JPSS DPA Program Planning Meeting
ATMS SDR Team

September 18, 2012

Outline

- Team Membership
- FY-12 Accomplishments
- Scientific Advancements
- Issues, Challenges, Setbacks
- Changes in Strategy due to funding constraints
- FY-13 Schedule and Milestones
- Path Forward (FY-14 thru FY-16)
- Summary

ATMS Team Membership

PI Name	Organization	Team Members	Funding Agency	FY13 Task
Fuzhong Weng	NOAA/STAR	N. Sun, T. Mo, X. Zou, Lin Lin, Li Bi	NJO	Support NPP/J1 Calval
Edward Kim	NASA	Joseph Lyu	NJO	Support NPP/J1 Calval
William Blackwell	MIT/LL	V. Leslie, C. Cull, I. Osaretin, R. Czerwinski, J. Samra, M. Tolman	NJO	Support NPP/J1 Calval
Neal Baker	DPA	M. Denning	NJO	Support NPP/J1 Calval
Kent Anderson	NGES	M. Landrum	NASA	Support NPP/J1 Calval
Degui Gu	NGAS	A. Foo, G. Amici	NASA	Support Transition
Wael Ibrahim	Raytheon		NASA	Support NPP/J1 Calval
Kris Robinson	USU/SDL		NJO	Support NPP/J1 Calval

ATMS SDR Requirements

#	Channel Freq.(MHz)	Polarization	Bandwidth Max. (MHz)	Freq. Stability (MHz)	Calibration Accuracy	Nonlinearity Max. (K)	NEΔT (K)	3-dB BW* (deg)
1	23800	QV	270	10	0.83	0.1	0.5	5.2
2	31400	QV	180	10	0.83	0.1	0.6	5.2
3	50300	QH	180	10	0.67	0.075	0.7	2.2
4	51760	QH	400	5	0.67	0.075	0.5	2.2
5	52800	QH	400	5	0.67	0.075	0.5	2.2
6	53596±115	QH	170	5	0.67	0.075	0.5	2.2
7	54400	QH	400	5	0.67	0.075	0.5	2.2
8	54940	QH	400	10	0.67	0.075	0.5	2.2
9	55500	QH	330	10	0.67	0.075	0.5	2.2
10	f_o=57290.344	QH	330	0.5	0.67	0.075	0.75	2.2
11	$f_o \pm 217$	QH	78	0.5	0.67	0.075	1.0	2.2
12	$f_o \pm 322.2 \pm 48$	QH	36	1.2	0.67	0.075	1.0	2.2
13	$f_o \pm 322.2 \pm 22$	QH	16	1.6	0.67	0.075.	1.5	2.2
14	$f_o \pm 322.2 \pm 10$	QH	8	0.5	0.67	0.075	2.2	2.2
15	$f_o \pm 322.2 \pm 4.5$	QH	3	0.5	0.67	0.075	3.6	2.2
16	88200	QV	2000	200	0.95	0.1	0.3	2.2
17	165500	QH	3000	200	0.95	0.1	0.6	1.1
18	183310± 7000	QH	2000	30	0.95	0.1	0.8	1.1
19	183310± 4500	QH	2000	30	0.95	0.1	0.8	1.1
20	183310± 3000	QH	1000	30	0.95	0.1	0.8	1.1
21	183310± 1800	QH	1000	30	0.95	0.1	0.8	1.1
22	183310± 1000	QH	500	30	0.95	0.1	0.9	1.1

FY12 STAR ATMS SDR Tasks

Task	Task Description
1	ATMS SDR Team Management and Coordination
2	Review and Approve the SDR DRs (Discrepancy Reports)
3	ATMS SDR Algorithm Development, Refinement and Maintenance
4	ATMS Radiometric and Data Quality Long-Term Monitoring (LTM)
5	ATMS Channel Noise Characterization
6	ATMS PRT Temperature Uniformity Check
7	ATMS Geolocation Accuracy Assessment
8	ATMS Optimal Space View Sector Selection
9	ATMS Scan Dependent Bias and Beam Efficiency Characterization
10	Characterization of Onboard ATMS Absolute Calibration Bias using GPSRO Data
11	ATMS SDR PCT update
12	Assessment of ATMS Lunar Intrusion Detection Algorithm
13	Characterization of ATMS Noise using Alternative BG

FY-12 Team Accomplishments (1/3)

- NPP First image and IDPS code verification/fix
  - NPP first SDR image (ATMS) was created by STAR on November 8th, 2011
  - IDPS code bugs were found and fixed; PCT update was performed

- Completion of Early-Orbit-Checkout (EOC)
  - The Team actively supports and participated in the EOC activities
  - Completed 85% of EOC Cal/Val tasks
  - ATMS SDR beta maturity review on January 13th, 2012
  - ATMS SDR beta release approved on February 10th, 2012
  - ATMS Remap SDR beta release approved on August 29th, 2012
  - TDR beta maturity from December 9th, 2011; Remap SDR beta maturity from April 19th, 2012

- Delivered/Developed:
  - BOEs and SOWs
  - Weekly/monthly reports
  - Two papers published in JGR/IEEE GSRL

FY-12 Team Accomplishments (2/3)

- ATMS SDR Calibration and Validation
  - Radiometric Sensitivity Evaluation/Channel Noise Characterization
  - Temperature Stabilization
  - Optimal Space View Sector Selection
  - Dynamic Range Evaluation
  - Lunar Intrusion Evaluation
  - Geolocation verification
  - Ascending/Descending comparisons
  - SDR Validation by NWP
  - Roll/Pitch Maneuvers for Beam Efficiency and Scan Dependent Bias Characterization
  - Remap SDR Evaluation
  - Onboard Calibration Bias Evaluation by GPS/RO

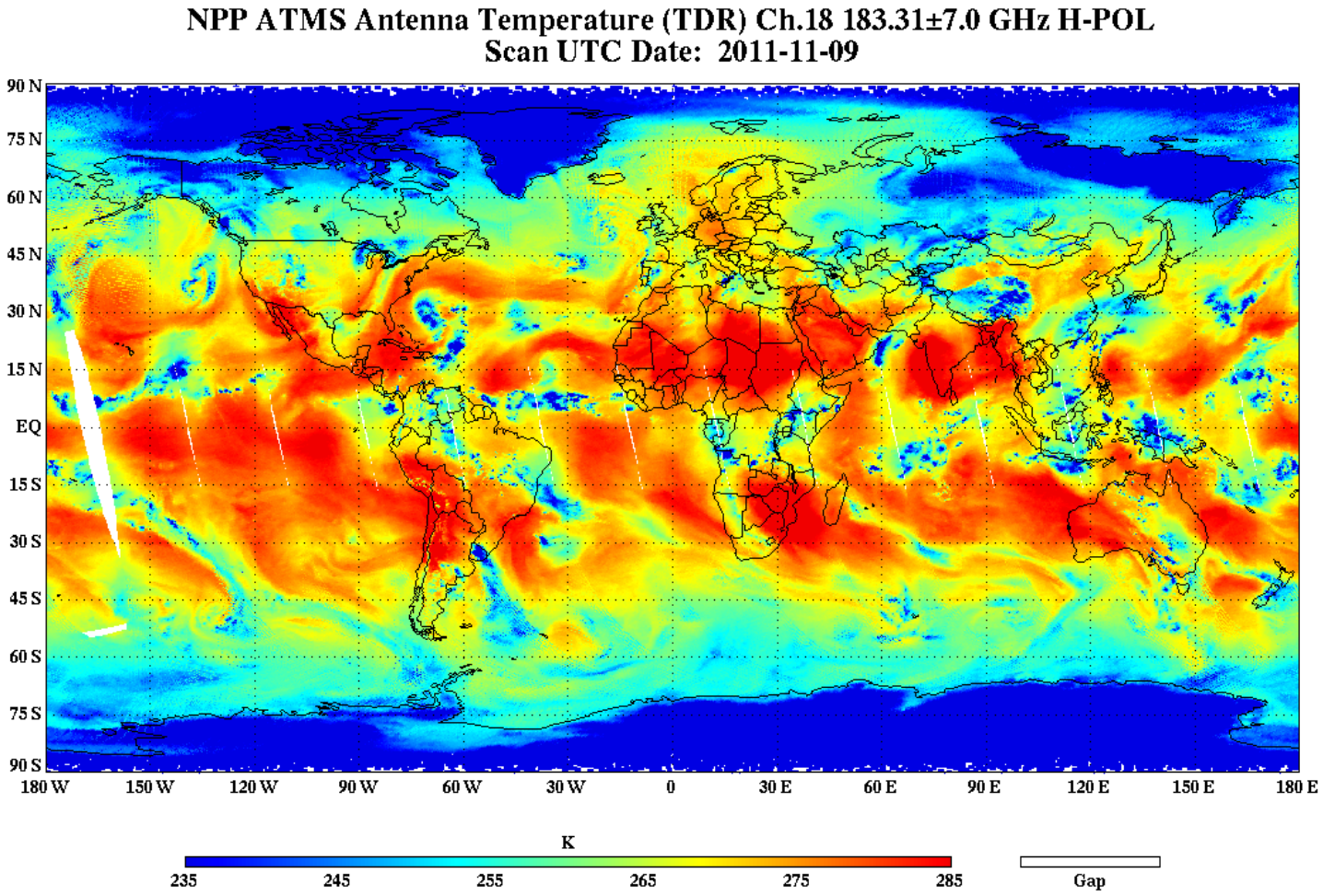
FY-12 Team Accomplishments (3/3)

- ATMS SDR team building and interactions
  - Weekly telecons to facilitate communications
  - Recognized forum for technical interactions among NASA/NOAA, SDR/EDR, Government/contractor
  - Team approach to addressing DRs

- Technical capability development
  - Data access
  - ATMS software tools for data analysis
  - Ability to run ADL3.0 with modified LUTs
  - NG LUT tutorial

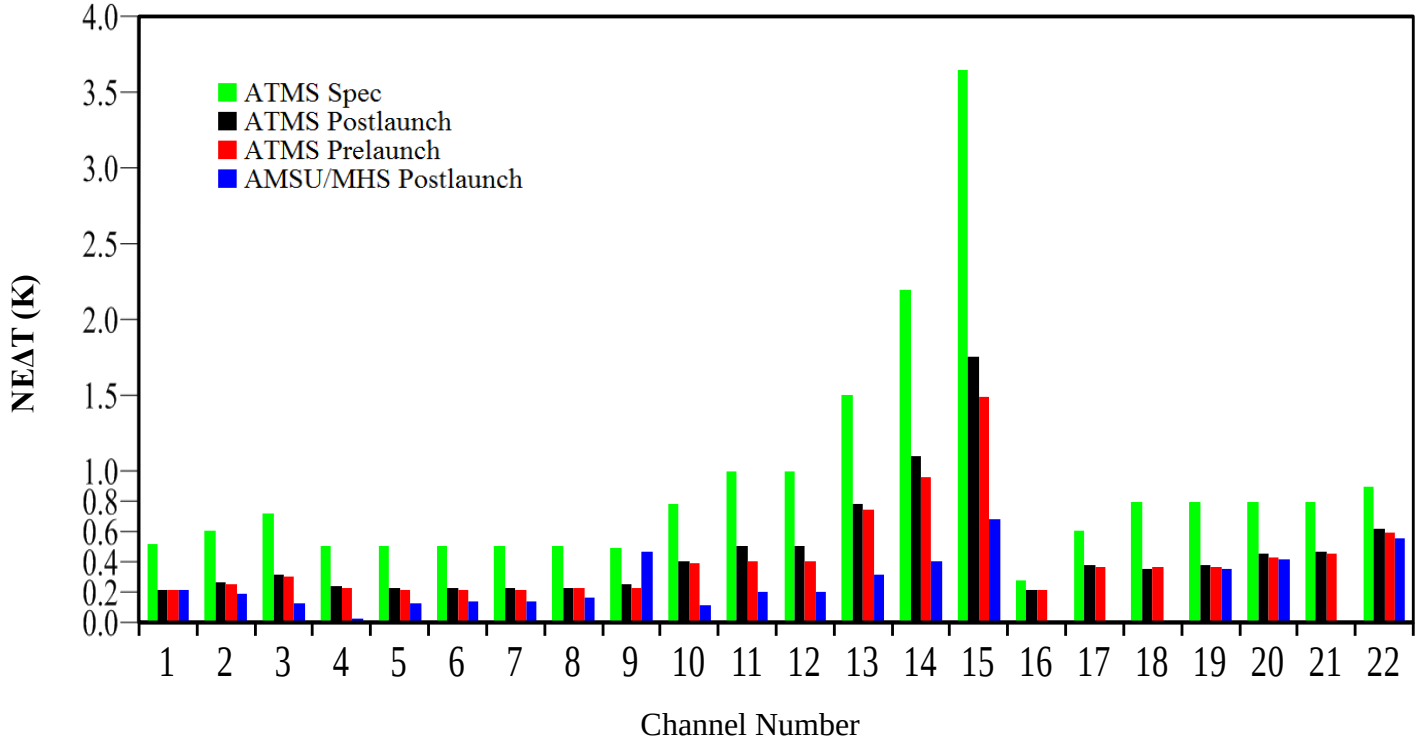
- User outreach
  - Tutorial at IGARSS
  - Calcon Conference presentations

NPP First Image (ATMS)



