The GOES-R Geostationary Lightning Mapper (GLM): A New Eye on Lightning

Steven J. Goodman, Richard Blakeslee, William Koshak, Douglas Mach, Jeffrey Bailey, Dennis Buechler, Larry Carey, Chris Schultz, Monte Bateman, Eugene McCaul, Jr., and Geoffrey Stano

http://www.goes-r.gov

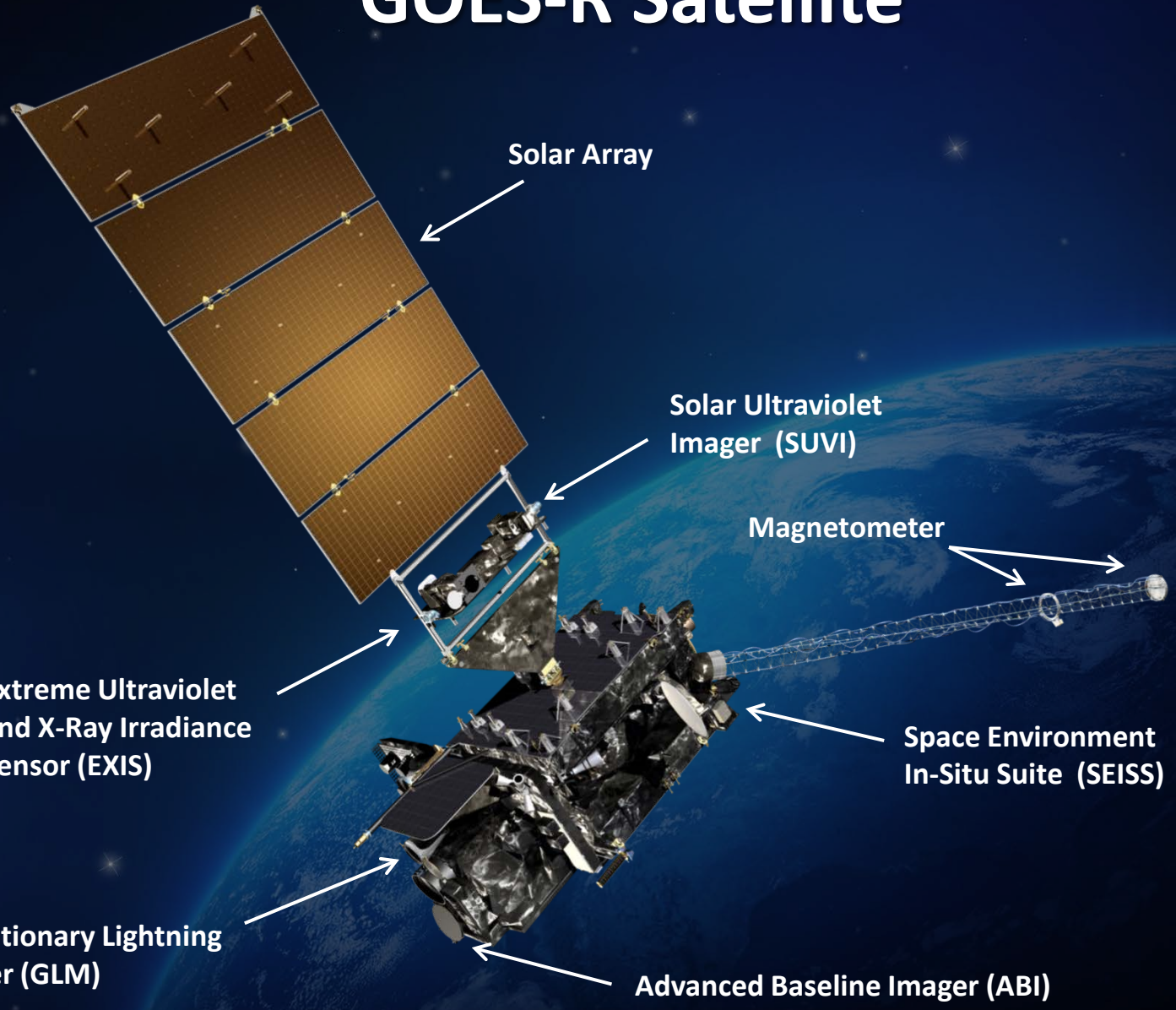
Joint Session- 9th Satellite and 6th Meteorological Applications of Lightning Data: 2012 AMS Annual Meeting

Austin, Texas January 6-10, 2013

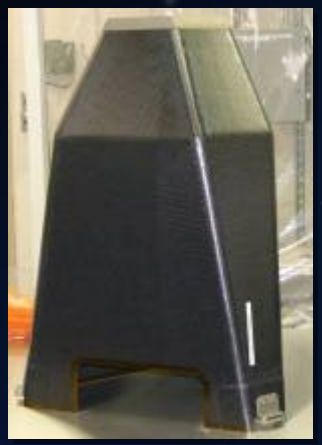
Outline

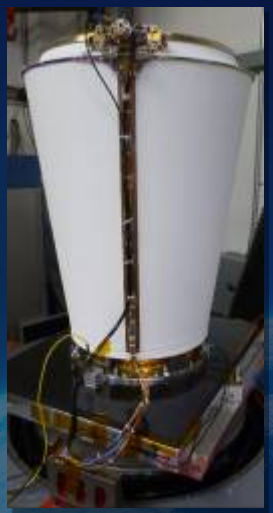
- GOES-R GLM Status
- Research and Applications
- GLM Validation
- Summary

GOES-R Satellite



GLM Sensor Unit Overview





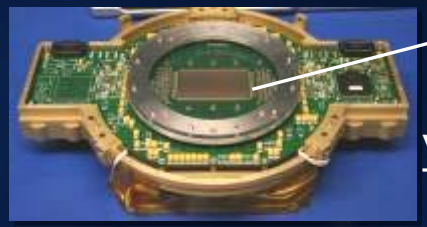
Solar Rejection Filter

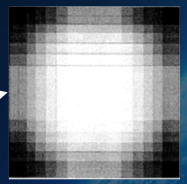
Solar Blocking Filter

Baffle Support

Baffle & Door

Lens Housing & Support Structure

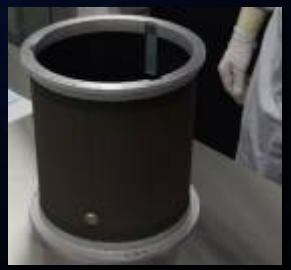




Variable Pitch CCD

Narrow Band Filter

Metering Tube



Focal Plane Array Assembly (FPAA)

Loop Heat Pipes (FPAA) and Thermal Straps (SEB)

Sensor Unit Electronics Box (SEB)

