Deriving a geostationary visible sensor calibration reference using DCC targets tied to the Aqua-MODIS band 1 calibration.

Conor Haney\textsuperscript{SSAI}, David Doelling\textsuperscript{NASA}, Arun Gopalan\textsuperscript{SSAI}, Benjamin Scarino\textsuperscript{SSAI}, Rajendra Bhatt\textsuperscript{SSAI}

CALCON 2014 Conference, Logan, Utah, August 11-14, 2014
Simple GEO to MODIS Ray-Matching Cross-Calibration Method

• None of the GEO visible sensors have onboard calibration
• Ray-match GEO counts (proportional to radiance) and MODIS radiances within a 0.5° cloudy ocean regions using selection constraints
  – $\Delta \text{SZA} < 5^\circ$ (15 minutes), $\Delta \text{VZA} < 10^\circ$, $\Delta \text{RAZ} < 15^\circ$, no sunglint
  – Domain $\pm 20^\circ$ E/W and $\pm 15^\circ$ N/S near sub-satellite point to maximize coincident matches
  – Use Aqua-MODIS Collection 6 as reference
  – Use a SCIAMACHY spectral band adjustment factor derived from all SCIA footprints over the same equatorial region
  – Normalize the cosine solar zenith angle
• Perform monthly linear regressions and derive monthly gains
  – Use published offsets
• Compute timeline trends from monthly gains
Simple MTSAT-2/Aqua-MODIS Ray-Matching

\[ A_{\text{qua}} \text{radiance} \left[ \frac{\cos(SZA_{\text{GEO}})}{\cos(SZA_{\text{Aqua}})} \right] \text{SBAF}_{\text{GEO/Aqua}} = G_{\text{GEO}}(\text{CNT} - \text{CNT}_{\text{space}}) \]
## Ray-Matching Uncertainty

<table>
<thead>
<tr>
<th>GEO satellite</th>
<th>Aqua-MODIS 0.65µm absolute calibration accuracy</th>
<th>Temporal trend Standard error</th>
<th>MODIS/GEO SBAF uncertainty</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTSAT-2</td>
<td>1.64%</td>
<td>0.60%</td>
<td>1.50%</td>
<td>2.30%</td>
</tr>
<tr>
<td>GOES-13</td>
<td>1.64%</td>
<td>0.52%</td>
<td>0.92%</td>
<td>1.95%</td>
</tr>
<tr>
<td>Met-9</td>
<td>1.64%</td>
<td>0.48%</td>
<td>0.28%</td>
<td>1.73%</td>
</tr>
</tbody>
</table>

- The long-term calibration uncertainty is shown above.

- The earth target that is most Lambertian (less angle matching dependency) and is most spectral flat (less SBAF dependency) are DCC making them ideal as calibration transfer targets.

- Uncertainty does not take into account inaccuracies due to band SRF, satellite navigation, imager noise <50km, orbit dependencies, solar spectra, etc.
SCIAMACHY spectra

- DCC are the brightest 46 FOV between 2002 and 2012
- The reflectance standard deviation of DCC is <3%
Spectral Band Adjustment Factor

SCIAMACHY footprint pseudo radiance pairs over the MTSAT-2 equatorial cloud ocean domain, 2002-2010
MTSAT-2 SBAF Comparison

All-sky Ocean

1.5% standard error

DCC

0.26% standard error
Predictor Enhancements
Aqua vs. GOES 13. Jan 2, 2011

The cyan regions were the only angle matches occur.

4 MODIS orbits intersects the GEO domain during the day.
DCC Ray-Matching

• The challenge of DCC raymatching technique is capturing the angle-matched DCC in the GEO domain

• Will there be enough samples?
DCC Ray-Matching Procedure

- Find Aqua equatorial crossings in GEO DCC domain (±40° E/W, ±20° N/S of GEO sub-satellite point)
- Predict GEO angles from MODIS pixel and output spatially averaged 0.65um radiance of surrounding region (9x9 km², 29x29 km²) if criteria met:
  - ΔSZA<5°, ΔVZA<10°, ΔRAZ<15°
  - Average region 11um T<205K
- Locate coldest regions, filter overlap, aggregate pixel data into monthly files
- Match with available GEO data from McIDAS, spatially average visible radiance same as with MODIS
- Normalize the cosine SZA, apply SHIAMACHY SBAF factor, perform monthly linear regressions to derive monthly gains
- Compute timeline trends from monthly gains
Subsampling & Regional Averaging

5x5 MODIS = 9x9 MTSAT-2
DCC Ray-Matching

1° lat/lon grid, MTSAT-2, July 20, 2011 2:32 GMT
The stability of the monthly mean MODIS radiances reveal that DCC are stable targets if analyzed collectively (Must have maintained sun-synch orbit)
Easily monitor the degradation of the MTSAT-2 monthly mean DCC counts
## Dependency test results

<table>
<thead>
<tr>
<th></th>
<th>Range test</th>
<th>optimum</th>
<th>Dependency</th>
</tr>
</thead>
<tbody>
<tr>
<td>σVIS</td>
<td>1.0 to 0.05</td>
<td>0.10</td>
<td>Yes</td>
</tr>
<tr>
<td>σIR</td>
<td>5 to 2</td>
<td>5</td>
<td>None</td>
</tr>
<tr>
<td>Angle</td>
<td>ΔAZA&lt;15, ΔVZA&lt;10</td>
<td>same</td>
<td>None</td>
</tr>
<tr>
<td>Time</td>
<td>15 to 5</td>
<td>15</td>
<td>Slight</td>
</tr>
<tr>
<td>Temp</td>
<td>220-200</td>
<td>205</td>
<td>Slight</td>
</tr>
<tr>
<td>Lambertian</td>
<td>All angles</td>
<td>VZA&lt;30, SZA&lt;30</td>
<td>Yes</td>
</tr>
<tr>
<td>FOV</td>
<td>10 and 30-km</td>
<td>30-km</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Spatial homogeneity dependency

SVS=0.05

SVS=0.1

SVS=0.5
FOV Spatial homogeneity vs monthly standard errors

SVS=0.05

SVS=0.1

SVS=0.5
FOV Spatial homogeneity vs timeline temporal standard error

- SVS=0.05
- SVS=0.1
- SVS=0.5
Only a slight reduction in monthly standard errors
Consistency of the calibration between methods

All-sky ocean

9-km

29-km
Conclusions

<table>
<thead>
<tr>
<th>GEO satellite</th>
<th>Aqua-MODIS 0.65µm absolute calibration accuracy</th>
<th>Temporal trend Standard error</th>
<th>MODIS/GEO SBAF uncertainty</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SIMPLE/DCC</td>
<td>SIMPLE/DCC</td>
<td>SIMPLE/DCC</td>
<td></td>
</tr>
<tr>
<td>MTSAT-2</td>
<td>1.64%</td>
<td>0.60% / 0.38%</td>
<td>1.50% / 0.26%</td>
<td>2.30% / 1.70%</td>
</tr>
<tr>
<td>GOES-13</td>
<td>1.64%</td>
<td>0.52% / 0.49%</td>
<td>0.92% / 0.42%</td>
<td>1.95% / 1.76%</td>
</tr>
<tr>
<td>Met-9</td>
<td>1.64%</td>
<td>0.48% / 0.25%</td>
<td>0.28% / 0.28%</td>
<td>1.73% / 1.68%</td>
</tr>
</tbody>
</table>

DCC ray-matching can provide improved total calibration uncertainty through lower temporal standard error and lower SBAF uncertainty