ATMS TDR at Channel 18 on 09-November-2011 produced by NESDIS/STAR

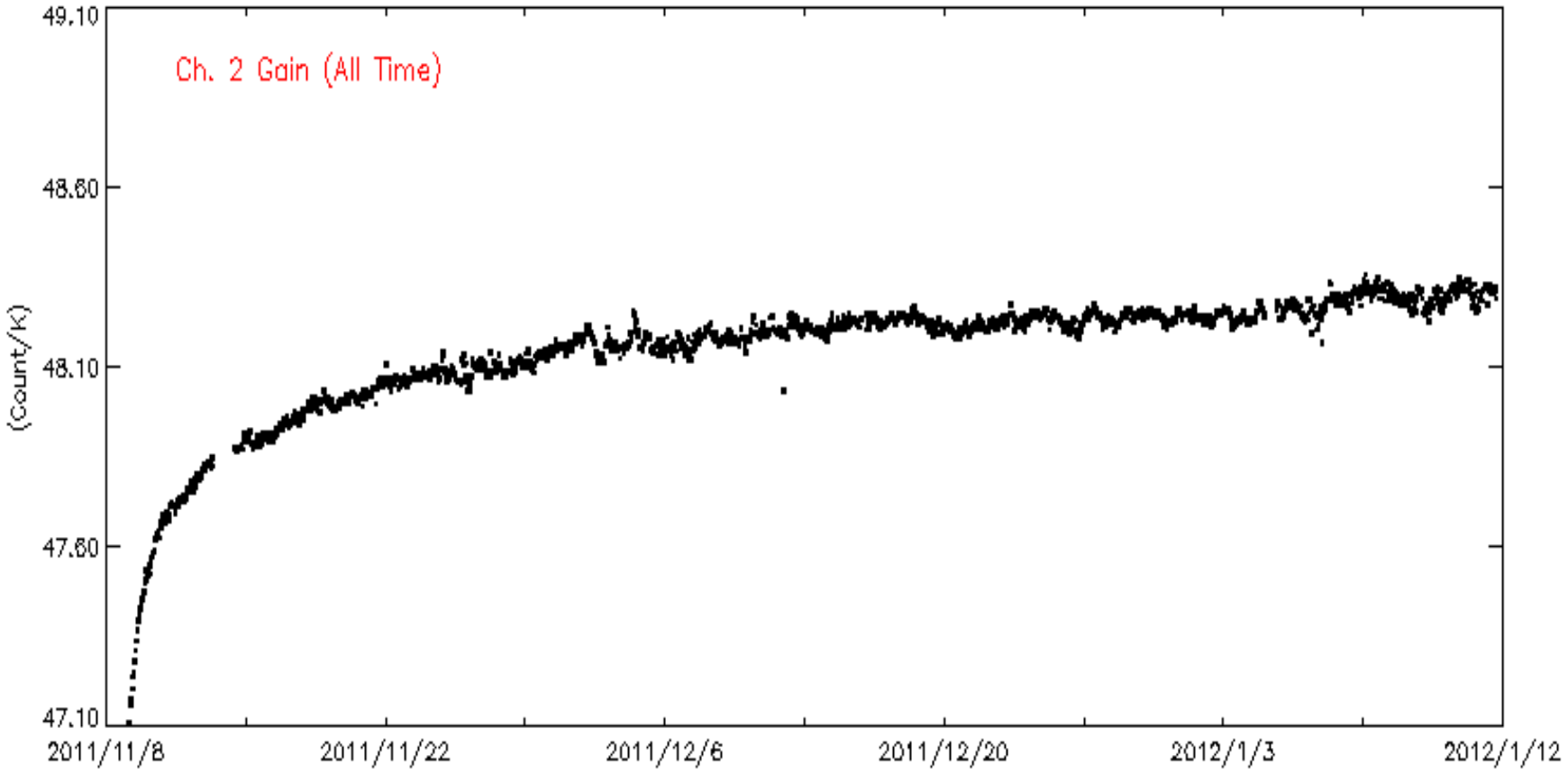
Channel Noise Characterization



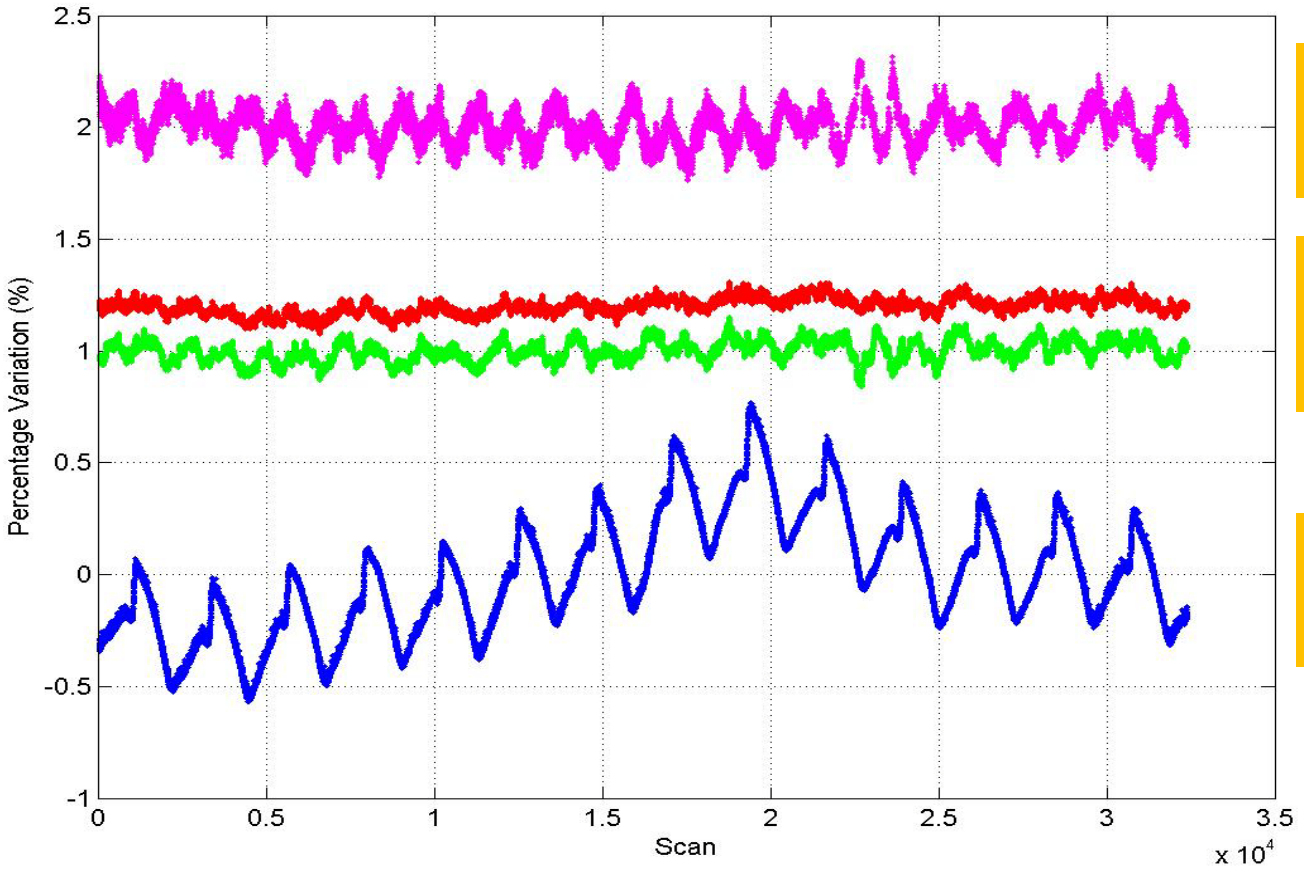
All Channels are within Specifications

Slide courtesy of STAR

ATMS Calibration Gain at Channel 2



Calibration Target Consistency Check



GAIN Variability (%). Shifted 2%

Warm (R) and Cold (G) Counts Variability (%). Shifted 1-1.2%

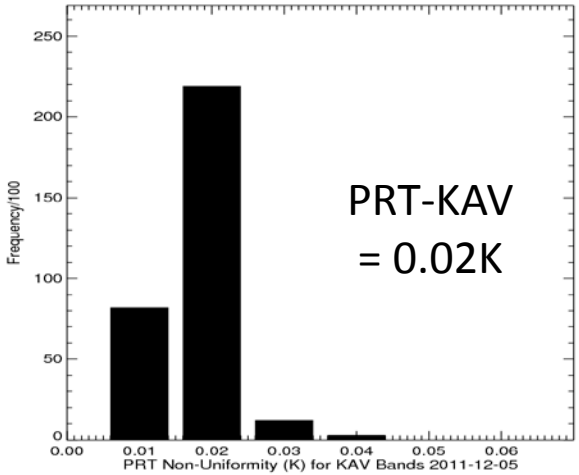
PRT Temperature Variability (%)

Slide courtesy of NGAS

ATMS calibration data consistency check. Channel 16. Nov 18, 2011. Data downloaded from GTP. Cold counts have more variability than warm counts, and gains also show significant variability. Need further investigation and assessment of impact on SDR quality

