Overview of the Suomi National Polar-orbiting Partnership (NPP) Sensor Data Records from CrIS, ATMS, VIIRS and OMPS

Fuzhong Weng, Suomi NPP/JPSS SDR Chair
Center for Satellite Applications and Research (STAR)
National Oceanic and Atmospheric Administration (NOAA)

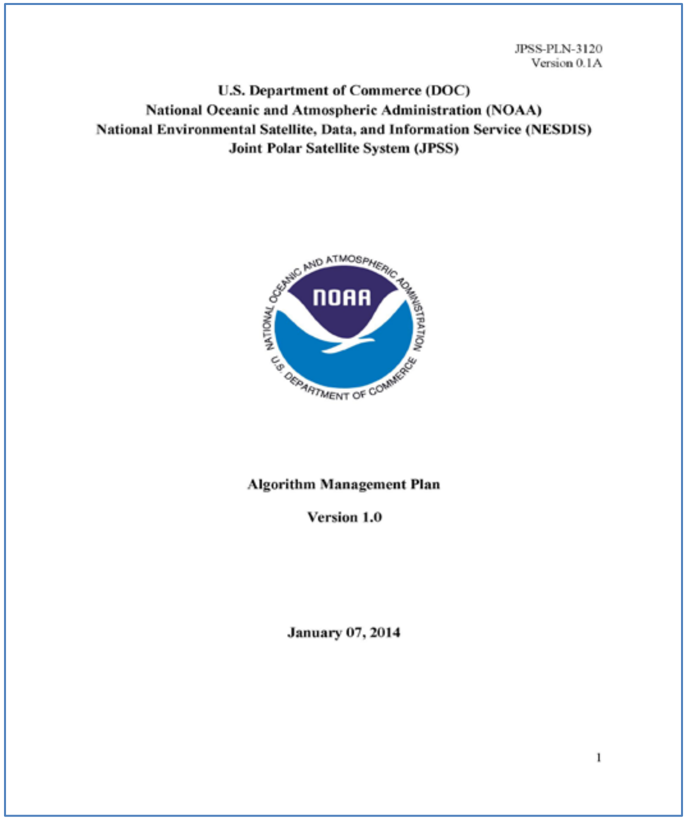
With Contributions from JPSS SDR Team Leads and

many other SDR Science Team Members

2014 STAR JPSS Science Teams Annual Meeting
May 12-16, 2014
5830 University Research Court, College Park, MD 20740

SDR/LTM Scope Defined in JPSS Algorithm Management Plan

- The SDR teams have the expertise to implement the SDR sensor calibration and to plan, manage and carry out sensor algorithm activities that will be required during pre-launch, operations, and sustainment to meet mission goals and requirements.
- The SDR Senior Lead (SDR Chair) defines the resources required for the science teams as well as coordinates activities. The SDR teams perform data analysis, produce on-orbit look-up tables for SDR algorithms, generate or validate operational SDR algorithms and maintain instrument SDRs.
- The SDR teams conduct monitoring and analysis of sensor parameters to determine modifications in both the ground processing and flight tables to maintain accuracy and stability of the SDRs.
- The teams work with the evolution of the S-NPP algorithms to JPSS-1 and JPSS-2 requirements as described in the JPSS L1RD, JPSS L1RD Supplement, and the JPSS System Requirements Specification.
- The four SDR teams are each assigned to one of the four sensors: Visible-Infrared Imaging Radiometer Suite (VIIRS) , Cross-Track Infrared Sounder (CrIS), Advanced Technology Microwave Sounder (ATMS) , Ozone Mapping Profiler Suite (OMPS), and any other sensor used to satisfy the JPSS L1RD
- The SDR teams identify and develop corrections for existing SDR algorithms, define requirements for the sensor test program, monitor long-term instrument performance and sensor trending, and provide re-analysis of sensor performance over the sensor lifetime & across satellite platforms.
- The SDR teams will establish the operational criteria and thresholds and maintain them through coordination with the STAR Long-Term Monitoring Team.
- The SDR team coordinates with instrument and flight projects to assure essential project elements are implemented efficiently.
- The STAR LTMS team will track and maintain sensor health and data product quality over the life of the mission by leveraging tools and collaborations between STAR and OSPO already in place. The LTMS tools and findings will support the operational flight and ground segments and will continue to support ongoing collaborations with Office of Satellite Products and Operations (OSPO) and NDE operational teams. The LTMS functions are provided both before and after the transition of the ground system to NOAA operations.



JPSS-PLN-3120
Version 0.1A

U.S. Department of Commerce (DOC)
National Oceanic and Atmospheric Administration (NOAA)
National Environmental Satellite, Data, and Information Service (NESDIS)
Joint Polar Satellite System (JPSS)

Algorithm Management Plan

Version 1.0

January 07, 2014

1

SNPP SDR Products Review for Declaring the Validated Maturity

Attendees for SUOMI NPP SDR Product Review Meeting in NOAA Center for Weather and Climate Prediction Auditorium

Review Outcomes: SNPP SDR Products Review Meeting was held on Dec. 18-20, 2013. NESDIS Senior Management Leads: Ms. Mary Kicza and Dr. Al Powell attended the review. The Cal/Val team scientists presented the results on their specific calval tasks and NWP and other users NWS/NOS offered their independent assessments of data product quality based on their intensive cal/val analyses. The review panel recommended that the CrIS, ATMS and VIIRS SDR products be ready to be declared validated scientifically. And three remaining issues were recommended to resolve before OMPS EV SDR goes to the validated stage: cross-track effects in NM need to be addressed; Stray-light improvements still needed in NP SDR; Artificial separation between EV SDR and Cal SDR should be eliminated

Significance: Suomi NPP CrIS and ATMS SDR products are continuing NOAA afternoon orbits sounding data for NWS NWP radiance assimilation. It is shown from CEP global forecast system (GFS) and ECMWF global models that uses of CrIS and ATMS data have similar or slightly better impacts on the global medium-range forecasts

Suomi NPP TDR/SDR Algorithm Schedule

Sensor	Beta	Provisional	Validated
CrIS	February 10, 2012	February 6, 2013	March 18, 2014
ATMS	May 2, 2012	February 12, 2013	March 18, 2014
OMPS	March 7, 2012	March 12, 2013	June, 2014
VIIRS	May 2, 2012	March 13, 2013	April 16, 2014

Beta

- Early release product.
- Initial calibration applied
- Minimally validated and may still contain significant errors (rapid changes can be expected. Version changes will not be identified as errors are corrected as on-orbit baseline is not established)
- 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

Provisional

- Product quality may not be optimal
- Incremental product improvements are still occurring as calibration parameters are adjusted with sensor on-orbit characterization (versions will be tracked)
- 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 consult the SDR product status document prior to use of the data in publications
- Ready for operational evaluation

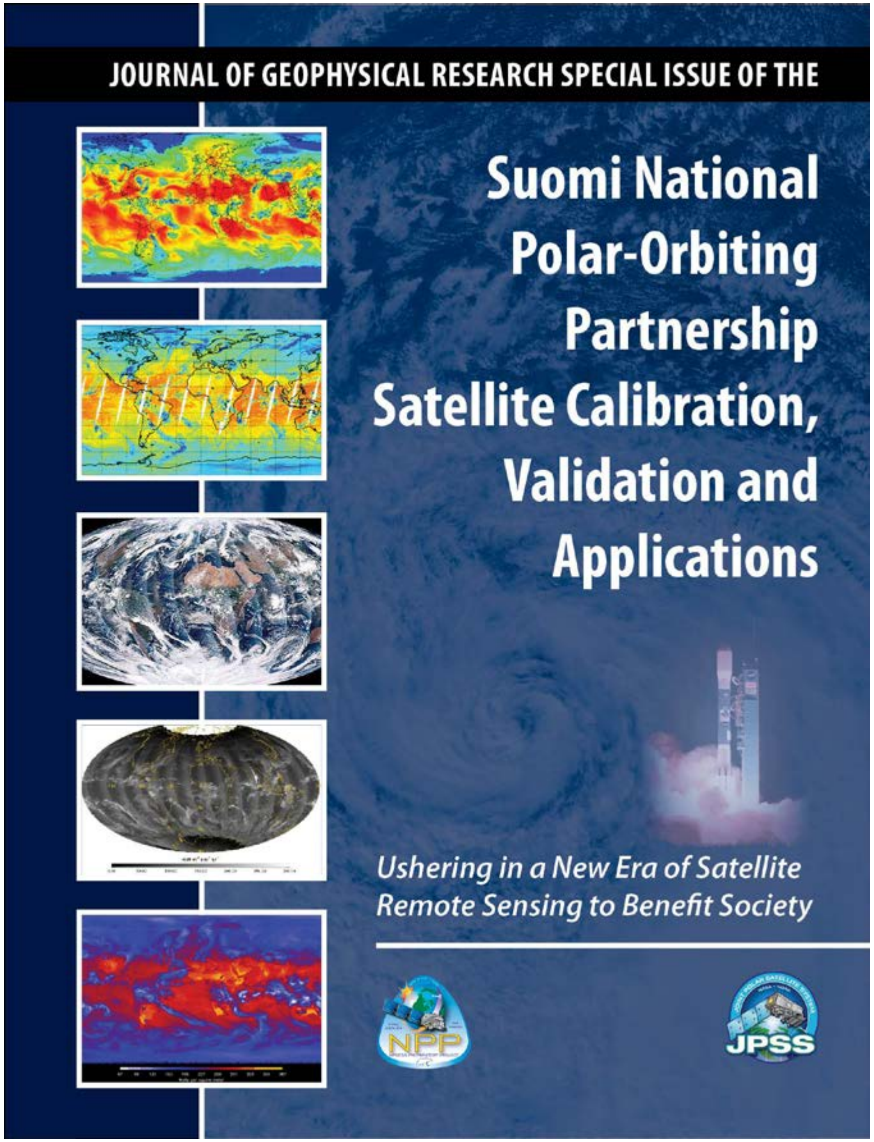
Validated

- On-orbit sensor performance characterized and calibration parameters adjusted accordingly
- Ready for use in applications and scientific publications
- There may be later improved versions
- There will be strong versioning with documentation

JGR Special Issue on Suomi NPP CalVal

34 papers have been accepted in AGU Journal Geophysical Research Special Issue on Suomi NPP satellite calibration, validation and applications.

Guest Editor: Fuzhong Weng



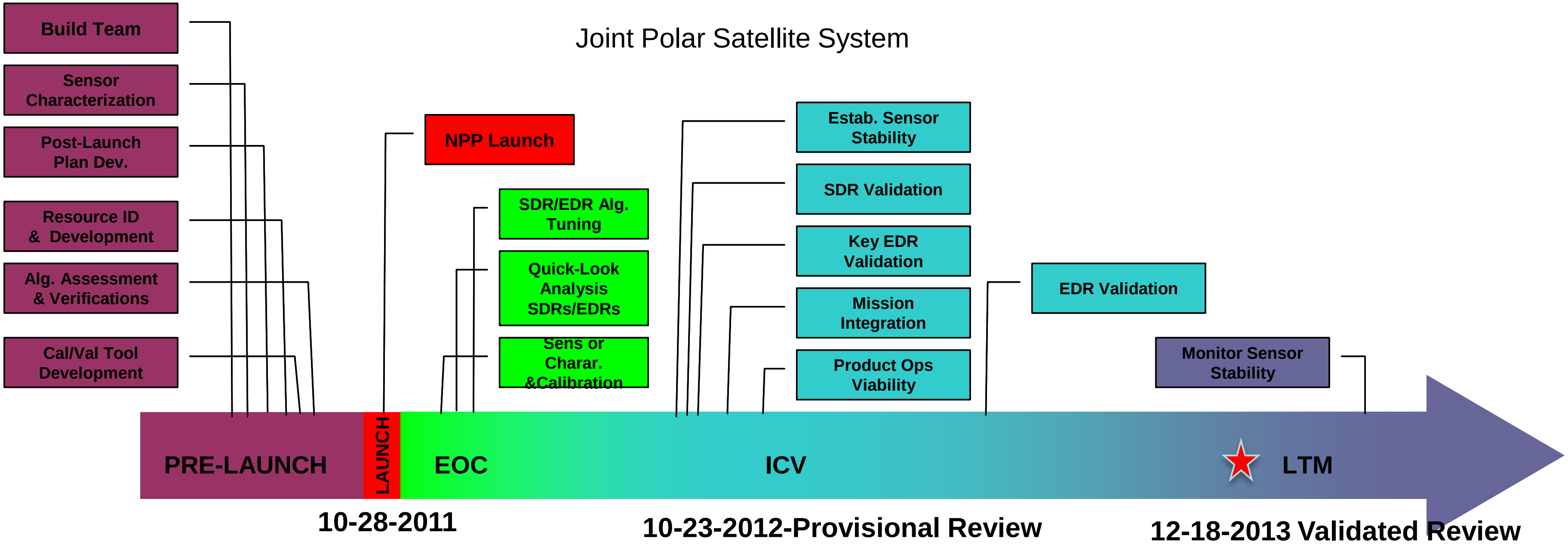
JOURNAL OF GEOPHYSICAL RESEARCH SPECIAL ISSUE OF THE

Suomi National Polar-Orbiting Partnership Satellite Calibration, Validation and Applications

Ushering in a New Era of Satellite Remote Sensing to Benefit Society

Suomi NPP Calibration/Validation Schedule

- Four Phases of Cal/Val:
  1. Pre-Launch; all time prior to launch – Algorithm verification, sensor testing, and validation preparation
  2. Early Orbit Check-out (first 30-90 days) – System Calibration & Characterization
  3. Intensive Cal/Val (ICV); extending to approximately 24 months post-launch – xDR Validation
  4. Long-Term Monitoring (LTM); through life of sensors after ICV
- For each phase:
  - Exit Criteria established
  - Activities summarized
  - Products mature through phases independently



Joint Polar Satellite System

Build Team

Sensor Characterization

Post-Launch Plan Dev.

Resource ID & Development

Alg. Assessment & Verifications

Cal/Val Tool Development

NPP Launch

SDR/EDR Alg. Tuning

Quick-Look Analysis SDRs/EDRs

Sens or Charar. &Calibration

Estab. Sensor Stability

SDR Validation

Key EDR Validation

Mission Integration

Product Ops Viability

EDR Validation

Monitor Sensor Stability

PRE-LAUNCH

LAUNCH

EOC

ICV

LTM

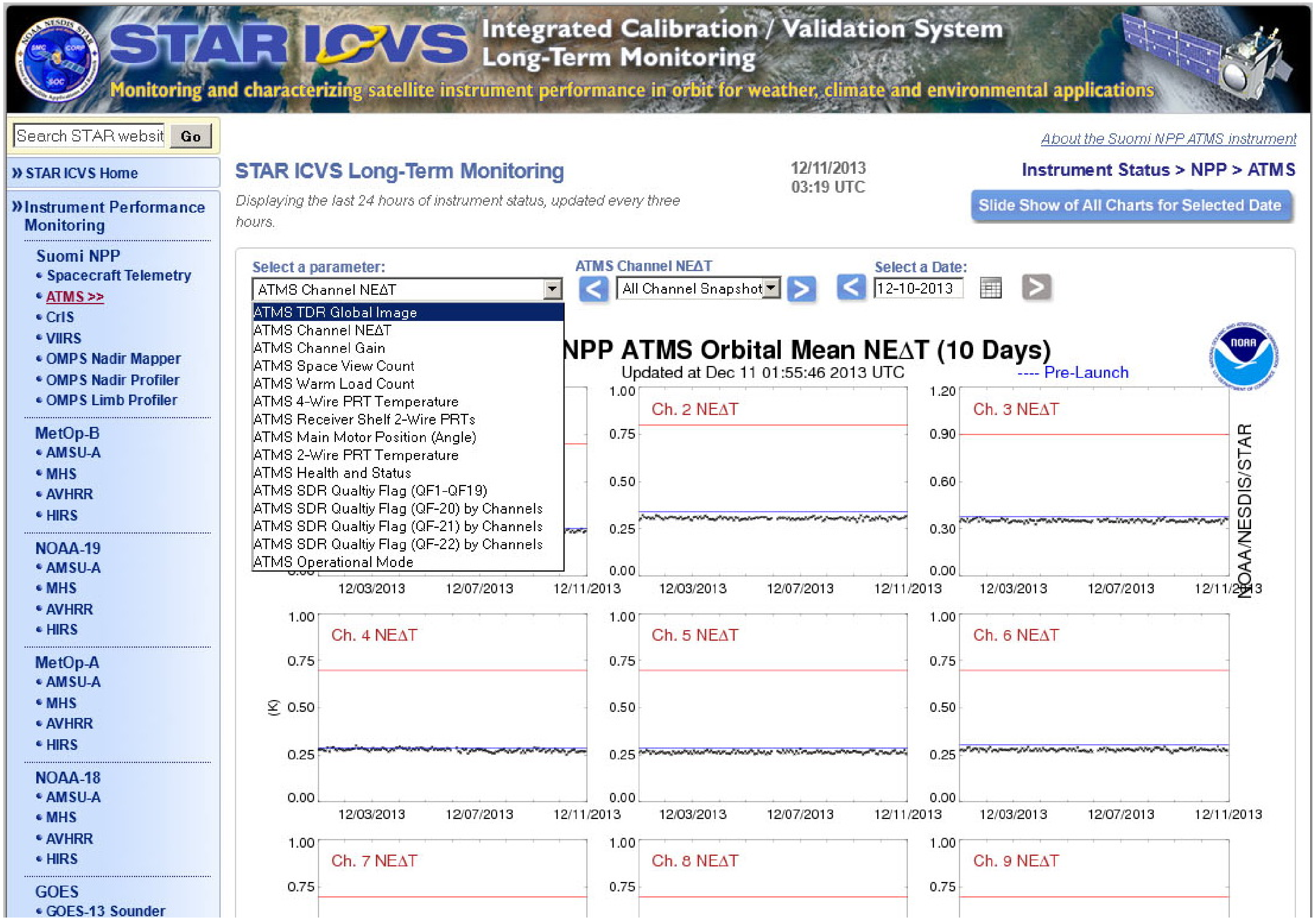
10-28-2011

10-23-2012-Provisional Review

12-18-2013 Validated Review

STAR ICVS-LTM for SNPP/JPSS

http://www.star.nesdis.noaa.gov/icvs/status_NPP_ATMS.php



STAR ICVS Long-Term Monitoring

Displaying the last 24 hours of instrument status, updated every three hours.

12/11/2013
03:19 UTC

Instrument Status > NPP > ATMS

Select a parameter: ATMS Channel NEΔT

ATMS Channel NEΔT: All Channel Snapshot

Select a Date: 12-10-2013

JPSS STAR Science Team Annual Meeting
ATMS SDR Team Report

Fuzhong Weng

ATMS SDR Lead

May 12, 2014

2014 STAR JPSS Science Teams Annual Meeting
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Outline

- Overview
  - Products, Requirements, Team Members, Users, Accomplishments
- SNPP Algorithm 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

ATMS SDR Calibration Requirements

- ATMS is a new generation of microwave sounding instrument. Compared to AMSU-A, and MHS, it has
  - a higher spatial resolution for better detection of severe weather features
  - more channels at WG bands to better delineate atmospheric water vapor
  - overlapping field of views that can be used for resampling and noise reduction
- Calibration requirements for ATMS are much more stringent than for AMSU, and include prelaunch data analysis and post-launch characterization of
  - instrument noise behavior including striping index, power spectrum and NEDT
  - calibration accuracy, nonlinearity and gain stability
  - detection and correction of lunar intrusion in cold target observations
  - scan angle dependent bias from antenna emission and polarization
  - generation of three SDR products: TDR, SDR, and RSDR

NOAA Microwave Calibration Prior to SNPP

- One federal scientist, Tsan Mo who retired in March 31, 2014, was in charge of all the operational calibration of AMSU/MHS instruments

- Other projects supported through NOAA climate data program and led by Cheng-zhi Zou on cross calibration of MSU and AMSU for climate data record

- STAR-based CalVal supported one contract scientist , Ninghai Sun, to develop the Integrated CalVal System (ICVS) for microwave applications

- Interactions with OSPO and EUMETSAT on operational upgrades of SDR or L1B algorithms were effective and efficient

- But, advanced calibration sciences have been generally lacking due to the resource limitation

New Approaches for ATMS SDR CalVal

- Builds a strong SDR science team which is participated by the key stakeholders
- Works closely with NASA on all the instrument related issues
- Develops innovative theory, analysis and methodology in ATMS calibration
- Utilizes unique SNPP and JPSS mission opportunities to learn new science
- Enhances STAR ICVS for real-time monitoring of SNPP instruments
- Works with NWP user community for timely feedbacks on ATMS SDR data quality
- Outreaches to the broad communities through peer-review papers
- Actively organizing JPSS meeting and attending various conferences (e.g. ITSC, IGARSS, AMS)

ATMS Calibration Team

PI Name	Organization	Team Members	Primary Role and Responsibility
Fuzhong Weng/Ninghai Sun	NOAA	T. Yang, M. Tian	Budget, Coordination, TVAC analysis, SDR sciences &algorithm, SRF, Long-term monitoring
Lin Lin/Andrew Collard	JCSDA/NCEP	Y. Chen	SRF analysis, LBLRTM, bias characterization, coordination with NWP users
Edward Kim	NASA	J. Lyu	NASA ATMS instrument scientist, TVAC data, instrument anomaly investigation
William Blackwell	MIT/LL	V. Leslie	Support NPP/J1 Calval, SDR sciences, PCT/LUT, prelaunch TVAC data analysis
Xiaolei Zou	NGI/FSU	Z. Qin, Y. Ma	Striping analysis and mitigation, cross calibration
Kent Anderson	NGES	M. Landrum	NGES ATMS instrument engineer
Degui Gu	NGAS	A. Foo	Algorithm test and integration for IDPS operations
Wael Ibrahim	Raytheon		IDPS operations
Kris Robinson	USU/SDL		ATMS geolocation error characterization

JPSS Science POCs and Leads at NOAA/NASA

Program
Mitch Goldberg – NOAA Program Scientist
Jim Gleason – NASA Project Scientist

Flight Project
Jim Butler – Project Scientist

ATMS
Ed Kim – Instrument Scientist

CrIS
Dave Johnson – Instrument Scientist

OMPS
Glen Jaross – Instrument Scientist

VIIRS
Kurt Thome – Instrument Scientist

CERES
Kory Priestley – Instrument Scientist

Ground Segment - SDR
Fuzhong Weng – STAR SDR Lead
Bruce Guenther – DPA SDR Lead

ATMS SDR
Fuzhong Weng – ATMS SDR Lead

CrIS SDR
Yong Han – CrIS SDR Lead

OMPS SDR
Xianqian Wu – OMPS SDR Lead

VIIRS SDR
Changyong Cao – VIIRS SDR Lead

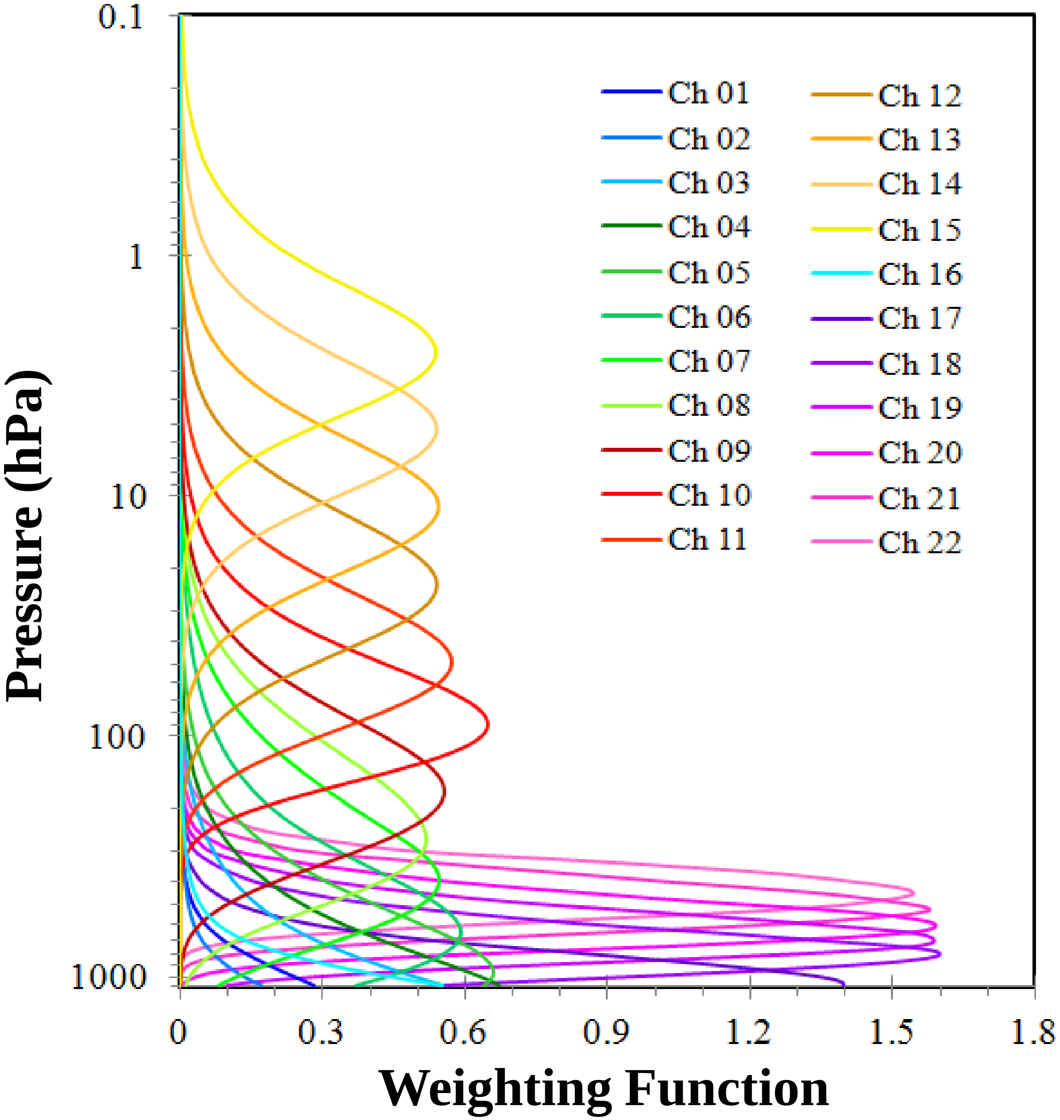
Ground Segment - EDR
Ivan Csiszar , Ingrid Guch, Paul Digacomo– STAR EDR Lead
Ray Godin– DPA EDR Lead

EDR Algorithms
Jeff Key – Cryosphere EDRs
Larry Flynn – Ozone EDRs
Ivan Csiszar – Land EDRs
Alexander Ignatov – SST EDRs
Don Hilger – Imagery EDRs
Tony Reale (acting) – Sounding EDRs
Andy Heidinger – Cloud EDRs
Istvan Laszlo – Radiation Budget EDRs
Menghua Wang – Ocean Color EDR
Shobha Kondragunta – Aerosol EDRs

MSU			AMSU/MHS			ATMS		
Ch	GHz	Pol	Ch	GHz	Pol	Ch	GHz	Pol
			1	23.8	QV	1	23.8	QV
			2	31.399	QV	2	31.4	QV
1	50.299	QV	3	50.299	QV	3	50.3	QH
						4	51.76	QH
			4	52.8	QV	5	52.8	QH
2	53.74	QH	5	53.595 ± 0.115	QH	6	53.596 ± 0.115	QH
			6	54.4	QH	7	54.4	QH
3	54.96	QH	7	54.94	QV	8	54.94	QH
			8	55.5	QH	9	55.5	QH
4	57.95	QH	9	fo = 57.29	QH	10	fo = 57.29	QH
			10	fo ± 0.217	QH	11	fo±0.3222±0.217	QH
			11	fo±0.3222±0.048	QH	12	fo± 0.3222±0.048	QH
			12	fo ±0.3222±0.022	QH	13	fo±0.3222±0.022	QH
			13	fo± 0.3222±0.010	QH	14	fo±0.3222 ±0.010	QH
			14	fo±0.3222±0.0045	QH	15	fo± 0.3222±0.0045	QH
			15	89.0	QV			
			16	89.0	QV	16	88.2	QV
			17	157.0	QV	17	165.5	QH
						18	183.31 ± 7	QH
						19	183.31 ± 4.5	QH
			19	183.31 ± 3	QH	20	183.31 ± 3	QH
			20	191.31	QV	21	183.31 ± 1.8	QH
			18	183.31 ± 1	QH	22	183.31 ± 1	QH

- 🟩 Exact match to AMSU/MHS
- 🟨 Only Polarization different
- 🟧 Unique Passband
- 🟥 Unique Passband, and Pol. different from closest AMSU/MHS channels

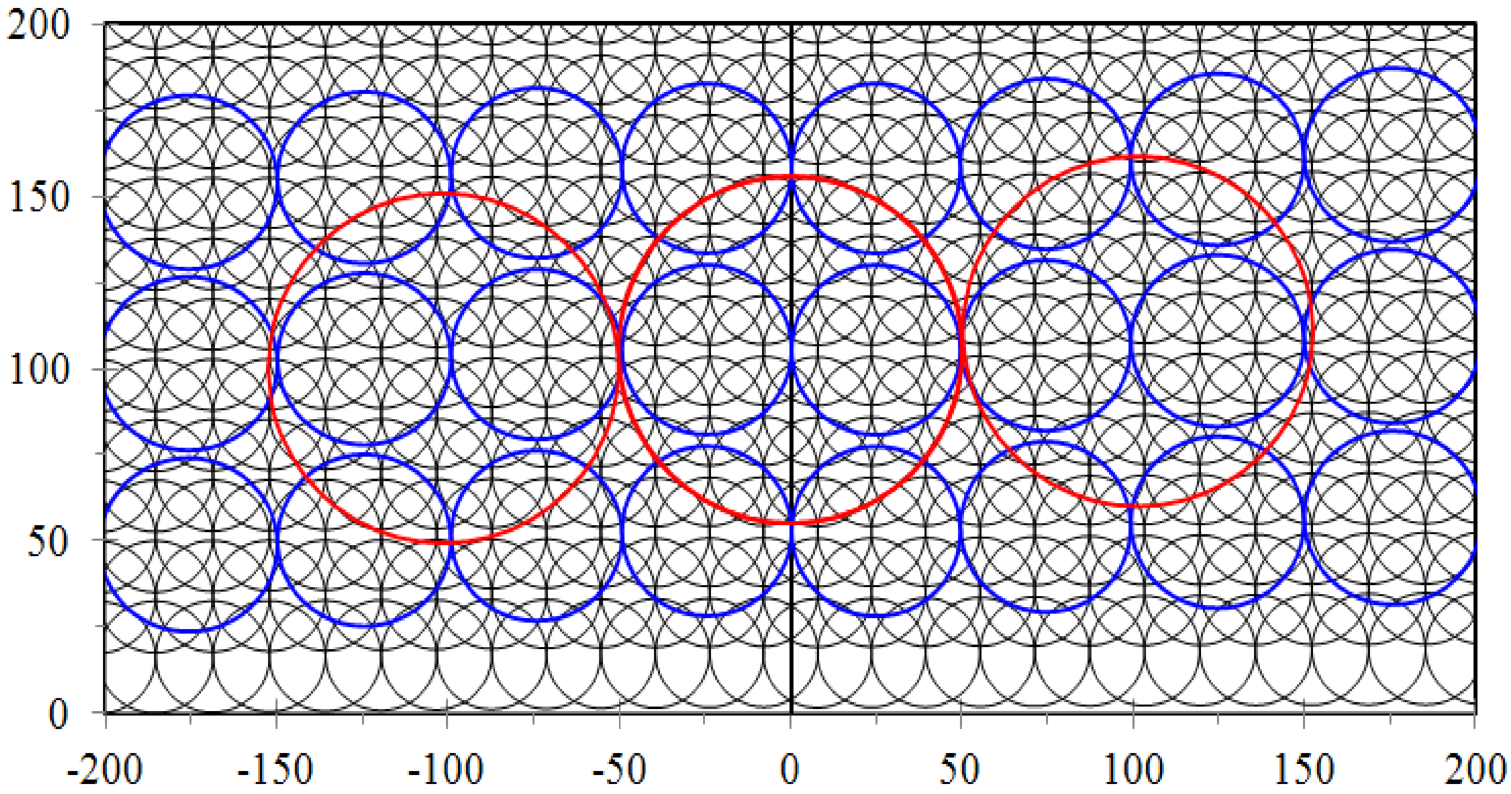
ATMS Channel Weighting Functions



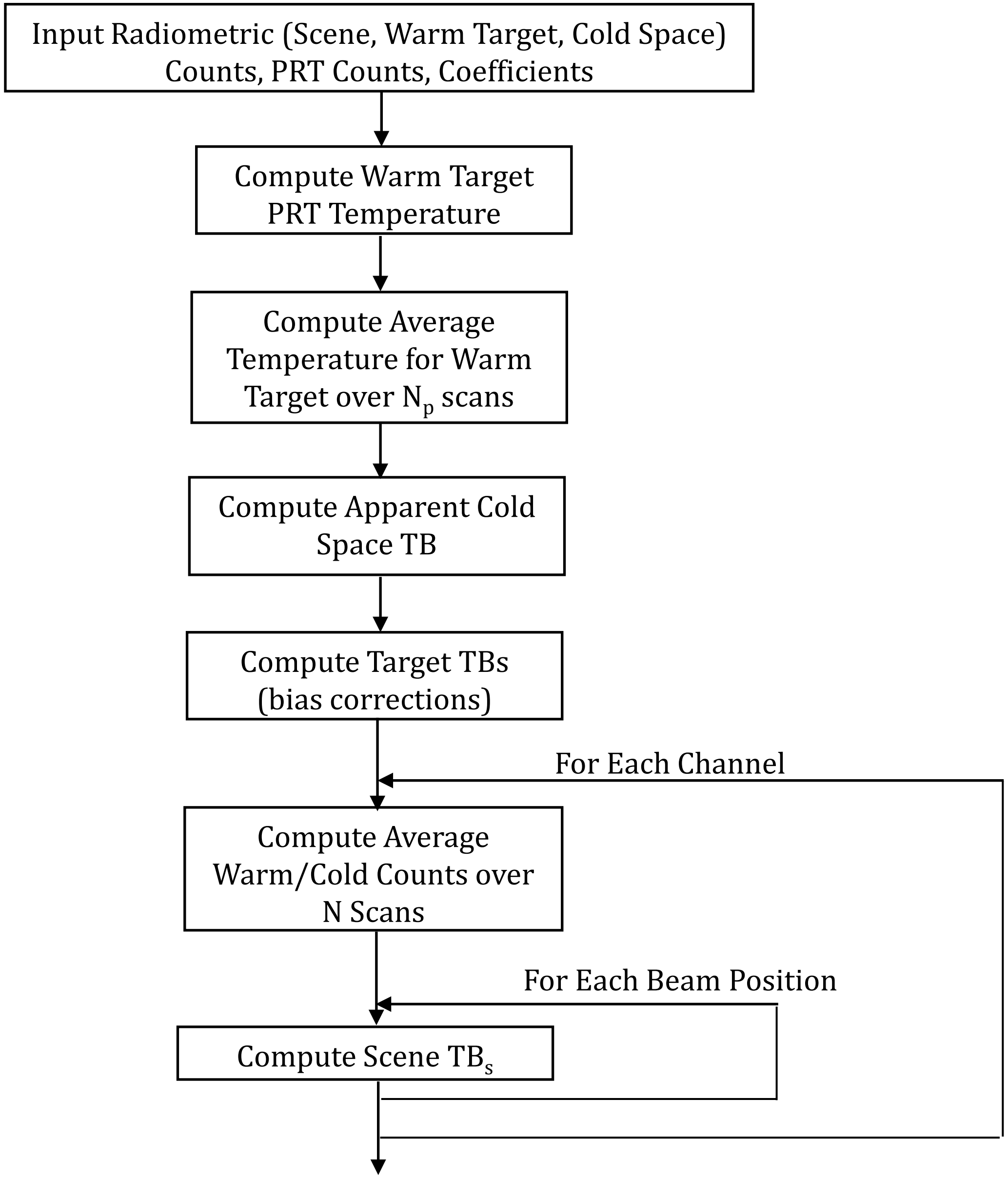
Three Generations of Microwave Sounding Instruments from MSU to AMSU/MHS to ATMS

ATMS Field of View Size for the beam width of 2.2^o – black line

ATMS Resample to the Field of View Size for the beam width of 3.3^o- blue line



ATMS Radiometric Calibration Flow Chart



Input Radiometric (Scene, Warm Target, Cold Space) Counts, PRT Counts, Coefficients

Compute Warm Target PRT Temperature

Compute Average Temperature for Warm Target over N_p scans

Compute Apparent Cold Space TB

Compute Target TBs (bias corrections)

For Each Channel

Compute Average Warm/Cold Counts over N Scans

For Each Beam Position

Compute Scene TB_s

ATMS Two-Point Calibration with Non-linearity Correction in Brightness Temperature

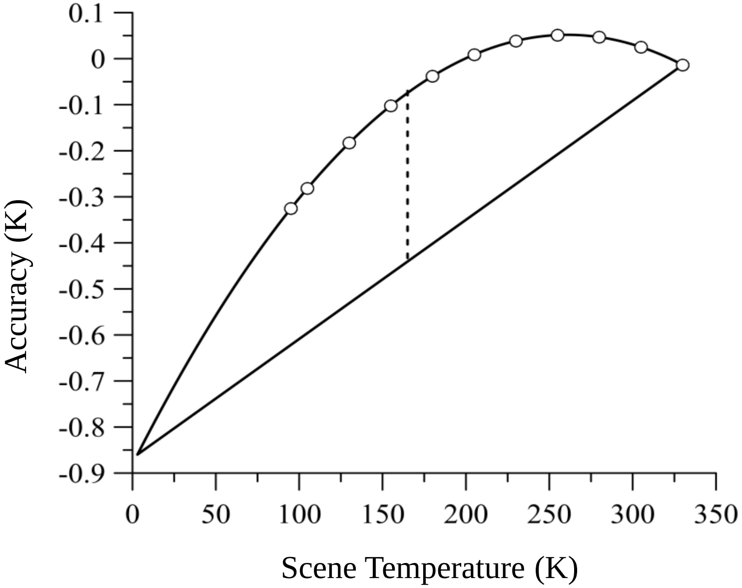
$$T_{b,ch} = T^{w}_{b,ch} + \frac{C^{s}_{ch} - \overline{C^{w}_{ch}}}{\overline{C^{w}_{ch}} - \overline{C^{c}_{ch}}}\left(T^{w}_{b,ch} - T^{c}_{b,ch}\right) + 4T_{NL}x(1-x)$$

$$\overline{C^{w}_{ch}}(i) = \sum_{k=i-N_s}^{i+N_s} \sum_{j=1}^{4} W_{k-i} C^{w}_{ch}(k,j)$$

$$\overline{C^{c}_{ch}}(i) = \sum_{k=i-N_s}^{i+N_s} \sum_{j=1}^{4} W_{k-i} C^{c}_{ch}(k,j)$$

$$\overline{G_{ch}}(i) = \frac{\overline{C^{w}_{ch}}(i) - \overline{C^{c}_{ch}}(i)}{\overline{T^{w}_{b,ch}}(i) - T^{c}_{b,ch}}$$

$$x = \frac{T_{b,l} - T_c}{T_w - T_c}$$

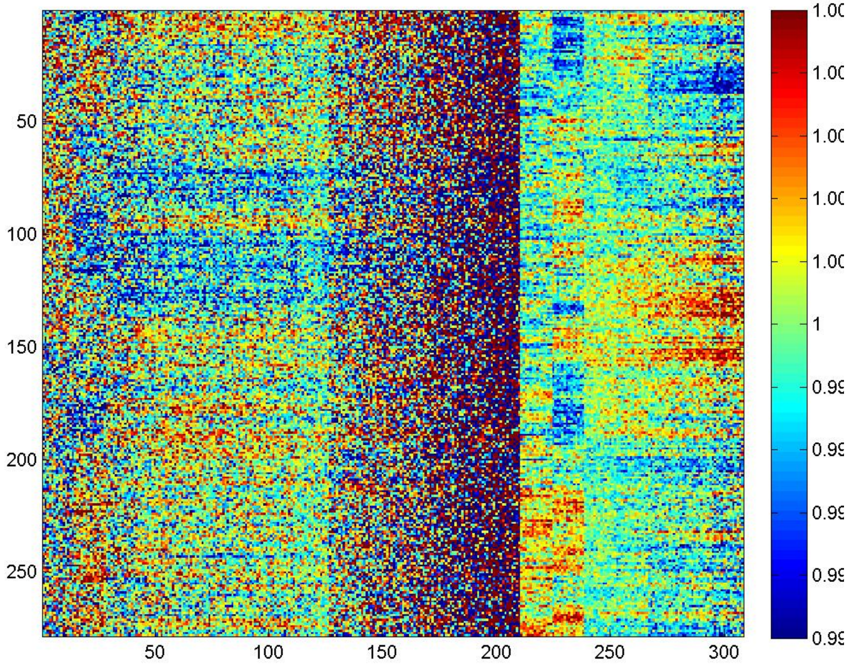


Nonlinearity of ATMS channel 1, calculated for cold plate (CP) at 5°C for redundancy configuration 1 (RC1). Blue dots represent the measured scene temperatures. Black solid curve represents the regression curve. Dashed line represents the peak nonlinearity.

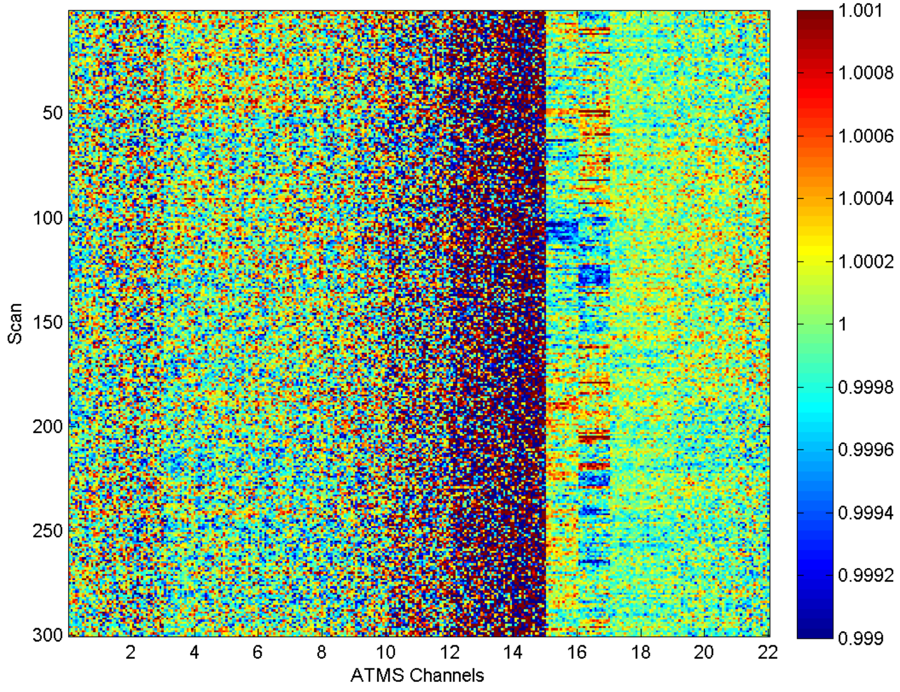
A dramatic difference from AMSU calibration is the treatment of nonlinearity term which is derived from the medium theorem and x is a parameter derived from the linear term.

Analysis of ATMS TVAC Test Data

SNPP TVAC Data (RC1 230K)

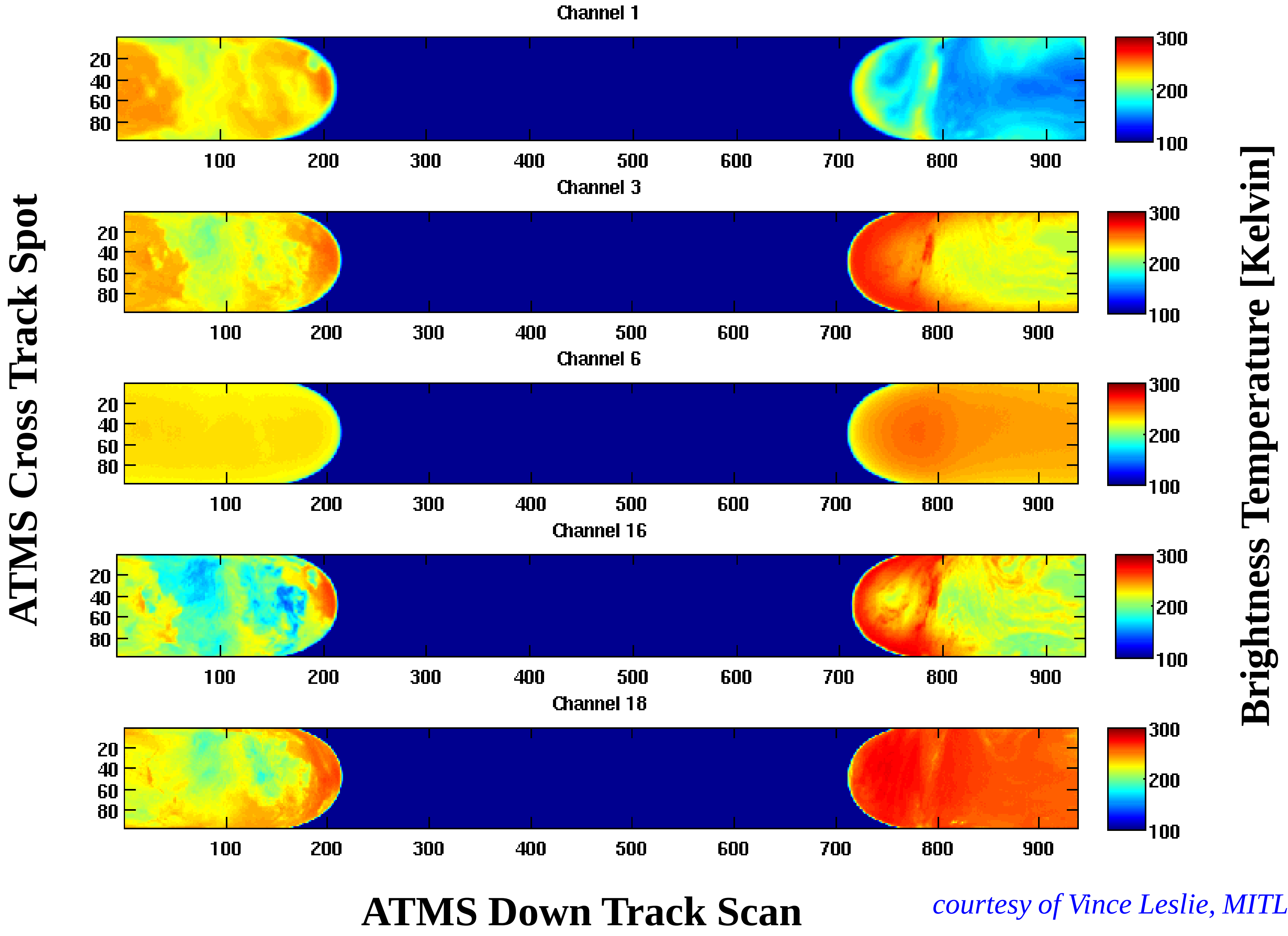


J-1 TVAC Data (RC4, 3/12/14)



Preliminary TVAC data analysis shows J1 ATMS is much cleaner than SNPP, except channel 16 and 17.

Uses of SNPP ATMS Pitch Maneuver Data
February 20, 2012

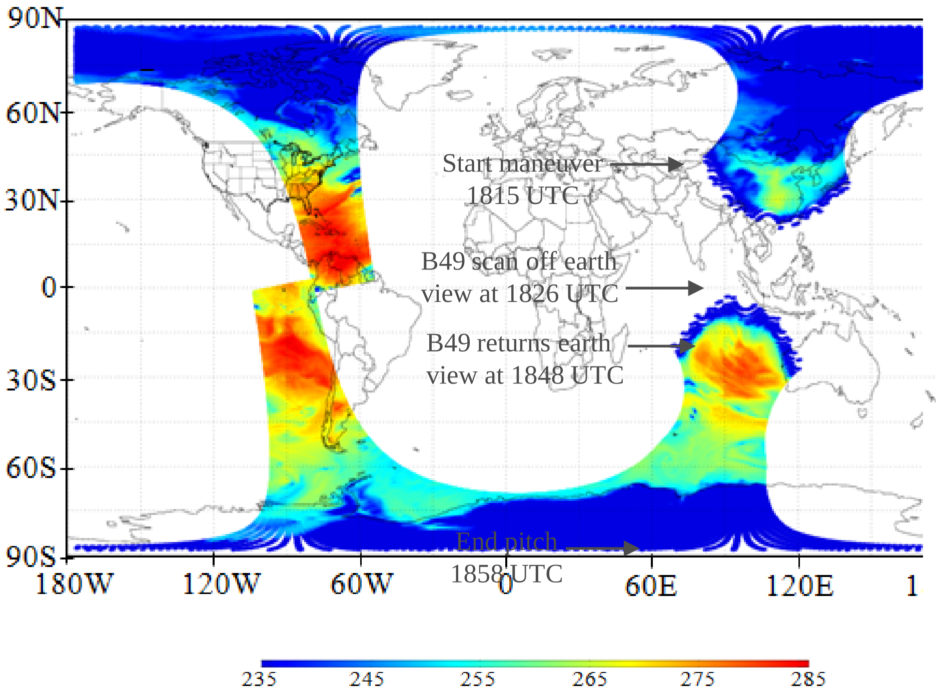


courtesy of Vince Leslie, MITLL

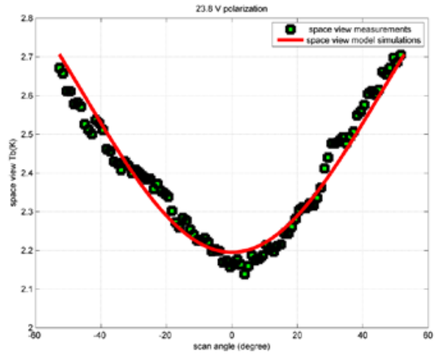
SNPP Pitch-Over Maneuver for ATMS Calibration

- Calibrated space view scene brightness temperature from IDPS are not equal to 2.7K cosmic background
- Strange scan angle dependent feature from IDPS TDR products

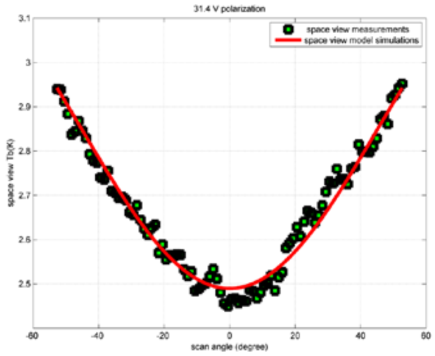
ATMS TDR at Ch18 on February 20, 2012



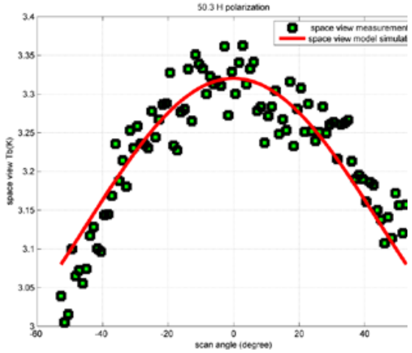
Channel 1



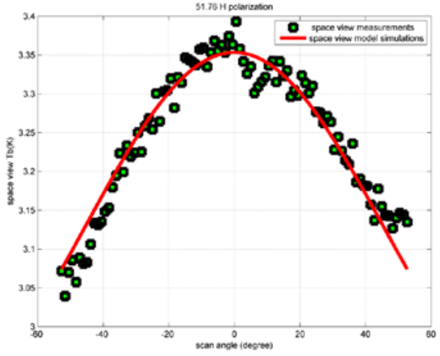
Channel 2



Channel 3



Channel 4



New ATMS SDR Algorithm Including Spill-over and Side-lobe Corrections

For Quasi-V (TDR) :

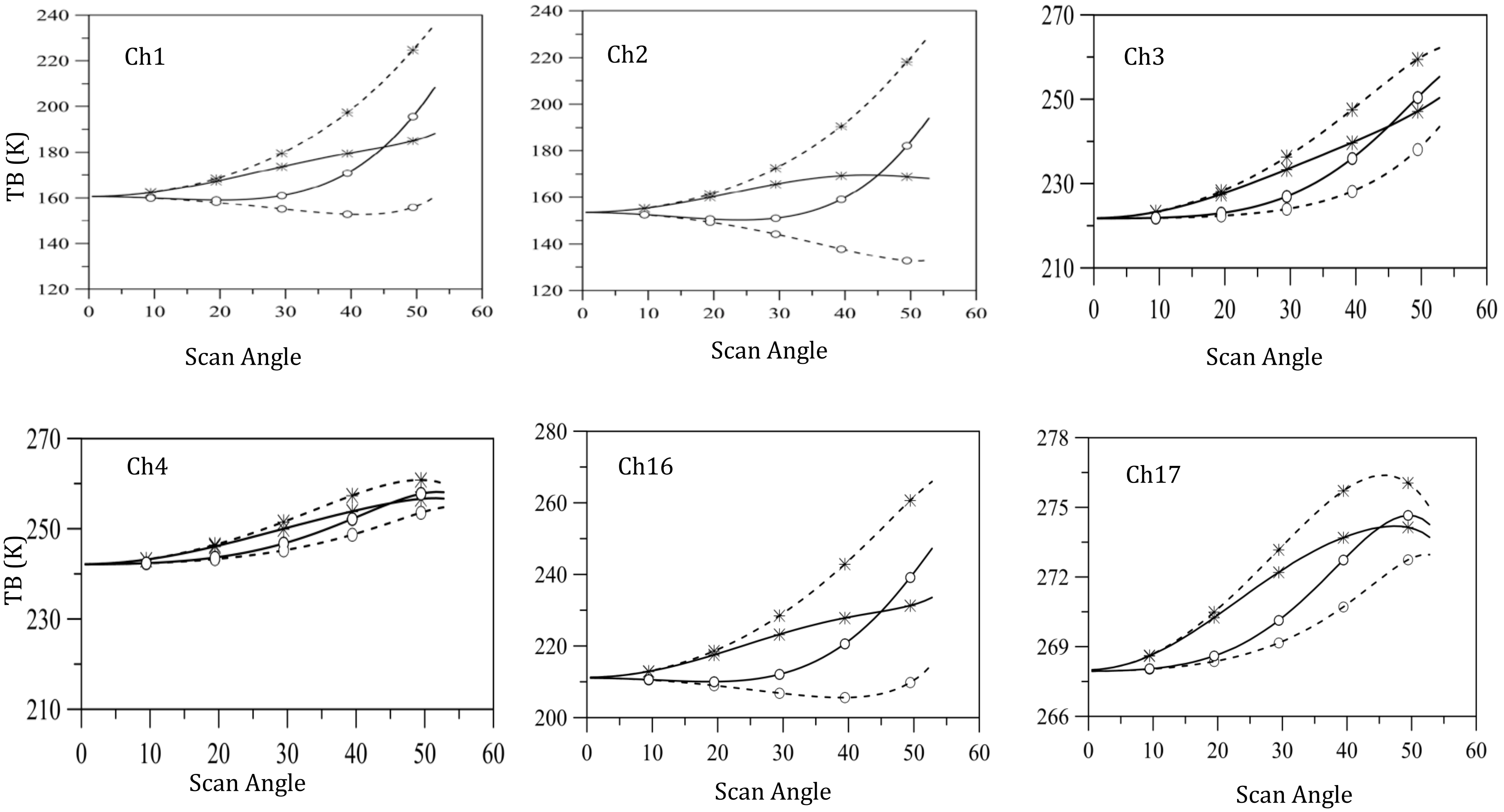
$$T_a^{Qv} = \eta_{me}^{vv} T_b^{Qv} + \eta_{me}^{hv} T_b^{Qh} + \eta_{se}^{vv} T_{b,se}^{Qv} + \eta_{se}^{hv} T_{b,se}^{Qh} + (\eta_{sc}^{vv} + \eta_{sc}^{hv}) T_{c,RJ} + S_a^{Qv}$$

For Quasi-H (TDR)

$$T_a^{Qh} = \eta_{me}^{hh} T_b^{Qh} + \eta_{me}^{vh} T_b^{Qv} + \eta_{se}^{hh} T_{b,se}^{Qh} + \eta_{se}^{vh} T_{b,se}^{Qv} + (\eta_{sc}^{hh} + \eta_{sc}^{vh}) T_{c,RJ} + S_a^{Qh}$$

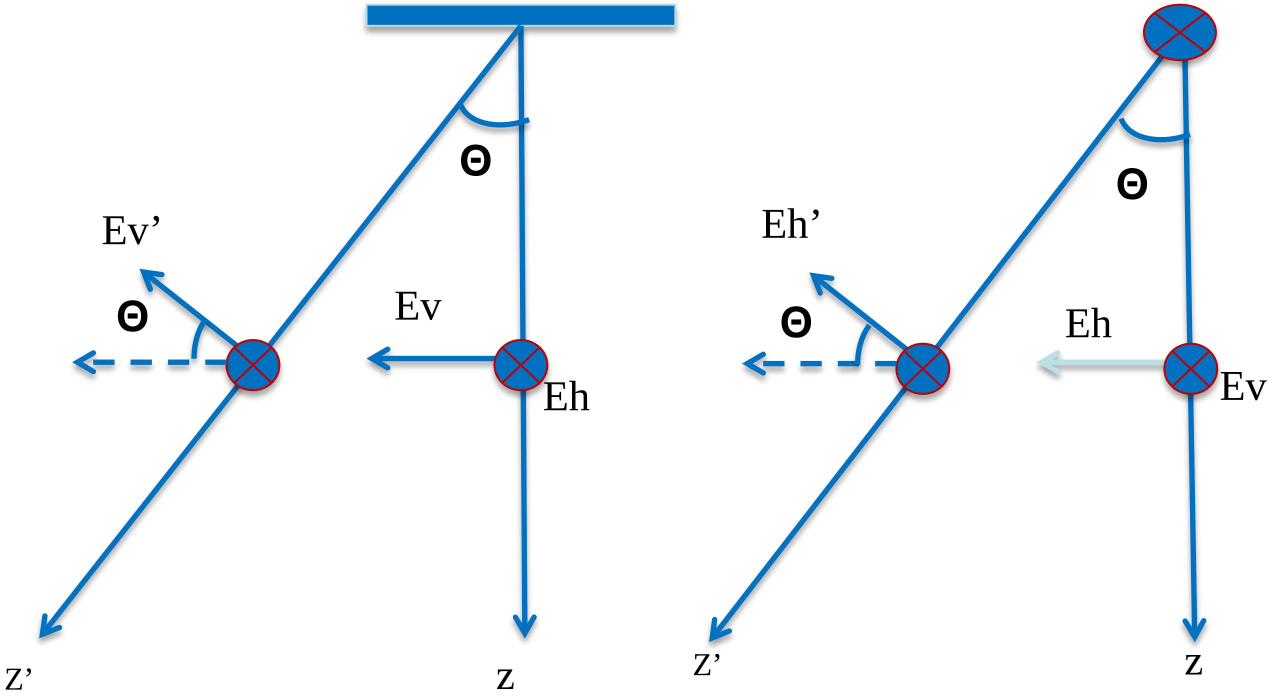
Weng, F*., X. Zou, M. Tian, W.J. Blackwell, N. Sun, H. Yang, X. Wang, L. Lin, and K. Anderson, 2013, Calibration of Suomi National Polar-Orbiting Partnership (NPP) Advanced Technology Microwave Sounder (ATMS), J. Geophys. Res,* ***118****, 1–14, doi:10.1002/jgrd.50840 ,*

ATMS Polarization vs. Scan Angle



The brightness temperature with pure (dashed curve) and quasi- (solid curve) horizontal polarization (circle) and vertical (star) polarization states using the US standard atmospheric profile with sea surface wind speed being 5 m/s and sea surface temperature being 290 K.

