



Using Optical Lightning Detection Data from the 2017 GOES-R Post Launch Test Field Campaign Flights as an Evaluation of Convective Processes

Kaitlyn Wheeler¹, Sarah M. Stough^{2,3}, Mason Quick⁴, T. Daniel Walker⁵

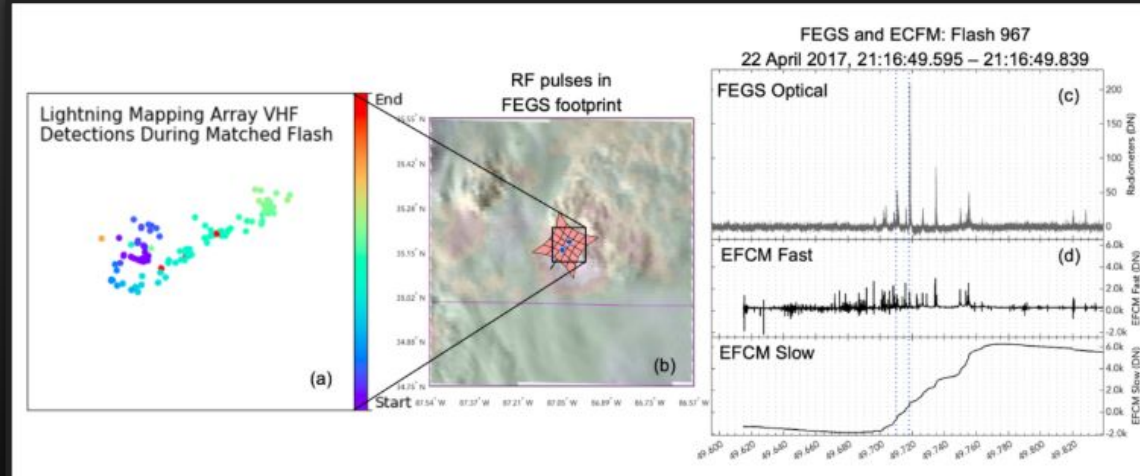
¹Department of Atmospheric and Earth Science, University of Alabama Huntsville, ²Cooperative Institute for Severe and High-Impact Weather Research and Operations, University of Oklahoma, ³NOAA/OAR National Severe Storms Laboratory, ⁴NASA Marshall Space Flight Center, ⁵Earth System Science Center, University of Alabama in Huntsville

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Project Goals

“Linking convective processes and satellite lightning measurements: New insights from modern analysis of cloud, precipitation, and lightning data collected during 2017 NASA ER-2 field campaign flights”

- a) Investigate how attributes of convection impact optical lightning signatures
- b) Derive assumptions about optical lightning measurements that can be made regarding convective dynamics and precipitation microphysics



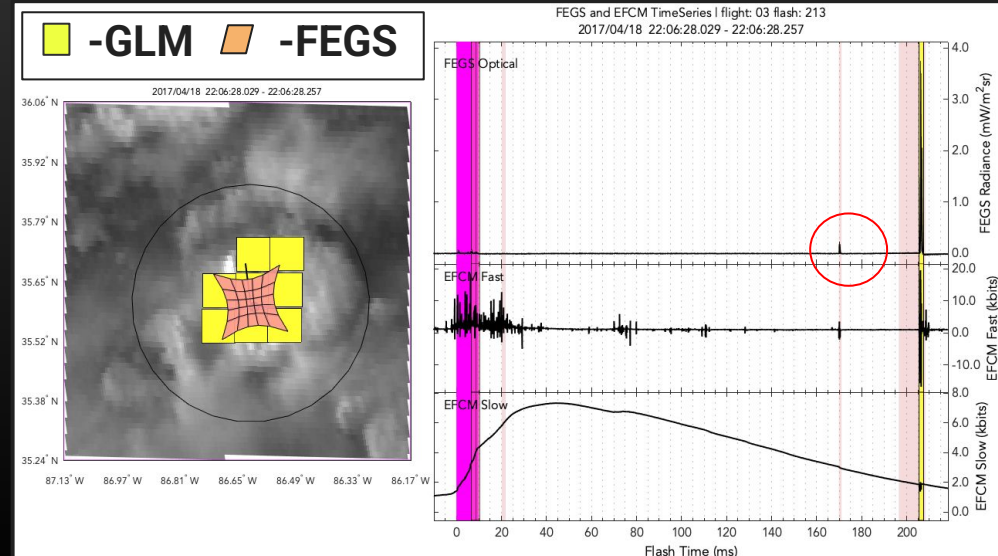
How are optical lightning observations modulated by the cloud depth?

And how does convective state impact optical lightning observations?

Furthering the Application of Optical Lightning Detection

- Known relationships between lightning properties and deep convective processes were established with radio measurements from ground-based instruments.
- Therefore, inferences regarding convective intensity cannot directly translate directly to optical observations without further study

NASA ER-2 aircraft was outfitted with numerous instruments, including the Fly's Eye GLM Simulator (FEGS), allowing detailed characterization of lightning processes

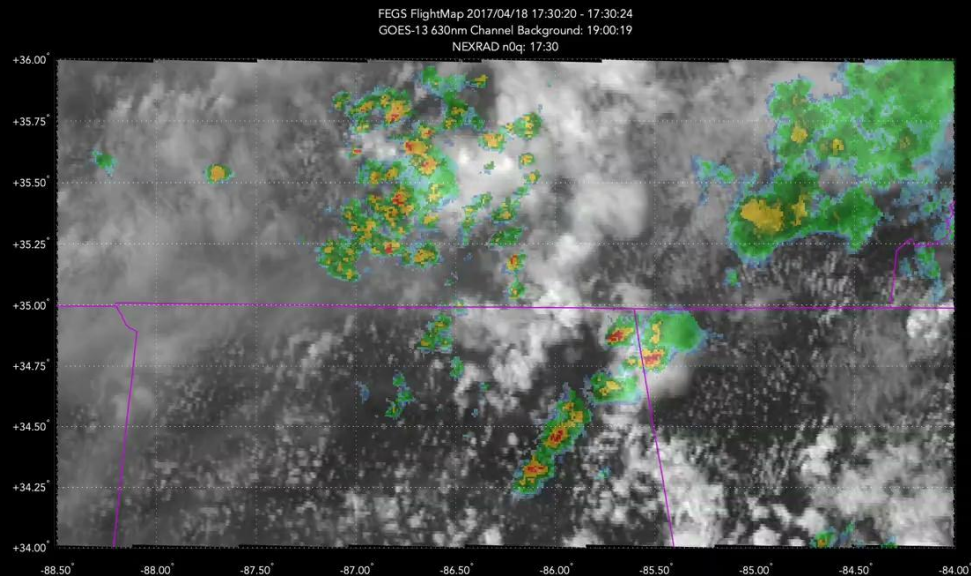


What is the Fly's Eye GLM Simulator?

