Comparison LMA data to GLM Level 0 and Level 1b : toward an application to LI performance assessment

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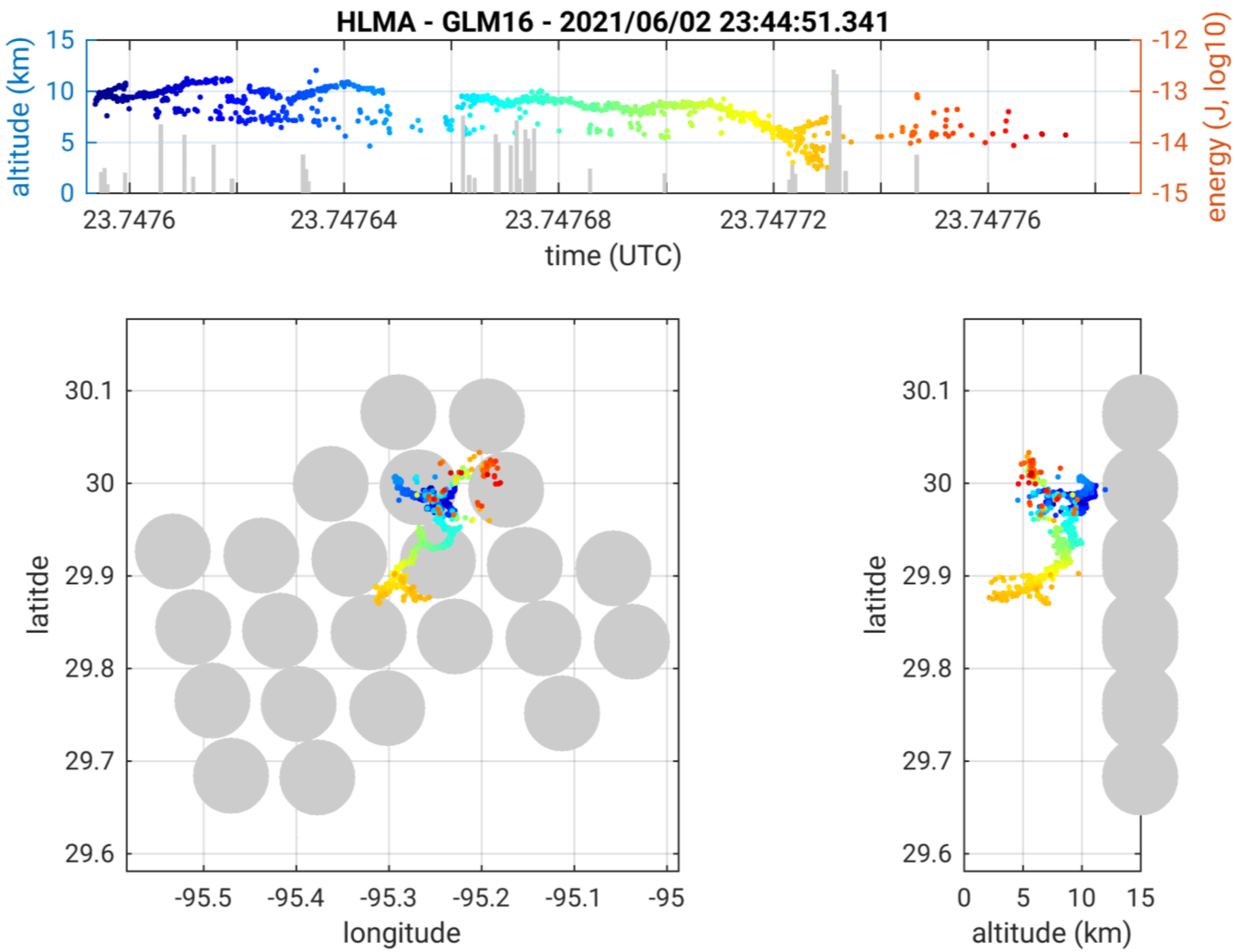
14th LIMAG Meeting

(6-7 December 2022 – Online)

Example of Concurrent HLMA and GLM Observations



- Bolt-from-Blue flash in the Houston area (Texas)
- GLM detects successive bursts of optical radiation of several millisecond duration with an energy ranging over 2 orders of magnitude
- HLMA maps in 3D the flash
- **LMA s are suitable to evaluate L1b data but also L0 data to quantify FDE, FFAR, and L0-to-L1b algorithm performances within ~120-km diameter in 3D (~300 km in 2D)**

(Houston LMA data, courtesy E. Bruning, TTU)

Comparison LMA data to GLM Level 0 and Level 1b

- Work presented by P. Bitzer ["*The Effect of Ground Processing on GLM Performance*"] during the GLM Science workshop (https://goes-r.nsstc.nasa.gov/home/meeting-agenda-2022)
  - Detection dependent on instrument performances and ground algorithms filtering noise from lightning
  - Methodology :
    - Identify GLM events that occur within the spatial-temporal bounds of a LMA flash (should eliminate any ambiguities caused by flash grouping)
    - Matching on both L1b and L0 data and comparison to assess the effect of ground processing (as L0 represents best possible performance with instrument, and L1b represents combined instrument + ground algorithm)
  - Key results :
    - Two RELEMPAGO storms studied (High Flash Rate / Anomalous Storm)
    - Operational algorithm with lower DE (40% / 46 %) than L0 detection (60% / 64%)
    - Loss Fraction (1- DE(L0)/DE(L1) :~30% of flashes filtered by ground processing
    - L0 dataset contains more flashes during the life cycle of the two studied storms
    - DE improves (significantly) with increasing flash size
    - Very little light is detected for small flashes at all altitudes
    - The L0 detections are slightly better at short duration flashes… but the biggest improvement is among 100-500 ms flashes
    - Based on similar event-per-flash distributions for L0 and L1b data, the L0 detections are not just single events detected during longer flashes!

