

Mission and Measurement

Mission

- Fly a flight-spares LIS on ISS to take advantage of unique capabilities provided by the ISS (e.g., high inclination, real time data).
- Integrate LIS as a hosted payload on the DoD Space Test Program-Houston 5 (STP-H5) 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.

Sensor Unit (legacy hardware)

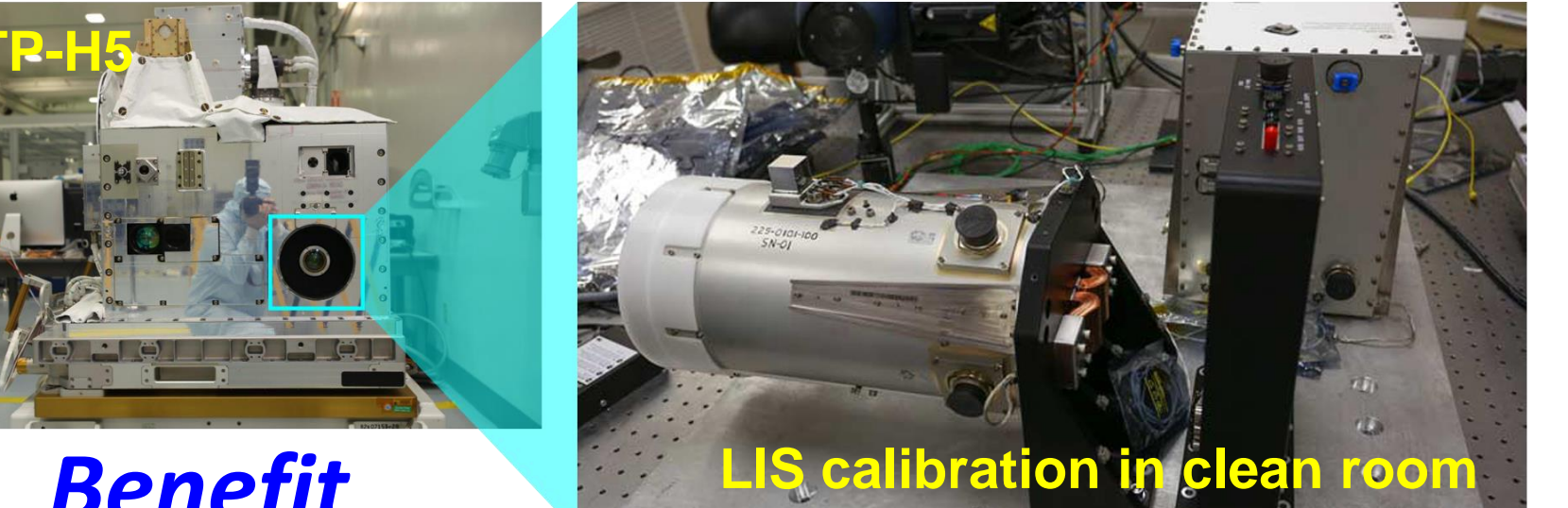
- Optical Assembly
- 128 x 128 CCD Focal Plane
- Lightning and Background detection

Electronics Unit (legacy hardware)

- Real Time Event Processor, Background removal, Data formatting
- Power conversion and control

Interface Unit (new hardware)

