

**GOES-16 GLM Level 2 Data
Full Validation Data Quality**
November 21, 2018

**Product Performance Guide
For Data Users**

**William Koshak¹, Douglas Mach², Monte Bateman²,
Pete Armstrong³, Katrina Virts¹**

¹ NASA Marshall Space Flight Center

² Universities Space Research Association

³ MIT Lincoln Lab

1. INTRODUCTION

The Geostationary Lightning Mapper (GLM, see Figure 1) on the Geostationary Operational Environmental Satellite Series-R (GOES-R) is the first of its kind for operations in GEO. The overarching objectives of GLM are to: (1) provide continuous, full-disk lightning measurements for storm warning and nowcasting, (2) provide early warning of tornadic activity, and (3) accumulate a long-term database to track decadal changes of lightning.

GLM is a high-speed nadir-staring optical (near-IR, 777.4 nm) camera Charge Coupled Device (CCD) imager (1372 x 1300 pixels) with uniform spatial resolution (8 km at nadir, 14 km at the edge of its field-of-view). Its coverage is approximately ± 54 degrees in latitude, and it monitors lightning activity 24/7 at a 2 ms frame rate across the Americas and adjacent oceanic regions. Total GLM downlink data rate is 7.7 Mbps, with a product latency requirement of under 20 s.

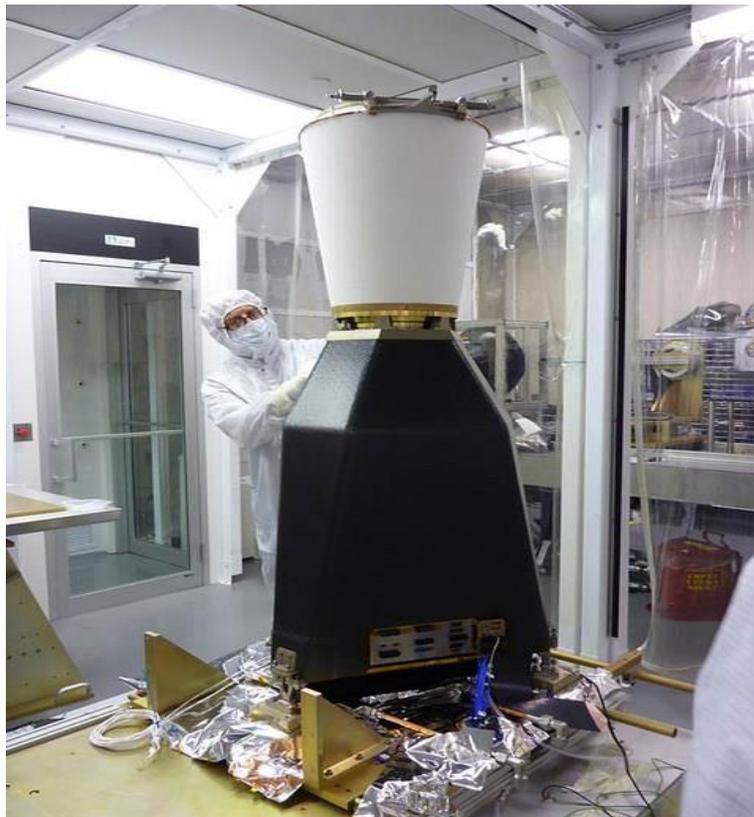


Figure 1. The Geostationary Lightning Mapper (GLM).

For the benefit of the user community, this document summarizes the key performance and existing issues of the GOES-16 GLM Level 2 (L2) data product that were found at the time of the Full Validation Peer/Stakeholder-Product Validation Review (PS-PVR) on November 1, 2018. Additional information relevant to understanding the GLM L2 product, the performance

requirements, and the methodologies for validating requirements are provided in the Product User's Guide (PUG) [1], the Mission Requirements Document (MRD) [2], and the Readiness, Implementation and Management Plan (RIMP) [3]. In order to obtain the most favorable results from the L2 lightning product, users are expected to use the data quality flags described in the PUG (e.g., flash_quality_flag values, and others), and to be aware of existing anomalies and planned improvements identified in this document. Users are also encouraged to contact the GLM calibration/validation scientists (william.koshak@nasa.gov; dmach@nasa.gov) to report anomalies or suggest improvements.

The remainder of this section introduces some of the key characteristics of the GLM L2 product and a timeline of the GLM product validation process. Section 2 compares the measured on-orbit GLM L2 product performance to mission requirements and the predicted Performance Baseline. Section 3 describes remaining issues within the GLM L2 products, and the process toward mitigating them. Finally, Section 4 provides a brief summary.

1.1 GLM Product Description

The GLM L2 product consists of three elements:

- *Events*: pixel-level optical detection in one frame.
- *Groups*: one or more (side/corner) adjacent pixel detections in one frame.
- *Flashes*: one or more groups within 330 ms (i.e., interstroke duration) and within 16.5km.

