Lightning Imaging Sensor (LIS) on the International Space Station (ISS): Assessments and Results from First Year Operations

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Mission and Measurement

Mission
- Fly a flight-spare LIS on ISS to take advantage of unique capabilities provided by the ISS (e.g., high inclination, 168-day orbit, 27-day repeat cycle time).
- Integrate LIS as a hosted payload on the DoD Space Test Program-Houston 5 (STP-HS) mission and launch on a Space X rocket for a minimum 2 year mission.

Measurement
- NASA and its partners developed and demonstrated effectiveness and value of using space-based lightning observations as a remote sensing tool.
- LIS measures lightning (amount, rate, radiant energy) with storm scale resolution, millisecond timing, and high detection efficiency, with no land-ocean bias.

Data Handling (Processing, Archival, and Distribution)

• The well-established and robust data handling infrastructure used for LIS on the Tropical Rainfall Measuring Mission (TRMM) was adapted for LIS.
• Therefore, lightning observations from LIS on ISS can be quickly delivered to and used by science and applications users.
• Both legacy TRMM LIS format (HDF4) and a new netCDF 4/CF data are being produced for LIS on ISS, by the Global Hydrology Resource Center, one of NASA’s Distributed Active Archive Centers.
• LIS data can be obtained from the GHRC DAAC at https://ghrc.nasa.gov/lightning/

Assessing and Achieving Level-1 Science Requirements

Level-1 Science Requirements
- Level-1 science requirements are the same for LIS on ISS as for TRMM LIS and its Optical Transient Detector (OTD) predecessor, and includes (1) day and night lightning detection, (2) storm scale (~4 km) resolution, (3) millisecond timing, (4) high, uniform detection efficiency without land/ocean bias, (5) calibrated radiant energy, and (6) background images/intensity.
- Real time lightning data was added as an additional (7th) Level-1 requirement for LIS on ISS.

Timing Accuracy and Stability
- Time offset of LIS compared to three reference sources demonstrates sub-millisecond timing accuracy.
- LIS on ISS data is processed in real time in 2-minute processing increments. This data is available from GHRC DAAC.
- Both 2 minute and 12 hour browse image are created in real time and displayed at: https://lightning.nasa.gov/glaisliss/glaislissnet

Geolocation Accuracy
- Distance offset of LIS compared with GLM (apples to apples) shows sub-km accuracy at 0.5-2.5 km.
- Distance offset of LIS compared with Earth Networks and GLD360 RF systems further verifies this excellent geolocation accuracy.
- Offset better than TRMM LIS but both will be comparable after represing TRMM.

Real Time Data Production
- LIS on ISS data is processed in real time in 2-minute processing increments.
- This data is available from GHRC DAAC.
- Both 2 minute and 12 hour browse image are created in real time and displayed at: https://lightning.nasa.gov/glaisliss/glaislissnet

Summary
- All Level-1 science requirements met and preliminary global flash statistic produced.
- Key science and operational applications of LIS lightning observations are being pursued that range from weather and climate to atmospheric chemistry and lightning physics.
- These applications exist due to the strong quantitative connections that can be made between lightning and other geophysical processes of interest.
- The space-based vantage point, such as provided by LIS on ISS, still remains an ideal location to obtain total lightning observations on a global basis.

Launch, Activation, and Operation

First Light!
- As it appeared on the Real Time Display and Command window.
  - LIS launched aboard Space X 2 Cargo Resupply Service 10 (CRS-10) mission on 19 February 2017.
  - STP-HS payload robotically installed with LIS in an Earth viewing position.
  - LIS powered-up on 27 February 2017.
  - Continuous operation has been maintained since LIS power-up.
- 5.16° inclination orbit, 425 km altitude (detects to ~55°N), ~600 km FOV.
- 60 days required for complete sample of diurnal cycle.

Other Preliminary Flash Statistics

Table shows flash rate (fls yr⁻¹) for LIS (ISS) versus climatology.

<table>
<thead>
<tr>
<th>Region</th>
<th>LIS</th>
<th>ISS</th>
<th>Climatology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boreal Spring</td>
<td>33.7 ± 0.9</td>
<td>32.6 ± 1.6</td>
<td>41.2 ± 8.4</td>
</tr>
<tr>
<td>Boreal Summer</td>
<td>52.5 ± 0.9</td>
<td>51.4 ± 1.6</td>
<td>59.0 ± 8.4</td>
</tr>
<tr>
<td>Boreal Autumn</td>
<td>22.5 ± 0.9</td>
<td>21.6 ± 1.6</td>
<td>29.6 ± 8.4</td>
</tr>
<tr>
<td>Boreal Winter</td>
<td>33.7 ± 0.9</td>
<td>32.6 ± 1.6</td>
<td>41.2 ± 8.4</td>
</tr>
</tbody>
</table>

Seasonal Global Flash Rate

Annual Global Lightening Rate (Flashess km⁻² yr⁻¹)
- Annual global lightning rate (Flashess km⁻² yr⁻¹) from LIS on ISS over first year with view time and detection efficiency corrections applied. Results similar to combined OTD/LIS climatology. Same for Seasonal behavior.