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STAR ATMS CalVal Activities and Findings

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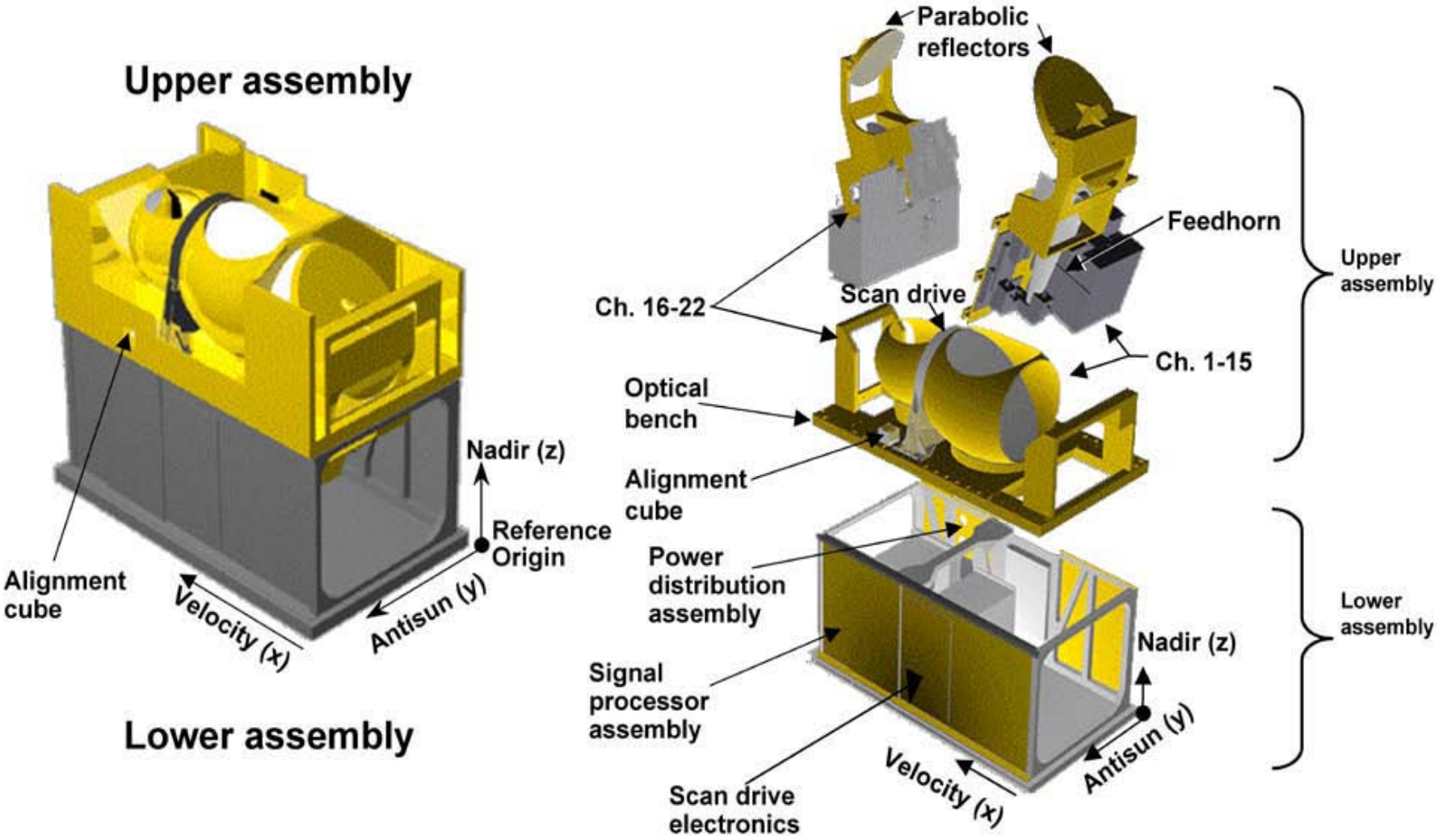
ATMS Instrument



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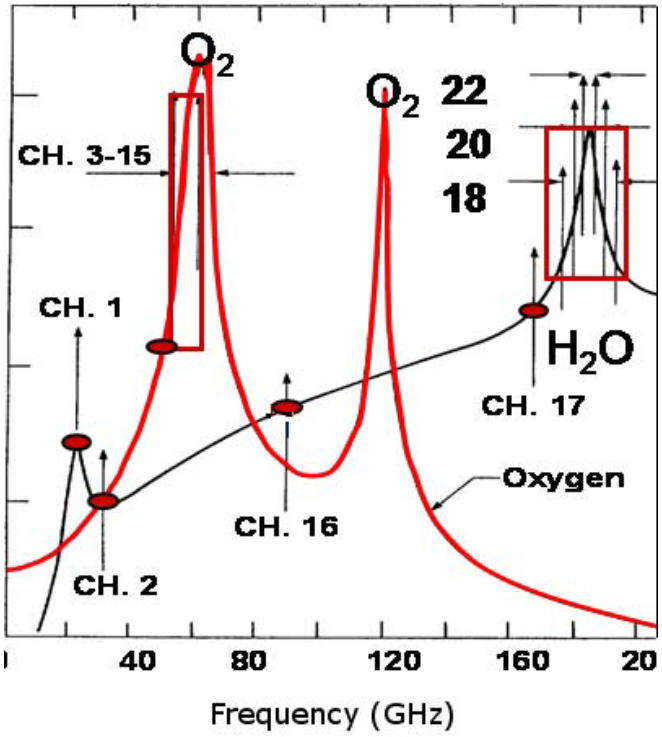
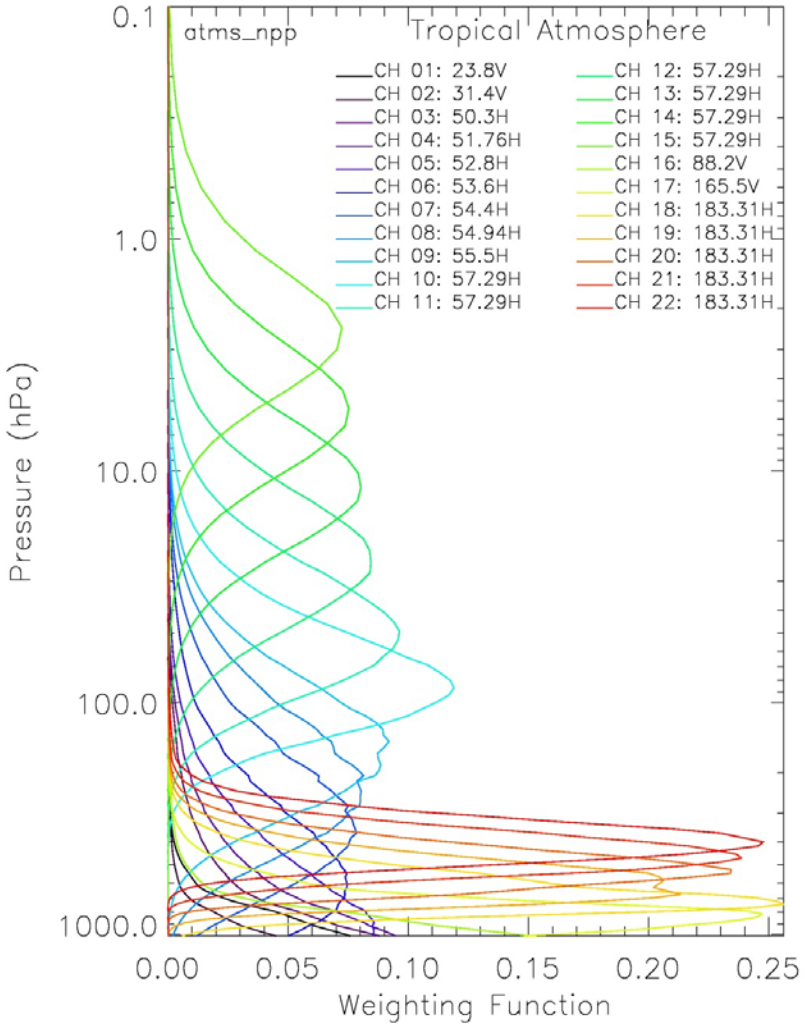
Spectral Differences

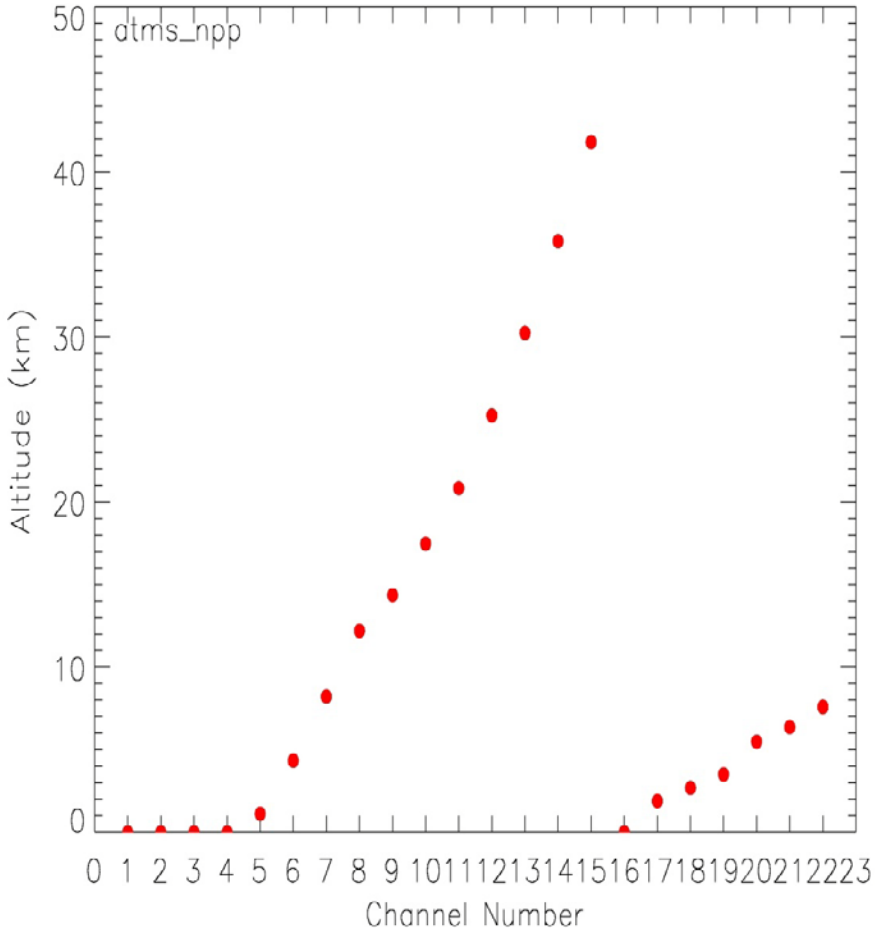


Exact match to AMSU/MHS
Only Polarization different
Unique Passband
Unique Passband, and Pol. different from closest AMSU/MHS channels

