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)

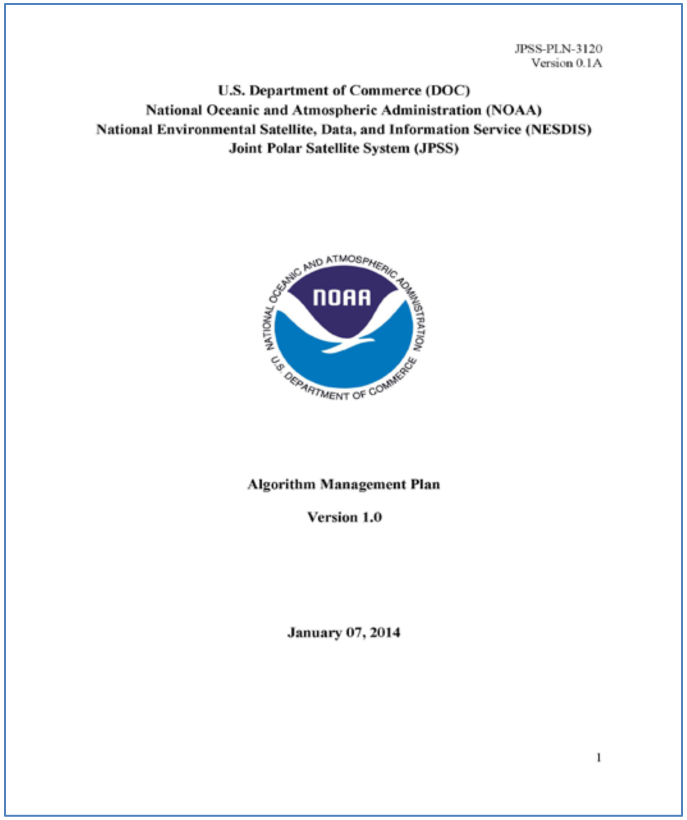
With Contributions from JPSS SDR Team Leads and

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.



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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

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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

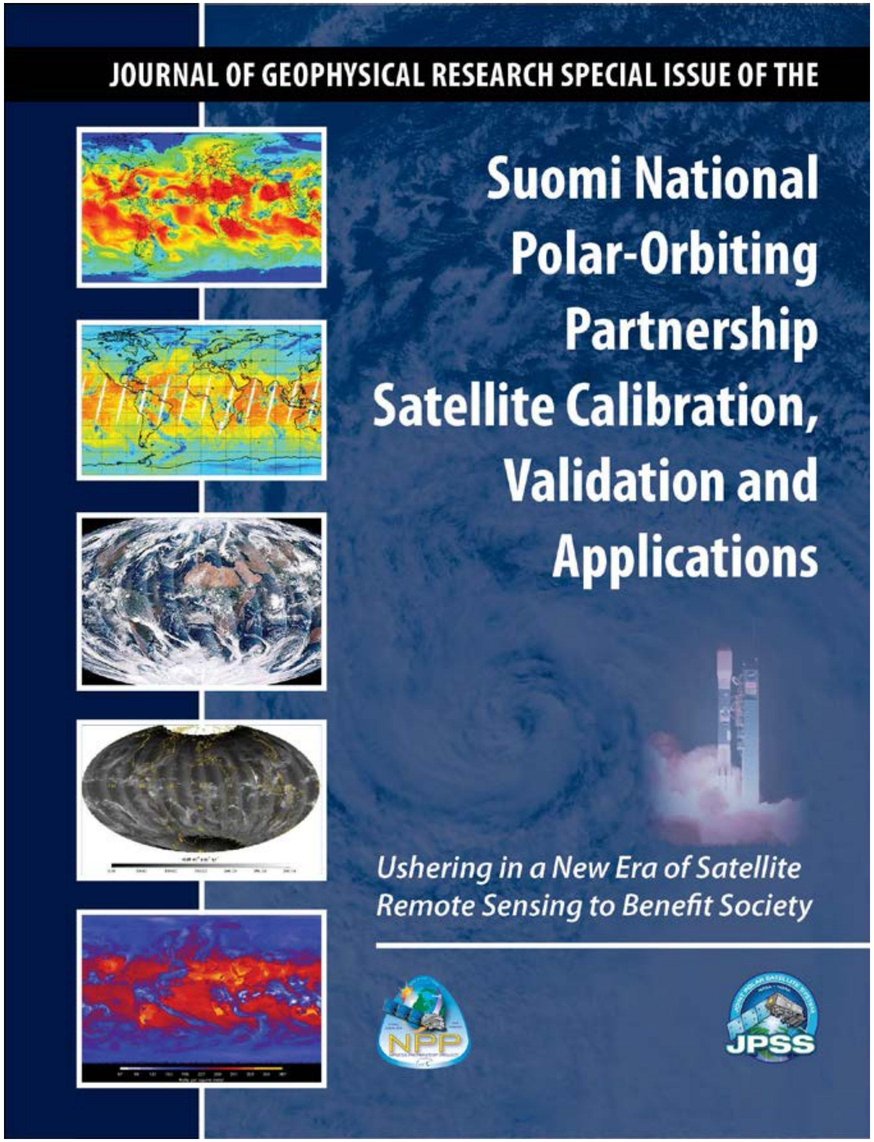
Validated

- 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

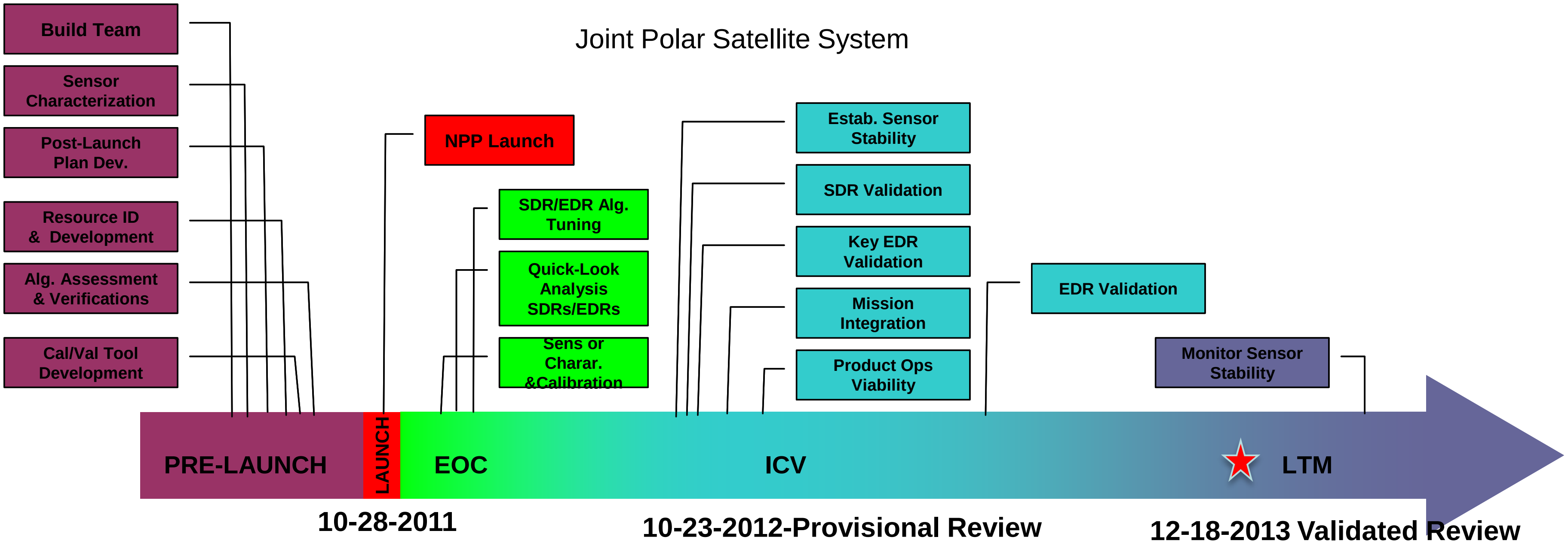
34 papers have been accepted in AGU Journal Geophysical Research Special Issue on Suomi NPP satellite calibration, validation and applications.

Guest Editor: Fuzhong Weng



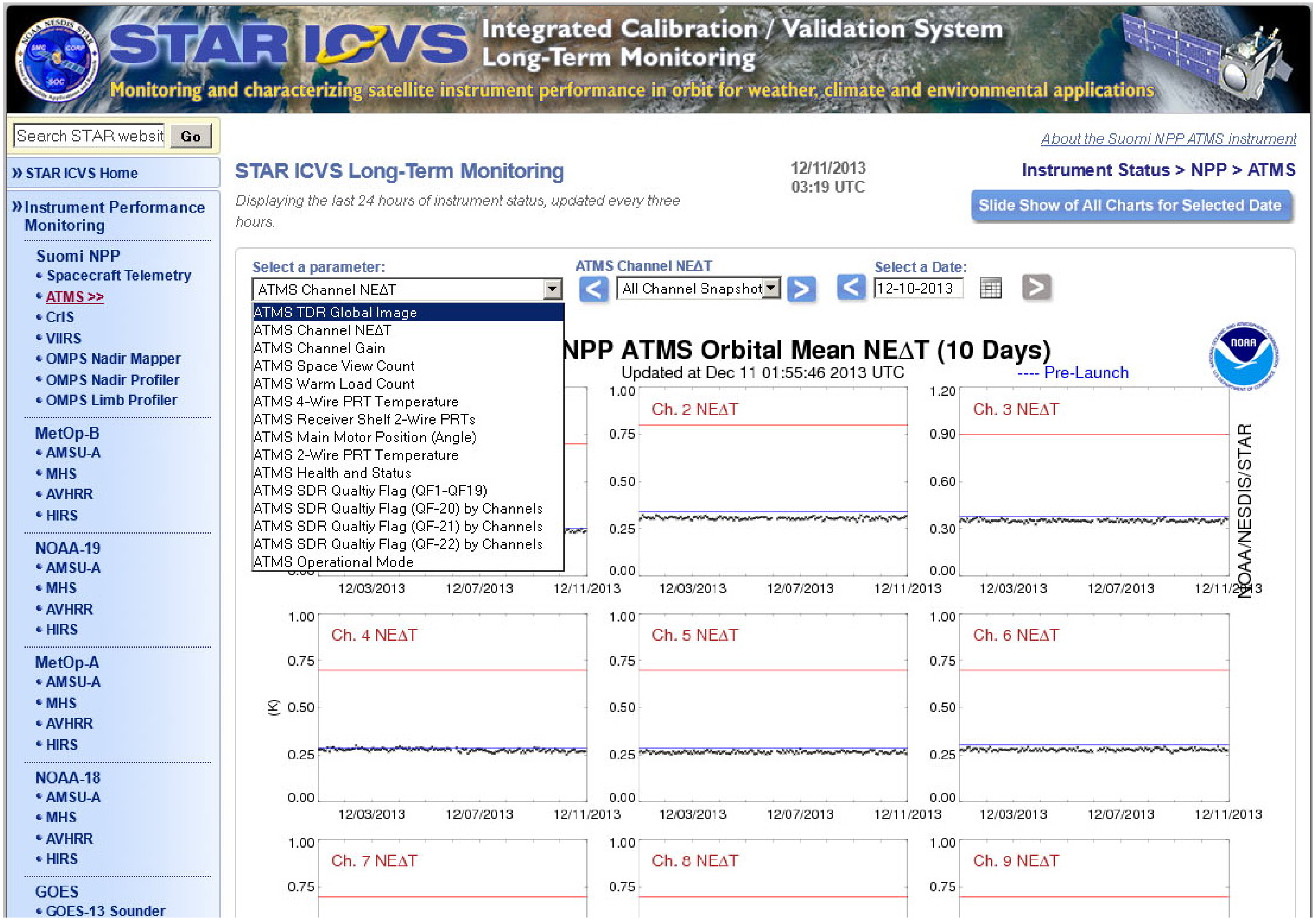
Suomi NPP Calibration/Validation Schedule

- 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



STAR ICVS-LTM for SNPP/JPSS

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



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
May 12-16, 2014
5830 University Research Court, College Park, MD 20740

