Suomi NPP ATMS Scan Reversal Study

Hu (Tiger) Yang, Ninghai Sun, Fuzhong Weng

NOAA/STAR ATMS SDR Working Group

Summary of Investigation

Scan Drive Current Anomaly

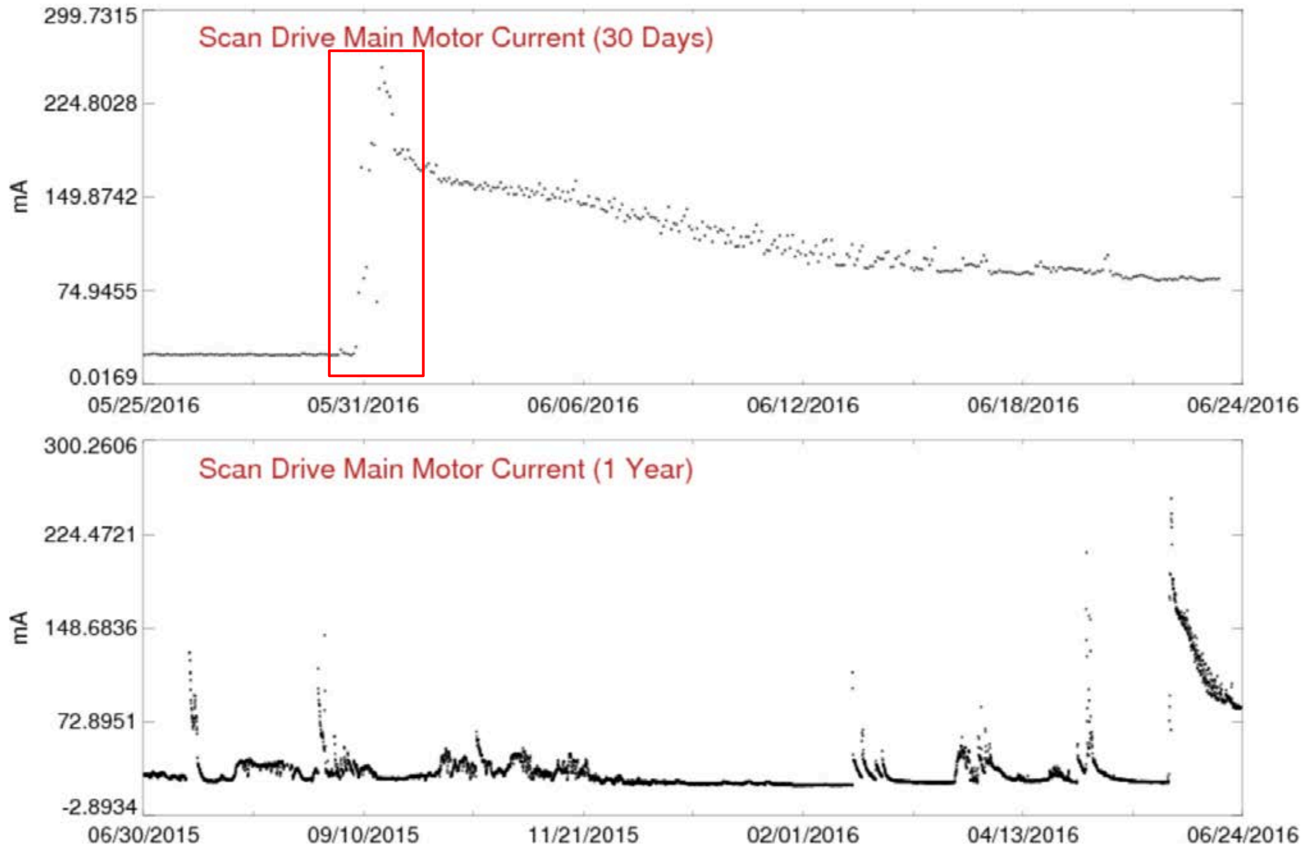
- Scan drive current is kept at a relatively high level after the anomaly happened at May.31,2016
- Scan angle of warm load/space view increased about 0.1°
- Instrument temperature and warm load temperature increased about 2°, temperature gradient is also slightly increased
- There is no calibration accuracy degradation observed in TDR products

Scan Reversal Data Processing Algorithm

- Scan reversal is carried out once every orbit near polar region;
- Two granules science data are lost during scan reversal operation;
- Reversal scan profile was studied from diagnostic data packets;
- Remapping algorithm was developed to minimize the impacts of scan reversal to data user
- Current calibration/geolocation algorithm need to be modified to adapt to reversal scan profile;

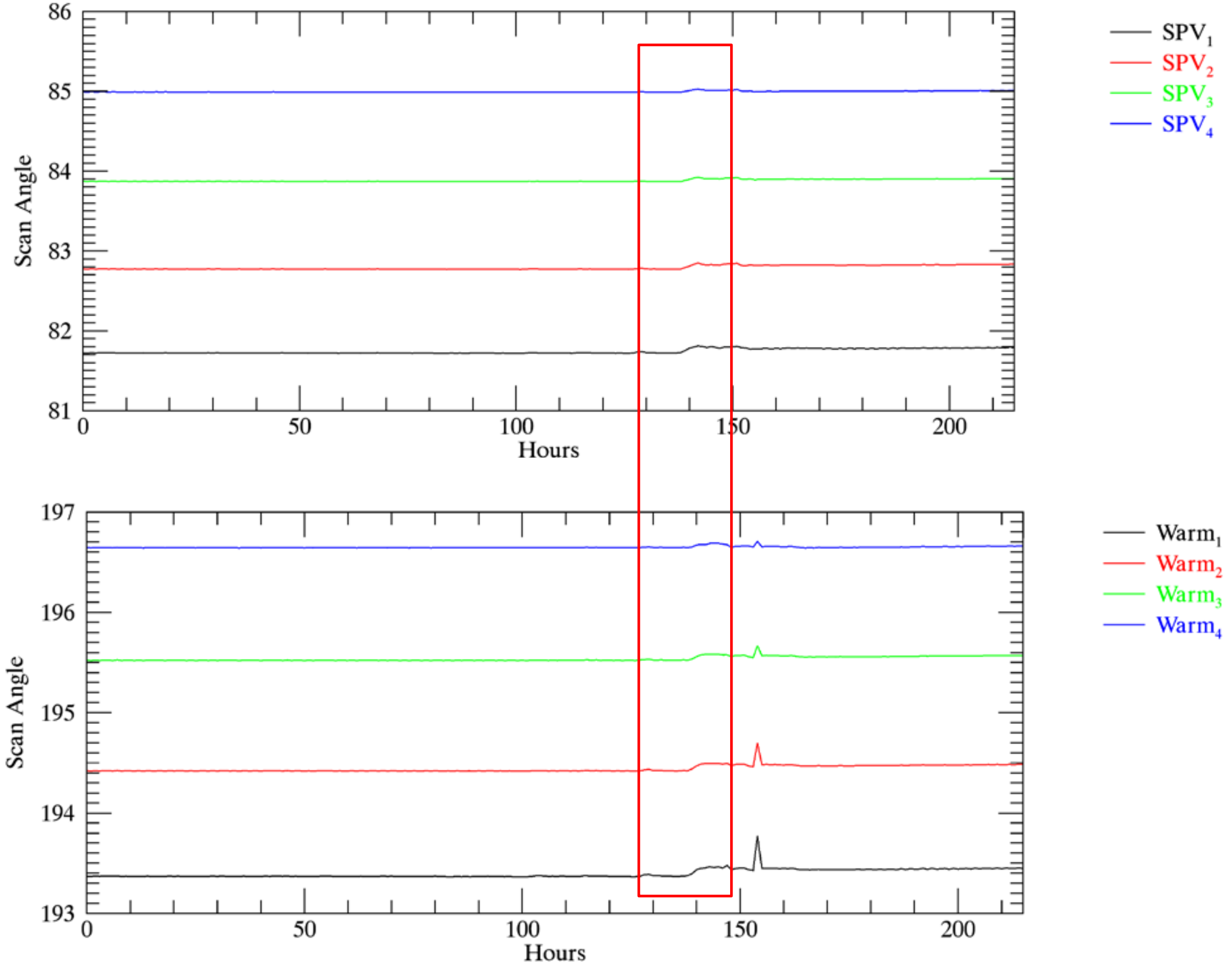
Impact of SD Current Abnormal on Science Data

