GLM Gridded Product Description

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The Geostationary Lightning Mapper (GLM) Level 2 files contain more information than many users need, much of which can be provided more efficiently via gridded products. The ground system produces GLM files every 20 seconds that report the locations and characteristics of all recorded lightning events, groups, and flashes. The GLM developers anticipated many derived products, so these 20 second files include nearly all conceivable information that can be conveyed efficiently. However, the L2 data are produced as points, resulting in a loss of information concerning the spatial extent of events, groups, and flashes. Pixel adjacency information (index on the CCD focal plane) is also absent in the L2 data, preventing the use of the native focal plane grid in defining the gridded product. A new gridded GLM product restores and disseminates the spatial footprint information implicit in the GLM data while greatly reducing file size. Users will benefit from bandwidth savings of at least a factor of 10 and likely closer to a factor of 100 while gaining a product that is readily visualized, separately or atop ABI data, with no further processing.

The GOES-R program funds Texas Tech University to develop gridded GLM products. Tools have been developed to produce gridded products by removing the effect of the lightning ellipsoid and re-navigating the GLM event latitude and longitude to the Advanced Baseline Imager (ABI) fixed grid. After navigation to the fixed grid, a corner point lookup table is used to create event polygons. Parent-child relationships are used to combine the event polygons into group and flash polygons. Then, these polygons are subdivided at the flash, group, and event levels by slicing them with the ABI fixed grid. The final step accumulates and weights the sliced polygons at the flash, group, and event levels to create several gridded products on the 2×2 km ABI grid. These tools are being tailored to the real-time processing requirements and display format needs of the National Weather Service (NWS) operational environment. NWS machines will host the initial real-time implementation while developers determine a permanent home.

As noted above, the gridding procedure also removes a lightning ellipsoid height assumption, and this step will greatly simplify the GLM training and use. The initial requirements were for the GLM to navigate the observations to the ground location below an assumed cloud top height. Therefore, the L2 data are projected onto an ellipsoid that varies in elevation from 6 km at the poles to 16 km at the equator. In practice, there are differences in the assumed and actual cloud top heights leading to position offsets that forecasters would need to adjust for with respect to ground-referenced data such as radar and ABI. The gridded product ensures registration of the GLM data to the ABI data, mitigating this challenge.

Polygon clipping techniques allow use of any prescribed grid and several were explored. The 2×2 km ABI grid was selected by considering both the computational performance and visual display. Matching the nominal GLM resolution of 10 km results in some bleed-over of detections across grid cells. An extremely fine grid resolution (< 0.5 km) would precisely outline the GLM pixel footprints, but would be computationally wasteful. Therefore, we have settled on a 2×2 km grid, which balances the representation of the pixel footprint shapes and computational cost. It also matches the resolution of many ABI products.

Gridded Product Description and Justification

Only the first product listed will be initially deployed to the NWS (flash extent density – FED), while the other products will be demonstrated to select forecasters to document the value added and justify their eventual inclusion. Once proven useful, a new gridded product will be rolled out every 2-3 months (with proper training) for the next year. The final temporal resolution(s) remain(s) to be determined.

1. Flash extent density (Initial NWS Product) – Many years of research and operational demonstrations using Lightning Mapping Array (LMA) data have demonstrated that the flash extent density (FED) is the preferred total lightning product (e.g., versus the much sparser flash centroid density or point displays). FED best portrays, in a single product, the quantity and extent of GLM flashes and events, and training language concerning its interpretation and utility is mature.

2. Average flash area – The average flash area has been shown to vary by storm mode and environment. Researchers have shown that knowledge of the average flash size can be used to make inferences regarding supercell lifecycles and convective/stratiform partitioning.

3. Total energy – The total energy reveals the total optical energy detected for each lightning feature, and therefore is most like what the human eye would detect while watching a storm. No other instrument can produce such information so it will be the first product of its type to be demonstrated to forecasters. While counts are easily interpreted, a product in physical units is preferable for science applications and relationships. This has potential to revolutionize the way forecasters use lightning data (e.g., using brightness to make inferences regarding cloud structure).

4. Event density – The event density is equivalent to group extent density and serves as the base for the other higher order parameters. It adds information to flash extent density by showing how frequently each part of a cloud is illuminated.

5. Average group area – The average group area can help reveal sub flash scale features that can provide additional insights into convective storm processes. For example, studies have shown long, propagating flashes to be more common in the trailing stratiform regions of mature MCSs, and large GLM groups have been shown to be more likely to have struck ground.

6. Flash centroid density – The flash centroid density is most similar to gridded density products provided by the ground-based lightning detection networks (NLDN, ENTLN). This tool will help with the transition between the ground- and satellite-based lightning datasets, and can be easily summed over a region to get a total flash rate (e.g., for a storm cell).

7. Group centroid density – The group centroid density is similar to the gridded stroke density products provided by select ground-based lightning detection networks (e.g., GLD360, WWLLN). This tool will help with the transition between the ground- and satellite-based lightning dataset, and like flash centroid density, can be summed over a region to give a total rate of optical pulses.