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

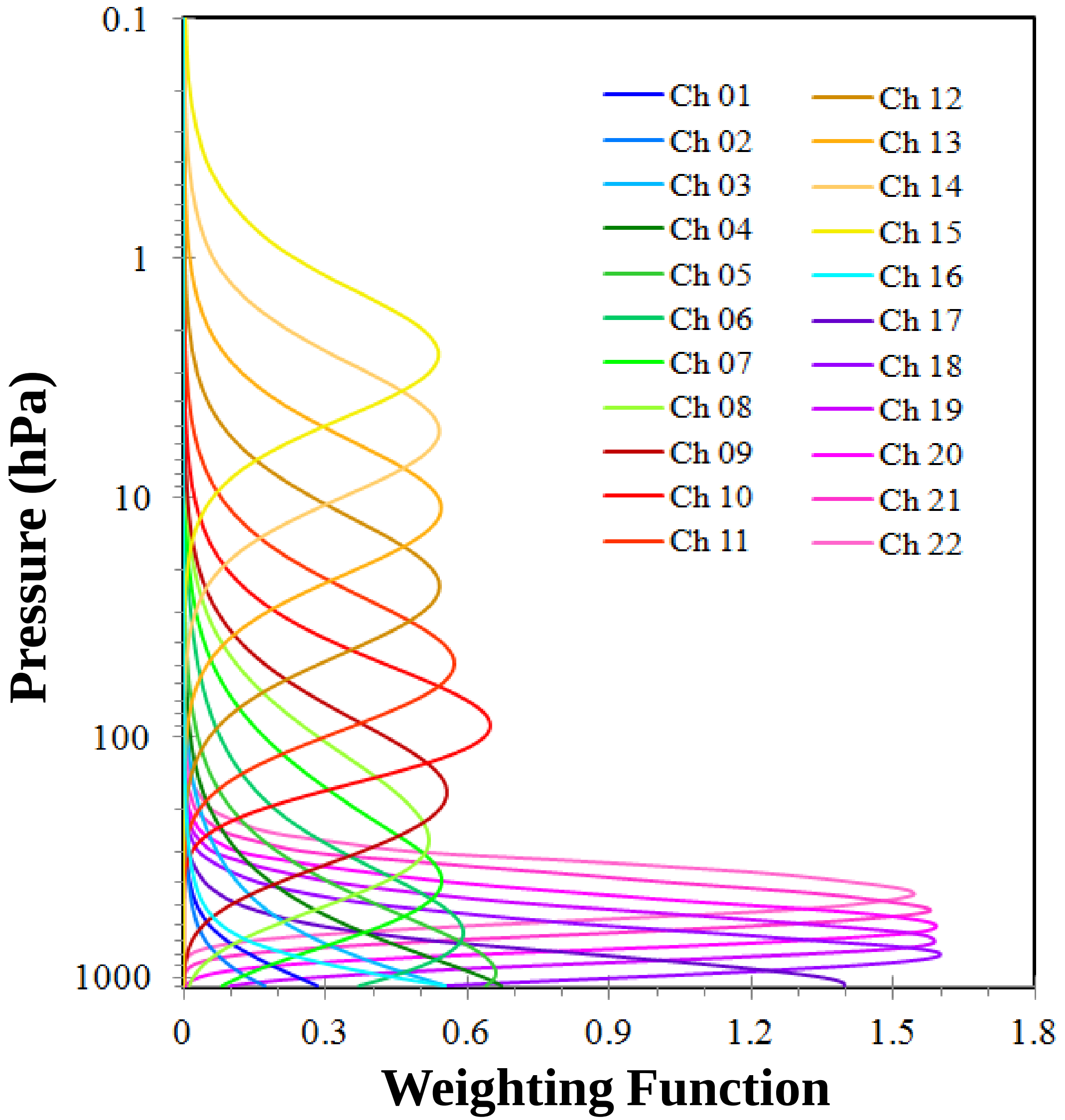
Ground Segment - EDR
Ivan Csiszar , Ingrid Guch, Paul Digacomo– STAR EDR Lead
Ray Godin– DPA EDR Lead

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

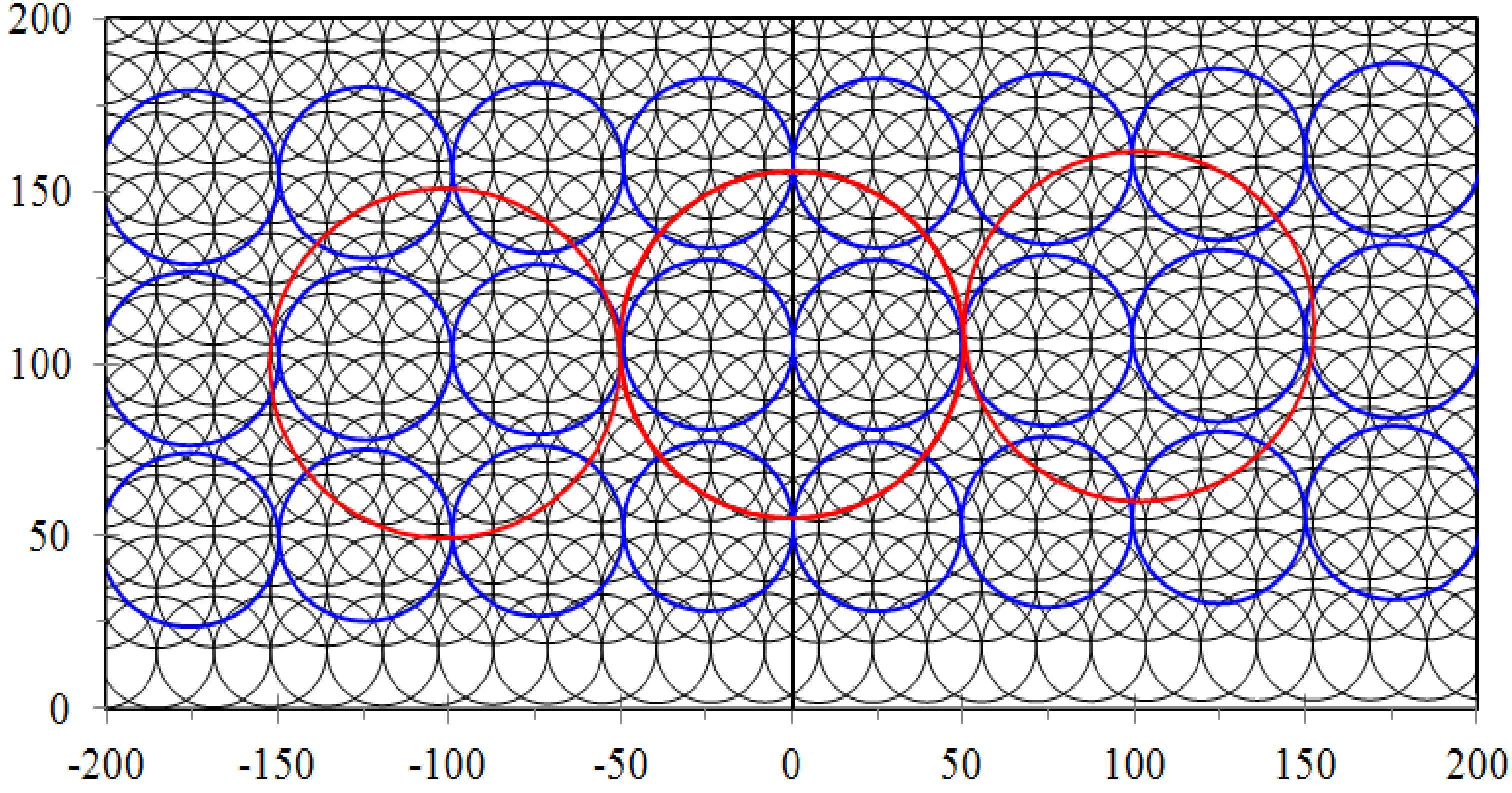
ATMS Channel Weighting Functions



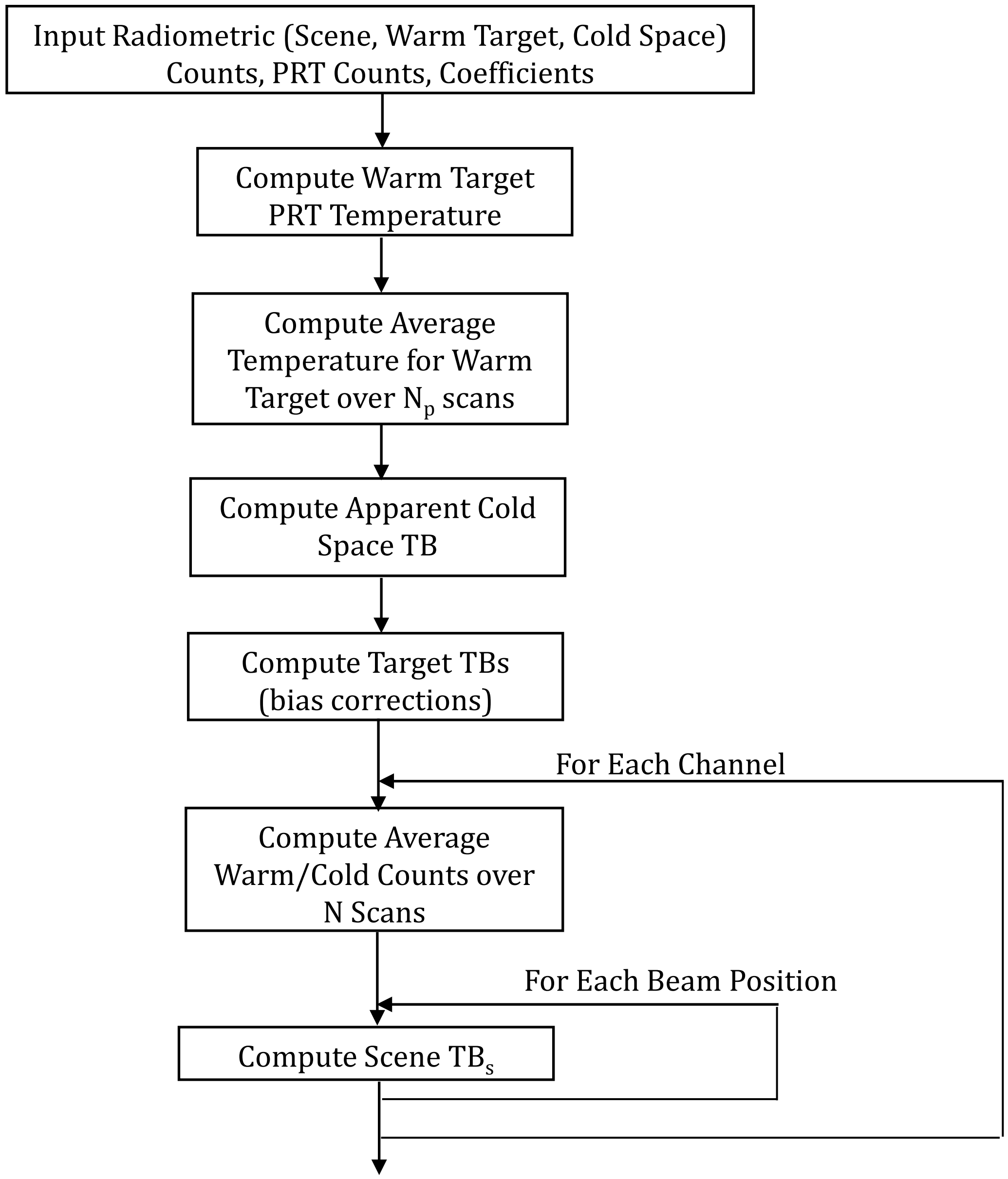
Three Generations of Microwave Sounding Instruments from MSU to AMSU/MHS to ATMS

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

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



ATMS Radiometric Calibration Flow Chart



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

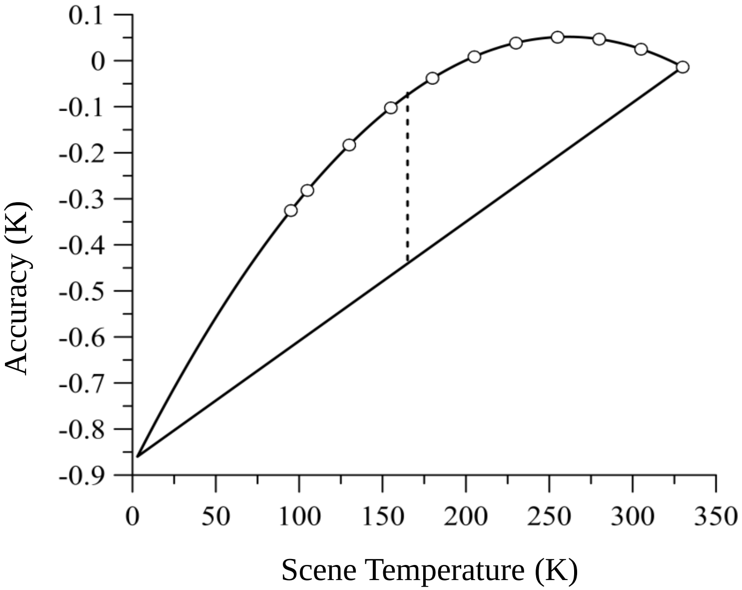
$$T_{b,ch} = T^{w}_{b,ch} + \frac{C^{s}_{ch} - \overline{C^{w}_{ch}}}{\overline{C^{w}_{ch}} - \overline{C^{c}_{ch}}}\left(T^{w}_{b,ch} - T^{c}_{b,ch}\right) + 4T_{NL}\,x(1-x)$$

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

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

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

$$x = \frac{T_{b,l} - T_{c}}{T_{w} - T_{c}}$$

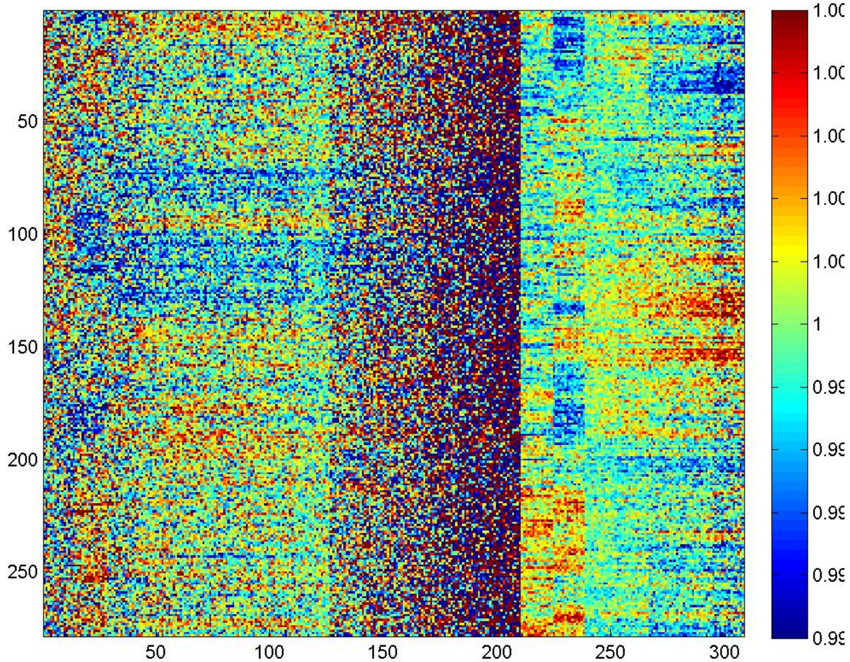


Nonlinearity of ATMS channel 1, calculated for cold plate (CP) at 5°C for redundancy configuration 1 (RC1). Blue dots represent the measured scene temperatures. Black solid curve represents the regression curve. Dashed line represents the peak nonlinearity.