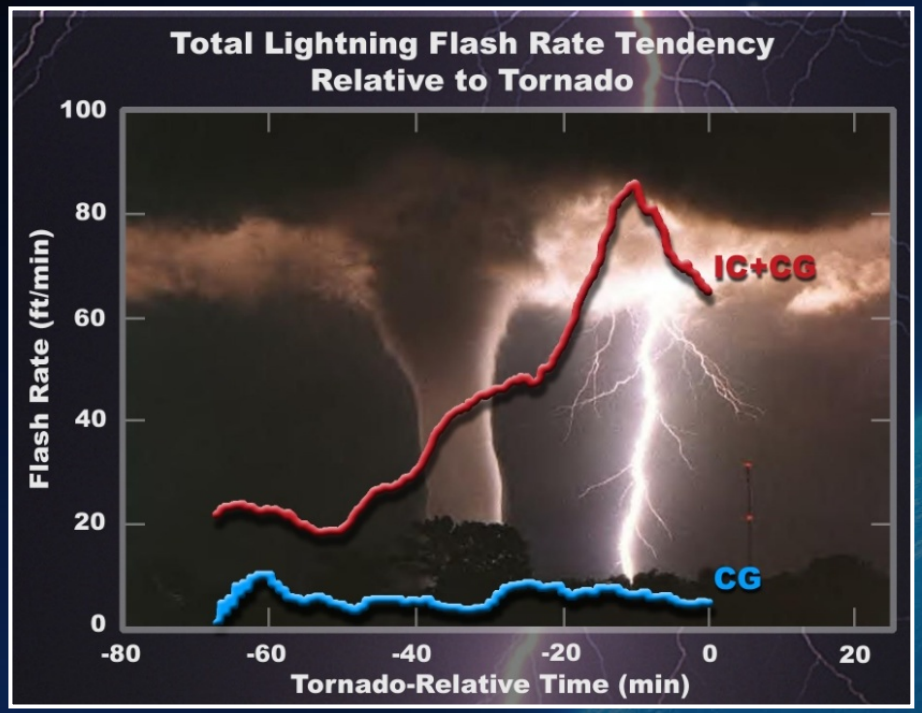
NWS Preparations for GLM Use

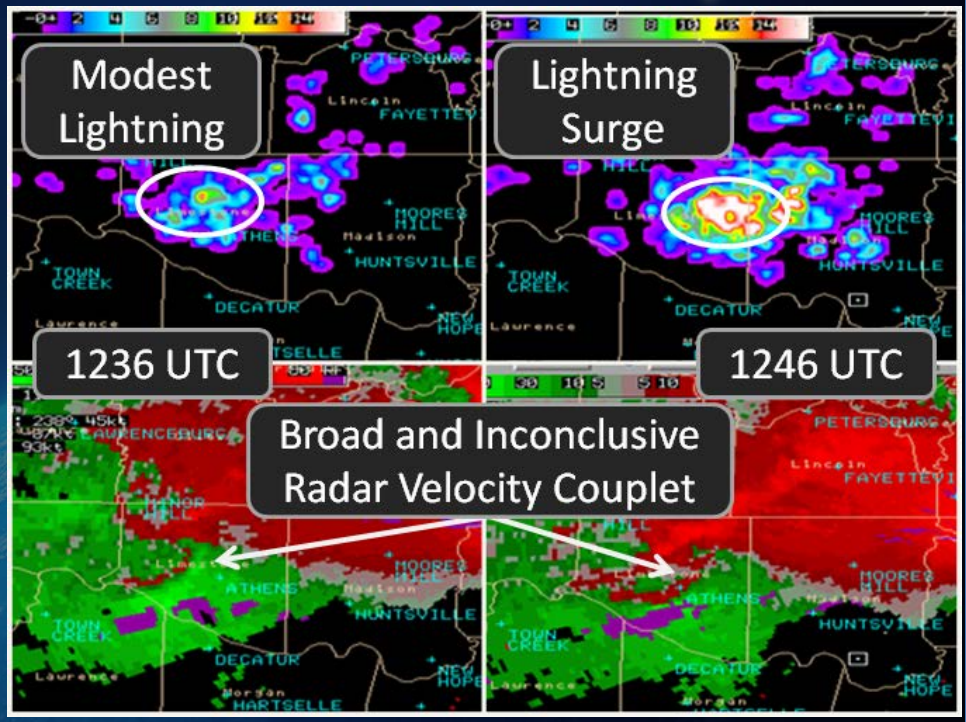
- GLM represents completely new/unique capability
  - High efficiency Total Lightning (TL) detection eventually stretching from the Pacific to the Atlantic (+ foreign, EUMETSAT-MTG, CMA FY-4)
- Strong evidence that GLM will significantly contribute to enhancing several key strategic priorities.
- With previous new satellite sensors (e.g. GOES Sounder) it took many years to develop and fully translate new capabilities into improved weather operations.
  - these sensors/capabilities are too expensive to waste operational life learning how to exploit
- GOES-R Proving Ground / Risk Reduction breaks this lack-of-readiness pattern by investing in readiness before launch
- Building applications into forecast process and anticipate significant benefit to enhanced societal services

Reducing Societal Impacts of High Impact Weather: Most-Promising GLM Contributions

- Improved Convective Warnings (combine TL, radar, other)
  - Reduced FAR, Increased POD, Increased Lead Time for Tornado Warnings and other Severe Convective Warnings
  - Enhanced Situational Awareness for Aviation Services over broad geographic area (especially trans-oceanic flights)
  - Enhanced Situational Awareness for Convective Precipitation (Flash-Flood)
- Improved Forecasts of Rapid Intensification (RI) and Rapid Weakening (RW) in Tropical Storms
- Short-term numerical weather prediction improvement
  - Assimilation of TL as proxy for strong convection
  - Better initialization of storms approaching CONUS from offshore (e.g. winter storms, heavy precipitation)

Lightning Detection





National Average for Tornado warning lead-time is 14 minutes

Operational demonstration underway beginning in April 2012 of the total lightning algorithm at the Hazardous Weather Testbed (at request of NWS)

