Lightning : An Essential Climate Variable

[1]Steven J. Goodman and [2]Katrina S. Virts
[1]GOES-R Program/TGA, [2]UAH,
Huntsville, AL USA

WMO/GCOS Task Team on Lightning Observation For Climate Applications (TT-LOCA)
Panel Members:
Steve Goodman, NOAA/NASA (ret), USA, Chair
Robert Holzworth, Univ. of Washington, USA
Vasiliki Kotroni, NOA, Athens, Greece
Yuriy Kuleshov, RMIT, BOM, Melbourne, Australia
Colin Price, Tel Aviv U., Israel
Bartolomeo Viticchie, EUMETSAT, Darmstadt, Germany
Earle Williams, MIT, USA
GCOS/WMO: Caterina Tassone, Tim Oakley

Outline

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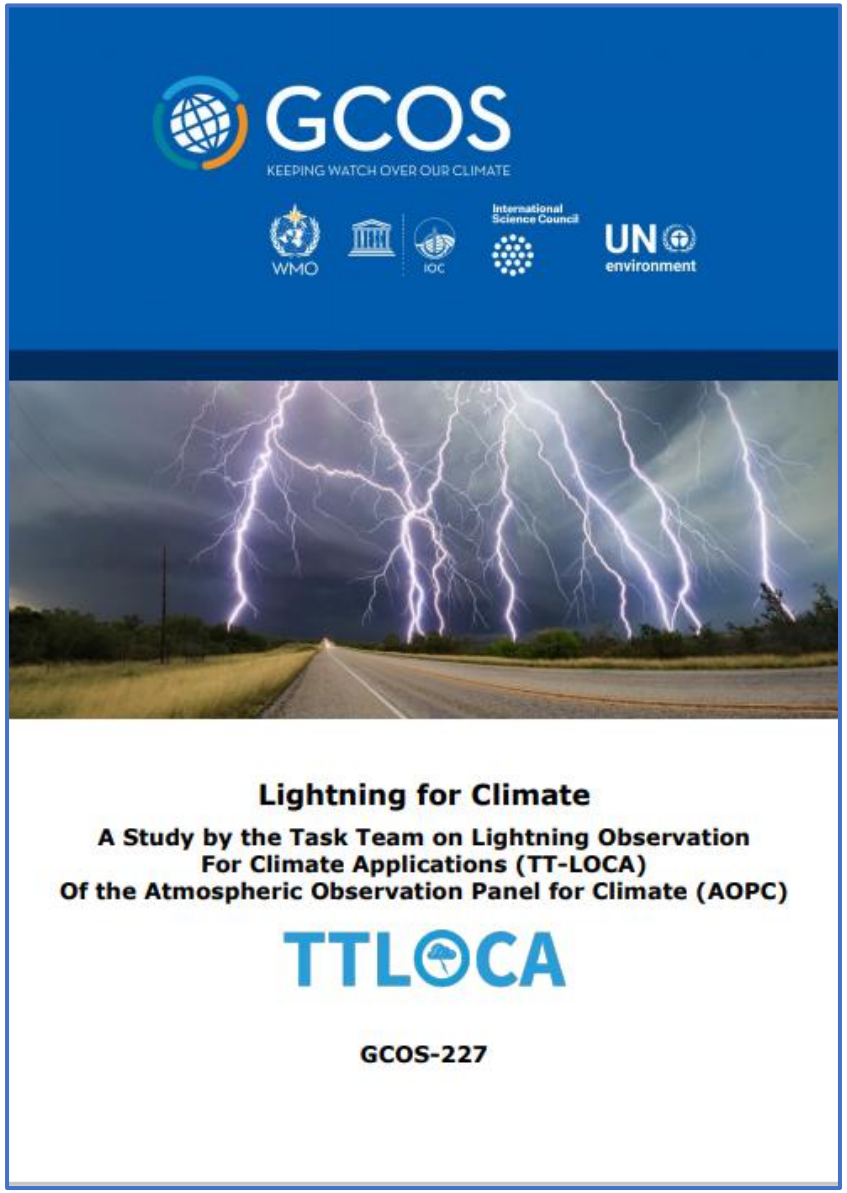
2. Metadata
3. Data Records and Archive
4. Reprocessing of Existing Data
5. Thunder Day Database
6. Summary



1. Requirements

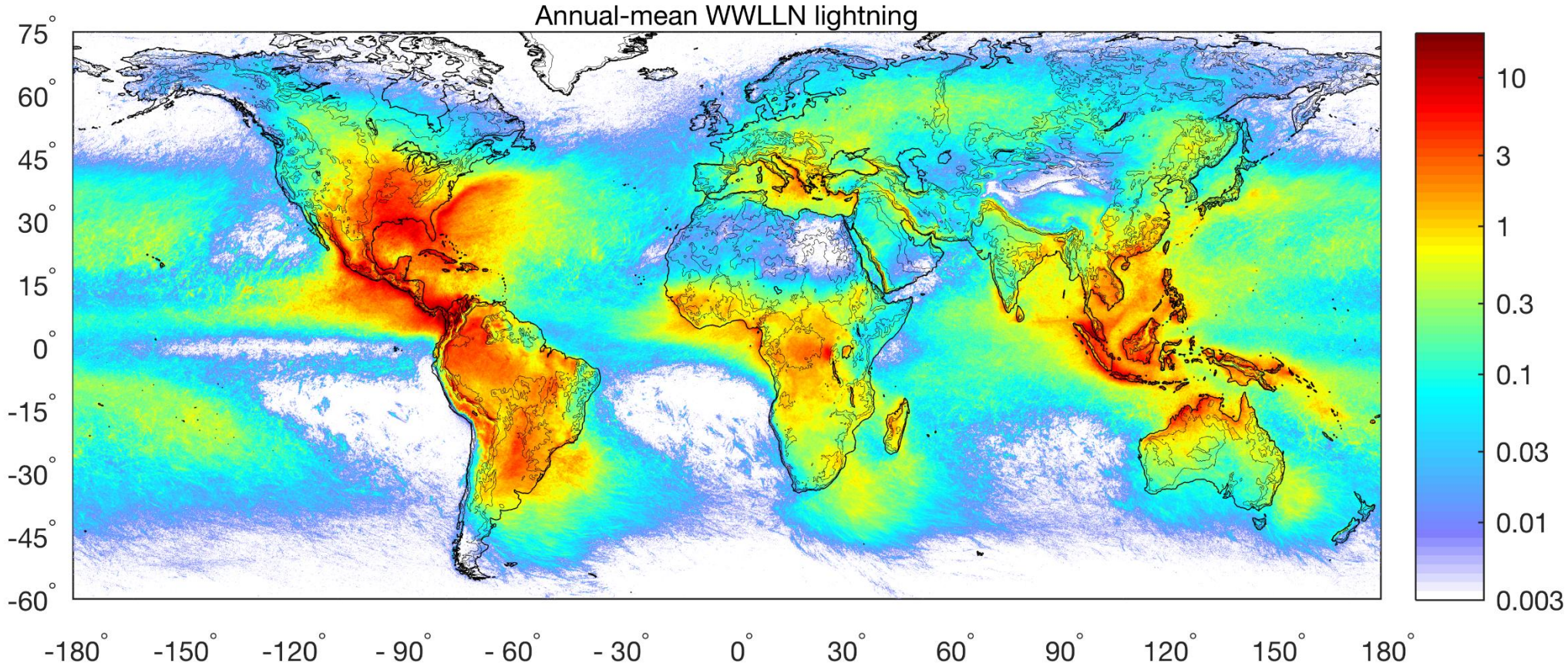
- **Space-based, Ground-based data sets**
- **Global 10 km x 10 km**
- **TBD temporal (desire daily or better- 1 to 3 hr)**

