GOES-R GLM Post Launch Product Tests (PLPTs)

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Joint MTG LI Mission Advisory Group & GOES-R GLM Science Team workshop
27-29 May, 2015
GLM L2+ Product Science Validation Baseline Schedule

Launch & Orbit Raising

Post-launch Testing (PLT) - 180 Days

Outgas

System Performance Operational Test (SPOT)

PLT Cal/INR

PLPT

Ex- tended Val

12 Days

30 Days

28 Days

60 Days

30 Days

32 Days*

6 Mo

9 Mo

Peer-Stakeholder L1b & KPP Product Validation Review
Handover L1b & KPP Products to OSPO

Post-Launch Assessment Review (PLAR) and Handover Readiness Review (HRR): Handover S/C Ops to OSPO

L+73 Days

L+103 Days

PLT End + 4 Months

PLT End + 12 Months

Operations - <=5yrs Storage + >=8.4 Yrs Ops

Products Not Yet Available to Public

Beta Stage Testing

Provisional Stage Testing

Validated Stage Testing

Beta Validated Product

Provisionally Validated Product

Fully Validated Product

* Data blackout due to COOP test and Station Change to 105W.
GLM PLPT Types

• The MSFC GLM L2+ team has 4 major categories of PLPTs
  – **Validate GLM Product with Reference Data Set Comparisons** (is the GLM actually meeting specifications for detecting lightning (DE), rejecting false alarms (FAR), and locating the lightning in time and space?)
  – **Algorithm Testing** (is the GLM algorithm correctly filtering, geolocating, and clustering the raw Level 0 (L0) data, both backgrounds and lightning, so that GLM is meeting specifications?)
  – **Instrument Navigation and Registration (INR) Testing** (is the GLM navigation correct so that GLM is meeting specifications?)
  – **Long Term Baseline Testing** (what is the current sensitivity of GLM, how does it compare to the Lightning Imaging Sensor (LIS) and the Optical Transient Detector (OTD), and how does it change over the years?)
Purpose GLM Validation PLPT

- Recertification of GLM Pre-Launched Predicted Performance
- GLM has a single product: Lightning Detection (with three components)
  - Events (L1b)
  - Groups (L2+)
  - Flashes (L2+)
- GLM Lightning Detection Requirements (the Five W’s)
  - Where? (location) – Geolocation error over the FOV is less than that created by a 112 μrad instrument pointing error (5 km at the sub-satellite point)
  - When? (time) – within 1 ms
  - Wow! (energy) – within 10% (waived due to schedule & cost constraints)
  - Right? (DE) – >70% over 24 hours
  - Wrong? (FAR) – <5% over 24 hours
- All tests contribute to Beta, Provisional, and Validated levels
  - Just more data, better statistics, more locations, more seasons
Validate GLM Product with Reference Data Sets (PLPT Format)

- **Objective:** Compare the GLM product (events, groups, & flashes) with those detected by well characterized networks and systems. Determine if GLM meets specified product values.

- **Description:** There are a number of systems (ground, airborne, and space based) that detect lightning at various locations, rates, and types. Each PLPT of this type uses one of these systems/networks to determine if the GLM detects the lightning. The detection of a “flash” by any of these systems is taken as "truth", and the percent detection of these “flashes”, locations, amplitudes, and times are used to determine the validity of the GLM product (does it meet specifications).

- **Success Criteria:** If analysis of the “ground truth” data shows the GLM detects at least 70% of the flashes, with a FAR of less than 5%, a location closer than 5 km, and a time within 1 ms, the GLM will have met success criteria for these tests.

- **Data Analysis Roles/Responsibilities:** Douglas Mach (or delegate), using internal VaLiD and other tools to access the “ground truth” datasets and GLM L1b-L2 data
GLM PLPT Reference Datasets

• To validate the GLM data (PLPT), must compare to well characterized lightning Reference Datasets

• Most Datasets are already at the National Space Science Technology Center (NSSTC), Global Hydrology Resource Center (GHRC)

• Others are readily or will/should be available
  • NOAA MOUs exists with cooperative institutes and international partners

• No one system can duplicate GLM (that’s why we need GLM and multiple other sources)
# GLM PLPT Reference Data Sources

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<tr>
<th>Data Type</th>
<th>Data Avail</th>
<th>Data From</th>
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<td>Vaisala</td>
<td>100 flashes in GLM FOV</td>
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<td>Max overlap w/ GLM FOV</td>
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<td>MSG SEVERI</td>
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* GLM is not an imager, data quantities are not fixed and depend on lightning quantities