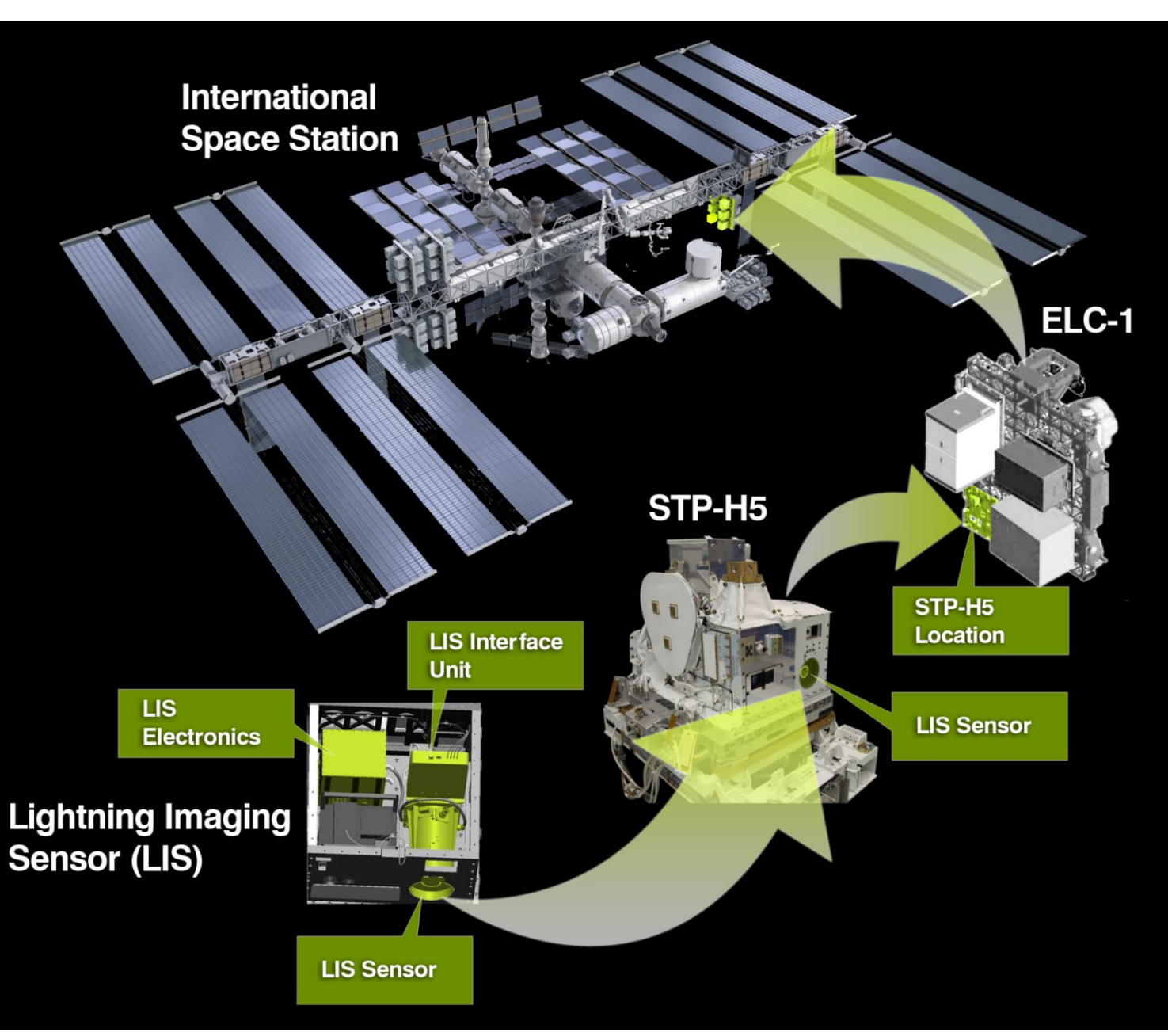
- Power conversion, timing, and control
- ISS interface



