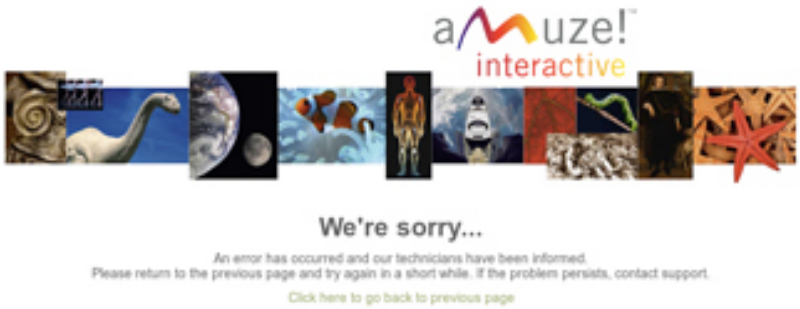
The International Space Station Lightning Imaging Sensor: Performance, Applications, and Cross-Platform Science



Timothy Lang (1), R. Blakeslee (1), D. Buechler (2), D. Mach (3), S. Bang (1), A. Biazar (2), T. Berendes (2), K. Brunner (2), S. Flynn (2), P. Gatlin (1), M. Heumesser (4), W. Koshak (1), S. Leake (5), E. McCaul (3), C. Schultz (1), S. Stough (2), K. Virts (2), Y. Wu (2)

(1) NASA MSFC, (2) University of Alabama in Huntsville, (3) USRA, (4) Technical University of Denmark, (5) Western Michigan University

PRESENTED AT:

AGU FALL MEETING
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1. INTRODUCTION

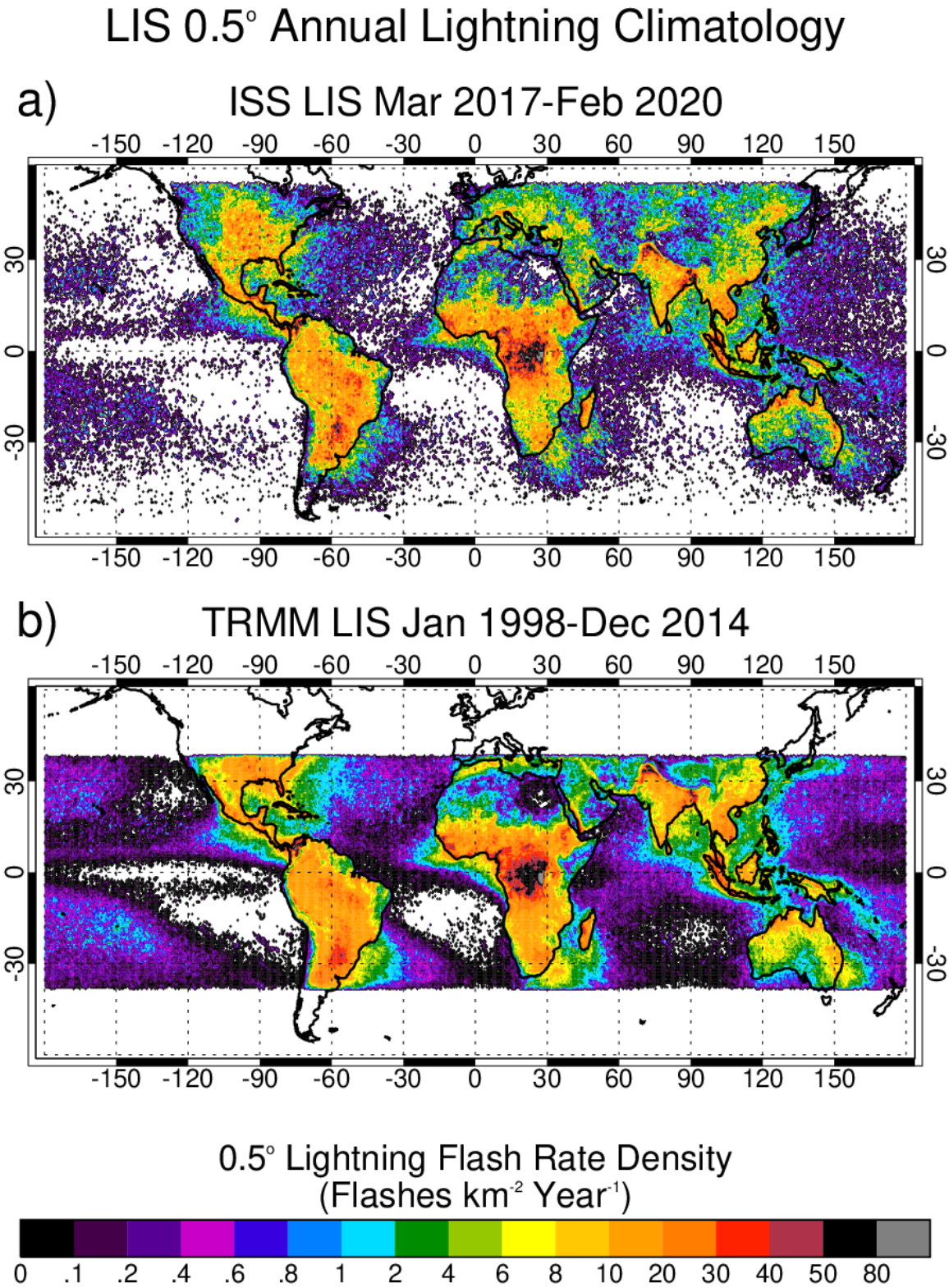
- The International Space Station Lightning Imaging Sensor (ISS LIS) is an optical lightning detector in an inclined low-Earth orbit (LEO).
- ISS LIS is part of the 5th Space Test Program - Houston (STP-H5) mission to the ISS, operating since 2017.
- ISS LIS uses the 777.4-nm emission line to sample lightning during day and night, with spatially uniform detection efficiency (60%+).