ATMS SDR Biases due to the 3rd Stokes Component



Wave guide slot direction
V polarization

Wave guide slot direction
H polarization

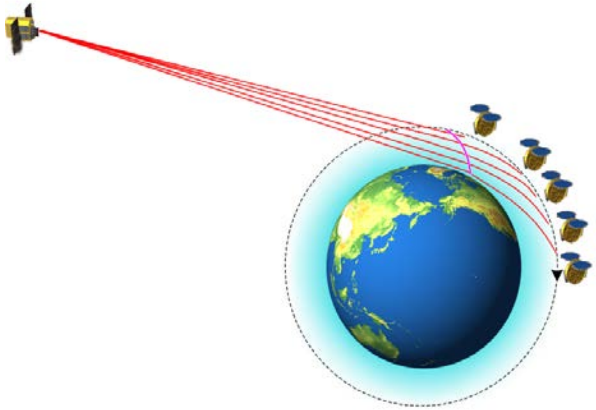
Eh vector is defined as the electronic vector perpendicular to wave propagation plane

$$\begin{bmatrix} T_B^{QV} \\ T_B^{QH} \\ T_B^{Q3} \\ T_B^{Q4} \end{bmatrix} = \begin{bmatrix} cos^2\theta & \sin^2\theta & 0.5\sin 2\theta & 0 \\ \sin^2\theta & cos^2\theta & -0.5\sin 2\theta & 0 \\ -\sin 2\theta & \sin 2\theta & \cos 2\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} T_B^V \\ T_B^H \\ T_B^3 \\ T_B^4 \end{bmatrix}$$

$$T_B^{QV} = T_B^H \sin^2\theta + T_B^V \cos^2\theta + T_b^3 \frac{1}{2}\sin 2\theta$$

$$T_b^{QH} = T_b^H \cos^2\theta + T_b^V \sin^2\theta - T_b^3 \frac{1}{2}\sin 2\theta$$

ATMS Calibration Accuracy Assessment Using COSMIC Data



- **Time period of data search:**

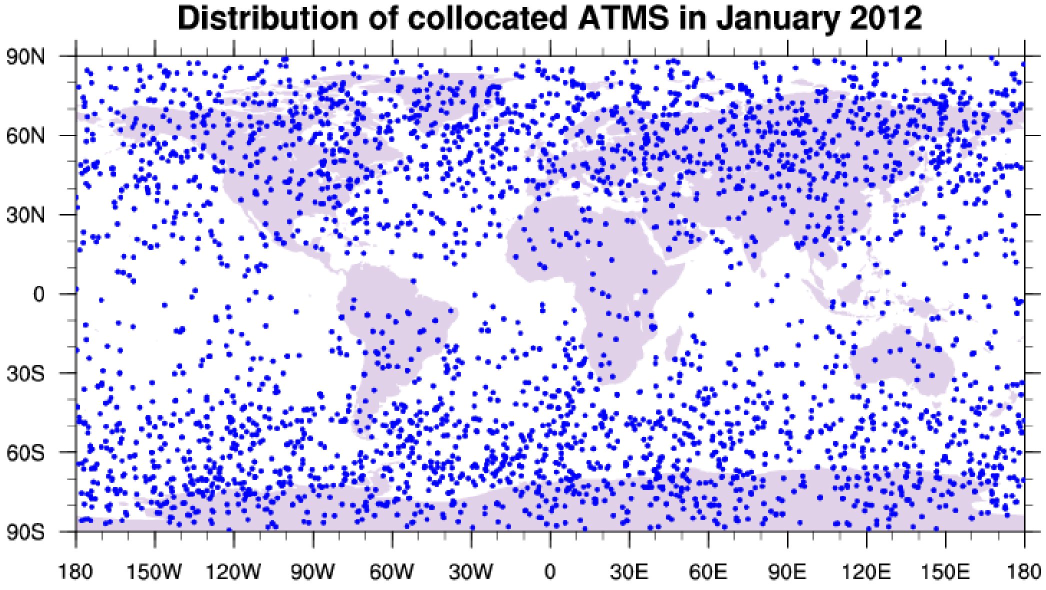
  January, 2012

- **Collocation of ATMS and COSMIC data:**

  Time difference < 0.5 hour

  Spatial distance < 30 km

  (GPS geolocation at 10km altitude is used for spatial collocation)



3056 collocated measurements

Slide Courtesy of Lin Lin

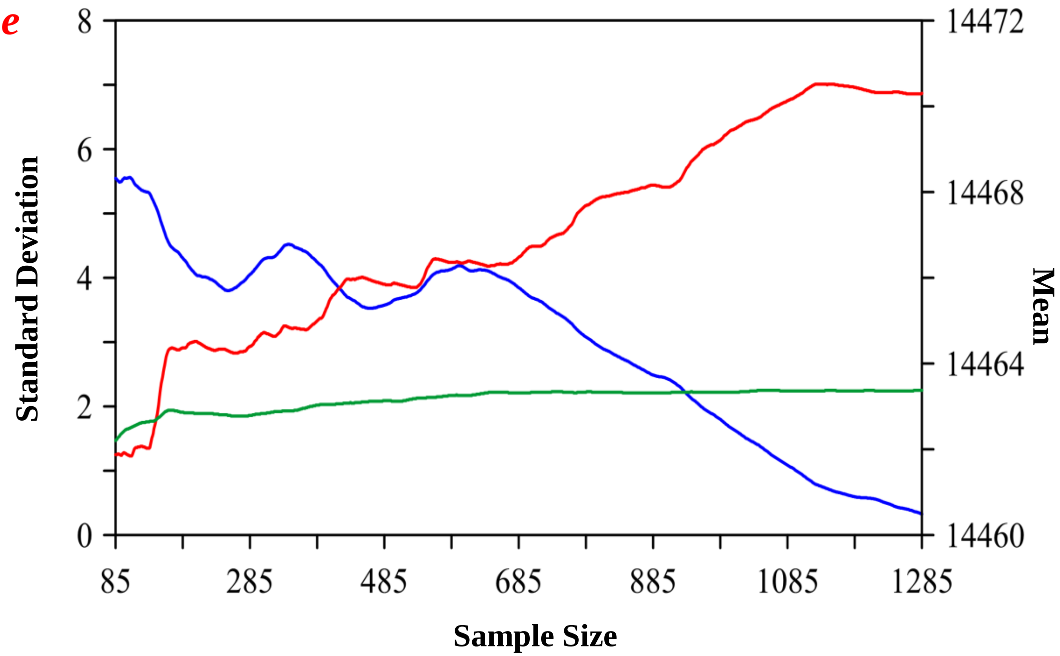
ATMS Noise Equivalent Temperature (NEDT)

For a time series with a stable mean, the standard deviation of the measurements can be used as NEDT:

$$\sigma_{ch} = \left[\frac{1}{4N} \sum_{i=1}^{N} \sum_{j=1}^{4} \left(\frac{C_{ch}^{w}(i,j) - \overline{C_{ch}^{w}}(i)}{\overline{G_{ch}}(i)} \right)^{2} \right]^{1/2}$$

For a non-steady mean such as ATMS warm count from blackbody target, Allan deviation is recommended for NEDT:

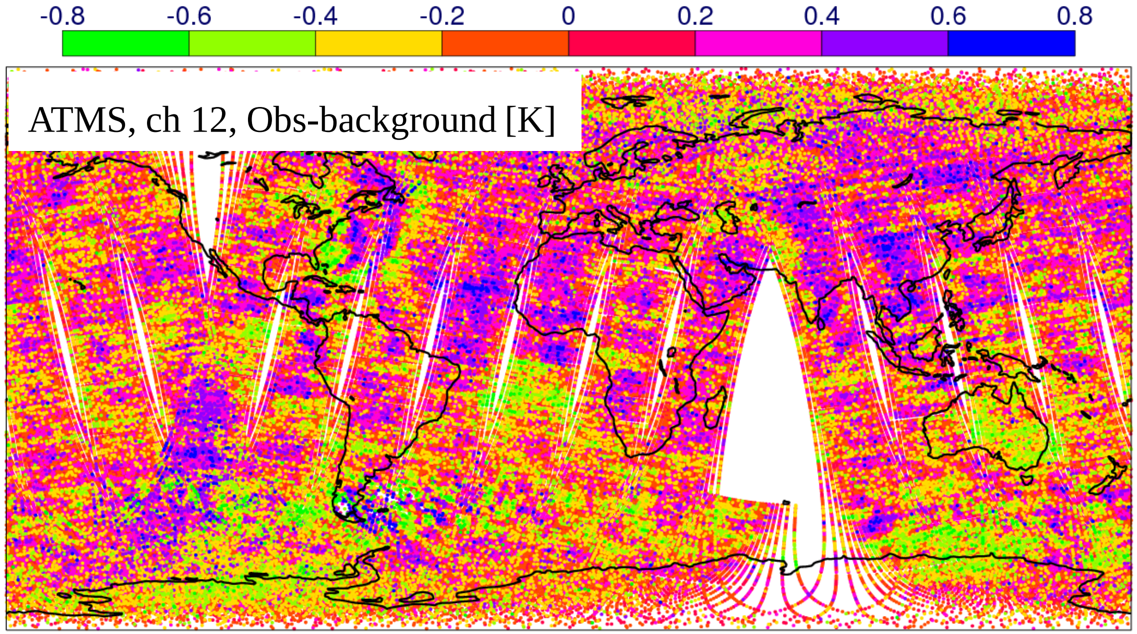
$$\sigma^{Allan}(m) = \sqrt{\frac{1}{2m^{2}(N-2m)} \sum_{j=1}^{N-2m} \left(\sum_{i=j}^{j+m-1} \left(C_{ch}^{w}(i+m) - C_{ch}^{w}(i) \right) \right)^{2}}$$

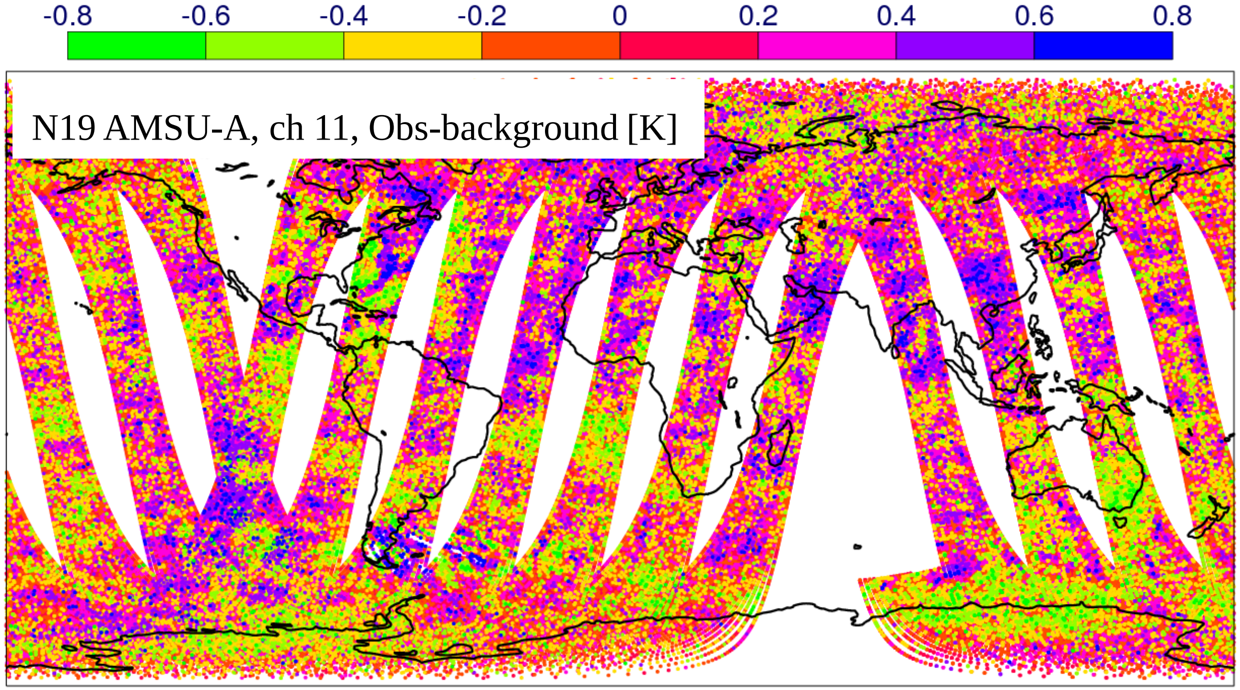


ATMS channel 1 warm count mean (blue, y-axis on the right), the standard deviation (red, y-axis on the left) and the overlapping Allan deviation (green, y-axis on the left) of the 17-scanline (m) average as a function of the total sample size (N).

ATMS: Striping

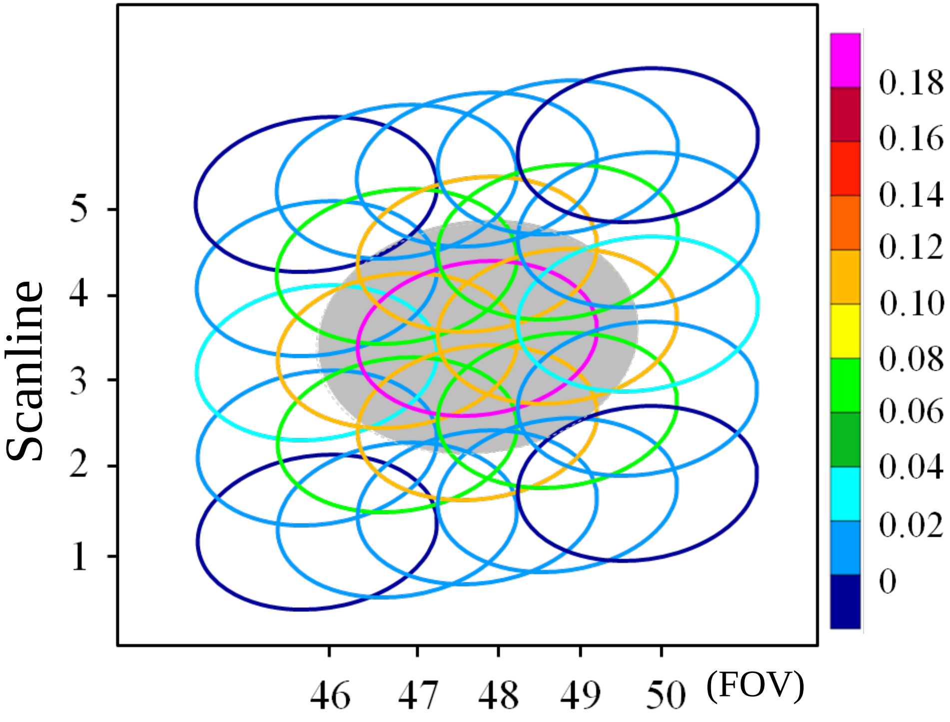
Weak cross-track striping effect, especially for stratospheric temperature-sounding channels.



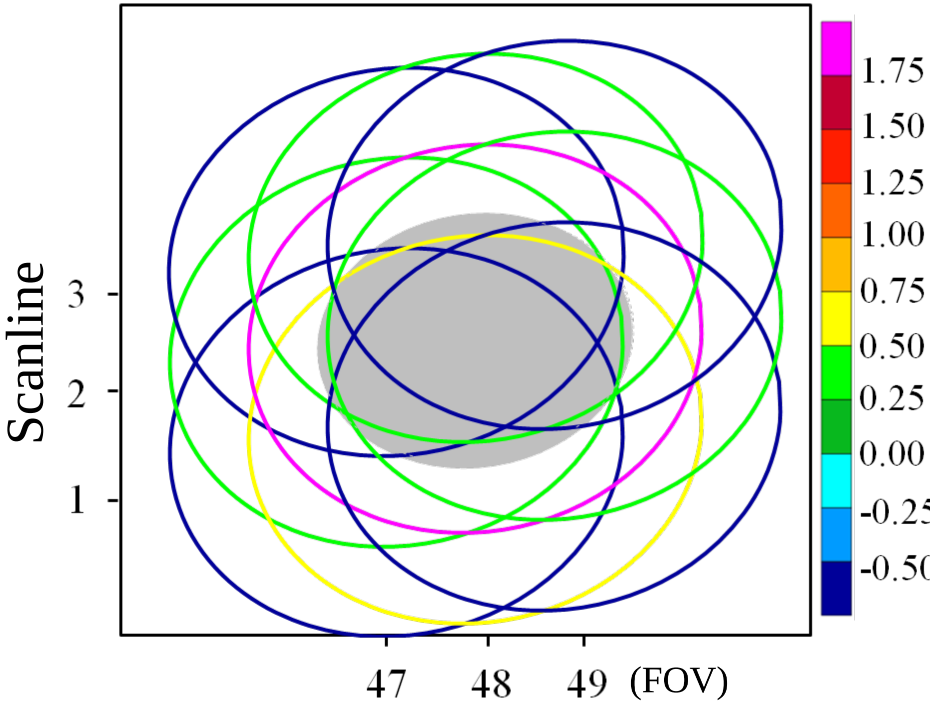


ATMS Resampling Algorithm Using the Backus-Gilbert (BG) Method

ATMS Channels 3-16



ATMS Channels 1-2



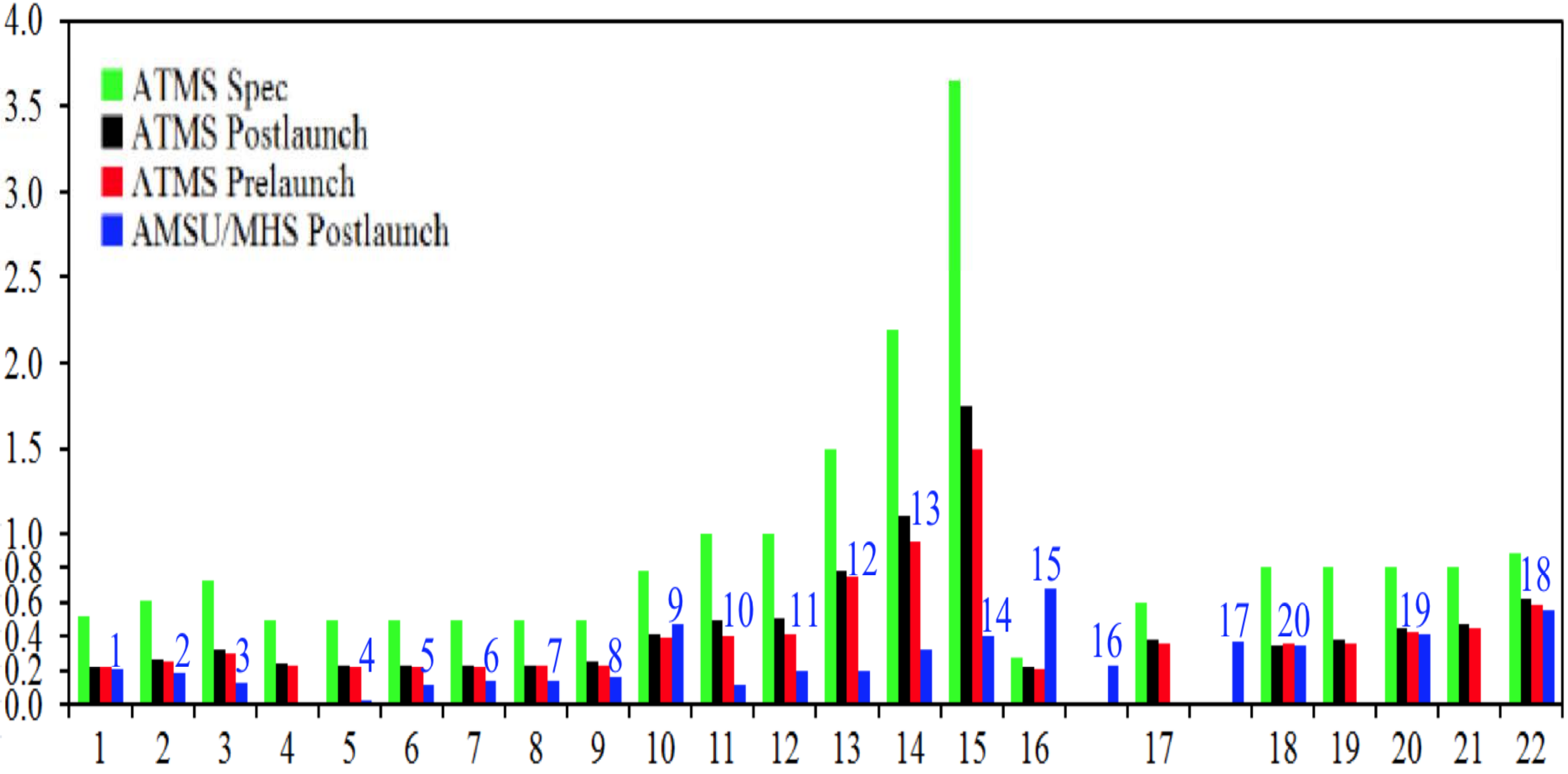
An effective AMSU-A target FOV: output of BG remap (shaded in gray)

ATMS effective FOVs: Circles with colors indicating the magnitude of BG coefficients

Major Accomplishment Highlights

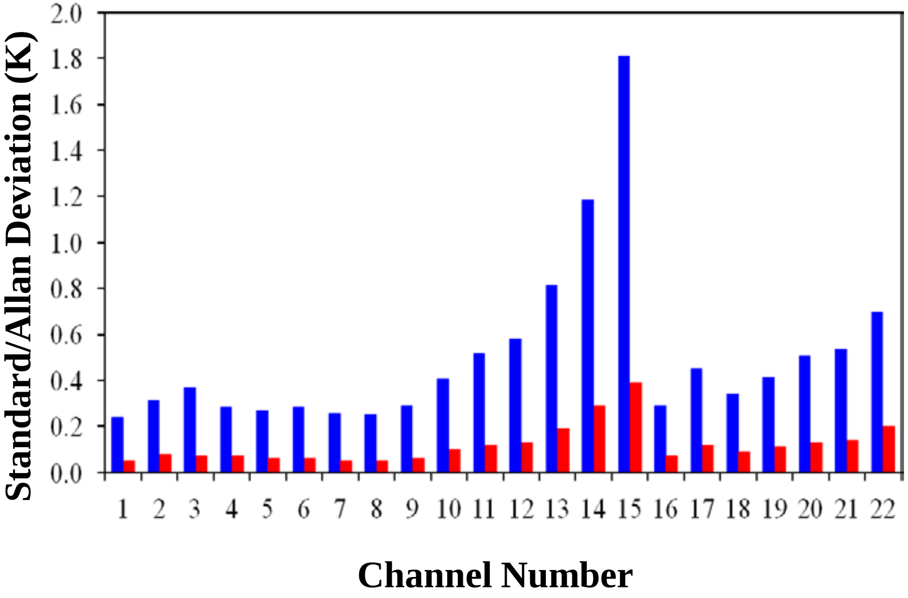
- ATMS TDR and SDR products have been declared a validated maturity level
- All the channels have noises much lower than specification
- ATMS processing coefficient table (PCT) were updated with nominal values
- Geolocation errors for all the channels are quantified and are smaller than specification
- On-orbit absolute calibration was explored using GPS RO data, LBLRTM and ATMS SRF. The biases at the upper-air sounding channels are characterized
- Remap SDR (RSDR) coefficients were optimally set and RSDR biases are assessed
- Complete dthe first cycle data analysis of J1 ATMS TVAC data

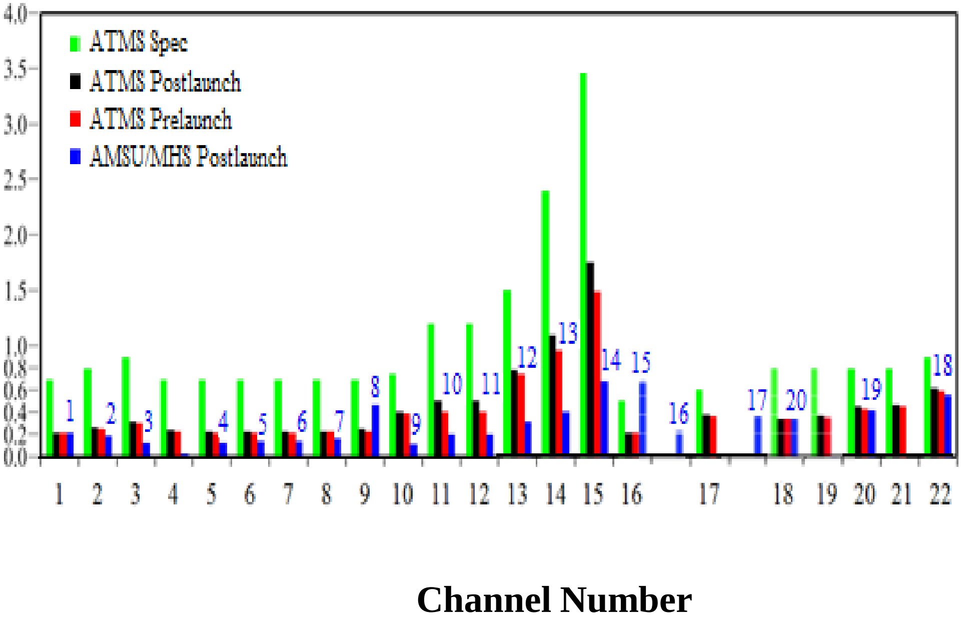
ATMS Channel Noise Characterization



All Channels are within Specifications (Weng et al., 2012, JGR)

ATMS Noise Equivalent Temperature (NEDT)

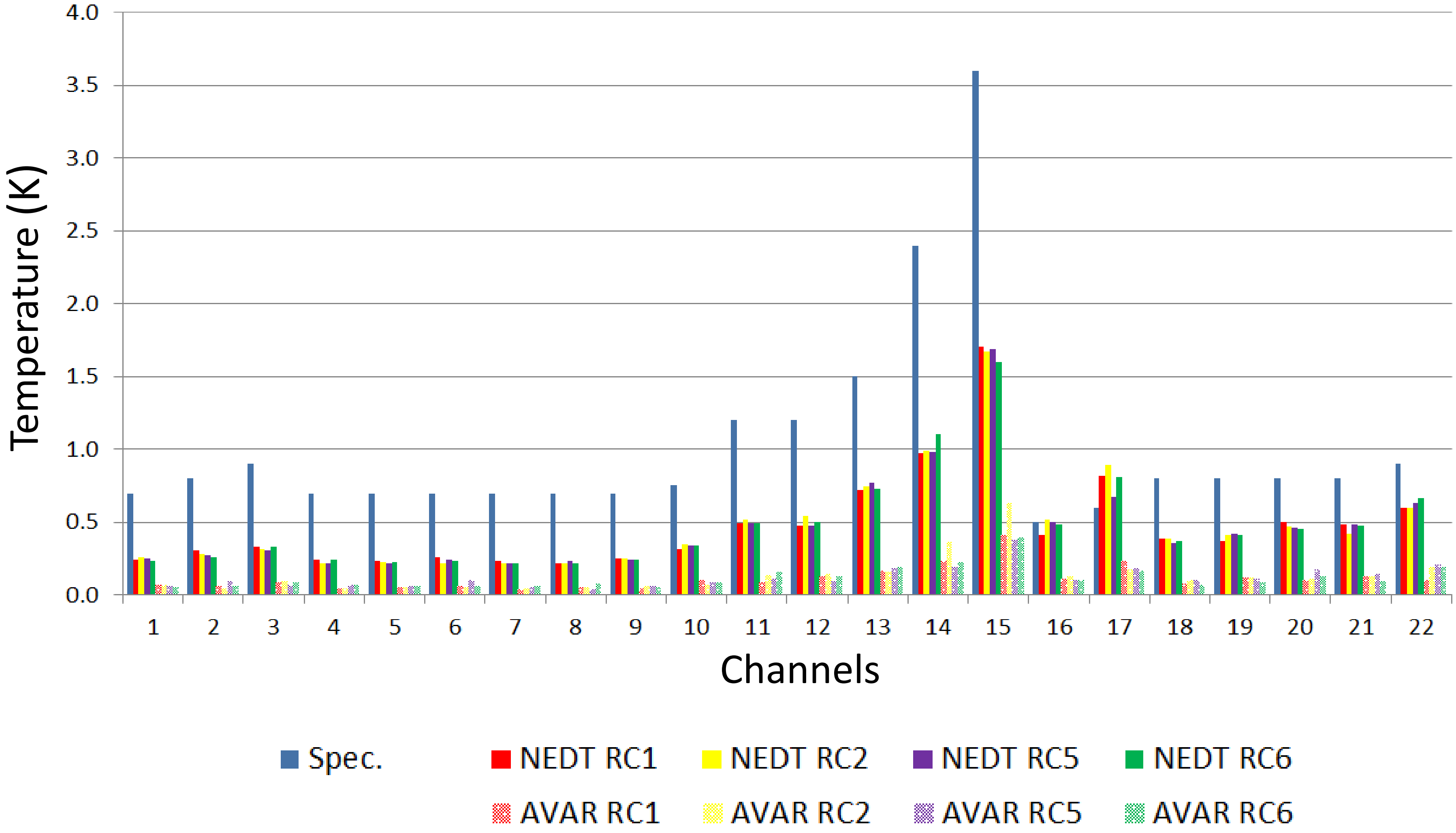




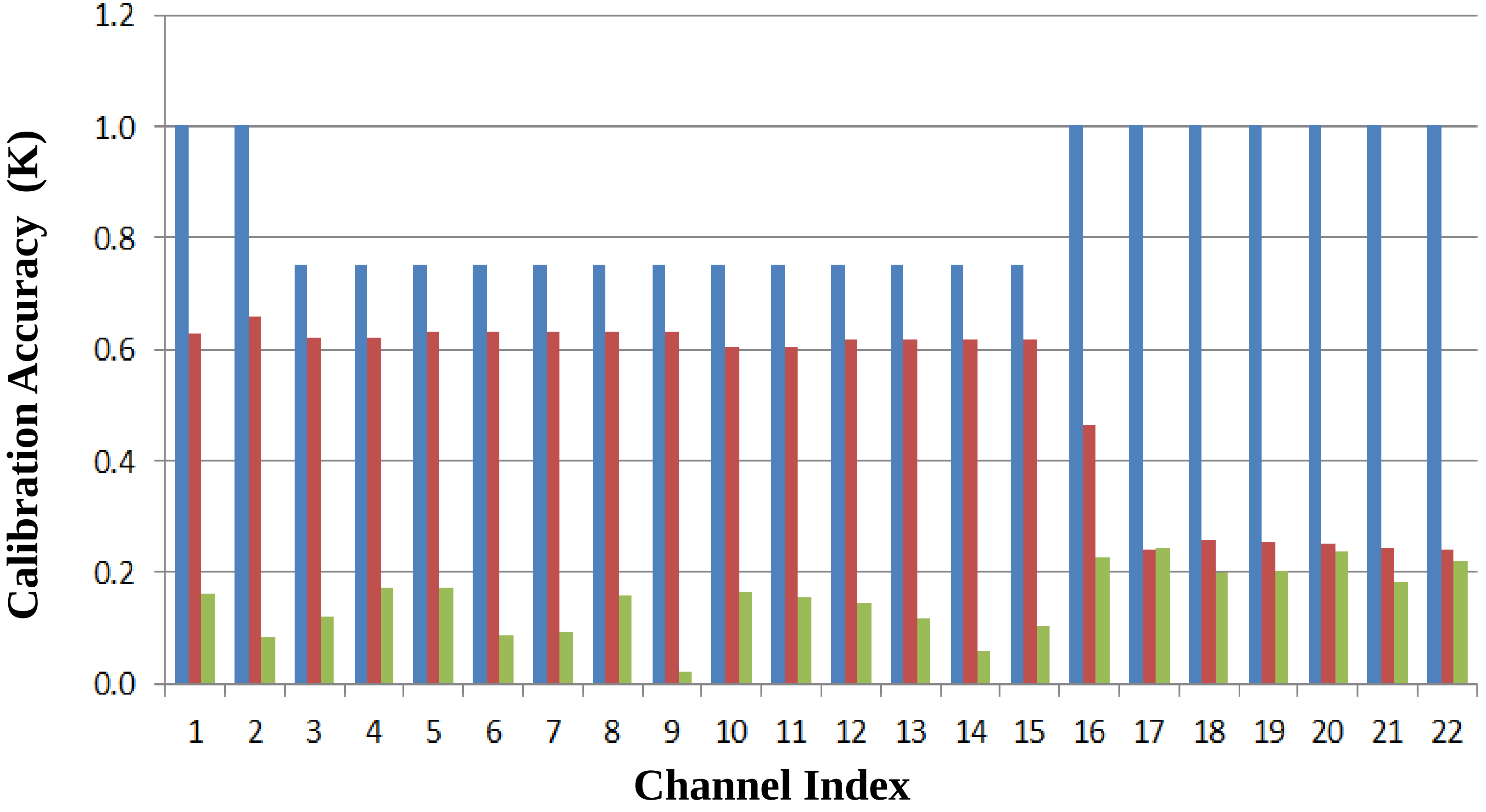
ATMS standard deviation (blue) and Allan deviation (red) with channel number. The sample size (N) is 150 and the averaging factor (m) for the warm counts is 17. The standard deviation is much higher than Allan deviation.

On-orbit ATMS noise from the standard deviation is lower than specification but is higher than AMSU/MHS. ATMS resample algorithm can further reduce the noise comparable to AMSU/MHS

J1 NEDT v.s. Allan Variance at 300K



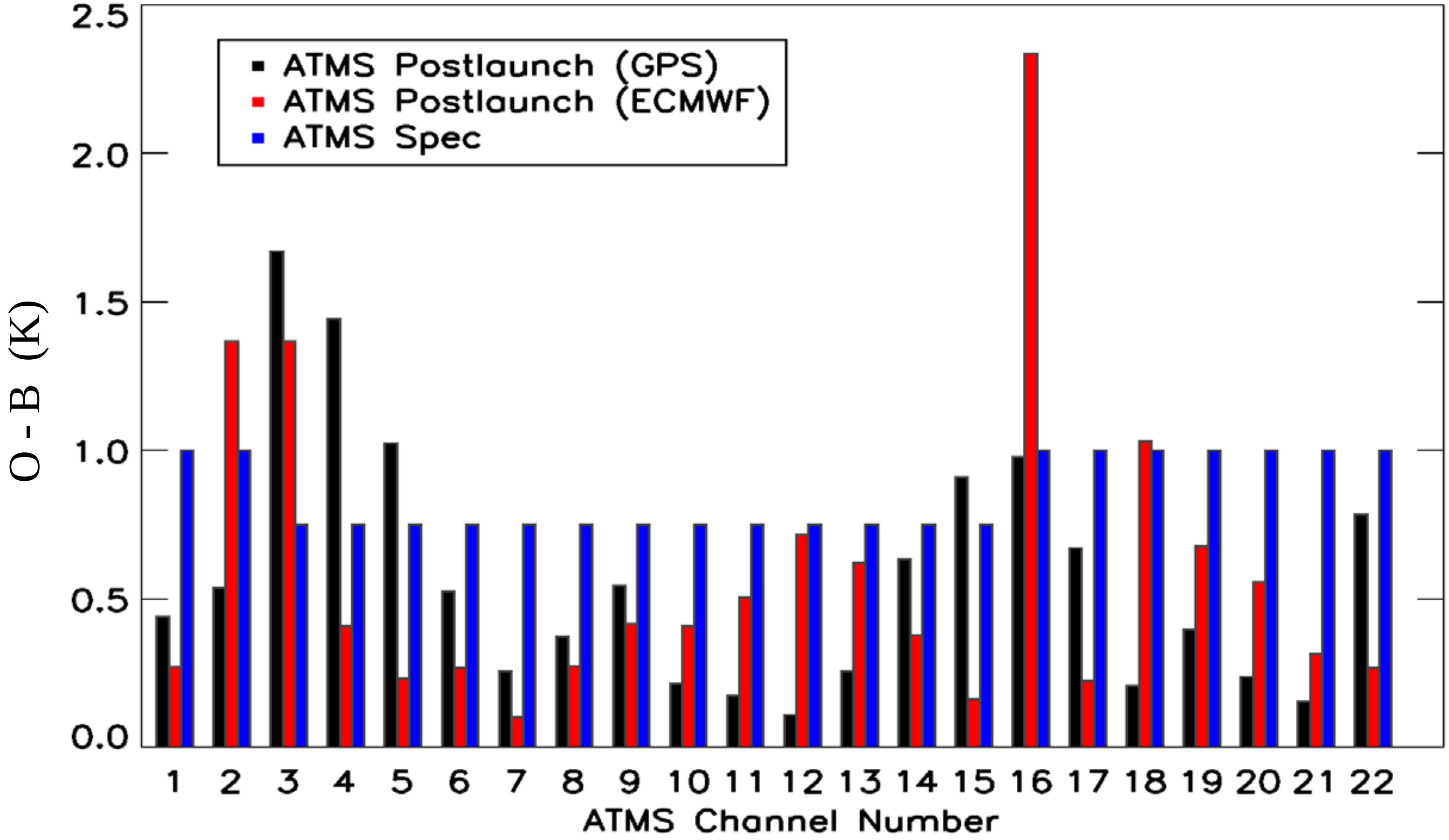
SNPP ATMS Pre-launch Calibration Accuracy through TVAC Data



Red – Calibration accuracy from nominal Thermal Vacuum (TVAC) data, Green – values obtained from the best TVAC data and Blue – specification

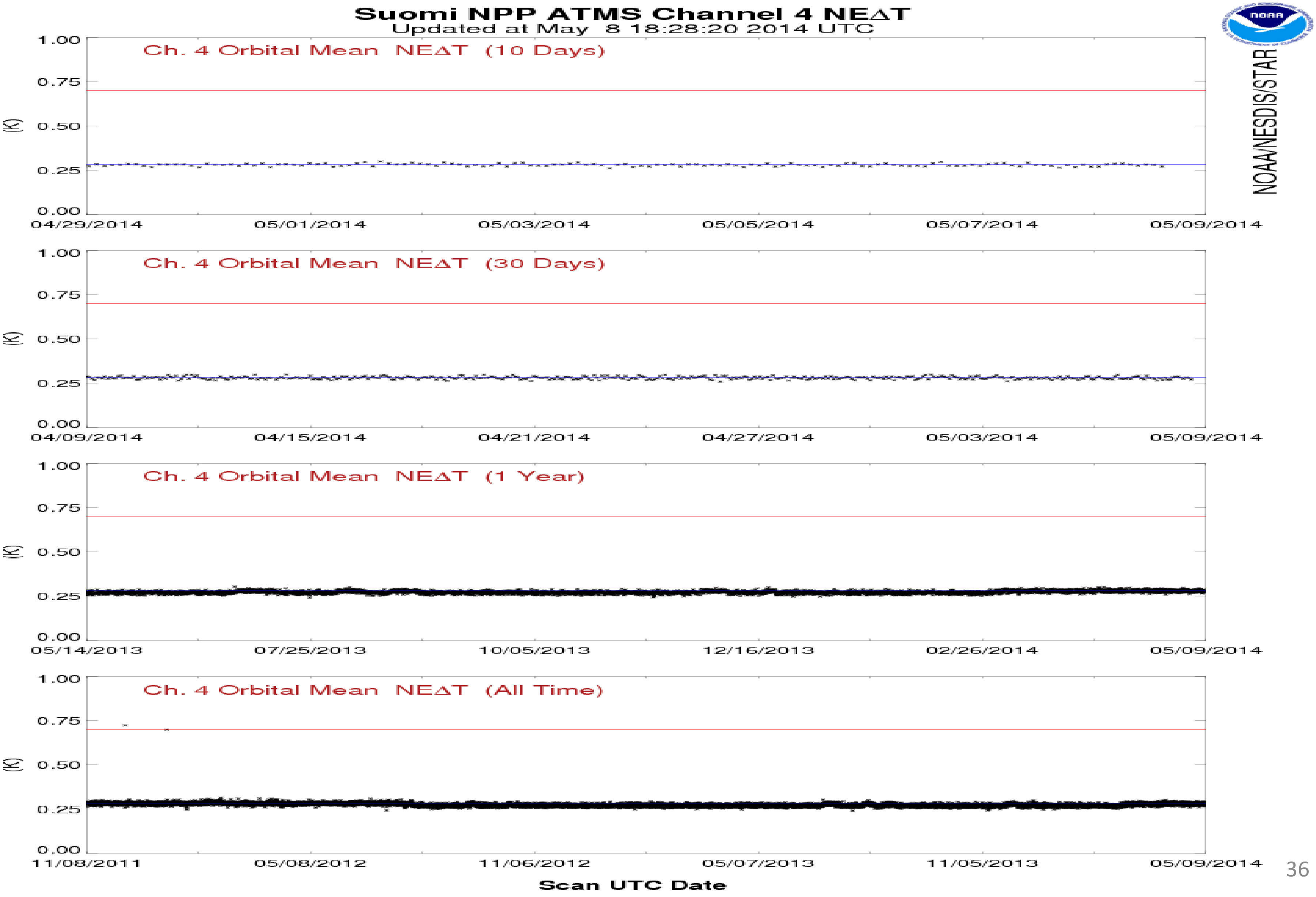
Prelauncht ATMS calibration accuracy is quantified from six redundant configuration (RC) thermal vacuum (TVAC) data and exceeds/is better than the specification

ATMS Post-launch Characterization of Calibration Accuracy through O-B



On-orbit ATMS calibration accuracy is characterized using GPSRO and ECMWF data as input to RT model and is better than specification for most of sounding channels.

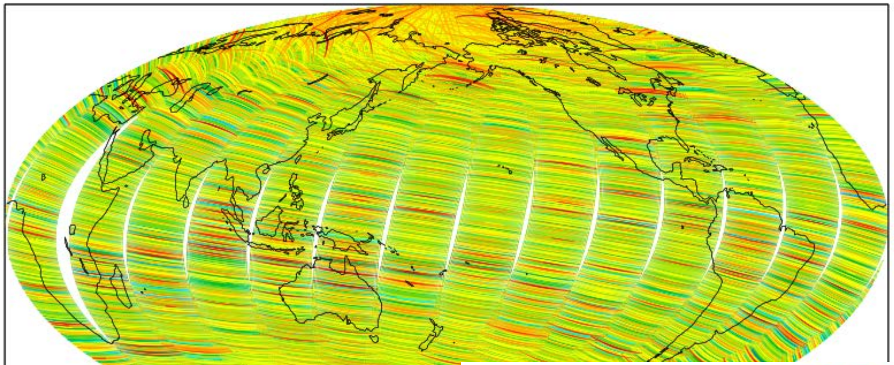
SNPP ATMS Has Stable Noise



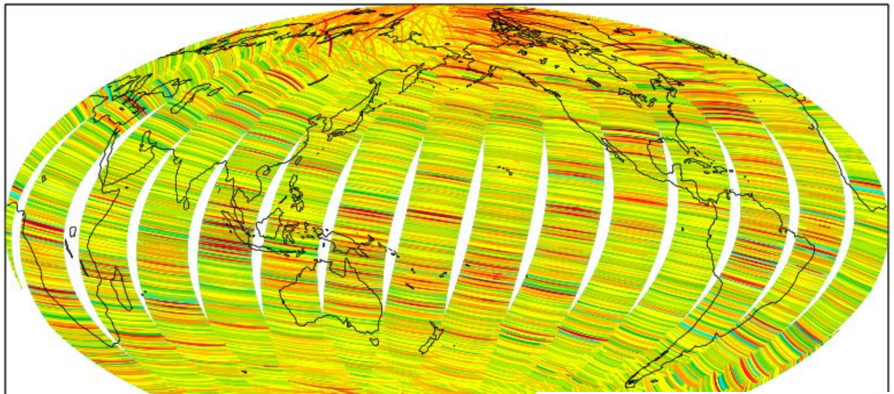
Microwave Radiometry Striping Noise

Striping noises are found in ATMS, MHS, and AMSU-B. The magnitudes of ATMS temperature and water vapor sounding channels are about ±0.3K and ±1.0K, respectively

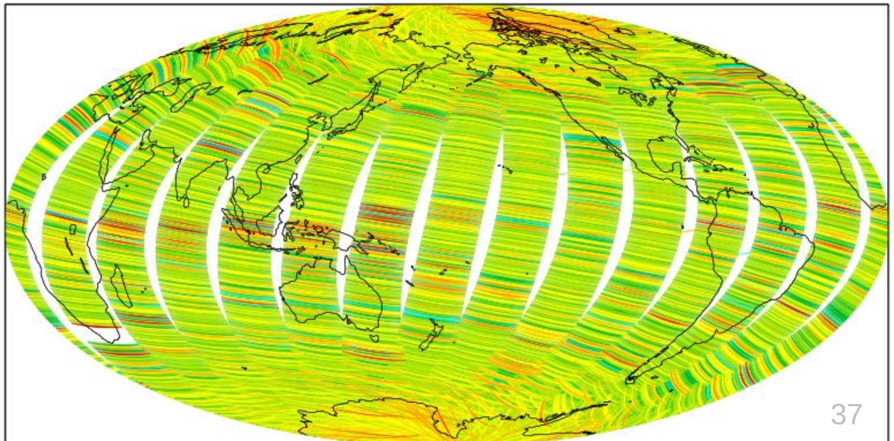
SNPP ATMS Ch 22



NOAA-18 MHS Ch3



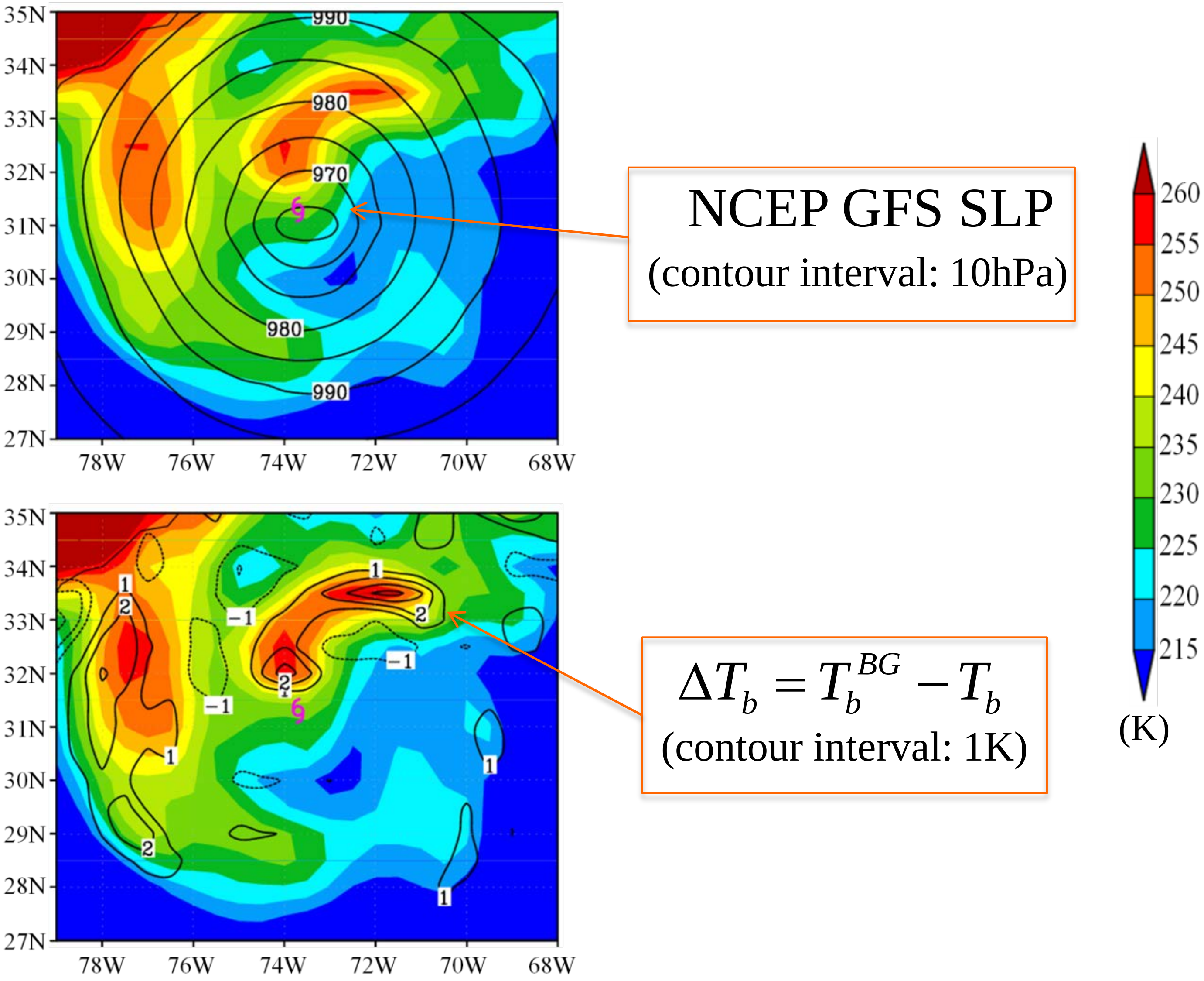
NOAA-16 AMSU-B Ch3



See Qin et al., 2013 JGR

T_b at Channel 1 within Sandy before and after Remap

(0600 UTC October 28, 2012)



T_b

(original)

T_b^{BG}

(after BG)

NCEP GFS SLP

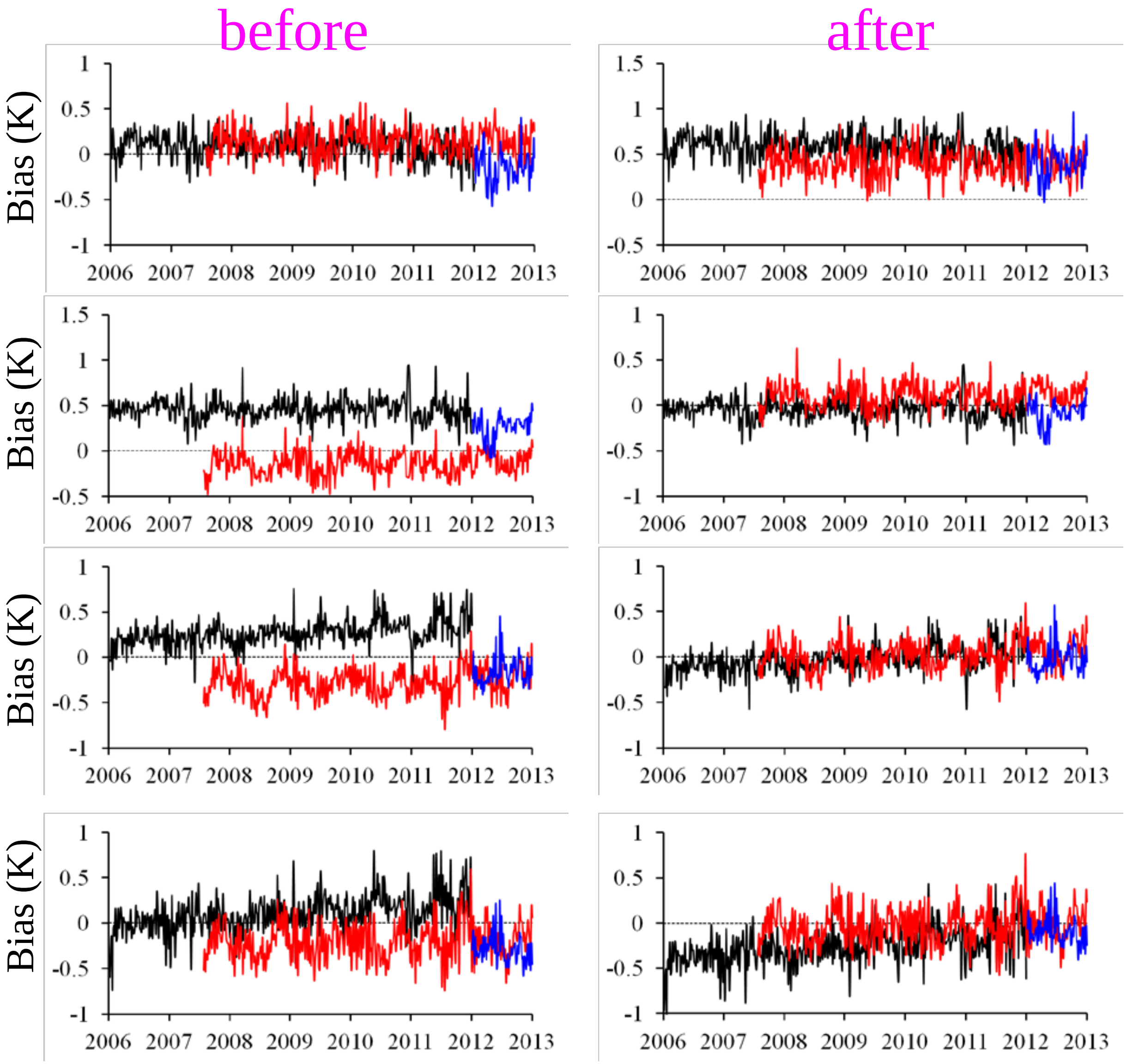
(contour interval: 10hPa)

$\Delta T_b = T_b^{BG} - T_b$

(contour interval: 1K)

(K)

Biases in the Tropics (NOAA-15, MetOp-A, SNPP)



ATMS channel 10

ATMS channel 11

ATMS channel 13

ATMS channel 14

NOAA-18 is subtracted. The pentad data set within ±30° latitudinal band.

