NOAA Cal/Val Progress Update

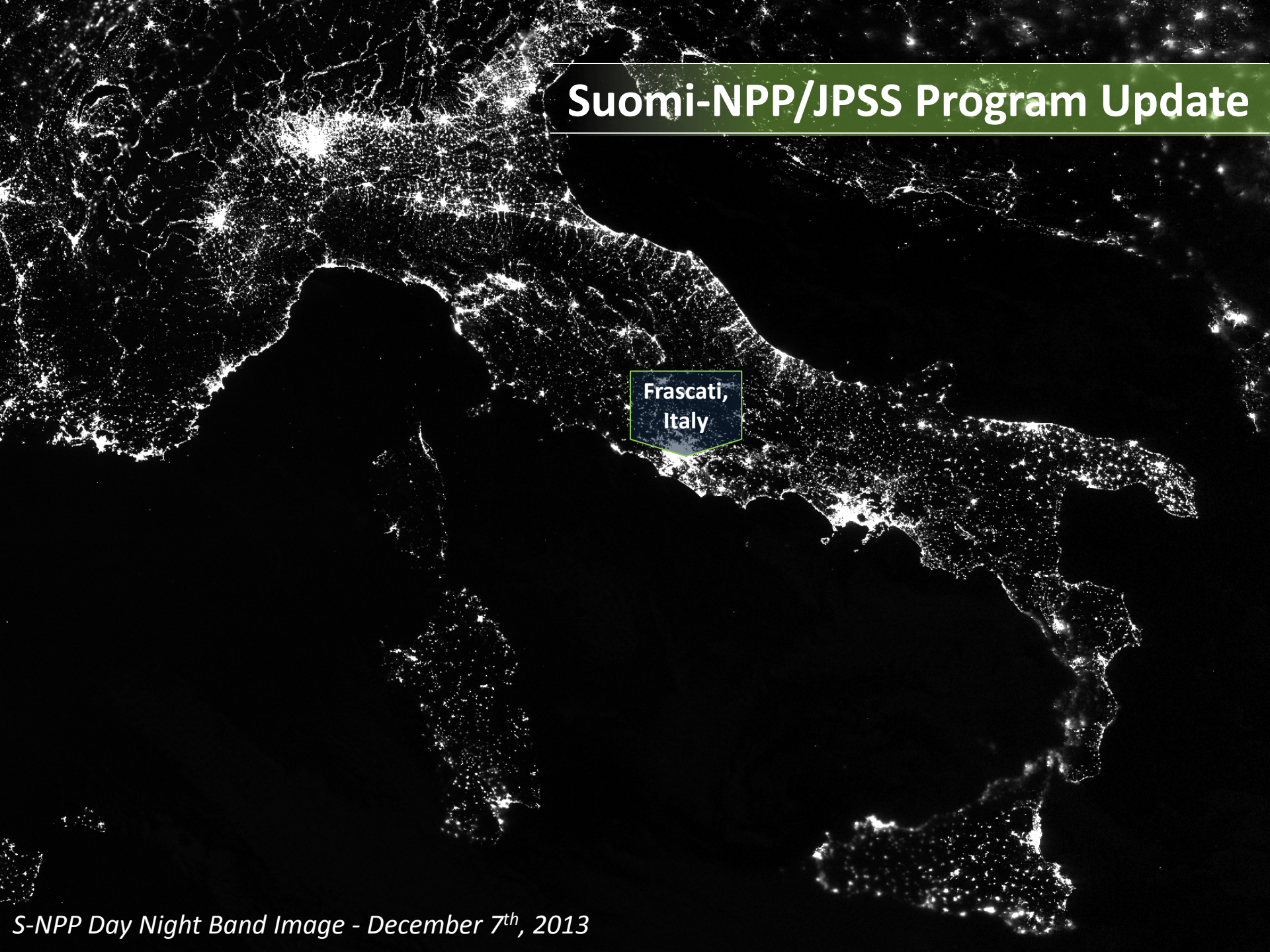
Changyong Cao and Francis Padula
NOAA/NESDIS/STAR

37th CEOS Working Group on Calibration and Validation Plenary
(WGCV-37)
Frascati, Italy, Feb 17-21, 2014

Outline

- Suomi-NPP/JPSS Program Update
  - » VIIRS data quality and maturity status
  - » Suomi-NPP VIIRS post-launch characterization and Cal/Val activities
- GOES Program Update
  - » GOES-R pre-launch and post-launch Cal/Val readiness activities
- NOAA/NESDIS/STAR Satellite Integrated Calibration/Validation System (ICVS) Update

Suomi-NPP/JPSS Program Update

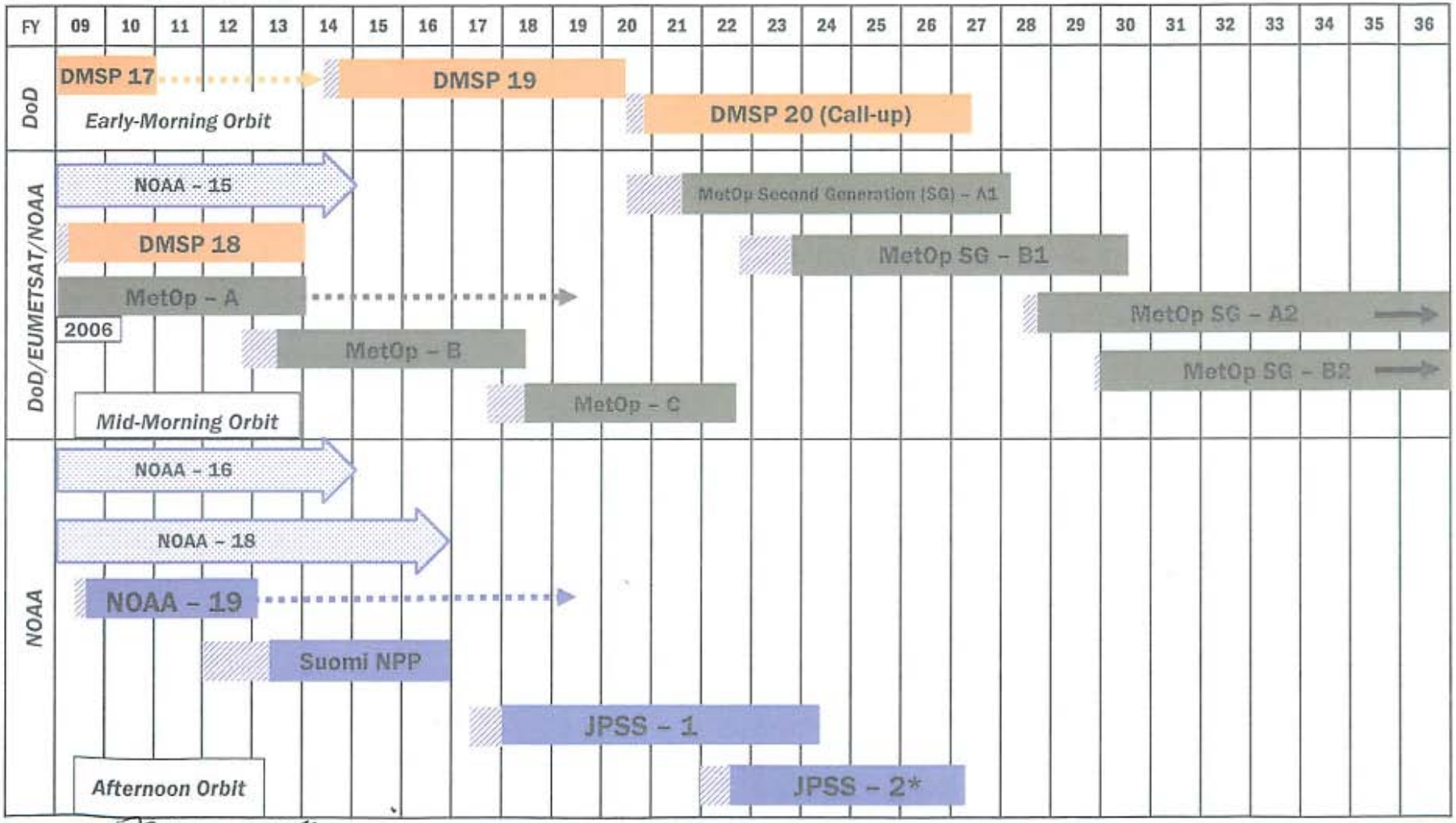


S-NPP Day Night Band Image - December 7th, 2013

Continuity of NOAA's Polar (Primary) Operational Weather Satellite Programs

Launch Dates based on U.S. PB 14

As of October 2013



Approved: Mary E. Kicza

Assistant Administrator for Satellite and Information Services

*Program funding provided through FY2025. The follow-on Program will provide funding for operations post 2025.

