GOES-R Program and Science Office Update

Steven J. Goodman
GOES-R Program Chief Scientist
http://www.goes-r.gov

GLM Science Team Meeting
Huntsville, AL
September 19-21, 2012

Outline

- New, Relatively New, and Returning Faces
- Recent Accomplishments
- Where We Are
  - Schedule
  - Science
  - Cal/Val
  - Proving Ground
  - Training
- The Road Ahead

New Faces- Who, What, Where

- Flight Project Manager-Pam Sullivan, NASA (was Mike Donnelly)
- Ground Project Manager, Acting-James Valenti, NOAA (was Vanessa Griffin)

- GLM Science Team
  - Scott Rudlosky- from UMCP/CICS to NESDIS/STAR/SCSB
  - Rachel Albrecht- from UMCP/CICS to INPE/CPTEC
  - Dan Cecil- from UAH to NASA/MSFC
  - Chris Schultz- from UAH to NASA/MSFC
  - Themis Chronis- from HCMR to UAH

- Satellite Liaisons
  - Michael Folmer, NCEP OPC-HPC-NHC-TAFB-SAB/UMCP-CICS
  - Amanda Terborg- NCEP AWC/UW CIMSS
  - Chad Gravelle- NWS Training Center/UW-CIMSS
  - Roy Huff- NWS Pacific Region/U. Hawaii-JIMAR
  - Kathryn Mozer- Proving Ground Coordinator/Omitron (new role, was B. Reed)

Recent Accomplishments: Ground Segment Progress

WCDAS Antenna Sites

RBU Antenna Sites

RBU Electrical Work

Harris C400 Development Lab

WCDAS Site 8 Radial Beam Installation

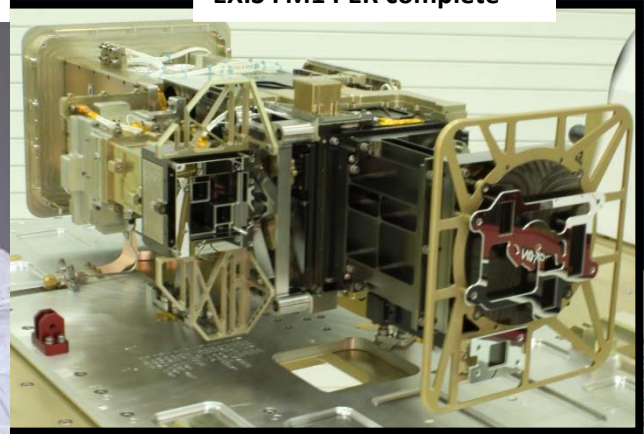
WCDAS Power House Construction

RBU Site 2 Foundation Footer

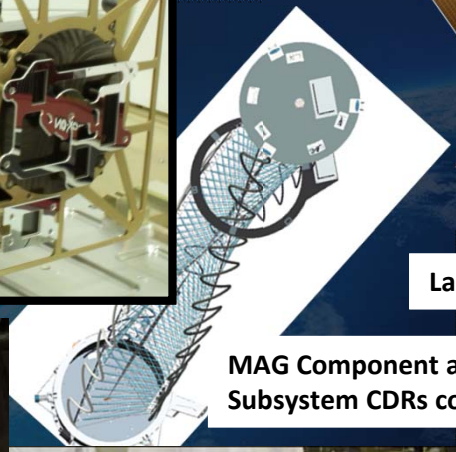
Recent Accomplishments: Flight Project Progress

ABI PTM Sensor Unit Successfully Completed System Test

EXIS FM1 PER complete

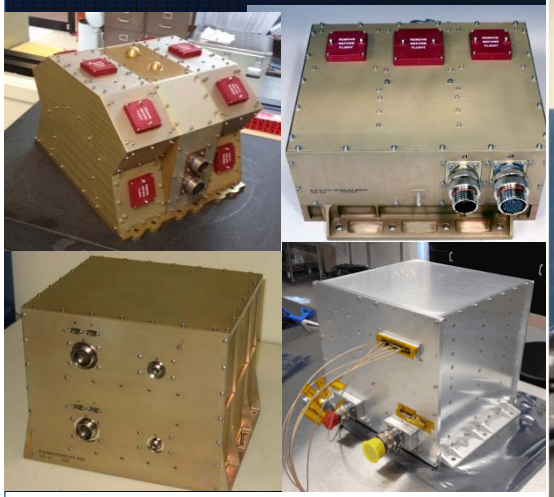


Spacecraft CDR complete

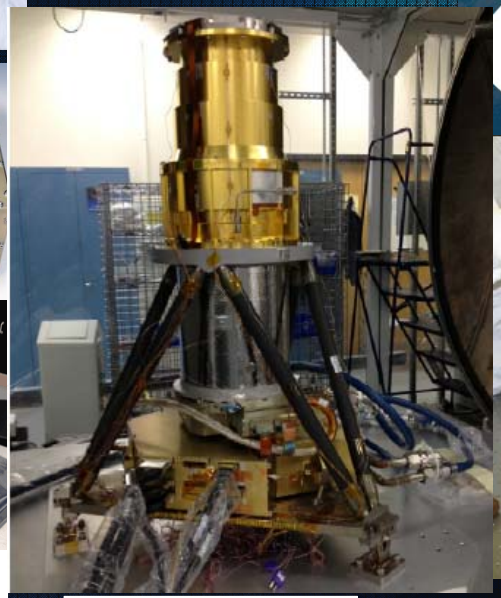


Launch Vehicle Contract Awarded

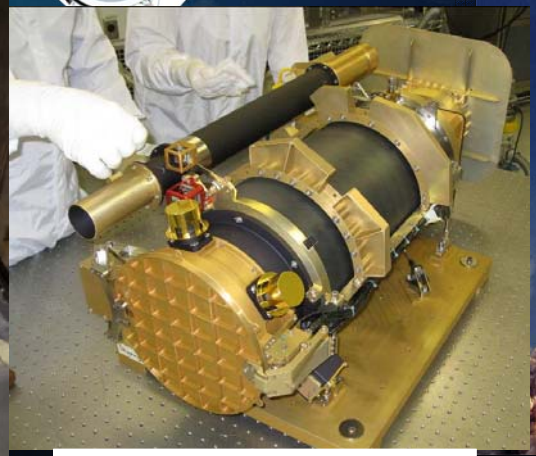
MAG Component and Subsystem CDRs complete



Successfully completed SEISS SGPS, MPS-HI, DPU, And EHIS Pre-Environmental Reviews

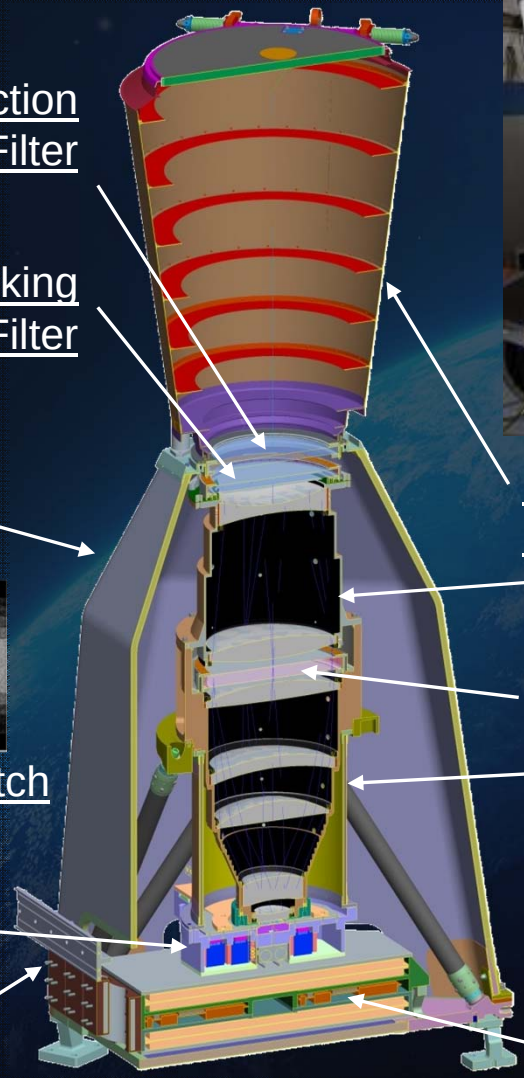


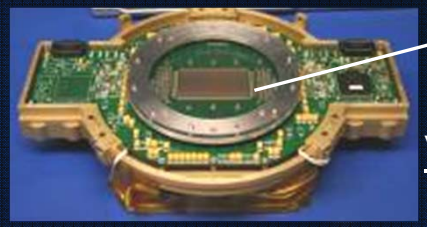
GLM EDU Complete

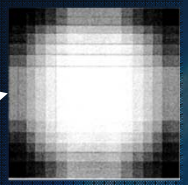


SUVI Structural Model testing complete and delivered to S/C

GLM Sensor Unit Overview







Solar Rejection Filter

Solar Blocking Filter

Baffle Support

Baffle & Door

Lens Housing & Support Structure

Narrow Band Filter

Metering Tube

Variable Pitch CCD

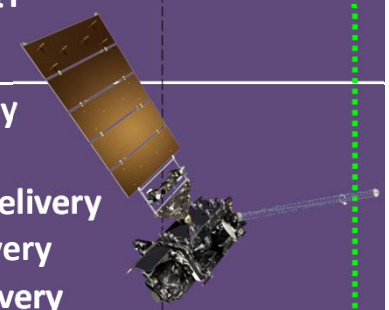
Focal Plane Array Assembly (FPAA)

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

Sensor Unit Electronics Box (SEB)

Where Are We: Schedule

	2010	2011	2012	2013	2014	2015
Program/ System	✓ System Design Review complete	✓ Mission PDR Part I	✓ Mission PDR Part II ✓ Mission CDR			Launch Readiness Oct. 2015
Flight Segment – Spacecraft	✓ S/C SDR complete	✓ S/C PDR complete	✓ S/C CDR	● S/C I&T		
Flight Segment – Instruments	✓ All instruments have passed CDR	✓ ABI Delta CDR complete		● ABI Delivery ● EXIS Delivery ● GLM Delivery ● MAG Delivery ● SEISS Delivery ● SUVI Delivery		
Ground Segment	✓ Core GS PDR completed ✓ Antenna System PDR completed ✓ 100 % delivery of baseline product algorithms	✓ GS Project PDR complete	✓ Core GS CDR ✓ Antenna System CDR ✓ ESPDS CDR ✓ CLASS CDR ✓ GS Project CDR	● RBU/NSOF/WCDAS installation ● WCDAS complete ● RBU complete ● NSOF complete		



