Aerosol Optical Thickness (AOT), Aerosol Particle Size Parameter (APSP) and Suspended Matter (SM) EDR Overview

I. Laszlo and S. Kondragunta
and the Aerosol Cal/Val Team

August 25, 2015

Cal/Val Team Members

Team Members	Organization	Roles and Responsibilities
Pubu Ciren	IMSG/NOAA	SM algorithm development and product validation
Bigyani Das	IMSG/NOAA	Algorithm integration
Ashley N. Griffin	PRAXIS, INC/NASA	JAM
Brent Holben	NASA/GSFC	AERONET observations for validation work
Jingfeng Huang	UMD/CICS	AOT Algorithm development and product validation
Edward J. Hyer	NRL	Product validation, assimilation activities
Shobha Kondragunta	NOAA/NESDIS	Co-lead
Istvan Laszlo	NOAA/NESDIS	Co-lead
Hongqing Liu	IMSG/NOAA	Visualization, algorithm development, validation
Chris van Poollen	Raytheon	Support code testing in IDPS
Lorraine A. Remer	UMBC	Algorithm development, ATBD, liason to VCM team
Hai Zhang	IMSG/NOAA	Algorithm coding, validation within IDEA
Stephen Superczynski	IMSG/NOAA	Product evaluation, data management

Instrument Overview

- Aerosol EDRs are derived from VIIRS

Visible Infrared Imaging Radiometer Suite (VIIRS)

- **cross-track scanning radiometer with ~3000 km swath – full daily sampling**
- **7 years lifetime**
- **22 channels (412-12,016 nm)**
  - 16 of these are M bands with 0.742 x 0.776 km nadir resolution
  - **aerosol retrieval is from M bands** →
- **high signal-to-noise ratio (SNR):**
  - M1-M7: ~200-400
  - M8-M11: ~10-300
- **2% absolute radiometric accuracy**
- **single look**
- **no polarization**

Band name	Wavelength (nm)	Bandwidth (nm)	Use in algorithm
M1*	412	20	L
M2*	445	14	L
M3*	488	19	L, T_L, T_O
M4*	555	21	T_O
M5*	672	20	L, O, T_O
M6	746	15	O
M7*	865	39	O, T_L
M8	1,240	27	O, T_L, T_O
M9	1,378	15	T_L
M10	1,610	59	O, T_L, T_O
M11	2,250	47	L, O, T_L, T_O
M12	3,700	191	T_L
M13	4,050	163	none
M14	8,550	323	none
M15	10,763	989	T_L, T_O
M16	12,016	864	T_L, T_O

*dual gain, L: land, O: ocean; $T_{L,O}$: internal test land/ocean

S-NPP Product Overview

Attribute	AOT	APSP
Applicable Conditions	Clear, daytime only, zenith angles ≤80°	same
Vertical Coverage	Total column	same
Horizontal Cell Size	6 km (nadir), 12.8 km (Edge of Scan)	same
Vertical Cell Size	Total column	same
Mapping Uncertainty, 3 σ	4 km	same
Measurement Range	0 to 2	-1 to +3 alpha units
Measurement Accuracy		
Over Ocean	0.08 (Tau < 0.3) 0.15 (Tau ≥ 0.3)	0.3 alpha units
Over Land	0.06 (Tau < 0.1); 0.05 (0.1 ≤ Tau ≤ 0.8) 0.20 (Tau > 0.8)	n/a
Measurement Precision		
Over Ocean	0.15 (Tau≤ 0.3) 0.35 (Tau ≥ 0.3)	0.6 alpha units
Over land	0.15 (Tau < 0.1) 0.25 (0.1 ≤ Tau ≤ 0.8) 0.45 (Tau > 0.8)	n/a
Refresh	At least 90% coverage of the globe every 24 hours (monthly average)	same

Products are generated in IDPS

S-NPP Product Overview

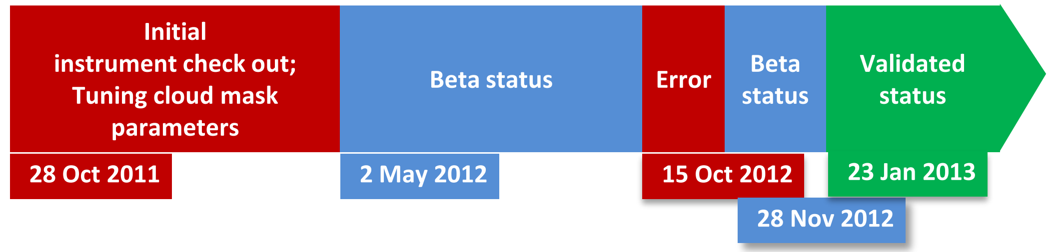
Attribute	SM
Applicable Conditions	Clear, daytime, for AOTs >0.2; SM includes dust, volcanic ash, and smoke at any altitude
Vertical Coverage	Total column
Horizontal Cell Size	3 km
Vertical Cell Size	Total column
Mapping Uncertainty, 3 σ	3 km
Measurement Range	Type: dust, volcanic ash, smoke. Smoke concentration: 0 to 150 μg/m^3
Measurement Accuracy (Probability of Correct Typing)	Land: 80% (dust and smoke); 60% (volcanic ash) Water: 80% (dust), 70% (smoke); 60% (volcanic ash)
Measurement Precision	N/A
Refresh	At least 90% coverage of the globe every 24 hours (monthly average)

Product generated in IDPS is Beta.
New algorithm to become operational in NDE in January 2016.

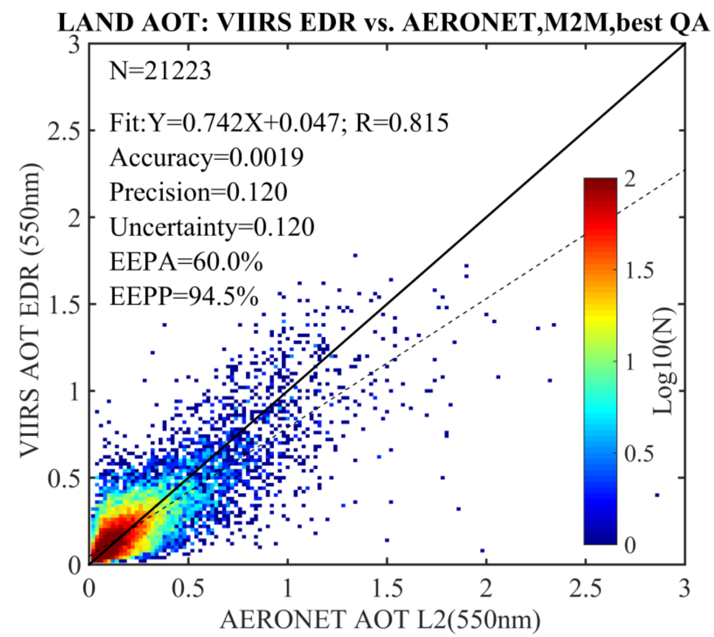
S-NPP Product Overview

- **S-NPP Cal/Val Status**
  - AOT: Validated Stage 2
  - APSP: Validated Stage 1
  - SM: Beta in IDPS.

AOT/APSP Product Status



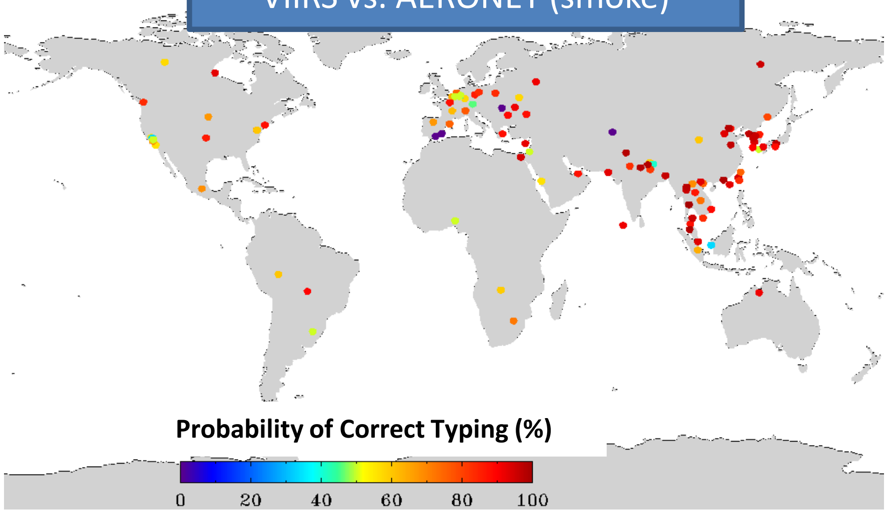
- **Accomplishments: AOT/APSP**
  - Enhanced internal tests to flag pixels that are not ideal for AOT retrieval (snow/ice, ephemeral water, bright pixel)
  - New evaluation with AERONET and established expected error of VIIRS AOT



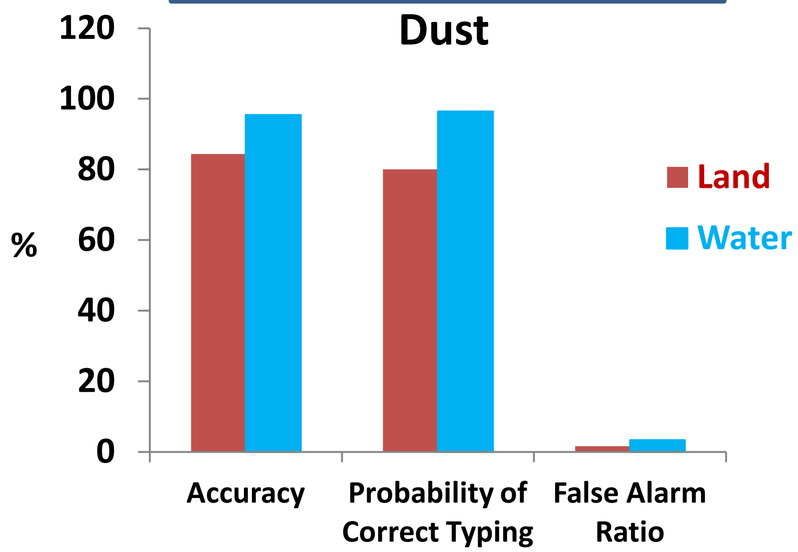
S-NPP Product Overview

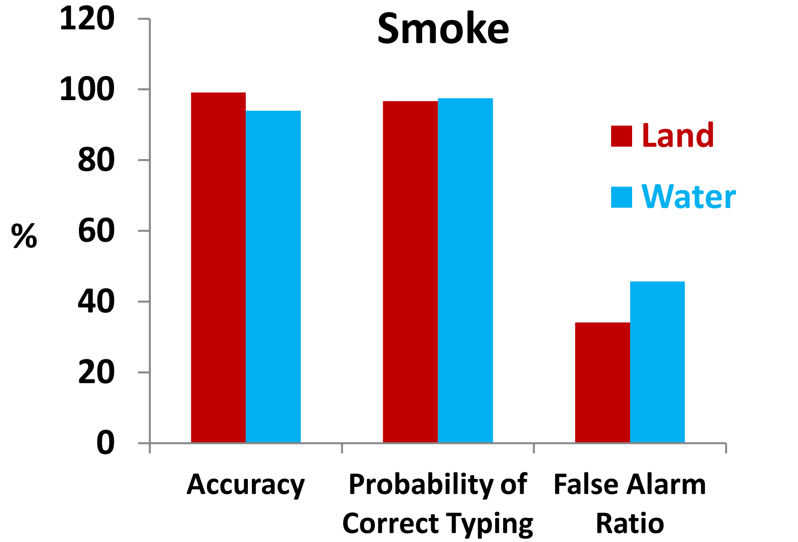
- **Accomplishments: SM**
  - Running J1 algorithm routinely on SNPP VIIRS direct broadcast data over CONUS. Smoke and dust only. *Volcanic ash information flows from an independent algorithm*
  - Working with users on feedback of the product.
  - Two years of SM product validated against CALIPSO, MISR, and AERONET.

VIIRS vs. AERONET (smoke)



VIIRS vs. CALIPSO





S-NPP Product Overview

- **Product Deficiencies**
  - **AOT**
    - ✓ AOT range restricted to 0-2
    - ✓ No retrieval over bright surface and inland water bodies
    - ✓ Globally constant surface reflectance ratio
  - **SM**
    - ✓ Smoke/haze discrimination
    - ✓ Preliminary approach to derive smoke concentration: scaling of AOD
    - ✓ False detections over bright surfaces (e.g., white sands)
    - ✓ Cirrus flag interference

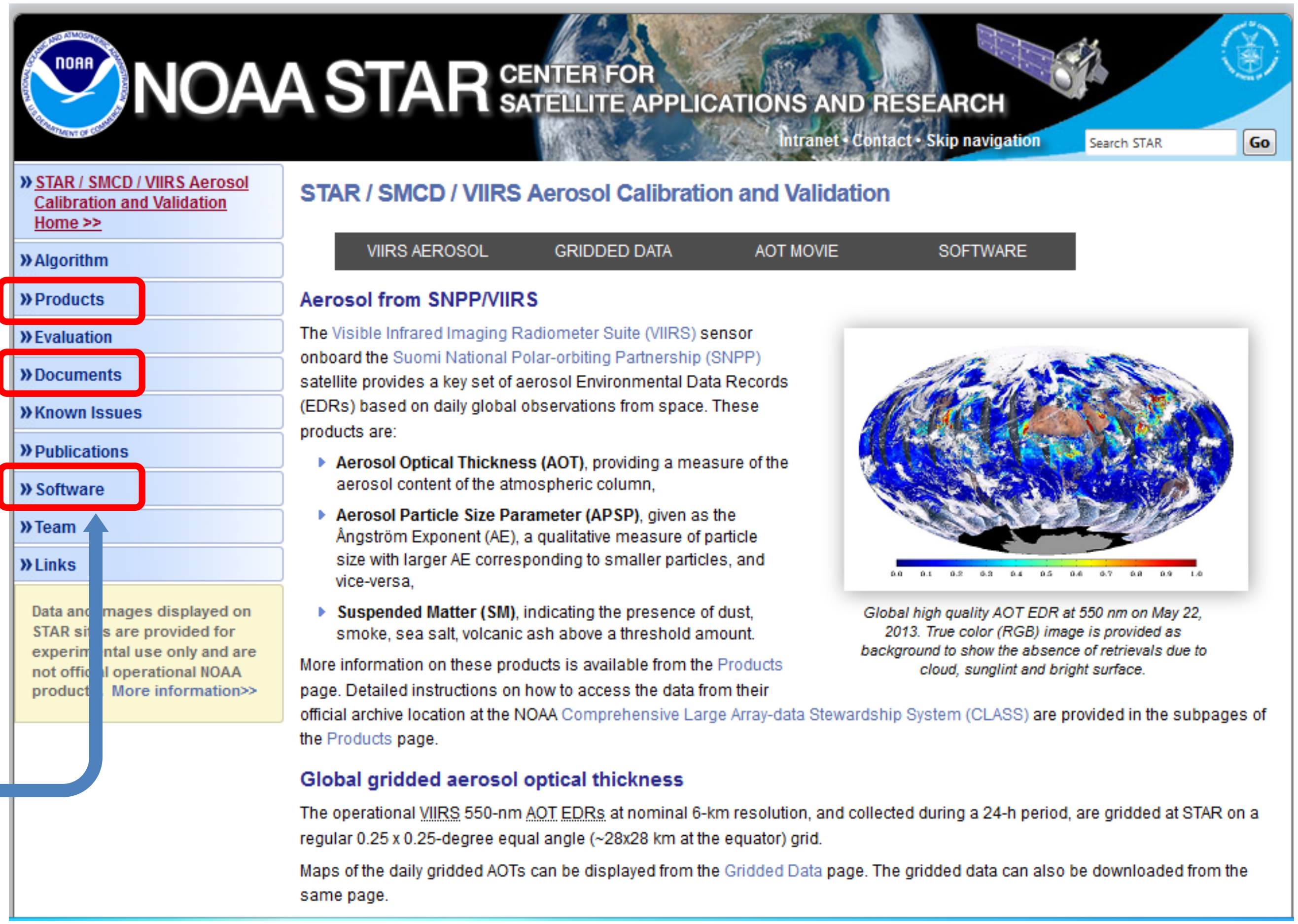
S-NPP Product Overview

- VIIRS Aerosol Calibration and Validation website http://www.star.nesdis.noaa.gov/smcd/emb/viirs_aerosol/index.php

Products page has links to CLASS and STAR FTP site for data download

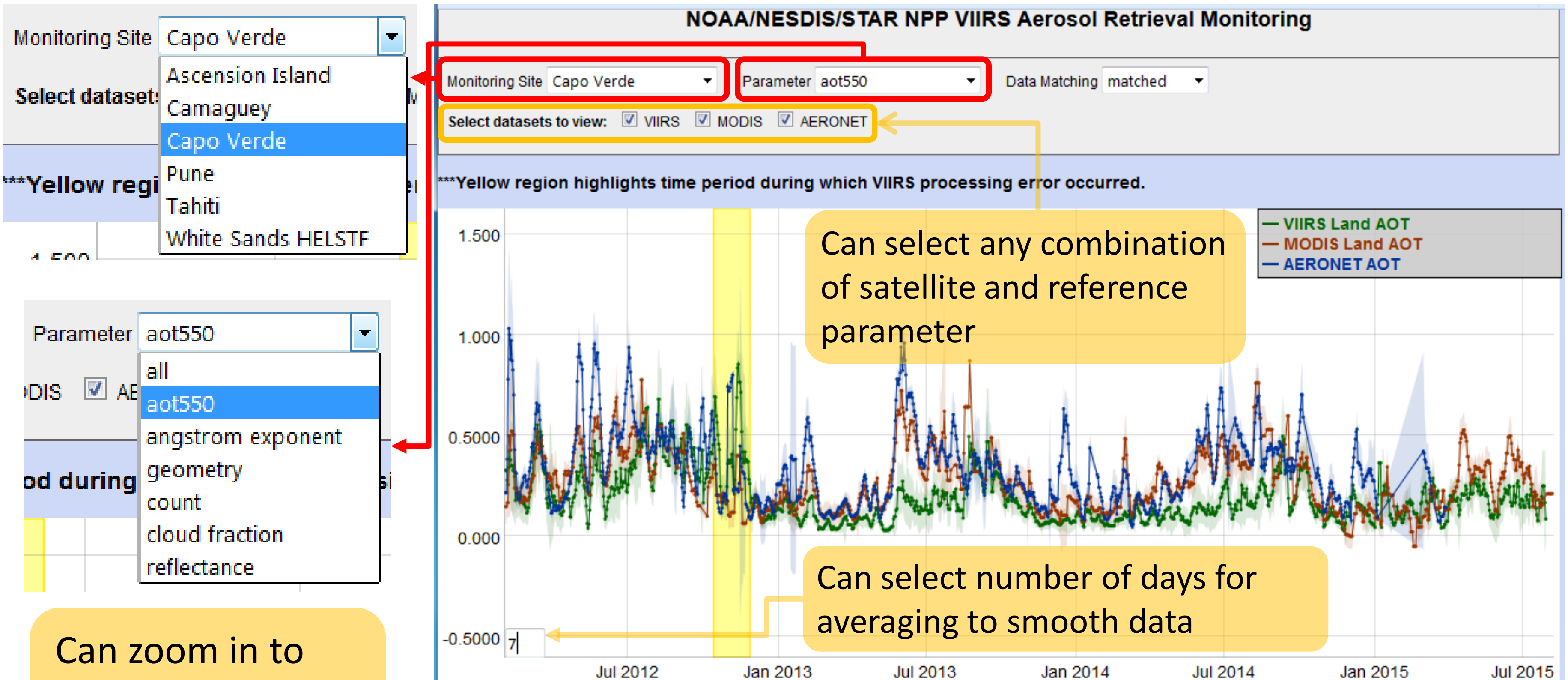
Links to ATBD, user's guide, product ReadMe, etc.

Software to display VIIRS aerosol products and convert data to MODIS-like EOS HDF format are available for download



S-NPP Product Overview

- Interactive (JAVA-based) LTM Website: http://www-dev.star1.nesdis.noaa.gov/smcd/spb/stephens/monitoring/WEB/monitoring_NEW.html (internal to STAR for now!)

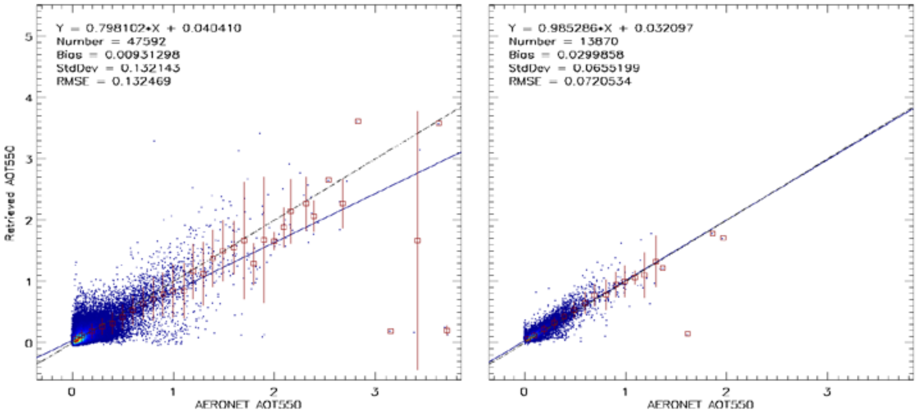


Can zoom in to select time period of interest

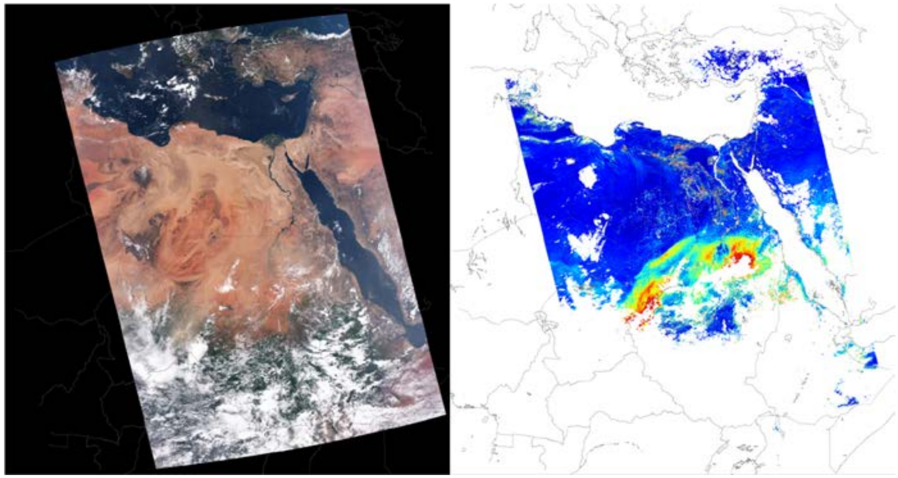
JPSS-1 Readiness

Major Accomplishments Moving Towards J1

- **Improved JPSS AOT/APS RR algorithm**
  - Pixel-level, dual scheme for better retrieval of high AOT; extended AOT range [-0.05, 5]; better screening for snow/ice/cloud; heavy aerosol detection; MODIS aerosol model with non-spherical dust; NDVI & redness dependent ratios
  - Successful Test Readiness Review
- **Developed global surface reflectance database**
  - Accounts for changes in surface reflectance ratio with location and scattering angle; 0.1x0.1 degrees
- **Developed Bright-surface algorithm**
  - Same method as in IDPS but uses global database of ratios of bright surface reflectances



Performance of JPSS Aerosol Algorithm



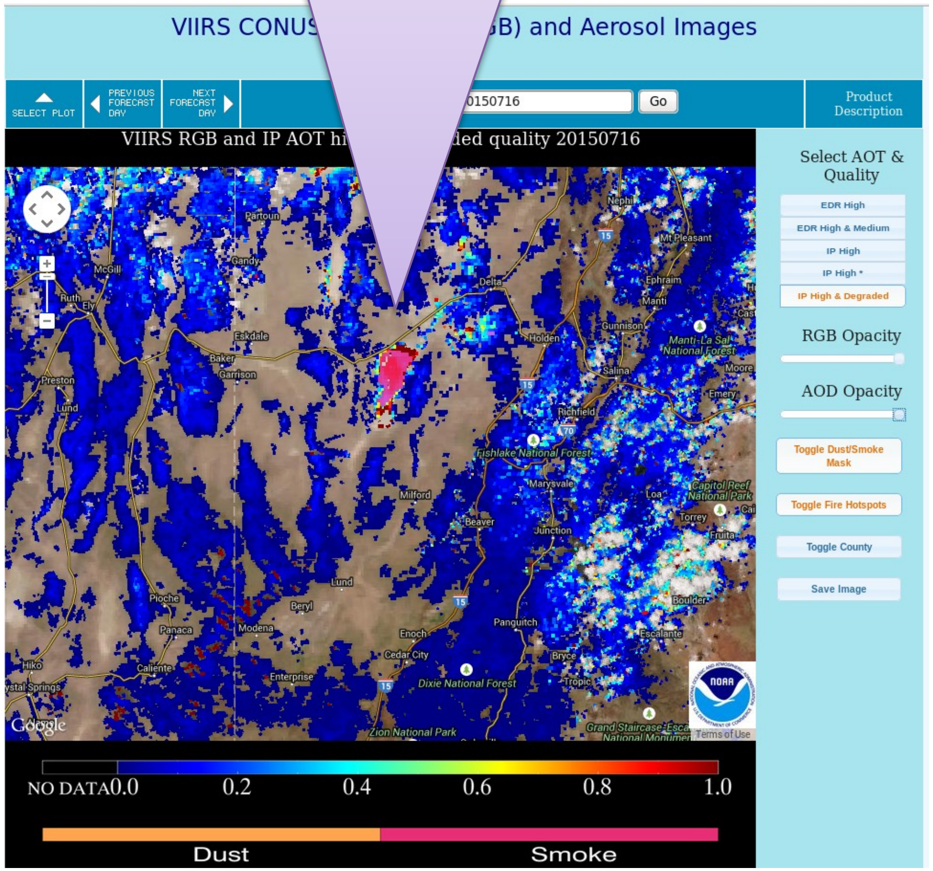
VIIRS RGB (left) and JPSS bright-surface AOT (right).

JPSS-1 Readiness

Major Accomplishments Moving Towards J1

- J1 Algorithm Summary
  - Algorithm is different from IDPS. Only smoke and dust in SNPP NDE algorithm. New volcanic ash algorithm for SNPP and J1 (Pavolonis).
  - Approach to derive smoke concentration is still in development. Preliminary approach involves simple scaling of AOT.
  - Preliminary version of SM cal/val website deployed (http://www.star.nesdis.noaa.gov/smcd/spb/aq/viirs_aqpg_2015/sdmask_monitor/index.php)
- Further Developments
  - Combined OMPS/VIIRS aerosol index approach.
  - Minimize false positives for dust and smoke over bright surfaces.
  - Develop a viable approach to derive smoke concentration.

Screenshot of IDEA website showing SNPP VIIRS AOT and smoke mask overlaid was sent to us as a feedback from NWS Western Region Incident Meteorologist. Area in pink shows false smoke over a dry lake bed in central Utah



JPSS-1 Readiness

- **J1 Cal/Val Overview**
  - *Timelines for Beta, Provisional and Validated Maturity*

Maturity	Time - AOT/APSP
Beta	3 months after data starts flowing from sensor
Provisional	6 months after VCM does initial tuning
Validated	19 months after VCM does initial tuning

  - *Pre-Launch Calibration/Validation Plans*
    - ✓ Year 1 (2015): Continue evaluation of Suomi-NPP VIIRS aerosol products.
    - ✓ Year 2 (2016): Modify validation software to ingest and to correctly interpret J1 data. Test impact of J1 instrument artifacts on aerosol products if needed.
  - *Post-Launch Calibration/Validation Plans*
    - ✓ Year 3 (2017): Inspect EOC data. Evaluate product for Beta level. Collect data (1 month) and perform ICV (2 months) to advance product to Provisional.
    - ✓ Year 4 (2018): 12 months of data collection and 4 months of analysis, documentation to advance product to Validated level.

JPSS-1 Readiness – Issues/Mitigation

- **Issue:** JPSS RR AOT algorithm and bright-surface retrieval module is not yet integrated.

  Mitigation: Integrate bright-surface retrieval module in RR AOT algorithm and test on global scale for extended period.
- **Issue:** Drift in SDR calibration affecting products, especially APSP

  Mitigation: Monitor time series of APSP. Requires 3-4 year time series!
- **Issue:** One or more of the primary data sources for evaluation (e.g. AERONET) are unavailable during JPSS-1 lifetime.

  Mitigation: Look for other sources, e.g., PHOTON (France), AEROCAN (Canada).
- **Issue:** Loss of independent satellite data.

  Mitigation: Rely on remaining sensors (MODIS/S-NPP-VIIRS) or switch to ground-based alternatives.
- **Issue**: A method to derive smoke concentration is not ready.

  Mitigation: Develop a method based on regression models developed from correlation between smoke/dust indices and surface PM2.5.

JPSS-1 Readiness

- Stake Holder Interactions, Users and Impact Assessment Plans
  - Users/Stake Holders, include:
    - Operational air quality forecasters
    - State and local environmental agencies
    - National Weather Service Weather Forecast Offices
    - National Weather Service global aerosol prediction system
    - Naval Research Laboratory (NRL)
  - How the products are being used by the users
    - Daily air quality forecasting
    - Exceptional events monitoring
    - Data assimilation to improve aerosol forecasting
  - User impact assessment
    - NRL (Ed Hyer): *"VIIRS+MODIS over MODIS only aerosol assimilation has a quantitative advantage in the Navy Aerosol and Analysis Prediction System (NAAPS)"*
    - Forecaster (Amy Huff): *see next slide*

JPSS-1 Readiness

- User impact assessment continued - Forecaster (Amy Huff):

  "*I am an operational air quality forecaster for several areas of the Mid-Atlantic region, including the Philadelphia metropolitan area and the State of Delaware. My team and I use the VIIRS AOD and smoke/dust mask products routinely for forecasting of fine particulate matter (PM2.5). We work under many time constraints related to forecast deadlines, so having the AOD imagery available on IDEA in near real-time is invaluable. We would not be able to utilize VIIRS AOD products if we had to access them in their native format via CLASS. The high-resolution VIIRS AOD products (EDR and IP) provide information on the distribution of AOD on the urban scale that is not possible with other products, such as MODIS AOD. The interactive Google-maps based tool on the IDEA website makes it very easy to zoom into the city level, where we have the most interest, and identify areas of high AOD. The quality flag buttons allow us the flexibility to view high, medium, or degraded quality AOD, depending on the conditions. For smoke plumes, for example, it is frequently preferable to view the medium or degraded AOD pixels. Having the option to change the quality flags enhances our analysis, and is only possible through the IDEA website. Many of the other features of the tool, including the opacity slider bars, toggle fire hotspots, and toggle county boundaries, were added at the request of users, and make it easier for us to focus in on areas of interest. The smoke/dust mask is a relatively new feature that we are exploring. It is particularly helpful during haze events when smoke and occasionally dust are mixed in with urban haze. Overall, the VIIRS AOD and smoke/dust mask products are very useful for PM2.5 forecasting - the high resolution (6 km and 3 km) of the VIIRS AOD products allow us to track the variations in AOD on the urban/suburban scale, which is critical for air quality forecasting. And we can't praise the IDEA website too highly - it is essential for operational users, such as forecasters, to access the various aerosol satellite products, including VIIRS products. Thanks to Shobha and Istvan and their team for developing the tools on IDEA and for making the VIIRS data available in near real-time!*"

Summary & Path Forward

- S-NPP AOT and APSP products are at Validated Stage
- Internal tests in IDPS algorithm were updated to better detect pixels not suitable for AOT retrieval
- AOT and SM algorithms for J1 were developed, evaluated – passed TRR
- Capability to retrieve AOT over bright surface was developed
- FY16 Milestones:

Task/Description	Start / Finish	Deliverable
Development (D) 1) Adapt SNPP AOT and SM algorithms for J1 VIIRS 2) Build LUTs for J1 VIIRS 3) Build reprocessing capabilities	October 1, 2016 September 30, 2017	V1 algorithm LUTs for J1 VIIRS
Integration & Testing (I) 1) Enhancements to bright surface AOT algorithm in production phase 2) Enhancements to SM algorithm in production phase	October 1, 2016 September 30, 2017	N/A
Calibration & Validation (C) 1) Validation of reprocessed bright surface AOT and SM products 2) Final version of cal/val plan	Ongoing	Validation report Final version of J1 cal/val plan
Maintenance 1) IDPS and NDE algorithms and products	Ongoing	N/A
LTM & Anomaly Resolution (L) 1) Daily monitoring of product to diagnose instrument/algorithm artifacts	Ongoing	Report

Summary & Path Forward

- J2 and Beyond: Future Improvements

	S-NPP	JPSS-1	JPSS-2
FY17	(1) maintain algorithm and products (2) continue validation of AOT and SM product	(1) participate in launch preparation reviews, (2) participate in checkout phase and post-launch validation of products, (3) work towards beta release of products	Build LUTs for J2 VIIRS and participate in meetings related to instrument waivers etc.
FY18	(1) maintain algorithm and products (2) continue validation of AOT and SM product	Work towards provisional release of AOT/APSP and SM products	Participate in meetings related to J2 mission and VIIRS instrument
FY19	(1) maintain algorithm and products (2) continue validation of AOT and SM product	Work towards validated release of AOT/APSP and SM products	Algorithm readiness and reviews such as CDR etc.
FY20	(1) maintain algorithm and products (2) continue validation of AOT and SM product	(1) maintain algorithm and products and update algorithms based on new science as needed, (2) continue validation of AOT/APSP and SM product	Prepare for J2 launch

OMPS EDR Overview

Ozone EDR Products

OMPS EDR Team

August 25, 2015

Outline

- SNPP/JPSS-1 OMPS Overview
- Algorithm and Cal/Val Team Members
- S-NPP Ozone Overview
- JPSS-1 Readiness and Upgrades
- Summary and Path Forward

Measurement Overview

Nadir Mapper (NM)

Grating spectrometer, 2-D CCD
110 deg. cross track,
300 nm to 380 nm spectral,
1.1nm FWHM bandpass

Nadir Profiler (NP)

Grating spectrometer, 2-D CCD
Nadir view, 250 km cross track,
250 nm to 310 nm spectral,
1.1 nm FWHM bandpass

Limb Profiler (LP)

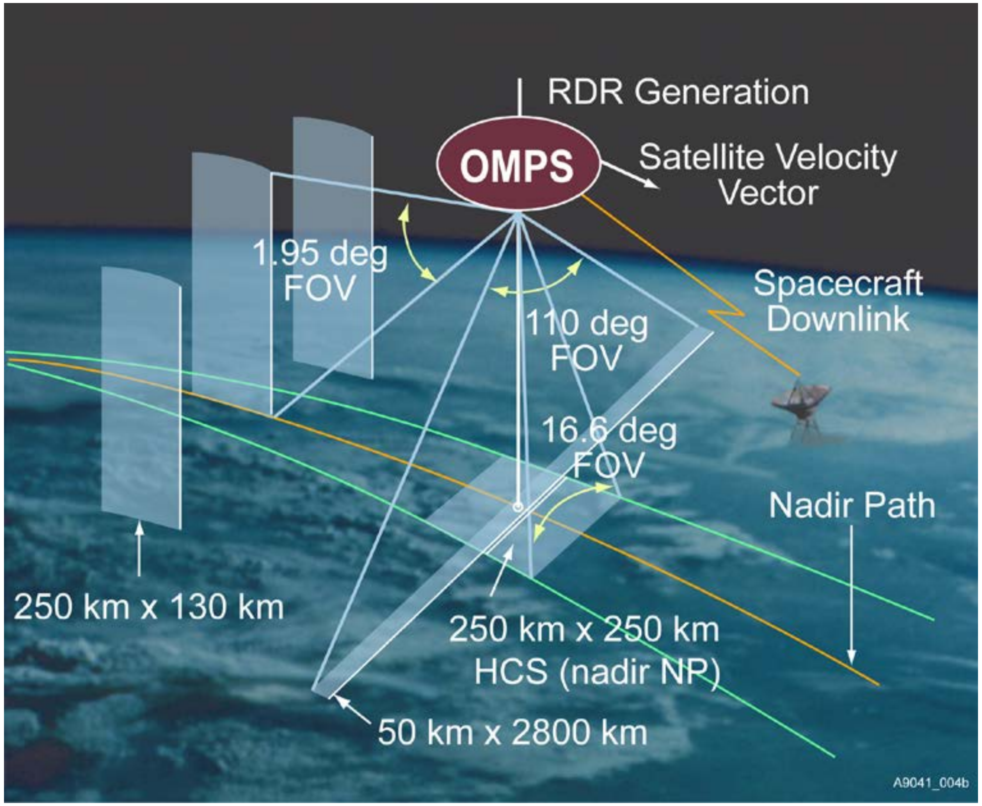
Prism spectrometer, 2-D CCD
Three vertical slits, -20 to 80 km,
290 nm to 1000 nm

The calibration systems use pairs of working and reference solar diffusers.

Ozone Mapping & Profiler Suite

Global daily monitoring of the three dimensional distribution of ozone and other atmospheric constituents.

Continues the NOAA SBUV/2, EOS-AURA OMI and SOLSE/LORE records.



Ozone Cal/Val/Alg Team Membership

EDR	Name	Organization	Task
Lead	Lawrence Flynn	NOAA/NESDIS/STAR	Ozone EDR Team
Sub-Lead	Irina Petropavlovskikh	NOAA/ESRL/CIRES	Ground-based Validation
Sub-Lead	Craig Long	NOAA/NWS/NCEP	Product Application
Sub-Lead	Trevor Beck	NOAA/NESDIS/STAR	Algorithm development and ADL implementation
Member	Jianguo Niu	STAR/IMSG/SRG	Algorithm development, trouble shooting, Limb Profiler science
Member	Eric Beach	STAR/IMSG	Validation, ICVS/Monitoring, Data management
Member	Zhihua Zhang	STAR/IMSG	V8 Algorithms implementation and modification
JAM	Maria Caponi	JPSS/Aerospace	Coordination

S-NPP Product Overview

- List of Products
  - Total Column Ozone (SO_2, reflectivity, Absorbing aerosol index)
    - V7MTTOz (IDPS)
    - V8TOz (IDPS Block 2.0) (Enterprise Algorithm)
    - V8TOZ/LFSO2 (NDE Planned) (No SO2 exclusion for J-01)
  - Nadir Ozone Profile
    - V8Pro (IDPS Mx8.11) (Enterprise/Heritage Algorithm)
  - Limb Ozone Profile
    - Limb V2.0 (NASA PEATE)
    - Limb V2.0 (NDE Planned)
- S-NPP Cal/Val Status
  - Preparing soft calibration adjustments
- ICVS pages are in transition from Demonstration

OMPS NP EDR Performance Characteristics

Table 4.2.4 - Ozone Nadir Profile (OMPS-NP)		
Attribute	**Threshold**	**Objective**
Ozone NP Applicable Conditions: 1. daytime only (3)		
a. Horizontal Cell Size	50 X 50 km^2 (1)	50 x 50 km^2
b. Vertical Cell Size	3 km reporting	
1. Below 30 hPa (~ < 25 km)	10 -20 km	3 km (0 -Th)
2. 30 -1 hPa (~ 25 -50 km)	7 -10 km	1 km (TH -25 km)
3. Above 1 hPa (~ > 50 km)	10 -20 km	3 km (25 -60 km)
c. Mapping Uncertainty, 1 Sigma	< 25 km	5 km
d. Measurement Range		
Nadir Profile, 0 - 60 km	0.1-15 ppmv	0.01 -3 ppmv (0-TH) 0.1-15 ppmv (TH-60 km)
e. Measurement Precision (2)		
1. Below 30 hPa (~ < 25 km)	Greater of 20 % or 0.1 ppmv	10% (0 -TH)
2. At 30 hPa (~ 25 km)	Greater of 10 % or 0.1 ppmv	3%
3. 30 -1 hPa (~ 25 -50 km)	5% -10%	1%
4. Above 1 hPa (~ > 50 km)	Greater of 10% or 0.1 ppmv	3%
f. Measurement Accuracy (2)		
1. Below 30 hPa (~ < 25 km)	Greater of 10 % or 0.1 ppmv	10% (0 -15 km)
2. 30 -1 hPa (~ 25 -50 km)	5% -10%	5% (15 -60 km)
3. At 1 hPa (~ 50 km)	Greater of 10 % or 0.1 ppmv	5% (15 -60 km)
4. Above 1 hPa (~ > 50 km)	Greater of 10 % or 0.1 ppmv	5% (15 -60 km)
g. Refresh	At least 60% coverage of the globe every 7 days (monthly average) (2,3)	24 hrs. (2,3)
Notes: 1. The SBUV/2 has a 180 km X 180 km cross-track by along -track FOV. It makes its 12 measurements over 24 Samples (160 km of along-track motion). The OMPS Nadir Profiler is designed to be operated in a mode that is able to subsample the required HCS. 2. The OMPS Nadir Profiler performance is expected to degrade in the area of the South Atlantic Anomaly (SAA) due to the impact of periodic charged particle effects in this region. 3. All OMPS measurements require sunlight, so there is no coverage in polar night areas.		

OMPS TC EDR Performance Characteristics

Attribute	Threshold	Objective
a. Horizontal Cell Size	50 x 50 km2 @ nadir	10 x 10 km2
b. Vertical Cell Size	0 - 60 km	0 - 60 km
c. Mapping Uncertainty, 1 Sigma	5 km at Nadir	5 km
d. Measurement Range	50 - 650 milli-atm-cm	50-650 milli-atm-cm
e. Measurement Precision	.	.
1. X < 0.25 atm-cm	6.0 milli-atm-cm	1.0 milli-atm-cm
2. 0.25 < X < 0.45 atm-cm	7.7 milli-atm-cm	1.0 milli-atm-cm
3. X > 0.45 atm-cm	2.8 milli-atm-cm + 1.1%	1.0 milli-atm-cm
f. Measurement Accuracy	.	.
1. X < 0.25 atm-cm	9.5 milli-atm-cm	5.0 milli-atm-cm
2. 0.25 < X < 0.45 atm-cm	13.0 milli-atm-cm	5.0 milli-atm-cm
3. X > 0.45 atm-cm	16.0 milli-atm-cm	5.0 milli-atm-cm
g. Latency	90 min.	15 min.
h. Refresh	At least 90% coverage of the globe Every 24 hours (monthly average)	24 hrs.
i. Long-term Stability	1% over 7 years	0.5 % over 7 years
1. Threshold requirements only apply under daytime conditions with Solar Zenith Angles (SZA) up to 80 degrees. 2. The EDR shall be delivered for all SZA up to 86 degrees. 3. 6 DU SO_2 exclusion removed.		

JPSS-1 Readiness – Algorithms

- Major Accomplishments and Highlights Moving Towards J-01
  - Implemented V8Pro (IDPS Mx8.11)
  - Delivered V8TOz single granule package ADL implementation
  - Developed 16-granule moving-window version of the LFSO2 Code
  - Developed Cal/Val Plan
- J1 Algorithm Summary
  - LFSO2/V8TOz + 17x17 km^2 FOV

The V8TOZ has been implemented in ADL and delivered to the program. It will be integrated into Block 2.0 of the IDPS build in March 2016. The LFSO2/V8TOz has been adapted to run on 16-granule sequences on the STAR LINUX system using the first-run V8TOz EDR as input. We are targeting NDE as the operational system to run this product but are also investigating procedure used to create the multiple granule products for VIIRS in IDPS.

There are two components to reach the smaller FOV target. The first is the granularization of the ancillary data and the second is bookkeeping within the retrieval algorithm. We are working on both components.

  - V8Pro + 50x50 km^2 FOV

The V8Pro has been implemented in IDPS and will transition to operations with Mx8.11 next month. We are working on a glue-ware aggregator to continue creating the 250x250 km^2 FOV for S-NPP until we implement the changes to reach the smaller FOV target. We are working with the SDR team on solar activity, throughput degradation, information concentration and bandpass modeling refinements.

  - DOAS Algorithms for Trace Gases

We have implemented a DOAS algorithm to create operational NO_2 products from the EUMETSAT GOME-2 measurements. The latest versions of these algorithms can create this and additional trace gas products from the OMPS measurements.

JPSS-1 Readiness – Cal/Val

- J1 Cal/Val Overview
  - Pre-Launch Calibration/Validation Plans
    - Cal/Val Plan Readiness Review (12/2015)
    - Demonstrate V8Pro and V8TOz soft calibration capabilities with S-NPP OMPS
    - Develop and test all analysis programs as described in the plan.
  - Post-Launch Calibration/Validation Plans
    - "Beta" ten days after activation and doors open (launch plus 60 days).
      - Geolocation, product range and reporting
    - "Provisional" L+120 days.
      - Precision and first iteration of soft calibration
    - "Validated 1" after ICV (L+210 days)
      - Accuracy and stability from six months
    - “Validated 3” After 1 year of measurements (L+410 days)
      - Accuracy and stability over one annual cycle

JPSS-1 Readiness – Issues & Applications

- Issues / Mitigation
  - Small FOV preparations / CCR Requesting upgrade for S-NPP OMPS to Flight Software 6.0 to allow development, testing and early demonstration of new capabilities
  - Program guidance on platform for OMPS products / Develop ADL and LINUX versions for IDPS or NDE paths
  - Total ozone ancillary data sets for smaller FOVs / Working with Raytheon
  - NP Degradation, wavelength scale, solar activity and bandpass / Working with SDR team to implement and demonstrate improvements for S-NPP OMPS.
  - Uneven records (moving targets) / Develop better reprocessing capabilities
- Users' Readiness
  - We are upgrading the BUFR products to be created from the OMPS V8 algorithm products and parameters. V8 algorithm BUFR products are already in use.
  - We are working on soft calibration to homogenize the suite of ozone products from OMPS, SBUV/2, OMI and GOME.
  - We are working with users of aerosol, NO_2, SO_2 and O_3 products to prepare them for the higher spatial resolution products.

Proposals for OMPS for J-03 and J-04
Expand OMPS Spectral Coverage; Improve FOV Resolution

- **Proposals**

Move and Expand the OMPS Spectral Coverage from 300 nm to 380 nm to 305 nm to 440 nm.

Improve OMPS resolution to 17 x 17 km^2 for most products and further improve to 5x10 km^2 for aerosol products.

- **Rationale**:

1. The shortest VIIRS channel is at 412 nm. Extending OMPS to 440 nm will allow measurement comparisons, help straylight corrections, and improve atmospheric NO_2 and aerosol products.
2. One of the major problems for air quality studies is clearly identifying sources. it's hard to isolate a city or power plant without good spatial resolution. The evidence for the improvements from the smaller FOVs are apparent in the research carried out with the OMI instrument. Some of the air quality and volcanic studies performed with OMI data from the EOS Aura 2014 Science Teams Meeting provide such examples and are included.
3. Aerosol products can be made at high resolution using just a few broad channels.

FY16 OMPS EDR Milestones/Deliverables

Task Category	Task/Description	Start	Finish	Deliverable
Development	Measurement Filtering using Empirical Orthogonal Functions and Nearest Neighbors	Present	Q3	Code modification for N-value subroutine
Integration & Testing	EDR capabilities for small FOV products (Glueware and V8 Algorithm upgrades)	Present	Q1, Q2, Q3	Code Logic and output changes
Calibration & Validation	New RT Tables for J01 New RT Tables for S-NPP Evaluation/validation of V8 products including SO2 Prepare tools and plan for J01	Present	Q4 Q1 Q1,Q2,Q4 Q2	New Tables New Tables Report and statistics on C/V C/V Plan CDR
Maintenance	Monitor performance and resolve anomalies	Ongoing	Ongoing	New DRs and CCRs as needed
LTM & Anomaly Resolution	Continue and expand ICVS Monitoring Trending of ground-based comparisons	Ongoing	Ongoing Q3	New ICVS content Report with V8 statistics

Summary

The S-NPP OMPS instrument is performing very well and the heritage/enterprise algorithms are entering the system. The J-01 upgrades to provide significant improvements in product quality and spatial resolution are moving forward at an acceptable pace. We have an afternoon of talks giving details on the progress and results tomorrow.

Ozone Applications	Craig Long	NOAA/CPC
OMPS Limb Profiler Products	P.K. Bhartia	NASA GSFC
OMPS Additional Trace Gases	Kai Yang	UMD (NASA)
Air Quality from OMPS	Daniel Tong	NOAA/ARL
TOAST to TACO to Limb TACO	Jianguo Niu	SRG (STAR)
V8 Algorithms	Trevor Beck	STAR
Ozone Product Monitoring	Eric Beach	IMSG (STAR)
OMPS Validation	Irina Petropavlovskikh	NOAA/ESRL
OMPS Aerosol Index Gallery	Colin Seftor	SSAI (NASA)

- Backup –
  - Near Term Plans
  - FY14-15 major accomplishments
  - FY17-20 High Priority
  - V7MTTOz Validation
- V8TOz Presentation
- V8Pro Presentation

Near Term Plans

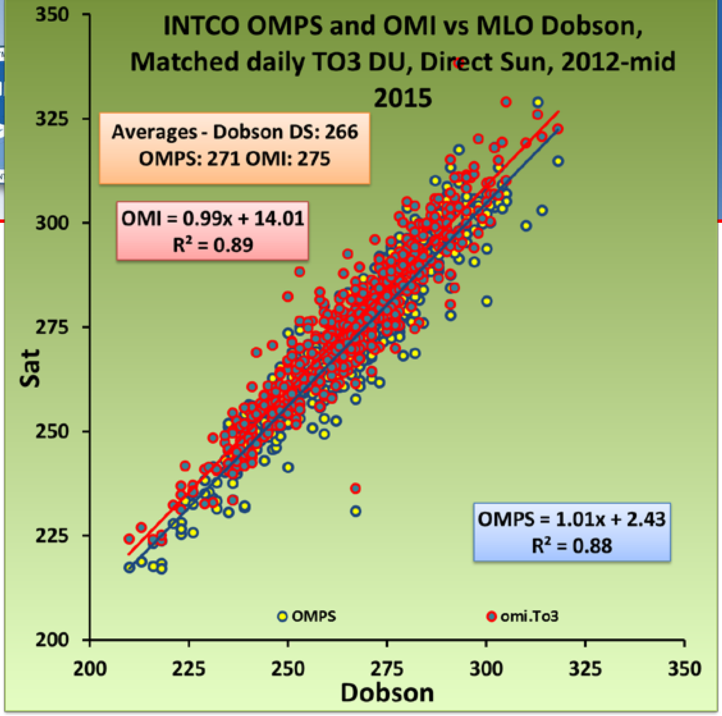
- **Assist in SRS Readiness Review**
- **Complete Validated status check list, presentation and read me**
- **Upgrade BUFR to V8 parameters**
- **For V8Pro**
  - Apply improve bandpass parameter
  - Reprocess NOAA-19 Chasing Orbit Days
    - Create soft calibration estimates
  - Implement Glueware Aggregator
  - Create smaller FOV products (50x50)
- **For V8TOz**
  - Reprocess week with OMI Chasing Orbit
  - Remove cross-track features from reflectivity, aerosols and ozone
    - Create soft calibration estimates
  - Create smaller FOV Products
  - Implement LFSO2/V8TOz in NDE

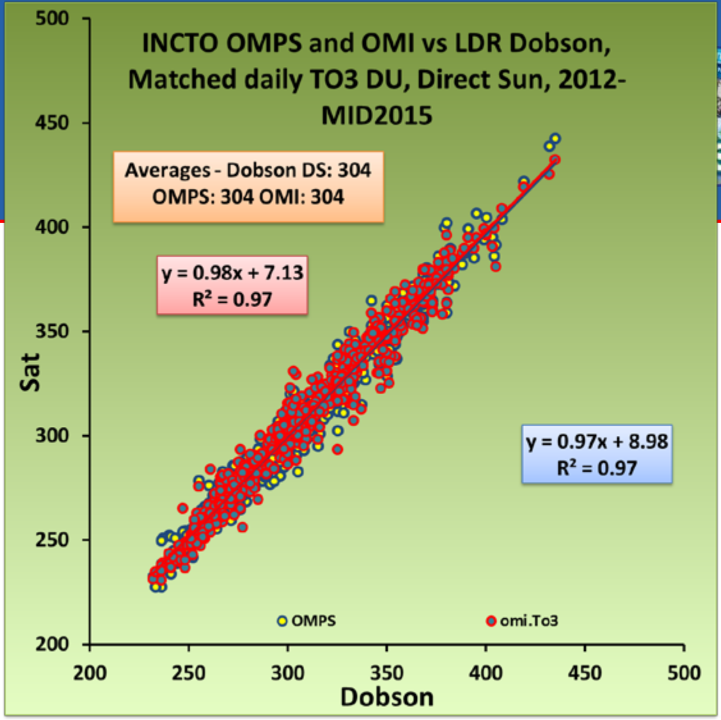
FY14-15 Top Accomplishments EDR

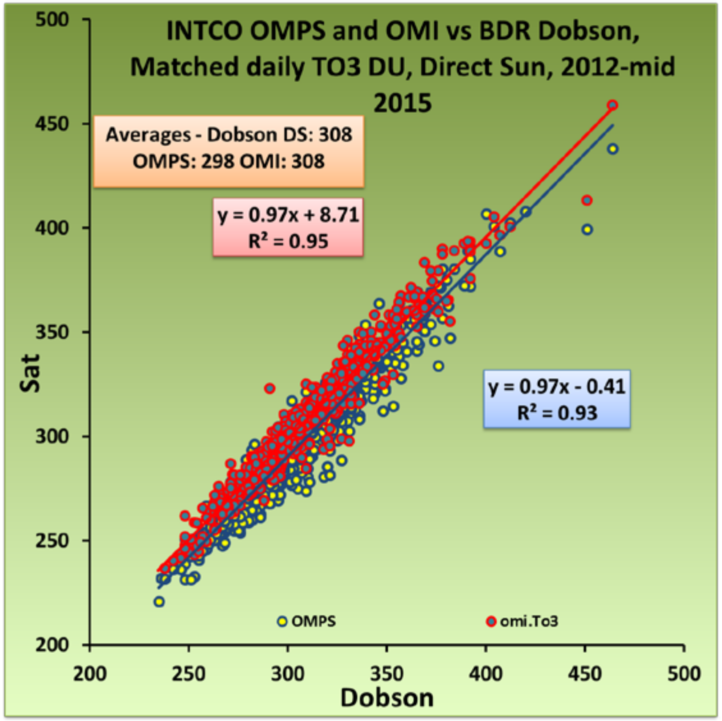
- OMPS NP V8Pro Delivery
- OMPS NM V8TOz Delivery
- Linear Fit SO2 Added to V8TOz Code (Expanded V8 ATBD)
- Developed OMPS NP Glueware for 5x5 Granules
- Regular ICVS Product Monitoring including internal consistency and SBUV/2 and GOME-2 comparisons
- Updates to SBUV/2 Chasing Orbits
- Updates to Ground-based Overpass comparisons
- JGR Paper on OMPS Products
- Developed J01 Validation Plans (Review Q4)

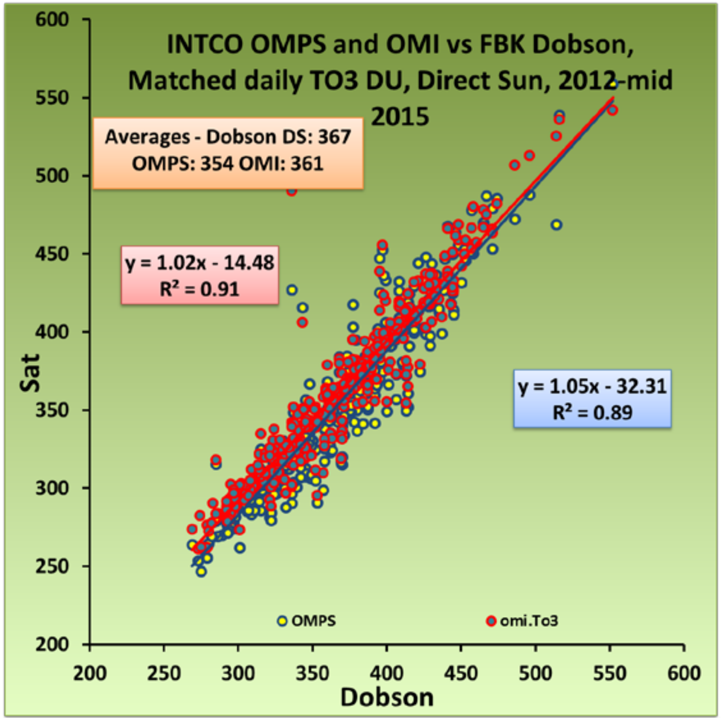
Path Forward (FY-17 thru FY-20)
High Priority Tasks/Milestones

	S-NPP	JPSS-1	JPSS-2
FY17	Monitor OMPS performance and update SDR LUTs as needed for Darks, CF Earth, Linearity, Wavelength Scale, Solar	Early Orbit Checkout, Start of SDR Validation (Beta L+4M, Provisional L+7M)	
FY18	Sustainment, monitoring, maintenance	Product reaches validated version (L+11m)	Receive calibration data from BATC, begin analysis and creation of tables
FY19	Sustainment, monitoring, maintenance	Sustainment, monitoring, maintenance	J02 SDR algorithm review including Limb Profiler
FY20		Sustainment, monitoring, maintenance	Code deliveries for J02 improvements


INTCO OMPS and OMI vs MLO Dobson, Matched daily TO3 DU, Direct Sun, 2012-mid 2015
Averages - Dobson DS: 266
OMPS: 271 OMI: 275
OMI = 0.99x + 14.01
R² = 0.89
OMPS = 1.01x + 2.43
R² = 0.88
OMPS
omi.To3
Sat
Dobson
350
325
300
275
250
225
200
200
225
250
275
300
325
350


INCTO OMPS and OMI vs LDR Dobson, Matched daily TO3 DU, Direct Sun, 2012-MID2015
Averages - Dobson DS: 304
OMPS: 304 OMI: 304
y = 0.98x + 7.13
R² = 0.97
y = 0.97x + 8.98
R² = 0.97
OMPS
omi.To3
Sat
Dobson
500
450
400
350
300
250
200
200
250
300
350
400
450
500


INTCO OMPS and OMI vs BDR Dobson, Matched daily TO3 DU, Direct Sun, 2012-mid 2015
Averages - Dobson DS: 308
OMPS: 298 OMI: 308
y = 0.97x + 8.71
R² = 0.95
y = 0.97x - 0.41
R² = 0.93
OMPS
omi.To3
Sat
Dobson
500
450
400
350
300
250
200
200
250
300
350
400
450
500


INTCO OMPS and OMI vs FBK Dobson, Matched daily TO3 DU, Direct Sun, 2012-mid 2015
Averages - Dobson DS: 367
OMPS: 354 OMI: 361
y = 1.02x - 14.48
R² = 0.91
y = 1.05x - 32.31
R² = 0.89
OMPS
omi.To3
Sat
Dobson
600
550
500
450
400
350
300
250
200
200
250
300
350
400
450
500
550
600

OMPS NM V8 Total Ozone

L. Flynn
July 29, 2015
CCR-

Outline

- Introduction to V8TOz Algorithm
- Details / Corrections
  - Aerosol,
  - Sun Glint, and
  - Profile Shape
- Enterprise Credentials
- Decisions on Multiple Triplet IP/EDR
- Input and Output
- Retrieval Sensitivities / Soft Calibration
- Path to Linear Fit SO_2
- Program Components

Introduction

The Version 8 total O3 algorithm (V8TOZ) is the most recent version of a series of BUV (backscattered ultraviolet) total O3 algorithms that have been developed since the original algorithm proposed by *Dave* & *Mateer* [*1967*], which was used to process Nimbus-4 BUV data [*Mateer* et al., *1971*]. These algorithms have been progressively refined [*Klenk* et al., *1982*; *McPeters* et al., *1996*; *Wellemeyer* et al., *1997*] with better understanding of UV radiation transfer, internal consistency checks, and comparison with ground-based instruments. However, all algorithm versions have made two key assumptions about the nature of the BUV radiation that have largely remained unchanged over all these years. Firstly, we assume that the BUV radiances at wavelengths greater than 310 nm are primarily a function of total O3 amount, with only a weak dependence on O3 profile that can be accounted for using a set of standard profiles. Secondly, we assume that a relatively simple radiative transfer model that treats clouds, aerosols, and surfaces as Lambertian reflectors can account for most of the spectral dependence of BUV radiation, though corrections are required to handle special situations. The recent algorithm versions have incorporated procedures for identifying these special situations, and apply semi-empirical corrections, based on accurate radiative transfer models, to minimize the errors that occur in these situations. In the following sections, we will describe the forward model used to calculate the top-of-the-atmosphere (TOA) reflectances, the inverse model used to derive total O3 from the measured reflectances, and give a summary of errors.

Details

The inverse algorithm consists of a 3-step retrieval procedure.

In the first step, a good first estimate of effective reflectivity (or effective cloud fraction) and total O3 is made by using the 21 standard profile radiance tables and the measured radiance to irradiance ratios at 318 nm and 331 nm.

In step 2, this estimate is corrected by using the Jacobians and seasonally and latitudinally varying O3 and temperature climatology. These corrections typically change total O3 by less than 2%.

In the final step, scenes containing large amounts of aerosols, sea glint, volcanic SO2, or with unusual O3 profiles are detected by using an approach based on the analysis of residuals (differences between measured and computed radiances at wavelengths not used in the first two steps). We use pre-computed regression coefficients applied to these residuals to correct for these effects. These coefficients are generated by off-line analysis of the relationship between retrieval errors and residues computed by accurately modeling radiances for a representative set of interfering species/events. An important benefit of this approach is that unusual events are easily flagged so they can be identified later for careful analysis. Past analyses of such events led to the discovery of a new method of studying aerosols by using BUV radiances.

Details: Corrections for Aerosols

- When one uses the R derived from 331 nm to calculate a radiance at 360 nm, the R-λ dependence produces a residue at 360 nm. This residue is positive when absorbing aerosols are present. By Mie scattering calculation, using various types of absorbing and non-absorbing aerosols, *Torres* & *Bhartia* [*1999*] showed that for the TOMS V7 algorithm a simple linear relationship between the residues and the O3 error exists. Similar calculations using the TOMS V8TOZ algorithm indicate that O3 is overestimated by ~2.5±0.5 DU when the 360-nm residue is 1%.
- TOMS data indicate that aerosol amounts are large enough to produce a 1% residue at 360 nm roughly 30% of the time, and most of these corrections are less than 5 DU.
- Since relatively large residues, not related to aerosols, are seen at large solar zenith angles in the TOMS data, the aerosol correction is applied only when the solar zenith angle is less than 70˚.

Details: Corrections for Sun Glint

- The apparent reflectivity of the ocean in the BUV in the glint direction (roughly a cone of ±15° from the nadir for the OMPS) varies with wavelength due to variations in the direct to diffuse ratio of the radiation falling on the surface. The magnitude of the sea-glint, and hence the R-λ dependence it produces, decreases with increase in surface winds and by the presence of aerosols and clouds which also decrease the direct to diffuse ratio. Radiative transfer calculations [*Ahmad* & *Fraser*, private communication] show that, though the cause of the R-λ dependence produced by sea-glint is quite different, its effect on O3 and residuals is similar to that for absorbing aerosols, and the same correction procedure also applies.
- However, there is one aspect of sea-glint that is different from absorbing aerosols- the fact that they can significantly increase the apparent brightness of the surface and are easily confused with clouds. Since sea-glint increases the absorption of radiation by O3 near the surface while clouds reduce the absorption, it is important to separate the two. The V8TOZ distinguishes clouds from sea-glint using the fact that clouds do not produce residues. So, in situations where geometry indicates the potential for sea-glint, retrievals with 360 nm residue greater than 3.5% are flagged as effected by sea-glint in the OMPS V8TOZ.

Details: Corrections for Profile Shape

- Strictly speaking, the BUV radiances at all wavelengths have some sensitivity to the vertical distribution of O3. Though the wavelengths used in the V8TOZ algorithm to derive total O3 have been selected to minimize this effect, and the step 2 correction procedure described in section 2.3.2 has been designed to correct any residual systematic errors, there are situations when the profile errors become too large to be acceptable. These situations begin to occur when the O3 slant column density (SCD), **Ω** × (secθ+secθ0), exceeds 1500 DU. At 80˚ soar zenith angle, the SCD can vary from less than 1000 DU to more than 4000 DU due to O3 variability, and simply discarding data with very large SCD would seriously bias the zonal means. Therefore, it is important to design the algorithm such that reasonable (5%, 1σ) total O3 values can be obtained for SCD of 5000 DU. From the error analysis of the TOMS algorithm [*Wellemeyer* et al., *1997*], we have determined that errors at SCD>1500 DU typically occur when the assumed O3 profile near 10 hPa is significantly different from that assumed in step 2 (**X2**). The error occurs because the algorithm has been explicitly designed (by using the standard profiles shown in Fig. 2-1 of the ATBD) to minimize errors near 100 hPa where most of the O3 variability takes place. This makes the algorithm sensitive to O3 profile variations away from the 100 hPa region. Fig. 2-4 of the ATBD (reproduced on the next slide) shows how a 10% error in the assumed profile between 4 hPa and 32 hPa (representing roughly 1σ variation of O3 profile) affects the Step 2-derived total O3 as a function of SCD.
- Fortunately, profile errors near 10 hPa can be detected by examining the residue at shorter BUV wavelengths which are more sensitive to O3 profile than the wavelengths used for deriving total O3. Fig. 2-5 of the ATBD shows how the 312.5 nm residue responds to the profile error assumed for Fig. 2-4. More detailed analysis of this error using a set of O3 profiles derived from high latitude ozonesondes indicates that a simple correction factor of 3.5 DU for 1% residue at 312.5 nm provides adequate correction to obtain reliable total O3 values (2%, 1σ) at SCDs of up to 3000 DU. However, the correction procedure becomes increasingly unreliable as the SCD exceeds 3000 DU.

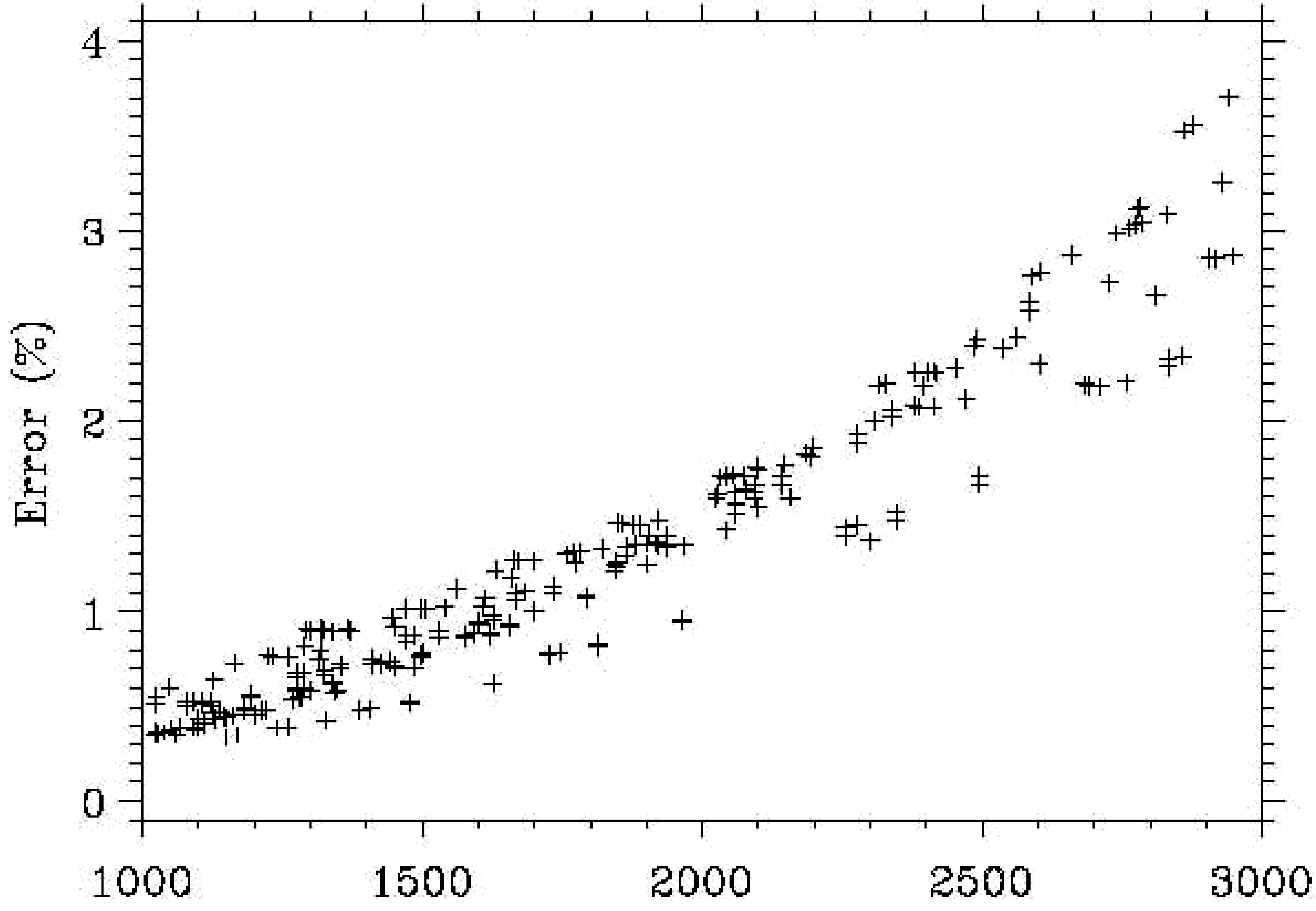


Figure 2-4: Error in retrieved total O_3 due to 10% more ozone in the 4 hPa to 32 hPa layer than assumed. The data shown are for the full range of solar zenith angles, satellite zenith angles and total O3 amounts seen by an ozone mapper.

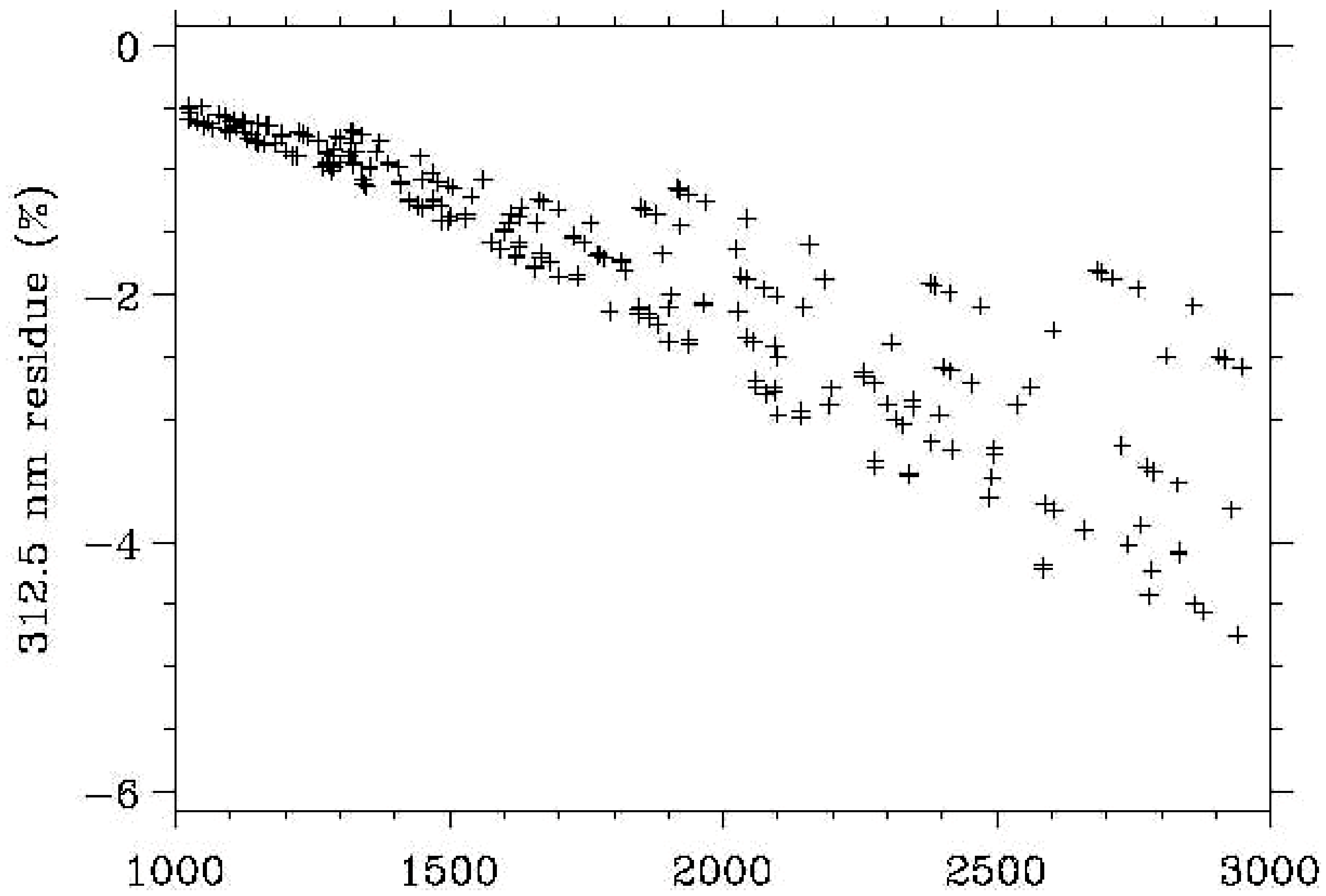


Figure 2-5: 312.5-nm residue for same profile errors as shown in Fig. 2-4.

V8TOz as the Total Column Ozone Enterprise Algorithm

- V8TOz is currently used to generate products for
  - SBUV/2 (as part of V8Pro to create NOAA operational and CDR products)
  - GOME-2 (to create NOAA operational products)
  - OMI (to create NASA direct broadcast, NRT and CDR products)
  - TOMS (to create CDR products)
- It is on its way, or already there to generate products for
  - OMPS NP (as part of V8Pro to create NOAA operational and CDR products)
  - OMPS NM (to create direct broadcast, NOAA operational and CDR products)

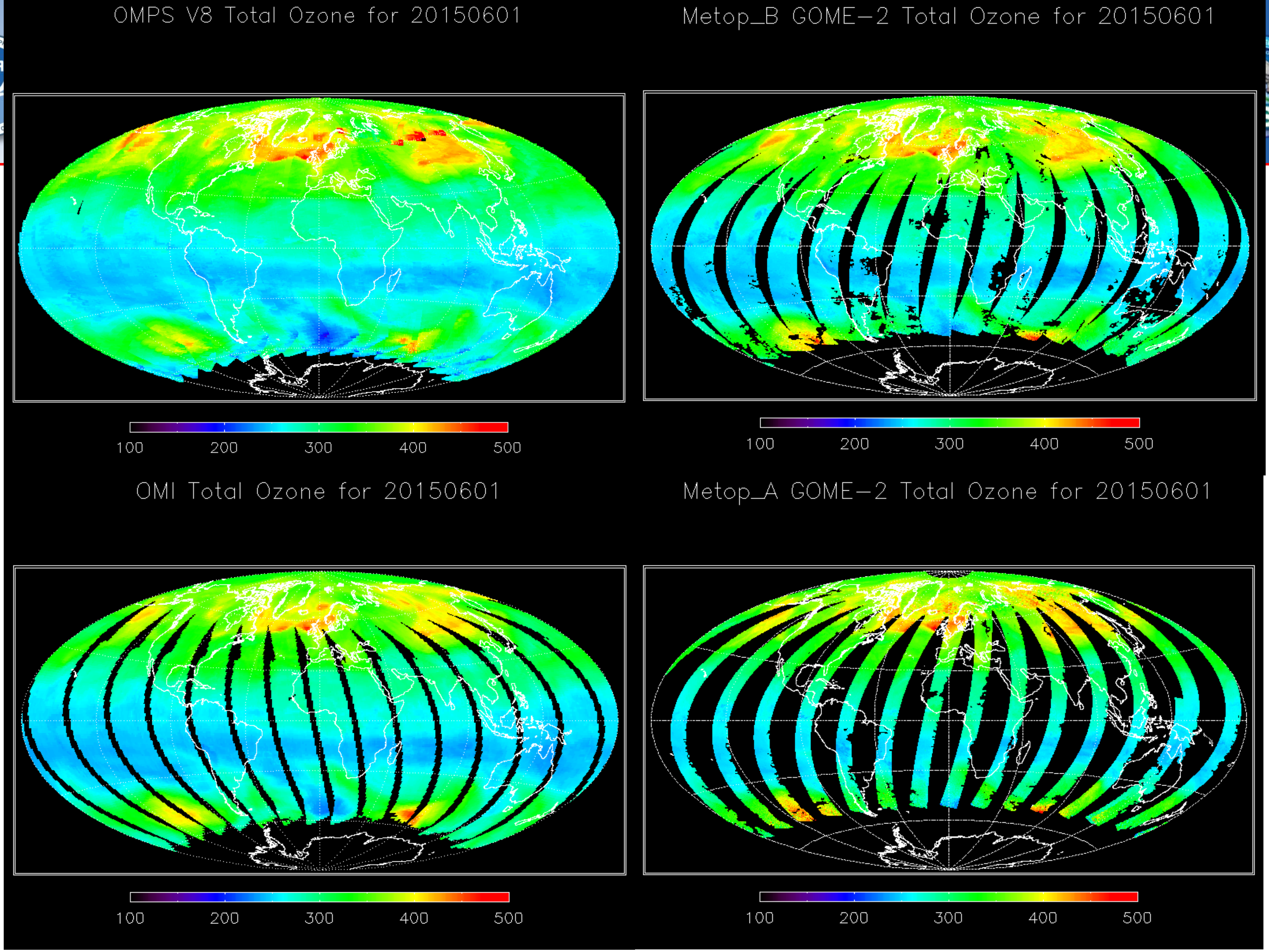


Figure 3: Daily maps of total column ozone.

The false color maps show the total column ozone in Dobson Units for June 1, 2015 for the V8TOz algorithm applied to S-NPP OMPS (Top Left), Metop-B GOME-2 (Top Right), EOS Aura (Bottom Left) and Metop-A GOME-2 (Bottom Right).

Multiple Triplet IP and EDR

- The V8TOz has been implemented as an extension of the OMPS Multiple Triplet (MT) First Guess IP process.
- The MT First Guess IP and EDR have been become almost duplicates as the original motivation has evaporated and the input auxiliary data sets have converged.
- The delivered implementation preserves the First Guess IP output. It is in a combined HDF with the new V8TOz EDR. The program could elect to write out the existing IP and then write out as second file with the combined IP/EDR as the EDR.

New Input

```
! Dims for V8 Lookup Tables from OMPS_TC_EDR_LUT xml
          INTEGER(KIND=4), PARAMETER :: npresT = 4
          INTEGER(KIND=4), PARAMETER :: nprofT = 21
          INTEGER(KIND=4), PARAMETER :: nszaT = 10
          INTEGER(KIND=4), PARAMETER :: nvzaT = 6
          INTEGER(KIND=4), PARAMETER :: nwlLUT = 12
          INTEGER(KIND=4), PARAMETER :: nLayP = 1

! Dims for OZCLIM and TMCLIM from OMPS_TC_EDR_LUT xml
          INTEGER(KIND=4), PARAMETER :: MONTH_INDEX       = 12
          INTEGER(KIND=4), PARAMETER :: MONTH_PLUS_INDEX  = 13
          INTEGER(KIND=4), PARAMETER :: LAT_RANGE_INDEX   = 18
          INTEGER(KIND=4), PARAMETER :: LAYER_INDEX       = 11
          INTEGER(KIND=4), PARAMETER :: LAYER11           = 11
          INTEGER(KIND=4), PARAMETER :: TOZ_RANGE_INDEX   = 10
          INTEGER(KIND=4), PARAMETER :: LON_HALFDEG_INDEX = 720
          INTEGER(KIND=4), PARAMETER :: LAT_HALFDEG_INDEX = 360
          INTEGER(KIND=4), PARAMETER :: LON_GRID_INDEX = 360
          INTEGER(KIND=4), PARAMETER :: LAT_GRID_INDEX = 180
           REAL(KIND=4) ::  c0_v8(nwlLUT)
           REAL(KIND=4) ::  c1_v8(nwlLUT)
           REAL(KIND=4) ::  c2_v8(nwlLUT)
           REAL(KIND=4) ::  logi0_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,TC_EDR_IFOV)
           REAL(KIND=4) ::  z1_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,TC_EDR_IFOV)
           REAL(KIND=4) ::  z2_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,TC_EDR_IFOV)
           REAL(KIND=4) ::  tr_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,TC_EDR_IFOV)
           REAL(KIND=4) ::  knb_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,TC_EDR_IFOV)
           REAL(KIND=4) ::  sb_v8(nprofT,nwlLUT,npresT,TC_EDR_IFOV)
           REAL(KIND=4) ::  wl0_v8(nwlLUT)
           REAL(KIND=4) ::  logi0_dndx_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,nLayP)
           REAL(KIND=4) ::  z1_dndx_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,nLayP)
           REAL(KIND=4) ::  z2_dndx_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,nLayP)
           REAL(KIND=4) ::  tr_dndx_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,nLayP)
           REAL(KIND=4) ::  knb_dndx_v8(nvzaT,nszaT,nprofT,nwlLUT,npresT,nLayP)
           REAL(KIND=4) ::  sb_dndx_v8(nprofT,nwlLUT,npresT,nLayP)
           REAL(KIND=4) ::  tzaprf_v8(LAYER11,TOZ_RANGE_INDEX,LAT_RANGE_INDEX,MONTH_PLUS_INDEX)
           REAL(KIND=4) ::  tmclim_v8(LAYER_INDEX,LAT_RANGE_INDEX,MONTH_INDEX)
           INTEGER(KIND=4) :: cat(LAT_HALFDEG_INDEX,LON_HALFDEG_INDEX)
           REAL(KIND=4) ::  nvcorr_v8(nwlLUT,TC_EDR_IFOV)
           REAL(KIND=4) ::  cloud_press(LON_GRID_INDEX,LAT_GRID_INDEX,MONTH_INDEX)
```

New Output

- DATASET "AerosolIndex_v8" F32LE(5, 35) -20 20 N-Value
- DATASET "AlgorithmFlag_v8" U8LE(5, 35) Flag
- DATASET "CloudFraction_V8" F32LE(5, 35) 0 to 1 Proportion
- DATASET "ColumnAmountO3_v8" F32LE(5, 35) 0 to 1000 DU
- DATASET " dNdOmega_v8" F32LE(5, 35, 12) -20 to 50 N-value/DU
- DATASET " dNdR_v8" F32LE(5, 35, 12) -600 0 N-value
- DATASET "ErrorFlag_v8" U16LE(5, 35) Flag
- DATASET "LayerEfficiency_v8" F32LE(5, 35, 11) -1 to 10 DU TOz /DU Layer
- DATASET "Latitude" F32LE(5, 35) -90 to 90 Degrees North
- DATASET "Longitude" F32LE(5, 35) -180 to 180 Degrees East
- DATASET "NValueAdjustment_v8" F32LE (5, 35, 12) -20 20 N-value
- DATASET "NValueMeasured_v8" F32LE (5, 35, 12) 0 to 6 N-value/100
- DATASET "O3BelowCloud_v8" F32LE(5, 35) 0 to 900 DU
- DATASET "Reflectivity331_v8" F32LE(5, 35) -50 150 Percent
- DATASET "Reflectivity360_v8" F32LE(5, 35) -50 150 Percent
- DATASET "RelativeAzimuthAngle" F32LE(5, 35) 0 to 360 Degrees
- DATASET "SatelliteViewAngle" F32LE(5, 35) -180 to 180 Degrees
- DATASET "So2Index_v8" F32LE(5, 35) -100 1000 DU
- DATASET "SolarZenithAngle" F32LE(5, 35) -0 to 180 Degrees
- DATASET "Step1Ozone_v8" F32LE F32LE(5, 35, 12) 0 to 1000 DU
- DATASET "Step1Residual_v8" F32LE(5, 35, 12) -50 to 50 N-value
- DATASET "Step2Ozone_v8" F32LE(5, 35) 0 to 1000 DU
- DATASET "Step2Profile_v8" F32LE(5, 35, 11) 0 to 1000 DU
- DATASET "Step2Residual_v8" F32LE(5, 35, 12) -50 to 50 N-value
- DATASET "Step3Residual_v8" F32LE(5, 35, 12) -50 to 50 N-value
- DATASET "Wavelengths_v8" F32LE(5, 35, 12) 300 to 420 nm

Using V8TOz dN/dR and dN/dO3 to determine soft calibration adjustments

The V8TOz output contains a variety of useful parameters in addition to the total column ozone estimates. In particular, the retrieval sensitivities, dy/dx can be used to give soft calibration estimates of the N-value changes to remove reflectivity and ozone bias. If you want to increase the effective reflectivity, R, and the total column ozone, Ω, by ΔR and ΔΩ then you should increase the N-values by

$$\Delta N318 = \Delta R \; dN318/dR + \Delta\Omega \; dN318/d\Omega$$

$$\Delta N331 = \Delta R \; dN331/dR + \Delta\Omega \; dN331/d\Omega$$

where dNw/dR is the rate of change of the N-value, Nw, for wavelength, w, with respect to changes in the effective reflectivity, R, and dNw/dΩ is the rate of change of the N-value, Nw, for wavelength, w, with respect to changes in the total column ozone, Ω.