Joint MTG LI Mission Advisory Group & GOES-R GLM Science Team workshop
27-29 May, 2015

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**ACTUAL DATA**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Avail</th>
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<th>Data Quantity</th>
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Validate GLM Product DE and FAR with Reference Data Sets (PLPTs)

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Validate GLM Product DE and FAR with Reference Data Sets (PLPTs) (cont)

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Validation of GLM Product
General Concepts

• Not all PLPTs may be activated
  – Weather at the time of the PLPT period will determine which ones will be utilized

• If multiple, possibly conflicting PLPTs can be activated, priority will be given to PLPTs in this general order:
  – Ground truth systems that are optical based (Airborne GLM Simulator (AGS), ISS-LIS)
  – Regions with no prior PLPT lightning (both temporal and spatial)
  – Ground truth systems with the highest DE, lowest FAR for total lightning
  – Note, these priorities are “flexible”
    • Field program based PLPTs (e.g., using AGS) would take priority over all others due to limited time/location of field program data
Other GLM PLPT Types

- **Algorithm Testing** (is the GLM algorithm correctly filtering, geolocating, and clustering the raw Level 0 (L0) data, both backgrounds and lightning, so that GLM is meeting specifications?)

- **Instrument Navigation and Registration (INR) Testing** (is the GLM navigation correct so that GLM is meeting specifications?)

- **Long Term Baseline Testing** (what is the current sensitivity of GLM, how does it compare to the Lightning Imaging Sensor (LIS) and the Optical Transient Detector (OTD), and how does it change over the years?)
Validate GLM Ground Processing Algorithm

- **Objective:** Determine if the GLM L0-L2 Ground Processing Algorithm (GPA) is working as specified by comparing the event/group/flash clustering/filtering to the results from the spec code created by MSFC.

- **Description:** The GLM L1b-L2 spec code and ATBD were written by the GLM-MSFC-AWG team. In addition we have an equivalent L0-L1b code. This series of PLPTs will:
  - take the L0 output of GLM, which is stored at our GHRC local Level Zero Storage System (LZSS)
  - remove sections of the GPA code
  - replacing them with the spec code that the GLM-AWG team produced
  - compare the output of the spec code with the output of the operational code to verify that the operational code is reproducing the spec code results.

- **Success Criteria:** If the GLM operational code is able to produce the same results as the AWG spec code, then the GLM L0-L2 code will have met success criteria for this test.

- **Data Analysis Roles/Responsibilities:** Douglas Mach, using VaLiD and other tools to display and compare GLM L2 data determined with the on-board code and with the independent MSFC code.
GLM Instrument Navigation and Registration

- **Objective:** To assess Instrument Navigation and Registration (INR) accuracy of GLM L0-L2 products.

- **Description:**
  - Assess geolocation of GLM L1-L2 products by comparing with lightning positions of coincidently observed lightning locations observed by ground networks (NLDN, WWLLN, ENTLN, NALMA, WTLMA, OKLMA, NMLMA, KLMA, HLMA, DCLMA, etc.).
  - Evaluate GLM INR relative to ABI. The relative offset of bright cloud target locations of the GLM background location of bright cloud targets are compared to those observed by the ABI visible channel and relative offsets computed.

- **Success Criteria:**
  - GLM L1-L2 products occur within 5 km of network lightning locations.
  - Bright cloud targets observed are observed by GLM and ABI and the relative INR offset is within 112 µrad.

- **Data Analysis Roles/Responsibilities:** Dennis Buechler, using VaLiD and other tools to display and compare GLM L0 background data ABI visible images.
GLM Baseline Radiances for Long Term Trending

• Objective: To obtain baseline radiance values of GLM L0-L2 data for long term trending to assess instrument degradation (DE and FER).

• Description:
  – Generate GLM L1-L2 radiance distributions, compare to LIS and AGS to obtain baseline L1-L2 product radiance distributions.
  – Determine the GLM background radiance (L0) distribution of Deep Convective Clouds (DCCs), identified using ABI IR channel. This will establish a GLM DCC radiance distribution baseline for monitoring long term trending of GLM instrument performance.

