2014 STAR JPSS Science Team Annual Meeting

VIIRS Aerosol EDR

Shobha Kondragunta and Istvan Laszlo

VIIRS Aerosol co-Leads

May 13, 2014

Outline

- Aerosol Cal/Val Team
- VIIRS AOT, APSP and SM
  - IDPS algorithms
  - products
  - requirements
  - data quality
  - future plans
  - alternative algorithms

VIIRS Aerosol Cal/Val Team

Name	Organization	Major Task
Kurt F. Brueske	IIS/Raytheon	Code testing support within IDPS
Bigyani Das	IMSG/NOAA	Algorithm integration
Ashley N. Griffin	PRAXIS, INC/NASA	JAM
Brent Holben	NASA/GSFC	AERONET observations for validation work
Robert Holz	UW/CIMSS	Product validation and science team support
Ho-Chun Huang	UMD/CICS	SM algorithm development and validation
Jingfeng Huang	UMD/CICS	AOT Algorithm development and product validation
Edward J. Hyer	NRL	Product validation, assimilation activities
John M. Jackson	NGAS	VIIRS cal/val activities, liaison to SDR team
Shobha Kondragunta	NOAA/NESDIS	Co-lead
Istvan Laszlo	NOAA/NESDIS	Co-lead
Hongqing Liu	IMSG/NOAA	Visualization, algorithm development, validation
Min M. Oo	UW/CIMSS	Cal/Val with collocated MODIS data
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

AEROSOL OPTICAL THICKNESS (AOT) AND AEROSOL PARTICLE SIZE PARAMETER (APSP)

VIIRS AOT Algorithm

- AOT is from cloud-free, daytime VIIRS M-band SRDs over dark surface
- Separate algorithms over land and over ocean

Land	Ocean
• retrieves AOT and surface reflectances by matching M3/M5 ratio of retrieved surface reflectances with expected ratio • selects one of five aerosol models that best match retrieved and expected surface reflectances in bands M1, M2, M3, M5, M11	• retrieves AOT by matching observed M7 TOA reflectance with calculated reflectance • selects fine and coarse mode models and their weights out of 2020 combinations of candidate models that best match observed and calculated TOA M5, M6, M7, M8, M10, M11 reflectances

M1: 412, M2: 445, M3: 488, M5: 672, M6: 746, M7: 865, M8: 1,240, M10: 1,610, M11: 2,250 nm

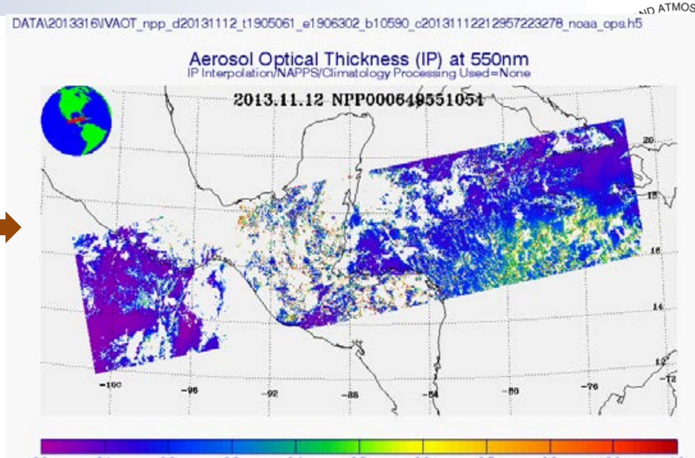
VIIRS Aerosol Products

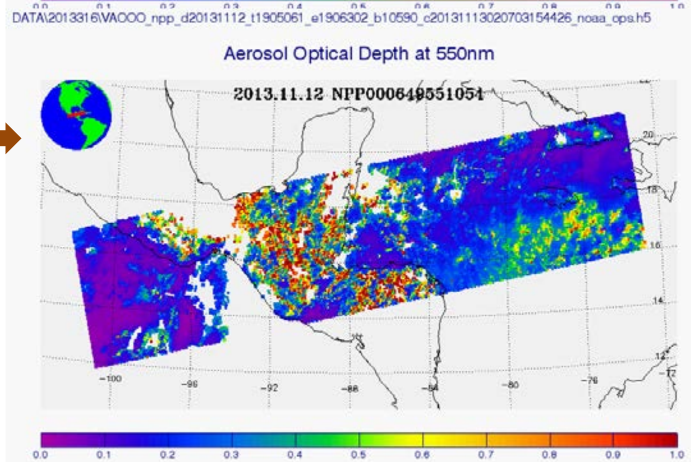
At NOAA Comprehensive Large Array-data Stewardship System (CLASS):

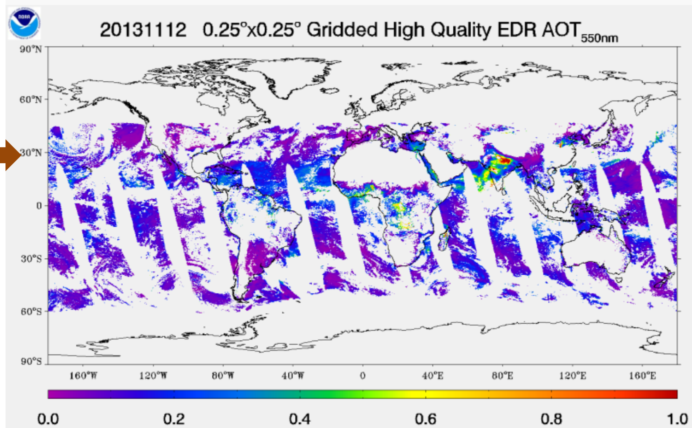
- **Intermediate Product (IP)**
  - 0.75-km pixel
    - AOT (550 nm); valid range: 0-2
    - APSP from AOTs at M2 (445 nm) and M5 (672 nm) over land, and M7 (865 nm) and M10 (1610 nm) over ocean
    - AMI (Aerosol Model Information)
    - quality flags
- **Environmental Data Record (EDR)**
  - 6-km cell aggregated from 8x8 IPs filtered by quality flags
    - **AOT** (10 M bands + 550 nm)
    - **APSP** (**over-land product is not recommended!)**
    - quality flags
  - 0.75 km
    - **SM**

At NOAA/NESDIS/STAR

- **Gridded 550-nm AOT EDR**
  - regular equal angle grid: 0.25°x0.25° (~28x28 km)
    - only high quality AOT EDR is used





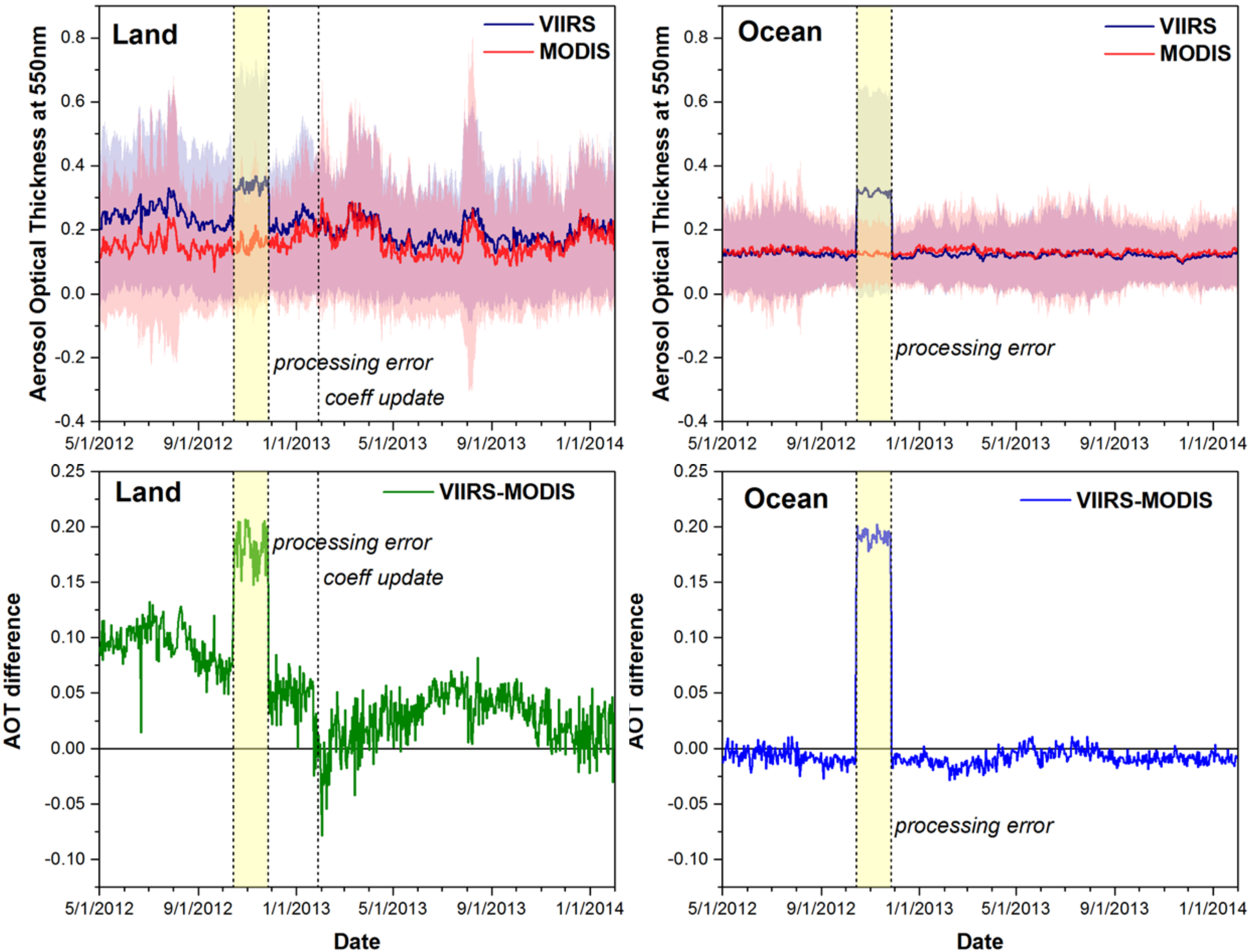


AOT Product Timeline

Red period:	Product is not available to public, or product should not be used.
Blue period: (Beta)	Product is available to public, but it should be used with caution, known problems, frequent changes.
Green period: (Provisional)	Product is available to public; users are encouraged to evaluate.

- **No changes to VIIRS aerosol algorithm between Jan 23, 2013 and Feb 20, 2014.**
- **Stable algorithm is needed for evaluation.**

Time Series of Daily Mean Aerosol Products (non-collocated) (05/02/2012 – 01/31/2014)



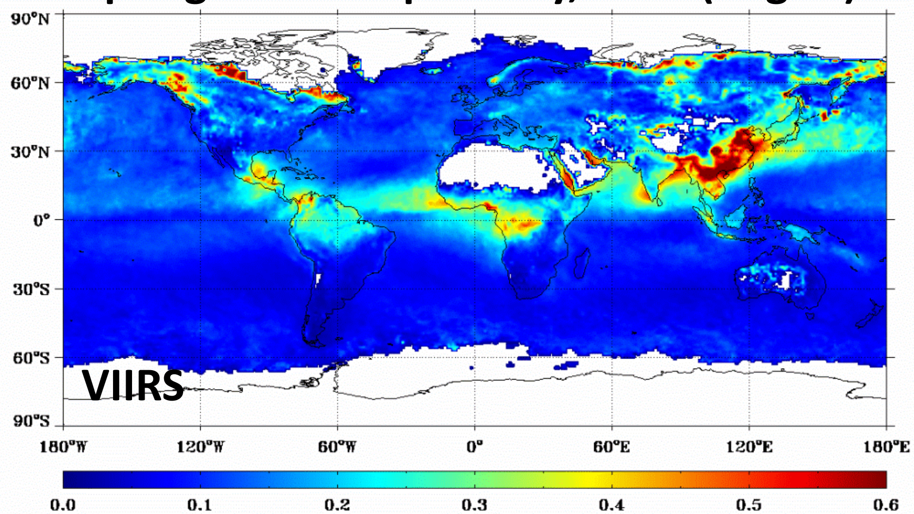
Comparisons with MODIS use MODIS Dark Target Collection 5.1 data

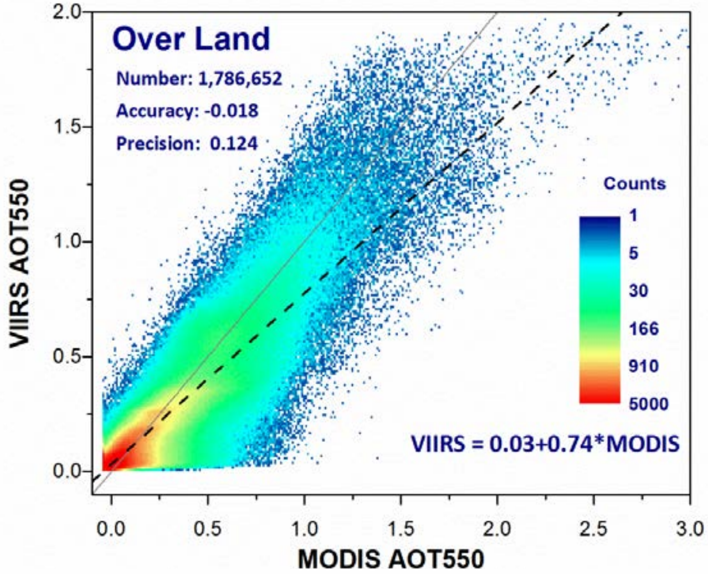
VIIRS vs. MODIS AOT

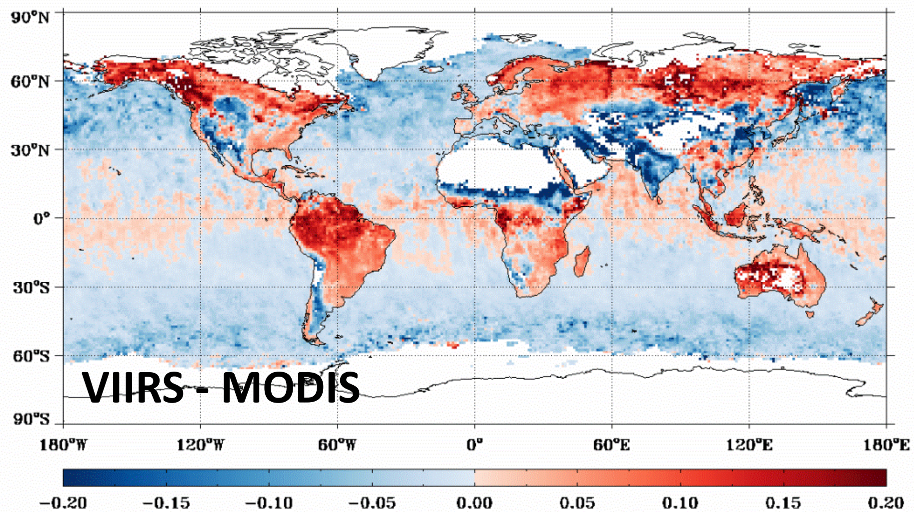
Comparisons use MODIS Dark Target Collection 5.1 data

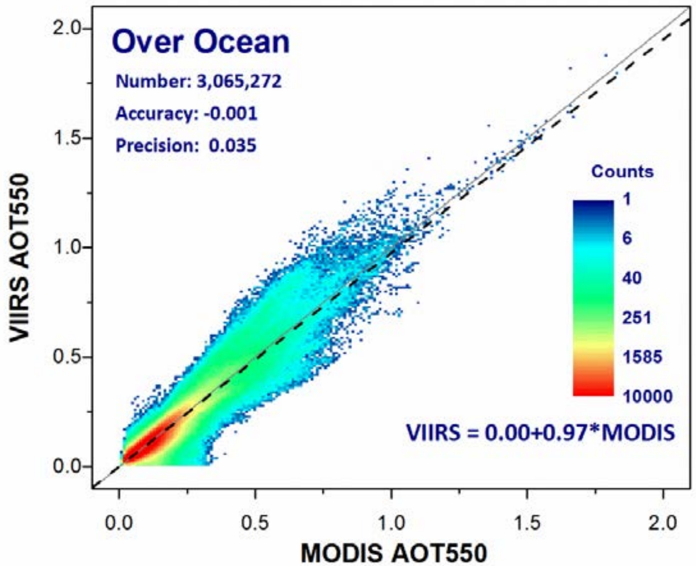
- **Collocated VIIRS and MODIS Retrievals**
  - Over land: 01/23/2013 – 01/31/2014
  - Over ocean: 05/02/2012 – 01/31/2014 excluding the processing error period (10/15/2012-11/27/2012

Spring: March-April-May, 2013 (1° grid)

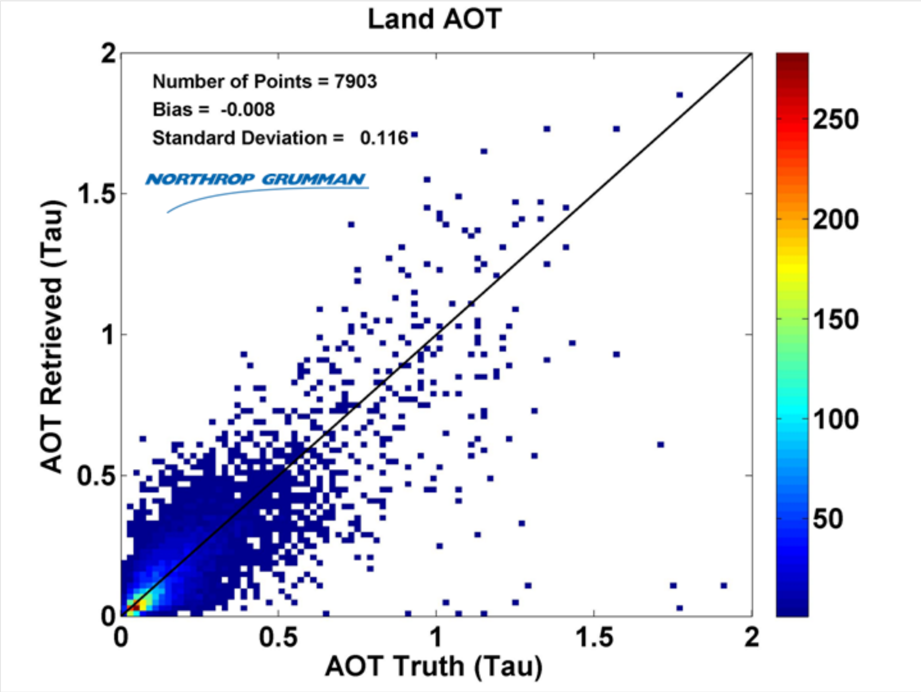


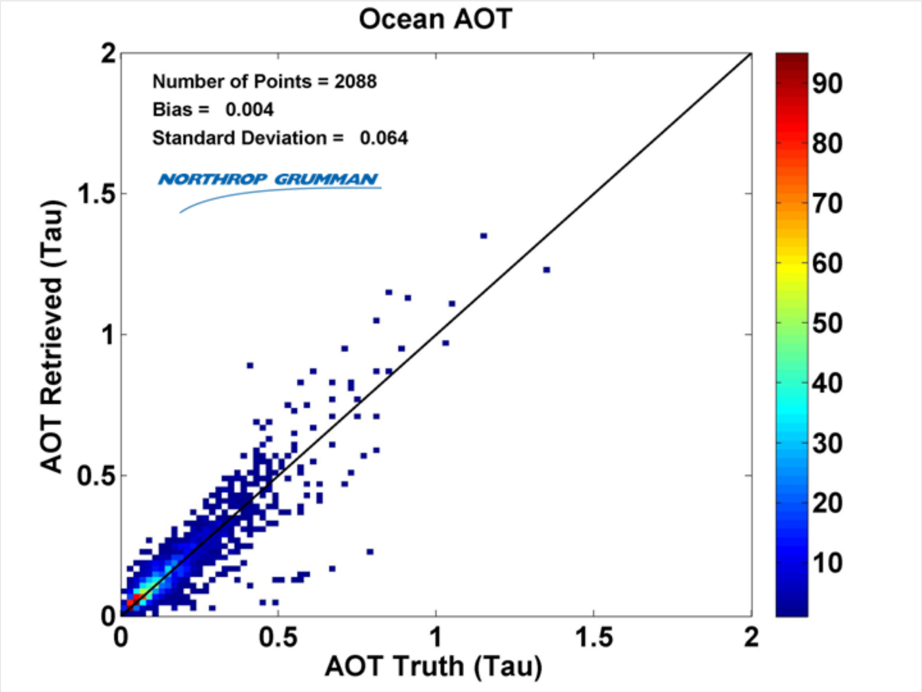






VIIRS AOT EDR vs. AERONET L1.5 AOT





- Data from the VIIRS Aerosol / AERONET Match-up PGE
- Period: May 2, 2012 – December 31, 2013
- VIIRS: **reprocessed using Mx8.2 aerosol code!** (TTO: 02/20/2014)
  - averaged min 25% of high quality AOT in 5x5 EDR cells
- Truth: AERONET L1.5 inversion (5/2012–2/2013) + direct sun (from 2/2013)
  - AOT averaged within +/- one hour

VIIRS EDR vs. AERONET L1.5

Time period: 05/02/2012 - 12/31/2013; VIIRS data: Mx8.2

LAND	N	ACCURACY		PRECISION	
AOT		Requirement	SNPP/VIIRS	Requirement	SNPP/VIIRS
<0.1	3244	0.060	0.012 √	0.150	0.058 √
[0.1, 0.8]	4498	0.050	0.016 √	0.250	0.117 √
>0.8	161	0.200	0.186 √	0.450	0.414 √
all	7903		-0.008		0.116

OCEAN	N	ACCURACY		PRECISION	
AOT		Requirement	SNPP/VIIRS	Requirement	SNPP/VIIRS
<0.3	1824	0.080	0.007 √	0.150	0.041 √
≥0.3	264	0.150	0.020 √	0.350	0.144 √
all	2088		0.004		0.064

OCEAN	N	ACCURACY		PRECISION	
APSP		Requirement	SNPP/VIIRS	Requirement	SNPP/VIIRS
865nm/1610nm	803	0.30	0.02 √	0.60	0.37 √

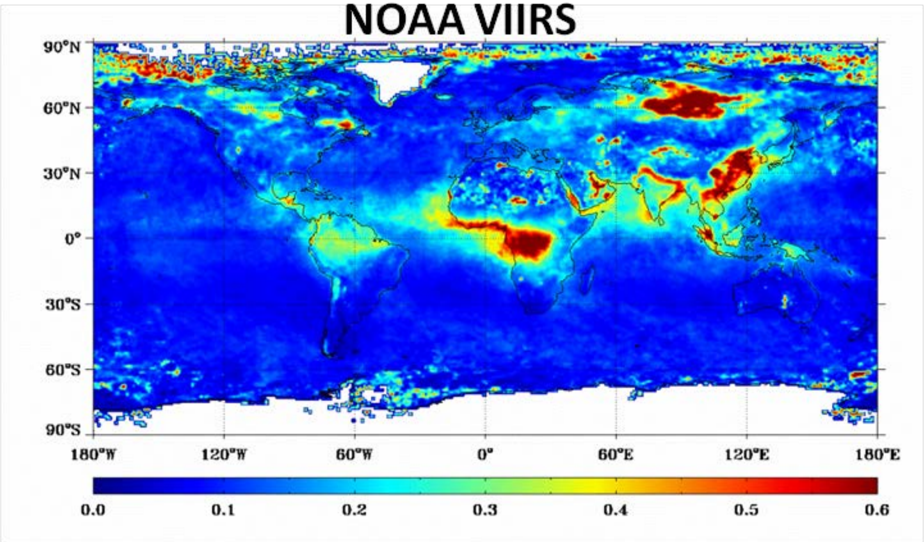
More in posters by Jingfeng Huang et al. and Ho-Chun Huang et al.

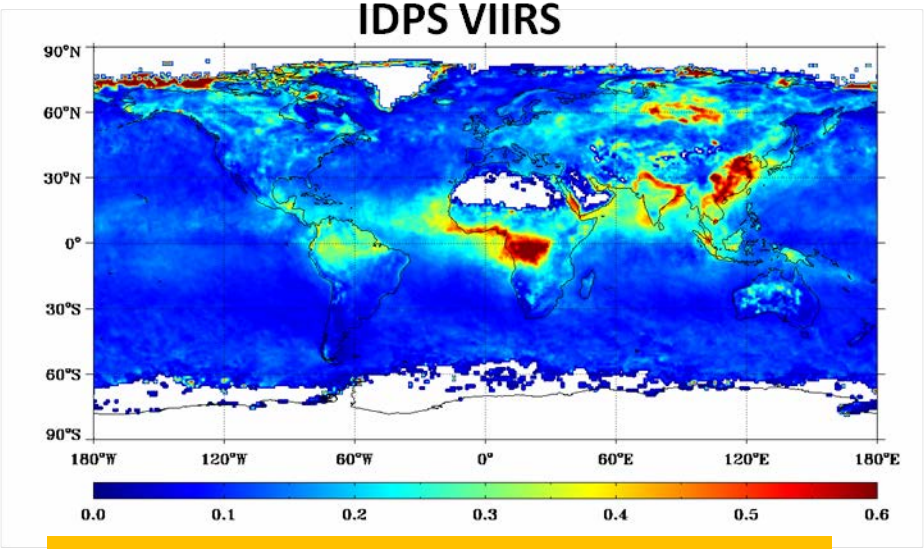
Plans for AOT

- Replace over ocean aerosol models with those more closely matching MODIS models
- Extend AOT range to [-0.05 to 5.00]
- Implement new internal tests to reduce snow/ice and possible residual cloud contamination:
  - Spatial homogeneity filter
  - Spectral filter (e.g., NDSI)
- Continue evaluation of other internal tests (fire, bright pixel, ephemeral water) and update thresholds.
- Develop and test regional, seasonal land surface reflectance ratios (*see poster by Hai Zhang et al*.)
- Extend (in time and scope) evaluation of AOT EDR
- Test/modify NGAS implementation of “deep-blue” retrieval and if needed develop new algorithm, and implement it

The JPSS RR Aerosol Algorithm

- **The JPSS Risk Reduction (RR) ("NOAA VIIRS") algorithm**
  - *over land*
    - VIIRS-like algorithm; switches to MODIS-like algorithm when VIIRS-like retrieval fails
    - surface reflectance ratios are linear functions of $NDVI_{SWIR}$ and surface redness
    - retrieves over areas where current IDPS algorithm does not retrieve AOT
  - *over ocean*
    - algorithm and aerosol model as in MODIS
  - AOT range [-0.05 to +5.0]
  - AE is from AOTs from independent-channel retrievals
  - **pixel level (750 m) product**

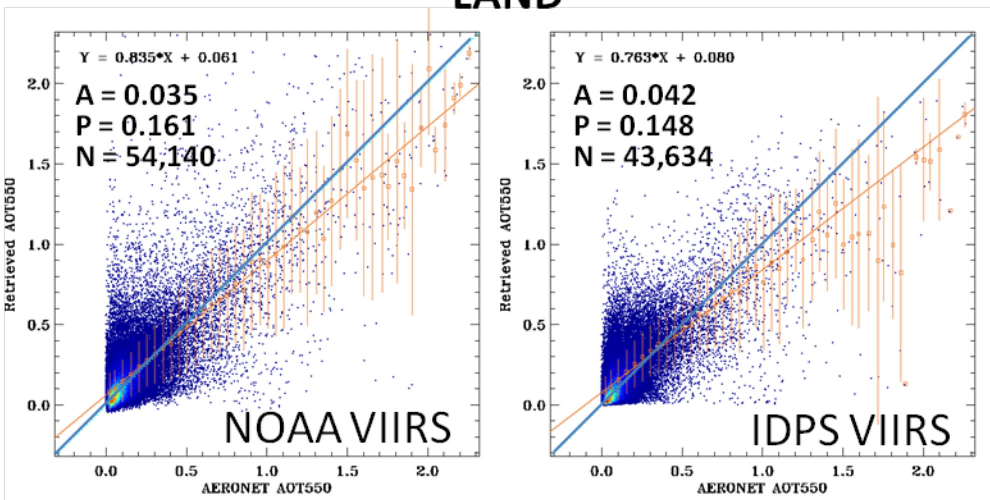




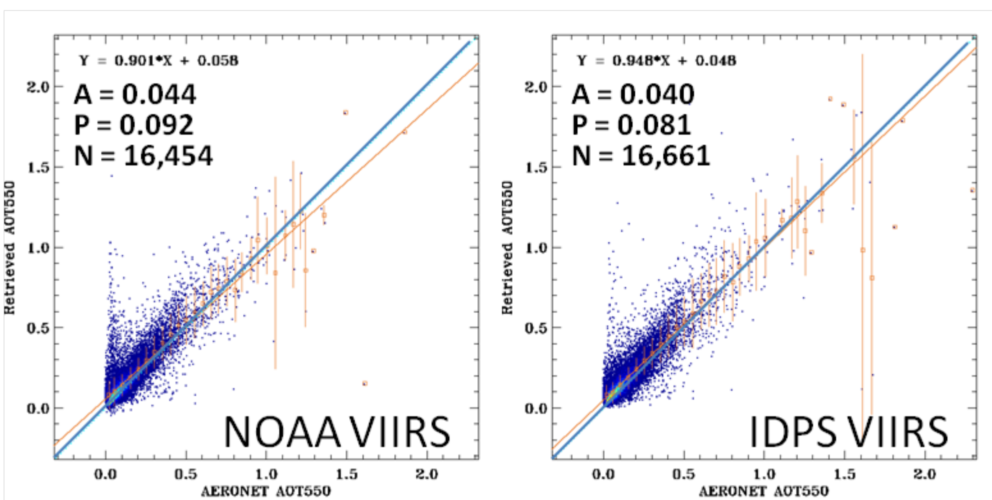
Data: average of every five days between 2013.03.01-2014.03.01; 750-m data

JPSS RR Aerosol Results

LAND



OCEAN



Daily 750-m VIIRS and AERONET matchup data for 2012.05.02 – 2014.03.31

"First look" results:

- Over land, more retrievals, better overall accuracy, but slightly worse precision.
- Over ocean, comparable accuracy, but slightly worse precision.
- Meets requirements.

Details and more results in talk by Hongqing Liu in Atmosphere Breakout on Wednesday at 14:50

Recommendation

- **JPSS RR aerosol algorithm can be an alternative for J1**
- The JPSS RR algorithm already has many updates planned for IDPS aerosol algorithm
  - over land
    - slightly better agreement with AERONET for high AOT values
    - retrievals over areas where current IDPS algorithm does not retrieve AOT
  - over ocean
    - same algorithm and aerosol model as in MODIS
  - meets J1 requirements
  - same algorithm works on VIIRS and ABI
  - **likely needs more adjustments, data filtering; would benefit from more evaluation, and needs consensus from Aerosol Cal/Val Team and users!**

AOT & APSP Summary

- Characterized long term (over a year) record of VIIRS AOT globally and regionally by comparing it similar records from MODIS and AERONET
- VIIRS AOT and APSP (Ångström Exponent) products meet the requirements specified in the Joint Polar Satellite System (JPSS) Program Level 1 Requirements document
- Developed and evaluated new internal tests (for residual cloud, snow/ice) – will be implemented in next version
- **More results and details in Atmosphere Breakout on Wednesday, 14:30-16:10 and in posters!**

SUSPENDED MATTER (SM)

Overview: Requirements in L1RD Supplement

Product	Threshold	Objective	Notes
SM	Dust, smoke, volcanic ash	Dust, smoke, volcanic ash, sea salt	
Smoke plume	0 to 150 µg/m^3	0 to 200 µg/m^3	
Accuracy			
SM	80%		
Smoke	70%		
Dust	80%		
Ash	60%		Dust can be mis-identified as ash
Mixed Aerosol		80%	Report not only dominant aerosol but other aerosol components as well

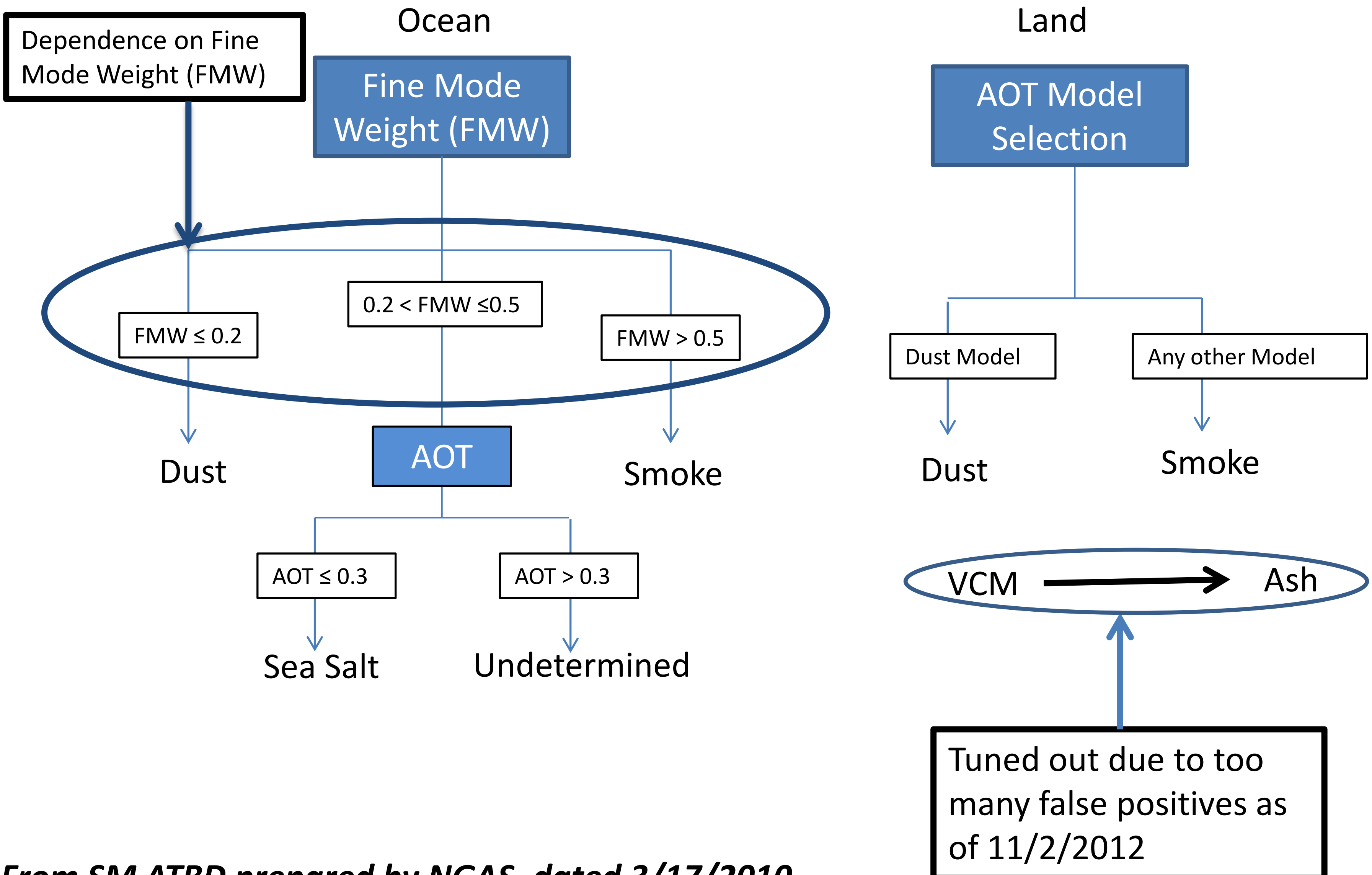
Applications

- Exceptional Events (EEs) monitoring (volcanic eruptions, fires, dust storms)
- Assimilation in regional and global aerosol models for daily weather and/or climate predictions
- Operational air quality forecasting

Users

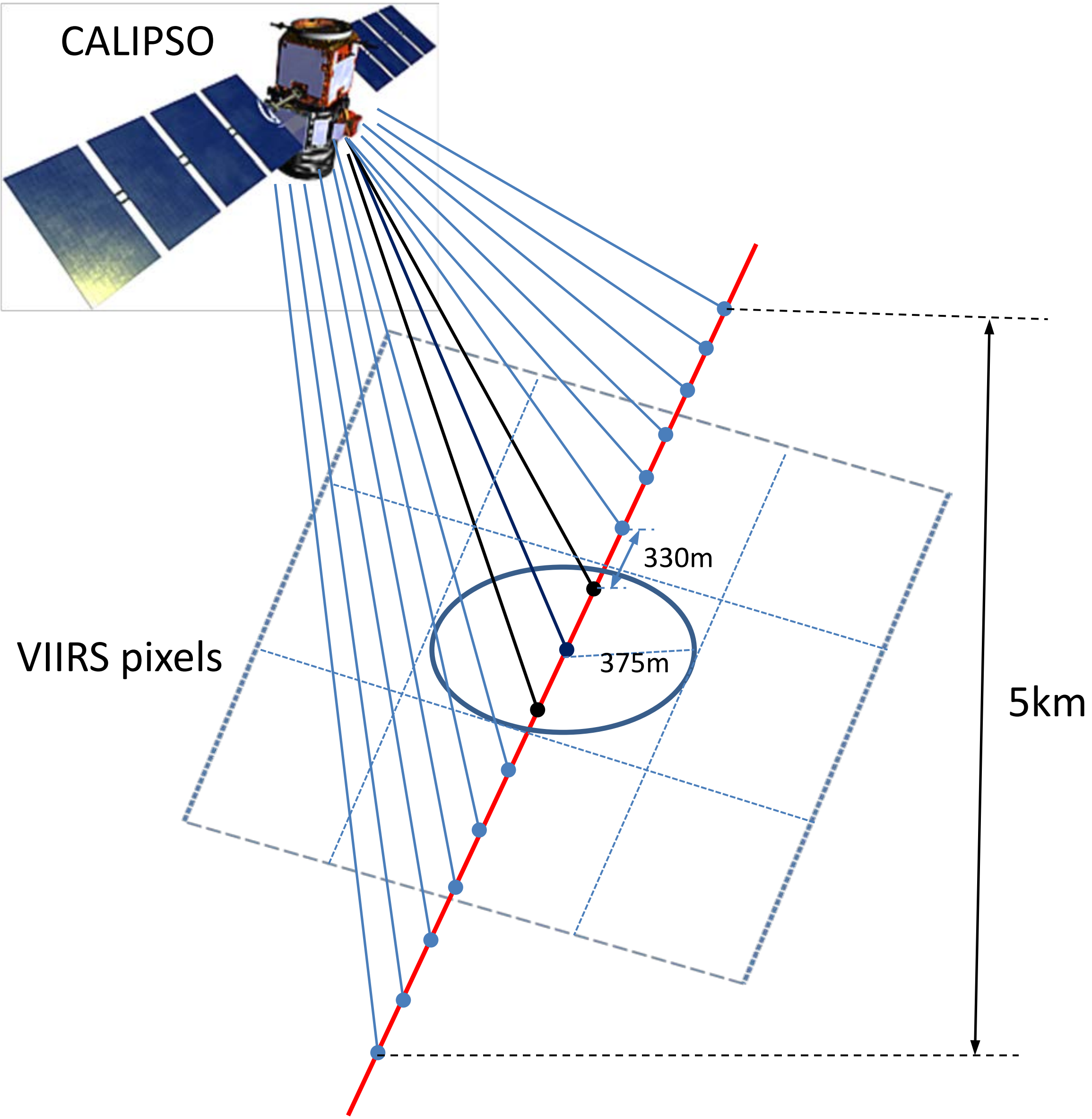
- National Weather Service, Environmental Protection Agency, State and local environmental agencies

Overview:
IDPS Suspended Matter Algorithm



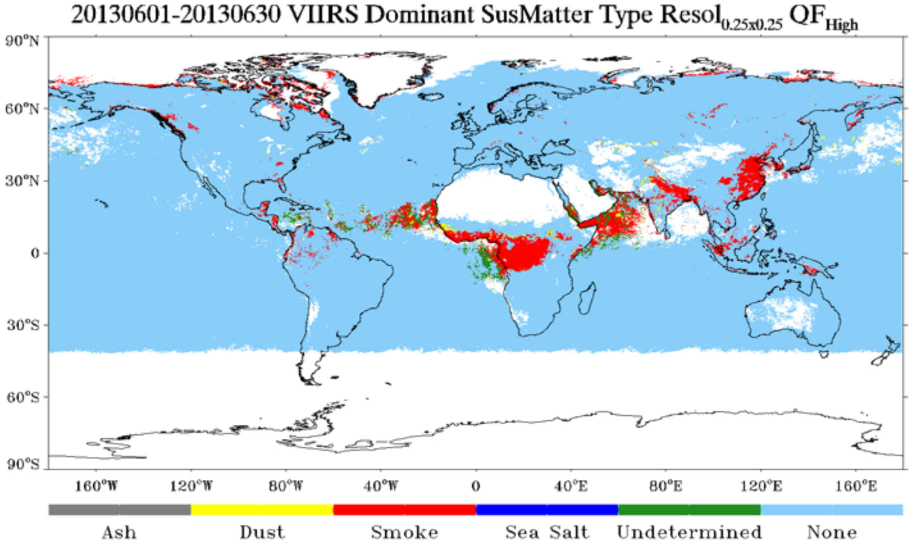
From SM ATBD prepared by NGAS, dated 3/17/2010

SNPP SM Algorithm Evaluation: Validation Approach



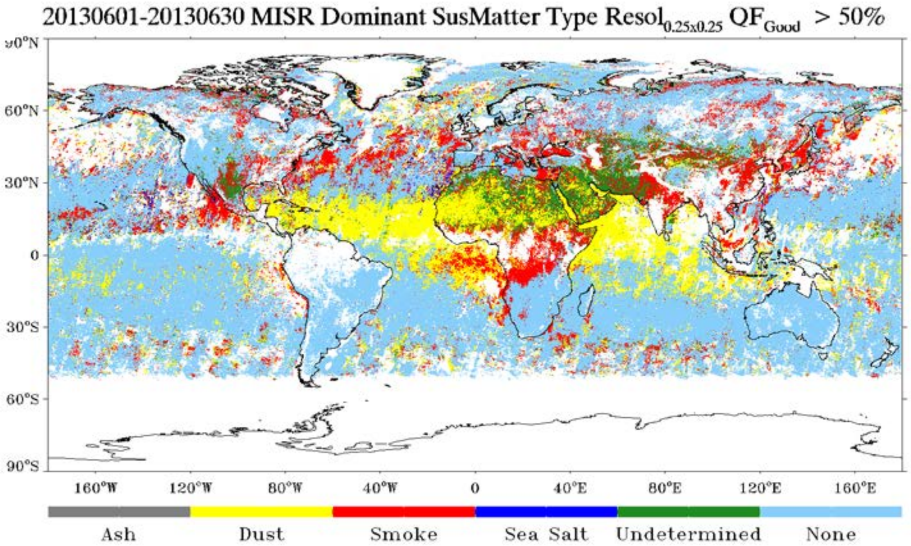
- Qualitative comparison of monthly global maps of VIIRS SM (dominant aerosol type), dust fraction, and smoke fraction to other correlative measurements (CALIPSO, MISR)
- Direct matchups of CALIPSO and VIIRS SM to compute accuracy, probability of detection, and false alarm ratio

SNPP SM Algorithm Evaluation: VIIRS vs. MISR



- SM is not a legacy NASA MODIS product
- VIIRS SM algorithm relies on AOT and other internal parameters (not validated) to identify and type SM.
- SM product very difficult to evaluate and validate due to non-availability of "truth" dataset. Comparisons with MISR show that VIIRS SM doesn't identify dust near the source and dust outflow regions (Sahara and Atlantic Ocean)..
- The VIIRS SM product is not recommended for use in any applications. An alternate algorithm has been developed and is being tested.

VIIRS SM accuracy is < 20% (requirement is 80%)



JPSS Risk Reduction Algorithm Development

Algorithm details to be presented in tomorrow's "atmosphere" breakout session by Pubu Ciren

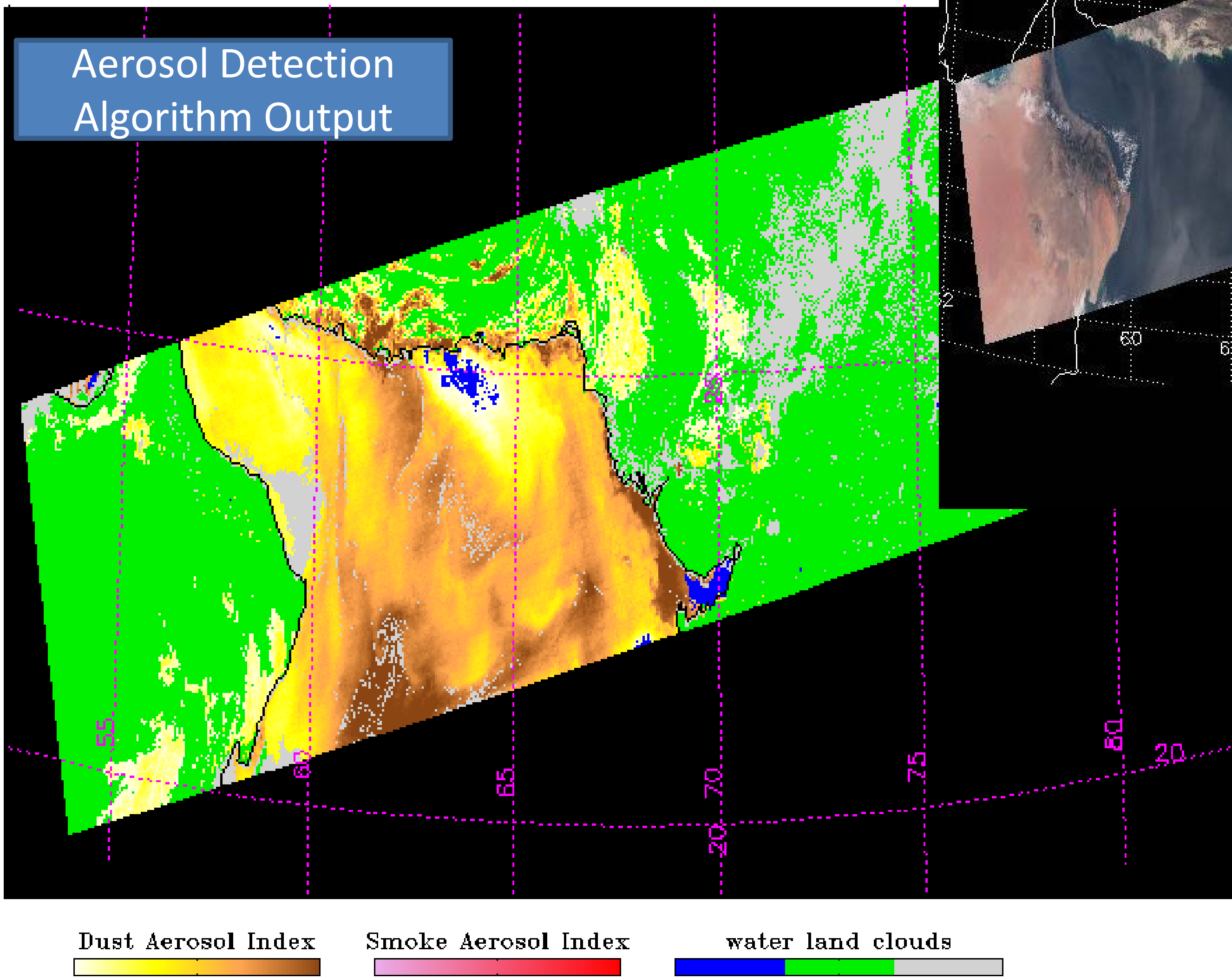
- **Adapt GOES-R ABI aerosol detection (dust and smoke) algorithm to VIIRS**
  - For dust, a slightly different algorithm than the one developed for GOES-R was used to take the advantage of deep blue (412 nm) channel present on VIIRS but will not be present on ABI.

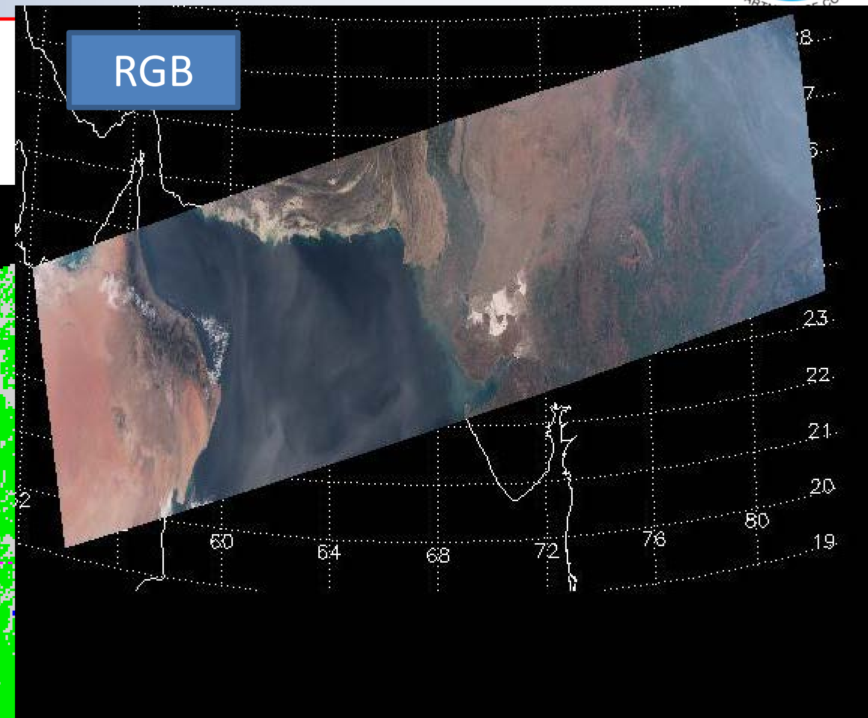
- **Advantages:**
  - Algorithm uses spectral threshold methods and some texture tests for uniformity to separate dust, smoke, and clouds.
  - Algorithm is fast and designed to run in near real-time.
  - Algorithm uses VIIRS blue channels (412 nm and 445nm) that GOES-R ABI will not have.

- **Disadvantages:**
  - Like any algorithm based on thresholds, tuning of thresholds will be needed for changes associated with calibration etc.

JPSS RR Algorithm:

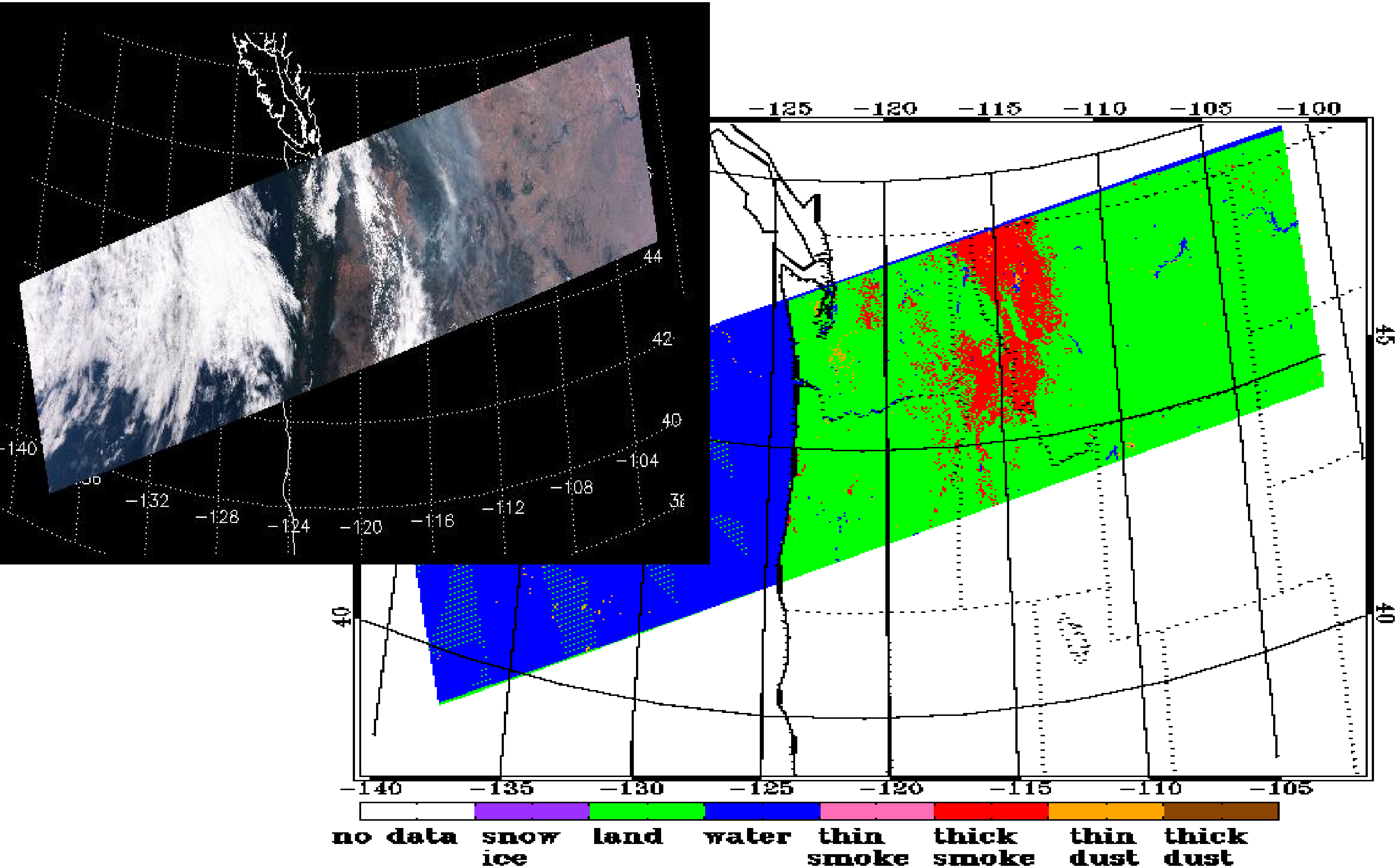
Dust Storm in the Arabian Sea on January 13, 2013





JPSS RR Algorithm:

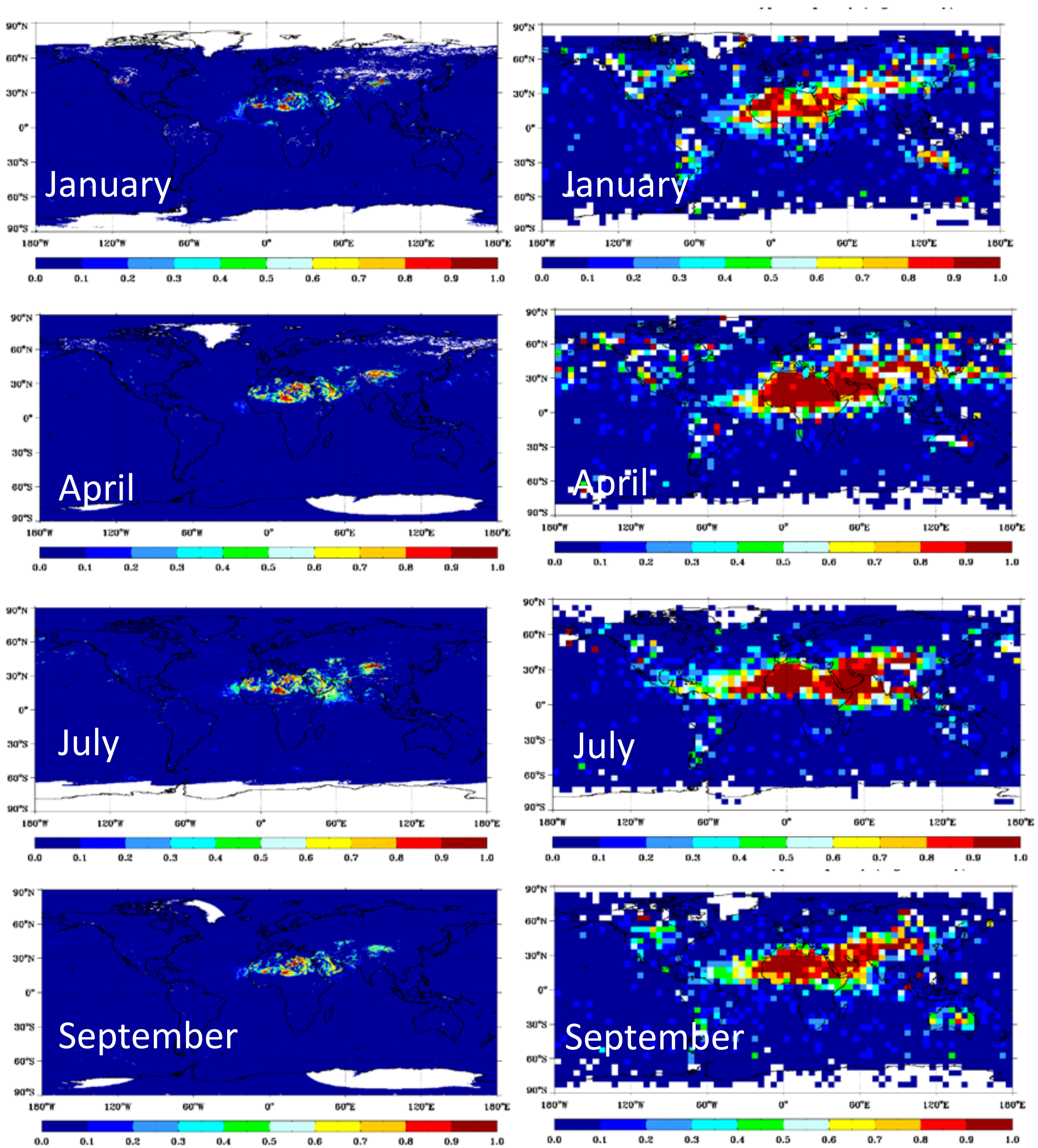
Smoke from Fires in the Western US on September 22, 2013



JPSS RR Algorithm:
VIIRS vs. CALIPSO Global Maps

VIIRS Dust Fraction

CALIPSO Dust Fraction



- CALIPSO data at a coarser grid resolution (5° x 5°). Due to narrow swath of CALIPSO, coarser resolution is need to get a good sample size;
- VIIRS data at a finer grid resolution (0.25° x 0.25°);
- CALIPSO dust detection is also based on a classification/typing algorithm and not a physical retrieval. Dust accuracy is 91%.

VIIRS is detecting dust only near the dust source and outflow regions whereas CALIPSO dust is detecting it more widely (e.g., Australia). Some but *not very distinct* seasonal pattern in VIIRS.

JPSS RR SM Algorithm Evaluation: VIIRS vs. CALIPSO Matchups for Dust

Month	Land											
	1	2	3	4	5	6	7	8	9	10	11*	12
Accuracy	100.0	99.4	99.9	99.9	98.4	99.4	99.6	98.7	100.0	100.0	-	100.0
POCD	N/A	71.4	77.8	80.0	75.3	73.4	97.9	76.5	N/A	N/A	-	N/A
POFD	N/A	50.0	8.7	42.8	13.5	53.4	39.4	35.3	N/A	N/A	-	N/A

Month	Water											
	1	2	3	4	5	6	7	8	9	10	11	12
Accuracy	99.8	99.8	99.9	99.9	99.8	99.6	99.7	99.8	100.0	100.0	-	100.0
POCD	54.2	N/A	N/A	N/A	N/A	80.0	94.8	91.8	N/A	N/A	-	N/A
POFD	56.6	N/A	N/A	N/A	N/A	46.1	49.5	47.6	N/A	N/A	-	N/A

* CALIPSO data not available

JPSS RR SM Algorithm Evaluation: VIIRS vs. AERONET Dust Matchups

Stations	True positive	False positive	True negative	False negative	Accuracy	POCD	POFD
Banizoumbou	10	1	65	12	85.2	45.4	9.0
Darkar	1	0	25	1	96.3	50.0	0.0
IER_Cinzana	2	0	23	1	96.2	66.6	0.0
Solar_Village	6	5	29	4	79.5	60.0	45.4
Capo_Verde	2	1	9	0	91.6	100.0	33.3
Cape_San_Juan	1	2	18	0	90.4	100.0	66.6

401 AERONET stations	Accuracy	POCD	POFD
Year of 2013	99.8	86.9	39.3

Conclusions

- The JPSS RR SM algorithm for dust and smoke is performing better than operational (IDPS) SM algorithm
  - Meets requirements for dust and smoke.
    - Dust detection evaluated using results from algorithm run on one year (2013) of data
    - Smoke detection evaluated on limited set of granules (22). Full one year run is forthcoming
  - Volcanic ash product will be passed on from VCM (when JPSS RR volcanic ash product is ready)
  - No sea salt will be detected
  - No smoke concentration will be reported. There is a user need for this and this information will come from a different algorithm (Automated Smoke Detection and Tracking Algorithm) that was developed using VIIRS fire hot spot and AOT products.
- Future work
  - Extensive evaluation of smoke product will be conducted
  - ATBD and other user documentation will be prepared
  - The dust algorithm is running in near real time on DB data and case studies will be selected and presented to NWS for discussion on transitioning from MODIS to VIIRS. Already had a conversation with NWS air quality program manager
    - Similar approach will be taken with other users.

BACKUP SLIDES

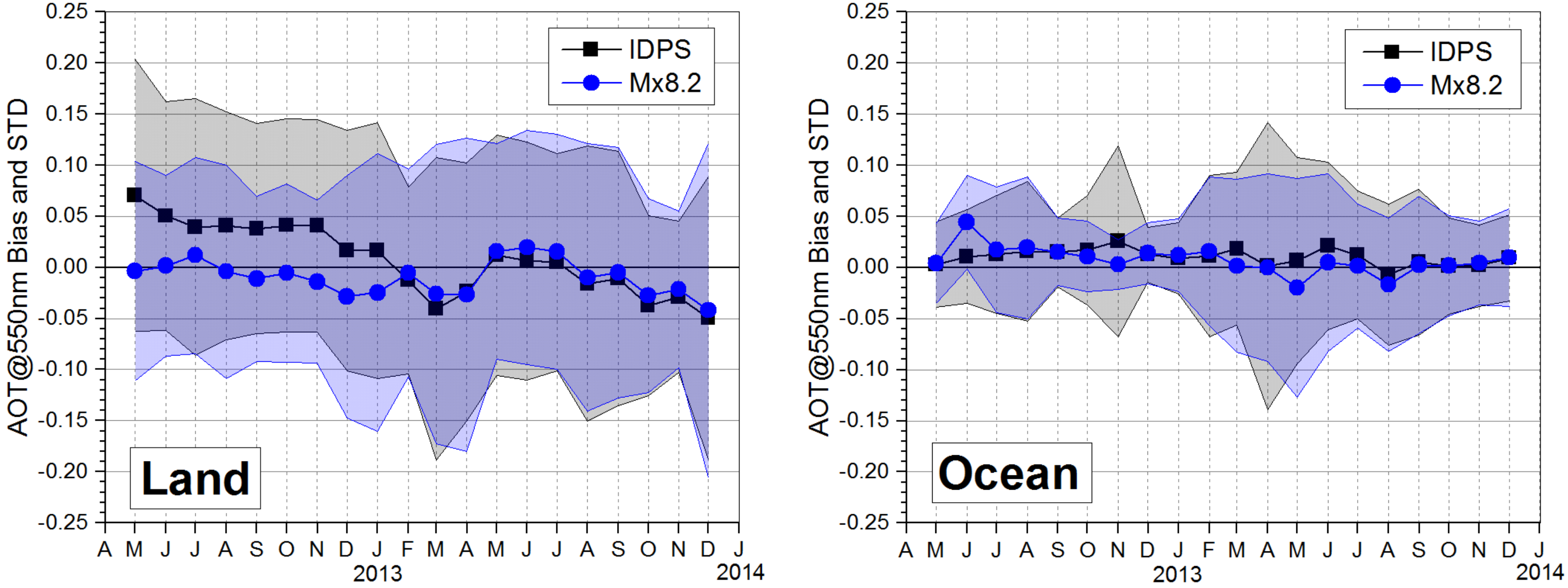
Over Land AOT Retrieval

- Atmospheric correction of reflectances [*Vermote and Kotchenova*, 2008]
  - Basis: aerosols change the ratios of spectral reflectances (spectral contrast) from those of the surface values
  - Dark target algorithm, conceptually similar to MODIS over-land alg.
- Lambertian surface reflection is assumed
- 5 aerosol models [*Dubovik et al*. 2002]:
  - dust, smoke (*high and low absorption*), urban (*clean & polluted*)
  - bimodal lognormal size distribution, function of AOT, spherical particles
- Surface reflectances in selected M bands are retrieved for varying AOT and their ratios are compared to expected values
- AOT and aerosol model that provide the best match between ratios of surface reflectances retrieved in multiple channels and their expected values are reported as solution

Over Ocean AOT Retrieval

- Close adaptation of the MODIS approach [*Tanré et al.*, 1997]
  - wind-dependent (speed and direction) ocean surface reflectance is calculated analytically
  - combines 4 fine mode and 5 coarse mode models with 0.01 increments in fine mode fraction (2020 models)
  - TOA reflectances in selected M bands are calculated and compared to observed ones to retrieve AOT aerosol models and their weights simultaneously
  - AOT and aerosol model that most closely reproduces the VIIRS-measured TOA reflectance in multiple bands are reported as solution

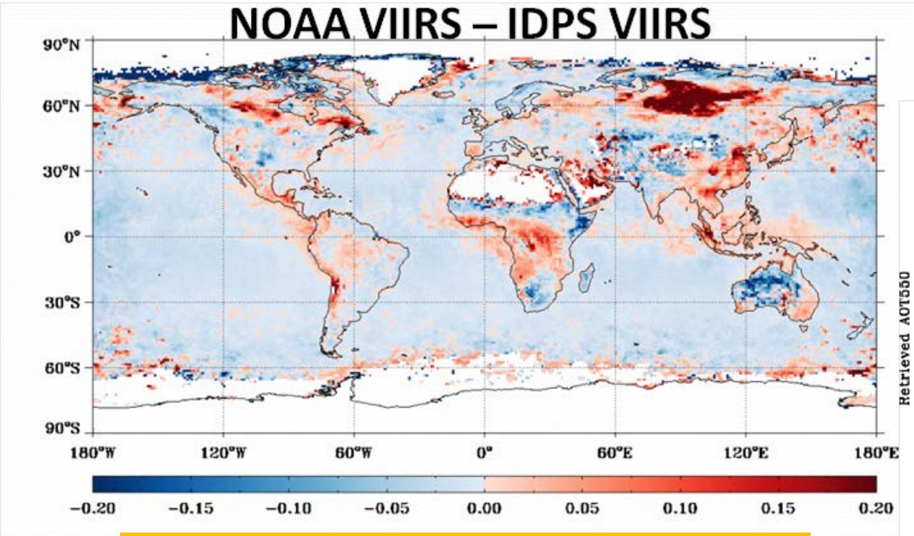
VIIRS AOT EDR vs. AERONET L1.5 AOT



- Time series of monthly average VIIRS-AERONET AOT difference and standard deviation of differences
- Mx8.2 bias < 0.04 over land and < 0.025 over ocean for almost all months examined.
- Mx8.2 std < 0.20 over land and < 0.10 over ocean.

More in posters by Jingfeng Huang et al. and Ho-Chun Huang et al.

JPSS RR Aerosol Results



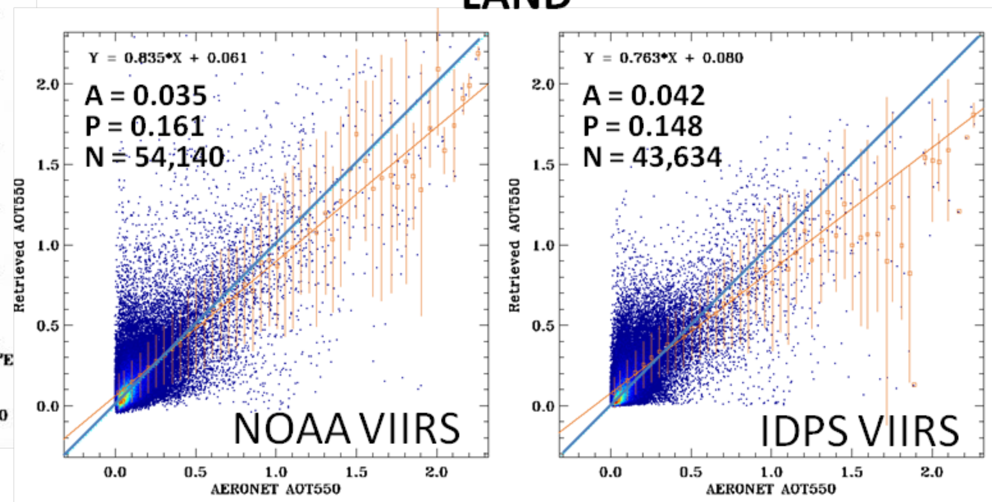
Data: average of every five days between 2013.03.01-2014.03.01, 750-m data

- Over land, better overall accuracy, but slightly worse precision.
- Over ocean, comparable accuracy, but slightly worse precision.
- Meets requirements.

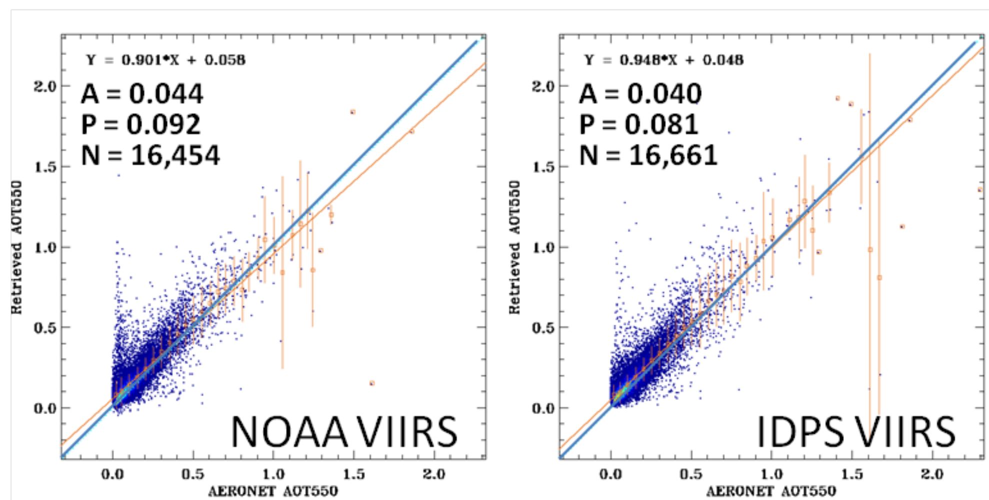
Details and more results in talk by H. Liu in Atmosphere Breakout on Wednesday at 14:50

daily 750-m data for 2012.05.02 – 2014.03.31

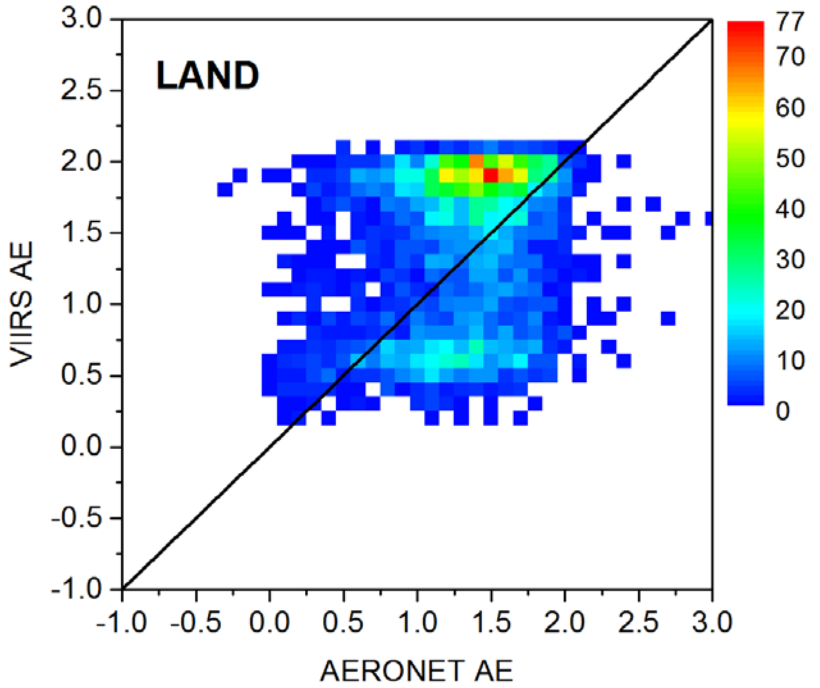
LAND



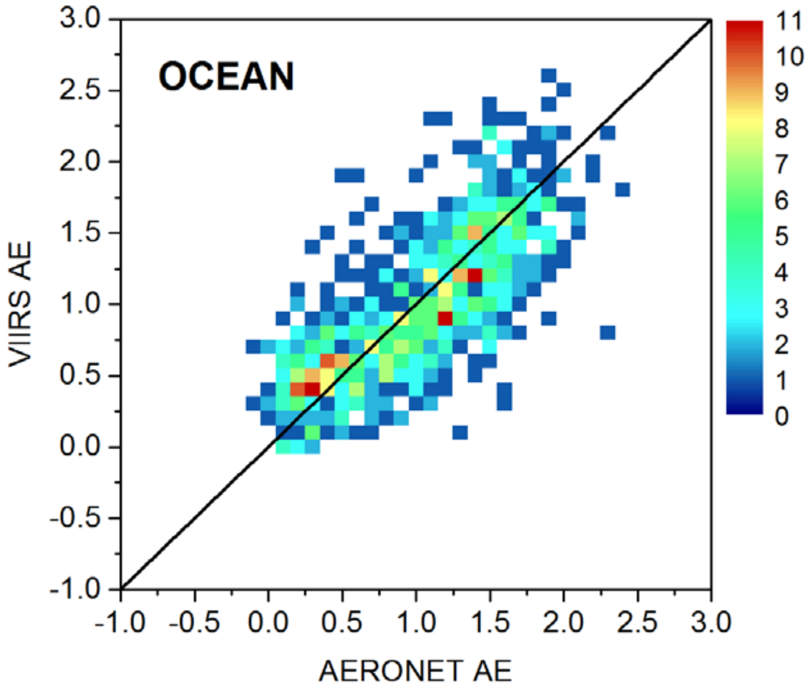
OCEAN



VIIRS AE EDR vs. AERONET L1.5 AE



No skill over land

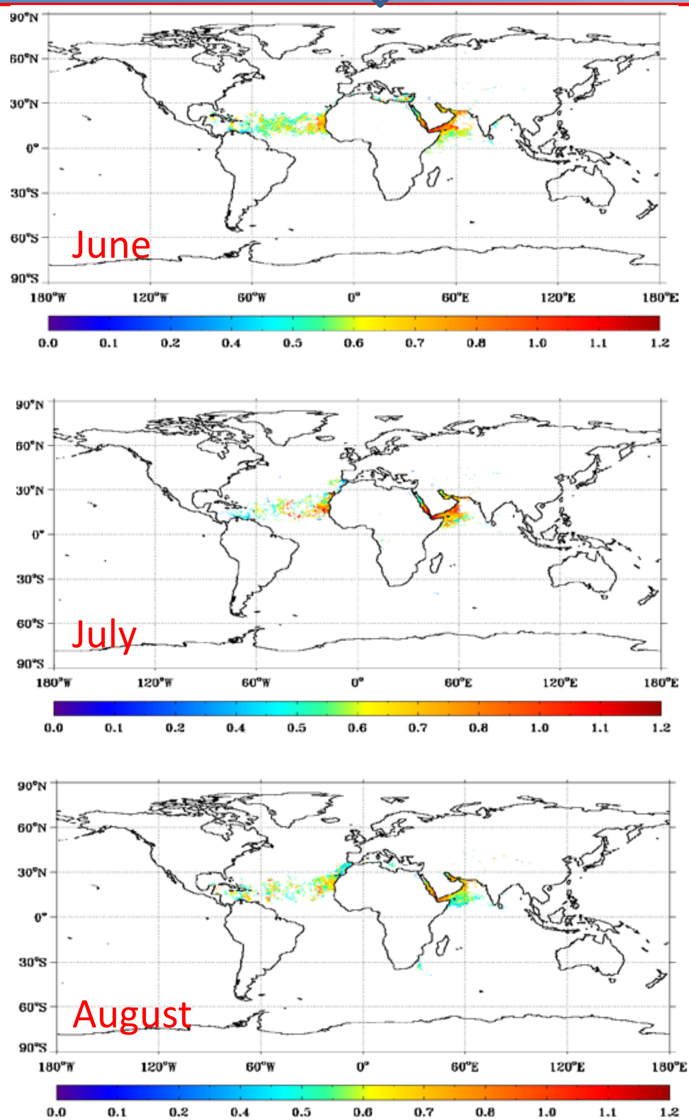


Some skill over ocean

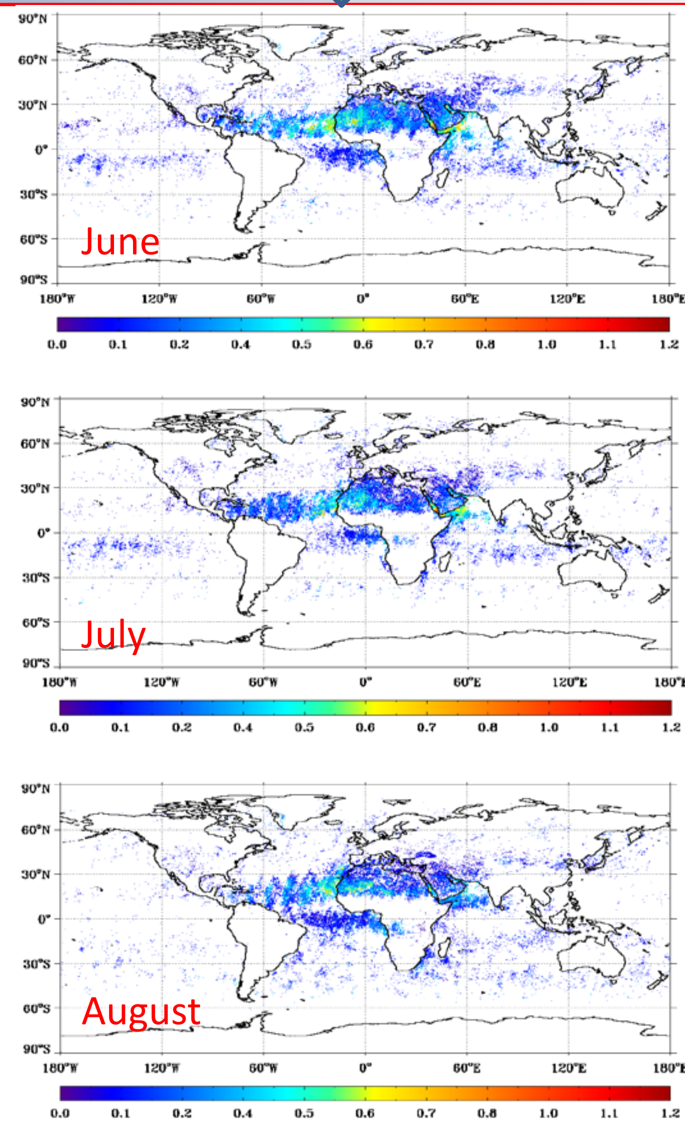
Time period: 05/02/2012 - 12/31/2013; Data: Mx8.2

OCEAN	N	ACCURACY		PRECISION	
		Requirement	SNPP/VIIRS	Requirement	SNPP/VIIRS
865nm/1610nm	803	0.30	0.02 √	0.60	0.37 √

VIIRS “Dust AOT”

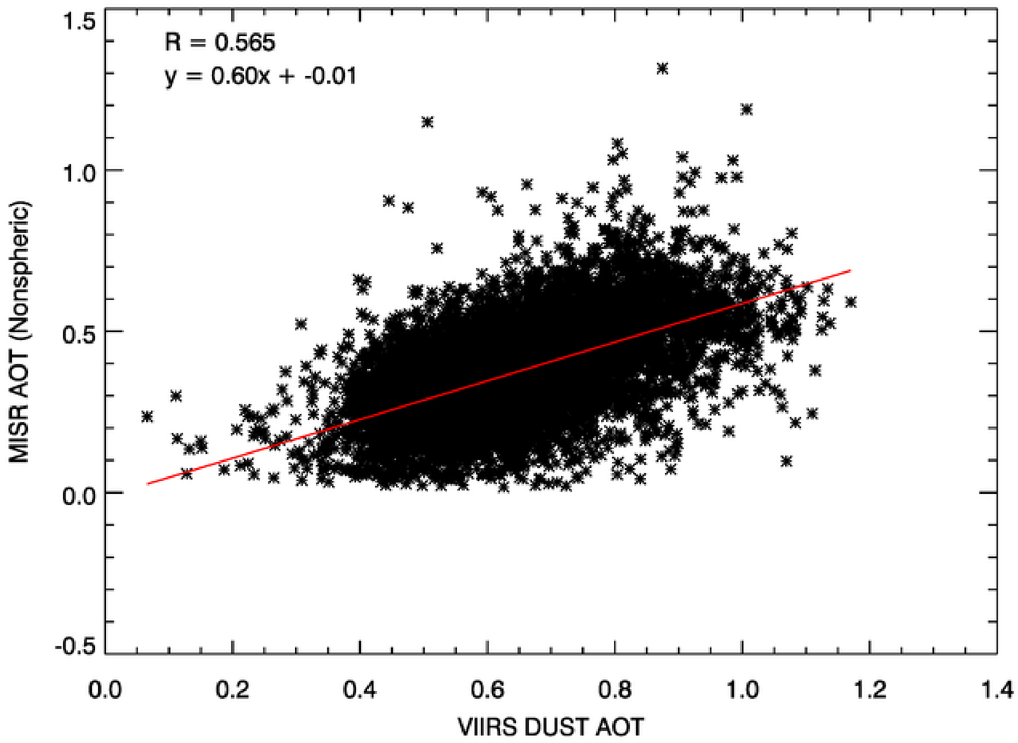


MISR “Dust AOT”

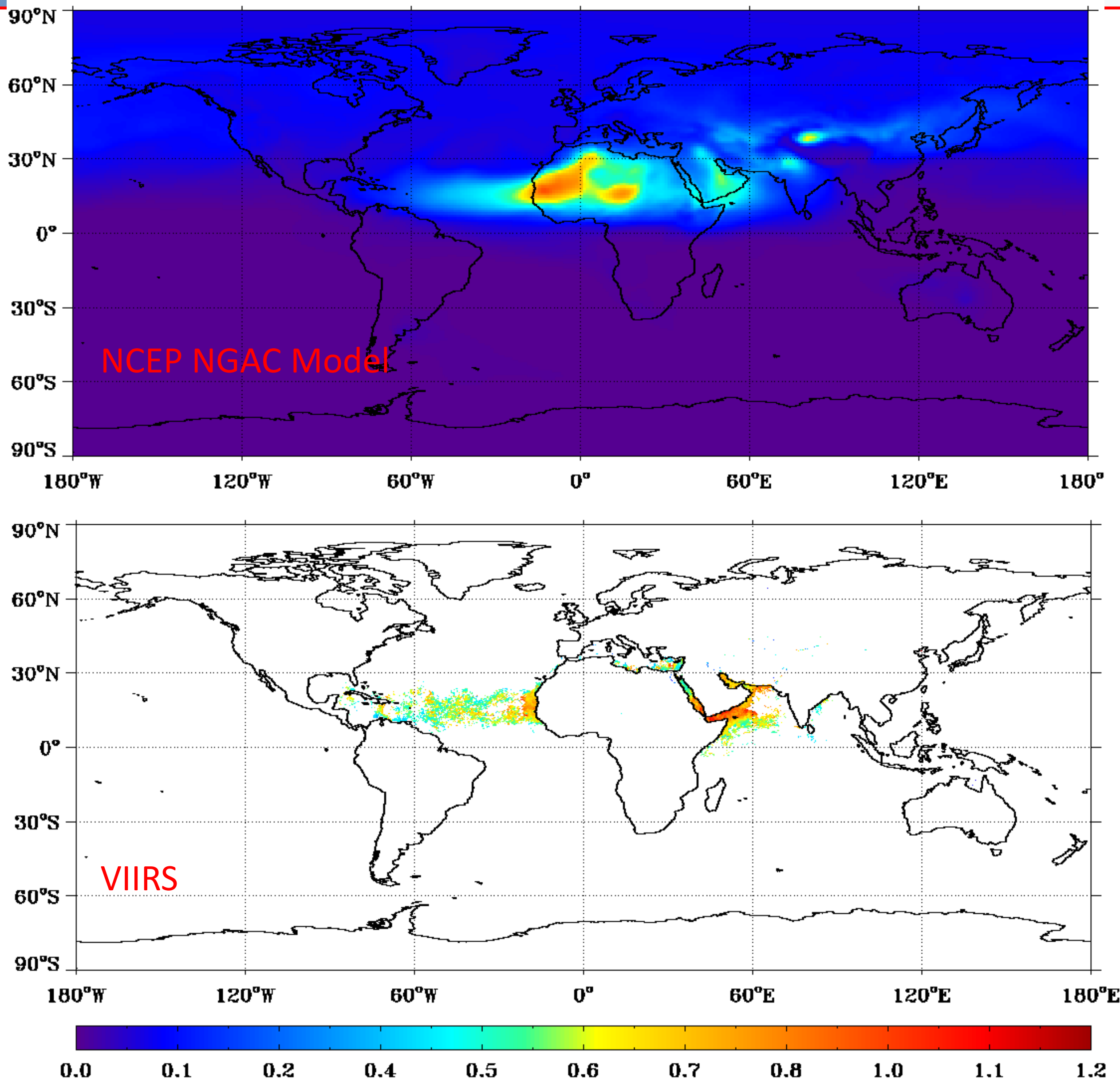


- VIIRS dust flag and best quality AOT are combined to generate “dust AOT”. MISR non-spherical AOT is assumed to be “dust AOT”.
- MISR dust AOT observed over the biomass burning region is likely coarse mode smoke aerosol?
- VIIRS dust AOT biased high compared to MISR.
- VIIRS high AOT observed year round in the Red Sea, Persian Gulf, and Arabian Sea.

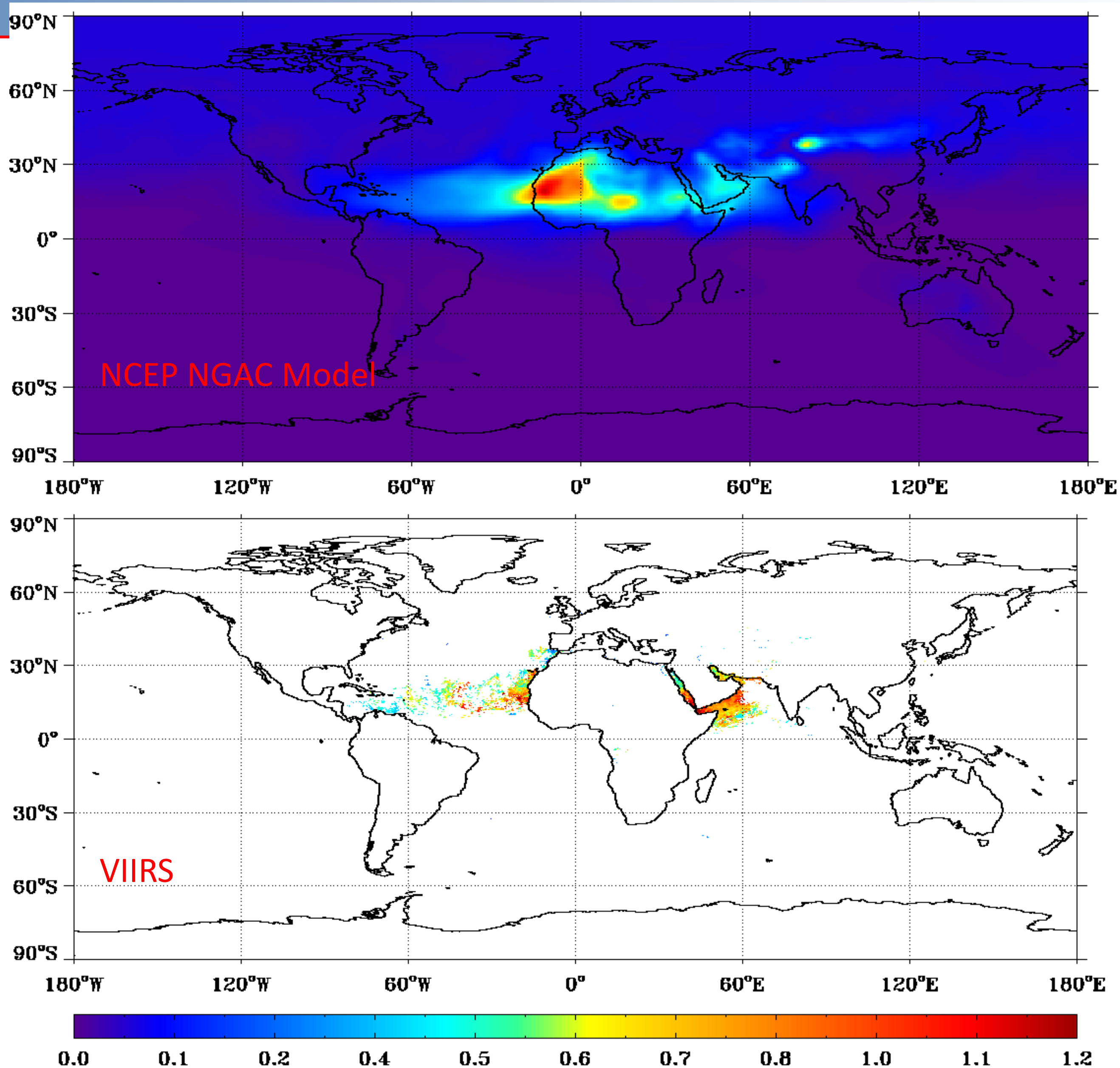
VIIRS vs. MISR Dust AOT Correlation
June 2013



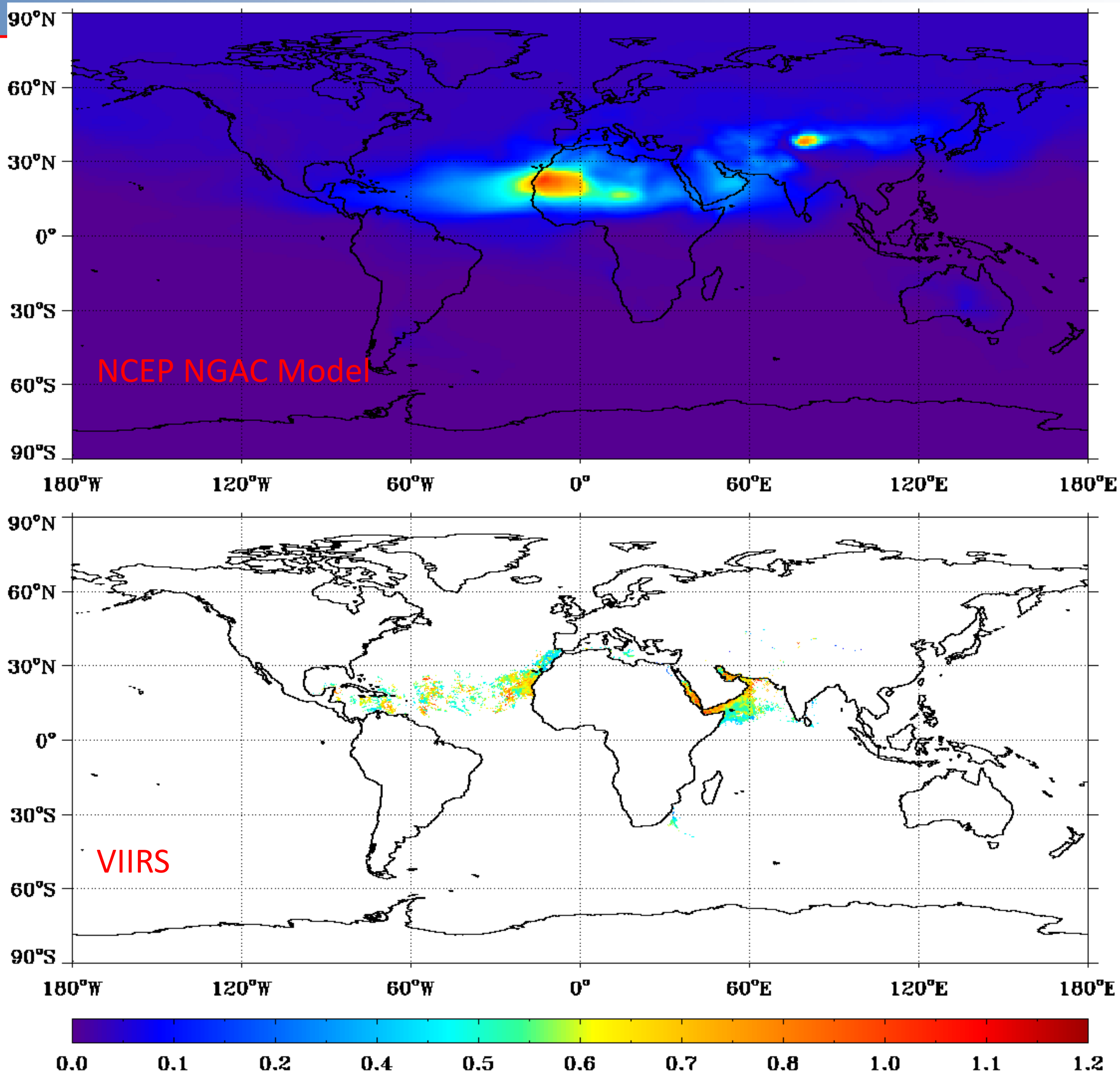
June 2013 Dust AOT



July 2013 Dust AOT



August 2013 Dust AOT



JPSS STAR Science Team Annual Meeting
Cloud EDR Team

Andrew Heidinger
Cloud EDR Lead

May. 12, 2014

Outline

- Overview
  - Products, Requirements, Team Members, Users, Accomplishments
- SNPP Algorithms Evaluation:
  - Algorithm Description, Validation Approach and Datasets, Performance *vs.* Requirements, Risks/Issues/Challenges, Quality Monitoring, Recommendations
- Future Plans
  - Plan for JPSS-1 Algorithm Updates and Validation Strategies, Schedule and Milestones
- Summary

Our Teams

- VIIRS Cloud Mask Team
  - Tom Kopp Lead & William Thomas JAM
  - STAR: Andrew Heidinger, Mike Pavolonis
  - NGAS: Keith Hutchison & Barbara Islager
  - Raytheon: Kurt Brueske
  - CIMSS: Rich Frey, Denis Botambekov, Corey Calvert

- VIIRS Cloud EDR Team
  - Andrew Heidinger Lead & Janna Feeley JAM
  - STAR: Dan Lindsey
  - NGAS: Eric Wong
  - CIRA: Steve Miller, Curtis Seeman, and Y.J. Noh
  - CIMSS: Bob Holz (Val Lead and NPP PEATE Liason), Min Oo, Greq Quinn, Andi Walther, Yue Li

Our Products

- VIIRS Cloud Mask (4-level) + decision bit flags
- VIIRS Cloud Type
- Daytime optical depth and particle size
- Nighttime optical depth and particle size
- Cloud Height/Temperature and Pressure
- Cloud Base
- Cloud-cover in layers (no IP)
- IPs are available at pixel resolution
- EDRs are 6 km

Our Processing Options

- **IDPS** runs the NPOESS algorithms modified with some NOAA-based modifications.
- GOES-R AWG algorithms are being implemented into the **NDE SAPF** led by Walter Wolf.
- **CLAVR-x** runs NOAA-heritage / GOES-R AWG VIIRS algorithms within Community Satellite Processing Package (**CSPP**).
- Our NDE algorithms are “enterprise” and support many geo and leo sensors. We do consider our program to span all of these sensors.
- We do expect to continue the POES climate records with VIIRS within the **PATMOS-x** project.
- We are also involved in the NPP Atmospheres Science Team which runs MODIS-heritage algorithms + the GOES-R AWG VIIRS Cloud height (**MODAWG**).

Accomplishments

- **VCM tuned and modified throughout S-NPP, achieved Val Stage 2 in January.**
- **VIIRS Cloud Products have undergone fewer but more major updates. Most are Provisional.**
  - **Adopted CLAVR-x form of inversion logic for low cloud heights**
  - **Adopted CLAVR-x DAY COP LUTS for conversion into the final IDPS Day COP LUTS**
  - **Updated k-ratio for ice microphysical model based on Ping Yangs data. (Which also similar to what is done in CLAVR-x)**
  - **Fixed some major coefficient bugs in Night COP**

Our Users

- VCM serves downstream applications.
- We know of no one using the IDPS cloud products operationally yet (they are provisional).
- We do have users of NOAA heritage algorithms.
  - NOAA cloud algorithms are in CSPP via CLAVR-x. CSPP CLAVR-x provides AVHRR, MODIS and VIIRS support.
  - Height, Type and daytime COP go into NWS WFO's for the Proving Ground Projects.
  - Global geo cloud altitude goes into NWS AWC.
  - We intend to include VIIRS in a Alaska Region morphed cloud product service beginning next year.
  - We need more users. We would be happy to collaborate with NCEP in their use of VIIRS SDR for cloud detection and cloud height estimation.

Algorithm Evaluations

Algorithm Evaluations Summary

1 = Keep NPOESS-era; 2 = Transition due to Performance; 3 = Transition for Other Reasons

Algorithm	Now -August 14	September 14+	NDE/JPSS
VCM	1	1	1/3
Cloud Type	1	1	1/3
Cloud Height	1	2/3	2/3
Day COP	1	2/3	2/3
Night COP	1	2	2
Cloud Base	1	2	2

- 1/3 for VCM in JPSS-1 means we will pursue the best NDE mask we can but decision should come from Application Teams
- 2/3 for Height and COP means that if planned changes to IDPS are successful, the main performance concerns may be mitigated and our decision for NDE is based more on other factors.

VIIRS Cloud Mask/Type Justification

- We believe we should stay the course with VCM until the Applications Teams are ready and willing to switch the NDE cloud mask.
  - The VCM is at Val Stage 2
  - The teams have self-calibrated to the VCM
  - The VCM is based on MODIS-heritage and the team is capable of tuning and evolving the mask further.
  - However, the IDPS does limit the long-term development and some of the VCM issues are not present in the NDE mask.
  - We plan to revisit this decision once the NDE mask is up and running and the Application Teams are ready to evaluate.

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  - We plan to revisit this decision once the NDE mask is up and running and the Application Teams are ready to evaluate.