Application to LI Observations

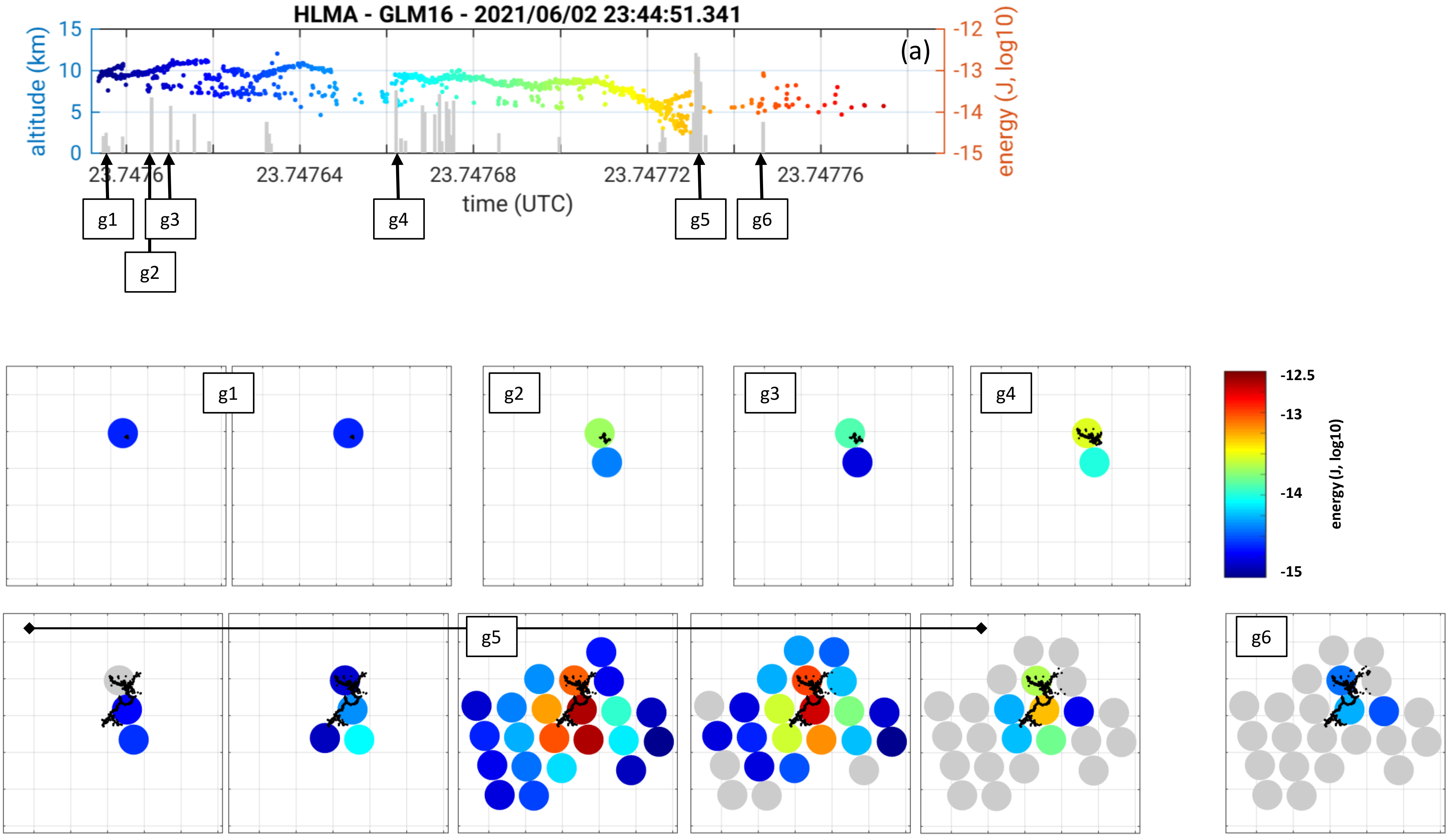
- Same methodology applicable to LI records using LMA records
  - LI **L0 dataset geo-referenced**, **parallax corrected** and **time-of-propagation corrected**
  - Need LI **L0-to-L1b parent-child link** to track i) what comes from what *[tracking]* and ii) why a L0-based flash that has been excluded *[Data filtering process and parameters]*
  - **Apply the same LMA source filtering parameters** (chi2, number of stations) and LMA source-to-flash algorithm setup; if not possible assess the effects of those different LMA-related (algorithm, network geometry) configurations
  - **Matching criteria** (time and space) *[sensitivity study to conduct]*
  - **Assess L0 and L1b performances** as a function of the LMA flash data (flash type, flash altitude range, flash duration; electrical charge structure; flash rate;…)
  - Apply to **different types of storm** documented during **their entire life cycles during daytime and nighttimes**
  - **Conduct the exercise on a long term basis and at all times during the day and season**
  - **Include a cloud characterization** from ground-based radar, FCI or LI background
  - **Assess DE and FAR performances** at L0 and L1b according to **LMA-deduced flash characteristics, cloud characterization and L0 & L1b radiometric signal**
  - **Include operational LLS observations** (CG stroke and IC pulse type & current) *[an eye on flash component DE and FAR…]*

- Same methodology could be applied on operational LLS observations

Thanks !

Backup #1

Concurrent HLMA and GLM observations



Backup #2

The Effect of Ground Processing on GLM Performance

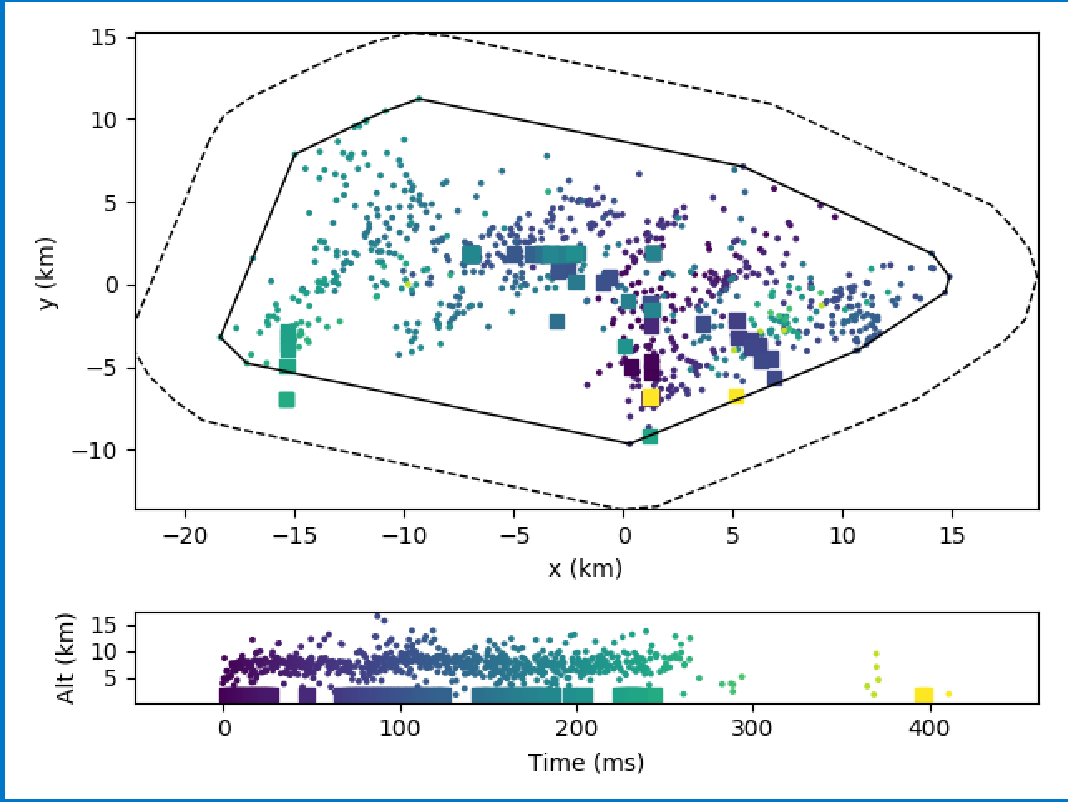
Phillip Bitzer

What goes into GLM detection efficiency?

- GLM performance, i.e., detection efficiency, is determined by two factors:
  - Instrument performance – how well does GLM detect light
  - Ground algorithms – how well does ground processing filter noise from lightning
- Each contribute to what the user cares about – how much lightning is detected.
- But can we improve what we have?

How do we assess performance?

