ATMS SDR SCIENCE REPORT

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NOAAA/STAR

Outline

- Cal/Val Team Members
- Sensor/Algorithm Overview
- S-NPP Product(s) Overview
- JPSS-1 Readiness
- Summary and Path Forward

Cal/Val Team Members

PI	Organization	Team Members	Roles and Responsibilities
Fuzhong Weng	NOAA/STAR	Neal Baker, Lin Lin, Wanchun Chen	ATMS SDR Lead: Budget and execution, strategic science direction, and oversight the SDR team Cal/Val tasks, reprocessing
Ninghai Sun	NOAA/STAR	Khalil Ahmad	ATMS SDR technical lead for science coordination, research to operation transition, ICVS monitoring
Xiaolei Zou	UMD/ESSIC	Yuan Ma, Xiaoxu Tian,	ATMS SDR destripping, RFI interference
Hu Yang	UMD/ESSIC	Jun Zhou,Xu Yang	ATMS SDR calibration algorithm development, improvement, and validation
Ed Kim	NASA/GSFC	Craig Smith, Joseph Lyu	ATMS instrument team for sensor pre- and post-launch characterization
Vince Leslie	MIT/LL		Prelaunch ATMS sensor characterization
Wael Ibrahim	Raytheon		IDPS operational ground processing system
Kent Anderson	NGES		NGES ATMS instrument calibration
Wesley Berg	CSU		ATMMS cross calibration

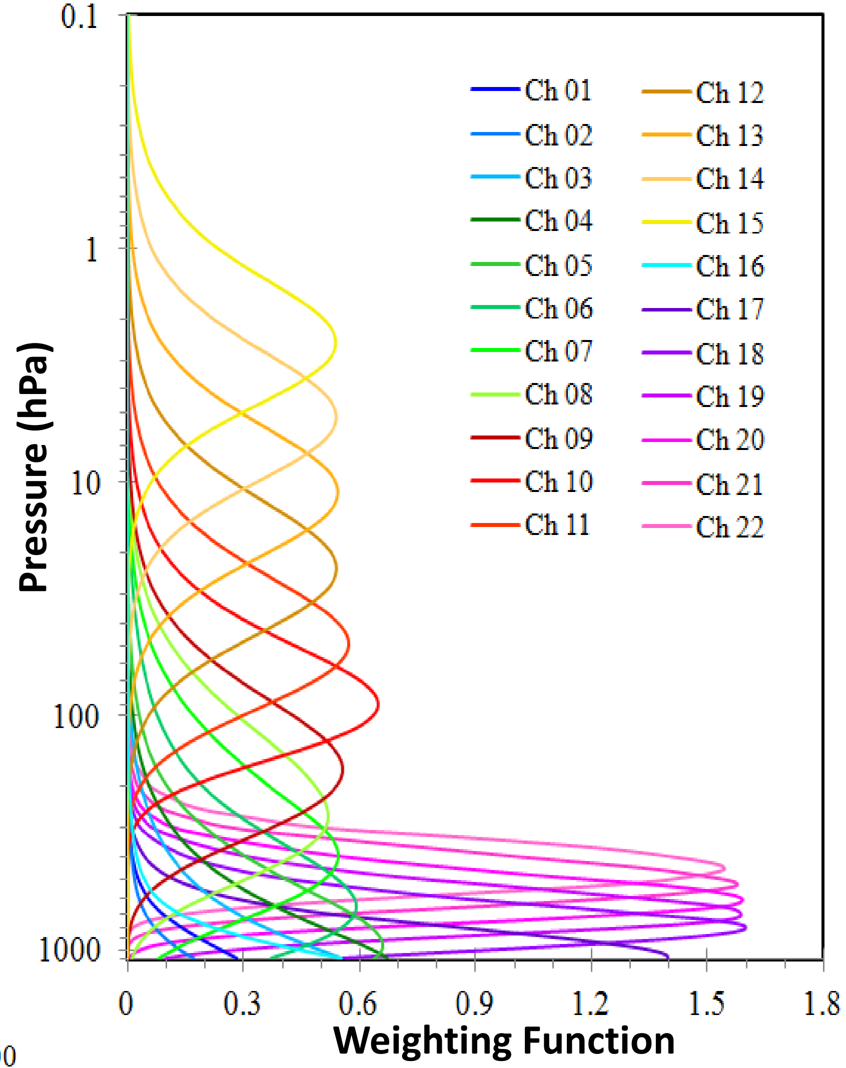
ATMS Sensor Overview

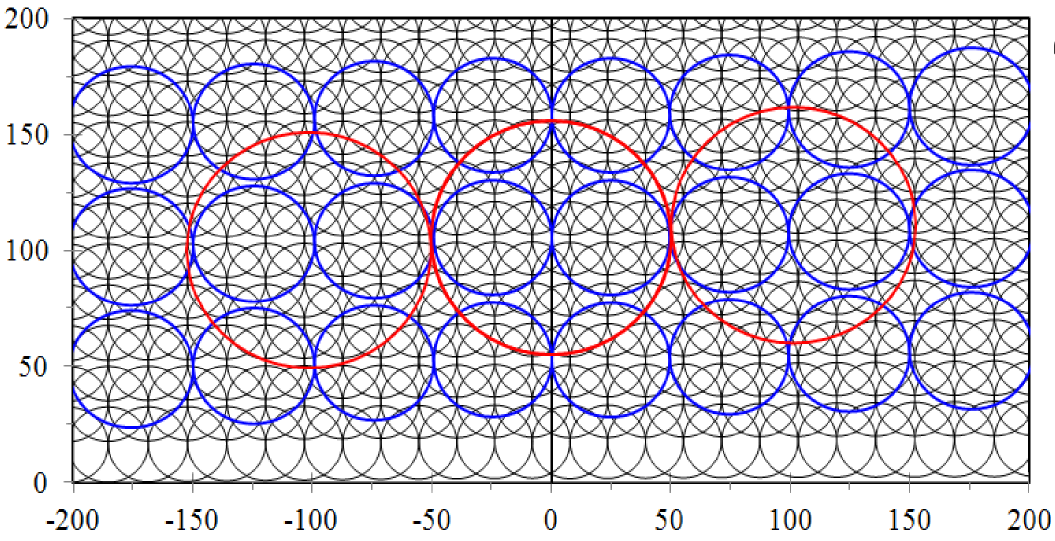
Ch	Channel Central Freq. (MHz)	Polarization	Bandwidth Max. (MHz)	Frequency Stability (MHz)	Calibration Accuracy (K)	Nonlinearity Max. (K)	NEΔT (K)	3-dB Bandwidth (deg)	Heritage Instrument	Nadir Weighting Function Peak & Primary Applications [1]
1	23800	QV	270	10	1.0	0.3	0.5	5.2	AMSU-A2	Surface & TPW, CLW, Ts, Es[2]
2	31400	QV	180	10	1.0	0.4	0.6	5.2	AMSU-A2	Surface & TPW, CLW, Ts, Es
3	50300	QH	180	10	0.75	0.4	0.7	2.2	AMSU-A1-2	Surface &Ts, Es
4	51760	QH	400	5	0.75	0.4	0.5	2.2		950 mb&Atmos Temp
5	52800	QH	400	5	0.75	0.4	0.5	2.2	AMSU-A1-2	850 mb&Atmos Temp
6	53596±115	QH	170	5	0.75	0.4	0.5	2.2	AMSU-A1-2	700 mb&&Atmos Temp
7	54400	QH	400	5	0.75	0.4	0.5	2.2	AMSU-A1-1	400 mb&&Atmos Temp
8	54940	QH	400	10	0.75	0.4	0.5	2.2	AMSU-A1-1	250 mb&&Atmos Temp
9	55500	QH	330	10	0.75	0.4	0.5	2.2	AMSU-A1-2	180mb&Atmos Temp
10	57290.344(f_o)	QH	330	0.5	0.75	0.4	0.75	2.2	AMSU-A1-1	90 mb&Atmos Temp
11	f_o± 217	QH	78	0.5	0.75	0.4	1.0	2.2	AMSU-A1-1	50 mb&Atmos Temp
12	f_o±322.2±48	QH	36	1.2	0.75	0.4	1.0	2.2	AMSU-A1-1	25 mb&Atmos Temp
13	f_o±322.2±22	QH	16	1.6	0.75	0.4	1.5	2.2	AMSU-A1-1	10 mb&Atmos Temp
14	f_o±322.2±10	QH	8	0.5	0.75	0.4	2.2	2.2	AMSU-A1-1	6 mb&Atmos Temp
15	f_o±322.2±4.5	QH	3	0.5	0.75	0.4	3.6	2.2	AMSU-A1-1	3 mb&Atmos Temp
16	88200	QV	2000	200	1.0	0.4	0.3	2.2	89000	Surface &Vapor, Cloud, Precip
17	165500	QH	3000	200	1.0	0.4	0.6	1.1	157000	Surface &Vapor, Cloud, Precip
18	183310±7000	QH	2000	30	1.0	0.4	0.8	1.1	AMSU-B	950mb&Vapor, Cloud, Precip
19	183310±4500	QH	2000	30	1.0	0.4	0.8	1.1		850mb&Atmos Vapor
20	183310±3000	QH	1000	30	1.0	0.4	0.8	1.1	AMSU-B/MHS	500mb&Atmos Vapor
21	183310±1800	QH	1000	30	1.0	0.4	0.8	1.1		400mb&Atmos Vapor
22	183310±1000	QH	500	30	1.0	0.4	0.9	1.1	AMSU-B/MHS	300mb&Atmos Vapor

1. Weighting function peak is computed from the standard atmosphere, 2. TPW: Total Precipitable Water, CLW: Cloud Liquid Water, Ts: Land Surface Temp, Es: Land Surface Emissivity.