VCM Justification

Overall: VCM meets the specification and Application Teams expressed their satisfaction

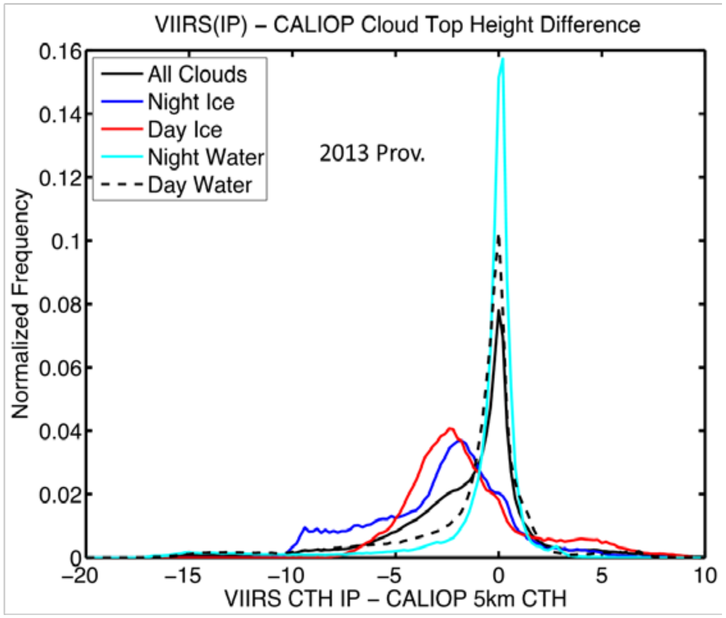
VCM Overall Results (Daytime) / Taken from Provisional

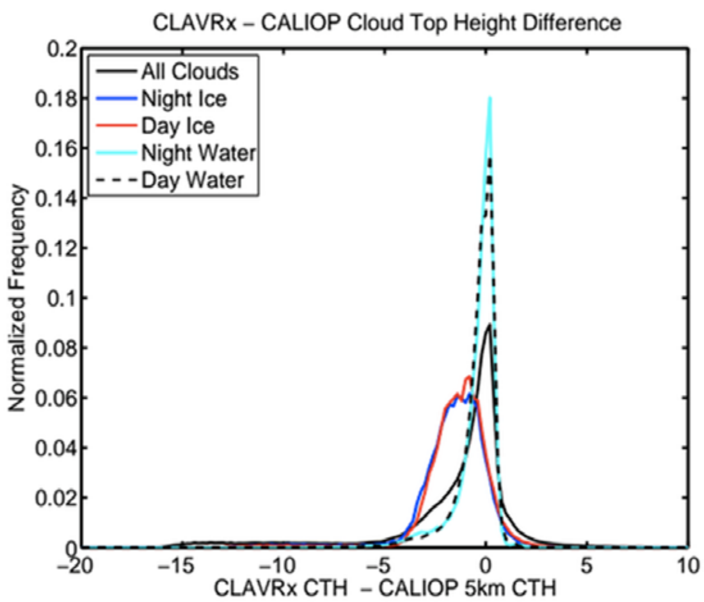
Requirement	Level 1	Match-Up	Golden Granule
PCT: Daytime, ocean	94%	95.3%	96.5%
PCT: Daytime, land	90%	93.9%	94.4%
PCT: Daytime, desert	90%	96.0%	95.7%
Leakage: Daytime, ocean	1%	0.6%	0.1%
Leakage: Daytime, land	3%	2.2%	0.7%
Leakage: Daytime, desert	3%	2.8%	1.2%
False Alarms: Daytime, ocean	5%	3.5%	2.6%
False Alarms: Daytime, land	7%	3.6%	4.2%
False Alarms: Daytime, desert	7%	1.2%	2.9%

Filter: No Probably Clear or Cloudy and COT > 1

VIIRS Cloud Height Justification

- NDE/CLAVR-x is still outperforming NPOESS-era algorithm in IDPS.





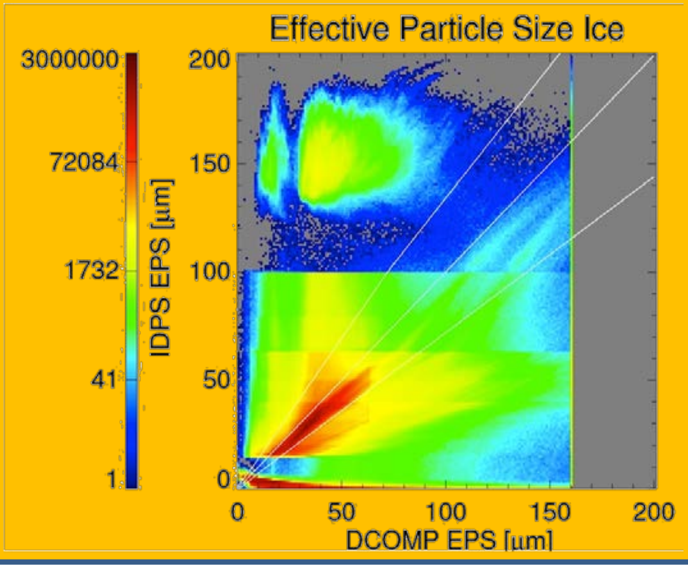
- However, the NPOESS-era IR RTM is not correct and needs updating. We feel this could fix some of the issues seen above.

- We expect to make to be able to make this RTM change prior to August 2014.

VIIRS Day COP Justification

- Very similar story to Height. NDE/CLAVR-x is still outperforming NPOESS-era algorithm in IDPS.

- NPOESS-era algorithm Cloud EPS shows artifacts not seen in DCOMP (NDE) or other algorithms.
- This after adoption of DCOMP LUTs.
- ***We suspect these are failed retrievals due to bad surface reflectance assumptions***.
- Roughly 1/3 of pixels fail now.



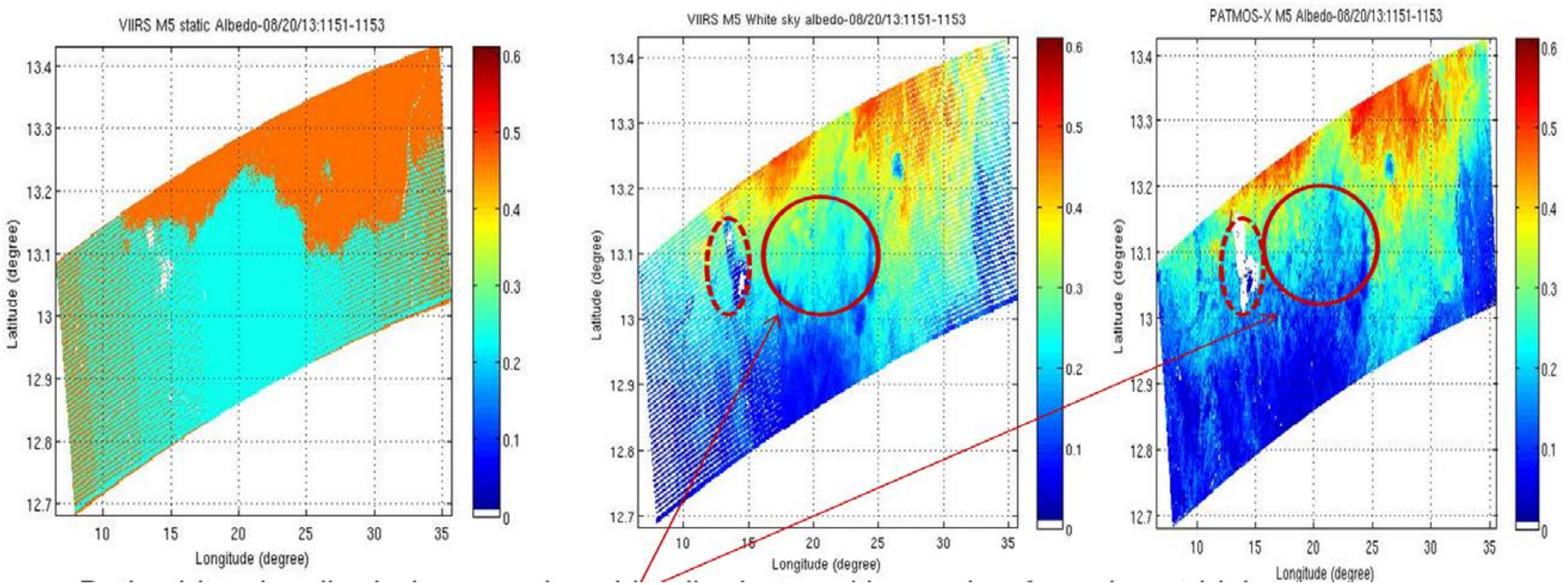
- However, the NPOESS-era surface reflectance assumptions are not valid and need updating. Use of the existing white-sky reflectance is being explored. Another option is adoption of the static white-sky data used in CLAVR-x.

- We expect to make this white-sky change prior to August 2014.

Example of Day COP Surface Reflectance Issue

- Current IDPS Surface Reflectance is unrealistic
- We propose adopting what is done in CLAVR-x and use a white-sky reflectance
- We are exploring using the standard VIIRS white-sky product
- Initial analysis indicates this is main driver of the day COP failures over land.

Current IDPS M5 *M5 White-Sky from IDPS* *M5 Current CLAVR-x*



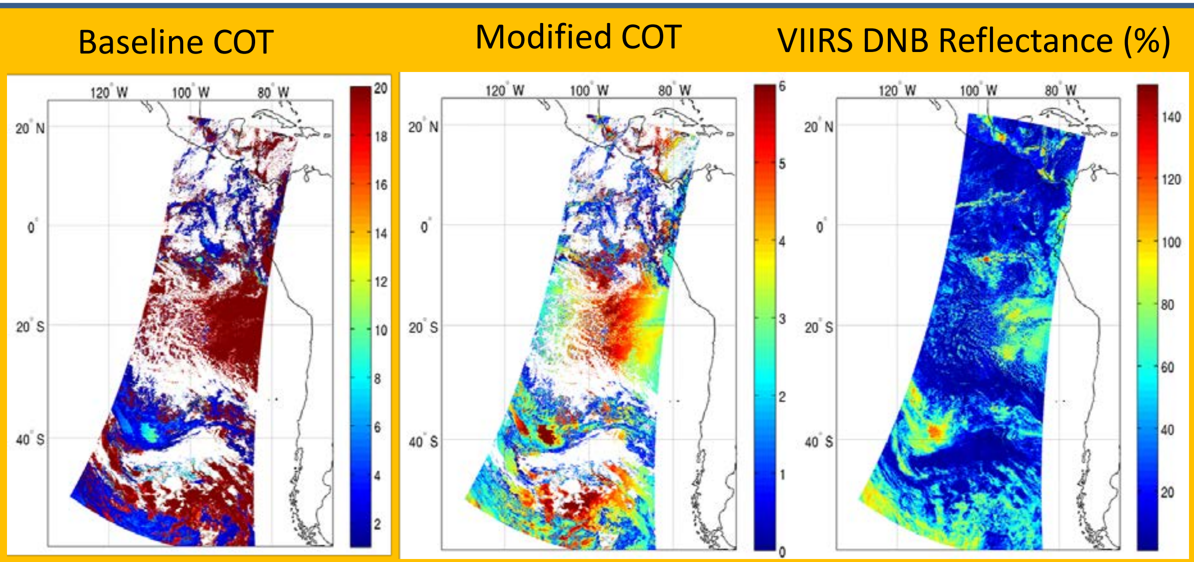
Areas of Difference Remain between CLAVR-x and VIIRS White Sky and will be explored

Eric Wong, NGAS

VIIRS Night COP Justification

- NPOESS-era IDPS Nighttime COP Algorithm is still not performing well. Did not achieve Provisional Status.

- NPOESS-era algorithm Cloud EPS shows issues with performance.
- Heavily modified from baseline (see example)
- Note, IR COT should be less than Daytime COT values.
- IR COT should be correlated with DNB Lunar Reflectance, it is not.



- NDE approach is the use Pat Minnis (NASA LaRC) algorithm which is same as GOES-R AWG.
- We think NDE approach is they way to move forward.
- Limitations of IR-only approaches will remain.

VCM Path Forward

- Continue on with IDPS VCM, evaluate NDE in the future.
- Primary function of the validation team in the next few months is twofold
  - Complete tuning for nighttime scenes
  - Address specific concerns from VIIRS Cal/Val teams
    - Cloud edges over water
    - Excessive leakage over snow/ice, including polar night
- Pursue quantitative validation of cloud phase and aerosol quality flags (validation stage 2)
- Continue to interact and be responsive to other VIIRS EDR team needs
  - The VCM must continue to address items where the downstream EDRs believe improvement is needed for their products to reach validation stage 1

Cloud Product Path Forward

- We will continue to push hard for two major fixes before NGAS support is gone (surface refl. and IR RTM).
- These fixes are required if Val Stage 1 for CTH and Day COP is to be met for NPOESS-era algorithms.
- We believe we have the go-ahead to transition to supporting NOAA-endorsed NDE algorithms.
- We want to go Val Stage 1 with those if the NDE schedule allows this.
- We'll continue to push forward on the NDE cloud mask and allow teams to weigh when appropriate.

Questions

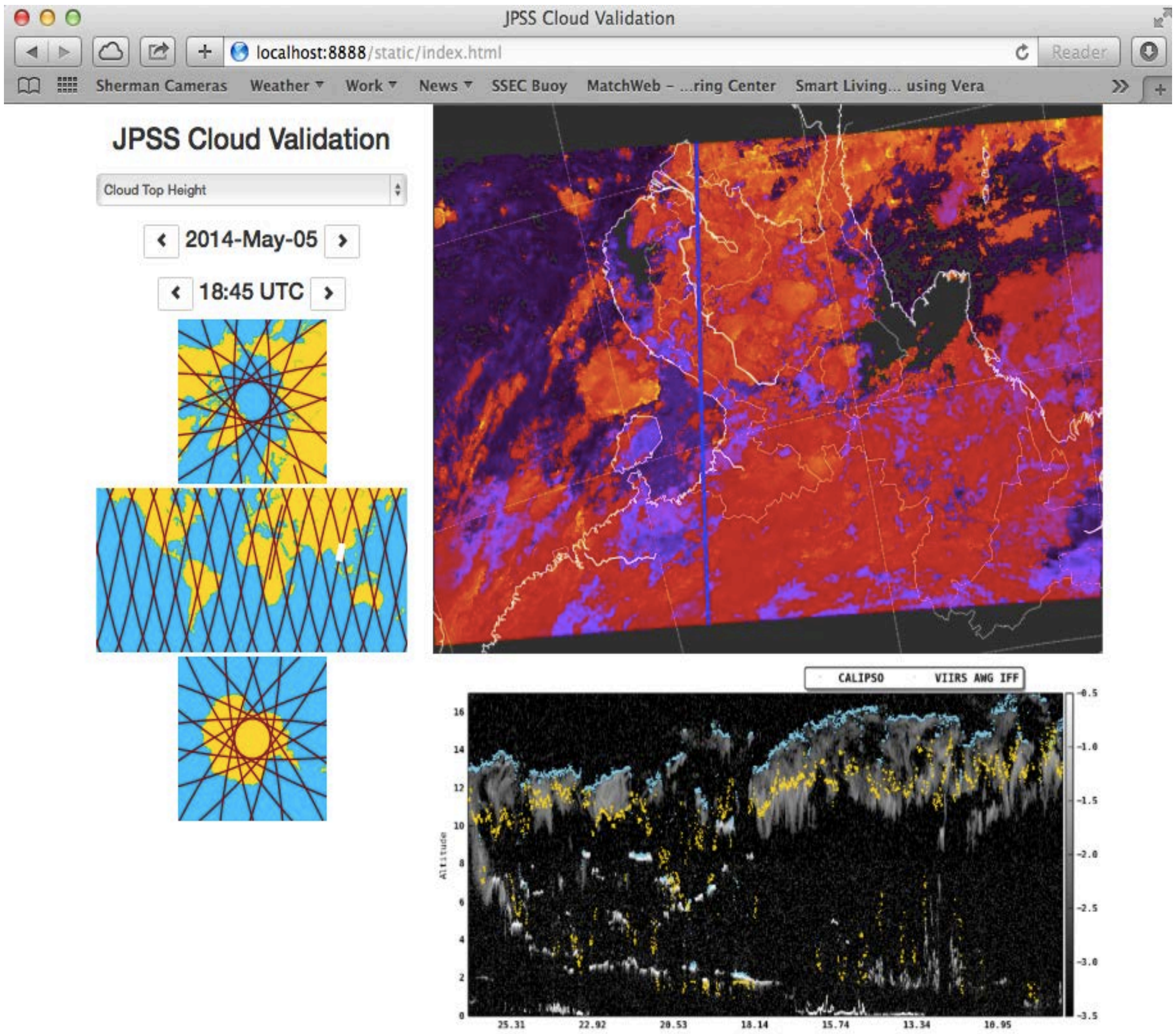
- For algorithms making the switch to NOAA-endorsed NDE algorithms, what do we do in the time prior to NDE becoming operational? (*It makes little sense to push for Val Stages on algorithms that are being replaced?*)

- Can we reached Val Stage 1 with an NDE algorithm before the NDE SAPF is operational? Can CLAVR-x or CSPP be used for the required testing?

- Is there an option #4, move IDPS algorithm into NDE?

JPSS Cloud Validation System

Screenshot of SSEC JPSS Cloud Val Website (Bob Holz)



- The JPSS cloud validation system provides both near real-time and long term validation of the JPSS products
- The system leverages the SSEC collocation and processing infrastructure allowing quantitative inter-comparisons between polar and geo-stationary observations and products
- The results are accessible through a web interface

Thank You

MiRS Algorithm for the SNPP/JPSS/GCOM-W

-Science and Products Overview-

Presented by

Sid Ahmed Boukabara
Chair, MiRS Oversight Board

MiRS Oversight Board
F. Weng, R. Ferraro, L. Zhao

MiRS Team:
X. Zhan (Govt Technical lead), C. Grassotti (Contractor Lead), T. Islam, C. Smith, P. Liang

With Contributions from:
K. Garrett (JCSDA)

Acknowledgements

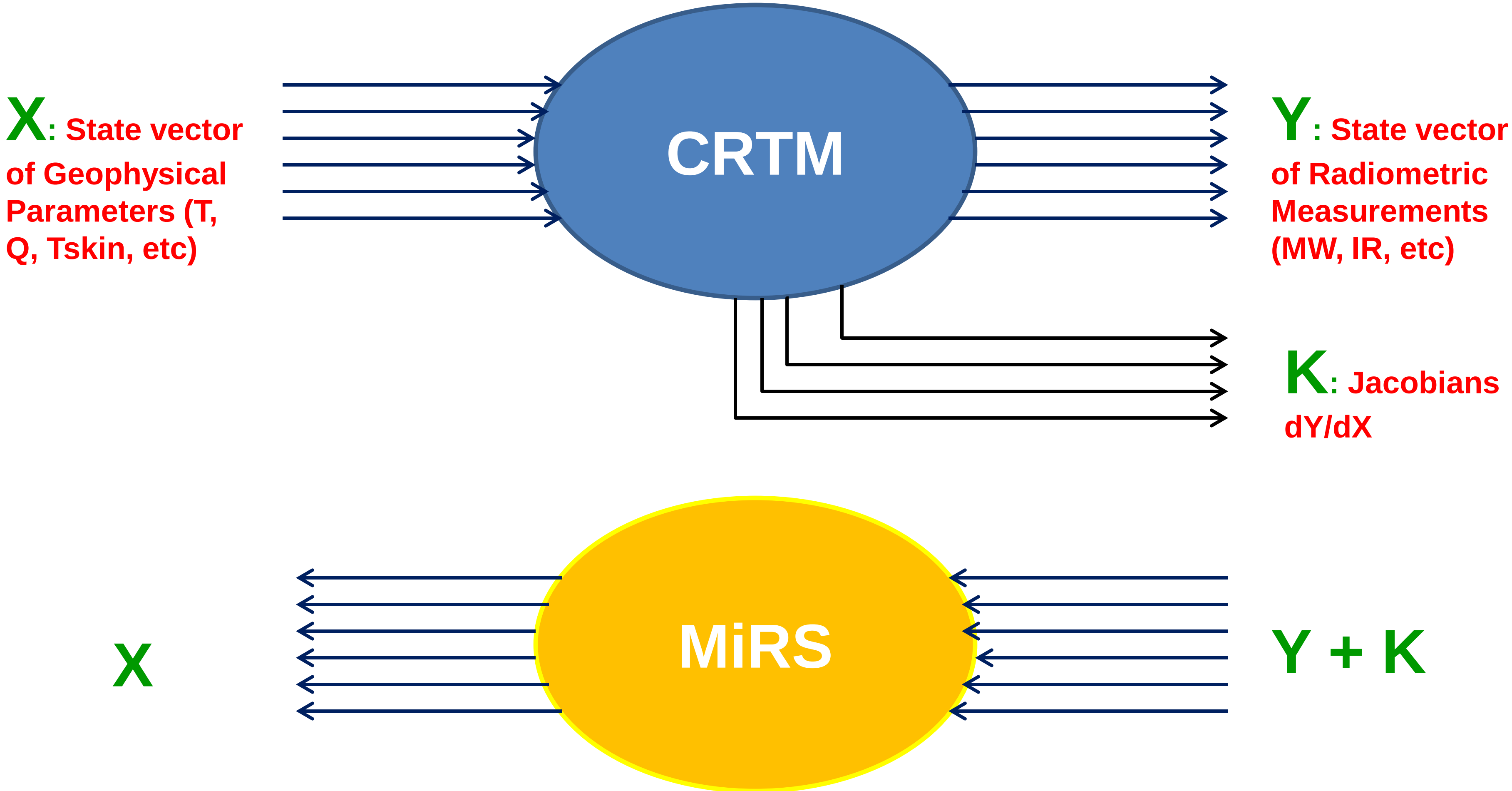
- ***Main sponsor of MiRS project over the years: U.S. NOAA/NESDIS Product System Development and Implementation (PSDI) program***

- **Support was also provided over the years from:**
  - *NDE program*
  - *JPSS Program*
  - *JCSDA*

- **Instrumental Feedback from Users (of package and products) over the years helped in shaping the project**
  - *CIRA team*
  - *OSPO team*
  - *NPROVS team*
  - *JPL team*
  - *IPWG/UMD team*
  - *CPTEC team/Brazil*
- **Past team members:** K. Garrett, F. Iturbide-Sanchez, W. Chen, T. Clough, R. Chen, Q. Liu, V. Zubko, Z. Jiang, A. Mims, L. Moy, Etc

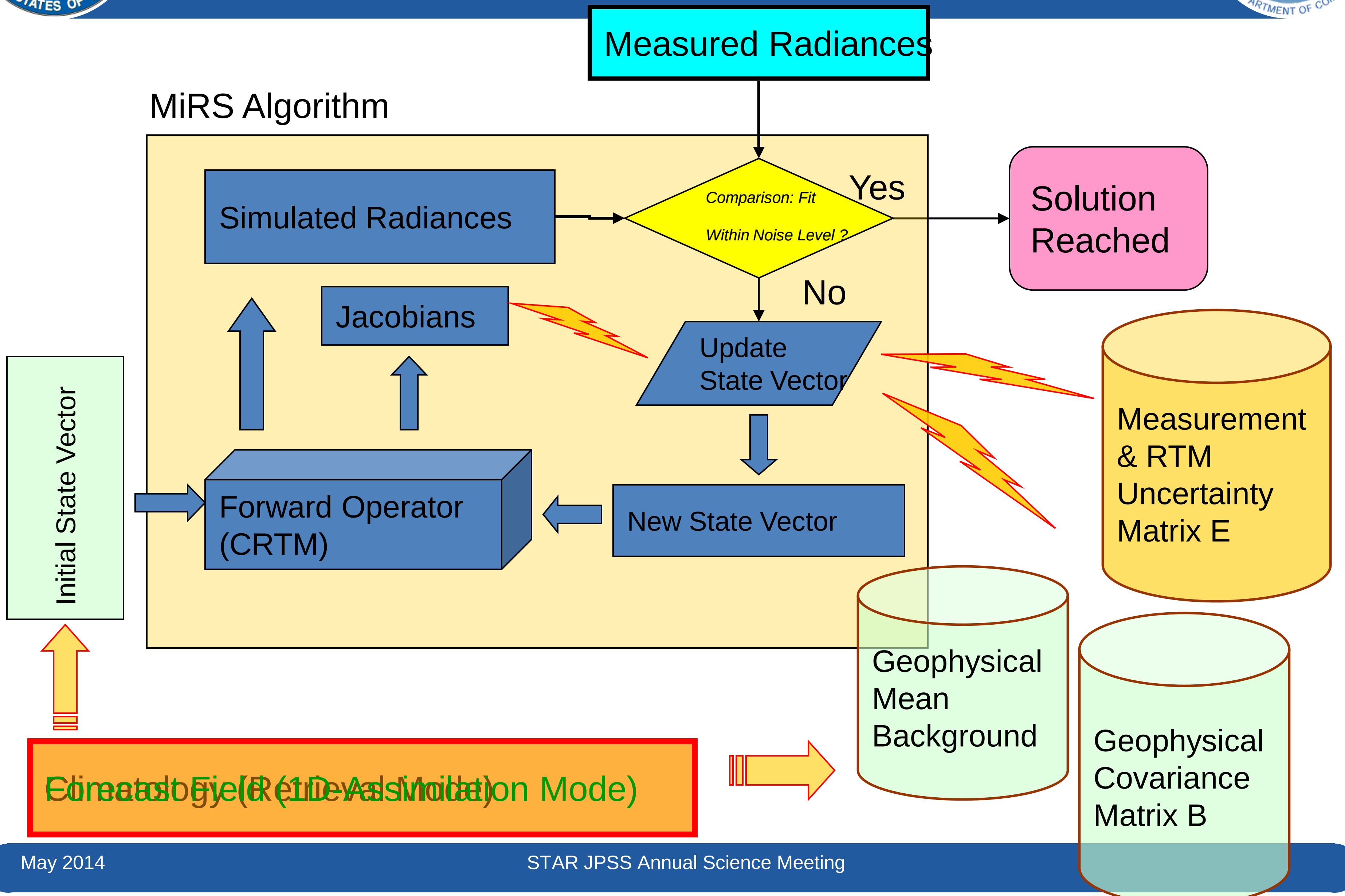
Contents

MiRS Concept



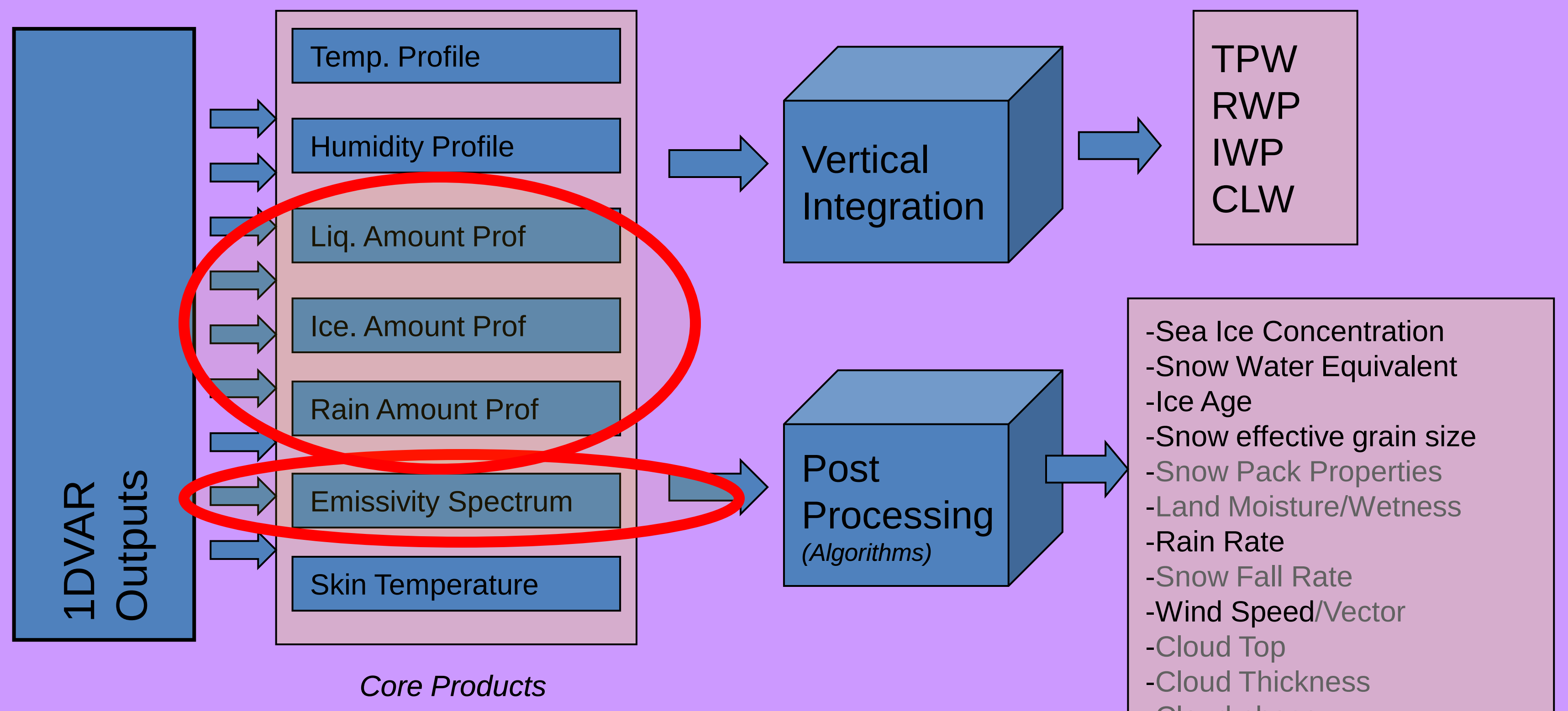
Conceptually, MiRS is the mirror image of CRTM

1D-Variational Retrieval/Assimilation



MiRS General Overview

Vertical Integration and Post-Processing



Main Characteristics

- **Significant leverage of RT science (and Jacobians) by using CRTM**
- **Resiliency to noise increases, channel failures.**
- **Valid for sensors for which CRTM is valid**
- **Trivial to extend to new sensors *(main effort is validation)***
- **Valid in cloudy/precipitating conditions *(as long as CRTM is valid)***
- **Valid over all surfaces *(thanks to emissivity part of the state vector)***
- **Most important:**
  - ***Scientifically:* Consistent retrieval of parameters (atmos., cryosph., surface, hydrometeors) fitting channels simultaneously**
  - ***Programmatically*: Cost effective approach (~ 7-13 products depending on sensor, ~10 sensors, sustained with a team of ~4-5)**

Applicability of MiRS –Products-

Official Products

1. **Temperature profile**
2. **Moisture profile**
3. **TPW (global coverage)**
4. **Surface Temperature**
5. **Emissivity Spectrum**
6. **Surface Type**
7. **Snow Water Equivalent (SWE)**
8. **Snow Cover Extent (SCE)**
9. **Sea Ice Concentration (SIC)**
10. **Cloud Liquid Water (CLW)**
11. **Ice Water Path (IWP)**
12. **Rain Water Path (RWP)**
13. **Rainfall rate**

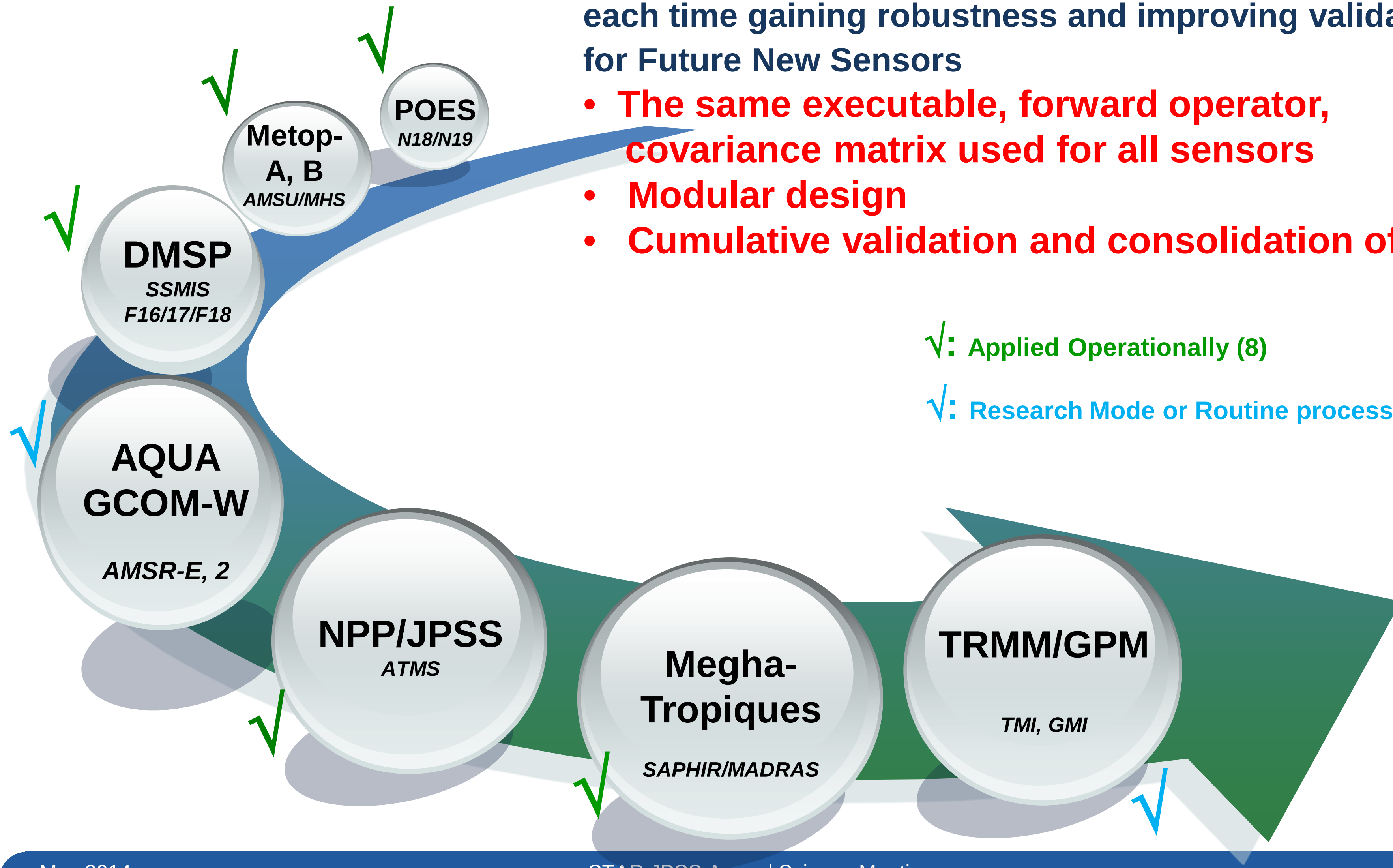
Products being investigated

1. Cloud Profile
2. Rain Profile
3. Atmospheric Ice Profile
4. Snow Temperature (skin)
5. Sea Surface Temperature
6. **Effective Snow grain size**
7. **Multi-Year (MY) Type SIC**
8. **First-Year (FY) Type SIC**
9. **Wind Speed**
10. Soil Wetness Index

Applicability of MiRS – Sensors-

MiRS is applied to a number of microwave sensors, each time gaining robustness and improving validation for Future New Sensors

- **The same executable, forward operator, covariance matrix used for all sensors**
- **Modular design**
- **Cumulative validation and consolidation of MiRS**



√: Applied Operationally (8)

√: Research Mode or Routine processing (3)

Contents

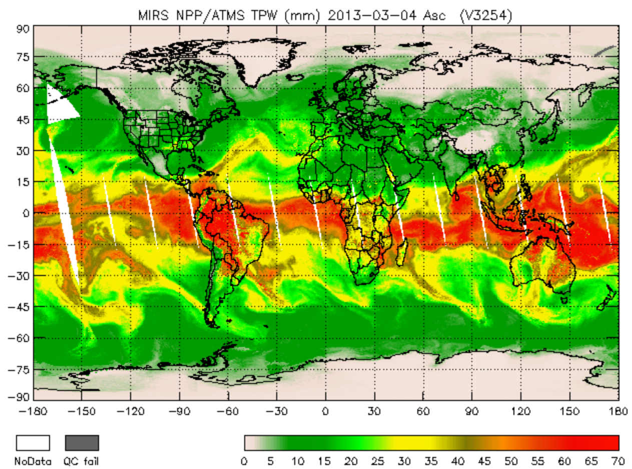
BACKUP SLIDES

SNPP/ATMS

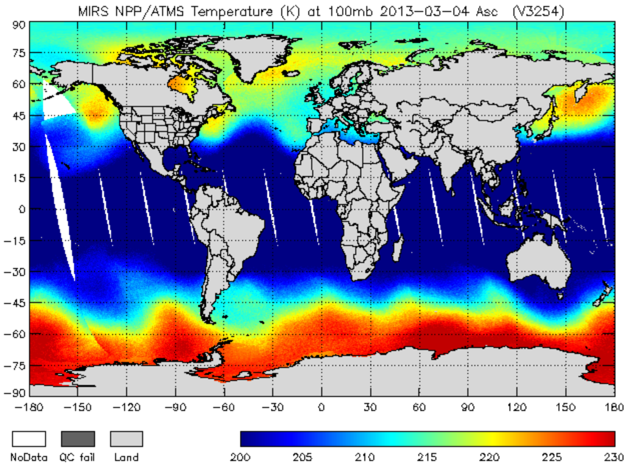
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

MiRS/ATMS Imagery & Sounding

MiRS/ATMS TPW



MiRS/ATMS T(p) -100mb-



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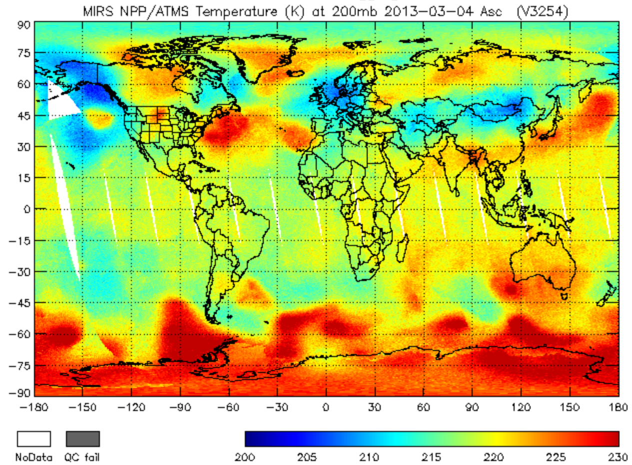
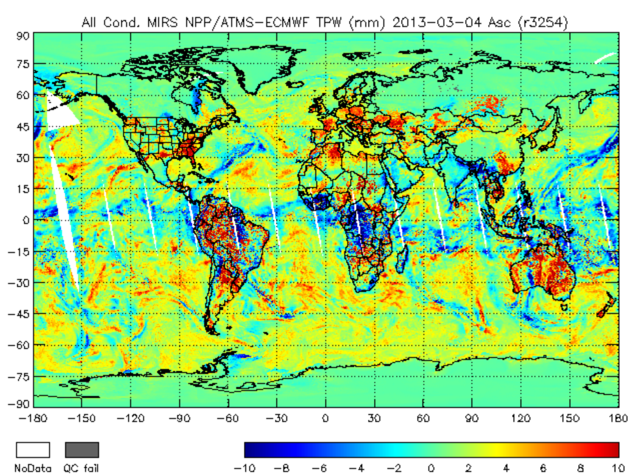
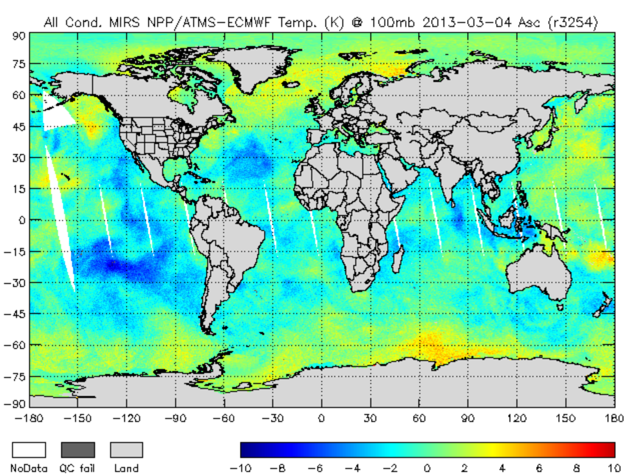


Presentation dedicated to MiRS-based Soundings will be given by C. Grassotti

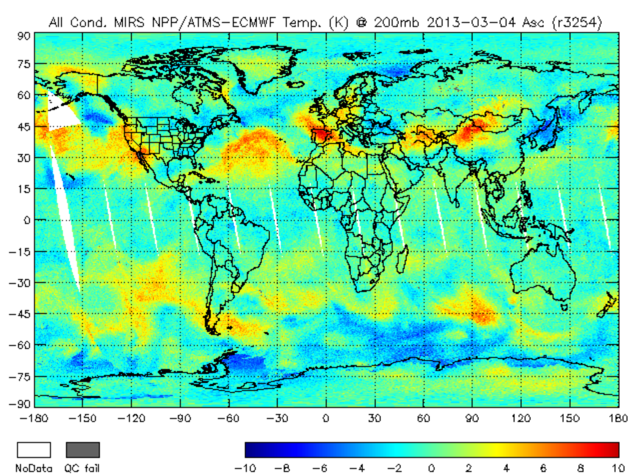
TPW Diff. wrt ECMWF



100mb T(p) Diff. wrt ECMWF



200mb T(p) Diff. wrt ECMWF

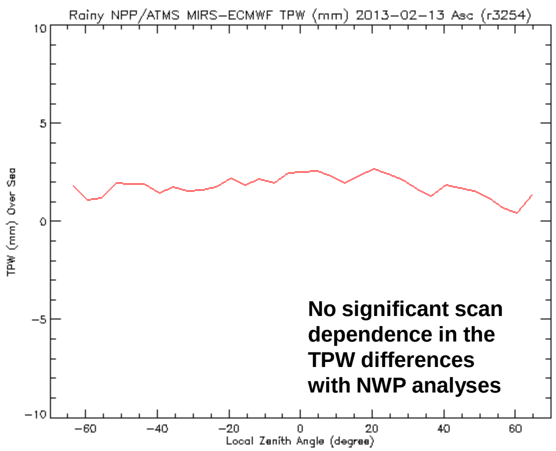


TPW in Exclusively Rainy Conditions

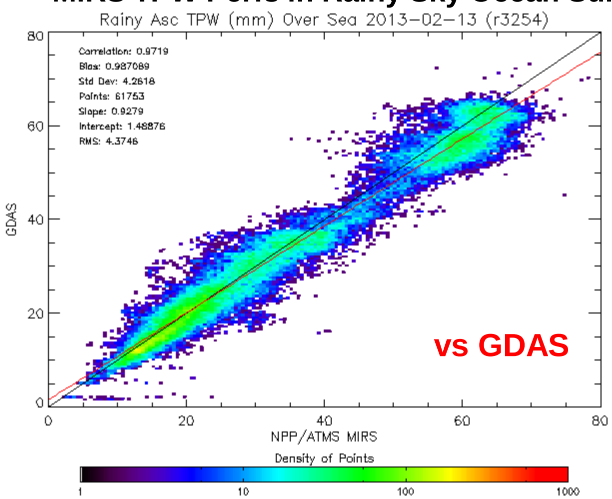
(ATMS)

Performances of MiRS TPW in e
surfaces present a good correla

Angle dependence of MiRS TPW Perfs in Rainy Sky - Ocean Surfaces



MiRS TPW Perfs in Rainy Sky Ocean Surfaces



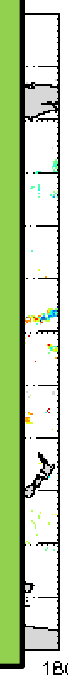
Summary of TPW Performance

	Bias (mm)	*Stdv (mm)*	*Corr.*	*RMSE (mm)*
Ocean	0.46	2.55	0.98	2.59
Land	0.48	4.47	0.95	4.50
Sea-Ice	0.42	1.28	0.82	1.35
Snow	0.25	0.89	0.93	0.92

Comparison vs. ECMWF

	SNPP bias/stdv (mm)	*NOAA-19 bias/stdv (mm)*	*Metop-A bias/stdv (mm)*
Ocean	7.25/15.40 (%)	8.26/15.69 (%)	8.89/13.7 (%)
Land	2.39/23.65 (%)	5.68/23.76 (%)	2.57/22.11 (%)

Comparison vs. Radiosonde



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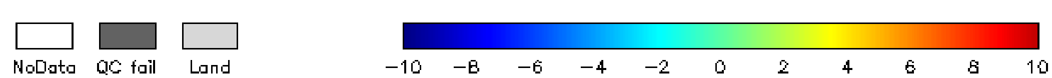
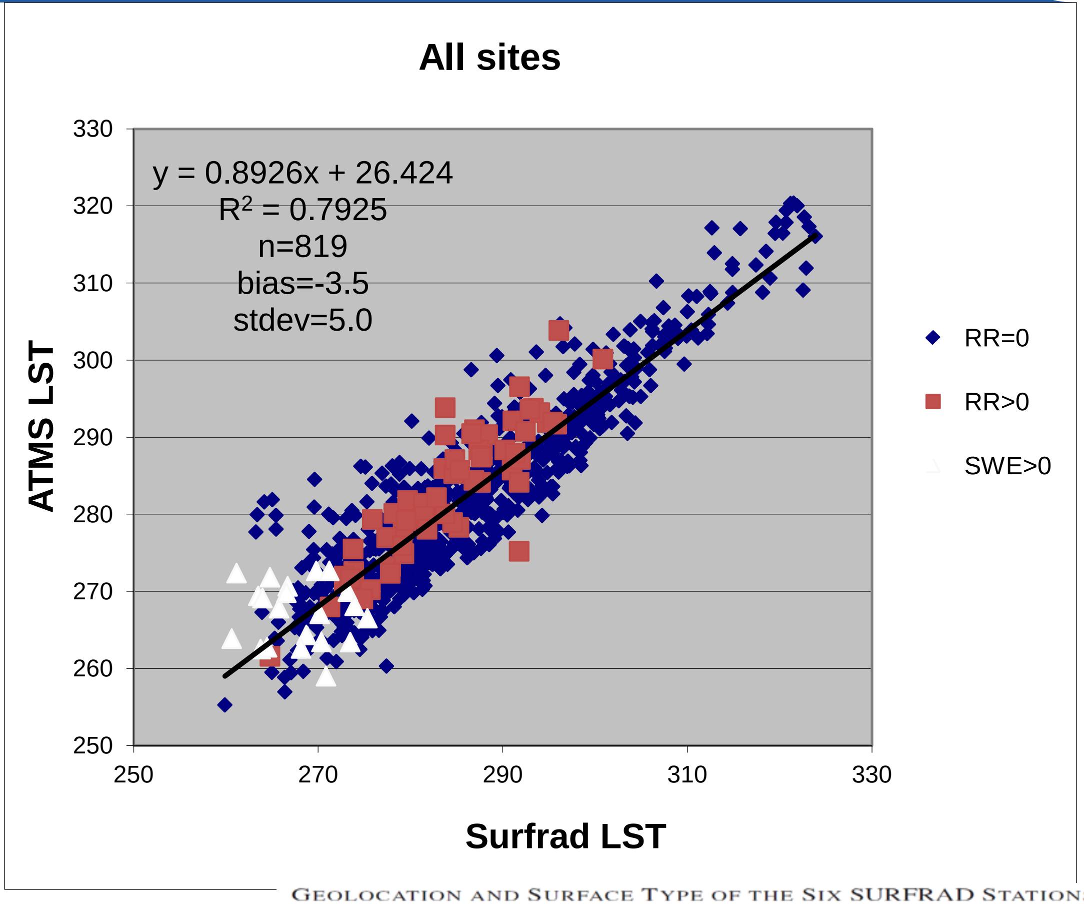


MiRS/ATMS LST Assessment

-Good performances of MiRS/ATMS wrt SURFARD ground measurements (correlation of 0.79)

- Performances are also consistent when snow is detected over the surface (green dots)



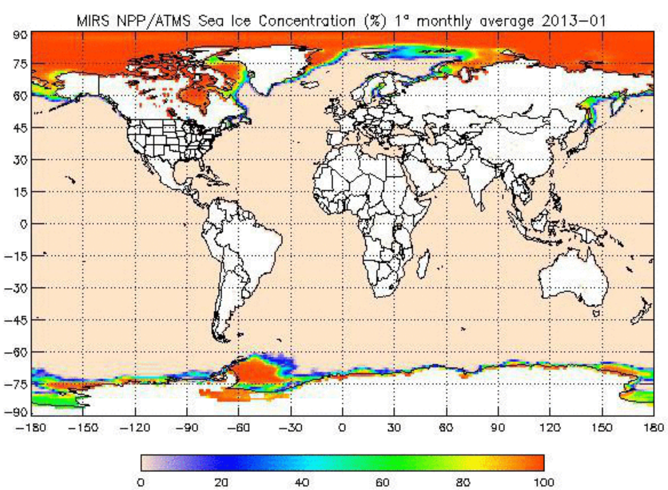
GEOLOCATION AND SURFACE TYPE OF THE SIX SURFRAD STATIONS

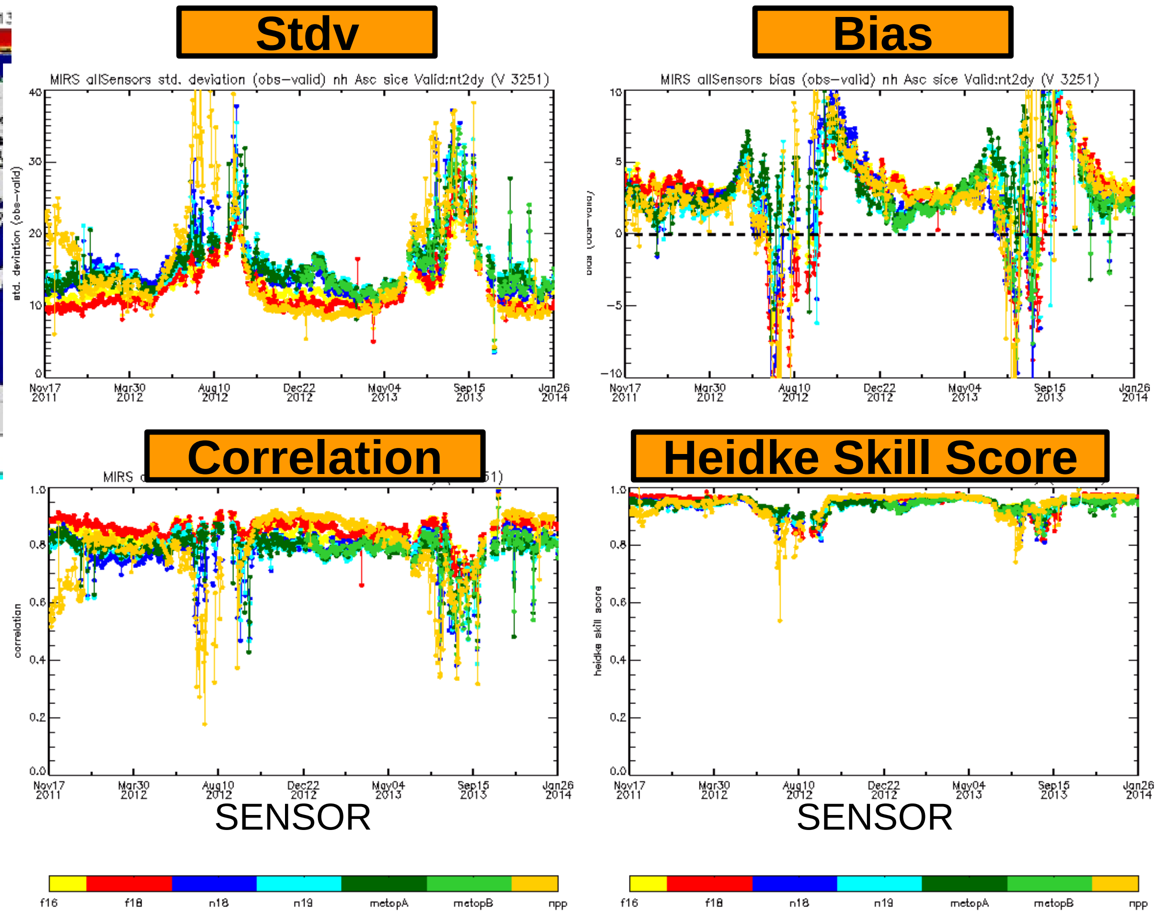
No.	Site Location	Lat(N)/Lon(W)	Surface Type*
1	Bondville, IL	40.05/88.37	Crop Land
2	Fort Peck, MT	48.31/105.10	Grass Land
3	Goodwin Creek, MS	34.25/89.87	Deciduous Forest
4	Table Mountain, CO	40.13/105.24	Crop Land
5	Desert Rock, NV	36.63/116.02	Open Shrub Land
6	Pennsylvania State University, PA	40.72/77.93	Mixed Forest

MiRS Sea-ice Concentration Assessment – NASA Team

Right – Time series of MiRS SIC performance (NH) for various sensors (ATMS in Orange)

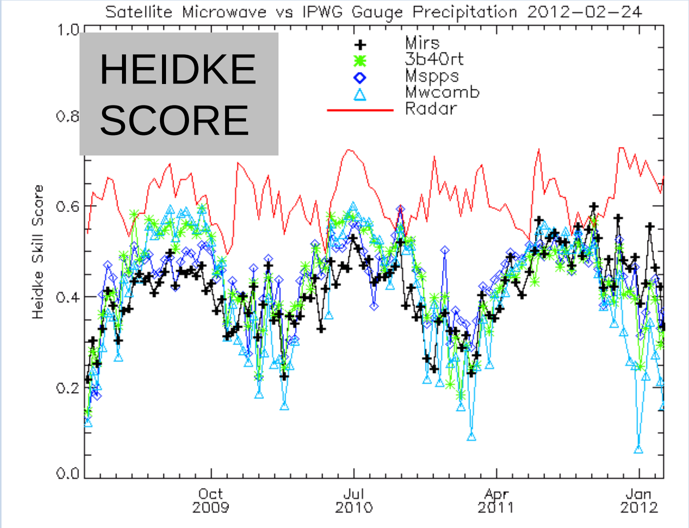
Bottom – Monthly SIC from MiRS ATMS for 2013

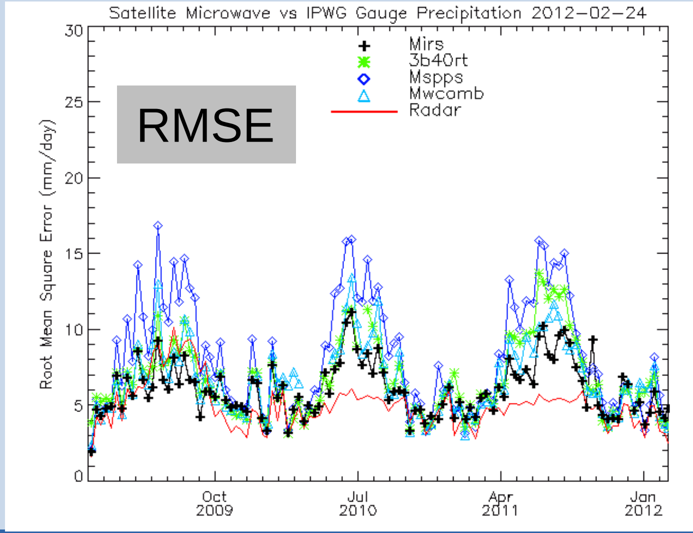


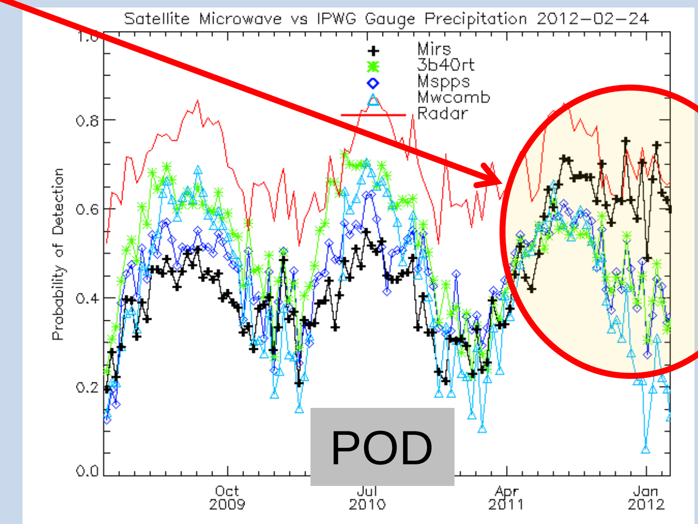


Independent RR Validation (IPWG)

- Monitor a running time series of statistics relative to rain gauges
- Intercomparison with other PE algorithms and radar
- MiRS composite uses all microwave sensors
- Tightening of RTM uncertainty in June 2011 improves POD & Heidke



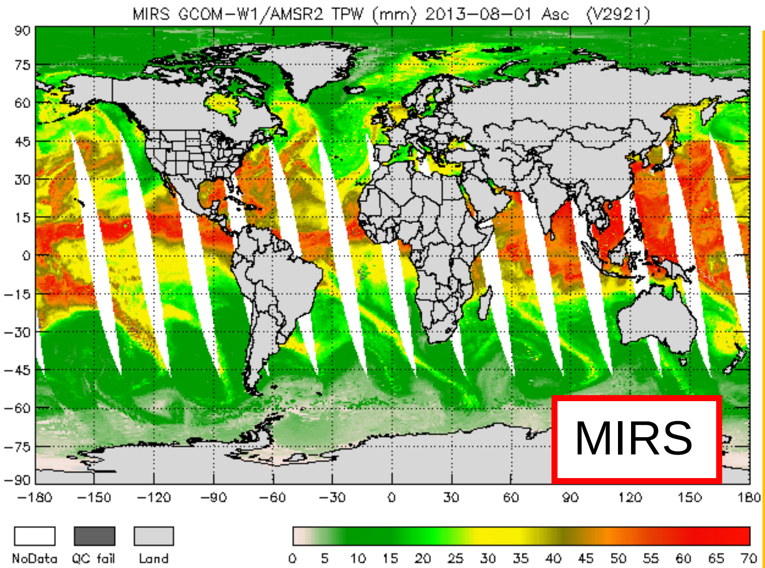




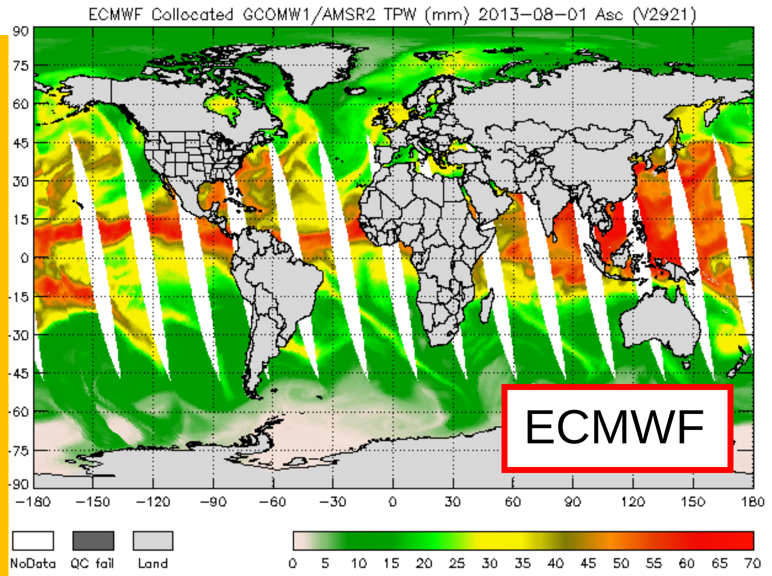
BACKUP SLIDES

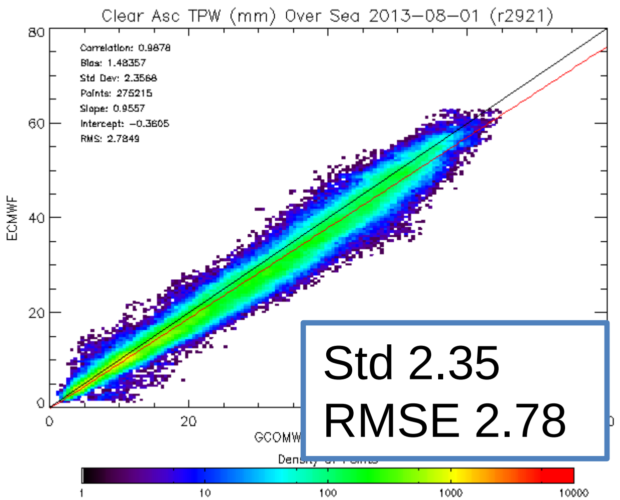
GCOM-W AMSR-2

GCOM-W1/AMSR2 TPW



Products from MiRS/AMSR2 include TPW, Cloud, SST, Emissivity, SIC, Age, Snow, LST, RR, and lower tropospheric sounding

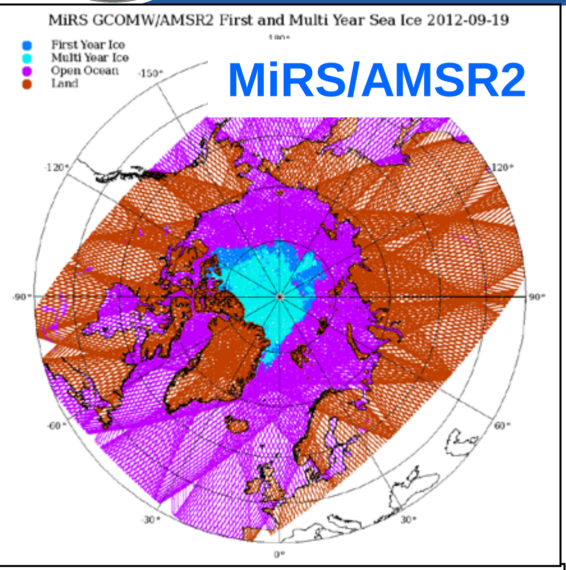


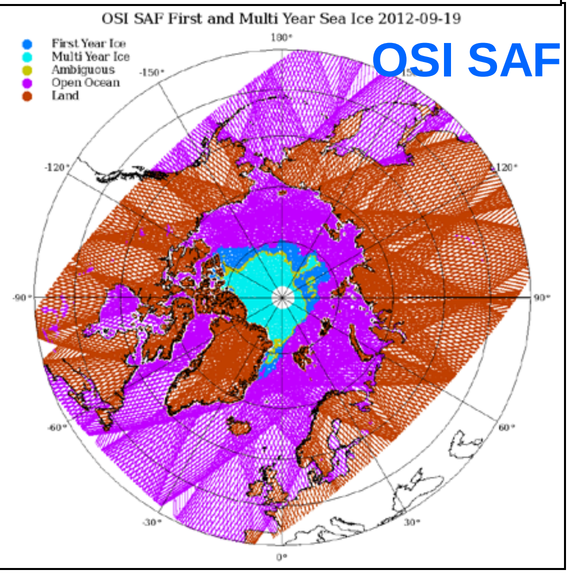


✓Good agreement with ECMWF.

✓Performances (2.35 mm std deviation) are similar to AMSU/MHS & SSMI/S instruments (global coverage).

Sea Ice Type (MY & FY): MiRS / OSI SAF





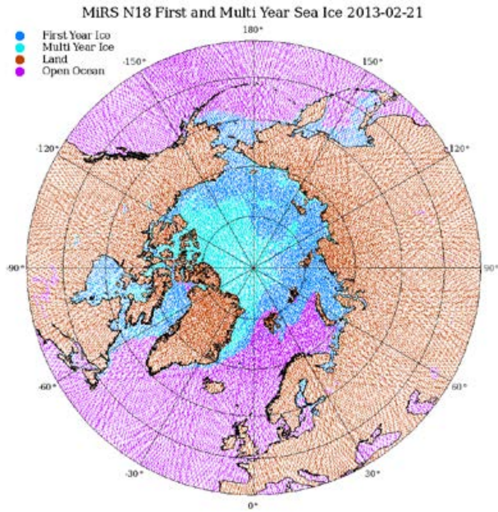
Late summer/Fall 2012

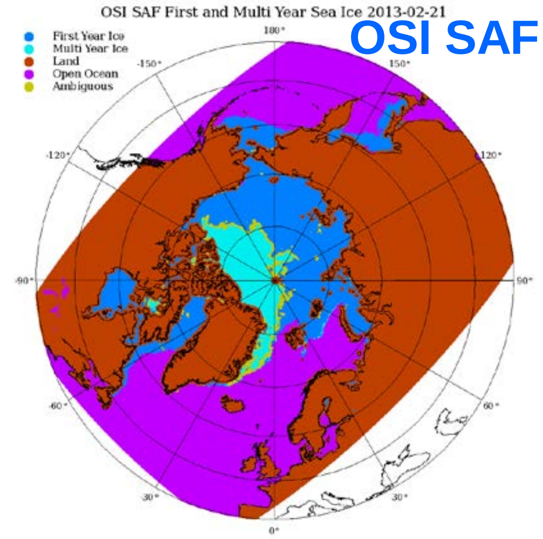
Qualitative assessment of the sea-ice type from MiRS (based on AMSR2 and POES data) by comparing it to EUMETSAT OSI SAF

The OSI SAF algorithm uses a Bayesian method, SSMIS + ASCAT.
It also uses estimates of uncertainty to weight the observations.

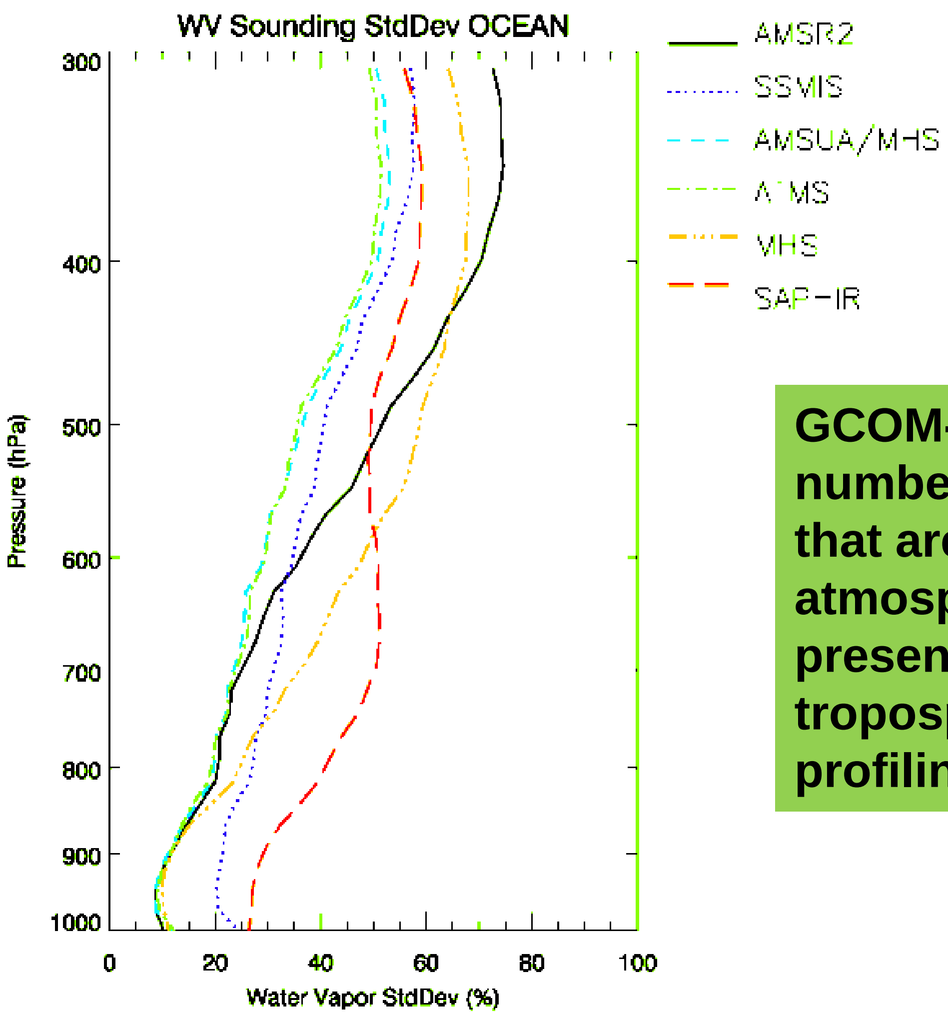
Winter 2013

MiRS/N18





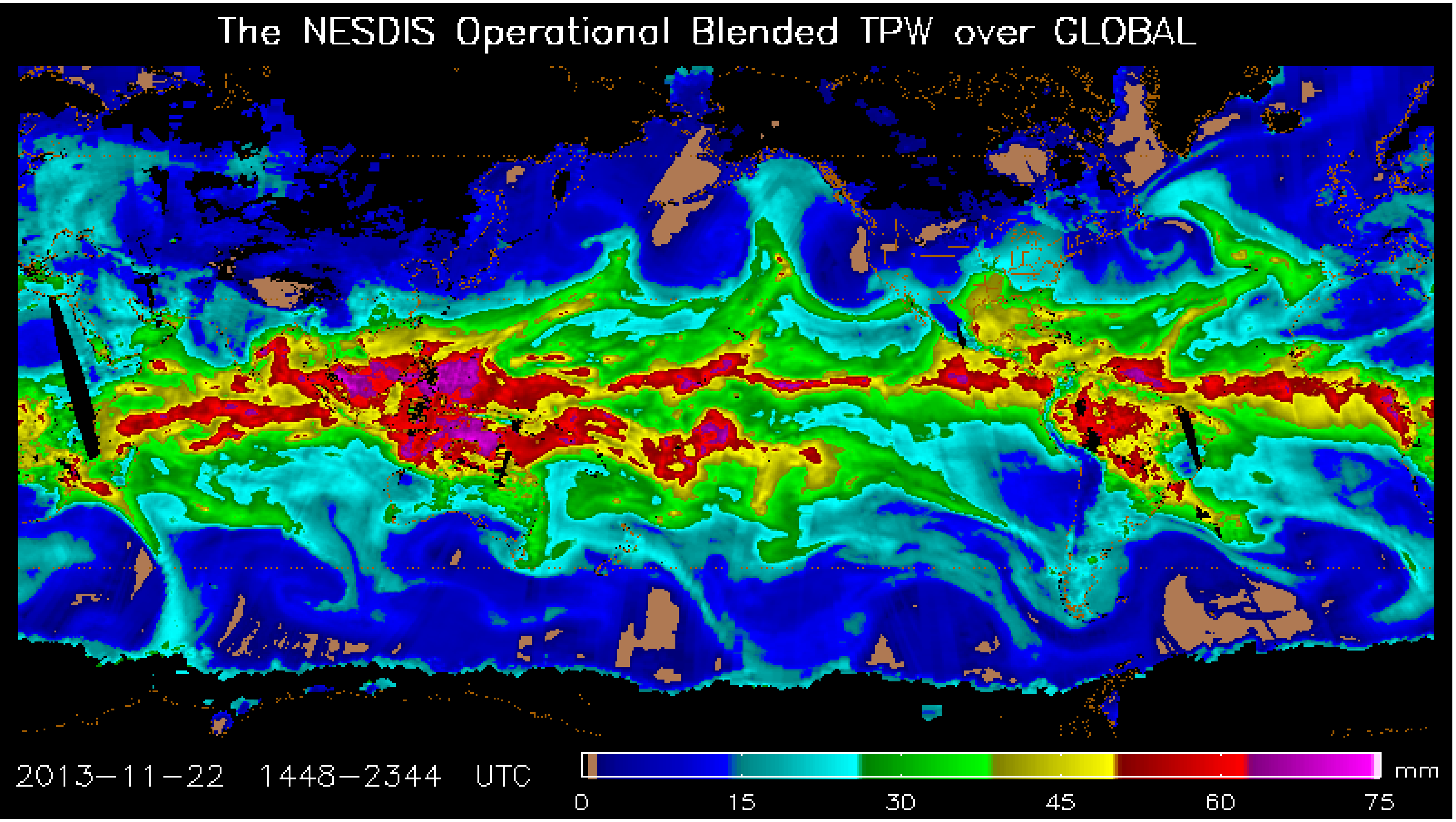
Tropospheric Moisture Sounding from AMSR2



GCOM-W AMSR-2 has a number of window channels that are sensitive to different atmospheric column depths, presenting a potential for lower tropospheric moisture profiling.

Contents

Blended TPW



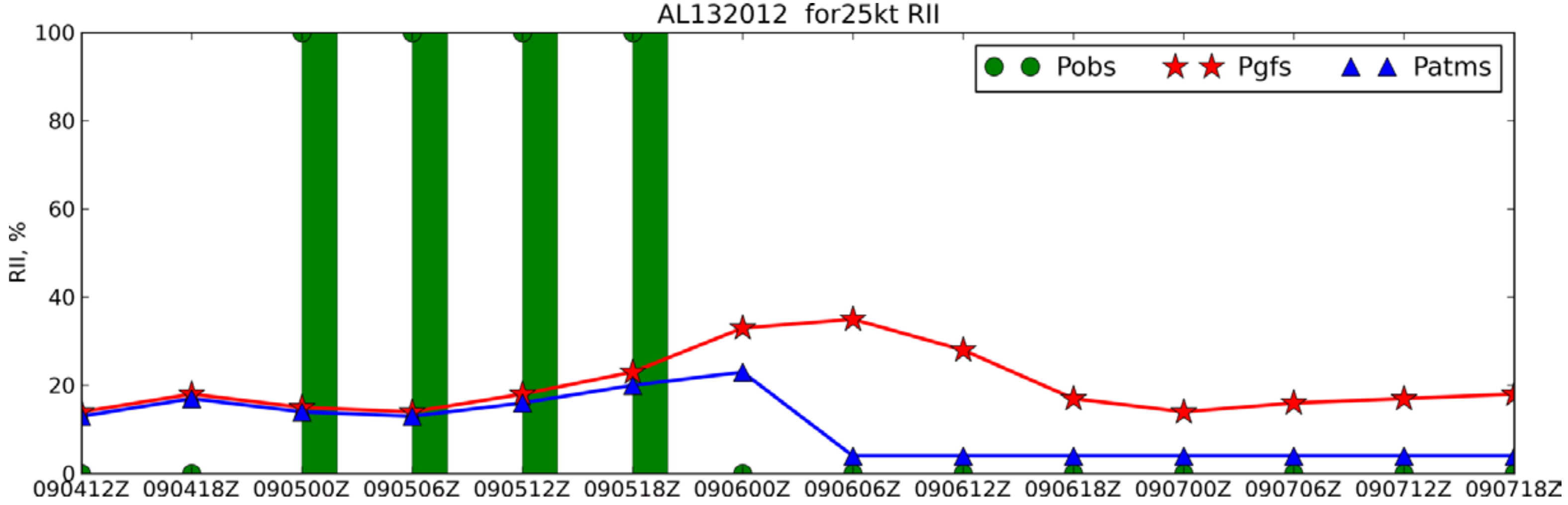
The blended TPW is available through AWIPS sectors that NWS forecasters use

MiRS from microwave sensors are included in the blended TPW. Extension in progress (for more sensors, over sea-ice, snow, etc)

Slide courtesy of the OSPO website: Effort led by CIRA: S. Kidder, J. Forsyth, L. Zhao and R. Ferraro

RI Forecast: GFS vs MiRS/ATMS Inputs

The bias of RI index (between obs. and RII algorithm output) is 1.67 when MiRS/ATMS data is used as inputs and 1.87 when GFS I sused.

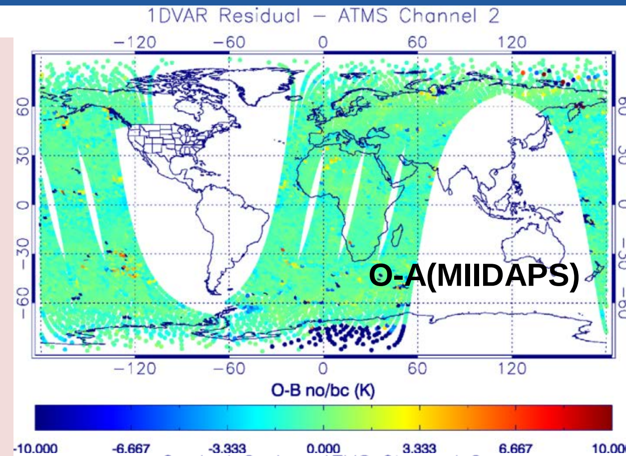


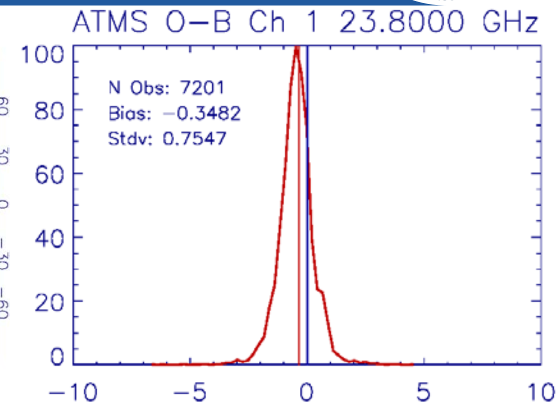
Preliminary results for the RII forecast show up to 3.1% increase in Brier Skill Score with the use of MiRS/ATMS data, and for the center-fix algorithm up to 10% better center location as compared to the first guess position from the NHC real-time forecast positions.

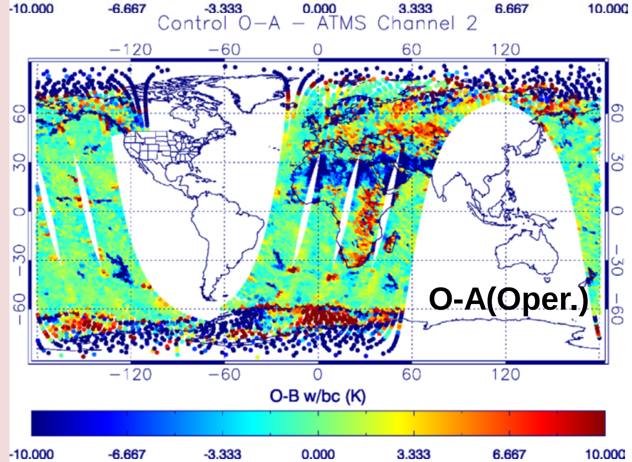
Slide courtesy of Galina Chirokova and Mark DeMaria

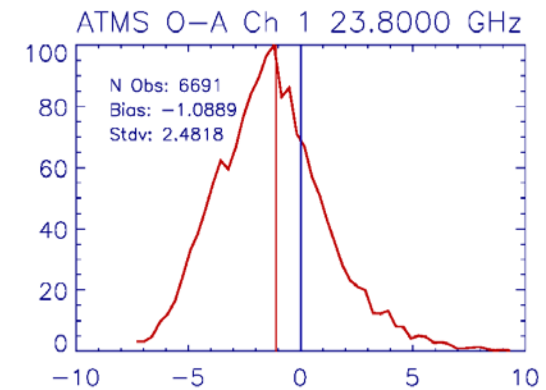
Data Assimilation Applications (MIIDAPS)

- **Efforts are on going to:**
  - Use MiRS technology (1DVAR) as a pre-processor to NWP
  - Allows uniform quality control of satellite data, rain and ice detection, coast contamination, RFI for imagers, etc
  - Implement dynamically-retrieved emissivity in the NWP
  - Assess assimilating sounding products in cloudy/rainy conditions



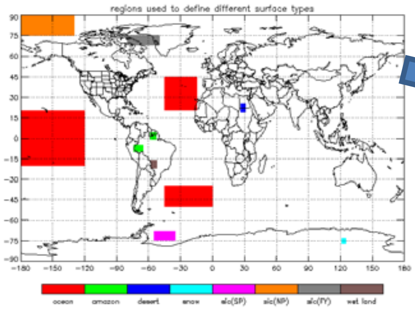


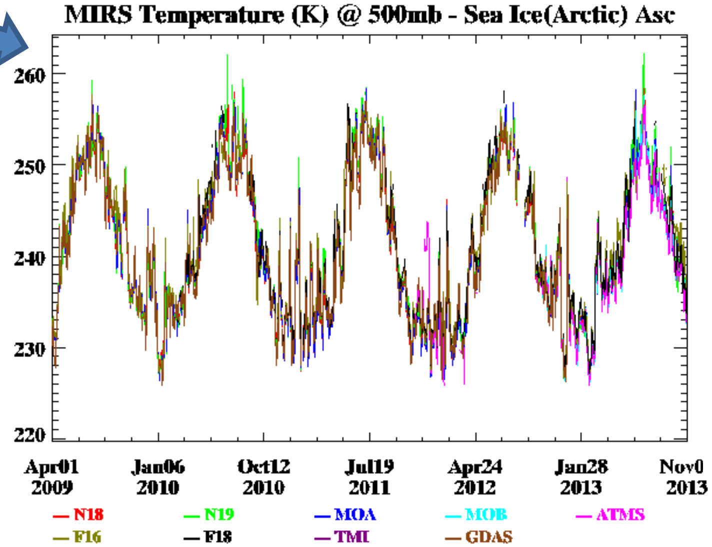




Goal is to have a community QC tool for satellite data assimilation pre-processing:
extend the MIIDAPS to all Sensors (IR & MW, geo/Pol)

Time series of MiRS-derived Products

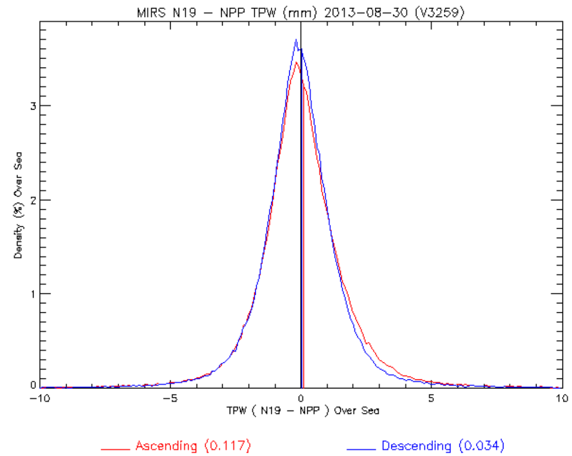




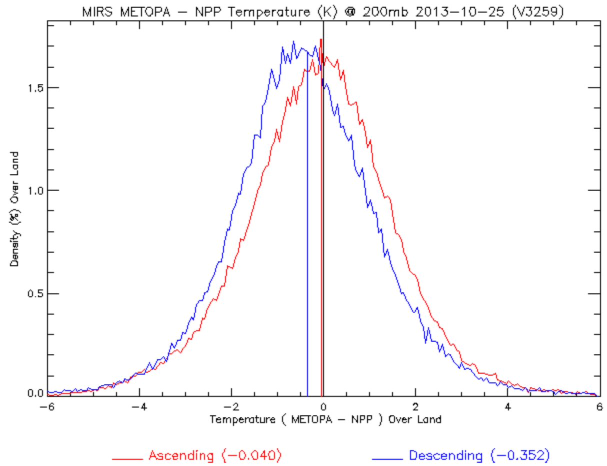
One algorithm approach
One radiative transfer
One set of assumptions,

Applied to all sensors, in all areas

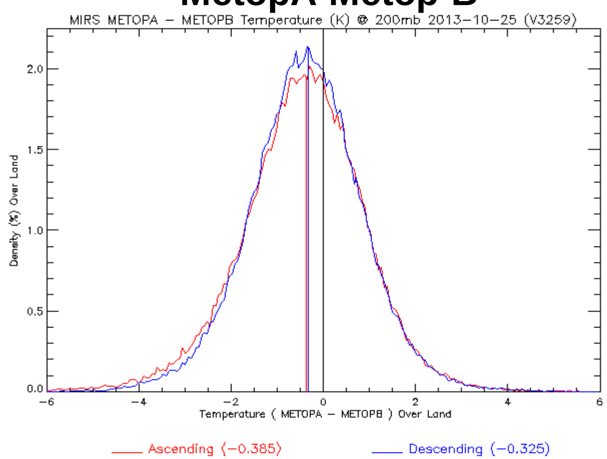
In theory should make interpretation easier



T(p) at 200mb over land (global) MetopA-SNPP



T(p) at 200mb over land (global) MetopA-Metop-B



Contents

Recommendation & Future Plans

- ***On-Going & Planned:***
  - Megha-Tropiques SAPHIR
  - GCOM-W AMSR-2
  - High spatial Resolution for existing sensors
  - To new Products: Sea Ice Age, Snow grain size
  - New Science: Dynamic Background (emissivity, sounding etc)
  - Extended validation using independent evaluations (RR, Soundings, SIC, IWP, Emiss, etc)
- ***Leveraging NOAA Activities in Support of JCSDA:***
  - Strong coordination with JCSDA activities (MIIDAPS)
  - CRTM constant improvements
  - Cloudy& rainy radiance assimilation
  - Extension of MIIDAPS to IR sensors could benefit MiRS
  - Access to S4 supercomputer
- ***Conclusions & Recommendations:***
  - MiRS is the consolidated algorithm at NOAA, for processing microwave sensors
  - It is applicable to ~10 sensors, to produce ~7-13 products for each sensor
  - It is expected it will be applied to JPSS ATMS sensors and GCOM-W AMSR2
  - Extension to IR, done in the context of MIIDAPS, could extend applicability

BACKUP SLIDES

BACKUP

Hurricane Rapid Intensification

MiRS/ATMS T,RH profiles used to compute ***(case of Hurricane Leslie, 2012)*****:**

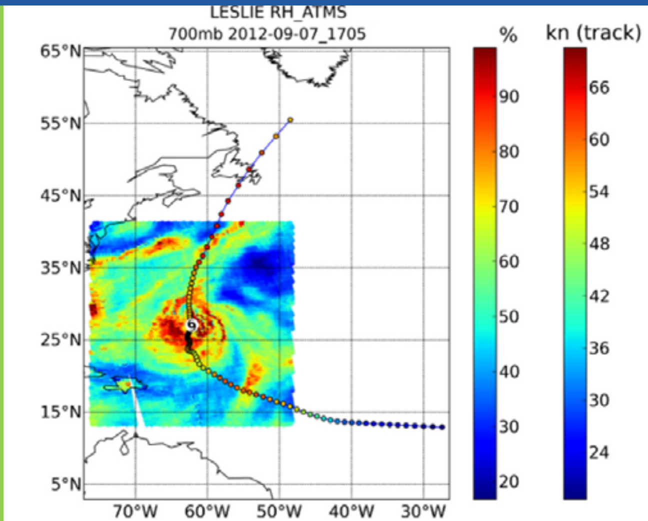
-Radial-height cross section

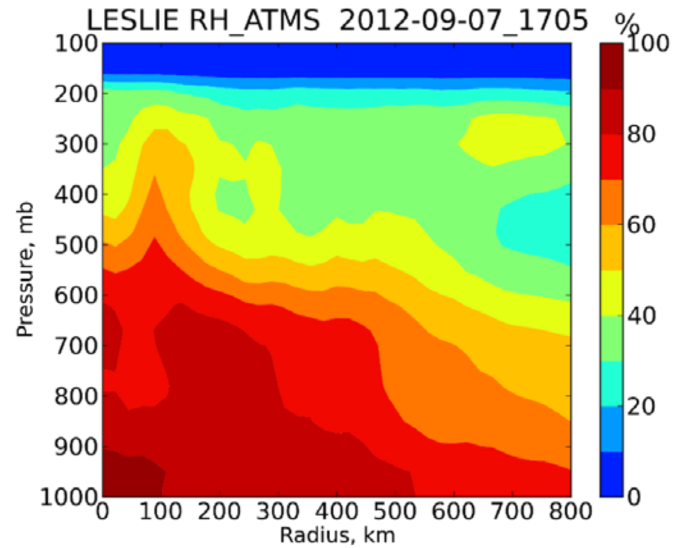
- Temperature Anomaly

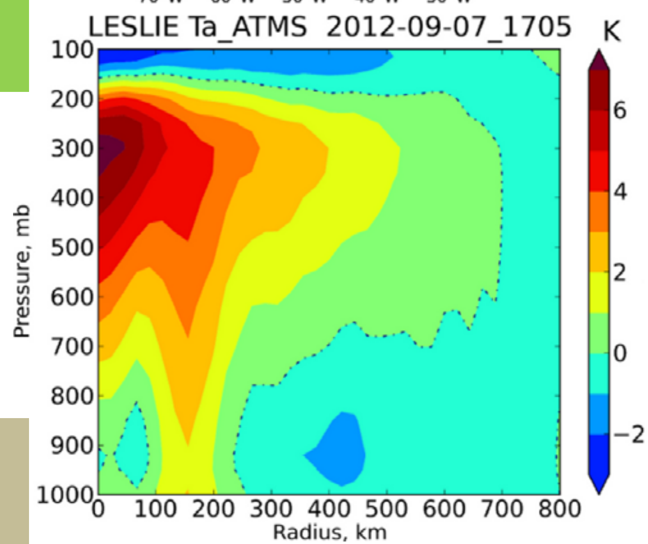
-500-800mb averaged values

These are fed to :
- Maximum Potential Intensity (**MPI**) algor.

MPI is then fed to :
- Rapid Intensification Index (**RII**) algor.



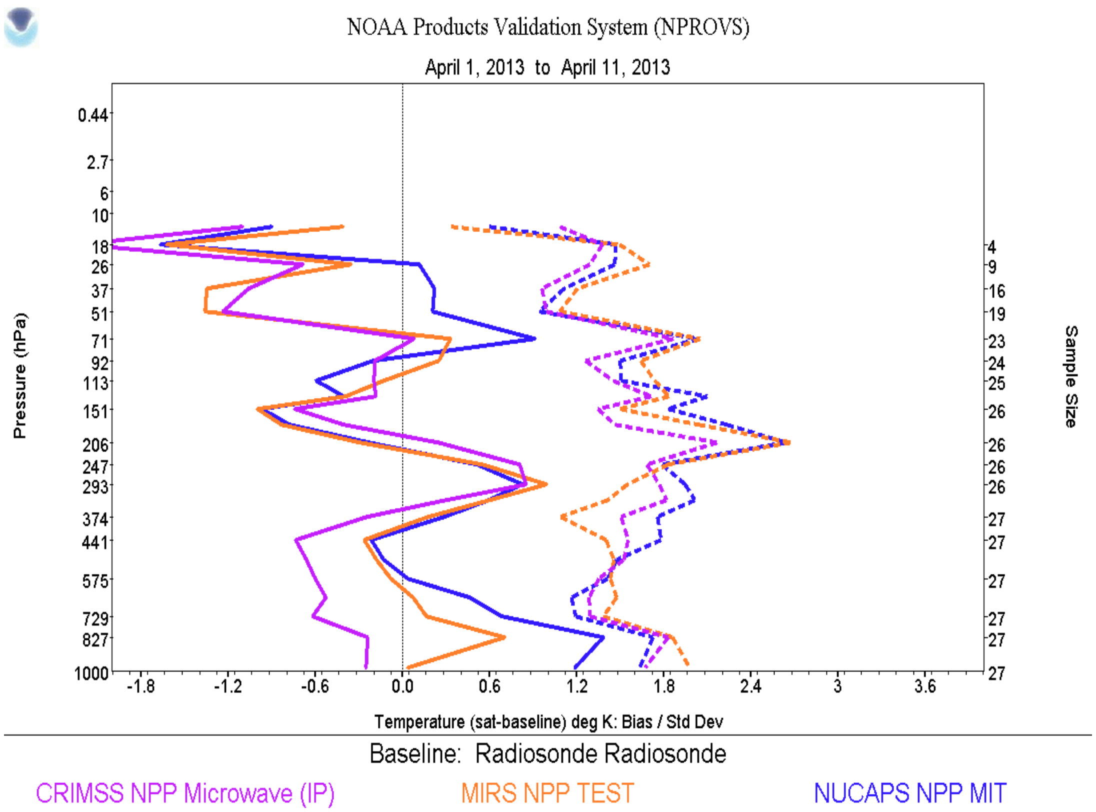




1. Average T, RH between r = 500 to 800 km to get $\overline{T}(p)$, $\overline{RH}(p)$
2. Input $\overline{T}(p)$, $\overline{RH}(p)$ environmental profiles to Emanuel (1988) MPI algorithm
3. Replace empirical MPI with ATMS MPI in RII and models

Slide courtesy of Galina Chirokova and Mark DeMaria

MiRS sounding assessment via NPROVS

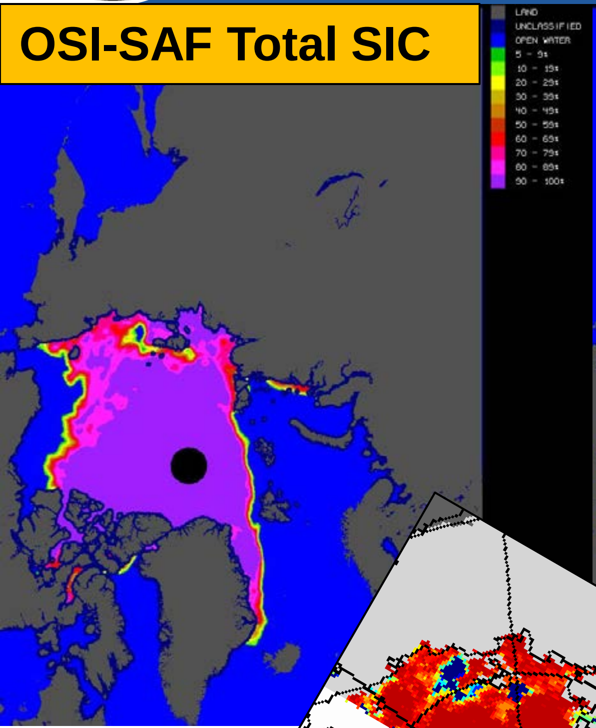


NPROVS performs assessment and intercomparisons by comparing several algorithms/ sevaral sensors to common reference of radiosondes

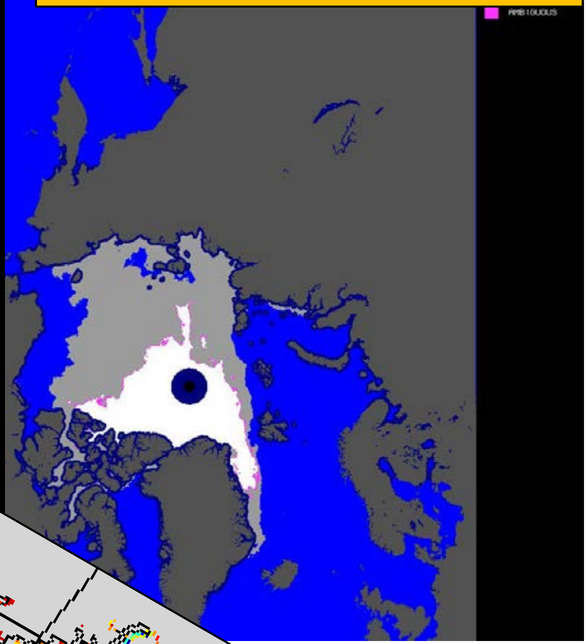
Slide courtesy of the Bomin Sun and Tony Reale (NPROVS project)

AMSR-2 Cryospheric Products

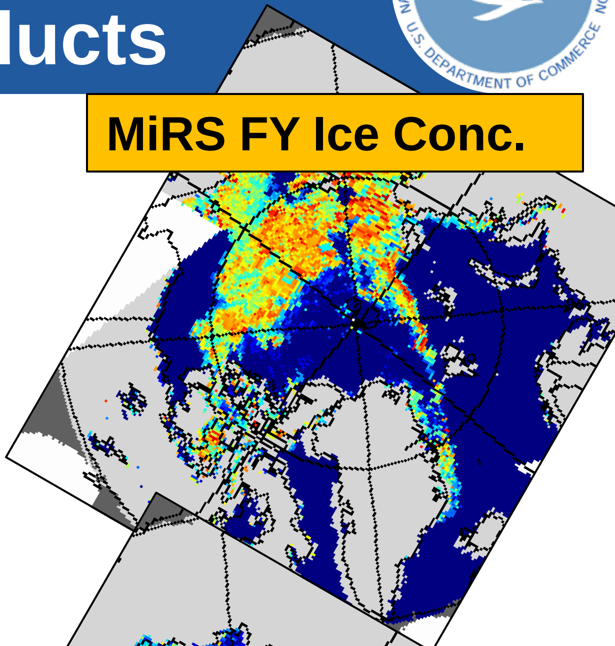
OSI-SAF Total SIC

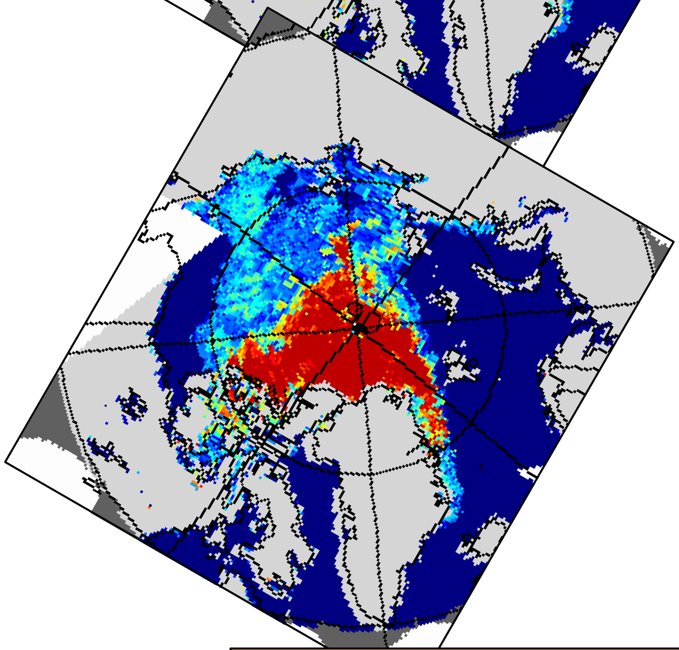


OSI-SAF Total Ice Type

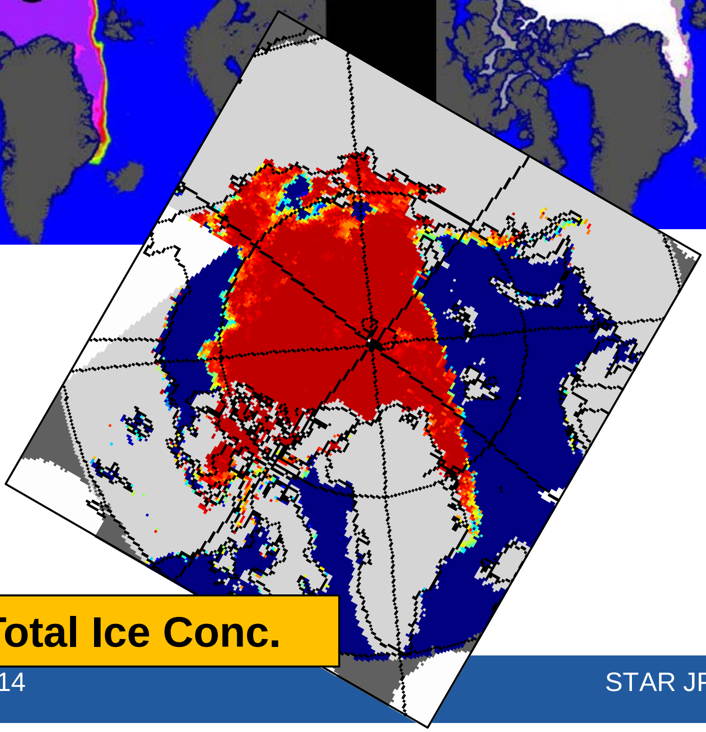


MiRS FY Ice Conc.



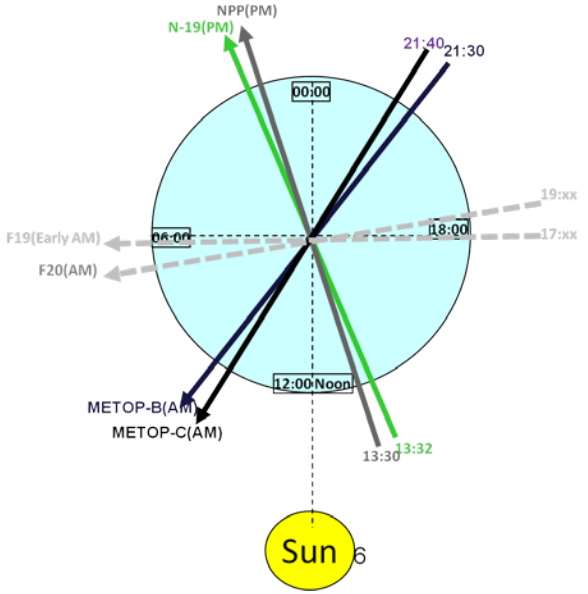


MiRS MY Ice Conc.