2. INSTRUMENT FUTURE

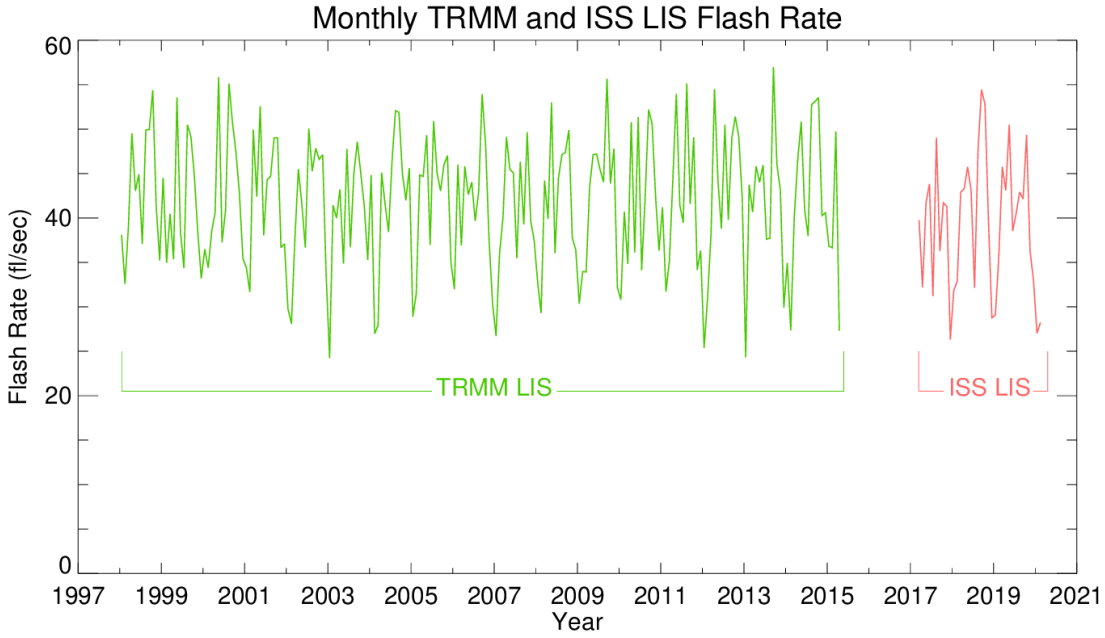
- ISS LIS successfully completed the Fiscal Year (FY) 2020 NASA Senior Review, and current plans are to operate thru at least FY23.
- During FY21 or FY22, ISS LIS (along with STP-H5) is expected to move to the other side of ELC-1 to accommodate a new instrument (EMIT).
- Post-FY23 plans are contingent on identifying another site for STP-H5 after FY23, and then completing the next NASA Senior Review.

3. GLOBAL CLIMATOLOGY OF LIGHTNING

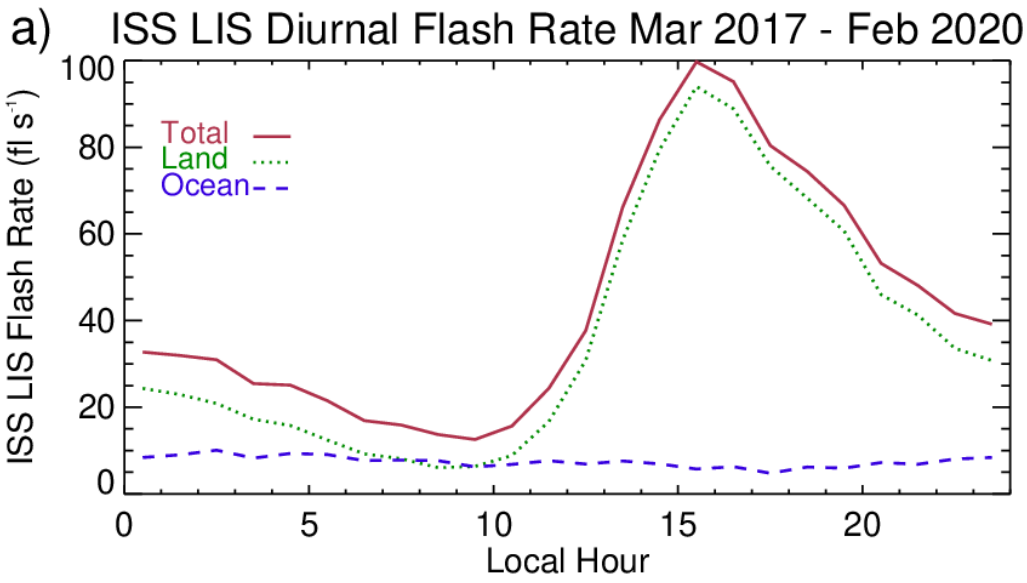
ISS LIS continues and expands to +/- 55 deg latitude the long-term climatology of lightning provided by the original LIS instrument on the Tropical Rainfall Measuring Mission (TRMM).

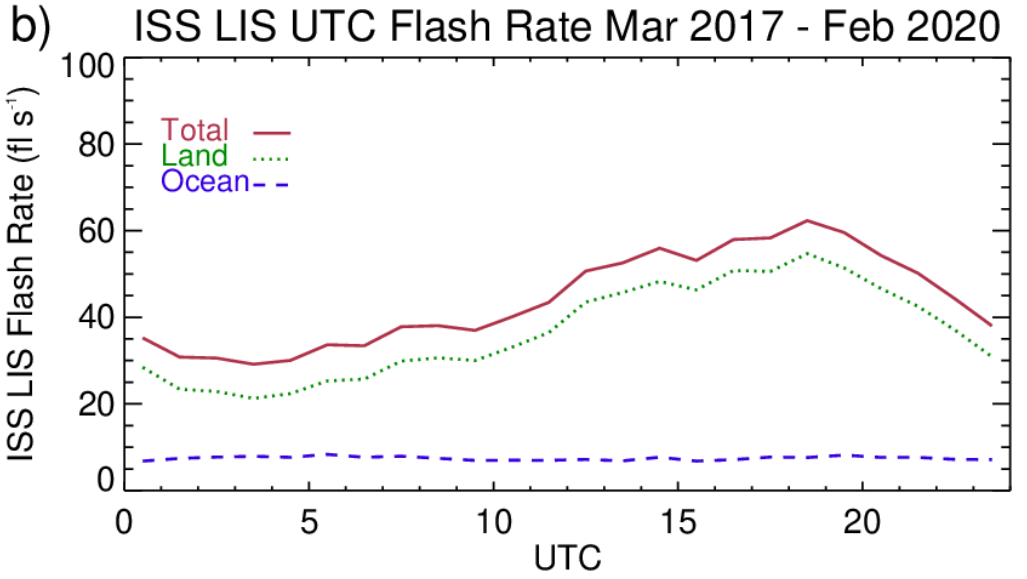


After 3 years in orbit, the ISS LIS global flash rate is ~44 flashes per second, within 5% of the TRMM LIS and Optical Transient Detector (OTD) flash rate for +/- 55 deg latitude (Cecil et al. 2014).