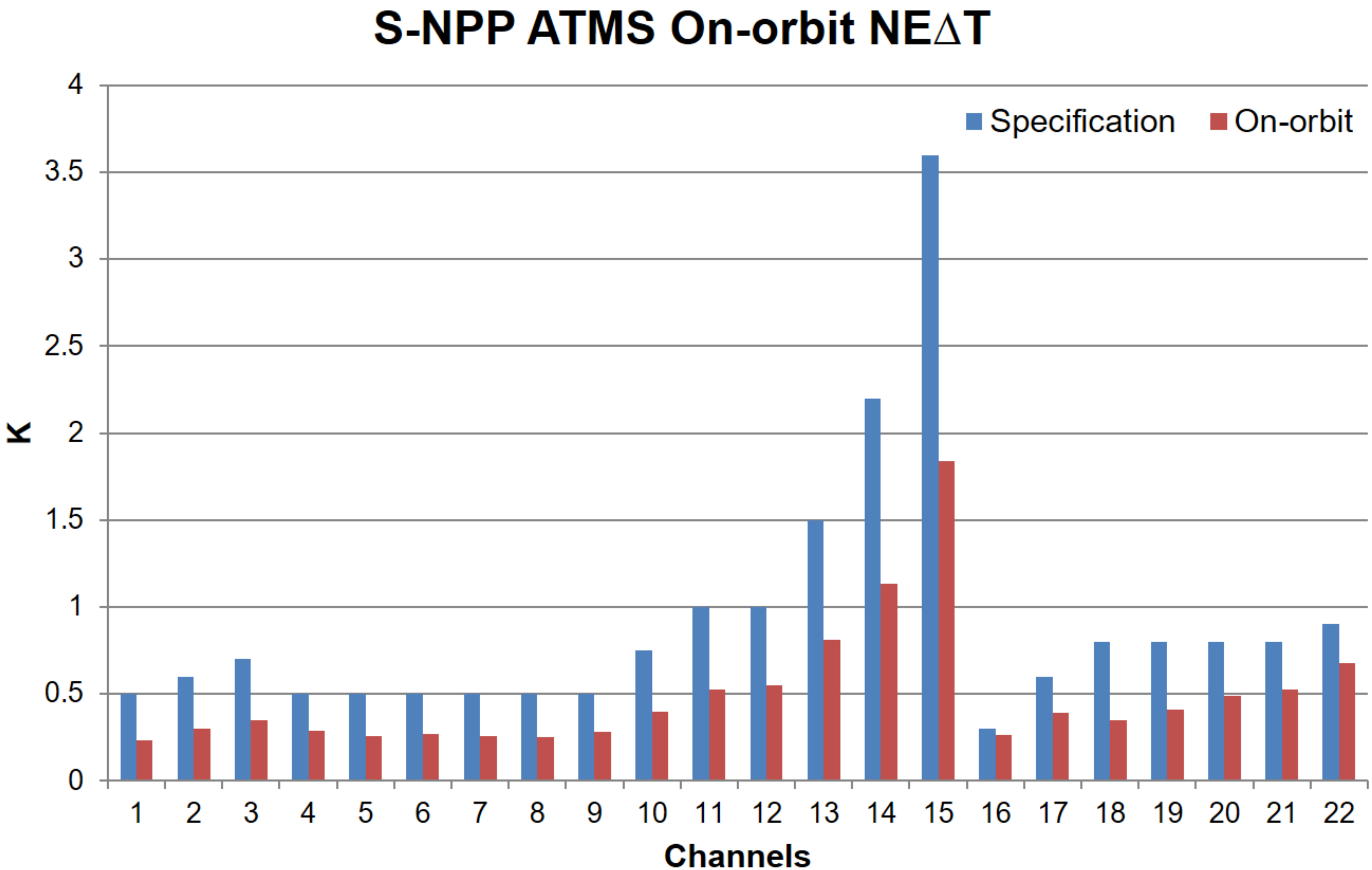
ATMS Sensor Overview

- 22 channels measuring from surface to upper atmosphere for temperature and water vapor profiling
- Scan swath: 2700 km
- Earth FOVs per scan: 98
- Scan angle range: 52.3 degree



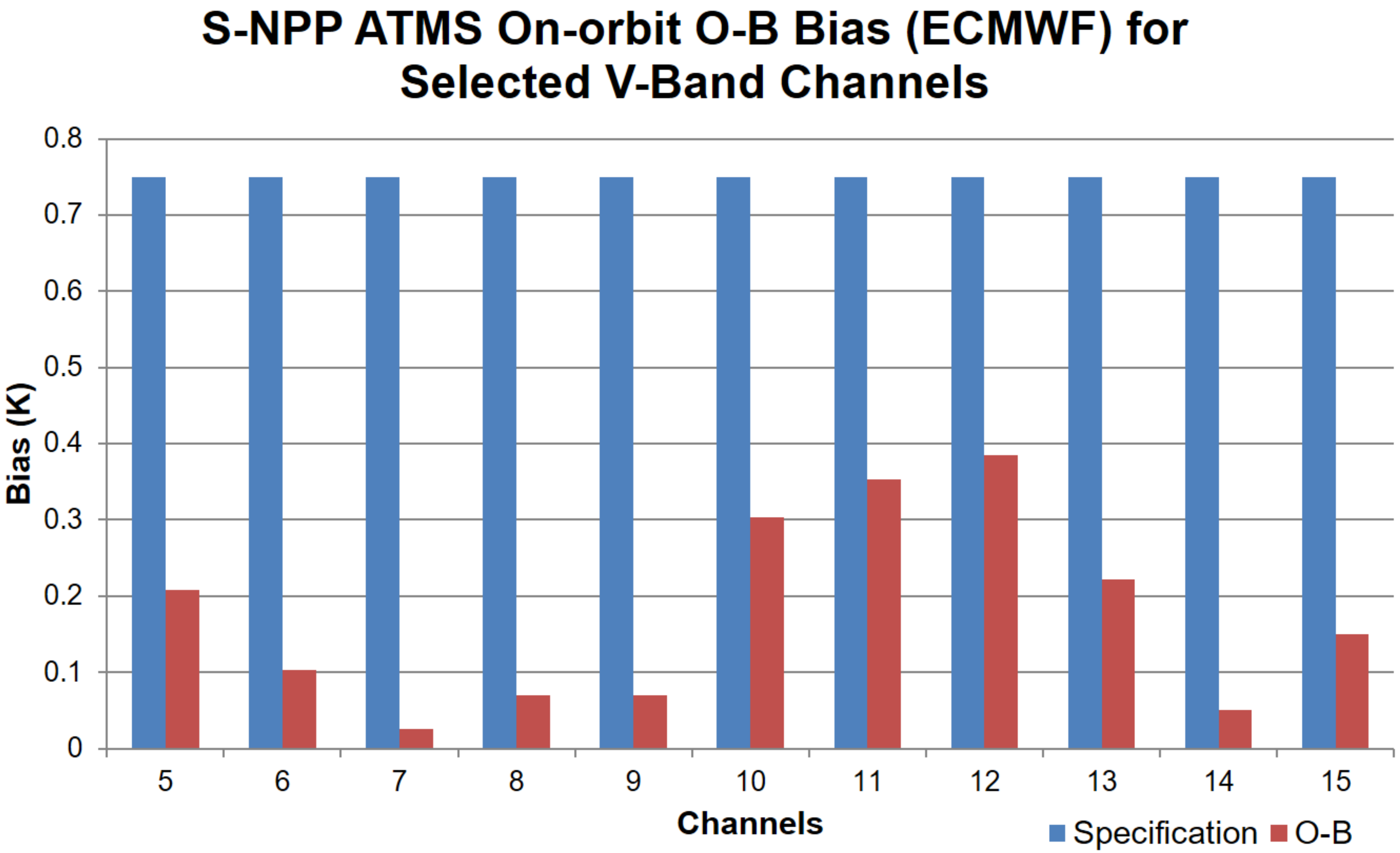


Suomi NPP ATMS On-orbit Performance



Suomi NPP ATMS all channel noise meets the requirement with margins

Suomi NPP ATMS On-orbit Performance

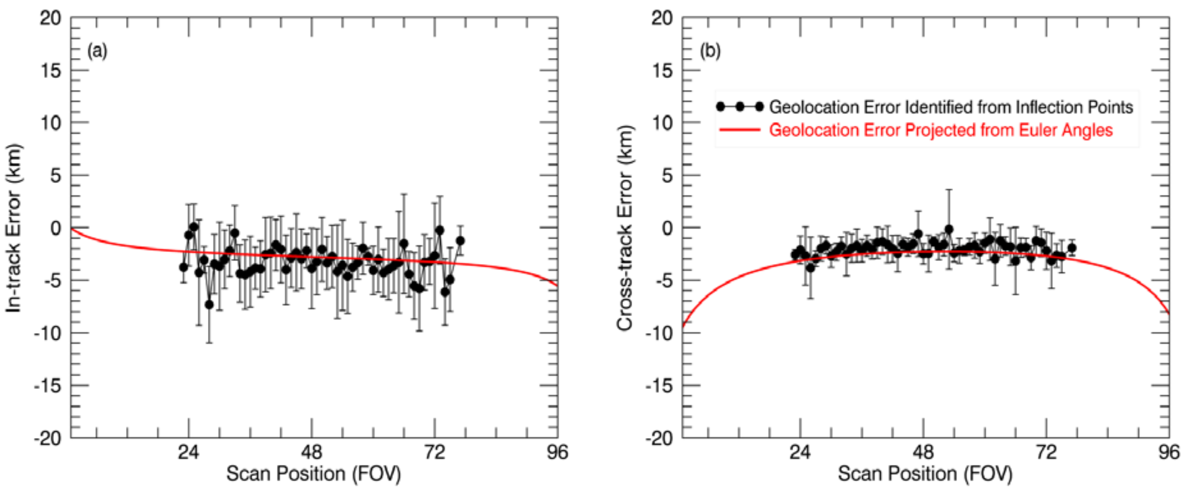


Suomi NPP ATMS on-orbit absolute bias (OBS-RTM) meet the requirement

Suomi NPP ATMS On-orbit Performance

Channel	Euler Angles (degree)			Ground Geolocation Error (km)					
				In-Track			Cross-Track		
	Roll	Pitch	Yaw	FOV Index=1	FOV Index=48	FOV Index=96	FOV Index=1	FOV Index=48	FOV Index=96
1	-0.13	0.21	-0.037	-0.058	-2.8	-5.6	-9.5	-2.3	-8.3
2	0.089	0.29	0.042	-6.9	-4.4	-3.3	2.8	0.76	5.4
3	-0.1	0.098	-0.17	4.0	-1.2	-6.4	-6.0	-1.7	-5.9
16	-0.065	-0.098	0.0053	2.5	1.5	1.2	-3.2	-0.76	-4.0