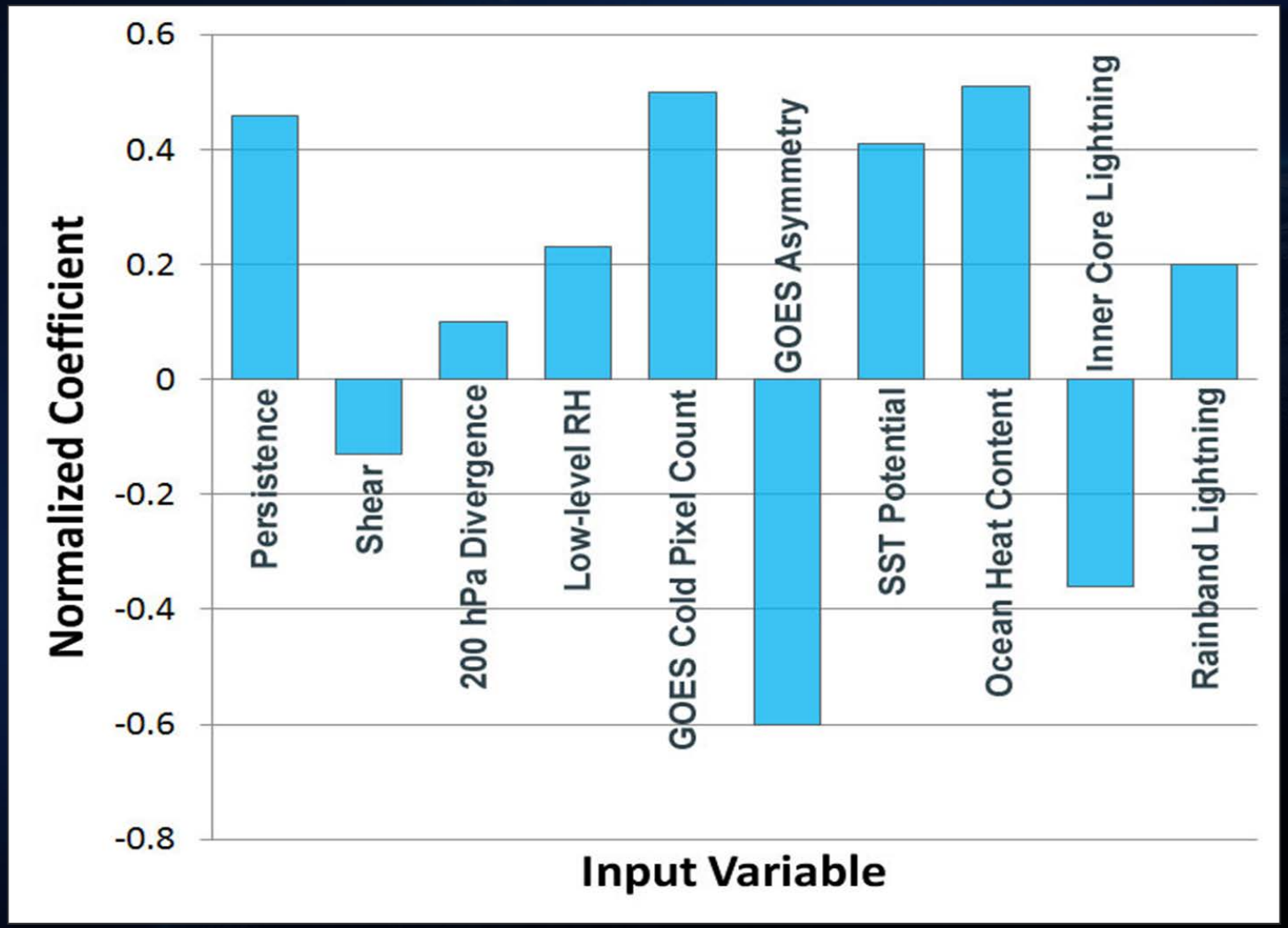
Tropical Storm
RI and RW Forecast Improvements

Demaria et al.

- Rapid Intensity (RI) forecast improvement is the highest priority development for NHC (and JTWC)
- TL observations have been correlated to being at least as strong a predictor as other parameters currently being used in statistical RI models
  - Ground-based systems demonstrate this correlation, but have low detection efficiency for TL
  - Current space-based optical systems have high-TL detection efficiency…but are polar orbiting…and don't allow continuous monitoring…and don't have needed operational latency
- Experimental rapid intensification probability forecast algorithm developed and being demonstrated (GOES-R PG)
- Fact that correlation exists holds promise for TL assimilation into cloud-resolving NWP model development

Normalized Discriminant Weights (Atlantic RII Algorithm)

Demaria et al.



GOES-14 SRSOR 1-min Imagery Experiment

The GOES-R **Algorithm Work Group** in partnership with the GOES-R **Risk Reduction Science Program** and **Proving Ground Demonstration Program** have developed a number of products and decision aids undergoing evaluation and feedback with NWS forecasters across the country.

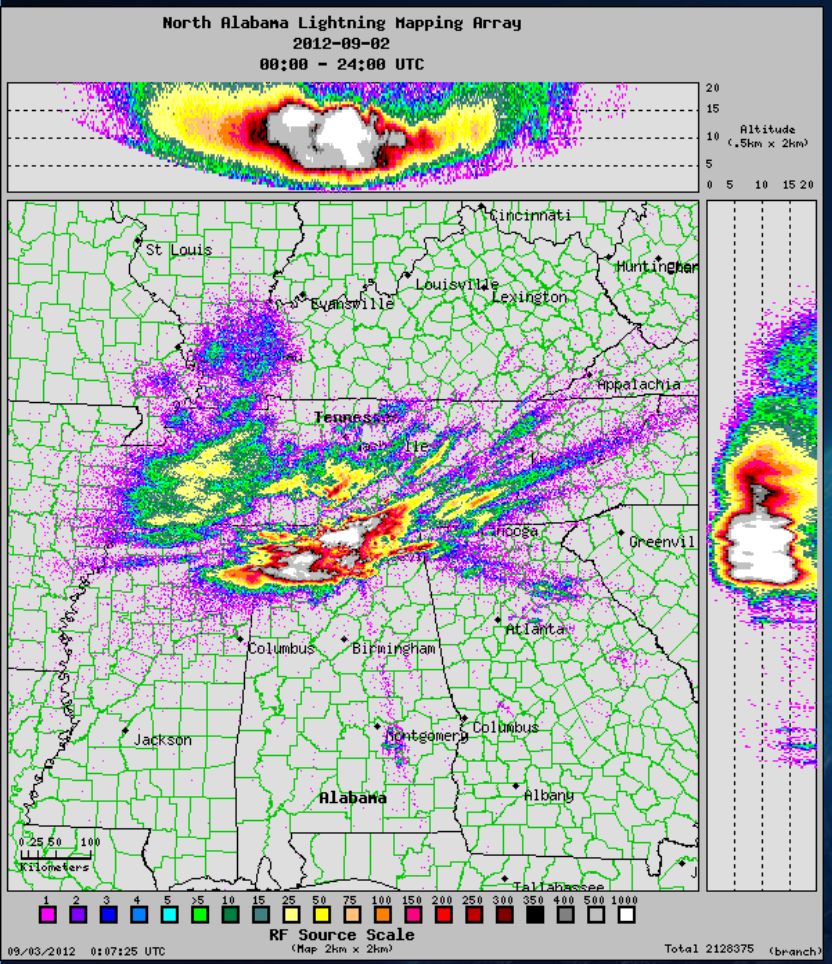
In the GOES-R Proving Ground, Baseline and Future Capability Products are demonstrated with and receive feedback from forecasters using proxy and simulated data sets. Some of the key products that are very useful for high impact weather forecasts and warnings include:

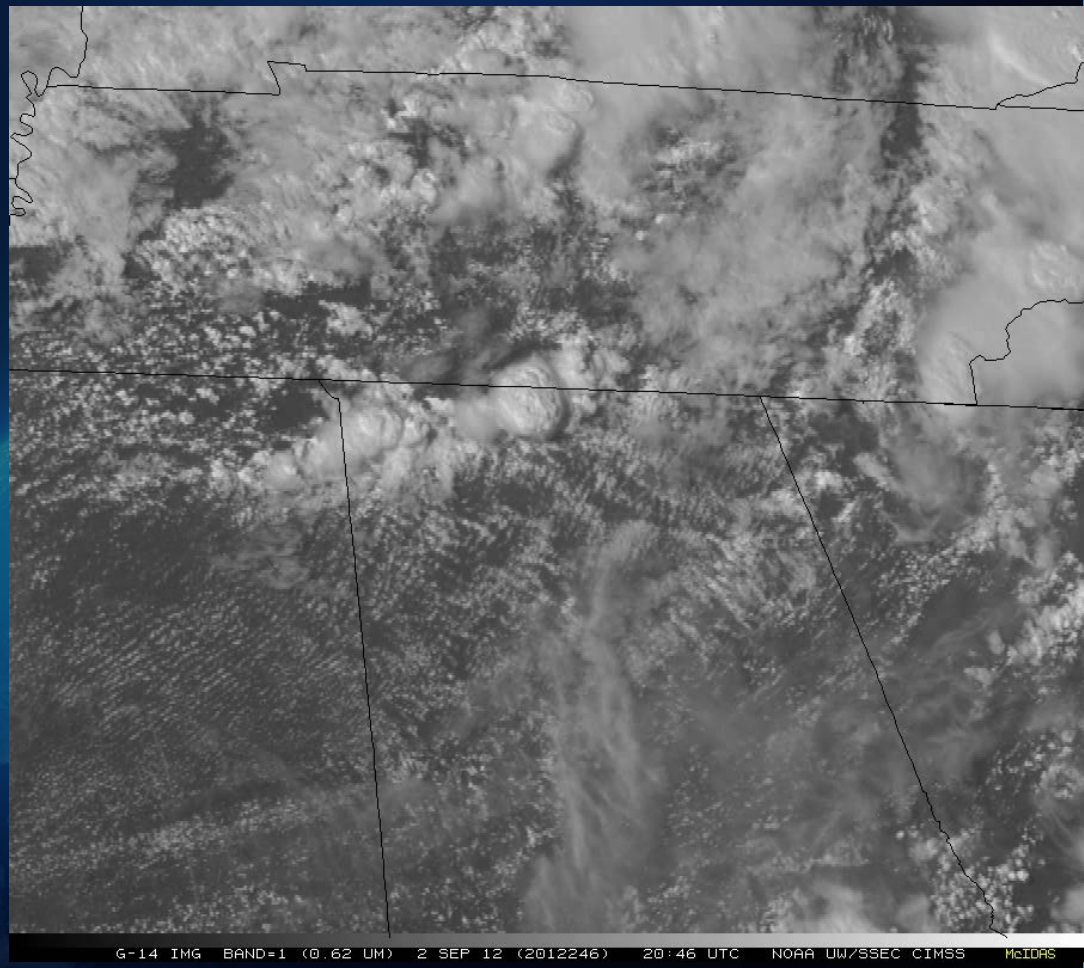
- Cloud and Moisture Imagery
- Hurricane Intensity Estimate
- Convective Initiation
- Overshooting Top Detection
- Lightning Detection

A deficiency in these product demonstrations is our inability to more fully demonstrate the added utility of the GOES-R imagery products at the higher 30 sec to 1 min mesoscale refresh rate that will be routinely possible with the ABI.

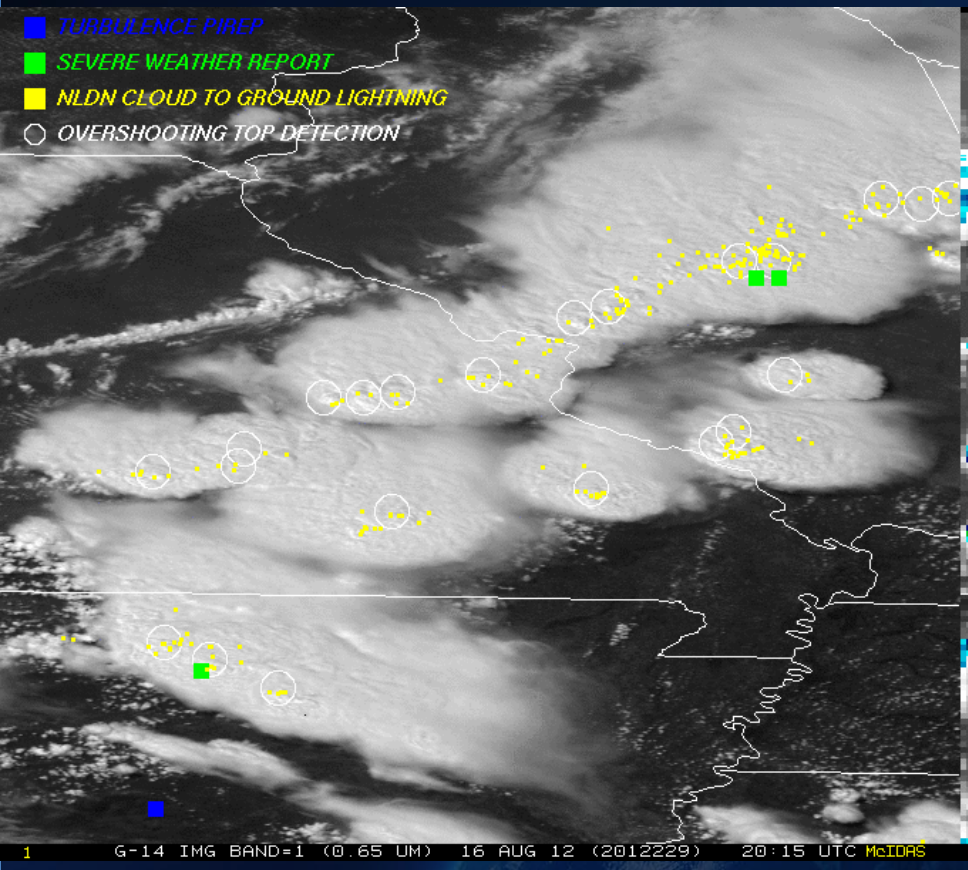
GOES-14 SRSOR Experiment :