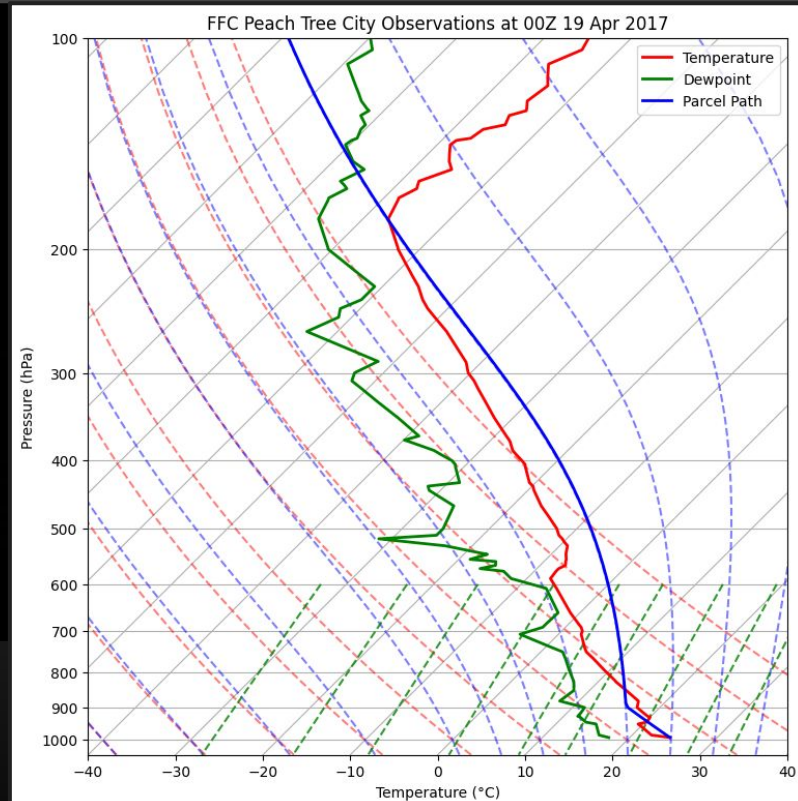
- Designed for the validation of the Geostationary Lightning Mapper (GLM)
- Flies aboard NASA's ER-2 aircraft
- Measures the optical radiance emitted by lightning with 25 radiometers in main array

Relevant FEGs Parameters	Description
Peak Radiance of Flash [W/m ² Sr]	Peak radiance of the most luminous optical pulse in the flash
Integrated Radiant Energy of Flash [J/m ² Sr]	Sum of radiant energy of all pulses in the flashes
Duration (ms)	Length of flash; fraction of a second, calculated from the subsecond start and end times
Max Pixels	Maximum number of pixels out of 25 illuminated during the flash
FOV Lat & Lon 1-4	GPS coordinates that form 4-point polygon outlining field of view around flash

Observations from North Alabama on 04-18-2017



- Weak shortwave with minimal synoptic forcing
- Isolated, no supercells
- Low lightning observations



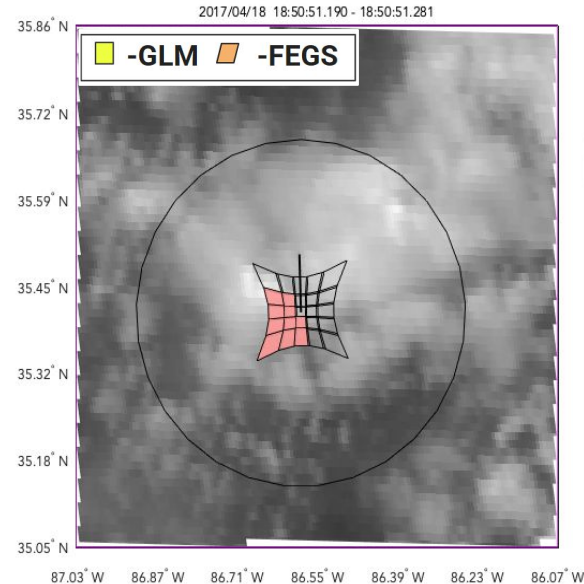
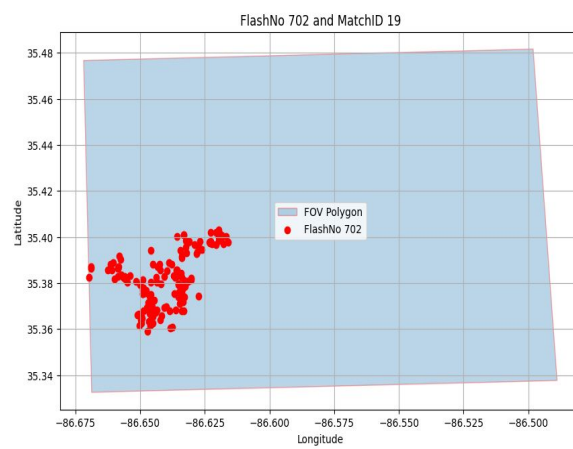
MUCAPE: 800-1000 J/kg
Bulk Shear:

Flash Comparison

- 222 matches between LMA and FEGS flashes based on time of occurrence and location
- Narrowed down to three well observed flashes
 - Overlap between LMA sources and FEGS FOV
 - Examples of different *altitudes, radiance, number of sources, spatial distribution.*
- Examined radar and hydrometeor properties related to propagating flash