ATMS Lunar Intrusion Correction Algorithm

Brightness temperature increment arising from lunar contamination can be expressed as a function of lunar solid angle, antenna response and radiation from the Moon

Space view Tb or radiance increment:

$$\Delta T_{moon} = G * \Omega * T_{moon}$$

Antenna response function:

$$G = e^{\frac{-(\beta' - \alpha_0)^2}{2\delta^2}}, \quad with\ \delta = \frac{0.5 \cdot \theta_{3dB}}{\sqrt{2 \cdot log2}}$$

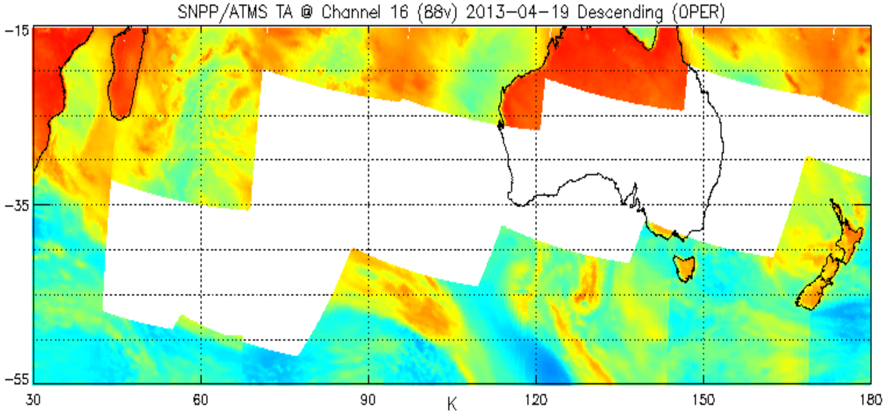
Weights of the Moon in antenna pattern:

$$\Omega_{moon} = \frac{\pi\left(\frac{r_{moon}}{D_{moon}}\right)^2}{\iint G(\theta,\varphi)d\theta d\varphi}$$

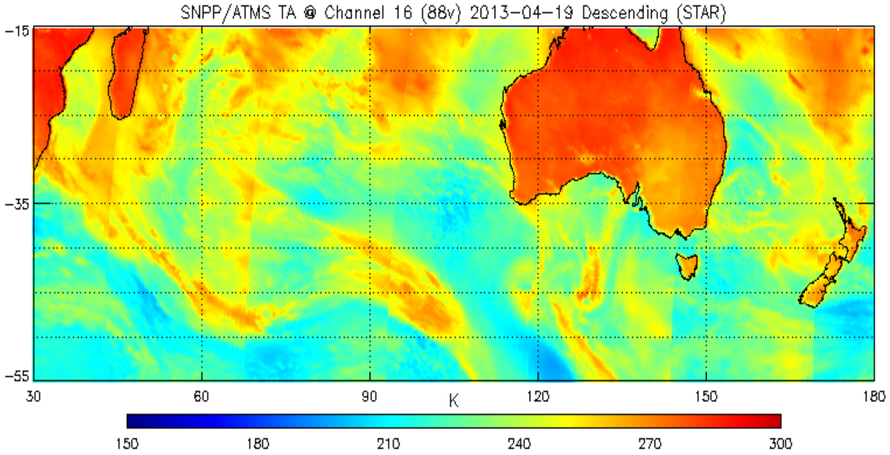
Brightness temperature of the Moon:

$$T_{moon} = 95.21 + 104.63 \cdot (1 - cos\Theta) + 11.62 \cdot (1 + cos2\Theta)$$

Without LI correction

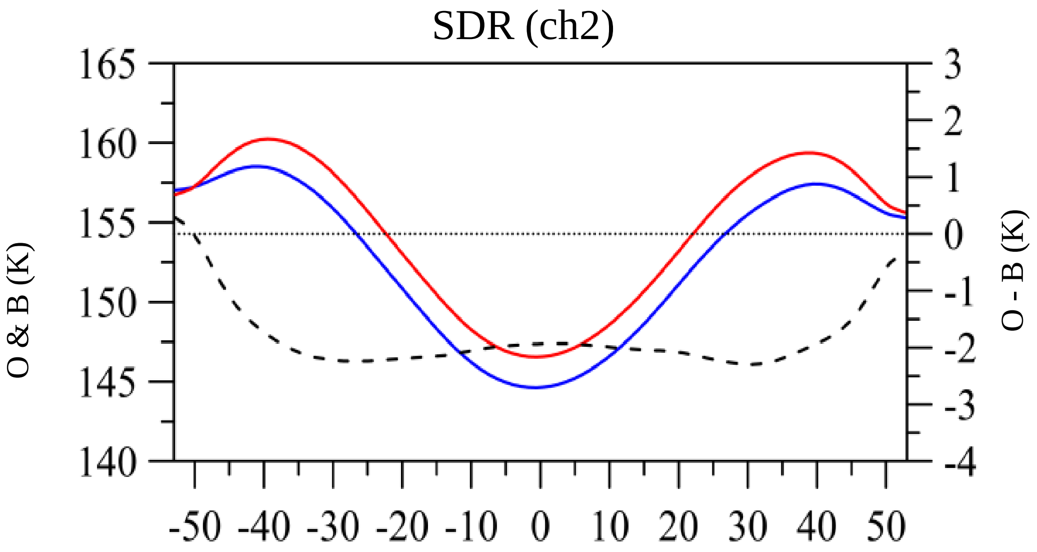


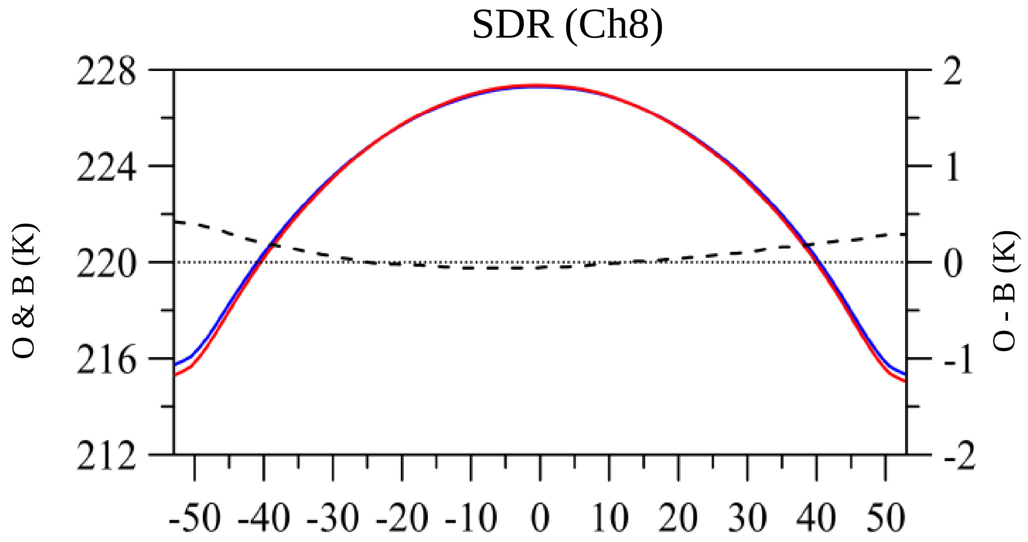
With LI correction



ATMS SDR Scan Angle Dependent Bias

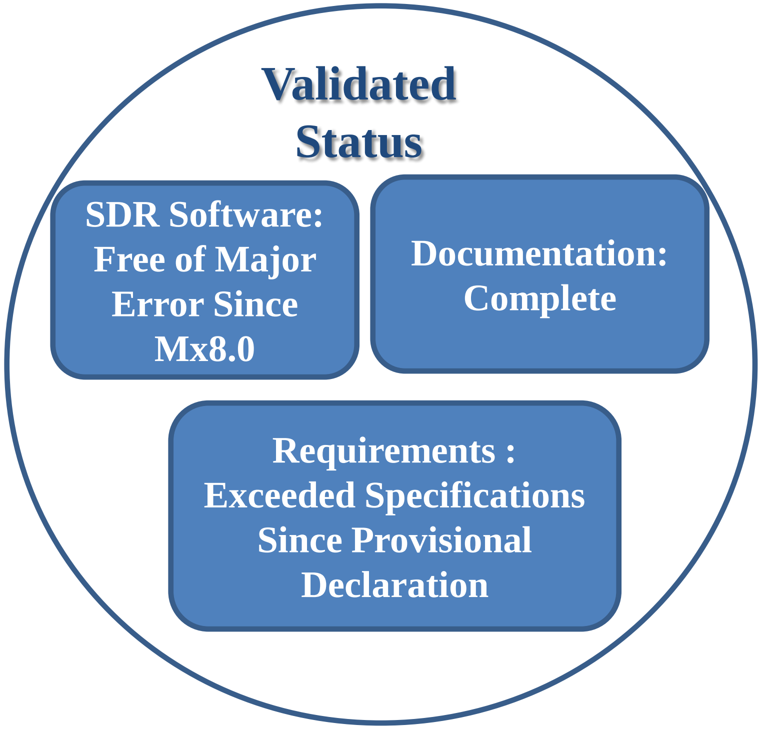
- **Methodology:**
  - SDR angular dependent biases are assessed using ECMWF and CRTM simulations
  - Cloud-affected radiances are removed with cloud liquid water algorithm (Weng et al., 2003)
  - Also, the measurements with the surface wind speeds are less than 10m/s are used
- **Results:**
  - ATMS SDR sounding channels have small bias but less angular dependent
  - But window channels have some significant biases


SDR (ch2)


SDR (Ch8)

ATMS SDR Maturity Level – Validated

- Requirements
  - Instrument & SDR performances exceeded requirements since Provisional status declaration 1/31/2013
- SDR software
  - Stable & free of errors since 11/14/2013 (Mx8.0)
- Documentation
  - 6 presentations in this meeting
  - 7 Journal papers
  - SDR ATBD (revised)
  - SDR user guide (new)
  - SDR error budgets



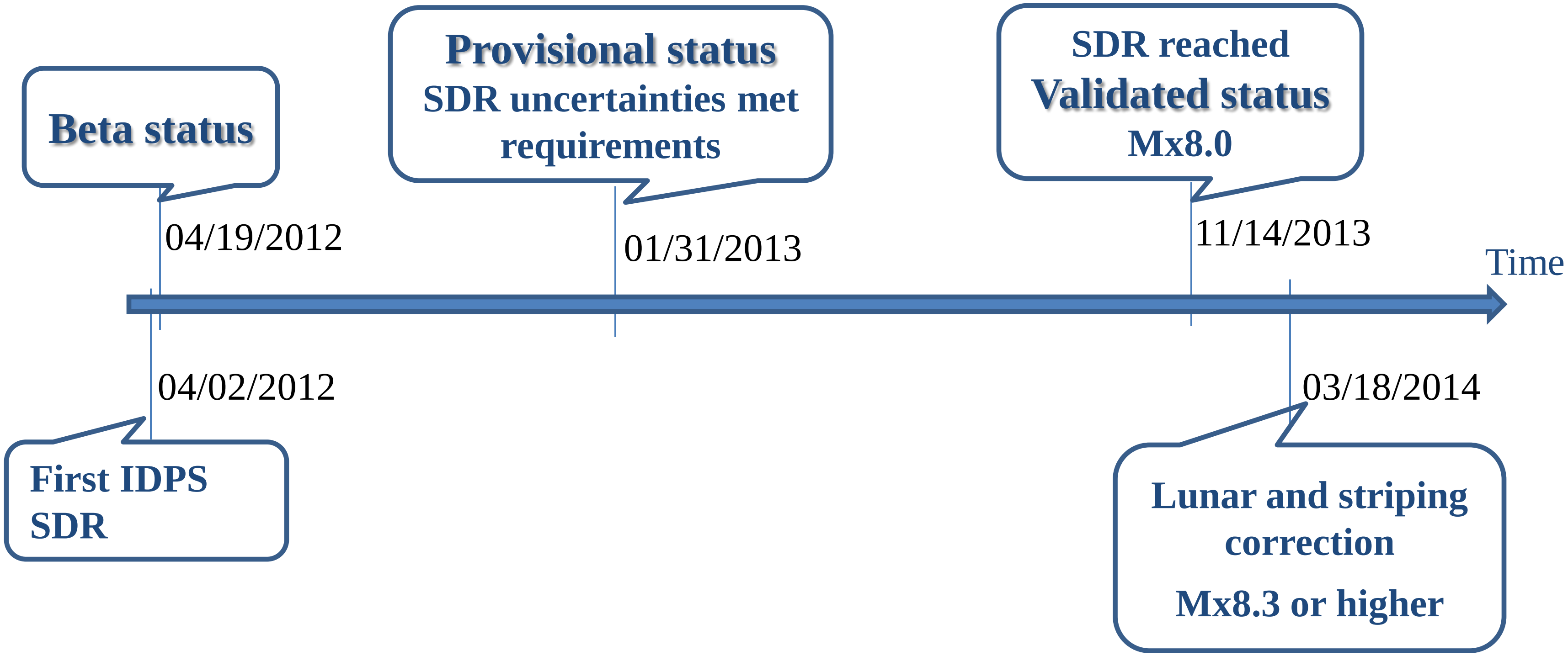
Validated Status

SDR Software: Free of Major Error Since Mx8.0

Documentation: Complete

Requirements : Exceeded Specifications Since Provisional Declaration

IDPS ATMS SDR CalVal Milestones



Beta status

04/19/2012

Provisional status

SDR uncertainties met requirements

01/31/2013

SDR reached

Validated status

Mx8.0

11/14/2013

Time

04/02/2012

First IDPS SDR

03/18/2014

Lunar and striping correction

Mx8.3 or higher

Major Issues

- From 19th ITSC, NWP community requests NOAA to develop and share the software on ATMS de-striping and to make available 30 days of TDR and SDR data
- The ATMS brightness temperatures from IDPS are peculiar and show angular dependent pattern when its antenna scans over the cold space during the pitch maneuver period
- Updating the ATMS PCT/LUT at IDPS is very complicated and slow. One simple PCT value update took more than two weeks. It may become faster since PCT update is now approved as fast track
- J1 ATMS TVAC instrument noise at channel 17 is out of specification and some of channels continue showing striping pattern, though the J1 striping magnitude is smaller than SNPP

Path Forward

- Suomi NPP
  - Refine ATMS scan bias corrections for TDR to SDR conversion with better characterization of xpol spill-over, W/G band slope (note intercept has been updated)
  - Develop ATMS radiometric calibration in full radiance to make the SDR data consistent with NOAA heritage AMSU-A/MHS
  - Refine striping mitigation algorithm for WG bands
- JPSS -1 and -2
  - Support of and participation in pre-launch testing, instrument characterization and calibration data development
  - Software update/improvement (implementations of new calibration algorithms, full resolution SDR and computation efficiency schemes), delivering the SDR code in January 2015.
  - Work with NGES to better characterize ATMS antenna (side-lobe, xpol spill-over, polarization twist angle) for J1/J2 mission
  - A comprehensive test data set derived from SNPP and J1 TVAC tests for J1 algorithm and software development and test
  - Support J1 and J2 waiver studies

ATMS SDR Data Sets

- IDPS
  - SDRs produced by IDPS with versions up to Mx8.3
  - Calibration PCT/LUT: Updated with beam efficiency and scan bias correction
  - Lunar correction DR was submitted and will be in Mx8.3 or high version
  - Striping correction DR was submitted and will be implemented in MX8.6 or high
- ARTS (ATMS Radiance Transformation System)
  - Use for reprocessing ATMS in radiance
  - Replace the current IDPS processing for J1 and J2 mission
  - B-G resample SDR will be in 2.2 degree for channel 1 to 16

Summary

- ATMS TDR/SDR data has reached a validated maturity *level (definition: on-orbit performance is characterized and calibration parameters are adjusted accordingly. The data is ready for use by the operational center and scientific publications)*
- ATMS SDR team made following major calval accomplishments:
  - On-orbit NEDT is well characterized in standard and Allan variance and both way shows the instrument meets specification
  - Bias (accuracy) is well characterized with GPSRO data and ECMWF model outputs
  - All the important quality flags are checked and updated
  - Calibration coefficients from TDR to SDR are updated
  - Lunar intrusion correction was in operation since March 18, 2014
  - ATMS and AMSU-A inter-sensor biases are well characterized and ATMS TDR data are now within AMSU-A family
  - STAR ICVS can provide long-term monitoring of ATMS instruments
  - All the calval sciences have been published through peer-reviewed process
  - Work on J1 TAC test and data analysis is progressing well

CrIS SDR Team Report

Yong Han, CrIS SDR Team Lead

2014 STAR JPSS Science Teams Annual Meeting
NOAA Center for Weather and Climate Prediction (NCWCP)
5830 University Research Park, College Park, Maryland
May 12-16, 2014

Outlines

- Team Membership
- Overview of last year’s Cal/Val activities and achievements
- Ongoing calibration algorithm/code improvements
- Challenges and risks
- Next year’s activities
- Summary

CrIS SDR Team

PI Name	Organization
Yong Han	NOAA/STAR
Deron Scott	SDL
Hank Revercomb	UW
Larrabee Strow	UMBC
Dan Mooney	MIT/LL
Degui Gu	NGAS
Joe Predina	Logistikos Engineering LLC.
Mike Cromp	Exelis
Dave Johnson	NASA
Wael Ibrahim	Raytheon
Carrie Root	JPSS/DPA

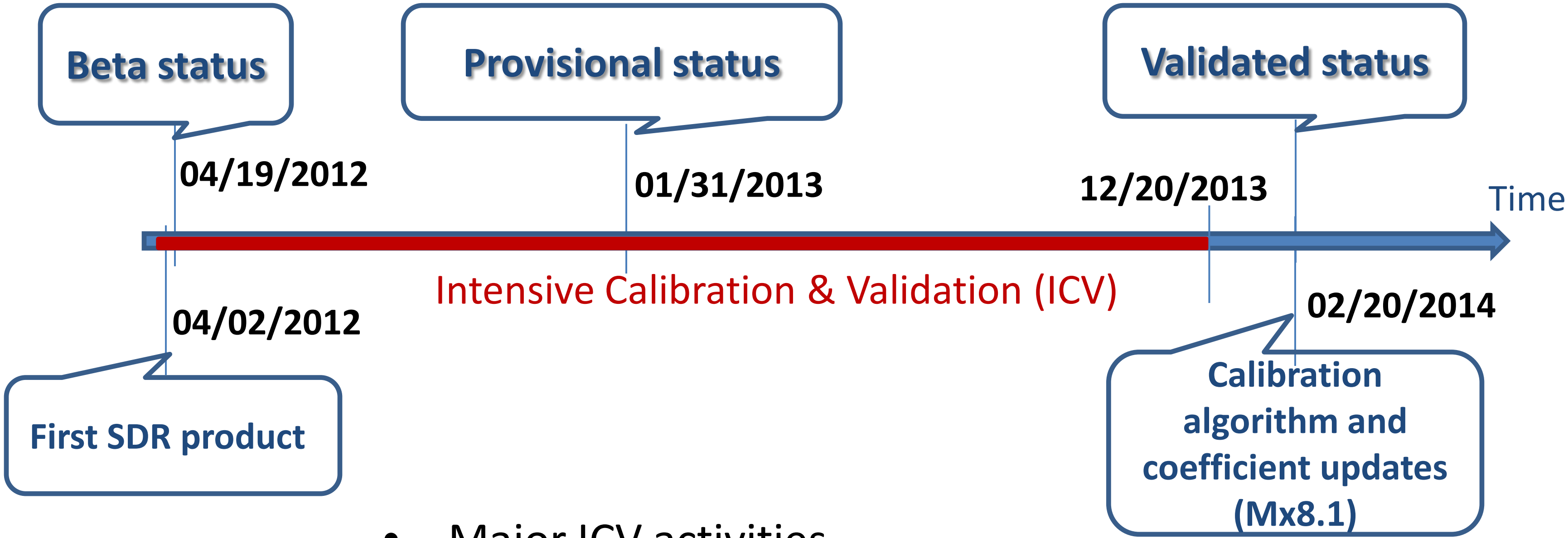
Team Activities
(May 2013 – May 2014)

- S-NPP
  - Intensive Cal/Val (ICV) activities (ended in Dec 2013) – great success; SDR product reached Validated status
  - Long-Term Monitoring (LTM) activities, covering all areas that are significant to the data quality
  - Preparation for processing full spectral resolution data
- JPSS-1
  - Calibration algorithm/code improvements
  - J1 test data analysis
  - Proxy data development for Ops software tests

Accomplishment Highlights

CrIS SDR CalVal Milestones

SDR validated in three stages: Beta, Provisional, and Validated



Beta status

04/19/2012

Provisional status

01/31/2013

Validated status

12/20/2013

Time

Intensive Calibration & Validation (ICV)

04/02/2012

First SDR product

02/20/2014

Calibration algorithm and coefficient updates (Mx8.1)

- Major ICV activities
  - SDR algorithm and software improvement
  - CrIS performance characterization
  - Radiometric CalVal
  - Spectral CalVal
  - Geolocation CalVal
  - CrIS instrument and SDR trending and monitoring

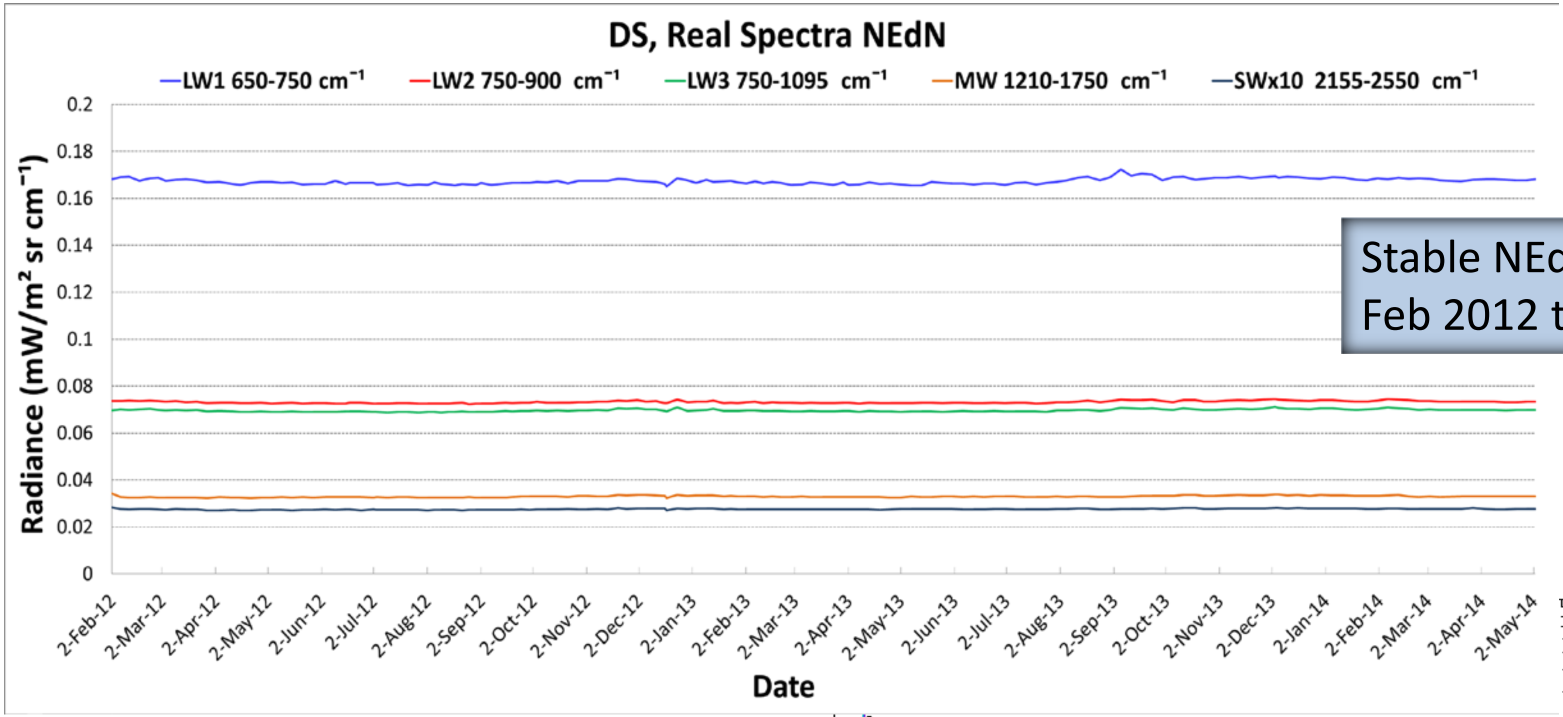
Validated CrIS SDR Product

CrIS SDR uncertainties (**blue**) vs. specifications (black)

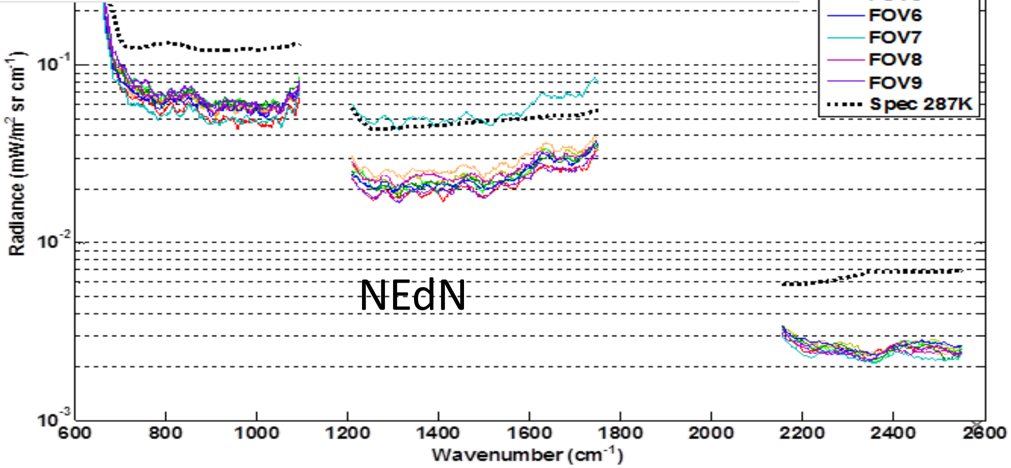
Band	NEdN @287K BB mW/m²/sr/cm⁻¹	Radiometric Uncertainty @287K BB (%)	Frequency Uncertainty (ppm)	Geolocation Uncertainty (km) *
LW	**0.098** (0.14)	**0.12** (0.45)	**3** (10)	**1.2** (1.5)
MW	**0.036** (0.06)	**0.15**(0.58)	**3** (10)	**1.2** (1.5)
SW	**0.003** (0.007)	**0.2** (0.77)	**3** (10)	**1.2** (1.5)

- Requirements
  - **Instrument & SDR performances exceed requirements by large margins**
- SDR software
  - **Stable & free of errors that could impact data quality since 11/14/2013 (Mx8.0)**
- Documentation
  - **SDR User's Guide (55 pages)**
  - **Revised ATBD**
  - **Peer-review Journal papers**

Stable Instrument Performance



Stable NEdN
Feb 2012 to May 2014



The noise levels substantially better than specification

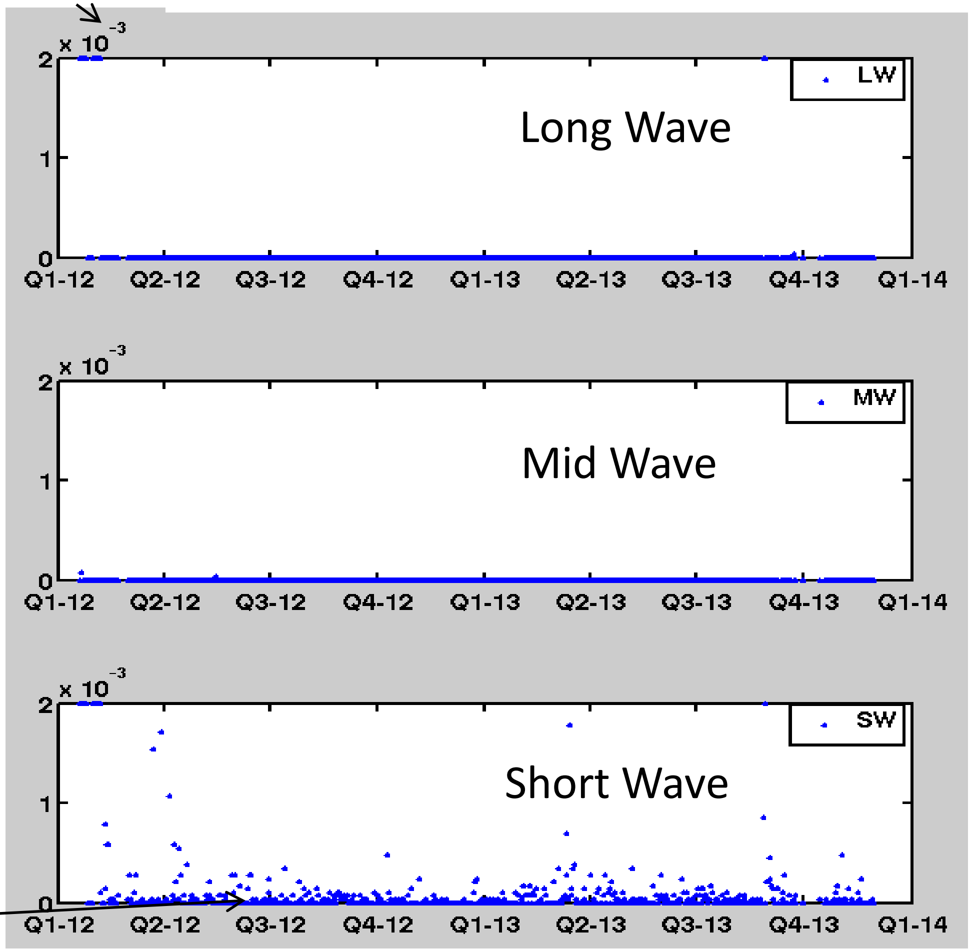
CrIS Data Quality

Daily occurrence of Good SDR spectra

LW	99.9817%
MW	99.9817%
SW	99.9816%

- **No ice contamination on detector so far**
- **No significant South Atlantic Anomaly (SAA) impact**
- **No Fringe Count Error (FCE) so far**

Daily Percentage of Invalid interferogram measurements (RDRs)



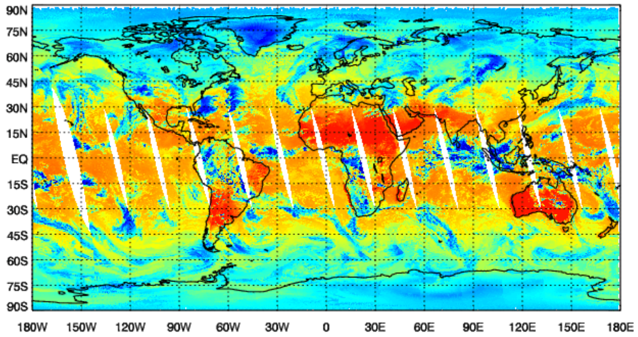
10^{-3}

Mainly due to sun-glint saturation

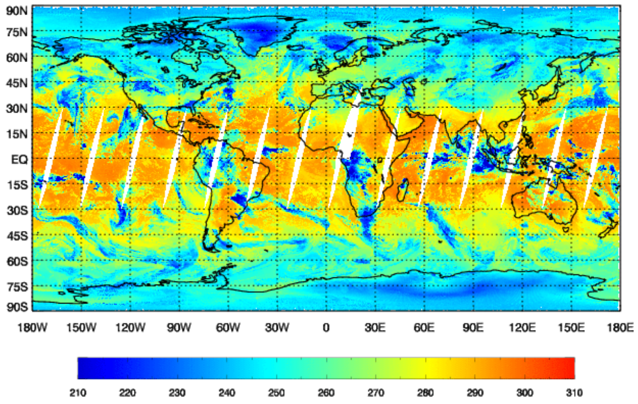
Example of Data Quality after Mx8.0

Radiance (900 cm^{-1})

NPP CrIS Brightness Temperature, 11 µm (900 cm^{-1}), Mapped, Ascending, 12/02/2013

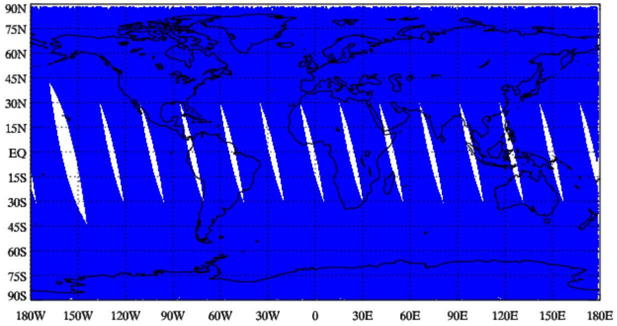


NPP CrIS Brightness Temperature, 11 µm (900 cm^{-1}), Mapped, Descending, 12/02/2013

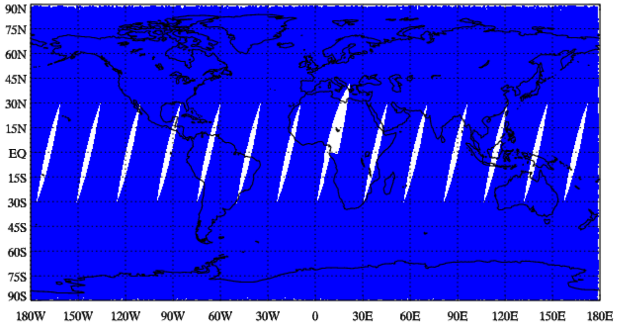


Overall SDR quality flag (Blue – good)

NPP CrIS Mid Wave SDR Overall Quality Flag, Mapped, Ascending, 12/02/2013
(Blue: Good; Green: Degraded; Red: Invalid)



NPP CrIS Mid Wave SDR Overall Quality Flag, Mapped, Descending, 12/02/2013



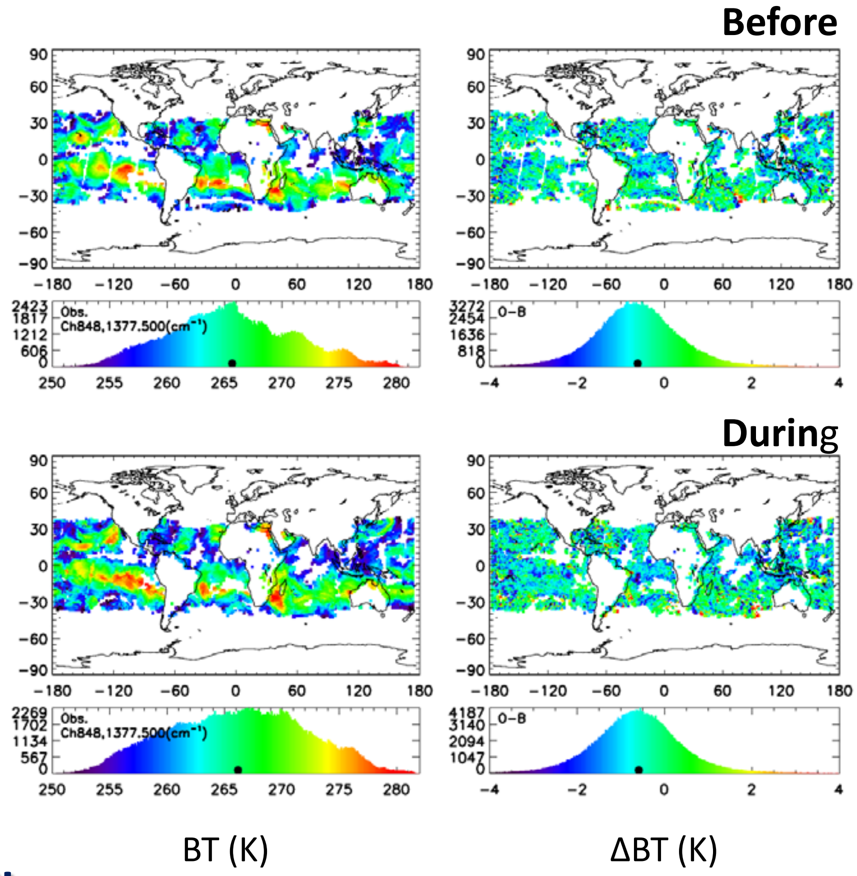
CrIS data monitoring website:

http://www.star.nesdis.noaa.gov/icvs/status_NPP_CrIS.php

A RDR Truncation Module Implemented and Validated for IDPS to Process Full Spectral Resolution RDRs

- Activities
  - IDPS RDR truncation module development
  - IDPS SDR evaluation/validation for 2 on-orbit full resolution tests
  - Bit trim mask evaluation/adjustment to meet data rate
  - Full resolution SDR processing experiments
  - 25 telecon meeting presentations
- Results
  - IDPS RDR truncation module was implemented & validated (Mx7.1)
  - Proposed Bit trim mask meets the data rate requirement
  - The noise impulse masks need to be lifted by 1 bit (no impact to the data rate)

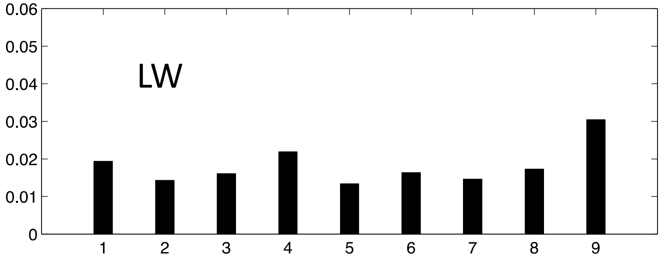
The Software truncation module works as expected: Obs – Calc results showing no difference before and during 8/27 FSR test



IDPS CrIS SDR code is ready to process full resolution RDRs and produce normal mode SDRs

Preliminary J1 NL Correction Coefficients Derived from Bench DM Data

FM1 (Suomi-NPP) EPv36



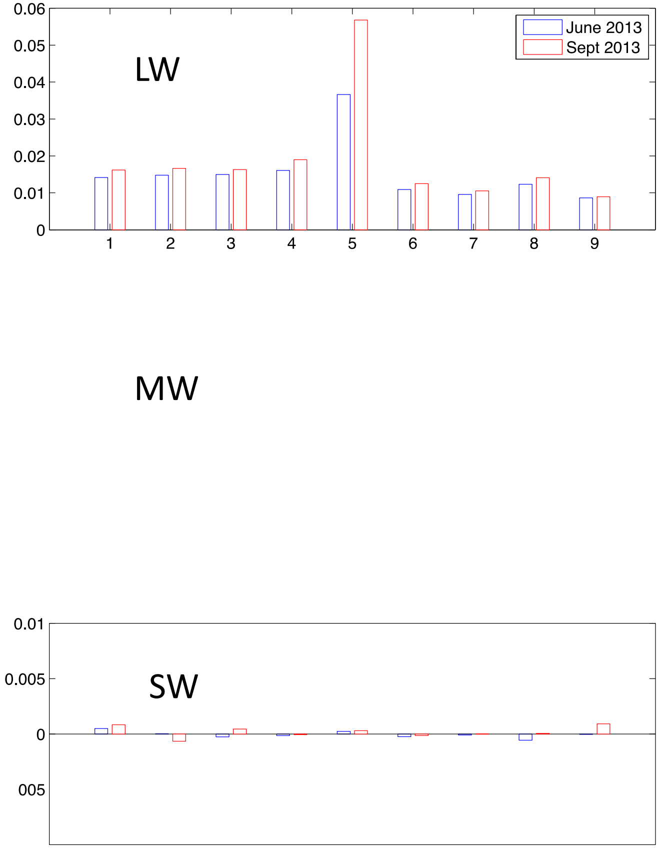
a_2 values

MW

SW

J1 Bench DM

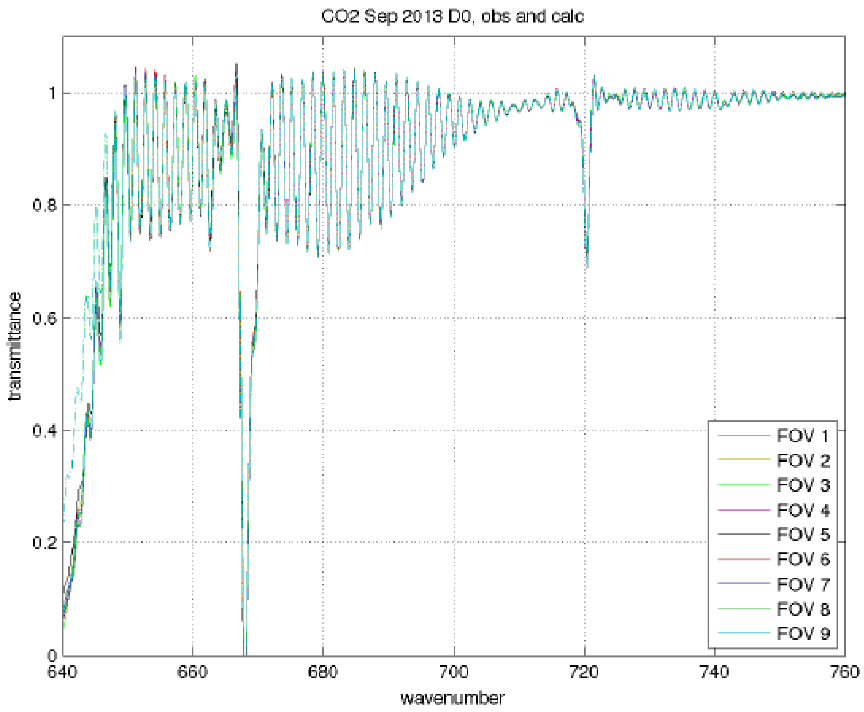
a_2 values



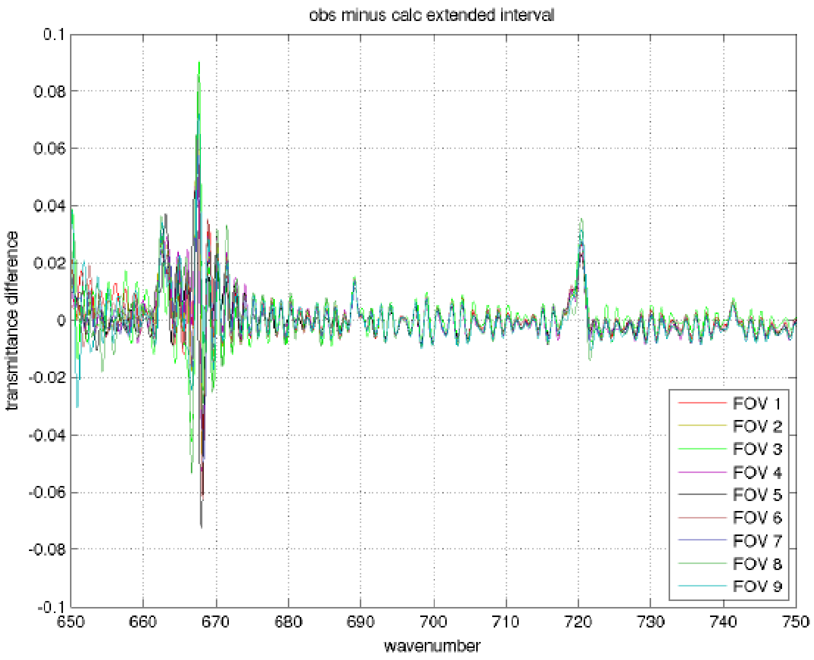
- ➢ The preliminary DM results for J1 are qualitatively similar to FM1 (SW is linear, some linear MW FOVs, all LW FOVs are nonlinear) and the same type of NL correction and TVAC and on-orbit a_2 analysis techniques will be needed for J1.
- ➢ Compared to FM-1, the J1 LW FOVs are more linear (except FOV5), and 8 of the J1 MW FOVs are very linear.
- ➢ Results are very similar to results found by Exelis (Lawrence S.)
- ➢ The difference between the June and Sept DM results (e.g. FOV5) are similar to inconsistent results seen for FM1 DM data analysis, which is still under investigation.

Preliminary Analysis of J1 Gas Cell Bench Test

Test results show good agreement with calculated data



Observed and calculated transmittance for all FOVs



Observed minus calculated transmittance spectra for all FOVs

Ongoing Calibration Algorithm and Software Improvements

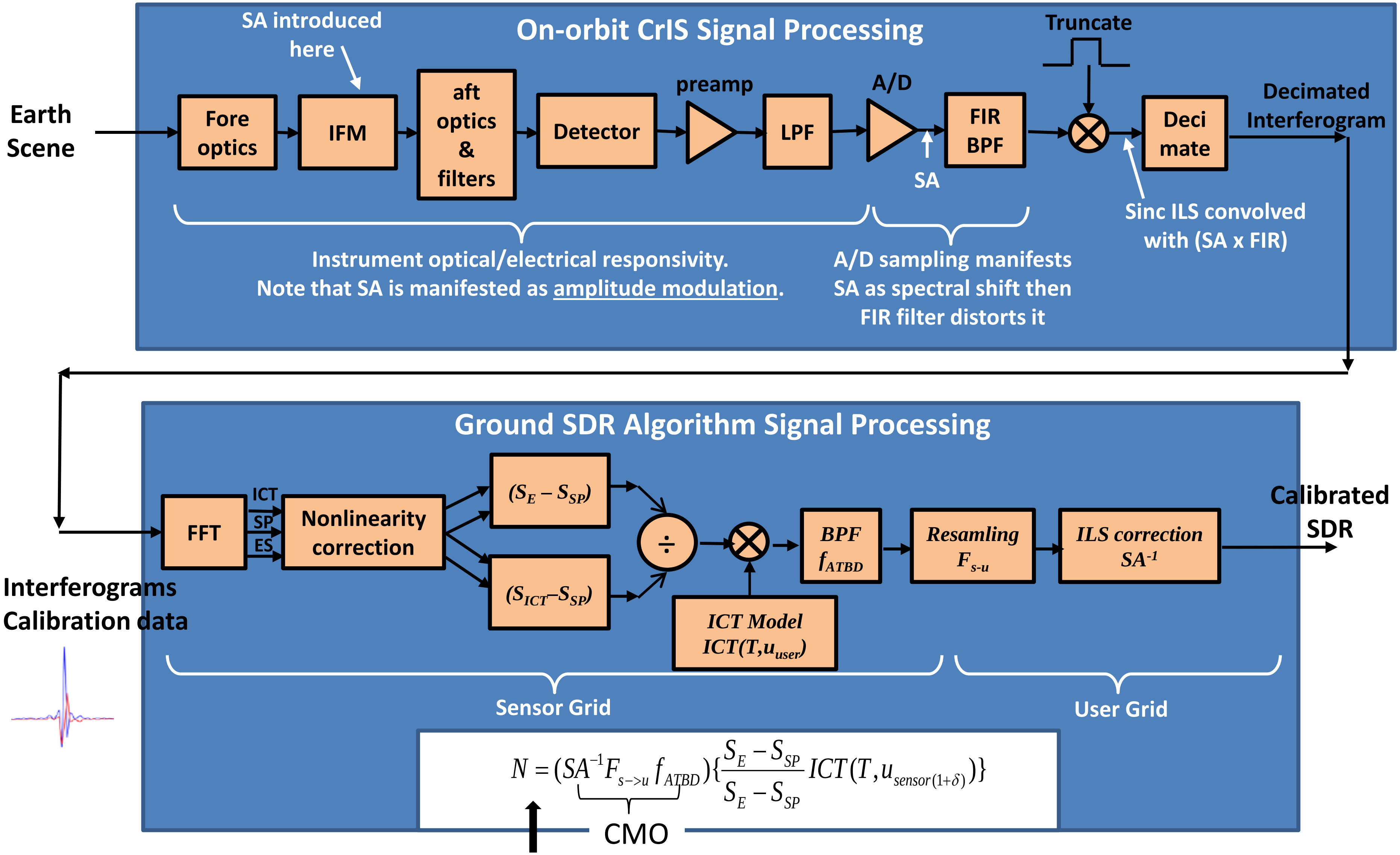
Why Need to Improve Calibration Algorithm/Software

- Recent progress in the investigation of spectral ringing artifacts indicates the current IDPS CrIS SDR calibration algorithms may not be optimal, especially for full spectral resolution SDR processing
- The NWP/Sounding community is interested in using unapodized CrIS data. However, the ringing artifacts in the unapodized data are not negligible
- The current implementation of the spectral Correction Matrix Operator (CMO) is not optimal and may be difficult to apply for some of the calibration algorithms under considerations

Calibration Algorithms under Evaluations

Item	Member	Calibration	CMO Principals	Calibration Order
1	IDPS	$N=(SA_u^{-1}\cdot F_{s\to u}\cdot f_{ATBD})\cdot\left\{\frac{S_E-S_{SP}}{S_{ICT}-S_{SP}}\cdot ICT(T,u_{sensor*(1+delta)})\right\}$	$SA_u^{-1}\cdot F_{s\to u}$	Calibration first, then CMO
2	ADL/CSPP	$N=(SA_u^{-1}\cdot F_{s\to u}\cdot f_{ATBD})\cdot\left\{\frac{S_E-S_{SP}}{S_{ICT}-S_{SP}}\cdot ICT(T,u_{sensor*(1+delta)})\right\}$		
3	Exelis (old)	$N=\left(SA_u^{-1}\cdot F_{s\to u}\cdot f_{ATBD}\right)\cdot\left\{\frac{S_E-S_{SP}}{S_{ICT}-S_{SP}}f_{BH}\cdot\left[SA_u^{-1}\cdot F_{s\to u}\right]^{-1}\cdot ICT(T,u_{sensor})\right\}$		
4	UMBC/UW** option A	$N=F_{s\to u}\cdot f\cdot SA_s^{-1}\cdot\left\{f\cdot\frac{FIR^{-1}\cdot(S_E-S_{SP})}{FIR^{-1}\cdot(S_{ICT}-S_{SP})}\cdot ICT(T,u_{sensor\_off\_axis})\right\}$	$F_{s\to u}\cdot SA_s^{-1}$	
5	CCAST Cal mode 1	$N=F_{s\to u}\cdot f\cdot SA_s^{-1}\cdot\left\{\frac{FIR^{-1}\cdot(S_E-S_{SP})}{FIR^{-1}\cdot(S_{ICT}-S_{SP})}\cdot ICT(T,u_{sensor\_off\_axis})\right\}$		
6	UMBC/UW** option B	$N=F_{s\to u}\cdot\left\{ICT(T,u_{sensor})\cdot f\cdot SA_s^{-1}\cdot\left\{f\cdot\frac{FIR^{-1}\cdot(S_E-S_{SP})}{FIR^{-1}\cdot(S_{ICT}-S_{SP})}\right\}\right\}$		
7	CCAST Cal mode 2	$N=F_{s\to u}\cdot f\cdot\left\{ICT(T,u_{sensor})\cdot SA_s^{-1}\cdot\left\{\mathrm{Re}\left[\frac{FIR^{-1}\cdot(S_E-S_{SP})}{FIR^{-1}\cdot(S_{ICT}-S_{SP})}\right]\right\}\right\}$		
8	LL(old)*	$N=\left\{\frac{M\cdot\left(FIR^{-1}\cdot(S_E-S_{SP})\right)}{M\cdot\left(FIR^{-1}\cdot(S_{ICT}-S_{SP})\right)}\right\}\cdot ICT(T,u_{user})$		CMO first, then Calibration
9	Proposed(1)	$N=F_{s\to u}\cdot f_{ATBD}\cdot\left\{\frac{SA_s^{-1}\cdot\left(FIR^{-1}\cdot(S_E-S_{SP})\right)}{SA_s^{-1}\cdot\left(FIR^{-1}\cdot(S_{ICT}-S_{SP})\right)}\cdot ICT(T,u_{sensor})\right\}$		
10	Proposed(2)	$N=ICT(T,u_{user})\cdot\left\{\frac{F_{s\to u}\cdot SA_s^{-1}\cdot f_{ATBD}\cdot\left(FIR^{-1}\cdot(S_E-S_{SP})\right)}{F_{s\to u}\cdot SA_s^{-1}\cdot f_{ATBD}\cdot\left(FIR^{-1}\cdot(S_{ICT}-S_{SP})\right)}\right\}$		
11	Exelis(new)	$N=\left\{\frac{\left(SA_u^{-1}\cdot F_{s\to u}\cdot(S_E-S_{SP})\right)}{\left(SA_u^{-1}\cdot F_{s\to u}\cdot(S_{ICT}-S_{SP})\right)}\right\}\cdot ICT(T,u_{user})$	$SA_u^{-1}\cdot F_{s\to u}$	

Current Ground SDR Algorithm



Earth Scene

On-orbit CrIS Signal Processing

SA introduced here

Fore optics

IFM

aft optics & filters

Detector

preamp

LPF

A/D

SA

FIR BPF

Truncate

Deci mate

Decimated Interferogram

Sinc ILS convolved with (SA x FIR)

Instrument optical/electrical responsivity.
Note that SA is manifested as amplitude modulation.