- Scan drive current is kept at a relatively high level after the anomaly happened at May.31,2016
- Instrument performance may be degraded during the process



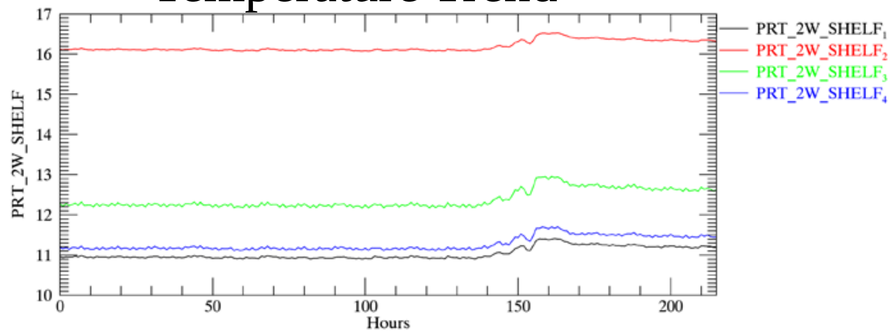
Impact on Warm load/Space view Scan Angle

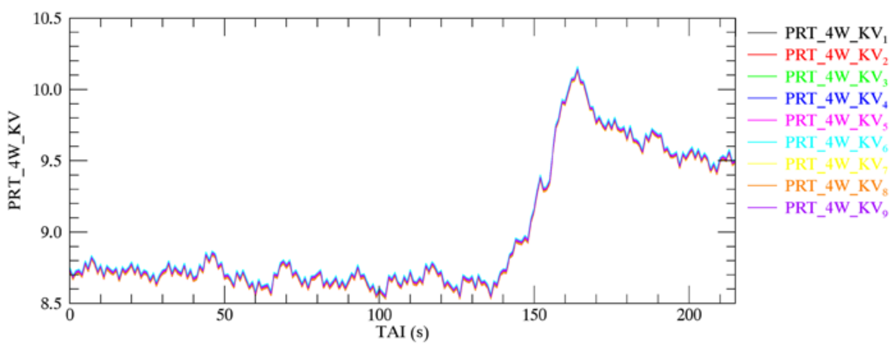
- Plotted data points start from 05/25/2016 00h to 06/02/2016 23h
- Both scan angles for warm target and space view increased about 0.1 degree after SD current anomaly accident on 05/31/2016