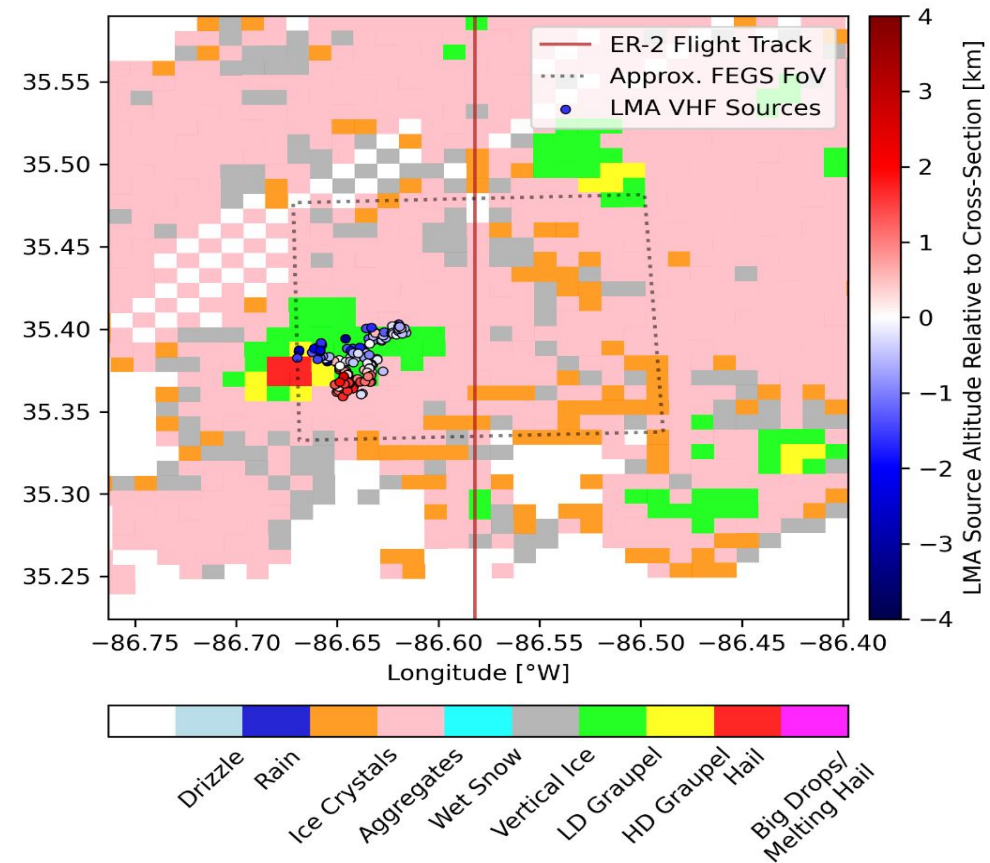
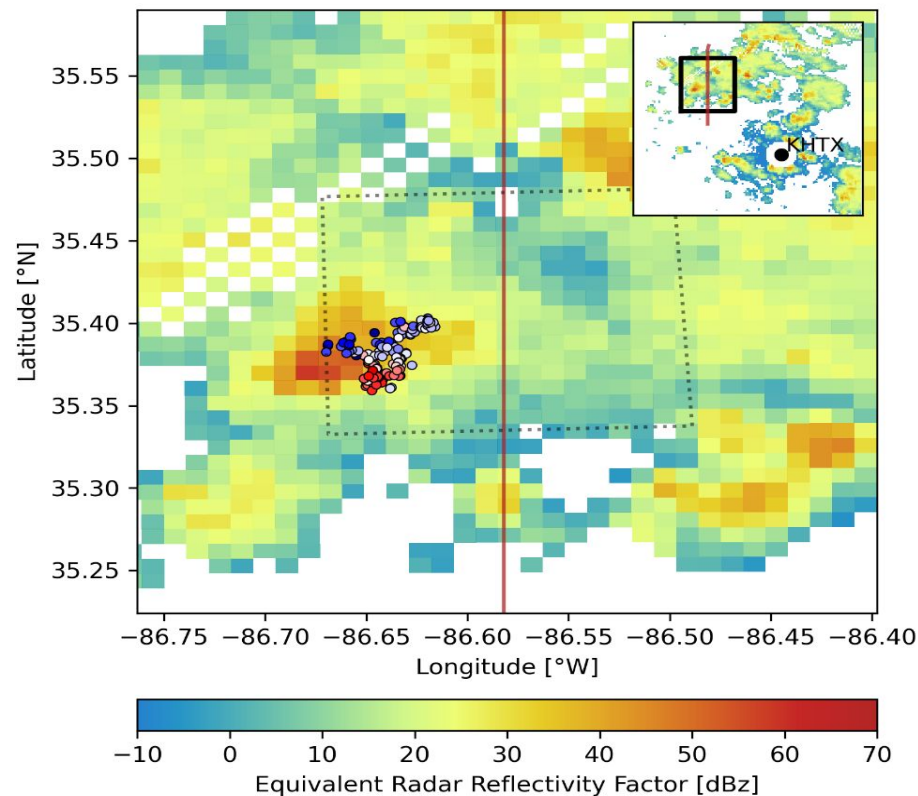
Flash #1

- Lowest radiance of three flashes
- Lowest median altitude in the atmosphere
- Shortest duration