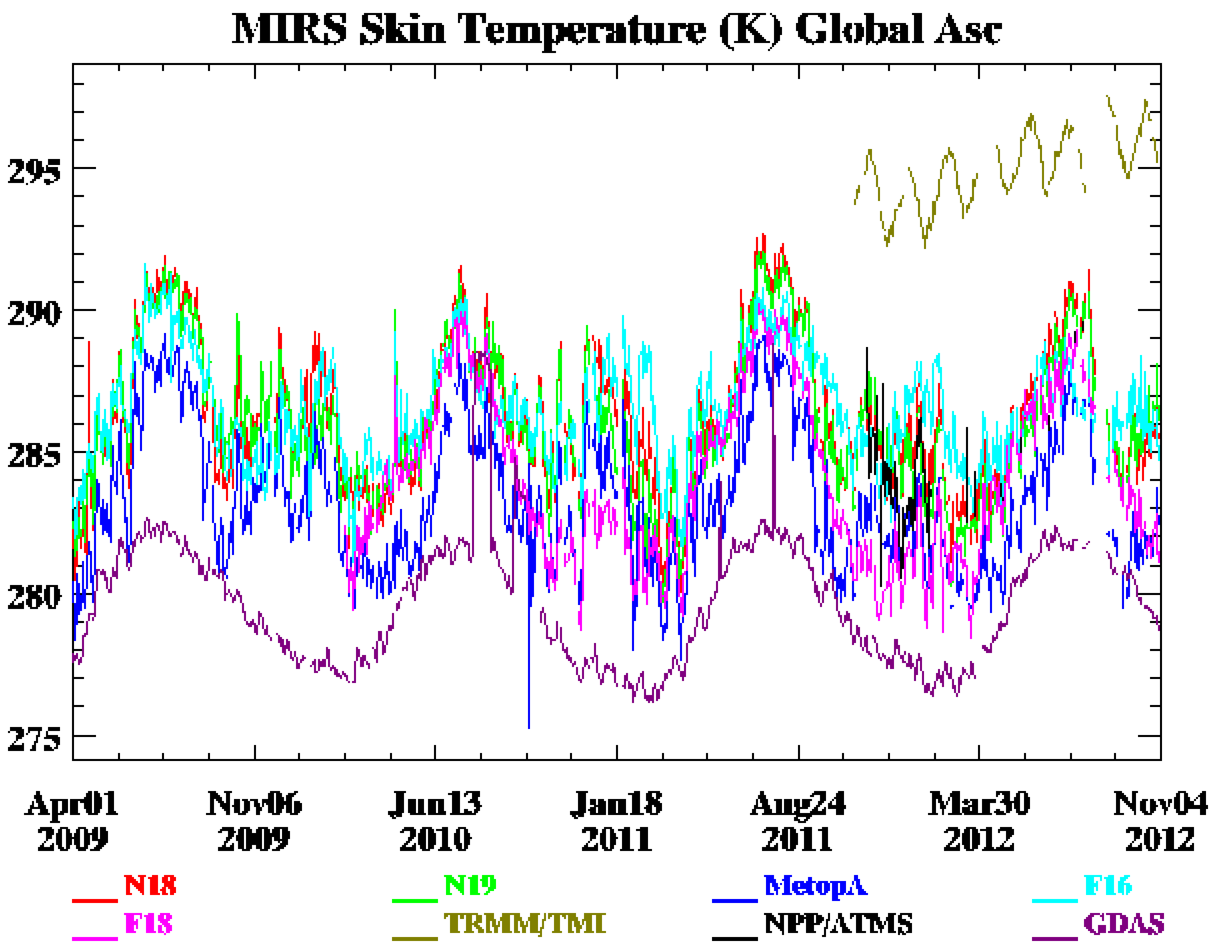


MiRS Total Ice Conc.

Inter Consistency in MiRS Retrievals for Climate Applications



Example of Tskin



Importance of the diurnal cycle and sensor measurement sampling in time and space

Advantages & Disadvantages of MiRS

- **Pros:**
  - Flexible and physical approach
  - Highly cost-effective: Cost to extend to new sensors greatly reduced (avoids stove-piping on both the sensors side and the products side).
  - MiRS can be consistently applied to sounders, imagers and combinations
  - MiRS uses the CRTM as forward operator (leverage of resources and science)
  - Applicable consistently on all surfaces and runs in all-weather conditions
  - Dual application for inversion and satellite data assimilation
- **Cons:**
  - Computationally expensive, although highly parallelizable (1D processing)
  - Cost effective approach, but need to sustain expertise in sounding, cryosphere, hydrometeors, surface emission, radiative transfer, calibration, etc in a single team (requires an efficient and strongly multi-disciplinary team)
  - Heavy constraints on the science approach: MiRS expected performances are the same as the single-product, single-sensor type algorithms, but with the significant added constraint that all parameters should fit all measurements simultaneously (keeps all results in check)

NOAA Unique CrIS ATMS Processing System and Validation

Quanhua (Mark) Liu, Tony Reale, (Soundings EDR)
Chris Barnet,Antonia Gambacorta,Nick Nalli,
Xiaozhen Xiong,Chanyyi Tan,Flavio Iturbide-Sanchez,
Ralph Ferraro,Walter Wolf, and Mitch Goldberg

STAR/JPSS Annual Science Meeting
May 13, 2014

Outline

- Overview
  - Sounding product users and applications
  - Requirements
  - Teams
- NUCAPS Product Status
- NUCAPS Product Validation
  - Global products
  - Global validation against radiosondes
  - NUCAPS product validation during AERONET expedition
- Future Plans
- Summary

Sounding Product Users and Applications

- CLASS
- AWIPS-II
- FNMOC – Fleet Numerical Meteorology and Oceanography Center
- Nowcasting
- Direct broadcast
- Support SDR data monitoring, retrieval products and SDR have the same time, the same location, and the same footprint.
- Timely temperature and moisture profiles for the warning of severe weather (Mark DeMaria) , e.g. atmospheric stability condition for tropical storm. For tornado warning, retrieval products of higher spatial resolution (~ 10 km) is needed.
- Carbon products for climate studies
- Air quality monitoring: Trace gas CO, HNO_3, O_3, SO_2 profiling, a flag indicating the presence of dust and volcanic emissions.
- Trace gas product for NWP radiance assimilation on temperature, water vapor, and ozone.

JPSS Program Level-1 Requirements, v2.9, 6/27/2013

AVTP Applicable Conditions: 1. All Scenes (cloud-free, partly cloudy, cloudy)	
a. Horizontal Cell Size	
1. Nadir	50 km (1)
b. Vertical Reporting Interval	
1. Surface to 850 mb	20 mb
2. 850 mb to 300 mb	50 mb
3. 300 mb to 100 mb	25 mb
4. 100 mb to 10 mb	20 mb
5. 10 mb to 1.0 mb	2 mb
6. 1.0 mb to 0.5 mb	0.2 mb
c. Mapping Uncertainty, 3 Sigma	5 km
d. Measurement Uncertainty - Expressed as an error in layer average temperature	
1. Cloud-Free to Partly Cloudy, Surface to 300 mb over ocean (2)	1.6 K per 1 km Layer
2. Cloud-Free to Partly Cloudy, 300 mb to 30 mb (2)	1.5 K per 3 km layer
3. Cloud-Free to Partly Cloudy, 30 mb to 1 mb (2)	1.5 K per 5 km layer
4. Cloud-Free to Partly Cloudy, 1 mb to 0.5 mb (2)	3.5 K per 5 km layer
5. Cloudy, Surface to 700 mb (3)	2.5 K per 1 km layer
6. Cloudy, 700 mb to 300 mb (3)	1.5 K per 1 km layer
7. Cloudy, 300 mb to 30 mb (3)	1.5 K per 3 km layer
8. Cloudy, 30 mb to 1 mb (3)	1.5 K per 5 km layer
9. Cloudy, 1 mb to 0.5 mb (3)	3.5 K per 5 km layer

Infrared ozone profile:
globally, day and night
From surface to 30 hPa, same requirements
on precision, accuracy,
and uncertainty as UV ozone-NP.

AVMP Applicable Conditions: 1. All scenes (cloud-free, partly cloudy & cloudy)	
a. Horizontal Cell Size	
1. Nadir	50 km (1)
b. Vertical Reporting Interval	
1. Surface to 850 mb	20 mb
2. 850 mb to 100 mb	50 mb
c. Mapping Uncertainty, 3 Sigma	5 km
d. Measurement Uncertainty (expressed as a percent of average mixing ratio in 2 km layers)	
1. Cloud-Free to Partly Cloudy, Surface to 600 mb (2)	Greater of 20 % or 0.2 g kg^{-1}
2. Cloud-Free to Partly Cloudy, 600 mb to 300 mb (2)	Greater of 35 % or 0.1 g kg^{-1}
3. Cloud-Free to Partly Cloudy, 300 mb to 100 mb (2)	Greater of 35 % or 0.1 g kg^{-1}
4. Cloudy, Surface to 600 mb (3)	Greater of 20 % or 0.2 g kg^{-1}
5. Cloudy, 600 mb to 400 mb (3)	Greater of 40 % or 0.1 g kg^{-1}
6. Cloudy, 400 mb to 100 mb (3)	Greater of 40 % or 0.1 g kg^{-1}

~50 km at nadir,
all 9 CrIS FOVs are used to produce one FOR sounding,

cloudiness	= 0%	Free
	> 0% and <= 50%	Partly cloudy
	> 50%	Cloudy

Refresh: at least 90% of the global every 18 hours (monthly average)

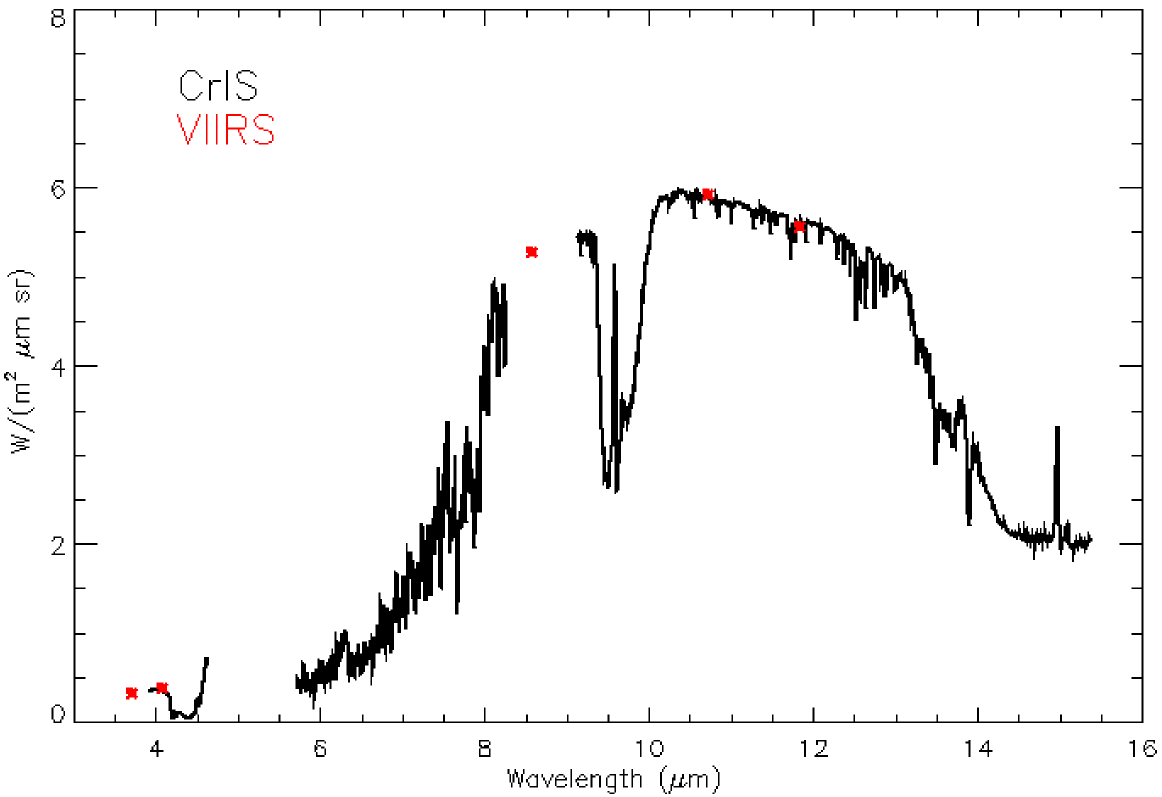
JPSS-1 Requirements

EDR Attribute	CO	CO_2	CH_4
Vertical Coverage	Total Column	Total Column	Total Column
Horizontal Resolution	100 km	100 km	100 km
Mapping Uncertainty, 3 sigma	25 km	25 km	25 km
Measurement Range	0 – 200 ppbv	300 – 500 ppmv	1100 – 2250 ppbv
Measurement Precision	35%	0.5% (2 ppmv)	1% (~20 ppbv)
Measurement Accuracy	±25%	±1% (4 ppmv)	±4% (~80 ppbv)
Refresh	24 h	24 h	24 h
Note			

Teams and Members

Lead for Activity	Organization	Task
Anthony Reale	NOAA/NESDIS/STAR	NPROVS and NPROVS+ operational RAOB comparisons
Quanhua (Mark) Liu	NOAA/NESDIS/STAR	A. Gambacorta (algorithm lead), N. Nalli (VALAR validation system), X. Xiong, C. Tan, F. Iturbide-Sanchez
Chris Barnet	STC	NOAA CrIS/ATMS EDRs in complex weather regimes
Xu Liu	NASA/LaRC	CrIS/ATMS EDR Assessment
Dave Tobin	SSEC, U. Wisconsin	ARM-RAOBS
James H. Mather	DOE Battelle Pacific Northwest National Laboratory	RAOBS, Validation

CrIS and ATMS SDR Data



SDR	Number of channels
ATMS	22, temperature/water vapor
CrIS	399 in total
window	24
temperature	87
water vapor	62
ozone	53
CO	27
N2O	24
HNO3	28
CH4	54
SO2	24
CO2	53

CrIS/ATMS SDR are used in the retrieval

NUCAPS Sounding Products Released at NOAA CLASS since April 8, 2014

- Atmospheric Vertical Temperature Profile
- Atmospheric Vertical Moisture Profile
- Infrared Ozone Profile

- (requirement: total column)
- Vertical CO Profile
- Vertical CO_2 Profile
- Vertical CH_4 Profile
- Outgoing Longwave Radiation (OLR)

- (new)
- Vertical HNO_3 Profile
- Vertical N_2O Profile
- Vertical SO_2 Profile
- A flag indicating the presence of dust and volcanic emissions
- Cloud-Cleared Radiances

- **Integrated Retrieval System for CrIS/ATMS, IASI/AMSU, and AIRS/AMSU**

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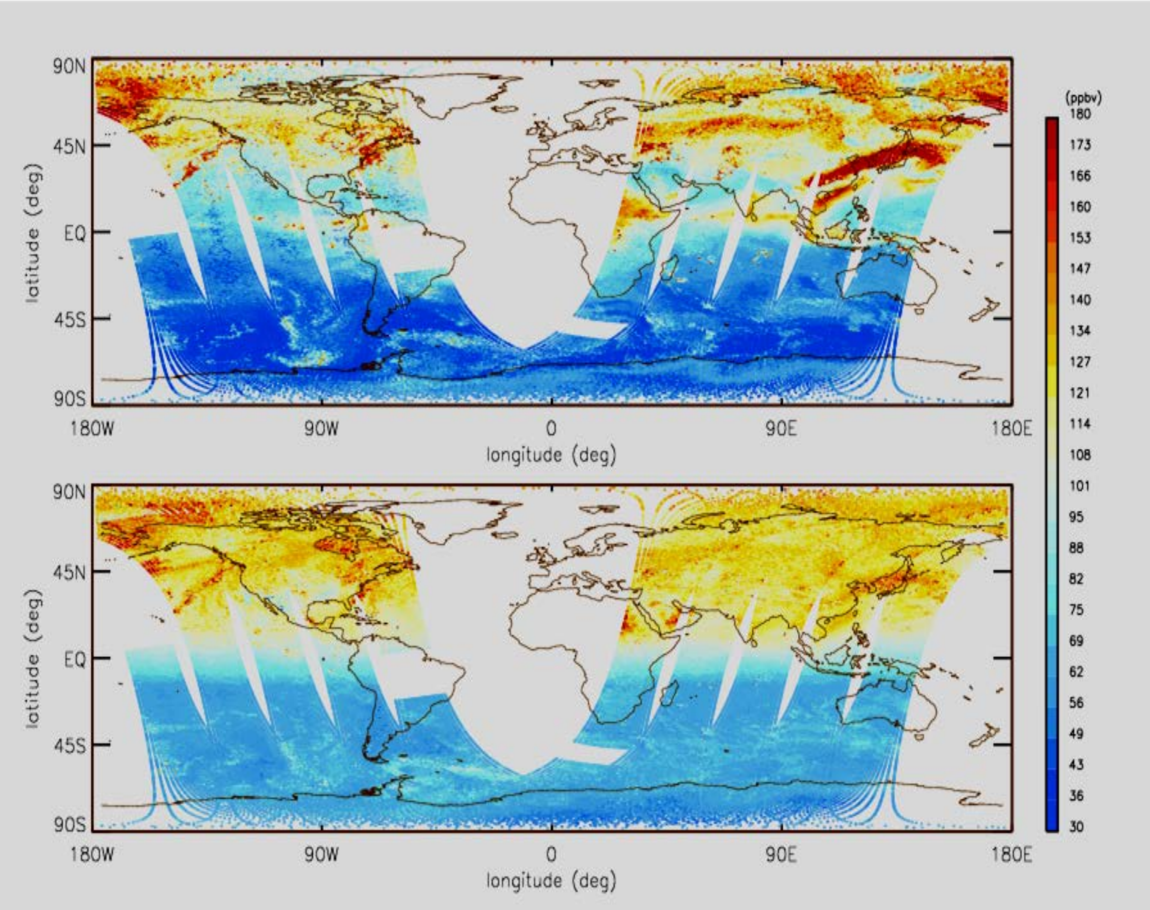
CO High Spectral Resolution vs Operational Low Resolution Results



NUCAPS CO retrieval (~450 hPa)

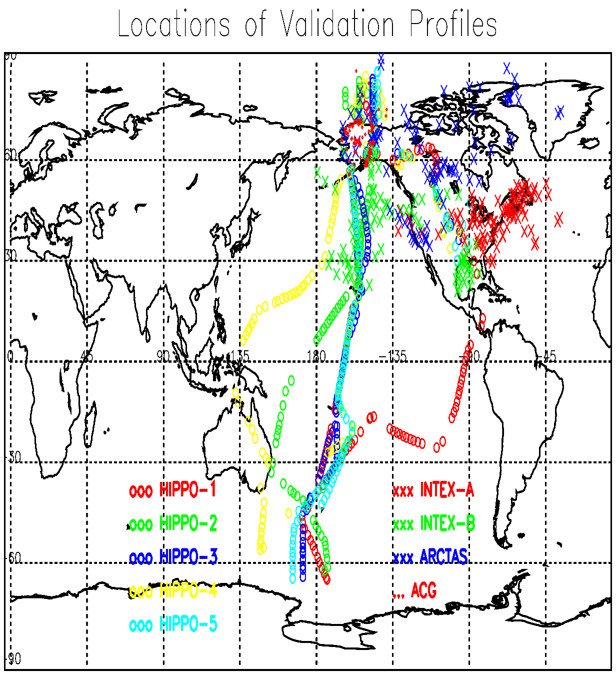
high

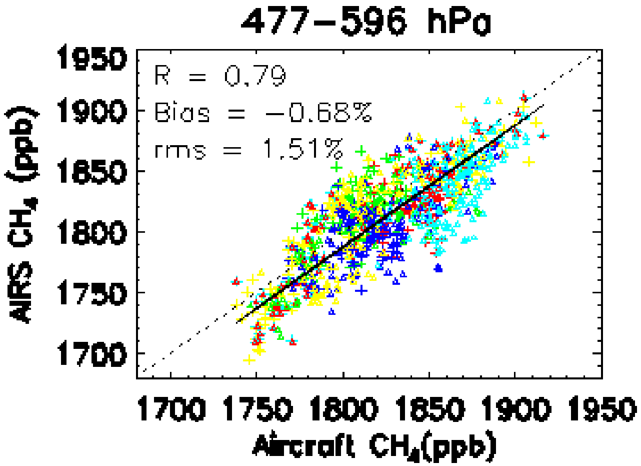
low

- The higher information content enables a larger departure from the a priori, hence the increased spatial variability observed in the high spectral resolution map (top left) compared to the low resolution (bottom left).
- A demonstration experiment in support for the need of high spectral resolution CrIS measurements.
- NUCAPS modular architecture has proven that there is no risk of disruption to the operational processing upon switching to high spectral sampling. (Ref. Gambacorta et al. 2013, IEEE Letters)

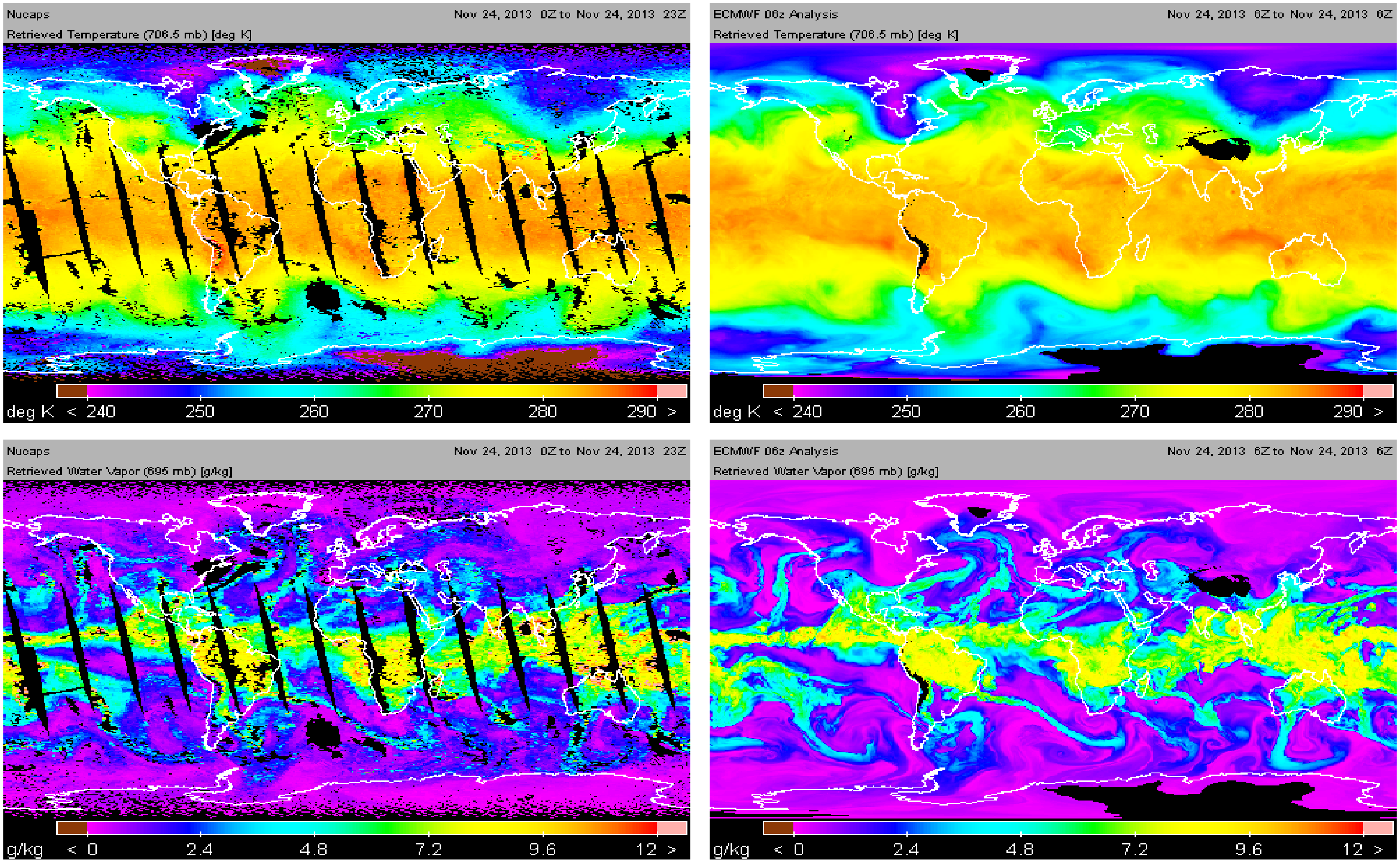
Current Status for Trace Gases

1. Started with Chris Barnet, STAR has been actively involved in CO_2, CO, CH_4, N_2O, HNO_3 and SO_2 retrievals using AIRS and IASI. Similar algorithm has been implemented in NUCAPS.
2. Dr.Xiaozhen Xiong took charge of the AIRS-v6 CH_4 product and its validation, and has published several papers (JGR,2008; ACP, 2009; Remote Sensing, 2010; JGR, 2011; GRL, 2013);
3. IASI CH_4 product has been validated with optimized QC (Xiong et al., 2013, AMT);
4. Significant improvement in N_2O retrieval using AIRS was recently made (Xiong et al, 2014, JGR, under revision).
5. Using AIRS and IASI to validate GOSAT (Japan) TIR CH_4 product since 2010 (MOU between STAR and NIES, Japan);





NUCAPS vs ECMWF, T and H_2O

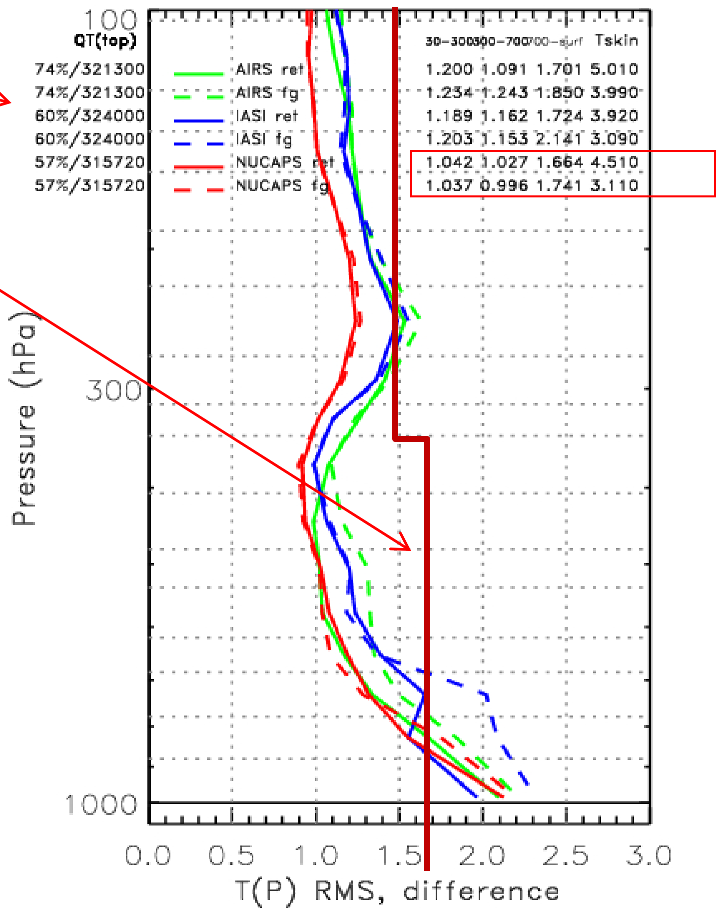


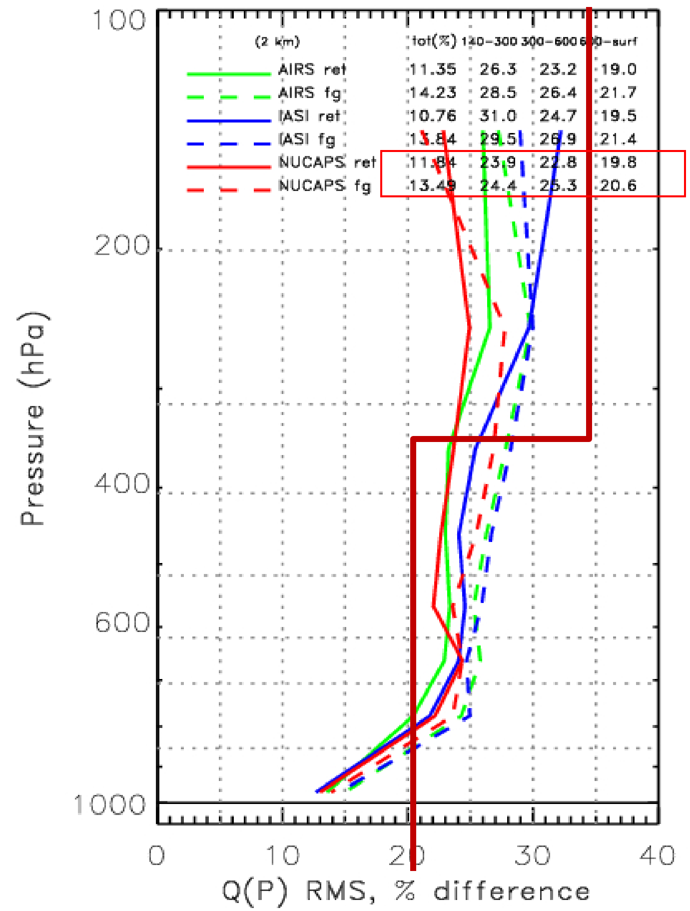
Black indicate where IR+MW and MW-only failed qc …

CrIS IASI AIRS (2012-05-15)
Global RMS Statistics vs ECMWF Analysis

QA Acceptance Yield

Vertical red bars indicate JPSS specification requirements

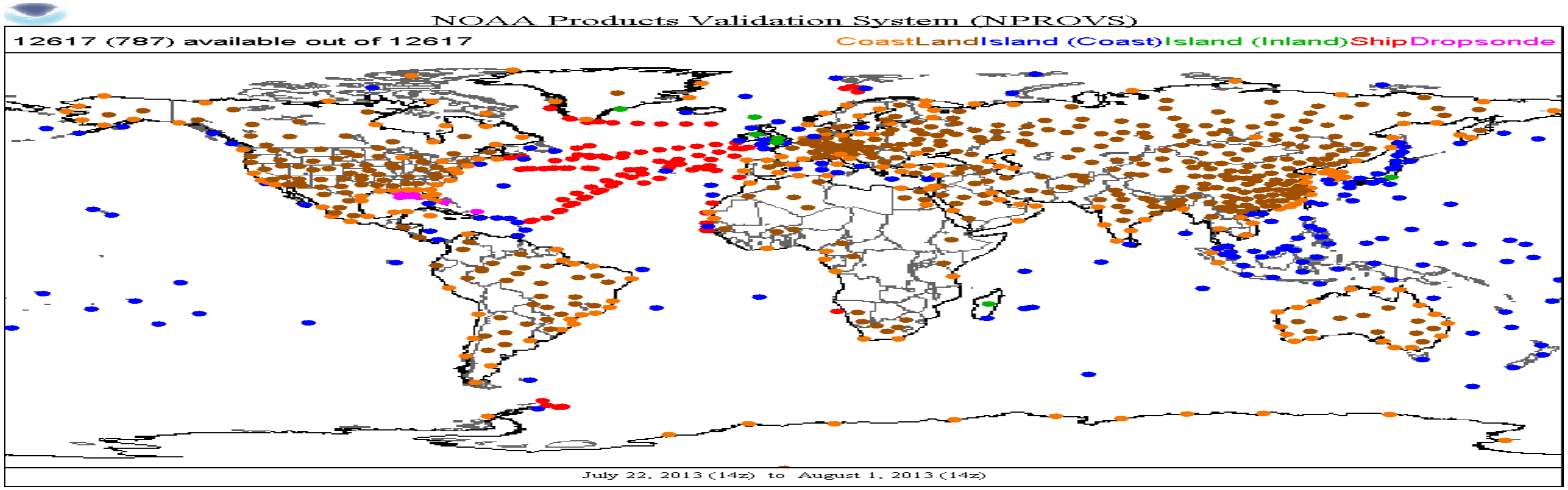




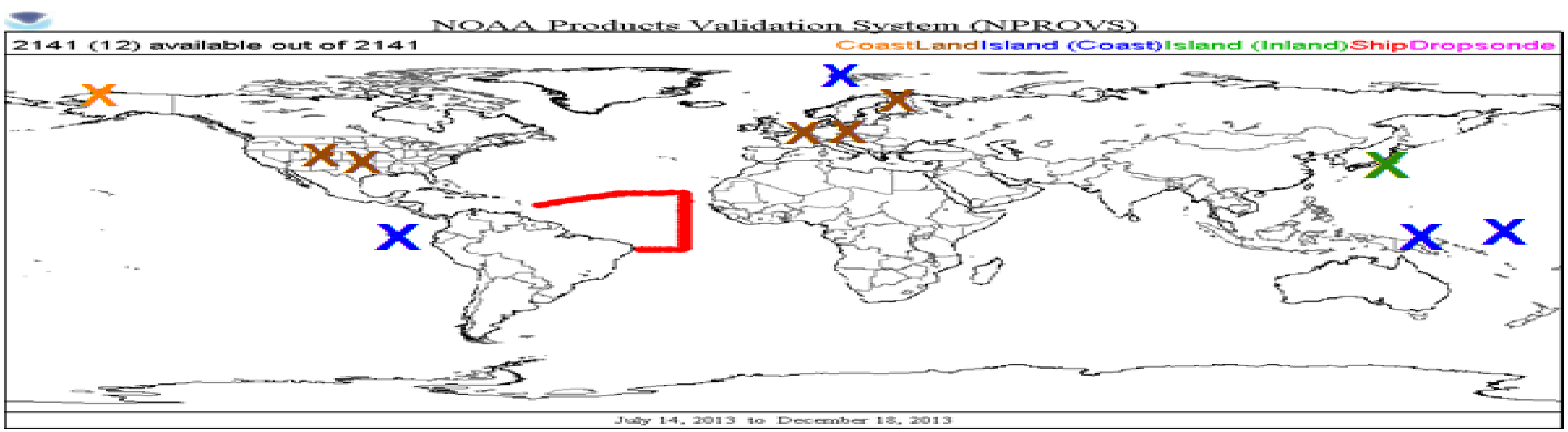
- Retrieval performance is stable and consistent across the three platforms.
- CrIS comparable to AIRS and IASI (10+ year maturity systems)
- Physical retrieval (solid) shows significant departure from first guess (dash line)

EDR Validation against RAOB

N P R O V S

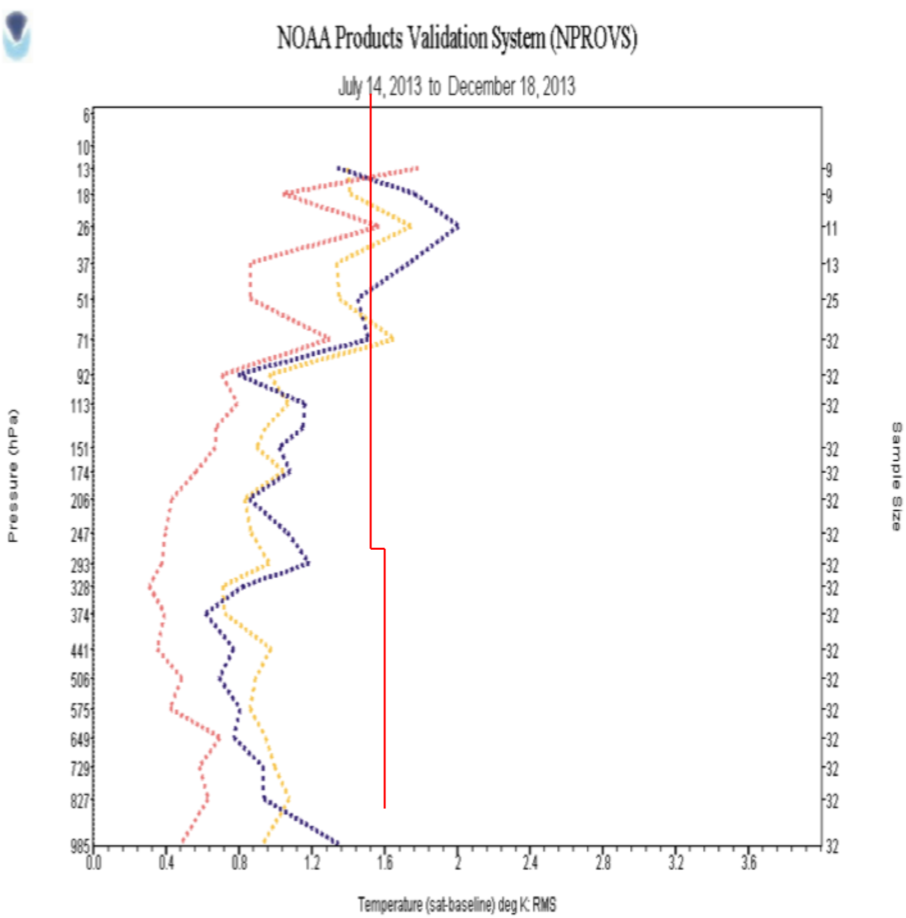


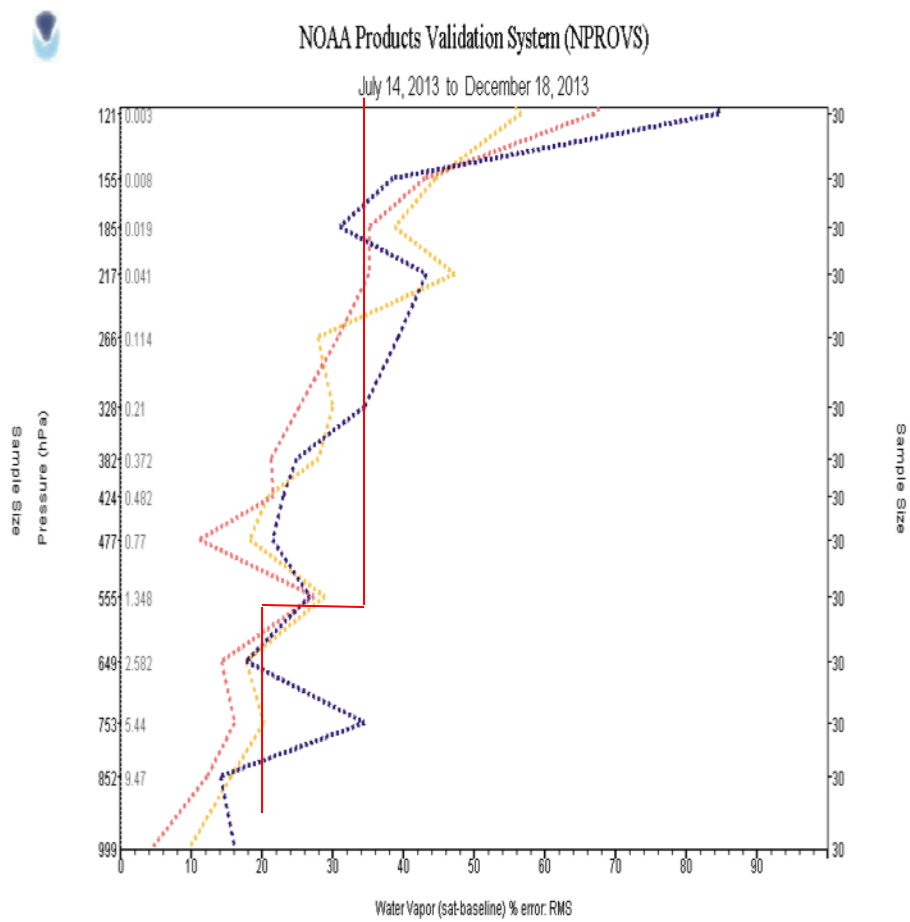
NPROVS+



2050 collocations (350 Dedicated, 1700 GRUAN) ... 5mos

NPROVS and NPROVS+ EDR Validation Results





Baseline: REFERENCE SONDE GRUAN RAOB

CRIMSS NPP Infrared (IP) **ECMWF ANALYSIS** **NUCAPS NPP TEST**

Baseline: REFERENCE SONDE GRUAN RAOB

CRIMSS NPP Infrared (IP) **ECMWF ANALYSIS** **NUCAPS NPP TEST**

IR + MW Pass QC … AEROSE only

Progress on the NUCAPS Microwave-Only Retrieval Improvement

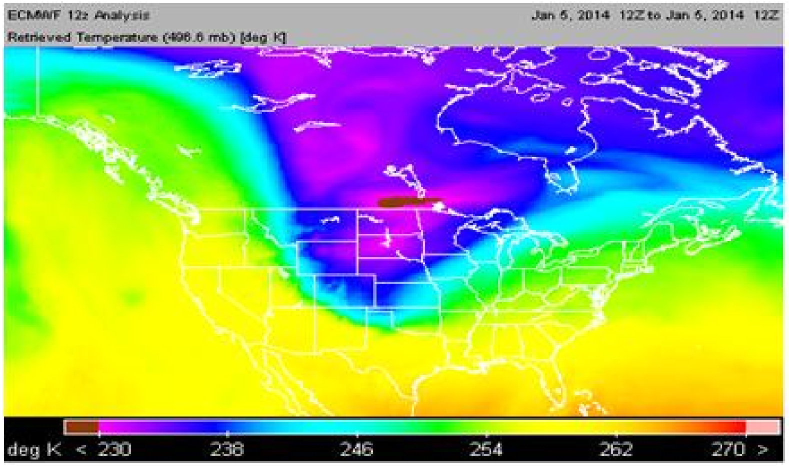
1) **NUCAPS MW-only retrieval has a problem over polar-vortex area.**

2) **The NUCAPS MW-only physical retrieval result hasn't been used in IR+MW retrieval.**

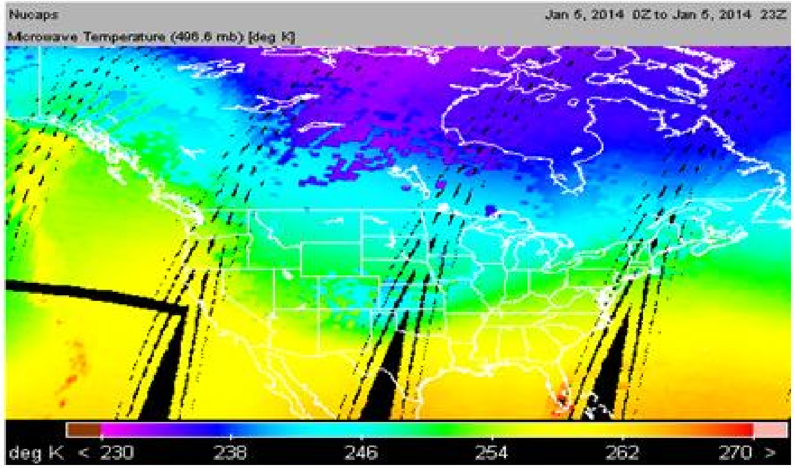
3) **Revise MW-only retrieval algorithm.**

4) **Pass MW-only physical retrieval results to IR+MW retrieval.**

ECMWF Temperature @496 hPa

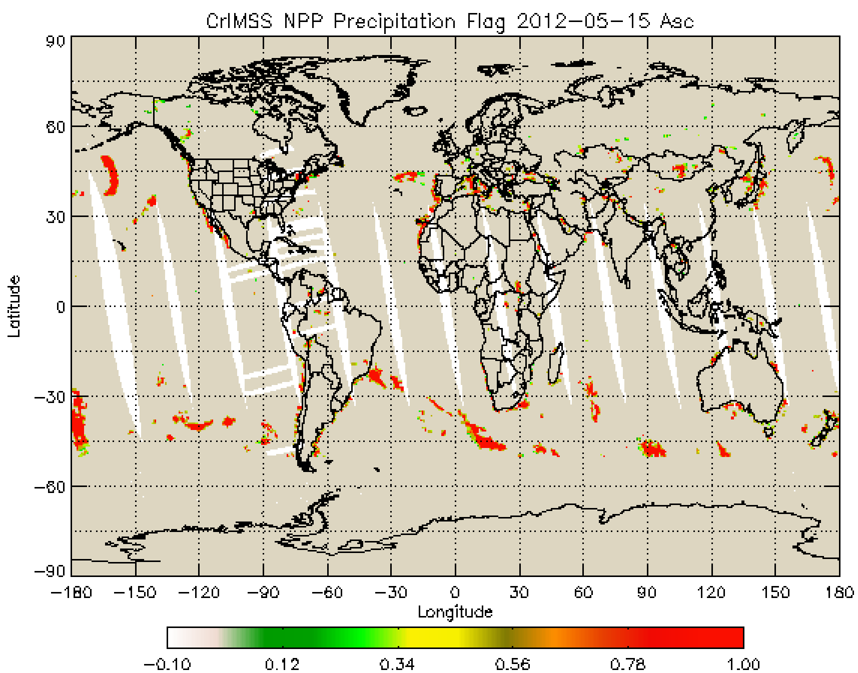


NUCAPS Temperature @496 hPa

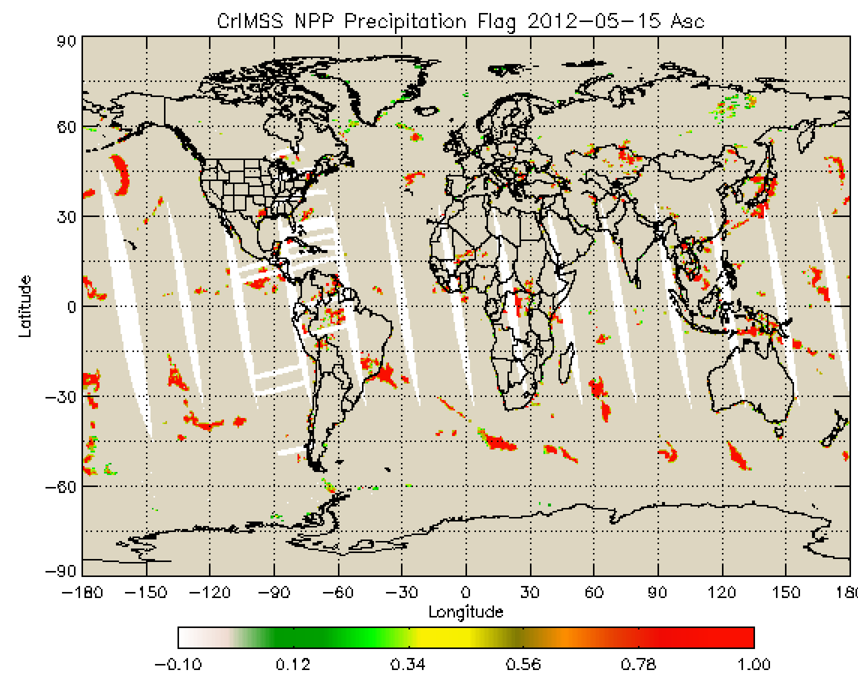


CrIMSS Precipitation Detection Algorithm for Ocean/Land Surfaces

- The new CrIMSS precipitation algorithm has improved the detection of precipitation and provided the confident rain flag to users.
- The new algorithm has not been implemented into IDPS.
- We will investigate the new algorithm for NUCAPS.
- Wenze Yang, Flavio Iturbide-Sanchez, Ralph Ferraro, Murty Divakarla, and Tony Reale, “Evaluation and Improvement of the S-NPP CrIMSS Rain Flag”. AMS 2014.



old



new

Session 5d: Soundings Breakout Session (Conf. Room 2552/2553)

Co-Chairs: Mark Liu/Tony Reale

Tomorrow 10:20 – 17:00

1120 - 1140	*Validation of CrIS Dual Regression Sounding Products during the Airborne Suomi-NPP Cal/Val Campaign*	Bill Smith	CMISS UW and Hampton University
1140 - 1200	*Analysis of CrIS/ATMS sounding data with an AIRS Version 6-like retrieval algorithm*	Joel Susskind	NASA/GSFC
1200 - 1330	*Lunch*		
1330 - 1350	*Status of the NOAA Hyper Spectral Infrared + Microwave Retrieval Algorithm*	Antonia Gambacorta	STAR
1350 - 1410	*Recent analysis of the NOAA CrIS/ATMS EDRs in complex weather regimes*	Chris Barnet	STC
1410 - 1430	*What can we learn from 11 years of AIRS observations?*	Eric Fetzer	NASA/JPL
1430 - 1450	*Single Field of View ATMS/CrIS Sounding Products Under All Sky Condition*	Xu Liu	NASA/LaRC
1450 - 1510	*MiRS Science Improvements and Sounding Product Performance for S-NPP/ATMS*	Christopher Grassotti/Jerry Zhan	STAR
1510 - 1530	*Break*		
1530 - 1550	*Updates on NUCAPS Operational Products and Services*	Awdhesh Sharma	NOAA/OSPO
1550 - 1610	*The NOAA PROducts Validation System and Plus*	Tony Reale, Bomin Sun	STAR
1610 - 1630	*Applications using Satellite Sounder Products at the NASA SPoRT Center*	Emily Berndt	NASA/SPoRT
1630 - 1650	*Validation of NUCAPS Operational Retrieval Products*	Nick Nalli	STAR
1650 - 1710	*GPS Units in the Pacific Region*	Bill Ward	NWS /PRH/ESSD
1710 - 1730	*The need for atmospheric chemistry products from CrIS*	Monika Kopacz	NOAA Climate Program Office

Future Plans

- MW-only retrieval (i.e. retrieval under cloudy condition) wasn't required for NUCAPS originally. It's the JPSS requirement.
- Revise Microwave Physical Retrieval for NUCAPS.
- Using MW Retrievals as the First Guess for IR Retrieval (Cloudiness < 50).
- NPROVS and NPROVS+ for Validations of NUCAPS and Uncertainty Estimation.
- Carbon Products (CO_2, CO, and CH_4), J1 new requirements, no F14 funding, scheduled in 2015.
- CrIS full spectral resolution retrieval.
- Integrated Sounding System for CrIS/ATMS, IASI/AMSU, and AIRS/AMSU

Summary

- Our validations showed that NUCAPS IR+MW sounding products meet threshold performance in general.
- MW only sounding product has problems that will be fixed.
- NUCAPS generates trace gas products, but they need to be evaluated and improved.
- A concern about information content over used.
- Integrated Sounding System for CrIS/ATMS, IASI/AMU, and AIRS/AMSU.

Status of Ozone Products

L. Flynn, Team Lead

with contributions from members of the
NOAA JPSS OMPS Ozone Products Team
and
NASA S-NPP OMPS Science Team

May 12, 2014
NOAA STAR JPSS Science Meeting

Outline

- Requirements,
- Team Members
- Instruments/ Measurements
- Products (performance)
- Algorithms
  - Descriptions
  - Recommendations / Paths Forward
- Validation and Applications
- Challenges

Table 2.1.3 - Ozone Total Column

EDR Attribute	Threshold (1,2)	Objective
a. Horizontal Cell Size	50 x 50 km^2 @ nadir (10)	10 x 10 km^2 (10)
b. Vertical Cell Size	0 - 60 km	0 - 60 km
c. Mapping Uncertainty, 1 Sigma (3)	5 km at Nadir (3)	5 km
d. Measurement Range	50 - 650 milli-atm-cm	50-650 milli-atm-cm
e. Measurement Precision (4)		
1. X < 0.25 atm-cm	6.0 milli-atm-cm (4,5)	1.0 milli-atm-cm
2. 0.25 < X < 0.45 atm-cm	7.7 milli-atm-cm (4,5) ~ 2%	1.0 milli-atm-cm
3. X > 0.45 atm-cm	2.8 milli-atm-cm + 1.1% (4,5)	1.0 milli-atm-cm
f. Measurement Accuracy (6)		
1. X < 0.25 atm-cm	9.5 milli-atm-cm (6,5)	5.0 milli-atm-cm
2. 0.25 < X < 0.45 atm-cm	13.0 milli-atm-cm (6,5) ~ 3%	5.0 milli-atm-cm
3. X > 0.45 atm-cm	16.0 milli-atm-cm (6,5)	5.0 milli-atm-cm
g. Latency	120 min. (7)	15 min
h. Refresh	At least 90% coverage of the globe every 24 hours (monthly average) (8)	24 hrs. (8)
i. Long-term Stability (9)	1% over 7 years	0.5% over 7 years
		v1.4.2, 7/29/11

Notes:

1. The OMPS Limb Profiler instrument does not fly on JPSS-1. Thus, only the Ozone Total Column elements are shown in this Table.
2. The loss of the OMPS Limb Profiler has had a small effect on the total column performance as the estimates of the profile shape and the tropospheric ozone are poorer, so the corrections are also poorer. There is new information that the OMPS algorithm use of the IR cloud top pressures will lead to errors as the IR values tend to be higher than the UV ones that should be used. A Discrepancy Report has

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.

OMPS LP Performance Requirements

The OMPS Limb Profiler provides global ozone observations at high vertical resolution (< 3 km). This EDR provides a measurement of ozone concentration within a specified volume.

Requirements are TBD per L1RDS V2.9 Action: Insert OMPS Limb Profiler SDR Performance Characteristics – Deferred until S-NPP Ozone Limb Profile performance is sufficiently validated to constrain the JPSS-2 instrument acquisition.

Table 3.3.1 - Ozone Limb Profile

Attribute	Threshold (1)	Objective
a. Horizontal Cell Size	250 km	100 km (7)
b. Vertical Cell Size		
1. 0 to TH (2)	N/A	3 km
2. Th to 25 km	5 km	1 km
3. 25 to 60 km)	5 km	3 km
c. Mapping Uncertainty, 1 Sigma (3)	< 25 km	25 km
d. Measurement Range		
1. 0 to TH (2)	N/A	0.01 to 3 ppmv
2. Th - 60 km	0.1 to 15 ppmv	0.1 to 15 ppmv
e. Measurement Precision		
1. 0 to TH (2)	N/A	10%
2. Th to 15 km	Greater of 10 % or 0.1 ppmv	3%
3. 15 to 50 km	Greater of 3 % or 0.05 ppmv	1%
4. 50 to 60 km	Greater of 10% or 0.1 ppmv	3%
f. Measurement Accuracy		
1. 0 to TH (2)	N/A	10%
2. Th to 15 km	Greater of 20 % or 0.1 ppmv	10%
3. 15 to 60 km	Greater of 10 % or 0.1 ppmv	5%
g. Latency	120 min. (4)	15 min
h. Refresh	At least 75% coverage of the globe every 4 days (monthly average) (5)	24 hrs (5)
i. Long-term Stability (6)	2% over 7 years	1% over 7 years
		v1.4.2, 7/29/11

Notes:

Sulfur Dioxide (SO2) Total Column EDR Description & Requirements Table – CCR in preparation

The Sulfur Dioxide Total Column EDR (also called Atmospheric SO_2) is defined as the amount of SO2 in a vertical column of the atmosphere measured in Dobson Units (milli-atm-cm). SO_2 absorption in the 305 nm to 315 nm region influence OMPS Nadir Mapper measurements of backscattered Ultraviolet radiances. Estimates of atmospheric SO_2 are obtained for three or more assumed heights for the amounts within the column averaged over the FOV from measurement residuals calculated by the OMPS total column ozone EDR algorithm. This product will continue the heritage SO_2 Index provided in the NOAA POES SBUV/2 operational Product Master File and the Atmospheric SO_2 products currently provided in NRT products from the NASA EOS Aura OMI.

Note: J1 will not have an SO_2 performance exclusion, so improved information on amounts and corrections to the ozone product will be required.

OMPS Nadir Mapper Atmospheric SO_2 Column Amount in DU*

	Threshold	Objective
a. Horizontal Cell Size:	25x25 KM^2	10X10 KM^2
b. Vertical Reporting NA	Column amount*	
c. Mapping Uncertainty, 3 Sigma	5 KM	2 KM
d. Measurement Precision	2 DU	0.5 DU
e. Measurement Accuracy	3 DU	1 DU
f. Measurement Uncertainty		
g. Latency	80 Minutes	30 Minutes
h. Refresh		

Daily global sunlit Earth** (multiple coverage at high latitudes)

* SO_2 column amounts will be reported as calculated for three heights as appropriate for their occurrence -- local pollution, transported pollution, volcanic eruption.

** SO_2 is not sensed below clouds

Ozone Cal/Val Team Membership

EDR	Name	Organization	Task
Lead	Lawrence Flynn	NOAA/NESDIS/STAR	Lead Ozone EDR Team
Member	Irina Petropavlovskikh	NOAA/ESRL/CIRES	Ground-based Validation Lead
Member	Craig Long	NOAA/NWS/NCEP	Product Application Lead
Member	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 & modification
Member	Eve-Marie Devaliere	STAR/ERT	Limb Profiler Research to operations
JAM	Maria Caponi	JPSS/Aerospace	Coordination
Member	Bhaswar Sen	NGAS	Current Algorithms

OMPS Fundamentals

NOAA, through the Joint Polar Satellite System (JPSS) program, in partnership with National Aeronautical Space Administration (NASA), launched the Suomi National Polar-orbiting Partnership (S-NPP) satellite on October 28, 2011. The Ozone Mapping and Profiler Suite (OMPS) consists of two telescopes feeding three detectors measuring solar radiance scattered by the Earth's atmosphere and solar irradiance by using diffusers. The measurements are used to generate estimates of total column ozone and vertical ozone profiles.

The nadir mapper (total column) sensor uses a single grating monochromator and a CCD array detector to make measurements every 0.42 nm from 300 nm to 380 nm with 1.0-nm resolution. It has a 110° cross-track FOV and 0.27° along-track slit width FOV. The measurements are currently combined into 35 cross-track bins: 3.35° (50 km) at nadir, and 2.84° at ±55°. The resolution is 50 km along-track at nadir, with a 7.6-second reporting period. The instrument is capable of making measurements with much better horizontal resolution.

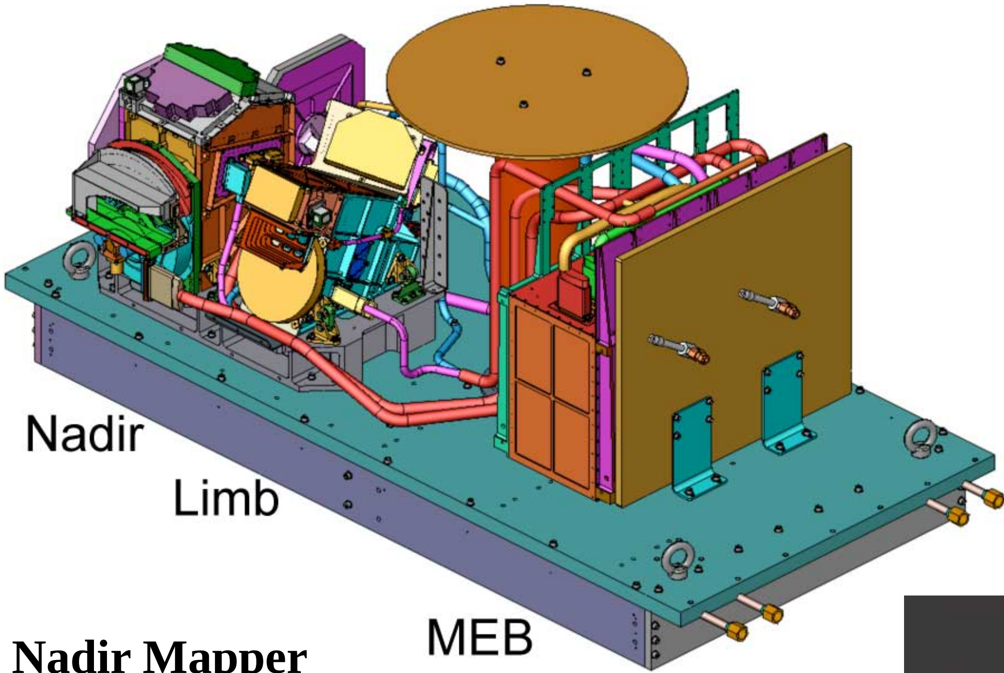
The nadir profiler sensor uses a double monochromator and a CCD array detector to make measurements every 0.42 nm from 250 nm to 310 nm with 1.0-nm resolution. It has a 16.6° cross-track FOV, 0.26° along-track slit width. The current reporting period is 38 seconds giving it a 250 km x 250 km cell size collocated with the five central total column cells.

The limb profiler sensor is a prism spectrometer with spectral coverage from 290 nm to 1000 nm. It has three slits separated by 4.25° with a 19-second reporting period that equates to 125 km along-track motion. The slits have 112 km (1.95°) vertical FOVs equating to 0 to 60 km coverage at the limb, plus offsets for pointing uncertainty, orbital variation, and Earth oblateness. The CCD array detector provides measurements every 1.1 km with 2.1-km vertical resolution. The measurements are used to generate high vertical resolution ozone and aerosol profiles down to the tropopause.

OMPS

Ozone Mapper Profiler Suite

Global daily monitoring of three dimensional distribution of ozone and other atmospheric constituents. Continues the NOAA SBUV/2, EOS-AURA OMI and SOLSE/LORE records.



Nadir Mapper

Grating spectrometer, 2-D CCD

110 deg. cross track, 300 to 380 nm spectral, 1.1nm FWHM bandpass

Nadir Profiler

Grating spectrometer, 2-D CCD

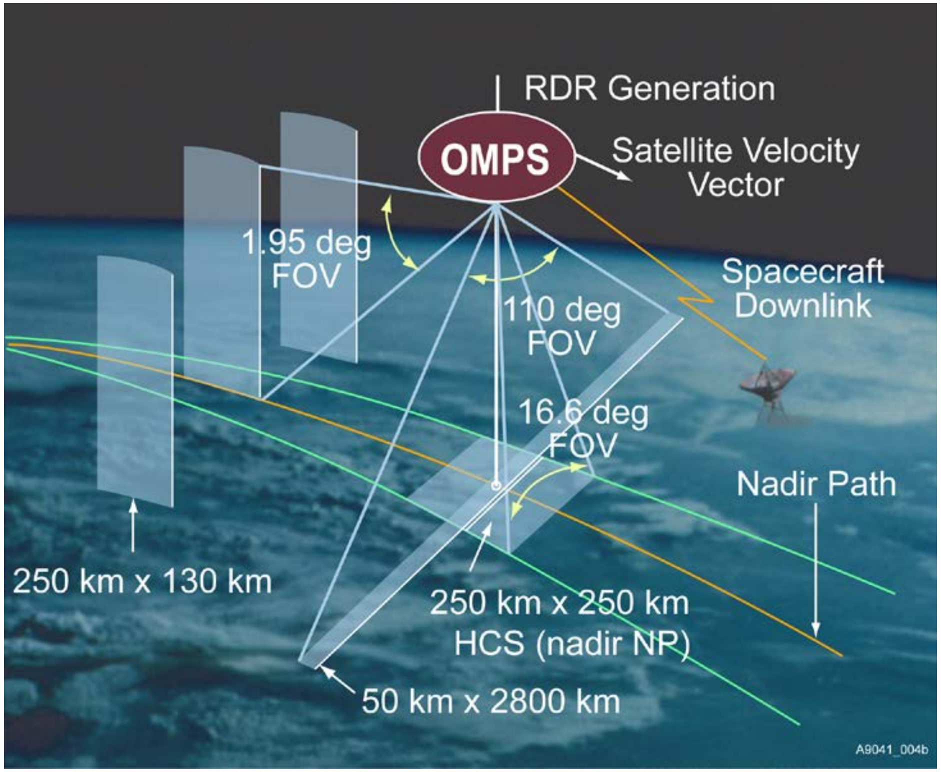
Nadir view, 250 km cross track, 270 to 310 nm spectral, 1.1 nm FWHM bandpass

Limb Profiler

Prism spectrometer, 2-D CCD

Three vertical slits, -20 to 80 km vertical, 290 to 1000 nm spectral

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



L. Flynn

Categories of products

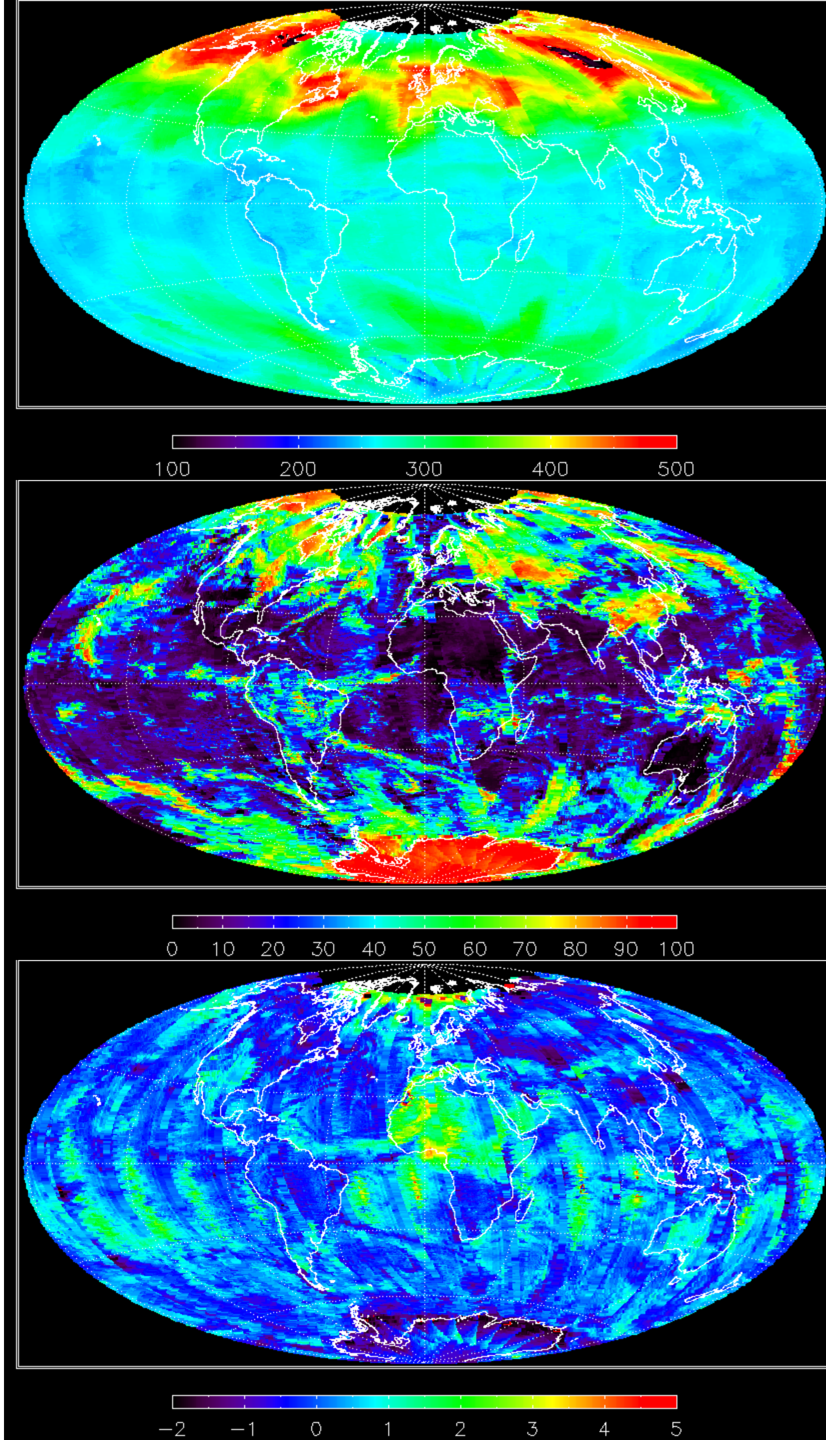
- In operations
  - Total column O_3, Nadir UV O_3 Profile, Aerosol Index, SO_2 Index
  - TOAST combined UV/IR analysis map
  - NUCAPS (CrIS/ATMS) trace gases (O_3, CO, CH_4, CO_2, N_2O, HNO_3, SO_2)
- Planned products
  - Limb O_3 Profile, Limb aerosol profile
- Likely future products
  - Total column SO_2
- Research products
  - Total Column NO_2
  - Combined UV/IR retrieval
  - UV absorbing aerosol optical depth, combined UV/Vis
  - UV cloud optical centroid (inelastic scattering – Ring effect)

The overall operational retrieval algorithm is working well but there are cross-track calibration biases. These will be corrected by July 2014.

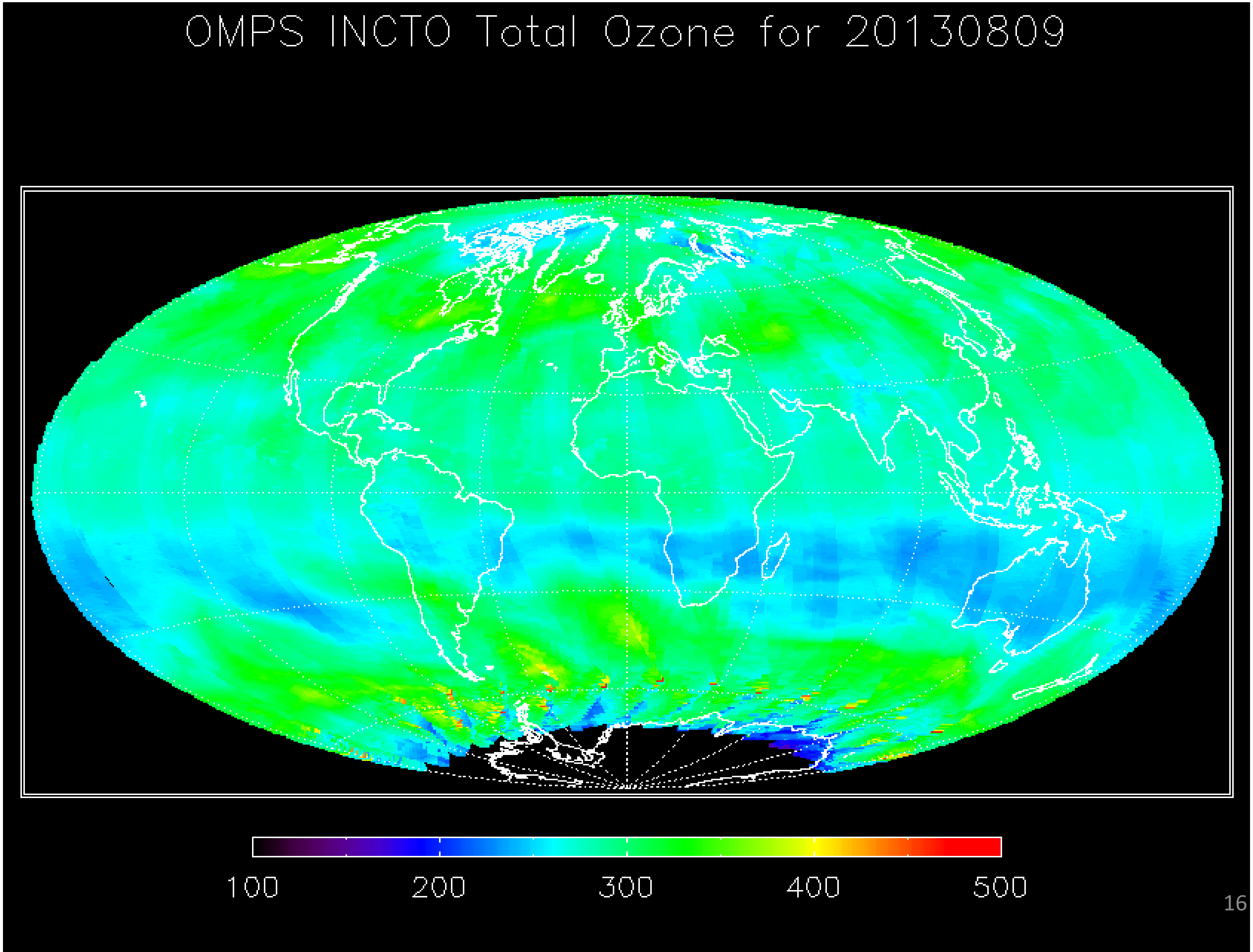
Daily global maps with false color images of three OMPS Version 8 algorithm products for February 17, 2014:
Top – Total column product. The color bar gives the amounts in Dobson Units (1 DU = 1 milli-atm-cm);
Middle – Effective Reflectivity. The colors show varying reflectivity in percent; and
Bottom – Absorbing aerosol index product. The colors show different levels of the index computed as a measurement residual for the 360 nm channel using the reflectivity estimate from the 331 nm channel. The units are in N-values which are approximately equivalent to 2.3% per unit. Sun-glint regions have not been filtered in this map.

Daily images for the full record to date are available through links at

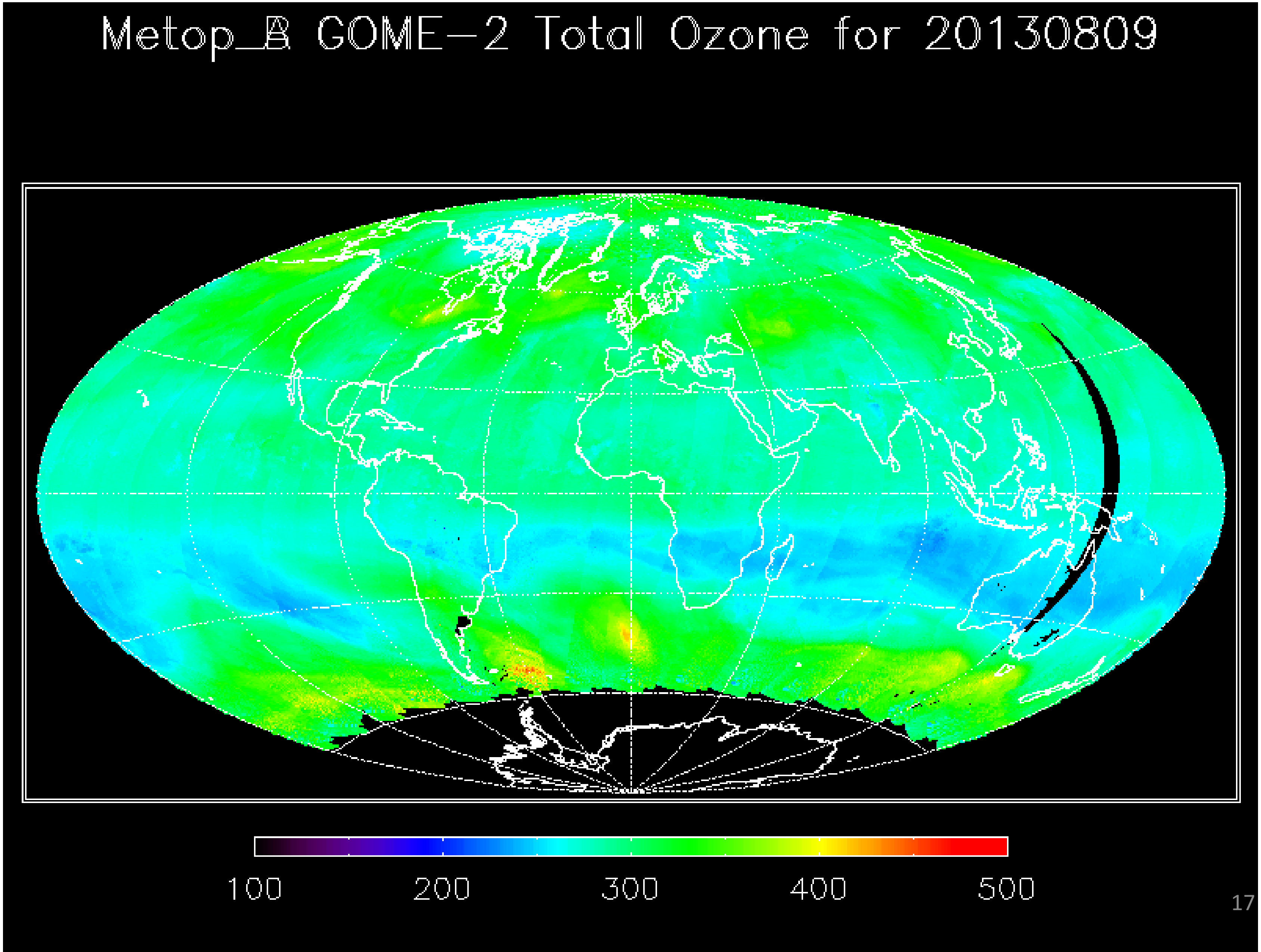
www.star.nesdis.noaa.gov/icvs/index.php.



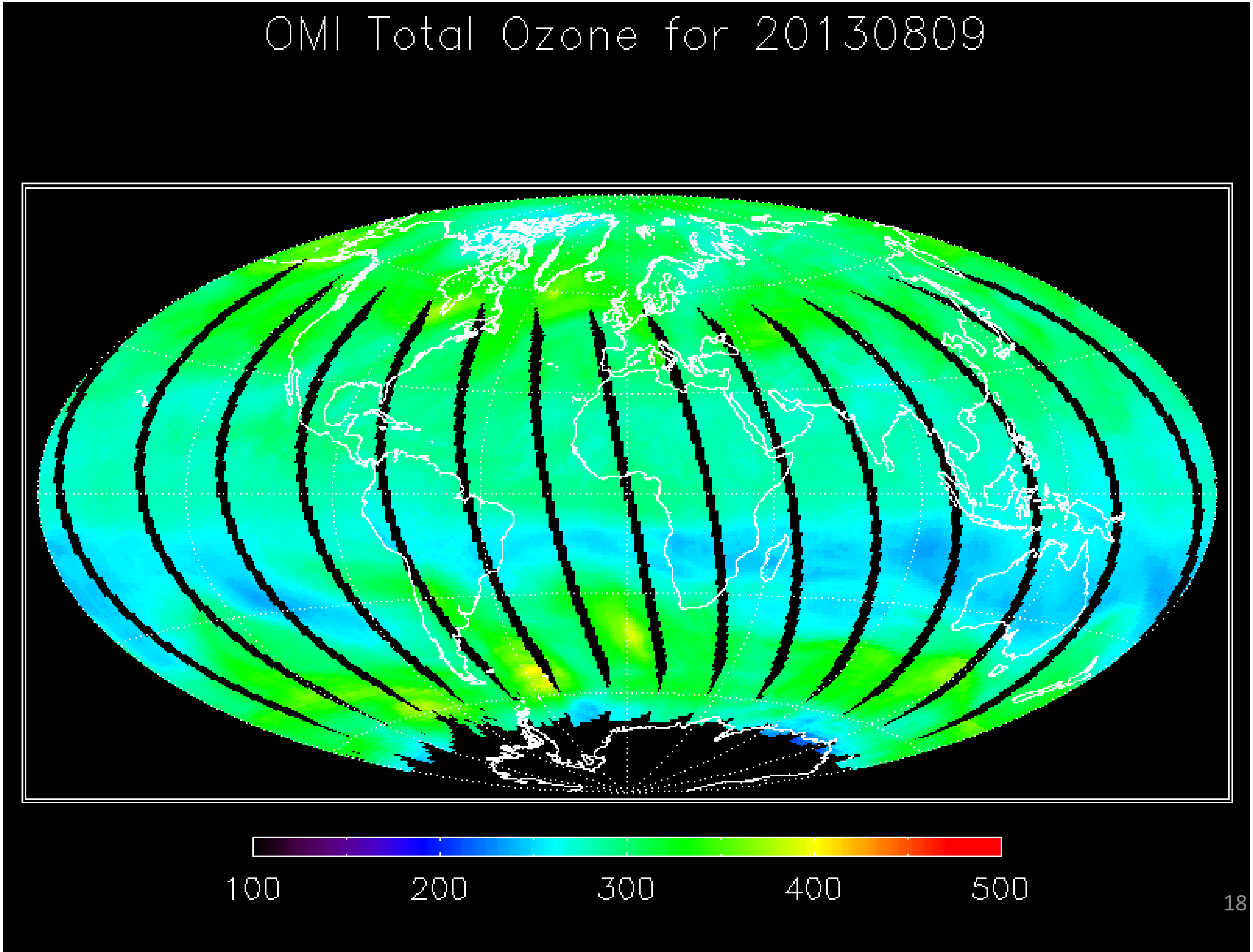
Sample OMPS INCTO Total Ozone Map



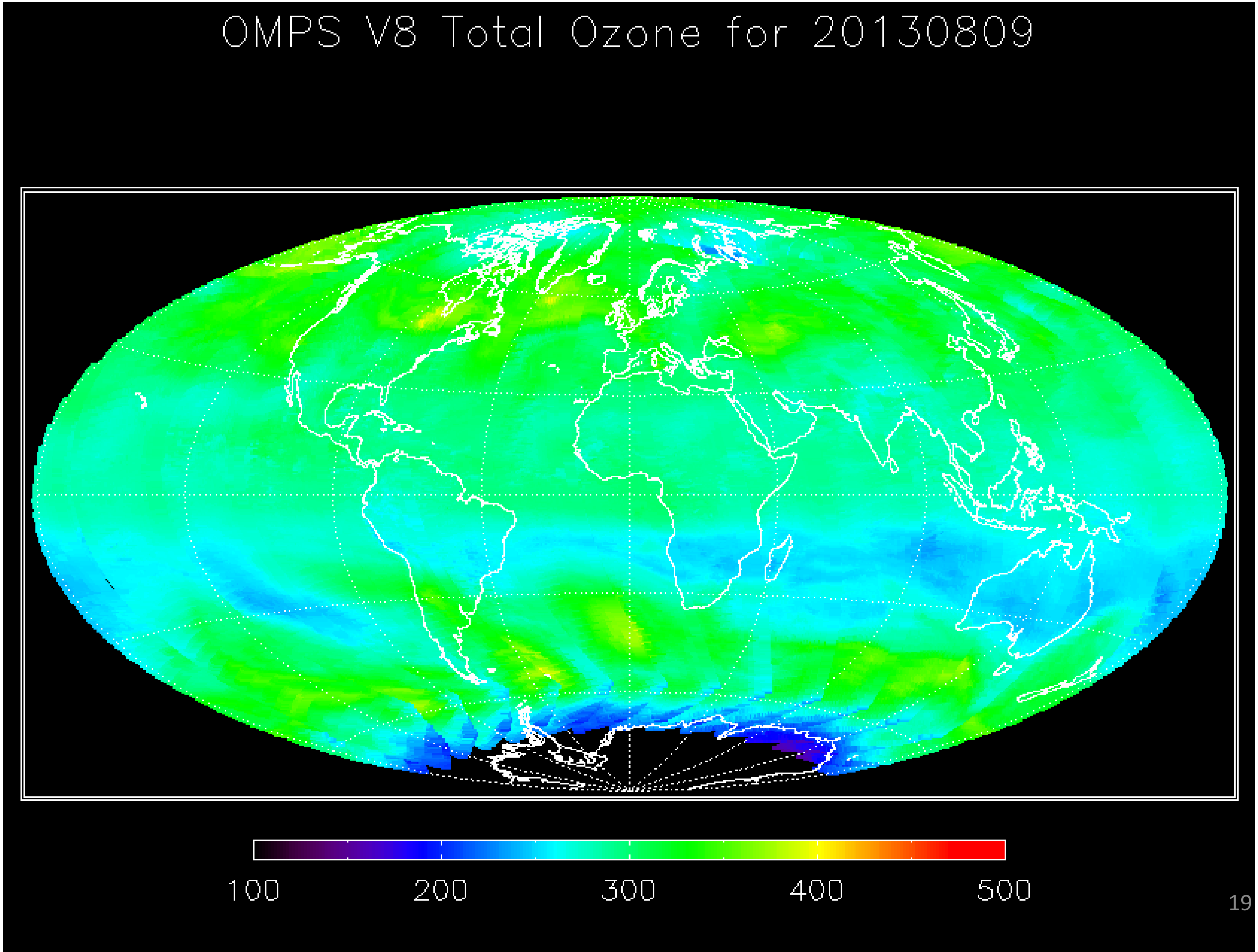
Sample MetOp-A+B GOME-2 V8 Total Ozone Map

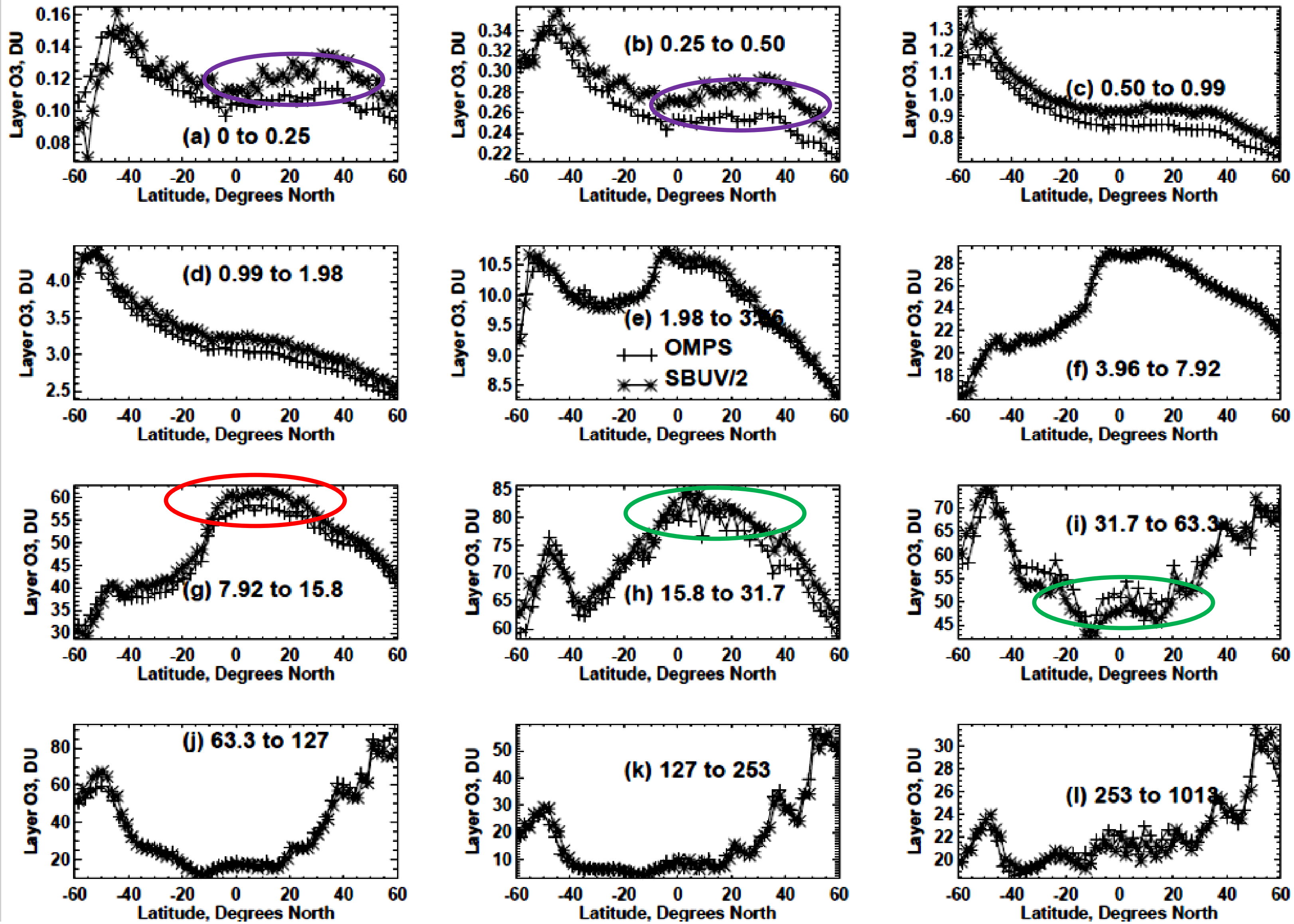


Sample EOS Aura OMI Total Ozone Map



Sample OMPS V8TOZ Total Ozone Map





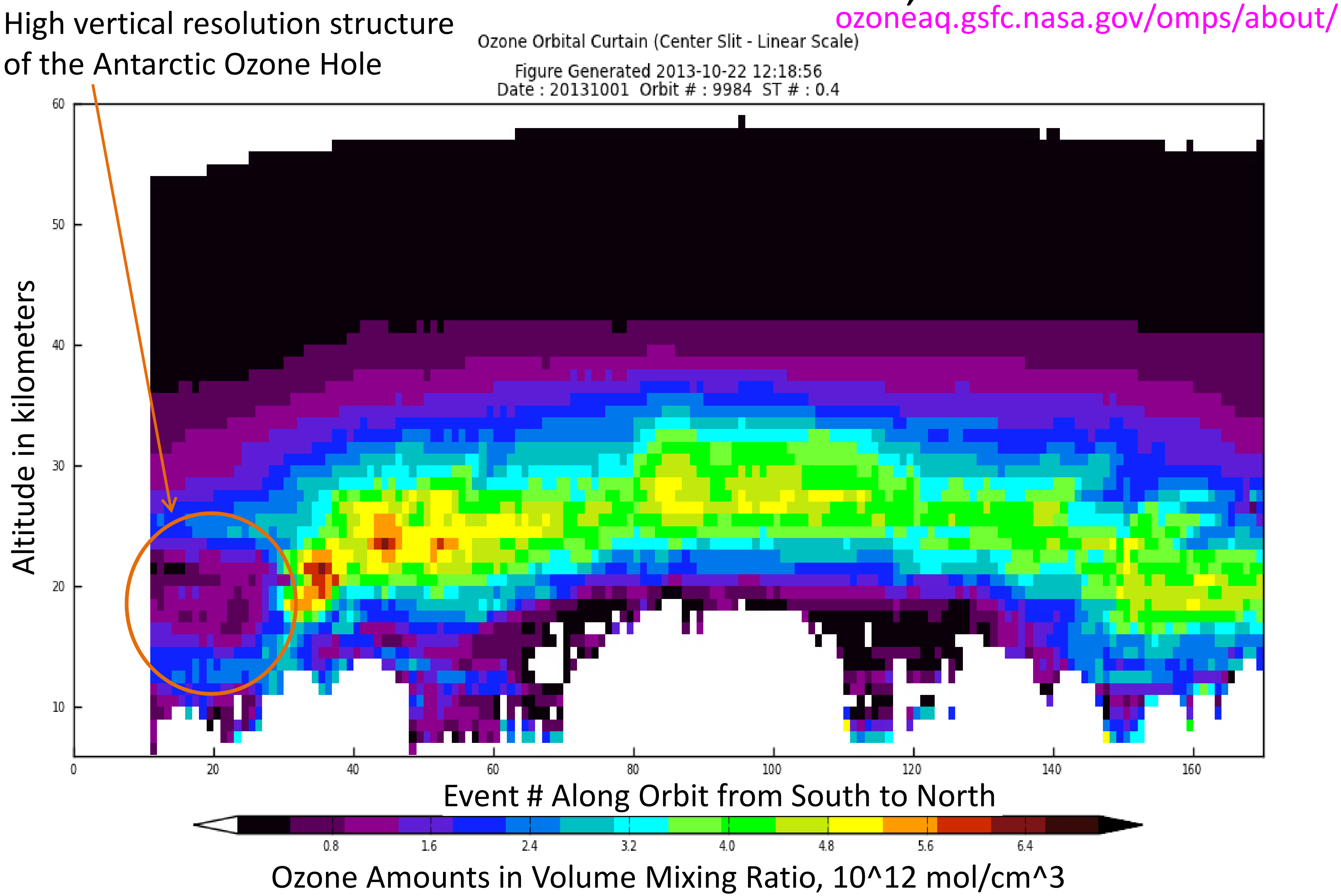
Biases and offsets from stray light, initial calibration errors and mismatched FOVs appear in the comparisons to NOAA-19 SBUV/2 ozone profiles for "chasing" orbits. Adjustments/ corrections are expected for all three by mid-2014.

Chasing orbit comparisons of SBUV/2 and OMPS-NP Version 6 Ozone Profiles for July 10, 2013. Figures (a)-(l) show the 12 Umkehr layer amounts versus latitude for the two products. The layer boundaries are given in hPa within the figures. The two orbits are within 50 km and 15 minutes of each other at the Equator.

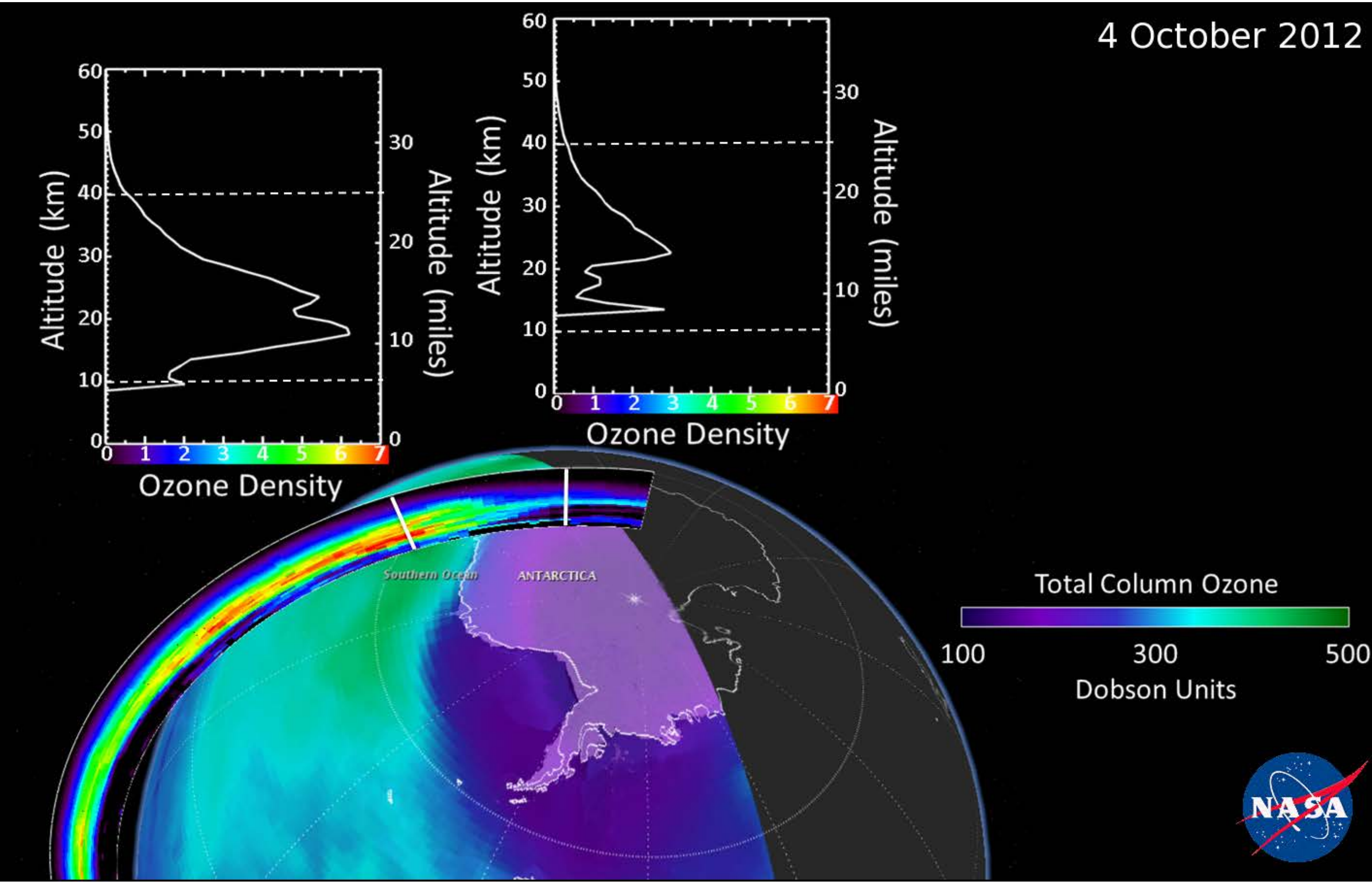
http://www.star.nesdis.noaa.gov/icvs/prodDemos/proOMPSbeta.O3PRO_IMOPO.php

Center Slit, OMPS Limb Ozone Profile Retrievals for one Orbit on October 22, 2013

ozoneaq.gsfc.nasa.gov/omps/about/

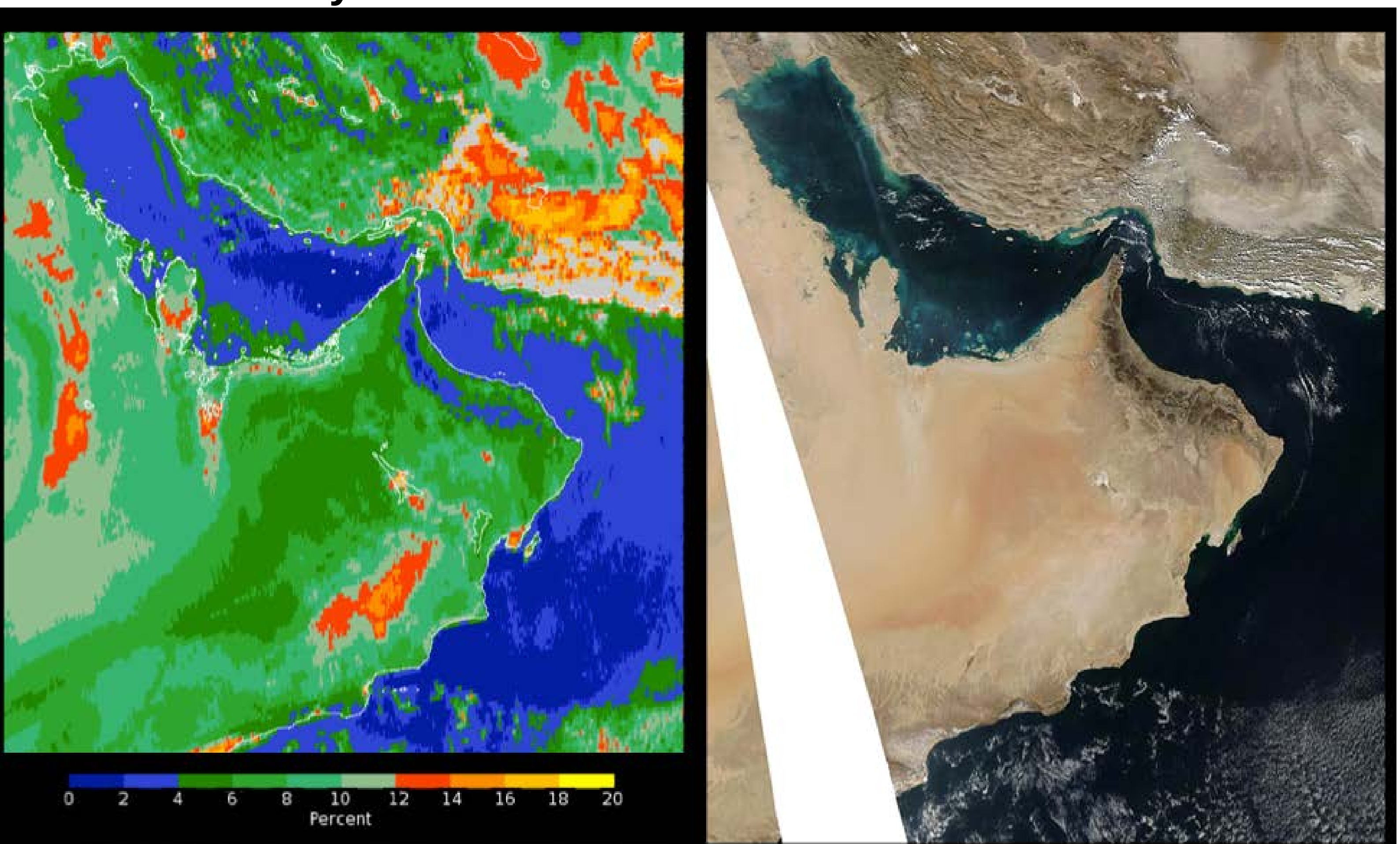


Limb Profiles outside and inside the Antarctic Ozone Hole



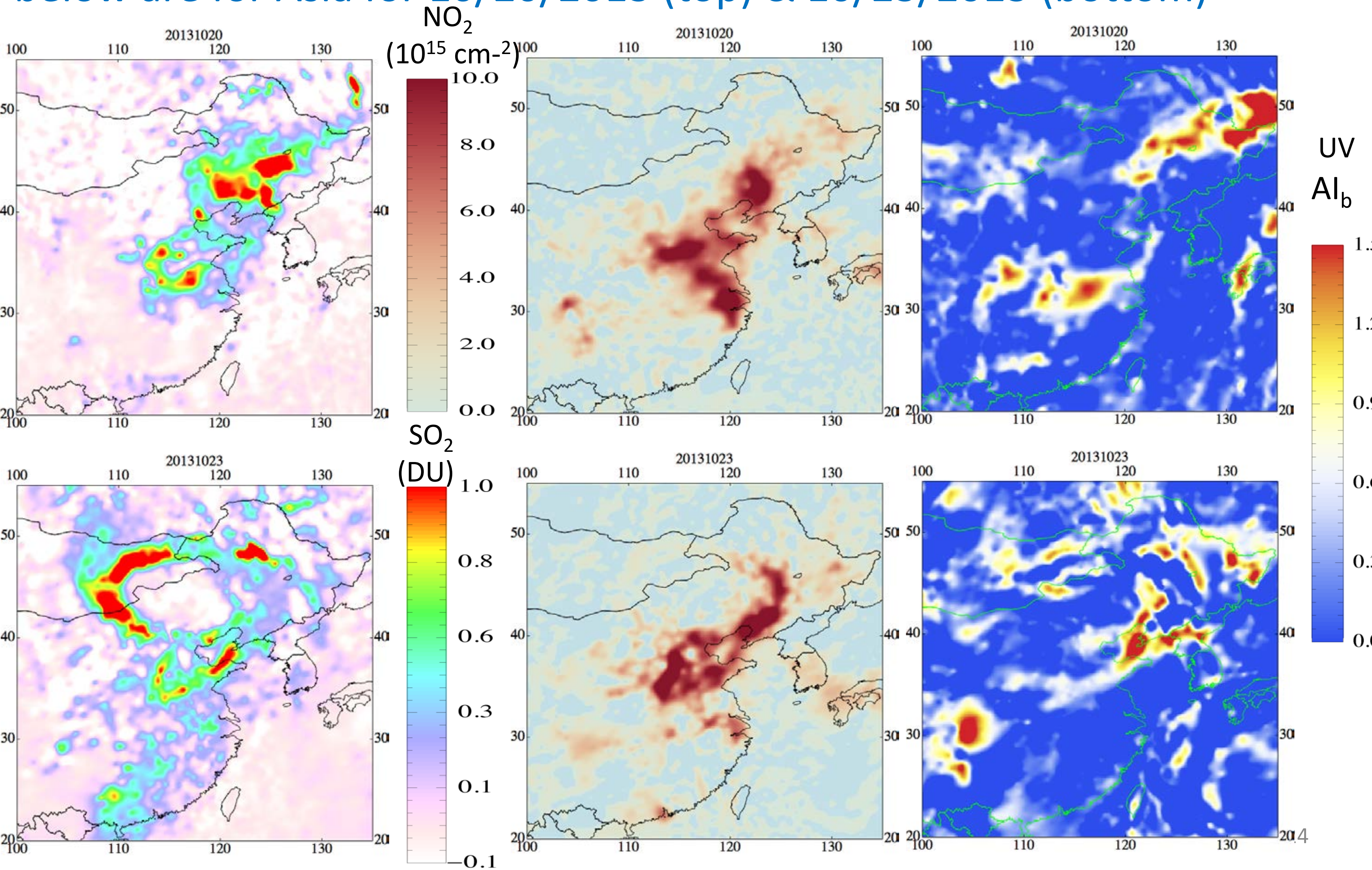
High-Spatial-Resolution Capabilities

The image on the left shows a false color map of the OMPS effective reflectivity (from a single Ultraviolet channel at 380 nm) over the Arabian Peninsula region for January 30, 2012 when the instrument was making a set of high-spatial-resolution measurements with 5×10 km^2 FOVs at nadir. The color scale intervals range from 0 to 2 % in dark blue to 18 to 20 % in yellow. The image on the right is an Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) Red-Green-Blue image for the same day.

