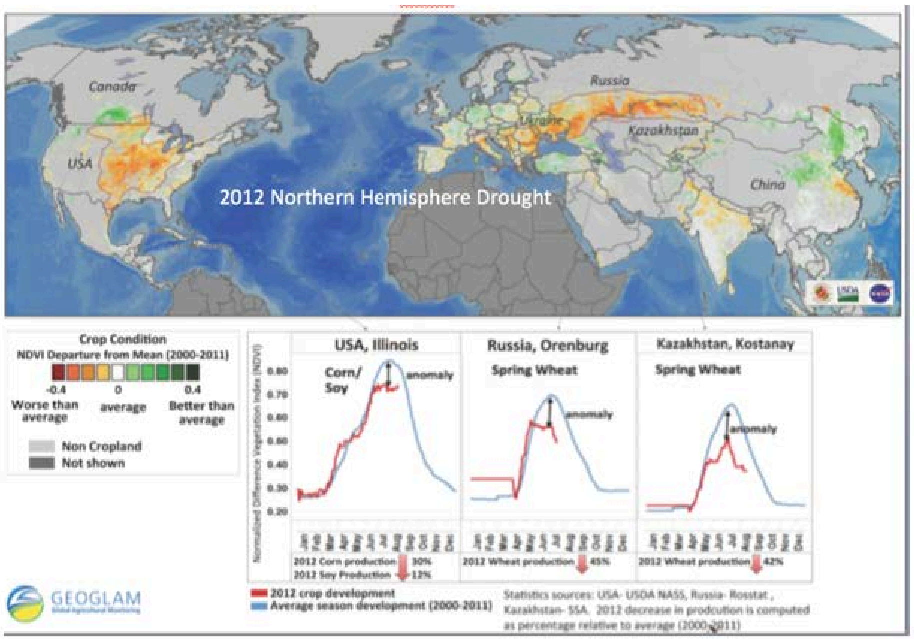
MODIS Red (left) and NIR (Right) APU for collection 5

Additional changes are being tested in LPEATE-SR (C1.1 reprocessing) and show improved performances

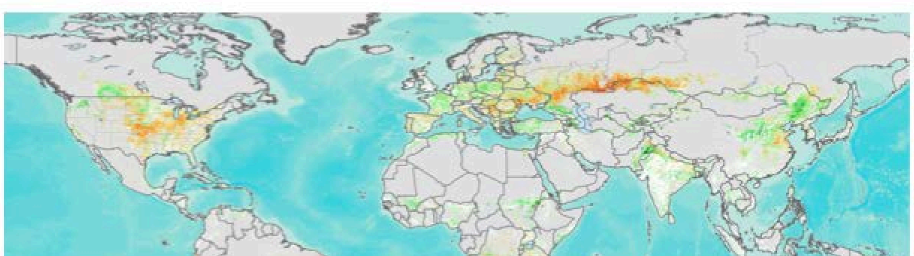




VIIRS SR potential to replace MODIS in agriculture applications (GEOGLAM drought monitoring) has been explored



Assessment of the impact of the 2012 Northern Hemisphere Drought from the MODIS Climate Modeling Grid daily NDVI data



A VIIRS NDVI anomaly (prototype) computed for the same date (July, 30th 2012) as the MODIS NDVI anomaly shown above, generated from data produced at the Land PEATE

Conclusions and future steps

- SDR and VCM improvements are being monitored by VIIRS-SR Team.
- SR shows continuous improvement and LPEATE is critical to test those
- Future steps will incorporate change to bring VIIRS SR equivalent to MODIS collection 6 and collaborate with VCM team to further improve/simplify VCM

SNPP VIIRS Vegetation Index EDR

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[2]Department of Natural Resources & Environmental Management University of Hawaii at Manoa,
[3]IM Systems Group, Inc., @NOAA/STAR, College Park, MD,
[4]University of Technology Sidney, Australia,
[5]Northrop Grumman Aerospace Systems, Redondo Beach, CA,
[6]The Aerospace Corporation, El Segundo, CA,
[7]NOAA National Centers for Environmental Prediction (NCEP), Environmental Modeling Center (EMC), College Park, MD

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

Outline

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

VI EDR Team Members

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

VI EDR Customers/Users

– NCEP
– STAR
– CLASS
– USDA
– USGS
– University of Hawaii at Manoa
– The Climate Corporation
– University of Technology Sydney

VI EDR Accomplishments

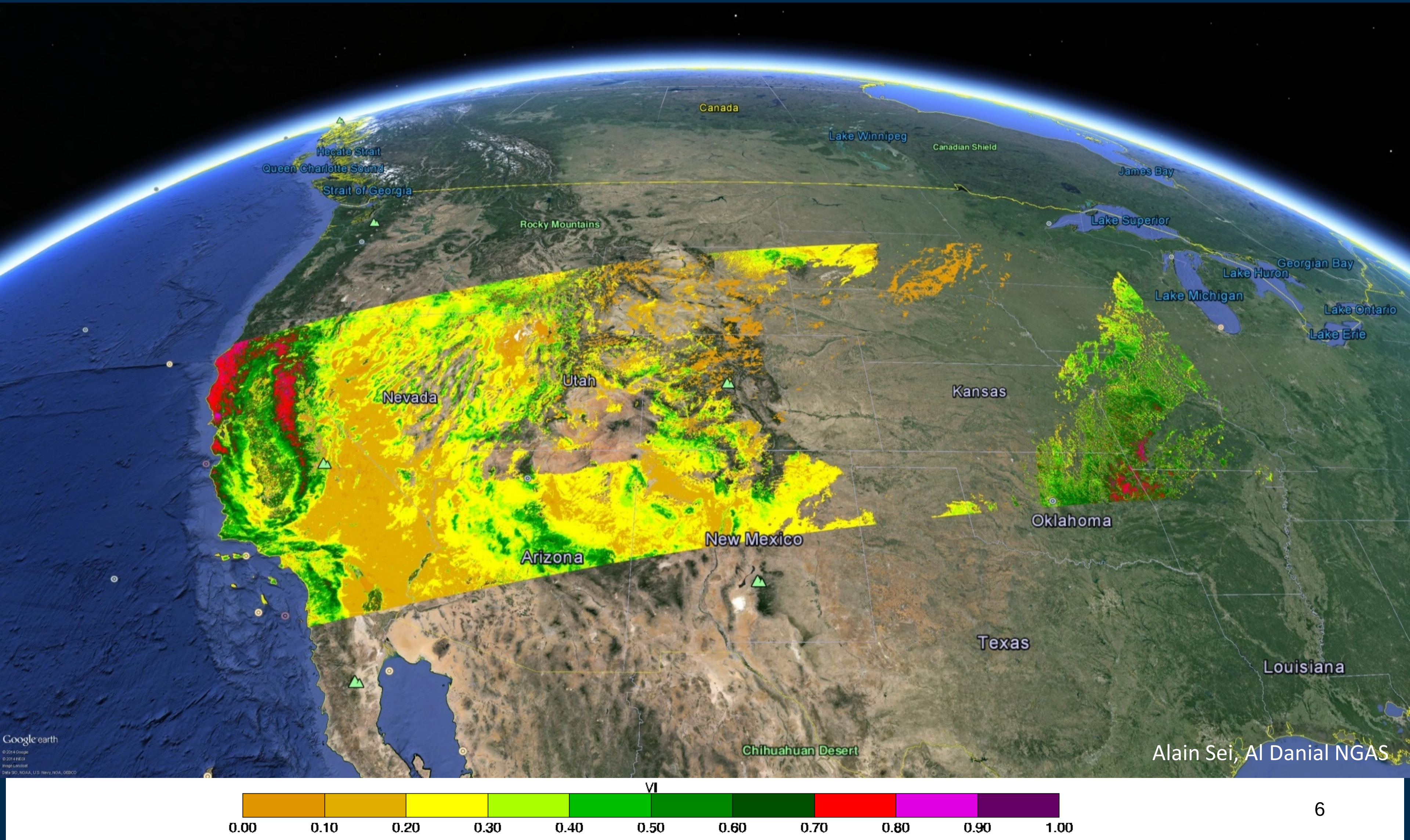
- Maturity Reviews
  - Beta Maturity: February 2012
  - Provisional Maturity: August 2013
- Product Improvements: Additional Quality Flags for the VI EDR will be implemented in Mx8.4
- Peer reviewed publications

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

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

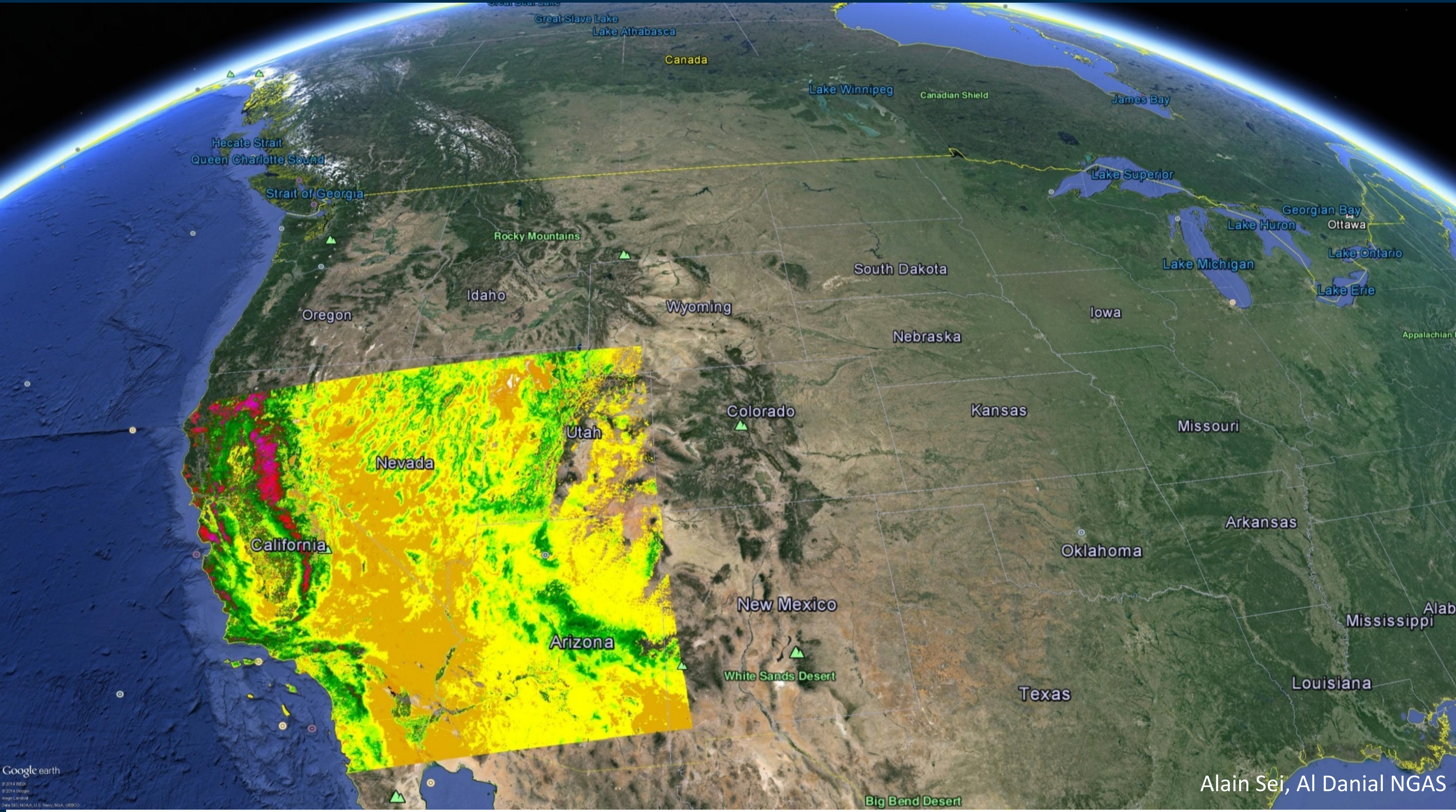
TOA NDVI May 01, 2013

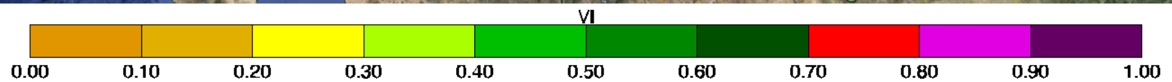
VIVIO_npp_d20130501_t2006109_e2007351_b07824_c20140509022958972057_noaa_ops.h5
VIVIO_npp_d20130501_t2007363_e2009005_b07824_c20140509022958972057_noaa_ops.h5



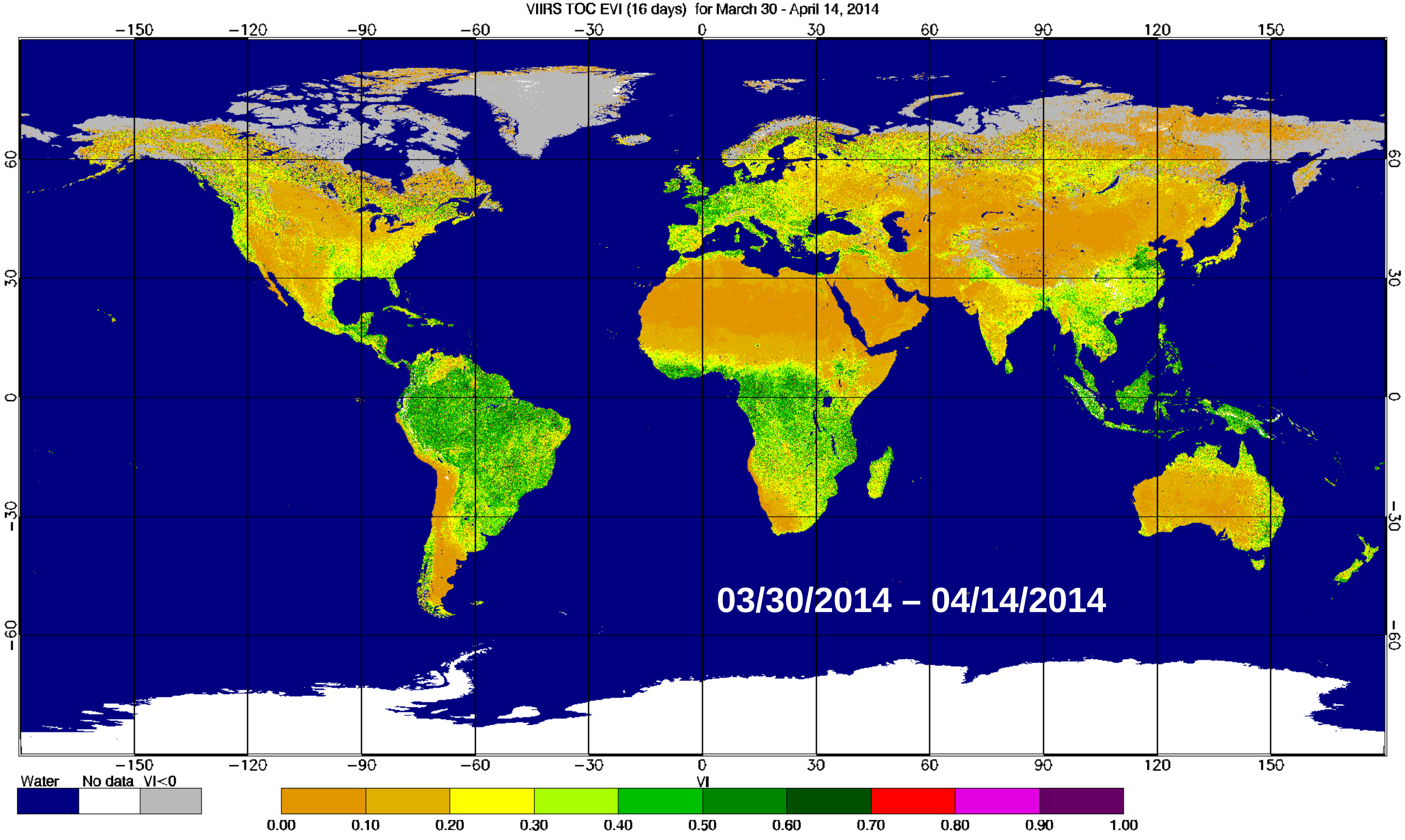
TOA NDVI April 30, 2014

VIVIO_npp_d20140430_t2127130_e2128372_b12989_c20140501040121992031_noaa_ops.h5
VIVIO_npp_d20140430_t2128385_e2130026_b12989_c20140501040121992031_noaa_ops.h5

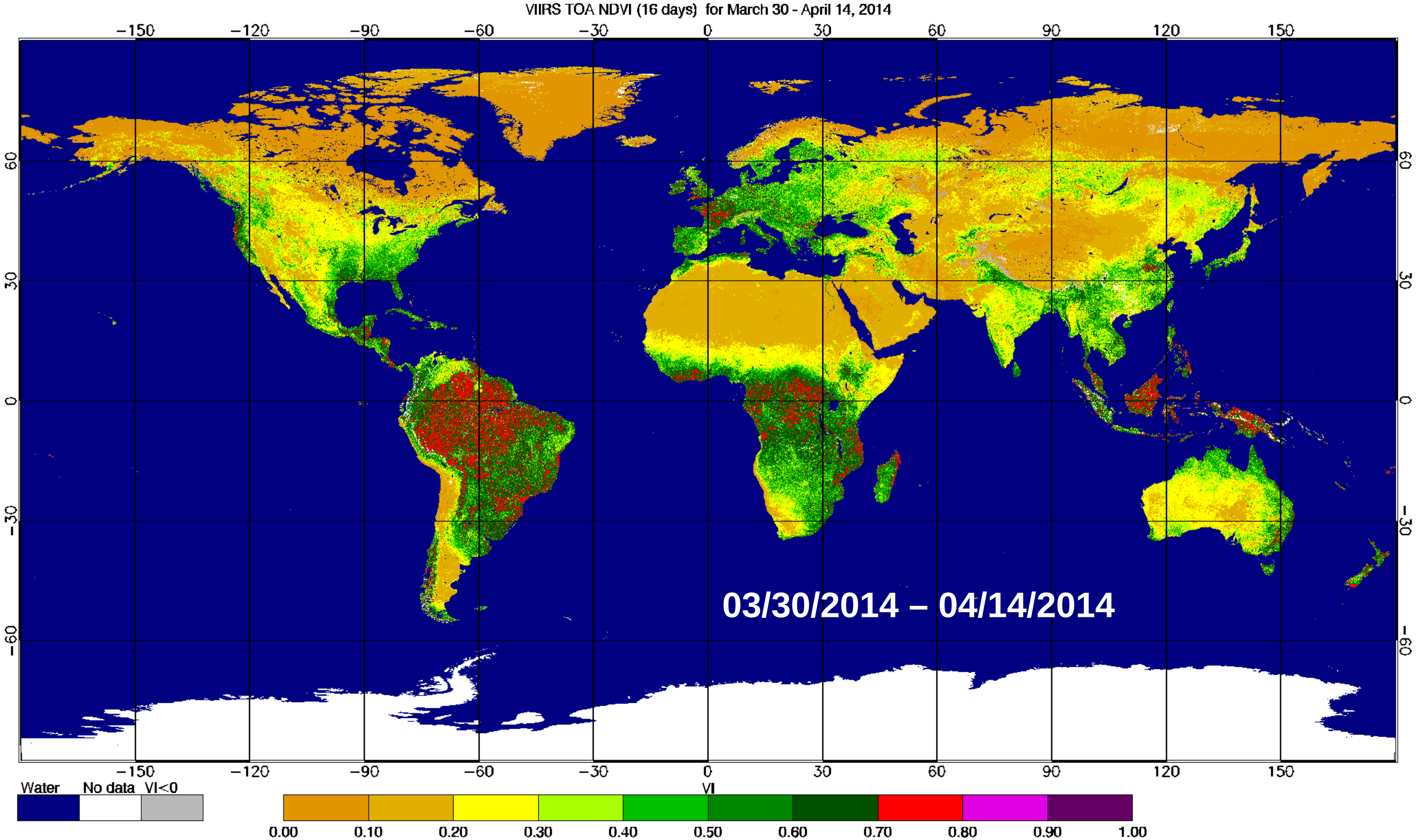




TOC EVI
16-day composite



TOA NDVI
16-day composite



VI EDR Product Requirements

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

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.

New for JPSS1

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

SNPP VIIRS VI EDR Algorithm Description

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

VI EDR Algorithm

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

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

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

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

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

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

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

C_1, C_2 and L are constants

VI EDR Validation Approaches

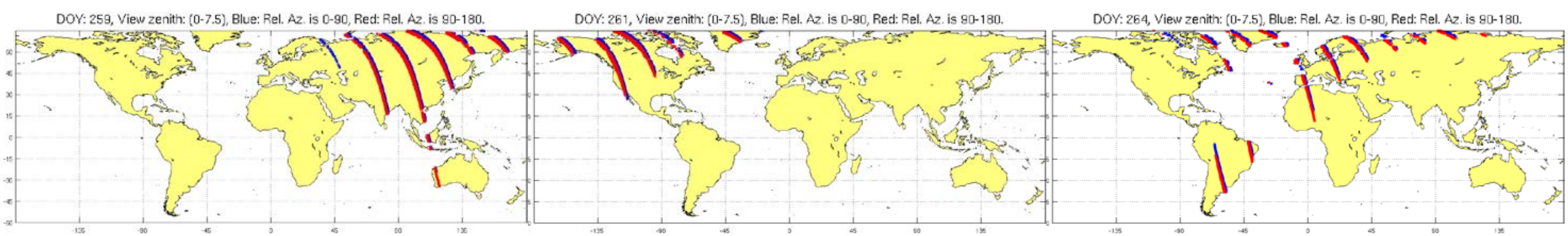
- Validation Using Aqua MODIS as a Reference
  a) Regional – Global Mosaic Analysis
  b) Subset Time Series Analysis

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

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

VIIRS vs. MODIS Global Comparison

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



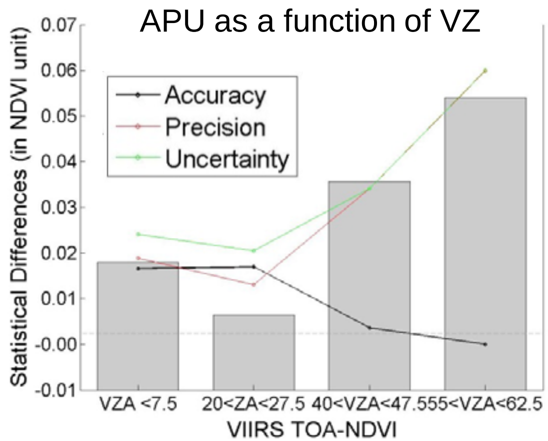
Figures indicating VIIRS-MODIS overlapping orbital tracks (VZ < 7.5^o)
(Red = forward scattering geometry; Blue = backward scattering geometry)

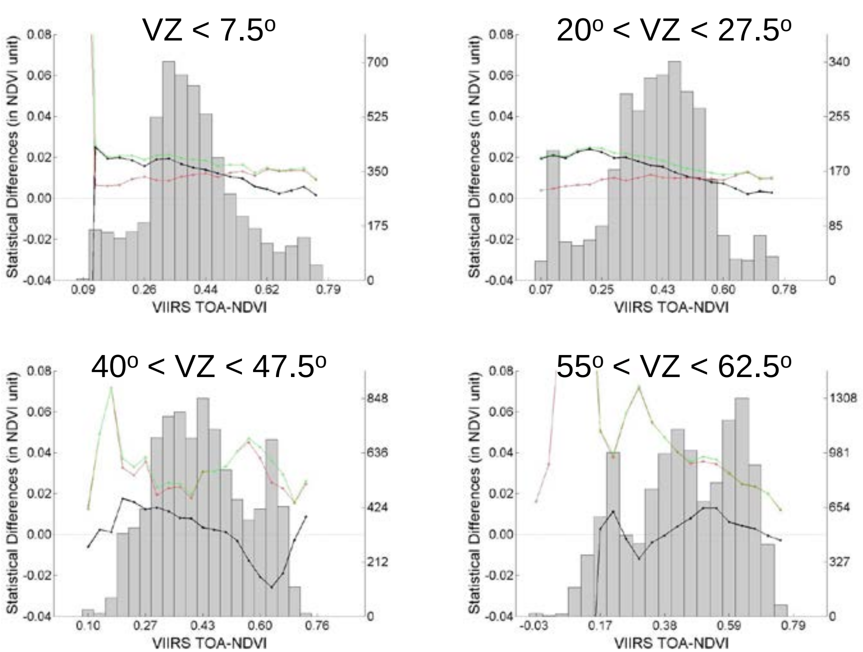
VIIRS vs. MODIS APU Metrics

(DOY 056, 058, & 061, 2014)

TOA-NDVI

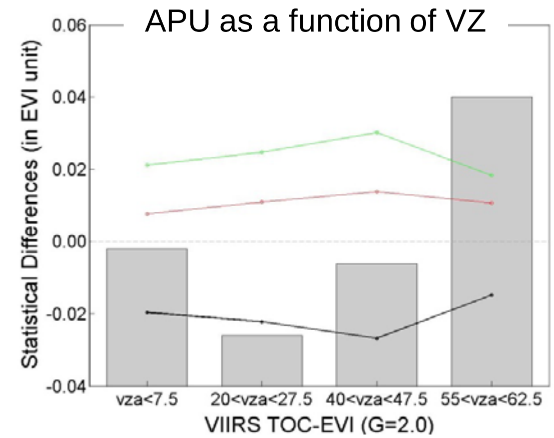
	Summary
A	0.007
P	0.030
U	0.033

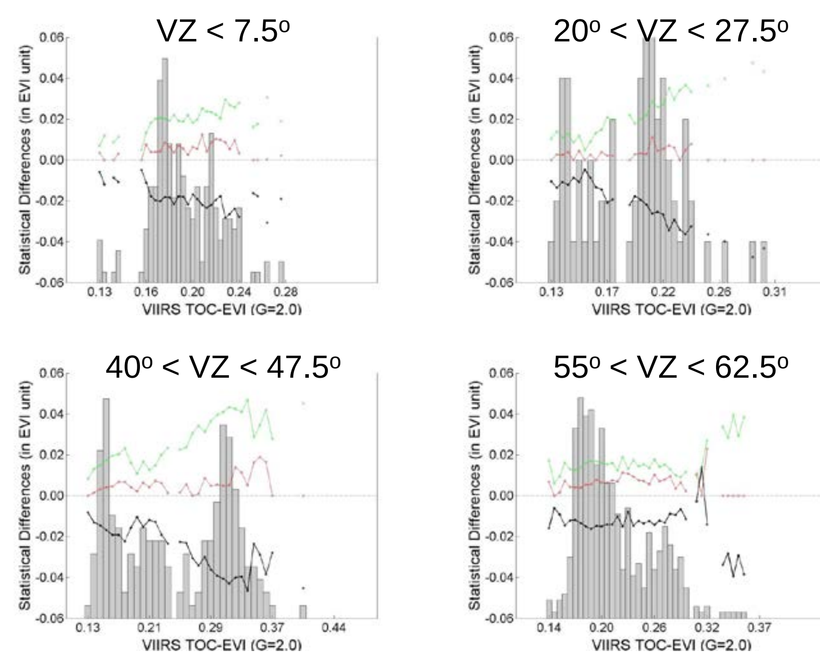




TOC-EVI

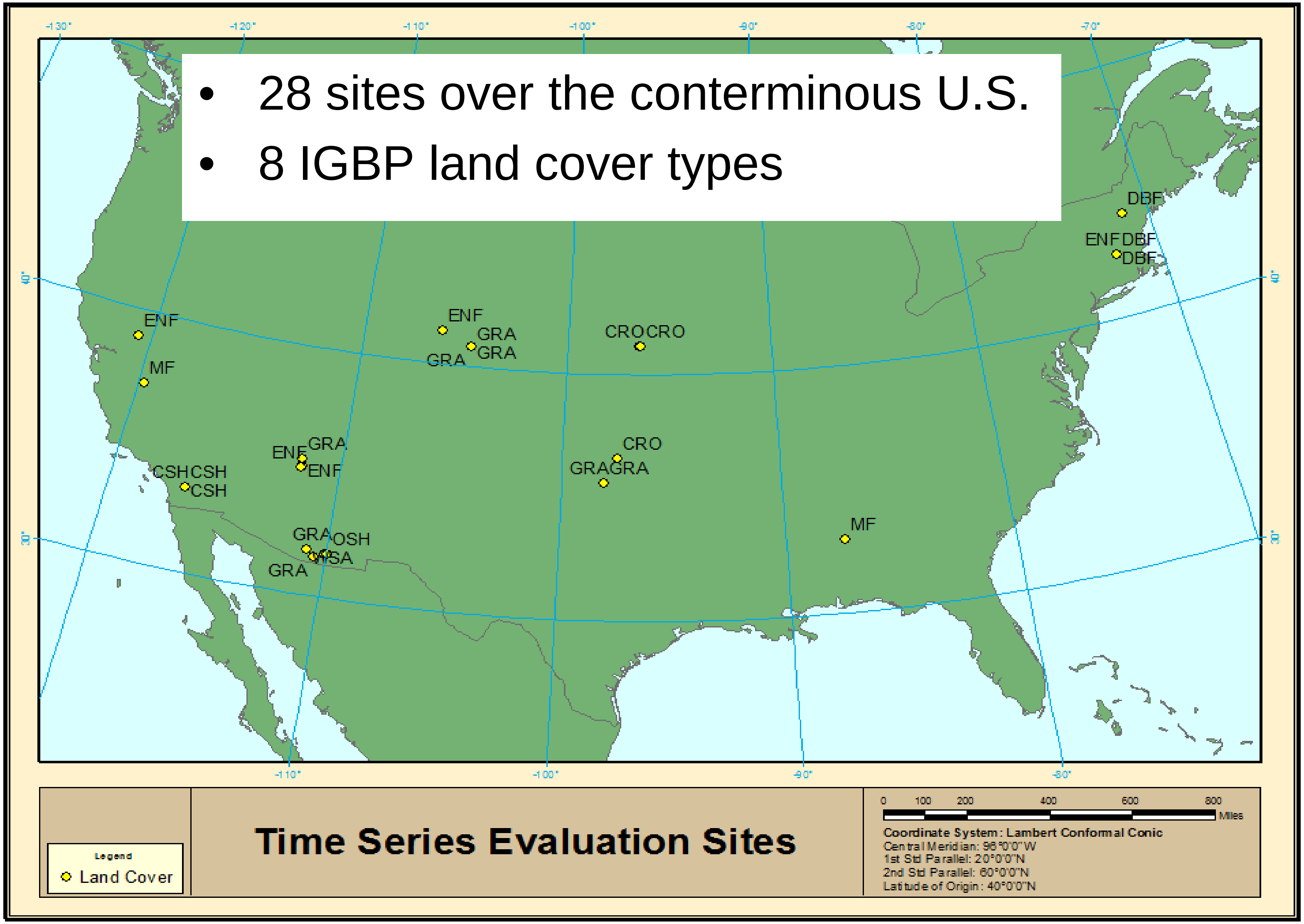
	Summary
A	0.021
P	0.010
U	0.023





VIIRS Vegetation Index Time Series

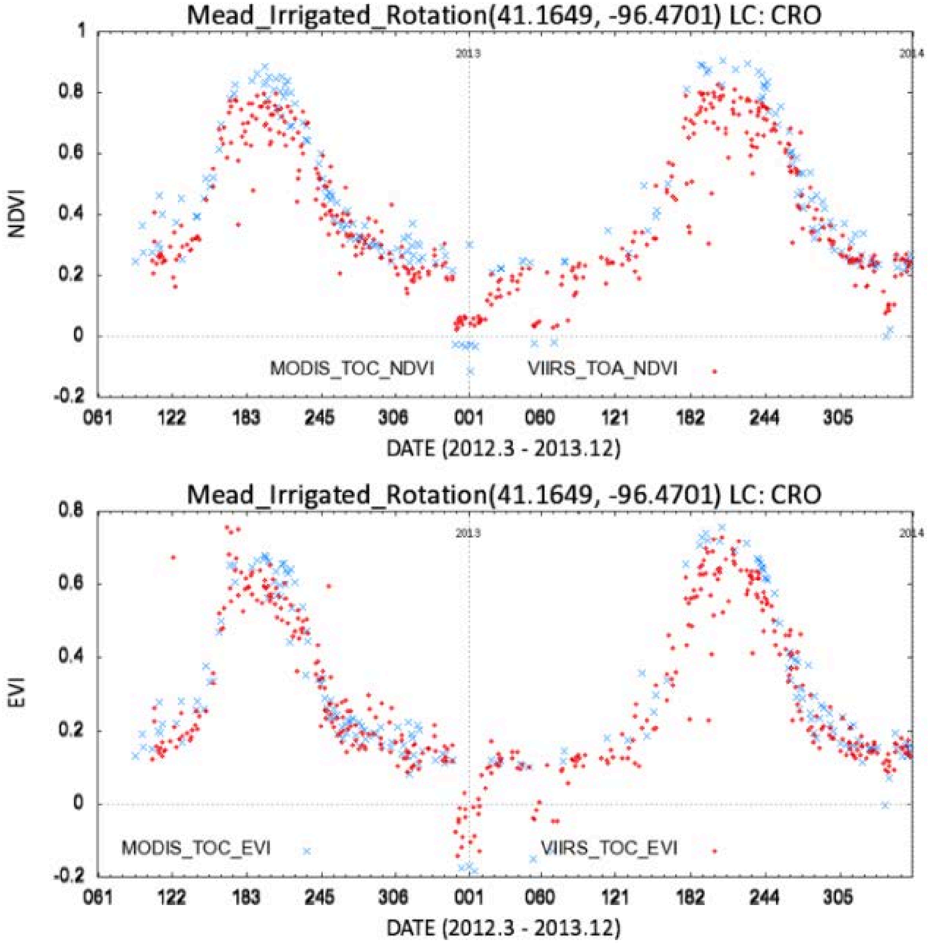
- 28 sites over the conterminous U.S.
- 8 IGBP land cover types



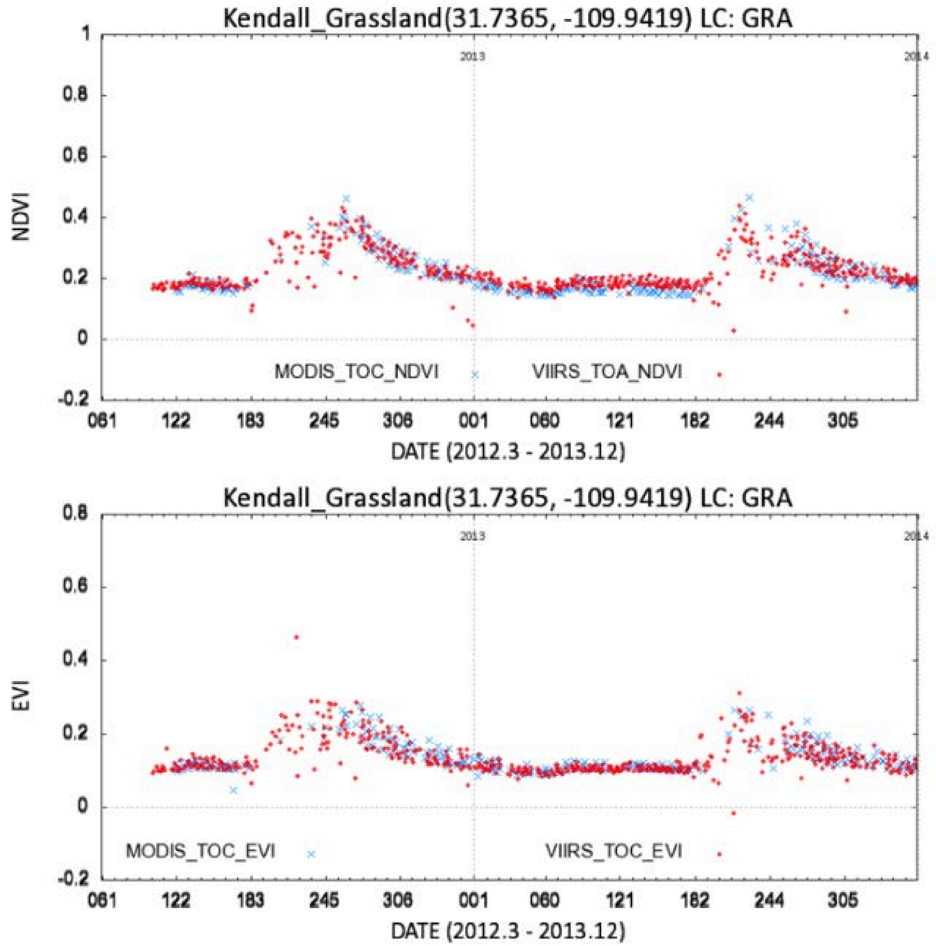
VIIRS Vegetation Index Time Series

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

Broadleaf Crop



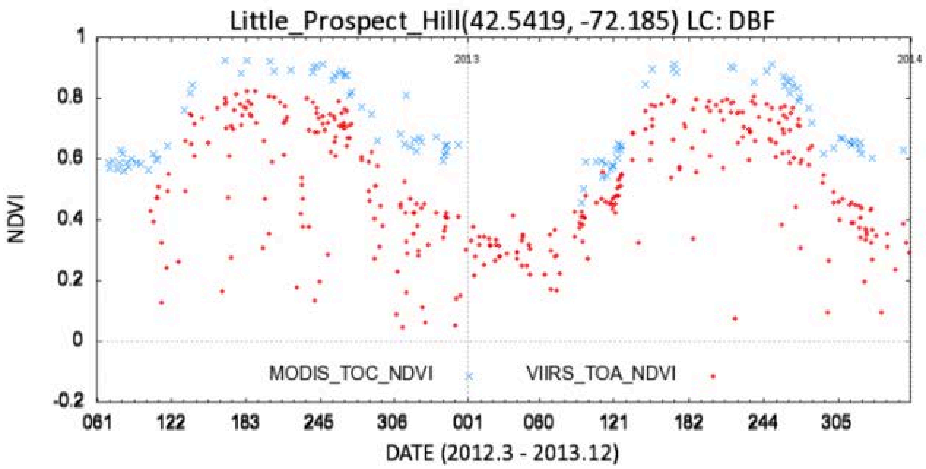
Grassland

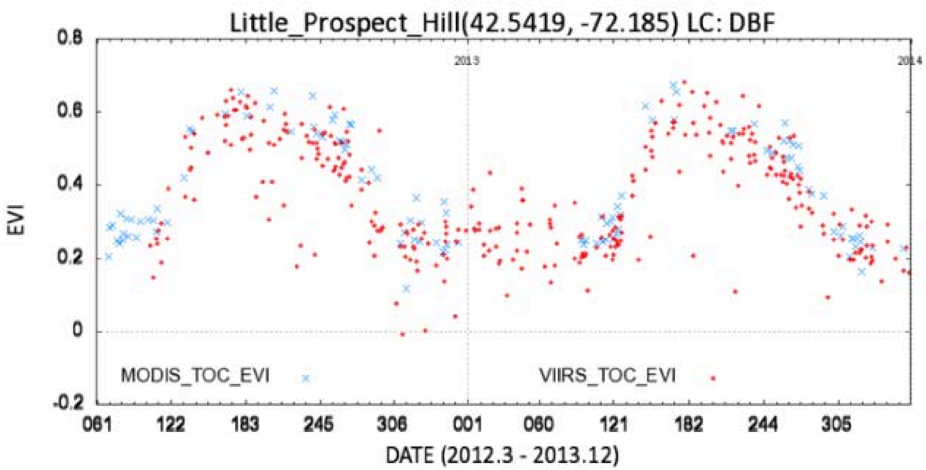


VIIRS Vegetation Index Time Series

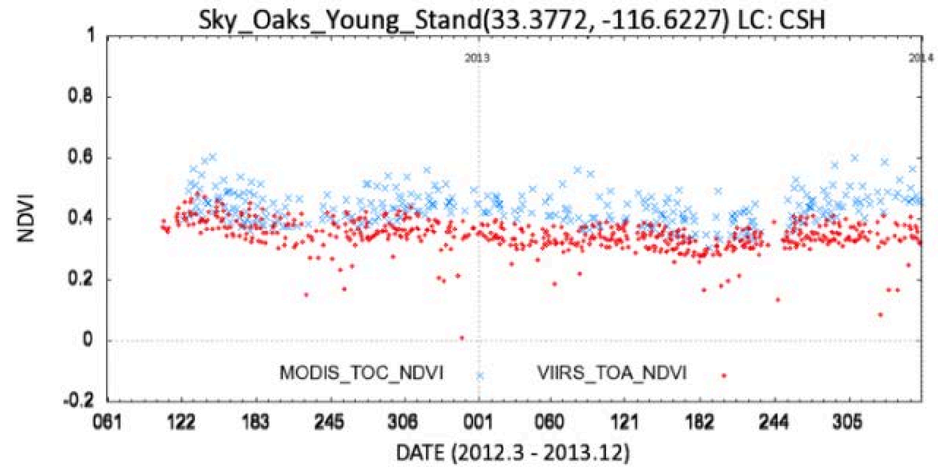
- VIIRS TOA NDVI and TOC EVI showing seasonal patterns comparable to those from the MODIS counterparts
- Higher cloud mask quality in 2013 than in 2012

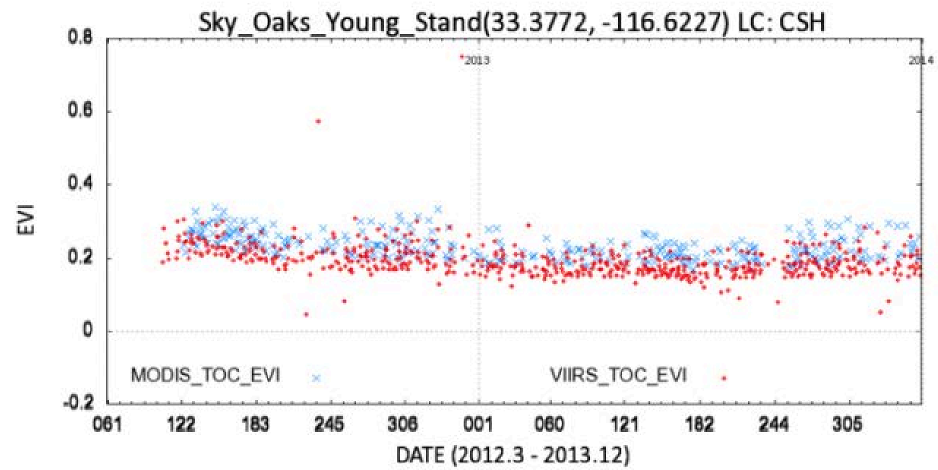
Deciduous Broadleaf Forest





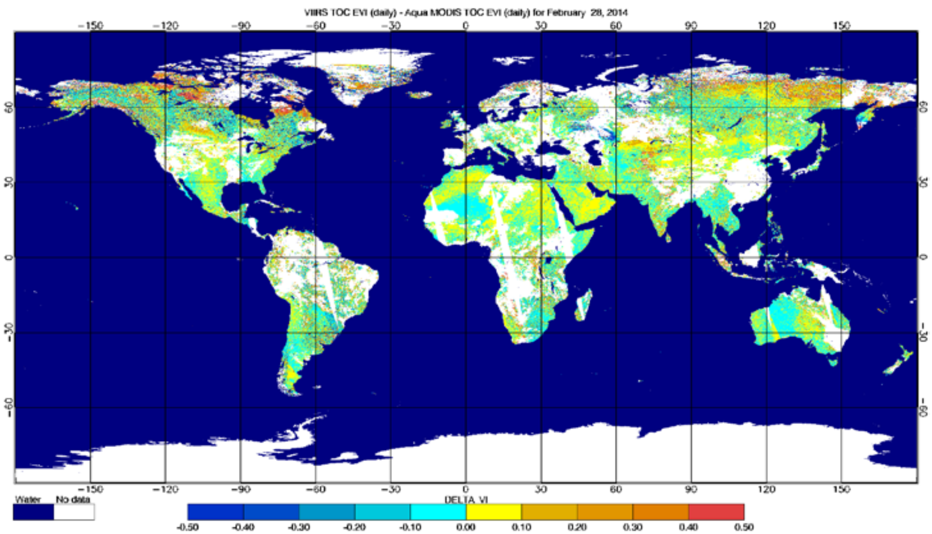
Closed Shrubland

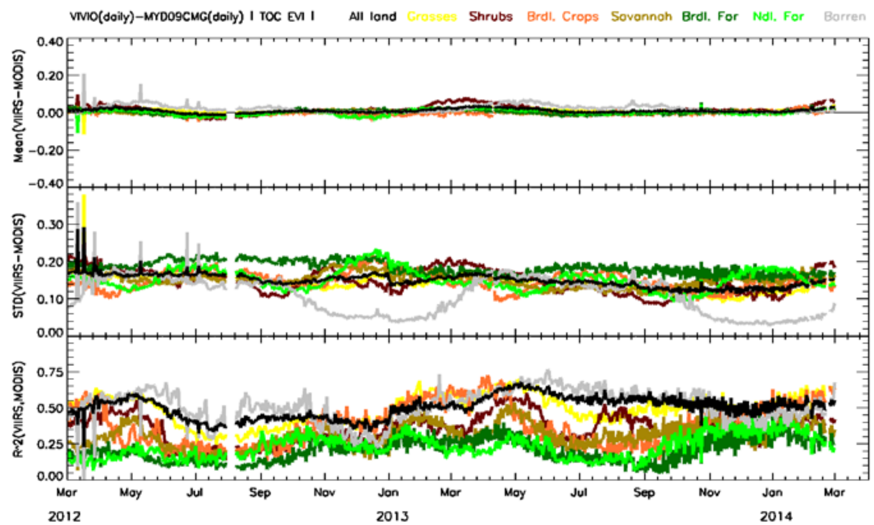


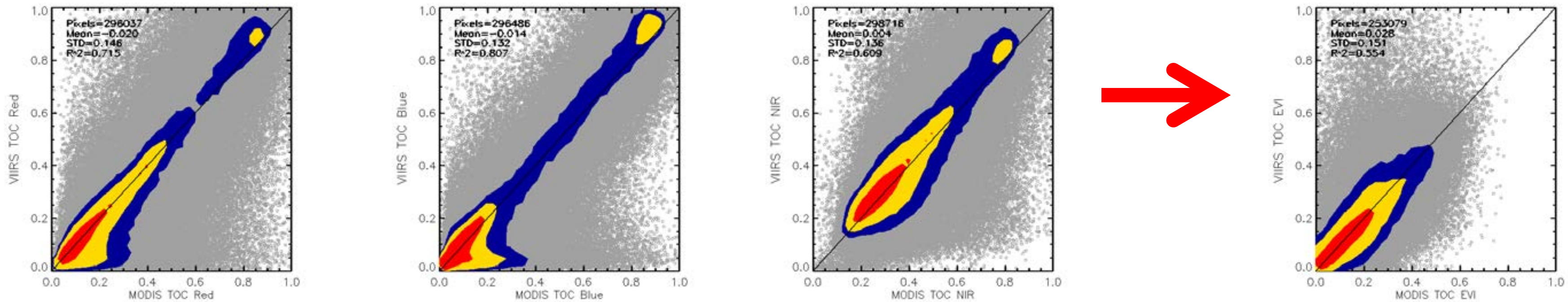


VIIRS Vegetation Index Time Series

Global <u>TOC EVI</u> VIIRS minus MODIS (February 28, 2014)



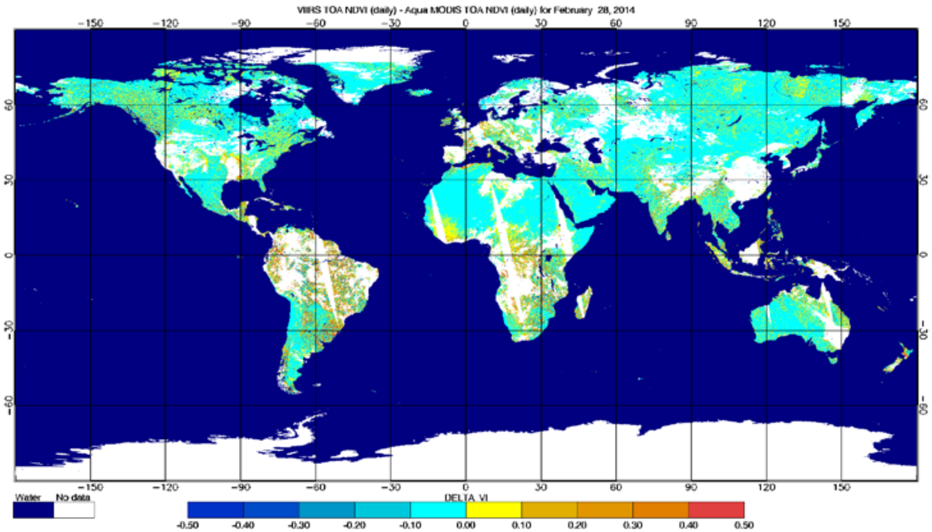


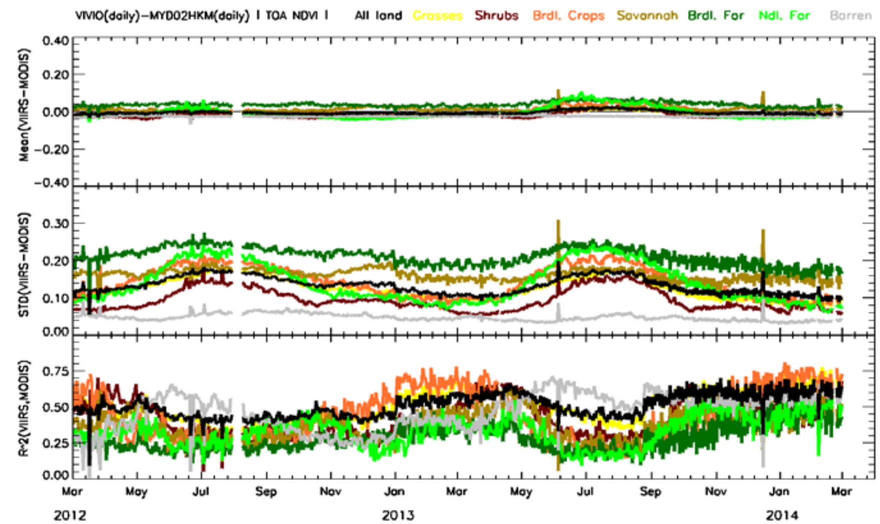


VIIRS and MODIS TOC EVI match each other on a global scale.

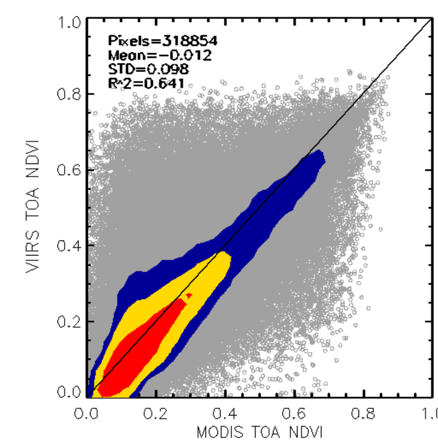
VIIRS Vegetation Index Time Series

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



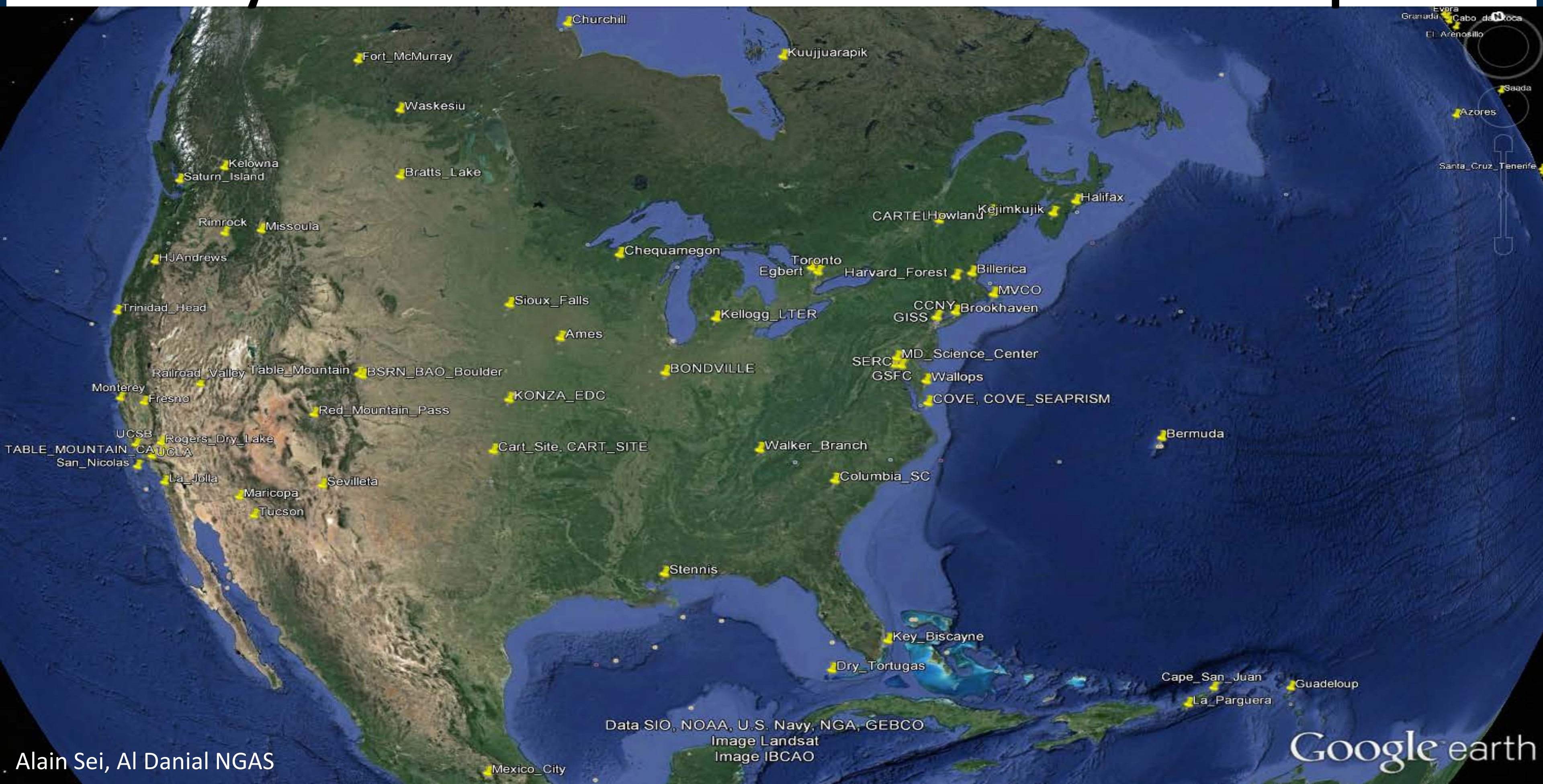


While VIIRS and MODIS TOA NDVI match on a global scale (overall bias is close to 0 in time series), for most typical pixels (highest density in scatterplots), VIIRS tends to underestimate TOA NDVI.



