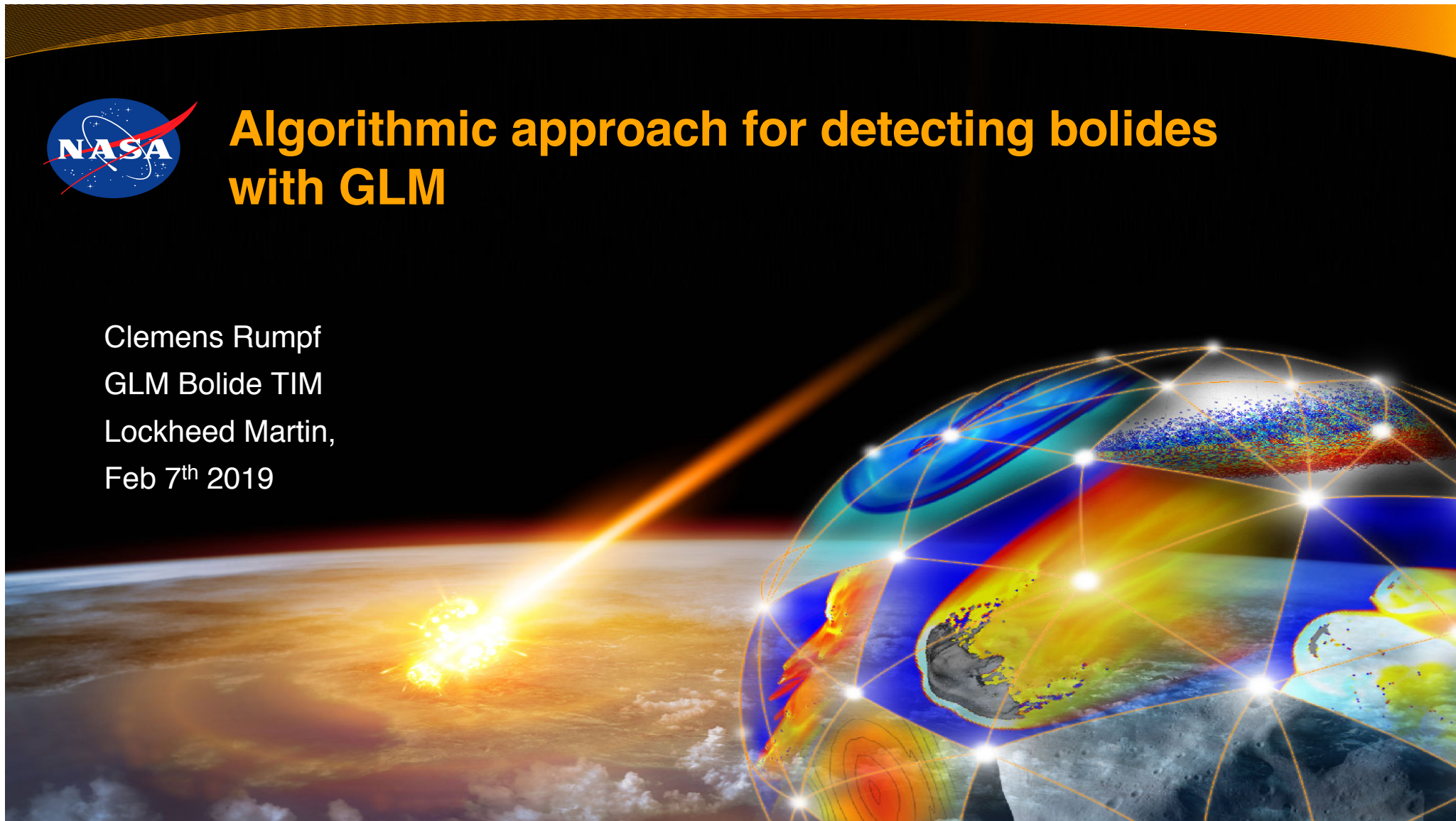




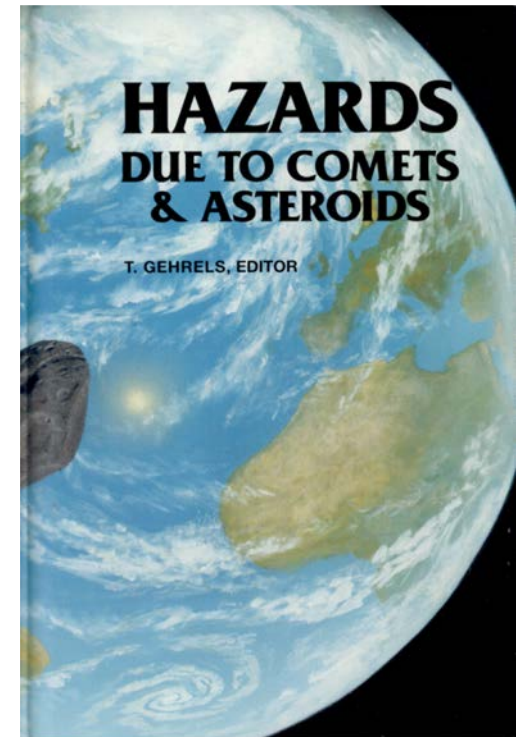
Algorithmic approach for detecting bolides with GLM

Clemens Rumpf
GLM Bolide TIM
Lockheed Martin,
Feb 7th 2019



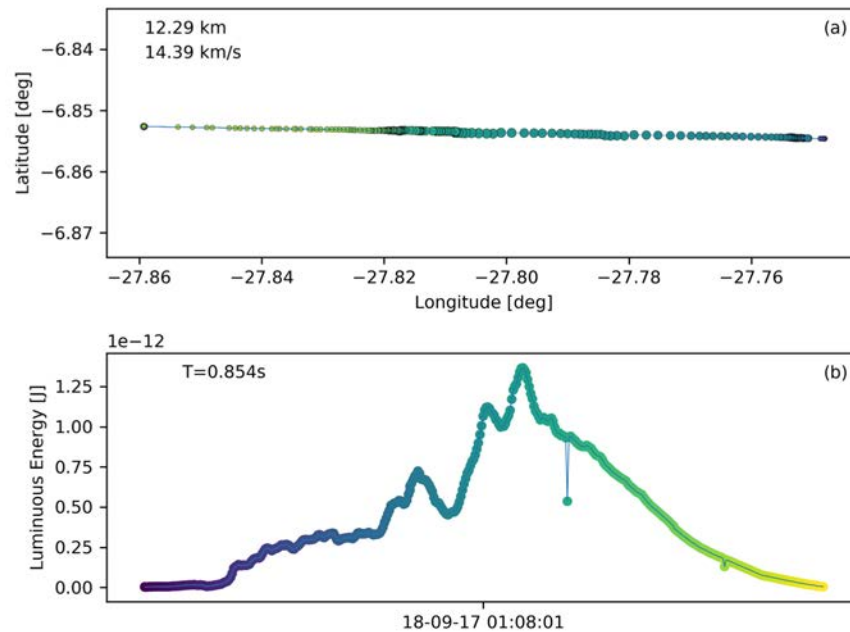
Historical Note

- One planned sensor system which undoubtedly will prove to have an extremely good capability for detecting and locating meteoroid impacts is the NASA Lightning Mapper. This instrument, developed by the Marshall Space Flight Center for the Geostationary Observational Environmental Satellites (GOES) weather satellites [...].
- E. Tagliaferri, R. Spalding, C. Jacobs, S. Worden, A. Erlich, *"Detection of Meteoroid Impacts by Optical Sensors in Earth Orbit"* in Hazards Due to Comets and Asteroids, 1994

