



Road to GLM Full Validation: Overview, Processes, and Status

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William Koshak, NASA/MSFC

(with inputs from additional Team Members)



OUTLINE



- The PS-PVR Process
- Tools & Tests
- Historical Highlights
- Upcoming Milestones
- The ADR/WR Process & Updates



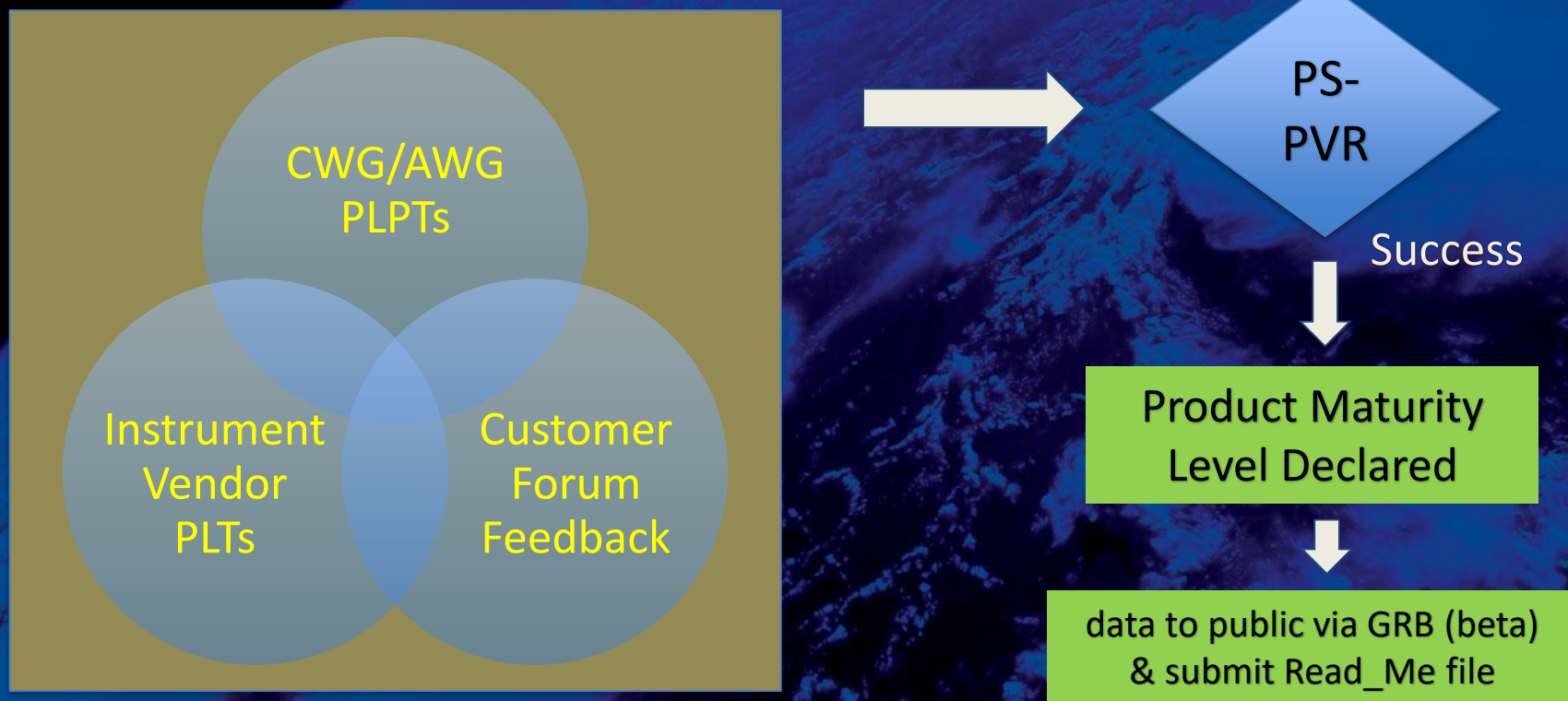
THE PS-PVR PROCESS



PS-PVR



- PS-PVR = Peer Stakeholder - Product Validation Review
- Assesses product quality relative to Program definitions
- PS-PVR Chair decides if products have achieved the product maturity level
- Provides guidance on work expected to achieve the next maturity level





Product Maturity Levels



GOES-R Product (L1b and L2+) Maturity Levels

Beta Validation

Preparation Activities

- Initial calibration applied (L1b).
- Rapid changes in product input tables, and possibly product algorithms, can be expected.
- Product quick looks and initial comparisons with ground truth data (if any) are not adequate to determine product quality.
- Anomalies may be found in the product and the resolution strategy may not exist.