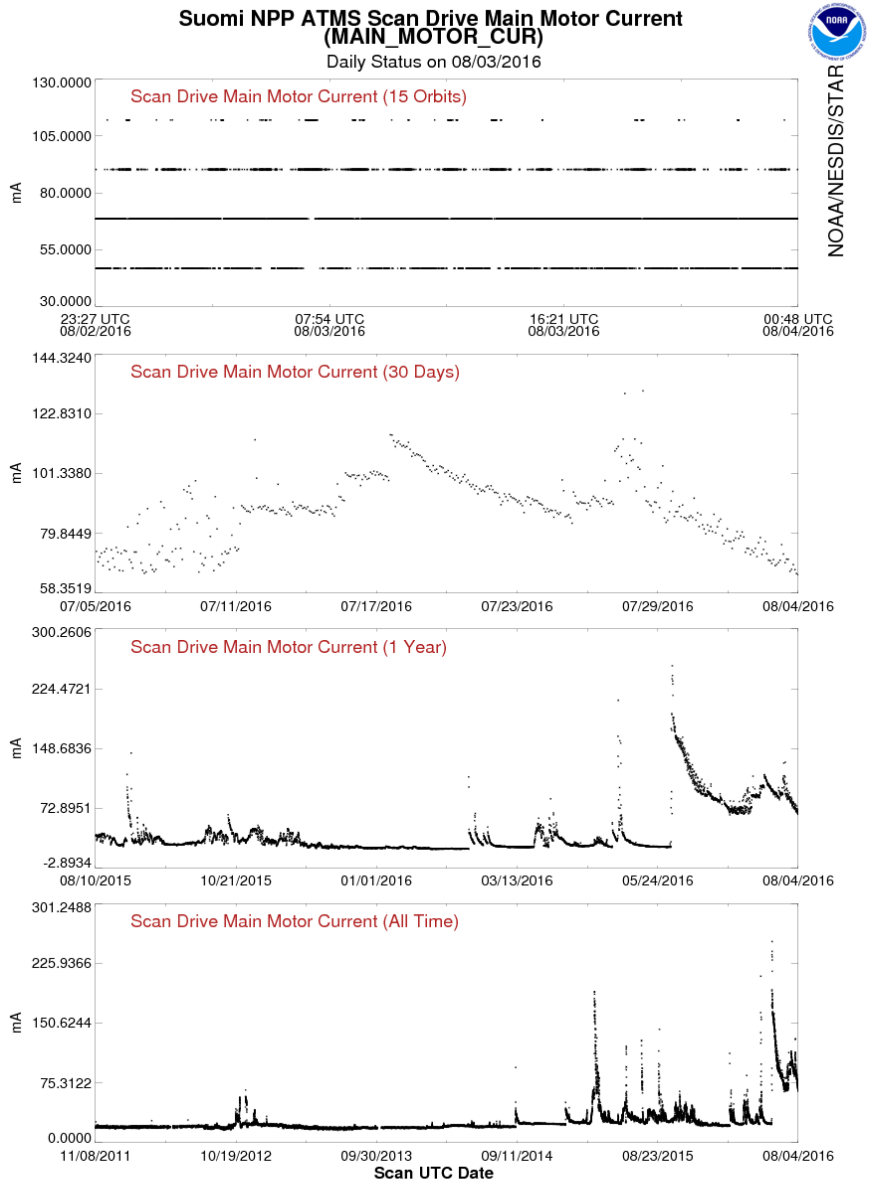
Ch.1 Ground Geolocation Error



Suomi NPP ATMS On-orbit Performance

ATMS scan drive main motor current major spikes detected

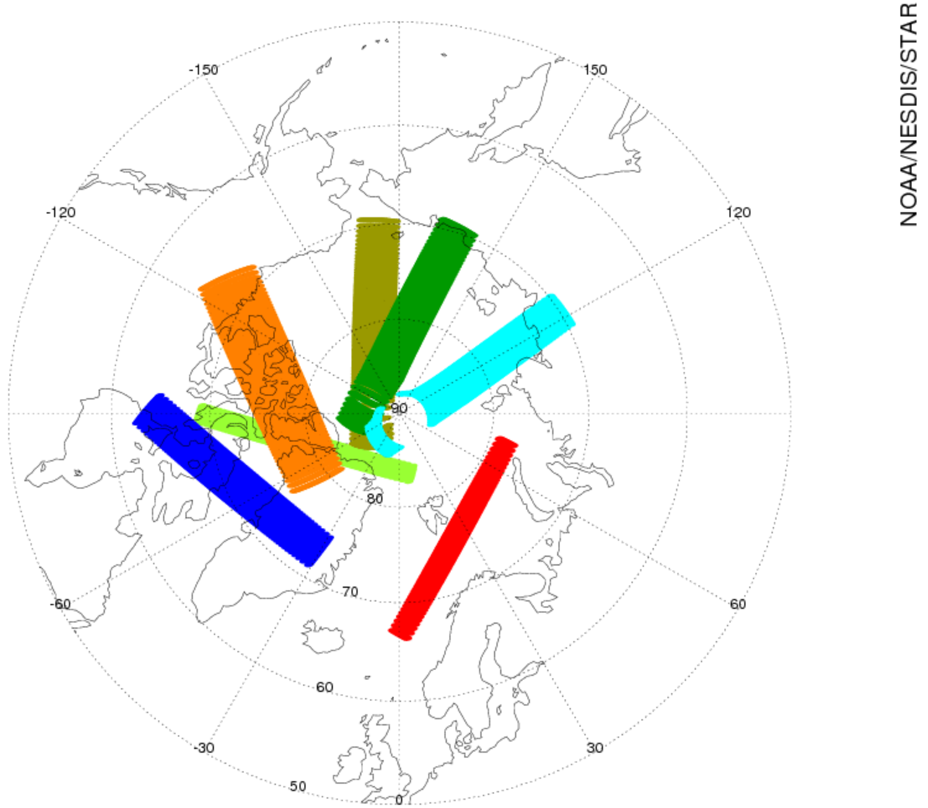
- Instrument temperature increased
- Scan angle shift observed after SD motor current spikes but still well below requirements
- Once per day scan reversal implemented from August 24, 2015
- Once per orbit scan reversal implemented from July 25, 2016 (staggering configuration among consecutive orbits)
- ATMS put in safe mode due to 1553 issue during once per day reversal
- Twice per orbit reversal (staggering configuration near north and south pole) to be implemented soon



ATMS Scan Reversal Scheme Study

S-NPP ATMS Scan Reversal Missing Granule Map

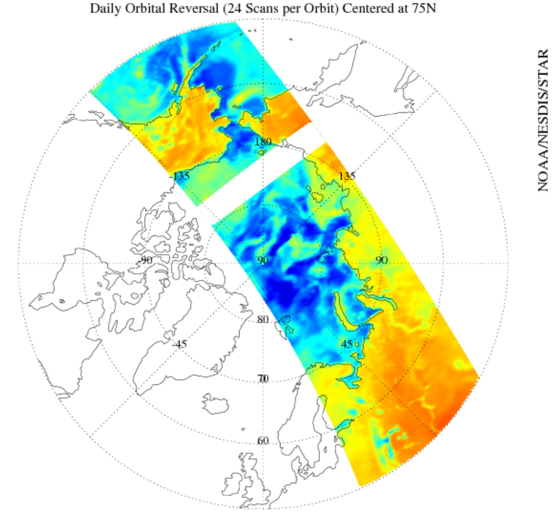
2016-07-25 Total Number of Reversal Events: 7



- B24573 09:26:08~09:26:24 UTC
- B24576 14:32:10~14:32:26 UTC
- B24577 16:10:45~16:11:01 UTC
- B24578 17:53:53~17:54:09 UTC
- B24579 19:37:26~19:37:43 UTC
- B24580 21:18:45~21:19:01 UTC
- B24581 23:01:53~23:02:09 UTC