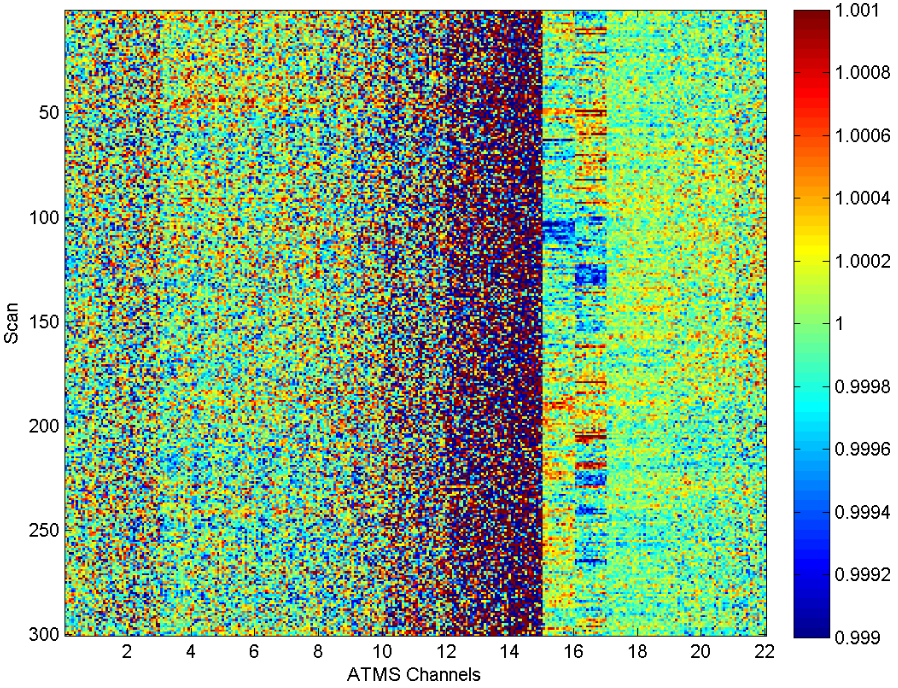
A dramatic difference from AMSU calibration is the treatment of nonlinearity term which is derived from the medium theorem and x is a parameter derived from the linear term.

Analysis of ATMS TVAC Test Data

SNPP TVAC Data (RC1 230K)

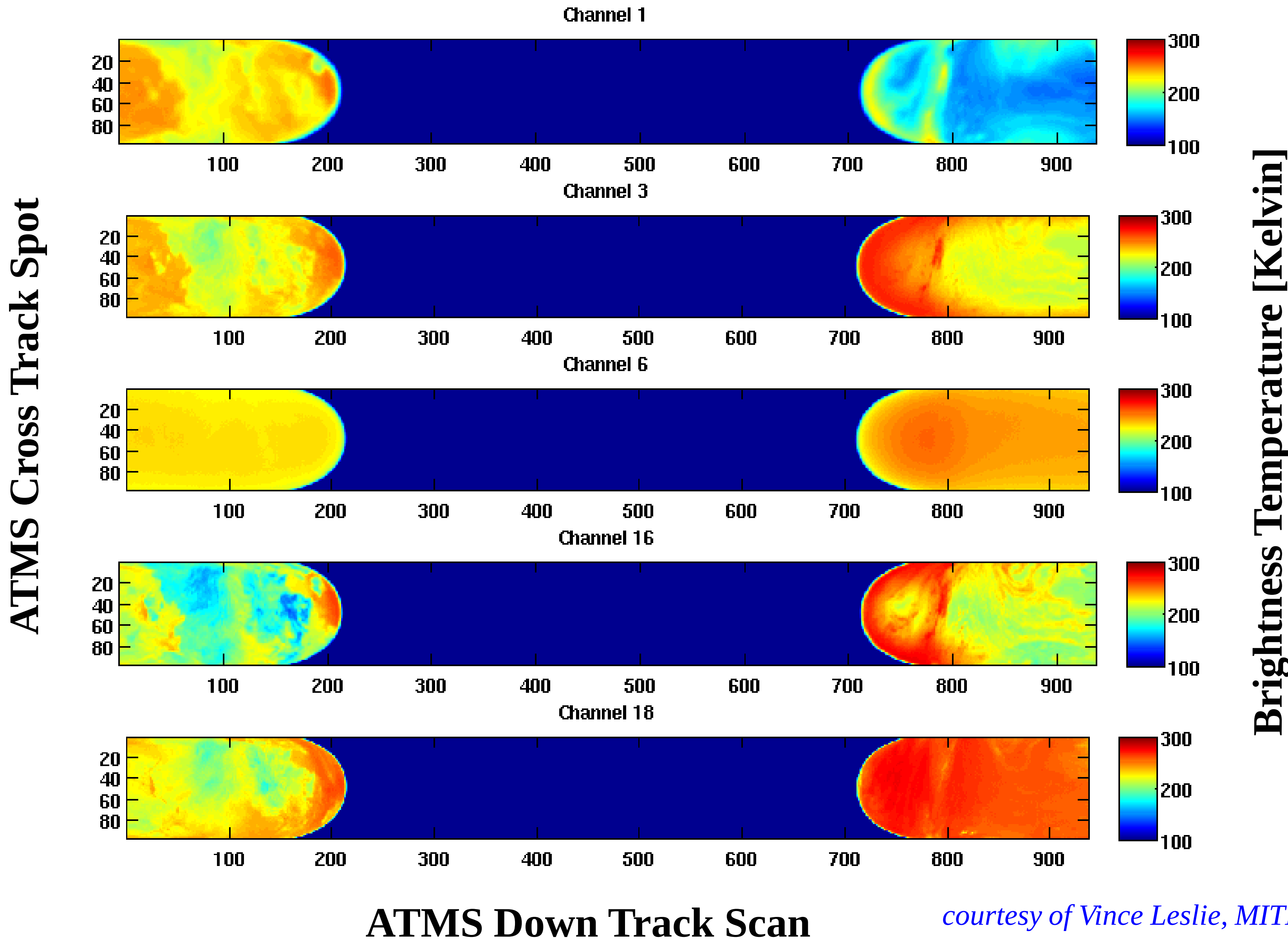


J-1 TVAC Data (RC4, 3/12/14)



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

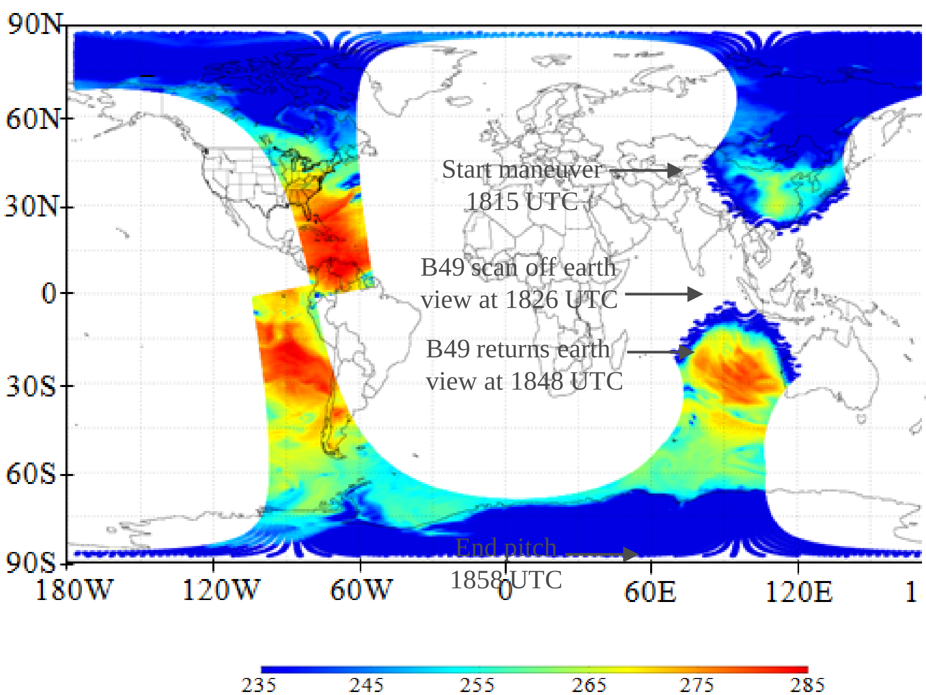


courtesy of Vince Leslie, MITLL

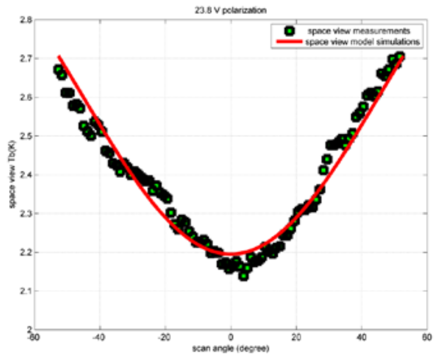
SNPP Pitch-Over Maneuver for ATMS Calibration

- 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

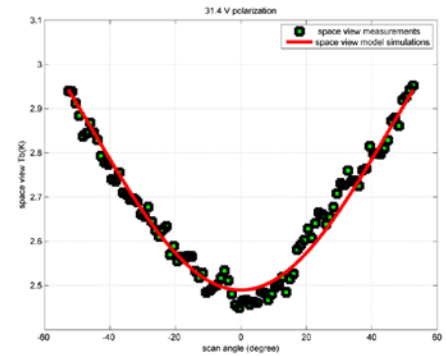
ATMS TDR at Ch18 on February 20, 2012



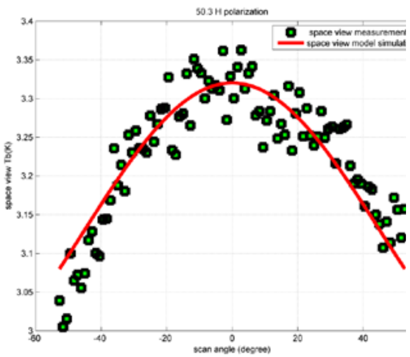
Channel 1



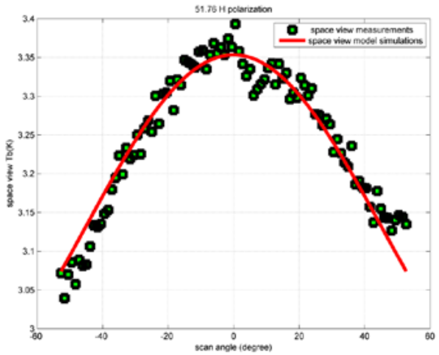
Channel 2



Channel 3



Channel 4



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

For Quasi-V (TDR) :

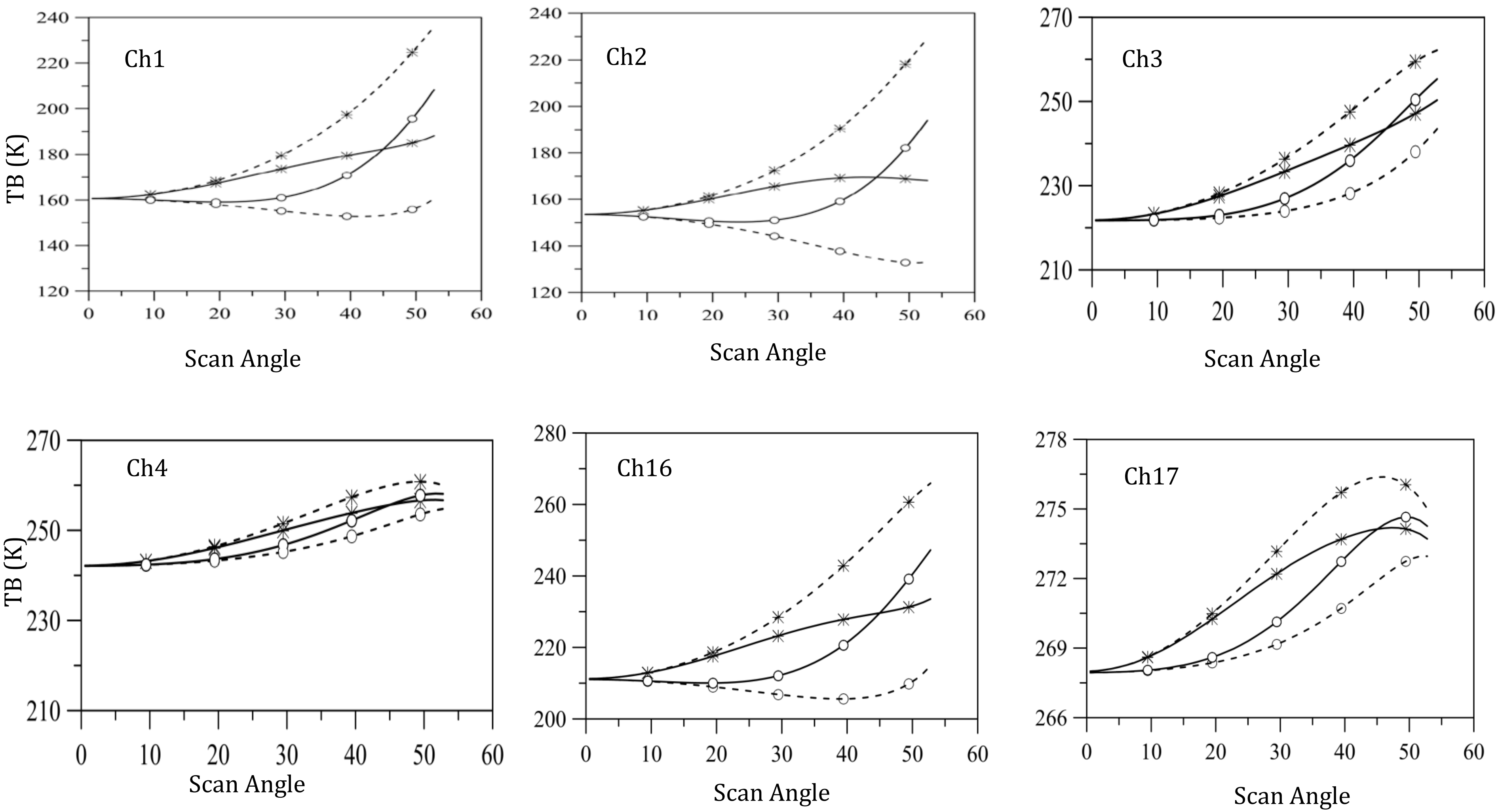
$$T_a^{Qv} = \eta_{me}^{vv} T_b^{Qv} + \eta_{me}^{hv} T_b^{Qh} + \eta_{se}^{vv} T_{b,se}^{Qv} + \eta_{se}^{hv} T_{b,se}^{Qh} + (\eta_{sc}^{vv} + \eta_{sc}^{hv}) T_{c,RJ} + S_a^{Qv}$$