A/D sampling manifests SA as spectral shift then FIR filter distorts it

Ground SDR Algorithm Signal Processing

Interferograms Calibration data

FFT

ICT

SP

ES

Nonlinearity correction

$(S_E - S_{SP})$

$(S_{ICT} - S_{SP})$

÷

BPF f_{ATBD}

Resamling $F_{s\text{-}u}$

ILS correction SA^{-1}

ICT Model $ICT(T,u_{user})$

Calibrated SDR

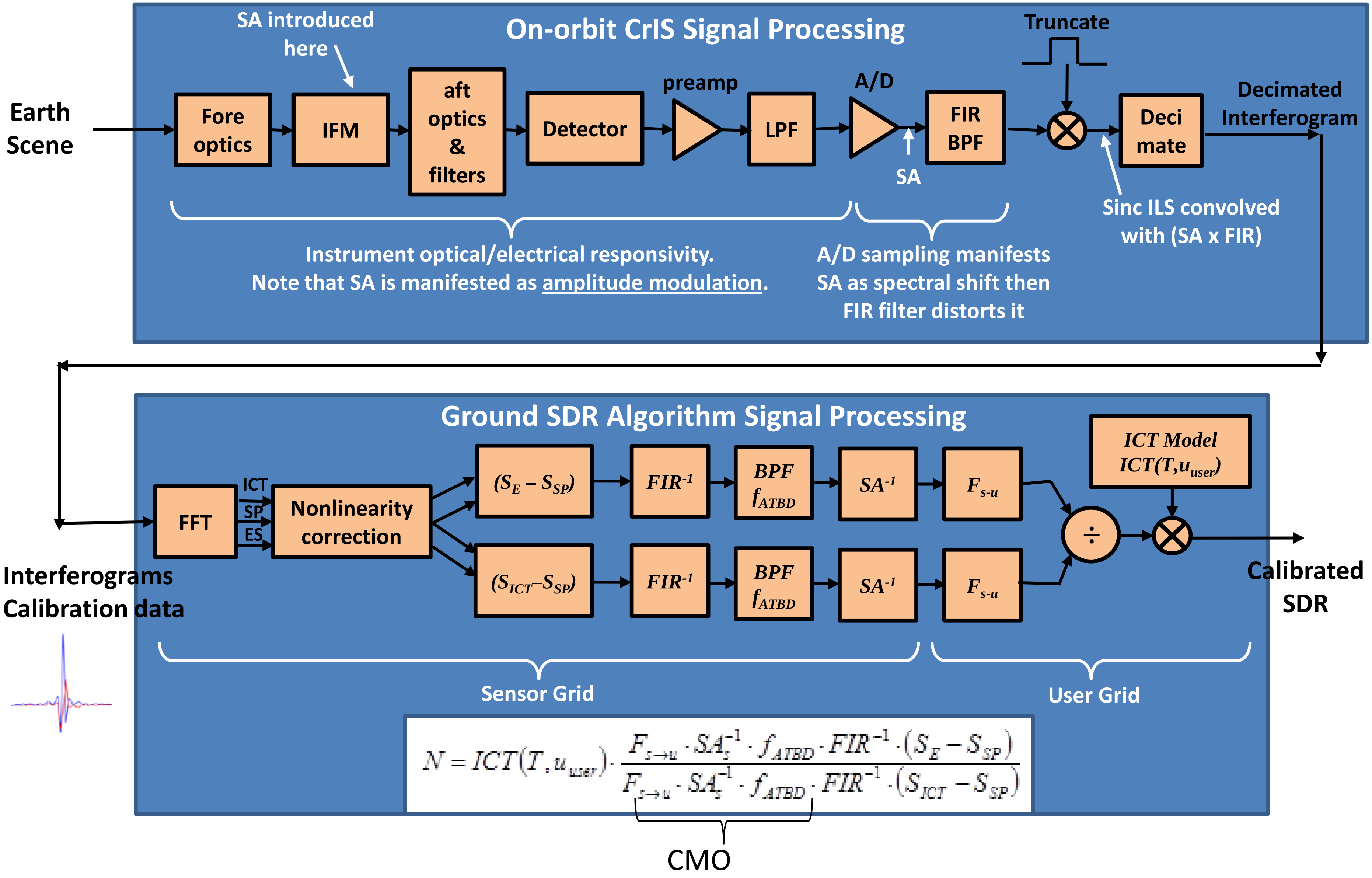
Sensor Grid

User Grid

$$N = (\underbrace{SA^{-1}F_{s->u}\, f_{ATBD}}_{\text{CMO}})\{\frac{S_E - S_{SP}}{S_E - S_{SP}}\, ICT(T, u_{sensor(1+\delta)})\}$$

Not optimal for full spectral resolution mode processing

A Proposed SDR Algorithm



On-orbit CrIS Signal Processing

Earth Scene

SA introduced here

Fore optics → IFM → aft optics & filters → Detector → preamp → LPF → A/D → FIR BPF → Truncate → Deci mate → Decimated Interferogram

SA

Sinc ILS convolved with (SA x FIR)

Instrument optical/electrical responsivity.
Note that SA is manifested as <u>amplitude modulation</u>.

A/D sampling manifests SA as spectral shift then FIR filter distorts it

Ground SDR Algorithm Signal Processing

Interferograms
Calibration data

FFT → ICT, SP, ES → Nonlinearity correction

$(S_E - S_{SP})$ → FIR^{-1} → BPF f_{ATBD} → SA^{-1} → $F_{s\text{-}u}$

$(S_{ICT} - S_{SP})$ → FIR^{-1} → BPF f_{ATBD} → SA^{-1} → $F_{s\text{-}u}$

÷

ICT Model $ICT(T,u_{user})$

Calibrated SDR

Sensor Grid

User Grid

$$N = ICT(T,u_{user})\cdot\frac{F_{s\to u}\cdot SA_s^{-1}\cdot f_{ATBD}\cdot FIR^{-1}\cdot(S_E - S_{SP})}{\underbrace{F_{s\to u}\cdot SA_s^{-1}\cdot f_{ATBD}}_{\text{CMO}}\cdot FIR^{-1}\cdot(S_{ICT} - S_{SP})}$$

Example of Cal. Algorithm Difference

Algorithms are implemented in ADL and then compared

Proposed 2

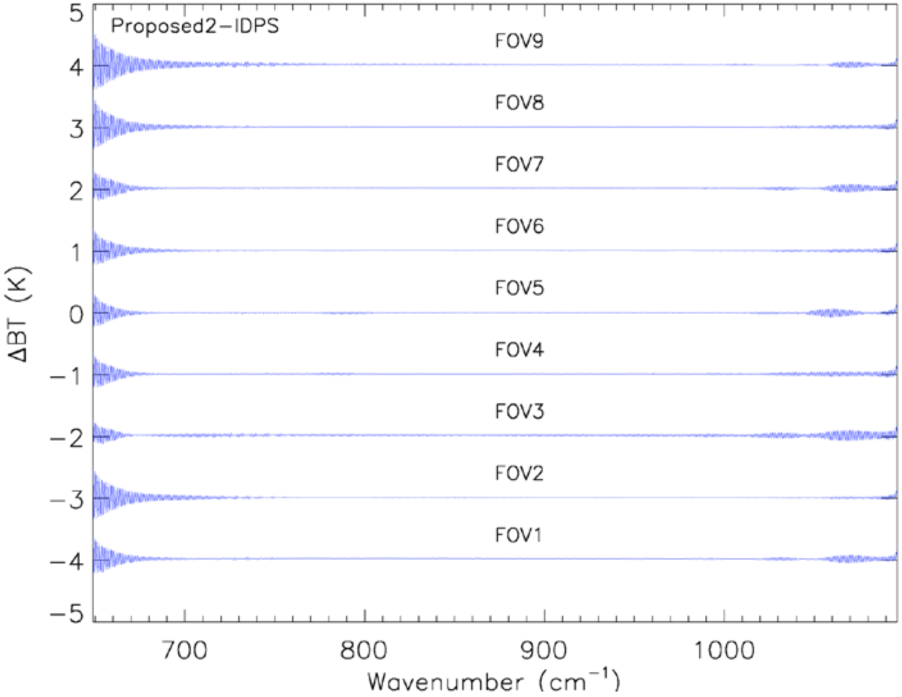
$$N = ICT(T, u_{user}) \cdot \left\{ \frac{F_{s \to u} \cdot SA_s^{-1} \cdot f_{ATBD} \cdot \left(FIR^{-1} \cdot (S_E - S_{SP}) \right)}{F_{s \to u} \cdot SA_s^{-1} \cdot f_{ATBD} \cdot \left(FIR^{-1} \cdot (S_{ICT} - S_{SP}) \right)} \right\}$$

minus

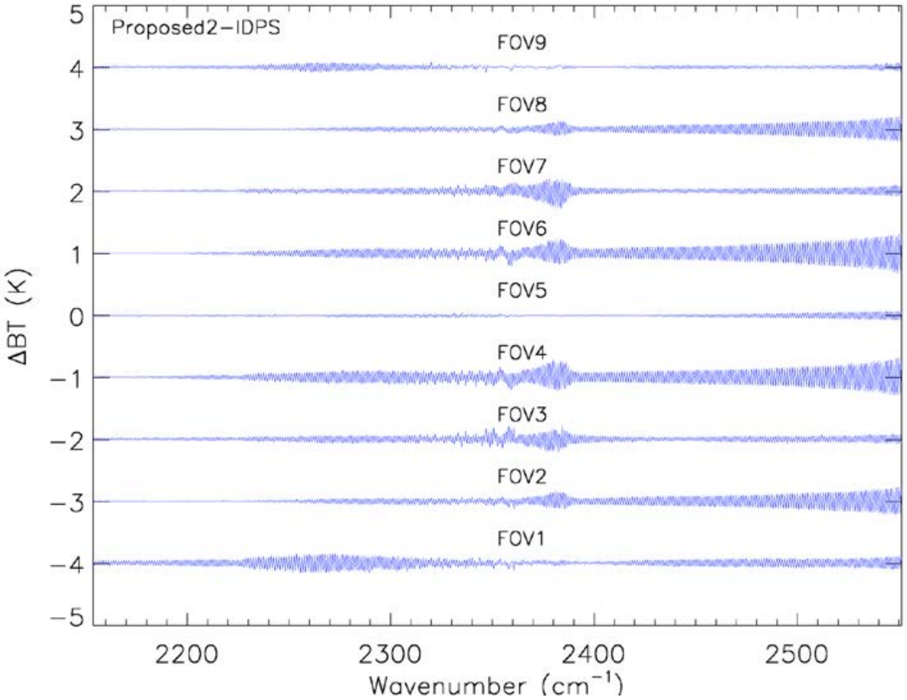
Current IDPS

$$N = (SA^{-1} F_{s->u} f_{ATBD}) \{ \frac{S_E - S_{SP}}{S_E - S_{SP}} ICT(T, u_{sensor(1+\delta)}) \}$$

LW Band (FOR 1)



SW Band (FOR1, full resolution)



Significant difference (ringing) seen in all three bands (unapodized) 0.1 – 0.5 K

Spectral Interpolation before/after the Calibration Ratio Has Big Difference

$$N = ICT(T,u_{user}) \cdot \left\{ \frac{F_{s\to u} \cdot SA_s^{-1} \cdot f_{ATBD} \cdot \left(FIR^{-1} \cdot (S_E - S_{SP})\right)}{F_{s\to u} \cdot SA_s^{-1} \cdot f_{ATBD} \cdot \left(FIR^{-1} \cdot (S_{ICT} - S_{SP})\right)} \right\}$$

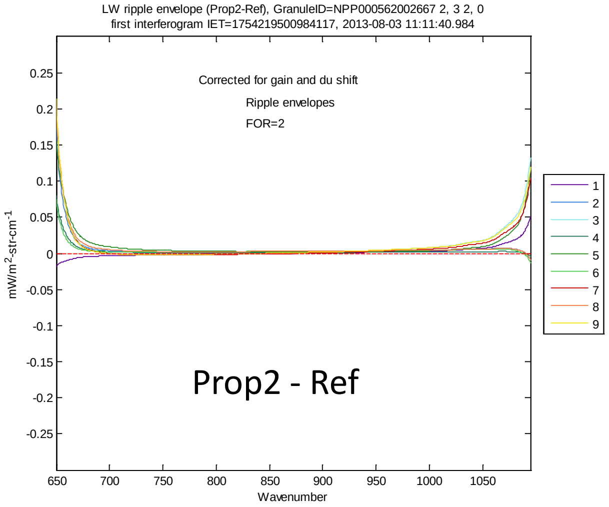
$$N = F_{s\to u} \cdot f \cdot SA_s^{-1} \cdot \left\{ \frac{FIR^{-1} \cdot (S_E - S_{SP})}{FIR^{-1} \cdot (S_{ICT} - S_{SP})} \cdot ICT(T,u_{sensor\_off\_axis}) \right\}$$

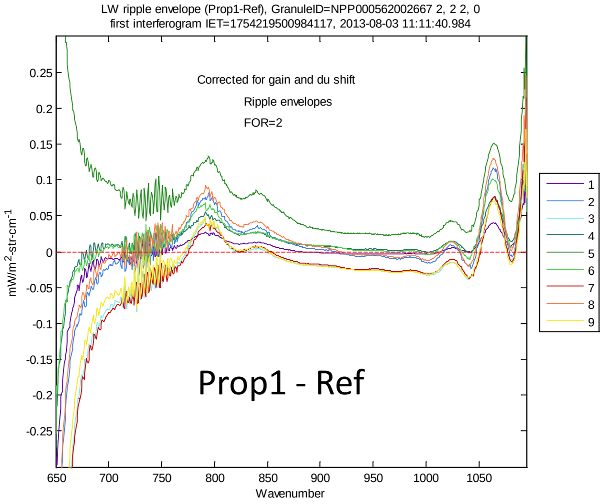
$$N = F_{s\to u} \cdot f_{ATBD} \cdot \left\{ \frac{SA_s^{-1} \cdot \left(FIR^{-1} \cdot (S_E - S_{SP})\right)}{SA_s^{-1} \cdot \left(FIR^{-1} \cdot (S_{ICT} - S_{SP})\right)} \cdot ICT(T,u_{sensor}) \right\}$$

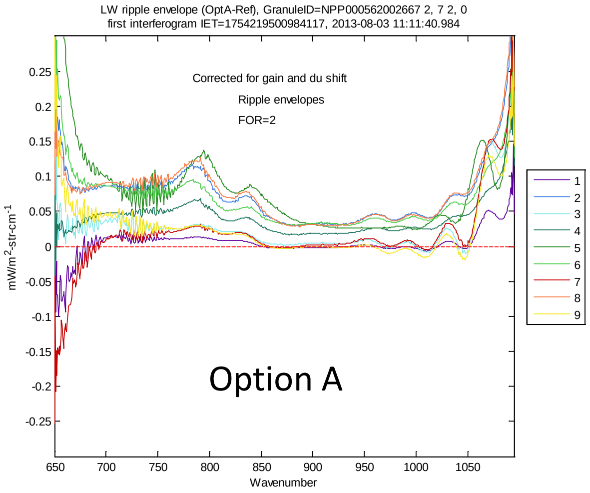
Ratio after interpolation & ISA

Ratio before interpolation

Ratio before interpolation & ISA





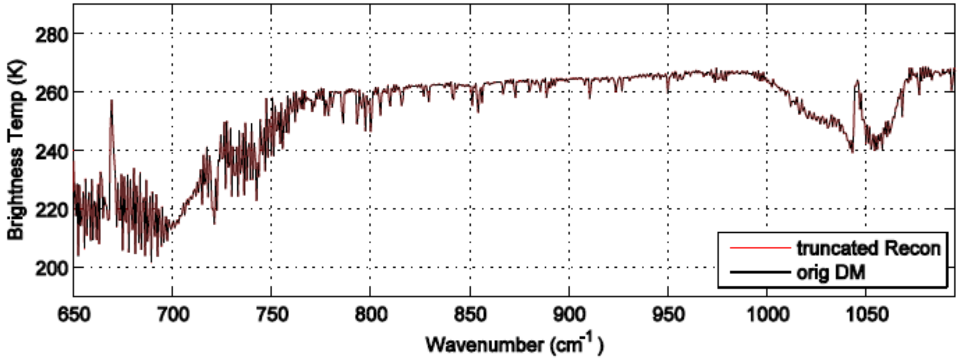


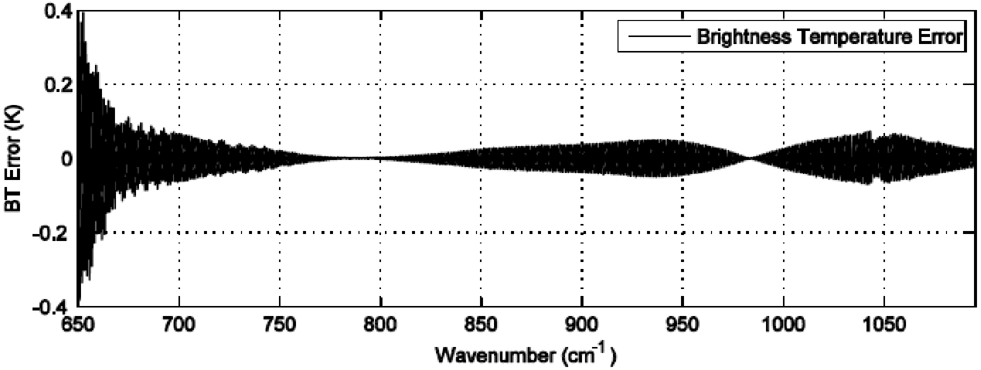
Ref

$$N = \left\{ \frac{M \cdot \left(FIR^{-1} \cdot (S_E - S_{SP})\right)}{M \cdot \left(FIR^{-1} \cdot (S_{ICT} - S_{SP})\right)} \right\} \cdot ICT(T,u_{user})$$

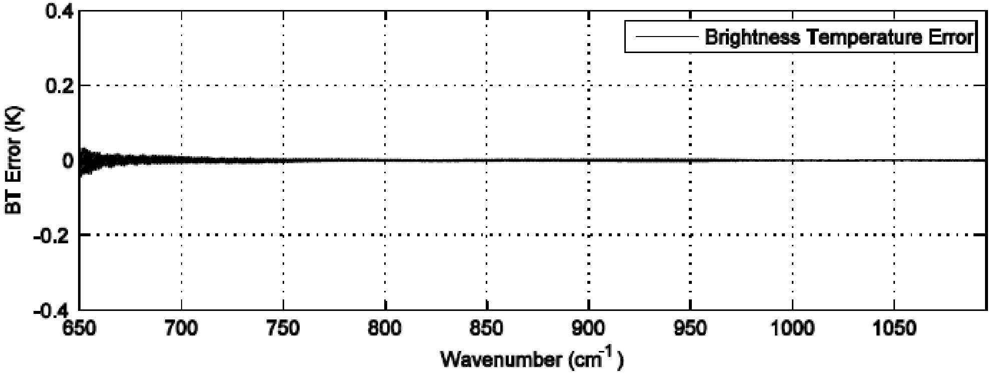
Note: Ref does interpolation before ratio

Ringing Artifact Reduction by Normalizing FIR Gain before Truncation of IGM





Significant ringing if spectrum is not normalized with FIR gain before interferogram (IGM) truncation and spectral interpolation



Ringing artifacts are largely reduced with the algorithm that normalizes S with the FIR gain

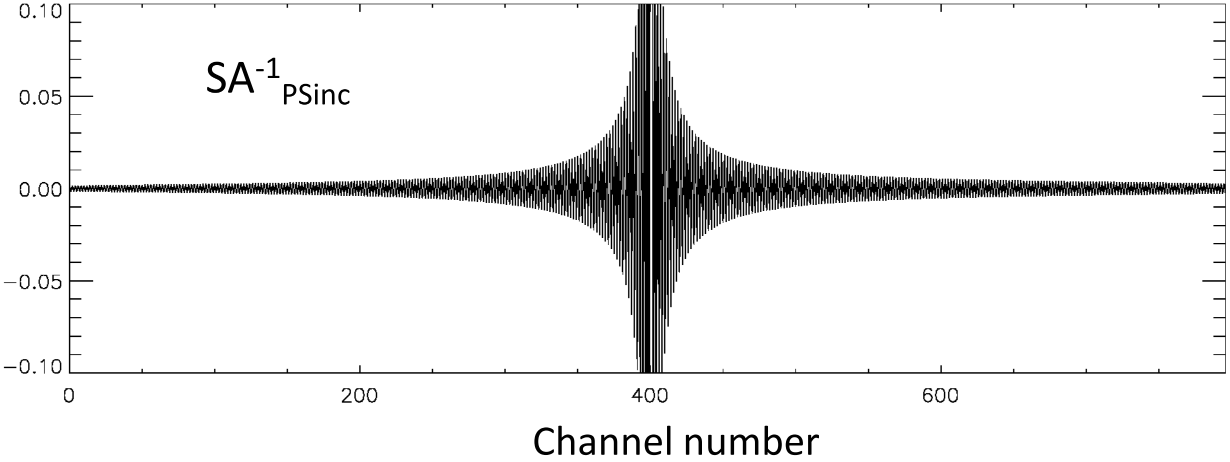
Issue in Self-apodization Correction Matrix SA^{-1}

- Recent investigation indicated the current IDPS SA^{-1} is not optimal and may introduce significant ringing artifacts in full spectral resolution SDR processing
- New algorithms are proposed and are being evaluated
  - Use periodic Sinc function instead of the current Sinc function
  - Double the size of the SA^{-1} matrix in computation
  - Derive the matrix SA^{-1} through minimization

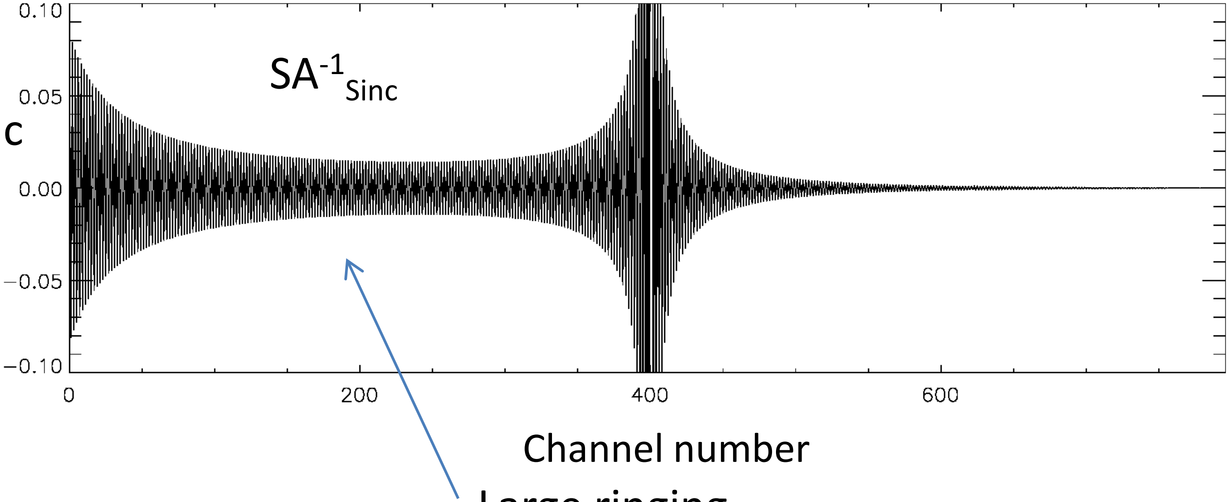
Difference of SA^{-1} Matrixes Calculated with Psinc and Sinc Functions

SW FOV1 SA^{-1} matrix row 400 (full resolution)

SA^{-1} calculated with Periodic Sinc function



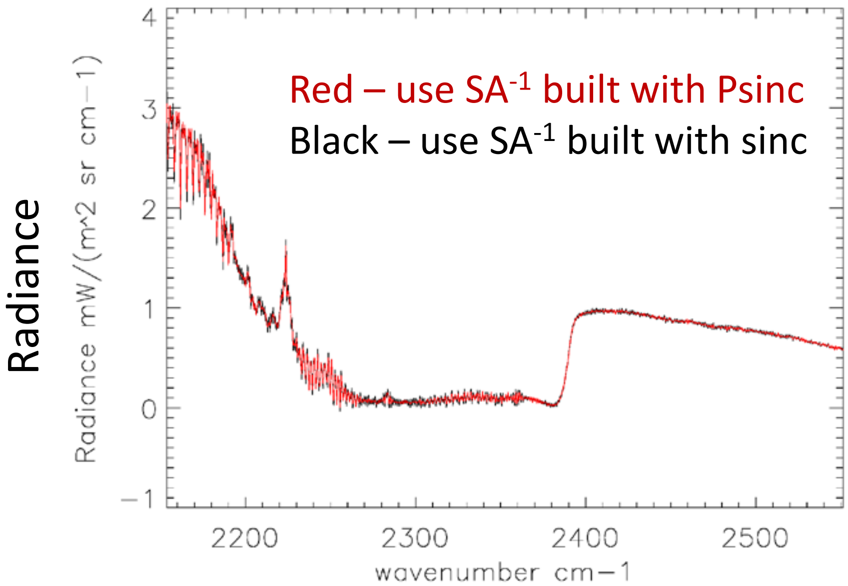
SA^{-1} calculated with Sinc function (current IDPS)

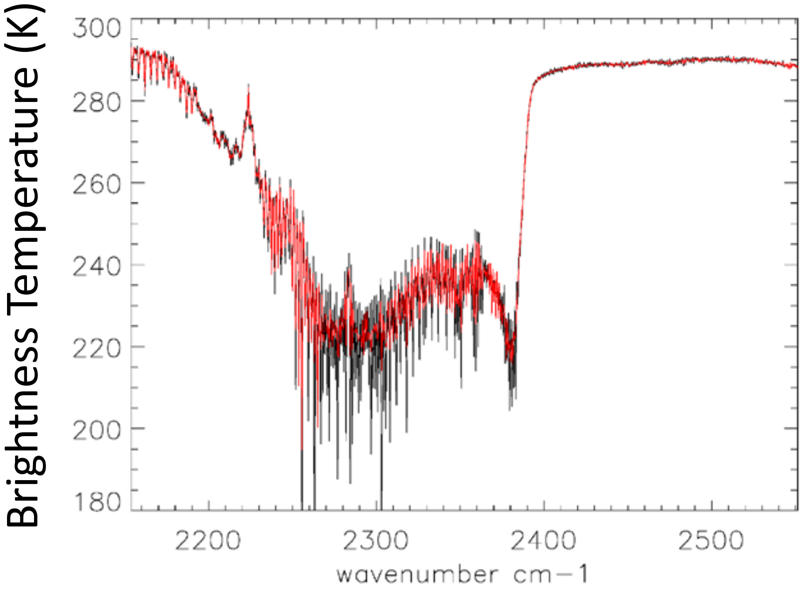


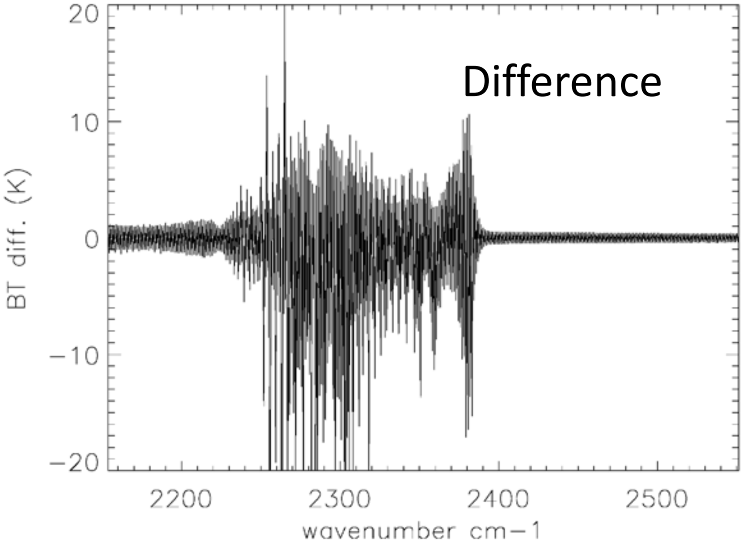
Large ringing

Radiance Difference due to the Difference in SA^{-1}

ADL Full Resolution SW FOV1 Spectrum







Large ringing artifacts produced with the current SA^{-1} algorithm is not acceptable for full spectral resolution processing

Challenges and Risks

- The delivery of CrIS SDR software is scheduled on Jan 15, 2015. However, we still have a large amount of work to do in both algorithm and code changes
- Implementation of the proposed calibration algorithm requires a lot of code changes, which normally start after the algorithm investigations. However, the delivery schedule is pushing us to start working on the code changes before the conclusion of the investigations.
- Current IDPS does not support a dynamic switch between the normal mode and full spectral resolution mode SDR processing; in other words, the switch requires recompiling the software

Work in the Coming Program Year

- Suomi NPP
  - Continuation of RDR and SDR monitoring
  - Fine adjustment of spectral and radiometric calibration parameters and geolocation mapping parameters, if needed.
  - Continuation of Full Spectral Resolution work, if required.
  - SDR algorithm improvement to address the potential issues (e.g. FCE detection/correction, reduction of ringing artifacts and polarization effect correction)
  - Continuation of SDR software improvements to address the remaining and future issues
- JPSS J1
  - Support of and participation in pre-launch testing and instrument characterization
  - Calibration data (LUTs and coefficients) development
  - Algorithm/software development and improvements (full resolution SDR capability, calibration algorithms and FCE detection/correction module), delivering the SDR code in January 2015
  - Development of a comprehensive test data set derived from NPP observations and J1 TVAC tests for J1 algorithm and software development

Summary

- The team has successfully completed the CrIS SDR ICV process and achieved the Validated status for the S-NPP CrIS SDR product
- LTM activities are being routinely carried out to ensure the data product quality
- Work has been successfully completed to add a truncation module to the IDPS CrIS SDR software: the software is ready for handling full spectral resolution RDRs
- The team is making efforts to improve the calibration algorithms and processing software. Progress has been made. However, it is challenging to meet the software delivery schedule.
- Preliminary analysis of the bench test data was performed and the results are within the expectation
- The team has a clear path moving forward for both NPP and J1 missions

JPSS STAR Science Team Annual Meeting
VIIRS SDR Team

Changyong Cao

VIIRS SDR Lead

May 12-16, 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

VIIRS SDR Team

Leads	Organization	Members
Changyong Cao	NOAA/NESDIS/STAR	Slawomir Blonski, Frank Padula, Wenhui Wang, Jason Choi, Sirish Uprety, Sean Shao, Yan Bai, Vicky Lin
Frank Deluccia	The Aerospace Corp.	David Moyer, Kameron Rausch, others
J. Xiong/R. Wolfe	NASA/VCST	Hassan Oudrari, Vincent Chang, Aisheng Wu, John Fulbright, Jeff McIntire, Boriana Efrmova, Ning Lei, Gary Lin, Masahiro Nishihama, others
Lushalan Liao	NGAS	Ronsan Chu, Stephnie Weiss, Tahru Ohnuki, Frank Sun, others
Chris Moeller	U. Wisc.	others

Products:

22 SDRs

Users:

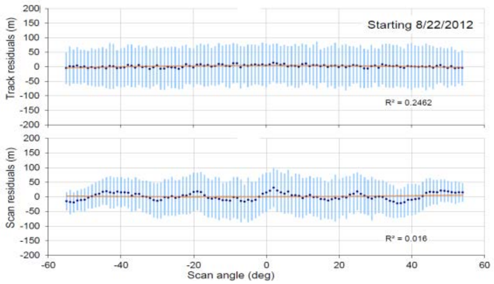
VIIRS EDR with more than 20 products

Major Achievements

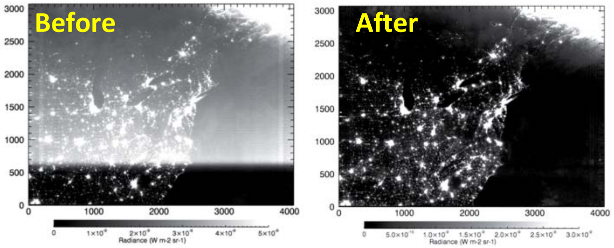
Major Achievements Since Provisional

- 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)

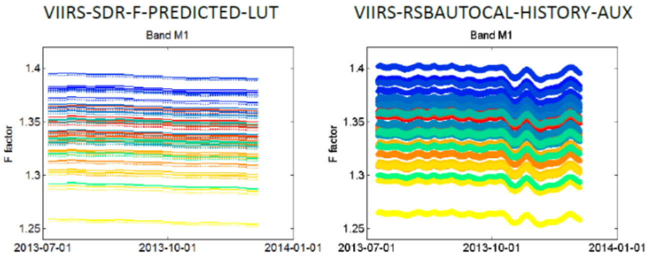
Geo-Location Accuracy



DNB Straylight Correction Implemented



RSBAutoCal Testing



Major Achievements and Events

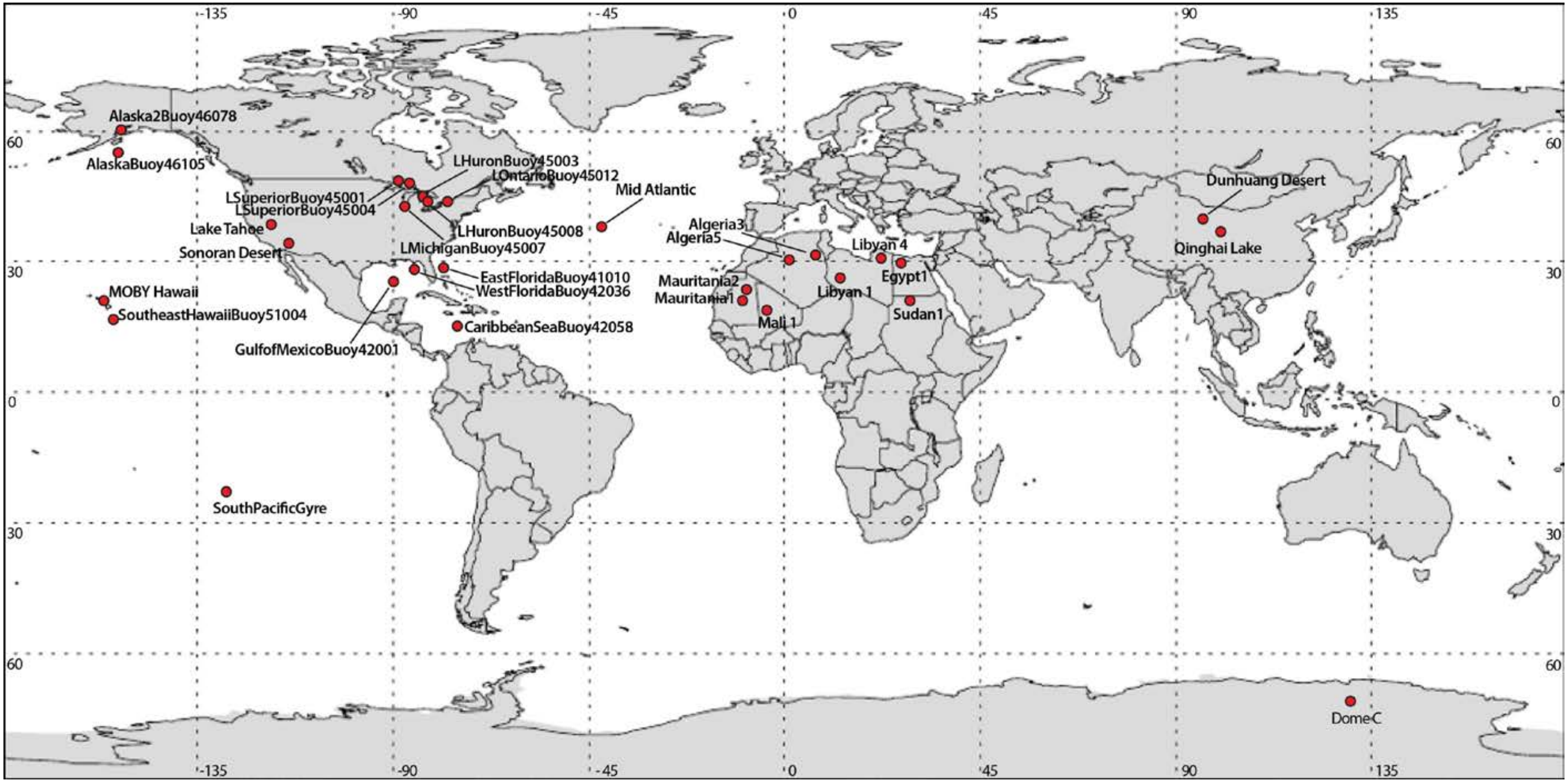
Since the validated maturity workshop in December 2013:

- VIIRS SDR achieved validated maturity
- Validation time series developed for ~30 sites worldwide (W. Wang)
- DCC time series since launch established (W. Wang)
- Lunar band ratio time series developed (S. Shao & J. Choi)
- Calibration coefficient changes (c0=0) implemented (May 2014)
- I3/M10 bias studies (new results from Lunar band ratio analysis, see X. Shao in breakout session)
- Sun vector error findings (NASA)
- DNB terrain corrected geolocation (March 18, 2014 with MX8.4)
- Single Board Computer Lockup(SBC) #6 (or 7), aka “Petulant mode” on Feb. 4, 2014
- Flattening in the degradation shown in H and F factors
- VIIRS J1 polarization studies

On-going work:

- Continued updating the calibration knowledge base, with new events analyzed and documented
- Continued bias time series analysis between VIIRS and MODIS
- Continued longterm trending and monitoring

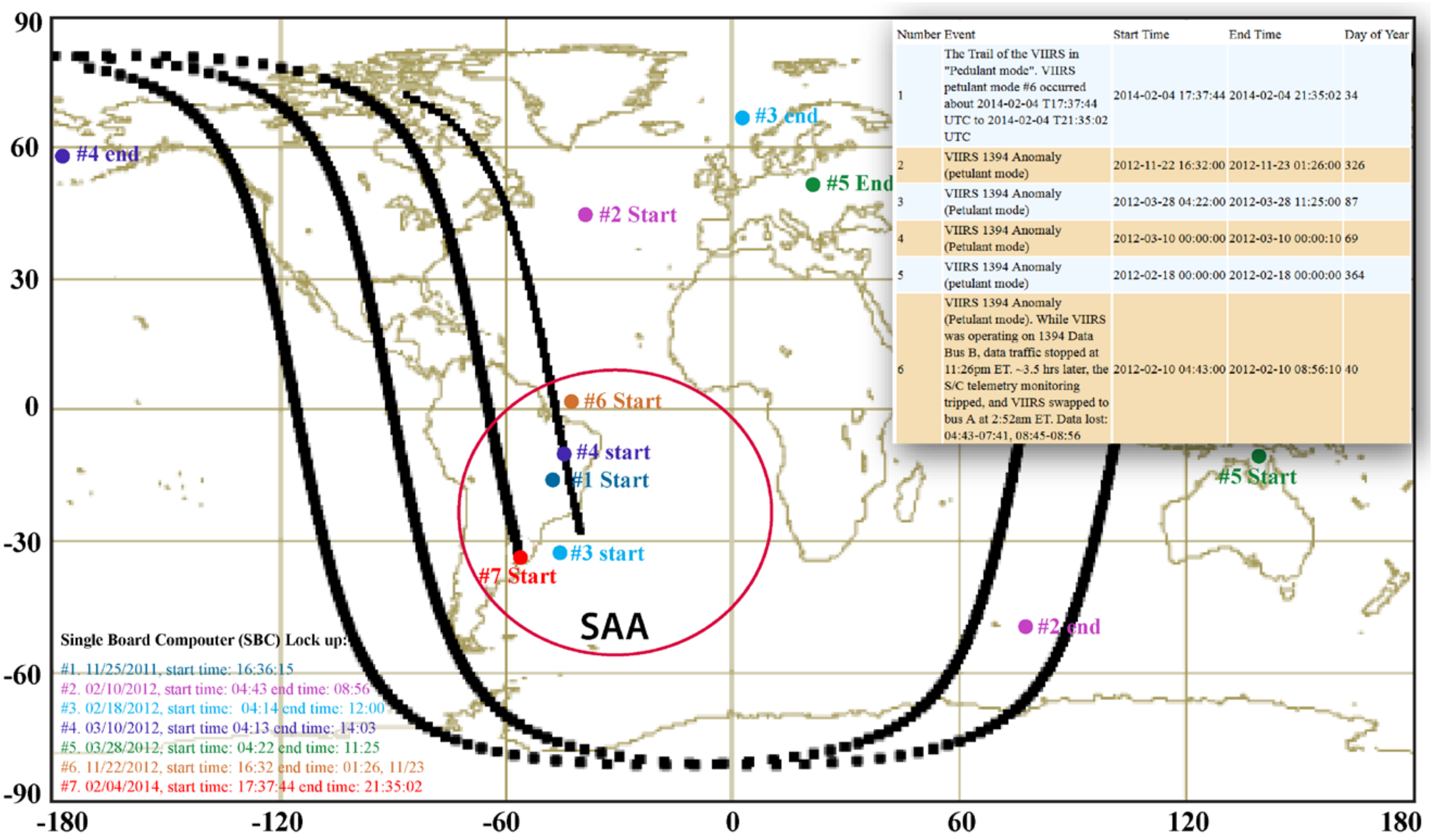
VIIRS Radiometric Validation Time Series at thirty validation sites world-wide



More details will be presented by W. Wang in the VIIRS Breakout session

VIIRS Event Log Database

An important part of the Calibration Knowledge base



Number	Event	Start Time	End Time	Day of Year
1	The Trail of the VIIRS in "Pedulant mode". VIIRS petulant mode #6 occurred about 2014-02-04 T17:37:44 UTC to 2014-02-04 T21:35:02 UTC	2014-02-04 17:37:44	2014-02-04 21:35:02	34
2	VIIRS 1394 Anomaly (petulant mode)	2012-11-22 16:32:00	2012-11-23 01:26:00	326
3	VIIRS 1394 Anomaly (Petulant mode)	2012-03-28 04:22:00	2012-03-28 11:25:00	87
4	VIIRS 1394 Anomaly (Petulant mode)	2012-03-10 00:00:00	2012-03-10 00:00:10	69
5	VIIRS 1394 Anomaly (petulant mode)	2012-02-18 00:00:00	2012-02-18 00:00:00	364
6	VIIRS 1394 Anomaly (Petulant mode). While VIIRS was operating on 1394 Data Bus B, data traffic stopped at 11:26pm ET. ~3.5 hrs later, the S/C telemetry monitoring tripped, and VIIRS swapped to bus A at 2:52am ET. Data lost: 04:43-07:41, 08:45-08:56	2012-02-10 04:43:00	2012-02-10 08:56:10	40

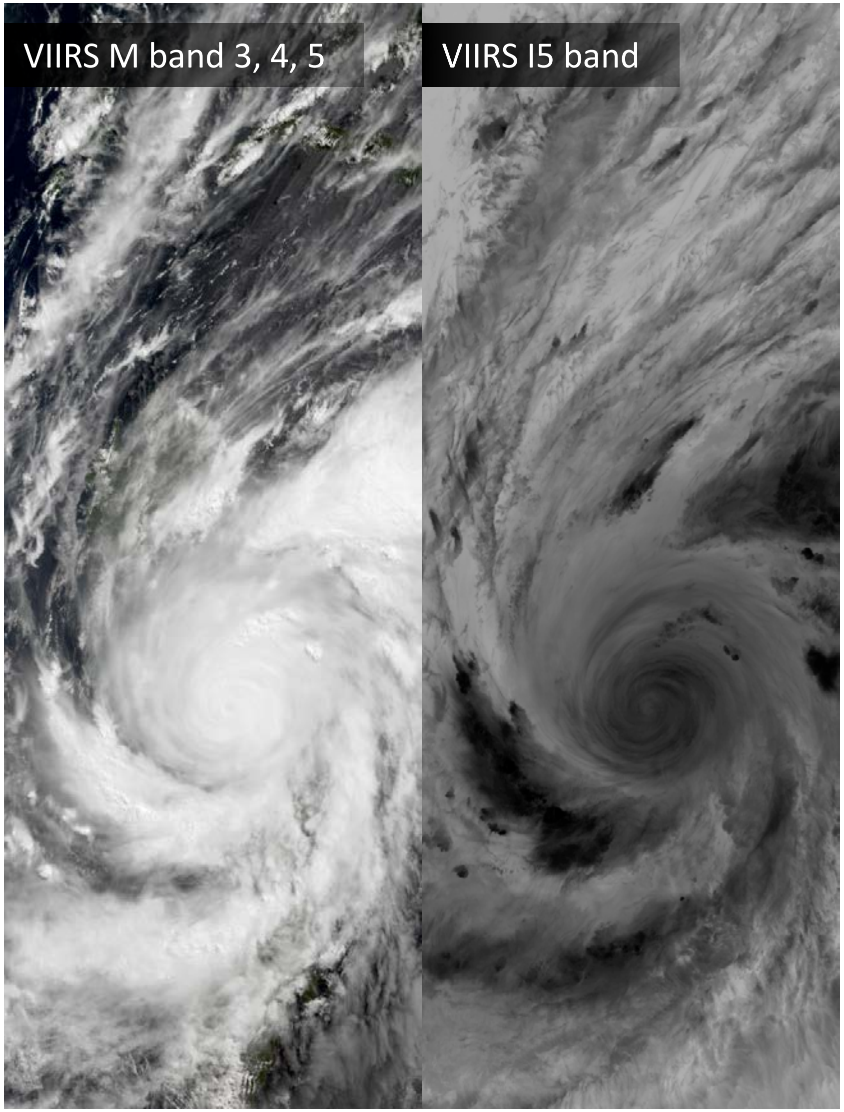
Single Board Compouter (SBC) Lock up:

#1. 11/25/2011, start time: 16:36:15
#2. 02/10/2012, start time: 04:43 end time: 08:56
#3. 02/18/2012, start time: 04:14 end time: 12:00
#4. 03/10/2012, start time 04:13 end time: 14:03
#5. 03/28/2012, start time: 04:22 end time: 11:25
#6. 11/22/2012, start time: 16:32 end time: 01:26, 11/23
#7. 02/04/2014, start time: 17:37:44 end time: 21:35:02

For more details, see poster by Y. Bai et al.

Suomi NPP VIIRS SDR Validated Maturity

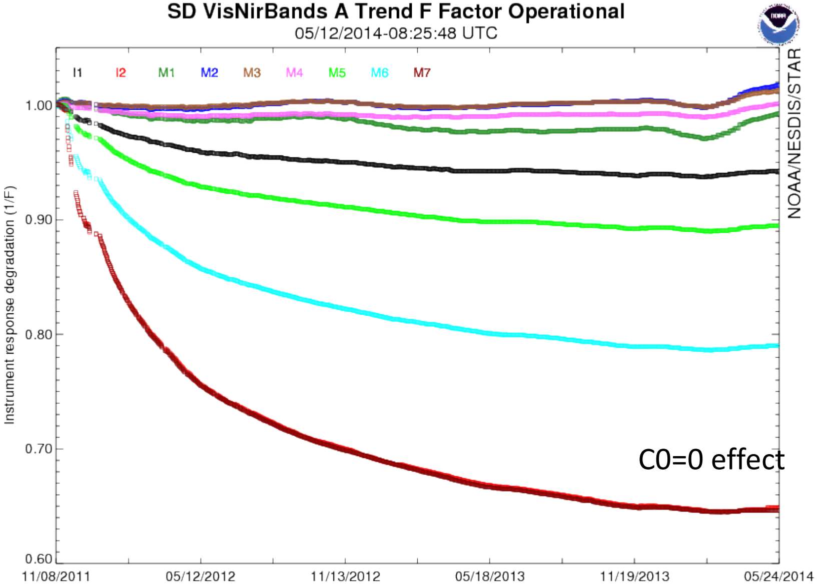
- **Milestone:** Successfully completed the VIIRS SDR Validated Maturity Workshop, and achieved validated status in March 2014.
- **Accomplishments**
  - STAR held a three-day Suomi NPP SDR Science and Validated Product Maturity Review (December 18-20, 2013) at the NOAA NCWCP to assess the readiness of the VIIRS SDR data product maturity
  - The VIIRS SDR team members and EDR users reported on the progress made since the Provisional Maturity Review demonstrating the VIIRS SDR maturity level
  - Concluding the Workshop the review panel members reached consensus that overall the VIIRS SDR product has reached the validated status and therefore is recommended to be approved by the Algorithm Executive Review Board (AERB)
  - The AERB approved the recomemnded validated status in March 2014.
- **Significance: VIIRS SDR has achieved the validated maturity**



VIIRS SDR Accuracy

	Requirement (absolute uncertainty for uniform scenes)	Prelaunch and onboard calibration	Validation: Relative to MODIS/CrIS/IASI/other thru Inter-comparisons	Note
VIIRS RSB	2% typical reflectance; 0.3% stability; 0.1% desirable for Ocean Color Applications	1.2% for M1-M7; 1.5% for M8&9 1.4% for M10 1.3% for I1&I2 1.6% for I3	2% (±1%) for matching bands	Except bands with very low signal (ex. M11); sub-percent accuracy for OC is very challenging. Geolocation error: expectation is half I-band pixel; achieved better than quarter I-band pixel (1-σ)
VIIRS TEB	M12/M13: 0.7%(0.13K) @270K M14: 0.6% (0.26K) @ 270K M15/M16: 0.4% (0.22K/0.24K) @270K I4: 5% (0.97K) @270K I5: 2.5% (1.5K) @270K	Better than 0.13K for all M bands except M13 (0.14); 0.47K for I4; 0.23K for I5	0.1K based on statistical comparison with MODIS and CrIS ER-2/SHIS Aircraft underflight shows excellent agreement M15 0.4 K bias relative to CrIS at 200K (in spec.)	M15 at 190K requirement is 2.1% radiance or 0.56K Geolocation uncertainty: expectation was half I-band pixel; achieved better than quarter I-band pixel (1-σ)
VIIRS DNB	• 5%, 10%,30% L_{min} (LGS,MGS,HGS)	3.5%, 7.8%, and 11% (LGS, MGS, HGS)	• 4%, 7.7%, 11.8% (LGS, MGS, HGS)	Geolocation error is a ~10th of a pixel (1-σ) on the ellipsoid earth but can exceed 1km (up to 24 km at the edges of scan) without terrain correction

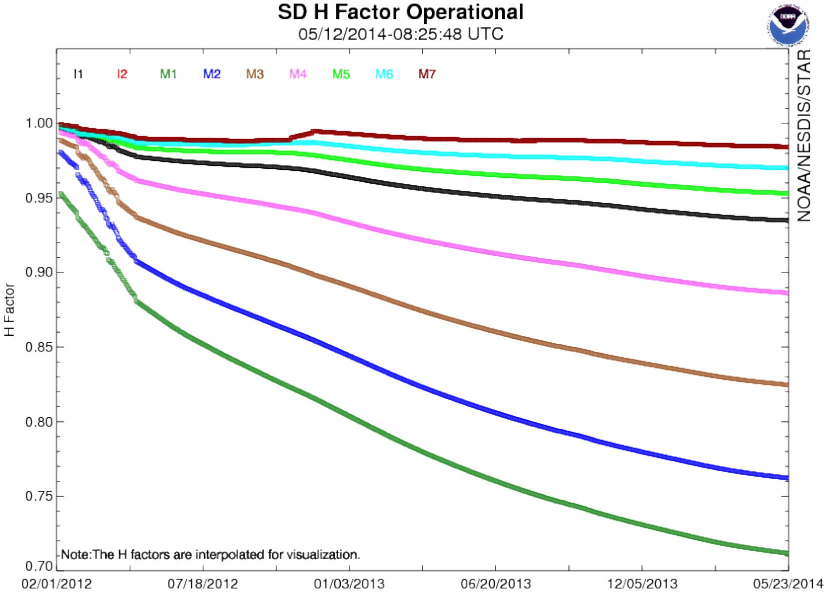
Recent RSB H&F factor trends



SD VisNirBands A Trend F Factor Operational

05/12/2014-08:25:48 UTC

C0=0 effect



SD H Factor Operational

05/12/2014-08:25:48 UTC

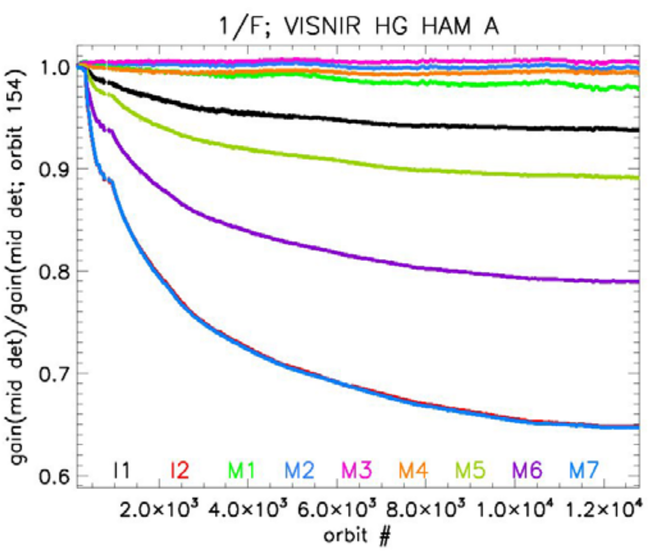
Note:The H factors are interpolated for visualization.

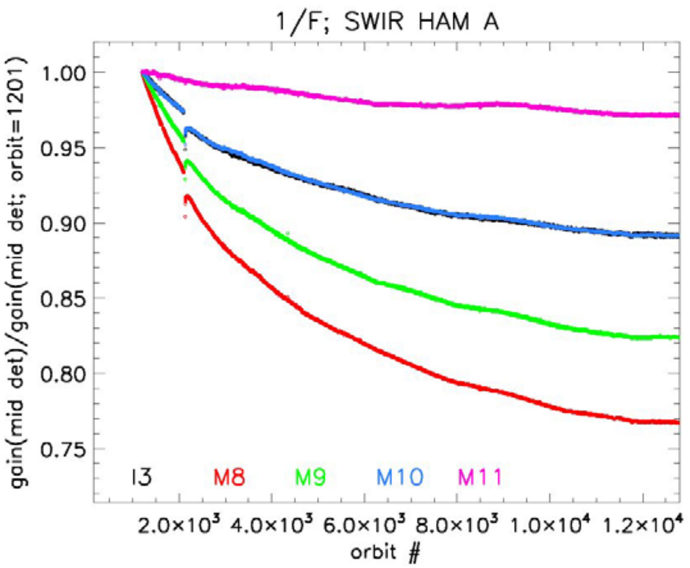
- Recent F-factors show significant trend change which suggests that degradation has stopped or even reversed
- Is this real or artificial?
- How can we tell through validation?
- Is this due to issues in the H-factor calculations?