End state

- Products are made available to users to gain familiarity with data formats and parameters.
- Product has been minimally validated and may still contain significant errors.
- Product is not optimized for operational use.

Provisional Validation

Preparation Activities

- Validation and quality assurance (QA) 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.
- Users are engaged in the Customer Forums (L2+ products only), and user feedback is assessed.

End state

- Product performance (L1b or L2+) has been demonstrated through analysis of a small number of independent measurements obtained from selected locations, periods, and associated ground-truth/field program efforts.
- Product analysis are sufficient to communicate product performance to users 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, tested, and shared with the user community.
- Testing has been fully documented.
- Product ready for operational use and for use in comprehensive calibration/validation activities and product optimization.

Full Validation

Preparation Activities

- Validation, QA, and anomaly resolution activities are ongoing.
- Incremental product improvements may still be occurring.
- Users are engaged and user feedback is assessed.

End state

- 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. e.g., blooming, data gaps, parallax, ...
- Product is operational.



Primary Emphasis for GLM



➤ Flash Detection Efficiency

GLMPORD74: The flash detection probability shall be at least **70%** after L1b processing.

The time span for this computation is 24 hours.

➤ Flash False Alarm Rate

GLMPORD75: The flash false alarm probability shall be less than **5%** after L1b processing.

The time span for this computation is 24 hours.

➤ Location Accuracy

GLMPORD94: The GLM navigation error shall not exceed $\pm 112 \mu\text{rad} \sim \frac{1}{2}$ pixel

(MRD1259, pg. 46: Product Mapping Accuracy 5 km)

➤ Time Accuracy

GLMPORD98: The GLM shall time tag each event to an accuracy of **1 msec**

... also benchmarking for DCC and lightning energy.



Team Organization



**PS-PVR
presentation**
(Koshak, Armstrong, et al.)

PS-PVR Panelists
Chair: Matt Seybold, Backup Chair:
Wayne Mackenzie; others.

**PS-PVR
decisions**

GOES-R Series Prog. Sci.
Scott Rudlosky (Dan Lindsey Funding Side)
[both positions formerly Steve Goodman
who is now a consultant]

CVCT PRO

Matt Seybold, Jon Fulbright, Liz Kline,
Randy Race, Dave Pogorzala, Wayne
Mackenzie (PAL), Ryan Williams, ...

**AART &
ARB**

Randy Race, Janet
Larsen, ...

CWG Leads

Changyong Cao, Steve Wu

AWG Lead

Jaime Daniels

Flight

Marc Rafal, Ruth Cholvibul

LMATC/UAH

S. Edgington, C. Tillier,
H. Christian

Cal/Val Team

Core:

Koshak, Armstrong, Mach, Buechler, Bateman, Bitzer, Virts, Blakeslee, Quick,
Burchfield

Remote (Primary):

Cummins, Krehbiel, Thomas, Rison, Bruning, MacGorman, Rutledge, Pickering,
Peterson, Sonnenfeld

Others: Both local & remote

GLM INR (Lasers)

Dennis Buechler

CVCT: Cal/Val Coordination Team
PRO: Product Readiness and Operations
AART: Algorithm Action Review Team
ARB: Algorithm Review Board