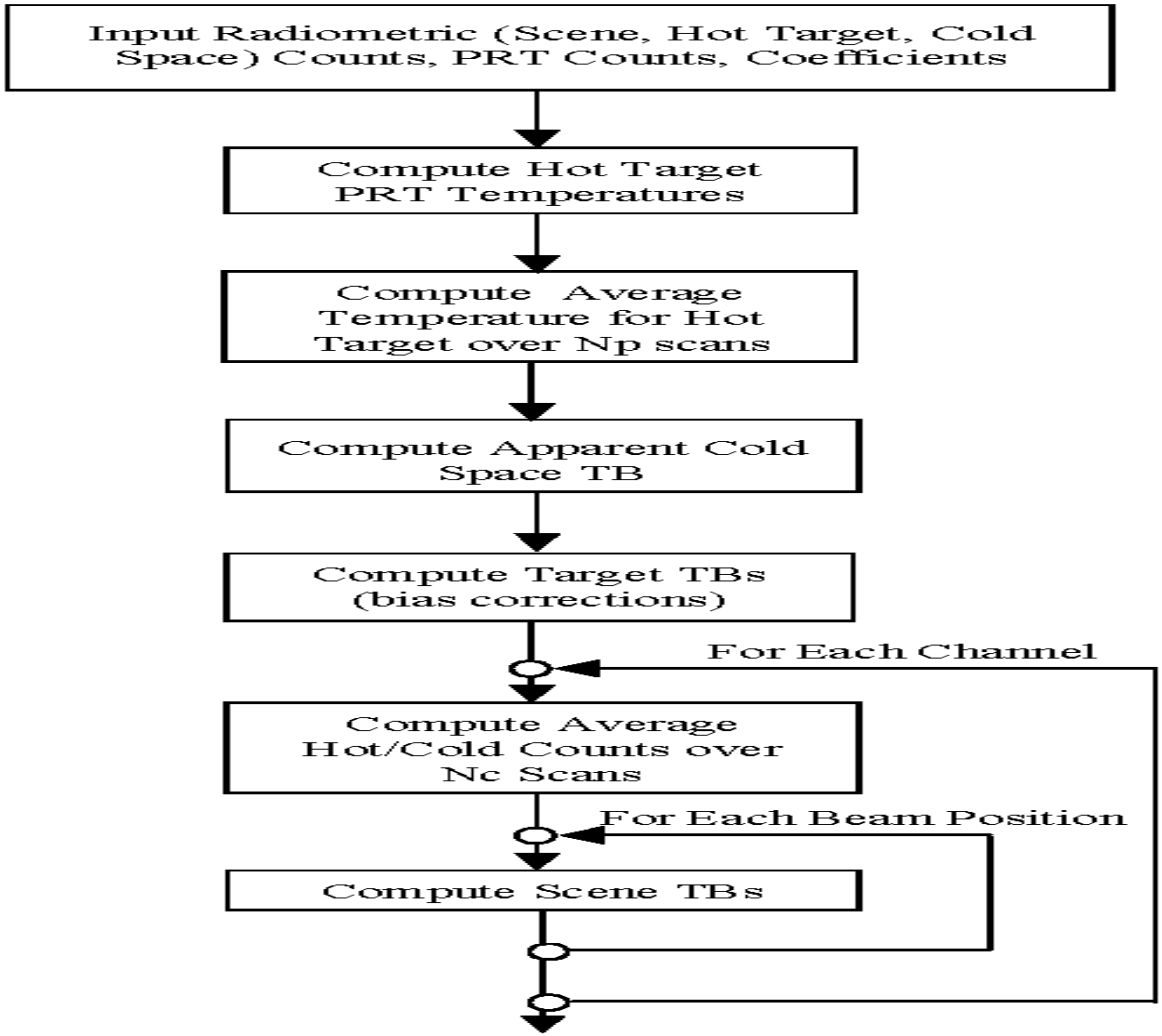
	AMSU/MHS			ATMS	
	Ch	GHz	Pol	Ch	GHz	Pol
AMSU-A	1	23.8	QV	1	23.8	QV
	2	31.399	QV	2	31.4	QV
	3	50.299	QV	3	50.3	QH
				4	51.76	QH
	4	52.8	QV	5	52.8	QH
	5	53.595 ± 0.115	QH	6	53.596 ± 0.115	QH
	6	54.4	QH	7	54.4	QH
	7	54.94	QV	8	54.94	QH
	8	55.5	QH	9	55.5	QH
	9	fo = 57.29	QH	10	fo = 57.29	QH
	10	fo ± 0.217	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			
MHS	16	89.0	QV	16	88.2	QV
	17	157.0	QV	17	165.5	QH
	18	183.31 ± 1	QH	18	183.31 ± 7	QH
	19	183.31 ± 3	QH	19	183.31 ± 4.5	QH
	20	191.31	QV	20	183.31 ± 3	QH
				21	183.31 ± 1.8	QH
				22	183.31 ± 1	QH

ATMS Weighting Function and Peak Height





ATMS SDR Flow Chart



Major Calibration Error Sources

Definition: ATMS Calibration accuracy is strictly defined as the difference between the means of the inferred and the actual brightness temperature when a large blackbody calibration target is placed directly in front of the antenna for an extended period of time.

Major Error Sources:

- Antenna spill-over correction
- Blackbody emissivity errors
- Surface temperature drifts between the time of temperature measurement and the time of radiometer measurement
- Temperature gradients in the blackbody
- Temperature measurement uncertainties
- Vertical gradients and uncertain origin of the radiation
- Cold space temperature due to side-lobe
- Instrument non-linearity

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ATMS CalVal Task Network

Index	Name	Cal/Val Plan Designation	IMT	NGES	MIT-LL	NASA/GSFC	STAR
1	Activation Sequence	SEV-1	yes	P	S	S	
2	Parameter Trending	SEV-2					P
3	Functional Evaluation	SEV-3	yes	P	S	S	
4	Optimal Space Vector	TUN-1	yes		CP	CP	CP
5	RFI: spacecraft	SEV-4			CP	CP	
6	RFI: terrestrial	SEV-5			CP	CP	
7	Dynamic Range	SEV-6		P	S	S	
8	Scan Angle	SEV-7		P	S	S	
9	Radiometric Sensitivity	VER-1		P	S	S	S
10	Temp. Stabilitization	SEV-8	yes	P	S	S	S
11	RF shelf to CP temp.	TUN-2			CP	CP	
12	Cal. Load Stares	TUN-x	yes		CP	CP	
13	Radiometric Characterization	TUN-y	yes		CP	CP	
14	Lunar Intrusion Mitigation	TUN-3				CP	CP
15	Roll/Pitch Maneuvers	TUN 4-6	yes		P	S	S
16	Geolocation Verification	VER-2					P
17	Center Freq. Stability	SEV-9			P		
18	SDR correction factors	TUN-7			S		P
19	Resample FOV to CrIS FOR	VER-3			P		S
20	Ascend/Descend comparisons	VER-4					P
21	Simultaneous Nadir Overpass	VER-5				S	P
22	Double Difference	VER-6					P
23	SDR Raob validation	VER-7			S		P
24	SDR NWP validation	VER-8			S		P
25	SDR Aircraft validation	VER-9			P	S	

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Task 2: ATMS Long Term Trending

Objective:

Trend a multitude of ATMS data to monitor the health, anomalies, and the response of external influences on the instrument

Methods and Tools:

Use all RDR calibration target PRT and counts, instrument telemetry and house-keeping data sets

Results and Recommendations:

ATMS on-orbit performance reaches stable condition

STAR Integrated Calibration/Validation System (ICVS) for NPP/JPSS

» Instrument Performance Monitoring - Telemetry >>
- NPP S/C Telemetry
- NPP ATMS >>
- NPP CrIS
- NPP VIIRS
- NPP OMPS

» Instrument Performance Monitoring - Bias

ATMS Channel NEdT
Channel 2 Display

ATMS Channel Gain
All Channel Snapshot Display

ATMS Cold Calibration Count
All Channel Snapshot Display

ATMS Warm Calibration Count
All Channel Snapshot Display

ATMS 4-Wire PRTs
K,Ka,V-Band Sensor Display

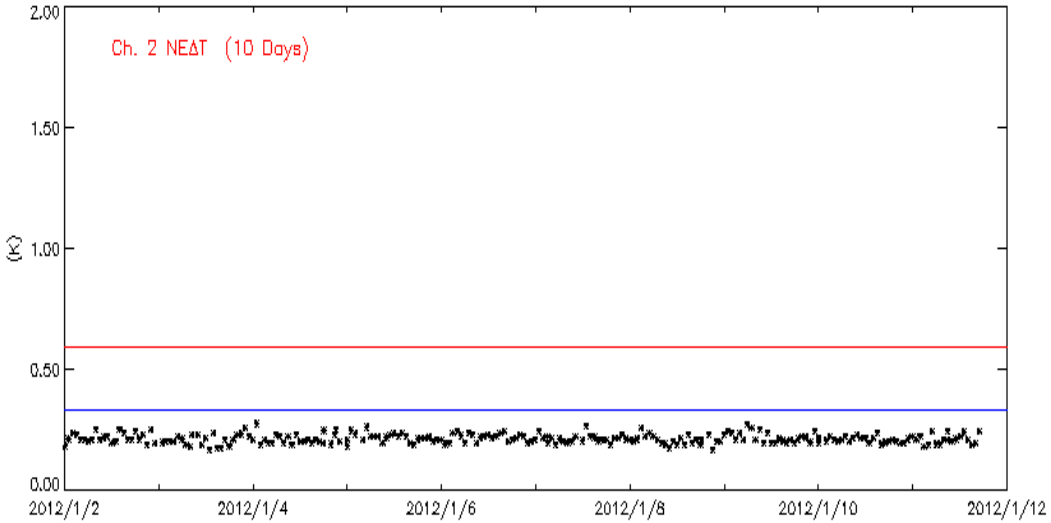
ATMS Receiver Shelf 2-Wire PRTs
K-Band Display

ATMS 2-Wire PRT (25 PRTs)
K-Band Receiver Front End Temperature Display

ATMS Health/Status Analog Parameters (35 Index)
Signal Processing Assembly +5V Seconary Voltage Display

NPP ATMS Ch.2 NEΔT
Science RDR

(Updated at Wed Jan 11 20:31:13 2012 UTC)



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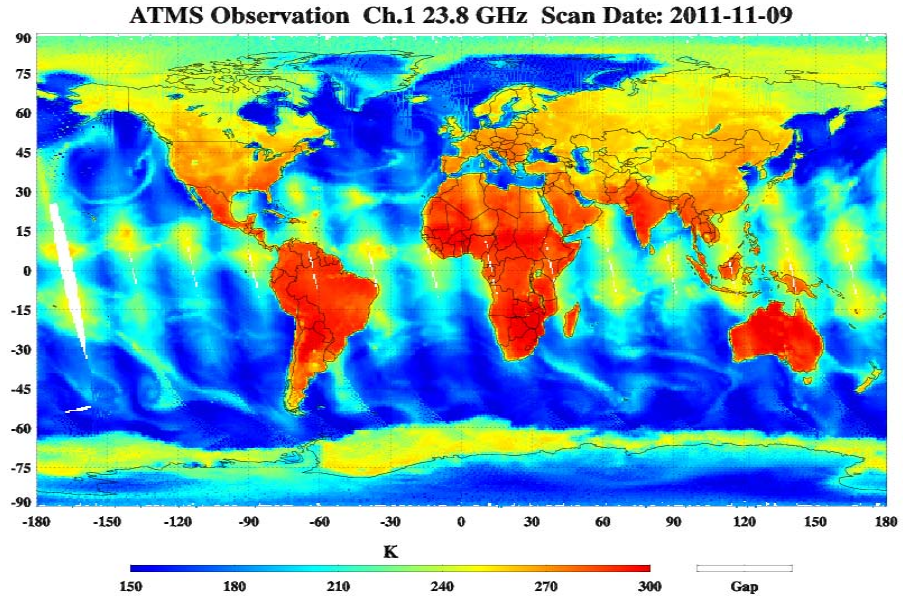
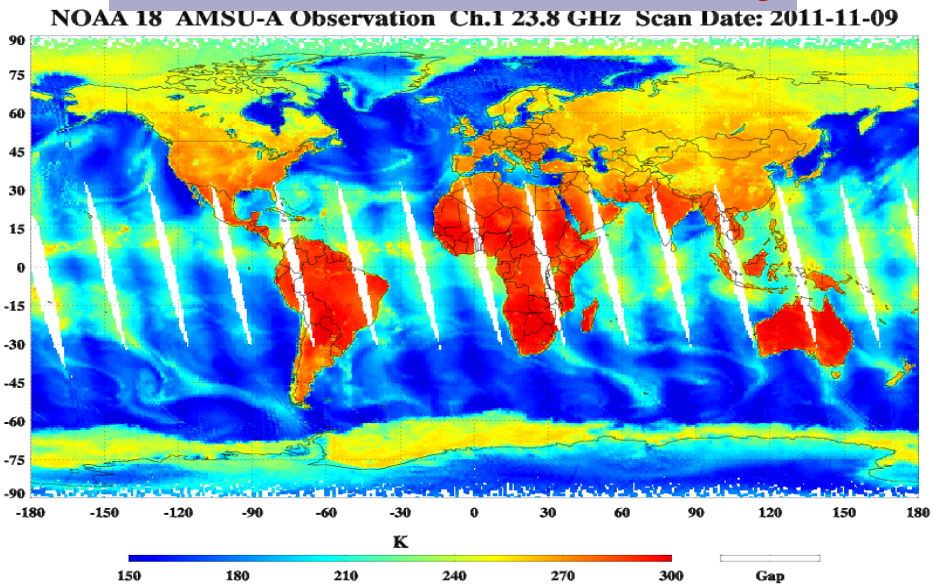
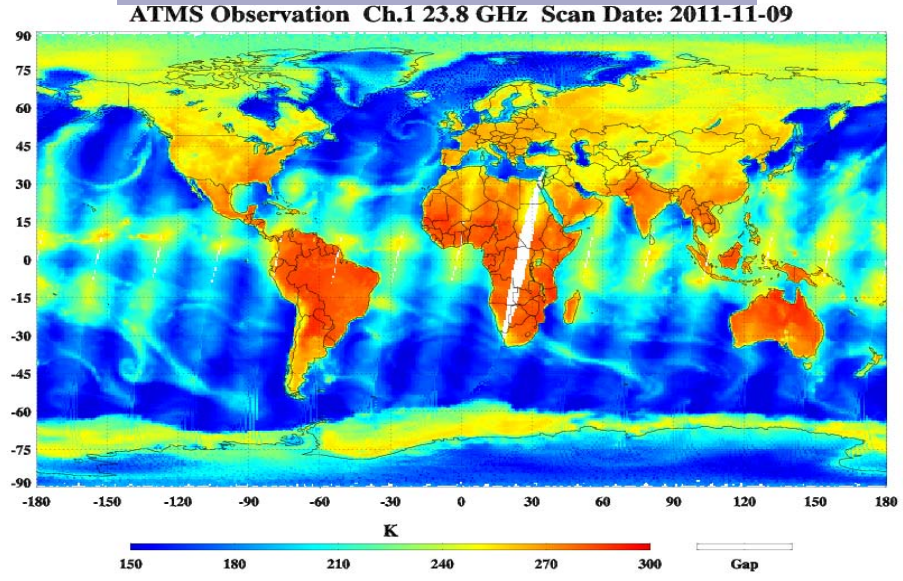
ATMS Observation Ch.1 Ascending