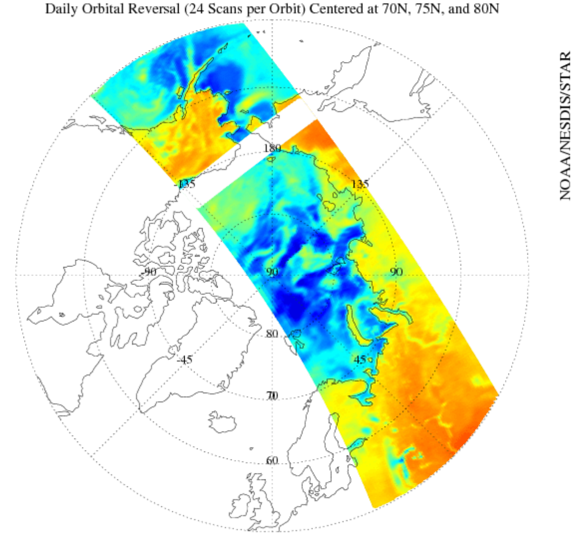
S-NPP ATMS Scan Reversal Coverage Map

Daily Orbital Reversal (24 Scans per Orbit) Centered at 75N

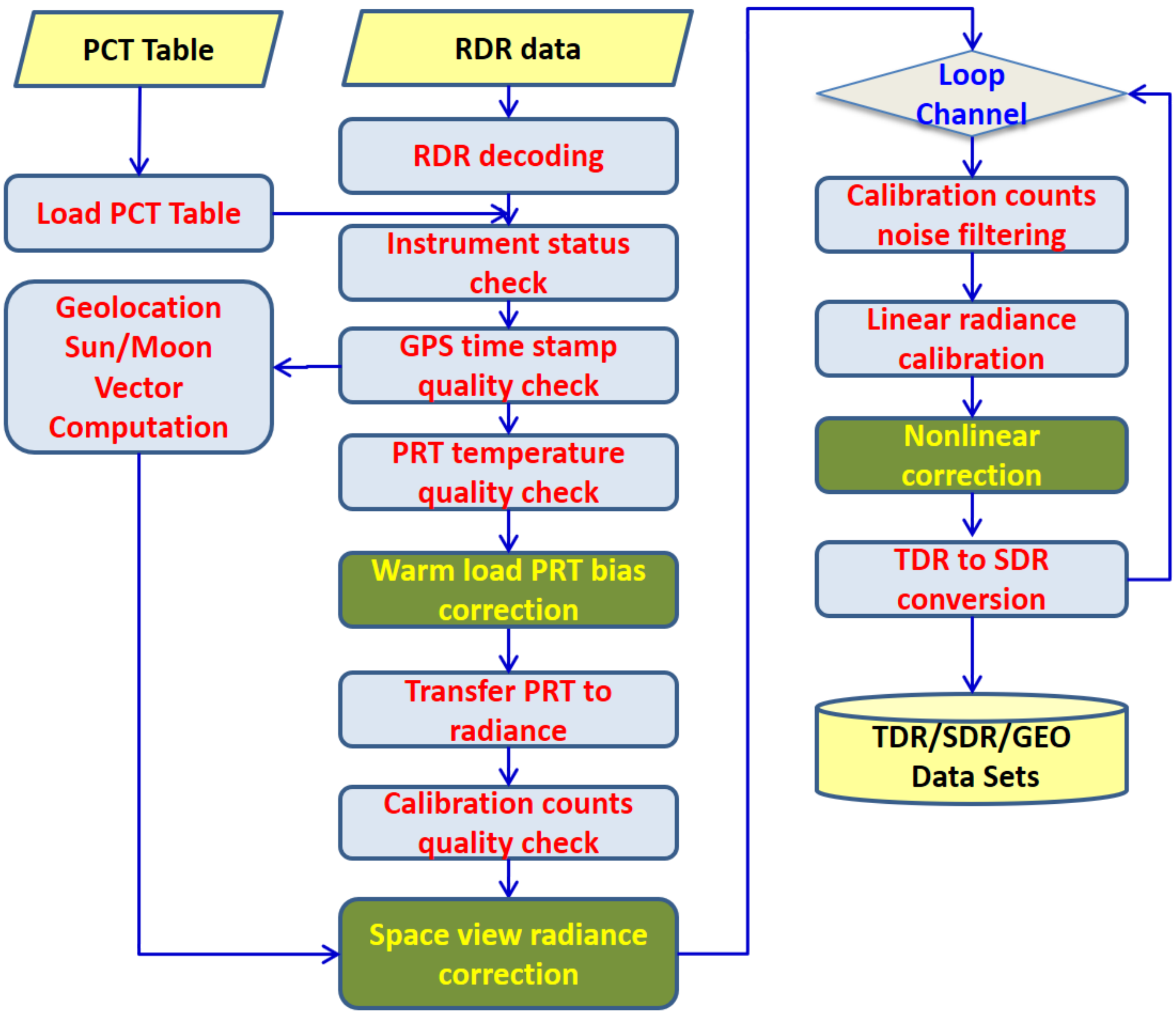


S-NPP ATMS Scan Reversal Coverage Map

Daily Orbital Reversal (24 Scans per Orbit) Centered at 70N, 75N, and 80N



ATMS Algorithm Overview



- Radiation from calibration targets are calculated as radiance instead of brightness temperature
- Lunar contamination correction is included in space view radiance correction
- Nonlinearity correction is based on "μ" parameter derived from TVAC
- Brightness temperature is computed from full Planck function in radiance space
- Error budget in calibration are traceable

ATMS Algorithm Overview

SNPP Launch
Since Oct. 28, 2011

- Mx5.0 — 2011-10-28
- Mx5.1 — 2011-12-09
  - Updated ATMS PCT on data range

Beta
Since Apr. 19, 2012

- Mx6.0(6.1/6.2) — 2012-08-09
- Mx6.3(6.4) — 2012-10-15
  - Updated ATMS PCT on TDR to SDR conversion

Provisional
Since Jan. 31, 2013

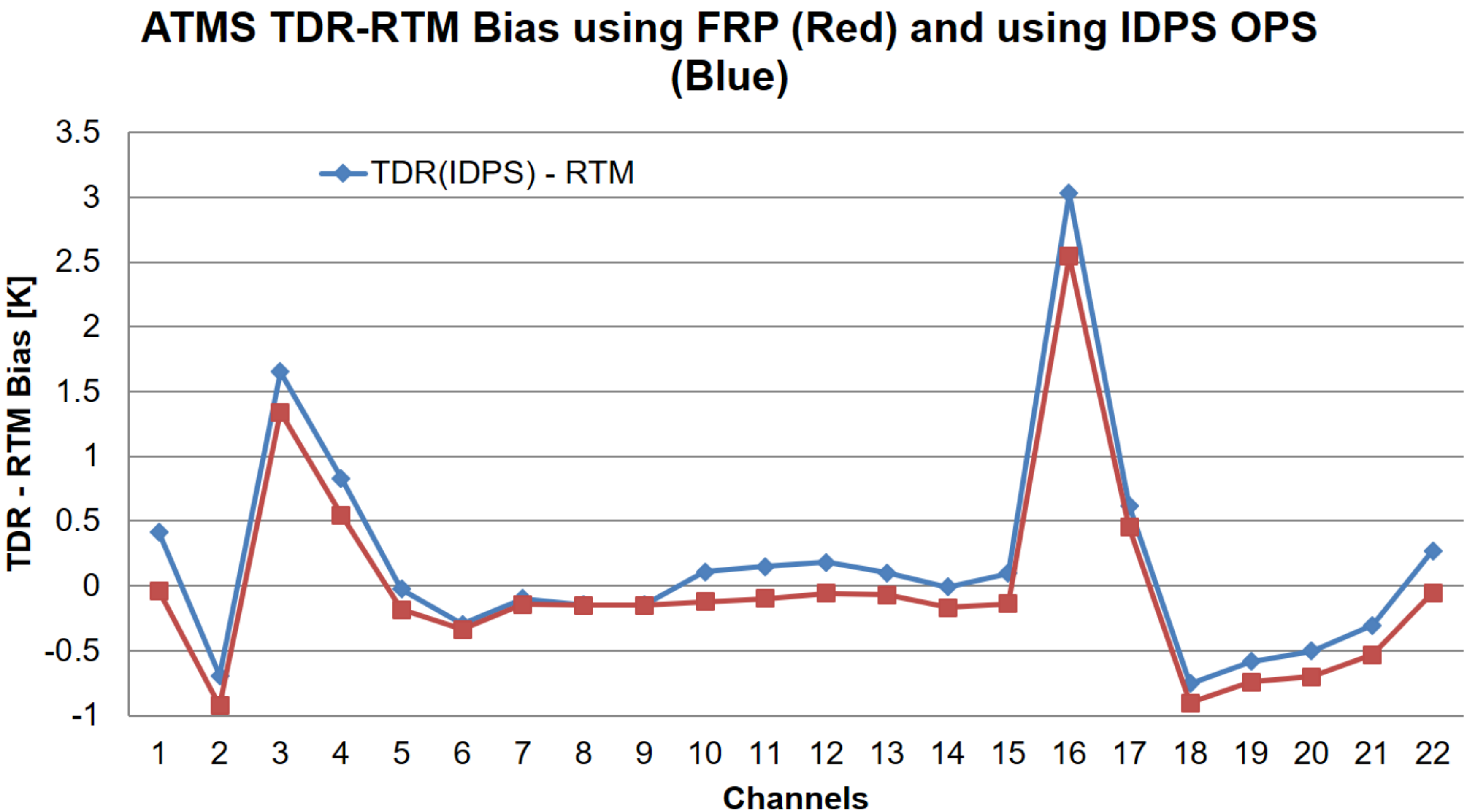
- Mx6.6 — 2013-02-28
- Mx6.7 — 2013-03-14
- Mx7.0(7.1) — 2013-07-10
- Mx7.2 — 2013-08-20
- Mx8.0 — 2013-11-14

Validated
Since Feb. 20, 2014

- Mx8.1(8.2) — 2014-02-20
  - Fixed 1958 issue
- Mx8.3 — 2014-03-18
  - Updated lunar intrusion correction
- Mx8.4 — 2014-05-22
  - Updated ATMS PCT on warm target range
- Mx8.5 — 2014-08-13
- Mx8.6 — 2014-11-21
  - Updated CMN Geo on lunar intrusion flag
- Mx8.7 — 2014-12-17
- Mx8.8 — 2015-03-06
- Mx8.10 — 2015-06-22
- Mx8.11 — 2015-12-17
  - Updated data gap QF

ATMS Algorithm Overview

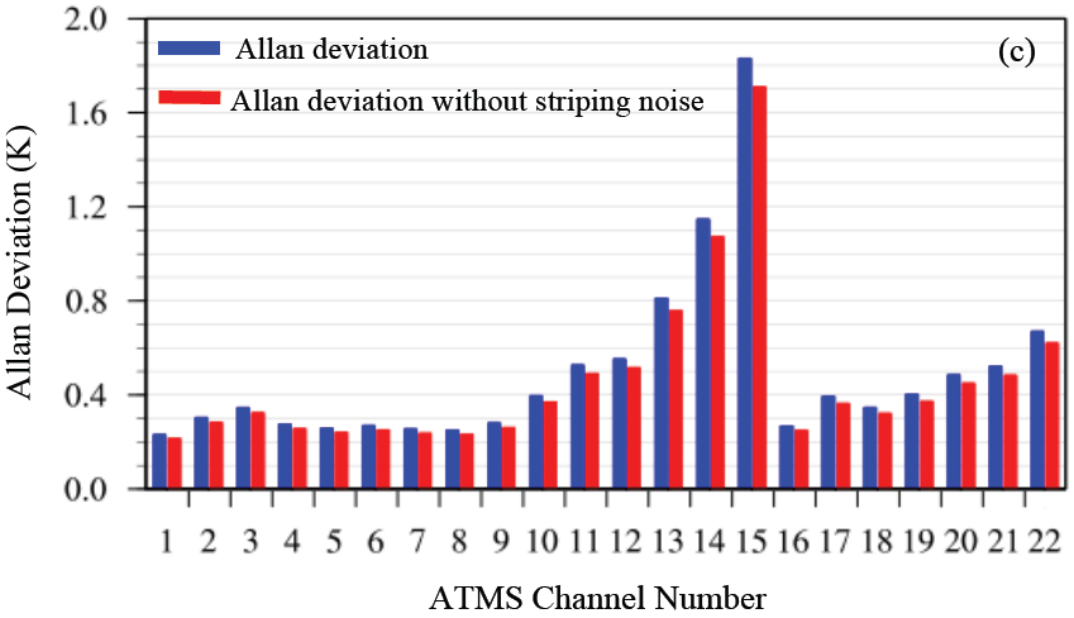
- Full radiance process has been tested in Advanced Radiance Transformation System (ARTS)
- FRP code update for IDPS, as well as associated PCT, has been approved for operational implementation