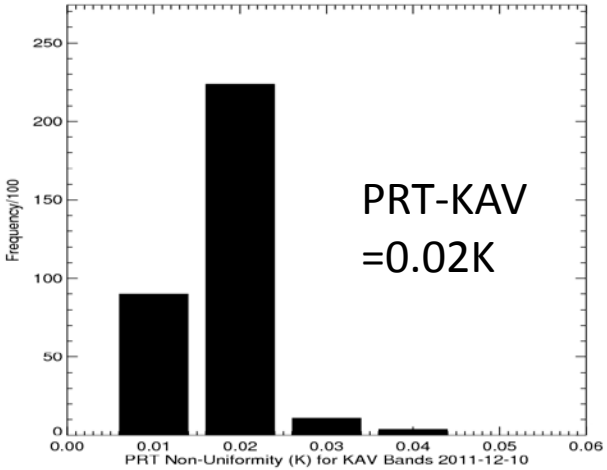
ATMS PRT Uniformity Check

12-05-2011



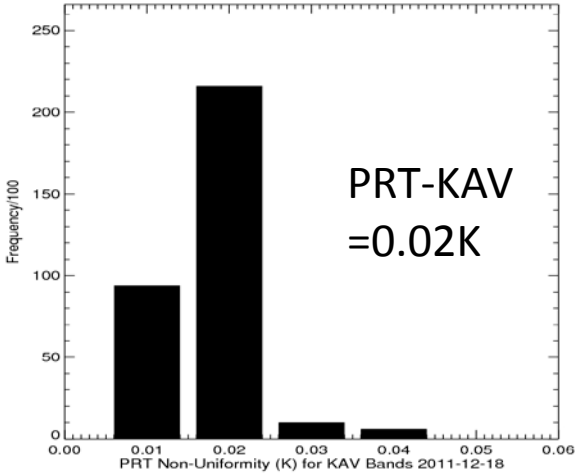
PRT-KAV
= 0.02K

12-10-2011

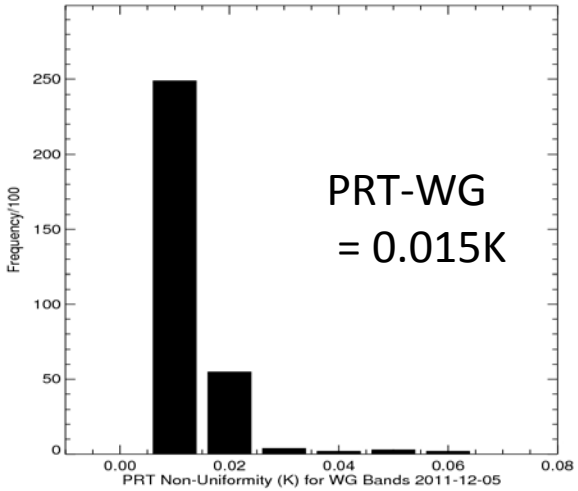


PRT-KAV
=0.02K

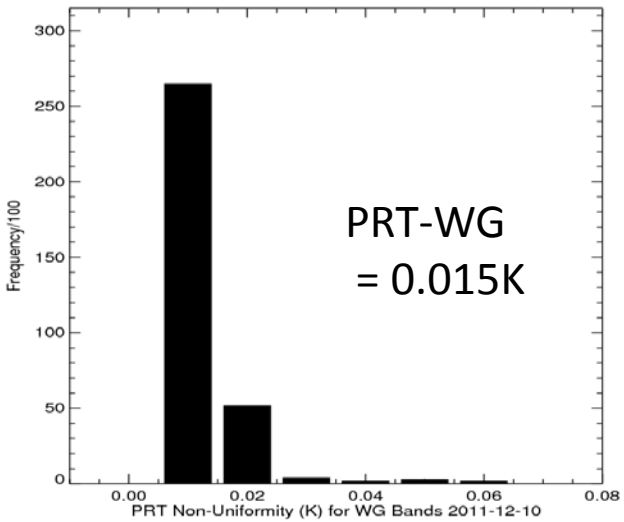
12-18-2011



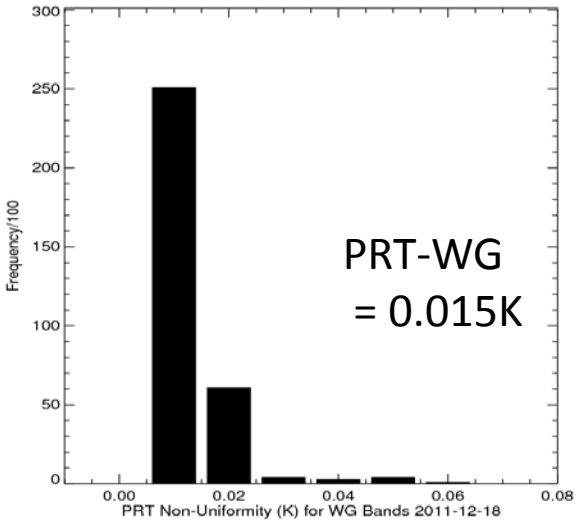
PRT-KAV
=0.02K



PRT-WG
= 0.015K

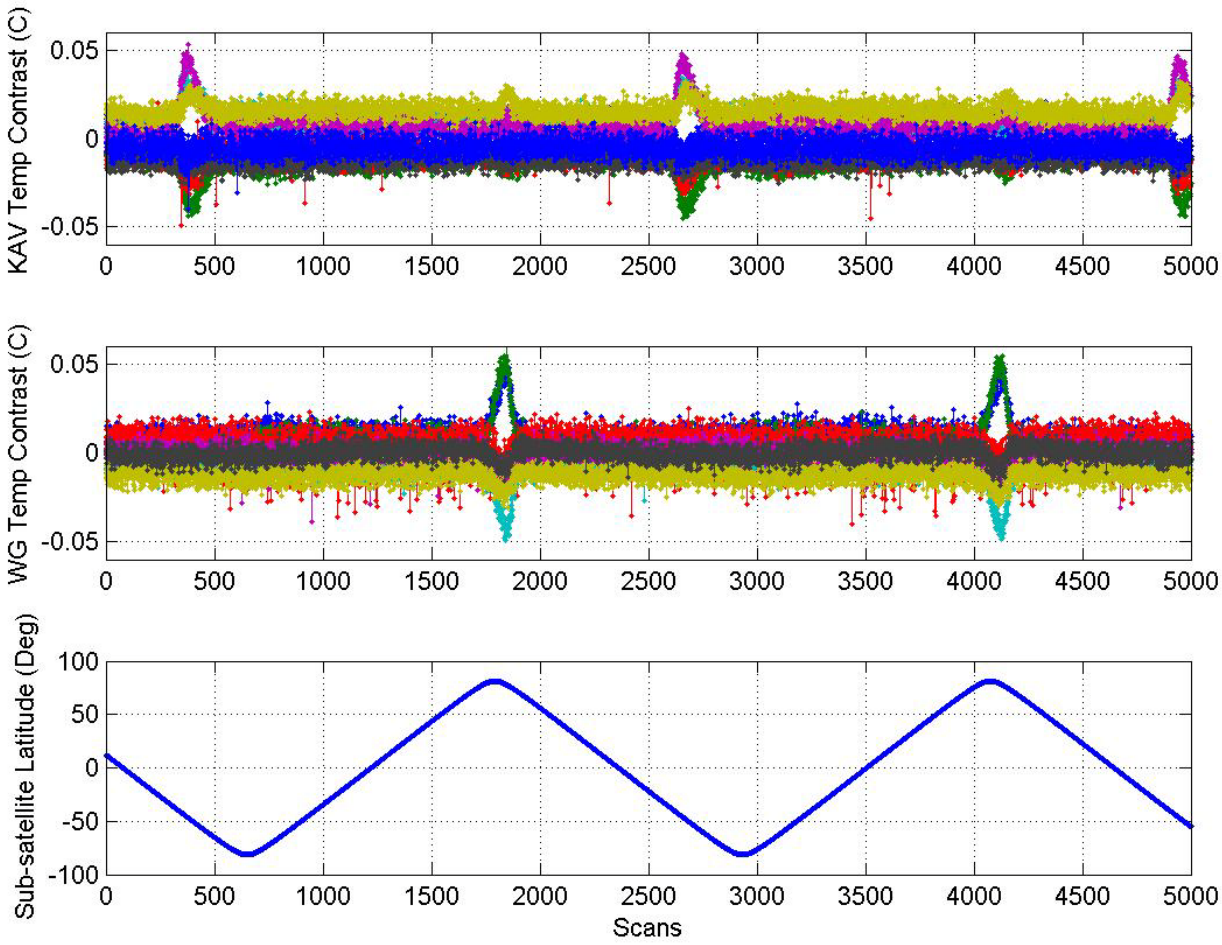


PRT-WG
= 0.015K



PRT-WG
= 0.015K

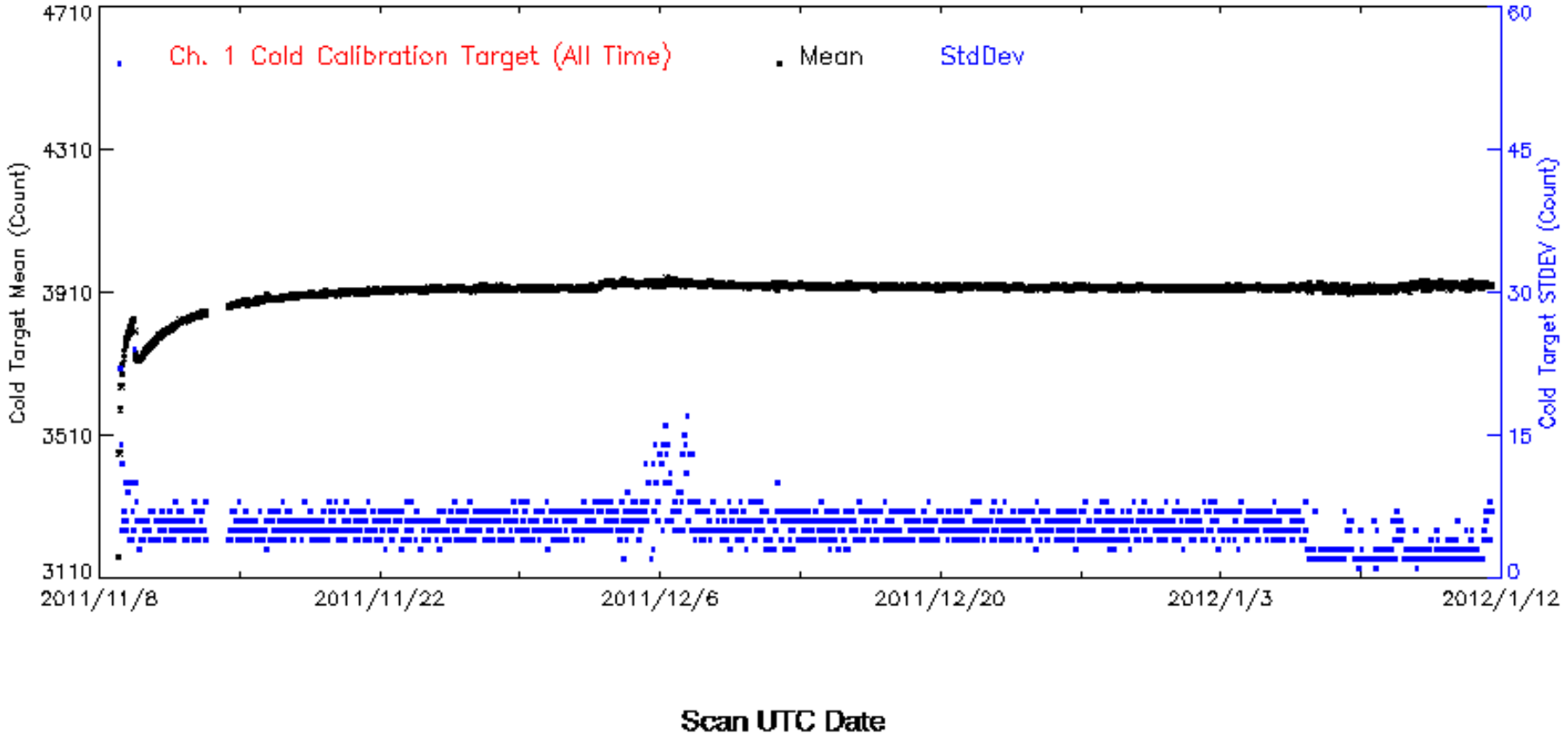
PRT Temperature Uniformity Check



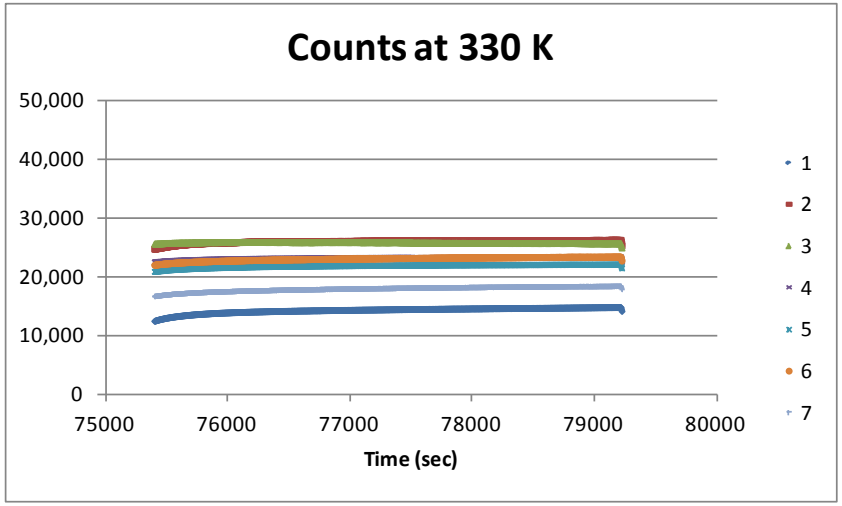
Slide courtesy of NGES

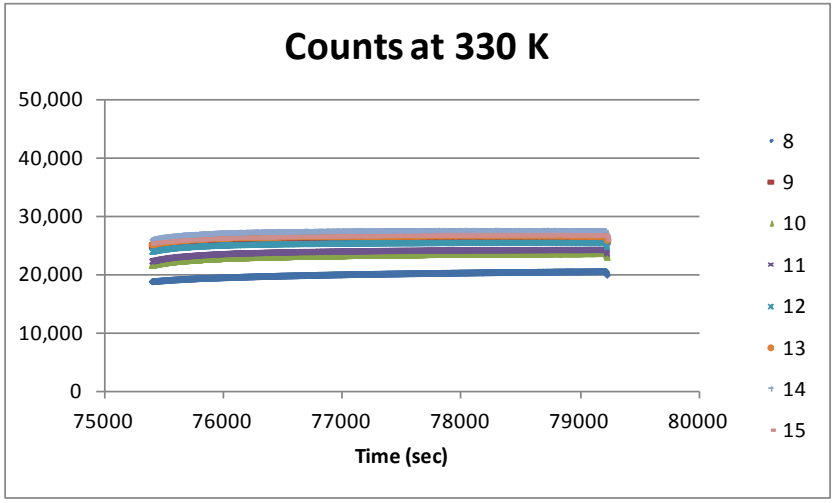
Warm load PRT temperature contrast spiked around the north pole for the WG bands. Similar spikes occurred at ~45 degree south for the KAV bands

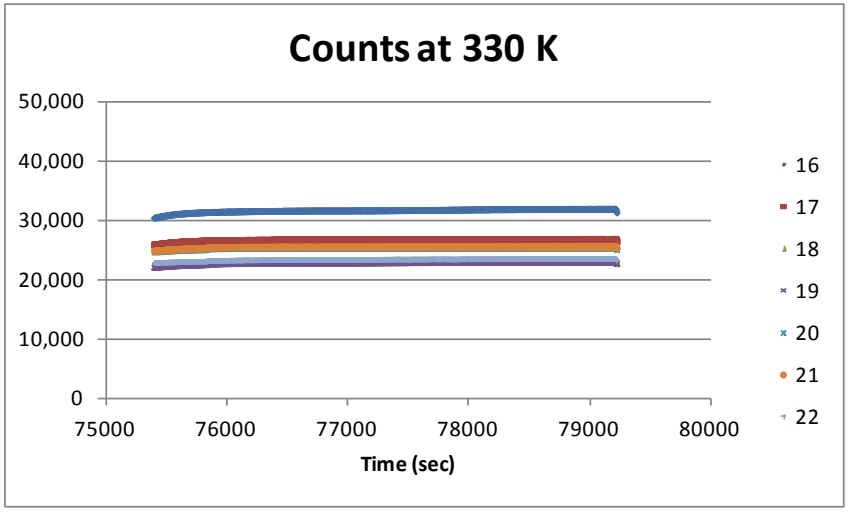
ATMS Dynamic Range Evaluation (Cold)



ATMS Dynamic Range Count (Warm)





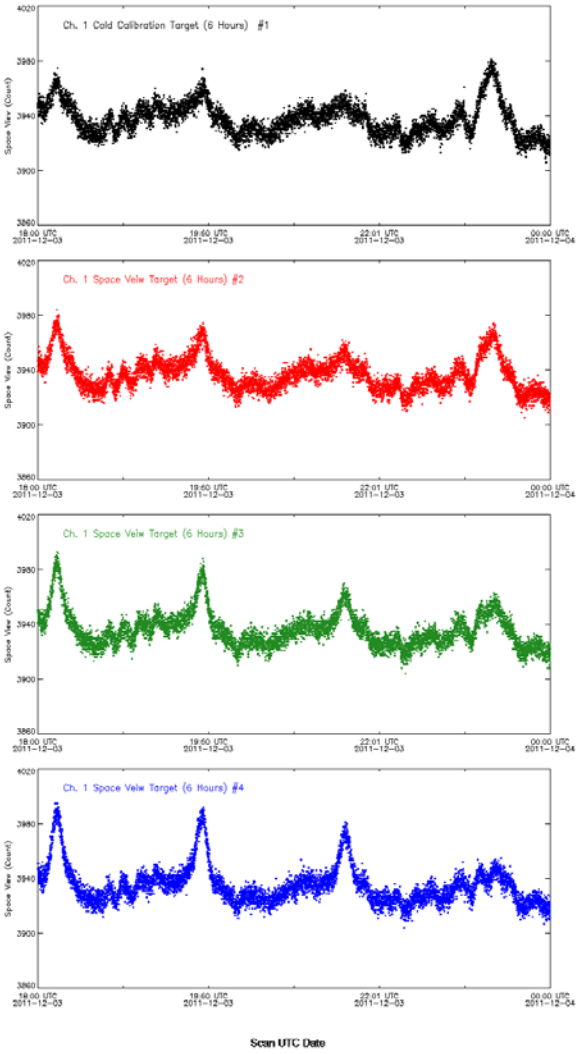


- Dynamic range is assessed by comparison to requirement that maximum allowable radiometric counts, for any channel, shall be < 45,150
- The dynamic range assessment is done by extrapolating the warm target counts to a 330 K temperature, using gains computed from on-orbit data.
- As shown in chart, for orbit 163, all channels consistently met the criterion that counts (330K) < 45,150. Over 13,100 counts margin relative to 45,150 limit. Dynamic range requirements are satisfied

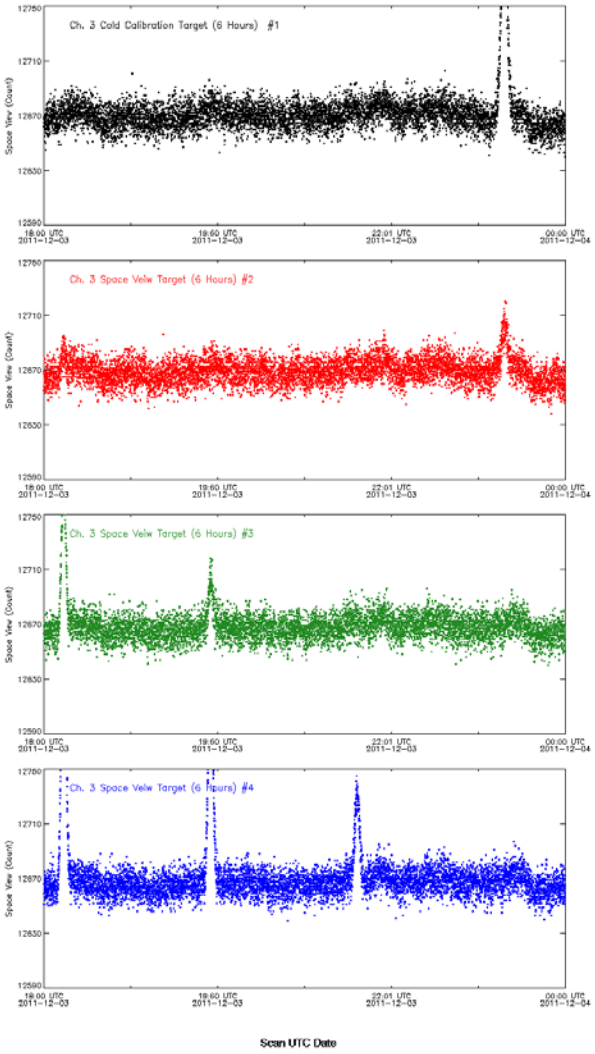
Slide courtesy of NGES

Lunar Intrusion Detection

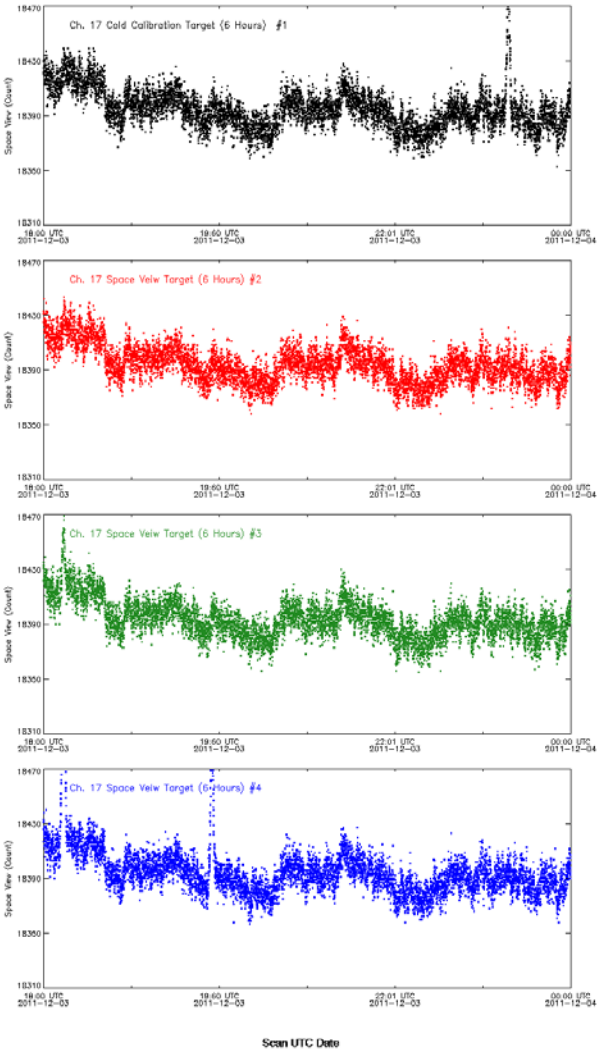
Channel 1 (FOV Size:5.2)



Channel 3 (FOV Size: 2.2)

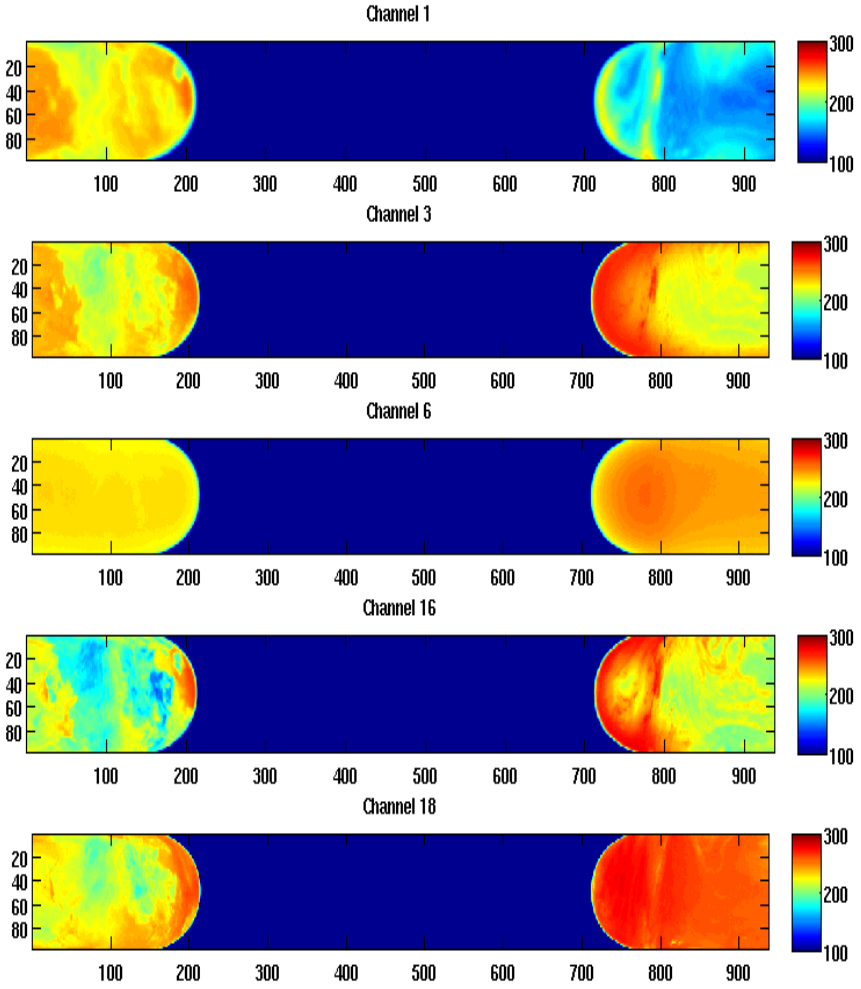


Channel 17 (FOV Size: 1.1)



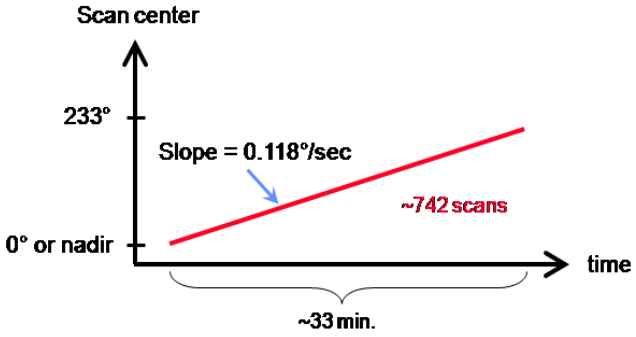
Slide courtesy of STAR

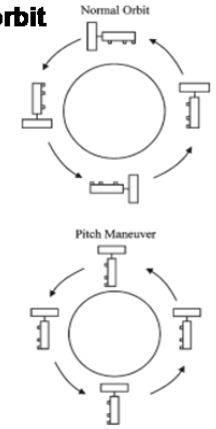
Pitch Over Maneuver



NPP Pitch Maneuver

- **Normal scan mode (scan period of 2.666 sec; two cal. loads)**
- **Constant pitch maneuver at 0.118°/sec for 33 minutes (~233°)**
- **Orbital pitch rate is 0.064°/sec, which will make up the rest of the 127°**
- **Moves ~0.485° per scan**
- **Maneuver starts at the terminator crossing of day to night (night portion of an orbit)**
- **NPP will essentially do a "back flip" during 1/3 of the orbit**



