Monitoring the Performance of Space-based Optical Lightning Instruments

Dennis Buechler
University of Alabama Huntsville
GHRC UWG, Huntsville, AL September 2014
GLM field of view from East and West positions. Lightning data is from OTD (1995-2000) and LIS (1998-2010) observations. L0 data will be stored at GHRC DAAC.
**Orbital Characteristics**

<table>
<thead>
<tr>
<th></th>
<th>OTD</th>
<th>LIS Pre-boost</th>
<th>LIS post-boost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inclination</strong></td>
<td>70°</td>
<td>35°</td>
<td>35°</td>
</tr>
<tr>
<td><strong>Altitude</strong></td>
<td>735 km</td>
<td>350 km</td>
<td>402 km</td>
</tr>
<tr>
<td><strong>FOV (across)</strong></td>
<td>1253 km</td>
<td>560 km</td>
<td>650 km</td>
</tr>
<tr>
<td><strong>Period to sample diurnal cycle</strong></td>
<td>~55 days</td>
<td>~46 days</td>
<td>~47 days</td>
</tr>
<tr>
<td><strong>Pixel FOV (nadir)</strong></td>
<td>7.9 km</td>
<td>3.6 km</td>
<td>4.2 km</td>
</tr>
<tr>
<td><strong>Observation time</strong></td>
<td>190 s</td>
<td>83 s</td>
<td>97 s</td>
</tr>
<tr>
<td><strong>Orbital Period</strong></td>
<td>99.5 min</td>
<td>91.5 min</td>
<td>92.56 min</td>
</tr>
</tbody>
</table>

TRMM boost completed August 22, 2001
OTD/LIS Characteristics

- Detects total lightning both day and night
- Fast lens, narrowband (~1 nm wide) filter at 777.4 nm
- 128 x 128 pixel CCD array
- 500 fps imaging (every 2 ms)
- Frame-to-frame subtraction used to isolate lightning transients against bright daytime background
- Backgrounds ~35 s for LIS and ~45 s for OTD (GLM every 2.5 min)
- Filter out noise events
- Cluster into groups and flashes
TRMM Orbit Boost

Comparison of LIS field of view pre and post orbit boost

Number of flashes detected by LIS per year. Values post-orbit boost exhibit little change.
• Peak: ~160 fl km\(^{-2}\) yr\(^{-1}\) in eastern Congo
• Higher resolution study shows peak near Lake Maracaibo, Colombia
• Other peaks in Maritime Continent, Bangladesh / East India, Pakistan, N. Argentina / Paraguay, west coasts of Mexico and Arabia
• Huge land-ocean contrast
Mean Annual Flash Rate

**Optical Transient Detector (OTD):**
1995-2000
High inclination orbit, sampled virtually all locations that have lightning

**Lightning Imaging Sensor (LIS):**
1998-2012*
35°inclination orbit (TRMM), higher quality data but limited to global tropics and subtropics

* LIS continues to collect data at present, this image is through 2012.
Seasonal 0.25° LIS Climatology
Day/Night 0.1° LIS Climatology

LIS Daytime Lightning (1998-2013)

LIS Nighttime Lightning (1998-2013)
• No on board calibration
• Deep Convective Clouds (DCCs) are used as vicarious calibration targets
• The radiance of DCCs near the tropics are nearly constant
• Use VIRS (Visible Infrared Sensor - collocated onboard TRMM with LIS) 11 µm IR channel to identify DCCs (Tb < 205K)
• Identify collocated LIS Background (BG) pixels
• Analyzed each July and August from 1998-2010
• Method to be used to monitor Geostationary Lightning Mapper (GLM) on-orbit performance
• For more details see Buechler et al., 2014: Assessing the performance of the Lightning Imaging Sensor (LIS) using Deep Convective Clouds, Atmos. Res.
LIS DCC analysis

Distribution of LIS background DCC radiance changes little from year to year

- Max LIS DCC radiance is 0.8%
- Mean LIS DCC background radiance does not exhibit a trend over the years
- Demonstrates the stability of LIS calibration
Conclusions

1) The DCC analysis of the LIS BG indicates no discernible degradation of instrument performance from 1998-2010.
2) Because of its similar design, the GLM should also experience little performance degradation.
3) The DCC technique can be used to monitor GLM instrument performance once in orbit.
4) Other vicarious calibration techniques are being examined
Flash rate diurnal cycle over the 10 maximums in Latin America

- 1st max: Lake Maracaibo, VE
- 2nd max: Rio de Oro, CO
- 3rd max: El Zaragoza, CO
- 4th max: Santa Lucia Cotzumalguapa, GT
- 5th max: Icuna, BL
- 6th max: El Obraje, HO
- 7th max: Trinidad, PY
- 8th max: Fortin Aguilar, AR
- 9th max: Santa Eva, PY
- 10th max: Barbosa, BR
Outline

• LIS Quality Assurance
• Lightning Climatology
• GLM
• LIS data process
  – GHRC ingests raw data and processes data daily
  – At end of month, GHRC reprocess of all data
  – Then a combination of manual and automated QA is done