TOOLS & TESTS



Primary Tools



Item	Tool	Description	Code Language	Developer
1	ValiD	Validate Lightning Data tool performs shallow/deep dives of GLM data using wide range of ground-based datasets discussed in RIMP.	C	Bateman/USRA
2	Cluster/Filter	In-house code for L0-L1b and L1b-L2 processing	Matlab	Mach/USRA
3	HUDAT	Huntsville Area Marx Meter Array (HAMMA) User Data Analysis Technology with emphasis on lightning energy/physics.	IDL	Bitzer/UAH
4	STROKE	STorm Retrievals frOm KSC E-Fields examines ground-based electric fields, lightning field changes, and the charges deposited by lightning in KSC, Florida.	IDL	Koshak/MSFC
5	INR/Parallax	Validates GLM INR with comparisons to well-located ground points and employs GLM background images & lightning, ABI background images, and Laser beacon data	IDL	Buechler/UAH
6	TT/DCC	Trending Tools for long-term trending of Deep Convective Clouds.	IDL	Buechler/UAH
7	TT/Lightning	Trending Tools for long-term trending of lightning counts, flash duration, and lightning energy.	IDL	Buechler/UAH Koshak/MSFC
8	LMT	24/7 Lightning Monitoring Tool (aka "Product Monitor") that alerts of problematic GLM performance	TBD	Product Area Lead (PAL, Wayne MacKenzie)
9	CompareLLS	Compare Lightning Location System tool performs shallow/deep dives of GLM data using wide range of ground-based datasets discussed in RIMP.	Matlab	Cummins, UA
10	XLMA	X Lightning Mapping Array tool for making standard 4-D plots of flashes.	IDL	Krehbiel & Rison of NMT
11	Imatools	Analyzes LMA data [sort VHF source data into flashes; calculate flash areas, volumes, and channel lengths; produce gridded products; time series statistics of flash rate and size data; simulate LMA performance].	Python	Bruning/TTU
12	FEGST	Fly's Eye GLM Simulator Tool: Data acquisition, display, and storage software [Note: s/w for analyzing FEGS data & inter-comparing it with other lightning optical datasets (e.g. GLM, ISS/LIS) will be done by beginning of Spring 2017 Field Campaign & some of these processing tools will be piggybacked to ValiD.]	IDL	Quick/NPP
13	ADTs	Ancillary Dataset Tools will be developed for processing datasets such as ABI, NEXRAD, SEVERI, WWLLN; some of these tools will be piggybacked to ValiD.	Matlab & McIDAS scripts	Mach/USRA Bateman/USRA
14	SITs	Specialized Impromptu Tools written "on-the-fly" to handle any analyses that are needed, but that were unexpected.	C, IDL, Matlab, Mathematica	Mach/USRA Bateman/USRA Buechler/UAH Koshak/MSFC
15	LATA	Location And Time Accuracy (LATA) Tool: Produces a variety of plots/histograms that characterize the overall location/time accuracy of GLM flashes/groups/events.	Matlab	Virts/NPP



Post Launch Product Tests



Test ID	Abbreviated Test Titles for GLM
PLPT-GLM-001	Validate DE/FAR using med/long-range networks (e.g., NLDN, EN, GLD360)
PLPT-GLM-002	Validate DE/FAR using short-range networks (e.g., LMAs)
PLPT-GLM-003	Validate Storm DE and Storm FAR using very long range systems (WWLLN, NEXRAD)
PLPT-GLM-004	Validate DE/FAR using very short range optical systems (FEGS)
PLPT-GLM-005	Validate DE/FAR using orbit-based optical systems (e.g., ISS/LIS)
PLPT-GLM-006	Validate DE/FAR using ground-based E-field networks (e.g. HAMMA)
PLPT-GLM-009	Validate L1b-L2 Cluster/Filter by comparing w/Spec (i.e. Mach) code
PLPT-GLM-010	Validate L0-L1b Filter Algorithms by comparing w/Spec (i.e. Mach) code
PLPT-GLM-011	Validate GLM INR w/comparisons to well-located ground points
PLPT-GLM-012	Validate GLM BG DCC radiances with trendings & comparisons
PLPT-GLM-013	Validate GLM Event Energies with trendings & comparisons

MSFC/MIT-LL CWG is conducting these tests to evaluate the L2 product quality.

Full test plans and procedures are given in the GLM Readiness, Implementation, and Management Plan (RIMP v1.2; 416-R-RIMP-0313)

FAR here refers to Flash False Alarm Rate



HISTORICAL HIGHLIGHTS



Highlights



- **19 Nov 2016 GOES-R Launch**
- **29 Nov 2016** GEO orbit attained (became GOES-16)
- **19 Dec 2016** 1st RTEP table uploaded
- **04 Jan 2017** Opened GLM Door
- **Jan - late Apr 2017:** Too many GS software issues ... VAL could not begin.
- **24 Apr 2017 @ 19:52 UTC (DO.04.04.00)** GLM Beta Validation Began
 - ✓ Clearquest shows 29 fixes associated with DO.04 (+ patches/emergency)
- **09 Jun 2017 PS-PVR Beta**
- **05 Jul 2017** GLM data to GRB (i.e. delay to GRB to mitigate noise/position errors w/patches)
- **24 Jul 2017** DO.05.00.00
- **31 Oct 2017** DO.06.00.00
- **28 Nov 2017** DO.06.02.00
- **Some INR averaging but interrupted for:**
 - Spacecraft Drift to East Slot
 - 7 d INR averaging
- **20 Dec 2017** Began Crunching Data for PS-PVR PROV
- **19 Jan 2018 PS-PVR Provisional**
- **01 Mar 2018 GOES-S Launch** (GLM powered on Mar 27, Door opened Apr 12, ...)
- **21 Aug 2018** DO.07.00.00 fixes placed in DE ... marks start of FULL VAL



