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UTILITY OF USING GEOSTATIONARY LIGHTNING MAPPER (GLM) LEVEL 0 DATA PRODUCTS FOR METER-SIZE AND LARGER IMPACTORS.

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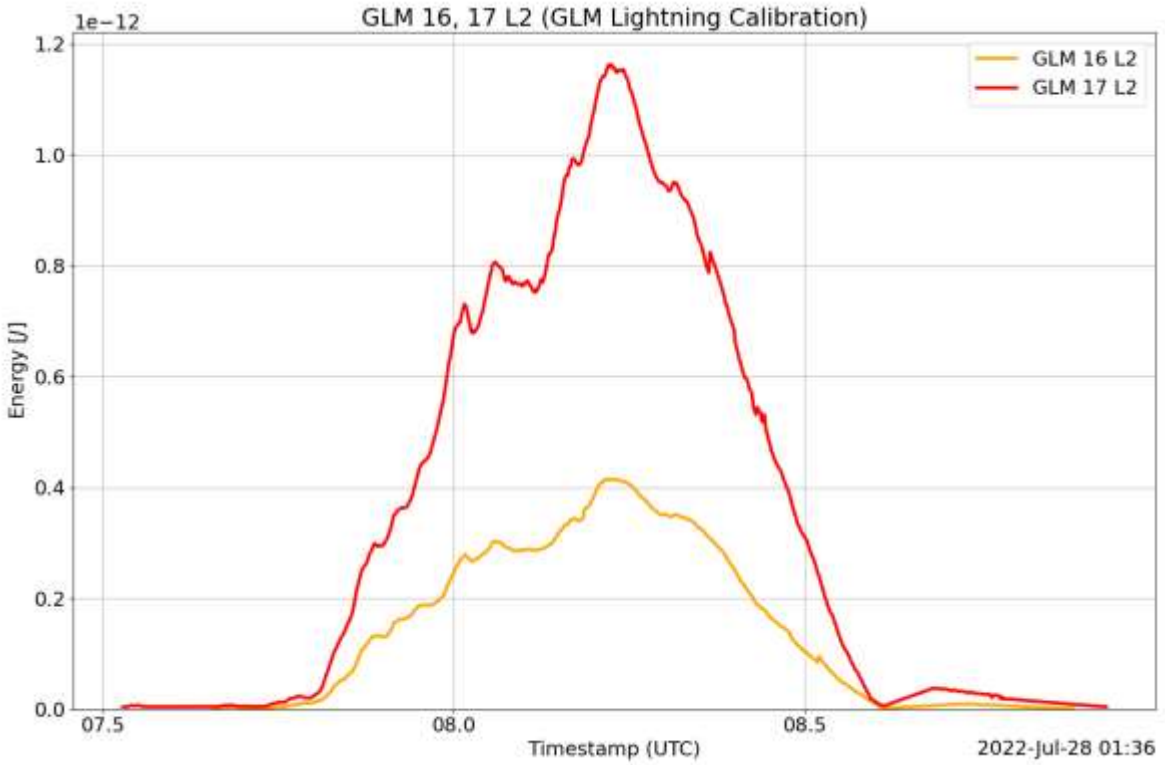
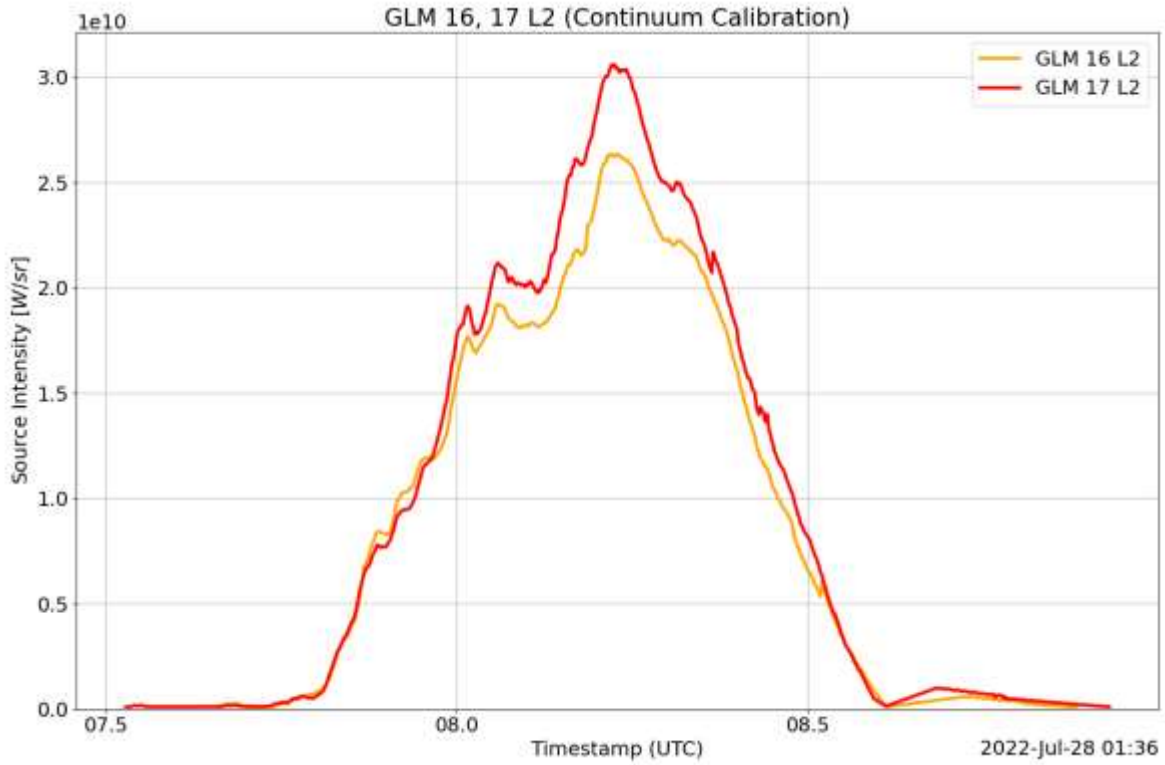
OVERVIEW

