Lightning : An Essential Climate Variable

Atmospheric Observation Panel for Climate (AOPC)
Task Team on Lightning Observation For Climate Applications (TT-LOCA)

TT-LOCA Panel Members:
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Dr. Yuriy Kuleshov, RMIT, Australia
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[1]New Roles, [2]New Members

Report to the WMO/GCOS AOPC-26 Joint Panel Meeting, 19-23 April 2021

Why Lightning for Climate?

Due to the relevance of lightning data, and potential for use as a climatological variable, lightning has been added to the list of Essential Climate Variables (ECV) in the **2016 GCOS Implementation Plan (IP) (GCOS, 2016),** including a first attempt to define the requirements for climate monitoring of lightning measurements.

Action 29 of the IP called for defining "**the requirement for lightning measurements, including data exchange, for climate monitoring and to encourage space agencies and operators of ground-based systems to strive for global coverage and reprocessing of existing datasets".**

The TT-LOCA was constituted to address these questions.

Work Plan Outputs, Status and Update

0. Organizational Update - 2 new members, 2 new GCOS advisors
1. Requirements
2. Metadata
3. Data Records and Archive
4. Reprocessing of Existing Data
5. Thunder Day Database
6. Field Campaign for Measuring Ionospheric Potential
7. Collaboration and Partnerships

1. Requirements

- **Space-based, Ground-based data sets**
- **Global 10 km x 10 km**
- **TBD temporal (desire daily or better- 1 to 3 hr)**

2. Metadata

- **Metadata – desire for # stations (ground-based), Detection Efficiency, resolution (time, space), and other cal/val performance parameters (e.g., network flash type – IC/CG) needed to make a climate data set most useful). Note no network or space measurement is 100% DE effective over its entire coverage area.**

- **Issue - are the commercial operators willing to provide more information and insight.**

3. Data Records and Archive

- **Provide exemplary data set – Q4**
- **Non-government lightning data – commercial providers are now interested in cooperating in producing ECV data sets.**
- **Vaisala to provide a GLD360 VLF global lightning data set for further discussion of attributes (time, location, peak current, DE, and formats (e.g., netCDF)**
- **Issue: TBD at what temporal resolution commercial data okay (so as not to cannibalize historical data sales)**

4. Reprocessing of Existing Data

- Reprocess ISS-LIS and GLM to the same temporal resolution of GLD360
- Note: GOES-R has no budget for GLM reprocessing
- Chair discussed Lightning ECV archive with NOAA/NCEI (GLM archive) and NASA GHRC DAAC (Hydro-meteorology), where the NASA LEO lightning missions are already archived. The GHRC will consider hosting the ECV space and ground-based datasets - would need to contact NASA ESDIS for approval and stewardship support.
- Consider if lightning archive should be associated with other variables, such as cloud (e.g., WMO ICWG ISCCP-NG), precipitation (e.g., TRMM and GPM), NOx (TROPOMI, GEMS/GOSAT-GW/Sentinel 4 UVN/TEMPO), and surface observations (e.g., temperature, severe weather reports)

5. Thunder Day Database

- **Thunder Day Database - data can extend lightning climatology well back into the 20th century (e.g., LaVigne, Liu, and Liu, JGR Special Collection 2019 – Thunder days correlated with TRMM LIS)**

- **Schumann Resonances - Lightning stimulates the earth-ionosphere wave guide to ring like bell with standing waves (at ELF frequencies). Time variations of the power in these Schumann Resonances gives information on cumulative lightning activity. What data (modes) are researchers willing to share ?**

6. Global Electric Circuit

- **The global circuit is driven by thunderstorms, and therefore can be used to summarize global electrification changes**
- **Recommended balloon field campaign for measuring ionospheric potential (GRUAN contacted)**
- **At present no sensors are available so this activity is on hold**