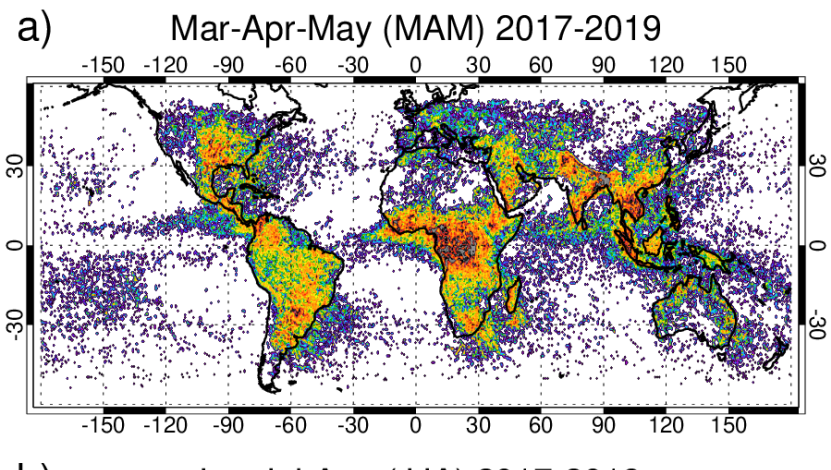


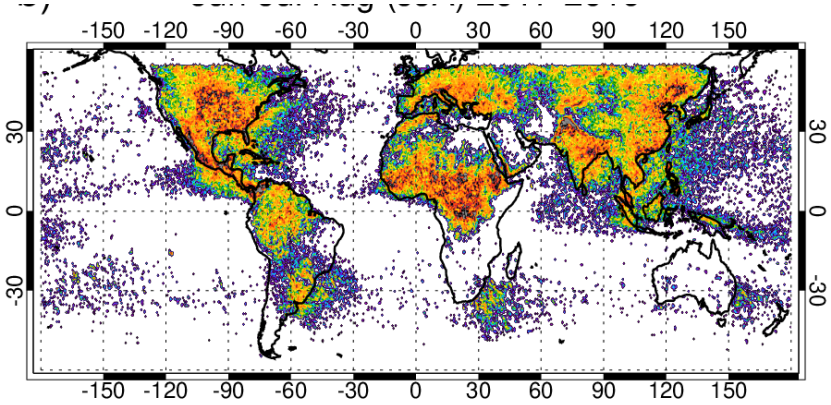
Seasonal and diurnal variability of global lightning are also well characterized by ISS LIS, and are in line with TRMM LIS/OTD.