- To assess how GLM is performing, we find GLM events that occur within the spatial-temporal bounds of a LMA flash
  - Eliminates any ambiguities caused by flash grouping
- Run matching on both L1b and L0
  - L0 represents best possible performance with instrument (as currently configured)
  - L1b represents combined instrument + ground algorithm
  - Comparison of L1b and L0 yields the effect of ground processing



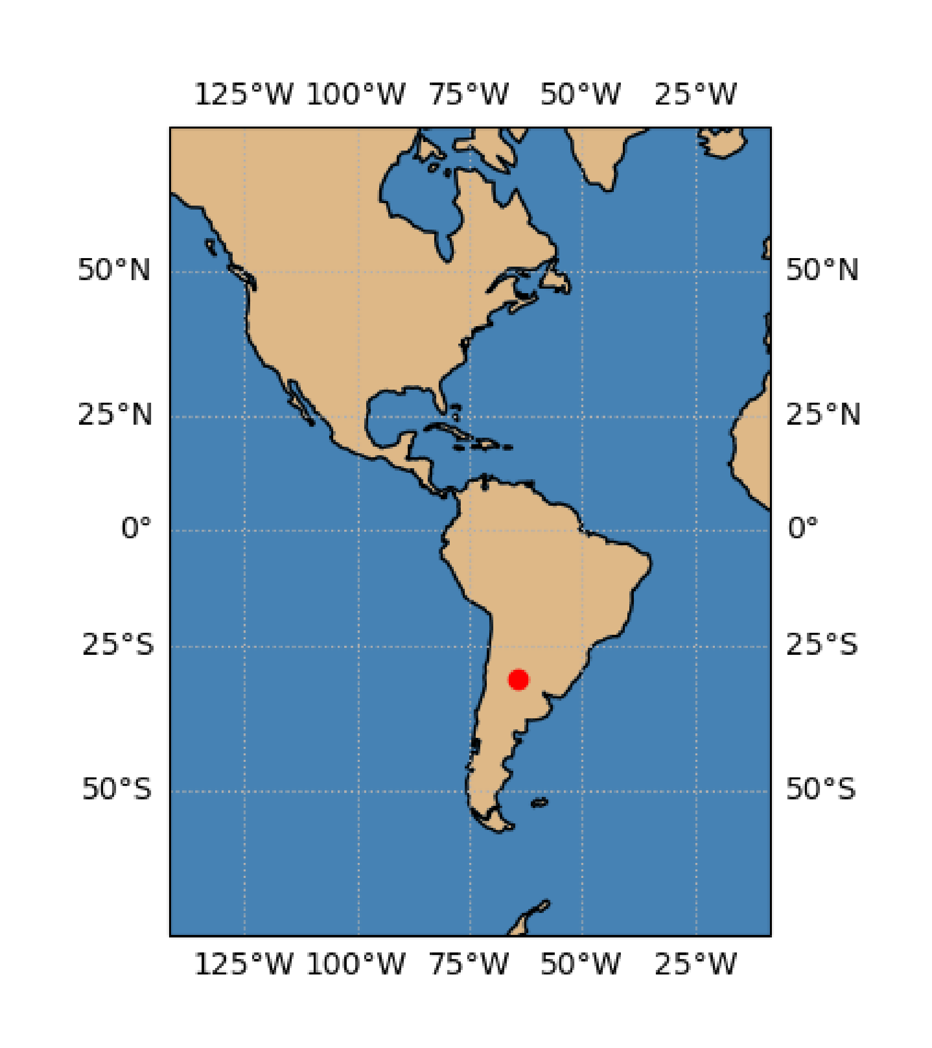
Previous Results

- We've reported DE using this technique before, mostly using PLT results
- Consistent with other researchers, DE varies as a function of flash area and storm mode/type
- But certain storm type/mode also yields low(er) DE for ground based systems

LMA Area (km^2)	DE (GLM | NALMA)	DE (GLM | COLMA)	DE (ENI | COLMA)
All	0.617	0.256	0.372
> 8	0.738	0.365	0.534
> 16	0.806	0.429	0.609
> 32	0.873	0.522	0.702
> 64	0.922	0.649	0.797
> 100	0.947	0.746	0.850

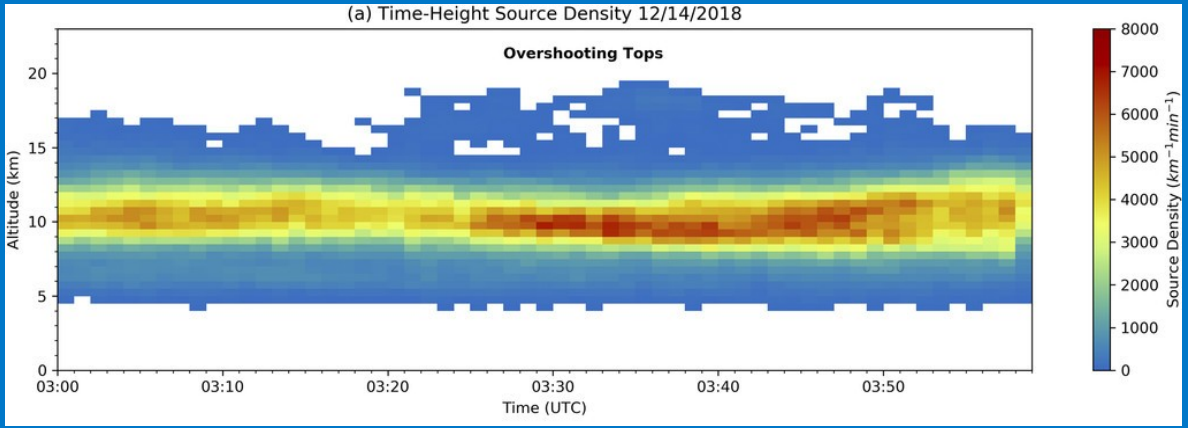
New Results

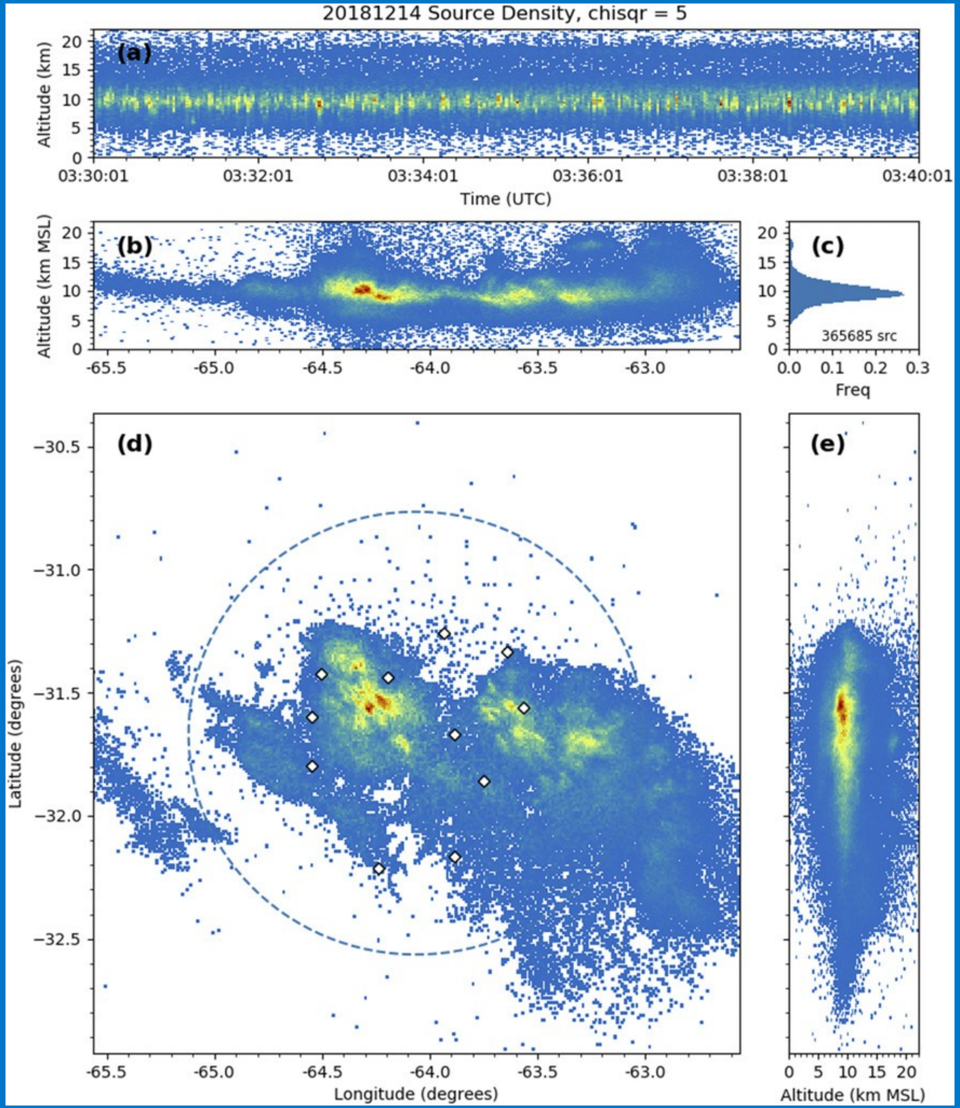
- Now, we'll look at a couple of cases from the Relampago campaign in Argentina, including an anomalous storm
- This gives results for storms post-PLT tuning, in addition to a slightly less off-axis viewing angle