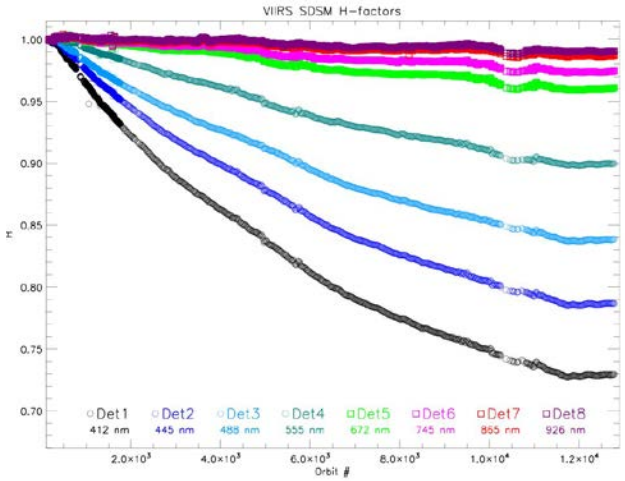
- H-factors in the above plot do not show major recent trend change due to smooth?
- The unsmoothed version does show trend change (such as those produced by Autocal)
- What's the impact on the F-factor calibrations?

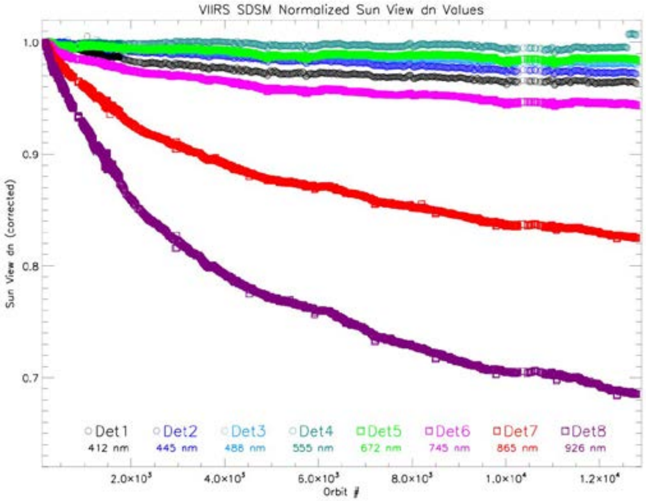
What's the impact on EDR products?

Source: STAR ICVS









Courtesy of N. Lei, VCST

VIIRS J1 Status Update

VIIRS J1 Status Update

- Ambient testing: Jan. 2014
- Pre-Environment Review (PER): Feb. 3-6, 2014
- Polarization issue (discussed later)
- Electromagnetic Interference (EMI) testing completed May 2014
  - -Sync loss issue resolved for J1
  - -Single Board Computer (SBC) Lockup (aka Petulant Mode) issueresolved for J1 (per Gleason and Raytheon)
- Thermal Vacuum testing: Jun.-Oct. 2014

VIIRS J1 Polarization Studies

- VIIRS J1 polarization sensitivity is significantly out of spec for several bands due to filter coating changes

- The VIIRS SDR team is working closely with the flight and vendor to study mitigation strategies
  - Better characterization through additional prelaunch tests
    - Measure at more scan angles, and T-SIRCUS spectral measrements
  - Better quantification of the polarization phenomenon and VIIRS on-orbit performance
  - Better understanding of impacts on EDR products

- Suomi NPP VIIRS polarization meets the polarization sensitvity specification. VIIRS J2 is expected to meet the specification

Recent Progress in VIIRS Polarization Related Studies

3/17/2014: Initiated working groups to study the impacts of polarization on products, with several actions from the first telecon on March 17 (M. Goldberg).

4/2/2014: VIIRS SDR special telecon on VIIRS J1 detector level polarization study shows large variation across detectors (presentation by J. McIntire, NASA/VCST)

4/16/2014: MODIS Terra/Aqua prelaunch and on-orbit polarization studies show large increase over the life time of the Terra/MODIS instrument (presentation by J. Xiong, NASA/VCST)

4/24/2014: Recommendations for additional prelaunch testing (telecon): More measurement angles, monochromatic characterization using T-SIRCUS.

Other progress:

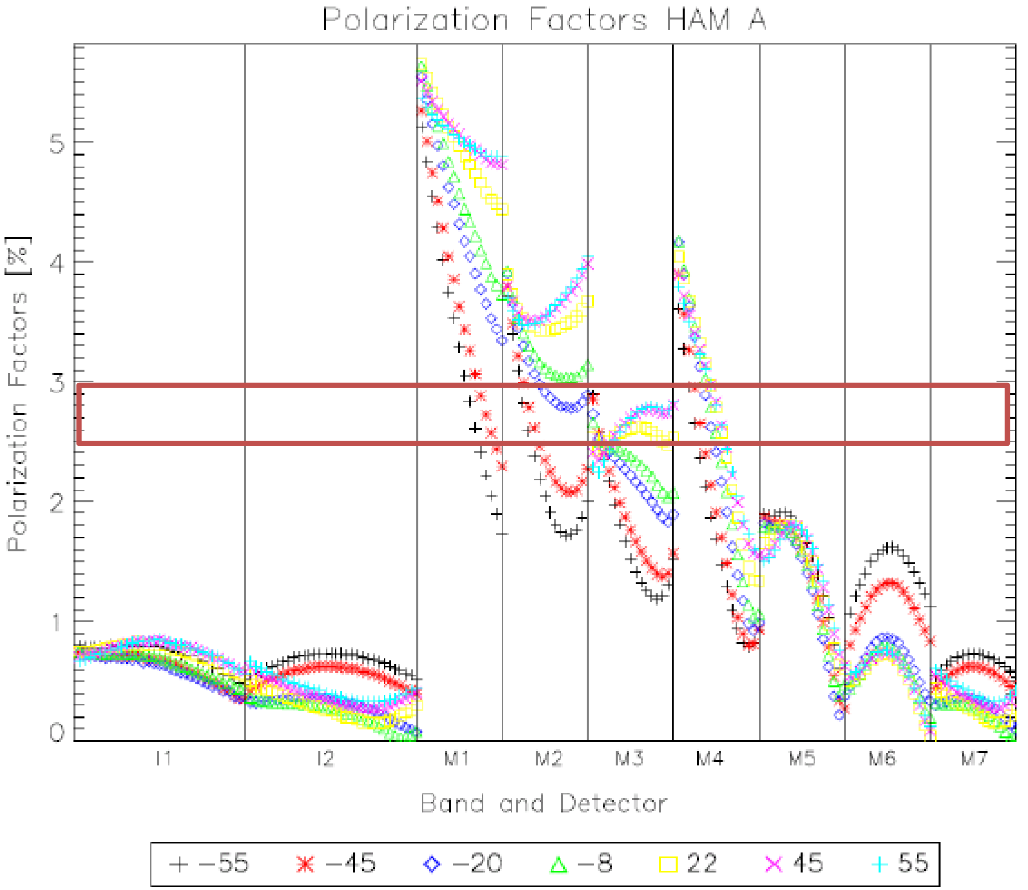
- GOME Polarization Measurement Device (PMD) on MetOp A and B
    - Sample data have been analyzed and a preliminary global map of DoLP map generated.
- Prototype polarization spectroradiometer developed leveraging the ASD spectrometer, with sample in-situ measurements

Final Polarization Factors (HAM A)

Polarization factors (combining all bvonir configurations) – HAM A

bvonir in: M1-M3; bvonir out: I1-I2, M4-M7

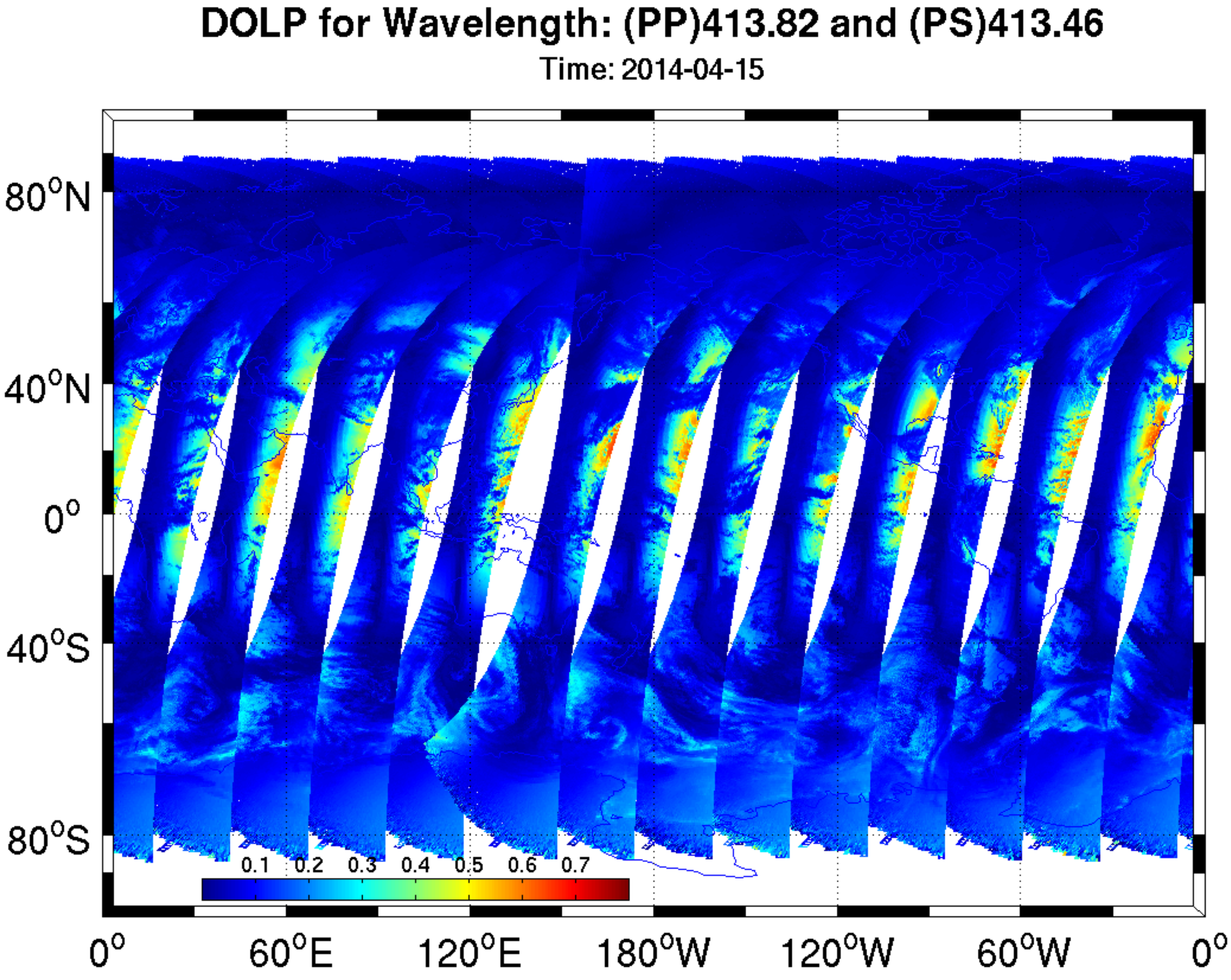
Factors above specification for M1-M4



specification

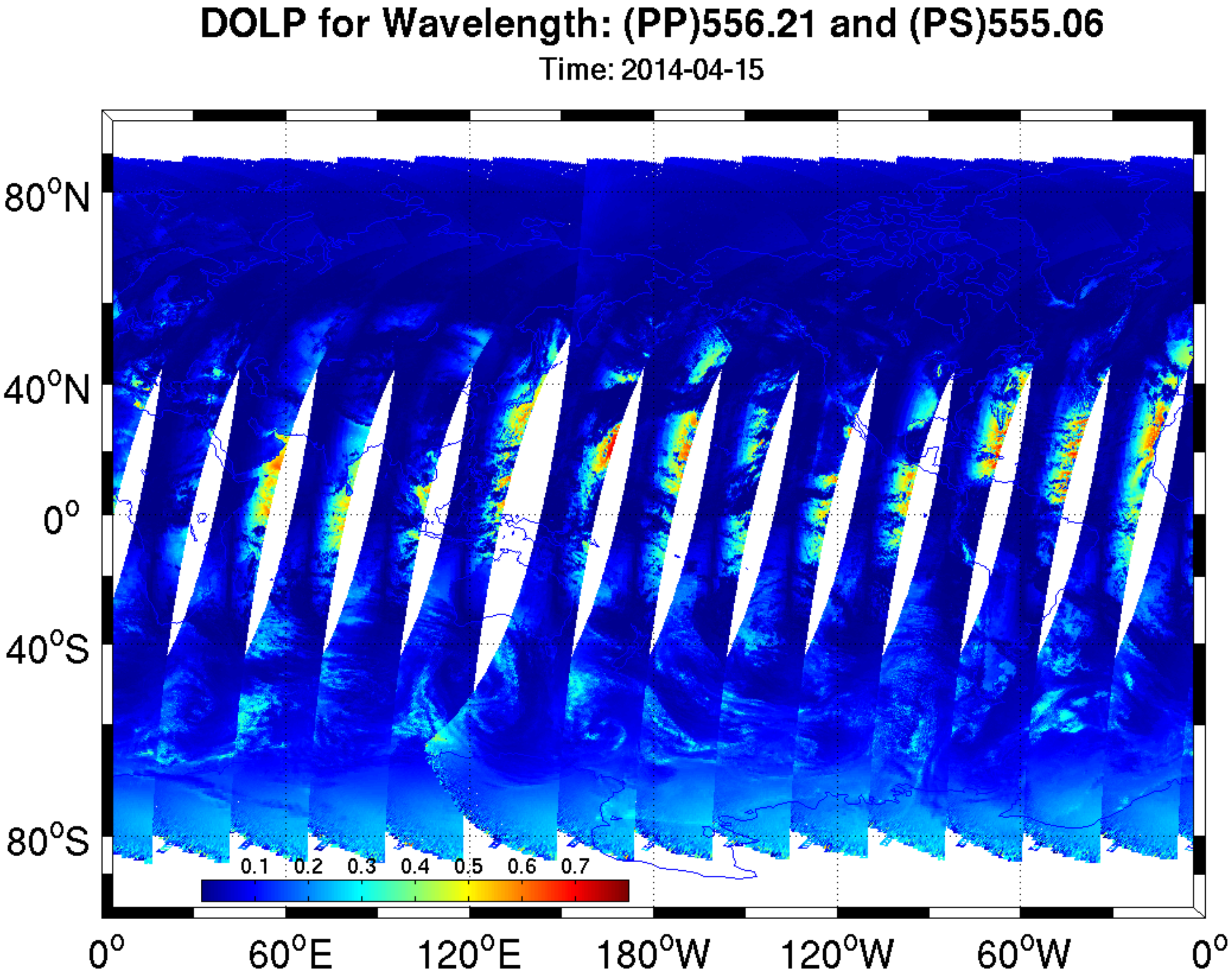
Courtesy of J. McIntire

Global Polarization Measurements from GOME PMD on MetOp B



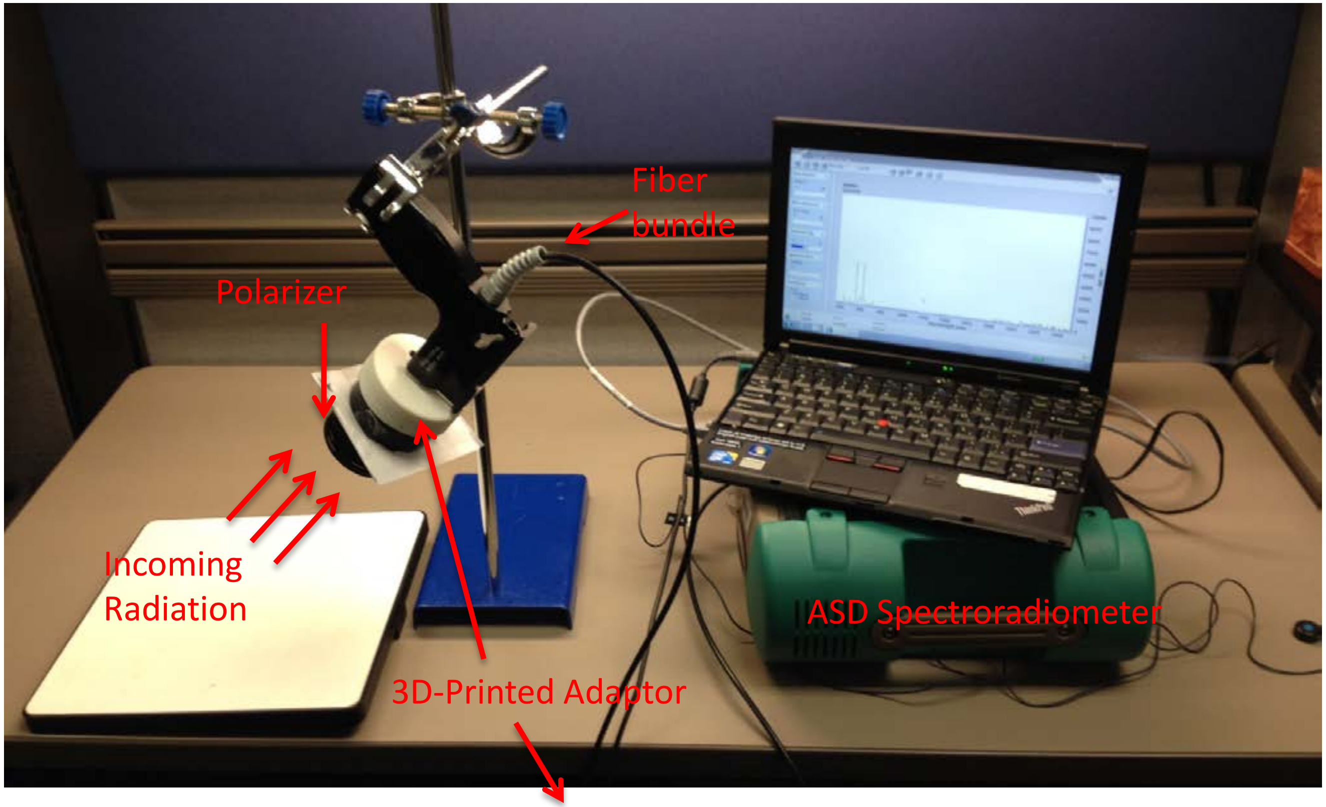
preliminary

Global Polarization Measurements from GOME on MetOp B

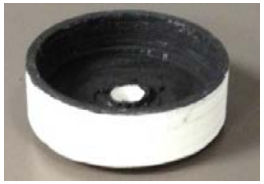


preliminary

Ground-Based Polarization Spectroradiometer for Validating VIIRS Polarization Sensitivity (Prototype)



(Protractor will be replaced with 3D- printed piece)



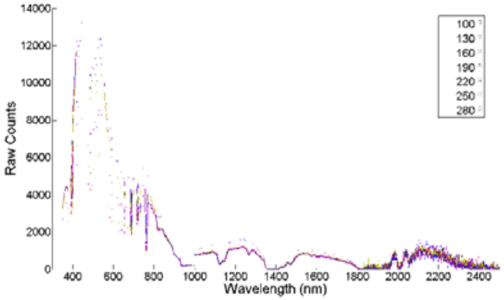
See poster by A. Pearlman et al for details

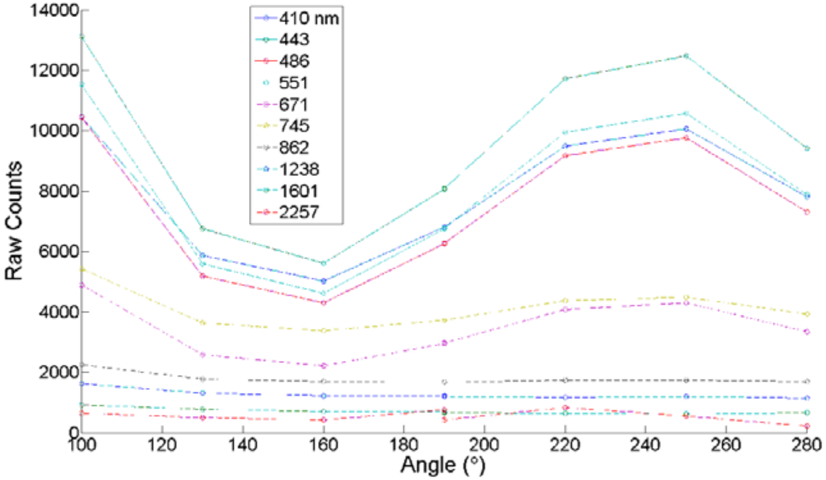
Preliminary Measurement Results

Location: M Square parking lot at 5:38 to 6:00pm (April 17, 2014)

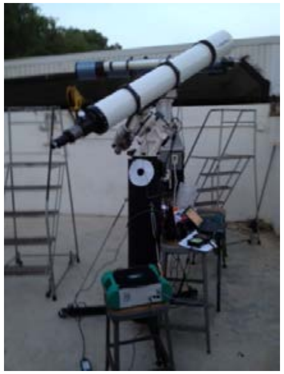
Took measurements of a highly polarized sky:

- Pointed sensor at ~90º to sun
- Mostly clear with cirrus clouds covering ~75% of sky
- Measurement time: 5 minutes





Future plan: Lunar polarization measurements at UMD observatory



Issues and Challenges

- **Achieving better calibration accuracy for Ocean Color applications**
- **Further improve onboard calibration**
  - **RSB autocal, solar vector, etc.**
- **Enhance vicarious monitoring capability to ensure high accuracy**

- **Striping in both SST bands and RSB**
- **Detector level RSR performance issues**
- **Polarization effects**
- **Single Board Computer Lockup (SBC), aka "Petulant mode"**
- **Sync loss**
- **J1 VIIRS support**

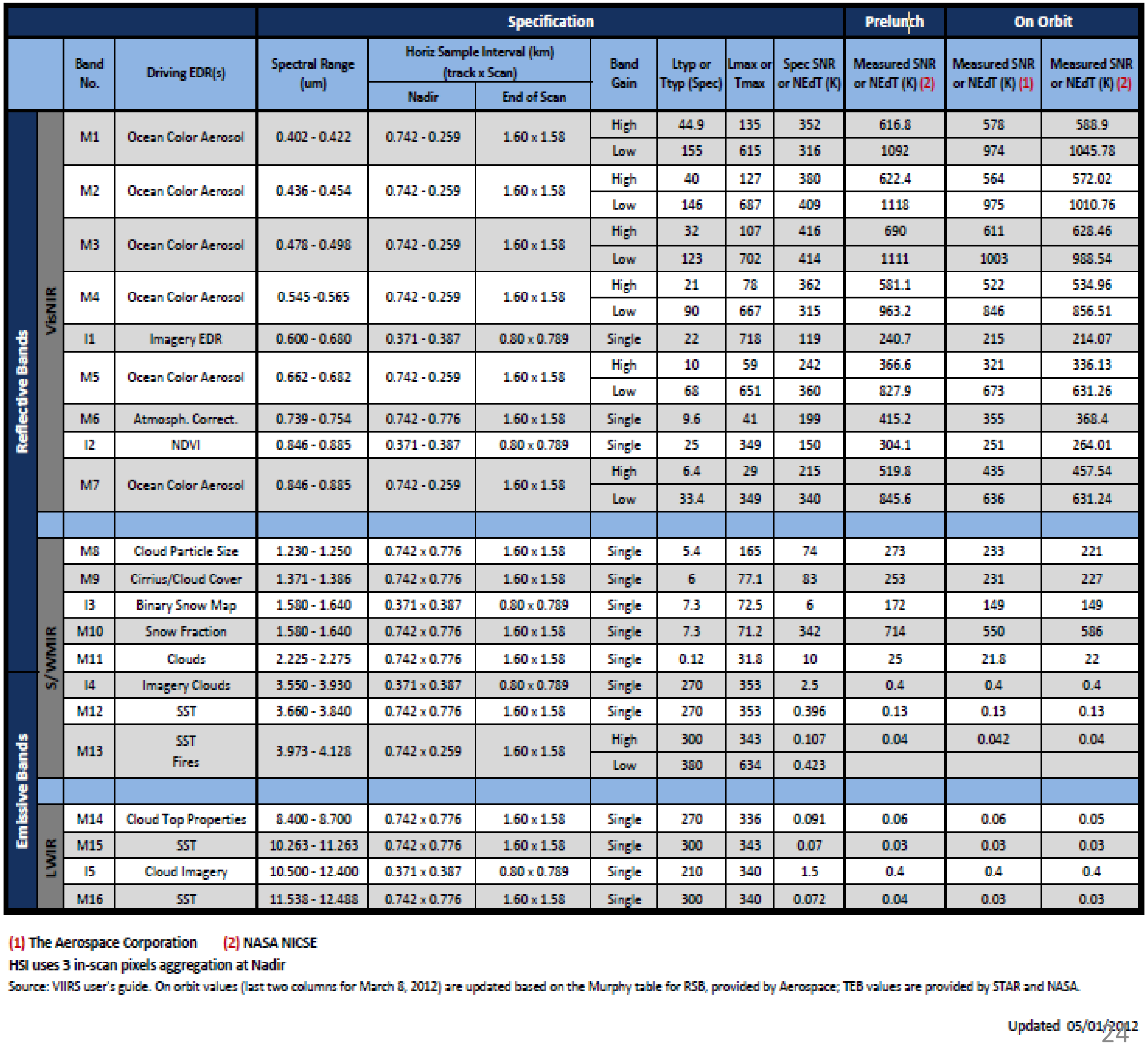
Summary

- VIIRS SDR has achieved calibrated/validated Maturity Status in both radiometry and geolocation
- Continue improving the radiometric accuracy to meet Ocean Color application needs
  - Fine tune calibration coefficients (e.g.: c0=0)
  - RSB autocal
  - Closely monitoring trend changes
  - Lunar band ratio analysis
- Future work focus on:
  - J1 calibration support, such as polarization studies (observations and RTM)
  - Further enhancements in instrument performance through research (such as striping, detector level processing, improved accuracy, etc)
  - Long term monitoring

Backup slides

VIIRS On-orbit Performance Table

- SDRs = L1b = calibrated, geolocated radiance, reflectance and brightness temperature
- 22 types of SDRs
  - –16 moderate resolution (MOD),
- 11 Reflective Solar Bands (RSB)
- 5 Thermal Emissive Bands (TEB)
  - –5 imaging resolution (IMG),
- 3 RSB; 2 TEB
  - –1 Day Night Band (DNB) imaging, broadband
- 6 non-gridded geolocation products
  - –DNB, IMG, IMG terrain corrected, MOD, MOD terrain corrected, MOD unaggregated
- 2 gridded geolocation products
  - –MOD, IMG



				Specification							Prelunch	On Orbit	
		Band No.	Driving EDR(s)	Spectral Range (um)	Horiz Sample Interval (km) (track x Scan)		Band Gain	Ltyp or Ttyp (Spec)	Lmax or Tmax	Spec SNR or NEdT (K)	Measured SNR or NEdT (K) (2)	Measured SNR or NEdT (K) (1)	Measured SNR or NEdT (K) (2)
					Nadir	End of Scan							
Reflective Bands	VisNIR	M1	Ocean Color Aerosol	0.402 - 0.422	0.742 - 0.259	1.60 x 1.58	High	44.9	135	352	616.8	578	588.9
							Low	155	615	316	1092	974	1045.78
		M2	Ocean Color Aerosol	0.436 - 0.454	0.742 - 0.259	1.60 x 1.58	High	40	127	380	622.4	564	572.02
							Low	146	687	409	1118	975	1010.76
		M3	Ocean Color Aerosol	0.478 - 0.498	0.742 - 0.259	1.60 x 1.58	High	32	107	416	690	611	628.46
							Low	123	702	414	1111	1003	988.54
		M4	Ocean Color Aerosol	0.545 -0.565	0.742 - 0.259	1.60 x 1.58	High	21	78	362	581.1	522	534.96
							Low	90	667	315	963.2	846	856.51
		I1	Imagery EDR	0.600 - 0.680	0.371 - 0.387	0.80 x 0.789	Single	22	718	119	240.7	215	214.07
		M5	Ocean Color Aerosol	0.662 - 0.682	0.742 - 0.259	1.60 x 1.58	High	10	59	242	366.6	321	336.13
							Low	68	651	360	827.9	673	631.26
		M6	Atmosph. Correct.	0.739 - 0.754	0.742 - 0.776	1.60 x 1.58	Single	9.6	41	199	415.2	355	368.4
		I2	NDVI	0.846 - 0.885	0.371 - 0.387	0.80 x 0.789	Single	25	349	150	304.1	251	264.01
		M7	Ocean Color Aerosol	0.846 - 0.885	0.742 - 0.259	1.60 x 1.58	High	6.4	29	215	519.8	435	457.54
							Low	33.4	349	340	845.6	636	631.24
	S/WMIR	M8	Cloud Particle Size	1.230 - 1.250	0.742 x 0.776	1.60 x 1.58	Single	5.4	165	74	273	233	221
		M9	Cirrius/Cloud Cover	1.371 - 1.386	0.742 x 0.776	1.60 x 1.58	Single	6	77.1	83	253	231	227
		I3	Binary Snow Map	1.580 - 1.640	0.371 x 0.387	0.80 x 0.789	Single	7.3	72.5	6	172	149	149
		M10	Snow Fraction	1.580 - 1.640	0.742 x 0.776	1.60 x 1.58	Single	7.3	71.2	342	714	550	586
		M11	Clouds	2.225 - 2.275	0.742 x 0.776	1.60 x 1.58	Single	0.12	31.8	10	25	21.8	22
Emissive Bands		I4	Imagery Clouds	3.550 - 3.930	0.371 x 0.387	0.80 x 0.789	Single	270	353	2.5	0.4	0.4	0.4
		M12	SST	3.660 - 3.840	0.742 x 0.776	1.60 x 1.58	Single	270	353	0.396	0.13	0.13	0.13
		M13	SST Fires	3.973 - 4.128	0.742 x 0.259	1.60 x 1.58	High	300	343	0.107	0.04	0.042	0.04
							Low	380	634	0.423			
	LWIR	M14	Cloud Top Properties	8.400 - 8.700	0.742 x 0.776	1.60 x 1.58	Single	270	336	0.091	0.06	0.06	0.05
		M15	SST	10.263 - 11.263	0.742 x 0.776	1.60 x 1.58	Single	300	343	0.07	0.03	0.03	0.03
		I5	Cloud Imagery	10.500 - 12.400	0.371 x 0.387	0.80 x 0.789	Single	210	340	1.5	0.4	0.4	0.4
		M16	SST	11.538 - 12.488	0.742 x 0.776	1.60 x 1.58	Single	300	340	0.072	0.04	0.03	0.03

(1) The Aerospace Corporation (2) NASA NICSE

HSI uses 3 in-scan pixels aggregation at Nadir

Source: VIIRS user's guide. On orbit values (last two columns for March 8, 2012) are updated based on the Murphy table for RSB, provided by Aerospace; TEB values are provided by STAR and NASA.

Updated 05/01/2012

VIIRS Sensor Specification

- RSB sensitivity

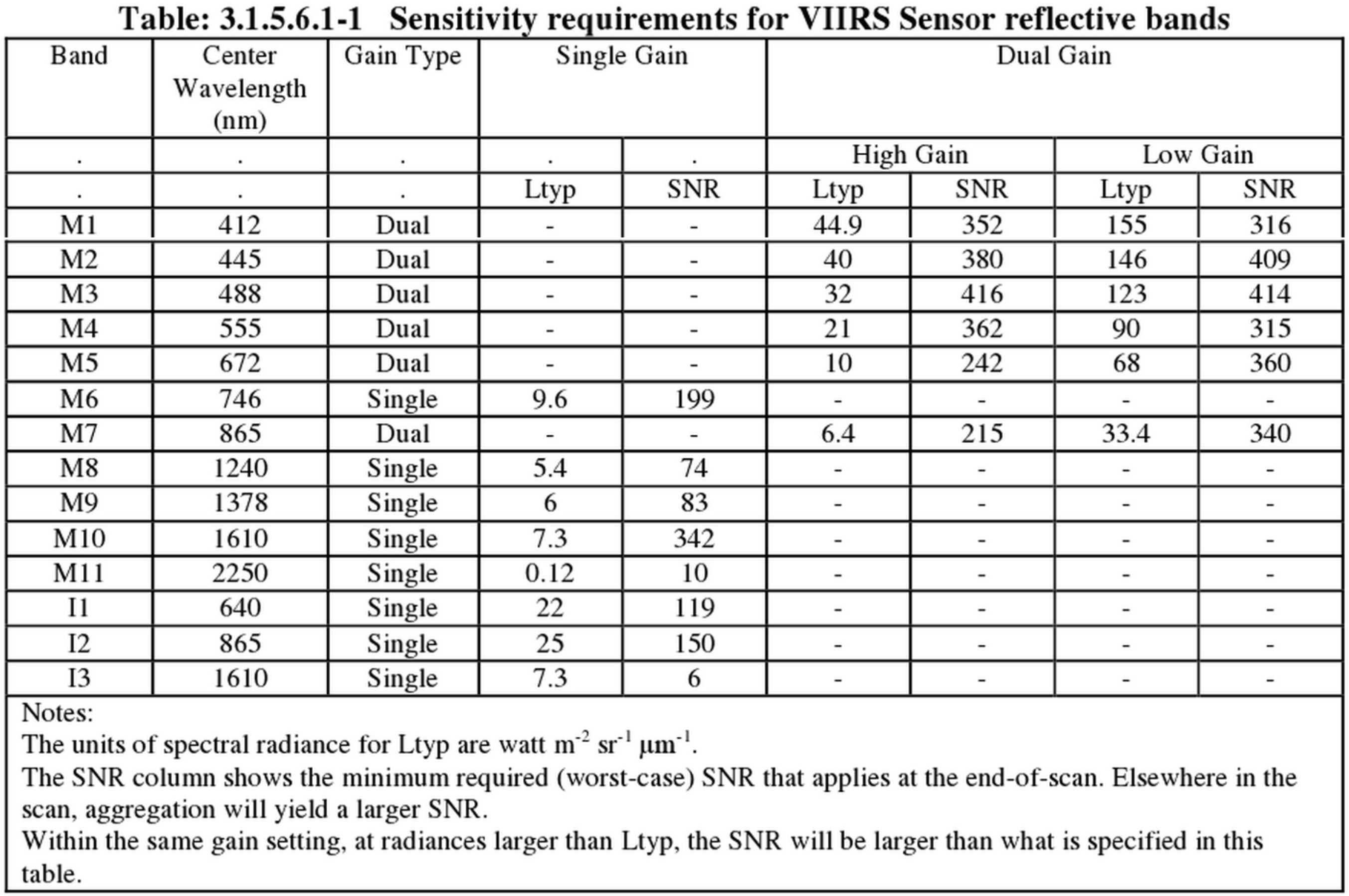


Table: 3.1.5.6.1-1 Sensitivity requirements for VIIRS Sensor reflective bands

Band	Center Wavelength (nm)	Gain Type	Single Gain		Dual Gain			
.	.	.	.	.	High Gain		Low Gain	
.	.	.	Ltyp	SNR	Ltyp	SNR	Ltyp	SNR
M1	412	Dual	-	-	44.9	352	155	316
M2	445	Dual	-	-	40	380	146	409
M3	488	Dual	-	-	32	416	123	414
M4	555	Dual	-	-	21	362	90	315
M5	672	Dual	-	-	10	242	68	360
M6	746	Single	9.6	199	-	-	-	-
M7	865	Dual	-	-	6.4	215	33.4	340
M8	1240	Single	5.4	74	-	-	-	-
M9	1378	Single	6	83	-	-	-	-
M10	1610	Single	7.3	342	-	-	-	-
M11	2250	Single	0.12	10	-	-	-	-
I1	640	Single	22	119	-	-	-	-
I2	865	Single	25	150	-	-	-	-
I3	1610	Single	7.3	6	-	-	-	-

Notes:
The units of spectral radiance for Ltyp are watt m^{-2} sr^{-1} μm^{-1}.
The SNR column shows the minimum required (worst-case) SNR that applies at the end-of-scan. Elsewhere in the scan, aggregation will yield a larger SNR.
Within the same gain setting, at radiances larger than Ltyp, the SNR will be larger than what is specified in this table.

Absolute radiometric calibration uncertainty for uniform scenes: < 2%

Source: JPSS VIIRS Performance Requirement Document
Code 472 472-00124

VIIRS Sensor Specification

- TEB sensitivity

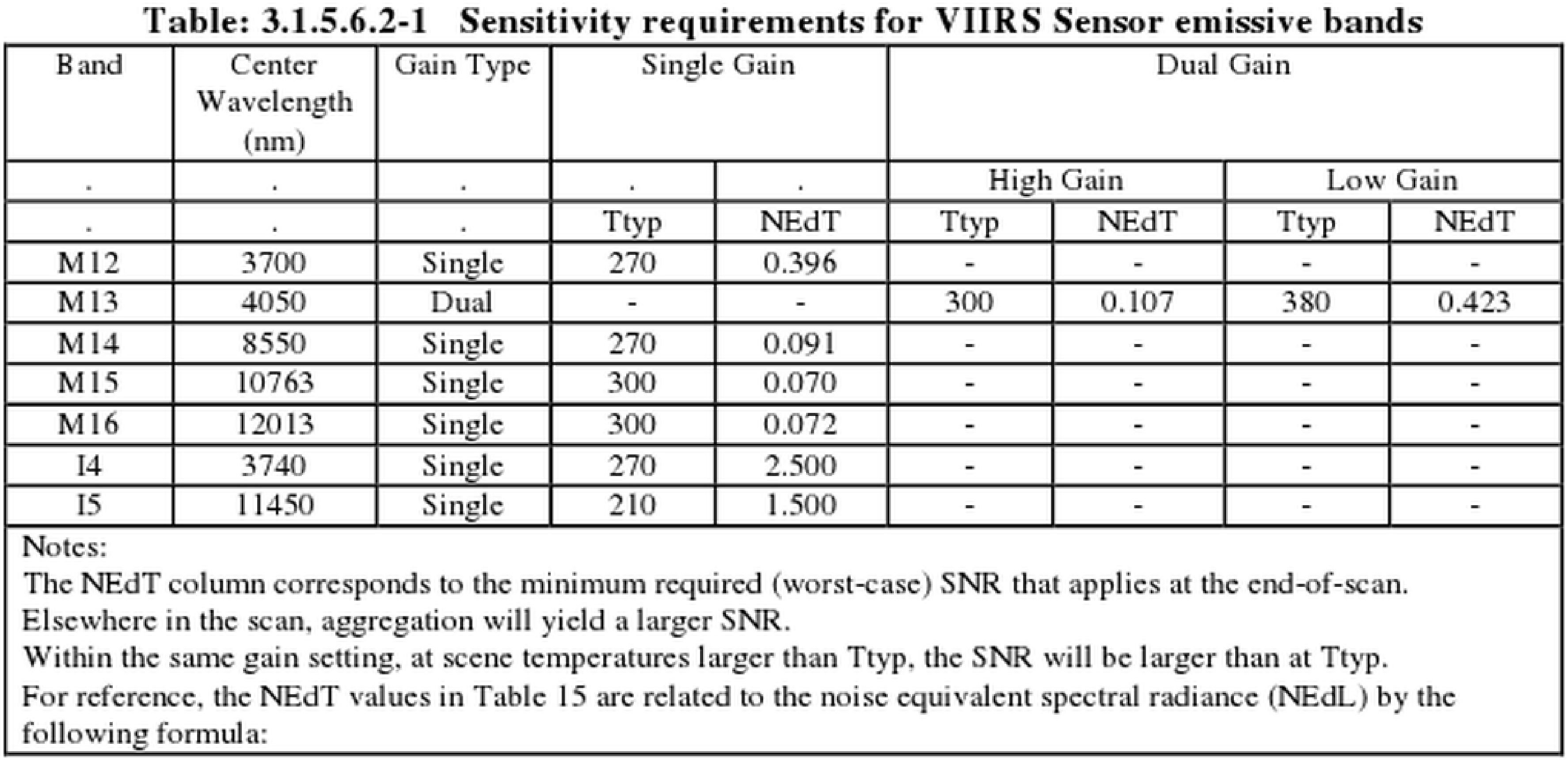


Table: 3.1.5.6.2-1 Sensitivity requirements for VIIRS Sensor emissive bands

Band	Center Wavelength (nm)	Gain Type	Single Gain		Dual Gain			
.	.	.	.	.	High Gain		Low Gain	
.	.	.	Ttyp	NEdT	Ttyp	NEdT	Ttyp	NEdT
M12	3700	Single	270	0.396	-	-	-	-
M13	4050	Dual	-	-	300	0.107	380	0.423
M14	8550	Single	270	0.091	-	-	-	-
M15	10763	Single	300	0.070	-	-	-	-
M16	12013	Single	300	0.072	-	-	-	-
I4	3740	Single	270	2.500	-	-	-	-
I5	11450	Single	210	1.500	-	-	-	-

Notes:
The NEdT column corresponds to the minimum required (worst-case) SNR that applies at the end-of-scan. Elsewhere in the scan, aggregation will yield a larger SNR.
Within the same gain setting, at scene temperatures larger than Ttyp, the SNR will be larger than at Ttyp.
For reference, the NEdT values in Table 15 are related to the noise equivalent spectral radiance (NEdL) by the following formula:

Source: JPSS VIIRS Performance Requirement Document
Code 472 472-00124

VIIRS Sensor Specification

- TEB Uncertainty

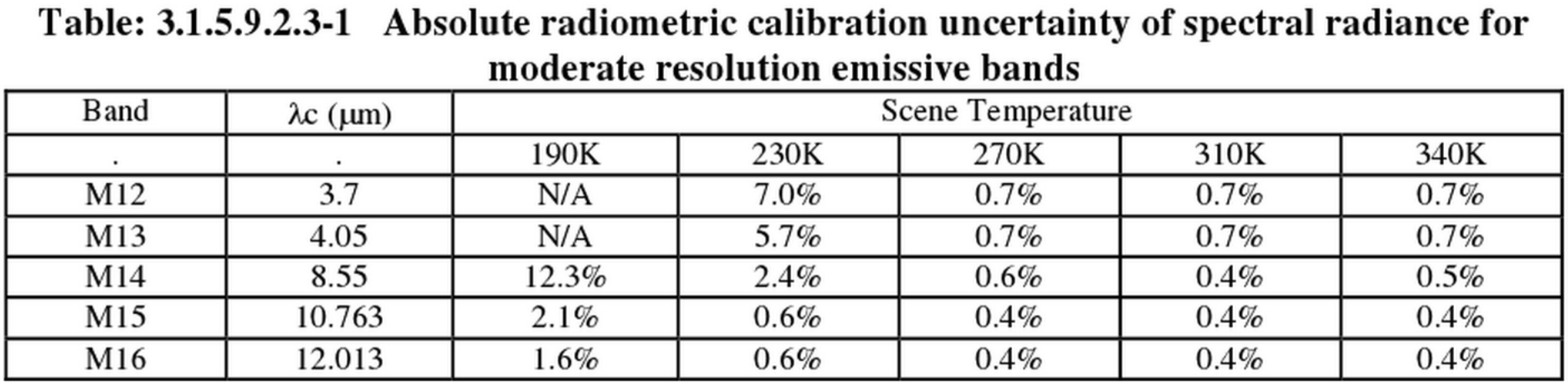


Table: 3.1.5.9.2.3-1 Absolute radiometric calibration uncertainty of spectral radiance for moderate resolution emissive bands

Band	λc (μm)	Scene Temperature				
.	.	190K	230K	270K	310K	340K
M12	3.7	N/A	7.0%	0.7%	0.7%	0.7%
M13	4.05	N/A	5.7%	0.7%	0.7%	0.7%
M14	8.55	12.3%	2.4%	0.6%	0.4%	0.5%
M15	10.763	2.1%	0.6%	0.4%	0.4%	0.4%
M16	12.013	1.6%	0.6%	0.4%	0.4%	0.4%

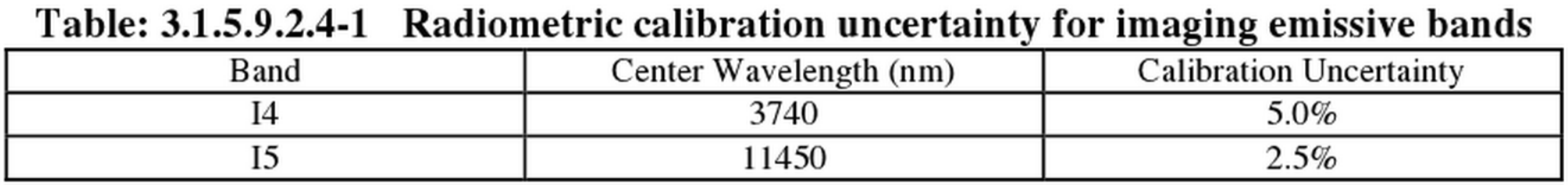


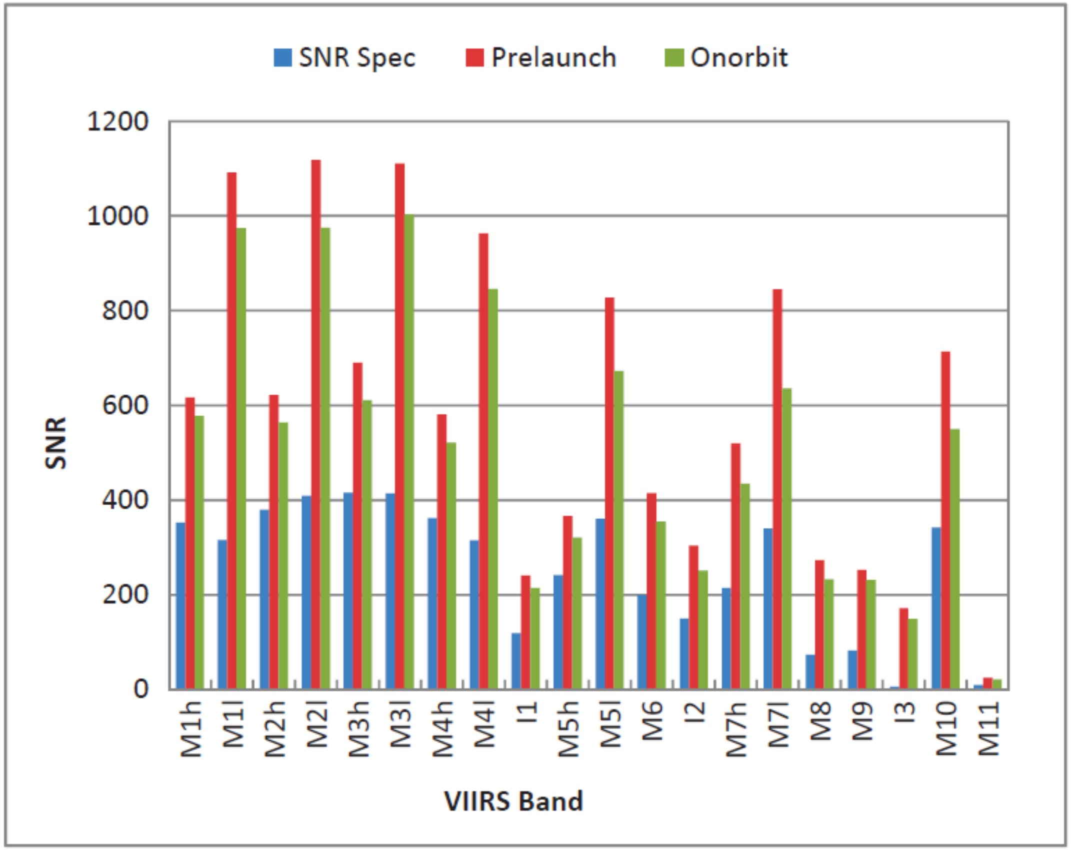
Table: 3.1.5.9.2.4-1 Radiometric calibration uncertainty for imaging emissive bands

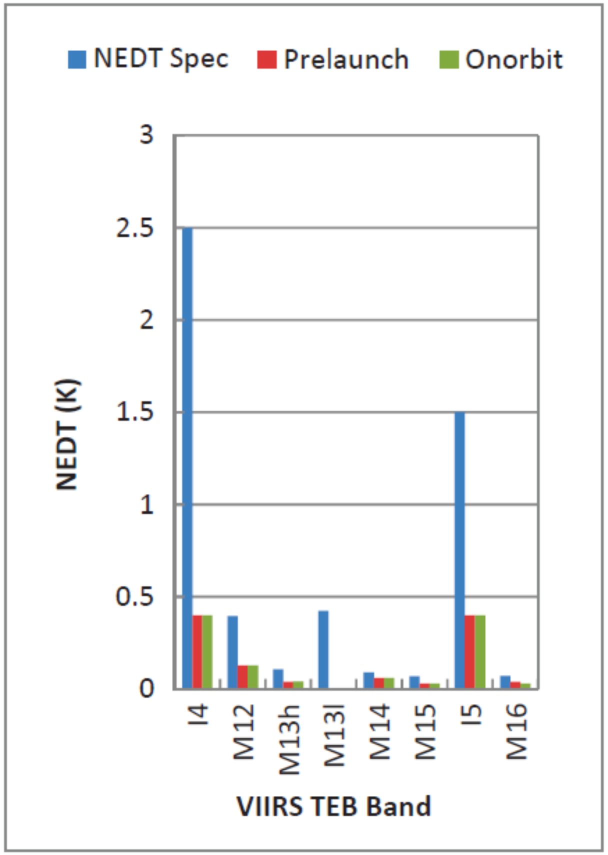
Band	Center Wavelength (nm)	Calibration Uncertainty
I4	3740	5.0%
I5	11450	2.5%

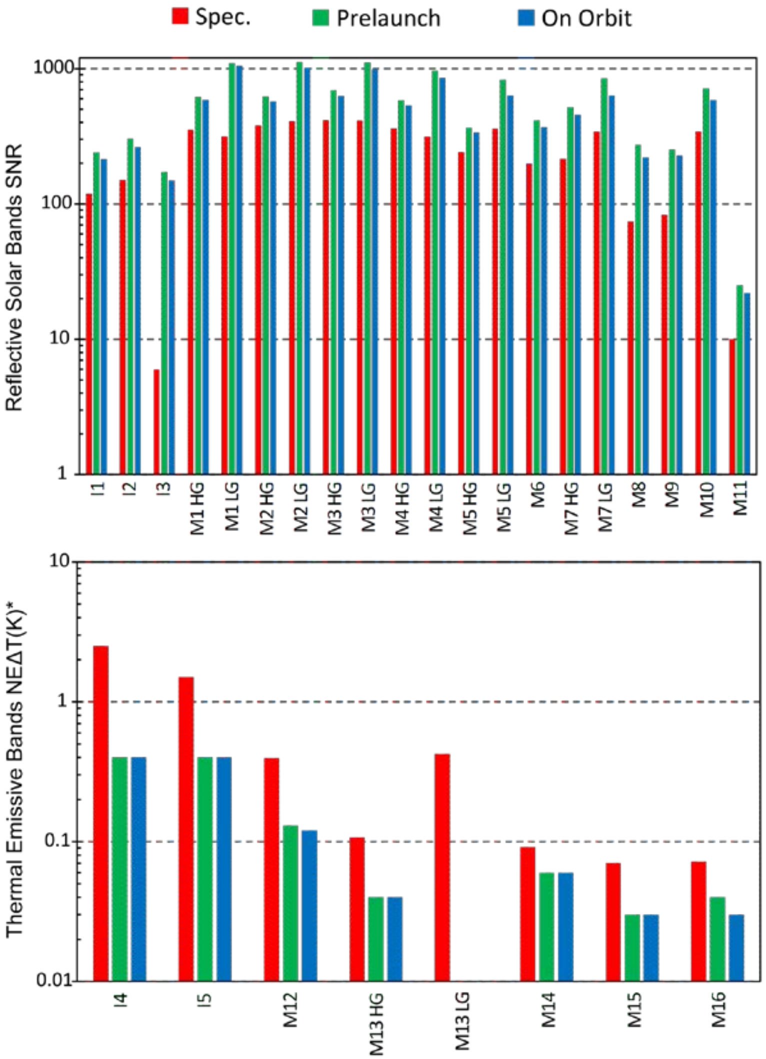
Source: JPSS VIIRS Performance Requirement Document
Code 472 472-00124

VIIRS On-orbit Performance

-SNR and NEDT



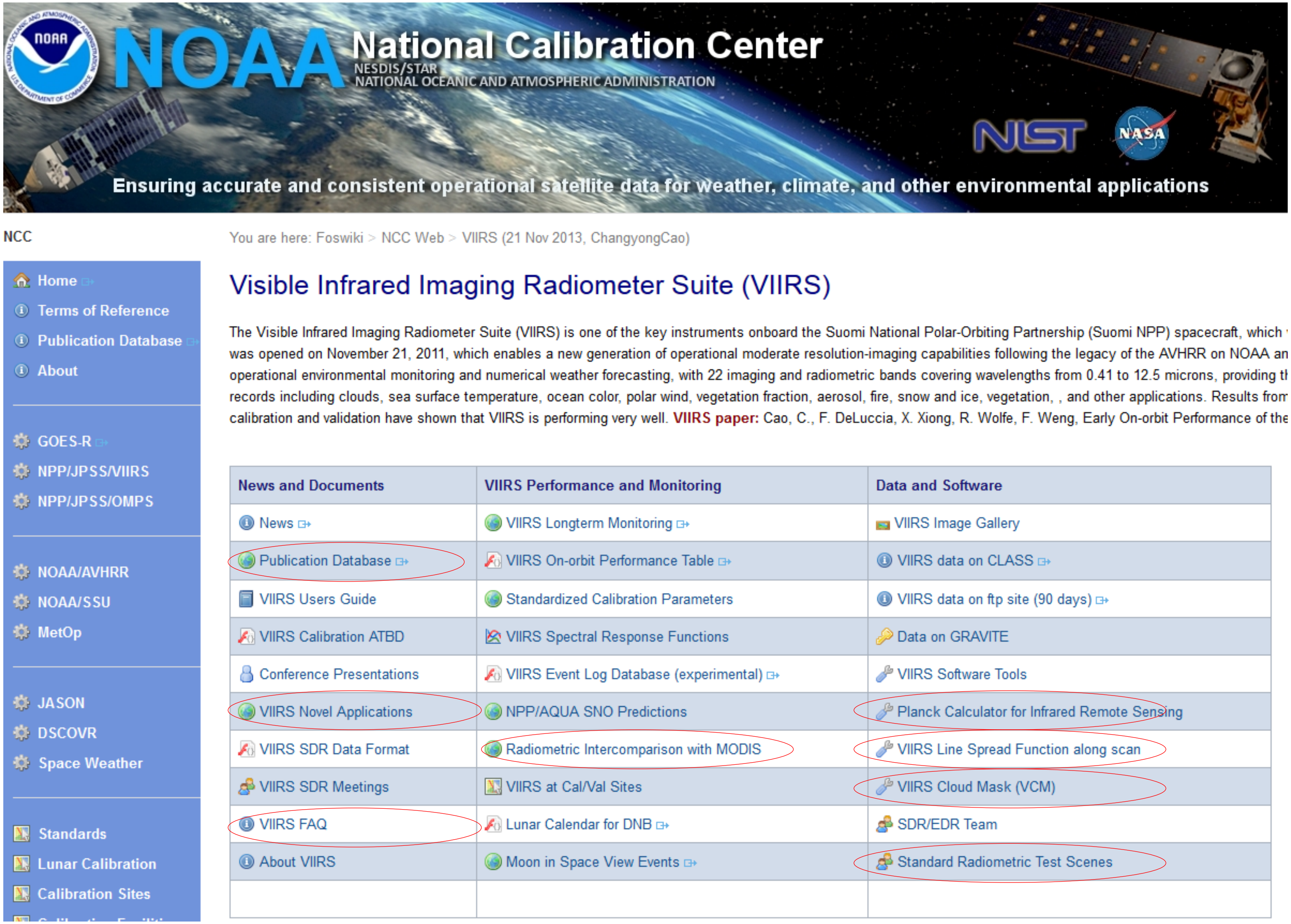




*Note NEΔT(K) is at specific temperatures (see Table 2).