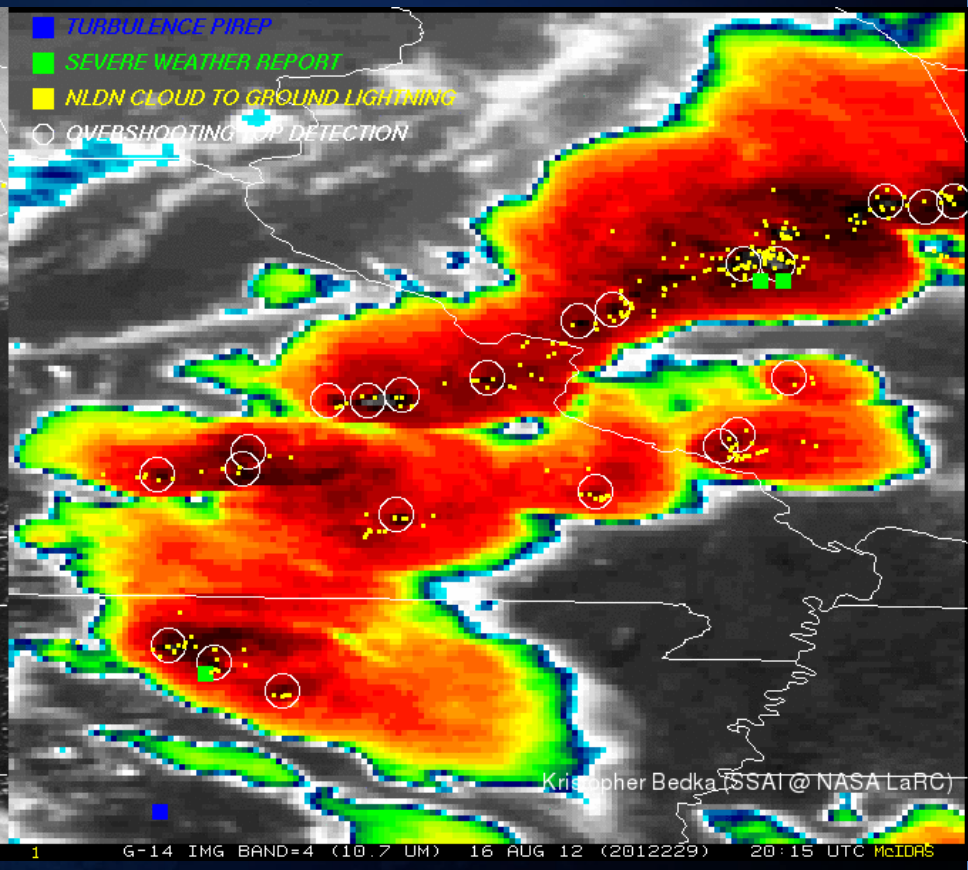
GLM Testbed Lightning Detection





GOES-14 SRSOR Experiment :
Overshooting Top Detection

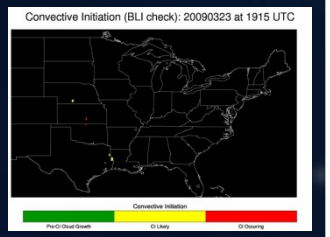




NWS Vision to Integrate ABI and GLM Products with Other Data and Models

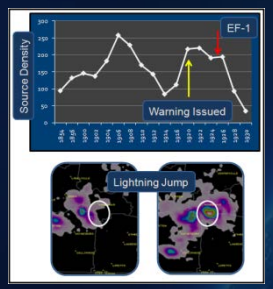
A Potential Operational Example: Convective Initiation/Severe Wx
How can we integrate the information in future tools?

CI

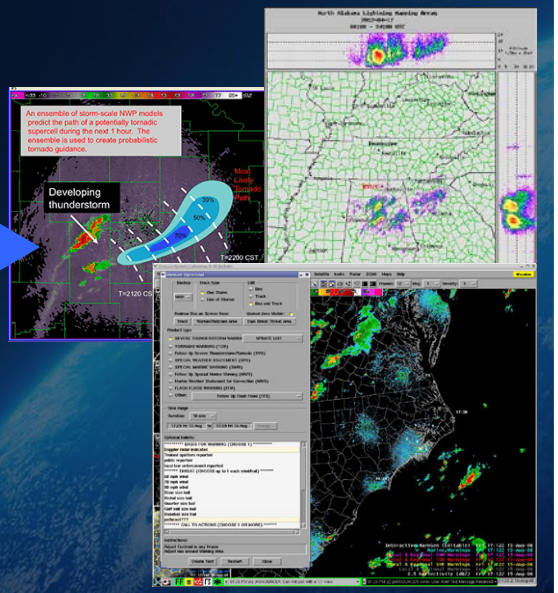


Over-shooting tops

Lightning Jumps



Next Generation Warning System



Why NWS needs this?

Situational Awareness
Warning confidence
Decision Support (venues)

Situational Awareness:

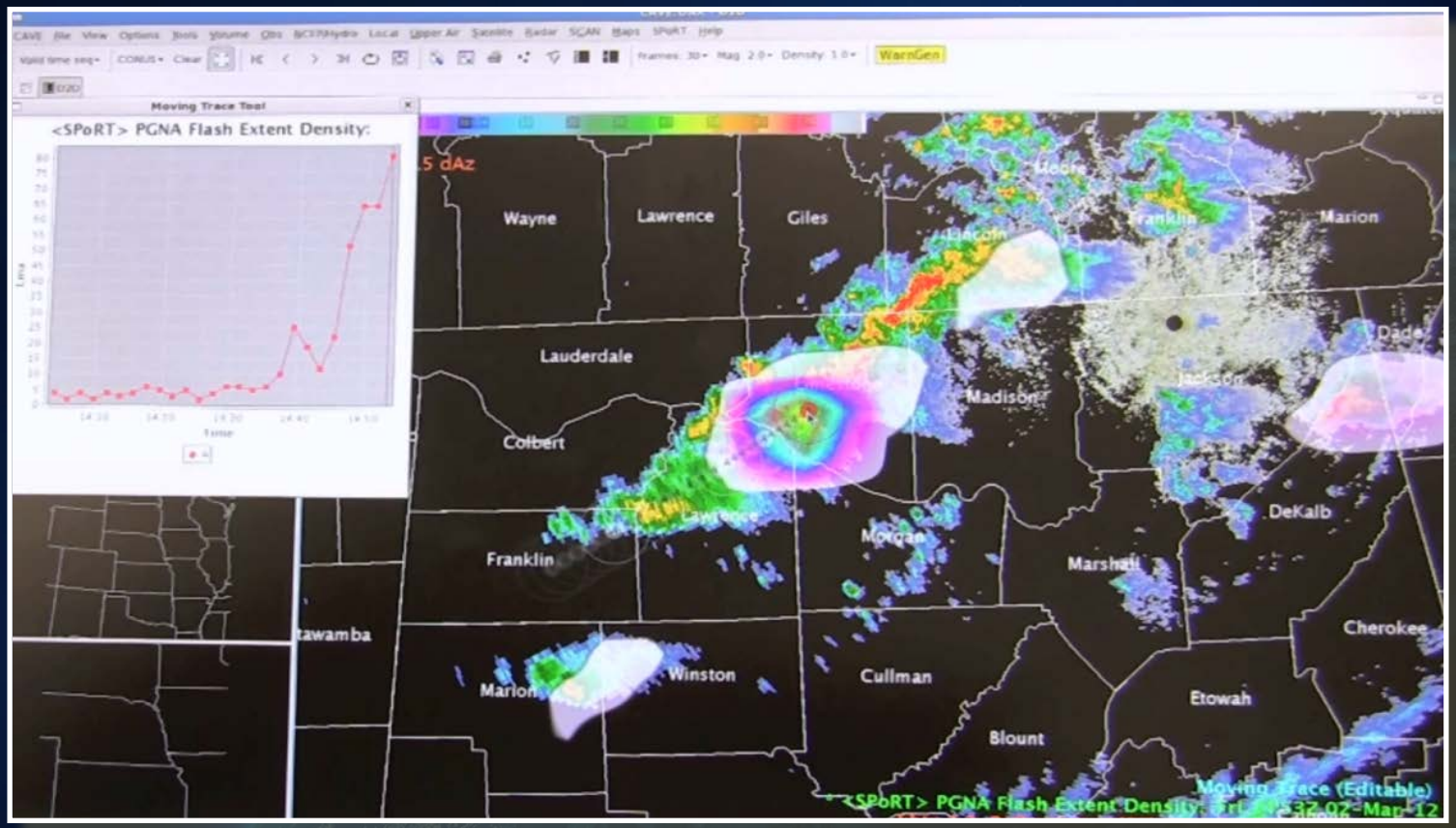
User comment: 'Cloud Top Cooling product is an excellent source of enhancing the situational awareness for future convective initiation, particularly in rapid scan mode'.

AWC Testbed forecaster

(June 2012)

NASA-SPORT AWIPS II Plug In-Development (Integration Example)

Stano et al.