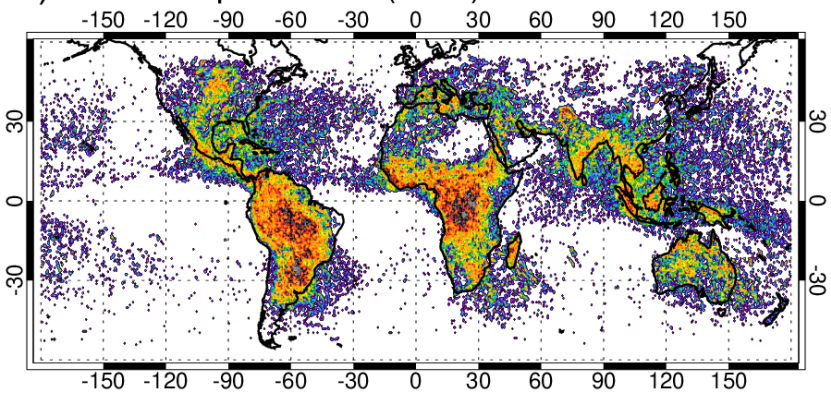


3 Year ISS LIS Seasonal Lightning Climatology

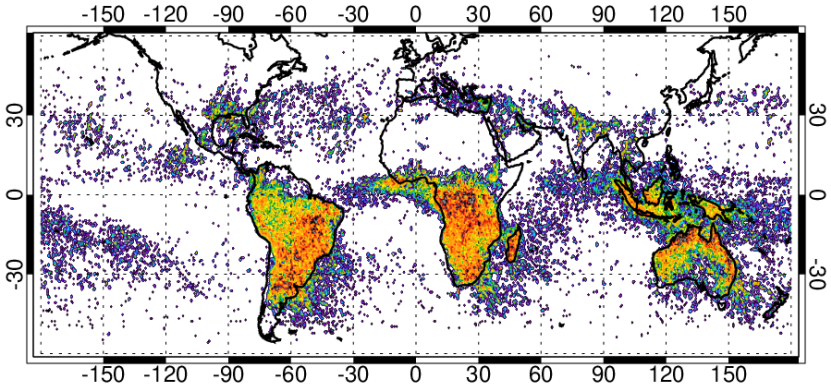


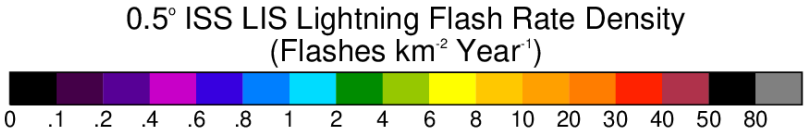


c) Sep-Oct-Nov (SON) 2017-2019



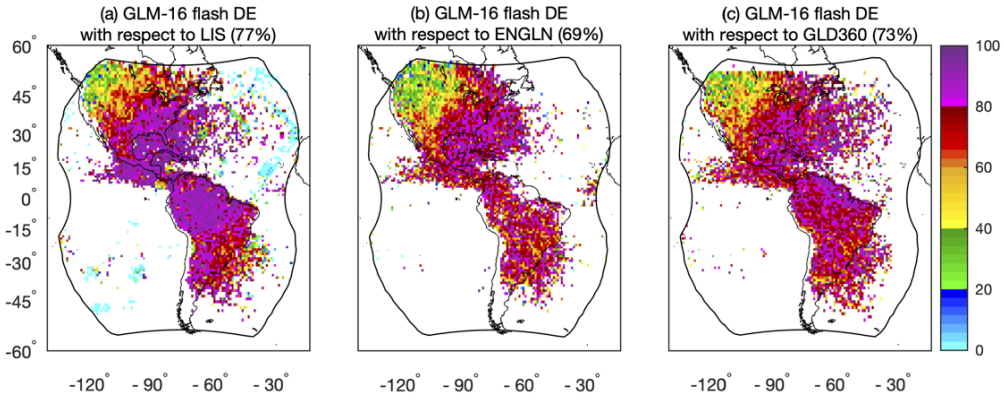
d) Dec-Jan-Feb (DJF) 2017-2020



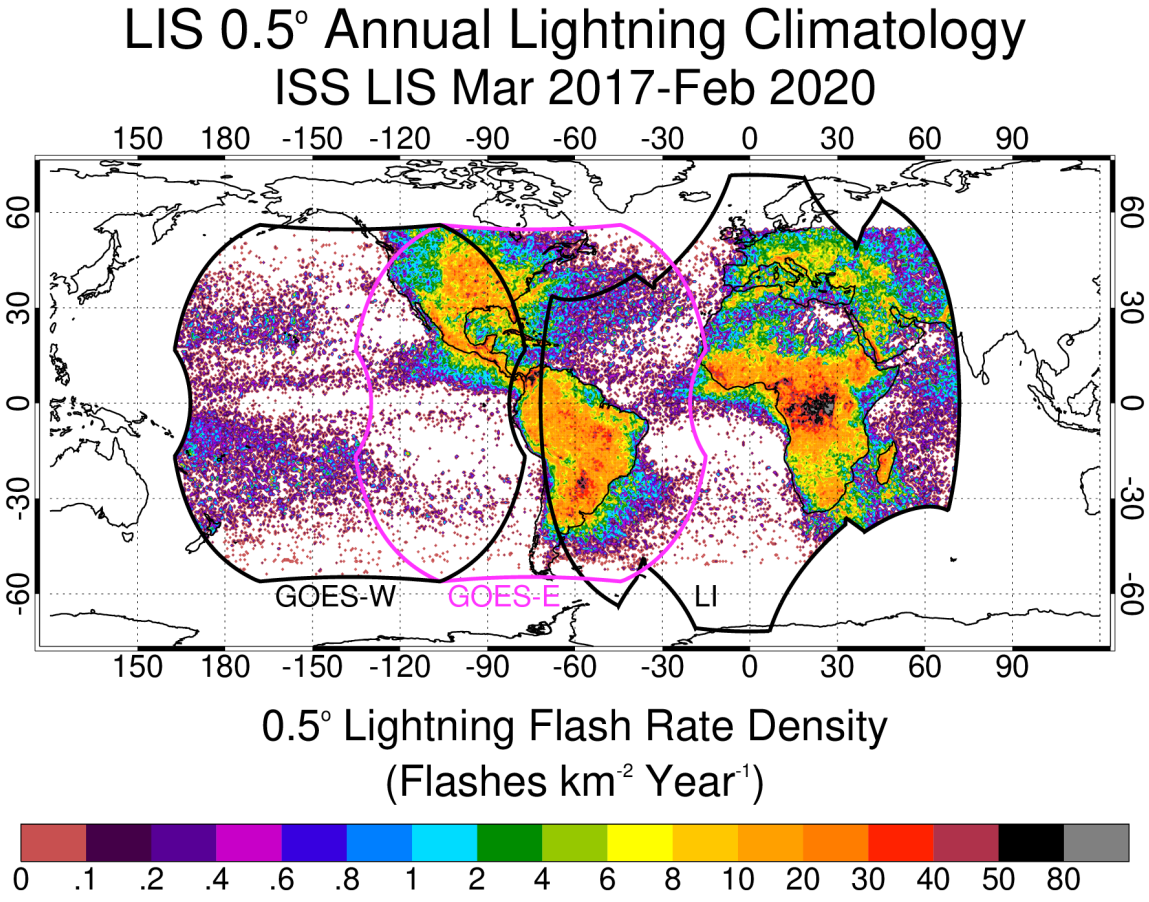


4. ONGOING WORK

ISS LIS is being validated against (and used as validation for) other lightning detectors, such as the Geostationary Lightning Mapper (GLM) and various ground-based networks.