Ground-based RF networks

Three main frequency bands: ELF, VLF and MF

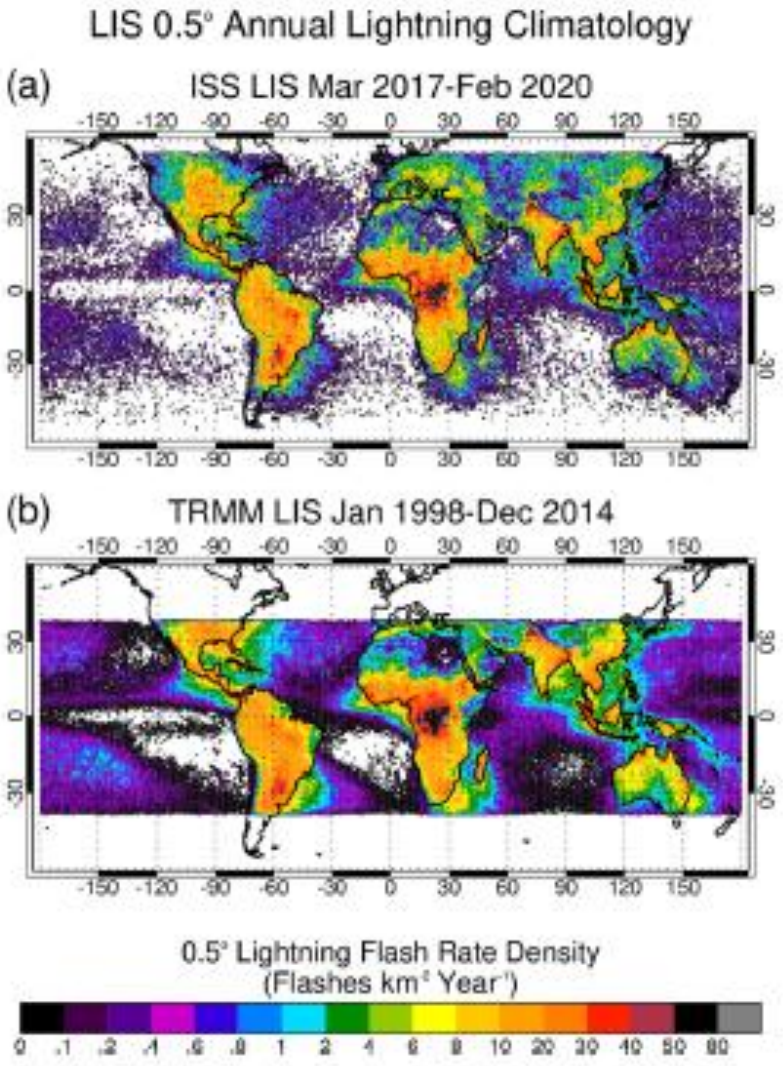
VLF and MF: Regional and Global (Regional networks exist in China, Russia, Europe, USA, New Zealand, and other countries, each covering important areas)

Global VLF: WWLLN, ENGLN and GLD360 - data available in real time for whole globe (back to 2004)