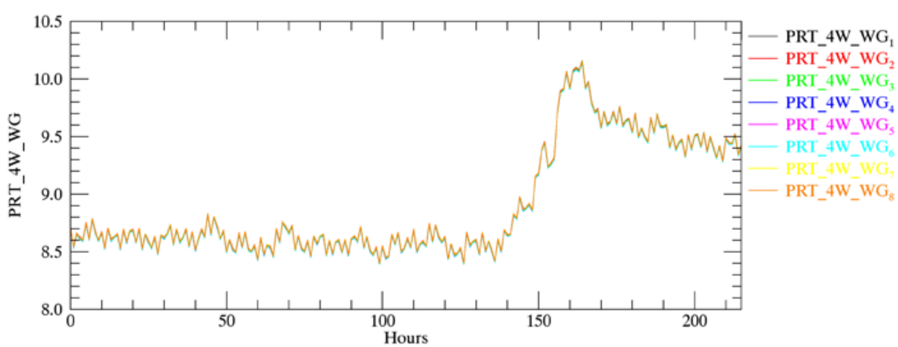


Impact on Instrument/Warm Load Temperature

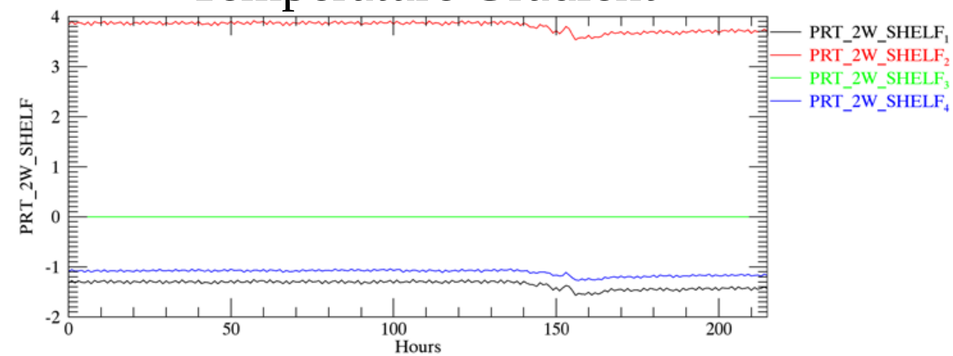
Temperature Trend

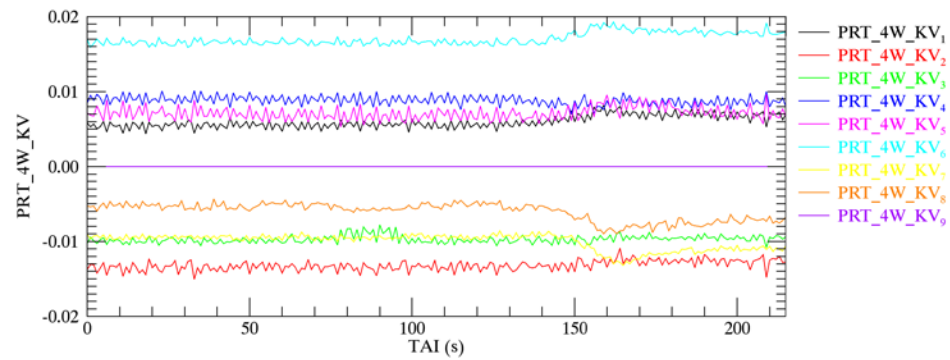


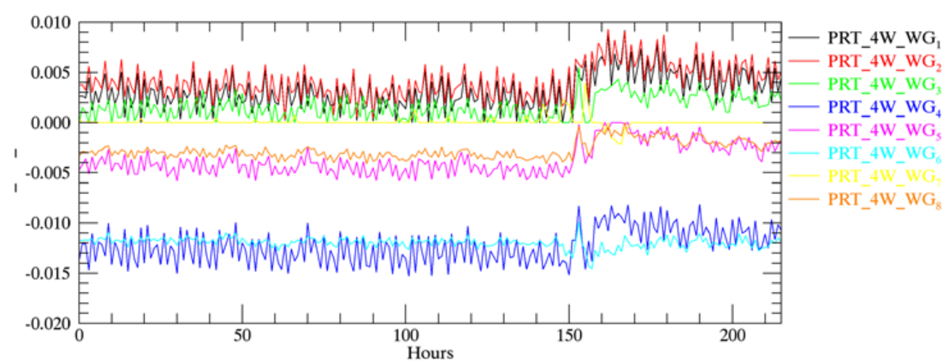




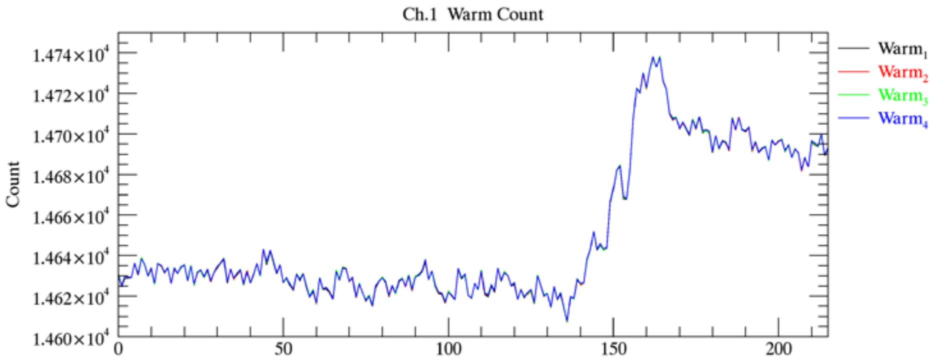
Temperature Gradient

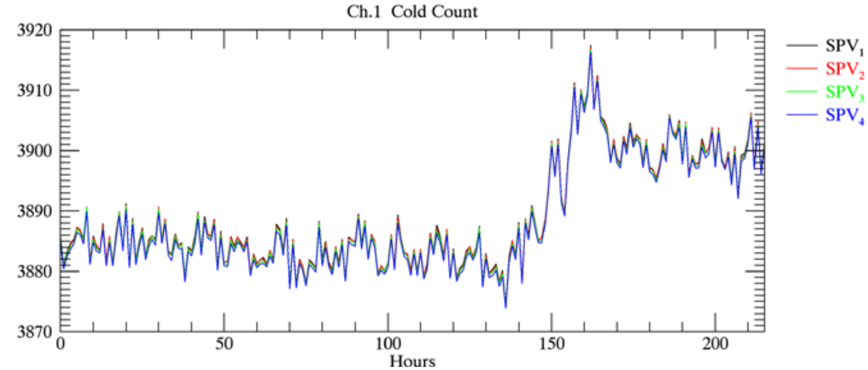


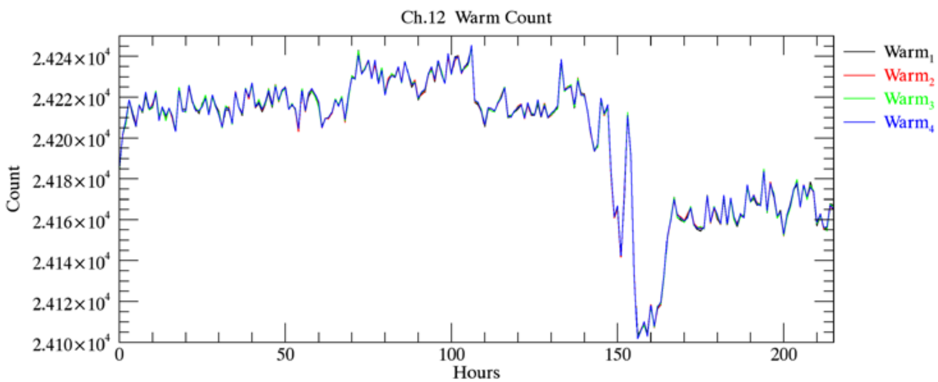


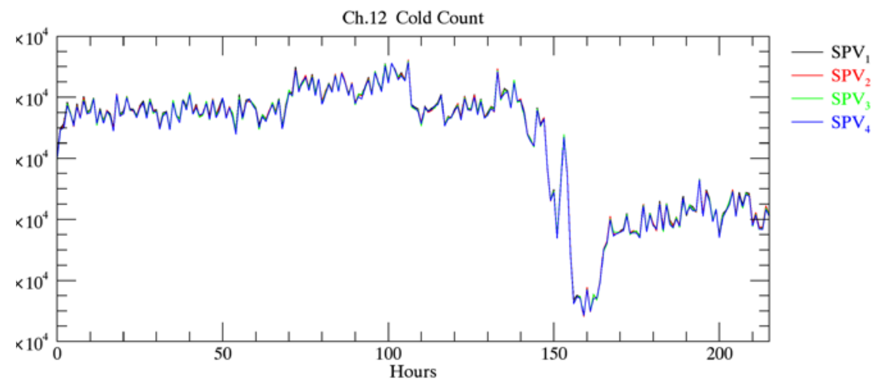


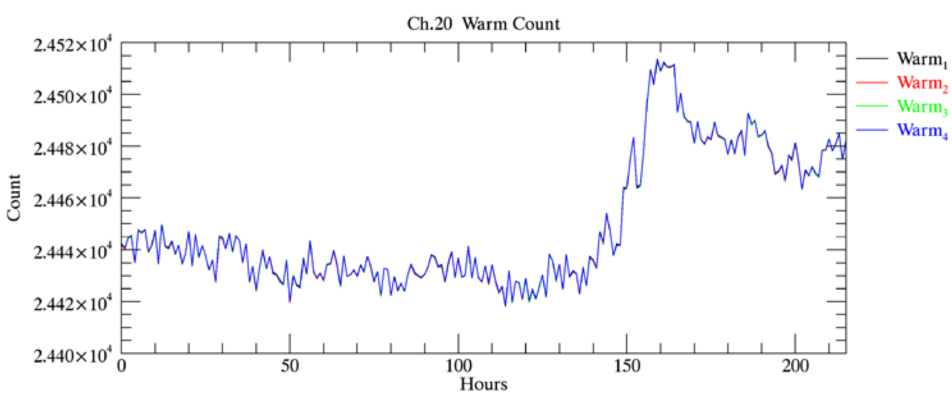