20181214 – High Flash Rate Storm

- Dec 14, 2018 00Z-09Z
  - MCS with max flash rate ~ 600/min and overshooting tops
  - Almost 22 000 flashes detected
  - LMA source altitude mode at approximately 10 km
  - Analyzed in Lang et al. 2020





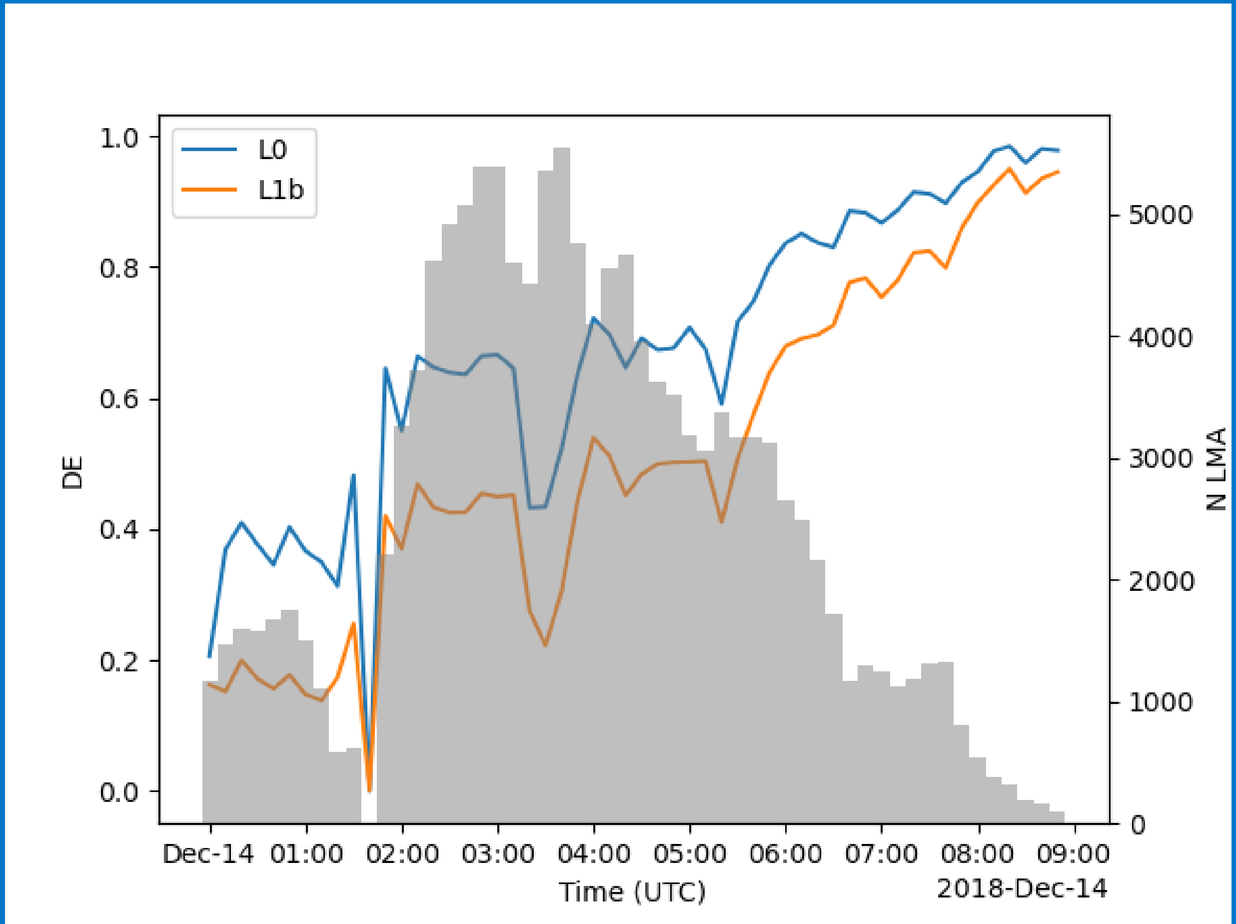
20181214 – High Flash Rate Storm

Area (km2)	Num LMA Flashes	Num GLM – L1b	DE – L1b	Num GLM – L0	DE – L0
All	20822	8222	0.395	12285	0.590
> 8	12651	6953	0.550	9494	0.751
> 16	8426	5472	0.649	6972	0.827
> 32	4918	3809	0.775	4485	0.912
> 64	2477	2185	0.882	2397	0.968
> 100	1414	1324	0.936	1399	0.989

Operational algorithm yields an overall DE of 40%,
yet almost 60% of the flashes were detected by the instrument