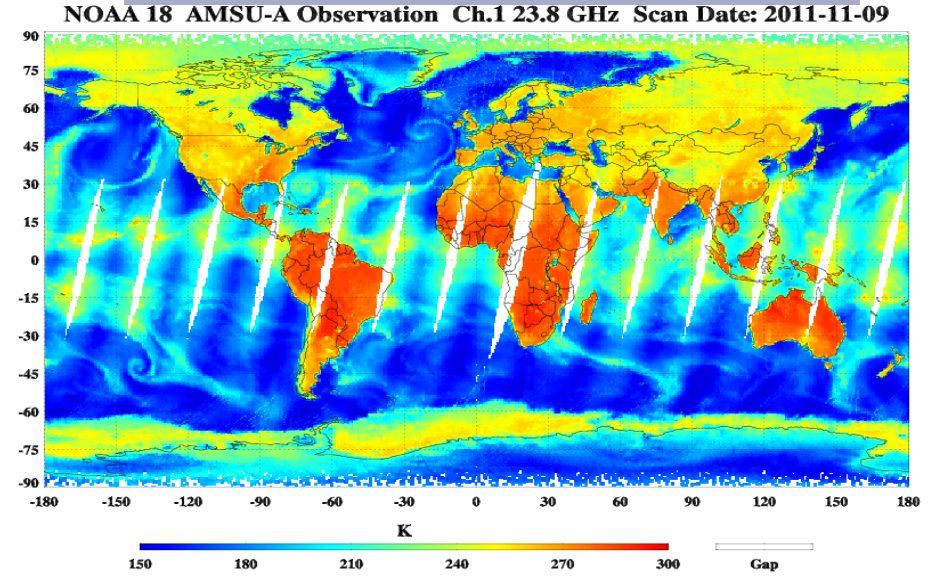
NOAA 18 AMSU-A Observation Ch.1 Ascending



ATMS Observation Ch.1 Descending



NOAA 18 AMSU-A Observation Ch.1 Descending



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Task 4: ATMS Space View Sector Selection

Objective:

Determine which of the pre-determined space view angles have the least interference from the spacecraft or Earth intercept

Methods and Tools:

Calculate consecutive 24-hour space view count mean obtained from four scan profiles at each channel and determine the optimal space view sector by selecting the one with the maximum number of channels that have minimum normalized mean space view count

Results and Recommendations:

- ✓ Minimum mean space view count channels:
  5 SV1, 12 SV2, 4 SV3, and 1 SV4
- ✓ Optimal space view sector : SV2

Optimal Space View Selection (Cont'd)

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

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Task 7: ATMS Dynamic Range Evaluation

Objective:

Verify that the radiometric counts do not exceed the specified maximum allowable for the instrument's Analog-to-Digital conversion

Methods and Tools:

STAR ICVS on-line trending of cold and warm counts and comparison with requirements

Results and Recommendations:

ATMS cold/warm counts were all out of lower limits in MX5.0

The new thresholds have been reset to 1000 to 60000 in MX5.1

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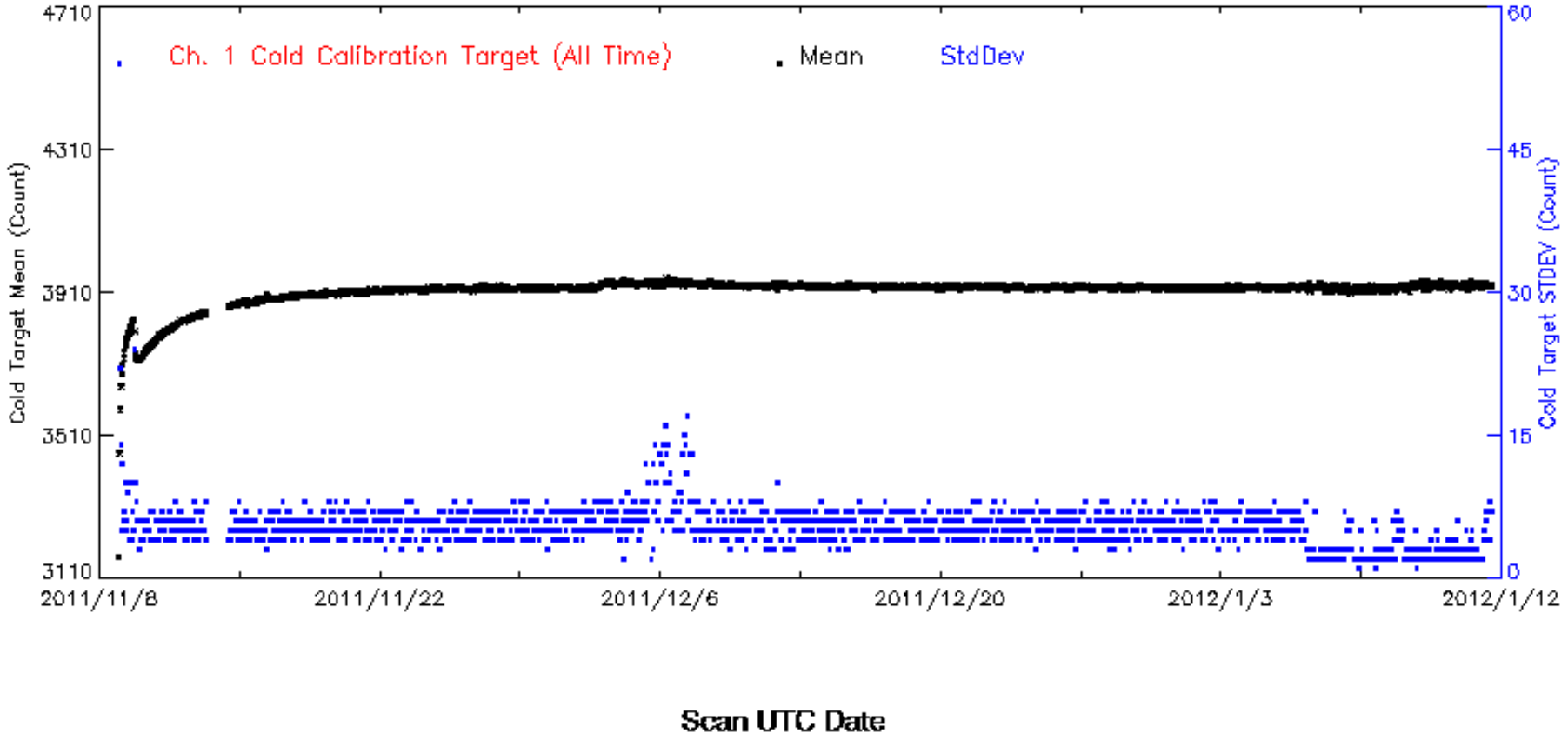
Task 7: ATMS Dynamic Range Evaluation



Task 8: ATMS Radiometric Sensitivity Evaluation

Objective:

Evaluate the on-orbit radiometric sensitivity (NEΔT)

Methods and Tools:

Calculate the warm counts from 250 scanlines to calculate their standard deviation divided by the calibration gain

Results and Recommendations:

ATMS all channel NEDT meet the requirements

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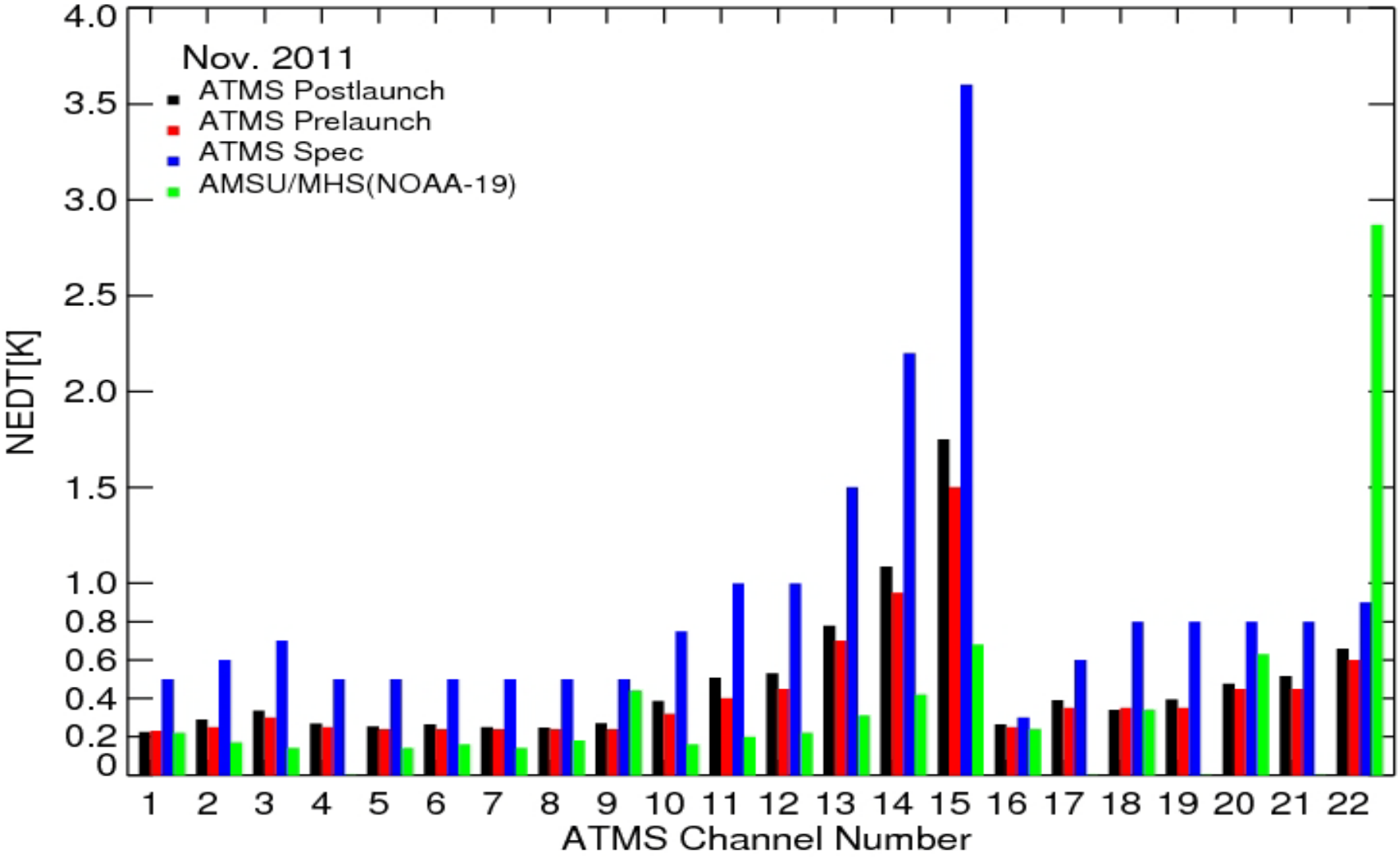
Task 8A: ATMS Noise Equivalent Differential Temperature (NEDT)



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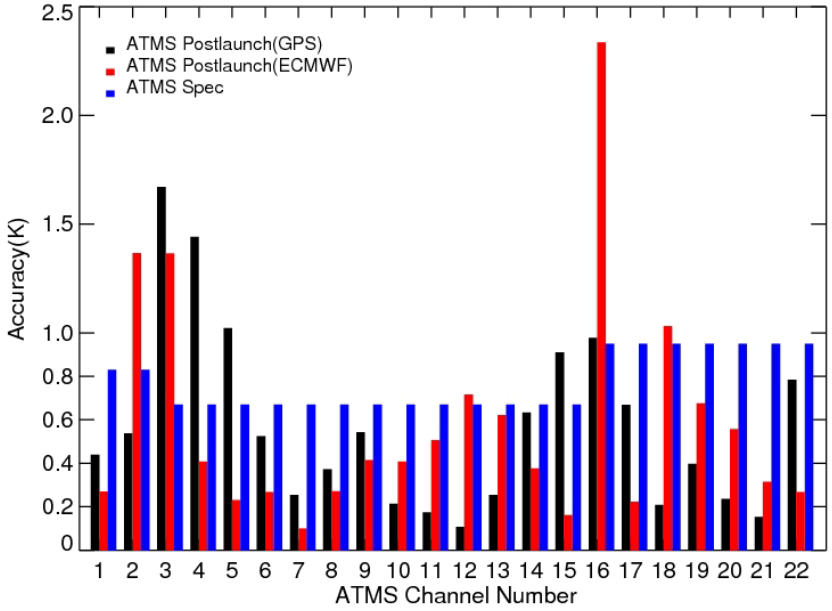
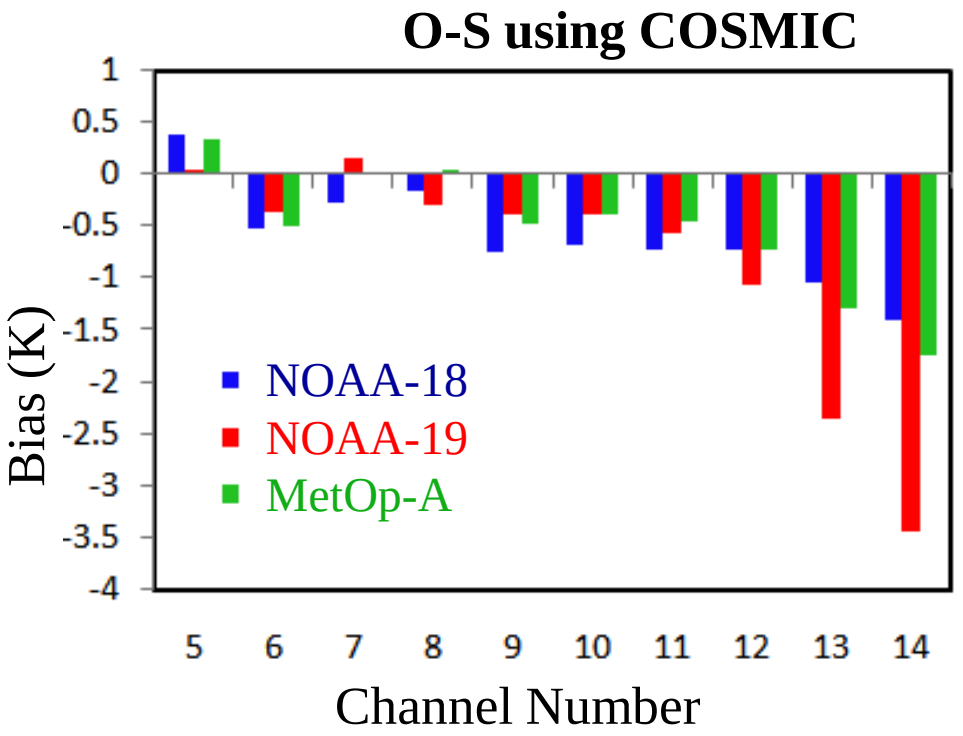
Task 8B: ATMS Accuracy Assessment Using ECMWF and COSMIC Data