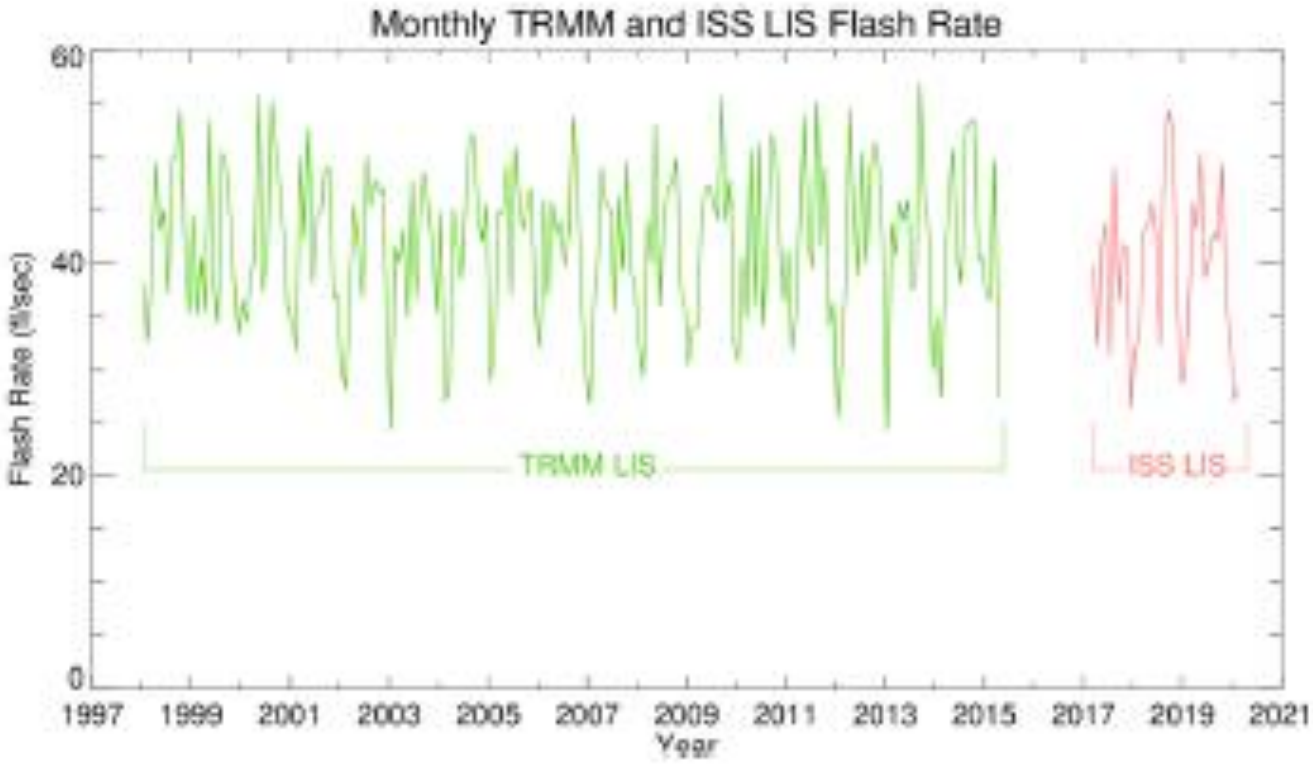


WWLLN lightning strokes accumulated for the years 2008–2017 (strokes per year per square kilometer on a 0.1° × 0.1°). Aich et al., EOS, 7 September 2018

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)

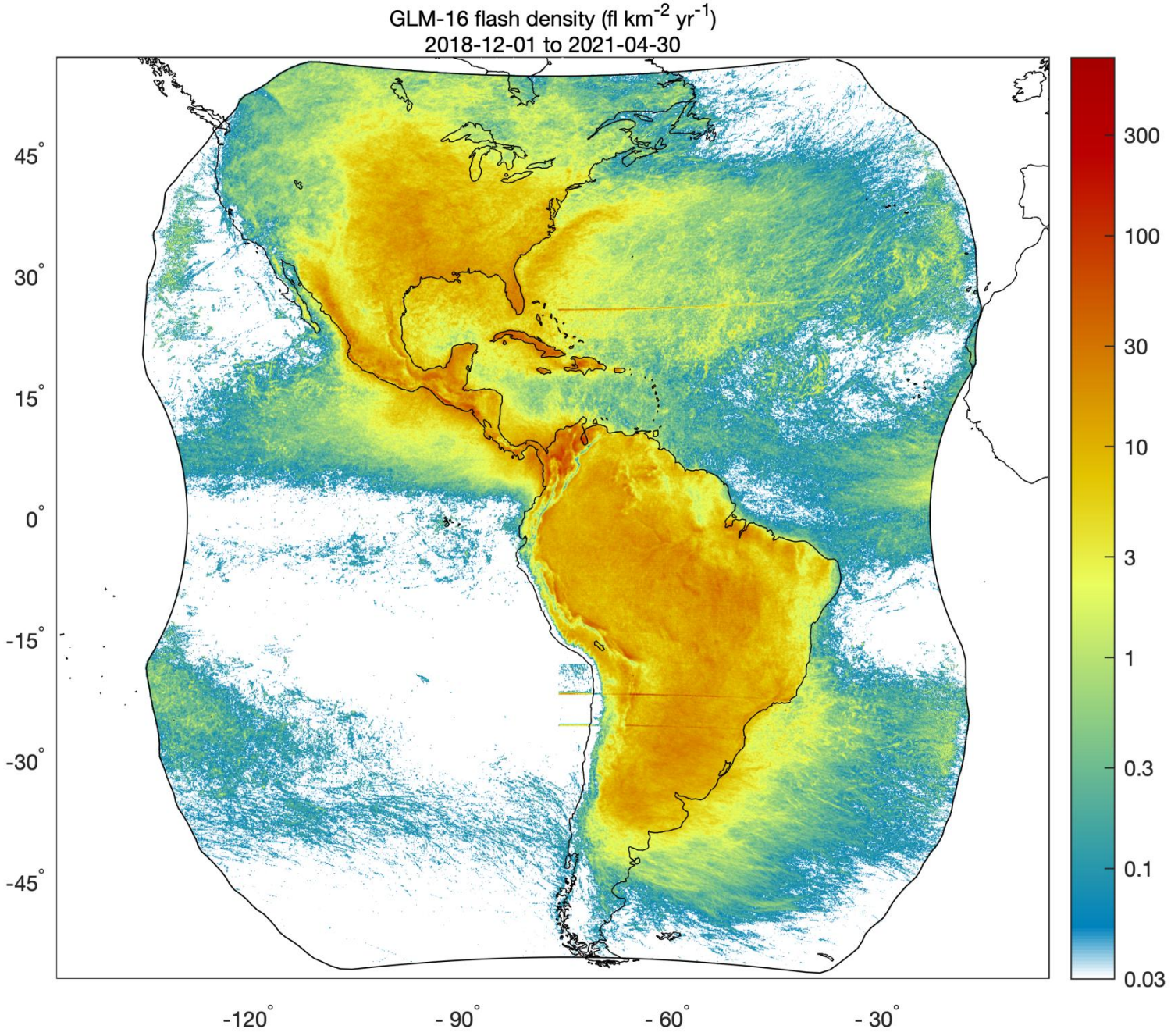
TRMM-LIS Global Climatology (16 years – 1998-2013, 0.1 x 0.1 deg grid)

Table 1. Continued.