Path to Provisional - Risks

(Status on 9 Jun 2017 PS-PVR Beta)



Risk	Description	Impact	Mitigation	Priority
Radiation "dots" (unexpected)	High energy particle noise	Increases FAR; Obstructs VAL (spacetime correlation made difficult)	WR4430 (substantial fix) ADR372 (full fix)	1
Position Error (unexpected)	~ 20 km SW location error	poor severe Wx warning; Obstructs VAL	ADR373	2
Blooming events (unexpected)	too many during glint and/or solar intrusion	Excessive false event rate possible during storms (esp. nocturnal MCS)	ADR374	3 or 4
Timestamp	TOF	Obstructs VAL	DO.06/07.00 .00 (WR4507/4589)	3 or 4
	Time order	Obstructs VAL	ADR375	
	Scale factor	Obstructs VAL	DO.05.00.00 (WR1937/ADR378)	
	time offsets (found by LMATC)	Obstructs VAL	ADR379	
Family Links	small % of members missing; downward link missing	Missing data; can't deep-dive a flash; Obstructs VAL	ADR376	5
Group Areas (unexpected)	Abnormally large group areas	Forecasting; Obstructs VAL	DO.06.00.00 (WR2691/ADR377/ADR382/ ADR384/ADR385)	6

All ADR requests occurred at reasonable times given Apr 24 start of PLPT, and recent reception of Vendor PLT Final Reports (which had to be obtained as expedited draft versions; no report draft or final received for Solar Intrusion).

Little Impact

Moderate Impact

Severe Impact



Path to Full Validation – Risks

(Status on 19 Jan 2018 PS-PVR Provisional)

Risk Name	Description	Impact	Mitigation and Schedule
Mission Data	IF CWG lacks many critical meta data	THEN CWG cannot function properly	- Raise awareness - Work with Ground
Operation Stability	IF corrections for known anomalies cannot be implemented timely	THEN the operation will not reach steady state for evaluation	- Raise awareness - Work with Ground
Data Quality Product	as discussed; Priority 1	Moderate	ADR 461 (on hold)
blooming filter	as discussed; Priority 2	Moderate	WR 4697 (need GS WR for this)
Overshoot & 2 nd Level Threshold	as discussed; Priority 3	Moderate	WR 5426 (fixed 1/10/18 – 21:46 UTC in PR06.05.00 but to be verified)
Solar Glint Box	as discussed; Priority 4	Moderate	PR.06.05 (fix needs to be verified)
TOF & associated	as discussed; Priority 5	Moderate	WR 4507
orphan/childless	as discussed; Priority 6	Moderate	WR 5525
time order	as discussed; Priority 7	Moderate	WR 4705
various (19 items)	as discussed; Priority 8 and lower	Little	(see remaining entries in slides 29-31)

Scale:

Little Impact

Moderate Impact

Severe Impact



UPCOMING MILESTONES



GLM-16:

01 Nov 2018: Full PS-PVR

GLM-17:

27 Sep 2018: Beta PS-PVR

03 Dec 2018: Prov PS-PVR

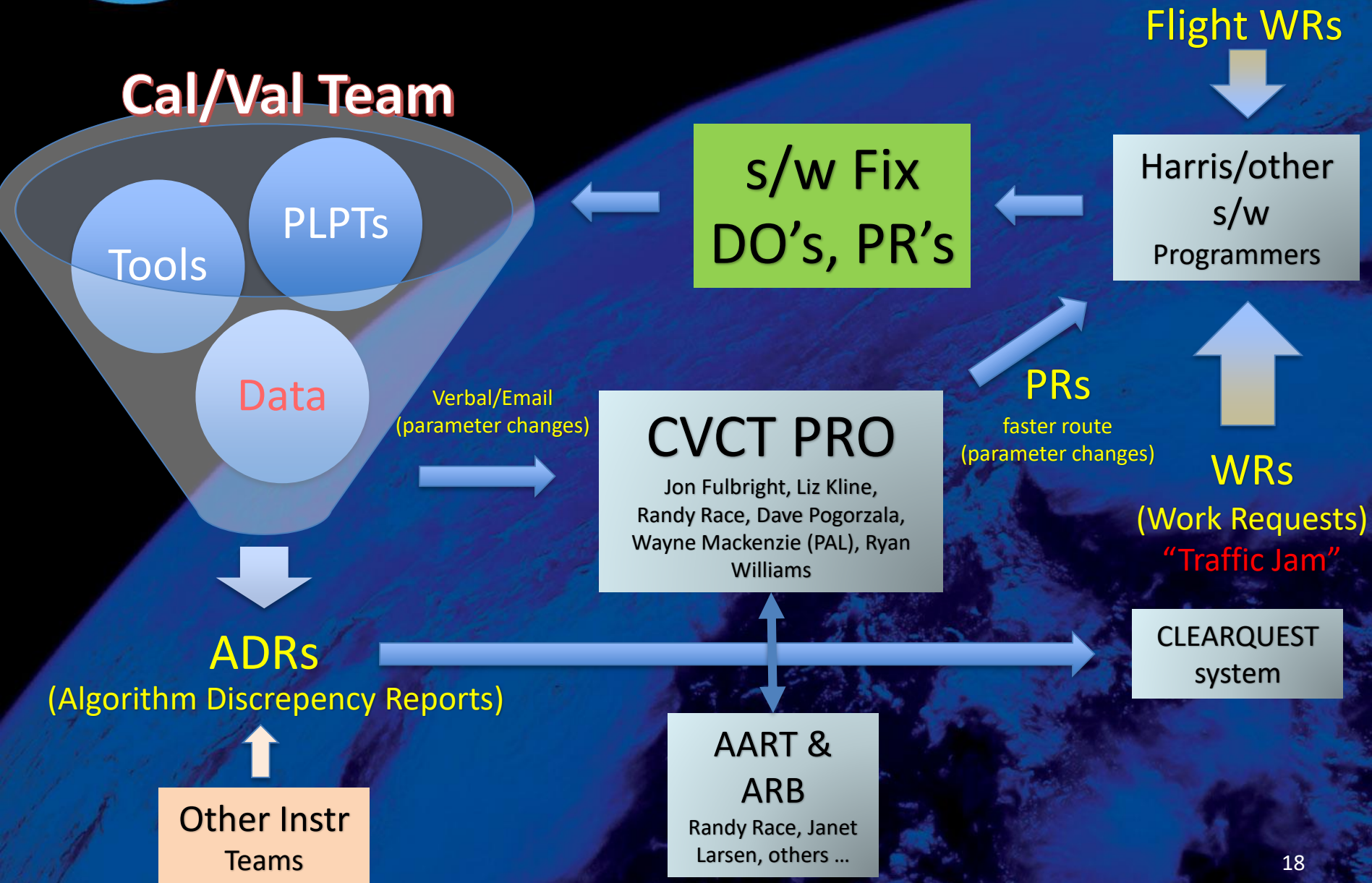
XX Sep 2019: Full PS-PVR



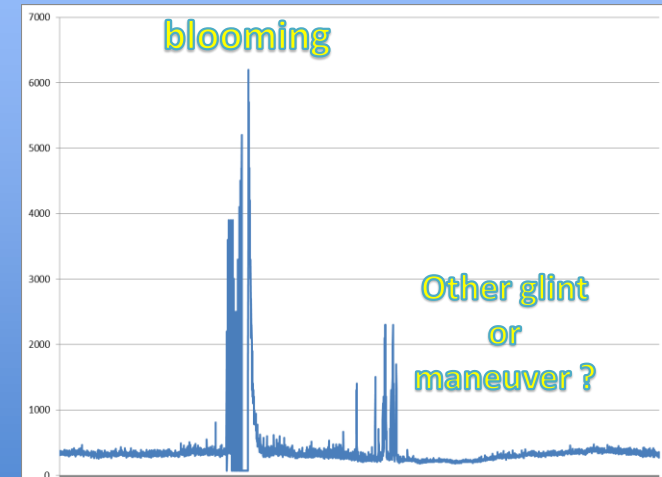