• Success Criteria:
  – GLM L1-L2 radiance distributions are similar to those of LIS
  – The GLM DCC background (L0) distribution is similar to LIS
  – The GLM DCC background (L0) is determined for use during instrument lifetime

• Data Analysis Roles/Responsibilities: Dennis Buechler, using VaLiD and other tools to display and compare GLM L0-L2 data, ABI IR images, and LIS data.
GLM L2+ PLPT Summary

- GLM L2+ PLPTs consist of 4 types
  - Validate GLM Product
  - Algorithm Testing
  - Instrument Navigation and Registration (INR) Testing
  - Long Term Baseline Testing
- Goal of GLM L2+ PLPTs is to help validate the GLM data for operational use
  - Reach Beta Validation (minimally validated, and may still contain significant errors) within 1 month of start of PLPT period
  - Reach Provisional Validation (analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose) within 4 months of the end of the PLPT period
  - Reach Full Validation (analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose) within 1 year of end of the PLPT period
Questions?
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Acronyms

- **ABI** = Advanced Baseline Imager
- **ADTNet** = Arrival Time Difference NETwork
- **AGS** = Airborne GLM Simulator
- **ATBD** = Algorithm Theoretical Basis Document
- **AWG** = Algorithm Working Group
- **BrazilDAT** = Sistema Brasileiro de Detecção de Descargas Atmosféricas
- **CWG** = Calibration Working Group
- **DCC** = Deep Convective Cloud
- **DCLMA** = District of Columbia Lightning Mapper Network
- **DE** = Detection Efficiency
- **ENTLN** = Earth Networks Total Lightning Network
- **FAR** = False Alarm Rate
- **FCLMA** = Fort Collins Lightning Mapper Network
- **FM** = Field Mill
- **GHRC** = Global Hydrology Resource Center
- **GLD360** = Vaisala Global Lightning Dataset
- **GLM** = Geostationary Lightning Mapper
- **GOES-R** = Geostationary Operational Environmental Satellite R-Series
- **GPA** = Ground Processing Algorithm
- **HAMMA** = Huntsville Area Marx Meter Array
- **HLMA** = Houston Lightning Mapper Network
- **INR** = Image Navigation and Registration
- **IR** = Infrared
- **ISS** = International Space Station
- **IV&V** = Independent Verification and Validation
- **KSC** = Kennedy Space Center
- **KSCLMA** = Kennedy Space Center Lightning Mapper Network
- **LIS** = Lightning Imaging Sensor
- **LM** = Lockheed Martin
- **LZSS** = Level Zero Storage System
- **MOU** = Memorandum Of Understanding
- **MSFC** = Marshal Space Flight Center
- **MSG** = Meteosat Second Generation
- **NALMA** = North Alabama Lightning Mapper Network
- **NEXRAD** = NEXt-generation RAdar
- **NGLMA** = North Georgia Lightning Mapper Network
- **NLDN** = National Lightning Detection Network
- **NMLMA** = New Mexico Lightning Mapper Network
- **NOAA** = National Oceanic and Atmospheric Administration
- **NSSTC** = National Space Science and Technology Center
- **OKLMA** = OKlahoma Lightning Mapper Network
- **OTD** = Optical Transient Detector
- **PLPT** = Post Launch Product Test
- **RINDAT** = Rede Integrada Nacional de Detecção de Descargas Atmosféricas
- **SEVERI** = Spinning Enhanced Visible and Infrared Imager
- **STARNet** = Sferics Timing And Ranging NETwork
- **TARANIS** = Tool for the Analysis of RAdiations from lightNIngs and Sprites
- **TBD** = To Be Determined
- **TLMA** = Toronto Lightning Mapper Network
- **TRMM** = Tropical Rainfall Measuring Mission
- **VaLiD** = Validate Lightning Data
- **WILMA** = Wallops Island Lightning Mapper Network
- **WTLMA** = West Texas Lightning Mapper Network
- **WWLLN** = World Wide Lightning Locating Network
Backup Slides
Validate GLM GPA (PLPTs)

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# GLM Instrument Navigation and Registration Tests

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<td>(reuse PLPTs 001-007 for INR)</td>
<td>PLPT</td>
</tr>
</tbody>
</table>
## GLM Baseline Radiances for Long Term Trending Tests

<table>
<thead>
<tr>
<th>Test ID</th>
<th>Class</th>
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<tbody>
<tr>
<td>GLM-L0_BG_DCC_RadCal-012</td>
<td>PLPT</td>
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<tr>
<td>GLM-L0_BG_DCC_RadCal_coincident-013</td>
<td>PLPT</td>
</tr>
<tr>
<td>GLM-L0_BG_DCC_EvGrFl_Rad-014</td>
<td>PLPT</td>
</tr>
</tbody>
</table>