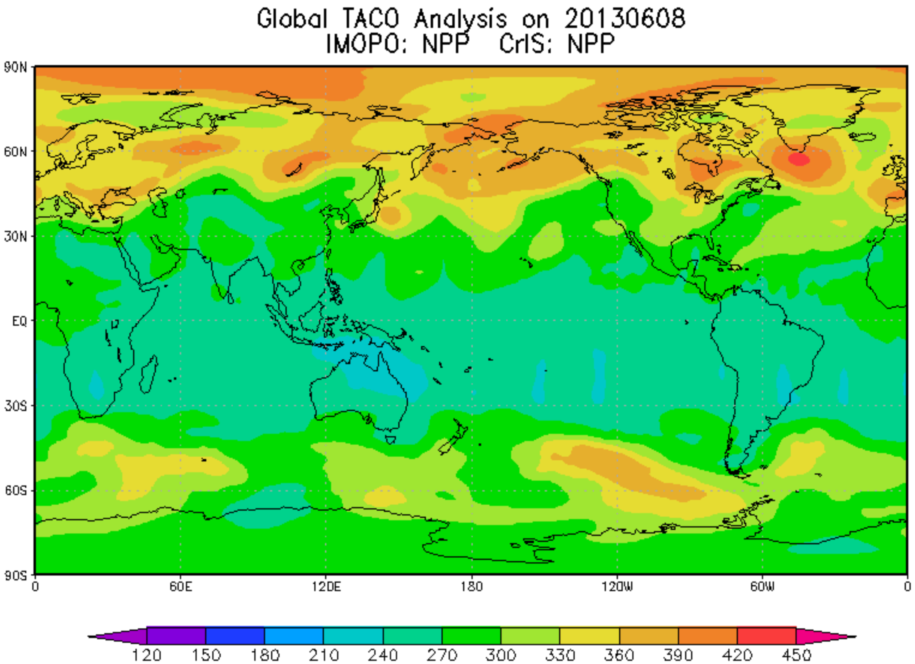


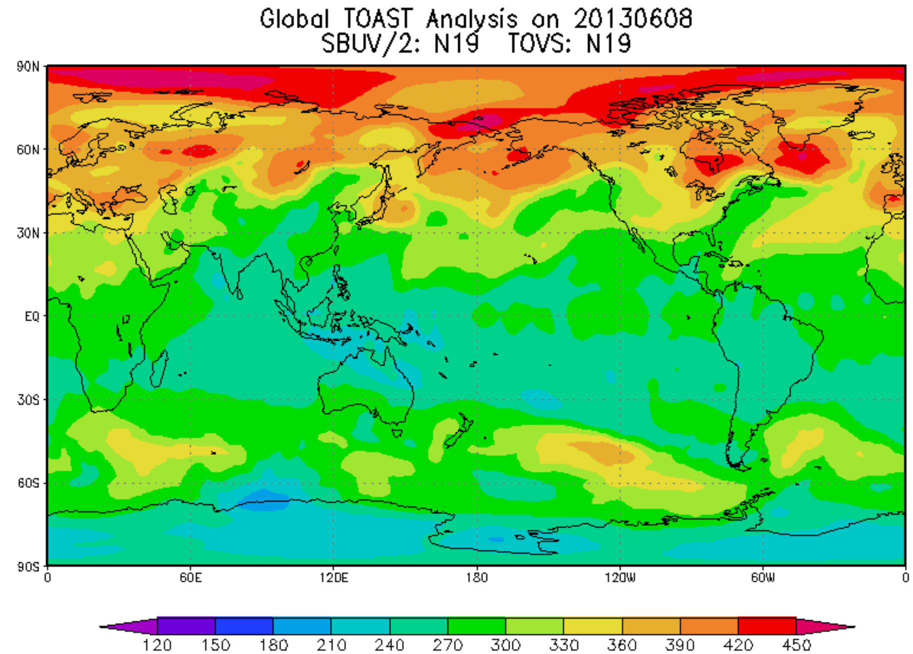
The OMPS Nadir Mapper instrument is very stable, extremely flexible, and has excellent SNRs.

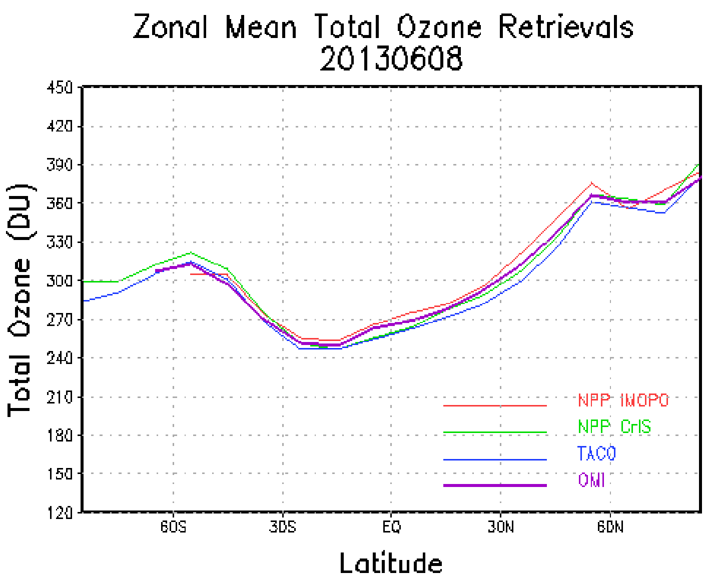
OMPS NM measurements can be used to make state-of-the-art SO_2, NO_2 and Aerosol retrievals for air quality and hazard applications. Examples below are for Asia for 10/20/2013 (top) & 10/23/2013 (bottom)



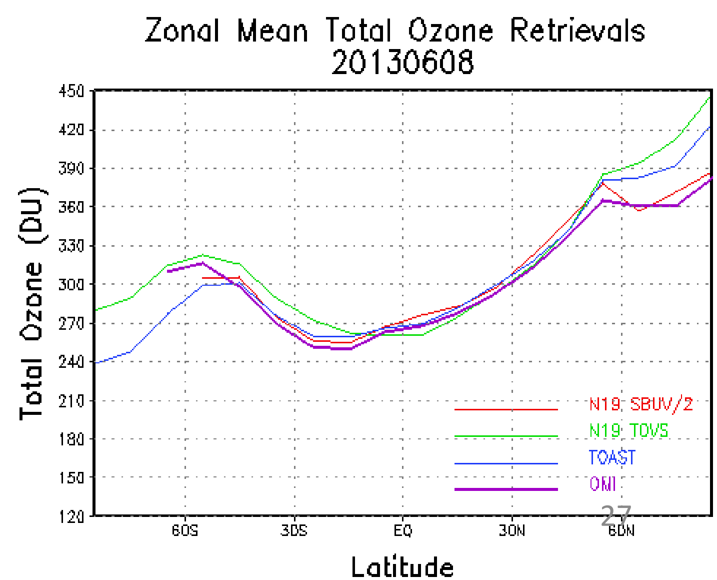
Comparison of TACO (OMPS and CrIS) with TOAST (SBUV/2 and TOVS/HIRS)







Combined products use UV retrievals for the stratosphere and IR retrievals for the Troposphere



Product Summary

- The OMPS instruments are performing well and can deliver ozone products to continue the over 30-years of satellite monitoring.
- Validated nadir total column ozone and ozone profiles will be available operationally by Fall 2014.
- The limb ozone profiles provide global coverage of the ozone layer with high vertical resolution.
- The OMPS measurements can be used to provide other atmospheric chemistry and composition products at good horizontal resolution.

Algorithm Evaluations

NOAA-endorsed algorithm are recommended for use because of legacy, synergy, blended products, performance, maintenance, and other considerations.

Why V8TOz instead of MTTOz?

Provides a set of products consistent with the TOz CDR from the TOMS/SBUV(/2)/OMI record. This also means it can serve as the first step in the CDR cycle of evaluation and reprocessing.

Versions of the algorithm are currently used in OSDPD to make the NOAA GOME-2 NRT TOz products and SBUV/2 TOz products. It is planned for use in making OMPS V8Pro TOz products.

The fundamental ozone estimates are from a single pair of channels simplifying validation studies, calibration adjustments, and anomaly resolution. The MTTOz requires soft calibration of 22 channels.

The V8TOz uses the 313 nm residual to adjust for profile shape variations. The MTTOz was going to use the Limb Profile to do this adjustment.

The V8TOz is synergistic with the Linear Fit SO2 Retrieval algorithm.

Why “I could have had a V8Pro”?

The V8Pro algorithm is in use for the operational and climate data records for the SBUV(/2). It improves on the Version 6 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 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

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 are 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.

Finally, the V8Pro is designed for expansion to perform retrievals for hyperspectral instruments, such as the Ozone Monitoring Instrument (OMI), the Global Ozone Monitoring Experiment (GOME-2) and the Nadir Profiler in the Ozone Mapping and Profiler Suite (OMPS).

Algorithm Paths Forward

OMPS NP V8Pro (Creates NRT and CDR ozone profiles for SBUV/2)

- A.i. Provide 12 soft calibration adjustments
- A.ii. Change to work with smaller FOVs (just along track)
- A.iii. Put in N-value fitting (Noise reduction, outlier identification and removal, and information concentration)
- A.iv. Add Solar Activity / Scale Factors

OMPS TC V8TOz (Creates NRT and CDR total ozone for GOME-2 and OMI)

- B.i. Provide 12 soft calibration adjustments
- B.ii. Put in Linear-Fit SO2 module. (Eight Granules)
- B.iii. Change to work with smaller FOVs (Interpolate the 35 Cross-track table as needed.)
- B.iv. Put in N-value fitting (Noise reduction, outlier identification and removal, and information concentration)

OMPS LP V2 (Creates high vertical resolution ozone profiles)

- C.i. Continue implementation in NDE
- C.ii. Address aerosol product options

Ozone Products Accomplishments for FY13 to date

- Paper on ozone product performance for Special Issue of JGR
- New DRs:
  - NP/NM FOV Matchup + five distinct scans
  - SZA coverage / orbit start and end of Earth View data
  - Small FOV NM and NP
  - V8TOz
  - SO2 Index and Product
- New CCRs/PCRs:
  - Mixing Fraction limits
  - NM/NP Glueware Correction
- New or Corrected PRO Code provided for IDPS use
  - Change to limit extrapolation of profile shapes
  - Version 8 Profile Retrieval Algorithm \
- Assisting SDR
  - Smear correction
  - measurement-based wavelength scale
  - NM OOB Straylight and NP Straylight corrections
  - new NM and NP SDR wavelength scales and Day 1 solar spectra

Validation and Applications

- Ground-based resources are provided rapidly for match up comparisons.
- Well-characterized satellite measurements are available for additional comparisons via zonal means, chasing orbits, and no local time differences analysis.
- Monitoring results including internal consistency and measurements residual tests are available at www.star.nesdis.noaa.gov/icvs/prodDemos/index.php
- Soft calibration adjustments have been developed and tested for the Version 8 algorithms.
- Users have begun testing provisional products in applications and comparing them to existing products.

(See talks and posters in other sessions.)

Ozone Team Challenges

- Soft Calibration
  Determination and implementation of soft calibration is a moving target as SDR improvements move into the system
- Validation
  Product validation analyses has to be repeated or adjusted as improvements and corrections enter the system.
- Performance versus Schedule issues
  - V8TOz implementation schedule is in competition with V8TOz improvements – SO_2 Linear Fit Algorithm module, small FOVs, Efficiency Factors, Outlier Detection / Information Concentration
  - V8Pro implementation schedule is in competition with V8Pro improvements – Small FOVs, Solar Activity, Outlier Detection / Information Concentration

Background Slides

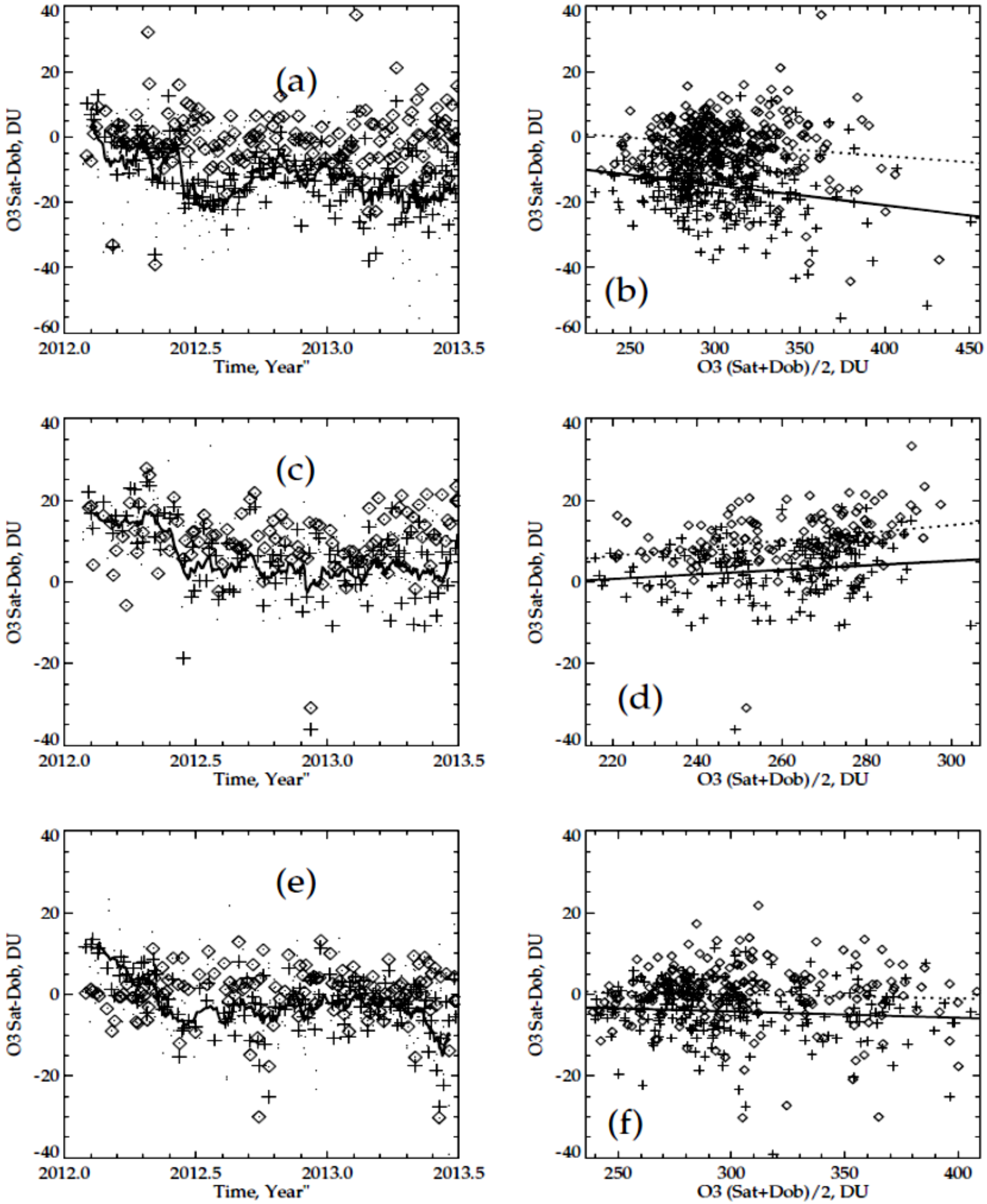


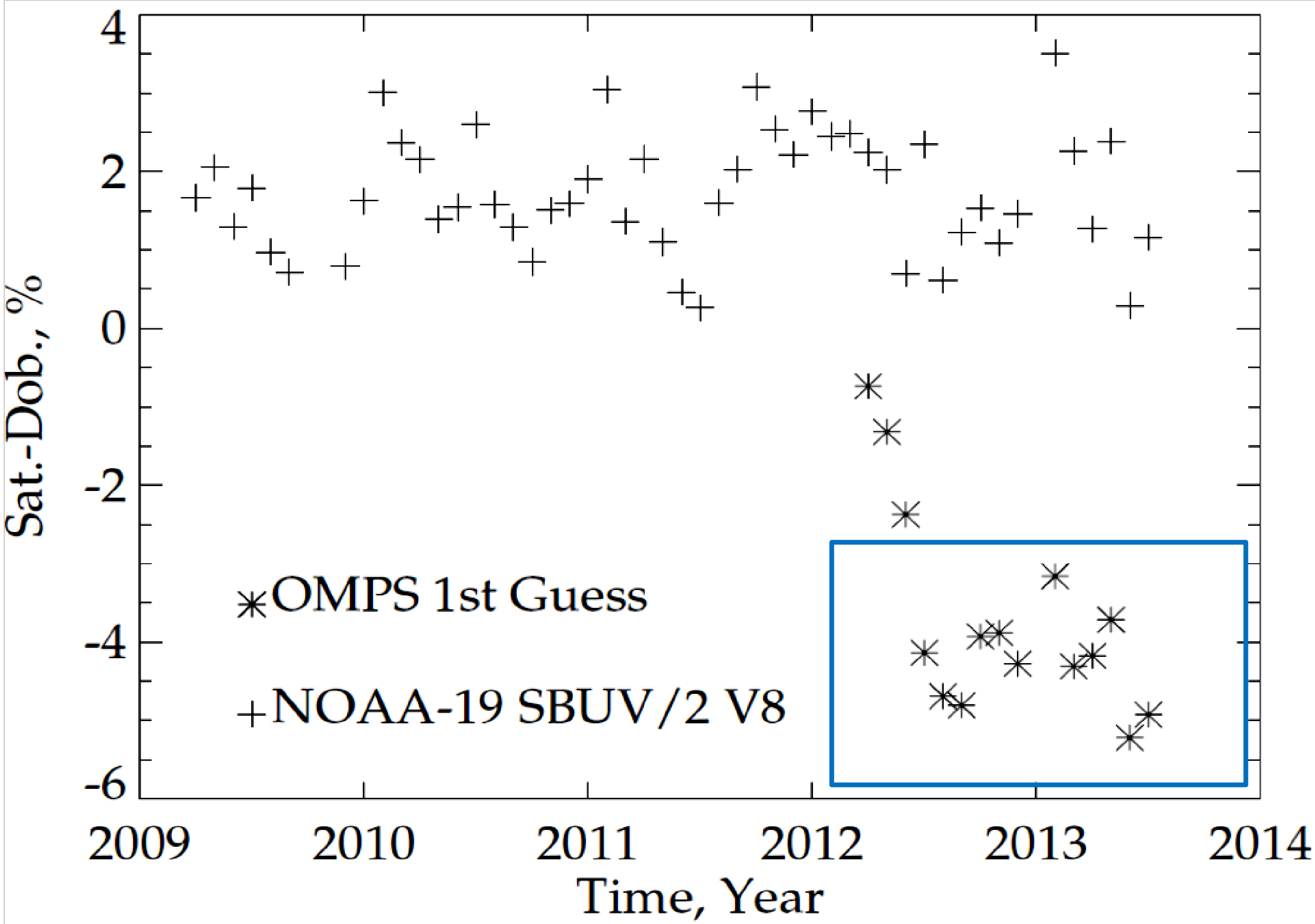
Figure 6. Comparison of OMPS and OMI total column ozone with Dobson estimates for Boulder CO, Manua Loa HI, and Lauder NZ. The figures on the left show the time series of differences for satellite overpass data minus the ground-based Dobson. The diamonds are for OMI and the plus signs are for OMPS. The solid line is the nine-point moving average for the OMPS data. The figures on the right are the satellite minus Dobson differences versus their averages. The solid lines are the linear regression fits for OMPS and the dotted lines are the fits for OMI both with equal noise assumptions. Figure pairs (a) and (b), (c) and (d), and (e) and (f) are for Boulder, Mauna Loa and Lauder, respectively.

Table 1. Statistics for Dobson Match-Up Data Sets In Figure 6.

Site # Days	Sat. Name	**Avg_G** DU	**Avg_S** DU	**m_G**	**m_S**	**m_E**	**σ**	**δ** DU	**ε** DU	**ρ**	**Min_E** DU	**Max_E** DU
BOU	OMPS	308.7	293.9	0.90	0.98	0.94	0.02	6.7	6.3	0.97	-10.6	-24.1
N=335	OMI	308.7	306.3	0.93	1.00	0.96	0.02	6.4	6.1	0.97	0.3	-8.1
MLO	OMPS	256.6[c]	259.4	0.99	1.13	1.06	0.03	4.7	4.9	0.93	0.4[c]	5.9[c]
N=217	OMI	256.6[c]	266.9	1.03	1.17	1.10	0.03	4.4	4.8	0.94	6.0[c]	15.6[c]
LAU	OMPS	304.5	300.2	0.97	1.00	0.99	0.02	4.8	4.7	0.99	-3.3	-5.8
N=270	OMI	304.5	304.4	0.97	1.01	0.99	0.02	5.3	5.2	0.98	0.6	-1.1

[c]The Dobson station is near the top of Mauna Loa. Satellite FOVs include ocean scenes. Adjustments from 6 to 12 DU have been used to account for these scene differences based on Hilo HI ozonesondes and standard ozone profiles.

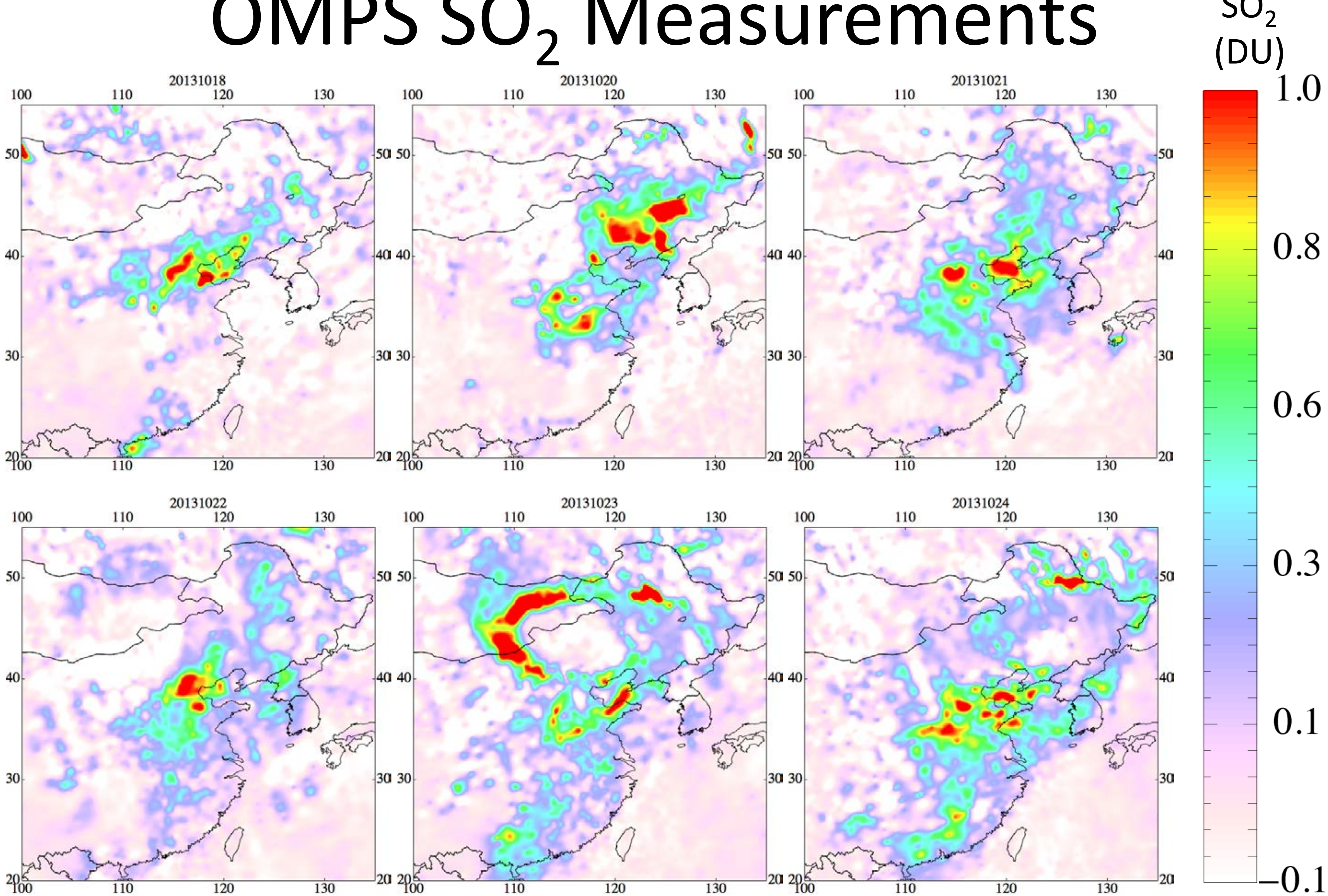
The OMPS Bias estimates at the maximum and minimum data values for each station show negative biases.



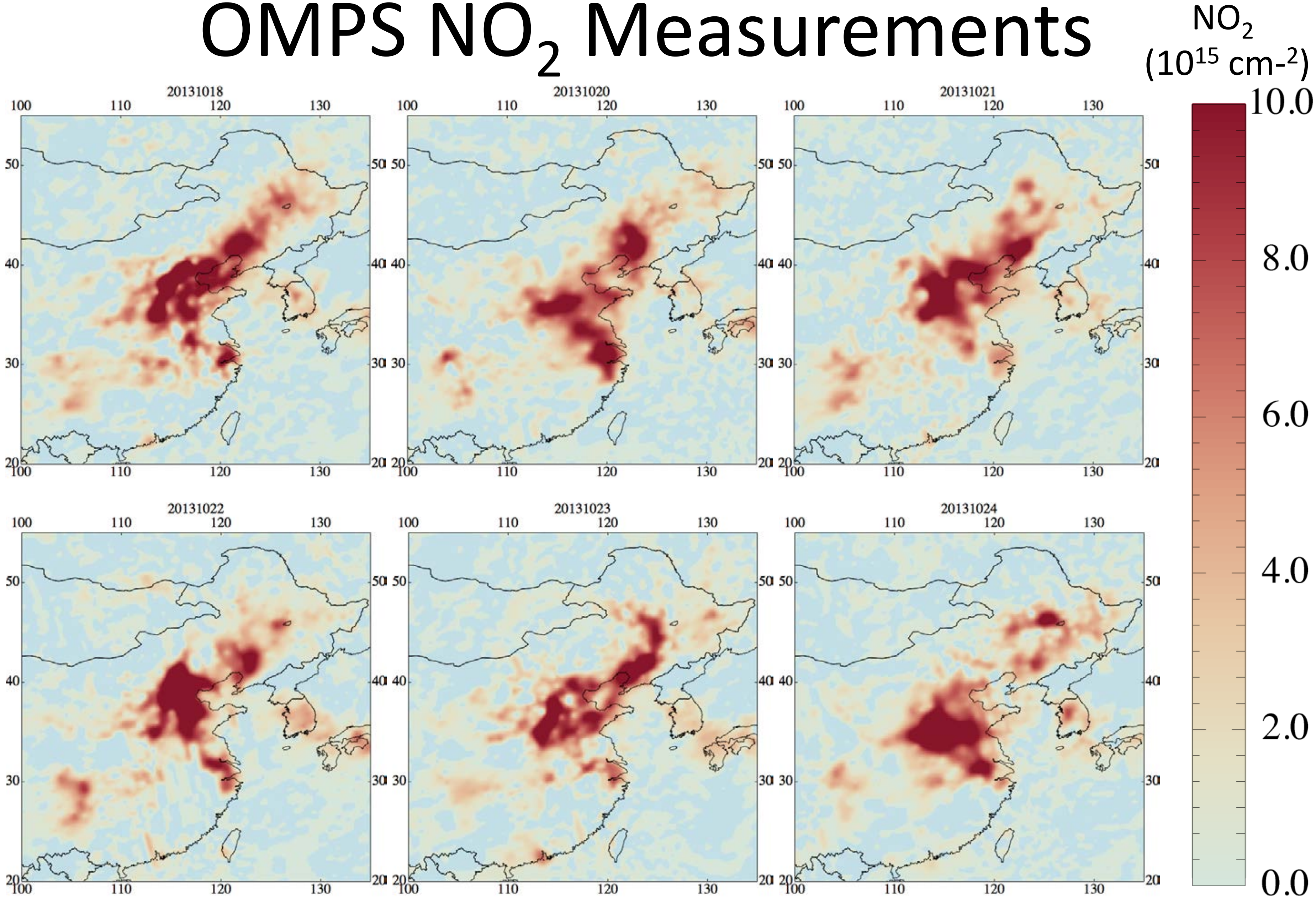
Another view of the negative overall bias in the OMPS TOZ relative to ground-based Dobson Station estimates.

Figure 7. Monthly differences between matchup NOAA-19 SBUV/2 Version 8 total column ozone and OMPS 1st Guess total column ozone with a collection of Dobson observations from 22 stations from the World Ozone Data Center. For OMPS, the data are distance-weighted averages for estimates within 0.5º Latitude and SEC(Latitude)º Longitude of each station's location. For SBUV/2, the data are distance-weighted averages for estimates within 2.0º Latitude and 20º Longitude of each station's location. Each data point is a monthly average difference for the satellite instrument versus the Dobson ones. At least six matchup values are required for a station to be used in the monthly average. As few as five stations may have reported enough data for the later values.

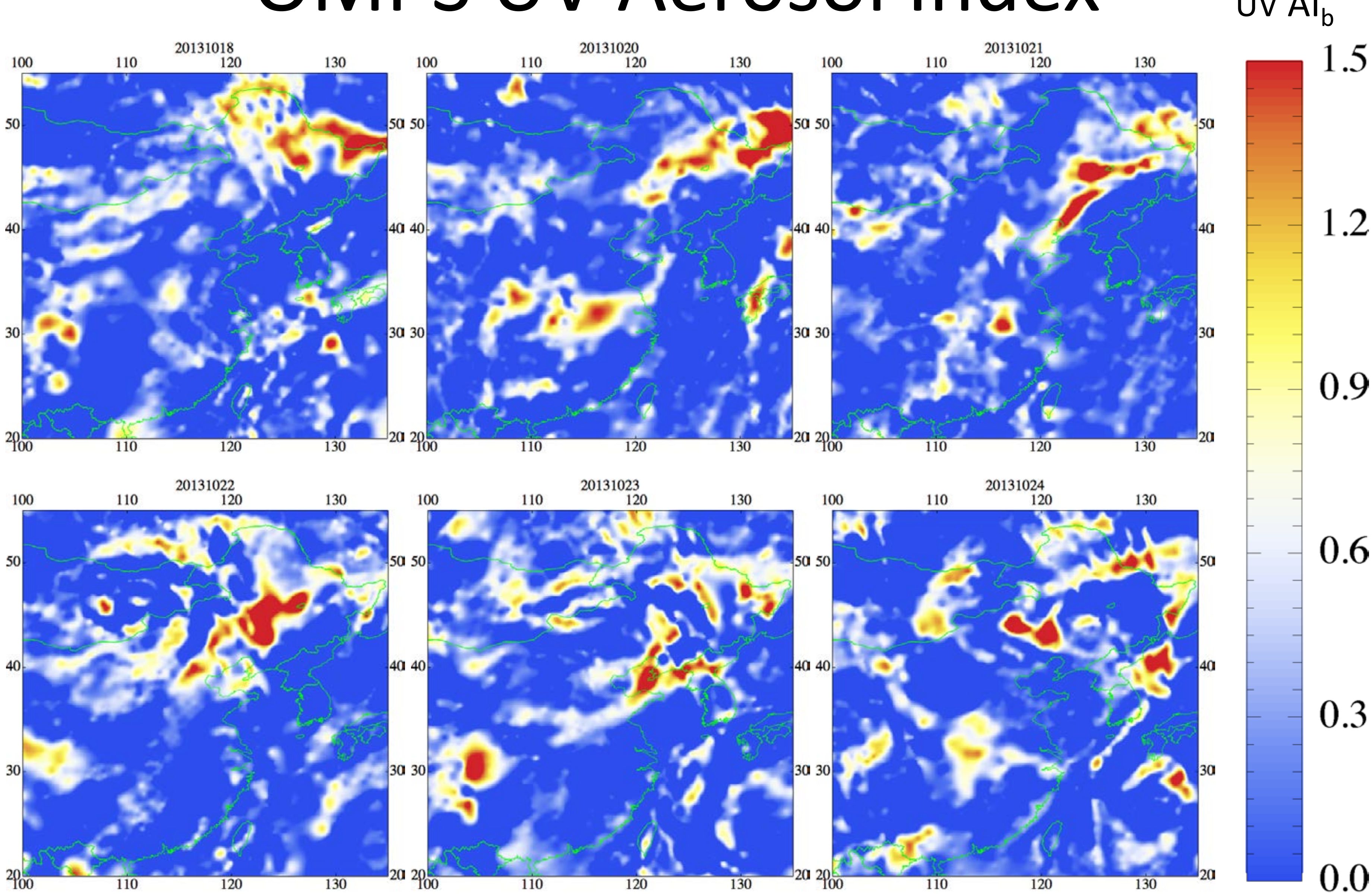
OMPS SO_2 Measurements



OMPS NO_2 Measurements



OMPS UV Aerosol Index



Nadir Mapper / Total Ozone Key Points

- The OMPS NM SDR needs calibration adjustments (consistent with the intra-orbit wavelength scale adjustments) to reduce offsets with other products and to remove cross-track biases.
- A new day 1 solar with a wavelength scale in the middle of the Earth-view range would give better results.
- A better Out-of-Range Stray Light correction could help to resolve the Nadir Profiler SDR characterization between 300 nm & 310 nm.
- The OMPS NM SDR can be used to provide a range of atmospheric composition product at high resolution.

Ozone Profile Product, **IMOPO**

The spectral measurements from the OMPS Nadir Profiler and Nadir Mapper of the radiances scattered by the Earth's atmosphere are used to generate estimates of the ozone vertical profile along the orbital track (**IMOPO**). The algorithm uses ratios of Earth radiance to Solar irradiance at a set of 12 wavelengths (at approximately 252, 273, 283, 288, 292, 298, 302, 306, 313, 318, 331 and 340 nm) with eight from the Nadir Profiler and four from the Nadir Mapper to obtain estimates of the total column ozone, effective reflectivity, and the ozone vertical profile in 12 Umkehr Layers. The radiances for the four longer wavelength are obtained from the 25 Nadir Mapper FOVs co-located with a single Nadir Profiler FOV. The longer channel radiance/irradiance ratios are used to generate estimates of the total column ozone and scene effective reflectivity. The total column ozone is used to generate a first guess ozone profile that becomes the A Priori for a maximum likelihood ozone profile retrieval using the ratios for the seven shortest wavelengths (omitting the 253 nm channel and including 313 nm at high SZA). Additional information is in the OMPS Nadir Profile Algorithm Theoretical Basis and Operational Algorithm Description Documents, and a volume of the Common Data Format Control Book at:
http://npp.gsfc.nasa.gov/documents.html

OMPS NP ATBD 474-00026_Rev-Baseline.pdf

OMPS NP OAD 474-00067_OAD-OMPS-NP-IP-SW_RevA_201

Intermediate Product CDFCB

474-00001-04-01_CDFCB-Vol4-Part1_Rev-_Block-1-1_31Mar2011.pdf20127.pdf

Instrument Performance – NP

Requirement	Specification/Prediction Value	On-Orbit Performance
Non-linearity	< 2% full well	< 0.46%
Non-linearity Knowledge	< 0.5%	~0.1%
On-orbit Wavelength Calibration	< 0.01 nm	
Stray Light NM Out-of-Band + Out-of-Field Response	≤ 2	average ~± 2%*
Intra-Orbit Wavelength Stability	<0.02 nm	< 0.013 nm
SNR	Channel Dependent	Similar to SBUV/2 at corresponding channels^
Inter-Orbital Thermal Wavelength Shift	<0.02 nm	0.03 nm annual cycle#
^CCD Read Noise	<60 –e RMS	< 25 –e RMS
Detector Gain	>43	~45
Absolute Irradiance Calibration Accuracy	< 7%	1~10% , average: ~7%
Absolute Radiance Calibration Accuracy	< 8%	< 5%

* A measurement-based correction using prelaunch characterization will improve accuracy and precision

Regular annual cycle affects accuracy and stability

^ Information concentration possible by using near-by channels.

C. Pan

Profile comparisons between OMPS & SBUV/2 V6Pro

The figures on the next four slides show comparisons of the ozone profile retrievals estimates between IMOPO and the NOAA-19 SBUV/2 processed with the Version 6 ozone profile retrieval algorithm. The data are from another single pair of orbits on June 15, 2013 where the two satellites are flying in formation (orbital tracks within 50 KM and sensing times with 10 minutes). The first of the four slides shows the orbital tracks. The second compares the initial measurement residuals at the nine profiling wavelengths.

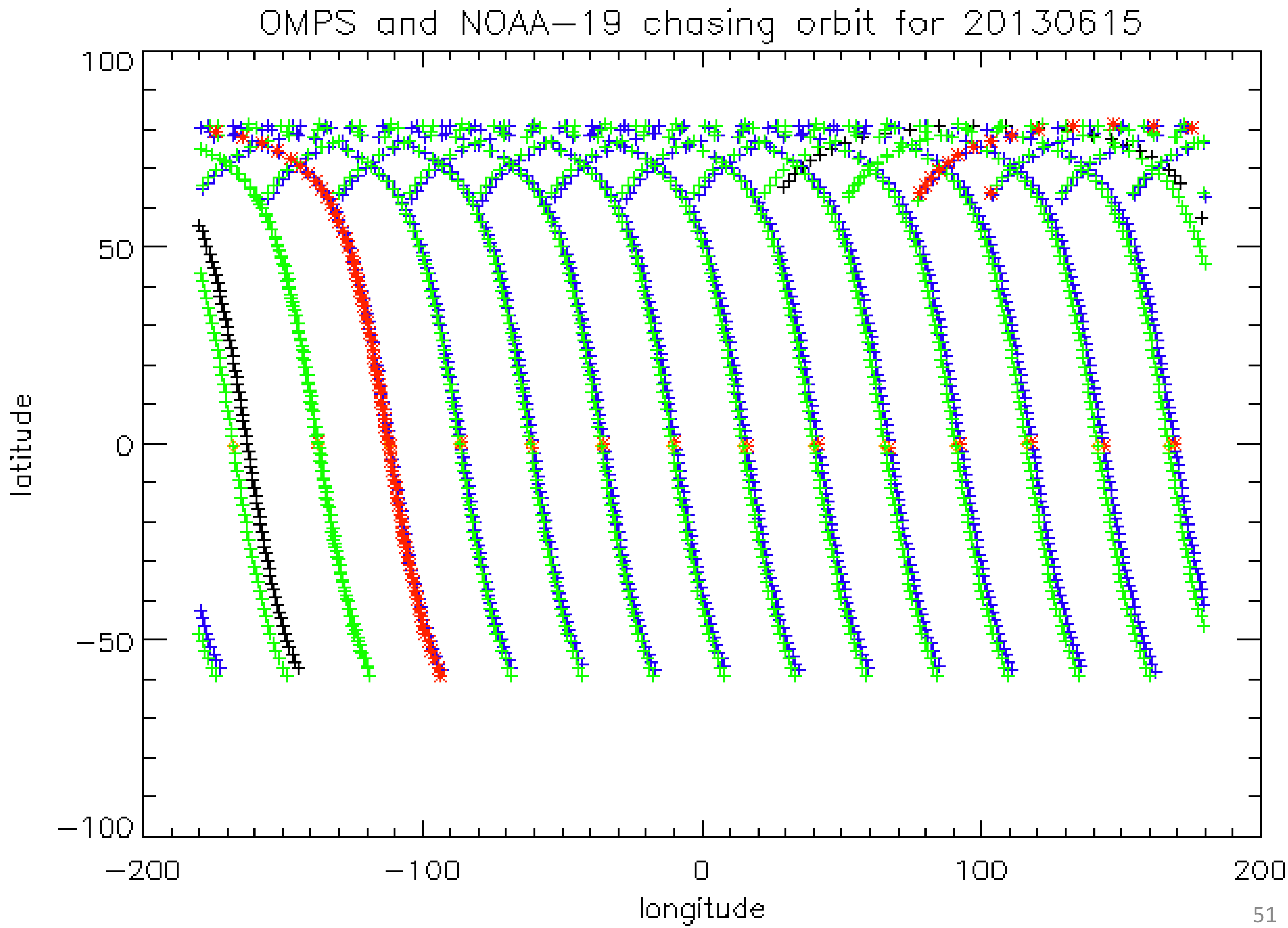
The third compares the ozone profile retrievals in 12 pressure layers in Dobson Units versus Latitude. The 12 layers are defined by the following 13 layer boundaries: [0.0,0.247,0.495,0.99,1.98,3.96,7.92,15.8,31.7,63.3,127.0,253.0,1013] hPa.

The top three layers' results are in the top row with the topmost layer on the upper left. The lowest layer's results are in the figure on the bottom right. The OMPS Nadir Profiler values are in Red and the **SBUV/2 are shown in Black**. A significant number of the OMPS Nadir Profilers contain fill values because of Error Codes incorrectly set to 20.

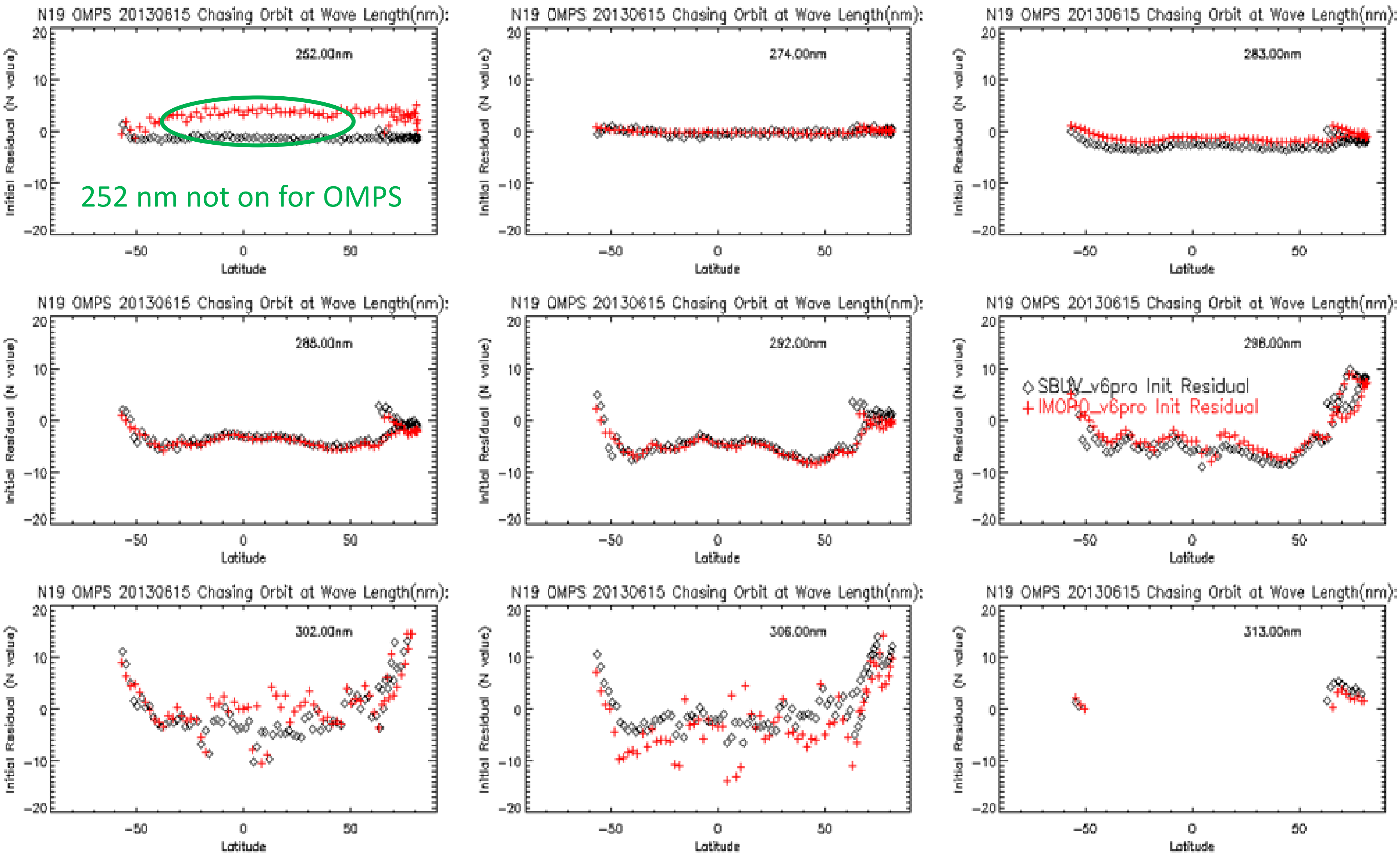
The fourth shows the results of comparison for the ozone mixing ratios at 19 pressure levels: [0.3,0.4,0.5,0.7,1.0,1.5,2.0,3.0,4.0,5.0,7.0,10.,15.,20.,30.,40.,50.,70.,100.] hPa. The arrangement from top to bottom follows the same convention as for the layers.

The two last sets of figures show similar results with general agreement between the retrievals for the two instruments but with the OMPS NP retrieving much smaller values at the top of the profiles. This is due to the inaccuracies in the initial calibration of the shorter wavelength channels and out-of-band of stray light in the shorter wavelength channels providing information at those levels.

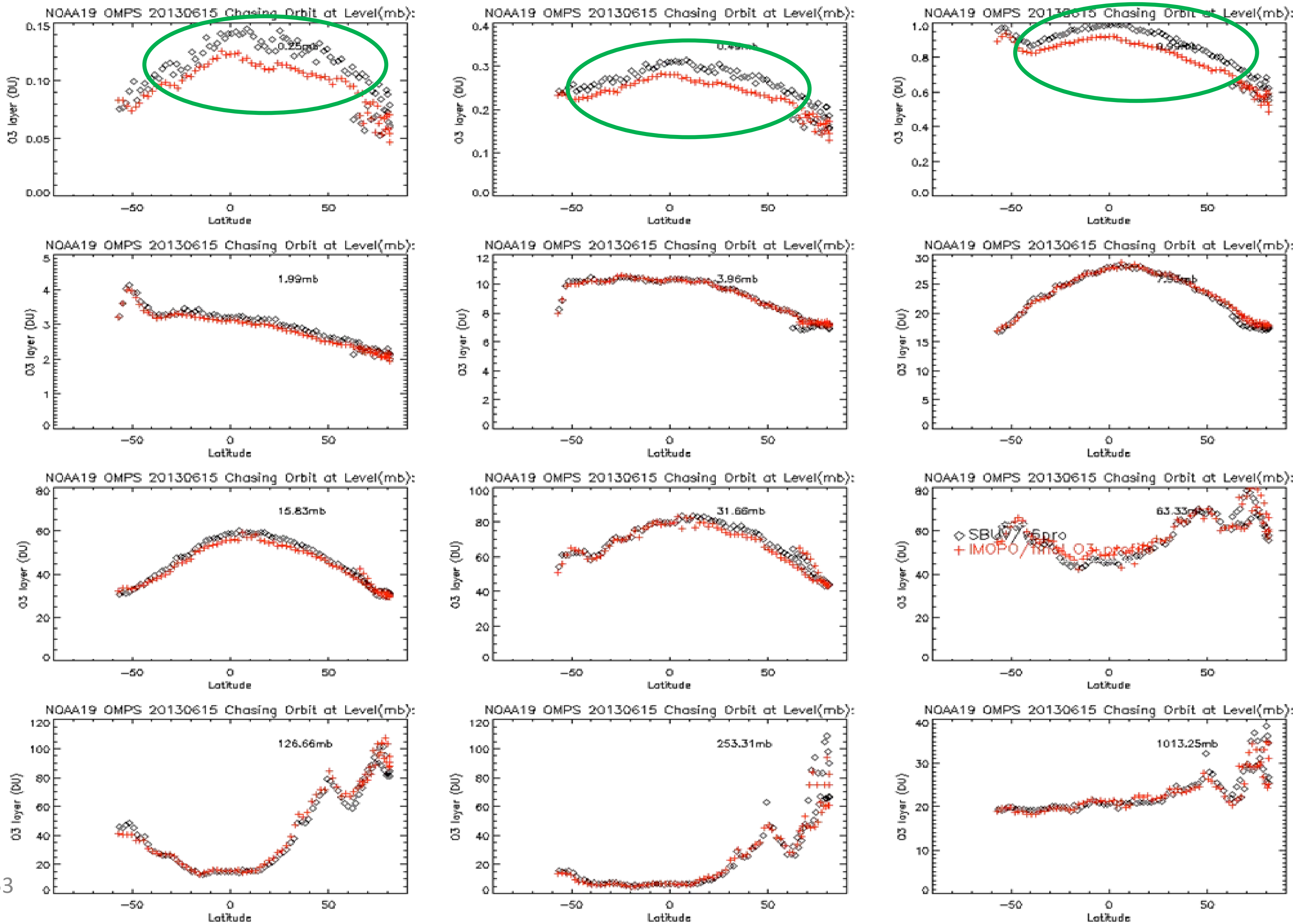
Well-matched Orbits for June 15, 2013

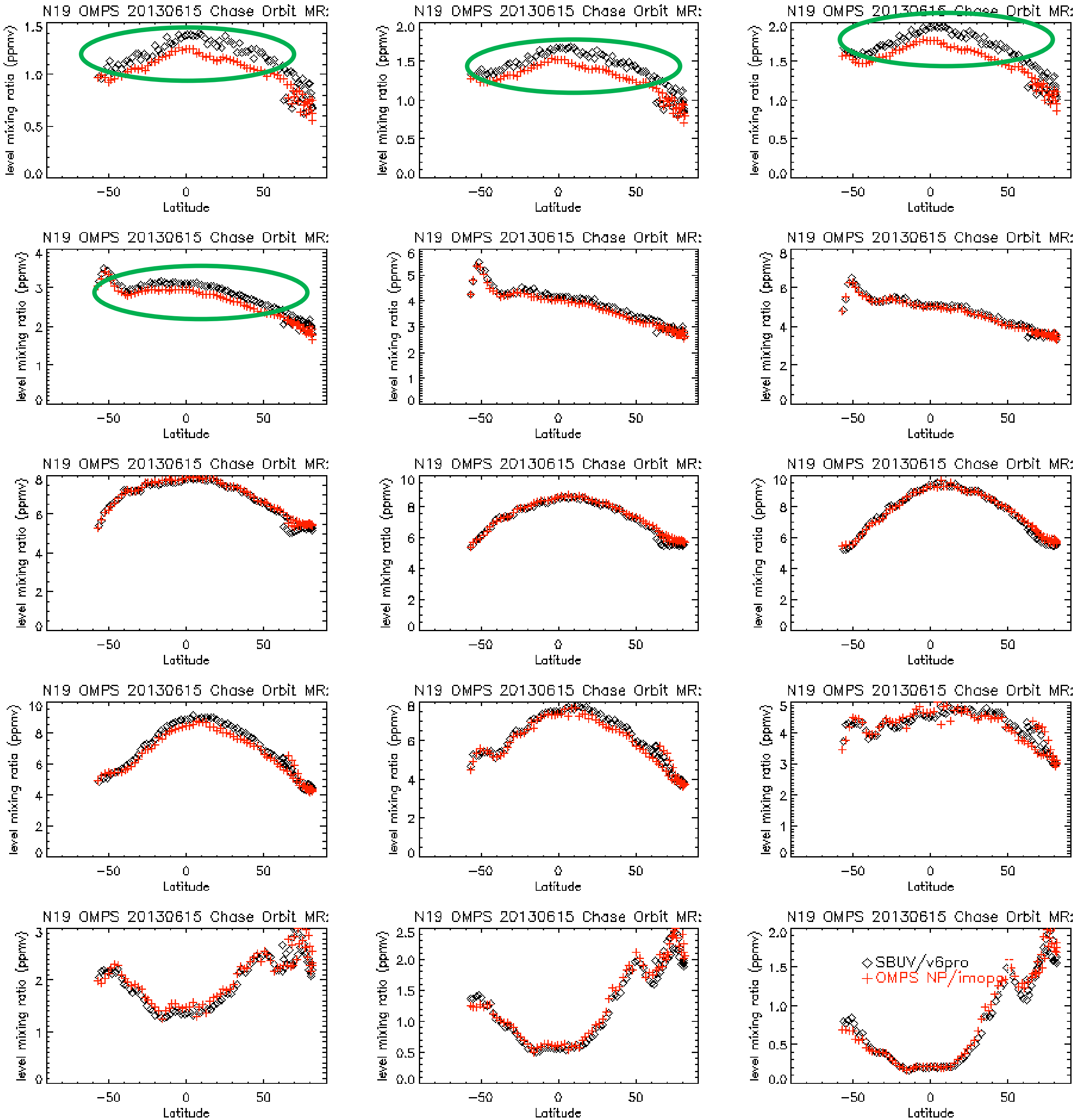


Comparison of Initial V6 Measurement Residuals for S-NPP OMPS NP and NOAA-19 SBUV/2



Chasing orbit comparisons of SBUV/2 & OMPS-NP Version 6 Ozone Profiles





Upper layers are most affected by stray light and 252 nm channel use.

[0.3,0.4,0.5,0.7,1.0,1.5,2.0,3.0,4.0,5.0,7.0,10.,15.,20.,30.,40.,50.,70.,100.] hPa.

Total Column Ozone* Products

The spectral measurements from the OMPS Nadir Mapper* of the radiances scattered by the Earth's atmosphere are used to generate estimates of the total column ozone. The algorithm uses ratios of Earth radiance to Solar irradiance at triplets of wavelengths to obtain estimates of the total column ozone, effective reflectivity, and the wavelength dependence of the reflectivity. Table values computed for a set of standard profiles, cloud heights, latitudes and solar zenith angles are interpolated and compared to the measured top-of-atmosphere albedos. The triplets combine an ozone insensitive wavelength channel (at 364, 367, 372 or 377 nm) to obtain cloud fraction and reflectivity information, with a pair of measurements at shorter wavelengths. The pairs are selected to have one "weak" and one "strong" ozone absorption channel. The hyperspectral capabilities of the sensor are used to select multiple sets of triplets to balance ozone sensitivity across the range of expected ozone column amounts and solar zenith angles. The "strong" ozone channels are placed at 308.5, 310.5, 312.0, 312.5, 314.0, 315.0, 316.0, 317.0, 318.0, 320.0, 322.5, 325.0, 328.0, or 331.0 nm. They are paired with a longer "weak" channel at 321.0, 329.0, 332.0, or 336.0 nm. The ozone absorption cross-sections decrease from 3.0 $(\text{atm. cm})^{-1}$ to 0.3 $(\text{atm. cm})^{-1}$ over the range of "strong" wavelengths. Typical ozone columns range from 100 DU or 0.1 atm-cm to 600 DU or 0.6 atm-cm.

*There is sometimes confusion on what to call the OMPS instruments and products. The OMPS Nadir Mapper (NM) makes the principal measurements that are used to create the Total Column Ozone (TC or TOZ) Products.

The 1^{st} Guess Total Ozone Product INCTO

The Multiple Triplet algorithm described in the previous slide is applied twice for each FOV. This was done to resolve the “Who goes first?” problem created by the desires to use information from other sensors in the retrieval algorithms, e.g., OMPS wanted to use the CrIS temperature profile, and CrIS wanted to use the OMPS ozone estimates. The “1^{st} Guess” OMPS products (**INCTO**) use climatological or forecast fields for surface reflectivity and pressure, snow/ice coverage, cloud optical centroid depth, and atmospheric temperature. They use internally calculated estimates of cloud fractions and effective reflectivity from measurements at non-ozone absorbing UV wavelengths. As we will show, this application of the algorithm is performing well. This product is sometimes called the Total Ozone First Guess Intermediate Product (TOZ IP).

REFERENCES – Additional information is in the OMPS Total Column Algorithm Theoretical Basis and Operational Algorithm Description Documents, and a volume of the Common Data Format Control Book: Available at http://npp.gsfc.nasa.gov/documents.html

OMPS Total Column Ozone ATBD 474-00029_Rev-Baseline.pdf

OMPS Total Column Ozone OAD 474-00066_OAD-OMPS-TC-EDR-SW_RevA_20120127.pdf

Atmospheric EDRs CDFCB 474-0001-04-02_Rev-Baseline.pdf

The 2nd Pass Total Ozone Product, OOTCO

The “2nd Pass or EDR” OMPS products (**OOTCO**) use the same UV cloud top pressures as INCTO but obtain snow/ice coverage from VIIRS near-real-time products and temperature profiles from CrIMSS products. The products use the same logic as INCTO to internally calculated estimates of cloud fractions and effective reflectivity from measurements at non-ozone absorbing UV wavelengths. As we will show, this application of the algorithm is performing well. This product is sometimes called the Total Ozone Environmental Data Record (TOZ EDR). The INCTO and OOTCO products use identical sets of measurements from the OMPS Nadir Mapper. The INCTO final ozone estimate is included as a parameter in the OOTCO output files.

REFERENCES – Additional information for this product is available in the documents listed for INCTO on the previous slide.

Nine Things to Know about the OMPS Total Ozone EDR

- The algorithm uses information at 22 wavelengths obtained from 44 macropixels (20 or more pixels) x 35 cross-track measurements
- Channels are combined three at a time to generate ozone, reflectivity and wavelength dependence of reflectivity (e.g., aerosol effects) estimates
- A single triplet is used to generate the heritage Version 7 ozone estimate
- A single triplet is used to generate the SO2 Index. It shows the effect of inter-channel biases and its use is problematic at high Solar Zenith Angles.
- Internal comparisons monitoring cross-track variations in ozone, reflectivity, aerosol and SO2 Index values provide direct information on inter-channel biases
- Absolute calibration of the reflectivity channels is tested by vicarious methods by using Greenland and Antarctic ice fields, cloud-free equatorial Pacific ocean, and minimum land values.
- Absolute calibration of ozone sensitive channels can be set to agree with the validation "truth" data set of choice.
- The First Guess IP and EDR products have been converging.
  - Partial Cloud calculations are the same except for the use of differing Snow/Ice information
    - Identical logic for cloud fractions and input for cloud top pressures
    - Snow/Ice for NRT VIIRS in EDR is still erroneous – improvements in the pipeline
    - Snow/Ice tilings in 1st Guess are better than climatology; will be daily starting in 2014
  - Temperature data options – Climatology, NCEP, CrIMSS (and correction On/Off)
    - Need to bring forecasts for the stratosphere into IDPS and turn on the correction for the IP.
  - Profile mixing fraction is problematic when it extrapolates (DR7310/CCR)
- The total ozone column products do not currently meet precisions requirements. Wavelength scale knowledge and soft calibration adjustments to remove inter-channel and cross-track calibration errors in the SDR are necessary to achieve the performance.

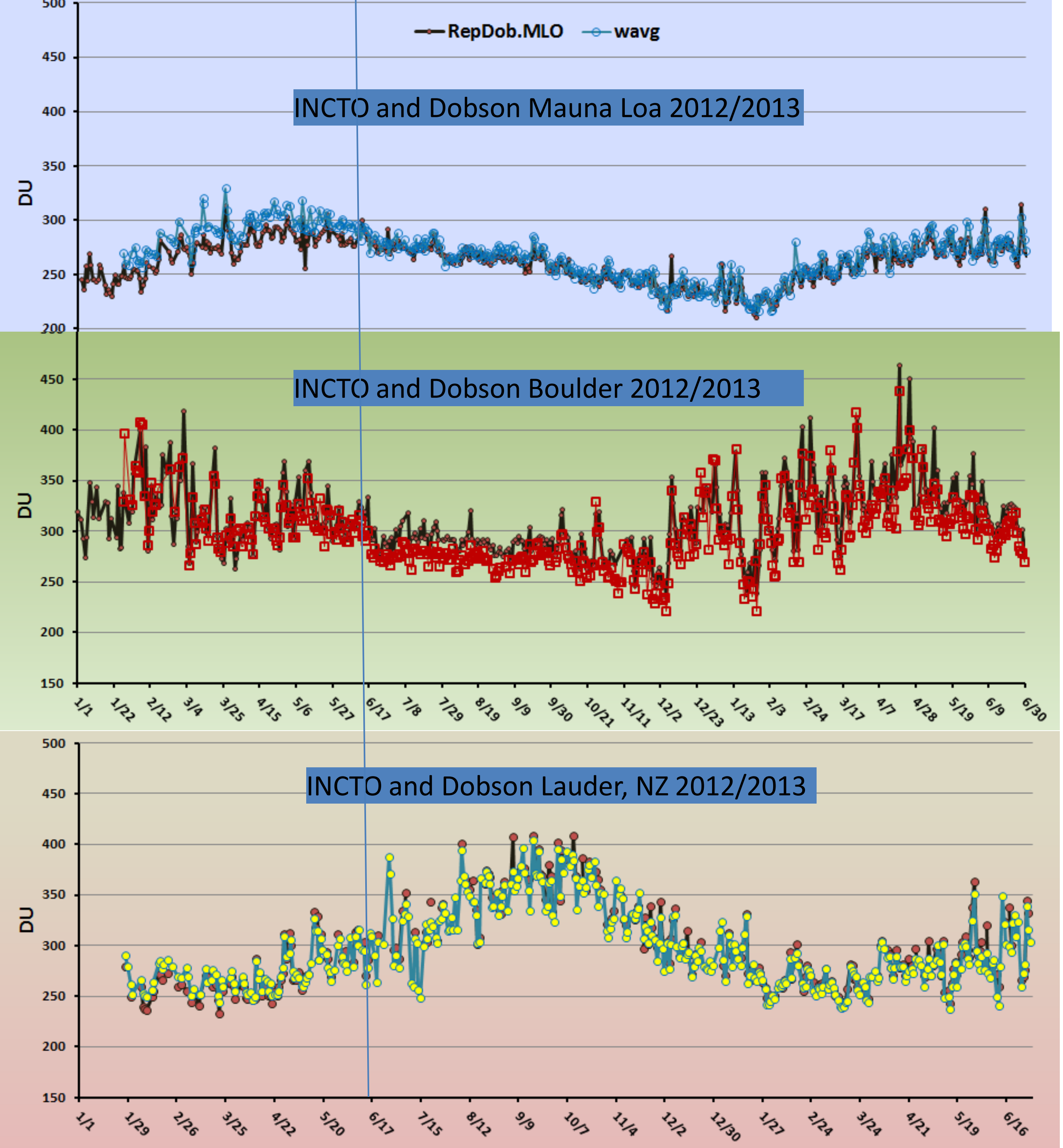
Instrument Performance – OMPS NM at Provisional

Requirement	Specification/Prediction Value	On-Orbit Performance
Non-linearity	< 2% full well	< 0.46%
Non-linearity Knowledge	< 0.5%	~0.1%
On-orbit Wavelength Calibration	< 0.01 nm	average ~0.01 nm RMS
Stray Light NM Out-of-Band + Out-of-Field Response	≤ 2	average ~± 2%^
Intra-Orbit Wavelength Stability	<0.02 nm	< 0.013 nm*
SNR	>1000	> 1000 from SV and EV
Inter-Orbital Thermal Wavelength Shift	<0.02 nm	<0.013 nm
CCD Read Noise	<60 –e RMS	< 25 –e RMS
Detector Gain	>46	~42
Absolute Irradiance Calibration Accuracy	< 7%	5%
Absolute Radiance Calibration Accuracy	< 8%	< 5%

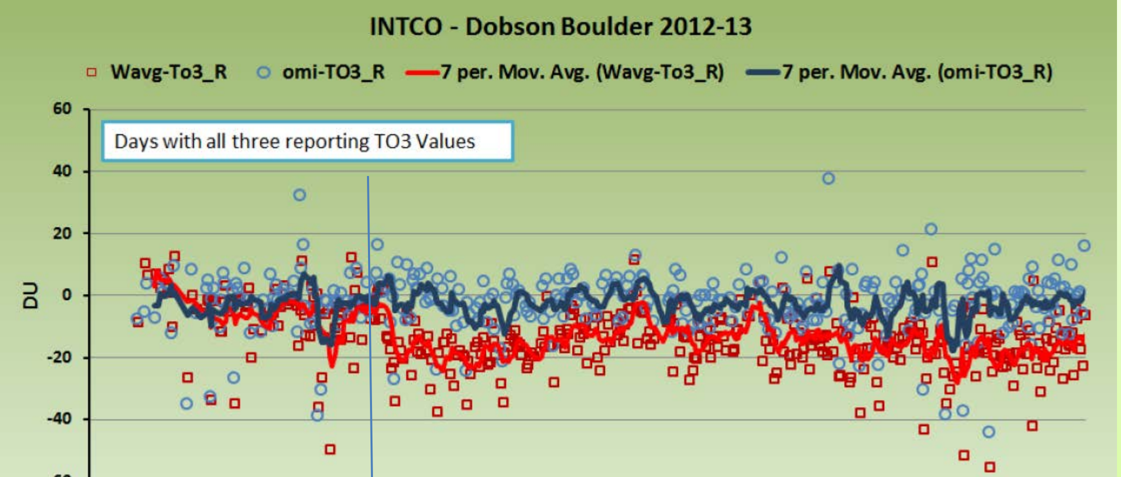
^ Need 0.5% pixel to pixel for triplet wavelengths after measurement-based correction.

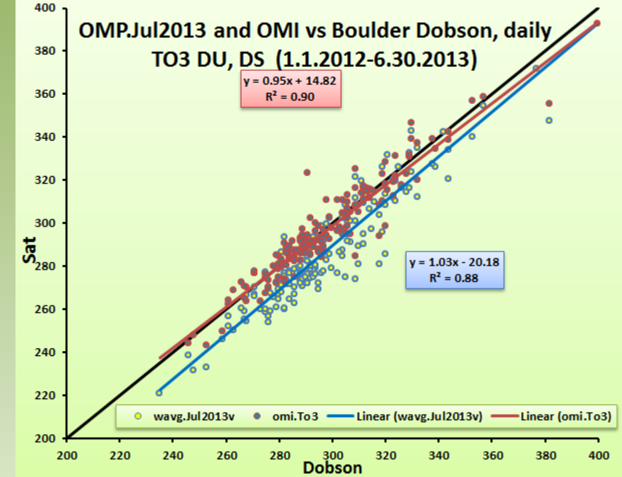
* New results show need for intra-orbit adjustments to reach this perfomance.

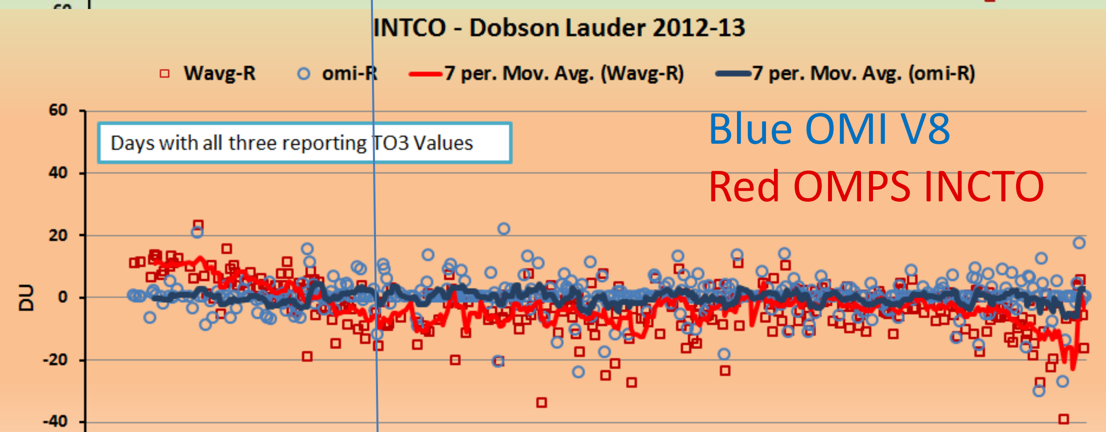
C. Pan

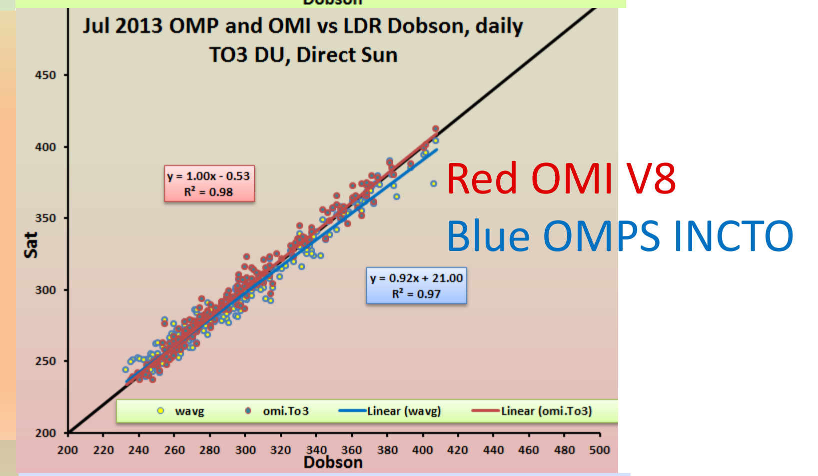


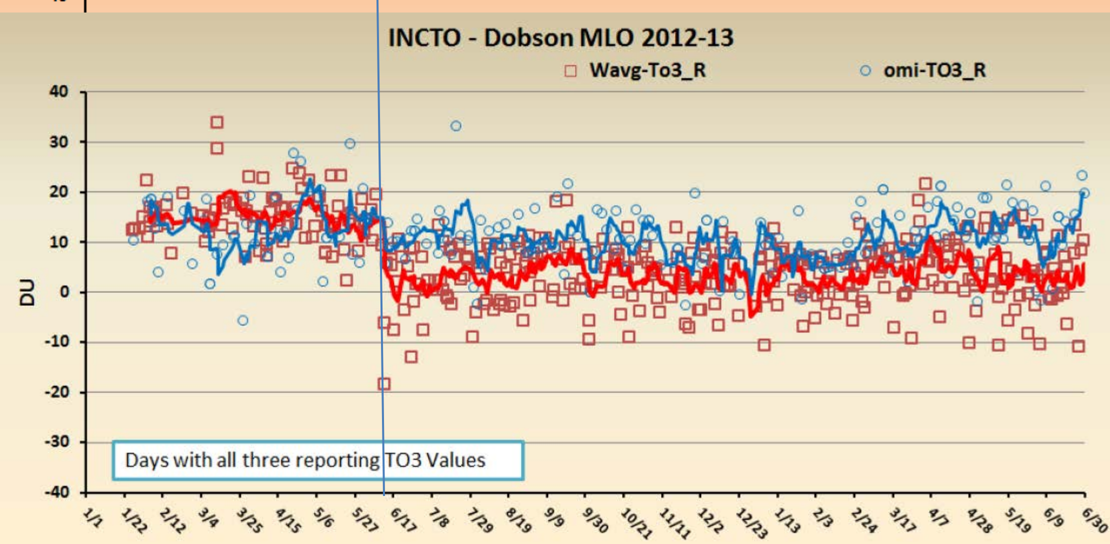
Comparisons of INCTO to three very good Dobson ground stations 1/2012 to 6/2013. Notice the shift in biases in June 2012 with the introduction of new solar flux and wavelength scales.

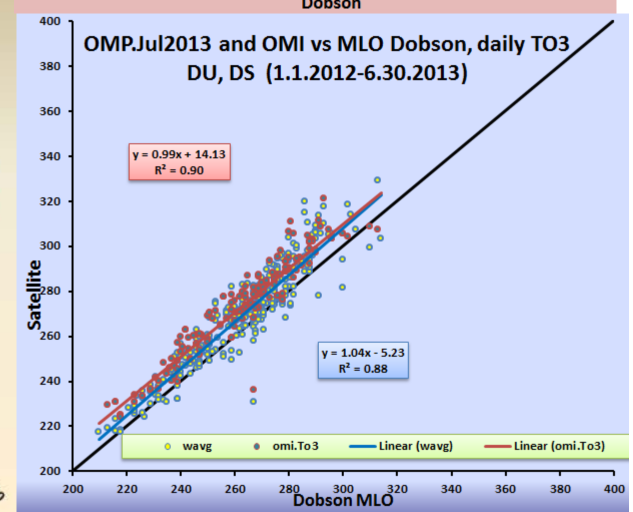

INTCO - Dobson Boulder 2012-13
Wavg-To3_R
omi-TO3_R
7 per. Mov. Avg. (Wavg-To3_R)
7 per. Mov. Avg. (omi-TO3_R)
Days with all three reporting TO3 Values
DU


OMP.Jul2013 and OMI vs Boulder Dobson, daily TO3 DU, DS (1.1.2012-6.30.2013)
y = 0.95x + 14.82
R² = 0.90
y = 1.03x - 20.18
R² = 0.88
wavg.Jul2013v
omi.To3
Linear (wavg.Jul2013v)
Linear (omi.To3)
Sat
Dobson


INTCO - Dobson Lauder 2012-13
Wavg-R
omi-R
7 per. Mov. Avg. (Wavg-R)
7 per. Mov. Avg. (omi-R)
Days with all three reporting TO3 Values
Blue OMI V8
Red OMPS INCTO
DU


Jul 2013 OMP and OMI vs LDR Dobson, daily TO3 DU, Direct Sun
y = 1.00x - 0.53
R² = 0.98
y = 0.92x + 21.00
R² = 0.97
Red OMI V8
Blue OMPS INCTO
wavg
omi.To3
Linear (wavg)
Linear (omi.To3)
Sat
Dobson

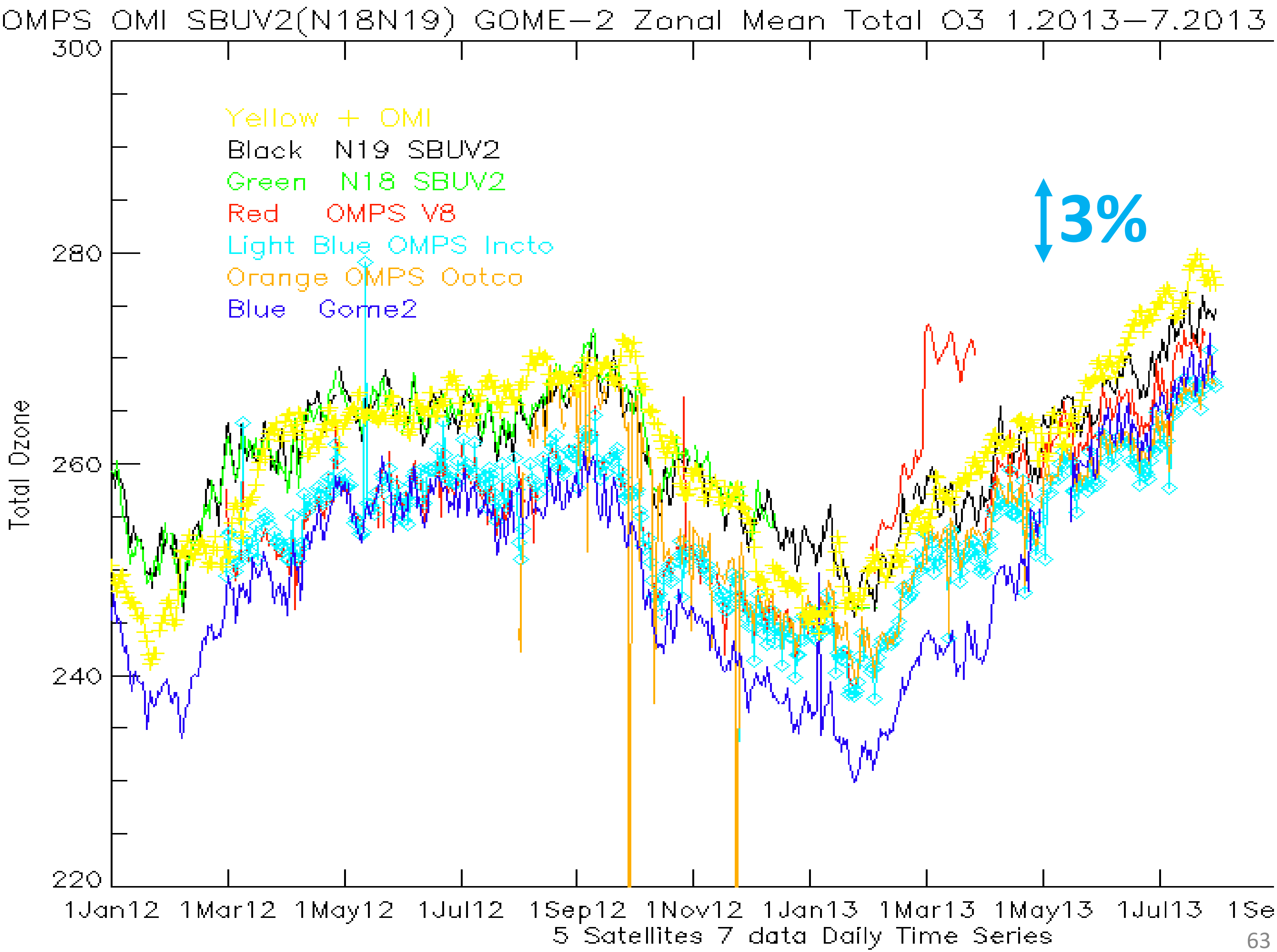

INCTO - Dobson MLO 2012-13
Wavg-To3_R
omi-TO3_R
Days with all three reporting TO3 Values
DU


OMP.Jul2013 and OMI vs MLO Dobson, daily TO3 DU, DS (1.1.2012-6.30.2013)
y = 0.99x + 14.13
R² = 0.90
y = 1.04x - 5.23
R² = 0.88
wavg
omi.To3
Linear (wavg)
Linear (omi.To3)
Satellite
Dobson MLO

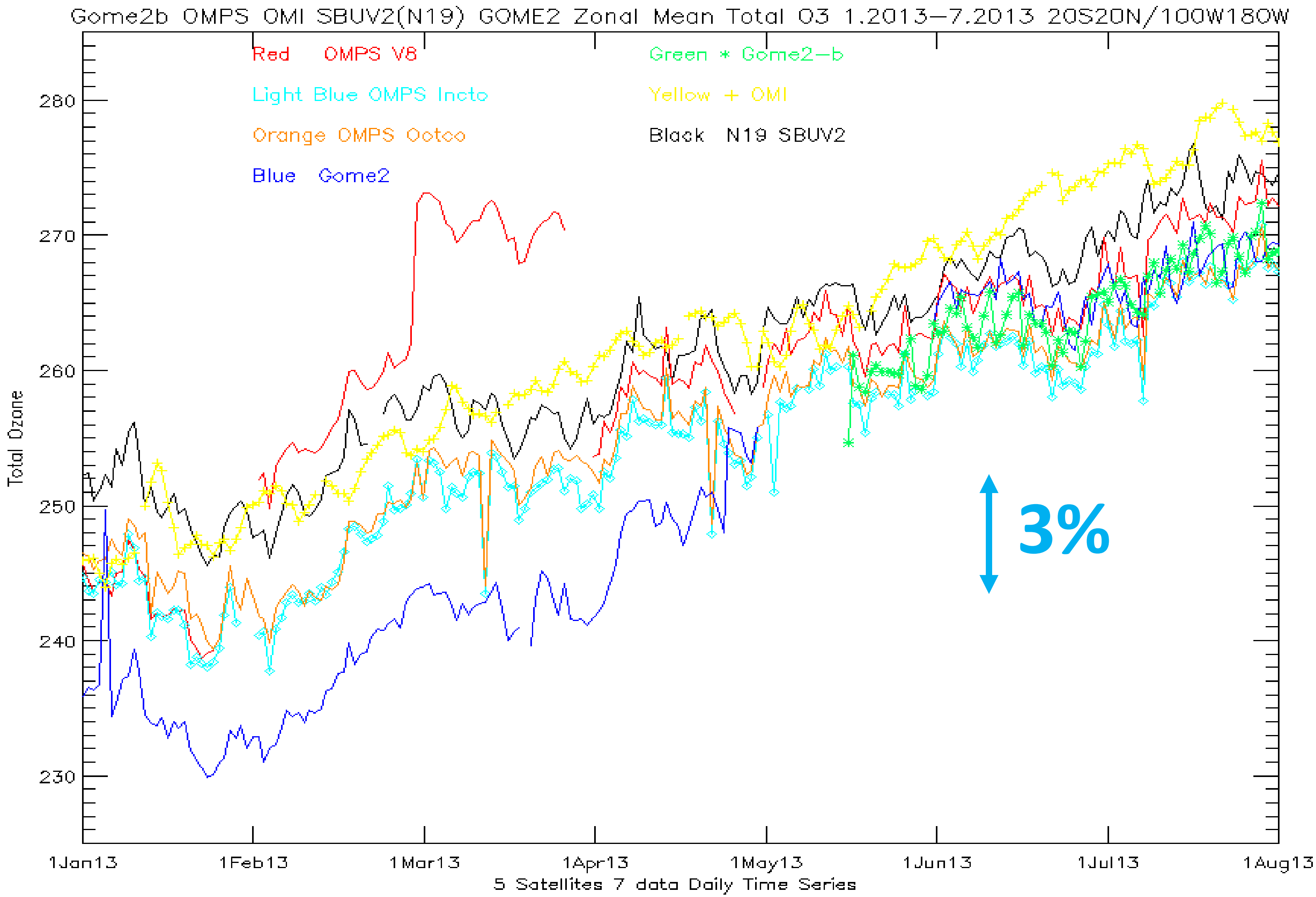
Time Series of Equatorial Pacific zonal means for INCTO and OOTCO versus other satellite measurements

- The next slide shows time series of zonal means for ozone estimates from NOAA-18 and NOAA-19 SBUV/2, MetOp-A GOME-2, NASA EOS Aura OMI and JPSS S-NPP OMPS INCTO, OOTCO and V8. The SBUV/2 and GOME-2 estimates are from Version 8 algorithms. The GOME-2 has not been adjusted for known degradation in the scan mirror until the end of the record.
- The figure on the first slides shows a bias of ~3% between the OMPS and SBUV/2 products. This is just below the accuracy performance limit.

Time series of daily zonal mean ozone for Pacific Box



Time series of daily zonal mean ozone for Pacific Box for 2013



SDR Path Forward (Solution Key: DONE, READY, KNOWN APPROACH, UNKNOWN, *FUTURE WORK*)

A. OMPS NP Ozone Profile

A.i. Turn on the 253 nm channel in the retrieval algorithm -- DONE.

A.ii. First version of the stray light correction. – March 17 in Mx8.3 DONE.

A.iii. Improved/tuned stray light correction table -- April (SDR Table Tuning) Analysis shows more work is needed. Which channels are the best proxies?

A.iv. New Day 1 Solar irradiance spectrum and wavelength scale – May (SDR Table Tuning)
I recommend that this be a simple -0.115 nm shift relative to Day 0. We would revisit with annual wavelength scale variations and wavelength dependent shifts in the future. (Should this also adjust the radiometric coefficients for the shift/dichroic? Should the solar activity level be picked for the current Mg II 27-day average state?)

A.v. Proper matchup for Nadir Mapper and Nadir Profiler FOVs – TTO May 19 in Mx8.4 (EDR only).

A.vi. Error in smear subtraction creating offset bias error – Correct code (in Mx8.5), Change Input Bias to 742 counts.

A.vii. Soft Calibration adjustments including dichroic to Day 1 Solar or CF Earth -- May (SDR Table Tuning*).*

A.viii. Annual variations in the wavelength scale correlated with temperature gradients. SDR.

A.ix. Adjustments to Day 1 Solar for solar activity. SDR.

B. OMPS NM Total Column Ozone

B.i. Measurement-based wavelength scale adjustments – February 19 Mx8.1. DONE.

B.ii. Revised profile mixing fraction logic – March 17 in Mx8.3 (EDR only) DONE

B.iii. First version of OOR Table for the stray light correction -- May (SDR Table Tuning and Code Change)
New Table received. OOR cross-track dependence requires code change.
CCR to proceed with this for the Mx8.5 build. It is a change to the code and table dimensions. Minor ATBD and OAD and CDFCB changes.

B.iv. New Day 1 Solar irradiance spectra and wavelength scales. Should be set to middle of orbital scale variation. Cross-track dependence is complex. – May (SDR Table Tuning)

B.v. Soft Calibration adjustments to Day 1 Solar or CF Earth -- May (SDR Table Tuning)

B.vi. *Check flagging and logic for total ozone out of range and fill for triplet retrievals. (EDR)*

B.vii. *Possible bandpass changes -- ground to flight, intra-orbit.*

Lines of Code for V8TOz

- 1) To prepare LUT: 1252 lines
- 2) To generate files and prepare SDR and GEO for processing: 920 lines
- 3) The algorithm source codes: 19828 lines

Total lines: 22000 lines.

Options for Basic Implementation of V8TOz

- IDPS (Need to introduce new Process, LUTs and output)
  - Implement as a follow-on process to the MTTOz. Make use of the INCTO input/output as input. INCTO still run in IDPS, or
  - Replace MTTOz with V8TOz as PRO.
    - Minor changes to select 12 channels from the current 22, add/remove some input tables and output parameters.
- NDE
  - Implement as a new process
    - Transition V8TOz implementation for OMPS on LINUX in use at STAR. Only SDRs and GEOs continue in IDPS.
    - Need OMPS NM SDRs (SOMPS) and GEOs (GOTCO) delivered to the NDE system
- OSPO/POES
  - Implement as another “GOME-2” with existing V8TOz processing code
    - Reader in use at STAR can provide V8TOz with GEO and 12 channels. Only SDRs and GEOs continue in IDPS.
    - Need OMPS NM SDRs (SOMPS) and GEOs (GOTCO) delivered to the POES system

What about future refinements for V8TOz?

Path to upgrades

Information concentration

Information concentration can be performed at the same step as the N-value creation, either in the input stage of the MTTOz or the input stage of the V8TOz (if the latter is working from SDRs).

Additional channels for SO2 and NO2

These would be best implemented as stand-alone processes/products, although one of the SO2 options can work directly from the V8TOz residuals

Smaller FOVs

Under the current plan, these products would not flow from IDPS starting points for SDRs or EDRs as those would use an aggregator.

The bookkeeping for retrieving total ozone for smaller fields of view from an SDR is simple but the output products would have to be resized or be dynamically sized whether for the MTTOz or V8TOz.

New ancillary Input

IDPS can access better data for snow/ice and surface pressure and use these in the V8TOz processing

So can NDE and OSDPD

We have removed most of the dependencies on VIIRS and CrIS EDRs.

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.), 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

- 1) To prepare LUT: 1253 lines
- 2) To generate orbit files, match up FOVs, and prepare SDRs and GEOs for processing: 1228 lines
- 3) Algorithm source codes: 15319 lines

Total lines: 17800 lines.

What about future 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
  - Under the current plan, these products would not flow from IDPS starting points for SDRs or EDRs as those would use an aggregator.
  - Recommend that the “aggregator” have a “non-aggregator” switch and we develop smaller FOV capabilities as part of V8Pro implementation.
  - Glueware (NM/NP Matchups) modifications on the appropriate system would be needed to handle new cases of FOVs.
- New ancillary Input
  - All three systems can access better data for snow/ice and surface pressure for use in the V8Pro processing

Recommendations for V8Pro

- OMPS ozone profile products should be made by using the V8Pro code as implemented for the SBUV/2.
  - This will require a flow of OMPS SDRs and GEOs.
  - Is this a long-term solution?
- The operational products should be the first step in CDR generation.
- Smaller FOVs should be accommodated by changes in the matchup glueware. Output products should be dynamically sized.
- Information concentration (noise reduction), outlier detection, solar activity adjustments, and intra-annual wavelength shifts should be implemented in the OMPS data input module for the V8Pro.
- Can the V8Pro in ADL jumpstart the IDPS.

JPSS STAR Science Team Annual Meeting

VIIRS EDR Imagery

Don Hillger, and Curtis Seaman, PhDs
EDR Imagery Team Product Lead
(Tom Kopp, Cal/Val Lead)
(Ryan Williams, JAM)
And the rest of the EDR Imagery Team!

12-16 May 2014

Outline

- Overview
  - Products, Requirements, Team Members, Users, Accomplishments
- S-NPP Algorithms Evaluation:
  - Algorithm Description, Validation Approach and Datasets, Performance *vs.* Requirements, Risks/Issues/Challenges, Quality Monitoring, Recommendations
- Future Plans
  - Plan for JPSS-1 Algorithm Updates and Validation Strategies, Schedule and Milestones
- Summary

EDR Imagery Cal/Val Team

- **NESDIS/StAR** (D. Hillger, D. Molenar, D. Lindsey, T. Schmit – GOES liaison)
- **CIRA/CSU** (C. Seaman, S. Miller, S. Kidder, S. Finley, R. Brummer)
- **CIMSS/SSEC** (T. Jasmin, T. Rink, W. Straka) **McIDAS-V**
- **Aerospace** (T. Kopp, J. Feeley)
- Stellar Solutions (R. Williams)
- **NOAA/NGDC** (C. Elvidge)
- **NRL** (J. Hawkins, K. Richardson, J. Solbrig)
- AFWA (J. Cetola)
- Northrop Grumman (K. Hutchison, R. Mahoney, C. Liang)
- NASA (W. Thomas, P. Meade)
- NOAA/OSPO (A. Irving)
- NASA/SPoRT (G. Jedlovec, M. Smith)

S-NPP/JPSS data sources

- **GRAVITE**[1] (Wash DC, ~7-hour delay)
- **NOAA CLASS**[2] (Asheville, ~7-hour delay) – not actively used
- **Atmosphere PEATE**[3] (Wisconsin, ~7-hour delay)
  - ADDE server for McIDAS
  - FTP and HTML
- **Direct Readout** (Wisconsin, ~0.5-hour delay, <u>only over North America</u>, when the satellite is with sight of Madison)
  - ADDE server for McIDAS
  - FTP
- **AFWA IDPS**[4] (Omaha, near real-time)

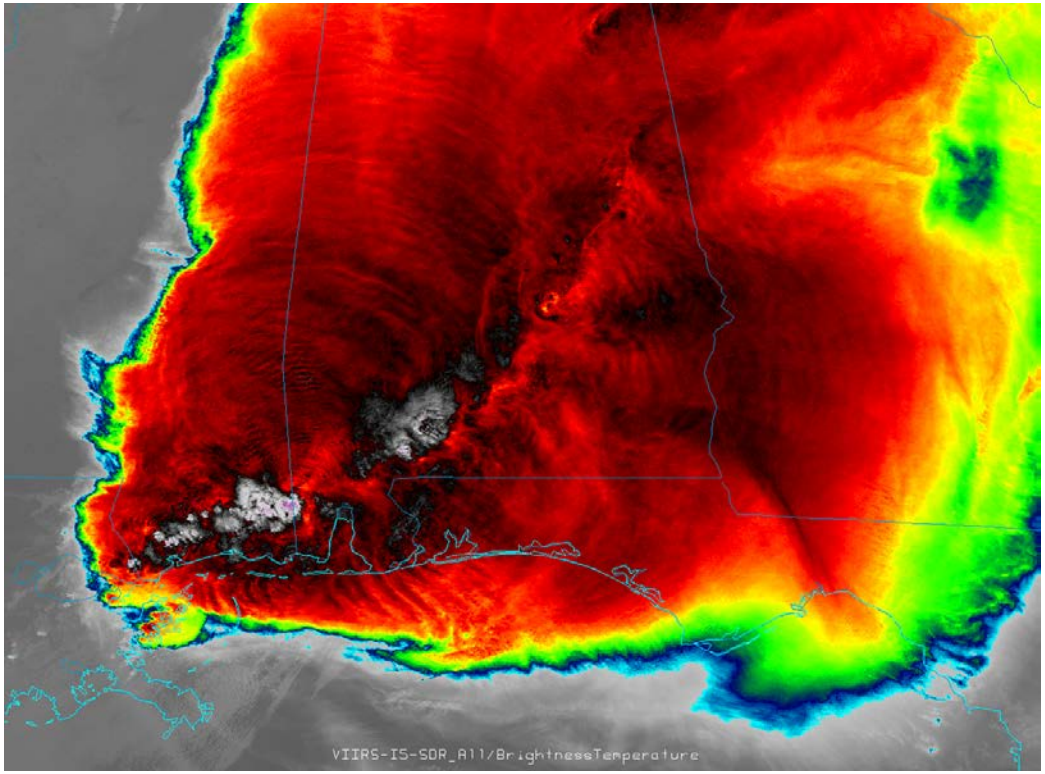
[1]Government Resource for Algorithm Verification, Independent Test, and Evaluation
[2]Comprehensive Large Array-data Stewardship System
[3]Product Evaluation and Algorithm Test Elements
[4]*Air Force Weather Agency* Interface Data Processing Segment

VIIRS Bands Created as EDR Imagery

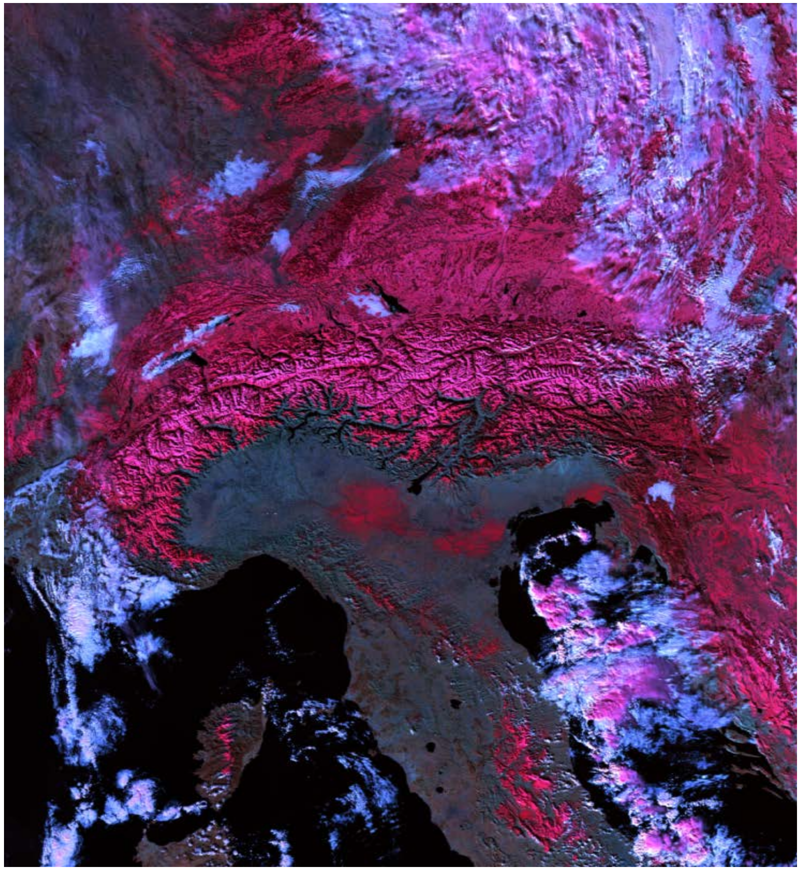
Bands in bold and highlighted in grey are available as Imagery EDRs.

VIIRS Band	Central Wavelength (µm)	Wavelength Range (µm)	Band Explanation	Spatial Resolution (m) @ nadir
M1	**0.412**	**0.402 - 0.422**	Visible	750 m
M2	0.445	0.436 - 0.454		
M3	0.488	0.478 - 0.488		
M4	**0.555**	**0.545 - 0.565**		
M5	0.672	0.662 - 0.682		
M6	0.746	0.739 - 0.754	Near IR	
M7	0.865	0.846 - 0.885		
M8	1.240	1.23 - 1.25	Shortwave IR	
M9	**1.378**	**1.371 - 1.386**		
M10	1.61	1.58 - 1.64		
M11	2.25	2.23 - 2.28		
M12	3.7	3.61 - 3.79	Medium-wave IR	
M13	4.05	3.97 - 4.13		
M14	**8.55**	**8.4 - 8.7**	Longwave IR	
M15	**10.763**	**10.26 - 11.26**		
M16	**12.013**	**11.54 - 12.49**		
DNB (NCC)	**0.7**	**0.5 - 0.9**	Visible	750 m across full scan
I1	**0.64**	**0.6 - 0.68**	Visible	375 m
I2	**0.865**	**0.85 - 0.88**	Near IR	
I3	**1.61**	**1.58 - 1.64**	Shortwave IR	
I4	**3.74**	**3.55 - 3.93**	Medium-wave IR	
I5	**11.45**	**10.5 - 12.4**	Longwave IR	

Suomi NPP VIIRS Imagery examples



High-resolution color-enhanced infrared of cloud tops. Image courtesy of Dan Lindsey.