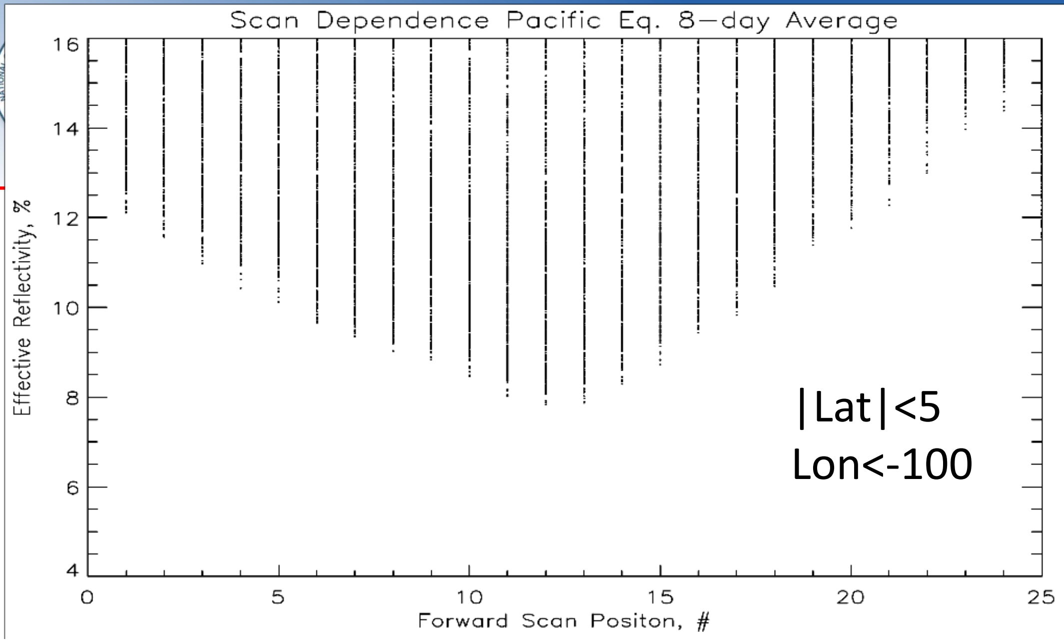
Conversely, if you increase the N values by C1=ΔN318 and C2=ΔN331, then the retrieved R and Ω increase by

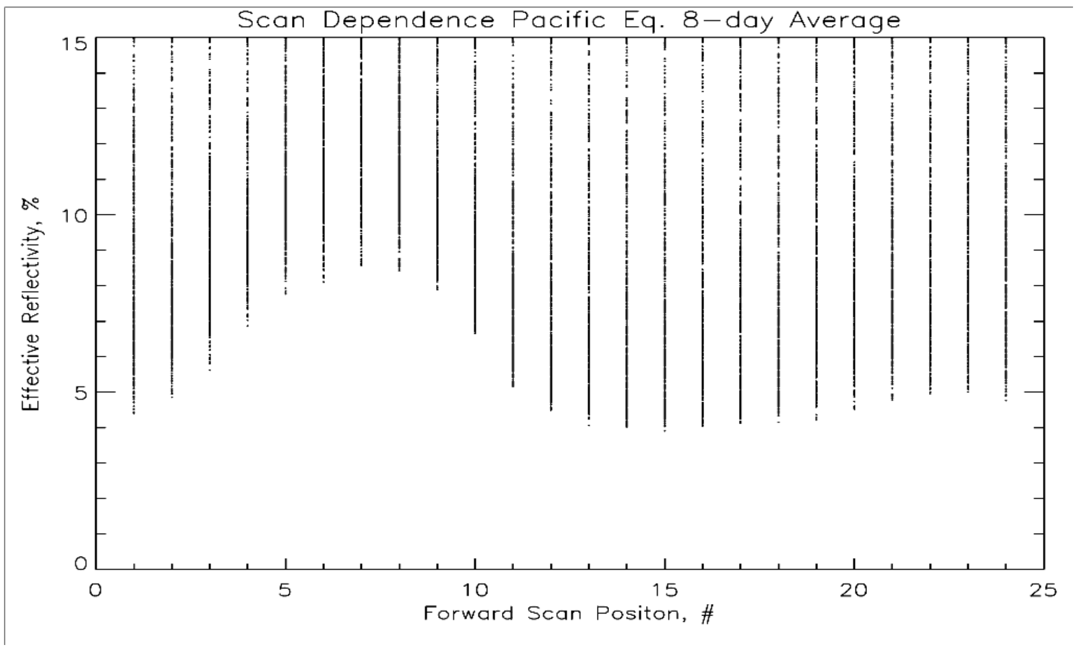
$$\Delta R = [C1 * dN331/d\Omega - C2 * dN318/d\Omega] / D$$

$$\Delta\Omega = -[C1 * dN331/dR, - C2 * dN318/dR] / D$$

$$D = [dN318/dR * dN331/d\Omega - dN331/dR * dN318/d\Omega]$$

Ω is total ozone in DU, R is effective reflectivity, and N is -100*log10(Radiance/Irradiance)





EAST WEST

Metop-A GOME-2 Version 8 331-nm Reflectivity for a box in the Equatorial Pacific.

The unadjusted values in the top plot reach a minimum of 8% (higher than expected for the open ocean) for the Nadir scan position.

A single calibration adjustment to the 331-nm channel lowers this value to 4% and also flattens out the scan dependence for West-viewing positions. The East-viewing results are not as good but there is sun glint contamination for those angles.

Linear Fit Algorithm: Path to SO_2

The V8 ATBD describes an algorithm to create SO_2 product from global mode UV measurements. The minimum SO_2 mass detectable by OMPS is about two orders of magnitude smaller than the detection threshold of the legacy Total Ozone Mapping Spectrometer (TOMS) SO_2 data (1978-2005) [This is due to the use of wavelengths better optimized for separating O_3 from SO_2.]

The algorithm uses the V8TOz as a starting point as a linearization step to derive an initial estimate of total ozone assuming zero SO_2. The residuals at the twelve wavelengths are then calculated as the difference between the measured and computed N-values ($N=-100*log_{10}(I/F)$, I is Earth radiance and F is solar irradiance) using a vector forward model radiative transfer code that accounts for multiple Rayleigh scattering, ozone absorption, Ring effect, and surface reflectivity, but assumes no aerosols. Cloudy scenes are treated as mixture of two opaque Lamberian surfaces, one at the terrain pressure and the other at a radiative cloud pressure from a UV-based climatology. In the presence of SO_2, the residuals contain spectral structures that correlate with the SO_2 absorption cross-section. The residuals also have contributions from other errors sources that have not yet been identified. To reduce this interference, a median residual for a sliding group of SO_2-free and cloud-free scenes, radiative cloud fraction < 0.15) covering sixteen consecutive OMPS granules (approximately 30 degrees of latitude along-track).

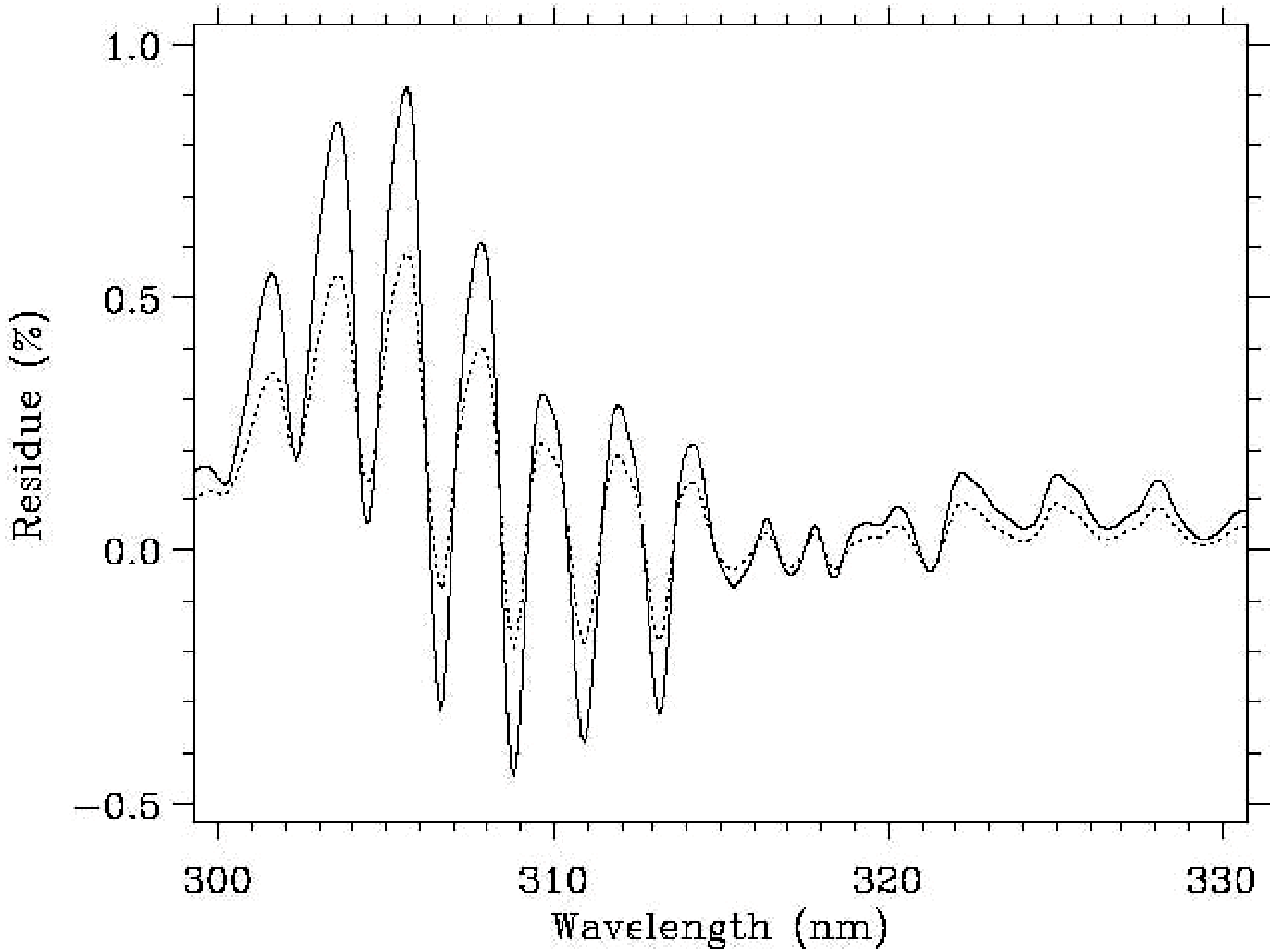
For each OMPS scene , it provides three different estimates of the column density of SO_2 in Dobson Units ($1DU=2.69 \cdot 10^{16}$ molecules/cm^2) obtained by making different assumptions about the vertical distribution of the SO_2. The users can use either the SO_2 plume height, or the center of mass altitude (CMA) derived from SO_2 vertical distribution, to interpolate between the three values:

Lower tropospheric SO_2 column (**ColumnAmountSO2_TRL**), corresponding to CMA of 2.5 km.

Middle tropospheric SO_2 column, (**ColumnAmountSO2_TRM**), usually produced by volcanic degassing, corresponding to CMA of 7.5 km,

Upper tropospheric and Stratospheric SO_2 column (**ColumnAmountSO2_STL**), usually produced by explosive volcanic eruption, corresponding to CMA of 17 km.

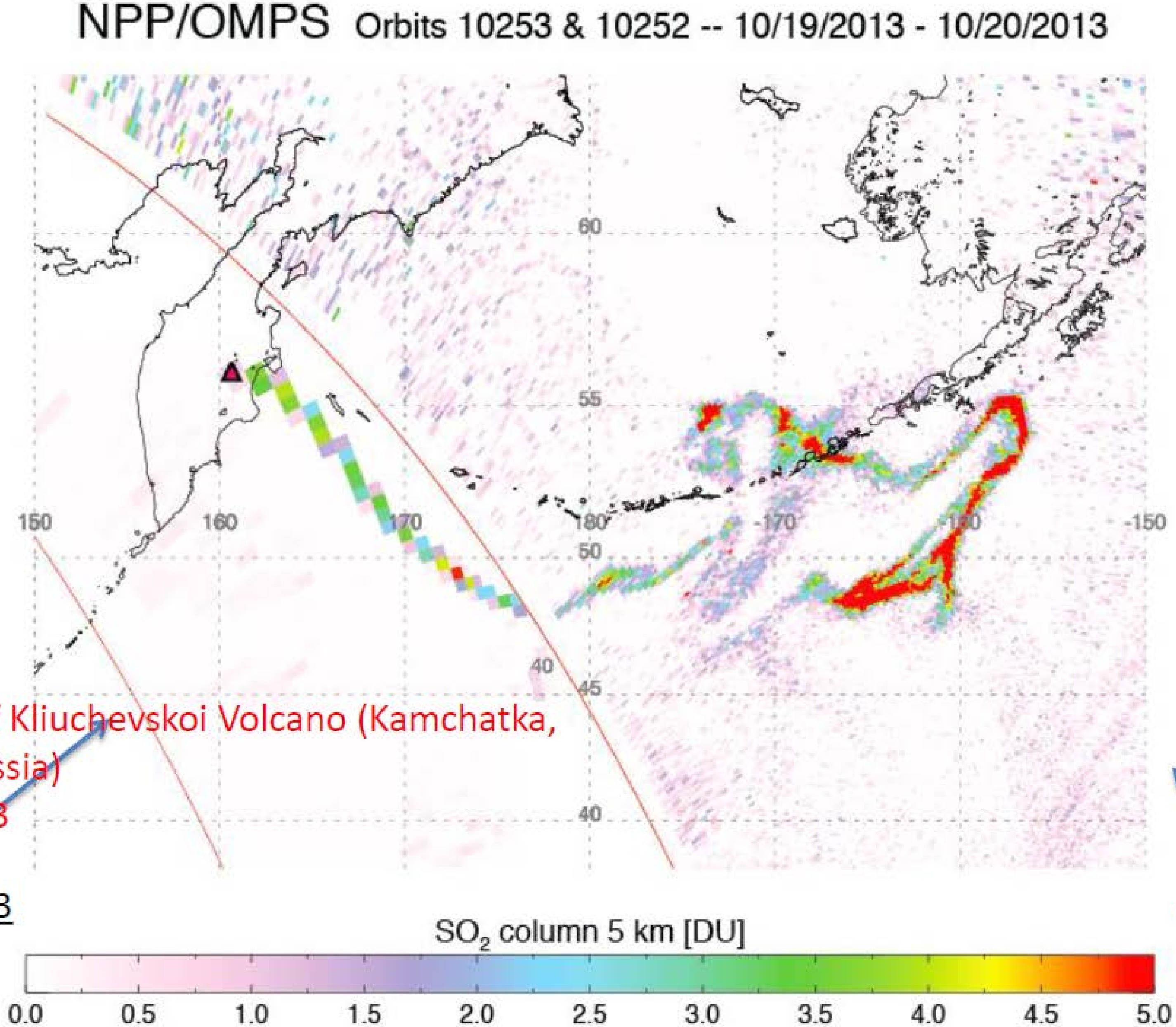
The LFSO2 algorithm has been implemented for OMPS V8TOz (NASA GSFC, NOAA STAR, Direct Broadcast)



Residuals produced by a 1 DU of SO_2 column at 45° solar zenith angle, nadir view. The Solid line is for an SO_2 layer at 7.4 km, and the Dotted line is one at for 2.5 km.

Six V8TOz channels are placed to provide sampling of these features at [308.7 310.8 311.9 312.6 313.2 314.4 317.6 322.4 331.3 345.4 360.2 372.8] nm

Near-Real-Time OMPS SO_2 Product



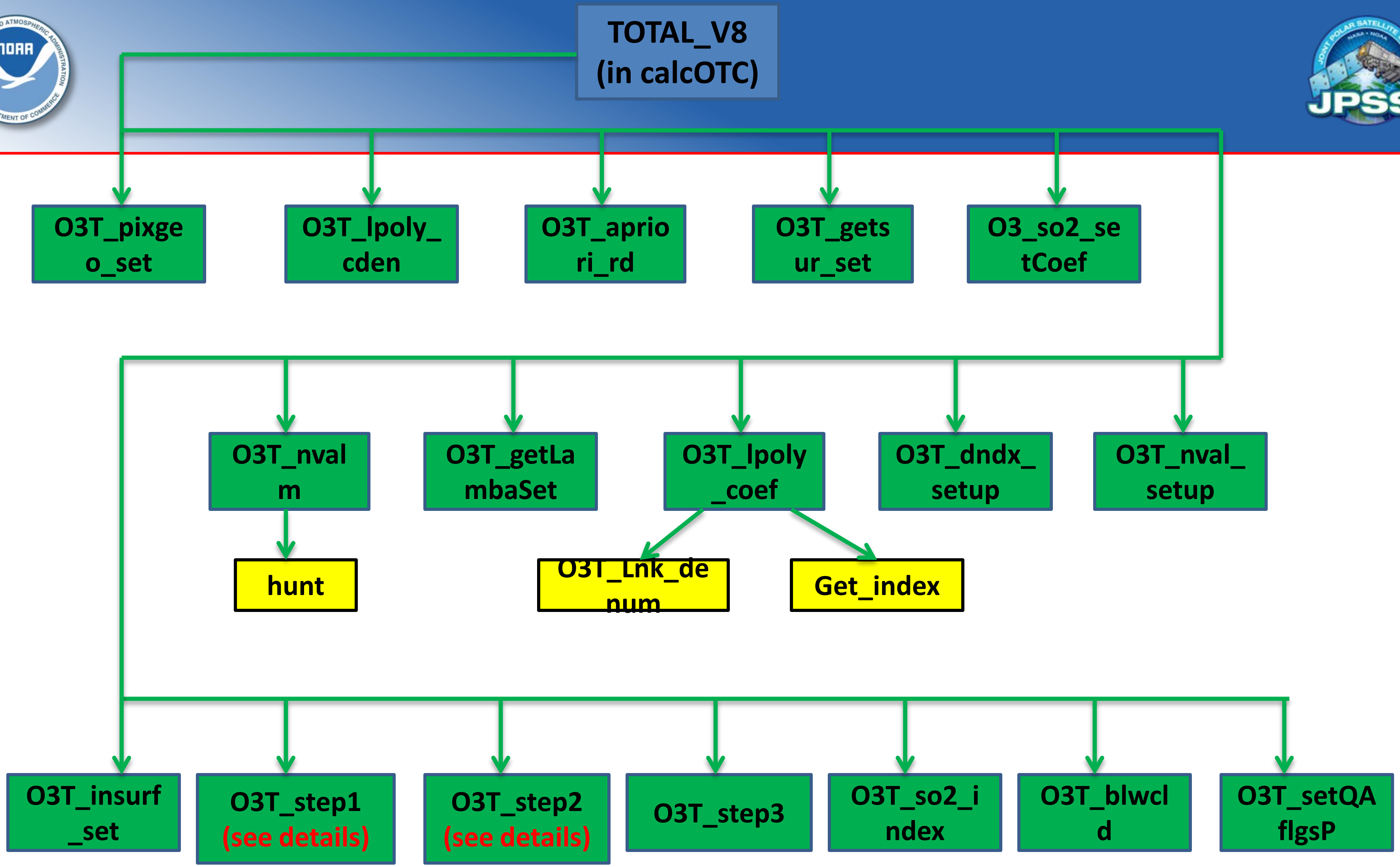
Eruption of Kliuchevskoi Volcano (Kamchatka, Eastern Russia) 10/19/2013

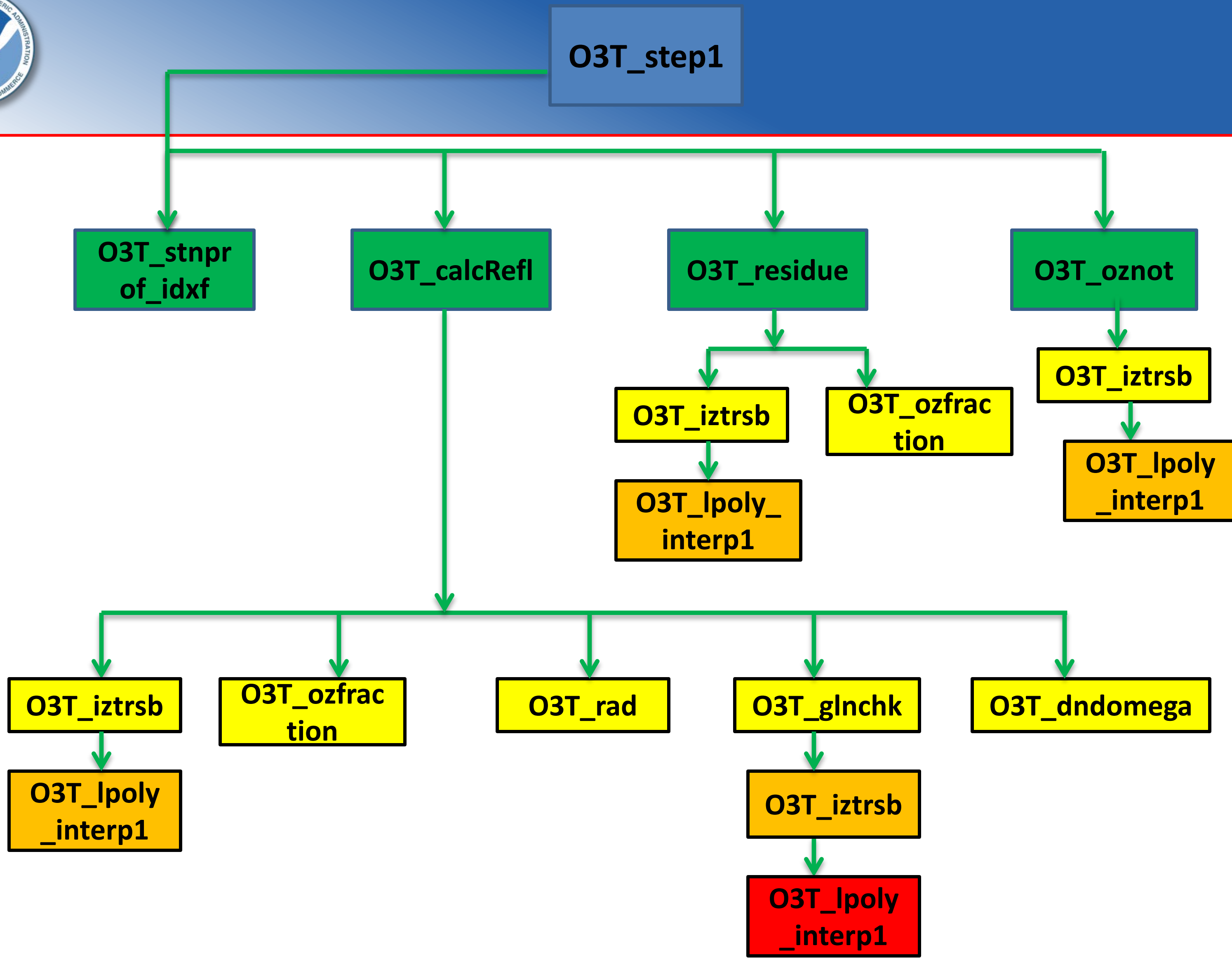
Orbit: 10253
Low-res

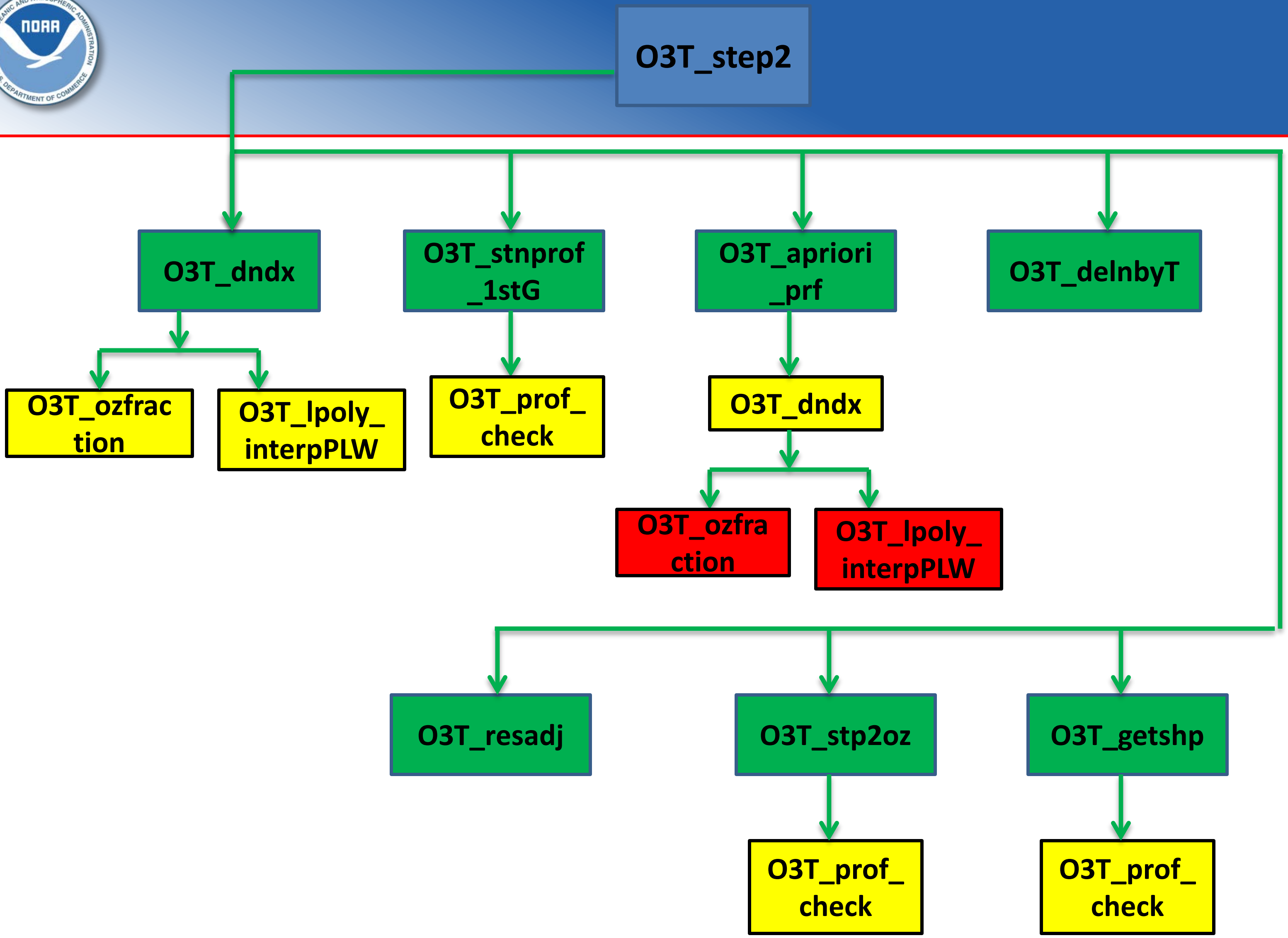
Orbit: 10252
Hi-res

Modules for V8TOz

- GOME_Climatology_class.f
- O3T_apriori_class.f
- O3T_class.f
- O3T_const.f
- O3T_dndx_class.f
- O3T_dndx_m.f
- O3T_iztrsb_m.f
- O3T_lpolycoef_class.f
- O3T_lpolyinterp_class.f
- O3T_nval_class.f
- O3T_pixel_class.f
- O3T_so2_class.f
- O3T_stnprof_class.f
- UTIL_mmddInterp_class.f
- UTIL_tools_class.f


TOTAL_V8
(in calcOTC)
O3T_pixgeo_set
O3T_lpoly_cden
O3T_apriori_rd
O3T_getsur_set
O3_so2_setCoef
O3T_nvalm
O3T_getLambaSet
O3T_lpoly_coef
O3T_dndx_setup
O3T_nval_setup
hunt
O3T_Lnk_denum
Get_index
O3T_insurf_set
O3T_step1
(see details)
O3T_step2
(see details)
O3T_step3
O3T_so2_index
O3T_blwcld
O3T_setQAflgsP


O3T_step1
O3T_stnpr of_idxf
O3T_calcRefl
O3T_residue
O3T_oznot
O3T_iztrsb
O3T_ozfrac tion
O3T_iztrsb
O3T_lpoly_ interp1
O3T_lpoly _interp1
O3T_iztrsb
O3T_ozfrac tion
O3T_rad
O3T_glnchk
O3T_dndomega
O3T_lpoly _interp1
O3T_iztrsb
O3T_lpoly _interp1



O3T_step2
O3T_dndx
O3T_stnprof_1stG
O3T_apriori_prf
O3T_delnbyT
O3T_ozfraction
O3T_lpoly_interpPLW
O3T_prof_check
O3T_dndx
O3T_ozfraction
O3T_lpoly_interpPLW
O3T_resadj
O3T_stp2oz
O3T_getshp
O3T_prof_check
O3T_prof_check

OMPS NP Implementation of the SBUV/2 Version 8 Ozone Profile Algorithm

CCR 15 - 2354 – DR 4256

Lawrence Flynn OMPS C/V lead

April 13, 2015

Outline

- V8Pro Requirements/performance
- V8Pro on ICE
  - V8Pro Improvements
  - V8Pro Consistency
  - V8Pro Efficiency
- Monitoring and Soft Calibration
- Chasing Orbits
- Averaging Kernels, Jacobians and Measurement Contribution Functions.

The designation of ozone profile requirements as "Nadir" or "Limb" is artificial. There are ozone profile requirements and we should try to get as good performance as the measurements allow.

The Threshold requirements here are supposed to represent the heritage SBUV/2 ozone profile product performance.

Table 2.1.4 - Ozone Nadir Profile

Attribute	Threshold (1)	Objective
a. Horizontal Cell Size	250 X 250 km (2,9)	50 x 50 km^2 (10)
b. Vertical Cell Size	5 km reporting	
1. Below 30 hPa (~ < 25 km)	10 - 20 km (3)	3 km (0 - Th)
2. 30 - 1 hPa (~ 25 - 50 km)	7 - 10 km (3)	1 km (TH - 25 km)
3. Above 1 hPa (~ > 50 km)	10 - 20 km (3)	3 km (25 - 60 km)
c. Mapping Uncertainty, 1 Sigma (4)	< 25 km	5 km (10)
d. Measurement Range		
Nadir Profile, 0 - 60 km	0.1-15 ppmv	0.01 - 3 ppmv (O - TH) 0.1-15 ppmv (Th - 60 km)
e. Measurement Precision (5)		
1. Below 30 hPa (~ < 25 km)	Greater of 20 % or 0.1 ppmv	10% (0 - TH)
2. At 30 hPa (~ 25 km)	Greater of 10 % or 0.1 ppmv	3%
3. 30 - 1 hPa (~ 25 - 50 km)	5% - 10%	1%
4. Above 1 hPa (~ > 50 km)	Greater of 10% or 0.1 ppmv	3%
f. Measurement Accuracy (5)		
1. Below 30 hPa (~ < 25 km)	Greater of 10 % or 0.1 ppmv	10% (0 - 15 km)
2. 30 - 1 hPa (~ 25 - 50 km)	5% - 10%	5% (15 - 60 km)
3. At 1 hPa (~ 50 km)	Greater of 10 % or 0.1 ppmv	5% (15 - 60 km)
4. Above 1 hPa (~ > 50 km)	Greater of 10 % or 0.1 ppmv	5% (15 - 60 km)
g. Latency	120 min. (6)	15 min
h. Refresh	At least 60% coverage of the globe every 7 days (monthly average) (7)	24 hrs. (7)
i. Long-term Stability (8)	2% over 7 years	1% over 7 years
		v1.4.2, 7/29/11

Notes:

1. The OMPS Limb Profiler instrument was not manifested on NPOESS. Thus, the Ozone Nadir Profile "Threshold" attributes are based upon current estimates using a variant of the SBUV/2 Version 8 algorithm with the Intermediate Product produced by the OMPS Nadir Profiler instrument. (See Note 10.) All of the Ozone Nadir Profile Threshold attributes are "TBR" until further analysis has been completed to determine the specifics of delivering the Ozone Nadir Profile EDR attributes using only the capability provided by this Intermediate Product.
2. The SBUV/2 has a 180 km X 180 km cross-track by along -track FOV. It makes its 12 measurements over 24 Samples (160 km of along-track motion). It is intended to operate the OMPS Nadir Profiler in a mode with this large FOV sub-sampled.
3. The SBUV/2 Version 8 Averaging kernels' Full Width Half Maximum values were used to define these VCS.
4. The IORD-II Mapping "Accuracy" of 25 km was changed to "Uncertainty, 1 sigma" in accordance with user desires as expressed by the OATS and JARG.
5. Values provided by L. Flynn of NOAA/NESDIS along with the two point values from BATC analysis.
6. Relaxed IORD-II Threshold requirement.
7. All OMPS measurements require sunlight, so there is no coverage in polar night areas. The IORD-II included threshold and objective Refresh requirements of 24 hrs for Ozone TC but none for Nadir Profile. This interpretation of the IORD-II Refresh requirement is consistent with the baseline OMPS Cross-track Swath Width design of ~ 250 km (16.7° FOV) for a single orbit plane. This swath width provides a good sample of the full global ozone profile pattern over ~ 7 days. A set of 4 days with 14 orbits/day by 250-km swaths will cover a little over one third of the 40,000 km equator. SBUV/2 has similar coverage over 5 days. The OMPS Nadir Profiler performance is expected to degrade in the area of the South Atlantic Anomaly (SAA) due to the impact of periodic charged particle effects in this region.
8. Long Term Stability is not a critical attribute for achieving operational performance but it is for climate applications.
9. The OMPS and other newer CCD array BUV instruments can be operated to generate products with higher spatial resolution. Numerical weather and air quality models can make good use of this information.

10. The IORD Total Column/Profile EDR had 25 km Mapping Accuracy for both the Threshold and Objective. The Nadir Profile Objective has been changed to 5 km for the following reasons per L. Flynn. The OMPS aggregates pixels to make the current 250X250 FOV in the threshold. We would aggregate 1/5 as many pixels to make the new objective 50X50 FOV. The requested change maintains

Table 4.2.4 - Ozone Nadir Profile (OMPS-NP)

Attribute	Threshold	Objective
Ozone NP Applicable Conditions: 1. Clear, daytime only (3)		
a. Horizontal Cell Size	250 X 250 km (1)	50 x 50 km2
b. Vertical Cell Size	5 km reporting	
1. Below 30 hPa (~ < 25 km)	10 -20 km	3 km (0 -Th)
2. 30 -1 hPa (~ 25 -50 km)	7 -10 km	1 km (TH -25 km)
3. Above 1 hPa (~ > 50 km)	10 -20 km	3 km (25 -60 km)
c. Mapping Uncertainty, 1 Sigma	< 25 km	5 km
d. Measurement Range		
Nadir Profile, 0 - 60 km	0.1-15 ppmv	0.01 -3 ppmv (0-TH) 0.1-15 ppmv (TH-60 km)
e. Measurement Precision (2)		
1. Below 30 hPa (~ < 25 km)	Greater of 20 % or 0.1 ppmv	10% (0 -TH)
2. At 30 hPa (~ 25 km)	Greater of 10 % or 0.1 ppmv	3%
3. 30 -1 hPa (~ 25 -50 km)	5% -10%	1%
4. Above 1 hPa (~ > 50 km)	Greater of 10% or 0.1 ppmv	3%
f. Measurement Accuracy (2)		
1. Below 30 hPa (~ < 25 km)	Greater of 10 % or 0.1 ppmv	10% (0 -15 km)
2. 30 -1 hPa (~ 25 -50 km)	5% -10%	5% (15 -60 km)
3. At 1 hPa (~ 50 km)	Greater of 10 % or 0.1 ppmv	5% (15 -60 km)
4. Above 1 hPa (~ > 50 km)	Greater of 10 % or 0.1 ppmv	5% (15 -60 km)
g. Refresh	At least 60% coverage of the globe every 7 days (monthly average) (2,3)	24 hrs. (2,3)
	(16.7° FOV)	v2,0, 9/22/12

Notes: 1. The SBUV/2 has a 180 km X 180 km cross-track by along -track FOV. It makes its 12 measurements over 24 Samples (160 km of along-track motion). The OMPS Nadir Profiler is designed to be operated in a mode that is able to subsample the required HCS. 2. The OMPS Nadir Profiler performance is expected to degrade in the area of the South Atlantic Anomaly (SAA) due to the impact of periodic charged particle effects in this region. 3. All OMPS measurements require sunlight, so there is no coverage in polar night areas.

Independence and Long Term Stability

- The OMPS 5% to 10% accuracy requirements were for its minimal performance as a stand-alone instrument.
- By using other assets we can set/correct its bias close to 0%.
- The long-term stability of the accuracy at 2% was also a stand-alone requirement, that is, the system was designed so that products' accuracy was not allowed to wander around between +5% and -5%.
- Users expect a stable product – applications are negatively affected by both short term jumps and discontinuities and longer term drifts.
- Over the course of a mission, new adjustments to the measurement characterizations are phased in as changes warrant.

Why "I should have a V8Pro"? 1. Improvements

V8Pro improves on the V6Pro SBUV(/2) algorithm described in Bhartia et al. (1996) as follows:

The V8Pro has a new set of a priori profiles varying by month and latitude, leading to better estimates in the troposphere (where SBUV/2 lacks retrieval information) and allowing simplified comparisons of SBUV/2 results to other measurement systems (in particular, to Umkehr ground-based ozone profile retrievals which use the same a priori data set).

The V8Pro has improved multiple scattering and cloud and reflectivity modeling. These corrections are updated as the algorithm iterates toward a solution.

Some errors present in the V6Pro will be reduced. These include the elimination of errors on the order of 0.5% by improved fidelity in the bandpass modeling.

The V8Pro incorporates several ad hoc Version 6 algorithm improvements directly. These include better modeling of the effects of the gravity gradient, better representation of atmospheric temperature influences on ozone absorption, and better corrections for wavelength scale errors.

The algorithm uses improved terrain height information and gives profiles relative to a climatological or forecast surface pressure.

The V8Pro is also designed to allow the use of more accurate external and climatological data and allow simpler adjustments for changes in wavelength selection.

The V8Pro has a true separation of the a priori and first guess. This simplifies averaging kernel analysis. Examples and further information are provided at

http://www.star.nesdis.noaa.gov/smcd/spb/ozone/Version8AlgorithmDesc.php

Why "I should have a V8Pro"? 2. Consistency

The V8Pro will place the OMPS NP retrievals in the fold with those from the SBUV and SBUV/2 records.

The V8Pro is used to create the current NOAA SBUV/2 operational products. These products are used by NCEP and other agencies. Creating OMPS product with the same behavior and content will ease their transition as the primary products. The V8Pro contains smaller vertical resolution products that capture the mid-stratospheric information better.

The V8Pro algorithm is in use for the production of climate data records (CDRs) for the SBUV(/2). The operational V8Pro from OMPS will be the first step in extending these records.

The V8Pro *A Prioris* and Averaging Kernels allow better comparisons to validation data sets include the ground-based Umkehr ozone profile retrieval which use a variation of the V8Pro retrieval and to higher vertical resolution products such as MLS and Balloonsonde ozone profiles.

Why "I should have a V8Pro"? 3. Efficiency

Use of the V8Pro will simplify the overall NOAA work for BUV ozone profiles.

The use of the same algorithms for OMPS and SBUV/2 will reduce the maintenance and support for algorithms. We have ten years of experience with the SBUV/2 V8Pro products.

Direct comparisons to V8Pro results from NOAA-19 SBUV/2 will be used to generate soft calibration coefficients. Chasing orbit results will quickly translate into SDR calibration adjustments. We have already been testing these in our off-line system

The extended content of the BUFR files desired by users is already in the definitions, tables and libraries for the SBUV/2 products.

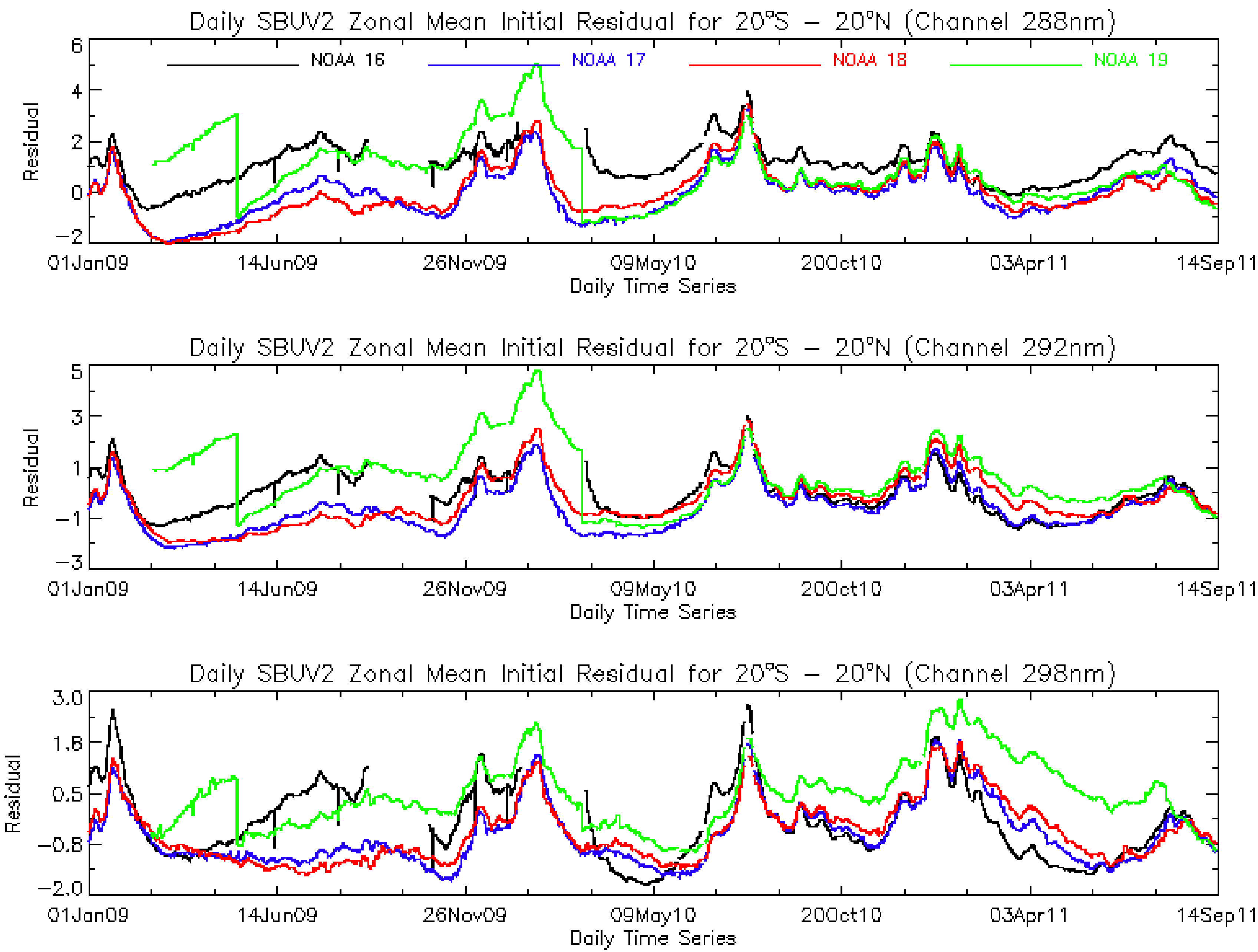
Existing V8Pro documents for the current operational processing include the Maintenance Manual, System Description, Interface Control, and Algorithm Theoretical Basis Documents.

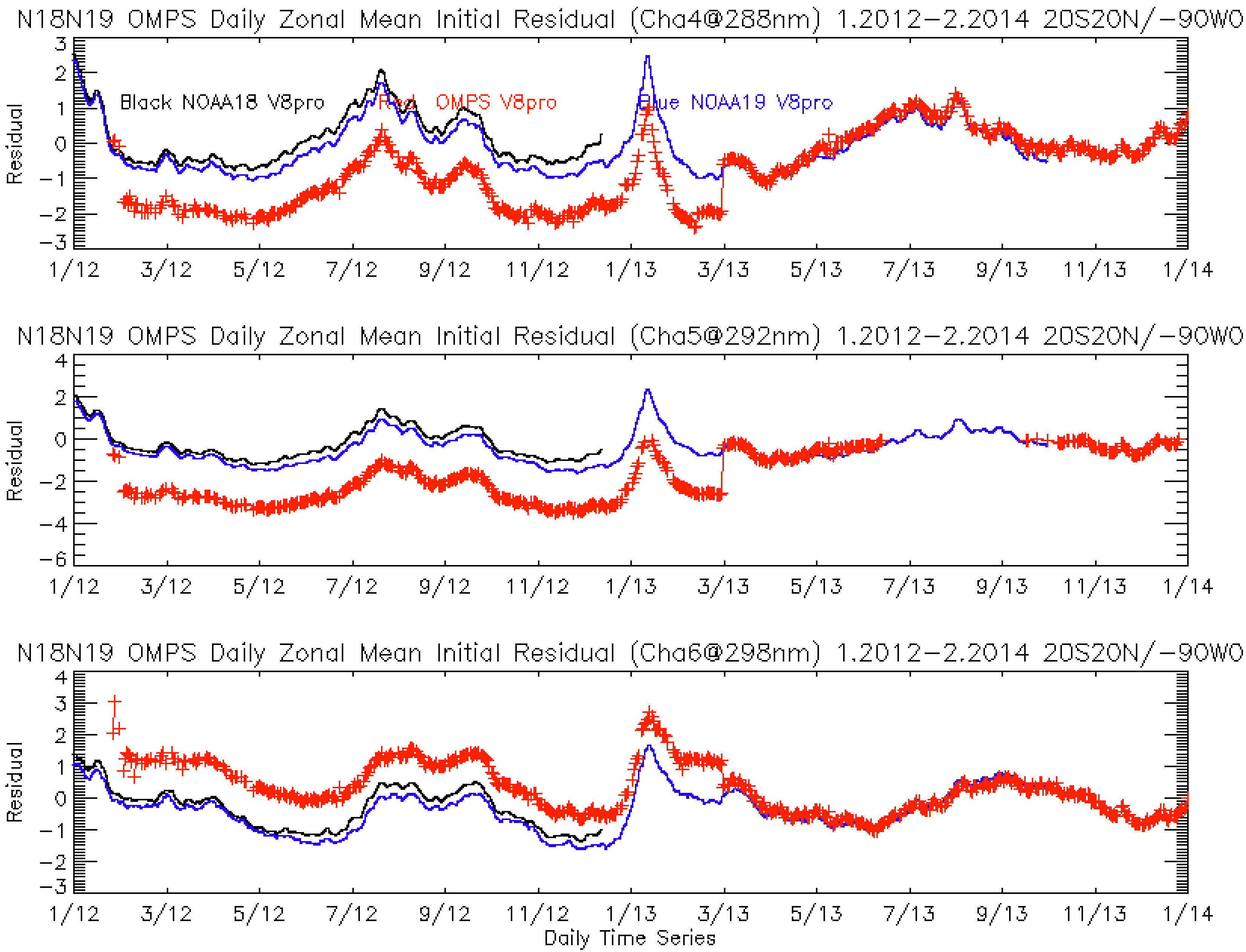
Existing ICVS monitoring pages can be simplified as we need only track the V8Pro products and can discontinue the V6Pro ones.

Monitoring and Soft Calibration

- The figure on the next two slides show time series of initial measurement residuals (measured N-values minus those predicted by a radiative transfer forward model using the first guess profile).
- The three figures on the next slide show how the NOAA-19 SBUV/2 extrapolated calibration was adjusted at different times to bring its products into agreement with those for other SBUV/2 instruments.
- The three figures on the slide after that show how the off-line processing of the OMPS V8Pro was adjusted in March 2013 and has kept good alignment with the NOAA-19 SBUV/2 results since then.

Operational Initial Residuals for SBUV/2



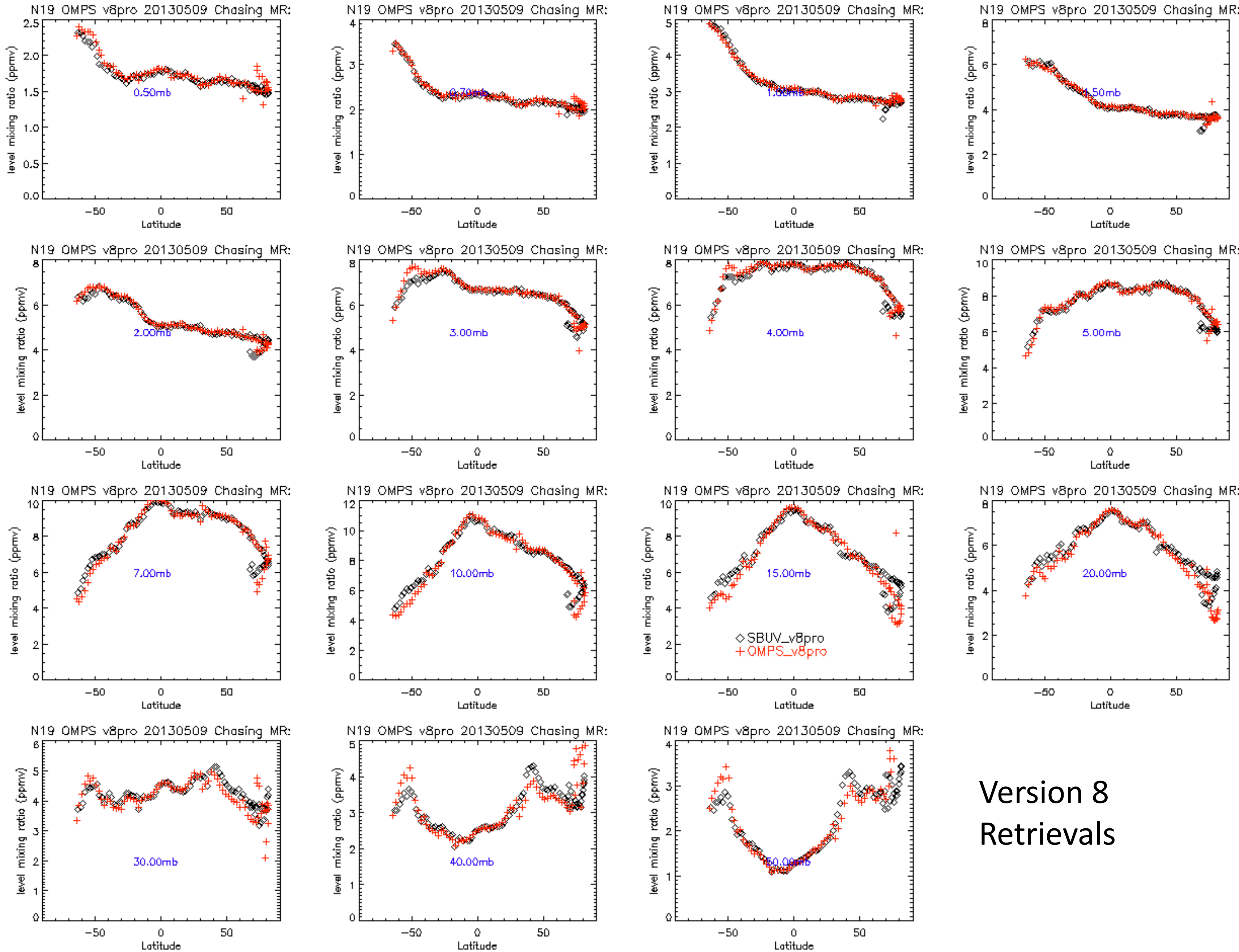

N18N19 OMPS Daily Zonal Mean Initial Residual (Cha4@288nm) 1.2012-2.2014 20S20N/-90W0
Black NOAA18 V8pro
Red OMPS V8pro
Blue NOAA19 V8pro
Residual
N18N19 OMPS Daily Zonal Mean Initial Residual (Cha5@292nm) 1.2012-2.2014 20S20N/-90W0
Residual
N18N19 OMPS Daily Zonal Mean Initial Residual (Cha6@298nm) 1.2012-2.2014 20S20N/-90W0
Residual
1/12 3/12 5/12 7/12 9/12 11/12 1/13 3/13 5/13 7/13 9/13 11/13 1/14
Daily Time Series

Chasing Orbit Comparisons of OMPS and SBUV/2 V8Pro

- The figures on the next show comparisons for the V8Pro products for OMPS and NOAA-19 SBUV/2. The plots show ozone mixing ratios for fifteen different pressure levels versus latitude for a "Chasing*" Orbit. Good agreement is seen for most latitudes
- We have discovered and corrected an error in the dN/dx tables that was affecting the accuracy for the higher latitudes in the northern hemisphere.

* Chasing orbits in this case are opportunistic formation flying that occurs once every twelve days when the S-NPP and NOAA-19 platforms follow close to the same orbital tracks.

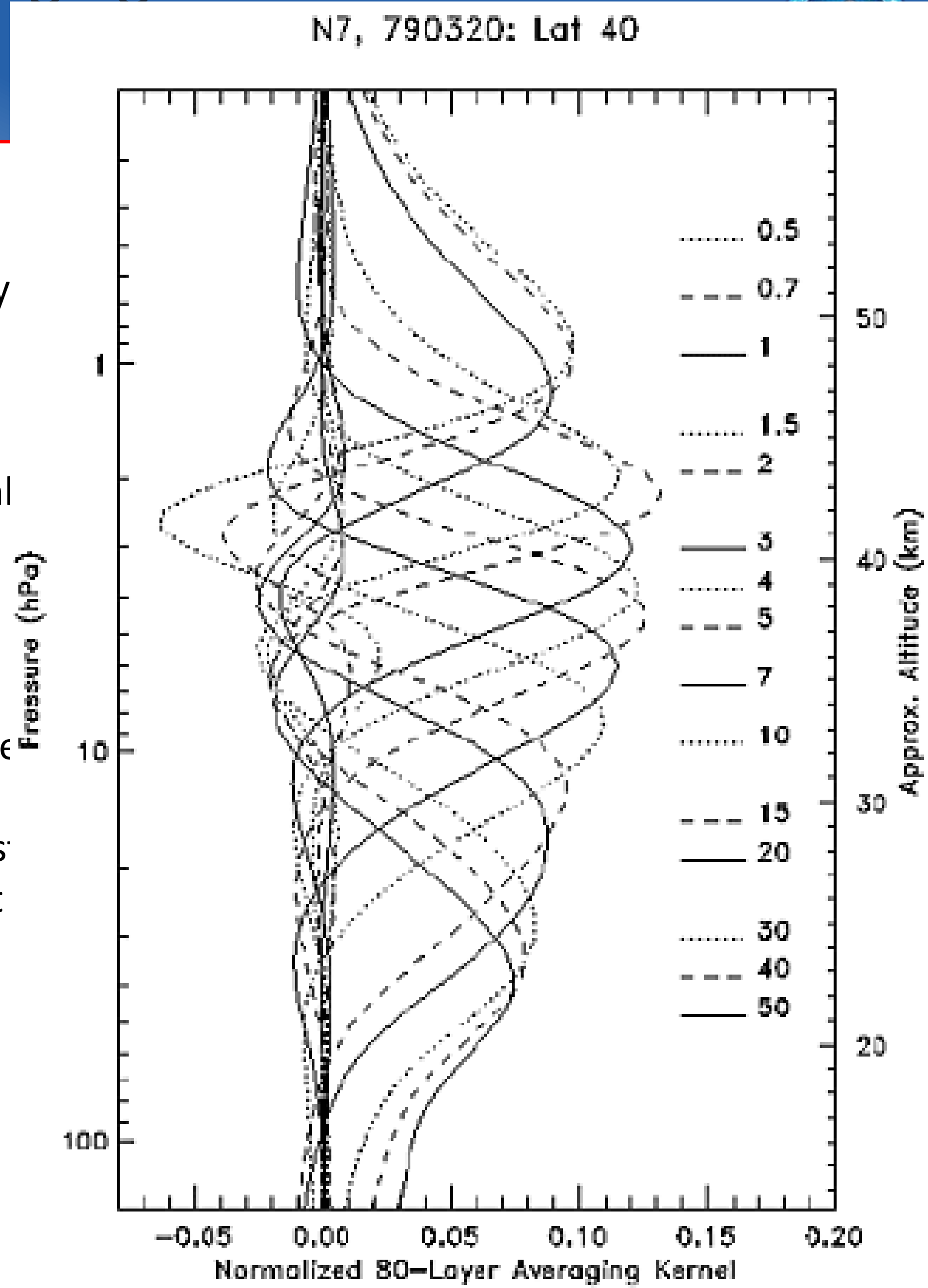
Chasing Orbit NOAA-19 SBUV/2 versus OMPS



Version 8
Retrievals

Version 8 Averaging Kernels

Averaging Kernels (AKs) (for fractional changes in ozone) at the 15 pressure levels. The short horizontal lines on the right side of the graph show the pressure levels and point to the corresponding AK. The horizontal and AK lines' styles correspond. In general, the (fractional) variation in the mixing ratio reported by SBUV at a given pressure level is a weighted average of the (fractional) variation of the mixing ratio at surrounding altitudes, relative to the a priori profile. Since the SBUV V8 a priori profiles have no inter-annual variation, the AKs also show how the algorithm would smooth a long-term trend in ozone mixing ratio. Note, however, that individual SBUV profiles usually have structures that are finer than those implied by the AKs; these structures come from the assumed a priori profile rather than from the measurements themselves. This figure shows typical AKs at the 40ºN. The AKs show best resolution of ~6 km near 3 hPa, degrading to ~10 km at 1 and 30 hPa. Outside this range the retrieved profiles have little information. For example, the (fractional) variation in ozone mixing ratio seen at 0.5 hPa actually represents the (fractional) variation from the region around 1 hPa, and the variation around 50 hPa represents the variation from around 40 hPa.



Adjustments using A, K, and Dy

The Averaging Kernel, A, is the product of the Jacobian of partial derivatives of the measurements with respect to the ozone profile layers, K, and the measurement retrieval contribution function, Dy:

$$A = Dy \# K$$

For a linear problem, the retrieved profile, Xr, is the sum of the A Priori Profile, Xa, plus the product of the Averaging Kernel, A, times the difference between the Truth Profile, Xt, and Xa:

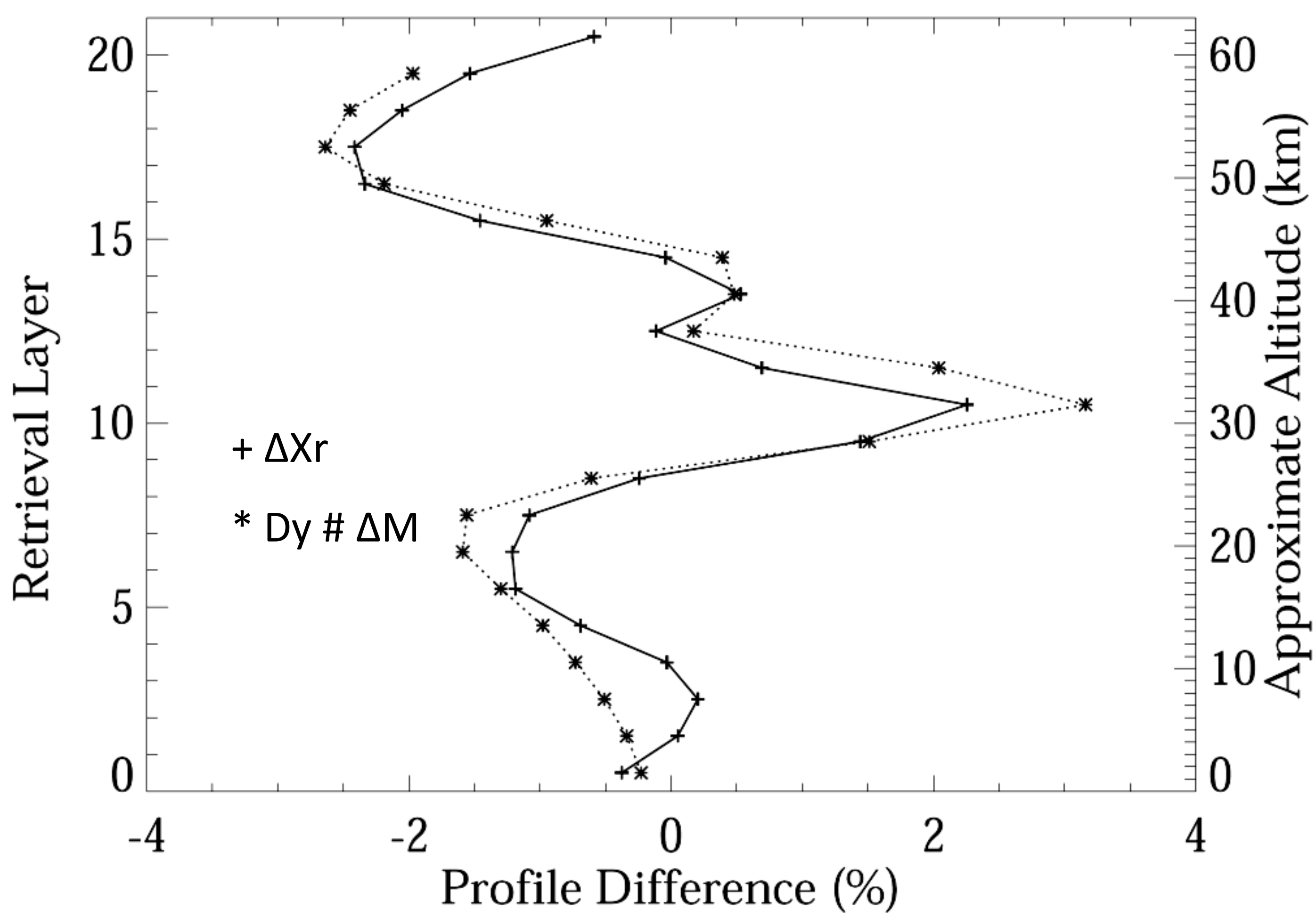
$$Xr = Xa + A \# [Xt - Xa]$$

The measurement change, ΔM, is the Jacobian times a profile change, ΔX:

$$\Delta M = K \# \Delta X$$

The retrieval change, ΔXr, is the contribution function times a measurement change, ΔM:

$$\Delta Xr = Dy \# \Delta M$$



Comparison of actual differences in annual tropical zonal mean profiles retrieved by NOAA-16 and NOAA-17 SBUV/2 for 2003 with those predicted by their differences in their initial residuals. The "+" symbols are Δ**Xr** computed directly and the * symbols are **Dy** Δ**M** with Δ**M** computed from the initial residuals. We can produce vary homogeneous Climate Data Records by determining the Δ**M** values.

Options for Basic Implementation of V8Pro

- IDPS (Need to introduce new content and format for LUTs and output in addition to new PRO components)
  - Implement as a companion process to the V6Pro. Make use of the V6Pro input/output as input. V6Pro still runs in IDPS. (Tested in ADL at STAR.) (This was the selected path.), or
  - Replace V6Pro with V8Pro as the Program part of IPO.
- NDE (Need to implement as a new process with new output)
  - From IMOPO – no new glueware, V6Pro still runs in IDPS, or
    - Need flow of IMOPO to NDE
  - From SONPS/GONPO & SOMTC/GOTCO – New glueware (in use at STAR), Only SDRs and GEOs in IDPS
    - Need flow of SDRs and GEOs to NDE
- OSPO/POES (Need to implement as another "SBUV/2" with existing V8 processing code)
  - From IMOPO – no new glueware, V6Pro still runs in IDPS, or
    - Need flow of IMOPO to POES processing system
  - From SONPS/GONPO & SOMTC/GOTCO – New glueware (in use at STAR), Only SDRs and GEOs in IDPS
    - Need flow of SDRs and GEOs to POES processing system

Lines of Code for V8Pro at STAR

- The V8Pro was provided to DPES in an ADL implementation as a sub-module of the existing V6Pro processing. It contains approximately 20000 new lines of code.
- The output was expanded and now includes both the V6Pro and V8Pro parameters.
- The programs to create and prepare additional LUTs (Radiative Transfer and Ground Pis) will be exercised offline at STAR as needed.

What about refinements for V8Pro?

Solar Activity and Wavelength Scales in the SDR or when SDR is read in.

- The daily Mg II Index values from GOME-2 can be used to adjust the Day 1 solar by using scale factors.
- The day of year values can be used to give the expected wavelength scale from intra-annual variations. The can be used to adjust the Day 1 solar and its wavelength scale. (The V8Pro can accommodate small variations in the wavelength scale about some mean values.)

Information concentration / Noise reduction and Outlier Detection and Removal

- Information concentration can be performed at the same step as the N-value creation, either in the input stage of the V6Pro or the input stage of the V8Pro (if the latter is working directly from SDRs). SONPO would maintain spectral coverage for smaller FOVs.

Smaller FOVs

- For the initial delivery, these products will not flow from IDPS starting points for SDRs or EDRs as those use a glueware aggregator.
- Glueware (NM/NP Matchups) modifications on the appropriate system will be made to handle new cases of FOVs J01. We will develop smaller FOV capabilities as part of J01 plans.

New ancillary Input

- The systems can access better data for snow/ice and surface pressure for use in the V8Pro processing

Plans for V8Pro

- OMPS ozone profile products will be made at IDPS by using the V8Pro code as implemented for the SBUV/2.
- The operational products will be the first step in CDR generation.
- Smaller FOVs will initially be accommodated by changes in the matchup glueware. Smaller EDR products will be obtained by code enhancements as part of the J01 upgrades.
- Solar activity adjustments and intra-annual wavelength shifts will be implemented by using the existing SDR table capabilities.
- Information concentration (noise reduction) and outlier detection will be implemented in future refinements for the the OMPS data input module for the V8Pro.

Overview of NOAA Unique CrIS ATMS Processing System (NUCAPS)

AVTP, AVMP, OLR, IR Ozone, CO, CO_2, and CH_4 Products

Q. Liu, N. Nalli, C. Tan, K. Zhang, F. Iturbide-Sanchez,
J. Smith, M. Wilson, B. Sun, T. Reale, W. Wolf, STAR
C. Barnet, A. Gambacorta, STC
X. Liu, S. Kizer, NASA/LaRC
A. Sharma, OSPO

Sounding EDR Team
August 25, 2015

Outline

- Soundings Cal/Val Team Members
- S-NPP Sounding Products Overview
- Products Online Monitoring, LTM
- JPSS-1 Readiness
- Major Accomplishments
- USERS
- Moving Forwards J1
- Summary
- FY16 Milestone
- J2 and Beyond: Future Improvements

Algorithm Cal/Val Team Members

PI	Organization	Team Members	Roles and Responsibilities
Quanhua (Mark) Liu	STAR	N. Nalli, C. Tan, F. Iturbide-Sanchez, K. Zhang, J. Smith	Maintain, validation, J1 algorithm development
Chris Barnet	STC	A. Gambacorta	Algorithm improvement, direct broadcast,
Xu Liu	NASA/LaRC	S. Kizer	Science support, independent assessment
Tony Reale	STAR	Bomin Sun, M. Pettey, F. Tilley, C. Brown	NROVS support for NUCAPS EDR validations
P. J. Mather	DOE	D. Holdrige	Dedicated radiosonde launch
D. Tobin	U. Wisconsin	L. Borg, R. Knuteson	Radiosonde launch schedule, radiosonde data analyze
A. Sharma	OSPO	O. Roytburd and W. OConnor	POC, Interact with users and data quality monitoring

S-NPP Product Overview

- AVMP (L1RD Sup. Table 5.2.3.1) from NDE
- AVTP (L1RD Sup. Table 5.2.4.1) from NDE
- CO (L1RD Sup. Table 5.2.5) from NDE
- CO_2 (L1RD Sup. Table 5.2.6) from NDE
- CH_4 (L1RD Sup. Table 5.2.7) from NDE
- IR ozone (L1RD Sup. Table 5.2.8) from NDE
- OLR (L1RD Sup. Table 5.4.2)
- S-NPP Cal/Val Status
  - AVMP and AVTP Stage-1 Validated Maturity;
  - OLR meets an objective requirement;
  - IR Ozone to reach Validated Maturity;
  - CO, CO_2, and CH_4 cannot achieve good accuracy for SNPP.

Online LTM

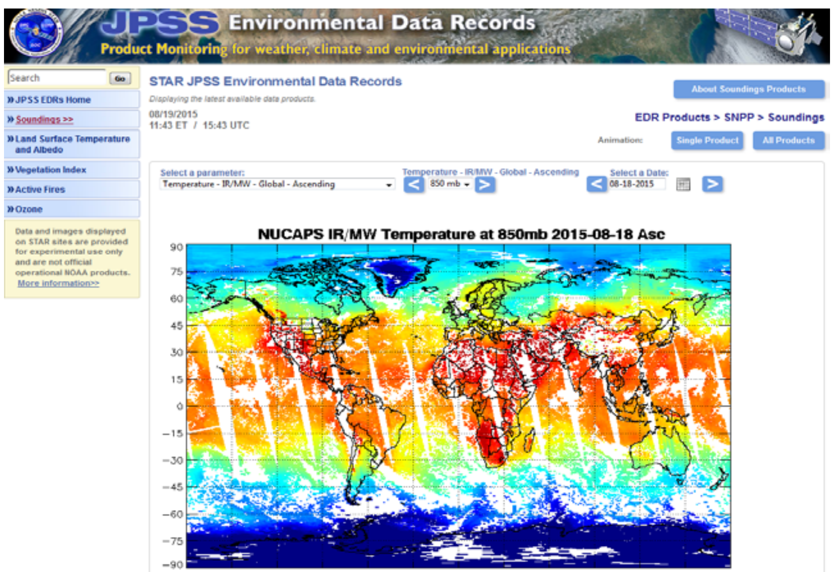
- OSPO

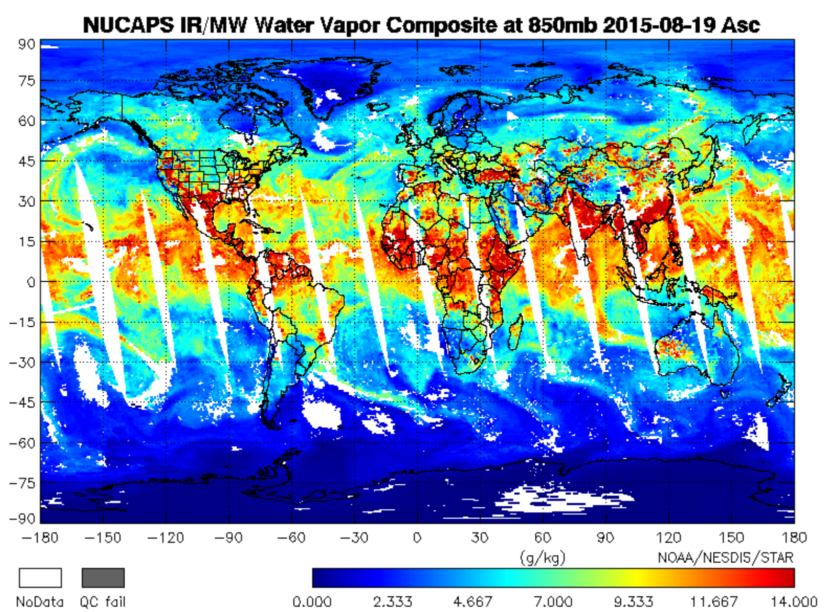
OSPO has developed websites for: NUCAPS Sounding Products, Global Granules Composite Images, Global Gridded Products, and Retrieval Statistics:

TIME	ACCPTD CASES	PRCNT LAND	AVG LAT	AVG LON	SOLAR ZENITH	200-1100 TRUEMEAN	200-1100 WATERBIAS	200-1100 WATERRMS	200-1100 WATERPERERR	200-1100 TEMPBIAS	200-1100 TEMPRMS	520-790 TEMPBIAS	520-790 TEMPRMS
0.007	44	14.08	62.07	-63.38	47.23	0.2770	-0.011300	0.0466	21.166	-0.113	1.187	0.689	1.113
0.016	60	46.75	63.83	-43.81	48.95	0.2560	-0.011400	0.0483	21.961	-0.212	1.342	0.771	1.263
0.024	82	71.04	65.57	-21.42	50.67	0.2810	-0.026600	0.0624	20.120	-0.161	1.574	0.885	1.426

- STAR

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





JPSS-1 Readiness (1)

- J1 Algorithm Summary
  - CrIS SDR data will change to the full-spectral resolution, which requires changes in NUCAPS
    - codes,
    - radiative transfer model (SARTA),
    - channel selections,
    - new noise characteristics,
    - new tuning parameters,
    - testing,
    - validation
  - New J1 EDRs CO, CO_2, and CH_4 require
    - accurate trace gas retrieval algorithms,
    - channel optimization,
    - validation data (MLS, OCO-2, aircraft and surface In-situ),
    - validation

JPSS-1 Readiness (2)

- J1 Cal/Val Overview
  - AVMP, AVTP: L+12 months (assuming validated ATMS and CrIS SDR).
  - OLR and IR ozone: L+18 months (assuming validated ATMS and CrIS SDR)
  - CO, CO_2, and CH_4: L+24 months (assuming validated ATMS and CrIS SDR)

  - Pre-Launch Calibration/Validation Plans

    Validation Archive (VALAR) and NOAA Products Validation System (NPROVS) enhancement
    Radiative Transfer Model (SARTA) for CrIS full-spectral radiance simulation and assessment
    NUCAPS code change for CrIS full-spectral data
    Channel selection for each stepwise retrievals in NUCAPS
    J1 sensor characteristics and tuning data
    J1 NUCAPS system level testing using synthetic radiance

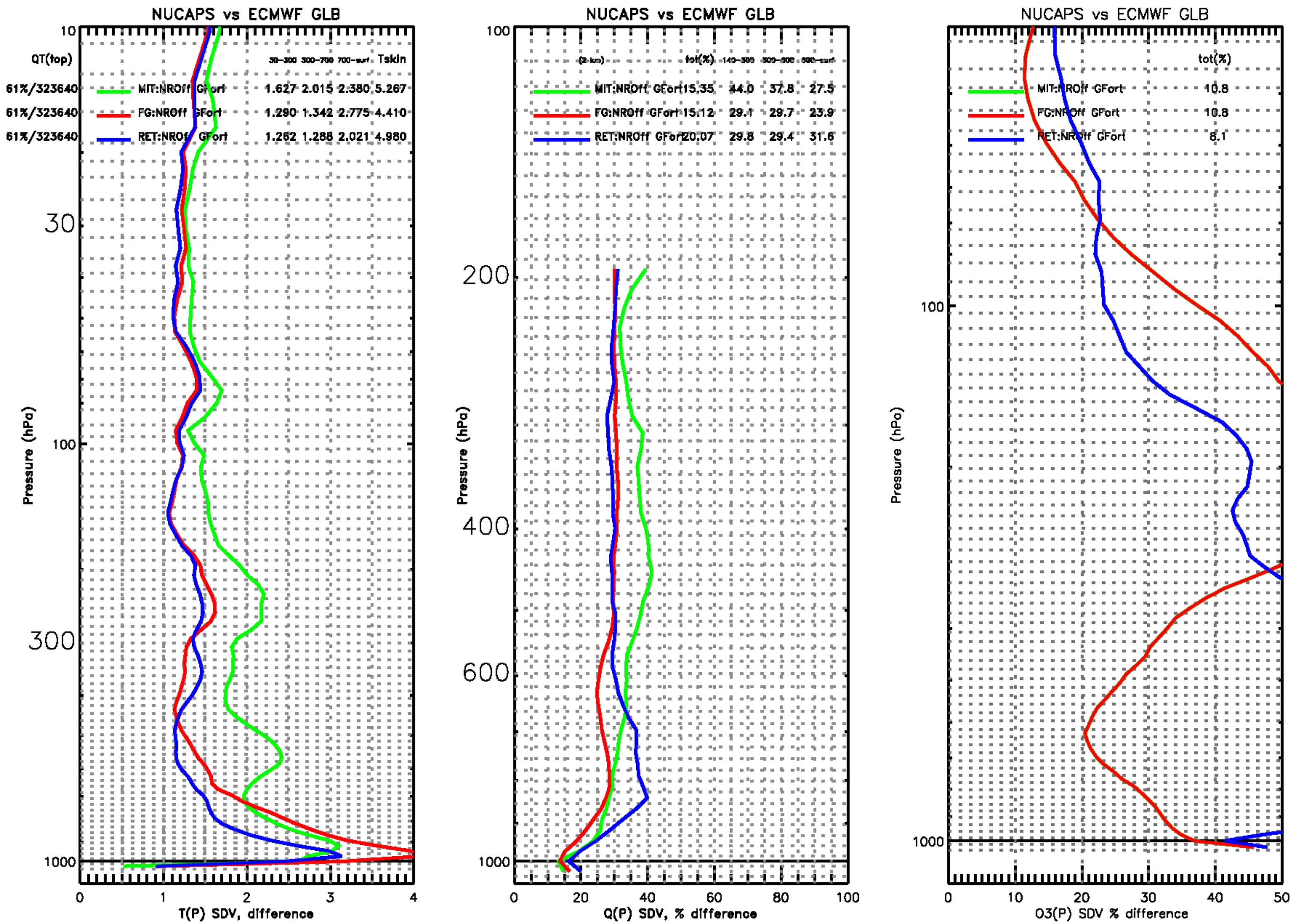
  - Post-Launch Calibration/Validation Plans

    Validation data (dedicated radiosonde, GFS data, ECMWF data)
    noise file (including RT modeling error), bias correction coeff, regression coeff
    Data collocation, analyze, and validation

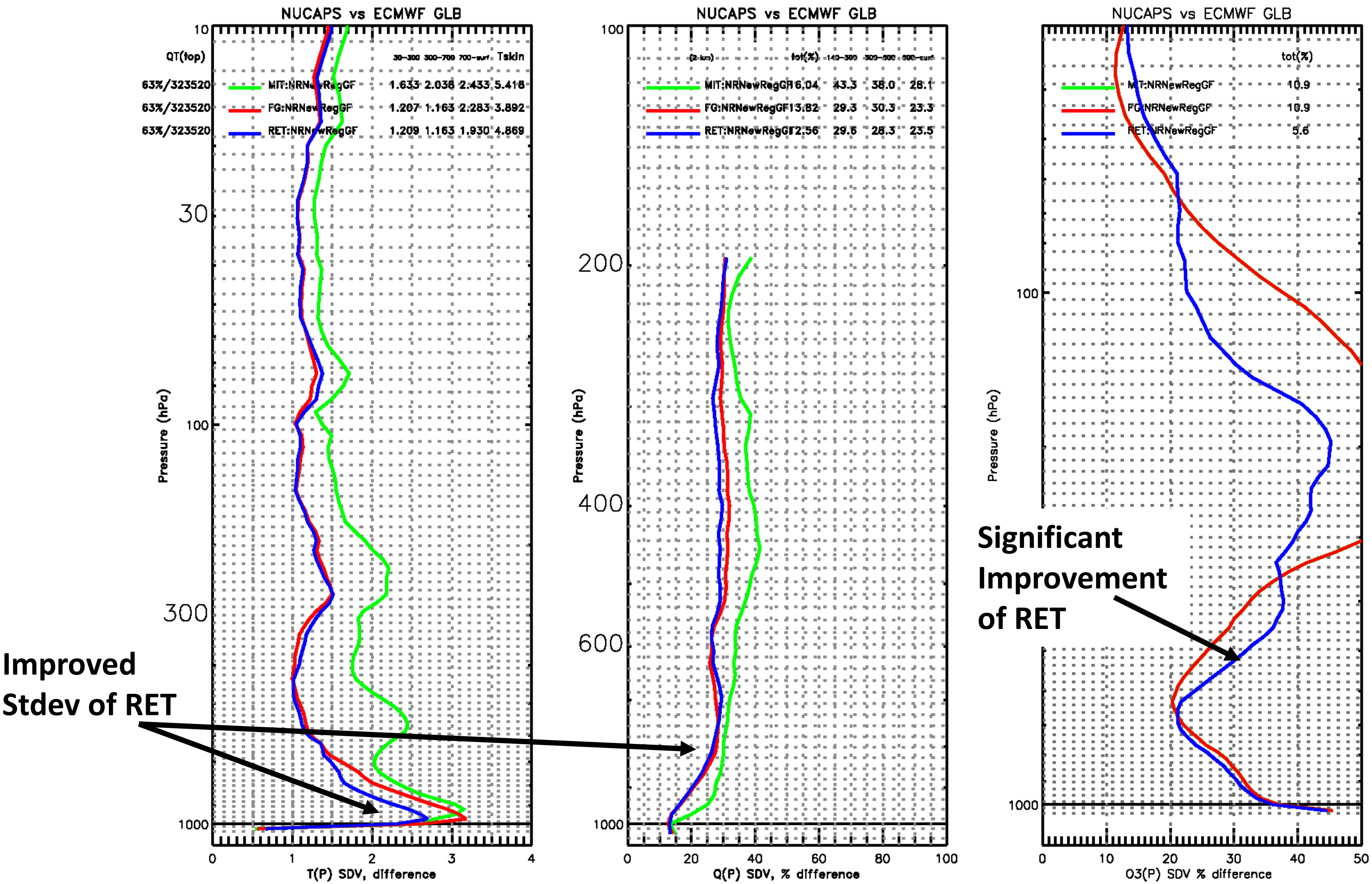
Major Accomplishments

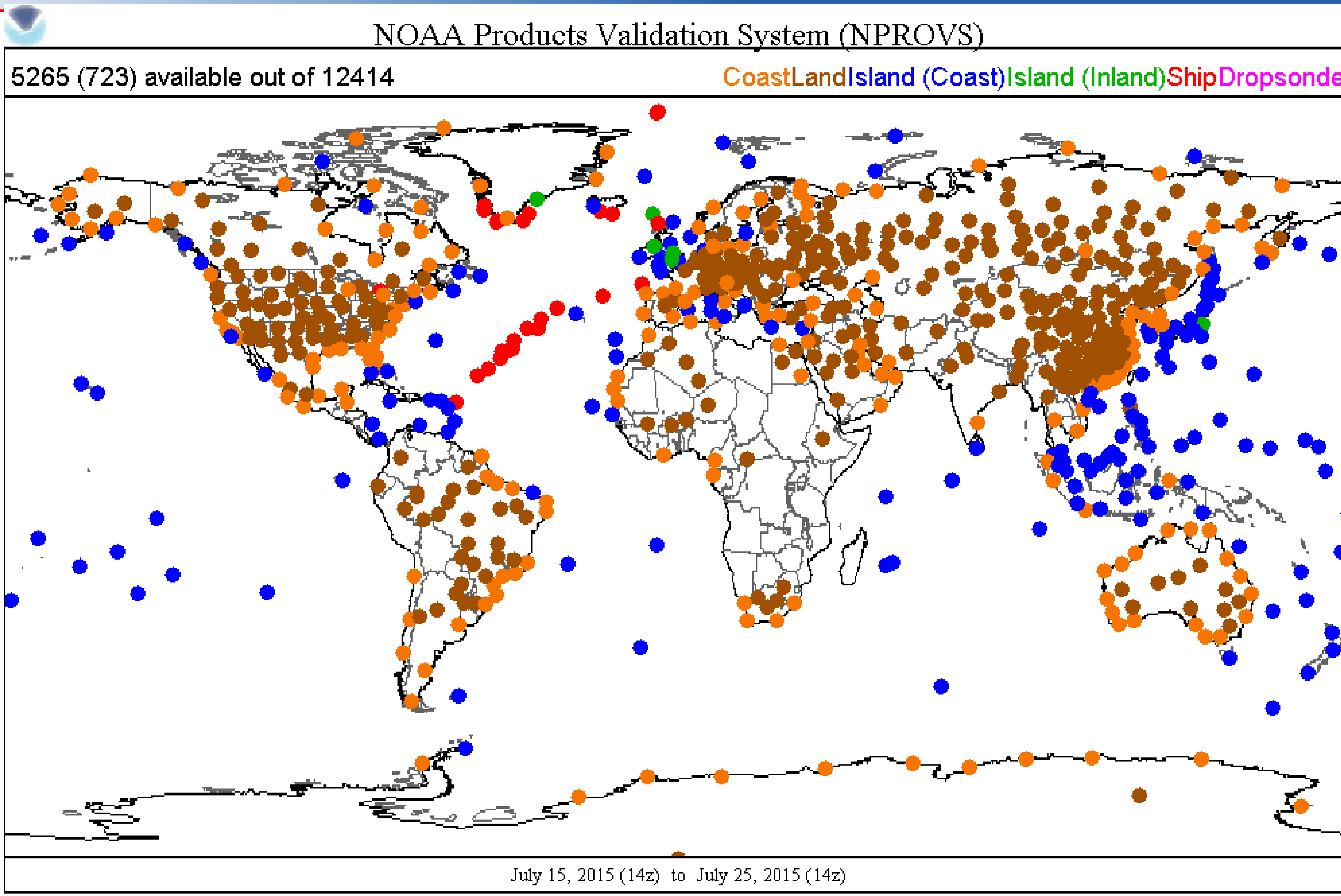
- AVTP and AVMP achieved validated maturity
- First comparison of SNPP CrIS OLR and CERES OLR
- NUCAPS parallel offline processing at STAR
- Migration of NUCAPS codes for GFORTRAN and IFORT by OSPO/NDE requirement
- Integrated ozonesonde truth dataset for validation of the CrIS ozone profile
- Supported 2015 CalWater/ACAPEX campaign onboard the NOAA Ship *Ronald H. Brown*
- Developed/implemented versatile ATMS/CrIS mapping algorithms
- EDR quality significantly improved after fixed bugs and used new regression coefficients
- Interactions with users: AWIPS, NOAA/CPC, NOAA/ARL

NUCAPS Nom. Res. Offline Old IR Regression Coeff. vs ECMWF: Stdev (2015-02-17)



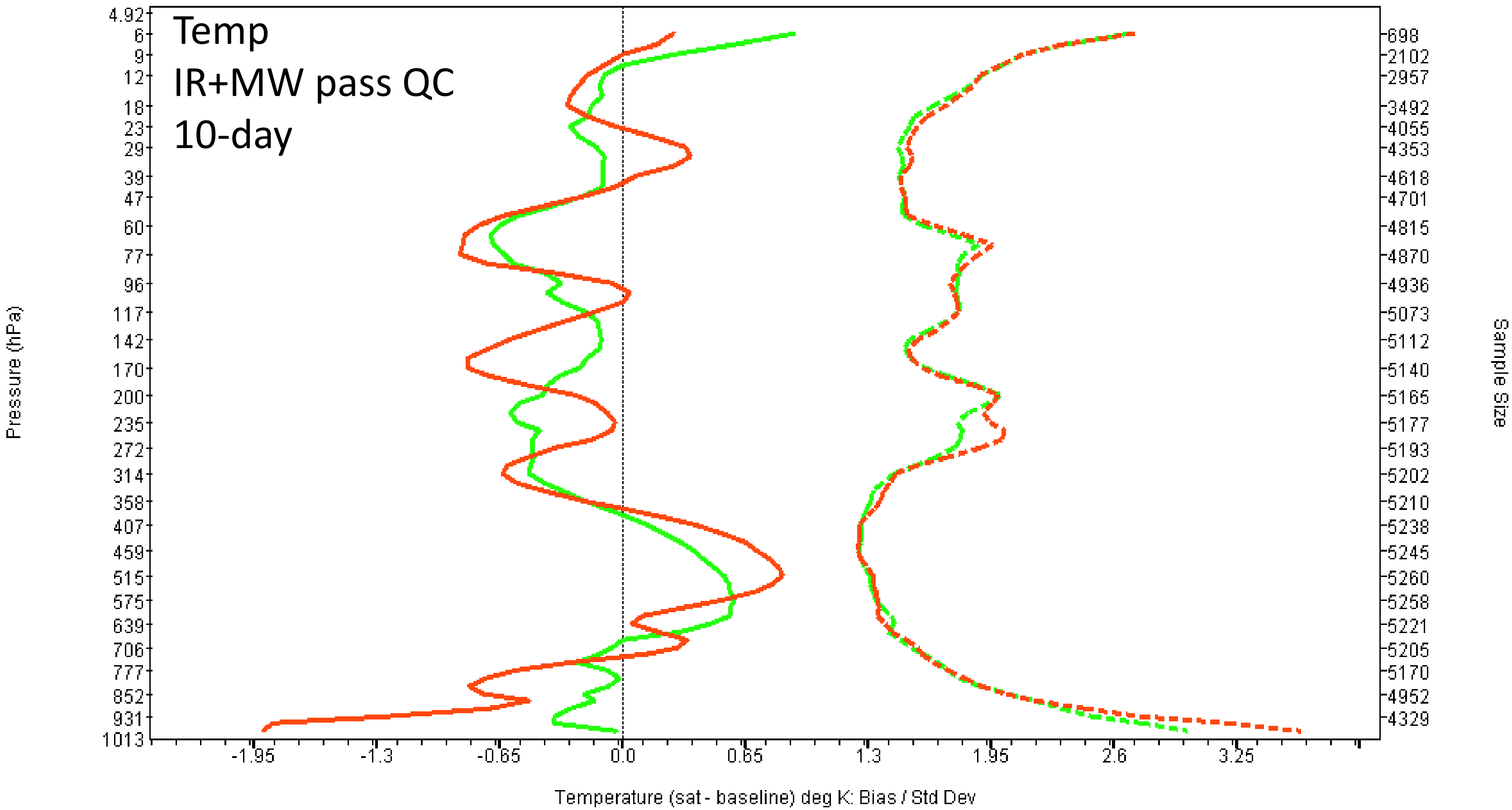
NUCAPS Nom. Res. Offline New IR Regression Coeff. vs ECMWF: Stdev (2015-02-17)





10-day sample collocated with NUCAPS IR+MW pass QC
including newly deployed NUCAPS parallel (test) system

NOAA Products Validation System (NPROVS)

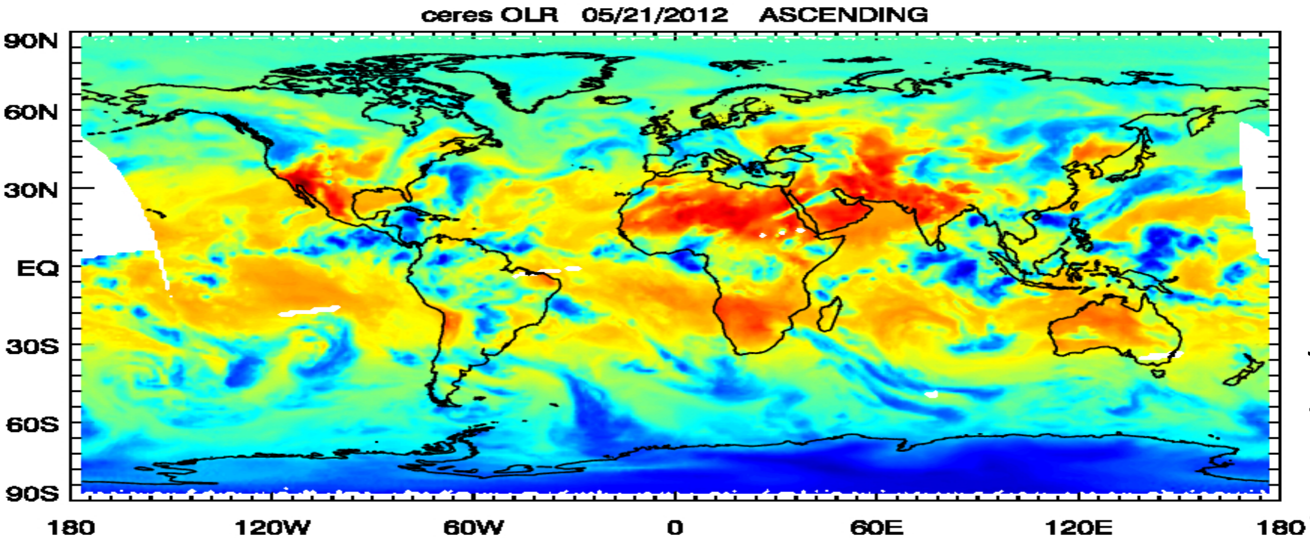


Baseline: Radiosonde Radiosonde

NUCAPS

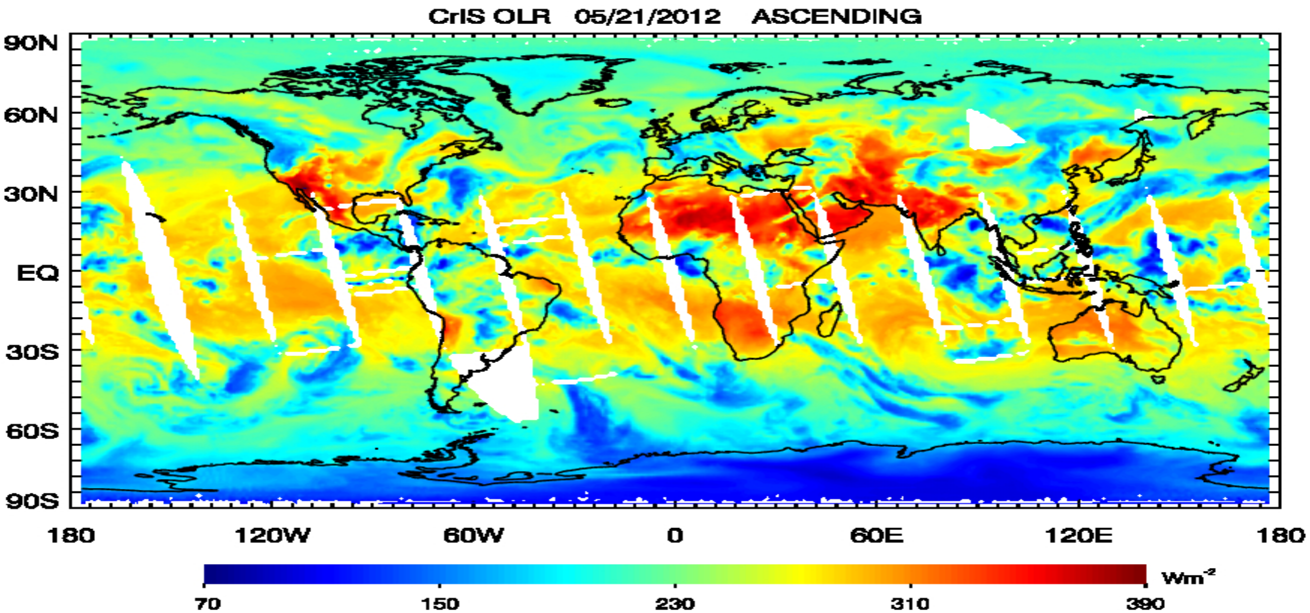
NUCAPS Test

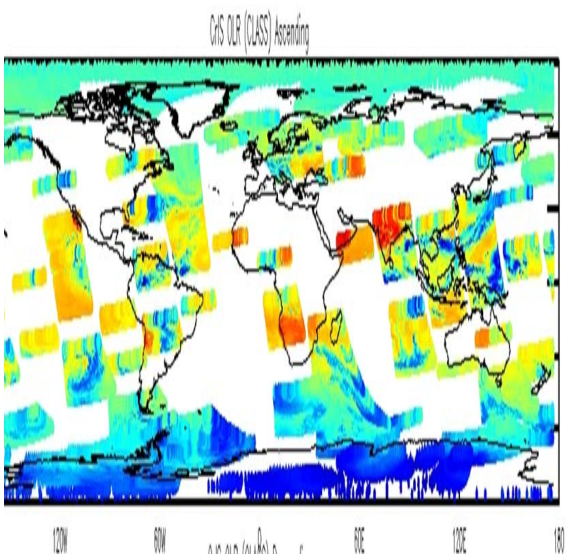
SNPP CrIS OLR vs CERES OLR, May 21, 2012



CERES S-NPP FM5 online
Available from
January 27 to May 31, 2012.