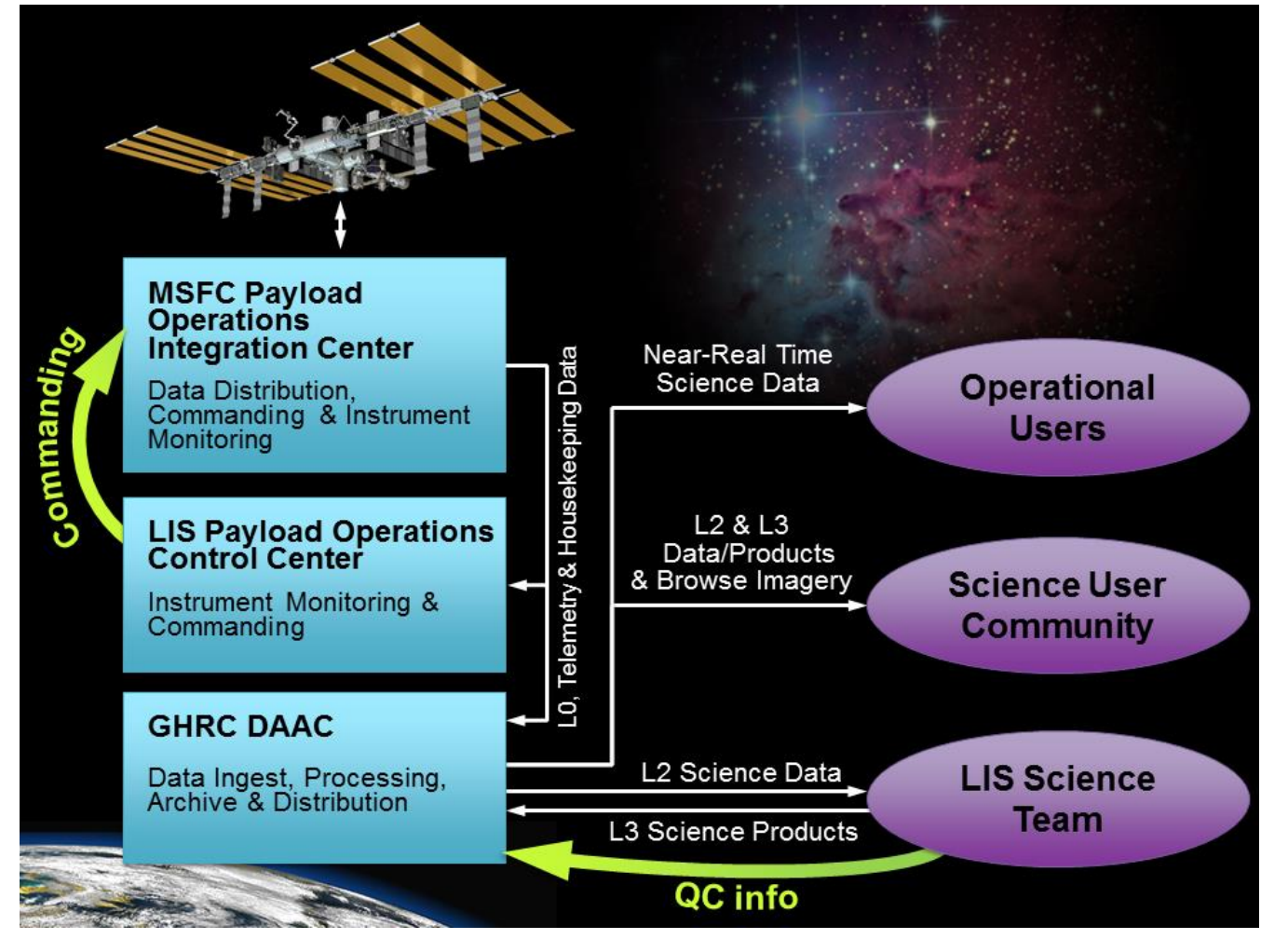
Benefit

- LIS on ISS will extend TRMM time series observations, expand latitudinal coverage, provide real time data to operational users, and enable cross-sensor calibration.

Launch, Activation, Operation, and Data Handling



- LIS launched aboard Space X Cargo Resupply Service-10 (CRS-10) mission on 19 February 2017.
- STP-H5 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.
- 51.6° inclination orbit, ~405 km altitude (detects to ~55°), ~ 600 x 600 km FOV.
- 60 days required for complete sample of the diurnal cycle.