For each event, group, or flash, the GLM L2 product file includes a location (energy-weighted location for events and groups), coverage area (for groups and flashes), time information, and amount of radiant energy. The L2 data files are broadcast every 20 seconds to meet the latency requirement. More information on the data files can be found in the Product User's Guide [1].

1.2 GOES-16 GLM Production Validation Timeline

On November 19, 2016, the first GOES-R Series satellite was launched. After successful orbit insertion by November 29, GOES-R became GOES-16. After outgassing, the GLM instrument was turned on, and a series of Post-Launch Tests (PLTs) were then conducted to verify that the instrument was functioning properly and that products were being produced as expected. Before the end of the PLT activity, Post-Launch Product Tests (PLPTs) were then conducted to perform "deep-dive" evaluations of the GLM L2 product performance using a broad collection of independent reference lightning datasets. Following the PLTs/PLPTs, a Peer Stakeholder–Product Validation Review (PS-PVR) for Beta Maturity was conducted on June 9, 2017. The review chair declared that the GOES-16 GLM L2 products reached the Beta Maturity, which means that:

- Product is made available to users to gain familiarity with data formats and parameters (via GRB)

- Product has been minimally validated and may still contain significant errors
- Product is not optimized for operational use.

To provide additional fixes (i.e., primarily to mitigate noise and some location errors), the L2 data was not released to the GOES Rebroadcast (GRB) until July 5, 2017.

Follow-on instrument adjustments and PLPTs were conducted (the PLPTs began on December 20, 2017 following a drift to East park, and 7 day INR averaging). This led to the successful achievement of Provisional Maturity on January 19, 2018, which means that:

- Product performance has been demonstrated through analysis of a small number of independent measurements obtained from select locations, periods, and associated ground truth or field campaign efforts.
- Product analysis is sufficient to communicate product performance to users relative to expectations (Performance Baseline).
- Documentation of product performance exists that includes recommended remediation strategies for all anomalies and weaknesses. Any algorithm changes associated with severe anomalies have been documented, implemented, tested, and shared with the user community.
- Product is ready for operational use and for use in comprehensive cal/val activities and product optimization.

On November 1, 2018, the final GOES-16 GLM L2 PS-PVR was held. The review concluded that the GLM L2 product has reached the Full Validation Maturity per GOES-R Program, which means that:

- Product performance for all products is defined and documented over a wide range of representative conditions via ongoing ground-truth and validation efforts.
- Products are operationally optimized, as necessary, considering mission parameters of cost, schedule, and technical competence as compared to user expectations.
- All known product anomalies are documented and shared with the user community.
- Product is operational.

2. KEY PERFORMANCE

This section provides a comparison between the measured on-orbit GLM L2 product performance with MRD requirements and the Performance Baseline predictions. The Performance Baseline is a prediction of the on-orbit product performance compiled by a team at MIT/Lincoln Labs based on vendor reports and pre-launch test data. Before this comparison is provided however, it is important to note the following over-arching validation principles since GLM is a new instrument (transient detector) unlike typical imaging instruments. The principles can be summarized as follows:

- **Targets of Opportunity (TOO):** VAL of a Lightning Sensor differs from VAL of typical imager; i.e. since lightning transient, VAL is restricted to TOO.
- **Flash DE is an Estimate:** Determination of Flash detection efficiency (DE) is only an estimate because reference data normally doesn't detect all lightning.
- **Source Physics:** GLM detects in the optical (near-IR) and many of the reference datasets are in the RF. [e.g., Lightning Mapping Arrays (LMAs) see discharge breakdown in the VHF that might not show up in optical → "apple/orange" comparison].
- **Source Scattering:** Optical is cloud-scattered, but cloud is transparent to radio. So often see GLM detections near cloud edges where no radio sources.
- **ISS/LIS and FEGS are Critical:** Since many independent lightning reference networks operates in the radio, it is critical to obtain optical (i.e., "apple/apple") comparison w/GLM. The optical measurements provided by the International Space Station Lightning Imaging Sensor (ISS/LIS) and the aircraft Fly's Eye GLM Simulator (FEGS) make this possible.

2.1 Performance Baseline Mapping

Tables 1 and 2 summarize the Mission Requirements that were directly validated by the PLPTs (see [3] for a detailed discussion of each PLPT).

MRD	Parameter	MRD Value	Perf. Baseline (Model)	Related PLPTs
1259	Production Mapping Accuracy [INR]	5 km (= $ \mu+3\sigma $ < 140 μ rad)	Nav error (7 d averaging) of 89.4 μ rad for GOES-E	-011, (also -001, -002, -003, -004, -005, -006)
1260	Product Measurement Range	(0-41900 evts/s, 0-8170 grps/s, 0-600 flsh/s)	Instr Vendor showed can handle peak 100 Kevts/s (600 flsh/s)	-009, -010 (also vendor results)
1261	Product Measurement Accuracy	70% total flash detection efficiency (DE)	Instr. Side: BOL* Primary: 81% Redundant: 83%	-001, -002, -003, -004, -005, -006, -009, -010
1264	Product Measurement Precision	5%	Open, with Flight reporting FAR ~0.12%, but open WRs on GS implementation loss	-001, -002, -003, -004, -005, -006, -009, -010

Table 1. The association of MRD values and Performance Baseline values. *BOL = Beginning of Life with reduced flash DE by ~6% due to Coherency Filter removing 1st group in flash.