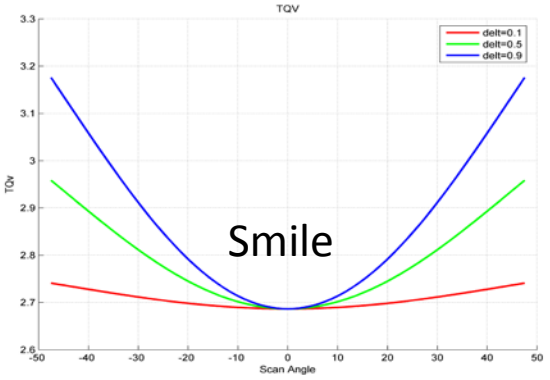


Slide courtesy of MITLL

ATMS Pitch Maneuver Antenna Temperature Model

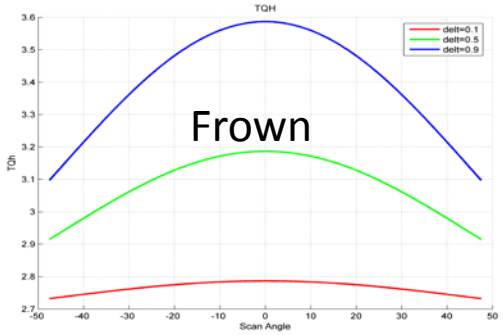
A smile pattern QV- antenna temperature:

$$T_a^{v_q} = (\eta_m^{vv} + \eta_m^{hv})T_b^c + \beta_0^v + \beta_1^v \sin^2\theta$$



A frown pattern QH- antenna temperature:

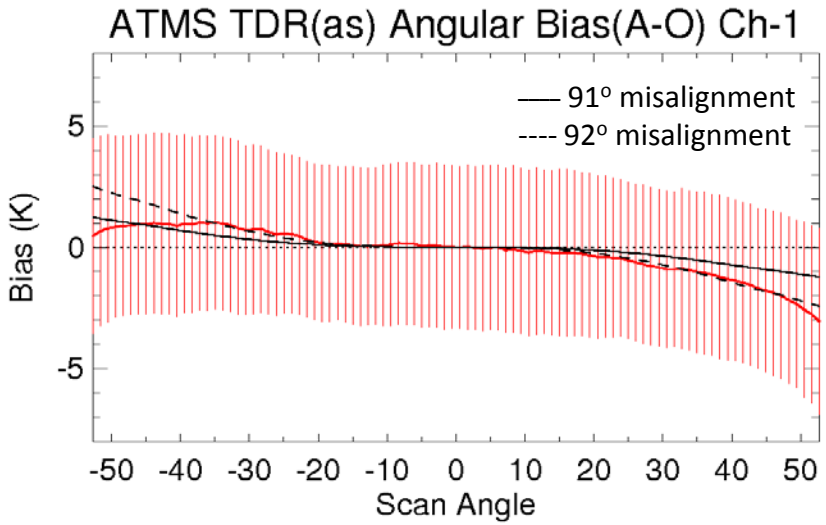
$$T_a^{h_q} = (\eta_m^{hh} + \eta_m^{vh})T_b^c + \beta_0^h + \beta_1^h \cos^2\theta$$

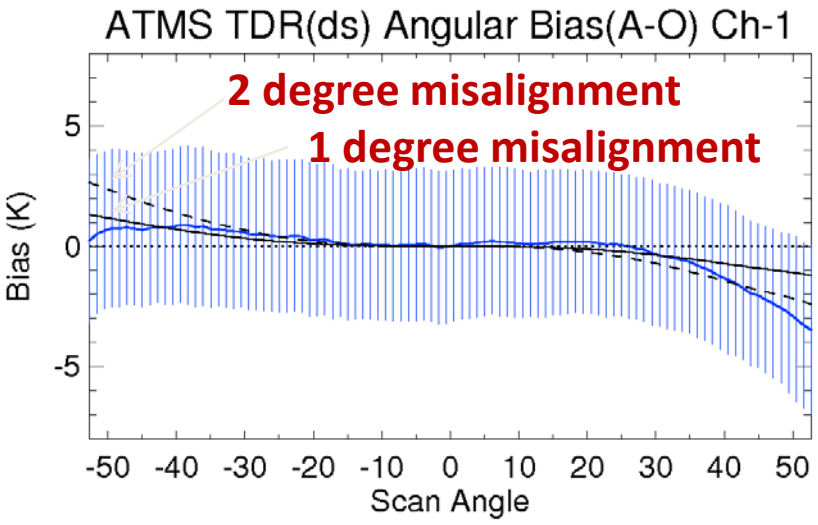


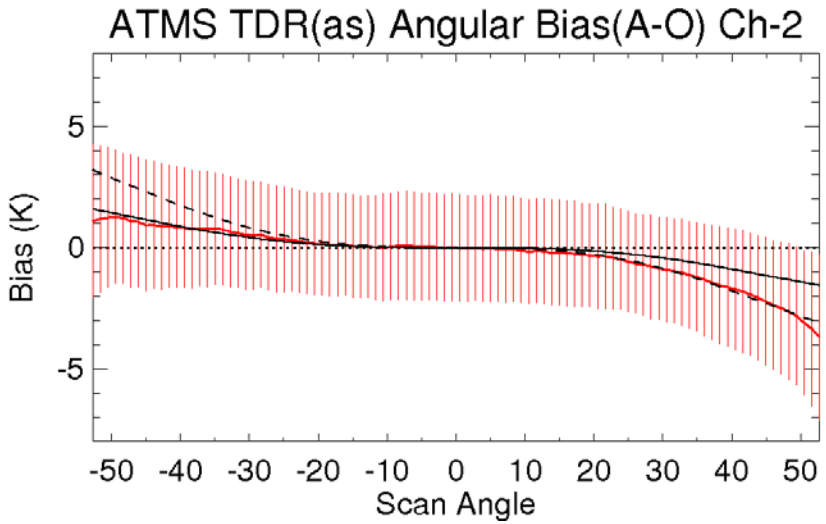
Weng, F., Y., Hu, X. Zou, 2012: On Convertibility from Antenna to Sensor Brightness Temperature for Advanced Technology Microwave Sounder (ATMS) , *IEEE Geoscience and Remote Sensing Letters*, (conditionally accepted)

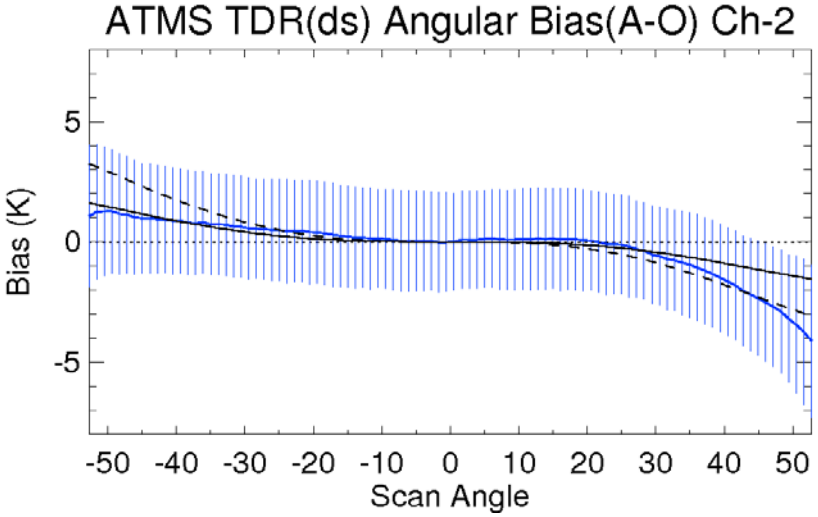
ATMS TDR Along-Scan Asymmetry

Angular dependent bias (A-O) Dec, 16-22, 2011
CRTM Sim: GSI analysis field ; OBS: ATMS TDR