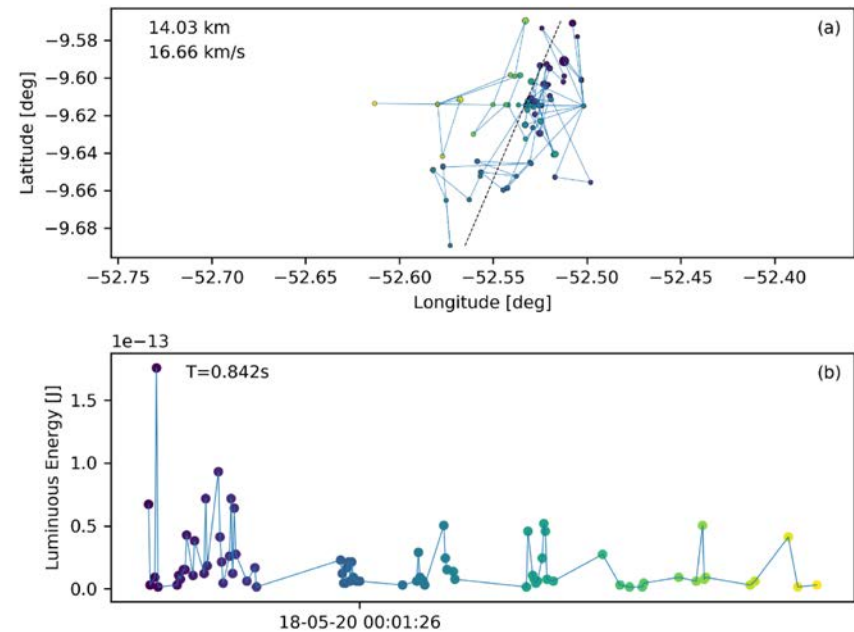


Bolide vs Lightning Signature

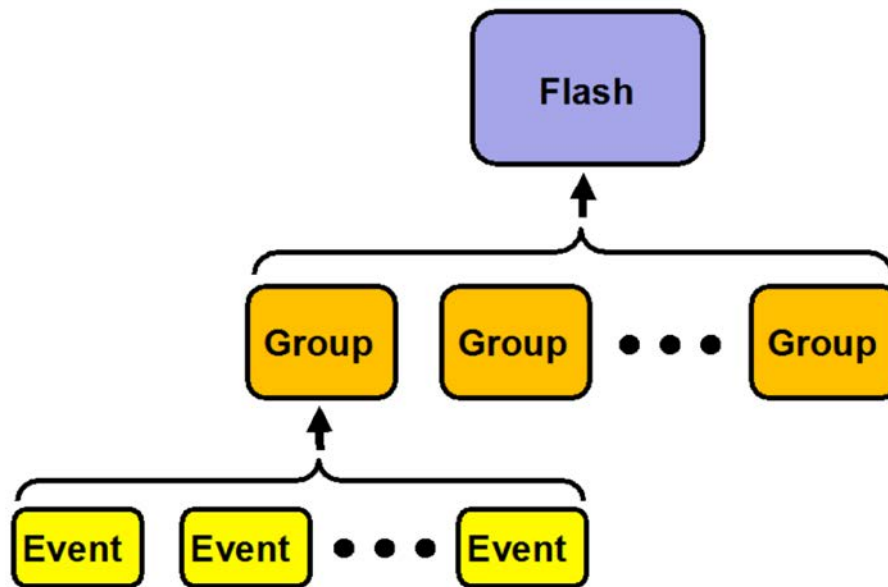
Bolide



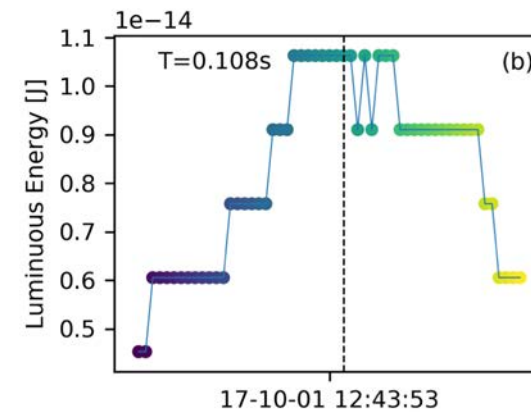
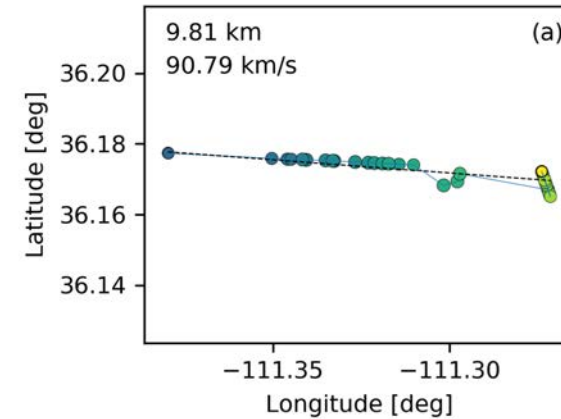
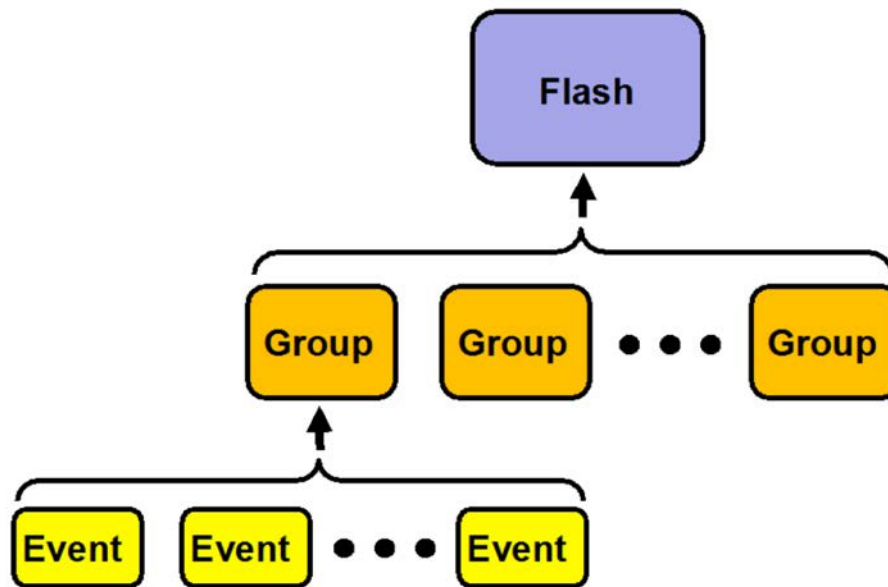
Lightning