Impact on Calibration Counts

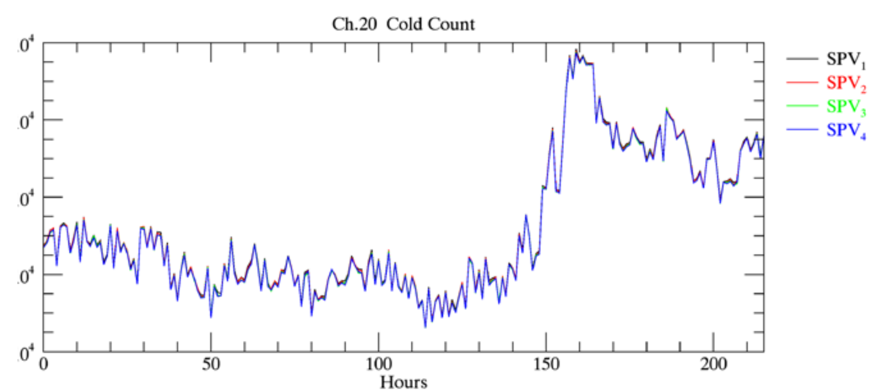




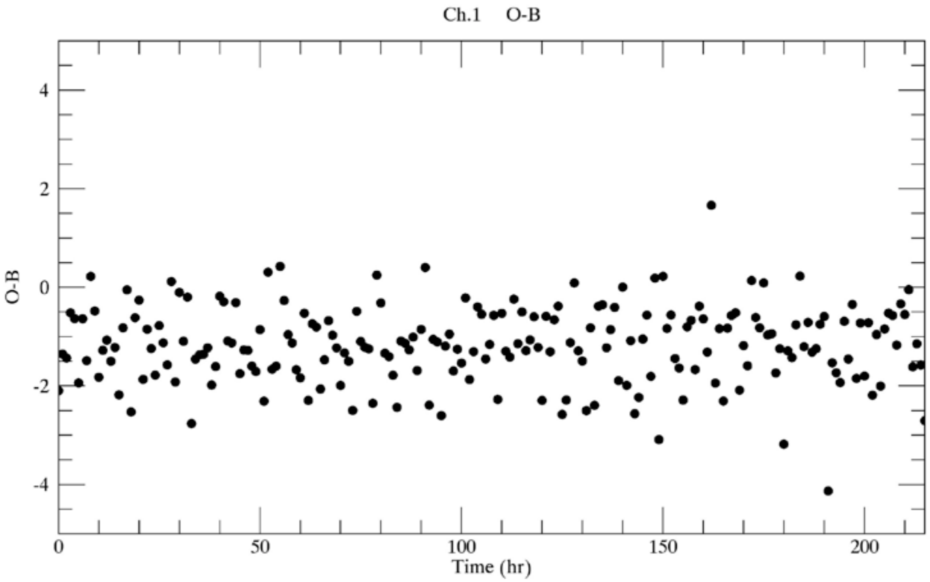


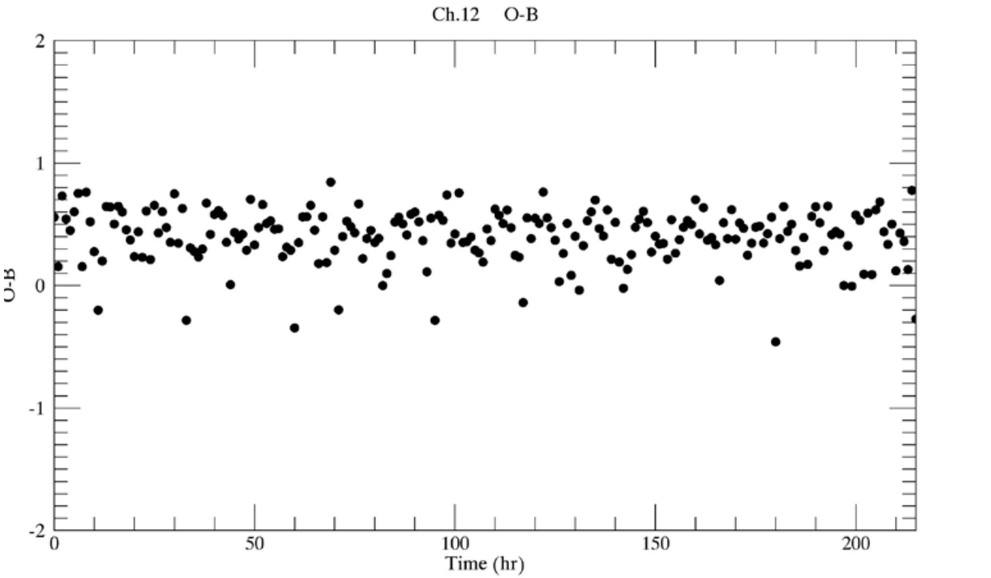


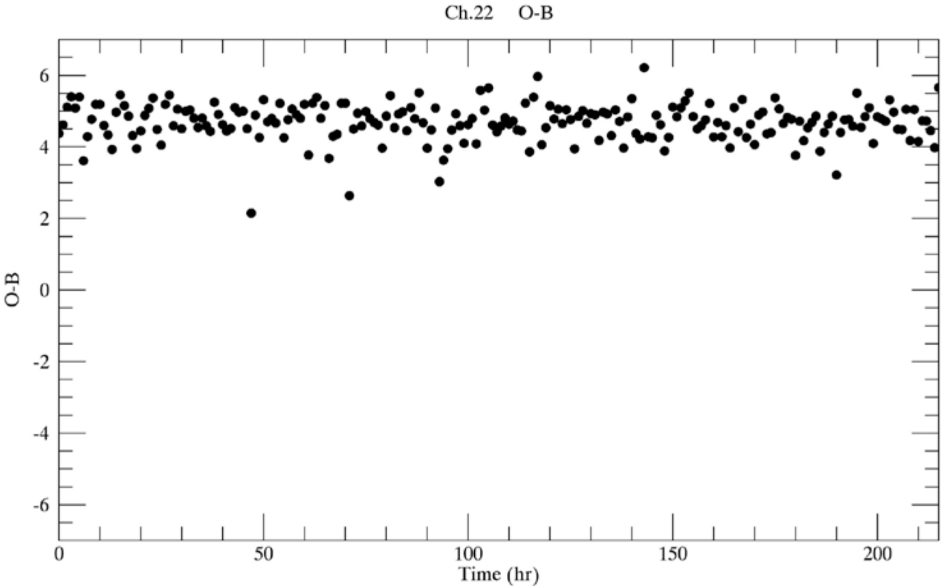




Impact on TDR Calibration Accuracy





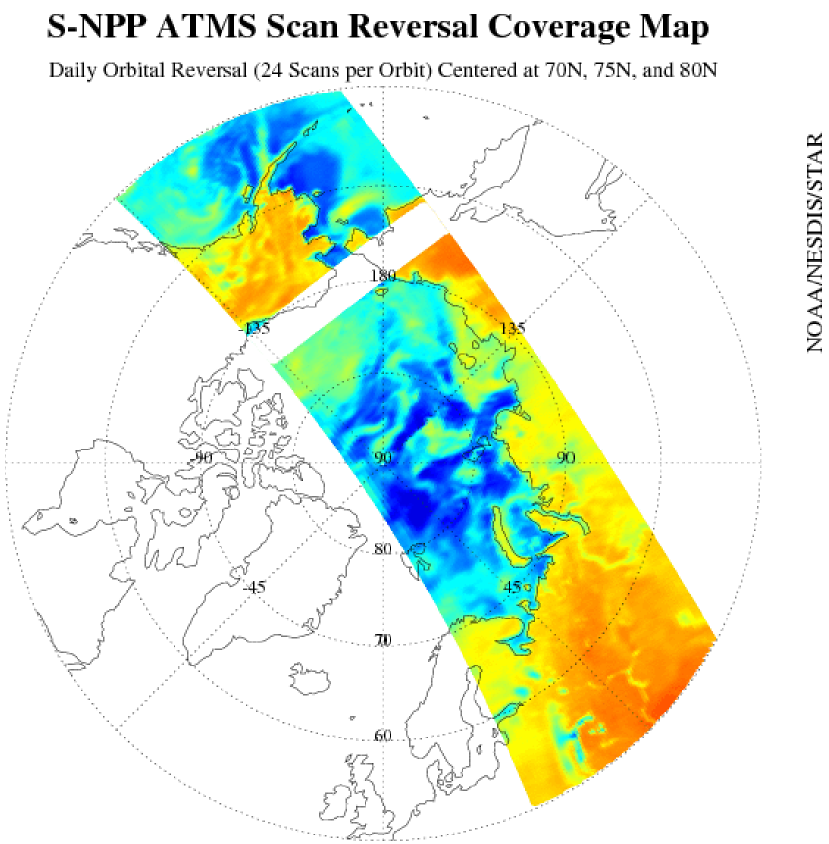


- O: IDPS ATMS TDR products
- B: Model simulation with GDAS forecasts as inputs
- Hourly averaged O-B since May.25 00h, 2016 was calculated
- No significant bias increase was observed