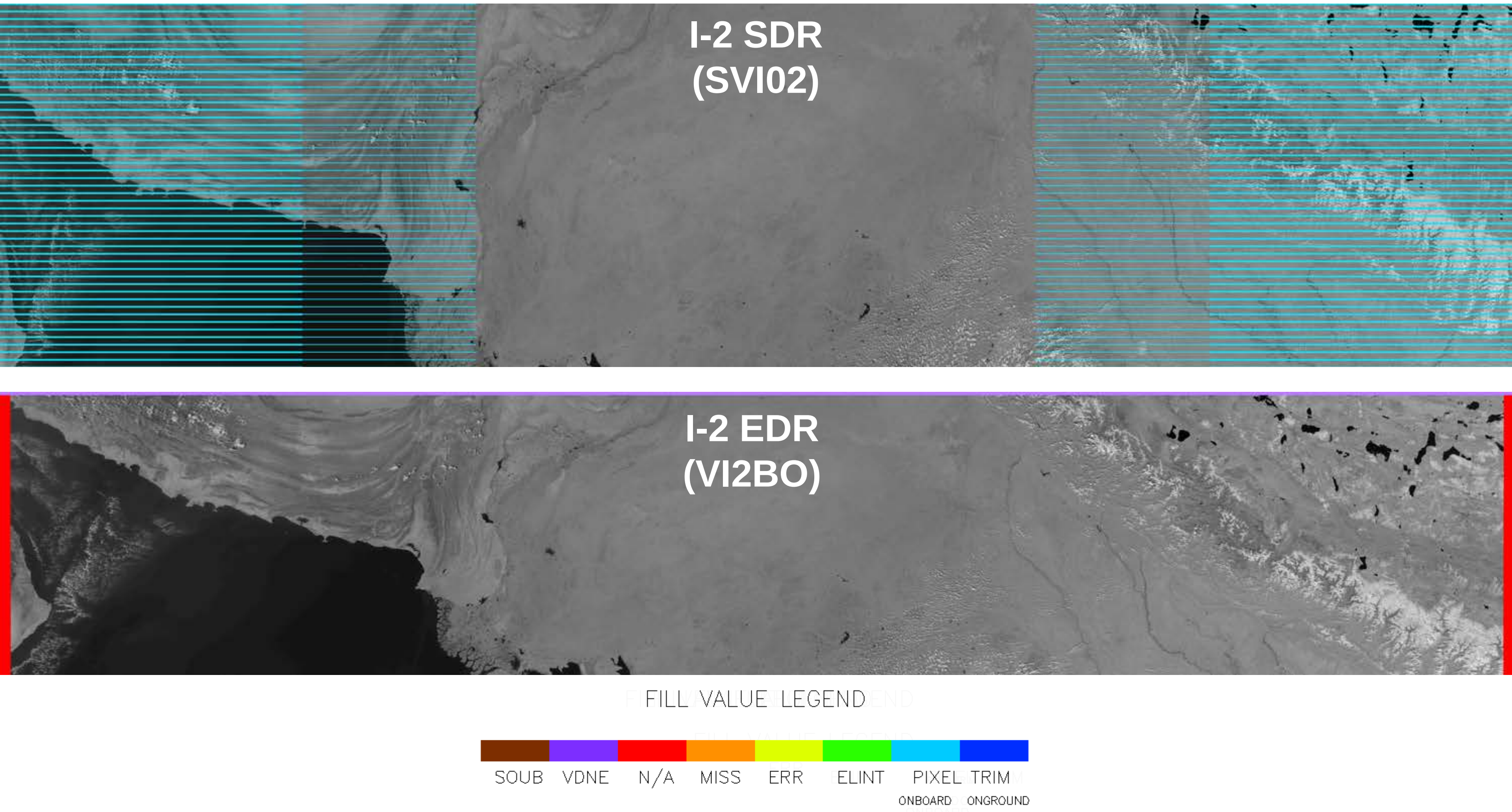


3-color image combination of visible and IR bands over northern Italy. Image courtesy of Curtis Seaman.

VIIRS EDR Imagery Basics

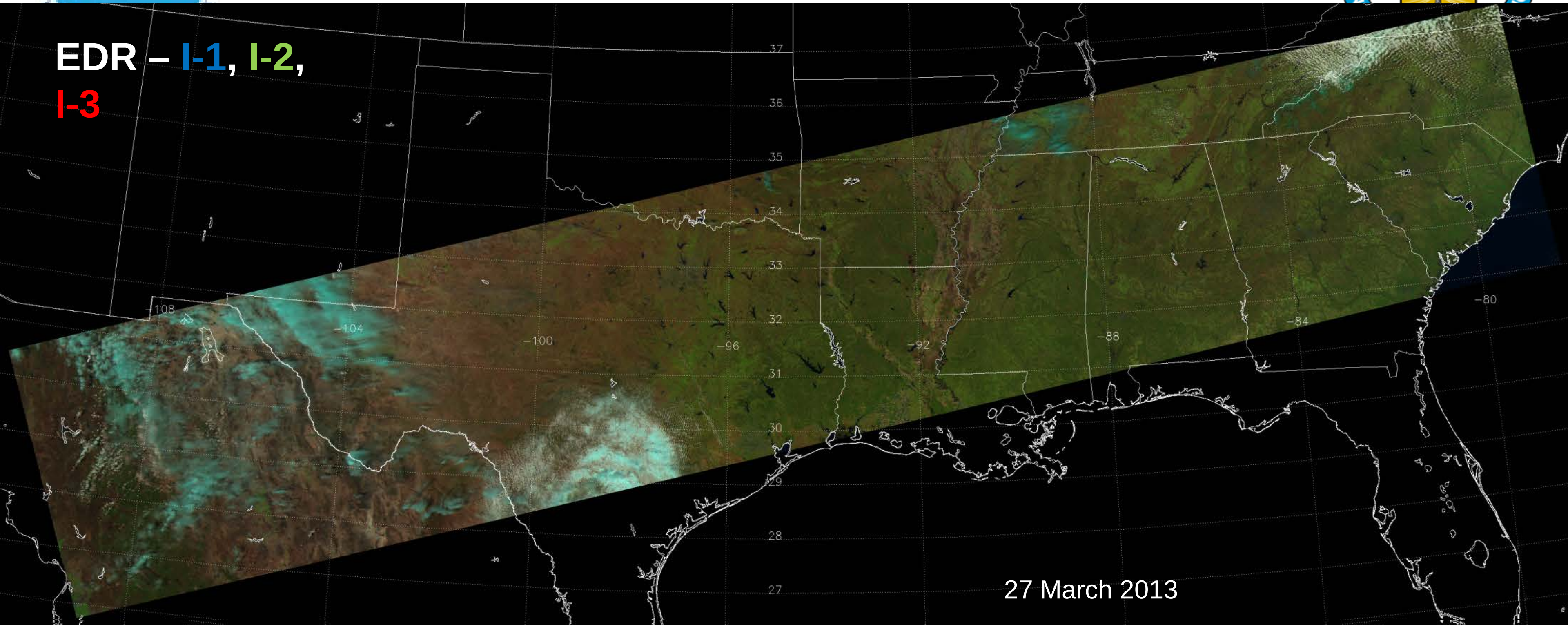
- The **Imagery EDR** is the projection of SDRs onto a **Ground Track Mercator (GTM)** layout (remapped)
  - For the non-DNB/NCC bands: the radiances/reflectances are the same
  - For the **DNB SDR: the Near Constant Contrast (NCC) EDR** Imagery product has additional calculations involved
- Advantages of Imagery EDRs:
  - Bowtie-deletions eliminated
  - Overlapping pixels eliminated
- Current EDR Imagery:
  - 5 I-bands (all of them)
  - 6 of the 16 M-bands (default set, leaving 10 M-bands behind!)

SDRs and EDRs: What's the difference?

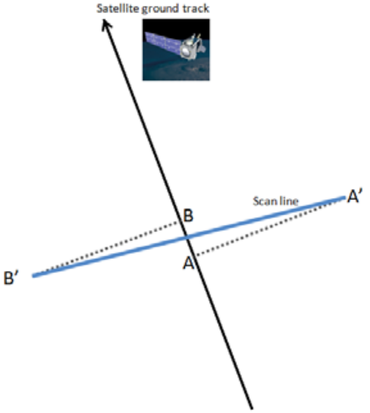


Unmapped SDR and EDR granules from 08:14 UTC 24 October 2013

SDRs and EDRs: Apparent Rotation

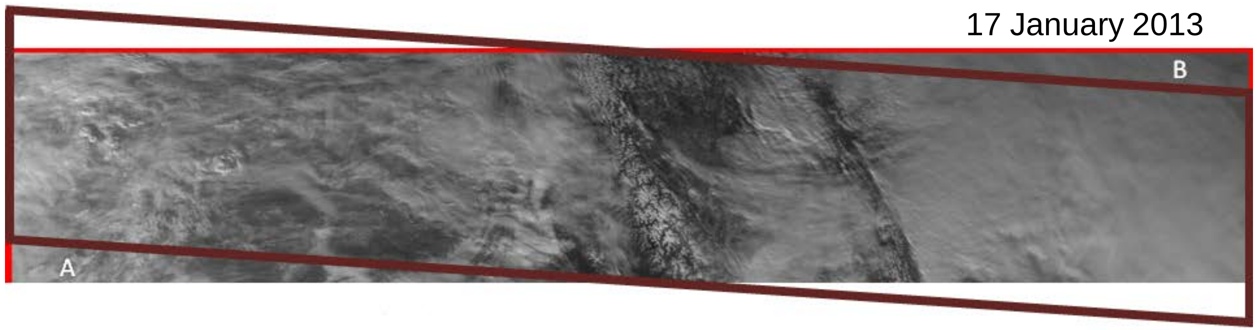


Scan lines in SDR data are not orthogonal to the satellite ground track, due to the constant motion of the satellite. Mapping the data to the Ground Track Mercator (GTM) grid restores orthogonality. This is the cause of the apparent rotation between SDRs and EDRs.



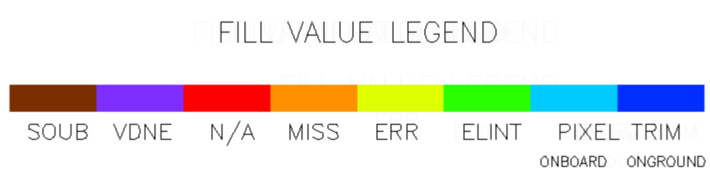
The Case of the Missing Triangles

17 January 2013



The brown outline shows where a SDR granule matches up with a given EDR granule. It takes three SDR granules to produce one EDR granule. If an SDR granule is missing when the EDR is created, you get a “missing triangle”…

24 February 2012



Unique features of VIIRS, as compared with its predecessors

- **Finer spatial resolution** for all bands (down to 375 m)
- **Finer spatial resolution at swath edge in particular**
- **Wider (3000 km) swath**, leaving no gaps between adjacent orbits
- **DNB / NCC enables visible light imagery under all natural and artificial illumination conditions**

NCC (EDR) vs. DNB (SDR)

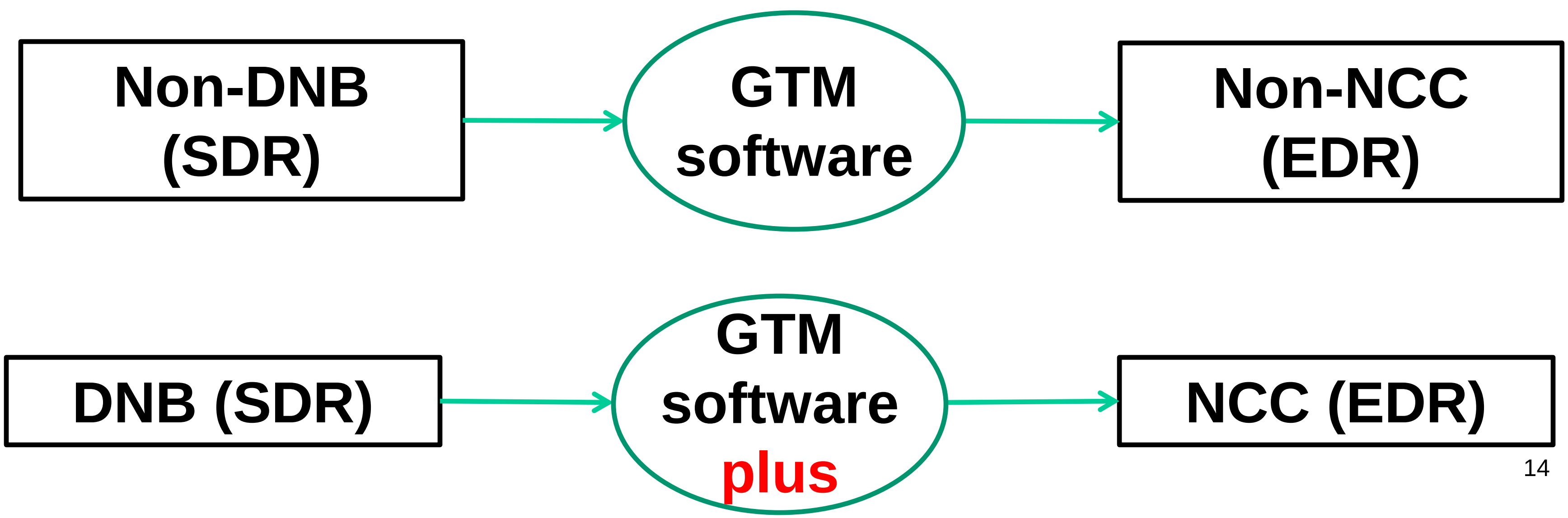
- **What are the differences?**

Product	xDR	Units	Mapping
DNB	SDR	Radiances	Raw
NCC	EDR	Pseudo-albedos	GTM

- **Which is better?**
- **Answer: Depends on the usage!**

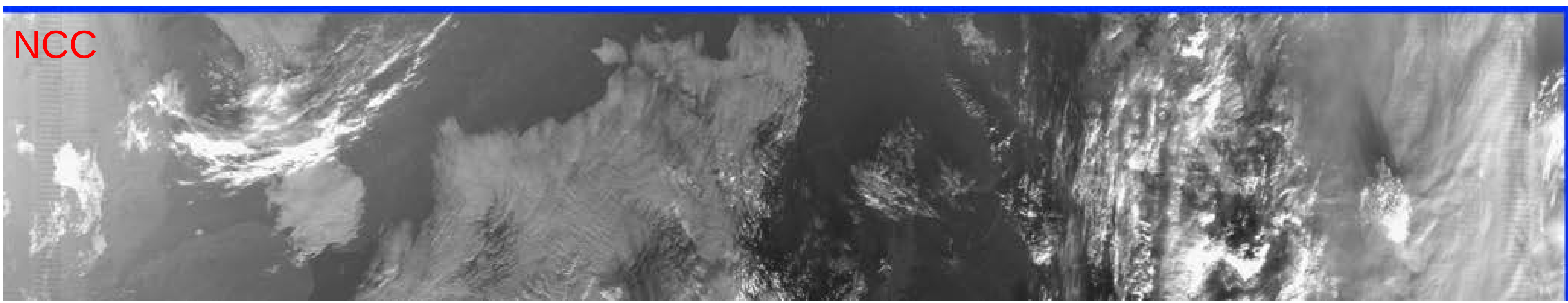
Sensor Data Record (SDR) to Environmental Data Record (EDR)

- **Ground Track Mercator (GTM)** remapping software.
  - GTM is a **remapping** of the data, but the **same radiances/reflectances** for Non-NCC bands only.
- For **NCC Imagery** there is **additional radiance processing**



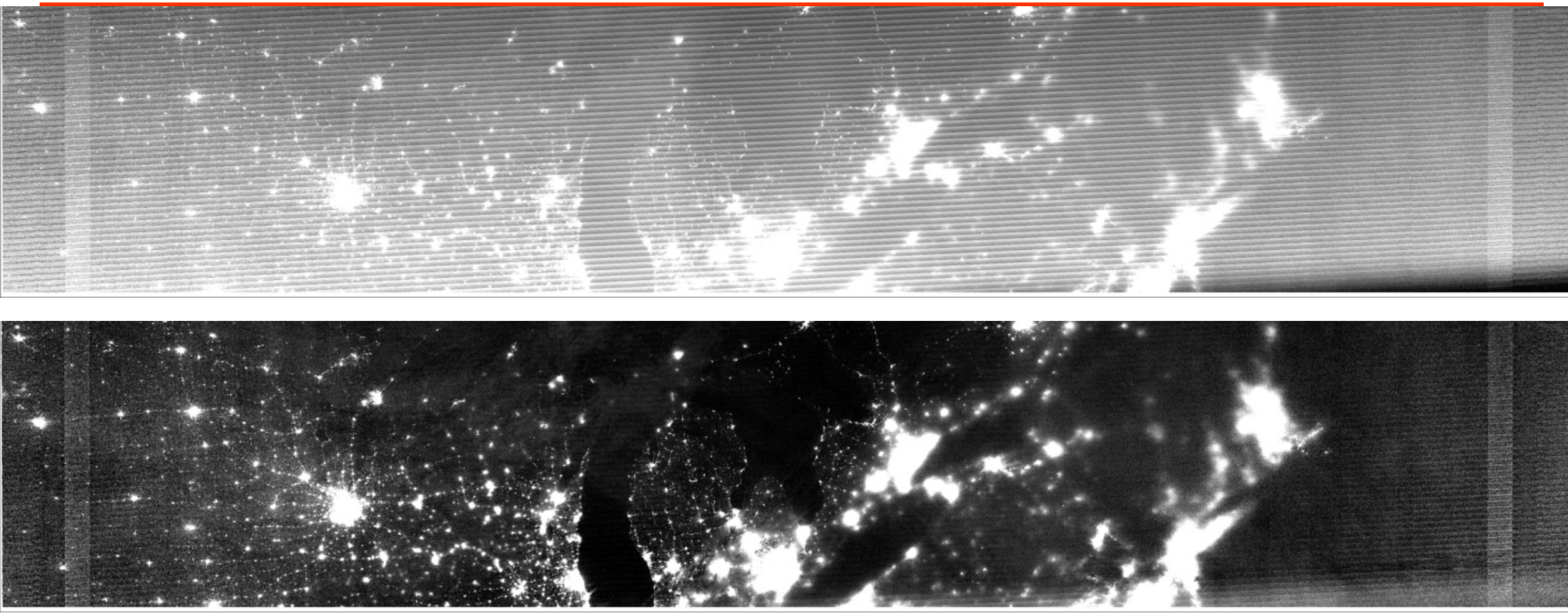
Near Constant Contrast (NCC) Product

NCC extends constant contrast into the twilight portion of the granule swath.



Cross-terminator DNB SDR (top) versus NCC Imagery EDR (bottom)

Stray light in NCC Imagery before (top) versus NCC after removal (bottom)



Artifacts in the DNB SDR are inherited by the NCC Imagery EDR. Before August 2013 the most significant of these was a stray light issue with the DNB on the dark side of the terminator. The DNB SDR algorithm was adjusted to correct for this error in August 2013. The impact on the NCC Imagery EDR was profound. The removal of the stray light is evident in the bottom image, taken from the granule over the upper Midwest of the United States on 9 August 2013. As a reference, Lake Michigan may be seen in the middle of the granule

Algorithm Evaluations
(Slide formatted as requested.)

- In the case of IDPS algorithms, we want the algorithm leads to provide 1 of 3 recommendations:

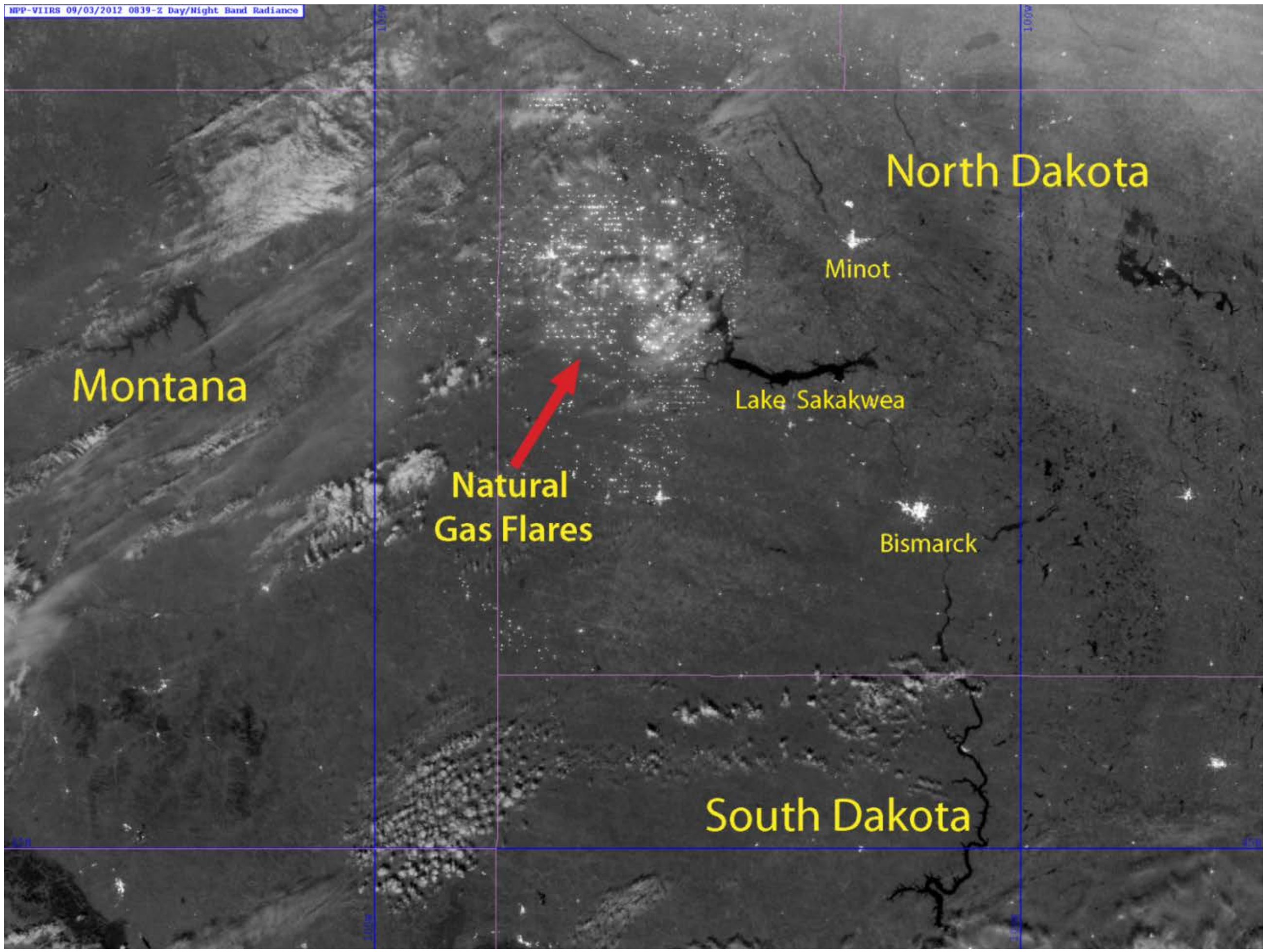
  1. **NPOESS algorithm has evolved into the NOAA-endorsed JPSS algorithm and any needed improvements should continue.**

  2. NPOESS (or evolved) algorithm will not meet requirements or effort is too large, replace with NOAA-endorsed JPSS algorithm

  3. NOAA-endorsed algorithm should be used even if NPOESS (or evolved) algorithm meets performance because of legacy, enterprise, blended products, and other considerations.

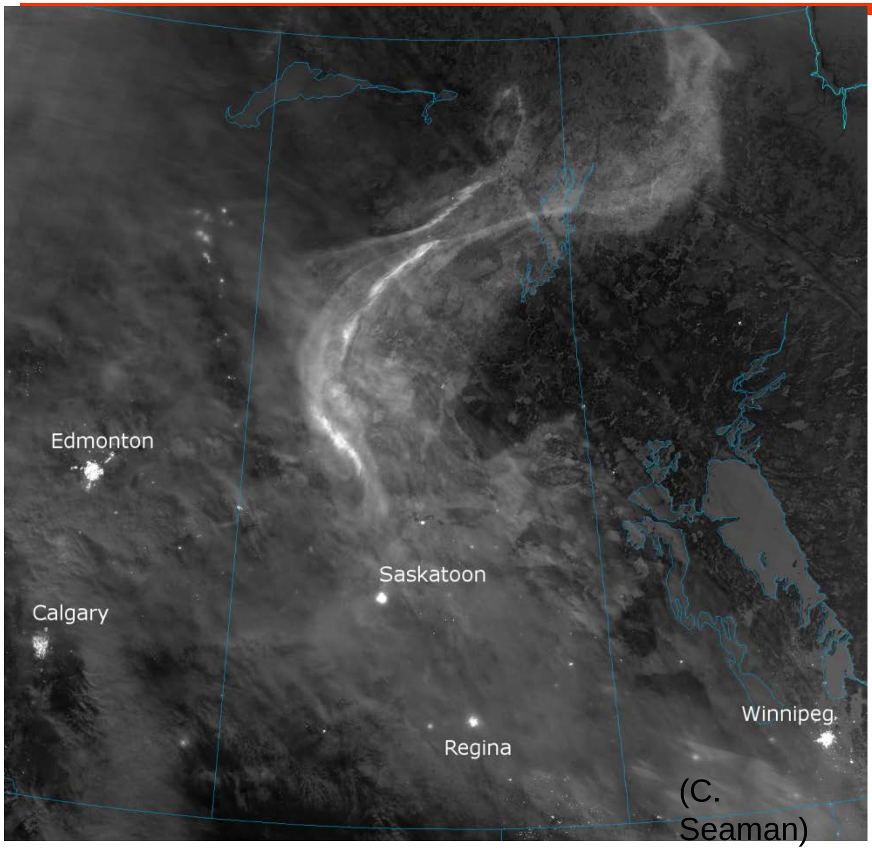
- For 2 or 3, present the alternative algorithm methodology description, algorithm performance against the level 2 supplement specification and any user assessments.

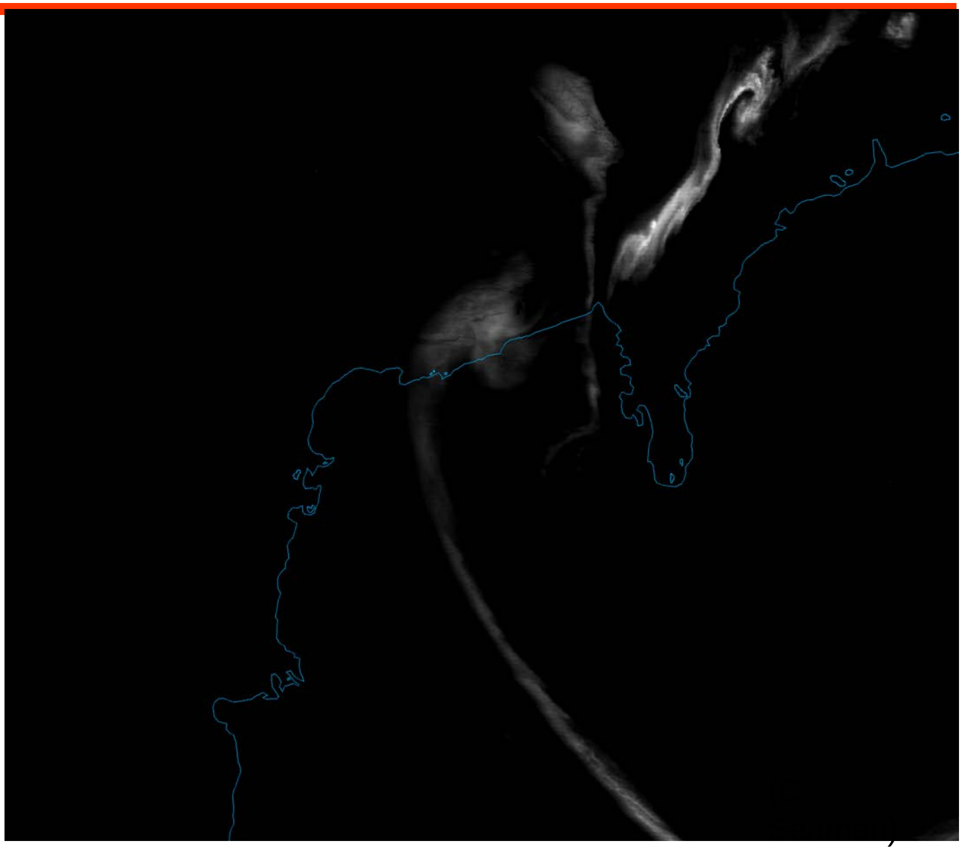
Mostly cloud-free DNB image over the U.S. Upper Midwest, 3 September 2012 at 0839 UTC



Note the lights from major cities, as well as a large cluster of oil flare signatures in northwestern North Dakota from the recently-developed Bakken formation.

Auroras in the DNB
Images courtesy Curtis Seaman (CIRA)



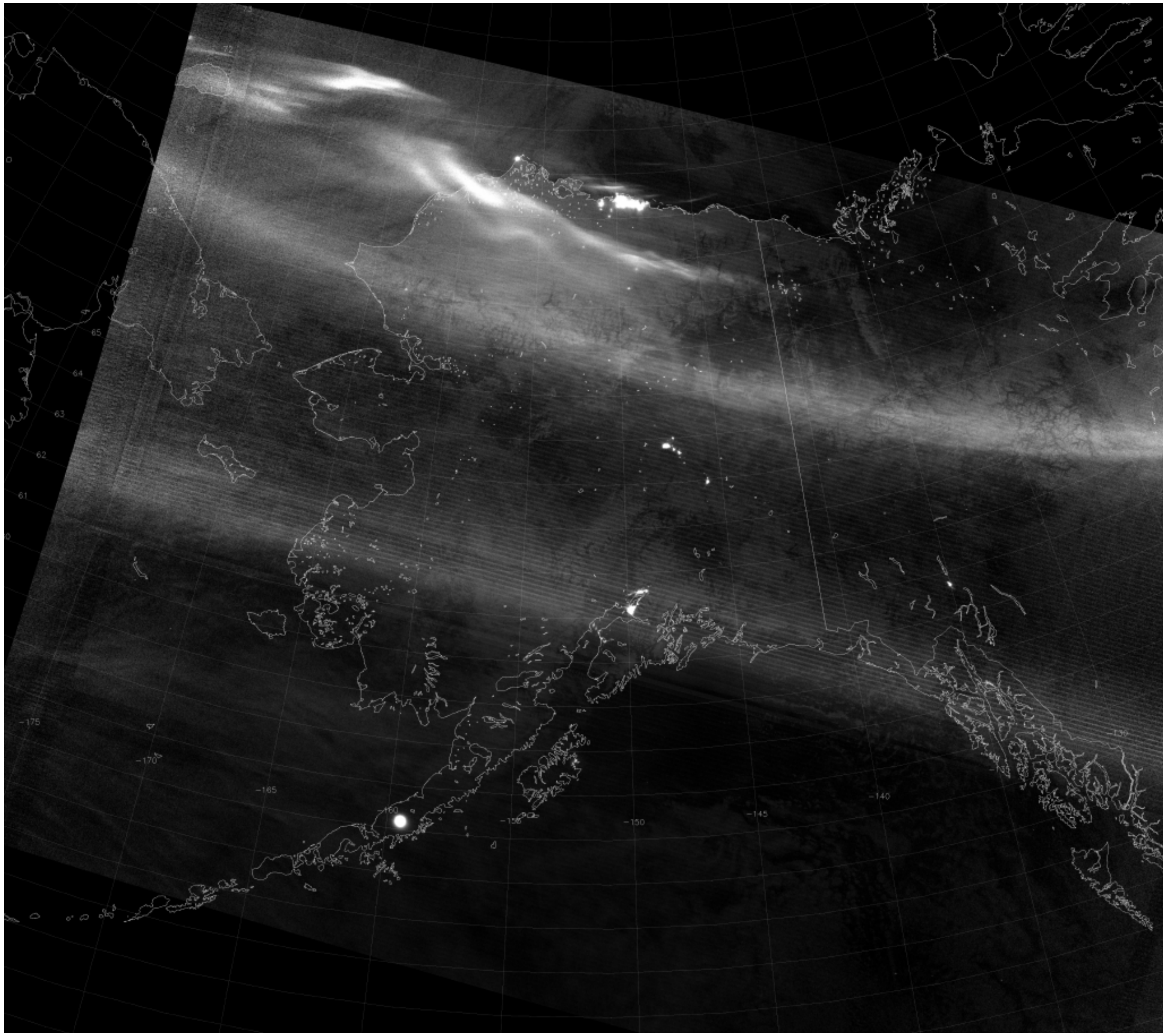


Aurora Borealis over Saskatchewan, Canada on 9 March 2012, visible during a full moon!

Aurora Australis over Antarctica on 15 September 2012, during a new moon.

VIIRS DNB image, 1219 UTC, 7 October 2013.

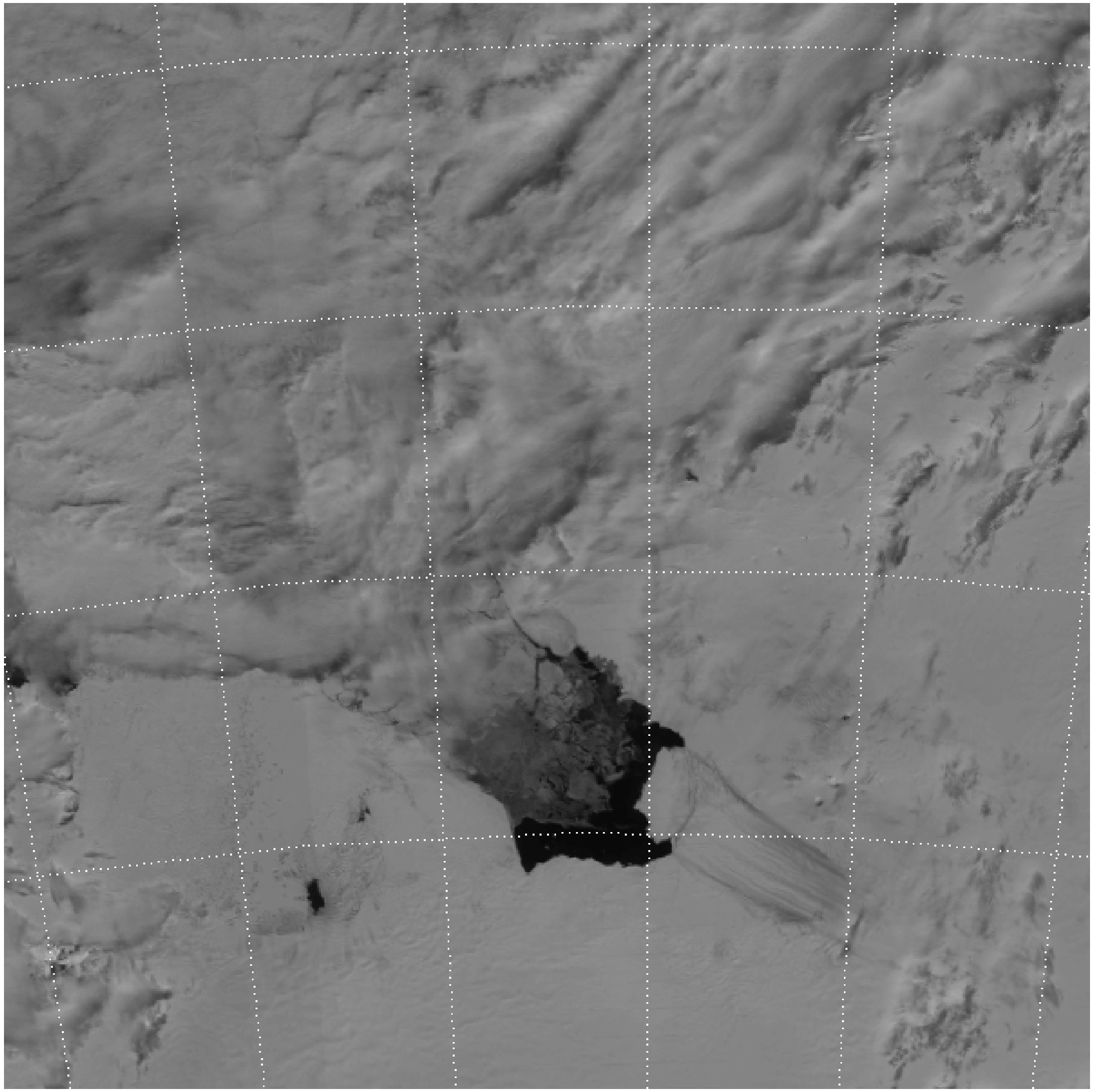
Image courtesy Curtis Seaman (CIRA)



Note Aurora (as well as stray light), Prudhoe Bay lights, and Veniamin of volcano on Aleutian Islands

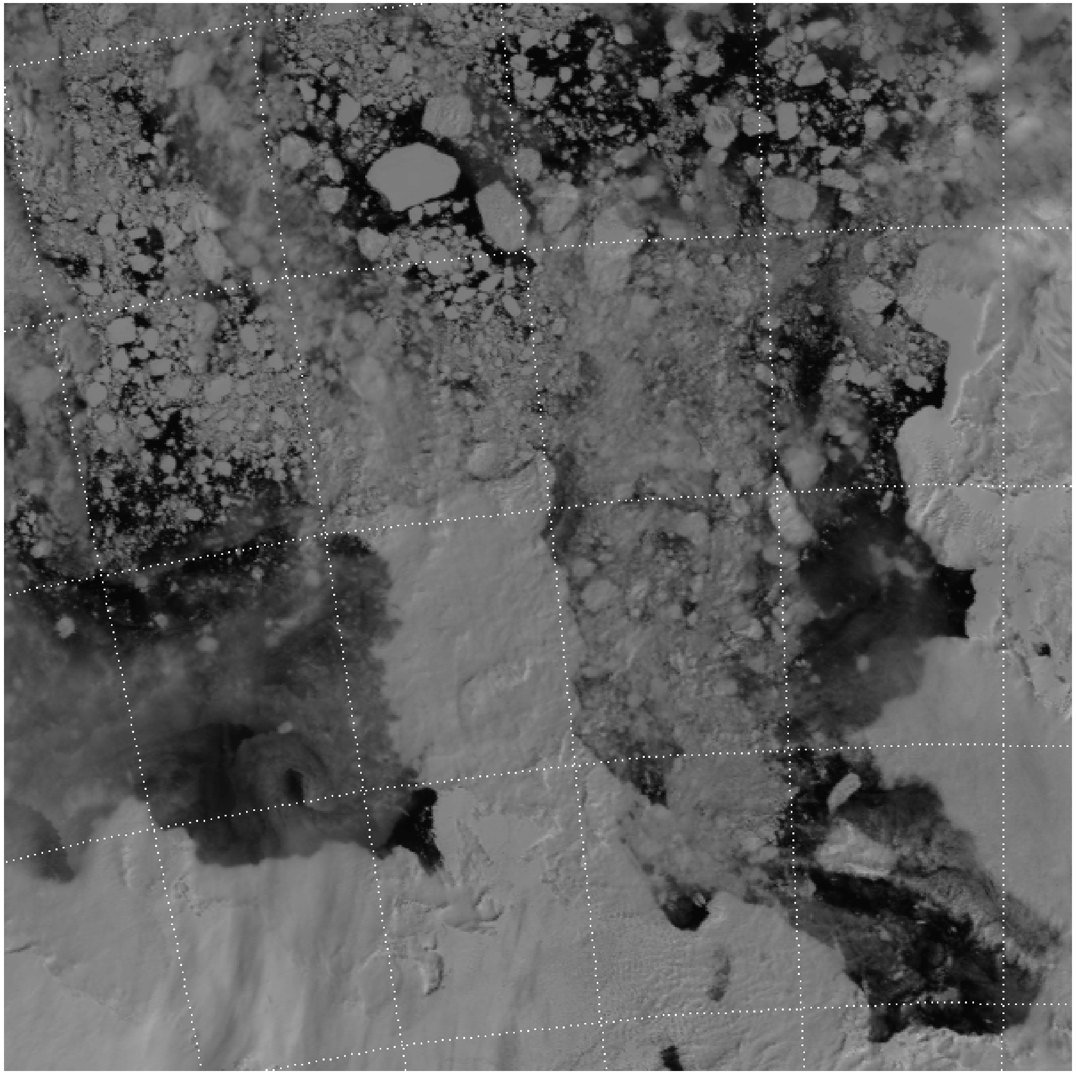
Animation of VIIRS NCC images of the Pine Island Glacier and a huge iceberg breaking away, 7-18 November 2013.

Images courtesy Curtis Seaman (CIRA)



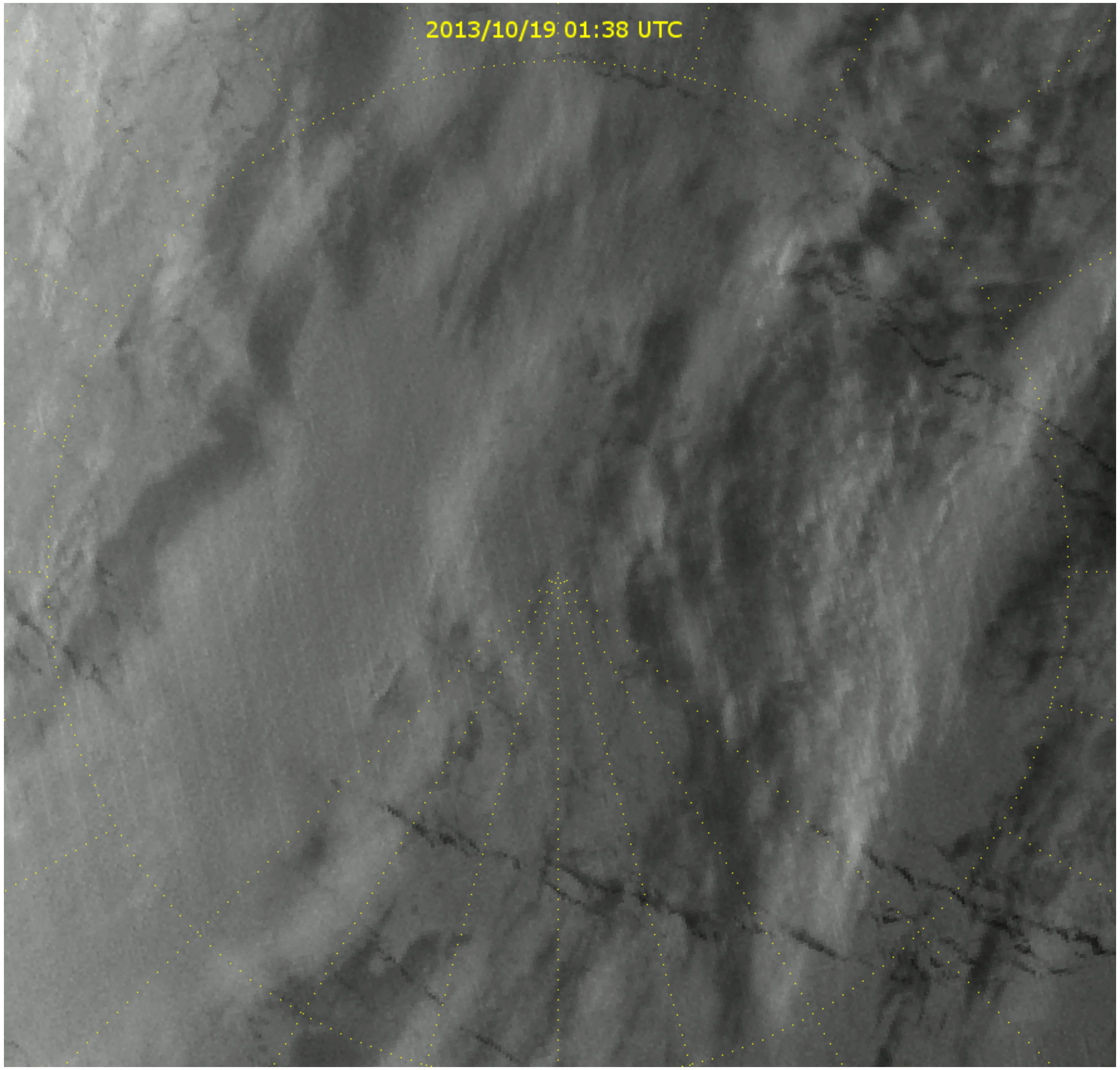
Animation of VIIRS NCC images of icebergs, 20-26 December 2013.

Images courtesy Curtis Seaman (CIRA)



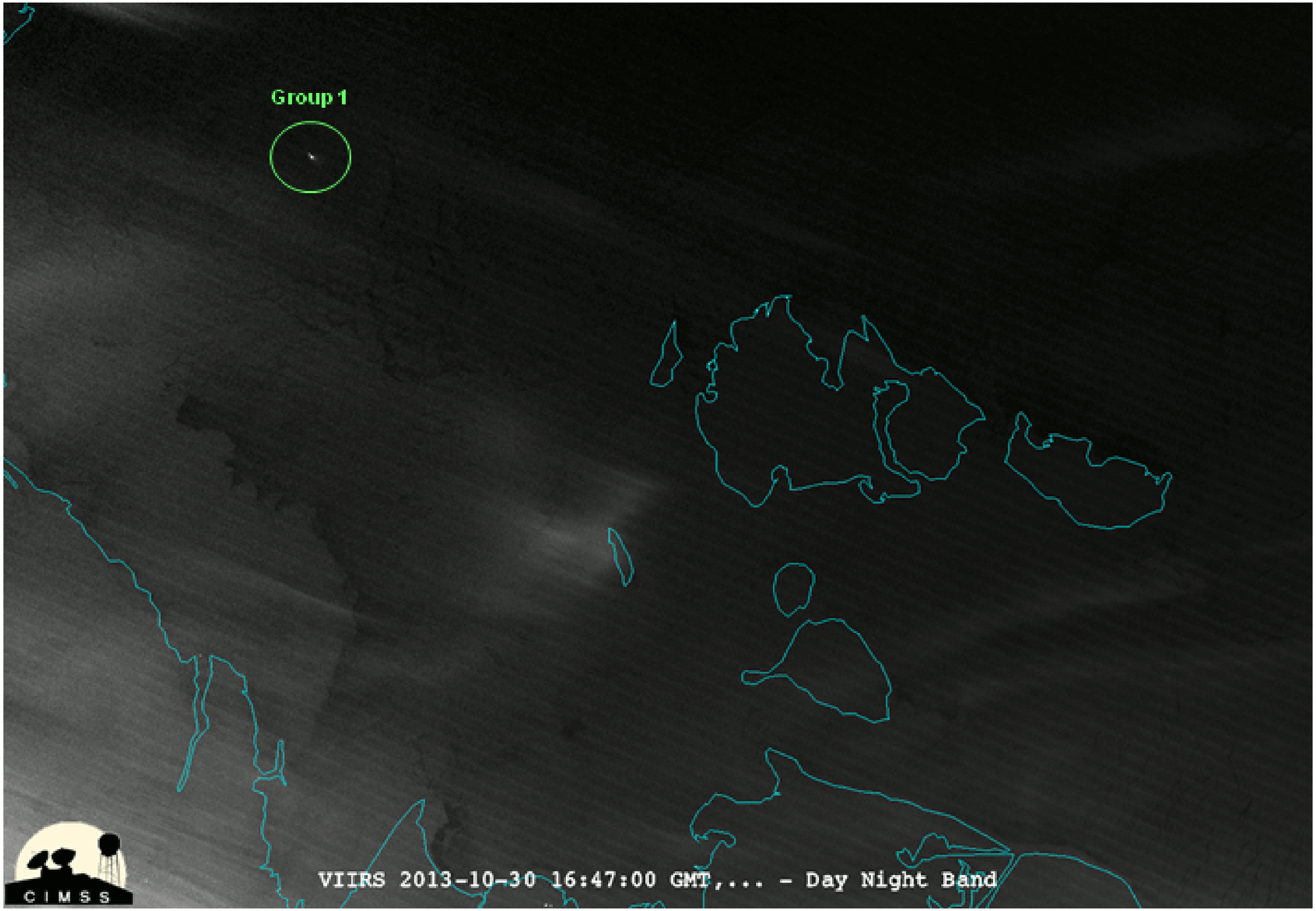
Animation of VIIRS DNB images from 19-20 October 2013. The North Pole is located at the center of the image. Light from the ship carrying the 2014 Winter Olympic torch is visible.

Images courtesy Curtis Seaman (CIRA)



Animation of selected VIIRS DNB images from 30 October to 2 November 2013.

Images courtesy William Straka III (CIMSS)



Future Plans

- **VIIRS EDR Imagery latency** (of 6-7 hours for non-direct broadcast imagery) is a major hindrance for real-time use by analysts and forecasters.
- **Missing M-bands as EDRs** limits many image products, including RGB combinations, one being true-color imagery.
- Remaining relatively-minor NCC Imagery issues continue:
  - **Stray light** will continue with JPSS-1
  - **Crosstalk** issue being studied
- **Involving additional Imagery users** depends on data availability issues, such as lack of bandwidth to carry VIIRS Imagery to AWIPS for example.

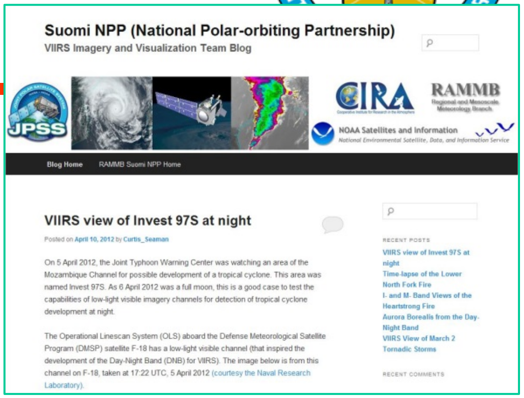
Summary

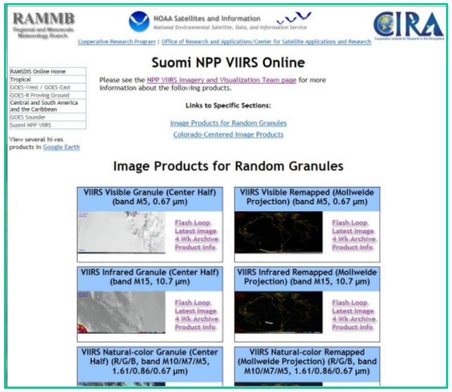
- VIIRS EDR Imagery (including NCC Imagery) has reached the **Validation 3 maturity stage** in April 2014, back dated to August 2013.
- **Feedback** is still requested from users.
- **DNB/NCC** will continue as **unique imagery** on JPSS-1 and JPSS-2!
- Only major concern is **data latency** for non-direct-broadcast users (~6 hours).

Don.Hillger@NOAA.gov

VIIRS Imagery outreach at RAMMB/CIRA

- 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





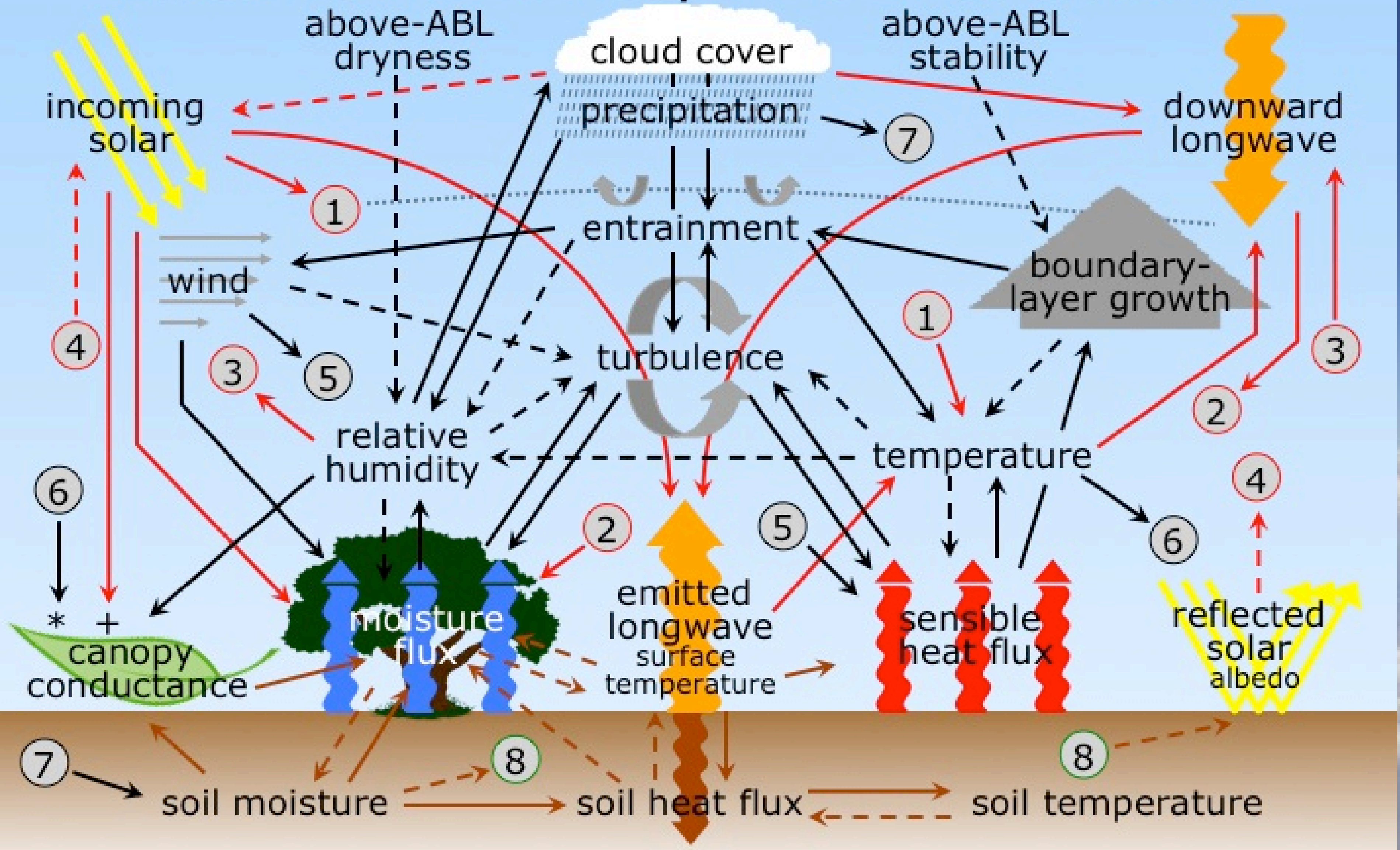
Suomi NPP Land Product Status Overview

Ivan Csiszar
NOAA JPSS Land Domain Lead
Land Product Leads and Team Members

Outline

- Overview
  - Products, Requirements, Team Members, Users, Accomplishments
- SNPP Algorithms Evaluation:
  - Algorithm Description, Validation Approach and Datasets, Performance *vs.* Requirements, Risks/Issues/Challenges, Quality Monitoring, Recommendations
- Future Plans
  - Plan for JPSS-1 Algorithm Updates and Validation Strategies, Schedule and Milestones
- Summary

Local Land-Atmosphere Interactions



radiation → surface layer & ABL → land-surface processes → feedbacks: → positive - - → negative

+positive feedback for C3 & C4 plants, negative feedback for CAM plants

*negative feedback above optimal temperature

M. Ek, NOAA/NCEP

NOAA JPSS SNPP VIIRS Land Products and Team Principals

Role or Product Focus	Name (+ et al.)	Affiliation
NOAA Product Team Lead, **Fire**	*Ivan Csiszar* / Wilfrid Schroeder	NOAA / UMD
NASA Coordination, Validation co-lead	Miguel Román, Chris Justice	NASA / UMD
Surface Reflectance, VCM, calibration	*Eric Vermote*	NASA
Surface Reflectance	Alex Lyapustin	NASA
Vegetation Index	*Marco Vargas*	NOAA
Vegetation Index	Tomoaki Miura/ Alfredo Huete	Univ. of Hawaii / Arizona
Albedo	*Yunyue (Bob) Yu* / Shunlin Liang	NOAA / UMD
Albedo	Crystal Schaaf	Univ. Mass.
Land Surface Temperature	*Bob Yu*	NOAA
NOAA CDR coordination, LST	Jeff Privette / Pierre Guillevic	NOAA / NASA JPL
Surface Type	*Jerry Zhan*	NOAA
Surface Type	Mark Friedl	Boston Univ.
STAR AIT Land	Walter Wolf, Youhua Tang	NOAA
NASA LandPEATE, **gridding/granulation**	Robert Wolfe, Sadashiva Devadiga	NASA
Northrop Grumman	Alain Sei, Justin Ip	NGAS
Raytheon	Daniel Cumpton	Raytheon
JPSS Algorithm Manager	Leslie Belsma	Aerospace

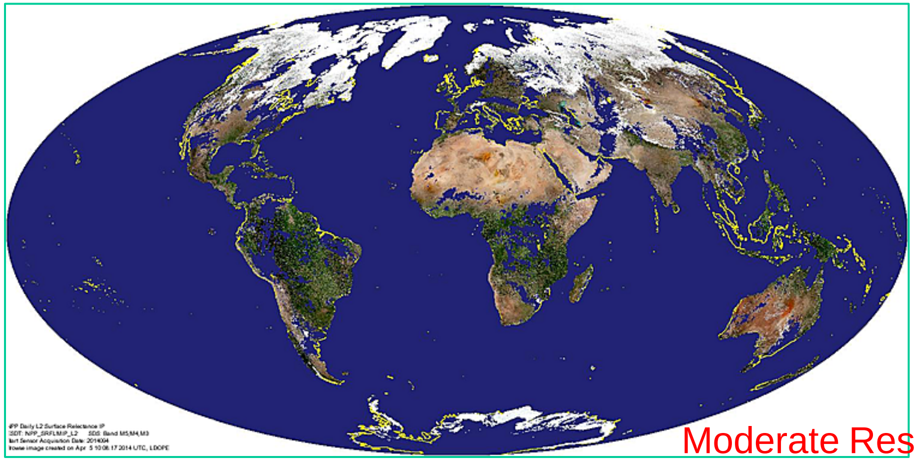
SNPP VIIRS SR Provisional Maturity

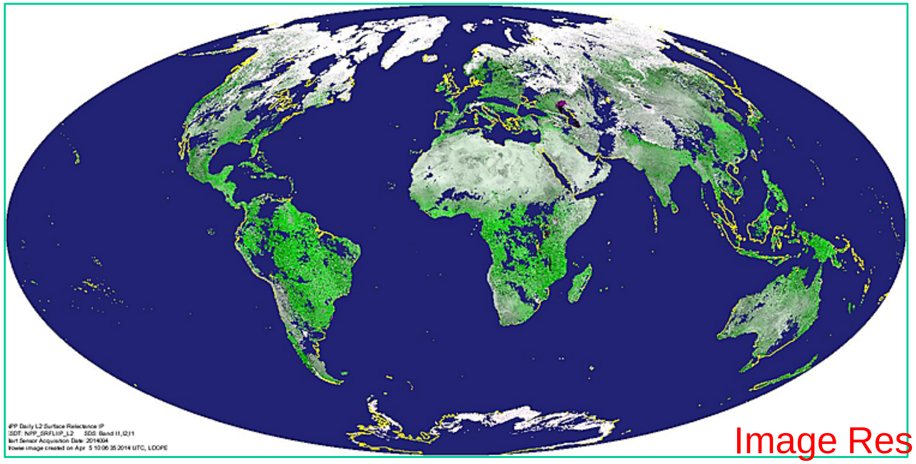
- This CCR declared that SNPP VIIRS Surface Reflectance Intermediate Product (VIIRS-Surf-Refl-IP) be upgraded to provisional maturity level with implementation of 474-CCR-13-1078 containing DRs 4488, 7141 and 7142 at IDPS.
- Algorithm build version Mx8.3 implemented 474-CCR-13-1078 and was put in operation at IDPS on March 18, 2014.
- Analysis of SR-IP from IDPS operation confirms successful implementation of the DRs with no negative impact on any downstream EDRs.

E. Vermote, S. Devadiga, NASA GSFC

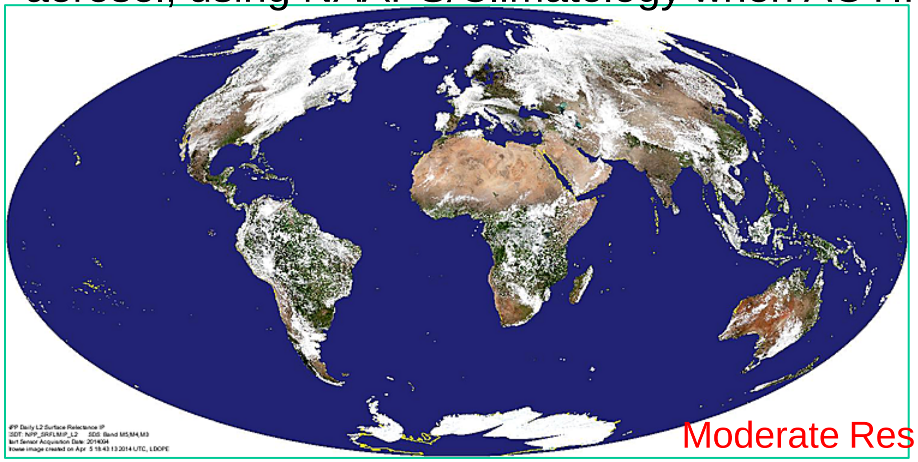
Surface Reflectance IP from Day 2014094

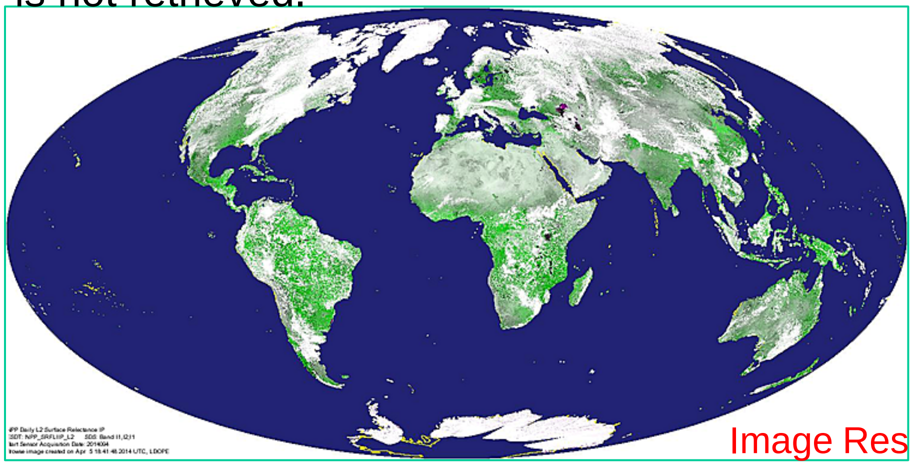
Retrieved under all atmospheric conditions for all non-ocean (not sea-water) pixels except for night pixels and where input L1B is invalid





Retrieval using Mx73 at Land PEATE – SRIP not retrieved under confidently cloud and heavy aerosol, using NAAPS/Climatology when AOTIP is not retrieved.





Retrieval using Mx83 at IDPS – SRIP retrieved under all atmospheric conditions replacing NAAPS/Climatology with MODIS Climatology.

E. Vermote, S. Devadiga, NASA GSFC

VI EDR Product Requirements

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

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

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

Notes:

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

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

VIIRS Vegetation Index EDR

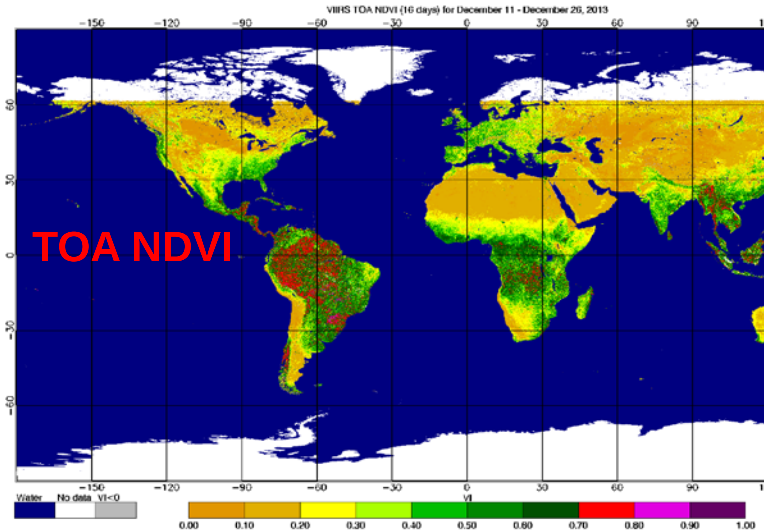
- **VI Product**: TOA-NDVI and TOC- EVI

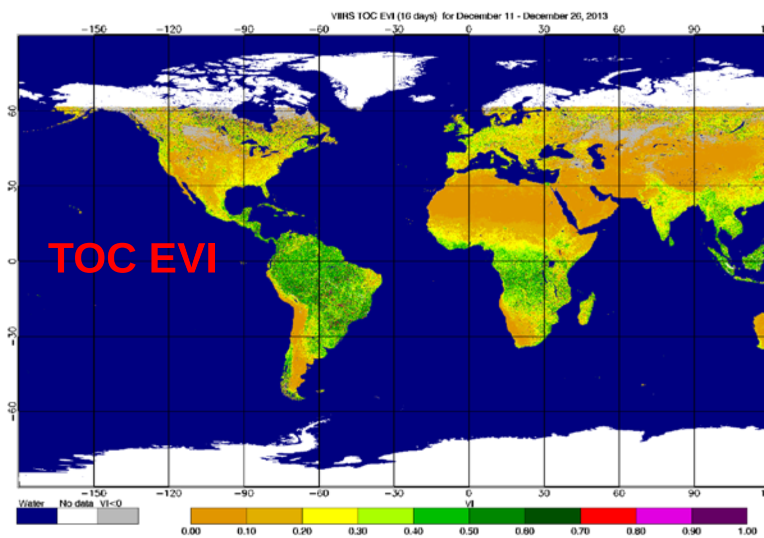
- **Maturity Status**: Provisional

- **Validation 1 maturity :** scheduled for Summer 2014

- **Product Improvements**: Additional Quality Flags, VIIRS VI EVI Backup Algorithm

- **J1**: Add top-of-canopy NDVI

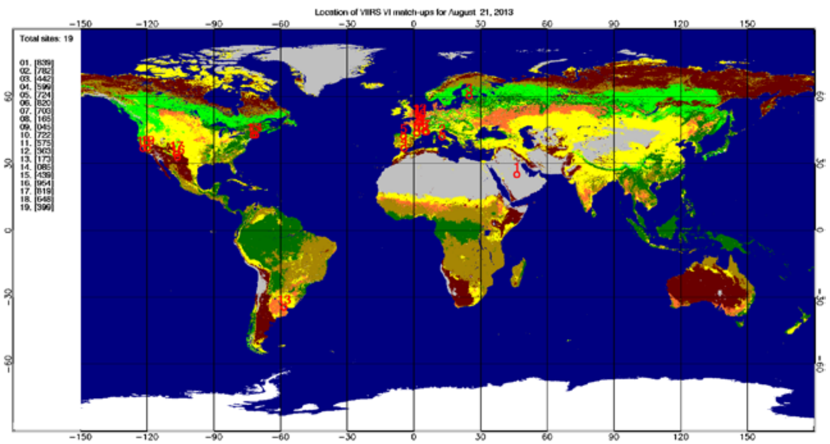


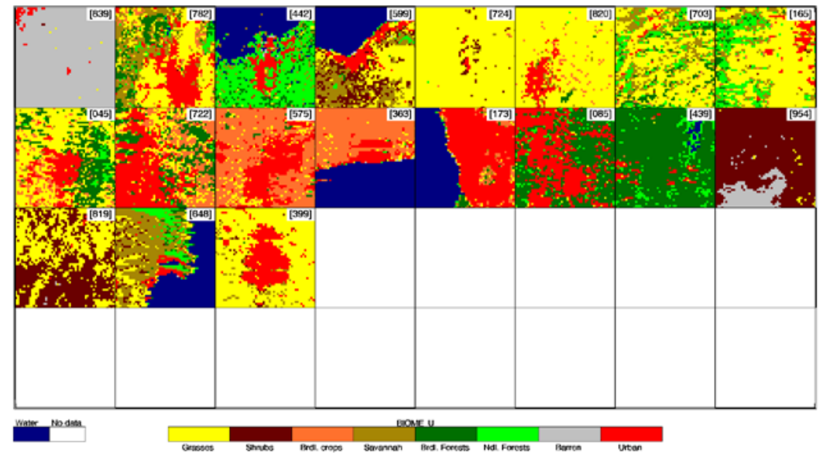


M. Vargas, NOAA/STAR

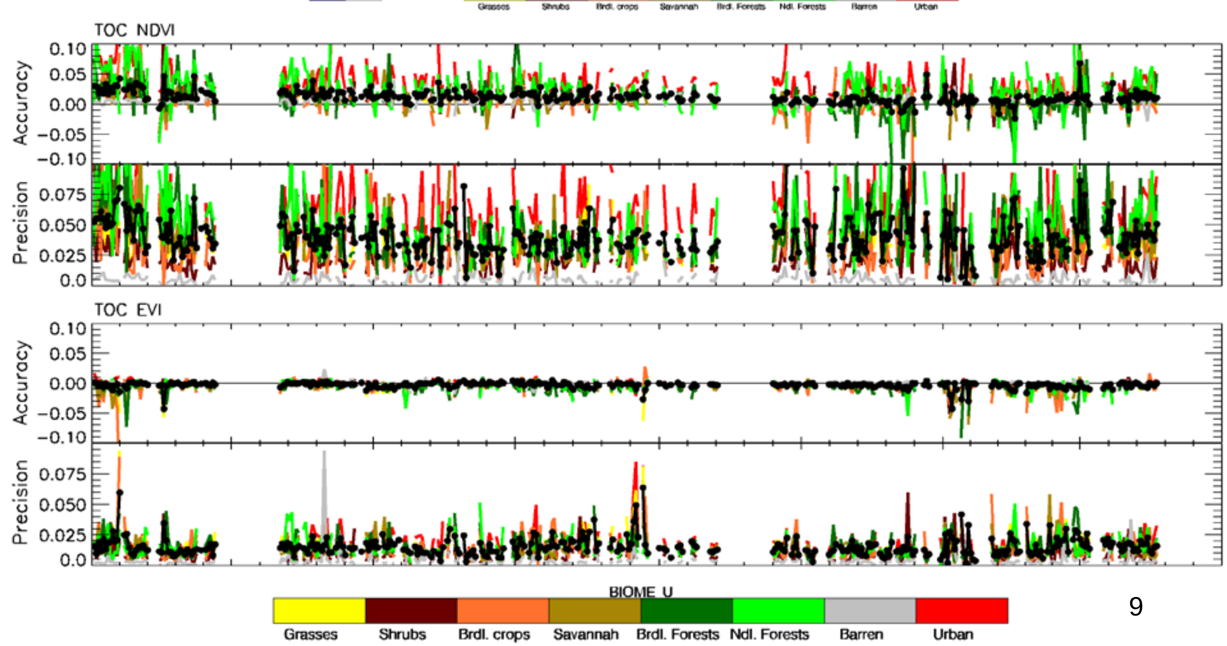
VI EDR Validation Using Aeronet Based SR

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





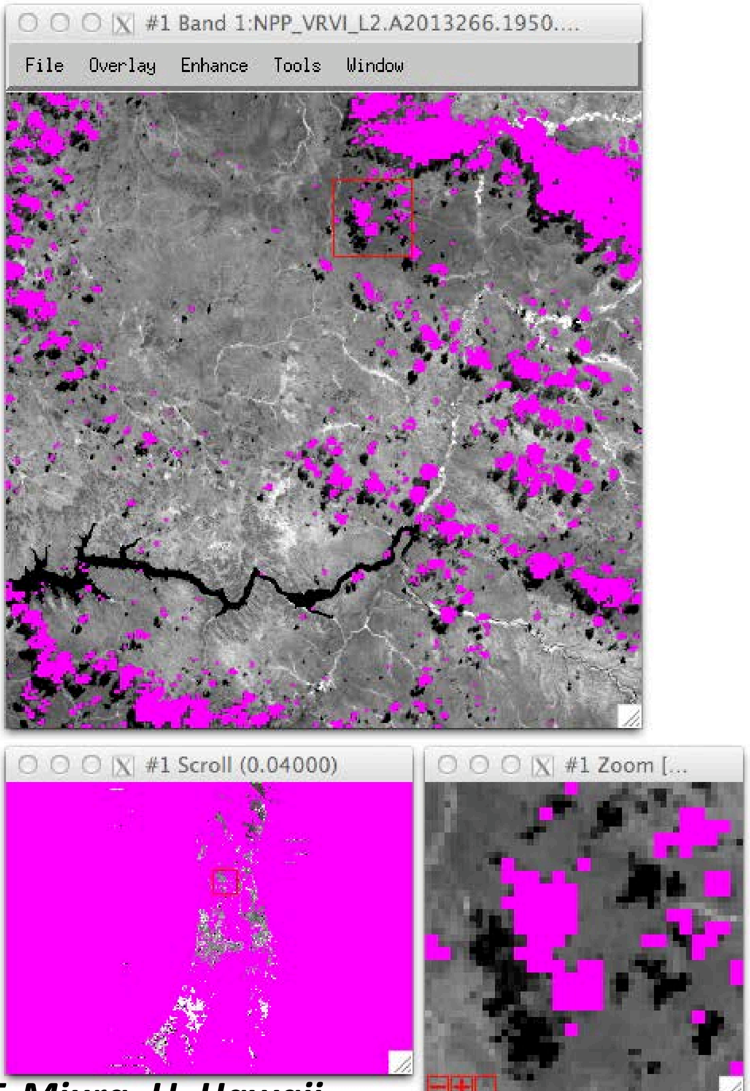
Sample of global daily distribution of match-up sites (August 21, 2013) covering different surface types and including urban areas. Global Land cover is derived from Combined Terra & Aqua MODIS LA/FPAR LC product (MCD12C1, ver. 5.1).



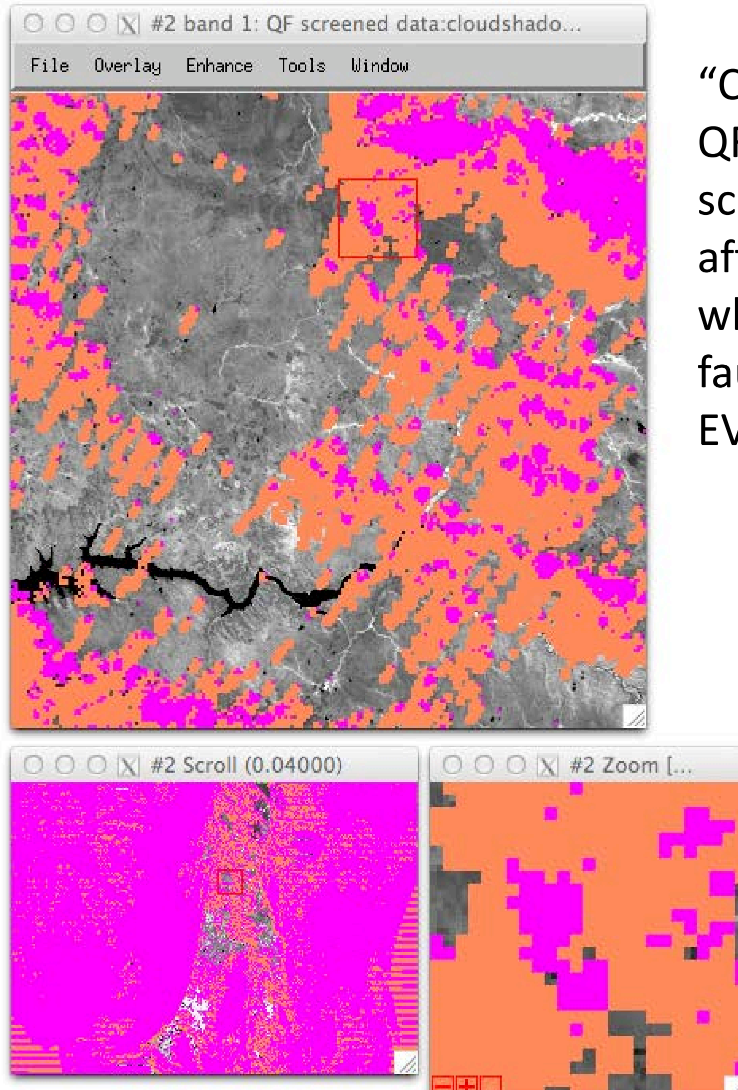
M. Vargas, NOAA/STAR

Additional QF3 Bit 7: Cloud Shadows

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



TOA NDVI:
Screened for "Cloud Shadows"



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

T. Miura, U. Hawaii

Green Vegetation on Our Planet

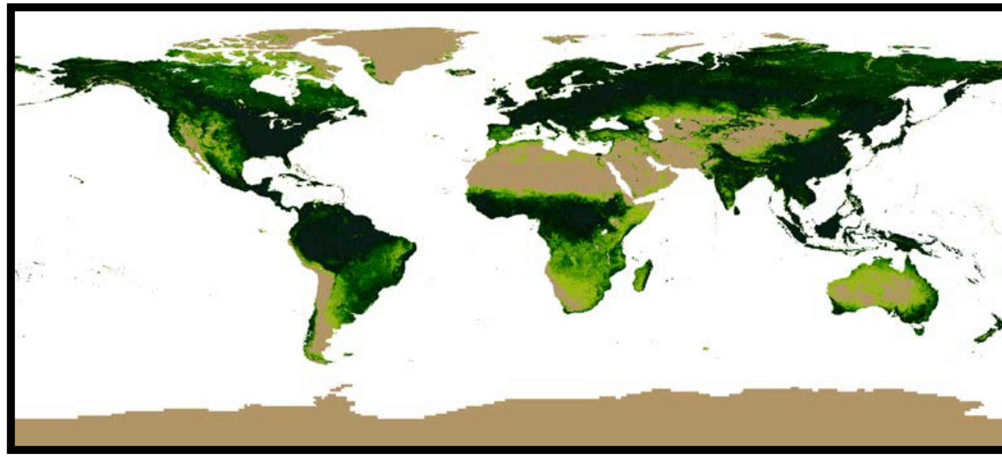
http://www.nnvl.noaa.gov/green.php

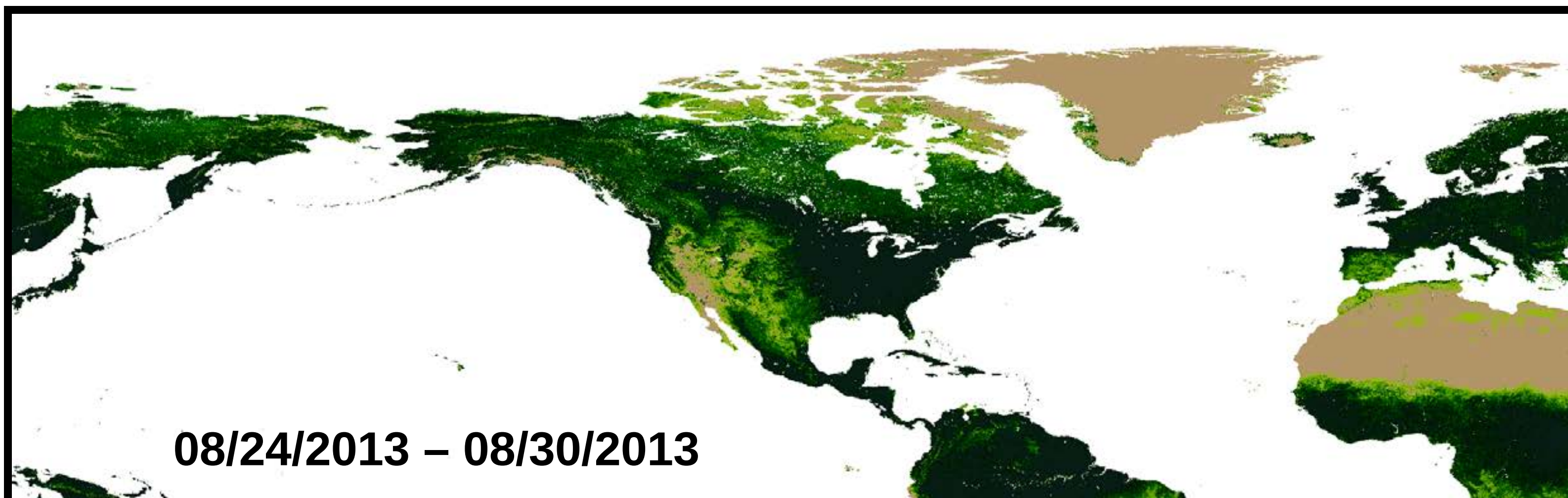
April 2012 – April 2013
500 m grid; NDVI weekly composite / gap filled

F. Kogan, NOAA/STAR
D. Pisut, NOAA Visualization Laboratory

NDE Green Vegetation Fraction

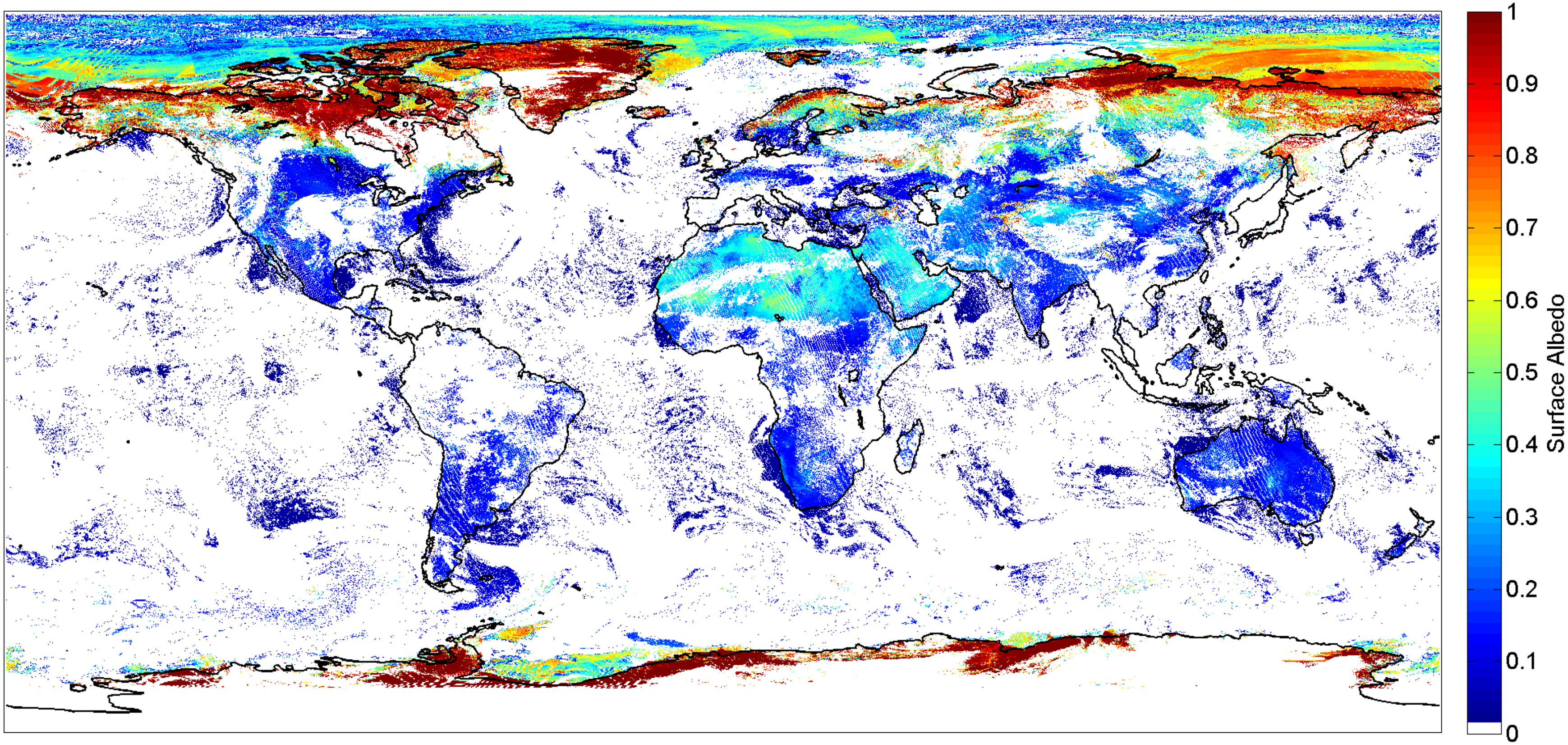
- •GVF products: global (4km res) and regional (1km res)
- • Global GVF product in NetCDF4 format will be archived at CLASS
- •GVF transition to operations in Summer 2014





M. Vargas
NOAA/STAR

Example of VIIRS surface albedo EDR

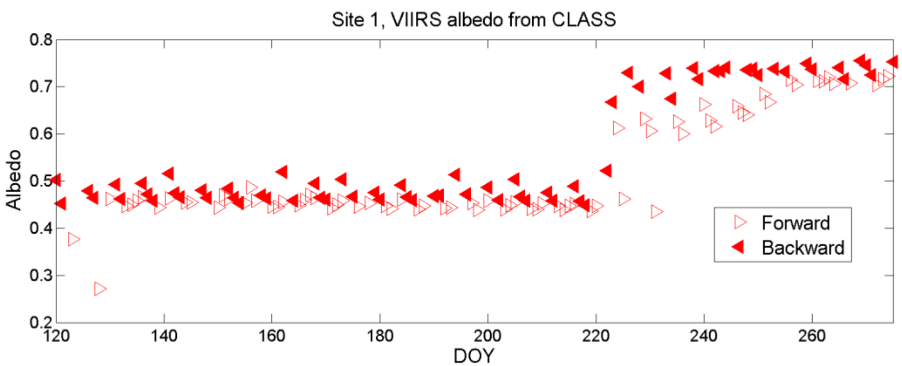


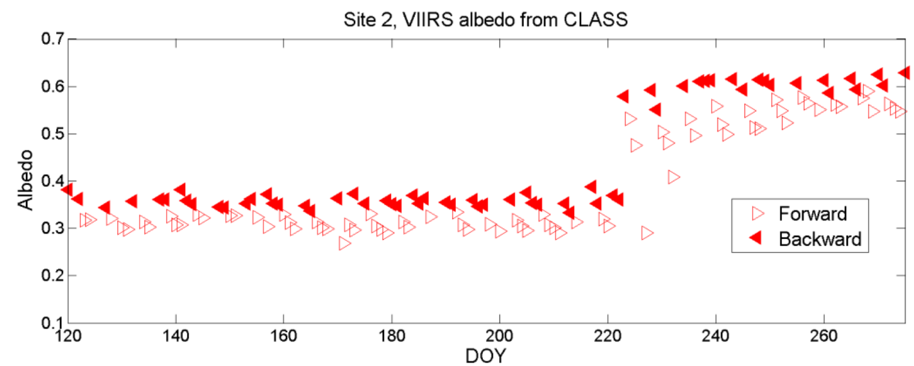
Map of VIIRS instantaneous albedo product acquired on April 3 2012

B. Yu, NOAA/STAR

Evaluation of LSA temporal variability

The LSA retrievals in the summer of 2012 over two Libya desert sites (Site 1: 24.42˚N 13.35˚E and Site 2: 26.45˚N, 14.08˚E) are used to illustrate the issue of temporal variability of LSA.

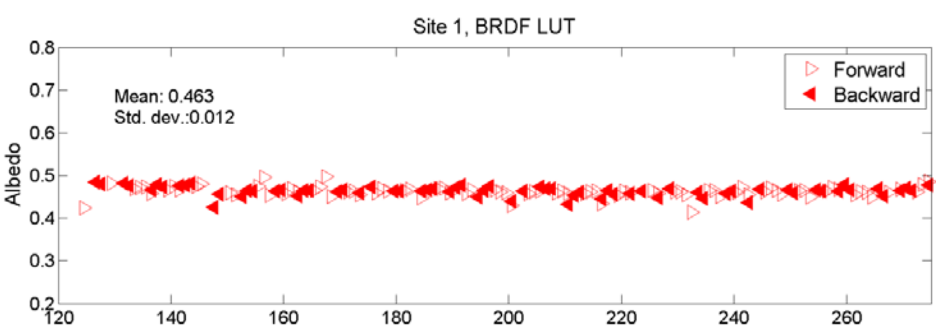


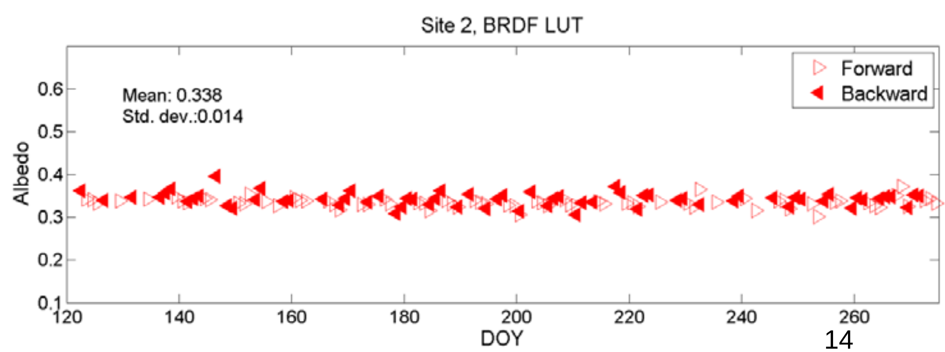


“Forward” means pixels with relative azimuth angle >90° and “backword” means those with relative azimuth angle <90°. Jumps around 8/9 were caused by the bugs in a early version of the operational codes.

New albedo estimated with the BRDF LUT has improved in temporal stability

LSA retrieved from new BRDF LUT. The spurious retrievals caused by undetected cloud and cloud shadow are excluded with the threshold of mean ± 0.05.





B. Yu, NOAA/STAR, D. Wang (UMD)

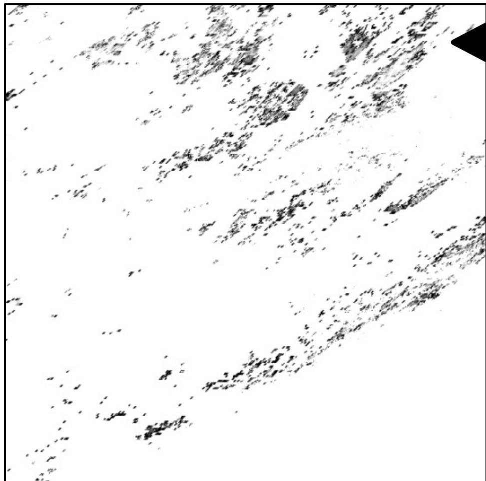
Summary of LSA validation: 2013

Summary of validation results at seven SURFRAD sites. Three satellite albedo data (VIIRS LSA from the Lambertian LUT, VIIRS LSA from the BRDF LUT and MODIS albedo) are validated against field measurements.

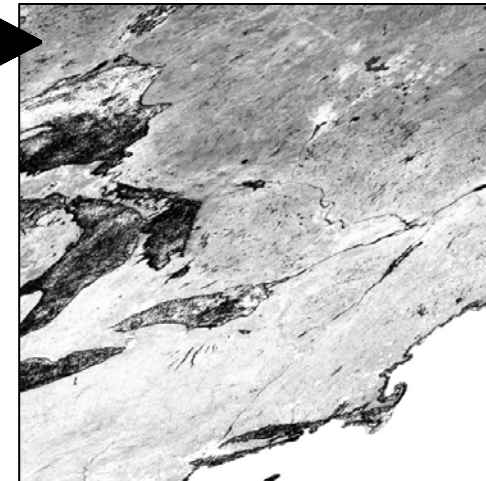
Site	VIIRS (BRDF LUT)			VIIRS (beta release)			MODIS		
	R^2	RMSE	Bias	R^2	RMSE	Bias	R^2	RMSE	Bias
Fort Peck	0.97	0.042	-0.006	0.94	0.063	0.001	0.99	0.064	-0.038
Goodwin Creek	0.02	0.037	-0.031	0.03	0.086	-0.010	0.02	0.048	-0.046
Desert Rock	0.06	0.038	0.029	0.07	0.101	0.048	0.29	0.013	-0.010
Penn State	0.98	0.081	-0.066	0.92	0.097	-0.069	0.28	0.066	-0.062
Sioux Falls	0.86	0.114	0.048	0.82	0.142	0.057	0.91	0.062	-0.007
Boulder	0.97	0.050	0.020	0.89	0.087	0.029	0.27	0.134	-0.037
Overall	**0.88**	**0.061**	**0.010**	**0.77**	**0.099**	**0.024**	**0.82**	**0.068**	**-0.026**

B. Yu, NOAA/STAR, D. Wang (UMD)

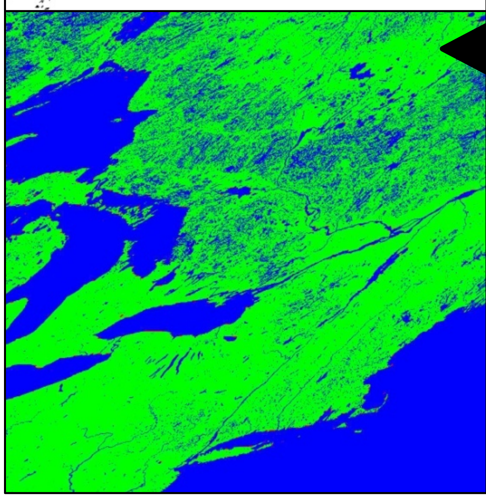
Evaluation of the VIIRS Dark Pixel Surface Albedo EDR
(New England 2013183)



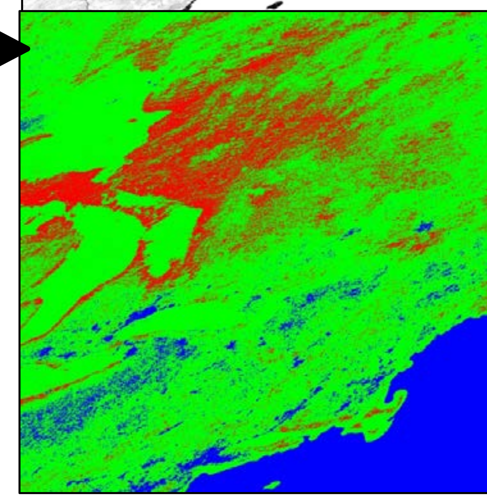
VIIRS DPSA White color is fill value. Valid retrievals are nearly all from history, and most of the historical data are fill values.



MODIS Aqua-only Black-Sky Albedo.



VIIRS DPSA QA. Red (missing) = full inversion, green = 'historical' data and blue = no-data values.



MODIS Aqua only QA. Red = full inversion, green = magnitude inversion and blue = no-data value.

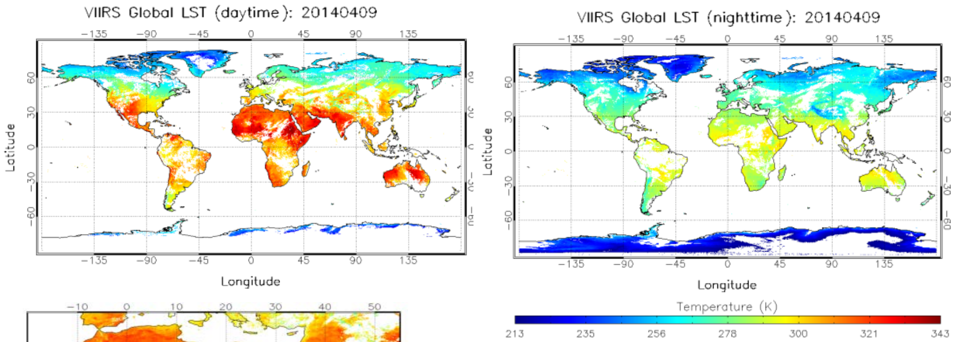
-- VIIRS DPSA albedo is uses the daily gridded surface reflectance IP as input and only few observations meet the reflectance overall quality for albedo retrieval.

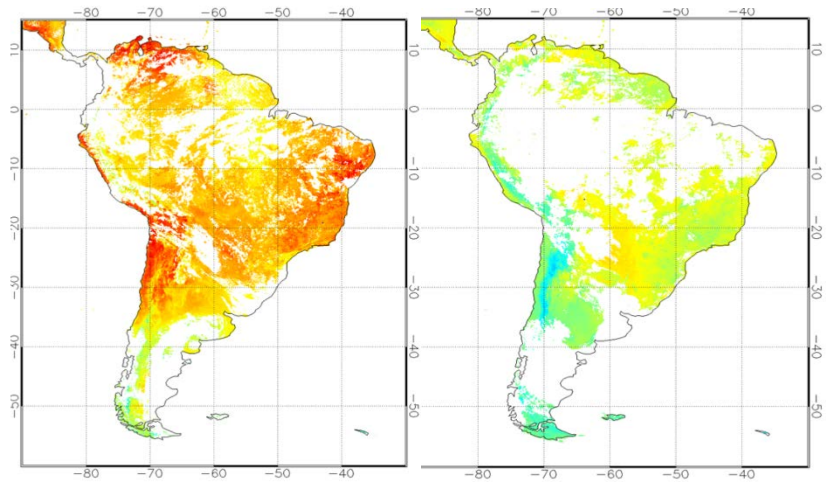
-- Current criteria for DPSA full inversion are limited. A crucial parameter, the WODs (weights of determination), which describes the angular sampling status of the input reflectances, are not even considered.