VIIRS Calibration Knowledge Base Updated

One stop shop for VIIRS SDR information



NOAA National Calibration Center
NESDIS/STAR
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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- JASON
- DSCOVR
- Space Weather
- Standards
- Lunar Calibration
- Calibration Sites

You are here: Foswiki > NCC Web > VIIRS (21 Nov 2013, ChangyongCao)

Visible Infrared Imaging Radiometer Suite (VIIRS)

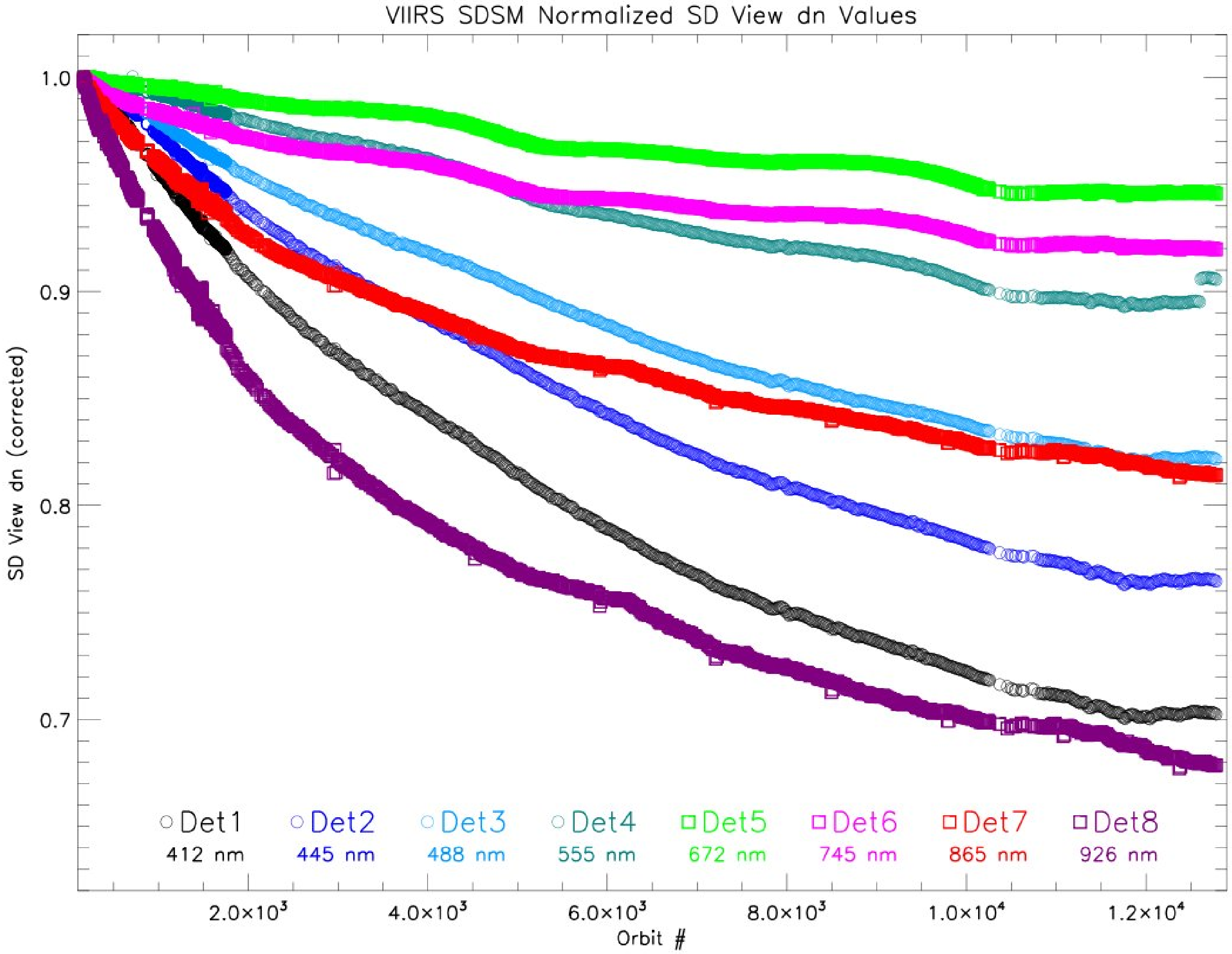
The Visible Infrared Imaging Radiometer Suite (VIIRS) is one of the key instruments onboard the Suomi National Polar-Orbiting Partnership (Suomi NPP) spacecraft, which
was opened on November 21, 2011, which enables a new generation of operational moderate resolution-imaging capabilities following the legacy of the AVHRR on NOAA an
operational environmental monitoring and numerical weather forecasting, with 22 imaging and radiometric bands covering wavelengths from 0.41 to 12.5 microns, providing t
records including clouds, sea surface temperature, ocean color, polar wind, vegetation fraction, aerosol, fire, snow and ice, vegetation, , and other applications. Results from
calibration and validation have shown that VIIRS is performing very well. **VIIRS paper:** Cao, C., F. DeLuccia, X. Xiong, R. Wolfe, F. Weng, Early On-orbit Performance of the

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 Cloud Mask (VCM)
VIIRS FAQ	Lunar Calendar for DNB	SDR/EDR Team
About VIIRS	Moon in Space View Events	Standard Radiometric Test Scenes

Google “NOAA NCC”

VIIRS SDR Peer Reviewed Publications

- Cao, C., F. Deluccia, X. Xiong, R. Wolfe, and F. Weng, 2013a, Early On-orbit Performance of the Visible Infrared Imaging Radiometer Suite (VIIRS) onboard the Suomi National Polar-orbiting Partnership (Suomi-NPP) Satellite, IEEE Transaction on Geoscience and Remote Sensing, DOI:10.1109/ TGRS.2013.2247768, in press (available online at IEEEXplore).
- Cao, C., X. Xiong, S. Blonski, Q. Liu, S. Uprety, X. Shao, Y. Bai, F. Weng, 2013, Suomi NPP VIIRS sensor data record verification, validation, and long-term performance monitoring, Journal of Geophysical Research: Atmospheres, DOI: 10.1002/2013JD020418
- Cao, C., X. Shao, S. Uprety, (2013b), Detecting Light Outages After Severe Storms Using the Suomi-NPP/VIIRS Day Night Band Radiances, IEEE Geoscience and Remote Sensing Letters, DOI: 10.1109/LGRS.2013.2262258, in press.
- Liu, Q., C. Cao, and F. Weng, 2013, Assessment of Suomi National Polar-Orbiting Partnership VIIRS Emissive Band Calibration and Inter-Sensor Comparisons, IEEE JSTAR, 10.1109/JSTARS.2013.2263197.
- Liao. L.B., S. Weiss, S. Mills, B. Hauss (2013), Suomi NPP VIIRS Day-Night-Band (DNB) On-Orbit Performance, Journal of Geophysical Research-Atmosphere, DOI: 10.1002/2013JD020475
- Wolfe, R., G. Lin, M. Nishihama, K. P. Tewari, J. C. Tilton, A. R. Isaacman et al., 2013, Suomi NPP VIIRS prelaunch and on-orbit geometric calibration and characterization, DOI: 10.1002/jgrd.50873, JGR special issue , in press.
- Rausch, K. et al., VIIRS RSB Autocal, JGR special issue , in press.
- Xiong, X., J. Butler, K. Chiang, B. Efremova, J. Fulbright, N. Lei, J. McIntire, H. Oudrari, J. Sun, Z. Wang, A. Wu (2013), VIIRS On-orbit Calibration Methodology and Performance, Journal of Geophysical Research-Atmosphere, DOI: 10.1002/2013JD020423.
- Uprety, S., C. Cao, X. Xiong, S. Blonski, A. Wu, and X. Shao, 2013, Radiometric Inter-comparison between Suomi NPP VIIRS and Aqua MODIS Reflective Solar Bands using Simultaneous Nadir Overpass in the Low Latitudes, JTech , doi: http://dx.doi.org/10.1175/JTECH-D-13-00071.1.



Courtesy of N. Lei, VCST

Algorithm Evaluations

- 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.

JPSS STAR Science Team Annual Meeting
OMPS SDR Team

Xiangqian Wu
OMSP SDR Lead
May. 12, 2014

Outlines

- OMPS SDR Team
- Products and Users
- Requirements and Performance
- Accomplishments
- Algorithms Evaluation
- Future Plans for J1
- Summary

OMPS SDR Team

PI Name	Organization	Primary Roles
Fred Wu	NOAA/STAR	Budget and coordination; Instrument and product performance monitoring; J1 code development; TVAC data analysis; SDR algorithm.
Glen Jaross	NASA	Instrument scientist; TVAC data acquisition and analysis; SDR algorithm.
Bhaswar Sen	NGAS	G-ADA test for IDPS operations; TVAC data analysis; SDR algorithm.
Maria Caponi	Aerospace	Algorithm changes coordination; DR and issues tracking
Daniel Cumpton	Raytheon	IDPS operations

Products and Users

- Products:
  - OMPS nadir mapper (NM) and nadir profiler (NP) earth view (EV) and calibration (CAL) SDR in both nominal and diagnostic mode.
- Users:
  - OMPS EDR Team
  - Wider and future users via CLASS

Requirements and Performance

Parameters	Specification/Prediction Value	On-Orbit Performance
Non-linearity	< 2% full well	< 0.46%
Non-linearity Accuracy	< 0.2%	±0.2%
On-orbit Wavelength Calibration	< 0.01 nm	0.15-0.25 nm
Stray Light NM Out-of-Band + Out-of-Field Response	For NM ≤ 2	average < 2%
Intra-Orbit Wavelength Stability	Allocation (flow down from EDR error budget) = 0.02 nm	~ 0.02 nm
SNR	1000	> 1000
Inter-Orbital Thermal Wavelength Shift	Allocation (flow down from EDR error budget) = 0.02 nm	~0.02 nm
CCD Read Noise	60 –e RMS	< 25 –e RMS
Detector Gain	43 (for NP) 46 (for NM)	47 (for NP) 51 (for NM)
Absolute Irradiance Calibration Accuracy	< 7%	< 3% in 300-310 nm: up to ~10 % for both NM and NP
Absolute Radiance Calibration Accuracy	< 8%	< 5% in 300-310 nm: up to ~6 % for NM and NP
Normalized radiance Calibration Accuracy	< 1%	< 1%

Accomplishments

- Beta maturity March 2012
- Provisional maturity March 2013
- Validated maturity
  - Primary review Dec 2013
  - Delta review planned for June 2014
    - Improved stray light correction and wavelength registration, for both NM & NP.
    - CAL SDR transition to GRAVITE is on schedule.

Algorithm Evaluation (1/3)

- Algorithm Description:
  - OMPS has three sensors. NOAA is responsible for SDR of two sensors (NM & NP).
  - Each sensor is configured to acquire earth view (EV) or calibration (CAL) data, in either nominal or diagnostic mode.
  - IDPS processes nominal EV data only
  - Transition is underway to process CAL SDR at GRAVITE
    - To automate the use of CAL SDR in EV SDR processing at IDPS
    - To archive the CAL SDR at CLASS

Algorithm Evaluation (2/3)

- Validation Approach and Datasets
  - Primary validation by examination of SDR characteristics such as dark, linearity, SNR.
  - Further validation:
    - Characteristics of EV SDR
    - Characteristics of EDR
    - Comparison with other measurements (GOME-2, SBUV/2)
    - Comparison with RTM (CRTM, MLS)
- Performance *vs.* Requirements
  - See earlier slide

Algorithm Evaluation (3/3)

- Risks/Issues/Challenges
  - Develop modifications to accommodate J1 upper
  - Produce CAL SDR in Ground System
- Quality Monitoring:
  - In place, and being continuously improved.
- Recommendations: NPOESS algorithm has evolved into the NOAA-endorsed JPSS algorithm and any needed improvements should continue. Substantial changes are expected for J1.

Future Plan for J1 Algorithm

- JPSS-1 Algorithm Milestones
  - May: Unit test for decompressor and aggregator
  - July: Integration of pre-processor into IDPS
  - Aug: functional test of LUTs
  - Sept: Accommodate sparse LUTs
  - Oct: integration test of LUTs with J1 code
  - Nov: delivery to STAR AIT
  - Dec: delivery to DPA

Future Plan for J1 Validation

- Validation Strategies
  - Pre-launch
    - Functional verification of LUT from SCDB
    - Integration tests of new LUTs and the modified code
  - Post-launch
    - Examination of SDR characteristics such as dark, linearity, SNR.
    - Characteristics of EV SDR
    - Characteristics of EDR
    - Comparison with other measurements (GOME-2, SBUV/2)
    - Comparison with RTM (CRTM, MLS)

Summary

- OMPS EV SDR is expected to reach the Validated maturity in June
- OMPS CAL SDR transition to GRAVITE is on schedule despite the setbacks
- Tasks and schedule for J1 preparation are well defined. Risk is low for performance but moderate for schedule and cost.

Instrument Performance and Sensor Data Quality Long Term Monitoring (LTM) in STAR Integrated Cal/Val System (ICVS)

Ninghai Sun, Fuzhong Weng, Michael Grotenhuis,
Xin Jin, Jason Choi, Wanchun Chen

Satellite Meteorology and Climatology Division
Center for Satellite Applications and Research
National Environmental Satellite, Data and Information Service

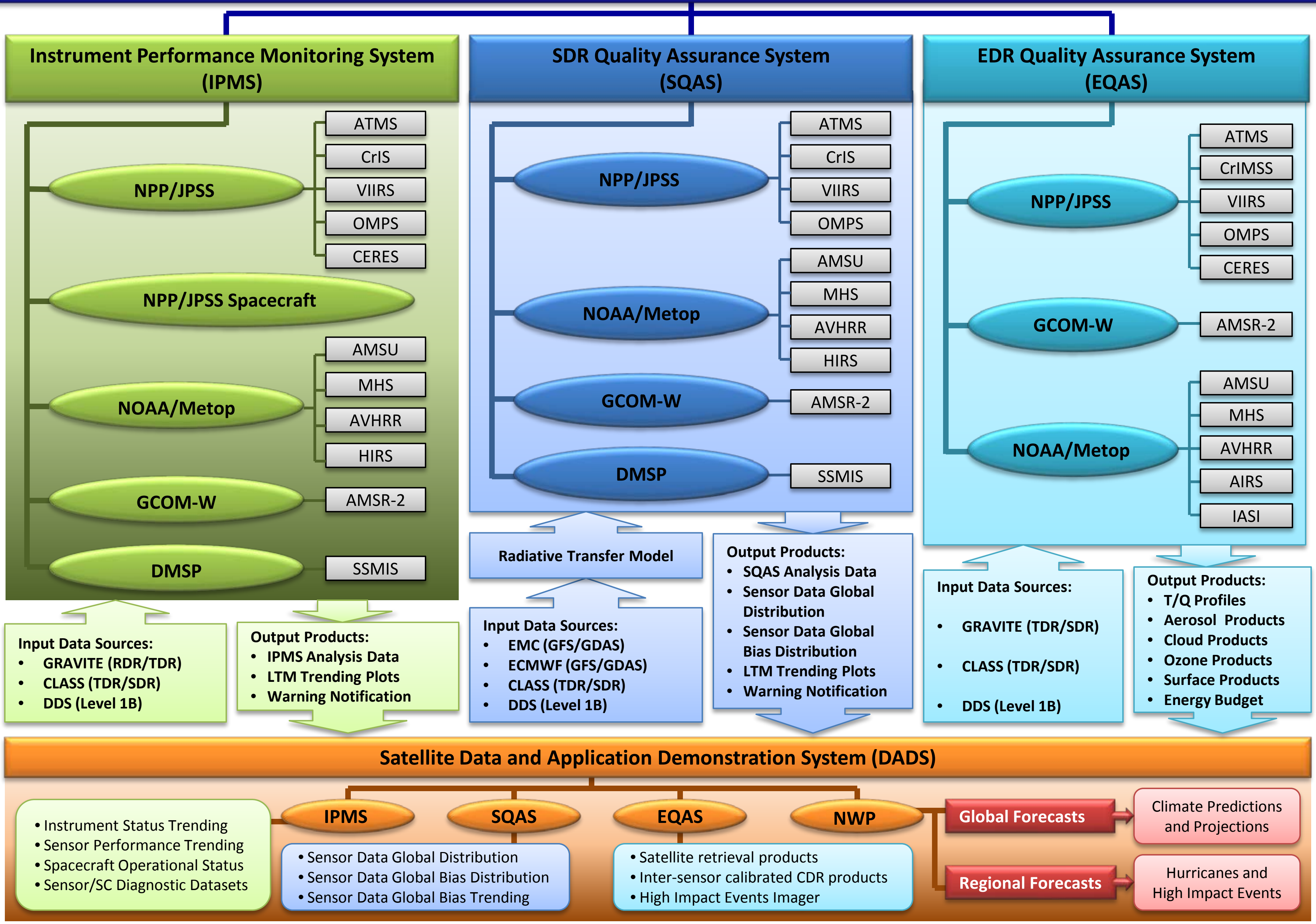
Outline

- Introduction to Instrument Performance and Sensor Data Quality Long-Term Monitoring (LTM) in STAR Integrated Cal/Val System (ICVS)

- STAR ICVS-LTM Modules and Anomaly Samples
  - S-NPP Spacecraft LTM
  - S-NPP ATMS LTM
  - S-NPP VIIRS LTM
  - S-NPP CrIS LTM
  - S-NPP OMPS LTM

- Path Forward

NOAA/NESDIS/STAR ICVS-LTM System



Instrument Performance Monitoring System (IPMS)

- NPP/JPSS
  - ATMS
  - CrIS
  - VIIRS
  - OMPS
  - CERES
- NPP/JPSS Spacecraft
- NOAA/Metop
  - AMSU
  - MHS
  - AVHRR
  - HIRS
- GCOM-W
  - AMSR-2
- DMSP
  - SSMIS

Input Data Sources:

- GRAVITE (RDR/TDR)
- CLASS (TDR/SDR)
- DDS (Level 1B)

Output Products:

- IPMS Analysis Data
- LTM Trending Plots
- Warning Notification

SDR Quality Assurance System (SQAS)

- NPP/JPSS
  - ATMS
  - CrIS
  - VIIRS
  - OMPS
- NOAA/Metop
  - AMSU
  - MHS
  - AVHRR
  - HIRS
- GCOM-W
  - AMSR-2
- DMSP
  - SSMIS

Radiative Transfer Model

Input Data Sources:

- EMC (GFS/GDAS)
- ECMWF (GFS/GDAS)
- CLASS (TDR/SDR)
- DDS (Level 1B)

Output Products:

- SQAS Analysis Data
- Sensor Data Global Distribution
- Sensor Data Global Bias Distribution
- LTM Trending Plots
- Warning Notification

EDR Quality Assurance System (EQAS)

- NPP/JPSS
  - ATMS
  - CrIMSS
  - VIIRS
  - OMPS
  - CERES
- GCOM-W
  - AMSR-2
- NOAA/Metop
  - AMSU
  - MHS
  - AVHRR
  - AIRS
  - IASI

Input Data Sources:

- GRAVITE (TDR/SDR)
- CLASS (TDR/SDR)
- DDS (Level 1B)

Output Products:

- T/Q Profiles
- Aerosol Products
- Cloud Products
- Ozone Products
- Surface Products
- Energy Budget

Satellite Data and Application Demonstration System (DADS)

IPMS

- Instrument Status Trending
- Sensor Performance Trending
- Spacecraft Operational Status
- Sensor/SC Diagnostic Datasets

SQAS

- Sensor Data Global Distribution
- Sensor Data Global Bias Distribution
- Sensor Data Global Bias Trending

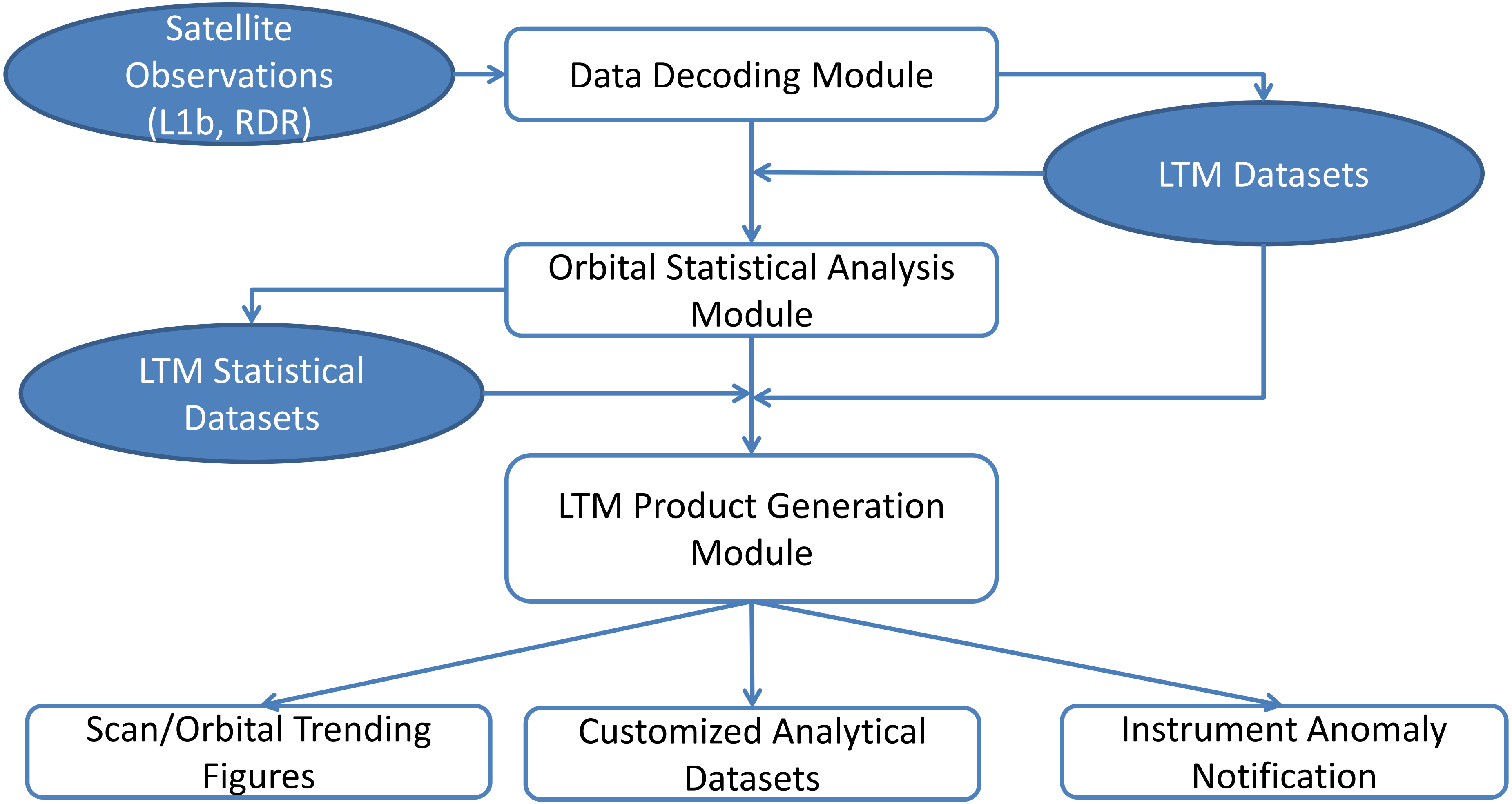
EQAS

- Satellite retrieval products
- Inter-sensor calibrated CDR products
- High Impact Events Imager

NWP

- **Global Forecasts** → Climate Predictions and Projections
- **Regional Forecasts** → Hurricanes and High Impact Events

Instrument Performance LTM Work Flow


Satellite Observations (L1b, RDR)

Data Decoding Module

LTM Datasets

Orbital Statistical Analysis Module

LTM Statistical Datasets

LTM Product Generation Module

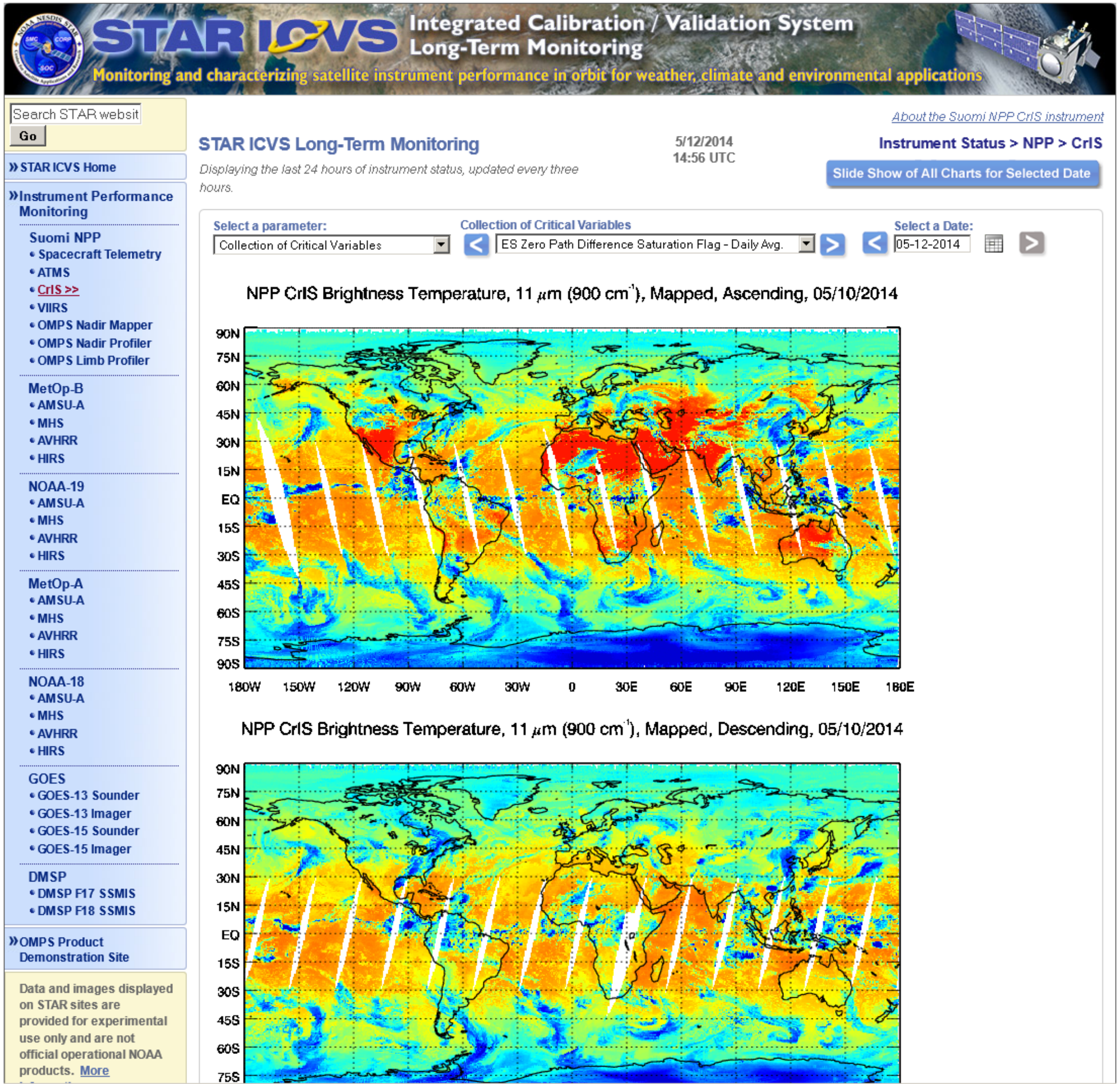
Scan/Orbital Trending Figures

Customized Analytical Datasets

Instrument Anomaly Notification

STAR ICVS-LTM Website

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



STAR ICVS Long-Term Monitoring

5/12/2014
14:56 UTC

Displaying the last 24 hours of instrument status, updated every three hours.

Select a parameter: Collection of Critical Variables

Collection of Critical Variables: ES Zero Path Difference Saturation Flag - Daily Avg.

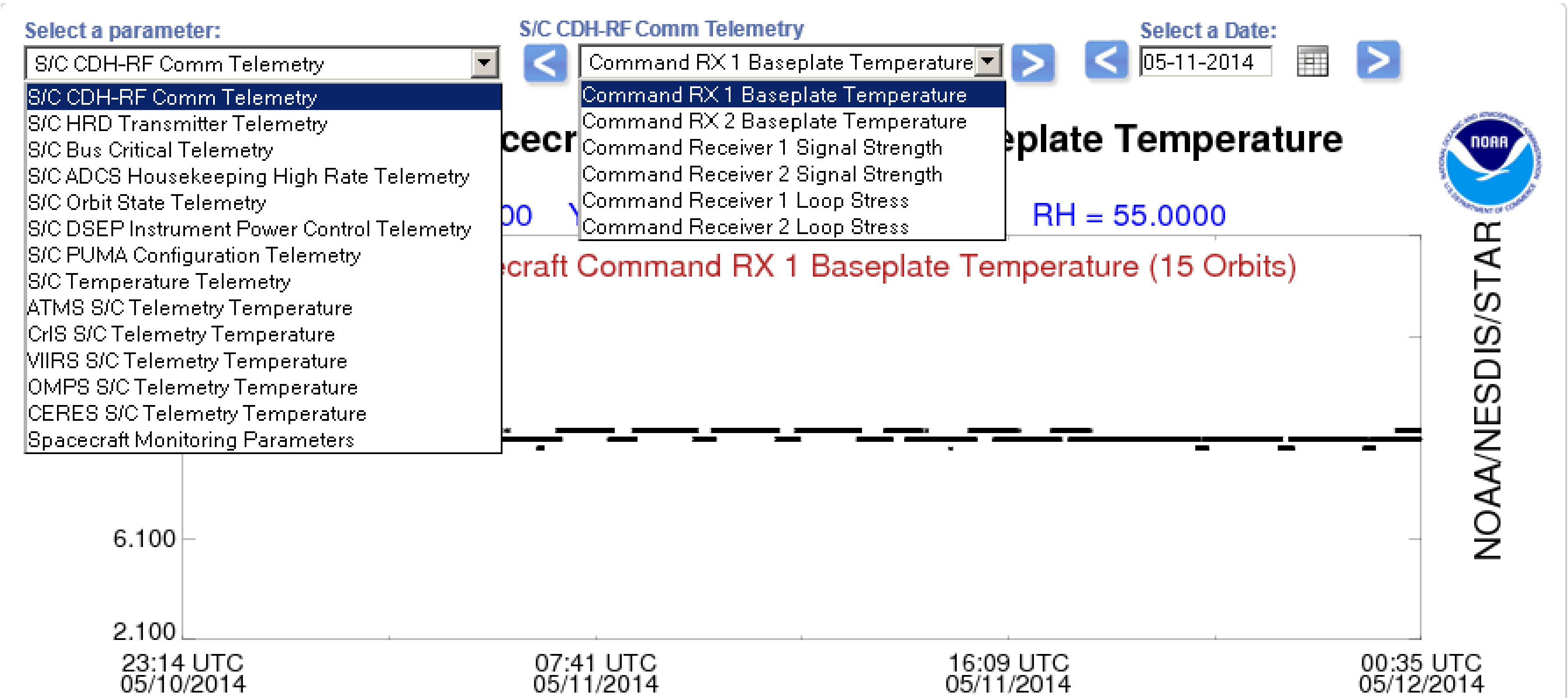
Select a Date: 05-12-2014

NPP CrIS Brightness Temperature, 11 μm (900 cm^{-1}), Mapped, Ascending, 05/10/2014

NPP CrIS Brightness Temperature, 11 μm (900 cm^{-1}), Mapped, Descending, 05/10/2014

Data and images displayed on STAR sites are provided for experimental use only and are not official operational NOAA products. More

S-NPP Spacecraft LTM Parameters



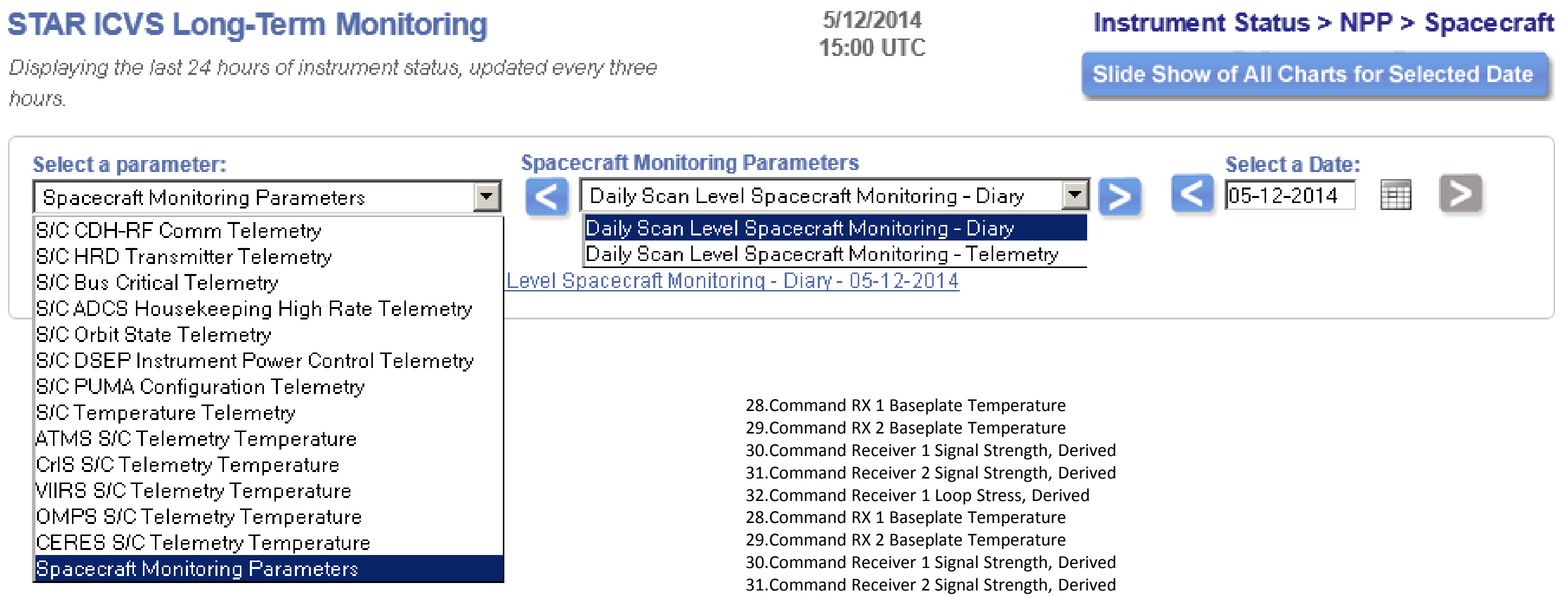
Select a parameter: S/C CDH-RF Comm Telemetry

S/C CDH-RF Comm Telemetry: Command RX 1 Baseplate Temperature

Select a Date: 05-11-2014

108 Parameters Provided in Real Time/LTM for S-NPP Spacecraft

S-NPP Spacecraft Customized Datasets



STAR ICVS Long-Term Monitoring

Displaying the last 24 hours of instrument status, updated every three hours.

5/12/2014
15:00 UTC

Instrument Status > NPP > Spacecraft

1. Scan Year
2. Scan Julian Day of the year
3. Scan UTC second from the midnight
4. Scan Orbit number
5. PUMA Bus Voltage
6. PUMA Total Bus Current
7. PUMA Battery 1 Voltage
8. PUMA Battery 2 Voltage
9. PUMA Battery 1 Pressure
10.PUMA Battery 2 Pressure
11.Wheel 1 Speed/Direction
12.Wheel 2 Speed/Direction
13.Wheel 3 Speed/Direction
14.Wheel 4 Speed/Direction
15.Gyro (TARA) 1 Motor Current
16.Gyro (TARA) 2 Motor Current
17.Gyro (TARA) 3 Motor Current
18.Reaction Wheel 1 Motor Current
19.Reaction Wheel 2 Motor Current
20.Reaction Wheel 3 Motor Current
21.Reaction Wheel 4 Motor Current
22.System Pressure
23.Propulsion Deck -Z Temperature
24.Propulsion Tank Temperature (Gas Side)
25.Control Frame Rate X
26.Control Frame Rate Y
27.Control Frame Rate Z
28.Command RX 1 Baseplate Temperature
29.Command RX 2 Baseplate Temperature
30.Command Receiver 1 Signal Strength, Derived
31.Command Receiver 2 Signal Strength, Derived
32.Command Receiver 1 Loop Stress, Derived
28.Command RX 1 Baseplate Temperature
29.Command RX 2 Baseplate Temperature
30.Command Receiver 1 Signal Strength, Derived
31.Command Receiver 2 Signal Strength, Derived
32.Command Receiver 1 Loop Stress, Derived
33.Command Receiver 2 Loop Stress, Derived
34.Star Tracker Maximum residual
35.Total System Momentum 1
36.Total System Momentum 2
37.Total System Momentum 3

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0.0590     0.0000    10.3897     9.3147  -106.9608  -103.9399  2890.5425  2886.5098     0.0001    -1.3824    -1.8048     0.0064
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550.3724     0.2960     0.2880     0.2920     0.0000    -0.6480    -0.4860    -0.4860   370.7336    13.5563    15.9864     0.0006    -
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0.0590     0.0000    10.3897     9.3147  -106.9608  -103.9399  2890.5425  2886.5098     0.0001    -1.4144    -1.8048    -0.0192
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552.4945     0.2960     0.2880     0.2920     0.0000    -0.8100    -0.3240    -0.6480   370.7336    13.5563    15.9864     0.0006    -
0.0596     0.0000    10.3897     9.3147  -106.9608  -103.9399  2890.5425  2886.5098     0.0000    -1.3376    -1.8432     0.0640
2013  68 83564  7074    32.4800    26.2400    32.3418    32.4018   952.2000   970.9200   373.9380  -550.2209  -403.9500  -
550.2209     0.2960     0.2880     0.2920     0.0000    -0.8100    -0.4860    -0.4860   370.7336    13.5563    15.9864    -0.0006    -
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201368 83565  7074    32.3200    26.2400    32.3418    32.4018   952.2000   970.9200   375.3022  -550.5240  -404.5563  -
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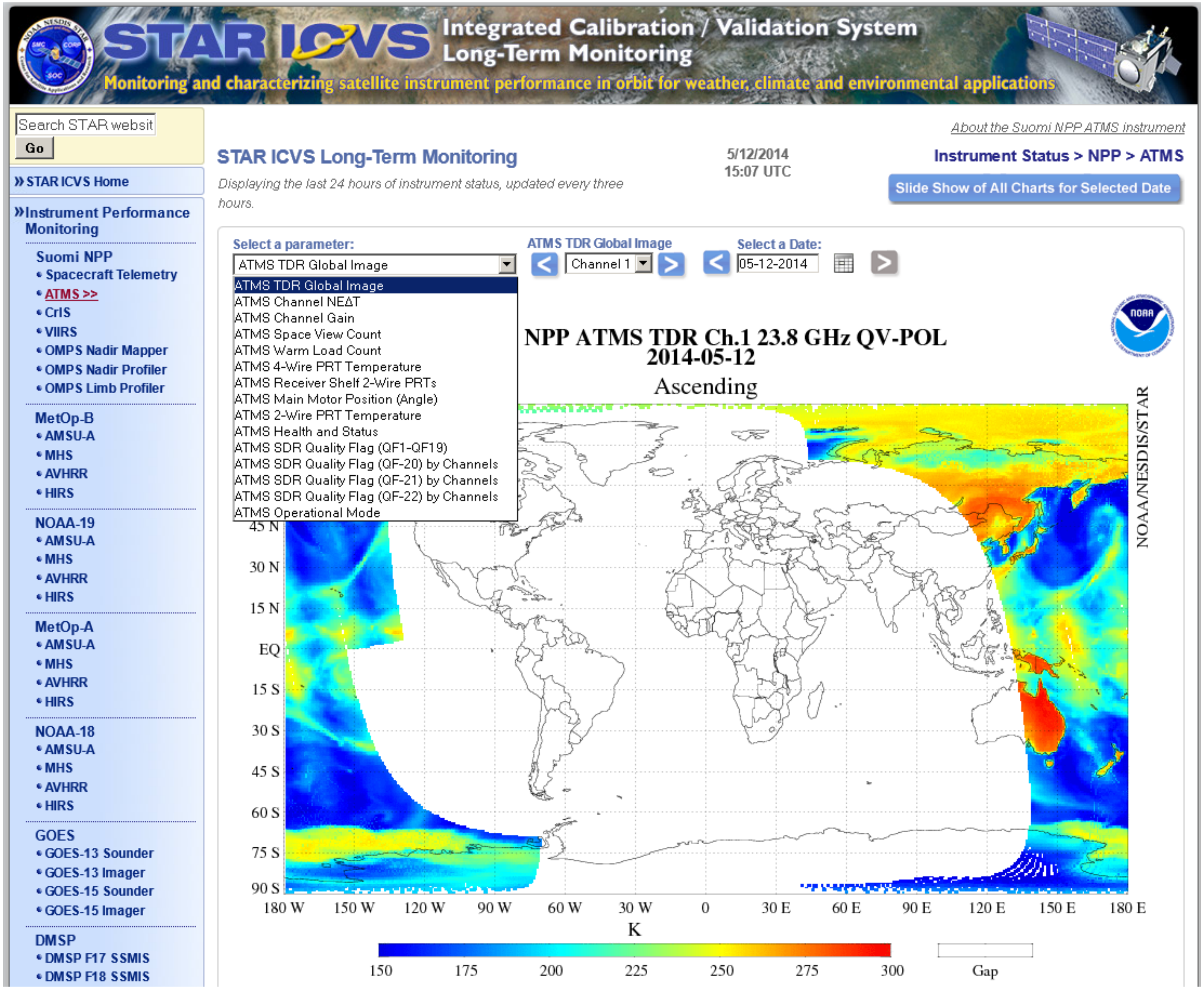
S-NPP ATMS LTM Parameters



STAR ICVS Long-Term Monitoring

Displaying the last 24 hours of instrument status, updated every three hours.

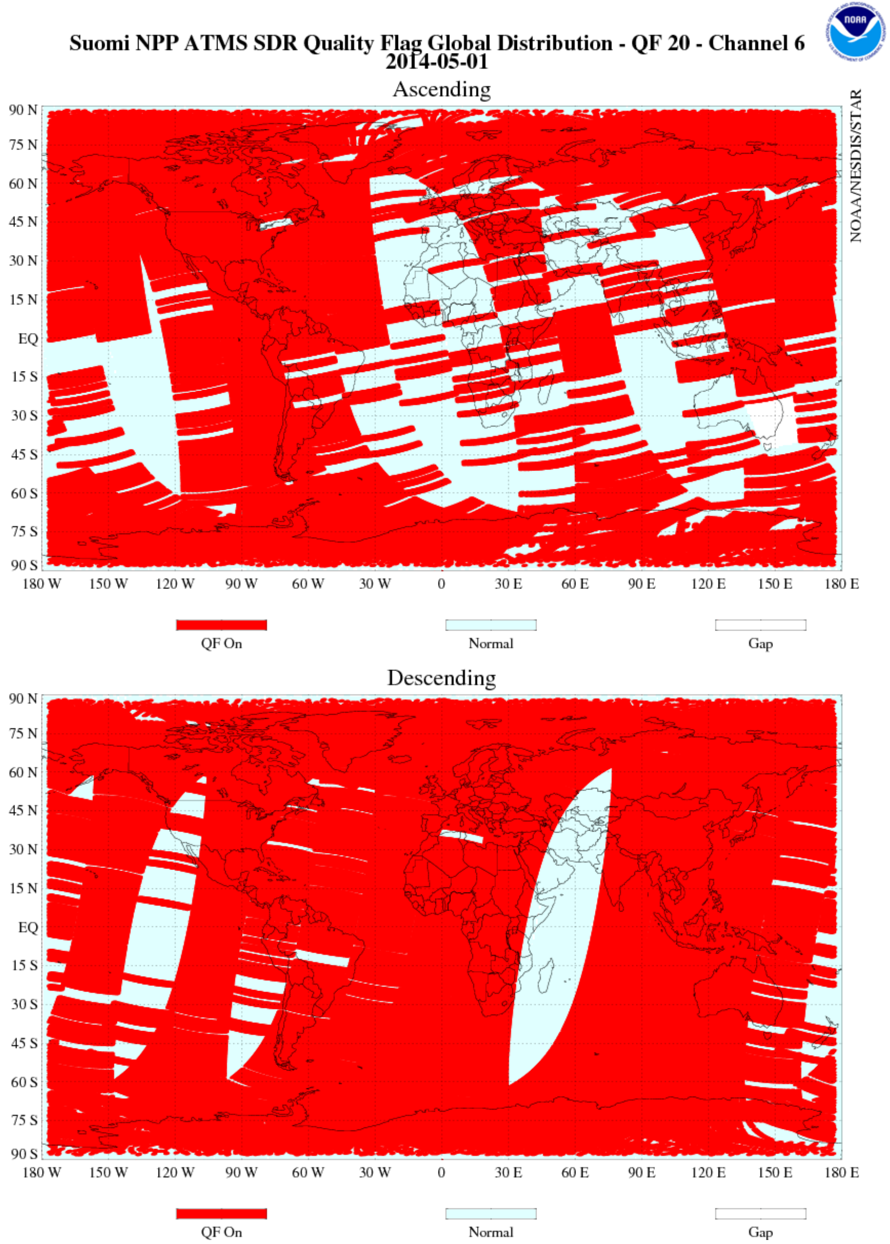
5/12/2014
15:07 UTC

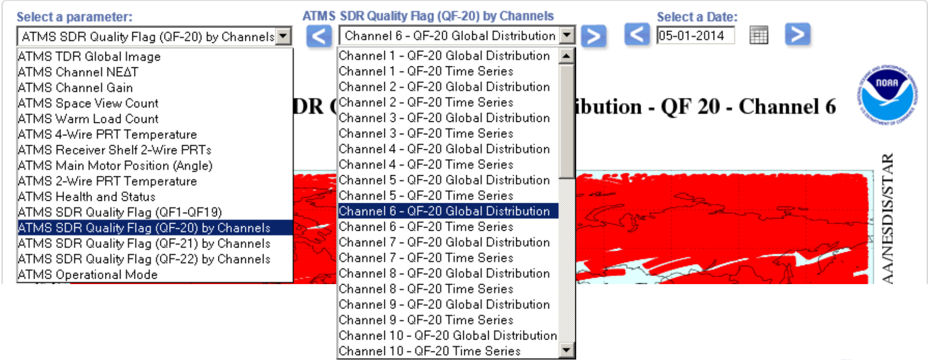
Select a parameter: ATMS TDR Global Image

ATMS TDR Global Image: Channel 1

Select a Date: 05-12-2014

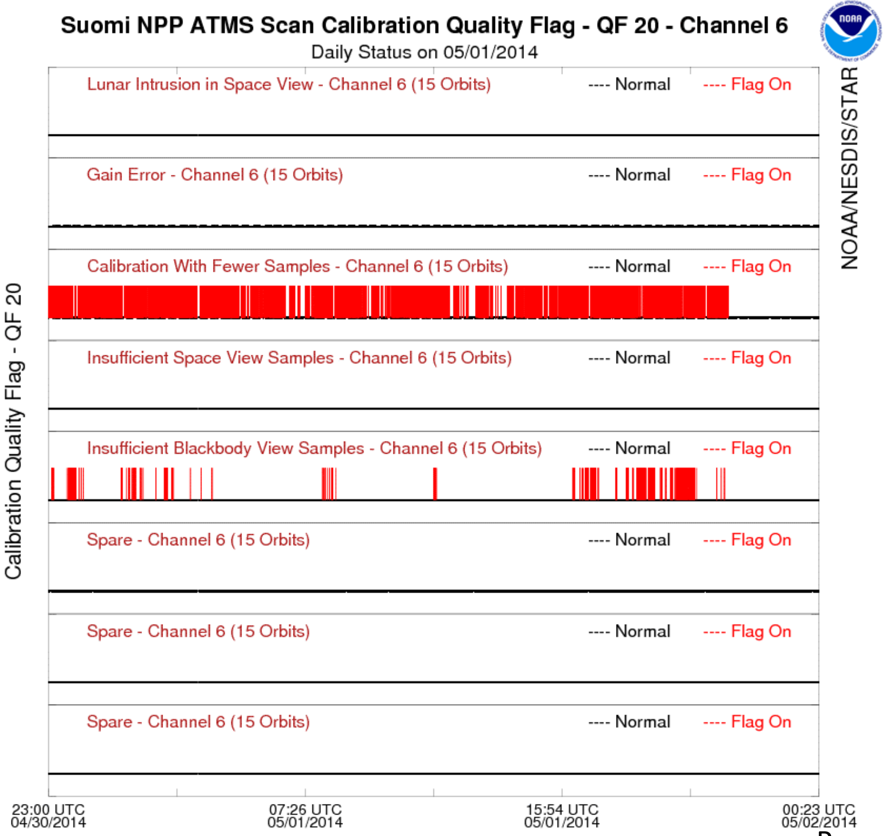
S-NPP ATMS Quality Flag 20



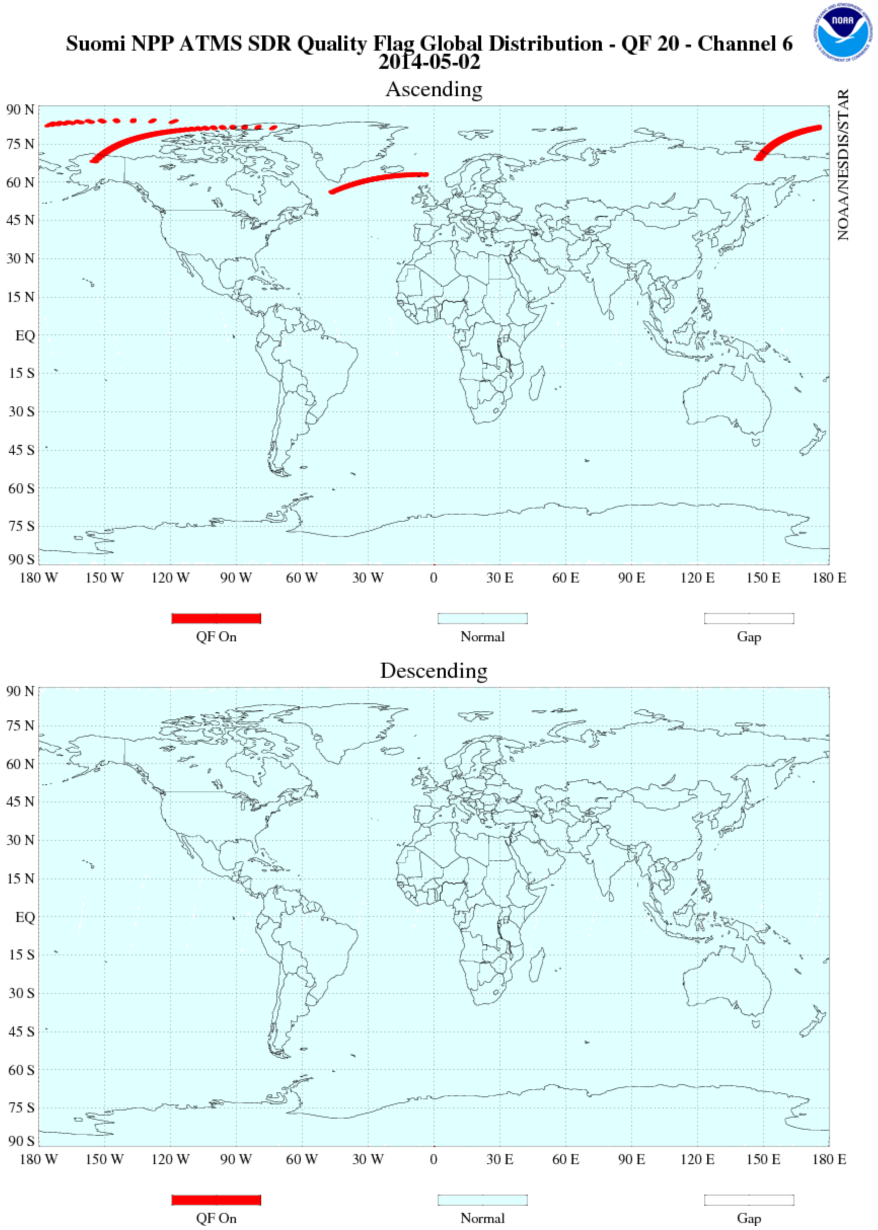


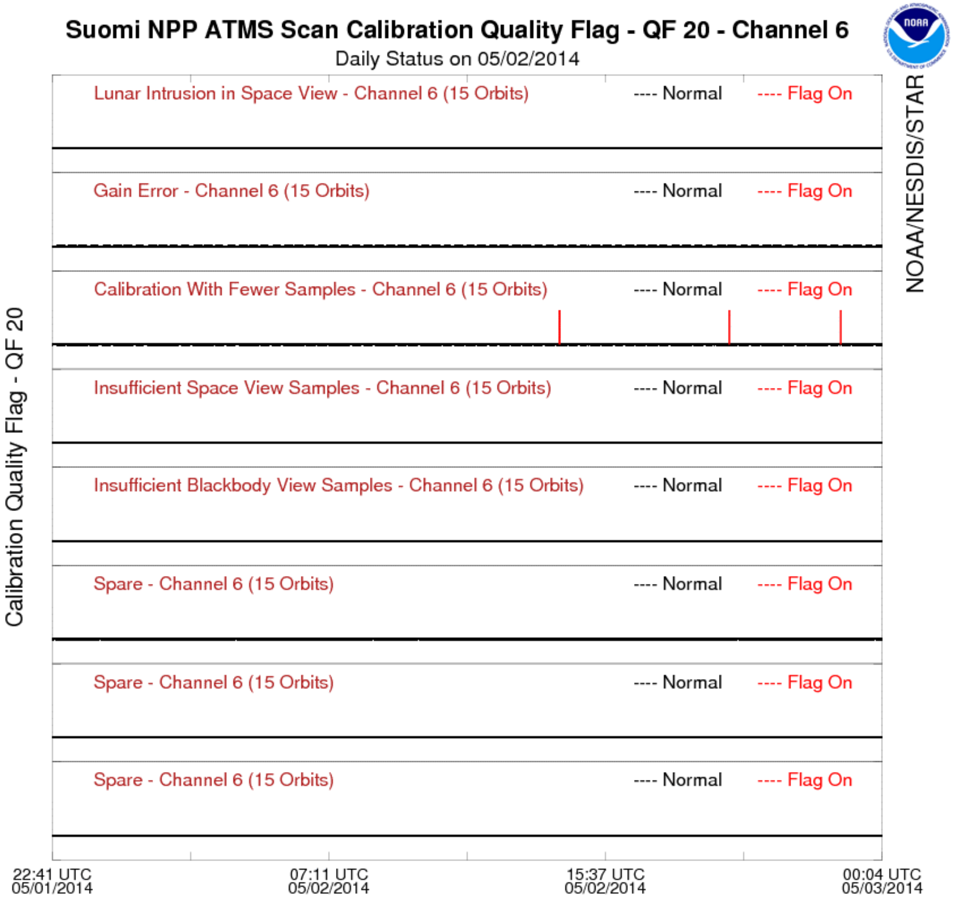
ATMS TDR Global Image
ATMS Channel NEΔT
ATMS Channel Gain
ATMS Space View Count
ATMS Warm Load Count
ATMS 4-Wire PRT Temperature
ATMS Receiver Shelf 2-Wire PRTs
ATMS Main Motor Position (Angle)
ATMS 2-Wire PRT Temperature
ATMS Health and Status
ATMS SDR Quality Flag (QF1-QF19)
ATMS SDR Quality Flag (QF-20) by Channels
ATMS SDR Quality Flag (QF-21) by Channels
ATMS SDR Quality Flag (QF-22) by Channels
ATMS Operational Mode