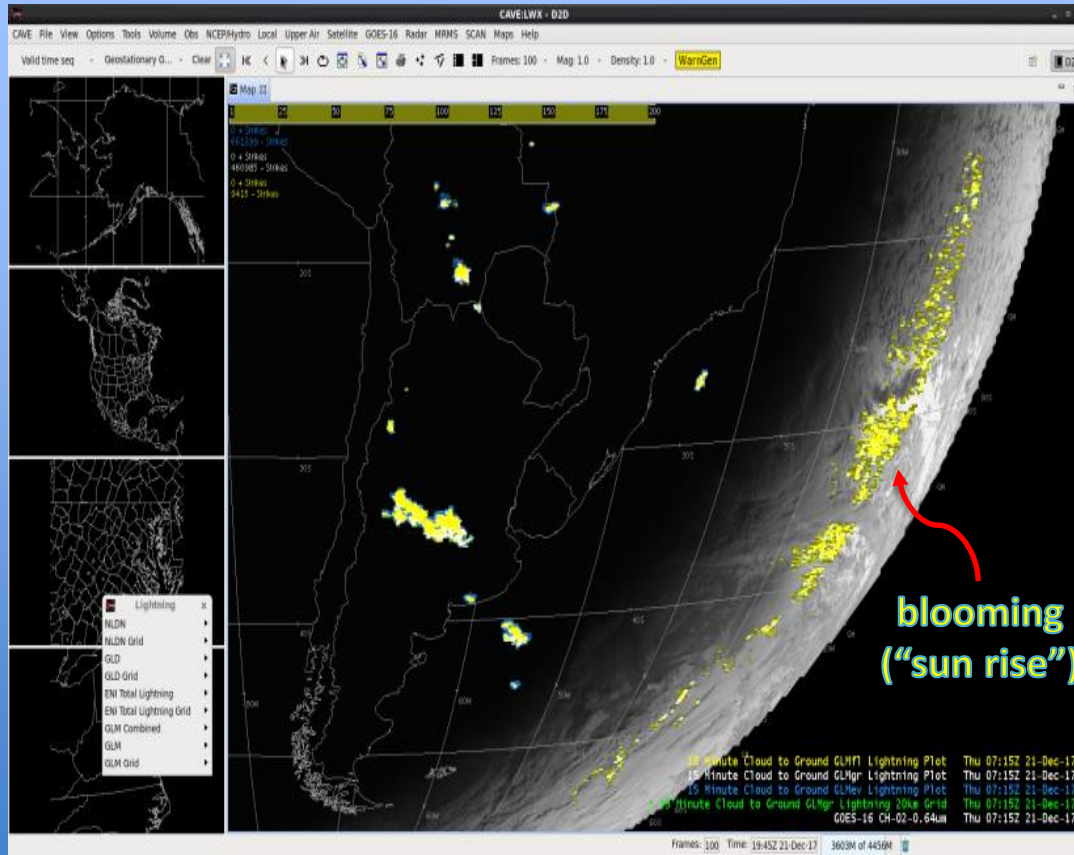
THE ADR/WR PROCESS & UPDATES



ADR to WR Overview



Blooming Example (WR 4697F/5937)