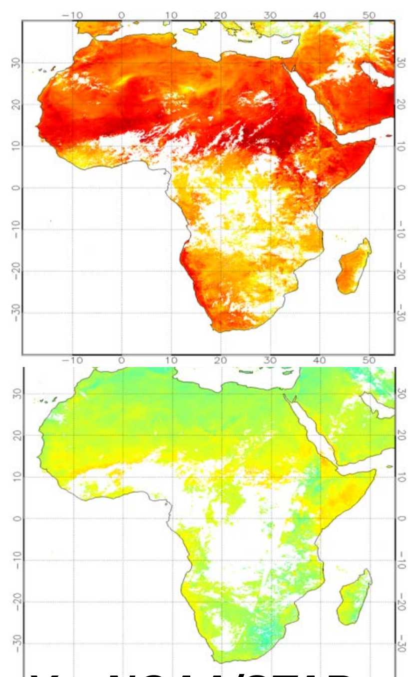
Zhuosen Wang, Yan Liu, and Crystal Schaaf (UMASS Boston)

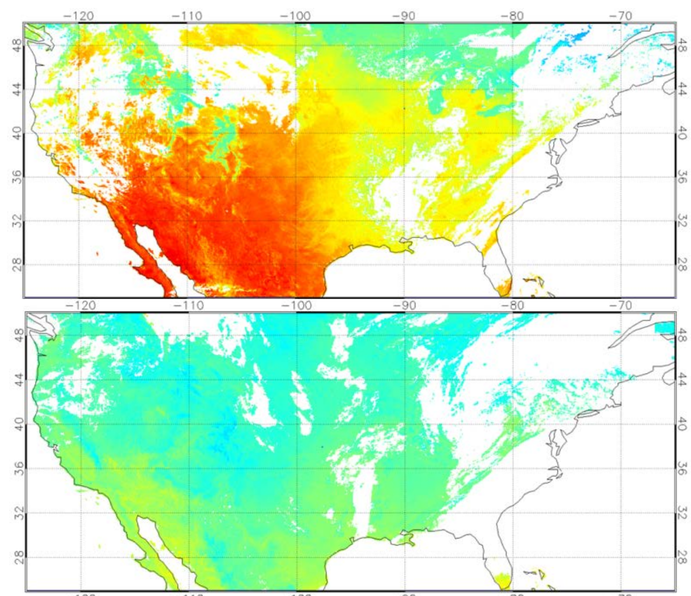
Land Surface Temperature

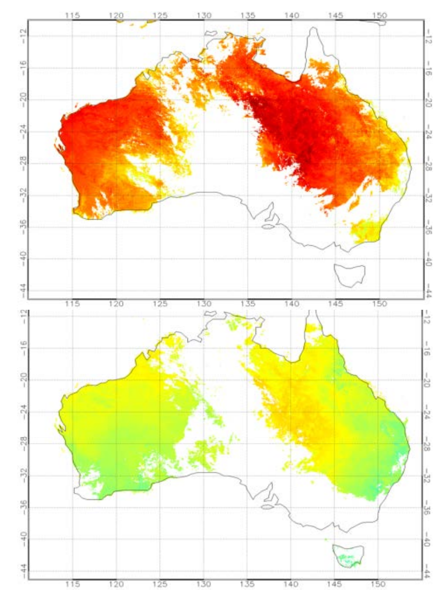
Provisional LST installed on IDPS





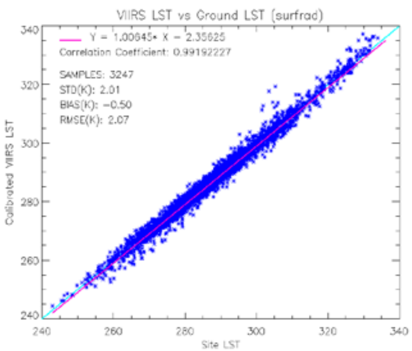


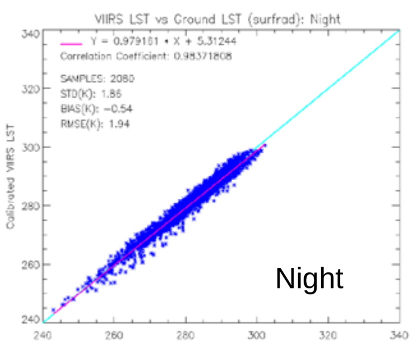


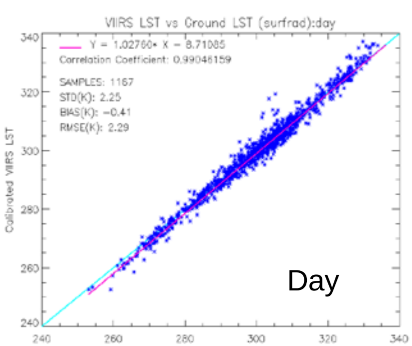


B. Yu, NOAA/STAR

LST Validation







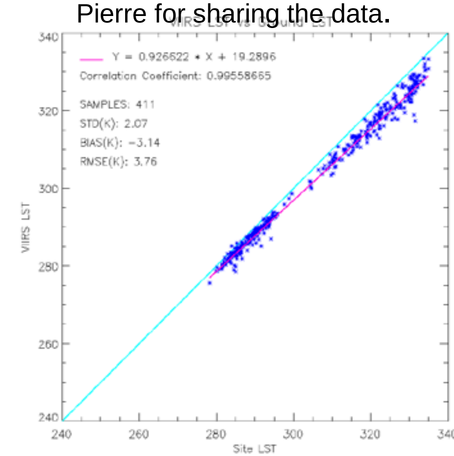
Evaluation against ground data

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

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

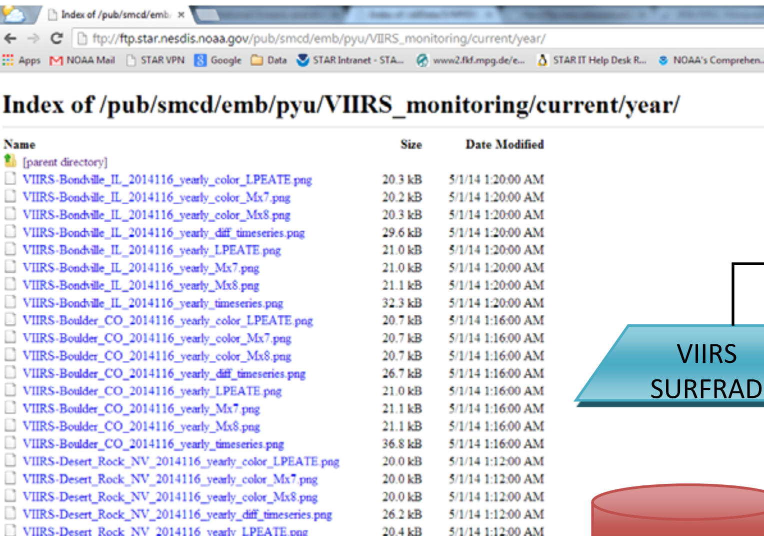
A ground dataset at Gobabeb in Namibia covering the time period of 2012.

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



LST Monitoring

A monitoring tool developed



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

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

Name	Size	Date Modified
[parent directory]		
VIIRS-Bondville_IL_2014116_yearly_color_LPEATE.png	20.3 kB	5/1/14 1:20:00 AM
VIIRS-Bondville_IL_2014116_yearly_color_Mx7.png	20.2 kB	5/1/14 1:20:00 AM
VIIRS-Bondville_IL_2014116_yearly_color_Mx8.png	20.3 kB	5/1/14 1:20:00 AM
VIIRS-Bondville_IL_2014116_yearly_diff_timeseries.png	29.6 kB	5/1/14 1:20:00 AM
VIIRS-Bondville_IL_2014116_yearly_LPEATE.png	21.0 kB	5/1/14 1:20:00 AM
VIIRS-Bondville_IL_2014116_yearly_Mx7.png	21.0 kB	5/1/14 1:20:00 AM
VIIRS-Bondville_IL_2014116_yearly_Mx8.png	21.1 kB	5/1/14 1:20:00 AM
VIIRS-Bondville_IL_2014116_yearly_timeseries.png	32.3 kB	5/1/14 1:20:00 AM
VIIRS-Boulder_CO_2014116_yearly_color_LPEATE.png	20.7 kB	5/1/14 1:16:00 AM
VIIRS-Boulder_CO_2014116_yearly_color_Mx7.png	20.7 kB	5/1/14 1:16:00 AM
VIIRS-Boulder_CO_2014116_yearly_color_Mx8.png	20.7 kB	5/1/14 1:16:00 AM
VIIRS-Boulder_CO_2014116_yearly_diff_timeseries.png	26.7 kB	5/1/14 1:16:00 AM
VIIRS-Boulder_CO_2014116_yearly_LPEATE.png	21.0 kB	5/1/14 1:16:00 AM
VIIRS-Boulder_CO_2014116_yearly_Mx7.png	21.1 kB	5/1/14 1:16:00 AM
VIIRS-Boulder_CO_2014116_yearly_Mx8.png	21.1 kB	5/1/14 1:16:00 AM
VIIRS-Boulder_CO_2014116_yearly_timeseries.png	36.8 kB	5/1/14 1:16:00 AM
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VIIRS-Desert_Rock_NV_2014116_yearly_color_Mx7.png	20.0 kB	5/1/14 1:12:00 AM
VIIRS-Desert_Rock_NV_2014116_yearly_color_Mx8.png	20.0 kB	5/1/14 1:12:00 AM
VIIRS-Desert_Rock_NV_2014116_yearly_diff_timeseries.png	26.2 kB	5/1/14 1:12:00 AM
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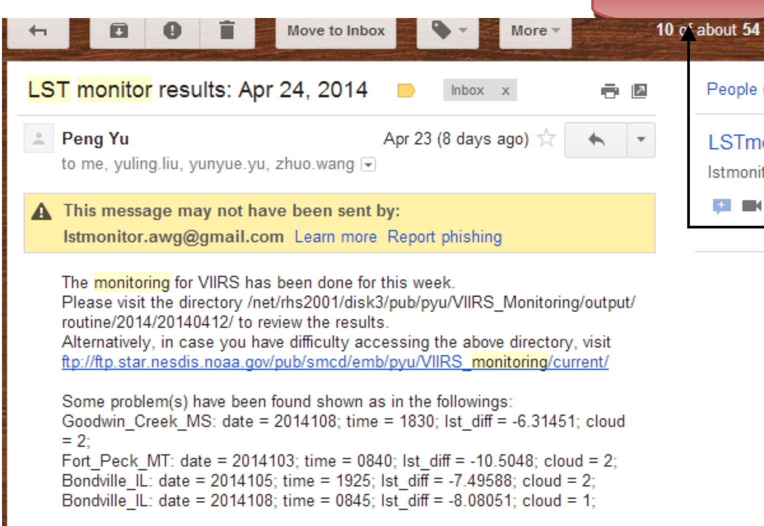


LST monitor results: Apr 24, 2014

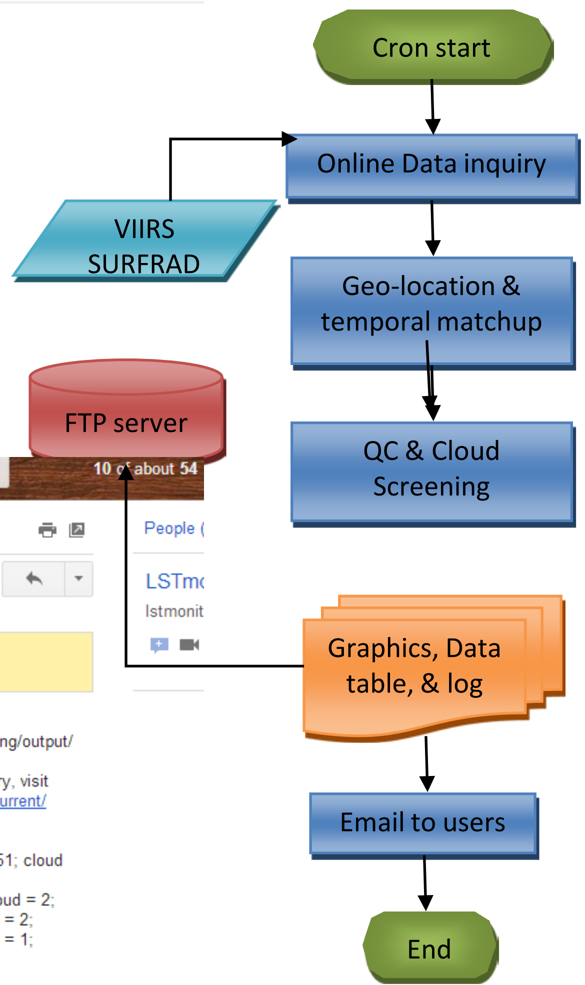
Peng Yu — Apr 23 (8 days ago)

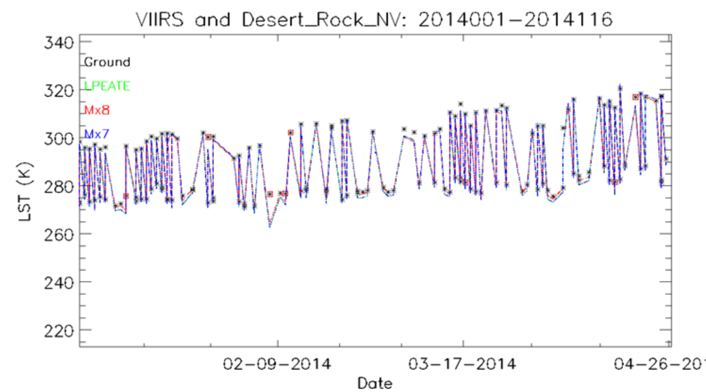
to me, yuling.liu, yunyue.yu, zhuo.wang

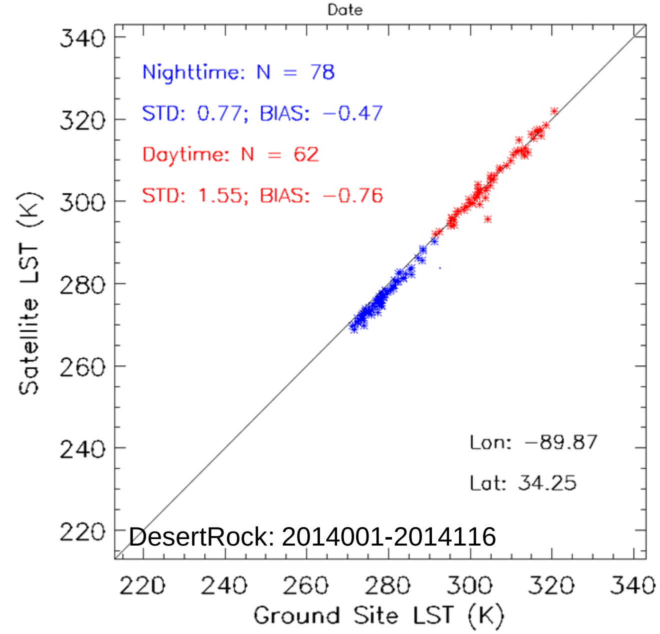
This message may not have been sent by: lstmonitor.awg@gmail.com Learn more Report phishing

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

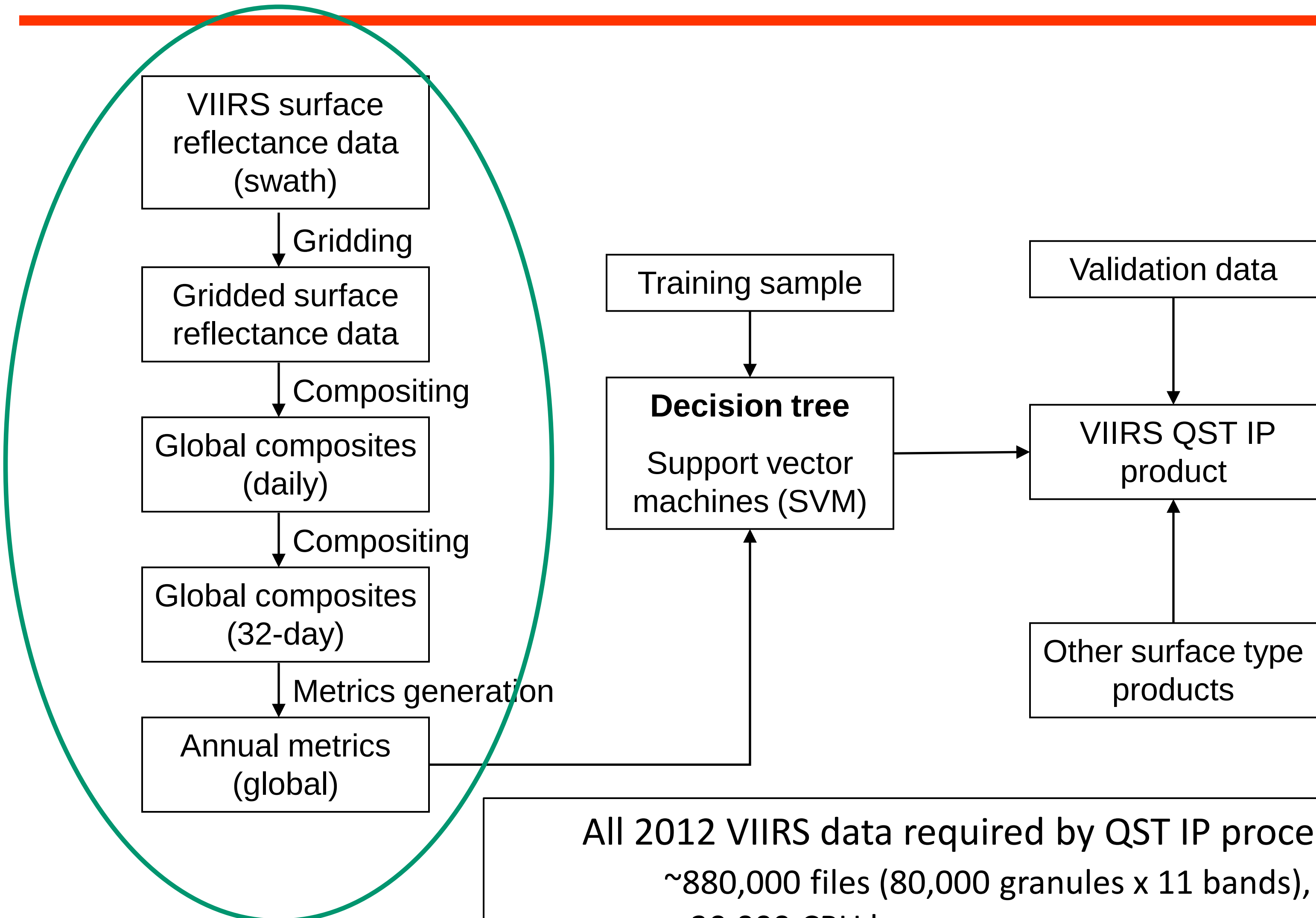
Some problem(s) have been found shown as in the followings:
Goodwin_Creek_MS: date = 2014108; time = 1830; lst_diff = -6.31451; cloud = 2;
Fort_Peck_MT: date = 2014103; time = 0840; lst_diff = -10.5048; cloud = 2;
Bondville_IL: date = 2014105; time = 1925; lst_diff = -7.49588; cloud = 2;
Bondville_IL: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







VIIRS Quarterly Surface Type IP Generation



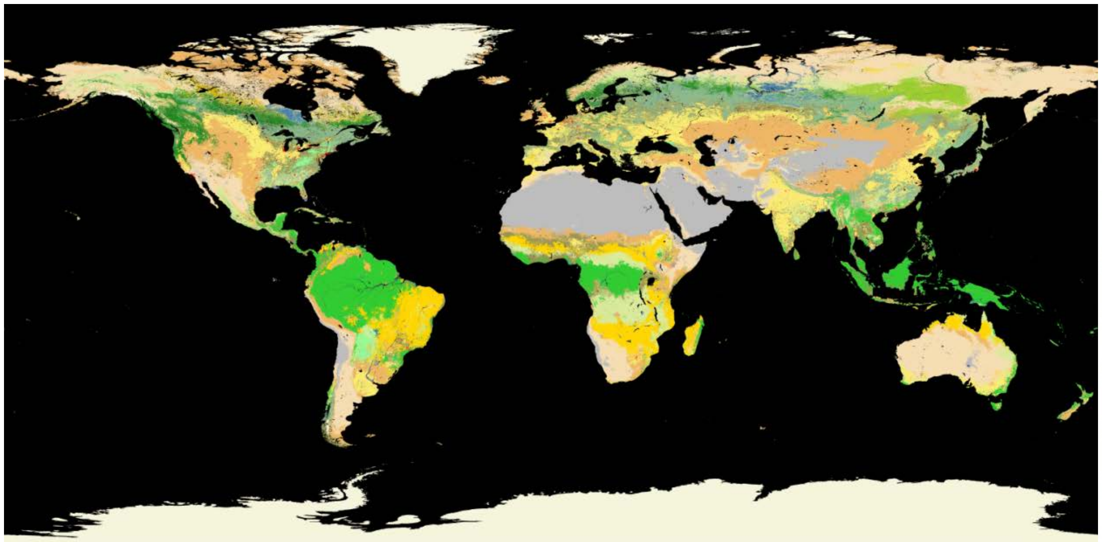
All 2012 VIIRS data required by QST IP processed at UMD:

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

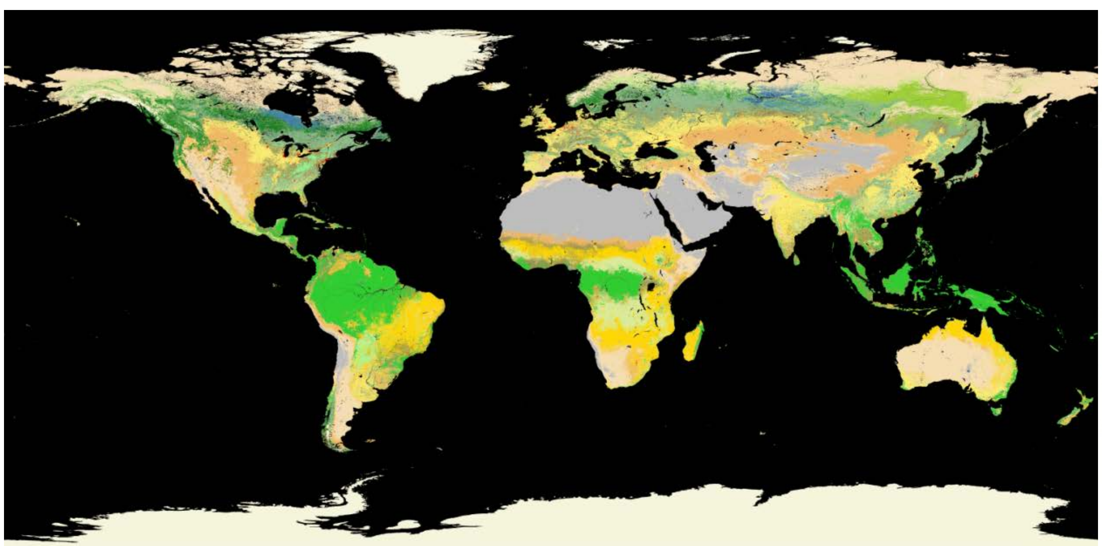
J. Zhan (STAR), C. Huang (UMD)

Similar Patterns between VIIRS QST IP and MODIS Seed

MODIS Seed



VIIRS QST IP

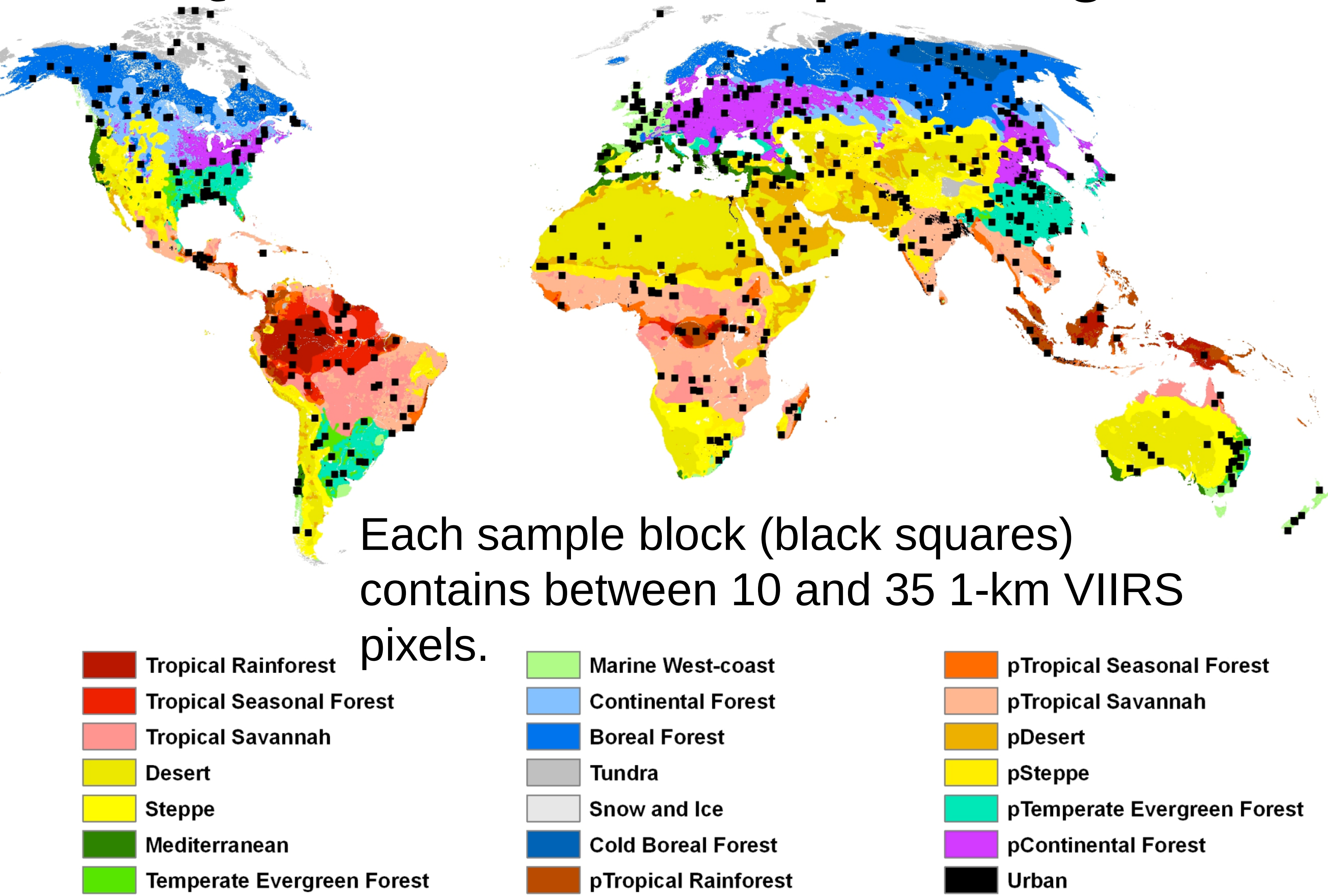


IGBP Legend

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

J. Zhan (STAR)
C. Huang (UMD)

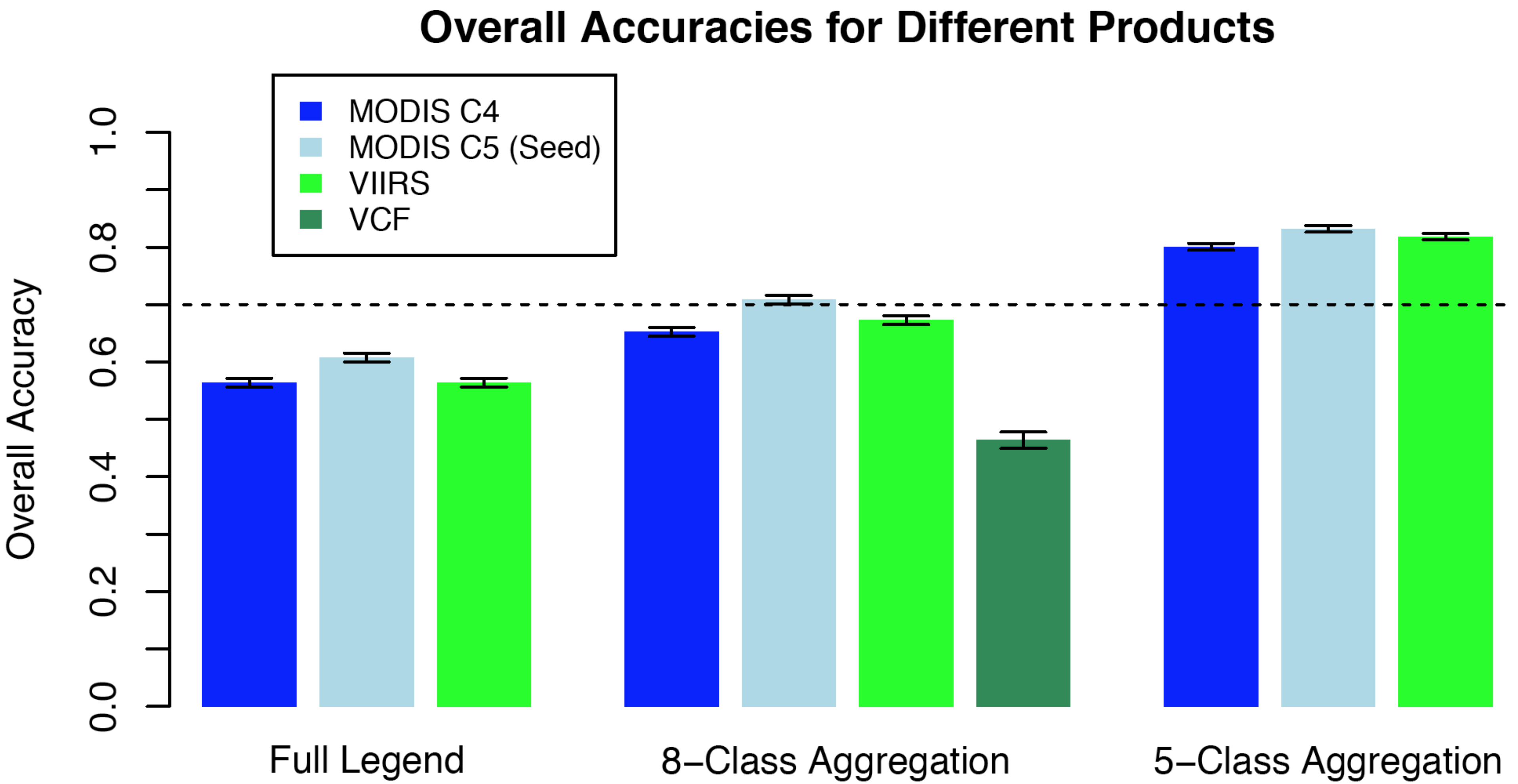
QST Validation Sample Design



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

Damien Sulla--‐Menashe, Mark Friedl, BU

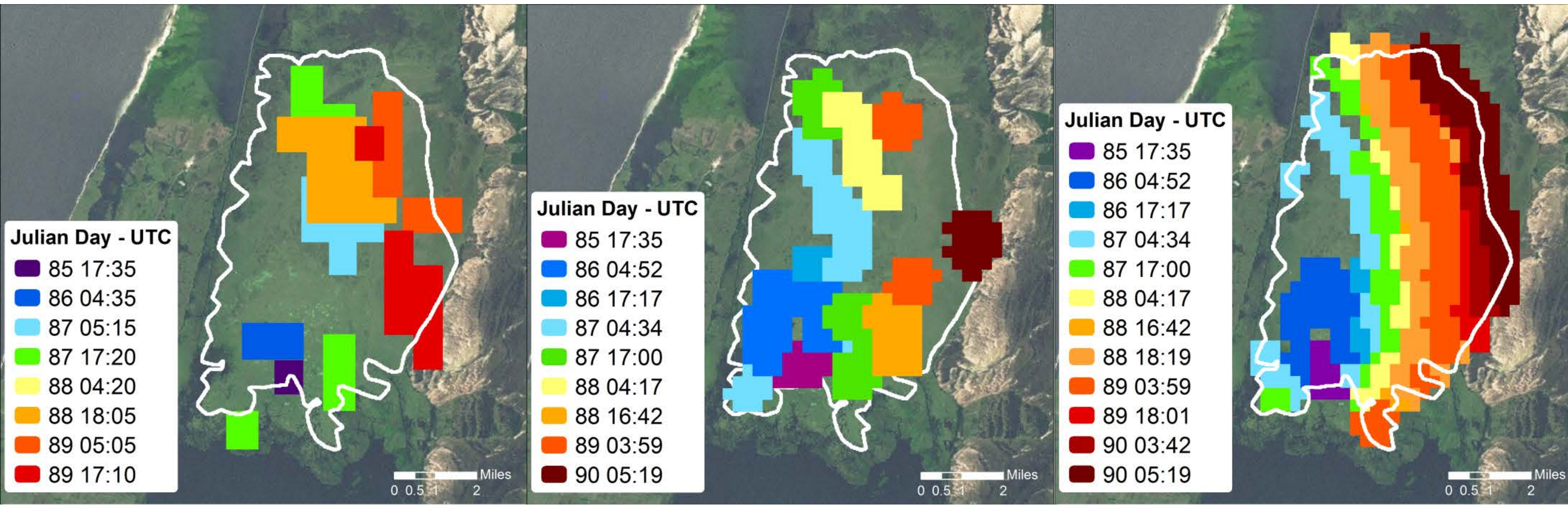
QST Algorithm Evaluation



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

Development of Spatially Refined Satellite Fire Products
Enabling Improved Fire Mapping

Grass fire in Southern Brazil, 26-31 March 2013

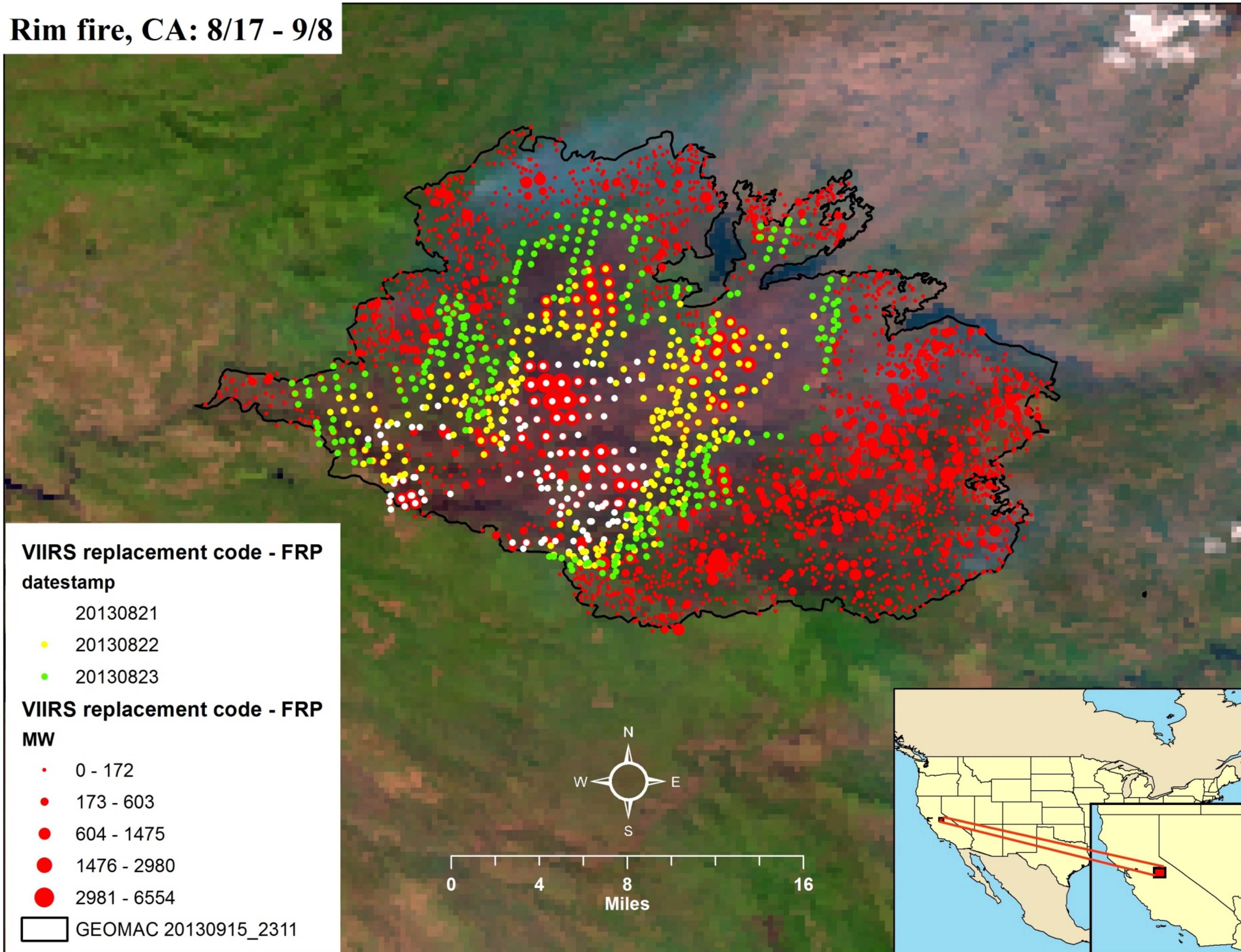


Aqua/MODIS 1 km
Spotty detection pixels and coverage gap at low latitudes

S-NPP/VIIRS 750 m
Spotty detection pixels

S-NPP/VIIRS 375 m
Improved fire line mapping

Credit: Wilfrid Schroeder (UMD)
See for example: Schroeder et al., 2014 [doi:10.1016/j.rse.2013.12.008]



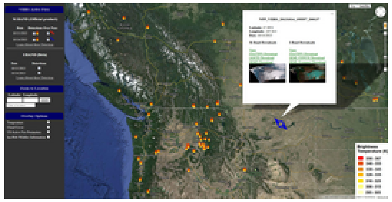
Rim fire, CA: 8/17 - 9/8
VIIRS replacement code - FRP
datestamp
20130821
20130822
20130823
VIIRS replacement code - FRP
MW
0 - 172
173 - 603
604 - 1475
1476 - 2980
2981 - 6554
GEOMAC 20130915_2311
N
W
E
S
0
4
8
16
Miles

Active Fire Data and Evaluation Portal

VIIRS Active Fire | Home | About | FAQ | VIIRS AF Products | VIIRS vs MODIS | Maps & Data | Contact Us

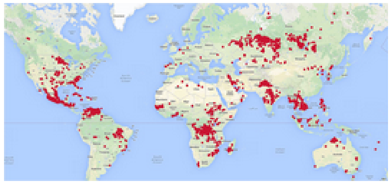
VIIRS AF Table Data

View CONUS Active Fire Map



View active fire detections. The map also provides an icon to represent the center of each VIIRS granule, weather information (temperature and cloud cover), and RSS feeds for US active fire perimeters and Incident Information. RSS feeds provided by GEOMAC and InciWeb, respectively.

View Global Active Fire Map



VIIRS daily global active fire detections

Data Archive

Displaying 1 - 20 of 4861

Date

Apply

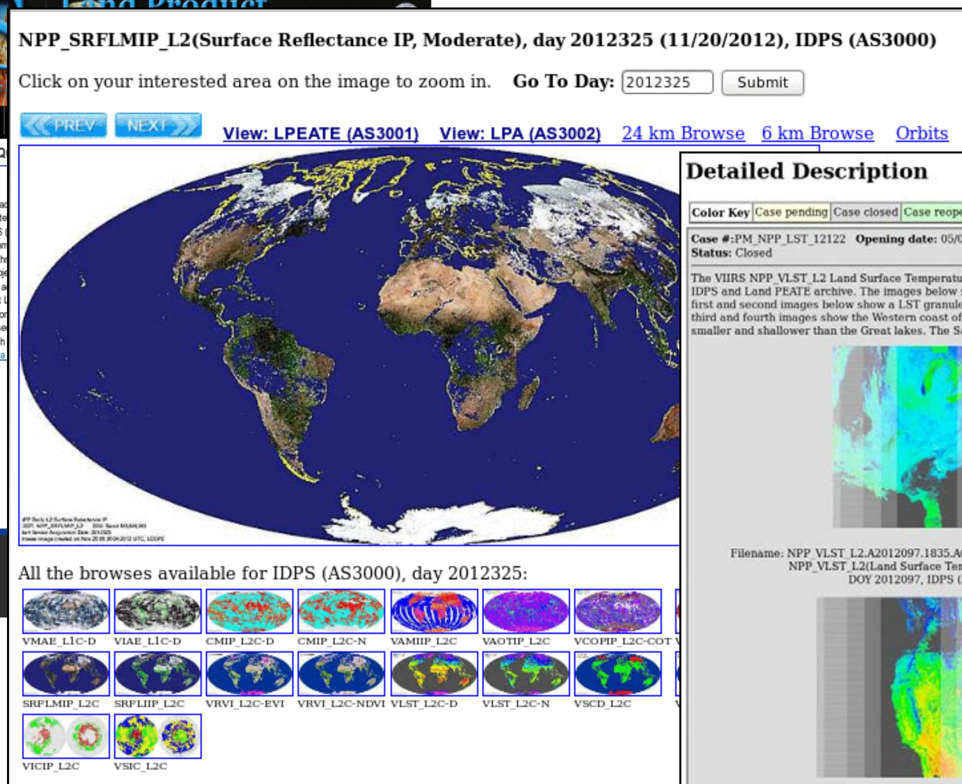
Date	Timestamp	ASCII	KMZ	TIFF	IBAND(png)	IBAND(GeoTIFF)	IBAND(kml)
2014-05-12	NPP_VIIRS_20140512_210500_211000	ASCII	KMZ	GeoTIFF	IBAND(png)	IBAND(GeoTIFF)	IBAND(kml)
2014-05-12	NPP_VIIRS_20140512_160000_160500	ASCII	KMZ	GeoTIFF	IBAND(png)	IBAND(GeoTIFF)	IBAND(kml)
2014-05-12	NPP_VIIRS_20140512_174000_174500	ASCII	KMZ	GeoTIFF	IBAND(png)	IBAND(GeoTIFF)	IBAND(kml)
2014-05-12	NPP_VIIRS_20140512_173500_174000	ASCII	KMZ	GeoTIFF	IBAND(png)	IBAND(GeoTIFF)	IBAND(kml)
2014-05-12	NPP_VIIRS_20140512_174500_175000	ASCII	KMZ	GeoTIFF	IBAND(png)	IBAND(GeoTIFF)	IBAND(kml)
2014-05-12	NPP_VIIRS_20140512_191500_192000	ASCII	KMZ	GeoTIFF	IBAND(png)	IBAND(GeoTIFF)	IBAND(kml)

http://viirsfire.geog.umd.edu/ - new version coming soon

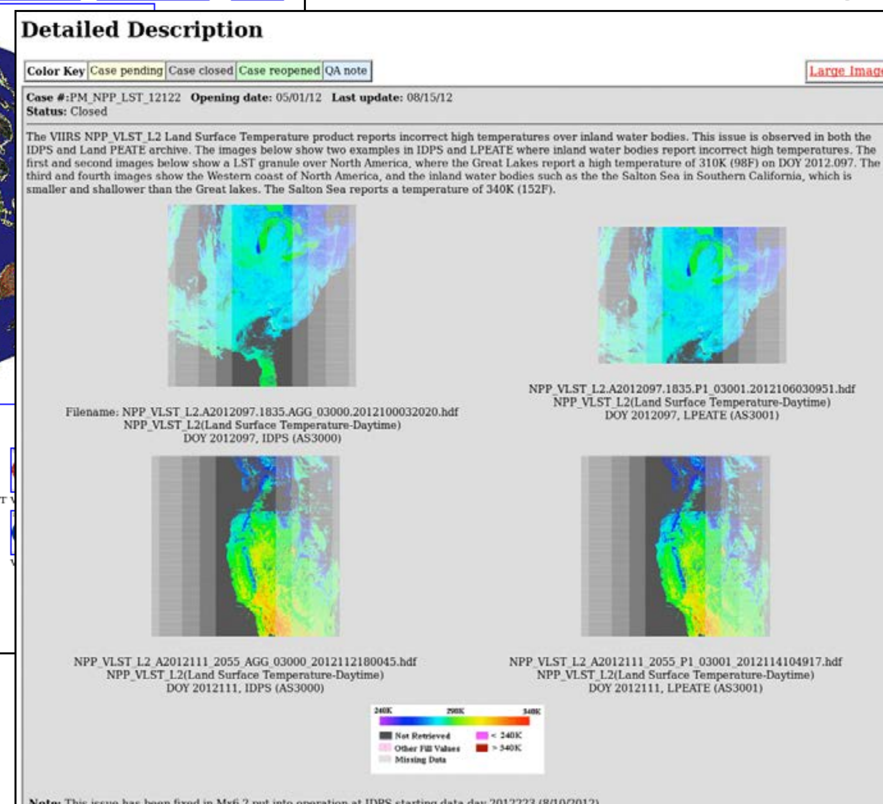
The Land PEATE: meeting the needs of the NASA Science Team and helping the NOAA IDPS

VIIRS LDOPE QA: http://landweb.nascom.nasa.gov/NPP_QA/

VIIRS Global Browse



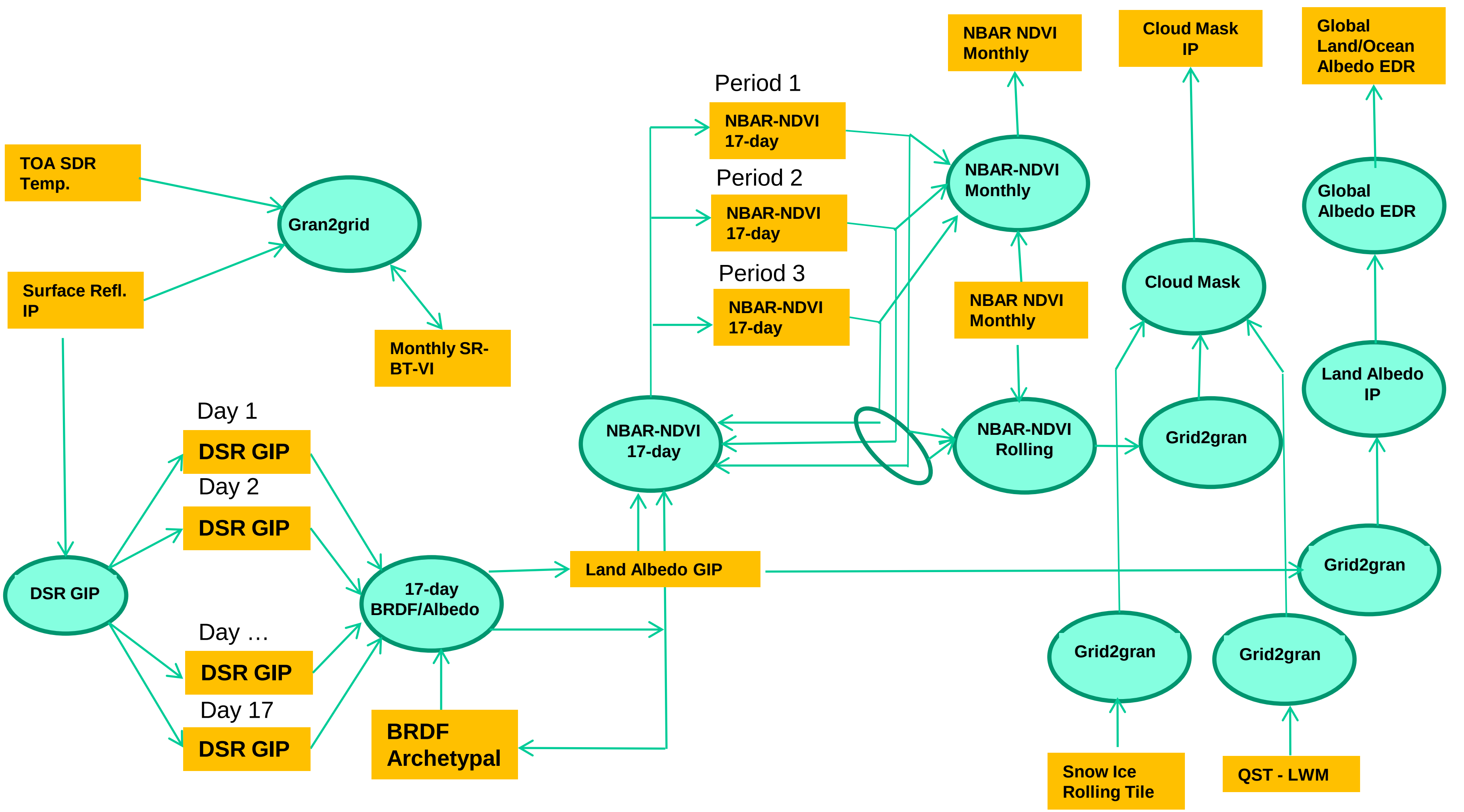
Known Issues Page



VIIRS Level 3 Products

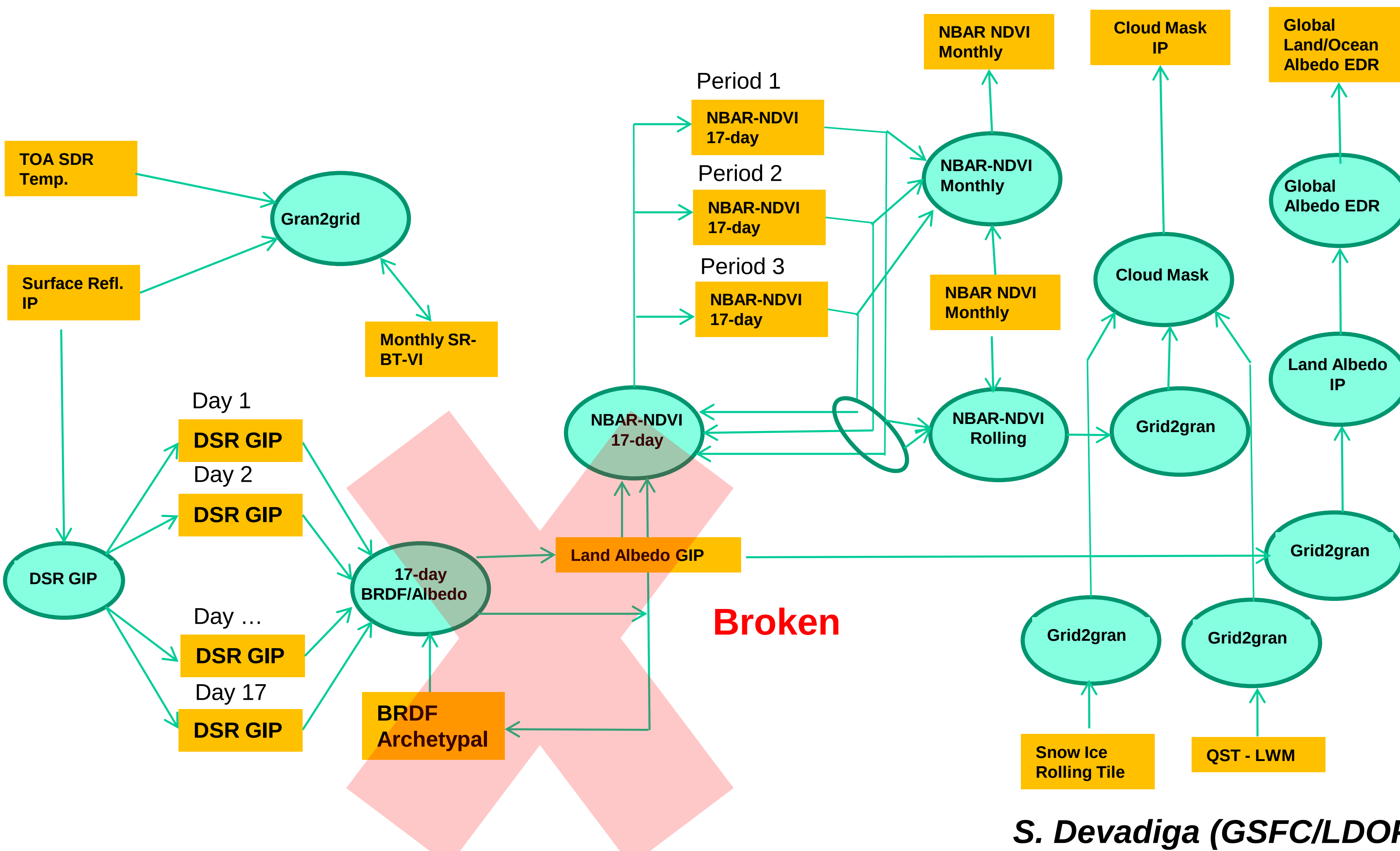
M. Román (GSFC)

Gridding/Granulation - Current



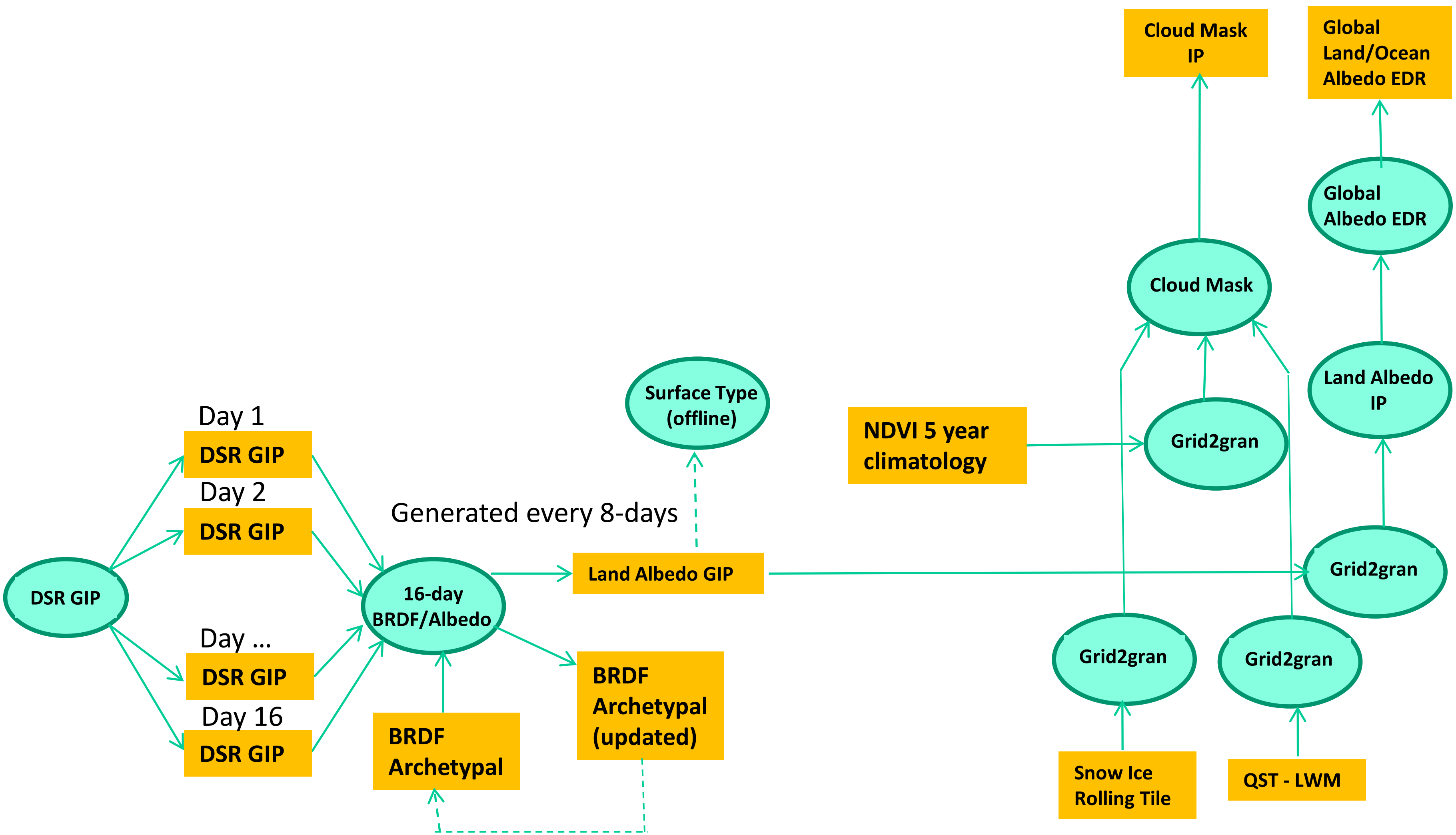
S. Devadiga (GSFC/LDOPE)

Gridding/Granulation - Current



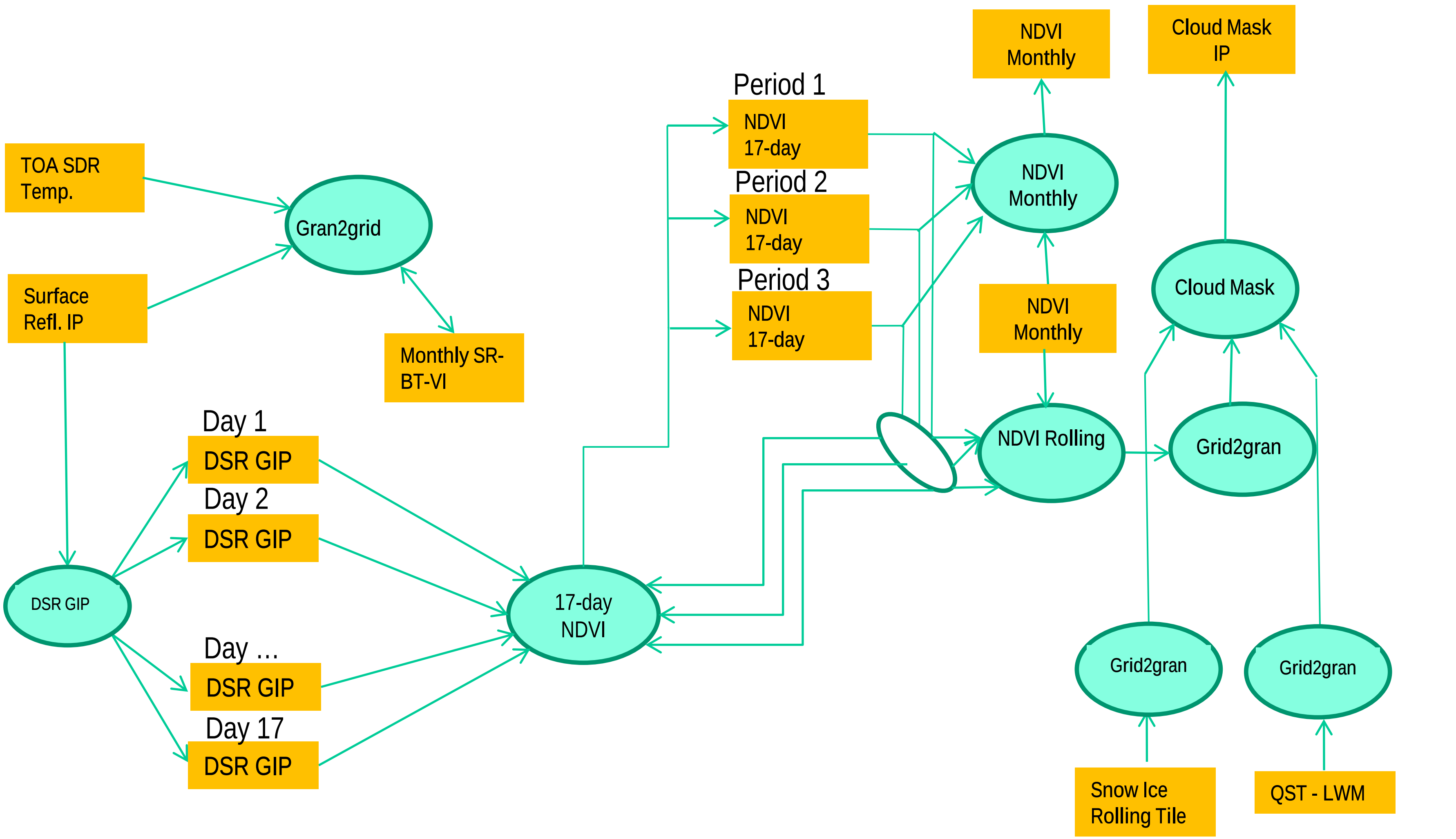
S. Devadiga (GSFC/LDOPE)

VIIRS Land Gridding/Granulation Proposed



S. Devadiga (GSFC/LDOPE)

Gridding/Granulation – Land/VCM Compromise



S. Devadiga (GSFC/LDOPE)

Summary and conclusions (1/2)

- S-NPP VIIRS land core IDPS product development and evaluation is progressing well
  - Provisional: Surface Reflectance, LST, Active Fires, Vegetation Index, Surface Type
  - Beta: albedo, science review held, up for AERB review
- Finish Suomi NPP product evaluation and development
  - Surface albedo to provisional; all products to validated
  - Gridding/granulation – specific proposals
- Continue interaction with upstream product teams
  - Overall SDR data quality is good - work is underway to resolve remaining quality flag and sensor performance issues (e.g. Active Fires)
  - VIIRS Cloud Mask – coordination regarding gridding/granulation – quality of input surface characterization feeds back to land EDR through VCM

Summary and conclusions (2/2)

- Development of data products not in the suite of operational NOAA products (i.e. IDPS or NDE)
  - NOAA JPSS Proving Ground and Risk Reduction
  - NASA SNPP Science Team
- Teams are continuing the development of improved and additional products
  - Green Vegetation Fraction, I-band Active Fires, LAI/FPAR etc.
- Development and operational implementation of products to meet new Level 1 requirements
  - Top-of-canopy vegetation index
  - Full active fire mask and fire radiative power
- Product continuity and reprocessing with latest algorithm
- Publications (JGR SNPP Special Issue and other)

JPSS STAR Science Team Annual Meeting

Cryosphere EDR Team Overview

Jeff Key

Cryosphere Team Lead

May 13, 2014

Overview of Data Products

1. Sea ice characterization
   - Currently this is an age category: no ice, new/young ice, other ice
2. Sea Ice concentration IP
   - Fractional coverage of ice in each pixel
3. Ice surface temperature (IST)
   - Radiating temperature of the surface (ice with or without snow)
4. Snow cover

   4a. Binary snow cover

   4b. Fractional snow cover (currently 2x2 averages of binary mask)

Notes:

- Information on ice and snow cover is needed by other EDRs.
- AMSR2 on GCOM-W1 will be used to generate other snow and ice products: Ice Characterization, Snow Cover, Snow Depth, and Snow Water Equivalent (SWE).

Cryosphere Team Membership and Funding

EDR	Name	Organization
Lead	Jeff Key	NESDIS/STAR
Co-Lead	Pablo Clemente-Colón	NESDIS/STAR and NIC
Wisconsin:		
Ice	Yinghui Liu	CIMSS/U. Wisconsin
Ice	Xuanji Wang	CIMSS/U. Wisconsin
Ice	Rich Dworak	CIMSS/U. Wisconsin
Maryland:		
Snow	Peter Romanov	CREST/CCNY
Snow	Igor Appel	IMSG
Colorado:		
Ice	Mark Tschudi	U. Colorado
Ice	Dan Baldwin	U. Colorado
Other:		
All	Paul Meade	DPE
All	Robert Mahoney	NGAS

Snow and Ice Product Users

- U.S. Users
  - NIC, National/Naval Ice Center
  - Naval Research Laboratory
  - NWS, National Weather Service, including the Alaska Ice Desk
  - OSPO, Office of Satellite and Product Operations
  - STAR, Center for Satellite Applications and Research
  - University of Washington, Polar Science Center
  - GSFC, NASA/Goddard Space Flight Center Hydrological Sciences Branch

- User Community
  - Navigation
  - Emergency Management
  - Operational Weather Prediction
  - Climate Research
  - DOD

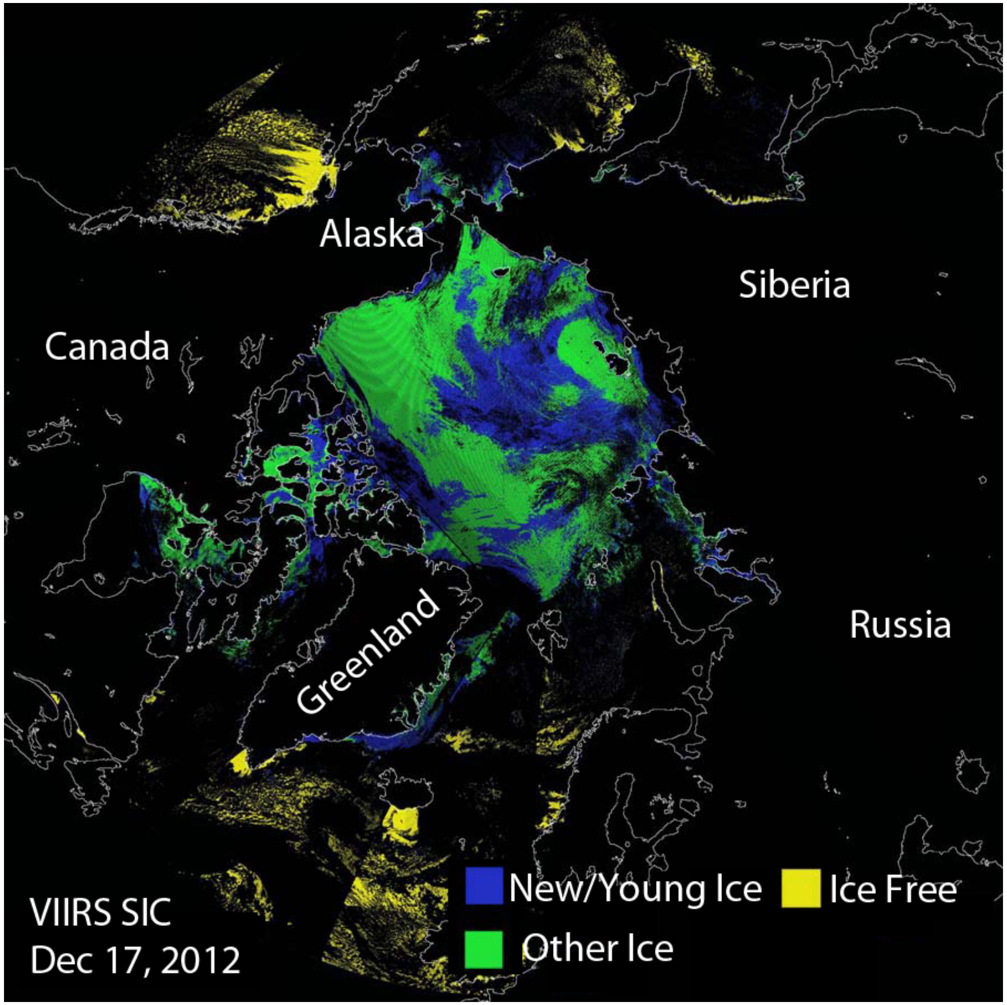
Cryosphere Accomplishments for FY14

- Maturity reviews:
  - IST: Provisional, Validated Stage 1
  - Sea Ice Characterization: Provisional
  - Snow Cover: Provisional, Validated Stage 1 for binary
- CCRs: 10
- Three Technical Interchange Meetings (TIMs) were held.
- Improved gridding significantly and made recommendations, though more could be done.
- Completed new, comprehensive validation studies for snow and ice products with in situ, aircraft, and satellite products. Automated validation is in place for some products.
- Implemented and began testing new fractional snow cover algorithm.
- Provided Land Team with help on update of the Surface Type EDR to perform a fall back to use the granulation of the gridded snow ice tiles.
- Published paper on snow and ice products and validation (JGR special issue).

See the breakout session presentations for more accomplishments and details!

Sea Ice Characterization

Description: An ice age classification for the categories: Ice -free, New/Young Ice (less than 30 cm thickness), and All Other ice. Freshwater ice is not included.



Sea ice characterization composite for 17 December 2012 New/young ice (less than 30 cm) is blue; older ice is green.

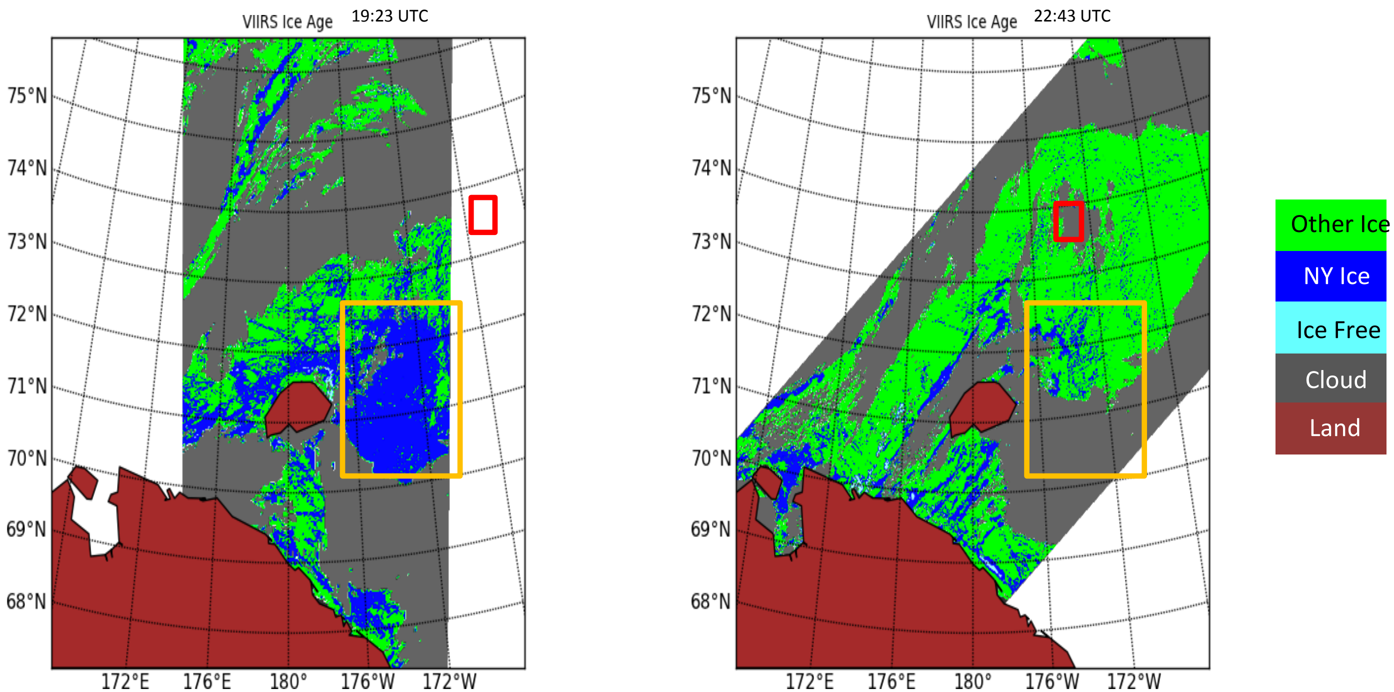
VIIRS Sea Ice Characterization EDR L1RD Requirements

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 Characterization

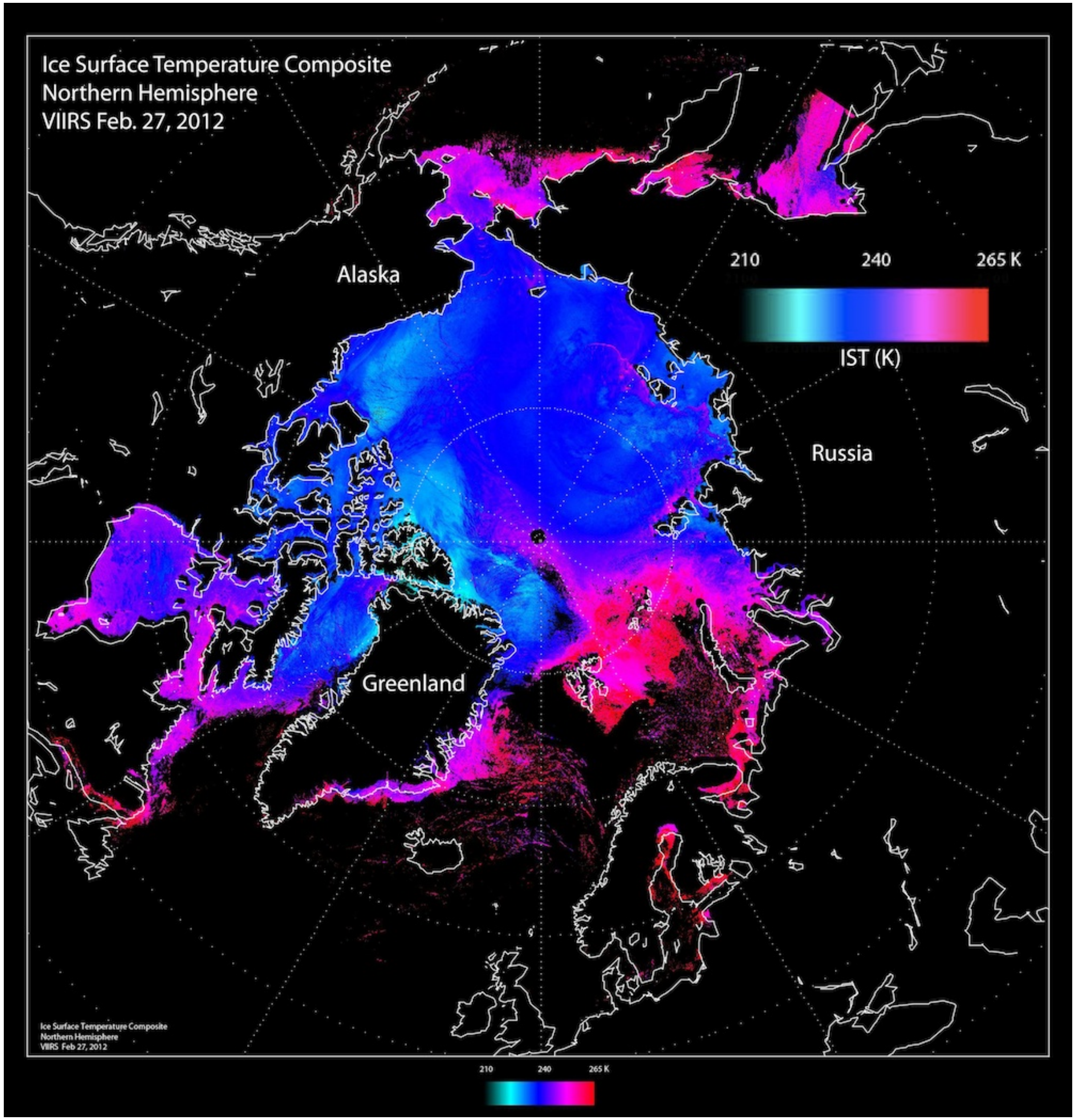
There are times when performance is good, and other times (too many) when performance is not good. Overall, it does not appear to be meeting the accuracy requirements. This is a complex algorithm where improvements may be required in a number of areas.



Region near Wrangle Island showed significant amounts of sea ice that were correctly classified as thicker "Other Ice" in 22:43 UTC orbit being misclassified as NY in the 19:23 UTC orbit

Ice Surface Temperature

Description: The surface (skin, or radiating) temperature of sea ice.



Composite of VIIRS Ice Surface Temperature on 27 Feb 2012.

VIIRS IST EDR L1RD Requirements

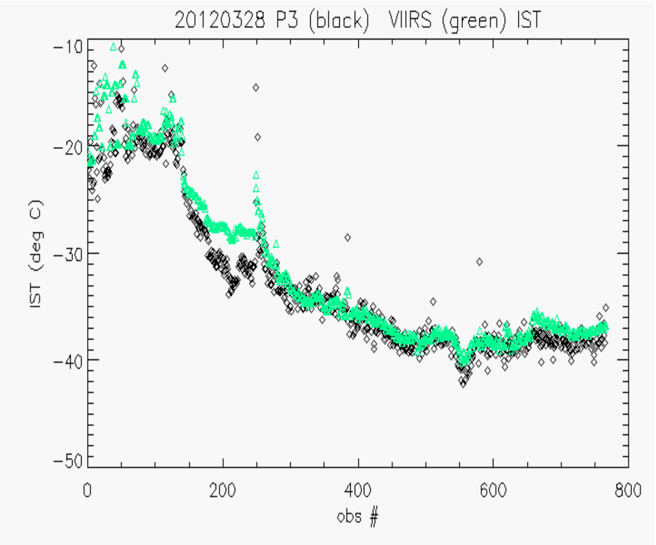
Ice Surface Temperature (IST) Requirements from L1RD Supplement. V2.9 (27 June 2013)

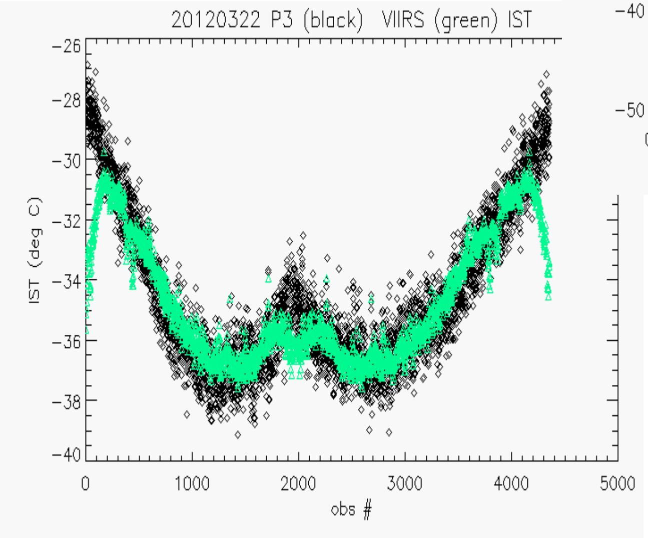
EDR Attribute	Threshold	Objective
IST Applicable Conditions **1. Clear, only**		
a. Sensing Depth	Ice Surface	Ice Surface
b. Horizontal Cell Size **1. Nadir** **2. Worst Case**	 1 km 1.6 km	 0.1 km 0.1 km
c. Mapping Uncertainty, 3 sigma **1. Nadir** **2. Worst Case**	 1 km 1.6 km	 0.1 km 0.1 km
d. Measure 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

IceBridge KT19 vs VIIRS IST, 2012

BIAS = VIIRS - KT19

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

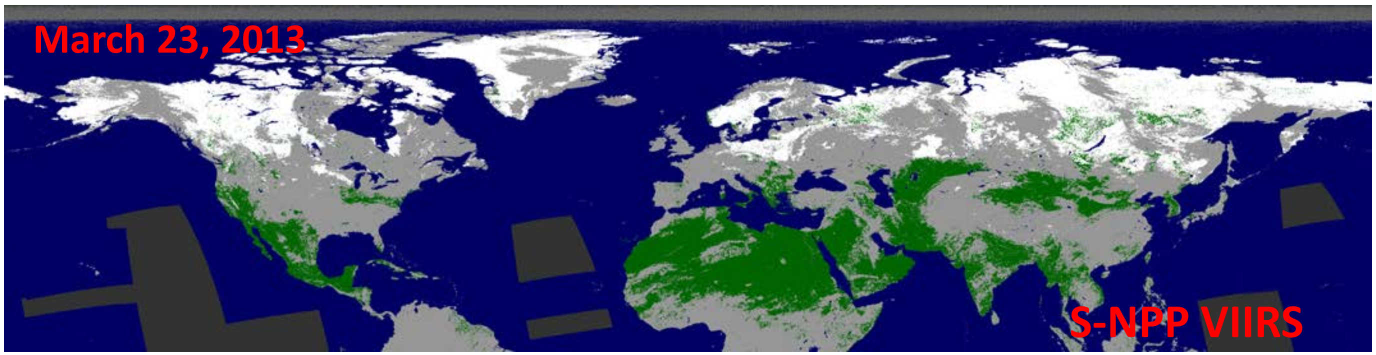




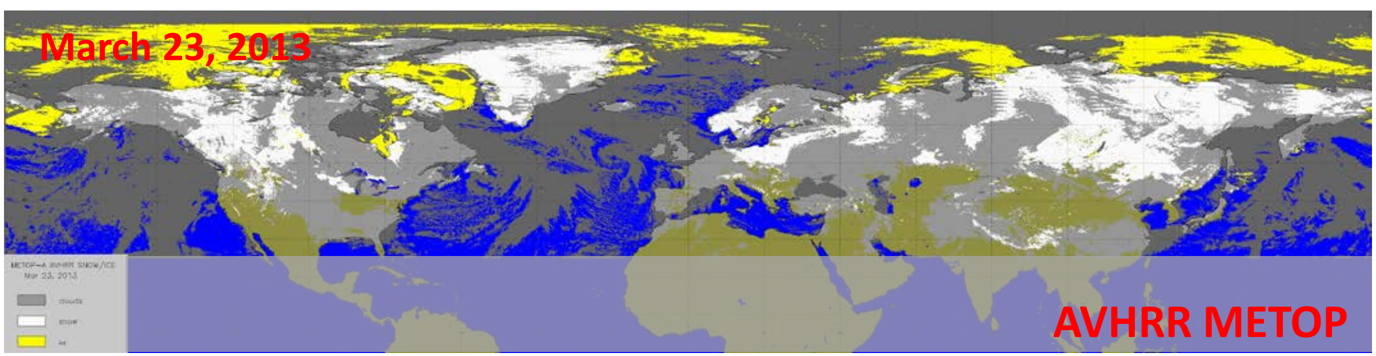
VIIRS IST has a 0.5+ K *cold bias* relative to the MODIS Ice Surface Temperature product. Comparisons to NCEP and International Arctic Buoy Program (IABP) air temperatures yield a VIIRS *warm bias* of 1 K. It meets the accuracy requirement under most conditions.

Binary Snow Cover

Description: Snow Cover is defined to be the horizontal and vertical extent of snow cover. In addition, a binary product gives a snow/no-snow flag.



snow land cloud No data



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]

VIIRS, AVHRR, MODIS Snow vs IMS

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

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

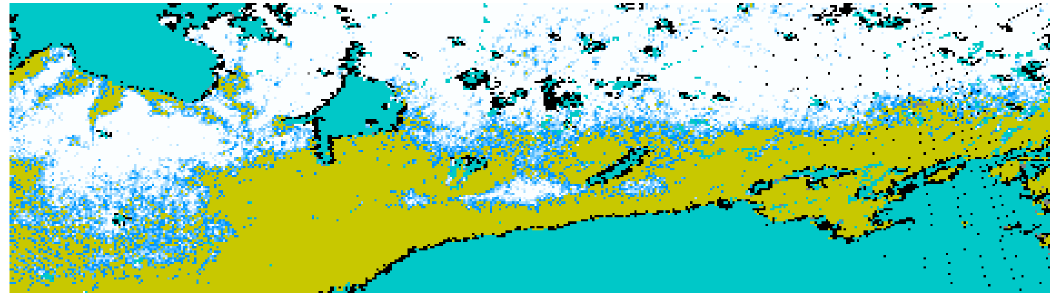
*Cloud-clear fraction is estimated in 25-60^{0}N latitude band

- Binary snow cover meets the accuracy requirement.
- Most issues are related to cloud masking; e.g., somewhat overestimated cloud extent and corrupted land/water mask.
- Some potential exists to improve the algorithm and the product, e.g., geometry-dependent threshold values.

Fractional Snow Cover

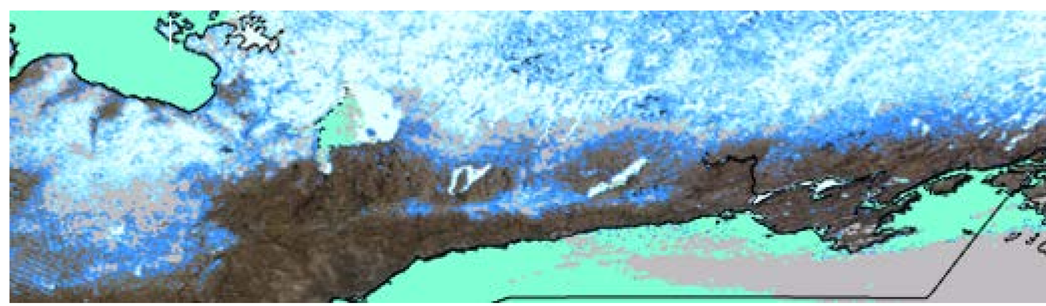
Description: VIIRS Snow Cover Fraction is derived from the Binary Snow Map as an aggregated snow fraction within 2x2 pixel blocks. The spatial resolution of the product is 750 m at nadir

VIIRS fraction



Image

MODIS fraction



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

Specification of VIIRS Snow Fraction

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

Snow Fraction Alternative Algorithms

The 2x2 pixel aggregation scheme can only provide a small set of values (0, 25, 50, 75, 100% if no missing pixels) and therefore cannot meet the 10% accuracy requirement throughout the measurement range.

A number of different snow fraction algorithms are available; the first two are being tested:

1. NDSI-based (Solomonson/Appel, Hall/Riggs)
2. Visible reflectance –based (Romanov/Tarpley)
3. Multiple endmember multispectral approach (Painter)

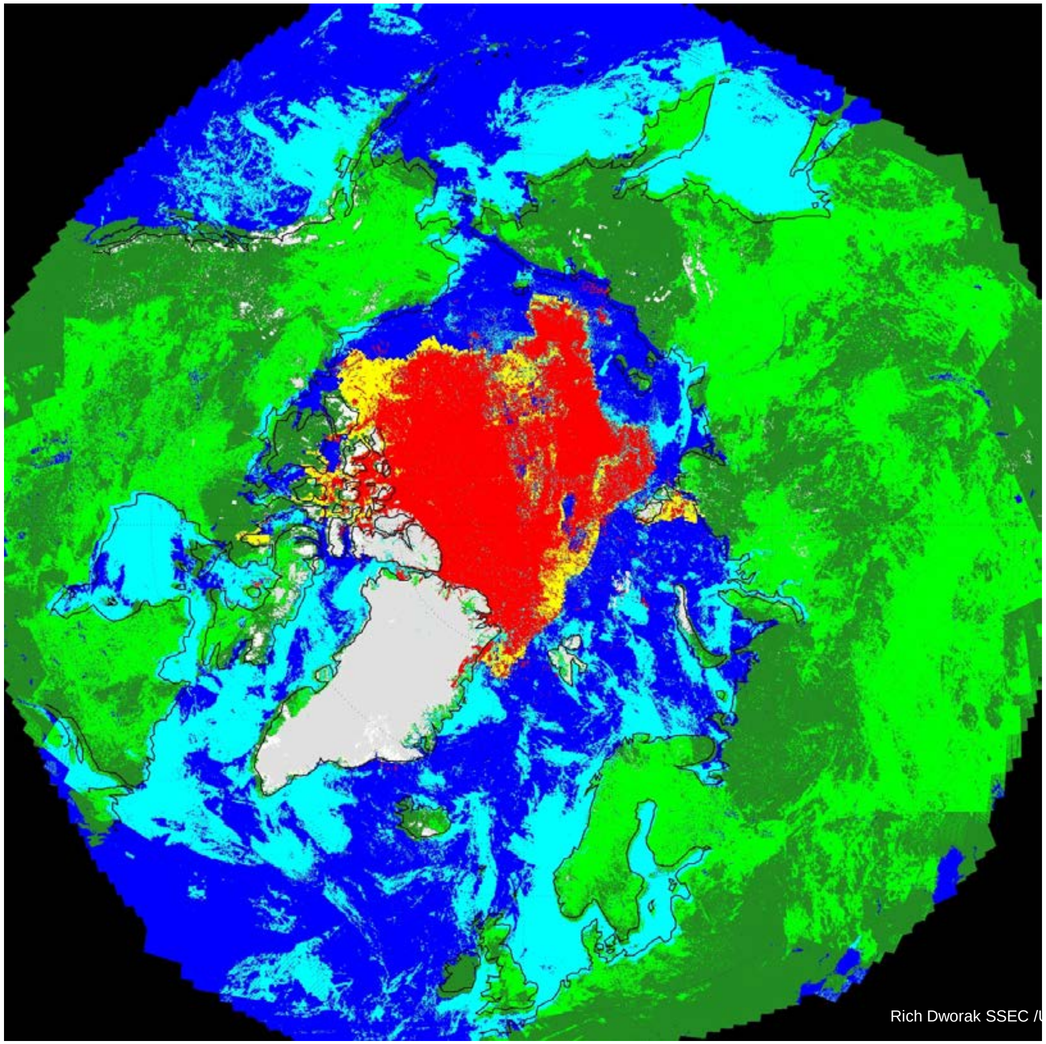
Algorithm Recommendations

Recommendations for IDPS algorithms:

Product	Through Aug 31	NPP after Aug 31	JPSS
Sea Ice Concentration IP	1	1	1 or 3
Ice Surface Temperature	1	1 or 3	3
Sea Ice Characterization/age	1	1 or 2 (TBD)	2 or 3
Binary Snow Cover	1	1	1 or 3
Fractional Snow Cover	2	2	2

1. NPOESS algorithm has evolved into the NOAA-endorsed JPSS algorithm and any needed improvements should continue.
2. NPOESS (or evolved) algorithm will not meet requirements or effort is too large, replace with NOAA-endorsed JPSS algorithm
3. NOAA-endorsed algorithm should be used even if NPOESS (or evolved) algorithm meets performance because of legacy, enterprise, blended products, and other considerations.

VIIRS Snow/Ice Gridding Tests



GMASI

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

VIIRS Updated

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

Snow/Ice Gridding Summary

- Improvements in the VIIRS gridded Snow/Ice have occurred due to the MX 7.2 VCM update and application of additional quality control criteria that included:
    1. Extended cloud adjacency applied to Sea Ice Concentration IP
    2. Standard cloud adjacency applied to Snow Cover EDR
    3. Confidently clear pixels only
    4. No thin cirrus
    5. Solar zenith angle limited to angles less than 80° (cloud shadow issue)
    6. Fallback to GMASI if no good quality VIIRS Snow/Ice after 5 days
- Sea Ice probability of detection and false alarm rate relative to NOAA AutoSnow for VIIRS gridded Sea Ice are approximately 87% and 7% respectively after testing with the proposed quality control criteria
- Significant regions were not updated by VIIRS Snow/Ice even after a 7 day gridding test period.
- Cloud shadows result in missing snow/ice in the Snow/Ice Rolling Tile grid. Further reduction in Snow/Ice gridding errors will require significant effort.

Cryosphere Team Challenges

- Unanticipated snow/ice gridding issues and problems have required the team to devote unscheduled resources. Gridding problems, including interactions with the cloud mask, have occupied all of our time and resources for the last 19 months.
- The team has had to spend a large amount of time on VCM issues, though there has been much improvement in the VCM and future work should be minimal.
- The FY14 budget is 30% less than FY13.
- The algorithm change process is cumbersome and lengthy. Too many steps and too much time for even the simplest of changes.

