**Orbit Opportunities for Innovative Cross-Sensor Validation: NPP* Over-flying the A-Train**

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*NPP, the NPOESS Preparatory Project, was originally a risk reduction mission for the National Polar-orbiting Operational Environmental Satellite System (NPOESS). The NPOESS program was terminated in 2010. The civilian component continues on as the Joint Polar Satellite System (JPSS) and the military component continues on as the Defense Weather Satellite System (DWSS). NPP continues as a joint NOAA-NASA mission.

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**The Orbits**

NPP and the planned JPSS satellites fly at an altitude of approximately 824 km, allowing full global coverage in a single day for sensors with a large field of regard. The A-Train missions operate at 705 km, which gives near daily global coverage in one day.

**The Sensors**

All NPP sensors have similar sensors on Aqua or Aura, & complementary sensors on other A-Train satellites.

<table>
<thead>
<tr>
<th>Type</th>
<th>Sensors</th>
<th>NPP Field of Regard</th>
<th>Aqua/Aura FOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imager</td>
<td>VIIRS/MODIS</td>
<td>56</td>
<td>55</td>
</tr>
<tr>
<td>Ozone</td>
<td>OMI/OMI</td>
<td>55</td>
<td>57</td>
</tr>
<tr>
<td>IR Sounder</td>
<td>CERES/CERES</td>
<td>48.3</td>
<td>49.5</td>
</tr>
<tr>
<td>Microwave Sounder</td>
<td>ATMS/AMSU-B</td>
<td>52.7</td>
<td>49.5</td>
</tr>
<tr>
<td>Earth Radiation Budget</td>
<td>CERES/ERES</td>
<td>56</td>
<td>55</td>
</tr>
</tbody>
</table>

**The Opportunity**

The difference in altitude (and therefore orbital period) means that the sensors can be compared over a wide range of differential viewing geometries as the satellites follow nearly identical ground tracks and having a common 16 day ground-track repeat cycle.

Approximately 30% of the time NPP & Aqua will be within ±15 minutes of each other and with relative scan angles between 0° & ±45°.

By comparing measurements of the same region at differing scan angles, we have the opportunity to assess:

- Response vs. scan angle variations
- Antenna beam patterns
- Algorithmic issues associated with atmospheric path length

**NPP Orbit Chosen to Mimic Aqua Orbit Characteristics.**

**NPP**
- Sun Synchronous
  - 1330 Ascending Node
  - 824 km
  - ±101.5 min orbit
  - 16 day ground-track repeat
  - ±277 revolutions

**Aqua**
- Sun Synchronous
  - 1330 Ascending Node
  - 705 km
  - ±98.5 min orbit
  - 16 day ground-track repeat
  - ±233 revolutions

- *Synodic Period (NPP directly over Aqua) = 2 days 16 hrs (2.667 days) - Synodic period is ~37.8 NPP orbits & ~38.8 Aqua orbits - Have a Simultaneous Nadir Overpass (SNO) every 2.667 days - SNO's occur at all latitudes & many longitudes over one year - Scan angle from Aqua to NPP nadir pixel ranges from 0 to ±5°

**Location of SNO’s* with NPP & Aqua in 13:30 Orbit**

* SO: Simultaneous Observation (one satellite viewing nadir)

**Variation of Relative Scan Angle with Identical Crossing Times**

<table>
<thead>
<tr>
<th>Cross Track Angle (deg)</th>
<th>Frequency count based upon 1 data capture per minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1000</td>
</tr>
<tr>
<td>10</td>
<td>800</td>
</tr>
<tr>
<td>20</td>
<td>700</td>
</tr>
<tr>
<td>30</td>
<td>600</td>
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<td>80</td>
<td>100</td>
</tr>
<tr>
<td>90</td>
<td>50</td>
</tr>
<tr>
<td>100</td>
<td>30</td>
</tr>
</tbody>
</table>

One year simulation, 18 second simultaneity requirement

**SNO’s Move to the Poles with Larger Difference in Crossing Times**

Relaxing the simultaneity requirement increases the number of “coincident” observations, but does not alter the longitudinal distribution.

**Tuning the Orbit**

- Changing the ascending node time of NPP allows a wide range of interesting viewing geometries
- The greater the gap in crossing times, the larger the scan angle range
- At larger time differences, the true SNO’s will occur only at higher latitudes

**Location of NPP Nadir Pixel when Aqua sees same location within ±15 Minutes**

Aqua ground tracks uniformly distributed in longitude whereas NPP ground tracks are not. Results from resonances between synodic period & the orbital period of NPP.

**Location of Aqua Nadir Pixel when NPP sees same location within ±15 Minutes**

These comparisons were made with slightly different orbital elements than previous charts, showing that the general patterns repeat, but they differ in the details.

**Opportunities & Acknowledgements**

- Details of the coincident observations are highly dependent on the orbital parameters
- Crossing times drift, requiring periodic orbital adjustments
  - Coordination among NPP, Aqua, Aura, operations is required
- More detailed orbit studies that explore the parameter space are needed
  - Trade off between strict simultaneity & scan angle differences
  - Optimize over ARM-CART or MOBY?
- Cross-platform data products utilizing differing viewing geometry?
- We have benefited from discussions with Dr James Gileason (NASA/GSFC) who had the original orbit studies conducted by Richard McIntosh (a.i. Systems) & Dr Robert Wolfe (NASA/GSFC)