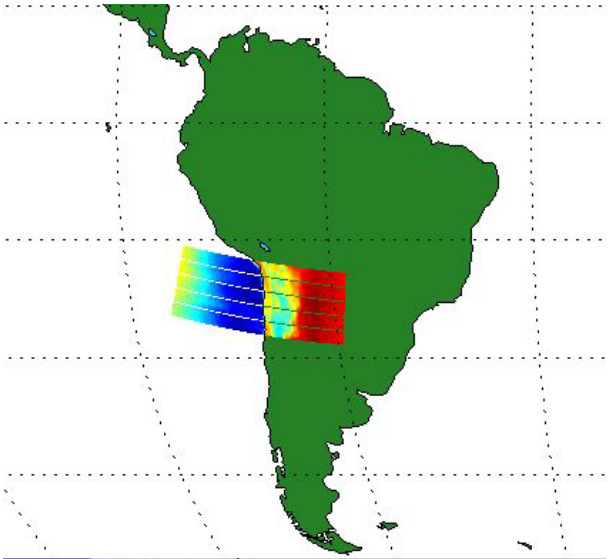


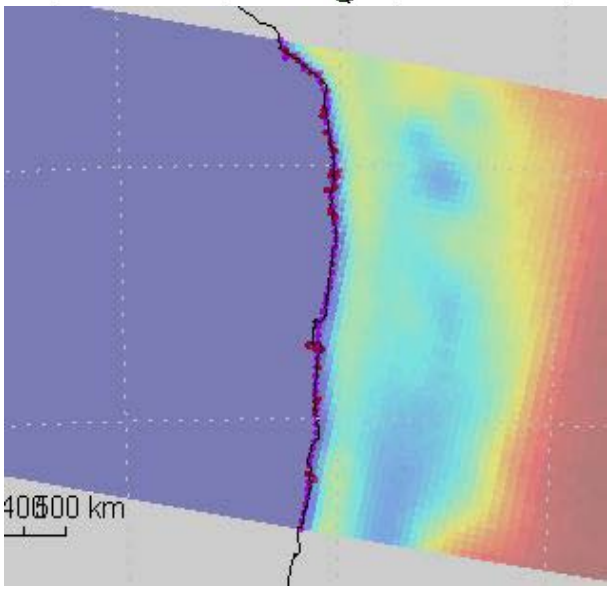




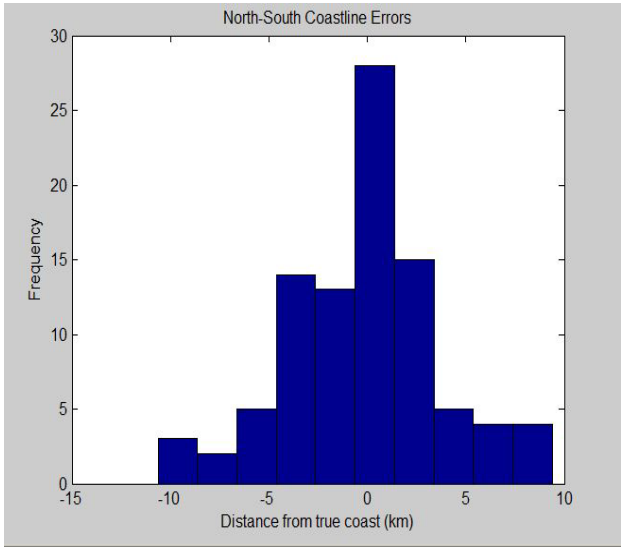


Geolocation Verification

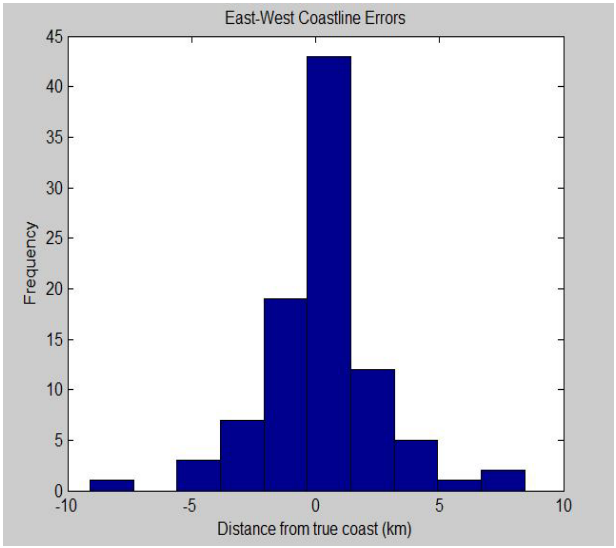




North – South
Mean -0.15km
0.01°
Std. Deviation
3.98km 0.28°



East – West
Mean -.027km
0.02°
Std. Deviation
2.34km 0.16°

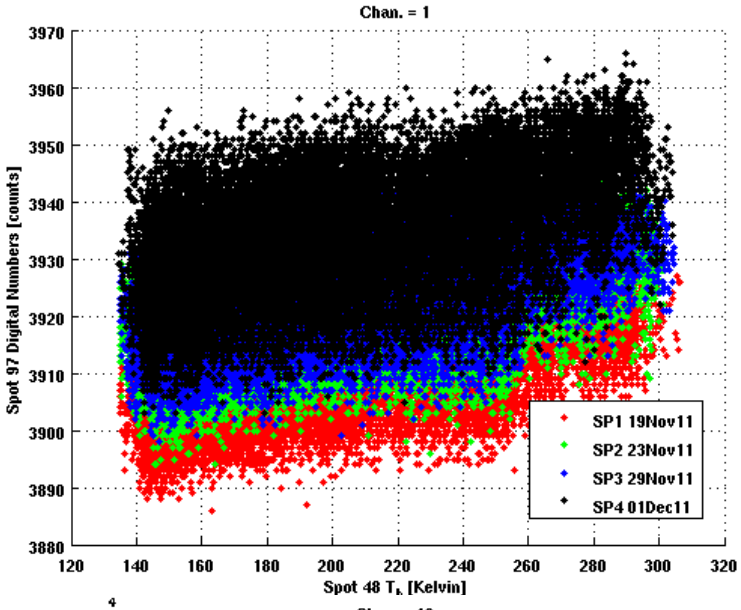


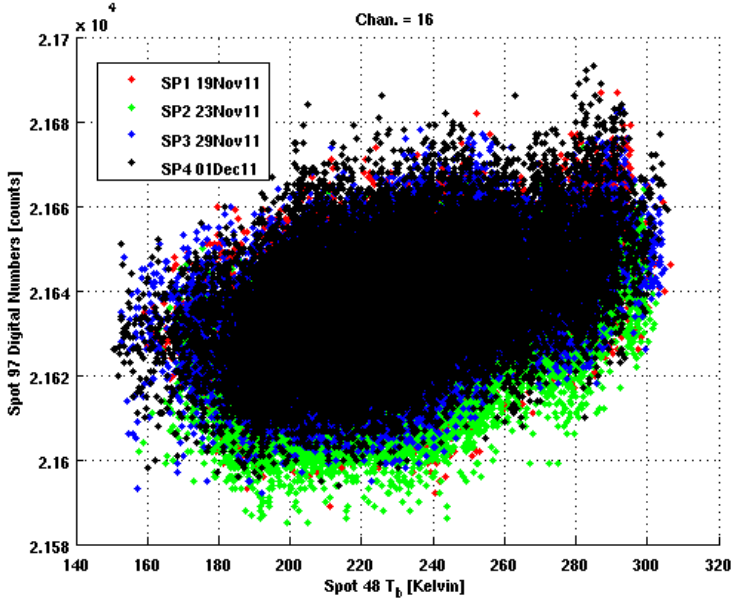
Optimal Space View Selection

Slope	Channel	SP1	SP1	SP1	SP2	SP2	SP2	SP2	SP2	SP2	SP3	SP3	SP4	SP4	Optimal	Second
count/day		1	2	3	4	5	6	7	8	9	10	11	12	13	Space View	Choice
1.343736	1	3919.602	3921.889	3923.185	3922.711	3923.057	3921.504	3922.7	3919.976	3918.463	3917.439	3915.725	3923.761	3927.438	SV3	SV2
2.695055	2	11324.37	11329.68	11329.18	11328.49	11325.39	11325.8	11325.7	11324.4	11324.91	11329.41	11330.62	11325.72	11326.63	SV1	SV2
1.845604	3	12650.17	12643.83	12645.08	12644.14	12644.39	12645.65	12646.4	12645.25	12641.11	12641.26	12646.32	12648.77	12647.83	SV2	SV3
0.354396	4	10969.93	10964.37	10965.92	10964.26	10962.41	10964.45	10966.1	10964.95	10960.69	10960.74	10965.58	10968.13	10969.27	SV2	SV3
-0.49011	5	10635.26	10629.15	10629.84	10629.53	10626.72	10628.21	10629	10627.39	10625.58	10625.87	10630.26	10632.25	10634.74	SV2	SV3
-0.56813	6	11536.79	11530.86	11533.53	11532.8	11529.46	11530.23	11531.6	11530.97	11529.04	11528.7	11533.27	11534.24	11536.21	SV3	SV2
-0.73082	7	9225.455	9220.776	9223.897	9223.178	9220.858	9220.949	9222.65	9222.901	9220.602	9219.412	9223.243	9223.774	9225.035	SV3	SV2
-1.45604	8	10070.26	10065.12	10066.88	10066.13	10064.09	10064.44	10066	10066.36	10063.61	10062.87	10067.02	10067.88	10069.34	SV3	SV2
-0.98626	9	15359.38	15354.57	15356.95	15356.54	15355.53	15356.81	15358.8	15359.49	15357.17	15356.56	15360.55	15356.33	15354.52	SV4	SV1
1.953846	10	11814.92	11808.07	11812.62	11807.36	11809.41	11816.15	11817.6	11813.85	11813.39	11809.84	11812.58	11811.53	11809.88	SV2	SV1
2.826923	11	12284.16	12277.03	12282.01	12276.98	12279.55	12285.63	12287.3	12283.67	12283.45	12279.72	12282.19	12280.47	12278.84	SV2	SV1
8.240659	12	12698.54	12692.1	12697.96	12693.62	12695.78	12702.14	12703.1	12698.56	12696.92	12692.78	12694.34	12697.8	12696.86	SV1	Sv3
6.805495	13	13456.33	13448.53	13453.92	13449.72	13451.71	13458.51	13459.1	13454.89	13453.49	13448.68	13450.48	13454.87	13453.87	SV1	SV3
7.049451	14	13677.8	13669.75	13675.5	13671.35	13673.6	13680.65	13681.2	13676.95	13675	13670.25	13672.1	13676.05	13675.5	SV1	SV3
8.291209	15	13435.65	13428.56	13434.66	13429.87	13433.58	13440.39	13441.6	13436.81	13434.52	13430.23	13432.04	13434.14	13432.85	SV1	SV2
0.453297	16	21636.32	21633.77	21632.61	21627.16	21628.61	21636.35	21634.4	21638.05	21633.59	21632.24	21631.19	21631.73	21634.48	SV2	SV2
-11.3549	17	18477.67	18463.43	18450.28	18447.84	18445.89	18436.55	18441.5	18442.05	18449.91	18447.86	18459.02	18464.07	18469.03	SV2	SV2
-3.2	18	18384.6	18384.1	18384.6	18384.7	18386.2	18381.9	18382.3	18380.8	18380.3	18382.8	18384.6	18384.7	18387.2	SV2	SV2
-3.5978	19	18244.61	18240.91	18238.41	18238.61	18239.4	18231.2	18235	18235.4	18233.9	18236.59	18238.49	18240.09	18247.39	SV2	SV2
-4.47967	20	19866.92	19865.2	19865.18	19864.26	19865.24	19856.82	19861.4	19856.68	19854.96	19859.64	19866.52	19866.3	19870.88	SV2	SV2
-4.97143	21	20115.17	20114.04	20115.11	20114.29	20115.16	20106.43	20112.3	20103.97	20101.74	20107.51	20116.09	20115.56	20121.53	Sv2	SV2
-3.91923	22	18490.38	18490.6	18495.12	18496.04	18495.56	18484.68	18491.2	18479.32	18477.34	18484.86	18493.98	18493.6	18501.22	SV2	SV2

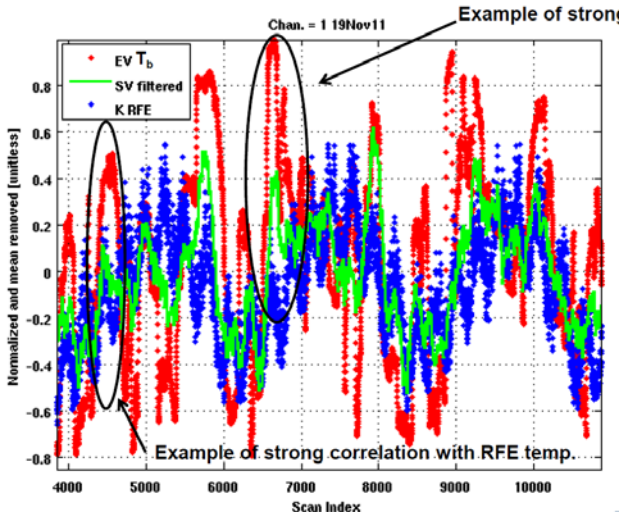
5 SV1, 12 SV2, 4 SV3, and 1 SV4

Optimal Space View Sector Selection

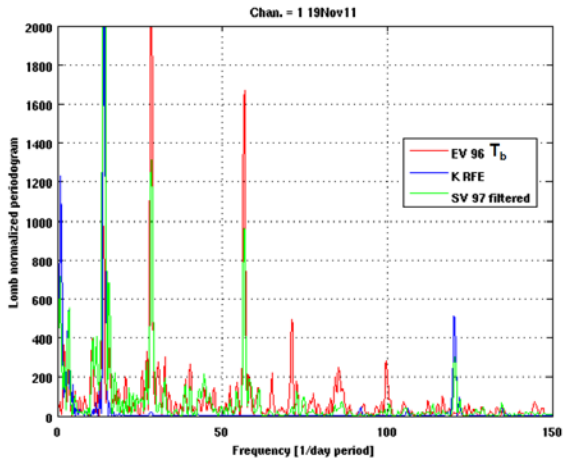




SVS #1 is currently selected as the optimal one



- Normalized
- Mean removed
- Entire day 19Nov11
- EV Spot 96 Tb
- Filtered SV 97 counts
- K RFE HK temp.
- Channel 1 K band



- Normalized Lomb Periodogram
- Mean removed
- Entire day 19Nov11
- EV Spot 96 Tb (red)
- Filtered SV 97 counts (green)
- K RFE HK temp. (blue)
- Channel 1 K band
- Similar results with other SV spots

SV shares harmonics with thermal drift *and EV Tb*

Slide courtesy of MITLL

ATMS Calibration Accuracy Assessment Using GPSRO

- **Time period of data search:**

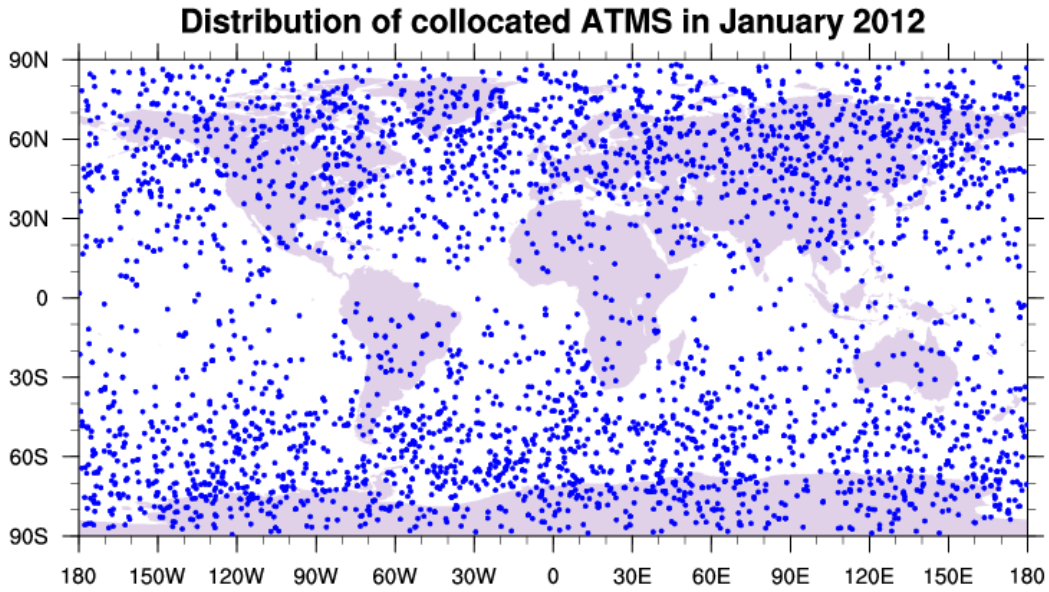
  January, 2012

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

  Time difference < 0.5 hour

  Spatial distance < 30 km

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

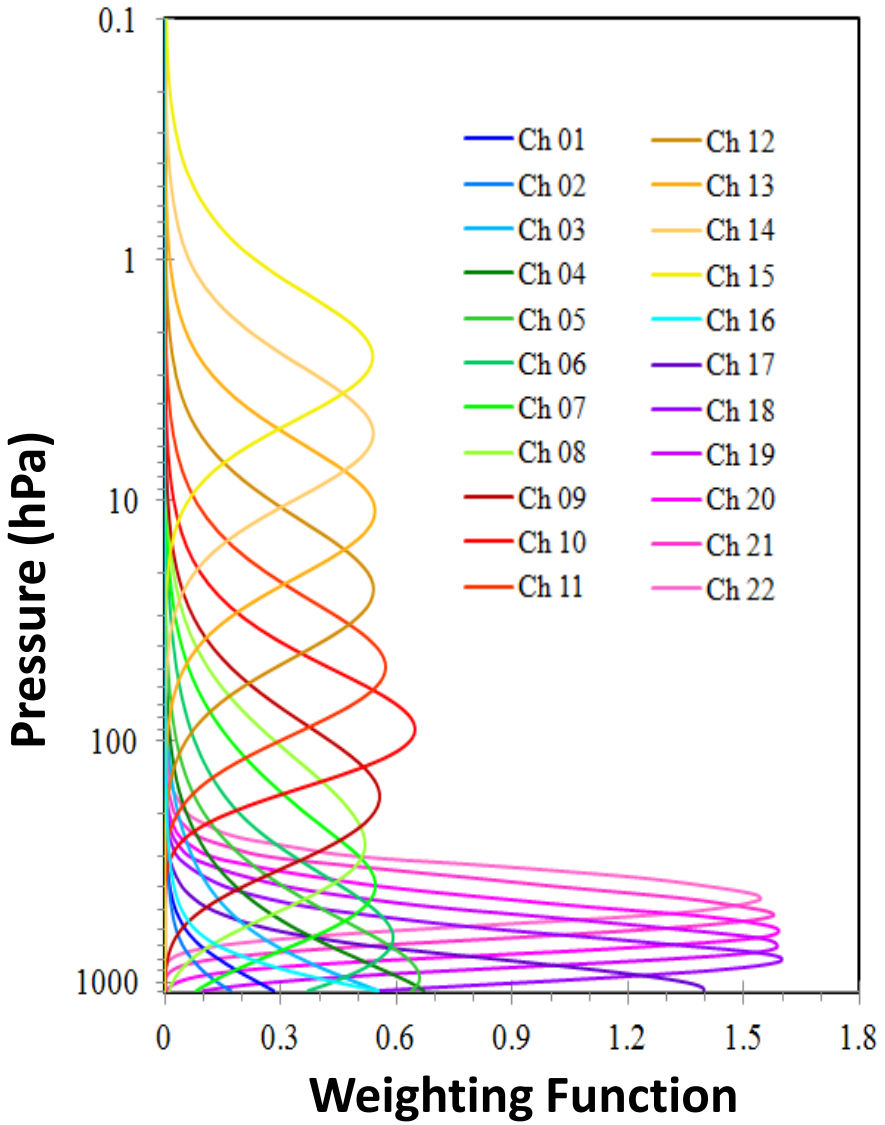


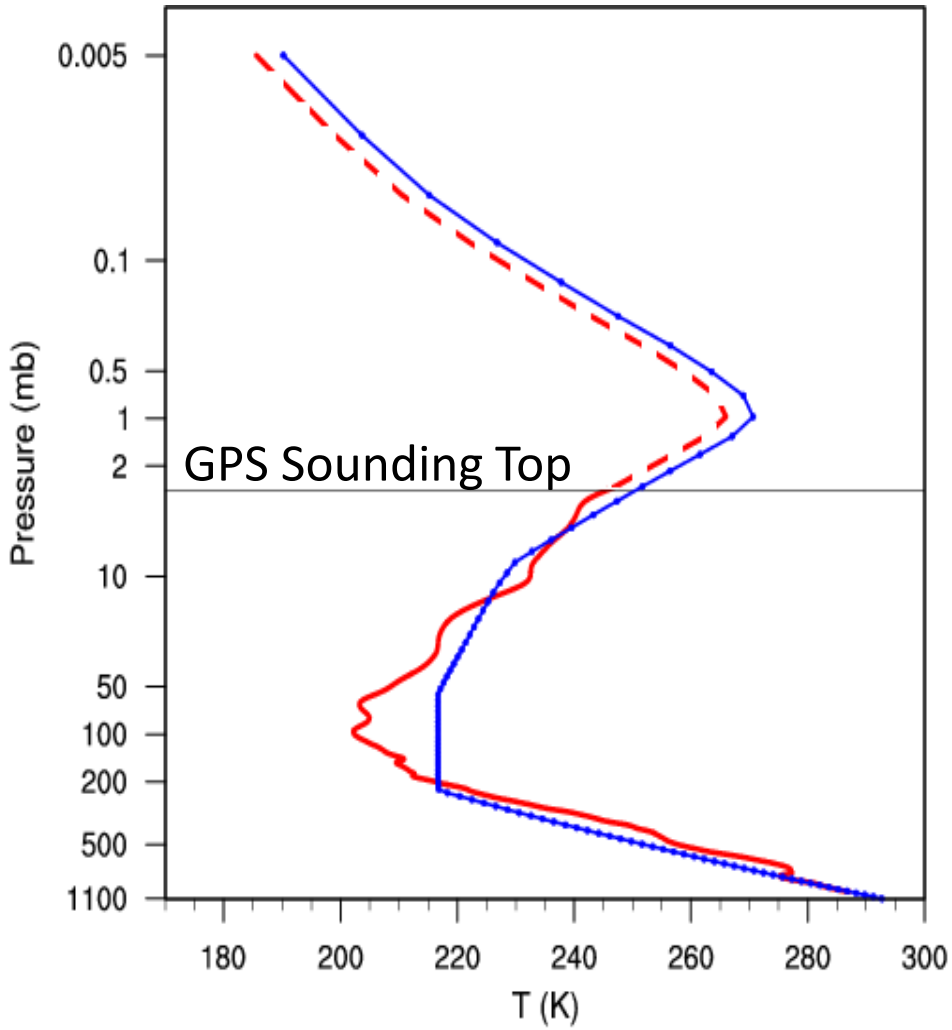
3056 collocated measurements

Courtesy of Lin Lin, STAR

ATMS WF (U.S. Standard Atmosphere)