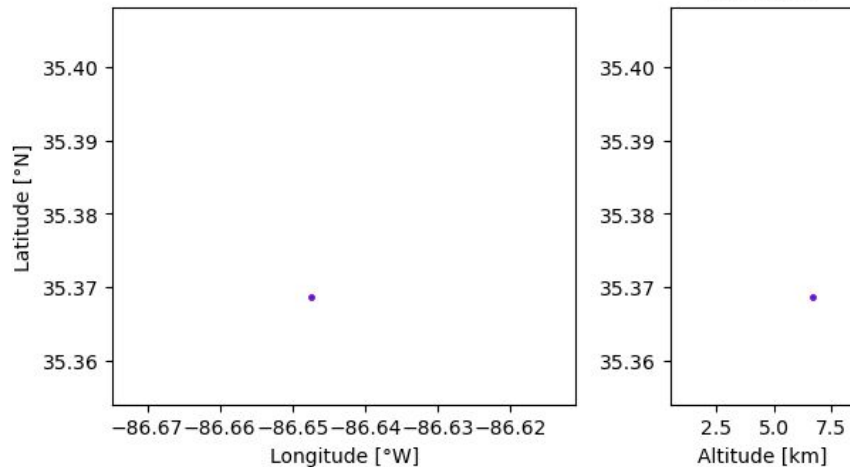
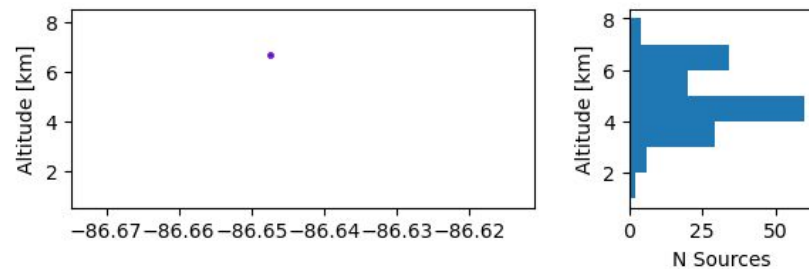
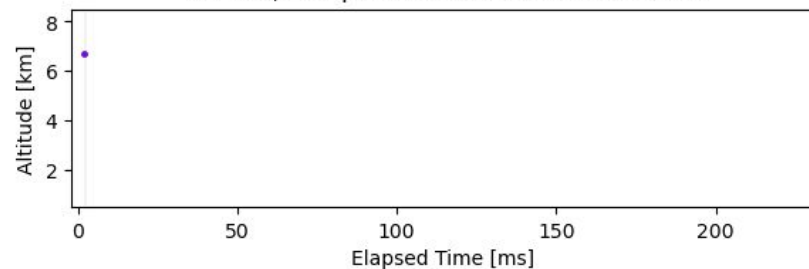
FEG S	Peak (W/m2 Sr)	Energy (J/m2 Sr)	Duration (ms)	Max FEGS Pixels
1	1.266e-3	1.364e-6	70.3	9
2	1.00012e-1	6.95379e-5	208.3	25
3	7.22e-3	5.45965e-5	929.5	25
LMA	Median Src Alt (km)	NSrcs	Duration (ms)	Area (km)
1	7.036 Depth: 8.3 km	155	288.7	13.69
2	9.242 Depth: 5.1km	123	282.2	20.04
3	7.204 Depth: 8.7	450	1004.5	268.08

18 Apr 2017 - KHTX - 18:48:22 UTC
z = 5 km

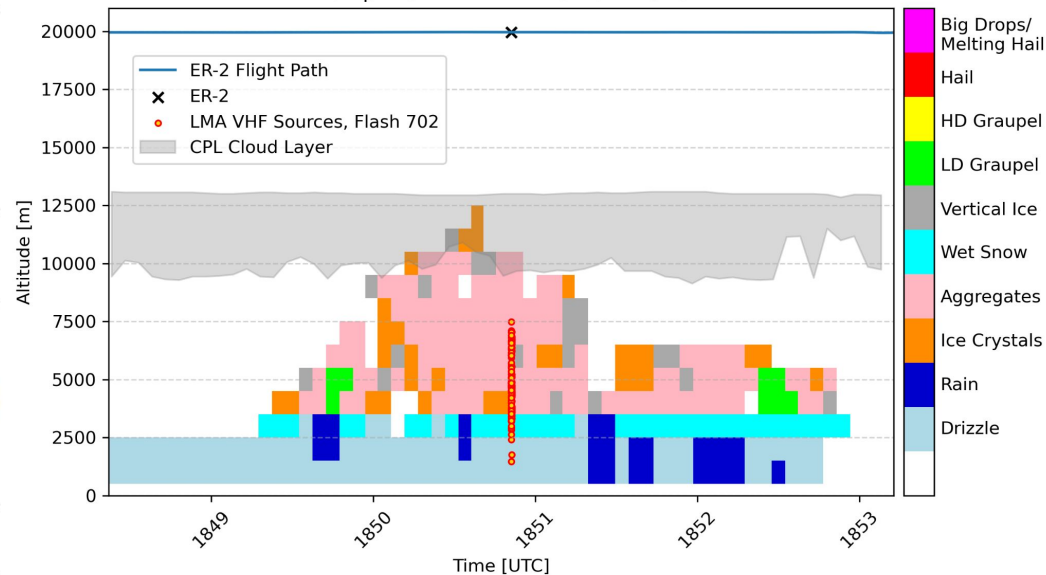


LMA sources grouped around reflectivity maxima and high concentrations of graupel - around the updraft

FL: 702, 18 Apr 2017 18:50:51.053381 UTC



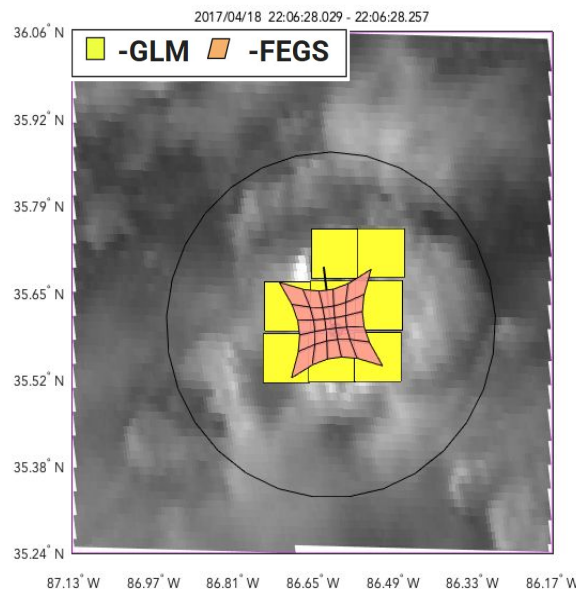
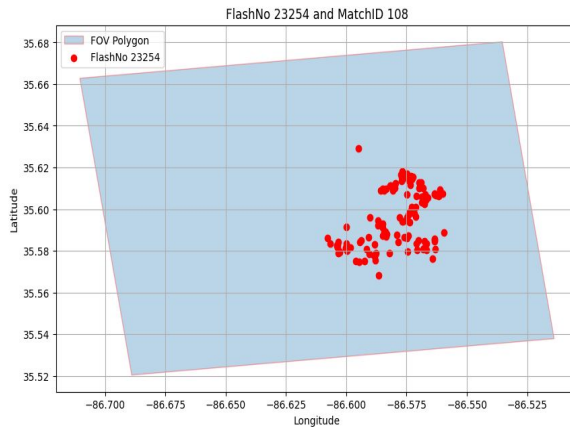
18 Apr 2017 - KHTX - 18:48:22 UTC