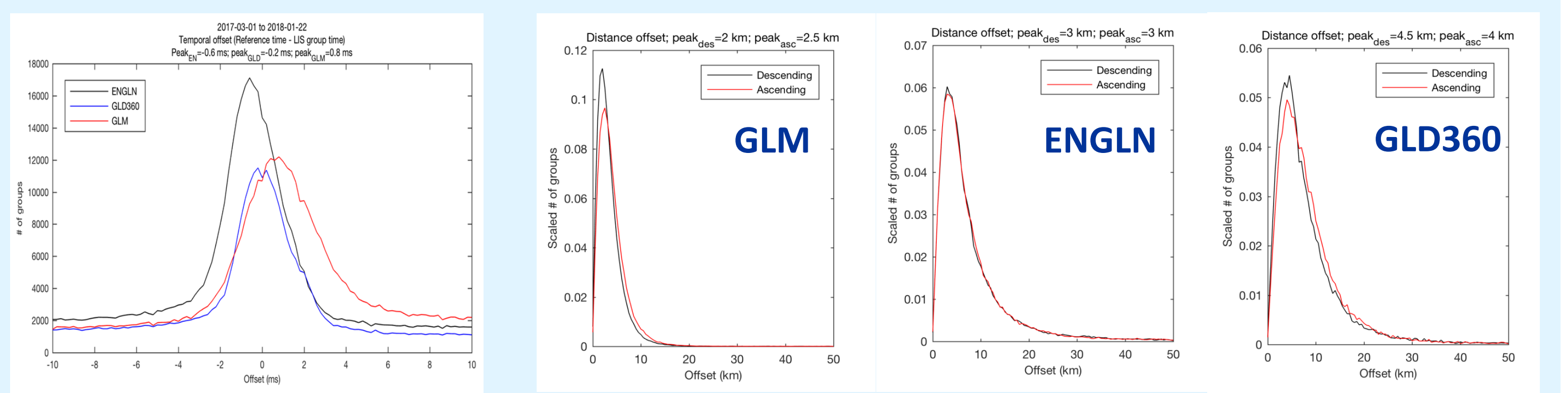


- LIS on ISS adapted the proven and robust data handling infrastructure used for LIS on the Tropical Rainfall Measuring Mission (TRMM).
- Near real time data (2 minute latency) available to operational users.
- The Global Hydrology Resource Center, one of NASA's Distributed Active Archive Centers, provides the LIS data in both legacy TRMM (HDF4) and a new netCDF-4/CF formats.
- LIS data can be obtained from the GHRC DAAC at <https://ghrc.nsstc.nasa.gov/lightning/>

Validation

Timing and Geolocation Accuracy

- Comparing LIS observations with reference "Truth" lightning data sources helped optimize the processing algorithms, validate the results and establish excellent timing and geolocation.
- The "Truth" data sources consisted of one space-based – *Geostationary Lightning Mapper (GLM)* – and two ground-based – *Earth Networks Global Lightning Network (ENGLN)* and *Vaisala GLD360* – lightning detection systems.