7. Collaborations and Partnerships

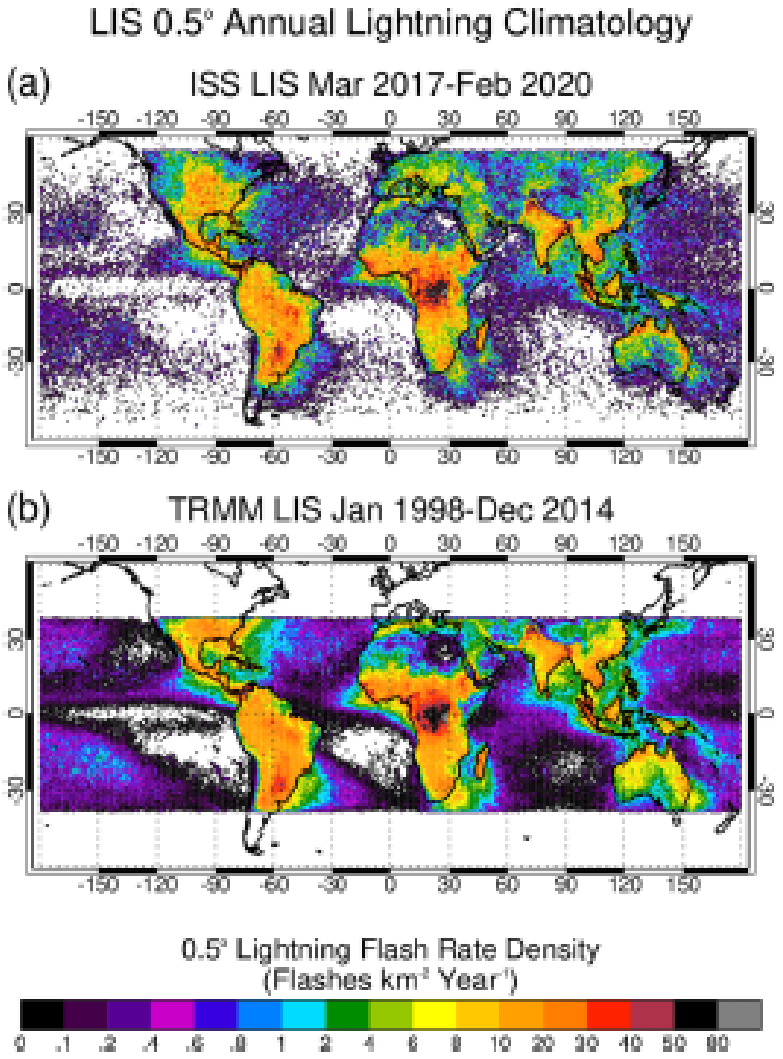
- **Identify providers offering to prepare an exemplary dataset (satellite - NASA, RF - Vaisala)**
- **Identify funding opportunities**
  - **for a research position**
  - **For reprocessing data sets**
- **Establish an integrated lightning data portal with GEO**
- **Raise lightning safety awareness – collaborate with WHO, WMO Disaster Risk Reduction Programme**

Historical Note about TT-LOCA

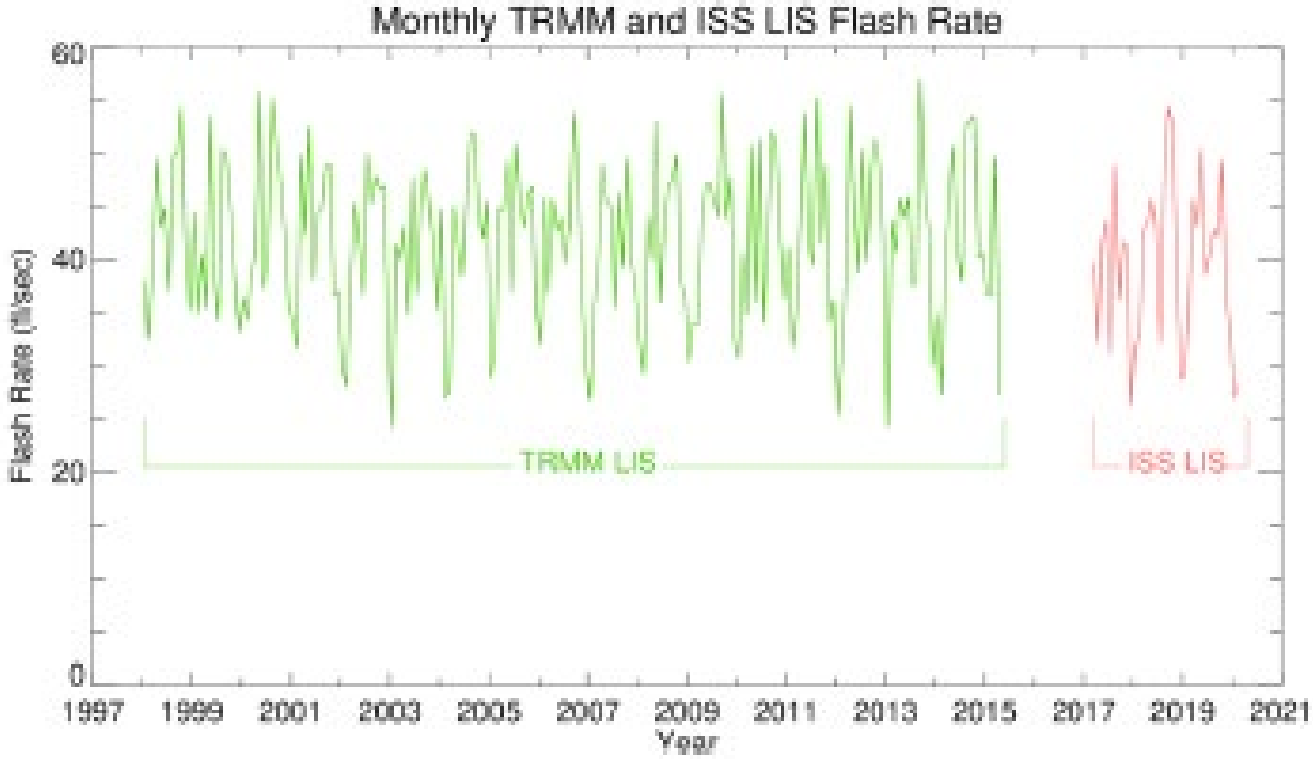
- **Task Team was constituted to include experts working in lightning research and observations. We held invited discussions with industry representatives of private lightning networks. Face to face meetings were held and active on-line discussions of major topics were conducted.**