- All VHF sources at or below 7.5 km
- Lightning propagates almost exclusively through small hydrometeors, no graupel
- Recall - this flash has the **lowest** optical radiance measurements from these examples

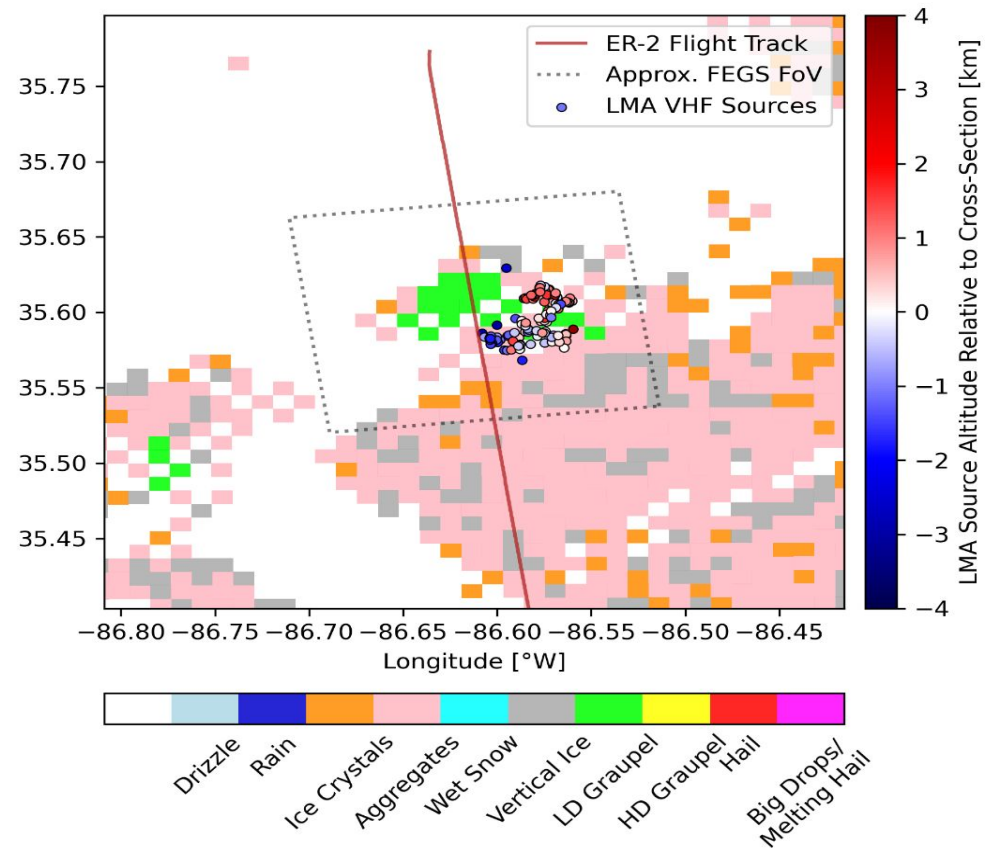
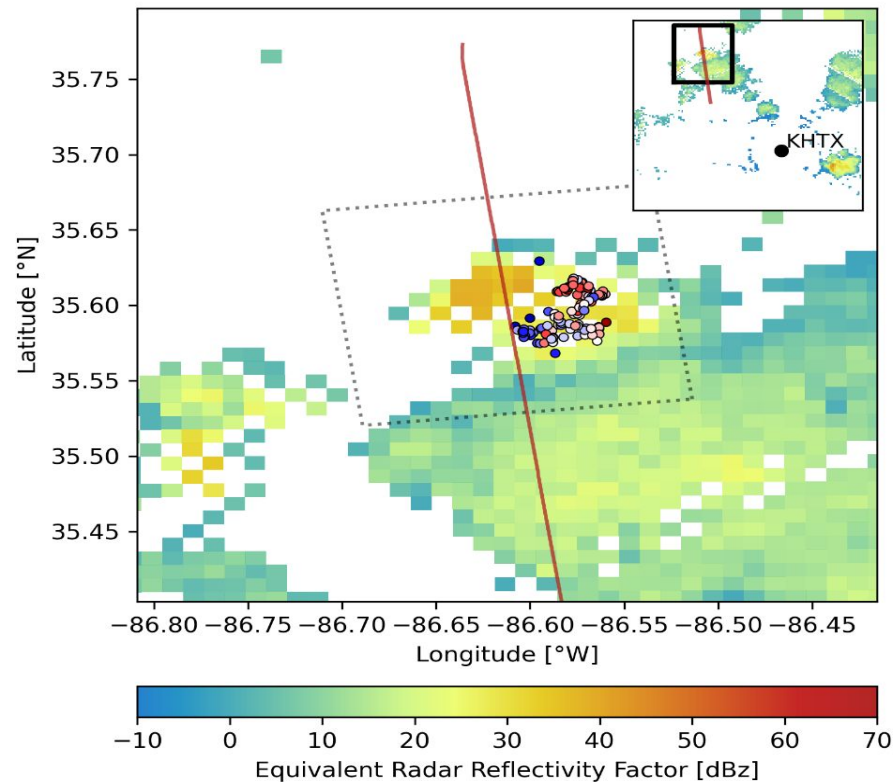
Flash #2