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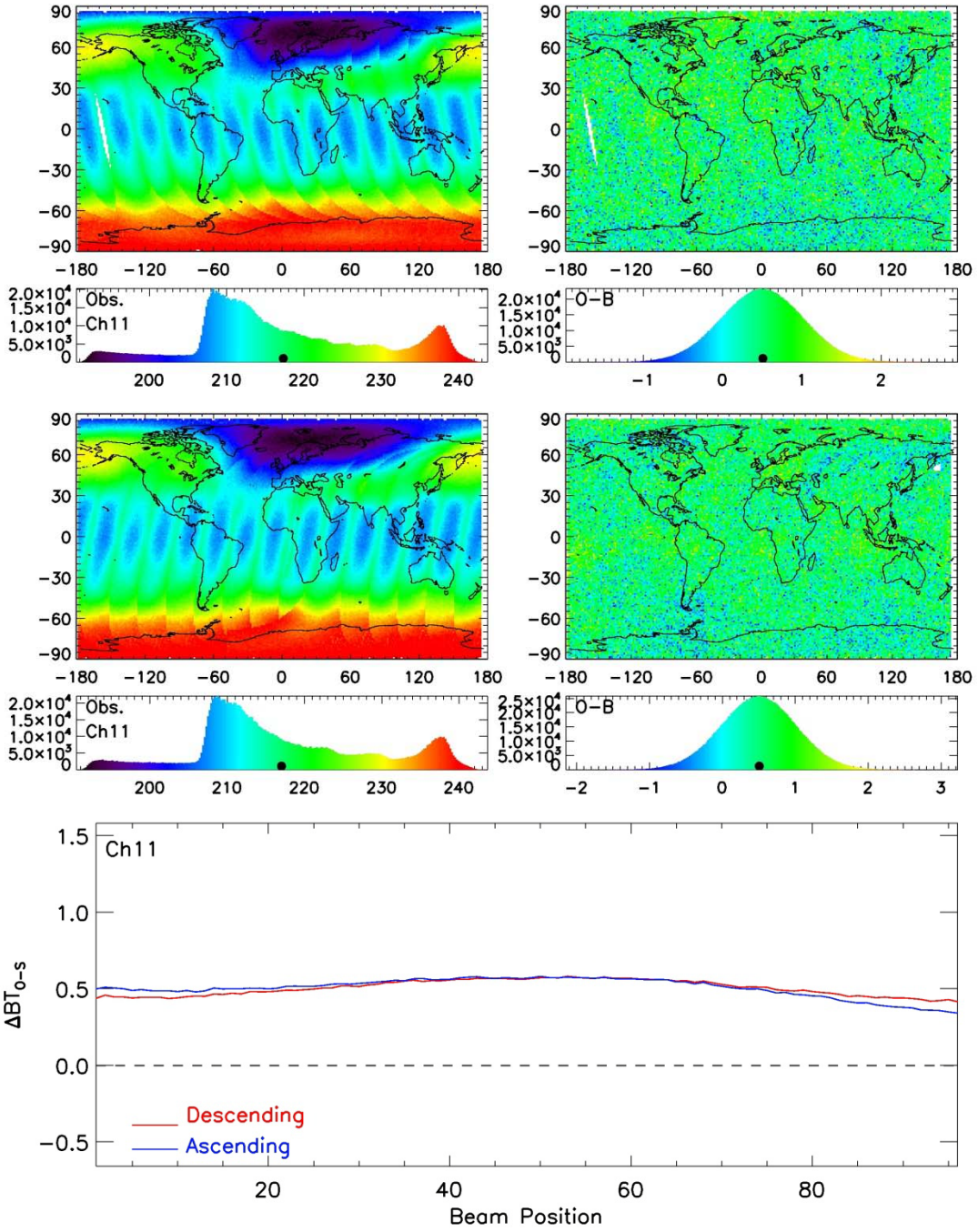
Task 8B: ATMS Accuracy Assessment

One day (01/08/2012) ATMS observations are obtained to compare with CRTM simulations using ECMWF analysis forecast data. Channels 1-5, and 16-22 are over ocean between 60^0S to 60^0N and cloud liquid water path is less than 0.08 kg/m^2 to remove water cloud, but ice cloud still exist.

All data for Channels 6-15 are used.



Task 10: ATMS Temperature Stabilization

Objective:

Allow the sensor's temperature to reach stabilization

Methods and Tools:

Use RDR telemetry data and post on-line

Results and Recommendations:

Instrument calibration gain parameter, PRT and instrument temperatures are reaching stable conditions

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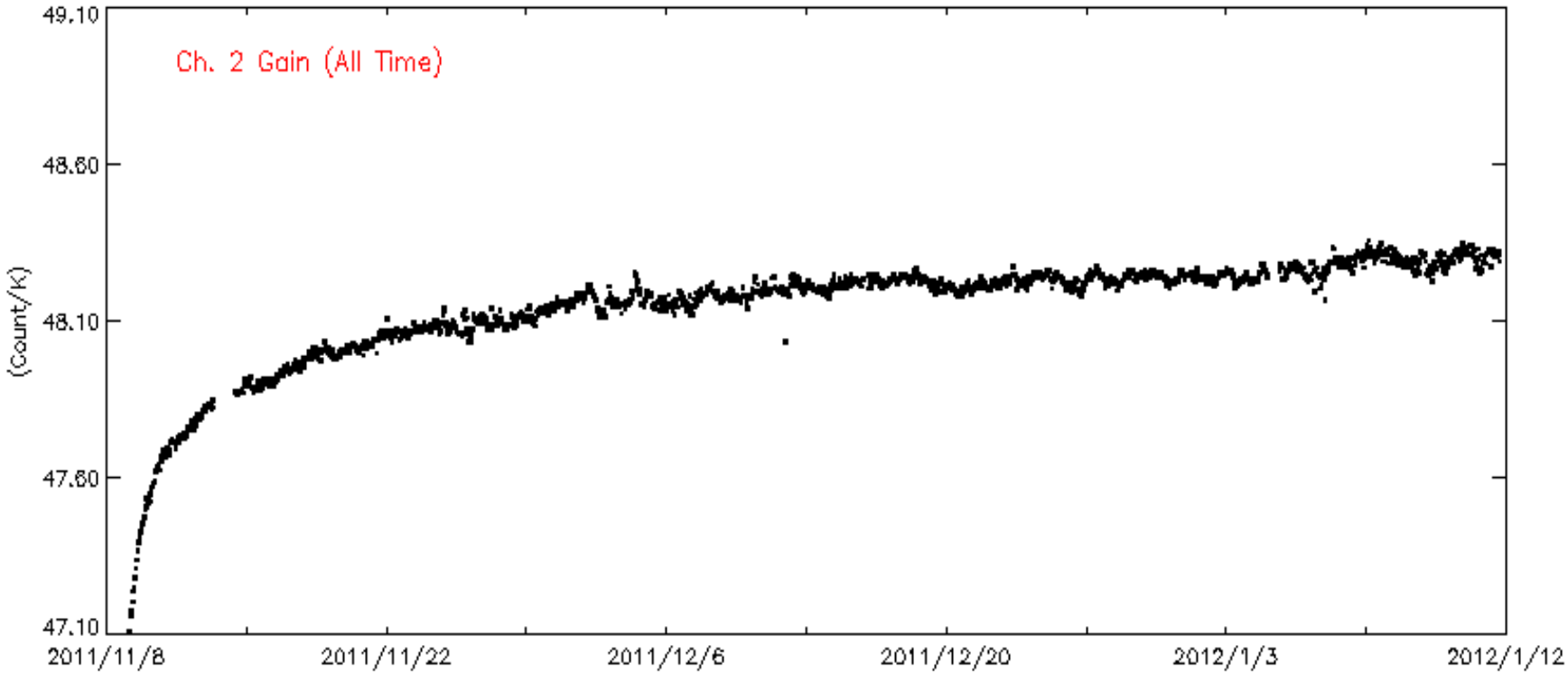
Task 10: ATMS Calibration Gain at Channel 2



Blackbody Uniformity Check

Blackbody (warm target) was sampled four times during each scan cycle

Five PRTs imbedded in blackbody for characterizing the non-uniformity

Callendar-Van Dusen equation

$$Rx = R0 \{1 + \alpha[Tx - \delta(Tx/100 - 1)(Tx/100) - \beta(Tx/100 - 1)(Tx/100)3]\}$$

The warm load physical temperature is determined as the average value derived from the embedded PRT's plus a bias-like correction factor (which is allowed to depend on the receiver's physical temperature). A weighted average in two dimensions (PRT # and across-scan sample) is implemented that allows for a weighted average. This makes it possible to

Physical temperature:
a. give more weight to certain PRTs than others
b. implement a non-equal time-weighted average (i.e. where samples closest in time are given more weight than those more distant)

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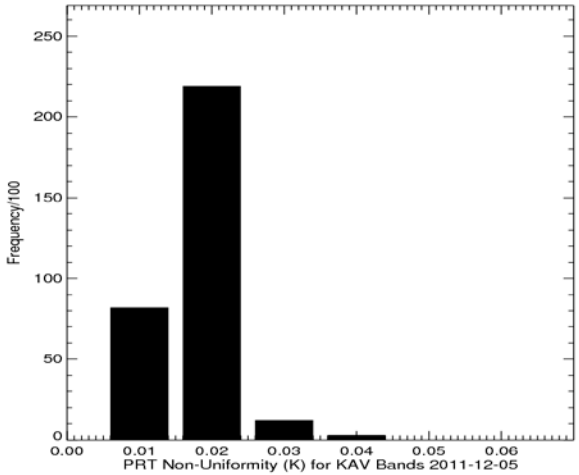
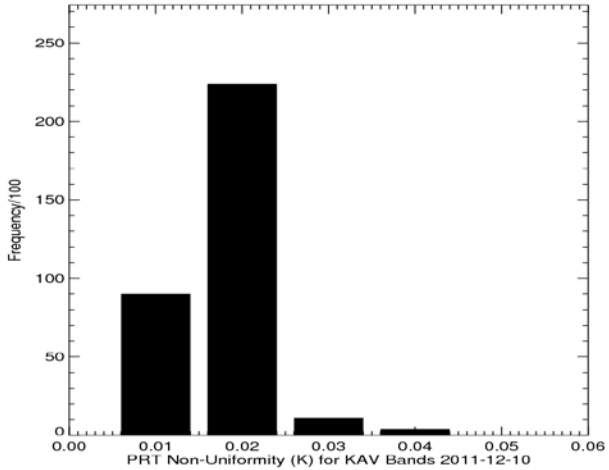
ATMS PRT Uniformity Check

12-05-2011



12-10-2011



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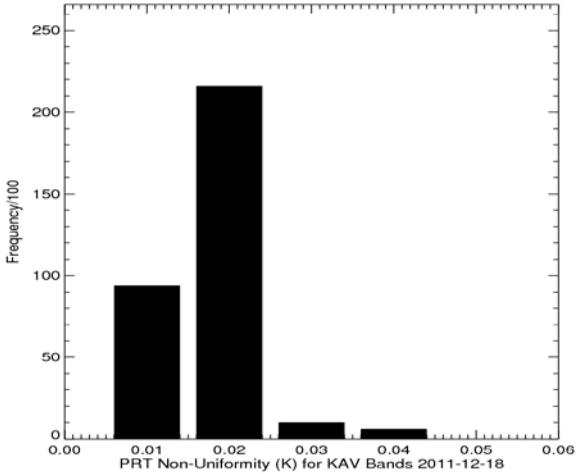