CrIS SDR has quality before June 2012 (see figure below) STAR AIT team re-process CrIS SDR data using current calibration method.





Users

- AWIPS-II (Soundings)
  - Atmospheric stability condition for severe storms
  - Nowcasting
  - Alaska (cold core)
  - Monthly telecon with AWIPS forecasters (Bill Sjoberg)
- NOAA/CPC (OLR)
- NOAA/ARL (IR ozone and trace gases)
- TOAST (IR ozone)
- Support CrIS future missions: close spectral gaps between bands, and improve spatial resolution.
- Basic and applied geophysical science research/investigation
  - Users via NOAA CLASS
  - Universities and peer-review publications

Moving Towards J1

1. Radiative transfer assessment for CrIS full-spectral data
2. NUCAPS upgrade for CrIS full-spectral data
3. Channel selections/subsets
4. Regression coefficient generation
5. Error/uncertainty characterization
6. Product tuning
7. NUCAPS ozone retrieval algorithm improvement and validation
8. Trace gas (CO, CO_2, and CH_4) algorithm development for JPSS CrIS
9. J1 product validation (soundings, OLR, trace gases…)
10. Dedicated testbed(s) and intensive field campaigns data for validation

Summary

- The accuracy of the offline NUCAPS EDRs has been improved.
- NUCAPS development, maintenance, and delivery are on track.
- Unified algorithm is now used for ATMS/CrIS and IASI/AMSU/MHS.
- First comparison between SNPP CrIS OLR and CERES OLR is conducted.
- NUCAPS parallel offline processing at STAR

Issues:

- Few validation data for trace gas EDRs.

FY16 SNPP Milestone

- Outgoing long-wave radiation (OLR) EDR validation review
- CrIS ozone algorithm improvement
- IR ozone validation review (provisional)
- NUCAPS upgrades including CrIS full-spectral data
- Trace gas EDRs (CO, CO_2, CH_4) algorithm development/improvement
- Aircraft, satellite, dedicated radiosonde campaign for NUCAPS validation
- Maintain dedicated radiosonde for NUCAPS validation

J2 and Beyond: Future Improvements

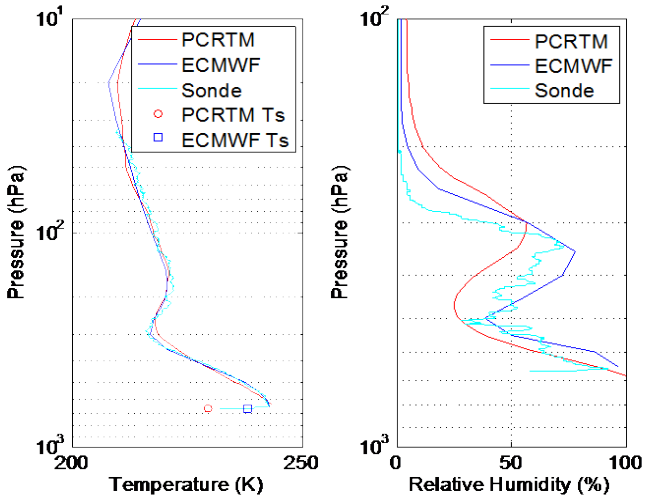
- We support CrIS SDR team and the SDR team studying
  - Close spectral gap: more information for trace gas retrievals
  - More FOVs (6x6 vs 3x3): increase homogeneous observations, significantly increase clear-sky hunting and overcast hunting.
- ATMS/CrIS/VIIRS Retrieval
  - Add cloud information to improve EDRs over cloudy areas
  - High spatial resolution for small-scale severe weather
- Customized Retrievals
  - Better trace gas EDR for air quality studies
  - Fine spatial resolution for small-scale severe weather
  - Selected super retrievals

Aircraft NAST-I / S-HIS and dropsonde for SNPP EDR Validation

- **SNPP-2 Field Validation Campaign conducted from March 7 to March 31, 2015 over Iceland and Greenland**
  - NUCAPS EDR products
  - METOP-A IASI/AMSU/MHS Level 1 products
  - METOP-B IASI/AMSU/MHS Level 1 products
  - NAST-I hyperspectral IR radiance spectra
  - ECMWF reanalysis data interpolated to CrIS/ATMS, IASI, and NAST footprints
  - Sondes collected for the overpass days
- **SNPP-1 Field Cal/Val Campaign campaign was conducted during May 2013**

D. Zhou, X. Liu et al., 2015: First Suomi NPP Cal/Val Campaign: Inter-comparison of Satellite and Aircraft Sounding Retrievals.

- **Single FOV all-sky Retrieval**



Sounding Session Wednesday Afternoon and Thursday Morning

1550 - 1730	***Session 7b: Soundings Breakout*** ***Chairs: Mark Liu and Tony Reale*** ***Conference Room B/C***		
1550 - 1610	*JPSS Soundings Product Program and Future Development*	Mitch Goldberg	JPSS Program
1610 - 1630	*NPROVS Utility in a Variety of Meteorological Cal/Val Scenarios*	Tony Reale	STAR
1630 - 1650	*Recent Algorithm Enhancements to NUCAPS*	Antonia Gambacorta	STC
1650 - 1710	*MiRS ATMS Retrievals: Algorithm Updates, Product Assessment, and Preparations for JPSS-1*	Chris Grassotti	UMD/ESSIC (STAR)
1710 - 1730	*Current SNPP Sounding Products from the Operational System and Way Forward for the JPSS-1 CrIS/ATMS Product*	Awdhesh Sharma	OSPO
0830 - 0850	*Atmospheric Soundings from JPSS - Retrievals for NWP Data Assimilation*	Bill Smith	UW,NASA SSAT
0850 - 0910	*Status and Plans for the Processing of CrIS/ATMS at the GSFC SRT*	Joel Susskind	NASA GSFC
0910 - 0930	*The MTG-IRS Level 2 Processor: Physical Basis, Selected Results, and Planned Evolution*	Stephen A. Tjemkes	EUMETSAT
0930 - 0950	*An Overview of NASA's Orbiting Carbon Observatory-2 (OCO-2)*	Lesley Ott	NASA GSFC
0950 - 1010	*NUCAPS Product Validation*	Nick Nalli	IMSG (STAR)
1010 - 1030	*Break*		
1030 - 1050	*Evaluation of NUCAPS within high impact mesoscale events: overview of the CalWater-2015 field campaign*	Chris Barnet	STC
1050 - 1110	*Applications Using Satellite Sounder Products at the NASA SPoRT Center*	Emily Berndt	NASA SPoRT
1110 - 1130	*NUCAPS Demonstration at the HWT 2015 Spring Experiment*	Bill Line	SPC
1130 - 1150	*The Utility of NUCAPS in Operational Forecasting*	Dan Nietfeld	NWS
1150 - 1210	*OLR for NOAA Precipitation Verification*	Pingping Xie	CPC
1210 - 1230	*Trace Gas Applications to Air Quality Forecasting*	Pius Lee	ARL

MiRS ATMS Retrievals: Algorithm Updates, Product Assessment, and Preparations for JPSS-1

Product/Algorithm: ***MiRS (Microwave Integrated Retrieval System)***

Contributors: ***X. Zhan, C. Grassotti, M. Chattopadhyay, J. Davies***

Date: August 24, 2015

MiRS Cal/Val Team Members

Team Member	Organization	Roles and Responsibilities
X. Zhan (Task Lead)	NESDIS/STAR/SMCD	Project management
C. Grassotti (Contractor, Technical Lead)	NESDIS/STAR/SMCD (U. MD./ESSIC)	Coordination of technical activities; review/deliverable planning
M. Chattopadhyay (Contractor, 50%)	NESDIS/STAR/SMCD (AER, Inc.)	DAP preparation, EDR generation/validation

MiRS S-NPP Product Overview: Product List

- **MiRS V9.2 Currently running on S-NPP/ATMS operationally at NDE (since 2013), also running at OSPO on 8 different satellites/sensors**
- **V11.0 delivered Sept 2014 (for N18, N19, MetopA, MetopB, F17 HR)**
- **V11.1 delivered August 2015 to OSPO (for N18, N19, MetopA, MetopB, F17, F18) and NDE for ATMS (pre-DAP for V11.2)**
- **Numerous algorithm updates/improvements in V11.0 and V11.1**

V9.2/V11.0
Atmospheric Temperature profile
Atmospheric Water Vapor profile
Total Precipitable Water
Land Surface Temperature
Surface Emissivity Spectrum
Sea-Ice Concentration
Snow Cover Extent
Snow-Water Equivalent
Integrated Cloud Liquid Water
Integrated Ice Water Path
Integrated Rain Water Path
Rainfall Rate

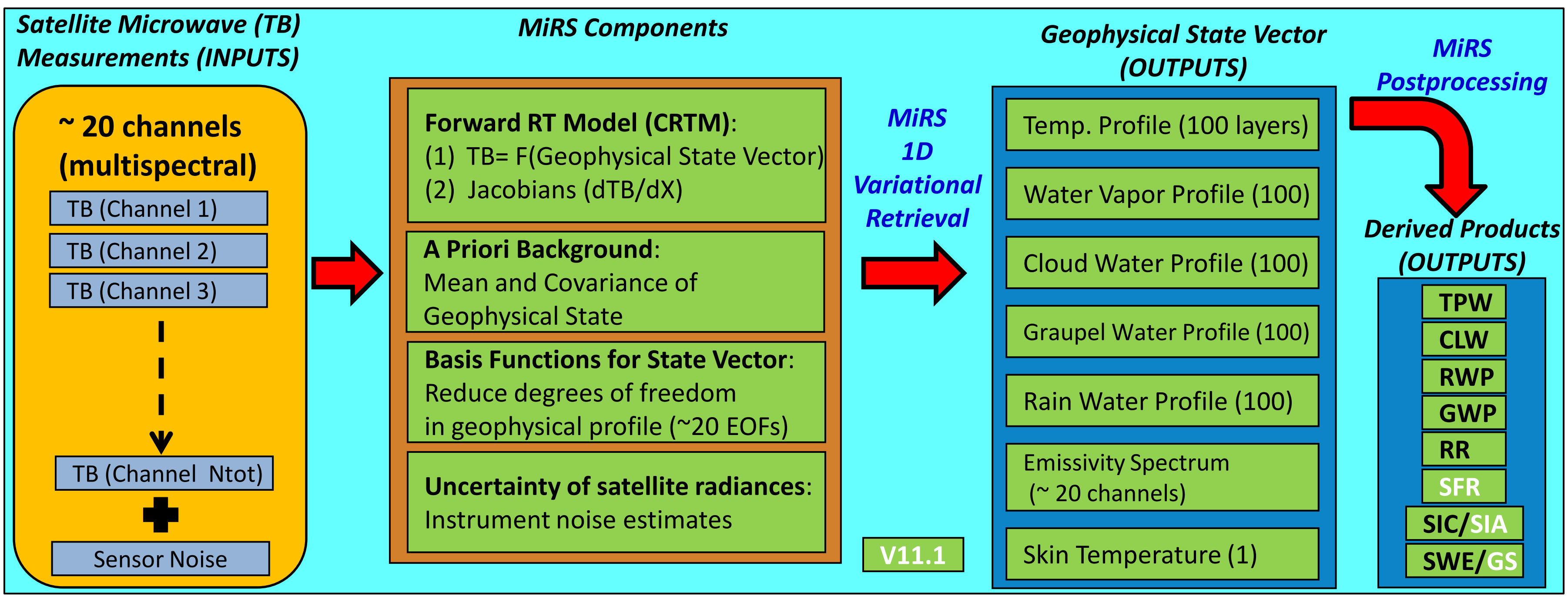
Added V11.1
Snowfall Rate (MSPPS, AMSU/MHS currently)
Sea Ice Age (FY, MY)
Snow Grain Size

MiRS S-NPP Product Overview: Cal/Val Status

- **All official EDRs are compared/validated against appropriate reference data:**
  - T and WV profiles and TPW: ECMWF and GDAS analyses, radiosondes
  - RR: Stage IV over CONUS, TRMM 2A12 (when operational), IPWG, CDC daily rainfall (new plans for this year to incorporate GPM official RR in comparisons)
  - Tskin: daily comparison with NWP, limited comparison with SURFRAD (more intensive comparisons planned starting March 2017 as per project plan)
  - Sea Ice Concentration: AMSRE, AMSR2, SSMIS NRT, European OSI-SAF
  - SWE: NOHRSC/SNOWDAS, European GlobSnow, AMSRE, AMSR2
- **V9.2 deficiencies included:**
  - WV, TPW moist bias in extreme cold/dry air outbreaks
  - Larger T profile std dev over land surfaces
  - Some underestimation of SWE in Siberia.
  - These have largely been addressed in the upgrade to V11.1
- **Long-term monitoring: MiRS website contains product maps, comparisons with reference data, and radiometric monitoring; plan to work with STAR webmaster (L. Brown) to update website to accommodate JPSS-1 requirements.**
  - http://www.star.nesdis.noaa.gov/smcd/mirs/

JPSS-1 Readiness: MiRS Algorithm Overview

- **Basic Retrieval Problem**: Given a limited set of satellite-based microwave radiometric measurements, which are related to the Earth atmospheric and surface conditions (state vector) in a linear or non-linear way, how does one determine the elements of this state vector?
  - State vector can have 100+ elements
  - Problem is underdetermined: many more variables to retrieve than measurements; more than one combination of atm/sfc conditions can "fit" the measurements
- **Variational Approach**: Find the "most likely" atm/sfc state that: (1) best matches the satellite measurements, and (2) is still close to an a priori estimate of the atm/sfc conditions

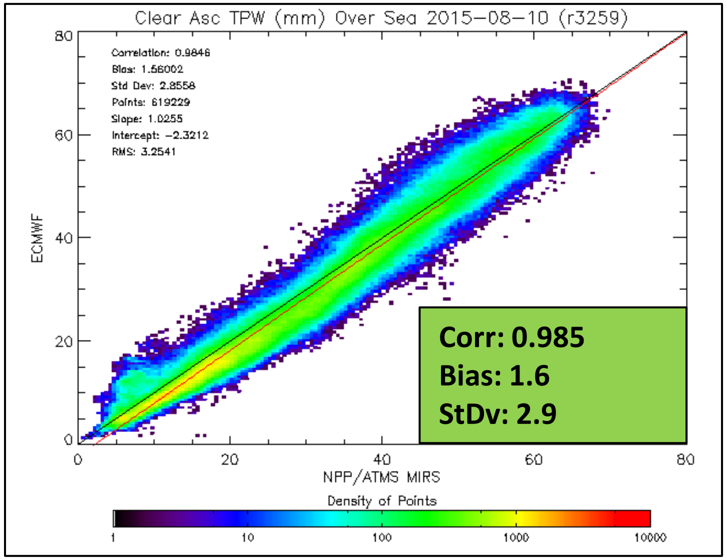


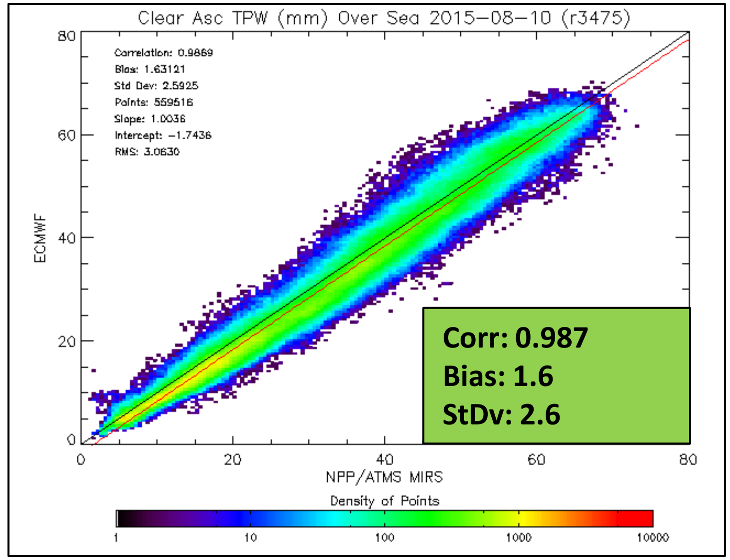
JPSS-1 Readiness: MiRS
Algorithm Changes in V11.1 (compared with v9.2)

Description	Satellites/Sensors Affected	Benefit
Integration of CRTM 2.1.1 (previously using pCRTM)	All: N18, N19, MetopA, MetopB/AMSUA-MHS, SNPP/ATMS, F17, F18/SSMIS , MT/SAPHIR	Better sync with CRTM development cycle; more realistic ice water retrievals (Jacobians)
Integration of new dynamic a priori atmospheric background	All	Large improvement in T, WV sounding; reduction in average number of iterations; increase in conv rate
Updated hydrometeor/rain rate relationships	All	Improved RR over land and ocean
Updated hydrometeor a priori background profiles	All	Improved RR over land and ocean; improved sounding products in rainy conditions
New bias corrections for all sensors	All	Needed for consistency with CRTM 2.1.1
Snow Water Equivalent (SWE) spatially-temporally variable climatology background	All	Better spatial and temporal constraint on SWE; also improved SGS retrieval
Snow Grain Size (SGS) and Sea Ice Age (SIA)	All	Preliminary Product, satisfies user request
Updated all Snow Emissivity Catalogs: finer SGS discretization and larger physical ranges	All	Smoother distributions for SGS, SWE, larger dynamic range for SGS.
Dynamic channel selection near sea ice boundary	N18, N19, MetopA, MetopB/AMSUA-MHS, SNPP/ATMS	Better convergence behavior for cross-track instruments
Miscellaneous changes to improve code efficiency, bug fixes	All	Matrix preparation time reduced from 40% to 5% of 1dvar computation time

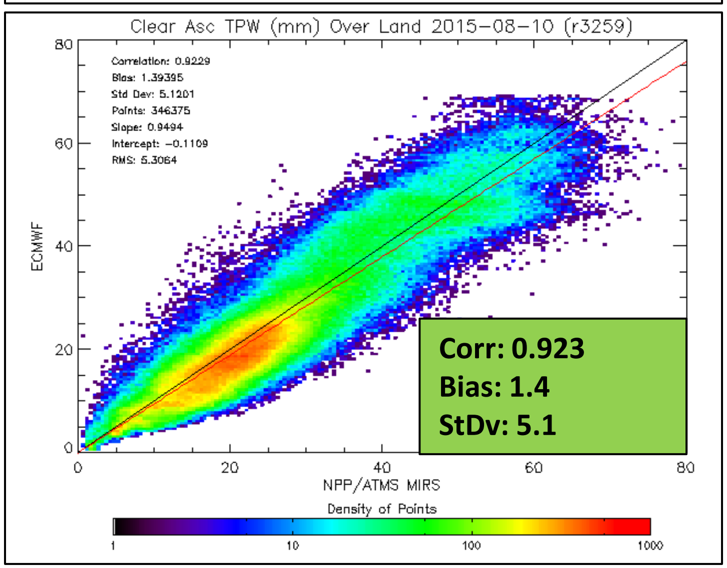
JPSS-1 Readiness: MiRS
S-NPP/ATMS TPW (mm) Performance vs. ECMWF

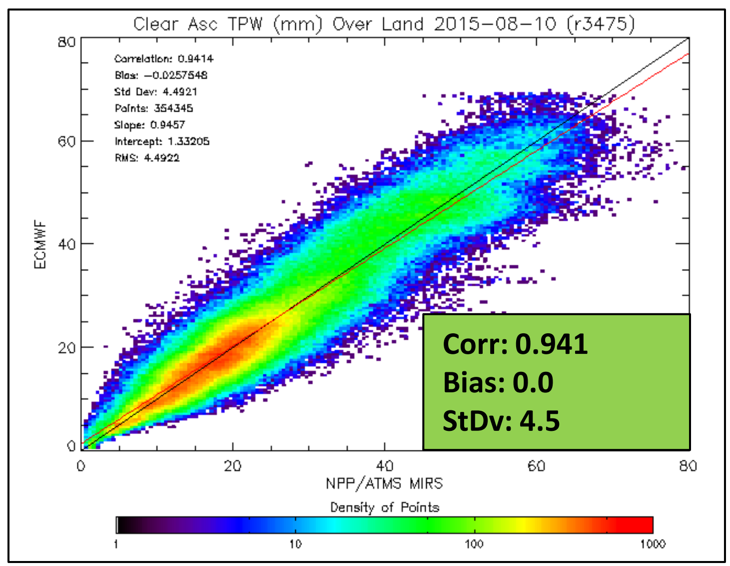
V9.2 | **V11.1**





Ocean





Land

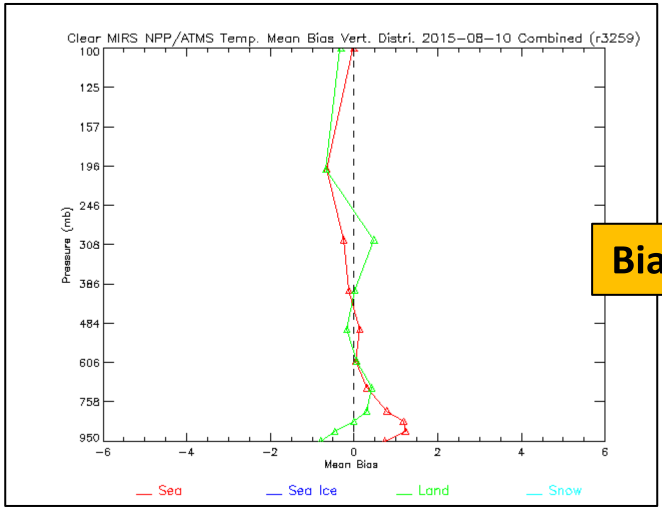
Produced daily on STAR website

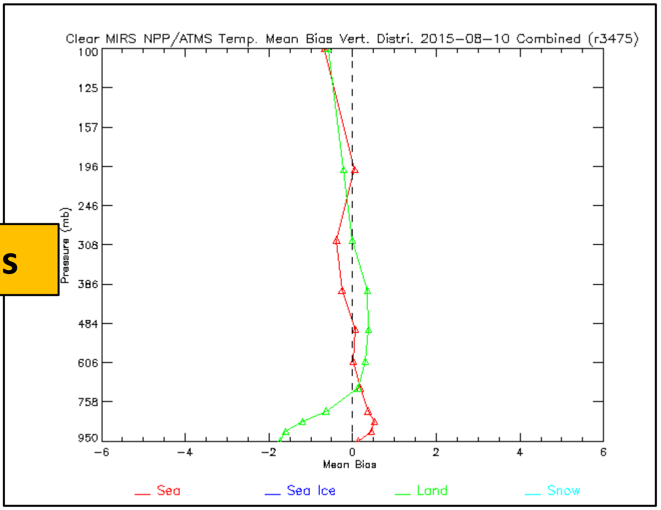
JPSS-1 Readiness: MiRS
S-NPP/ATMS Temp Sounding Performance vs. GDAS

V9.2

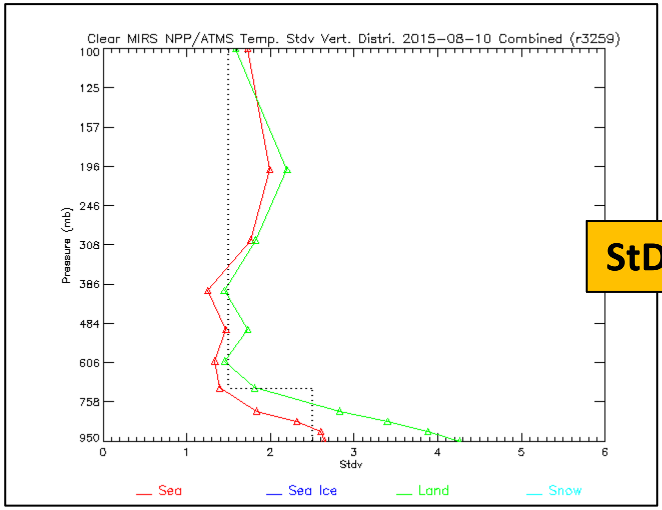
V11.1

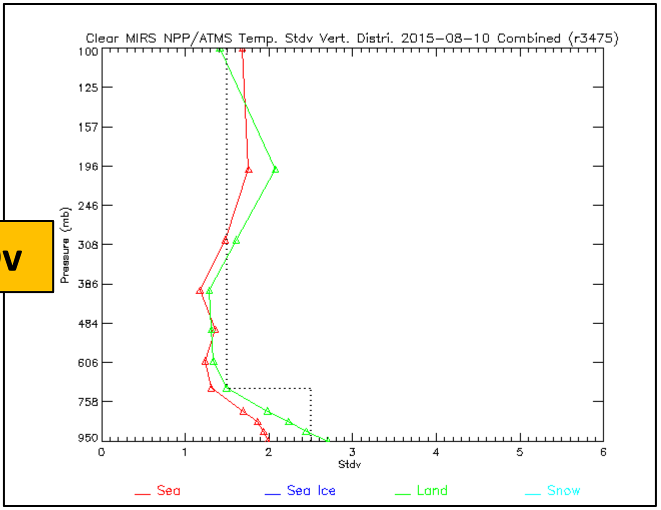
vs. GDAS





Bias





StDv

Land

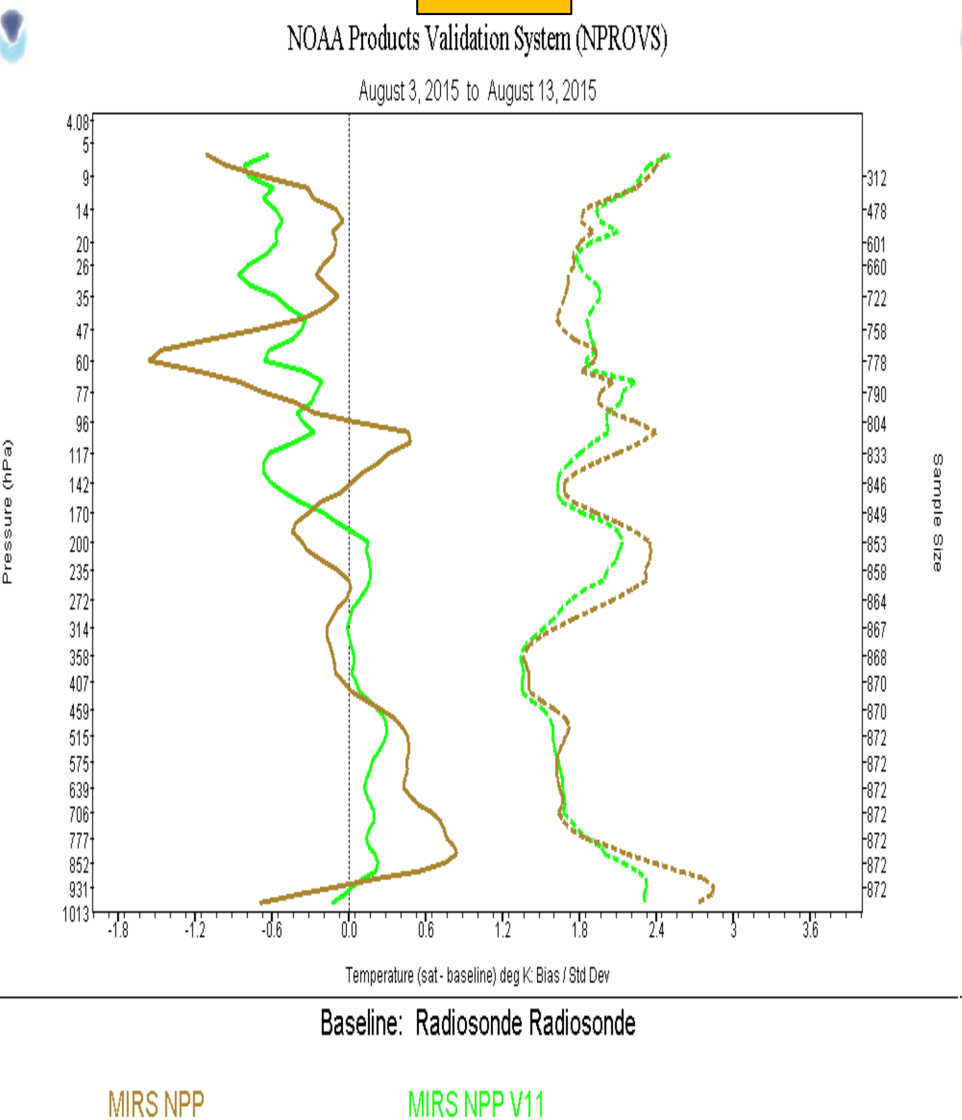
Ocean

- **V11.1 Reduction in both bias and std dev at most layers**
- **Low level cold bias over land**

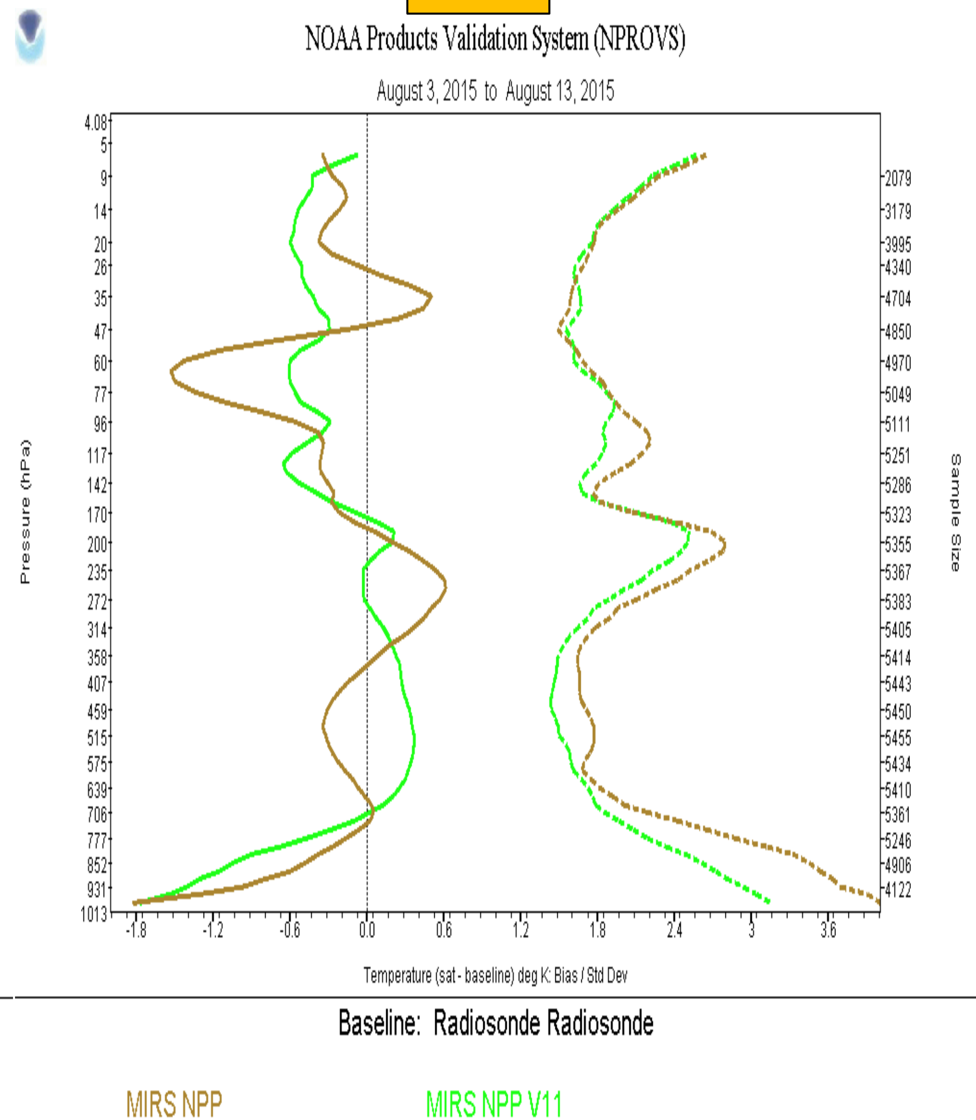
Produced daily on STAR website

JPSS-1 Readiness: MiRS
S-NPP/ATMS Temp Sounding Performance: RAOBs

Ocean

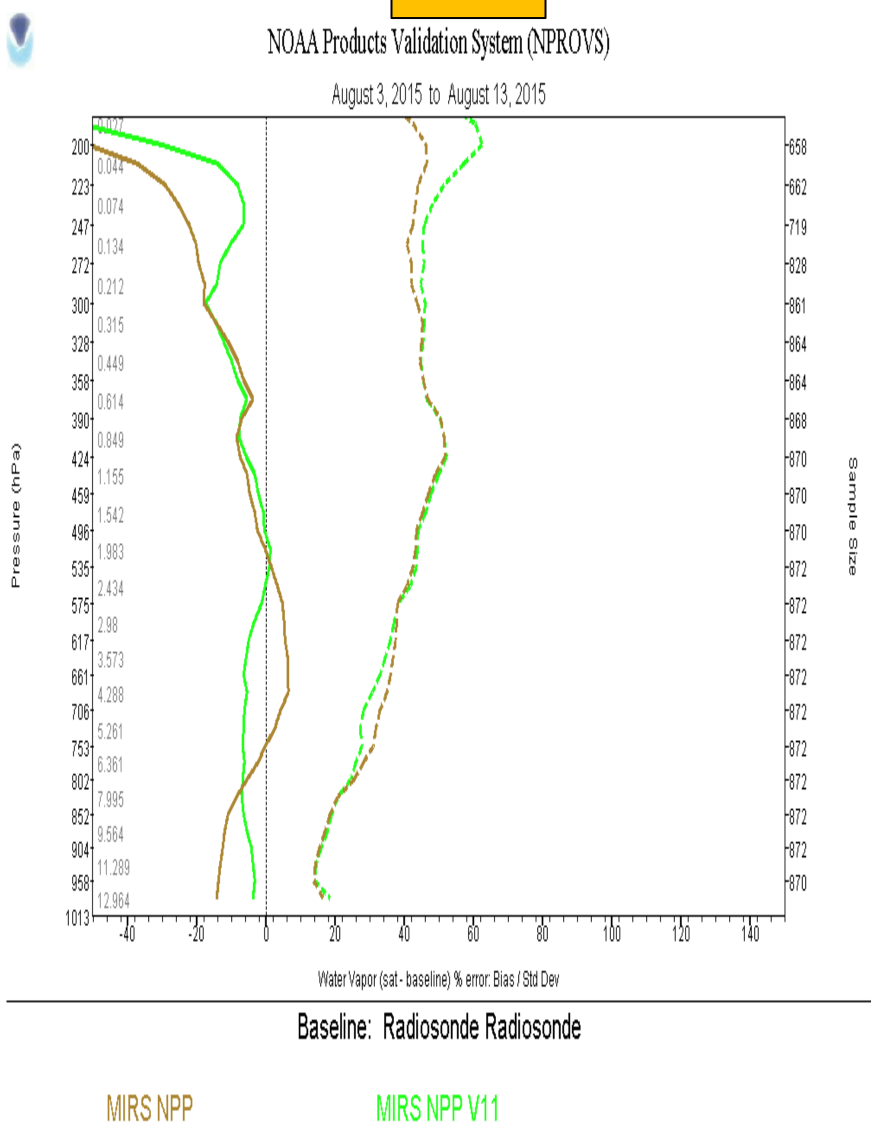


Land

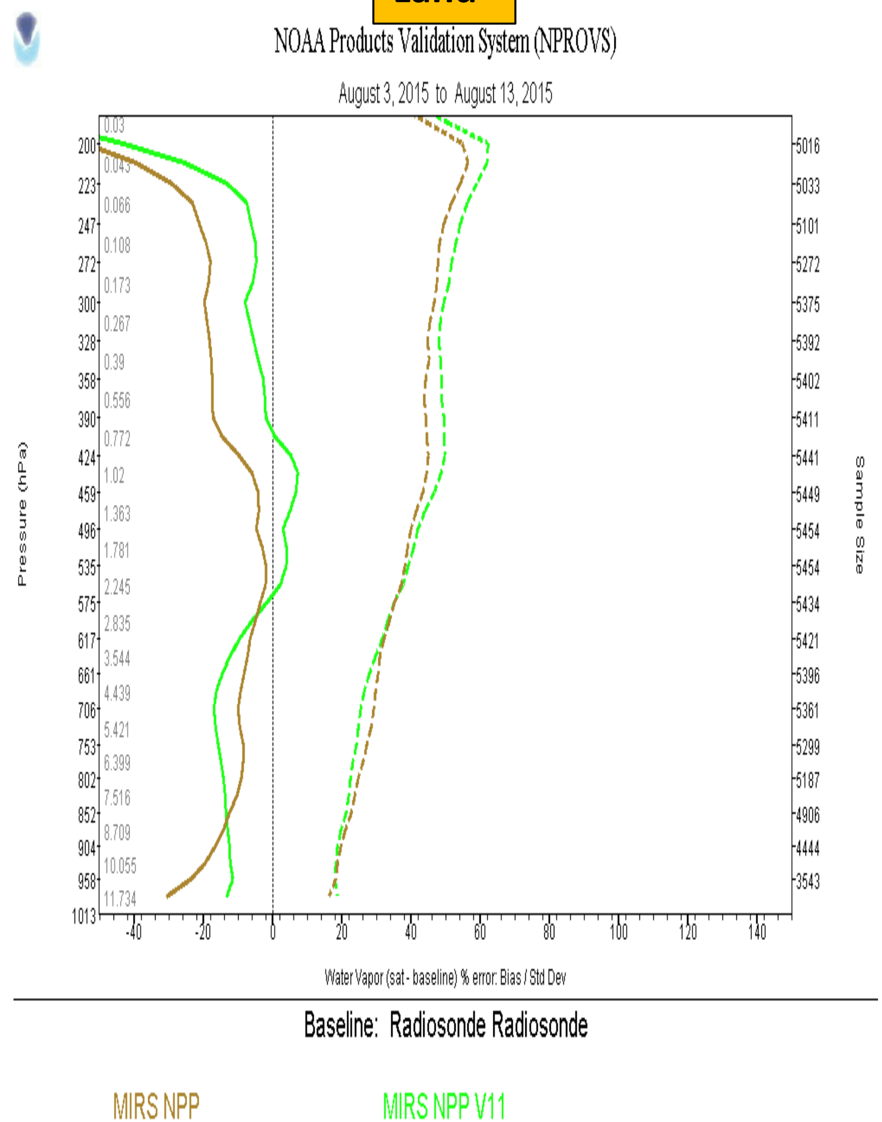


JPSS-1 Readiness: MiRS
S-NPP/ATMS WV Sounding Performance: RAOBs

Ocean



Land

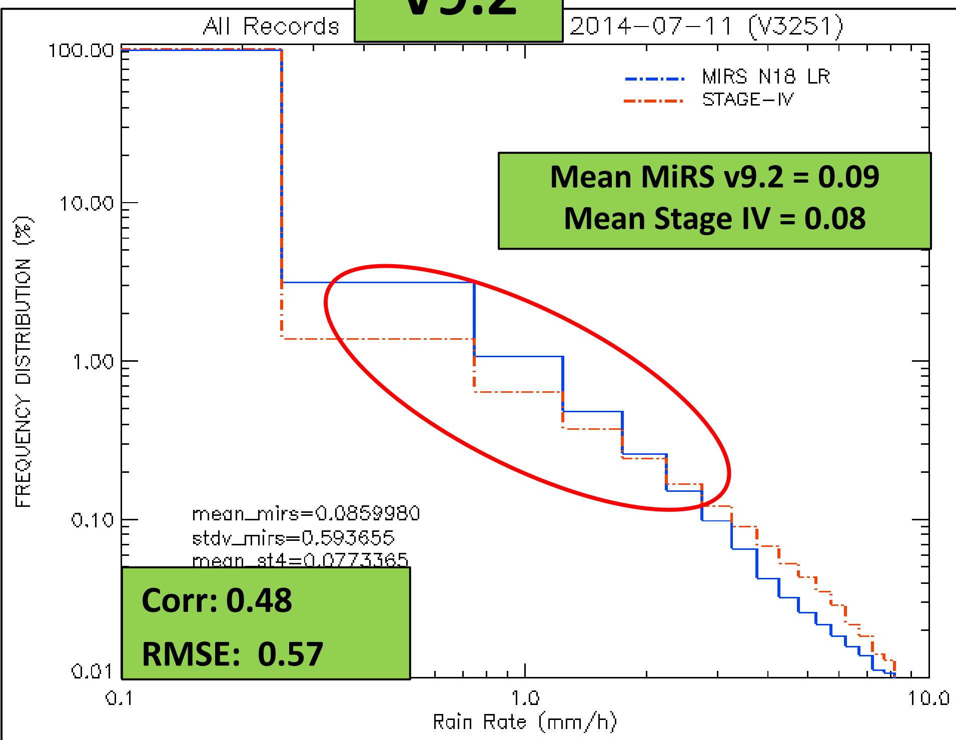


JPSS-1 Readiness: MiRS Rain Rate Performance (AMSU/MHS)

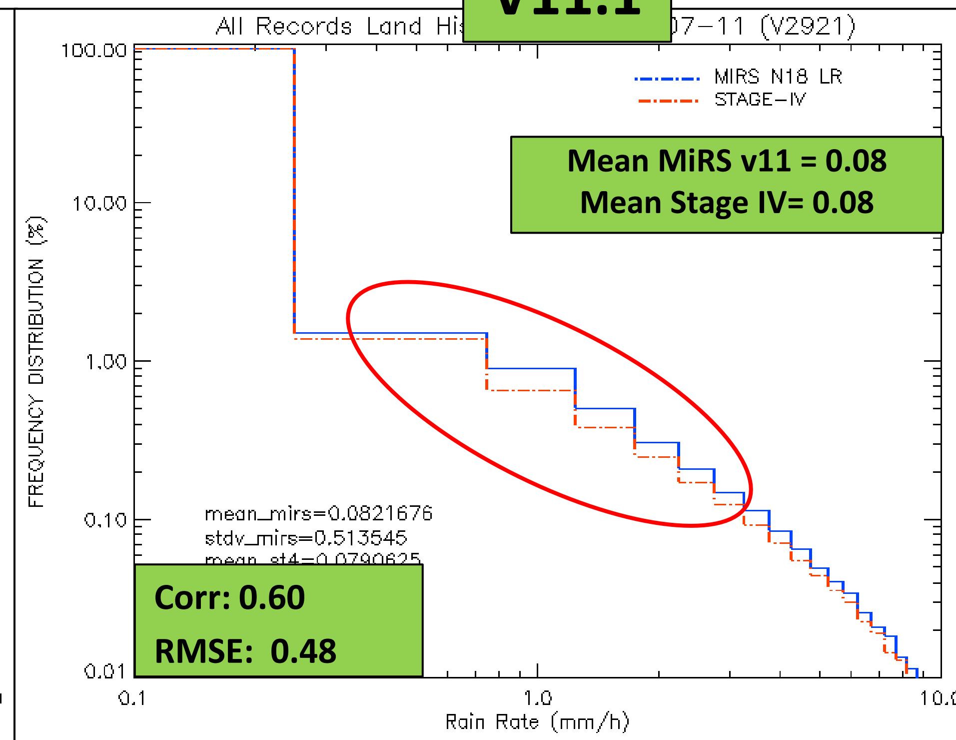
N18 Rain Rate (vs. Stage IV)

Assessment period (2009-2014)

V9.2

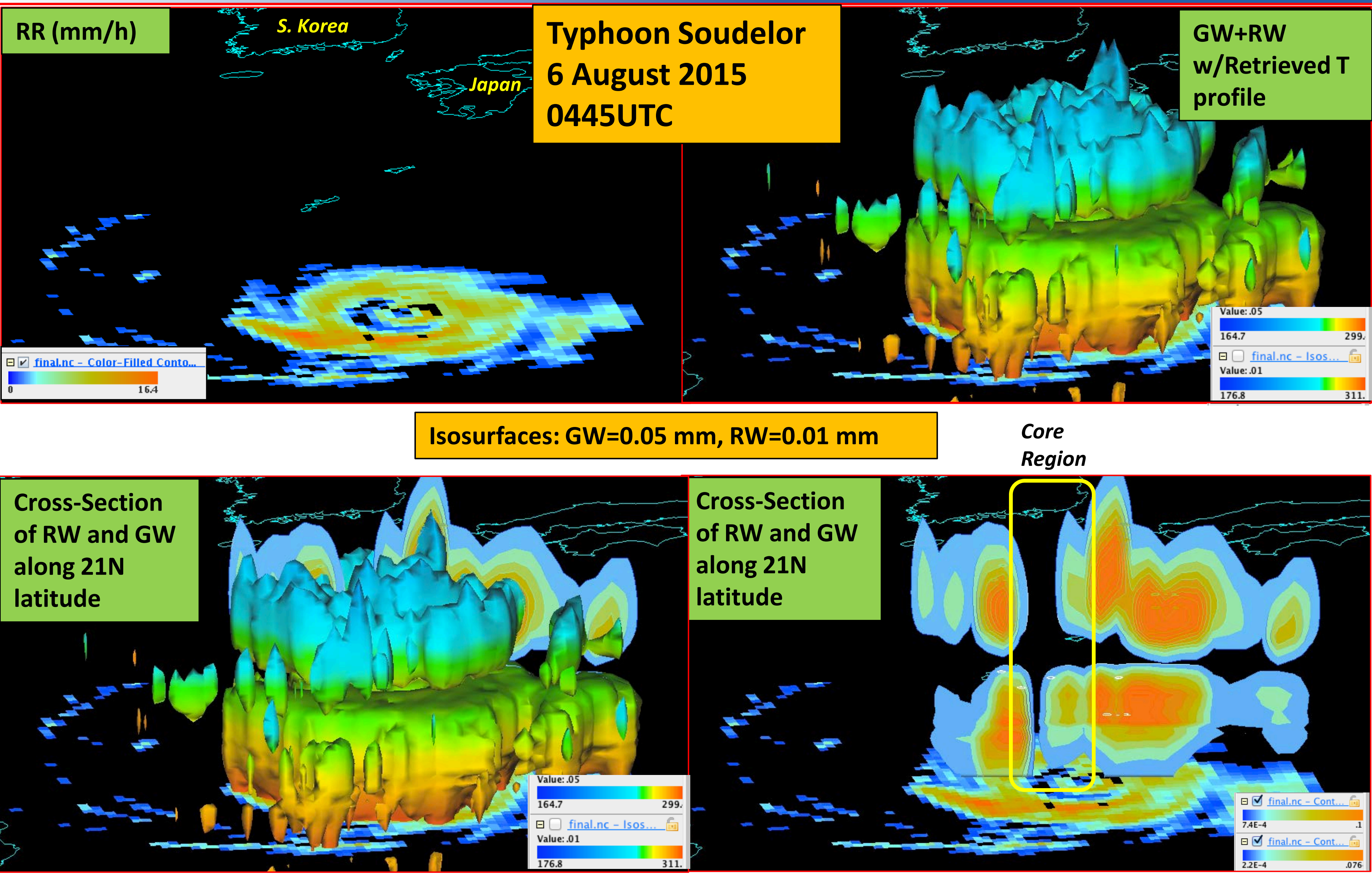


V11.1



- Better agreement in low intensities
- More consistent at higher intensities (> 3 mm/h)
- Improved correlation and lower RMSE

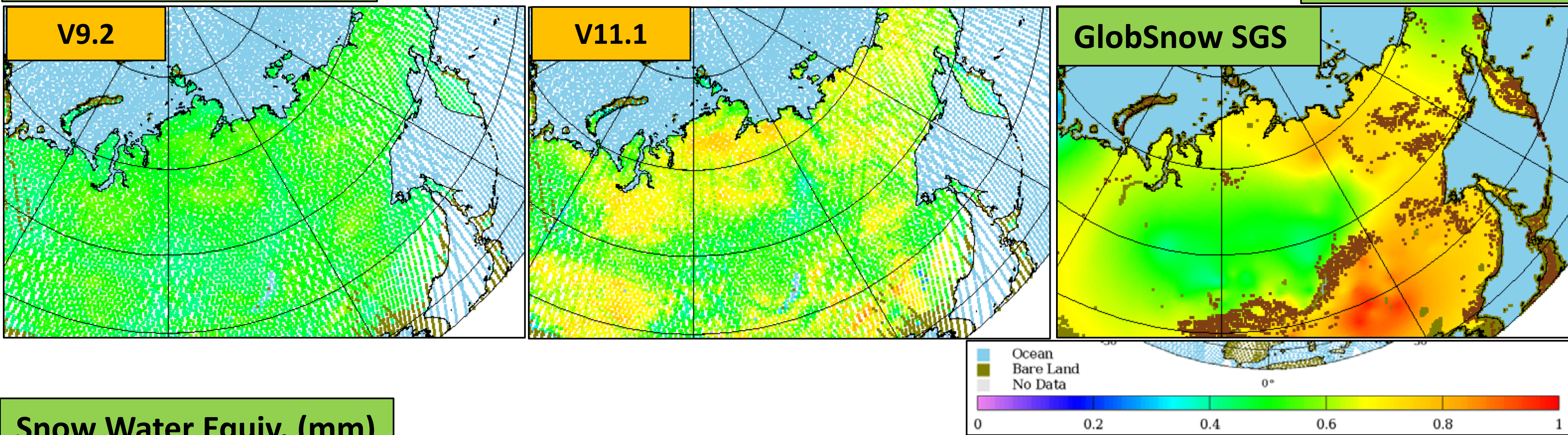
JPSS-1 Readiness: MiRS Hydrometeor Retrievals (ATMS)



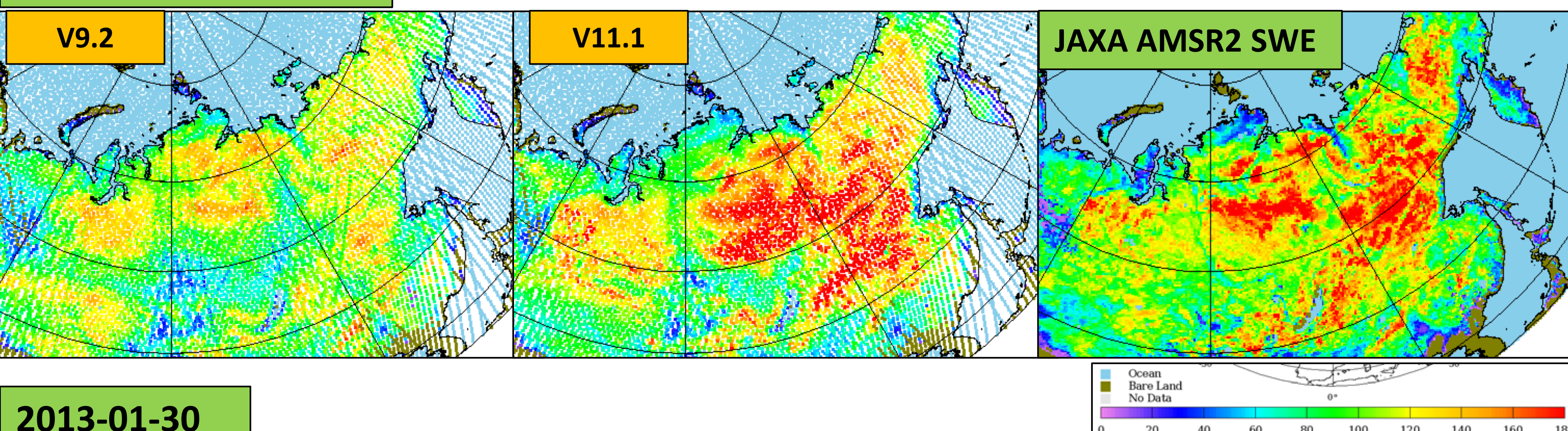
JPSS-1 Readiness:
MiRS Snow Grain Size and SWE (AMSU/MHS)

Snow Grain Size (mm)

Courtesy of FMI/ESA



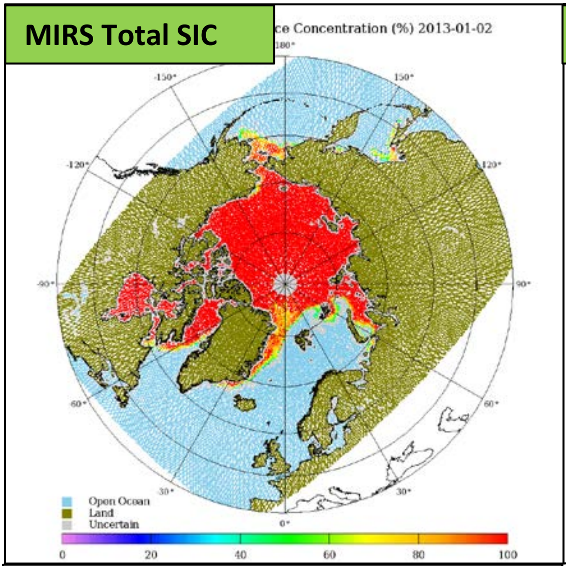
Snow Water Equiv. (mm)



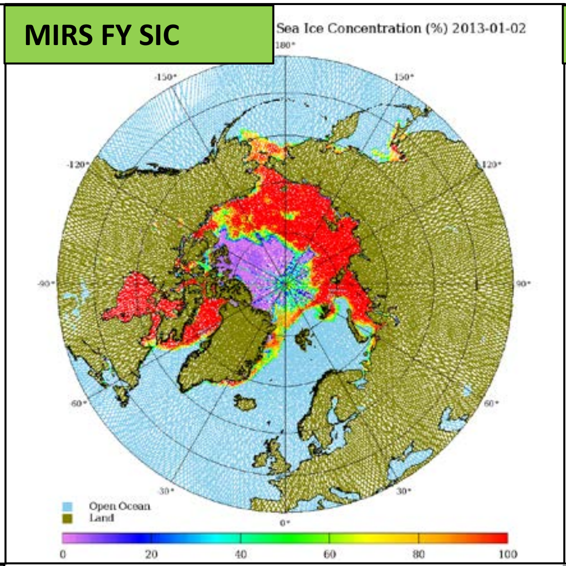
2013-01-30

JPSS-1 Readiness: MiRS Sea Ice Conc and Ice Age (AMSU/MHS)

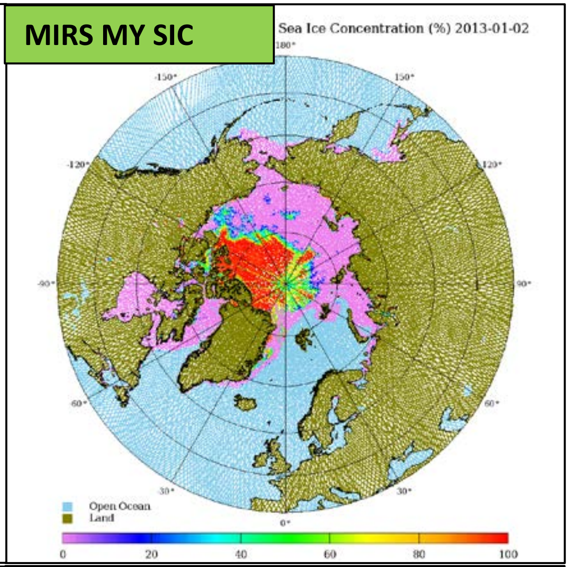
MIRS Total SIC



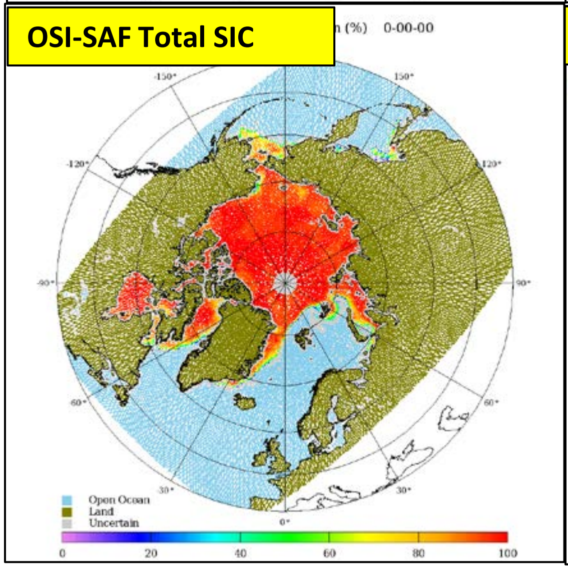
MIRS FY SIC



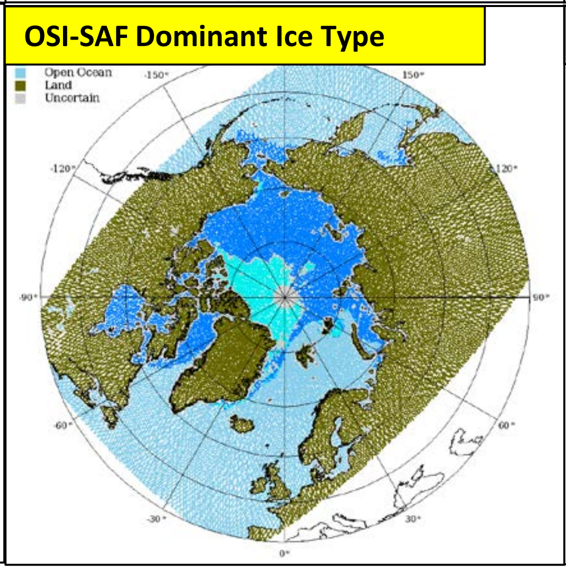
MIRS MY SIC



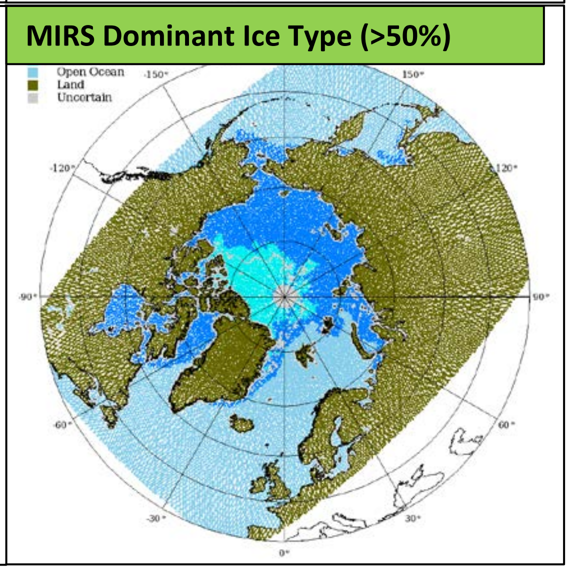
OSI-SAF Total SIC



OSI-SAF Dominant Ice Type



MIRS Dominant Ice Type (>50%)



2013-01-02

JPSS-1 Readiness: MiRS Plans/Deliverables in FY16 and Beyond

- **Good working relationship with POCs at NDE, facilitates delivery and integration.**
- **No major changes to basic MiRS software architecture anticipated**

Date(s)	Activities	Comment/Deliveries
Jul - Oct 2016	Code + data extension to JPSS-1/ATMS	****Need CRTM sensor coefficient files for J-1/ATMS and sample data****
Oct 2016	Critical Design Review	**CDR Docs**
Oct 2016 - Apr 2017	MiRS algorithm testing with sample/proxy data	
Apr 2017	**JPSS-1 Launch**	
May 2017	Preliminary DAP delivery to NDE	**pDAP (radiometric bias corrections based on limited post-launch data)**
Apr 2017 - Mar 2018	Algorithm Verification and Validation with real data	
Mar/Apr 2018	Algorithm Readiness Review + Final DAP delivery to NDE	**ARR Docs + DAP**
Oct 2017 - Sep 2018	MiRS JPSS-1/ATMS products validated to Stage 1	
Oct 2018 - Sep 2019	MiRS JPSS-1/ATMS products validated to Stage 2	

Summary & Path Forward

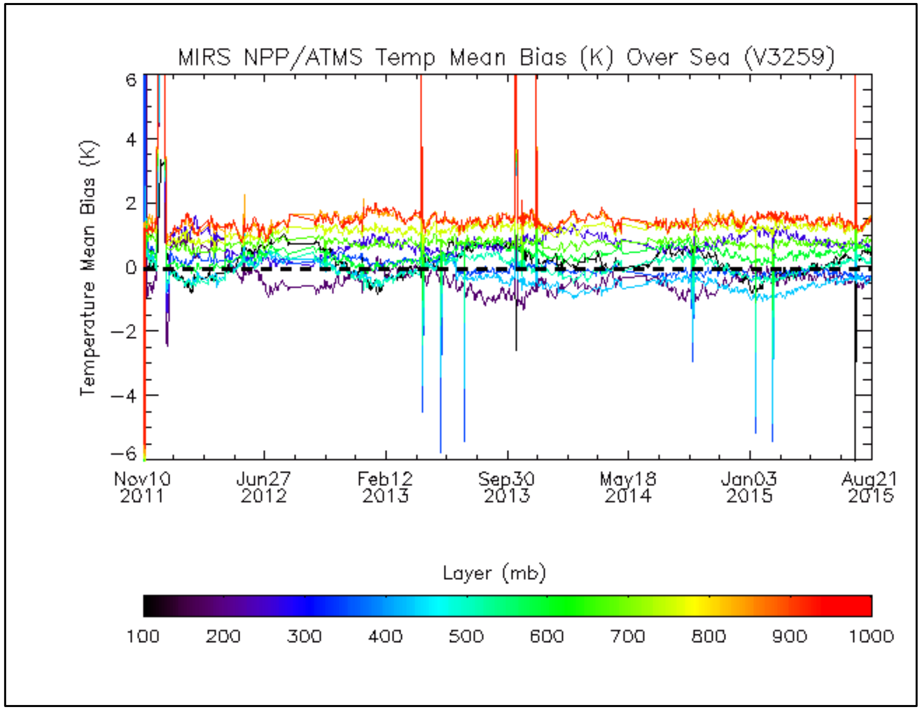
- MiRS is a robust, flexible satellite retrieval system designed for rapid, physically-based atmospheric and surface property retrievals from passive microwave measurements.
- MiRS v9.2 running at NDE since 2013.
- MiRS v11 released in September 2014, V11.1 released in this month, and V11.2 expected delivery to NDE in near future: contains numerous changes, leading to improved performance for T, WV sounding, hydrometeor, cryospheric products.
- MiRS software package already contains features designed to facilitate validation of certain EDRs (T and WV soundings). Additional off-line software exists in STAR for additional assessment and validation of RR, surface and cryospheric parameters.
- **Future Improvements:**
  - Bias corrections (air mass dependence, rainy conditions)
  - Precipitation: hydrometeor size, and distribution parameters, stratiform/convective
  - Background constraint in rainy conditions: Impacts on T and WV sounding through rain
  - Surface emissivity: project plan 2017-2018 S-NPP/ATMS emissivity product cal/val
  - Surface type: currently 4 types, move toward mixed types with unique emissivity characteristics (e.g. fuzzy clustering)

Backup Slides

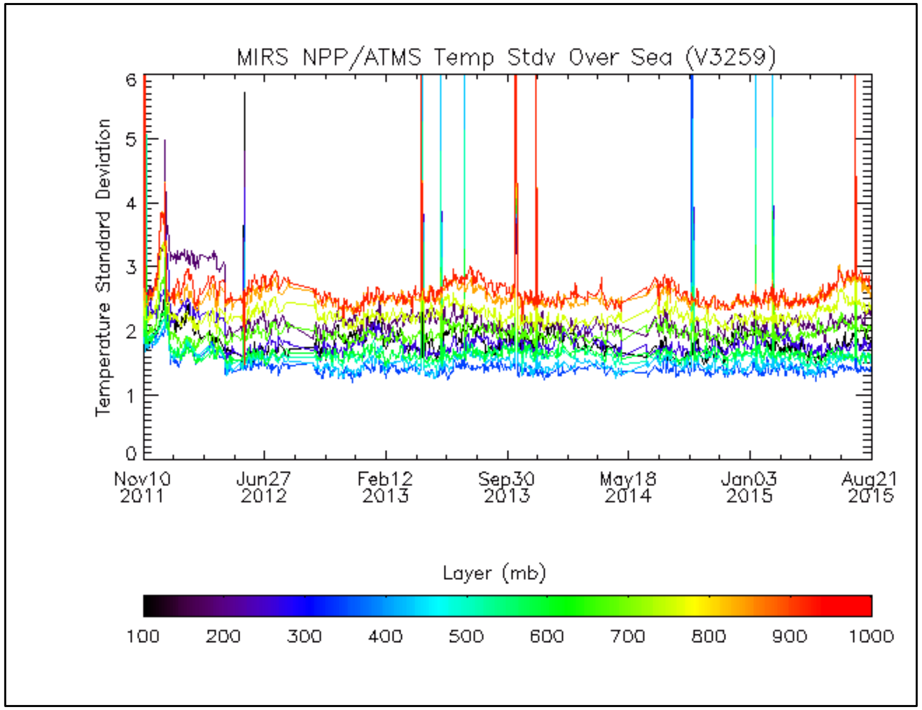
JPSS-1 Readiness: MiRS Long-Term Monitoring

- **S-NPP/ATMS MiRS v9.2 Temperature Retrieval Bias and Std Dev vs. ECMWF since Nov 2011 (Ocean)**

Bias



StDv



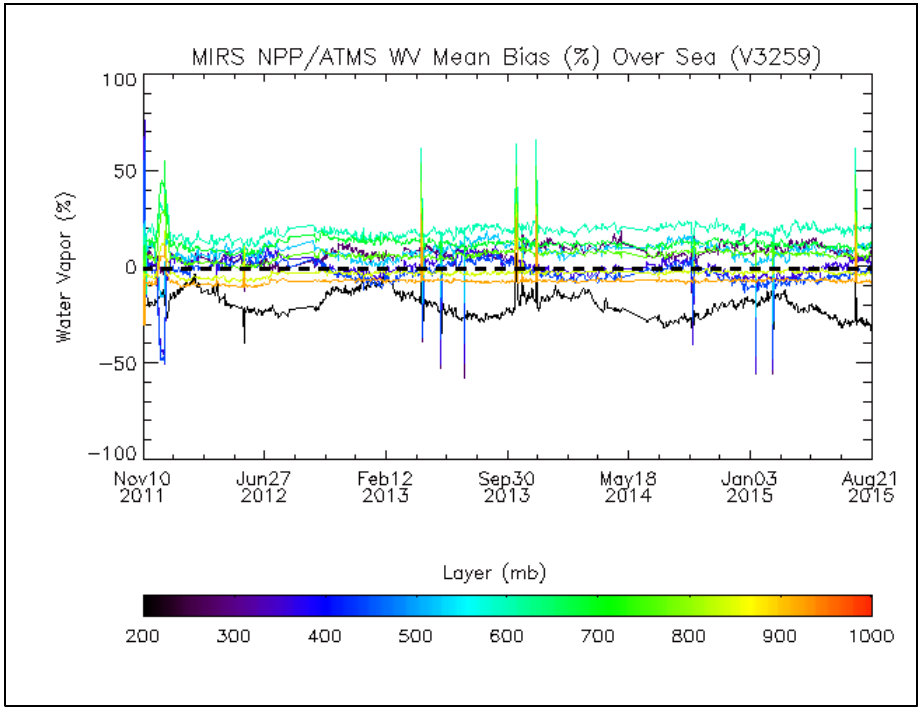
Outliers are processing errors, not retrievals

Produced daily on STAR website

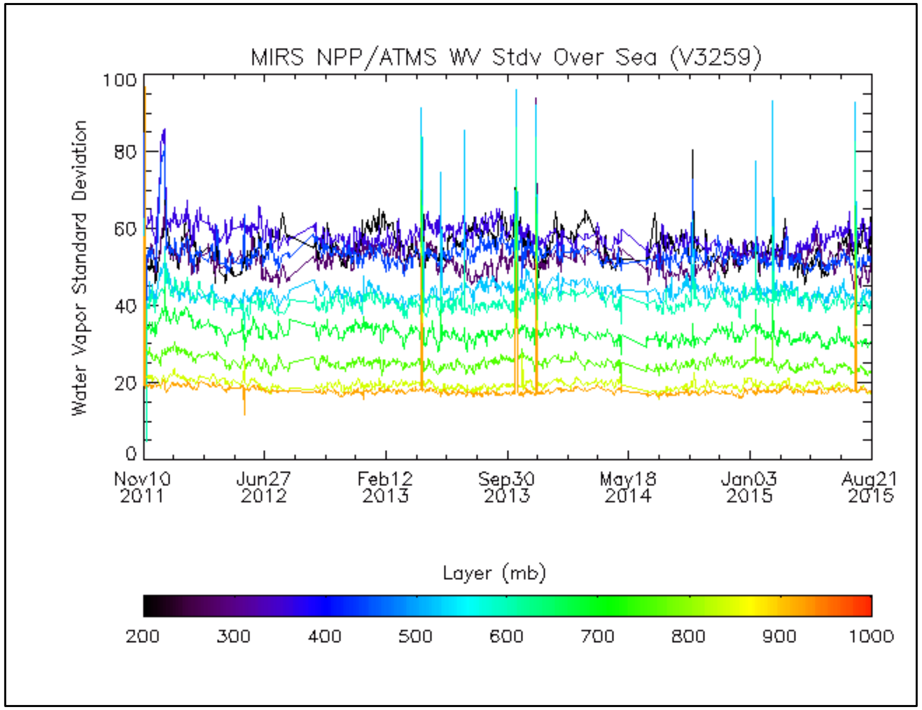
JPSS-1 Readiness: MiRS Long-Term Monitoring

- **S-NPP/ATMS MiRS v9.2 Water Vapor Retrieval Bias and Std Dev vs. ECMWF since Nov 2011 (Ocean)**

Bias



StDv

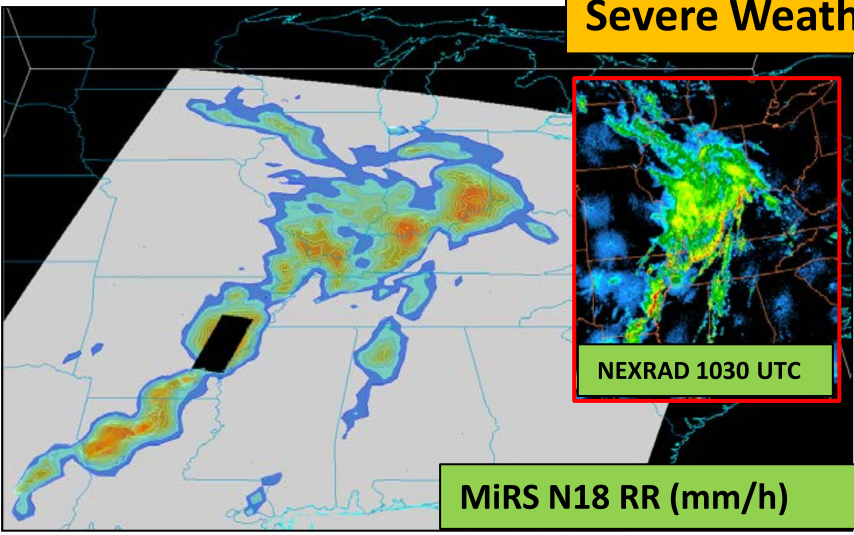


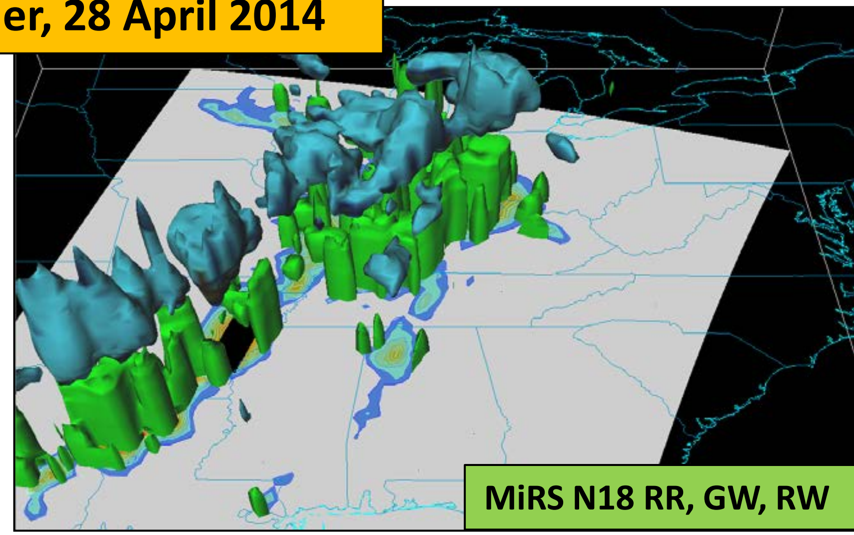
Outliers are processing errors, not retrievals

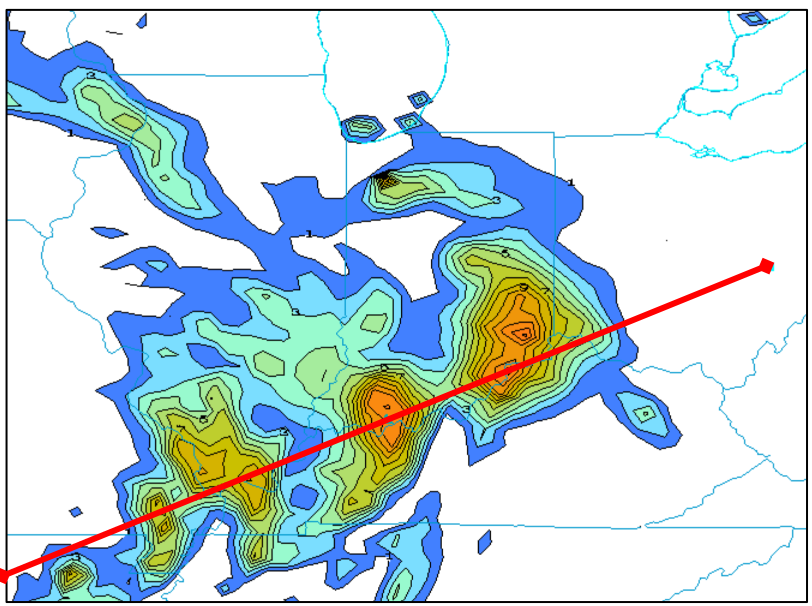
Produced daily on STAR website

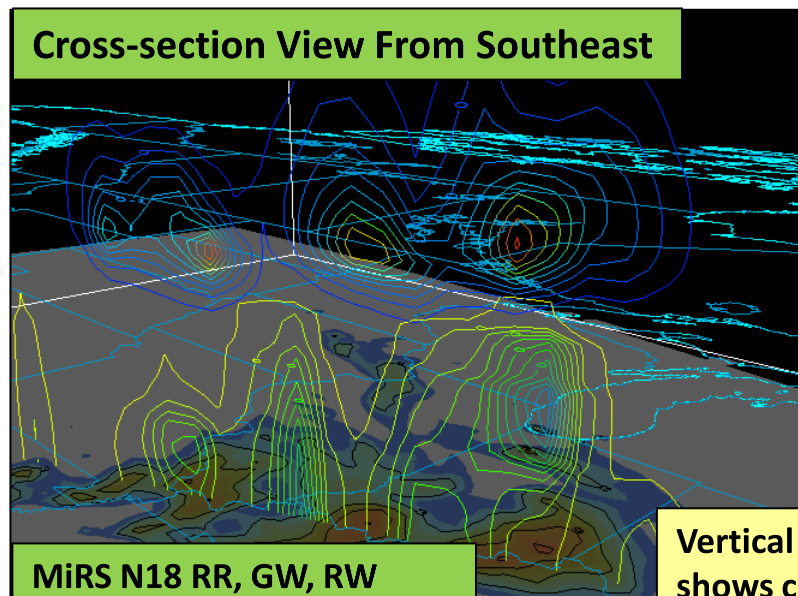
JPSS-1 Readiness: MiRS Hydrometeor Retrievals (AMSU/MHS)

Severe Weather, 28 April 2014



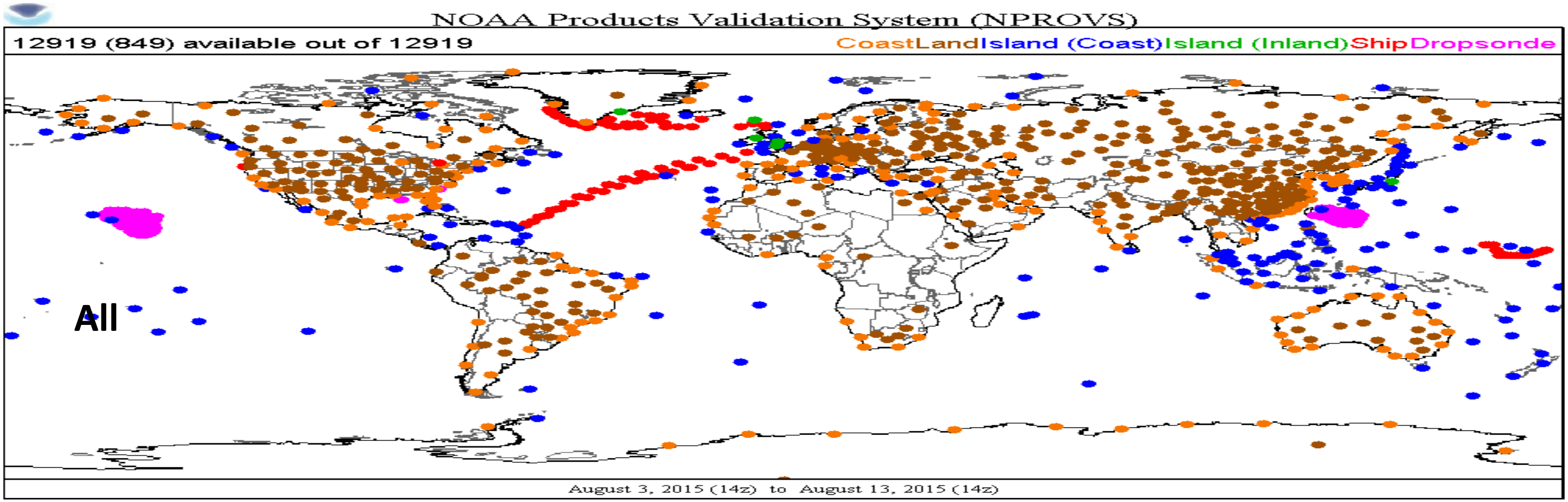


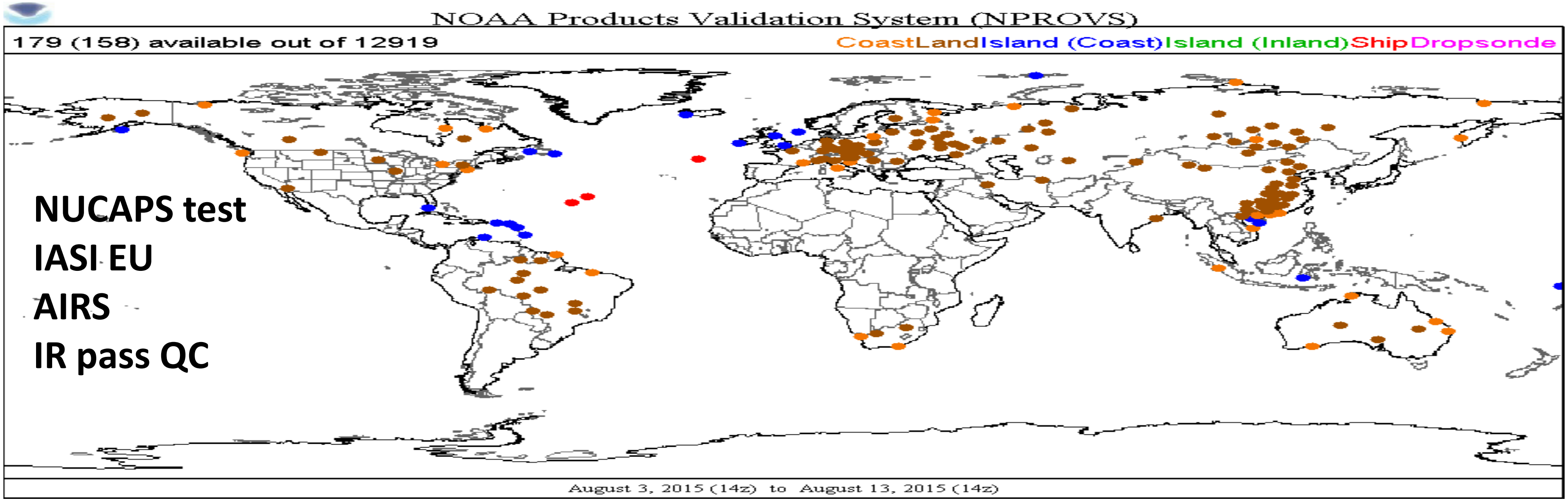




Vertical structure shows complexity (GW vs. RW distribution)

Radiosonde Locations





EDR Imagery Overview

Don Hillger
(StAR) Product Lead

Tom Kopp
(Aerospace) Cal/Val Lead

And the rest of the **VIIRS EDR Imagery Team**!