- Brightest peak pulse
- Illuminated all radiometers
- Highest in the atmosphere
- Similar size and amount of sources to Flash #1



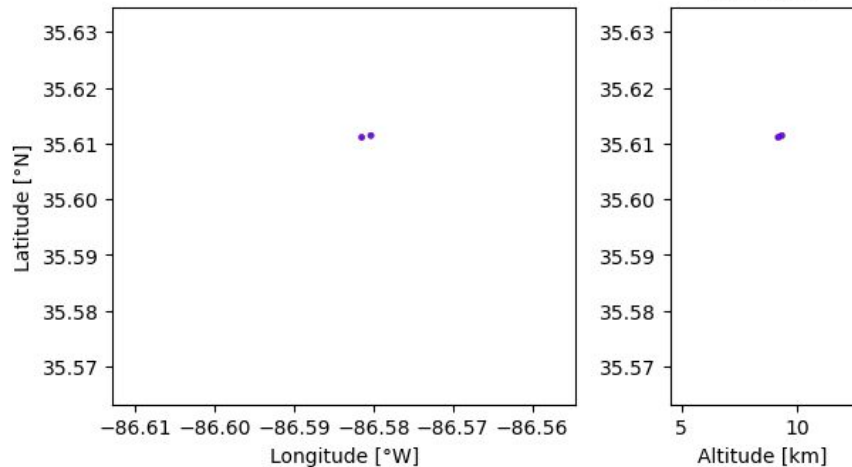
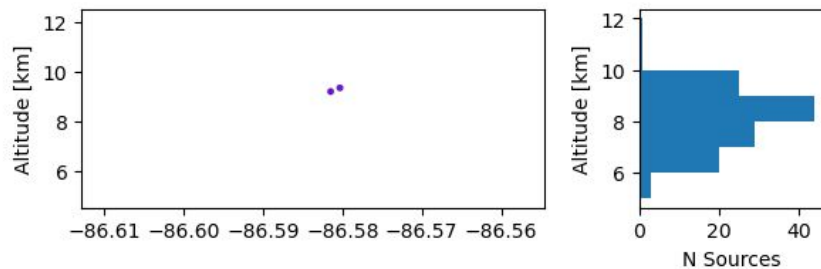
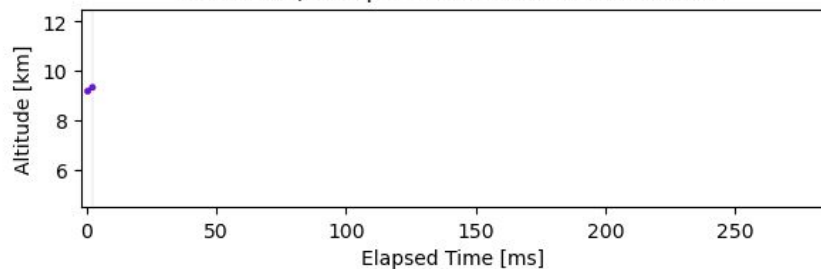
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18 Apr 2017 - KHTX - 22:03:15 UTC
z = 8 km

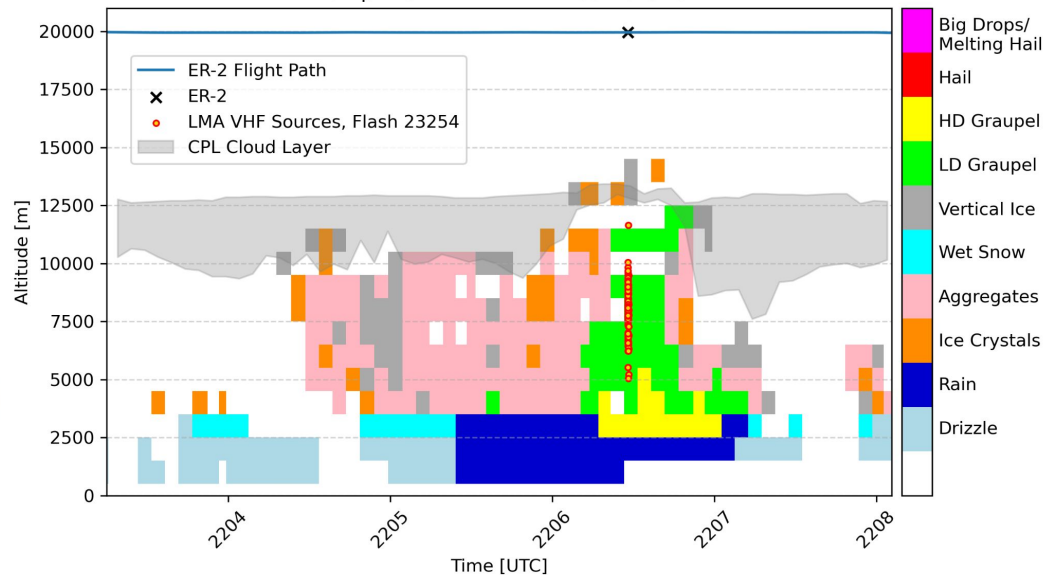


LMA sources grouped around reflectivity maxima and high concentrations of graupel - around the updraft