ATMS Algorithm Overview

Channel	NEDT (K)		Allan Deviation (K)	
	Before	After	Before	After
1	0.3490	0.3256	0.2324	0.2171
2	0.3977	0.3593	0.3052	0.2843
3	0.3945	0.3464	0.3473	0.3248
4	0.3279	0.2883	0.2772	0.2581
5	0.3232	0.2871	0.2603	0.2422
6	0.3433	0.3069	0.2714	0.2526
7	0.3518	0.3201	0.2559	0.2382
8	0.3453	0.3138	0.2518	0.2345
9	0.3421	0.3046	0.2816	0.2628
10	0.4542	0.3968	0.3981	0.3716
11	0.5675	0.4900	0.5277	0.4922
12	0.6140	0.5365	0.5534	0.5174
13	0.8718	0.7527	0.8123	0.7593
14	1.1849	1.0179	1.1479	1.0727
15	1.8476	1.5651	1.8319	1.7110
16	0.3914	0.3578	0.2692	0.2501
17	0.9237	0.8865	0.3954	0.3650
18	0.5496	0.5103	0.3479	0.3230
19	0.6637	0.6149	0.4041	0.3740
20	0.7636	0.7039	0.4859	0.4508
21	0.8862	0.8202	0.5239	0.4848
22	1.1194	1.0337	0.6712	0.6217

- Channel noise reduced after applying striping mitigation algorithm
- 45-day de-striping BUFR data generated for NWP impact study



Qin, Z., X. Zou and F. Weng, 2013: Analysis of ATMS and AMSU striping noise from their earth scene observations. *J. Geophy. Res.*, 118, 13,214-13,229, doi: 10.1002/ 2013JD020399

Ma, Y. and X. Zou, 2015: Optimal filters for striping noise mitigation within ATMS calibration counts. *IEEE Trans. Geo. Remote Sensing*, (submitted)

Suomi NPP ATMS Reprocessing

Major updates in S-NPP ATMS Reprocessing

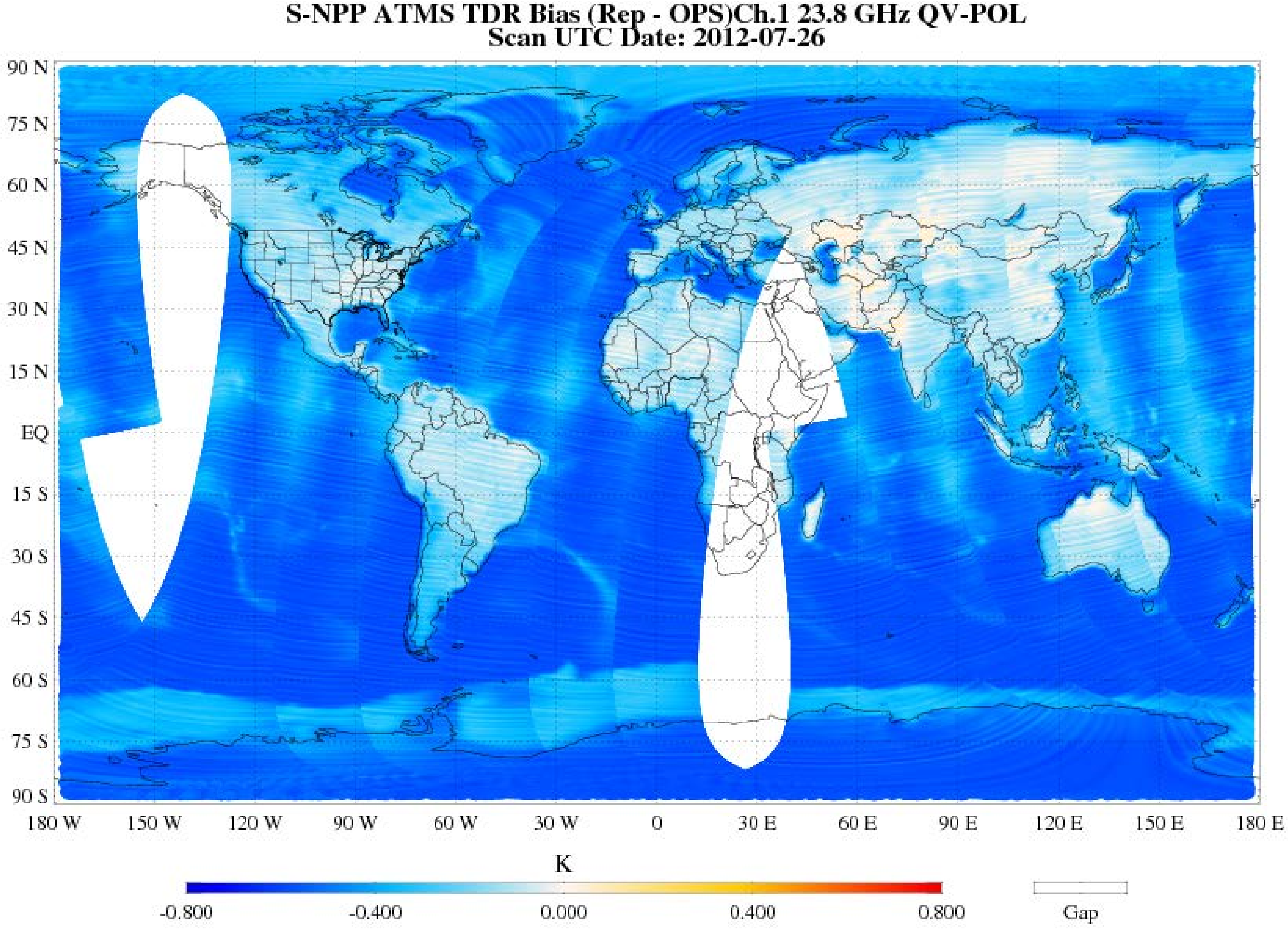
- Calibration algorithm upgraded from R-J approximation based to radiance based
  - Update non-linearity correction coefficients using radiance calibration algorithm
  - Reduce TDR values systematically

- Calibration target smoothing method unified to boxcar
  - Change striping pattern for OPS data using triangular smoothing method prior to October 2012

- Degraded TDR regenerated using updated processing coefficients table

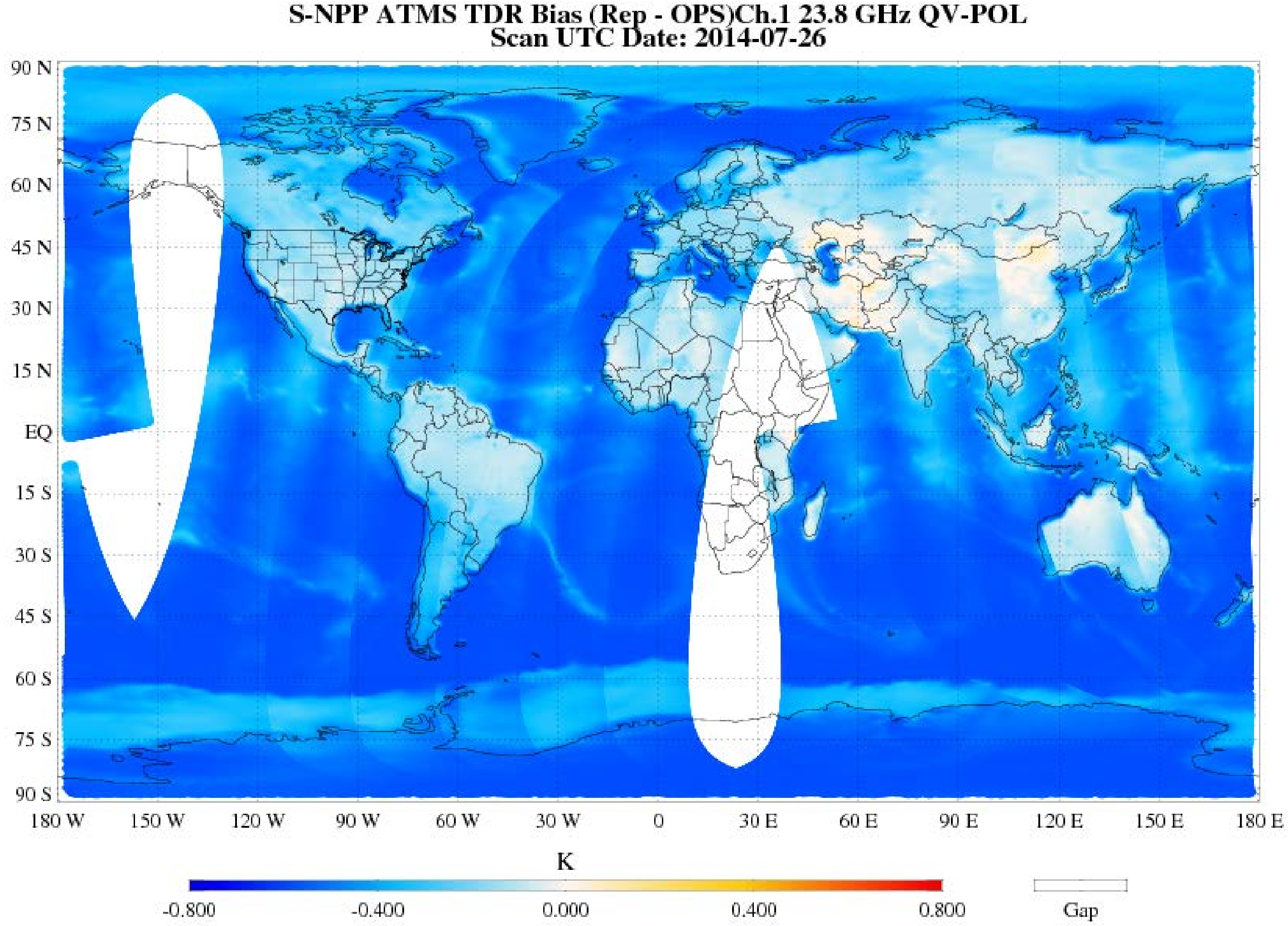
- Lunar intrusion correction applied to life time ATMS TDR
  - Quality flag triggered locations
  - TDR correction updated