Preliminary Study for Processing Reversal Scan Data

- Evaluated the impact of scan profile change on ATMS data quality
- Developed new remapping algorithm to rebuild normal-scan TDR products from reverse scan datasets with 48 FOVs
- Tested remapping algorithm on simulated reversal scan observations

Impact of Current Scan Reversal on IDPS TDRs



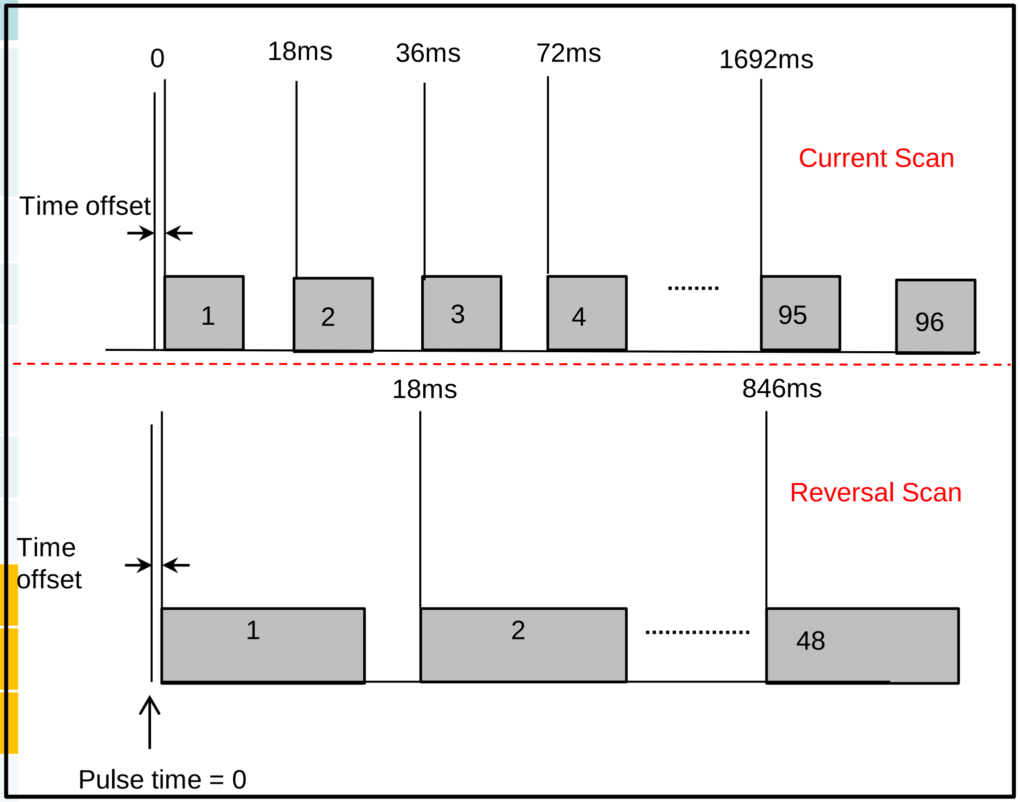
- Frequency of current scan reversal is once every orbit, total of 2 granules are effected and data gap being generated in IDPS TDR products
- Scan reversal operation is carried out at polar region, scan start position is set to random
- Science data can only be found at diagnostic data packet

Comparison of Scan Geometry for Current and Reverse ATMS Scan Profiles

Comparison of Scan Geometry between Current and New Scan Profiles

Scan mode		Current	Reverse
Satellite Altitude (km) and inclination angle		824, sun-synch (i=98.7 deg), 1:30 pm Ascending Node	
Ground Speed (km/s)		7.0	
Scan Period (s)		8/3	
Earth View Scan Rate (degree/s)		60.9	121.8
Earth View Scan Time (s)		1.728	0.864
FOVs/Scan		96	48
Step Angle (degree)		1.1	2.2
Sampling Time (ms)		18.0	18.0
Integration Time (ms)		17.6	17.6
Nadir EFOV Size (Km)	K/Ka	91x75	106x75
	V/W	47x32	63x32
	G Bands	32x16	47x16

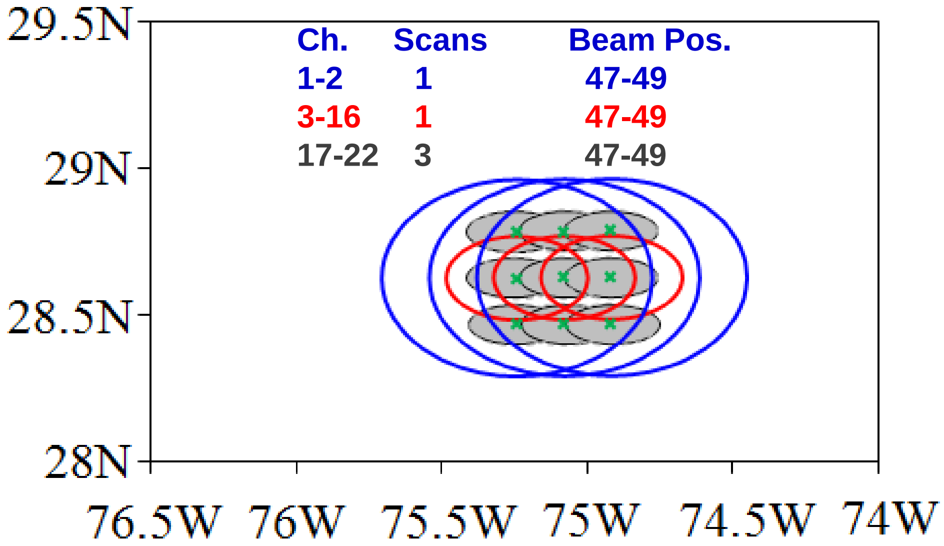
Comparison of Sampling/Integration Time between Current and New Scan Profiles



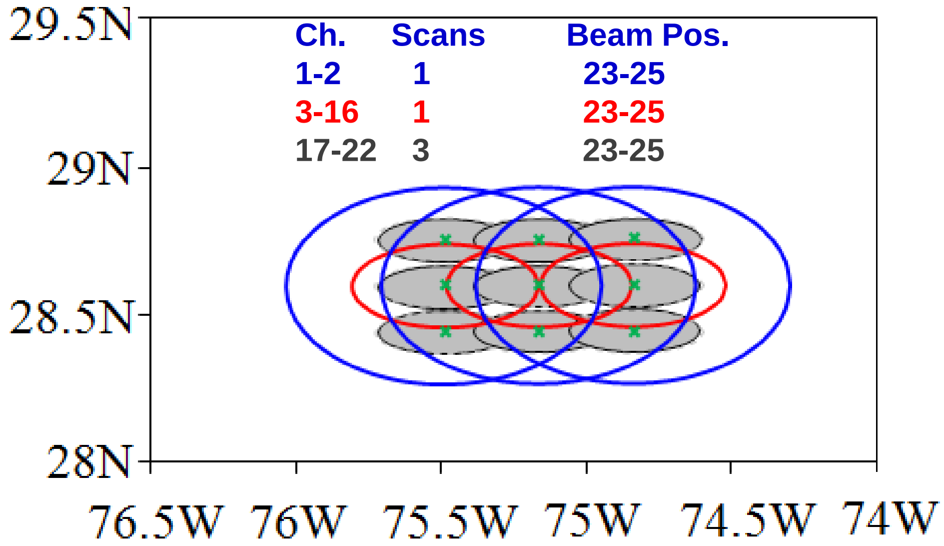
Comparison of ATMS FOVS Between Current and Reversal Scan Profiles