PORD	Parameter	PORD Value	Related PLPTs
094	GLM Navigation Error	4 km (= $ \mu+3\sigma < 112 \mu\text{rad}$)	-011
098	Event Time Tag Accuracy	1 ms	-001, -002,-003, -004, -005, -006

Table 2. The association of PORD values and PLPTs [4].

2.2 Performance Summary

Finally, Tables 3 and 4 summarize the performance of the GOES-16 GLM L2 relative to the mission requirements and predicted performance baseline. Because the GLM noise filtering has not been fully optimized (and will not until the DO.08.00.00 software build expected to go operational in mid-2019), the flash false alarm rate (FAR) presently exceeds the 5% requirement.

MRD	Parameter	MRD Value	Performance Baseline (Model)	Performance Result			
				VaLiD	LATA	INR	Mach SIT
1259	Production Mapping Accuracy	5 km (= $ \mu+3\sigma < 140 \mu\text{rad}$)	89.4 μrad	n/a	3 km	101.5 ^{&} μrad (3.6 km)	n/a
1260	Product Measurement Range	(0-41900 evts/s, 0-8170 grps/s, 0-600 flsh/s)	100 Kevts/s (600 flsh/s)	n/a	n/a	n/a	verified *LCFA can handle above max rate spec
1261	Product Measurement Accuracy	70% total flash detection efficiency (DE)	81%	78%	n/a	n/a	n/a
1264	Product Measurement Precision	5% (flash FAR) [also MRD 639 which states same 5% value]	Open, with Flight reporting FAR ~ 0.12%, but open WRs on GS implementation loss	<u>22%</u>	n/a	n/a	n/a

Table 3. A summary of the GOES-16 GLM L2 performance results relative to MRD requirements and the Performance Baseline. *LCFA = Lightning Cluster Filter Algorithm. [&]101.5 = 82+19.5 (see PLPT-GLM-011). MRD1259: 28 μrad per km.

PORD	Parameter	PORD Value	Performance Result	
			LATA	INR
094	GLM Navigation Error	4 km (= $ \mu+3\sigma < 112 \mu\text{rad}$)	n/a	3.6 km
098	Event Time Tag Accuracy	1 ms	-0.8 ms	n/a

Table 4. A summary of the GOES-16 GLM L2 performance results relative to PORD requirements. PORD 094: 28 μrad per km.

Note that both the flash detection efficiency (DE) and flash False Alarm Rate (FAR) vary spatially, diurnally, and seasonally. The DE and FAR values in Tables 3 and 4 represent a spatial average across the GLM FOV following the most recent Ground Segment software version DO.07.00.00 (operational October 15, 2018). A broader historical perspective of DE/FAR performance is provided in Tables 5 and 6; the SFGL2 (Software-Fixed GLM L2 data) in the last row is the DO.07.00.00 software version performance. Again, improvements in DE/FAR are anticipated in the DO.08.00.00 software build expected to become operational in mid-2019.

Period (2018)	GLM16 vs. GLD360			GLM16 vs. Combined Ground Networks		
	Flash DE	Flash DE (day)	Flash DE (night)	Flash DE	Flash DE (day)	Flash DE (night)
Jan	0.84	0.79	0.89	0.75	0.71	0.81
Feb	0.83	0.76	0.88	0.72	0.69	0.78
Mar	0.83	0.79	0.88	0.72	0.71	0.79
Apr	0.82	0.79	0.87	0.75	0.75	0.80
May	0.80	0.78	0.84	0.74	0.74	0.80
Jun	0.80	0.76	0.84	0.75	0.78	0.82
Jul	0.78	0.77	0.83	0.76	0.77	0.84
Aug	0.80	0.79	0.85	0.74	0.79	0.79
Sep	0.85	0.83	0.89	0.77	0.77	0.82
SFGL2 (Sep26-Oct24)	0.85	0.81	0.88	<u>0.78</u>	0.74	0.82

Table 5. Historical overview of DE performance.