StAR JPSS (2nd) Annual Science Meeting
24-28 August 2015

Outline

- **VIIRS Imagery Overview**
  - Imagery Cal/Val Team Members
  - Imagery Product Overview
  - JPSS-1 Readiness
  - Summary and Path Forward

VIIRS EDR Imagery

VIIRS EDR Imagery consists of:

- **VIIRS Imagery** remapped to the **Ground Track Mercator (GTM**) grid, eliminating overlapping pixels and bowtie deletions.
- **NCC Imagery** is a pseudo-albedo derived from the DNB, creating an image product that removes the large radiance contrast in **DNB** from day to night.

Characteristic	SDR	EDR
Visible and IR bands	Radiances and/or reflectances	Radiances and/or reflectances (**same** as SDR)
Geo-spatial mapping	Satellite projection • Cross-track scans • Bowtie (on spacecraft) deletions • Overlapping pixels	**Ground Track Mercator (GTM)** projection: • Rectangular grid • No imagery gaps • No pixel overlap
Day/night imagery	**DNB** (radiances)	**NCC** (pseudo-albedos)

EDR Imagery Cal/Val Team Members

PI	Organization	Team Members	Roles and Responsibilities
D. Hillger	**StAR/RAMMB**	D. Lindsey, D. Molenar	Imagery product lead
T. Kopp	**Aerospace**		Cal/Val Lead, VIIRS heritage
S. Miller	**CIRA/RAMMB**	C. Seaman, S. Kidder, S. Finley	Imagery cal/val , VIIRS online, end user support, (social) media interactions
D. Santek	**CIMSS/SSEC**	T. Jasmin, T. Rink, W. Straka III	McIDAS-V McIDAS-X
J. Solbrig	**NRL – Monterrey**	K. Richardson, A. Kuciauskas	NexSat, VIIRS web
C. Elvidge	**NGDC (NCEI – Boulder)**	K. Baugh	DNB
JAM	NASA DPE	B. Thomas	Algorithm testing
	Noblis	G. Mineart	Requirements
	Raytheon	K. Ahmad, W. Ibrahim	Operations
AIT	StAR	M. Tsidulko	Integration
Alaska users	GINA, NWS	E. Stevens, others	End users, analysis and forecasting

EDR Imagery Product Overview

- EDR Imagery is a **Priority 1** VIIRS product
  - Certain EDR Imagery bands are **Key Performance Parameters (KPPs)**
    - **I1, I4, I5, M13, M14, M15** (6 original L1RD KPPs)
    - **DNB/NCC and I3 (2 more)** are being considered for KPP status.
  - The number of KPP bands (**6**), the number of bands created as Imagery from the operational system (**12**), and the total number of bands (**22**), do not match, because no tall VIIRS bands are EDRs!
- S-NPP Cal/Val Status
  - Imagery has been Validated since early 2014 (about 2 years after first light VIIRS imagery)
  - Remaining Imagery issues are minor, except for long data latency for most non-Direct Broadcast imagery
  - LTM (Long Term Monitoring)
  - Several websites for the Imagery
  - Engaging users as validation

Table 1
Required Imagery EDR Products

Key Performance Parameters (KPPs) – 6 bands

Imagery EDR Product	VIIRS Band	Wavelength (μm)	Spatial Resolution Nadir/Edge-of-Scan (km)
Daytime Visible	**I1**	0.60 – 0.68	0.4/0.8
Mid-Wave IR (MWIR)	**I4**	3.55 – 3.93	0.4/0.8
Long-Wave IR (LWIR)	**I5**	10.5 – 12.4	0.4/0.8
LWIR	**M14**	8.4 – 8.7	0.8/1.6
LWIR	**M15**	10.263 – 11.263	0.8/1.6
LWIR	**M16**	11.538 – 12.488	0.8/1.6

Table 2
Other IDPS-generated Imagery EDRs

Other Priority 1 (non-KPP) EDRs – 6 more bands

Imagery EDR Product	VIIRS Band	Wavelength (μm)	Spatial Resolution Nadir/Edge-of-Scan (km)
Near Infrared (NIR)	I2	0.846 – 0.885	0.4/0.8
Short Wave IR (SWIR)	**I3**	1.58 – 1.64	0.4/0.8
NCC	**DNB**	0.5 – 0.9	0.8
Visual	M1	0.402 – 0.422	0.8/1.6
Visual	M4	0.545 – 0.565	0.8/1.6
SWIR	M9	1.371 – 1.386	0.8/1.6

JPSS-1 Cal/Val Plan

- Validation levels:
  - Beta
  - Provisional
  - Validated
- L + 85 days (for validation)
- "Minimum Mission Success"
  - Checkout not only in **Alaska**, but **worldwide** in lieu of equivalent high latitude examples.

JPSS-1 Cal/Val Plan

- What does VIIRS EDR Imagery Cal/Val entail?
  - SDR Cal/Val for radiances/reflectances
  - EDR Validation by **Imagery users**
- JPSS-1 Image Cal/Val Plan
  - Quantitative at SDR level
  - **Qualitative validation** of Imagery
- Preparations for JPSS-1 VIIRS Imagery
  - **DNB** changes due to increased pixel aggregation at edge of scan
  - No changes to **NCC** software/product expected
  - This will be tested using simulated data for JPSS-1

Table 3
Imagery Product Requirements (from L1RD)

Attribute	Threshold	Objective
1. The Imagery EDR shall be delivered under all weather conditions, including any rain rate		
a. Horizontal Spatial Resolution for visible and IR Imagery bands		
1. Nadir	0.4 km	0.1 km
1. Edge of Swath	0.8 km	0.1 km
1. Night-time visual, Nadir	2.6 km	0.65 km
a. Horizontal Spatial Resolution for moderate resolution bands		
1. Nadir	0.8 km	NS
1. Edge of Swath	1.6 km	NS
a. Mapping Uncertainty		
1. Nadir	1 km	NS
1. Edge of Swath	3 km	0.5 km
1. Night-time visual, Nadir	TBS	1 km
a. Refresh for Visible and IR bands	At least 90% coverage of the globe every 12 hours	NS

These requirements are validated by SDR and geo-location teams

Imagery Product Requirements (from Imagery Cal/Val Plan)

There is a single component of the VIIRS Imagery product that is considered a **Key Performance Parameter (KPP).** The **KPP** itself reads as follows:

"VIIRS Imagery EDR for bands I1, I4, I5, M14, M15, and M16 for latitudes greater than 60°N in the Alaskan region"

There are no requirements that specifically address the quality of the Imagery products. Nevertheless **the end users are a critical aspect of any Imagery**, and is therefore an important consideration in the Cal/Val process.

Ultimately, it is the **(Alaska) user** that decides if the quality of the Imagery is acceptable, and as such including the **users** in the Validation process for Imagery is a key consideration in the strategy.

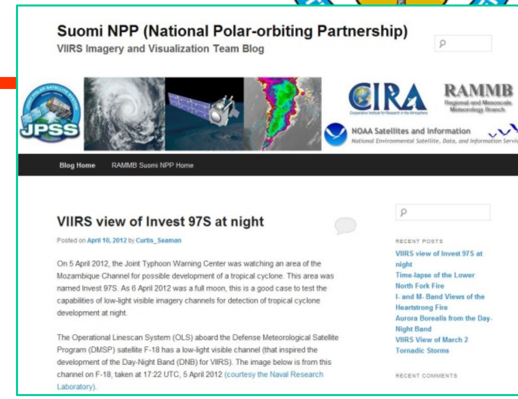
JPSS-1 Cal/Val Plan

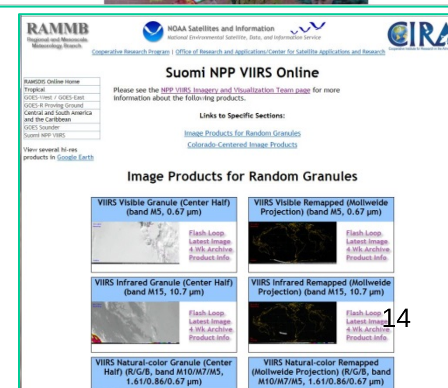
- Quantitative:
  - Mainly accomplished at the SDR level
  - VIIRS radiances/reflectances mapped from SDR to EDR using Ground Track Mercator (GTM) software
  - Exception is NCC pseudo-albedos (individually-scaled DNB multi-gain pixels across an image)
- Qualitative:
  - Depends on **user** acceptance of VIIRS Imagery (especially Alaska)
  - **Feedback from users** on imagery issues/artifacts (including noise and striping)
  - **Ability of users to discern/discriminate atmosphere, cloud, and land features** (volcanic ash, ice edges, and fires/smoke)

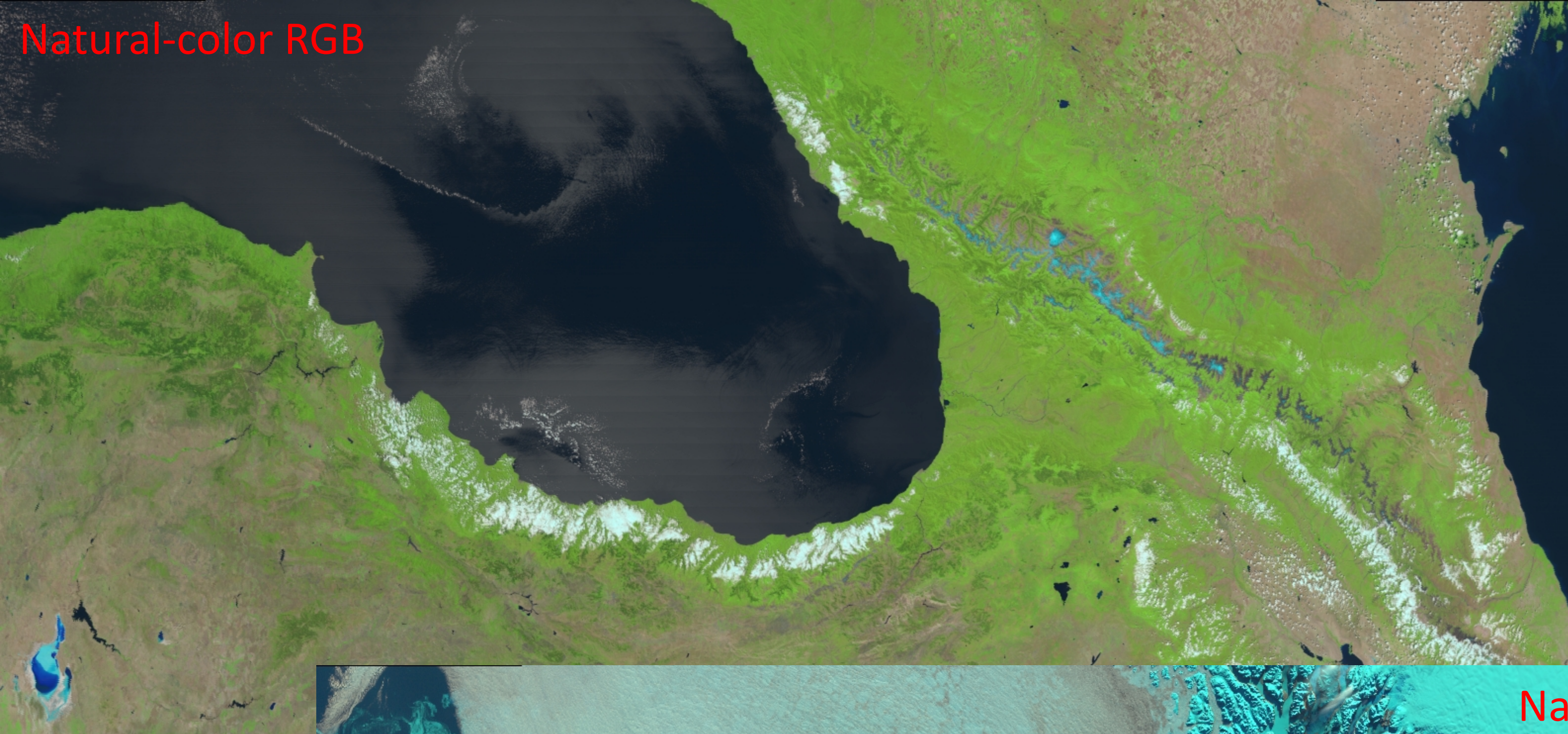
VIIRS Imagery outreach at RAMMB/CIRA and others

- VIIRS Imagery and image products outreach:
  - **VIIRS Imagery and Visualization Team Blog** (http://rammb.cira.colostate.edu/projects/npp/blog/)
  - **Seeing the Light: VIIRS in the Arctic** (http://rammb.cira.colostate.edu/projects/alaska/blog/)
  - **Suomi NPP VIIRS Online (including direct-broadcast imagery)** (http://rammb.cira.colostate.edu/ramsdis/online/npp_viirs.asp)

- **NRL-Monterey** uses of VIIRS:
  - **NexSat** http://www.nrlmry.navy.mil/NEXSAT.html
  - **VIIRS Cal/Val** http://www.nrlmry.navy.mil/VIIRS.html
- **NGDC Earth Observation Group (EOG):**
  - **VIIRS** http://ngdc.noaa.gov/eog/viirs.html

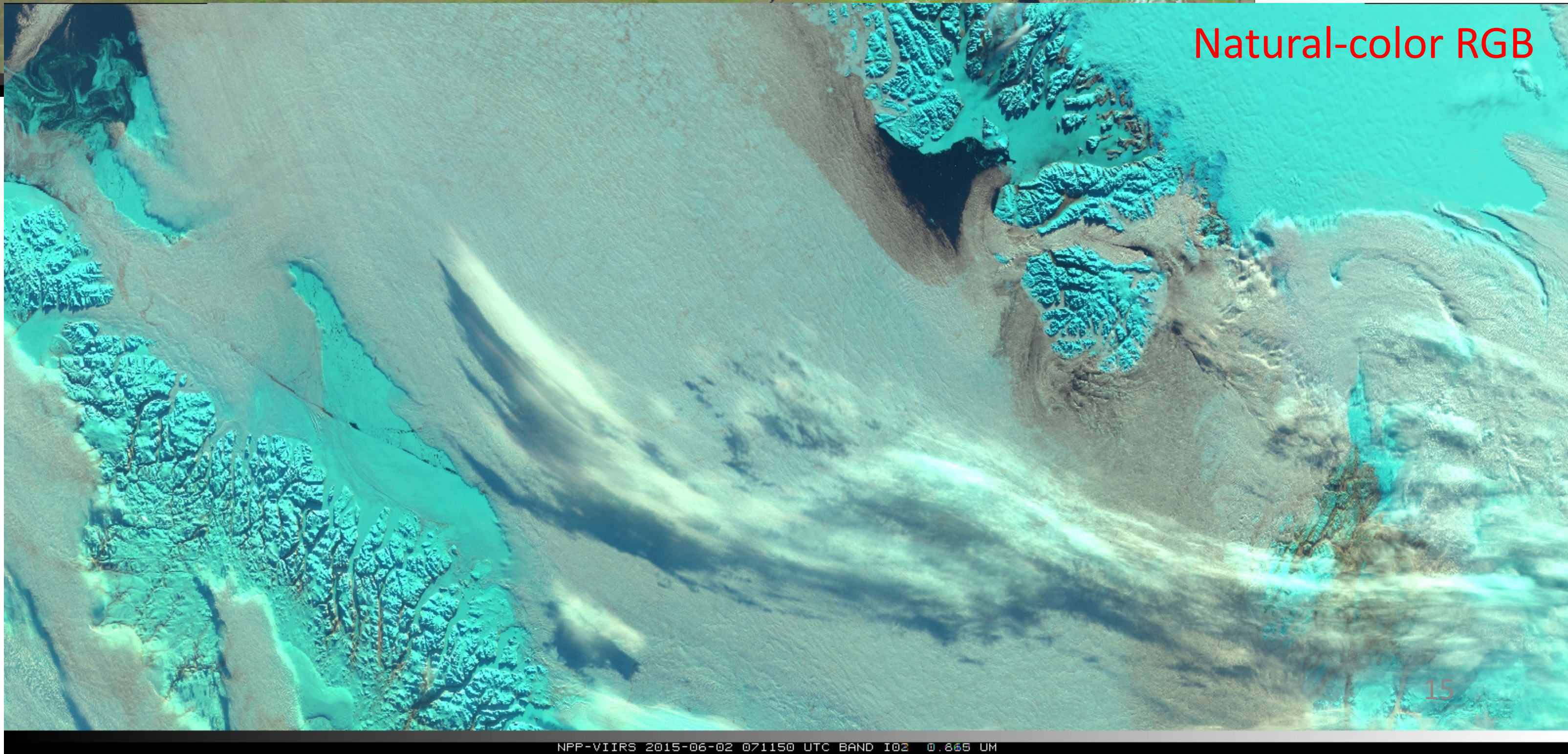






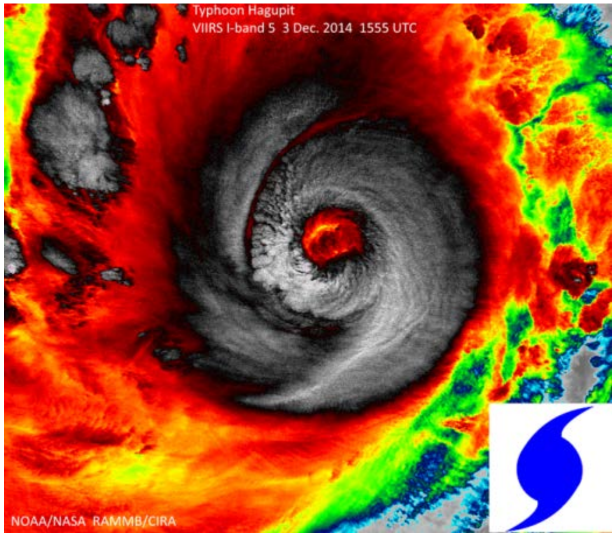
<u>VIIRS Online</u> realtime Imagery validation

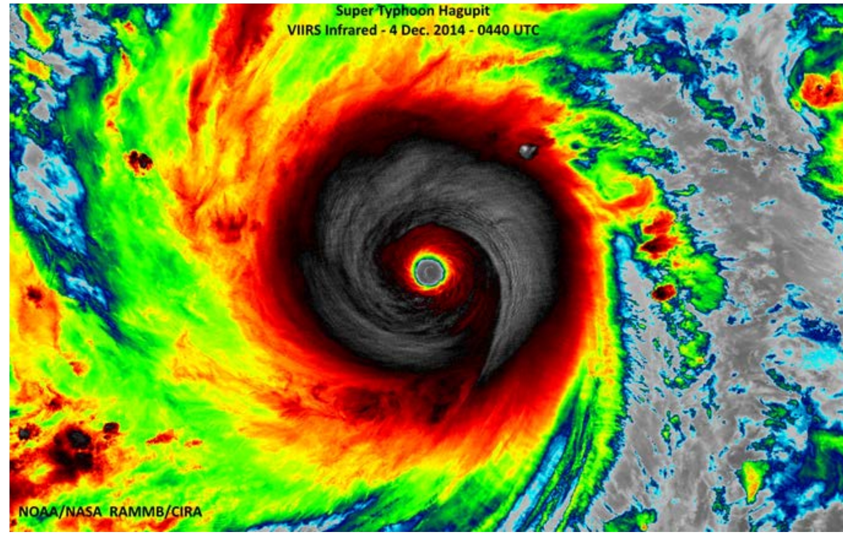
VIIRS natural-color (RGB) images showing vegetation/ land (above) and snow/cloud discrimination (below)

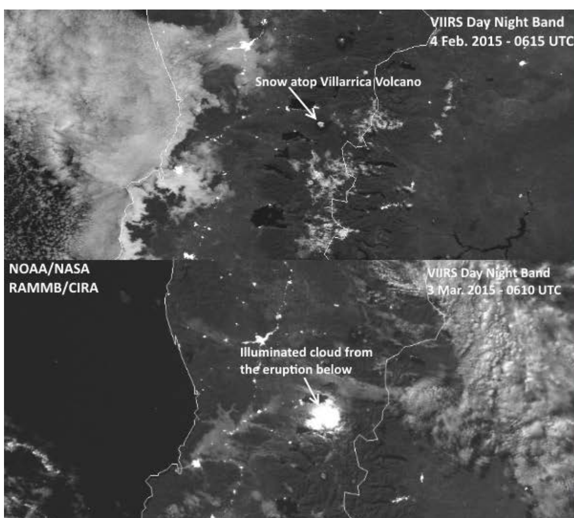


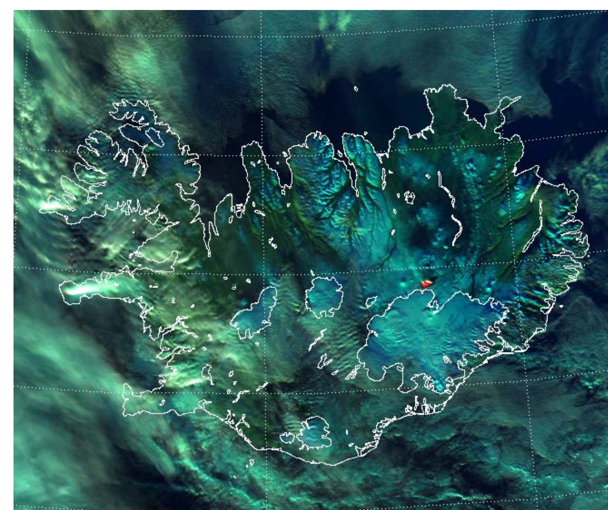
VIIRS Imagery (Visible/IR and DNB)

Various VIIRS Imagery examples, depicting details in cloud formations or on the ground which are not seen with other instrumentation. **Many examples used by Social Media.**





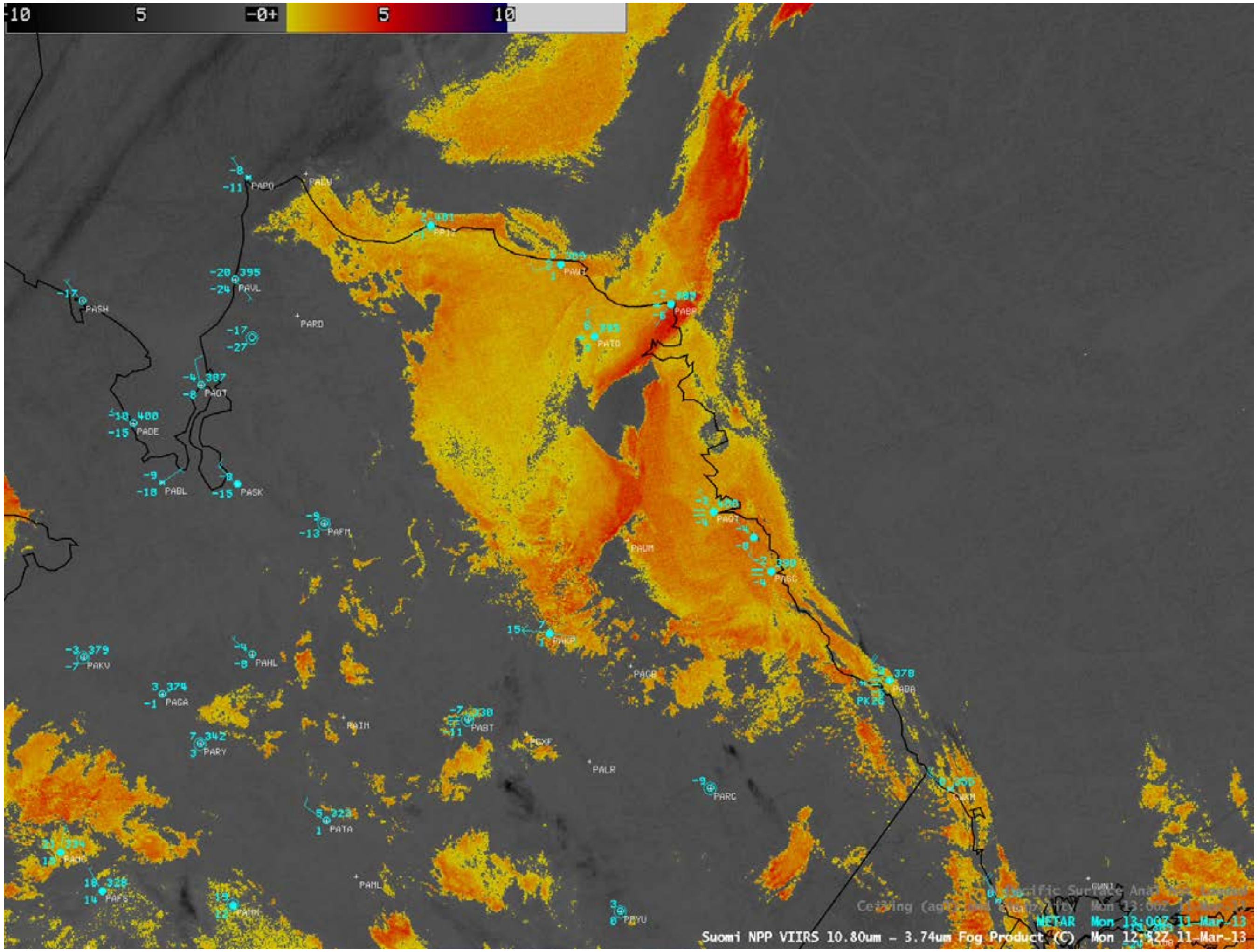




Examples of VIIRS Imagery uses/strengths (2/2)

- Alaska **operational** uses in particular:
  - Alaska fog/low stratus, 11 March 2013
  - Gulf of Alaska complex circulations, 21 Nov 2012
  - Alaska blowing dust, 21 Oct 2012, and 3 Feb 2015
  - Areal extent of smoke in Yukon and Alaska, 26 June 2015
  - Fires and smoke in Alaska, 4 July 2015
  - Aurora across Alaska, 4 July 2015
  - Areal flooding and river-ice breakup (nothing shown here, details in AMS, AGU and OCONUS presentations)
- Worldwide in **operations**
  - Hurricane/TC center at night, 29 July 2013

Fog and stratus deck over the North Slope region of Alaska, 11 March 2013



AWIPS images of the Suomi NPP VIIRS IR brightness temperature difference "fog/stratus product" showed the coverage of the fog and stratus over the area.

Fog and stratus deck over the North Slope region of Alaska, 11 March 2013

The Area Forecast Discussion issued by the National Weather Service forecast office in Fairbanks mentioned the presence of a layer of fog and stratus over parts of the North Slope region of Alaska:

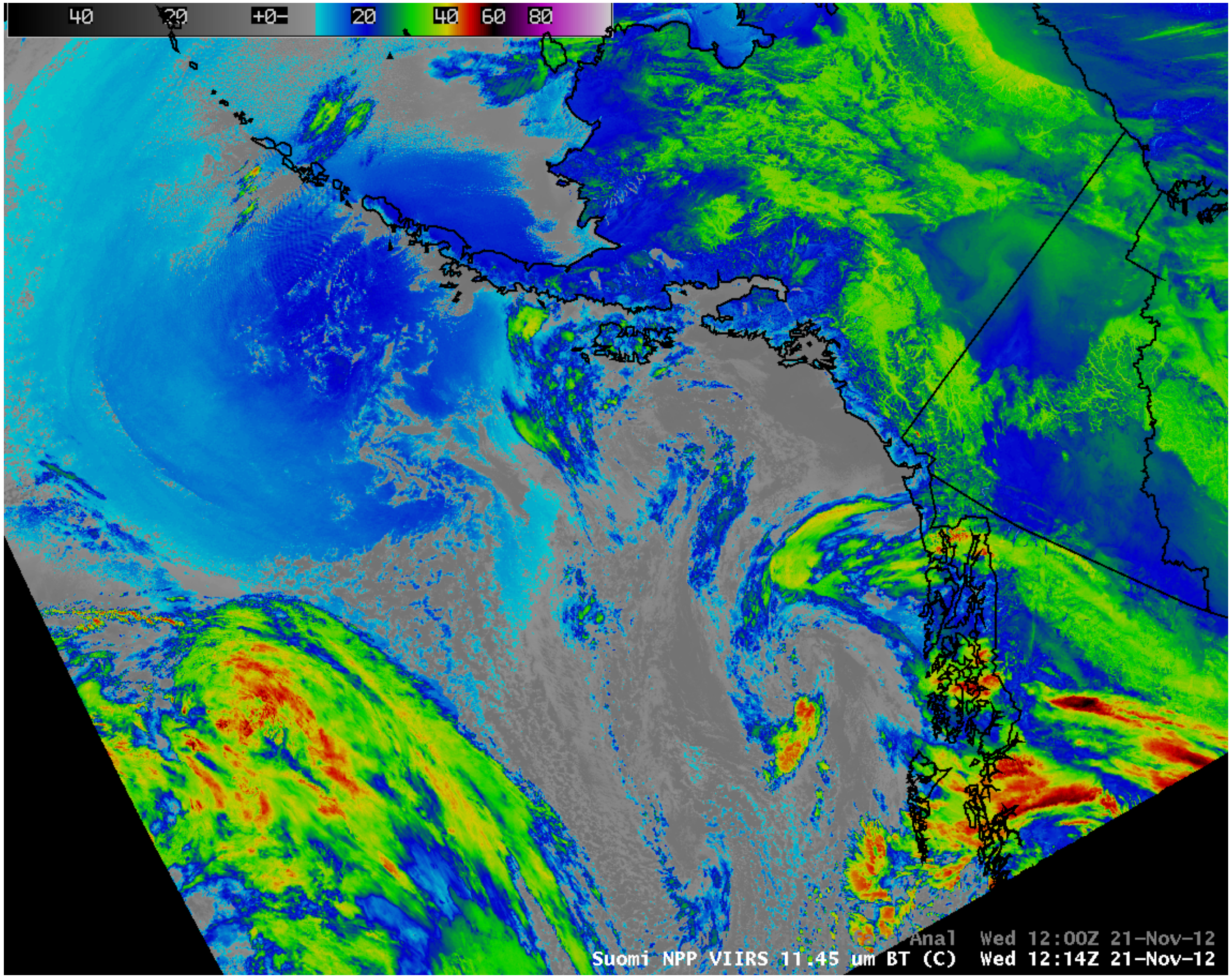
NORTHERN ALASKA **FORECAST DISCUSSION**

NATIONAL WEATHER SERVICE FAIRBANKS AK

1258 PM AKDT MON MAR 11 2013

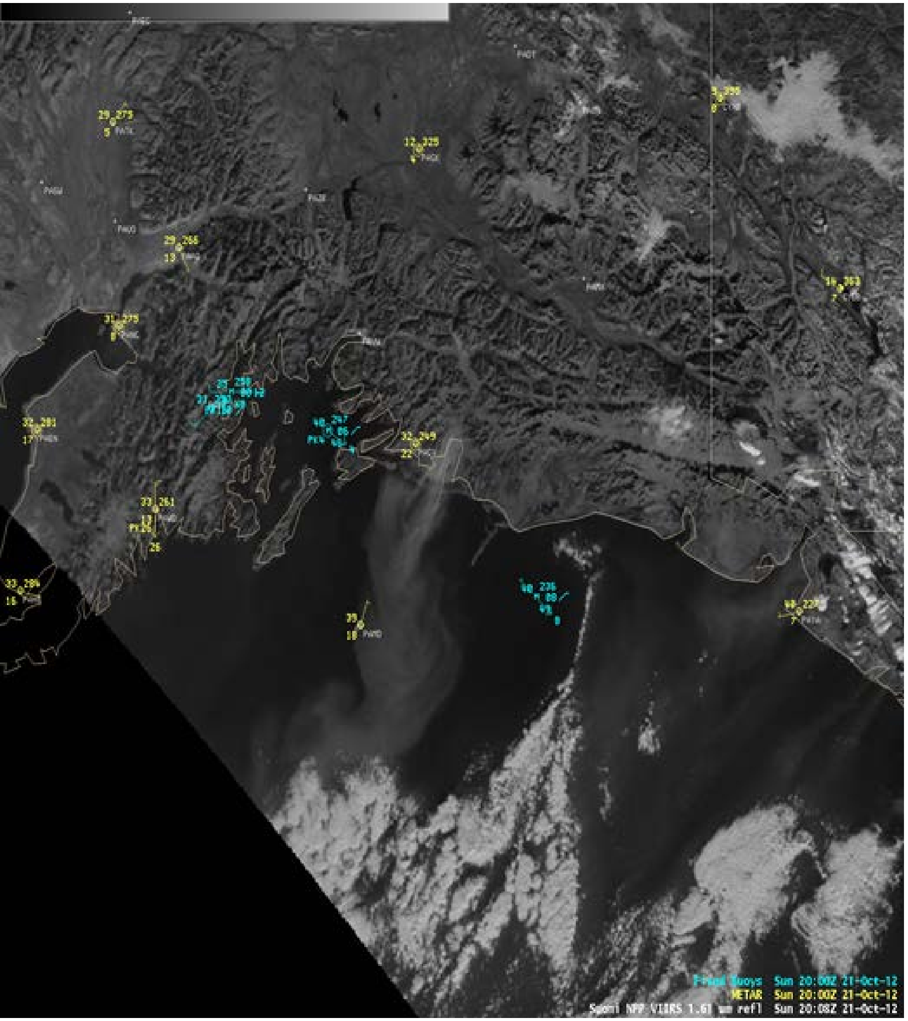
NORTH SLOPE…**THE SUOMI NPP VIIRS SATELLITE FOG PRODUCT WAS INDICATING A DECENT LAYER OF STRATUS ALONG THE NORTH SLOPE.** OBSERVATIONS ACROSS THE AREA GENERALLY INDICATED 1 TO 2 MILES IN VISIBILITY WITH FLURRIES AND FOG. THE IFR CONDITIONS ALIGN VERY WELL WITH THE HIGHER PROBABILITIES OF MODIS IFR PRODUCT. THERE ARE SOME VERY ISOLATED POCKETS OF HIGHER PROBABILITIES OF THE MODIS LIFR CONDITIONS. THESE CONDITIONS SHOULD REMAIN THROUGH TUESDAY EVENING OR WEDNESDAY MORNING AS THE SURFACE HIGH PRESSURE REMAINS WITHIN THE AREA. BY WEDNESDAY MORNING THE SURFACE PRESSURE GRADIENT BEGINS TO TIGHTEN…PROVIDING AN INCREASE IN WINDS AND PERHAPS A BREAK IN SOME OF THE FOG.

Using VIIRS imagery to help diagnose complex Gulf of Alaska circulations, 21 November 2012



Suomi NPP VIIRS 11.45 µm IR image with surface analysis

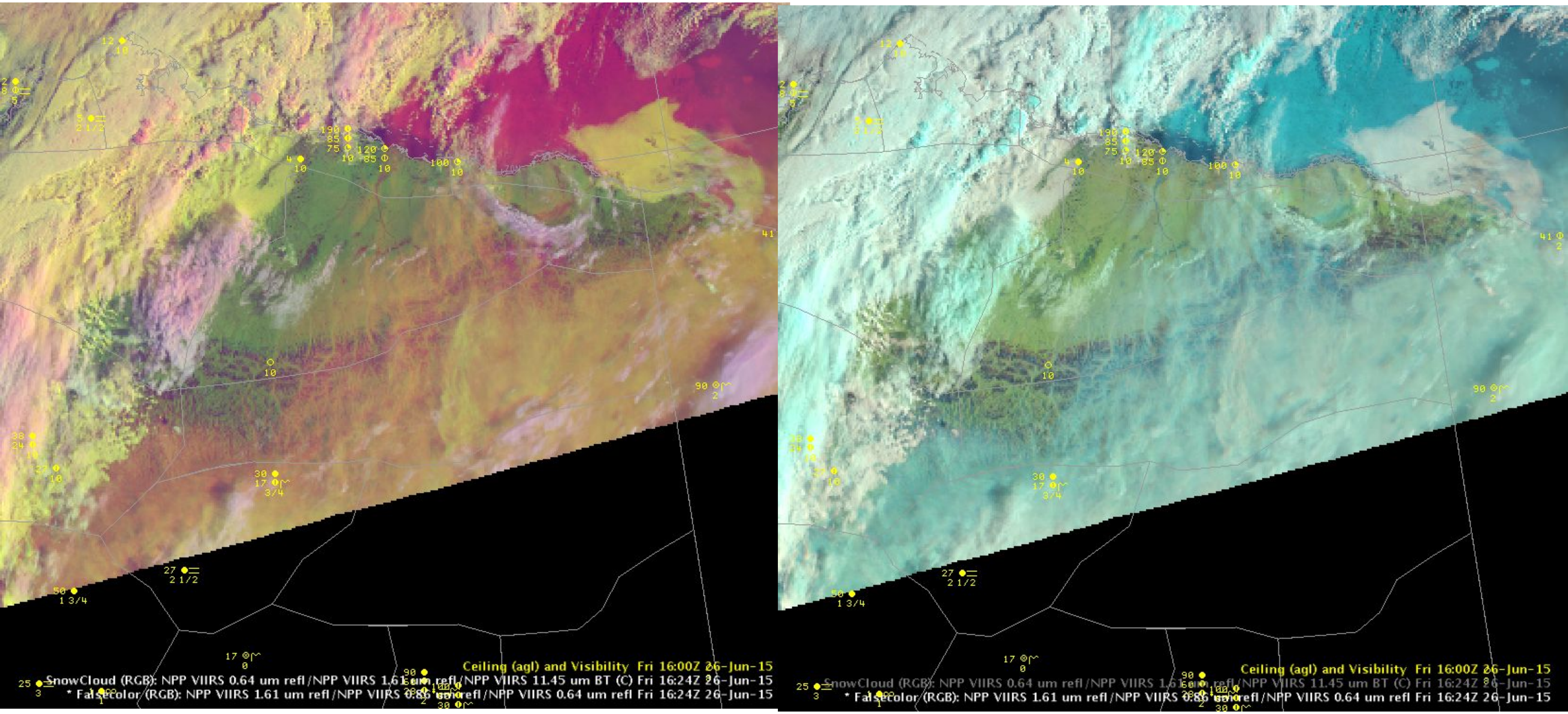
<u>Blowing Dust</u> in Alaska – 21 Oct 2012



Attached is an **AWIPS screen capture of the VIIRS 1.61 um I3 band showing <u>blowing dust blasting out of the Copper River Delta southward over the Gulf of Alaska on a windy day</u>.** This image courtesy of WFO Anchorage Science Officer Jim Nelson. While the 1.61 um channel seems most commonly to be used by the NWS here as a component of RGBs discriminating snow and ice on the ground from clouds above, it has also gotten some secondary use in identifying blowing glacial silt as a single-channel image during the daytime.

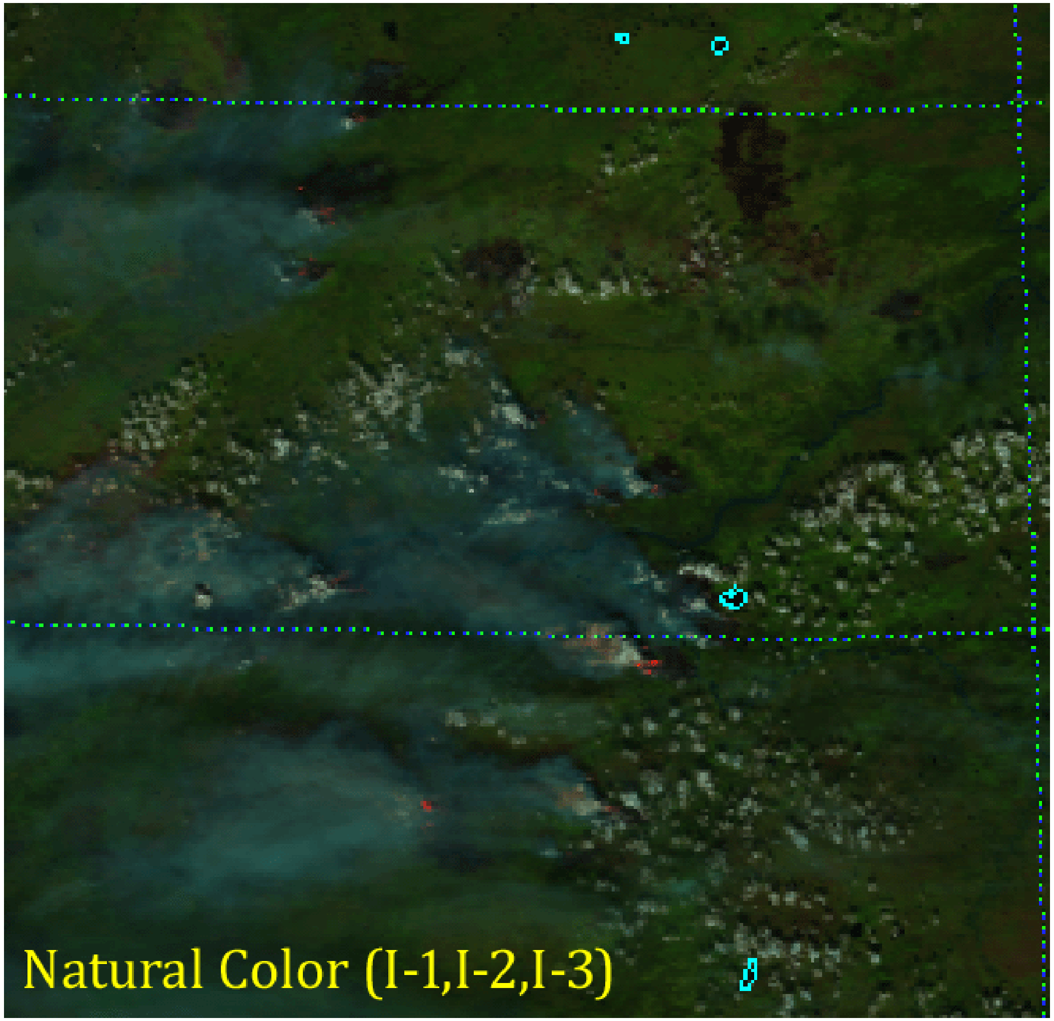
The neat thing about this glacial silt application of the 1.61 um channel is that it allows forecasters to "see" the wind, at least qualitatively. Images like this give forecasters more confidence when including verbiage like "stronger local gusts out of bays and passes" in the marine forecasts for the North Gulf Coast, despite the lack of observations from buoys or ships indicating such winds. Very broadly speaking, in a region suffering from a sparse network of surface-based observations, **satellite products like this help forecasters fill in the gaps and develop their mental model of what is going on.** (Eric Stevens, GINA, Fairbanks)

Areal extent of smoke in Yukon Territory and Alaska – 25 June 2015



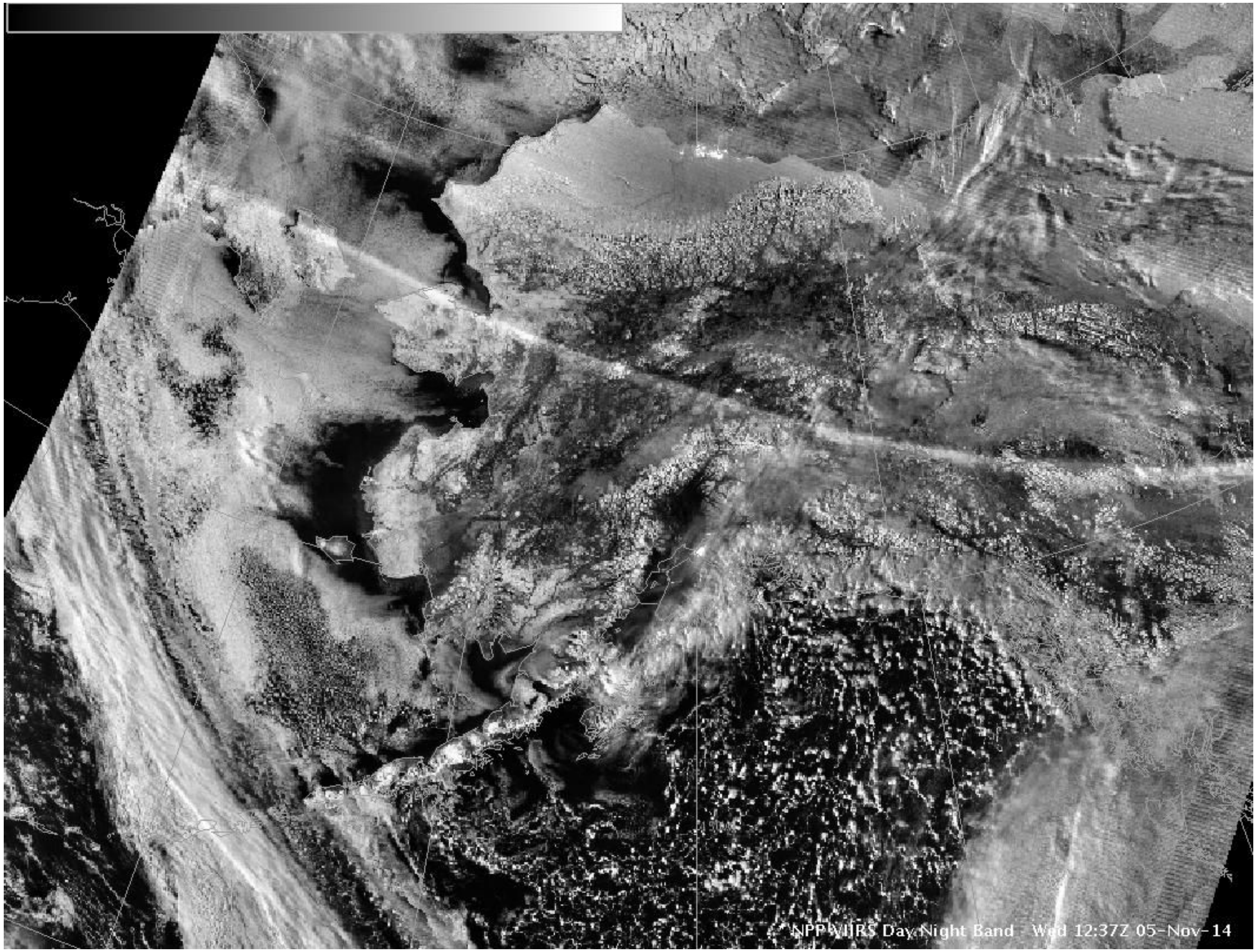
From the morning of 2015 June 26. This was a case where the "**natural color" RGB** and the **"cloudoversnow" RGB** satellite imagery helped the Public forecast. Specifically, to help see the **areal extent of the smoke**. The smoke had spread north into the Yukon Territories and spilled through the Brooks Range. Note the 2SM vis reports being measured at Shingle Point, YK and Old Crow, YK. (Ed Townsend [NWS, AK])

Fires and smoke in Alaska in two VIIRS RGBs – 4 July 2015

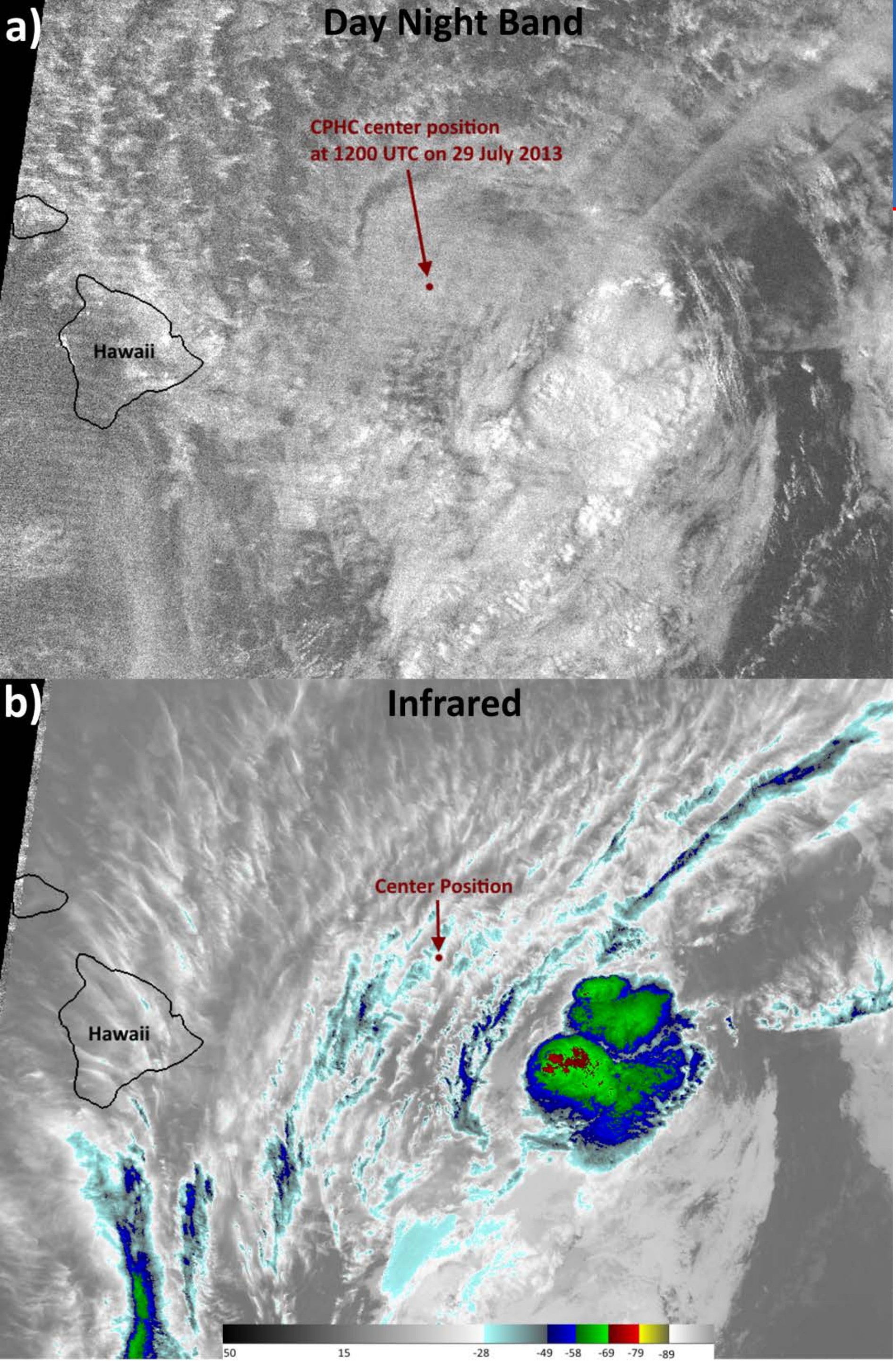


2015 July 4th, screenshots over the AK Central Interior where the **"Natural color" RGB** was useful in delineating smoke and detecting fire 'hot spots'. (Ed Townsend [NWS, AK], C. Seaman [CIRA])

Aurora across Alaska in DNB – 4 July 2015



VIIRS Day/Night in which with a band of Aurora crosses the entire state of Alaska (Ben Bartos, NWS, Fairbanks)



Tropical Cyclone position/center at night with DNB

VIIRS a) Day Night Band and b) I-band 5 showing **Tropical Storm Flossie east of Hawaii** on 29 July 2013 at 1103 UTC. The analyzed position by the Central Pacific Hurricane Center of the center of the storm at 1200 UTC is denoted by a maroon dot in both images. The units of brightness temperature in b) are degrees C.

TC position/center with DNB

The VIIRS Day Night Band can be useful for identifying low cloud features in the presence of higher overlapping clouds. A good example occurred east of Hawaii on 29 July 2013. Tropical Storm Flossie was east of the big island of Hawaii moving generally to the west-northwest.

The Central Pacific Hurricane Center (CPHC) stated in one of their forecast discussions: "THE **CENTER OF FLOSSIE** WAS HIDDEN BY HIGH CLOUDS MOST OF THE NIGHT BEFORE **VIIRS NIGHTTIME VISUAL SATELLITE IMAGERY** REVEALED AN **EXPOSED LOW LEVEL CIRCULATION CENTER FARTHER NORTH THAN EXPECTED**. **WE RE-BESTED THE 0600 UTC POSITION BASED ON THE VISIBLE DATA."** (http://www.prh.noaa.gov/cphc/tcpages/archive/2013/TCDCP1.EP062013.019.1307291511) **Figure a** shows the VIIRS Day Night Band image at 1103 UTC that was being referred to, and **Figure b** shows the corresponding I-band 5 image (11.4 µm infrared). High cirrus clouds with brightness temperatures around -30°C can be see in the infrared image to the northwest of the deepest convection, but in the day night band some low clouds can be seen underneath. CPHC inferred the center of circulation based on the shape of these low level clouds, and their 1200 UTC analysis of the center location is denoted in the figure with a maroon dot. The infrared imagery alone would not have been useful in locating the center.

Summary & Path Forward

- VIIRS Imagery is **excellent**:
  - Visible/IR are <u>especially high quality</u> (and best spatial resolution of operational satellites)
  - <u>DNB/NCC is the innovative product</u> from VIIRS that is not available from any geostationary satellite/orbit.
- Path Forward
  - New **"Image of the Month**", requested by Lihang for StAR JPSS website.
  - **New DNB aggregation modes** for end of swath pixels on JPSS-1
    - NCC algorithm/product to be tested using simulated DNB from VIIRS SDR Team.
  - **J2 and Beyond**: Recommend changes to bands (suggest water vapor imagery)

VIIRS Cloud Team Overview

JPSS Science Team Meeting

August 27, 2015

Algorithm Cal/Val Team Members

PI	Organization	Team Members	Roles and Responsibilities
Andrew Heidinger	STAR & CIMSS	Andi Walther, Yue Li, Denis Botambekov	NOAA Enterprise Cloud Products. IDPS Cloud Product Maintenance
Tom Kopp	Aerospace	Bill Thomas, Rich Frey	VCM Maintenance
Michael Pavolonis	STAR & CIMSS	Corey Calvert	Cloud Phase (Enterprise and VCM)
Steve Miller / Dan Lindsey	STAR & CIRA	Y.J Noh, Curtis Seamen, John Forsythe	Cloud Base and Cloud Cover Layers
Bob Holz	SSEC	Greq Quinn	CALIPSO tools and validation site.

Instrument Overview

Cloud EDRs are derived from VIIRS (M,I and DN Bands)

Visible Infrared Imaging Radiometer Suite (VIIRS)

- **Primarily use M-bands**
- **I-bands used in cloud mask for spatial filtering**
- **VIIRS provides excellent spectral information for cloud remote sensing in VIS/SWIR (similar to MODIS).**
- **Lack of IR channels in CO_2 and H_2O absorption bands can be mitigated with CrIS obs. (RR)**
- **DNB also being used for cloud properties. (RR)**
- **Exceeds MODIS in resolving spatial variation in clouds.**

Band name	Wavelength (nm)	Bandwidth (nm)	Use in algorithm
M1*	412	20	M
M2*	445	14	none
M3*	488	19	none
M4*	555	21	none
M5*	672	20	M,O
M6	746	15	none
M7*	865	39	M
M8	1,240	27	O
M9	1,378	15	M
M10	1,610	59	M,O
M11	2,250	47	M,O
M12	3,700	191	M,T,O
M13	4,050	163	M
M14	8,550	323	M,T,H
M15	10,763	989	M,T,H
M16	12,016	864	M,T,H

*dual gain, M: Mask, T:Type, O=Optical, H=Height

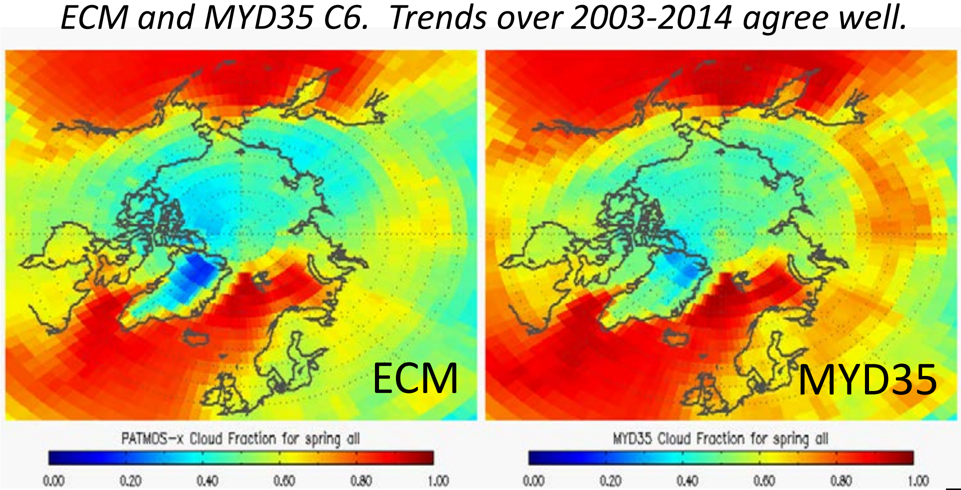
S-NPP VCM summary

- The VIIRS Cloud Mask (VCM) continues to meet or exceed its documented requirements
- Noticeable improvements occurred with the implementation of a daily (versus monthly) snow/ice field on 1 December 2014
- Over the last year concerns from users have been addressed concerning:
  - Cloud Shadows
  - Ephemeral Water
- The clouds over fires mitigation is on track to be implemented in Build 8.12.
- One more tuning event before the Block 2.0 freeze is planned in 4-6 weeks to address leakage over cold backgrounds and deserts
- More details in a presentation on Thursday

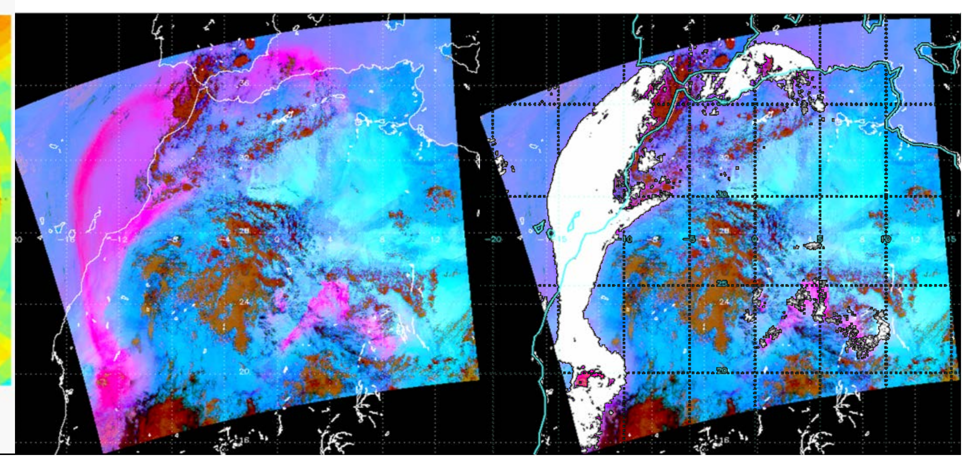
S-NPP NOAA Ent. Cloud Mask

- Delivered to SAPF since April 2015. ARR scheduled in a month.
- **Presentation on the use of the NOAA Enterprise Cloud Mask (ECM) in on Thursday.** ECM provides a 4-level mask like VCM but also provides a floating point (0.0-1.0) cloud probability (CP).
- We want teams to use the CP to optimize ECM for their application.
- As requested ECM includes masks for Dust, Shadow, Fire Smoke and Glint. (see below). Feedback on these masks sought.
- Completed a comparison to C6 MYD35 over 2002-2014 to test robustness of ECM.

Comparison mean Winter Arctic Cloud Fractions from ECM and MYD35 C6. Trends over 2003-2014 agree well.



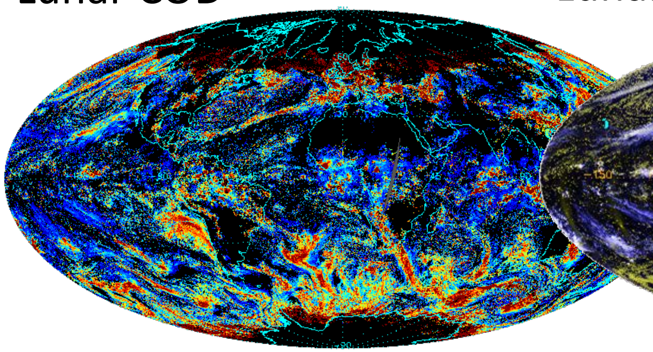
Example of the ECM Dust Mask applied VIIRS 8/6/2015



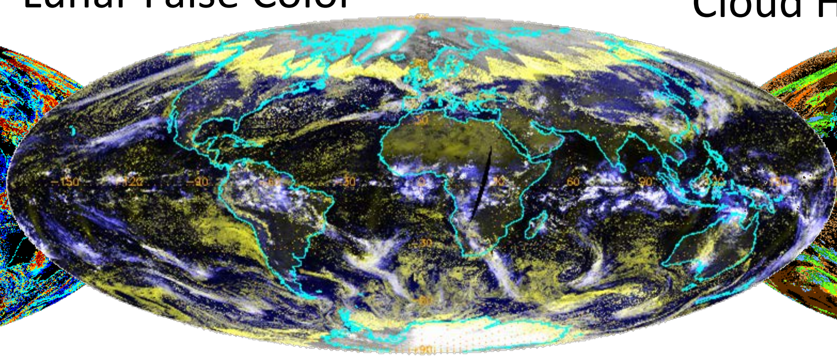
S-NPP NOAA Ent. Cloud Props

- NOAA Enterprise algorithms transitioned to SAPF in July.
- TRR held and ARR coming in September.
- Same versions of most cloud algorithms in are available to the community via CLAVR-x CSPP v2015.
- Reprocessed entire S-NPP record in limited regions for LTM.
- Operational in early 2016 along with other Enterprise algs.
- SIPS at SSEC is now running them globally.
- Making global and polar composites for ESRL Global Model Val.

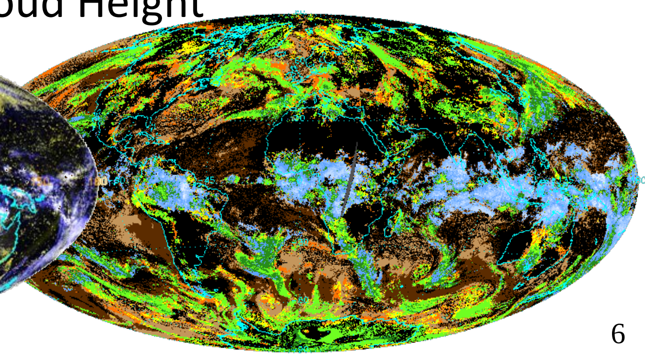
Lunar COD



Lunar False Color

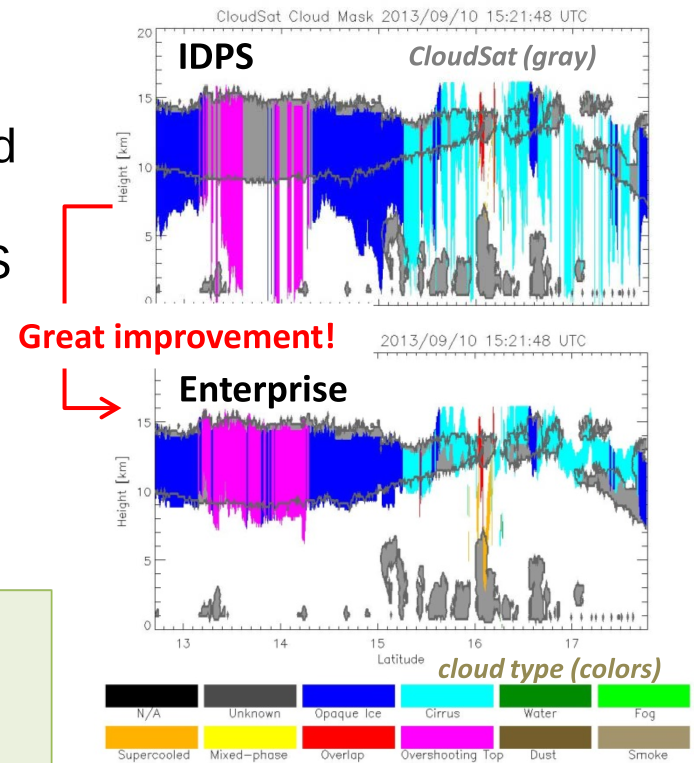


Cloud Height



Cloud Base / Cloud Cover Layers Summary

- CIRA developed a new statistical CBH algorithm constrained by CTH and CWP using A-Train satellites (July daytime data CloudSat/CALIPSO and Aqua MODIS data from 2007-2010).
- The enterprise CBH algorithm outperforms the IDPS one. The optimized cloud geometric thickness information can be used to modulate the layered cloud fraction by introducing additional cloud coverage at lower levels of the profile.



Enterprise Cloud Base (Uppermost Layer)

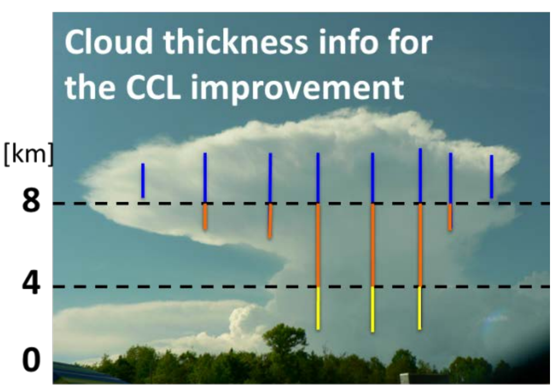
VIIRS CLAVR-x **Cloud Top Height**

VIIRS CLAVR-x **Cloud Water Path**
- CWP from COT and EPS using DCOMP and NLCOMP
- CWP from NWP as supplementary data

Appropriate CIRA cloud geometric thickness (ΔZ) regression

VIIRS CLAVR-x Cloud Type to modify cirrus and overshooting top bases
- Extinction method for high thin cirrus
- CBH=CCL_NWP for deep 'overshooting' type cloud

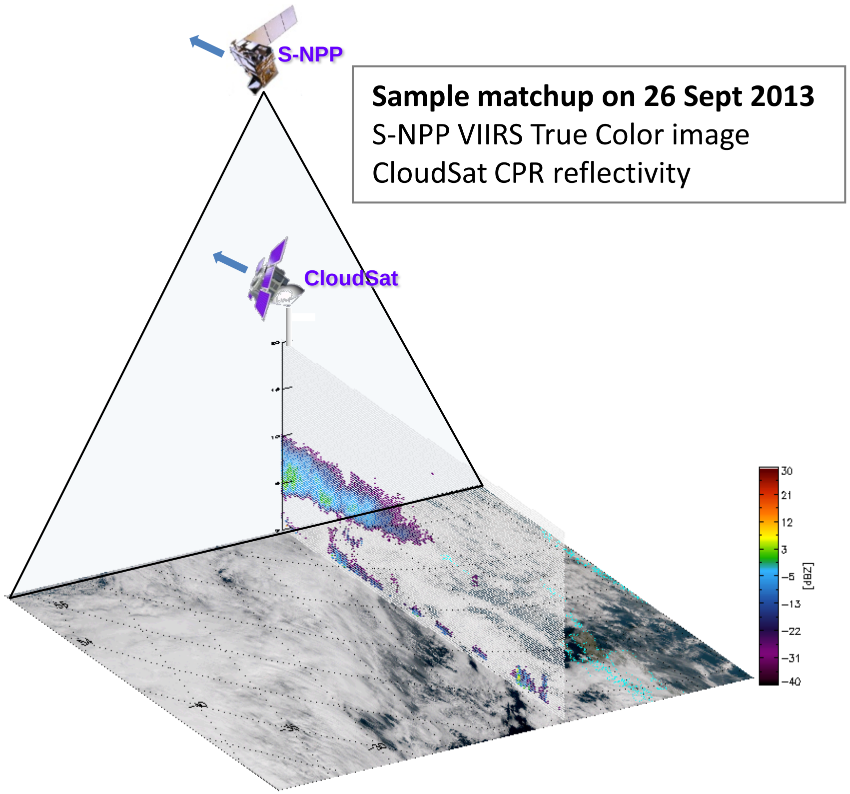
CBH retrieval
CBH = CTH - ΔZ

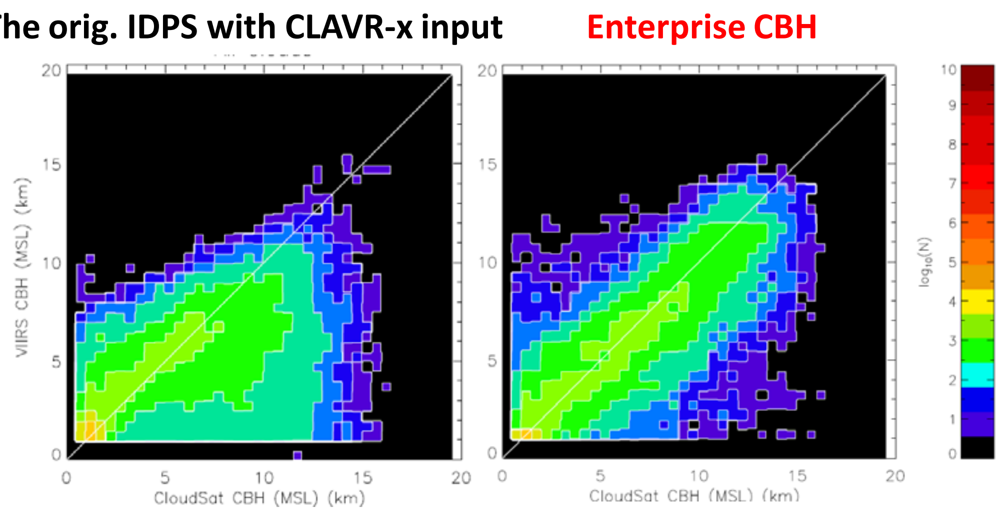


SSEC JPSS Validation Highlight

Validation of CBH algorithms using CloudSat

IDPS vs. Enterprise CBH





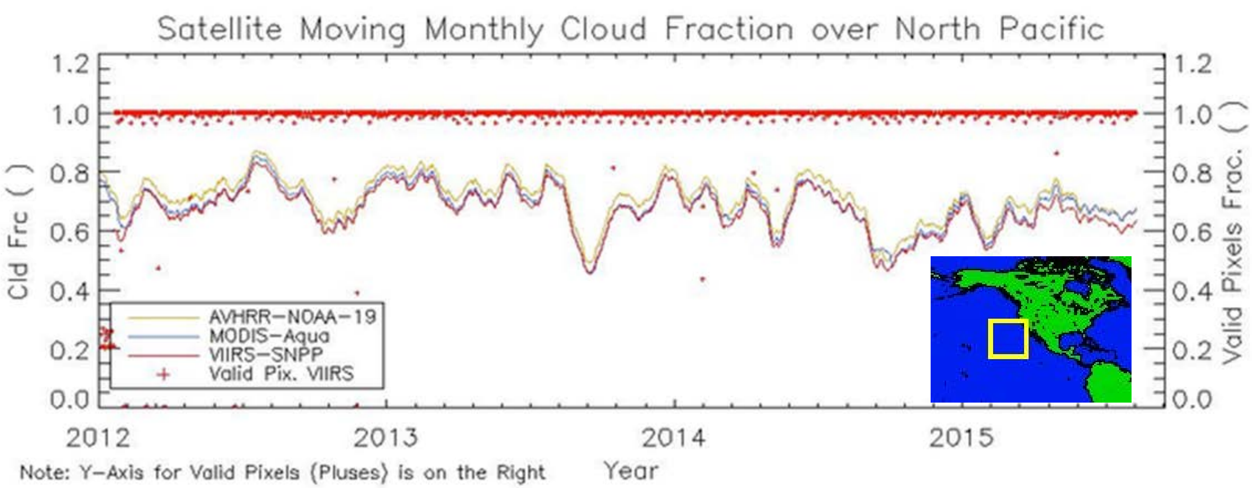
(82599 VIIRS-CloudSat matchup points when CTH is "within spec" for Sept-Oct 2013)

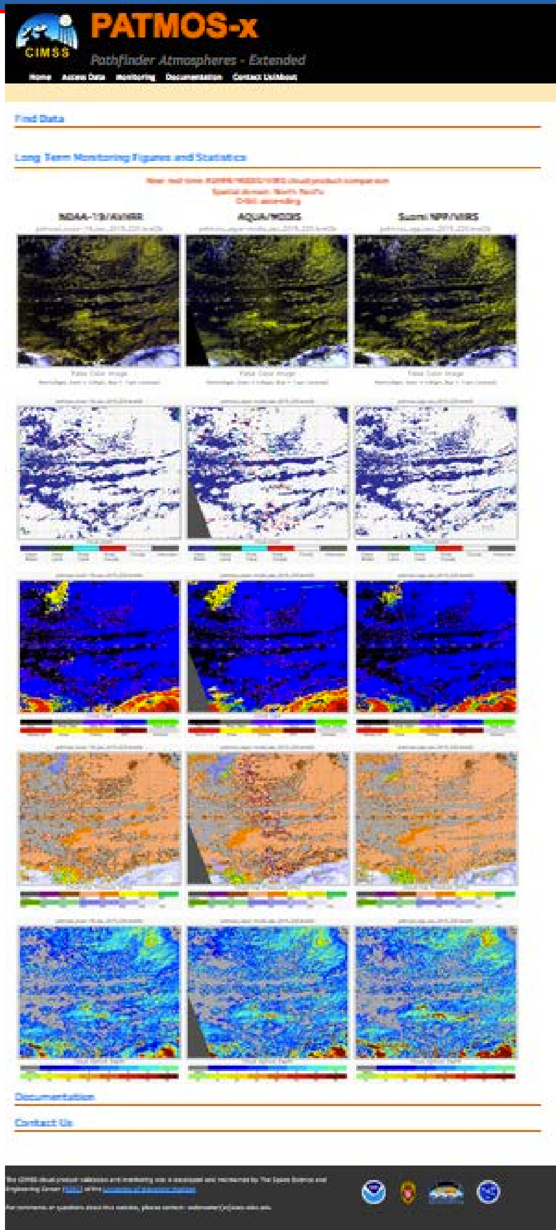
CBH [km]	Avg error	RMSE	Std of error	r^2
IDPS	0.7	2.7	2.6	0.45
Enterprise	0.3	1.8	1.8	0.76

- **The enterprise CBH algorithm outperforms the original IDPS algorithm.**
- Validation efforts are ongoing for an extended CloudSat matchup period (Jan-May 2015) including nighttime CBH performance test with ARM ceilometer data and comparisons with CALIPSO for thin cirrus.

S-NPP Long-Term Monitoring Site Summary

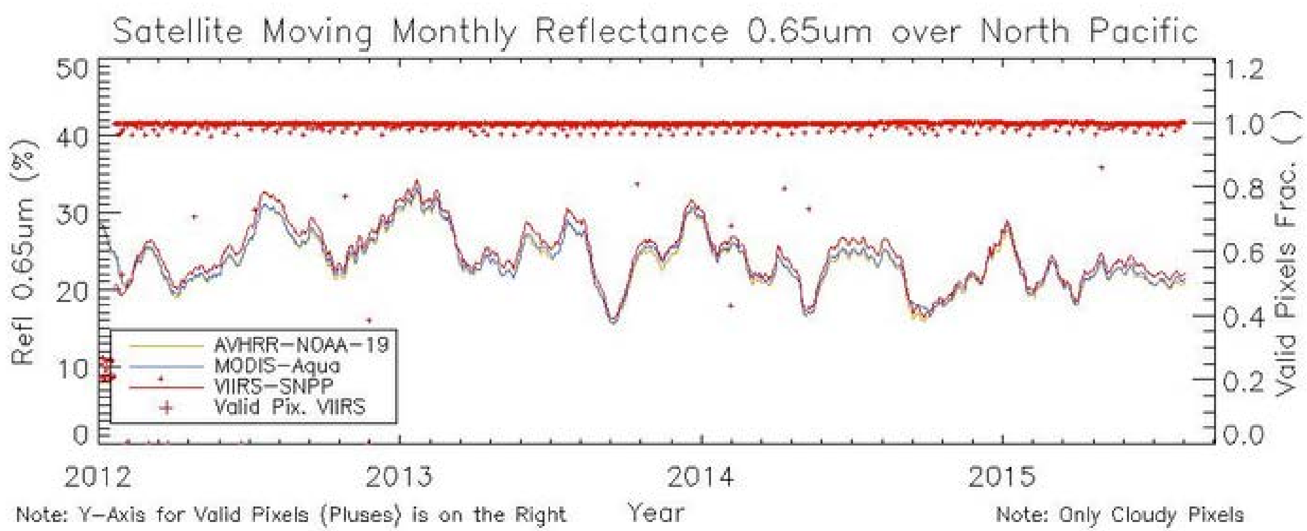
- LTM site uses the NOAA Enterprise Algs in CLAVR-x.
- **We reprocess AQUA/MODIS, NOAA-19/AVHRR and SNPP/VIIRS from 2012 to present.**
- We choose a 20x20^{o} region in North Pacific near California. It is dominated by stratus with a known annual and diurnal cycle.
- Sample images are available (see image on the right).
- Time-series of monthly means shown (see below).
- Cloud detection skill against CALIOP also shown.

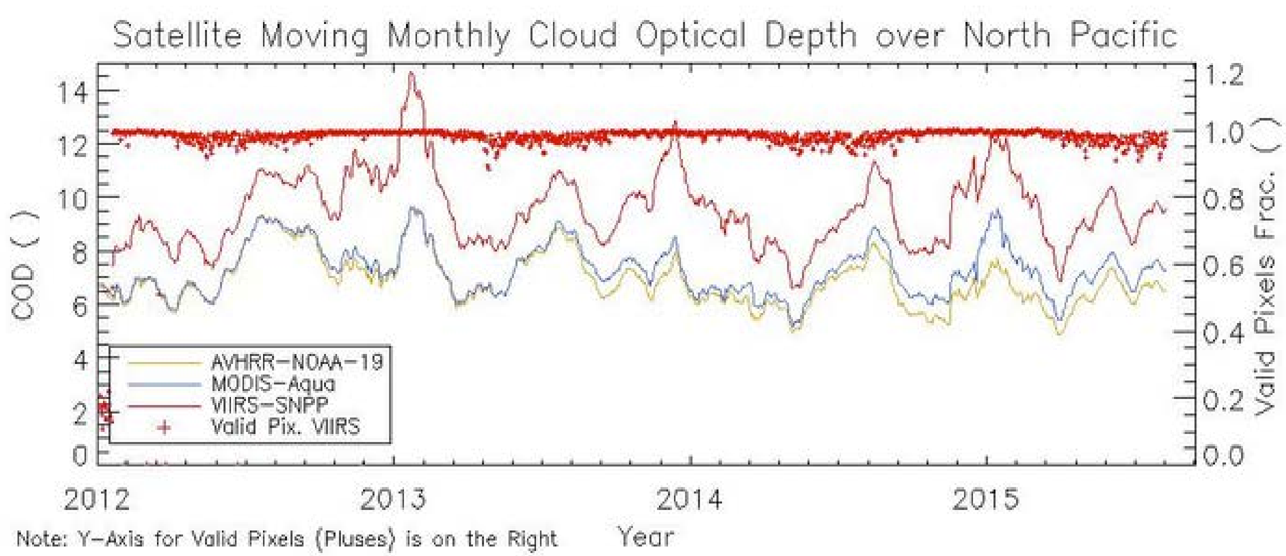




VIIRS/MODIS COD Discrepancy

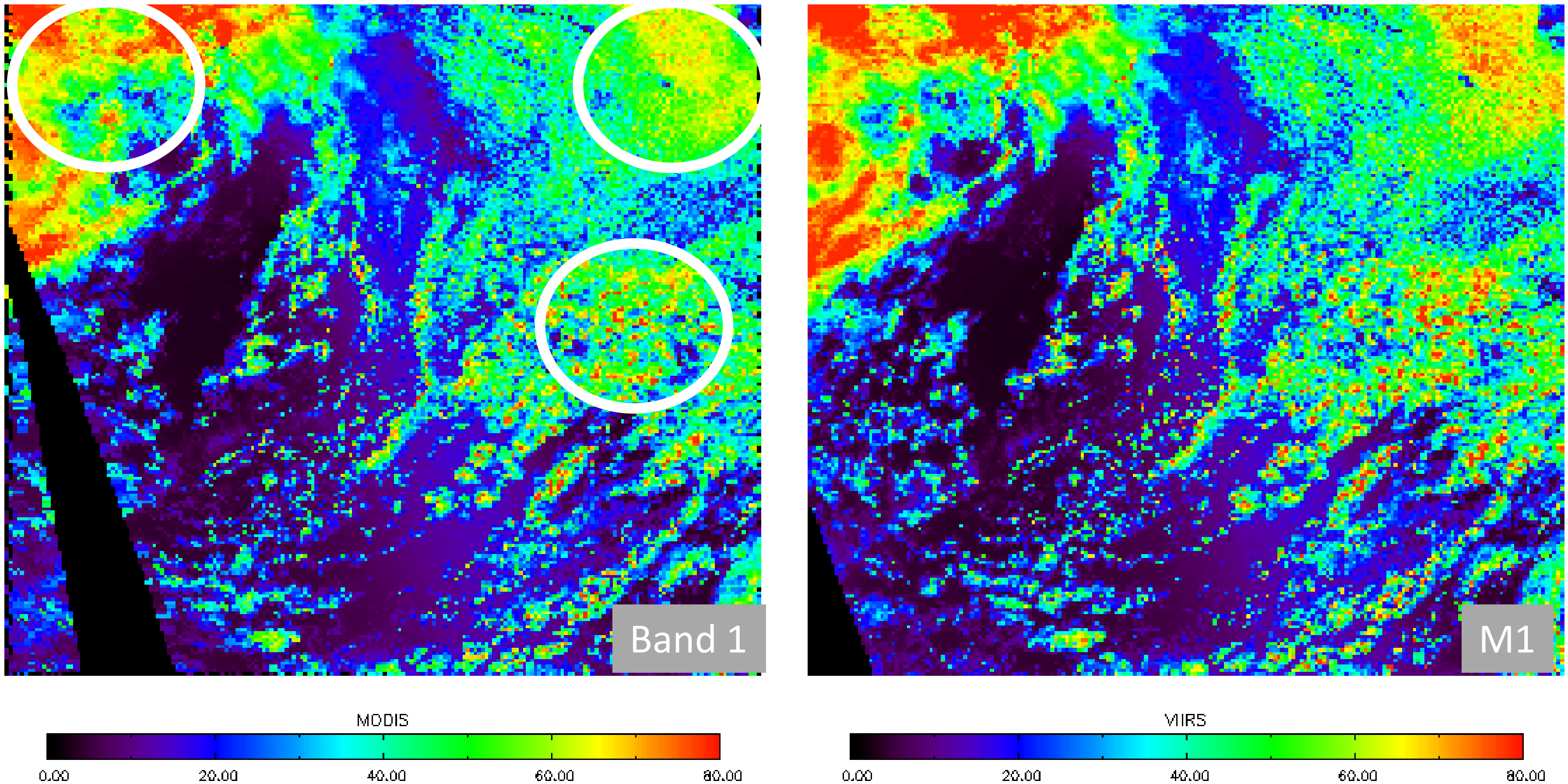
- The reflectance shows a slight bias in VIIRS.
- The most obvious feature in LTM site is VIIRS bias in COD relative to MODIS and VIIRS.
- The COD bias is more significant ranging 1 to 4 and is persistent through the year.
- This could a calibration issue or a spatial resolution issue?





Investigation in VIIRS/MODIS COD Discrepancy

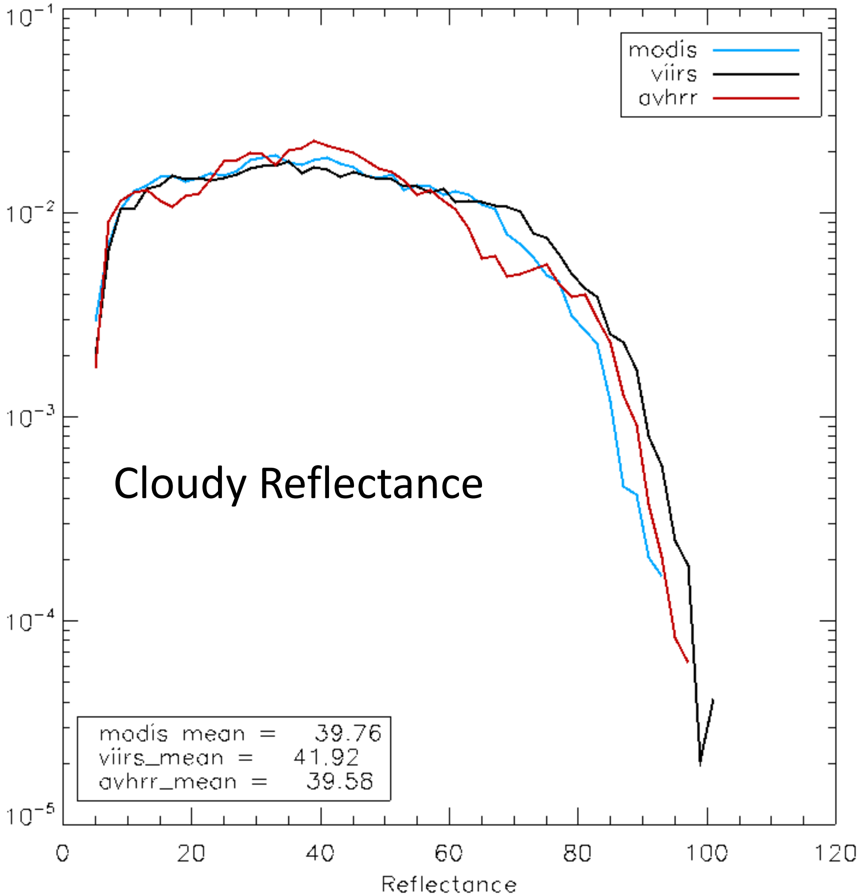
- Inspection of imagery does show that VIIRS has higher numbers of bright pixels
- These are not always in regions where spatial resolution should be an issue.