VI EDR Validation Matchup Analysis

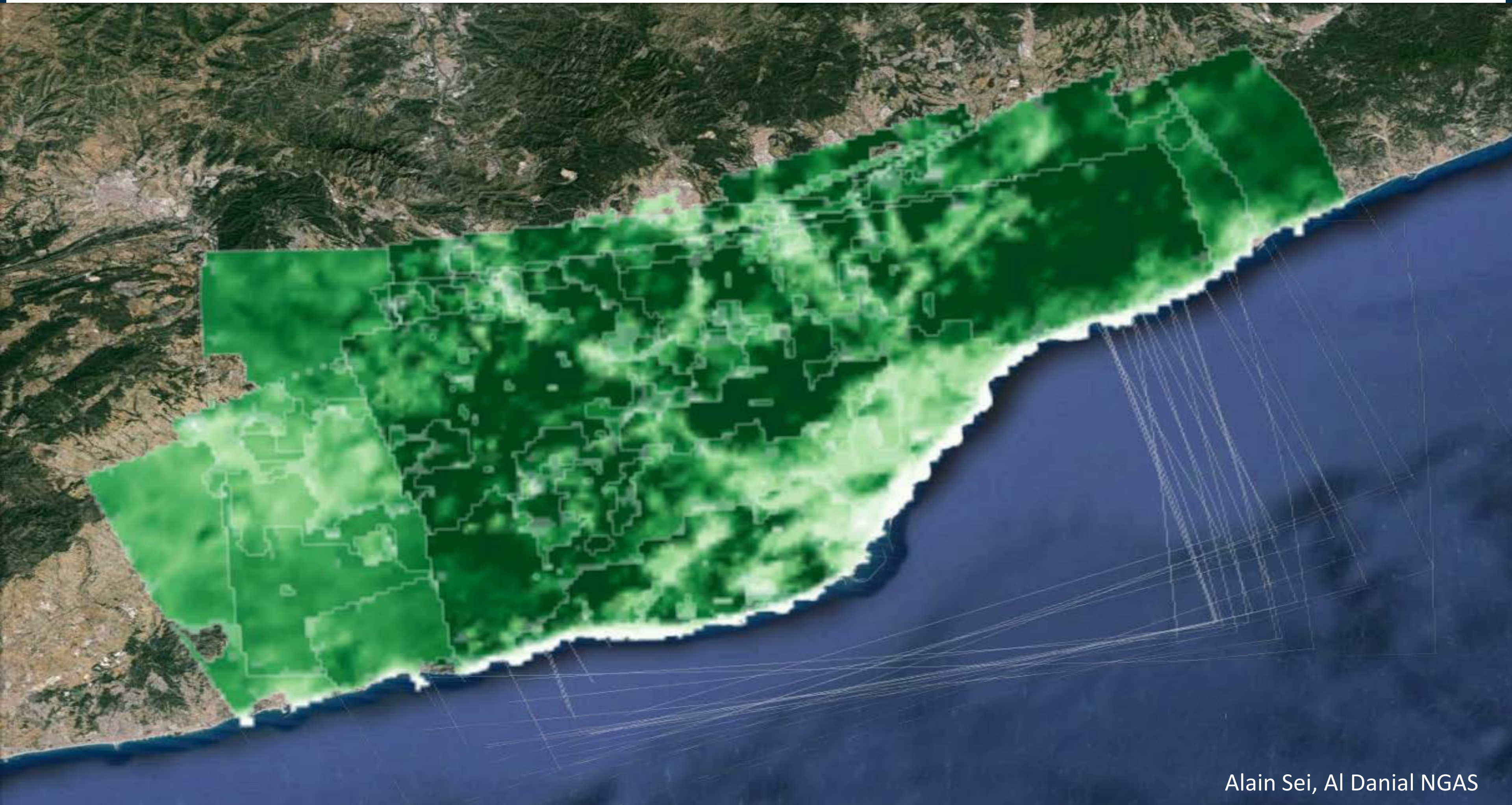
Surface Reflectance and VI cutouts collected daily at 229 Aeronet sites: North America Example



Alain Sei, Al Danial NGAS

VI EDR Validation Matchup Analysis

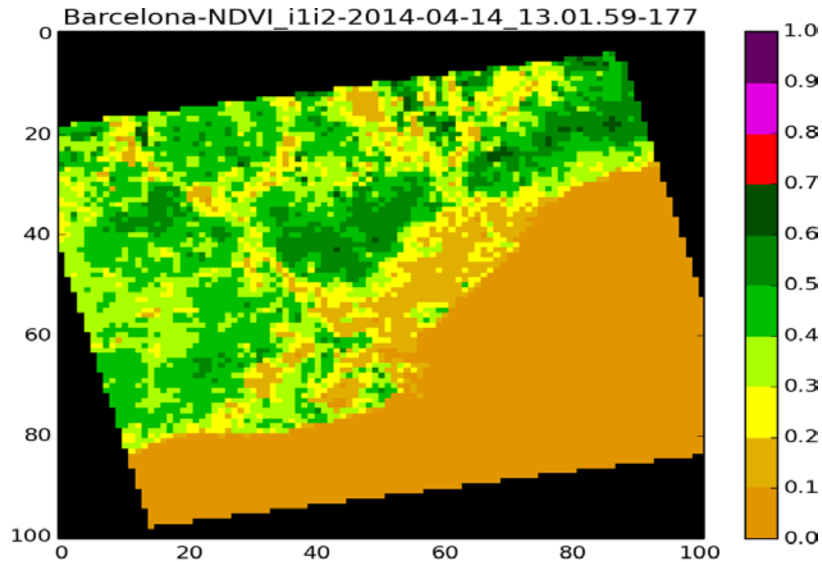
Example of Cutouts of TOA NDVI at Barcelona. First three weeks in April, 2014

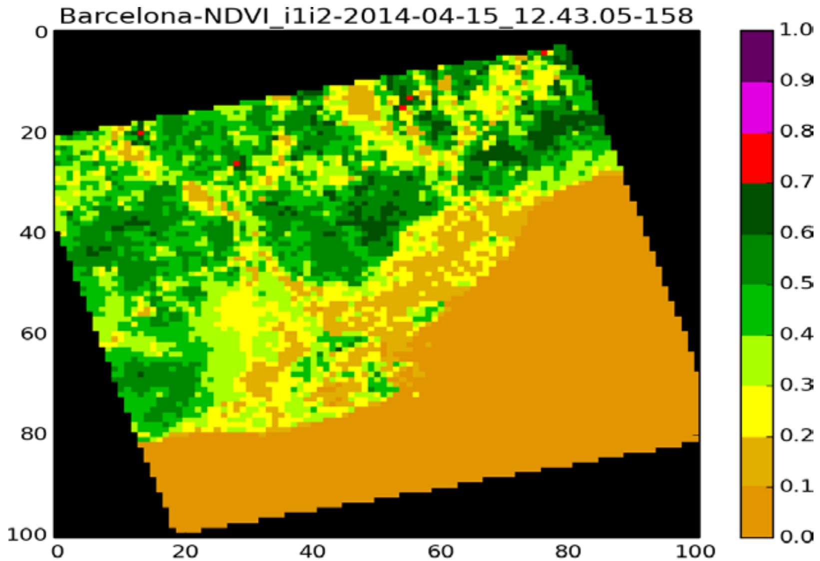


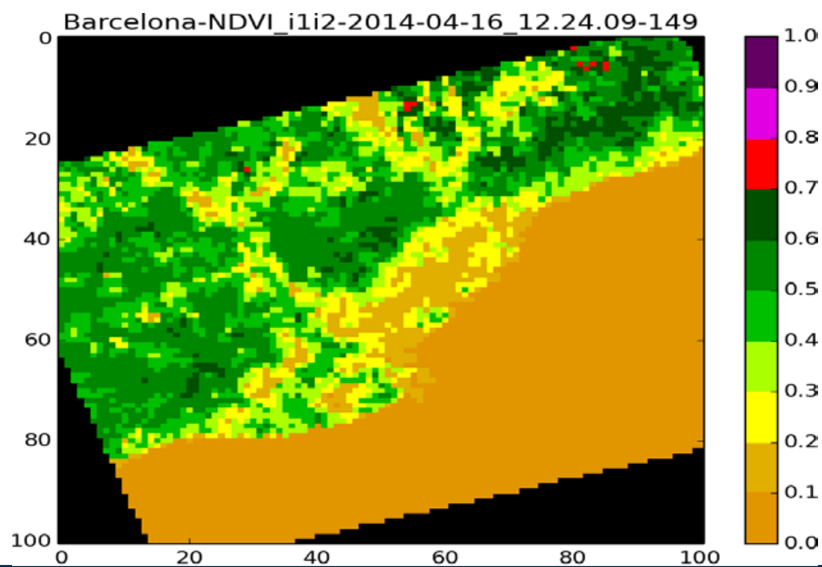
Alain Sei, Al Danial NGAS

VI EDR Validation Matchup Analysis

Sinusoidal Projection Allows Colocated 500 m Cells to be Tracked Chronologically

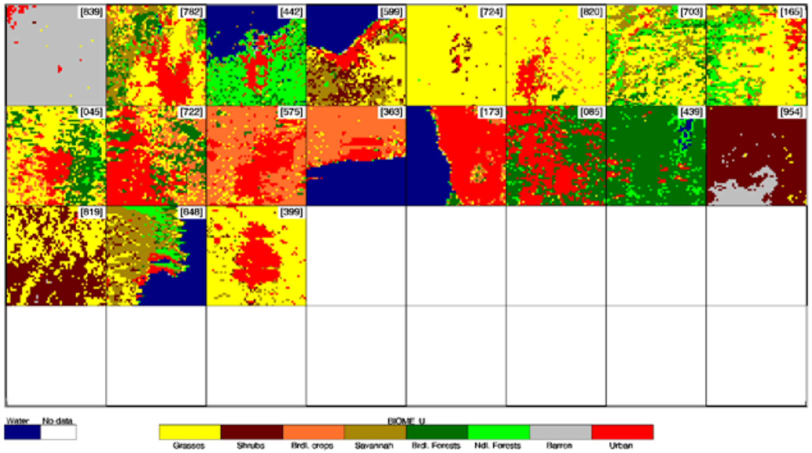


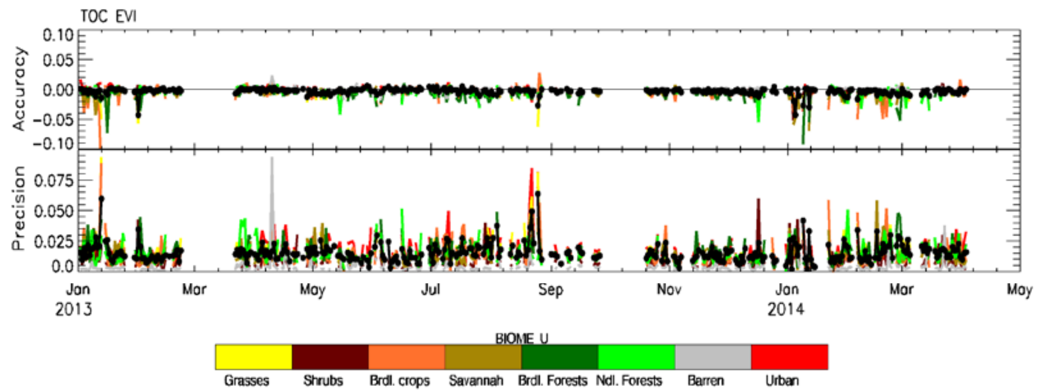


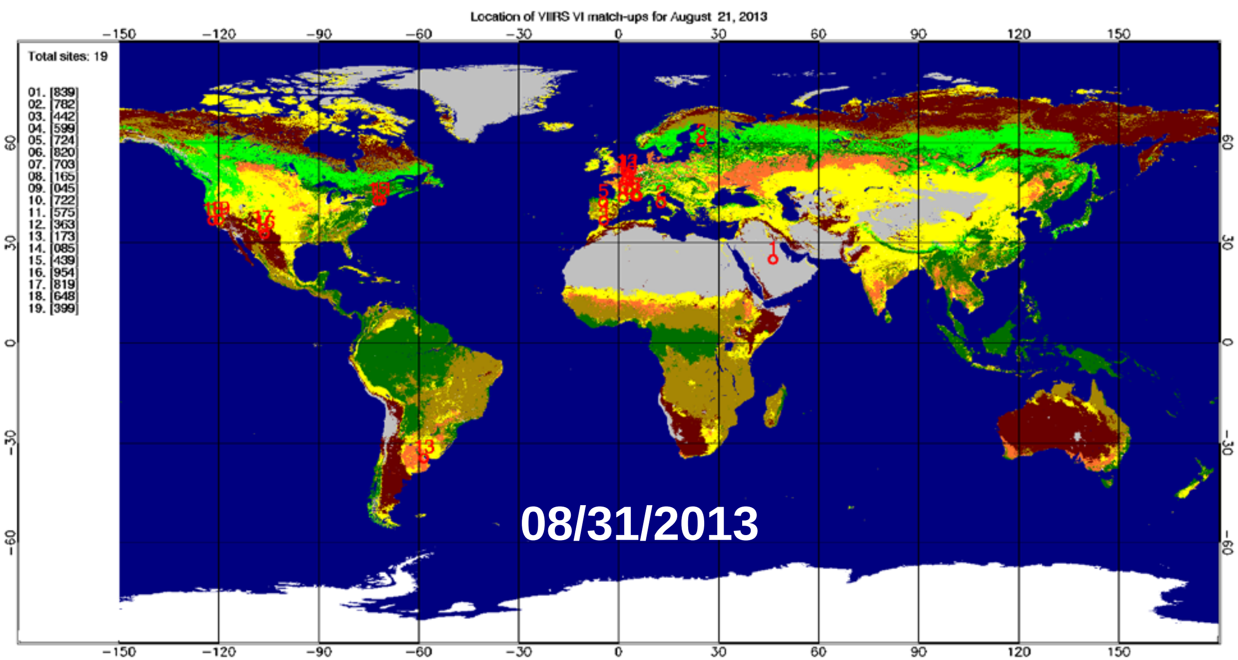


Alain Sei, Al Danial NGAS

VI EDR Validation Using Aeronet Based SR (Matchup Data)







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

VI EDR Product Improvements (DR7038)

Mapping of Additional QFs (Mx8.4)

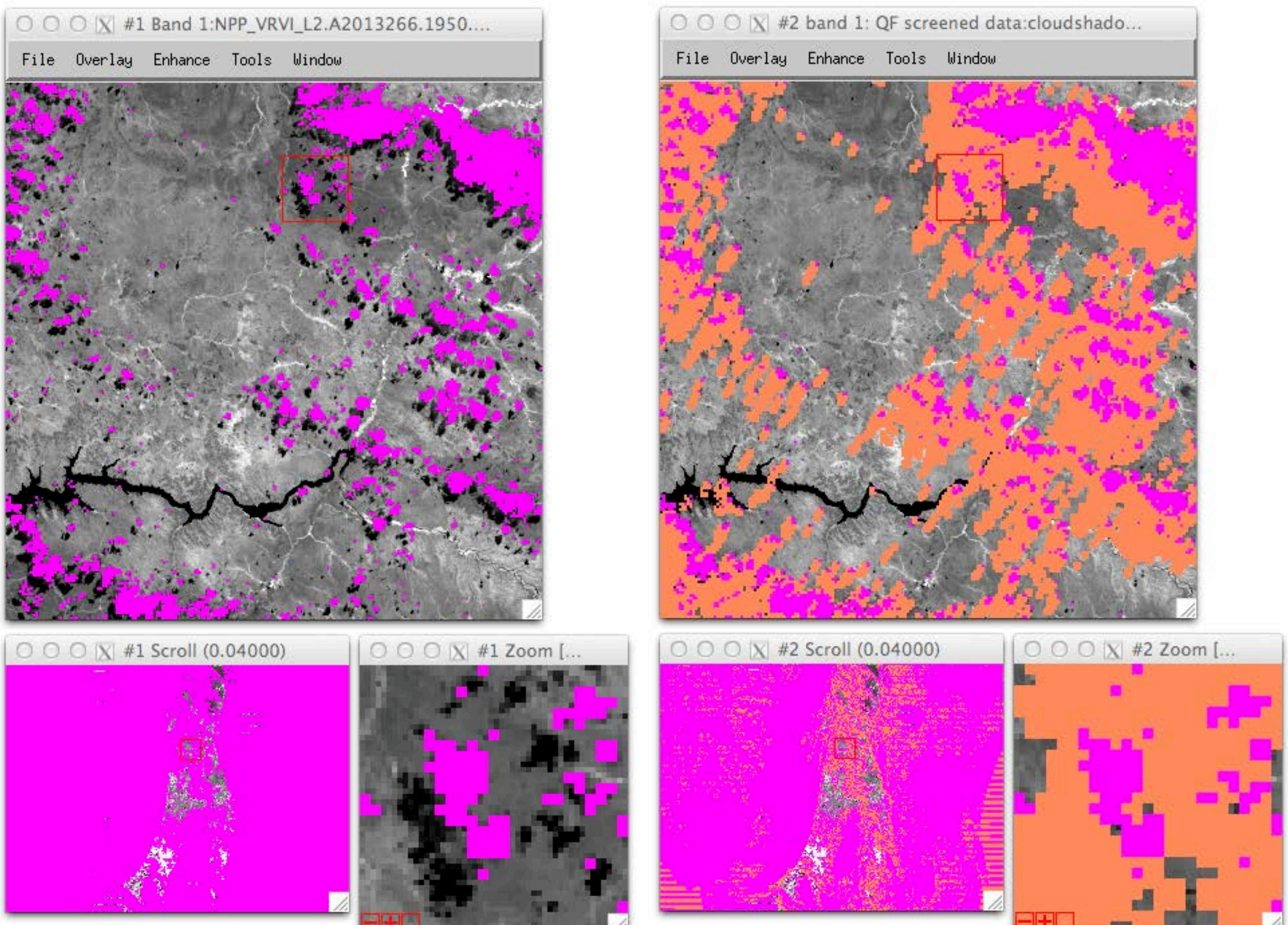
- Include the following four additional QFs into QF3_VIIRSVIEDR
  1) snow/ice <= to be copied from Bit 0 of SR IP QF7
  2) adjacent clouds <= to be copied from Bit 1 of SR IP QF7
  3) aerosol quantity <= to be copied from Bits 2-3 of SR IP QF7
  4) cloud shadow <= to be copied from Bit 3 of SR IP QF2

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

VI EDR Product Improvements (DR7038)

TOA NDVI: Screened for "Confident Cloudy" & "AOT > 1.0"

TOA NDVI: Screened for "Cloud Shadows"



Additional QF3 Bit 7: Cloud Shadows

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

TOC EVI Backup Algorithm Prototype

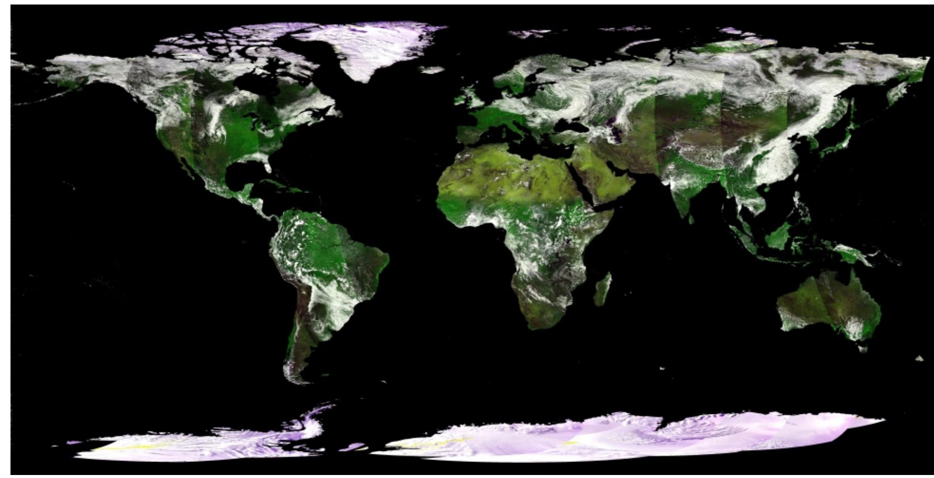
- DR 7039 - A backup algorithm for EVI over snow/ice and clouds
- TOC EVI is unstable over snow/ice and cloud edges
- An EVI backup algorithm is being prototyped based on the MODIS VI algorithm
  - It switches the EVI equation to a two-band EVI equation
- The current set of criteria (prototype) are: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

TOC EVI Backup Algorithm Prototype

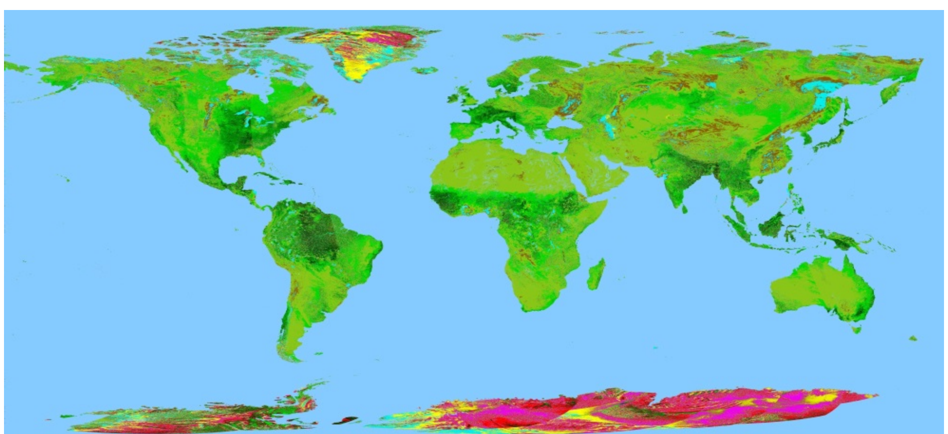
- TOC EVI values are unrealistically high/low over the snow/ice covered areas in the high northern latitude area and most of Antarctica as well as over clouds
- They become around "zero" in the backup algorithm output

VIIRS Data of Sep 23, 2013

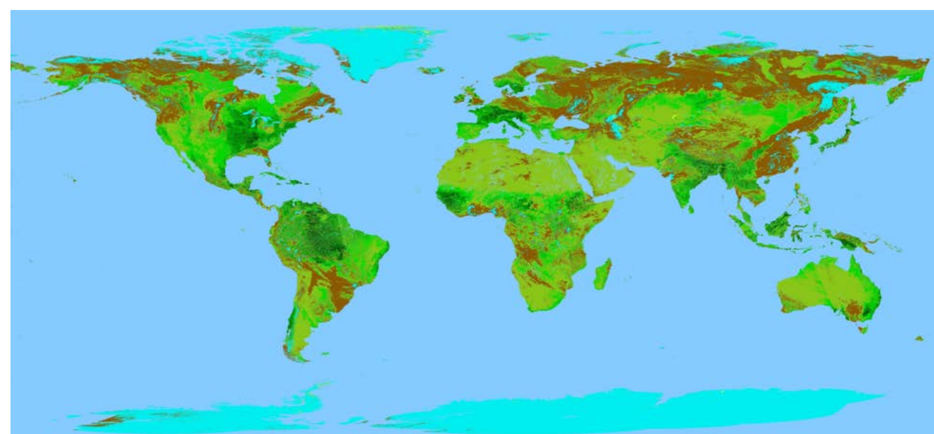
TOC Reflectance (RGB: I1, I2, M3)



TOC EVI Current Algorithm



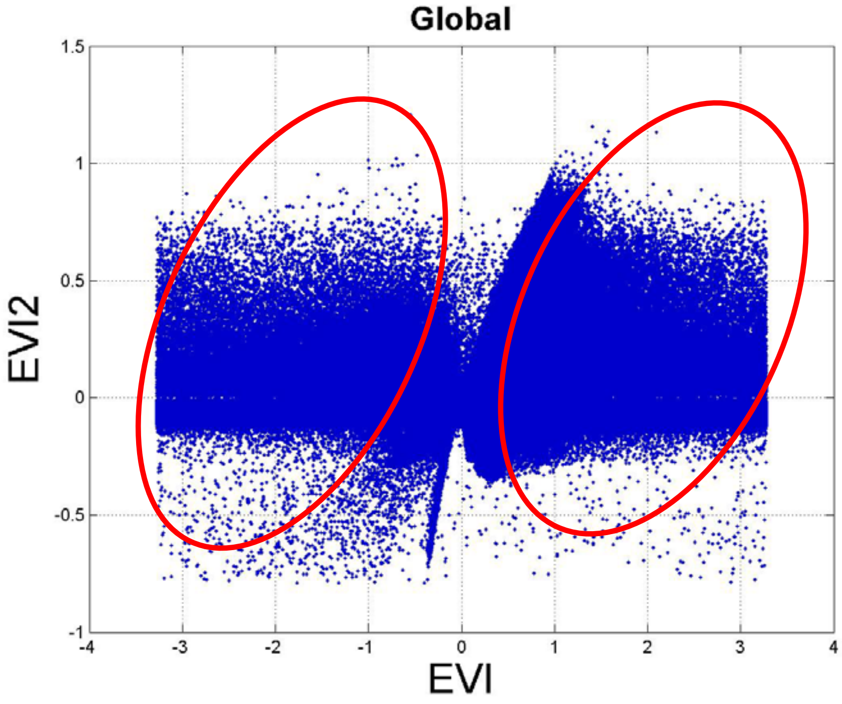
TOC EVI with Backup Algorithm



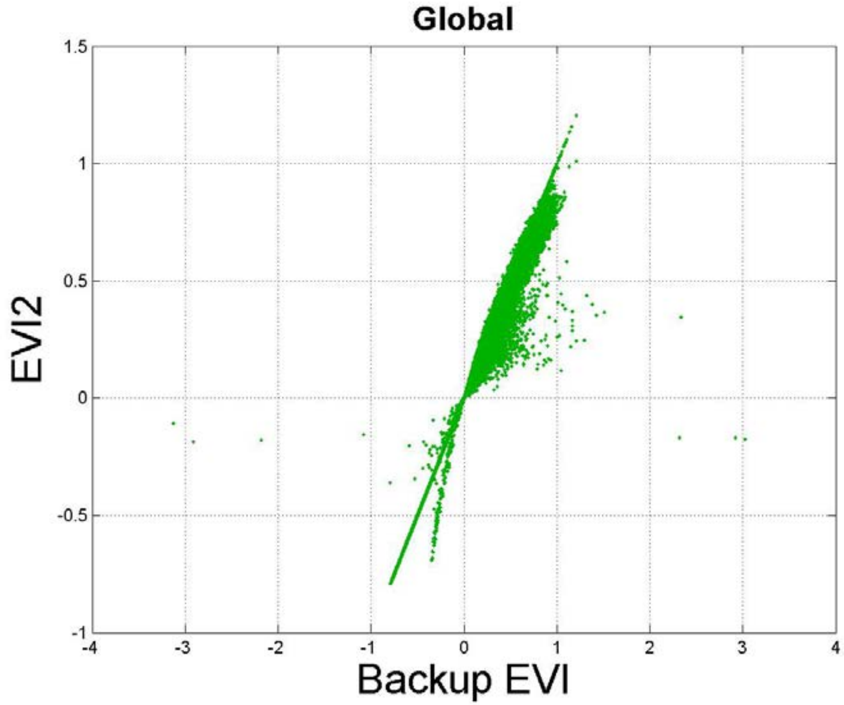
TOC EVI Backup Algorithm Prototype

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

TOC EVI Current Algorithm

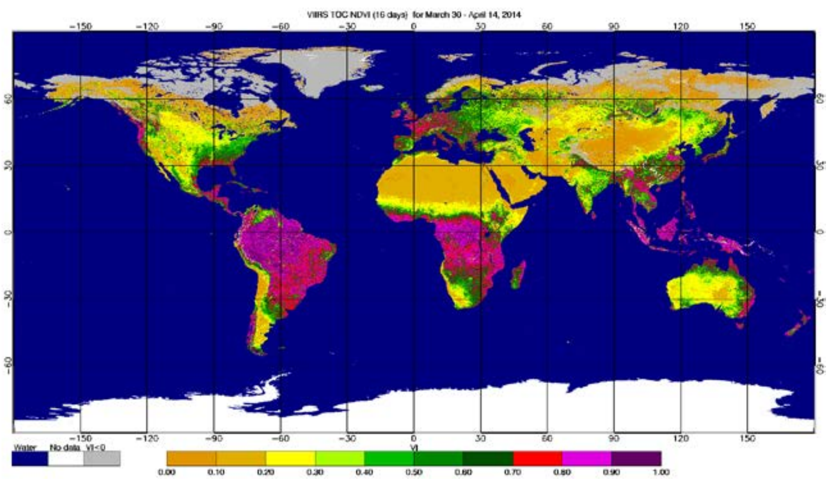


TOC EVI with Backup Algorithm

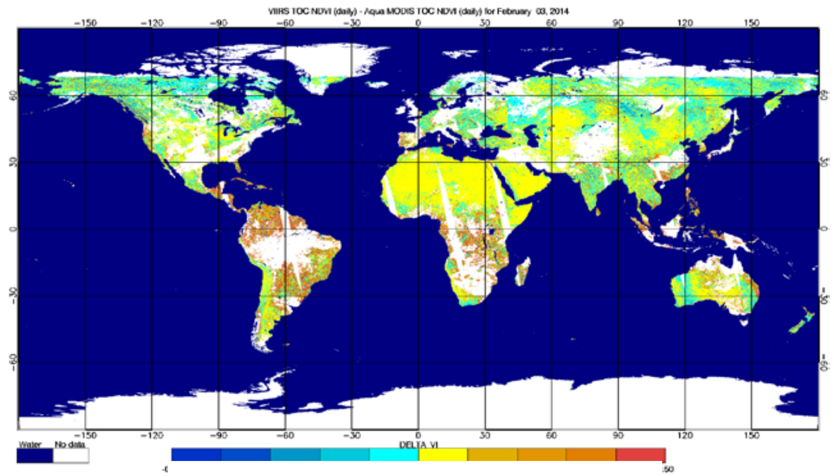


JPSS1 TOC NDVI Development

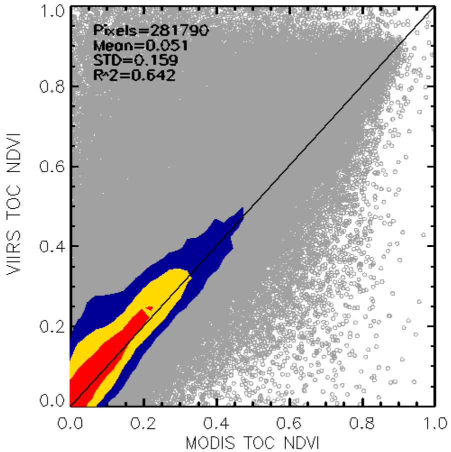
VIIRS derived TOC NDVI March 30 - April 14, 2014 (using S-NPP data)



TOC NDVI (VIIRS minus MODIS)



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



VI-EDR Future Plans

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

Summary

- Analysis results indicate that the VIIRS Vegetation Index EDR operational product is performing well
  - Summary statistics meet the L1 requirements
  - Additional QFs critical in meeting the L1 requirements
- VI EDR will meet Validation 1 status based on the definitions and the analysis performed (summer 2014)
- The JPSS1 TOC NDVI algorithm will be developed to meet the Level 1 Requirements

NDE NUP Green Vegetation Fraction

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

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

GVF Team Members

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

GVF Customers/Users

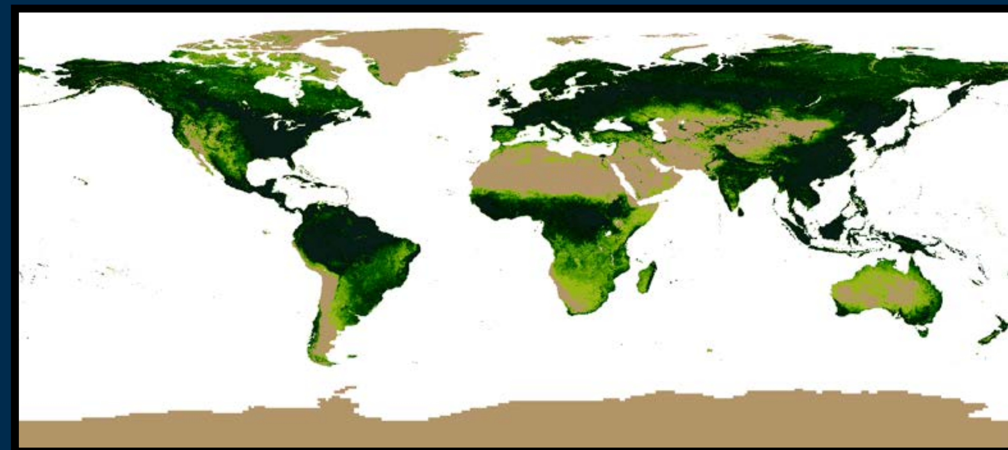
- – **NCEP/EMC**
- – **CLASS**
- – **NASA/SPoRT**

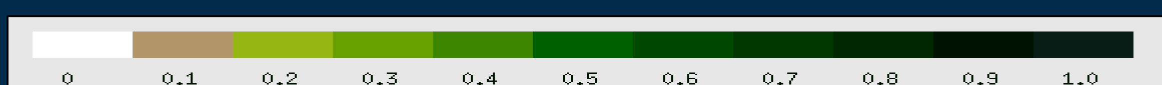
NDE NUP GVF Product

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

NDE NUP GVF Product

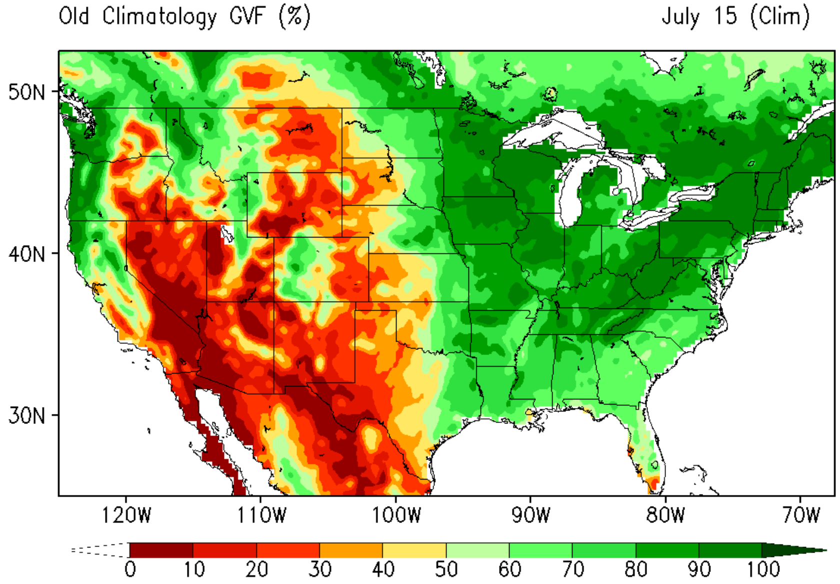
- Two GVF weekly products: global (4km res) and regional (1km res)
- Global GVF product in NetCDF4 format will be archived at CLASS



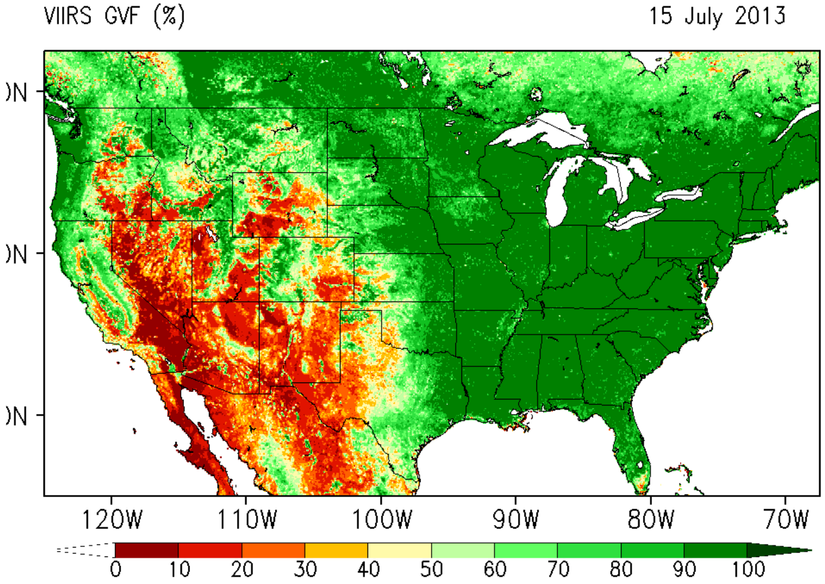


NDE NUP GVF Product

AVHRR (16 km res)



VIIRS (4km res)



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

GVF Accomplishments

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

GVF Future Plans

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

Thank you

ACTIVE FIRES: SDR QUALITY, REPLACEMENT CODE AND I-BAND PRODUCT

Louis Giglio[1], Wilfrid Schroeder[1], Evan Ellicott[1], William Walsh[1], Ivan Csiszar[2]

[1]University of Maryland, College Park, MD

[2]NOAA/NESDIS Center for Satellite Applications and Research, Camp Springs, MD

Outline

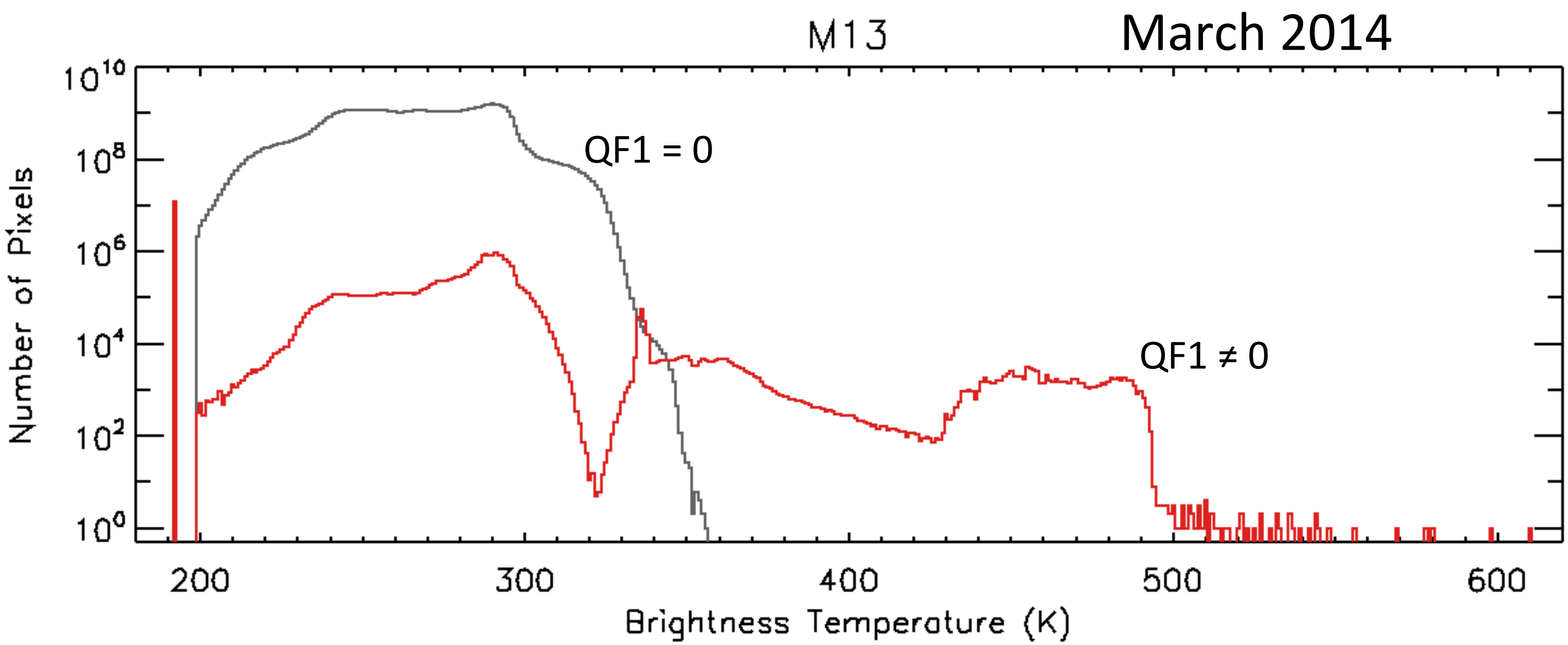
- SDR quality flag issues
- Product status
  - IDPS
  - replacement code (J1)
  - I-band product status
- Validation

SDR QUALITY

Reference Table for QA bits

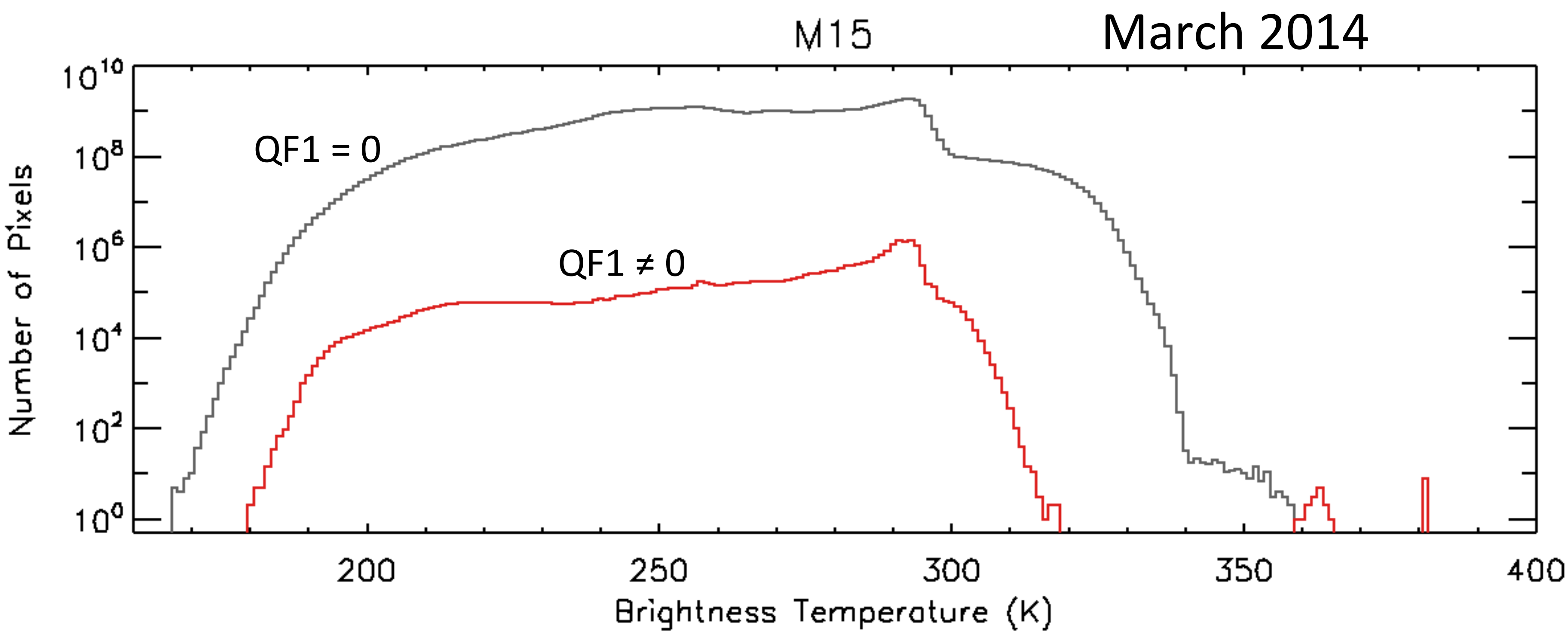
QF1_VIIRSMBANDSDR 1 byte(s) 768 3200	Description	Datum Offset	Data Type	Legend Entries	
	Quality - Indicates calibration quality due to bad space view offsets, OBC view offsets, etc or use of a previous calibration view	0	2 bit(s)	Name	Value
				Good	0
				Poor	1
				No Calibration	2
				Not Used	3
	Saturated Pixel - Indicates the level of pixel saturation	2	2 bit(s)	Name	Value
				None Saturated	0
				Some Saturated	1
				All Saturated	2
				Not Used	3
	Missing Data - Data required for calibration processing is not available for processing	4	2 bit(s)	Name	Value
				All data present	0
				EV RDR data missing	1
				Cal data (SV, CV, SD, etc.) missing	2
				Thermistor data missing	3
	Out of Range - Calibrated pixel value outside of LUT threshold limits	6	2 bit(s)	Name	Value
				All data within range	0
				Radiance out of range	1
				Reflectance or EBBT out of range	2
				Both Radiance and Reflectance/EBBT out of	3

QA	Definition
5	Poor Cal - Some saturated
18	No Calibration - None Saturated - EV RDR Data Missing
33	Poor Cal - None Saturared - Cal Data Missing
34	No Calibration - None Saturated - Cal Data Missing
50	No Calibration - None Saturated - Thermistor Data Missing
129	Poor Cal - None Saturated - All Data Present - Reflectance or EBBT Out of Range (165 cal data missing)
193	Not used – Radiance out of range
65	Poor – Reflectance or EBBT out of range



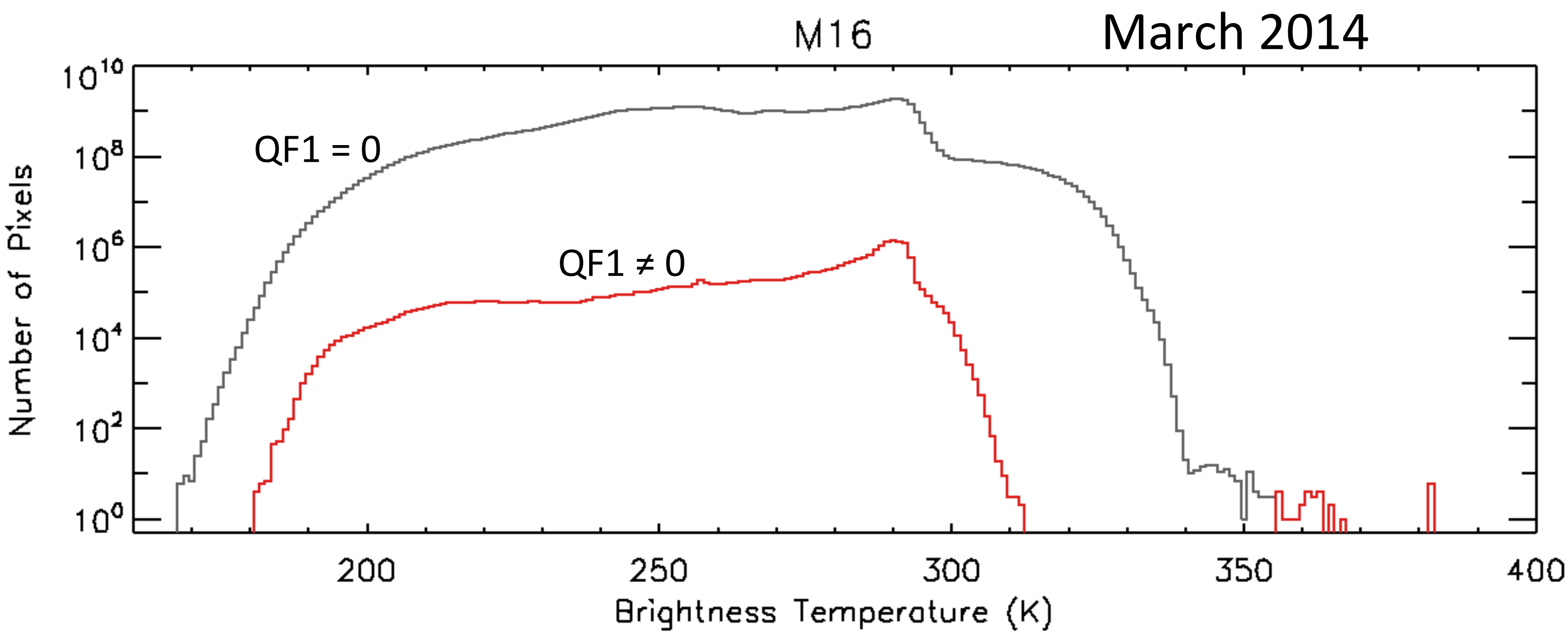
- All pixels > 358 K flagged as having poor calibration
- Partially saturated pixels have high radiance but T_b = 192 K
- Mysterious spike in calibration quality near 335 K
- Mysterious “ravine” in calibration quality near 322 K

NB. QF1 ≠ 0 curve does not include trim (QF1 = 2) or fill (QF1 > 247).



- Brightness temperatures near 362 K are incorrect
- Gap in brightness temperatures from 365 K – 380 K

NB. QF1 ≠ 0 curve does not include trim (QF1 = 2) or fill (QF1 > 247).



- Brightness temperatures near 362 K are incorrect
- Gap in brightness temperatures from 365 K – 380 K

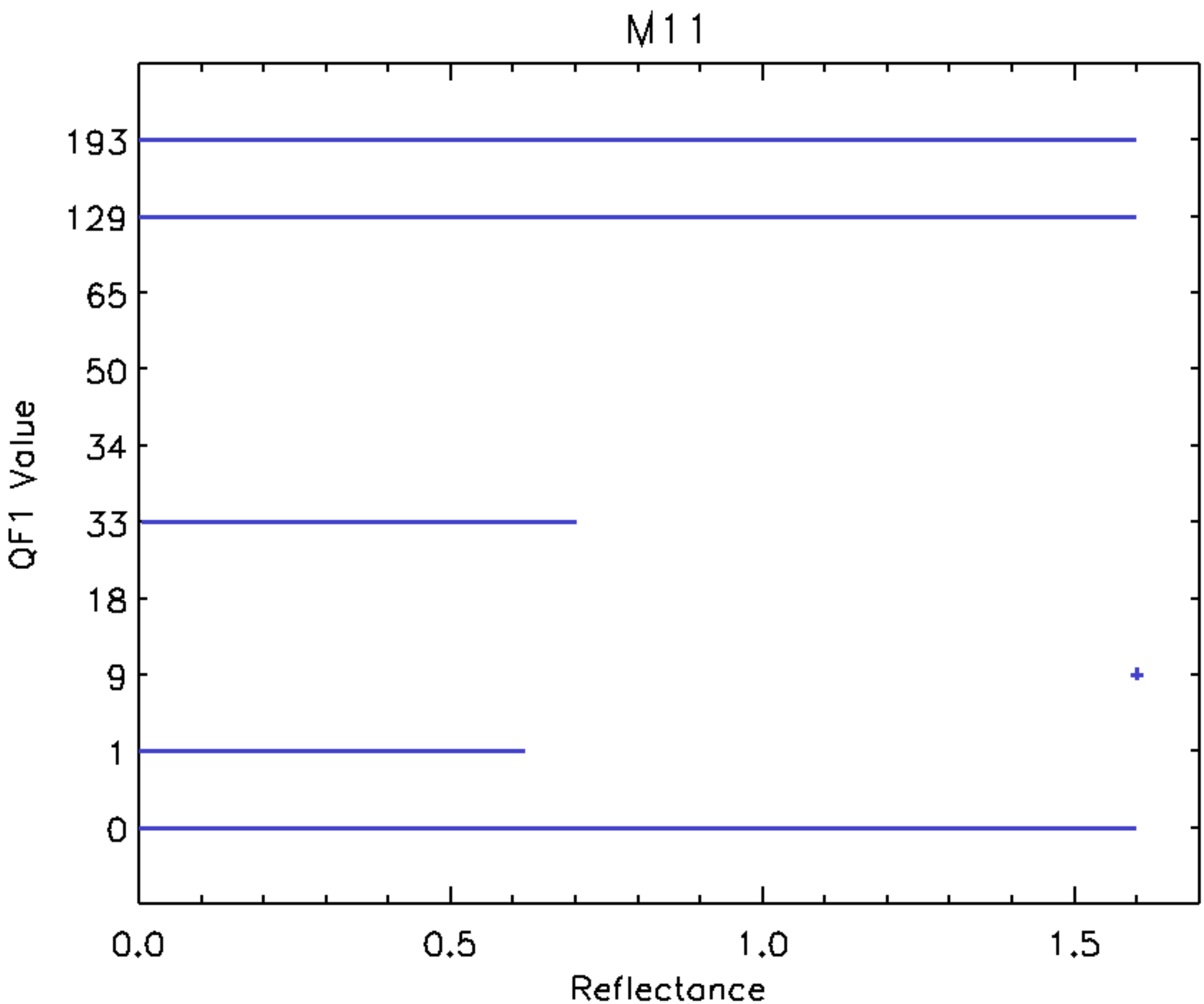
NB. QF1 ≠ 0 curve does not include trim (QF1 = 2) or fill (QF1 > 247).