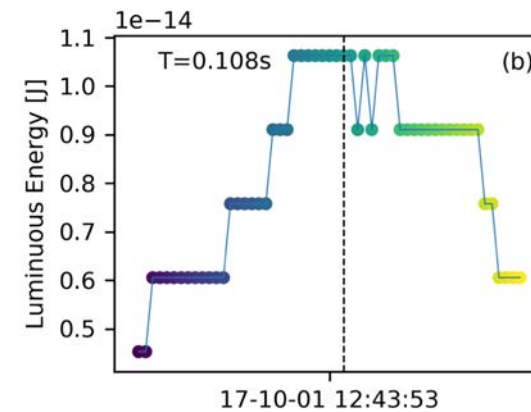
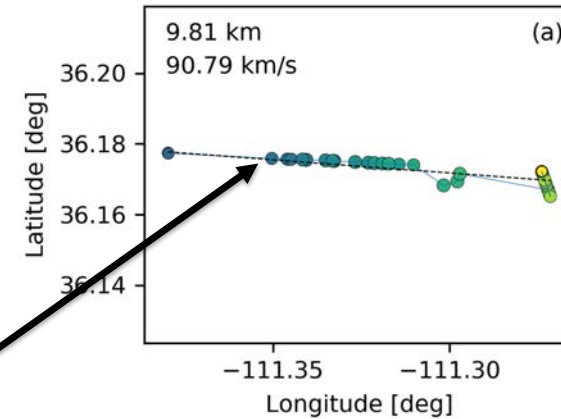
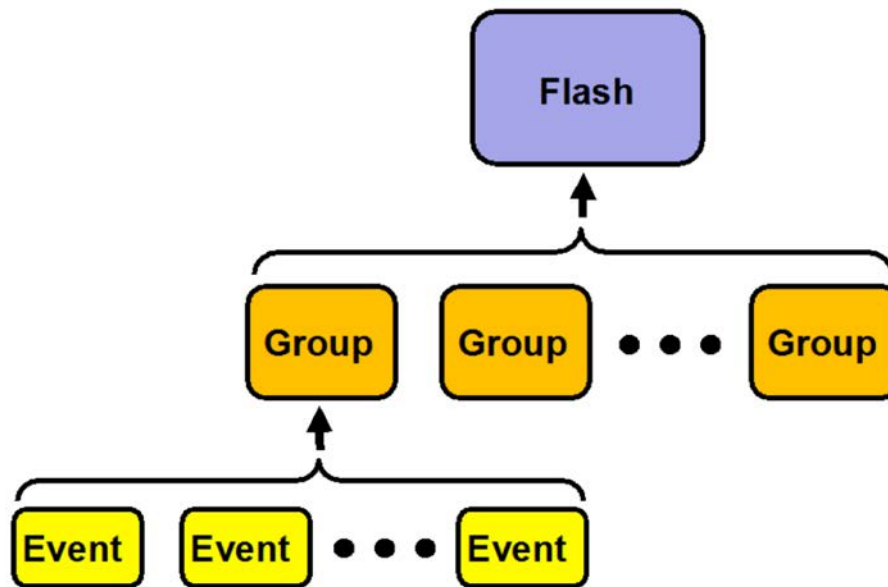
Definition: Flash – Group – Event