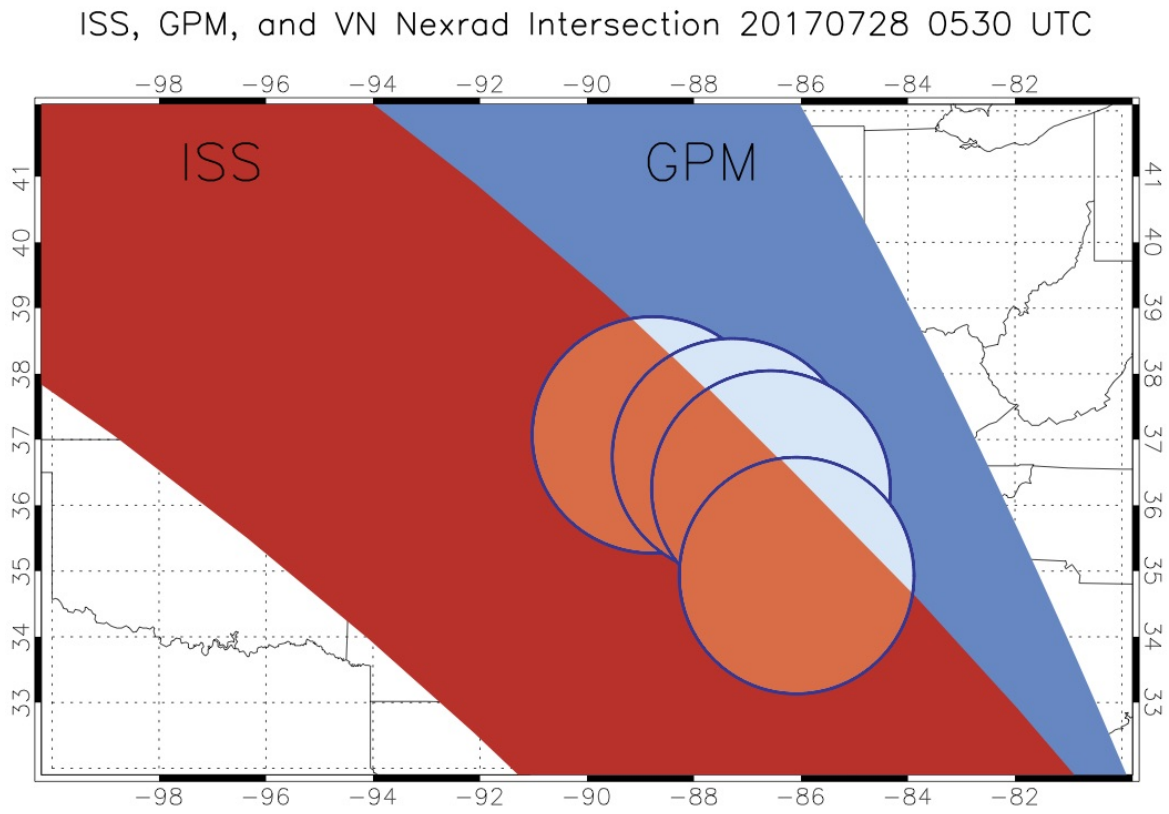


ISS LIS also is being used in preparations for the forthcoming Meteosat Third Generation Lightning Imager (MTG-LI).

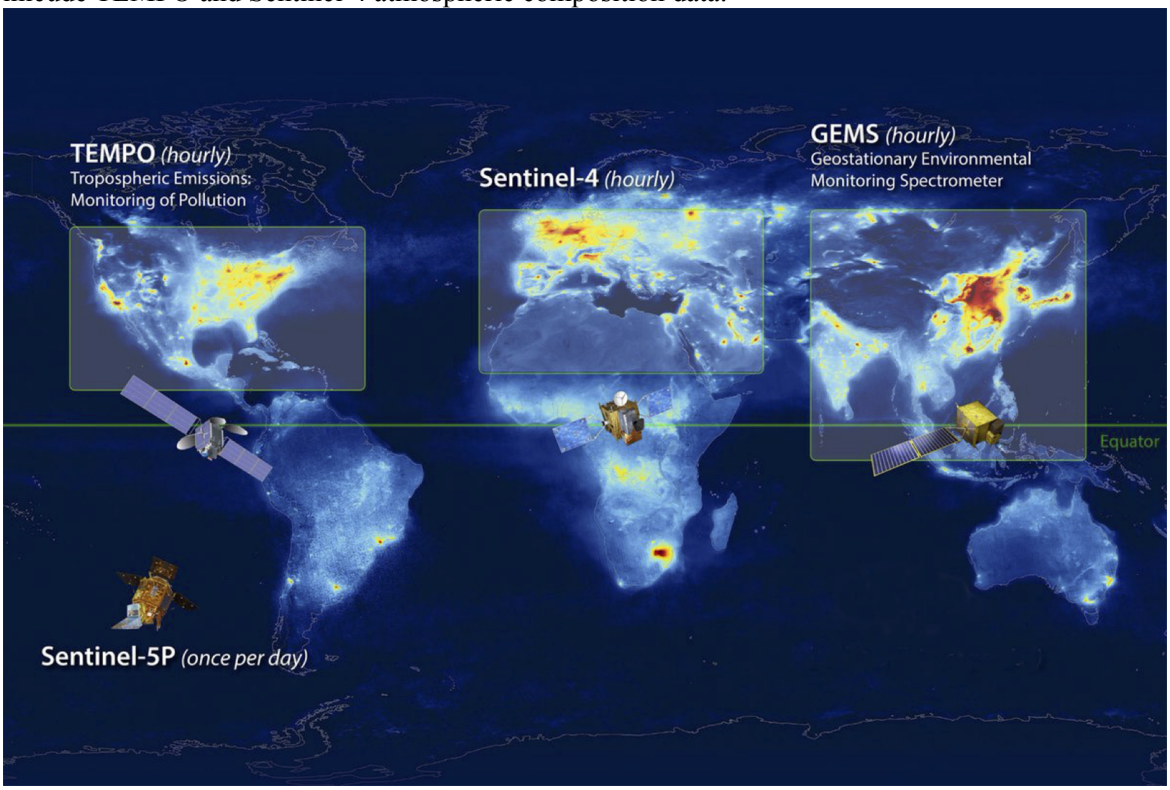


ISS LIS overpasses of the GPM validation network (VN) are being paired with coincident GPM and ground-based radar scans (including multi-Doppler wind retrievals) in order to use lightning observations to quantitatively characterize the microphysical and kinematic structure of convection.

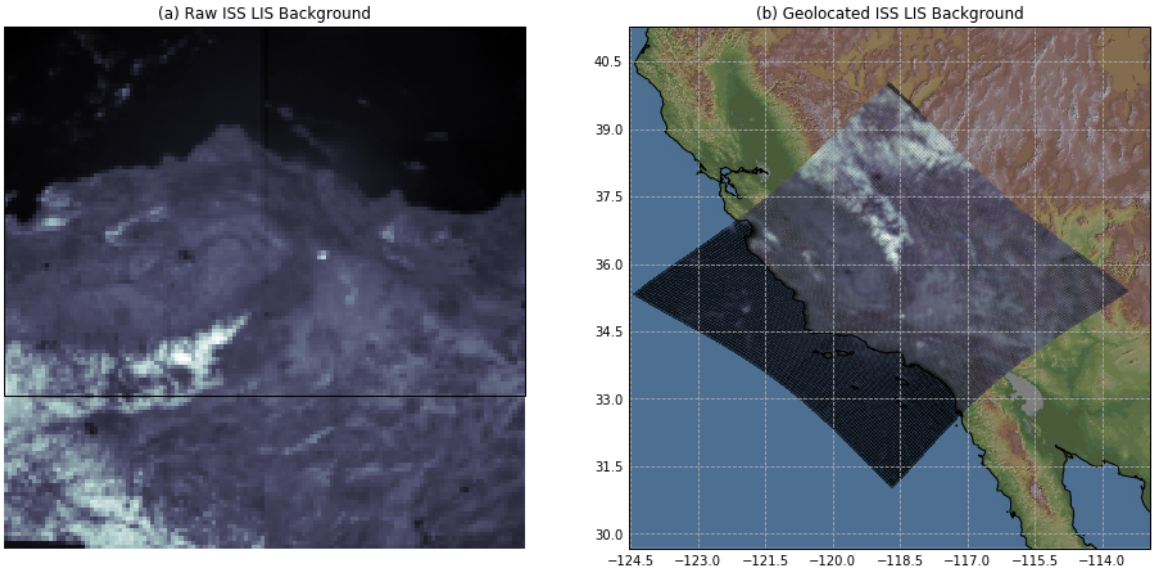
Similar work is being done using NU-WRF simulations of thunderstorms that resolve lightning flashes.