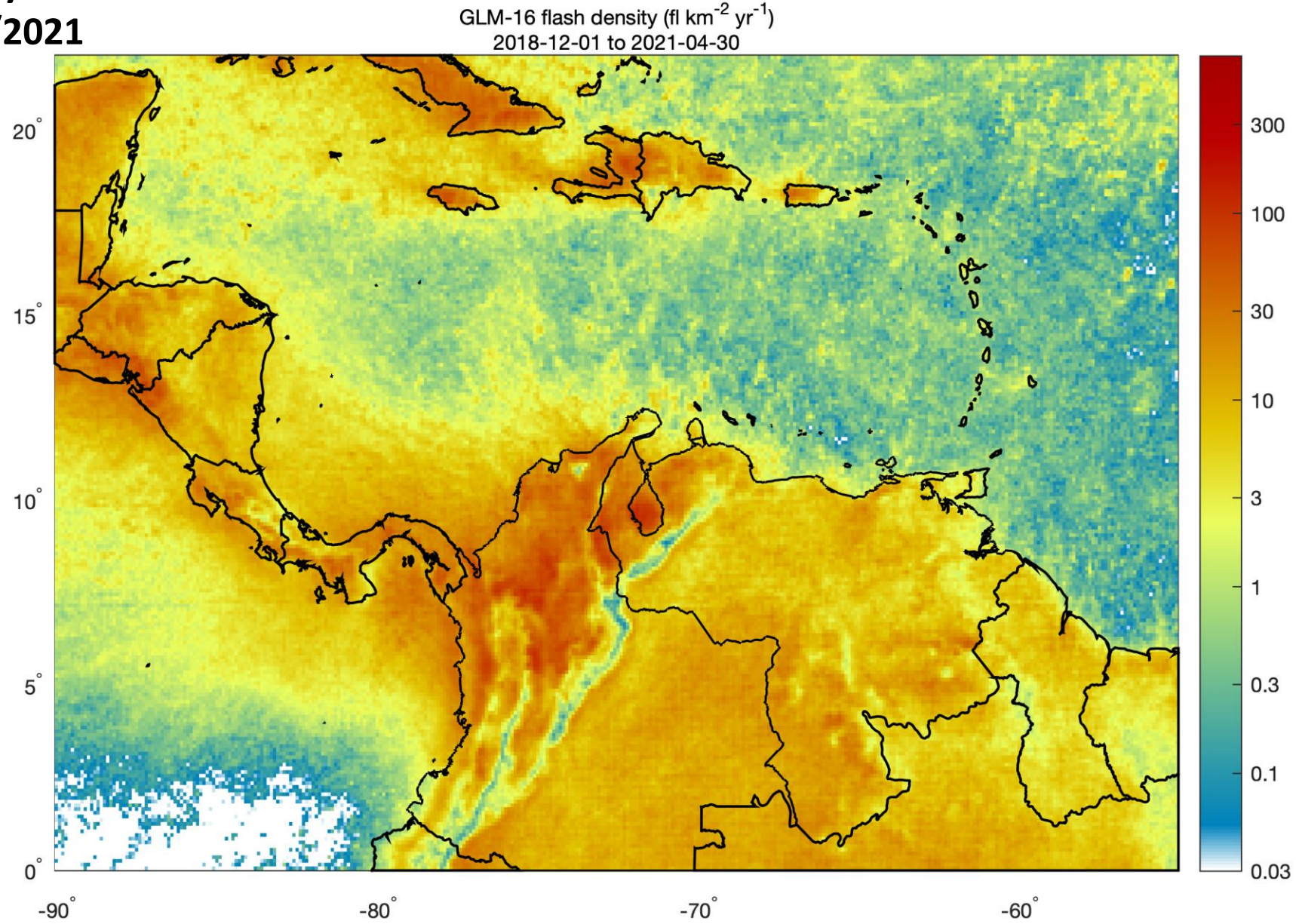
Global rank	FRD	Lat (°)	Lon (°)	PPL	Country	PPL lat (°)	PPL lon (°)	Dist (km)
North America								
17	116.76	14.35	–91.15	Patulul	Guatemala	14.42	–91.17	7.6
29	103.23	14.85	–92.05	Catarina	Guatemala	14.85	–92.08	2.8
33	100.63	22.35	–83.95	San Luis	Cuba	22.29	–83.77	20.1
34	100.24	18.55	–74.35	Chambellan	Haiti	18.57	–74.32	4.0
37	99.39	13.15	–87.25	San Jerónimo	Honduras	13.18	–87.14	12.7
39	98.22	22.35	–80.65	Rodas	Cuba	22.34	–80.56	9.8
40	98.06	21.75	–78.85	Venezuela	Cuba	21.74	–78.80	5.8
47	95.32	22.85	–82.15	Mañalich	Cuba	22.81	–82.15	4.3
82	86.96	22.25	–105.25	Rosamorada	Mexico	22.12	–105.21	14.9
90	85.78	18.15	–77.65	Balaclava	Jamaica	18.17	–77.64	2.6

Top 10 FRD (fl km^{-2} yr^{-1}) for each continental landmass, its position in the global ranking, latitude (Lat) and longitude (Lon) position on TRMM LIS 0.1° climatology grid, the name of the nearest populated place name (PPL), position (PPL lat, PPL lon), and distance from grid point (Dist), according to the GeoNames database (Albrecht et al., BAMS, 2016).

GLM Flash Density
12/01/2018 – 04/30/2021
(0.1 x 0.1 deg grid)