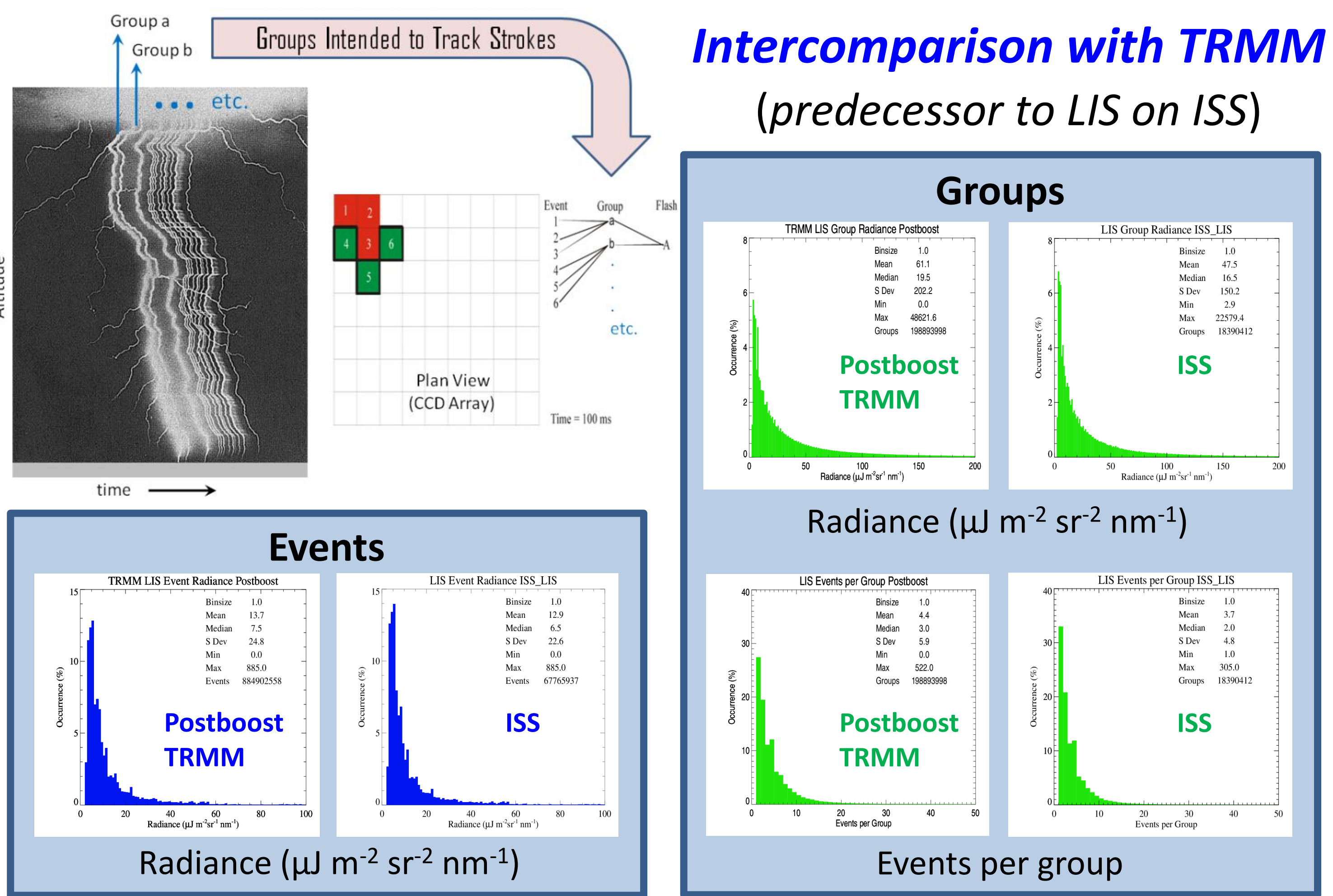


Time offset of LIS compared to the three reference sources demonstrates sub-millisecond timing accuracy.

Distance offset of LIS compared with GLM ("apples to apples optical") shows sharp peak with sub-pixel accuracy of 2-2.5 km.

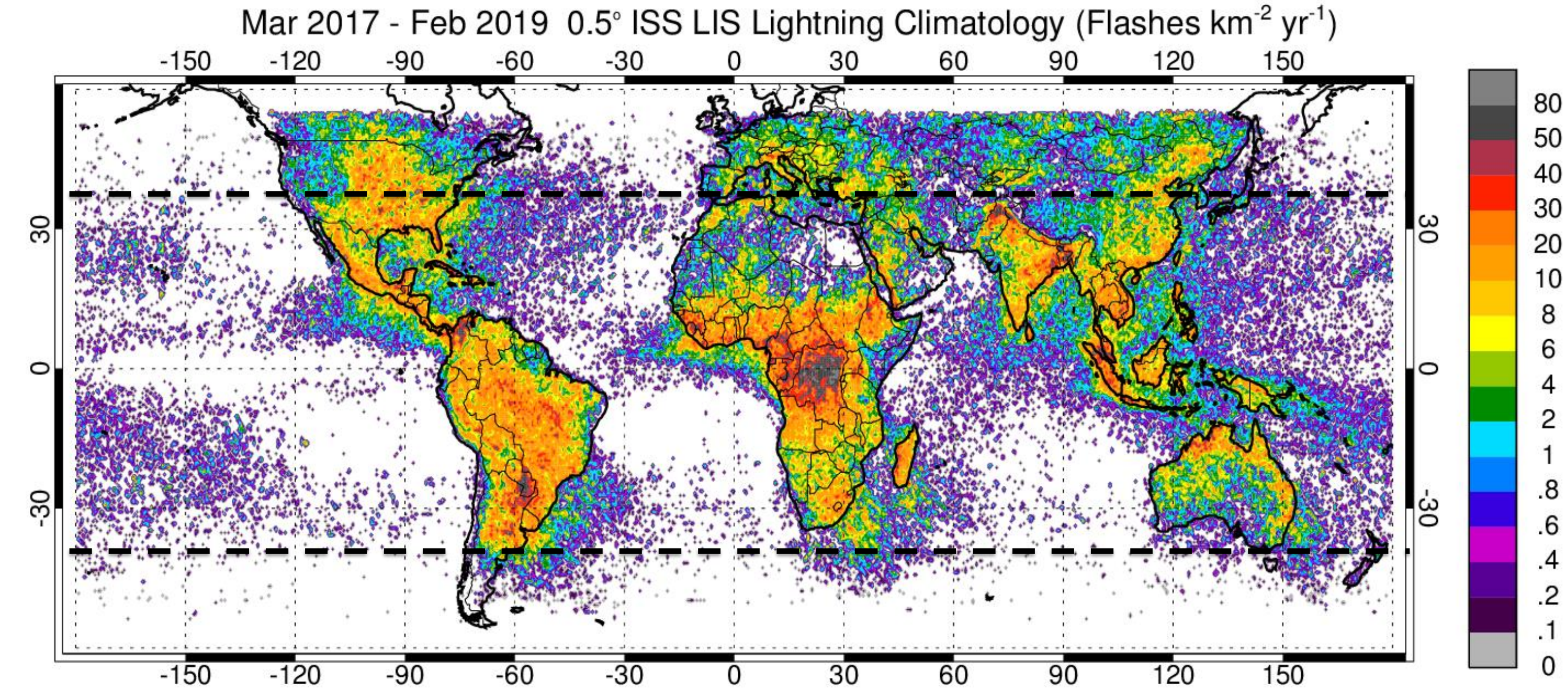
Distance offsets of LIS compared with the long-range Earth Networks and GLD360 RF systems further verifies this excellent geolocation accuracy.

