Overview of Lightning Science at NASA Marshall Space Flight Center

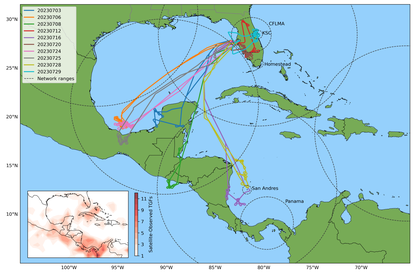
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Earth Science Branch (ST11)

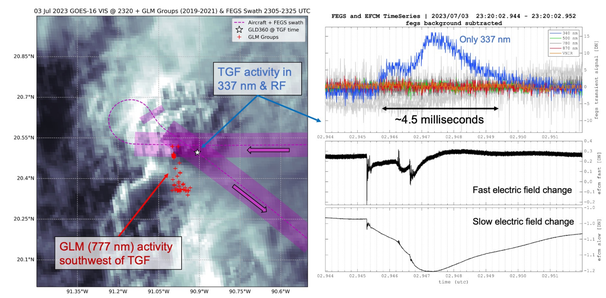
Overview

NASA Marshall Space Flight Center (MSFC) is a recognized world leader in the science of lightning. To date, MSFC has led three space-based global lightning observing missions and has helped lead multiple suborbital field campaigns involving lightning observations. Recently, the MSFC Lightning Team is closing out the recently completed International Space Station Lightning Imaging Sensor (ISS LIS) mission, including developing a nearly three-decade global climatology of lightning from space. This work also includes integrating lightning observations with data from NASA precipitation missions. The Team is also busy analyzing data from a recent airborne field campaign that observed dozens of terrestrial gamma-ray flashes (TGFs) from intense tropical thunderstorms. Lightning Team members are also leaders in validation of the Geostationary Lightning Mapper (GLM) operated by NOAA, and in developing lightning safety applications and studying the relationship between lightning and wildfires. The Lightning Team also studies chemical production by lightning and contributes to the National Climate Assessment (NCA). Finally, the Lightning Team is busy developing the next generation of spaceborne lightning sensors to broaden our understanding of the relationships between lightning, weather, climate, and atmospheric composition.

Studying Thunderstorms from Aircraft

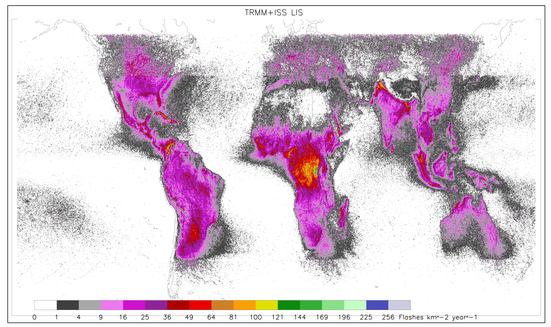
- ALOFT campaign in July 2023 flew the NASA ER-2 over tropical thunderstorms with lightning, microwave, and gamma-ray sensors
- Collaboration with University of Bergen and other institutions
- Discovered new kinds of TGFs, documented utility of multispectral lightning observations, and helped validate spaceborne lightning sensors



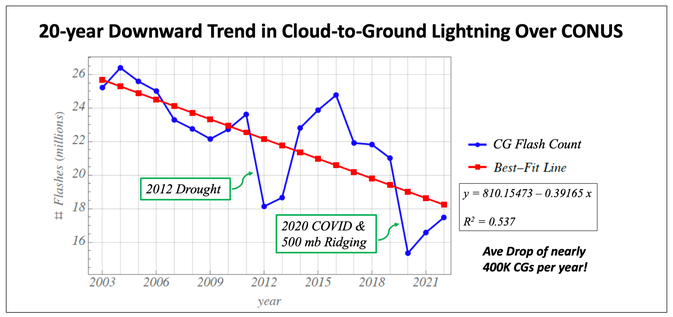


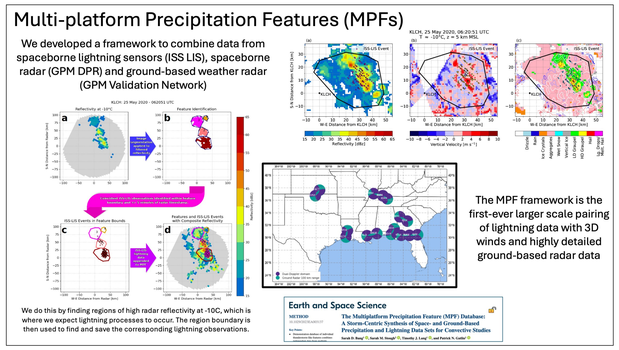
Lightning and the Earth System

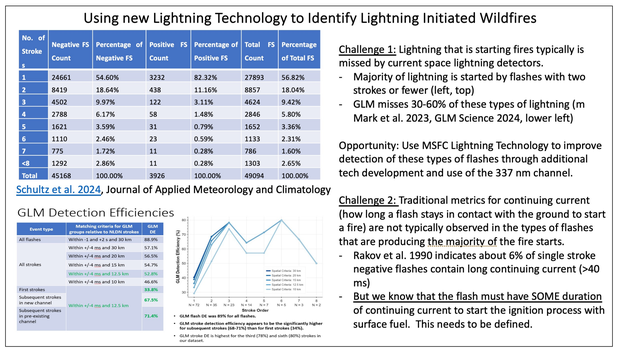
- ISS LIS observations are being combined with older missions to provide a multi-decadal record of global lightning from space.
- MSFC also studies how lightning interacts with the broader Earth system, including climate, precipitation, and wildfires