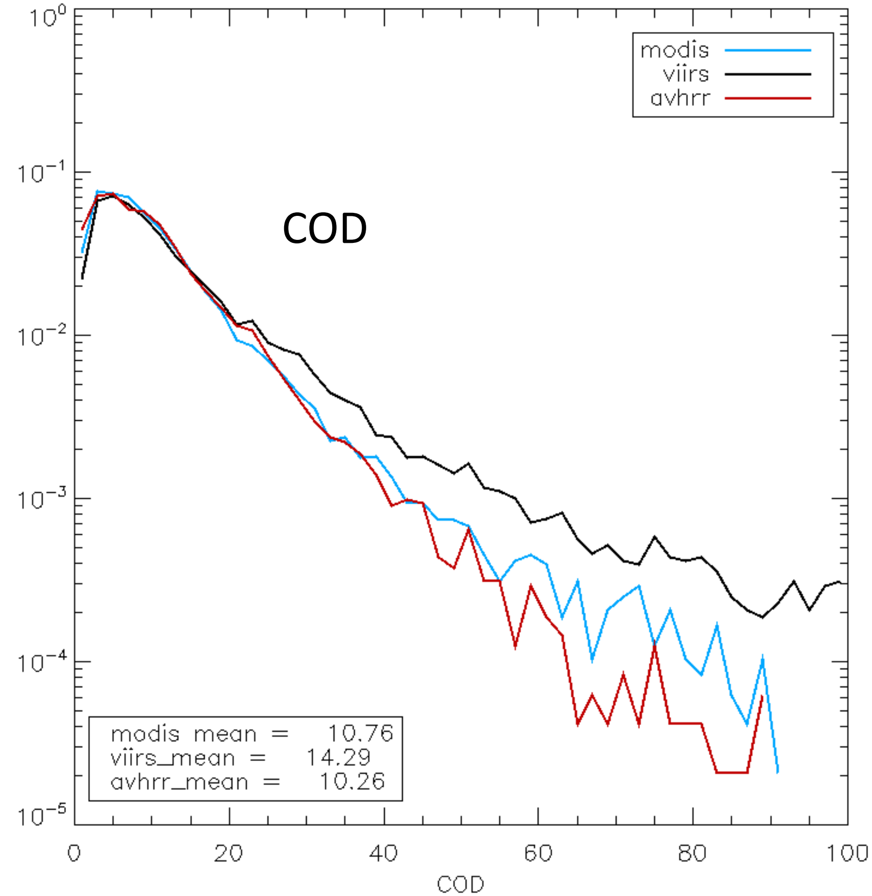


Day 149 of Year 2015; chosen due to similarity in MODIS and VIIRS viewing geometry.

Investigation in VIIRS/MODIS COD Discrepancy

- Analysis of histograms confirms VIIRS always more brighter pixels (Ref > 60%)
- Resulting COD histogram shows typical bias. Note COD alg should handle all angular and spectral differences.

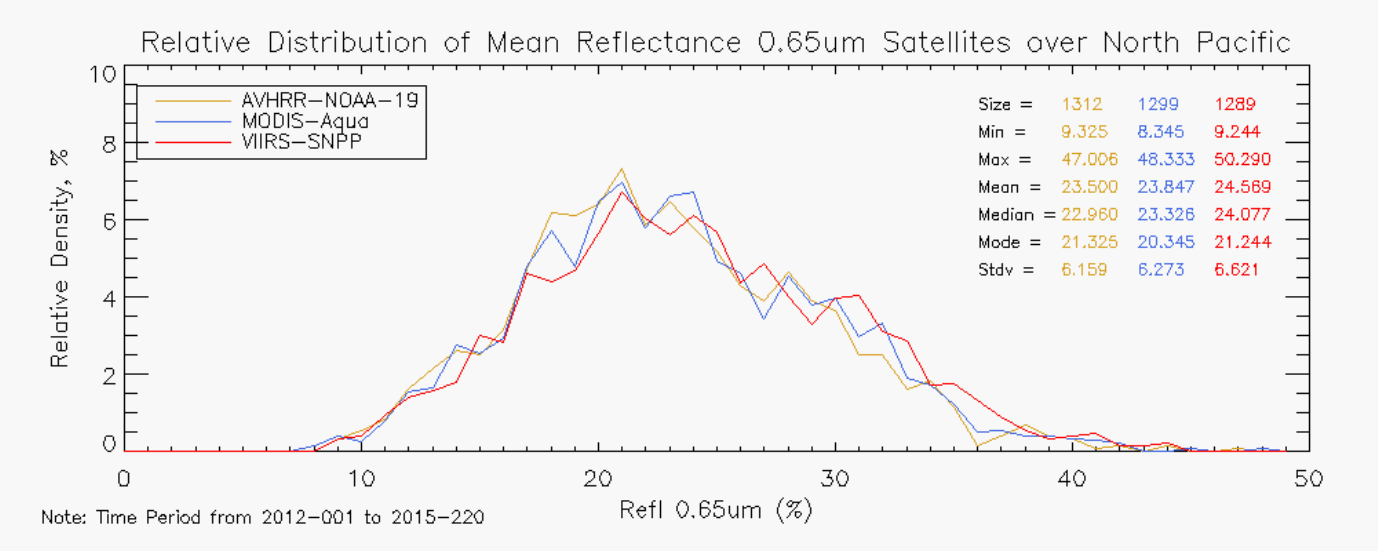


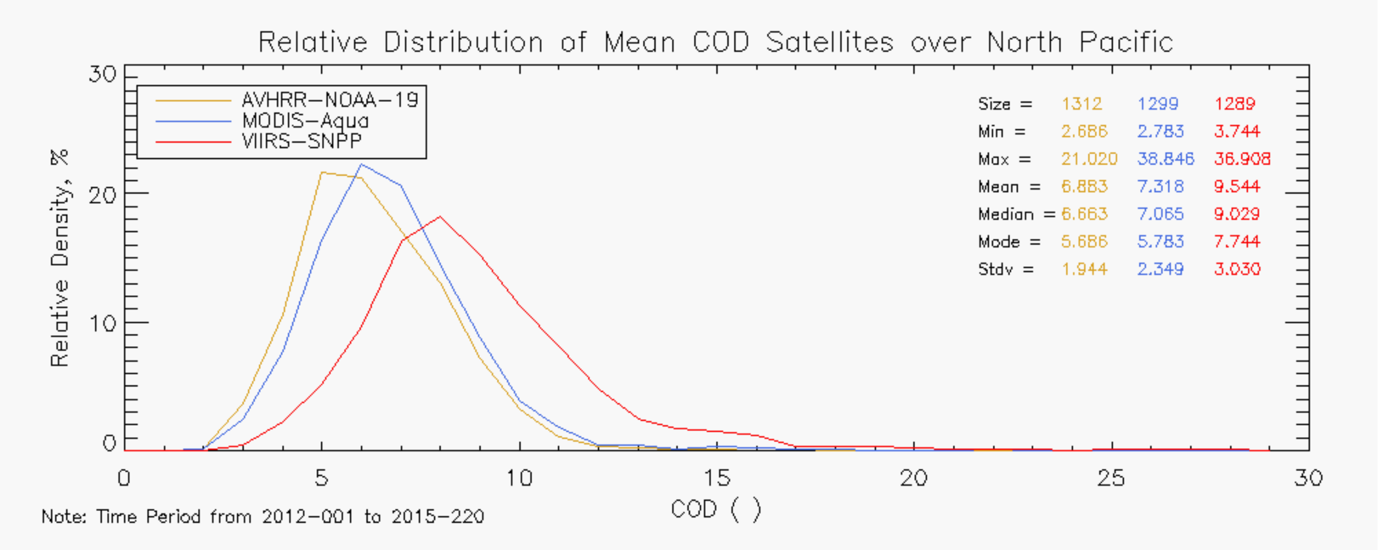


Similar findings by NPP Atmosphere Team. Continue to investigate.

Distributions of Mean Values

- The images show the distribution of the daily mean values of M5 reflectance (top) and COD (bottom).
- Confirms the systematic bias of about 2 in VIIRS COD compared to MODIS and AVHRR.
- Similar findings by NPP Atmosphere Team.





JPSS-1 Readiness

- J1 Algorithm Summary
  - We want incorporate two major initiatives support by JPSS-RR
    - Incorporation of Lunar Reflectance in multiple cloud algorithms
    - Merger of Sounder with VIIRS to provide missing absorption channels.
    - Merging LEO and GEO cloud detection and heights.
- J1 Cal/Val Overview
  - +3 months (Beta), +6 months (Provisional), +18 months(Validated)
  - We plan to keep using active sensors but plan for new versions (CATS and EarthCare)
  - Cal/Val Plan Drafts delivered July, 2015.
  - Mask plan includes VCM and ECM. 30 day spin-up will be done as for S-NPP.
- Major Accomplishments and Highlights Moving Towards J1
  - Complete transition to the SAPF should occur in 2016 of JPSS-1 ready algorithms
  - Through RR and PG, we hope to mature our Lunar and VIIRS/CrIS modifications and transition to SAPF when appropriate.
- Stake Holder Interactions, Users and Impact Assessment Plans
  - List of Users/Stake Holders, include:
    - CSPP delivering Enterprise cloud products to DB community.
    - Global verification data being generated for NWP.
    - Cloud ceilings, heights and CCL for NWS AWC
    - Plan on putting VIIRS into the Alaska Cloud Products application (Tony Wimmers) which is supported by the Alaska NWS.

Summary & Path Forward

- Summary
  - We are looking forward to achieving operational status with the larger NOAA Enterprise effort in 2016 on S-NPP.
  - We have two current RR activities (Lunar Ref and VIIRS/CrIS) that leading to significant algorithmic improvements. (See talks in Cloud Breakout)

- Path Forward
  - Passing NOAA Enterprise ARR is critical.
  - Transition of Cloud Base and CCL is planned in 2016.
  - Success of cloud mask depends on interaction from the teams. Applies to VCM and ECM.

Thank you!

Overview of Cryosphere EDRs

Jeff Key

Cryosphere Team Lead

August 25, 2015

Algorithm Cal/Val Team Members

EDR	Name	Organization
Lead; ice and winds	Jeff Key	NESDIS/STAR
Co-Lead; ice and snow	Pablo Clemente-Colón	NESDIS/STAR and NIC
Wisconsin:		
Ice conc., temp.	Yinghui Liu	CIMSS/U. Wisconsin
Ice thickness	Xuanji Wang	CIMSS/U. Wisconsin
Ice	Rich Dworak	CIMSS/U. Wisconsin
Maryland:		
Snow cover, fraction	Peter Romanov	CREST/CCNY
Snow fraction	Igor Appel	IMSG
Colorado:		
Ice temp., conc.	Mark Tschudi	U. Colorado
Ice temp., conc.	Dan Baldwin	U. Colorado
Other:		
All	Paul Meade	DPE

Products

1. Sea ice characterization (IDPS and NDE)
   - Age category: no ice, new/young ice, other ice (IDPS); thickness (NDE)
2. Sea Ice concentration IP (IDPS and NDE)
   - Fractional coverage of ice in each pixel
3. Ice surface temperature (IST) (IDPS and NDE)
   - Radiating temperature of the surface (ice with or without snow)
4. Snow cover (IDPS and NDE)

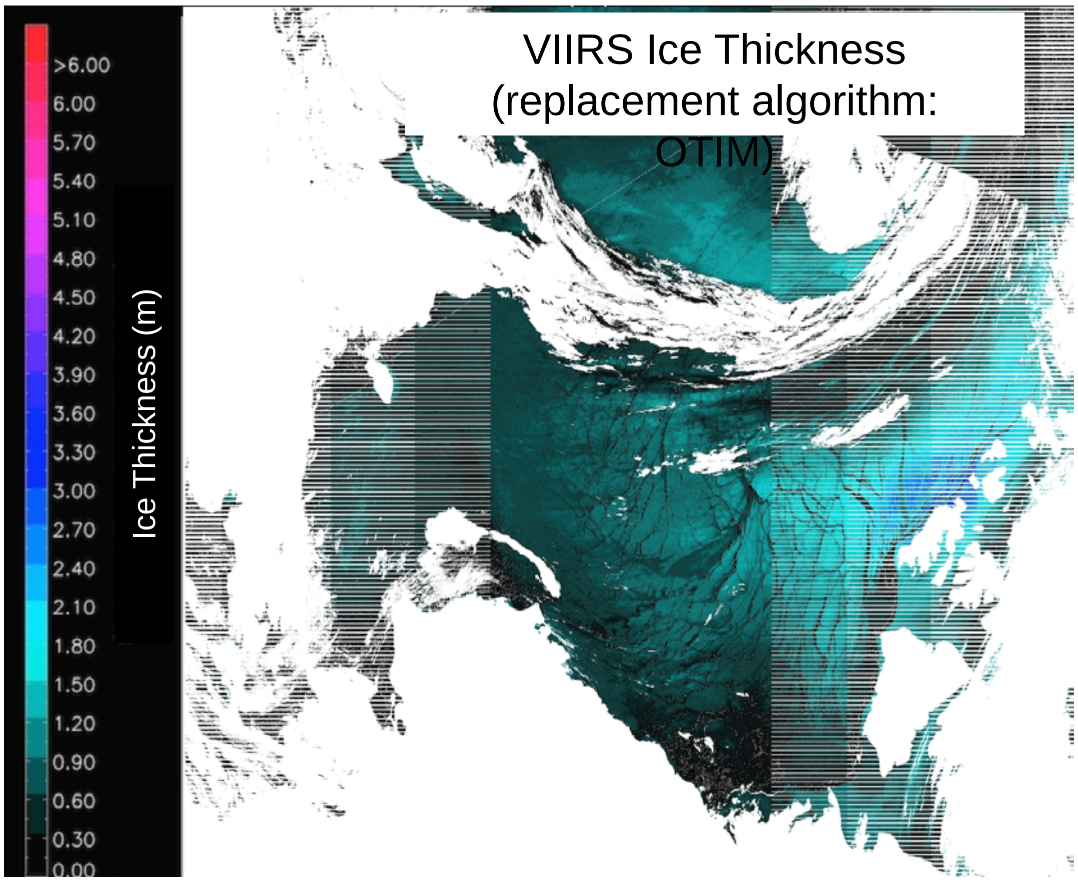
   4a. Binary snow cover

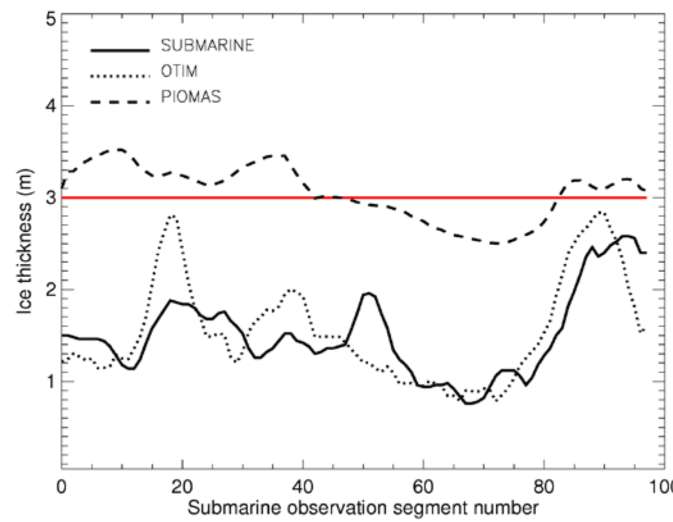
   4b. Fractional snow cover (currently 2x2 averages of binary mask)
5. Polar winds (NDE; *historically funded by PSDI*)
   - Tropospheric winds at various levels

- NOTE: AMSR2 on GCOM-W1 will have other snow and ice products that will be operational in 2016: Ice Characterization, Snow Cover, Snow Depth, Snow Water Equivalent (SWE)

Sea Ice Thickness

The IDPS Sea Ice Characterization EDR is a 3-category product: new/young ice (< 30 cm thick), “other ice”, and ice-free. The IDPS product does not meet requirements. The new product for JPSS-1 will provide a continuous ice thickness range from 0 ~ 2.5 m.

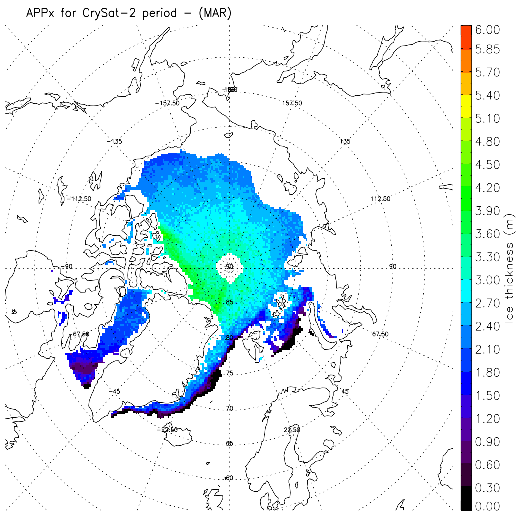




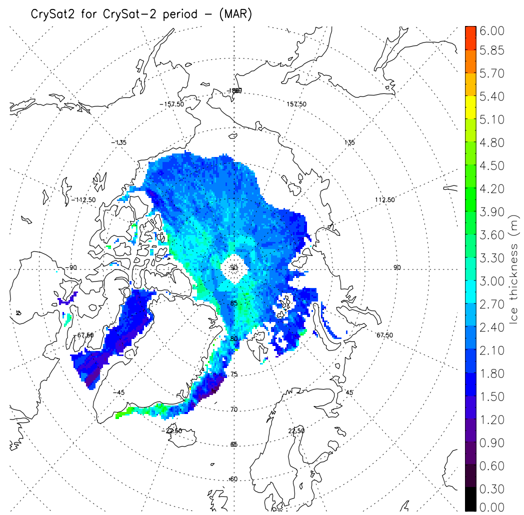
Validation with submarine sonar and modeled ice thicknesses.

Ice Thickness Intercomparison

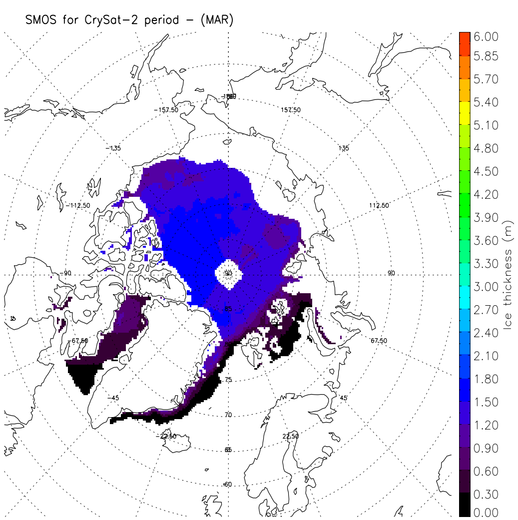
APP-x (VIIRS algorithm)



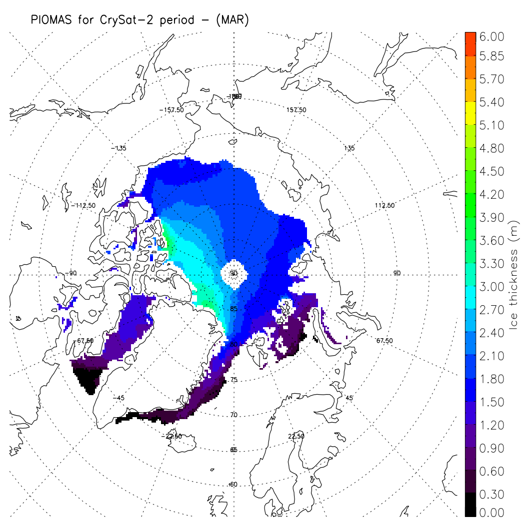
CryoSat-2



SMOS



PIOMAS



Period: 01/2011 – 03/2013, March

APP-x - PIOMAS: Bias=0.51 m
CryoSat-2 – PIOMAS: Bias=0.57 m
SMOS – PIOMAS: Bias=-0.43m

Sea Ice Characterization Requirements

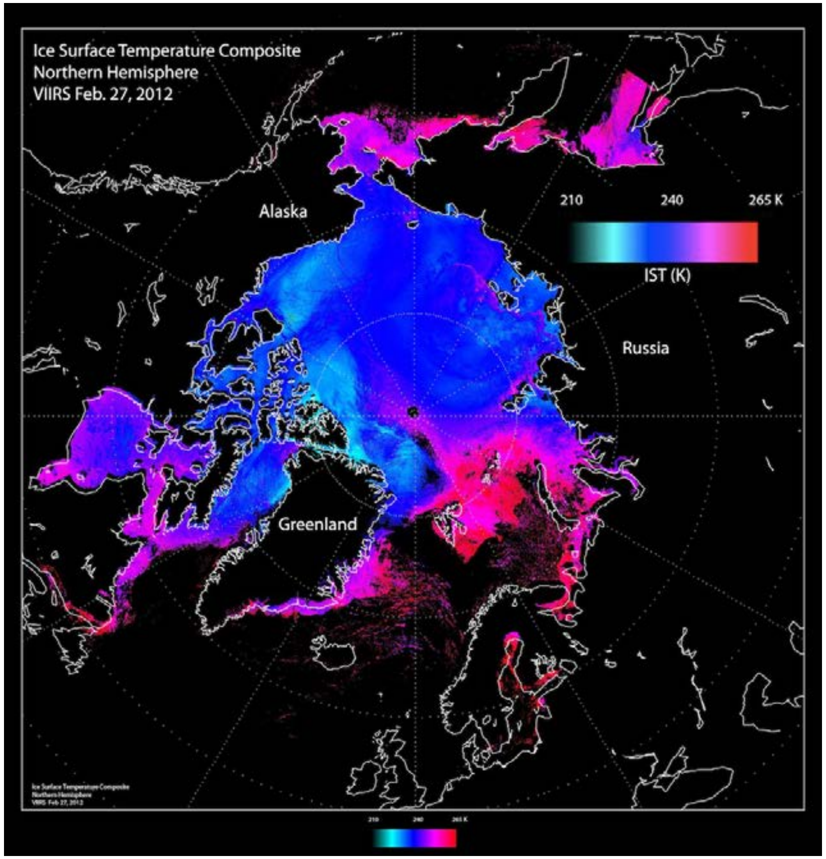
Sea Ice Characterization Requirements from L1RD version 2.4

EDR Attribute	Threshold	Objective
a. Vertical Coverage	Ice Surface	Ice Surface
b. Horizontal Cell Size **1. Clear** **2. All weather**	 1.0 km No capability	 0.5 km 1 km
c. Mapping Uncertainty, 3 sigma **1. Clear** **2. Cloudy**	 5 km No capability	 0.5 km 1 km
d. Measure Range **1. Ice Age** **2. Ice Concentration**	 Ice Free, New Young, all other ice 0/10 to 10/10	Ice free, Nilas, Gray White Grey, White, First Year Medium, First Year Thick, Second Year, Multiyear, Smooth and Deformed Ice 0/10 to 10/10
e. Measurement Uncertainty **1. Probability of Correct Typing (Ice Age)** **2. Ice Concentration**	 70% Note 1	 90% 5%
f. Refresh	At least 90% coverage of the global every 24 hours (monthly average)	6 hrs
g. Geographic coverage	All Ice-covered regions of the global ocean	All Ice-covered regions of the global ocean

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

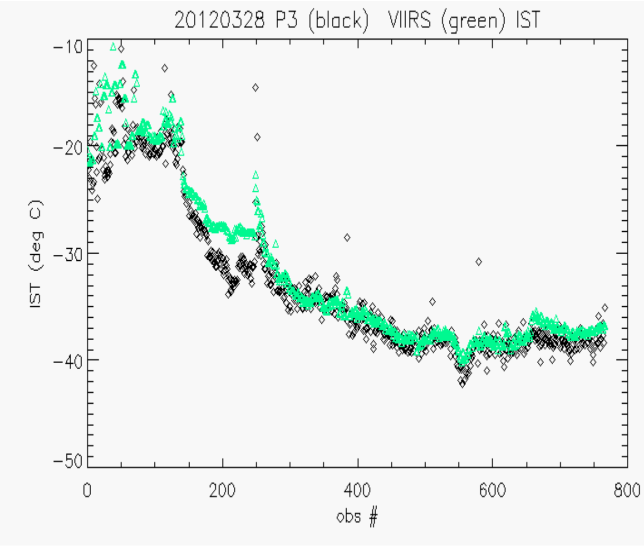
Ice Surface Temperature

The Ice Surface Temperature (IST) is the surface skin, or radiating, temperature of sea ice. Validation has been done primarily with IceBridge aircraft data.



Composite of VIIRS Ice Surface Temperature on 27 Feb 2012.

IceBridge KT19 vs VIIRS IST, 2012



DATE	BIAS	RMS
3/14	0.56	0.08
3/15	-0.84	0.63
3/16	1.01	0.71
3/21	-0.55	0.41
3/22	-0.21	0.14
3/27	0.12	0.21
3/28	1.12	0.53
3/29	0.46	0.10
4/02	0.66	0.19

BIAS = VIIRS - KT19

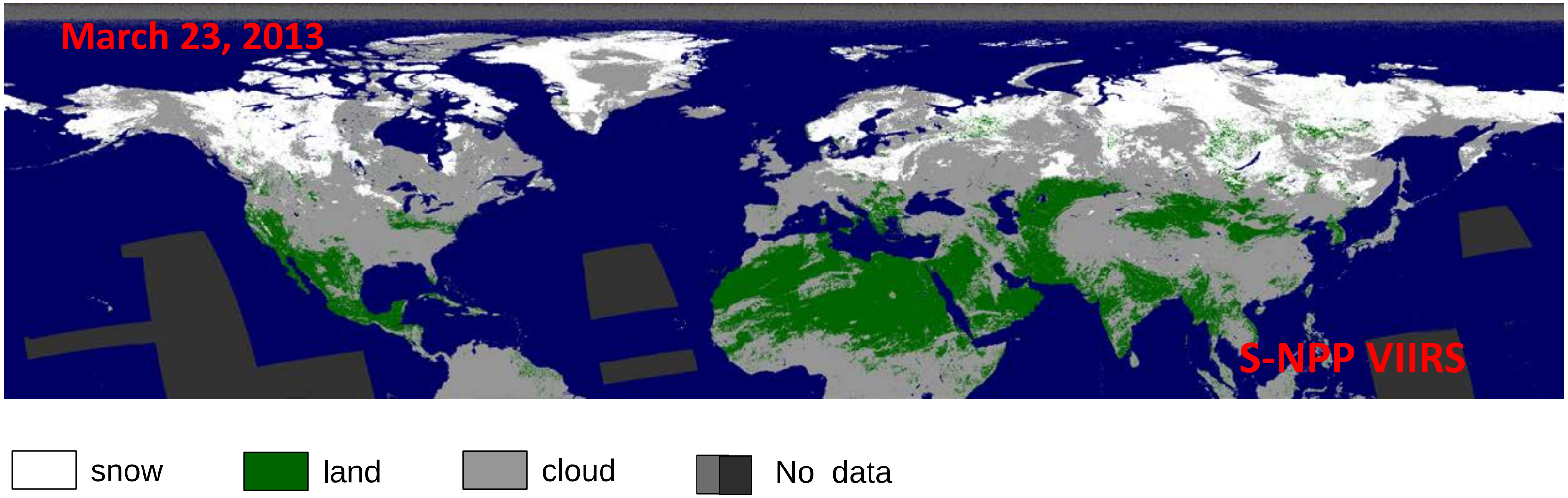
Ice Surface Temperature Requirements

Ice Surface Temperature (IST) Requirements from L1RD Supplement. V2.9 (27 June 2013)

EDR Attribute	Threshold	Objective
IST Applicable Conditions **1. Clear, only**		
a. Sensing Depth	Ice Surface	Ice Surface
b. Horizontal Cell Size **1. Nadir** **2. Worst Case**	 1 km 1.6 km	 0.1 km 0.1 km
c. Mapping Uncertainty, 3 sigma **1. Nadir** **2. Worst Case**	 1 km 1.6 km	 0.1 km 0.1 km
d. Measure Range	213-275 K	213-293 K (2 m above ice)
e. Measurement Uncertainty	1 K	
f. Refresh	At least 90% coverage of the global every 24 hours (monthly average)	12 hrs
g. Geographic Coverage	Ice-covered oceans	All ice-covered waters

Binary Snow Cover

Snow Cover is the horizontal and vertical extent of snow cover. The binary product gives a snow/no-snow flag.



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

Binary Snow Cover Requirements

Parameter	Specification Value
a. Binary Horizontal Cell Size,	
1. Clear – daytime (Worst case)	0.8 km
2. Clear – daytime (At nadir)	0.4 km
3. Cloudy and/or nighttime	N/A
b. Horizontal Reporting Interval	Horizontal Cell Size
c. Snow Depth Range	> 0 cm (Any Thickness)
d. Horizontal Coverage	Land
e. Vertical Coverage	> 0 cm
f. Measurement Range	Snow / No snow
g. Probability of Correct Typing	90%
h. Mapping Uncertainty	1.5 km

1. The probability of correct snow/no-snow detection applies only to climatologically snow-covered regions.
2. The accuracy of snow detection does not apply over forested/mountainous areas where snow may be hidden by vegetation or topographic shading.

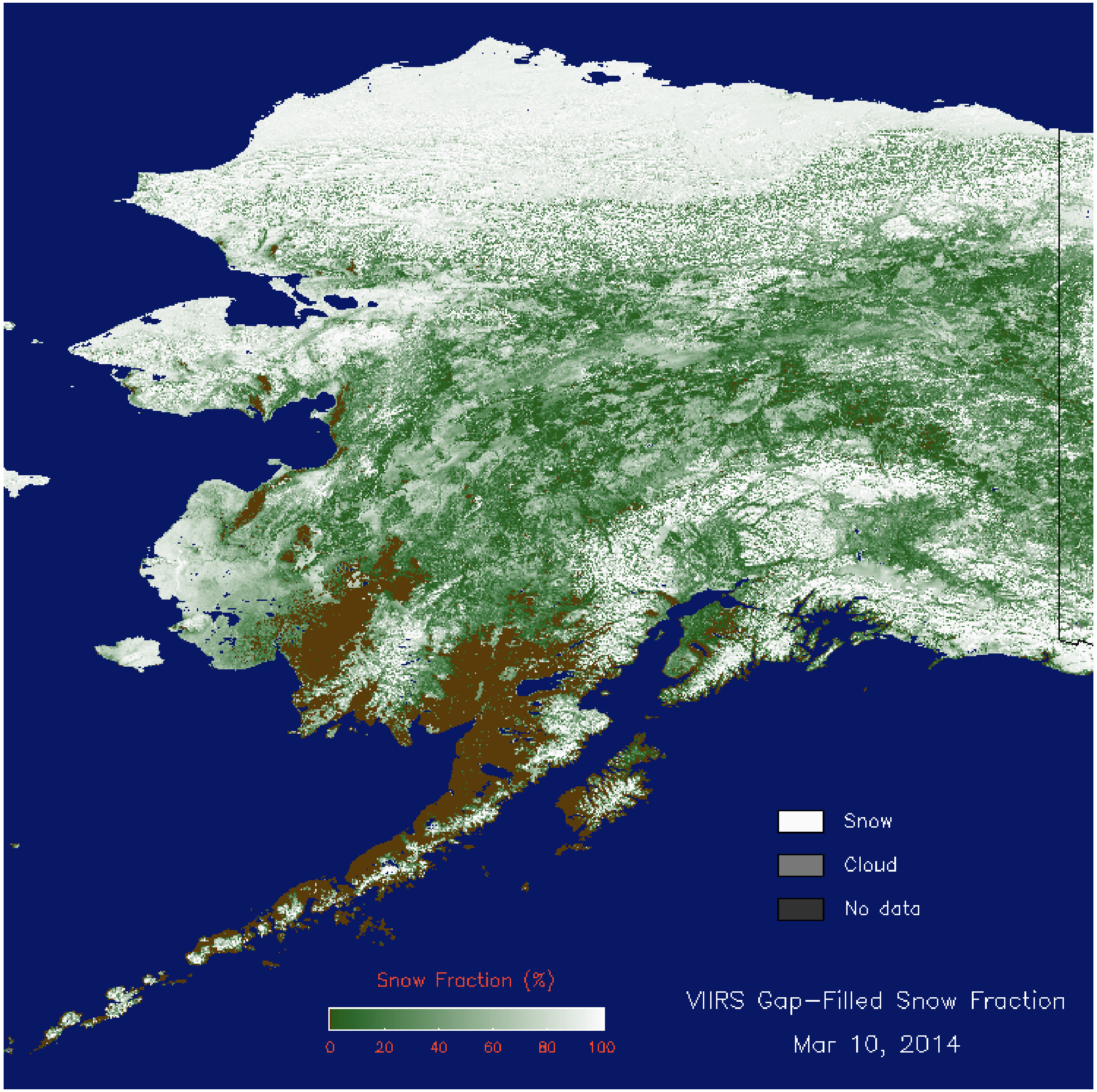
[Joint Polar Satellite System (JPSS) Program Level 1 Requirements SUPPLEMENT – Final Version: 2.9 June 27, 2013]

Snow Fraction

The IDPS snow fraction product is not useful, given that it is a 2x2 pixel binary snow mask average.

The new enterprise product provides the sub-pixel snow fraction. It is based on the normalized difference snow index (NDSI), also used by NASA for MODIS.

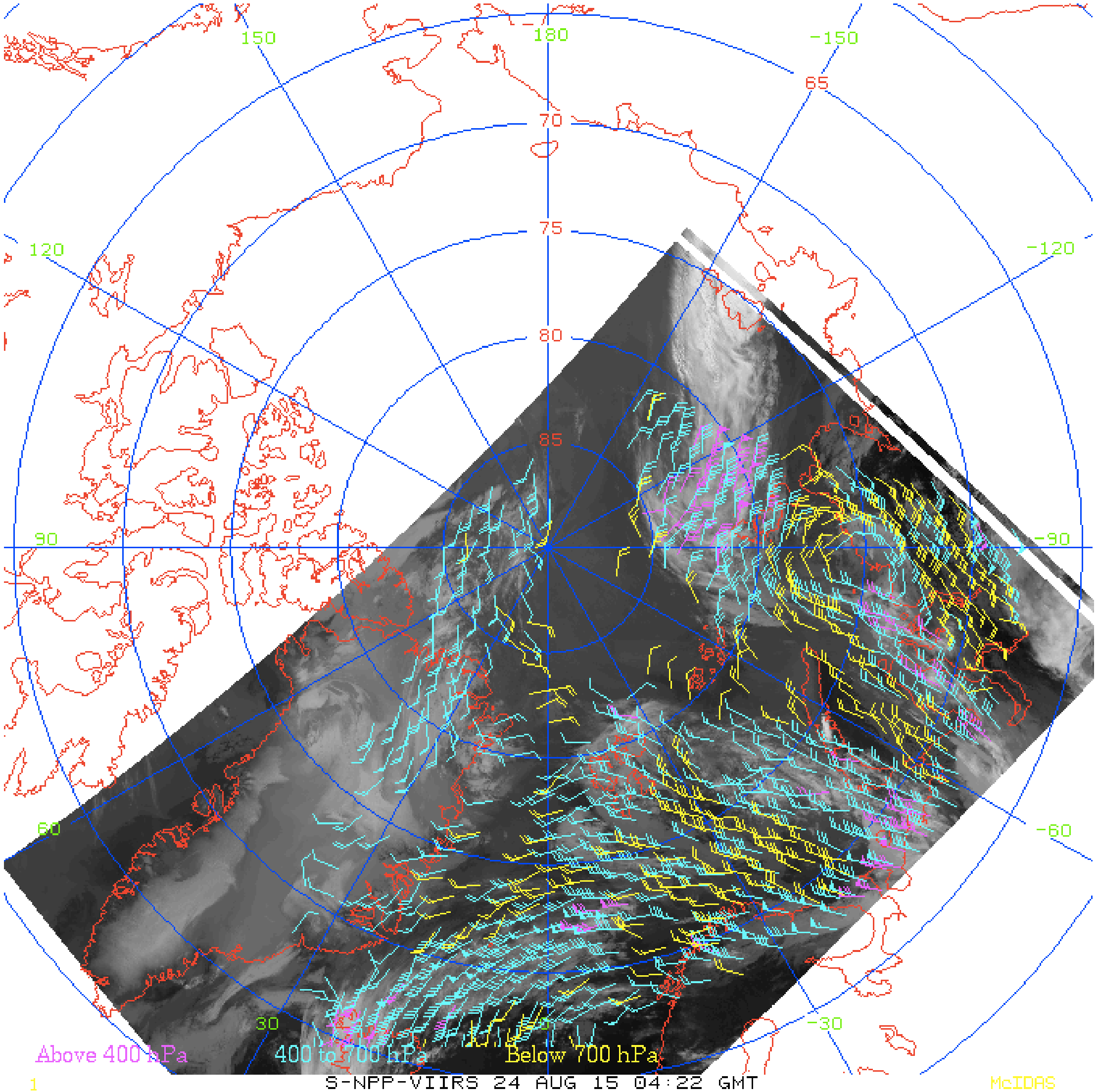
A reflectance-based product will also be generated.



Snow Fraction Requirements

Parameter	Specification Value
a. Horizontal Cell Size,	
1. Clear – daytime (Worst case)	1.6 km
2. Clear – daytime (At nadir)	0.8 km
3. Cloudy and/or nighttime	N/A
b. Horizontal Reporting Interval	Horizontal Cell Size
c. Snow Depth Ranges	> 0 cm (Any Thickness)
d. Horizontal Coverage	Land
e. Vertical Coverage	> 0 cm
f. Measurement Range	0 – 100% of HCS
g. Measurement Uncertainty	10% of HCS (Snow/No Snow)
h. Mapping Uncertainty	1.5 km

VIIRS Polar Winds



VIIRS polar winds are derived by tracking clouds in infrared imagery. Wind speed, direction, and height are estimated throughout the troposphere, poleward of approximately 70 degrees latitude.

Left: VIIRS winds from Sodankylä, Finland on 24 August 2015

Polar Winds Requirements

Table 5.2.12 - Polar Winds (VIIRS)		
EDR Attribute	**Threshold**	**Objective**
a. Vertical Coverage	Surface to Tropopause	Surface to 20 km
b. Horizontal Resolution	10 km	10 km
c. Vertical Reporting Interval	At cloud tops	0.1 km
d. Mapping Uncertainty, 3 sigma	5 km	5 km
e. Measurement Range	Speed: 3 to 100 m/sec (1) Direction: 0 to 360 degrees	Speed: 0 to 100 m/sec Direction: 0 to 360 degrees
f. Measurement Precision	Mean vector difference: 3.8 m/sec	0.5 m/s
g. Measurement Accuracy	Mean vector difference: 7.5 m/sec	± 1 m/s
h. Refresh	100 min	1 hour
		v2.4, 12/10/12
Notes: 1. Changed from "0 - 100 m/s" to "3 - 100 m/s" as wind vectors below 3 m/s are usually removed.		

14

Unique VIIRS Characteristics for Winds

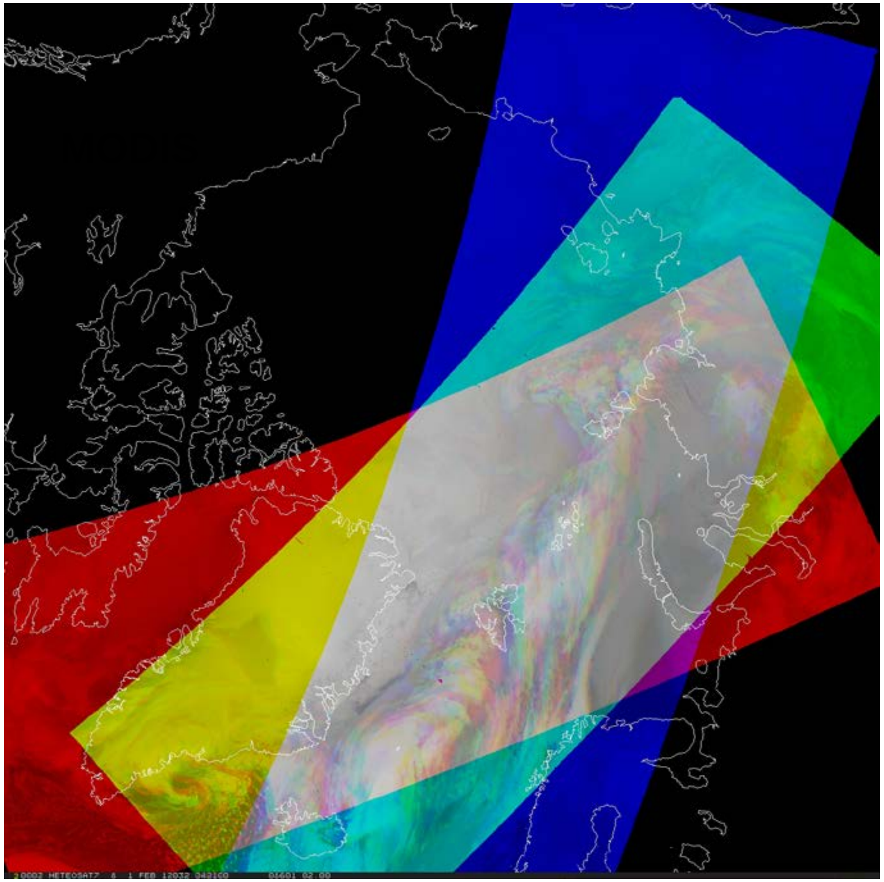
- The Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi National Polar-orbiting Partnership (S-NPP) satellite was launched 28 October 2011.
- VIIRS will be on the JPSS series of satellites, replacing AVHRR as NOAA's operational polar-orbiting imager.

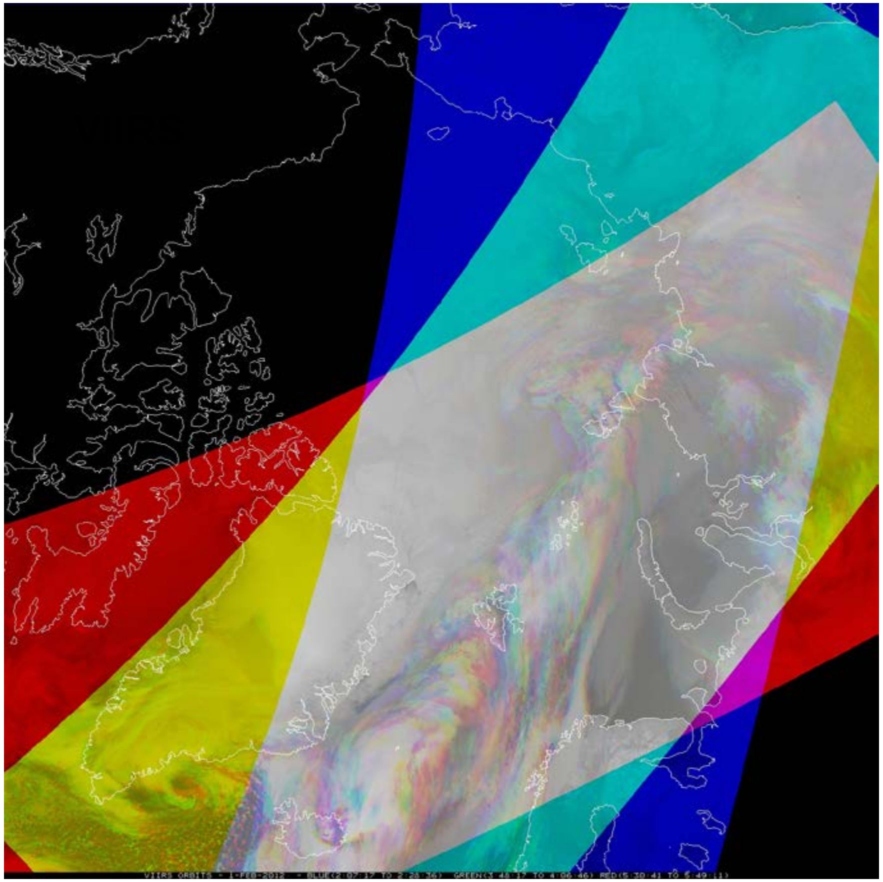
- VIIRS' unique characteristics relevant to a polar winds product include:
  - **Higher spatial resolution (750 m for most bands; 375 m for some)**
  - **Wider swath than MODIS**
  - **Constrained pixel growth: better resolution at edge of swath**
  - **Day-night band (DNB)**
  - Disadvantage: No thermal water vapor band so no clear-sky WV winds

- The VIIRS polar winds processing **utilizes the GOES-R AMV algorithm**.

VIIRS Coverage: Wider Swath

VIIRS has a wider swath (3000 km) than MODIS (2320 km), so the coverage will be better and will extend further south.

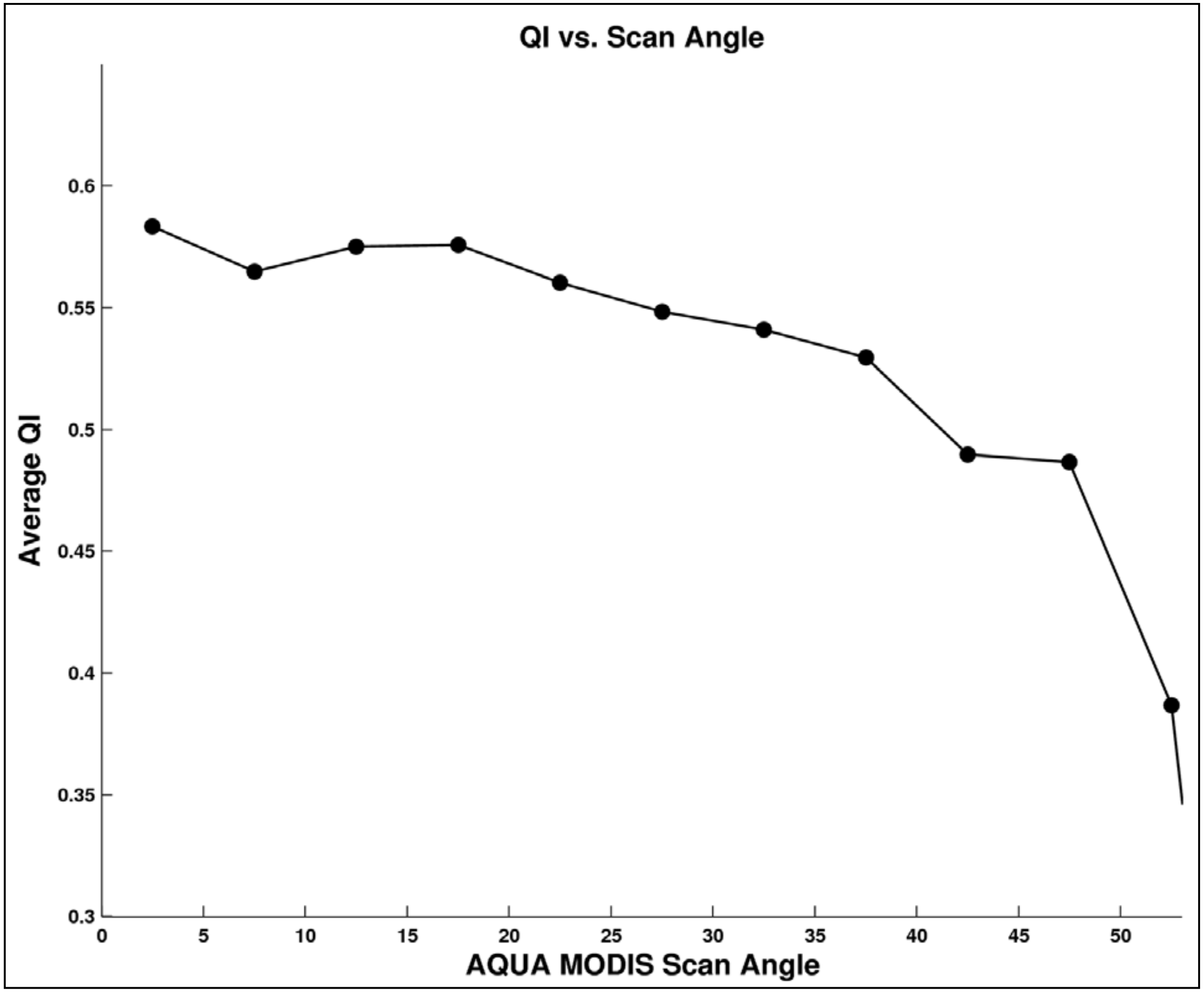




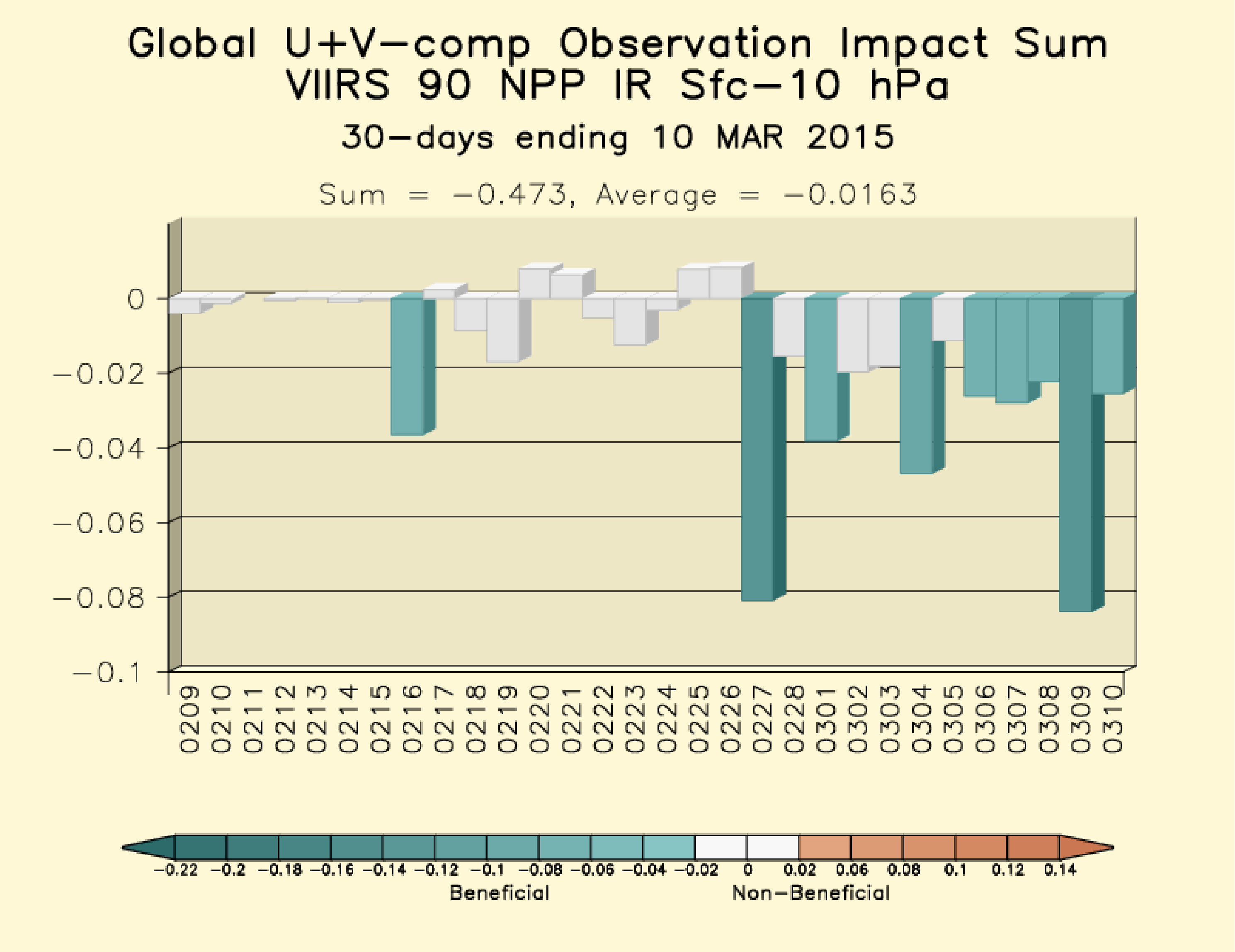
A wider swath means more winds with each orbit.

Effects of Scan Angle on Winds

Does the improved resolution away from nadir matter for wind retrieval?



VIIRS Winds Model Impact at NRL



FY14-15 Top Accomplishments

Accomplishment #1: Developed a new VIIRS sea ice thickness product. Provides a reasonable estimate of actual ice thickness, not just ice in two categories. The IDPS EDR is problematic.

Accomplishment #2: Developed a new VIIRS snow fraction product. The snow fraction product in the IDPS Snow Cover EDR is of limited value (2 x 2 pixel average of binary snow cover) so a new algorithm was implemented outside of IDPS. The new algorithm provides MODIS heritage. A second algorithm with GOES heritage was also implemented.

Accomplishment #3: VIIRS polar winds became operational through NDE in May 2014. Direct broadcast VIIRS winds are now generated at Fairbanks, Alaska, and Sodankylä, Finland. Users report positive impact as good or better than MODIS winds.

Accomplishment #4: Some of these algorithms are being applied to Himarwari-8 AHI data. They were developed for GOES-R.

Uses and Users

- Numerical Weather Prediction (NWP centers)
  - Snow and ice cover are commonly used (though not from VIIRS yet)
  - Ice thickness is not yet utilized; should be used universally!
  - Polar winds (13 NWP centers in 9 countries use the various polar winds products)
- Navigation and Transportation (National Ice Center, Alaska Ice Desk, Navy, USCG, local services)
  - Ice concentration (currently evaluating)
  - Ice thickness (near future)
  - Snow cover/fraction (currently evaluating)
- Hydrologic Modeling (NOHRSC, local services)
  - Snow fraction

FY16 Milestones/Deliverables

Task Category	Task/Description	Start	Finish	Deliverable
Development (D)	NSDI-based snow fraction algorithm; sea ice thickness algorithm	9/2014	12/2015	NDE snow fraction product; sea ice thickness product
Integration & Testing (I)	Snow fraction algorithm; sea ice thickness algorithm	6/2015	3/2016	same
Calibration & Validation (C)	Revise cal/val plans; Implement cal/val plan tasks (see plans for details);	6/2015	Ongoing	Product error assessments
Maintenance	Algorithm maintenance and minor improvements	10/2014	Ongoing	Product improvements
LTM & Anomaly Resolution (L)	Develop LTM website	10/2015	9/2016	LTM website for cryosphere products

Path Forward (FY17 thru FY20)
High Priority Tasks/Milestones

	S-NPP	JPSS-1	JPSS-2
FY17	Operational generation of new snow fraction and sea ice thickness products in enterprise environment.	• Begin transitioning to JPSS • Redefine products if needed • Generate LUTs for J1 VIIRS sensor	
FY18	Algorithm maintenance and minor improvements; long-term validation of VIIRS snow and ice products; product reprocessing	• Evaluate use of dual S-NPP/JPSS-1 pairing for polar winds • Algorithm maintenance and minor improvements	Define validation plan
FY19	Long-term validation of VIIRS snow and ice products	• Blended VIIRS/CryoSat/ICESat ice thickness? • Long-term validation of JPSS-1 VIIRS snow and ice products	• Hold algorithm preliminary and critical design reviews, as necessary • Begin transitioning to JPSS • Redefine products if needed • Generate LUTs for J2 VIIRS sensor
FY20	Long-term validation of VIIRS snow and ice products	Long-term validation of JPSS-1 VIIRS snow and ice products	

Summary

Robust validation has been performed for all snow and ice products. Validation data include aircraft radiometer and laser measurements, in situ observations, and other satellite products.

Significant deficiencies were found in the operational Sea Ice Characterization EDR and the snow fraction portion of the Snow Cover EDR.

Two new VIIRS products have been developed and are being implemented in the enterprise system:

- Sea ice thickness
- Snow fraction

The other operational snow and ice products – ice surface temperature, ice concentration (currently an IP), and binary snow cover – perform reasonably well. Nevertheless, enterprise versions of these products are also being implemented.

VIIRS polar winds are seeing increased use by NWP centers and positive impact.

Land EDR Overview

Land product suite

Presenter: Ivan Csiszar (STAR)

Contributors: STAR JPSS Land Team and external team members / partners

Date: August 25, 2015

Algorithm Cal/Val Team Members

PI	Org.	Key Team Members	Roles and Responsibilities
Ivan Csiszar	STAR/UMD	Louis Giglio, Wilfrid Schroeder	NOAA Product Team Lead, **Fire**
Miguel Román	NASA/UMD	Chris Justice, Sadashiva Devadiga	NASA Coordination, Validation co-lead, SIPS
Eric Vermote	NASA/UMD	Belen Franch	**Surface Reflectance**, VCM, calibration
Marco Vargas	STAR/U HI/AER	Tomoaki Miura, Zhangyan Jiang	**Vegetation Index, Green Vegetation Fraction**
Felix Kogan	STAR/IMSG	Wei Guo	**Vegetation Health**
Yunyue (Bob) Yu	STAR/SDSU	Xiaoyang Zhang	**Phenology**
Yunyue (Bob) Yu	STAR/UMD	Shunlin Liang, Dongdong Wang	**Albedo**
Bob Yu	STAR/ UMD	Yuling Liu, Zhen Song, Peng Yu	**Land Surface Temperature**
Jerry Zhan	STAR/ UMD	Chengquan Huang, Rui Zhang	**Surface Type**
Kevin Gallo	STAR/ USGS		Validation, data continuity
Walter Wolf	STAR/ IMSG	Marina Tsidulko, Qiang Zhao	STAR AIT Land
Leslie Belsma	Aerospace		JPSS Algorithm Manager
Mike Ek	NCEP/IMSG	Yihua Wu, Weizhong Zheng, Helin Wei	NCEP Land Team, data assimilation

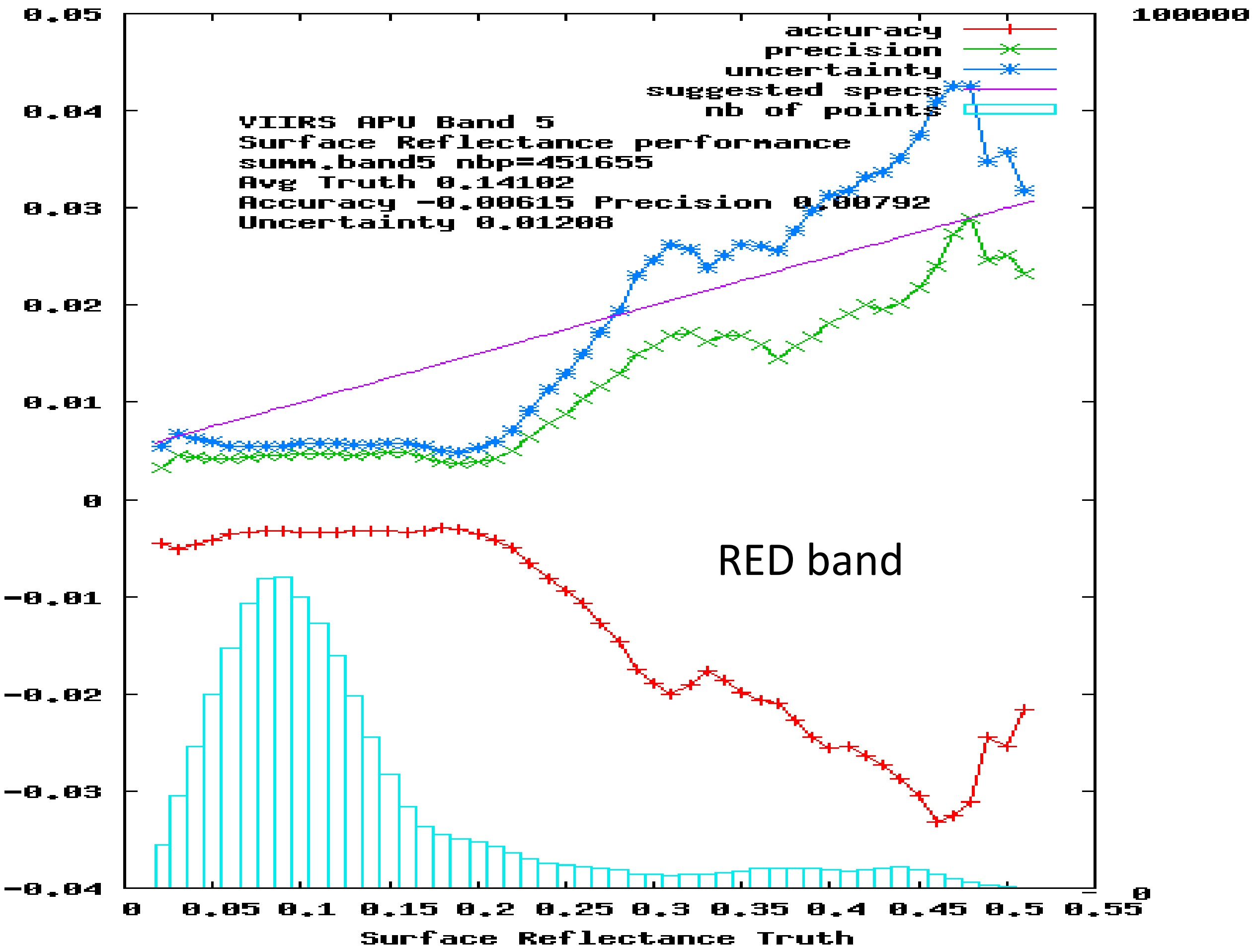
IDPS: Interface Data Processing Segment; ***NDE: NOAA-Unique***; ***PGRR: Proving Ground / Risk Reduction***

VIIRS Surface reflectance status

- Overall goal is to keep the NASA Science Product and the NOAA Operational product in sync
- Current the VIIRS SR product is directly heritage from collection 5 MODIS and that it has been validated to stage 1
  - Land PEATE adjusted version
  - ongoing code change for IDPS implementation
- MODIS algorithm refinements from Collection 6 will be integrated into the VIIRS algorithm
  - candidates for further improvements in the NOAA JPSS operational product
- NOAA algorithm integration supported by STAR AIT
- Algorithm is generic and tied to documented validated radiative transfer code so the accuracy is traceable enabling error budget.
- The use of BRDF correction enables easy cross-comparison of different sensors (MODIS,VIIRS,AVHRR, LDCM, Landsat, Sentinel 2 ,Sentinel 3…)

Evaluation of Algorithm Performance

VIIRS C11 reprocessing



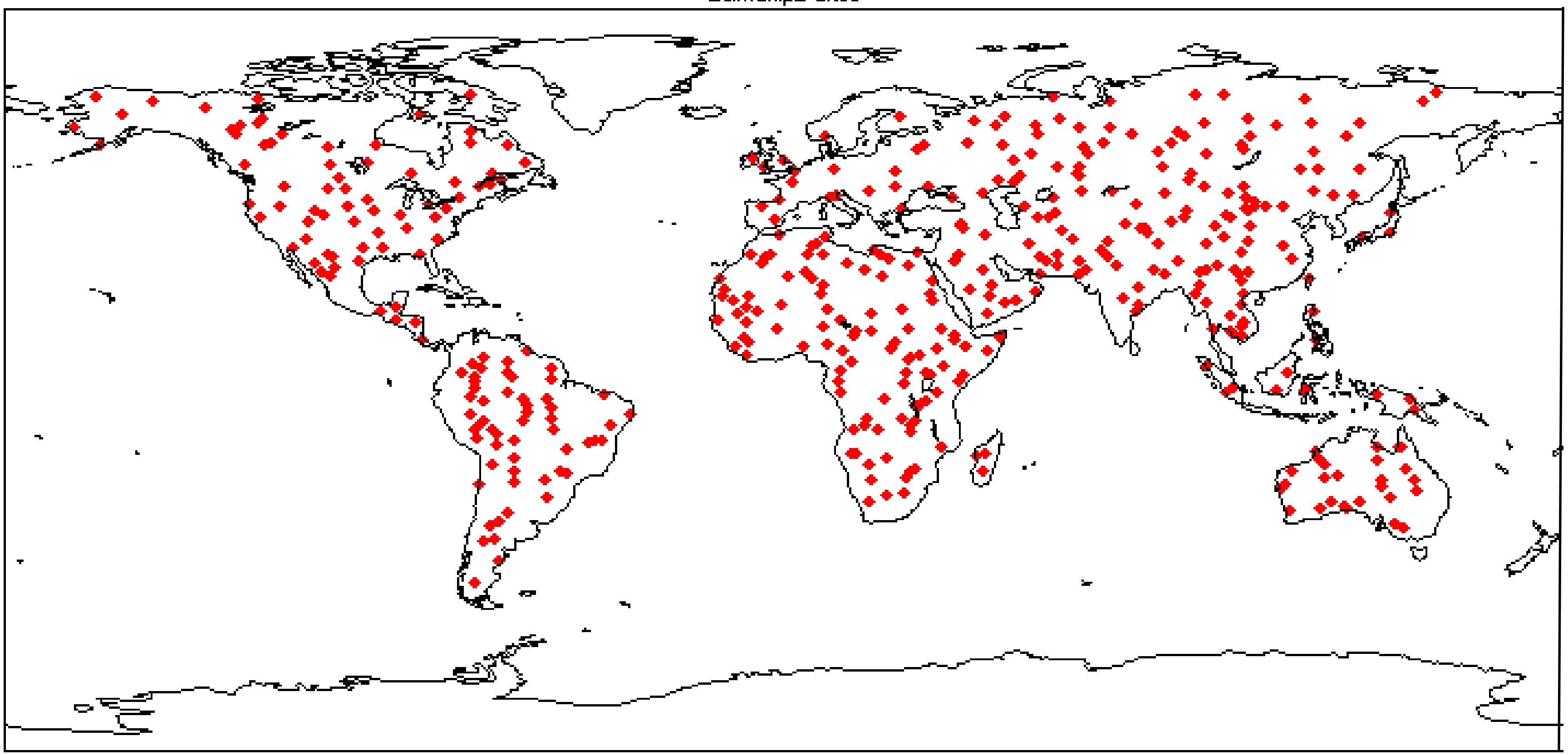
450000 pixels were analyzed for each band.

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

On average well below magenta theoretical error bar

Cross comparison with MODIS over BELMANIP2

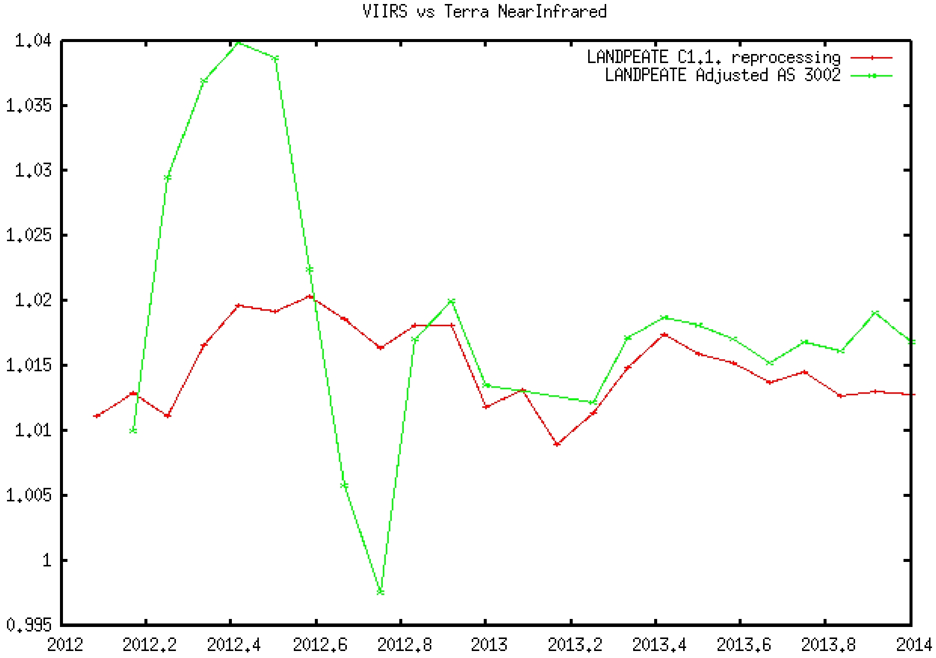
The VIIRS SR is now monitored at more than 400 sites (red losanges) through cross-comparison with MODIS.

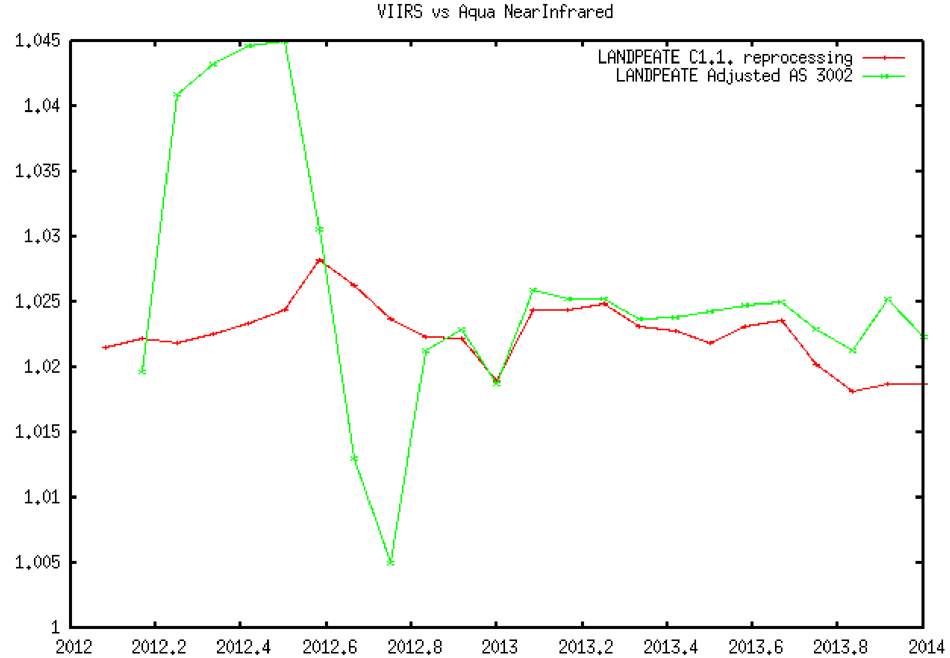


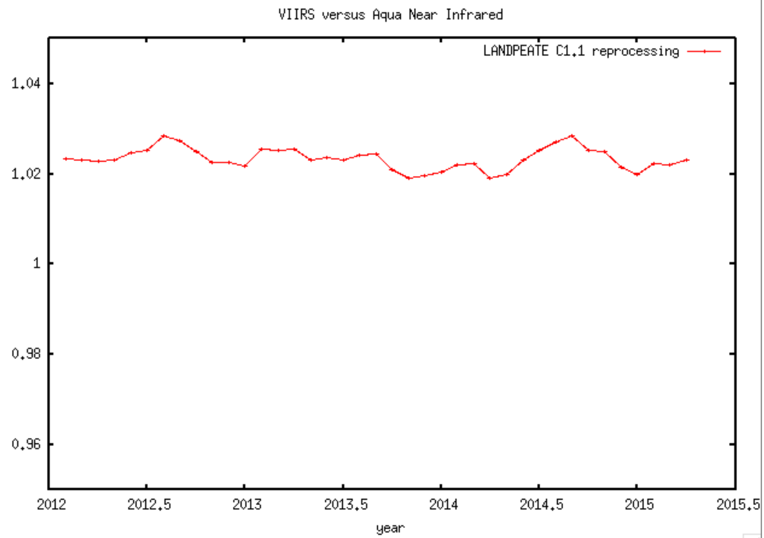
BELMANIP2:* *Benchmark Land Multisite Analysis and Intercomparison of Products

http://calvalportal.ceos.org/web/olive/

Results over BELMANIP2







Algorithm improvements have ensured good consistency with validated MODIS SR product

For direct validation AERONET is central and a "standard" protocol for its use to be defined (CEOS CVWG initiative)

SNPP VIIRS Vegetation Index EDR Current Status

SNPP VI EDR Maturity: <u>Validated Stage 1</u>

JPSS1 Algorithm Development (J1 Upper)

- Completed the development of TOC NDVI
- CCR-15-2382 approved by AERB in July 2015

Validation activities

- Global comparisons with Aqua MODIS
- Evaluation over AERONET sites
- Time series validation over FLUXNET sites

Instrument/product quality

- High radiometric quality, meeting the L1RDS requirements
- Low atmospheric correction quality along cloud edges
- Overestimation of cloud shadows

VI algorithm issues

- Unrealistic EVI for snow/ice or cloud-contaminated pixels
- EVI compatibility with MODIS

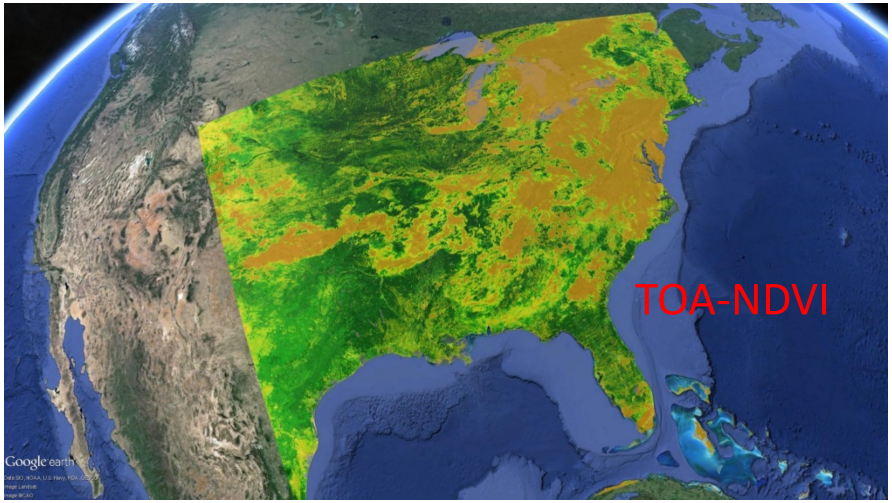
Long Term Monitoring (LTM)

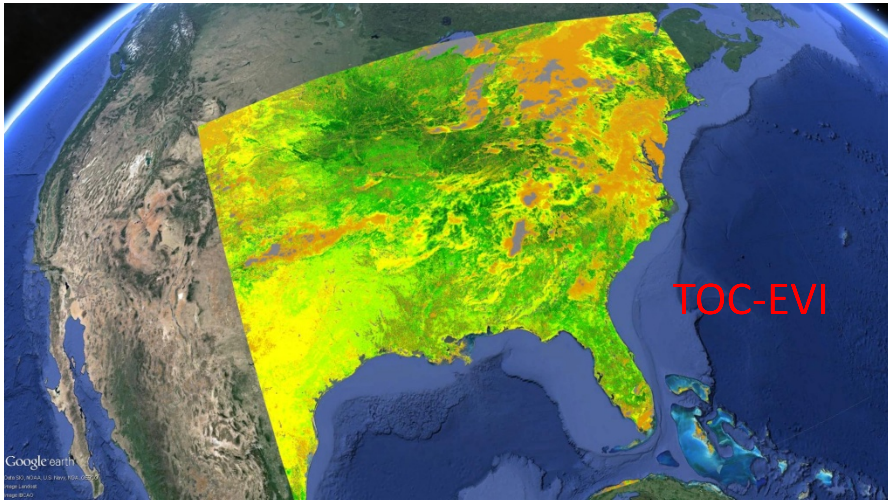
- Ongoing

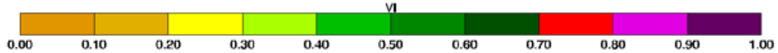
<u>Global APU Estimates (2014 - 2015)</u>

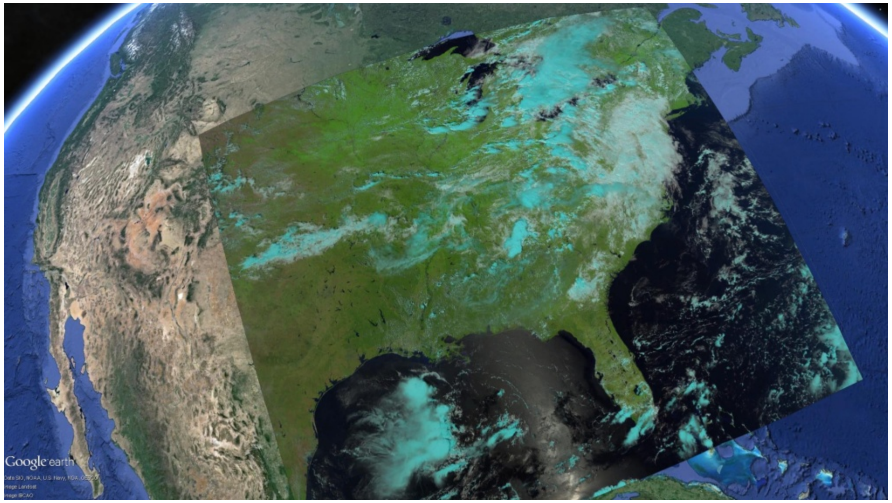
Attribute	L1RDS Threshold (VI units)	Validation Results
TOA NDVI Accuracy	0.05	0.005
TOA NDVI Precision	0.04	0.017
TOA NDVI Uncertainty	0.06	0.020
TOC EVI Accuracy	0.05	0.037
TOC EVI Precision	0.04	0.011
TOC EVI Uncertainty	0.06	0.039
TOC NDVI Accuracy	0.05	0.007
TOC NDVI Precision	0.04	0.023
TOC NDVI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

VI-EDR August 10, 2015





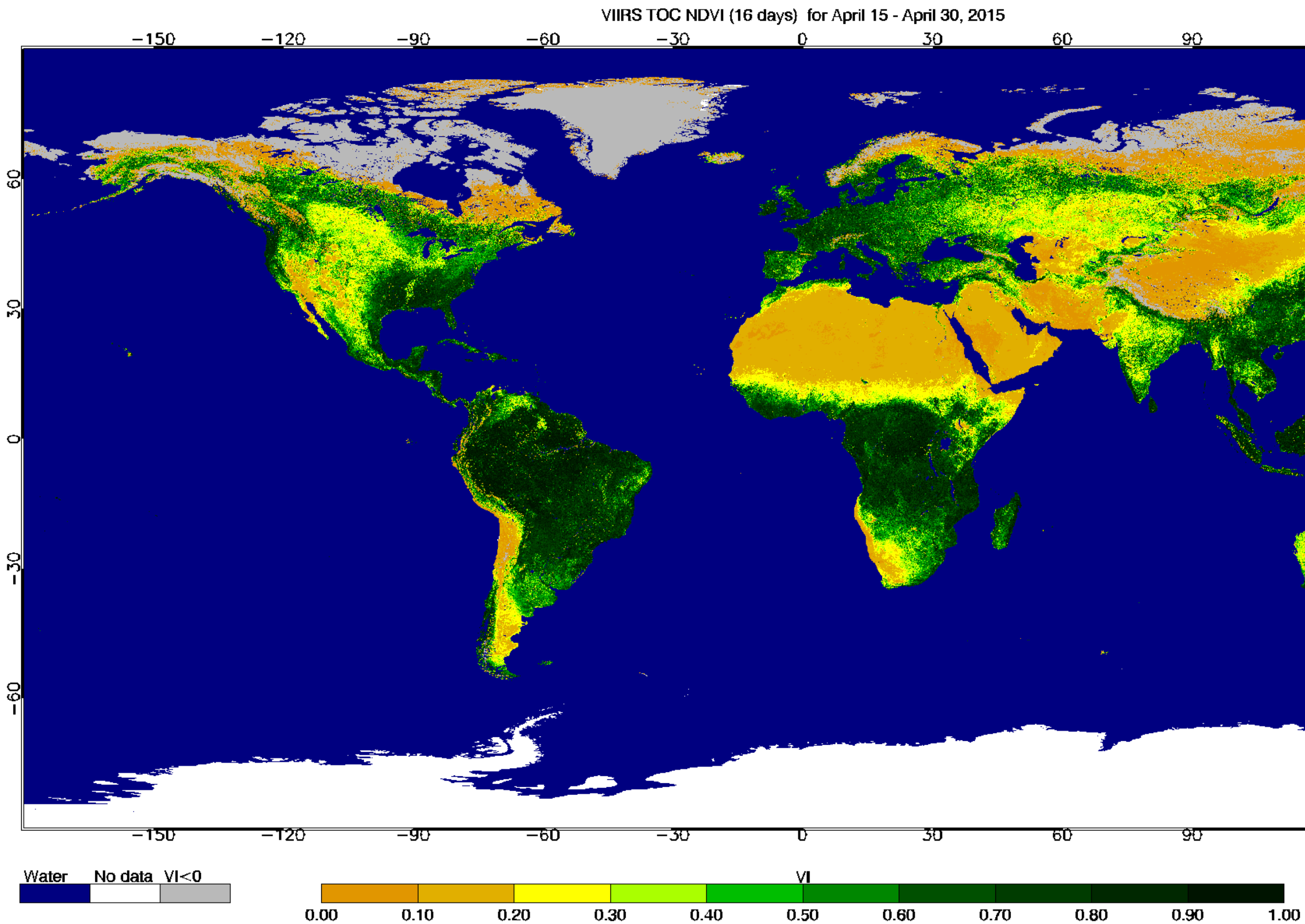




5 VIIRS VIVIO Granules

timestamp d20150810_t1844472
timestamp d20150810_t1846126
timestamp d20150810_t1847380
timestamp d20150810_t1849034
timestamp d20150810_t1850288

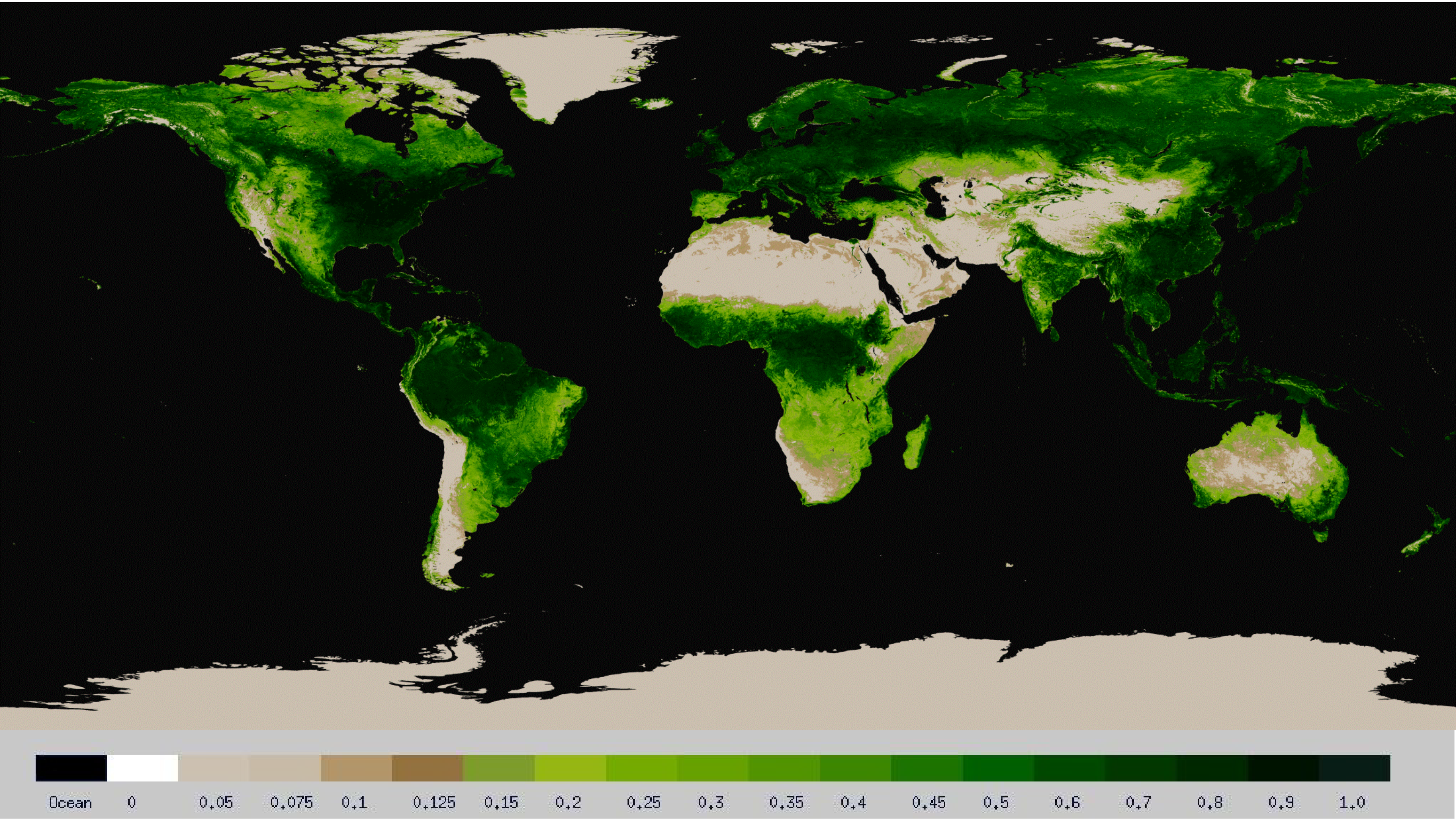
TOC-NDVI
16-day composite



SNPP VIIRS Green Vegetation Fraction

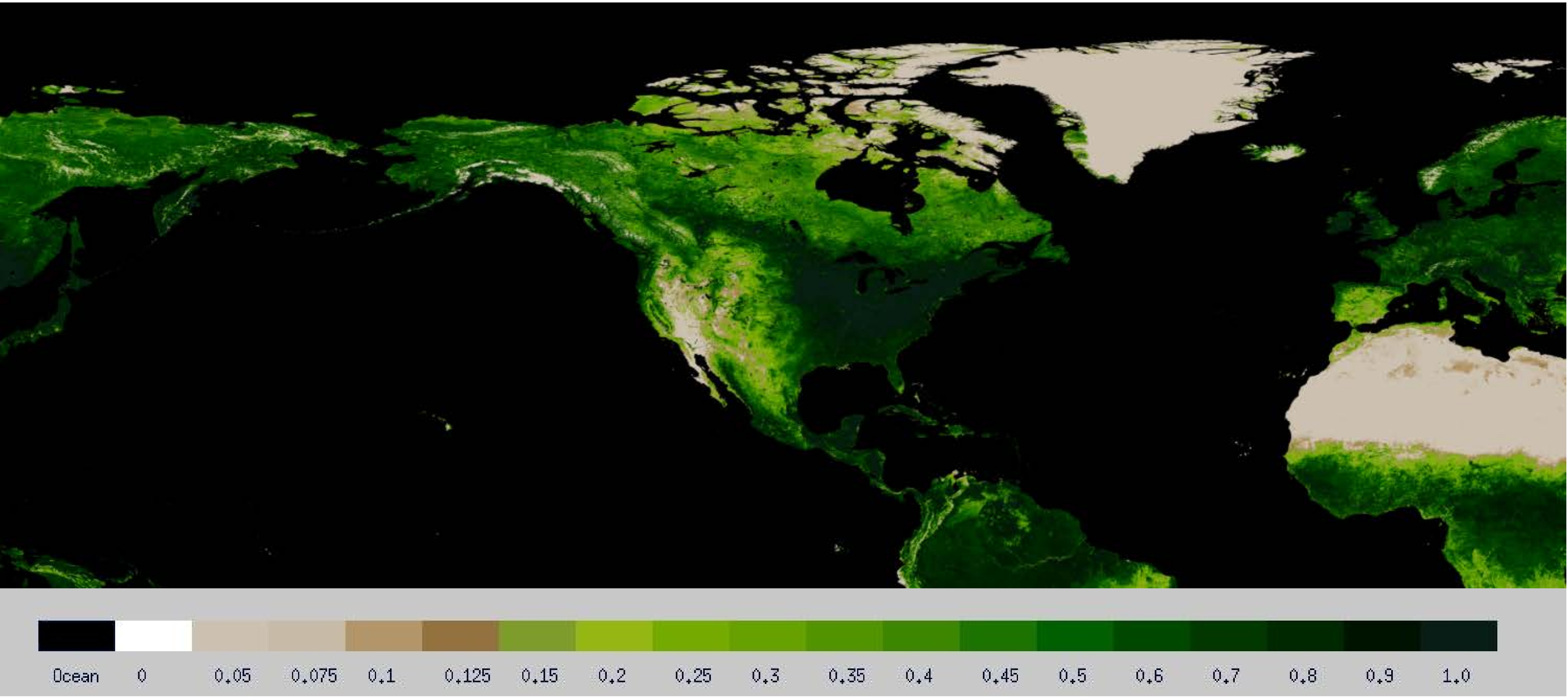
- The SNPP VIIRS GVF consists of two products:
  - Daily Rolling Weekly 4-km GVF on a global grid
  - Daily Rolling Weekly 1-km GVF regional
- SNPP VIIRS GVF products are derived from VIIRS surface reflectance data (Bands I1, I2 and M3)
- Surface reflectance data are gridded, composited and used for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

SNPP VIIRS GVF
Global (4km res)



4km resolution weekly global GVF (August 10-16, 2015)

SNPP VIIRS GVF
Regional Product (1km res)



1km resolution weekly regional GVF (August 7-13, 2015). Coverage Lat 90°N - 7.5°S, Lon 130°E - 30°E

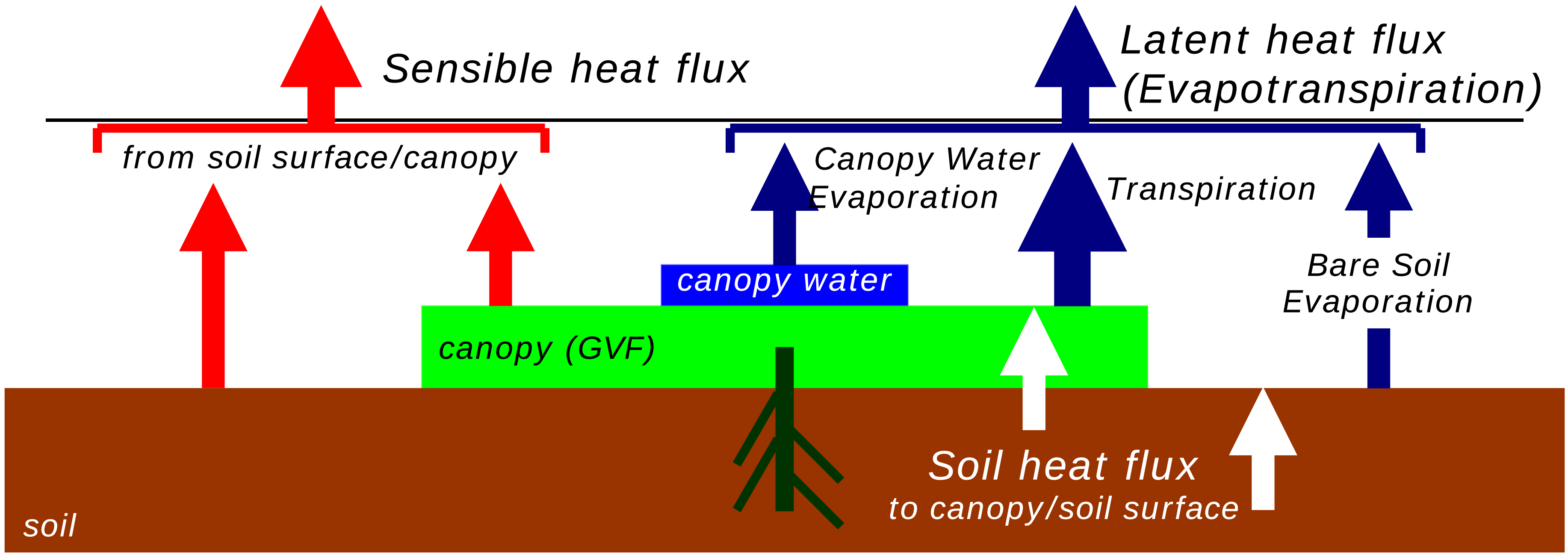
GVF: Recent Accomplishments

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

The "Science": Surface Fluxes

$$H = \rho c_p C_h U (T_{sfc} - T_{air})$$

$$LE = LE_c + LE_t + LE_d$$

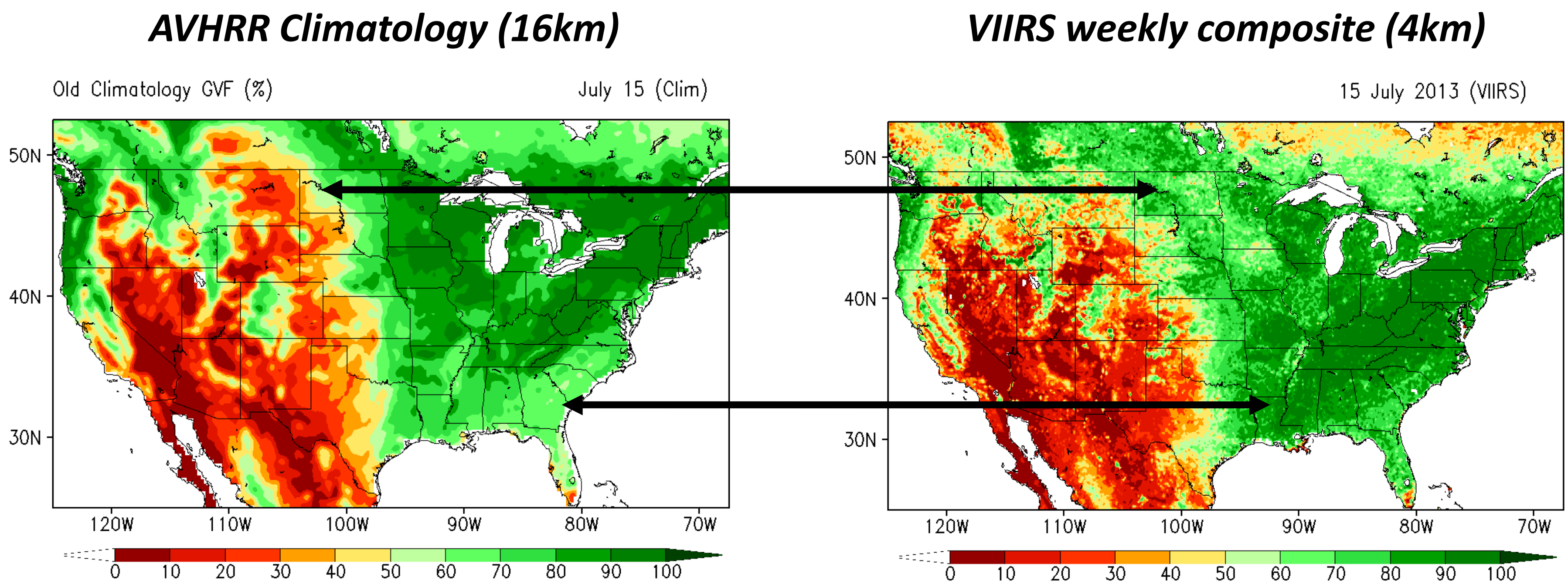


$$G = \left(\frac{K_T}{\Delta z}\right)(T_{sfc} - T_{soil})$$

$$R_n = H + LE + G$$

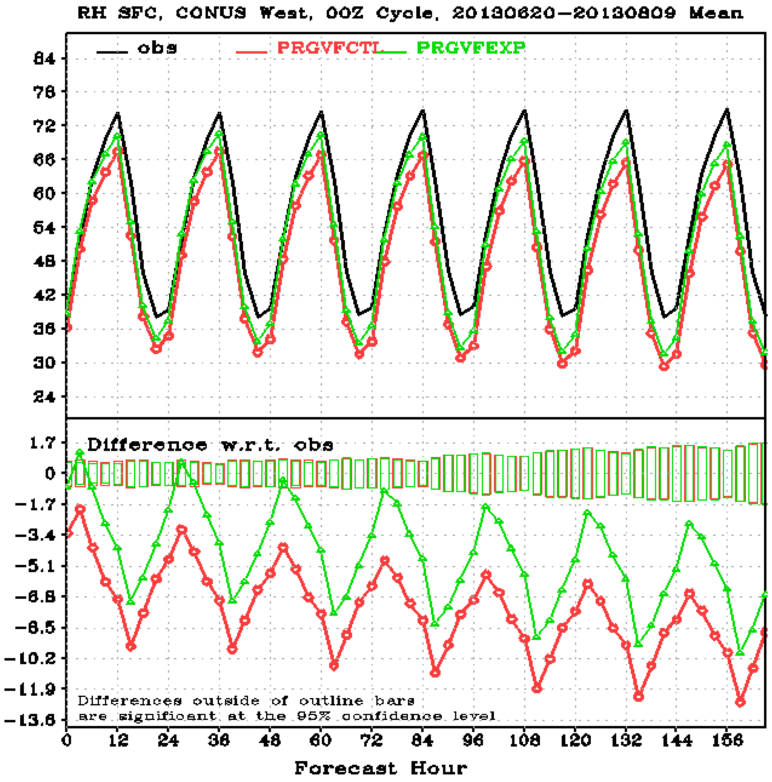
- **Surface fluxes balanced by net radiation (Rn), = sum of incoming and outgoing solar and terrestrial radiation, where GVF is important for energy partition between H, LE and G, i.e. surface roughness & near-surface turbulence (H), vegetation processes (LE), and heat transport through canopy (G), affecting evolving boundary-layer, clouds/convection, and precipitation.**

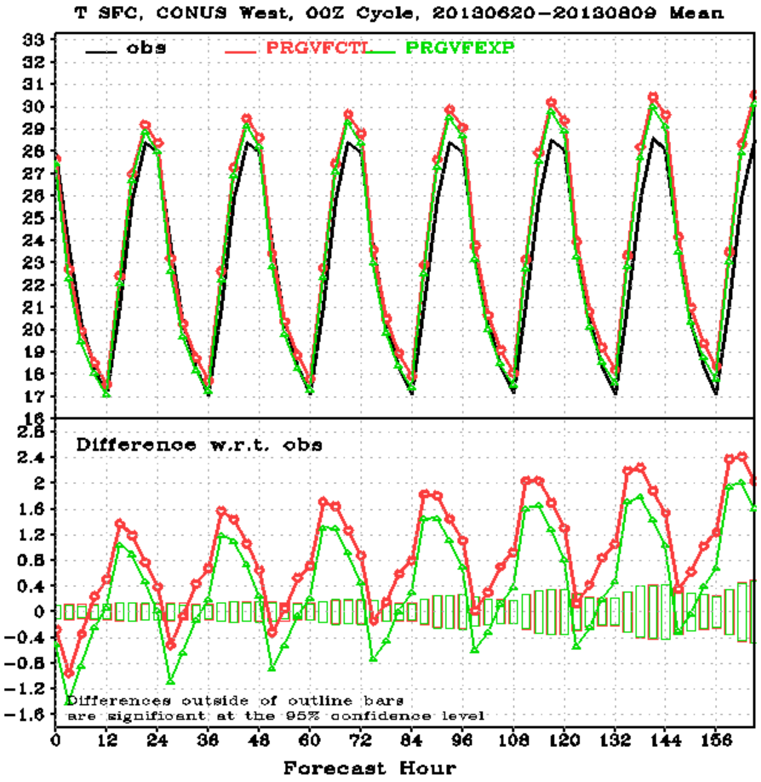
NOAA NESDIS VIIRS Green Vegetation Fraction



Weekly GVF composites updated daily are being generated for use by the NOAA National Weather Service (NWS) National Centers for Environmental Prediction (NCEP). Early sensitivity studies have shown a reduction of errors of temperature, humidity and wind speed forecasts, and an improvement of precipitation scores in Global Forecasting System (GFS) performance, compared to the use of the heritage AVHRR-based climatology.