Development → Integration and Testing

Conferences and Events

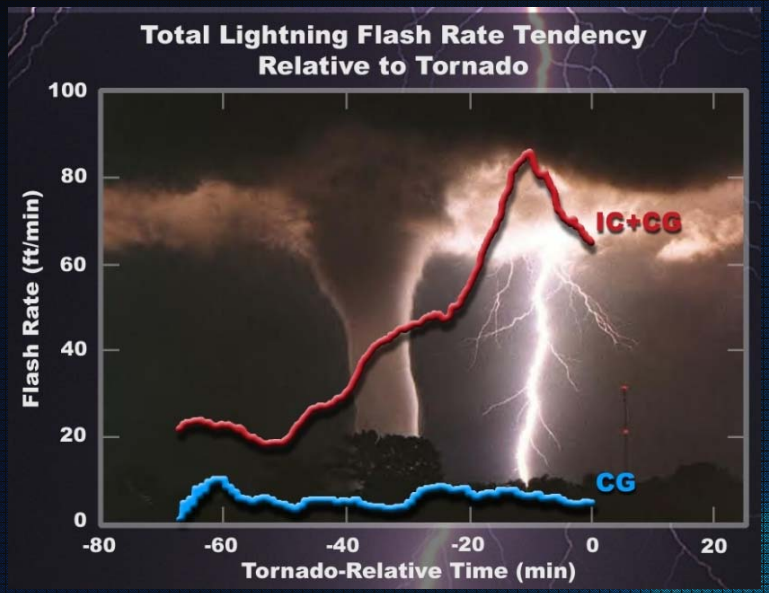
7th GOES Users' Conference

Live Media Event

NOAA Satellite Science Week

Education and Outreach

Lightning Detection



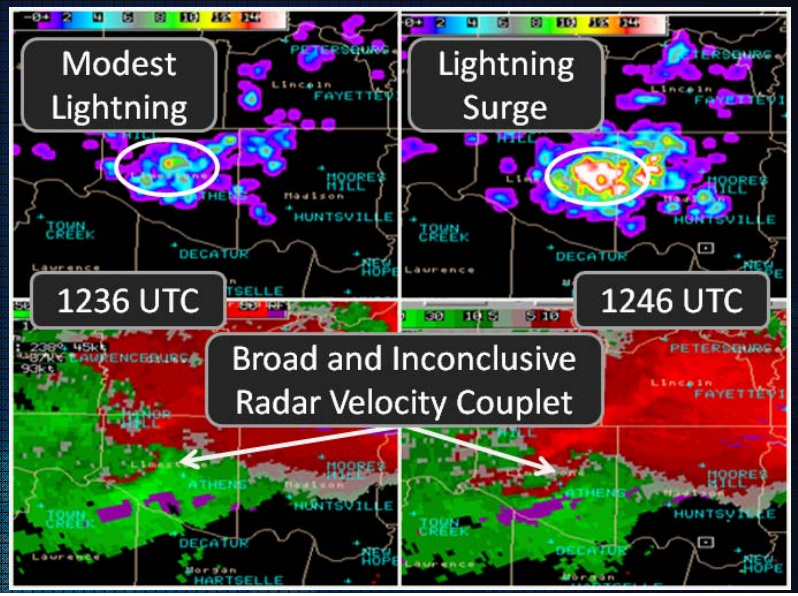


TABLE 3. Skill scores and average lead times using the sample set of 711 thunderstorms for both total lightning and CG lightning, correlating trends in lightning to severe weather.

	POD	FAR	CSI	HSS	lead time (all)	lead time (tornado)
Total lightning	79%	36%	55%	0.71	20.65 mins	21.32 mins

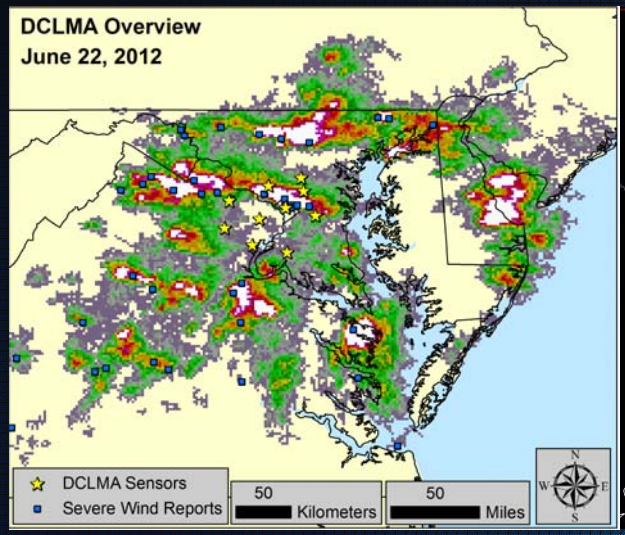
National Average for Tornado warning lead-time is only 14 minutes

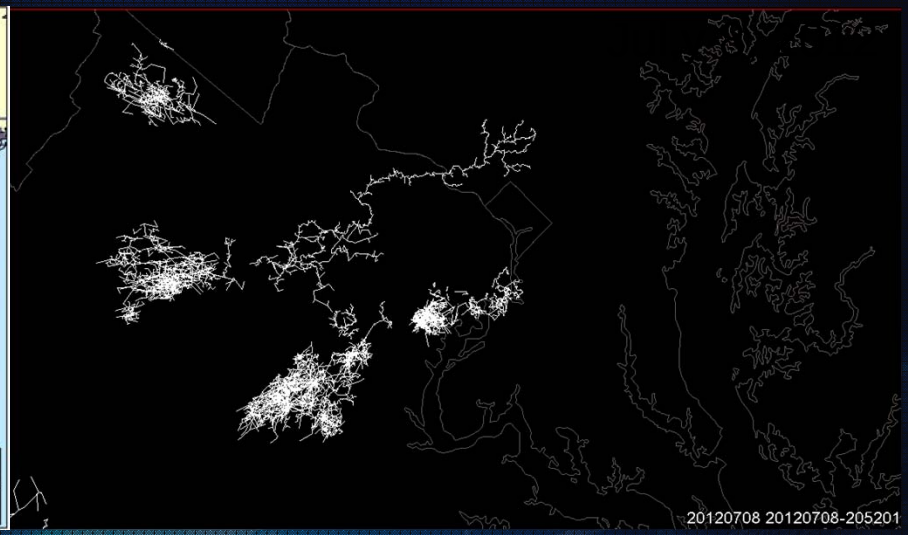
An operational demonstration of the total lightning algorithm at the Hazardous Weather Testbed (at request of NWS) began in early April and is currently in progress.

Table courtesy Larry Carey and Chris Schultz

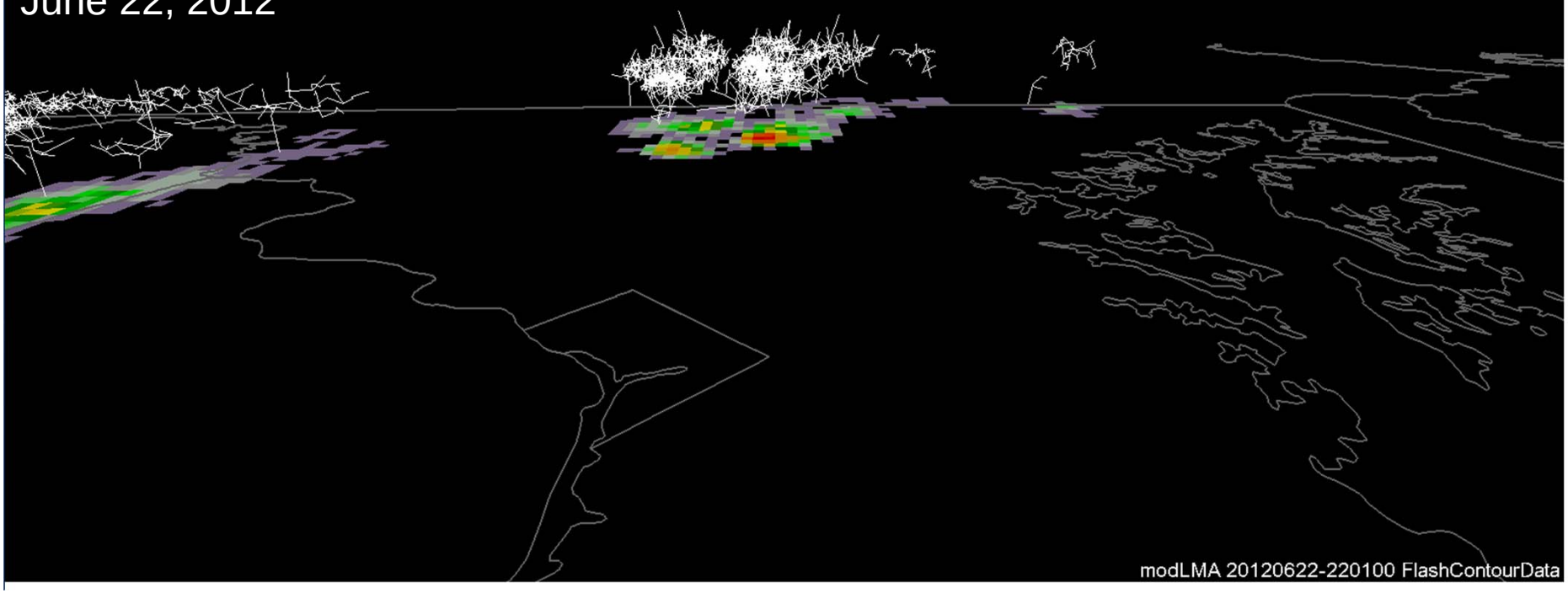
Studies of Severe Storms and Lightning

GLM
DCLMA
Testbed





June 22, 2012

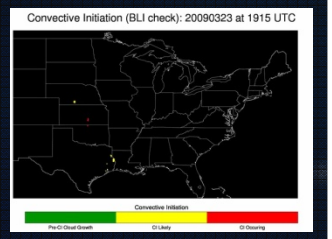


Courtesy Scott Rudlosky

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

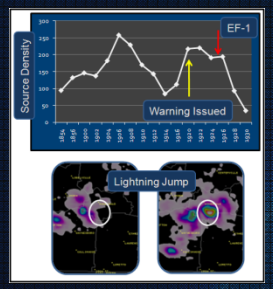
A Potential Operational Example: Convective Initiation/Severe Wx
How can we integrate the information in future tools?

CI

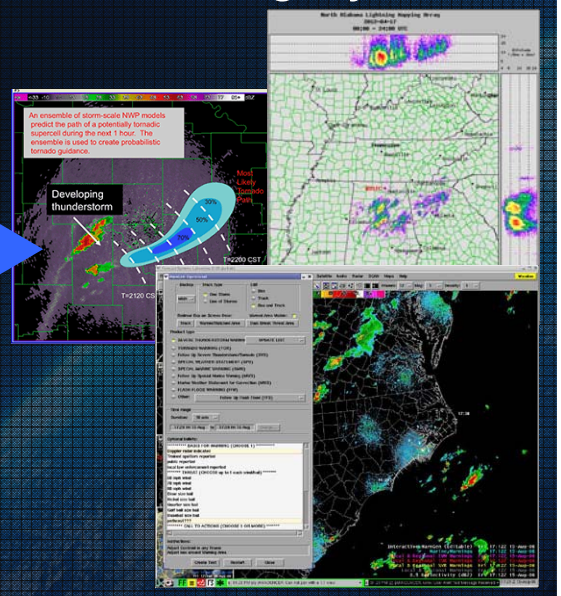


Over-shooting tops

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)

Combining GLM and ABI Data for Enhanced GOES-R Rainfall Estimates

(Robert Adler and Nai-Yu Wang)

Limitations of infrared-based rain estimates:

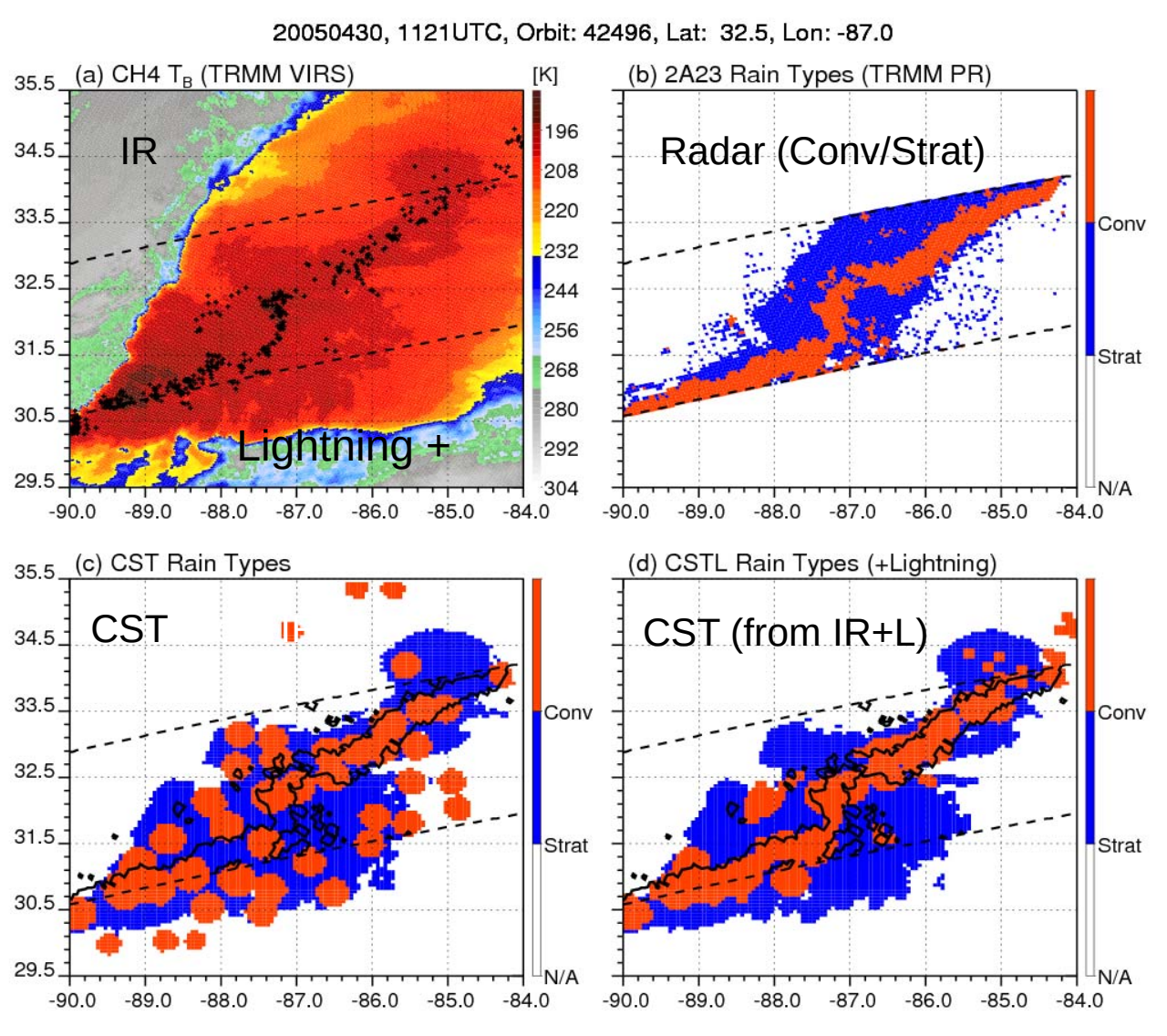
-- Only "see" the top of precipitating cloud;
(though cloud growth or structure can be considered)
-- May treat cold cirrus clouds as intense convection;
-- May misrepresent convective rain: location, area and rain intensity;
(especially under relatively uniform cold cloud shields in mature MCSs)
(but geostationary rain estimation still very important because of temporal resolution and rapid access)

How would lightning information help?

-- Provide information associated with <u>convection location</u> and intensity (~ rainfall rate)
-- Lightning information will be used to define convective cores "unseen" by IR and eliminate IR cloud top minima incorrectly identified as "convective"

Enhanced GOES-R Instantaeous Rain Rate IR-Lighting-Combined C/S Technique (CSTL)

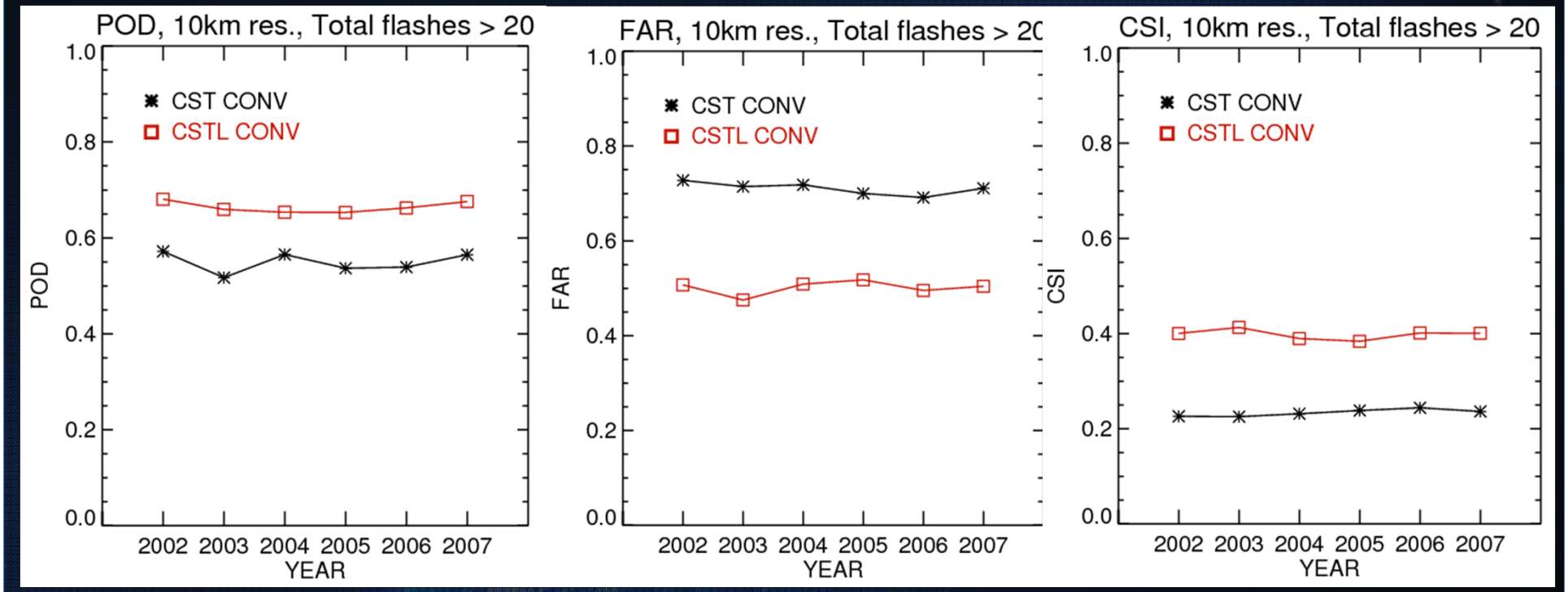
- Conv. cores w/o lightning in mature systems are removed
- Conv. areas (with flash) missed by CST are added



Courtesy, Bob Adler et al)

Identification of Convective Cores by Adding Lightning

* Estimates of Convective ID evaluated by PR;
* CST and CSTL run in an area (600x600 km^2);
* 2000 cases (> 20 lightning flashes) are selected;



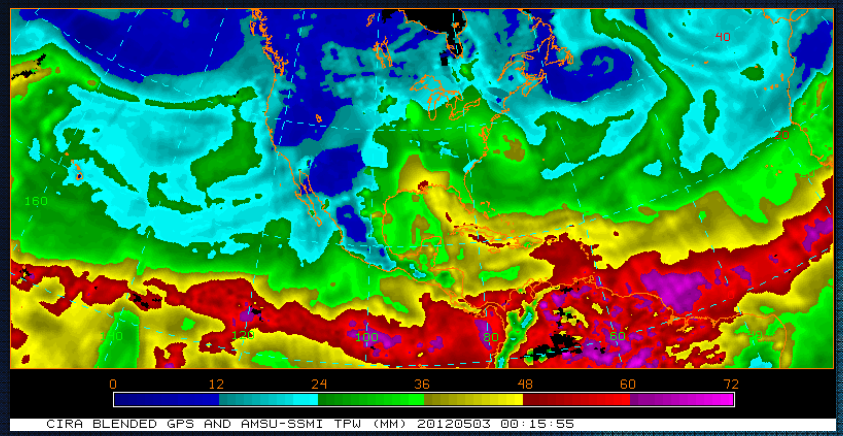
Lightning improves convective detection (POD); lowers FAR

Xu, W., R. F. Adler, and N.-Y. Wang, 2012: Improving Geostationary Satellite Rainfall Estimates Using Lightning Observations, I: Underlying Lightning-Rainfall Relationships. *J. Appl. Meteor. Climatol.,* (submitted).

Wang, N-Y, K. Gopalan, and R. Albrecht, 2012: Lightning, radar reflectivity and passive microwave observations over land from TRMM: Characteristics and application in rainfall retrievals, *J. Geophysical Research* (submitted).

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

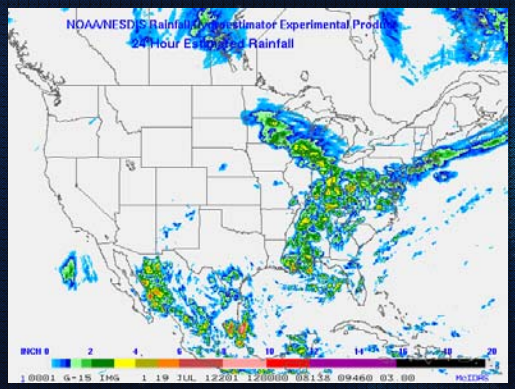
A Potential Data Fusion Example: QPE
Can we do a Blended TPW-like QPE?



Blended TPW

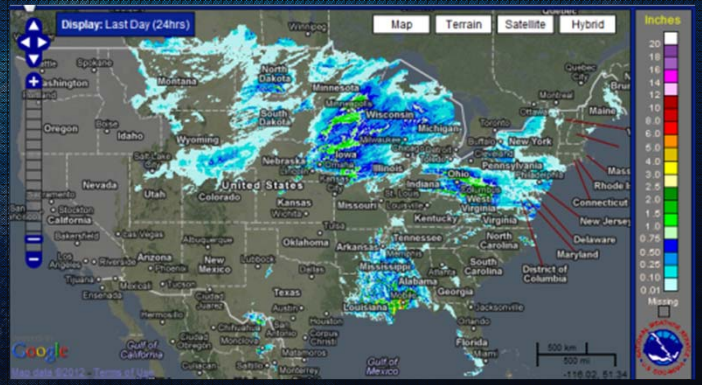
Why NWS needs this?