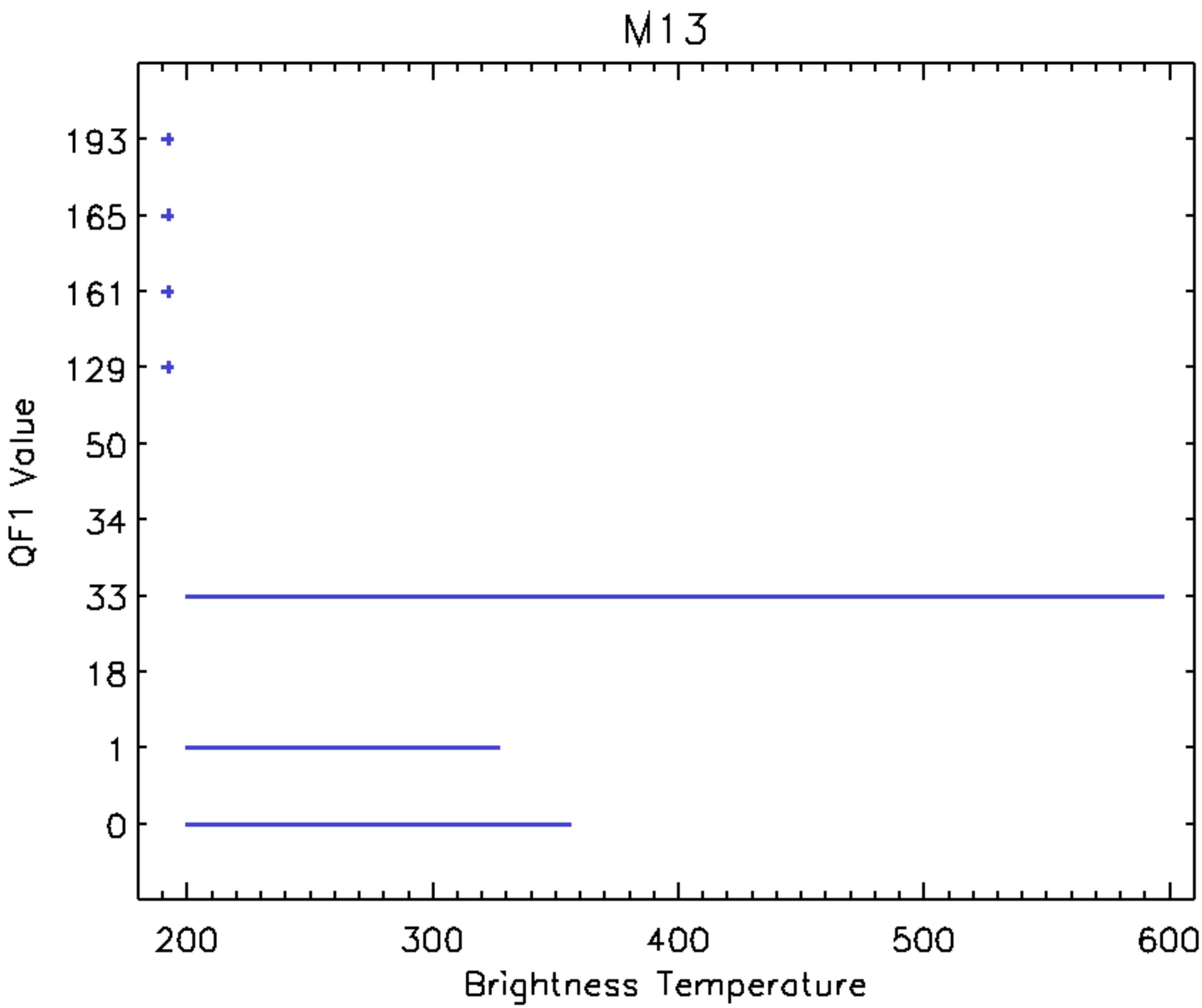
Generic VIIRS SDR Problems

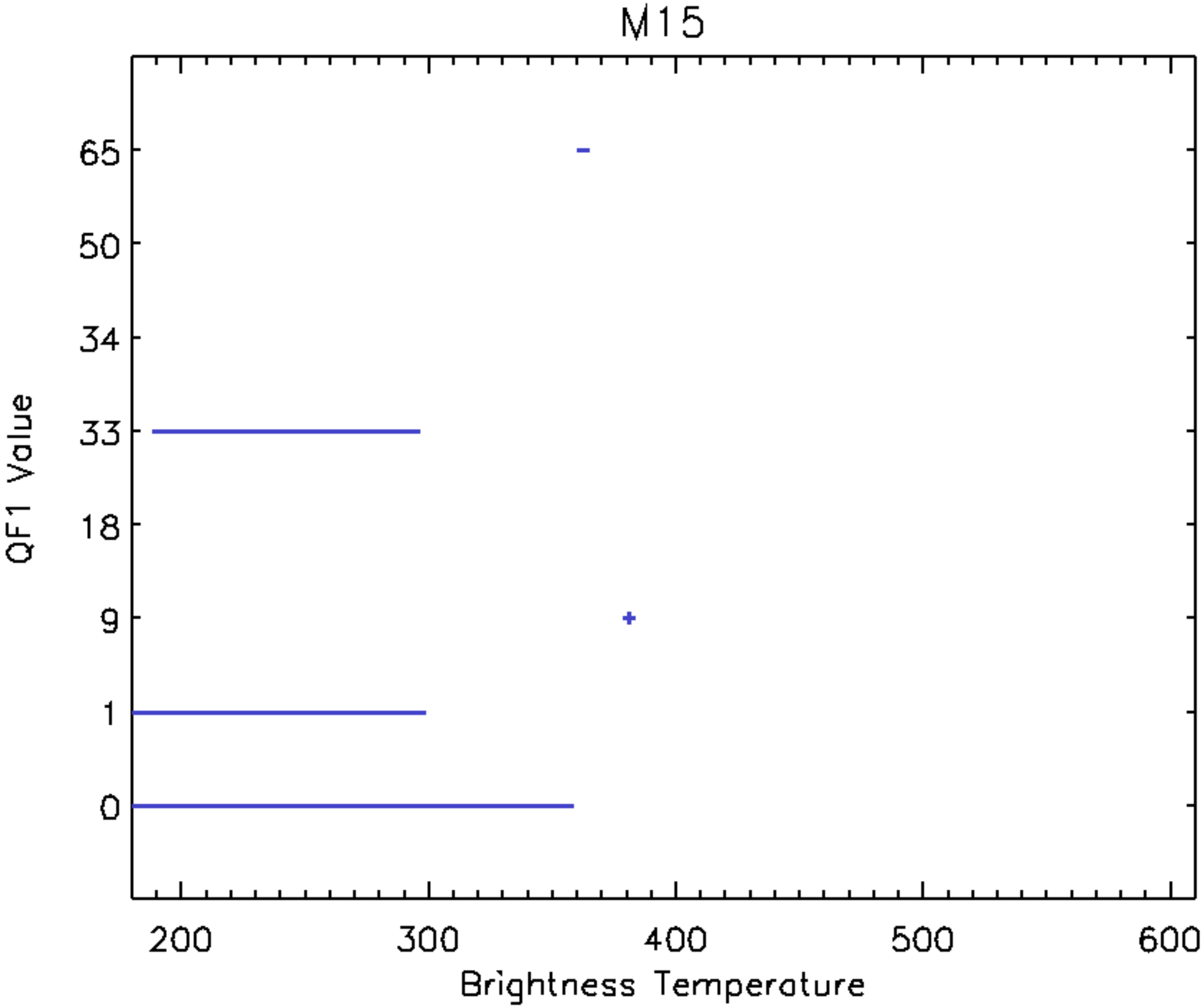
- Non-unique mapping of radiance to brightness temperature near saturation
  - Example: M15 radiance of 20.50 W m^{-2} sr^{-1} um^{-1} assigned T_b = 360.1 K, 363.8 K, 363.9K, 364.1 K, 381 K, etc. within same granule (2014 080 06:55)
- Ongoing confusion between sensor specification and actual sensor capabilities in SDR software lookup tables

Generic VIIRS SDR Problems

- QF1 bits often set haphazardly
  - M13: All pixels > 358K flagged as "poor quality, calibration data missing"
  - Reflective bands: River edges and cloud shadows often non-informatively flagged as "poor quality"
  - Reflective bands: Invalid QF1 values of 35 and 163 occur in ~1,000 pixels/day
  - Currently impossible to reliably filter bad input data via QFs without also considering radiance *and* reflectance/brightness temperature


M11
193
129
65
50
34
33
18
9
1
0
QF1 Value
0.0
0.5
1.0
1.5
Reflectance


M13
QF1 Value
193
165
161
129
50
34
33
18
1
0
200
300
400
500
600
Brightness Temperature

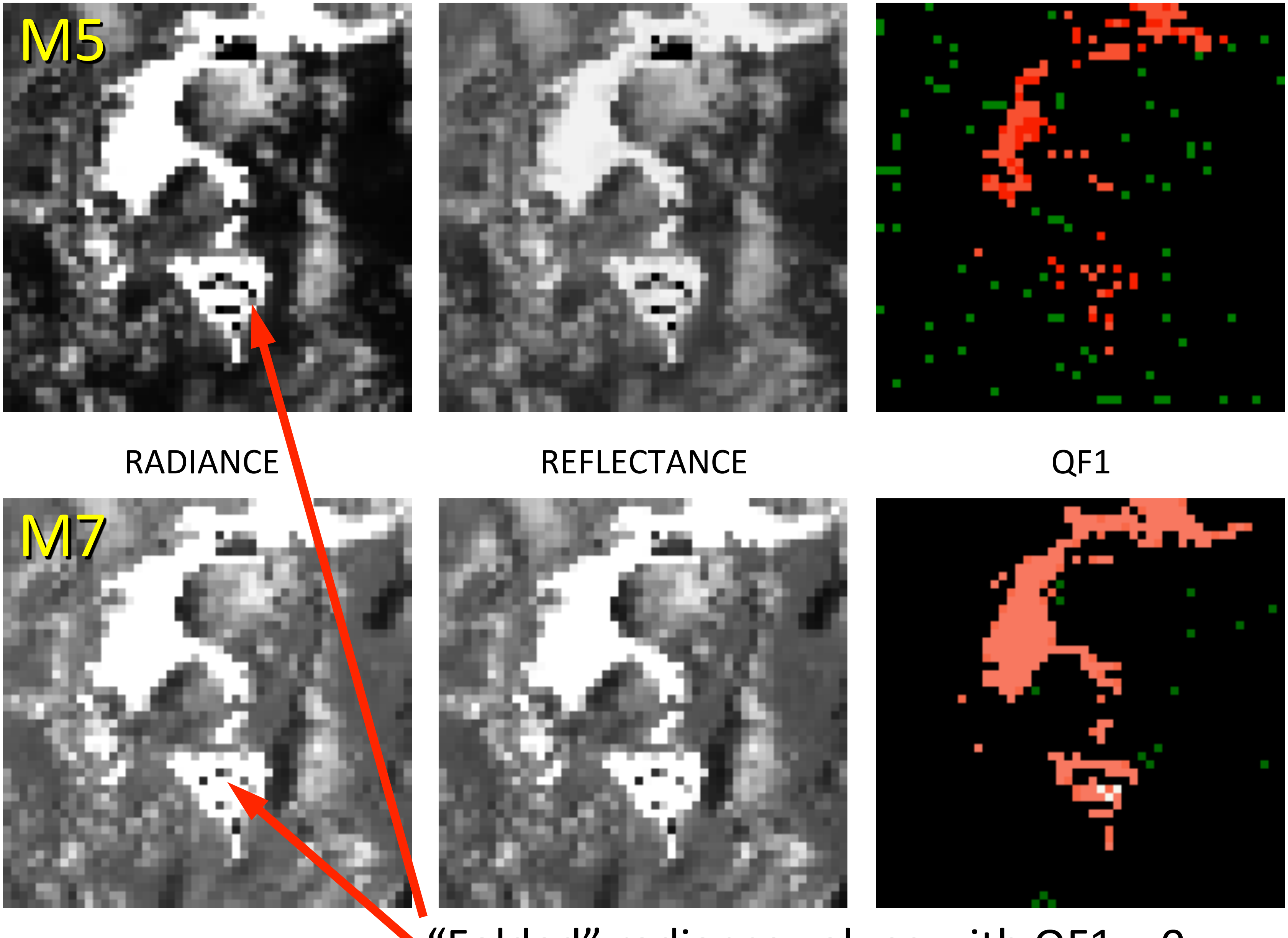


M15
65
50
34
33
18
9
1
0
QF1 Value
200
300
400
500
600
Brightness Temperature

Generic VIIRS SDR Problems

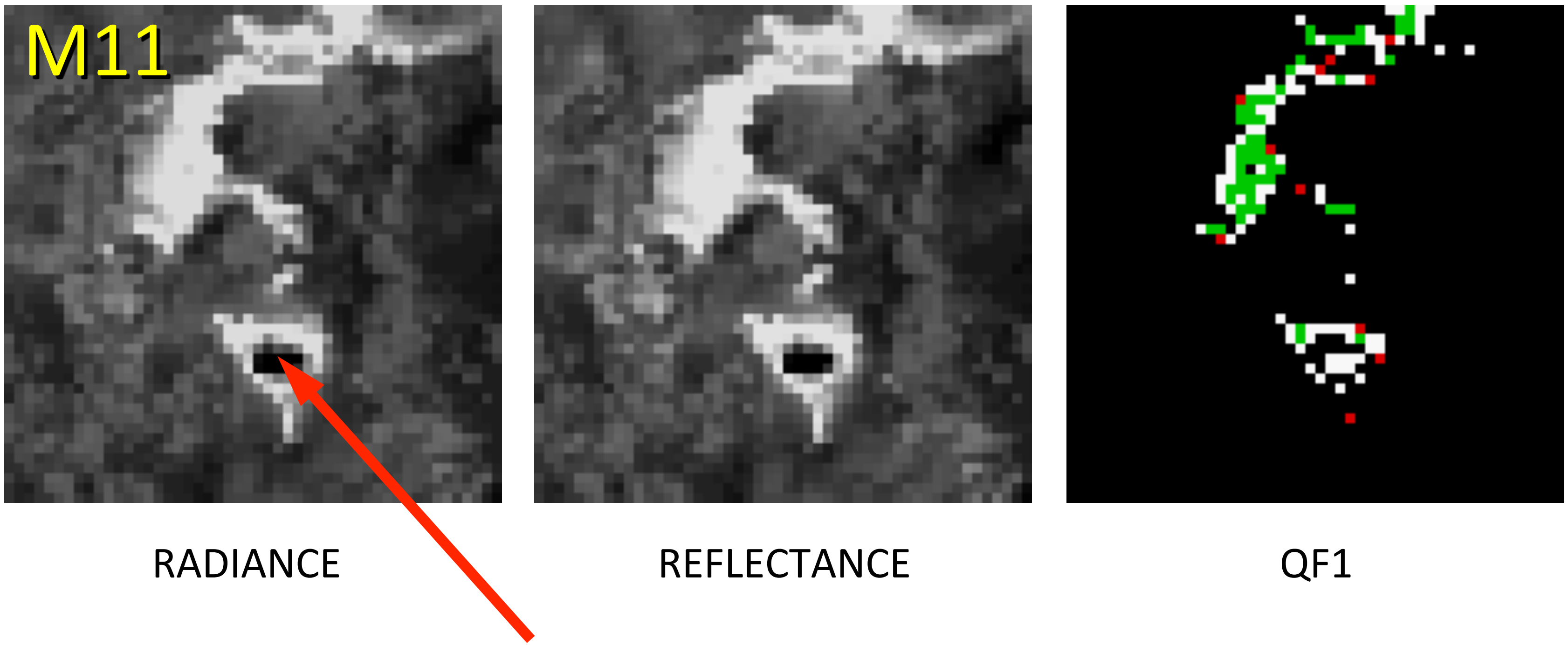
- "Folded" radiance values due to saturation not flagged as invalid
  - Observed in M5 (dual gain), M7 (dual gain), and M11 (single gain)
  - Reflectance values look normal (0.02 – 0.6)
  - QF1 = 0

Sun glint example (2014070 16:45)



"Folded" radiance values with QF1 = 0

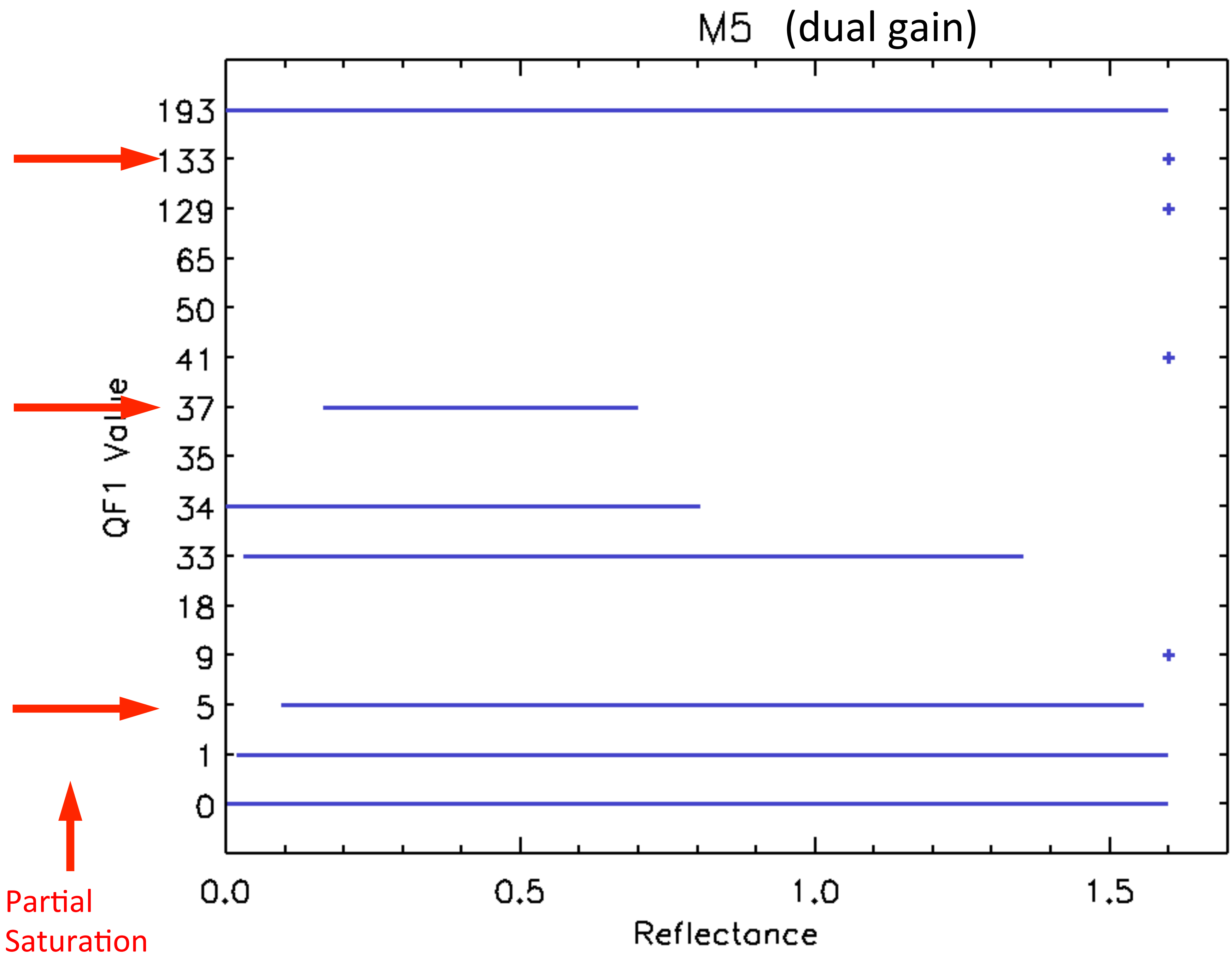
Sun glint example (2014070 16:45)



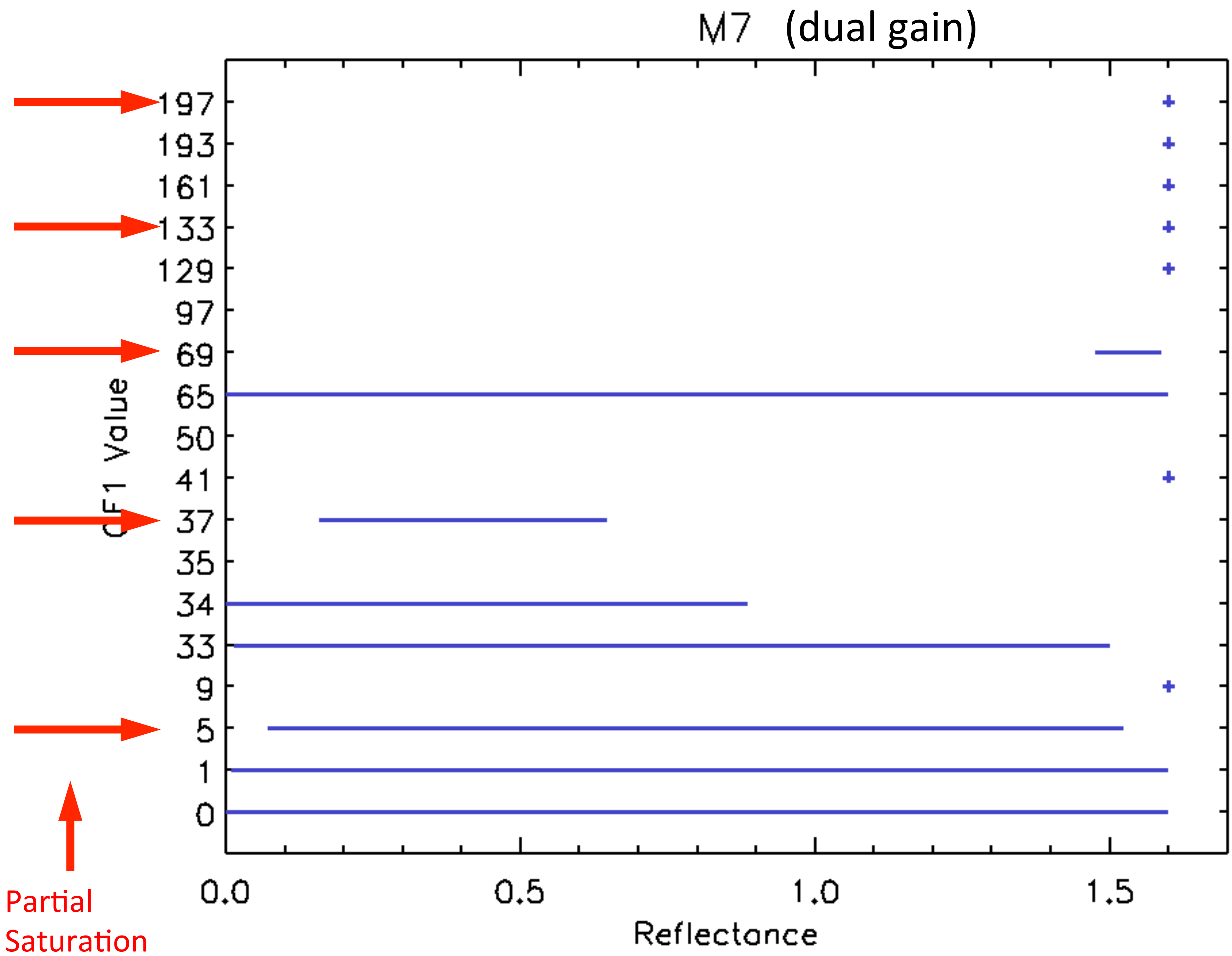
“Folded” radiance values with QF1 = 0

Generic VIIRS SDR Problems

- On-board aggregation bug
  - Affects all non-dual gain bands
  - No reliable method to detect corrupt radiance values arising as a result of this bug

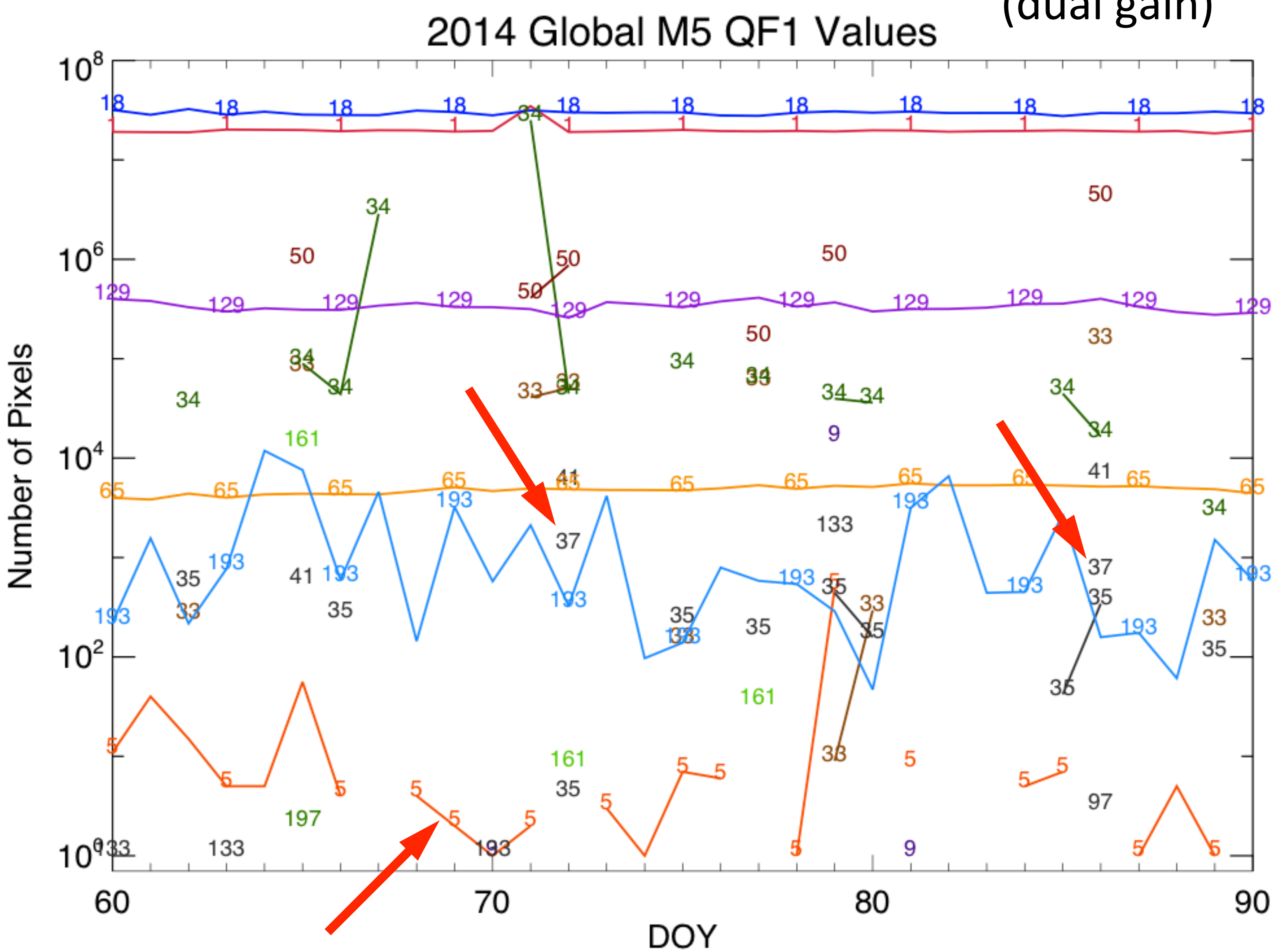


M5 (dual gain)
193
133
129
65
50
41
37
35
34
33
18
9
5
1
0
QF1 Value
0.0
0.5
1.0
1.5
Reflectance
Partial
Saturation

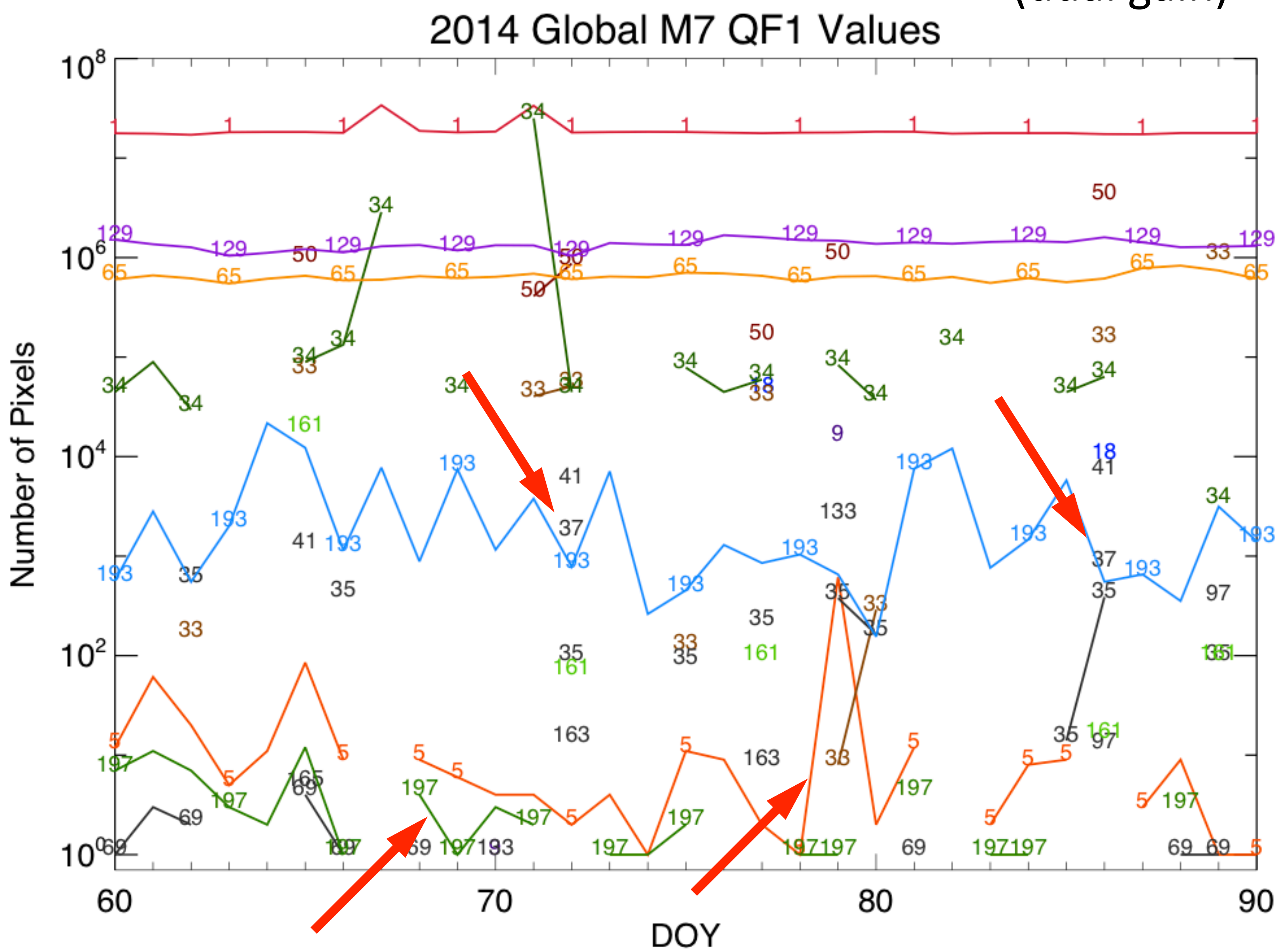


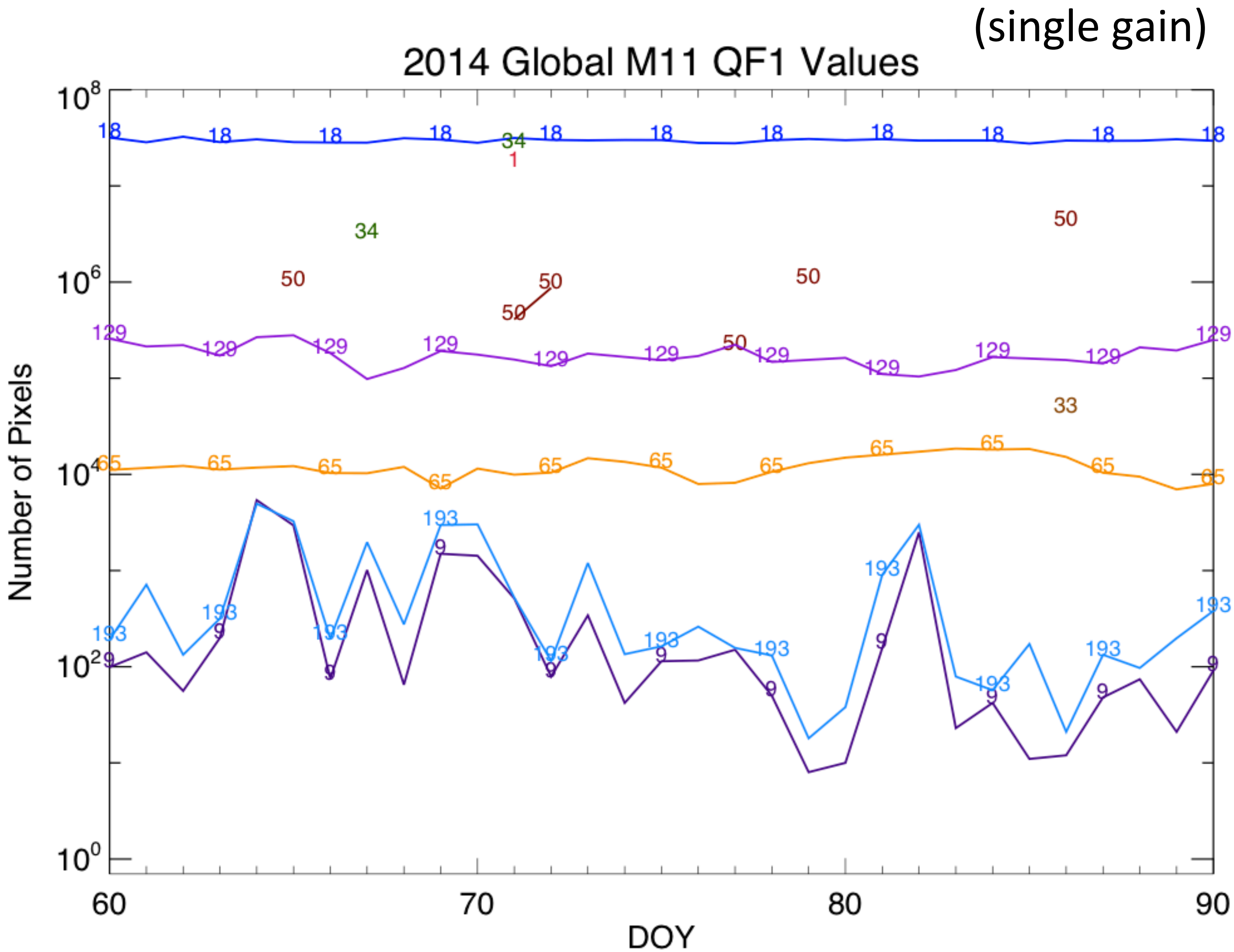
M7 (dual gain)
CF1 Value
197
193
161
133
129
97
69
65
50
41
37
35
34
33
9
5
1
0
0.0
0.5
1.0
1.5
Reflectance
Partial Saturation

(dual gain)



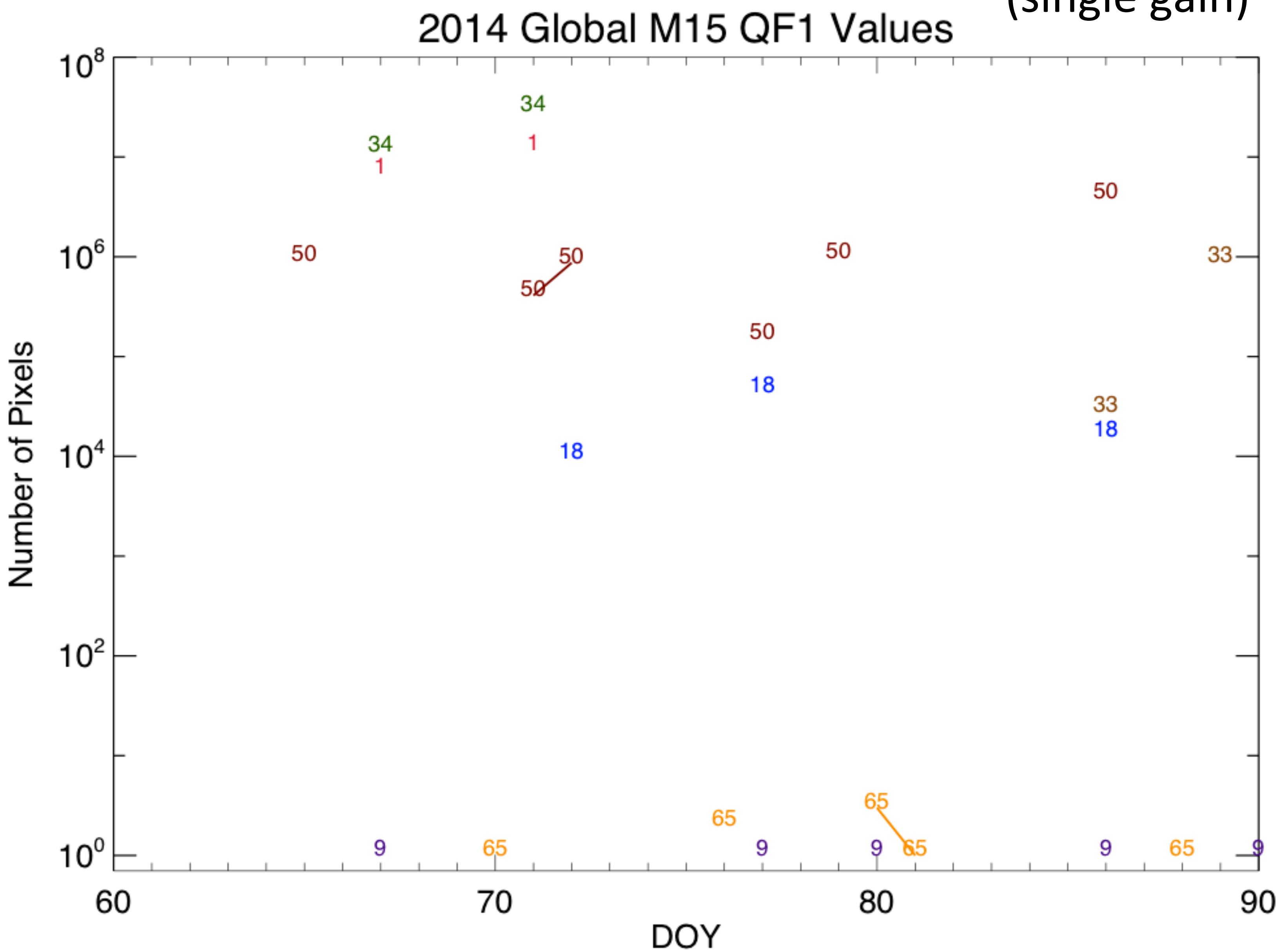
(dual gain)





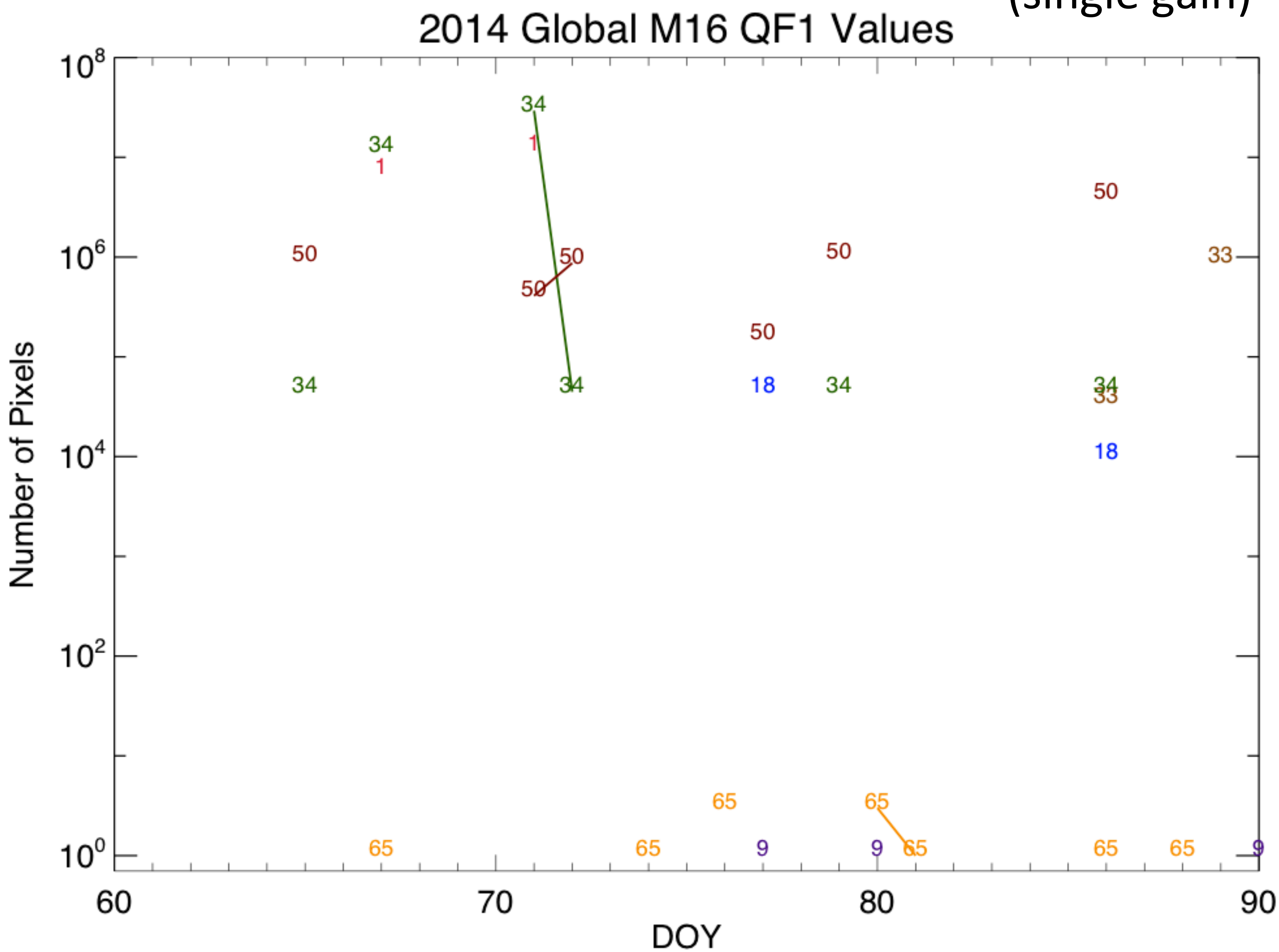
(single gain)
2014 Global M11 QF1 Values
Number of Pixels
DOY
10^8
10^6
10^4
10^2
10^0
60
70
80
90
18
34
1
50
129
33
65
193
9

(single gain)



2014 Global M15 QF1 Values
Number of Pixels
DOY
60
70
80
90
10^0
10^2
10^4
10^6
10^8
34
34
1
1
50
50
50
50
50
50
33
33
18
18
18
65
65
65
65
65
9
9
9
9
9

(single gain)

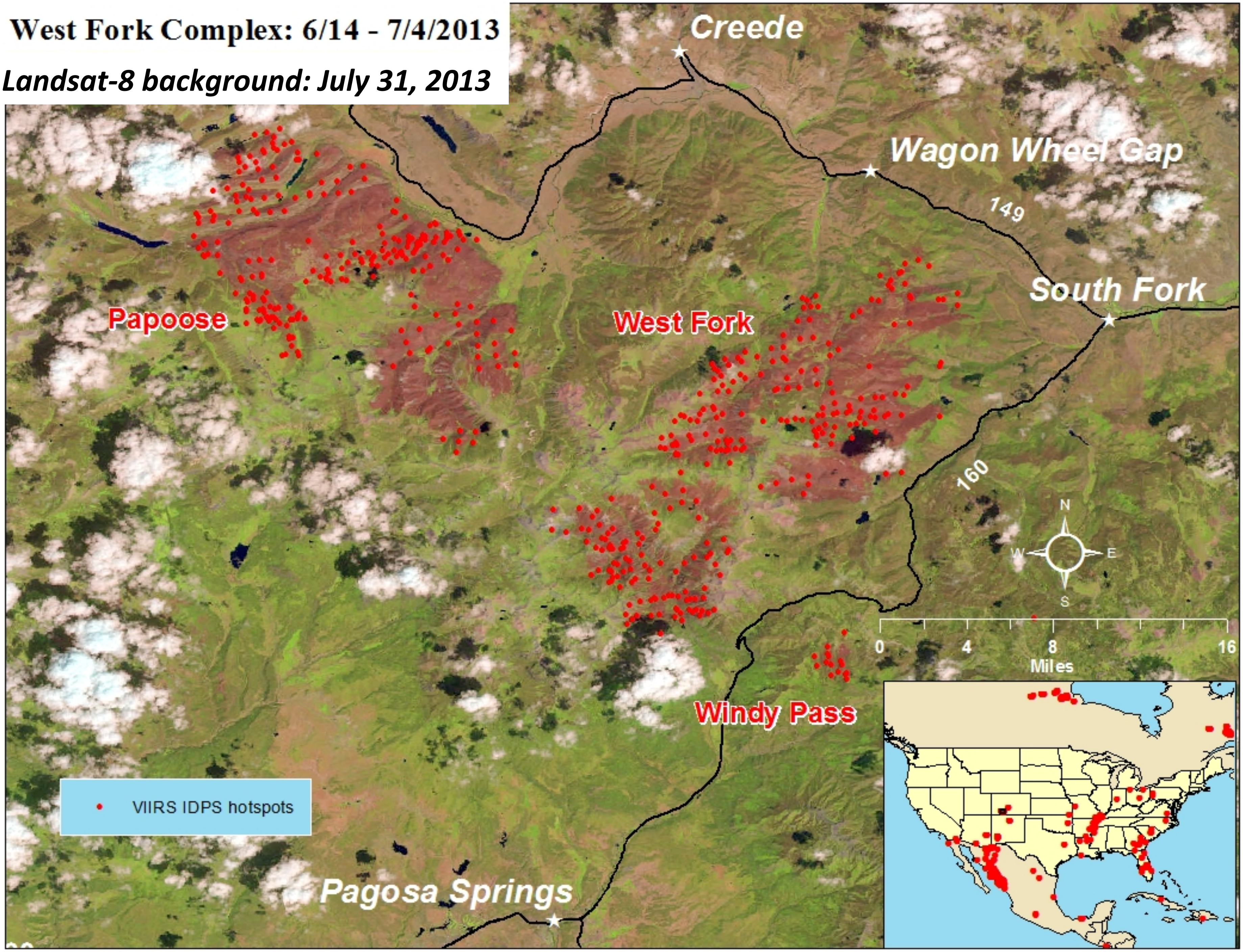


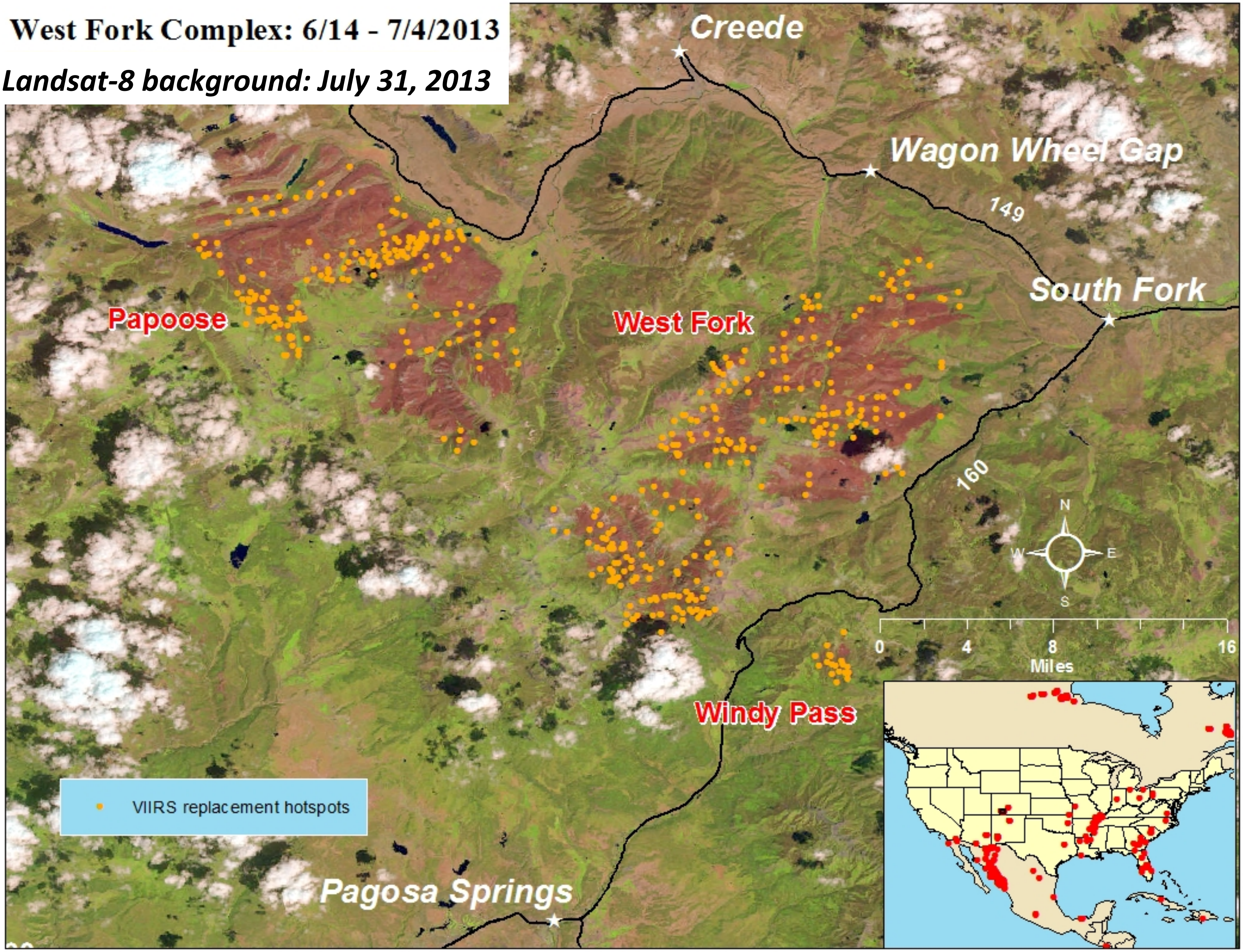
2014 Global M16 QF1 Values
Number of Pixels
DOY
10^8
10^6
10^4
10^2
10^0
60
70
80
90
34
1
50
18
65
9
33

