GLM Bolide Detection Update
GLM Science Meeting
September, 2020

Lionel Delmo
Jessie Dotson
Chris Henze
Randy Longenbaugh
Nina McCurdy
Rob Morris
Clemens Rumpf
Jeff C. Smith

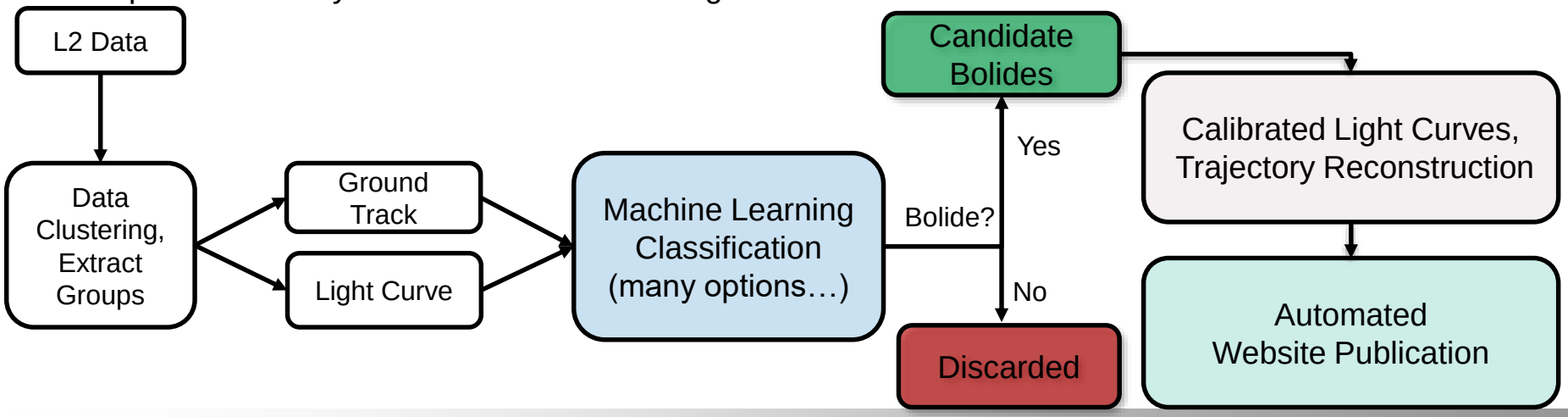
NASA Planetary Defense Coordination Office

Topics to be covered

- GLM detection pipeline processing
- Detection Technique Utilizing GLM Stereo Detection and Renavigation
- GLM vetting process
- Documentation of GLM bolide detections
- Interesting GLM bolide events and statistics

GLM Bolide Detection Pipeline and Future Development

- ***Current***: running on NASA Ames Supercomputer
  - Daily processing of any new GLM L2 data
    - Based on classical sequential matched filter techniques (Rumpf et al. 2019)
    - Can process an entire day in ~15 minutes
    - Finds dozens of promising events daily
    - Requires manual vetting to obtain set for publication on website
- ***Future improvements***:
  - Apply more sophisticated Machine Learning techniques to the detection and classification of candidate GLM Bolides
  - Reduce false positives such that full processing from detection to website publication can be automated
  - Automatic calibration of light curves and trajectory reconstruction from raw L0 data on any detected bolides
  - Improve efficiency of bolide candidate vetting



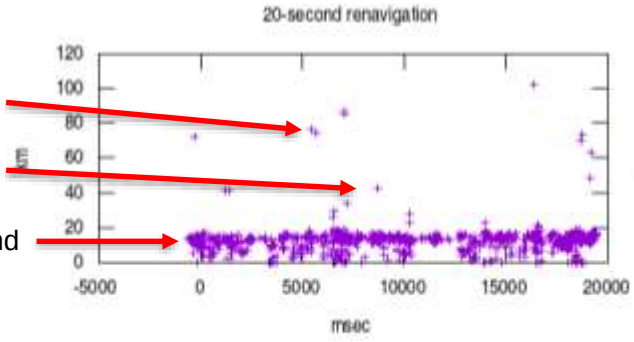
Detection Technique Utilizing GLM Stereo Detection and Renavigation