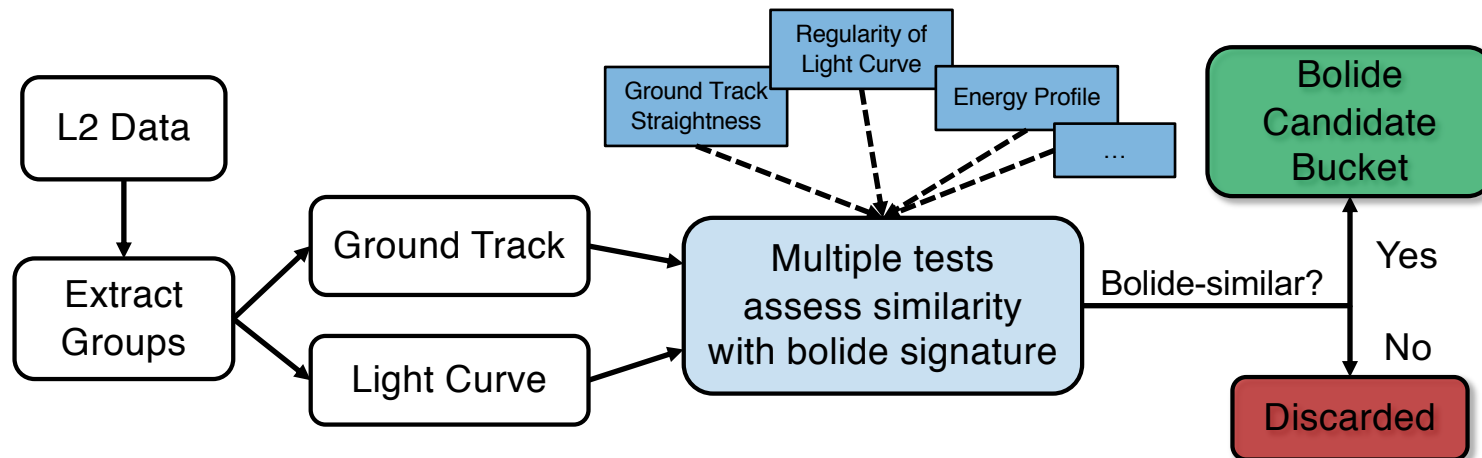
Definition: Flash – Group – Event



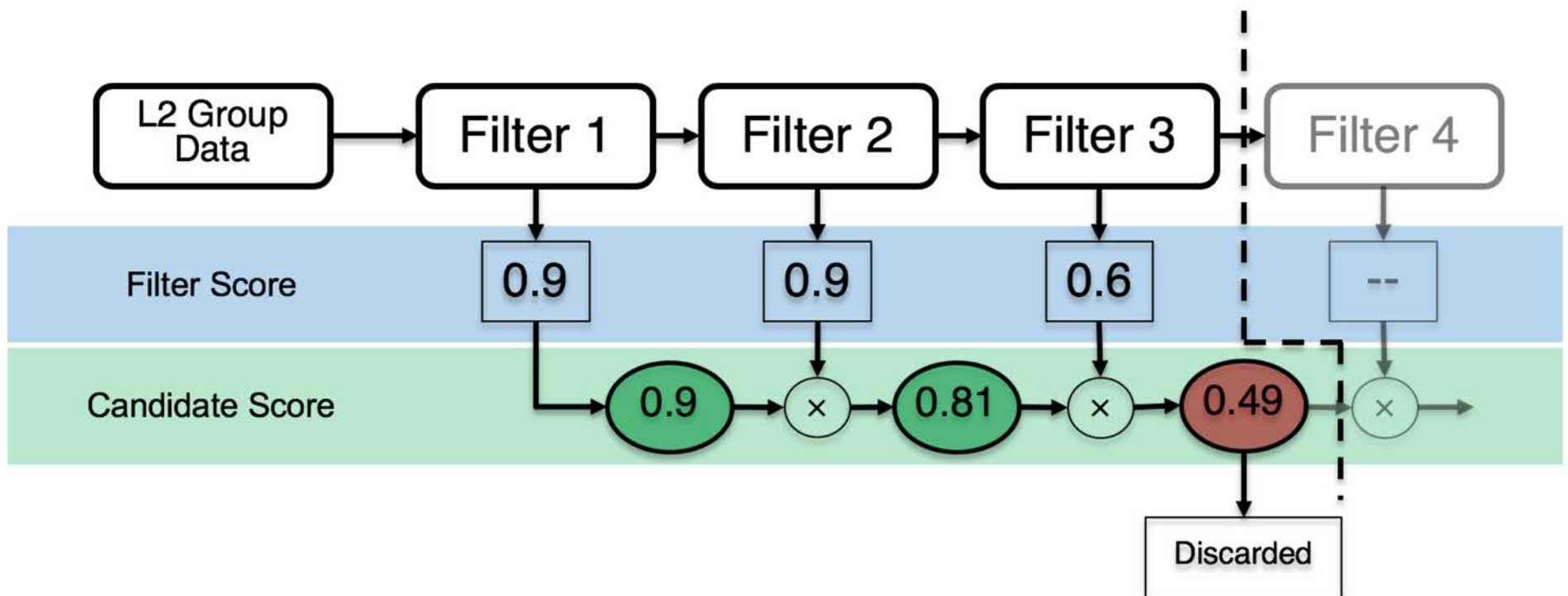
Definition: Flash – Group – Event



Processing Pipeline



Algorithm Architecture

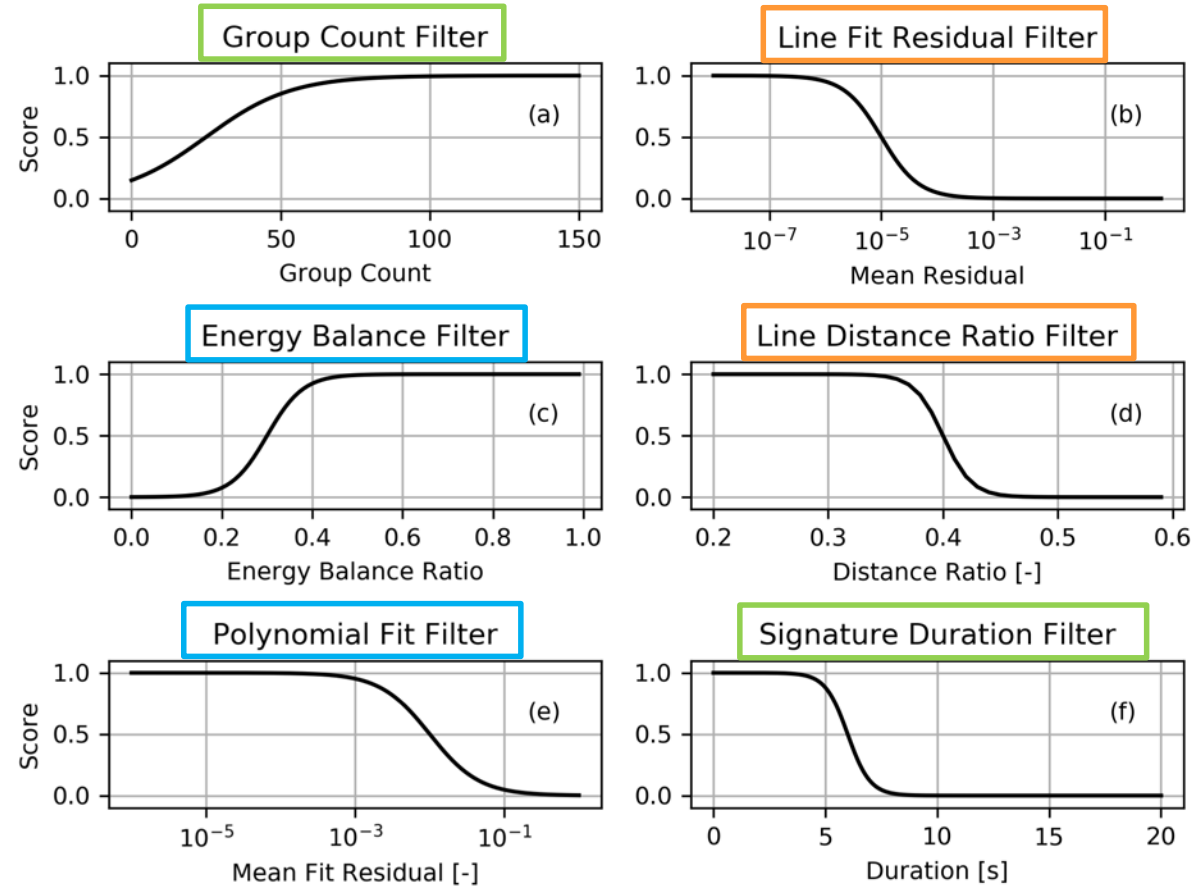


Filter Functions

Meta

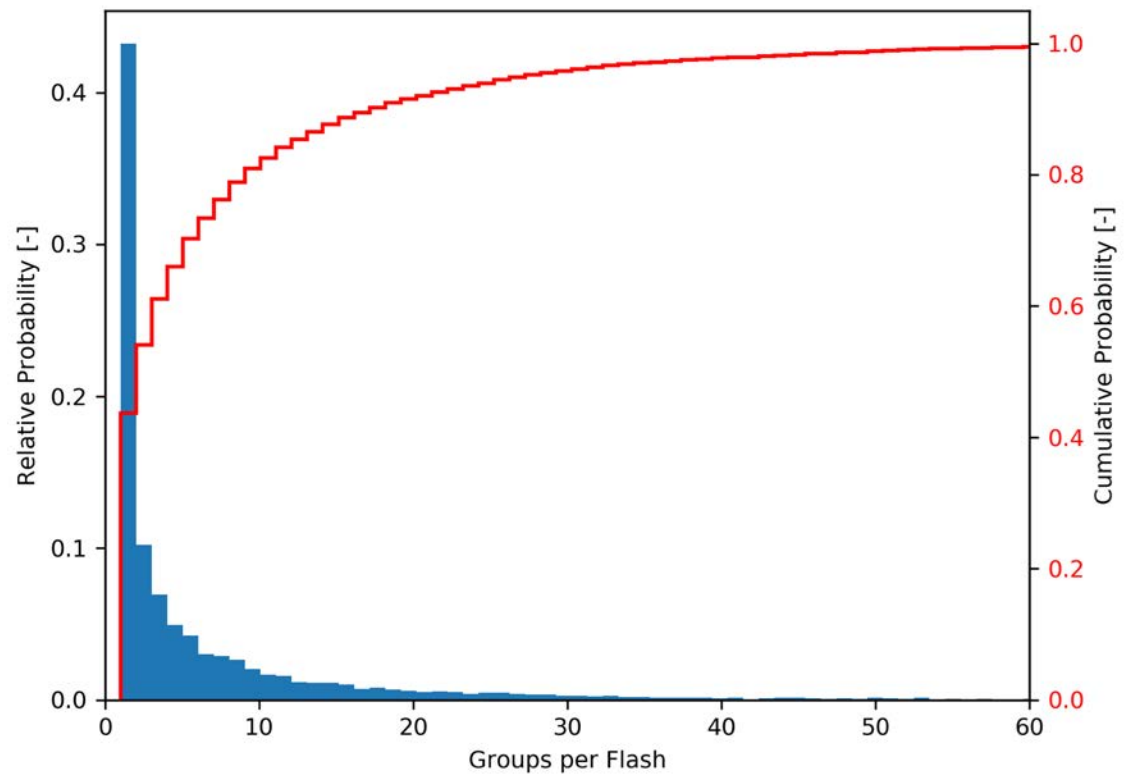
Ground
Track

Light
Curve



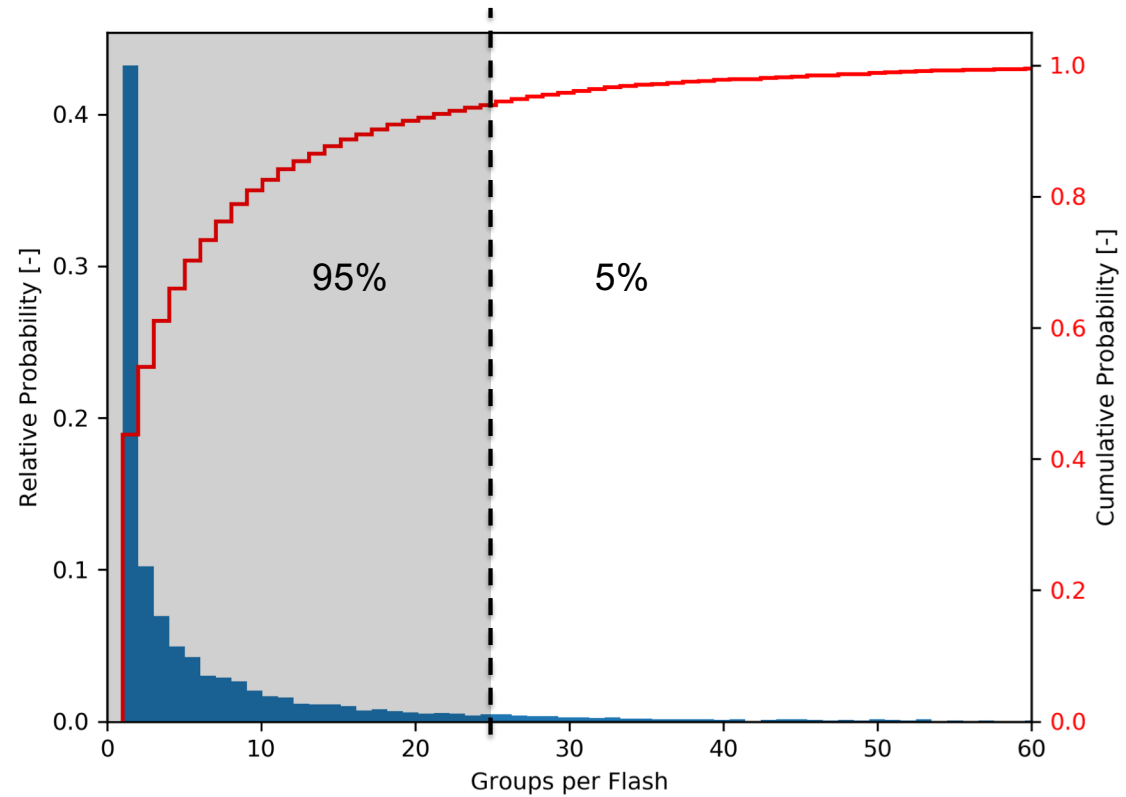
Filter 1: Group Count

- 8864 flashes
- 3 minutes and 20 seconds worth of data