- Jenniskens et al (2018) have shown that the GLM sensors onboard GOES-East and GOES-West satellites are able to detect bolides.
- GLM can also geolocate and provide light curves (albeit in a narrow bandpass near 777nm)
  - The time intensity recording of a bolide impact and disintegration is referred to as a 'light curve'
- Recently the US Space Force has released decades of bolide light curve data recorded by USG sensors to supplement the already existing fireball data set public on the CNEOS-JPL fireball website.
  - USG sensors are broadband silicon with spectral range from ~400nm to 1200nm (Tagliaferri et al, 1994)
- We can now compare GLM signals against independently-observed light curves generated by a USG sensor system that also provides and estimate of peak intensity (W/sr) and total radiated energy (J).
  - Direct comparisons are made possible by applying a unique GLM look up table for continuum radiation developed by Lockheed Martin Advance Technology Center (LMATC)
- This work demonstrates comparisons between L0, L2, and USG data for selected bolide events.
- GLM ground processing, namely L1b and L2, have significant impacts on light curve reproduction for bolides.

WHY DO WE NEED TO RECALIBRATE?

- GLM processing is focused on reproducing lightning energy information (see plot to left), which is only partially useful for bolides.
  - To resolve bolide radiation, we need to re-calibrate GLM data in the context of a broadband emission.
  - Lockheed Martin have provided continuum calibration tables to estimate Source Intensity of signals at a pixel level (see plot to right).





THE RTEP: HARDWARE LEVEL ERRORS IN BOLIDE DATA

RTEP PROCESSING FILTER

- Recall that the GLM focal plane is divided into 56 sub-arrays (see plot to right).
- Each sub-array is processed by a Real Time Event Processor (RTEP).
- When a single pixel is triggered at a high energy for a long period of time, the RTEP can “spill over” to pixels above or below it.
  - In general, the “spill over” moves equatorward.
- This presents a quirk of GLM for use with bolides: is it moving east-west, or north-south? This matters!