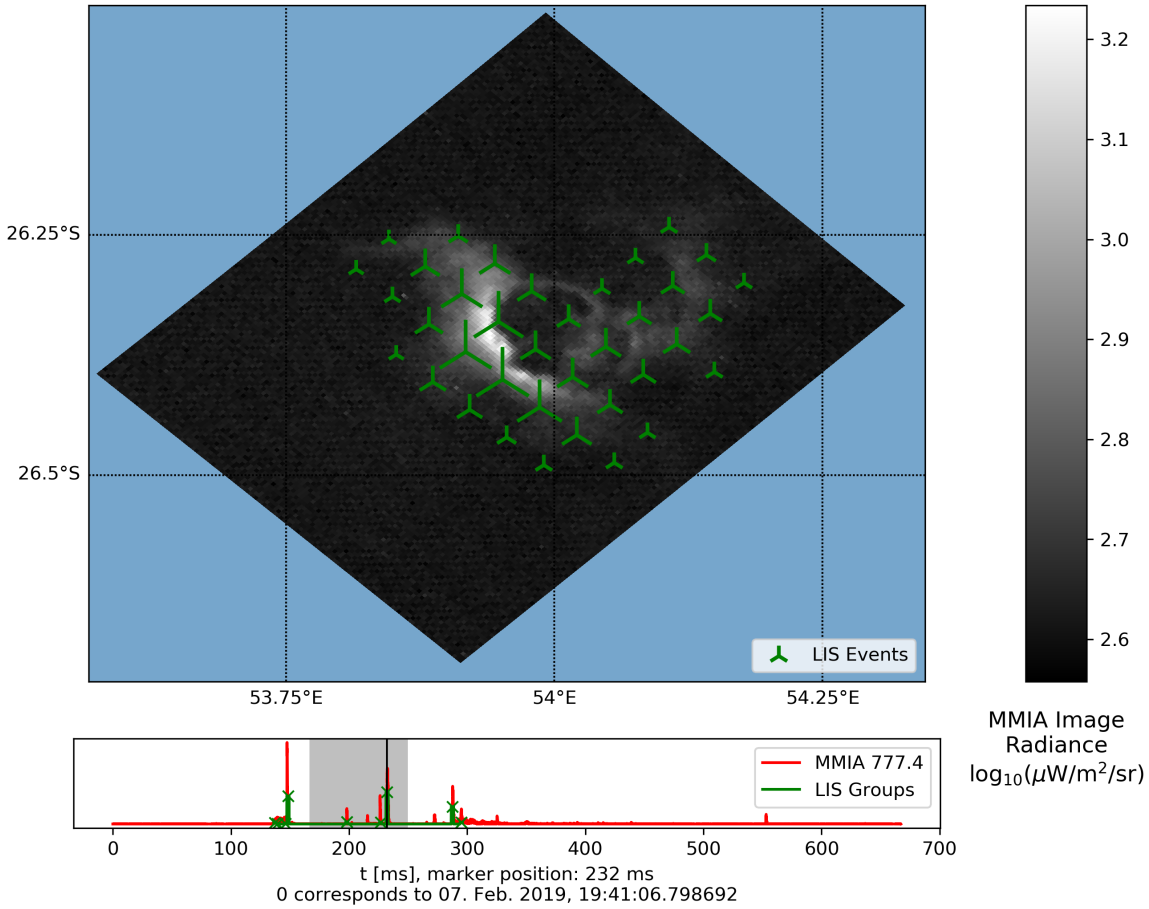
Lightning NOx (LNOx) estimates from ISS LIS are being validated against GEMS NO_2 and O_3 measurements in order to develop a more accurate global LNOx budget. Future work will also inlcude TEMPO and Sentinel-4 atmospheric composition data.



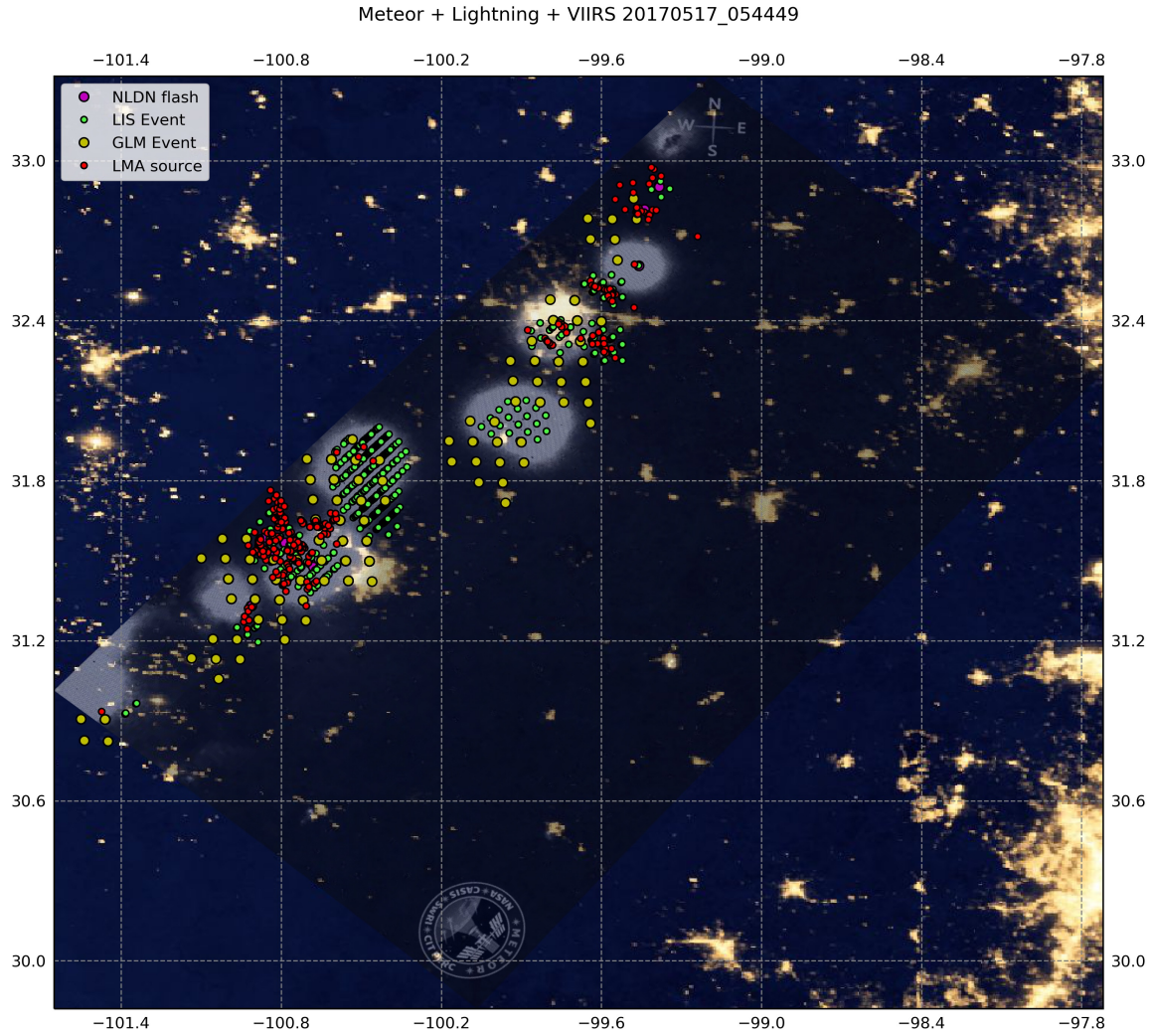
A new addition to the open source ISS Camera Geolocate (https://github.com/nasa/ISS_Camera_Geolocate) software package allows rapid geolocation of ISS LIS background imagery, enabling new non-lightning applications for ISS LIS.