Plans, Milestones

	Suomi NPP	JPSS J1
FY15	• Validated Stage n (various) maturity reviews • Implement, test, and deliver new fractional snow cover algorithm • Continued validation of all products • Improve or recommend replacement of Sea Ice Characterization algorithm • Recommendations on snow/ice gridding	JPSS Risk Reduction Projects: • Run GOES-R algorithms on VIIRS products • Minor algorithm improvements
FY16	• Algorithm maintenance and minor improvements	• Hold algorithm preliminary design reviews • Define validation plan
FY17	• Long-term validation of VIIRS snow and ice products	• Hold algorithm critical design reviews • Begin transitioning to JPSS • Redefine products if needed • Generate LUTs for J1 VIIRS sensor
FY18	• Long-term validation of VIIRS snow and ice products	• J1 launch • Beta maturity status

Status of JPSS SST Products

Alexander Ignatov, John Stroup, Yury Kihai, Boris Petrenko, Xingming Liang, Prasanjit Dash, Irina Gladkova, Marouan Bouali, Karlis Mikelsons, John Sapper, Feng Xu, Xinjia Zhou

NOAA; CIRA; GST Inc; CUNY

Bruce Brasnett

Canadian Met Centre

Acknowledgements

- JPSS Program – Mitch Goldberg, Kathryn Schontz, Bill Sjoberg
- NASA SNPP Project Scientist – Jim Gleason
- NOAA NDE Team – Tom Schott, Dylan Powell, Bonnie Reed
- JPSS DPA – Eric Gottshall, Janna Feeley, Bruce Gunther
- VIIRS SDR & GSICS – Changyong Cao, Frank DeLuccia, Jack Xiong, Mark Liu, Fuzhong Weng
- NOAA STAR JPSS Team – Ivan Csiszar, Lihang Zhou, Paul DiGiacomo, many others
- NOAA CRTM Team – Yong Han, Yong Chen, Mark Liu

JPSS SST Team

Name	Affiliation	% Funding	Tasks
Ignatov	STAR	NOAA	Lead, JPSS Algorithm & Cal/Val
Stroup, Kihai, Dash, Liang, Petrenko, Xu, Bouali, Zhou, Gladkova, Mikelsons	STAR/CIRA STAR/STG STAR/GST STAR/GST	JPO, NOAA ORS, GOES-R, NASA	Quality Monitoring of VIIRS SSTs (SQUAM), Radiances (MICROS), and in Situ SSTs (*i*Quam) Data support; IDPS SST code, Match up, Cloud Mask, SST retrievals; Destriping L1b & SST
May, Cayula, McKenzie, Willis	NAVO	Navy, NJO	NAVO SEATEMP SST & Cal/Val VIIRS Cloud Mask evaluation
Minnett Kilpatrick	U. Miami	JPO, U. Miami	Uncertainty & instrument analyses; RTM; VAL vs. drifters & radiometers; skin to sub-skin conversion
Arnone Fargion	USM/NRL UCSD	NJO, USM	SST Algorithm Analyses, SST improvements at slant view zenith angles/swath edge
LeBorgne Roquet	Meteo France	EUMETSAT	Processing VIIRS and Cal/Val using O&SI SAF heritage; Comparisons with AVHRR/SEVIRI

Past Year Focus Areas

Sustained NRT Monitoring/VAL of VIIRS SSTs and Radiances

- ✓ SQUAM www.star.nesdis.noaa.gov/sod/sst/squam/ - comprehensive cross-evaluation of various SST products and VAL against in situ data
- ✓ iQuam www.star.nesdis.noaa.gov/sod/sst/iquam/ - QCed in situ data
- ✓ MICROS www.star.nesdis.noaa.gov/sod/sst/micros/ - feedback to SDR

SST EDR is Provisional

- ✓ Improved & Consolidated SST Algorithm in IDPS / ACSPO – JGR special issue
- ✓ EDR Review Jan 2014 - Provisional status granted Apr 2014
- ✓ Based on users feedback & performance, JPO recommend to "discontinue IDPS and focus on NOAA ACSPO sustainment, Cal/Val and development"

→ **ACSPO Production**

- ✓ Operational at NDE Mar 2014; Archival at JPL/NODC underway
- ✓ Work with NAVO partners to cross-evaluate NAVO and ACSPO VIIRS products
- ✓ Work with users to assess ACSPO SST, provide feedback to SST Team

Destriping and ACSPO Clear-Sky Mask improvements

- ✓ Progress with operational destriping – SDR & SST breakouts – Mikelsons
- ✓ Pattern-recognition ACSPO clear-sky mask – SST break-out, Innovative science talk / I. Gladkova

VIIRS SST Products

IDPS – NOAA Interface Data Processing Segment (IDPS)

- ✓ Official NPOESS SST EDR, Now owned by NOAA JPSS PO
- ✓ Developed by NGAS; Operational at Raytheon; Archived at NOAA CLASS
- ✓ Jan 2014: JPO recommends “discontinue the IDPS EDR, concentrate on ACSPO”
- ✓ IDPS will be phased out as soon as ACSPO SST is archived at JPL/NODC
- ✓ As of this report, meets specs at night, does not meet during daytime

→ *ACSPO – NOAA Advanced Clear-Sky Processor for Ocean (ACSPO)*

- ✓ NOAA heritage SST system (AVHRR GAC and FRAC heritage)
- ✓ VIIRS operational Mar 2014, GDS2 archival at JPL/NODC underway
- ✓ Meet/exceed APU specs (both day/night), good global coverage

→ *NAVO – SEATEMP*

- ✓ Builds on NAVO AVHRR & NOAA pre-ACSPO heritage
- ✓ VIIRS operational Mar 2013; GDS2 archived at JPL/NODC May 2013
- ✓ Meet/exceed APU specs (both day/night), coverage restricted

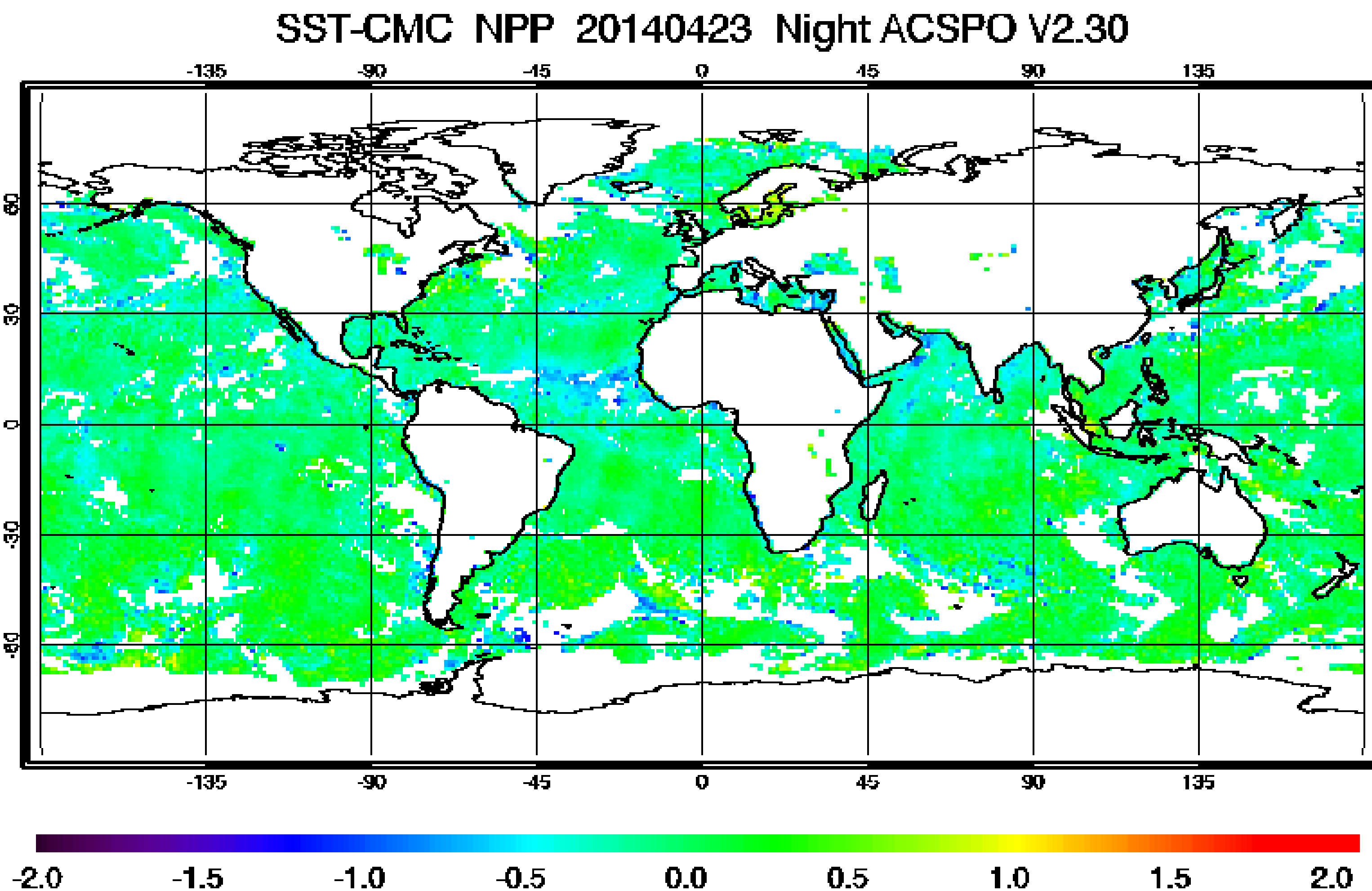
Objective & Methodology

- **Objective: Compare ACSPO and NAVO SSTs to advise users on the specifics of the two products**

- **Methodology: Compare ACSPO/NAVO SST domain & performance against two global reference SSTs**
  - **L4 SST (Canadian Met Centre CMC0.2 Analysis. Note that VIIRS data are not assimilated in CMC0.2)**
  - ***in situ* SST (QCed drifting buoys in iQuam *www.star.nesdis.noaa.gov/sod/sst/iquam/*)**

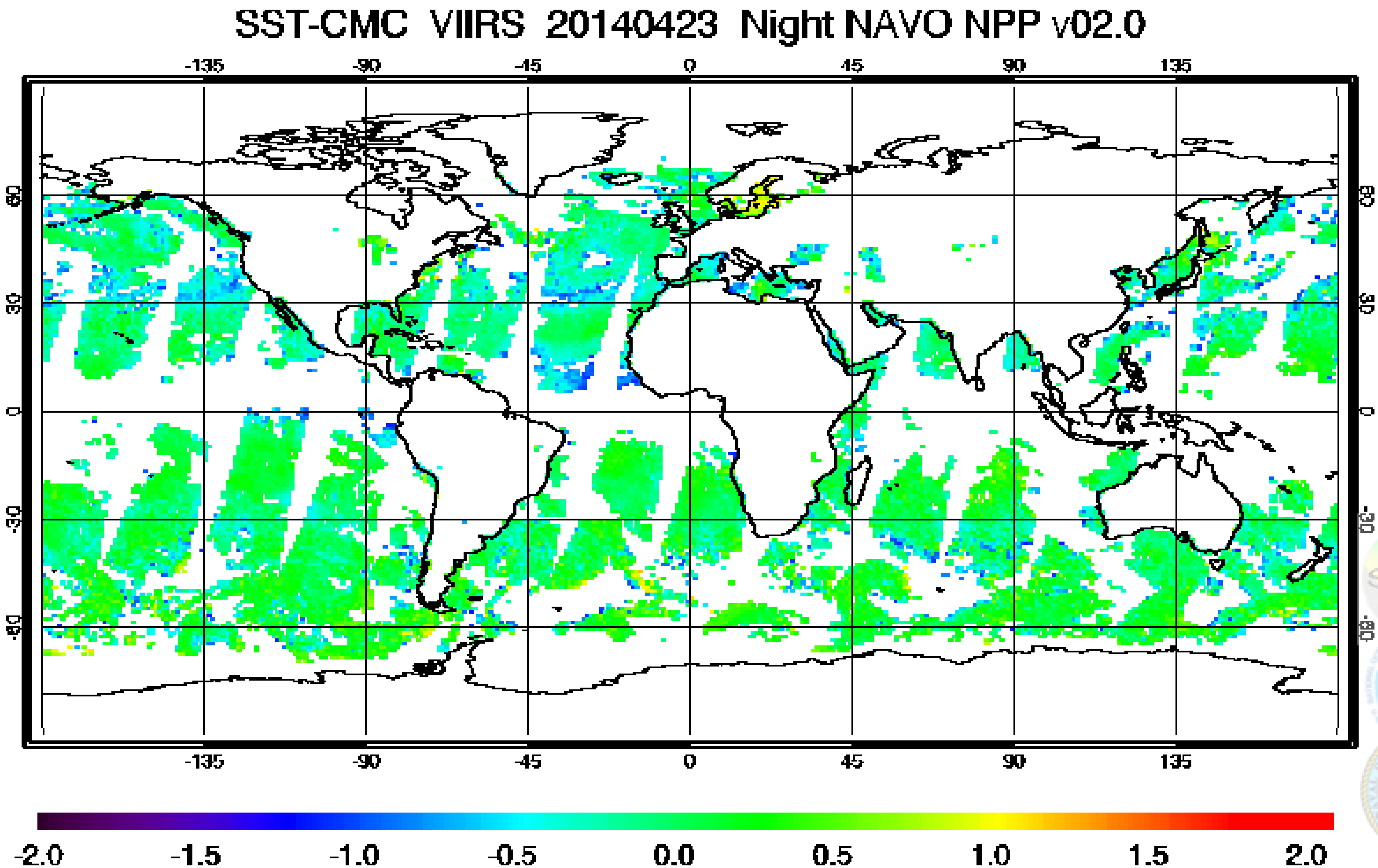
Data: one representative day of global data – 23 April 2014 – in SST Quality Monitor (SQUAM) *www.star.nesdis.noaa.gov/sod/sst/squam/*

NIGHT: ACSPO L2 minus CMC L4
23 April 2014



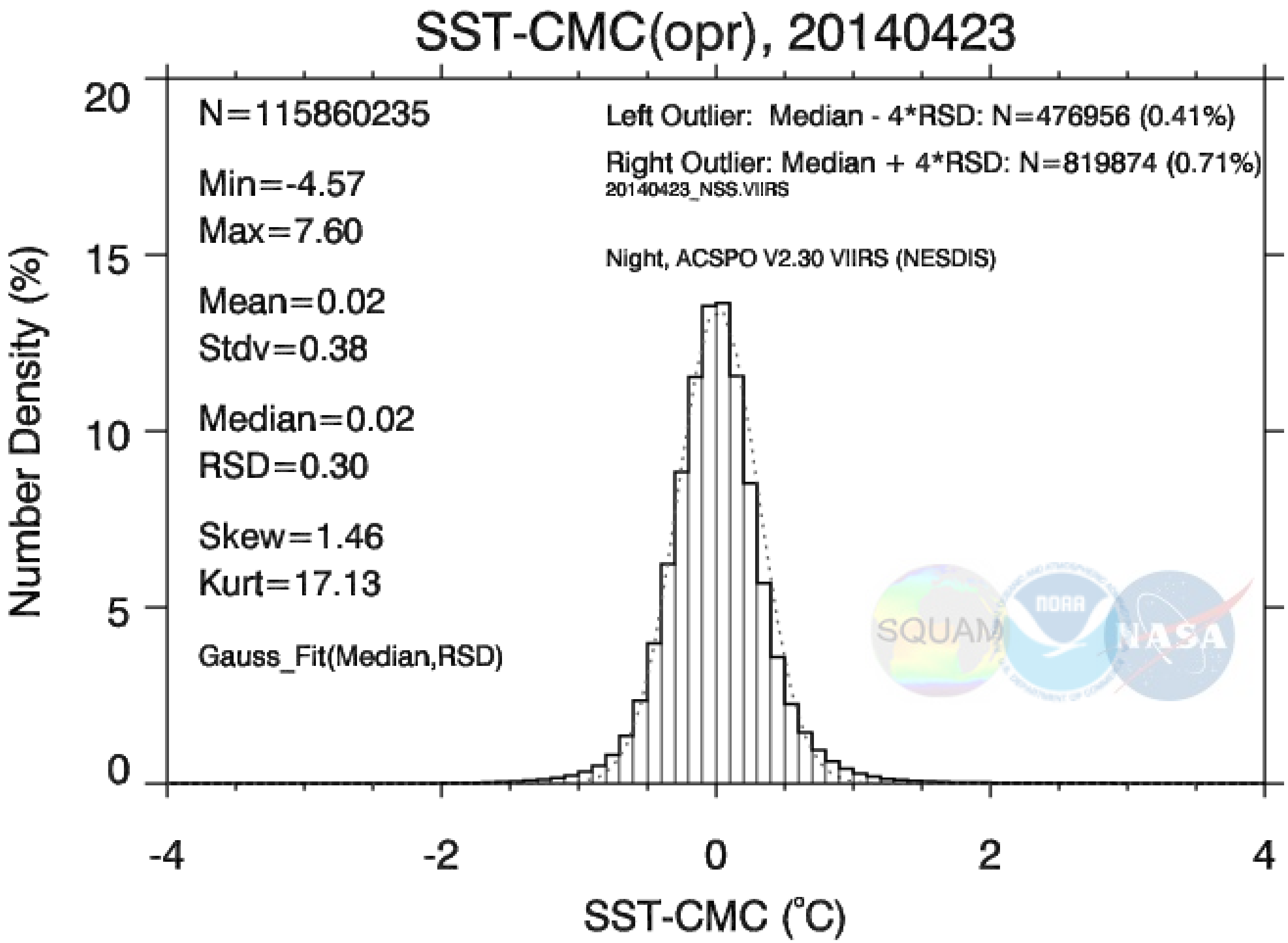
- ***Delta close to zero as expected***
- ***Cold spots – Residual Cloud/Aerosol leakages***

NIGHT: NAVO L2 minus OSTIA L4
23 April 2014



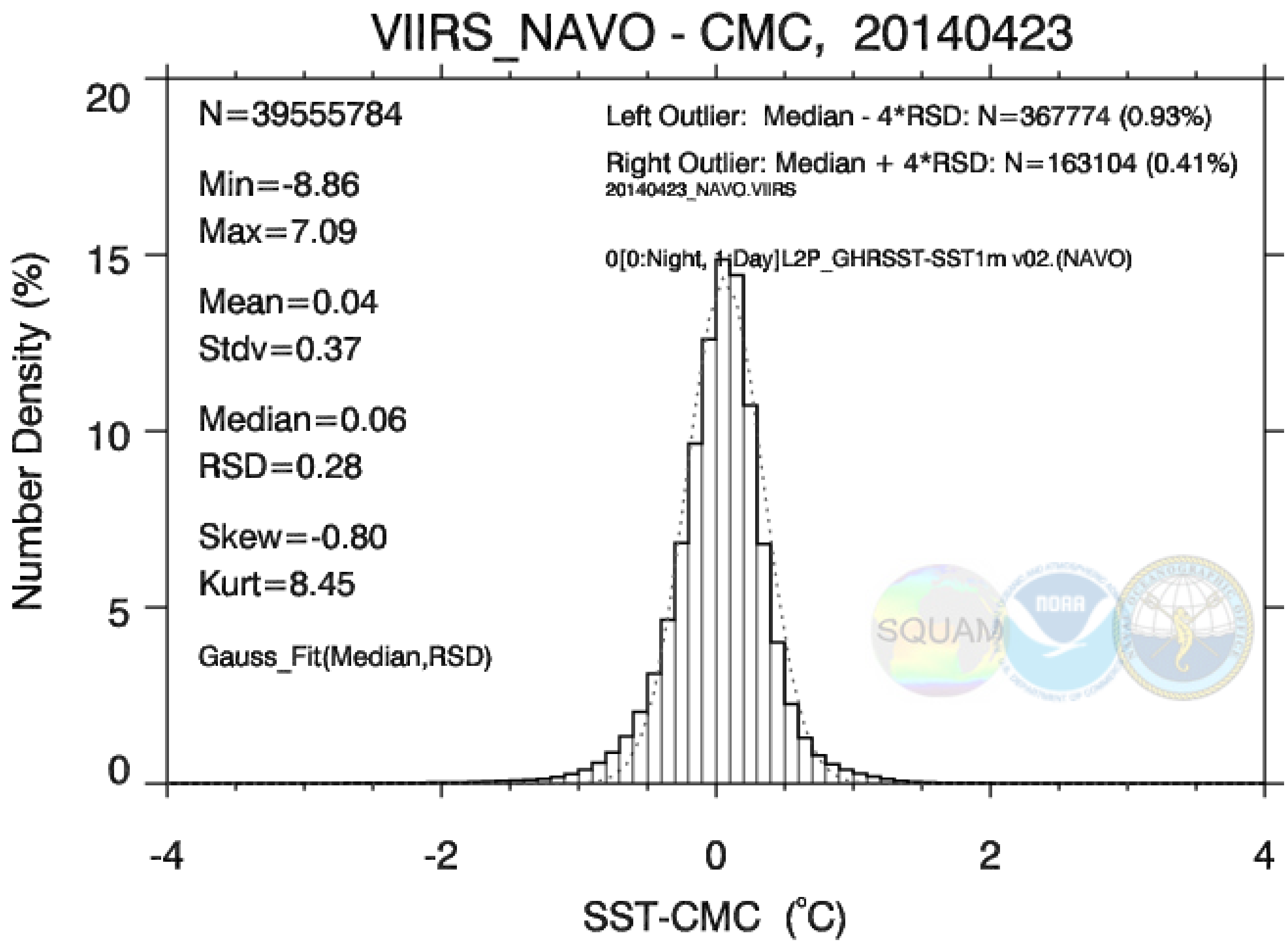
- ***Retrievals limited to VZA<54°***

NIGHT: ACSPO L2 minus CMC L4
23 April 2014



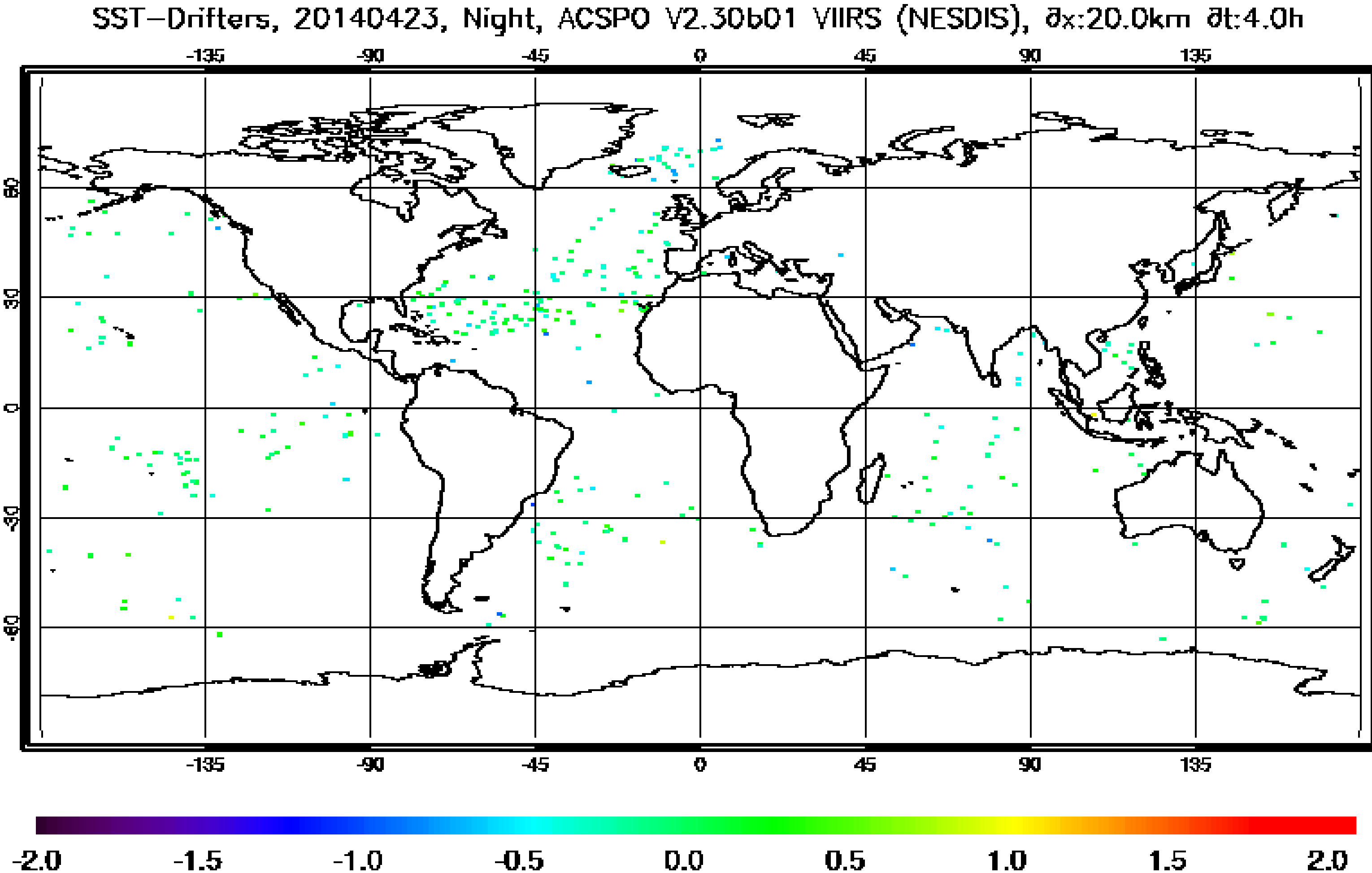
- ***Shape close to Gaussian***

NIGHT: NAVO L2 minus CMC L4
23 April 2014



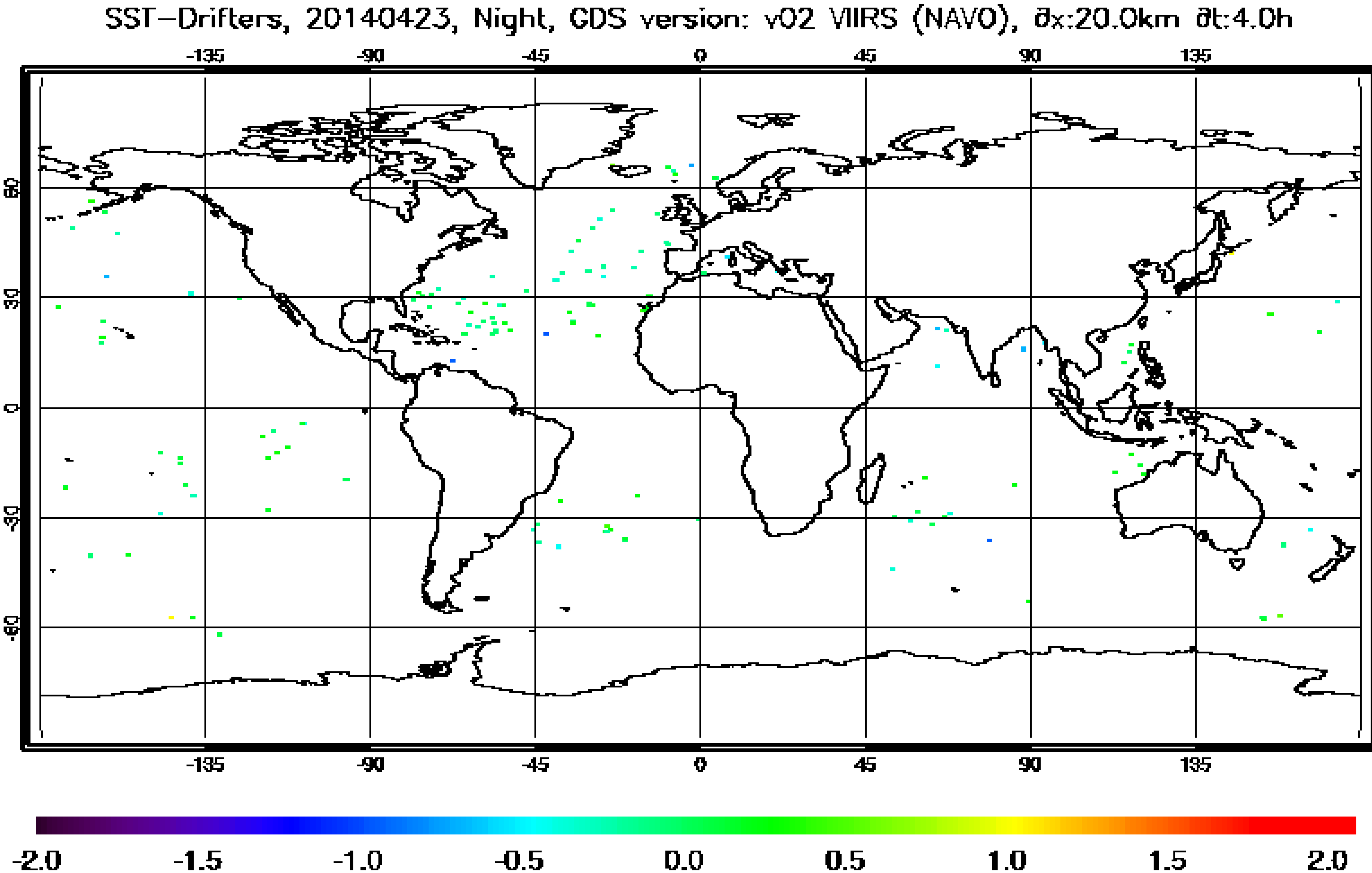
- ***Shape close to Gaussian***
- ***Domain smaller, STD slightly better***

NIGHT: ACSPO L2 minus *in situ* SST
23 April 2014



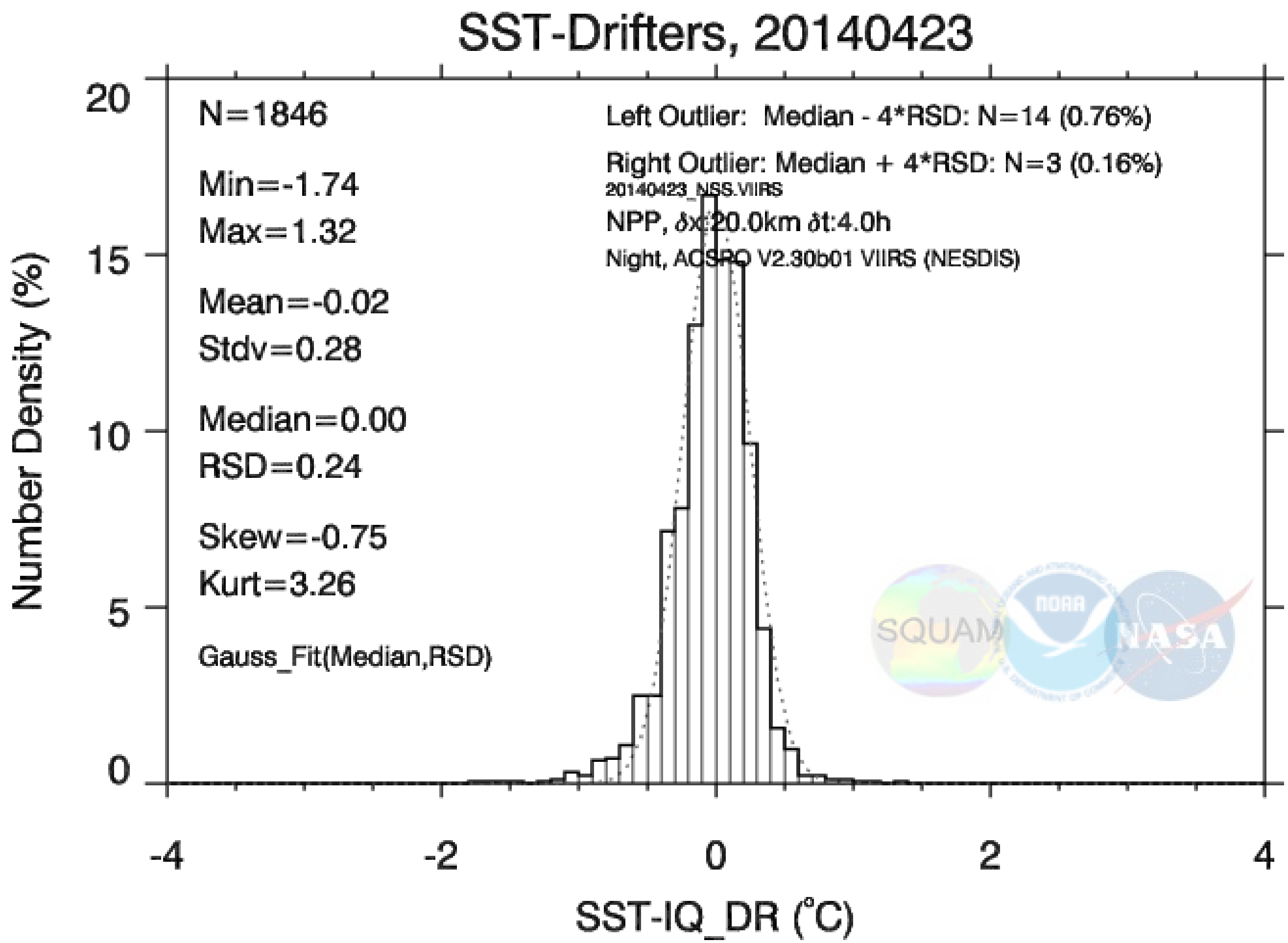
- ***Much sparser data coverage***
- ***Not fully representative of the globe***

NIGHT: NAVO L2 minus *in situ* SST
23 April 2014



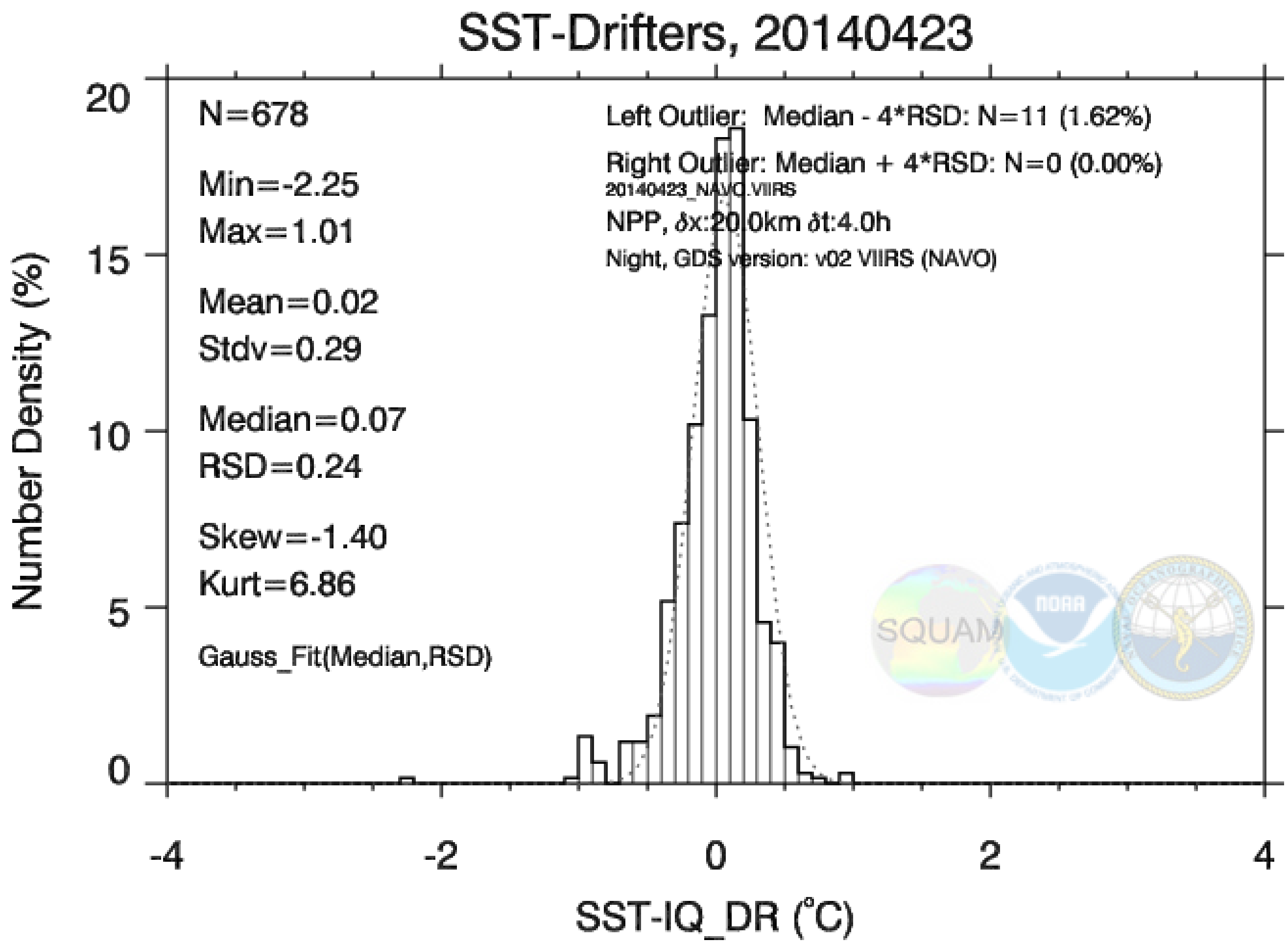
- ***Much sparser data coverage***
- ***Not fully representative of the globe***

NIGHT: ACSPO L2 minus *in situ* SST
23 April 2014



- ***Shape close to Gaussian – small cold tail***
- ***Performance Stats well within specs (Bias<0.2K, STD<0.6K)***

NIGHT: NAVO L2 minus *in situ* SST
23 April 2014



- ***Shape close to Gaussian – small cold tail***
- ***Performance Stats well within specs (Bias<0.2K, STD<0.6K)***

NIGHT – Summary

Vs. L4

ΔT = "VIIRS minus CMC" SST (expected ~0)

	NOBS (%ACSPO)	Min/ Max	Mean/ STD	Med/ RSD
IDPS	116.8M (101%)	-13.1/+12.6	-0.04/0.46	-0.00/0.31
ACSPO	115.9M (100%)	- 4.6/+7.6	-0.02/0.38	-0.02/0.30
NAVO	39.5M (34%)	- 8.9/+7.1	+0.04/0.37	+0.06/0.28

- ***IDPS: SST domain is +1% larger than ACSPO, All stats degraded***
- ***NAVO: SST domain is factor of ×3 smaller than ACSPO, stats improved***

Vs. in situ

ΔT = "VIIRS minus in situ" SST (expected ~0)

	NOBS (%ACSPO)	Min/ Max	Mean/ STD	Med/ RSD
IDPS	2,082 (113%)	-2.9/+5.6	-0.06/0.43	-0.01/0.26
ACSPO	1,846 (100%)	-1.7/+1.3	-0.02/0.28	-0.00/0.24
NAVO	678 (37%)	-2.3/+1.0	+0.02/0.29	+0.07/0.24

- ***IDPS: SST domain is +13% larger than ACSPO, All stats degraded***
- ***NAVO: SST domain is factor of ×3 smaller than ACSPO, stats comparable***

DAY – Summary

Vs. L4

ΔT = "VIIRS minus CMC" SST (expected ~0)

	NOBS (%ACSPO)	Min/ Max	Mean/ STD	Med/ RSD
IDPS	120.4M (100%)	- 28.7/+10.4	+0.20/0.77	+0.24/0.45
ACSPO	121.0M (100%)	- 5.4/+ 9.2	+0.29/0.59	+0.21/0.41
NAVO	41.3M (34%)	- 8.2/+ 7.5	+0.28/0.56	+0.22/0.40

- *IDPS: SST domain is comparable with ACSPO, All stats degraded*
- *NAVO: SST domain is factor of ×3 smaller than ACSPO, stats comparable*

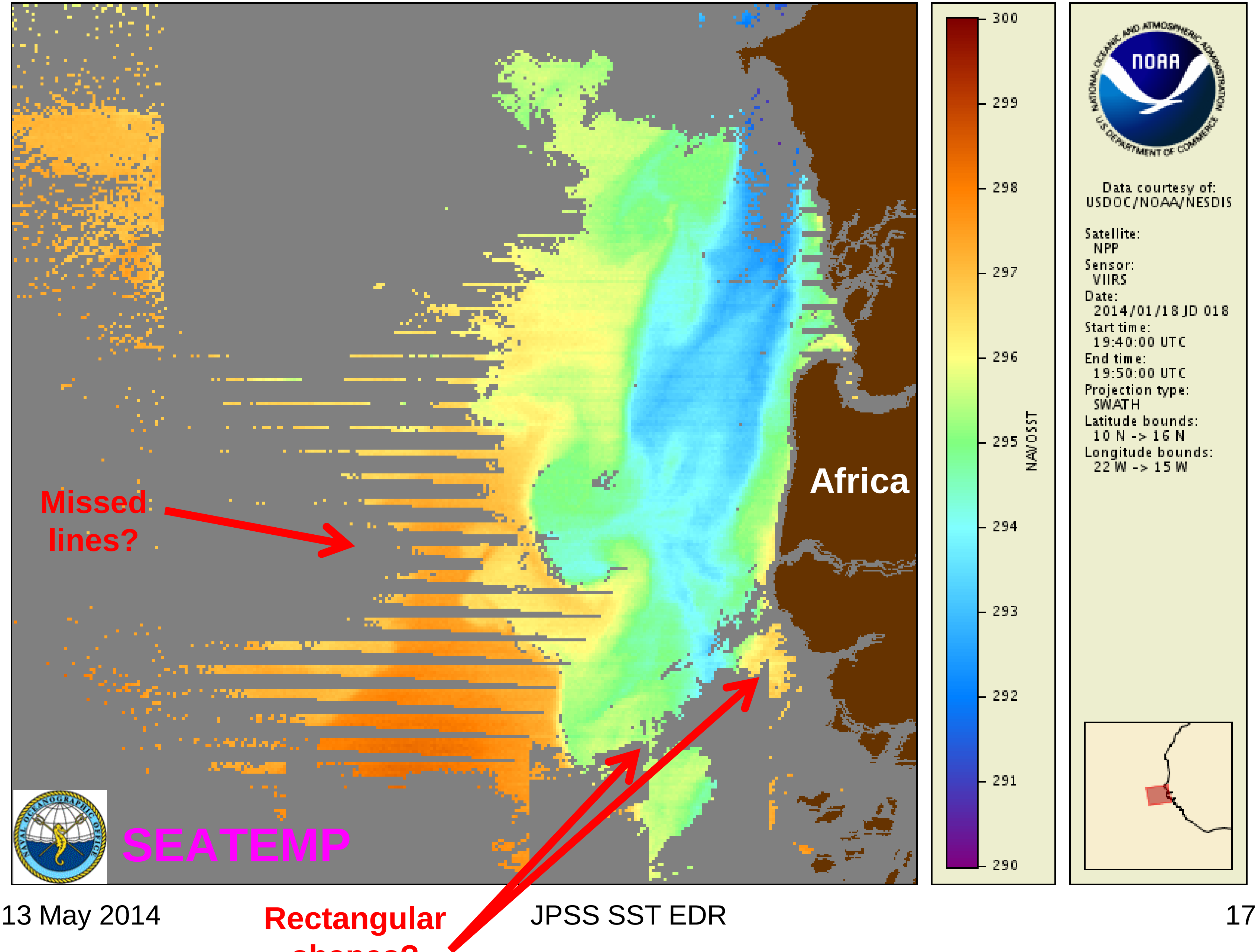
Vs. in situ

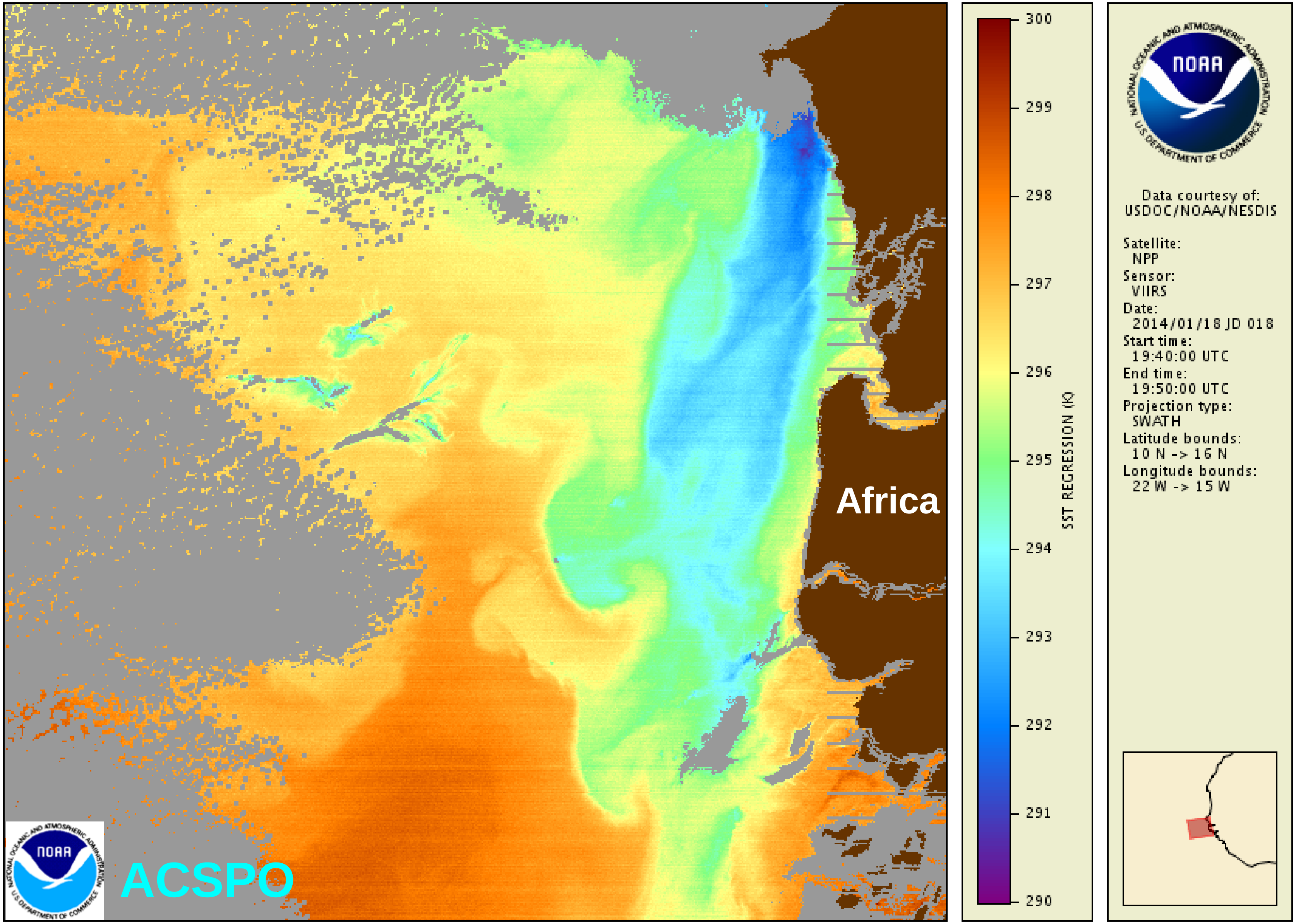
ΔT = "VIIRS minus in situ" SST (expected ~0)

	NOBS (%ACSPO)	Min/ Max	Mean/ STD	Med/ RSD
IDPS	1,758 (105%)	-5.3/+2.7	-0.06/0.77	+0.10/0.48
ACSPO	1,680 (100%)	-1.4/+2.8	+0.07/0.42	+0.06/0.37
NAVO	510 (30%)	-1.2/+2.1	+0.12/0.35	+0.07/0.35

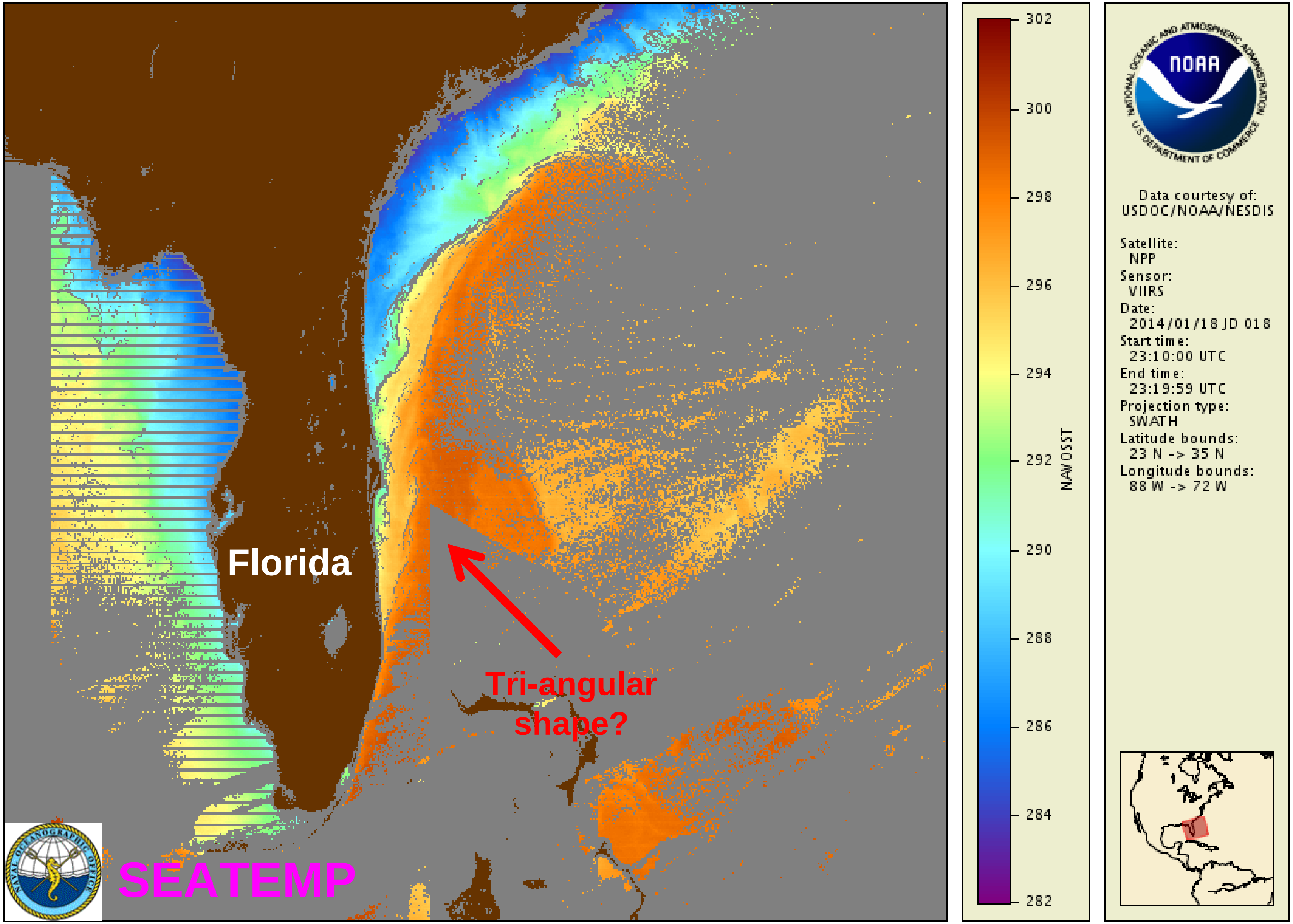
- *IDPS: SST domain is +5% larger than ACSPO, All stats degraded*
- *NAVO: SST domain is factor of ×3 smaller than ACSPO, stats improved*

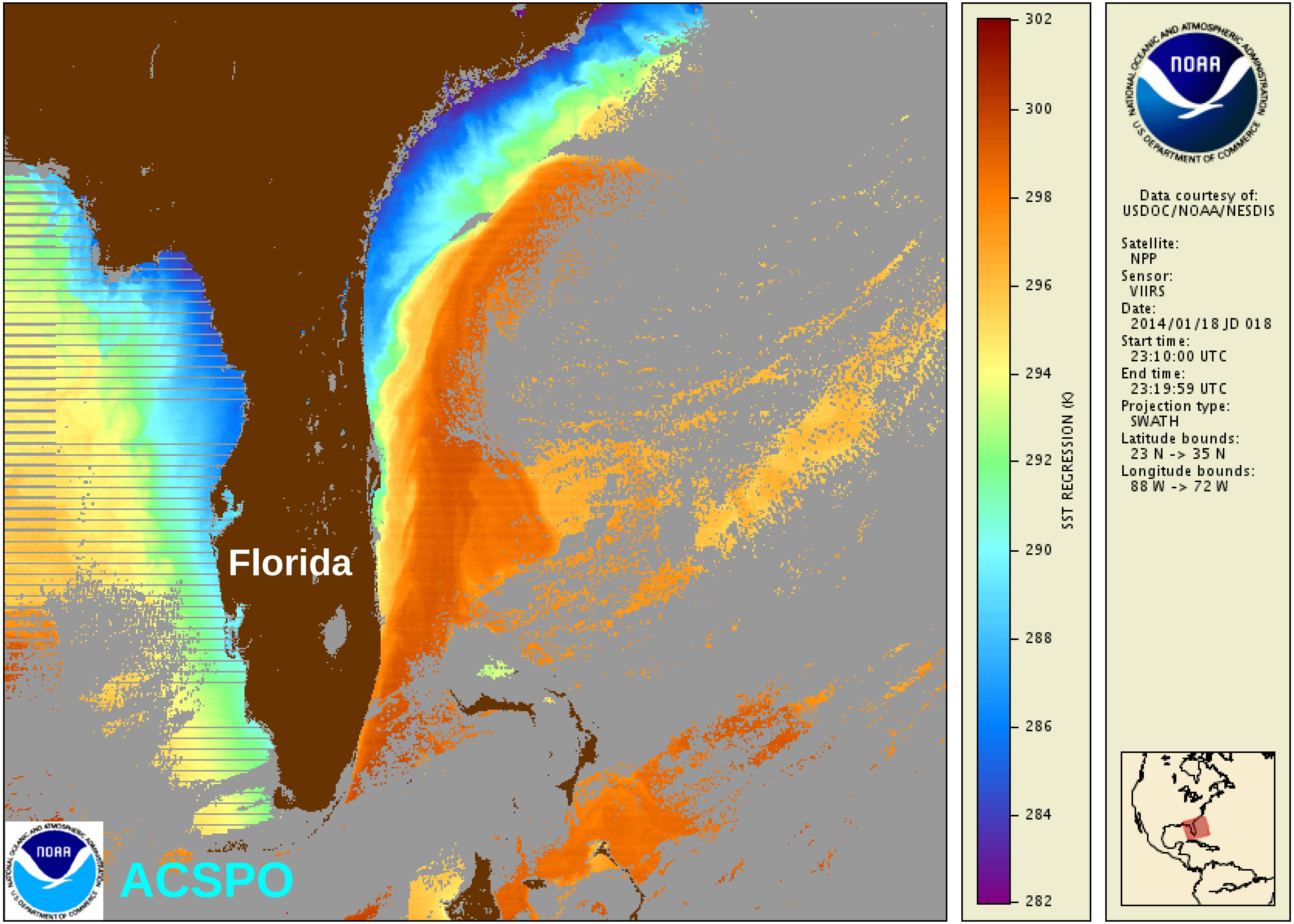
ACSPO_V2.30b01_NPP_VIIRS_2014-01-18_1440-1450_20140314.174252_NAVO



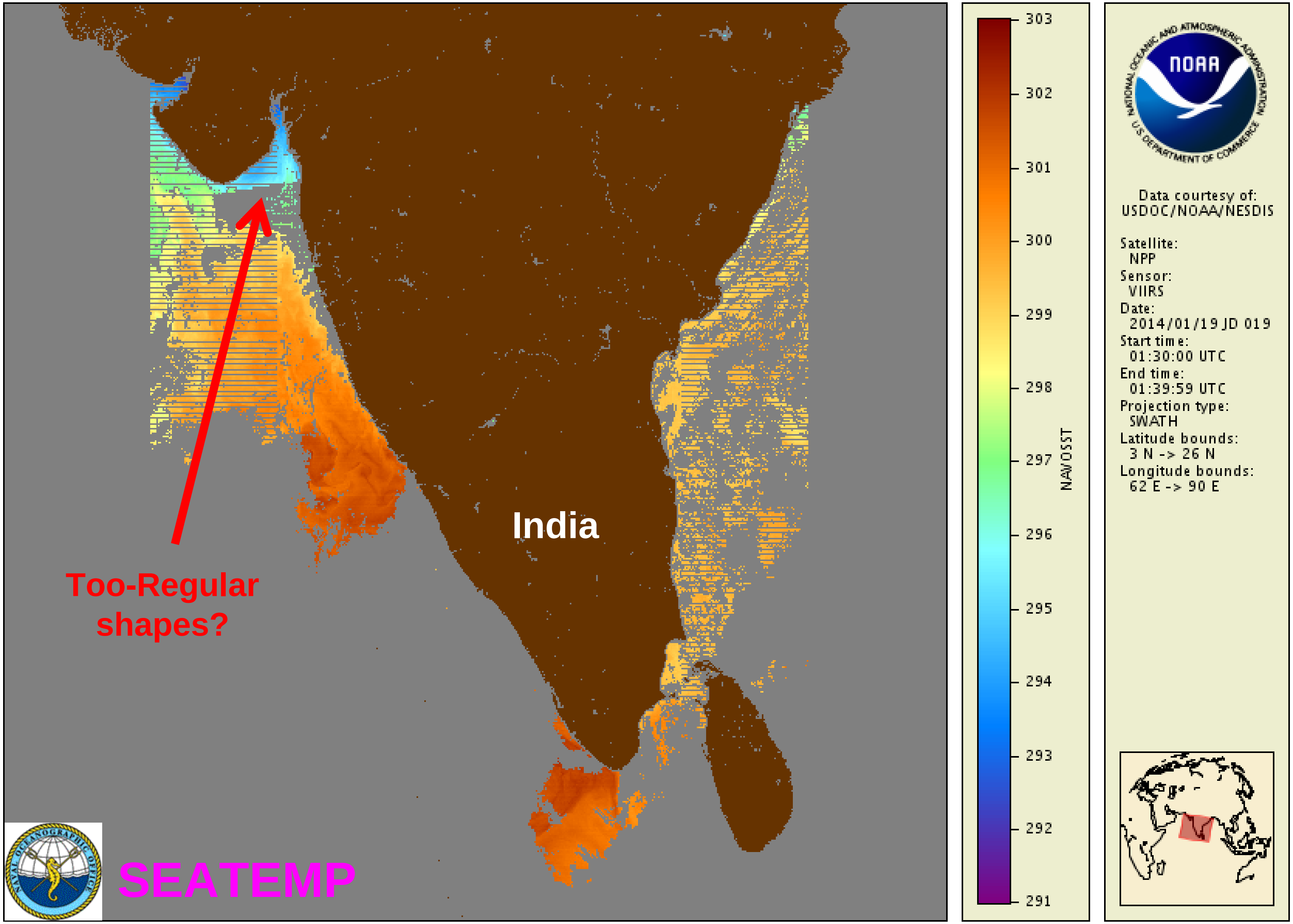

Africa
ACSPO
300
299
298
297
296
295
294
293
292
291
290
SST REGRESSION (K)
Data courtesy of:
USDOC/NOAA/NESDIS
Satellite:
NPP
Sensor:
VIIRS
Date:
2014/01/18 JD 018
Start time:
19:40:00 UTC
End time:
19:50:00 UTC
Projection type:
SWATH
Latitude bounds:
10 N -> 16 N
Longitude bounds:
22 W -> 15 W

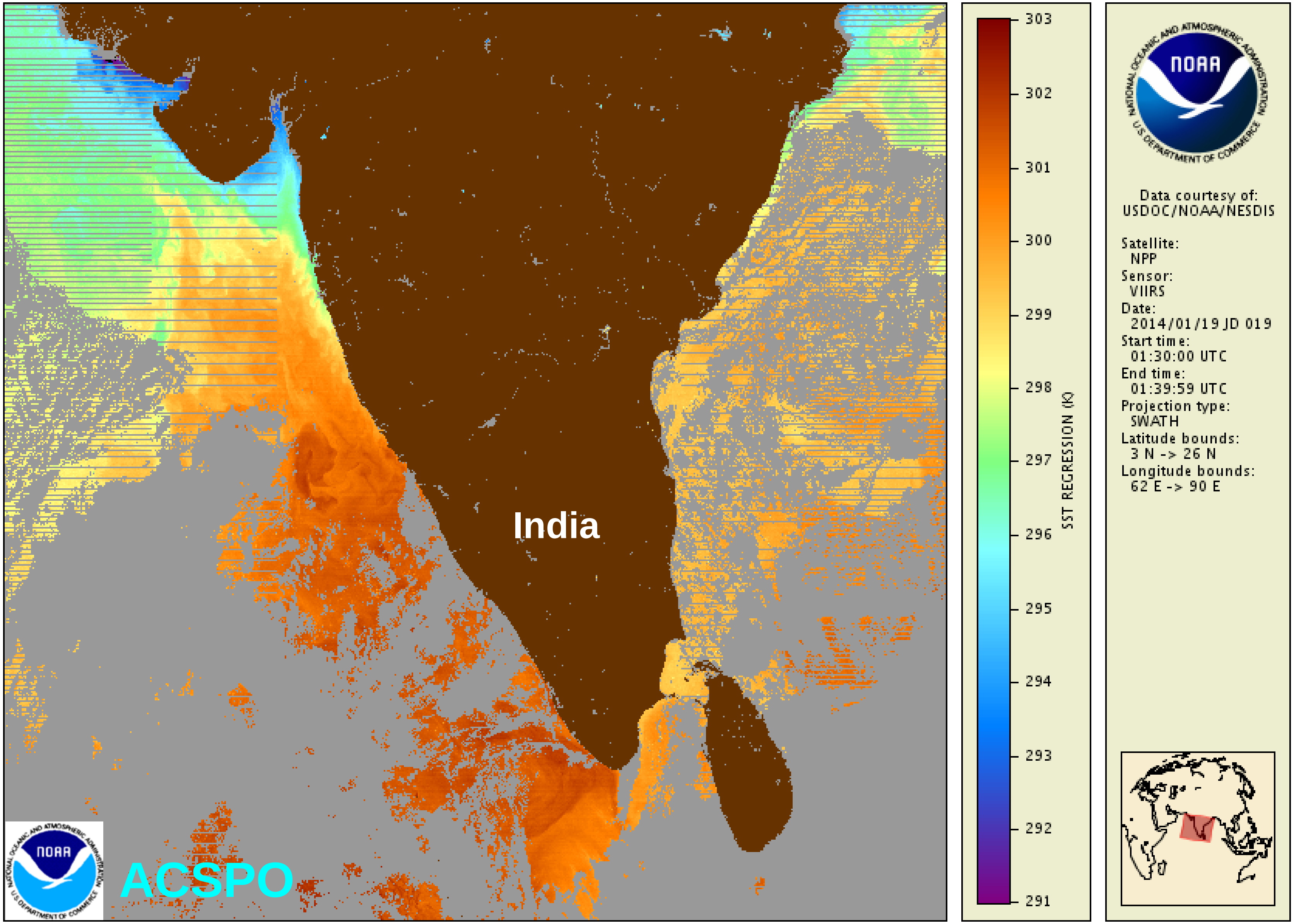
ACSPO_V2.30b01_NPP_VIIRS_2014-01-18_1810-1819_20140314.184153_NAVO



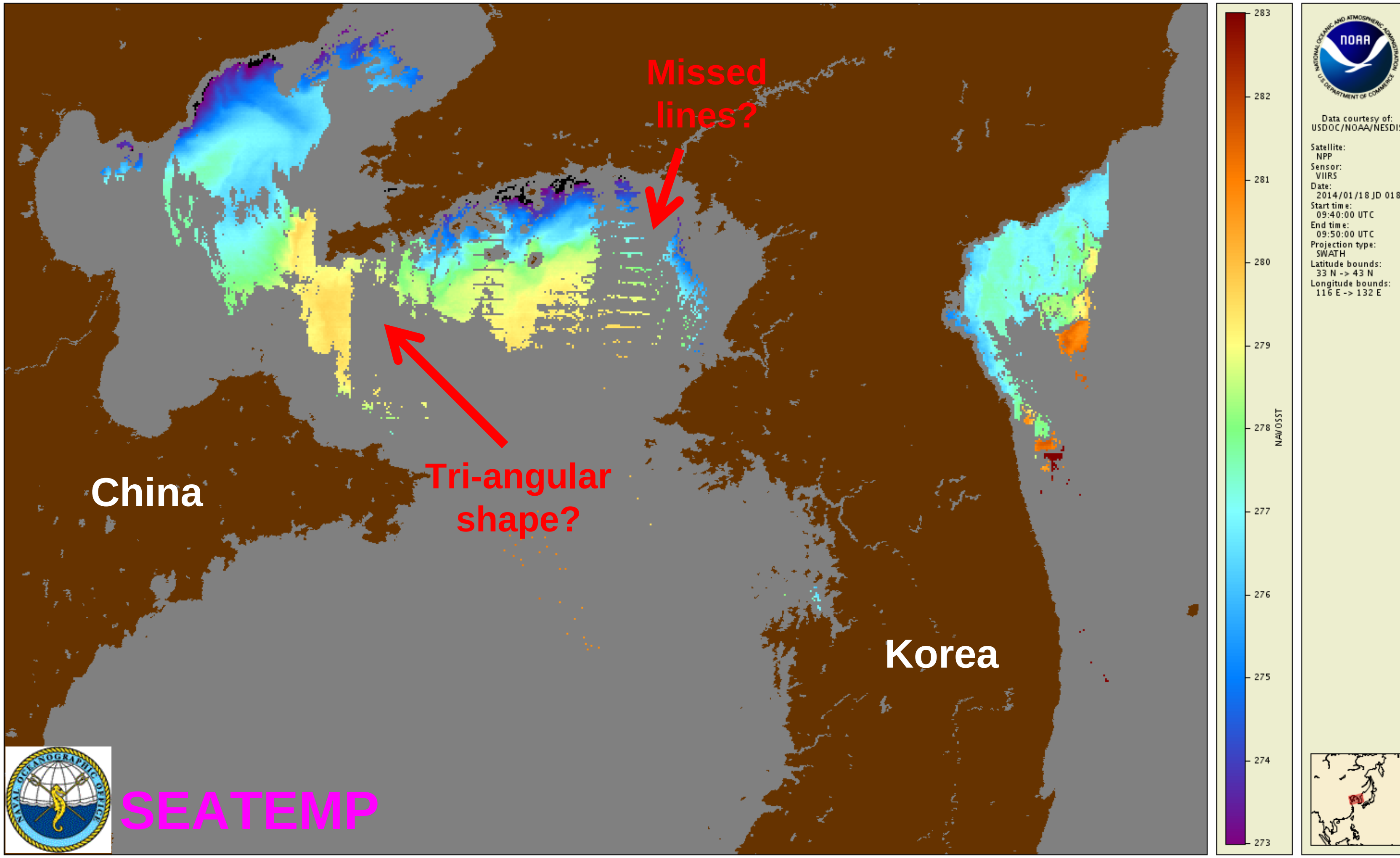

Florida
ACSPO
302
300
298
296
294
292
290
288
286
284
282
SST REGRESSION (K)
Data courtesy of:
USDOC/NOAA/NESDIS
Satellite:
NPP
Sensor:
VIIRS
Date:
2014/01/18 JD 018
Start time:
23:10:00 UTC
End time:
23:19:59 UTC
Projection type:
SWATH
Latitude bounds:
23 N -> 35 N
Longitude bounds:
88 W -> 72 W

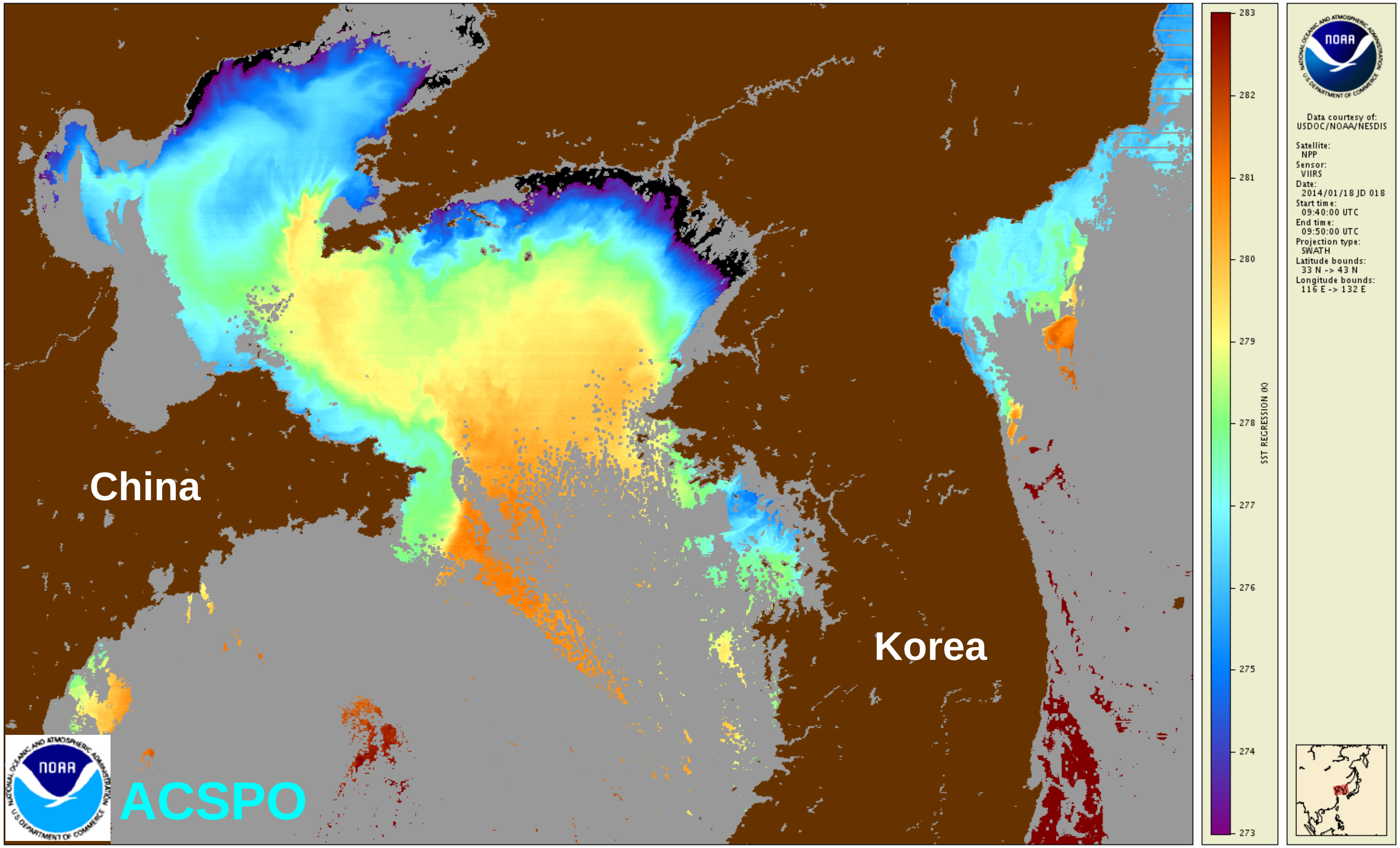
ACSPO_V2.30b01_NPP_VIIRS_2014-01-18_2030-2039_20140314.192134_NAVO




India
ACSPO
303
302
301
300
299
298
297
296
295
294
293
292
291
SST REGRESSION (K)
Data courtesy of:
USDOC/NOAA/NESDIS
Satellite:
NPP
Sensor:
VIIRS
Date:
2014/01/19 JD 019
Start time:
01:30:00 UTC
End time:
01:39:59 UTC
Projection type:
SWATH
Latitude bounds:
3 N -> 26 N
Longitude bounds:
62 E -> 90 E

ACSPO_V2.30b01_NPP_VIIRS_2014-01-18_0440-0450_20140314.145310_NAVO




China
Korea
ACSPO
283
282
281
280
279
278
277
276
275
274
273
SST REGRESSION (K)
Data courtesy of:
USDOC/NOAA/NESDIS
Satellite:
NPP
Sensor:
VIIRS
Date:
2014/01/18 JD 018
Start time:
09:40:00 UTC
End time:
09:50:00 UTC
Projection type:
SWATH
Latitude bounds:
33 N -> 43 N
Longitude bounds:
116 E -> 132 E

Users' Feedback

Environment Canada Environnement Canada

Some Early Results Assimilating ACSPO VIIRS L2P Datasets

Bruce Brasnett

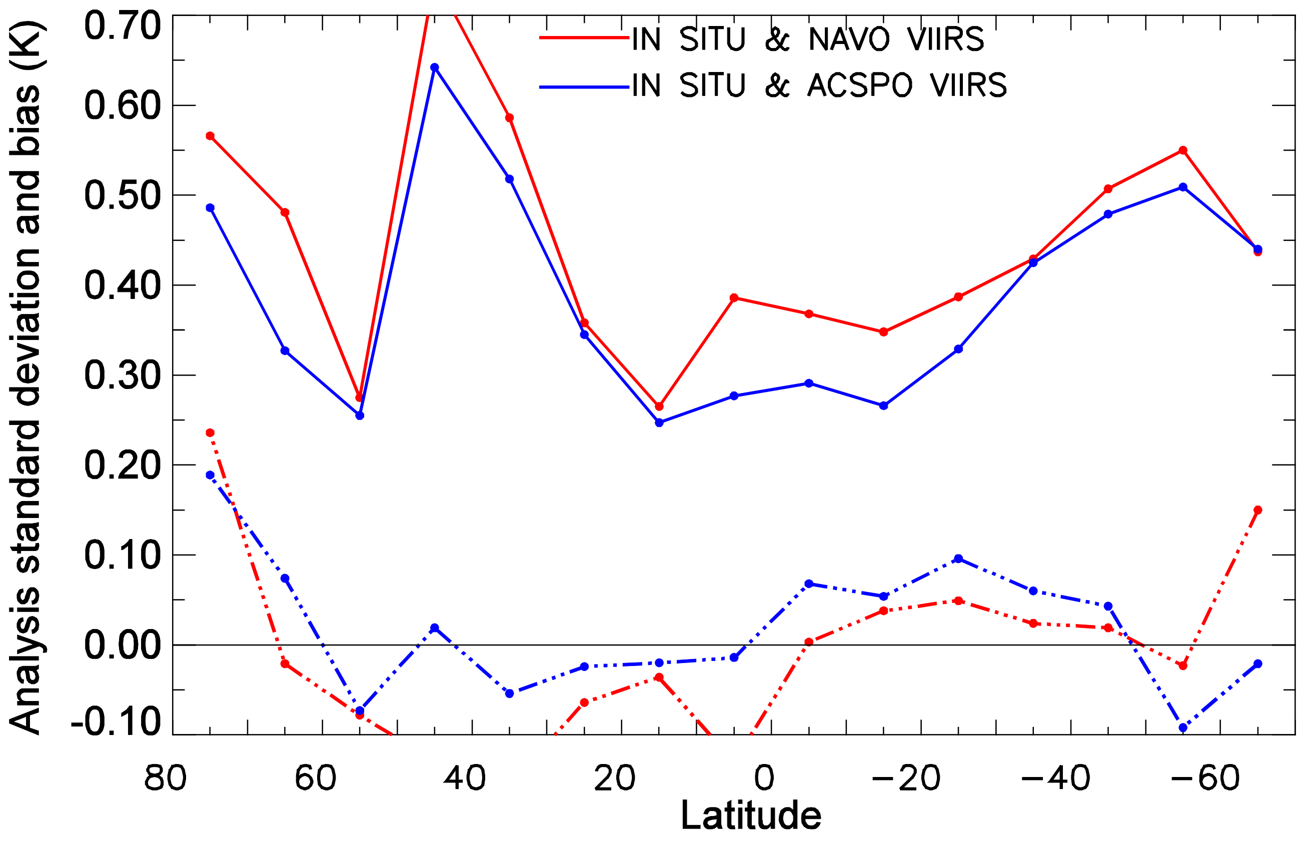
Canadian Meteorological Centre

May, 2014

ACSPO VIIRS L2P Datasets

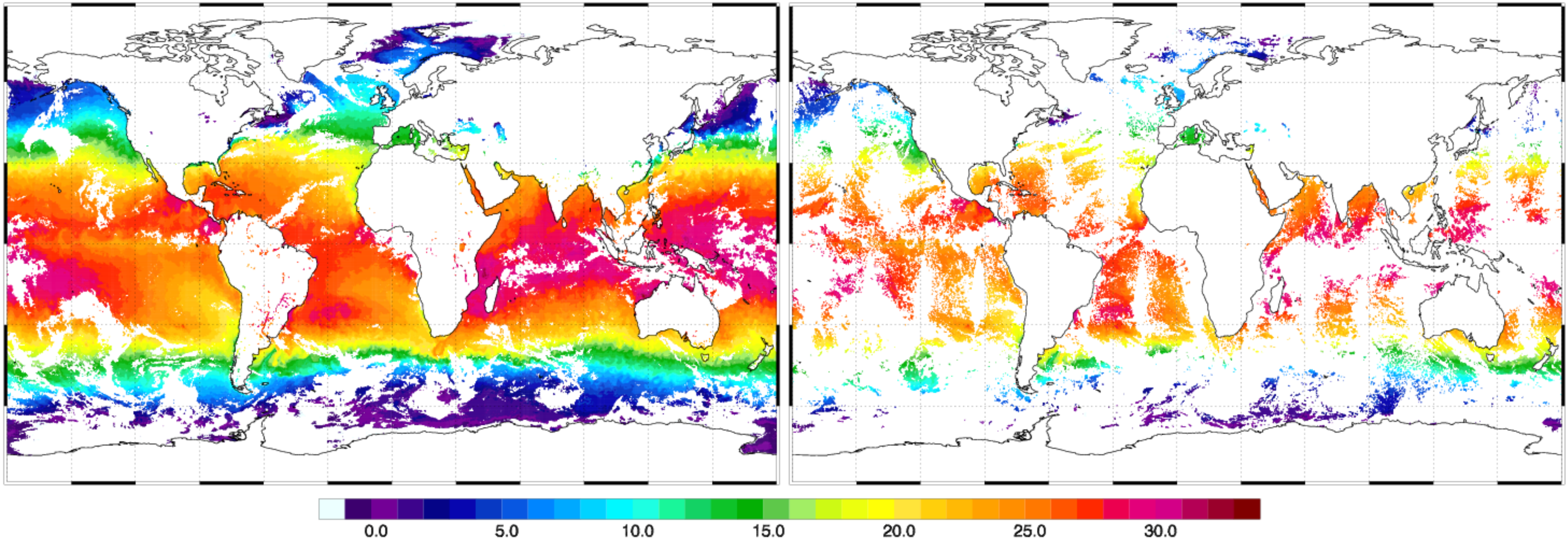
- Received courtesy of colleagues at STAR
- Two periods: 1 Jan – 31 Mar 2014 & 15 Aug – 9 Sep 2013
- Daily coverage is excellent with this product
- Experiments carried out assimilating VIIRS data only and VIIRS data in combination with other satellite products
- Rely on independent data from Argo floats to verify results
- Argo floats do not sample coastal regions or marginal seas

Assessing relative value of 2 VIIRS datasets: NAVO vs. ACSPO



Using ACSPO instead of NAVO improves assimilation

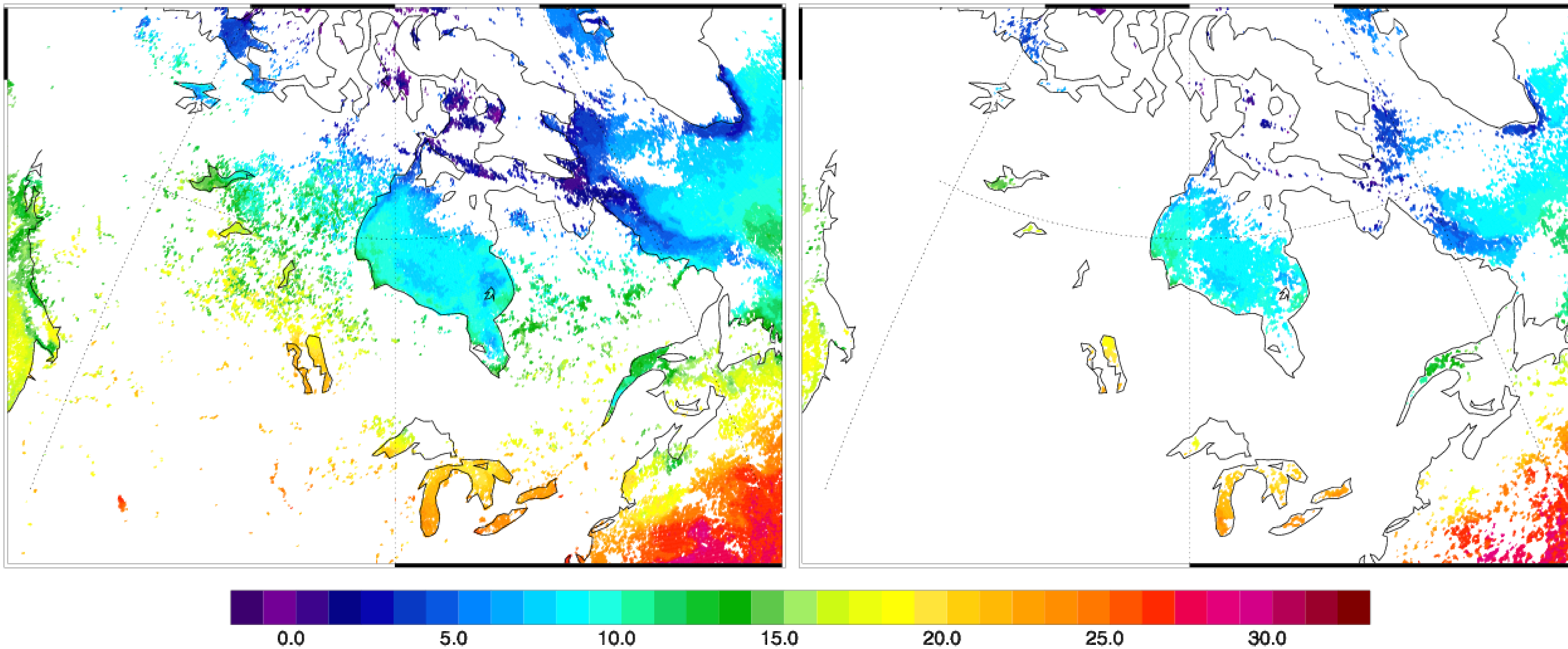
Coverage for 2014/02/01



ACSPO VIIRS

NAVO AVHRR19

Coverage for 2013/09/01



ACSPO VIIRS

NAVO AVHRR18 & 19
and Metop-A combined

CMC Summary

- ACSPO VIIRS L2P is an excellent product
- Based on the Jan – Mar 2014 sample, VIIRS contains more information than either the OSI-SAF MetOP-A or the RSS AMSR2 datasets
- L2P ancillary information: quality level flags and wind speeds are useful but experiment with SSES bias estimates was inconclusive
- Current plan at CMC is to assimilate ACSPO VIIRS L2P dataset when it becomes available

Conclusion to ACSPO/NAVO comparison

ACSPO and NAVO are two viable VIIRS SST choices for users

- ✓ Both are available in GDS2 (ACSPO shortly will be) via JPL/NODC
- ✓ ACSPO retrieval domain is larger than NAVO, by a factor of ~3, due to narrow NAVO swath VZA<54°, and conservative cloud mask
- ✓ NAVO STDs are smaller than ACSPO by a narrow margin
- ✓ Initial ACSPO assimilation in CMC L4 analysis suggests that ACSPO adds information to the currently used L2 SSTs (AMSR2, OSI SAF and NAVO AVHRR, NAVO VIIRS), mainly due to its superior coverage
- ✓ ACSPO areas for improvement: Warm bias in the high latitudes, SSES bias is calculated but was found not informative to improve assimilation

Coming Year Work

- ✓ Continue Monitor, Validate and cross-evaluate various SST products in SQUAM, iQuam, MICROS
- ✓ Go validated with ACSPO SST product (already meet specs)
- ✓ Archive ACSPO GDS2 format at JPL/NODC, discontinue IDPS
- ✓ Explore improved quality flags / Levels in ACSPO
- ✓ Establish reprocessing and back-fill ACSPO VIIRS to Jan'2012
- ✓ Received multiple user requests for ACSPO VIIRS Level 3 product – will need to generate
- ✓ Implement destriping operationally (SDR feedback/Tue PM – Ignatov; SST breakout/Wed – K. Mikelsons)
- ✓ Implement version 1 pattern recognition ACSPO clear-sky mask enhancements (SST breakout/Wed and innovative science talk/Fri – I. Gladkova)

U. Miami Input
(presented at SST breakout)

VIIRS Atmospheric Correction Algorithms

Miami V6:

- $SST2b = a_0 + a_1 T_{11} + a_2(T_{11} – T_{12})\, T_{sfc} + a_3(T_{11}-T_{12})\, S_\theta$
- $SST3b = a_0 + a_1 T_{11} + a_2(T_{3.7} – T_{12})\, T_{sfc} + a_3\, S_\theta$

Miami V7:

- $SST2b = a_0 + a_1 T_{11} + a_2(T_{11} – T_{12})\, T_{sfc} + a_3(T_{11}-T_{12})\, S_\theta + a_4\, S_\theta + a_5\, S_\theta^{\chi}$

$$\chi = fn(lat)$$

- $SST3b = a_0 + a_1 T_{11} + a_2(T_{3.7} – T_{12})\, T_{sfc} + a_3\, S_\theta + a_4\, S_\theta^{\chi}$

$$\chi = 0.1 \text{ for } |lat| \le 40°;\ 2.0 \text{ for } |lat| > 40°$$

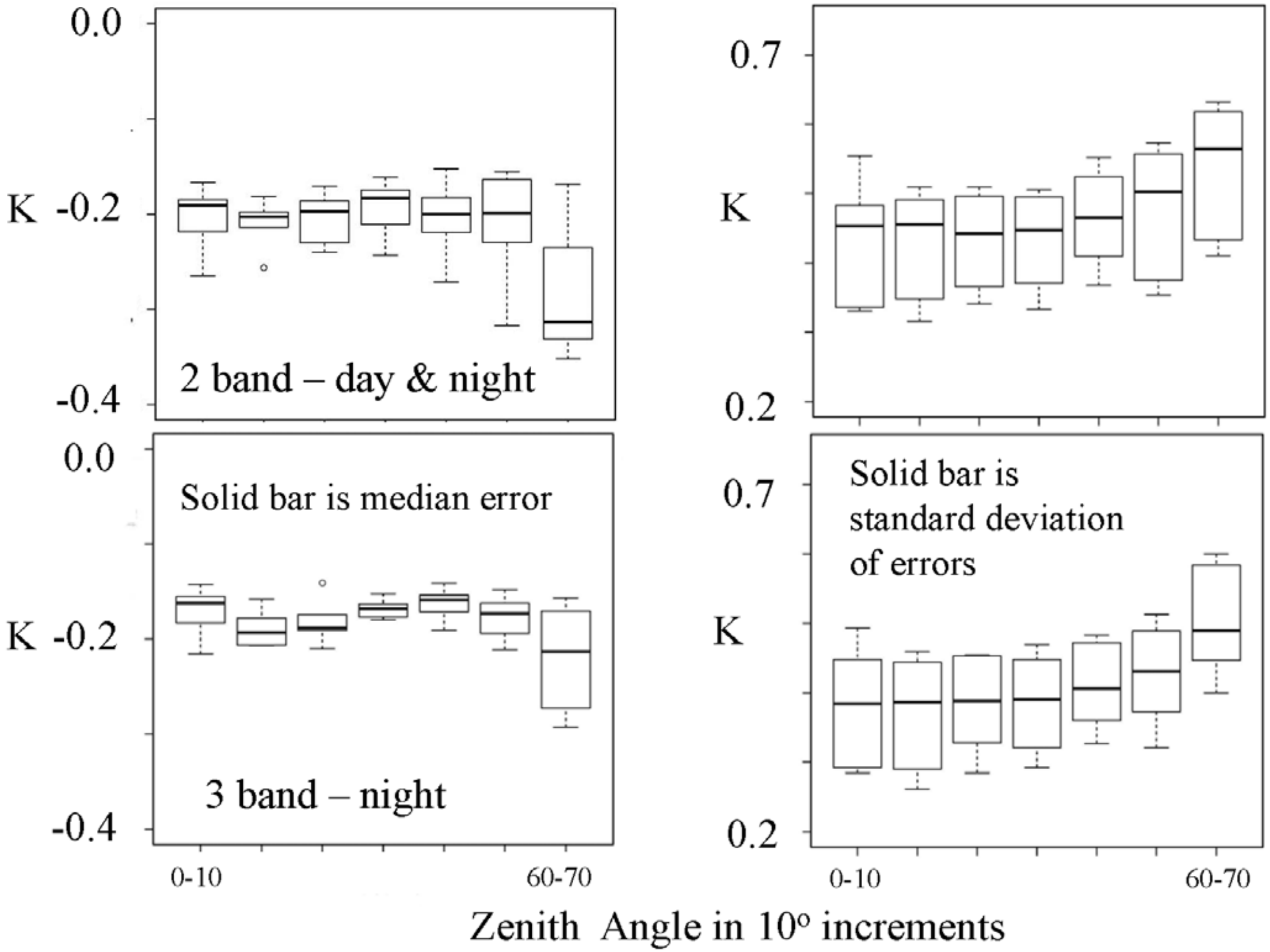
$$S_\theta = \sec(\theta)-1$$

Simple Global Statistics

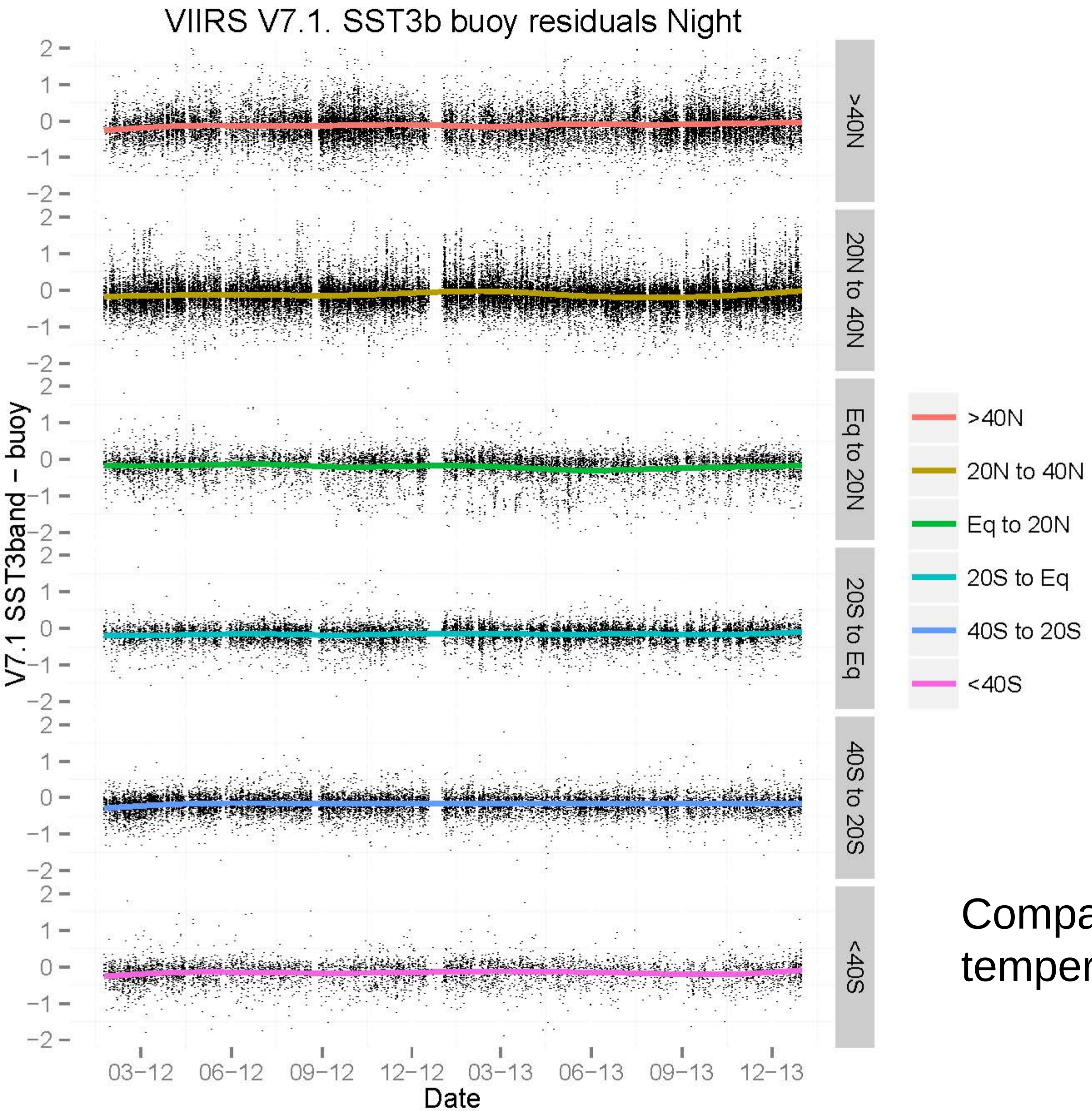
Algorithm	N	Mean	Std Dev	Median	Median Abs Diff
Satellite zenith <55^o					
SST - day	92061	-0.089	0.510	-0.085	0.337
SST - night	126174	-0.160	0.436	-0.153	0.331
SST_3 - night	81155	-0.172	0.395	-0.152	0.230
Satellite zenith >55^o					
SST - day	34693	-0.105	0.647	-0.149	0.536
SST - night	29922	-0.193	0.519	-0.206	0.485
SST_3 - night	35982	-0.131	0.489	-0.161	0.355

Statistics of the differences between the VIIRS skin SST retrievals and the subsurface temperatures measured from drifting buoys.

Zenith angle dependence



Time dependences – in latitude bands



Comparisons to buoy temperatures

NAVO Input
(presented at SST breakout)

Effect of VIIRS Cloud Mask on accuracy of SST

J-F Cayula and Doug May

NAVOCEANO

VCM effect on SST accuracy

- Evaluation of the VIIRS Cloud Mask (VCM) on the accuracy of "cloud-free" SST retrievals
- NAVOCEANO Cloud Mask (NCM) used as comparison standard because it produces very clean SST for input into oceanographic models.
- VCM requires additional tests as SST cloud detection usually handles all contaminants:
  - → Daytime: reflectance test contingent on field test
  - → Nighttime: NCM aerosol test + adjacency test/field test

"Cloud-free": classified as "confidently clear" and determination is "High quality"

VCM effect on SST accuracy

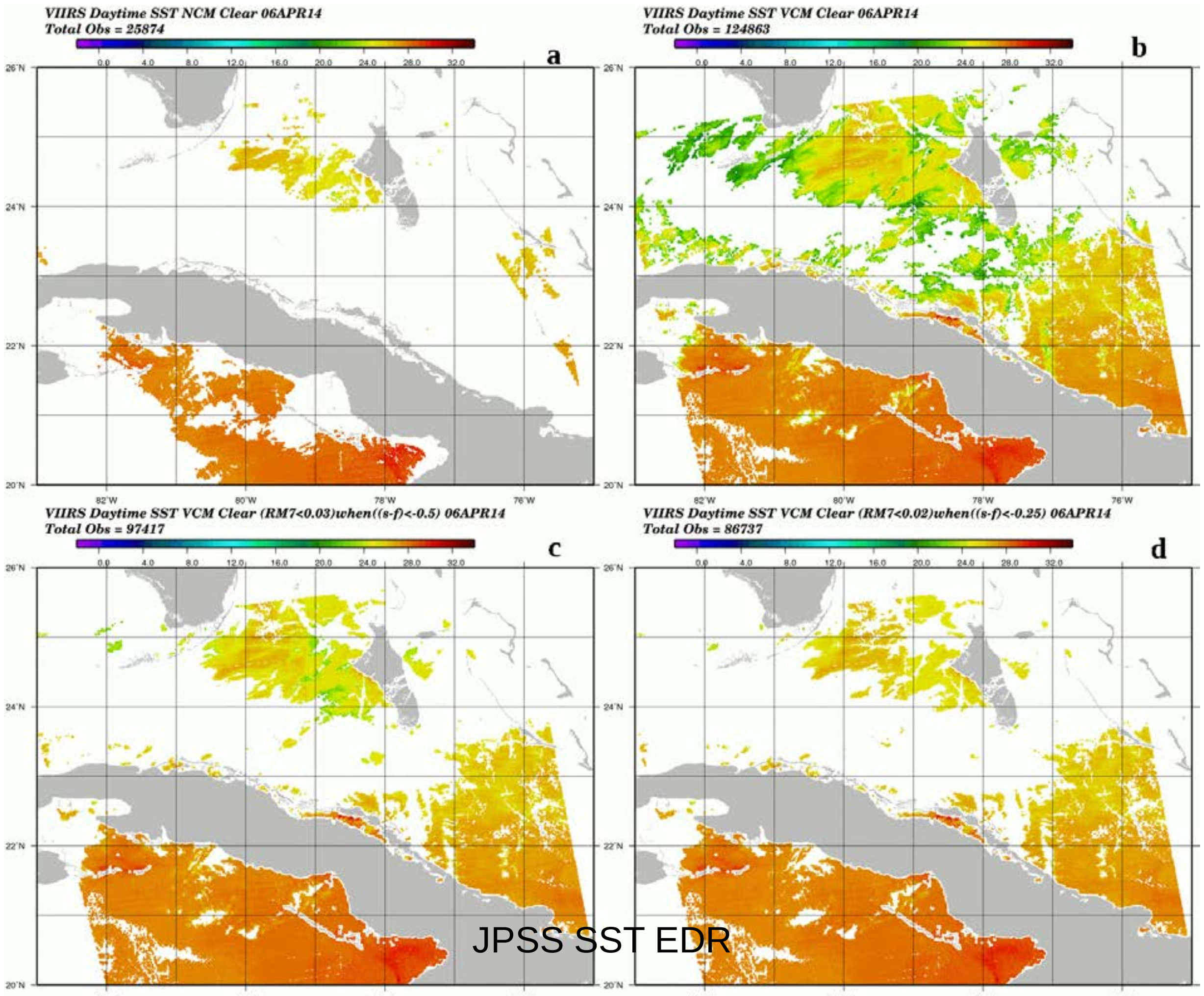
Daytime / February	Buoy matches	RMS error
NCM / NCM + test	4967 / 4901	0.51 / 050
VCM / VCM + test	16844 / 14863	0.70 / 0.51

Nighttime / February	Buoy matches	RMS error
NCM	6785	0.36
VCM / VCM + tests	21052 / 17171	0.56 / 0.34

- VCM with additional tests performs as well as NCM, with better coverage
- However closer inspection shows that most of the VCM improvements come from the additional tests flagging retrievals adjacent to detected clouds. This indicates significant cloud leakage with the original VCM.

VCM effect on SST accuracy

Example: Daytime SST fields on April 6, 2014 a) for NCM clear, b) for VCM clear, c) for VCM clear with additional test, d) with a tightened additional test to remove remaining cloud leakage



NAVO Input
(presented at SST breakout)

Sea Surface Temperature (University of Southern Miss)

Arnone, Vandermeulen, Fargion,

Objectives: VIIRS Cal Val – SST EDR products

Evaluate SST product performance for operational use and science applications

Evaluate Regional Coast SST products

Updates for IDPS processing and algorithms

Project Accomplishments: Past year

1. **Assembled SST products from IDPS , and OSI_SAF and Miami algorithms in Gulf of Mexico .**
2. **Compared SST products in Coastal Fronts and coastal regions.**
3. **Demonstrated use of the VIIRS orbital overlap for sensor validation. - Poster**
4. **Began SST validation in Coastal areas (Mississippi Sound, Mobile Bay)**
5. **Evaluated the SST assimilation into Ocean Models (NCOM, HYCOM)**

Future Plans –

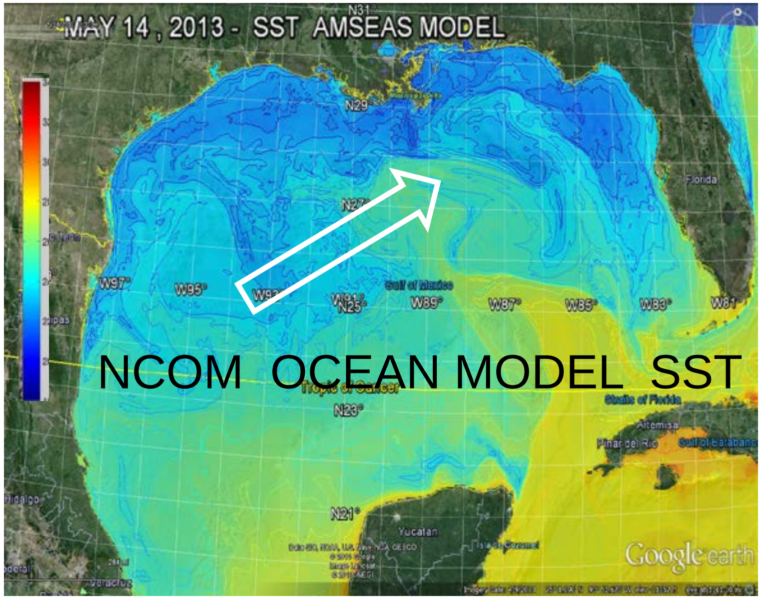
Paper on SST Cal Val Over lap orbits with J.Cayula and S. Ignatov

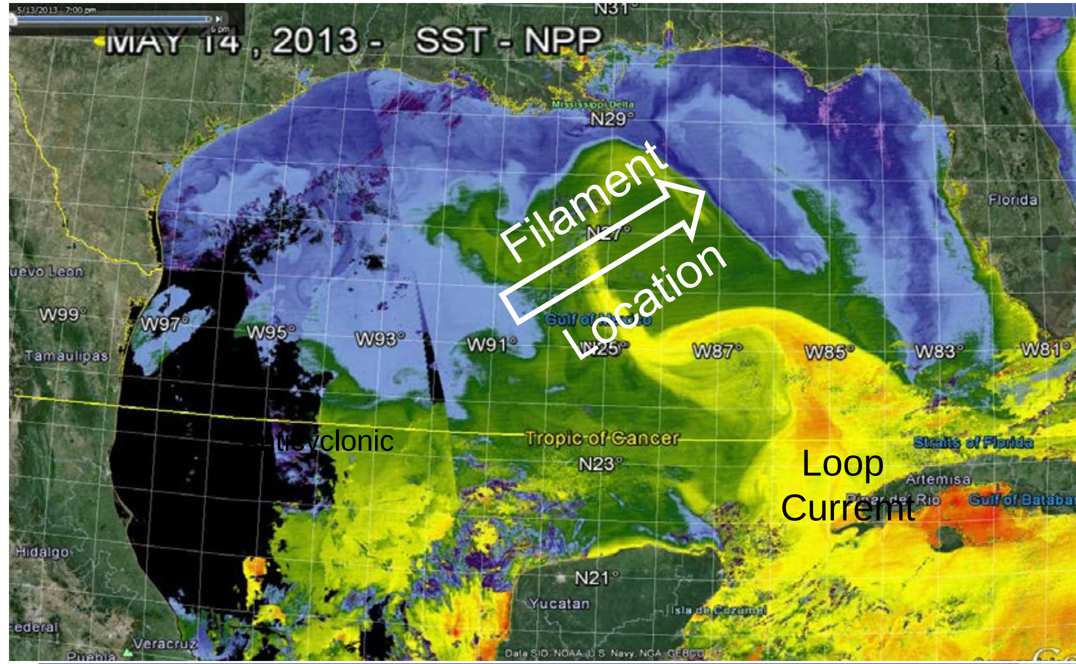
Validation SST products in Coastal and estuary areas –

Examine the Detector response on SST retrievals

Sea Surface Temperature (University of Southern Miss)

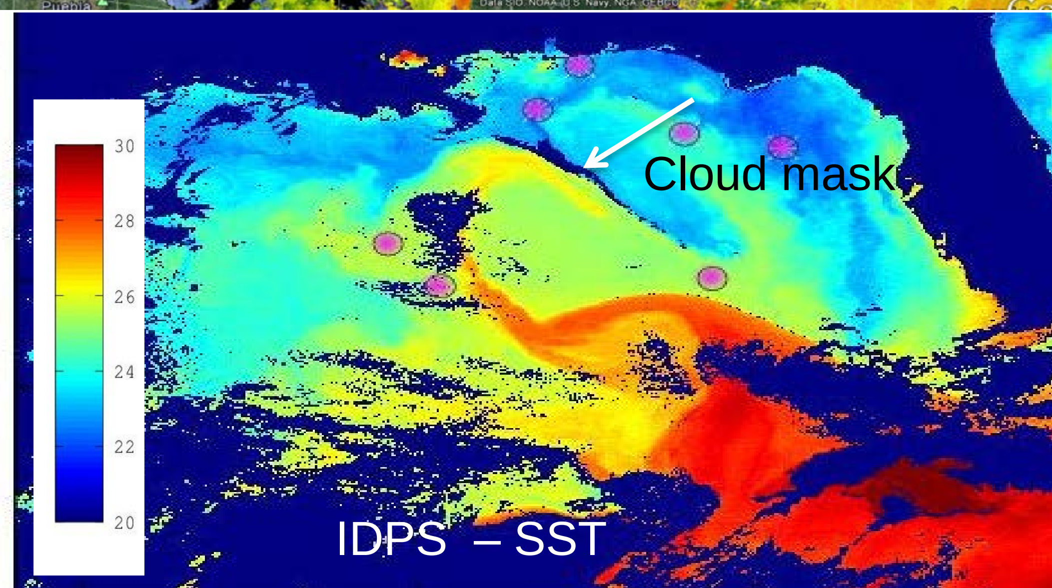
Regional Studies - Filament Location





Over compensation in Cloud Mask can impact the Ocean Model SST

Difference in Filament location of Model and SNPP SST - associated with Assimilation and Cloud MASK



JPSS STAR Science Team Annual Meeting
12-16 May 2014
VIIRS EDR Ocean Color Team

Menghua Wang
VIIRS EDR Ocean Color Lead
13 May 2014

VIIRS Ocean Color Team Members' Roles & Responsibilities

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

Working with: VIIRS **SDR team**, DPA/DPE (e.g., R. Williamson, Neal Baker), Raytheon (e.g., Marine Hollingshead), NOAA OC Working Group, NOAA various line-office reps, NASA OC Working Group (K. Turpie, B. Franz , et al.), NOAA OCPOP, etc.
Collaborators: D. Antoine (BOUSSOLE), B. Holben (NASA-GSFC), G. Zibordi (JRC-Italy), and others

Summary of VIIRS OCC EDR Algorithms

- **Inputs**: VIIRS M1-M7 bands SDR data, terrain-corrected geo-location file, SST EDR data (not used for current OC3V chlorophyll-a algorithm), cloud mask Intermediate Product (IP), on-board calibrator IP, 7 ancillary data files, 7 lookup tables, and 1 configurable parameter file.

- **Outputs**: Chlorophyll-a (Chl-a) concentration, normalized water-leaving radiance (nLw's) at bands M1-M5, Inherent Optical Properties (IOP-a and IOP-s) at VIIRS bands M1-M5, and quality flags. Primary outputs are chlorophyll-a and normalized water-leaving radiances.

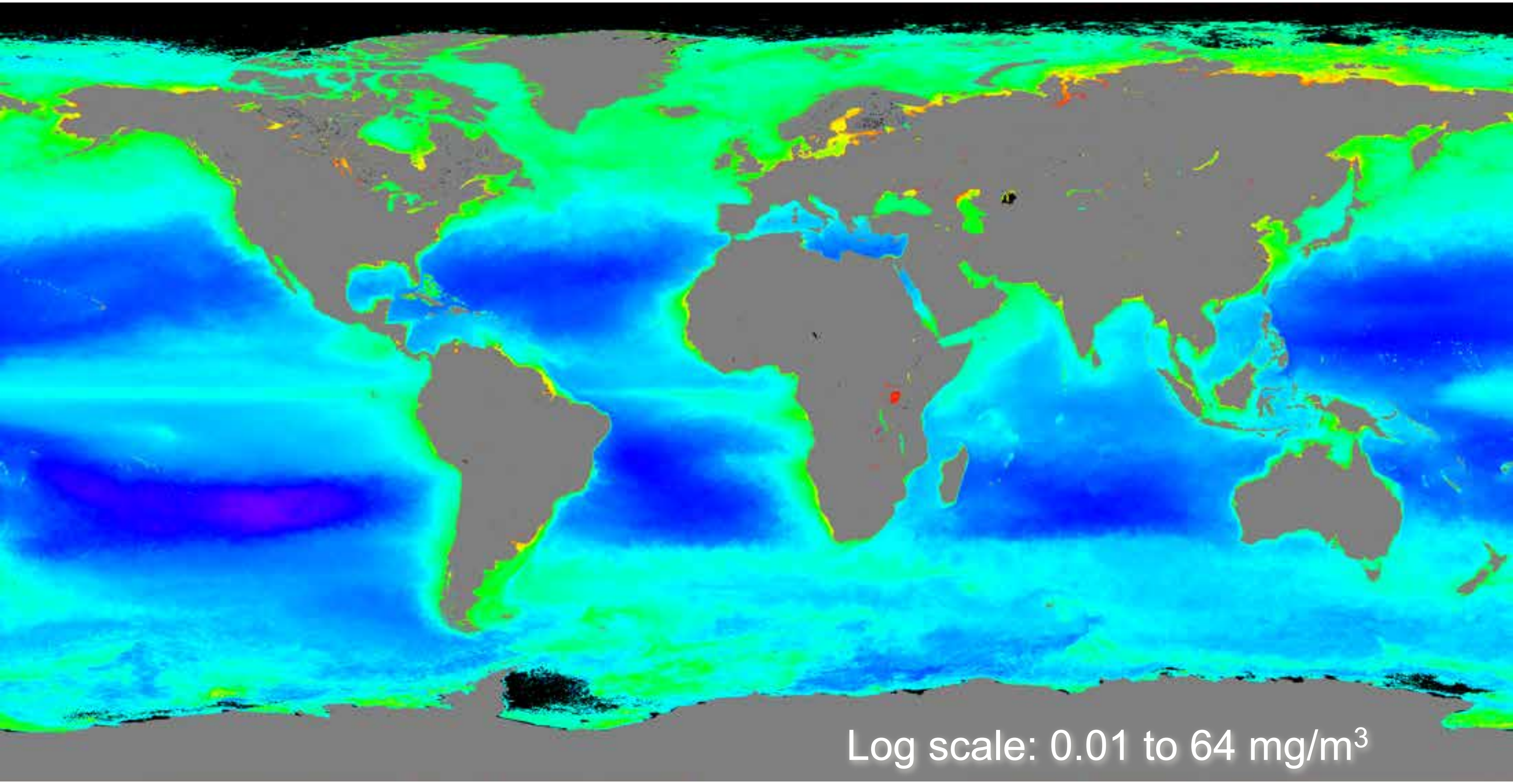
- There are three sets of algorithms in the IDPS OCC-EDR data processing:
  - The Gordon & Wang (1994) atmospheric correction algorithm: including corrections for ozone, Rayleigh (molecules) and aerosols, ocean surface reflection, sun glint, whitecap, and sensor polarization effects.
  - chlorophyll-a algorithm: currently with OC3V algorithm (heritage algorithm), with option to switch between the OC3V and Carder chlorophyll-a algorithms.
  - IOP algorithm: Carder IOP algorithm.