DMSP: Defense Meteorological Satellite Program
JPSS: Joint Polar Satellite Program
Suomi NPP: Suomi National Polar Partnership

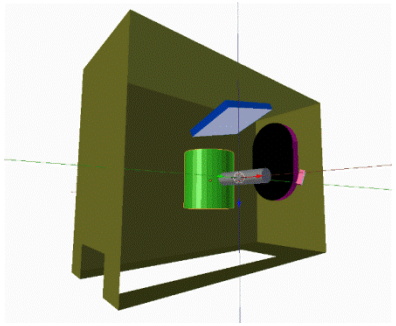
Post Launch Test
Operational
Secondary
Operational beyond FY 2036
Predicted Extended Mission Life

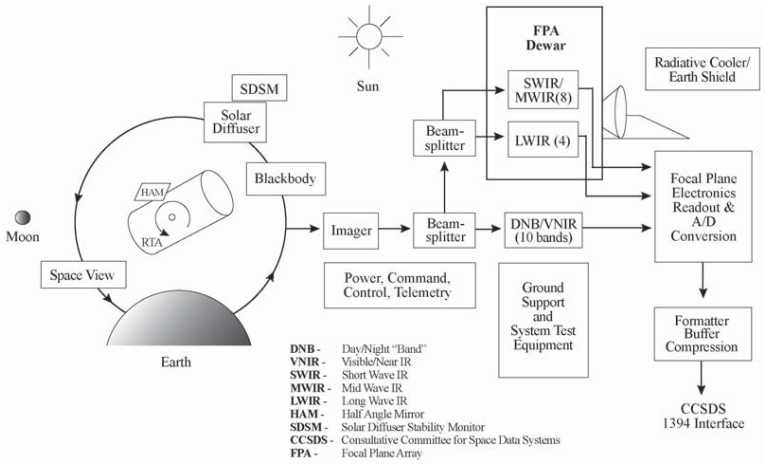
Overview of VIIRS Data Products

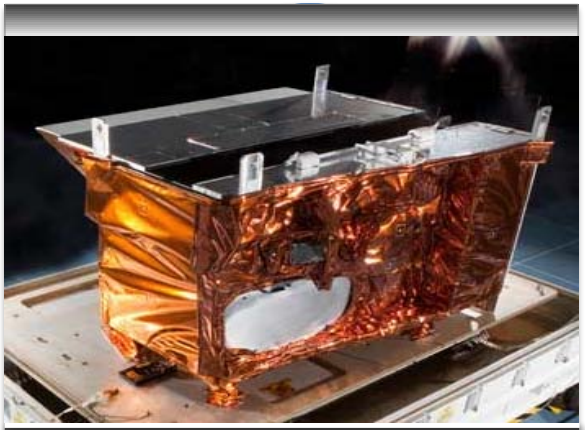
National Polar-orbiting Partnership satellite

Bridge mission between NASA's EOS (Earth Observing System) & the next-generation NOAA's JPSS (Joint Polar Satellite System)

- **SDRs (Sensor Data Records) = Level 1b**
  - » Calibrated and geo-located: radiance, reflectance, and brightness temperature
- **VIIRS SDR team** consists of experts from NOAA, NASA, The Aerospace Corp., University of Wisconsin, MIT/Lincoln Lab, NGAS & Raytheon
- Providing life cycle/end-to-end calibration support to S-NPP/JPSS VIIRS (pre-launch, post-launch, & long-term monitoring)
- VIIRS SDR product is used to produce 20+ Environmental Data Records (EDRs)







Suomi NPP VIIRS
Launched: October 28, 2011

22 SDRs Types

16 Moderate resolution bands
M-Bands (0.75 km):

11 Reflective Solar Bands (RSB)
5 Thermal Emissive Bands (TEB)

5 Imaging resolution bands
I-Bands (0.375 km):

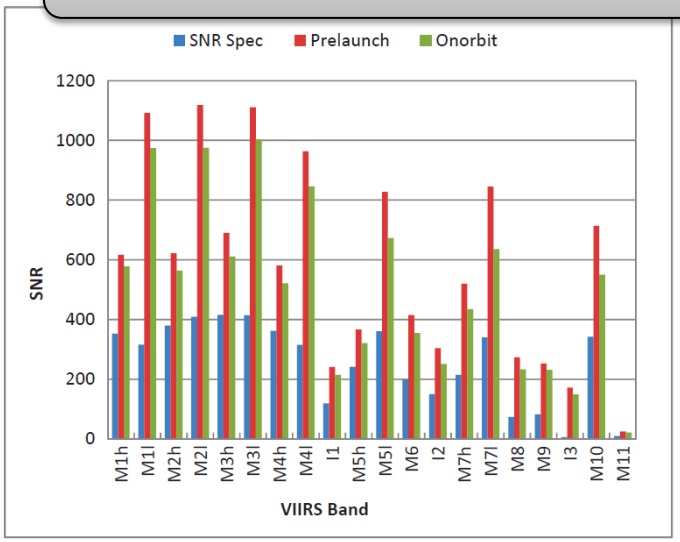
3 RSB
2 TEB

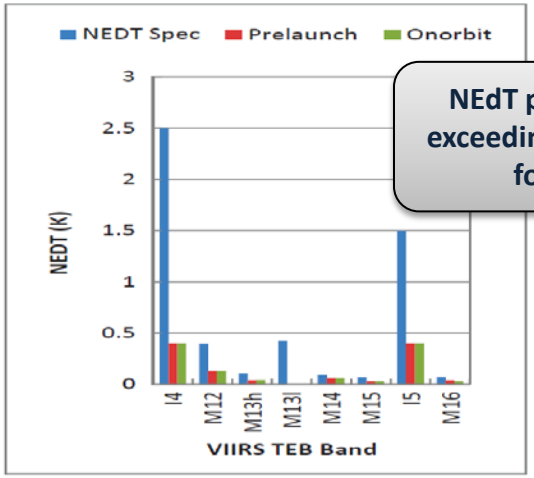
1 Day Night Band (DNB) broadband
DNB (0.75 km)

VIIRS SDR Product Maturity

- **Achieved Beta Status in April 2012**
  - » Early release product, initial calibration applied, minimally validated and may still contain significant errors
  - » Available to allow users to gain familiarity with data formats and parameters
  - » Product is not appropriate as the basis for quantitative scientific publications studies and applications
- **Achieved Provisional Status in Jan. 2013**
  - » Product quality may not be optimal
  - » Incremental product improvements are still occurring as calibration parameters are adjusted with sensor on-orbit characterization
  - » General research community is encouraged to participate in the QA and validation of the product, but need to be aware that product validation and QA are ongoing
  - » Users are urged to contact NPP Cal/Val Team representatives prior to use of the data in publications
- **Calibrated/Validated Status in 2014**
  - » On-orbit sensor performance characterized and calibration parameters adjusted accordingly
  - » Ready for use by the Centrals, and in scientific publications
  - » There may be later improved versions
  - » There will be strong versioning with documentation

SNR performance is exceeding requirements for all Reflective Solar Bands





NEdT performance is exceeding requirements for all TEBs

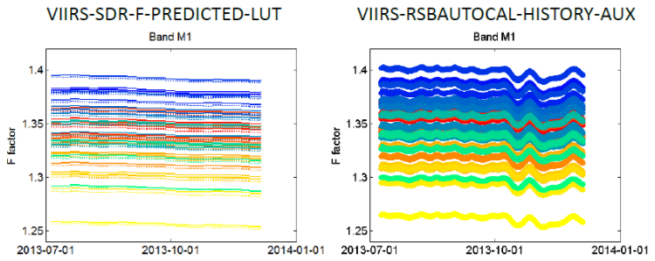
VIIRS SDR has achieved Calibrated/Validated Maturity Status

http://www.star.nesdis.noaa.gov/star/meeting_SNPPReview2013_agenda.php

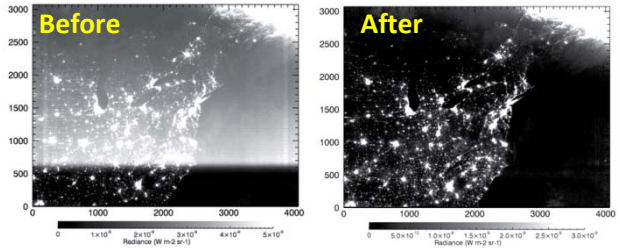
Major Achievements Since Provisional

- VIIRS on-orbit performance is well characterized & meets specifications
- RSBAutoCal being tested and independently validated by NOAA
- VIIRS DNB Straylight Correction implemented (Aug. 2013); tool kit has been evaluated by NOAA
- Geo-location uncertainties for I-/M-bands are ~ 70 m at nadir, meeting specifications at nadir and edge-of-scan (DNB terrain corrected geo-location product is expected in Mx8.3 in March 2014)
- Implementation of modulated RSR (April 2013)
- Updates to the SD and SDSM attenuation screens transmission look-up tables (for improved offline calc. of the radiometric cal. Coef.'s)
- SST striping studies
- TEB validation (further cross comparisons with CrIS, aircraft under-flight, DCC analysis)
- I2/M7 correlation analysis
- Ocean Color LUT effects and comparisons
- STAR ICVS Quality Flag map added to monitor data quality
- Continued monitoring (SNO, LTM), long-term trending & monitoring
- Continued bias time series analysis between VIIRS and MODIS
- Continued WUCD, and Lunar data acquisition
- Excellent publication and outreach (peer-review publications, conferences, outreach to EDR teams)