Period (2018)	GLM16 vs. GLD360			GLM16 vs. Combined Ground Networks		
	Flash FAR	Flash FAR (day)	Flash FAR (night)	Flash FAR	Flash FAR (day)	Flash FAR (night)
Jan	0.31	0.33	0.25	0.25	0.29	0.19
Feb	0.35	0.36	0.28	0.28	0.31	0.22
Mar	0.35	0.34	0.28	0.28	0.29	0.21
Apr	0.35	0.32	0.29	0.25	0.25	0.20
May	0.38	0.38	0.33	0.26	0.26	0.21
Jun	0.35	0.33	0.30	0.25	0.22	0.18
Jul	0.33	0.33	0.29	0.24	0.23	0.16
Aug	0.34	0.30	0.30	0.26	0.21	0.21
Sep	0.29	0.29	0.25	0.23	0.24	0.18
SFGL2 (Sep26-Oct24)	0.27	0.30	0.22	<u>0.22</u>	0.27	0.18

Table 6. Historical overview of FAR performance.

Regarding lightning geolocation errors, a two-parameter ellipsoidal surface model is used to describe cloud-top height. The height of the ellipsoidal surface at the equator (e) and pole (p) are the two parameters, and by adjusting these one is able to reduce lightning geolocation errors. Recent adjustments demonstrate the improvement (i.e. Figure 2a location errors using parameter values $e = 16$ km, $p = 6$ km are improved using the values $e = 14$ km, $p = 6$ km shown in Figure 2b). In the future, a more flexible 3 degree resolution monthly grid model of cloud-top height will be implemented (two estimates of the errors associated with this method are provided in Figures 2c and 2d).

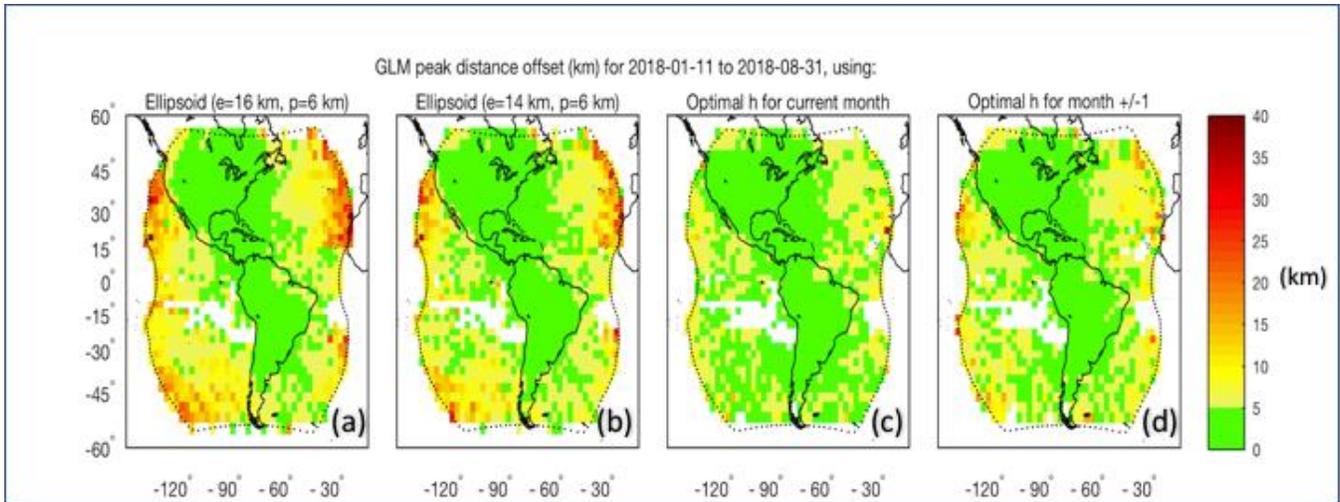


Figure 2. Location errors for different cloud-top height modeling. Plots a, b are current "lightning ellipsoid" approach; plots c, d represent a future model.

A summary of current lightning optical group location and timing errors are provided in Table 7.

Period (2018)	Peak Location Accuracy (km)	Peak Timing Accuracy (ms)
Jan	3.5	-0.6
Feb	3.5	-0.4
Mar	3.5	-0.6
Apr	3.0	-0.6
May	3.0	-1.0
Jun	3.0	-0.6
Jul	3.0	-1.0
Aug	3.0	-1.0
Sep	3.0	-0.6
Sep26-Oct10	<u>3.0</u>	<u>-0.8</u>

Table 7. Historical overview of location and timing errors.

3. EXISTING ISSUES FOR USER AWARENESS

The subsections below summarize existing issues, and indicate (if applicable) an Algorithm Discrepancy Report (ADR) reference number associated with the future software fix.

3.1 Flash Detection Depletion in NW CONUS

GOES-16 (and GOES-17) GLM L2 products show a notable depression in flash detection efficiency (DE) extending from the US Great Plains to the Pacific Northwest (see Figure 3), and the exact causes are presently still being examined. There is evidence to suggest that the instrument filter throughput decreases (as does pixel size) with increasing boresight angle, and this effect is particularly evident moving from nadir to the NW CONUS. In addition, it is known from independent studies that oceanic lightning is more energetic (hence more easily detectable) than lightning over land; hence, the NW CONUS is marked by both large boresight angle and land. By contrast, the far SW, NE, and SW quadrants of the GLM field-of-view are over ocean.