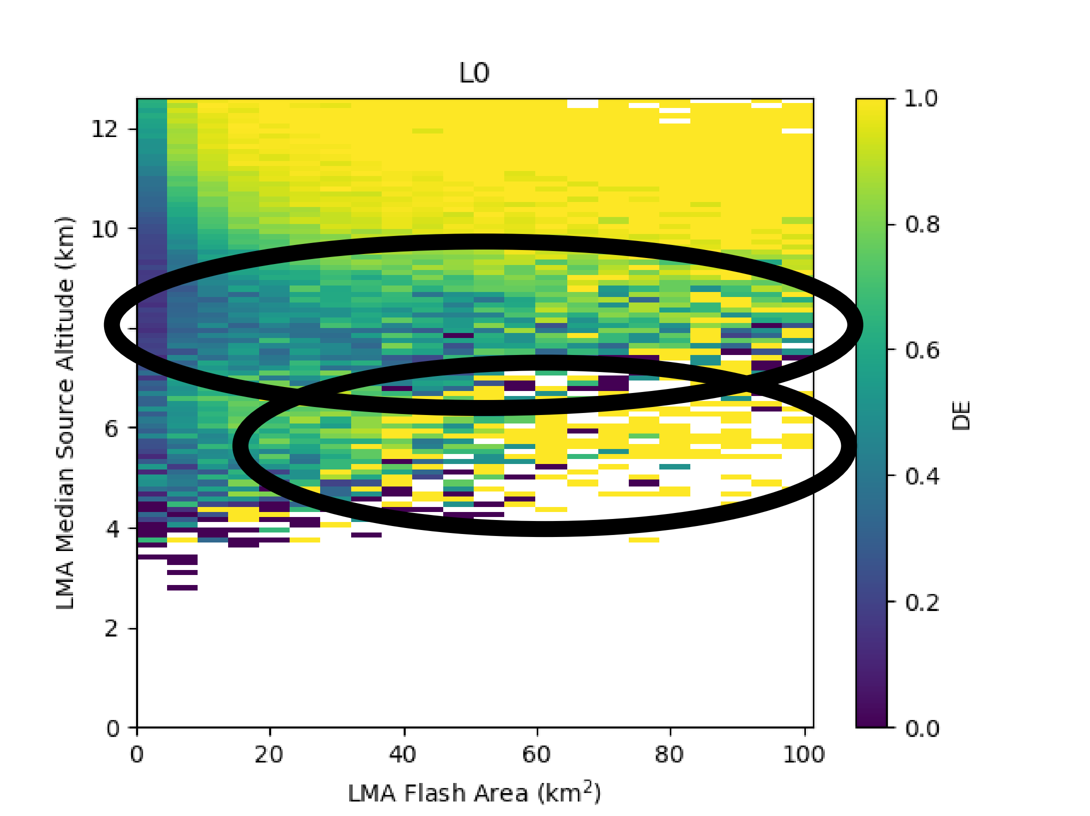
Consistent with previous results,
DE improves (significantly) with increasing flash size.