GVF impact studies: Summer 2013 example



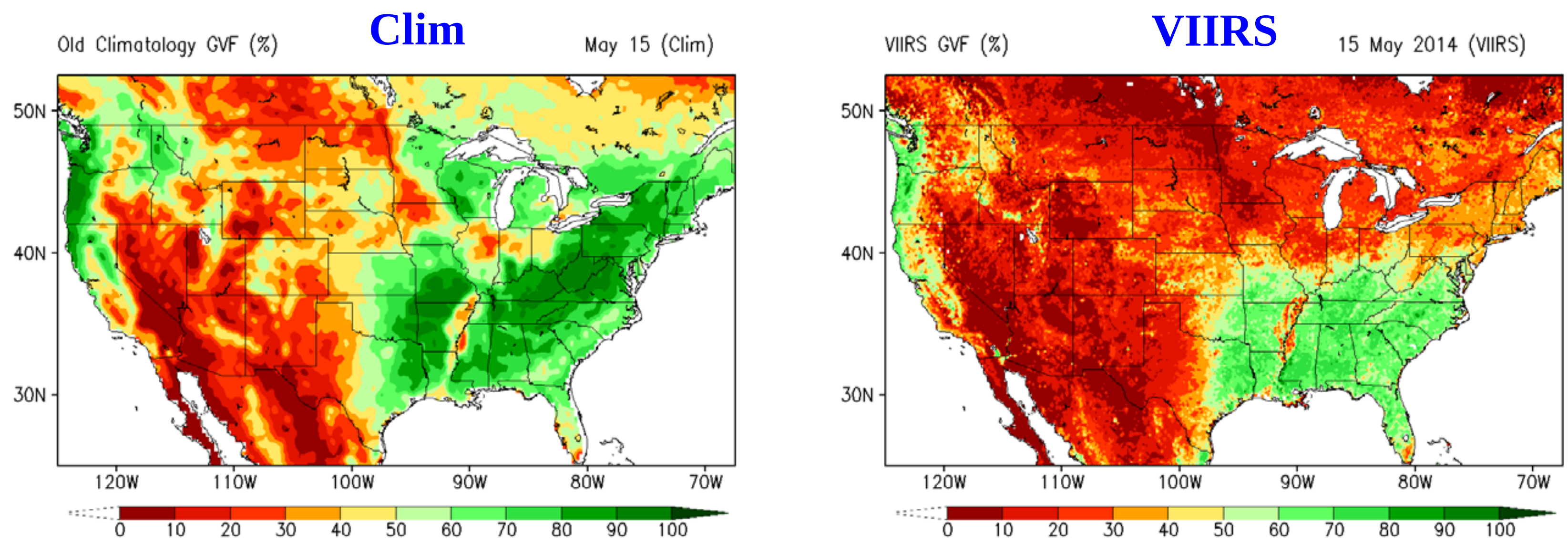


Surface relative humidity (left) and air temperature (right) GFS model runs for the Western CONUS for June 20 – August 9 2013. Black: observed; red: control run using AVHRR climatology; green: experimental run using VIIRS near-real-time data.

GVF anomalies: Spring 2014

15 May 2014

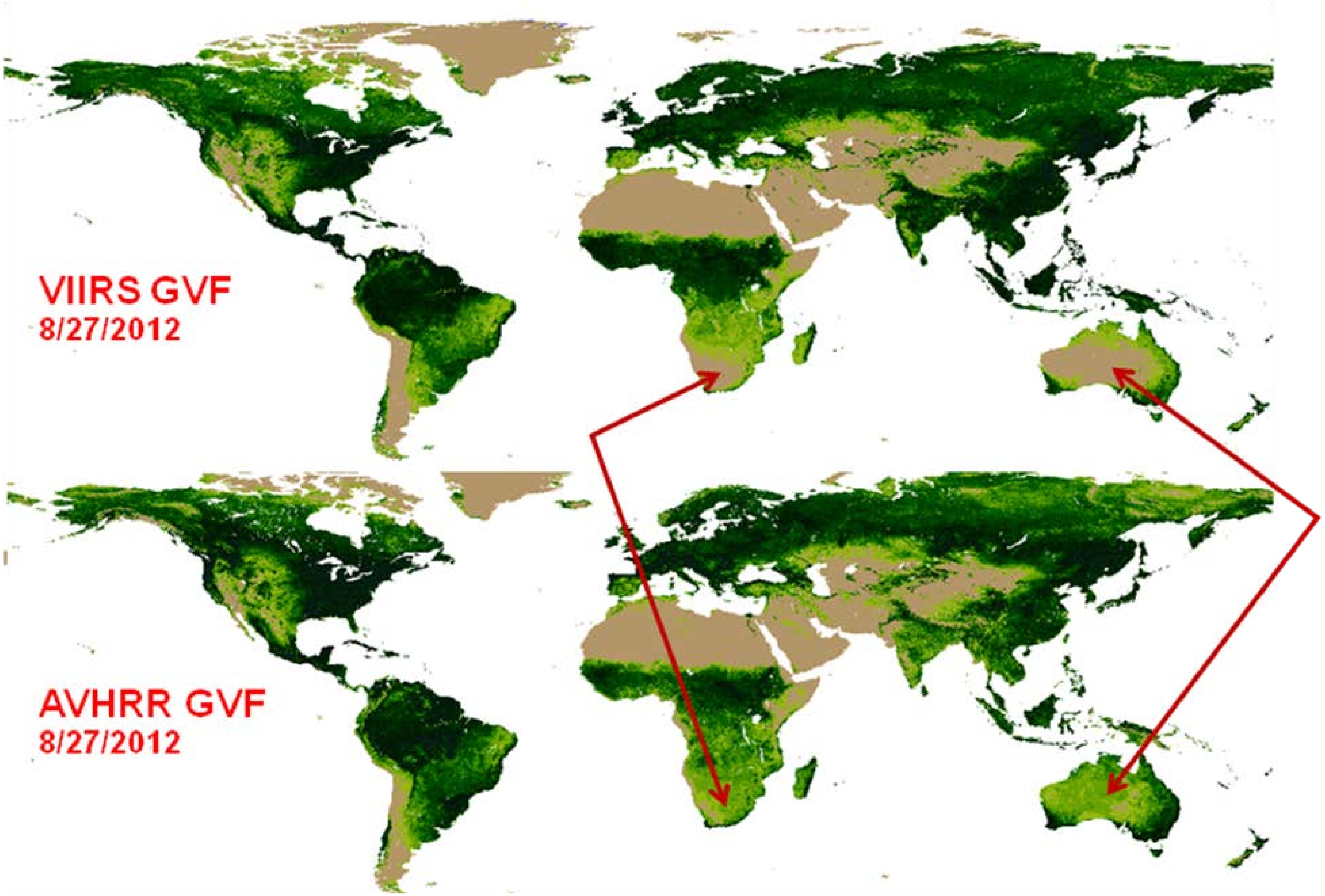
Drought in Spring



There is a critical need for establishing relationship between VIIRS and heritage AVHRR GVF for the characterization of anomalies.

VIIRS vs. AVHRR GVF

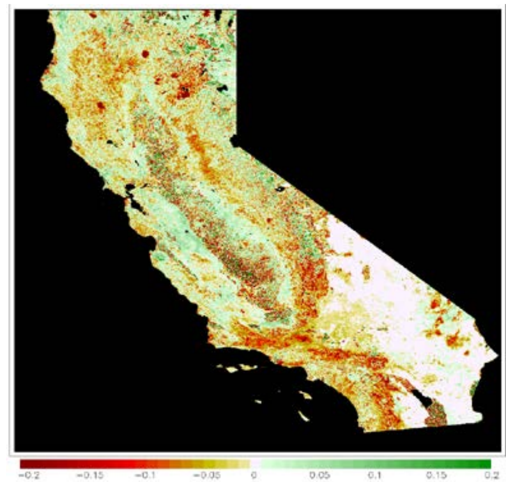
differences need to be understood and characterized to ensure continuity and incremental improvements



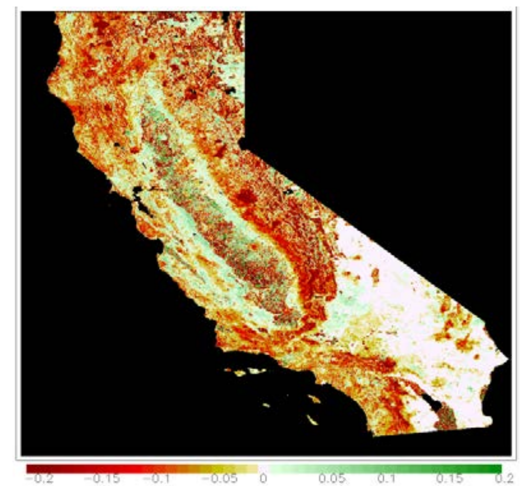
Monitoring Drought in California With SNPP VIIRS GVF

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

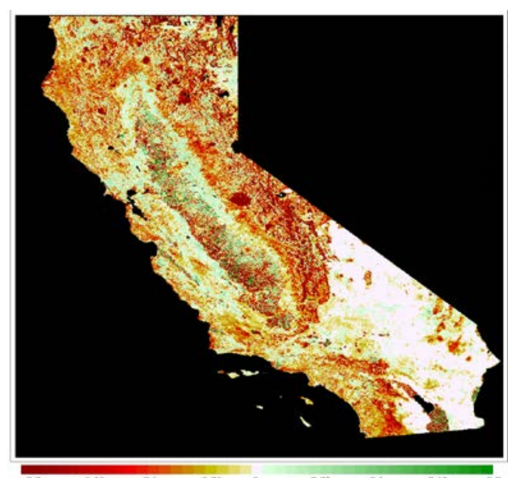
2013-08-15 minus 2012-08-15



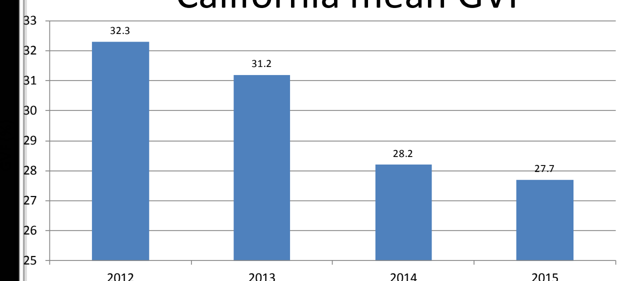
2015-08-15 minus 2012-08-15



2014-08-15 minus 2012-08-15



California mean GVF



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

SNPP VIIRS GVF Validation

SNPP VIIRS GVF product Validation

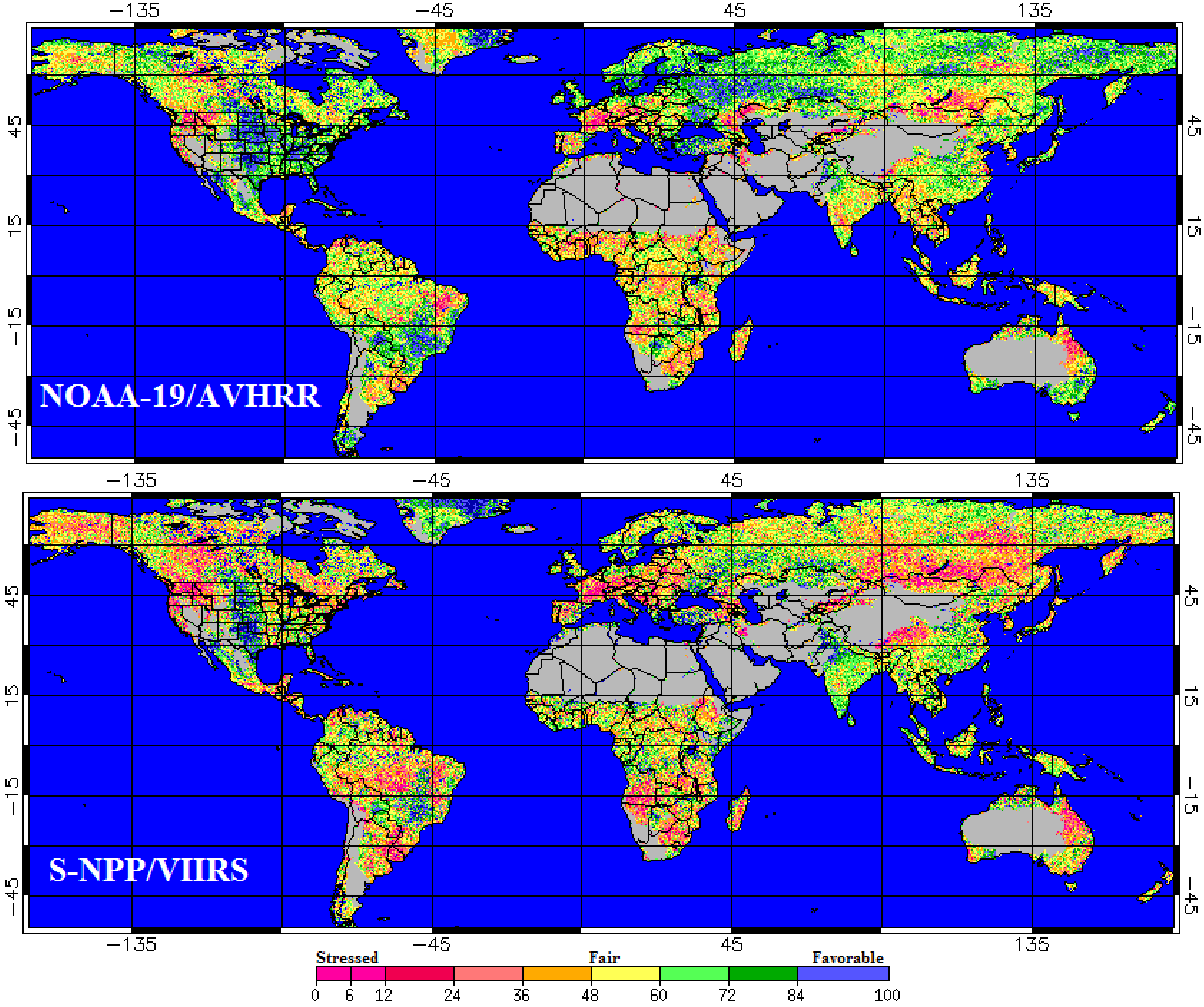
- GVF product maturity: Provisional
- The SNPP VIIRS GVF pre-operational product was shown to meet the threshold performance attributes identified in the JPSS Level 1 Requirements Supplement
- SNPP VIIRS GVF pre-operational product was validated against Landsat derived GVF, and compared with AVHRR derived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

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

Vegetation Health product suite (VCI, TCI & VHI)

- Current operational: Applications
- (a) NOAA-19/AVHRR: 4 km, global (until the sensor deteriorate)
- (b) S-NPP/VIIRS: 4 km, global
- Future operational: Development
- (a) S-NPP/VIIRS: 1 km, global (2016-2017)
- (b) JPSS-1 & S-NPP/VIIRS: 0.5 km, global (after 2017)
- Cal/Val
- (a) S-NPP/VIIRS: 4 & 1 km, global – algorithm improvement
- (b) JPSS-1 & S-NPP/VIIRS validation
- (c) New indices
- Development of new products
- **Short term**: Vegetation health, Drought features, Moisture condition/stress, Thermal condition/stress, Malaria, Fire risk, Soil saturation, Growing season, Ecosystem productivity;
- **Long term:** Land cover change, Environmental condition change; Climate warming, Climate forcing, Ocean forcing

Vegetation health (VHI)



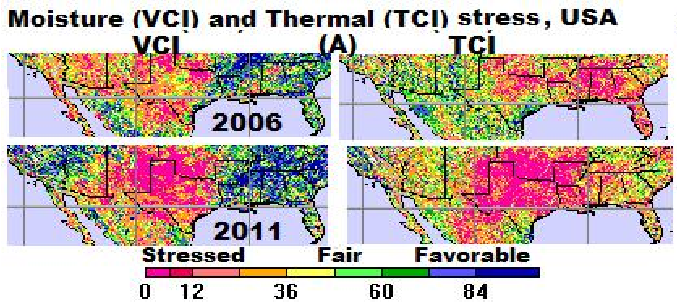
VEGETATION HEALTH, August 6, 2015

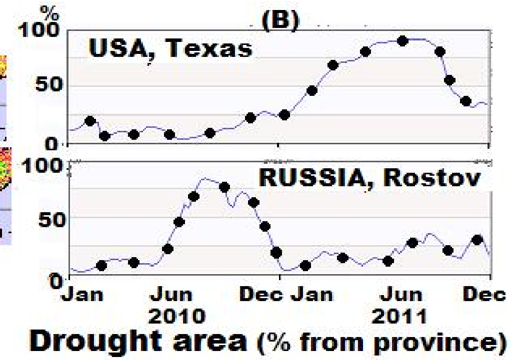
VH Applications

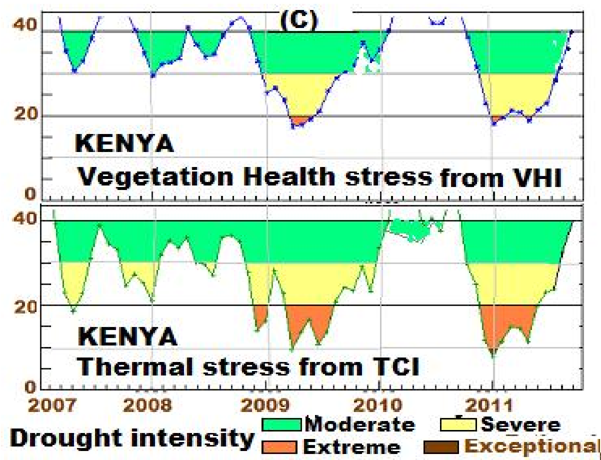
http://www.orbit.nesdis.noaa.gov/smcd/emb/vci

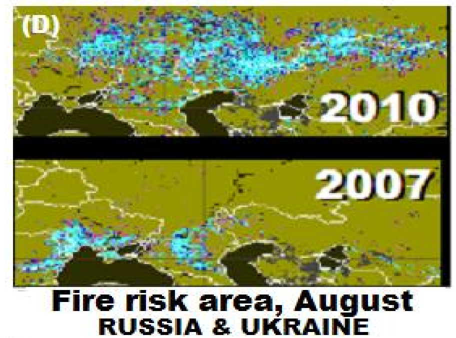
APPLICATIONS

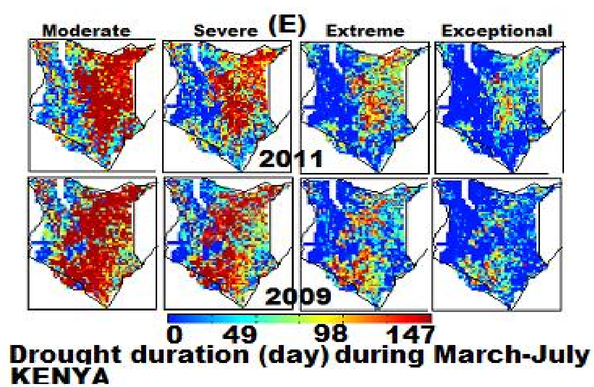
(A) Moisture & Thermal stress
(B) Drought area
(C) Intensity of vegetation stress
(D) Fire risk
(E) Drought duration
(F) Drought detection/prediction

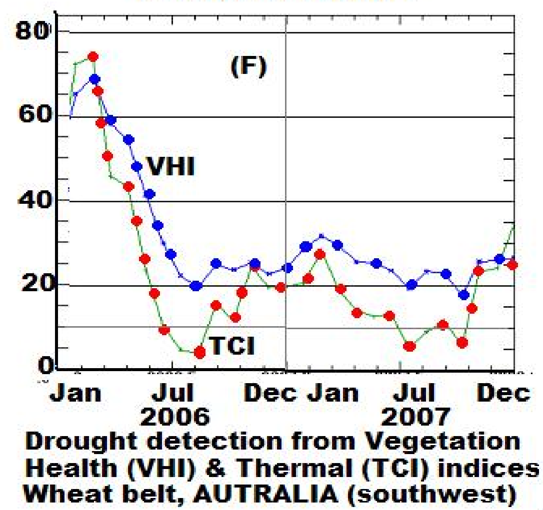




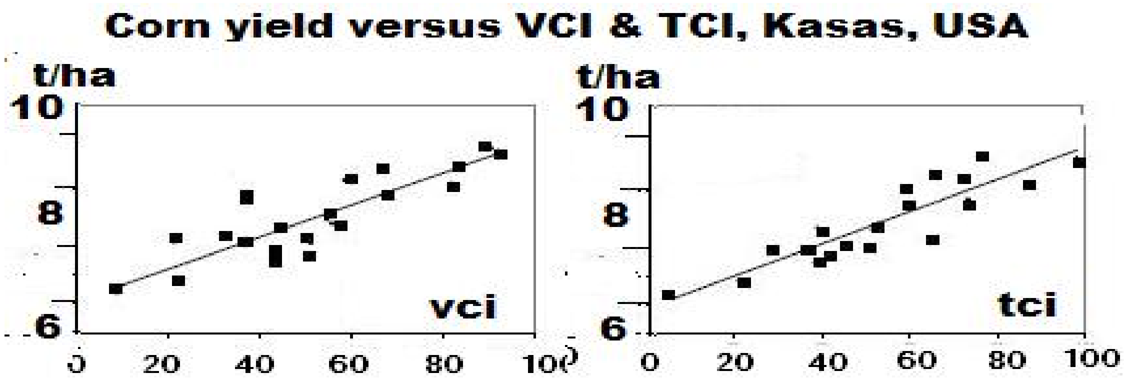








VH Applications



APPLICATIONS

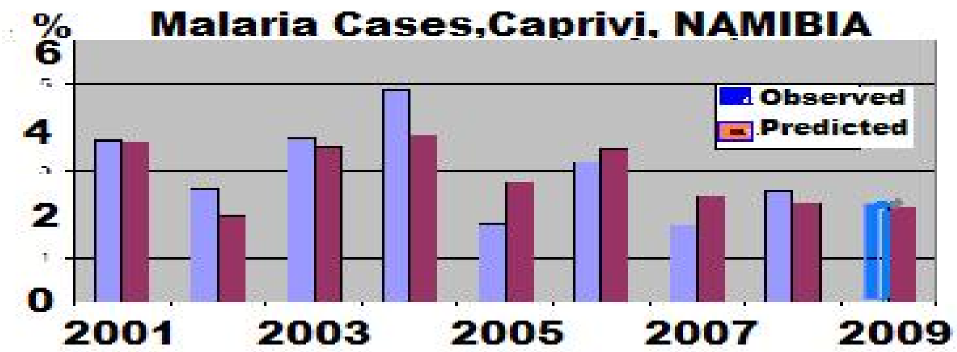
Crop/Pasture Production

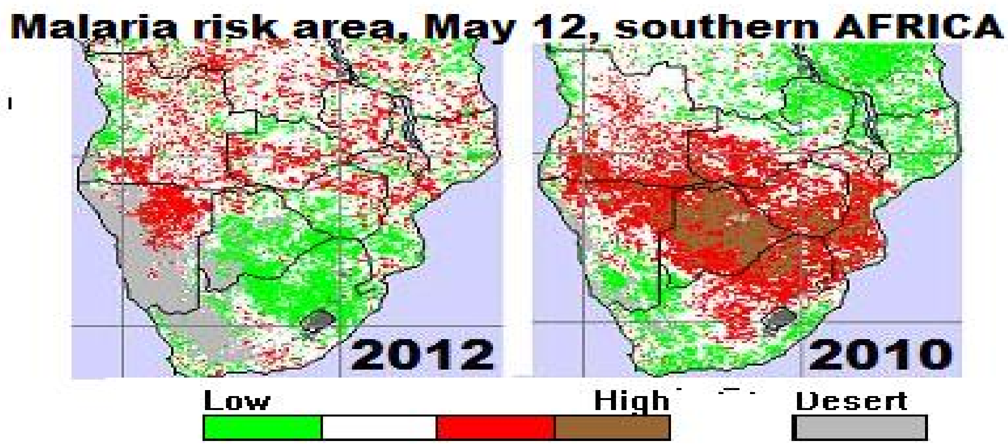
Malaria:

Number of affected people

Affected area

Intensity

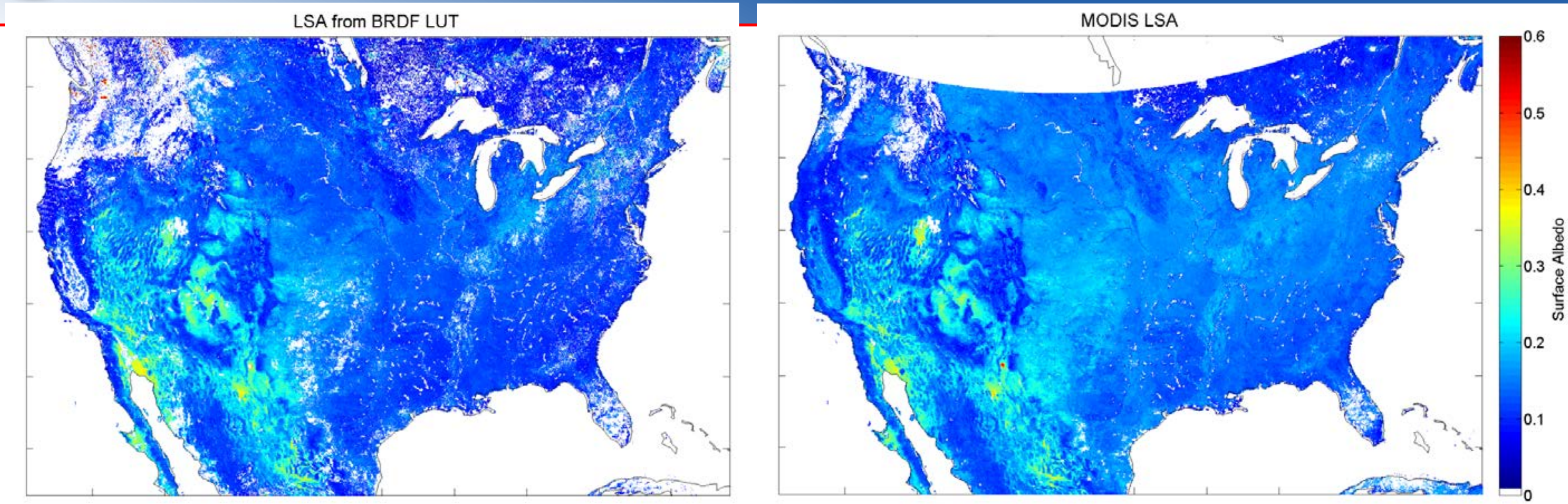




Status of VIIRS surface albedo EDR

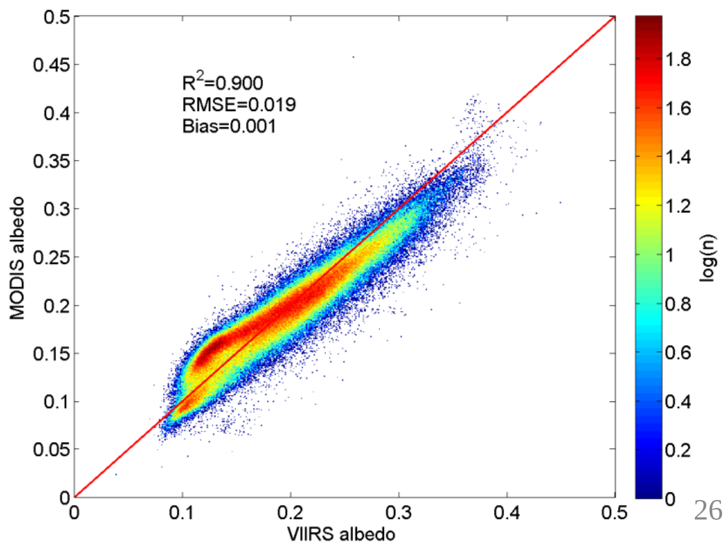
- Surface albedo (SA) EDR consists of land surface albedo (LSA), sea ice surface albedo and ocean surface albedo.
- A direct estimation method (BPSA) is developed to retrieve LSA from VIIRS clear-sky TOA reflectance data.
- The beta release was effective on 6/25/13 and the provisional release of LSA was effective on 4/17/14.
- The maturity of Validated Stage 1 was achieved on 11/28/14.
- Validation results suggest the VIIRS direct estimation approach can generate albedo retrievals with accuracy similar (or superior) to existing products.
- Surface albedo EDR is a full resolution ***granule instantaneous*** product. LSA is only generated for ***clear-sky*** pixels.
- We propose to develop a new high-level daily gridded LSA product with data gaps filled.

Inter-comparison with MODIS albedo



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

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



LST Product Status

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

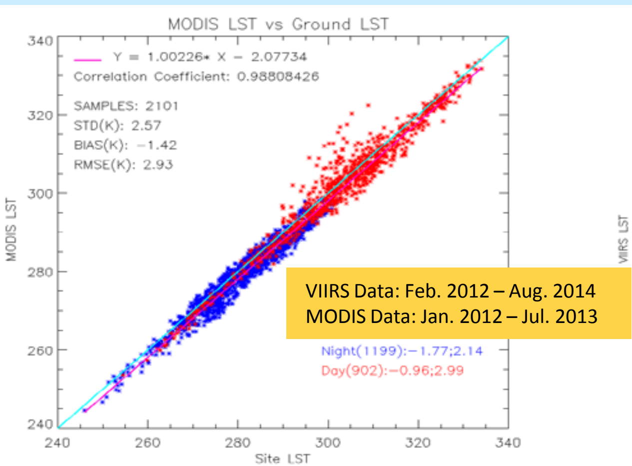
Attribute Analyzed	L1RD Thresh old	Validation Result	Description
In-situ Validation	1.4K (2.5K)	**-0.37 (2.35)**	Results are based on the VIIRS data over SURFRAD sites for over 2.5 years . The error budget estimation is limited by ground data quality control, cloud filtering procedure and upstream data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

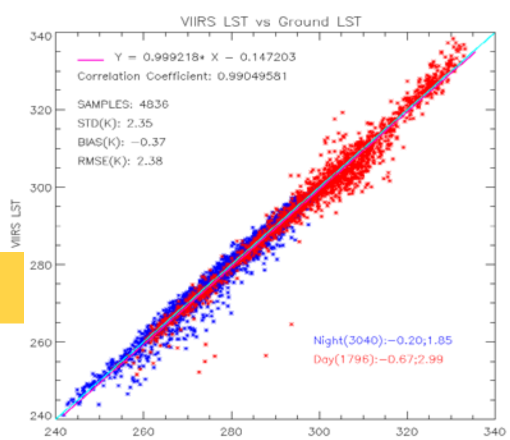
Validation summaries of the LST EDR are shown in Table (**right**); validated 1 maturity approval in Dec. 2014. Marginally meet the requirement with limited "in-situ" data

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

U.S. SURFRAD stations

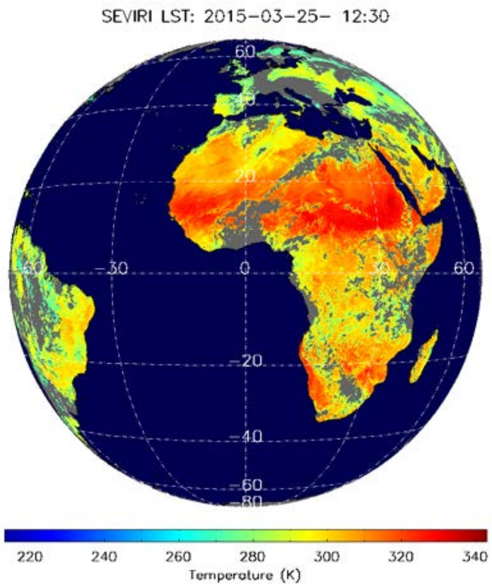
Season	Samples	Overall		Day		Night	
		Bias	STD	Bias	STD	Bias	STD
Spring	1297	-0.54	2.78	-0.69	3.82	-0.46	1.97
Summer	1403	-0.1	2.43	-0.87	3.68	0.26	1.39
Fall	1160	-0.28	1.9	-0.32	2.04	-0.24	1.79
Winter	976	-0.65	2.01	-0.83	1.65	-0.53	2.21

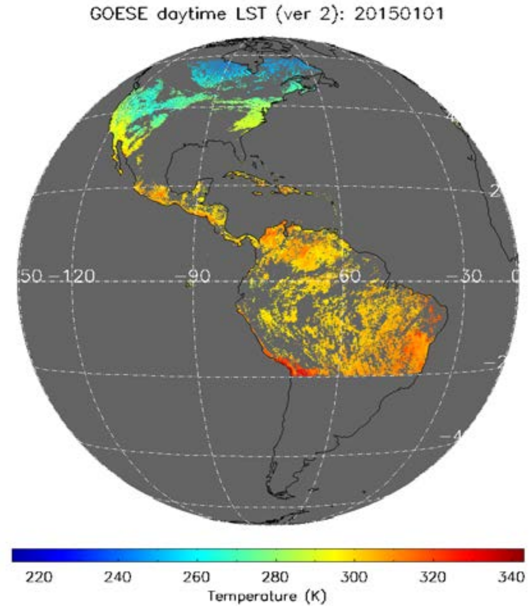


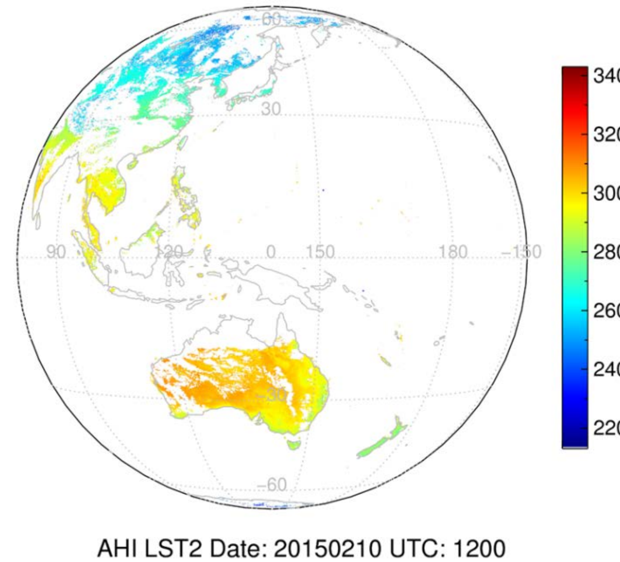


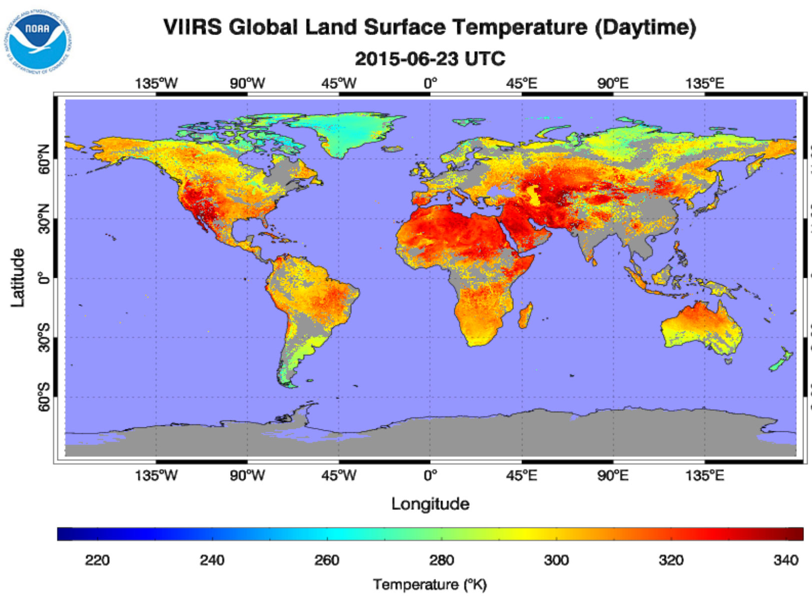
IGBP type	Samples	Overall		Day		Night	
		Bias	STD	Bias	STD	Bias	STD
4	18	-1.41	3.01	-1.82	2.66	-1.26	3.22
6	96	-0.98	1.41	-0.5	1.88	-1.32	0.84
7	955	-0.2	1.59	0.24	2.06	-0.61	0.79
8	286	0.19	2.56	-1.7	2.6	1.38	1.66
10	1048	-0.49	1.81	-0.85	2.3	-0.37	1.59
12	1238	-0.35	2.68	-0.63	3.8	-0.22	1.91
14	857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

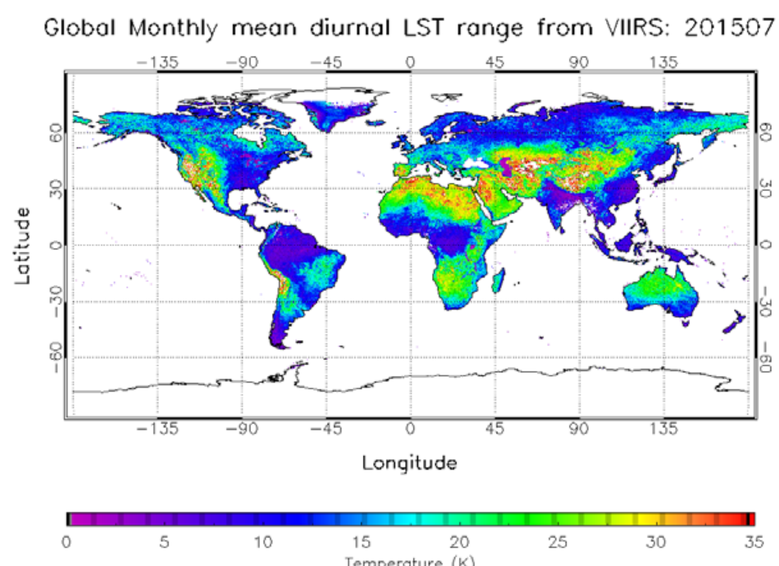
Monitoring -- LST images



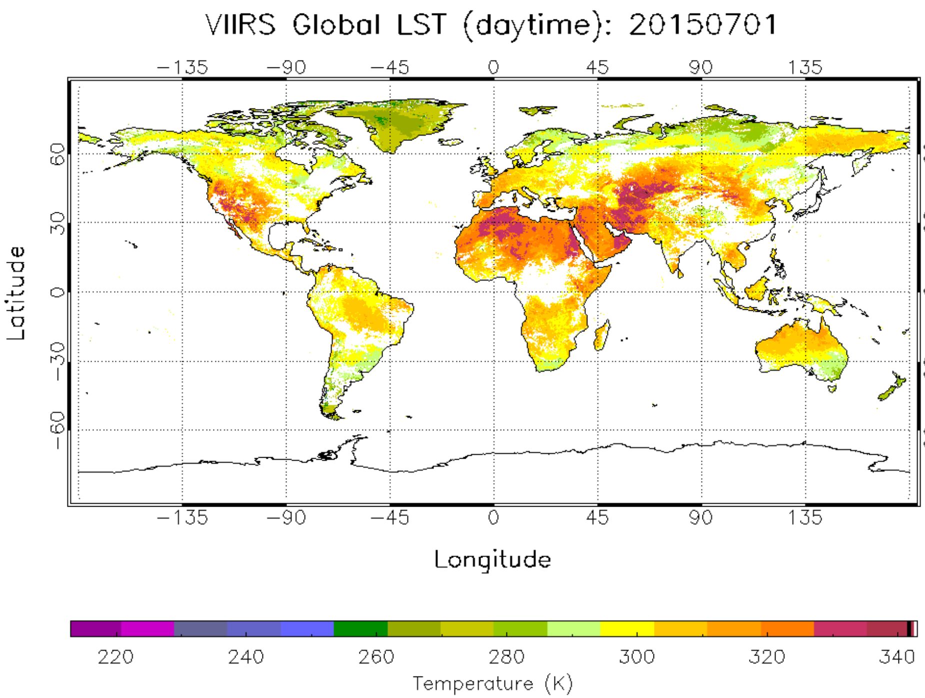


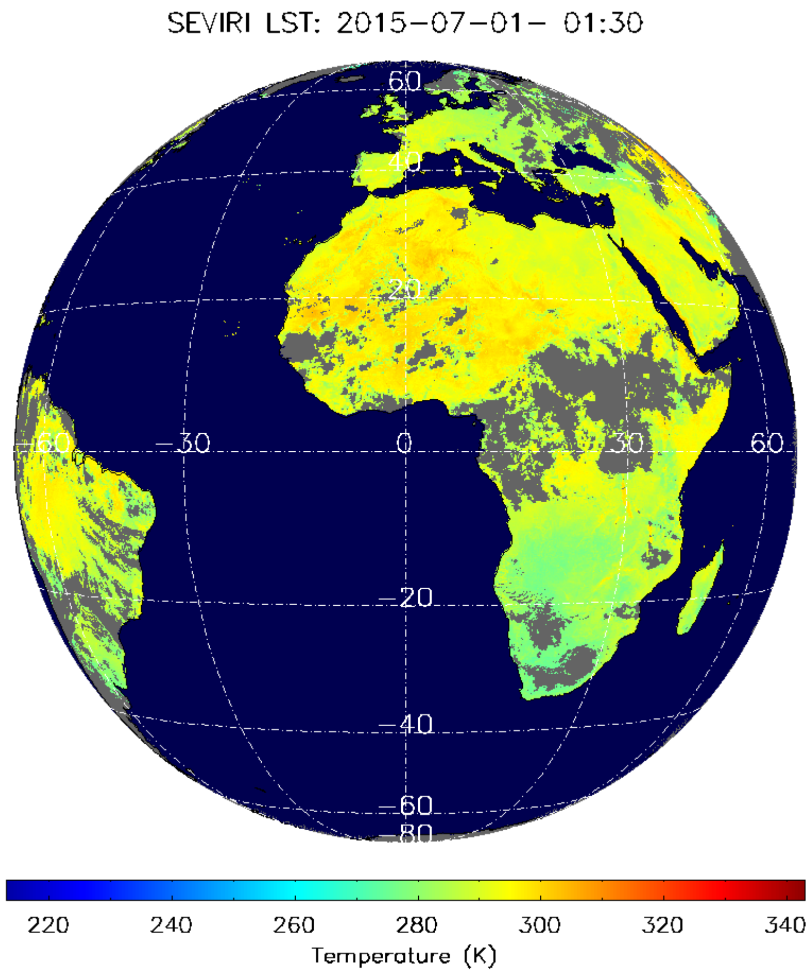


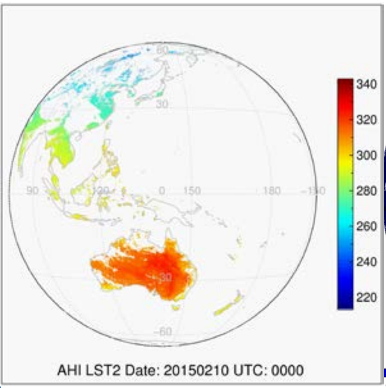


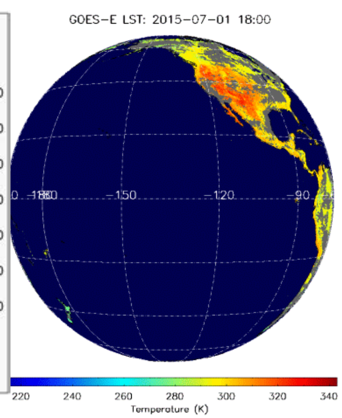


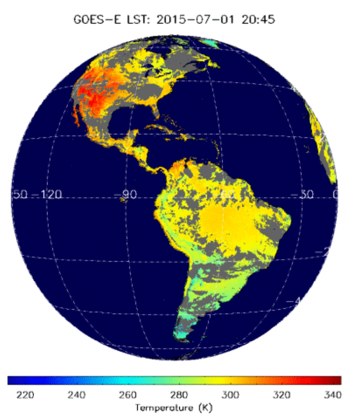
Monitoring -- Animation of Time Series



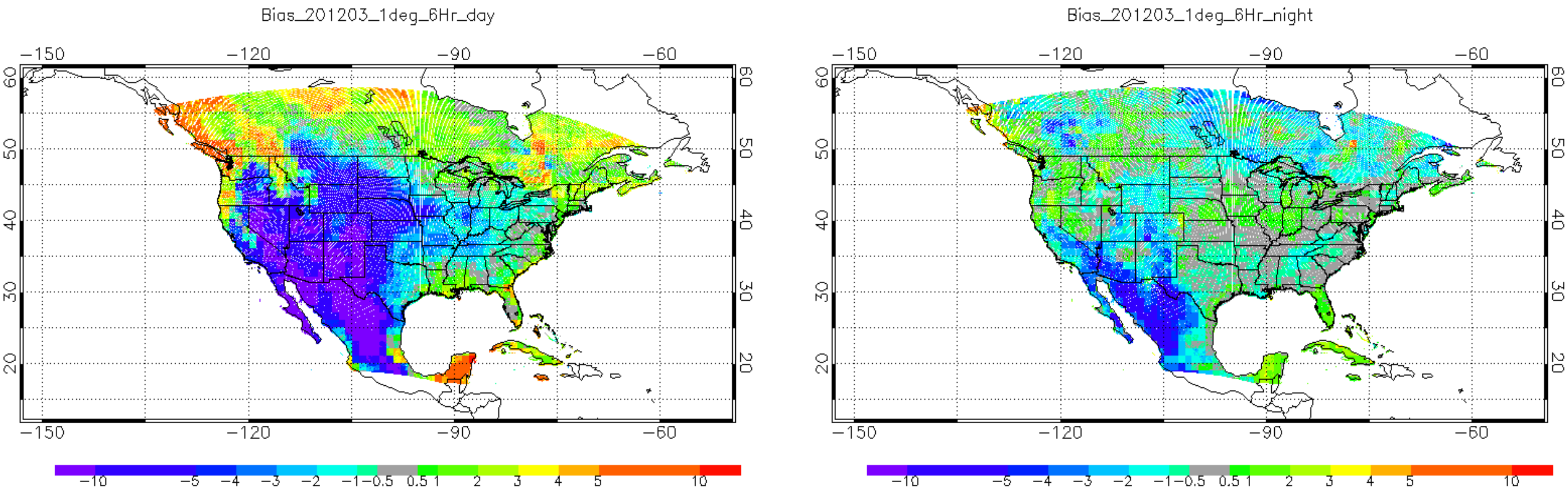








Observed vs. model LST



Distribution of monthly mean LST difference (NAM−VIIRS) between NAM hourly forecast (f00 cycle) and VIIRS LST in March 2012. Left; daytime; right: nighttime

NOAA Operational Fire product status

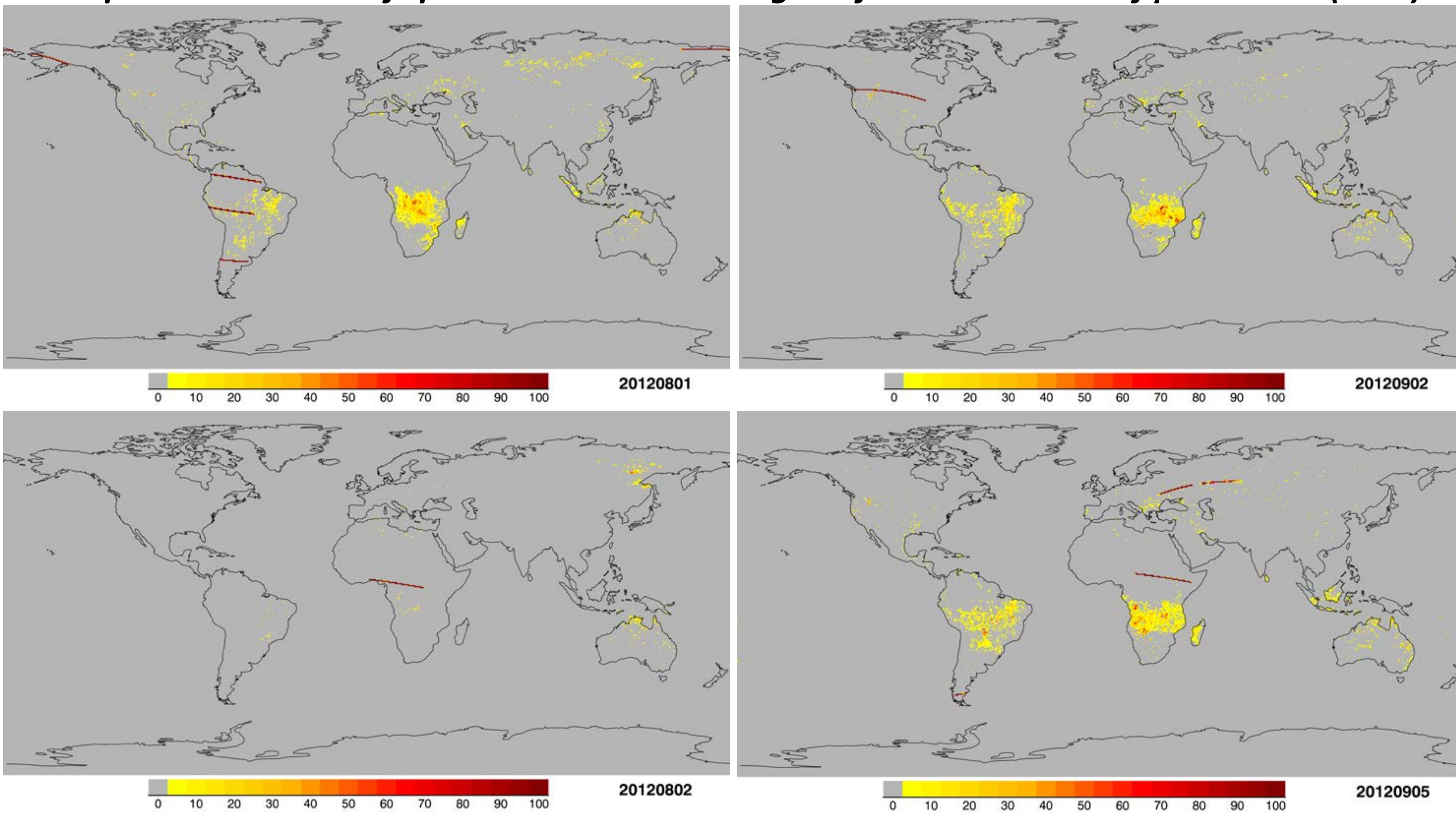
- **Current 750m operational product** in IDPS*
  - delivers a list of fire pixels
  - reached **Validated 1 maturity status** with an effectivity date (i.e. IDPS implementation) of **August 13, 2014**.
  - **declared NOAA Operational** product in September 2014
  - **long-term monitoring** and maintenance continues
- **Upcoming 750 NOAA operational product** in NDE**
  - the product is developed at UMD and is **tailored subset of the NASA science product** for real-time NOAA operations
  - **global mask of thematic classes** including water, cloud, non-fire clear land and fire at three confidence levels
  - **fire radiative power** for each fire-affected pixel
  - **new algorithm elements** to improve detection performance
- NOAA operational products are **archived** at NOAA CLASS***

IDPS: Interface Data Processing Segment; **NDE: Suomi NPP Data Exploitation (NOAA operational ground data production systems)

*******Comprehensive Large Array-Data Stewardship System; www.class.noaa.gov***

Examples of early IDPS product

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



Examples of the operational real-time IDPS product as archived in NOAA CLASS.

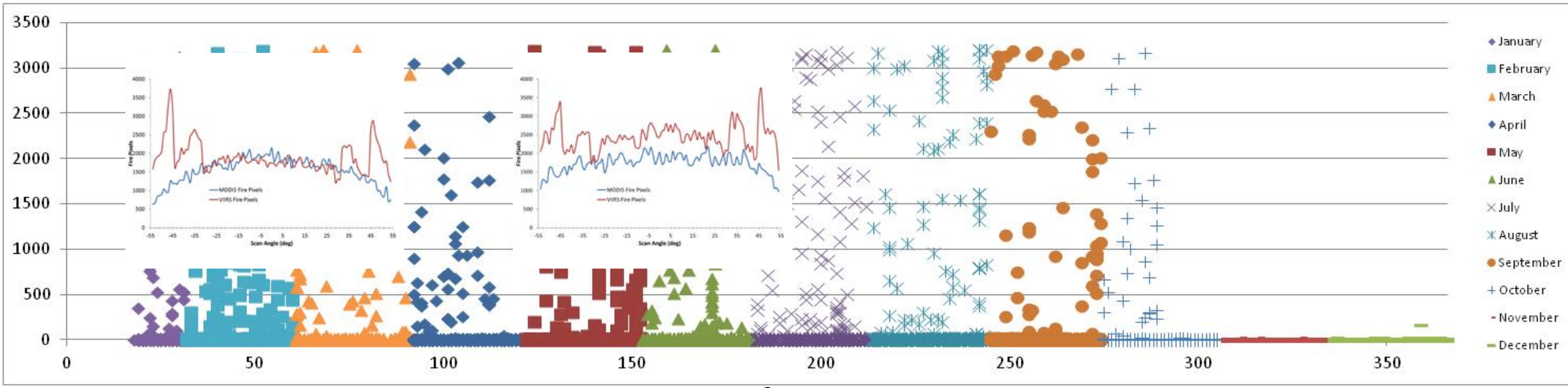
Not reprocessed; not to be used for science analysis. Product history demonstration only.

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

2012

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

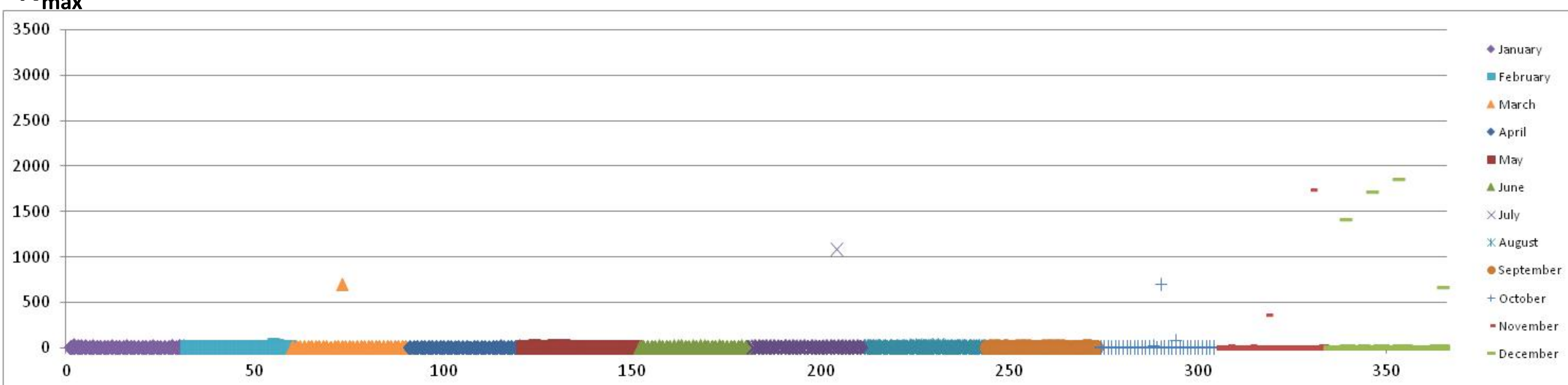
N_{max} ← *Pre-Beta* → ← *Beta* → ← *Provisional* →



Day of Year

2013

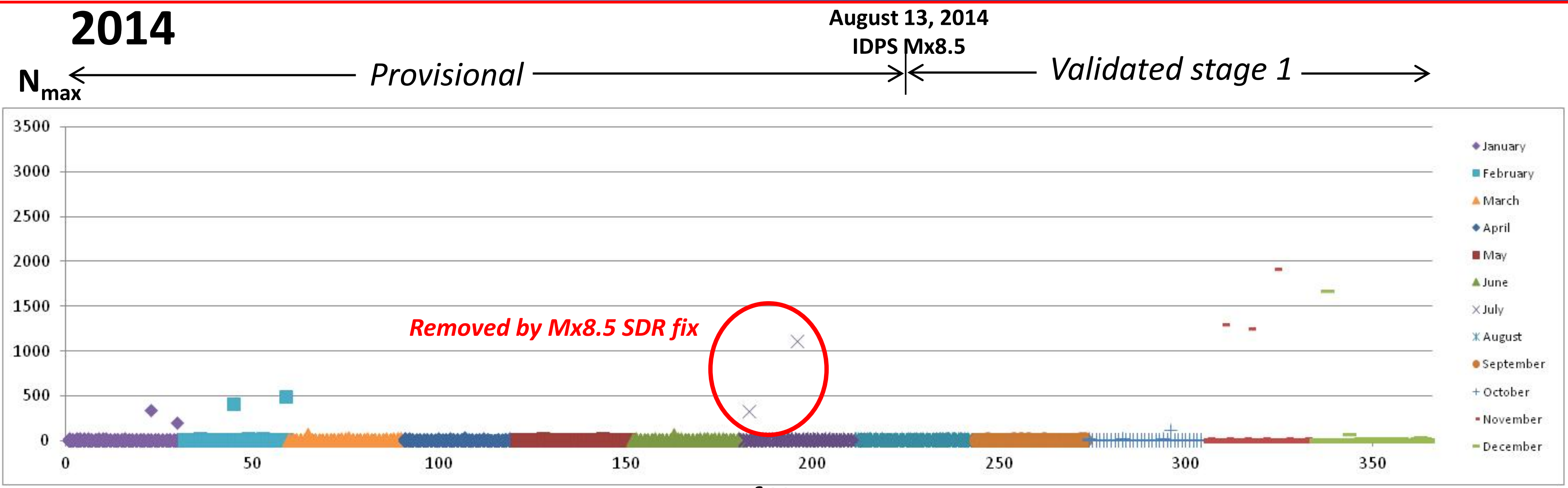
N_{max} ← *Provisional* →

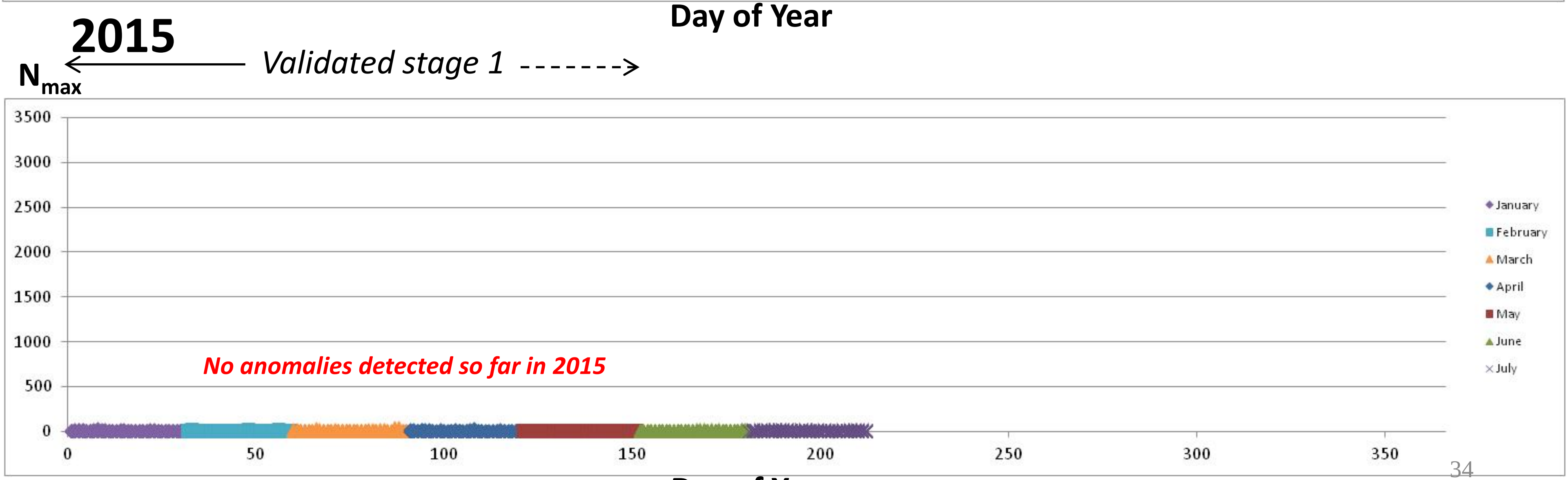


N_{max}: maximum number of detections within a scanline

Day of Year

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

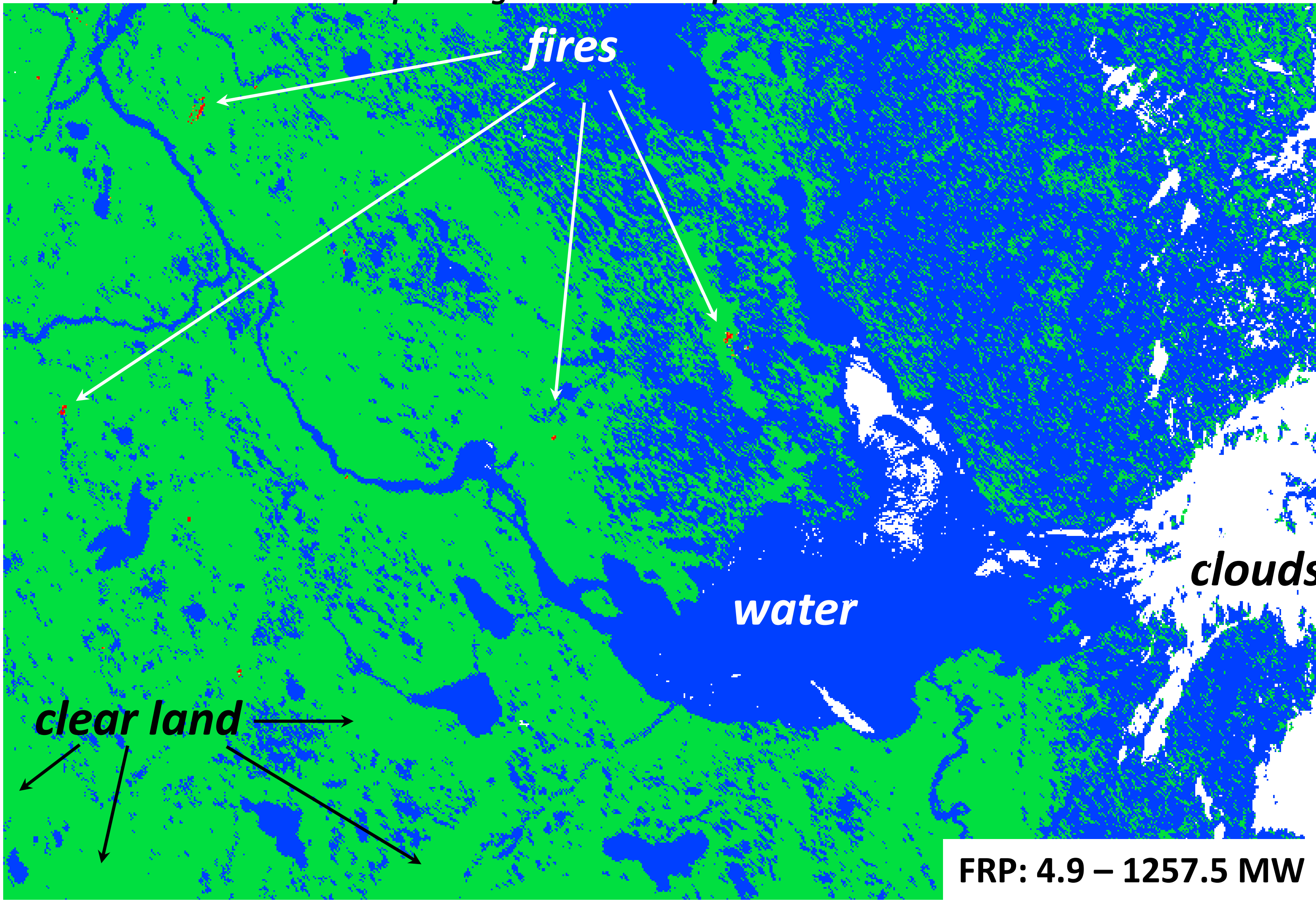




N_{max}: maximum number of detections within a scanline

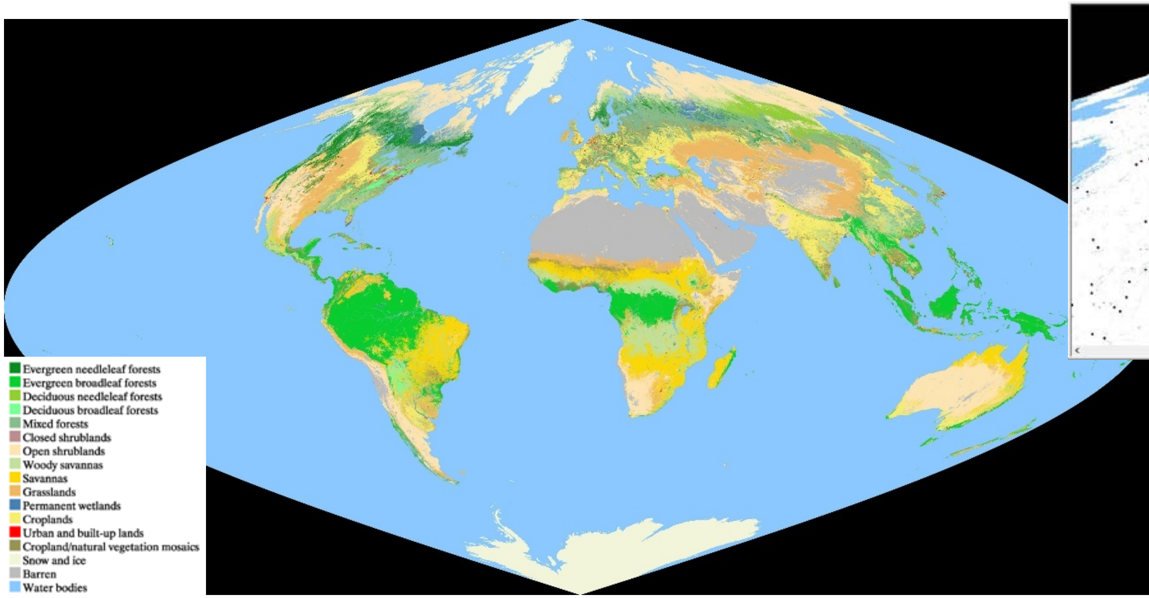
NOAA NDE VIIRS Active Fire Product

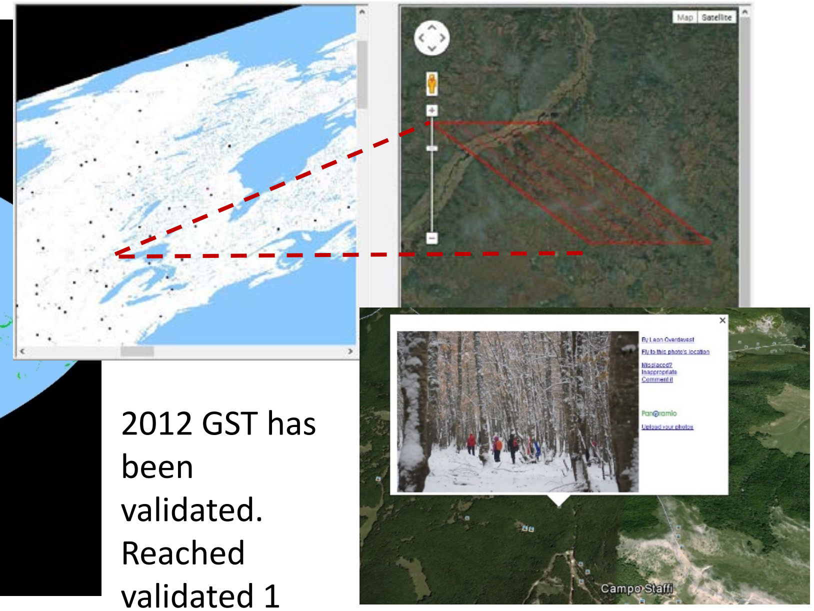
VIIRS fire mask generated at NOAA/NESDIS/STAR from IDPS input data. The NOAA Level-2 product is consistent with the corresponding NASA science product



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

Surface Type EDR Achievements

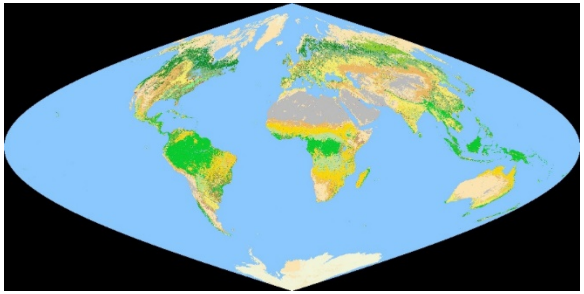




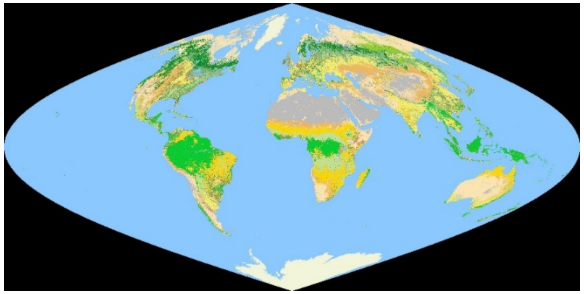
2012 GST has been validated. Reached validated 1 maturity

2012 Global gridded surface type classification map (GST) created using C5.0 decision tree. (shown on top)

2013 and 2014 GST are in production using the Support Vector Machines classification algorithm. (Preliminary results shown on right)

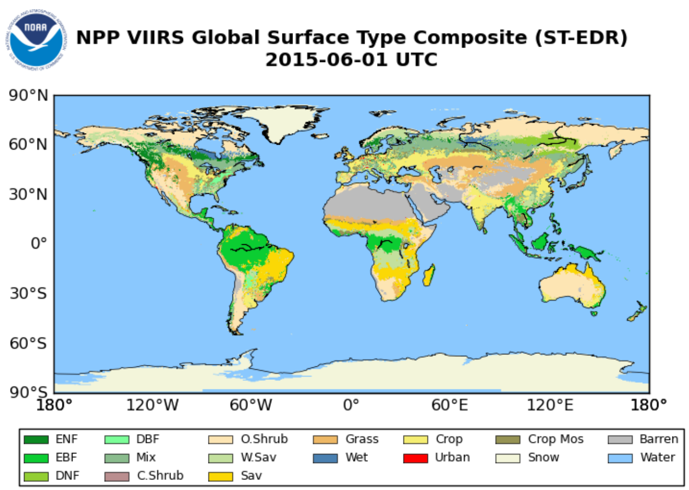


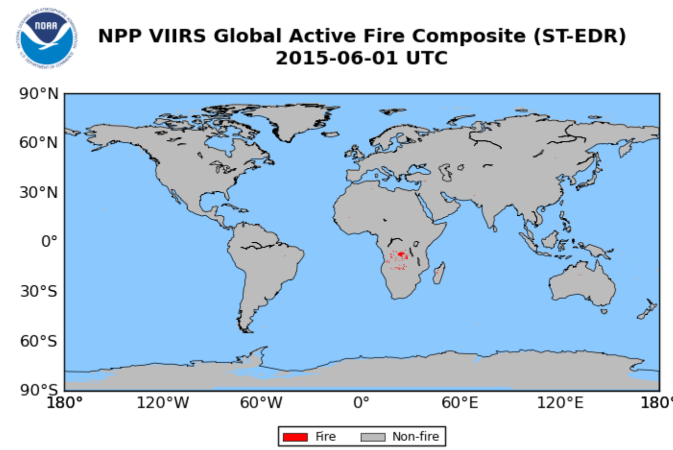
2013 GST

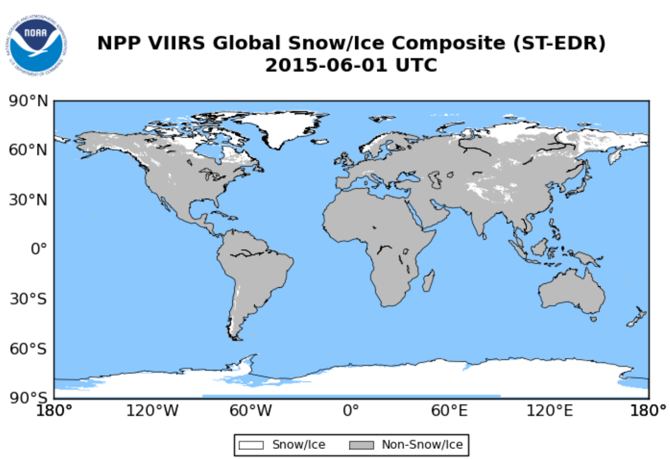


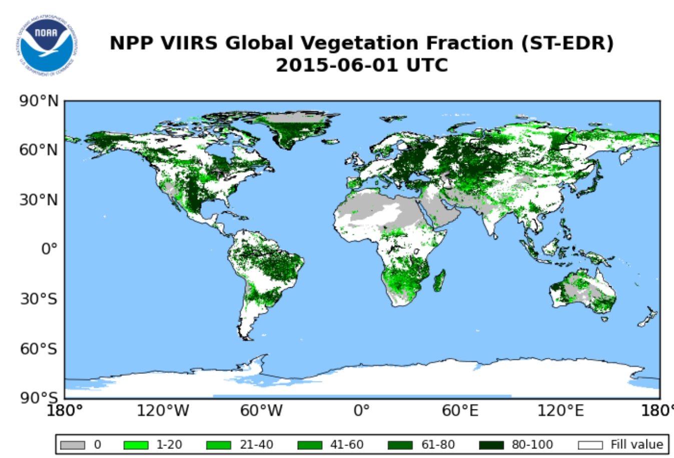
2014 GST

Surface Type EDR Achievements: LTM



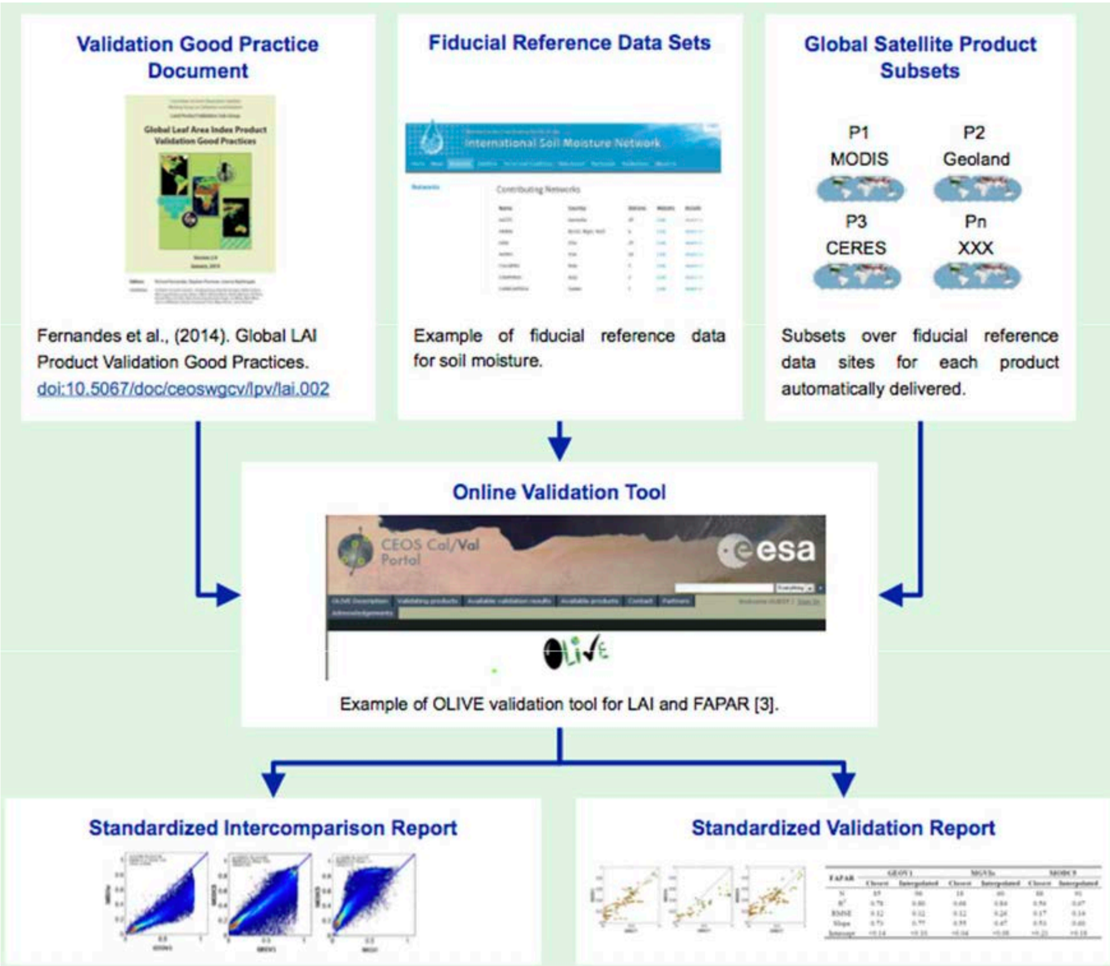






Daily global surface type, active fire, snow/ice and vegetation fraction maps are composited from the ST-EDR data for the long term monitoring

CEOS-WGCV Land Product Validation (LPV) Framework



- ***JPSS Land cal/val team has adopted the CEOS/WGCV LPV framework & validation stages.***
- ***Key JPSS contributions:***

1. Tower-based reference data (CRN, BSRN-SURFRAD)
2. Airborne-UAV reference data (MALIBU: Román et al.)
3. Land Product Characterization System (LPCS: K. Gallo)

- ***Participating CEOS member agencies:*** *NOAA-STAR, NOAA-NCDC, USGS-EROS, NASA-GSFC, ESA-ESRIN.*

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

Land Product Validation plan comparison

Product	Variable	Metric	Correlative data	Reference data	Field Campaigns	Tools
SR	Surface Reflectance	APU	SNPP, MODIS, Landsat	AERONET, BELMANIP2		6SV radiative transfer code APU computation
VI	TOA NDVI		SNPP, MODIS, Landsat, AVHRR, Sentinel, GCOM SGLI	AERONET, BSRN, PEN, FLUXNET, NEON, SpecNet	ABoVE, NASA's Tree-Grass project	Monitor VIIRS Data Display VIIRS VI Time Series VI Cross-Comparison Global APU Computation VIIRS Matchup Display and Analysis VI Phenological Metrics
	TOC NDVI					
	TOC EVI	APU				
LSA	BPSA	APU	SNPP, MODIS (+GLASS), Landsat, AVHRR	BSRN, ARM, SURFRAD, GC-Net, FLUXNET	MALIBU (?)	Vizualiztion, monitoring and validation
LST	LST	APU	SNPP, MODIS, HI, FY, GOES-R	SURFRAD, BSRN		Matchup, QC, statistical analysis, reporting
AF	Detection	Probability of detection	SNPP, Aqua MODIS, TET, BIROS	Higher resolution (<30m) imagery		Sensor collocation / intercomparison
	FRP	APU	SNPP, Aqua MODIS, TET, BIROS	Higher resolution imagery, ground	opportunistic	Sensor collocation / intercomparison
ST	Surface type	Confusion matrix	MODIS, SNPP	High resolution imagery		Subset interpretation interface

- Ensure consistency of timeline with product precedence, including SDR, cloud mask etc.
- Linkage to CEOS validation protocols, resources and terminology
- Leverage validation tools and resources between JPSS and GOES-R
- Include use of LPVS where applicable

LPCS

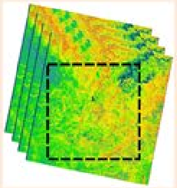
Land Product Characterization System

Land Product Characterization System

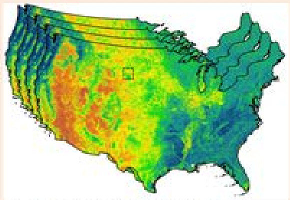
A web-based system designed to use moderate to high-resolution satellite data for characterization, and assist with validation, of GOES-R ABI and JPSS VIIRS land products.