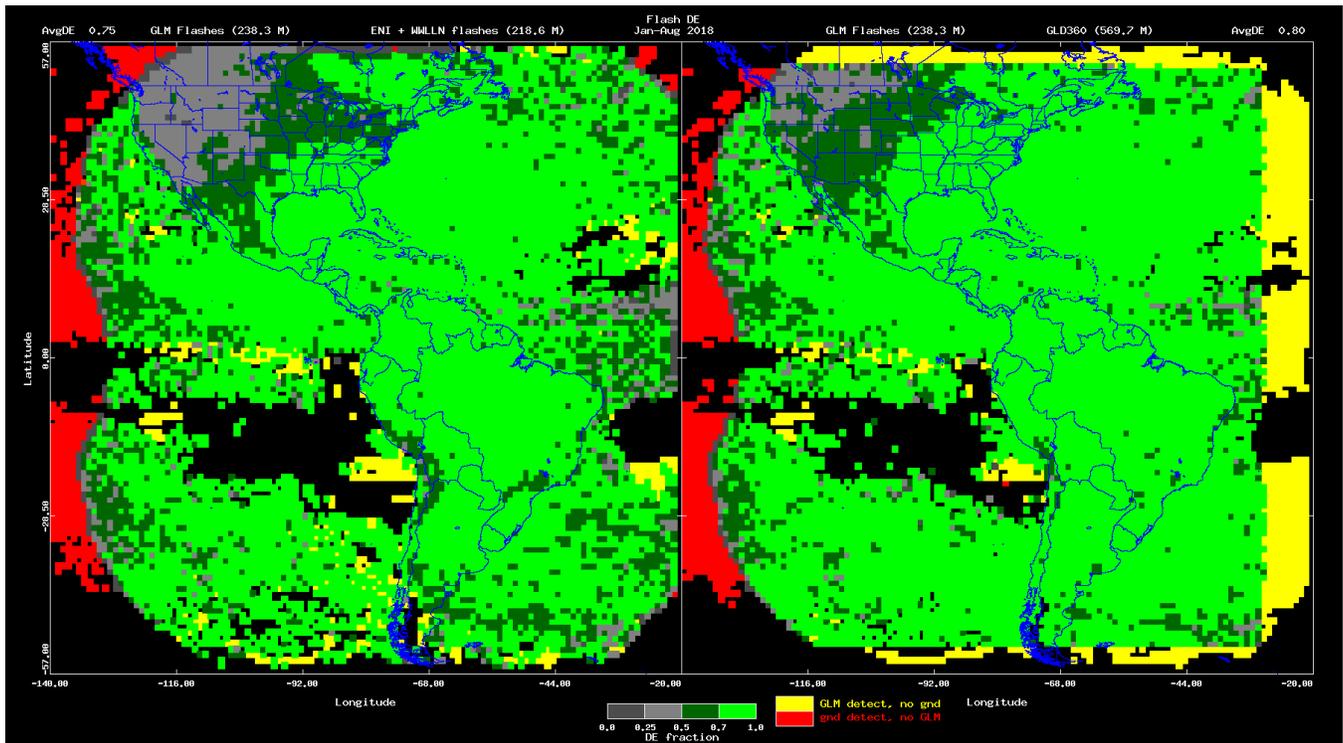


Figure 3. Depressed (grey, 25-50%) flash DE over NW CONUS region Jan-Aug 2018. Green is >70% DE. Left panel is 75% DE vs. ENTLN; Right panel is 80% DE vs. GLD360. ~240 million flashes.

3.2 Flash DE Depletion in Certain Storm Types

From a local perspective, there is evidence that the flash DE is substantially smaller in anomalous (i.e., inverted polarity) storms, and in severe (e.g., hail-producing) storms, or storms with deep liquid water path. In general, because the flash DE associated with reference data is

itself variable and typically below 100%, it is not always possible to exactly/unambiguously determine the GLM flash DE in all cases.

3.3 False Events

In this section we briefly summarize several sources of false events.

3.3.1 Solar Glint and Solar Intrusion (ADR 374, ADR 638):

Solar glint occurs from specular reflection off of lakes, rivers, and oceans. Sunrise and sunset leads to solar glint off the Atlantic and Pacific oceans, respectively, resulting in routine sunrise and sunset false events over predictable oceanic regions. Solar intrusion, which involves solar rays intruding directly into the GLM lens system (i.e., for relatively short periods during the eclipse season as shown in Figure 4) is also a source of false events.