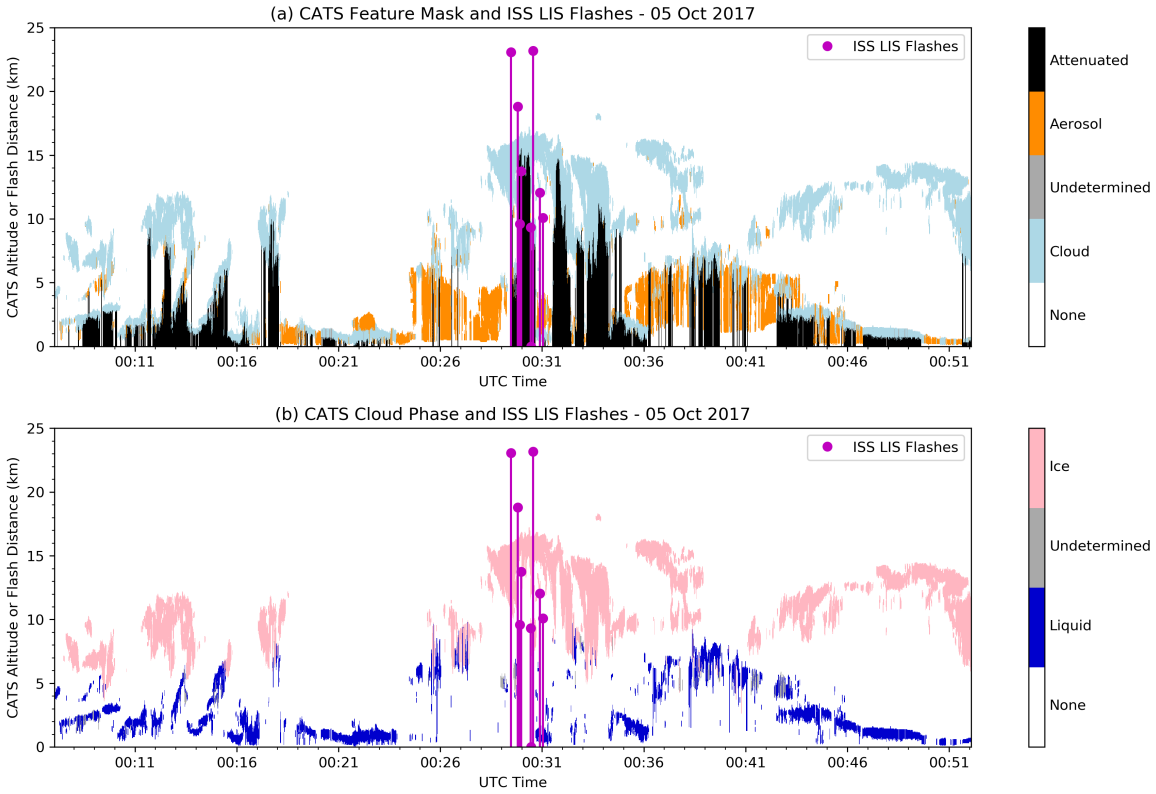


ISS LIS is being compared to Atmosphere-Space Interactions Monitor (ASIM) data in order to understand LIS response to faint optical pulses, and to inform designs for next-generation global lightning mappers.

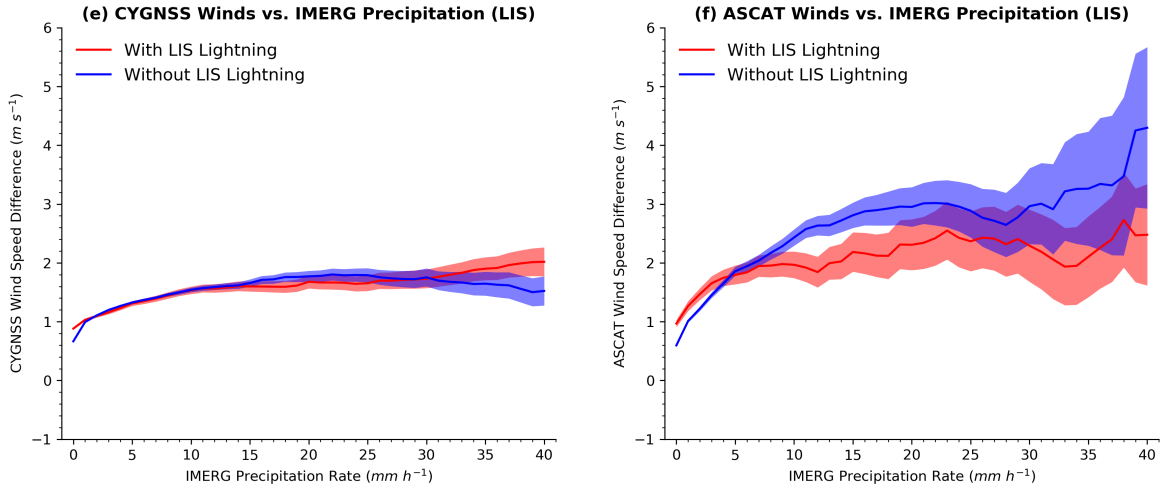


ISS LIS also is being compared to other ISS-based instruments such as the METEOR camera and the Cloud Aerosol Tranport System (CATS) lidar, enabling novel combinations of scientific datasets and new applications for ISS LIS data.