Data Product Statistics



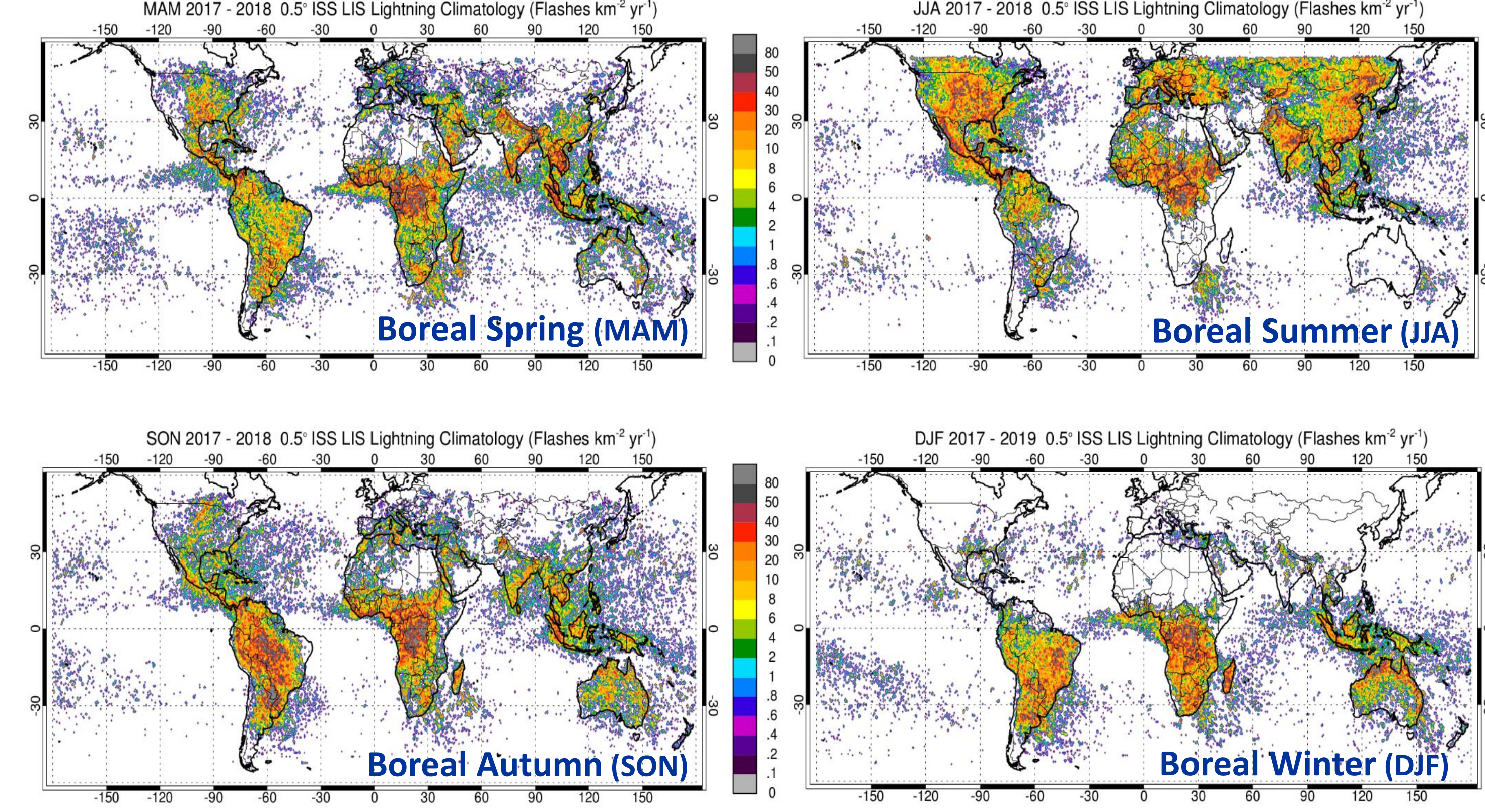
Flash Rate Statistics

Annual Global Flash Rate



- Annual global lightning flash rate density (Flashes $\text{km}^{-2}\text{yr}^{-1}$) from LIS on ISS during two years on orbit with view time and detection efficiency corrections applied. Climatology agrees closely with results from the prior two missions. Dash lines represent TRMM LIS limit.
- For the first time since the OTD mission ended in 2000, LIS now observes mid-latitude storms from space, and provides coverage of full CONUS and Middle & Southern Europe.

