

## GOES-16 GLM Level 2 (Events, Groups, Flashes) Release, Provisional Data Quality

January 19, 2018  
Read-Me for Data Users

The GOES-R Peer/Stakeholder Product Validation Review (PS-PVR) for GLM L2 Provisional Maturity was held on January 19, 2018. As a result of this review, following closure of some open issues, NOAA has confirmed that the GLM L2 data are at Provisional Validation Maturity as of January 19, 2017.

The GLM L2 product consists of geo-located and time-stamped *events, groups, and flashes*, with associated calibrated optical amplitudes (in units of Joules).

Provisional maturity means:

- Validation activities are ongoing and the general research community is now encouraged to participate.
- Severe algorithm anomalies are identified and under analysis. Solutions to anomalies are in development and testing.
- Incremental product improvements may still be occurring.
- Product performance has been demonstrated through analysis of a small number of independent measurements from select locations, periods, and associated ground truth and field campaign efforts.
- Product analysis is sufficient to establish product performance relative to expectations.
- 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, and tested.

Provisional users bear all responsibility for inspecting the data prior to use and for the manner in which the data are utilized. Persons desiring to use the GOES-16 GLM Provisional-maturity L2 products for any reason, including but not limited to scientific and technical investigations, are encouraged to consult the GLM Calibration/Validation science team members for feasibility of the planned applications. Commentary on important GLM data characteristics and known issues being resolved include:

1. **Flash Detection:** GLM flash detection efficiency (FDE) over the field-of-view and over a 24 hr period appears to exceed 70%. However, since the FDE associated with reference data are below 100%, it is difficult to exactly determine the GLM FDE. In addition, the FDE is substantially smaller in anomalous (i.e. inverted polarity) storms. Finally, erroneous GLM flash splitting occurs (but is rare and typically only happens with large, long duration flashes) and a solution is presently under analysis.
2. **False Events:** Significant reductions in false events have been achieved in Provisional relative to Beta. High energy radiation particles, aka "radiation dots", have been reduced by removing Single Group Flashes (SGFs), but future adjustments to this filter will be tested so as to mitigate removal of natural flashes. False events due to the data handling issue that produced "duplicative dots" has been fully resolved. False events due to blooming, created from glint and/or solar intrusion, are still present but a blooming filter and improvements to glint processing are planned.

3. **Position Errors:** Significant reduction in lightning position errors have been achieved in Provisional relative to Beta. There is now subpixel accuracy over most of the GLM domain, but GLM positions near the edge of the field-of-view must be shifted outward to match reference data. Overall, the distribution of the errors between GLM optical group locations and the reference data peaks at about 4 km; if one considers just group locations near the edge of the field-of-view the distribution peaks at about 11 km. Mitigation of parallax errors that arise from inaccurate cloud-top height estimation, and ways to combat location errors that are due to side-cloud illumination are being tested. Mitigation of any INR inaccuracies due to diurnal variations will also be examined.
4. **Timestamp:**
  - TOF: The timestamp on events, groups, and flashes still do not properly account for the Time-Of-Flight (TOF) of the photons from cloud-top to sensor. Until a formal fix is applied, we recommend that the user apply their own TOF correction of about 125 ms [i.e., the actual TOF correction is estimated to range from 119 ms (nadir) to 131 ms (edge of FOV)]. With this adjustment, the distribution of the errors between GLM group times and reference data time peaks at 0.7 ms (K. Virts analysis).
  - The sequence in a L2 data file of event times (as well as group time, flash start time, and flash end time) are not in time order.
5. **Family Links:** There exists “orphan” and “childless” events and groups. For example, a “childless” group is a group with no events; an “orphan” event is an event with no parent group.
6. **Areas:** Small discrepancies in group and flash area values are being examined.
7. **Unsigned Integer Read:** This is an issue that affects multiple instruments on GOES-16, and a pilot fix is being worked. The classic model for NetCDF does not support unsigned integers larger than 8 bits. Many of the variables in GOES-16 data files are unsigned integers that are either 16-bits or 32-bits. So, until a fix is achieved, we recommend using the following process to convert:
  - Retrieve the variable data (using low level routines).
  - If there is an attribute “\_Unsigned” then cast the variable data to unsigned.
    - This step must be completed before applying scale\_factor and add\_offset values to convert from scaled integer to science units. For example, when reading the NetCDF files, one has to MANUALLY read in the event lat/lon as an unsigned integer (using low level routines), and then manually take care of the scale and offset.
8. **Data Quality Product:** This product is not yet available but is in planning.
9. **Data Recommended:** The Calibration Working Group (CWG) recommends that data on or after January 11, 2018 is best to use since it follows the important algorithm patches (DO.06.02.00 in November, PR.06.05.00 in early January), INR averaging, satellite drift, and settling the INR averaging at the East slot.

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