Atmospheric Rivers
Heavy rain/snow
Flood/Blizzard
Drought
Convective Storms
Transportation



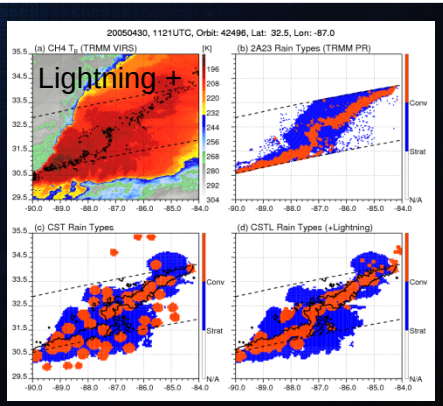
Hydro-Estimator IR

+



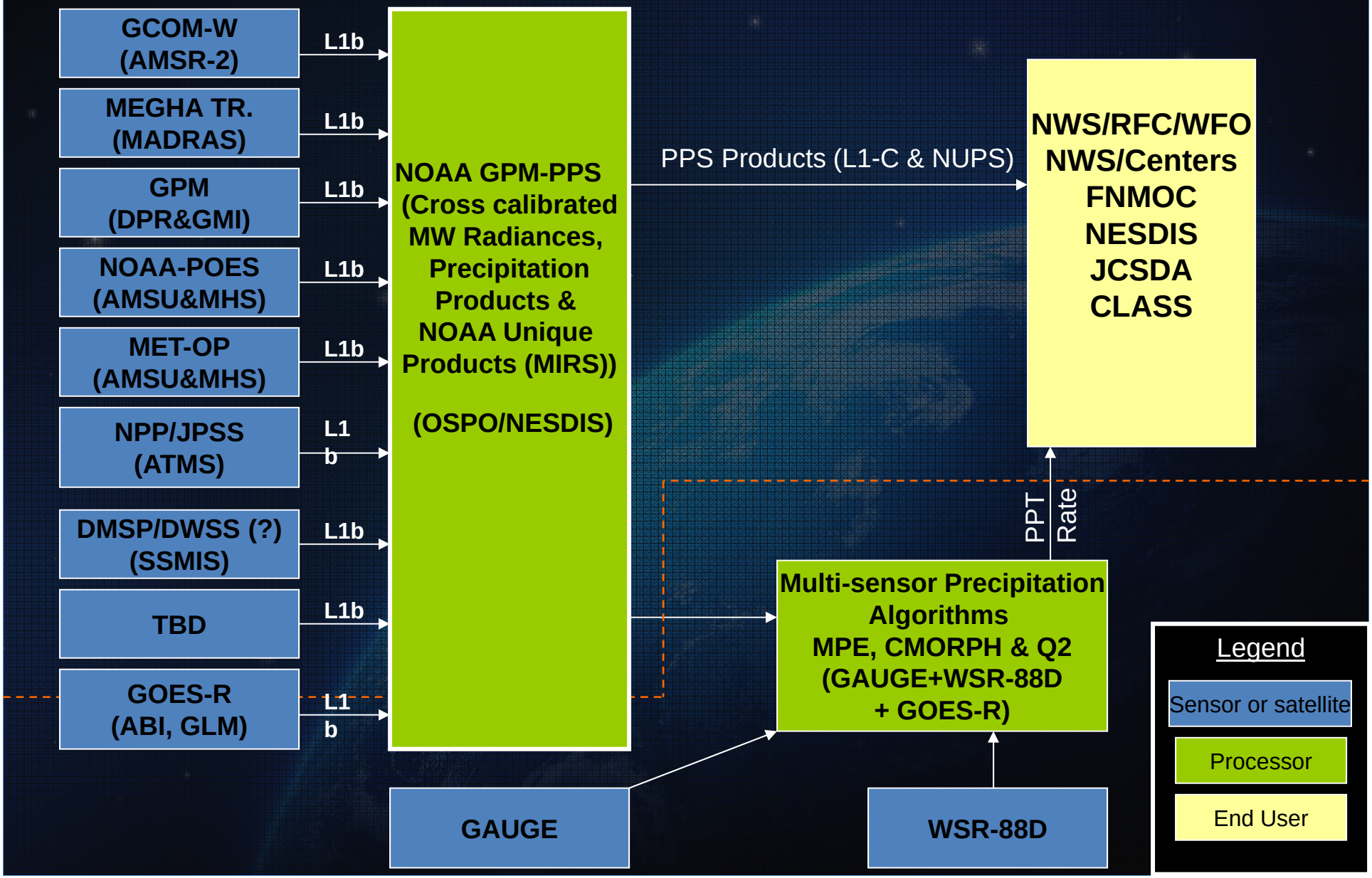
Radar/sfc obs

+



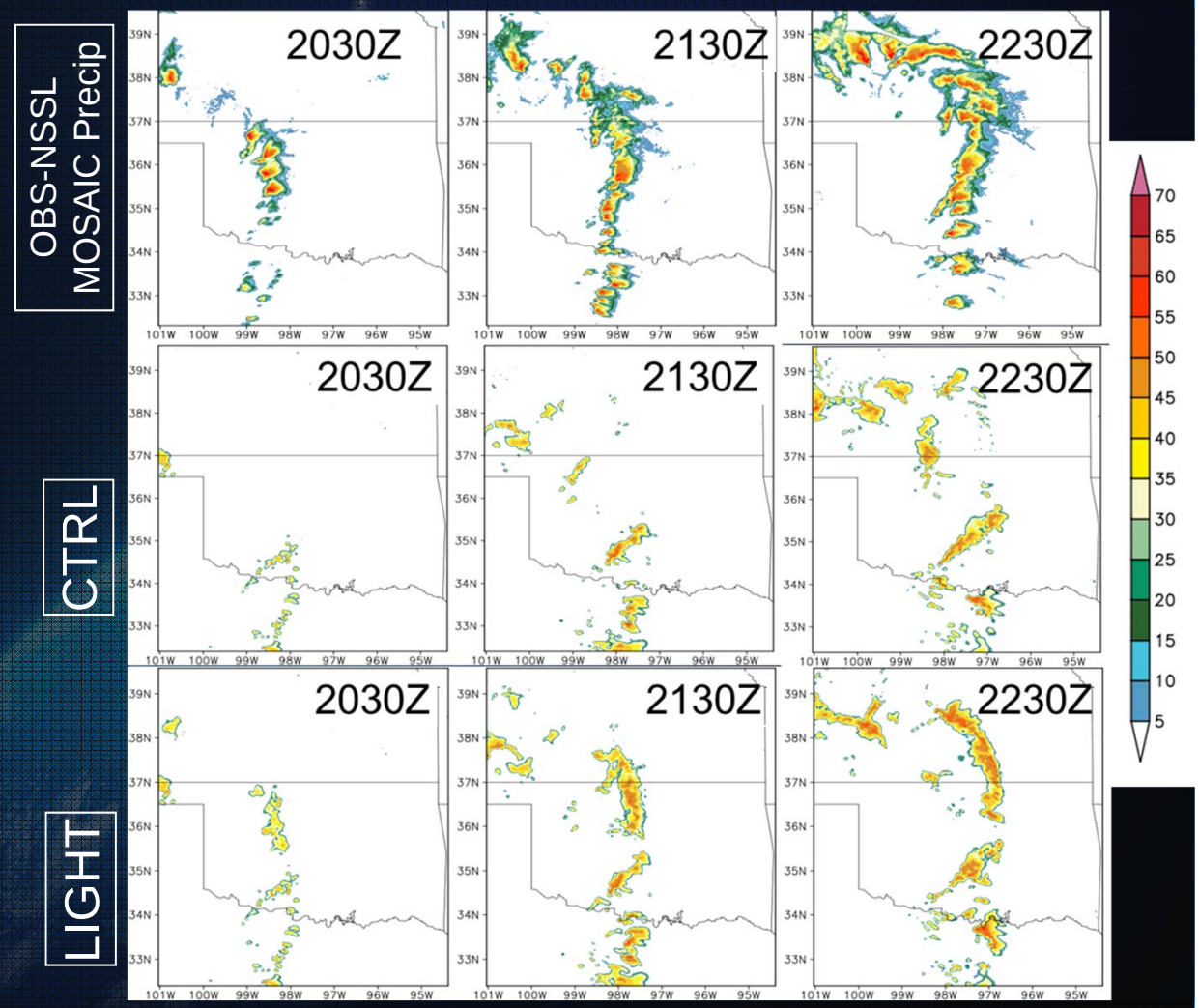
Lightning/IR/uwave

Unified Precipitation Processing (Concept)



Total lightning data used as a tool within NWP models to provide better initial conditions

- GLM Total lightning proxy data from the ENTLN were assimilated into the WRF-ARW model at cloud-resolving scales.
- Improved Initial Conditions will provide a better physical background at analysis time towards improving short term high impact weather forecasts (~3h). Lightning data can also used to limit the presence of spurious convection (and cold pools). Key in radar data sparse areas.
- To alleviate the need to use proxies for lightning in the model (e.g. lightning threats), full charging/discharge physics are currently being implemented into WRF-ARW within the NSSL 2-moment microphysics.



Courtesy of A. Fierro, CIMSS/NOAA

Concept of Operations and Operational Requirements:
*Lightning Data Program (05-033)

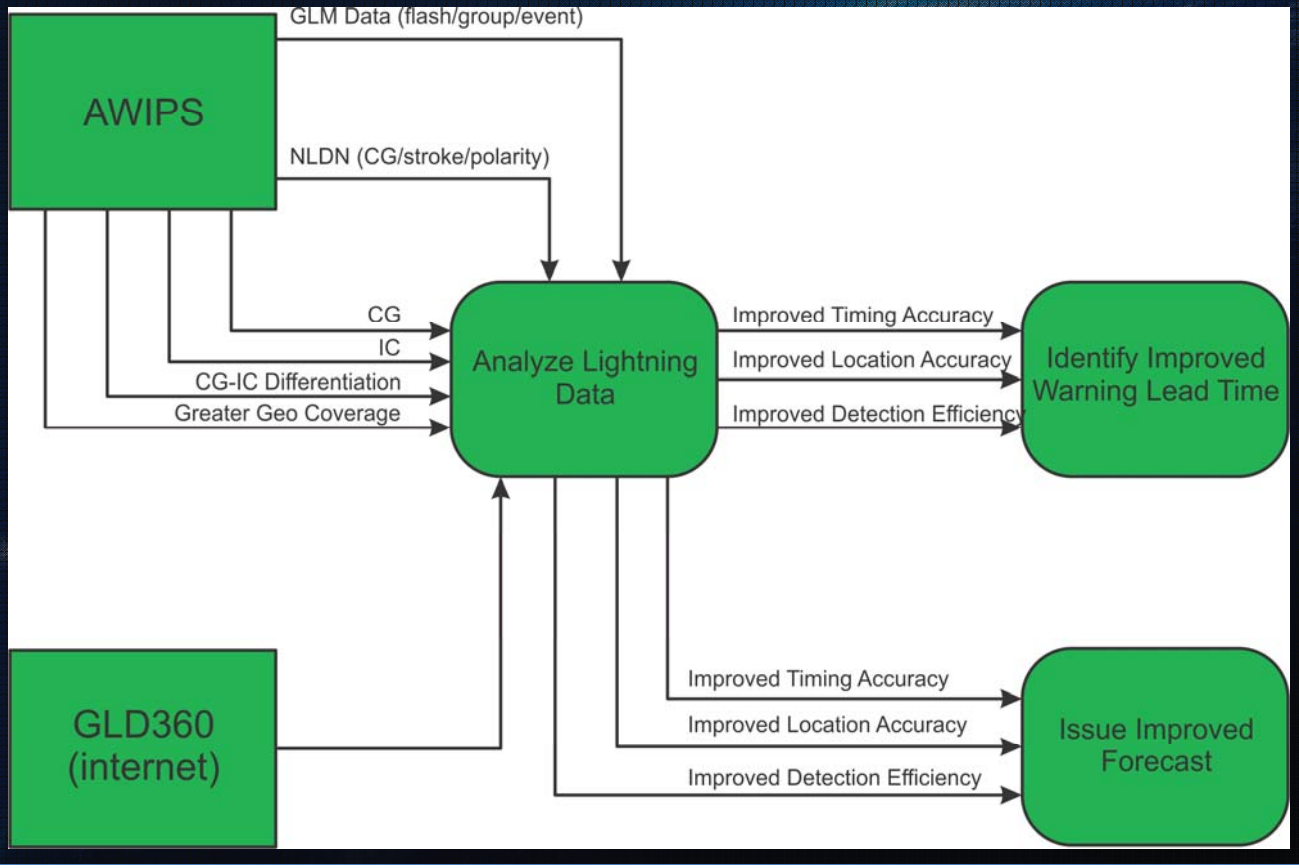
- Current State of Lightning Operations
  - NLDN for CONUS and surrounding areas
    - 1-minute product
    - CG data
    - Some IC data
  - GLD360 for worldwide lightning (known uneven coverage)
    - Not displayed in AWIPS
    - Hurricane data (Pacific & Atlantic)
- Proposed Concept of Lightning Operations
  - NLDN for CONUS and surrounding areas (same as Current)
  - GLM total lightning
    - Total lightning over GLM FOV
  - Use AWIPS-II
    - Plot total lightning data
    - Monitor total lightning trends
    - Use data to obtain more detailed information (database query)
    - Archive lightning data