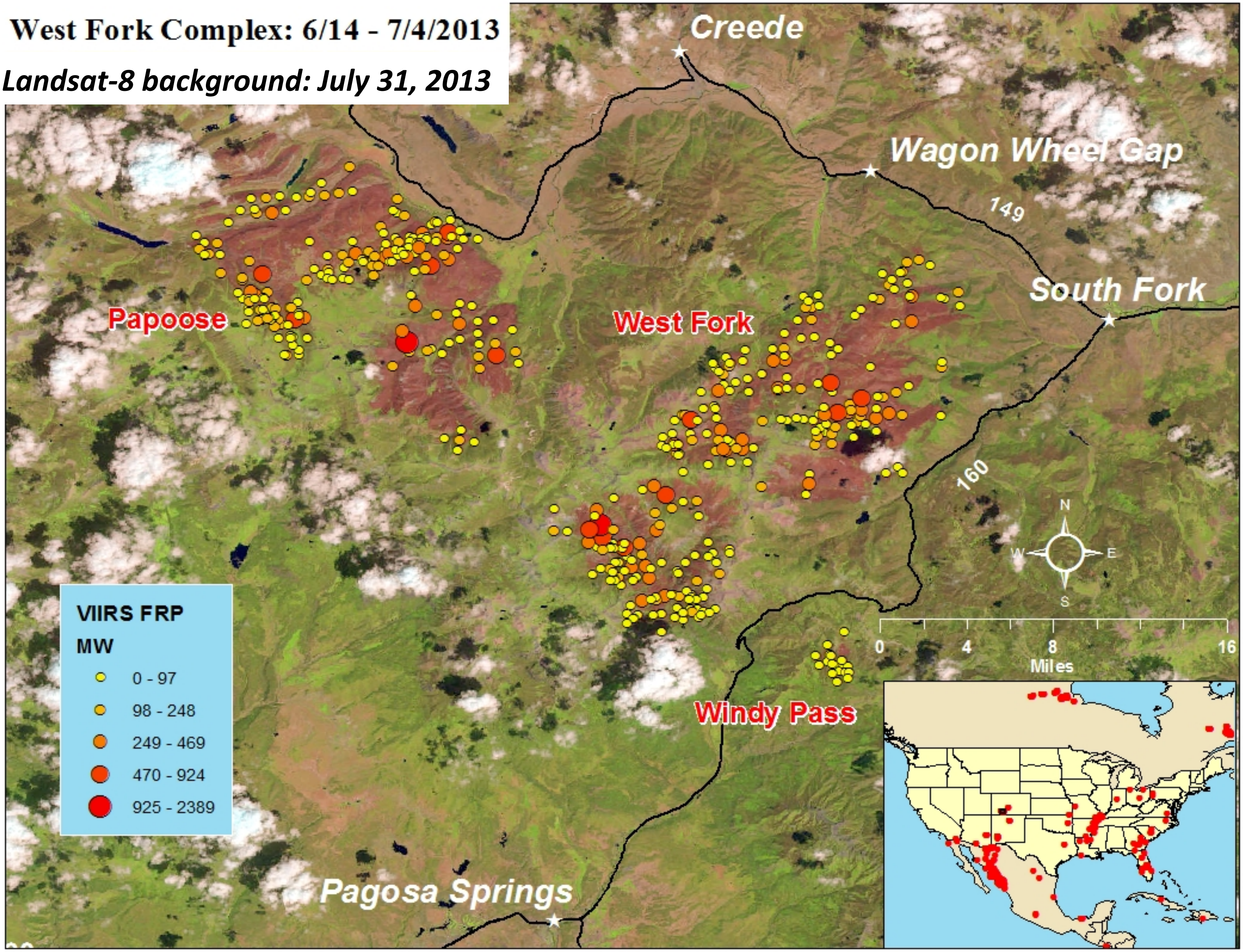
Generic VIIRS SDR Problems

- Disproportionally affect the VIIRS fire product
- Poorly documented outside of the JPSS program
  - In particular, details and dates

PRODUCT STATUS

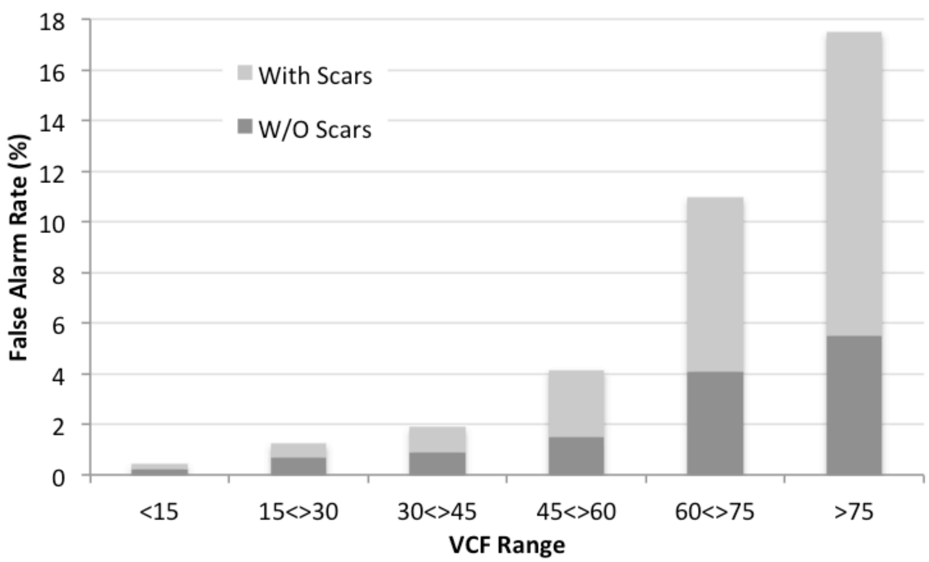

West Fork Complex: 6/14 - 7/4/2013
Landsat-8 background: July 31, 2013
Creede
Wagon Wheel Gap
149
South Fork
Papoose
West Fork
160
N
W
E
S
0
4
8
16
Miles
Windy Pass
VIIRS IDPS hotspots
Pagosa Springs


West Fork Complex: 6/14 - 7/4/2013
Landsat-8 background: July 31, 2013
Creede
Wagon Wheel Gap
149
South Fork
Papoose
West Fork
160
N
W
E
S
0
4
8
16
Miles
Windy Pass
VIIRS replacement hotspots
Pagosa Springs



West Fork Complex: 6/14 - 7/4/2013
Landsat-8 background: July 31, 2013
Creede
Wagon Wheel Gap
149
South Fork
Papoose
West Fork
160
Windy Pass
Pagosa Springs
N
W
E
S
0
4
8
16
Miles
VIIRS FRP
MW
0 - 97
98 - 248
249 - 469
470 - 924
925 - 2389

VIIRS 750m Fire Algorithm Update/Refinement: Implementation of MODIS Collection 6 Equivalent

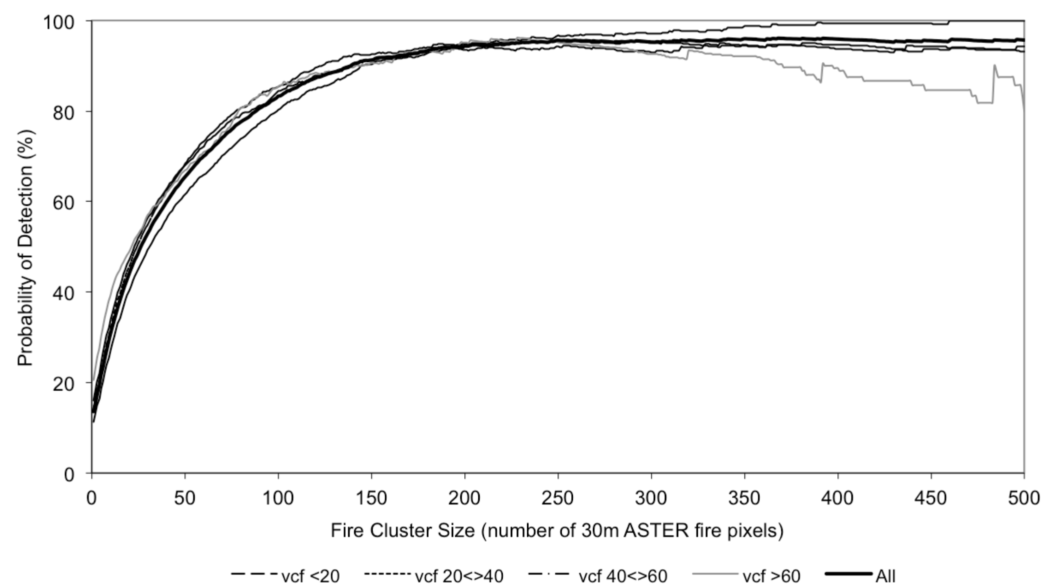


False alarm rates as a function of tree cover

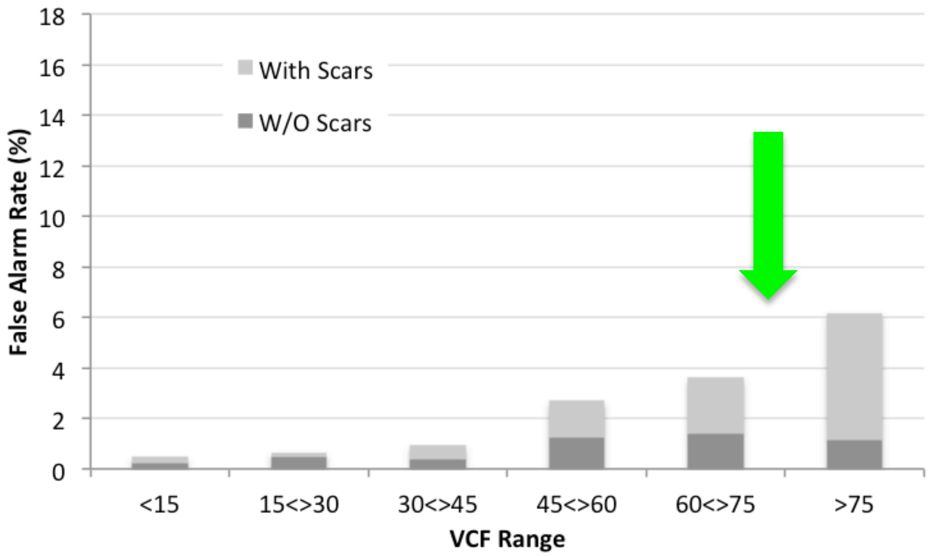
C5

MODIS results based on +2,300 reference ASTER scenes

Probability of detection as a function of tree cover



VIIRS 750m Fire Algorithm Update/Refinement: Implementation of MODIS Collection 6 Equivalent

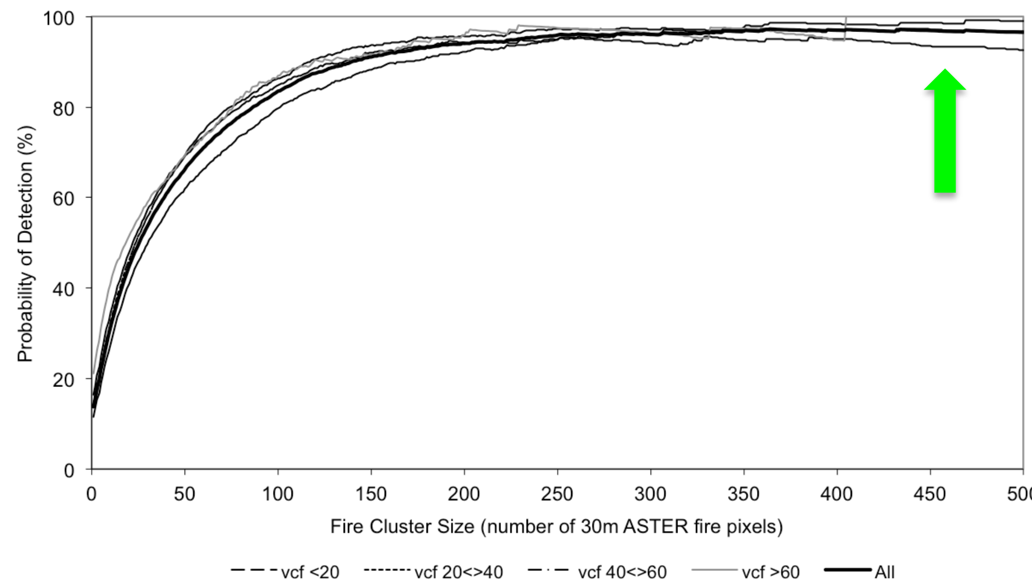


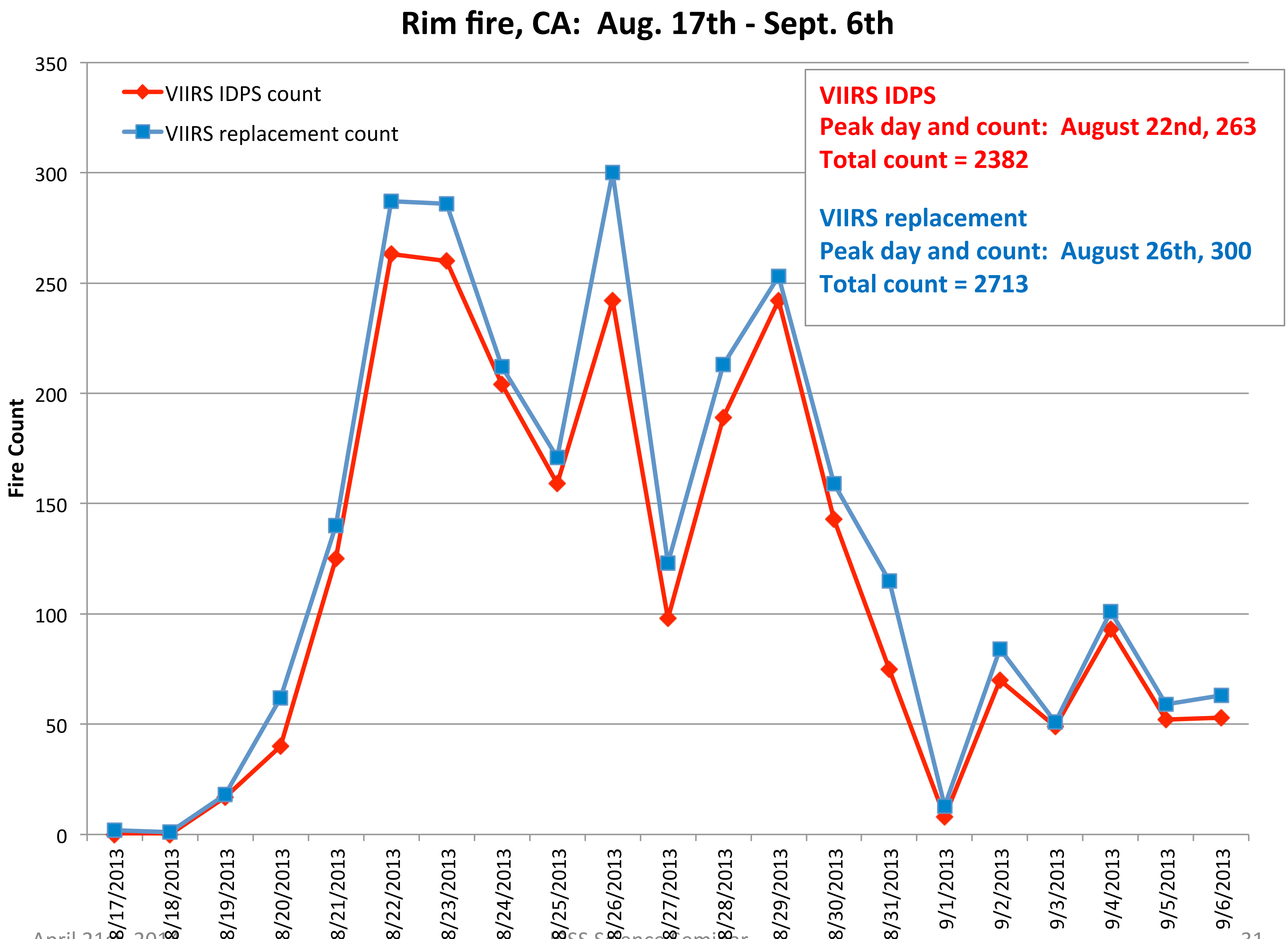
False alarm rates as a function of tree cover

C6

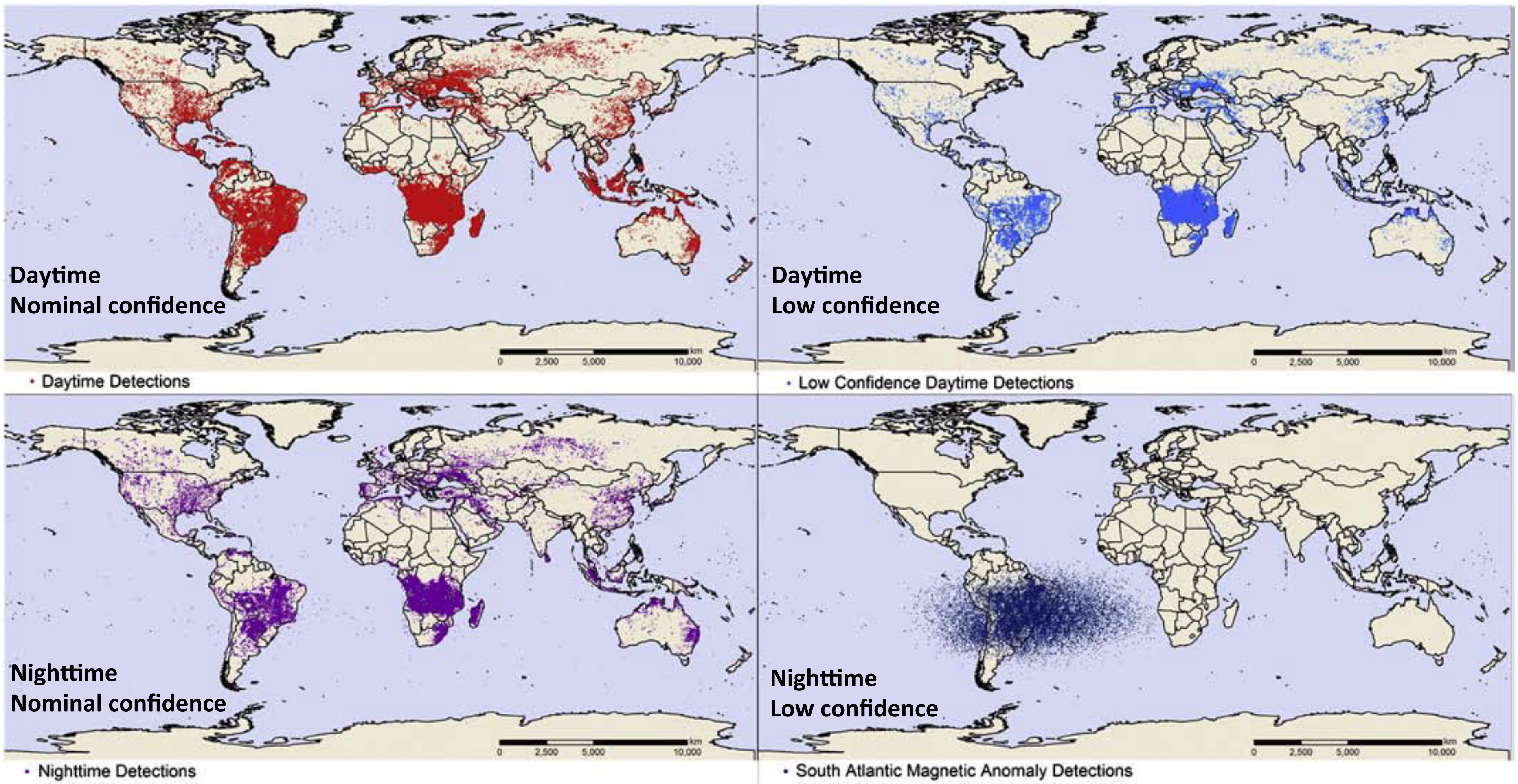
MODIS results based on +2,300 reference ASTER scenes

Probability of detection as a function of tree cover




Rim fire, CA: Aug. 17th - Sept. 6th
VIIRS IDPS count
VIIRS replacement count
VIIRS IDPS
Peak day and count: August 22nd, 263
Total count = 2382
VIIRS replacement
Peak day and count: August 26th, 300
Total count = 2713
Fire Count
350
300
250
200
150
100
50
0
8/17/2013
8/18/2013
8/19/2013
8/20/2013
8/21/2013
8/22/2013
8/23/2013
8/24/2013
8/25/2013
8/26/2013
8/27/2013
8/28/2013
8/29/2013
8/30/2013
8/31/2013
9/1/2013
9/2/2013
9/3/2013
9/4/2013
9/5/2013
9/6/2013

Global fires from I-band data



VIIRS 375 m fire algorithm output showing the accumulated daytime nominal confidence fire pixels (upper left), low confidence daytime pixels (upper right), nighttime fire pixels (purple; lower left), and SAMA-related low confidence nighttime pixels (dark blue; lower right) during 1–30 August 2013.

Wilfrid Schroeder, Patricia Oliva, Louis Giglio, Ivan A. Csiszar, The New VIIRS 375 m active fire detection data product: Algorithm description and initial assessment, Remote Sensing of Environment, Volume 143, 5 March 2014, Pages 85-96, ISSN 0034-4257, http://dx.doi.org/10.1016/j.rse.2013.12.008.

I-Band Active Fire Detection Algorithm Status

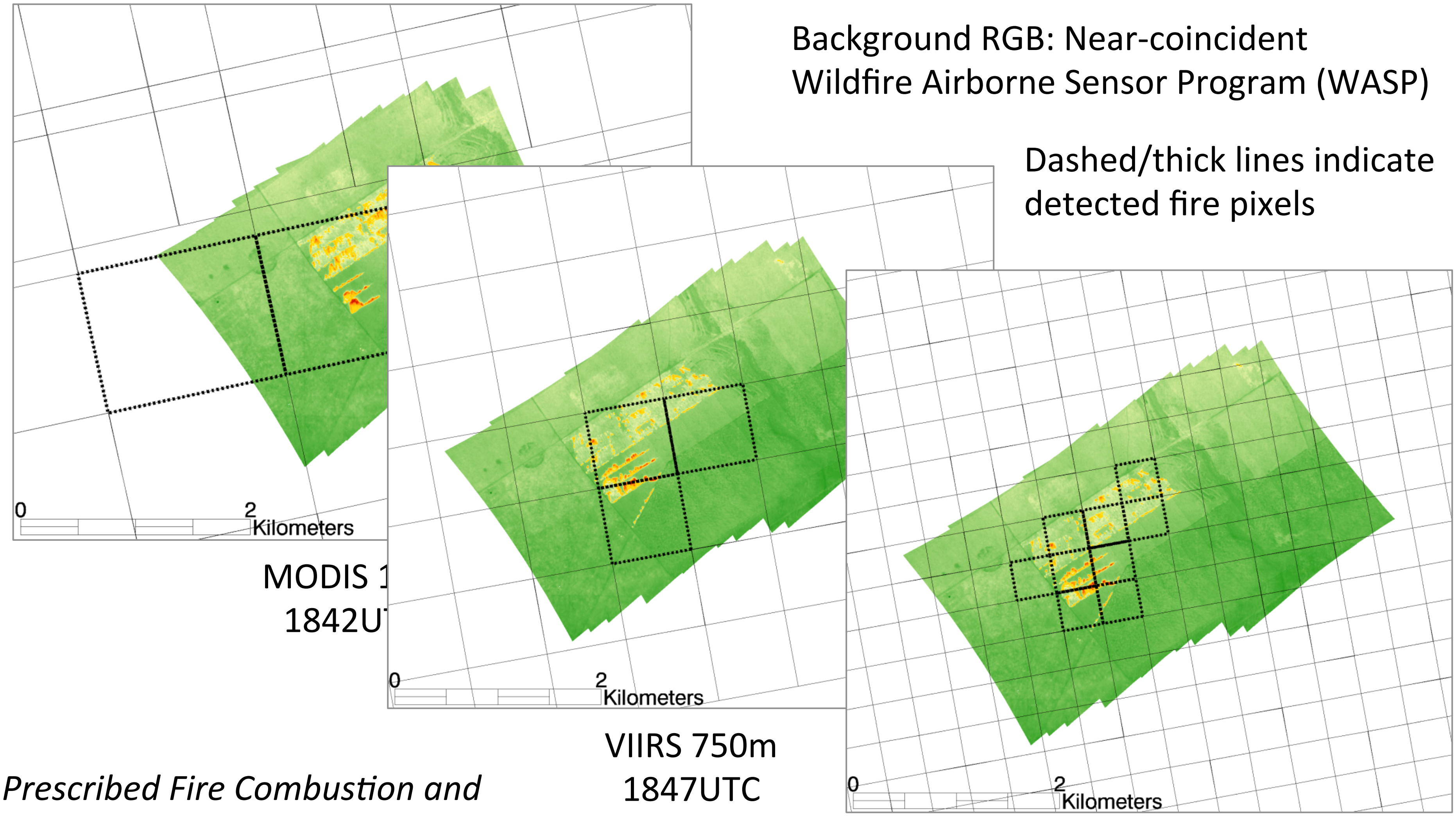
- Fire product being displayed online through proving ground website: http://viirsfire.geog.umd.edu/
- Fire product being generated in pseudo-operational mode (NRT) by US Forest Service and South African partners with very positive results (http://demo.afis.co.za/)
- In house I-band algorithm re-processing to use NASA's LandPEATE archive 3110 data for consistent investigation of product performance since sensor activation
- Continue research of I-band SDR anomalies and quality flag idiosyncrasies impacting fire-affected and other unique pixel conditions (e.g.: saturation (complete/partial), radiance folding)
- Continue research exploring potential M and I band hybrid fire algorithm
- I-band science algorithm to be ported to IPOPP Direct Broadcast package (pending NASA funding)
- I-band fire product application development to continue in support of wildland fire diagnostics/forecasting (pending NASA funding)

VALIDATION

VIIRS Active Fire Detection and Retrieval (FRP) Validation Using Multiple Near-Coincident Fine Resolution Reference Data Sets

Background RGB: Near-coincident Wildfire Airborne Sensor Program (WASP)

Dashed/thick lines indicate detected fire pixels



MODIS 1
1842UT

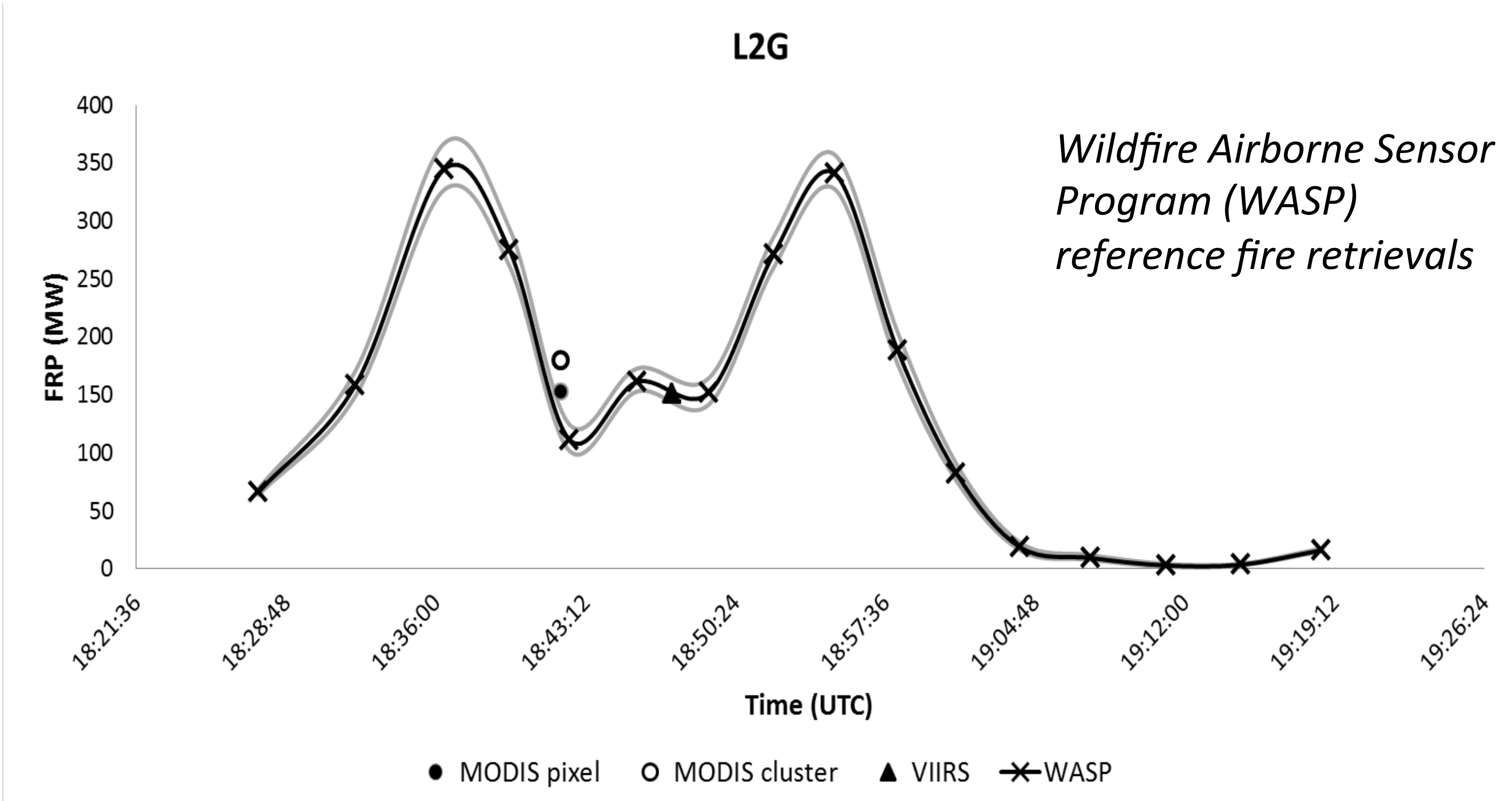
VIIRS 750m
1847UTC

VIIRS 375m
1847UTC

Prescribed Fire Combustion and Atmospheric Dynamics Research (RxCADRE) project (FL/2012)

VIIRS Active Fire Detection and Retrieval (FRP) Validation Using Multiple Near-Coincident Fine Resolution Reference Data Sets

Initial results over select sites indicate good overall agreement (<10%) among near-coincident surface-leaving fire retrievals acquired under clear sky conditions



Dickinson et al. [2014]

S-NPP Land Surface Temperature Product: Accomplishments and Issues

Prepared by

Bob Yu , NESDIS/STAR

Lucy Liu, Peng Yu, Jennifer Wang, UMD/CICS

May 2014

Basic of the VIIRS LST Product

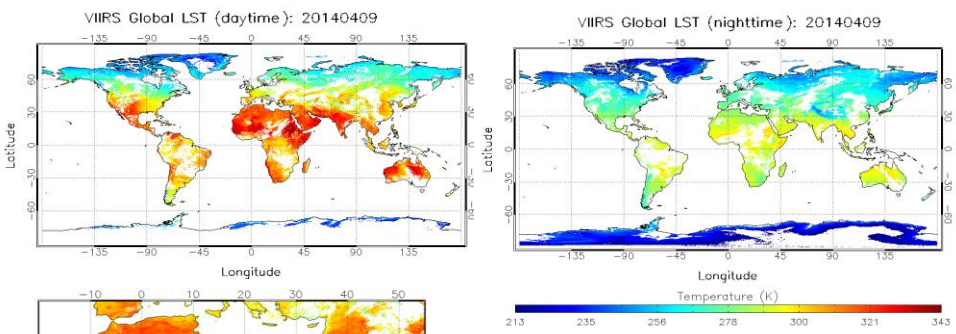
- VIIRS LST EDR provides effective land surface skin temperature value at the time of overpass
- VIIRS design allows for full (high) resolution LST measurements over global land covers, *under clear, probably clear and probably cloudy* conditions.
- Represents continuity with NASA EOS MODIS and NOAA POES AVHRR LST production, also with international missions such as (A)ATSR
- Product is expected to be used by weather forecasting models, Agriculture monitoring, drought prediction and monitoring, ecosystem monitoring; climate studies etc.

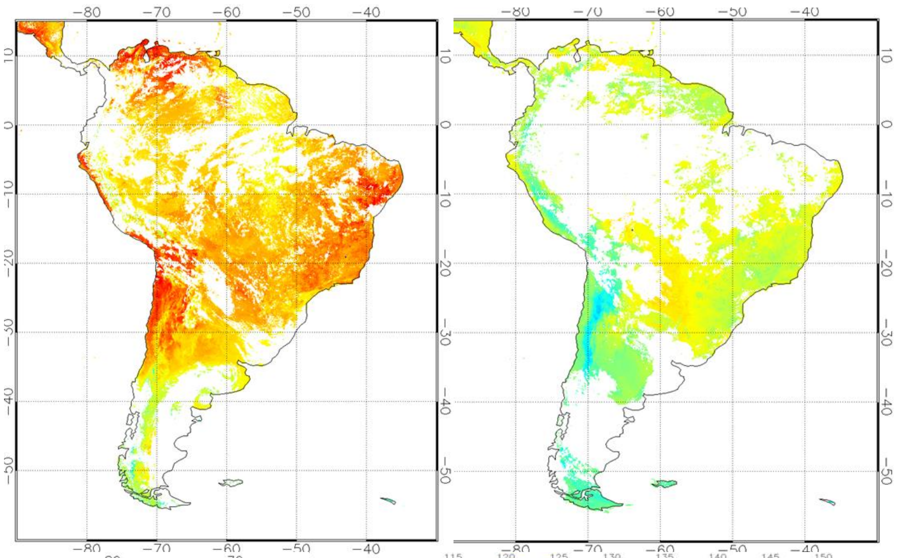
LST EDR Team Membership

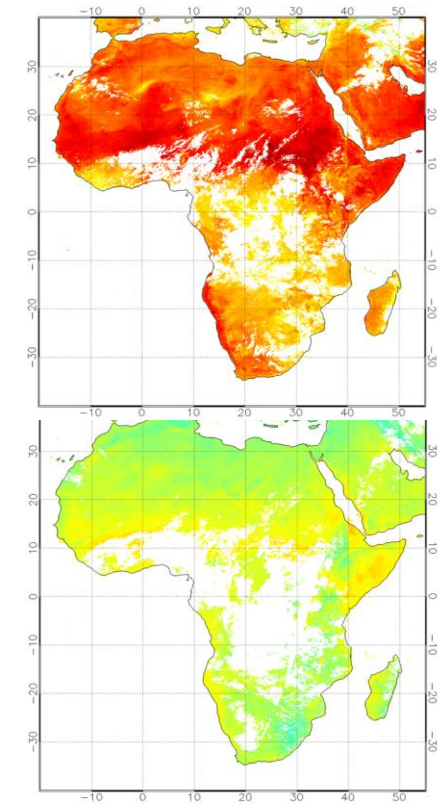
Project		Institute	Function
JPSS	Land Lead: Ivan Csiszar,	NOAA/NESDIS/SATR	Project Management
	EDR Lead: Yunyue YU	NOAA/NESDIS/SATR	Team management, algorithm development, validation
	Yuling Liu	UMD/CICS	algorithm development, validation
	Zhuo Wang	UMD/CICS	Simulation, algorithm improvement
	Peng Yu	UMD/CICS	algorithm improvement, product monitoring
	Youhua Tang	IMSG	STAR AIT support: code verification, delivery
	Mike Ek' team	NOAA/NWS/NCEP	User representative
	Leslie Belsma	JPSS/DPA	lgorithm Manager (JAM) for Land
NASA Land LPEATE			
	Robert Wolf' team	NASA/GSFC	Cal/Val support
NASA NPP Science Team			
	Miguel Roman	NSAS/GSFC	Cal/Val support
	Simon Hook	NASA/JPL	Cal/Val support

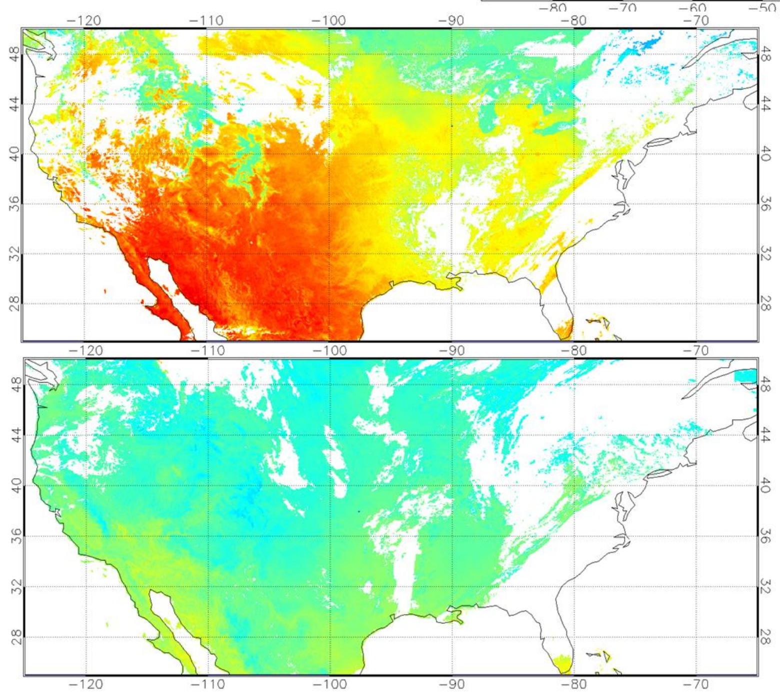
Accomplishments

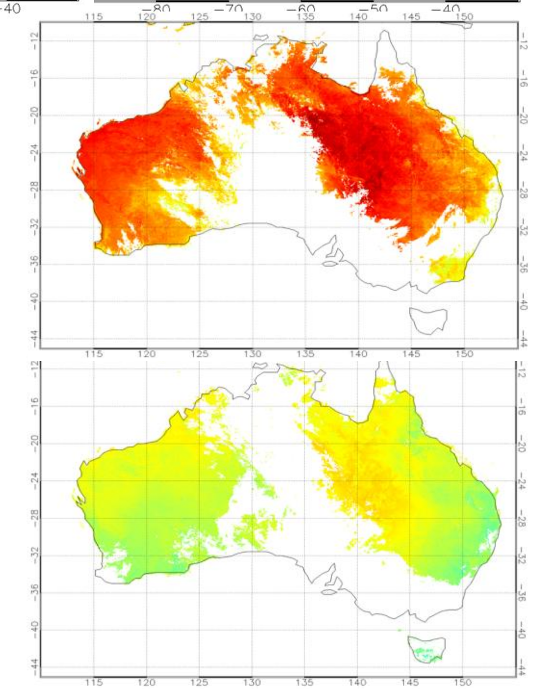
Provisional LST installed on IDPS



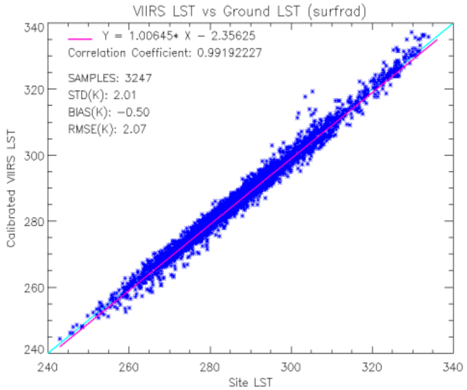


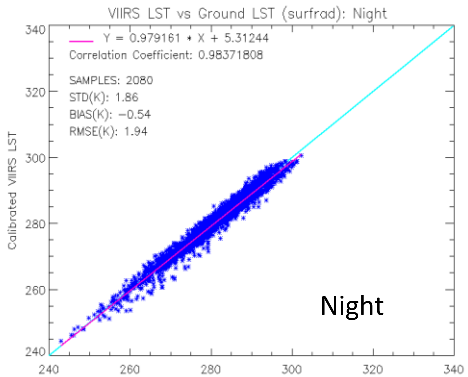


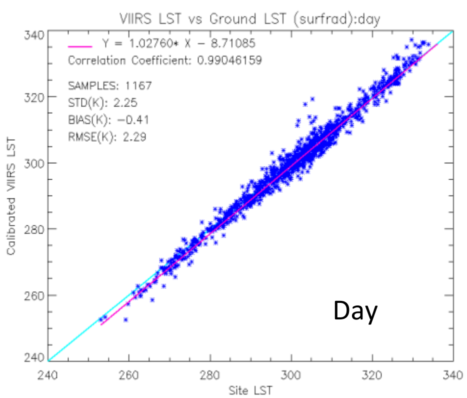




Accomplishments







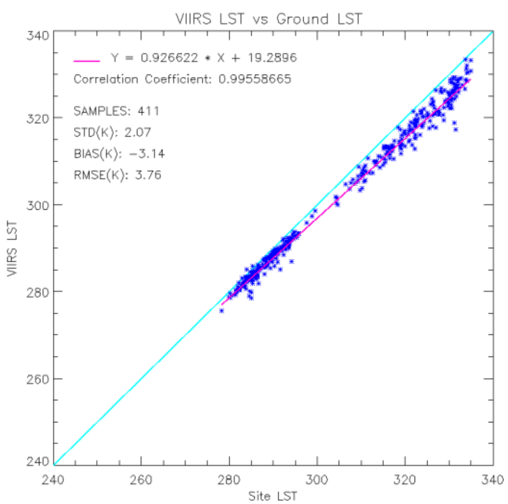
Evaluation against ground data

Surface type	Day/ Night	data num	Provisional		Beta	
			Bias	STD	Bias	STD
Deciduous Broadleaf Forest	day	4	-0.67	0.80	0.31	3.10
	night	11	-0.13	1.60	-0.13	1.60
Closed Shrub lands	day	37	-0.81	1.77	-1.16	1.77
	night	57	-1.37	0.80	-2.48	0.63
Open Shrub lands	day	277	-0.1	1.90	0.67	1.90
	night	327	-0.88	0.79	-2.38	0.79
Woody Savannas	day	46	-1.09	2.39	-0.34	2.81
	night	81	1.38	1.35	1.38	1.35
Grasslands	day	172	-0.38	1.90	1.11	2.36
	night	500	-0.35	1.41	-0.35	1.41
Croplands	day	266	0.14	2.95	2.39	3.54
	night	558	-0.21	1.58	-0.21	1.58
Cropland/Natural Veg Mosaics	day	208	-0.83	1.98	0.13	2.15
	night	459	0.47	1.94	0.47	1.94
Snow/ice	day	97	-1.16	1.67	-1.95	1.70
	night					
Barren	day	60	0.72	1.68	0.12	2.10
	night	87	-1.17	0.88	-2.67	0.88

SURFRAD LST over 6 sites covering the time period from Feb. 2012 to December 2013

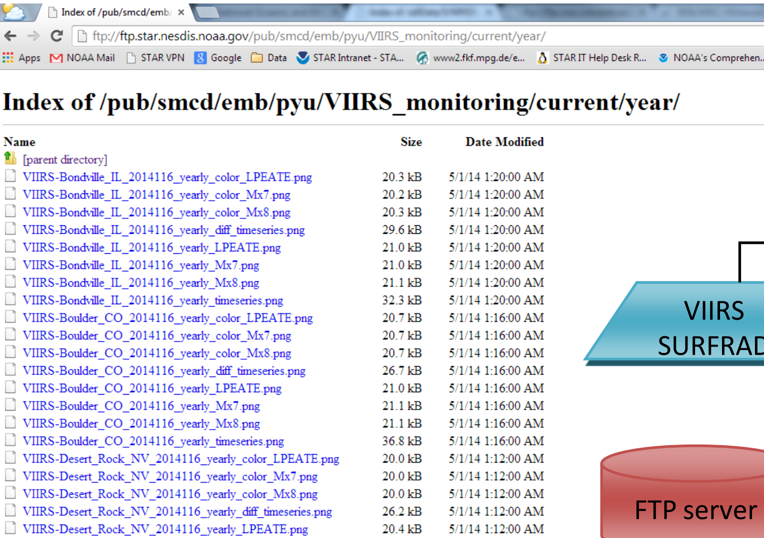
A ground dataset at Gobabeb in Namibia covering the time period of 2012.

*The data is provided by Frank Goettsche, thanks Pierre for sharing the data.



Accomplishments

A monitoring tool developed



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

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

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

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VIIRS-Boulder_CO_2014116_yearly_color_Mx8.png	20.7 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
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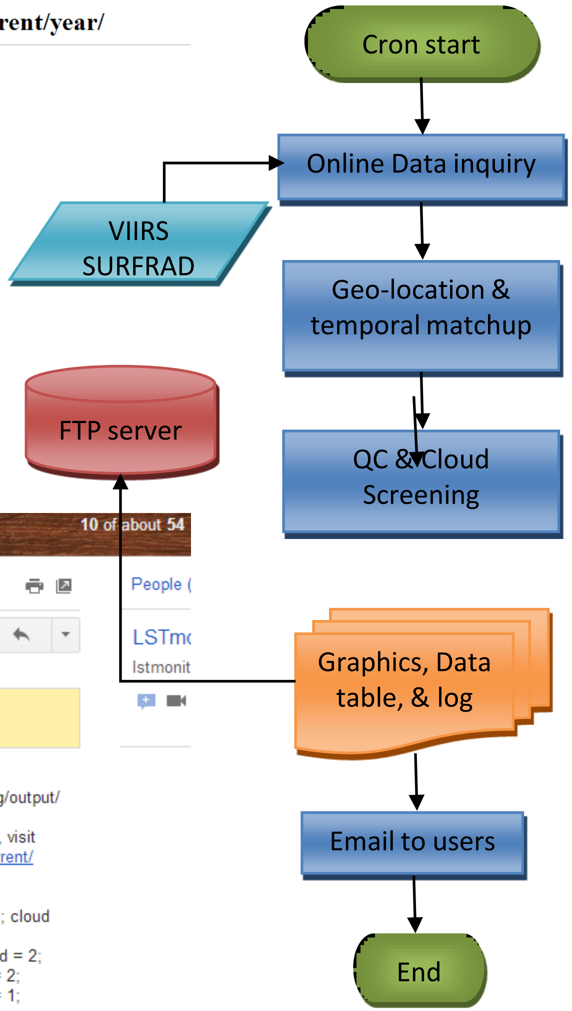
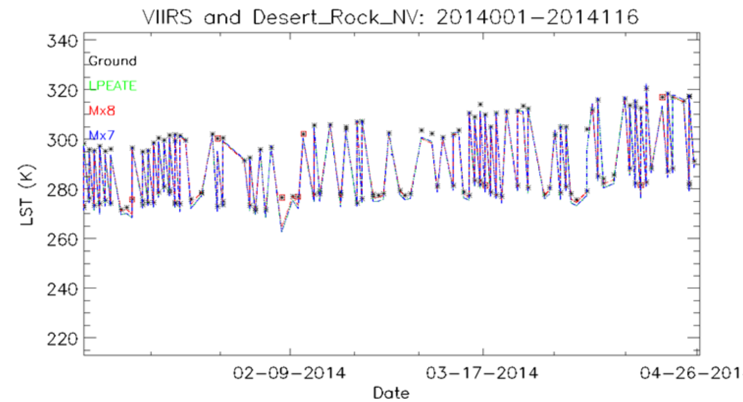
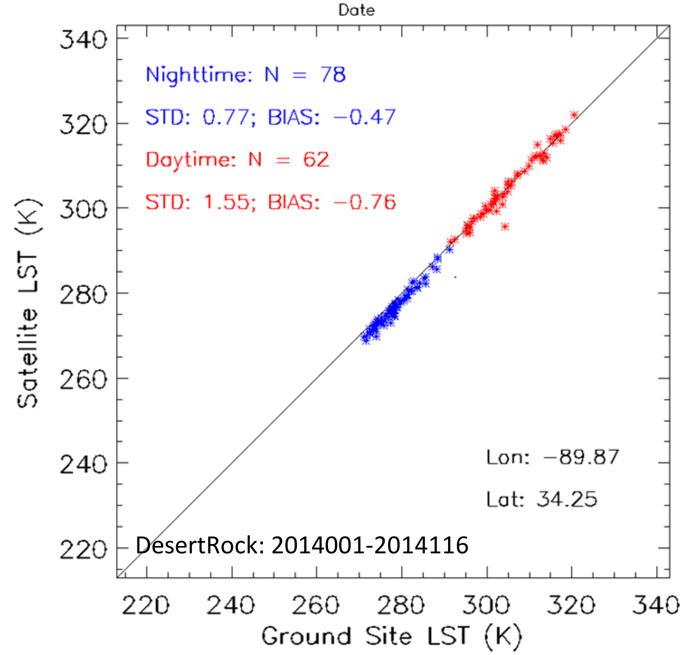
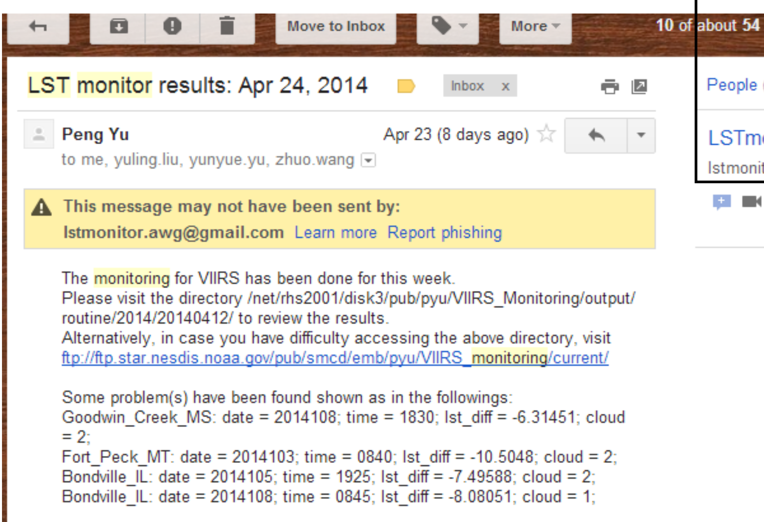








Move to Inbox | More | 10 of about 54

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/

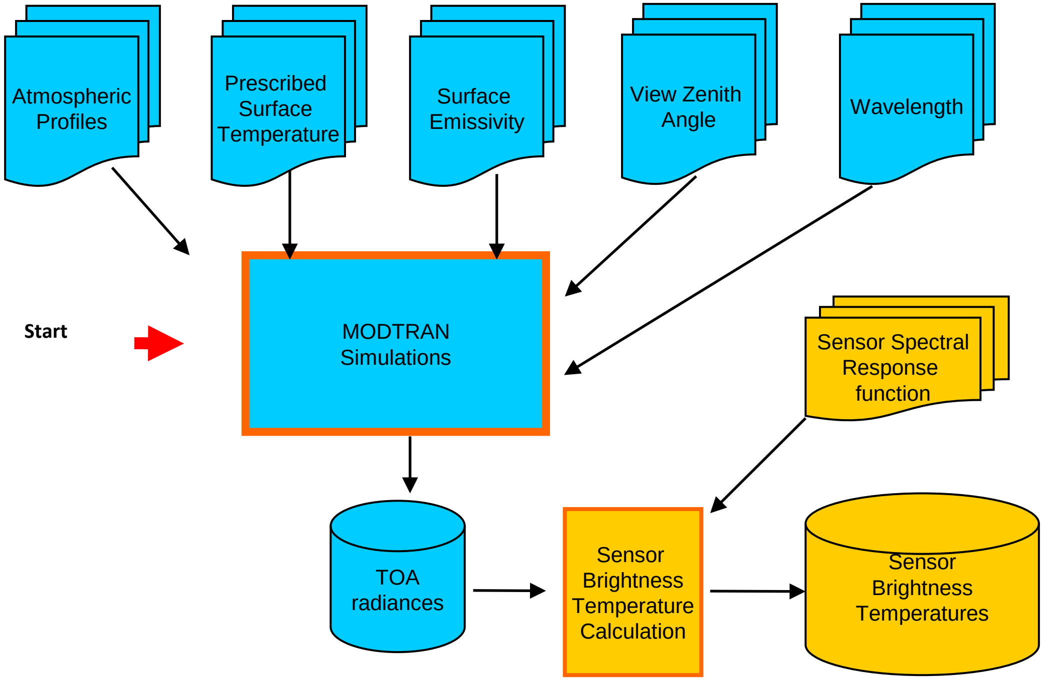
Some problem(s) have been found shown as in the followings:
Goodwin_Creek_MS: date = 2014108; time = 1830; lst_diff = -6.31451; cloud = 2;
Fort_Peck_MT: date = 2014103; time = 0840; lst_diff = -10.5048; cloud = 2;
Bondville_IL: date = 2014105; time = 1925; lst_diff = -7.49588; cloud = 2;
Bondville_IL: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

Accomplishments

A Comprehensive Simulation dataset generated

- 1,714,608 data pairs of land surface skin temperature and TOA infrared spectral radiance/brightness temperature, associated with satellite-solar geometry, surface emissivity, atmospheric profile, etc.