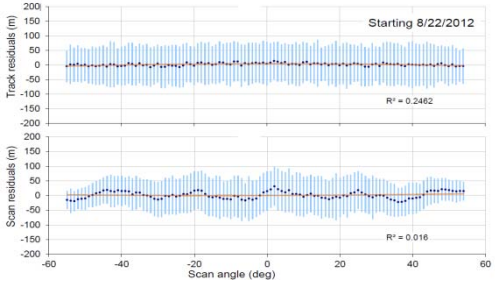
RSBAutoCal Testing



DNB Straylight Correction Implemented



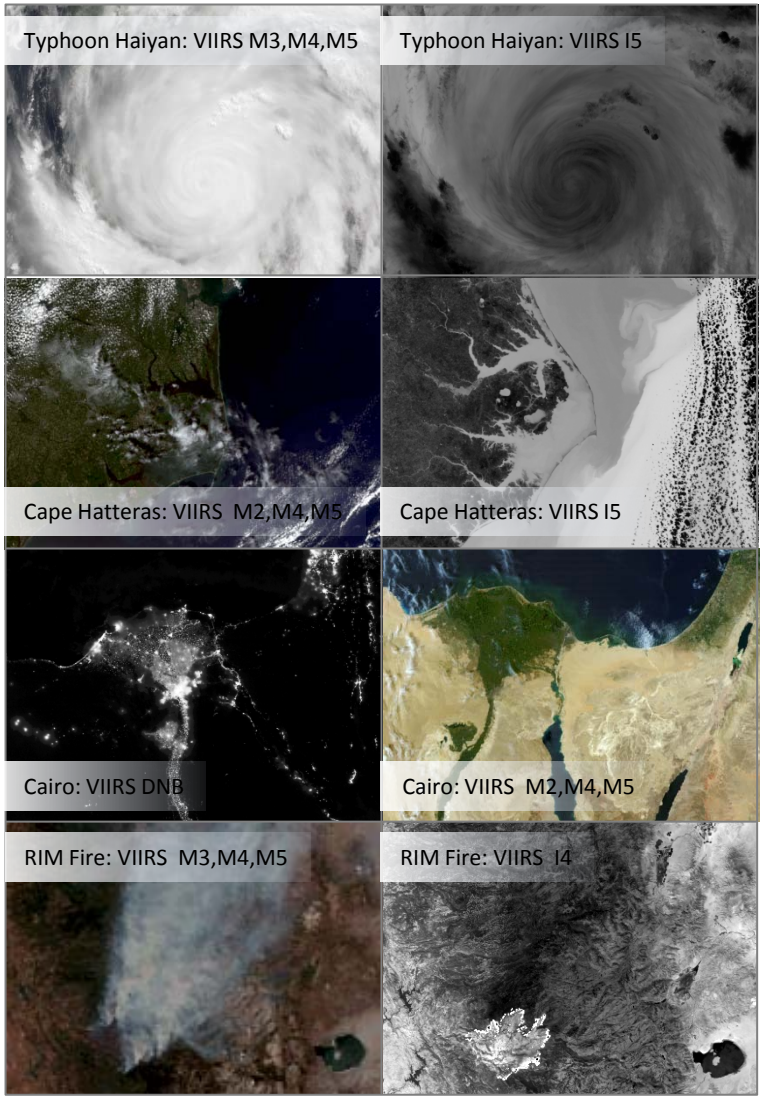
Geo-Location Accuracy



SDR Team Support To EDR Teams

- **Working closely with VIIRS EDR teams to address VIIRS performance issues**
- **SDR Team has demonstrated strong positive action in response to user inputs:**
  - » Support spans from addressing:
    - Clear errors impacting data quality to questions that challenge the state-of-the-art of space-based imaging system performance
  - » Sea Surface Temperature EDR Team
    - Small yet apparent striping pattern (at noise level)
  - » Ocean Color EDR Team
    - Discrepancies between VIIRS and MODIS-Aqua chlorophyll-a since early 2013
  - » Fire EDR Team
    - Data quality and saturation limits

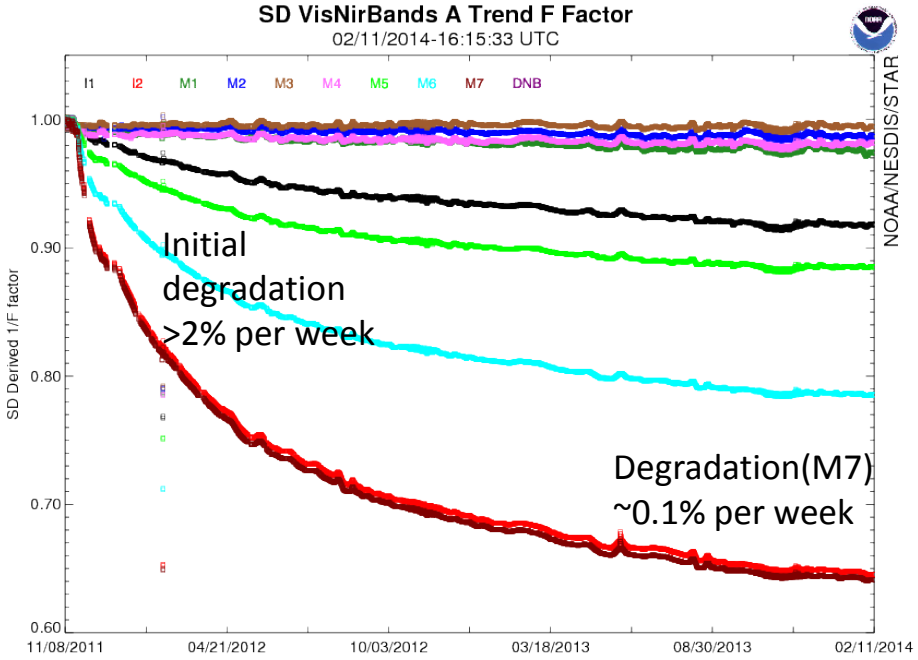
EDR Product Maturity Readiness Review Slides:
http://www.star.nesdis.noaa.gov/star/meeting_SNPPEDR2014_agenda.php



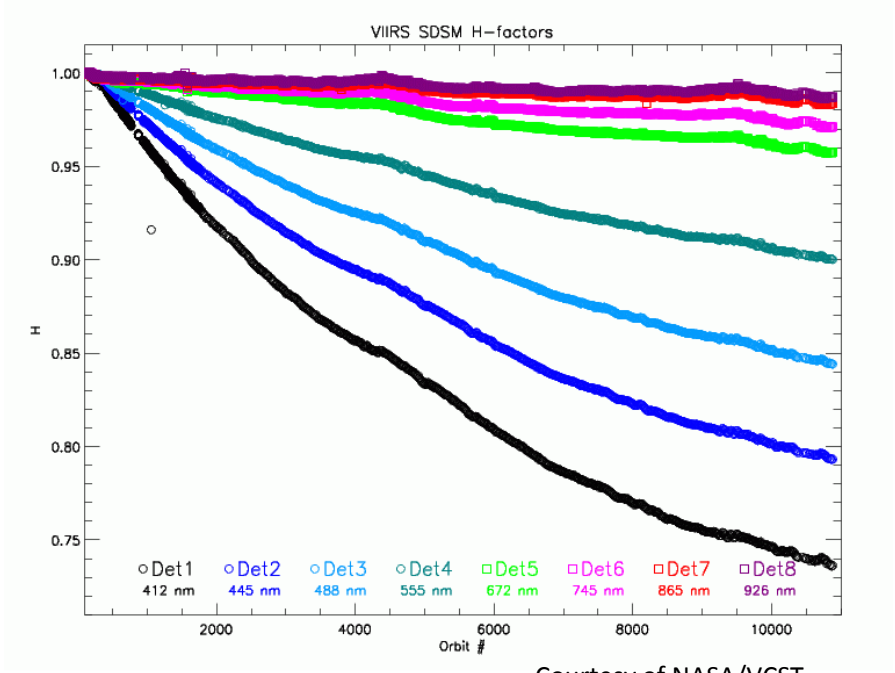
Images Courtesy: https://cs.star.nesdis.noaa.gov/NCC/GalleryPage04