- **GCOS report 227 was approved by all TT members.**

25 Years of Lightning from Space



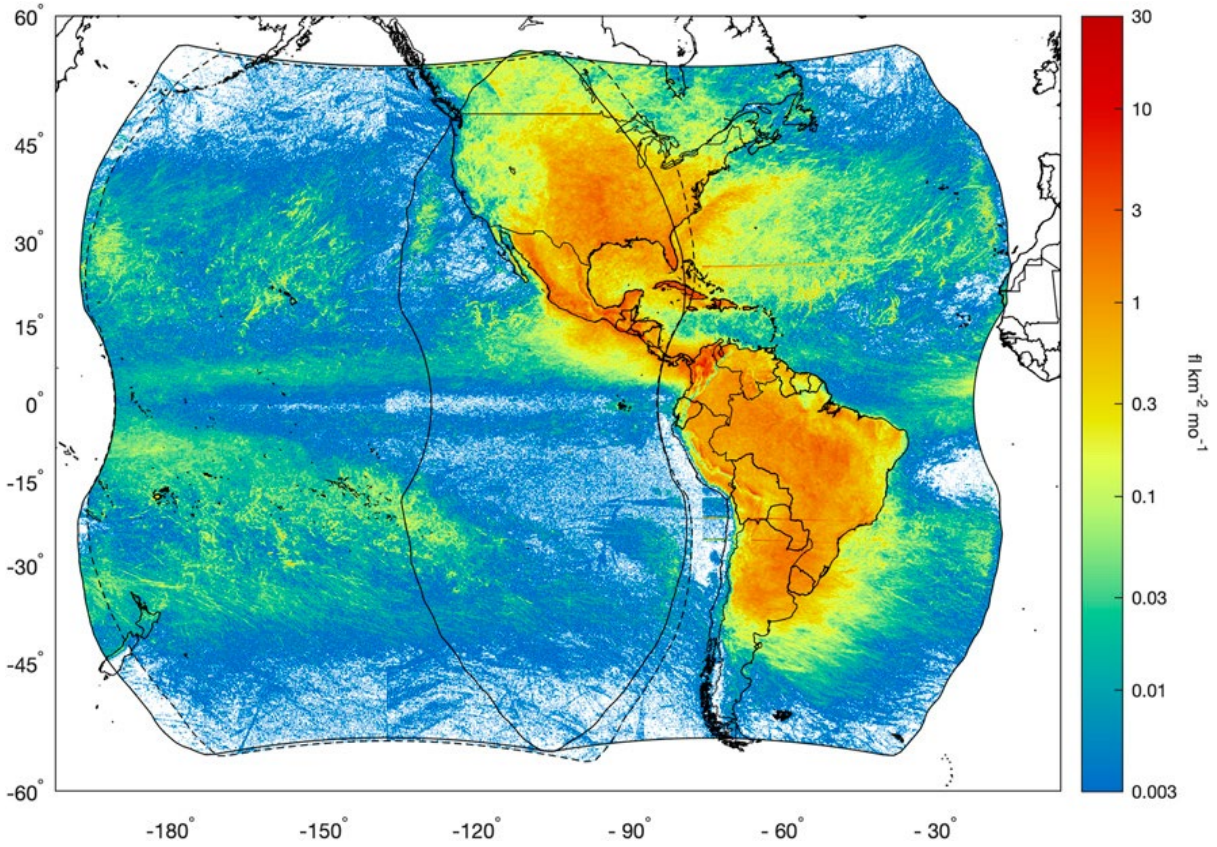
(a) Three-year (March 2017 through February 2020) climatology of global lightning from ISS LIS. (b) Postboost climatology of lightning from TRMM LIS (September 2001 through December 2014).