- 126 cloud-free atmospheric profiles, global distribution: 60 profiles for daytime and 66 profiles for nighttime.

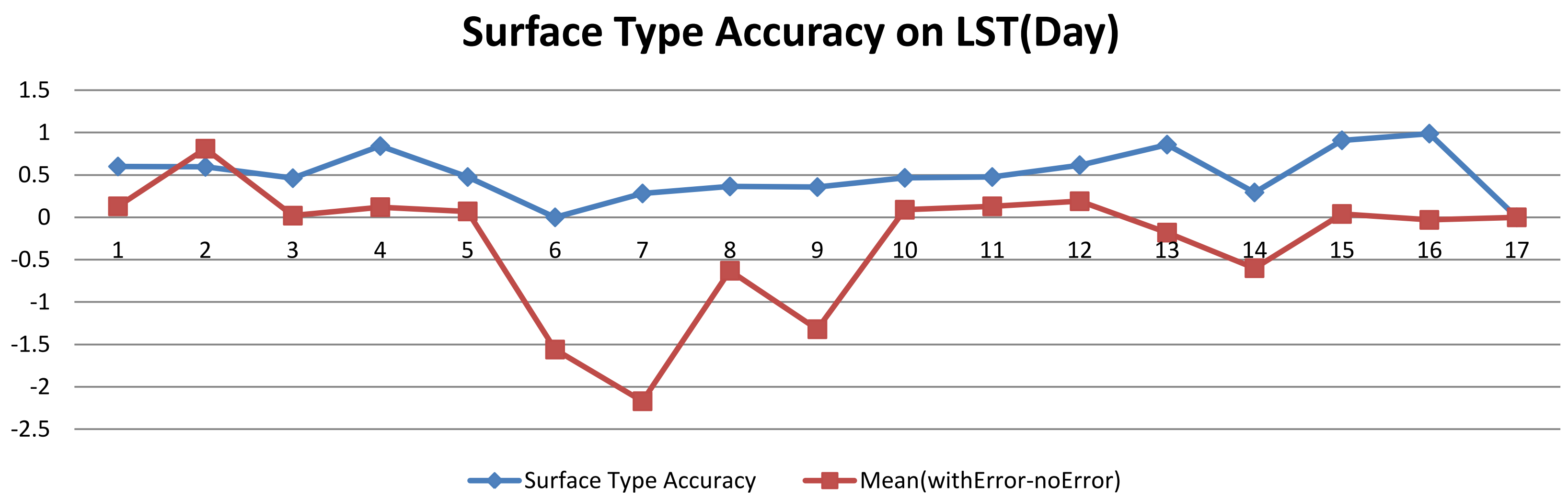


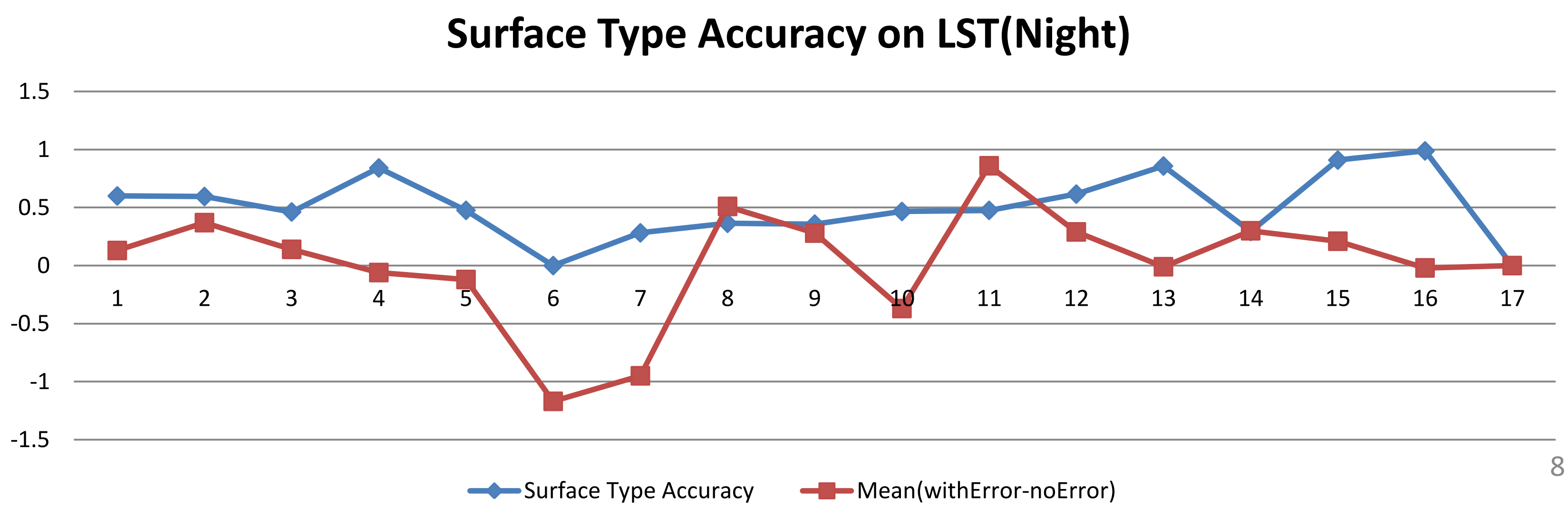
- A Gaussian distribution of ($T_S - T_{air}$) is prescribed for real surface temperature simulation.

- Infrared Spectral range : 3.4 –13 µm; surface emissivity range: [0.90-0.9999]; view zenith range: 0 - 70°

Issues -- Algorithm

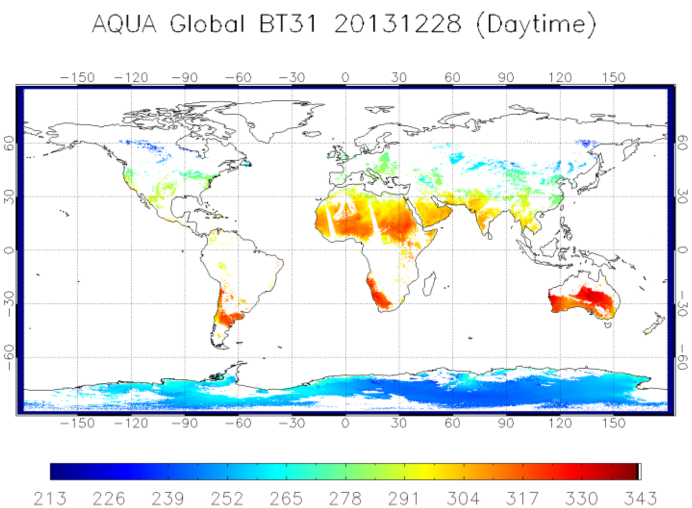
Impact of the Type EDR error

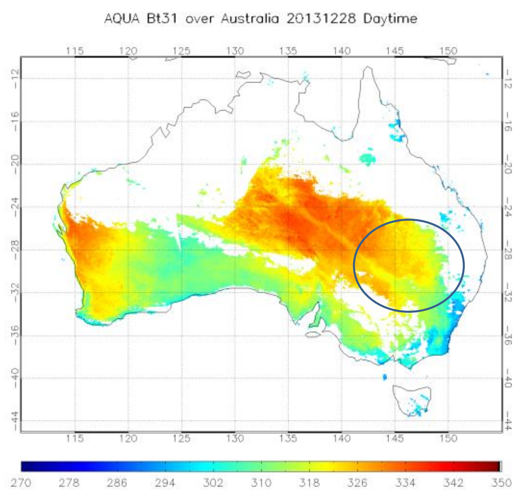


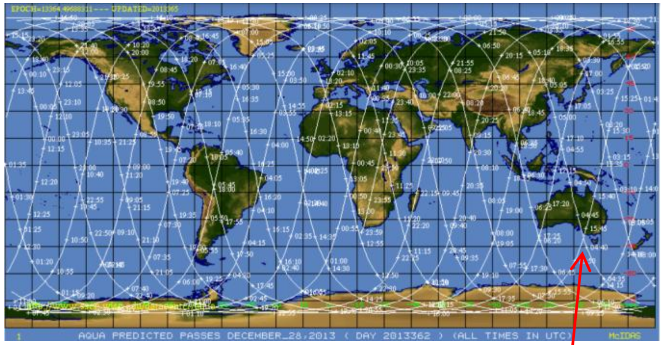


Issues – Validation

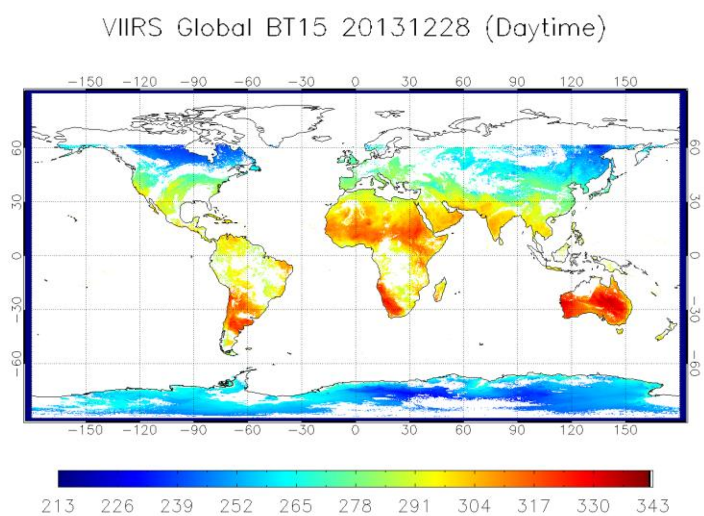
Impact of time difference in cross-satellite comparison

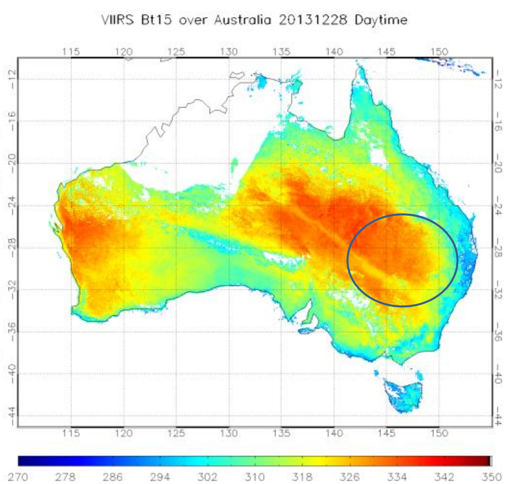


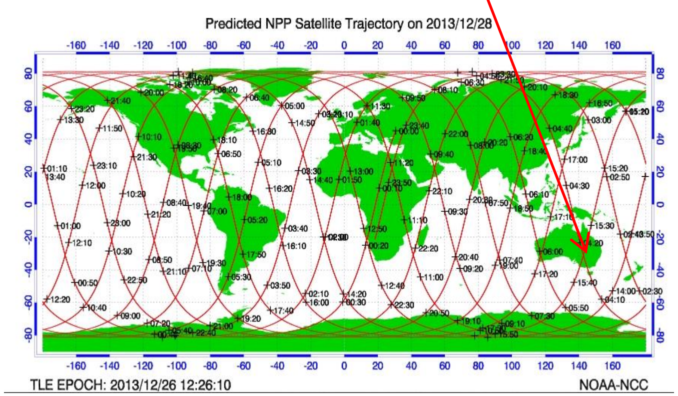




About 25 min difference between VIIRS and MODIS

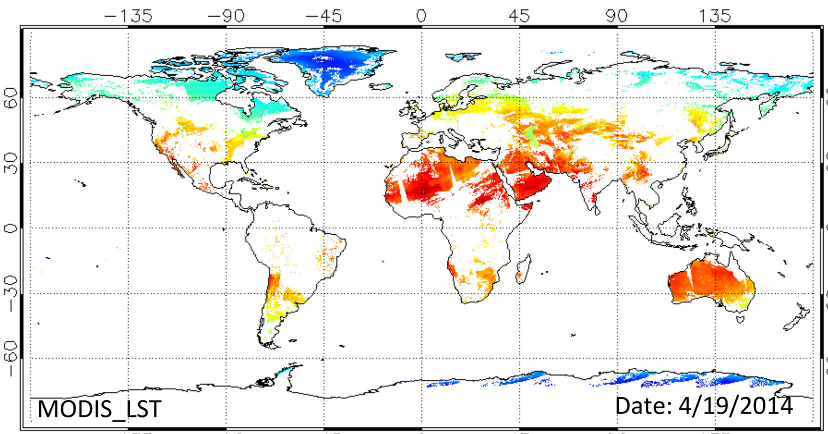


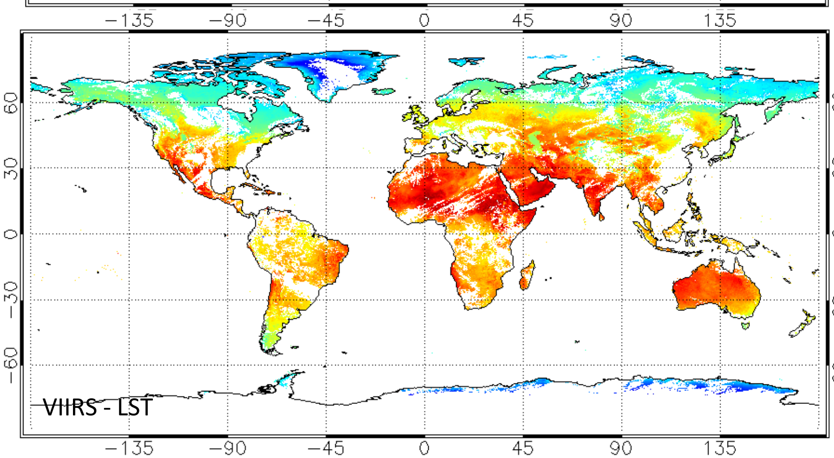


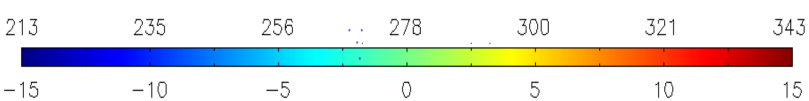


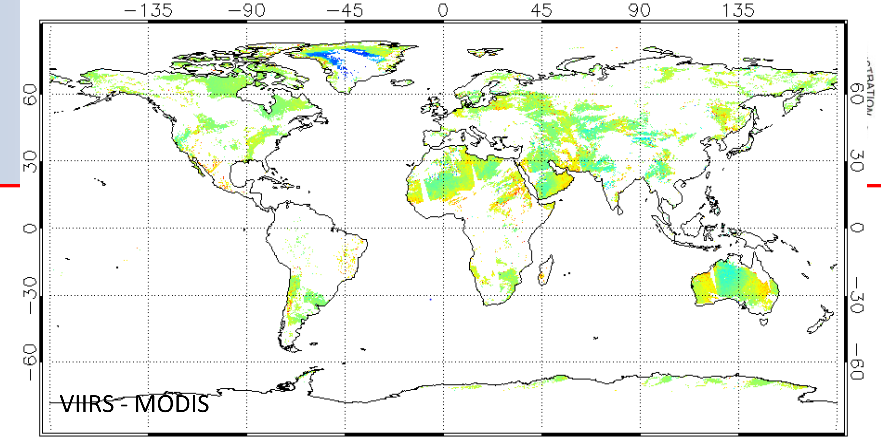
Issues – Validation

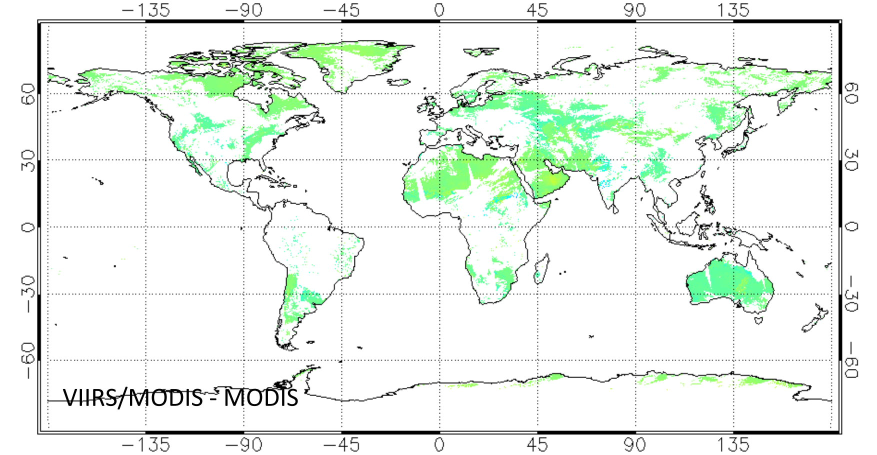
Cross-satellite comparison

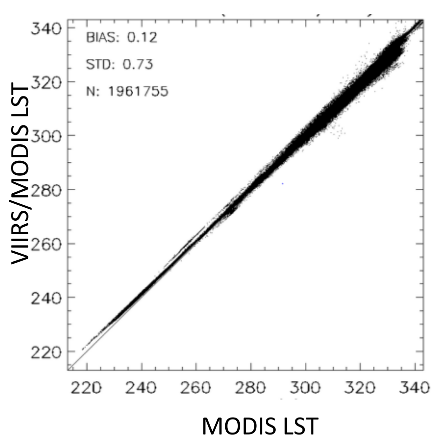










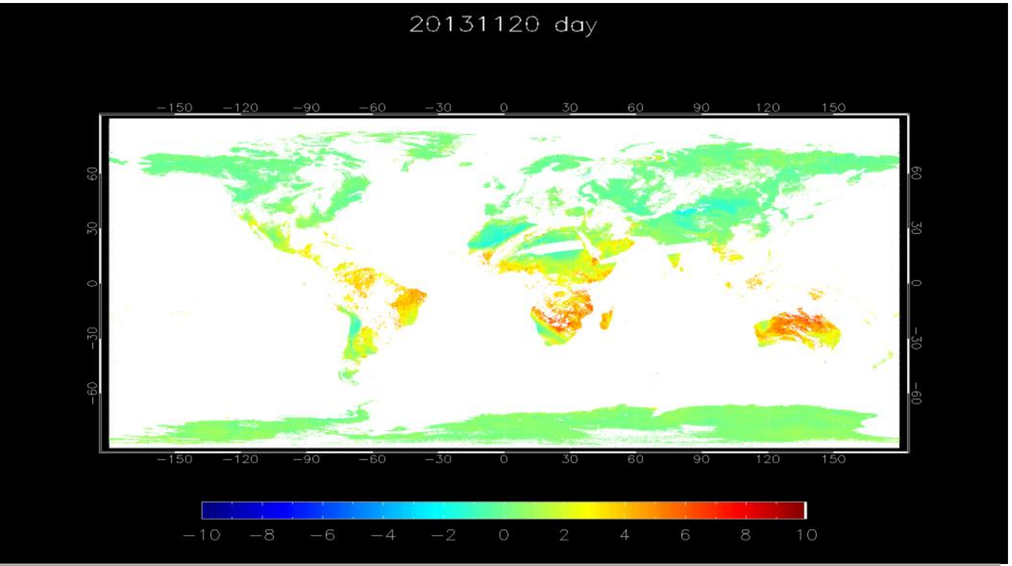


Cross-satellite LST comparison is used in VIIRS LST evaluation.

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

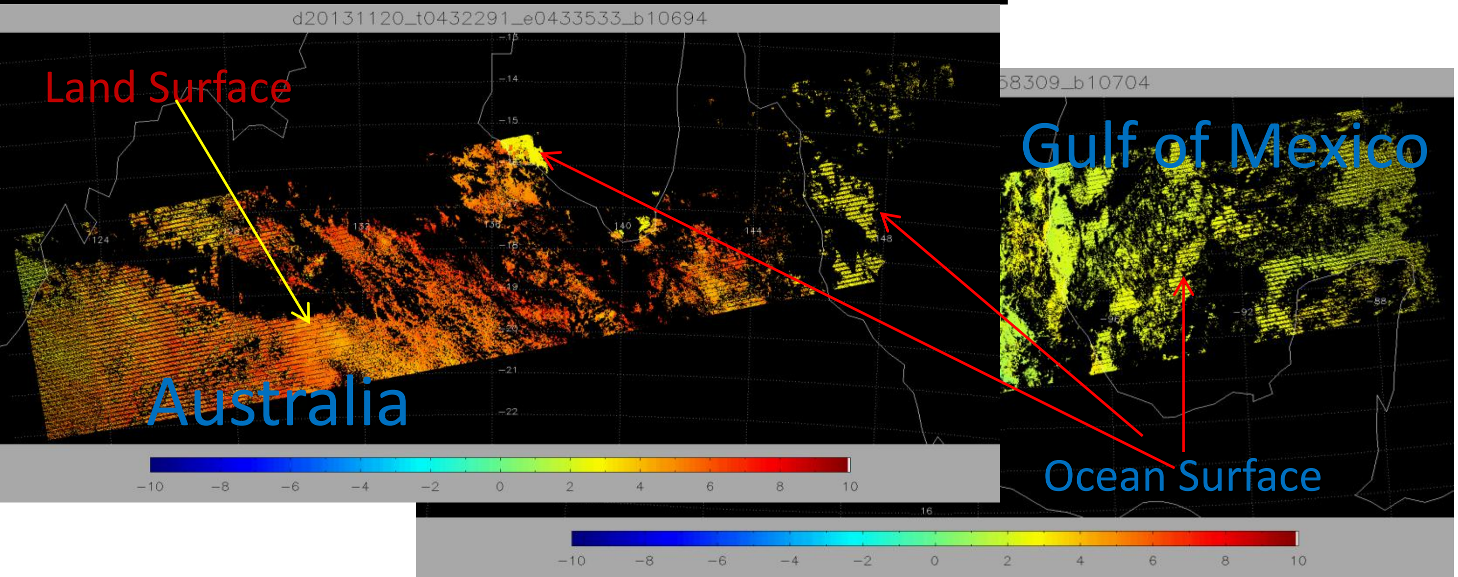
Issues -- Algorithm

BT difference correction



<u>Split-window algorithm feature</u>: brightness temperature difference at 11 and 12 μm is used for atmospheric correction. It is the SST heritage. However, the BT difference can be very different over land. Additional measure is needed.

BT difference at daytime

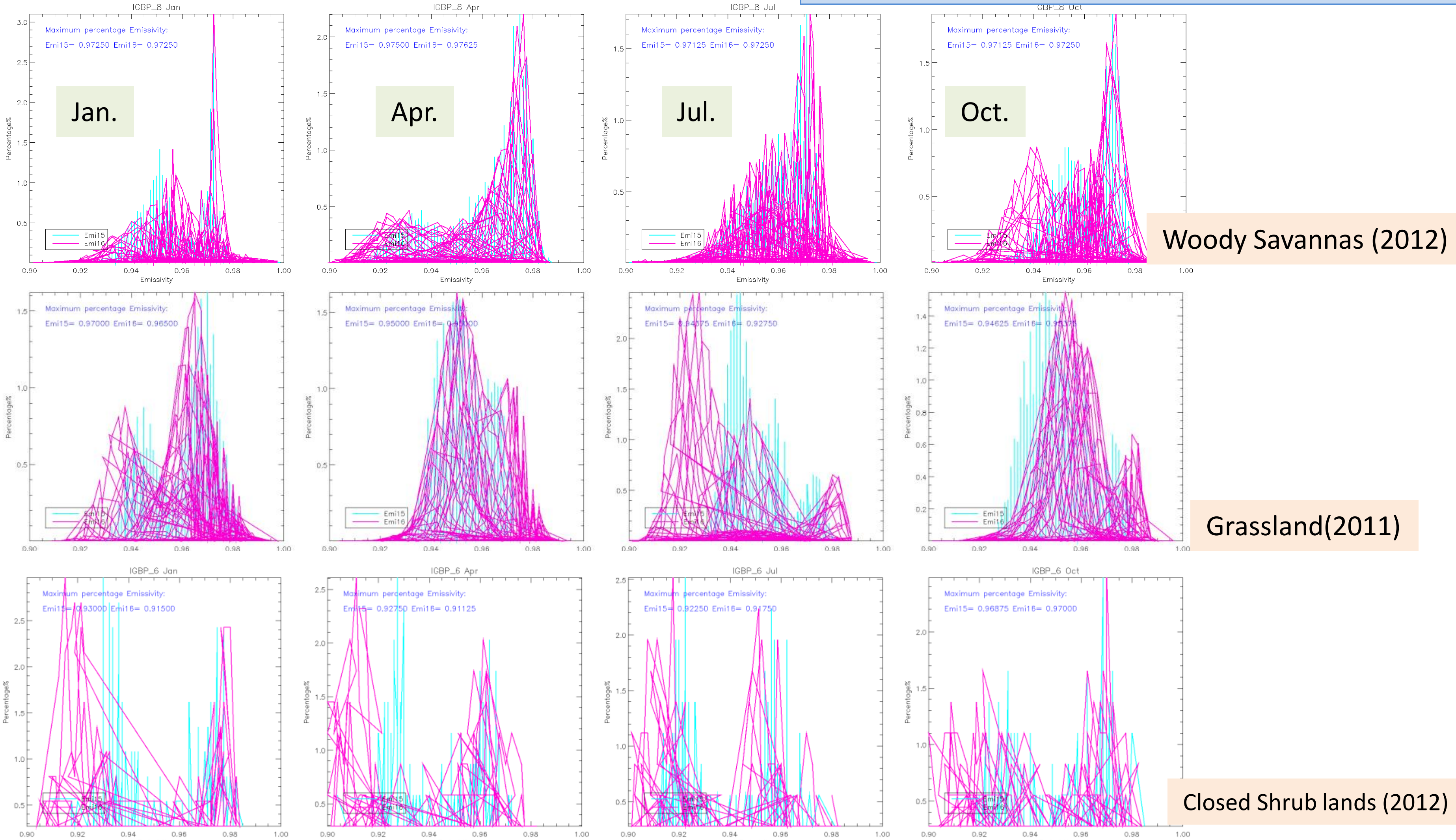


Left: Significant BT differences over land and sea water surface. The BT difference is much smaller over sea surface

Issues -- Algorithm

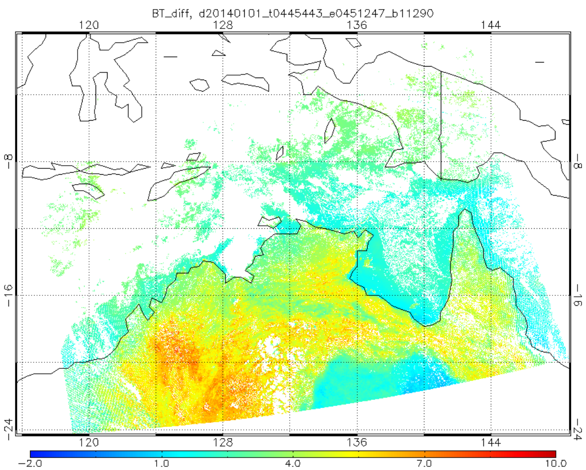
Emissivity Impact to LST

- *Considerable seasonal emissivity variation over some surface types*
- *Considerable emissivity variation within cover types*

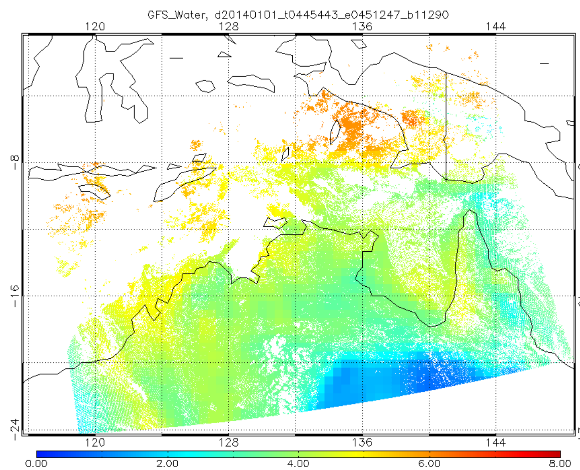


Issues -- Algorithm

Emissivity Impact to LST

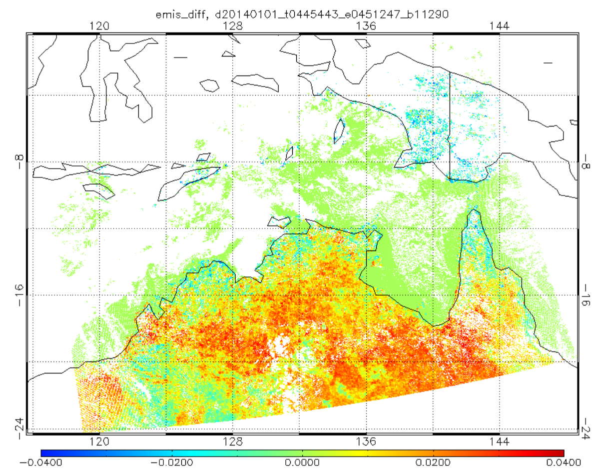


BT difference map for VIIRS granule d20140101_t0445443



GFS water vapor map

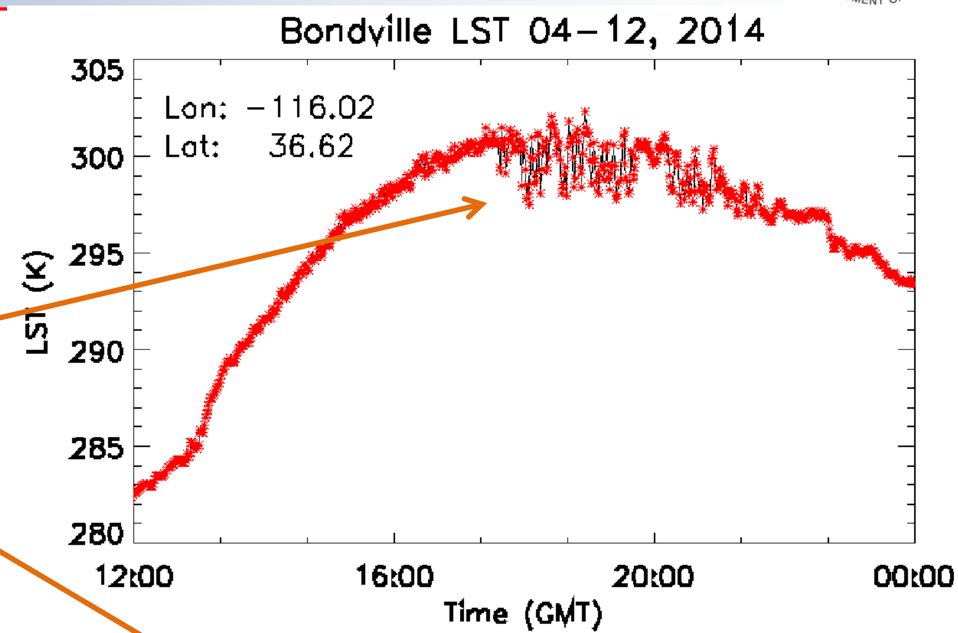
Emissivity difference map

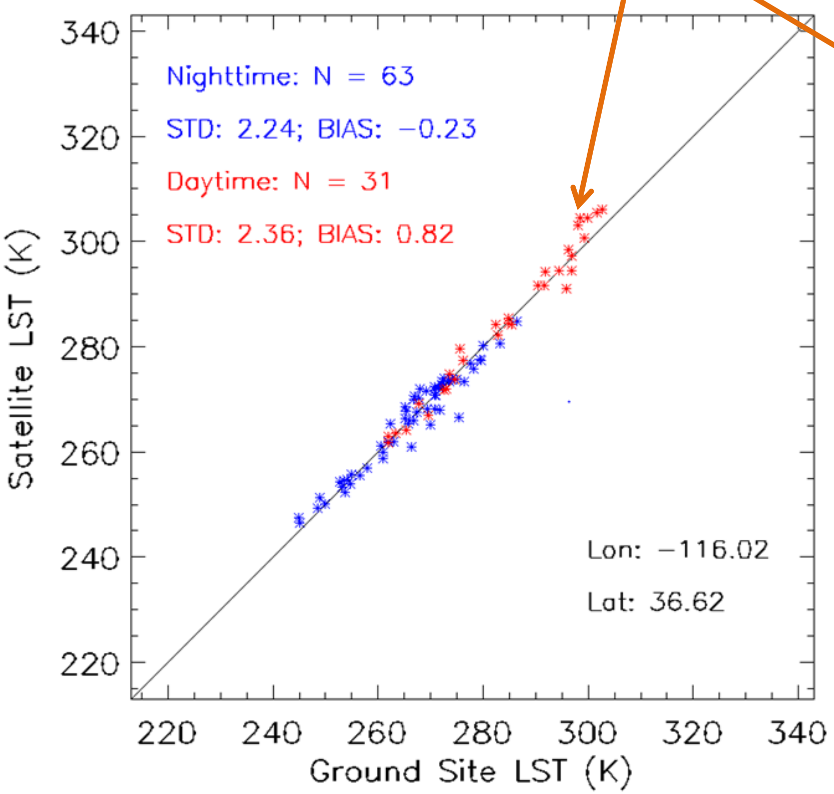


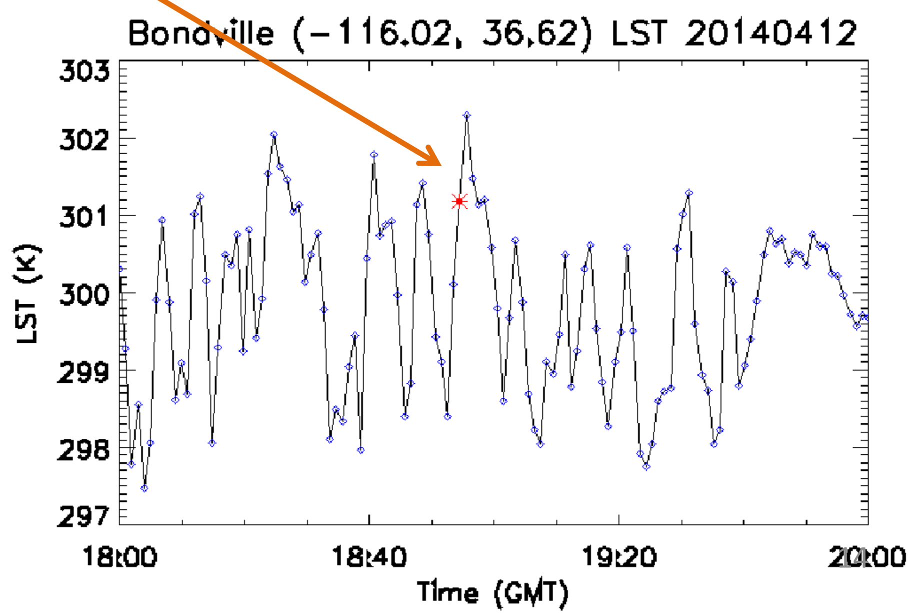
Issues -- Validation

Ground data fluctuation

The ground LST estimate can be fluctuated significantly, resulting big match-up uncertainty (~6K)







Summary

- Split Window LST(SWLST) is applied for VIIRS LST production
- Provisional release
  - Provisional version delivery done in 07/2013, in production in 10/2013
  - Errors found in 10/2013, switch back to beta in 11/2013
  - Provisional update delivery in 02/2014, in production in 04/2014
- Evaluation underway
  - Cross-satellite comparisons (MODIS LST product)
  - Ground data comparisons
    - Comparisons with SURFRAD LST estimates
    - Comparisons with individual field data
  - Radiance-base comparisons
  - Monitoring tool in use
- Issues found
  - Algorithm issues
    - significant impact from the Type EDR
    - Emissivity impact to LST (vs. to SST)
  - Validation issues
    - impact of time difference in cross-satellite comparison
    - Ground data quality, heterogeneity.

Future Works

- Algorithm Improvement
  - ✓ Emissivity explicit *vs.* implicit
  - ✓ Additional water vapor correction
  - ✓ Emissivity correction
- User Promotion
  - ✓ Enhance LST product usage in EMC assimilation/forecasting model
- Monitoring tool
  - ✓ Daily/weekly/monthly/year maps and graphics
- Validation methodology
  - ✓ Cross-satellite comparisons
  - ✓ evaluation against ground data
- International cooperation
  - ✓ NOAA-CMA bilateral program: land product validation subtask
  - ✓ US-Portugal bilateral program : remote sensing subtask
  - ✓ EUMETSAT Land SAF
  - ✓ International Land Surface Temperature and Emissivity Working Group

Thanks

and

Questions?

JPSS STAR Science Team Annual Meeting
Surface Type

NOAA Task Lead: Xiwu Zhan
UMD Team: Chengquan Huang, Rui Zhang
BU Team: Mark Friedl, Damien Sulla-Menashe

May 14, 2014

Outline

- Overview
  - Products, Requirements, Team Members, Users, Accomplishments
- Surface Type Algorithm Evaluation:
  - Algorithm Description
  - Validation Approach and Results
  - Challenges, New Progress, Next Steps
- Plans JPSS-1 and Future Missions
- Summary

Overview

- VIIRS Surface Type
  - Describe surface condition using 17 IGBP classes
  - Two groups of products
    - QST IP:
      - Generated quarterly using 12 months VIIRS data
      - Continuity with NASA EOS MODIS and NOAA POES AVHRR land cover products
    - EDR:
      - Provides type info for each VIIRS overpass
      - QST IP updated for fire and snow
  - Required accuracy is 70%

Overview-continue

- Product users:
  - Essential Climate Variable
    - Modeling studies
      - Land surface parameterization for GCM
      - Biogeochemical cycles
      - Hydrological processes
    - Carbon and ecosystem studies
    - Biodiversity
  - Feed to other VIIRS products
    - BRDF/Albedo
    - Land surface temperature (LST)

Overview-continue

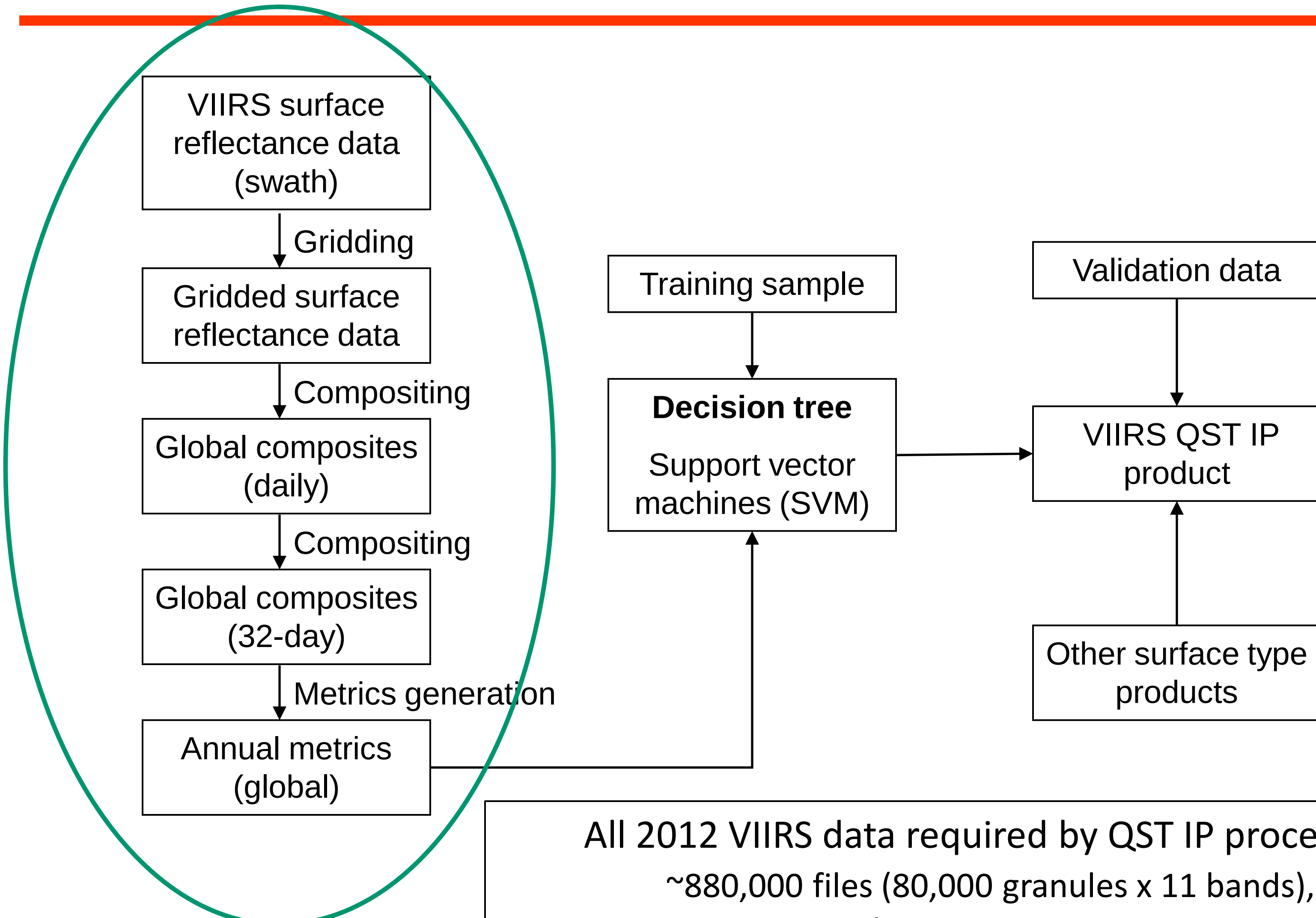
- Team member:
  - STAR: Xiwu Zhan, Task Lead
  - UMD: Chengquan Huang, Rui Zhang
  - BU: Mark Friedl, Damien Sulla-Menashe

- Accomplishment:
  - ST EDR beta maturity passed
  - QST IP provisional maturity delivery (in progress),
  - Preliminary validation,
  - Recent improvements: product derived using a new alternative algorithm Support Vector Machines (SVM).

Algorithm Evaluation

- Algorithm Description:
  - ST-EDR is primarily based on QST-IP updated with snow/ice and fire flags.
    - Passed beta maturity review
  - The QST-IP is generated using C5.0 decision tree algorithm from one full year's (2012) surface reflectance data.
    - Provisional delivery in progress
- Validation approach and dataset:
  - Use an independent global validation dataset
    - stratified random sample of 500 blocks, 10-35 VIIRS 1km pixels per block
    - 17 IGBP classes
    - "Truth" determined by human interpretation of available high resolution images.

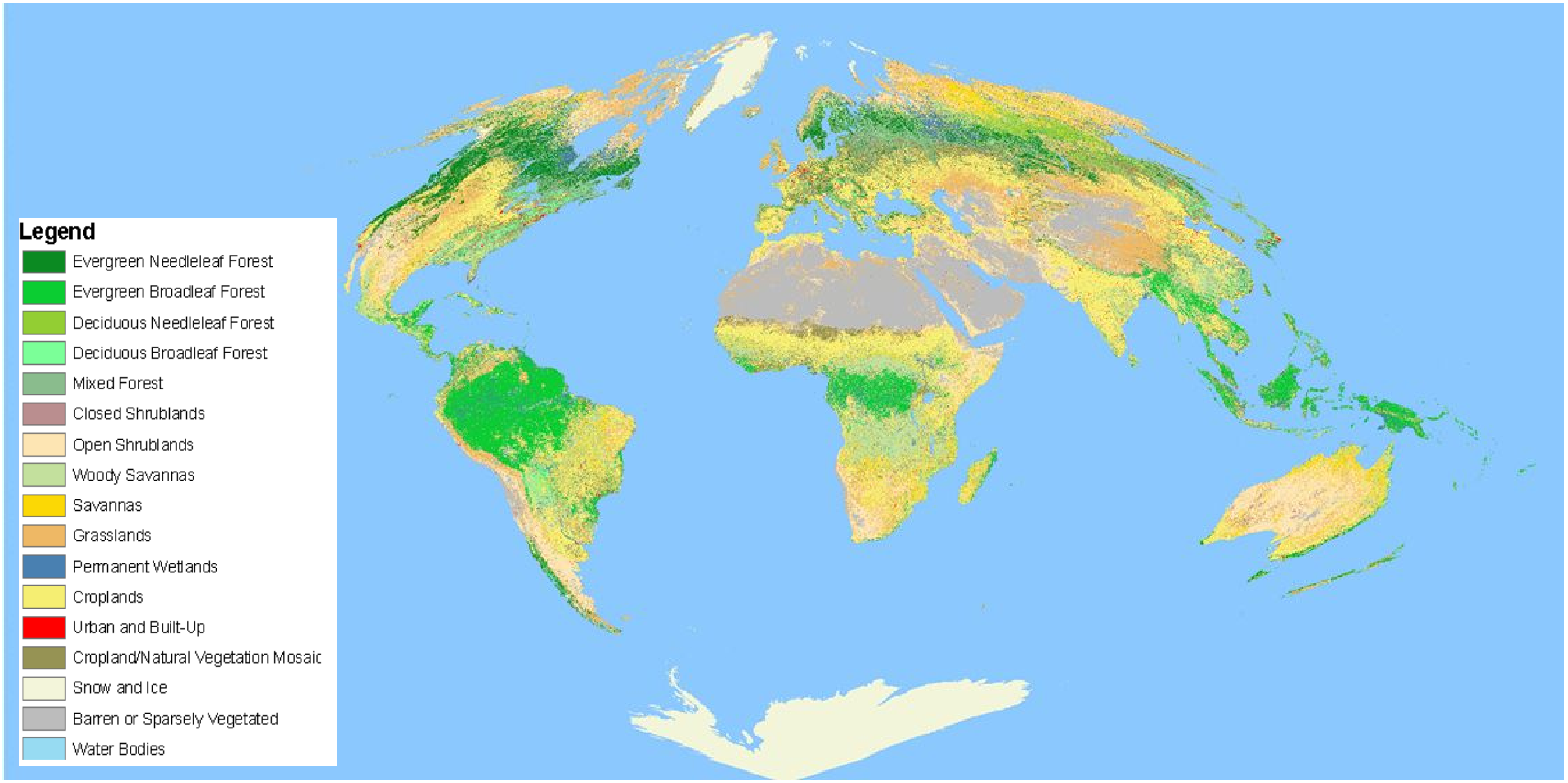
VIIRS QST IP Generation



All 2012 VIIRS data required by QST IP processed at UMD:

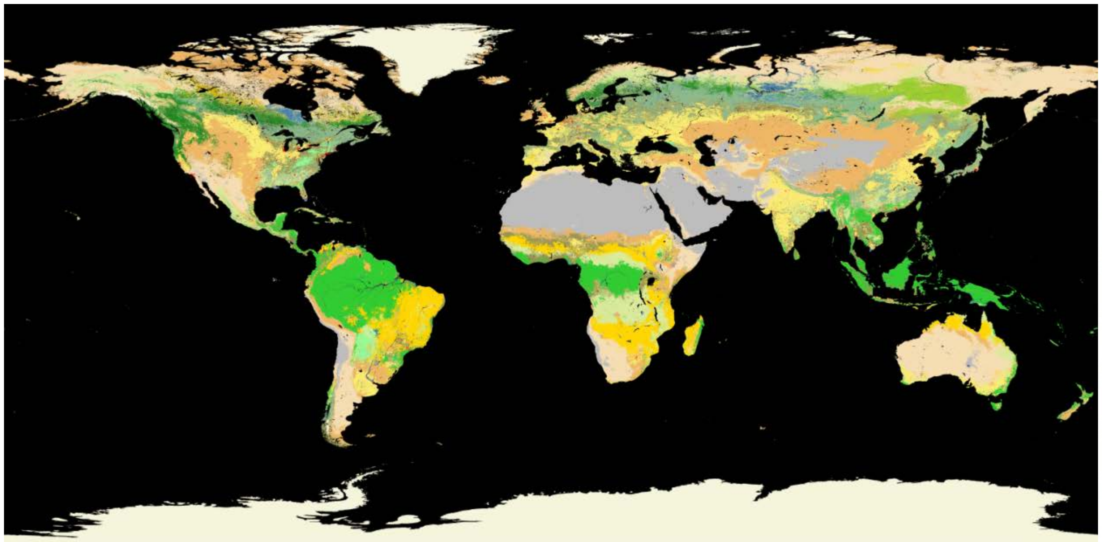
- ~880,000 files (80,000 granules x 11 bands), totaling ~150 TB
- > 30,000 CPU hours

First VIIRS QST IP from 2012 VIIRS Data

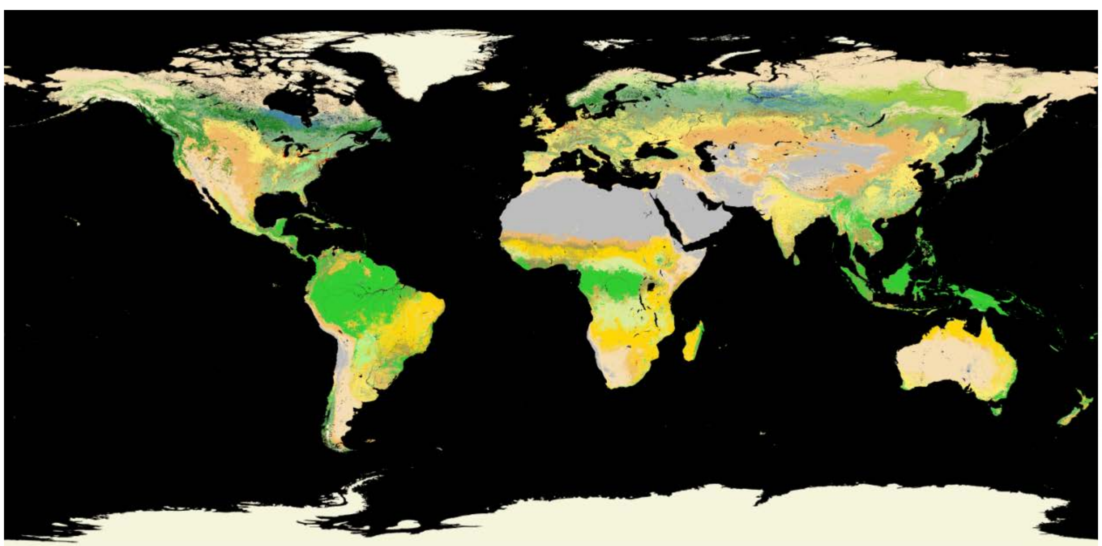


Similar Patterns between VIIRS QST IP and MODIS Seed

MODIS Seed



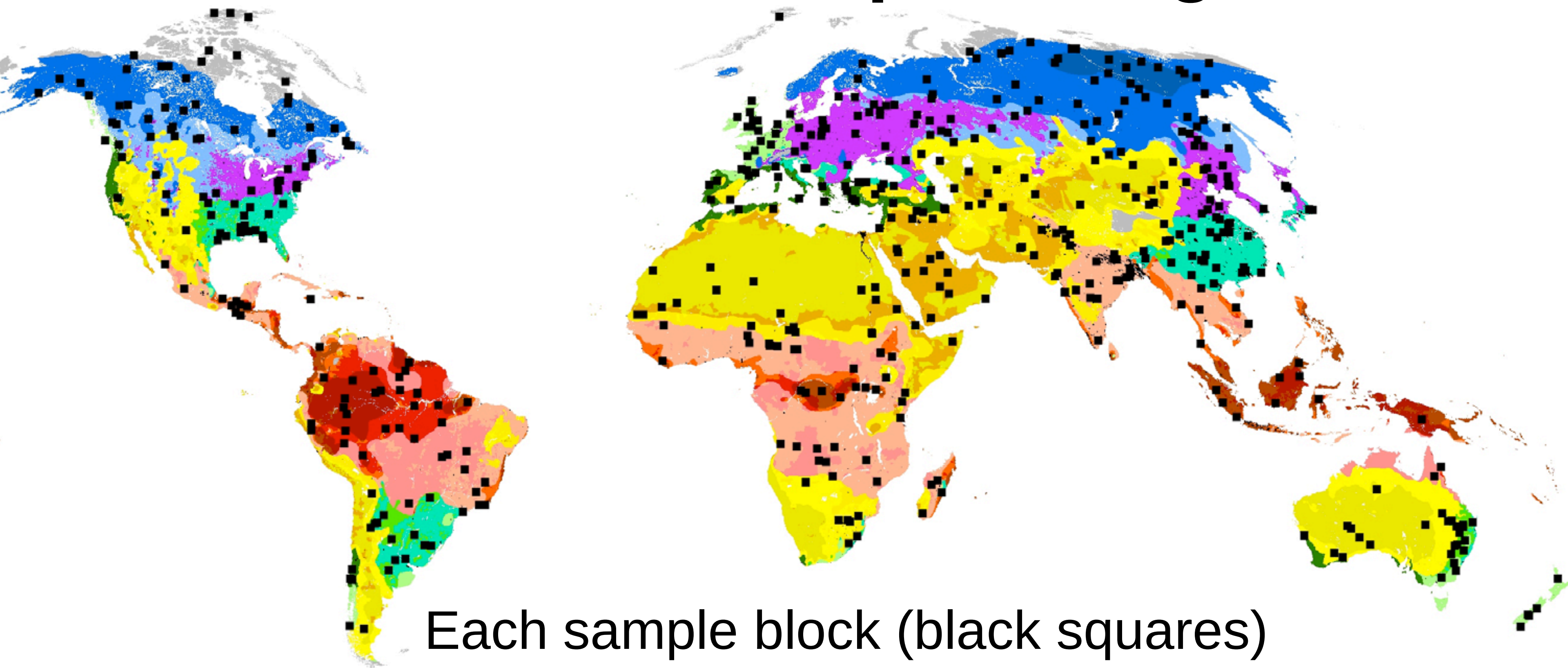
VIIRS QST IP



IGBP Legend

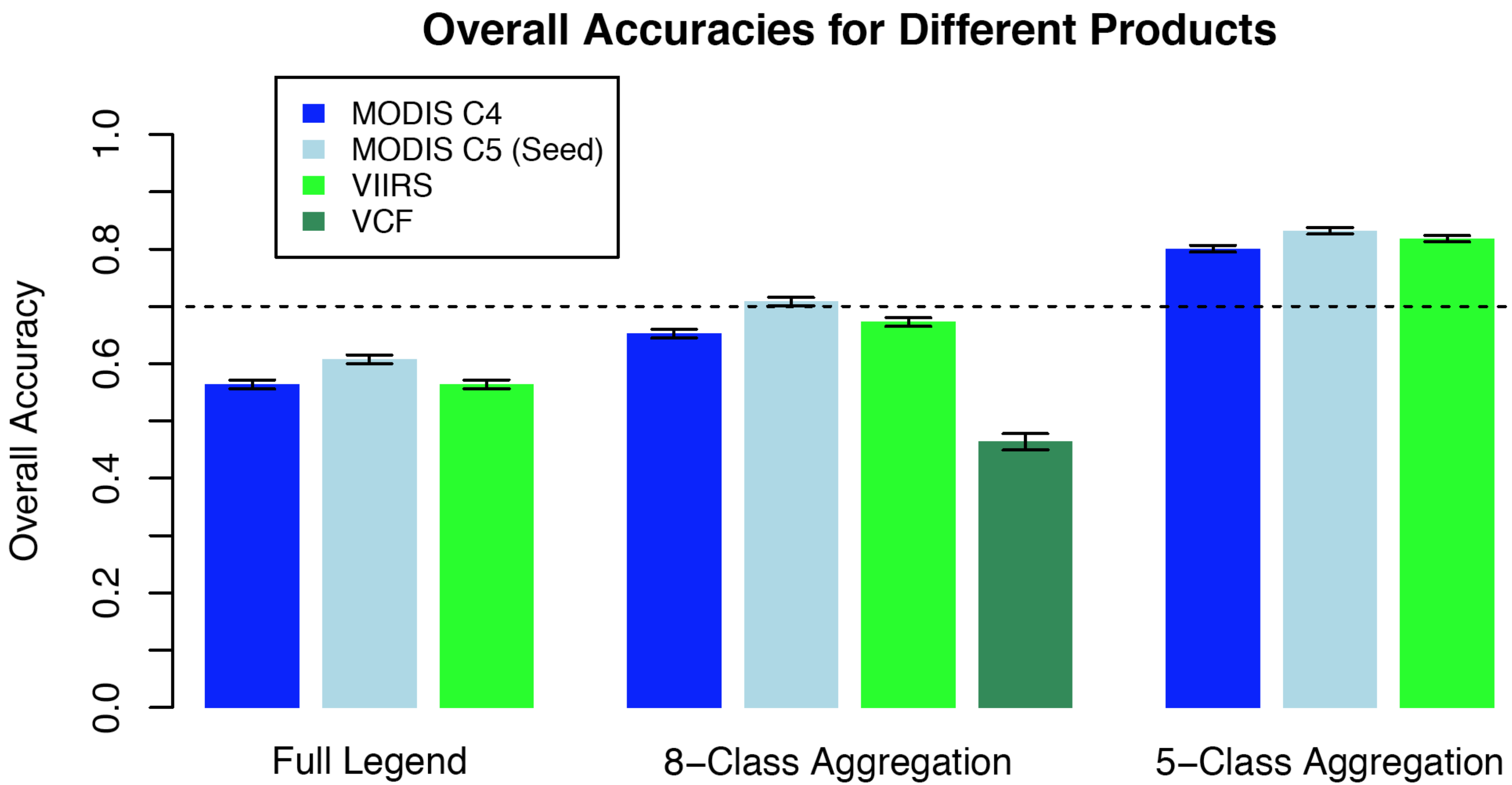
- Water Bodies
- Evergreen Needleleaf Forests
- Evergreen Broadleaf Forests
- Deciduous Needleleaf Forests
- Deciduous Broadleaf Forests
- Mixed Forests
- Closed Shrublands
- Open Shrublands
- Woody Savannas
- Savannas
- Grasslands
- Permanent Wetlands
- Croplands
- Urban and Built-up Lands
- Cropland/Natural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

Validation Sample Design



Each sample block (black squares) contains between 10 and 35 1-km VIIRS pixels.