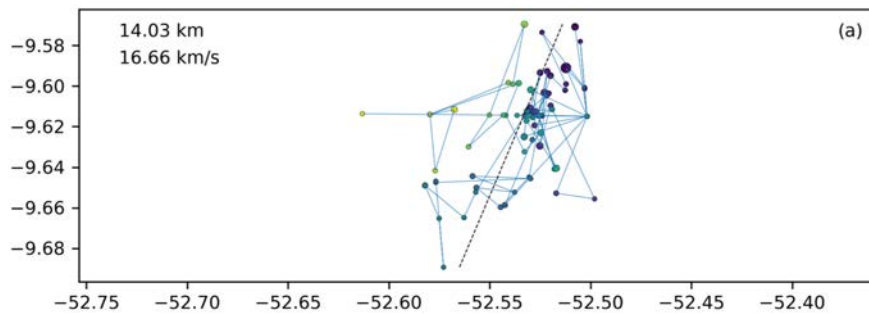
Filter 1: Group Count

- 8864 flashes
- 3 minutes and 20 seconds worth of data

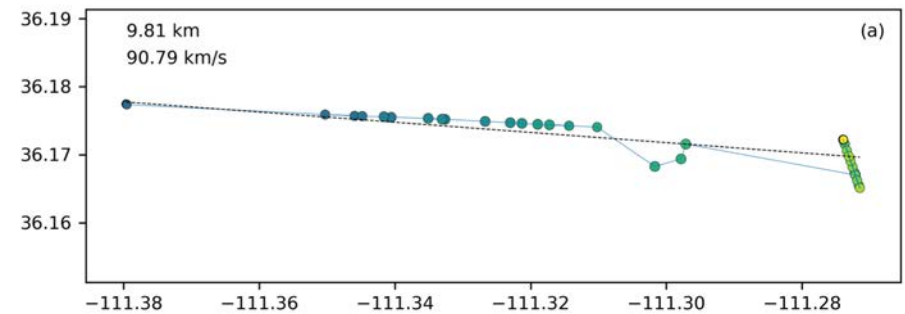


Filter 2: Line Fit

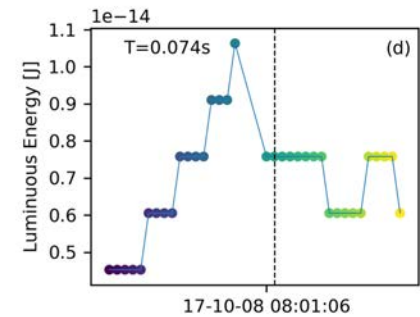
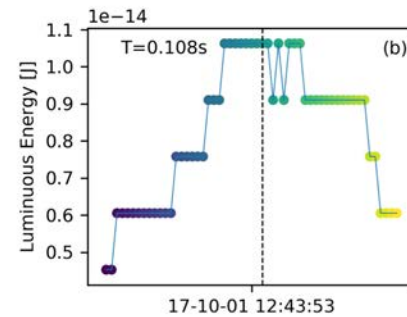
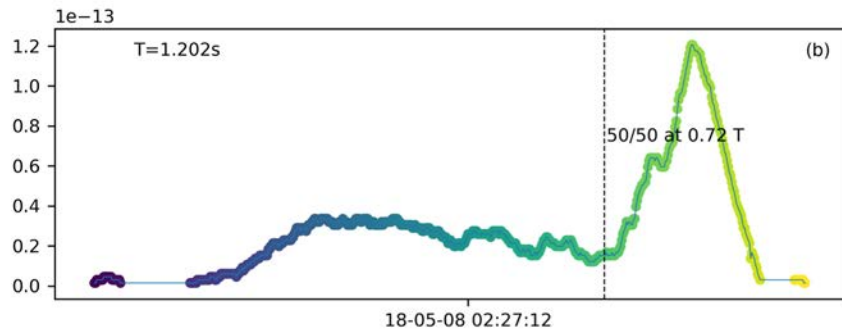
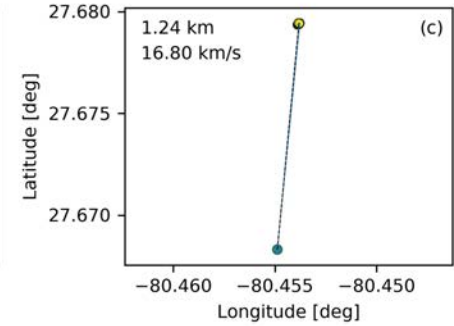
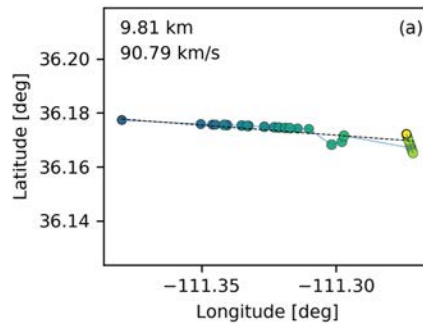
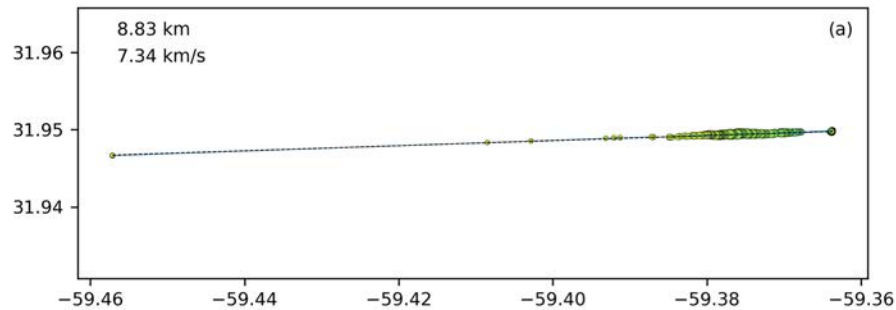
Lightning