8. Quality product – The quality product is a placeholder for the wealth of quality information available in the ground system and/or being accumulated and formalized during the cal/val process. Initially it will use the event, group, and flash level quality flags as well as other quality information now or expected to be available to provide an informative, information-rich bit mask for each pixel in the target grid (e.g., distinguishing known glint regions from CCD blooming).

Figures 1 and 2 provide examples of the GLM gridding process. The next/final page provides samples of five gridded products at 0515 UTC on 4 January 2018 (centroid density and quality products are too sparse for visualization at this scale). There is a large flash in the southwestern-most cell and higher flash rates (up to 14 in flash extent density) in another cell. The differences in each of these products illustrate that they emphasize different characteristics of the lighting dataset which can then be related to a broader understanding of the convective-scale meteorological processes.

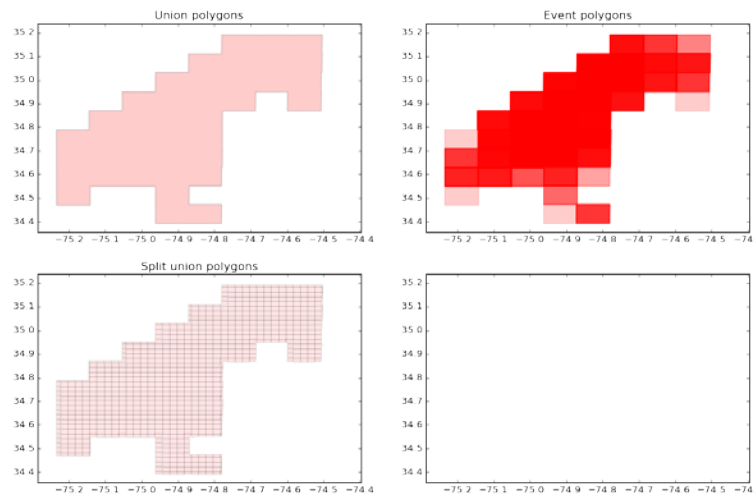


Figure 1: GLM event polygons (upper right) from a single flash, their union into a single flash polygon (upper left) and the subdividied flash polygon (lower left) after slicing by the target grid. The lower right panel is blank by intention. Axis labels are latitude and longitude, but the actual gridded product would be defined in fixed grid coordinates.