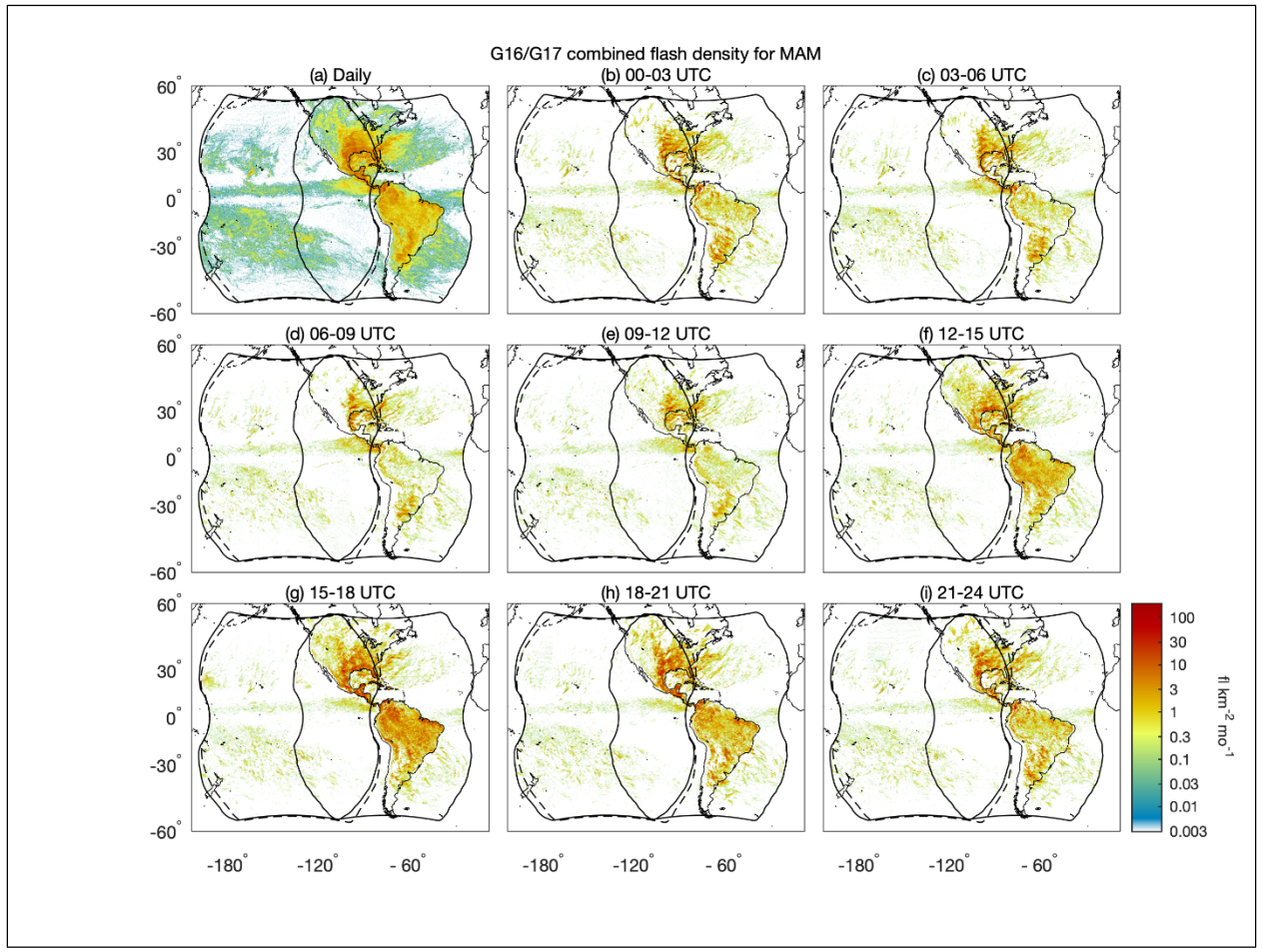
Monthly time series of global lightning flash rate (between ±38° latitude) from TRMM LIS and ISS LIS.