*Source:NWS/Sergio Marsh-CONOPS prior to recent ENTLN Data Buy

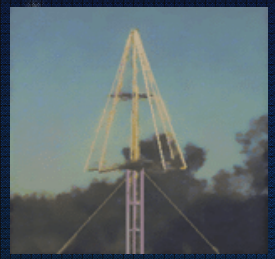
NWS Concept of Operations and Operational Requirements

Lightning Data Program (05-033)

- GLM Will Add Major Total Lightning Data Source to the Operational Pallet of Resources

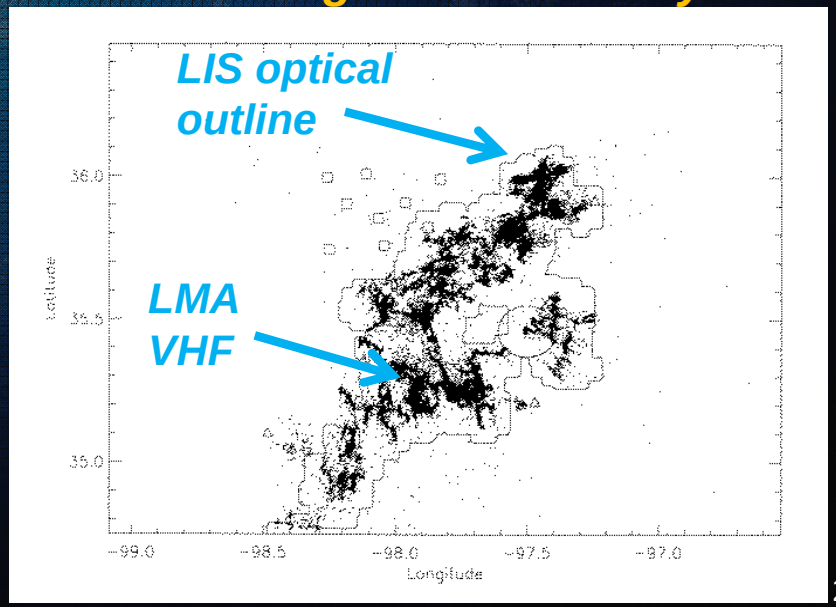


Validation Data



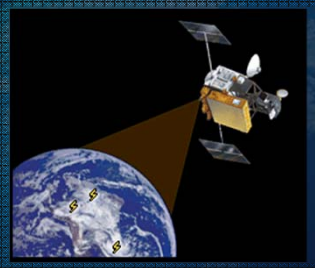
- **Ground Truth Datasets:**
  - Short-Medium Range Lightning
    - LMA (North Alabama (NASA-NOAA), DC (NASA-NOAA), Oklahoma (OU CIMMS-NSSL), West Texas (TTU), NMTECH, Camp Blanding (UF-DARPA), Colorado Front Range (CSU), Houston (TAMU), NASA-KSC and Wallops, Atlanta (GTRI), St. Louis (SLU-Cardinals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

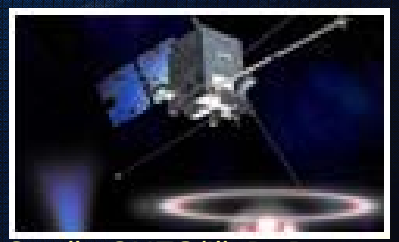
Building the GLM Proxy



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 (target DC3, HS3, other field campaigns).



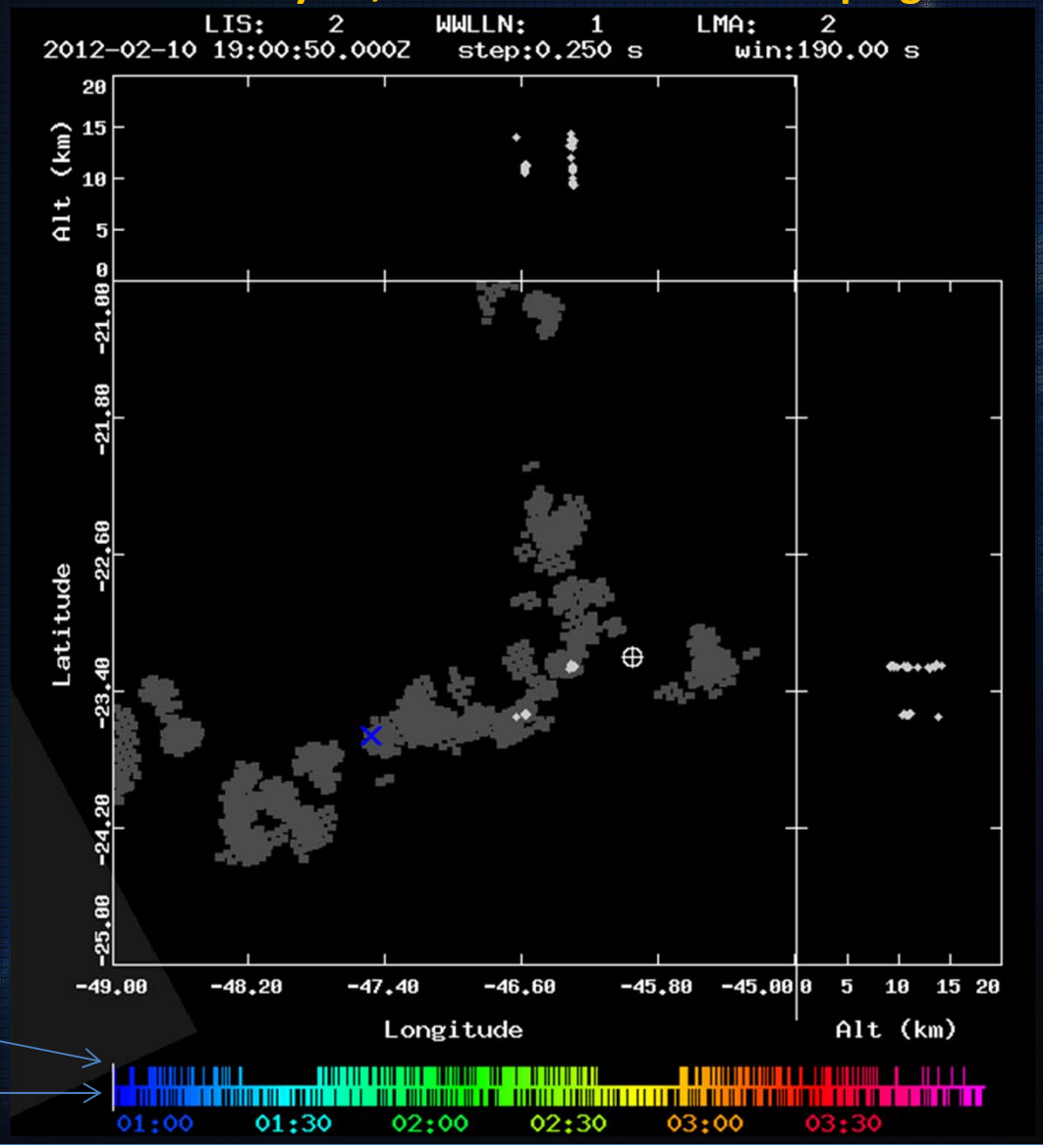


Credit: CNES/Ill. D. Ducros

- **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 ? (next slide)
  - 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)

Comparison of Space-Based and Ground-Based Lightning Observations

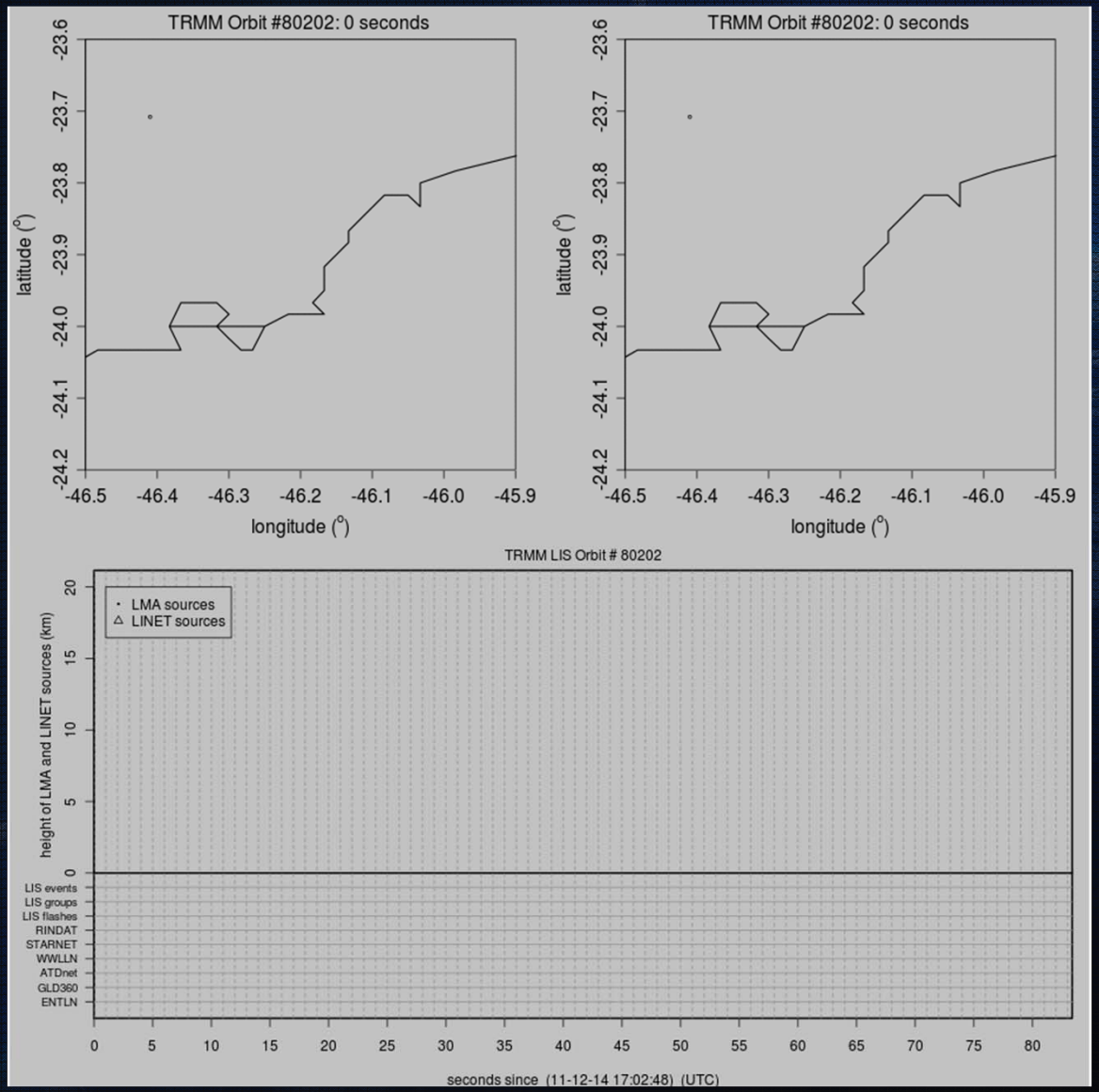
SPLMA, WWLN TRMM/LIS Overpass
February 10, 2012 GLM CHUVA Campaign