Looking forward to the national perspective

- Update existing plug-ins
- Trend tool, IC-CG comparison

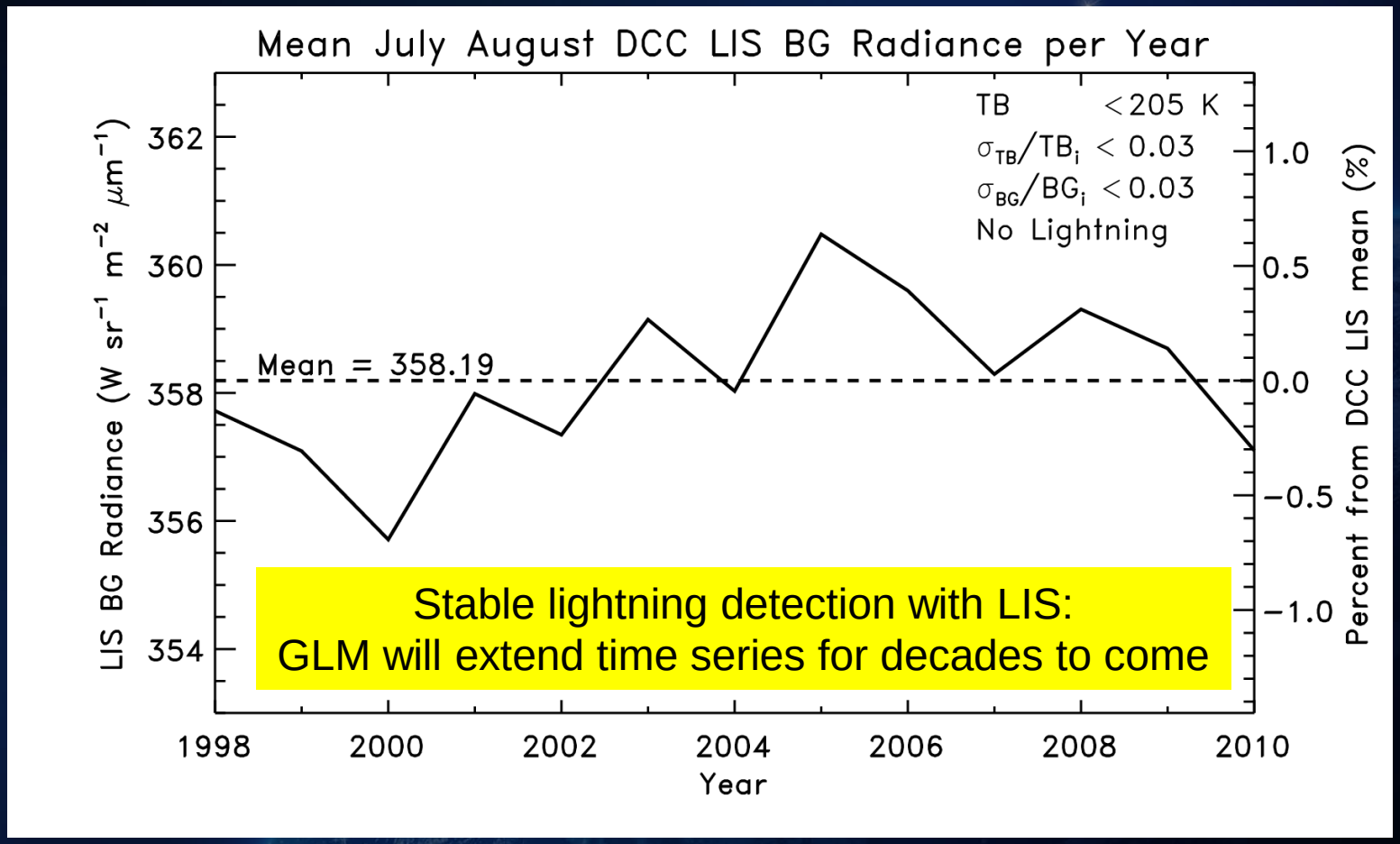
GOES-R Cal/Val Scope

- Ensure instrument calibration requirements are met
- Enhance data integrity by leveraging NIST SI-traceable calibration standards, and testing capabilities and procedures
- Reduce risks associated with possible operational failure of on-board calibration systems
- Prepare NOAA satellite calibration scientists and engineers for monitoring, analyzing and maintaining GOES-R series instrument calibration and product integrity
- Support product validation to determine the degree to which GOES-R science data meets user needs

GOES-R Program commitment to cal/val enhances understanding of data quality, and encourages “Day-1” readiness and long-term user confidence.

Deep Convective Cloud Technique

(LIS backgound variation < 0.7%)



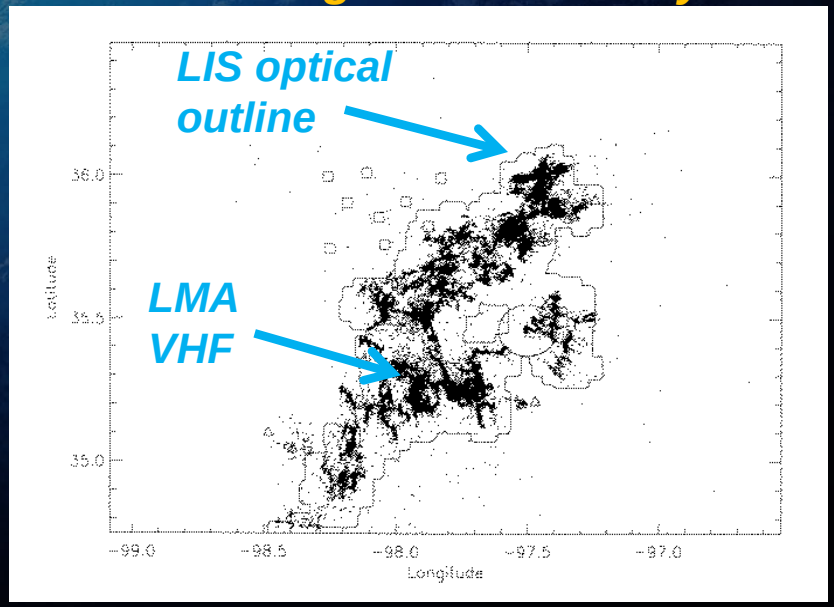
Yearly trend of mean LIS BG DCC radiance for each combined July and August from 1998-2010. The dashed line is the mean of each July August DCC radiance over the period (358.19 W sr W sr^{-1} m^{-2} µm^{-1}). The left hand scale is in W sr W sr^{-1} m^{-2} µm^{-1} and the right scale indicates the percentage departure from the mean July August 1998-2010 DCC radiance values (Buechler et al., *Atmos. Res.*, 2012).