Seasonal Global Flash Rate

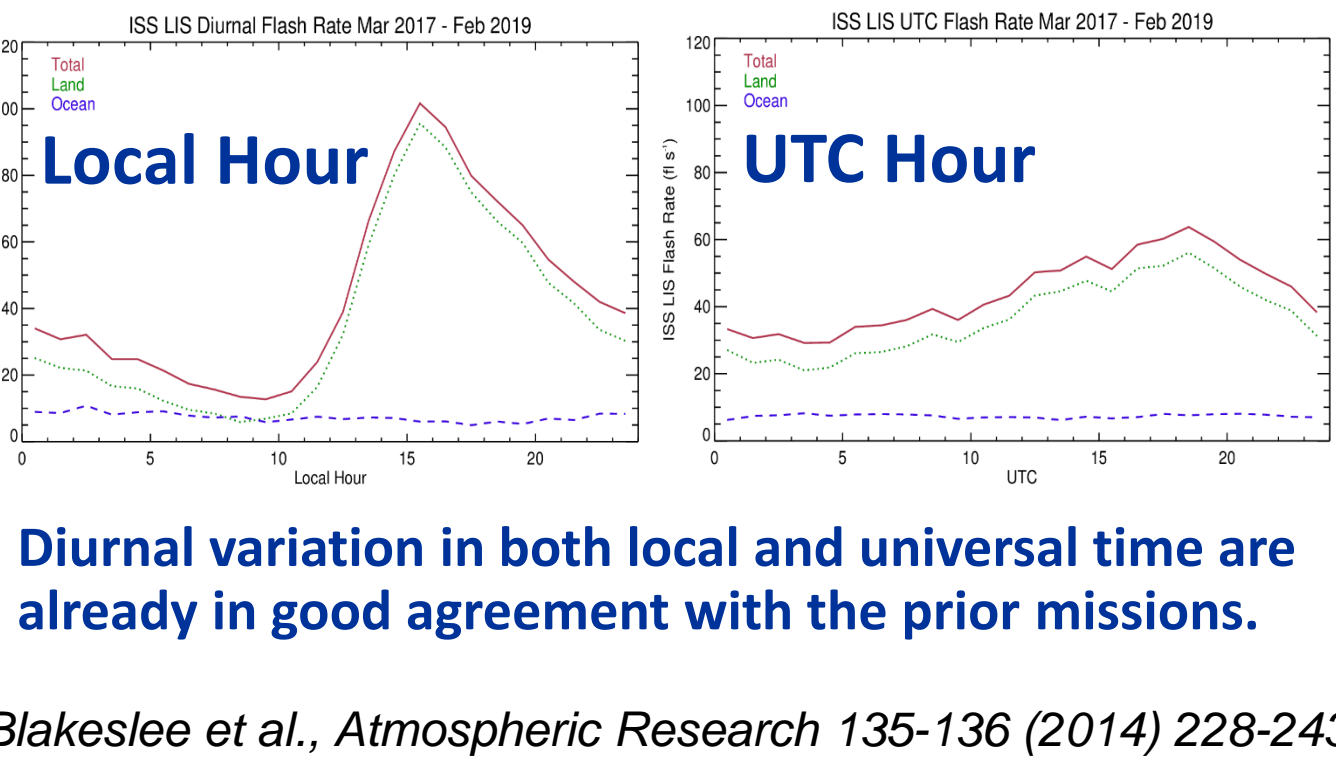


Other Global Flash Statistics

Table shows flash rate (flashes s^{-1}) for LIS on ISS versus prior space-based OTD/LIS climatology¹.

Excellent agreement (5-10%) is found even after only two years on-orbit.