- Field of views at nadir position for both current and new scan profiles are simulated
- Smearing effects are considered in this FOV simulation.
- The reversal scan profile yields larger FOV sizes with less overlapping between FOV

Current Scan Profile



Reverse Scan Profile

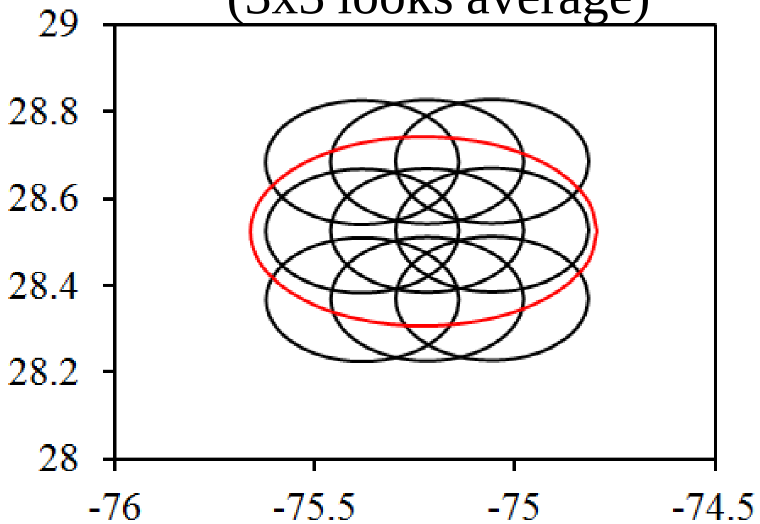


Resolution degradation:
K/V Bands: 17% **V/W Bands: 32%** **G Bands: 48%**

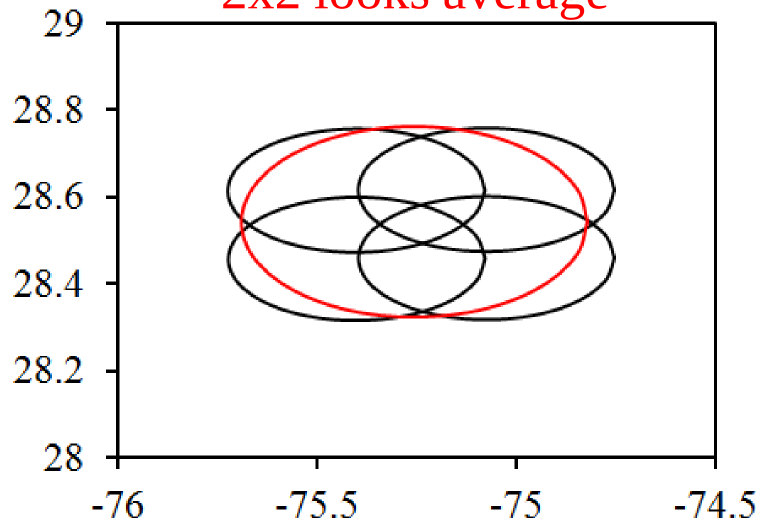
Comparison of ATMS NEDT Between Current and New Scan Profiles

Red : CRIS FOV at nadir
Black: ATMS FOV at nadir

Current
(3x3 looks average)



New
2x2 looks average



Noise from Current Scan | Noise from new Scan

Noise for single observation

$$NE\Delta T = \frac{T_{sys}}{\sqrt{B \cdot \tau}} \qquad NE\Delta T = \frac{T_{sys}}{\sqrt{B \cdot \tau}}$$

Noise after average over multiple looks

$$NE\Delta T = \frac{T_{sys}}{3 \cdot \sqrt{B \cdot \tau}} \qquad NE\Delta T = \frac{T_{sys}}{2 \cdot \sqrt{B \cdot \tau}}$$

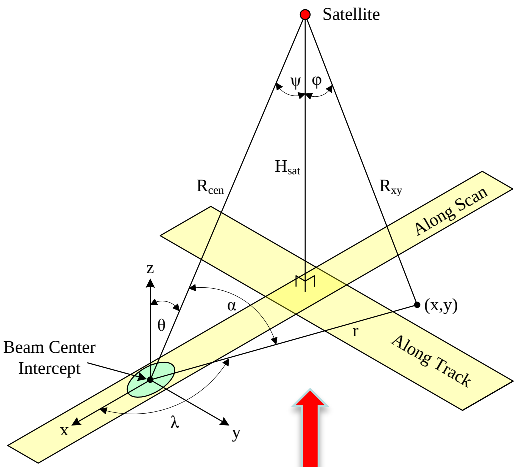
ATMS Current/New Scan Profile NEDT

Ch.	NEDT (K) AMSU/MHS	NEDT (K) TDR	RSDR Current	RSDR New
1	0.30	0.25	0. 08	0.13
2	0.30	0.34	0. 11	0.17
3	0.40	0.39	0. 13	0.20
4		0.30	0. 10	0.15
5	0.25	0.30	0. 10	0.15
6	0.25	0.30	0. 10	0.15
7	0.25	0.30	0. 10	0.15
8	0.25	0.29	0. 10	0.14
9	0.25	0.31	0. 10	0.16
10	0.40	0.44	0. 15	0.22
11	0.40	0.59	0. 20	0.30

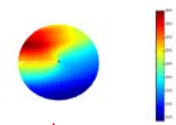
Ch.	NEDT (K) AMSU/MHS	NEDT (K) TDR	RSDR Current	RSDR New
12	0.40	0.62	0.21	0.31
13	0.60	0.90	0.30	0.45
14	0.80	1.25	0.42	0.62
15	1.2	2.03	0.68	1.02
16	0.5	0.30	0.10	0.15
17		0.47	0.16	0.23
18	0.84	0.38	0.13	0.19
19	0.60	0.46	0.15	0.23
20	0.70	0.54	0.18	0.27
21	1.06	0.59	0.20	0.29
22		0.73	0.24	0.37