Add 1976 U.S. Standard Atmosphere State to GPS Soundings

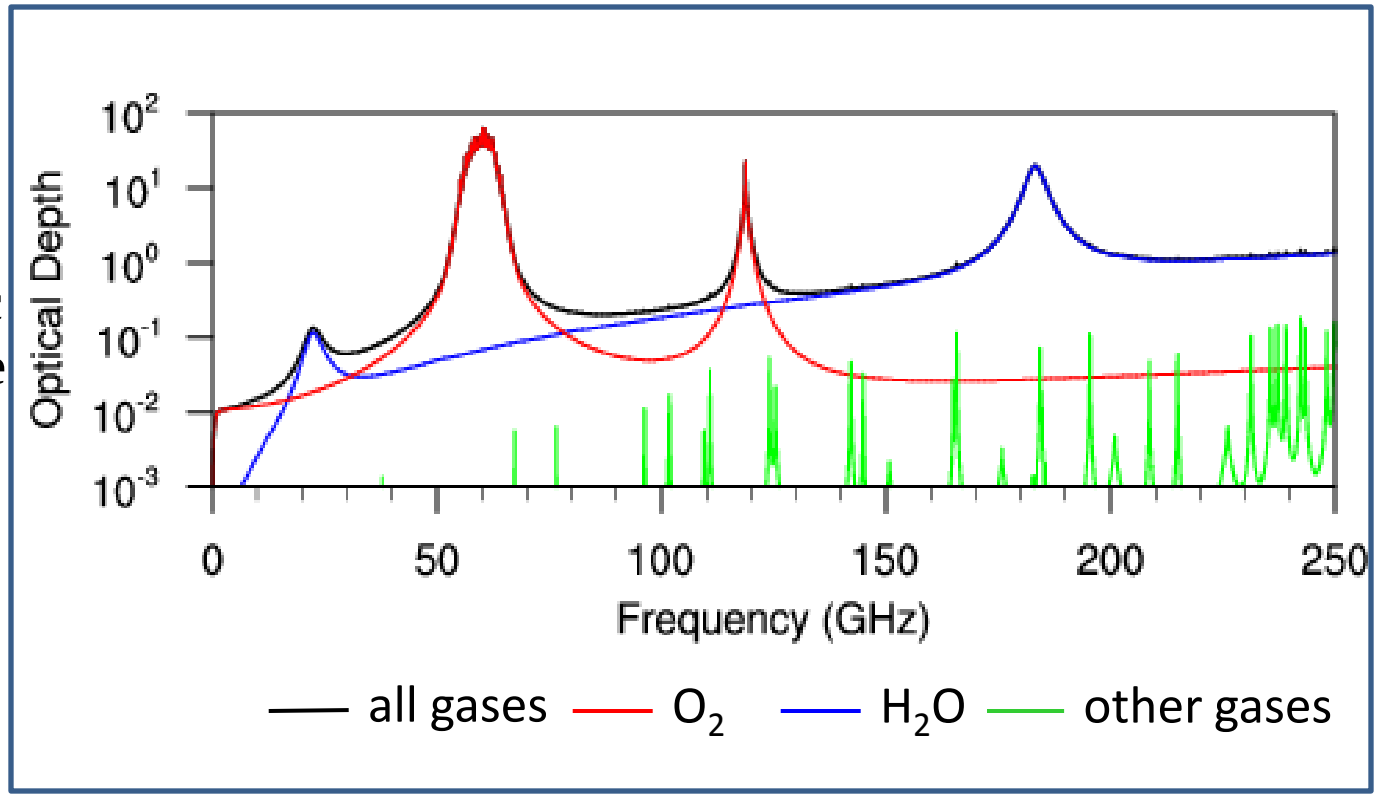




1051 UTC on January 1, 2012

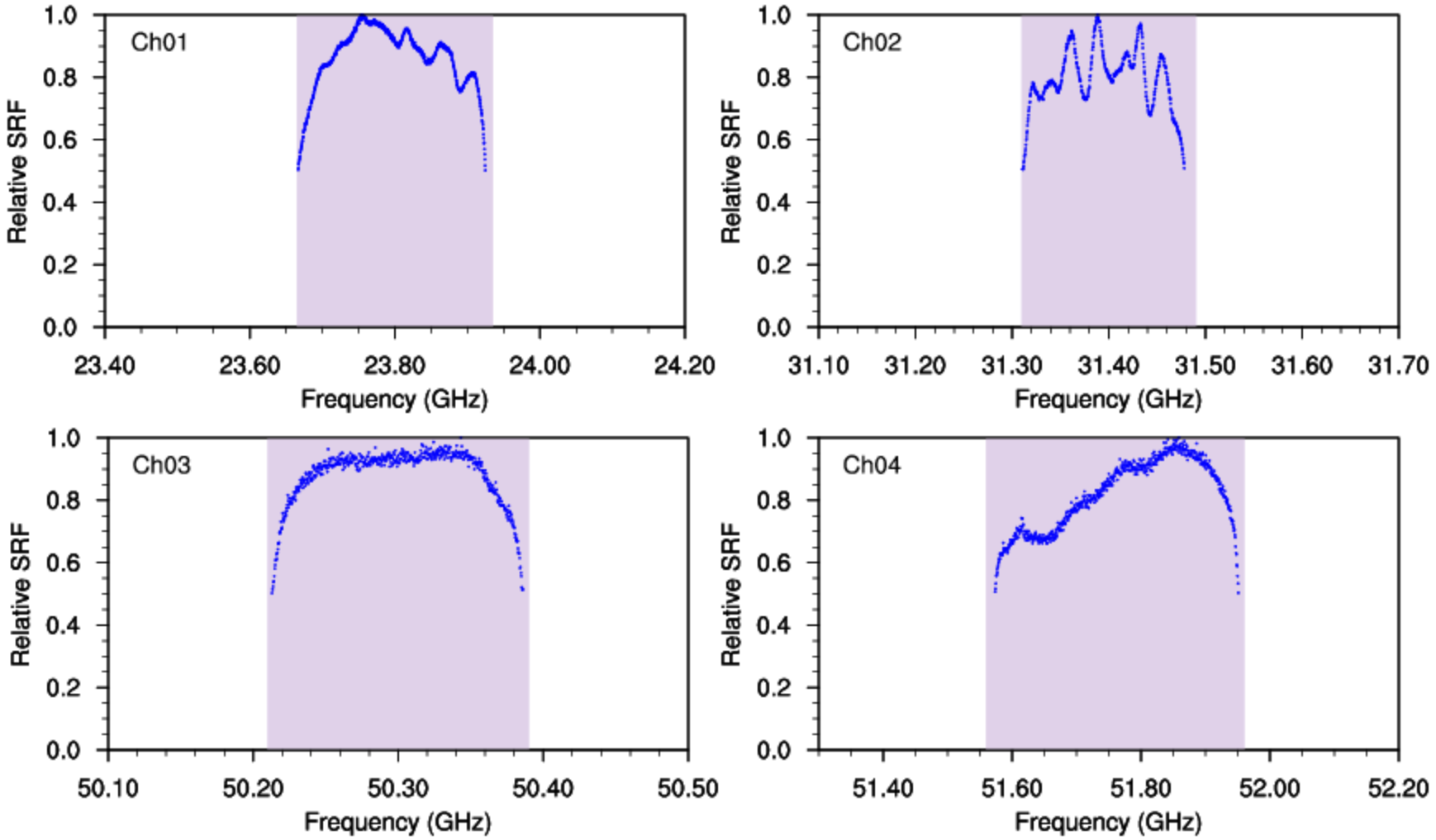
Line by Line RTM

- Perform a line by line radiative transfer calculation
- Accurate atmospheric spectroscopy data base
- Only gaseous absorption
- Vertical stratification

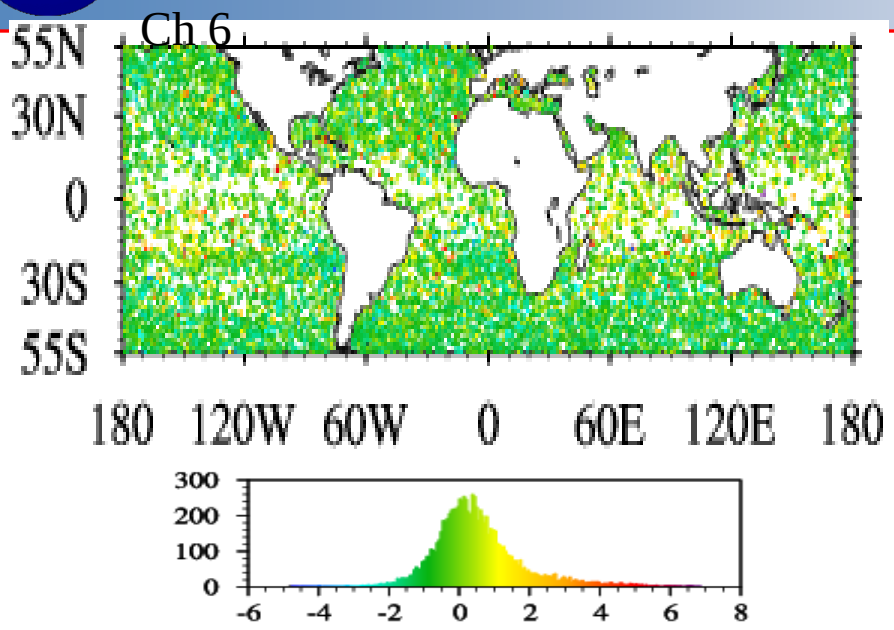


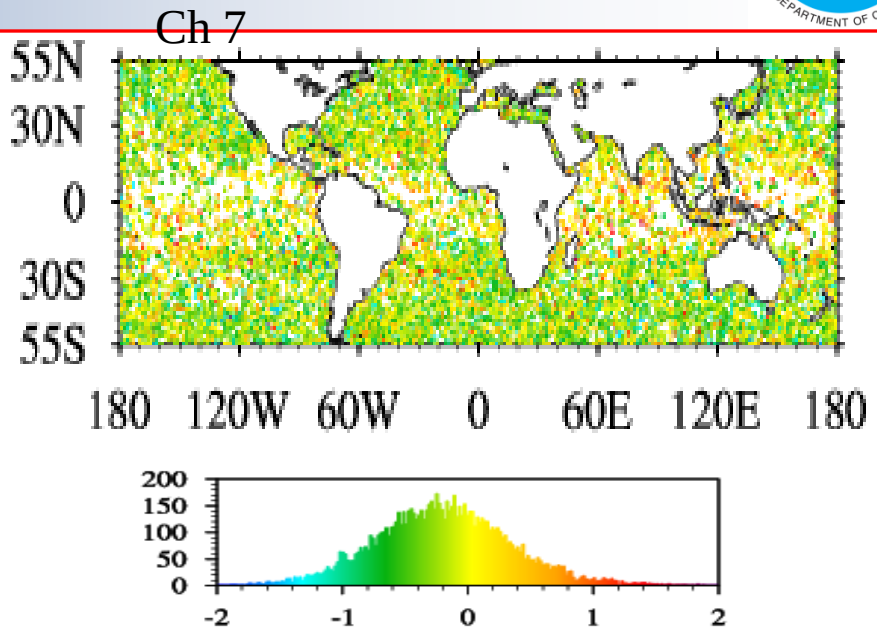
Microwave sounding channels at 50-60 GHz O_2 absorption band can be best simulated under a cloud-free atmosphere using line by line calculation

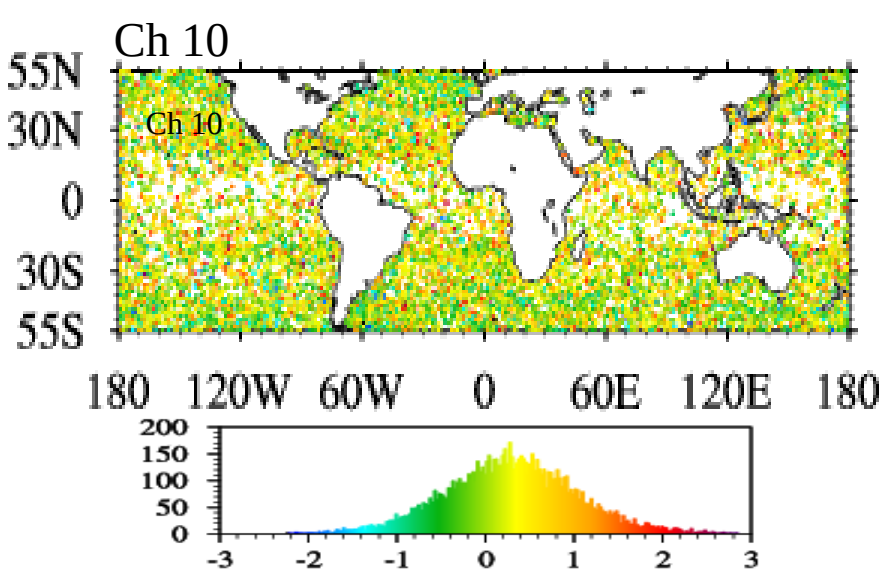
Effects of ATMS Spectral Response Function