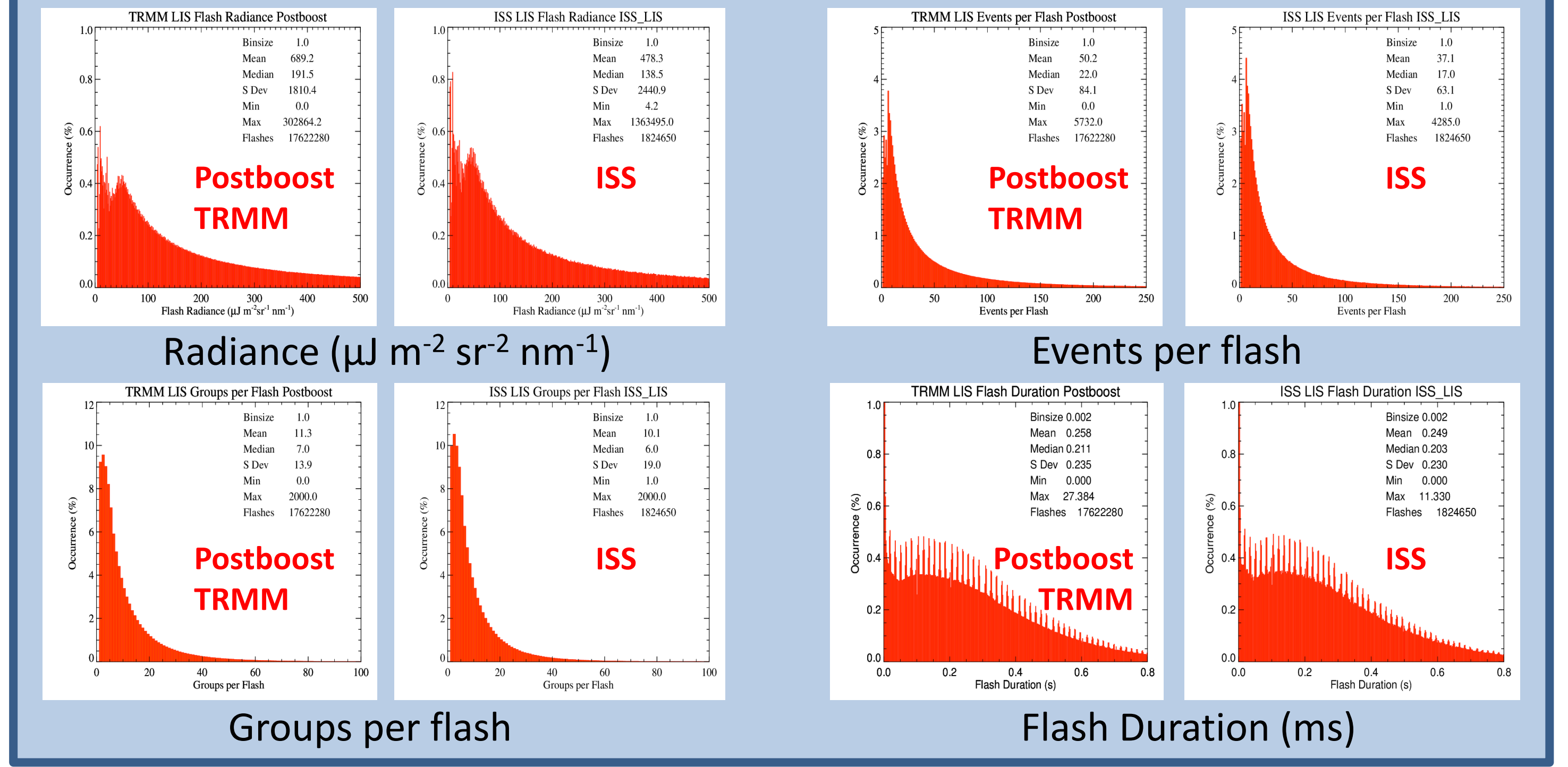
| Region | Annual | MAM | JJA | SON | DJF |
|----------------|--------|------|------|------|------|
| World * | 45.7 | 44.1 | 55.7 | 47.2 | 35.9 |
| ISS LIS 55° | 43.6 | 43.1 | 53.6 | 46.8 | 32.2 |
| <37.5° * | 40.7 | 40.9 | 42.5 | 44.6 | 34.9 |
| ISS LIS <37.5° | 39.1 | 40.7 | 40.6 | 45.0 | 31.5 |



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 include (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.

Flashes



Summary

- LIS working well and global flash statistics in excellent agreement with prior missions.
- 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 global lightning observations and serve as a "gold standard" measurement.