ATMS Observation Simulation for Different Scan Profile

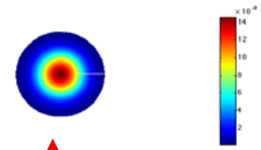
Scan Geometry



Tb obs. within one single FOV



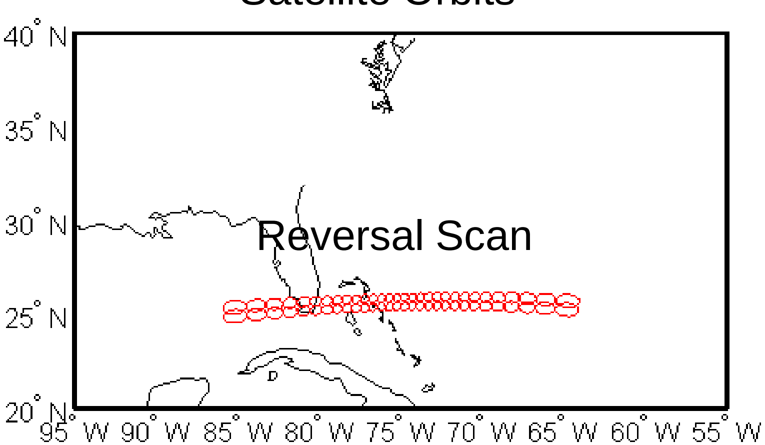
Antenna Pattern within one single FOV

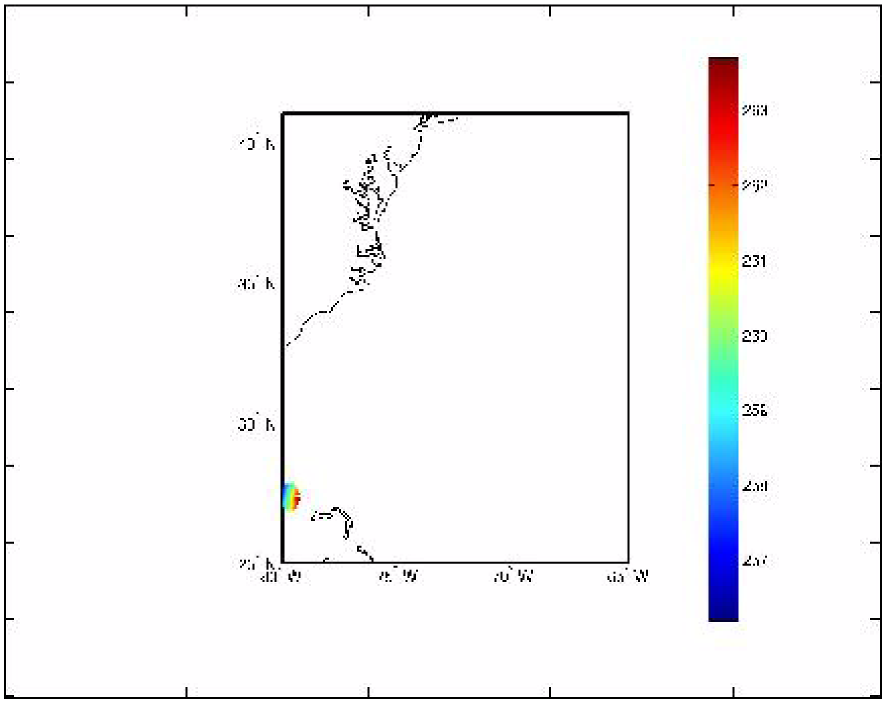


$$Ta = \int T_B(\rho) G_i(\rho) dA$$

Ta is calculated by convoluting Tb with ATMS antenna pattern

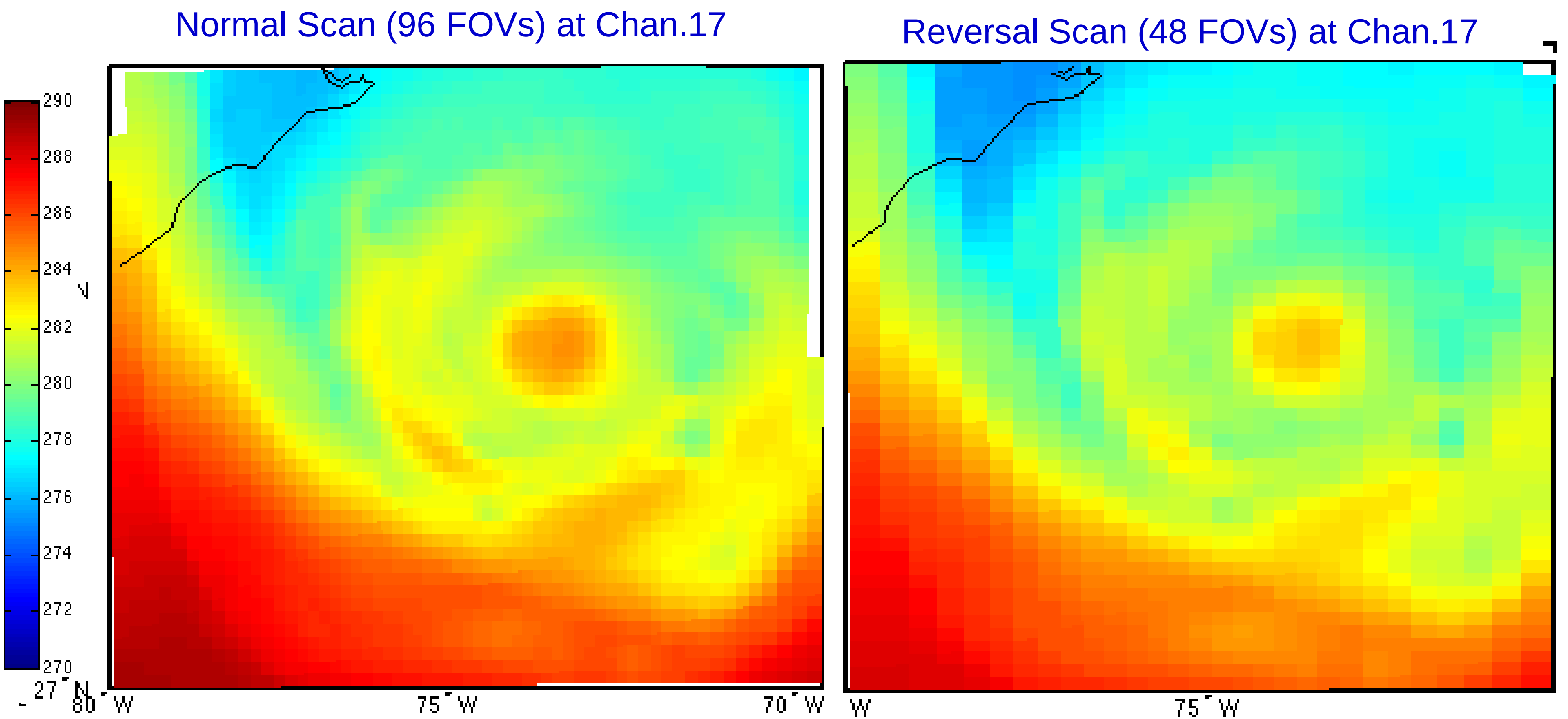
Satellite Orbits





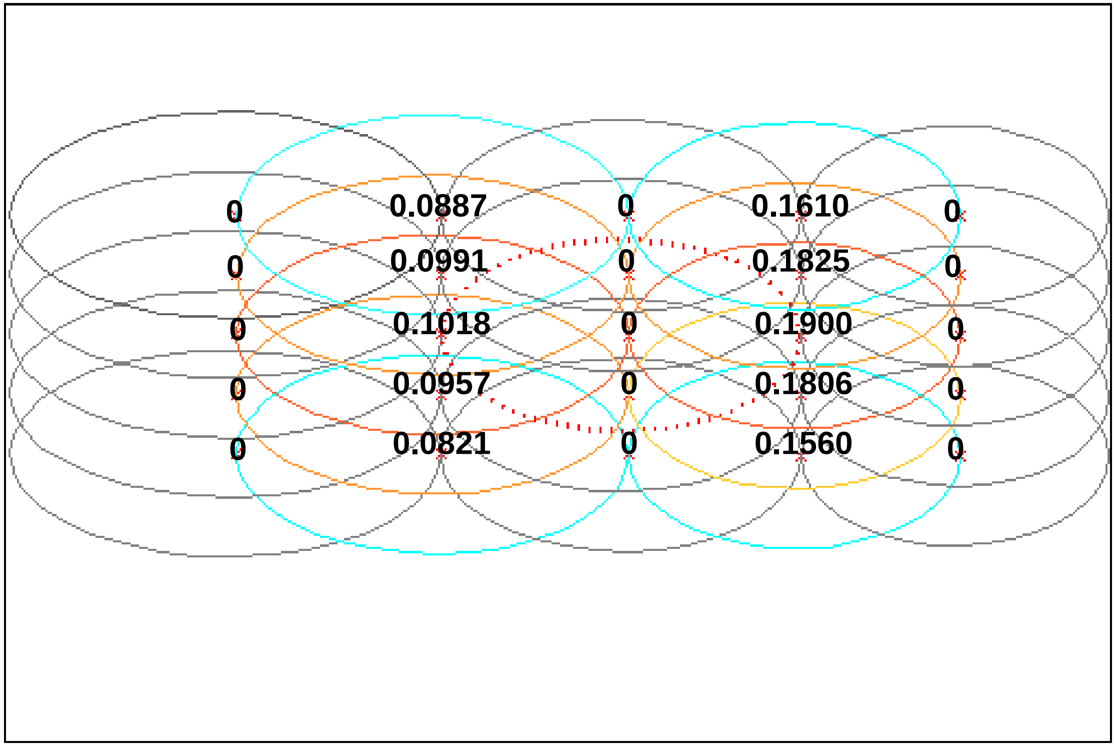
Comparison of ATMS Observations for Different Scan Profile

ATMS observations are simulated for both normal and reverse scan profiles. Simulated case is Hurricane Sandy at 06:00 UTC, Oct. 28, 2012 using CRTM model with the input surface and atmosphere geophysical parameters being provided from the HWRF 9km grid resolution forecasts.



Remapping Algorithm for Reversal Scan Observations

Weighting Coefficients at Edge of Scan for V/W Bands



Construct a cost function, in which the antenna pattern being used as source and target function, and should be minimized by a set of optimal remapping coefficients

$$Q_0 = \int \left[\sum_{i=1}^{n} a_i G_i(\rho) - F(\rho) \right]^2 J(\rho) dA$$