Algorithm Evaluation

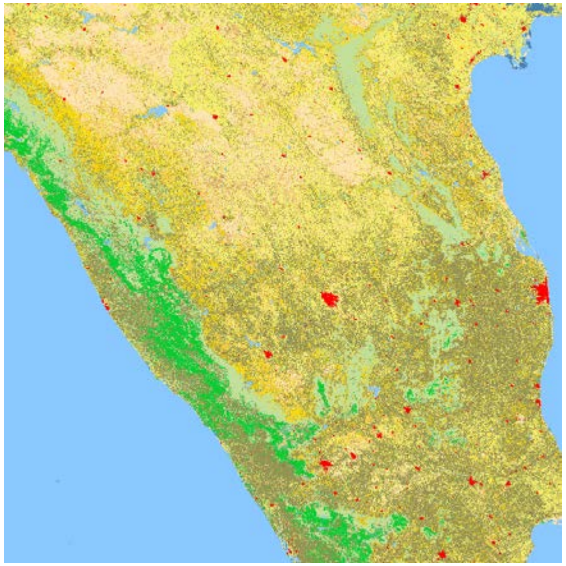


VIIRS QST overall accuracies are similar to MODIS C4 and C5 (Seed)

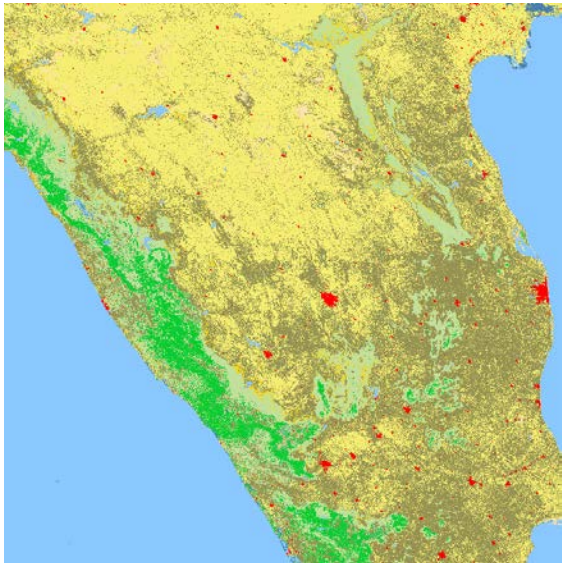
Issues from Preliminary Assessment

- Most confusions are between:
  - Cropland and grassland
  - Cropland and agriculture-nature vegetation mosaic
    - Post classification modeling
  - Grassland and open shrubland
  - Shrubland and grassland
  - Woody savanna and deciduous forest
  - Woody savanna and savanna

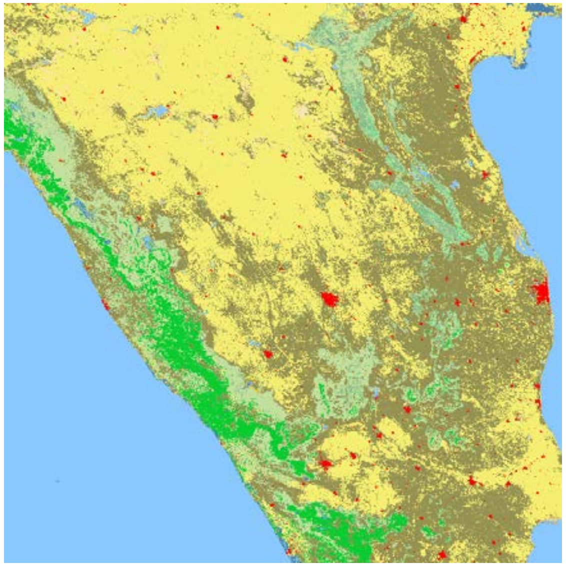
Post-Classification Modeling of Cropland



Initial QSTIP



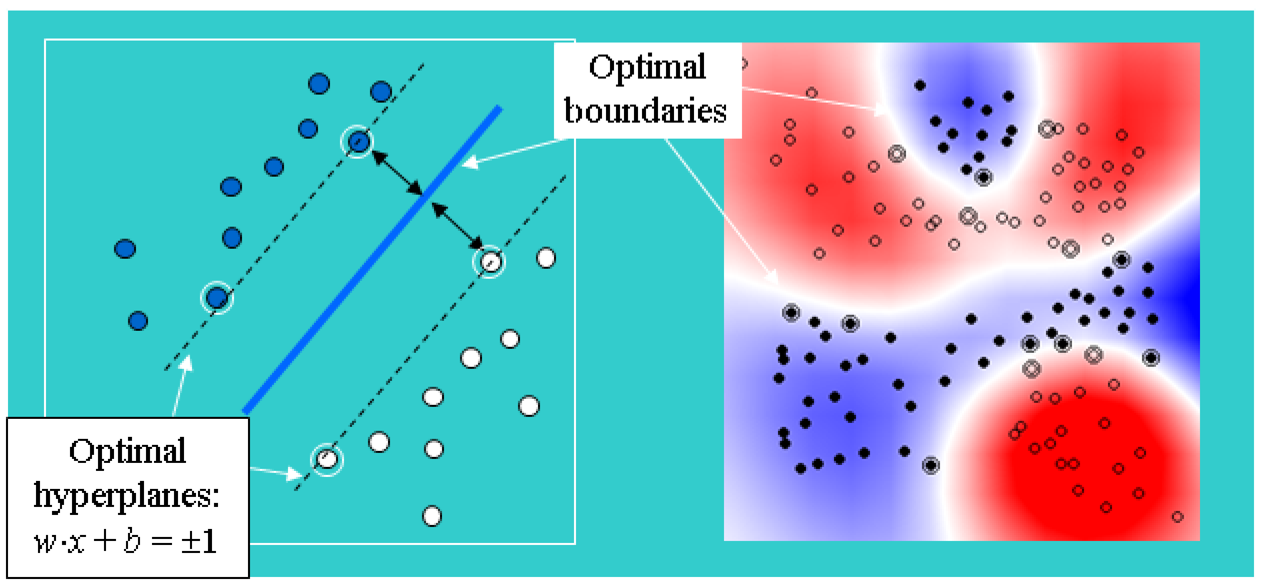
QSTIP R2 (post-classification modeling)



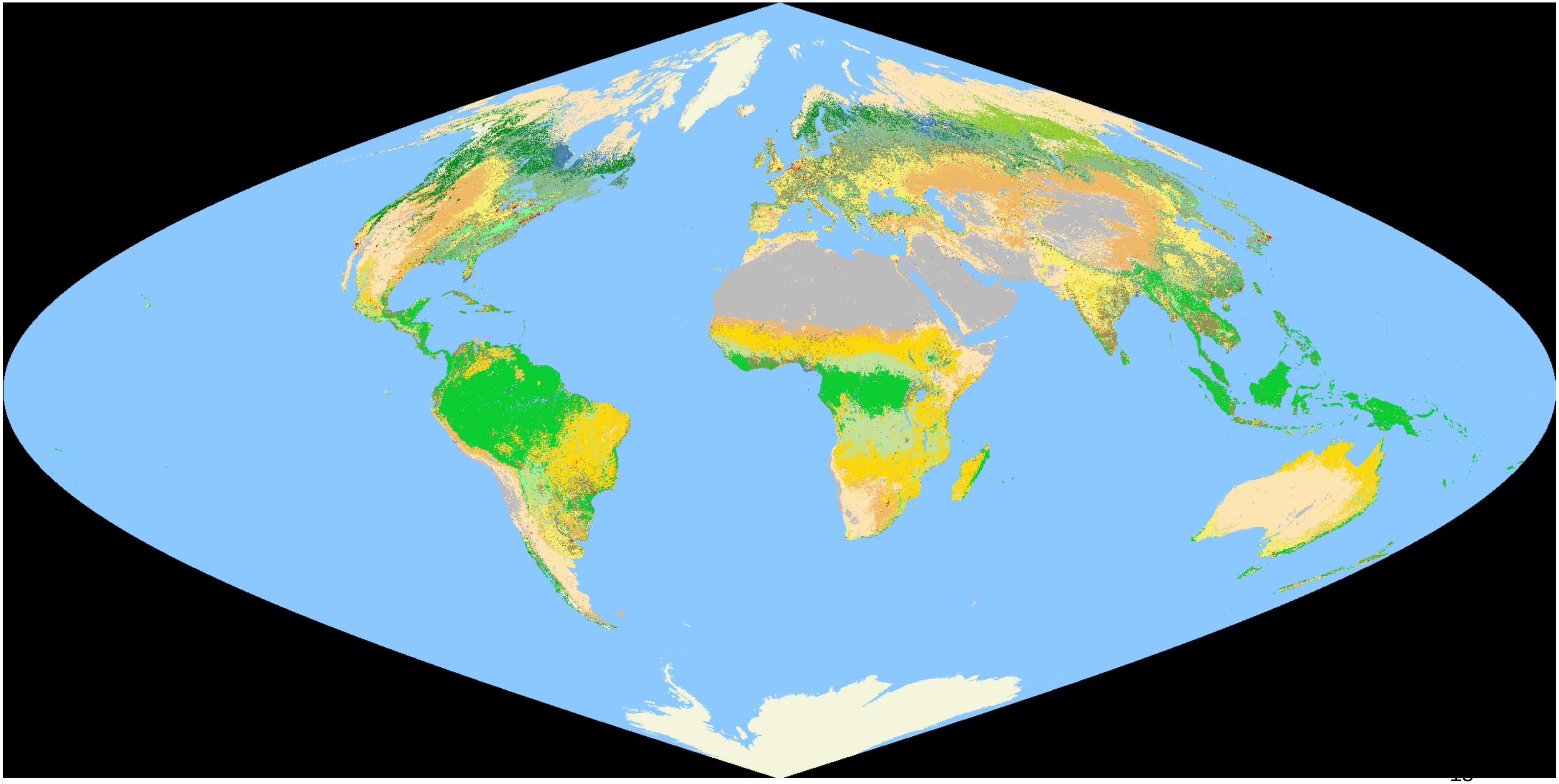
MODIS-based Seed

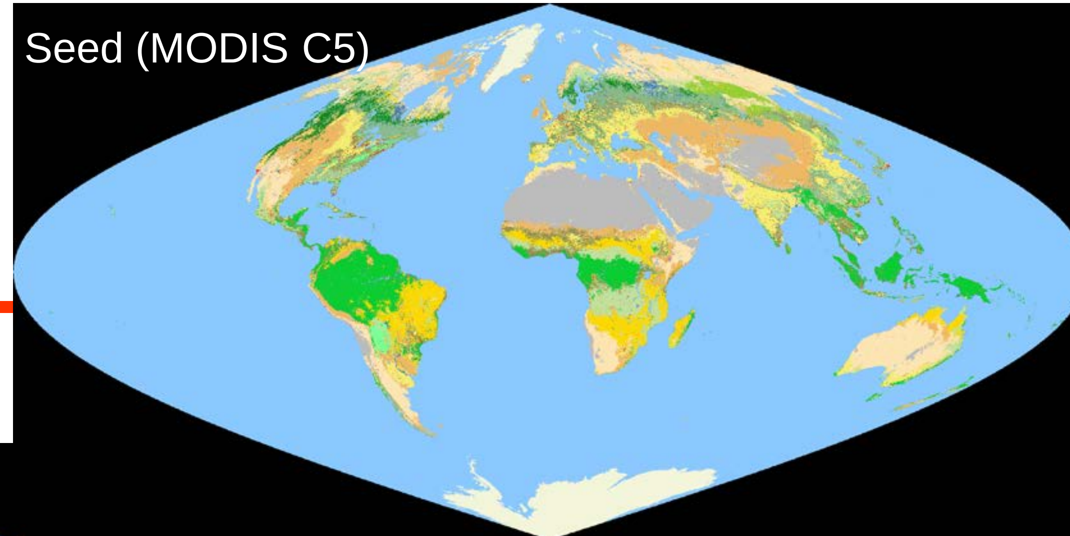
Exploring Better Classifiers

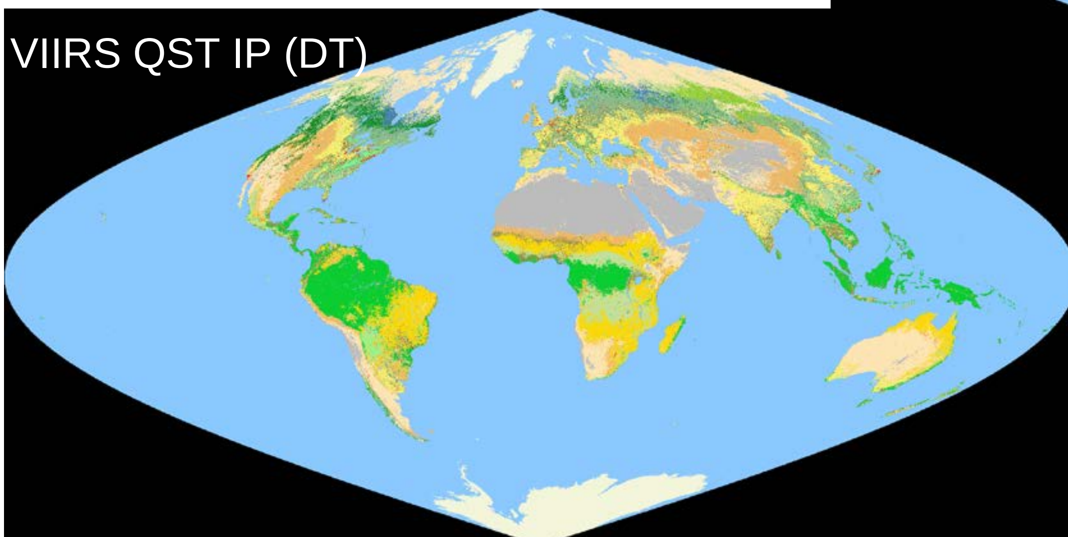
- DT is a MODIS/AVHRR heritage algorithm
- Support Vector Machines (SVM) better
  - Designed to search for optimal solutions
  - Consistently better accuracies than DT
    - (e.g., Huang et al. 2002; Foody and Mathur 2004; Pal and Mather 2005; Mountrakis et al. 2011)
  - More CPU intensive

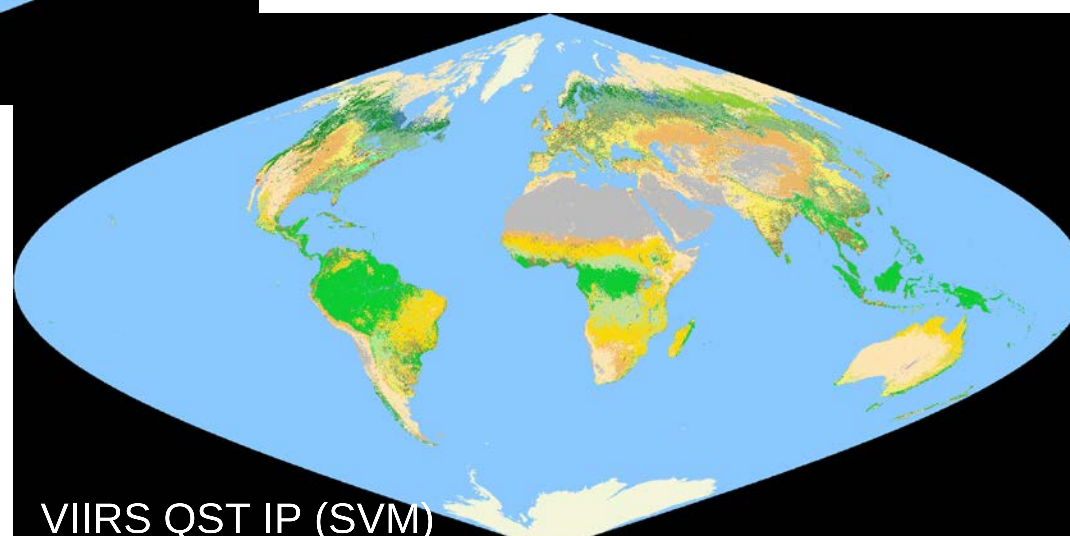


Preliminary QST IP from SVM

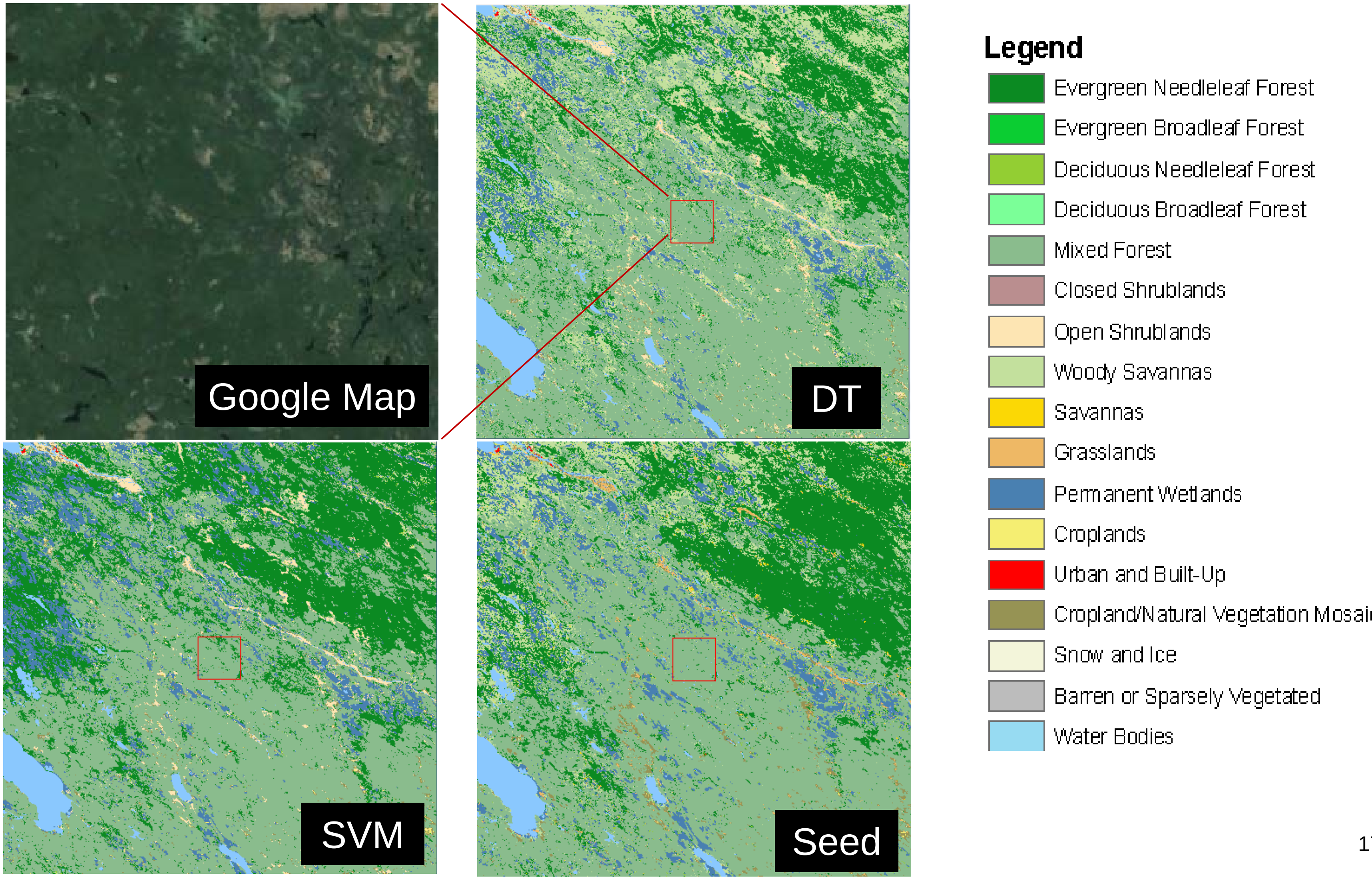



Seed (MODIS C5)

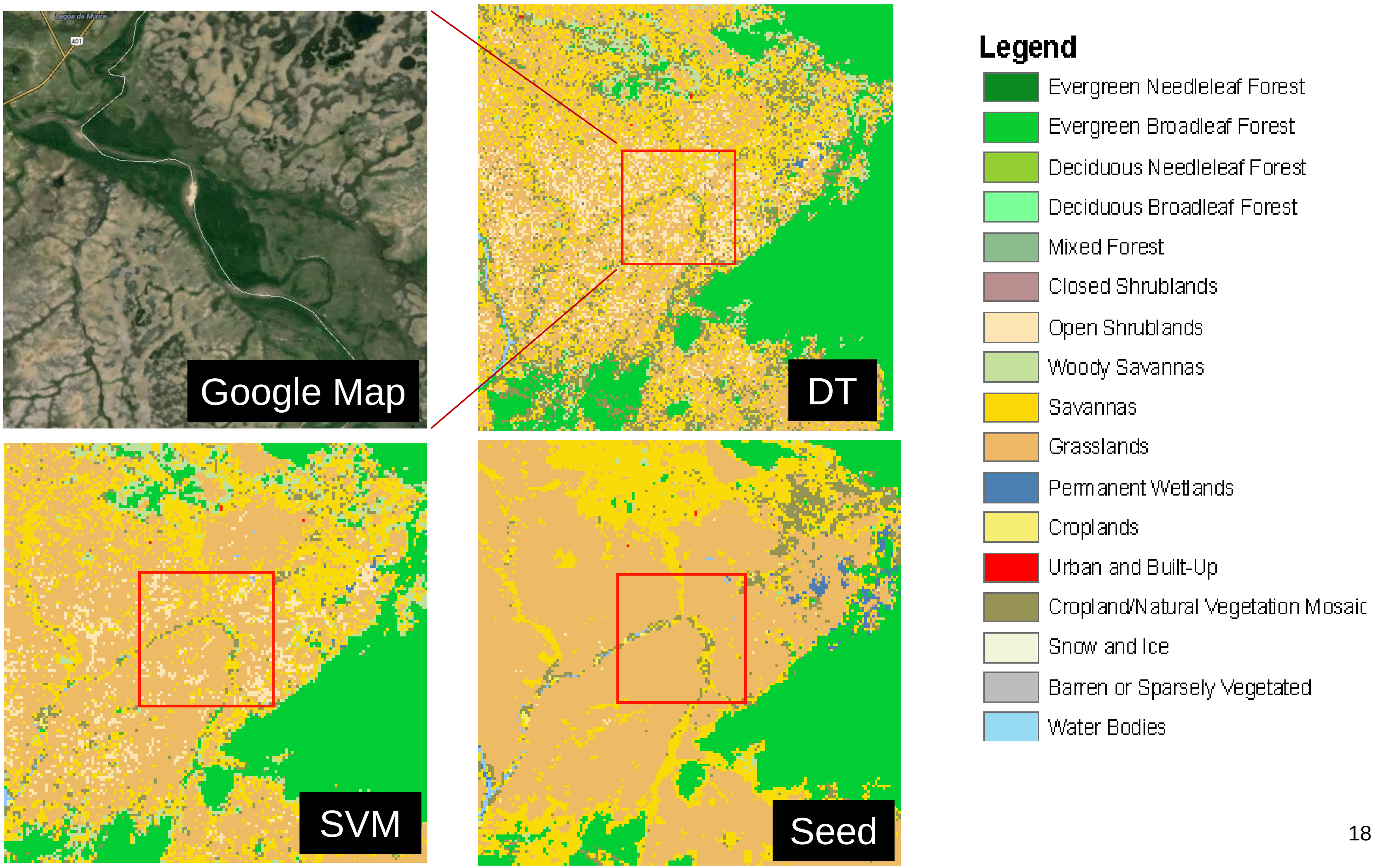

VIIRS QST IP (DT)


VIIRS QST IP (SVM)

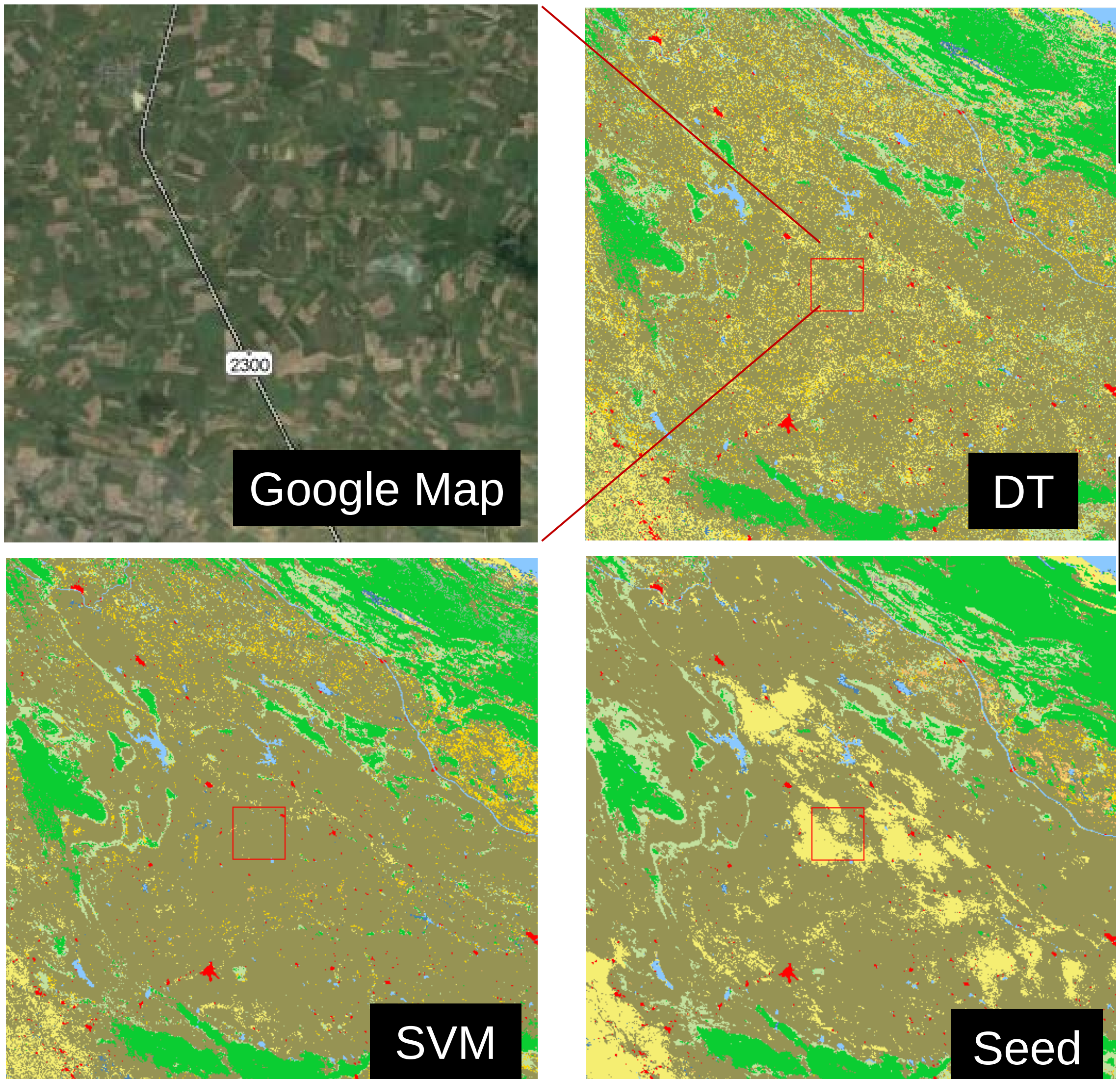
Similar in Forested Areas (Northern Europe)



SVM Less Salt-Pepper than DT (South America)



Post-Classification Modeling Needed for Crop and Crop Mosaics (Southeastern Asia)



Cropland

Lands covered with temporary crops followed by harvest and a bare soil period (e.g., single and multiple cropping systems.

Cropland/Natural Vegetation Mosaics

Lands with a mosaic of croplands, forest, shrublands, and grasslands in which no one component comprises more than 60% of the landscape.

Next Steps

- More comprehensive assessment of SVM results
  - Accuracy assessment using validation data (BU)
- Post-classification modeling
  - Cropland
- Use multi-year VIIRS data
  - Reduce cloud contamination
  - Reduce impact of inter-annual variability
  - 3 years used in MODIS C5
- Improve training data representativeness

Future Plans

- Replace DT with SVM in JPSS-1 QST algorithm
  - Further evaluations and comparisons are needed.
- Better characterize classes inherently challenging, e.g. urban, wetland
  - Mostly mixed
  - Subpixel fraction estimation more appropriate
- Harness knowledge in existing products
  - Agreements -> class prior probability
  - Disagreements -> focus of improvement effort
- More comprehensive validation strategy
- Change products

VIIRS Surface Type Algorithm Summary

- Two algorithms
  - Surface Type EDR algorithm
    - Operational on IDPS
    - Perform as designed
    - Issues identified and addressed
  - QST IP algorithm
    - Off-line algorithm running outside IDPS
    - Heritage DT algorithm produces results comparable with MODIS LC
    - Improvements identified
      - Needed to meet requirement

VIIRS Daily BRDF, NBAR and Albedo

Crystal Schaaf, Yan Liu, Qingsong Sun, Zhuosen Wang*

School for the Environment, University of Massachusetts Boston
http://www.umb.edu/spectralmass
Department of Earth and Environment, Boston University

*NASA/GSFC

Suomi NPP VIIRS Albedo

- **Suomi National Polar-orbiting Partnership (NPP)**
  - Launched Oct 2011
- **VIIRS Albedo algorithm** provides only a **Single Daily Broadband Albedo**
  - **I**n swath, at the time of overpass
  - No BRDF, no NBAR
  - No spectral quantities (no bands or broadband vis or NIR)
  - Minimal Quality Flags
  - No reprocessing

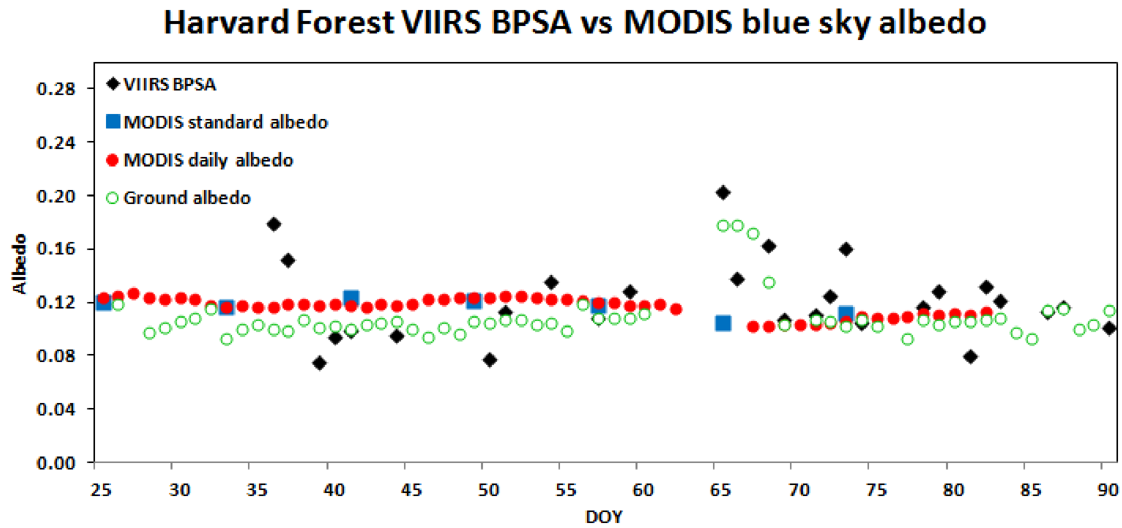
UMASS BOSTON

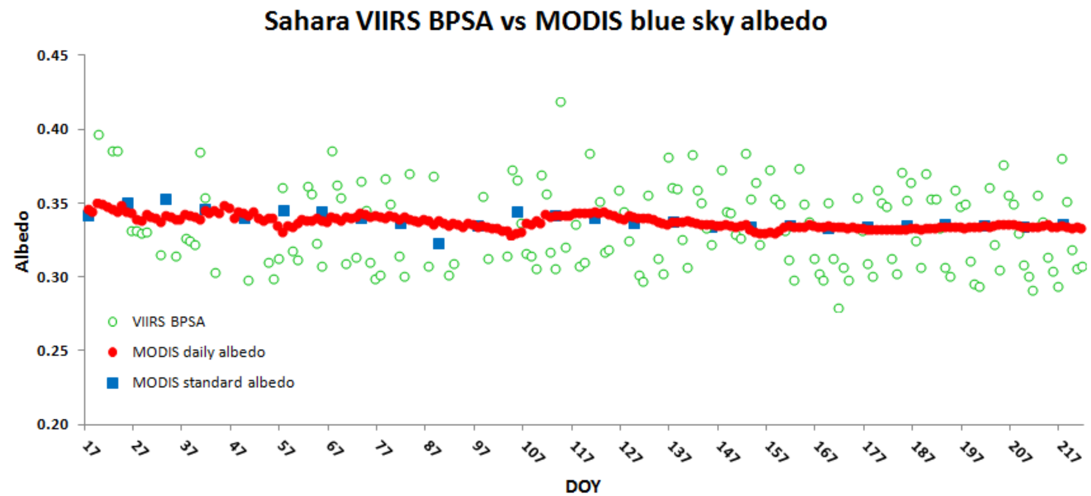
Suomi-NPP VIIRS Albedo

- **Two algorithms were originally implemented in code**
  - **Bright Pixel Surface Albedo (BPSA)** uses a **TOA LUT** approach
    - Liang, 2003; Liang et al., 2010
    - Designated as primary algorithm
    - **BPSA is now the ONLY Albedo provided**
      - Low quality Beta results currently being output from CLASS
  - **Dark Pixel Surface Albedo (DPSA)** based on **MODIS heritage**
    - **Spectral** BRDF models, coarse **NBAR,** were supposed to be produced in **unreleased IP**
    - Discovered after launch that DPSA code had been turned off
    - Subsequent evaluation found the DPSA code poorly implemented
      - Require a major redelivery and redesign of code
      - Decision made in April 2014 not to attempt to correct
- **Note at present VIIRS will not provide MODIS continuity**

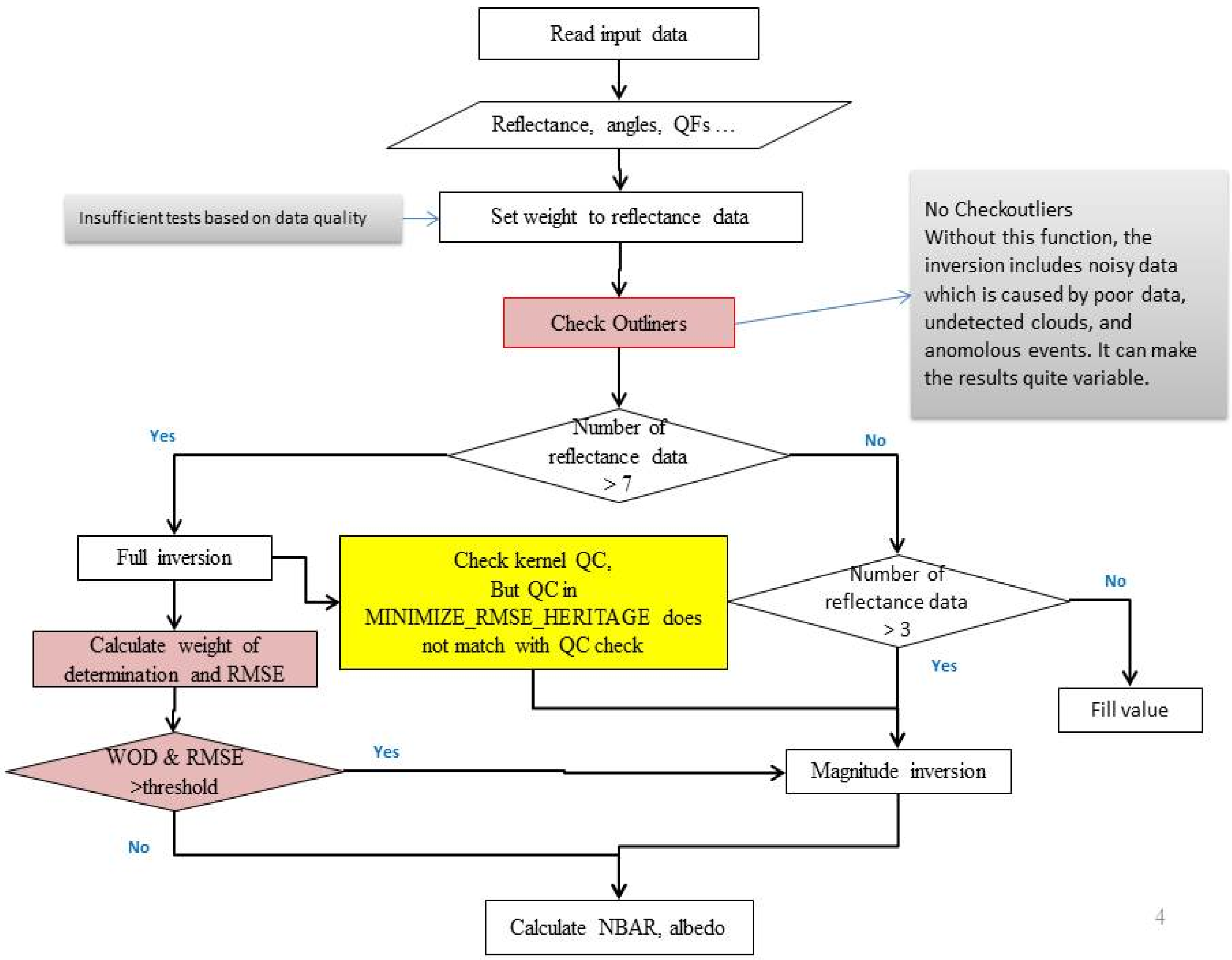
VIIRS Albedo Evaluation

- VIIRS Beta BPSA Albedo extremely unstable
  - **Problems with cloud/snow/SR continue**
- BPSA <u>**only**</u> algorithm being processed
  - prototype gridded DPSA had to be primarily evaluated at NASA LPEATE and offline
- Monitoring VIIRS
  - versus daily MODIS V006
  - versus tower albedometers





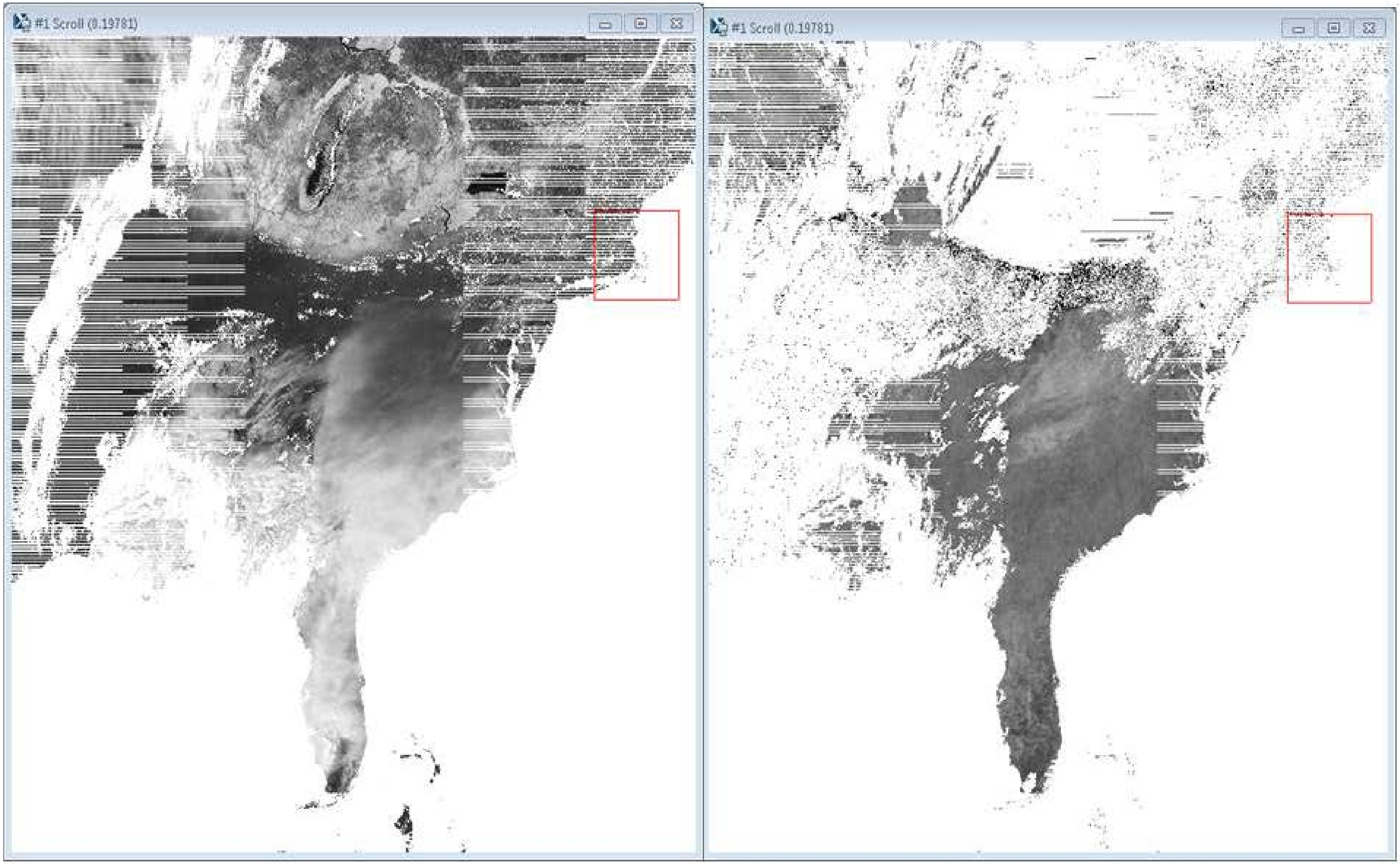
Differences with ADL code and why it matters



Poor Quality control throughout DPSA process

Insufficient Quality flags assigned to DPSA (and BPSA) output

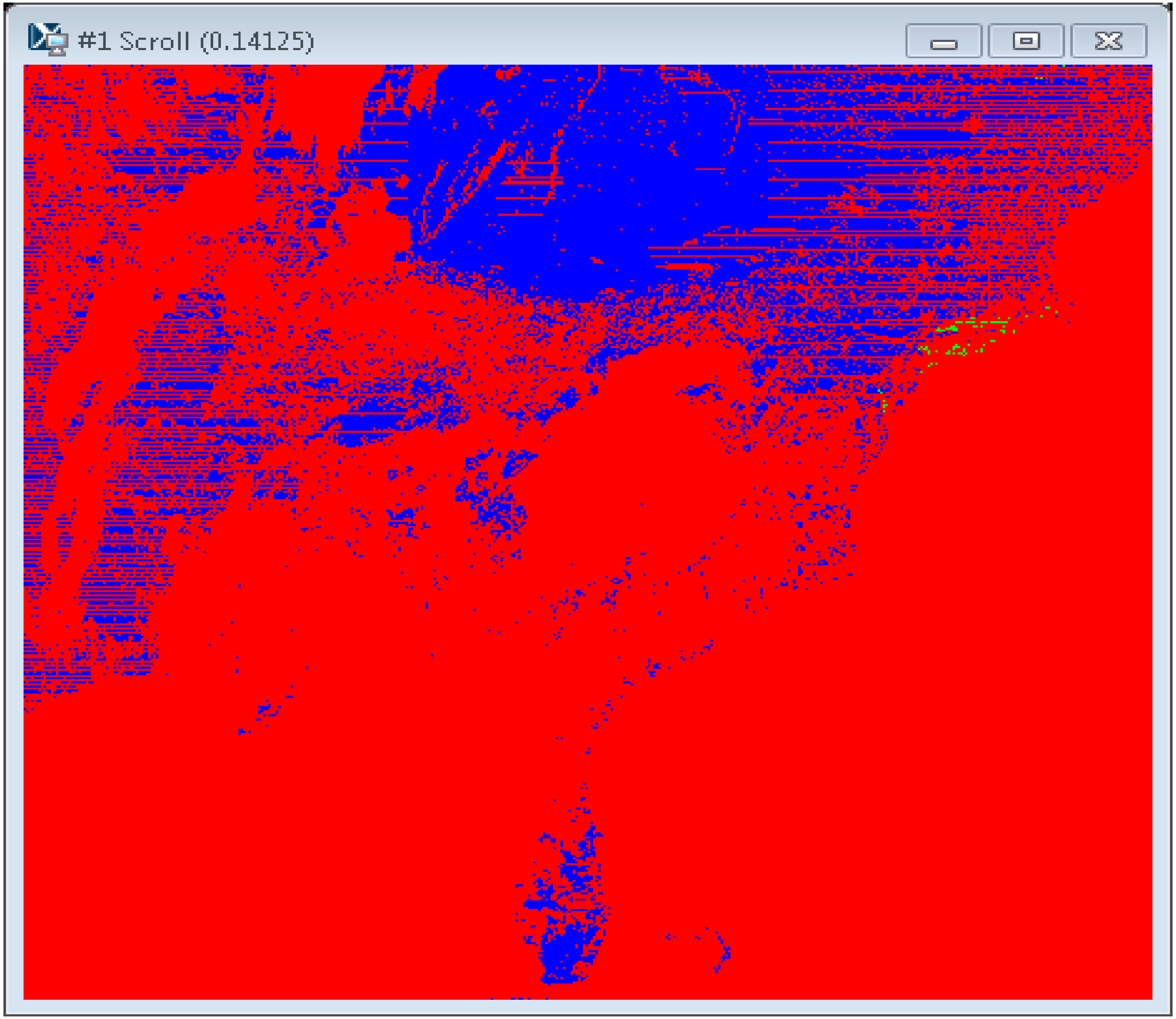
(Thanks to the LPEATE



a) Current BPSA (b) DPSA (2014-03-06)

BPSA and DPSA of eastern USA as being currently produced by the Mx8.3 I&T in the IDPS (NOTE: BPSA has extensive clouds and DPSA generates very few retrievals)

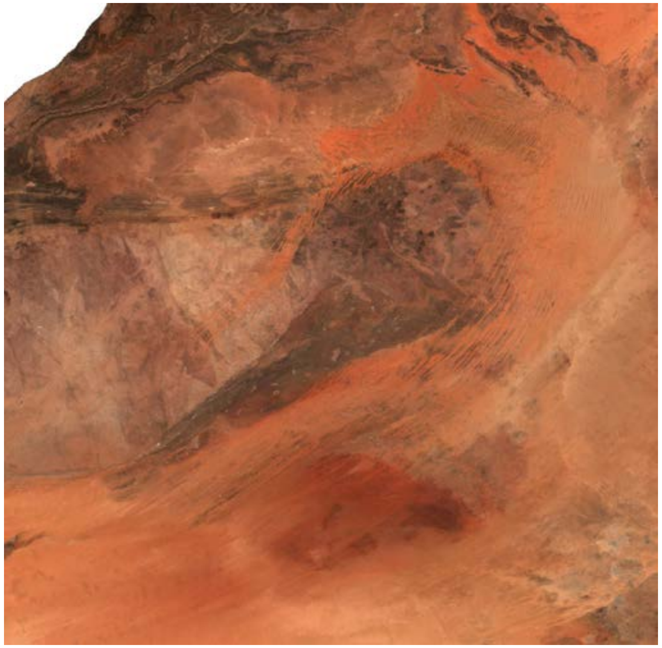
UMASS BOSTON



QA number	Color	Meaning
0	Red	N/A
1	Green	full inversion
2	Blue	magnitude inversion

Flagged with virtually no full retrievals (NY) and mostly fill

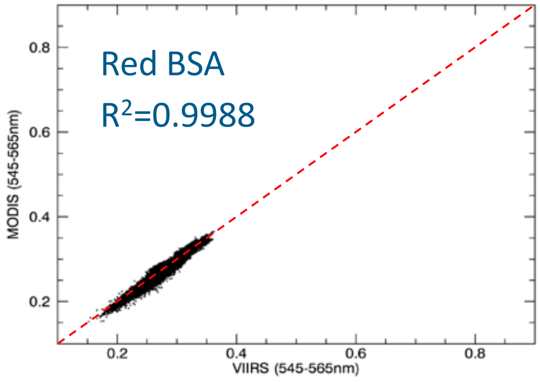
Offline version of DPSA under development