Suomi-NPP VIIRS Long-Term Monitoring

VIIRS Mirror Degradation Status



Solar Diffuser Degradation



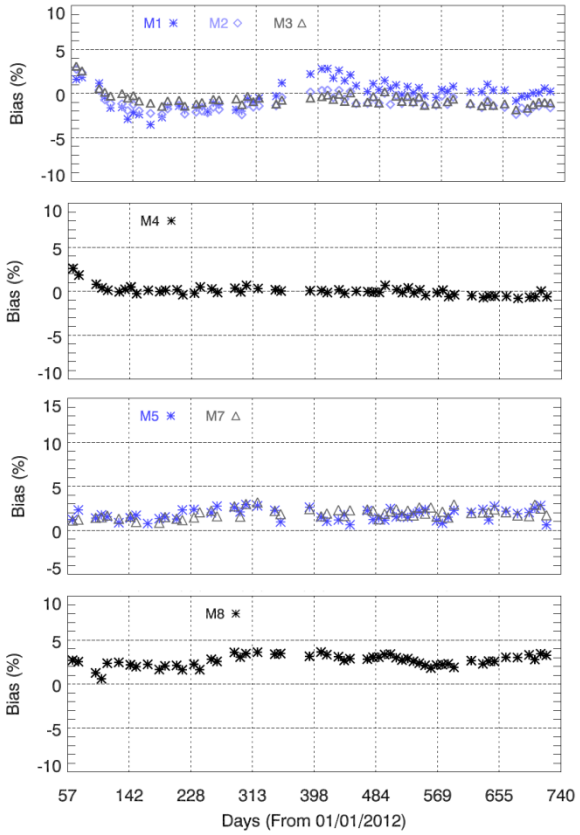
Courtesy of NASA/VCST

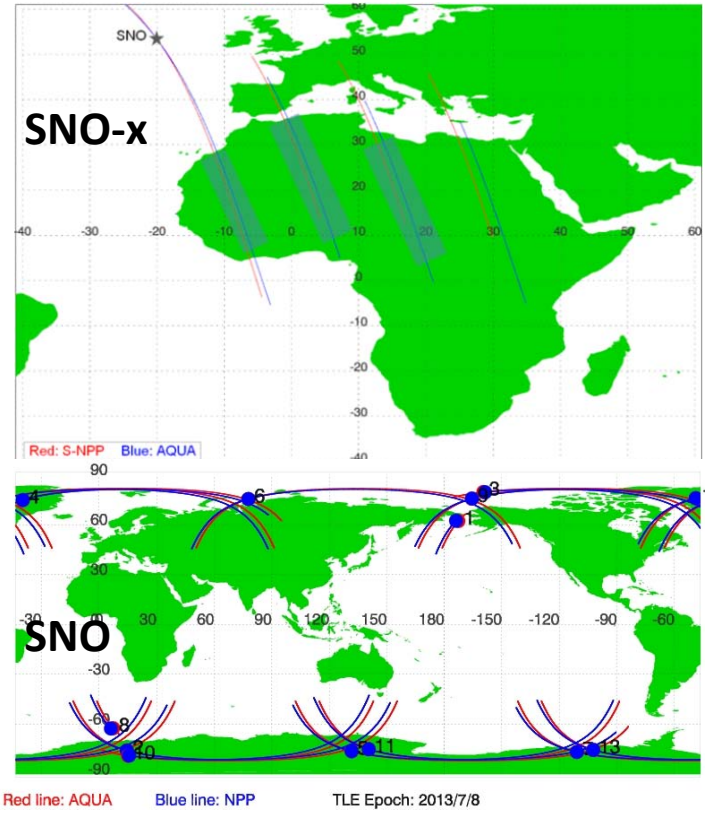
NOAA/NESDIS/STAR **Satellite Integrated Calibration / Validation System (ICVS)**
http://www.star.nesdis.noaa.gov/icvs/NPP/ipm_telemetry_npp_viirs.php

- RTA degradation leveling-off while H-factor degradation continues

VIIRS and MODIS Inter-comparison

SNO-x (N. African Desert)



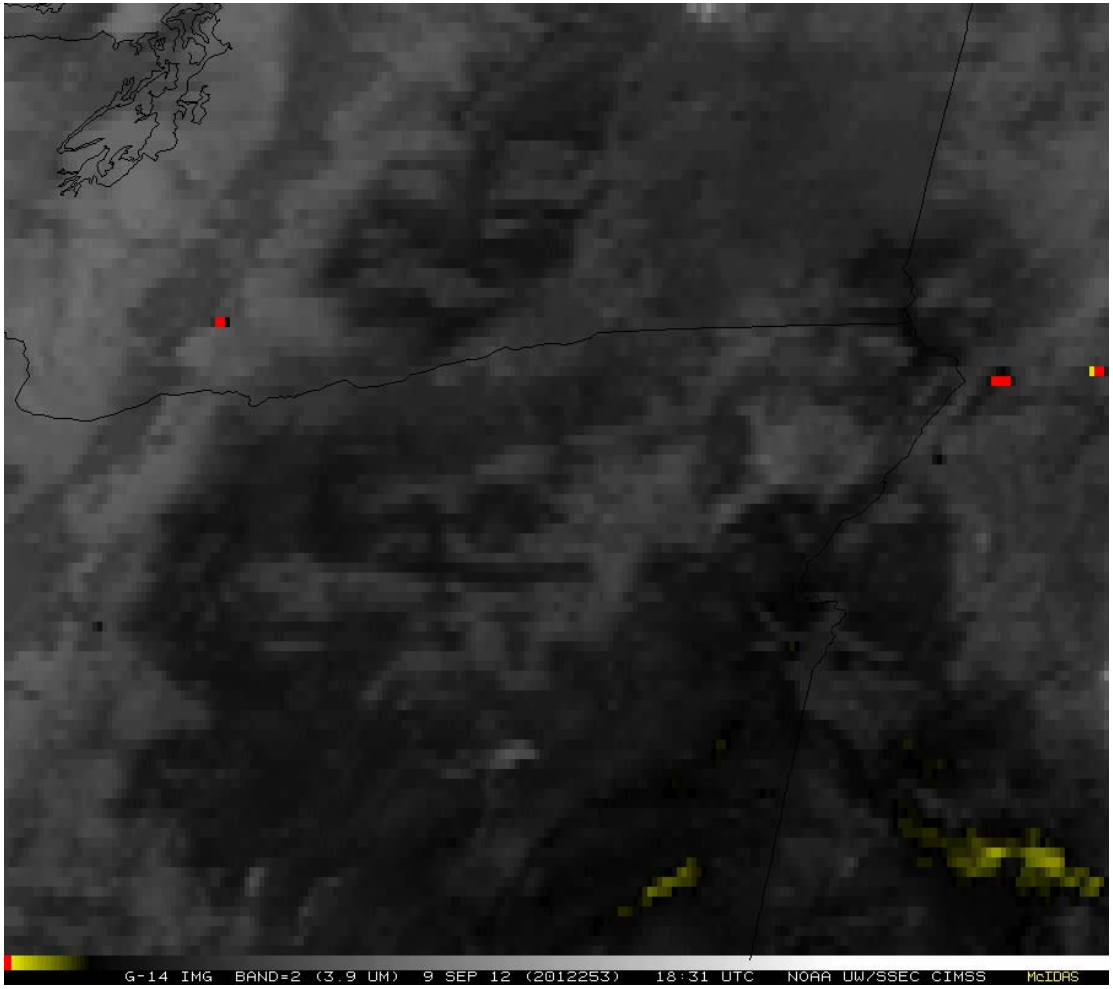


Through the second year of the Suomi NPP on orbit operations, the biases between VIIRS and MODIS SNO measurements in the reflective solar bands have remained small and mostly within the combined 2% uncertainty requirements for VIIRS and MODIS

Uprety, Sirish, Changyong Cao, Xiaoxiong Xiong, Slawomir Blonski, Aisheng Wu, Xi Shao, 2013: Radiometric Inter-comparison between Suomi-NPP VIIRS and Aqua MODIS Reflective Solar Bands Using Simultaneous Nadir Overpass in the Low Latitudes. J. Atmos. Oceanic Technol., 30, 2720–2736.
doi: http://dx.doi.org/10.1175/JTECH-D-13-00071.1

GOES Program Update

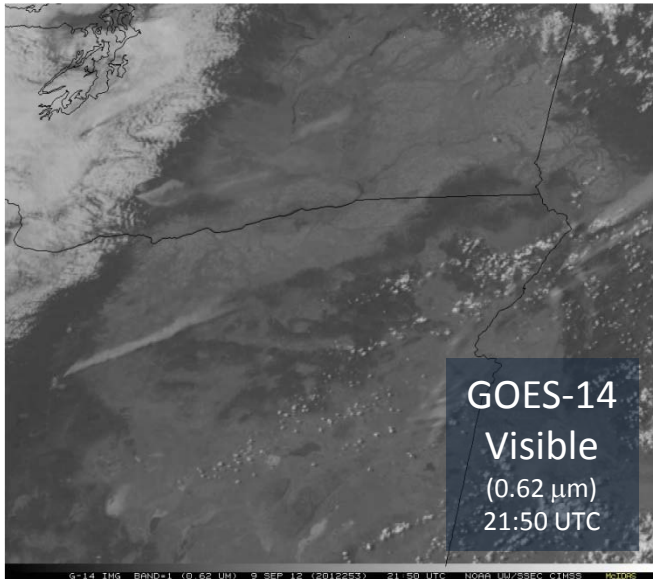
GOES-14 Super Rapid Scan Operations to Prepare for GOES-R



« GOES-14
1 minute IR Imagery
(3.9 μm)

GOES-14 provided very unique data and offered a glimpse into the possibilities that will be provided by the ABI on GOES-R in one minute mesoscale imagery