For Quasi-H (TDR)

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

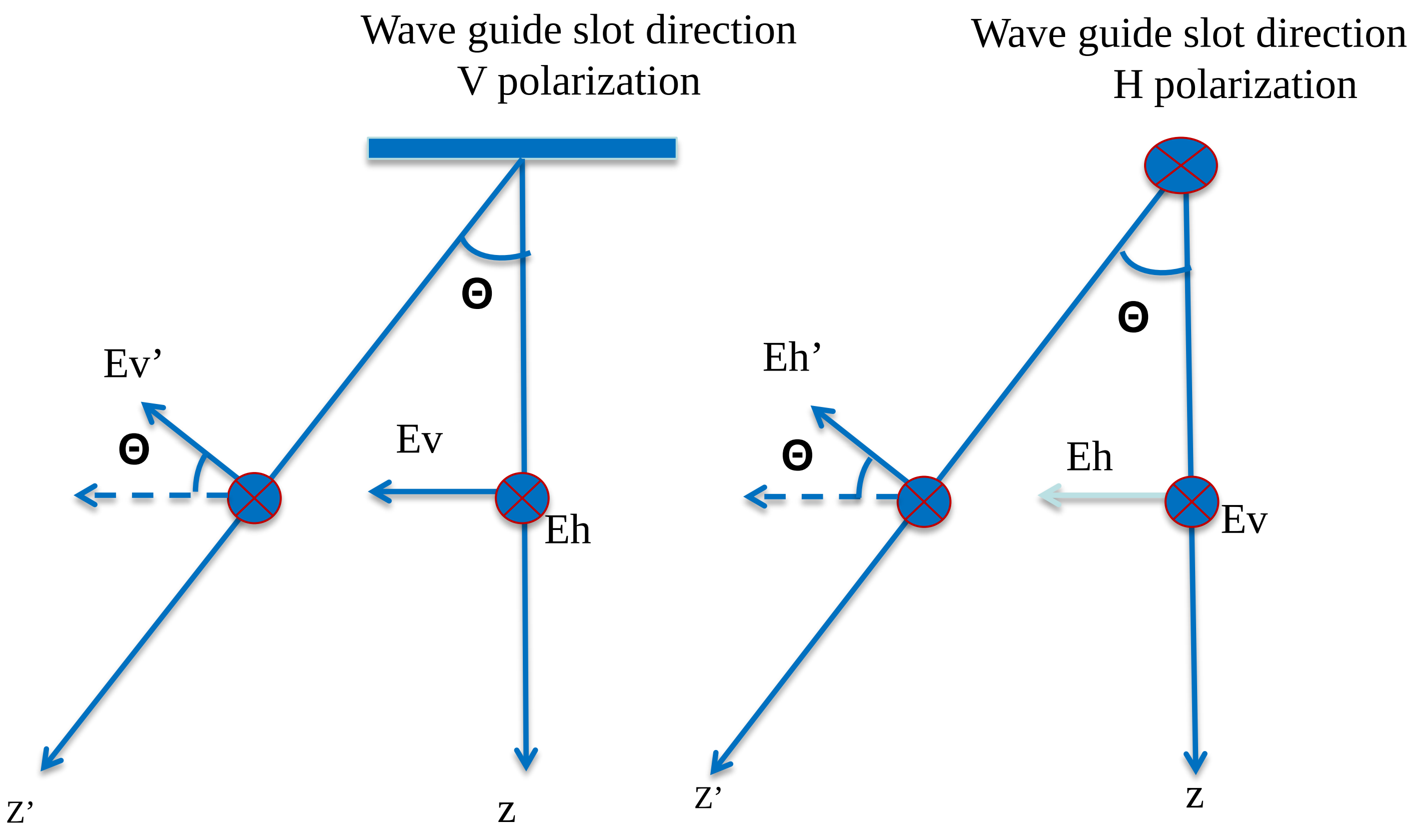
__Weng, F__., X. Zou, M. Tian, W.J. Blackwell, N. Sun, H. Yang, X. Wang, L. Lin, and K. Anderson, 2013, Calibration of Suomi National Polar-Orbiting Partnership (NPP) Advanced Technology Microwave Sounder (ATMS), J. Geophys. Res, __118__, 1–14, doi:10.1002/jgrd.50840 ,

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



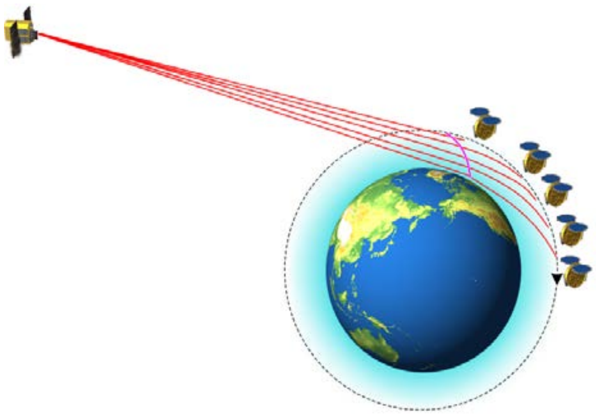
Eh vector is defined as the electronic vector perpendicular to wave propagation plane

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

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

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

ATMS Calibration Accuracy Assessment Using COSMIC Data



- **Time period of data search:**

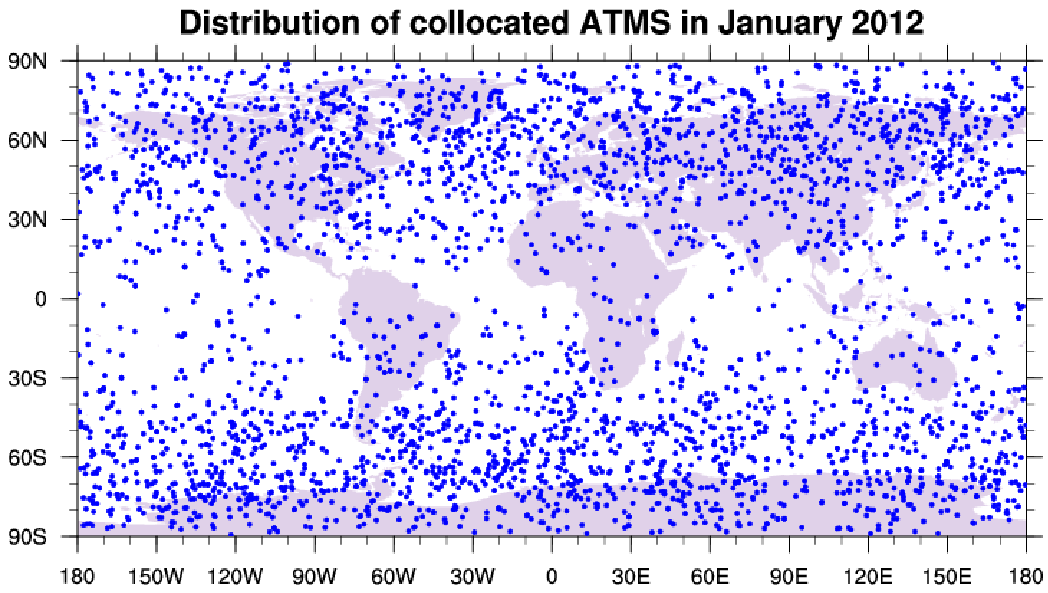
  January, 2012

- **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

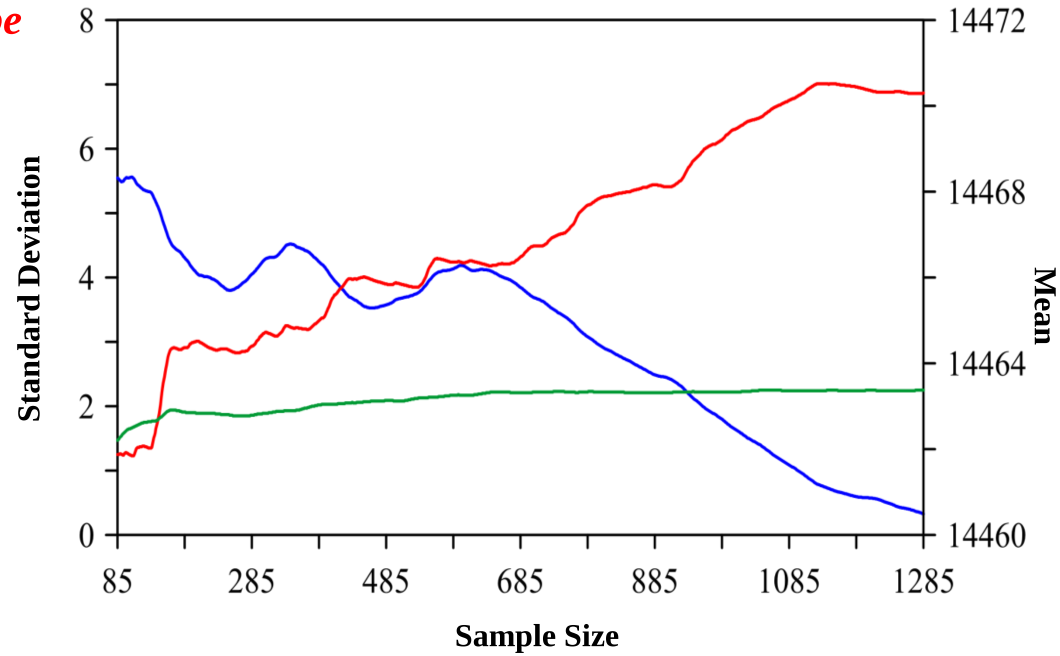
ATMS Noise Equivalent Temperature (NEDT)

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:

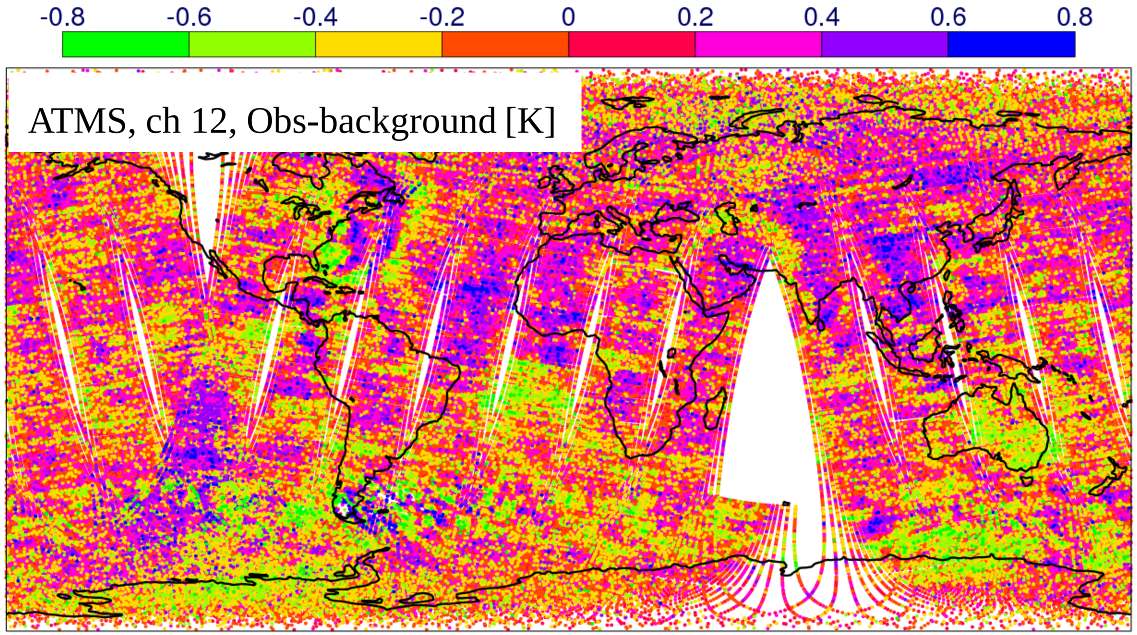
$$\sigma^{Allan}(m) = \sqrt{\frac{1}{2m^{2}(N-2m)} \sum_{j=1}^{N-2m} \left(\sum_{i=j}^{j+m-1} \left(C_{ch}^{w}(i+m) - C_{ch}^{w}(i) \right) \right)^{2}}$$