Bolide

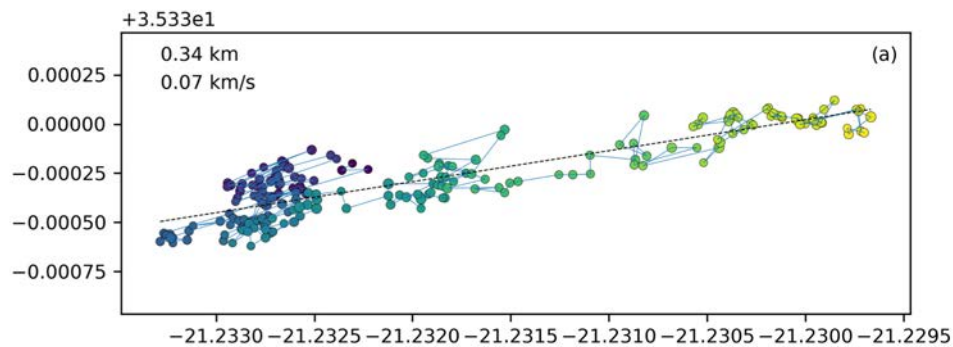


Filter 3: Energy Balance

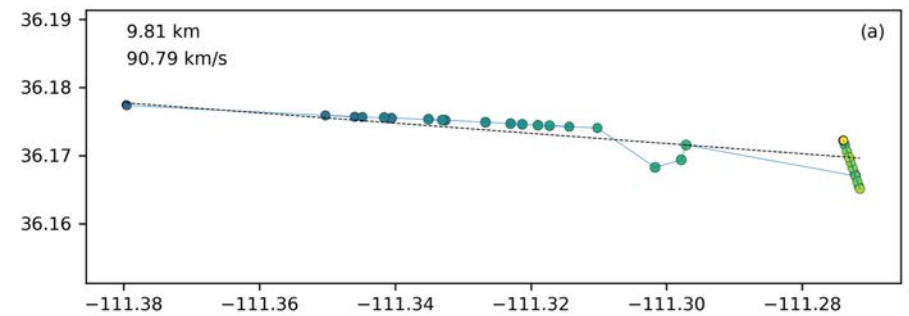
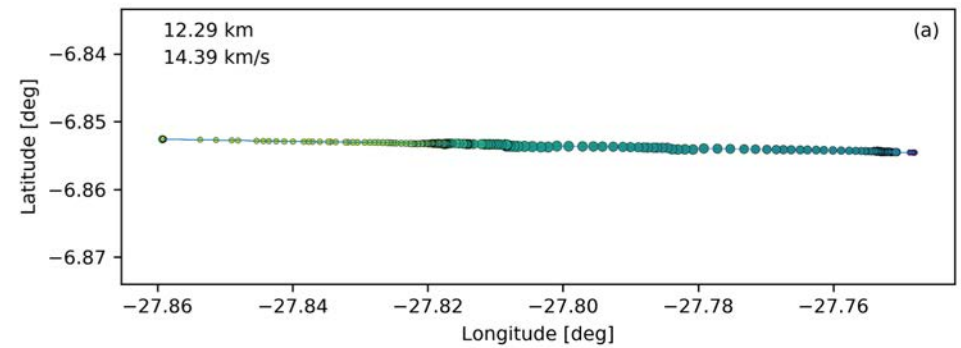


Filter 4: Line Distance

Lightning

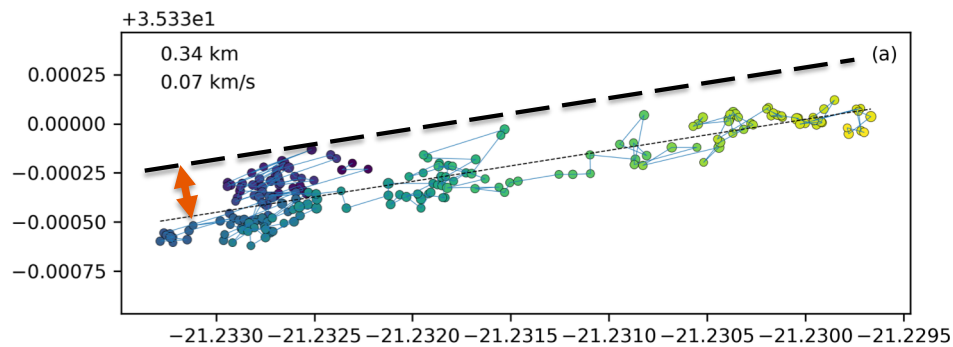


Bolide

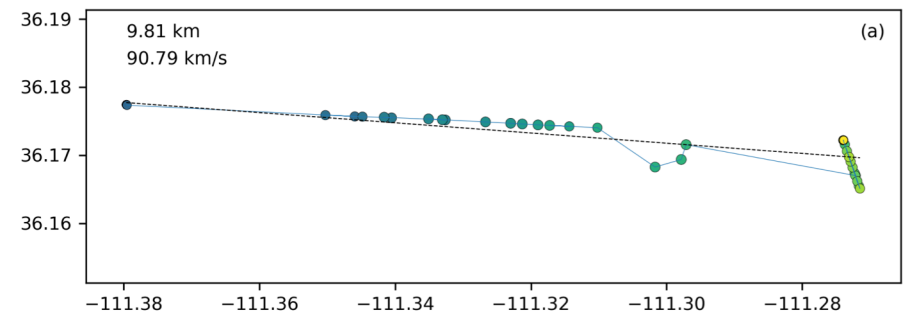
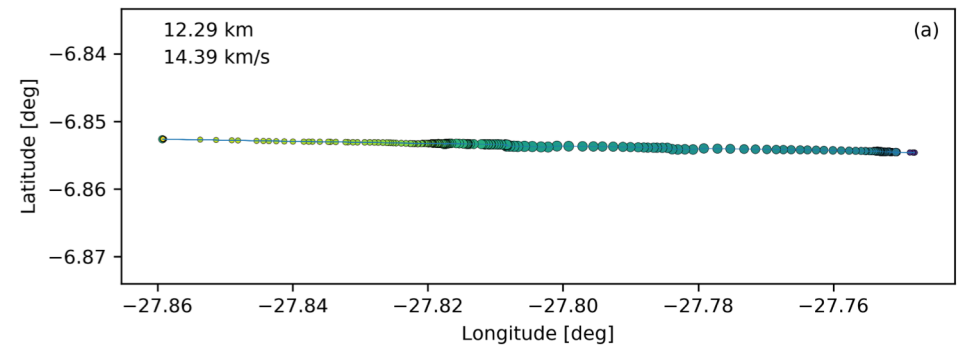