(Blakeslee, R. J., et al. (2020). Three years of the Lightning Imaging Sensor onboard the International Space Station, JGR,125, doi.org/10.1029/2020JD032918)

GOES Geostationary Lightning Mapper (GLM) Flash Density

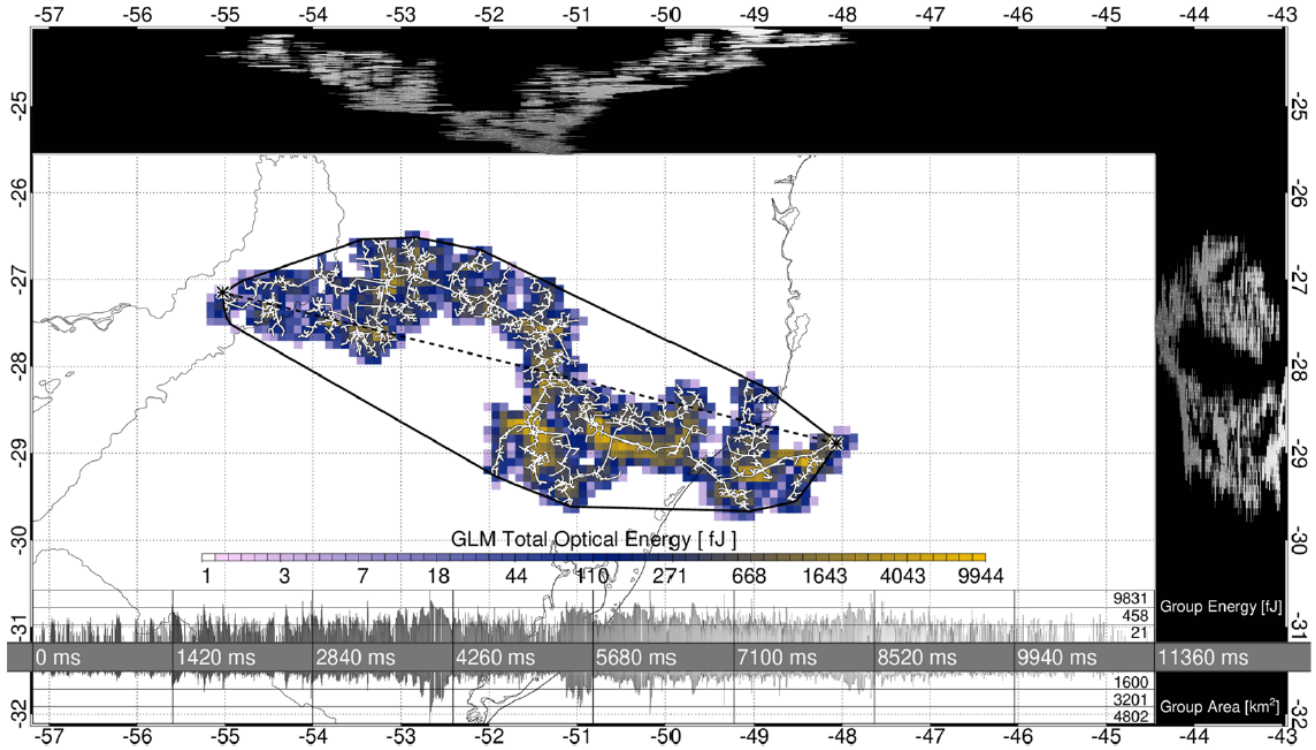


Combined GOES-16 and -17 flash densities during 1 Dec 2018–31 May 2020 with units of flash count per square kilometer per month. Flashes observed by either sensor are included in the overlapping region. Black lines indicate the nominal field of view boundaries for both instruments. For G17, the solid (dashed) line depicts coverage during boreal summer (winter). (Rudlosky and Virts, 2021, DOI: 10.1175/MWR-D-20-0242.1)