Validation Data



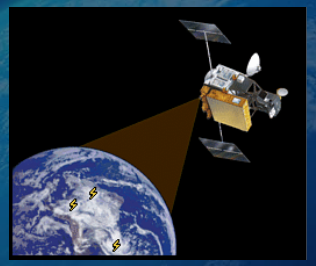
- **Ground Truth Datasets:**
  - Short-Medium Range Lightning
    - LMA North Alabama (NASA-NOAA), DC (NASA-NOAA), Oklahoma (OU CIMMS-NSSL), West Texas (TTU), NMTech, Camp Blanding (UF-DARPA), Colorado Front Range (CSU), Houston (TAMU), NASA-KSC and Wallops, Atlanta (GTRI)
    - HAMMA/Delta E Array (North Alabama)
    - High Speed Video Cameras
    - KSC Field Mills (KSC Florida)
    - NLDN (CONUS)
  - Long Range Lightning
    - GLD360
    - WWLLN
    - ENTLN

Building the GLM Proxy



Validation Data (cont.)

- **Airborne GLM Simulator**
  - Build an airborne detection system that will make high resolution optical measurements as a GLM simulator.
  - Deploy on aircraft (e.g., ER2, Global Hawk) to observe cloud-top lightning pulses (field campaigns of opportuntity).
- **Satellite Observations**
  - LIS
    - GLM proxy data development
    - Pre-launch validation simulations (including val tool testing)
    - Pursue opportunity to a LIS on International Space Station
    - TRMM Extended Mission
    - TARANIS (Tool for the Analysis of RAdiation from lightNIng and Sprites)
    - Launch 2015, CNES/France; nadir staring (2 cameras, 4 photometers)
    - Directly compare with GLM data
  - Cross-Calibration Between GLM and MTG LI (2017) (at 777.4 nm)