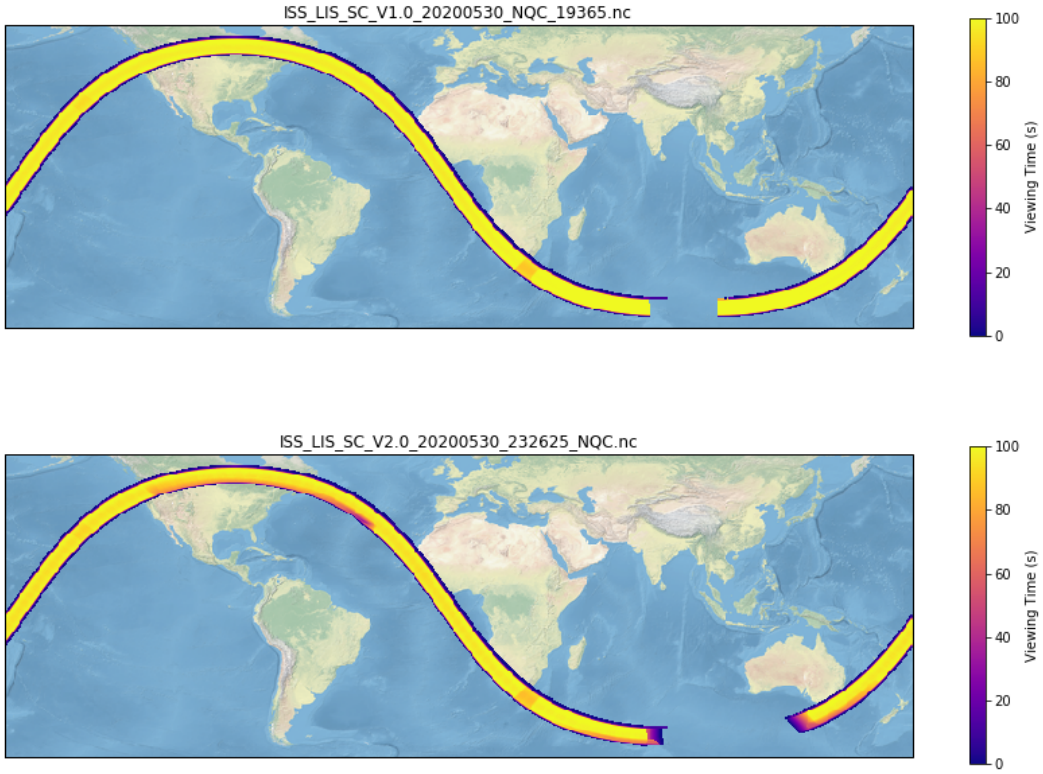


Last but not least, ISS LIS is being compared with Cyclone Global Navigation Satellite System (CYGNSS) and other ocean wind datasets to study thunderstorm outflows over the ocean.



5. FUTURE DATASETS

In FY21, two new ISS LIS datasets are planned to be released, including quality-controlled (QC) Version 1 data followed by a Version 2 dataset. Both datasets will be available at the Global Hydrology Resource Center (https://ghrc.nsstc.nasa.gov/lightning/data/data_lis_iss.html).



Version 2 data will provide more accurate estimates of packet loss and solar panel obscuration effects on viewing time, leading to improvement in the effective detection efficiency of the instrument.

6. CONCLUSIONS

- ISS LIS has been on orbit for over three years, and will continue to operate thru at least FY23.
- ISS LIS global climatology of lightning agrees well with the long-term TRMM LIS/OTD record.
- Ongoing and future work will bring new ISS LIS datasets and applications, and will address important science questions relevant to the most recent Earth Science Decadal Survey.

ABSTRACT

The Lightning Imaging Sensor (LIS), an optically based lightning detector developed at NASA Marshall Space Flight Center, was launched to the International Space Station (ISS) in February 2017, detecting optical signatures of lightning with storm-scale horizontal resolution (4-km) during both day and night. ISS LIS data are available 1 March 2017 to present. Millisecond timing allows detailed intercalibration and validation with other spaceborne and ground-based lightning sensors. Initial comparisons with those other sensors suggest flash detection efficiency around 60% (diurnal variability of 51-75%), false alarm rate under 5%, timing accuracy better than 2 ms, and horizontal location accuracy around 3 km. The spatially uniform flash detection capability of ISS LIS from low-Earth orbit allows assessment of spatially varying flash detection efficiency for other sensors and networks, particularly the Geostationary Lightning Mappers (GLMs). ISS LIS provides research data suitable for investigations of lightning physics, climatology, thunderstorm processes, and atmospheric composition, as well as realtime lightning data for operational forecasting and aviation weather interests. ISS LIS enables enrichment and extension of the long-term global climatology of lightning from space, and is the only recent platform that extends the global record to higher latitudes (± 55°). The global spatial distribution of lightning from ISS LIS is broadly similar to previous datasets, with globally averaged seasonal/annual flash rates (3-year average: ~44 s^{-1}) about 5-10% lower. This difference is likely due to reduced flash detection efficiency that will be mitigated in future ISS LIS data processing, as well as the shorter ISS LIS period of record. The expected land/ocean contrast in the diurnal variability of global lightning is also observed. The near-realtime ISS LIS data make the instrument important to operational weather forecasting and related applications, including public safety. Finally, ISS LIS is demonstrating utility as part (or potential part) of cross-platform studies examining a diverse array of topics, including lightning physics, thunderstorm processes, convective precipitation, and atmospheric composition.

REFERENCES

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- Cecil, D. J., Buechler, D. E., & Blakeslee, R. J. (2014). Gridded lightning climatology from TRMM-LIS and OTD: Dataset description. Atmospheric Research, 135, 404-414.