Big Video, CHUVA

Courtesy, Monte Batema

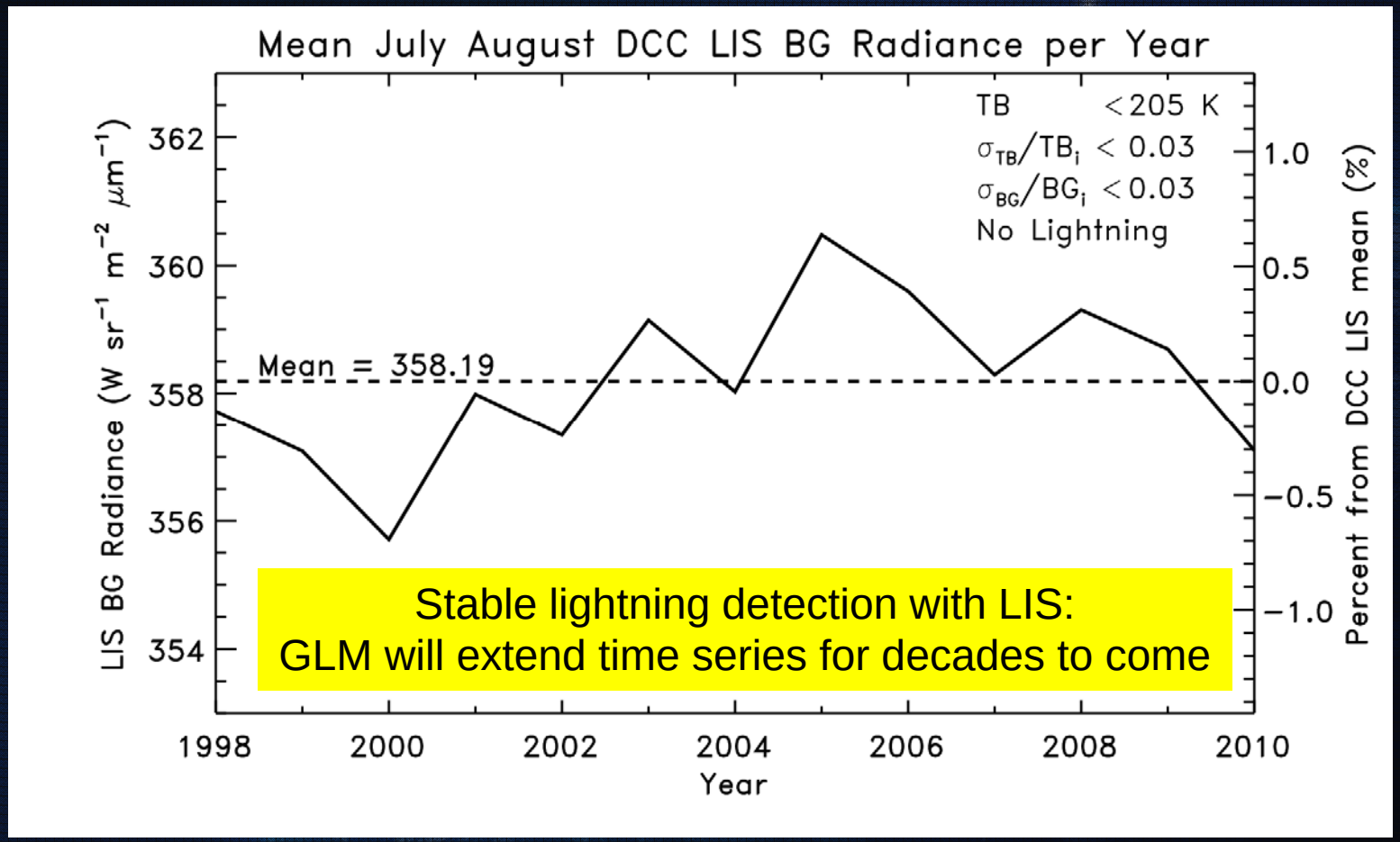
SPLMA, WWLN TRMM/LIS Overpass
February 10, 2012 GLM CHUVA Campaign



Courtesy, Rachel Albrech

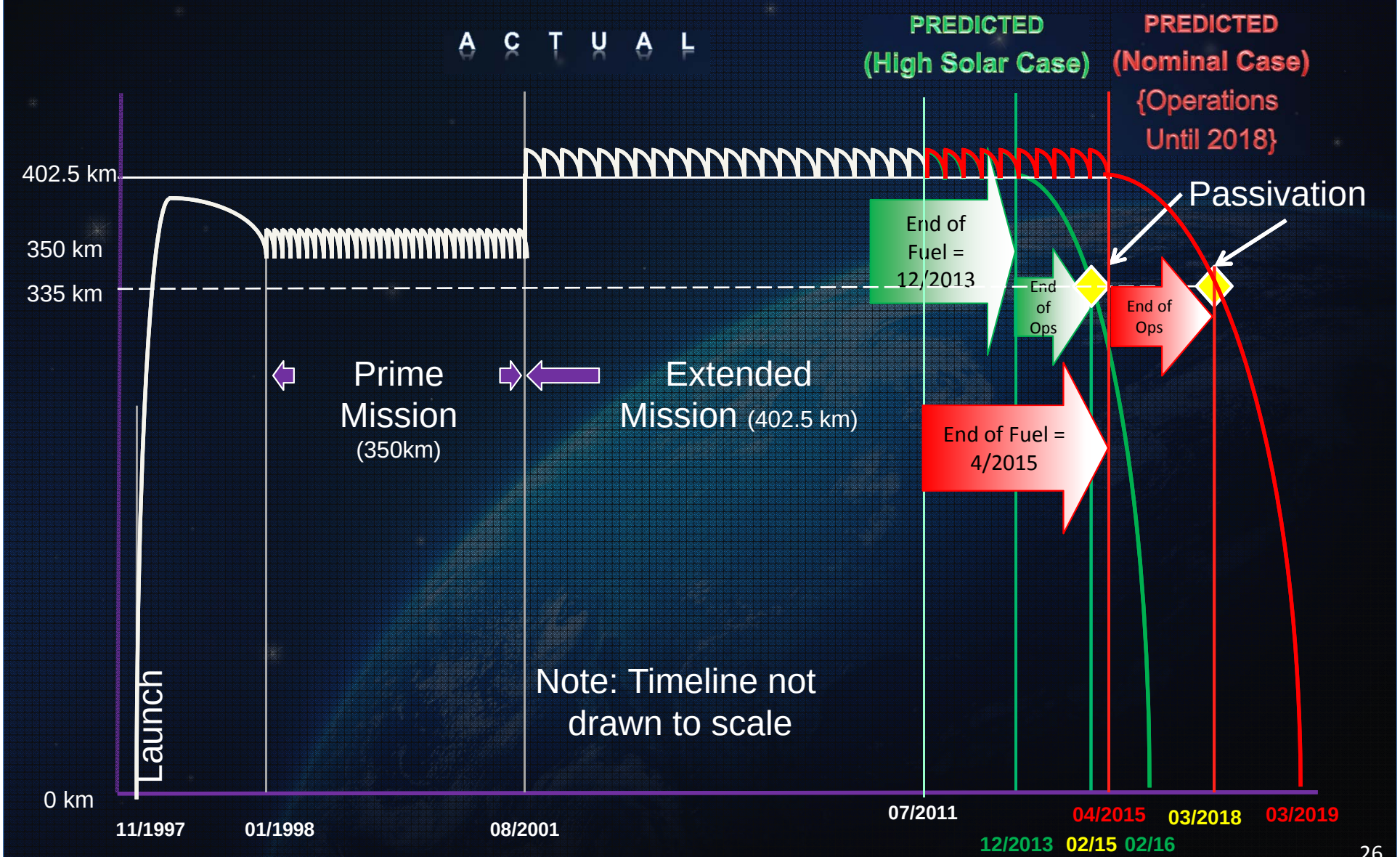
Deep Convective Cloud Technique

(LIS backgound variation < 0.7%)



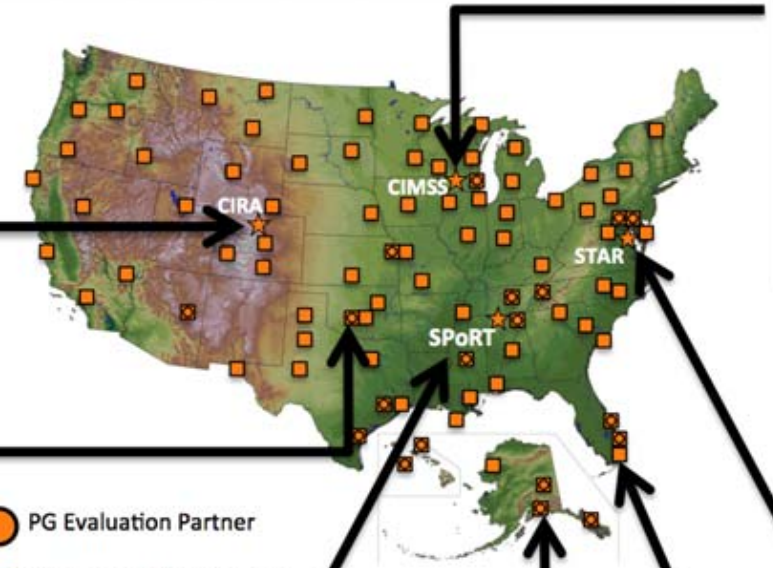
Yearly trend of mean LIS BG DCC radiance for each combined July and August from 1998-2010. The dashed line is the mean of each July August DCC radiance over the period (358.19 W sr W sr^{-1} m^{-2} μm^{-1}). The left hand scale is in W sr W sr^{-1} m^{-2} μm^{-1} and the right scale indicates the percentage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