Suomi NPP ATMS Reprocessing



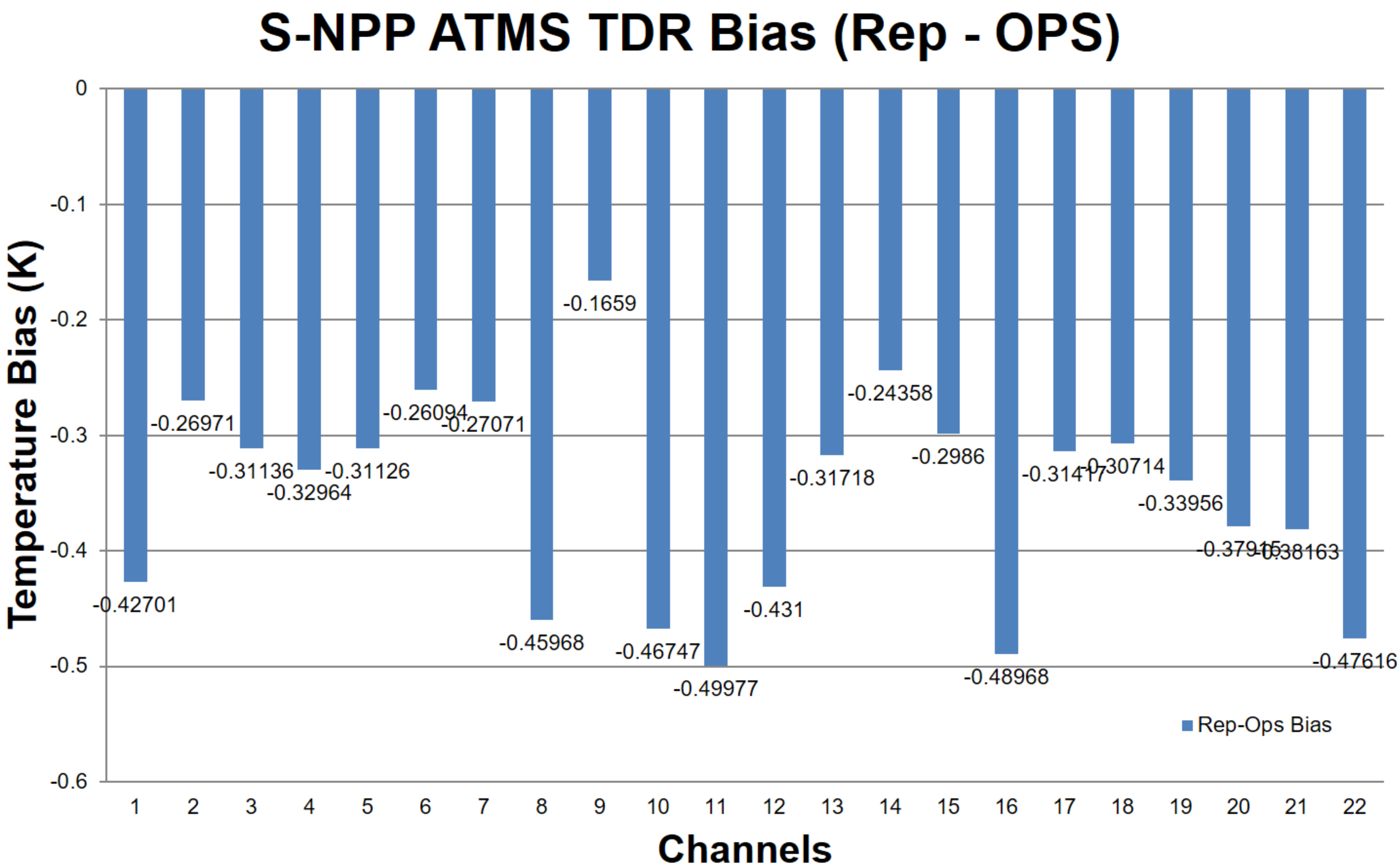
Striping pattern is caused by different smoothing methods, triangular v.s. boxcar