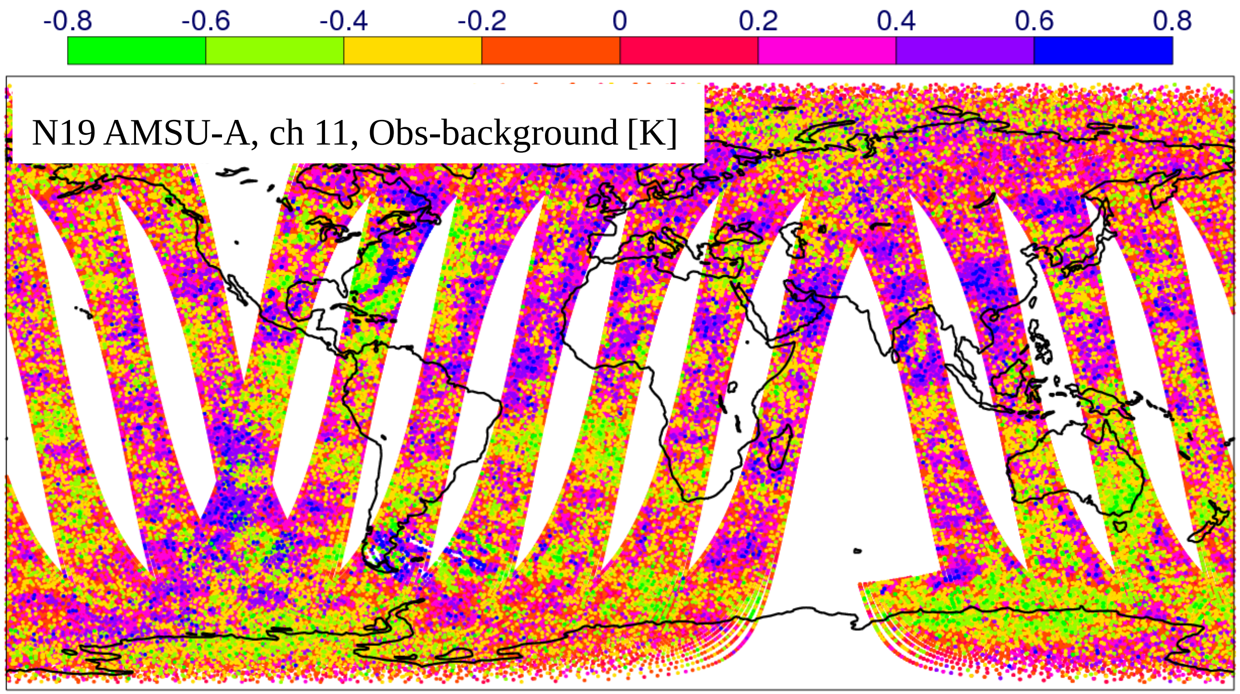


ATMS channel 1 warm count mean (blue, y-axis on the right), the standard deviation (red, y-axis on the left) and the overlapping Allan deviation (green, y-axis on the left) of the 17-scanline (m) average as a function of the total sample size (N).

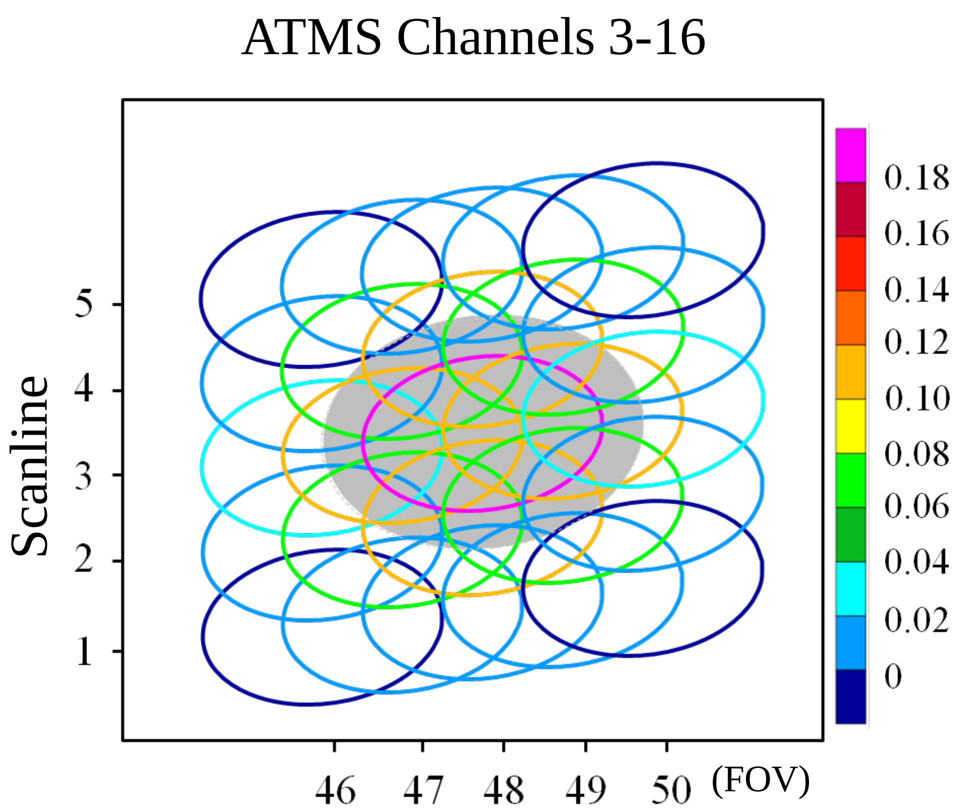
ATMS: Striping

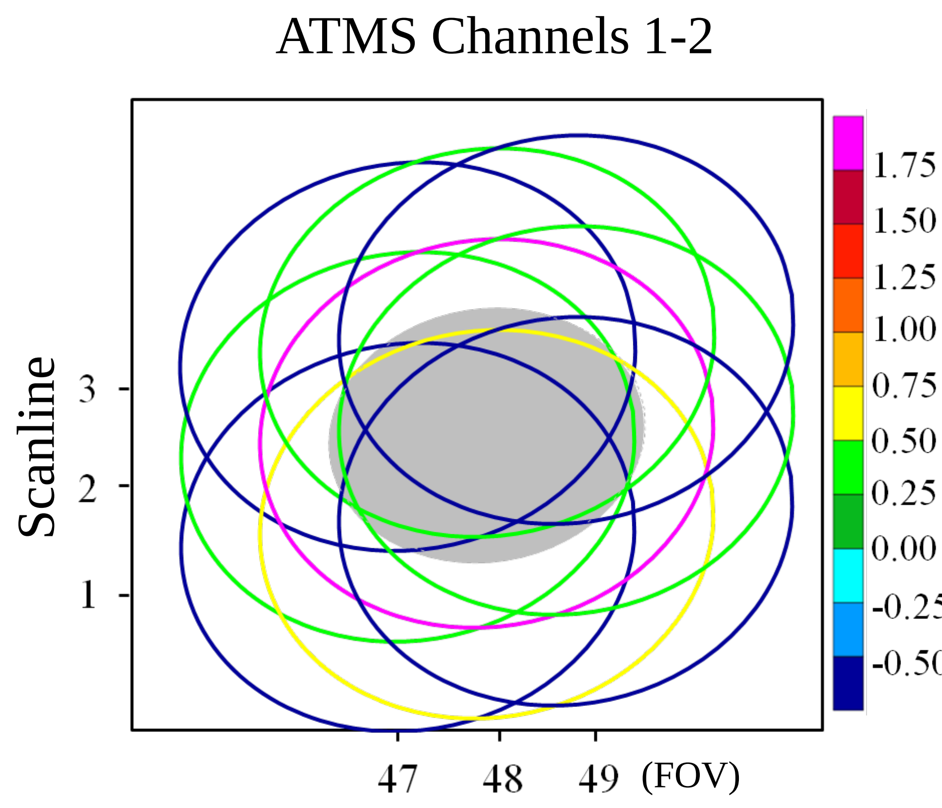
Weak cross-track striping effect, especially for stratospheric temperature-sounding channels.





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





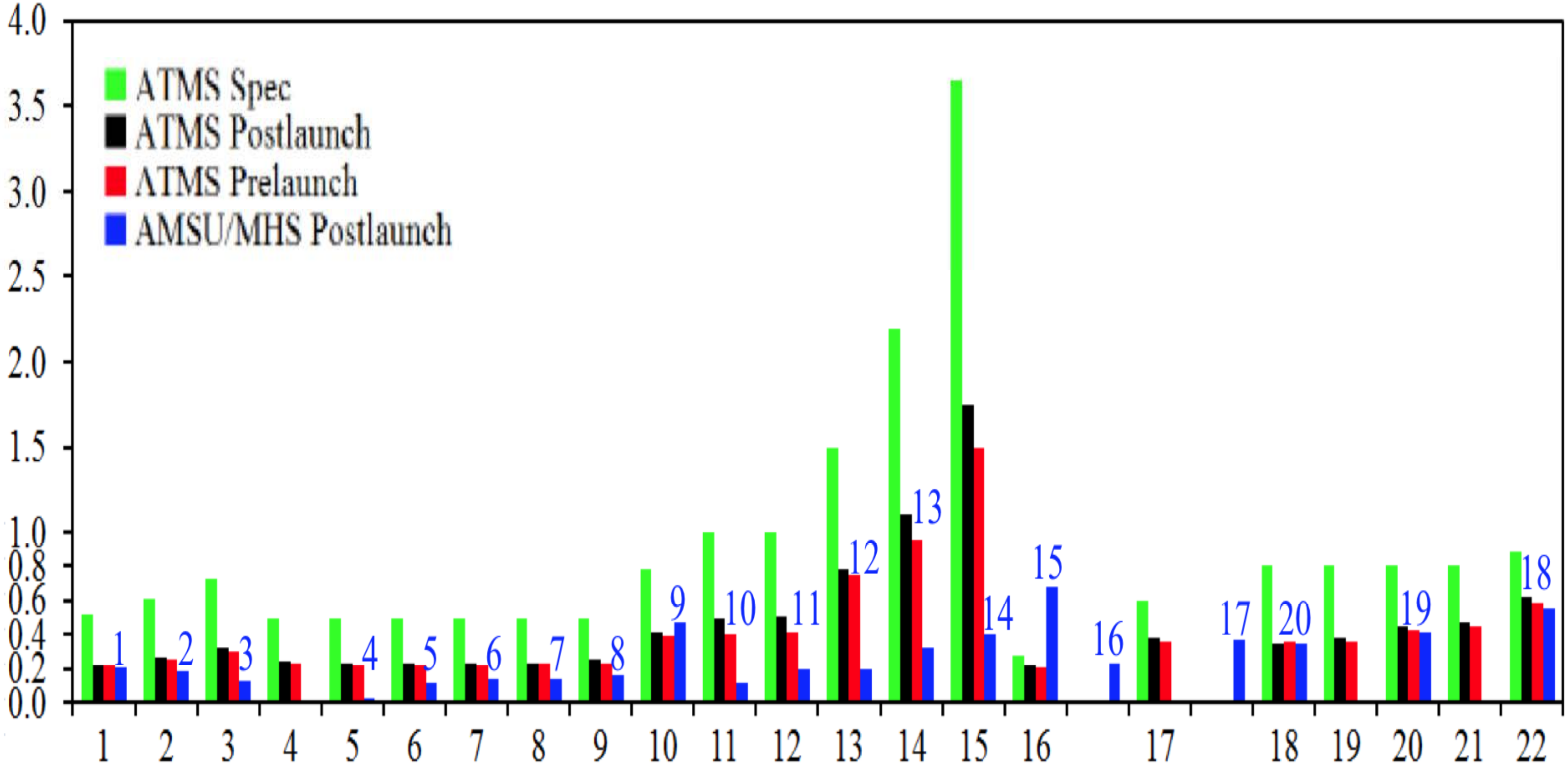
An effective AMSU-A target FOV: output of BG remap (shaded in gray)

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

Major Accomplishment Highlights

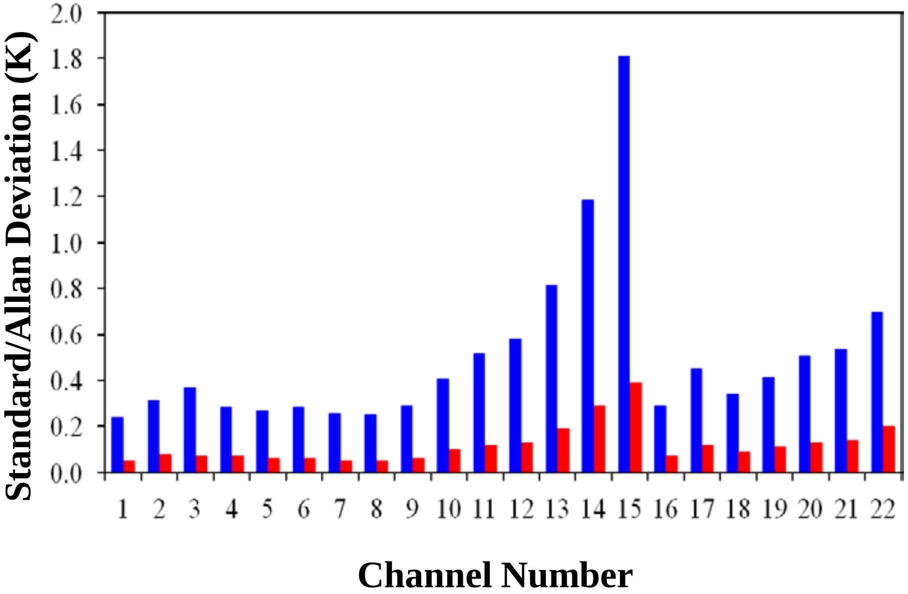
- ATMS TDR and SDR products have been declared a validated maturity level
- All the channels have noises much lower than specification
- ATMS processing coefficient table (PCT) were updated with nominal values
- Geolocation errors for all the channels are quantified and are smaller than specification
- 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