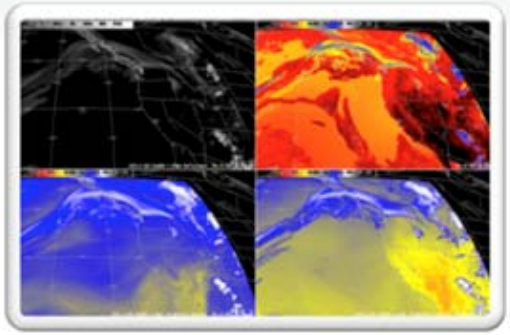
TRMM Notional Timeline



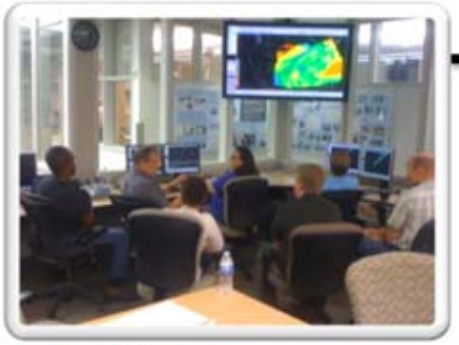
GOES-R Proving Ground Partners

CIRA - Ft. Collins, CO
ABI Simulated Natural Color

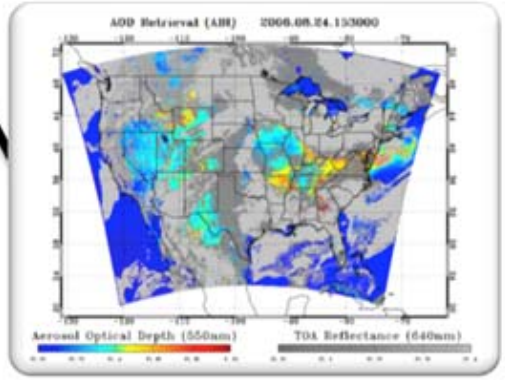




CIMSS – Madison, WI
Simulated ABI Bands

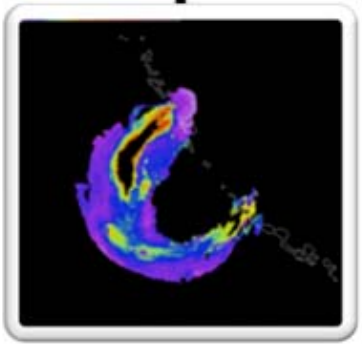


SPC – Norman, OK
Nearcast Training at the Hazardous Weather Testbed

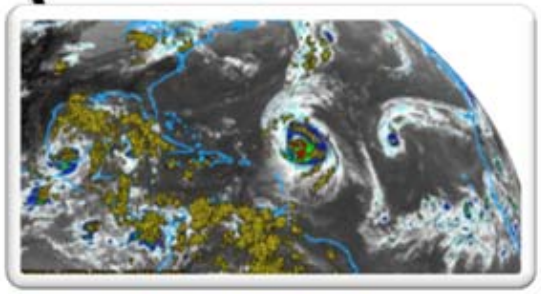


STAR – Camp Springs, MD
Aerosol Optical Depth Product

SPoRT – Huntsville, AL
GLM Lightning Flash Density



AFC – Anchorage, AK
Volcanic Ash Product



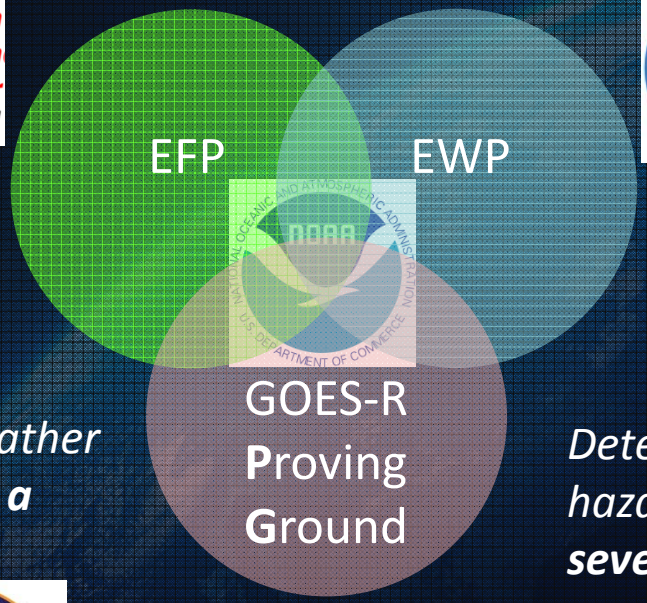
NHC – Miami, FL Rapid Intensification Index

GOES-R PG Partnership with NOAA's Hazardous Weather Testbed

works with users to accelerate use of products

Experimental
Forecast
Program

*Prediction of hazardous weather events from **a few hours to a week in advance***



Experimental
Warning
Program

*Detection and prediction of hazardous weather events **up to several hours in advance***

Demonstrate and evaluate GOES-R products and capabilities within an operational warning environment

GOES-R Proving Ground

- Proving Ground Paper published in July issue of the Bulletin of the American Meteorology Society
- Highlights HWT and NHC demonstrations
- Forecaster Feedback

THE GOES-R PROVING GROUND

Accelerating User Readiness for the Next-Generation Geostationary Environmental Satellite System

BY STEVEN J. GOODMAN, JAMES GURKA, MARK DEMARIA, TIMOTHY J. SCHMIT, ANTHONY MOSTEK, GARY JEDLOVEC, CHRIS SIEWERT, WAYNE FELTZ, JORDAN GERTH, RENATE BRUMMER, STEVEN MILLER, BONNIE REED, AND RICHARD R. REYNOLDS

By demonstrating the advanced capabilities of the next generation of geostationary satellites, the proving ground addresses user readiness and the research-to-operations-to-research loop.

The Geostationary Operational Environmental Satellite R series (GOES-R) Proving Ground (PG) is an initiative to accelerate user readiness for the next generation of U.S. geostationary environmental satellites. The GOES-R system is a joint development between the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA), with NASA responsible for the space segment (spacecraft and instruments) and NOAA responsible for the overall program and ground segment. The GOES-R PG is a collaborative effort between the GOES-R Program Office (GPO); NOAA Cooperative Institutes; NASA's Short-Term Prediction Research and Transition Center (SPoRT); National Weather Service (NWS) Weather Forecast Offices (WFOs); NWS National Centers for Environmental Prediction (NCEP); National Environmental Satellite, Data, and Information Service (NESDIS) Office of Satellite and Product Operations (OSPO) and the Center for Satellite Applications and Research (STAR); and NOAA test beds to conduct demonstration activities to gain early experience with GOES-R capabilities in an operational environment. Improved spacecraft and instrument technology will support expanded detection of environmental phenomena, resulting in more timely and accurate forecasts and warnings. The Advanced Baseline Imager (ABI), described by Schmit et al. (2005), is a 16-channel imager with 2 visible channels, 4 near-infrared channels, and 10

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The abstract for this article can be found in this issue, following the table of contents.

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Proving Ground Forecaster Feedback: Lightning Detection

- "The total lightning data is an excellent tool for monitoring convection, I see much promise for such data in the future…"
- "I utilized it as a situational awareness product …the PGLM data gave me more confidence in my warning."
- "Total lightning data preceded the CG network (NLDN) anywhere from 10-40 minutes. I was able to quickly determine when flash rate was significantly increasing, and then compare with satellite and updraft/downdraft parameters for a nice big picture."
- "Coming into the day, I wasn't quite sure when or where to or why to use the data, but after using it. I really think it has a lot of functionality and is useful in warning operations. I look forward to it as a product from the GOES-R."

"We saw several instances where the total lightning was picking up on storms before the AWIPS lightning [NLDN] program picked up on them. One could see the utility of this in the future, bringing with it a potential for lightning statements and potentially lightning based warnings."

-*Pat Spoden (SOO, NWSFO Paducah, KY)*

2012 Demonstrations

- Hazardous Weather Testbed
  - Focus on Severe Storms
- NHC/Joint Hurricane Testbed
  - Focus on tropical cyclones/hurricane intensity and track
- Aviation Weather Testbed
  - Focus on High Impact Convective Weather
- OPC and SAB (Camp Springs MD)
  - Focus on offshore thunderstorms
- High Latitude and Arctic Experiment (Alaska Region)
  - Focus on precipitation/snow/cloud/ash/aviation
- HPC and SAB (Camp Springs MD)
  - Focus on precipitation/QPF
- Air Quality (UMBC)
  - Focus on aerosol detection
- Pacific Region (Hawaii)
  - Focus on tropical cyclones/heavy rainfall/aviation
- Space Weather (NWS SWPC: Boulder CO)
  - Focus on GOES-R like level 2 products

GOES-R Products Demonstrated at the 2012 Aviation Weather Testbed

- UAH CI SATCAST (GOES-R algorithm)
- UWCI Cloud Top Cooling (CTC)
- Overshooting Top/Thermal Couplet Detection
- NearCasting Model
- Low Cloud/Fog
- Lightning
  - PGLM
  - WRF/HRRR lightning threat
- Volcanic Ash/SO_2
- Aircraft Icing Threat
- Turbulence

Summary
GOES 14 SRSOR Experiment

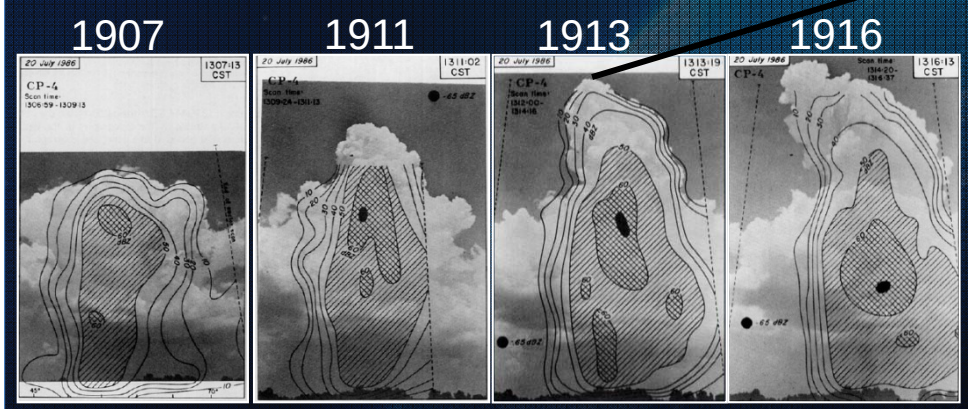
http://cimss.ssec.wisc.edu/goes/srsor/GOES-14_SRSOR.html

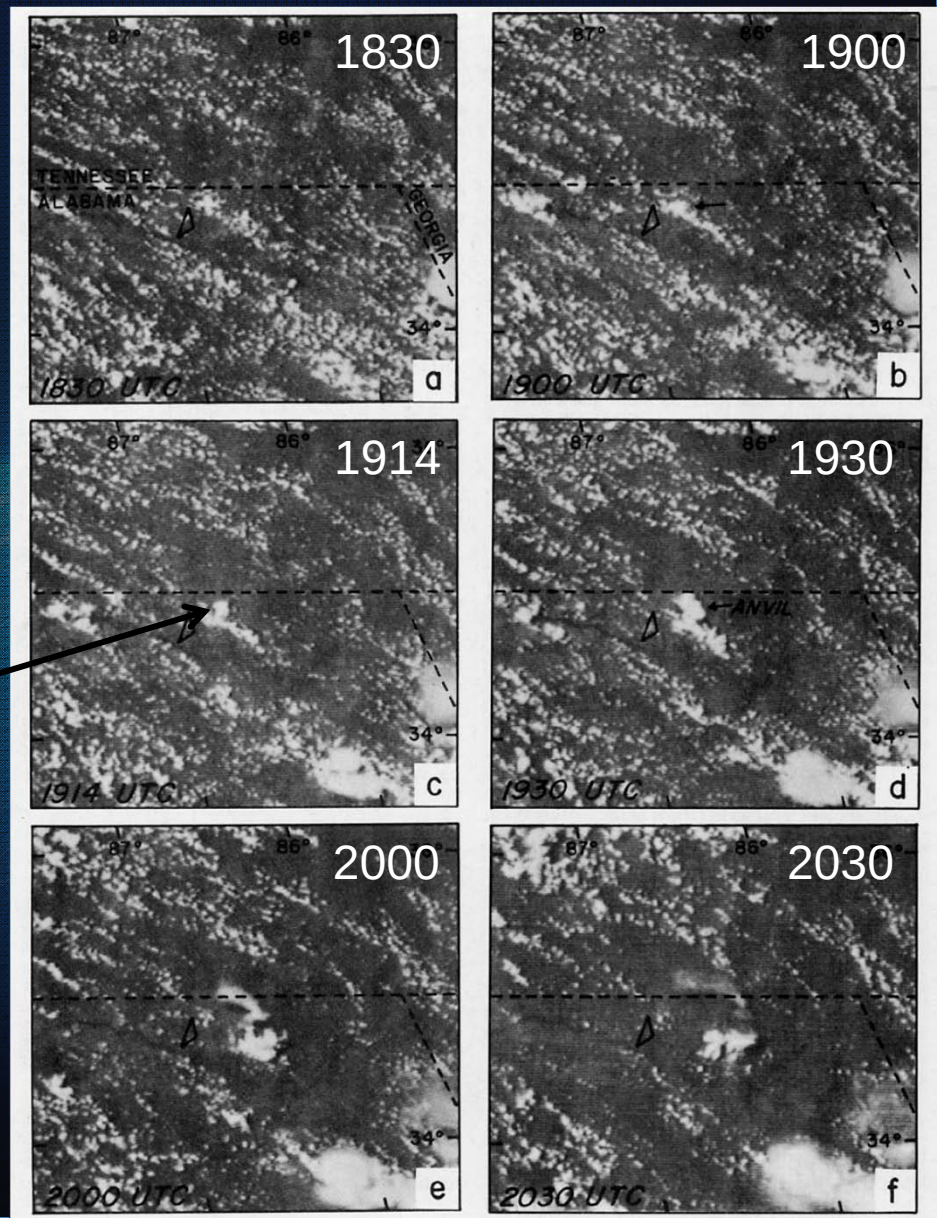
- Outcomes: Operational use of ABI and GLM for nowcasting
  - 1 min imagery, 1 minute lightning, 1 min radar volume scans
- Time: August 16-October 31, 2012
- Locations:
  - Norman, OK- NEXRAD, MPAR, OKLMA (primary site)
  - Huntsville, AL- NEXRAD, UAH dual-pol radars, NALMA
  - Sterling, VA- NEXRAD, TDWR, DCLMA
  - Fort Collins, Colorado- NEXRAD, CSU-CHILL, NCLMA
  - Melbourne/KSC, FL- NEXRAD, LDAR II
  - Atlantic Ocean/GulfMex Basin- NASA EV-1 Hurricane and Severe Storm Sentinel-HS3 science flights 20 Sept-5 Oct coincidence with GOES-R products (http://espo.nasa.gov/missions/hs3)