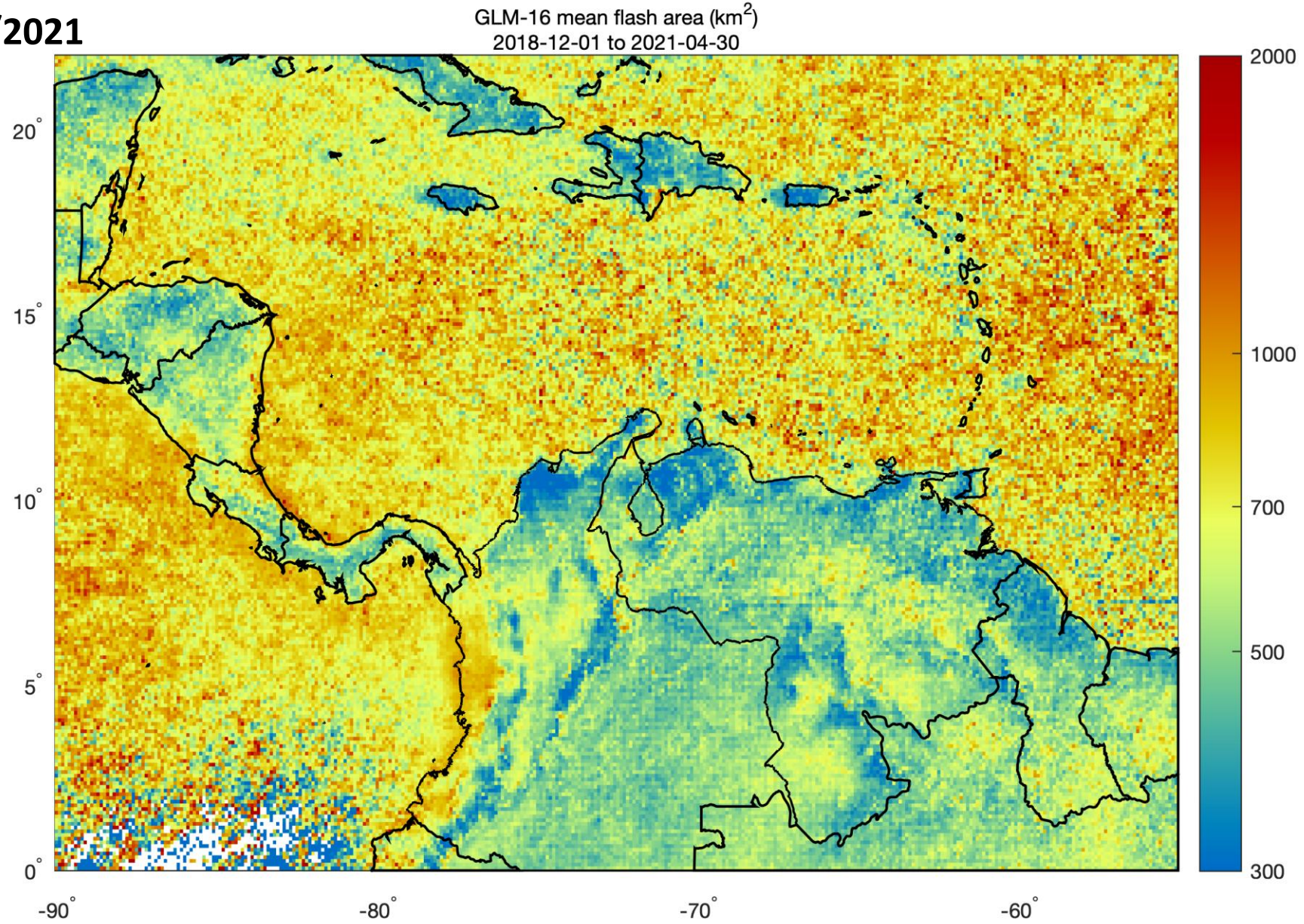


GLM Flash Density
12/01/2018 – 04/30/2021

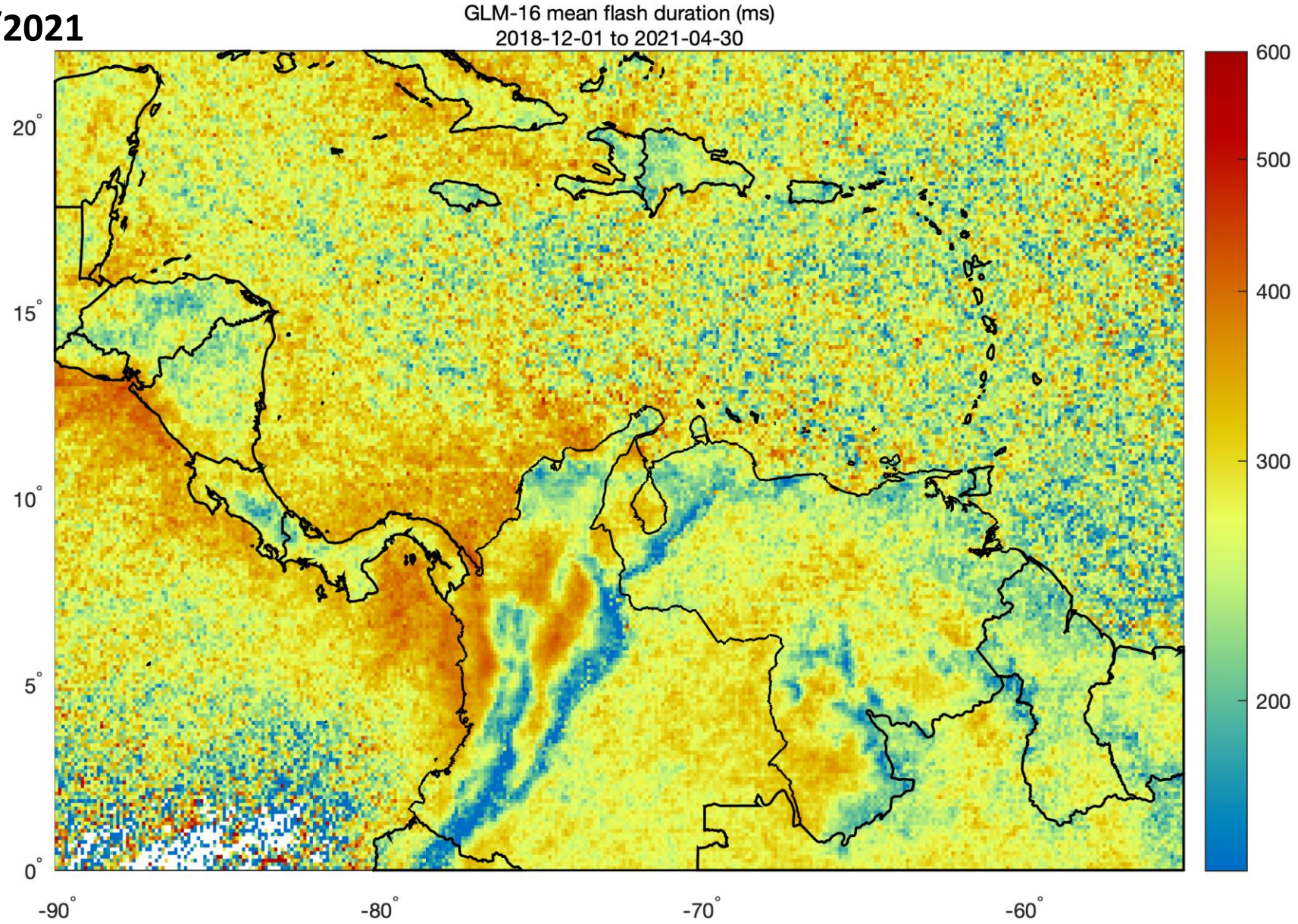


	Peak Lightning Density	
Country	ENGLN	GLM16
Anguilla	0.35	1.02
Antigua and Barbuda	0.50	0.75
Barbados	0.58	2.66
Belize	92.29	47.16
British Virgin Islands	0.85	1.73
Cayman Islands	6.12	7.10
Dominica	0.82	1.76
Grenada	0.52	0.71
Guyana	3.38	25.57
Jamaica	36.99	61.30
Montserrat	1.10	1.25
Saint Kitts and Nevis	0.75	2.73
Saint Lucia	0.45	1.45
Saint Vincent and the Grenadines	0.78	2.14
Trinidad and Tobago	1.03	5.76
Turks and Caicos Islands	4.63	3.55