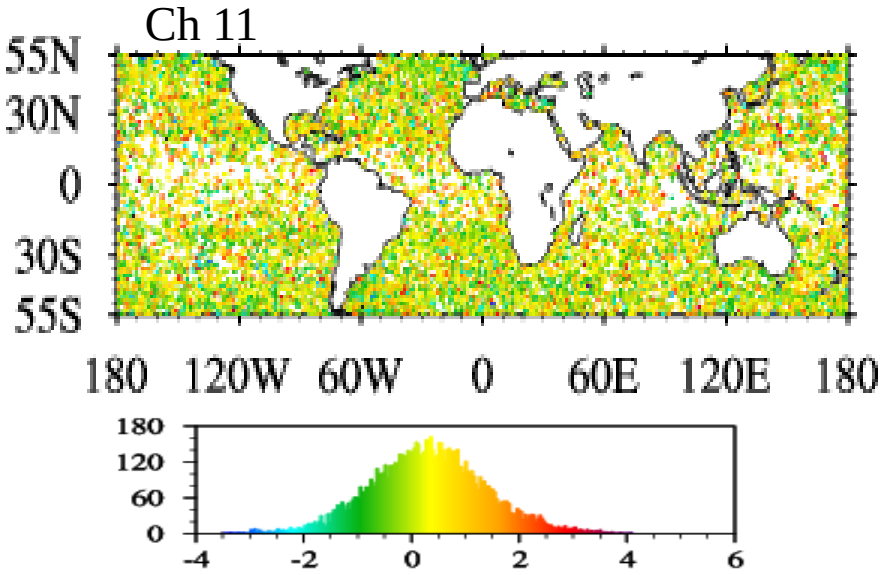


ATMS Bias Obs (TDR) - GPS Simulated

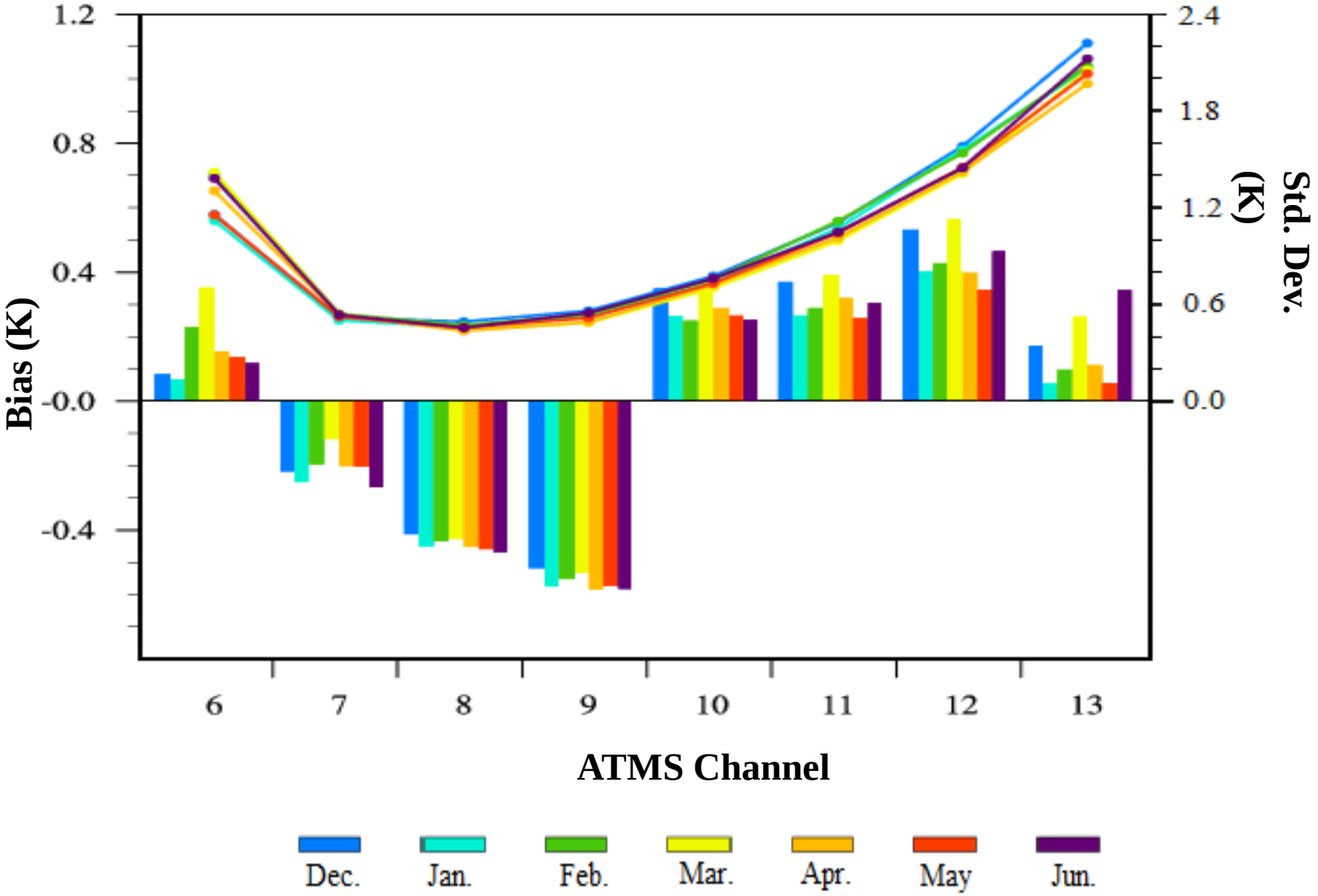




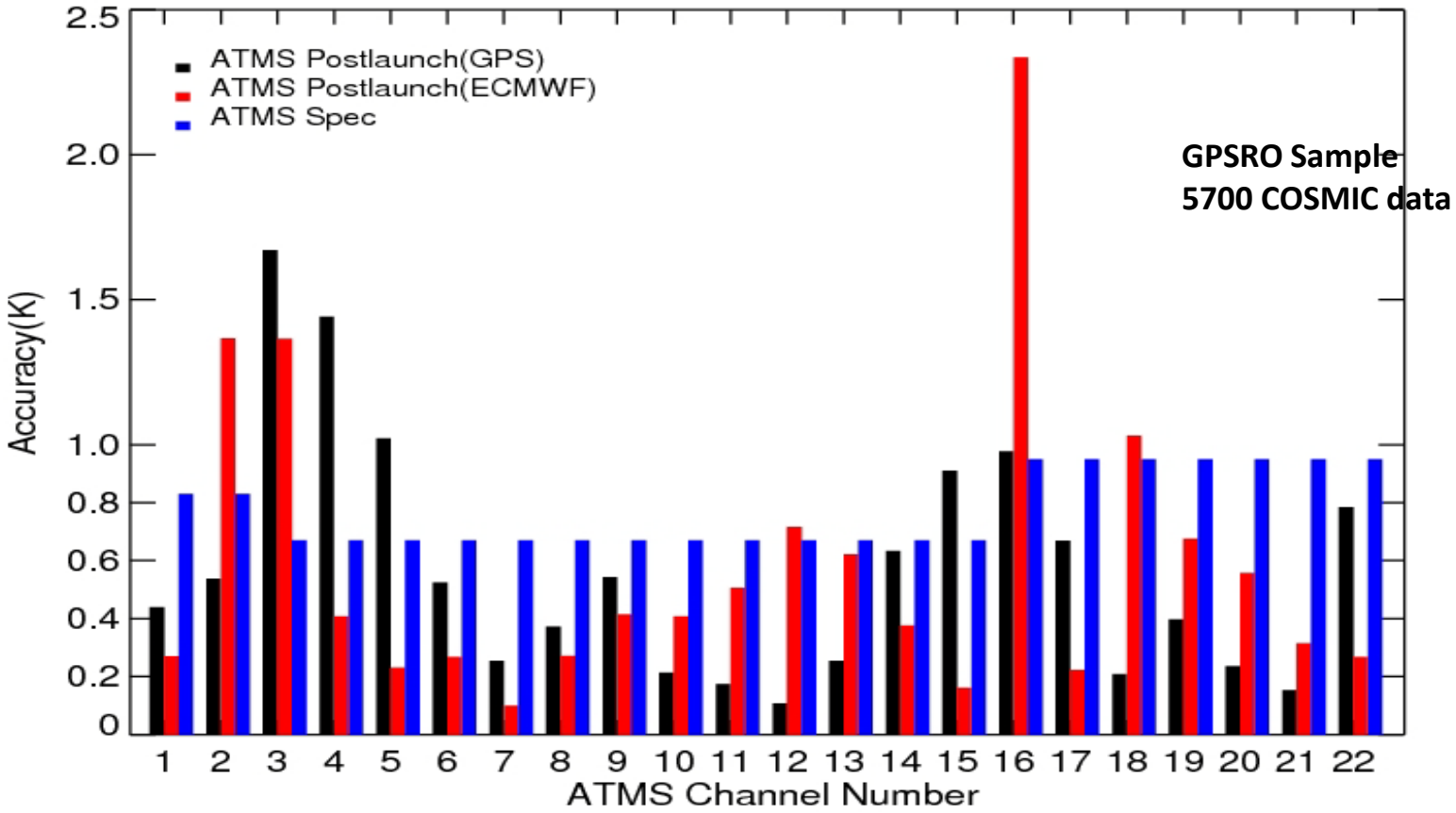




ATMS Bias Obs - Sim (GPSRO)



ATMS Calibration Accuracy Using GPSRO Data

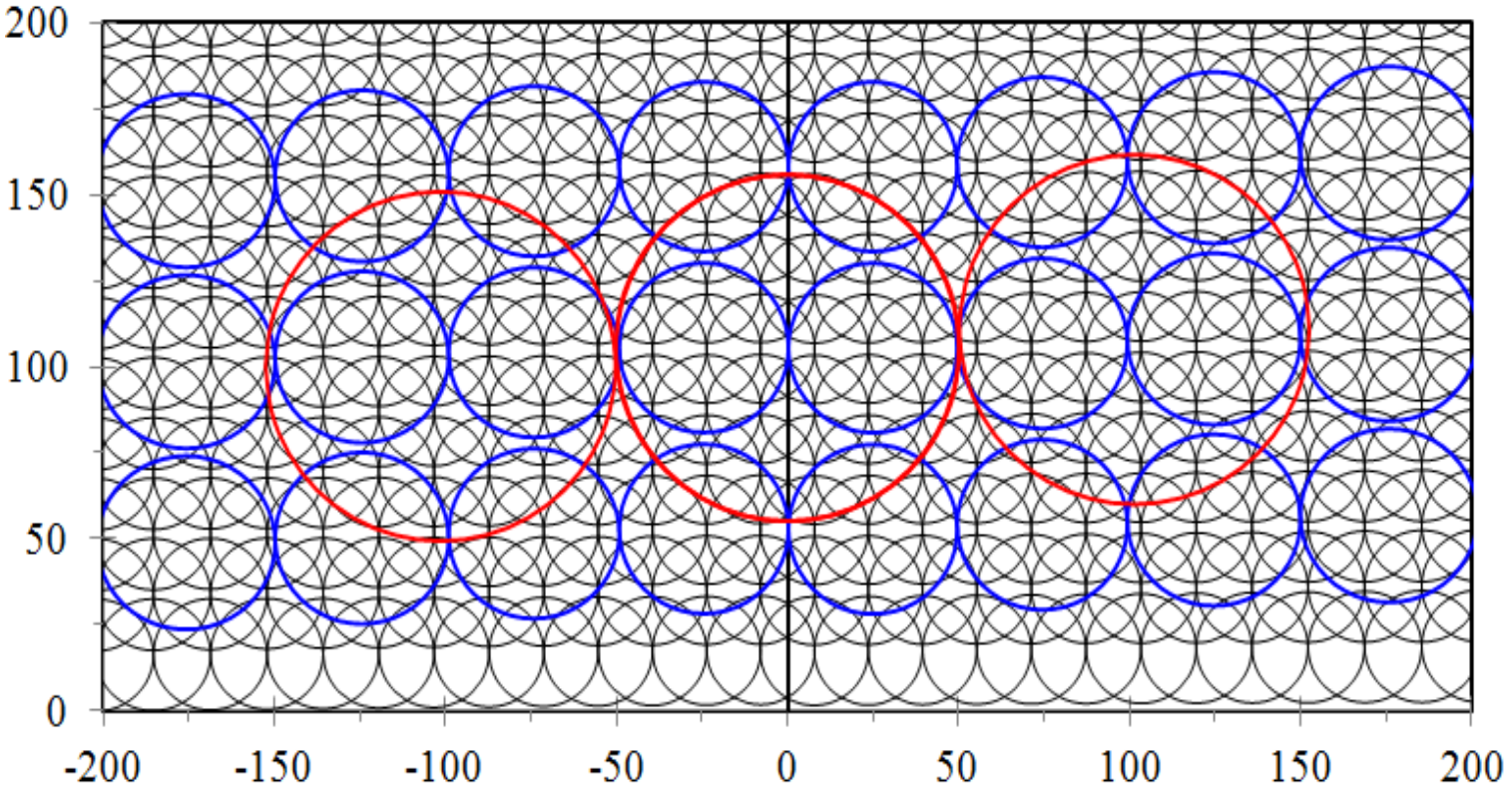


On-orbit ATMS calibration accuracy is quantified using GPSRO data as input to RT model and is better than specification for most of sounding channels.

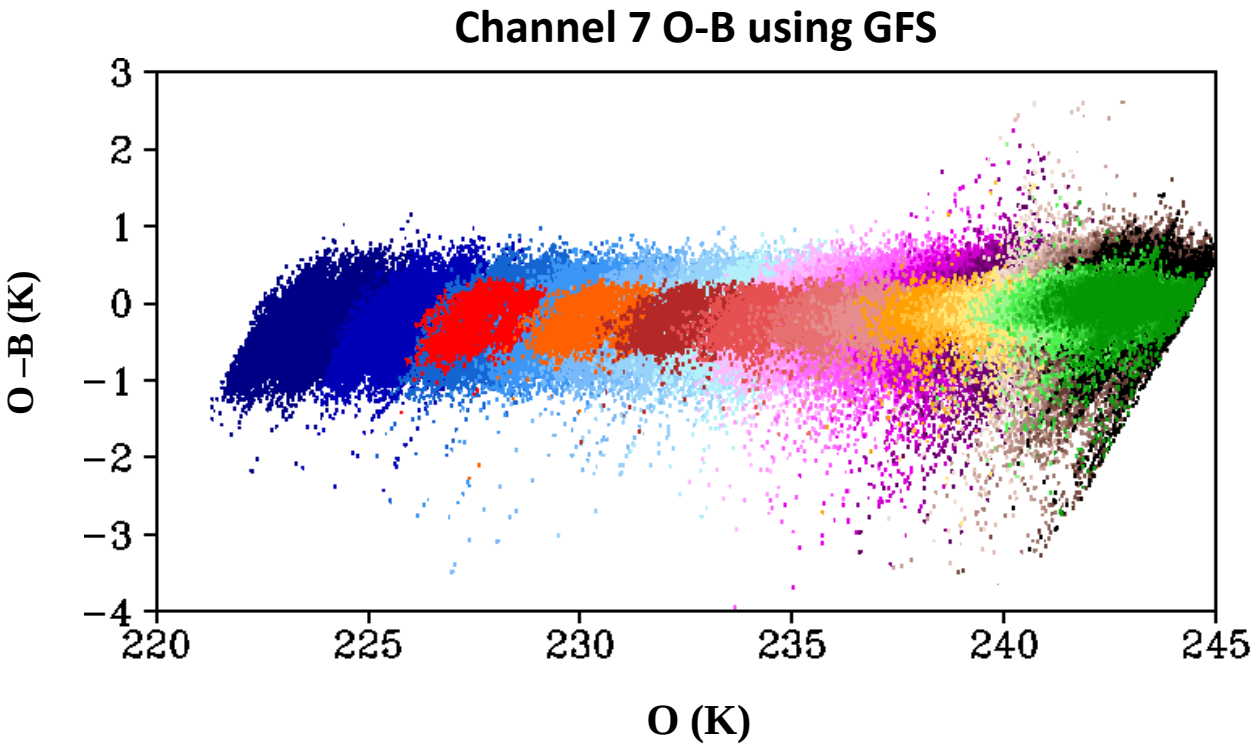
ATMS Spatial Sampling Distribution

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

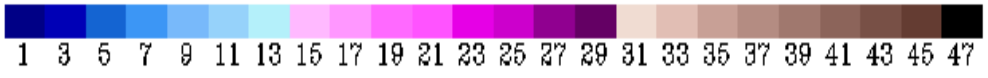
ATMS Resample to the Field of View Size for the beam width of 3.3^{o}- blue line



Assessments of ATMS Remap SDR (RSDR)



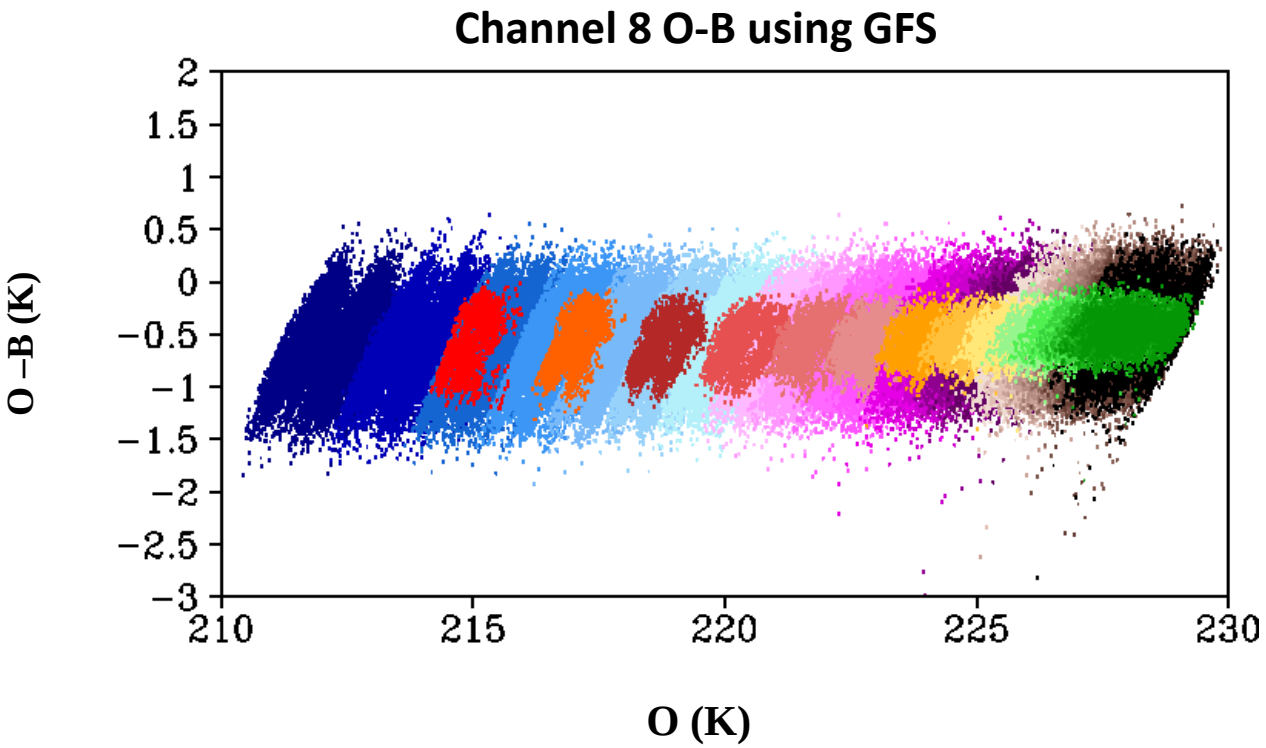
Resampled ATMS has the same bias at all brightness temperatures but much smaller spread (high innovation)



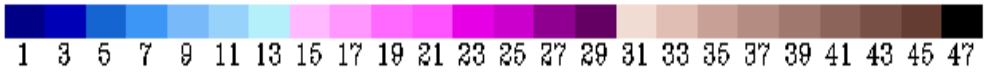
Original ATMS

Remap ATMS

Assessments of ATMS Remap SDR (RSDR)