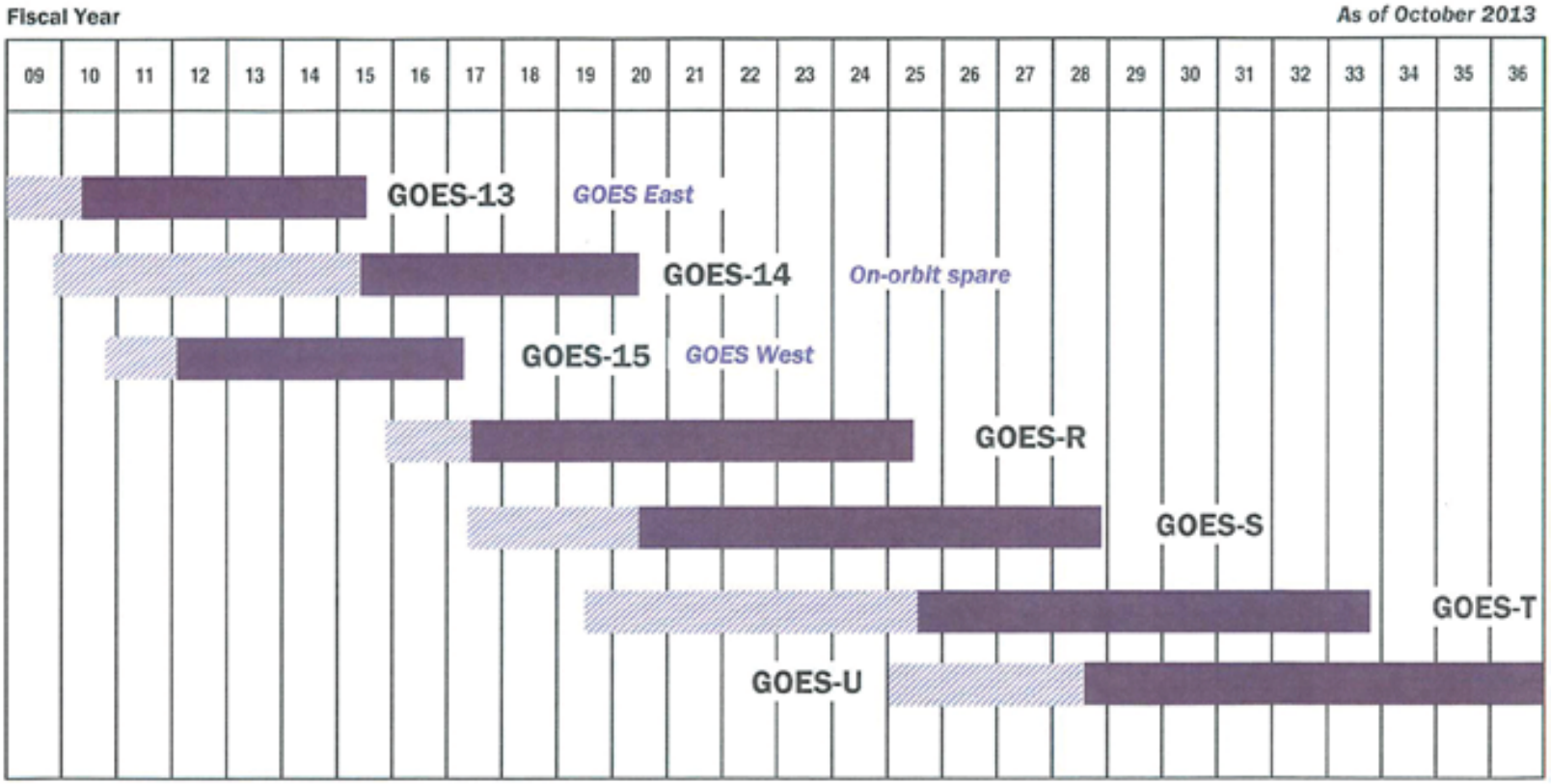
Images Courtesy: Tim Schmit (NOAA)



http://remotesensing.spiedigitallibrary.org/data/Journals/APPRES/926148/JARS_7_1_073462_ds005.mov

http://cimss.ssec.wisc.edu/goes/srsor/800x900_GOES_B1_RSRSO_FIRES_OR_ID_animated_2012253_180000_182_2012253_220000_182_X.mov

Continuity of GOES Mission



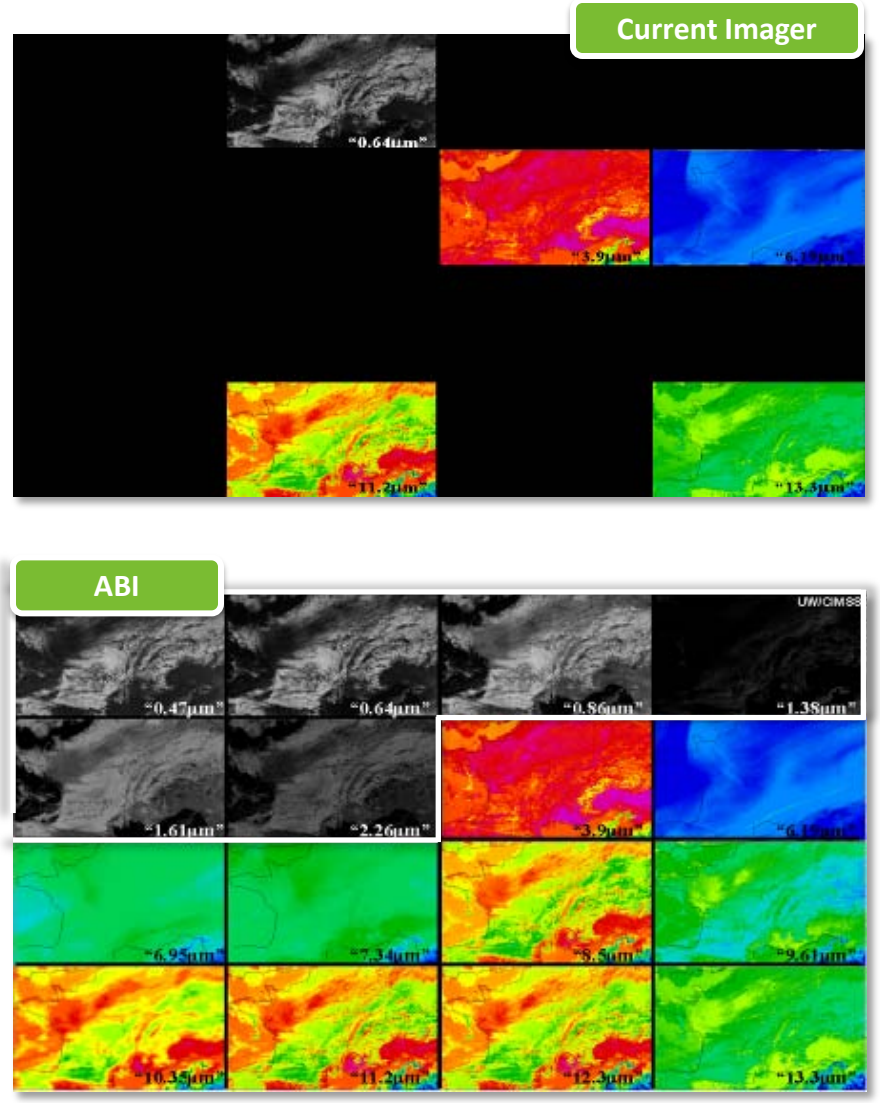
Approved: Mary E. Kicza

Assistant Administrator for Satellite and Information Services

GOES: Geostationary Operational Environmental Satellite

- On-orbit storage
- Operational
- Operational beyond design life

GOES-R Advanced Baseline Imager (ABI)



http://cimss.ssec.wisc.edu/goes/abi/

ABI is the next generation GOES Imager

GOES-R is scheduled to launch in 2015

	Current	ABI
Spectral Coverage	5 Bands	16 Bands
Spatial Resolution		
0.64 μm visible	1.0 km	0.5 km
Other visible/near-IR	N/A	1.0 km
1.38 μm	N/A	2 km
Bands > 2μm	4 km	2 km
Spatial Coverage		
Full disk	Scheduled (3 hrs)	4 per hour
Visible (Reflective)		
On-orbit calibration	No	Yes

- **Increase in spectral coverage facilitates more quantitative products**
- **Increased emphasis on calibration**

GOES-R ABI Cal/Val Update

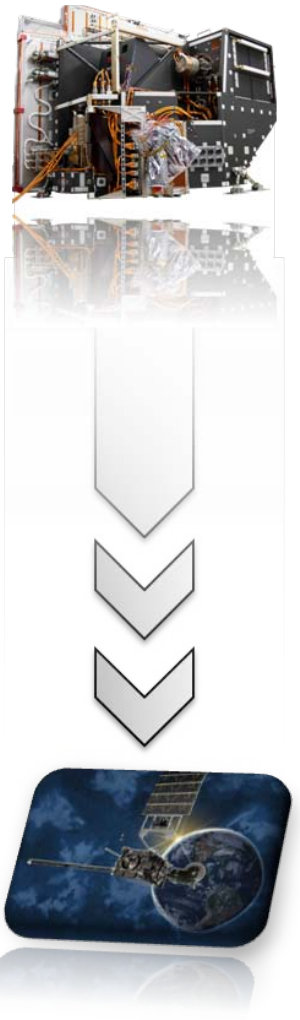
Instrument Status:

- » Calibration Working Group (CWG) pre-launch assessment of GOES-R ABI complete:
  - Successful GOES-R ABI Pre-Shipment Review held September 24-26 in Fort Wayne, IN
  - ABI FM1 instrument can proceed towards shipment
- » CWG is continuing pre-launch support for GOES-S ABI

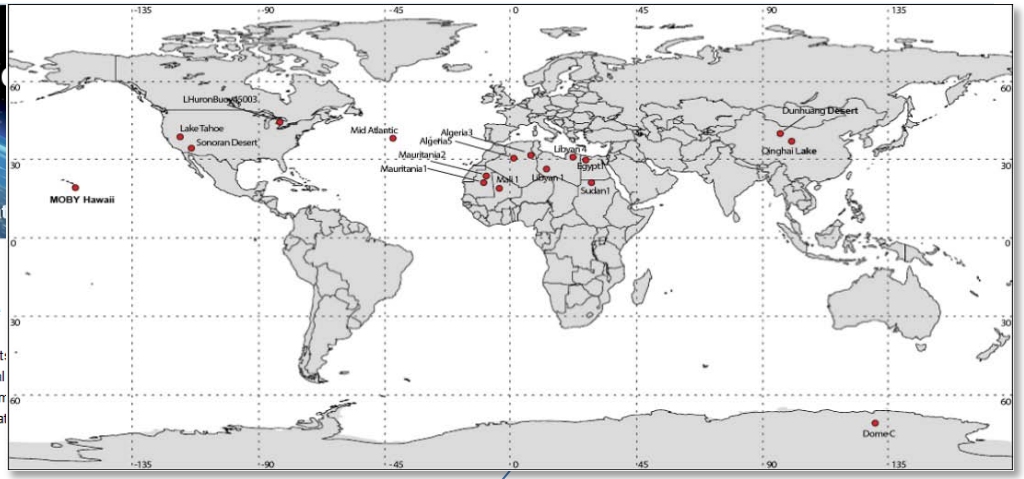
- Version 2 of GOES-R ABI SRFs released:
  - » Significant differences exist from version 1
  - » Update reflects results from pre-launch testing and analysis
    - https://cs.star.nesdis.noaa.gov/GOESRCWG/ABISRF