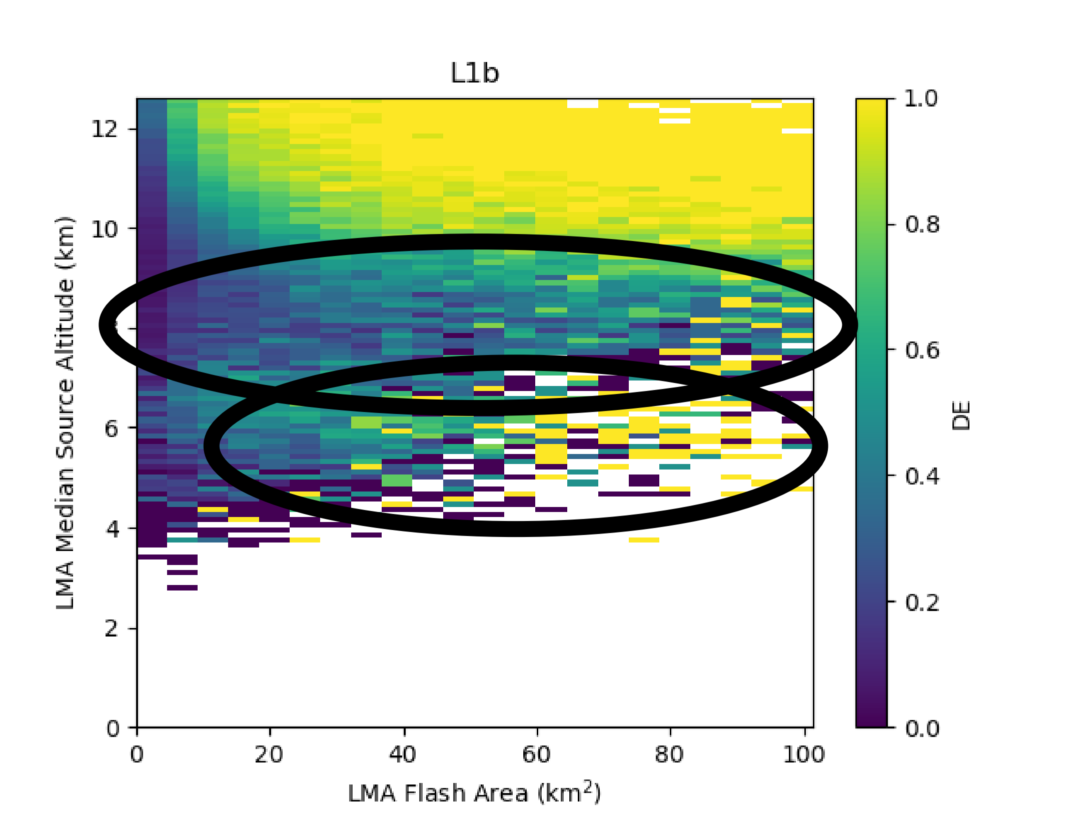
20181214 – High Flash Rate Storm



L0 detects more flashes during times when L1b struggles

20181214 – High Flash Rate Storm

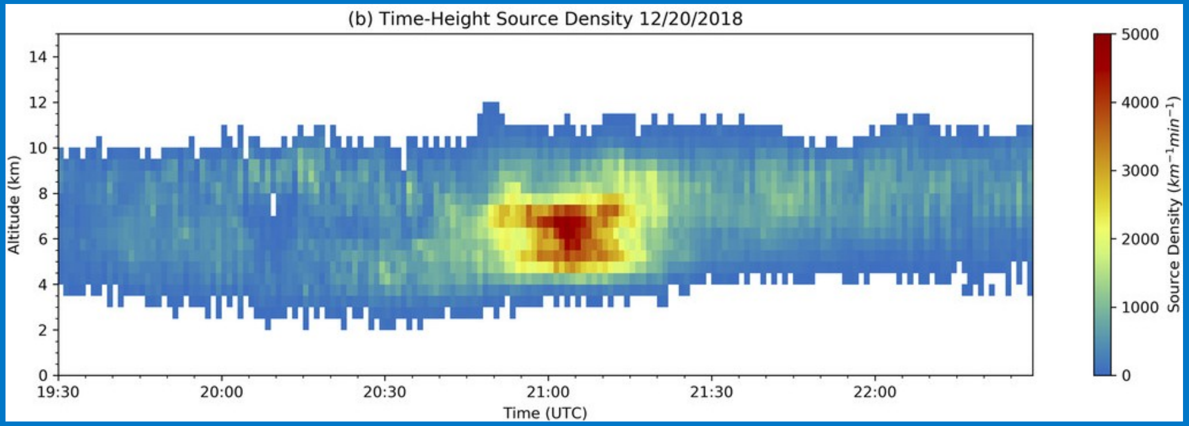


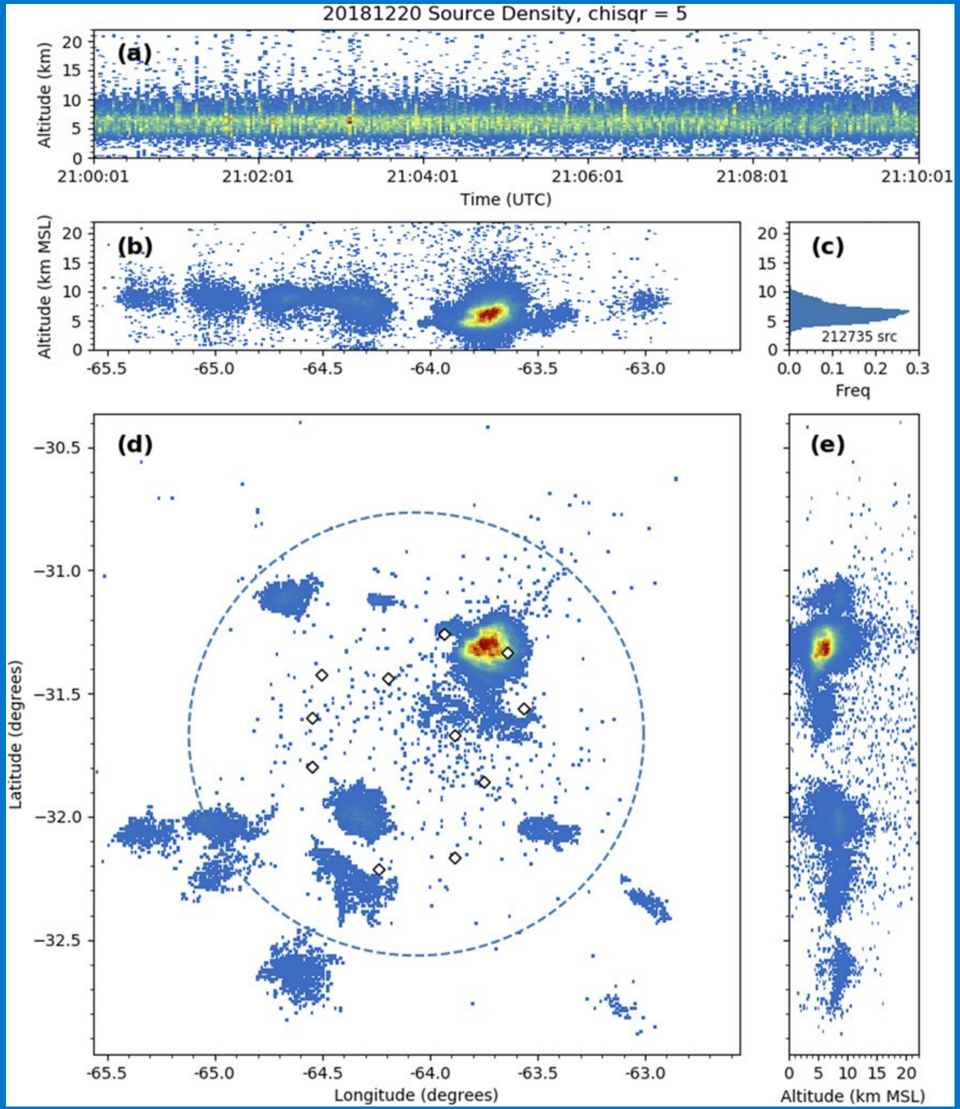


While there is a dependence of DE on flash area and altitude, it is not linear. Very little light is detected for small flashes at all altitudes.

20181220 – Anomalous Storm

- Dec 20, 2018 17Z-2359Z
  - Anomalous charged storm (likely) with max flash rate ~ 250/min
  - Almost 140 000 flashes detected
  - LMA source altitude mode at 4-8 km
  - Analyzed in Lang et al., 2020





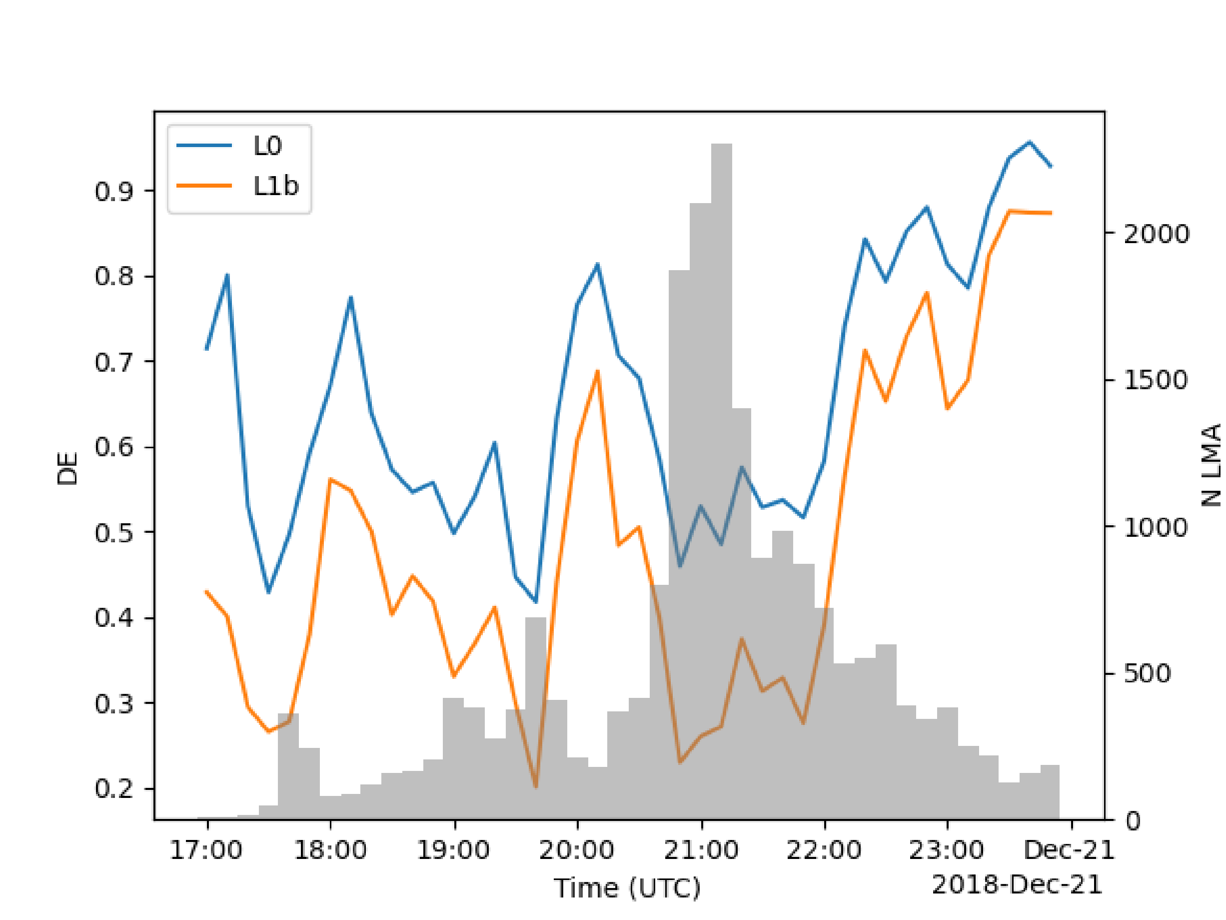
20181220 – Anomalous Storm

Area (km2)	Num LMA Flashes	Num GLM – L1b	DE – L1b	Num GLM – L0	DE – L0
All	135956	62897	0.463	87888	0.646
> 8	69687	46506	0.667	57190	0.821
> 16	43893	32775	0.747	38191	0.870
> 32	24274	19961	0.822	22192	0.914
> 64	11940	10494	0.879	11304	0.947
> 100	7133	6430	0.901	6840	0.959

Again, there is almost a 20 percentage point improvement in DE!