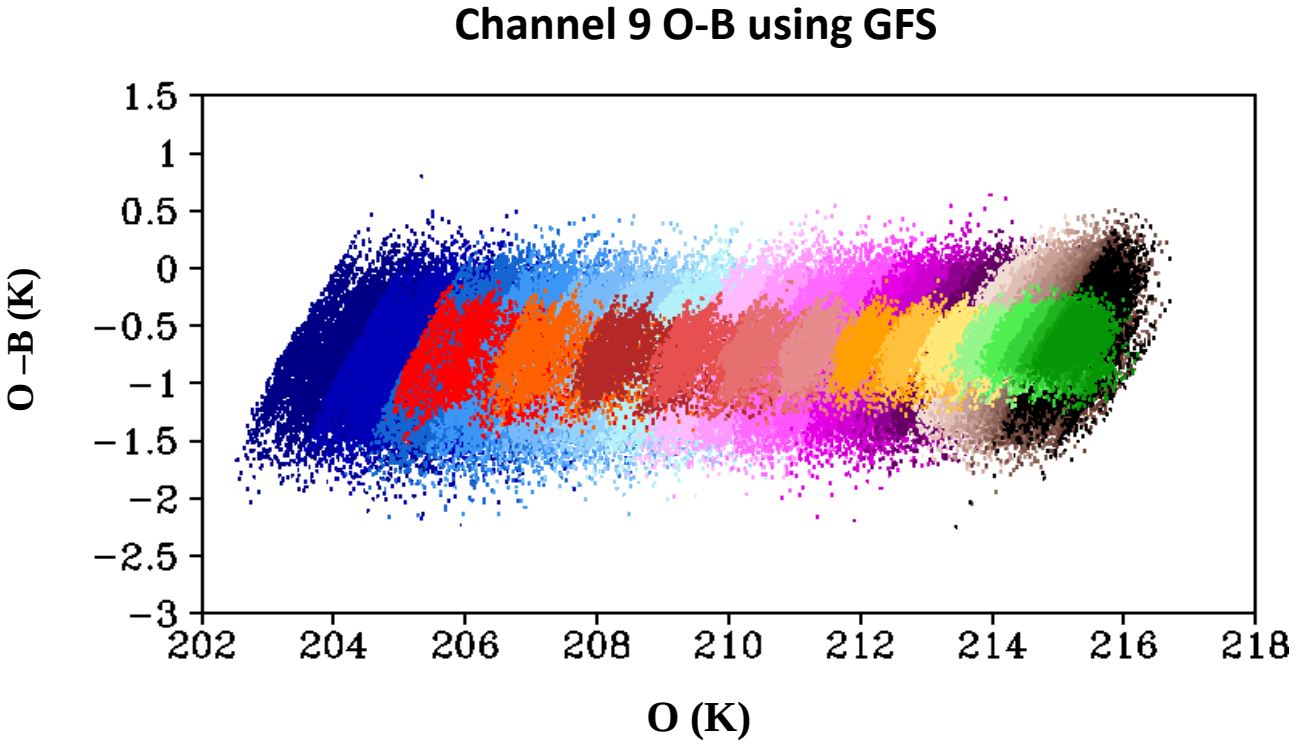
Resampled ATMS has the same bias at all brightness temperatures but much smaller spread (high innovation)



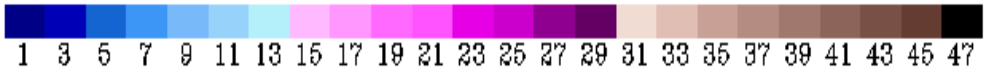
Original ATMS

Remap ATMS

Assessments of ATMS Remap SDR (RSDR)



Resampled ATMS has the same bias at all brightness temperatures but much smaller spread (high innovation)

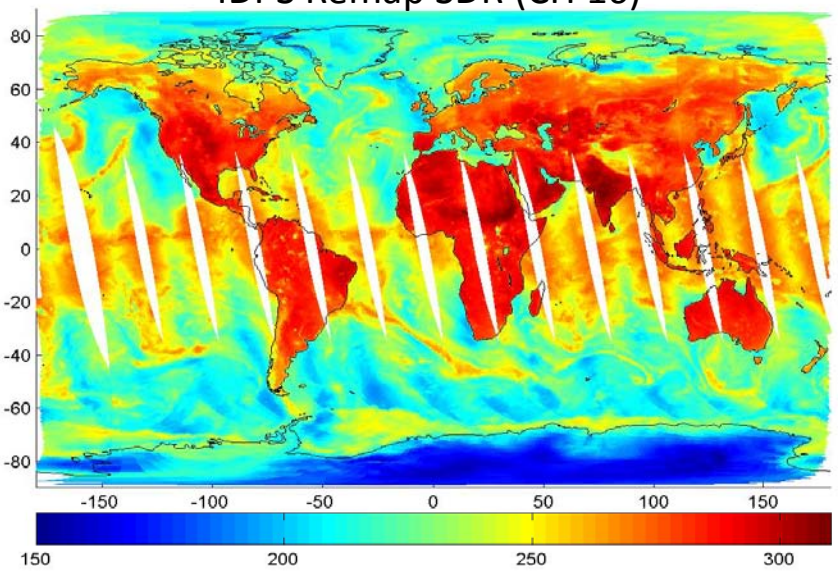


Original ATMS

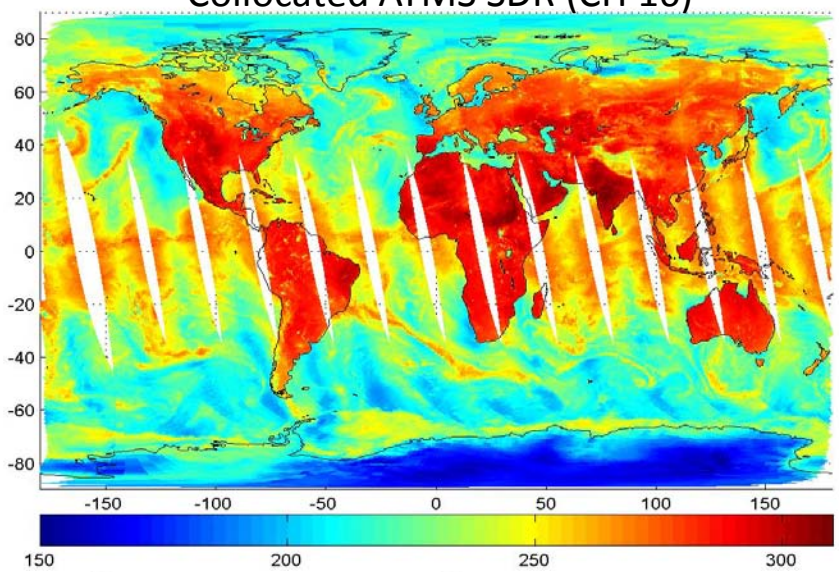
Remap ATMS

ATMS Remap SDR Evaluation

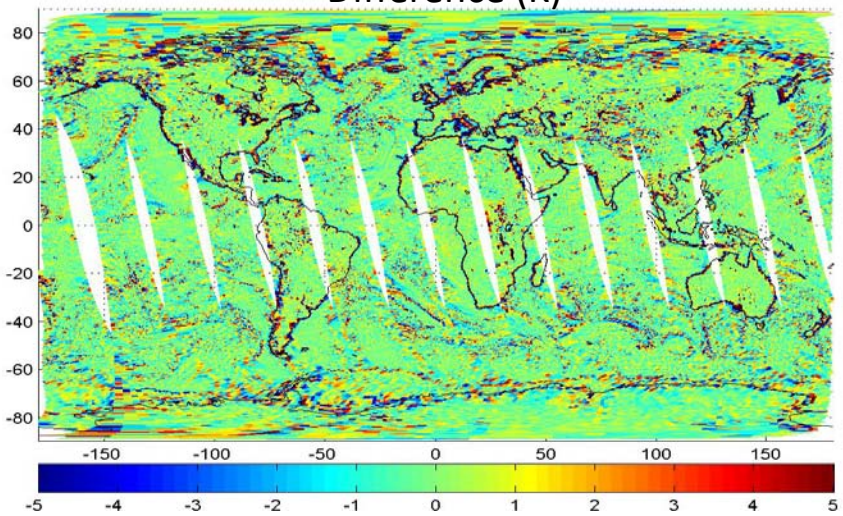
IDPS Remap SDR (CH 16)

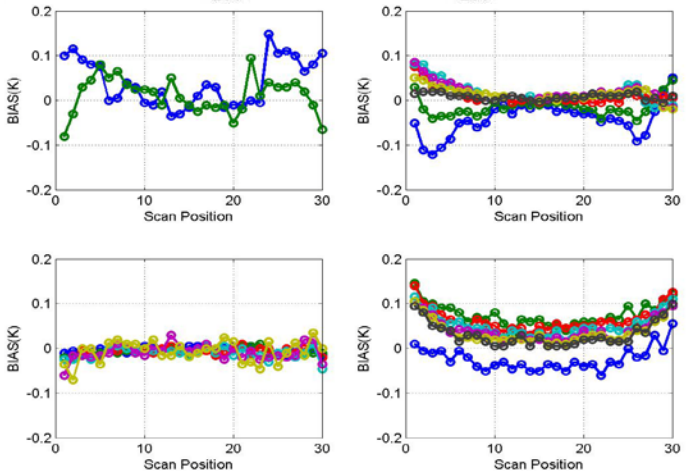


Collocated ATMS SDR (CH 16)



Difference (K)





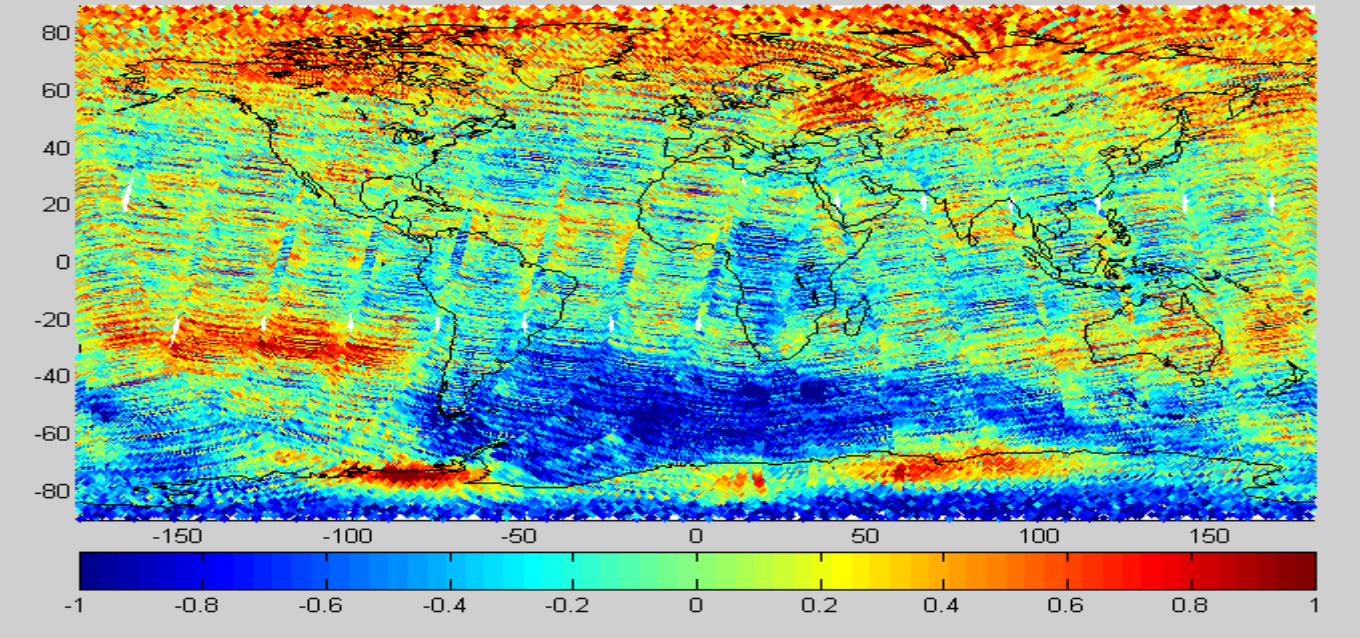
No Significant Biases Between Remapped SDRs and Collocated ATMS SDRs

Slide courtesy of NGAS

ATMS TDR Stripping Noise

- Discovered ATMS SDR striping noise issue and investigated the root cause
  - Concluded that the striping is caused by ATMS SDR calibration noise, specifically the noise in the warm counts. Contributions to the overall calibration noise from cold counts and PRT readings are much smaller
  - The level of the striping noise is insignificant and well within ATMS SDR noise spec level

ATMS Brightness Temperature Difference: Simulated – Observed



Slide courtesy of NGAS

Scientific Advancements

- Two peer-reviewed publications in JGR and IEEE GRSL
- Uses of GPSRO from COSMIC to routinely monitor sounding channel bias toward the on-orbit absolute calibration
- Successfully run the Backus-Gilbert re-sampling software for all the ATMS at 2.2 degree FOV and other user-oriented re-sampling data
- Performed LBLRT with the ATMS spectral response function
- Started testing ATMS data Hurricane Weather and Research Forecast (HWRF) model
- Updated ATMS snow surface emissivity model for global ATMS assimilation in NCEP GFS

Issues, Challenges, Setbacks

- Some DRs remain open, backlogged and continue affecting SDR data quality
- Causes of calibration residuals caused by the fundamental in the current processing system
- Impacts of Backus-Gilbert coefficients on noise reduction and amplification
- Channel dependent calibration procedure for reducing the striping

ATMS Discrepancy Reports

DR #	Title	Status	DR #	Title	Status
4408	Polarization Angle	(01) DR Open	4566	ATMS SDR Duplicate/Fill Granules	(01) DR Open
4413	synch problem with B-G LUT functional test	(15) DPA Closed	4593	Operations wants working DQN's for Provisional Status	(06) POC Assigned and CCR in Work
4446	Gelocation QC flag does not reflect dummy scans	(09) PCR Open	4642	Geo Discrepancy between G-ADA and IDPS Ops	(15) DPA Closed
4460	Limits to high on space view counts for channels 7-8	(01) DR Open	4687	New ATMS SDR/TDR DQN	(01) DR Open
4461	Ops code tailored to scan profile #1	(01) DR Open	4729	ATMS SDR should not process fill packets	(12) PCR in Verification
4462	QF19 position error triggering	(15) DPA Closed	4730	QF Correction Part 2	(06) POC Assigned and CCR in Work
4463	Out of limits on channel cold counts	(15) DPA Closed	4732	Remapped SDR QF	(01) DR Open
4471	Lack of Tb with scan profile 2	(15) DPA Closed	4741	ATMS-SDR-CC PCT Update	(06) POC Assigned and CCR in Work
4472	delta G/G stability	(01) DR Open	4752	Update NPP Mission Data Format Control Book	
4479	Instrument data limits exceeded in Mx5.1	(15) DPA Closed	4806	Scan bias & Beam eff.	(05) POC Assigned
4480	Warm Load Bias Corrections are 0 for SP2, SP3, and SP4	(15) DPA Closed	4811	Turn on PRT consistency check	(01) DR Open
4492	Review of Raytheon OAD	(00) New Submission	4813	ATMS calibration striping investigation	(05) POC Assigned
4494	Receiver temperature anomaly work around	(01) DR Open	4815	ATMS Remap SDR beta release	(06) POC Assigned and CCR in Work
4511	Beta Baseline Version	(01) DR Open	4837	ATMS stand-alone remapped SDR in error	(15) DPA Closed
4512	NEdT in SDR output noisy	(03) Rejected	4842	ATMS TDR provisional maturity level	(04) Approved for Future Re-Evaluation
4514	ATMS TDR geolocation packaging anomaly	(01) DR Open	4843	Zero NeDT in ATMS SDR	(03) Rejected
4521	Maneuver Flag	(01) DR Open	4847	ATMS-SDR-CC SideB update	(06) POC Assigned and CCR in Work
4522	Noise Factors in PCT files too small	(01) DR Open	4601	ATMS RDR non-readable Packet	(01) DR Open
4561	QF1-QF9 Trigger Verification	(12) PCR in Verification			

Changes in Strategy (due to funding constraints)

- STAR team will be more focusing on operational calibration, accelerating test and implementation of new calval algorithms, and work toward the end-to-end capability

- Leveraging existing resources and expertise for ATMS SDR post-launch Cal/Val support

- Sharing and re-planning Cal/Val task responsibilities and prioritization among different teams

FY13 STAR ATMS SDR Tasks

Task	Task Description
1	ATMS SDR Team Management and Coordination
2	Update ATMS SDR Algorithm Theoretical Basis Algorithm Document (ATBD)
3	ATMS SDR algorithm development, refinement and maintenance
4	Assessment of ATMS SDR/Remap SDR Algorithms
5	Assessment of J1 ATMS SRF and polarization alignment
6	Improve ATMS Calibration Processing Using Radiance
7	Achieving validated version of ATMS TDR and SDR
8	NGAS ATMS SDR science transition
9	ATMS SDR Product User's Guide
10	ATMS SDR PCT updates

FY-13 Schedule and Milestones

- October 2012 – ATMS TDR/SDR provisional version peer review
- January 2013 – Alternative algorithm for ATMS calibration in radiance
- June 2013 – ATMS SDR validated version peer-review
- September 2013 – Updated Algorithm Theoretical Base Document

Path Forward (FY-14 thru FY-17)

- Improve ATMS SDR products (e.g. noise reduction, radiance calibration)
- Preparation for J1 & J2 ATMS Flight Models
- J1 Sensor-level EMI/EMC testing
- J1 Sensor-level TVAC testing
- J1 Pre-Ship Review
- SDR validation field campaigns
- Update OPSCON and Cal/Val Tasks Document for J1

Summary

- ATMS SDR team members are well coordinated and worked very closely in supporting all phases of ATMS Cal/Val
- Team has developed innovative methodology for instrument calibration
- Team members are continuing work on J1 ATMS. Lessons learned from NPP will be incorporated
- Worked closely with other SDRs, CrIMSS EDR team, and users community