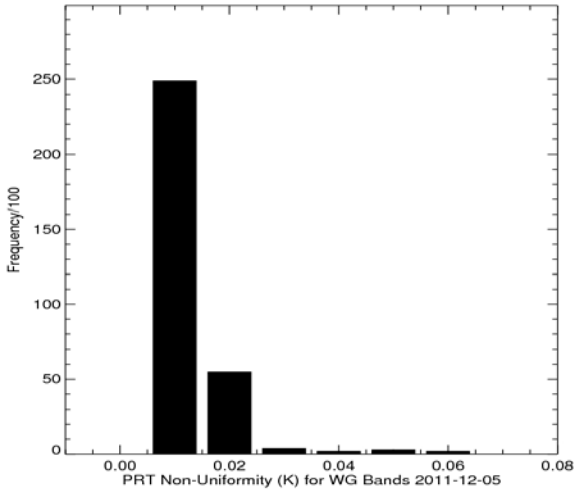

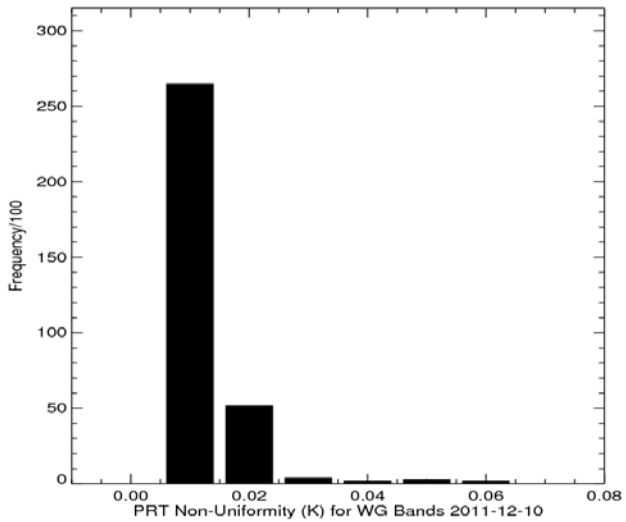

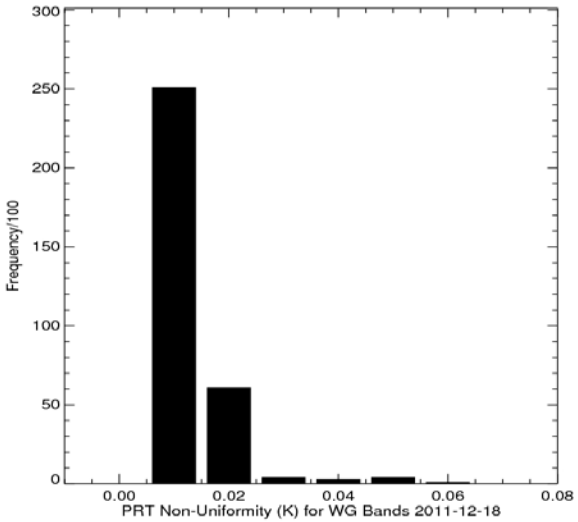

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Task 11: ATMS RF Shelf to Cold Plate LUT Verification

Objective:

Verify the SDR algorithm LUT then covert the RF Shelf temperature to an appropriate cold plate temperature. Such LUT is used to determine the nonlinearity correction factor based on the present RF Shelf temperature

Methods and Tools:

Use RDR telemetry data and post on-line

Results and Recommendations:

RF temperature is stable and in a correct range that can be used to calculate nonlinearity after 11/9/2011

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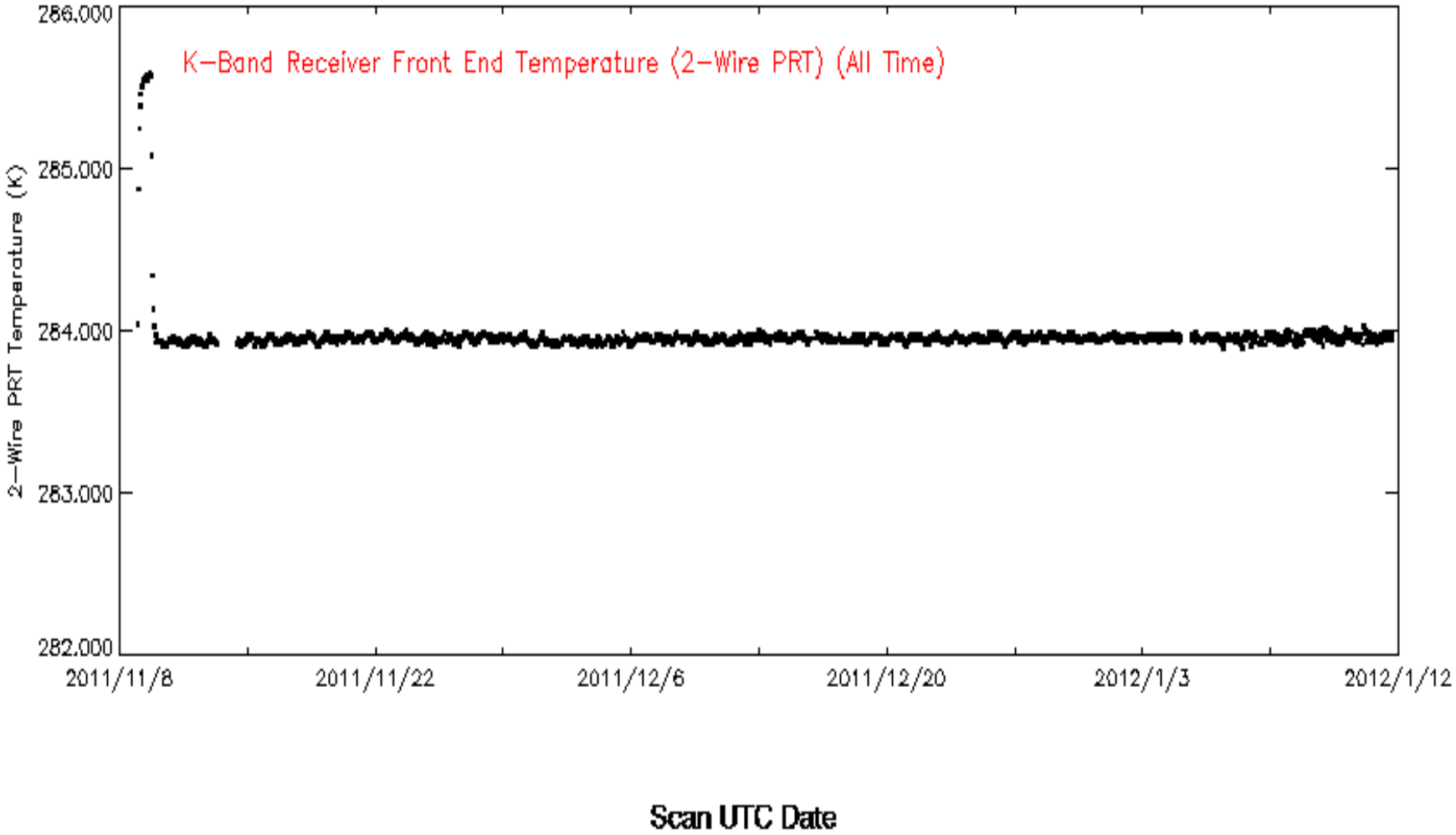
Task 11: ATMS RF Shelf to Cold Plate LUT Verification



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Task 14: ATMS Lunar Intrusion Evaluation and Mitigation

Objective:

Determine a routine procedure for dealing with lunar contamination of the cold space calibration target

Methods and Tools:

STAR ICVS on-line trending of space view cold counts at four angles

1. Remove the count spikes during lunar events
2. Correct cold space temperature using lunar model

Results and Recommendations:

During the lunar event, the duration of ATMS cold count contamination increases with the antenna beam width. For example, it is often to have more than 3 SV counts are contaminated at Channel 1 and 2.

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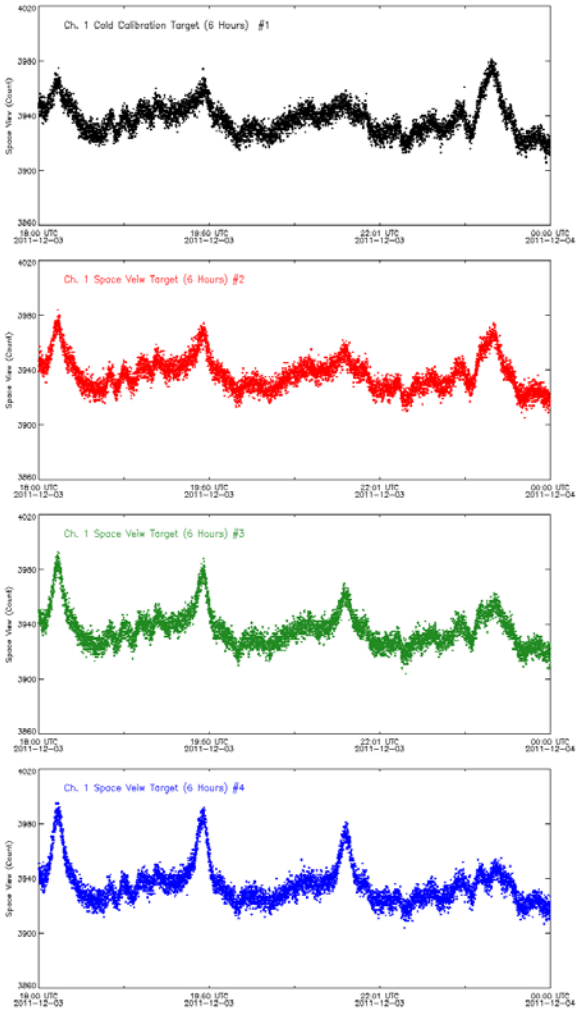
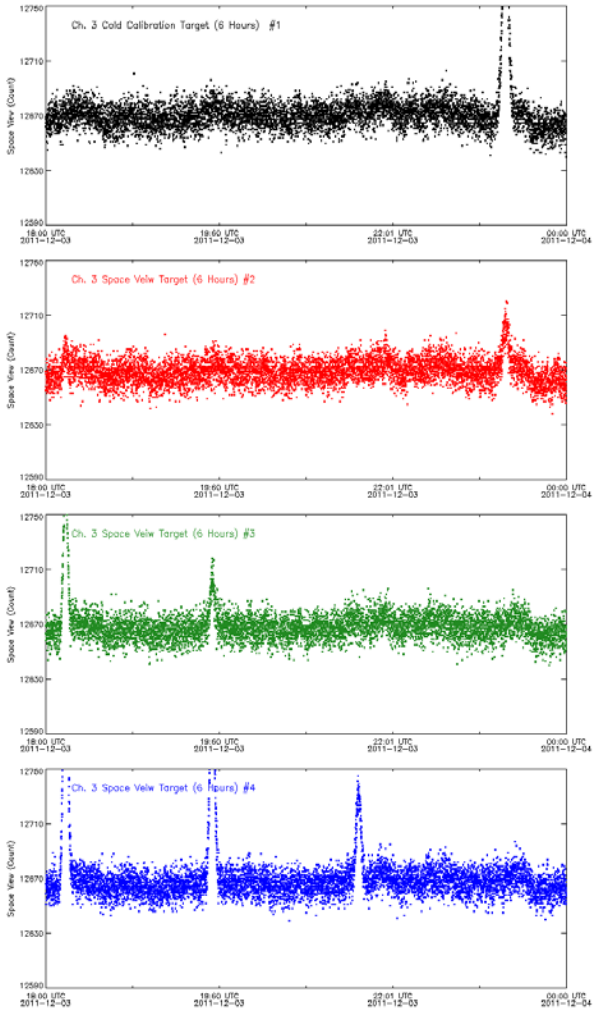
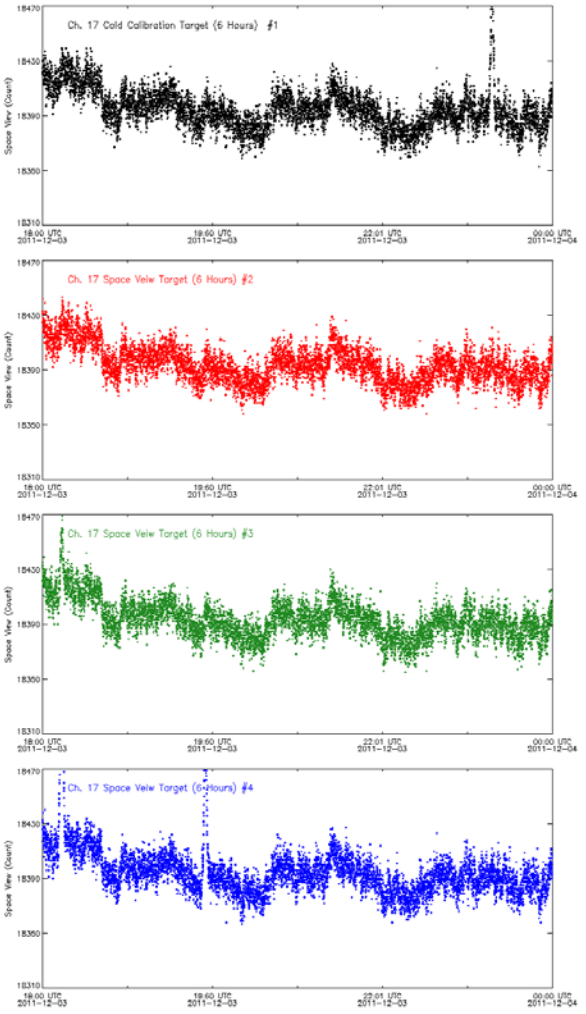
ATMS Calibration Count due to Lunar Radiation

Channel 1 (FOV Size:5.2)	=	Channel 3 (FOV Size: 2.2)	Channel 17 (FOV Size: 1.1)