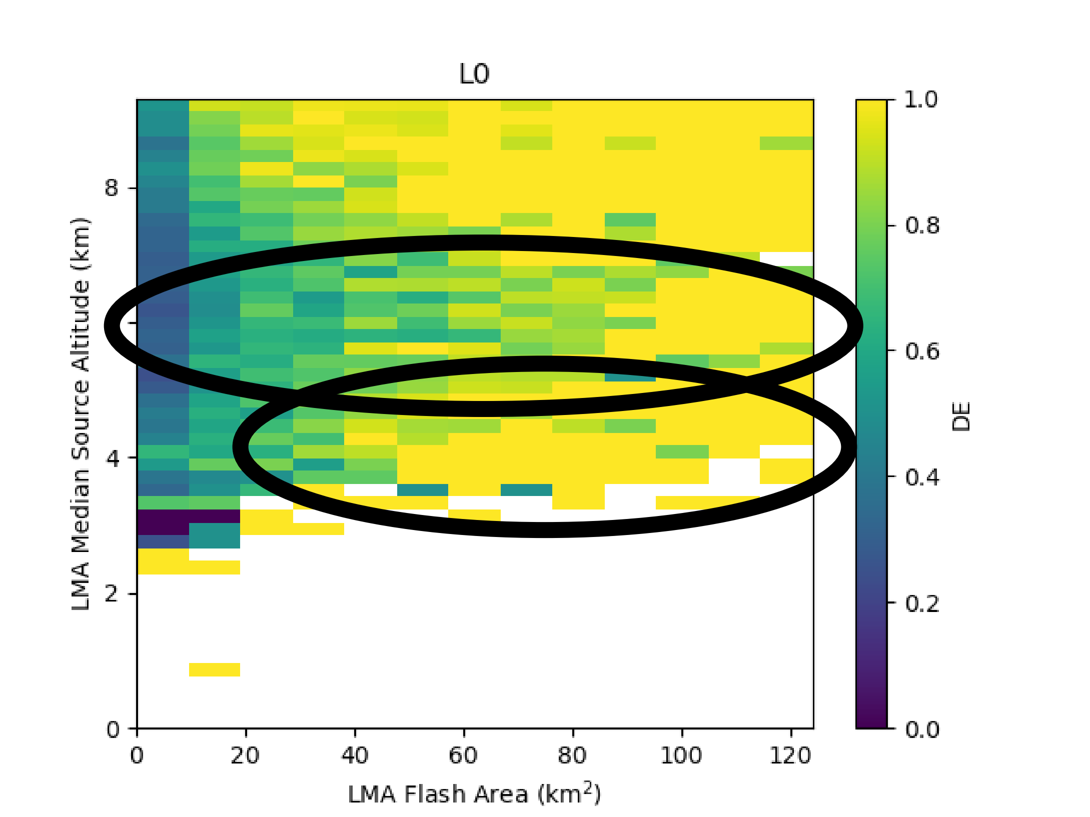
There are decreasing gains with increasing area.

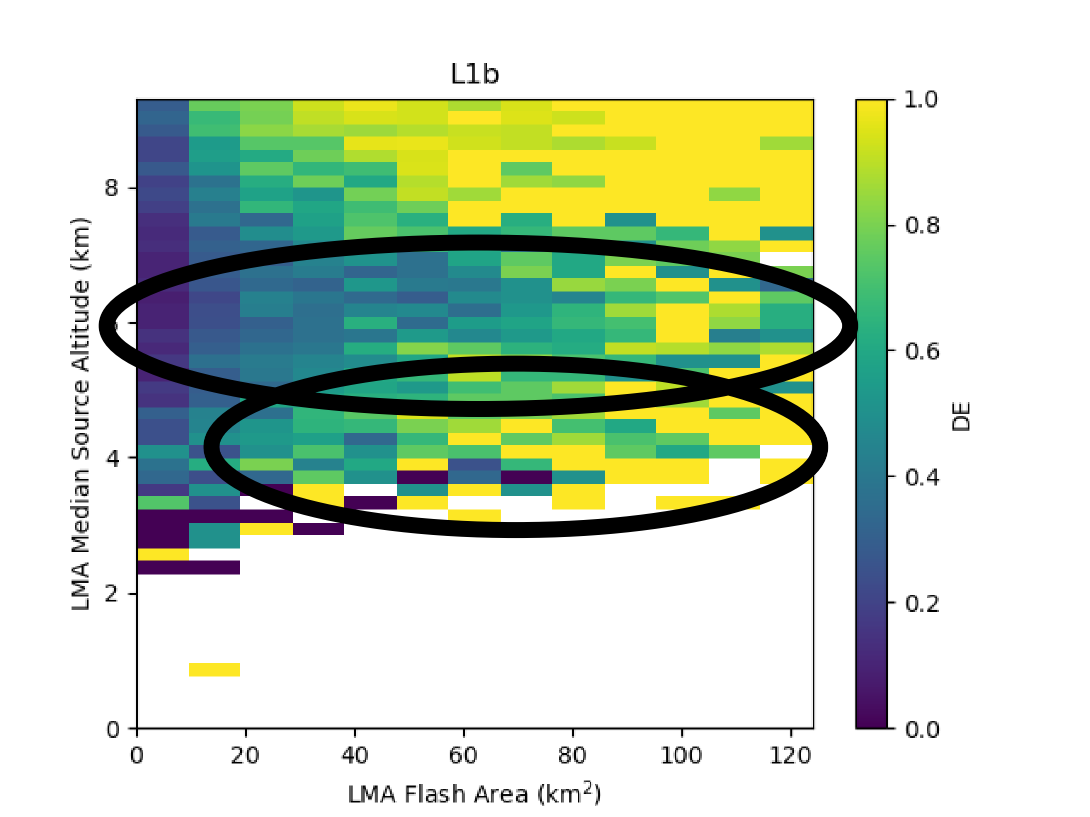
20181220 – Anomalous Storm



L0 detects more flashes during times when L1b struggles

20181220 – Anomalous Storm





While there is a dependence of DE on flash area and altitude, it is not linear. Very little light is detected for small flashes at all altitudes.

Loss Fraction: 1- DE (L0)/DE (L1)

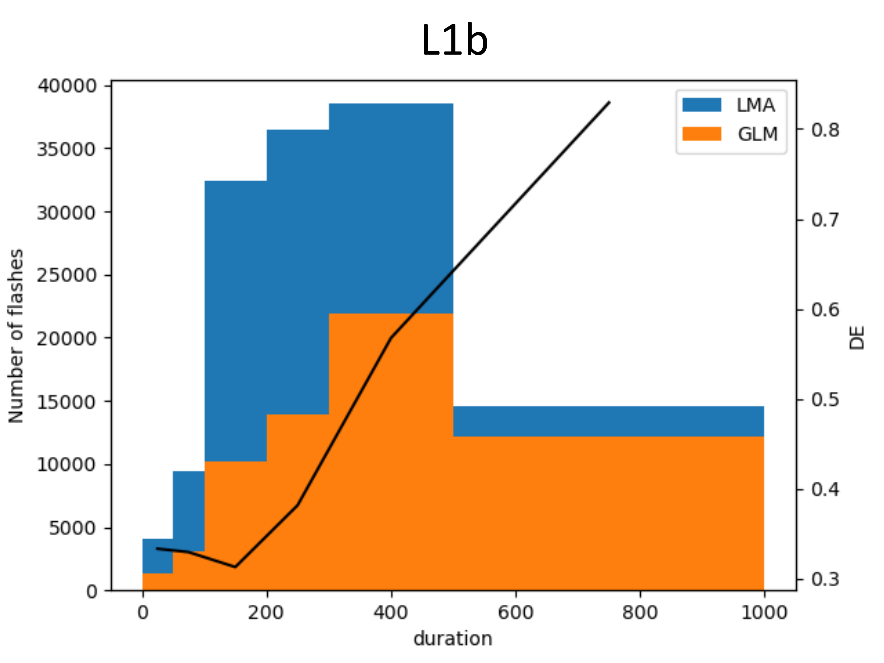
- Another way to thing about it is: how much performance is “thrown out” by ground processing?