Post-Launch Readiness:

- CWG is well positioned to provide post-launch support and ensure ABI's performance throughout the lifetime of the instrument
  - » Ramping up support for GOES-R post-launch efforts:
    - » Post-Launch Test (PLT), Science Tests, and Long-Term Monitoring
    - » Leveraging the VIIRS Post Launch Activities (57 tasks), current GOES PLT, and others
- Collaborating with Japan Meteorological Agency (JMA) to enhance GOES-R Readiness
  - » Himawari-8 Advanced Himawari Image (AHI), planned to launch in the Fall of 2014, a sister instrument to the future GOES-R ABI
  - » NOAA Memorandum Of Understanding (MOU) between NESDIS and JMA:
    - *"JMA shares with NOAA early on-orbit calibration and instrument performance data"*
    - NOAA will host JMA visiting scientist
  - » Use Suomi-NPP VIIRS as a transfer radiometer to perform inter-comparisons between AHI and ABI, presented at the 2014 American Meteorological Society Annual meeting



NCC Calibration Knowledge Base Updated



NCC

- Home
- Terms of Reference
- Publication Database
- About
- GOES-R
- NPP/JPSS/VIIRS
- NPP/JPSS/OMPS
- NOAA/AVHRR
- NOAA/SSU
- MetOp
- JASON
- DSCOVR
- Space Weather
- Standards
- Lunar Calibration
- Calibration Sites
- Calibration Facilities
- Portable Instruments
- Tools

You are here: Foswiki > NCC Web > VIIRS (06 Feb 2014, ChangyongCao)

Visible Infrared Imaging Radiometer Suite

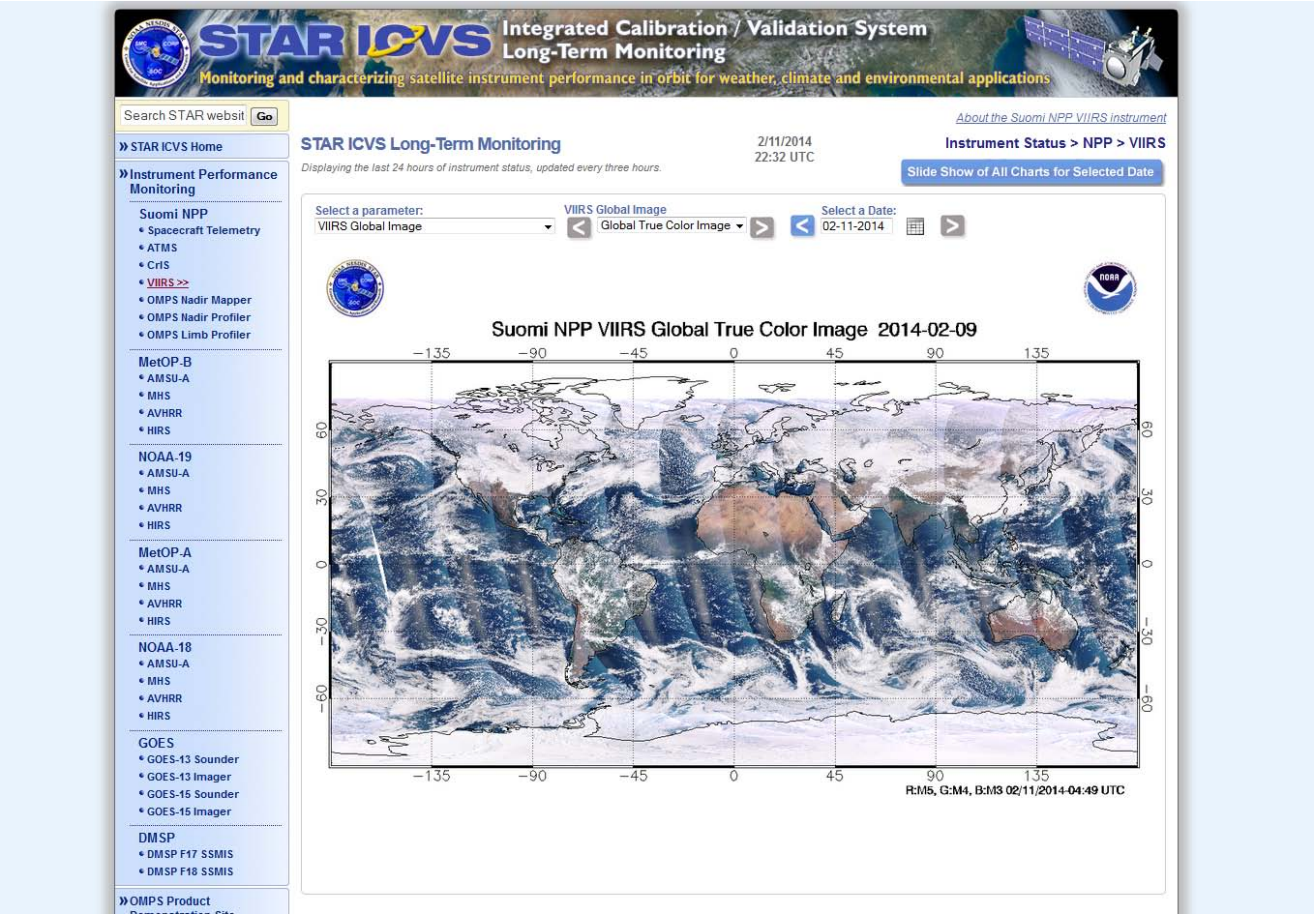
The Visible Infrared Imaging Radiometer Suite (VIIRS) is one of the key instrument
was opened on November 21, 2011, which enables a new generation of operational
operational environmental monitoring and numerical weather forecasting, with 22 in
records including clouds, sea surface temperature, ocean color, polar wind, vegetat
calibration and validation have shown that VIIRS is performing very well.

News and Documents	VIIRS Performance and Monitoring	Data and Software
News	VIIRS Longterm Monitoring	VIIRS Image Gallery
Publication Database	VIIRS On-orbit Performance Table	VIIRS data on CLASS
VIIRS Users Guide	Standardized Calibration Parameters	VIIRS data on ftp site (90 days)
VIIRS Calibration ATBD	VIIRS Spectral Response Functions	Data on GRAVITE
Conference Presentations	VIIRS Event Log Database (experimental)	VIIRS Software Tools
VIIRS Novel Applications	NPP/AQUA SNO Predictions	Planck Calculator for Infrared Remote Sensing
VIIRS SDR Data Format	Radiometric Intercomparison with MODIS	VIIRS Line Spread Function along scan
VIIRS SDR Meetings	VIIRS at Cal/Val Sites	
VIIRS FAQ	Lunar Calendar for DNB	SDR/EDR Team
About VIIRS	Moon in Space View Events	Standard Radiometric Test Scenes
	Validation Site Time Series	

VIIRS paper: Cao, C., X. Shao, X. Xiong, S. Blonski, Q. Liu, S. Uprety, X. Shao, Y. Bai, F. Weng, Suomi NPP VIIRS sensor data record verification, validation, and long-term performance monitoring, Journal of Geophysical Research: Atmospheres. DOI: 10.1002/2013JD020418. 2013. **(click here)**

https://cs.star.nesdis.noaa.gov/NCC

NOAA/NESDIS/STAR Satellite Integrated Calibration/Validation System (ICVS)