Suomi NPP ATMS Reprocessing

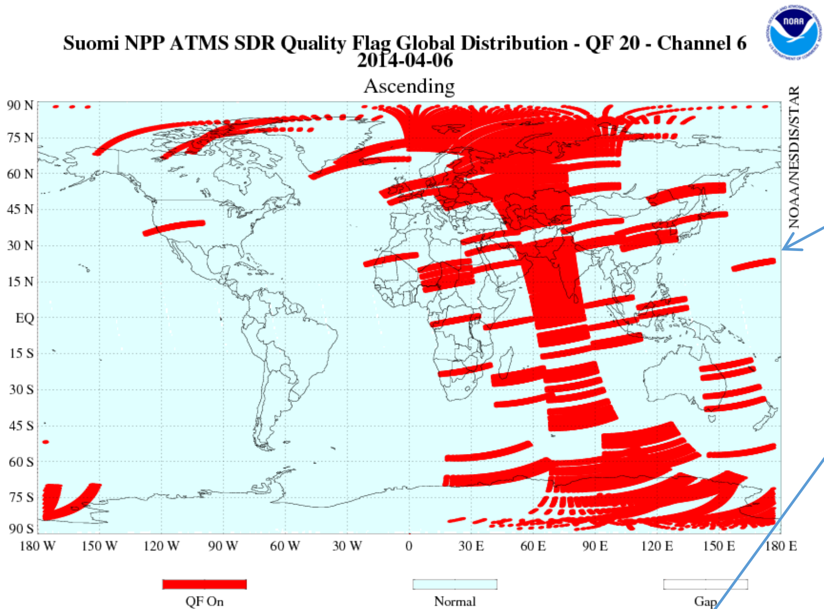


No striping after October 2012 due to the same smoothing method (boxcar) applied

Suomi NPP ATMS Reprocessing



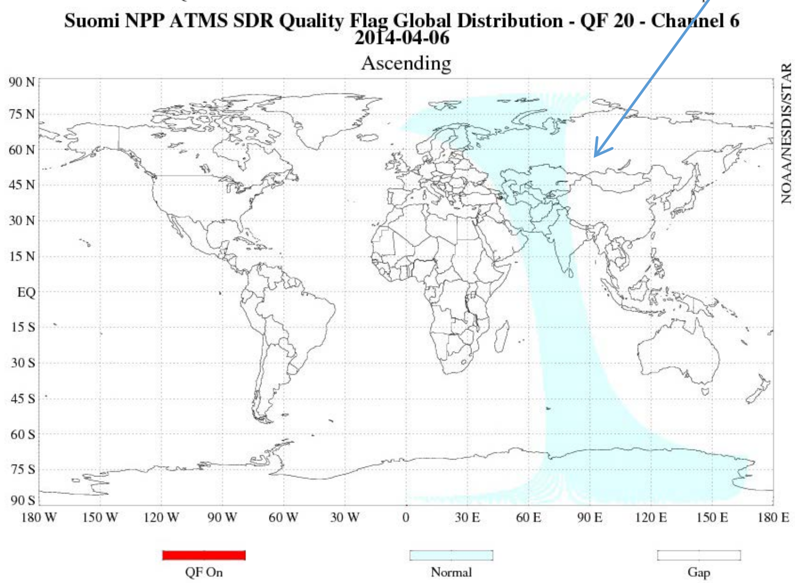
Suomi NPP ATMS Reprocessing

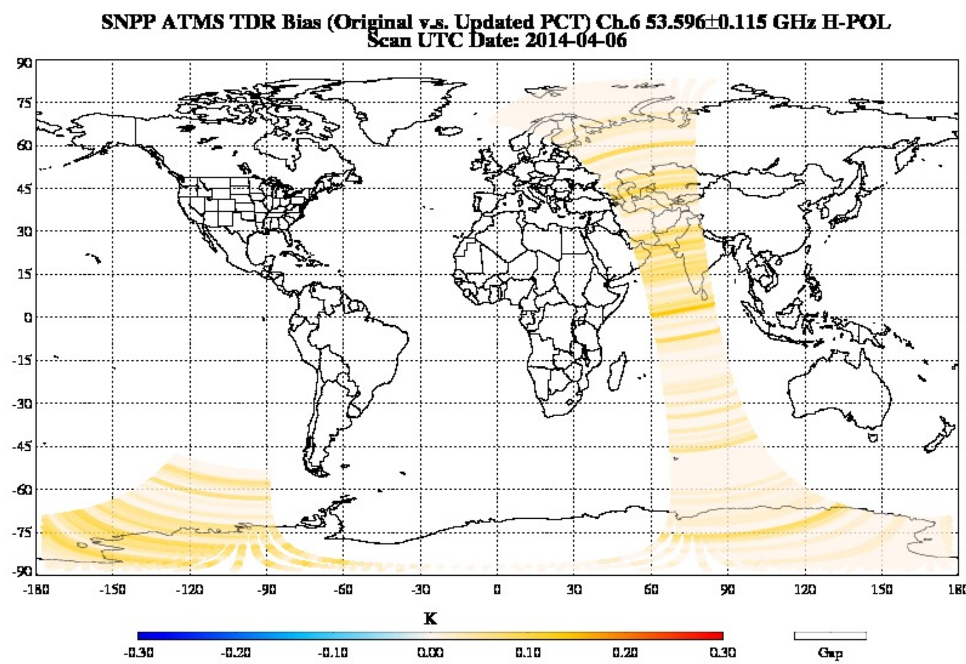


Quality flag triggered before PCT update

Quality flag off after update of PCT

TDR bias before and after PCT update



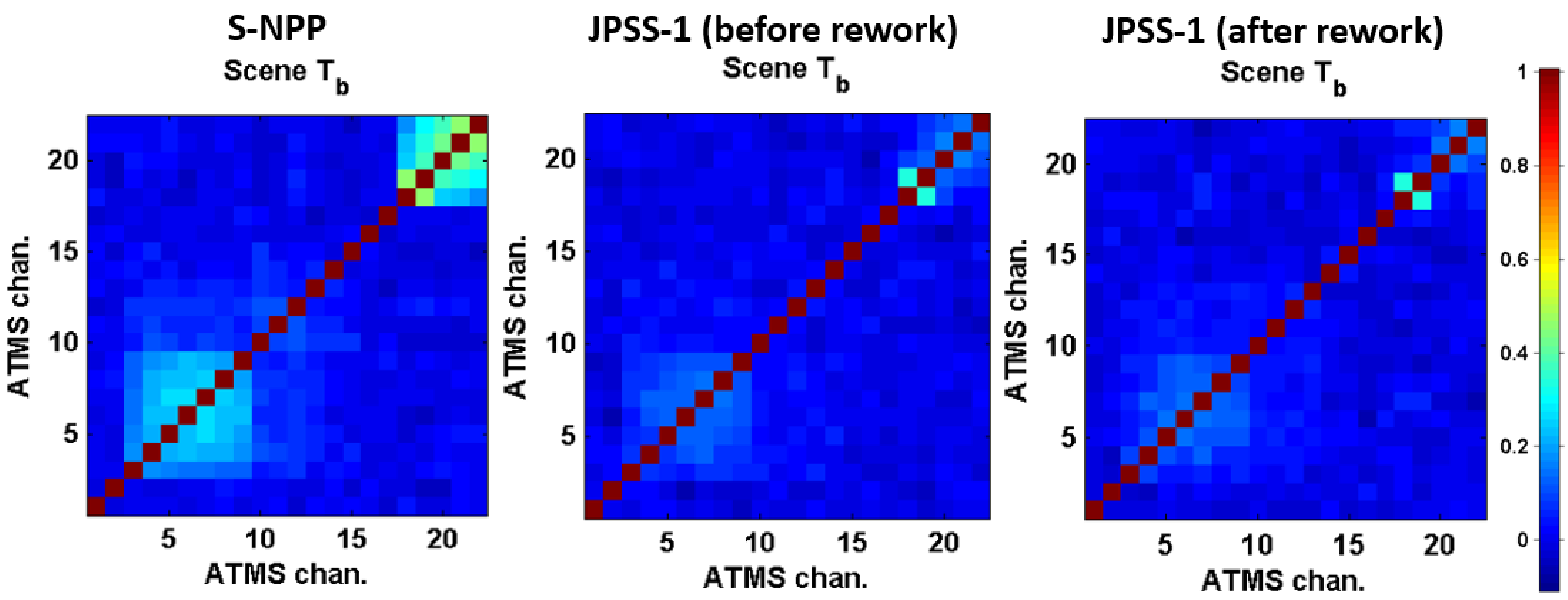


JPSS-1 ATMS Readiness

- Radiance based ATMS SDR calibration algorithm and associated PCT have been approved for operational implementation
- J1 ATMS pre-launch instrument characterization was completed
- J1 ATMS post-rework TVAC data analysis and coefficients generation were performed successfully
- J1 ATMS instrument to spacecraft mounting matrix was generated and updated in J1 PCT
- J1 ATMS channel 17 anomaly in flight unit was observed during EMI testing. Further investigation is ongoing. Now, J1 ATMS EDU is put back to the spacecraft for EMI testing

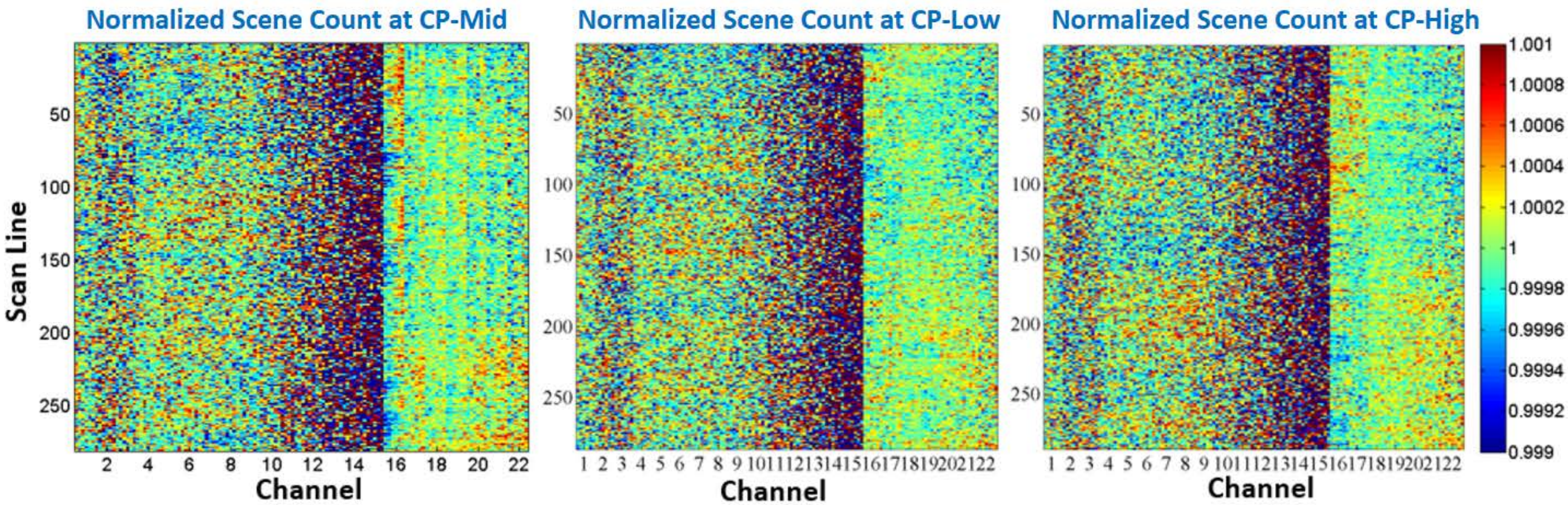
JPSS-1 ATMS Readiness

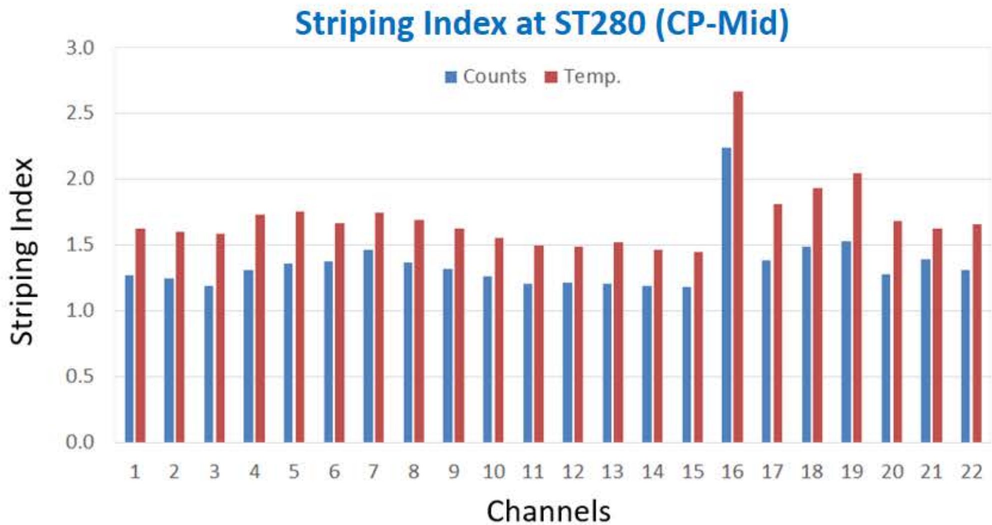
- Overall lower channel correlation observed in JPSS-1 ATMS
- Relatively large channel correlation at channel 18 and 19 is possibly due to the shared harmonics



JPSS-1 ATMS Readiness

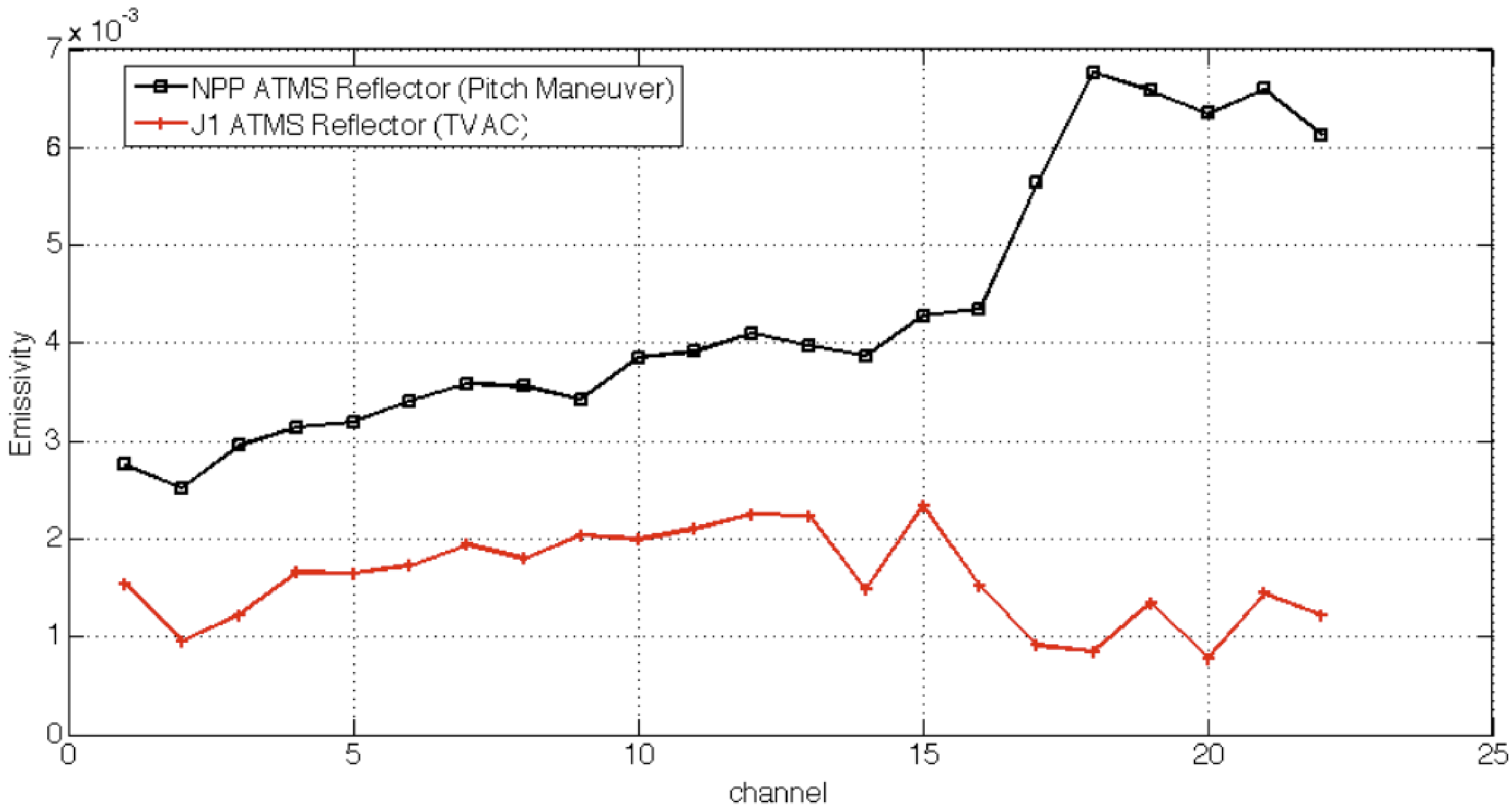
JPSS-1 ATMS presents lower striping noise