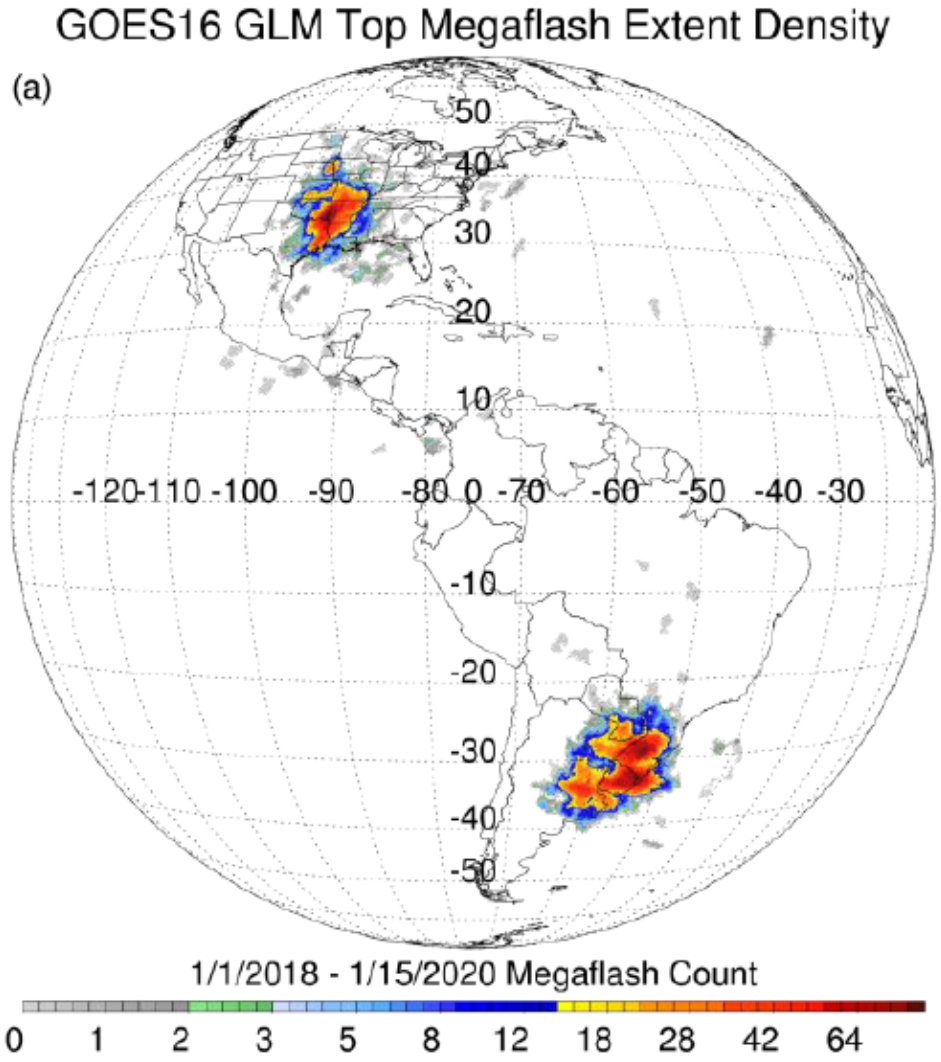


GLM 16/17 combined lightning flash density diurnal cycle (3-hr increments) for March - May.

WMO certified record lightning flash extent



Evolution of a 709 km megaflash on 31 October 2018 with a 11.36 s duration over southern Brazil. Incremental flash development is plotted over a total optical energy grid in the central panel. Timeseries of group energy (above) and group area (below) are shown aligning the bottom of the figure. The dashed line connects the most distant groups (marked with asterisks), while the solid line draws a convex hull around the groups in the flash. (Peterson, M. J., et al., 2020, New World Meteorological Organization certified megaflash lightning … recorded from space. Geophys. Res. Lett., 47, doi.org/10.1029/2020GL088888.



GLM top megaflash frequency in North America and South America hotspots. (Peterson, 2021, Bull. Amer. Meteor. Soc., DOI 10.1175/BAMS-D-20-0178.1