Apply the coefficients to source observations

$$\overline{T_{Bi}} = \int T_B(\rho) G_i(\rho) dA$$

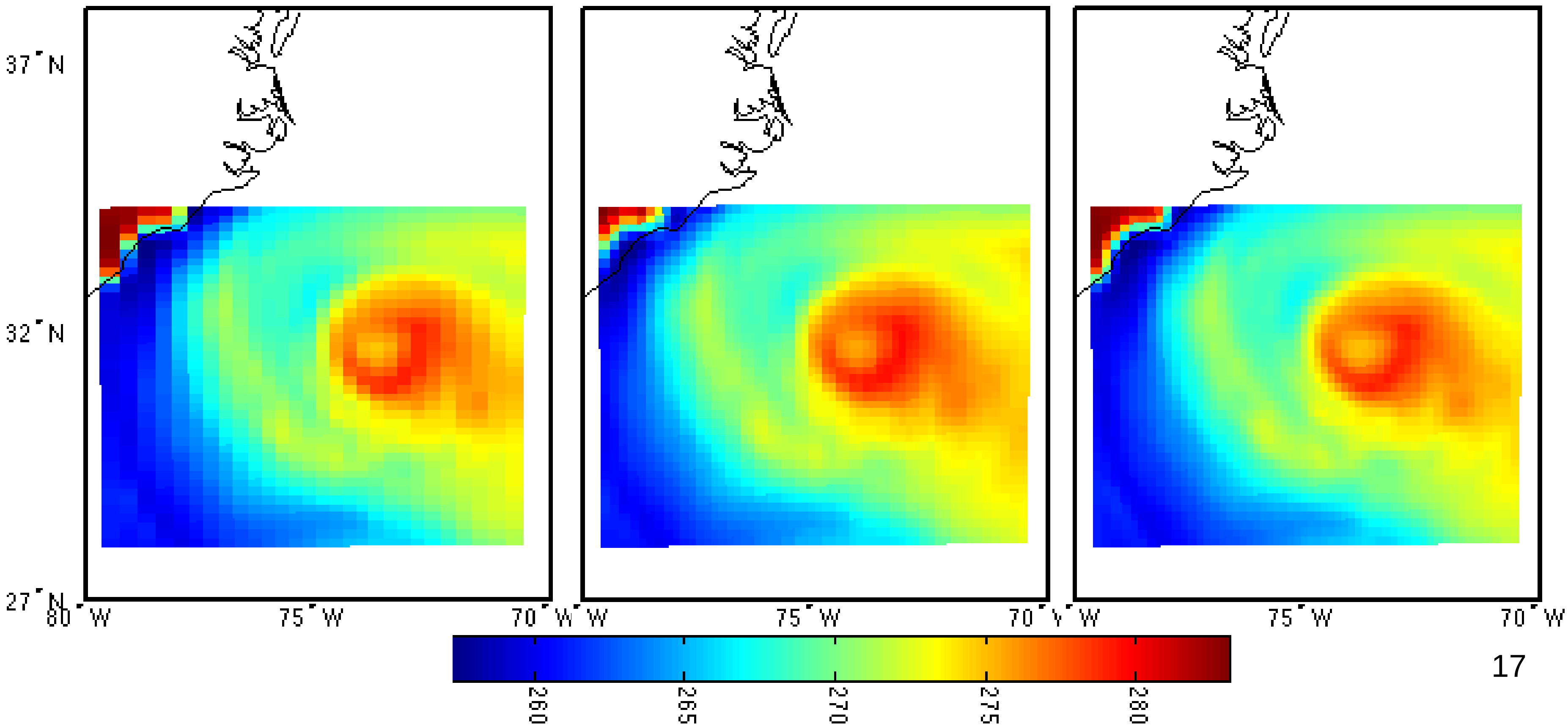
Finally reconstruct observations at target FOV size

$$T_B = \sum_{i=1}^{n} a_i \overline{T_{Bi}} = \int T_B(\rho) \sum_{i=1}^{n} a_i G_i(\rho) dA$$

Preliminary Results for Reversal Scan Remapping Results

- ATMS channel 16 antenna temperature was simulated for both reversal and normal scan
- Remapping coefficients was applied to reversal scan simulations to generate normal scan observations with 96 FOVs
- Comparison between rebuilt and original normal scan observations shows data quality improvement

Reverse Scan with 48 FOVs **Rebuilt Normal Scan with 96 FOVs** **Normal Scan with 96 FOVs**



Conclusion and Future Work

- Scan reversal data was studied and remapping algorithm was developed to generate normal-scan-like TDR products from reversal scan observations with only 48 FOVs

- Future work is to implement scan reversal data processing module to current NOAA offline ATMS ground processing software ARTS

- Reprocessing ATMS TDRs to fill the reversal scan data gap by using ARTS if there is such requirements in future