Global lightning climatology at 0.1-deg resolution





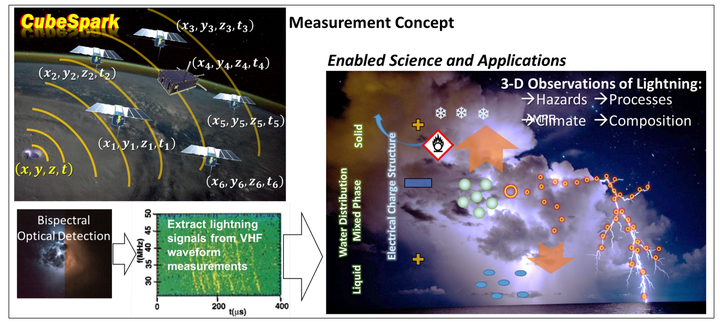


No. of Stroke s	Negative FS Count	Percentage of Negative FS	Positive FS Count	Percentage of Positive FS	Total FS Count	Percentage of Total FS
1	24661	54.60%	3232	82.32%	27893	56.82%
2	8419	18.64%	438	11.16%	8857	18.04%
3	4502	9.97%	122	3.11%	4624	9.42%
4	2788	6.17%	58	1.48%	2846	5.80%
5	1621	3.59%	31	0.79%	1652	3.36%
6	1110	2.46%	23	0.59%	1133	2.31%
7	775	1.72%	11	0.28%	786	1.60%
>8	1292	2.86%	11	0.28%	1303	2.65%
Total	45168	100.00%	3926	100.00%	49094	100.00%

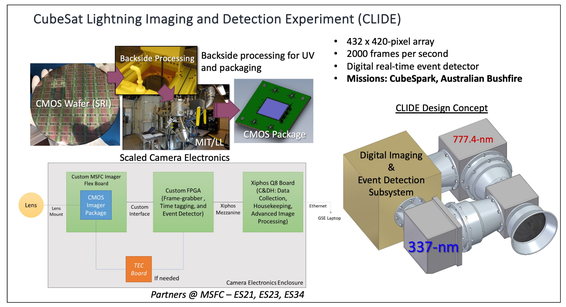
Event type	Matching criteria for GLM groups relative to NLDN strokes	GLM DE
All flashes	Within -1 and +2 s and 30 km	88.9%
All strokes	Within +/-4 ms and 30 km	57.1%
	Within +/-4 ms and 20 km	56.5%
	Within +/-4 ms and 15 km	54.7%
	Within +/-4 ms and 12.5 km	52.9%
	Within +/-4 ms and 10 km	46.6%
First strokes		33.8%
Subsequent strokes in new ground flashes	Within +/-4 ms and 12.5 km	67.3%
Subsequent strokes in pre-existing channel		71.4%

- GLM flash DE was 85% for all flashes.
- GLM stroke detection efficiency appears to be the significantly higher for subsequent strokes (68-71%) than for first strokes (34%).
- GLM stroke DE is highest for the third (78%) and sixth (80%) strokes in our dataset.

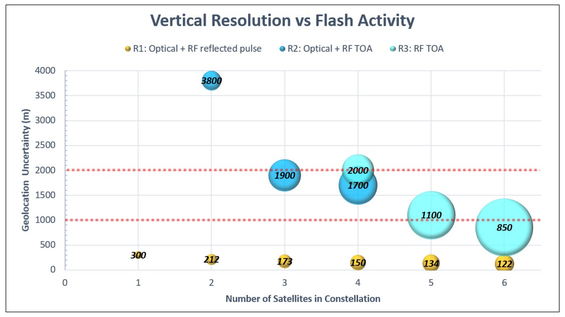
Next Generation Lightning Mission



- The CubeSpark mission concept is a collaboration between MSFC and Los Alamos National Lab
- Combined bispectral optical and VHF measurements from space
- MSFC is building optical sensor (CLIDE)
- Combined optical and VHF can retrieve lightning flash altitude, a new spaceborne measurement with many applications



- 432 x 420-pixel array
- 2000 frames per second
- Digital real-time event detector
- **Missions: CubeSpark, Australian Bushfire**



Major Points

- Lightning is an important component of the Earth system that interacts with weather, climate, and processes beyond Earth's troposphere.
- MSFC is a world leader in lightning research and lightning observations from space.
- MSFC is helping develop the next generation lightning sensor for low-Earth orbit (CubeSpark).
- MSFC also does airborne field campaigns to make new discoveries about lightning and test new measurement technologies.