Channel 1 - QF-20 Global Distribution
Channel 1 - QF-20 Time Series
Channel 2 - QF-20 Global Distribution
Channel 2 - QF-20 Time Series
Channel 3 - QF-20 Global Distribution
Channel 3 - QF-20 Time Series
Channel 4 - QF-20 Global Distribution
Channel 4 - QF-20 Time Series
Channel 5 - QF-20 Global Distribution
Channel 5 - QF-20 Time Series
Channel 6 - QF-20 Global Distribution
Channel 6 - QF-20 Time Series
Channel 7 - QF-20 Global Distribution
Channel 7 - QF-20 Time Series
Channel 8 - QF-20 Global Distribution
Channel 8 - QF-20 Time Series
Channel 9 - QF-20 Global Distribution
Channel 9 - QF-20 Time Series
Channel 10 - QF-20 Global Distribution
Channel 10 - QF-20 Time Series

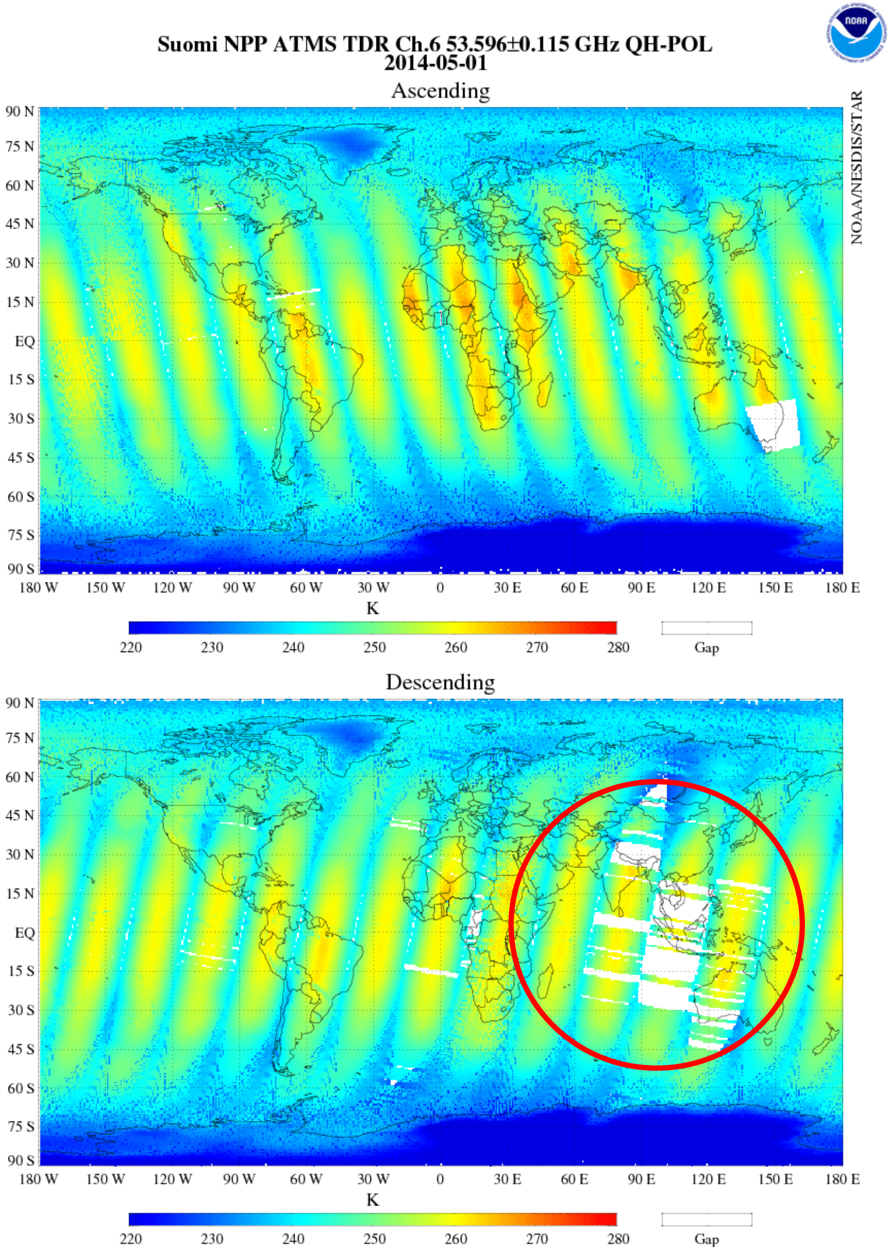


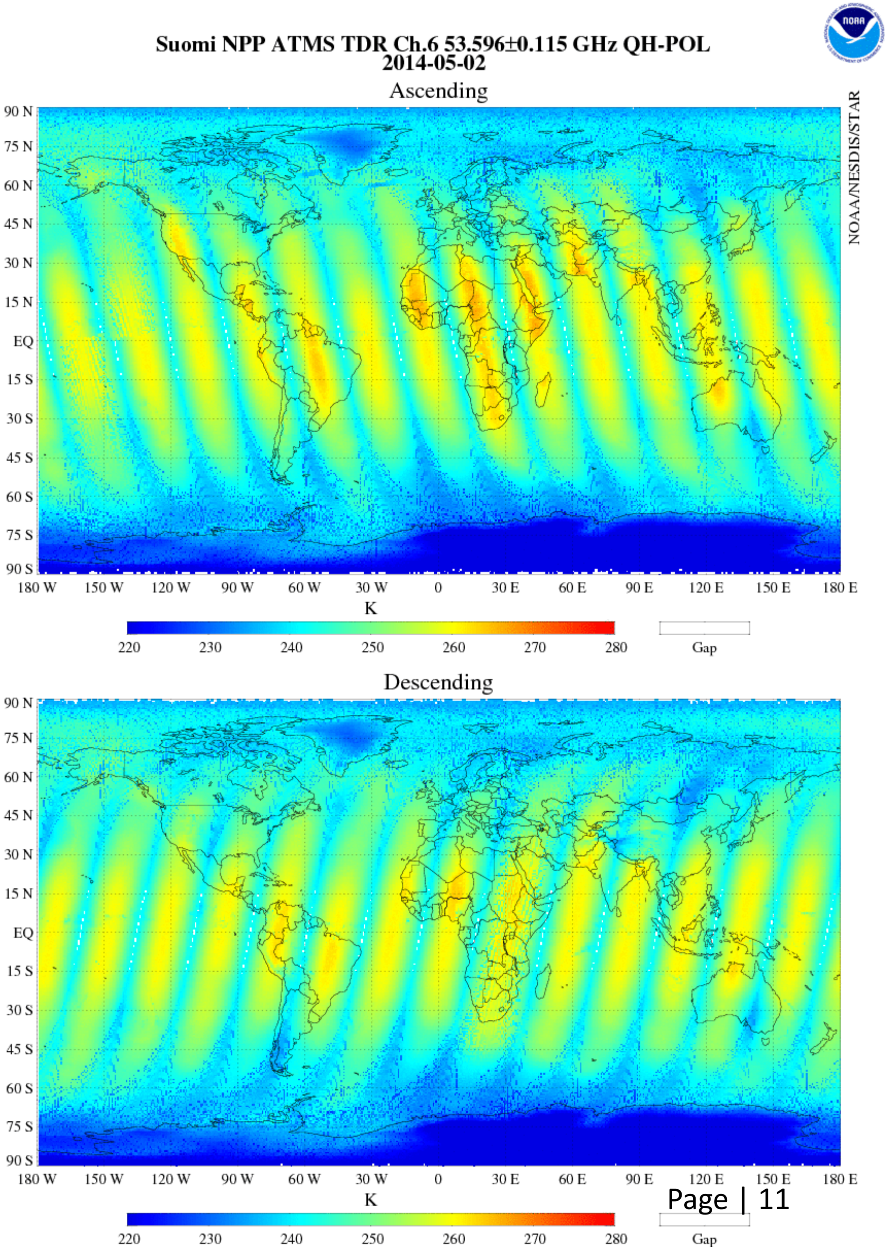
S-NPP ATMS Quality Flag 20



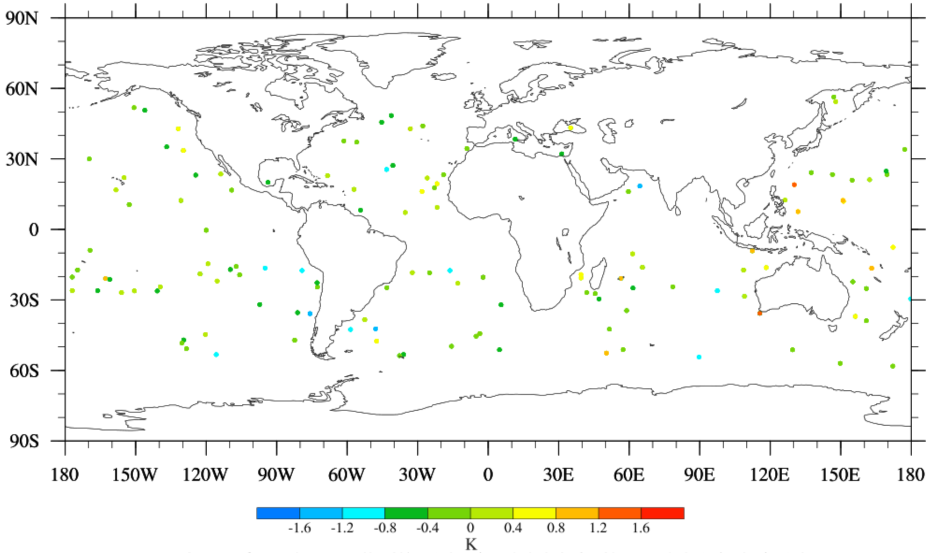


TDR Before/After PCT Update



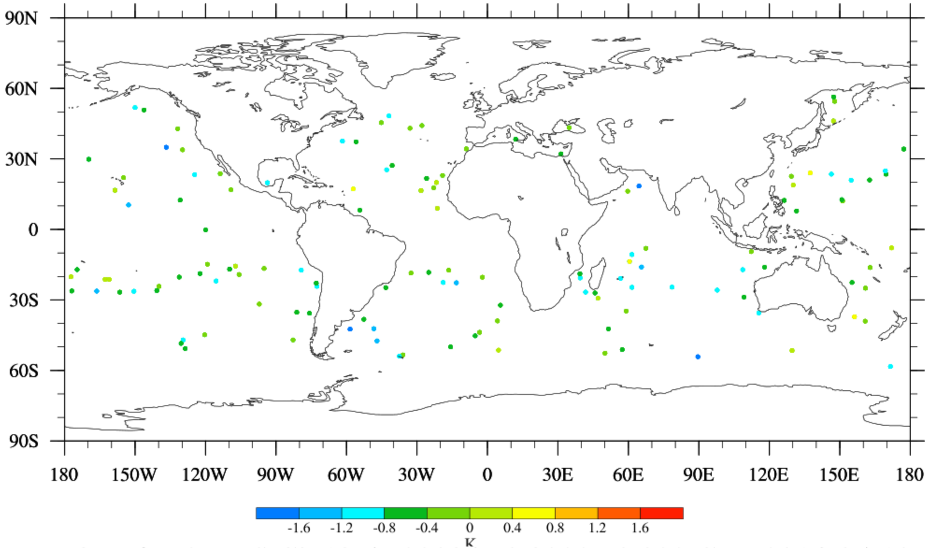


S-NPP ATMS LTM Parameters



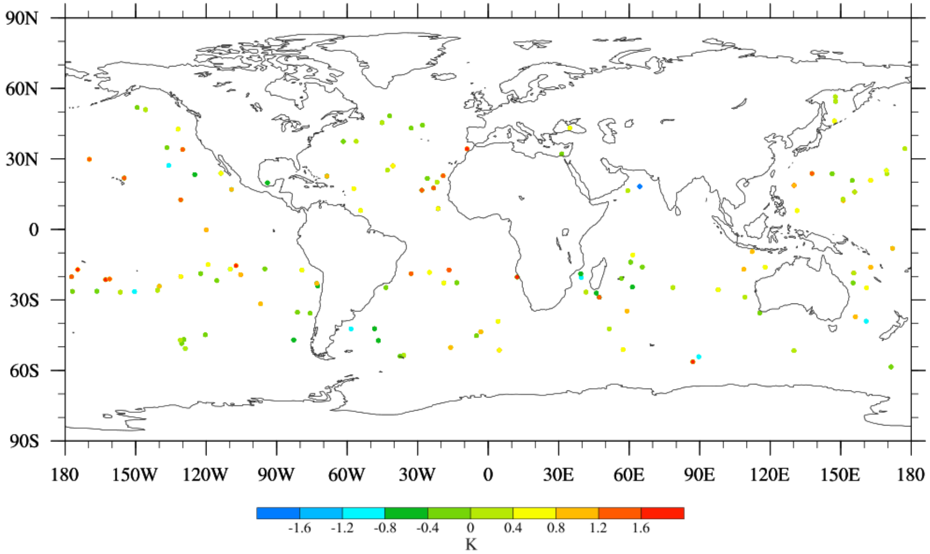
O-B for ATMS Ch.7 54.4 GHz 2014-05-10

(clear-sky, over ocean, 60°S-60°N)



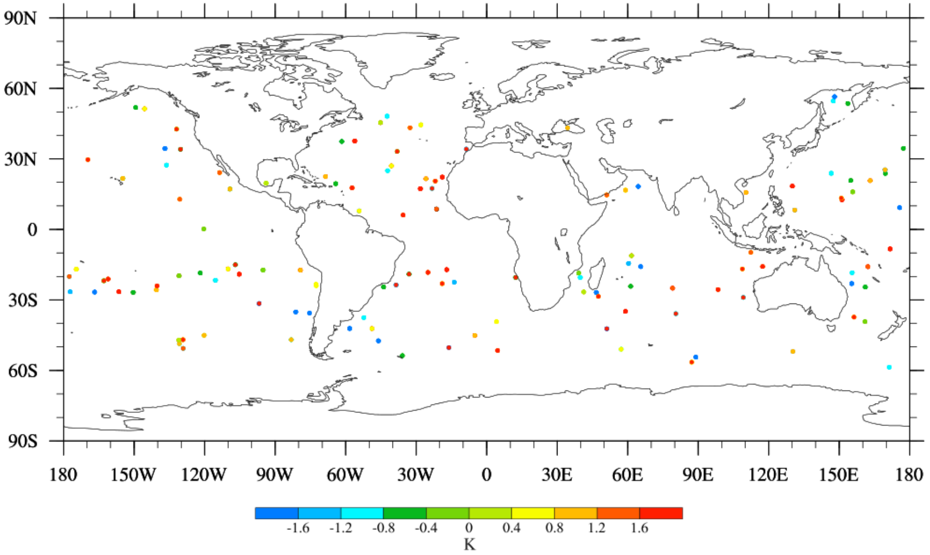
O-B for ATMS Ch.9 55.5 GHz 2014-05-10

(clear-sky, over ocean, 60°S-60°N)



O-B for ATMS Ch.10 57.29034 GHz 2014-05-10

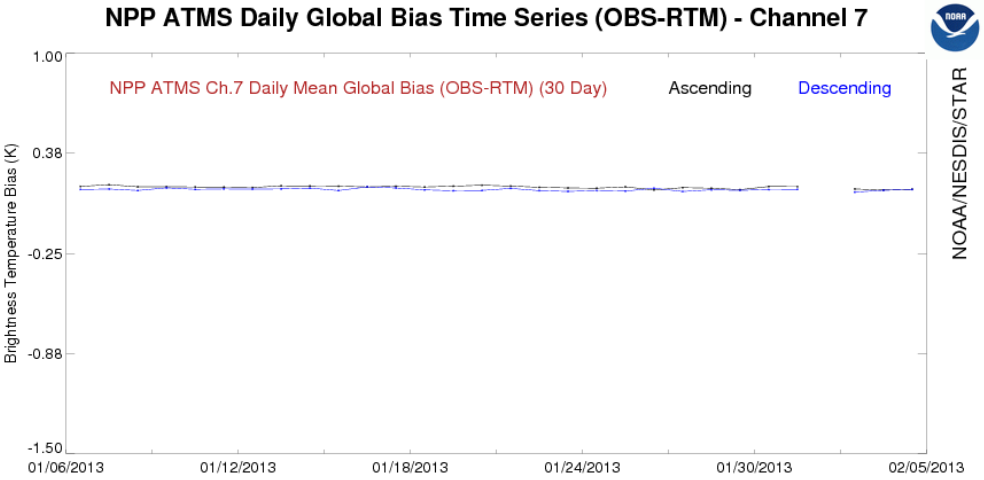
(clear-sky, over ocean, 60°S-60°N)



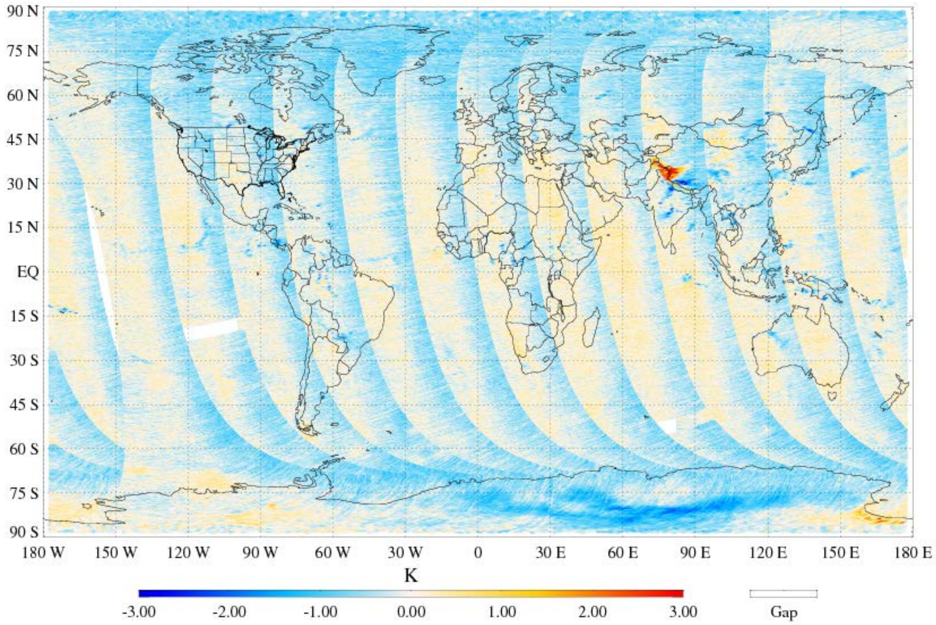
O-B for ATMS Ch.13 57.29034 ± 0.3222 ± 0.022 GHz 2014-05-10

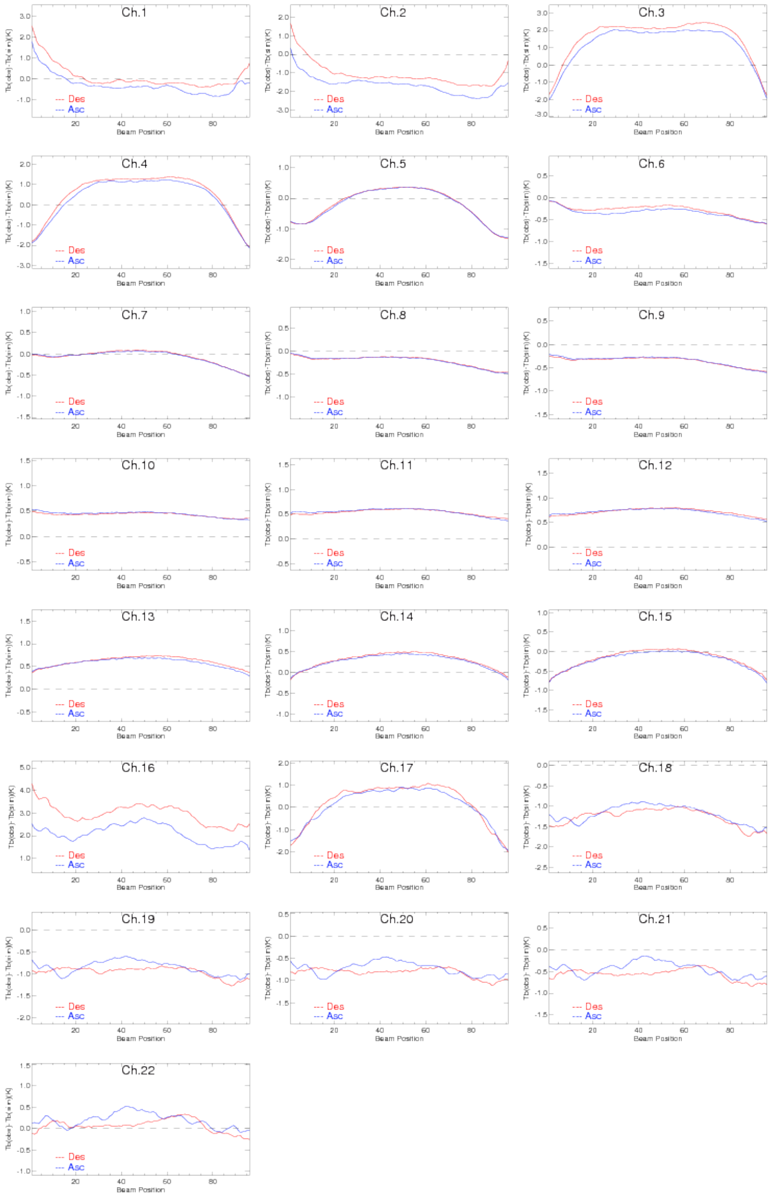
(clear-sky, over ocean, 60°S-60°N)

S-NPP ATMS LTM Parameters



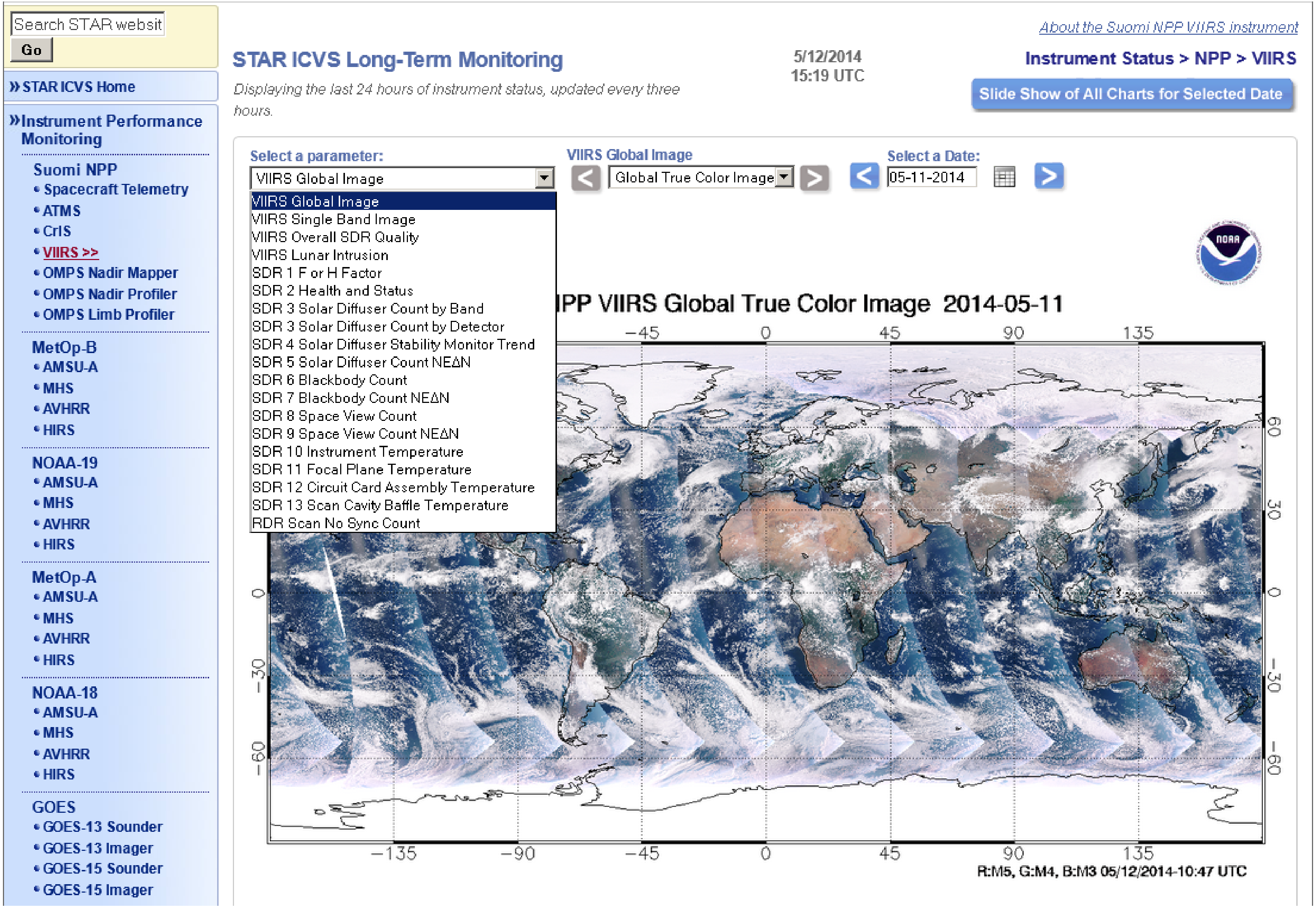
NPP ATMS Daily Global Bias Time Series (OBS-RTM) - Channel 7





ATMS Angular Dependence Over Ocean Clear-Sky 2013-02-19

S-NPP VIIRS LTM Parameters



STAR ICVS Long-Term Monitoring

5/12/2014
15:19 UTC

Displaying the last 24 hours of instrument status, updated every three hours.

Select a parameter: VIIRS Global Image

VIIRS Global Image: Global True Color Image

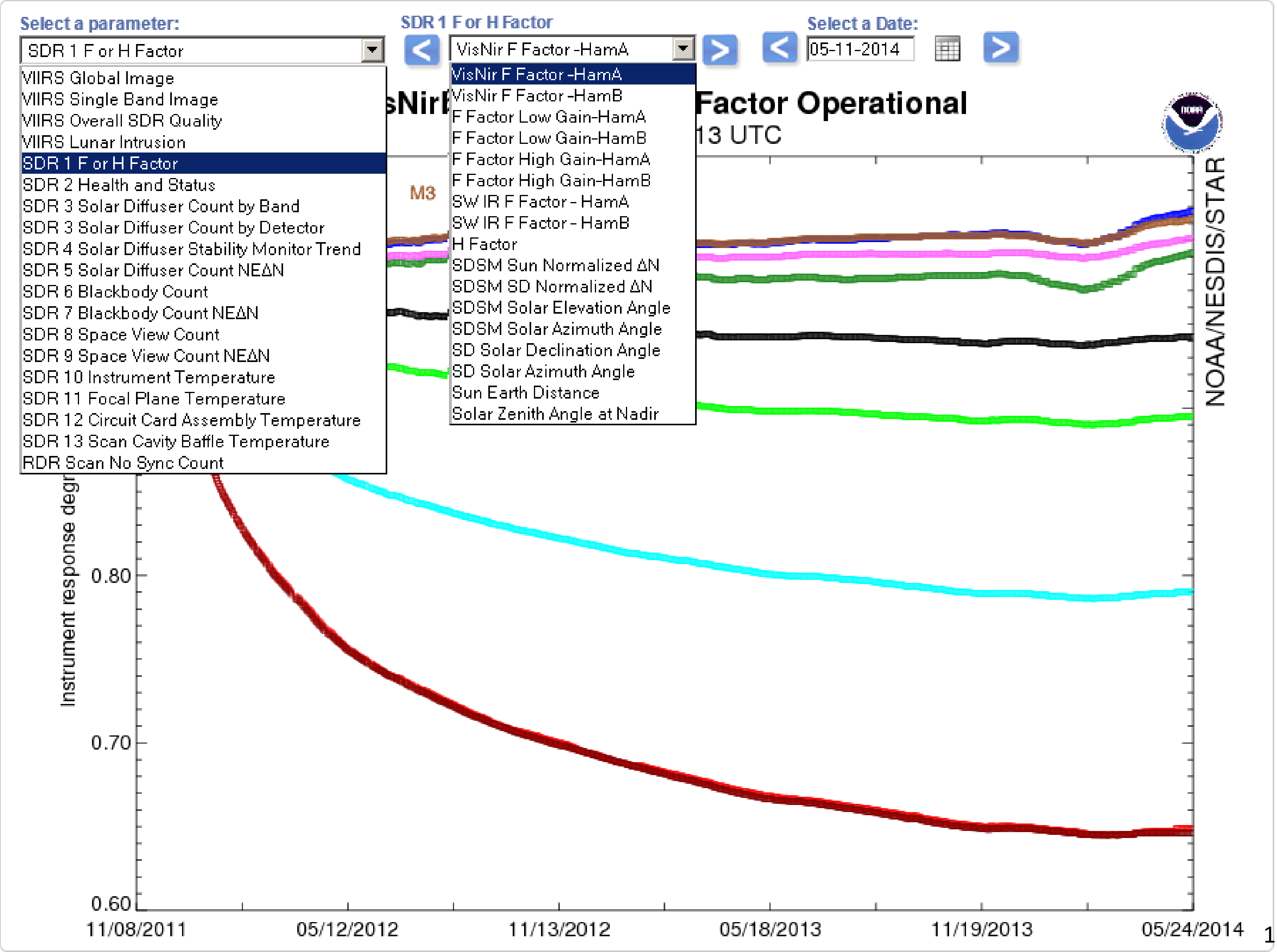
Select a Date: 05-11-2014

- VIIRS Global Image
- VIIRS Single Band Image
- VIIRS Overall SDR Quality
- VIIRS Lunar Intrusion
- SDR 1 F or H Factor
- SDR 2 Health and Status
- SDR 3 Solar Diffuser Count by Band
- SDR 3 Solar Diffuser Count by Detector
- SDR 4 Solar Diffuser Stability Monitor Trend
- SDR 5 Solar Diffuser Count NEΔN
- SDR 6 Blackbody Count
- SDR 7 Blackbody Count NEΔN
- SDR 8 Space View Count
- SDR 9 Space View Count NEΔN
- SDR 10 Instrument Temperature
- SDR 11 Focal Plane Temperature
- SDR 12 Circuit Card Assembly Temperature
- SDR 13 Scan Cavity Baffle Temperature
- RDR Scan No Sync Count

IPP VIIRS Global True Color Image 2014-05-11

R:M5, G:M4, B:M3 05/12/2014-10:47 UTC

S-NPP VIIRS LTM Parameters

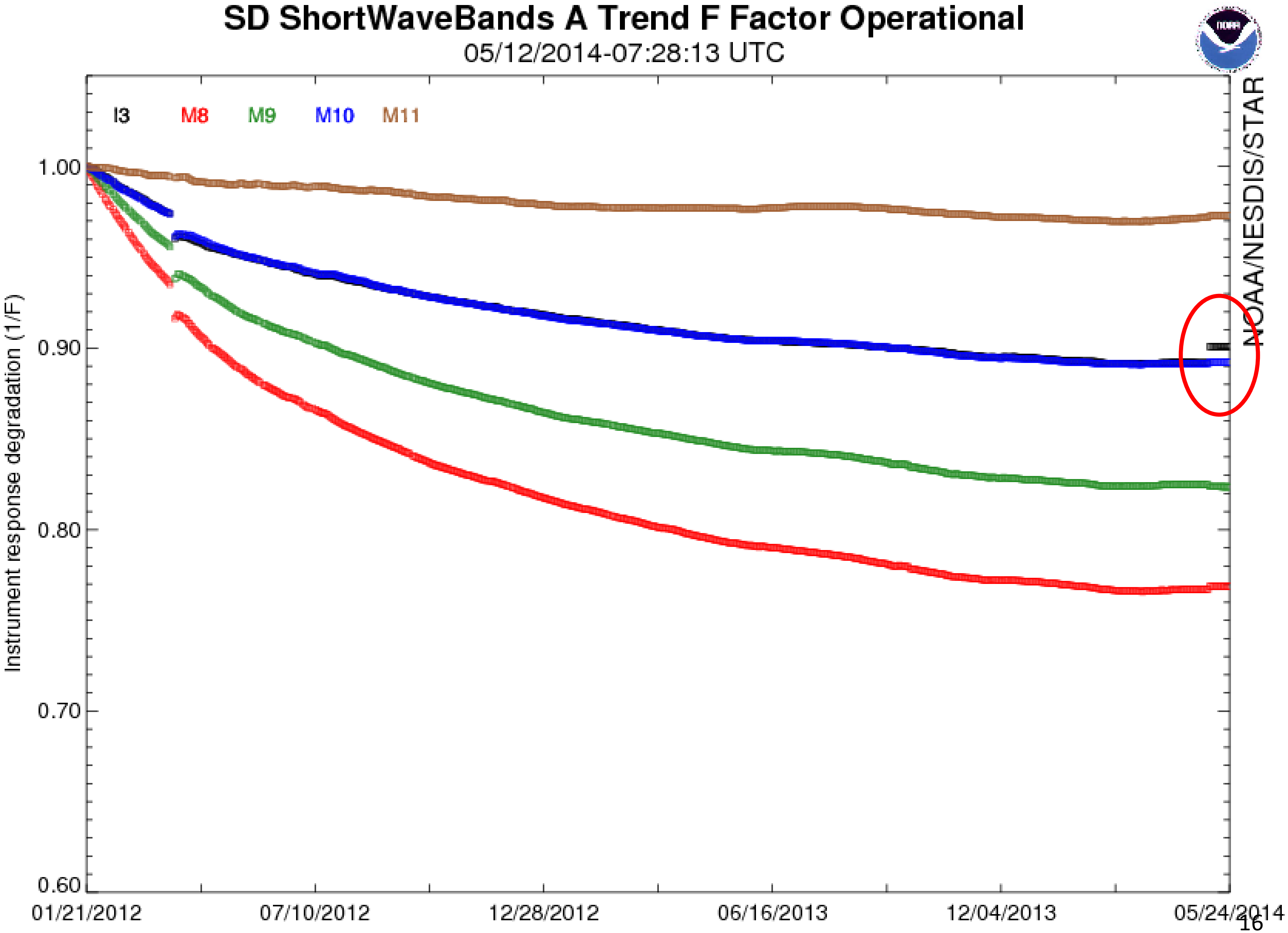


Select a parameter: SDR 1 F or H Factor

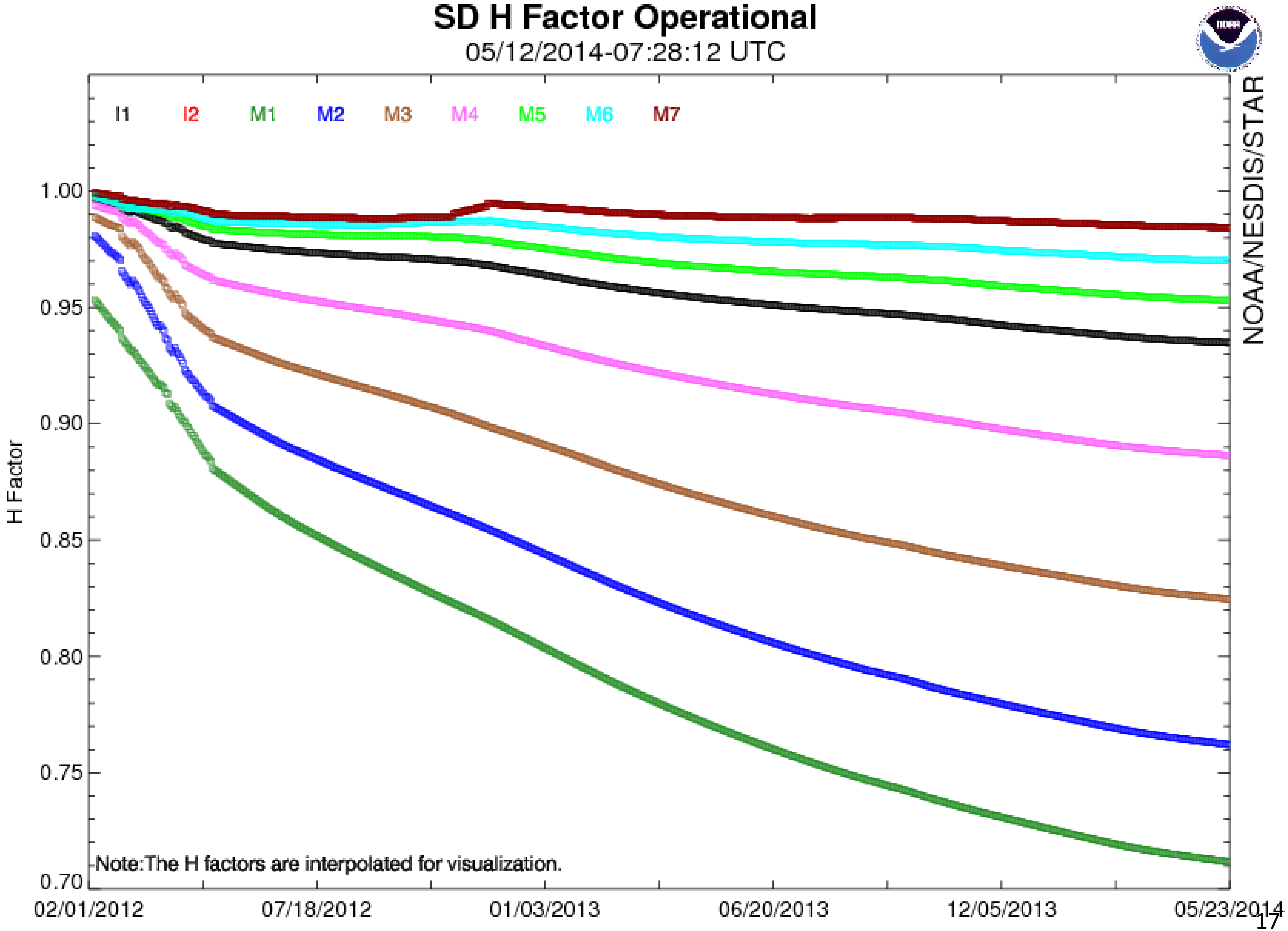
SDR 1 F or H Factor: VisNir F Factor -HamA

Select a Date: 05-11-2014

S-NPP VIIRS LTM Parameters

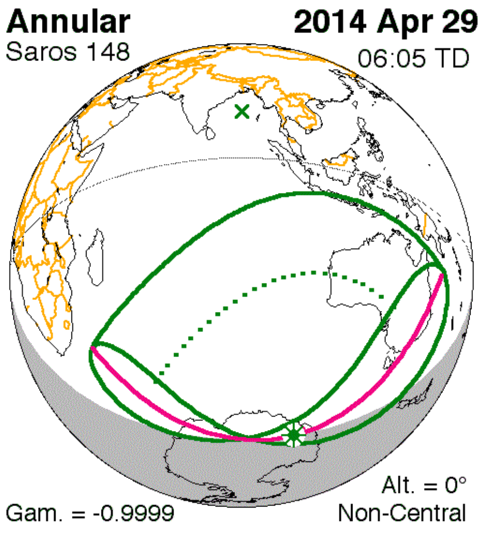


S-NPP VIIRS LTM Parameters

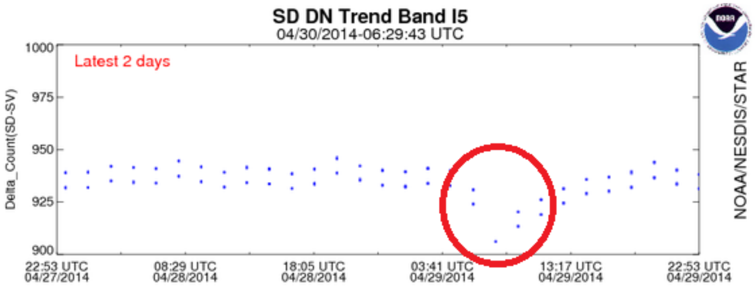


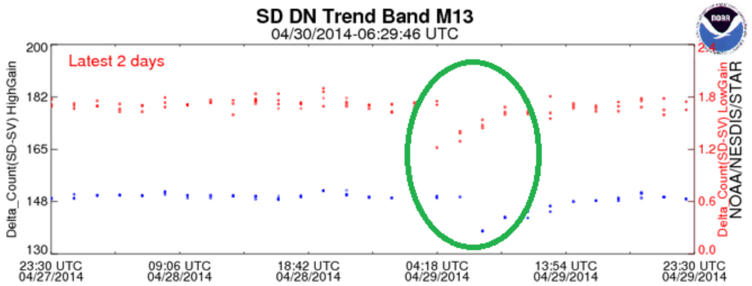
S-NPP VIIRS Solar Eclipse

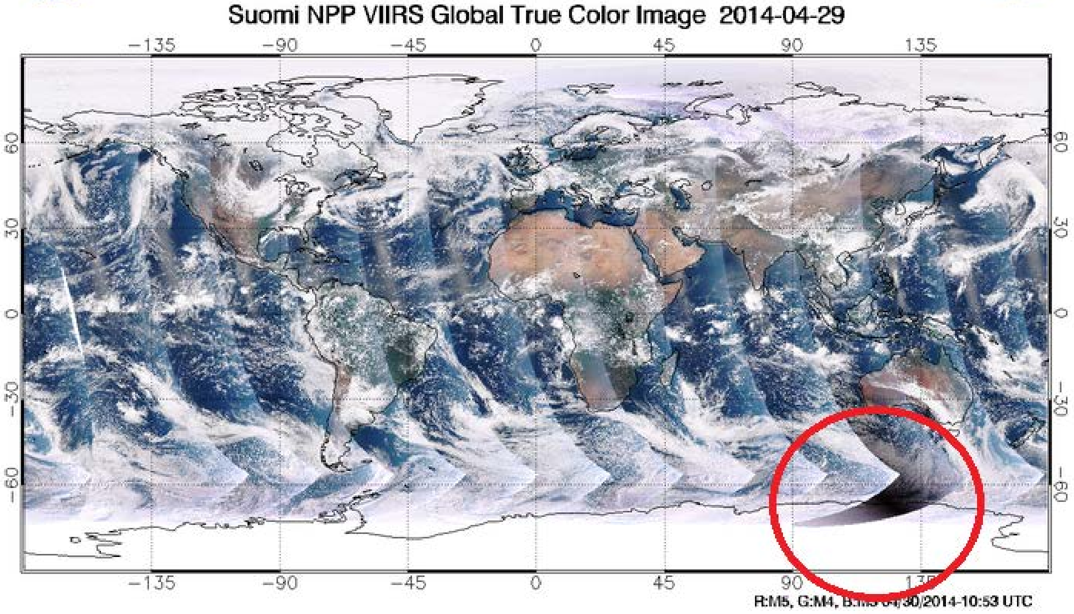
- Solar eclipse - The northern edge of the shadow first touches down in Antarctica at 05:57:35 UTC. The instant of greatest eclipse occurs just six minutes later at 06:03:25 UTC.
- VIIRS global true color image is darken by the solar eclipse;
- VIIRS solar diffuser count for M12 to 16, I4 and I5 bands decreased at about 5:00 - 7:00 UTC;



Five Millennium Canon of Solar Eclipses (Espenak & Meeus)

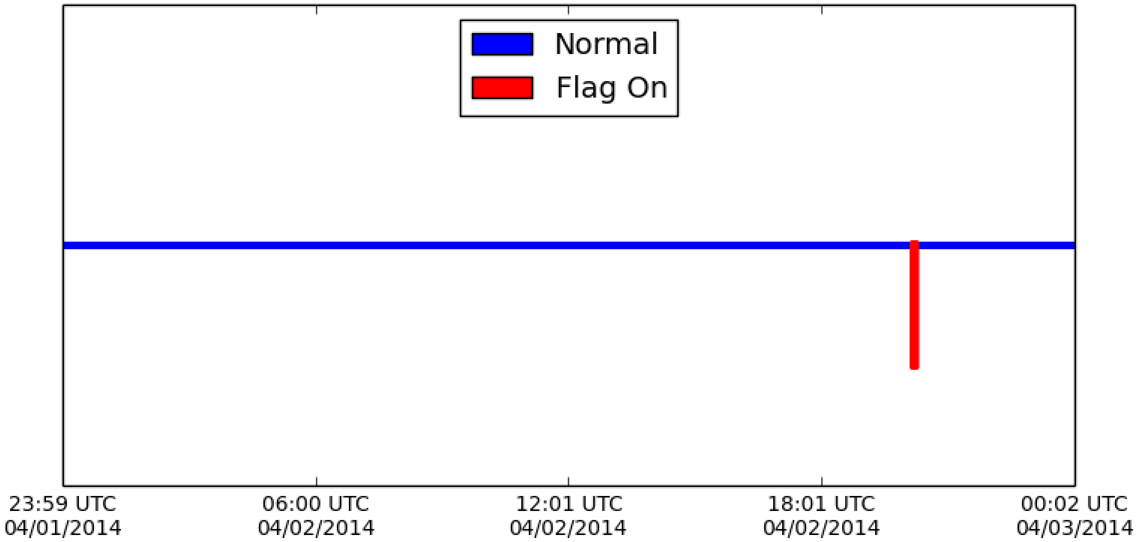




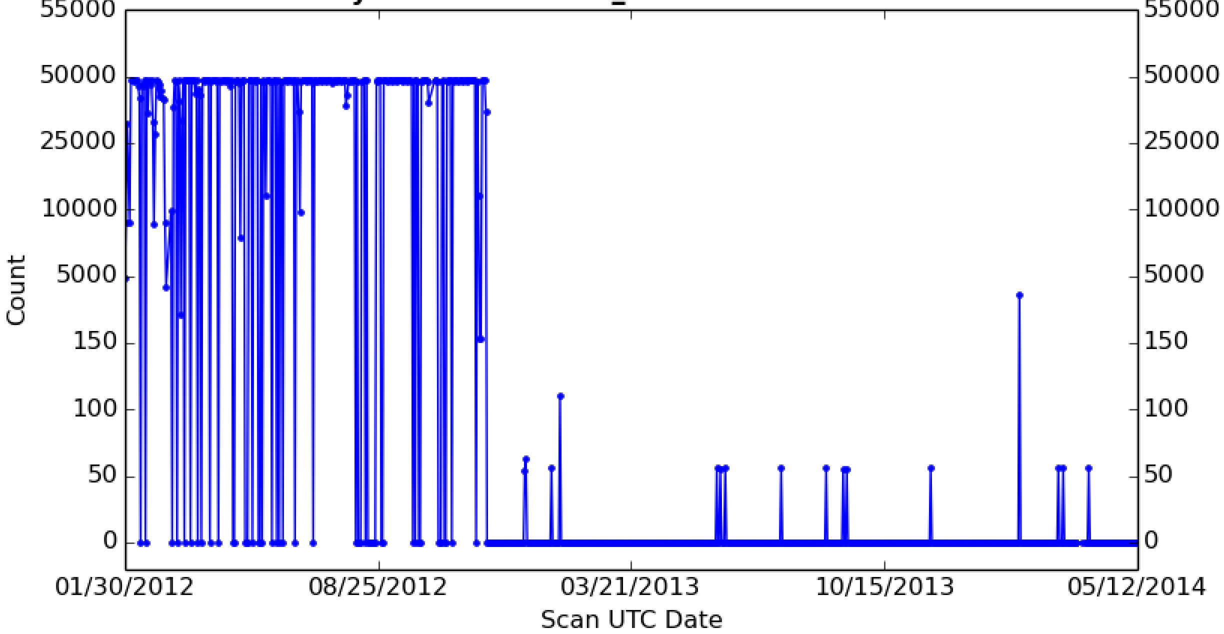


S-NPP VIIRS NO_SYNC LTM

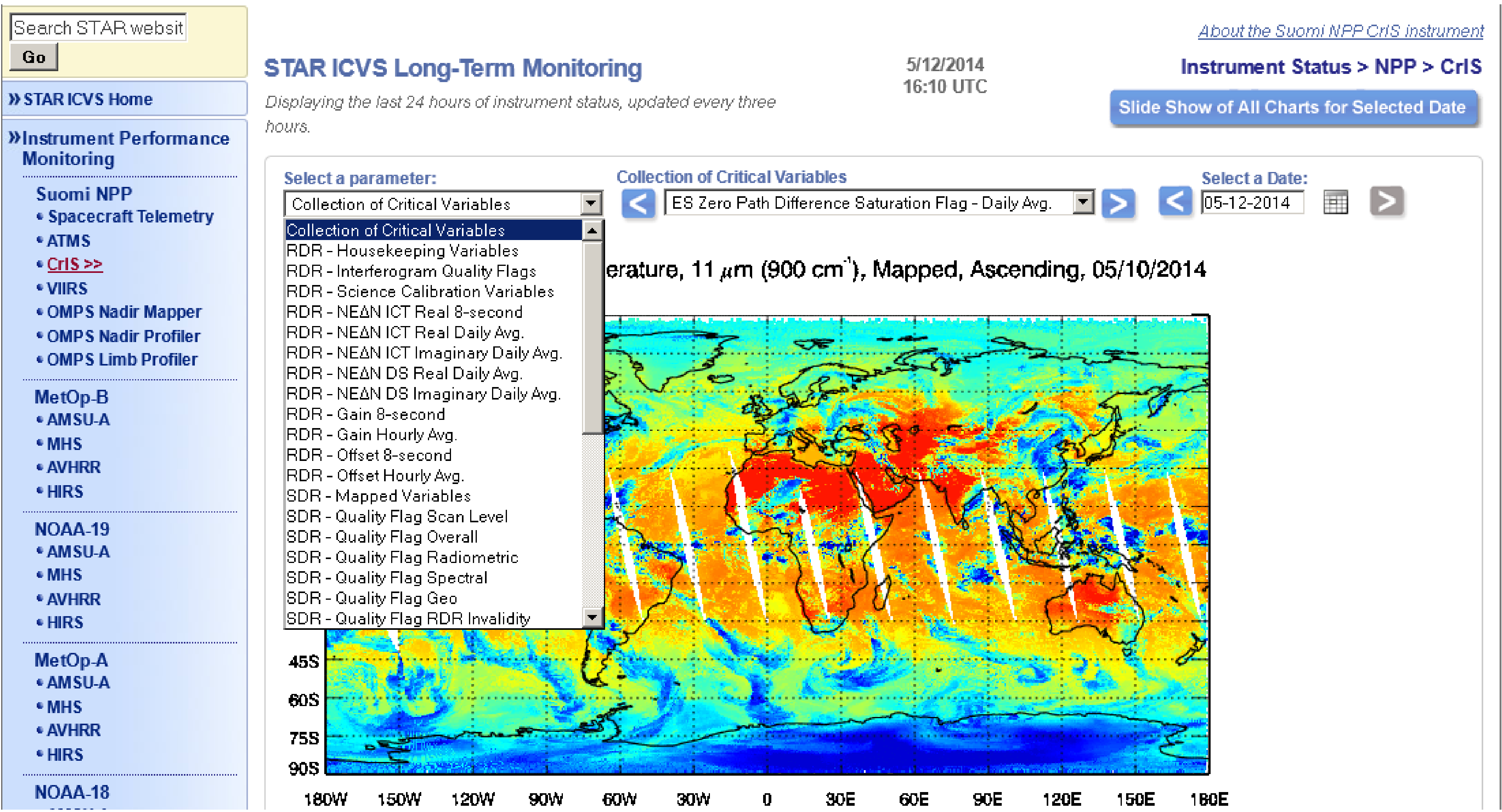
Suomi NPP VIIRS Scan Sync Lock Bit - 2014-04-02



Daily S-NPP VIIRS NO_SYNC Count - Life Time



S-NPP CrIS LTM Parameters



STAR ICVS Long-Term Monitoring

Displaying the last 24 hours of instrument status, updated every three hours.