GLM Mean Flash Area
12/01/2018 – 04/30/2021



GLM Mean Flash Duration
12/01/2018 – 04/30/2021



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

- On-going - Develop exemplary data set for evaluation
- Non-government lightning data – commercial providers are interested in cooperating in producing ECV data sets.
- ENTLN developed a “Thunder Hour” data set (DiGiangi et al, BAMS, 2021 in revision).
- Vaisala developing a GLD360 VLF global lightning data set for further discussion of attributes (time, location, peak current, DE, and formats (e.g., netCDF).

4. Reprocessing of Existing Data

- Reprocess ISS-LIS and GLM to the same temporal resolution of GLD360.
- Note: NOAA/GOES-R has no budget for GLM reprocessing; initiated discussions with GOES-R Program.
- 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.
- How might lightning ECV archive 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

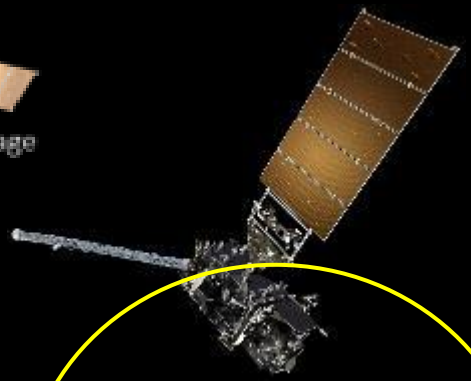
- Thunder Day Database - data can extend lightning climatology well back into the 20th century (e.g., LaVigne, Liu, and Liu, JGR Special Collection 2019 – Thunder days correlated with TRMM LIS)

  Lavigne, Thomas et al., 2019. "How does the Trend in Thunder-days relate to the variation of lightning flash density," https://doi.org/10.1029/2018JD029920

- 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?

Recommended GEO-XO Constellation

(Preliminary, pending program approval)



GEO-West
Vis/IR Imager
Lightning Mapper
Ocean Color
Solar UV Imager*
Irradiance Monitor*
Coronagraph*
Particle Detectors*
Magnetometer*

GEO-Central
Hyperspectral IR Sounder
Atmospheric Composition
Partner Payload

GEO-East
Vis/IR Imager
Lightning Mapper
Ocean Color
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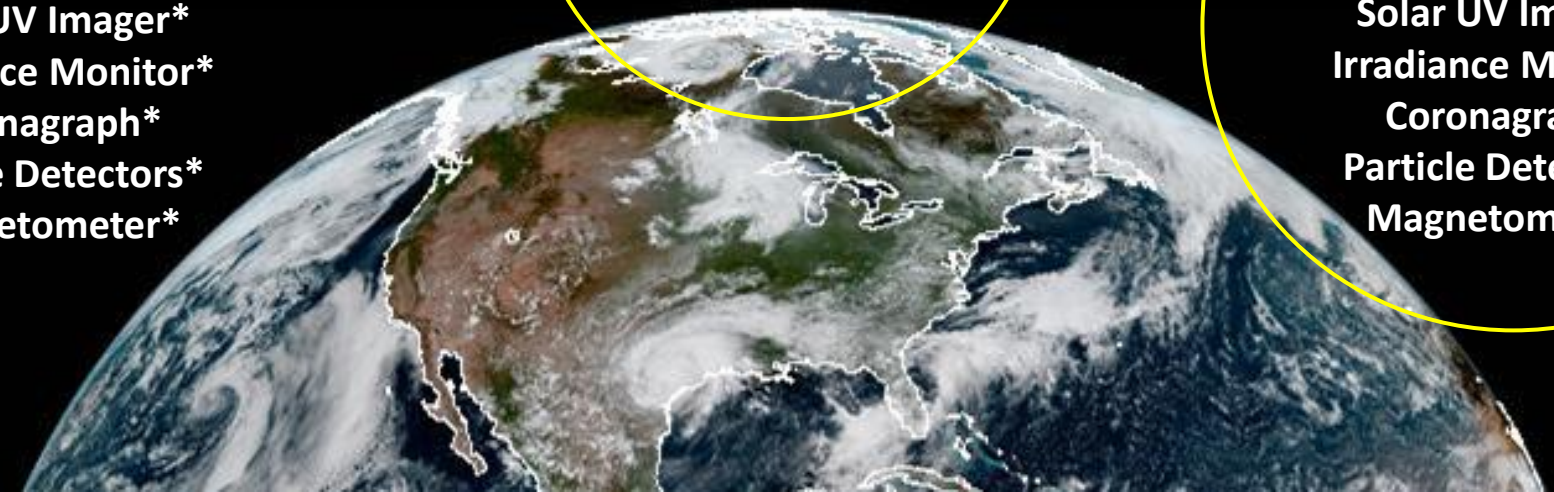
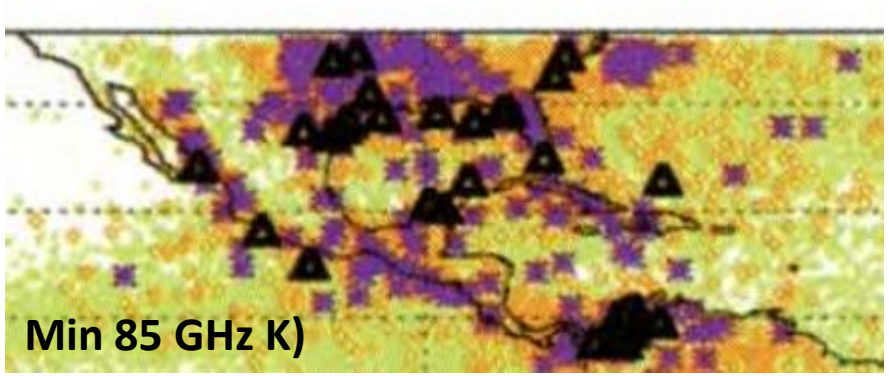
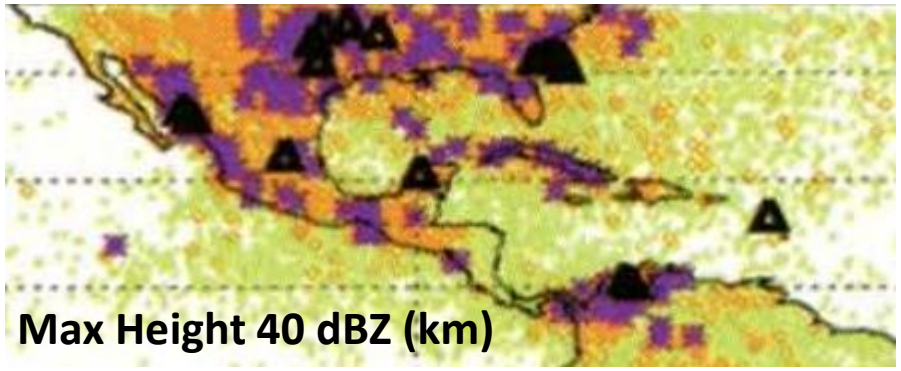
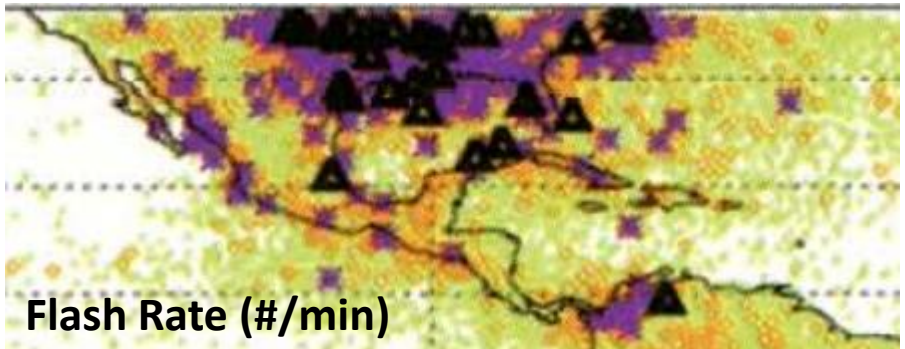