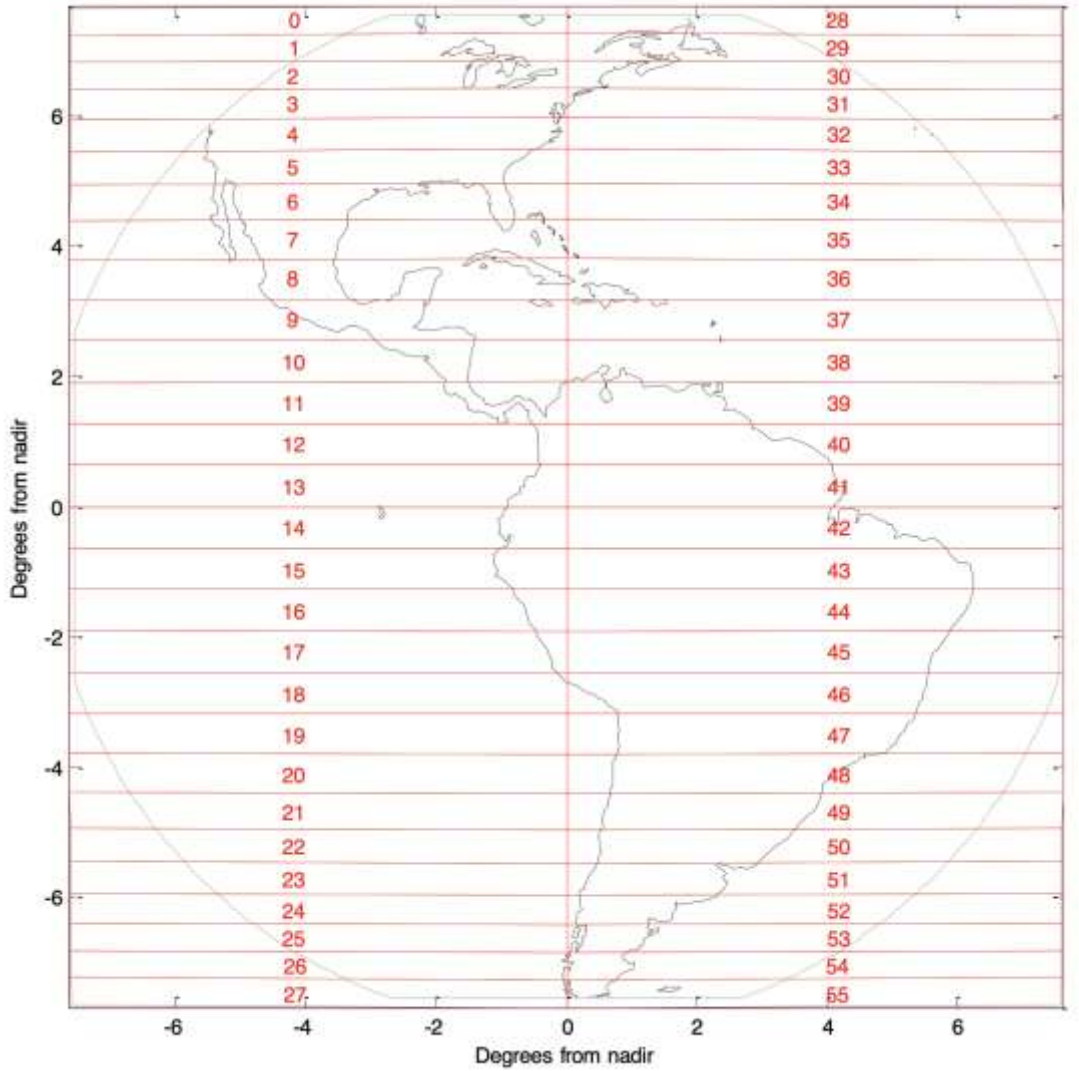