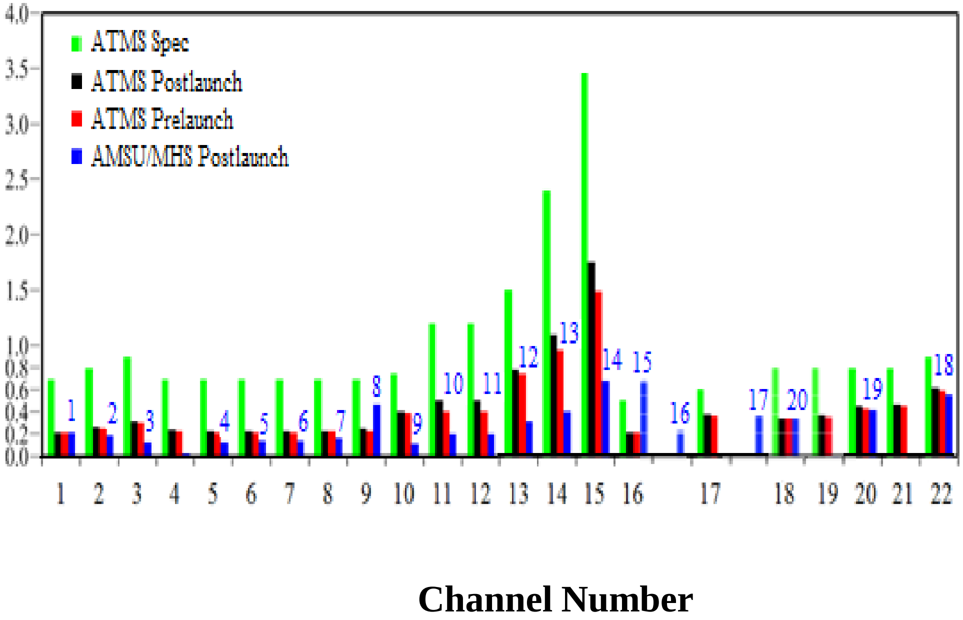
ATMS Channel Noise Characterization



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

ATMS Noise Equivalent Temperature (NEDT)

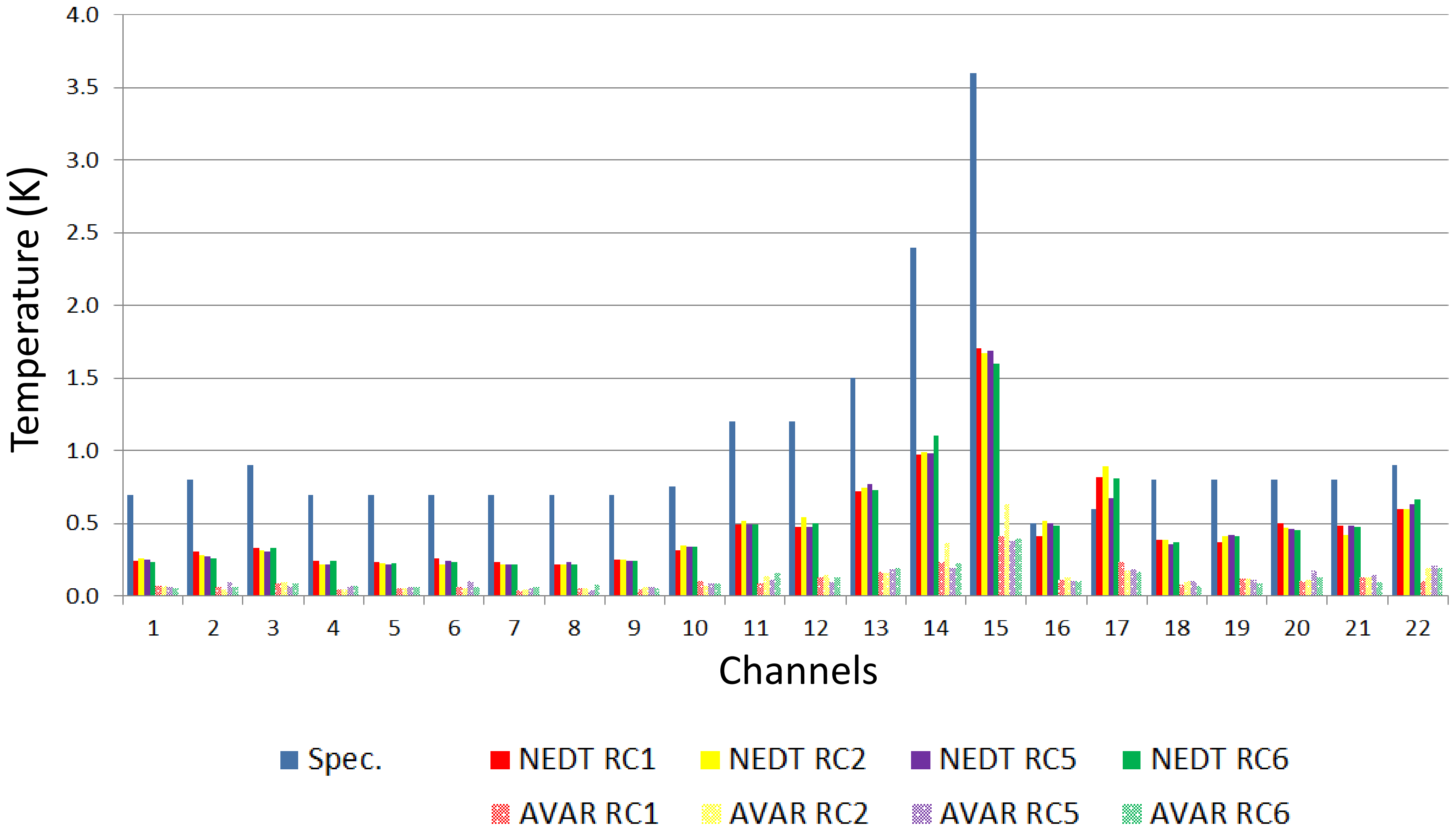




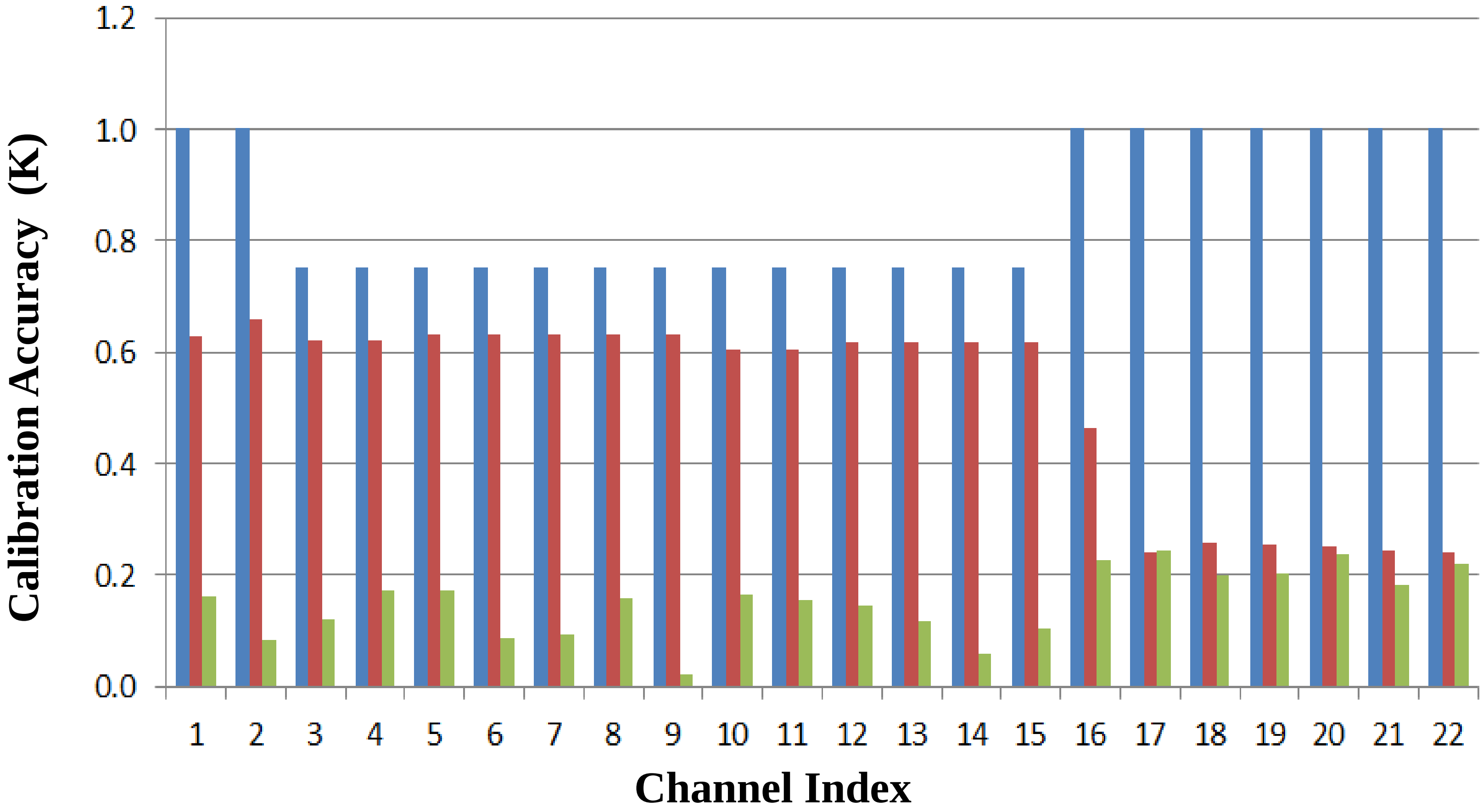
ATMS standard deviation (blue) and Allan deviation (red) with channel number. The sample size (N) is 150 and the averaging factor (m) for the warm counts is 17. The standard deviation is much higher than Allan deviation.

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



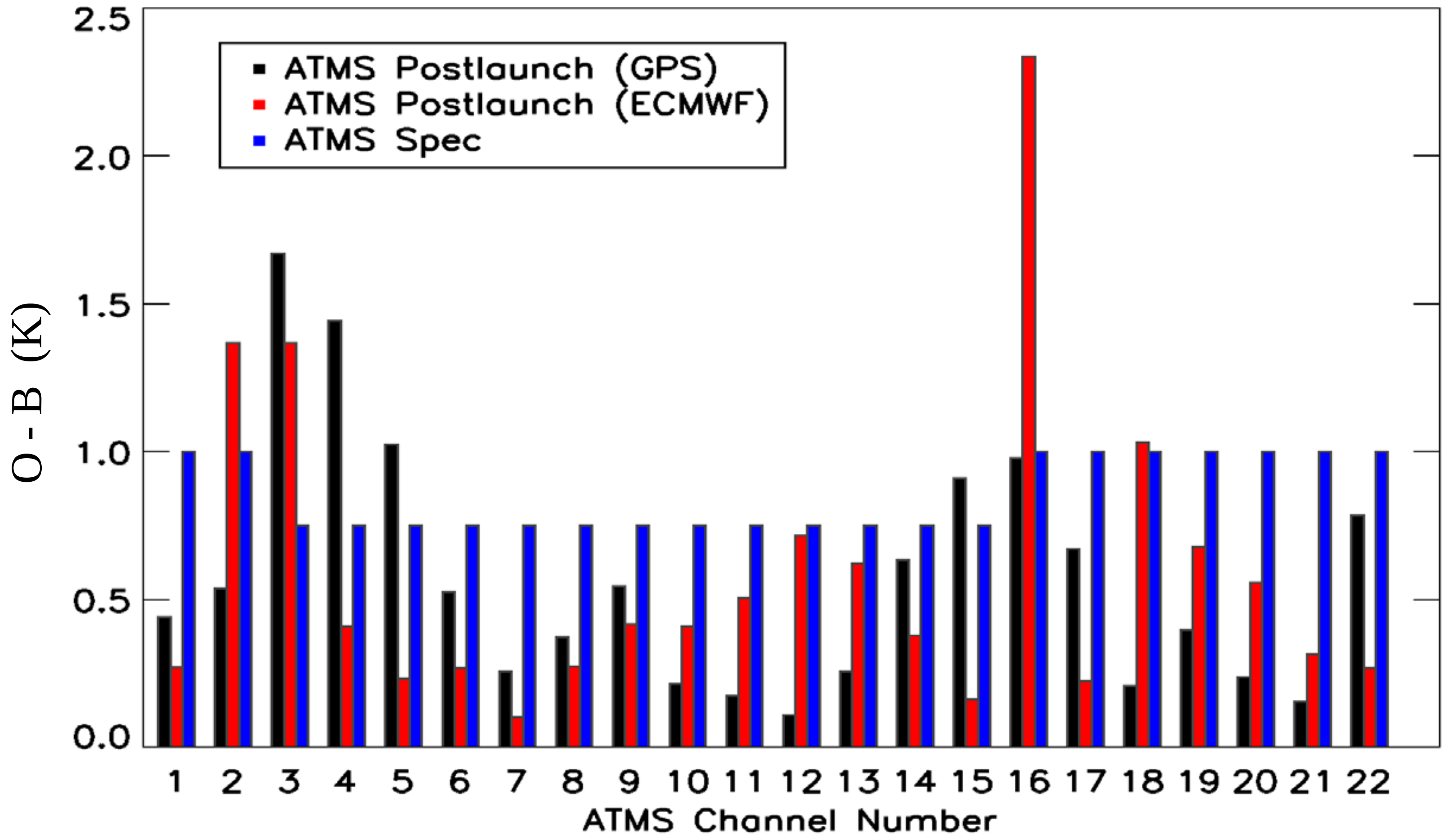
SNPP ATMS Pre-launch Calibration Accuracy through TVAC Data