**Solar and In-Situ instruments provided by Space Weather Program under separate initiative*

Zipser, E. J., , C. Liu, , D. J. Cecil, , S. W. Nesbitt, , and D. P. Yorty, 2006: **Where are the most intense thunderstorms on Earth?**, *Bull. Amer. Meteor. Soc.*, **87**, 1057–1071, doi:10.1175/BAMS-87-8-1057.







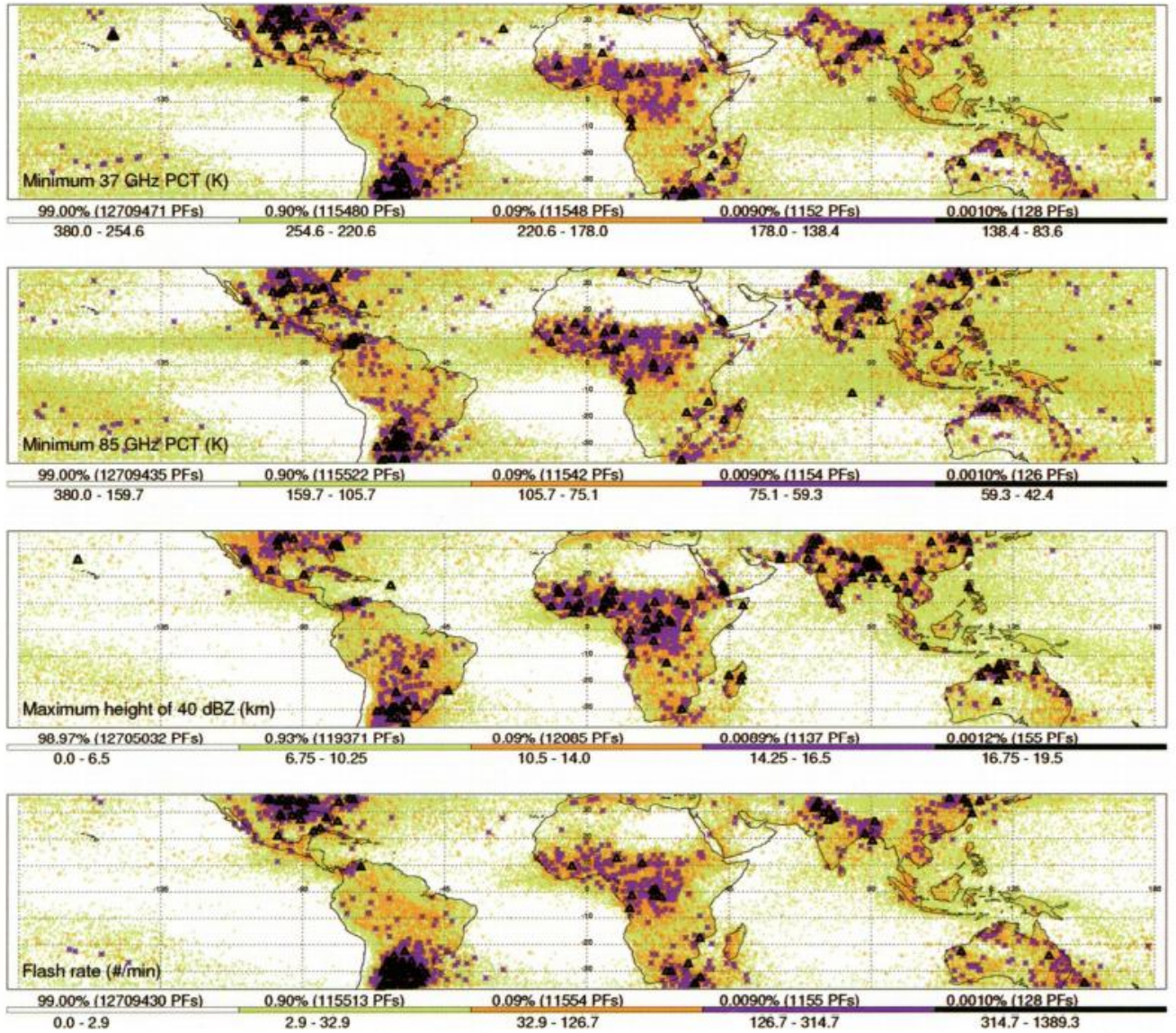
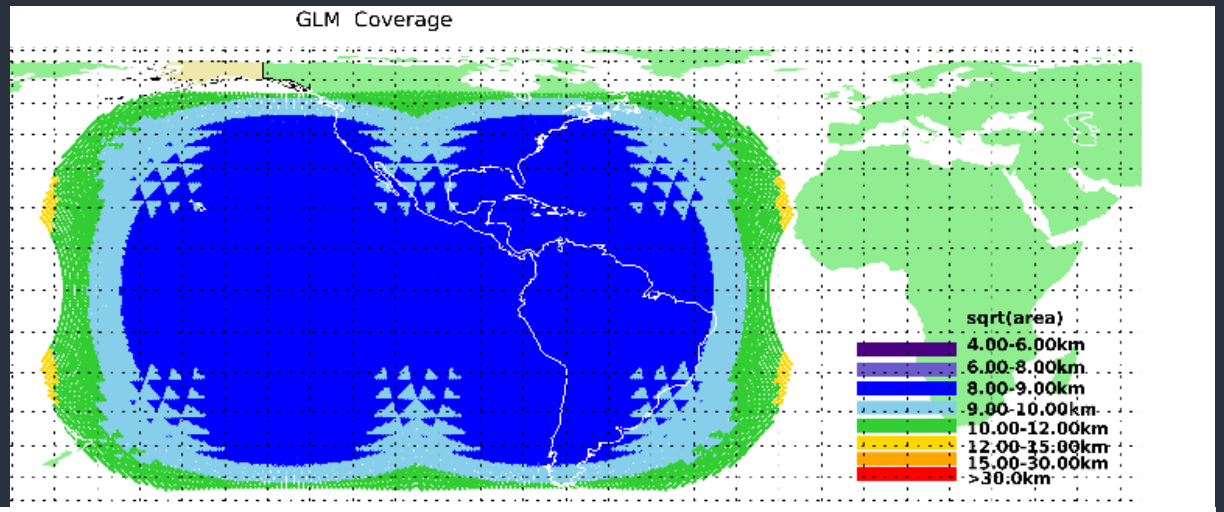