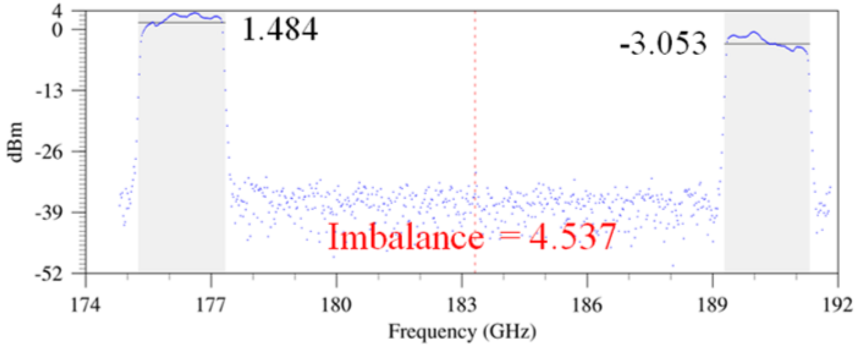
JPSS-1 ATMS Readiness

- ATMS reflector emissivity was retrieved from TVAC test when scene target temperature is close to cold target temperature
- On-orbit emissivity may be changed due to the uncertainty in cold and scene target temperature measurements

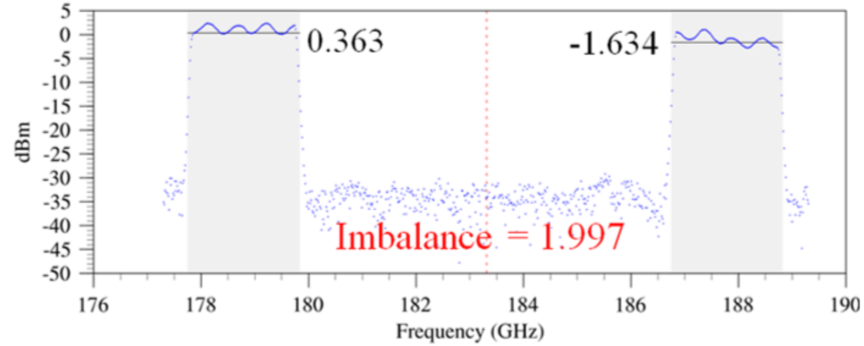


JPSS-1 ATMS Readiness

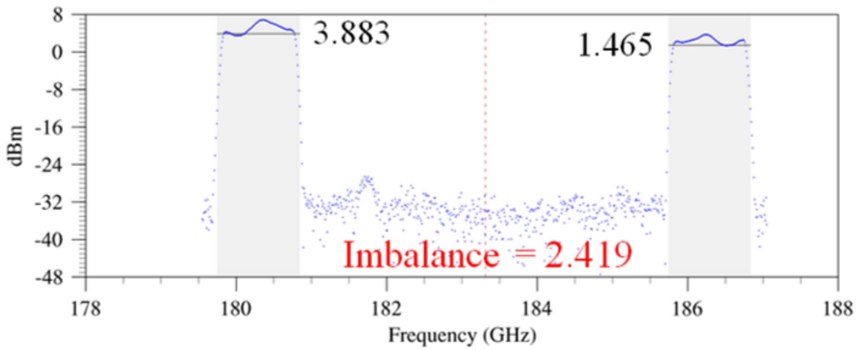
Channel 18: 183.31 ± 7 GHz



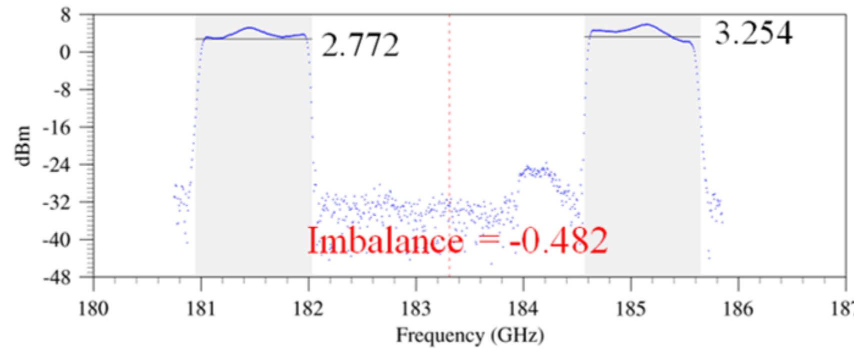
Channel 19: 183.31 ± 4.5 GHz



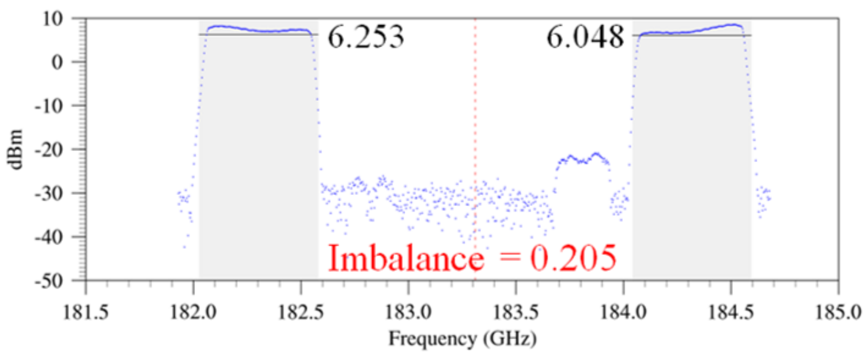
Channel 20: 183.31 ± 3 GHz



Channel 21: 183.31 ± 1.8 GHz



Channel 22: 183.31 ± 1 GHz



	Channel				
	18	19	20	21	22
STAR	4.537	1.997	2.419	-0.482	0.205
NASA	4.949	2.228	2.625	-0.607	0.263
MIT/LL	4.371	1.958	2.387	-0.017	0.061

STAR's imbalance value is comparable with NASA's result.

Summary & Path Forward

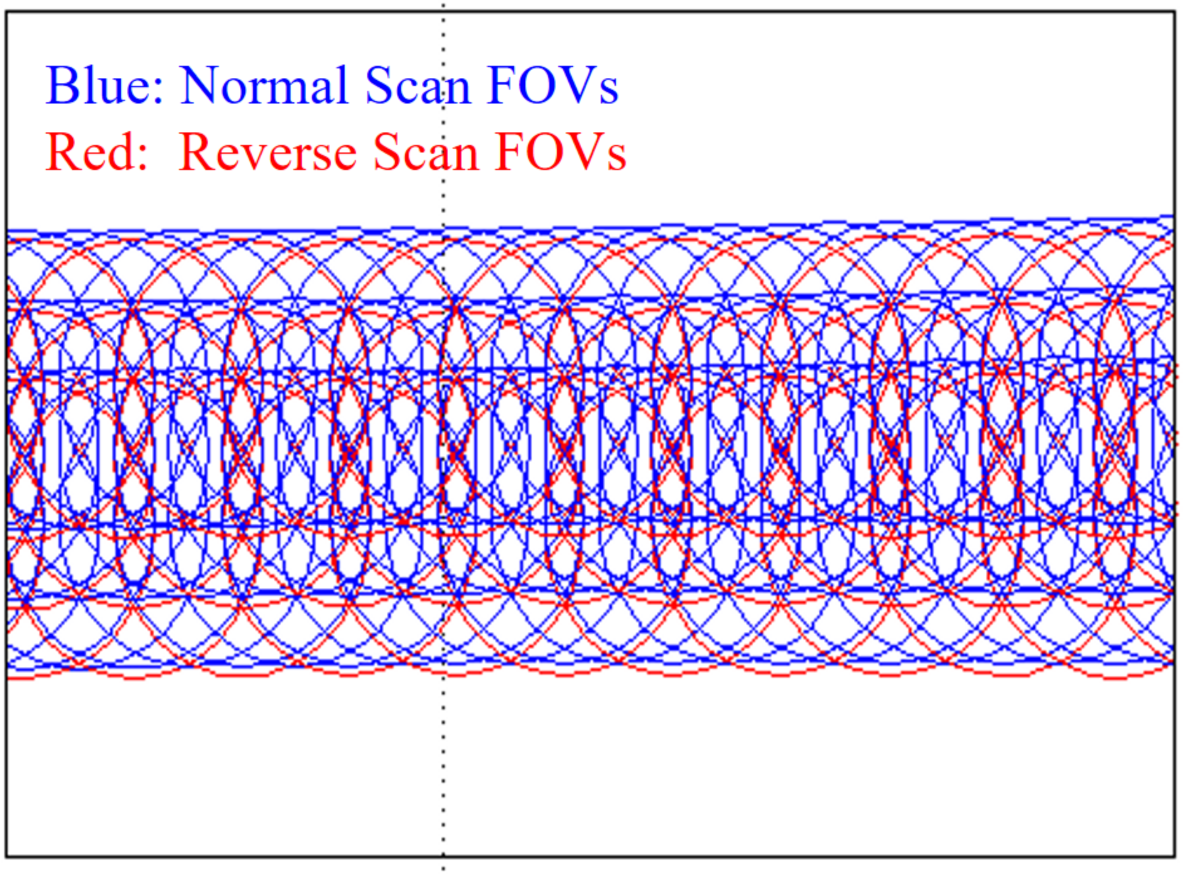
- Summary
  - S-NPP ATMS scan drive motor current increased during the last year. More frequent scan reversal activities can help to reduce motor current
  - S-NPP ATMS on-orbit channel performance meets the requirement with margins
  - JPSSS-1 ATMS post-rework characterization was performed and ground processing system PCT has been updated using newly derived coefficients
  - Radiance based ATMS SDR calibration algorithm has been approved and is waiting for IDPS operational implementation
  - JPSS-1 ATMS flight unit anomalies observed in spacecraft EMI testing are under investigation

Summary & Path Forward

- Path Forward
  - Implement reflector emissivity correction algorithm
  - Revisit JPSS-1 ATMS PCT for launch readiness
  - Work with ATMS SDR team members to support JPSS-1 ATMS post-launch characterization
  - Work with STAR ICVS team for JPSS-1 ATMS health status and performance monitoring
  - Perform additional S-NPP ATMS reverse scan data analysis

Summary & Path Forward

Re-construct normal scan FOVs from reverse scan to minimize impact to data users



- Current scan profile and reversal scan profile are used for the study
- Reverse scan antenna pattern is used as source and normal scan antenna pattern as target function, calculate coefficients for each channel at every normal scan FOV
- Apply the coefficients to reversal scan observations , reconstruct normal observations with 96 FOVs at target FOV size