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

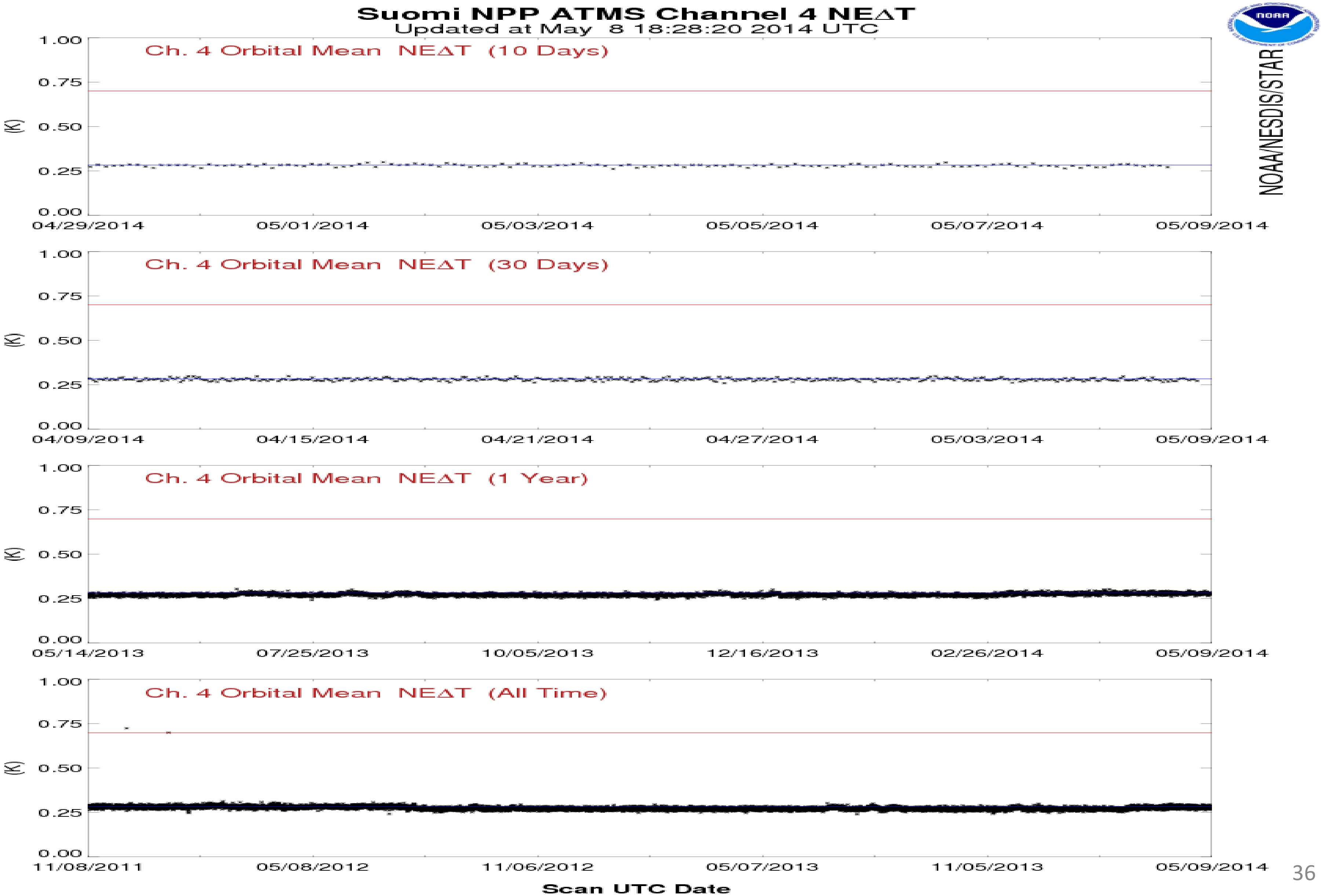
Prelauncht ATMS calibration accuracy is quantified from six redundant configuration (RC) thermal vacuum (TVAC) data and exceeds/is better than the specification

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.

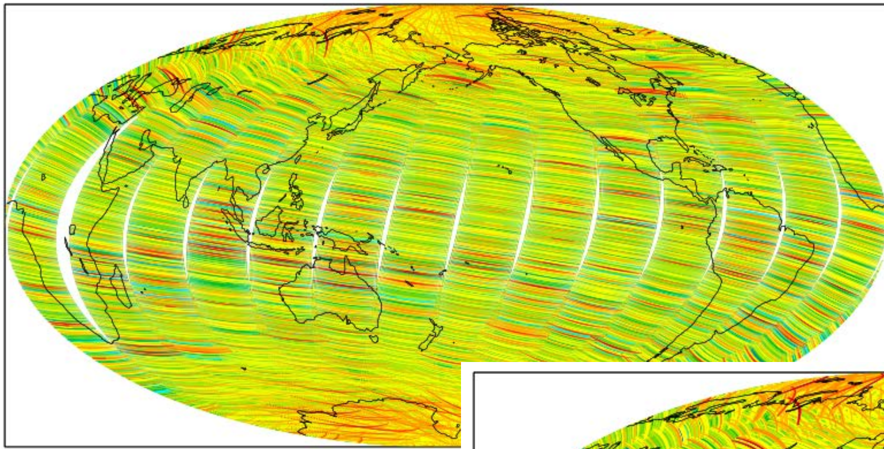
SNPP ATMS Has Stable Noise



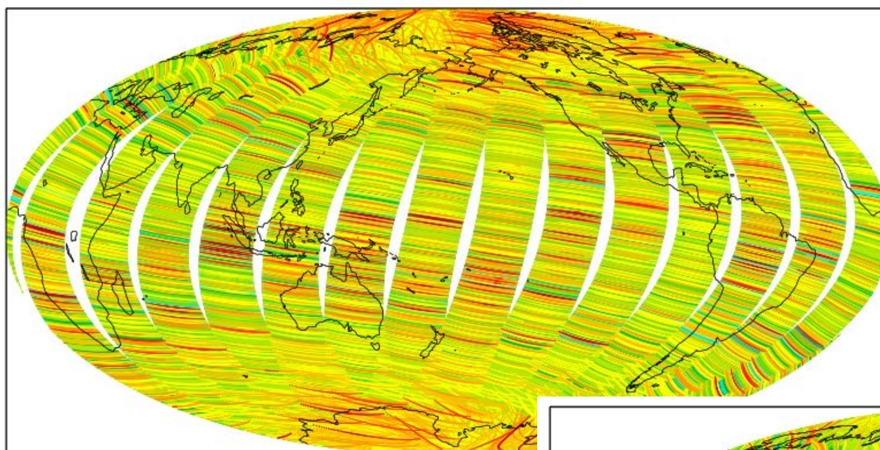
Microwave Radiometry Striping Noise

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

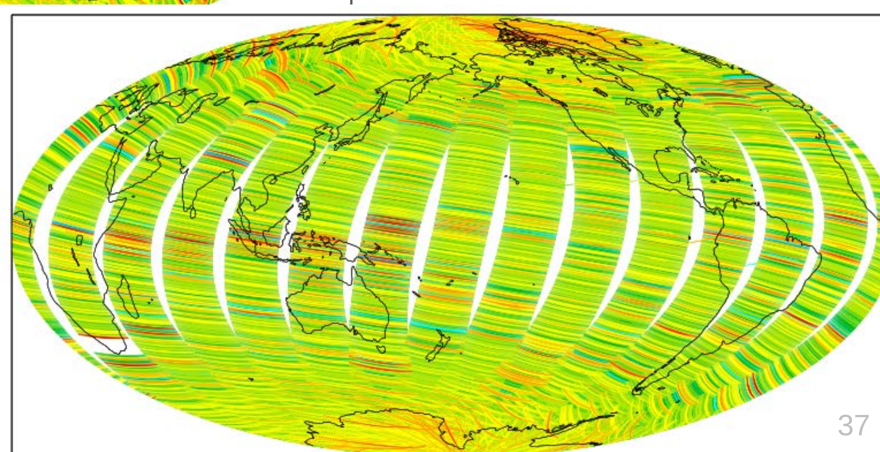
SNPP ATMS Ch 22

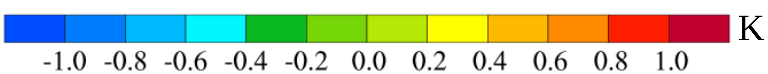


NOAA-18 MHS Ch3



NOAA-16 AMSU-B Ch3





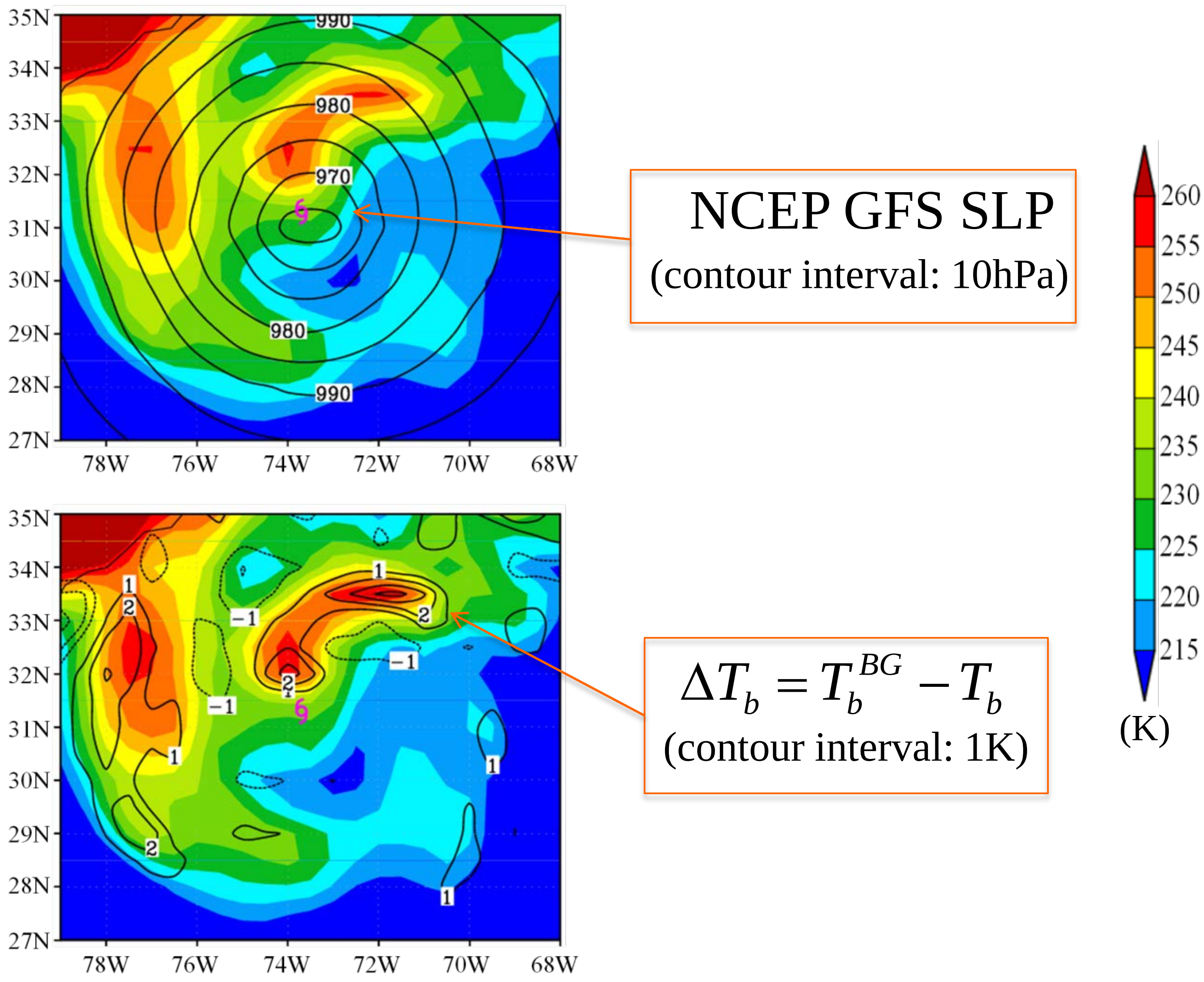
See Qin et al., 2013 JGR

T_b at Channel 1 within Sandy before and after Remap

(0600 UTC October 28, 2012)

T_b
(original)

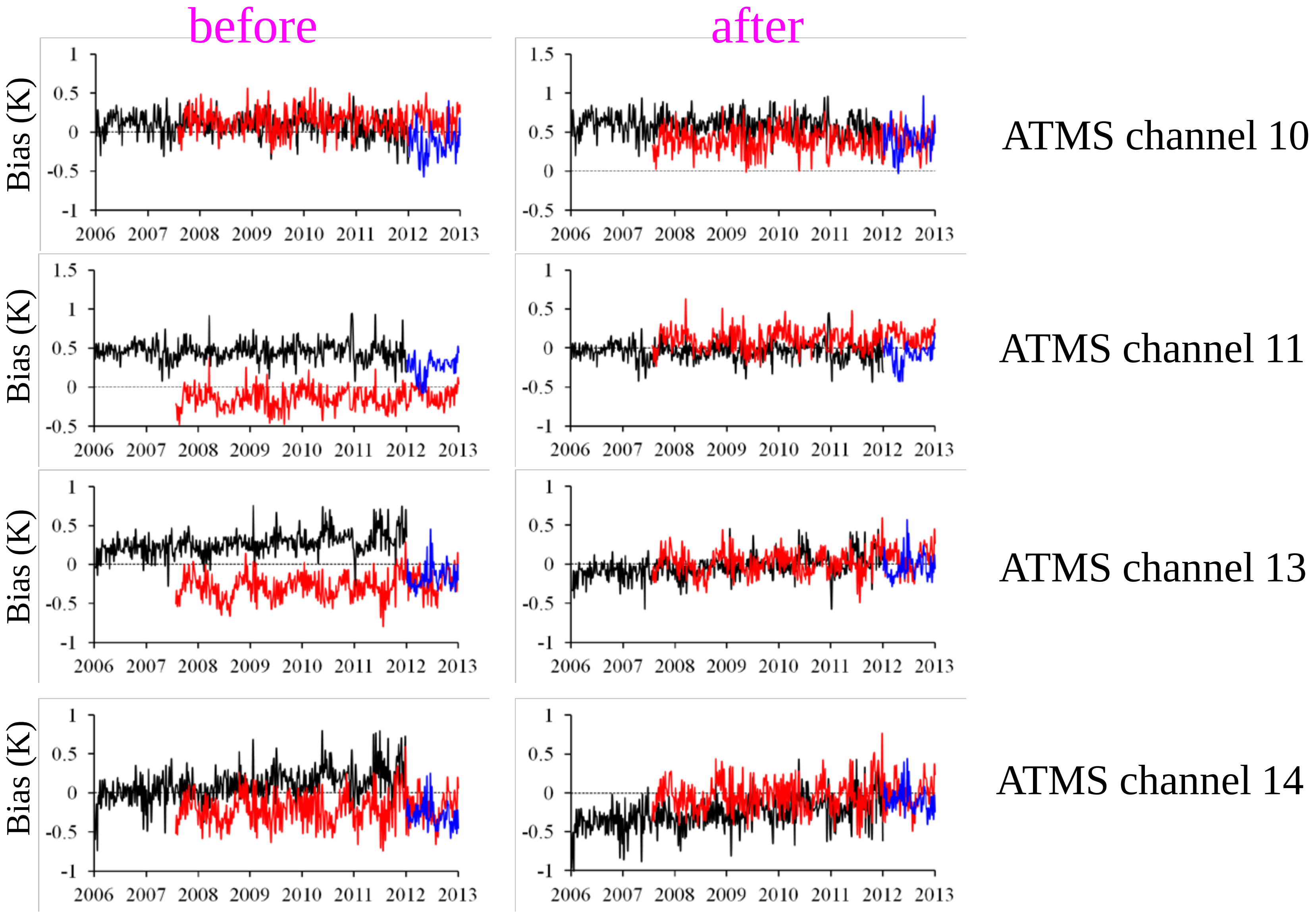
T_b^{BG}
(after BG)