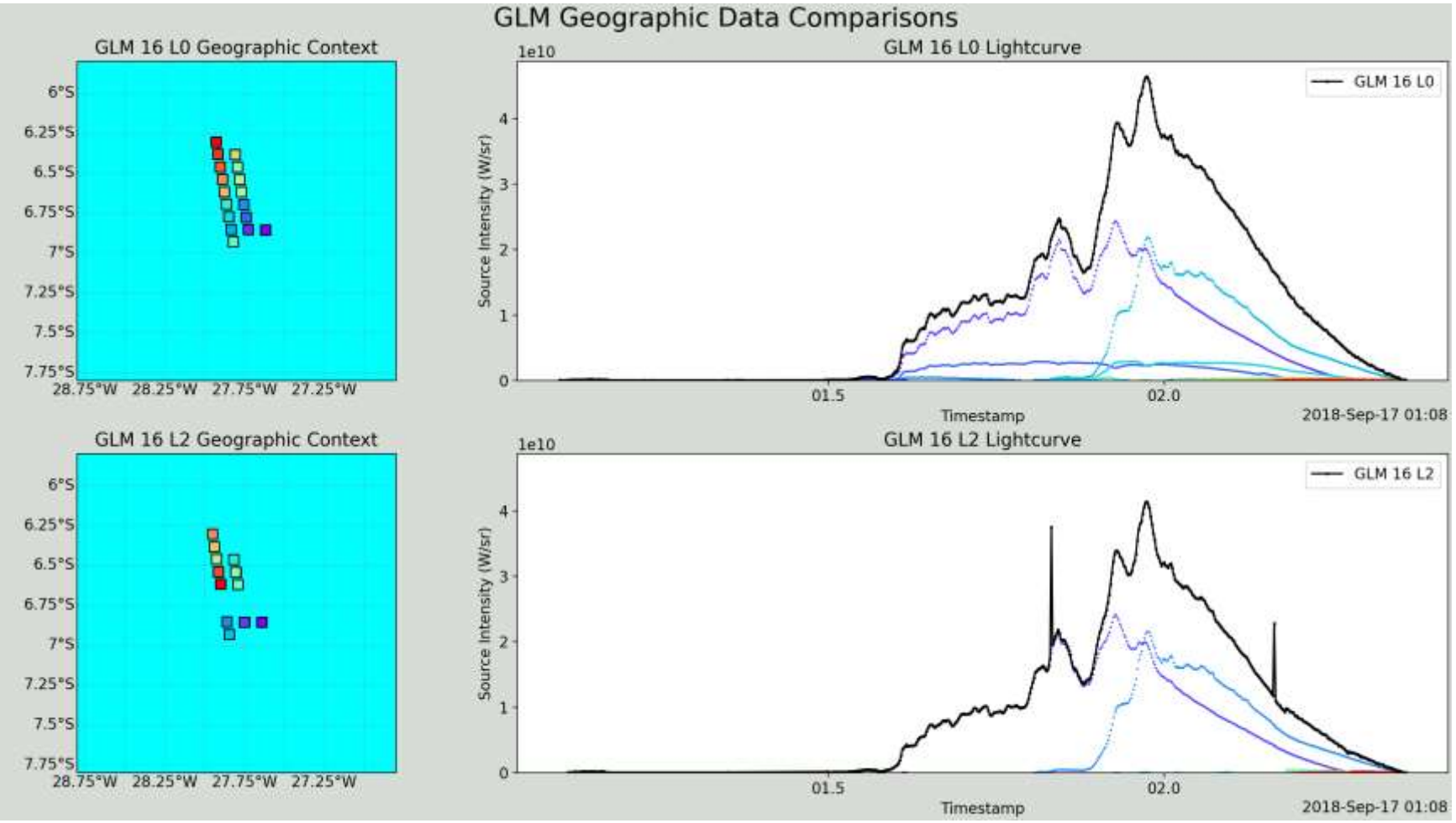