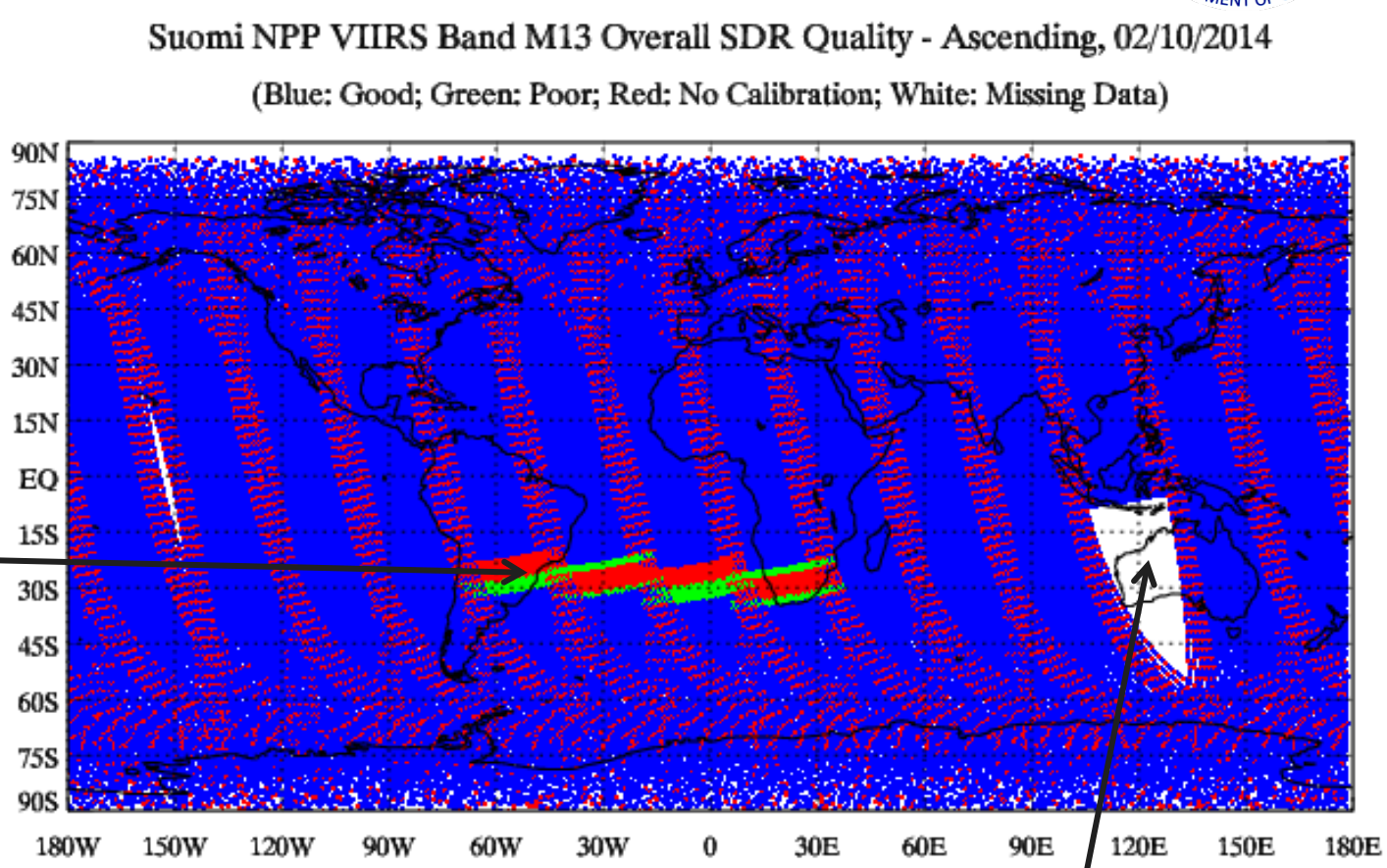


- **ICVS supports:**
  - » Suomi NPP, MetOP-A, MetOP-B, NOAA-18, NOAA-19, DMSP, & GOES instruments
- **Currently preparing for GOES-R**

Long-Term Monitoring: VIIRS Quality Flag Mapping (ICVS)

VIIRS SDR Quality Flag

- good
- poor
- no calibration
- missing data



Data flagged due to Moon in Space View

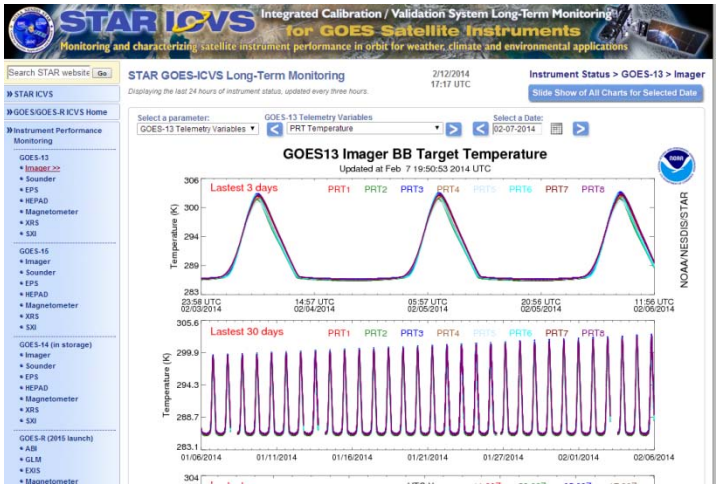
Missing VIIRS Earth View (EV) data due to lunar maneuver event

ICVS VIIRS SDR quality flag map:

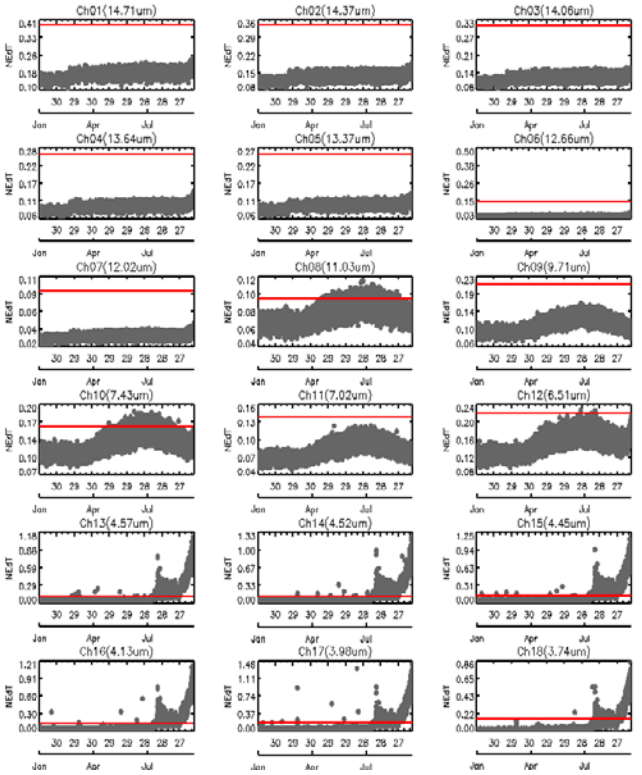
- » Produced for each band daily for both ascending and descending orbits
- » Demonstrated to be an important tool to investigate VIIRS global data quality and to identify events that impact data quality

GOES/GOES-R ICVS Development

- To provide instrument scientists with calibration healthy status and users with the information regarding the satellite data quality for product generation
- As part of NOAA STAR ICVS, the GOES ICVS continues to evolve for the instrument performance and radiance quality monitoring
- While still under development, it already played a key role in detecting the calibration anomaly, diagnosing the root cause and assessing the impacts of anomalous events.



Current GOES/GOES-R ICVS Development.



An example of GOES-13 Sounder IR noise expressed as NEdT@300K from Jan. 1, 2012 to Sept. 23, 2012 before the GOES-13 shutdown event on Sept. 23, 2012. The jumped and elevated noise at LW channels were apparent since July 2012.

GSICS - CEOS collaboration

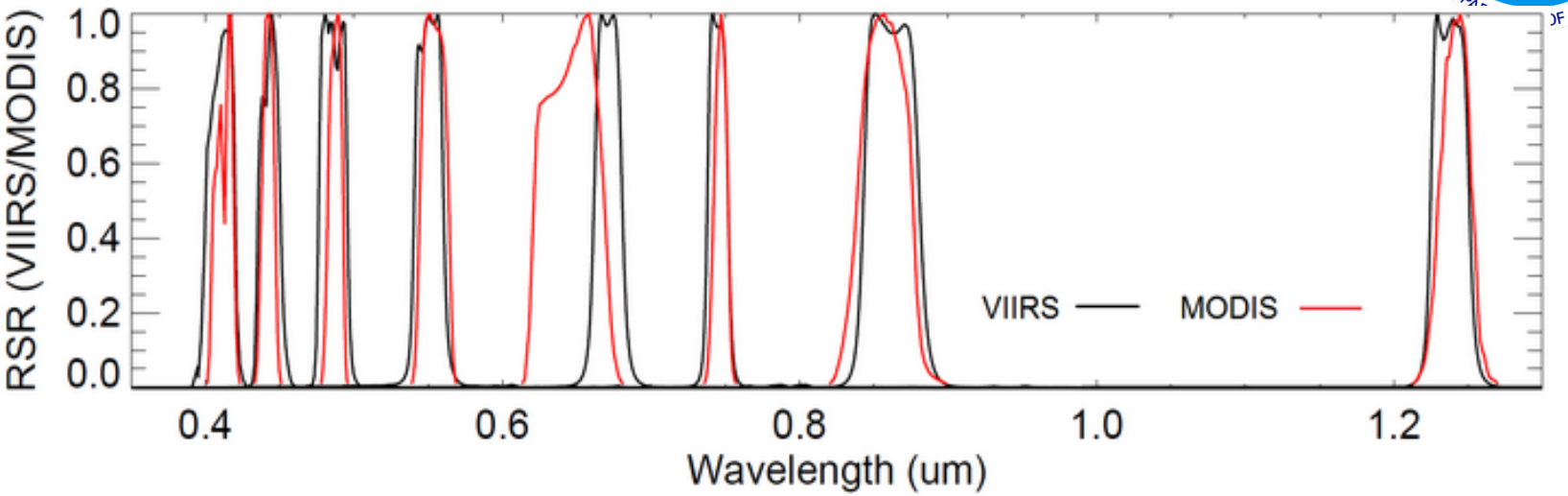
- **2009: IVOS: Best Practice Guideline for Pre-launch Characterization and Calibration of Instruments for Passive Optical Remote Sensing**
- **2011: QA4EO: Design of GSICS Procedure for Product Acceptance**
- **2012: IVOS: Cooperative development of vicarious methods/model validation**
- **2013: IVOS: Special Issue of TGARS on Inter-Calibration**

