Suomi NPP ATMS Scan Reversal Study

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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

Ch. 1 Warm Count

Ch. 1 Cold Count

Ch. 12 Warm Count

Ch. 12 Cold Count

Ch. 20 Warm Count

Ch. 20 Cold Count

- Warm_1
- Warm_2
- Warm_3
- Warm_4

- SPV_1
- SPV_2
- SPV_3
- SPV_4
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 between Current and New Scan Profiles

<table>
<thead>
<tr>
<th>Scan mode</th>
<th>Current</th>
<th>Reverse</th>
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</thead>
<tbody>
<tr>
<td>Satellite Altitude (km) and inclination angle</td>
<td>824, sun-synch (i=98.7 deg), 1:30 pm Ascending Node</td>
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<tr>
<td>Ground Speed (km/s)</td>
<td>7.0</td>
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<tr>
<td>Scan Period (s)</td>
<td>8/3</td>
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<tr>
<td>Earth View Scan Rate (degree/s)</td>
<td>60.9</td>
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<td>Earth View Scan Time (s)</td>
<td>1.728</td>
<td>0.864</td>
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<td>FOVs/Scan</td>
<td>96</td>
<td>48</td>
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<td>Step Angle (degree)</td>
<td>1.1</td>
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<tr>
<td>Sampling Time (ms)</td>
<td>18.0</td>
<td>18.0</td>
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<tr>
<td>Integration Time (ms)</td>
<td>17.6</td>
<td>17.6</td>
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### Comparison of Sampling/Integration Time between Current and New Scan Profiles

- **Current Scan**
  - Time offset: 18ms
  - Time: 18ms, 36ms, 72ms, ... 1692ms
  - Pulse time = 0

- **Reversal Scan**
  - Time offset: 36ms
  - Time: 18ms, 48ms, ... 846ms
  - Pulse time = 0

### Additional Details

- **Nadir EFOV Size (Km)**
  - K/Ka: 91x75, 106x75
  - V/W: 47x32, 63x32
  - G Bands: 32x16, 47x16
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.

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

Noise from Current Scan
Noise from new Scan

Noise for single observation

\[ NE\Delta T = \frac{T_{sys}}{\sqrt{B \cdot \tau}} \]

Noise after average over multiple looks

\[ NE\Delta T = \frac{T_{sys}}{3 \cdot \sqrt{B \cdot \tau}} \]
<table>
<thead>
<tr>
<th>Ch.</th>
<th>AMSU/MHS</th>
<th>TDR</th>
<th>RSDR</th>
<th>Ch.</th>
<th>AMSU/MHS</th>
<th>TDR</th>
<th>RSDR</th>
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<td>22</td>
<td>0.73</td>
<td>0.24</td>
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ATMS Observation Simulation for Different Scan Profile

Scan Geometry

Tb obs. within one single FOV

Antenna Pattern within one single FOV

\[ T_a = \int T_B(\rho)G_i(\rho)dA \]

Ta is calculated by convoluting Tb with ATMS antenna pattern

Satellite Orbits

Reversal Scan
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.
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 were 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.

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**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.