Figure 3: GLM pixel sub-arrays and typical geographic coverage of each sub-array. *GOES-R Series Data Book.*

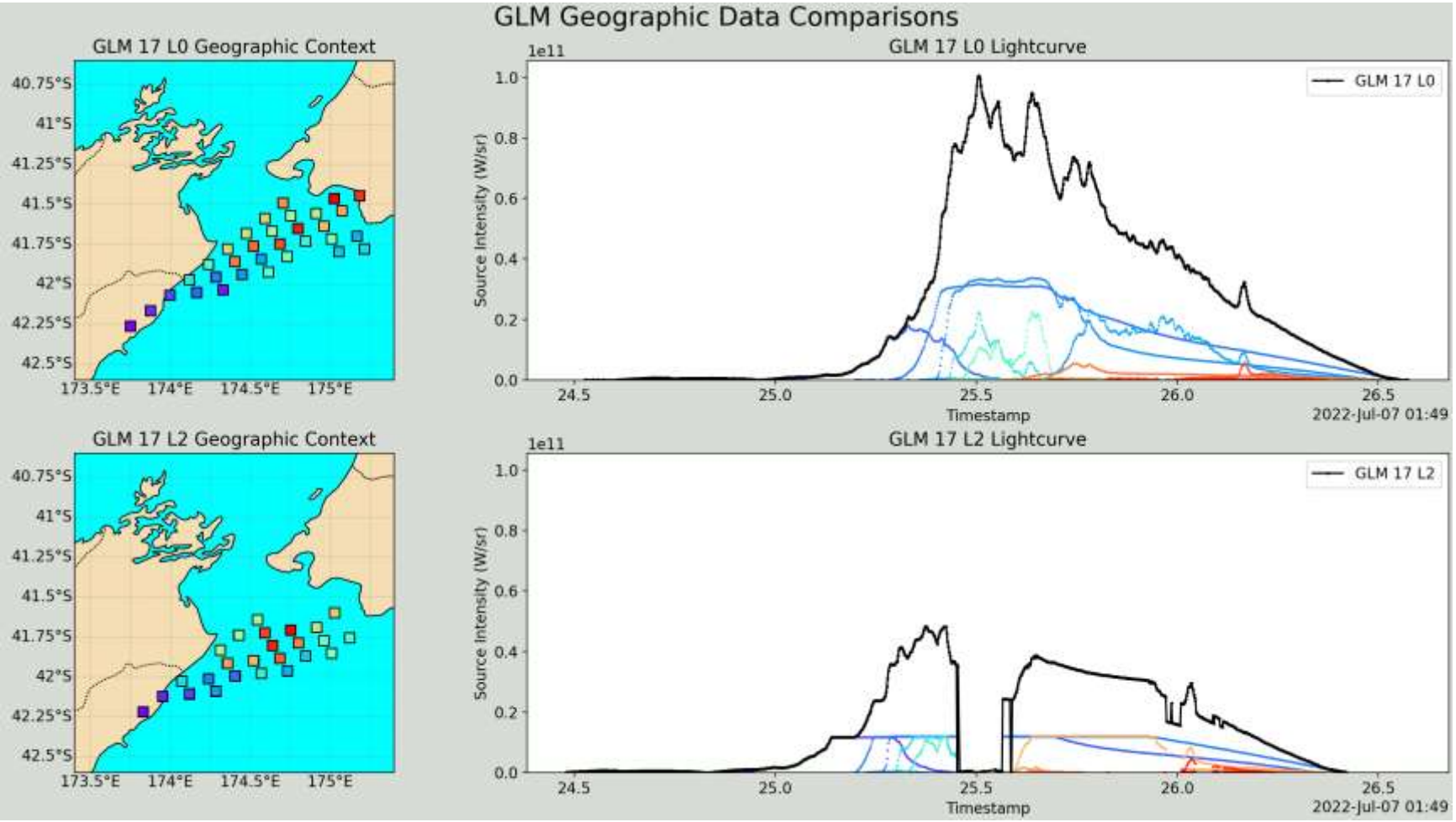
BOLIDE 2018-260 (GLM 16) – AN EAST-WEST EXAMPLE



- September 17th, 2018 at 01:08 UTC.
- Around 6.8S, 27.8W (GLM 16).
- L0 slightly higher response compared to L2
- L2 has some oddities.
- L0 selection considers more pixels, which may explain difference between L0 and L2.
  - GLM Group processing removes pixels in L2 that are retained in L0.