21 Dec 2017

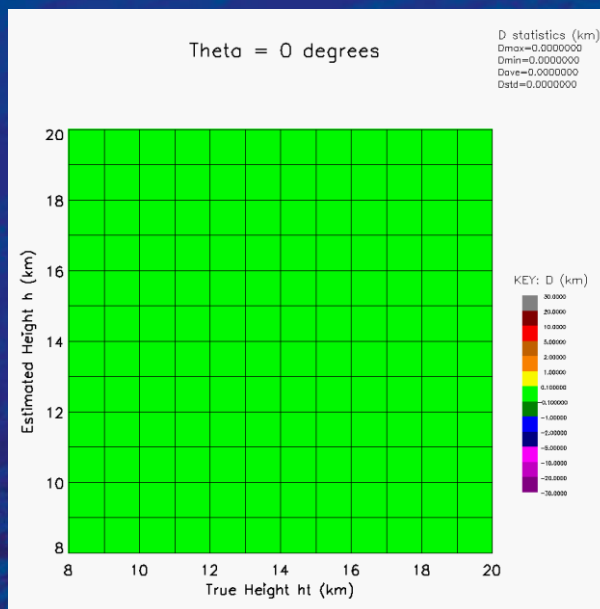
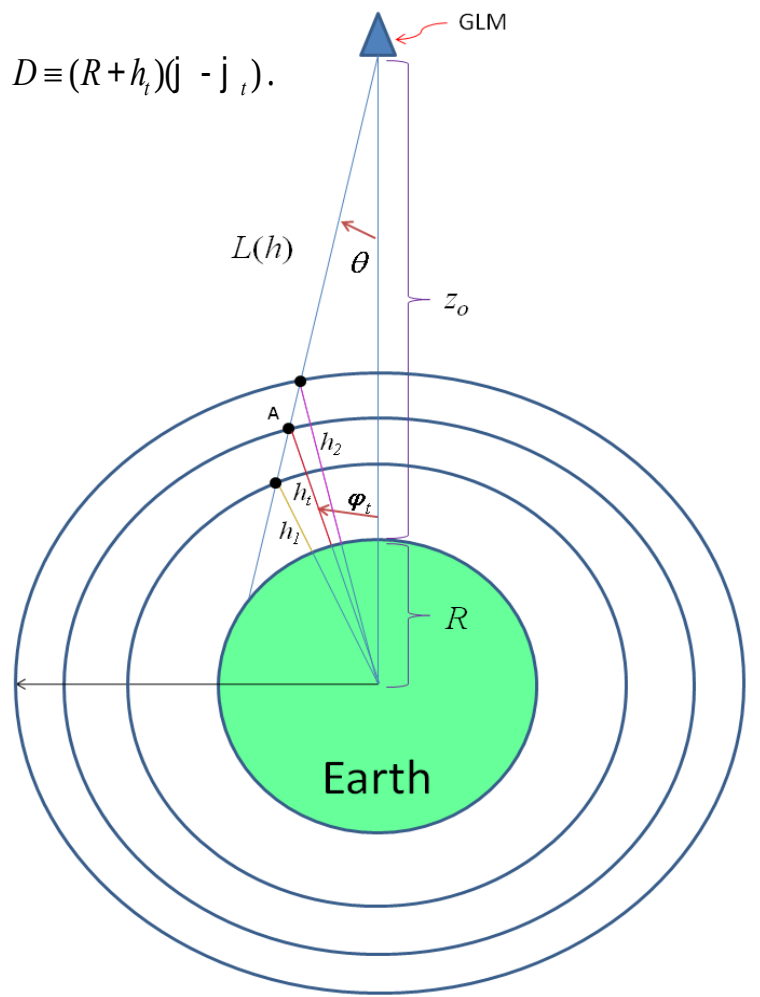
analyses: Rudlosky (AWIPS)

These GOES-16 data are preliminary, non-operational data and are undergoing testing. Users bear all responsibility for inspecting the data prior to use and for the manner in which the data are utilized.

ADR 637/645 Parallax

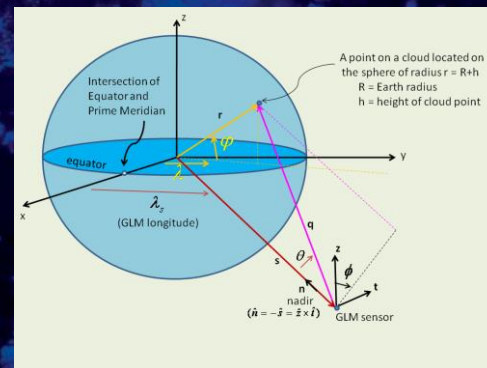
some history first ...

16 June **2010** Report (Koshak): Insight on Choosing an Optimal Thundercloud Top Height for Minimizing GLM Parallax Error



A fixed cloud-top height (~ 12 km) was the initial plan, but this 2010 Report demonstrated parallax errors would violate location accuracy spec

Report also included more complex generalizations





ADR 637/645 Parallax (cont.)

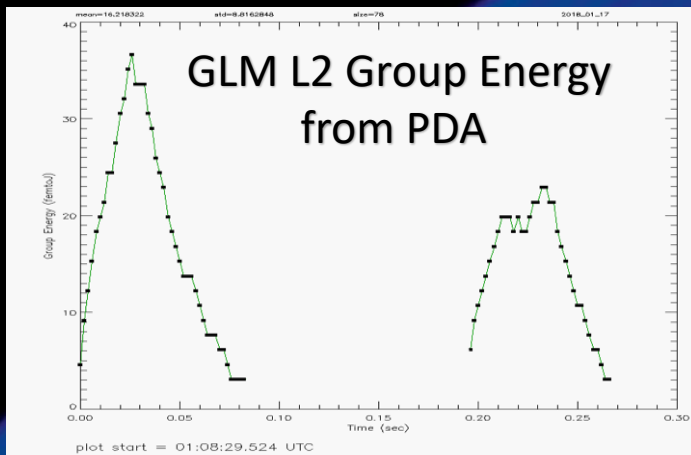


- Virts authored 637/645
- Tillier provided ellipsoid model code
- **637:** Optimized 2-parameter (eq/pole) heights in ellipsoid model
- **645:** Created optimal monthly $3^{\circ} \times 3^{\circ}$ res cloud-top height “topography”
- See Virts talk for details (**great parallax mitigation**)

ADR 738 Energy Scale/Offset

- Problem discovered by Koshak in comparing LMATC/Rudlosky Jan 2018 Michigan Bolide to PDA data.

