Suomi NPP CrIS On-orbit Geometric Calibration Performance

Likun Wang¹*, Denis Tremblay², Yong Han³, Mark Esplin⁴, Denis Hagan⁵, Joe Predina⁶, Lawrence Suwinski⁶, Yong Chen¹, and Xin Jin⁷

1.* Univ. of Maryland, College Park, MD; Likun.Wang@noaa.gov
2. Science Data Processing Inc., Laurel, MD
3. NOAA/NESDIS/STAR, College Park, MD
4. Space Dynamics Laboratory, Utah State University, Logan, UT
5. Northrop Grumman Aerospace Systems, Redondo Beach, CA,
6. Exelis, Fort Wayne, IN
7. ERT Inc., Laurel, MD

SUOMI NPP SDR Science and Validated Product Maturity Review
College Park, MD; December 18-20 2013
Outlines

1. Introduction and objectives
   • Specification, Algorithms, and Challenges
2. Method
   • Using VIIRS Geolocation dataset
3. Geolocation performance
   • At Nadir
   • Along with Scan Angels
   • Possible angle adjustment
4. Band-to-band co-registration
5. Geolocation changes for EP V36
6. Summary and future work
CrIS Scan Patterns and Specification

1.5 km (1 sigma)

Percentage of FOV size change with Scan

Percentage of FOV size
CrIS Geometric Calibration Algorithm

**Sensor Level Algorithms**

Compute the LOS relative to S/C

**Spacecraft Level Algorithms**

Resolve LOS intersection with Earth Ellipsoid
Challenges for On-orbit Assessment

Unlike an imager, it is very hard to assess geolocation sub-pixel accuracy for CrIS using the land feature method because of 1) relatively large footprint size (above 14 km); 2) the gap between footprints; and 3) Uneven spatial distribution of CrIS Footprints.
Reference: Using VIIRS Geolocation (I5 band: 375m resolution)

Table 2. VIIRS Geolocation Accuracy

<table>
<thead>
<tr>
<th>Residuals</th>
<th>First Update</th>
<th>Second Update</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23 February 2012</td>
<td>18 April 2013</td>
</tr>
<tr>
<td>Track mean</td>
<td>-24 m, -7%</td>
<td>2 m, 1%</td>
</tr>
<tr>
<td>Scan mean</td>
<td>-8 m, -2%</td>
<td>2 m, 1%</td>
</tr>
<tr>
<td>Track RMSE</td>
<td>75 m, 20%</td>
<td>70 m, 19%</td>
</tr>
<tr>
<td>Scan RMSE</td>
<td>62 m, 17%</td>
<td>60 m, 16%</td>
</tr>
</tbody>
</table>

from Wolf et al. 2013
Spectral Integration: from CrIS to VIIRS

CrIS spectrum is convolved with VIIRS SRFs for I5 band (350m spatial resolution)

\[ L_i = \frac{\int_{v_1}^{v_2} R(v) S_i(v) dv}{\int_{v_1}^{v_2} S_i(v) dv} \]
Compute CrIS FOV Footprint

Satellite Direction

CrIS Scan Direction

VIIRS Scan Direction

FOR 1

FOR 14

FOR 30
Collocating VIIRS with CrIS FOV

Histogram of VIIRS M16 in CrIS FOV

CrIS FOV footprint

VIIRS Pixels

CrIS FOV Spatial Response

Histogram of VIIRS M16 in CrIS FOV

VIIRS FOV footprint
Quantitative Assessment

• Choose un-uniform (better for cloud scene) CrIS granules over tropical region (large dynamic range)

• Collocate VIIRS with CrIS nadir FOVs (FOR 13-16) and then compute spatially averaged radiances

• Convert CrIS spectra into VIIRS band radiances using VIIRS spectral response functions (SRFs)

• Define the cost function as \textit{Root Mean Square Errors (RMSE)} of CrIS-VIIRS BT difference

• Shift VIIRS image toward along- and cross-track direction to find the minimum of the cost function, which represent best collocation between VIIRS and CrIS

Orbit 02477 on April 20 2102
An Example
Time Series of Assessment Results

CrIS SDR Geolocation Assessment by VIIRS

VIIRS geolocation side A to side B switch

Since Provisional Review Meeting

All FOVs From FOR 14 to 15

Time
Statistical Results

0.354 ± 0.047 km

0.209 ± 0.082 km (1 sigma)
In VIIRS data, in order to minimize data rate, some of this redundant data is not transmitted and thus referred to as “bowtie deletion” when scan angle is larger than 32°.
Possible Angle Adjustment
Under Discussion

Adjust Pitch

Adjust Yaw
Band-to-Band Co-Registration (1)

- Three different detector arrays are used for three bands.
- Only LW detector angles are used for geolocation calculations.
- LW, MW, and SW band detector angels are adjusted for FOV-to-FOV spectral calibration.
- Band-to-band co-registration for CrIS is 1.4% of FOV footprint size, which is 196 m for nadir FOV (14.0km).

Do the three CrIS bands “see” the Earth at the same location?
Three geolocation dataset were generated by ADL using LW, MW, and SW band detector angles, respectively.

The distance was calculated by checking geolocation distance between LW and MW/SW bands for the different FOVs at nadir.

For Nadir FOVs: Performance is less than 100 m (0.7%) of FOV size

Specification is 196 m (1.4%) of FOV size
From EngPkt V35 to V36

Scan Direction

+3  +2  +1

In-track Direction

+6  +5  +4

+9  +8  +7

Note only longwave detector angles are used for geolocation computations.

<table>
<thead>
<tr>
<th>FOV</th>
<th>V35 (longwave) crosstrack</th>
<th>V36 (longwave) crosstrack</th>
<th>V35 (longwave) intrack</th>
<th>V36 (longwave) intrack</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18784</td>
<td>18751</td>
<td>19301</td>
<td>19270</td>
</tr>
<tr>
<td>2</td>
<td>-359</td>
<td>-359</td>
<td>19370</td>
<td>19307</td>
</tr>
<tr>
<td>3</td>
<td>-19547</td>
<td>-19514</td>
<td>19346</td>
<td>19315</td>
</tr>
<tr>
<td>4</td>
<td>18792</td>
<td>18725</td>
<td>158</td>
<td>160</td>
</tr>
<tr>
<td>5</td>
<td>-359</td>
<td>-359</td>
<td>158</td>
<td>160</td>
</tr>
<tr>
<td>6</td>
<td>-19526</td>
<td>-19461</td>
<td>158</td>
<td>160</td>
</tr>
<tr>
<td>7</td>
<td>18809</td>
<td>18776</td>
<td>-19010</td>
<td>-18975</td>
</tr>
<tr>
<td>8</td>
<td>-359</td>
<td>-359</td>
<td>-19049</td>
<td>-18982</td>
</tr>
<tr>
<td>9</td>
<td>-19524</td>
<td>-19492</td>
<td>-19007</td>
<td>-18973</td>
</tr>
</tbody>
</table>

Geolocation change for Nadir FOVs ADL run V35-V36

Conclusion and Future Work

• CrIS Geolocation performs well and is very stable since provisional review.

• Using VIIRS as a references:
  – At nadir: $0.354 \pm 0.047$ km in scan direction and $0.209 \pm 0.082$ km in track direction
  – Within 30 degree scan angles: less than 1.3 km

• Band-to-band co-registration meets the specification.

• From EP35 to EP36, the expected geolocation change is very small.

• **Future work**
  – Possible angle adjustment
  – Need evaluation for FORs above 30 scan angles