- Bolide are luminous at high altitudes
  - Well above typical lightning altitudes (> 30 km)
  - L2 data product assumes a lightning altitude that is approximately 10km
- New technique matches data from each GLM in time and space
  - Clustering of data called ”runs” are renavigated until ground track differences are minimized
  - Data mismatches can cause false positives
- Bolides stick out from lightning background due to high altitude re-nav
- New technique finds all stereo bolides
  - and finds events that are too small for pipeline detection
- Higher altitude convergence increases our confidence that the event is a bolide
  - Helps the vetting process

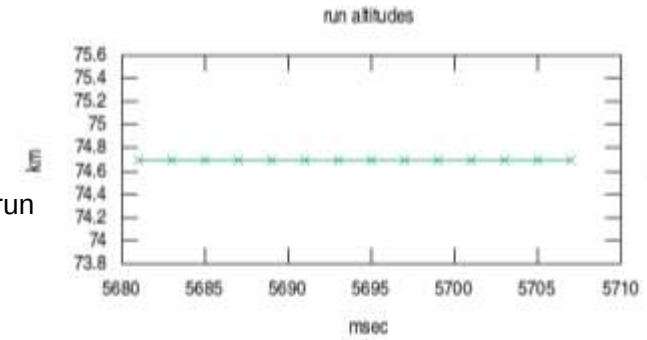
Coherent clustered or run

Mismatched lightning false positives

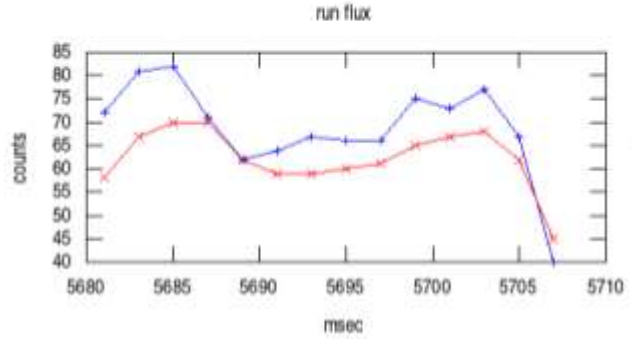
Typical lightning background



Renavigated altitude for run

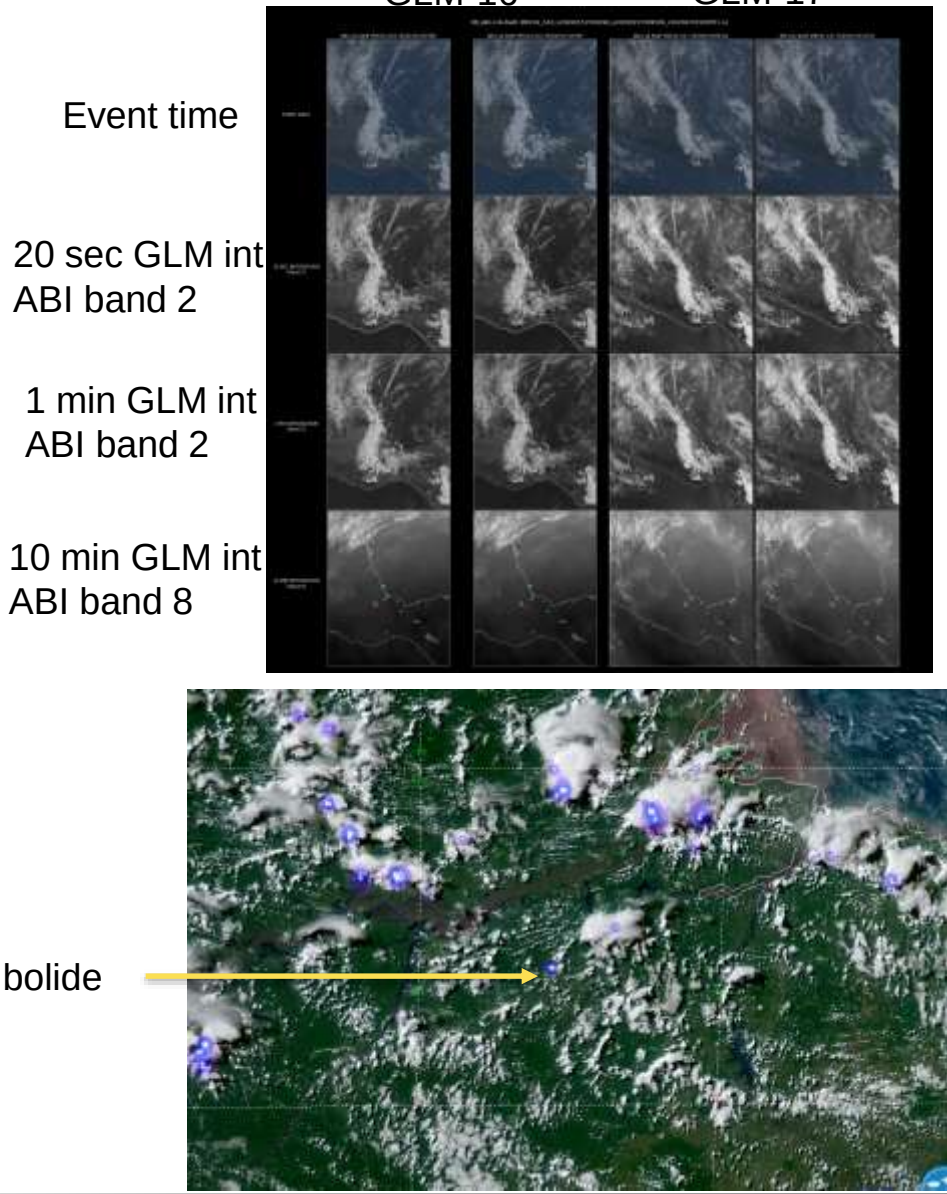


Light Curve Overlay



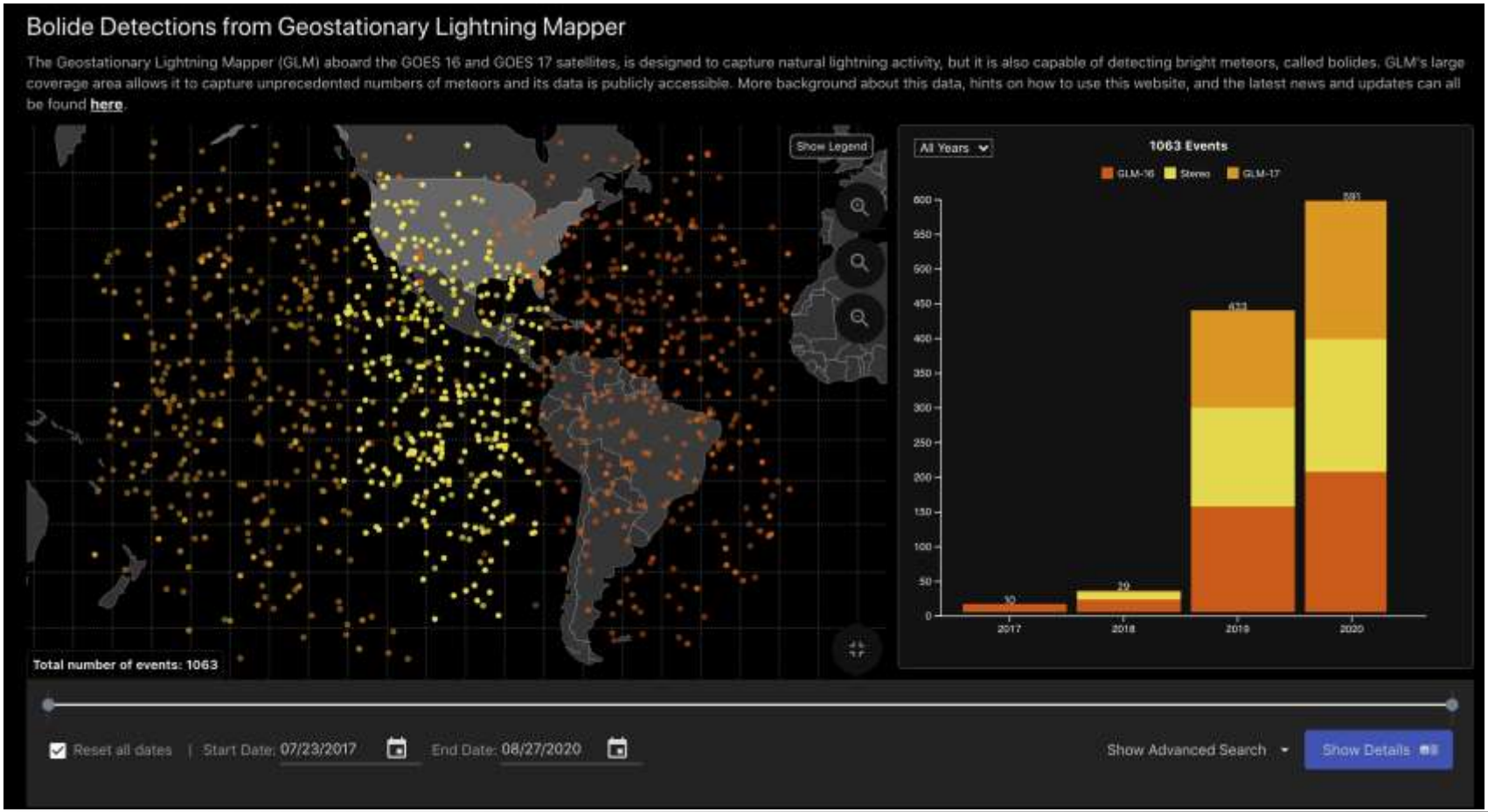
GLM Vetting – Investigating Bolide Candidates

- In most cases we do not have other data to correlate and confirm such as USG, ground based camera data
- We rely on GLM and ABI to investigate local region to determine if there is local lightning activity and what the weather is doing
  - In the past we relied on a tool developed by Colorado State called the Satellite Loop Interactive Data Explorer in Real-time (SLIDER)
    - GLM data only available in a ten-minute integration window
    - Slow and cumbersome to use
    - https://rammb-slider.cira.colostate.edu/
- We have now developed static visualization images that fuse GLM and ABI data to improve and streamline the vetting process
  - Investigating different GLM integration times
  - Investigating different ABI bands
- Also looking at ABI data for bolide contrails