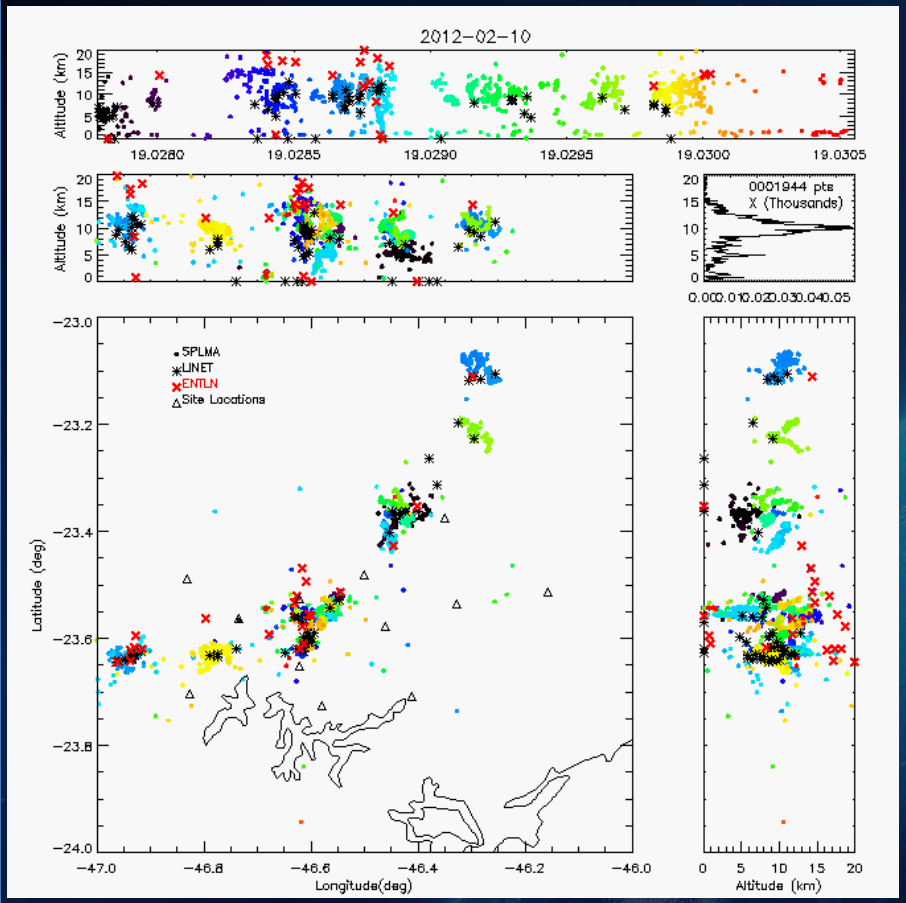


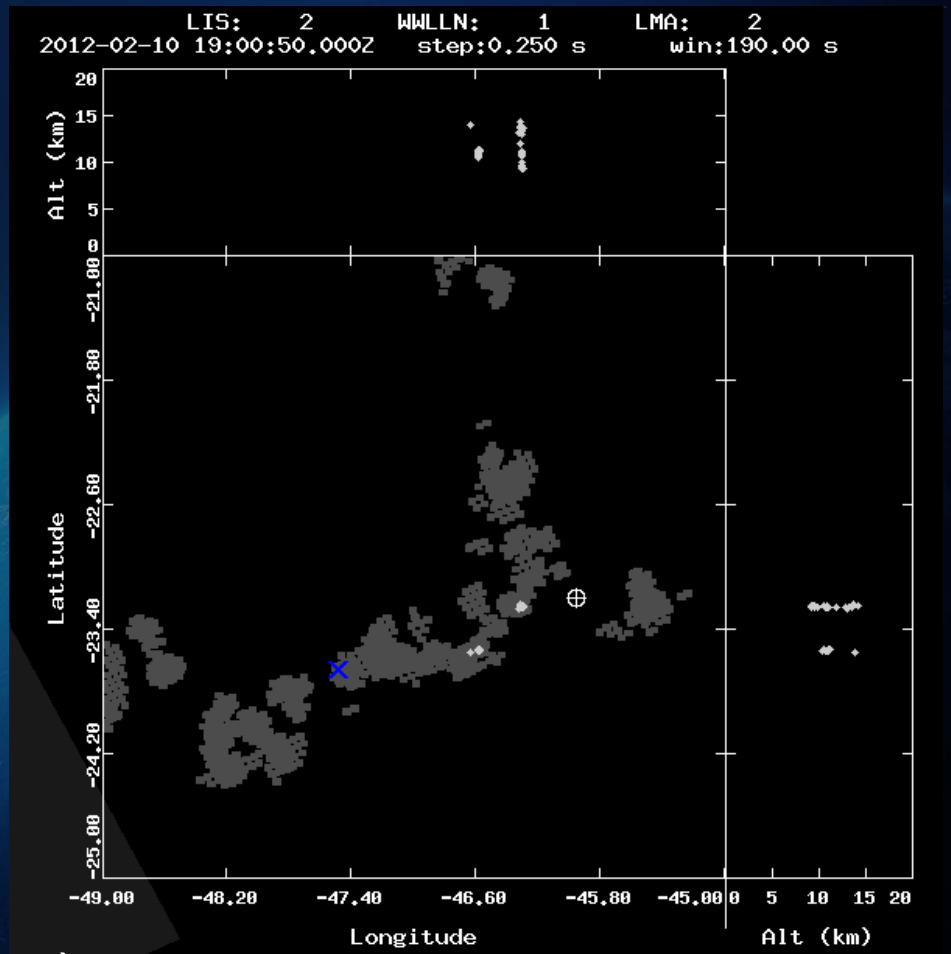
Credit: CNES/Ill. D. Ducros

Comparison of Space-Based and Ground-Based Cal/Val Lightning Observations

TRMM/LIS Overpass

February 10, 2012 GLM CHUVA Campaign





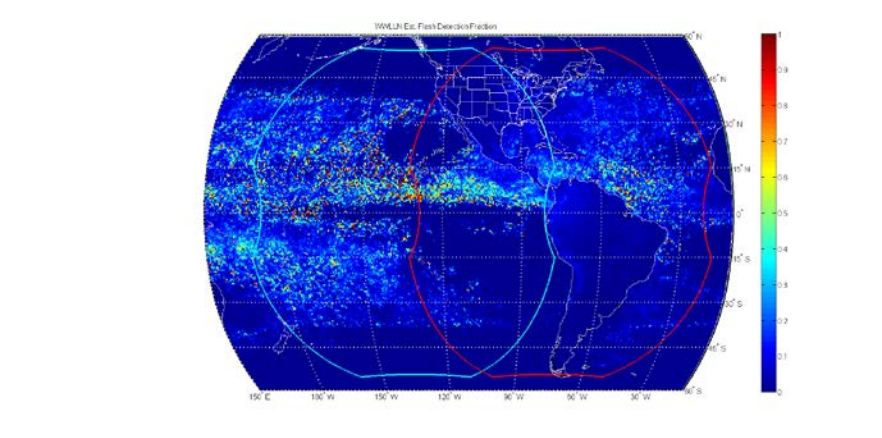
LIS (upper)
LMA (lower)

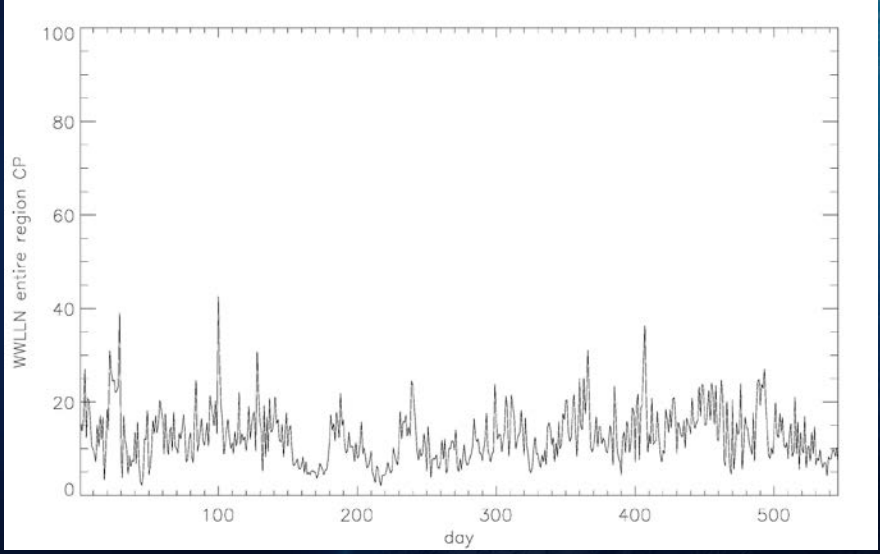
Courtesy, Jeff Bailey and Monte Bateman

Big Video, CHUVA

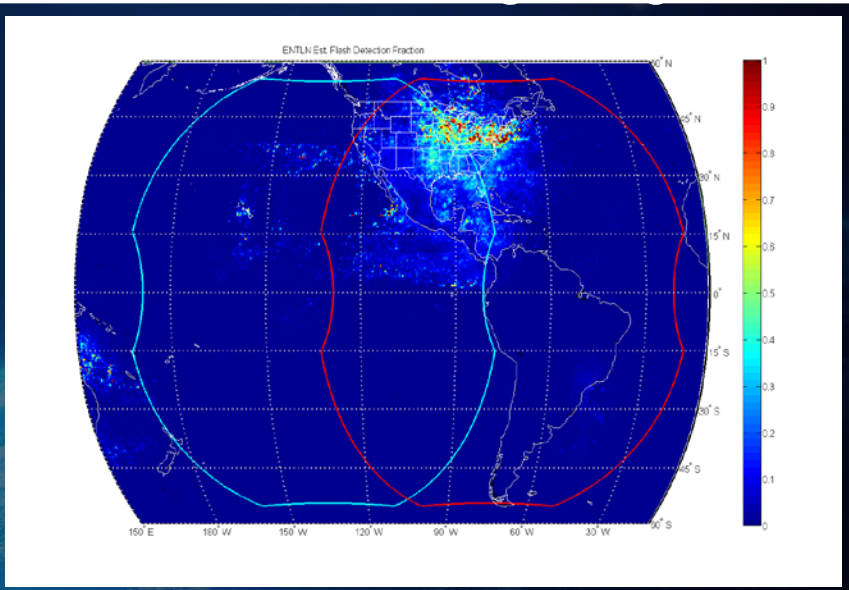
18-month GLM Coincidence Comparison with Ground-Based Networks (Using LIS proxy)

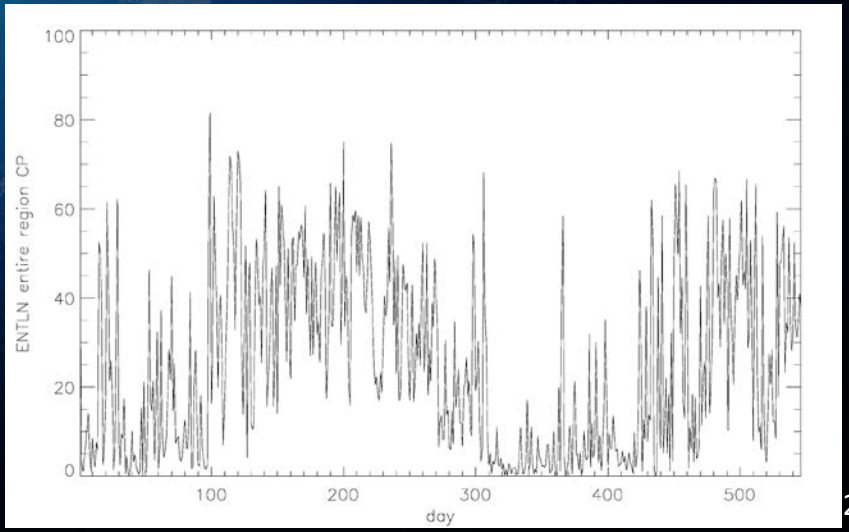
Worldwide Lightning Location Network





Earth Networks Total Lightning Network





Coincidence fraction above, temporal variability below
Courtesy, Kelsey Thompson/UAH and Monte Bateman/USRA

Summary

Pre-launch demonstrations with GLM proxy data benefits users to prepare them to fully exploit all GOES-R instruments and capabilities

- Instrument Development and AWG Algorithms
  - GLM Instrument Development on Track- FM1 2013
  - AWG L2 Code Development Delivered & Within Specifications
  - Proxy data and Cal/Val tools in Development for Monitoring GLM Performance
- Exploratory Algorithms and Future Capabilities
  - New Products and Applications
  - Multisensor-Multiplatform
  - Nowcasting and Data Assimilation
- GOES-R Product Demonstrations and Training
  - GOES-R capabilities demonstrated and evaluated by users
  - Forecaster Evaluation and Feedback
  - Training content and module development coordination with NWS, COMET, VISIT


QUESTIONS?