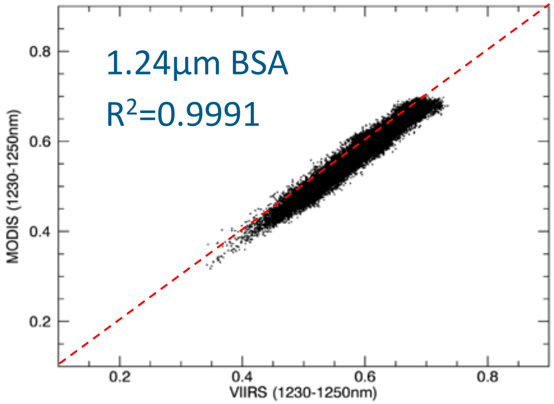
Suomi-NPP VIIRS Sahara Black Sky Albedo 2014 DOY013

MODIS Version 006 (

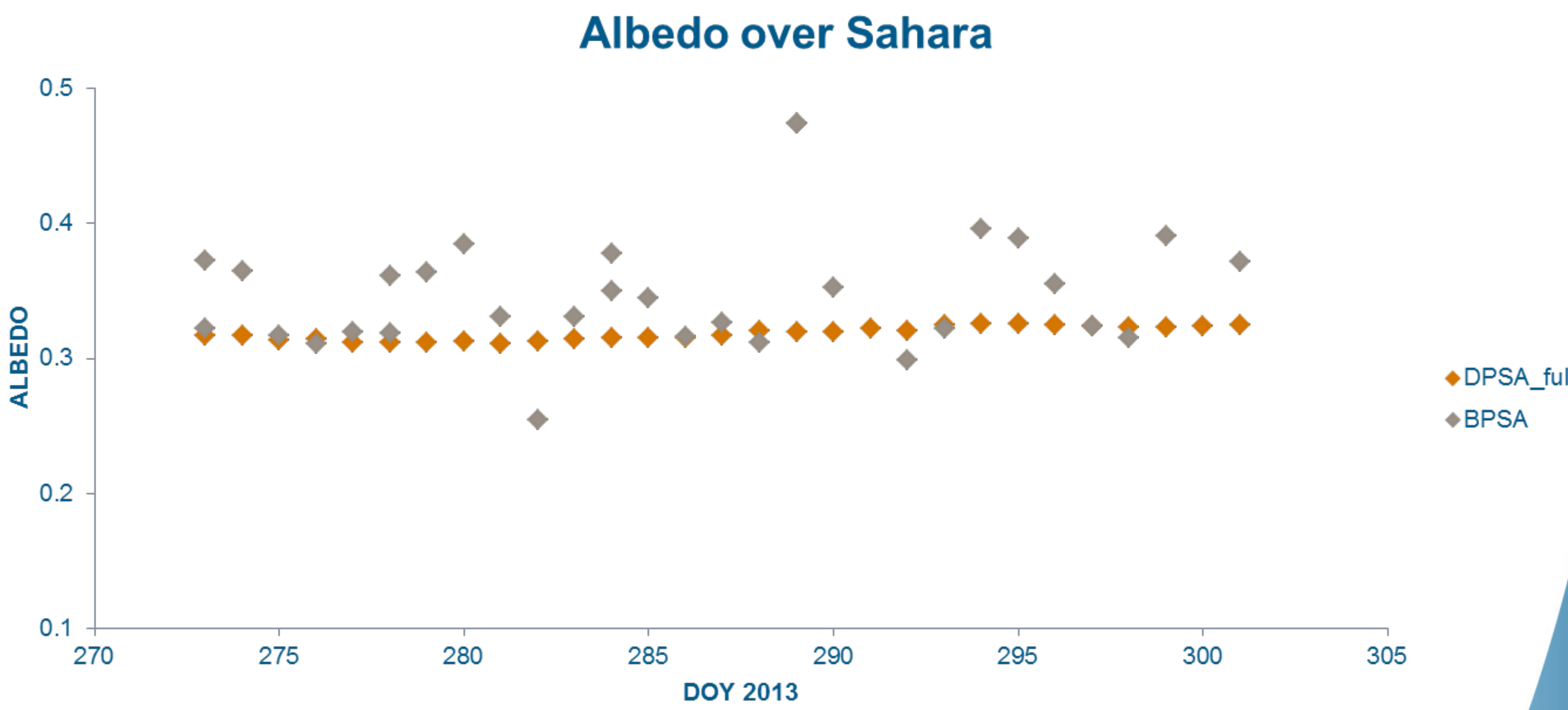
VIIRS Tile H17V06



	R	G	B
VIIRS	662 - 682 nm	545 -565 nm	478 - 488 nm
MODIS	620 - 670 nm	545 - 565 nm	459 - 479 nm



VIIRS offline Daily DPSA vs current BPSA



VIIRS DPSA offline vs MODIS Daily V006

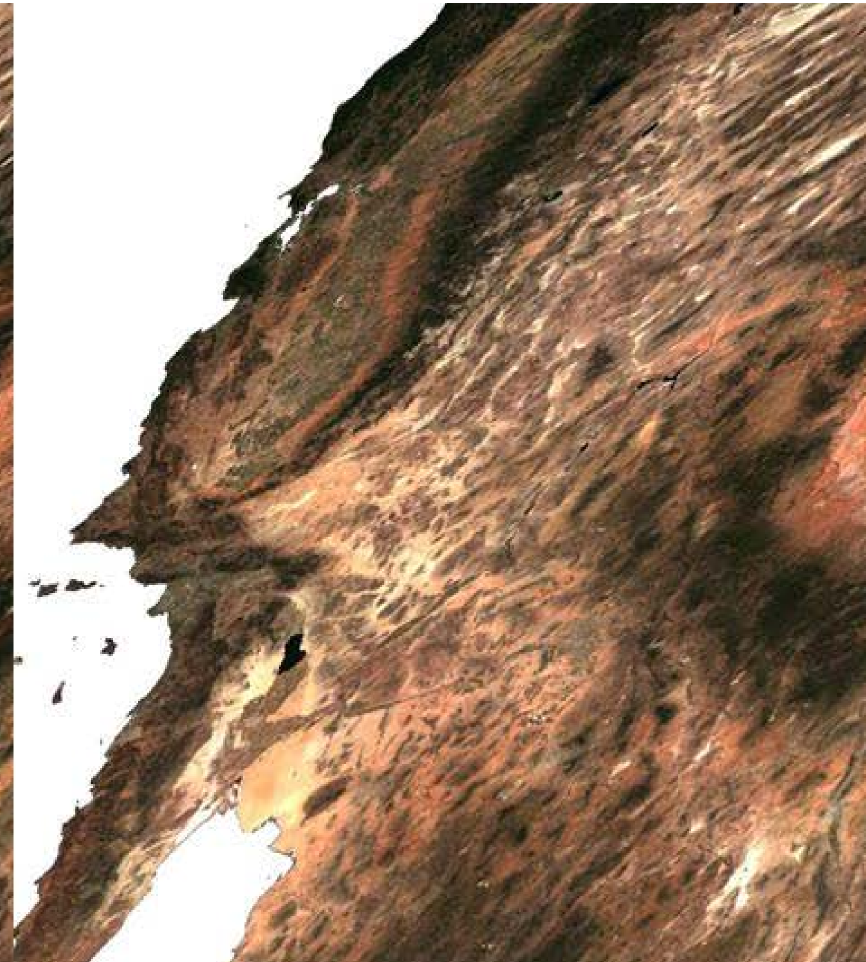
Suomi NPP VIIRS

MODIS V006

True color BSA of tile H12V04 of New England and southeastern Canada, Sept 2013

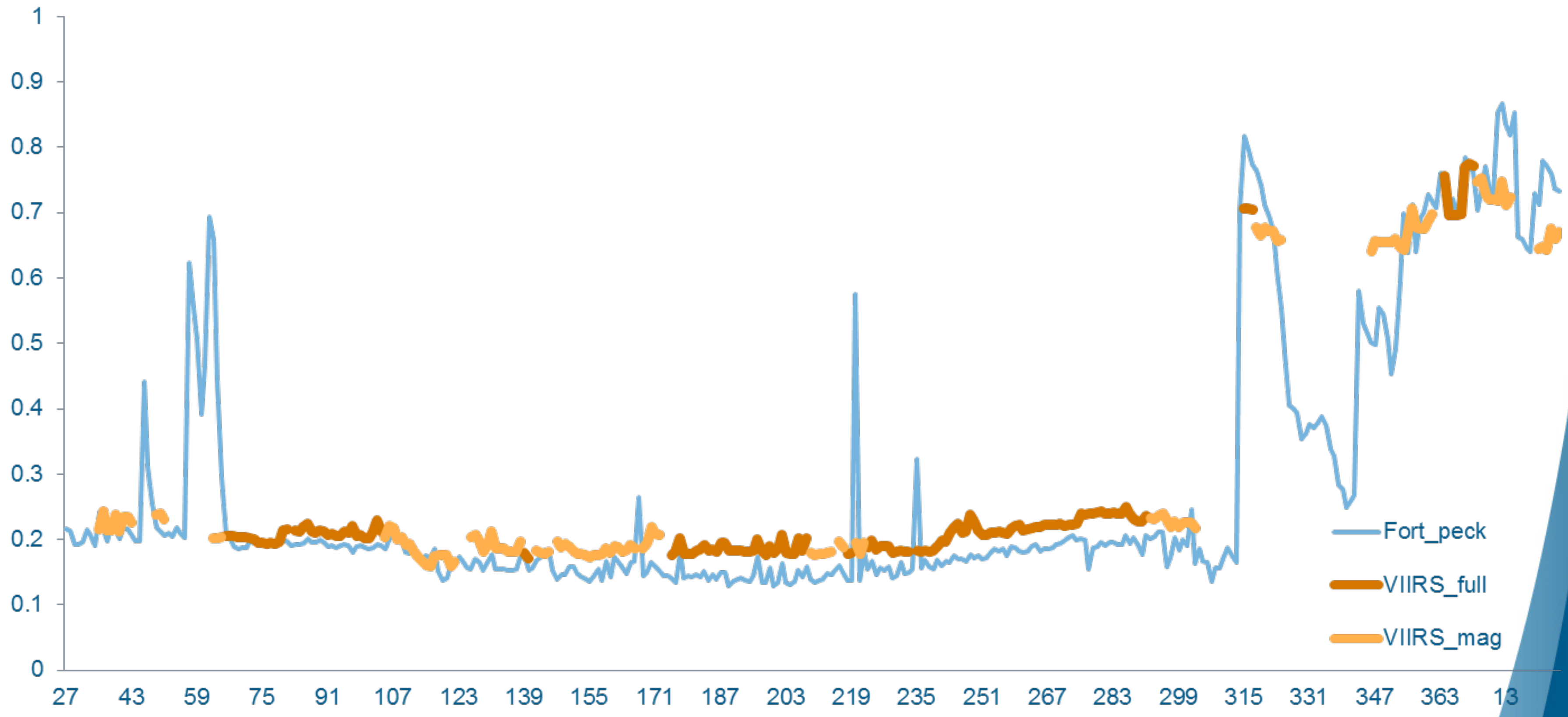
Suomi NPP VIIRS DPSA offline NBAR (Nadir BRDF Adjusted Reflectance)

Two adjoining Suomi NPP VIIRS surface reflectance swaths over tile h08v05 for Day 278 2013



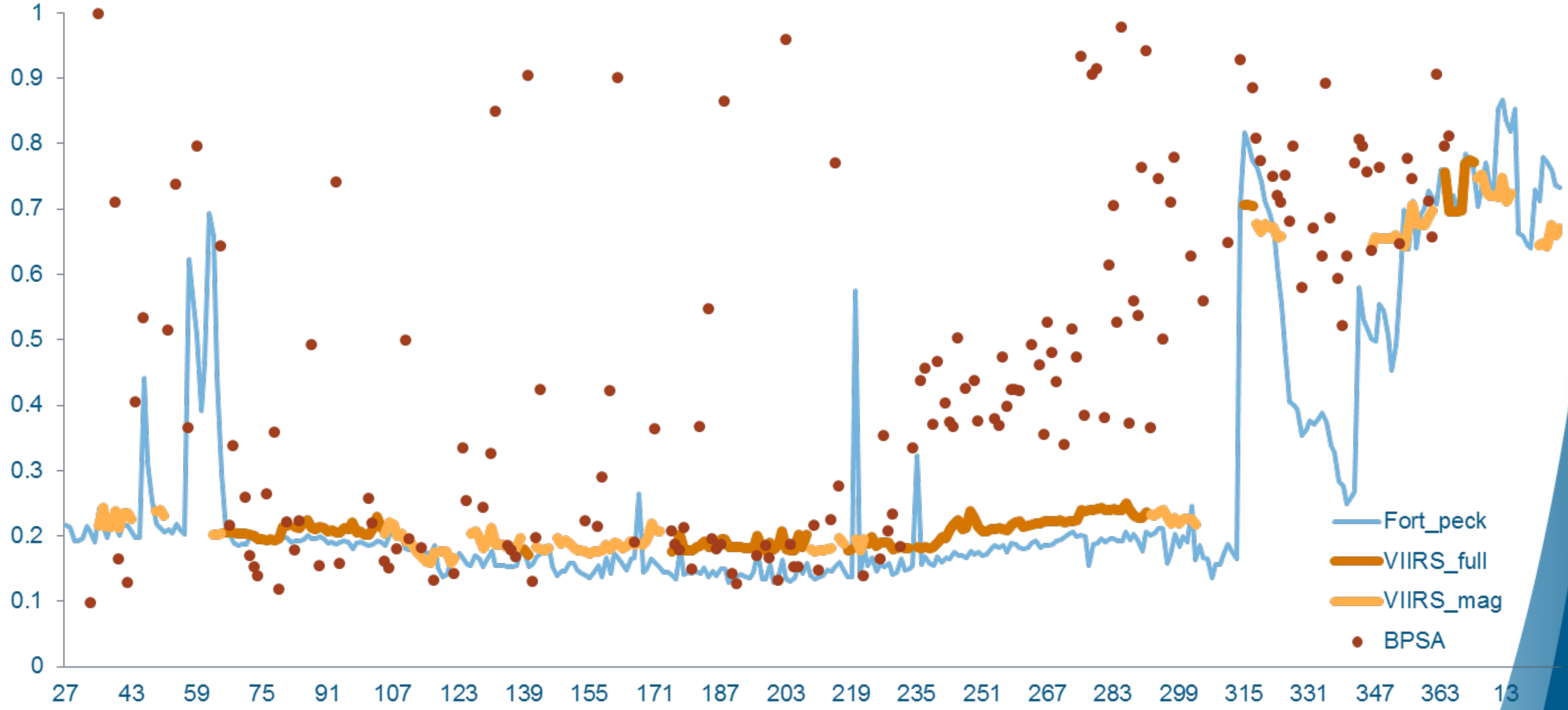
Resultant NBAR after BRDF correction with offline DPSA algorithm

Validation over Spatially Representative SURFRAD Sites Offline DPSA



Ft Peck MT, 2012

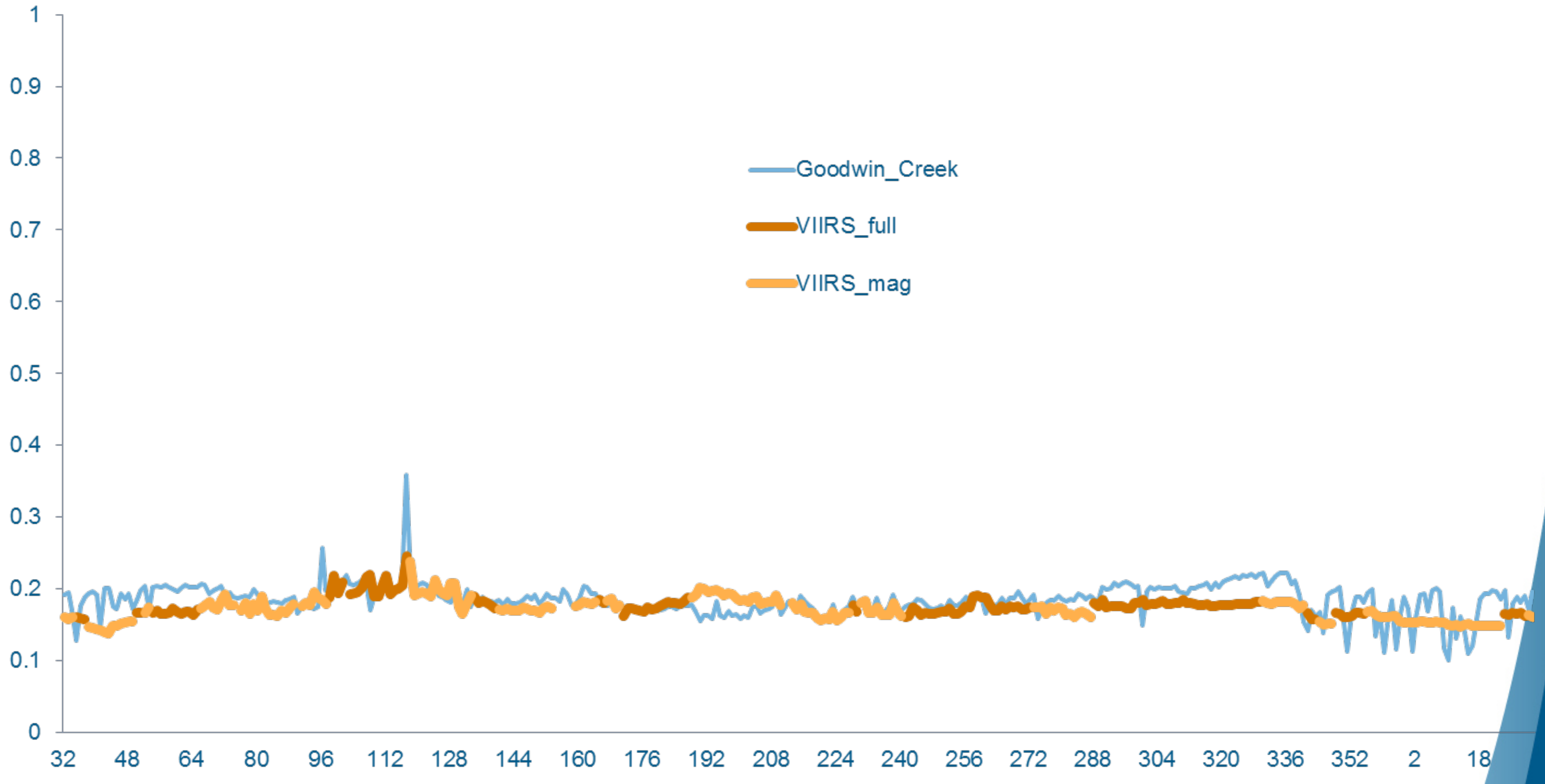
Validation over Spatially Representative SURFRAD Sites Offline DPSA and Current BPSA



Ft Peck MT, 2012

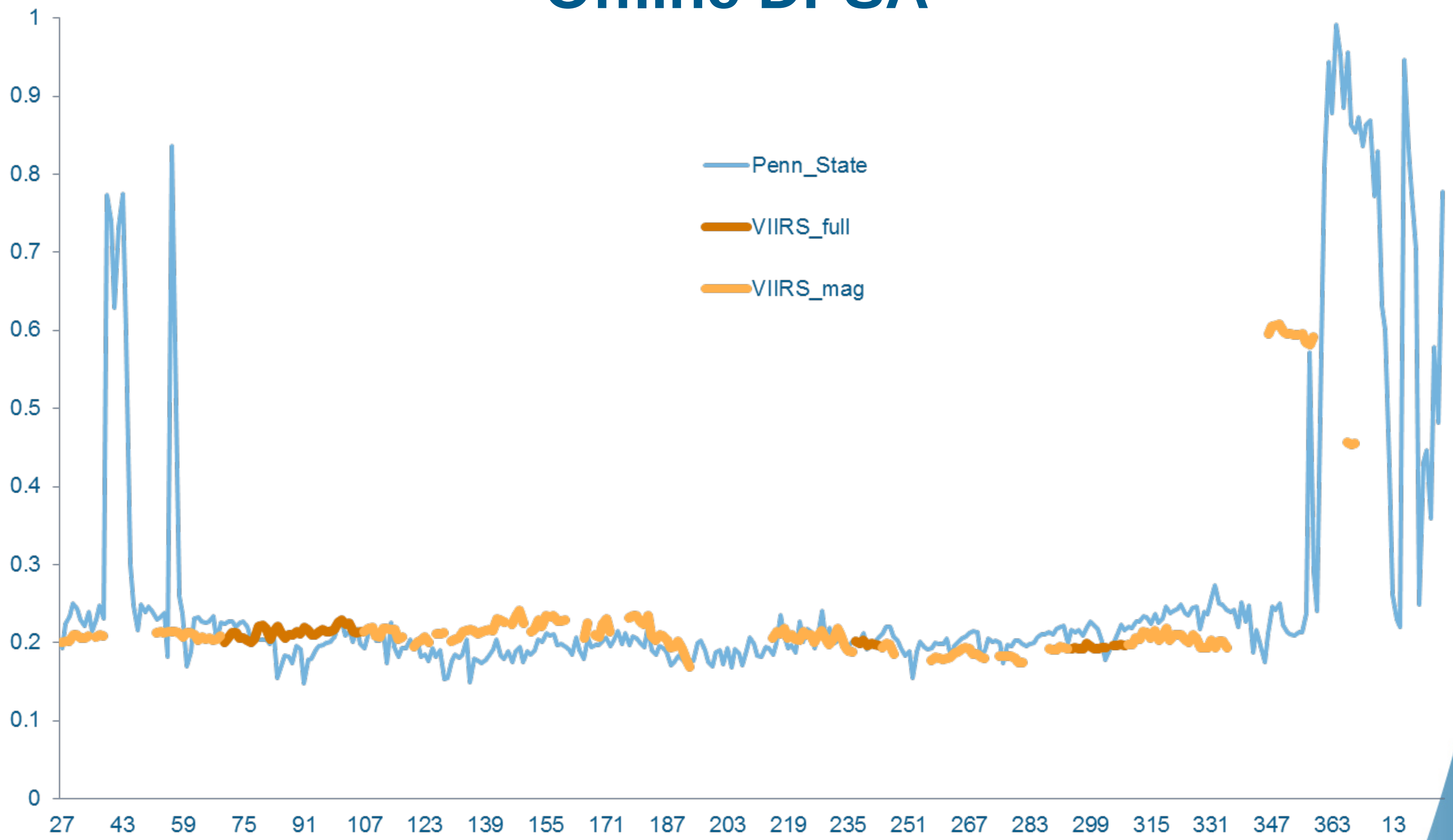
UMASS BOSTON

Offline DPSA



Goodwin Creek MS, 2012

Offline DPSA



Penn State PA, 2012

Summary

- DPSA implemented in IDPS code is irreparably broken
  - Only BPSA will be provided by CLASS

- Inability to obtain, evaluate, and make corrections to the IDPS products is a serious problem – will be for NPP and into the future with JPSS.

- Offline MODIS heritage DPSA code has been produced
  - Difficulties with upstream products continue (currently resulting in fewer high quality retrievals than from MODIS data stream)
  - However offline DPSA results indicate that high quality BRDF, NBAR, and Albedo products are achievable (VIIRS products need to be accompanied by sufficient quality flags to aid the user)

NOAA-USGS Land Product Validation System

STAR JPSS Science Team Meeting
14 May 2014

Kevin Gallo: NESDIS/STAR
John Dwyer: USGS/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

LPVS USGS science for a changing world
Land Product Validation System
USGS Home
Contact USGS
Search USGS
Earth Resources Observation and Science (EROS) Center
Land Product Validation System (LPVS) Home

Land Product Validation System (LPVS)

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

Land Product Validation System (LPVS)

What is LPVS

Why LPVS developed/hosted at EROS

Highlights of LPVS

1. Inventory & Ordering
2. Analysis Tools

Path Forward

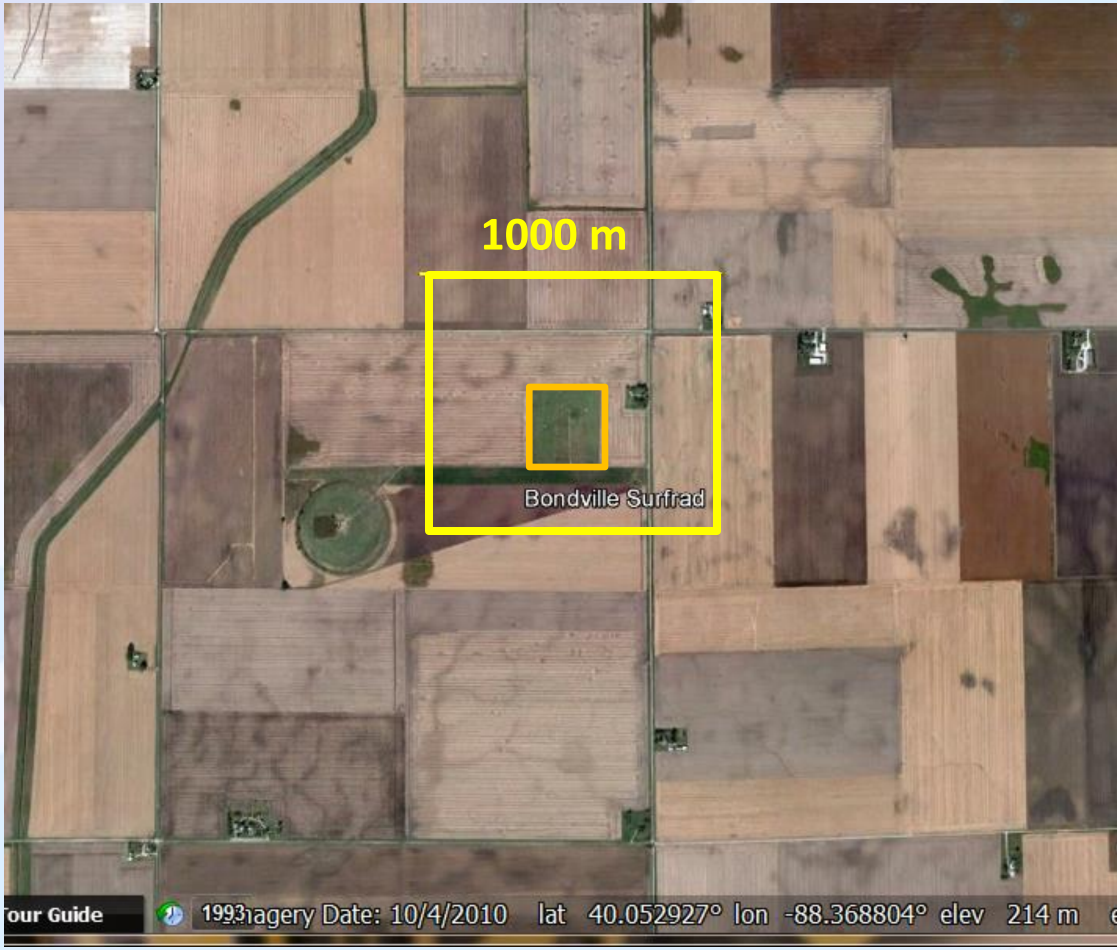
Summary

What is LPVS

1. General characteristics
2. Desired functionality

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

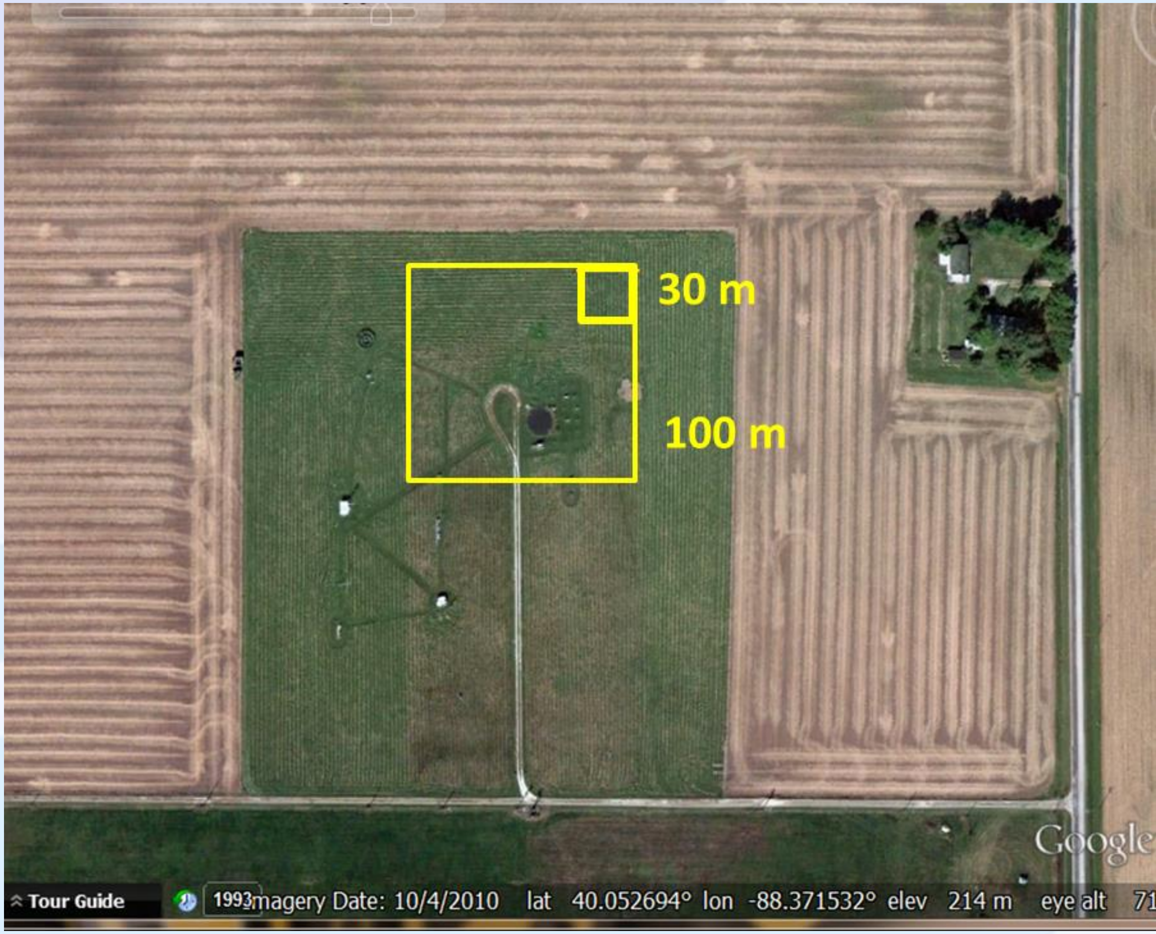


What is LPVS

1. General characteristics
2. Desired functionality

Landsat 8 spatial resolution
vis/near IR 30 m
Thermal IR 100 m

Bondville, IL SURFRAD



What is LPVS

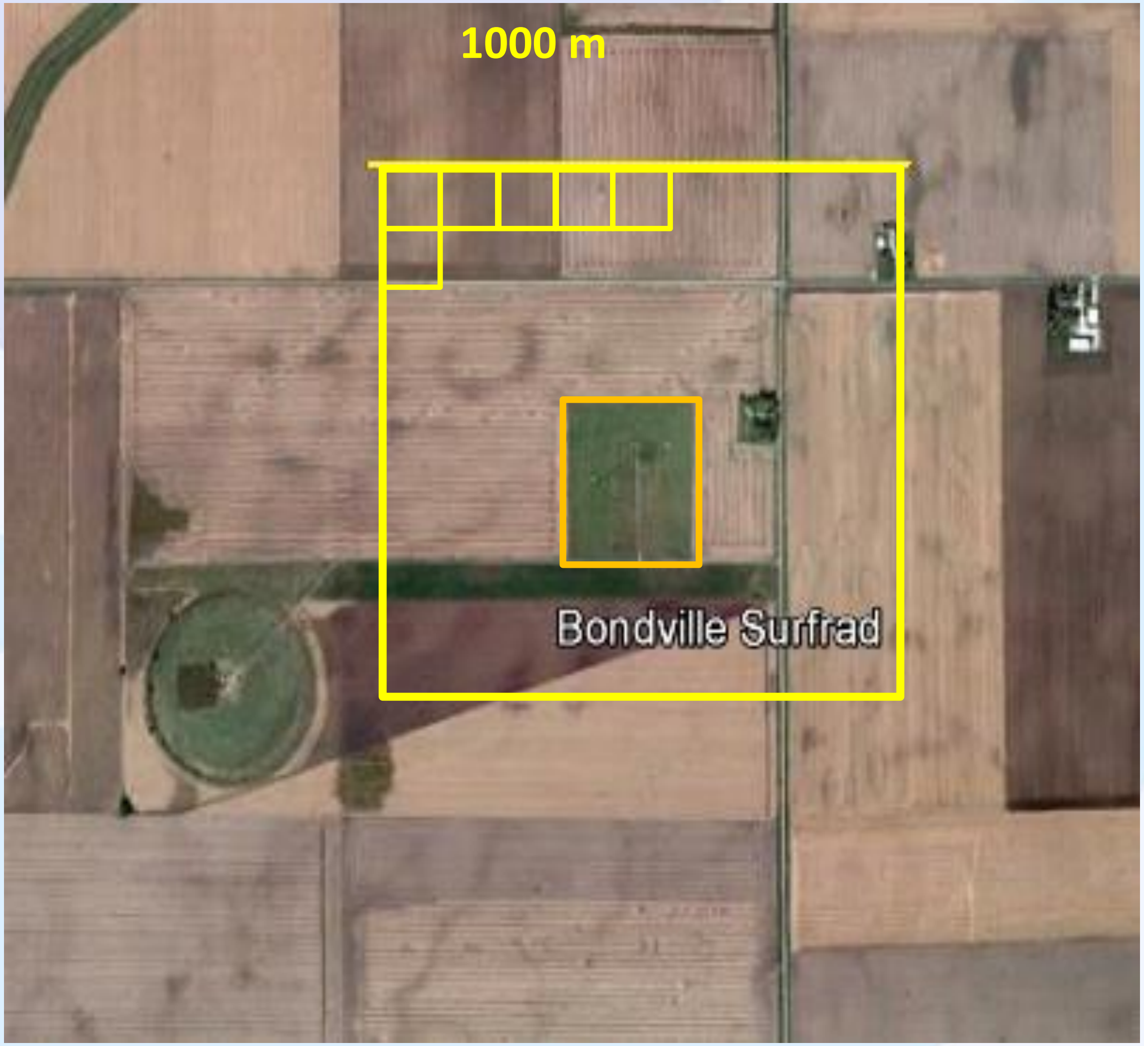
1. General characteristics
2. Desired functionality

Landsat sampling for 1000 x 1000 m target:

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

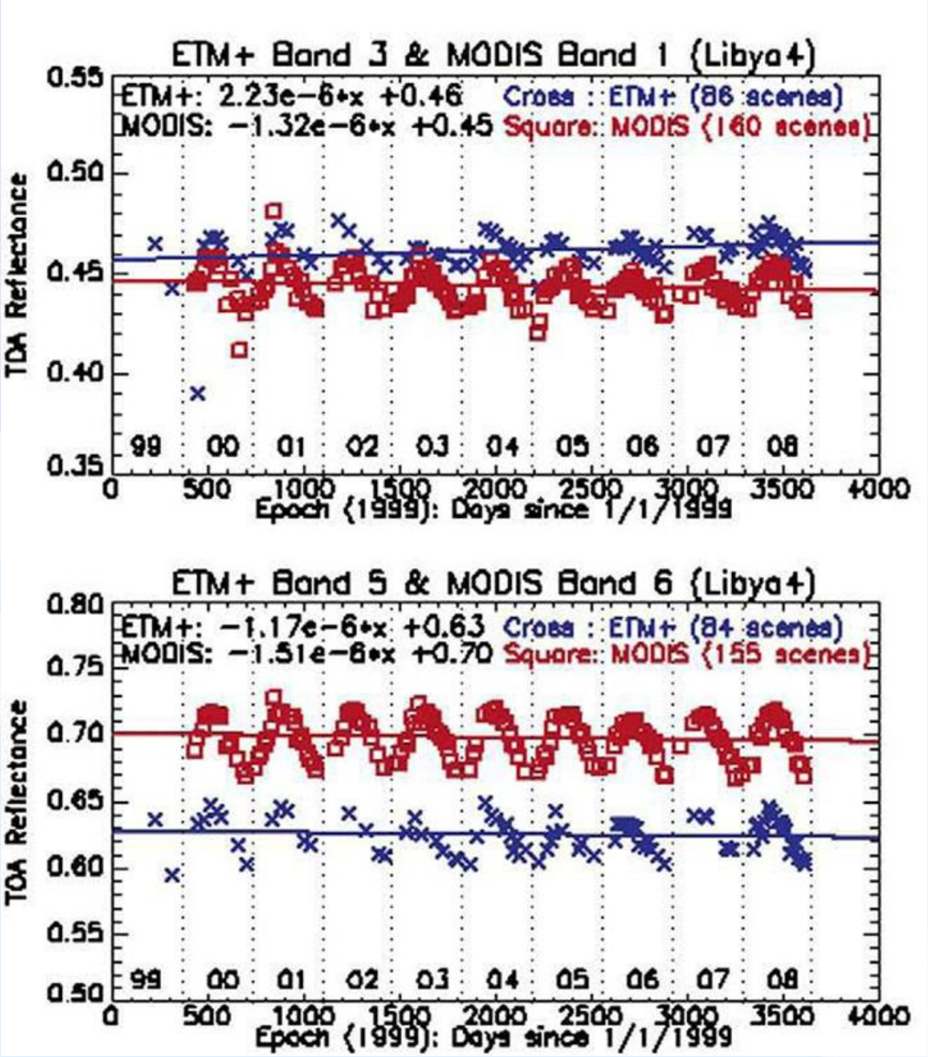
Ready for GOES-R and JPSS-VIIRS pre- and post-launch testing and validation.

Bondville, IL SURFRAD



What is LPVS: General Characteristics
Output examples

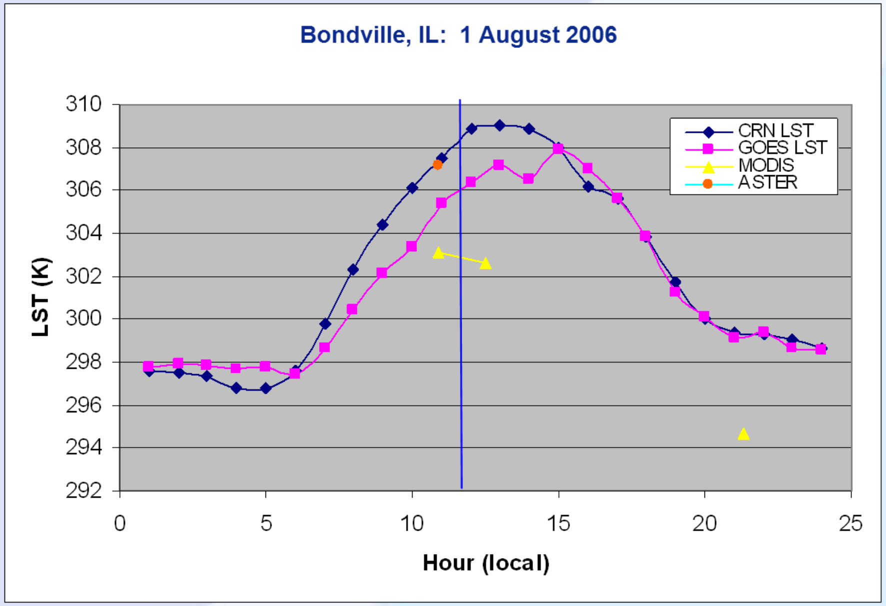
Trending of similar bands of data from multiple sensors.



What is LPVS: General Characteristics
Output examples

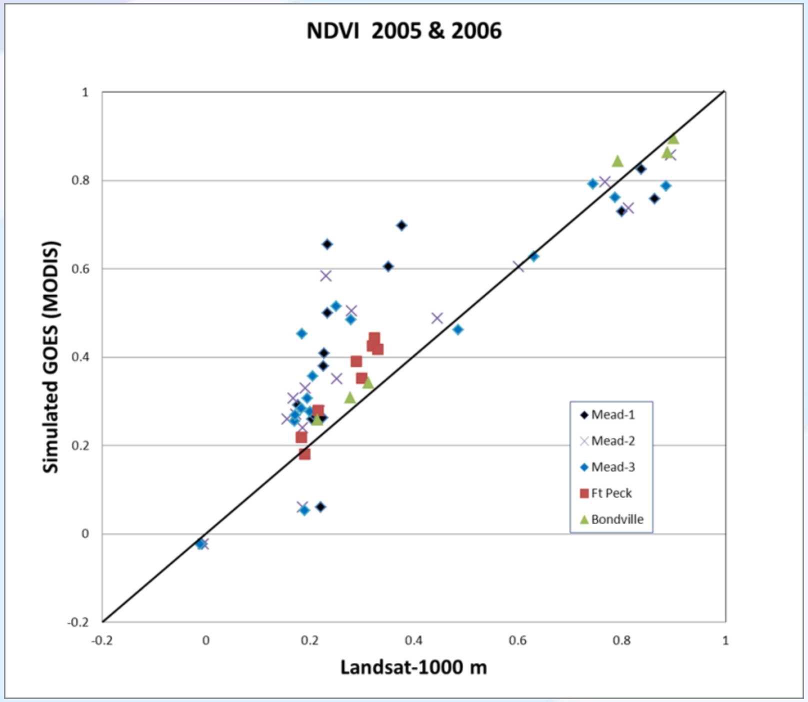
Land Surface Temp.

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



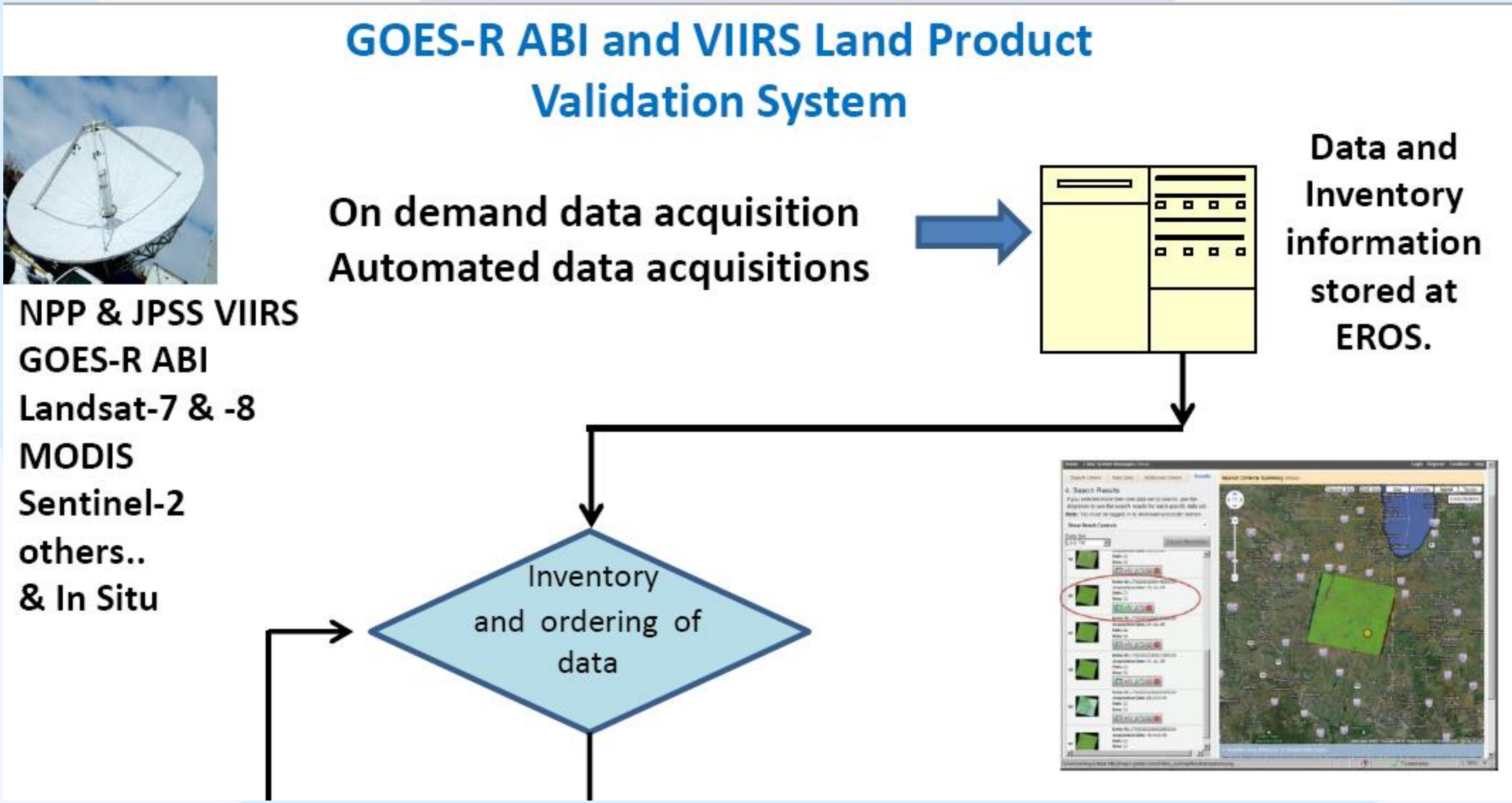
NDVI

Multiple sensor comparison for multiple locations and multiple dates.

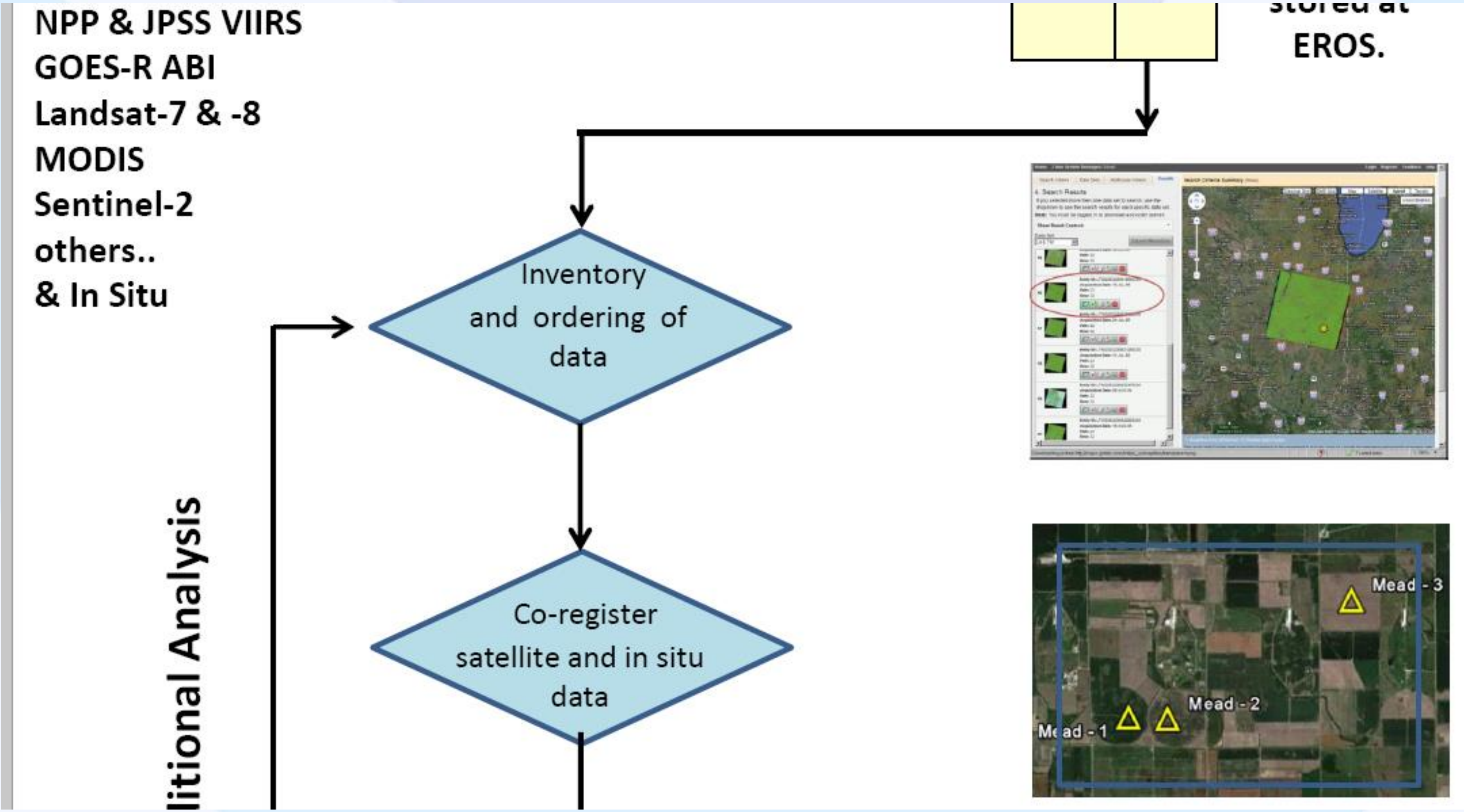


What is LPVS

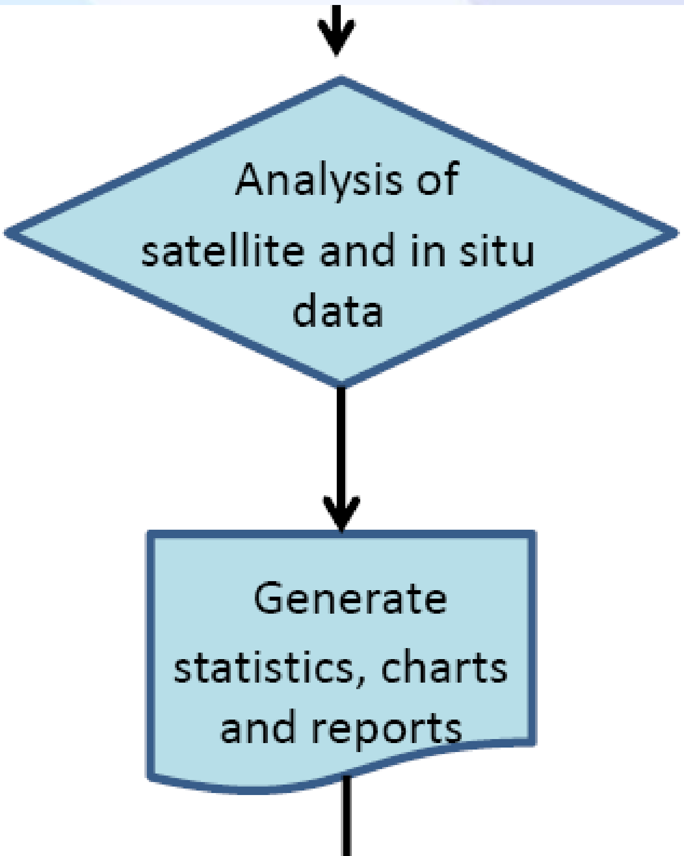
Characteristics and desired functionality

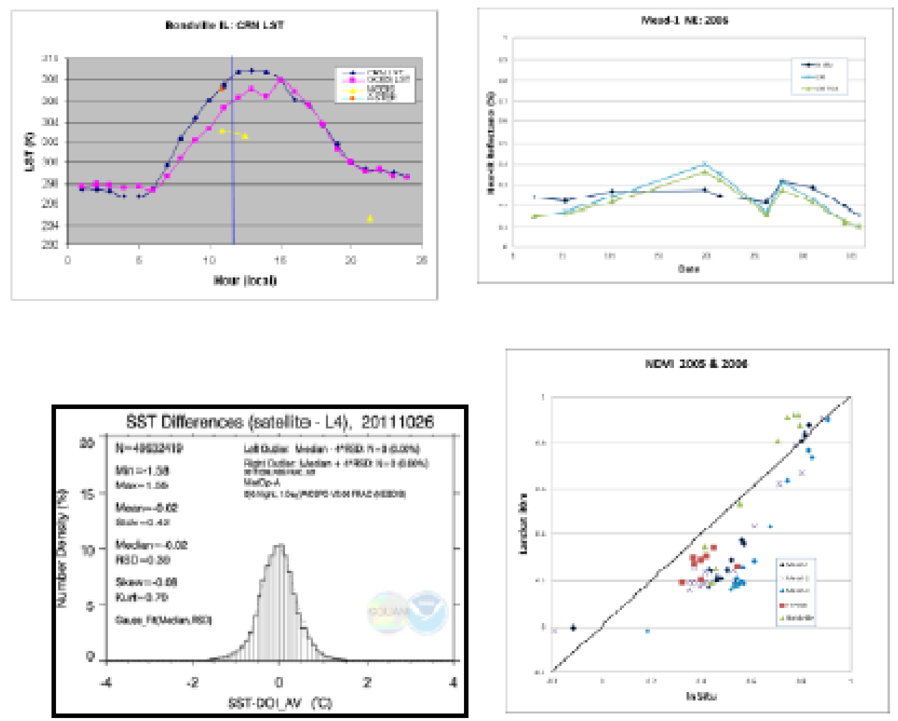


What is LPVS
Characteristics and desired functionality



What is LPVS
Characteristics and desired functionality





Land Product Validation System (LPVS)

What is LPVS

Why LPVS developed/hosted at EROS

Highlights of LPVS

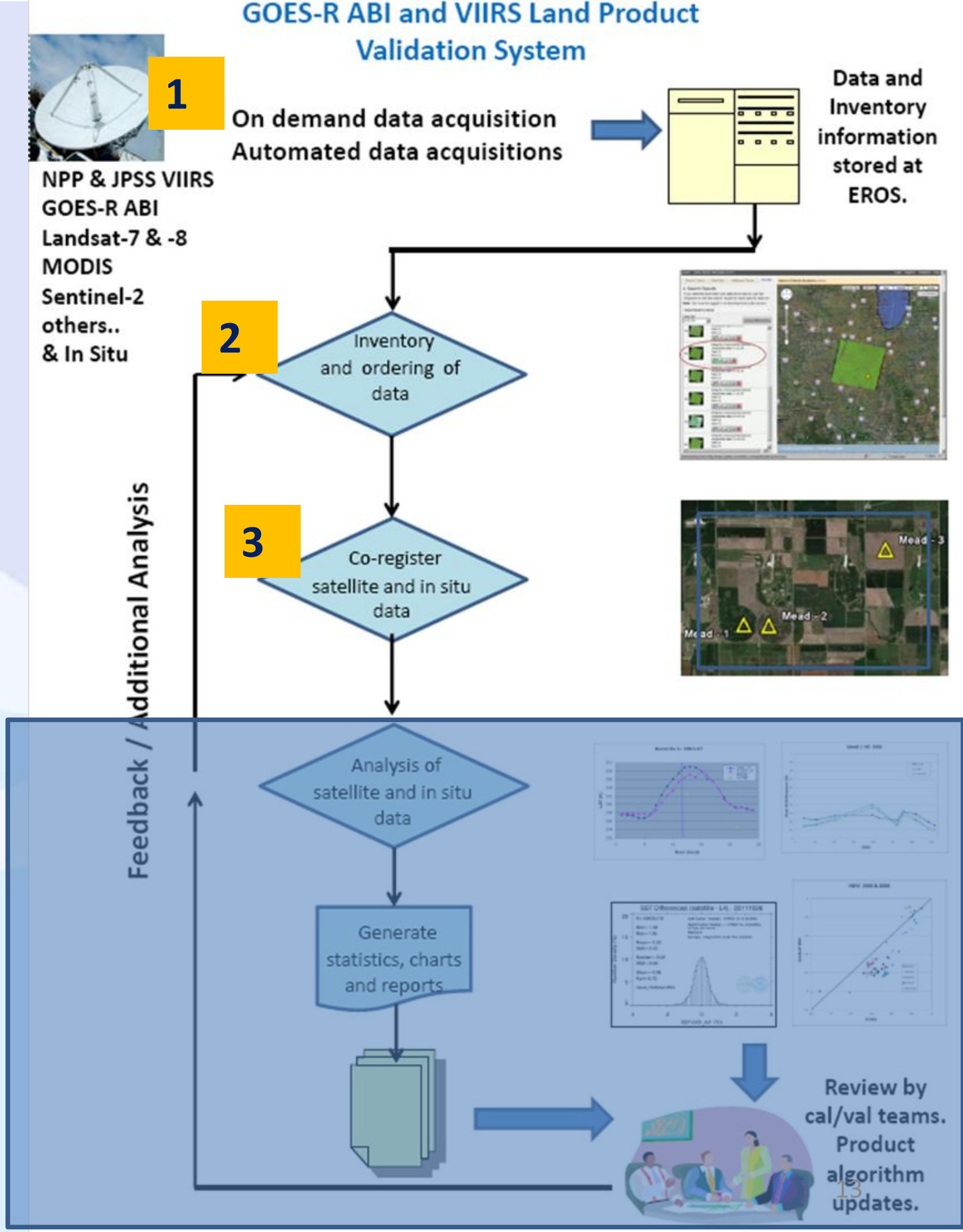
1. Inventory & Ordering
2. Analysis Tools

Path Forward

Summary

Why LPVS developed and hosted at USGS/EROS?