Filter 4: Line Distance

Lightning

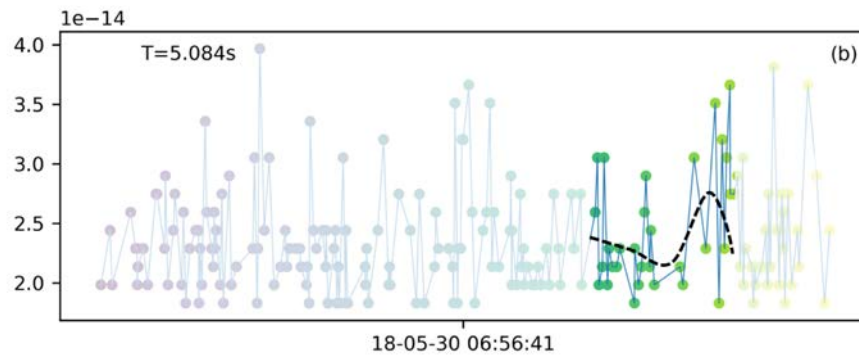


Bolide

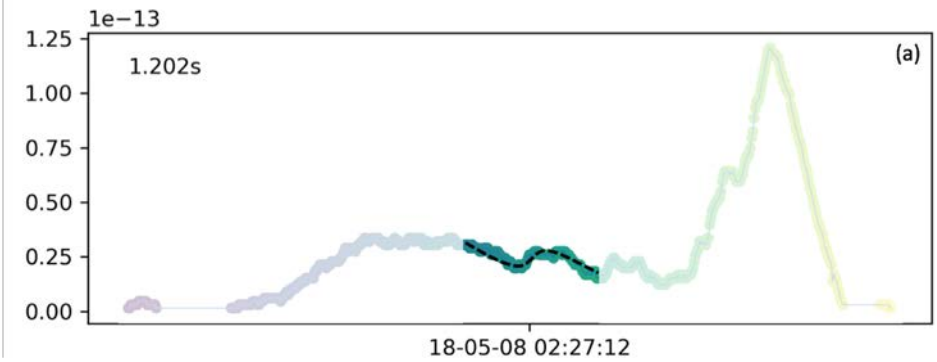


Filter 5: Polynomial Fit

Lightning



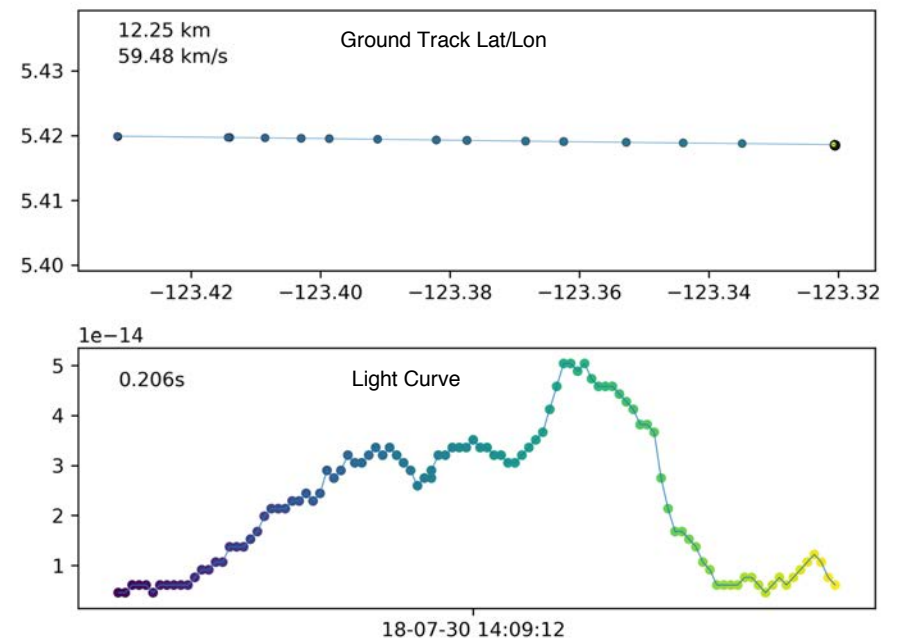
Bolide



Performance

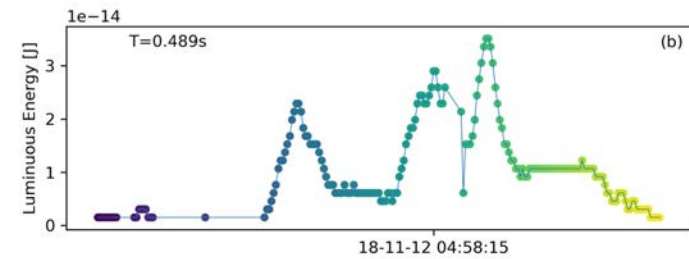
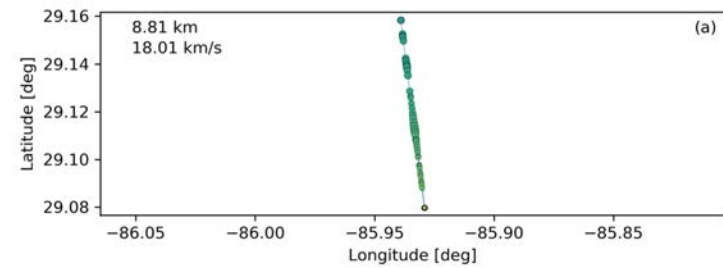
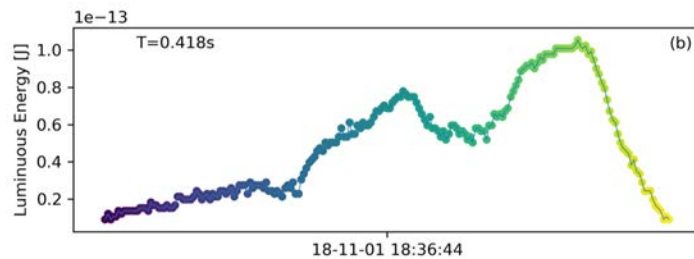
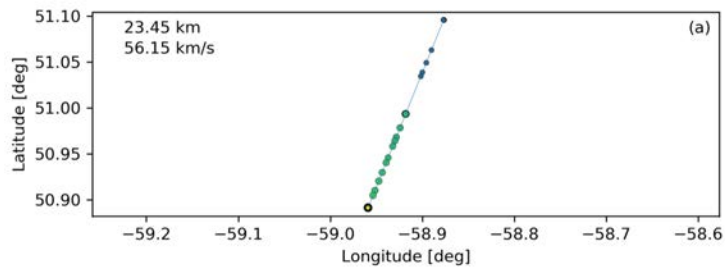
- In performance test, algorithm identified an interesting signature in 1.44% of the input files.
 - 144845 files (34 days worth of data)
 - 2252 flagged files
- A human has to look at data to judge if true or false positive.