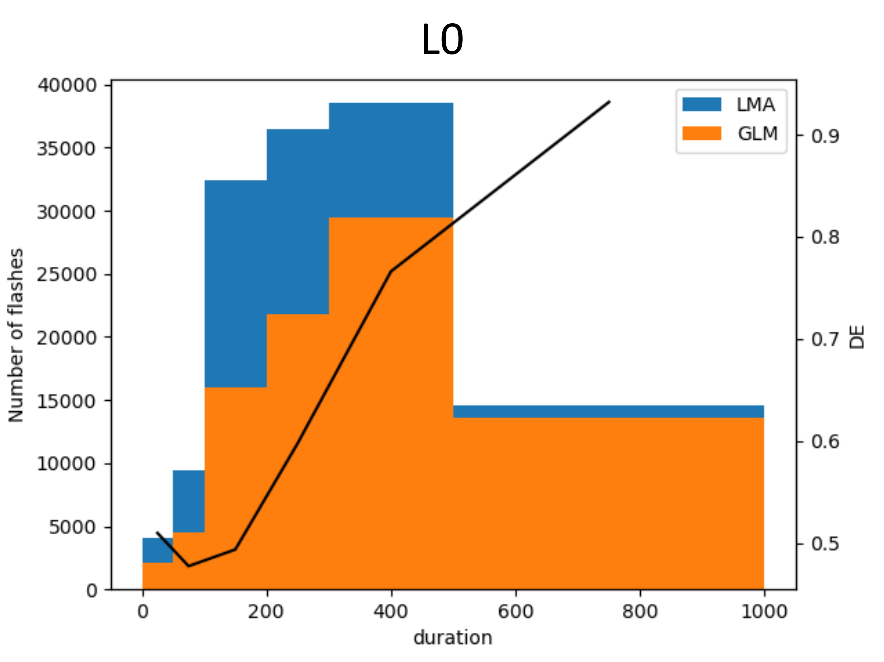
Area (km2)	DE L0	DE L1b	Delta DE	Loss Fraction
All	0.637	0.451	0.186	0.292
< 8	0.807	0.645	0.162	0.200
< 16	0.861	0.728	0.133	0.155
< 32	0.912	0.812	0.101	0.110
< 64	0.950	0.878	0.071	0.075
< 100	0.964	0.907	0.057	0.059

Almost 30% of flashes are filtered by ground processing!

Does duration of the flash matter?

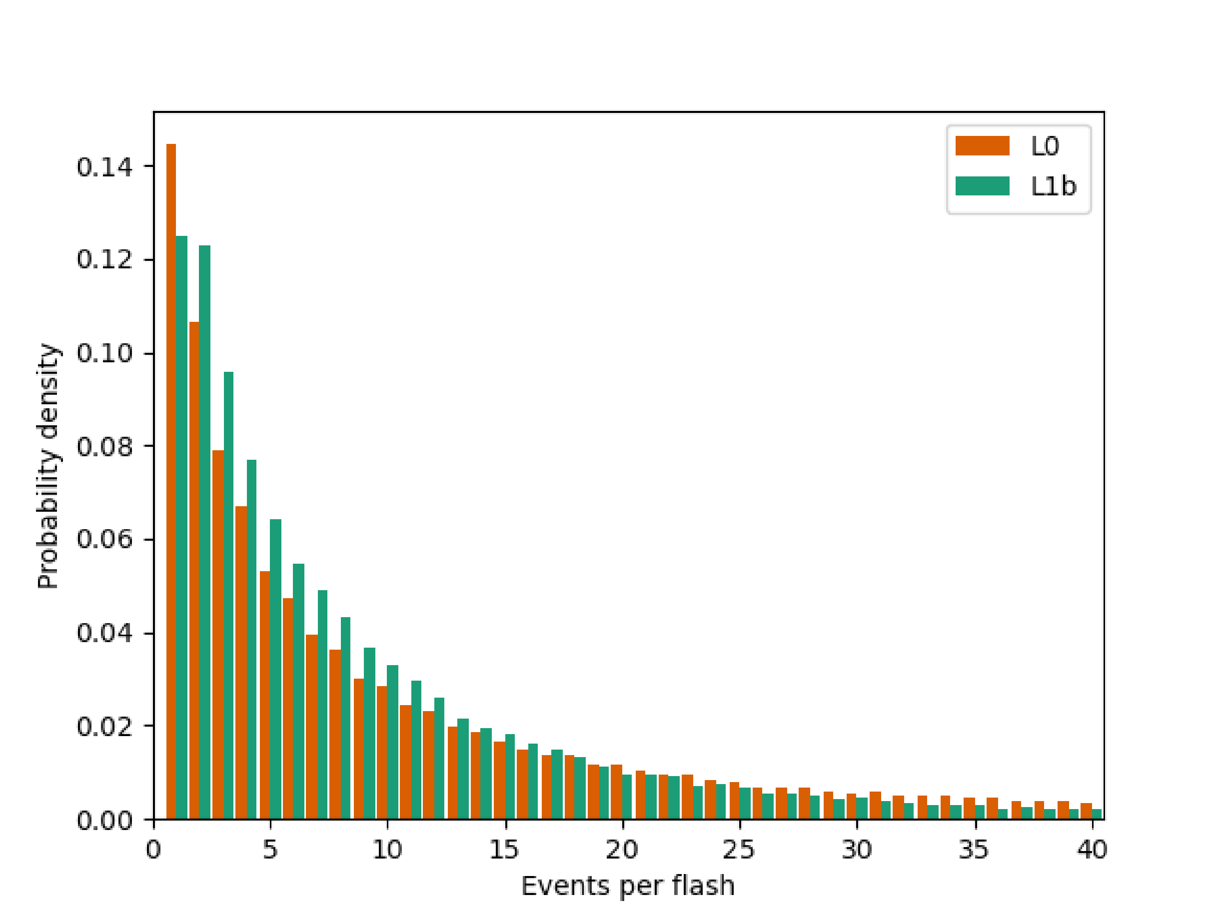
- The L0 detections are slightly better at short duration flashes…
- …but the biggest improvement is among 100-500 ms flashes.
  - Note the L1b result is slightly different from Zhang and Cummins (2020), which showed a monotonic increase of DE with flash size.
- Begs the question: is L0 just picking up single event flashes?





Does L0 matching pick up noise?

- Although unlikely, an event during the time of a flash, an event in the spatial footprint of the flash could be due to noise.
- However, the distribution of events per flash doesn't change appreciably.
  - Since we're detecting more smaller/shorter flashes, some shift to fewer events/flash is expected
- But since the distribution is largely similar, the L0 detections are not just single events detected during longer flashes!



Ground processing affects DE!

- Current ground processing throws out almost 30% of flashes that the GLM *instrument* detects.
- If the detected light during these flashes were correctly (not) filtered, then it leads to a nearly 20 percentage point improvement in detection efficiency.
- The largest gains are realized with small flashes.
- The distribution of events per flash does not change appreciably.
- Also to note: On average, L0 detects flashes about 30 ms earlier that L1b (median: 5 ms).

The next steps

- So, if the GLM instrument is detecting light during flashes, but current ground processing are not classifying it correctly, then there is an opportunity to improve the end product.
- Current testing of a new operational-type algorithm (i.e., satisfying ordering and latency requirements) shows at least a few percentage points improvement even in these difficult storms
  - Anomalous storm 39% -> 45% overall
  - Note: current iteration is unoptimized - more improvements to be realized!
- See Clem’s talk Thursday!