GLM Data Quality Status **19 January 2018**

This document characterizes the remaining GLM processing and data quality issues. An extensive calibration and validation effort has been underway since the GLM data first became available, and great progress has been made. A well-designed process identifies issues, determines solutions, and makes fixes via a series of ADRs and WRs. Some fixes are minor while others take longer to diagnose and remedy. In terms of priority, every indication has been that the GLM falls low on the list (ABIs little brother), which often results in schedule slips for the GLM-specific fixes. The updates to GS software versions DO 06.00.00 (10/31) and DO 06.02.00 (11/28) produced marked improvement in the GLM data. Data processing and quality issues are categorized below into 1) position errors, 2) false alarms, 3) flash grouping, 4) timing, 5) data structure, and 6) general.

Position Errors:
The GLM location accuracy is well within specs (i.e., less than one pixel), but still can be improved. Two factors contribute to GLM position errors: 1) Image Navigation and Registration (INR) and 2) parallax corrections. The INR calculations convert the observations from pixel space to earth-based coordinates. Several fixes have improved the INR, most recently the roll, pitch, and yaw (RPY) variables were calculated and used properly. Additional fixes planned for 2018 will further improve the INR calculations. The parallax correction (mission requirement) likely will require feedback from users to determine the optimal configuration. Presently, a simple ellipsoid model is used to assume a tropopause height, varying from 6 km at the poles to 16 km at the equator, and the GLM observations are projected to this altitude. This can lead to position errors when the height of the cloud top differs from the assumed tropopause height. The parallax issue is most apparent near the edges of the field of view where lightning often illuminates the sides of clouds. Several modifications to the parallax correction are being considered, but user feedback will be requires prior to their implementation.

False Alarms:
Overshoot, solar glint, and crosstalk filters have been implemented to help reduce the number of false lightning events. These filters help eliminate false optical events before the GLM categorizes them as lightning. Tuning of these filters will continue as the sensor and software are optimized. Issues with the solar glint filter are evident by false lightning events with unusual structure found in the Level 2 database. These features typically appear as long, straight lines over bodies of water or saturated land. Blooming is a specific type of solar glint. A blooming filter has been developed, but is not yet operational. Blooming results in a cascading saturation of GLM pixels. This causes large areas of false events that do not resemble lightning and occur independent of thunderstorm location. Most blooming occurs during eclipse season (April and October) due to the stray light reaching the GLM focal plane. Two types of space craft maneuvers result in data spikes composed of false events. The first type occurs once daily at varying times and lasts a few seconds. The second type occurs quarterly, but can result in spikes that last a few seconds periodically over a period of a few hours.

Single event flashes associated with high energy particles intersecting the instrument focal plane initially were making it through the radiation filter that was designed to filter out streaks of high energy particles. The near term fix of removing all single event flashes was implemented in DO. 06.02. This

rather blunt filter may remove a small fraction of real lightning (especially near the FOV edges), so a longer term solution is under development for inclusion in a future software build. Issues with the linear buffer in the LCFA initially resulted in duplicative dots, but this issue also was fixed in DO.06.02.

Flash Grouping:
The base GLM observation is an event, the occurrence of a single pixel exceeding the detection threshold during a single ~2 ms frame. The Lightning Cluster Filter Algorithm (LCFA) combines one or more simultaneous GLM Events observed in adjacent (neighboring/diagonal) pixels into GLM groups. The LCFA then defines flashes as one or more sequential GLM groups separated by less than 330 ms and 16.5 km. Several additional fixes are likely required to improve the LCFA grouping and parent child relationships. Individual GLM flashes are being erroneously split into multiple flashes by the LCFA. One known cause is artificial maxima of 100 groups per flash and 100 events per group built into the ground system software. This issue will be fixed in a future software build. Some fraction of GLM flashes with less than 100 groups are also being split by the LCFA, but the cause of this remains under investigation. Much of this flash splitting related to the cause of the "Charlie Brown" striping issue (ADR 385). This was determined to emanate from the LCFA due to issues with matching floating point values. This has been fixed in GS 06.00 which also had the effect of greatly reducing the splitting of GLM flashes.

Timing:
The GS software has timing artifacts that can result in time offsets and position uncertainty. Many of the fixes to date have sought to improve the timing of the GLM observations. Examples include a corrected time scale factor and proper origin time in L2 files. The GLM still does not properly account for time-of-flight from the cloud top to the satellite. WR 4589 addresses this issue which will be resolved in a future software update. These timing issues can have wide-ranging effects, so extra caution is required when making these modifications.

Data Structure:
The greatest data structure issue is the use of unsigned integers for many of the L2 variables. This issue must be accounted for when reading the base L2 files

General:
A community code set is under development to help collaborative research efforts and promote use of the GLM. This code set will help users read, process, and visualize the GLM data. This also will help to promote product/process uniformity, and will ensure that users get the most out of the GLM data. Additional parameter changes will be implemented periodically into the GS software by the instrument vendor and AWG/CWG.

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