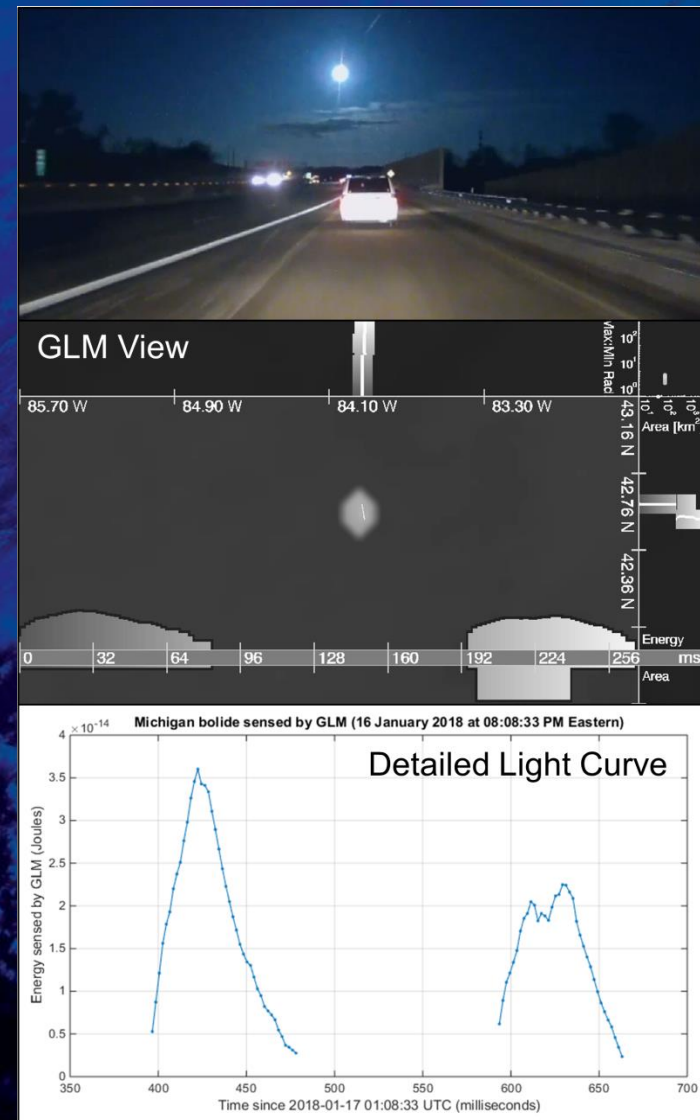
From Rudlosky/LMATC/Peterson ...



- Problem deep-dived by Armstrong and he suggested following fix:

	Current (L2+PUG values)		Recommended Update	
Lightning	scale_factor	add_offset	scale_factor	add_offset
Events	1.52597E-15	0	9.567E-18	2.870E-16
Groups	1.52597E-15	0	4.275E-16	2.870E-16
Flashes	1.52597E-15	0	3.750E-15	2.870E-16

These GOES-16 data are preliminary, non-operational data and are undergoing testing. Users bear all responsibility for inspecting the data prior to use and for the manner in which the data are utilized.





~ 2018 Activity Summary



36 fixes:

- 6 PRs (since 15 Dec 2017)

- Update CDRL 79 Rev J [Parallax Lite, 2nd lev filter to remove Bahama Bar] now in DE but to OE Oct 9 or later; 5 others completed.

- 7 for DO.07 (DE: 21 Aug 2018; OE: 9 Oct 2018)

- Adj evt times (TOF, etc), Grp/Flash areas, family links, 4 others not as important.

- 13 targeted for DO.08 (DE: ~ 4 Feb 2018; OE: TBD)

- Blooming, burst/outage, 2nd Level Threshold, Coherency LUT (sooner?), Data Burst Filter, Glint Box, Time Order, Event geolocation, 5 others not as important.

- 10 with target date uncertain

- Parallax, INR Diurnal Variation, INR optical monitoring, LCFA Radiation Filter (SGF), GPA keep 1st Event in Flash, Data Quality Product, Gridded Product, Optical Energy Distortions in PDA, Double Events/Groups, Dark Flashes.