Input Products in Native Projections

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



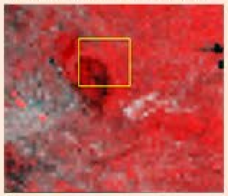
Landsat ETM+ (7), Landsat OLI/TIRS (8)



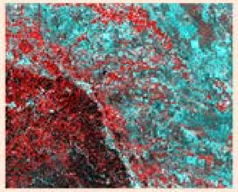
MODIS MOD/MYD09 (Surface Refl.) MODIS MOD/MYD13 (NDVI & EVI)

Geographically Registered Output Products

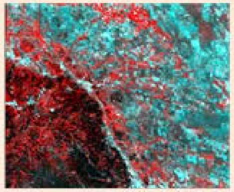
Simulated GOES-R ABI



Landsat



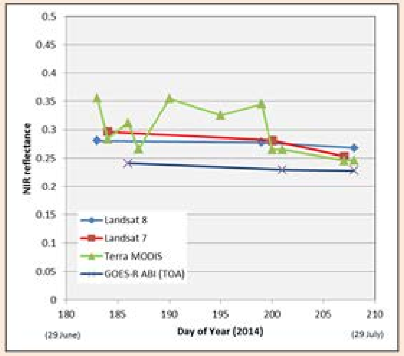
MODIS



Tables and Charts of Individual Bands or Indices

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

Mean, minimum, maximum, standard deviation



Near-IR time series inter-comparisons

NOAA Operational Land Product Status

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

NOAA Land Operational Product Status

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

Land Products: Moving forward

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

NOAA JPSS Land and Cryosphere Products on VIIRSLAND website

NOAA Land Products

viirsland.gsfc.nasa.gov/NOAAprod.html

National Aeronautics and Space Administration
Goddard Space Flight Center

Search NASA.gov GO
Sciences and Exploration

Suomi NPP VIIRS Land
Visible Infrared Imaging Radiometer Suite

Home | Products | Validation | People | Tools | Publications | Links

- **NOAA Standard Products**
  - Active Fires EDR
  - Land Surface Temperature EDR
  - Surface Type EDR
  - Surface Albedo EDR
  - Vegetation Index EDR
  - Surface Reflectance IP
  - Snow Cover EDR
  - Ice Characterization EDR
  - Ice Surface Temperature EDR
- **NOAA Unique Products**
  - Green Vegetation Fraction

VIIRS NOAA Land Data Production

Data from uomi NPP are being used by NOAA to generate, among other things, a suite of Land products for use in a number of applications, ranging from real-time weather operations to forecast model input and environmental monitoring applications.

Most VIIRS land products are currently being processed in NOAA's Interface Data Processing Segment (IDPS), which receives raw instrument data and telemetry from ground stations supporting the Suomi NPP mission. The IDPS converts the Level 0 Raw Data Records (RDRs), generated by sensors on Suomi NPP, into calibrated geolocated Level 1 measurements called Sensor Data Records (SDRs), and then into Level 2+ geophysical parameters or Environmental Data Records (EDRs). In addition to SDRs and EDRs, the IDPS produces Intermediate Products (IPs), which are produced as an interim step in the EDR processing. SDRs, EDRs, and most IPs are stored for long term archiving and distribution at the NOAA Comprehensive Large Array-Data Stewardship System (CLASS). Note that the standard VIIRS IDPS-generated products (EDRs and IPs) are produced in swath-based format. Thus, only information from a single orbit is used, and available 'per-pixel' information from overlapping swaths is not used.

In addition to IDPS, some NOAA Land Products are generated within the Suomi NPP Data Exploitation (NDE) System (products generated by NDE are also referred to as NOAA Unique Products). The NDE Green Vegetation Fraction product is operational and generates a sliding weekly composite, gridded both globally and regionally, on a daily basis. The NDE system will also be running the continuation of the heritage Vegetation Health product suite using VIIRS data as input. The VIIRS Active Fire algorithm that is compliant with the NOAA JPSS Level 1 requirements is being implemented into NDE.

Below is a table of JPSS accuracy requirements (Threshold and Objective accuracy requirements are as listed in version 2.10 of the JPSS Level 1 Requirements Supplement) and estimated performance are based on NOAA and NASA VIIRS Science Team evaluations. Note that additional specifications (that are not listed here) typically apply to each product, such as revisit time, coverage, long term stability and mapping, precision, and uncertainty. Further, each product has an associated set of exclusion conditions (e.g., high solar zenith angles) for which the specifications are relaxed.

Land: user involvement and added value products

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

For further details and information

- COMING UP THIS THURSDAY:

- Land / Cryosphere Breakout Session 7c: Conference Room A 8:30 - COB

- Land-related posters: Thursday during lunch break

Land / Cryosphere Breakout Agenda (am)

Product overviews

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

10:15 Break

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

12:15 Lunch break

Land / Cryosphere Breakout Agenda (pm)

Product validation and long-term monitoring

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

NOAA Enterprise system

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

3:00 Break

NOAA operational applications of JPSS land and cryosphere products

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

Open discussion and wrap-up

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

JPSS SST

Sasha Ignatov

STAR: John Stroup, Yury Kihai, Boris Petrenko, Prasanjit Dash, Irina Gladkova, Maxim Kramar, Xinjia Zhou, Xingming Liang, Yaoxian Huang, Yanni Ding, Feng Xu, Marouan Bouali, Karlis Mikelsons

NOAA ; CIRA; GST Inc; CCNY

Reanalysis (RAN): Liam Gumley, Steve Dutcher
U. Wisconsin / CIMSS

Archive: Ken Casey, Sheekela Baker-Yeboah, Korak Saha, Ed Armstrong, Yibo Jiang
NCEI Silver Spring and PO. DAAC

L4 users of VIIRS SST: Dorina Surcel Colan, Bruce Brasnett, Andy Harris, Eileen Maturi, Emma Fiedler, Helen Beggs, Mike Chin, Masakazu Higaki, Toshiyuki Sakurai, Shiro Ishizaki
CMC; NOAA; Met Office; ABoM; JPL; JMA

Algorithm Cal/Val Team Members

Name	Organization	Tasks
Ignatov	STAR	JPSS Algorithm & Cal/Val Lead
Stroup Kihai Dash Liang Zhou, Xu Petrenko Ding	STAR – SGT STAR – GST STAR – CIRA STAR – CIRA STAR – CIRA & GST STAR – GST STAR – CIRA	Technical Liaison; ACSPO Development; ACSPO Reanalysis ACSPO code; Match ups with in situ; Destriping SST Quality Monitor (SQUAM) Monitoring IR Clear-sky Radiances Oceans for SST (MICROS) In Situ SST Quality Monitor (*i*Quam) ACSPO Clear-Sky Mask and SST Algorithm ACSPO Regional Val (high Latitudes); ACSPO L3 product
Gladkova Shahriar	STAR – CCNY, CREST & GST	Improved SST imagery; Pattern Recognition Improvements (Cloud Mask, Ocean Fronts); ACSPO Regional Monitor (ARM)
Arnone	U. Southern Mississippi	SST Cal/Val in coastal areas and from overlapping passes
May Cayula	NAVO	SST Consistency from overlapping orbits NAVO SEATEMP SST and Cal/Val
Minnett Kilpatrick	U. Miami	Improved SST retrievals in High latitudes and at swath edges
Roquet	Meteo France	VIIRS and Metop AVHRR Processing at EUMETSAT

JPSS SST Requirements

Attribute	Threshold	Objective
a. Horizontal Cell Size (Res)	1.6km[1]	0.25km
b. Mapping Uncertainty, 3σ	2km[1]	0.1km
c. Measurement Range	271 K to 313 K	271 K to 318 K
d. Measurement Accuracy[2]	0.2K	0.05K
e. Measurement Precision[2]	0.6K	0.2K (<55° VZA)
f. Refresh Rate	12 hrs	3 hrs
g. Latency	90 min	15 min
h. Geographic coverage	Global cloud and ice-free ocean; excluding lakes and rivers	Global cloud and ice-free ocean, plus large lakes and wide rivers

[1]Worst case scenario (corresponding to swath edge); both numbers are ~1km at nadir

[2]Represent global mean bias and standard deviation validation statistics against quality-controlled drifting buoys (for day and night, in full VIIRS swath, in full range of atmospheric conditions). Uncertainty is defined as square root of accuracy squared plus precision squared. Better performance is expected against ship radiometers.

S-NPP SST: Products, Progress, RAN, Users

- **Advanced Clear-Sky Processor for Oceans (ACSPO) Products**
  - Produced by NOAA ESPC/NDE; Archived w/GHRSST (PO.DAAC / NOAA NCEI)
  - L2 (swath projection; 10min granules; 27GB/day): May 2014-on
  - 0.02° L3U (Uncollated): May 2015-on (requested by ABoM, Met Office, JMA)
  - ACSPO code integrated into direct readout CSPP package at UW
- **Two ACSPO versions implemented (v.2.31/2.40) / Archived w/GHRSST**
  - Fixed warm low stratus cloud leakage
  - Produced new 0.02° L3U product (10min granules, 1 GB/day)
  - improved error characterization (facilitates data assimilation in L4 analyses)
  - Implemented destriping in the operations
- **ACSPO VIIRS SST Reanalysis (w/U. Wisconsin)**
  - Unfunded ‘demo’ effort w/UW L. Gumley’s group – need sustainable model
- **ACSPO VIIRS SST Users (L4 producers)**
  - Included in NOAA geo-polar blended & CMC L4s; Being explored in Met Office, BoM, NCEP, JMA, MUR, NCEI L4s

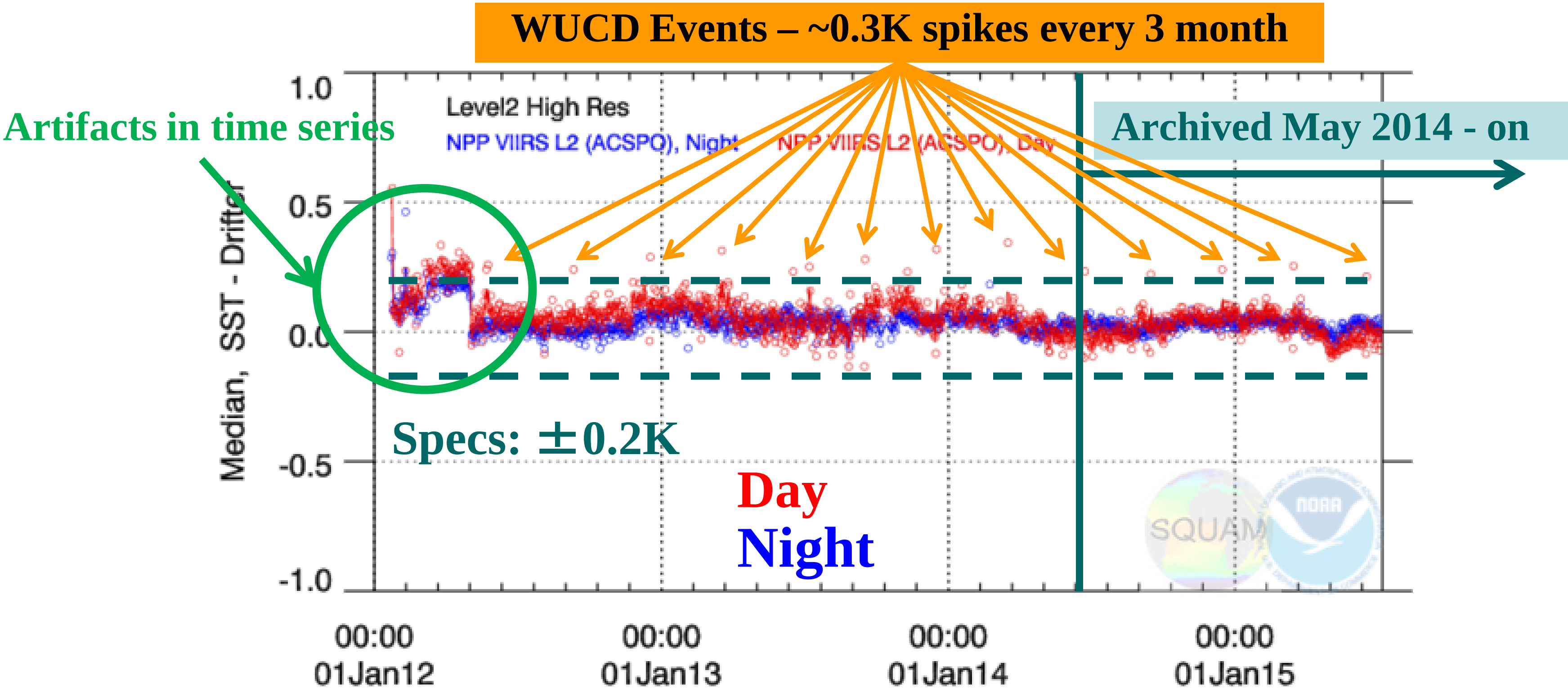
S-NPP SST: Cal/Val, Deficiencies, LTM

- **Status of ACSPO Cal/Val – Fully meet specs**
  - ACSPO L2 SST declared "Validated 3" in Sep 2014
  - ACSPO L3U SST (May 2015 – on) shows comparable performance

- **Known ACSPO Deficiencies**
  - Incomplete (May 2014 – on) & non-uniform record – RAN underway
  - Limited Regional Monitoring – ACSPO Regional Monitor for SST under development
  - Clear-Sky Mask in dynamic, coastal, hi-lat ocean has room for improvement – Future work
  - VAL time series show periodic (3-month) spikes of ~0.3 K, due to Warm-Up/Cool-Down exercises – Need SDR Team to fix the RDR-to-SDR code to minimize the effect on SST

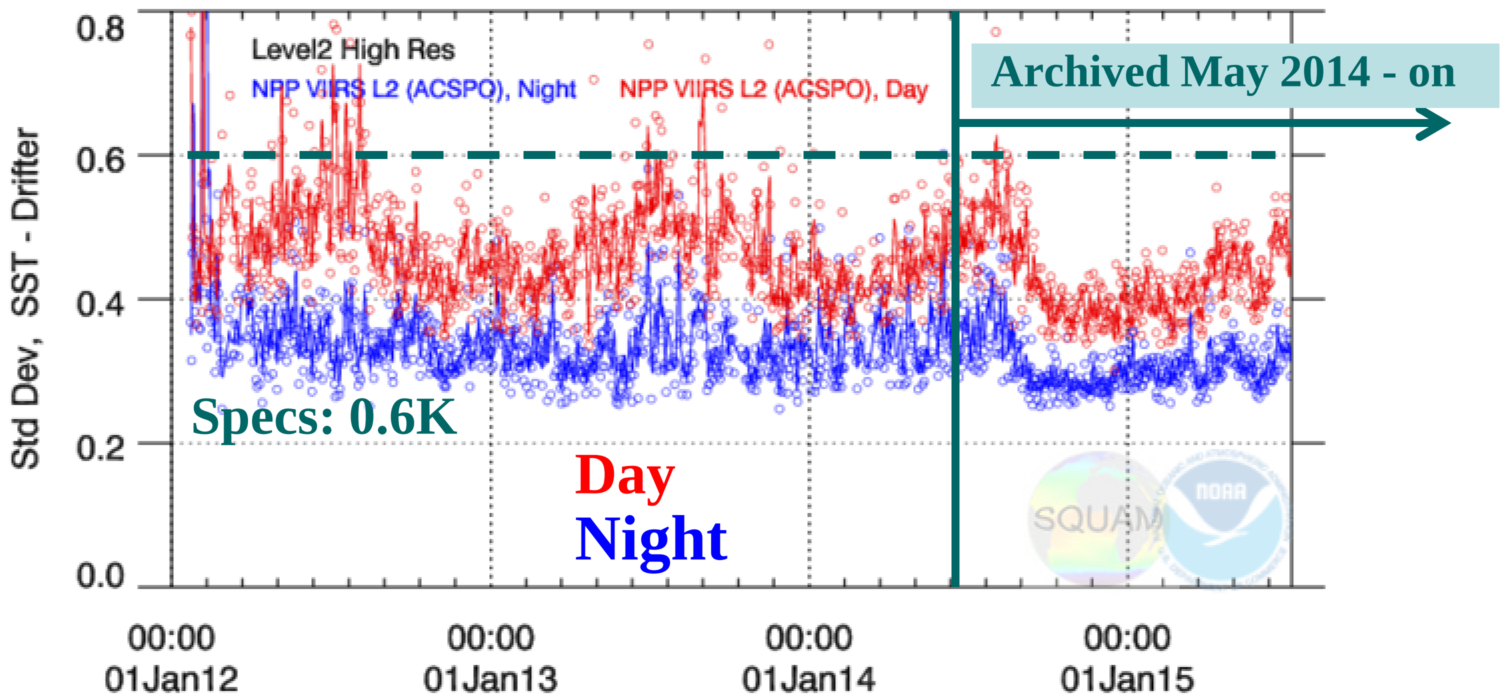
- **ACSPO Long-Term Monitoring**
  - SST Quality Monitor (SQUAM) www.star.nesdis.noaa.gov/sod/sst/squam/ - VIIRS SSTs
  - *In situ* Quality Monitor (*i*Quam) www.star.nesdis.noaa.gov/sod/sst/iquam/ - *in situ* SSTs
  - Monitoring IR Clear-Sky Radiances over Oceans for SST (MICROS) www.star.nesdis.noaa.gov/sod/sst/micros/ - VIIRS radiances associated with SST
  - ACSPO Regional Monitor for SST (ARMS) – development underway

VAL BIAS: Real Time ACSPO VIIRS L2



- ACSPO SST only archived from May 2014 – pr
- SST gradually improved due to SST algorithms improvements
- Every 3 month, "global warming" of ~0.3 K occurs, due to WUCDs
- Reprocessing with UW will produce uniform time series (except WUCD)

VAL STD: Real Time ACSPO VIIRS L2



- STD gradually improved with time as ACSPO SST algorithms matured
- Current STDs ~0.35 K (Night); ~0.45K (daytime) are well within specs
- STD smaller at night (VIIRS skin SST being closer to bulk buoy)
- Reprocessing with UW underway to produce uniform time series

ACSPO SST Users (L4 producers)

- **Active Users (assimilate in L4 analyses)**
  - Canadian Met Centre, CMC02 L4 SST (Dorina Surcel-Colan, Bruce Brasnett)
  - NOAA geo-polar blended L4 SST (Andy Harris, Eileen Maturi)
- **Advanced Users (testing)**
  - Met Office, OSTIA L4 SST (Emma Fiedler)
  - Australian Bureau of Meteorology, GAMSSA/RAMSSA L4 SSTs (Helen Beggs)
- **Users who established access to data (exploring)**
  - NCEP MMAB, RTOFS and RTG SST (Carlos Lozano, Avichal Mehra, Bob Grumbine)
  - JPL, MUR L4 SST (Mike Chin)
  - JMA, MGDSST L4 (Masakazu Higaki, Toshiyuki Sakurai, Shiro Ishizaki)
  - NCEI, Reynolds SST (Viva Banzon)
- **Tasks in 2015-2017**
  - Work with current users (to evaluate L3U product, and new error characterization)
  - Work with emerging users, to assess the impact of VIIRS SST on L4 analyses

J1 Readiness: Algorithm, Cal/Val Plans

✓ J1 Algorithm

- ACSPO code available by J1 launch will be implemented with J1 VIIRS

✓ Pre-launch Cal/Val

- Analyze proxy data: S-NPP VIIRS, AVHRR (FRAC and GAC), MODIS, AHI/ABI
- Continue ACSPO development: Release ACSPO v2.50/2.60 in 2016
- Sustain SST Cal/Val Tools: SQUAM, MICROS, *i*Quam

✓ Post-launch Cal/Val

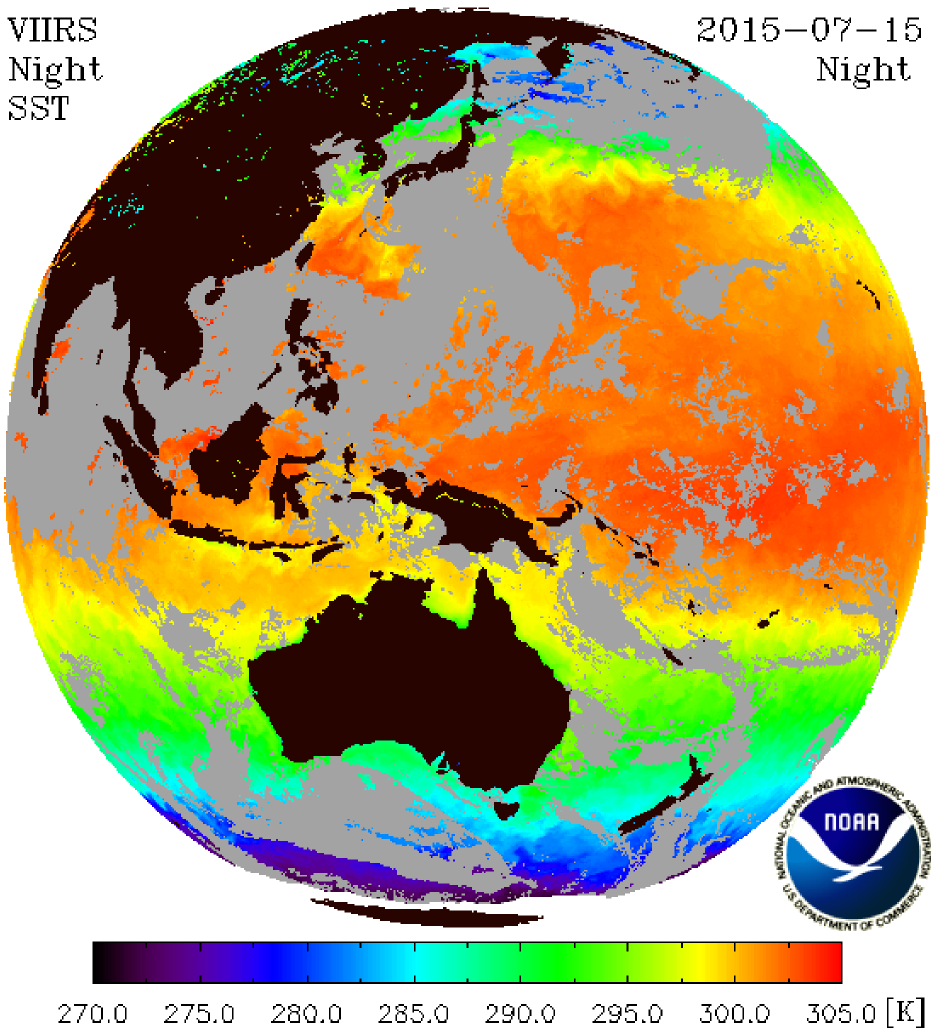
- Early Orbit Checkout (EOC): Emphasis on sensor performance / Work w/SDR to resolve
- Intensive Cal/Val Phase (ICV): Emphasis on SST performance
- Long-Term Monitoring (LTM): Create match-ups w/iQuam; Add J1 to SQUAM/MICROS
- Based on evaluation and monitoring, refine SST algorithms (recalculate coefficients, etc)

✓ Cal/Val Timelines (cryoradiator doors open at T0)

- Assuming that performance of J1 VIIRS is comparable to that on S-NPP:
  Beta: T0+3mo; Provisional: T0+6mo; VAL: T0+12mo

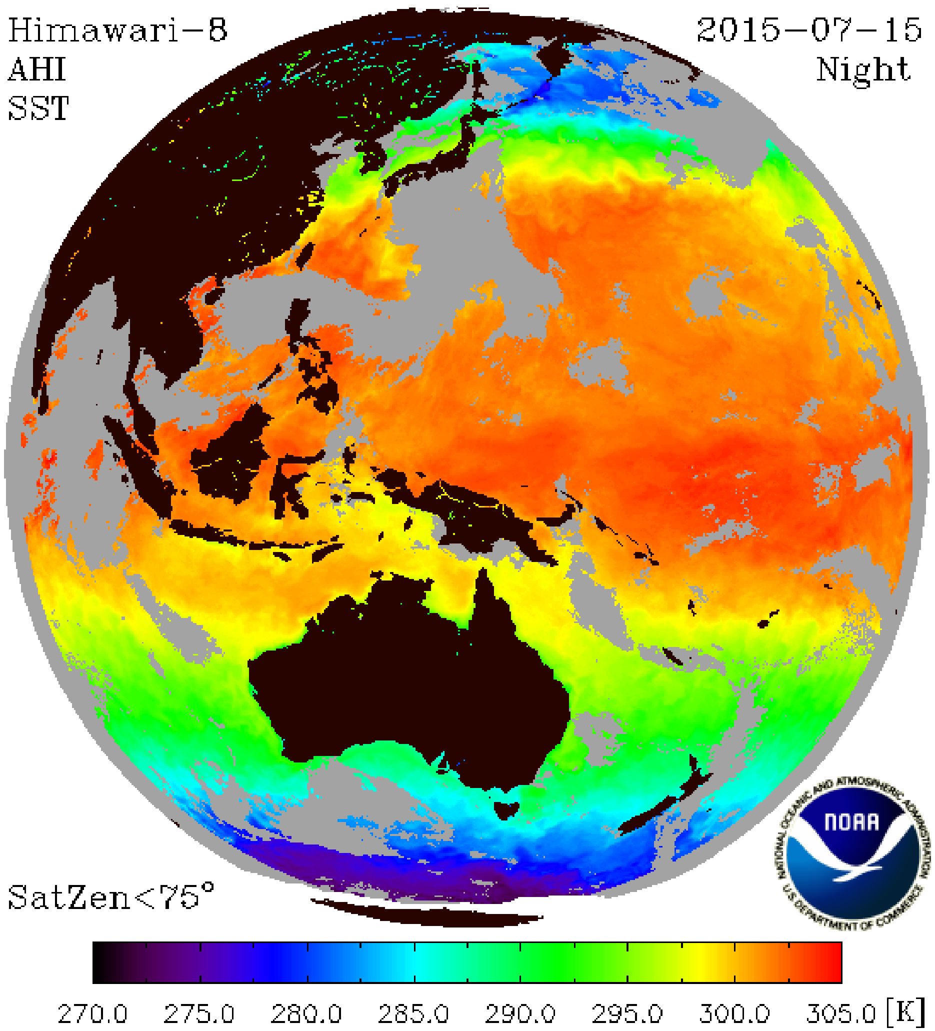
VIIRS Night SST Composite in Himawari-8 Domain

- VIIRS SST composite in H8 domain
- Large areas are cloudy during S-NPP overpass @ 1:30 am



Himawari-8 Night SST Composite

- Enterprise ACSPO algorithm applied to H8
- AHI composite covers larger domain, due to 10min refresh rate
- SST Team will be ready for J1 and GOES-R launch



ACSPO Priorities in FY16

1. (Prerequisite for tasks 2-3) Improve BT and SST Imagery: resample (“de-bowtize”) and restore pixels in bow-tie areas deleted onboard – ACSPO v2.50 (Mar 2016)

2. (Main Objective) Improve clear sky mask based on pattern recognition approach: Focus on dynamic, coastal, and high-latitude areas – ACSPO v2.60 (Dec 2016)

3. (By-product of pattern recognition) Produce Ocean Thermal Fronts – ACSPO v2.60 (Dec 2016)

Why Pattern Recognition is Important?

1. All current “in-pixel” IR clear-sky masks tend to be overly conservative. ACSPO is on a less conservative side, but still produces quite a few “false alarms” (especially in the dynamic, coastal, and high-latitude areas)

2. As a result, some areas (with variable SST, or colder than surrounding waters, or colder than expected “L4” SST) may remain unobserved for extended periods of time

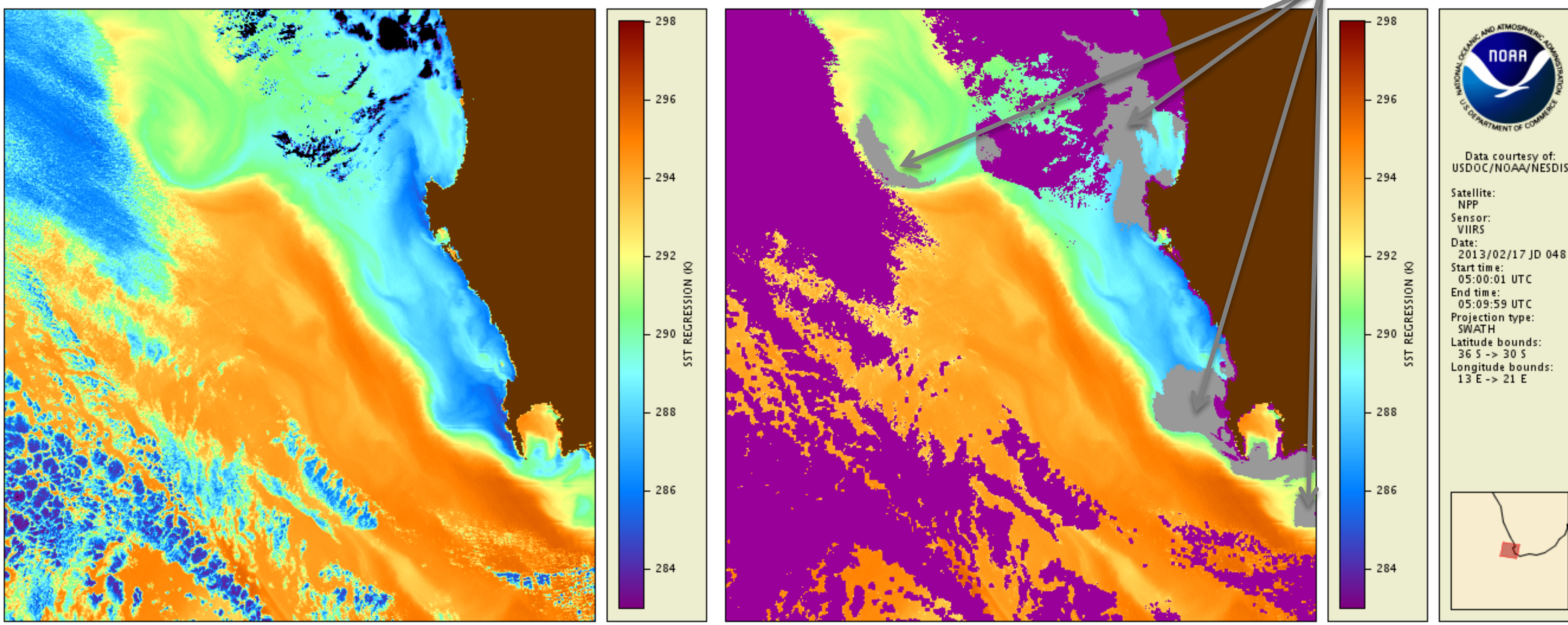
3. These areas are most interesting to users – in particular, producers of hi-res L4 analyses (which may rely on climatological SSTs here)

4. VIIRS imagery has excellent potential. We plan to fully realize it, to satisfy wide range of SST users

ACSPO v2.60: Improved Clear-Sky Mask

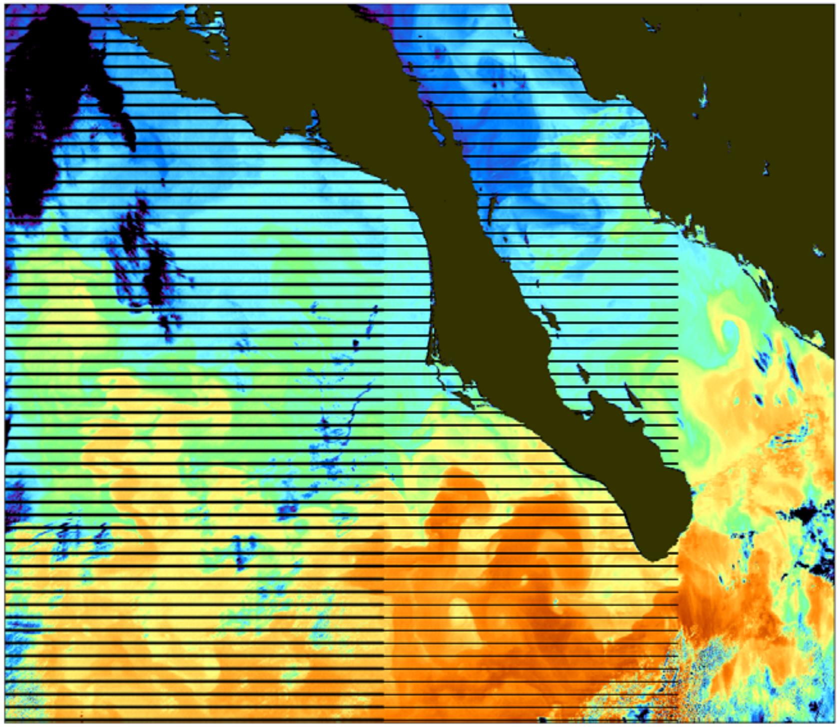
S. Africa, 02/17/2013 (day pass)

Misclassified clear sky areas

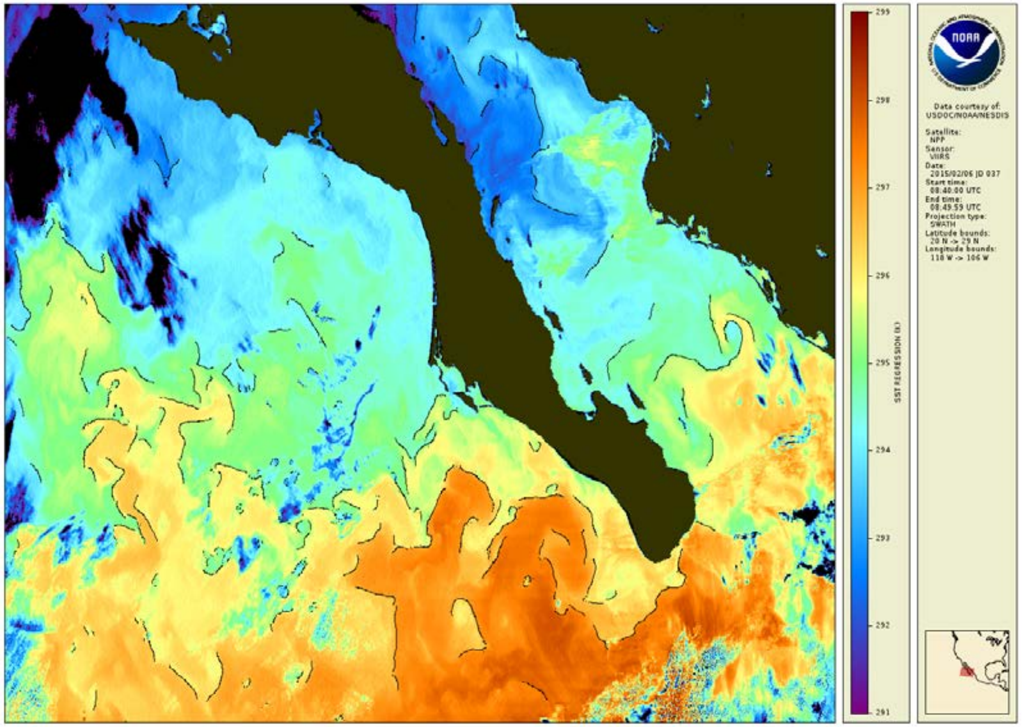


Cold upwelling and some other dynamic and coastal areas (shown in grey) are misclassified by the current ACSPO as cloud

ACSPO v2.60: Ocean Fronts



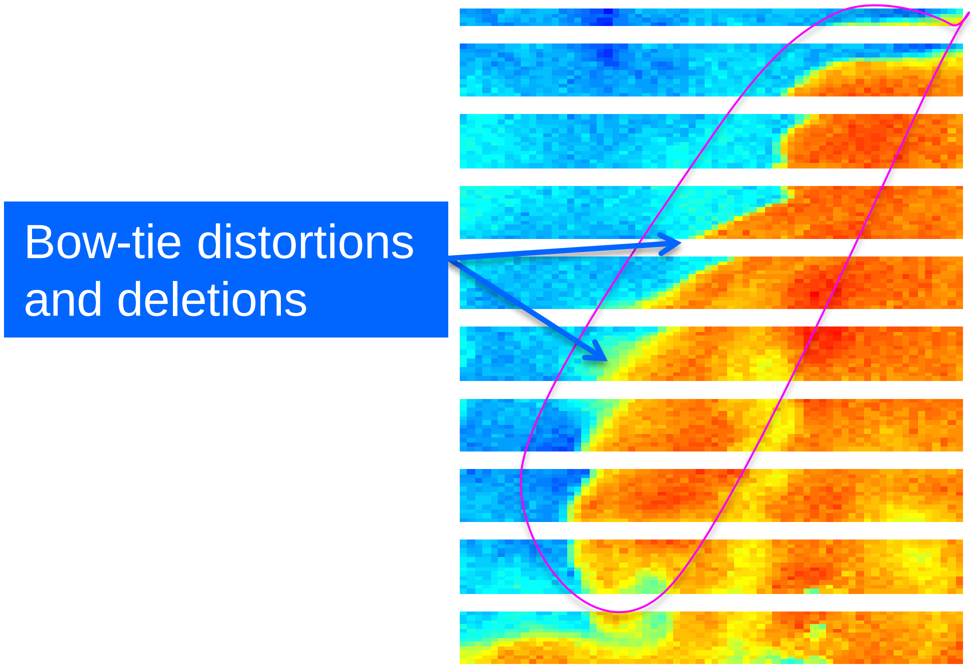
Original VIIRS SST imagery



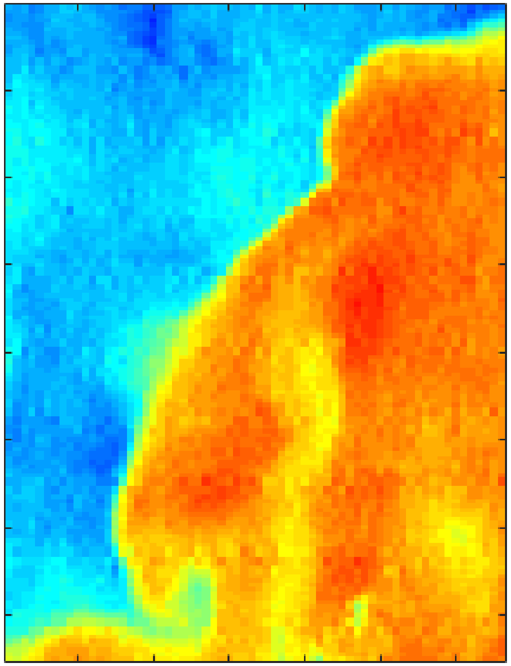
Resampled imagery with oceanic thermal fronts superimposed

ACSPO v2.50: Prerequisite to v2.60

- VIIRS swath data have bow-tie distortions, onboard deletions and aggregations
- This creates spatial discontinuities and artifacts in the gradient fields, and prevents implementation of pattern recognition algorithms
- ACSPO v2.50 will fix these artifacts as best as we can but.. **we strongly recommend against bow-tie deletions on J1 & beyond!!**

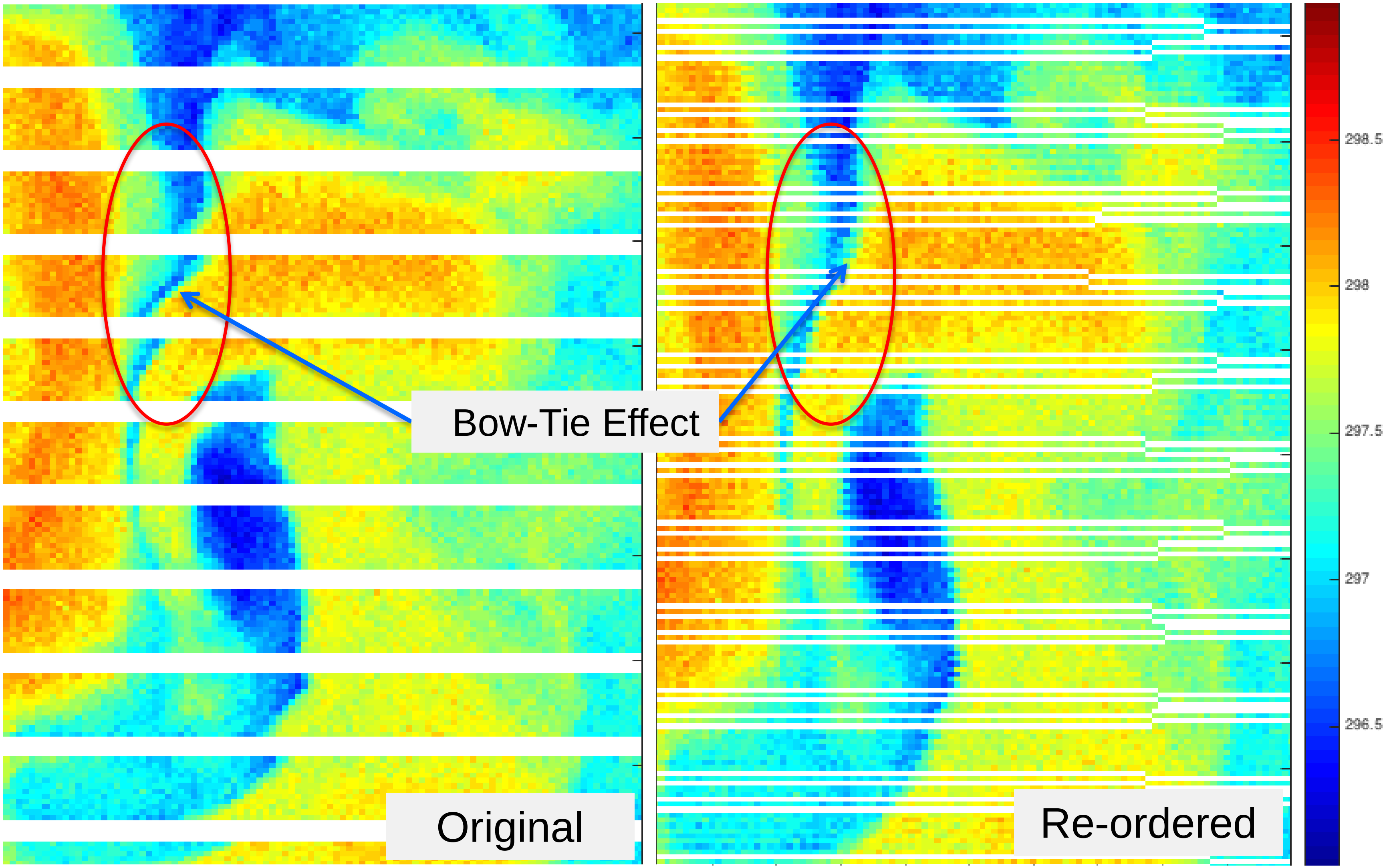


Current SST

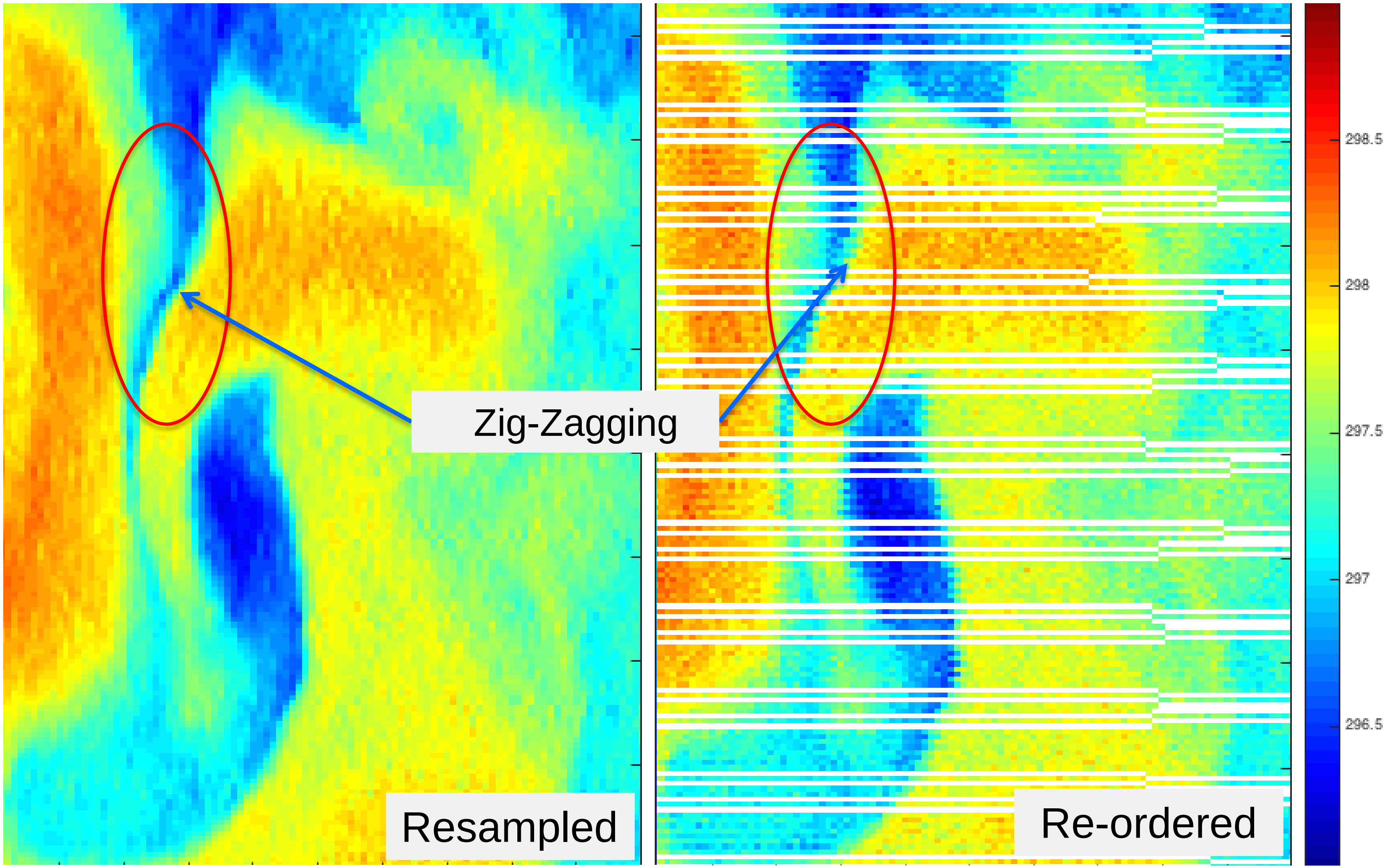


SST in ACSPO 2.50

ACSPO v2.50



ACSPO v2.50



Other SST Tasks in 2016

Complete VIIRS RAN1

- ✓ Display online in SQUAM and MICROS, QC, fix remaining issues
- ✓ Archive with NCEI Silver Spring

Sustain near-real time global VAL/Monitoring online

- ✓ Sustain match-ups with in situ SSTs (*i*Quam)
- ✓ Monitor in SQUAM and MICROS

Focus on Regional Validation

- ✓ Recommended by JPSS PO at Validated Review (Sep 2014)
- ✓ ACSPO Regional Monitor for SST (ARMS) is being developed

Work with VIIRS SST Users (L4 producers)

- ✓ Established users: Test improvements (L3U, error characterization)
- ✓ New/Emerging Users: Test improvements from assimilating VIIRS SST

Issues to Discuss at the Meeting

VIIRS Warm-Up / Cool-Down exercises affect SST

- ✓ Fix RDR to SDR code, to minimize the ~0.3K “global warming” artifacts
- ✓ Discuss with JPSS PO, STAR JPSS Management, SDR Team

ACSPO VIIRS Reanalysis (RAN)

- ✓ Unfunded “demo” RAN-1 underway with UW group (L. Gumley)
- ✓ Results look promising, need a sustained support
- ✓ Discuss with JPSS PO, UW, STAR JPSS Management

VIIRS L1.5 product? (bow-ties filled in, geo-rectification applied)

- ✓ SST will “fix” SDR in ACSPO v2.50 for pattern recognition analyses
- ✓ If you are a VIIRS data producer or user, interested in a L1.5 – please provide feedback to SST/SDR/Imagery/JSTAR Leads
- ✓ SST Team plans discuss w/JPSS PO, JSTAR, SDR, Imagery and other EDR Teams during the meeting

VIIRS Ocean Color Products

Menghua Wang &
Ocean Color EDR & Cal/Val Teams
Date: August 25, 2015

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

Ocean Color Teams contributed **21** posters (Thursday)

VIIRS Ocean Color EDR & Cal/Val Teams Members

EDR	Name	Organization	Funding Agency	Task
Lead	**Menghua Wang (OC EDR & Cal/Val Lead),** L. Jiang, X. Liu, W. Shi, S. Son, L. Tan, X. Wang, J. Sun, K. Mikelsons, V. Lance, **M. Ondrusek,** E. Stengel	NOAA/NESDIS/ STAR	JPSS/NJO	Leads – Ocean Color EDR Team & Cal/Val Team OC products, algorithms, SDR, EDR, Cal/Val, vicarious cal., refinements, data processing, algorithm improvements, software updates, data validations and analyses
Ocean Color	**Robert Arnone** Sherwin Ladner, Ryan Vandermeulen Adam Lawson, Paul Martinolich, Jen Bowers	U. Southern MS NRL QinetiQ Corp. SDSU	JPSS/NJO	Satellite data evaluation, in situ data Look Up Tables – SDR-EDR impacts, vicarious calibration Satellite matchup tool (SAVANT) – Golden Regions Cruise participation and support WAVE_CIS (AERONET-OC site) operation
	Carol Johnson	NIST	JPSS/NJO	Traceability, AERONET-OC Uncertainty
	Curt Davis, Nicholas Tufillaro	OSU	JPSS/NJO	Ocean color validation, Cruise data matchup West Coast
	Burt Jones, Matthew Ragan	USC	JPSS/NJO	Eureka (AERONET-OC Site)
	Sam Ahmed, Alex Gilerson	CUNY	JPSS/NJO	LISCO (AERONET-OC Site) Cruise data and matchup
	Chuanmin Hu	USF	JPSS/NJO	NOAA data continuity, cruise participation/support
	Ken Voss & MOBY team	RSMAS –Miami	JPSS/NJO	Marine Optical Buoy (MOBY)
	Zhongping Lee, Jianwei Wei	UMB	JPSS/NJO	Ocean color IOP data validation and evaluation Ocean color optics matchup, cruise participation

Working with: NOAA **CoastWatch**, VIIRS **SDR team**, DPA/DPE, Raytheon, NOAA OC Working Group, NOAA Coral Reef Watch, NOAA various line-office reps, NASA OBPG, NOAA OCPOP, etc.

Collaborators: D. Antoine (BOUSSOLE), B. Holben (NASA-GSFC), G. Zibordi (JRC-Italy), R. Frouin (for PAR), and others.

Summary of VIIRS Ocean Color EDR Products

- **Inputs**:
  - VIIRS M1-M7 and the **SWIR** M8, M10, and M11 bands SDR data
  - Terrain-corrected geo-location file
  - Ancillary meteorology and ozone data
- **Operational (Standard) Products** (8):
  - Normalized water-leaving radiance (nL_w's) at VIIRS visible bands M1-M5
  - Chlorophyll-a (Chl-a) concentration
  - Diffuse attenuation coefficient for the downwelling spectral irradiance at the wavelength of 490 nm, $K_d(490)$ (New)
  - Diffuse attenuation coefficient of the downwelling photosynthetically available radiation (PAR), $K_d(PAR)$ (New)
  - Level-2 quality flags
- **Experimental Products:**
  - Inherent Optical Properties (IOP-a, IOP-a_{ph}, IOP-a_{dg}, IOP-b_b, IOP-b_{bp}) at VIIRS M2 or other visible bands (M1-M5) from the Quasi-Analytical Algorithm (QAA) (Lee et al., 2002)
  - Photosynthetically Available Radiation (PAR) (R. Frouin)
  - Chlorophyll-a from ocean color index (OCI) method (Hu et al., 2012)
  - Others from users requests

➢ Data quality of ocean color EDR are extremely sensitive to the SDR quality. It requires **~0.1%** data accuracy (degradation, band-to-band accuracy…)!

Multi-Sensor Level-1 to Level-2 (MSL12) Ocean Color Data Processing

- Multi-Sensor Level-1 to Level-2 (MSL12)
  - ✓ **MSL12 is the official VIIRS ocean color data processing system.**
  - ✓ MSL12 was developed for the purpose of using a consistent and common data processing system to produce ocean color products from multiple satellite ocean color sensors (Wang, 1999; Wang and Franz, 2000; Wang et al., 2002), i.e., it is **measurement-based** ocean color data processing system.
  - ✓ It has been used for producing ocean color products from various satellite ocean color sensors, e.g., SeaWiFS, MOS, OCTS, POLDER, MODIS, GOCI, etc.
- MSL12 Ocean Color Data Processing
  - ✓ MSL12 is based on SeaDAS version 4.6.
  - ✓ Some significant improvements: (1) the SWIR-based data processing, (2) **Rayleigh** (new) and aerosol LUTs, (3) algorithms for detecting absorbing aerosols and turbid waters, (4) ice detection algorithm, (5) improved straylight/cloud shadow algorithm, & others.
  - ✓ In 2014, some new algorithms (BMW–new NIR reflectance correction, Destriping, K_d(PAR), etc.)
- MSL12 for VIIRS (and others) Ocean Color Data Processing
  - ✓ Routine ocean color data processing (daily, 8-day, monthly) since VIIRS launch.
  - ✓ Coastal turbid and inland waters from other approaches, e.g., the **SWIR approach**, results in the US east coastal, China's east coastal, Lake Taihu, Lake Okeechobee, Aral Sea, etc.
  - ✓ Capability for multi-sensor ocean color data processing, e.g., MODIS-Aqua, VIIRS, GOCI, and will also add J1, OLCI/Stentinel-3, and SGLI/GCOM-C data processing capability.

End-to-End Ocean Color Data Processing

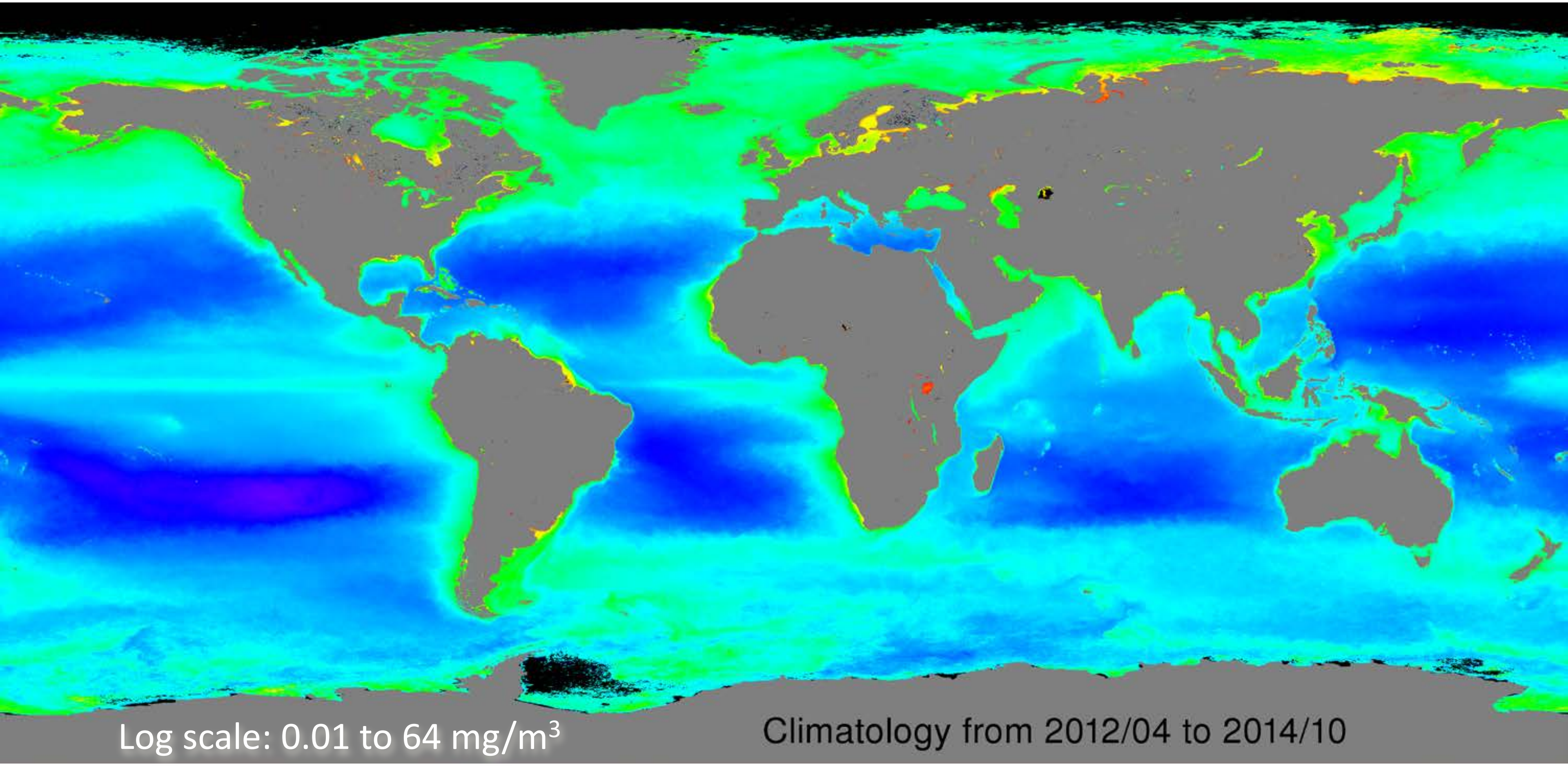
- NOAA Ocean Color Team has been developing/building the capability for the **End-to-End** satellite ocean color data processing including:
  - Level-0 (or Raw Data Records (RDR)) to Level-1B (or Sensor Data Records (SDR)).
  - Level-1B (SDR) to ocean color Level-2 (Environmental Data Records (EDR).
  - Level-2 to global Level-3 (routine daily, 8-day, monthly, and climatology data/images).
  - Validation of satellite ocean color products (in situ data and data analysis capability).
- Support of in situ data collections for VIIRS Cal/Val activities, e.g., **MOBY**, **AERONET-OC** sites, **NOAA dedicated cruise**, etc.
- On-orbit instrument calibration (solar and **lunar**) for ocean color data processing (Cal effort is needed to meet ocean color requirement):
  - J. Sun and M. Wang, "Radiometric calibration of the VIIRS reflective solar bands with robust characterizations and hybrid calibration coefficients," *Appl. Opt.* (Submitted).
  - J. Sun and M. Wang, "On-orbit calibration of Visible Infrared Imaging Radiometer Suite reflective solar bands and its challengers using a solar diffuser," *Appl. Opt.*, **54**, 7210-7223, 2015.
  - J. Sun and M. Wang, "On-orbit characterization of the VIIRS solar diffuser and solar diffuser screen," *Appl. Opt.*, **54**, 236-252, 2015.
  - J. Sun and M. Wang, "Visible Infrared Imaging Radiometer Suite solar diffuser calibration and its challenges using solar diffuser stability monitor," *Appl. Opt.*, **53**, 8571-8584, 2014.
- RDR (Level-0) to SDR (Level-1B) data processing (needed for quick data reprocessing):
  - Sun, J., M. Wang, L. Tan, and L. Jiang, "An efficient approach for VIIRS RDR to SDR data processing," *IEEE Geosci. Remote Sens. Lett.*, **11**, 2037–2041, 2014.
  - L. Tan, M. Wang, J. Sun, and L. Jiang, "VIIRS RDR to SDR Data Processing for Ocean Color EDR," *Proc. SPIE* 9261, *Ocean Remote Sensing and Monitoring from Space*, October 13-16, 2014.

Two Data Streams for VIIRS Ocean Color EDR

To meet requirements from **All** users (operational, research, modeling, etc.), we plan to produce VIIRS ocean color products in two data streams:

- **Near-Real-Time (NRT) Ocean Color Data Processing (**12-24 hours**):**
  - Quick turn around with ~12-24 hours latency (operational)
  - Using standard IDPS SDR data
  - Ancillary data using the Global Forecast System (GFS) model
  - Data may not be completed due to various issues (SDR missing, computer, etc.)
  - Data will be processed in NOAA CoastWatch and OSPO
- **Science Quality Ocean Color Data Processing (**One-two weeks delay**):**
  - About one-two weeks delay
  - Reprocessed mission-long ocean color data and continue-forward data stream
  - Using improved SDR (based on IDPS SDR data)
  - Science quality (assimilated) NCEP ancillary data
  - Complete global coverage
  - May expand to more experimental products & test with improved algorithms
  - Ocean color EDR will be reprocessed (mission-long) about every two-three years (or as needed, e.g., short-term data reprocessing, error fixing, etc.)
  - Data will be processed in NOAA/STAR and transferred to CoastWatch for distributions

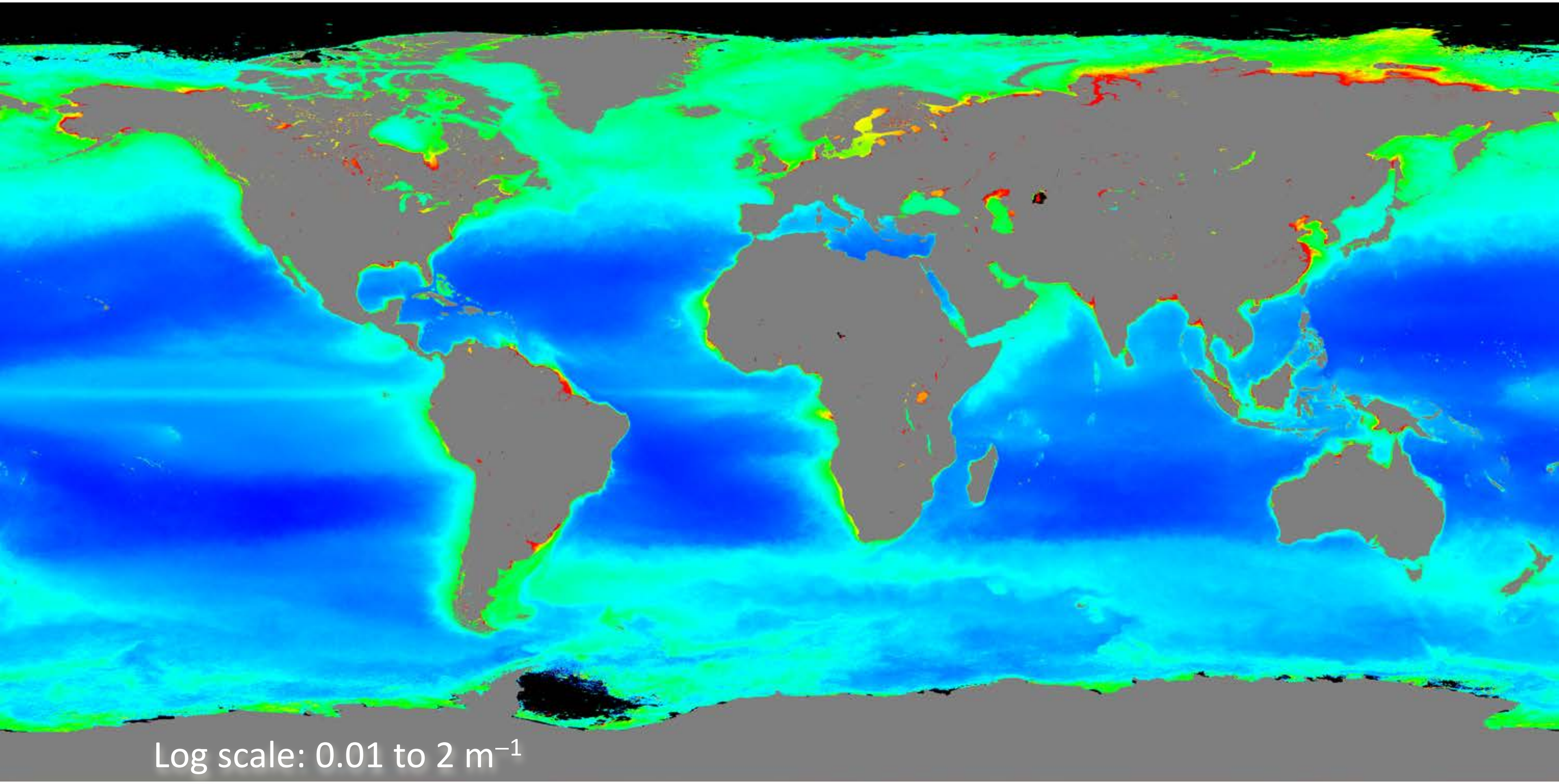
VIIRS Climatology Chlorophyll-a Image
(April 2012 to October 2014)



Generated using MSL12 for VIIRS ocean color data processing

Wang, M., X. Liu, L. Tan, L. Jiang, S. Son, W. Shi, K. Rausch, and K. Voss, "Impacts of VIIRS SDR performance on ocean color products," *J. Geophys. Res. Atmos.*, **118**, 10,347–10,360, 2013. http://dx.doi.org/10.1002/jgrd.50793

VIIRS Climatology $K_d(490)$ Image
(March 2012 to February 2015)

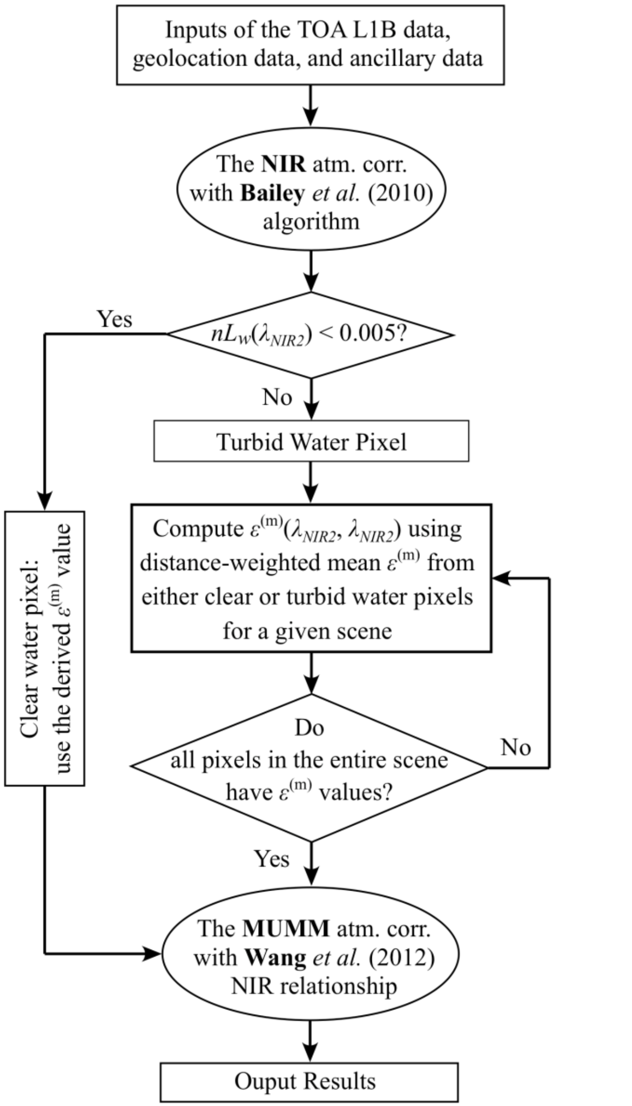


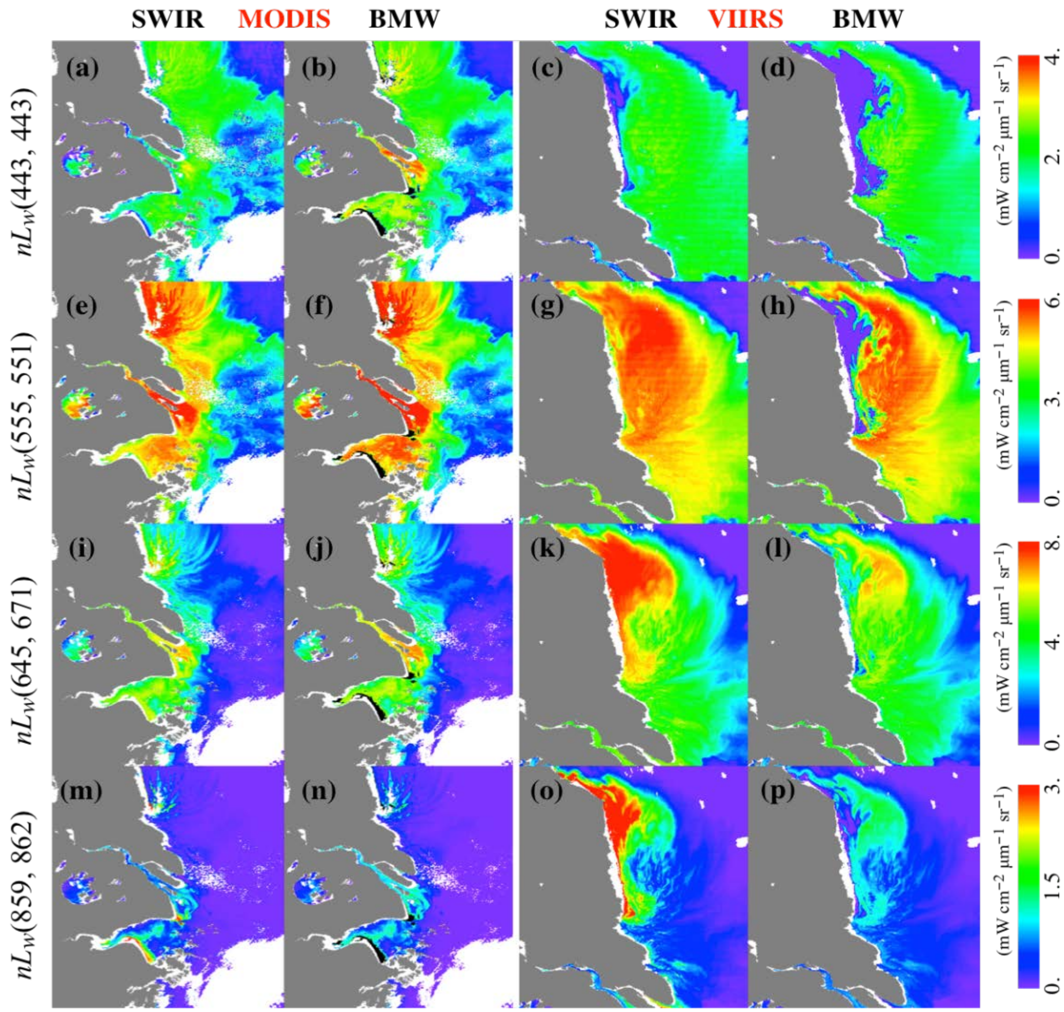
Generated using MSL12 for VIIRS ocean color data processing

Wang, M., S. Son, and L. W. Harding Jr., "Retrieval of diffuse attenuation coefficient in the Chesapeake Bay and turbid ocean regions for satellite ocean color applications," *J. Geophys. Res.*, **114**, C10011, 2009. http://dx.doi.org/10.1002/2009JC005286

Developed new NIR ocean reflectance correction algorithm: BMW (*Bailey* (2010), *MUMM* (2000), and *Wang* (2012))

The BMW Algorithm for Ocean Color Data Processing





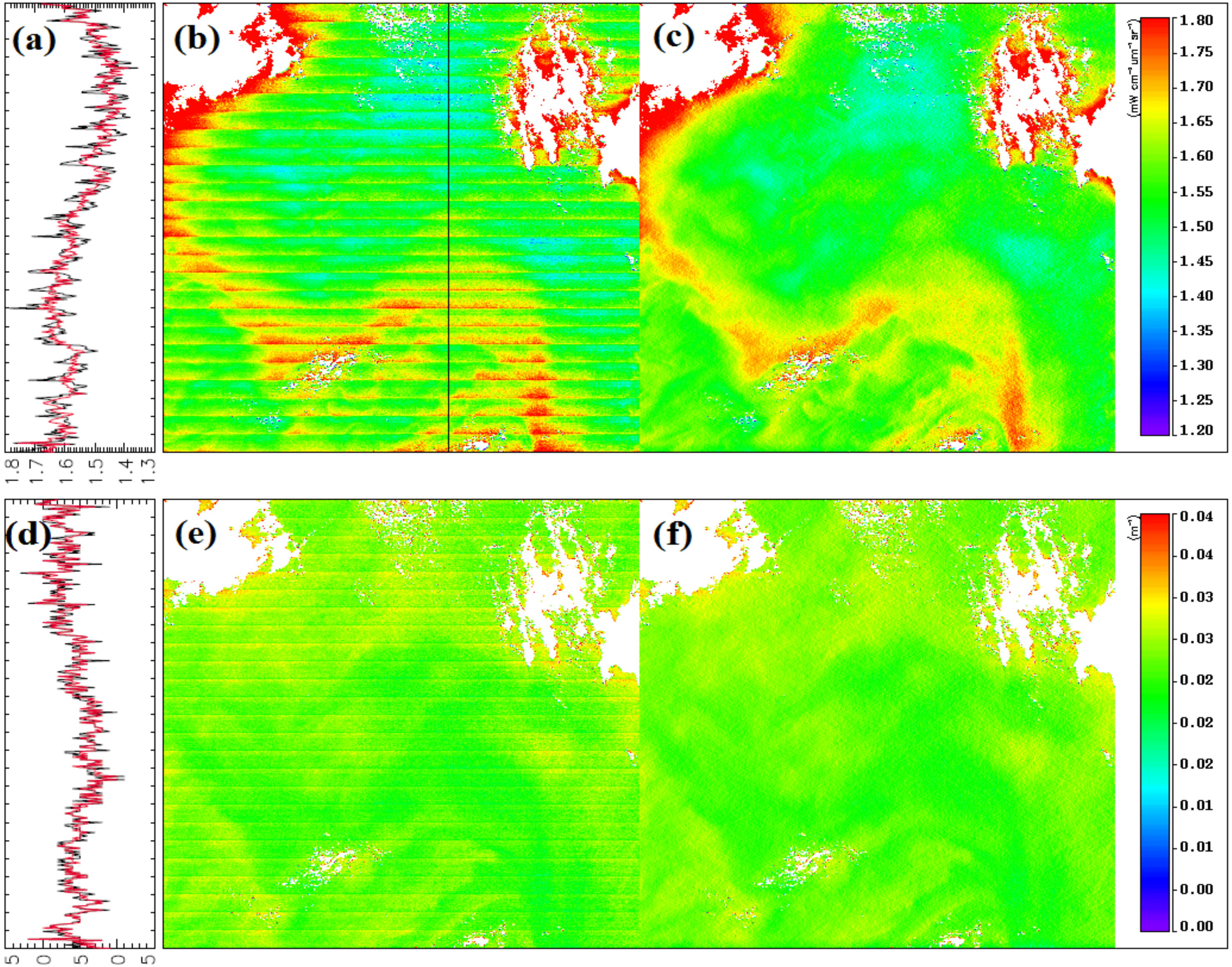
Comparisons of MODIS and VIIRS-derived $nL_w(\lambda)$ images at four selected bands.

Jiang, L. and M. Wang, "Improved near-infrared ocean reflectance correction algorithm for satellite ocean color data processing," *Opt. Express*, **22**, 21,657–21,678, 2014. http://dx.doi.org/10.1364/OE.22.021657

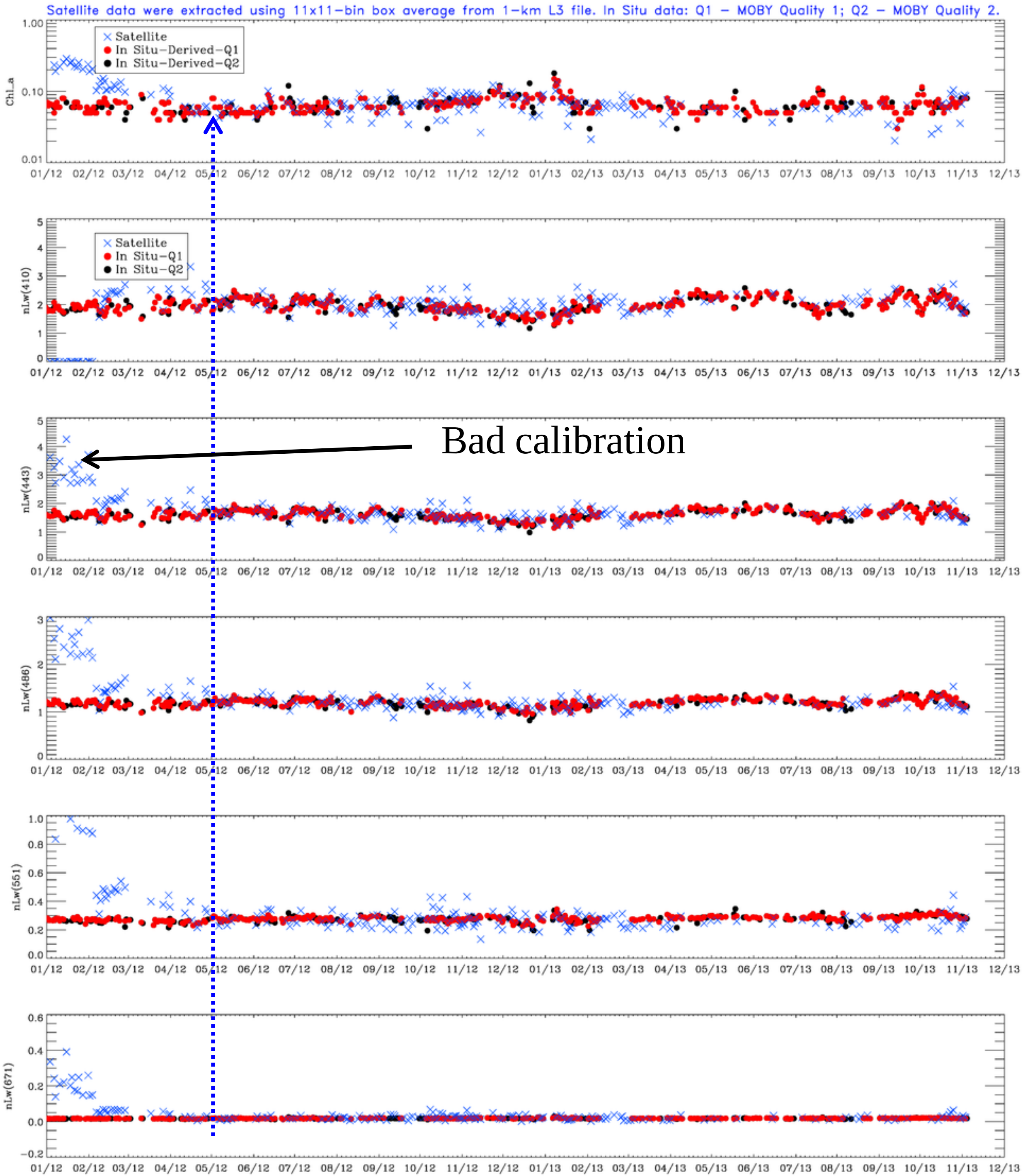
Destriping of VIIRS Ocean Color Products
(Examples)

$nL_w(412)$

$K_d(490)$



Mikelsons, K., M. Wang, L. Jiang, and M. Bouali, "Destriping algorithm for improved satellite-derived ocean color product imagery," *Opt. Express*, **22**, 28058-28070, 2014. http://dx.doi.org/10.1364/OE.22.028058



MOBY

Comparison of NOAA VIIRS ocean color products with **Marine Optical Buoy** (**MOBY**) in situ data.

Note:
Vicarious calibration gains applied since **May 2012**.

Vicarious gains were derived using **MOBY** in situ data.

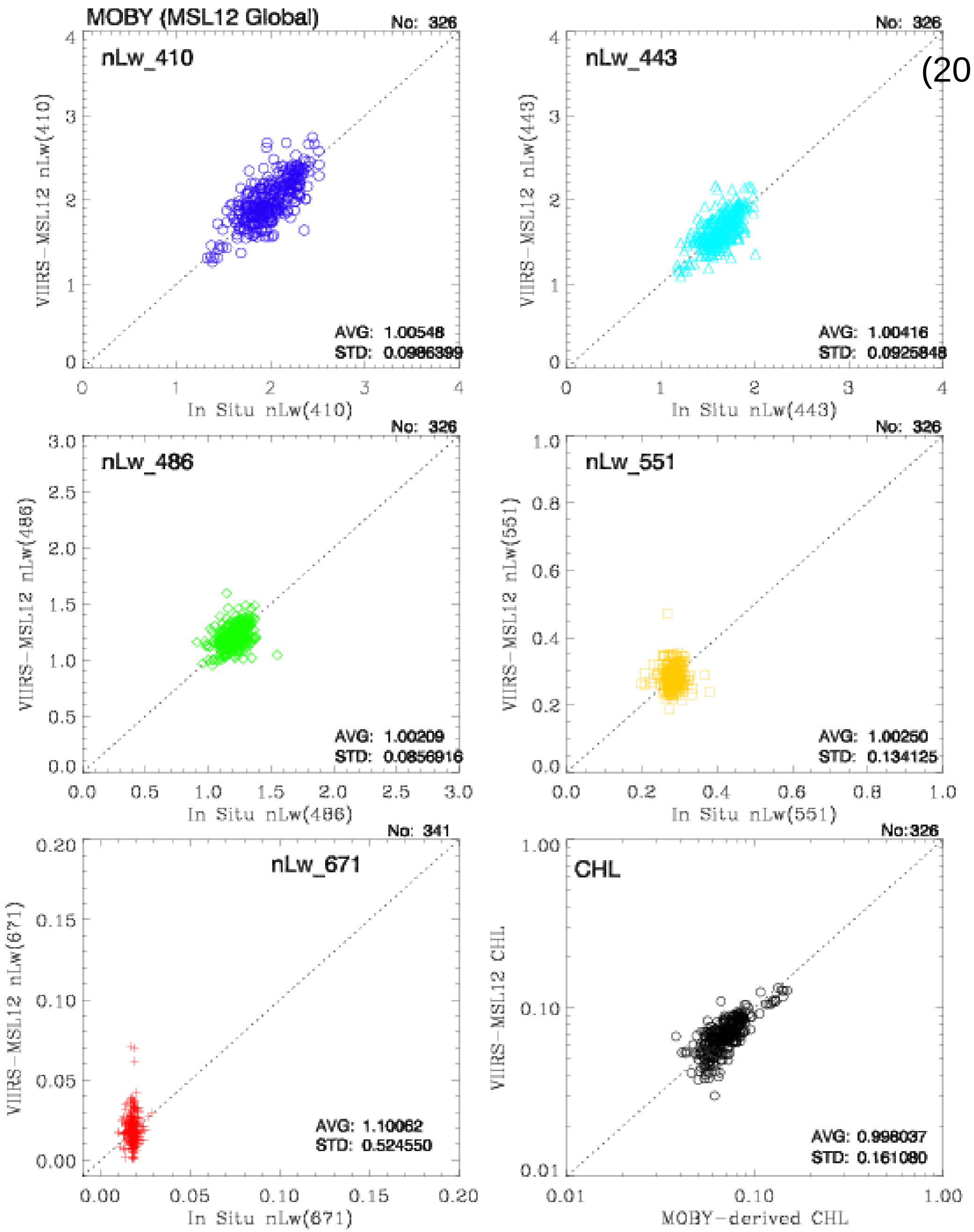
MOBY in situ optics data have been providing critical data set in support of VIIRS calibration and validation activities, including VIIRS Level-1B (SDR) data monitoring for sensor on-orbit calibration.