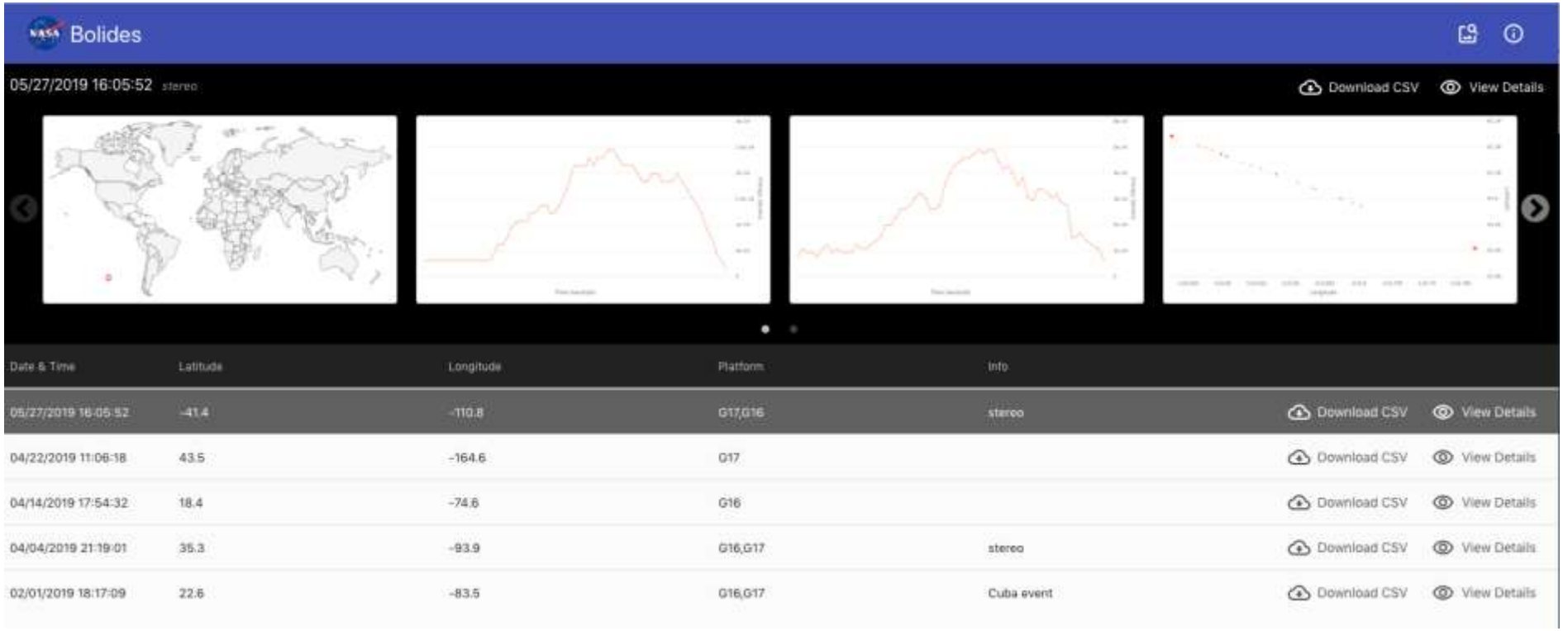
GLM Bolide Website

- A major revision to the GLM bolide website (https://neo-bolide.ndc.nasa.gov/#/) was launched in May 2020
  - New landing page with visualizations summarizing the data set
  - Improved search capability