➢ Data quality of OC 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 was developed during NASA SMIBIOS project (1997-2003) for a consistent and common ocean color data processing for multiple satellite ocean color sensors (*Wang*, 1999; *Wang and Franz*, 2000; *Wang et al.*, 2002).
  - It has been used for producing ocean color products from various satellite ocean color sensors, e.g., SeaWiFS, MOS, OCTS, POLDER, MODIS, etc.
- NOAA-MSL12 Ocean Color Data Processing
  - NOAA-MSL12 is based on SeaDAS version 4.6.
  - Some significant improvements: (1) the SWIR-based data processing, (2) Rayleigh and aerosol LUTs, (3) detecting absorbing aerosols and turbid waters, (4) ice detection algorithm, (5) improved straylight and cloud shadow algorithm, and others.
  - Capability for multi-sensor ocean color data processing, e.g., MODIS, **VIIRS**, GOCI, and will add OLCI/Stentinel-3, SGLI/GCOM-C, **J-1**, **J-2**, and others.
- NOAA-MSL12 for **VIIRS** Ocean Color Data Processing
  - Standard ocean color products: normalized water-leaving radiances ($nL_w(\lambda)$) at VIIRS M1 to M5 bands; chlorophyll-a concentration, and water diffuse attenuation coefficient at the wavelength of 490 nm ($K_d(490)$).
  - Experimental products: photosynthetically available radiation (PAR), inherent optical properties (IOPs), and others.

VIIRS Climatology Chlorophyll-a Image
(April 2012 to December 2013)

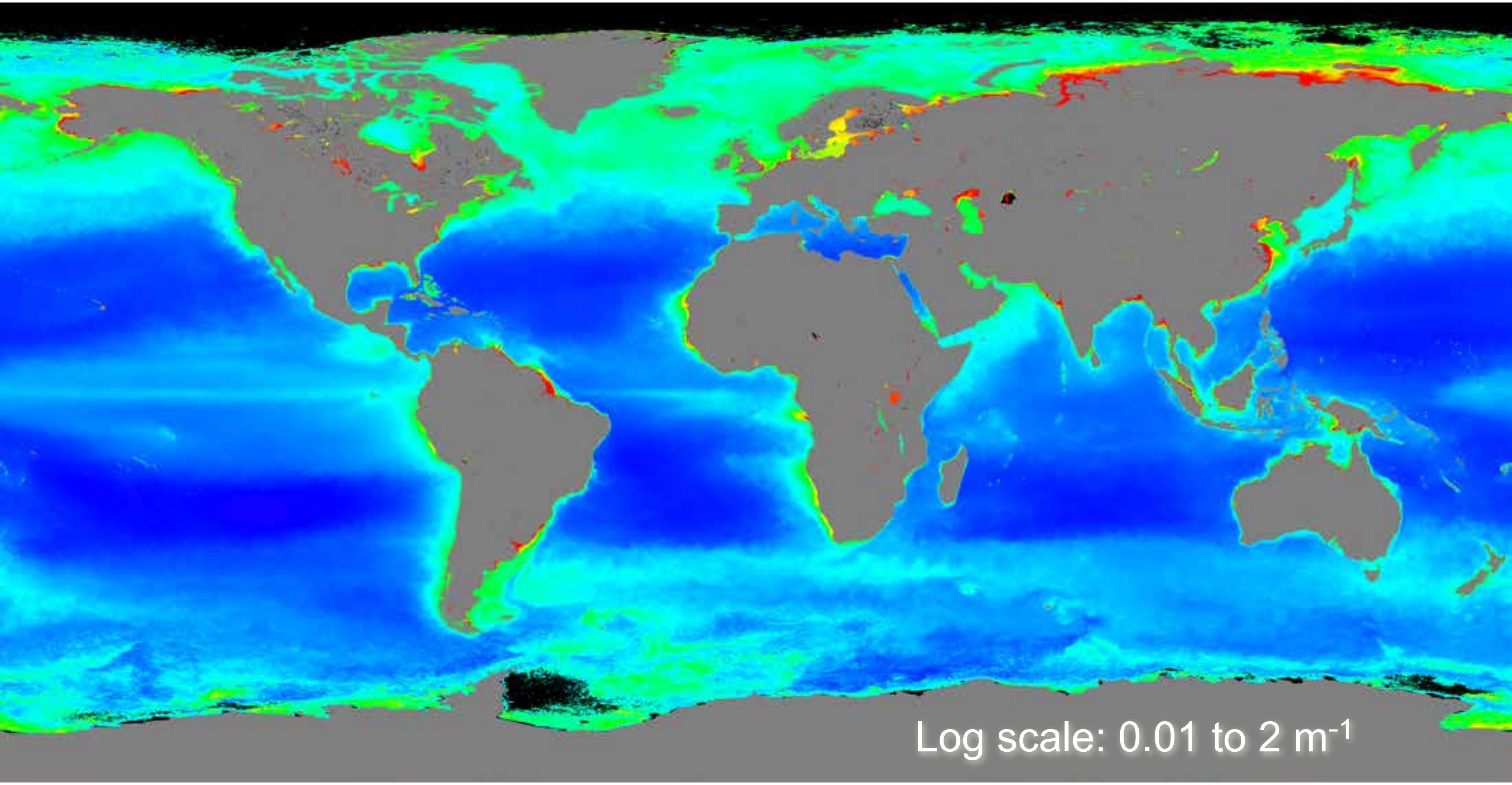


Generated using NOAA-MSL12 for VIIRS ocean color data processing

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

Menghua Wang, NOAA/NESDIS/STAR

VIIRS Climatology K_d(490) Image
(April 2012 to December 2013)



Generated using NOAA-MSL12 for VIIRS ocean color data processing

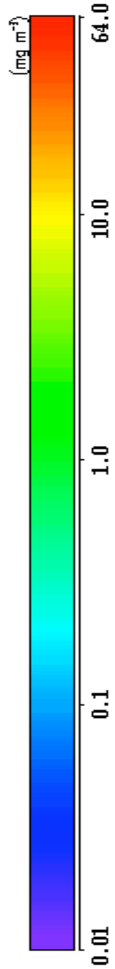
Wang, M., S. Son, and L. W. Harding, Jr., "Retrieval of diffuse attenuation coefficient in the Chesapeake Bay and turbid ocean regions for satellite ocean color applications," *J. Geophys. Res.*, **114**, C10011, 2009. http://dx.doi.org/10.1029/2009JC005286.

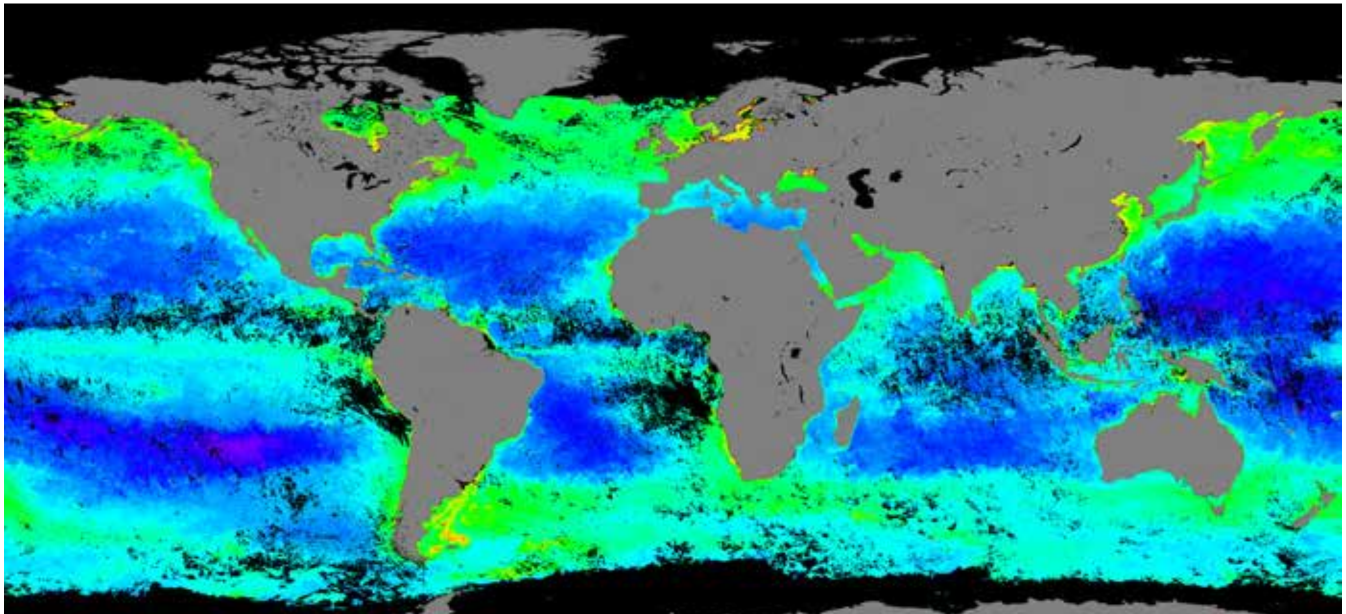
Menghua Wang, NOAA/NESDIS/STAR

VIIRS (IDPS) vs. MODIS-Aqua (Monthly)

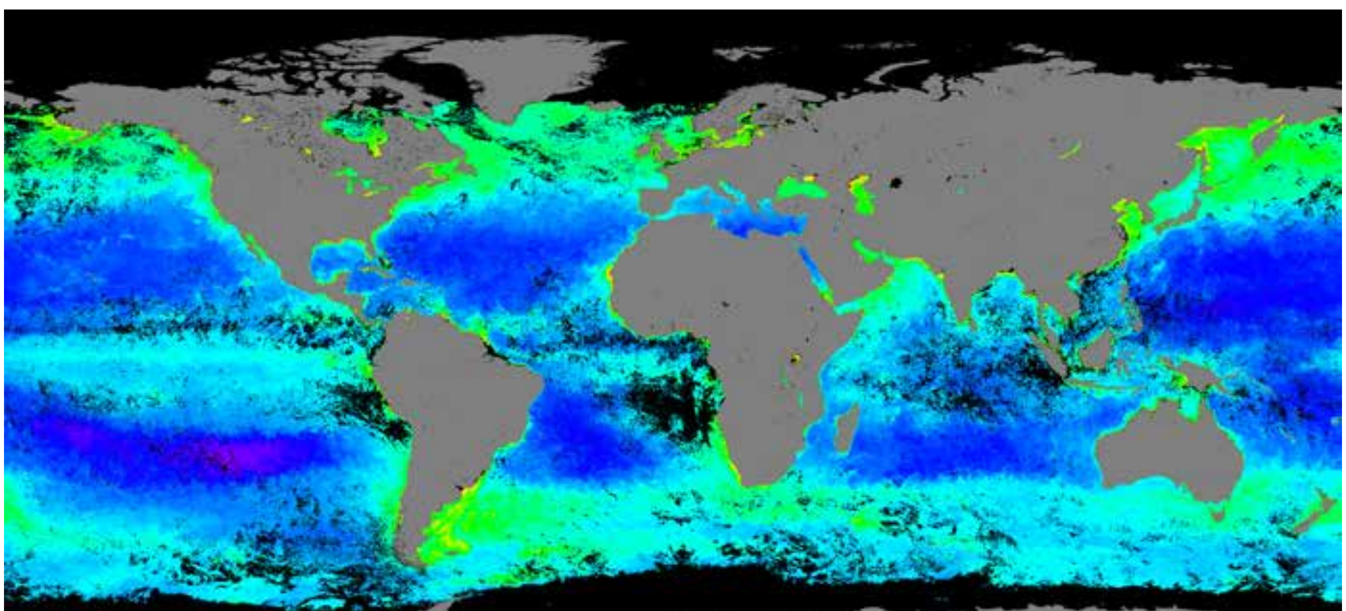
Chlorophyll-a

Log scale:
0.01 to 64 mg/m3





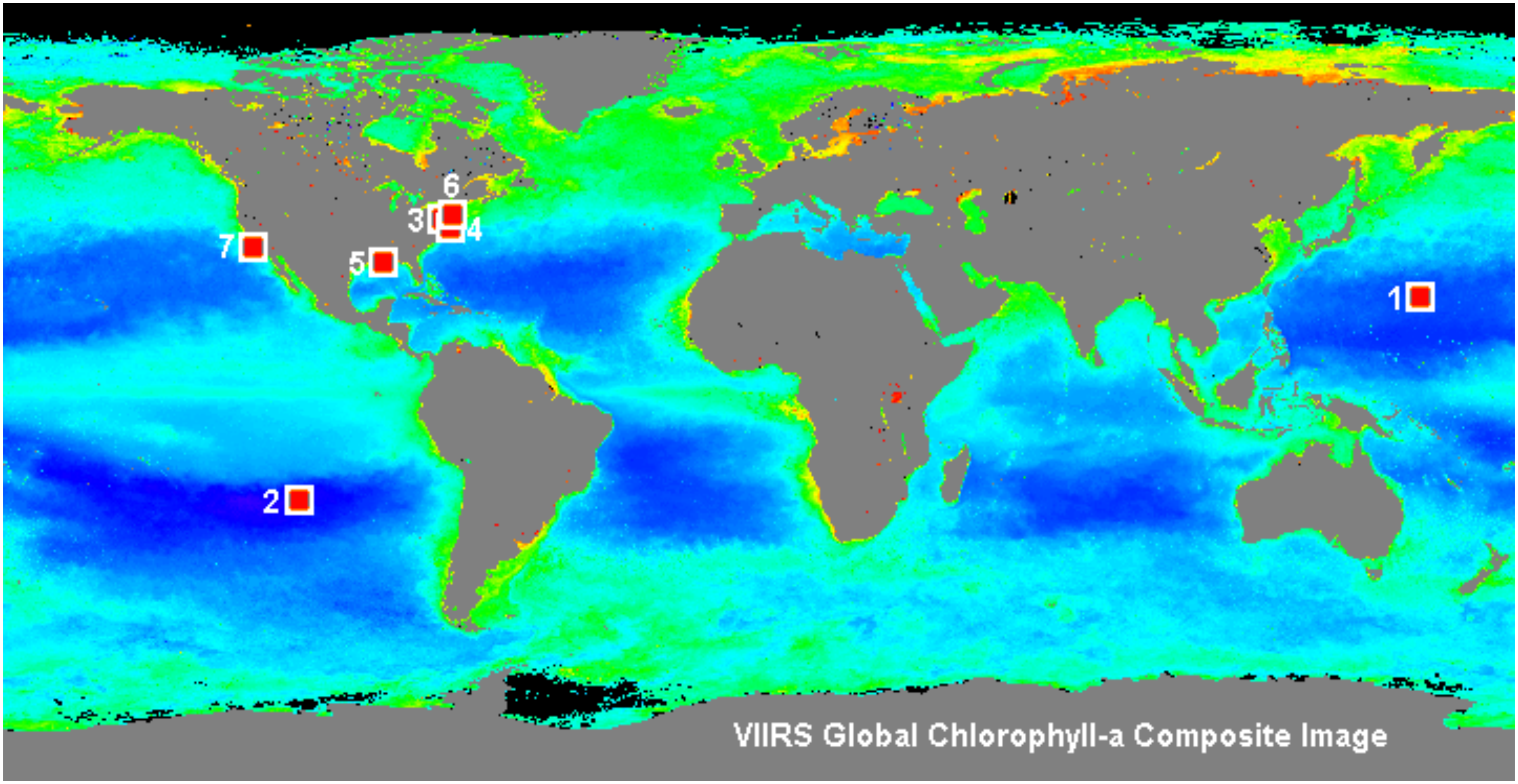
VIIRS (IDPS) Chl-a, monthly composite October 2012



MODIS-Aqua Chl-a, monthly composite October 2012

MODIS-Aqua data were obtained from NASA/OBPG ocean color website.

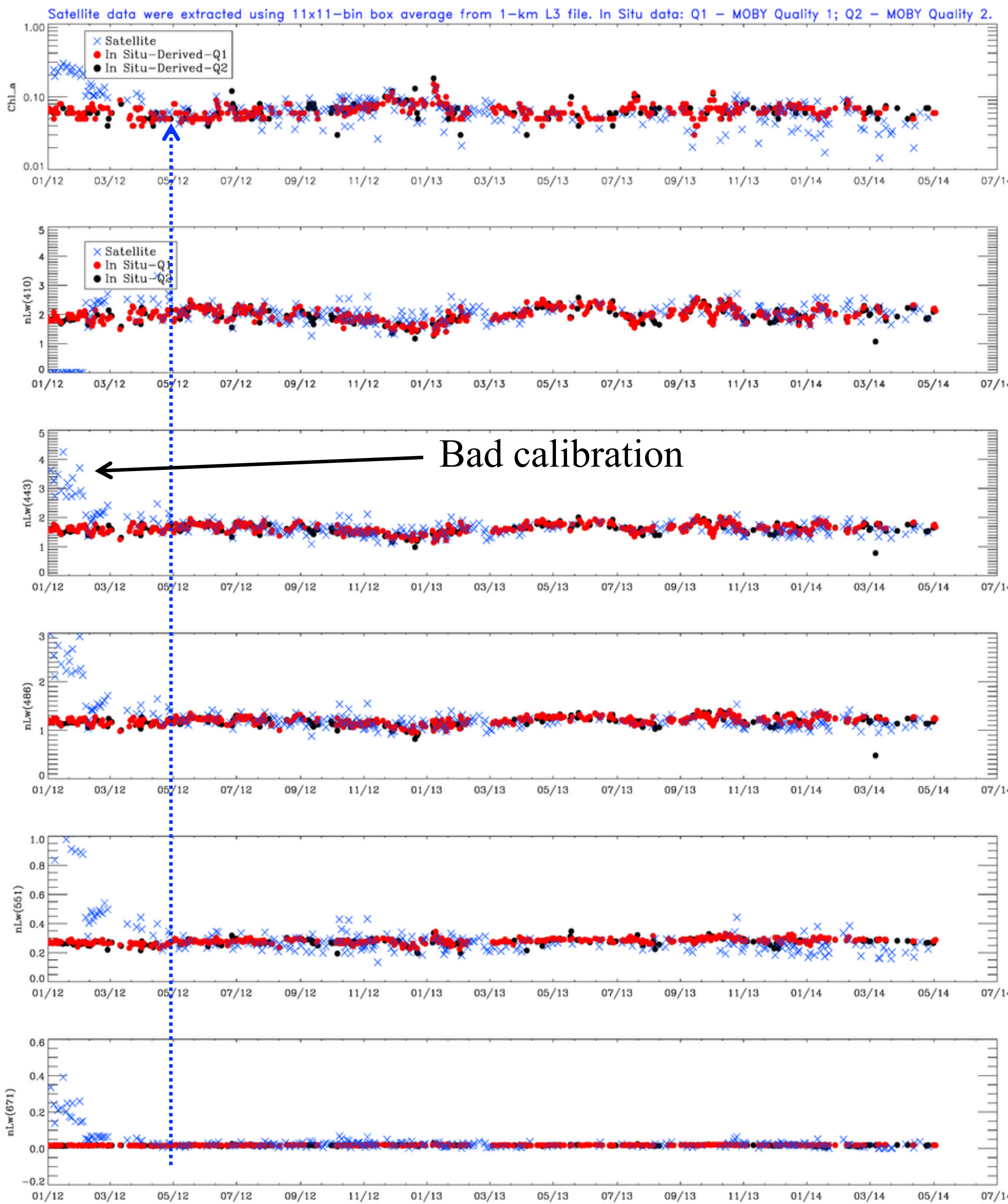
VIIRS Ocean Color EDR Monitoring Sites



1. MOBY Site; 2. South Pacific Gyre; 3. Chesapeake Bay; 4. US East Coast; 5. AERONET-OC CSI Site; 6. AERONET-OC LISCO Site; 7. AERONET-OC USC Site.

Website:

http://www.star.nesdis.noaa.gov/sod/mecb/color/



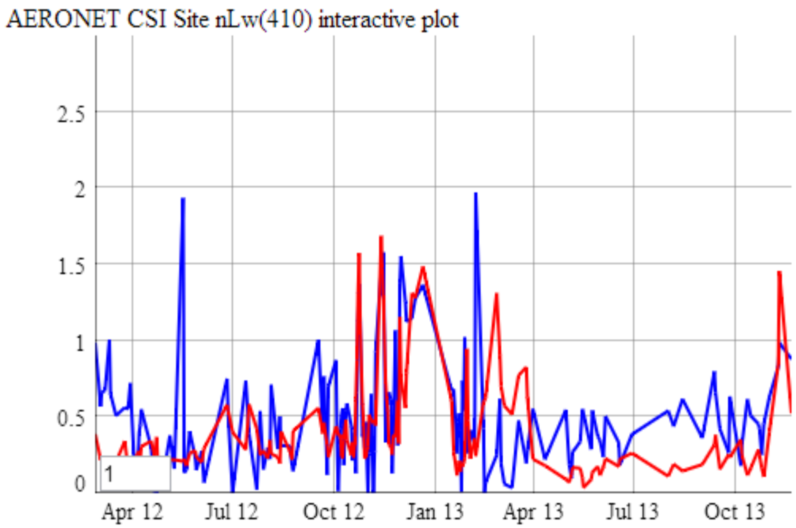
Comparison of VIIRS **NOAA-MSL12** results with MOBY in situ data.

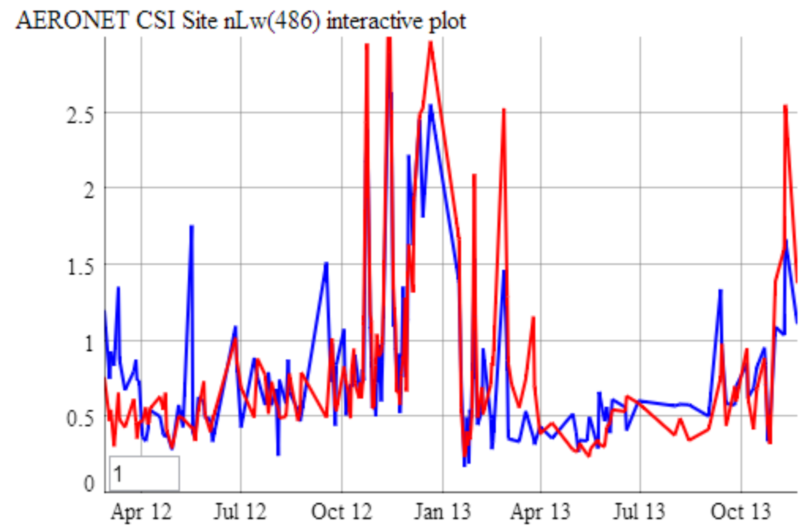
Note:
Vicarious calibration gains applied since **May 2012**.

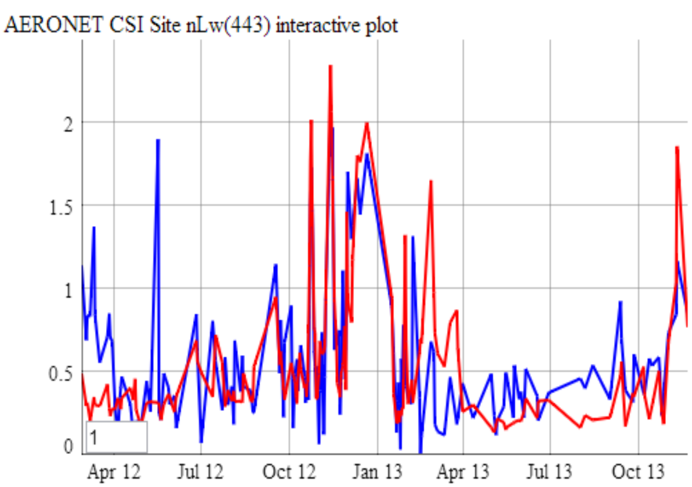
Gains derived using MOBY data.

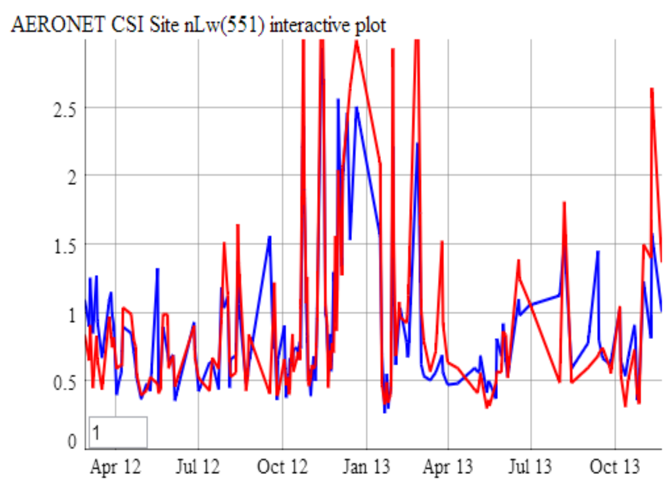
VIIRS ocean color products reached **Beta** status in January 2013, and plan to reach **Provisional** status in summer 2014.

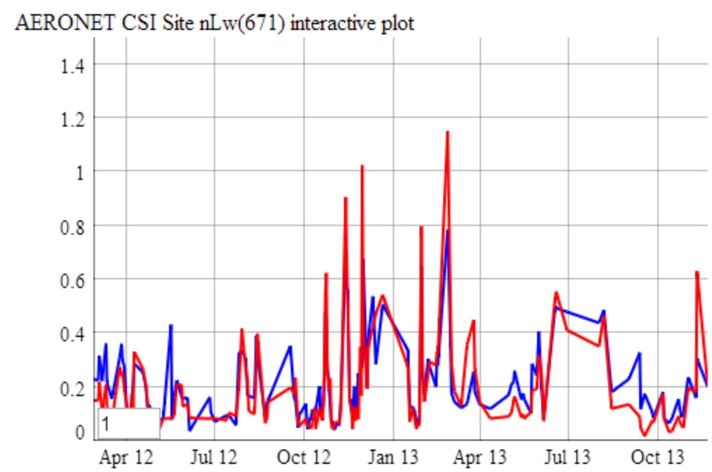
AERONET-CSI nL_w Time Series











In Situ

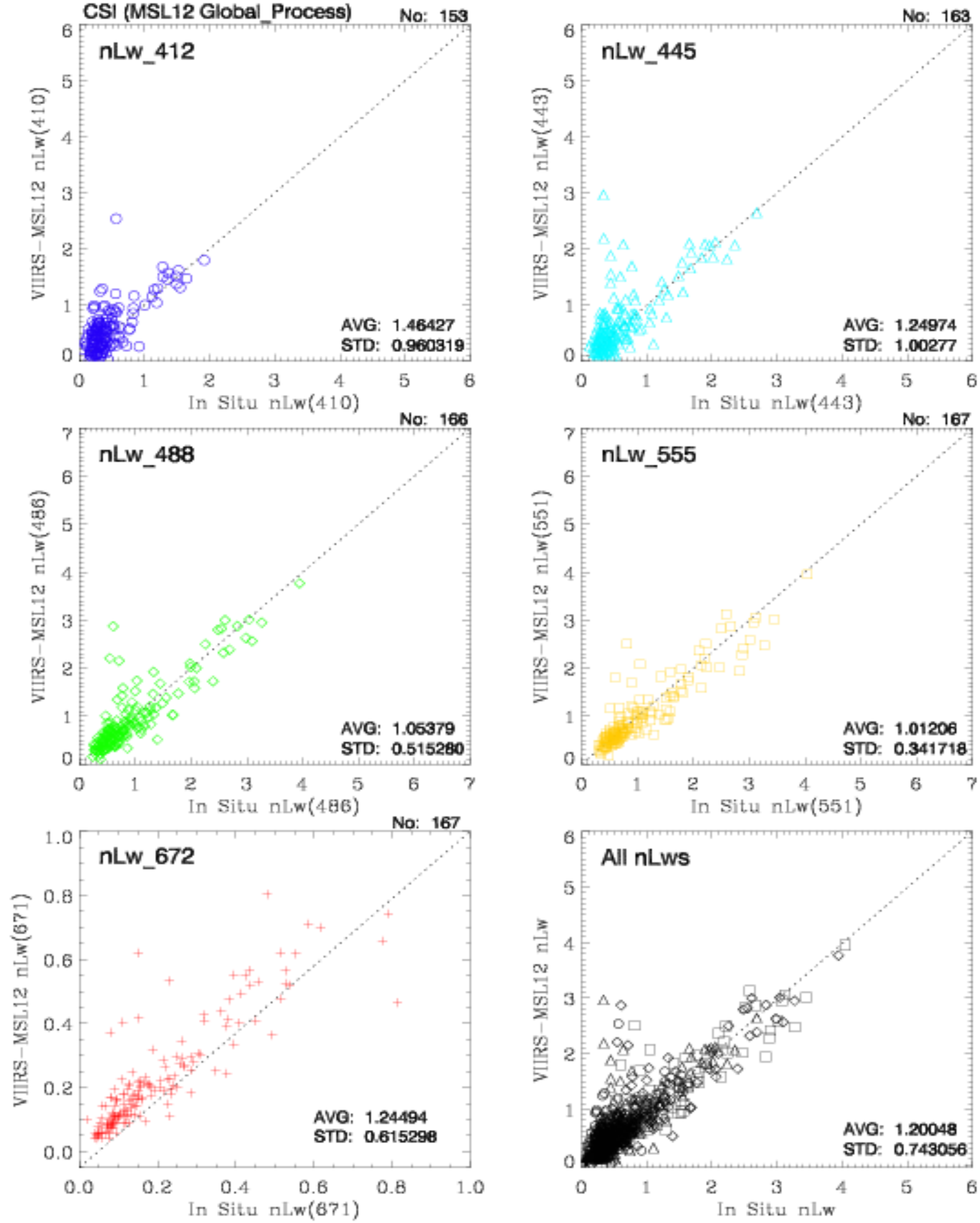
VIIRS (NOAA-MSL12)

AERONET-OC (CSI)

Matchup with

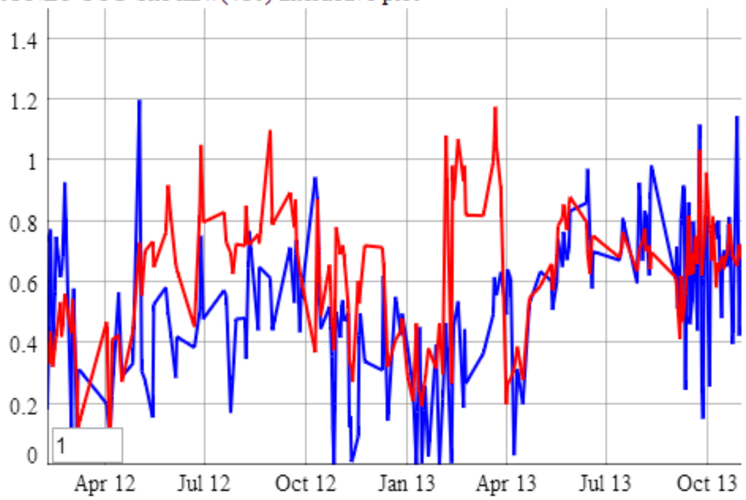
VIIRS

MSL12-Global

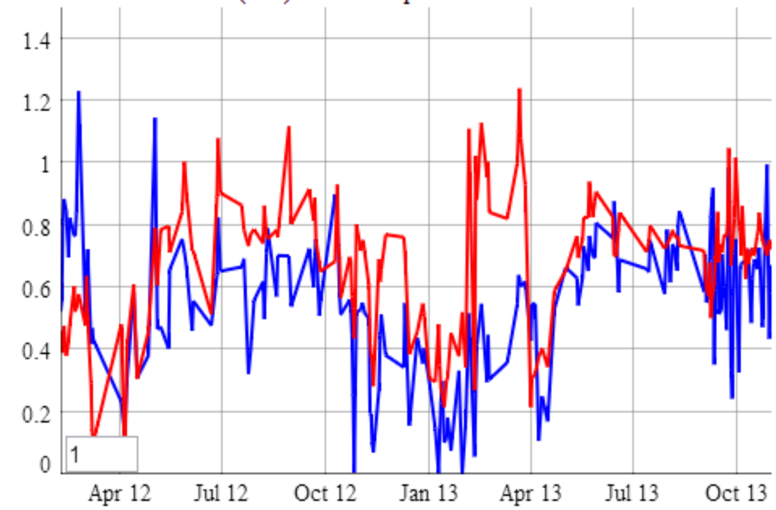


AERONET-USC nL_w Time Series

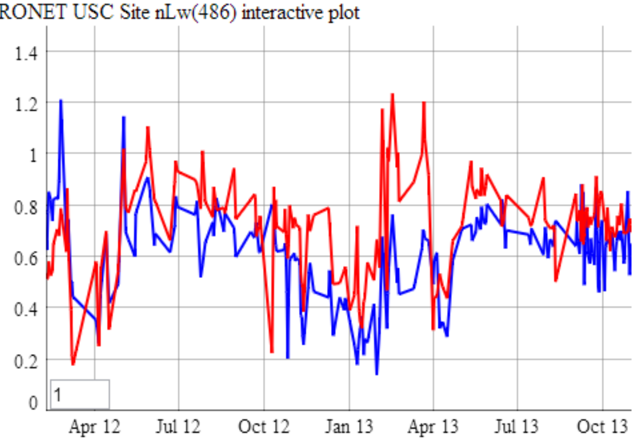
AERONET USC Site nLw(410) interactive plot



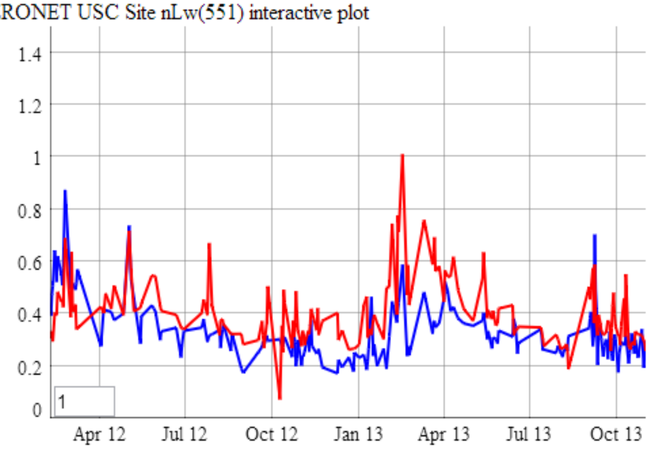
AERONET USC Site nLw(443) interactive plot



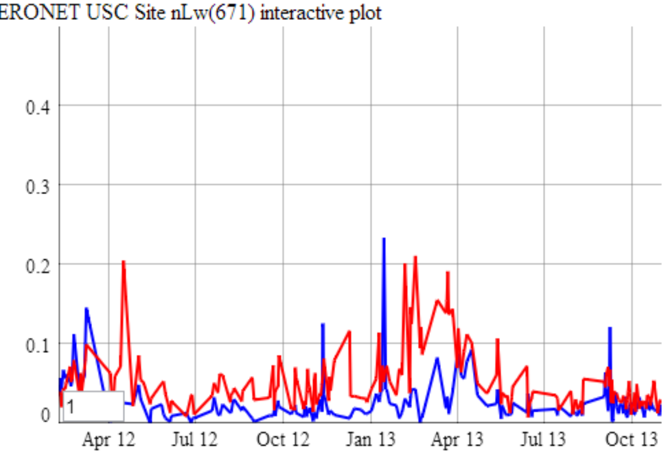
AERONET USC Site nLw(486) interactive plot



AERONET USC Site nLw(551) interactive plot



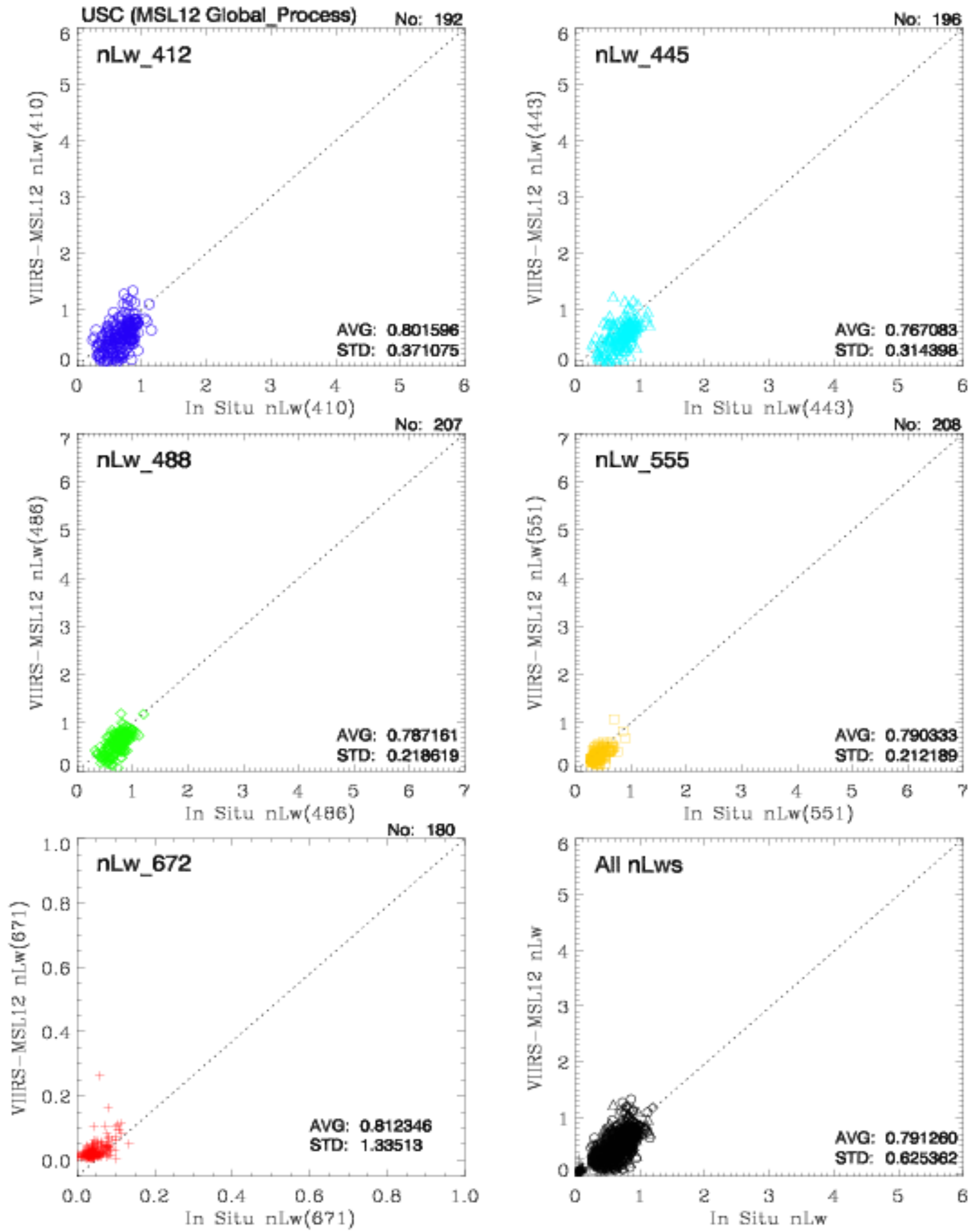
AERONET USC Site nLw(671) interactive plot



In Situ

VIIRS (NOAA-MSL12)

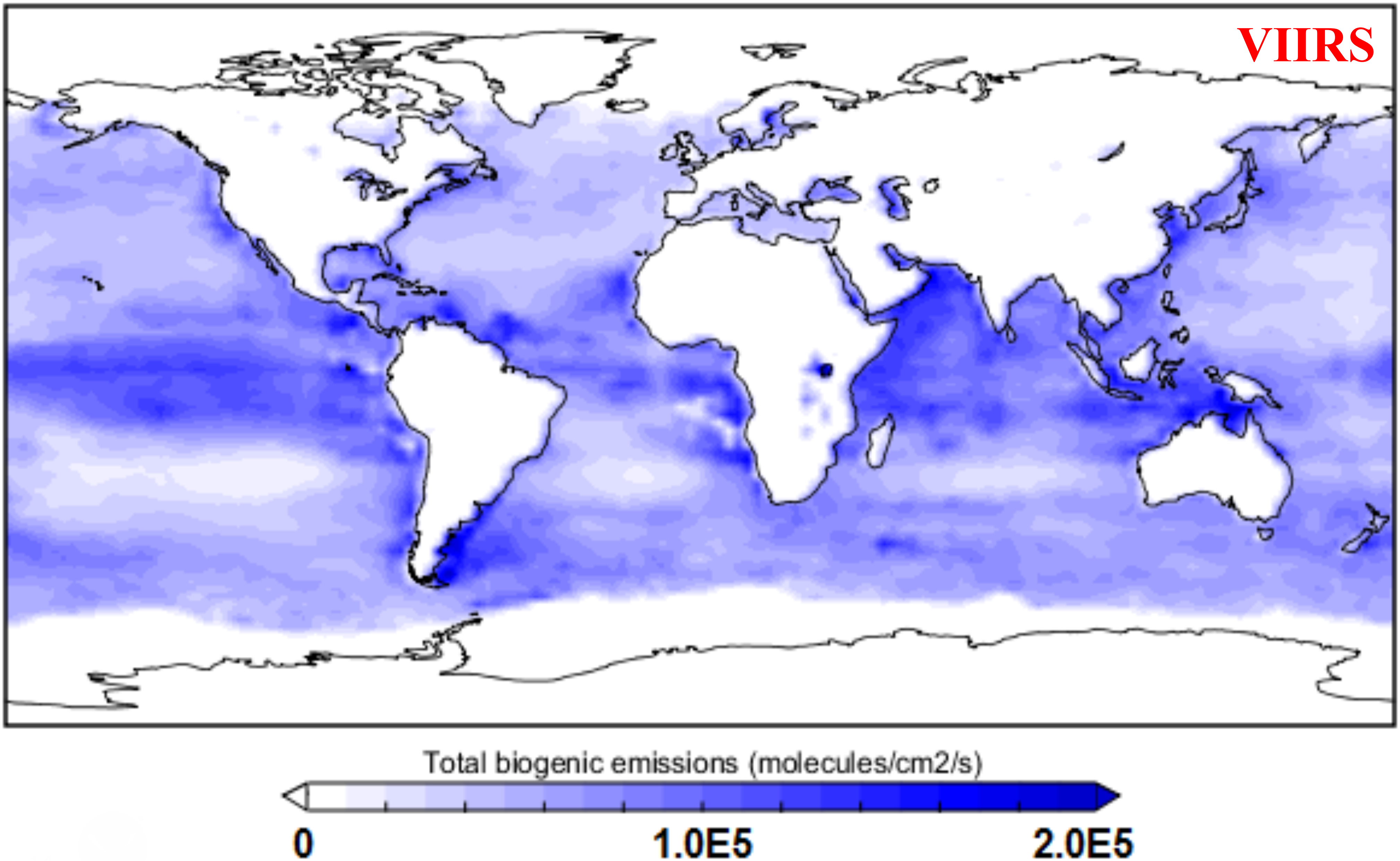
AERONET-OC (USC)
Matchup with
VIIRS
MSL12-Global



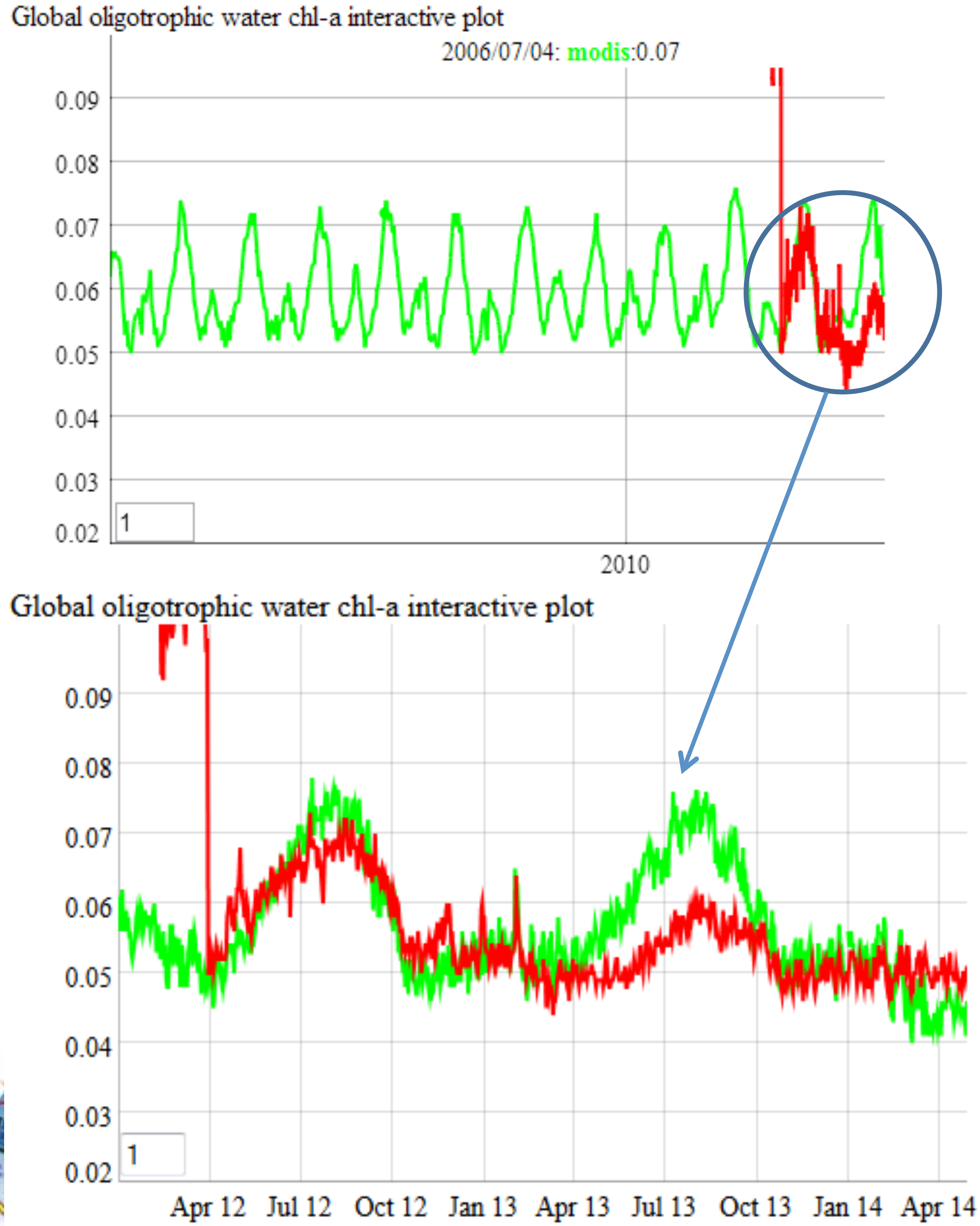
JPSS Proving Ground Project

Global marine isoprene emissions (Tong *et al.*)

Inputs: **Chl-a, K_d(490), PAR**



The Existing VIIRS Calibration Issue



MODIS-Aqua global oligotrophic water Chl-a from 2002 to 2013 (green), overplotted with VIIRS data from 2012 to 2013 (red)

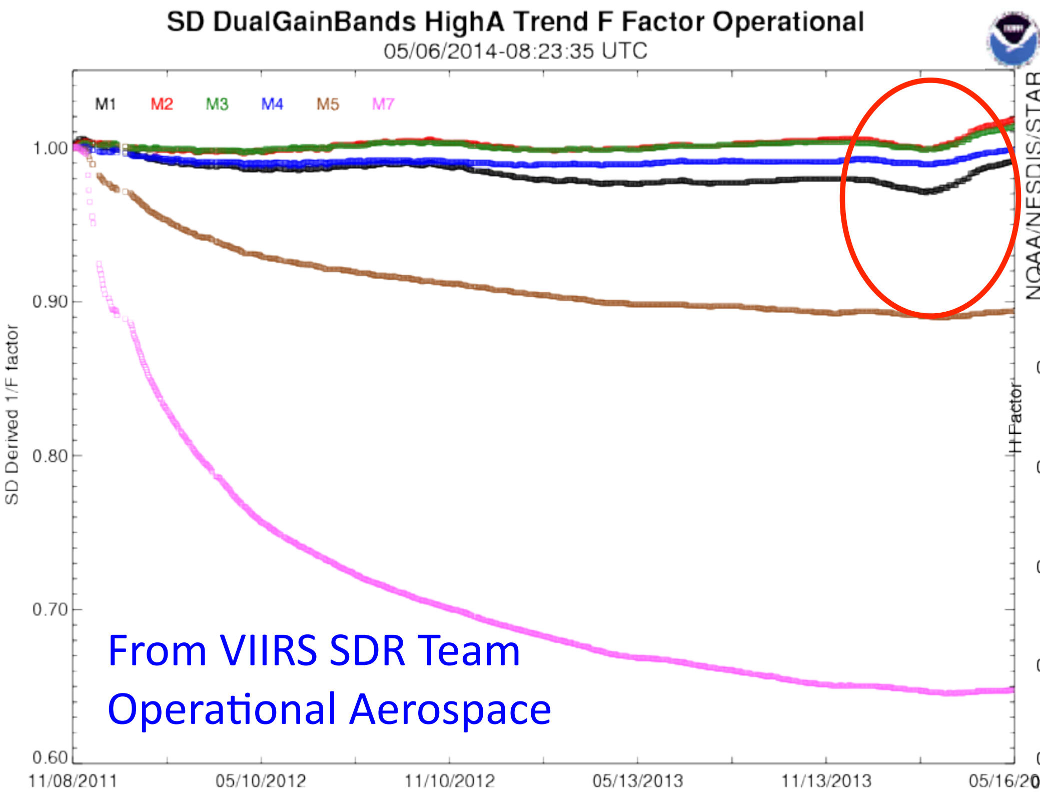
—— MODIS-Aqua

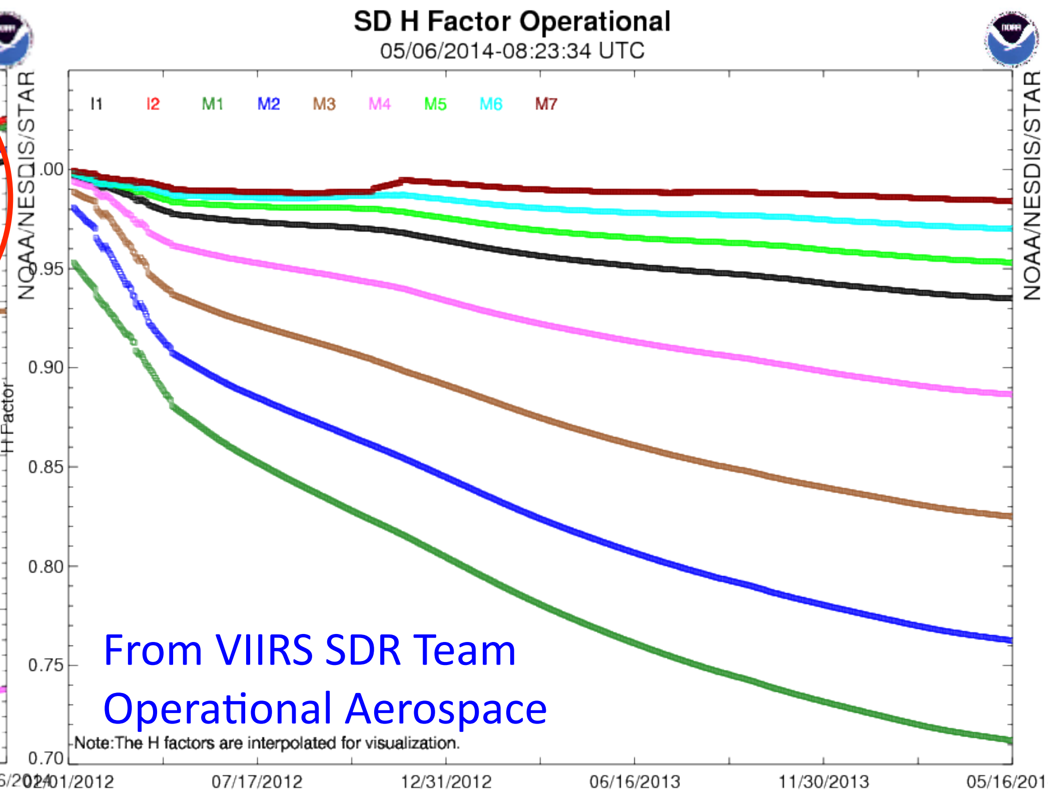
—— VIIRS (NOAA-MSL12)

- VIIRS and MODIS-Aqua match each other quite well in 2012.
- They have noticeable difference in 2013 (biased low from VIIRS).
- Since MODIS-Aqua has a reasonable Chl-a annual repeatability, It is confirmed that VIIRS SDR has calibration issues, in particular, for the M4 (551 nm) band (**biased low**), at least for 2013.

Recent Operational RSB H&F Factors Trends

(More detail this afternoon)



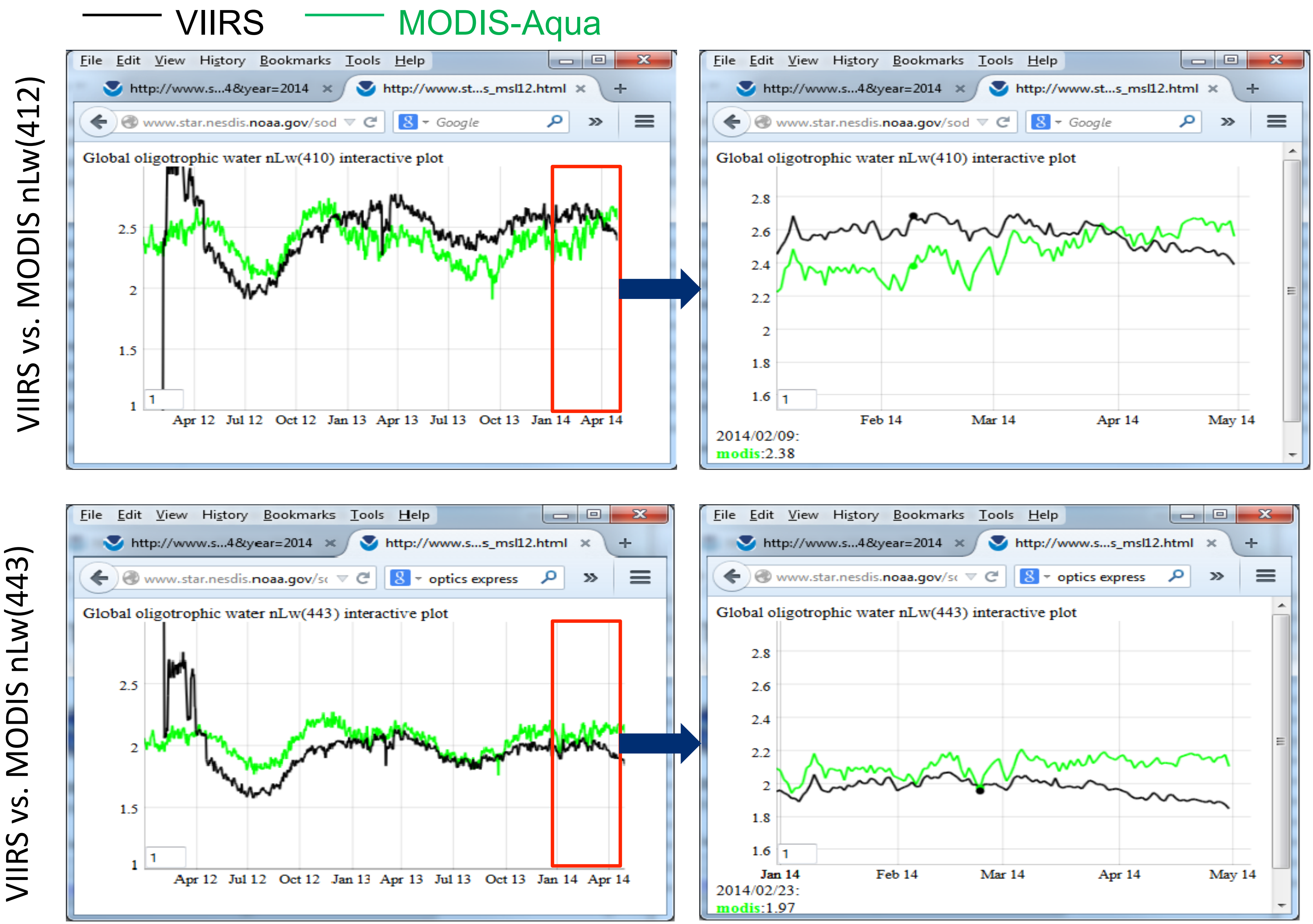


•Recent F-factors (1/F) show significant trend change which suggests that degradation has stopped or even reversed.

•F-lookup tables (1/F) for M1-M4 show significant increase of ~1-2% since early February. F factors for M1 and M2 increased ~2% in 3 months.

•Thus, calibration gains (TOA radiances) are decreased by ~2% for M1 and M2.

Quantitative Evaluation for Global Oligotrophic Waters



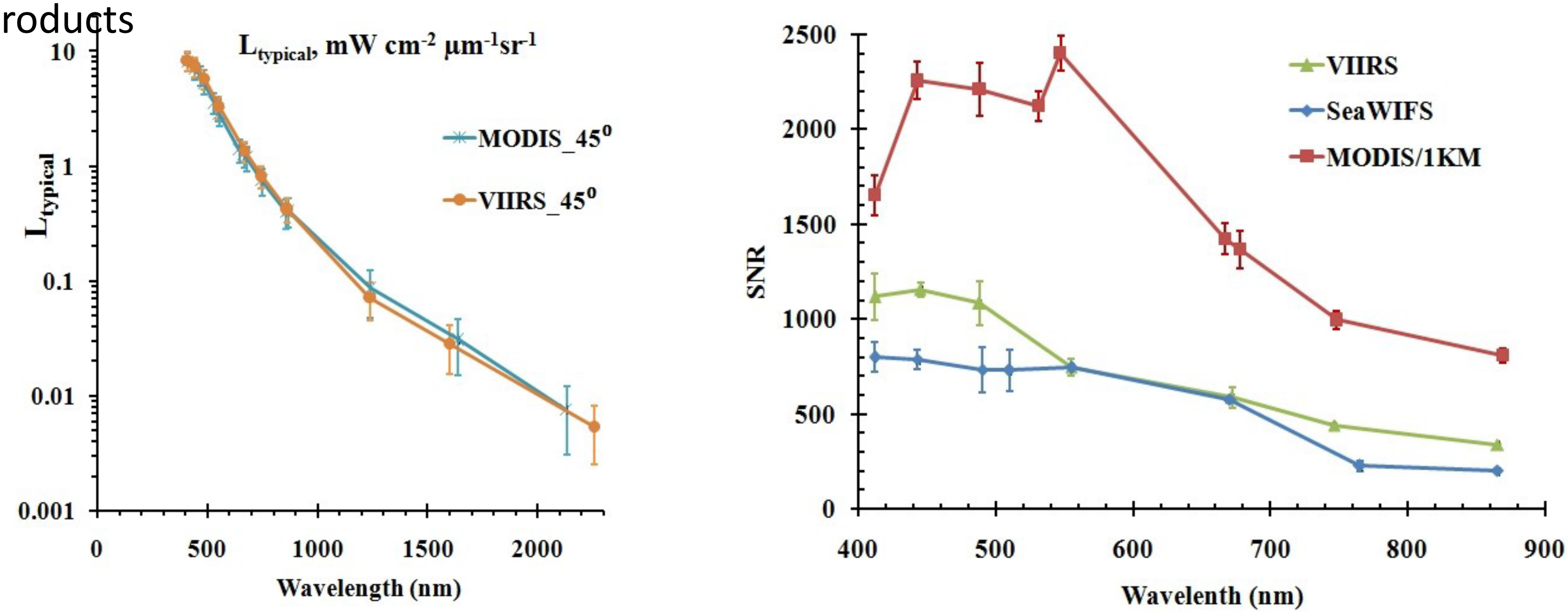
Some Selected Results from Various

OC Cal/Val Team PIs

Chuanmin Hu/U. South Florida

- Project Objectives:
  - Evaluate VIIRS general performance (SNR, product noise)
  - Evaluate VIIRS IDPS data products for coastal waters
- Project Accomplishments:

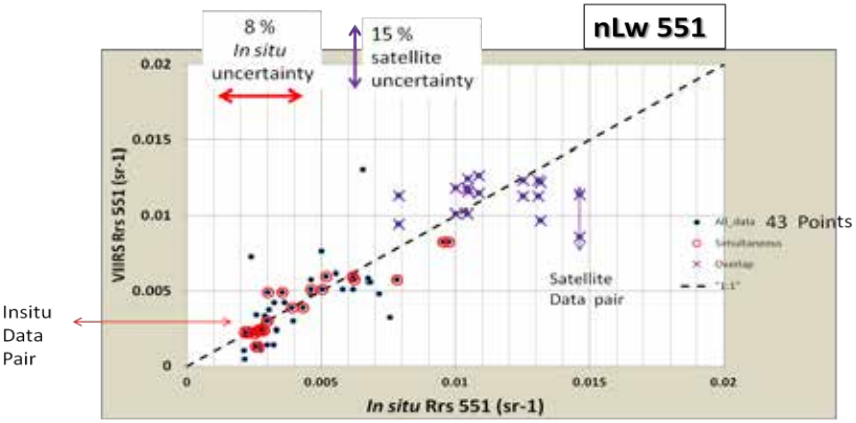
VIIRS SNR(NIR) > SeaWiFS but < MODIS. Therefore, VIIRS Rrs and Chl data products should have less speckle noise than SeaWiFS. Is this true? We are evaluating these products



$L_{typical}$ and SNR calculated from measurements using approaches of Hu et al. (2012, Applied Optics).

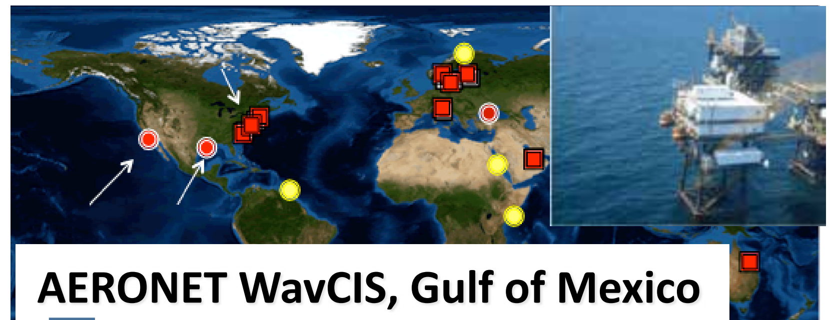
Stennis Group (USM, NRL, QNA, SDSU)

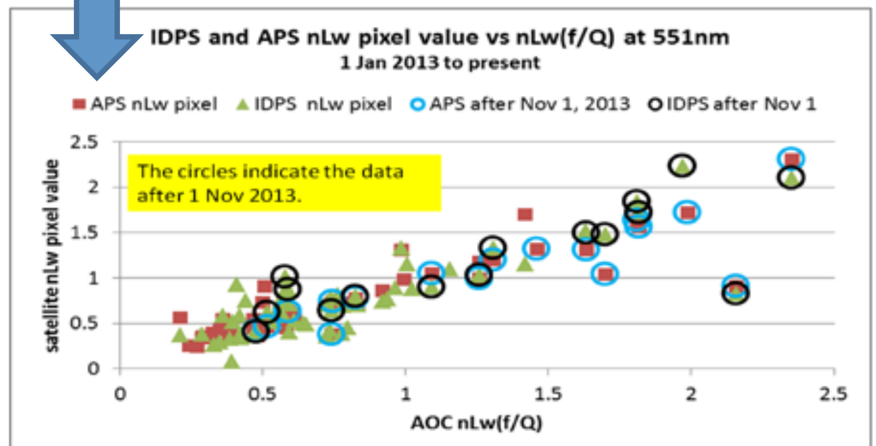
Arnone, Vandermeulen, Ladner, Fargion, Bowers, Crout, Martinolich



Defined the Uncertainty of sensor and in situ data

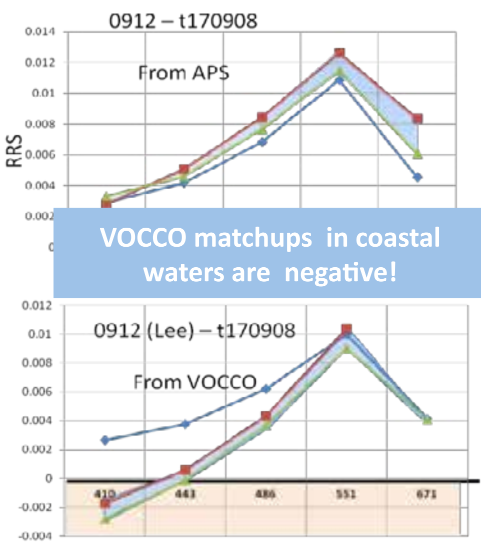
Tracking VIIRS Consistency in performance

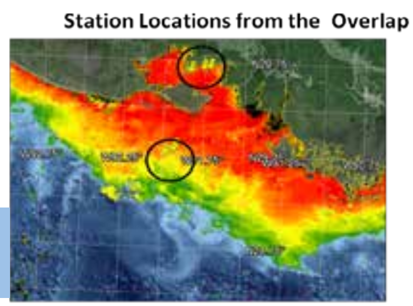


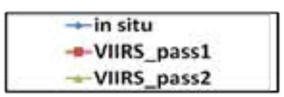


	1 Jan 2013 - 31 Oct 2013			1 Nov 2013 - present		
	y-intercept	slope	r2	y-intercept	slope	r2
AOC:APS (555nm)	0.0670	0.9712	0.8127	0.1035	0.7389	0.7313
AOC:IDPS (555nm)	0.1094	0.7893	0.6117	0.2959	0.6976	0.6355

Orbital Overlap within 100 minutes applied to VIIRS







Multiple data sets show VOCCO can be improved in coastal waters.

VIIRS sensor is good for coastal products.
NIR processing required for Coastal waters.

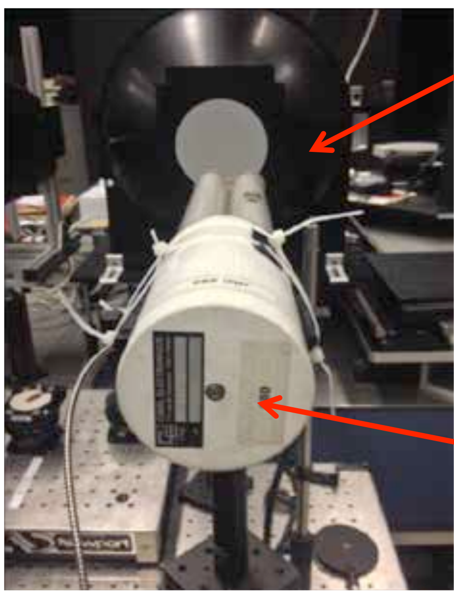
Plans to examine the detectors' impact on Validation

Established users of VIIRS Ocean Color products:

- Used for Science University and NASA research
- Navy Applications and transitions to operations
- Oil Spill research
- Ocean Weather Laboratory - USM
- NOAA - Fisheries

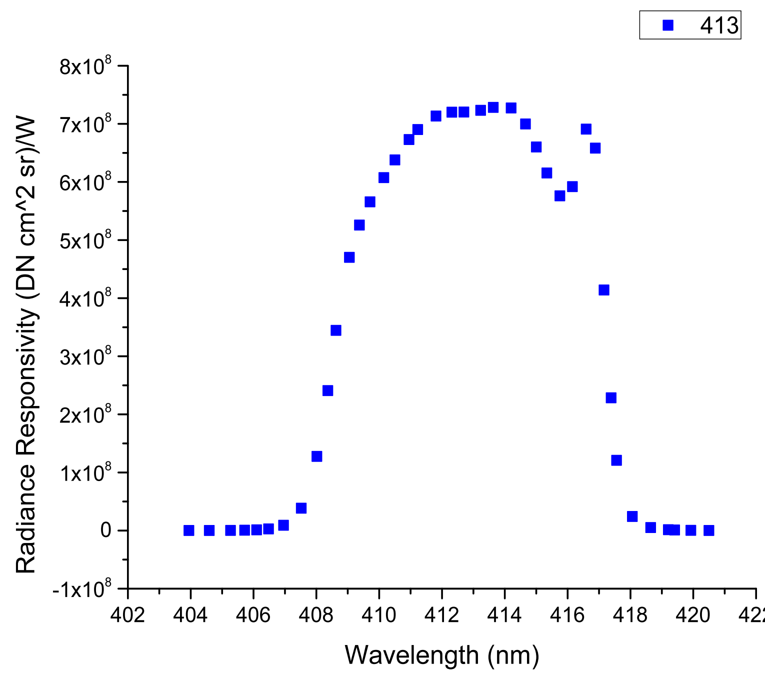
Carol Johnson/NIST

- Project Objectives:
  - Characterize and calibrate a SeaPRISM for absolute radiance responsivity for several ocean color channels and compare to calibration coefficients from broadband sources (NASA/GSFC and JRC/Italy)



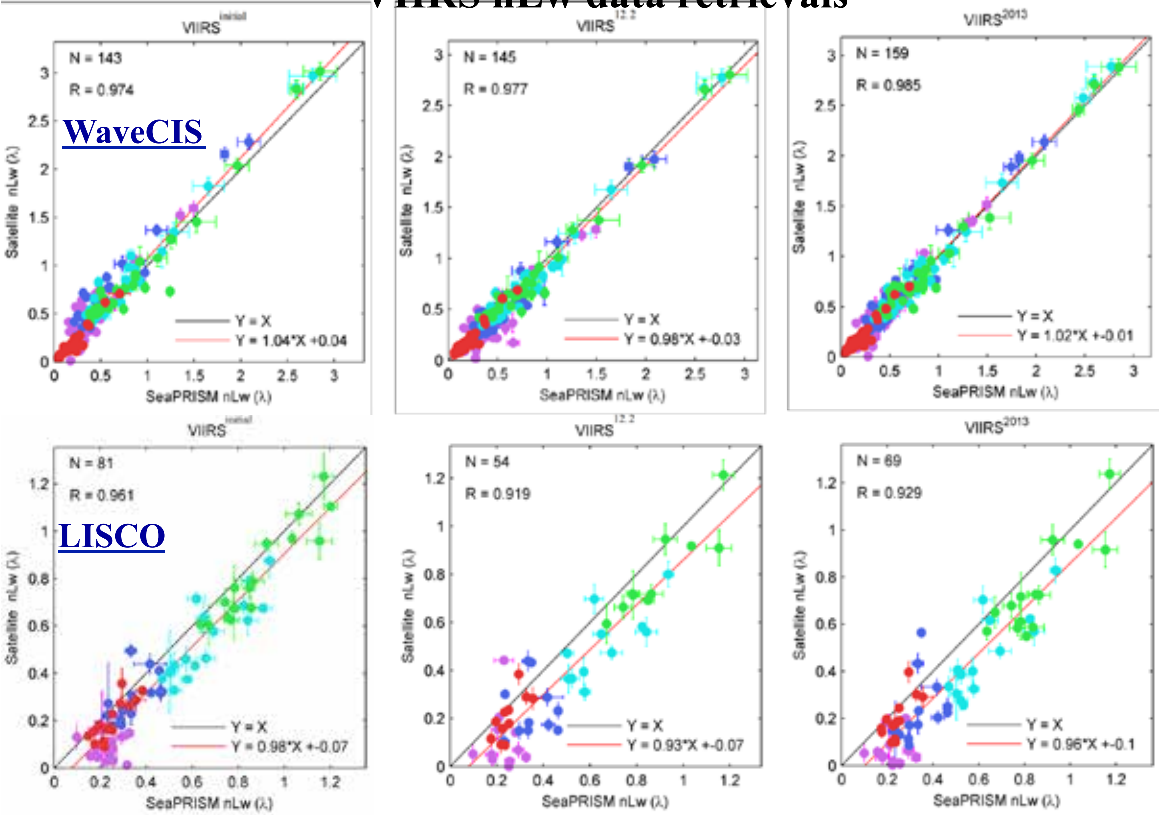
Laser-illuminated sphere

SeaPRISM080

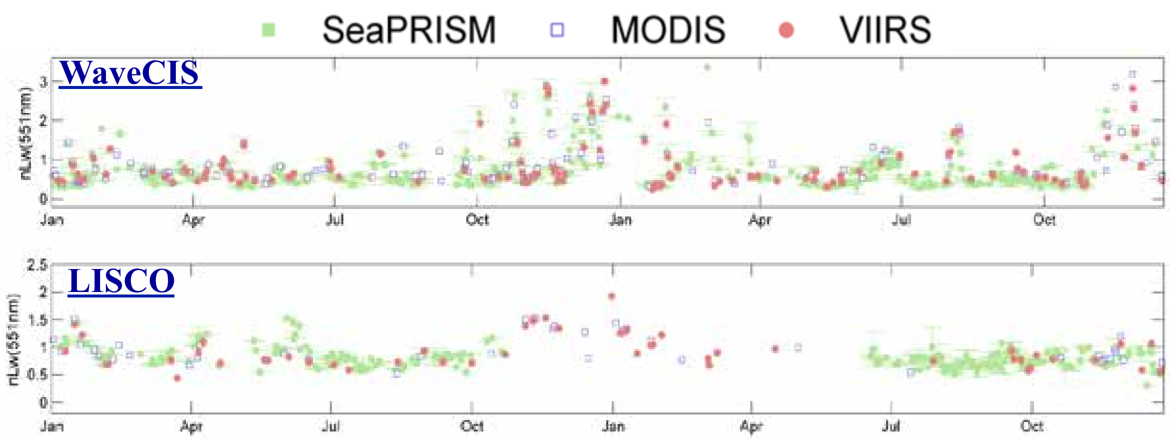


City College of New York - NOAA CREST

Evaluations of the impacts of processing schemes on VIIRS nLw data retrievals



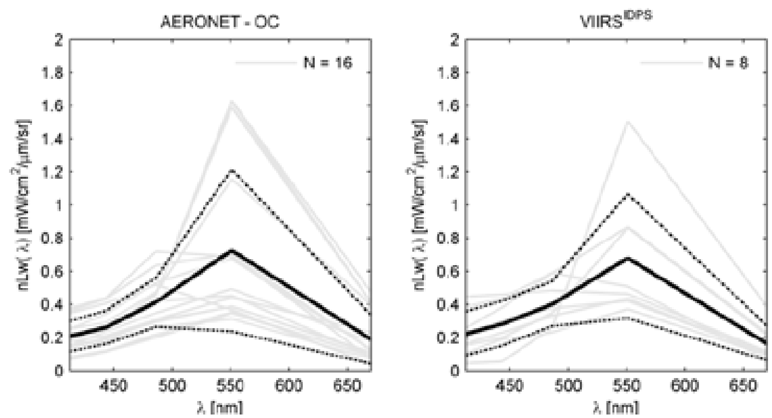
Time series of normalized water-leaving radiance, nLw(λ)



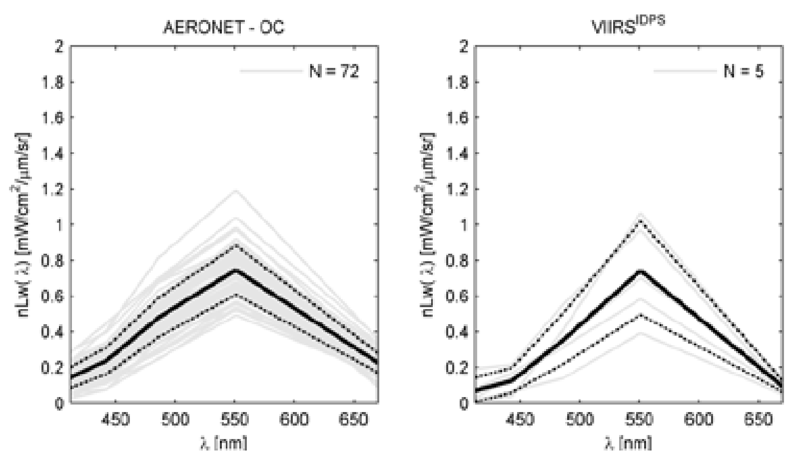
nLw(λ) match-up spectra of AERONET-OC and VIIRS^{IDPS} (with vicarious gains applied)

for June 17th to September 15th of 2013 period.

WaveCIS AERONET-OC site of gulf of Mexico



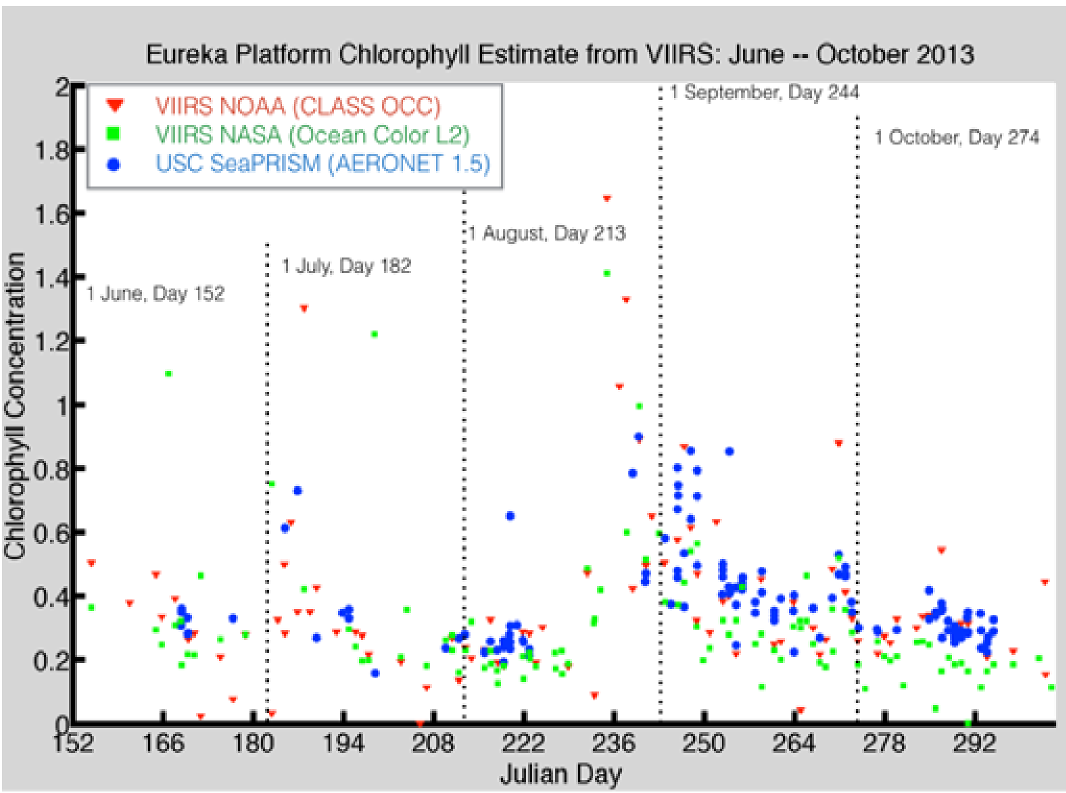
LISCO AERONET-OC site of Long Island Soun

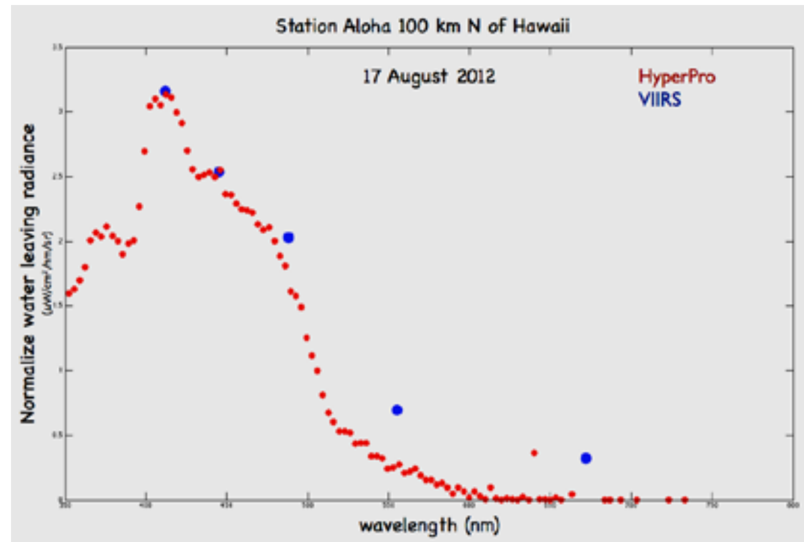


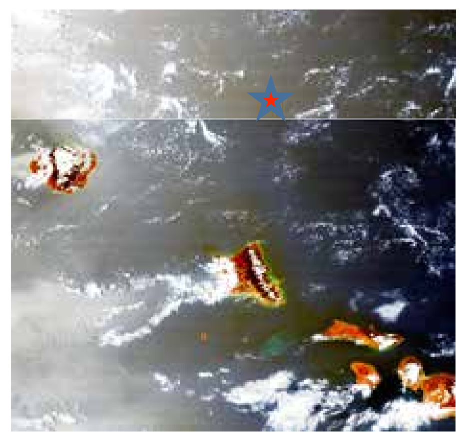
Ocean Color EDR Cal Val Team
OSU (C. Davis, N. Tufillaro and J. Nahorniak)

- Project Goal: Validate VIIRS ocean color data for Coastal (Platform Eureka, CA SeaPRISM data) and Open Ocean (Hawaiian Ocean Time series (HOT HyperPRO data) to validate NOAA, Navy and NASA ocean color products.

- Completing second year of matchups.





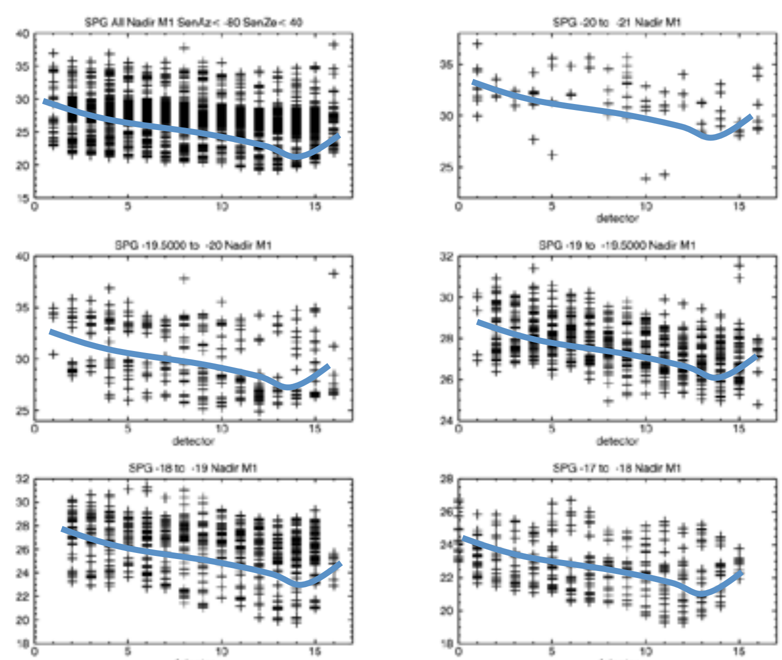


VIIRS image over Hawaii from 17 August 2012 (23:43 GMT). The star marks Station ALOHA.

Northrop Grumman Aerospace Systems

- Project Objectives:
  - A - Support ocean color calibration (sensor and/or algorithm artifacts and characterization)
    - Verify polarization sensitivity/characterize detector dependence (in progress)
  - B –support in-situ field work with OMT (sample from Antarctic)

nLw vs detector 412 nm



Conclusions

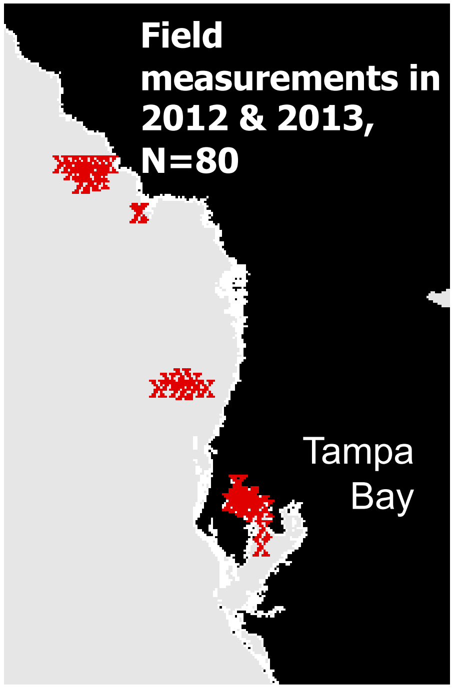
- In general, VIIRS OC normalize water-leaving radiance spectra show reasonable agreements with in situ measurements at MOBY, AERONET-OC sites, and various other ocean regions.
- In global deep waters and oligotrophic waters, the VIIRS ocean color products generated from NOAA-MSL12 were consistent with MODIS-Aqua in 2012, but discrepancy started to become noticeable for IDPS and MSL12 Chl-a data since early 2013. We confirmed that this is a VIIRS calibration problem in 2013.
- Since later 2013 (about Oct-Nov.), VIIRS Chl-a data from MSL12 are consistent with those from MODIS-Aqua, but there are noticeable differences since Feb. of 2014.
- Following the reverse trends of VIIRS SDR F-LUTs, global VIIRS nL_w data show decreasing trends from February to May of 2014. Using MODIS-Aqua as reference, nL_w(410) (M1) and nL_w(443) (M2) drifted lower ~**15-20**% as of early May 2014, and nL_w(488) (M3) decreased ~**8-10**% for global oligotrophic waters. The nL_w trends are continuing, and the correct F-LUTs should be used now!
- Although the OC EDR product quality is still not optimal, incremental product improvements have been made, and are occurring. With our efforts, VIIRS can provide high quality ocean color products.

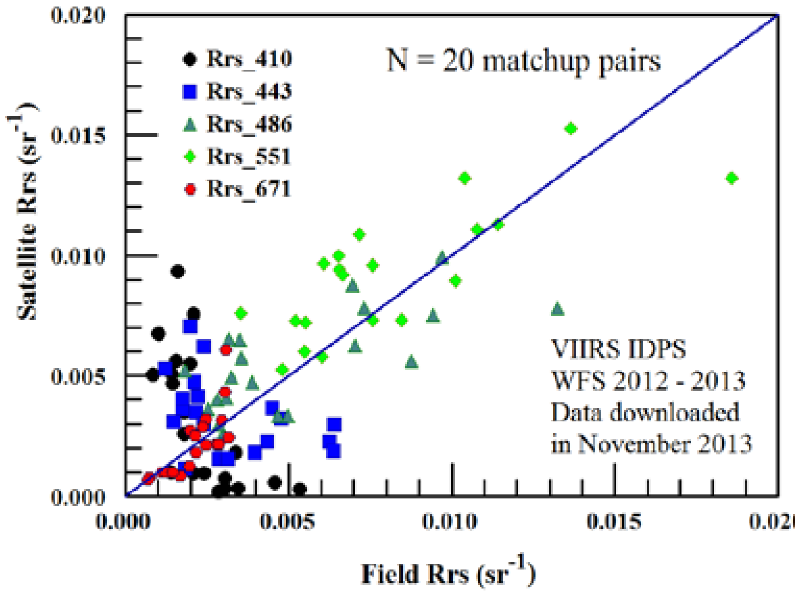
Some Backup Slides

Thank You!

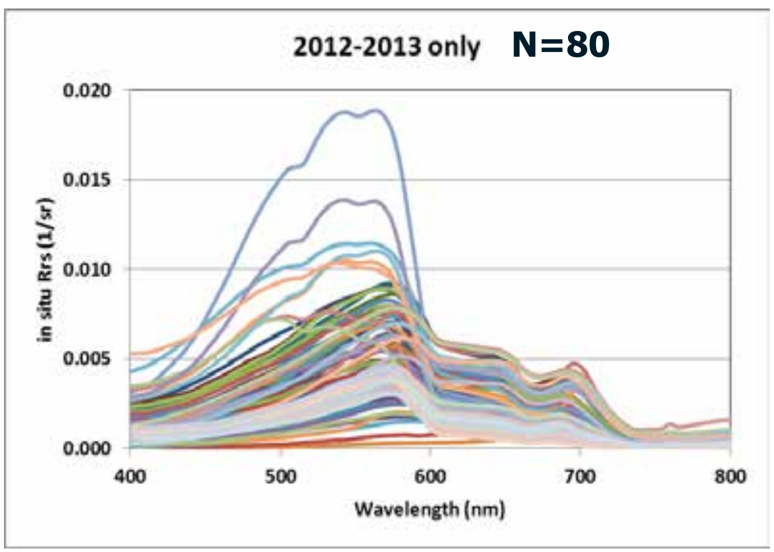
Some Additional Results from the **OC Team PIs** shown in following slides

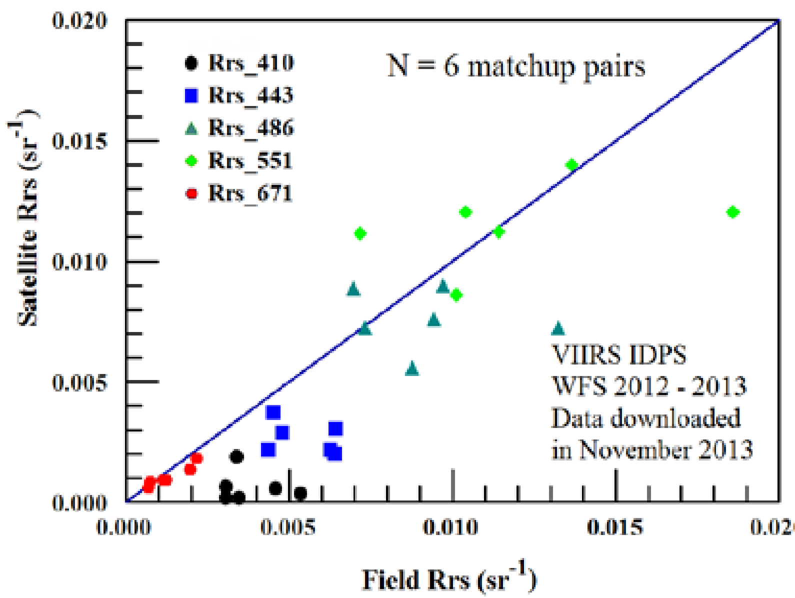
Chuanmin Hu/U. South Florida





No QC flags applied





QC flags applied

Stennis Group (USM, NRL, QNA, SDSU)

Arnone, Vandermeulen, Ladner, Fargion, Bowers, Crout, Martinolich

Project Objectives: VIIRS Cal Val – ocean EDR products - nLw, Chlor_a, and IOP's

Evaluate color product performance for operational use and science applications

Validate products in open and coastal waters

Recommend updates to VOCCO processing and algorithms

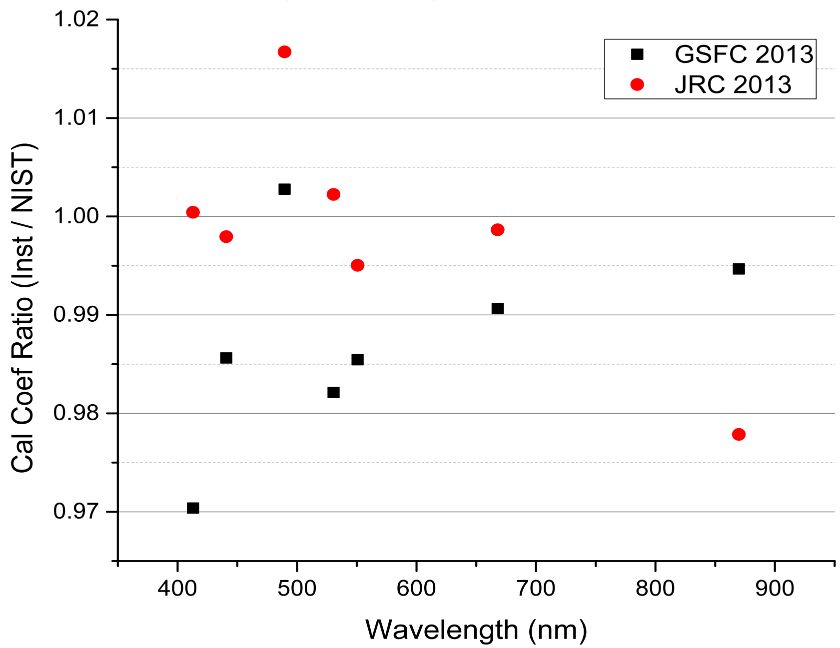
Recommendations to SDR team on impact to Ocean Color EDR

Project Accomplishments: Past year

1. Tracked VIIRS performance at MOBY and WAVCIS AERONET Site - established VIIRS gains
2. Participated in 5 field exercises to validate VIIRS products with NASA, NOAA, Navy and Universities:
   1) NOAA - Fisheries Cruise, 2) NASA GEOCAPE, 3) Navy - OCOLOR, 4) USM Gliders, 5) NOAA - Chesapeake Bay
3. Established IDPS limitations in coastal waters
4. Demonstrated successful coastal processing of VIIRS sensor using Navy's processing system
5. Recommended Coastal NIR algorithms for IDPS to improve coastal products for operations
6. Demonstrated use of the VIIRS orbital overlap for sensor validation
7. Defined VIIRS matchup methods for characterizing uncertainty from detector, sensor and in-situ data
8. Evaluated the VIIRS flags for use in match-up masks
9. Evaluated the M and I bands for Ocean Color products
10. Stennis presented 6 presentations to the cal/val team.
11. Outreach: 8 papers and presentations on successful VIIRS ocean color products
12. Established a user community (University, Navy and NMFS)

Carol Johnson/NIST

- Project Accomplishments:
  - Custom interface to filter wheel/radiometer head
  - Data acquisition software necessary to interface to SIRCUS
  - Empirical model developed to explain observed discrepancies in values and nonlinearities – involves behavior of background counts in this interface mode
  - Preliminary results are in good agreement with GSFC and JRC



City College of New York - NOAA CREST

- Project Objectives:
  - To monitor the validity of the VIIRS^{IDPS} ocean color products for coastal waters.
  - To evaluate the consistency of the VIIRS processing and cal/val schemes.

Science accomplishments

✓ Quality of VIIRS's OC data retrievals (*nLw* and atmospheric parameters) for different processing schemes (gain sets) are analyzed based on comparison with AERONET-OC and MODIS data. (Remote Sensing of Environment, December 2013)

✓ A novel radiative transfer based OC satellite sensor vicarious cal/val approach has been developed. This approach has been shown to be very promising and gains of the VIIRS and MODIS sensors are derived with data from both the LISCO and WaveCIS AERONET-OC sites.(A paper is in preparation for submission to a peer-reviewed journal).

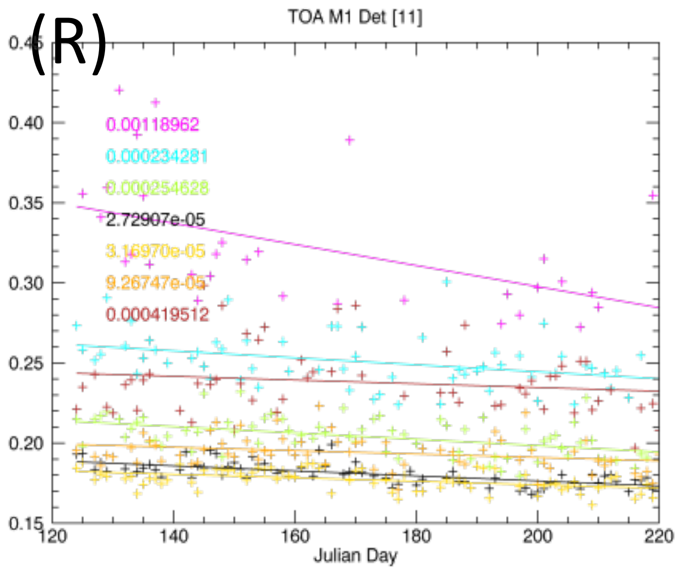
Publications

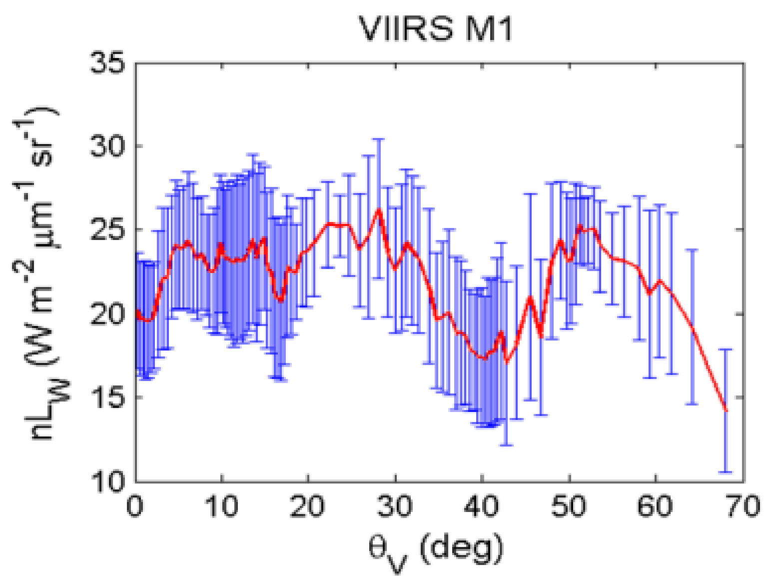
1. S. Hlaing, T. Harmel, A. Gilerson, R. Foster, A. Weidemann, R. Arnone, M. Wang, S. Ahmed, "Evaluation of the VIIRS ocean color monitoring performance in coastal regions, " **Remote Sensing of Environment, "139, 398–414, 2013**.
2. S. Ahmed, A. Gilerson, S. Hlaing, A. Weidemann, R. Arnone, M. Wang, "Evaluation of ocean color data processing schemes for VIIRS sensor using in-situ data of coastal AERONET-OC sites," Proceeding of SPIE 8888, Remote Sensing of the Ocean, Sea Ice, Coastal Waters, and Large Water Regions 2013, 88880H (October 16, 2013); doi:10.1117/12.2028821.
3. S. Ahmed, A. Gilerson, S. Hlaing, I. Ioannou, M. Wang , A. Weidemann, R. Arnone, "Evaluation of VIIRS ocean color data using measurements from the AERONET-OC sites," Proceeding of SPIE 8724, Ocean Sensing and Monitoring V, 87240L (June 3, 2013); doi:10.1117/12.2017756.
4. S. Ahmed, A. Gilerson, S. Hlaing, A. Weidemann, R. Arnone, and M. Wang, "Assessments of VIIRS Ocean Color data retrieval performance in coastal regions", Proceeding of IOCS 2013 meeting, May 2013.

Presentations (**1**) S. Ahmed, SPIE, Dresden, Germany, September, 2013. (**2**) IOCS 2013 meeting, Darmstadt, Germany, May 2013 (**3**) SPIE, Baltimore, Maryland, April, 2013. (**4**) S. Hlaing, AGU, Honolulu, Hawaii, March 2014

Northrop Grumman Aerospace Systems

- Project Accomplishments:
  - A - identified scan dependency (verified by community) is apparent in trending (L) but not on daily times scales (R)





  - B – prepared DR7384 for sun-glint correction code update
  - C – supported DPE functional and regression testing of DR