MOBY Matchup
with
VIIRS OC-SDR/EDR Processing (BMW-nc4)

MOBY

(2012-01-01 ~ **2014-05-31**)
Q1+Q2, ±3hr

Use OC-SDR with New MSL12



Menghua Wang, NOAA/NES

MOBY

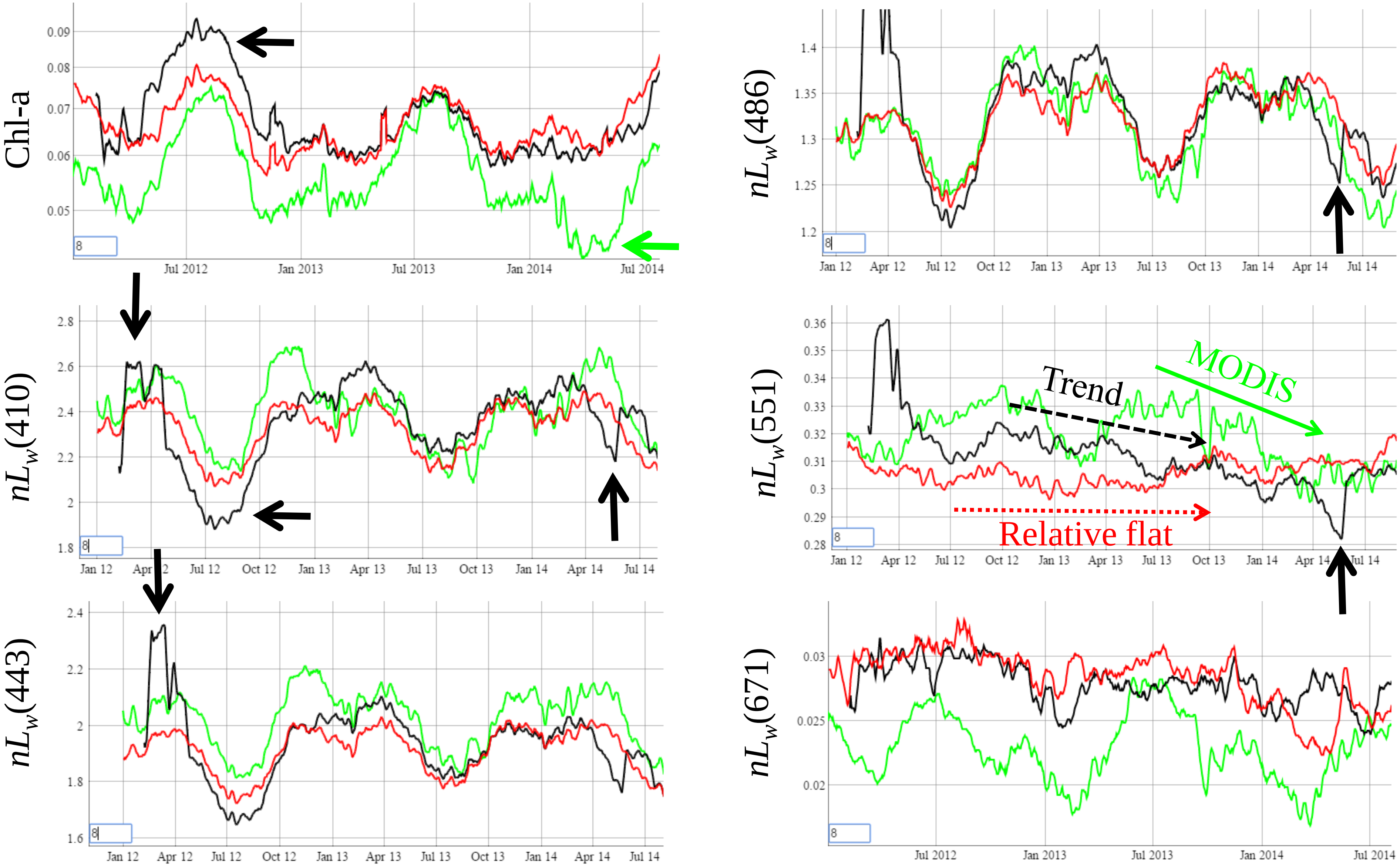
Statistics of VIIRS MSL12 vs. In-Situ (MOBY)

	Current Data Processing (2012-01-01 ~ **2014-05-31**)				New EDR Processing (BMW-hdf) (2012-01-01 ~ **2014-05-31**)				OC-SDR/EDR Processing (BMW-netCDF4) (2012-01-01 ~ **2014-05-31**)			
	AVG	**MED**	**STD**	**No**	**AVG**	**MED**	**STD**	**No**	**AVG**	**MED**	**STD**	**No**
***nL_w*(410)**	**1.0426**	1.0329	0.126	304	**1.0110**	1.0065	0.099	287	**1.0055**	1.0002	0.099	326
***nL_w*(443)**	**1.0679**	0.9904	0.294	329	**1.0436**	1.0107	0.210	299	**1.0042**	1.0009	0.093	326
***nL_w*(486)**	**1.0642**	0.9743	0.329	329	**1.0472**	1.0071	0.225	299	**1.0021**	0.9992	0.086	326
***nL_w*(551)**	**1.2029**	0.9225	0.897	329	**1.1376**	1.0077	0.600	299	**1.0025**	0.9947	0.134	326
***nL_w*(671)**	**1.9579**	1.1263	2.796	340	**1.5479**	1.1000	2.599	315	**1.1006**	1.0588	0.525	341
Chl-a	**1.1372**	0.9488	0.781	329	**1.1293**	1.0333	0.501	299	**0.9980**	0.9852	0.161	326
***K_d*(490)**	**1.0867**	0.9846	0.435	329	**1.0698**	1.0214	0.281	299	**0.9769**	0.9769	0.101	506

Global Oligotrophic Water OC Product Time Series

OC-SDR: Generated by the OC Team with OC calibration approach
IDPS-SDR: From operational IDPS-generated SDR

Reprocessed both mission-long SDR data using the **same new MSL12**



Red: VIIRS **OC-SDR** Black: VIIRS **IDPS-SDR** Green: **MODIS**-Aqua (NASA)

Dedicated VIIRS Cal/Val Cruise

NOAA Ship *Nancy Foster*

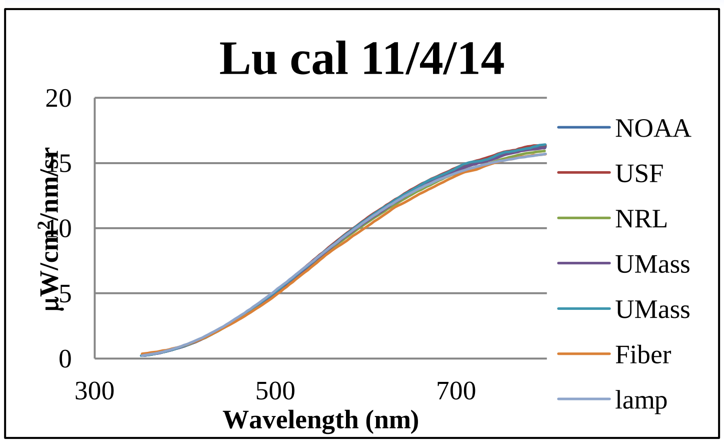
11-21 November 2014

International, Interagency, and Academic Collaborations:

4 US Agencies, EU-JRC, 6 Universities

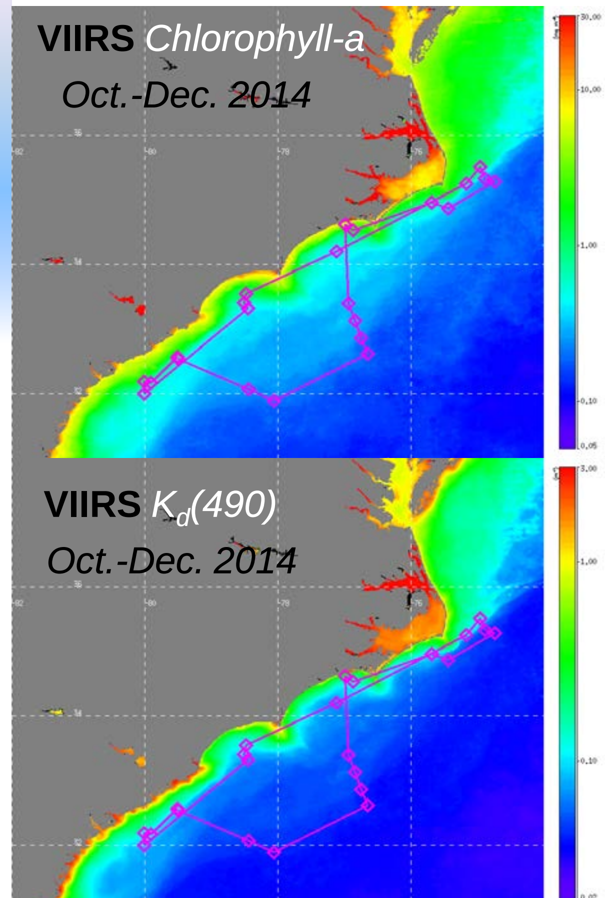
Validation Measurements

Water-leaving radiance; Chlorophyll-a; Absorption and backscattering coefficients; Bi-directional radiance distribution; Phytoplankton physiology; Carbon; Total suspended matter; Aerosol optical depth, etc.



Pre-cruise inter-calibration results for 5 radiance sensors

Cruise Track



Validation Results

- **Occupied 23 stations over 10 days**
- **Simultaneous measurements at each station for:**
  - ✓ **4 profiling radiometers**
  - ✓ **2 floating radiometers**
  - ✓ **6 above-water radiometers**
- **Conducted pre- and post-cruise inter-calibrations**

11 potential station matchups with VIIRS

The cruise report is completed!

Conclusions/Path Forward (1)

- With improved SDR (calibration) and EDR (data processing algorithms), **VIIRS ocean color products are now comparable to or better than those from MODIS-Aqua.**
- We have completed mission-long OC data reprocessing using IDPS-SDR with new MSL12.
- We have started VIIRS mission-long science quality ocean color data **reprocessing** (including **SDR** and **EDR**), and will finish that in **late 2015**, & the data stream will go forward. **Two data streams will be produced: near-real-time and science quality ocean color data.**
- Calibration from both solar and lunar is necessary. We need lunar model data!
- VIIRS ocean color products have been improved after the implementation of some important updates, new algorithms, and with vicarious calibrations.
- In general, VIIRS **normalize water-leaving radiance** spectra show reasonable agreements with in situ measurements at MOBY, AERONET-OC sites, and various other ocean regions.
- The new NIR ocean reflectance correction algorithm (BMW) improves ocean color data over coastal and inland waters. The destriping algorithm significantly improves VIIRS-derived ocean color imageries.
- New **K_d(PAR)** product has been developed and routinely produced to meet users requirements.
- NOAA dedicated Cal/Val cruise in Nov. 2014, and plan to have it in late 2015. The report for the 2014 Cal/Val cruise has been completed.
- There will be many applications using VIIRS ocean color products.
- We have developed VIIRS instrument calibration capability, and with new calibration LUTs, VIIRS ocean color products are significantly improved.
- Our evaluation results show that VIIRS-SNPP is capable of providing high-quality global ocean color products in support of science research and operational applications.
- We have been actively working with other current and future ocean color sensors, e.g., MODIS-Aqua, Korean GOCI, EUMETSAT for Sentinel-3 (launch late 2015), JAXA GCOM-C (launch early 2017), and **VIIRS on J1** (launch 2017).

Conclusions/Path Forward (2)

- Complete VIIRS mission-long ocean color data reprocessing (science quality, i.e., improved SDR, algorithms, and science quality ancillary data).
- VIIRS reprocessed data stream will go forward (about one-two weeks delay). VIIRS science quality data will be distributed through CoastWatch and other means (e.g., NODC effort).
- Cal/Val team will finish the 2014 VIIRS dedicated cruise report and in situ data analyses (e.g., improve in situ data quality).
- More in situ data are needed for validation and improvement of VIIRS ocean color products.
- In situ data quality (instrument calibration, measurement protocols, data processing methodology, etc.)
- Dedicated VIIRS ocean color Cal/Val cruise in December 2015, and establishing annual Cal/Val cruises.
- Continue work on sensor on-orbit calibration (solar and lunar), algorithms improvements, etc.
- We have been working on J1 instrument. Need more efforts for J1 VIIRS pre-launch data analyses as J1 close to launch (access to J1 sensor data).
- Algorithms improvements for both open oceans and coastal/inland waters. In particular, significant efforts are needed for coastal/inland waters.

Details: Ocean color breakout session and the Team 21 posters on Thursday!

STAR GCOM-W1/AMSR2 Product Development and Validation Project

AMSR2 Level 1 and Level 2 products

STAR GCOM-W1 Project Team

Presented by Ralph Ferraro

Paul Chang, Ralph Ferraro, Zorana Jelenak, Suleiman Alsweiss, Patrick Meyers, Jun Park, Qi Zhu, Micah Baker, Xiwu Zhan, Jicheng Liu, Eileen Maturi, Fuzhong Weng, Andy Harris, Jeff Key, Cezar Kongoli, Walt Meier, Yong-Keun Lee, Walter Wolf, Tom King, Letitia Soullaird, Peter Keehn, Mike Wilson …

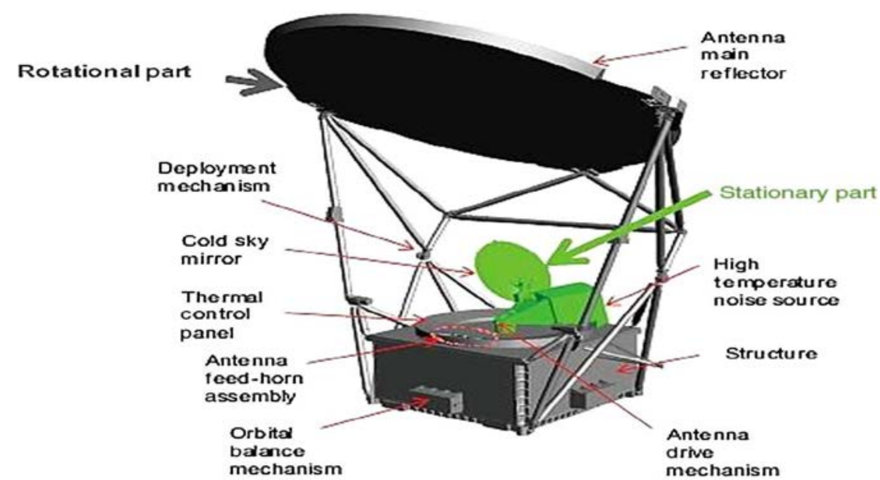
August 25, 2015

Outline

- GCOM-W1/AMSR2 Instrument Overview
- Project Structure and Schedule
- Product Status, Overview and Examples
- Summary and Path Forward

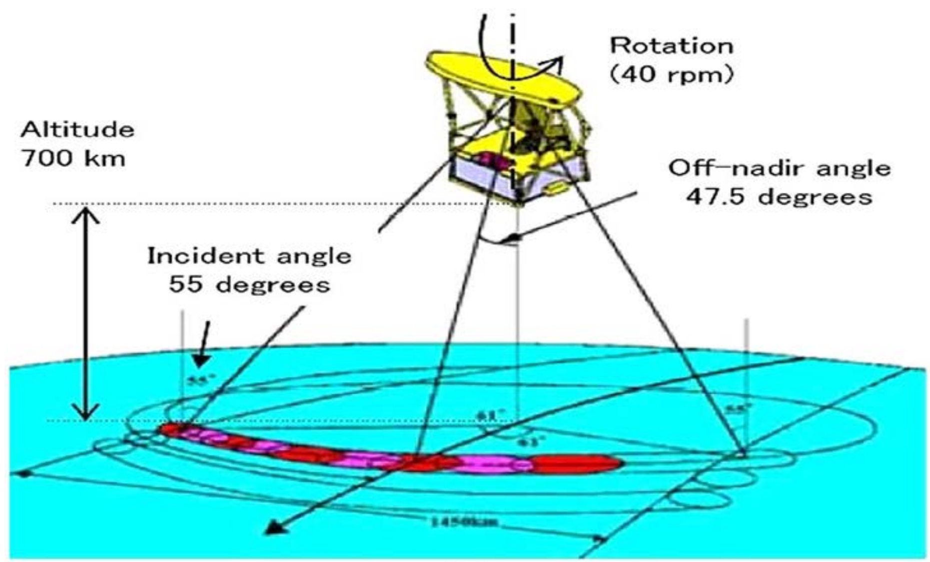
AMSR2 Instrument Overview

- General Information
  - Launched: JAXA, 05/2012
  - Swath: 1450 km
  - EIA: 55°
  - Rate: 40 rpm



(a)

Center freq. (GHz)	Band width (MHz)	Beam width (3 dB, deg.)	Ground IFOV (km)	Sampling interval (km)
6.925/7.3	350	1.8	35 x 62	10
10.65	100	1.2	24 x 42	
18.7	200	0.65	14 x 22	
23.8	400	0.75	15 x 26	
36.5	1000	0.35	7 x 12	
89.0	3000	0.15	3 x 5	5



(b)

NOAA GCOM-W1 Project Responsibilities

The NOAA JPSS Office (NJO) is providing funding to OSD, STAR, and OSPO to operationally generate and make available AMSR2 SDR and EDR products to support NOAA's user needs.

OSD has developed a system called the GCOM-W1 Processing and Distribution System (GPDS) to perform the following tasks.

- Ingest AMSR2 RDRs and ancillary data; Run the JAXA RDR-to-SDR software; Run the STAR GCOM-W1 AMSR2 Algorithm Software Processor (GAASP); Transfer products for distribution; Interact with OSPO monitoring and control systems.

STAR:

- Developed a software package, called the GCOM-W1 AMSR2 Algorithm Software Processor (GAASP), to generate the AMSR2 EDRs and perform product reformatting to netCDF4.
- Developed operational documentation for the GAASP package and the EDR algorithms following existing SPSRB templates.
- Delivered the GAASP and documentation to the OSD contractor for integration into their GPDS.

OSPO:

- Received the GPDS (with JAXA and GAASP packages integrated into it) from the OSD contractor.
- Operationally run and maintain the GPDS for the lifecycle of the project.

Project Schedule Overview

- Key Milestones – Day 1 Products:
  - Preliminary Design Review – Nov 8, 2012
  - Critical Design Review – May 1, 2013
  - Software Code Review – Sept 18, 2013
  - Algorithm Readiness Review – Dec 19, 2014
  - ***Operational Readiness Review – Aug 21, 2015***
  - ***SPSRB Decision Briefing – Sept 23, 2015***
  - Operations Commence – Pending for the NDE build 1.0.8 release schedule, targeted on late of Oct 2015

- Since June 2013: Products available in near real-time to users (NHC, JTWC, NRL, etc.) via the GAASP on the STAR GCOM-W1/AMSR2 product development and validation system

- Discontinuities were found the level 1 files that were introduced by the IDPS granules. This necessitated moving to full orbit contacts through IDPS which is currently an ongoing effort.

STAR GAASP Development

Delivery 1:

Day 1 GAASP Product Capability

- Microwave Brightness Temperature (MBT)
- Cloud Liquid Water (CLW)
- Sea Surface Temperature (SST)
- Total Precipitable Water (TPW)
- Precipitation Type/Rate (PT/R)
- Sea Surface Wind Speed (SSW)

GAASP netCDF4 Reformatting Capability

SPSRB documentation ***(See backup slides for Day 1 data flow)***

Delivery 2:

Day 2 GAASP Product Capability

- Soil Moisture (SM)
- Snow Cover/Depth (SC/D)
- Sea Ice Characterization (SIC)
- Snow Water Equivalent (SWE)

Updated GAASP netCDF4 Reformatting Capability

Updated SPSRB Documentation

Deliveries 3,4,…

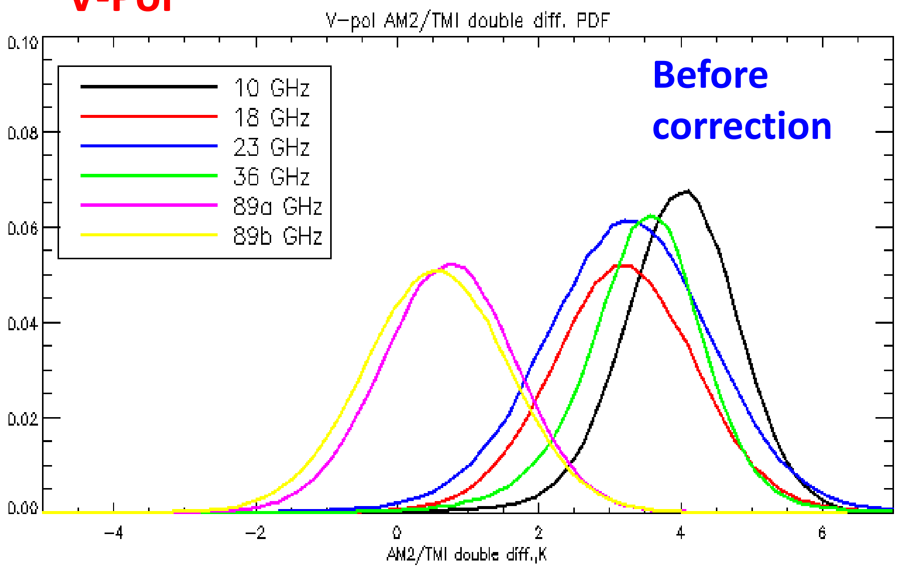
Updates and enhancements to existing EDRs

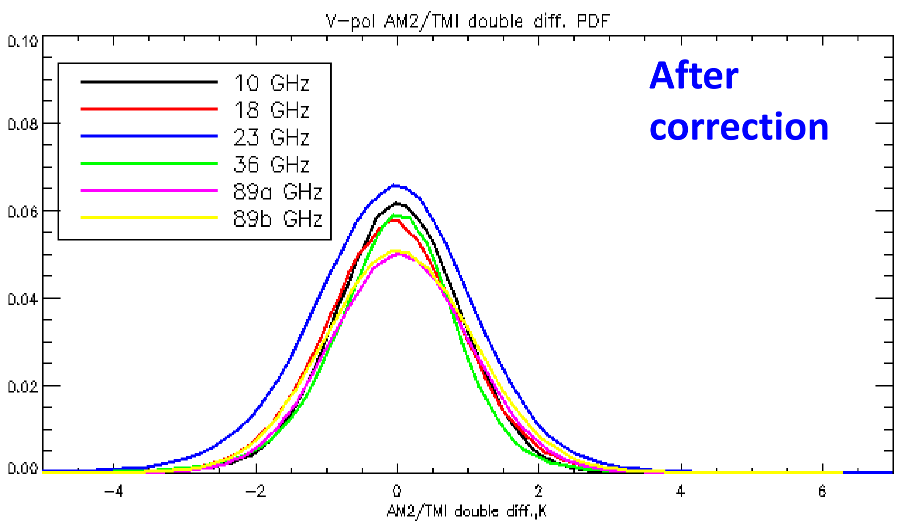
AMSR-2 On Orbit Calibration

- Accounting for residual calibration errors in AMSR-2 TB's received from JAXA significantly improves the performance & accuracy of geophysical retrieval algorithms
  - Double difference analyses were utilized to characterize the residual calibration biases
    - TMI 1B11 V7 calibrated Tbs were used as a reference radiometer data

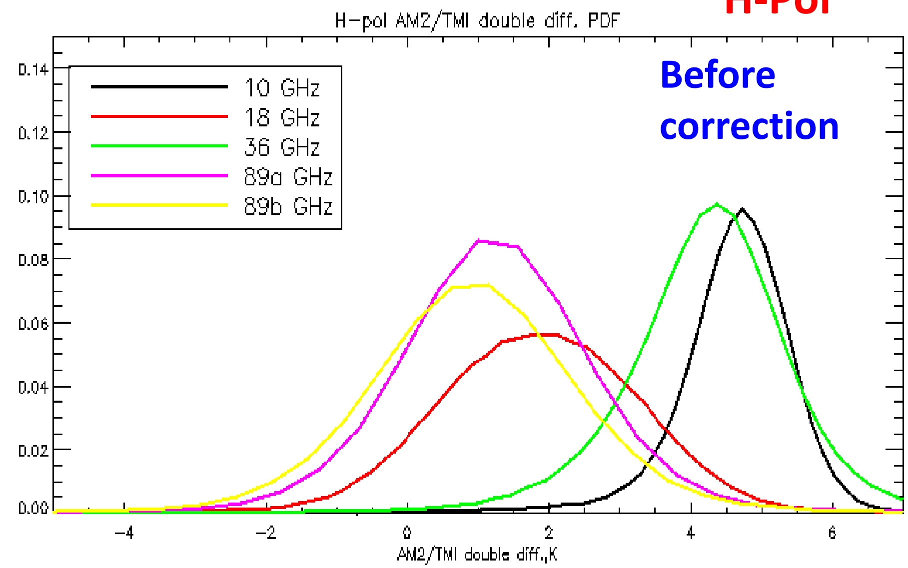
Double Difference PDFs

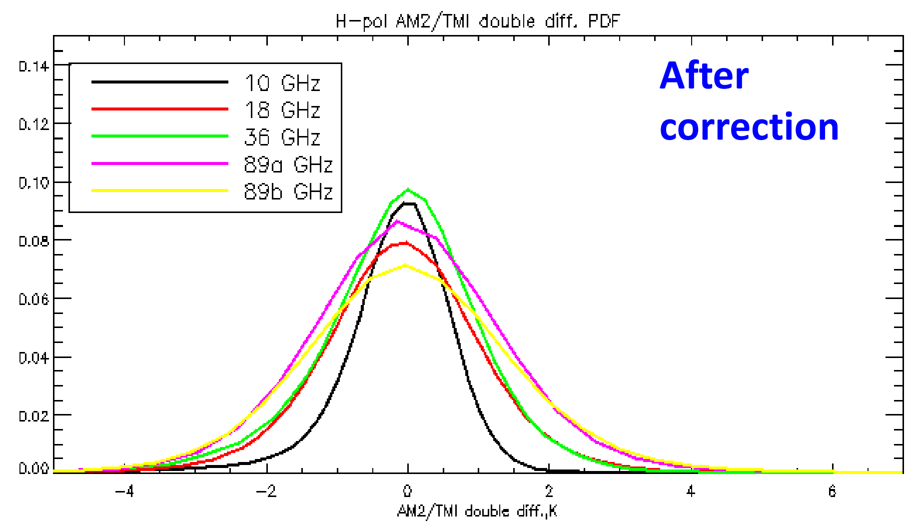
V-Pol





H-Pol





JAXA-NOAA Technical Exchange Meeting – November 21-22, 2014; Tokyo, Japan

Day-1 Ocean EDR Improvements

- Some issues found in the initial Day-1 ocean products are being addressed
  - Retrieved SST values match models in daytime (ascending AMSR2 passes)
    - Models tend to underestimate SST by ~ 2 K at low winds
  - Small dependence on earth incidence angle (EIA)
    - Apply EIA correction
  - Occasional horizontal lines (artifacts) appear in some Day-1 products
    - Latitude stepwise regressions were not used

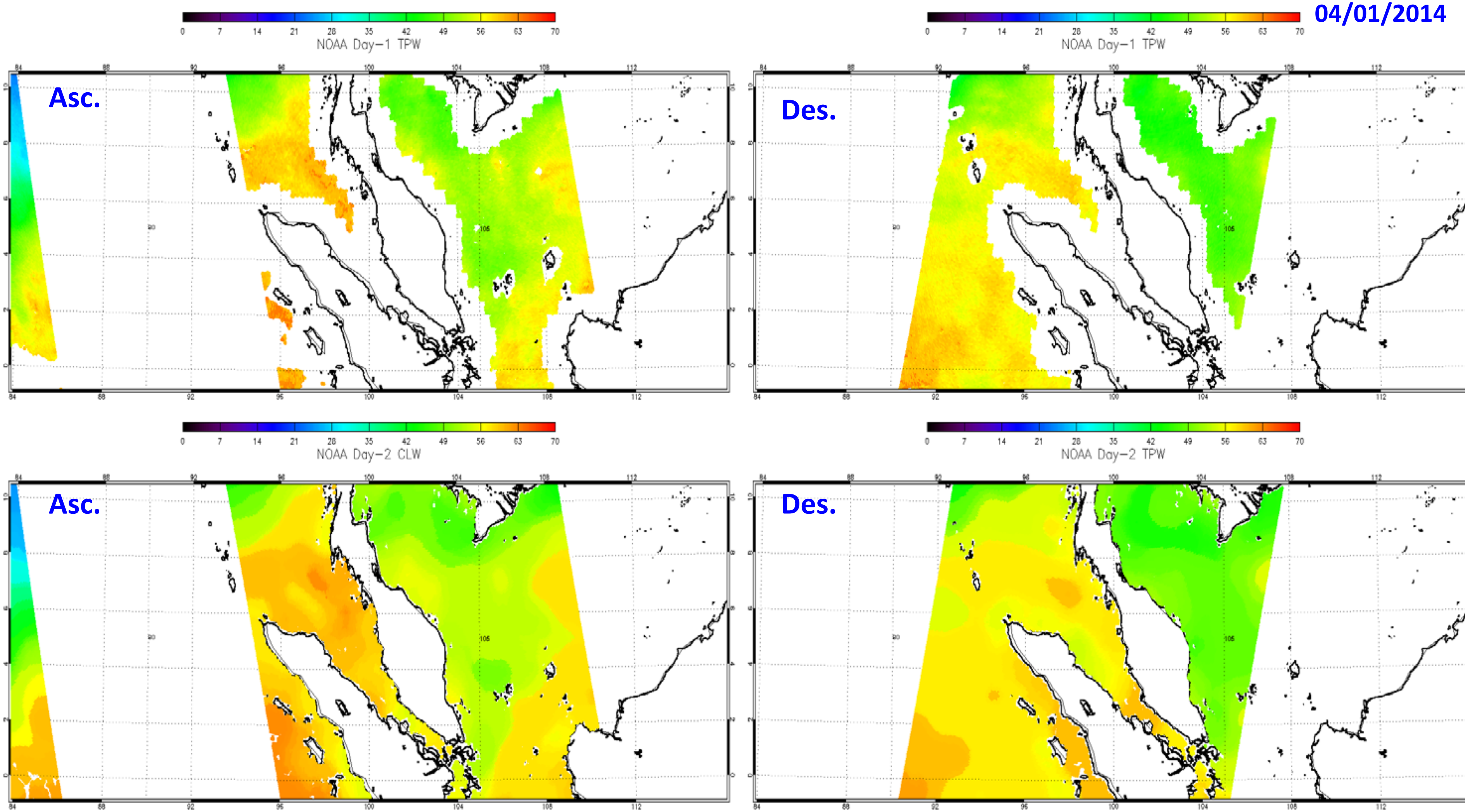
Day-1 Ocean EDR Improvements (cont.)

- Initial CLW & TPW retrievals utilized all AMSR-2 channels including the 6 & 7 GHz channels
  - Affected by sun glint
  - Not able to get close to coast line due to bigger IFOV of low frequency channels

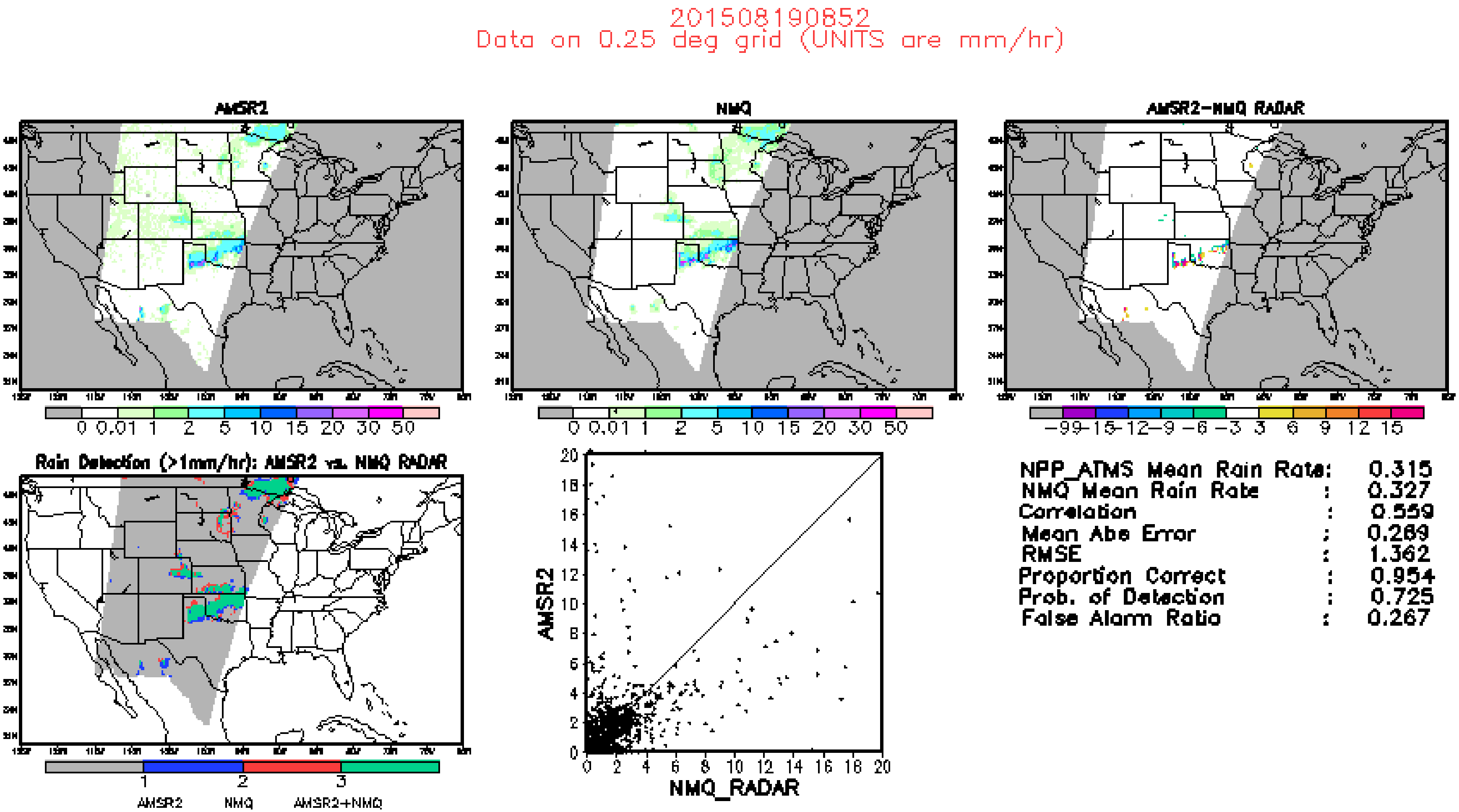
- Enhanced Day-1 TPW & CLW use 23 & 36 GHz channels
  - No sun glint issues
  - Can get much closer to the coast line
    - ➢ Better utilization by NWS in certain regions with complex coastlines

TPW Retrievals Available Closer Coast

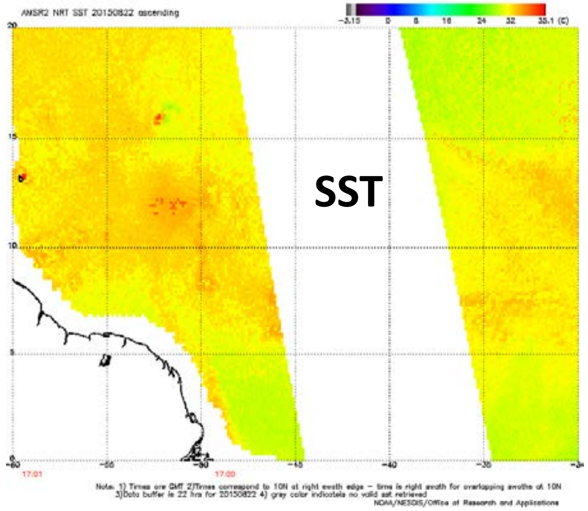
04/01/2014

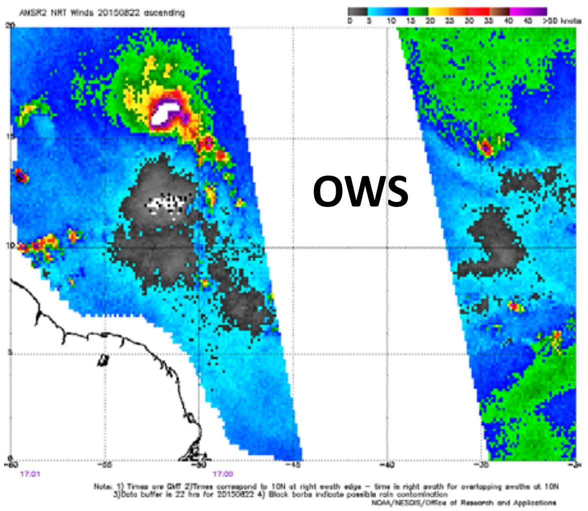


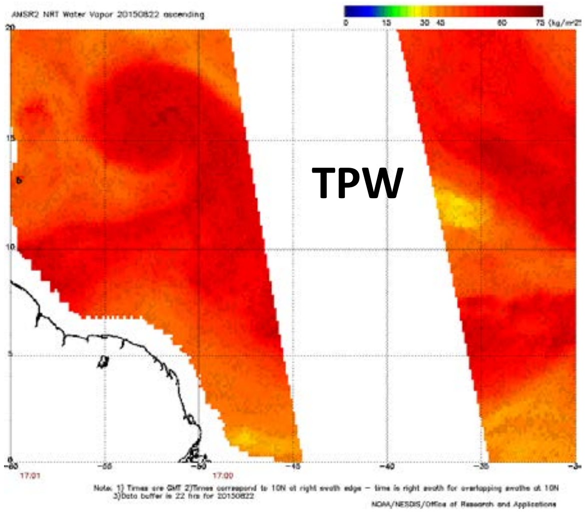
Rainfall/Monitoring over CONUS

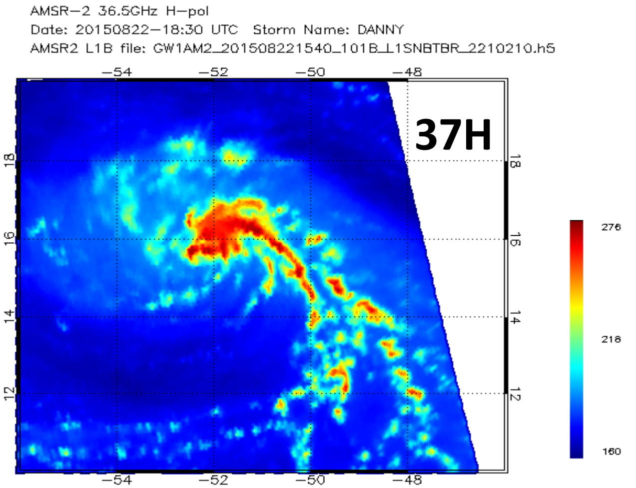


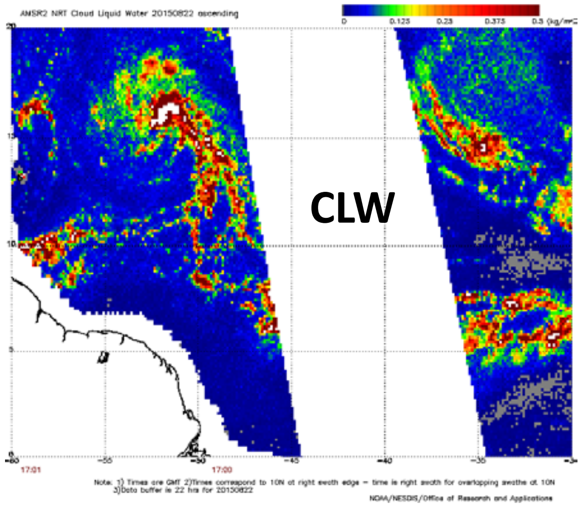
Hurricane Danny Examples (8/22/15)

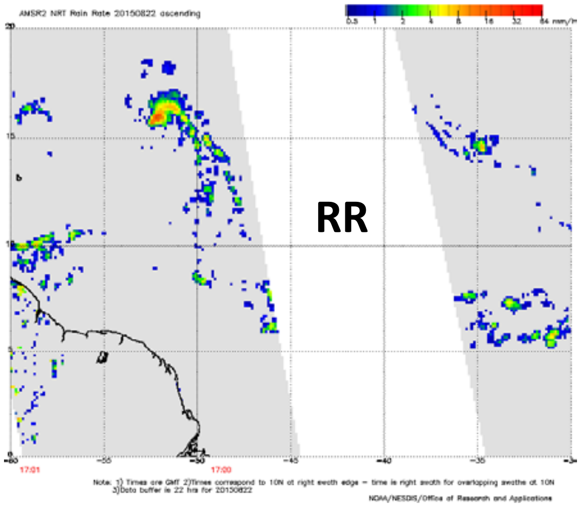




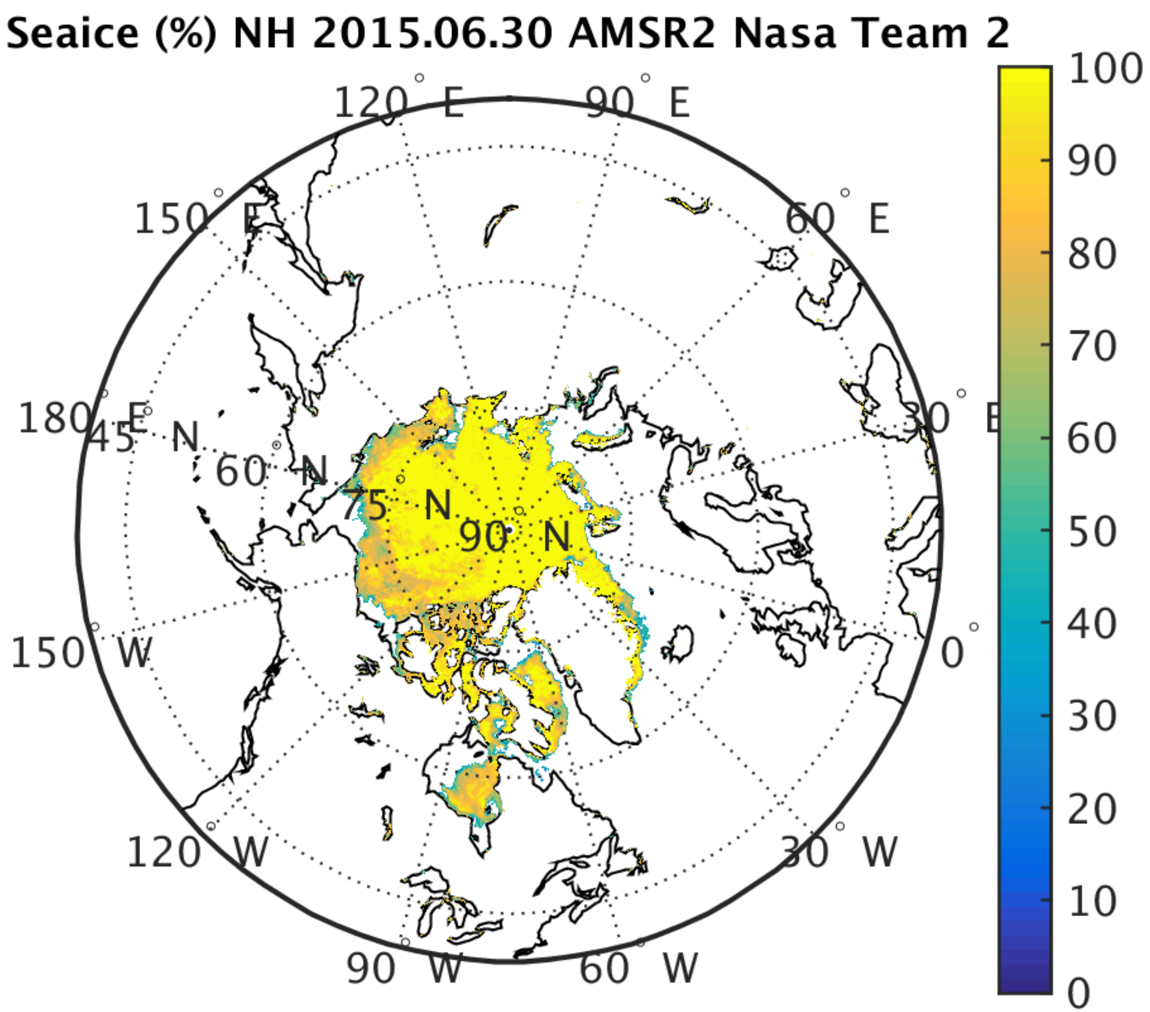




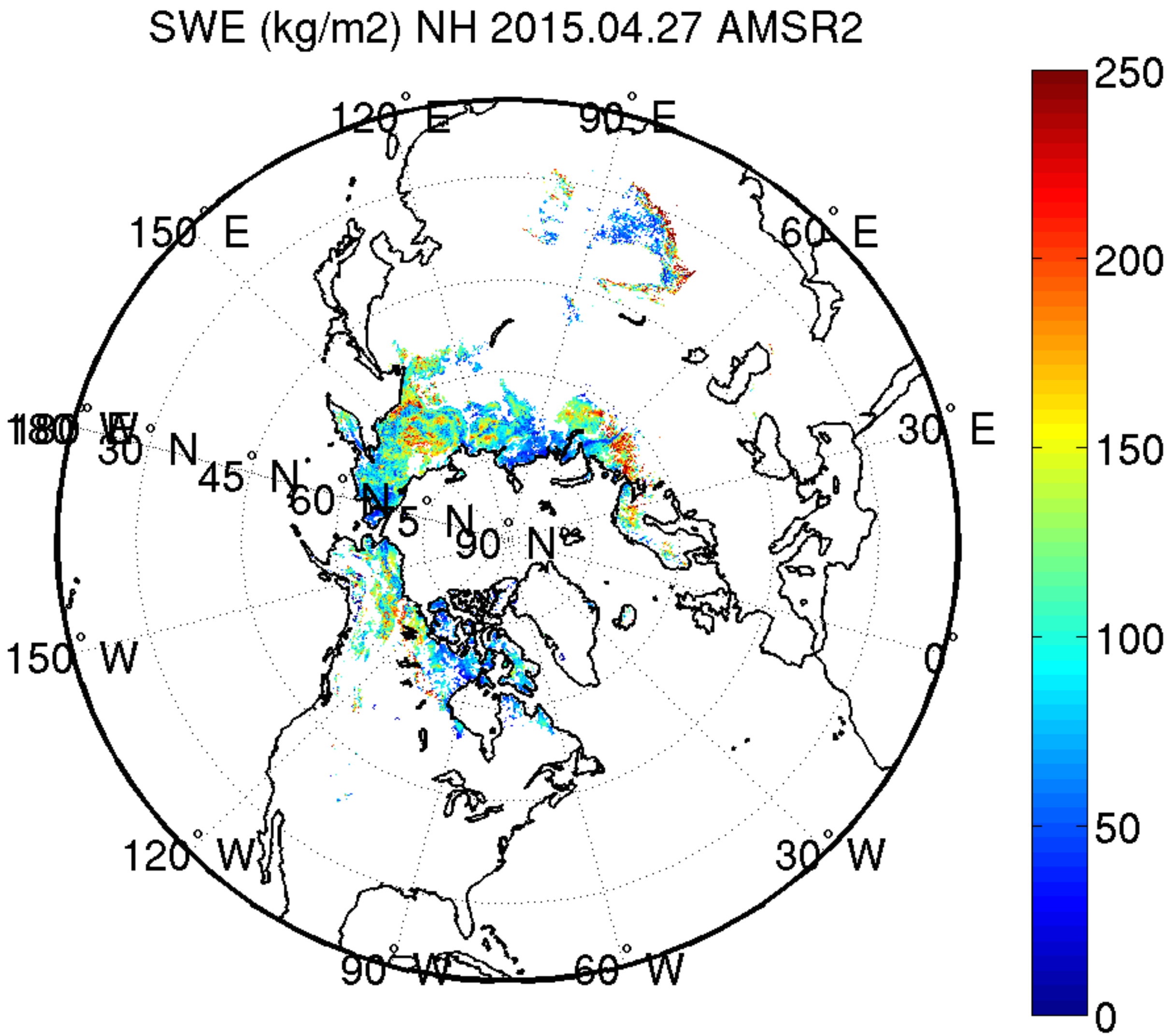




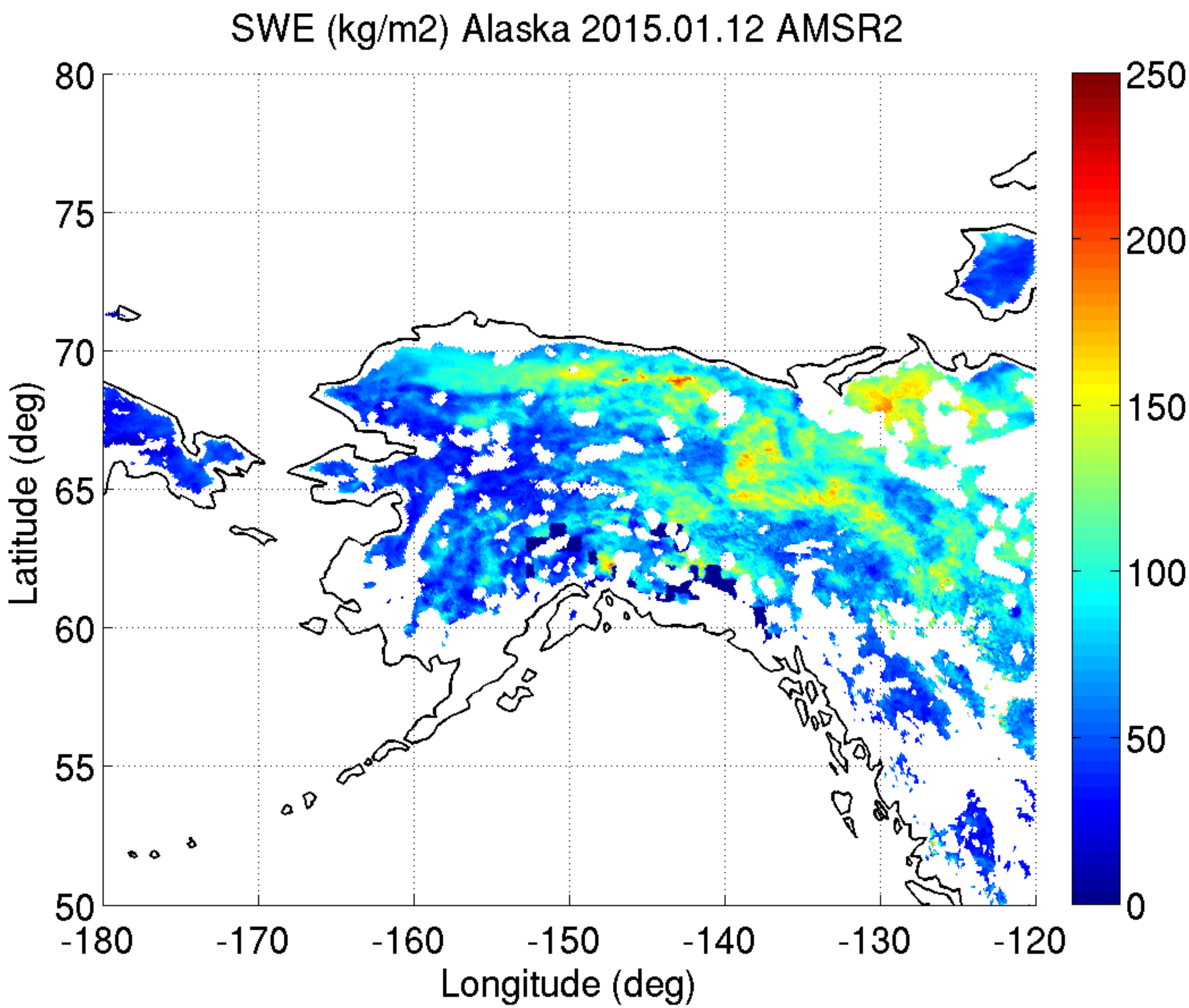
AMSR2 Sea Ice Concentration



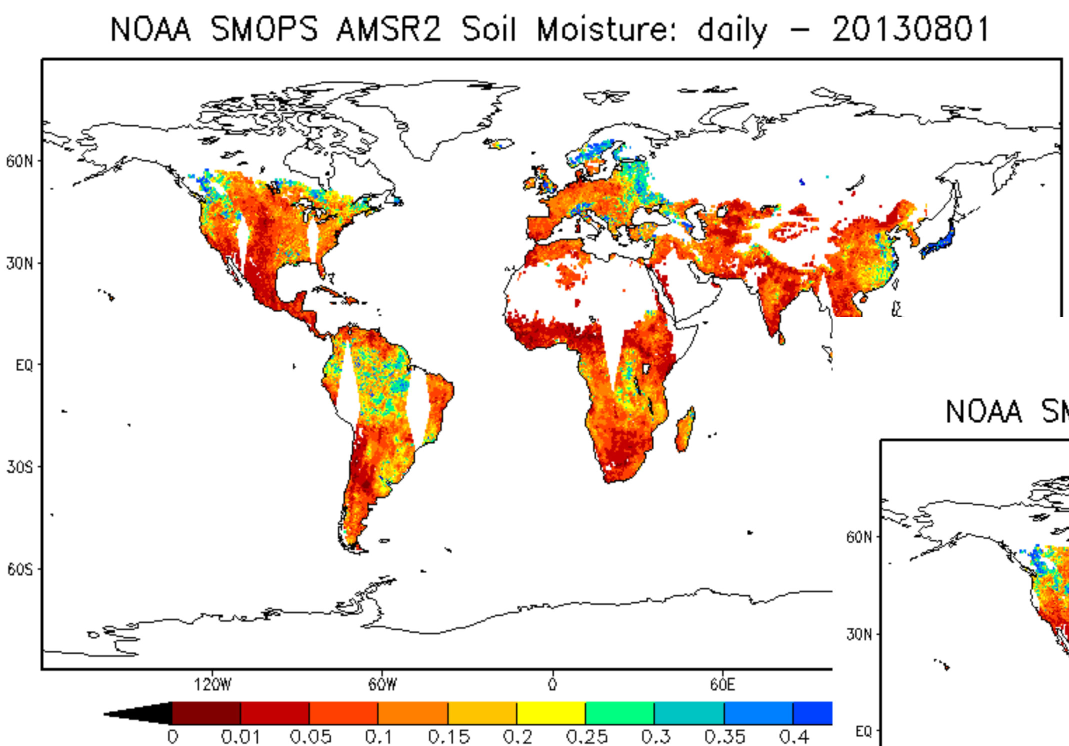
AMSR2 Snow Water Equivalent

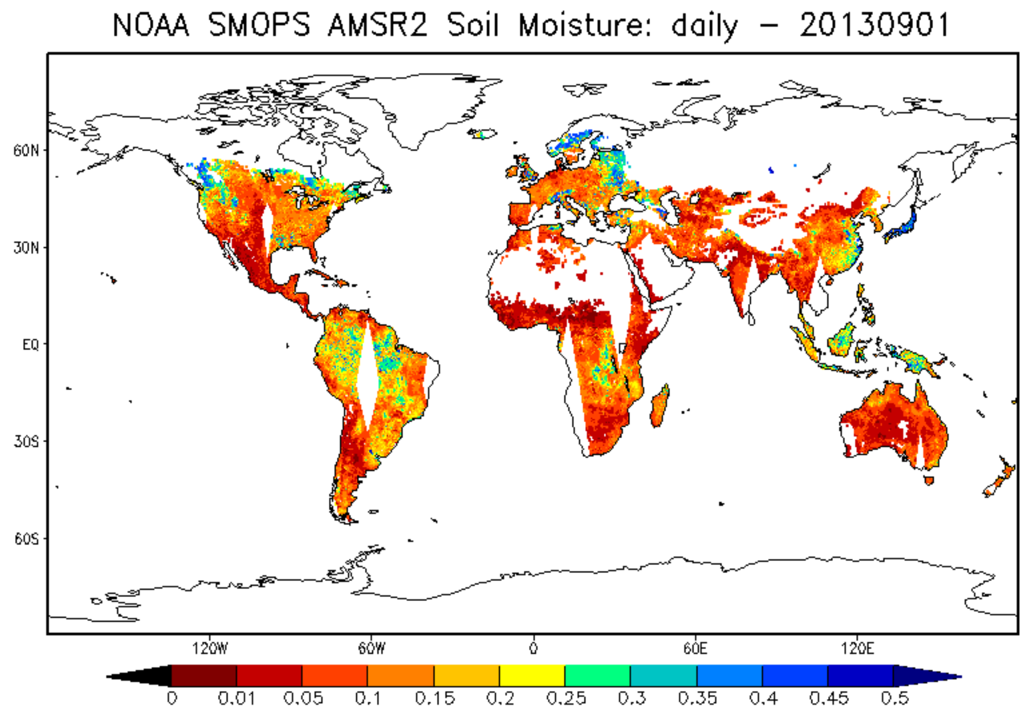


AMSR2 Snow Water Equivalent (SWE)



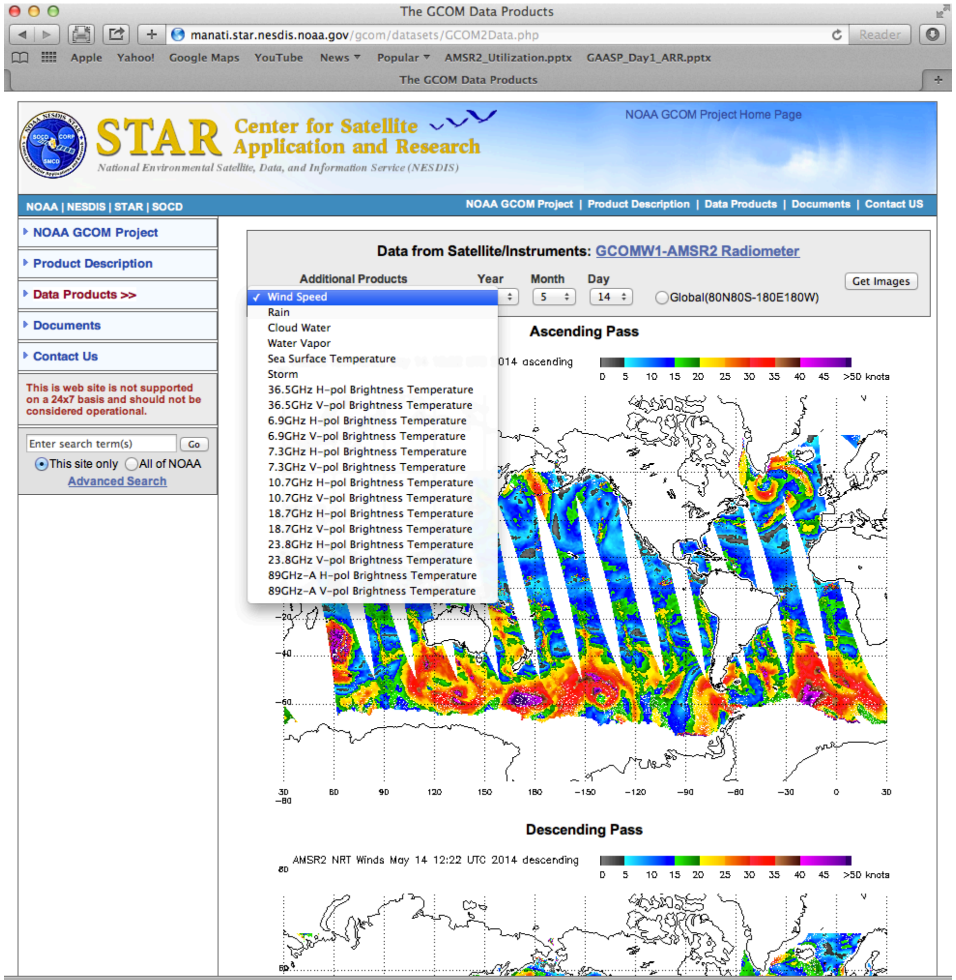
NOAA AMSR2 Soil Moisture Maps

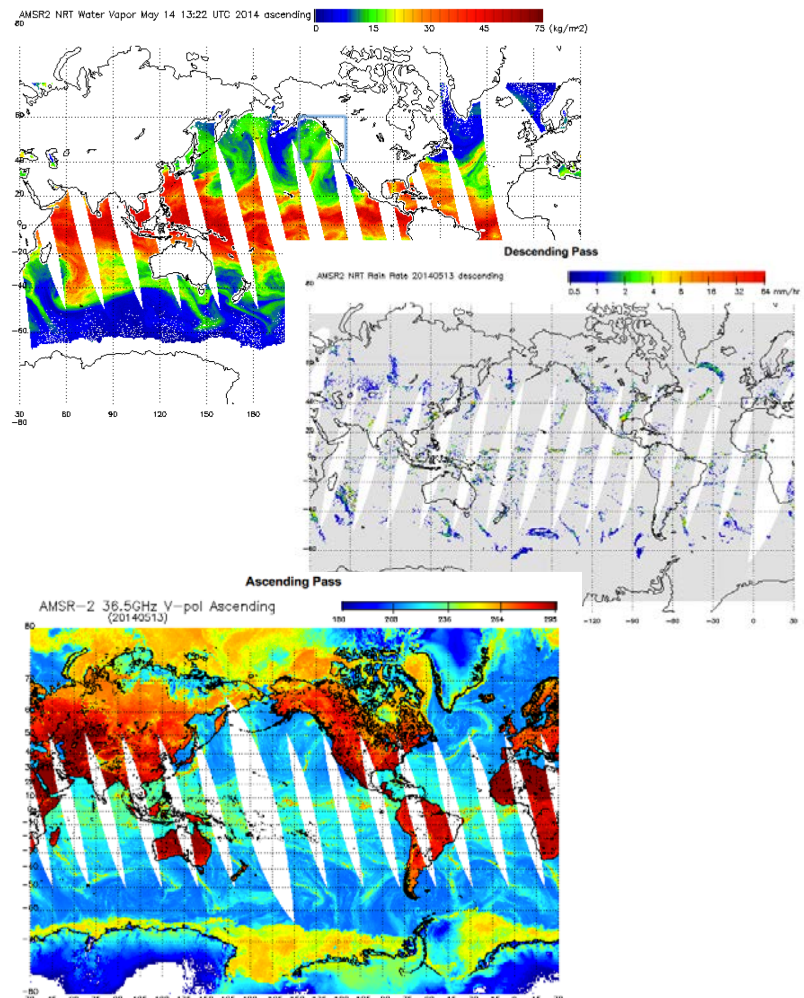




STAR GCOM-W1 AMSR2 Web Page

Near Real-Time and Retrospective AMSR2 Product Portal





http://manati.star.nesdis.noaa.gov/gcom

STAR AMSR2 Product Monitoring

http://manati.star.nesdis.noaa.gov/gcom

- NOAA GCOM Project
- Product Description
- Data Products >>
  - Data Files
- Documents
- Contact Us

This is web site is not supported on a 24x7 basis and should not be considered operational.

Enter search term(s) Go

This site only All of NOAA

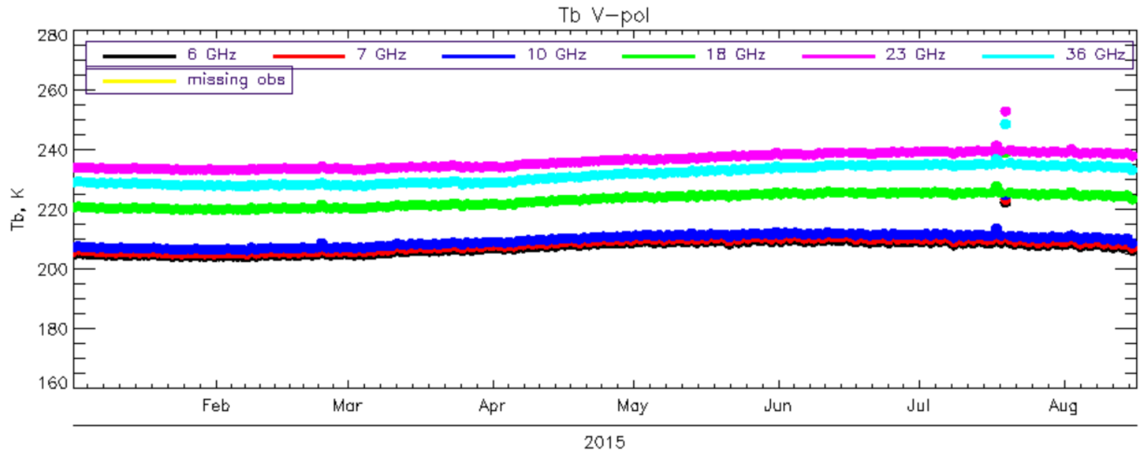
Advanced Search

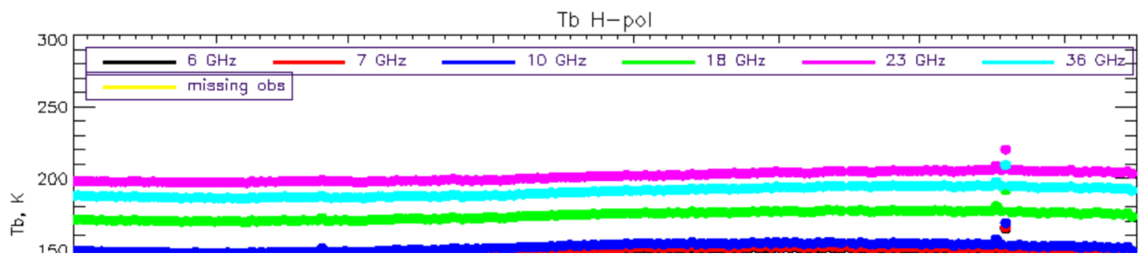
Data from Satellite/Instruments: GCOMW1-AMSR2 Radiometer

Additional Products	Year	Month	Day
Monitor	2015	8	20

Get Products

- TB (daily)
- Incidence Angle (daily)
- Model-Obs diff (daily)
- Buoy-Obs diff (daily)
- Model-Obs diff (monthly)
- Buoy-Obs diff (monthly)





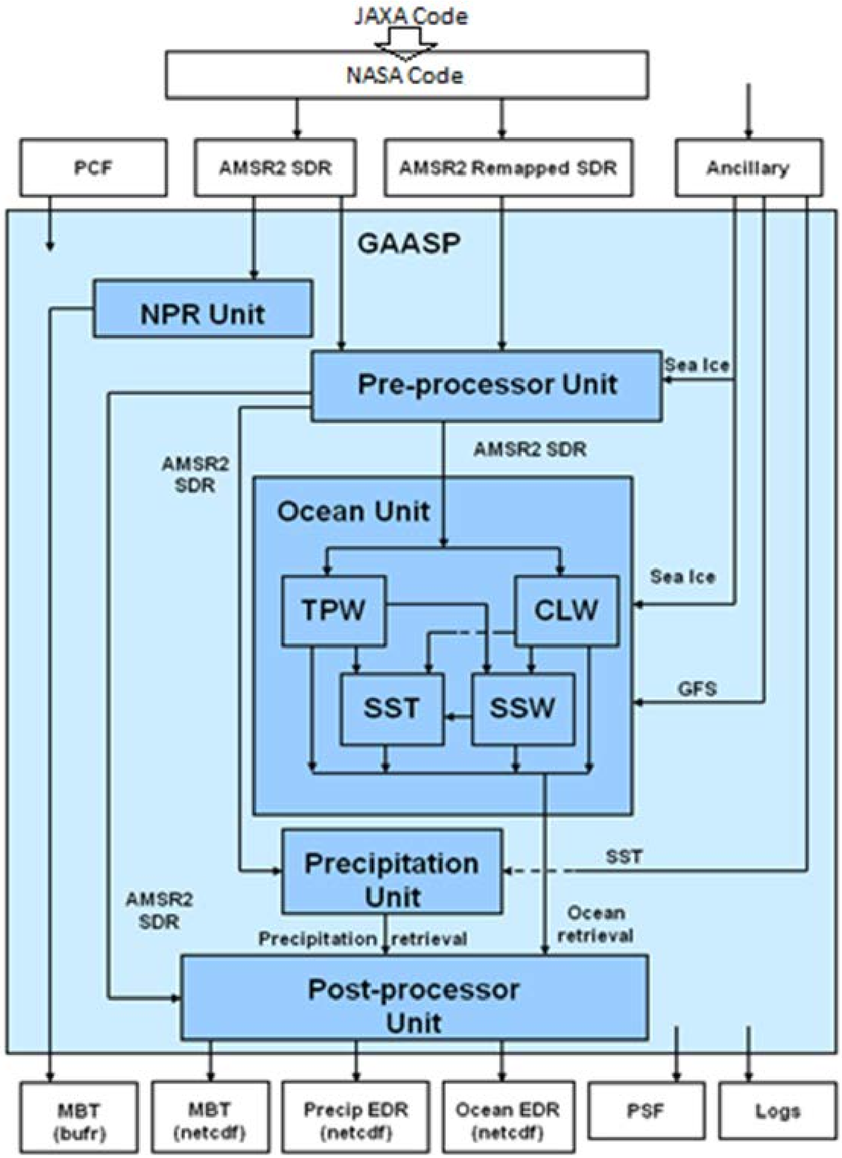
Summary & Path Forward

- Day 2 products and Day 1 product improvements being finalized in the next GAASP delivery for integration in NDE 2.0 (~October 2015)

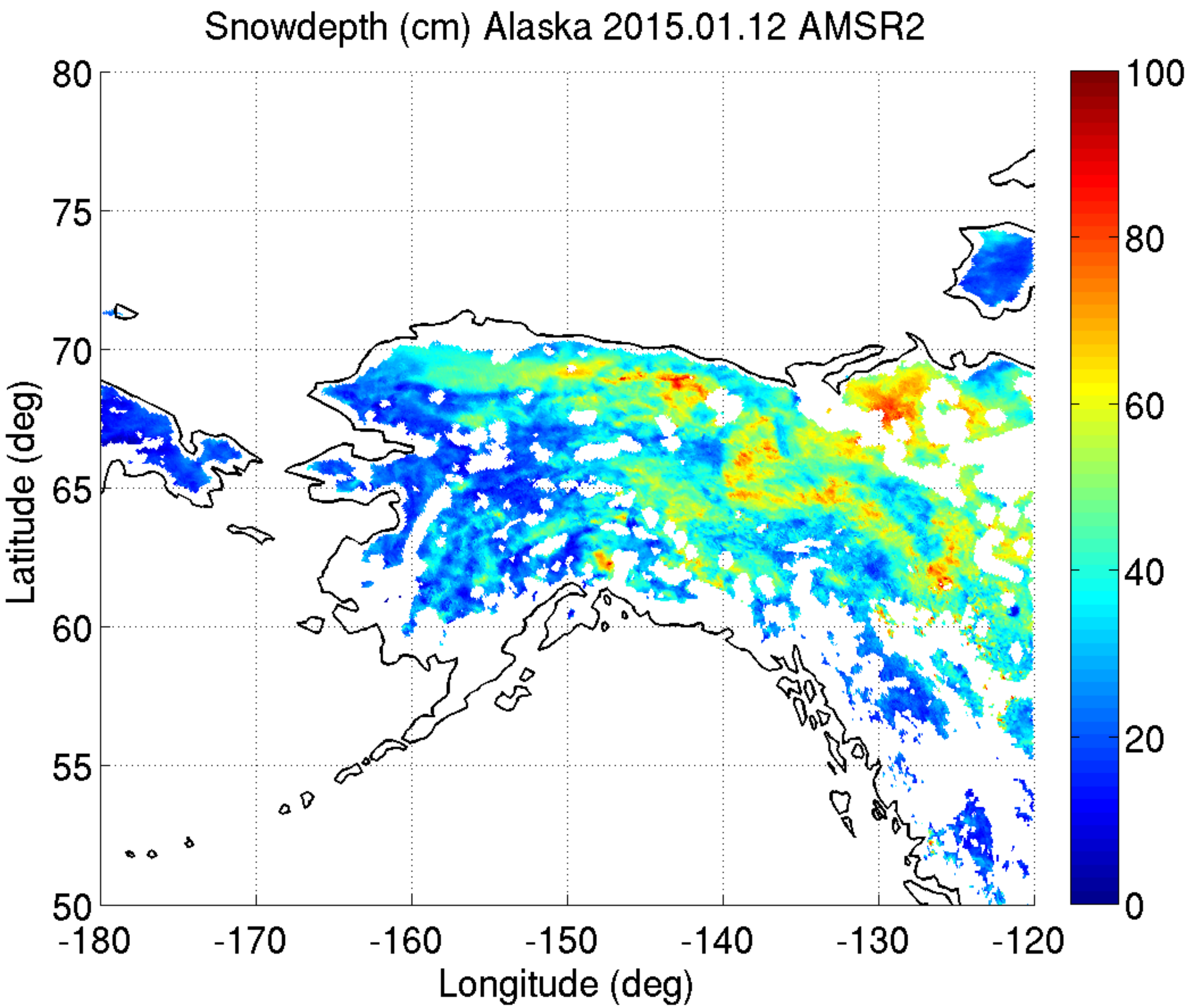
- Calibration updates, product updates and continued monitoring and quality control
  - Continue working with JAXA on Level 1 calibration improvements
  - Address JAXA updates to Level 1 processing software
  - Continue validation and product monitoring and implement product updates as needed
  - User product training and outreach

BACKUP SLIDES

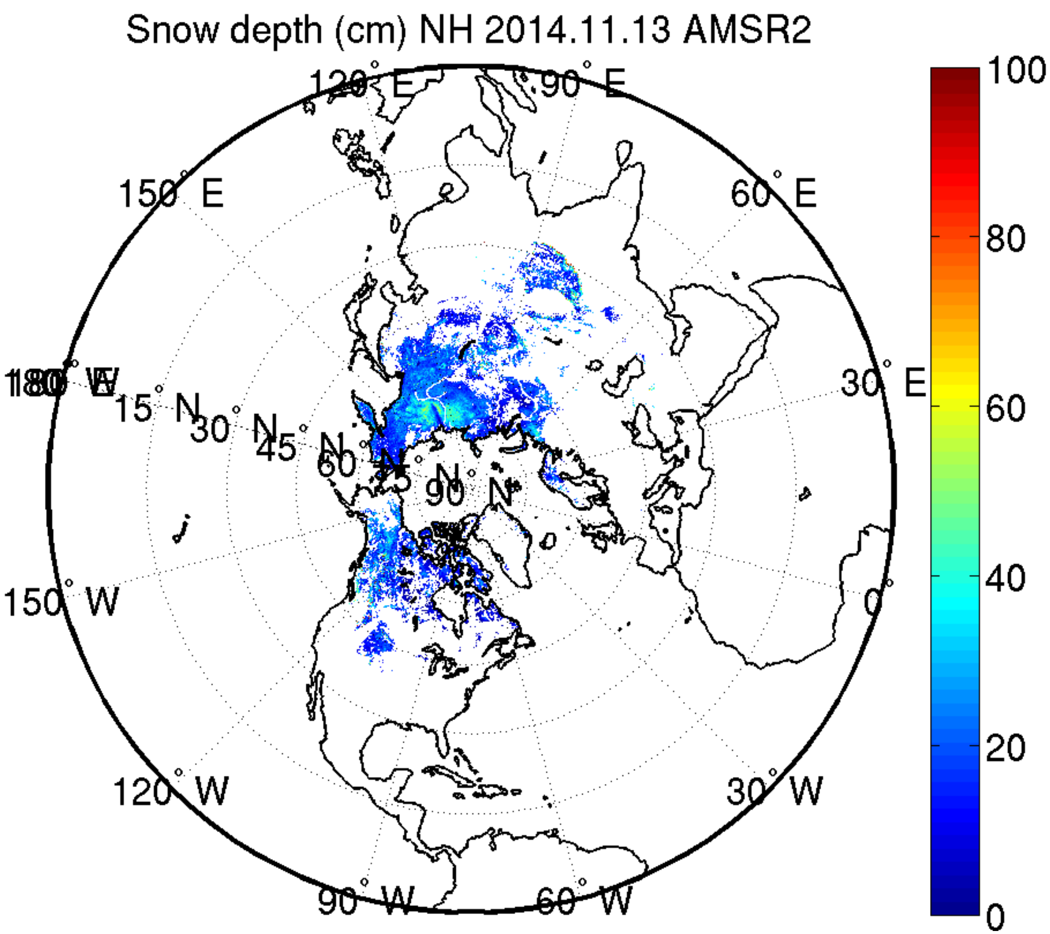
GAASP Software Day 1 Data Flow

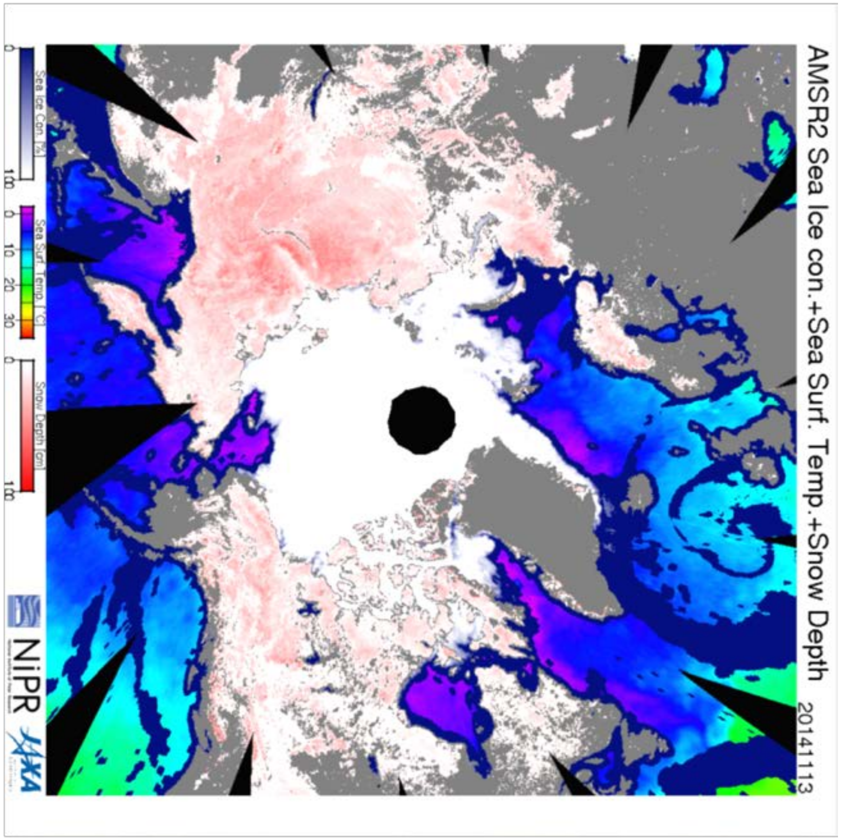


AMSR2 Snow Depth

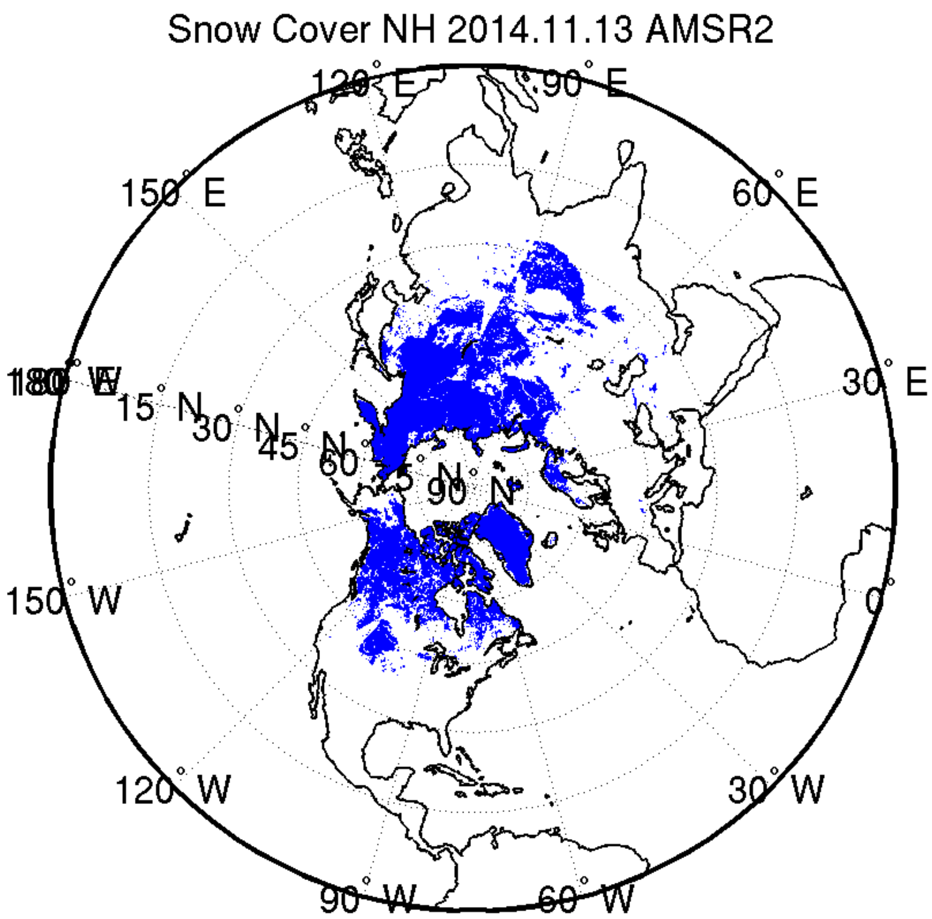


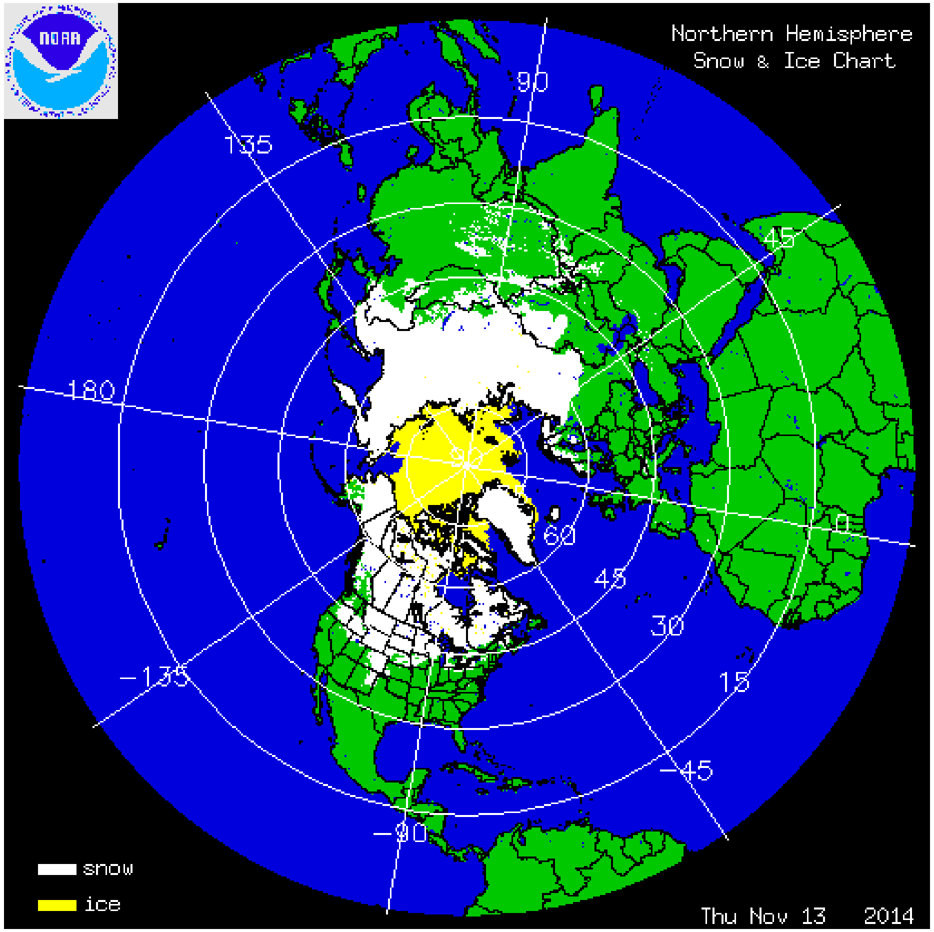
AMSR2 Snow Depth





Enhanced Grody Algorithm Validation with AMSR2





JPSS EDR

Long Term Monitoring & Product Repository

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

Presented at the 2015 STAR JPSS Science Meeting

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

JPSS EDR Product Repository Early Discussions

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

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

ICVS as an EDR Repository Platform

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

Prototype Now Online with 7 Product Groups

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

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

JPSS EDR Product Monitoring Demo

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

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

EDRs Are Not Quite the Same as Cal/Val Metrics

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

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

JPSS EDR Site vs. Team Sites

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

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

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

Steps to Produce & Publish EDR Products - 1

- Product Teams: figure out what you want to include on your page. Suitable content may include:
  - EDR deliverable products (at a minimum, we need these for the site);
  - Comparison products from other satellite instruments;
  - Quality measure charts, like NEΔN.
  - Usually images (.jpg, .gif, .png, but can also include .txt, .zip)
  - Please note: content for the page is ideally content that is refreshed daily.
    - Land Surface Temperature for Global Surface – 8/22/2015 – **YES**!
    - 10 day composite of anything – probably not.
- Meet with JPSS EDR to go over style guide, layout of maps, formatting preferences;
- Product Team develops a 'test set' of product images, JPSS EDR team reviews, revises, and approves.

Steps to Produce & Publish EDR Products - 2

- JPSS EDR team:
  - Establishes a directory structure on the webserver to house Team's products;
  - Develops the CSV file that lists product file descriptions and locations;
  - Add the new Product page;
  - To add or remove content, we edit the CSV file to reflect additions / changes / deletions from the product set.
- Product Teams
  - Run charts as far back as you can (we are aiming for EDRs back to Jan. 1, 2015), and write them to the specified location on STAR webserver;
  - Set the product generation script on a cron job;
  - No website to maintain, no HTML to write, just generate your products

Next Steps To Complete The EDR Repository

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