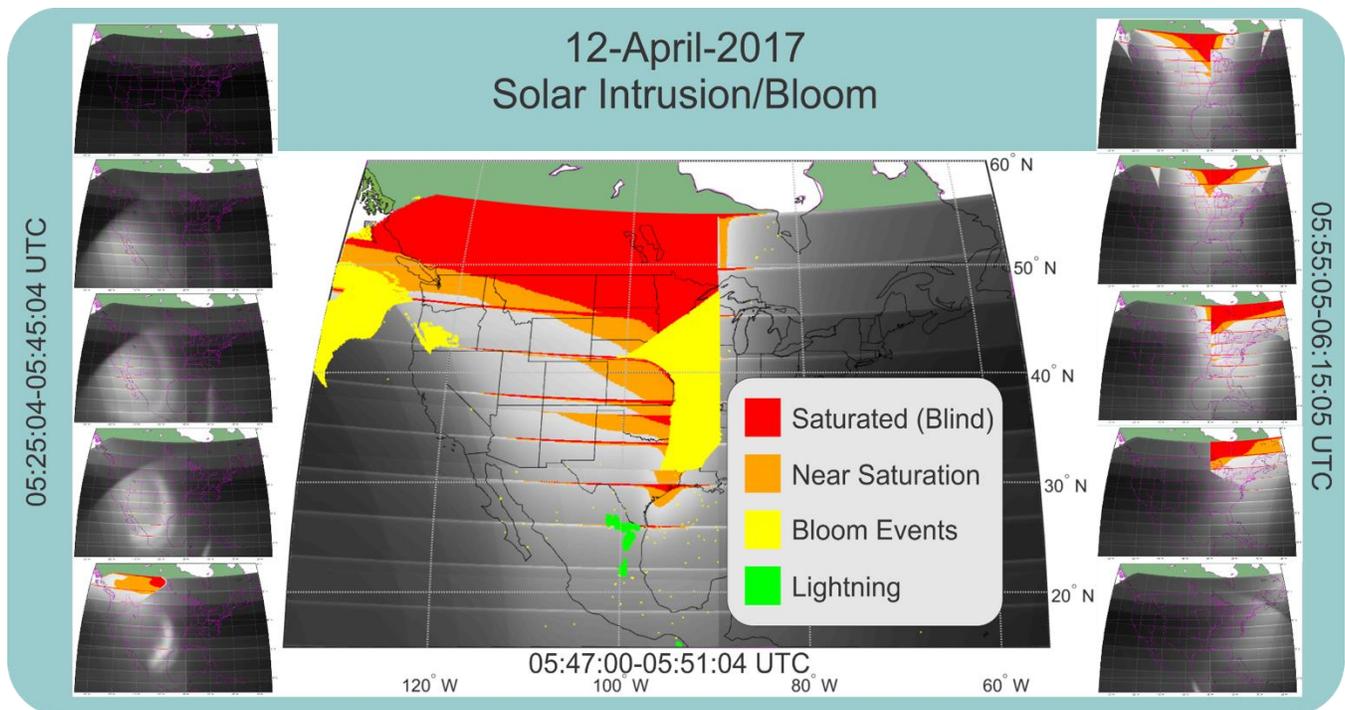


Figure 4. Solar intrusion false events during eclipse season; 5 min images shown.

A new blooming filter algorithm as part of ADR 374 has been developed and tested by the Instrument Vendor and will be delivered to the Ground Segment for implementation as part of the DO.08.00.00 software build with expected operational release in mid-2019. The new blooming filter is expected to remove a substantial fraction of blooming events, but not every last one. [Note: regarding solar glint, an improvement to the solar glint box via ADR 638 is also planned for DO.08.00.00. ADR 638 is a correction to the processing parameters used by the Ground Segment. The Instrument Vendor has a multiplier for the size of the glint box used in the glint filter. The correct value for this multiplier is 5, but it is presently incorrectly set to 2, so this is a relatively simple fix. The Instrument Vendor intends to turn-off the glint filter when the blooming filter goes online. The blooming filter provides better overall performance than the glint

filter, and the glint filter will not provide additional filtering capability after the blooming filter becomes operational.]

3.3.2 False Event "Bars" at RTEP Boundaries (ADR 647, ADR 648)

Horizontal streaks or "bars" of false events at the boundary between certain GLM Real Time Event Processors (RTEPs) occur; the first was noticed in the Bahamas and coined the "Bahama Bar". These bar artifacts will be removed from second-level threshold filtering as part of ADR 647. In conjunction with ADR 647, improvements will also be made to the Coherency Filter look up table (LUT) via ADR 648, which shall improve FAR mitigation (and optimize flash DE).

3.3.3 Residual Radiation "Dots" (ADR 519)

Owing to the improvements to ground processing software in preparation for GOES-16 GLM Provisional Maturity, false events due to high energy radiation particles, aka "radiation dots" have been largely removed by implementing a Single Group Flash (SGF) filter. However, future adjustments to this filter as part of ADR 519 will be tested so as to mitigate removal of legitimate flashes.