FL: 23254, 18 Apr 2017 22:06:27.973078 UTC



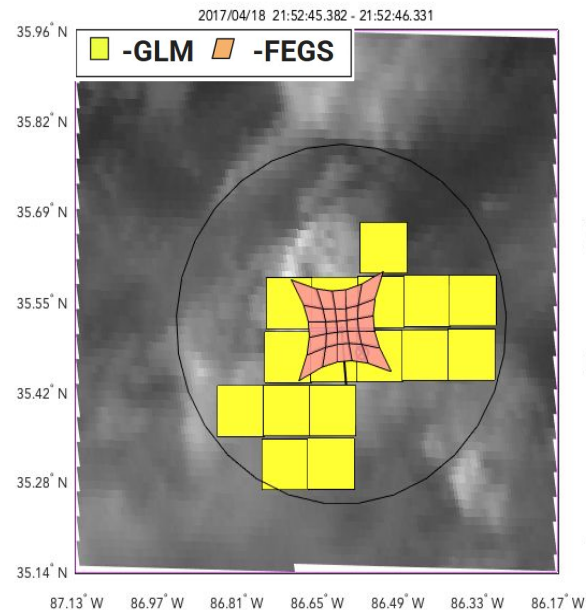
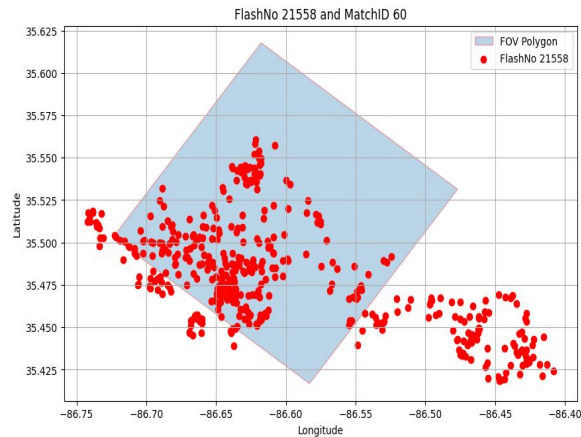
18 Apr 2017 - KHTX - 22:03:15 UTC



- Flash occurs highest in the atmosphere, with a majority of sources measured above 7.5 km
- Primarily larger hydrometeors - low density graupel
- ***Significantly more optical radiance detected than previous flash***

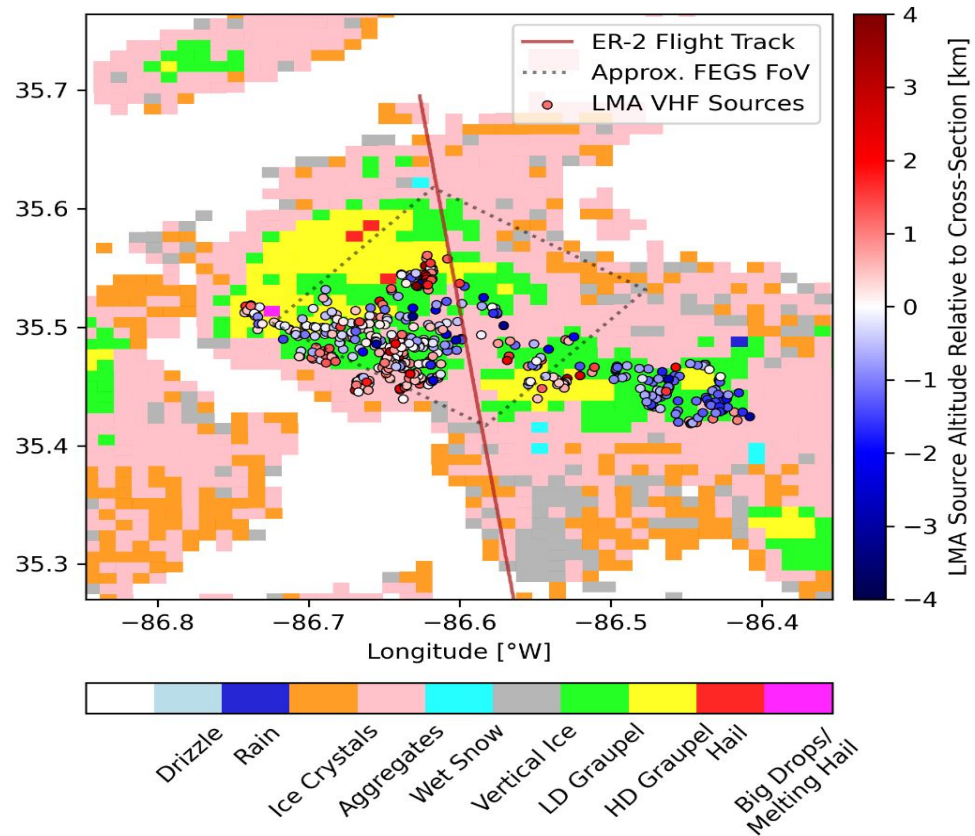
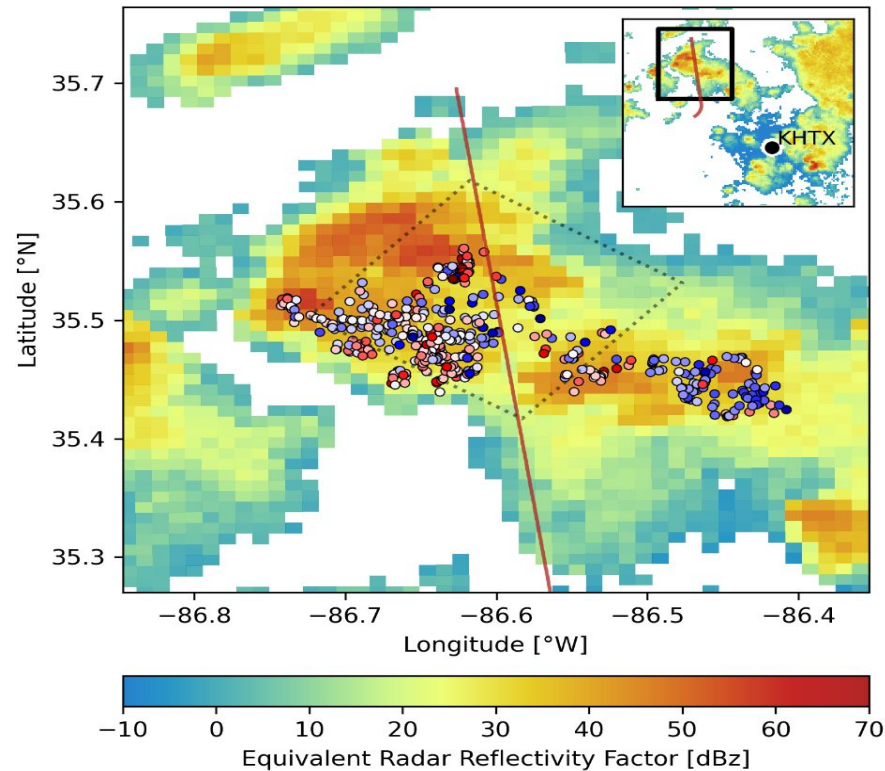
Flash #3