Likely meteor discovered by algorithm



Performance in November

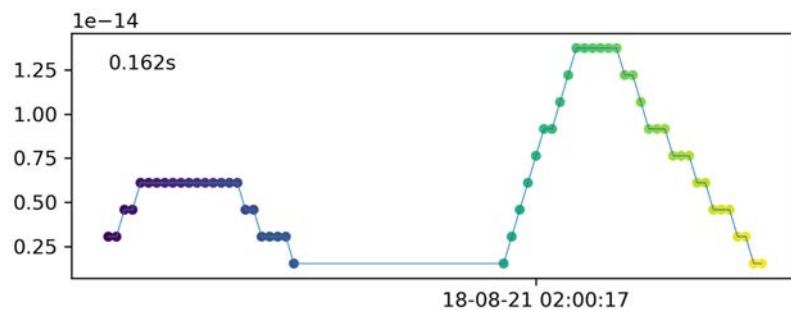
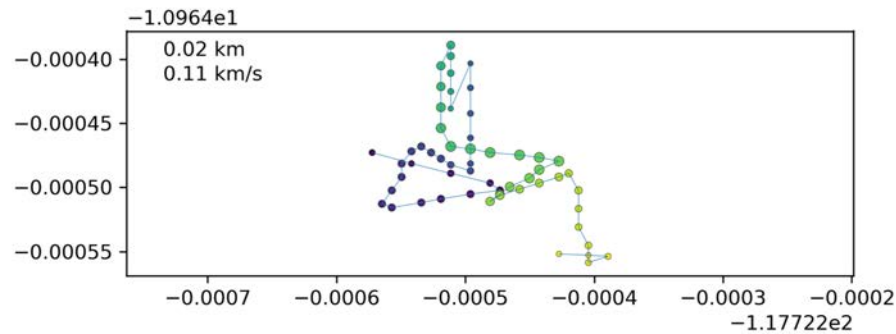
Date/Time (UT)	Julian day	Latitude (deg)	Longitude (deg)	Time Duration (sec)	Total Radiated Energy (J)	Available Data sources
11/1/18 18:36:44	305	51.0N	58.9W	0.462	1.05E-11	GLM-16
11/3/18 12:36:21	307	5.0N	102.3W	0.155	1.49E-12	GLM-16
11/11/18 7:58:29	315	34.1N	35.6W	0.078	7.25E-13	GLM-16
11/12/18 4:58:15	316	29.1N	85.9W	0.837	2.09E-12	GLM-16, all-sky
11/15/18 8:02:44	319	42.4N	52.8W	0.877	1.33E-10	USG, GLM-16
11/20/18 12:17:52	324	34.9N	118.4W	0.36	9.55E-12	GLM-16, GLM-17, all-sky
11/22/18 13:10:46	326	33.1N	122.2W	0.324	1.14E-11	GLM-16, GLM-17, all-sky



Challenges

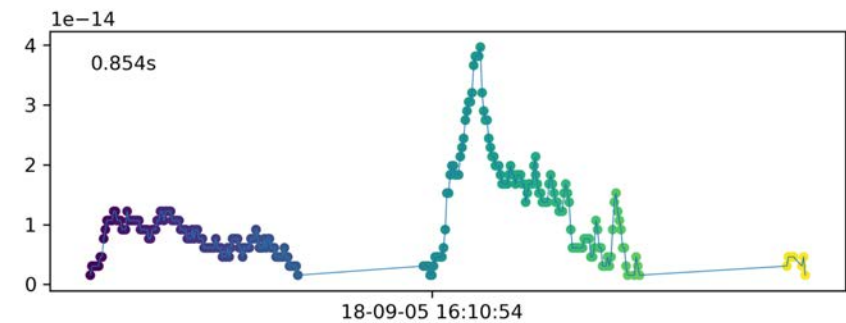
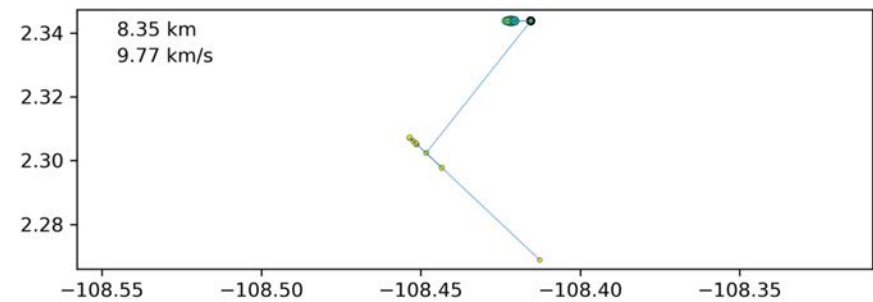
- True Positive

- Challenging ground track issue
- Rethinking of approach to handle ground track data

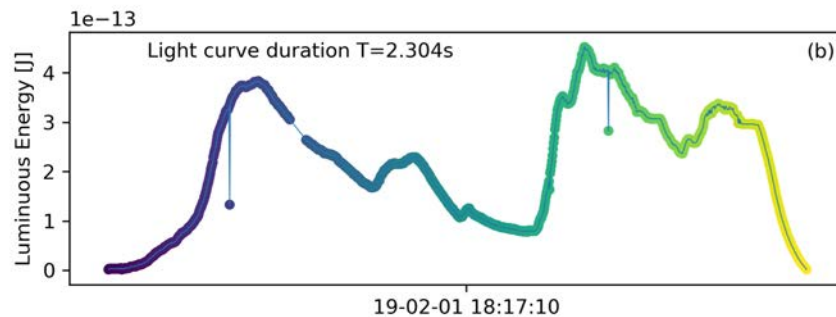
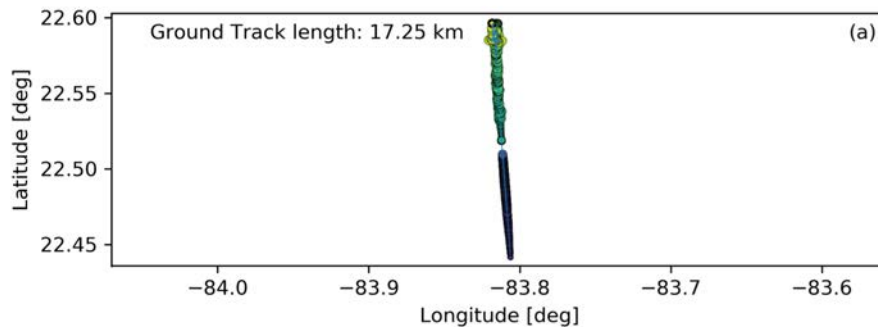


- True Negative

- Recovered after tip-off
- Challenging ground track
- Atypical light curve



Feb 1st Cuba event



Peak Brightness Date/Time (UT)	Latitude (deg.)	Longitude (deg.)	Altitude (km)	Velocity (km/s)
2019-02-01 18:17:10	22.5N	83.8W	23.7	16.3

Velocity Components (km/s)			Total Radiated Energy (J)	Calculated Total Impact Energy (kt)
vx	vy	vz		
-2.4	13.6	8.7	57.9e10	1.4

Impact Angle:
35.17 deg

- GLM based data enabled to be first to publish light curve and ground track
- Corrected initial assumption of a North → South trajectory



Parallel Approaches



- Logistical regression model
- Neural network
- Main issues at the moment are number of training samples.



Currently Publishing



- Title: *"Algorithmic Approach for Detecting Bolides with the Geostationary Lightning Mapper"*
- Send me an email if interested and I will send you a copy once published.
- Clemens.rumpf@nasa.gov



Open Question



- How do we confirm if a good signature is actually a bolide?



Thanks for your attention

Clemens Rumpf

clemens.rumpf@nasa.gov