1. Facility Assets
2. Landsat
3. Landsat product development



Why LPVS developed and hosted at USGS/EROS?

1. Facility Assets
2. Landsat characteristics
3. Landsat product development

Launched 11 Feb. 2013

LDCM (Landsat 8)
11 Bands
9 vis to mid-IR; 15-30 m resolution
2 thermal IR; 100 m resolution → 30 m
Absolute calibration of OLI and TIRS

Bands	Wavelength (micrometers)	Resolution (meters)
Band 1 - Coastal aerosol	0.43 - 0.45	30
Band 2 - Blue	0.45 - 0.51	30
Band 3 - Green	0.53 - 0.59	30
Band 4 - Red	0.64 - 0.67	30
Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
Band 6 - SWIR 1	1.57 - 1.65	30
Band 7 - SWIR 2	2.11 - 2.29	30
Band 8 - Panchromatic	0.50 - 0.68	15
Band 9 - Cirrus	1.36 - 1.38	30
Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100
Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100

http://landsat.usgs.gov/band_designations_landsat_satellites.php

Landsat characteristics

Landsat 8

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VIIRS

VIIRS Band	Spectral Range (um)	Nadir HSR (m)
DNB	0.500 - 0.900	750
● M1	0.402 - 0.422	750
● M2	0.436 - 0.454	750
● M3	0.478 - 0.498	750
● M4	0.545 - 0.565	750
I1	0.600 - 0.680	375
● M5	0.662 - 0.682	750
● M6	0.739 - 0.754	750
I2	0.846 - 0.885	375
● M7	0.846 - 0.885	750
M8	1.230 - 1.250	750
M9	1.371 - 1.386	750
I3	1.580 - 1.640	375
M10	1.580 - 1.640	750
M11	2.225 - 2.275	750
I4	3.550 - 3.930	375
M12	3.660 - 3.840	750
M13	3.973 - 4.128	750
M14	8.400 - 8.700	750
M15	10.263 - 11.263	750
I5	10.500 - 12.400	375
M16	11.538 - 12.488	750

● Dual-gain Band

Landsat characteristics

Landsat 8

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● Dual-gain Band

Landsat characteristics

GOES-R ABI
Visible/NIR

Landsat 8

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Future GOES imager (ABI) band	Wavelength range (μm)
1	0.45–0.49
2	0.59–0.69
3	0.846–0.885
4	1.371–1.386
5	1.58–1.64
6	2.225–2.275

Landsat characteristics

GOES-R ABI
Visible/NIR

Landsat 8

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GOES-R ABI
IR Bands

7	3.80–4.00
8	5.77–6.6
9	6.75–7.15
10	7.24–7.44
11	8.3–8.7
12	9.42–9.8
13	10.1–10.6
14	10.8–11.6
15	11.8–12.8
16	13.0–13.6

Why LPVS developed and hosted at USGS/EROS?

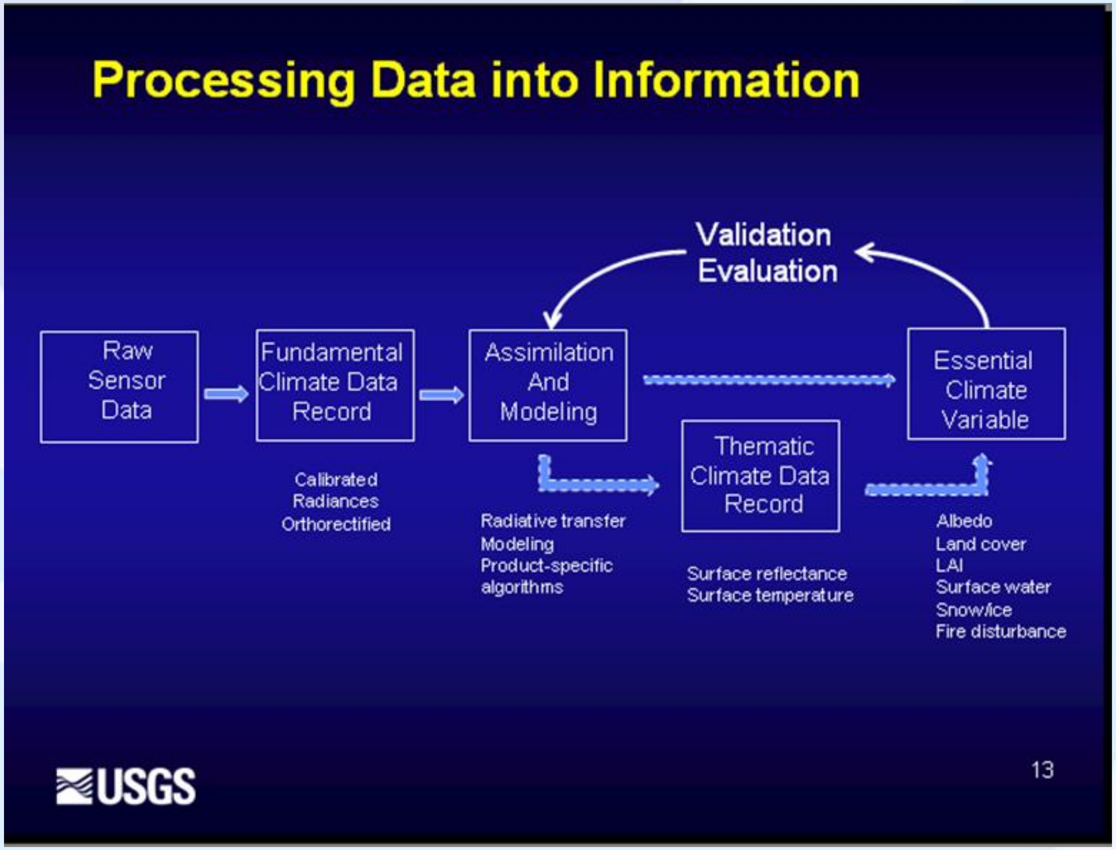
1. Facility Assets
2. Landsat
3. Landsat product development

CDRs and ECVs (some available starting in Q3 2014)

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

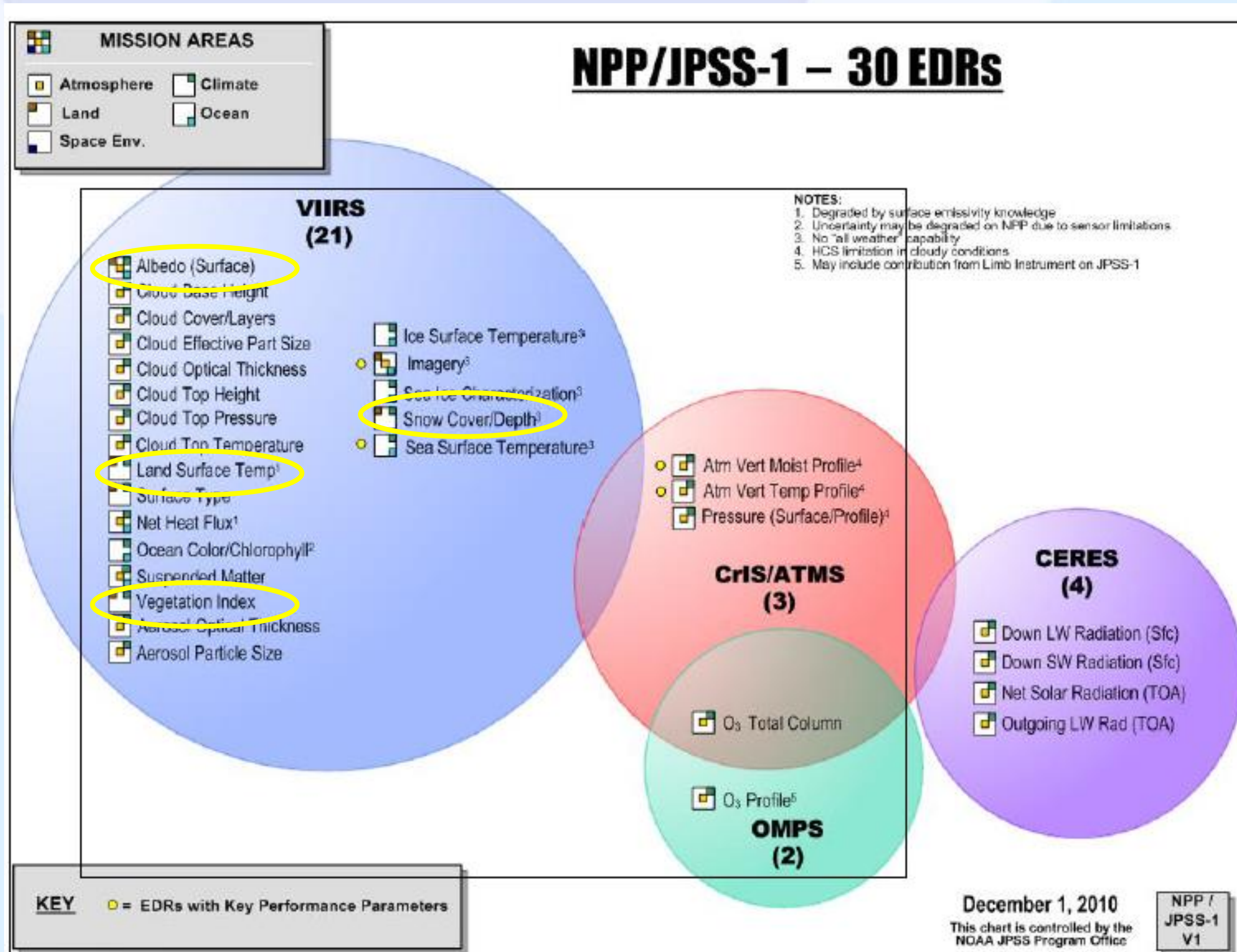
ECVs
Surface Water Extent, Burned Area Extent, Snow Covered Area

Landsat Product Development



EROS-NOAA validation synergy

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



EROS-NOAA validation synergy

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

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

KEY

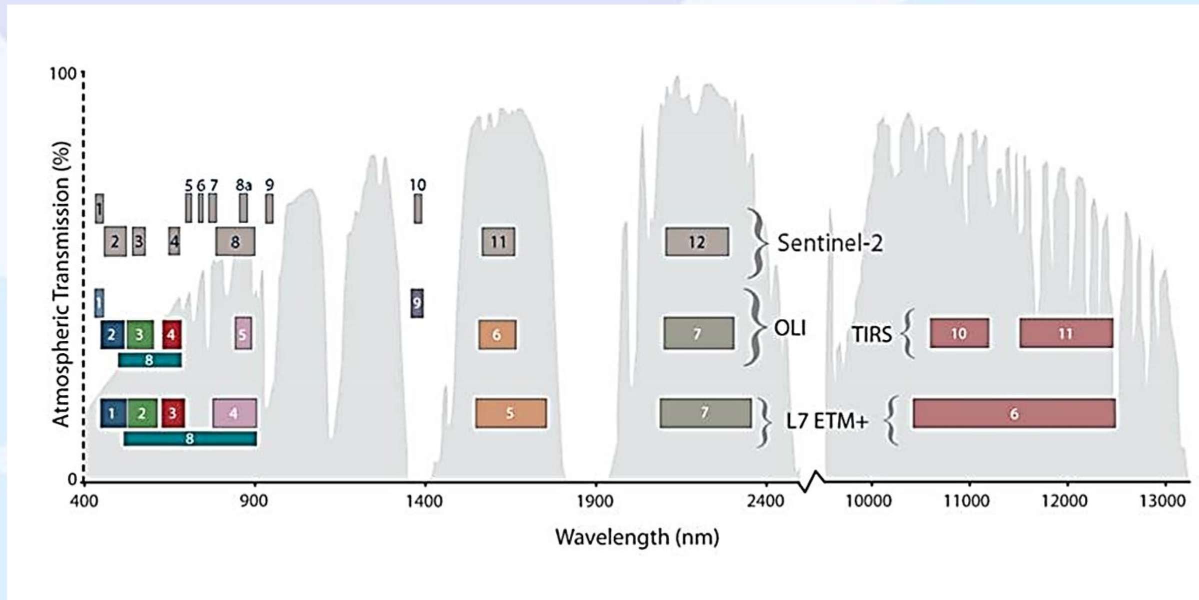
ABI	SUVI	EXIS
GLM	SEISS	MAG

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

Why LPVS developed and hosted at USGS/EROS

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

Landsat-7, Landsat-8 and Sentinel-2 Spectral Bands



Anticipated launch 2015

Land Product Validation System (LPVS)

What is LPVS

Why LPVS developed/hosted at EROS

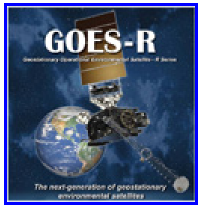
Highlights of LPVS

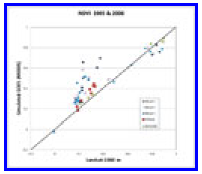
1. Inventory & Ordering
2. Analysis Tools

Path Forward

Summary

Land Product Validation System (LPVS)





Within the next few years the National Oceanic and Atmospheric Administration (NOAA) will launch two environmental satellites, the Geostationary Operational Environmental Satellite - R Series (GOES-R), and the Joint Polar Satellite System (JPSS). Each will carry instruments to monitor current meteorological conditions, observe information for use in numerical weather prediction models, and provide high quality products for monitoring trends in the long-term climate.

The U.S. Geological Survey (USGS) Earth Resources Observation and Science Center (EROS) is collaborating with NOAA to develop a *Land Product Validation System (LPVS)*. This system will facilitate the characterization and validation of land-related products from GOES-R and JPSS (e.g., surface reflectance, Normalized Difference Vegetation Index, and Land Surface Temperature). The LPVS plans to utilize data from the USGS Landsat satellites, the European Space Agency (ESA) Sentinel series, and others, to validate land products from the GOES-R Advanced Baseline Imager (ABI) and JPSS Visible Infrared Imager Radiometer Suite (VIIRS) sensors. The LPVS will also be useful for validation of the VIIRS products available from the Suomi NPP (National Polar-orbiting Partnership) satellite currently on orbit, as well as for characterization and validation of future Landsat-8 products.

The LPVS will include data access, inventory, and analysis functions so that data from multiple archives can be co-registered and compared statistically through a single interface. This functionality is evolving through a prototype phase (2012) and a beta operational phase (2013) before becoming operational in 2014. The land science community is encouraged to test LPVS capabilities, and is invited to provide feedback to the development project.

Access LPVS Prototype Data Search and Retrieval Services

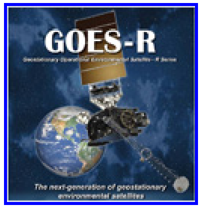
Access LPVS Prototype Test Site Trending

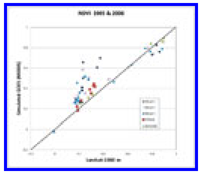
Community Feedback Form

User Support

Project Partners:

Land Product Validation System (LPVS)





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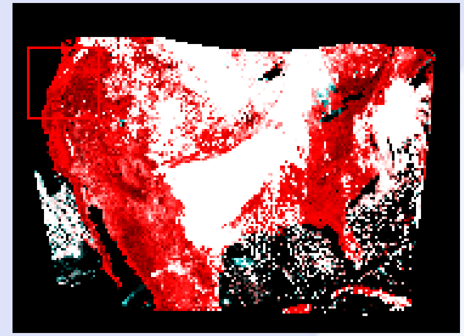
http://lpvsexplorer.cr.usgs.gov/

Search for Landsat data on date of simulated GOES-R ABI data : 23 April 2013 (provided by Univ. Wisc./CIMSS).



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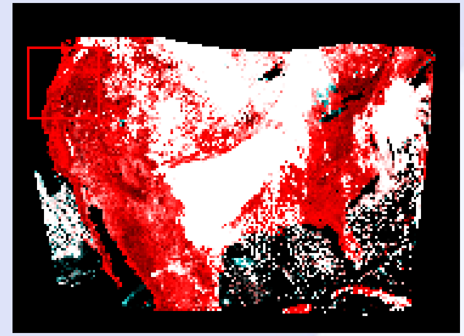

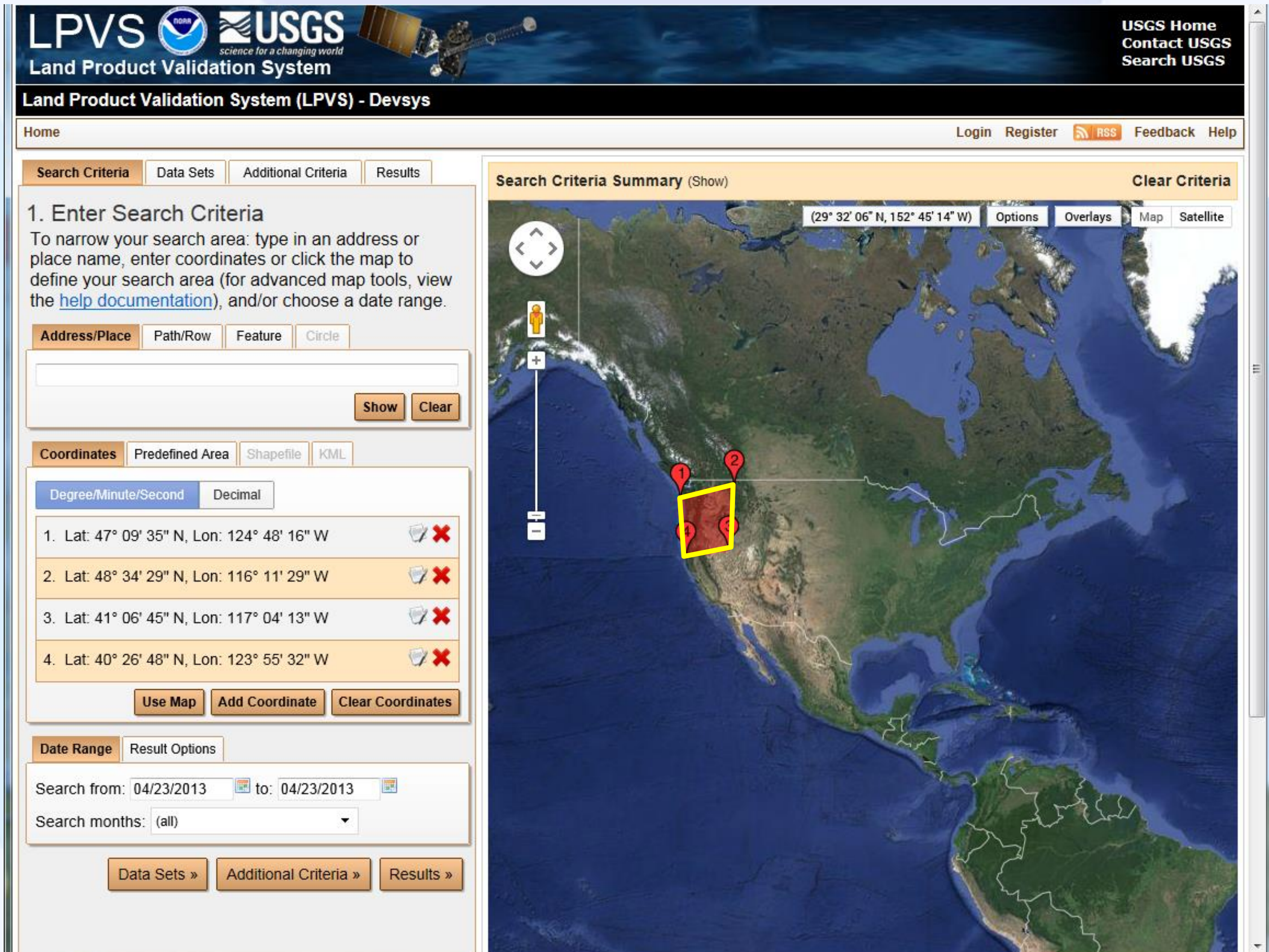

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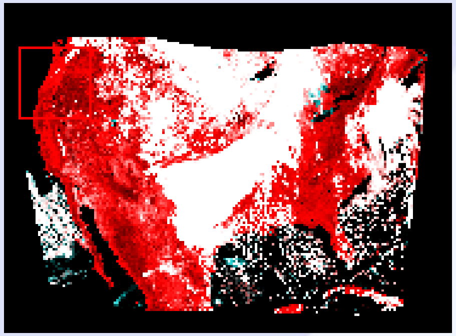
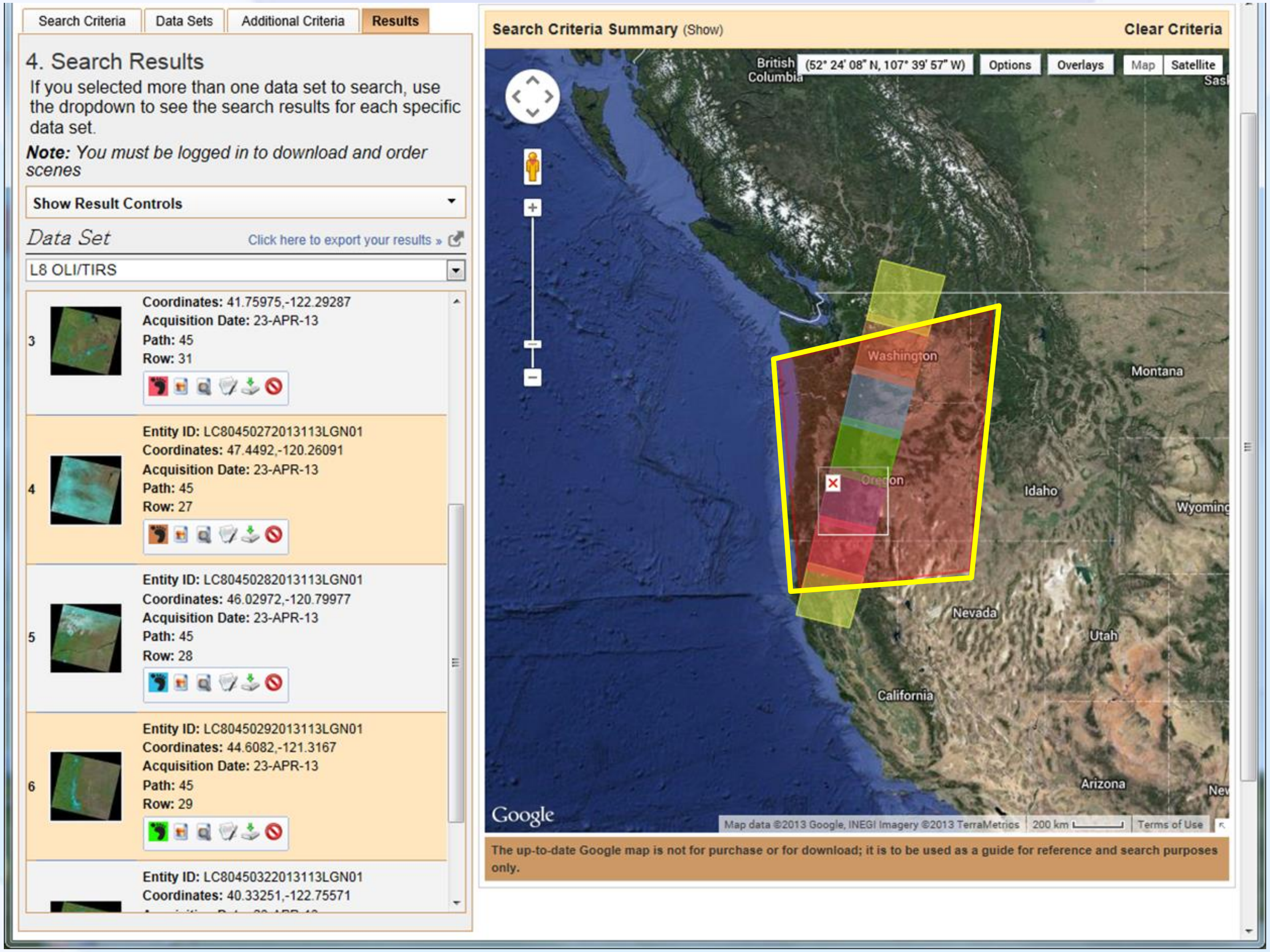




Enhanced Landsat Products

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

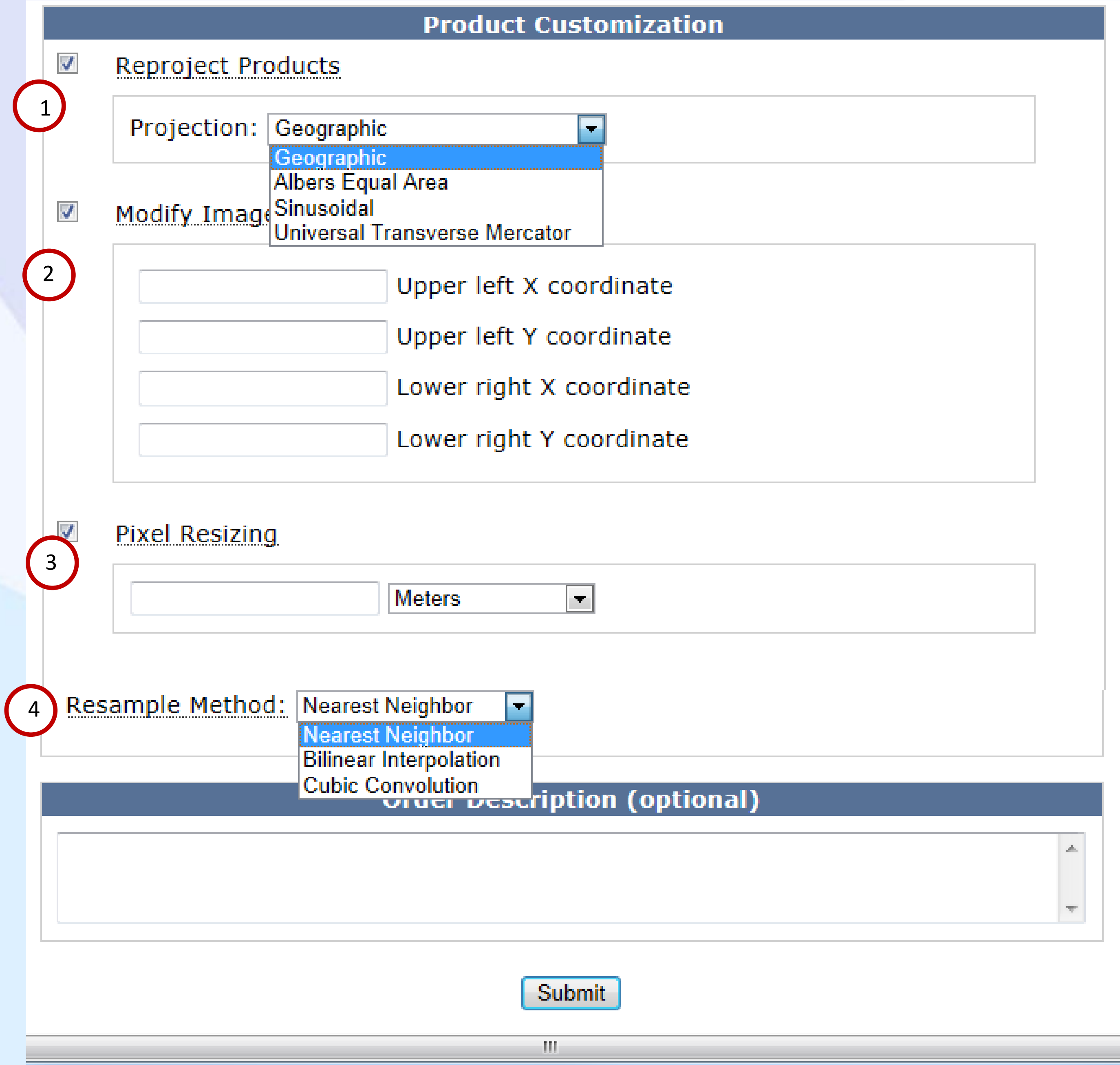
Spectral Indices
☐ Surface Reflectance NDVI
☐ Surface Reflectance NDMI
☐ Surface Reflectance NBR
☐ Surface Reflectance NBR2
☐ Surface Reflectance SAVI
☐ Surface Reflectance EVI

Other Products
☐ CFMask (standalone file)
☐ Solr Index

Product Customization

Enhanced Functionality

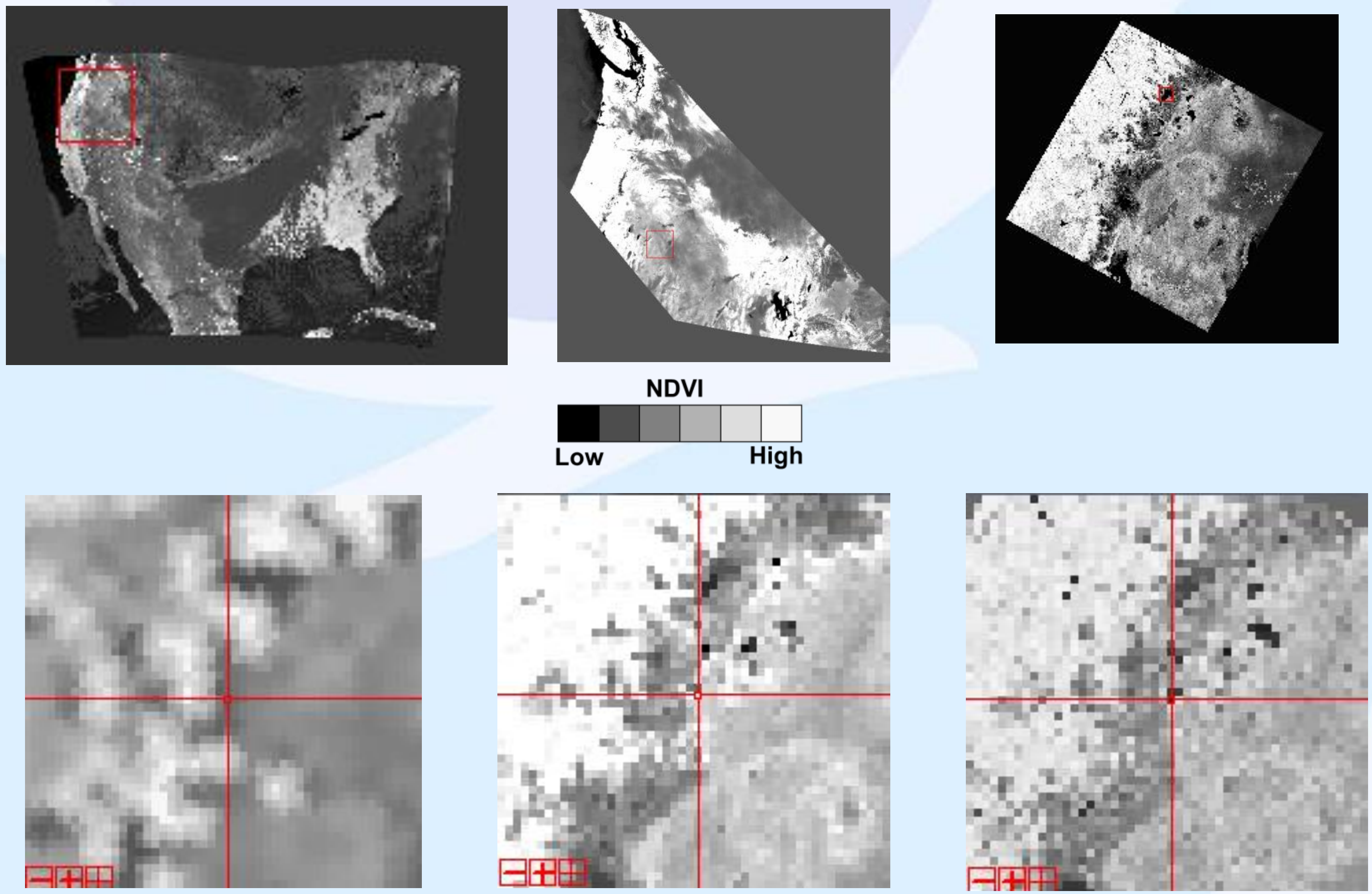
1. Auto-registration of data to common map projections for analysis.
2. User defines area of interest for analysis
3. Match pixel size for all images
4. Several resampling options



Example of New Functionality

Example of georegistration of ABI, VIIRS and Landsat for 23 April 2013.

Simulated GOES-R ABI | VIIRS | Landsat

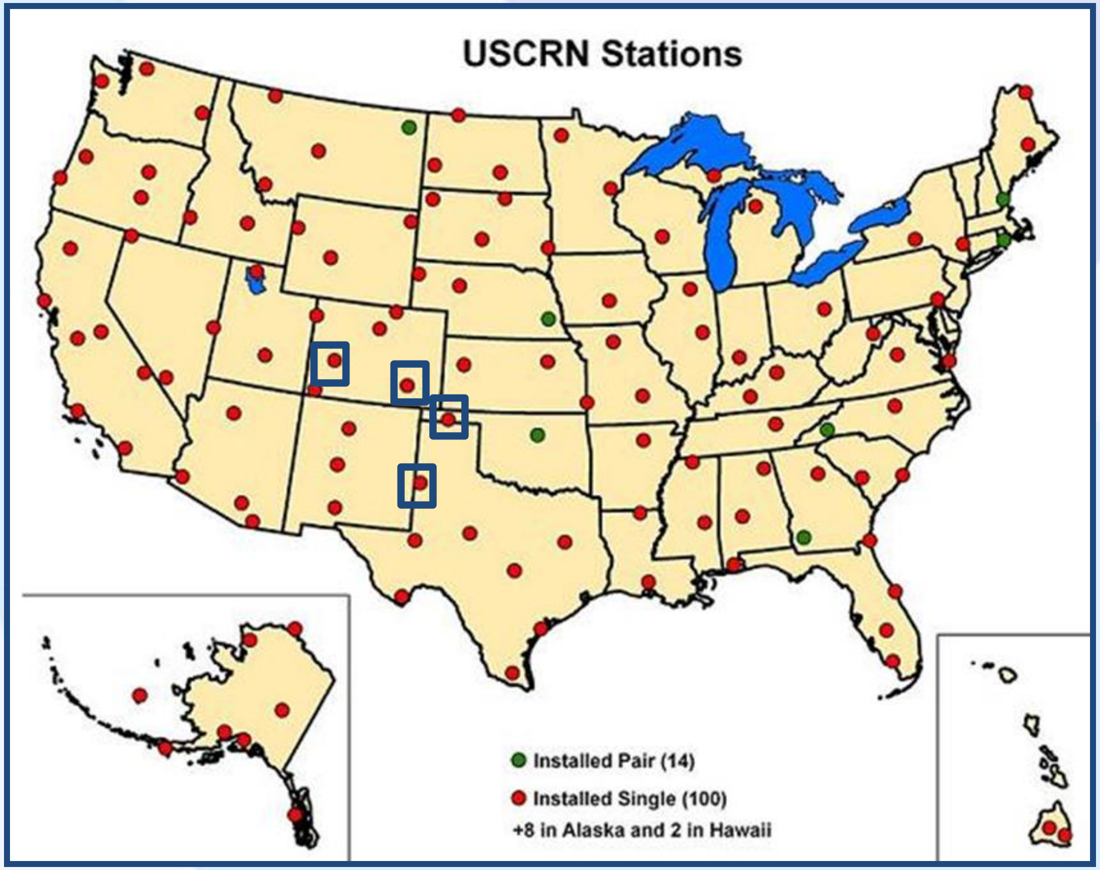


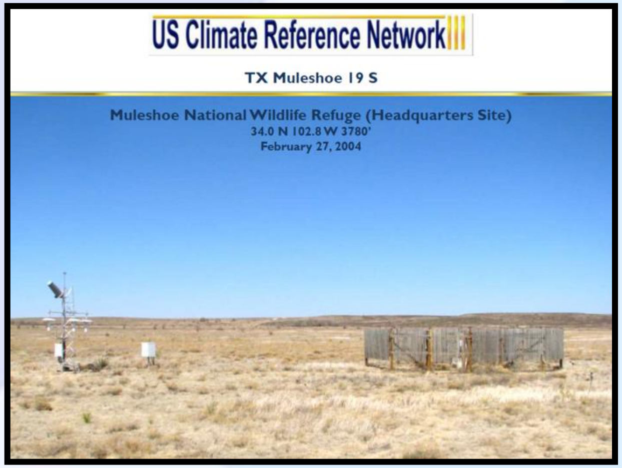
Georegistered Data

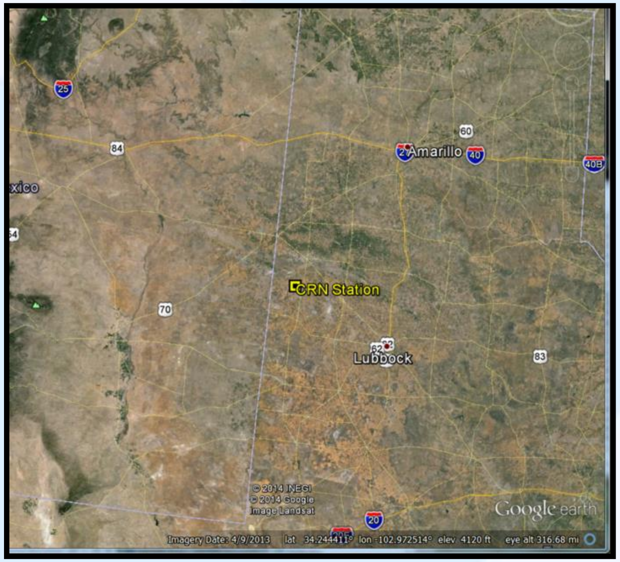
- Same Pixel Size: 2222 m
- Same Map Projection: Lambert Azm Eq Area

Example of New Functionality

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



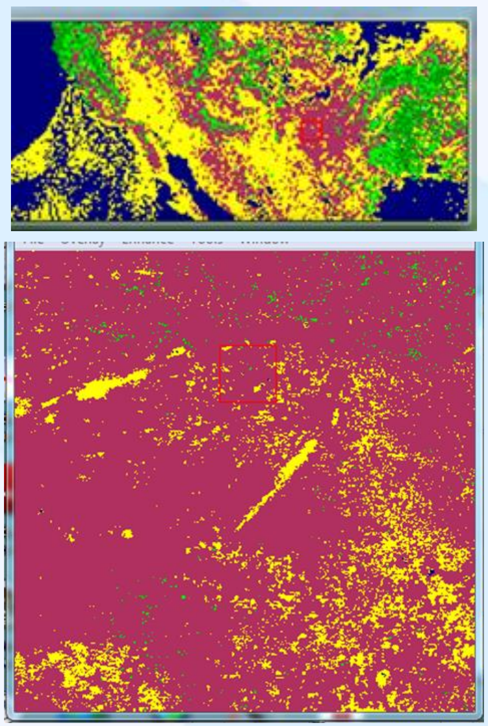




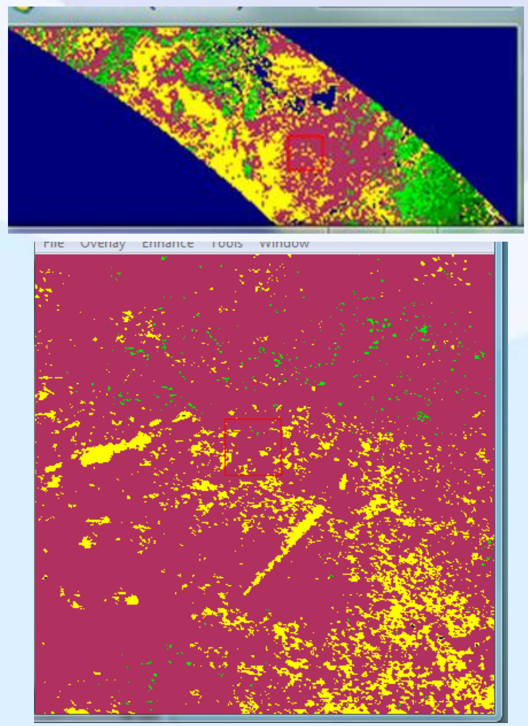
Example of New Functionality

Data extracted for VIIRS (NOAA and NASA products) and Landsat 8 for four CRN station locations (sample regions of 0.5 x 0.5 degrees).

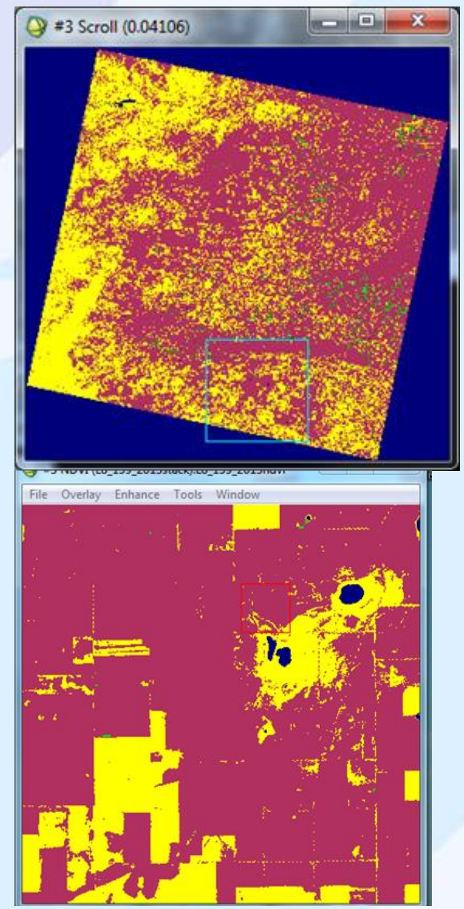
NOAA VIIRS
(STAR GVI Daily)



NASA VIIRS
(NPP_DSRFHKD_L2GD



Landsat 8



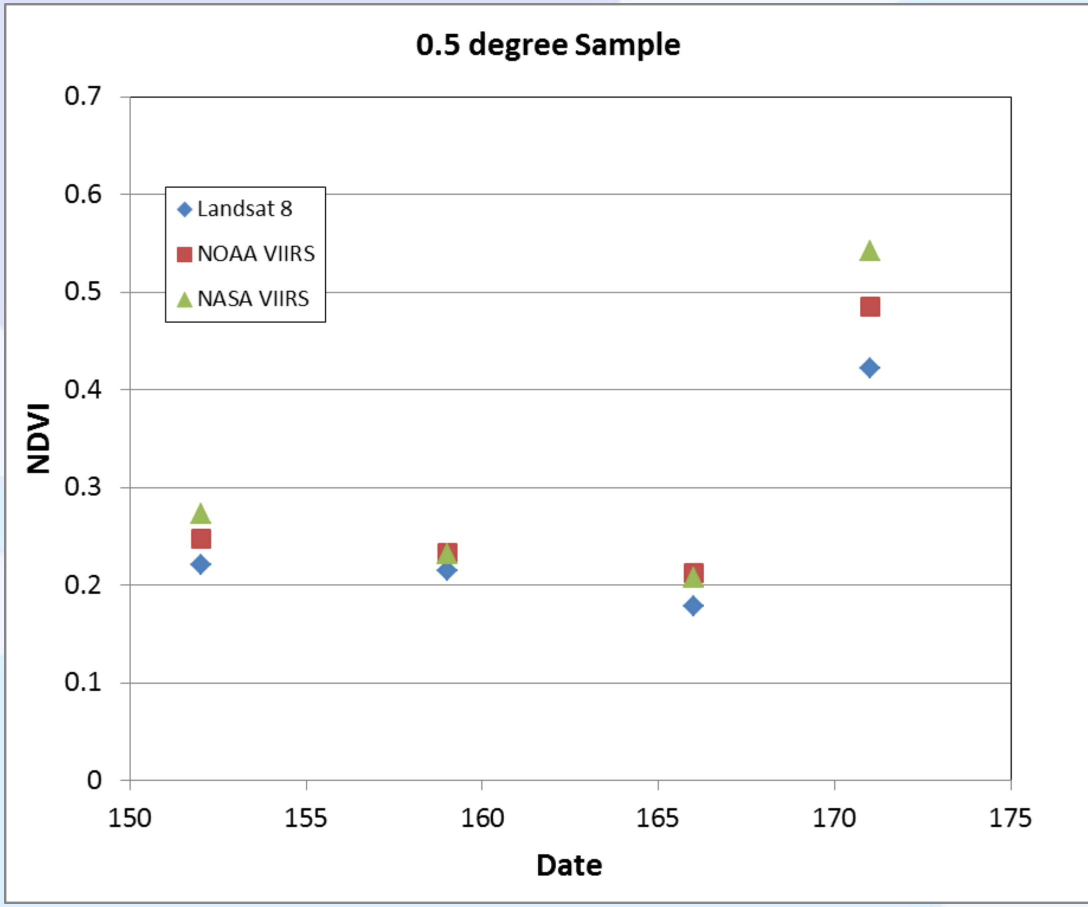
Example of Potential Analysis

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

Land Product Validation System (LPVS)

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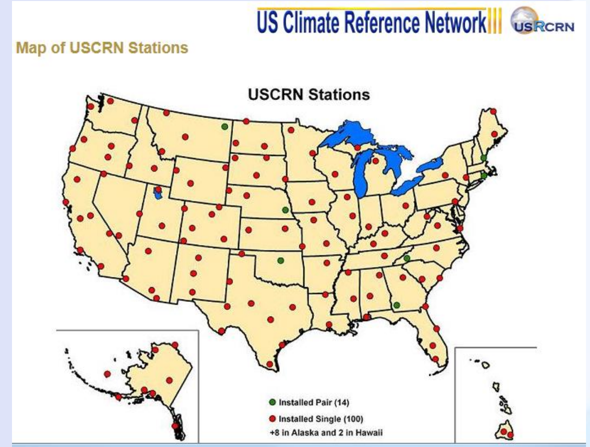
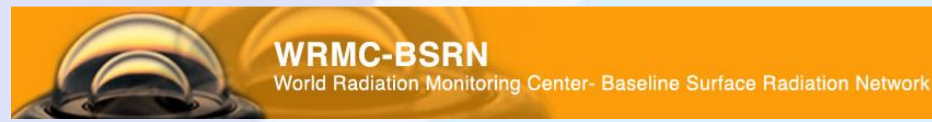
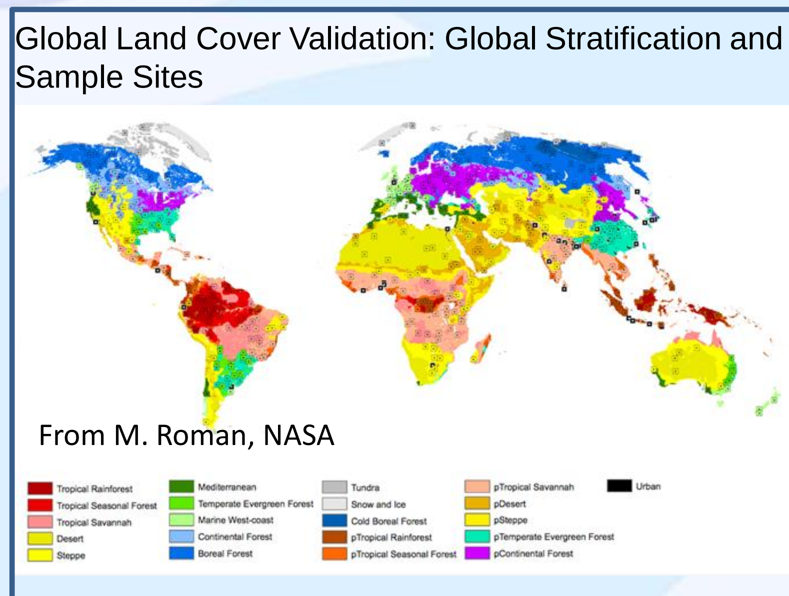
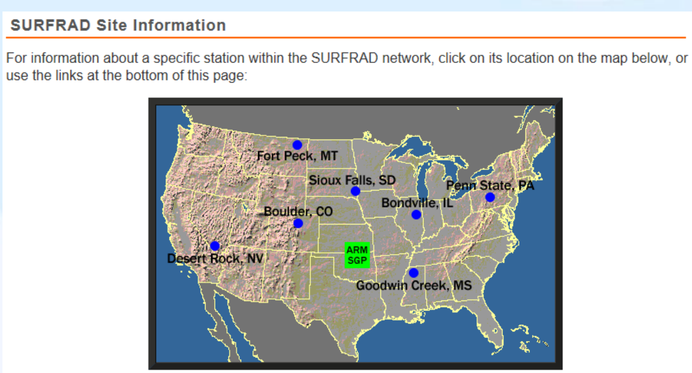
Predefined sample sites: user selectable for satellite (and potential in situ) inter-comparisons









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What is LPVS

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

Ready for GOES-R and JPSS-VIIRS pre- and post-launch testing and validation.

GOES-R ABI and VIIRS Land Product Validation System