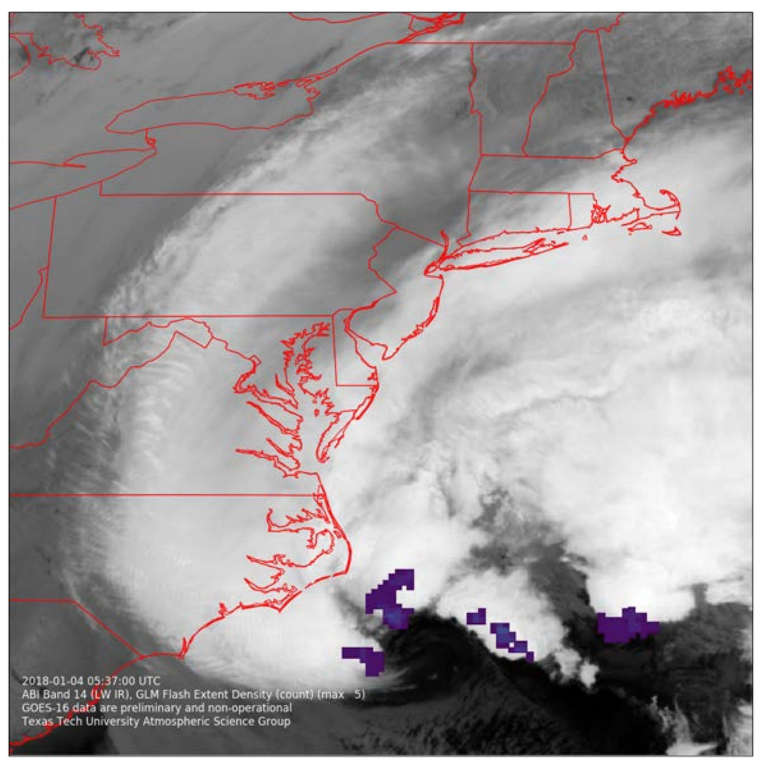
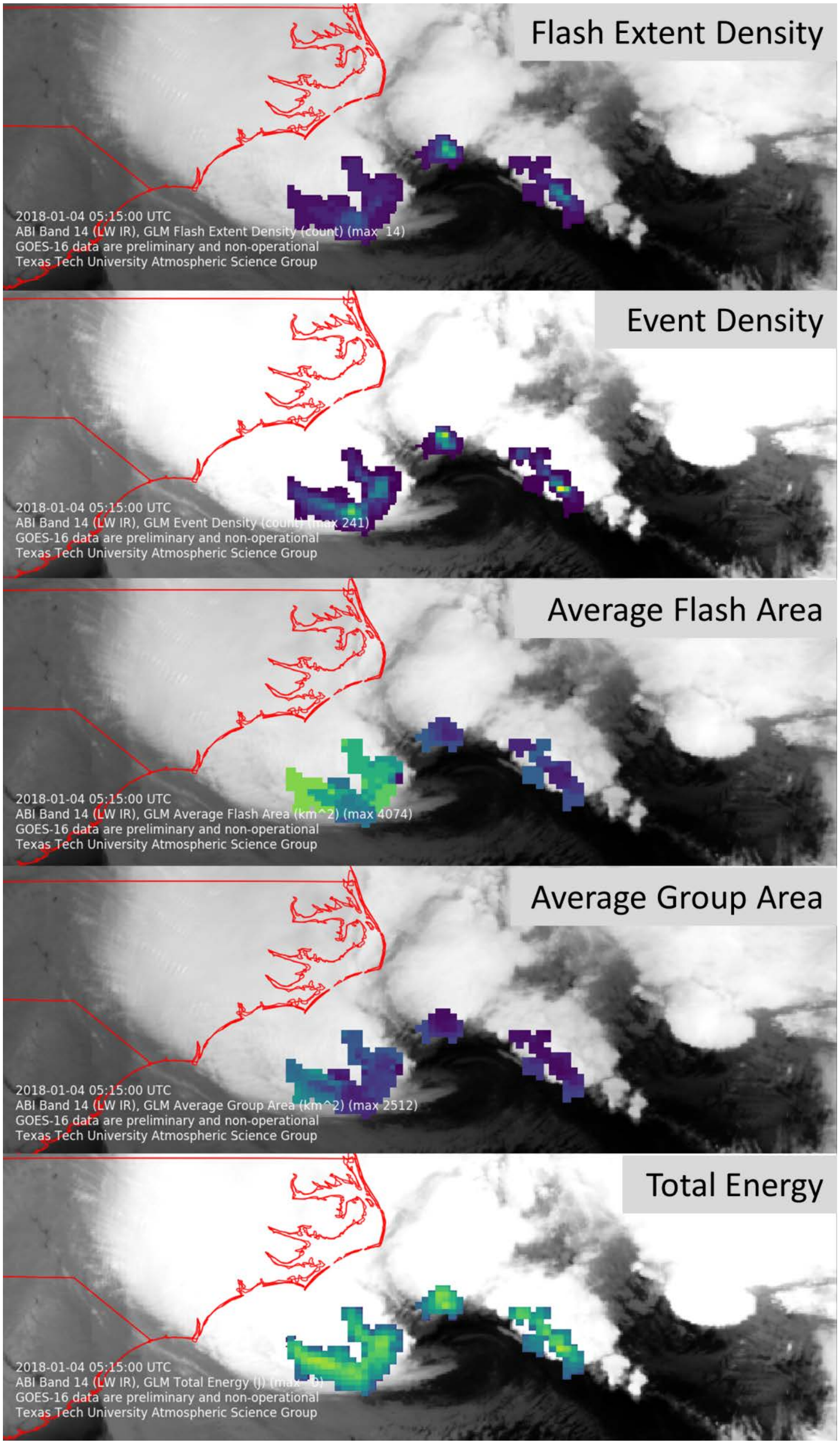


Figure 2: Flash extent density on the 2 km ABI fixed grid for the minute beginning 0537 UTC on 4 January 2018 overlaid on an ABI mesoscale sector (band 14 shown). The flash from Figure 1 is in the northwestern-most cloud with lightning. Most pixels had only one flash, but pixels with as many as five flashes are visible with close inspection of the image.


Flash Extent Density
2018-01-04 05:15:00 UTC
ABI Band 14 (LW IR), GLM Flash Extent Density (count) (max 14)
GOES-16 data are preliminary and non-operational
Texas Tech University Atmospheric Science Group
Event Density
2018-01-04 05:15:00 UTC
ABI Band 14 (LW IR), GLM Event Density (count) (max 241)
GOES-16 data are preliminary and non-operational
Texas Tech University Atmospheric Science Group
Average Flash Area
2018-01-04 05:15:00 UTC
ABI Band 14 (LW IR), GLM Average Flash Area (km^2) (max 4074)
GOES-16 data are preliminary and non-operational
Texas Tech University Atmospheric Science Group
Average Group Area
2018-01-04 05:15:00 UTC
ABI Band 14 (LW IR), GLM Average Group Area (km^2) (max 2512)
GOES-16 data are preliminary and non-operational
Texas Tech University Atmospheric Science Group
Total Energy
2018-01-04 05:15:00 UTC
ABI Band 14 (LW IR), GLM Total Energy (J)
GOES-16 data are preliminary and non-operational
Texas Tech University Atmospheric Science Group