FIG. 3. Locations of intense convective events using the color code matching their rarity. The parameter limits for each category are indicated above each color bar. For example, of the 12.8 million PFs, only about 0.001% (128) have more than 314.7 lightning flashes per minute. The exact percentages for the break points are slightly different from the 40-dBZ echo-top figure because radar data are reported in discrete increments of 250 m.

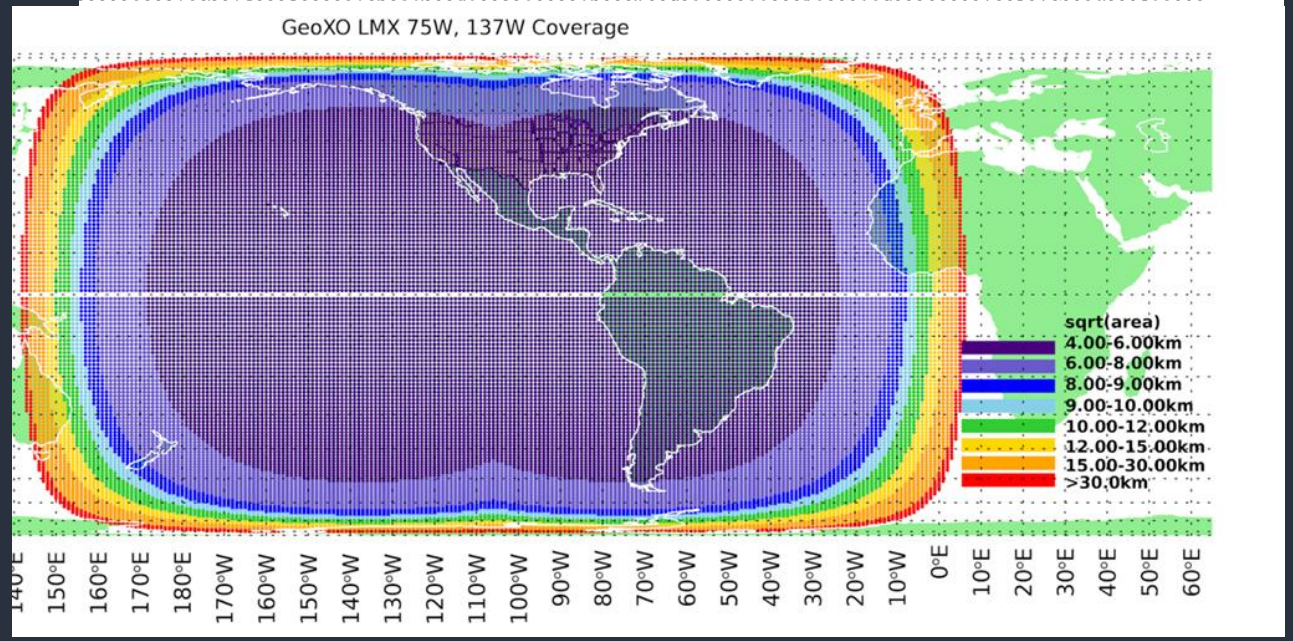
Lightning Mapper Performance

	GLM Legacy	LMX Baseline
Coverage Area	Lightning Full Disk CONUS	Full Disk CONUS plus northern latitudes
Spatial Resolution @ nadir	8 km	4 km
Frame Time	500 Hz	500 to 1000 Hz
Signal to Noise Ratio	4	> 4
Event detection	>70% flashes	>70% events
False alarms	<5% flashes	<5% events

2 GOES-R GLMs at 137W and 75W



2 GEO-XO LMs at 137W and 75W



6. Summary

- Identify providers offering to prepare an exemplary dataset (satellite - NASA, RF – Earth Networks, 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