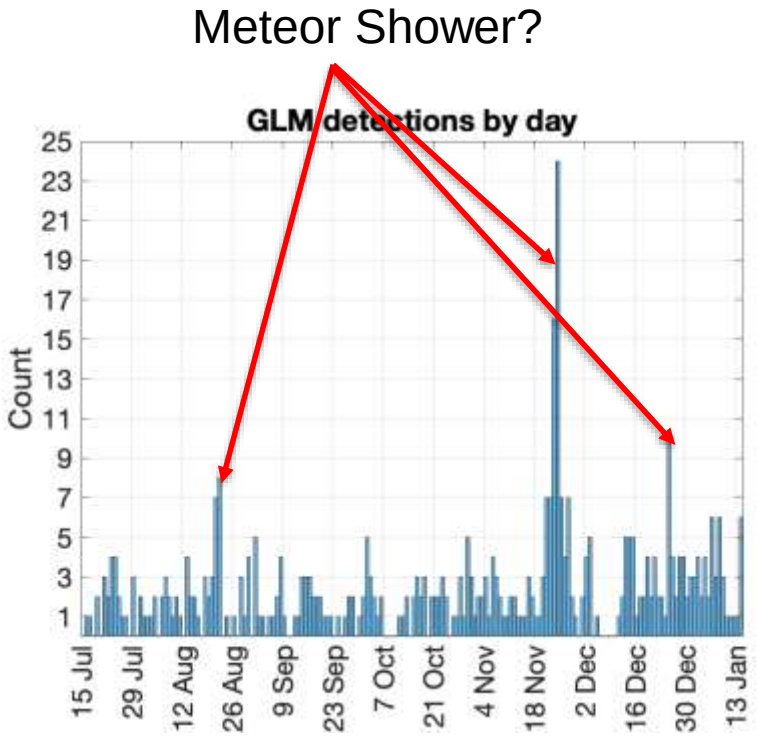


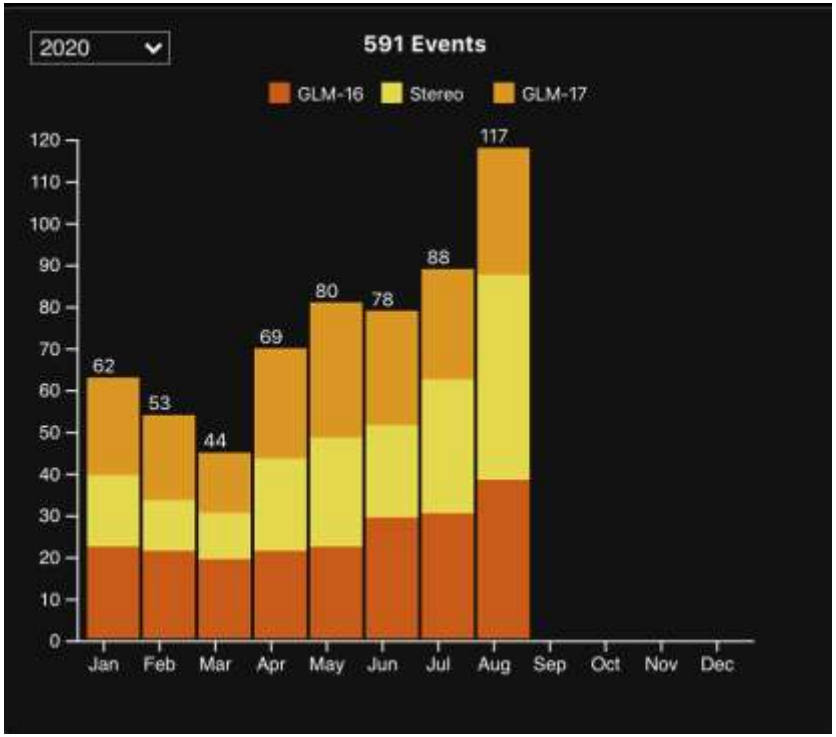
GLM Bolide Website

- Currently we show raw L2 GLM data but have plans to increase the functionality of the website and provide calibrated light curves and reconstructed trajectories
- As of 08/27/2020 there are 1063 documented GLM bolide events
  - Averaging about two to three events per day
- User interface includes a map showing impact location, light curve(s), and ground track(s)



Geographic distribution of GLM bolide detections





- Detection rates are dependent on algorithms ability to find them
  - For example we know there are dimmer events not being found by the current algorithm
- As we increase our detection catalog, we will have enough events to perform statistical analysis of bolide populations

GLM Publications and Contact Information

- Jenniskens, P., Albers, J., Tillier, C. E., Edgington, S. F., Longenbaugh, R. S., Goodman, S. J., et al., 2018. Detection of meteoroid impacts by the Geostationary Lightning Mapper on the GOES-16 satellite. *Meteoritics & Planetary Science*, *53*(12), 2445–2469. http://doi.org/10.1111/maps.13137
- Rumpf, C., Longenbaugh, R., Henze, C., Chavez, J., Mathias, D., 2019. Algorithmic Approach for Detecting Bolides with the Geostationary Lightning Mapper. Sensors, Remote Sensors, Manuscript ID: sensors-429054
- Fall, 2019 AGU presentations
  - **"Extracting Bolide Light Curves from GOES GLM Data"** Abstract ID: 620917 **-** Robert Morris, Jeffrey C. Smith, Jessie Dotson, Randy Longenbaugh, Clemens Rumpf, Christopher Henze, Donovan Mathias
  - **"An Automated Bolide Detection and Lightcurve Pipeline from GOES GLM data"** Abstract ID: 567787 **-** Jeffrey C. Smith, Clemens Rumpf, Robert Morris, Randy Longenbaugh, Jessie Dotson, Christopher Henze, Donovan Mathias
- Other relevant Publications
  - AGU - "Using Deep Learning to Automate Inference of Meteoroid Pre-Entry Properties" Abstract ID: 519737, by Ana M Tarano