5/12/2014
16:10 UTC

Select a parameter: Collection of Critical Variables

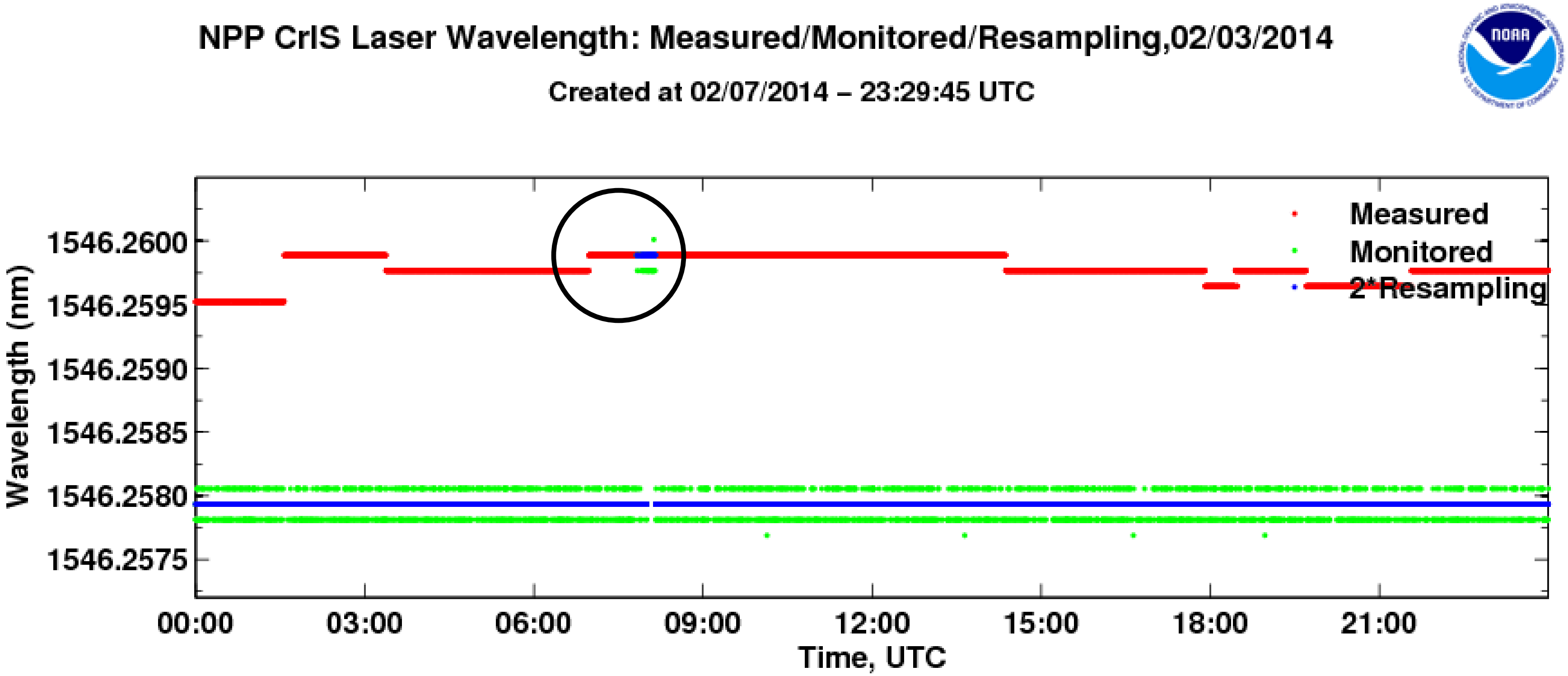
Collection of Critical Variables: ES Zero Path Difference Saturation Flag - Daily Avg.

Select a Date: 05-12-2014

350+ CrIS RDR/SDR LTM Parameters Provided in STAR-ICVS

S-NPP CrIS RDR

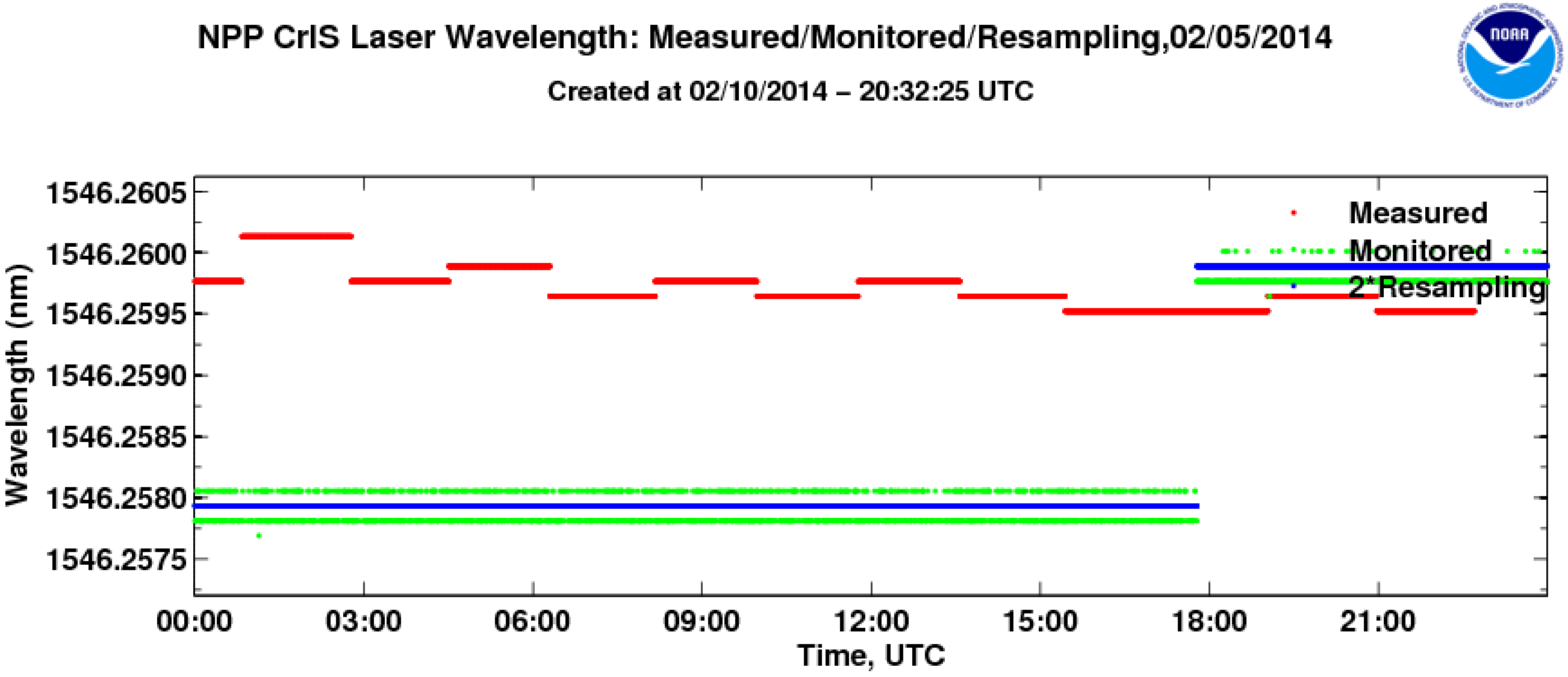
- **Sketchy jump of re-sampling laser wavelength on Feb 03.**



Laser drifted about 1.23 ppm < 2 ppm

S-NPP CrIS RDR

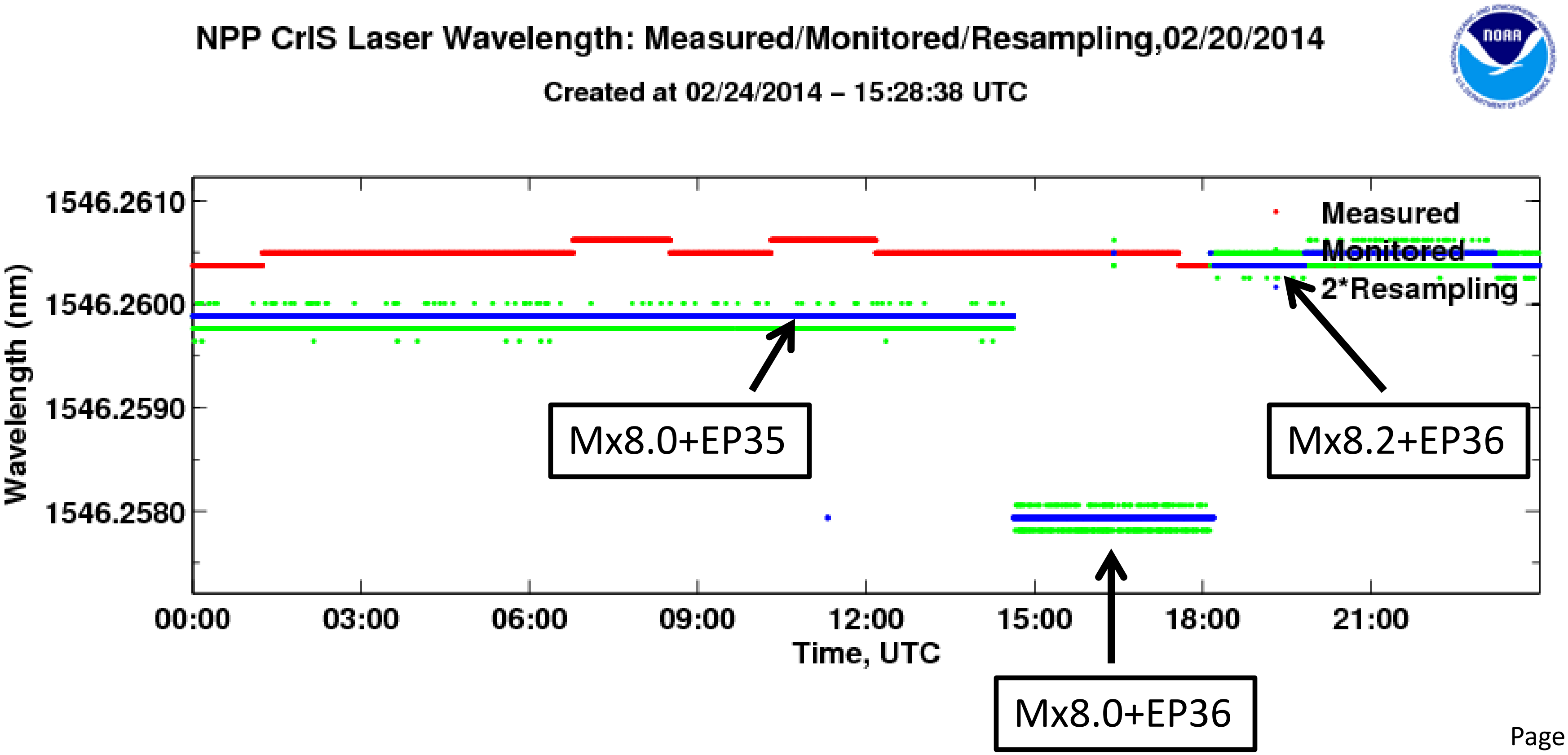
- **Unexpected updating of re-sampling laser wavelength on Feb 05.**



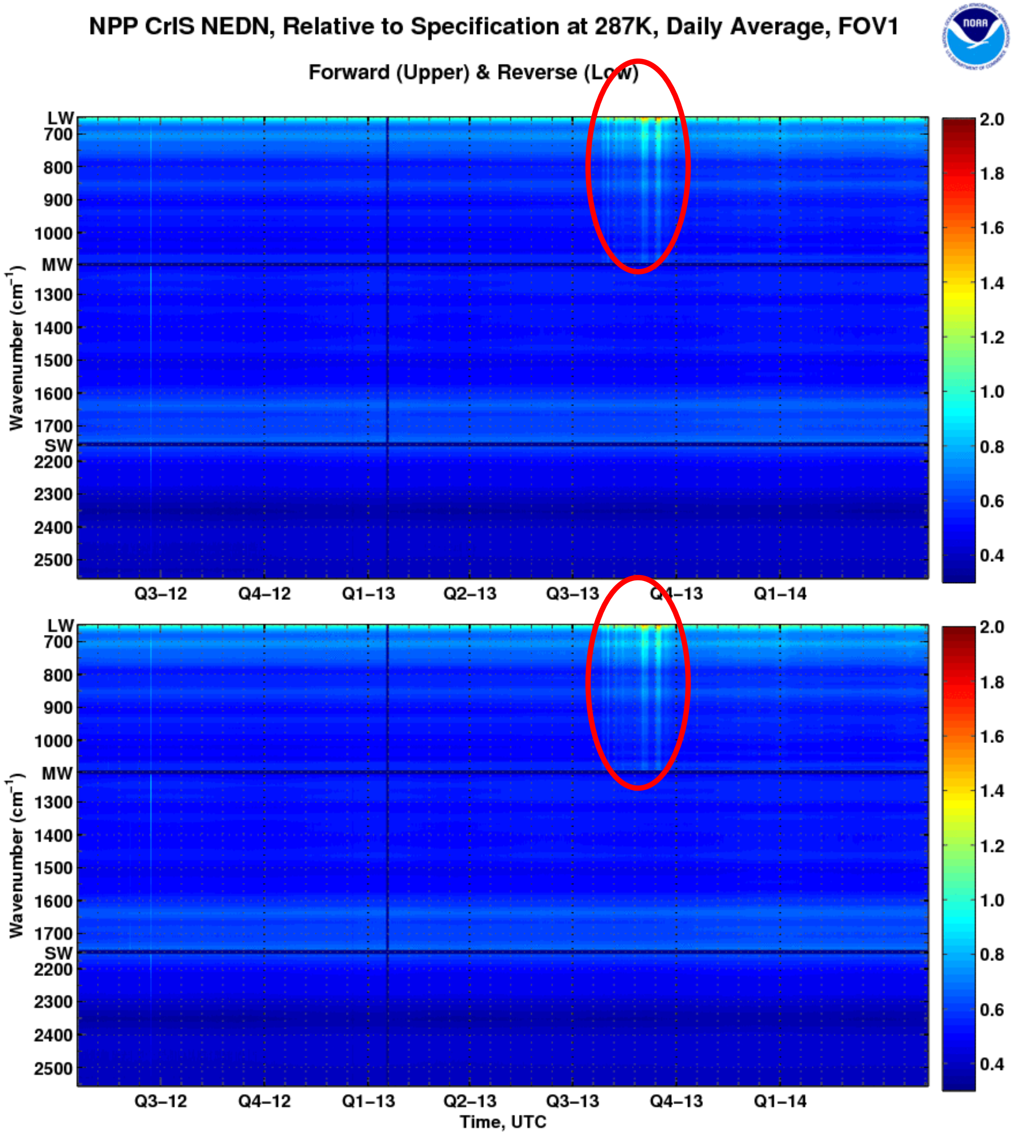
Laser drifted about 1.23 ppm < 2 ppm

S-NPP CrIS RDR

- **IDPS SDR algorithm is updated from Mx8.0 to Mx8.2 on Feb 20**
- **The engineering packet is updated from v35 to v36 on the same day**

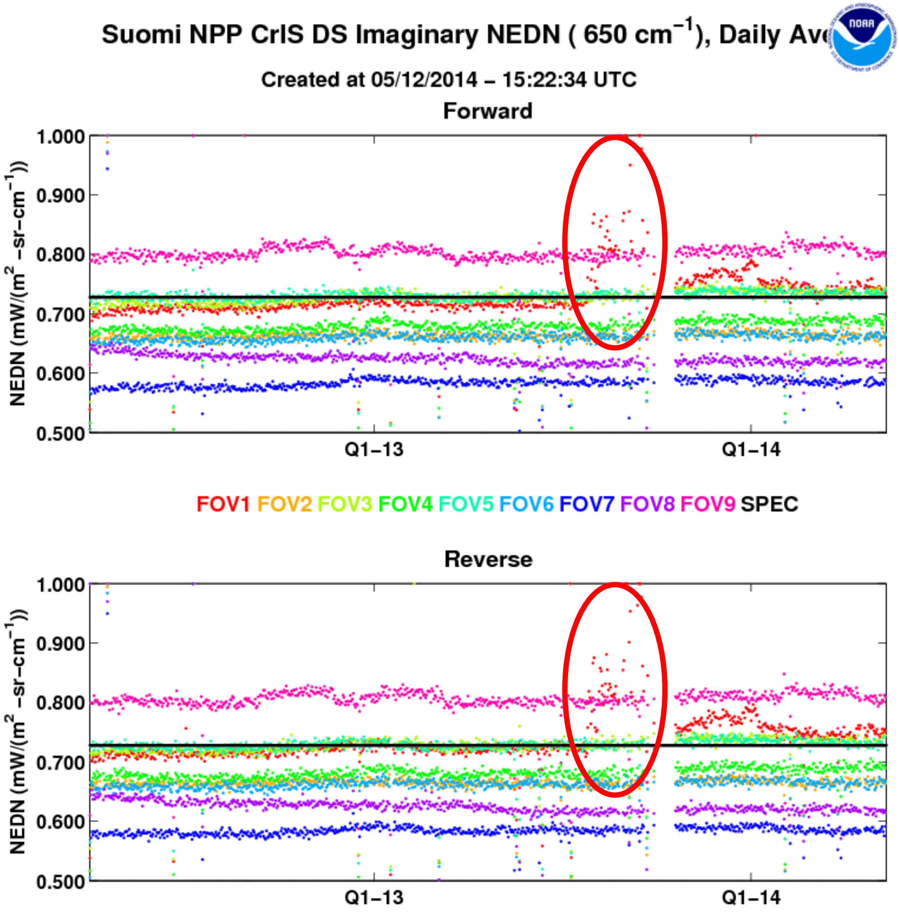


S-NPP CrIS Channel Performance



NPP CrIS NEDN, Relative to Specification at 287K, Daily Average, FOV1

Forward (Upper) & Reverse (Low)

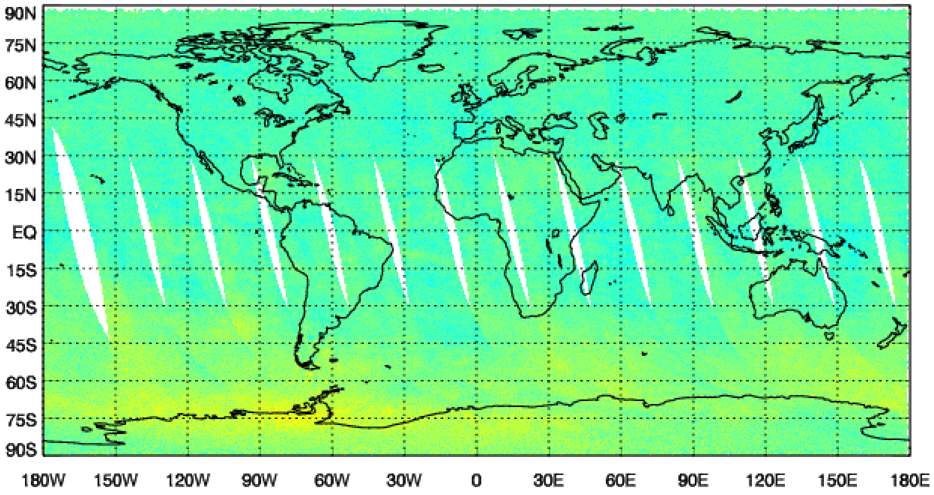


Suomi NPP CrIS DS Imaginary NEDN (650 cm^{-1}), Daily Ave

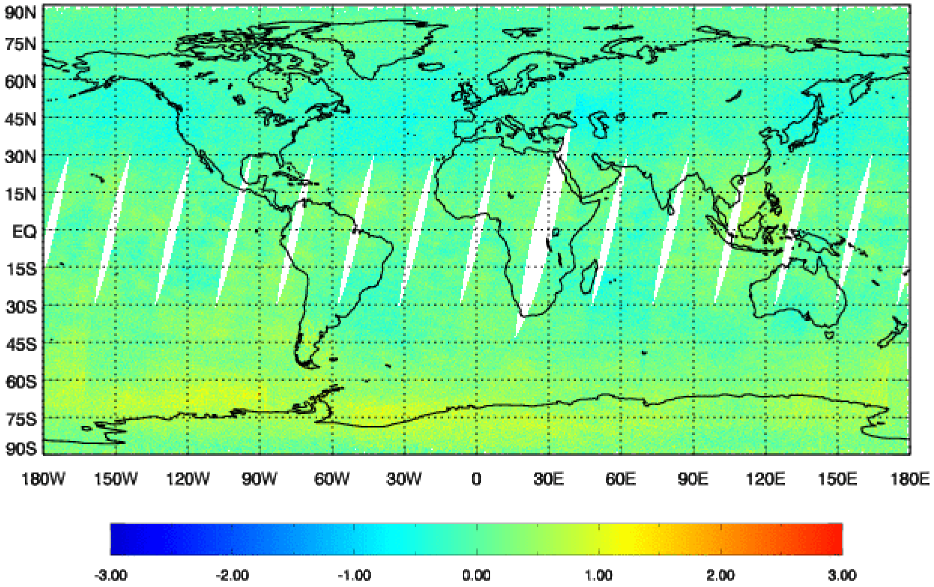
Created at 05/12/2014 – 15:22:34 UTC

S-NPP CrIS SDR Bias

NPP CrIS BT Observ. - Calc., 14.93 μm (670 cm^{-1}), Mapped, Ascending, 05/04/2014

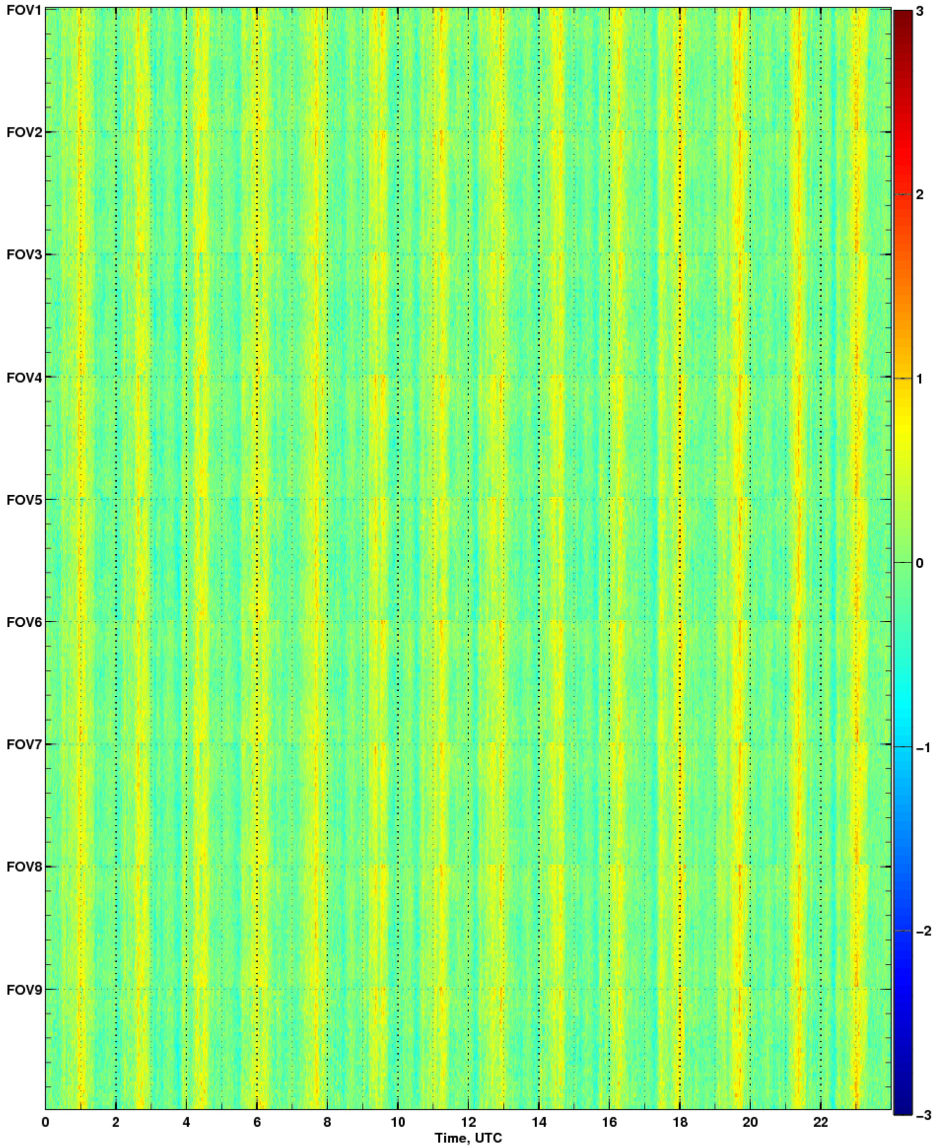


NPP CrIS BT Observ. - Calc., 14.93 μm (670 cm^{-1}), Mapped, Descending, 05/04/2014

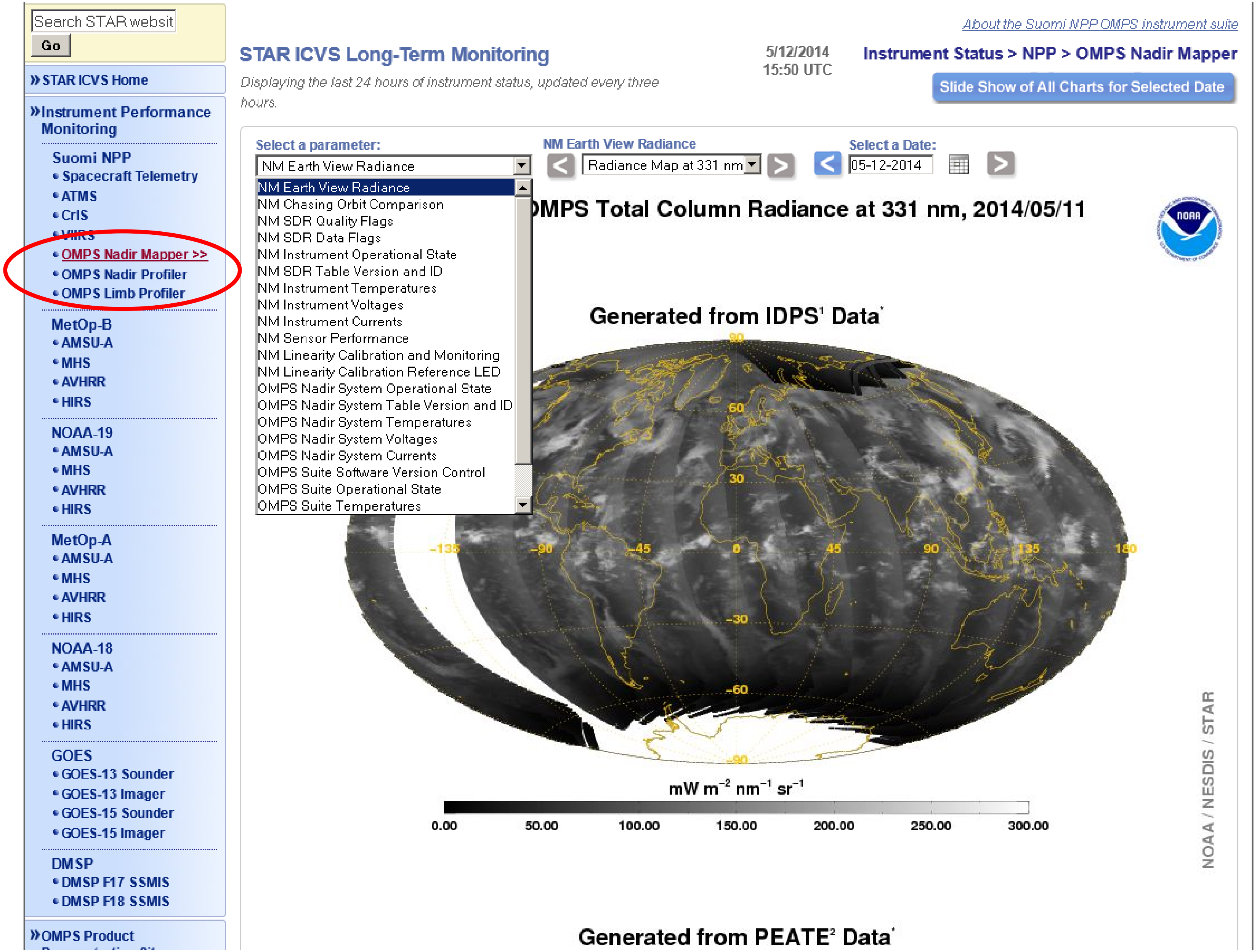


NPP CrIS 670 cm^{-1} BT (K) Observ. – CRTM Calc., 05/04/2014

Created at 05/06/2014 – 02:30:08 UTC



S-NPP OMPS LTM Parameters



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- DMSP F18 SSMIS

» OMPS Product

About the Suomi NPP OMPS instrument suite

STAR ICVS Long-Term Monitoring

Displaying the last 24 hours of instrument status, updated every three hours.

5/12/2014
15:50 UTC

Instrument Status > NPP > OMPS Nadir Mapper

Slide Show of All Charts for Selected Date

Select a parameter: NM Earth View Radiance

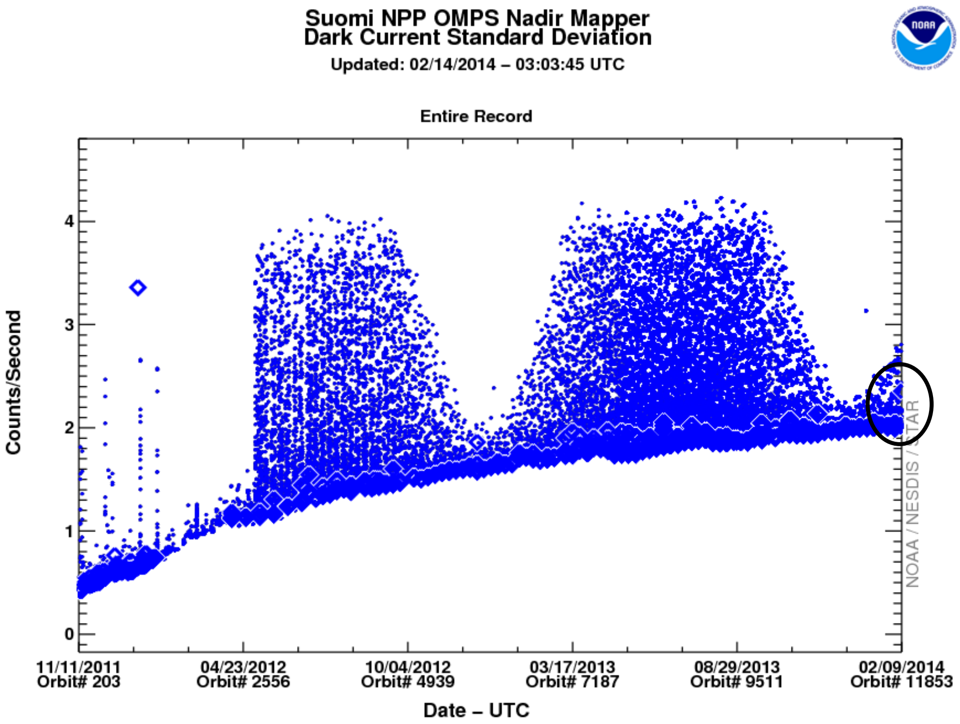
NM Earth View Radiance: Radiance Map at 331 nm

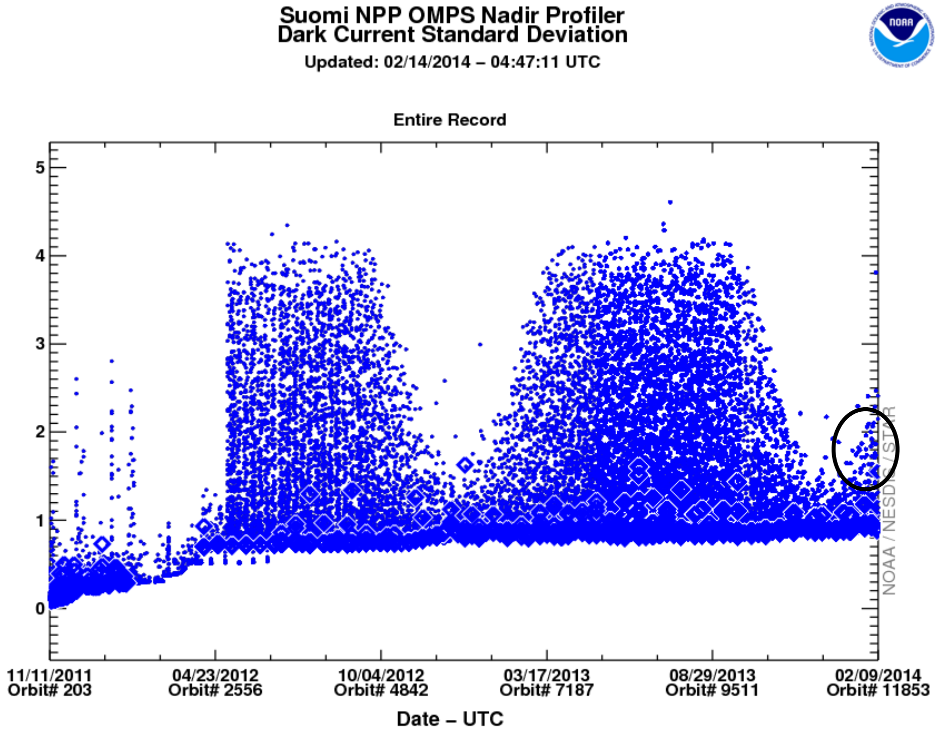
Select a Date: 05-12-2014

- NM Earth View Radiance
- NM Chasing Orbit Comparison
- NM SDR Quality Flags
- NM SDR Data Flags
- NM Instrument Operational State
- NM SDR Table Version and ID
- NM Instrument Temperatures
- NM Instrument Voltages
- NM Instrument Currents
- NM Sensor Performance
- NM Linearity Calibration and Monitoring
- NM Linearity Calibration Reference LED
- OMPS Nadir System Operational State
- OMPS Nadir System Table Version and ID
- OMPS Nadir System Temperatures
- OMPS Nadir System Voltages
- OMPS Nadir System Currents
- OMPS Suite Software Version Control
- OMPS Suite Operational State
- OMPS Suite Temperatures

S-NPP OMPS NM/NP Anomaly

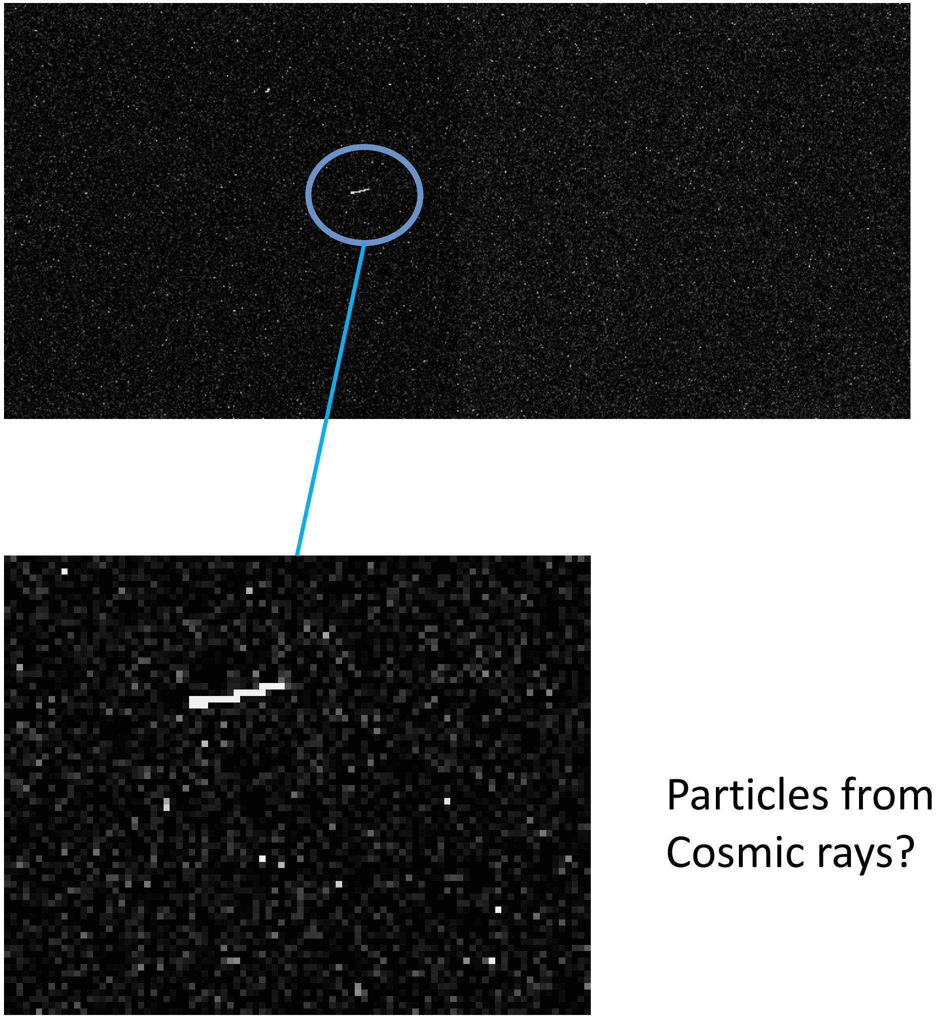
- The OMPS calibration monitoring system detected anomalies in the NM and NP standard deviation of dark current from dark calibration images acquired on Feb. 9, 2014



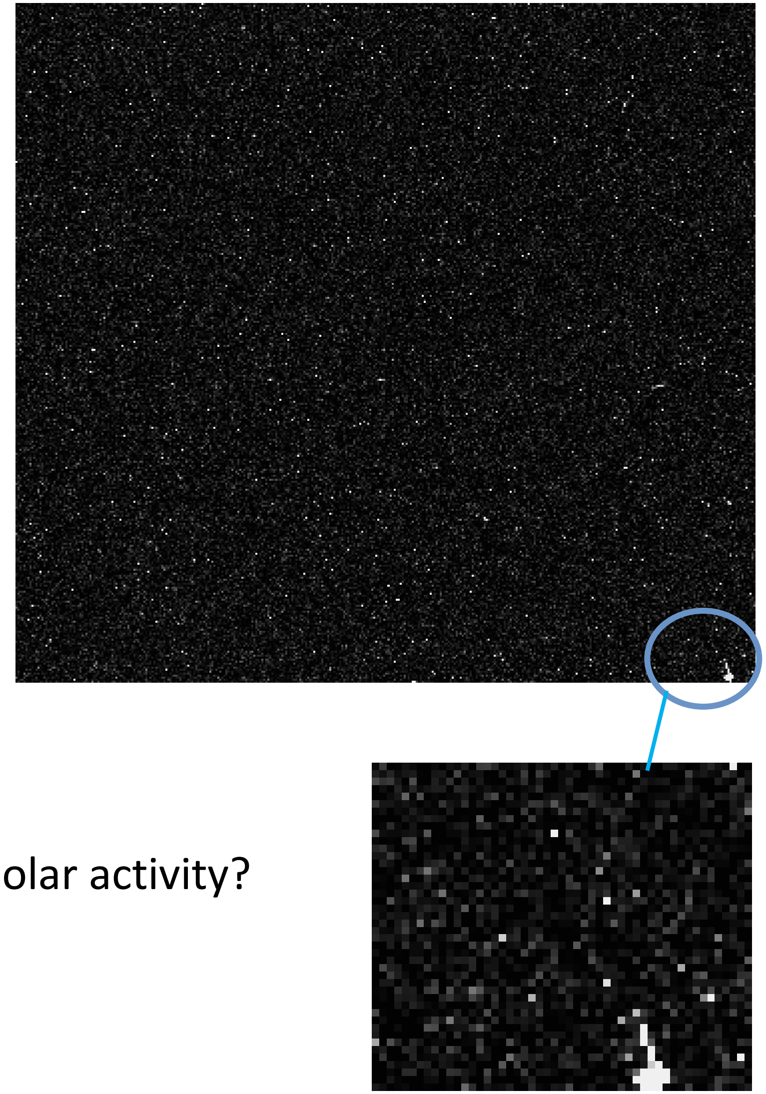


S-NPP OMPS NM/NP Anomaly

NM Anomalous Calibration Image



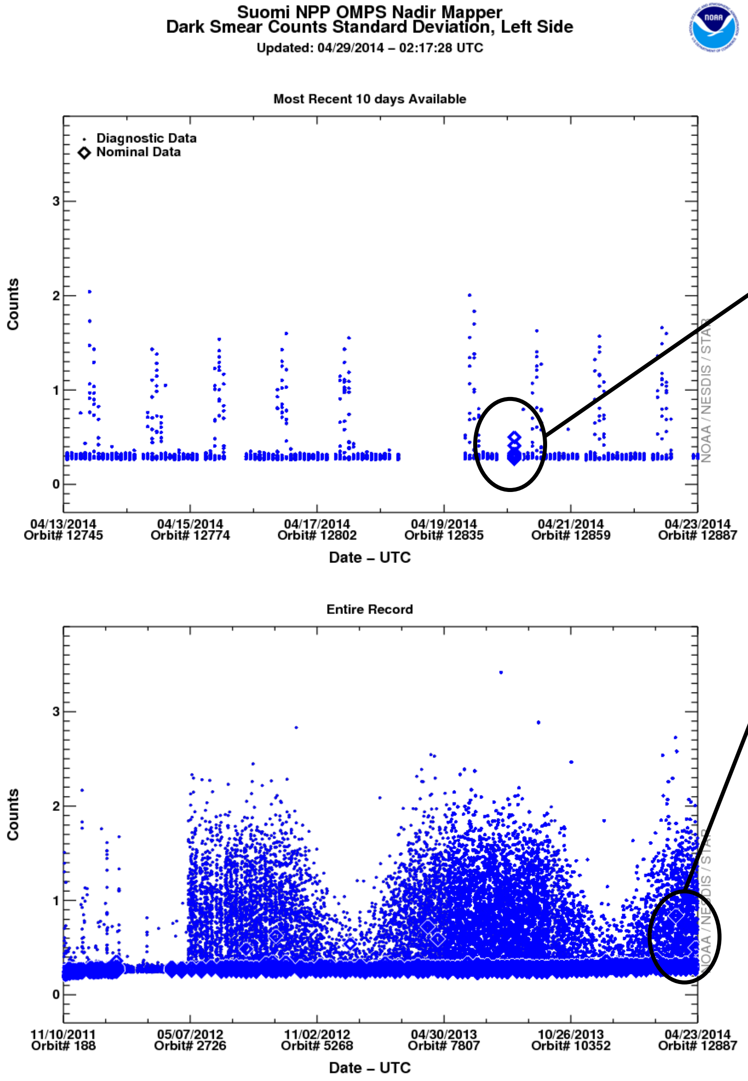
NP Anomalous Calibration Image



Particles from solar activity?
Cosmic rays?

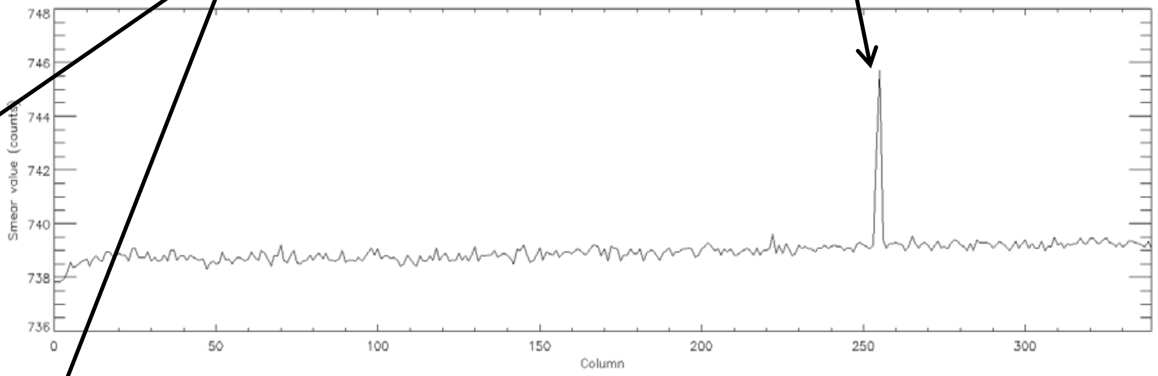
S-NPP OMPS NM Anomaly

NM Anomaly in PEATE Calibration SDR data on April 20th: “spike” for one column of CCD1 smear signal in calibration dark image



High standard deviation for the smears corresponding to the image with the transient

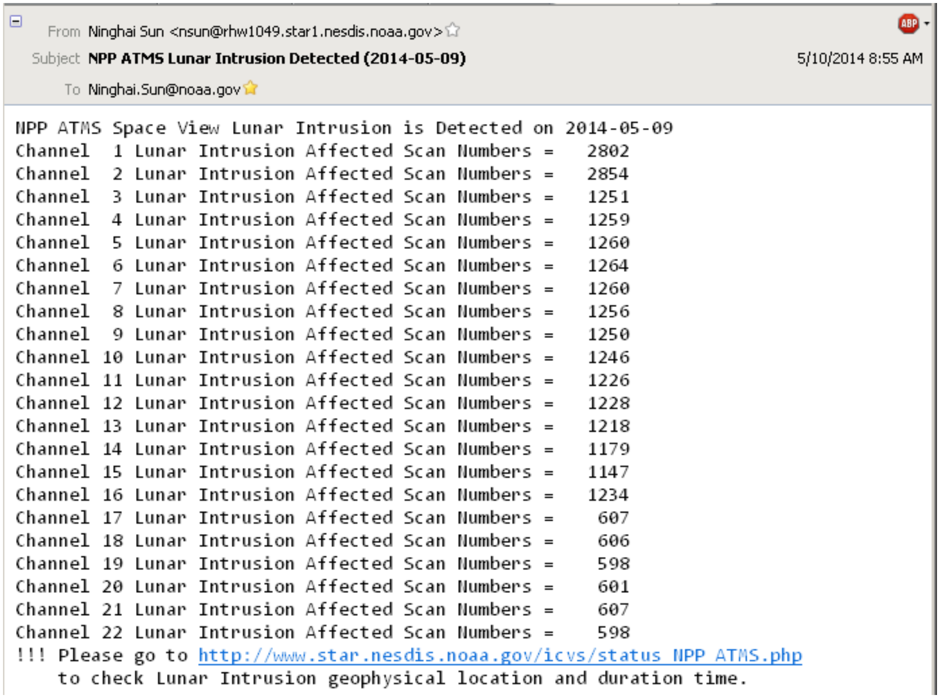
Transient found in two columns of 35th NM nominal dark image from April 20th



- Smear transients do affect Earthview (EV) data
- Effect is small
  - ✓ Caused 0.13% and 0.07% error in dark current rates, which amounts to 0.39 and 0.21 EV count (out of ~230,000).
- OMPS team is working to fix the necessary filters.

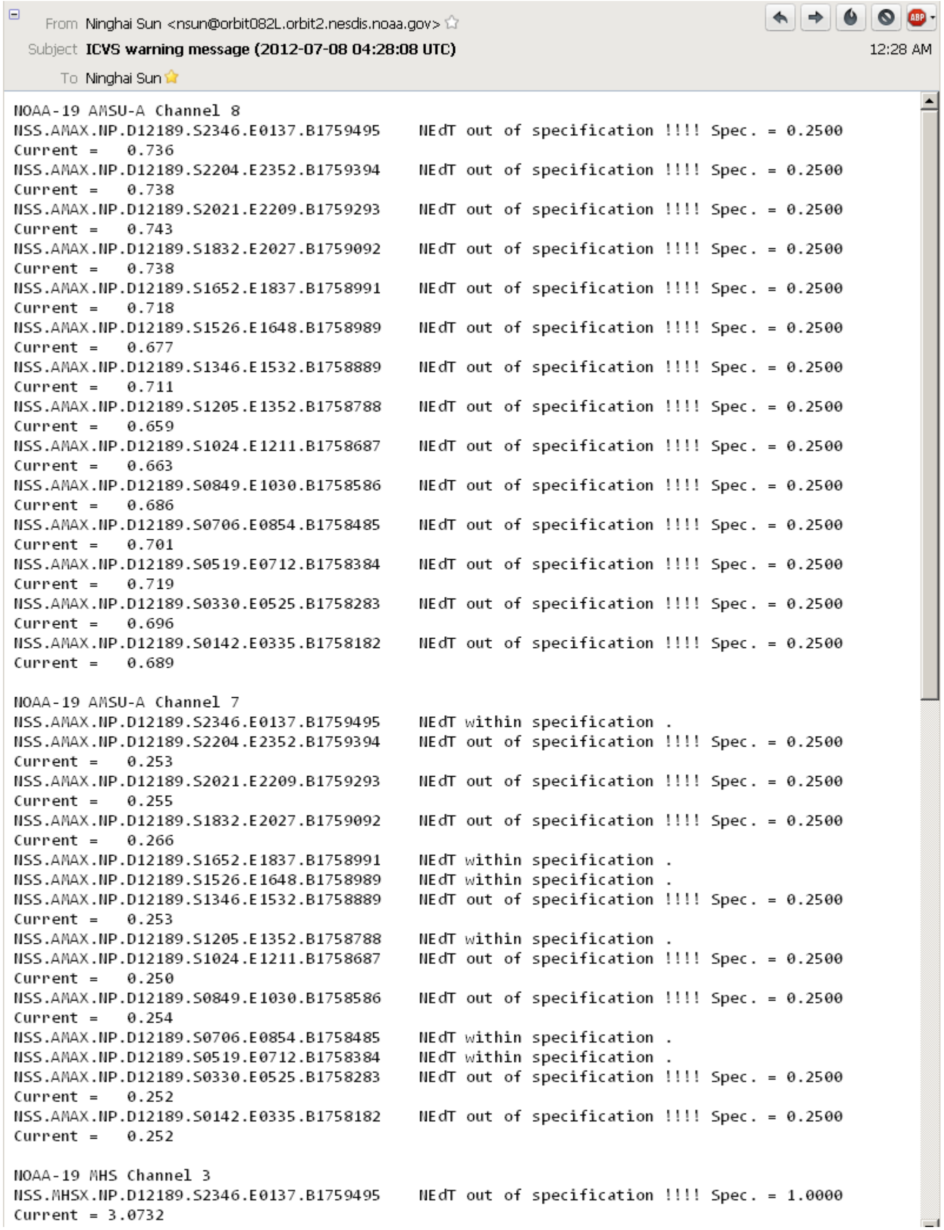
Instrument Anomaly Notification

- Notify through e-mails
- Provide instrument status
- Provide data availability
- Provide data quality



From Ninghai Sun <nsun@rhw1049.star1.nesdis.noaa.gov>
Subject **NPP ATMS Lunar Intrusion Detected (2014-05-09)** 5/10/2014 8:55 AM
To Ninghai.Sun@noaa.gov

```
NPP ATMS Space View Lunar Intrusion is Detected on 2014-05-09
Channel  1 Lunar Intrusion Affected Scan Numbers =   2802
Channel  2 Lunar Intrusion Affected Scan Numbers =   2854
Channel  3 Lunar Intrusion Affected Scan Numbers =   1251
Channel  4 Lunar Intrusion Affected Scan Numbers =   1259
Channel  5 Lunar Intrusion Affected Scan Numbers =   1260
Channel  6 Lunar Intrusion Affected Scan Numbers =   1264
Channel  7 Lunar Intrusion Affected Scan Numbers =   1260
Channel  8 Lunar Intrusion Affected Scan Numbers =   1256
Channel  9 Lunar Intrusion Affected Scan Numbers =   1250
Channel 10 Lunar Intrusion Affected Scan Numbers =   1246
Channel 11 Lunar Intrusion Affected Scan Numbers =   1226
Channel 12 Lunar Intrusion Affected Scan Numbers =   1228
Channel 13 Lunar Intrusion Affected Scan Numbers =   1218
Channel 14 Lunar Intrusion Affected Scan Numbers =   1179
Channel 15 Lunar Intrusion Affected Scan Numbers =   1147
Channel 16 Lunar Intrusion Affected Scan Numbers =   1234
Channel 17 Lunar Intrusion Affected Scan Numbers =    607
Channel 18 Lunar Intrusion Affected Scan Numbers =    606
Channel 19 Lunar Intrusion Affected Scan Numbers =    598
Channel 20 Lunar Intrusion Affected Scan Numbers =    601
Channel 21 Lunar Intrusion Affected Scan Numbers =    607
Channel 22 Lunar Intrusion Affected Scan Numbers =    598
!!! Please go to http://www.star.nesdis.noaa.gov/icvs/status_NPP_ATMS.php
    to check Lunar Intrusion geophysical location and duration time.
```



From Ninghai Sun <nsun@orbit082L.orbit2.nesdis.noaa.gov>
Subject **ICVS warning message (2012-07-08 04:28:08 UTC)** 12:28 AM
To Ninghai Sun

```
NOAA-19 AMSU-A Channel 8
NSS.AMAX.NP.D12189.S2346.E0137.B1759495    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.736
NSS.AMAX.NP.D12189.S2204.E2352.B1759394    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.738
NSS.AMAX.NP.D12189.S2021.E2209.B1759293    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.743
NSS.AMAX.NP.D12189.S1832.E2027.B1759092    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.738
NSS.AMAX.NP.D12189.S1652.E1837.B1758991    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.718
NSS.AMAX.NP.D12189.S1526.E1648.B1758989    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.677
NSS.AMAX.NP.D12189.S1346.E1532.B1758889    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.711
NSS.AMAX.NP.D12189.S1205.E1352.B1758788    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.659
NSS.AMAX.NP.D12189.S1024.E1211.B1758687    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.663
NSS.AMAX.NP.D12189.S0849.E1030.B1758586    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.686
NSS.AMAX.NP.D12189.S0706.E0854.B1758485    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.701
NSS.AMAX.NP.D12189.S0519.E0712.B1758384    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.719
NSS.AMAX.NP.D12189.S0330.E0525.B1758283    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.696
NSS.AMAX.NP.D12189.S0142.E0335.B1758182    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.689

NOAA-19 AMSU-A Channel 7
NSS.AMAX.NP.D12189.S2346.E0137.B1759495    NEdT within specification .
NSS.AMAX.NP.D12189.S2204.E2352.B1759394    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.253
NSS.AMAX.NP.D12189.S2021.E2209.B1759293    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.255
NSS.AMAX.NP.D12189.S1832.E2027.B1759092    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.266
NSS.AMAX.NP.D12189.S1652.E1837.B1758991    NEdT within specification .
NSS.AMAX.NP.D12189.S1526.E1648.B1758989    NEdT within specification .
NSS.AMAX.NP.D12189.S1346.E1532.B1758889    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.253
NSS.AMAX.NP.D12189.S1205.E1352.B1758788    NEdT within specification .
NSS.AMAX.NP.D12189.S1024.E1211.B1758687    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.250
NSS.AMAX.NP.D12189.S0849.E1030.B1758586    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.254
NSS.AMAX.NP.D12189.S0706.E0854.B1758485    NEdT within specification .
NSS.AMAX.NP.D12189.S0519.E0712.B1758384    NEdT within specification .
NSS.AMAX.NP.D12189.S0330.E0525.B1758283    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.252
NSS.AMAX.NP.D12189.S0142.E0335.B1758182    NEdT out of specification !!!! Spec. = 0.2500
Current =   0.252

NOAA-19 MHS Channel 3
NSS.MHSX.NP.D12189.S2346.E0137.B1759495    NEdT out of specification !!!! Spec. = 1.0000
Current = 3.0732
```

Path Forward

- Support SDR teams to maintain high quality satellite data products for S-NPP
  - Improve anomaly notification function
  - Provide flexible customized datasets for analysis
  - Improve ICVS-LTM system execution efficiency
  - Provide support for more sensors and more parameters
  - Improve sensor absolute bias monitoring module
  - Improve function of current ICVS-LTM website

- Extend current ICVS-LTM to support future NOAA and collaborative satellite programs
  - JPSS
  - GOES-R
  - GCOM