Lunar Correction on Cold Space Temperature

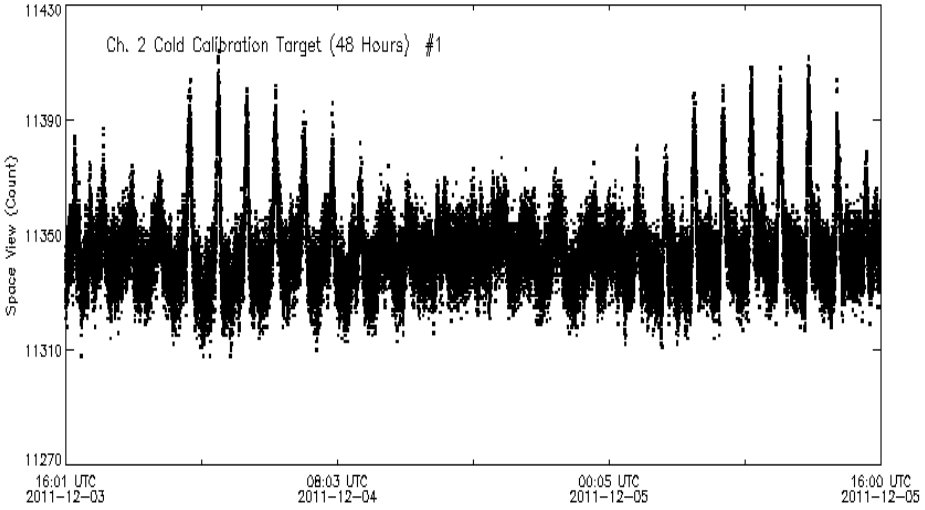
$$\Delta T_c = \exp\left[-\frac{(\alpha-\alpha_0)^2}{2\alpha_S^2}\right]\exp\left[-\frac{(\delta-\delta_0)^2}{2\delta_S^2}\right]\beta\, T_{moon}\; r$$

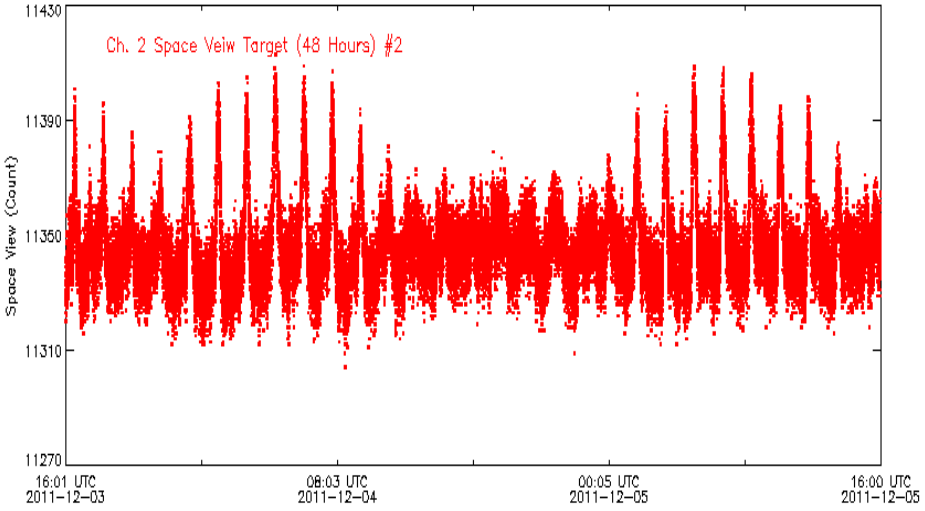
$$T_c = 2.726 + (\Delta T_{RJ}) + \Delta T_c$$

$$T_{moon} = 95.21 + 104.63(1-\cos\theta) + 11.62(1+\cos 2\theta)$$

Where:

θ	separation angle between the moon and sun
Cw	*blackbody count*
Cc	*observed space counts, including lunar contamination*
Tw	blackbody temperature
Tc	deep space cosmic background temperature
α	*lunar azimuth angle*
$\alpha 0$	*field of view (FOV) center of lunar azimuth angle*
αS	*lunar azimuth size factor*
δ	*lunar elevation angle*
$\delta 0$	*FOV center of lunar elevation angle*
δS	*elevation size factor*
β	*area ratio of lunar disk to FOV convolved with the antenna patterns powers [3].*
r	*distance ratio = (60.3x6378/d)2, where d is the distance (in km) between the satellite and moon*





Task 16: Roll/Pitch Maneuvers

Objective:

Cross-track scan bias dependence and determine at least part of any asymmetries that may exist toward the anti-sun side of the bus

Methods and Tools:

RDR data is ideal for this analysis but RDR2TDR needs some special tuning
TDR can be also used if the scene count is not set to filled values (Roll 250, 12/9/2011)

Results and Recommendations:

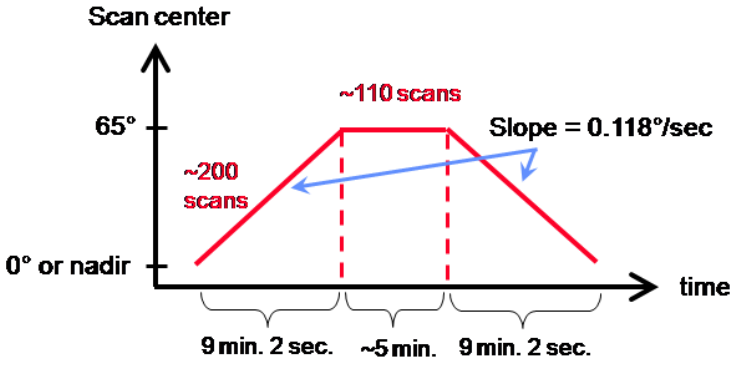
250 roll maneuver data from FOVs 76 to 96 appears to be values for estimating the antenna efficiency and along scan bias

NPP Roll Maneuver for ATMS

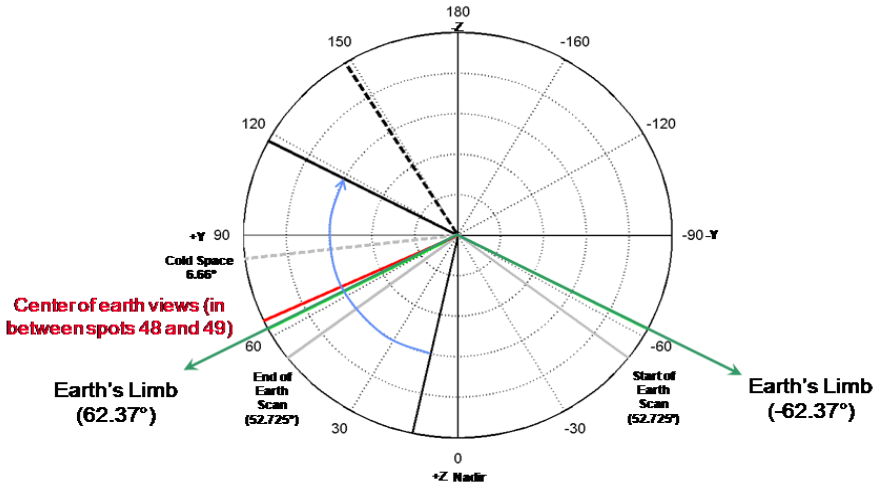
NPP Roll Maneuver 1

Cross Track Scan Check

- **Normal scan mode (scan period of 2.666 sec; two cal. loads)**
- **Maneuver lasts less than a 1/3 of an orbit**
- **Roll is toward cold sky (a.k.a. anti-sun)**
- **Moves ~0.31° per scan**
- **Spots 49 to 96 will cross over the earth's limb**

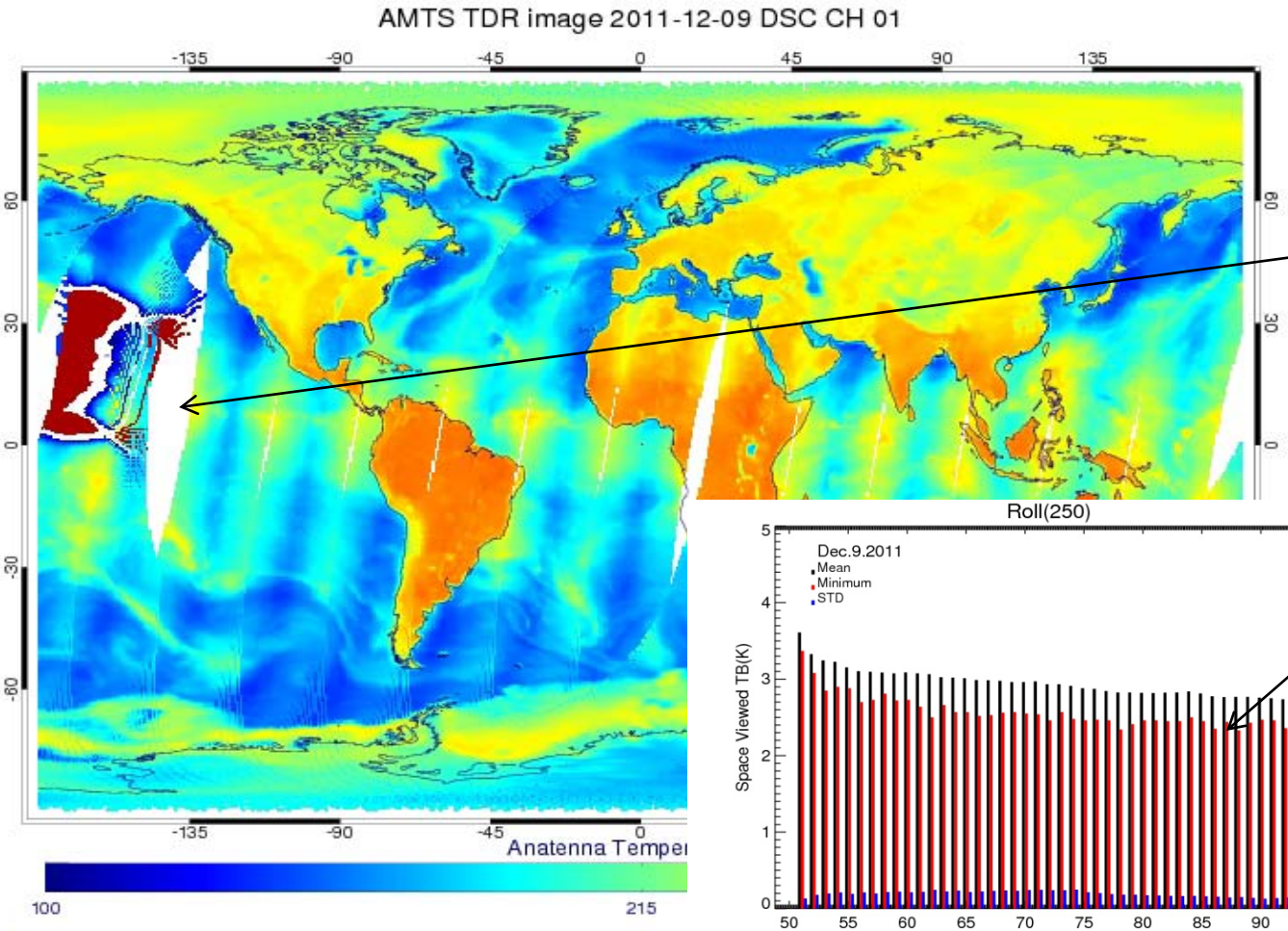


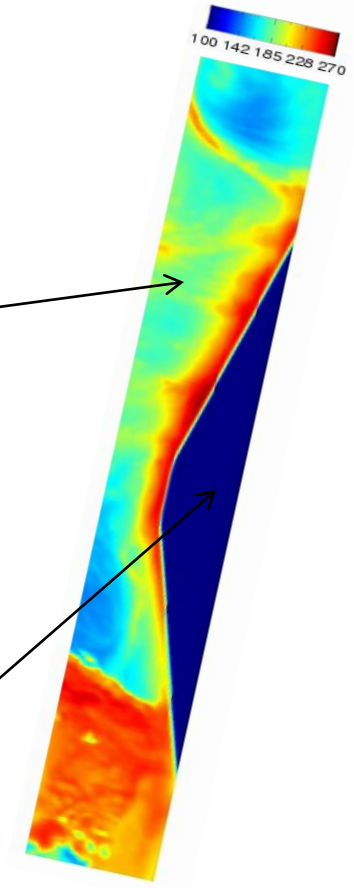
Roll Maneuver # 1



Gray lines denote standard orientation
Black lines denote plateau (max. roll) in this maneuver