3.3.4 Put-Back Filter (ADR submission is pending further testing/refinement)

Most filters (L0-L1b, and L1b-L2) are fundamentally based on the background noise-rate. However, by passing some events and filtering other events one obtains a better estimate of the background noise. With this more accurate estimate of the background noise rate, some marginal events (that were initially considered to be noise) are now deemed to be legitimate lightning events. This "Put Back" filter is the mechanism for identifying these legitimate events, and restoring them to the L2 data stream.

3.3.5 Bursts Associated with Spacecraft Activities (ADR 615)

It was discovered on-orbit that the GOES-16 GLM product was sensitive to spacecraft attitude perturbations. The net effect of certain spacecraft activities would be to cause bursts of false events. In extreme cases, the signal from the false events would swamp the natural lightning signal and cause processing issues. One mitigation step has been to modify the spacecraft operations that cause false events. Additionally, the blooming filter (Section 6.1 above) should eliminate a large fraction of false events from solar intrusion and glint. A final backstop mitigation to prevent processing issues (performed under ADR 615) is to skip processing the data temporarily if the event rate is too high. That is, if within a second of data there are too many candidate events (based on a limit set to well above the expected maximum natural lightning event rate), the processing of that second of data will be skipped. This process may lead to blank periods of data. This fix is in test at the time of writing and may be in the operational stream by the end of 2018.

3.3.6 Bursts Associated with Data Formatter (ADR 649)

When the GLM Sensor Unit and Electronics Unit lose synchronicity, the RTEPs in the data formatter end up comparing the video signal to the wrong background pixel which results in a burst of events. This will be mitigated via the Data Formatter Burst Filter in ADR 649, to be implemented in the DO.08.00.00 software version. ADR 649 is a modification to the current event burst filter. The original filter design looked for burst characteristics in four RTEPs, and this ADR provides the ability to look at three instead of four RTEPs for the burst signature.

3.4 Additional Issues

3.4.1 Position Errors (ADR 728, ADR 645, ADR 650, ADR 373)

These lightning geolocation accuracy improvements were discussed in Figure 2 above. Technically, the improved ellipsoid model parameters (ADR 728) was only implemented into the Development Environment on September 25, 2018, and is anticipated to be implemented into the OE in early November 2018. This fix is called "Parallax Lite" since its greatest benefit is in reducing location errors near the edges of the field-of-view. The more robust monthly 3 degree grid cloud-top model (ADR 645) will eventually replace the ellipsoid model as part of the DO.08.00.00 software implementation in order to further mitigate location errors (as shown in Figure 2). Further mitigation of Instrument Navigation and Registration (INR) inaccuracies due to diurnal variations (ADR 650) will also be a part of DO.08.00.00, but are of lower priority.

3.4.2 Timestamp (ADR 338, ADR 375)

The timestamp on events, groups, and flashes has now been fixed as part of ADR 338 (DO.07.00.00; implemented into the OE on October 15, 2018) to properly account for the Time-Of-Flight (TOF) of the photons from cloud-top to sensor. Therefore, users no longer need to perform their own TOF correction to the data following this implementation date. There are still time-order issues with L2 data event times (as well as group time, flash start time, and flash end time), but these issues normally do not pose any major problems for most analyses; a fix via ADR 375 is planned as part of DO.08.00.00.

3.4.3 Family Links (ADR 376)

Family linkages refer to the correspondence between events, groups and flashes. For example, a "childless" group is a group with no events, and an "orphan" event is an event with no parent group. All downward family links have been fixed (effective when the DO.07.00.00 software version went operational on October 15, 2018). Upward family links will not be done, due to bandwidth constraints.

3.4.4 Group and Flash Areas (ADR 382)

Improvements to group and flash area values are anticipated (effective when the DO.07.00.00 software version went operational on October 15, 2018).

3.4.5 Unsigned Integer Read (ADR 844)

In order to save storage space, some floating-point variables (such as times, latitude, and longitude) are stored in the GLM NetCDF file as a lower resolution internal format with a “scale_factor” and “add_offset” attribute. Some of the GLM data is stored in a non-standard format (as unsigned integers). This is an issue that affects multiple instruments on GOES-16/17, and a pilot fix was worked via ADR 844 with implementation on November 5, 2018. The classic model for NetCDF does not support internal storage of unsigned integers larger than 8 bits. Despite this, many of the variables in the GOES-16/17 data are stored internally in the NetCDF files as either 16-bits or 32-bits unsigned integers. A future version of NetCDF (CDF5) will have options for internal storage of unsigned integers, but the GOES program does not use that version (CDF5). To get around this lack of unsigned integer support, the GOES program added a non-standard attribute “_Unsigned”, to designate which variables are stored internally as unsigned. Unfortunately, with the DO.07 version of the code, some variables that are stored as unsigned integers are not marked as such with the “_Unsigned” attribute (this is a bug in the code). So, until a fix is achieved (for both the non-standard “_Unsigned” attribute and the totally unmarked unsigned integers), we recommend using the low level NetCDF readers (the ones that read the NATIVE file formats) and use the following process to convert from the native format to the actual data format:

Retrieve the variable data (using low level routines): For MOST of the variables that should be read as unsigned integers, there is an attribute “_Unsigned” for that variable. The internal variable should then be read and cast to an unsigned integer of either 16 or 32 bits (depending on the size of the internal variable). This step must be completed before applying scale_factor and add_offset values to convert from scaled unsigned integer to science units.