GSICS: Bali,M Flynn,L Wu, F Hewison, T

Summary

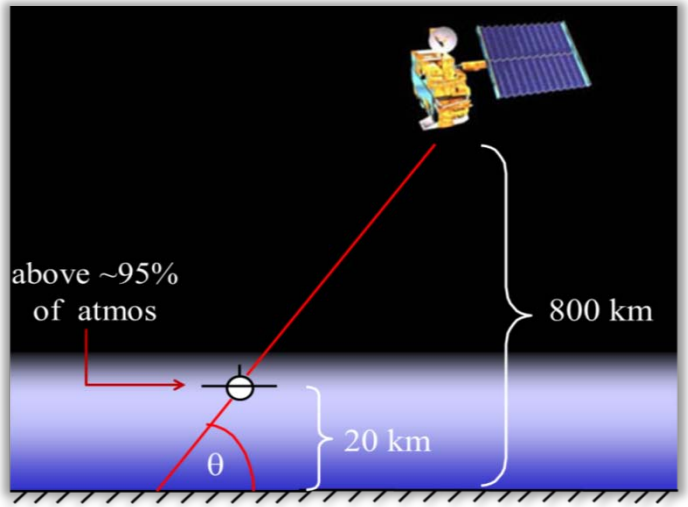
- Suomi-NPP VIIRS achieved Calibrated/Validated Maturity Status at the science level (to be announced March 2014)
  - » VIIRS radiometric performance is very good
- NOAA scientists are leading post-launch SDR Cal/Val and long-term monitoring for all major NPP instruments
  - » Continue pre-launch Cal/Val support and analysis of J1
- Successful GOES-R Pre-Shipment Review
  - » ABI has been qualified with overall excellent radiometric performance per-launch
  - » Continue pre-launch Cal/Val support and analysis of GOES-S
  - » Preparations for GOES-R post-launch activities
- Continued development of the NOAA ICVS monitoring system

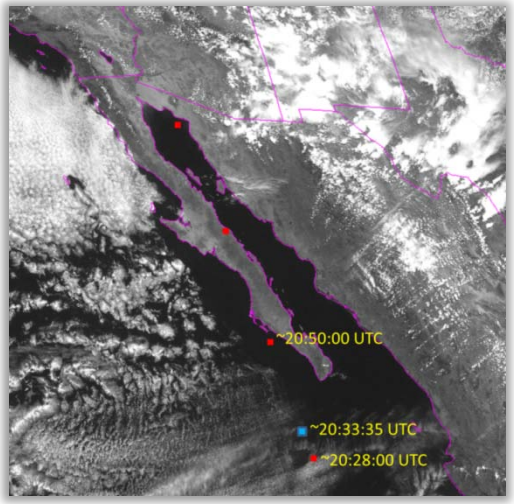
Backup slide



VIIRS and MODIS matching bands used in the inter-comparison			
VIIRS		MODIS	
Band	Wavelength (μm)	Band	Wavelength (μm)
M1	0.402 - 0.422	8	0.405 - 0.420
M2	0.0.436 - 0.454	9	0.438 - 0.448
M3	0.0.478 - 0.498	10	0.483 - 0.493
M4	0.0.545 - 0.565	4	0.545 - 0.565
M5	0.662 - 0.682	1	0.620 - 0.670
M6	0.739 - 0.754	15	0.743 - 0.753
M7	0.846 - 0.885	2	0.841 - 0.876
M8	1.230 - 1.250	5	1.230 - 1.250

S-NPP Field Validation Campaigns: NASA ER-2 Underflights





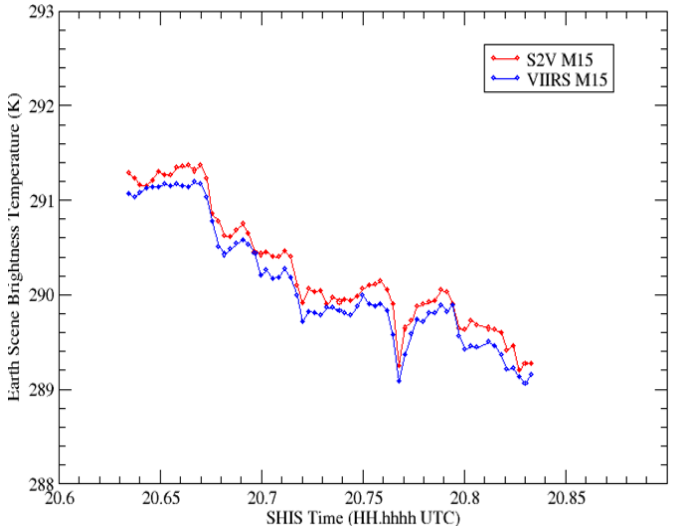
- VIIRS SDR accuracy evaluation
- SHIS (NIST-traceable blackbody source, 0.1 K)
- MASTER (50 m spatial resolution mapping)
- 3 underflights for S-NPP

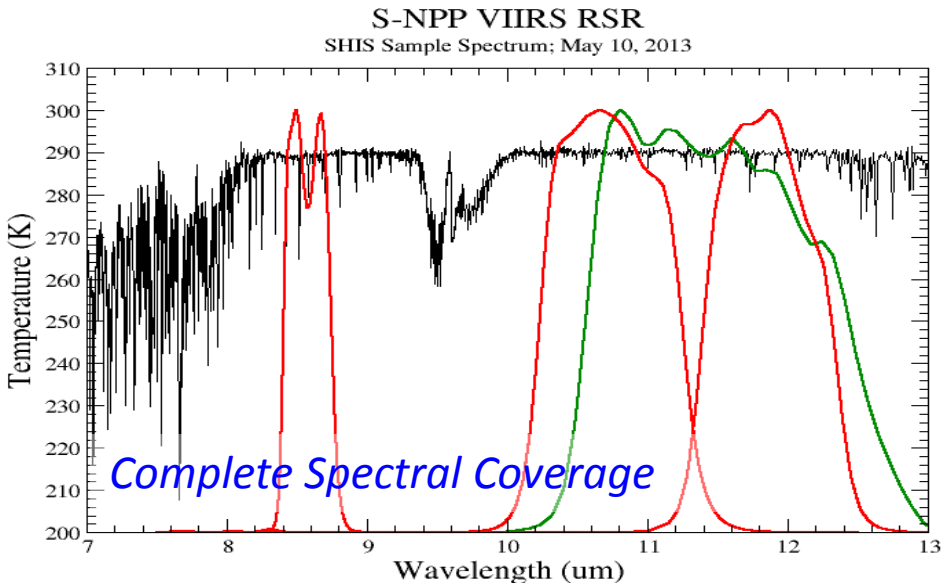
RSS Total Uncertainty Estimate

~0.12 K (I4, I5, M12, M13, M15, M16)

0.21 K (M14)

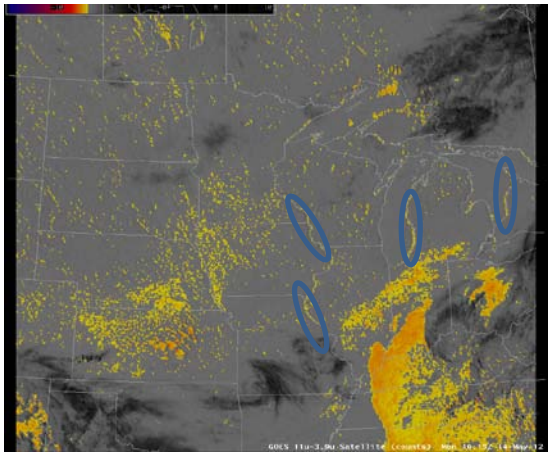
SHIS – VIIRS Comparison



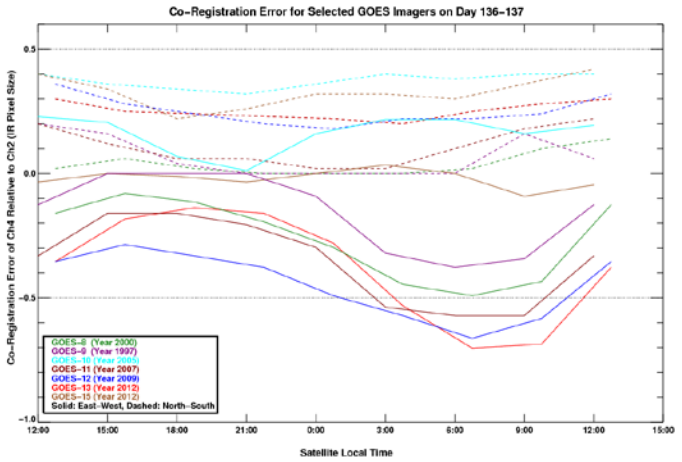


GOES Imager IR Co-registration Error

- Users reported co-registration error between GOES-13 Imager Ch2 and Ch4 caused “false” fog product
- NOAA found that this co-registration error exists at all GOES Imagers with diurnal/seasonal variation patterns, which were later confirmed by the vendor
- An operational mitigation algorithm was developed by NOAA and currently under implementation.



“False” fog products, by CIMSS/UW



Diurnal co-registration errors at GOES-8 thru G15