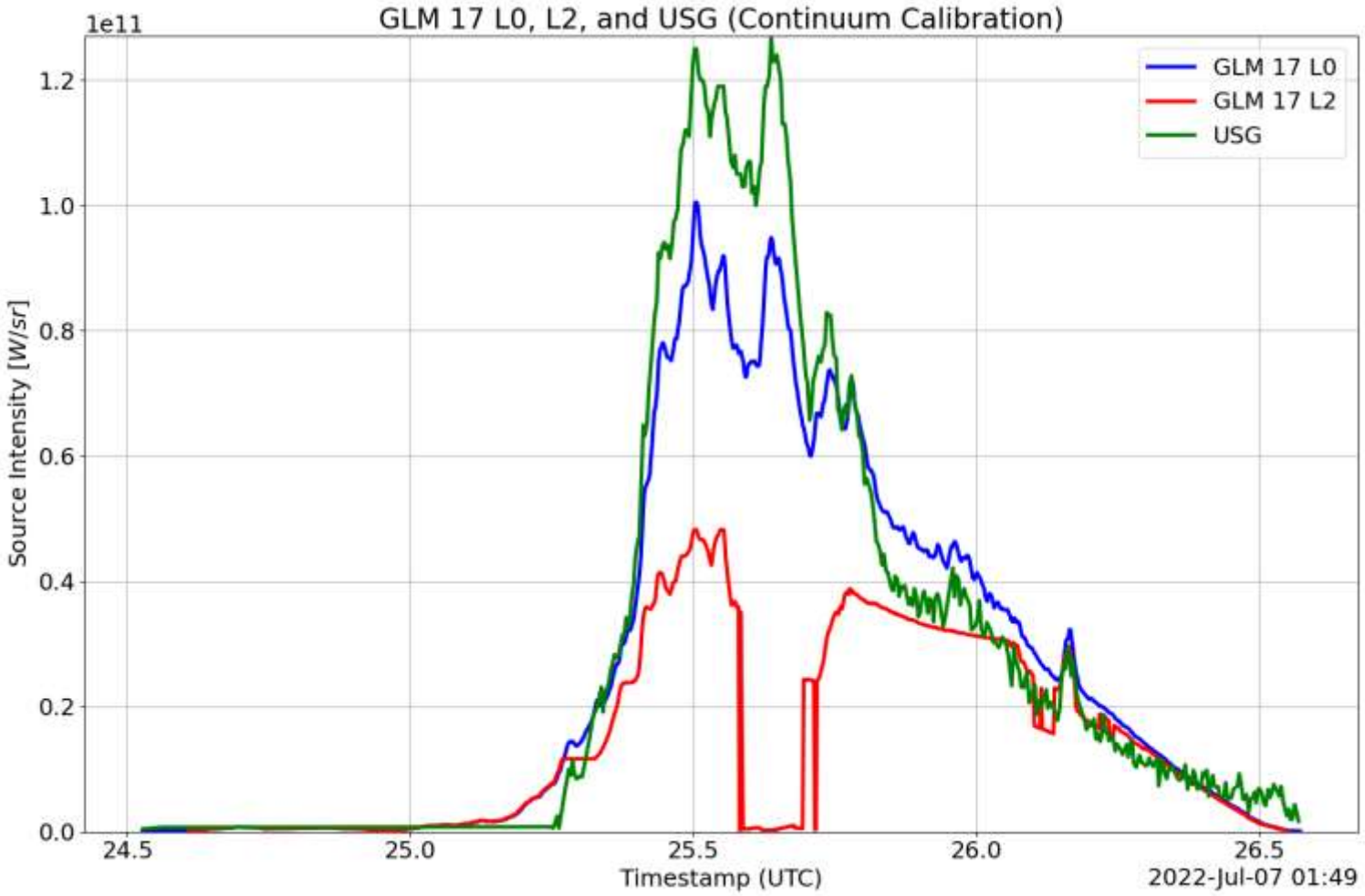
L2 DATA ENCODING ARTIFACTS: 16 BIT INTEGERS

BOLIDE 2022-188 (GLM 17) – HOW BAD CAN IT BE?



- July 7th, 2022 at 01:49 UTC
- Around 42S, 173.75E (GLM 17)
- L2 processing has removed a large portion of the light curve compared to L0
- Many pixels show the flat-top response artifact.
- These “flat tops” are the result of the 16 bit integer being registered as “-1”, which set the pixel data to the maximum value instead

HOW BAD IS IT?



- In this case, it's clear that L0 is the way to go.
- L2 ground processing appears to mangle half the light curve or more.

	L0	L2	USG
Total Integrated Energy [J]	66.721×10^{10}	35.922×10^{10}	65.020×10^{10}
Peak Brightness [W/sr]	10.053×10^{10}	4.827×10^{10}	12.7×10^{10}
Estimated Impact Energy [kt]	1.625	0.939	1.588

SUMMARY

- GLM clearly useful for bolides!
- Pixel selection matters, L2 processing can make some significant changes to individual pixel energy response.
  - Ground processing algorithm remove pixels from L2 data that L0 shows as worthwhile, but L2 can be more selective using group and flash clustering.
- USG is a good comparison, even with differences in measurement.
  - Keep in mind that USG isn't measuring the same thing (broadband), and USG processing isn't the same as GLM.
  - With that said, good comparisons throughout, and one can potentially inform the other.
- Key takeaways:
  - When we see something interesting, we go hunting - and GLM can help track things down.
  - If you want to use GLM for bolides, start with L0 if you can.
  - If you can't use L0, look for some telltale signs of L2 processing artifacts (large chunks eaten out of light curve, flat top pixel responses, etc.).