Exceptions to the Rule: As it turns out, not all unsigned internal variables are actually marked with the attribute “_Unsigned”. We have designated these variables as “stealth unsigned variables” (SUVs). There is no physical way to determine which of the remaining variables are SUVs. The list below indicated the current set (the ones we have found) that are SUVs in DO.07 and will need to be converted like the variables that have the “_Unsigned” attribute (note, each of these):

Variable	Meaning	When Added
event_time_offset	GLM L2+ Lightning Detection: event's time of occurrence	DO.01.00.00
group_time_offset	GLM L2+ Lightning Detection: mean time of group occurrence actually marked with the attribute	DO.01.00.00
flash_time_offset_of_first_event	GLM L2+ Lightning Detection: time of occurrence of first constituent event in flash	DO.01.00.00
flash_time_offset_of_last_event	GLM L2+ Lightning Detection: time of occurrence of last constituent event in flash	DO.01.00.00
group_frame_time_offset	GLM L2+ Lightning Detection: mean frame time of group's constituent events' times of occurrence	DO.07.00.00

flash_frame_time_offset_of_first_event	GLM L2+ Lightning Detection: frame time of occurrence of first constituent event in flash	DO.07.00.00
flash_frame_time_offset_of_last_event	GLM L2+ Lightning Detection: frame time of occurrence of last constituent event in flash	DO.07.00.00

As an aside, the times in the prior versions of the output (prior to DO.07.00.00) have been changed from milliseconds to seconds. Although this change is actually documented, it is still a major change (and might require changes to the reading routines).

How to Determine If Data is DO.07.00.00 or a Prior Version: There are no external indications in the file that the format has changed. One way to determine which version of the file you are working with is to count the number of variables in the file. If it is 45, it is the OLD format, will not have the SUVs (but will still have the “_Unsigned” designation for the non-standard unsigned integers). If the variable count is 48, it is the DO.07.00.00 version of the file and will have the list of SUVs (above) along with the “_Unsigned” designation for the non-standard unsigned integers.

3.4.6 Gridded Data and Data Quality Products

These products are not yet available but are being developed, with plans for eventual submission to the Ground Segment via a formal Algorithm Discrepancy Report (ADR) along with fully tested meta-code.

3.4.7 Granularity/Max Energy and Dark Flashes (ADR 738, ADR 739)

The event, group, and flash energy scale_factor and add_offset parameters need to be adjusted to avoid poor granularity issues at the low-end (i.e., "stair-step" pattern in energy plots due to poor resolution), while at the same time being able to handle the expected maximum energy values within the allotted digital count range. This will be achieved via ADR 738, and it is expected to rectify the dark flash energy issue (ADR 739). These ADR fixes will be implemented as part of DO.08.00.00, or possibly earlier.

3.4.8 Duplicate Groups and Events and Zero Energy Items (ADR 740)

Currently, there are both duplicative events and groups along with zero energy events and groups. On a daily basis, the number of duplicative groups range from about 100 to as much as 2000. On a daily basis, the number of duplicative events range from 6000 to 70,000. The number of zero energy groups ranges (on a daily basis) from about 300 to 30,000. The number of zero energy events ranged from 2000 to 200,000. The fractions are around 0.1% of the groups and events. So, it is not a huge fraction, but over the span of 6 months, the numbers are as large as 10,144,987 events with zero energy. The frequency of these errors does not show any significant patterns, either in absolute numbers or in fractions of total.

4. SUMMARY

Overall, GLM on GOES-16 is in good shape. Currently, the flash detection efficiency (DE) meets specifications against most ground truth systems. The flash false alarm rate (FAR) is still above specifications, but corrections and additions to the analysis code should bring the FAR down to specification. There are several (mostly) minor issues with the GLM data that have been detailed in this document. As the analysis software is updated, more and more of these (mostly) minor issues will be solved. It is the user's responsibility to understand which issues have been and have not been fixed in the data being used. Although this document provides the best-informed estimates for software fixes, the system is fluid and so upgrades can occur either earlier or later than planned.

Contact for further information: OSPO User Services at SPSD.UserServices@noaa.gov

GLM contacts for specific information on the GLM L2 data:

Scott Rudlosky: scott.rudlosky@noaa.gov

William Koshak: william.koshak@noaa.gov

Douglas Mach: dmach@nasa.gov

Pete Armstrong: peter.armstrong@ll.mit.edu

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