ATMS Roll Maneuver for Antenna Efficiency and Scan Dependent Bias



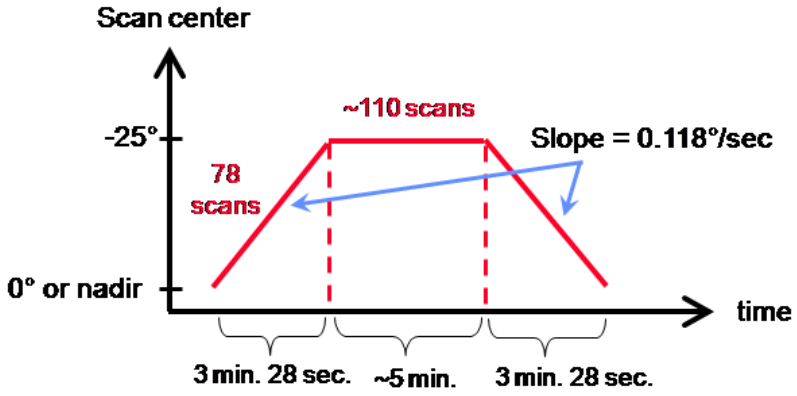


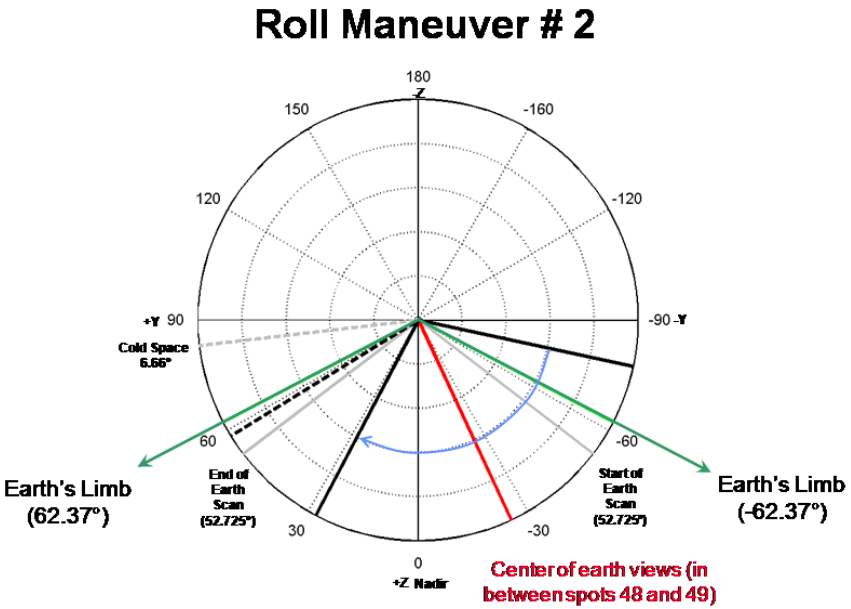
NPP Roll Maneuver for ATMS

NPP Roll Maneuver 2

Imaging of Earth's Limb (sun-side)

- **Normal scan mode (scan period of 2.666 sec; two cal. loa**
- **Roll is toward the sun**
- **Moves ~0.31° per scan**
- **Spots 1 to ~14 will cross over the earth's limb**





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Task 19: ATMS Re-sampling Validation Using CrIS

Objective:

Validate the ATMS FOV re-sampling to the CRIS FOR

Method and Tools:

Compare ATMS only SDR and SDR remap data (global and region scale) from IDPS

Results:

ATMS remap SDR has some biases near coastal and cloud/precipitation edges, etc.

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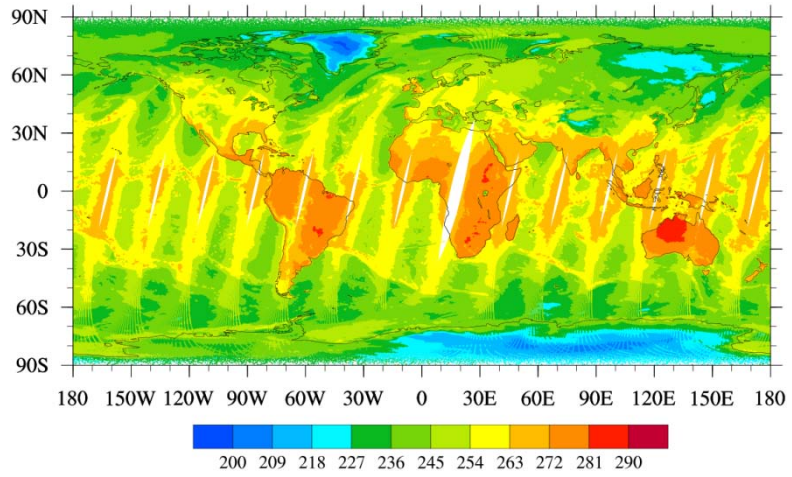
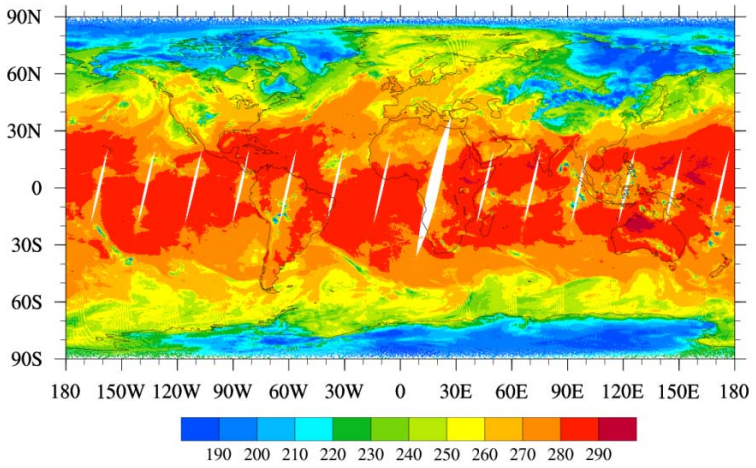
Task 19: ATMS Re-sampling Validation Using CrIS

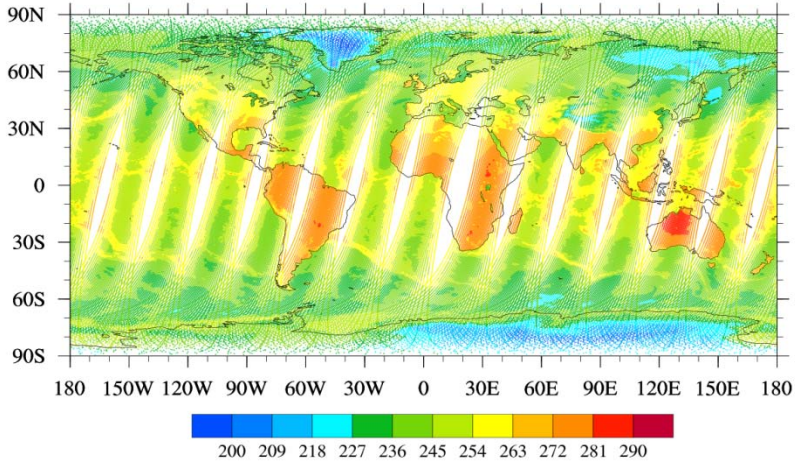
SDR Channel 4



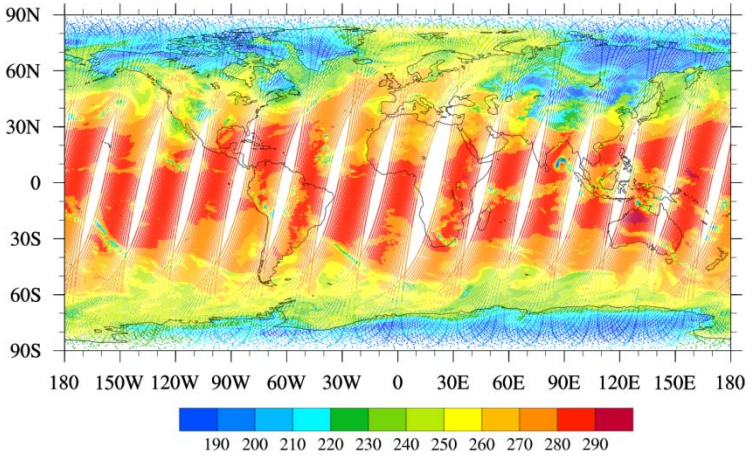
SDR Channel 17



SDR-remap Channel 4



SDR-remap Channel 17



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Task 20: ATMS TDR Ascend/Descend Comparisons

Objective:

To determine pointing, navigation, and asymmetry errors by separating ascending/descending nodes

Method and Tools:

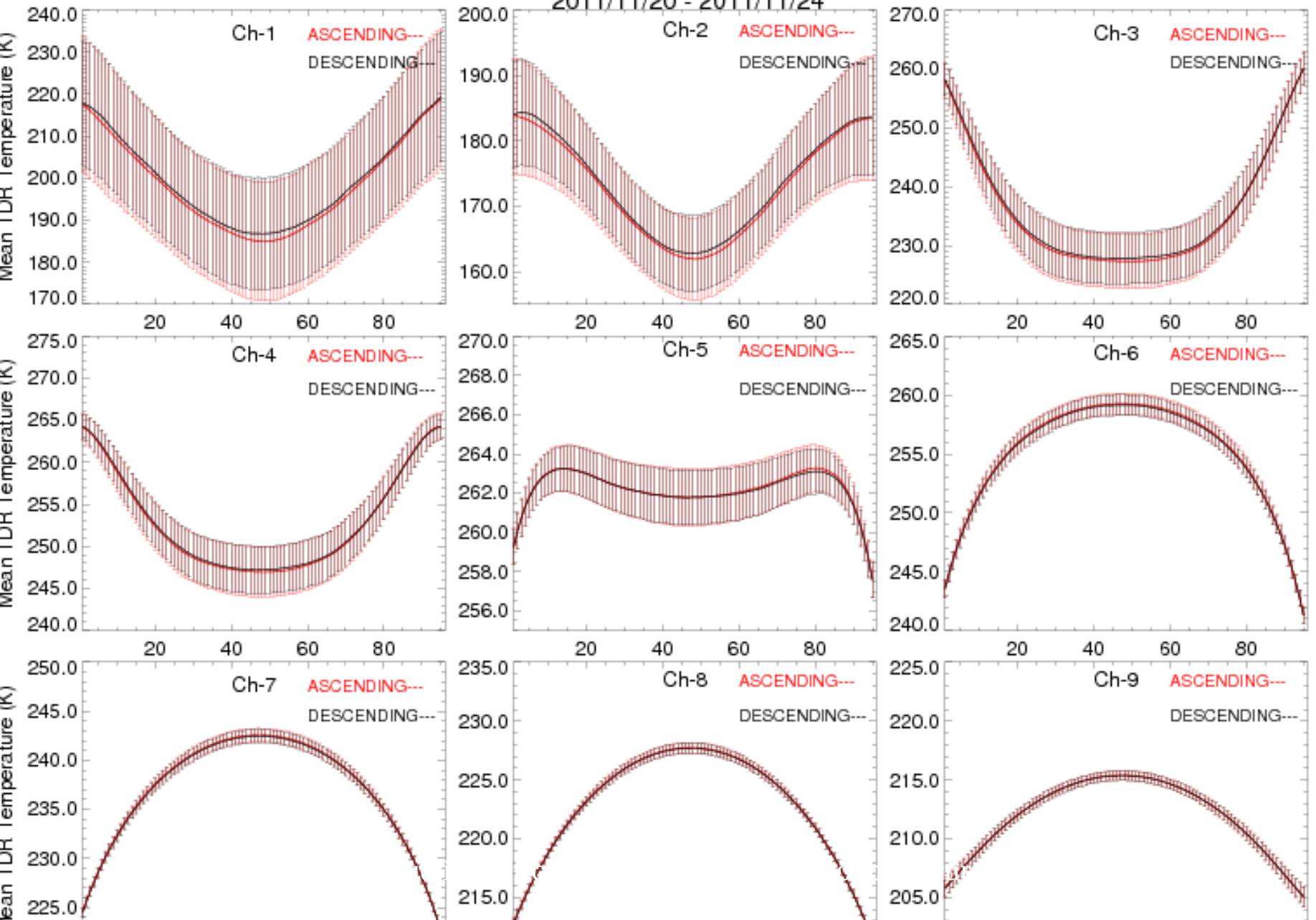
ATMS TDR data, 7 days of average over oceanic scene between 20 degree north and south, no clouds

Results:

There are some slight differences in angular dependant features between as and ds nodes. The overall features are similar to AMSU

National Environmental Satellite, Data, and Information Service

ATMS Mean TDR Temperature (Clear Sky Over Ocean 20°S~20°N)
2011/11/20 - 2011/11/24



National Environmental Satellite, Data, and Information Service

Task 24: ATMS SDR Validation by NWP

Objective:

Identify SDR and remap SDR bias using NCEP GFS/GDAS data

Methods and Tools:

1. NCEP Global Forecast System analysis fields
2. Community Radiative Transfer Model (CRTM)
3. ATMS TDR orbital files

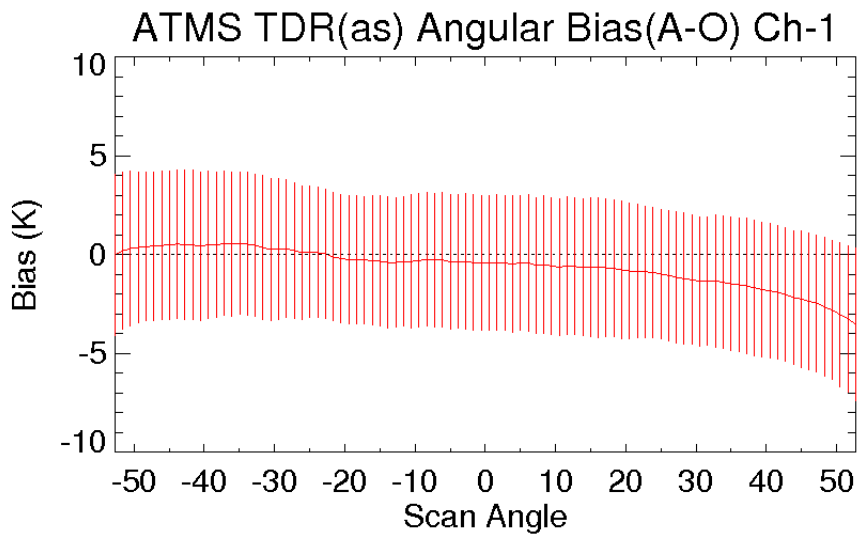
Results and Recommendations:

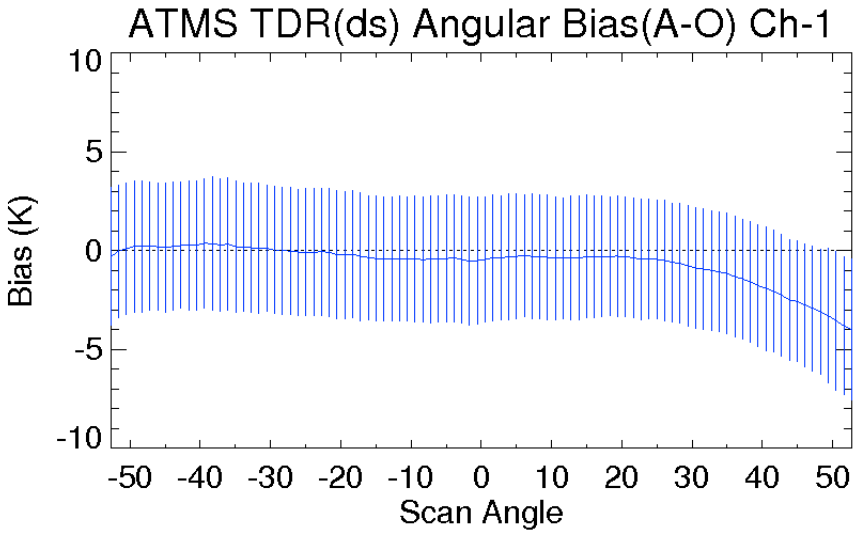
Channel 1 and 2 display along-scan asymmetry in brightness temperature

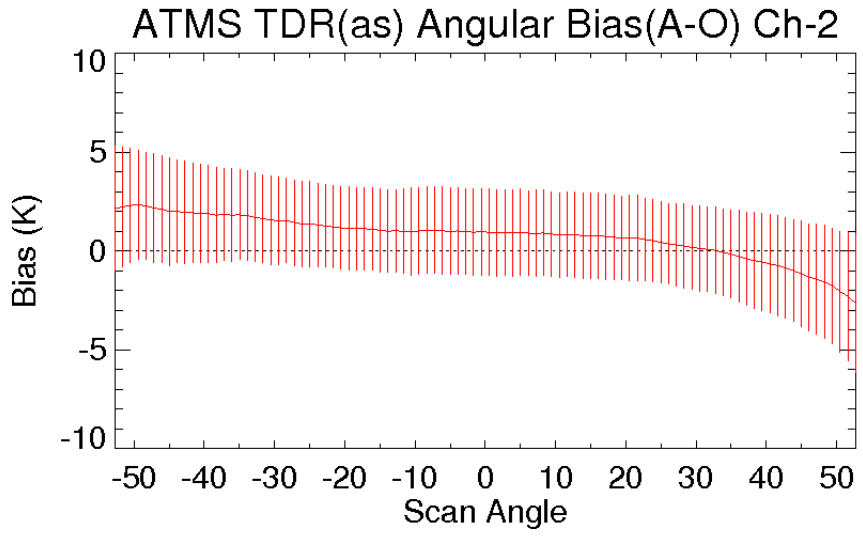
National Environmental Satellite, Data, and Information Service

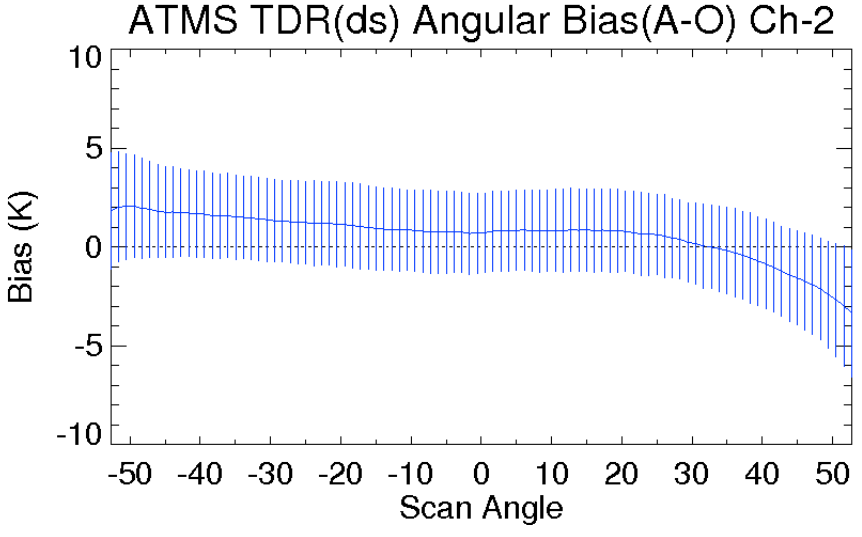
ATMS TDR Along-Scan Asymmetry

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









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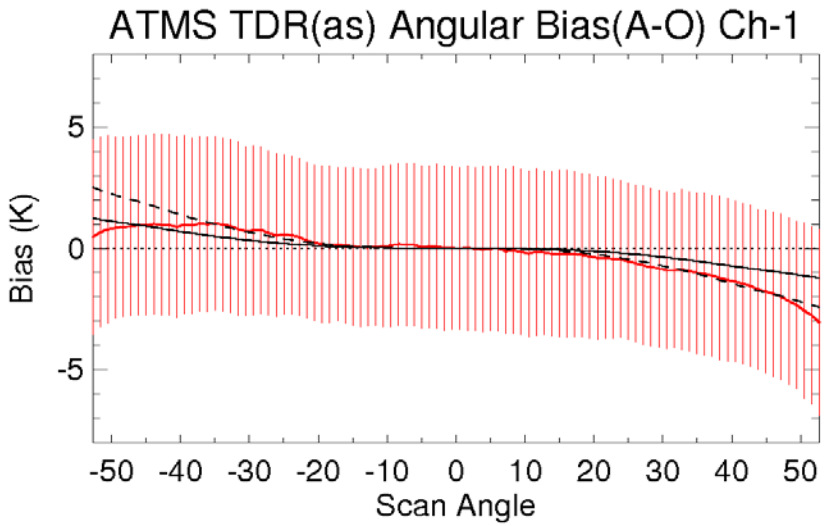
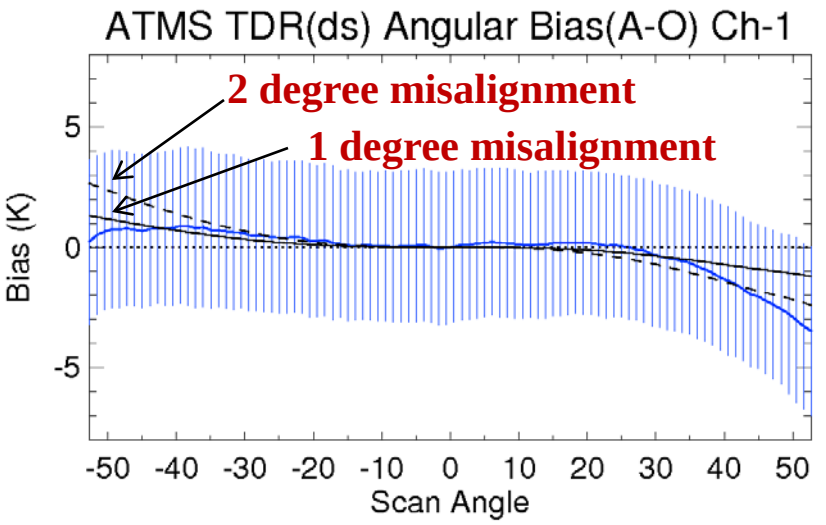
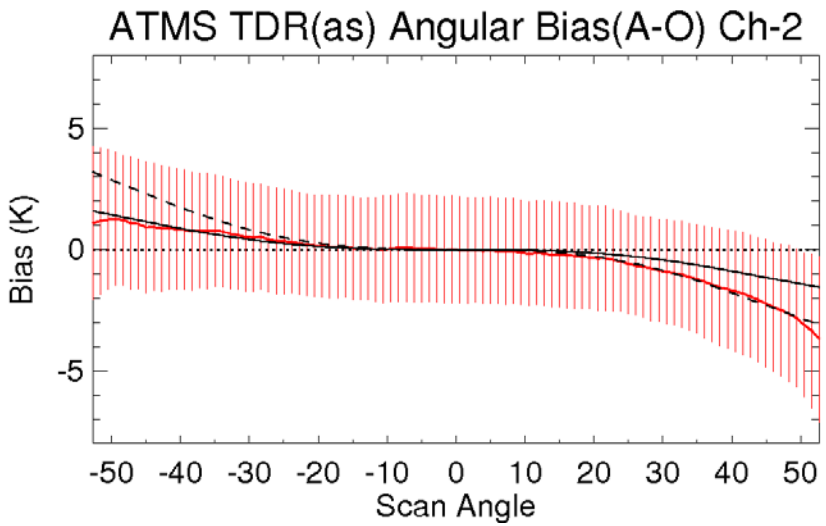
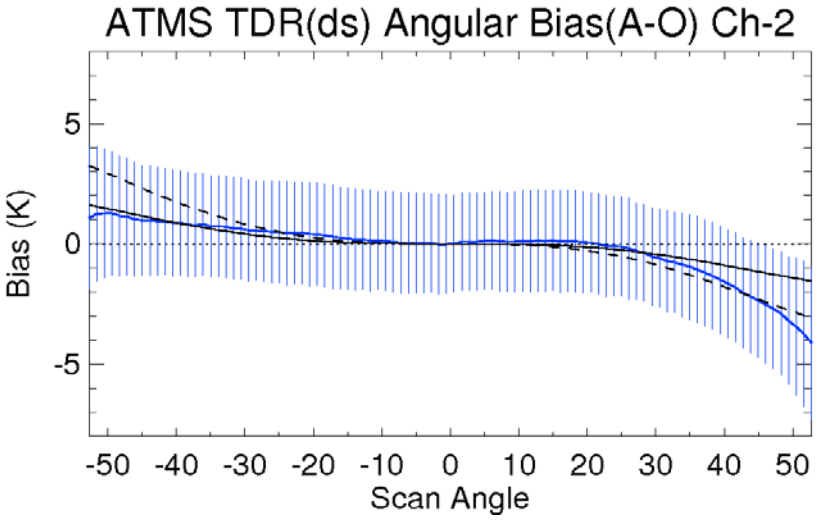
ATMS TDR Along-Scan Asymmetry

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





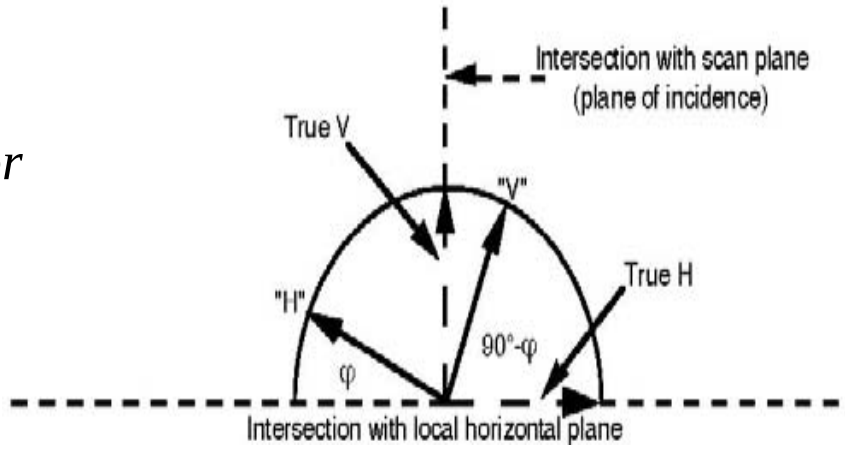




ATMS Polarization Alignment

ATMS has 22 channels and AMSU/MHS have 20, with polarization differences between some channels

- QV = Quasi-vertical *polarization vector is parallel to the scan plane at nadir*
- QH = Quasi-horizontal *polarization vector is perpendicular to the scan plane at nadir*



Summary of STAR ATMS SDR Tasks

SDR Tasks Completed (11 of 25)

Task 2, 4,7,8,10,11,14,16, 19, 20,24

SDR Tasks to be Conducted

Task 6: ATMS NPP Terrestrial Interference Evaluation
Task 13: ATMS Radiometric Environmental Characterization
Task 17: ATMS Central Frequency Stability
Task 18: SDR Correction Analysis
Task 19: ATMS Resampling Validation using CrIS
Task 21: Simultaneous nadir overpass (SNO)
Task 22: Double difference
Task 23: ATMS SDR validation by RAOB

Summary

- ATMS calibration accuracy and precision are assessed characterized and are similar in magnitude to AMSU-A/MHS
- Overall ATMS bias characteristics wrt NWP simulations are stable and similar to AMSU-A/MHS
- On-orbit performance of ATMS instrument is trended online at STAR ICVS
- ATMS granule TDR, SDR and SDR data are aggregated and available for user assessments
- ATMS has a polarization angle misalignment by one to two degrees