- Largest spatially, with most VHF sources
- Illuminated all radiometers
- Around same height as Flash #1 - though significantly brighter



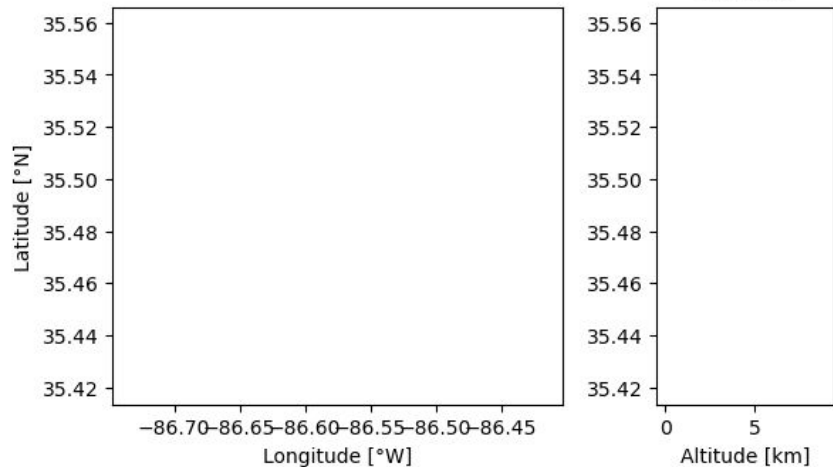
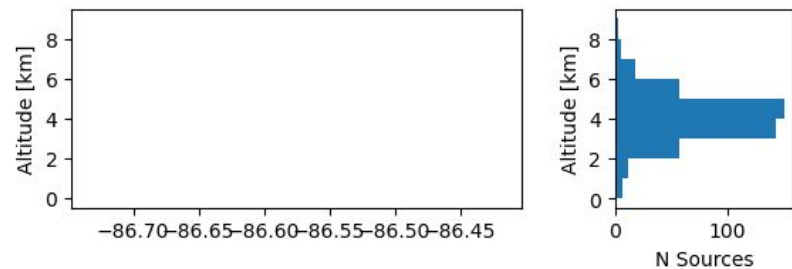
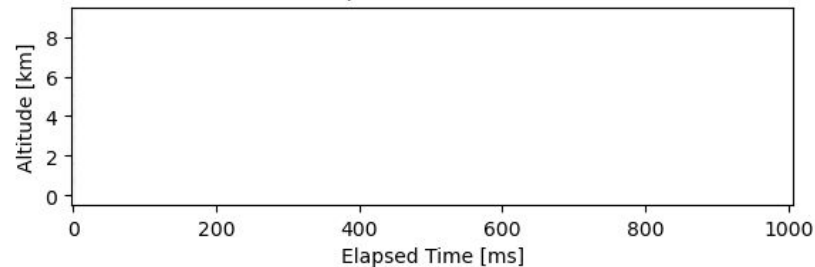
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18 Apr 2017 - KHTX - 21:51:12 UTC
z = 4 km

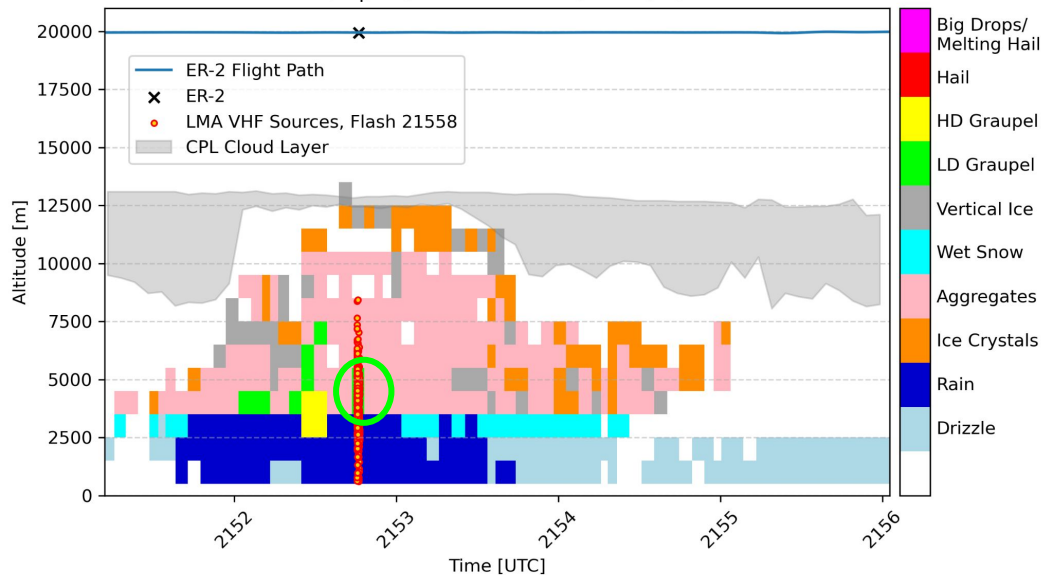


**Flash is interacting with multiple updraft
cores in multicell convection**

FL: 21558, 18 Apr 2017 21:52:45.348985 UTC



18 Apr 2017 - KHTX - 21:51:12 UTC



- Similar to Flash #1, a majority of LMA sources are at or below 7.5 km
- Primary hydrometeor type - aggregates, though lightning propagates through LD graupel in circled area
- ***Less radiance than #2, more than #1***

Summary of Current Results

- Presented a combined analysis on three flashes using LMA and FEGS properties
- Found examples of how different microphysical characteristics and lightning properties affect the FEGS optical observations

Plans for Continuing this Work

- Expand this analysis to a greater magnitude of flashes in a variety of storm modes & charge structures
- 3D wind retrieval to infer updraft characteristics
- Incorporate analysis of optical pulse and EFCM data
- Graupel volume and mass calculations