NCEP GFS SLP
(contour interval: 10hPa)

$\Delta T_b = T_b^{BG} - T_b$
(contour interval: 1K)

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



NOAA-18 is subtracted. The pentad data set within ±30º 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:

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

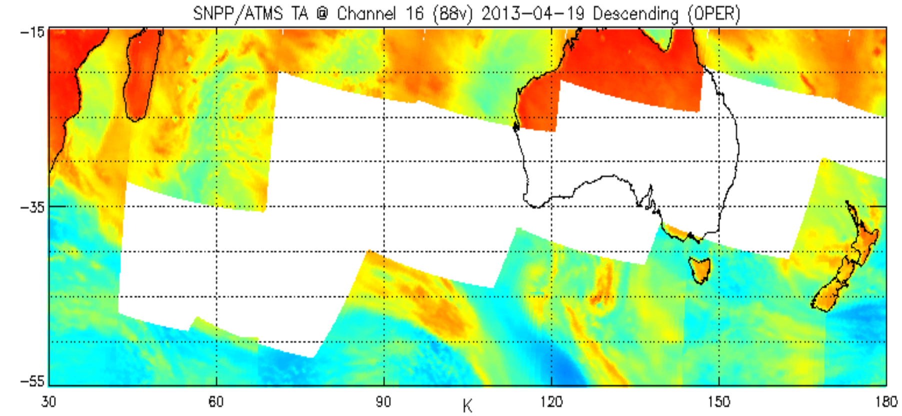
Weights of the Moon in antenna pattern:

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

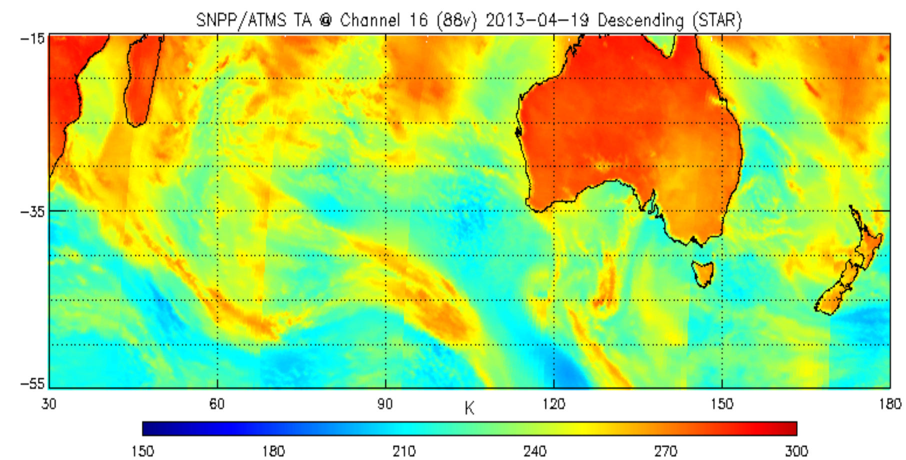
Brightness temperature of the Moon:

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

Without LI correction

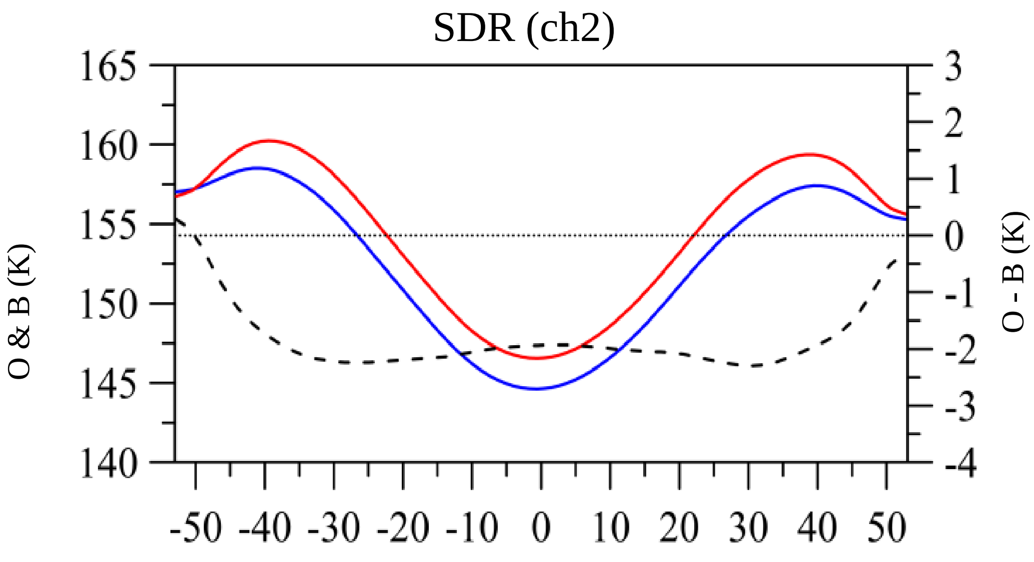


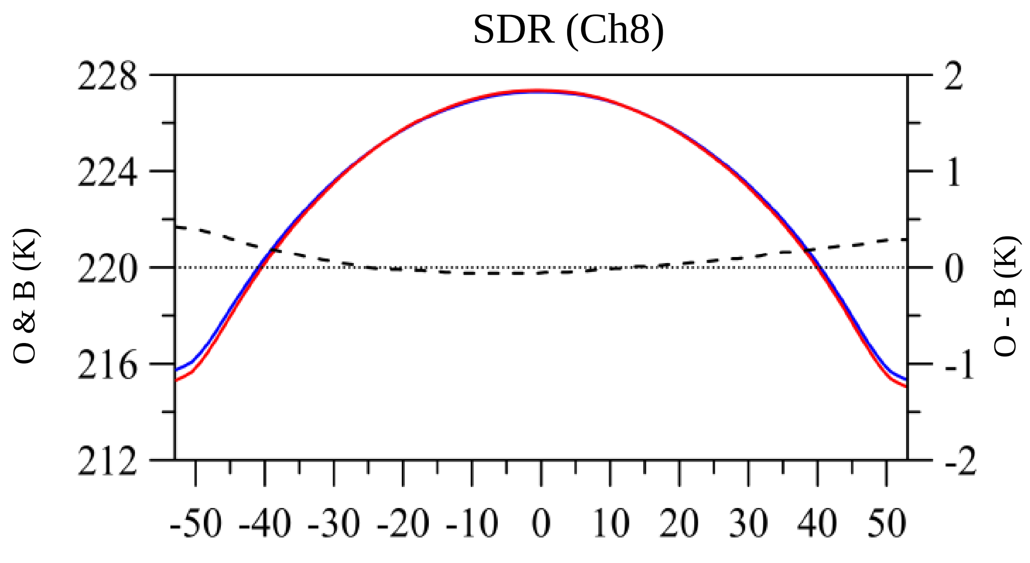
With LI correction



ATMS SDR Scan Angle Dependent Bias

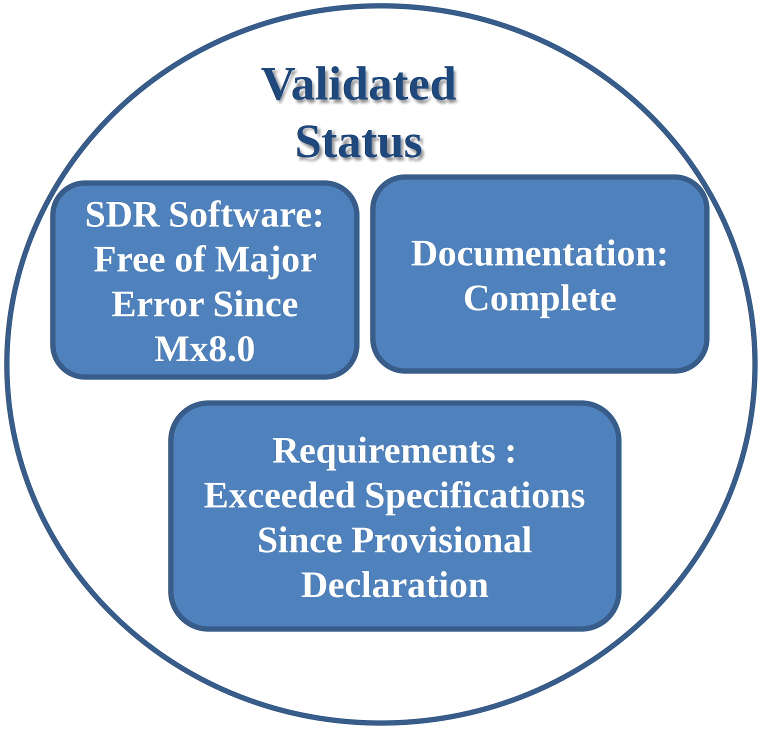
- **Methodology:**
  - SDR angular dependent biases are assessed using ECMWF and CRTM simulations
  - Cloud-affected radiances are removed with cloud liquid water algorithm (Weng et al., 2003)
  - Also, the measurements with the surface wind speeds are less than 10m/s are used
- **Results:**
  - ATMS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



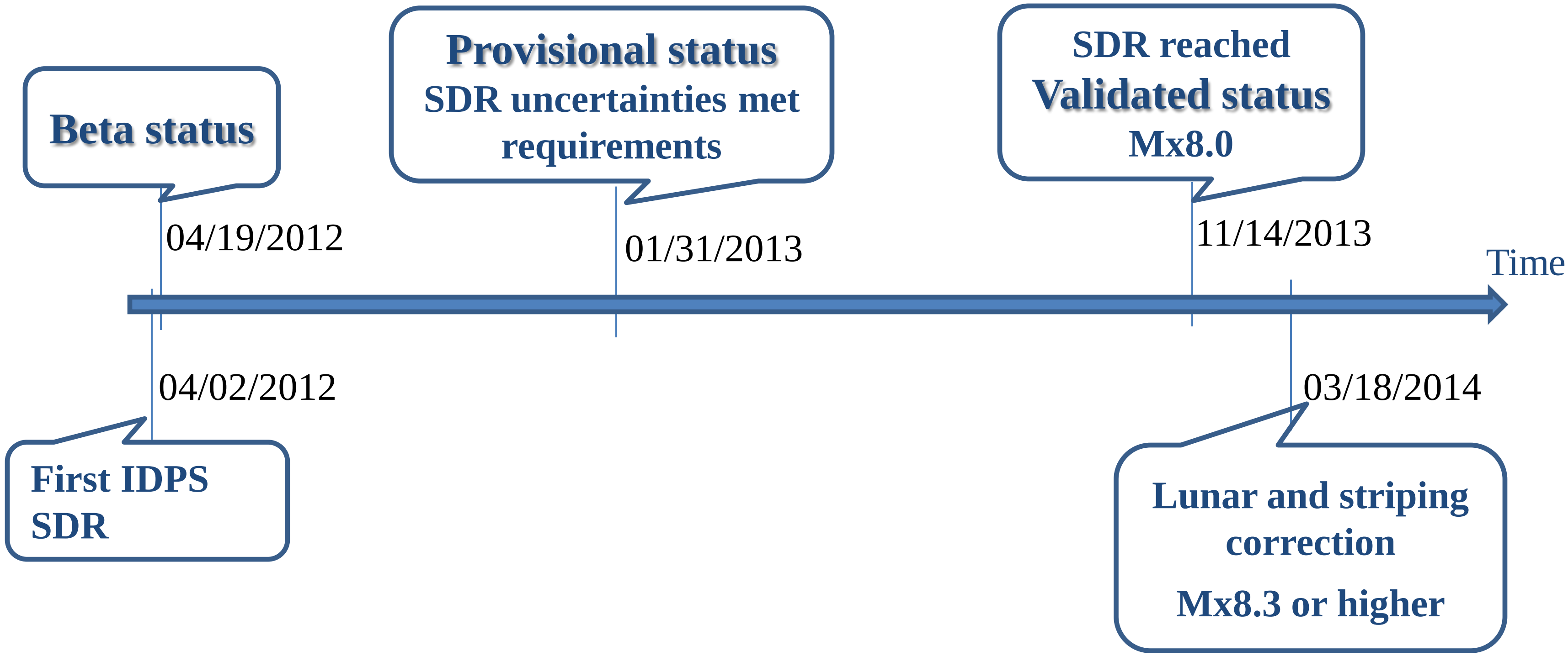


ATMS SDR Maturity Level – Validated

- 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



IDPS ATMS SDR CalVal Milestones



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