Added GLM Value for Severe Storm Operations and Decision Aids

- Small Air Mass Thunderstorm
  - Huntsville “Monrovia” Microburst, 20 July 1986
  - Pulse air mass storm, 65 dBZ max Z
  - Pea size hail, 40 kt outflow
  - 110 total lightning , 6 CG strikes

Cloud top temperatures continue cooling after reaching the mature stage as cirrus anvil fills imager fov

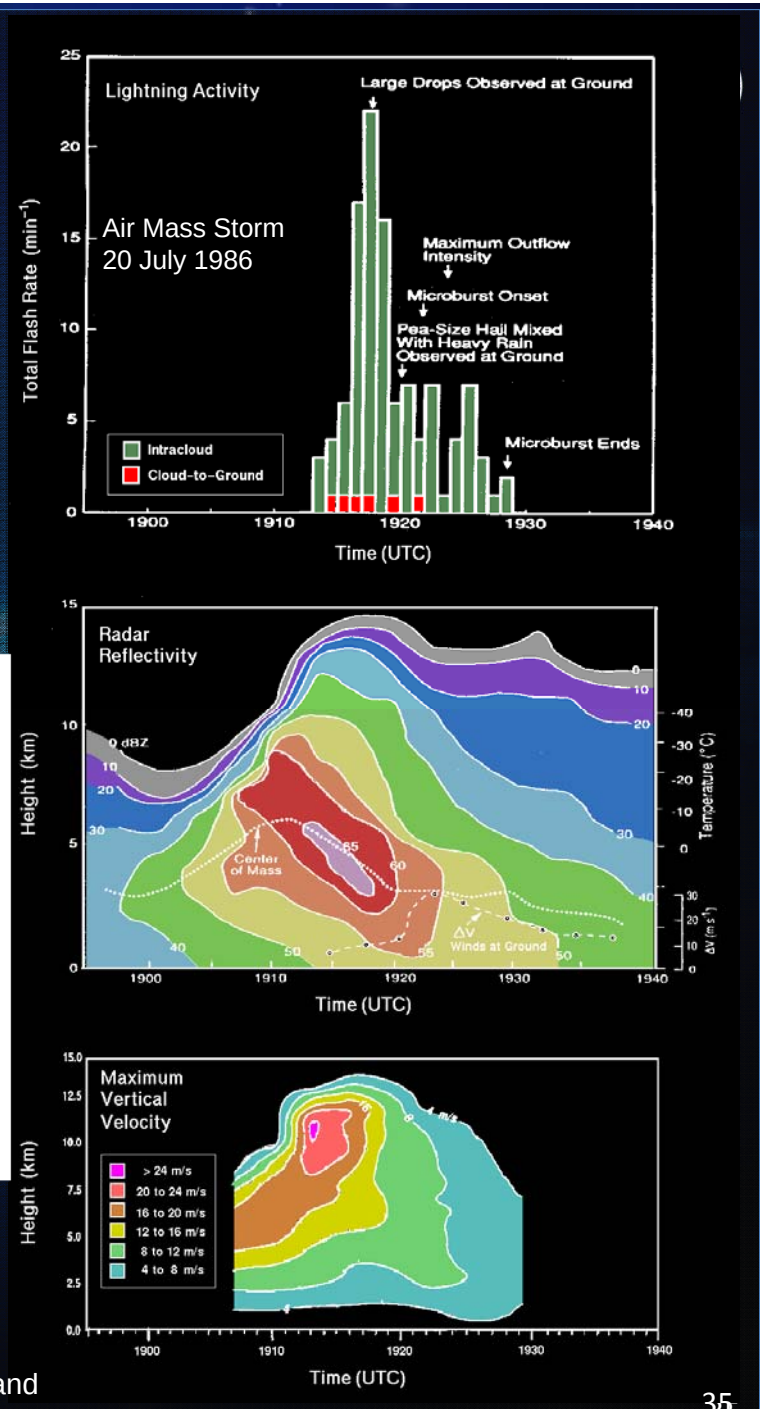




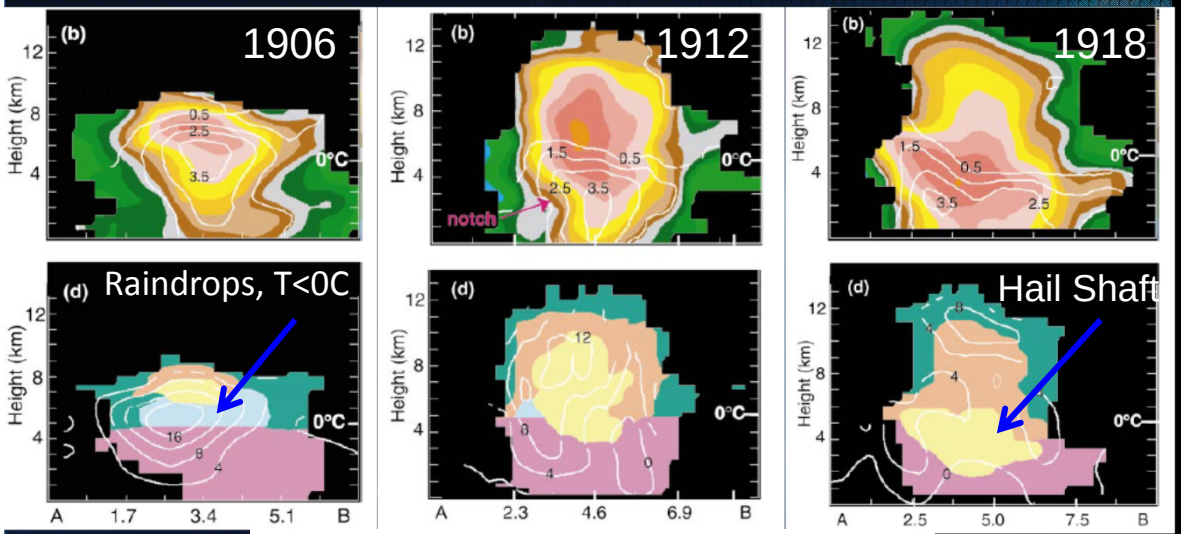
From Wakimoto and Bringi, 1988; Photos, K. Knupp

Lightning Connection to Storm Updraft, Storm Growth and Decay

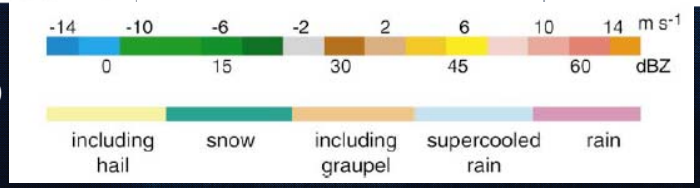
- Total Lightning —responds to updraft velocity and concentration, phase, type of hydrometeors, integrated flux of particles →
- Dual-Pol WX Radar — responds to concentration, size, phase, and type of hydrometeors- integrated over small volumes



Growth, Zdr>0 Glaciated, Zdr<0

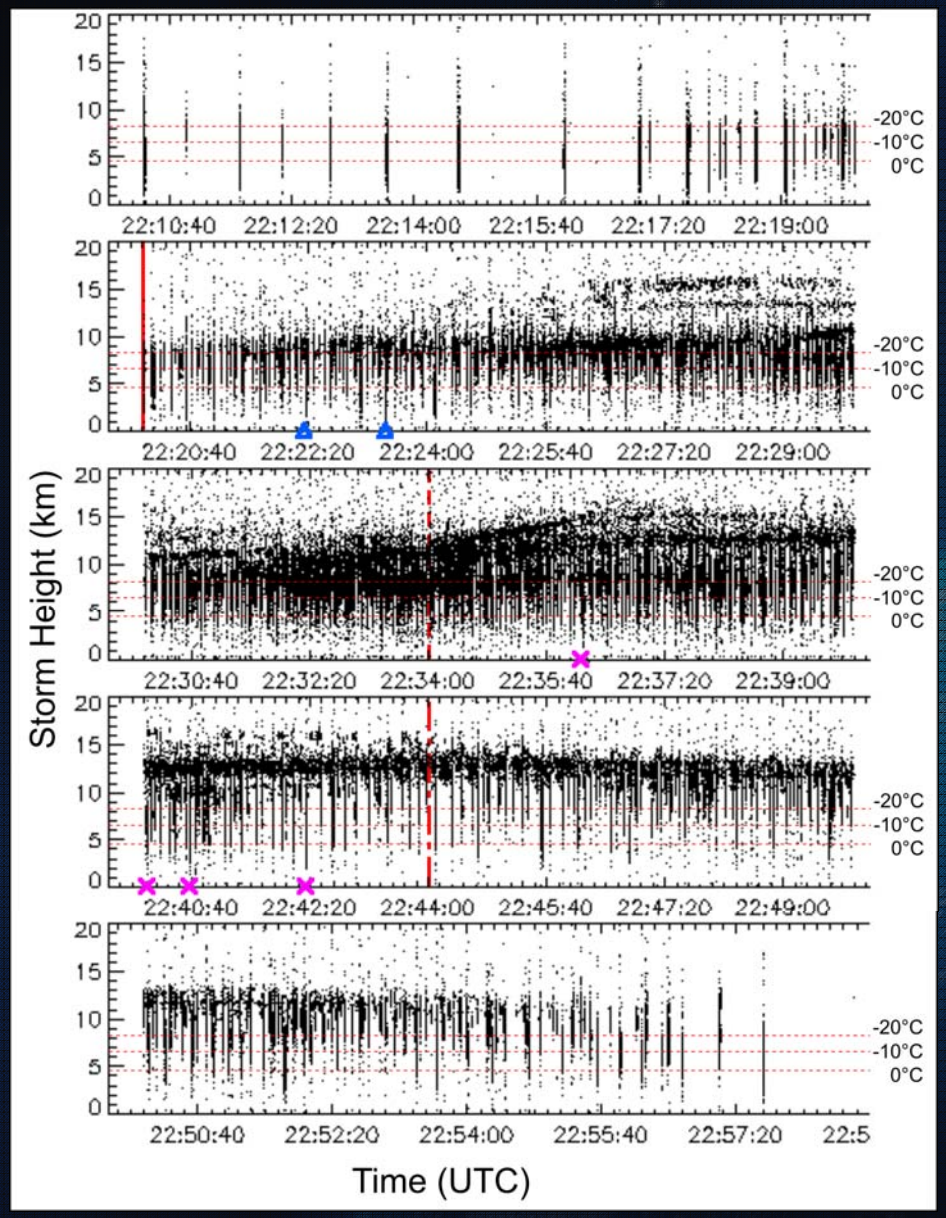


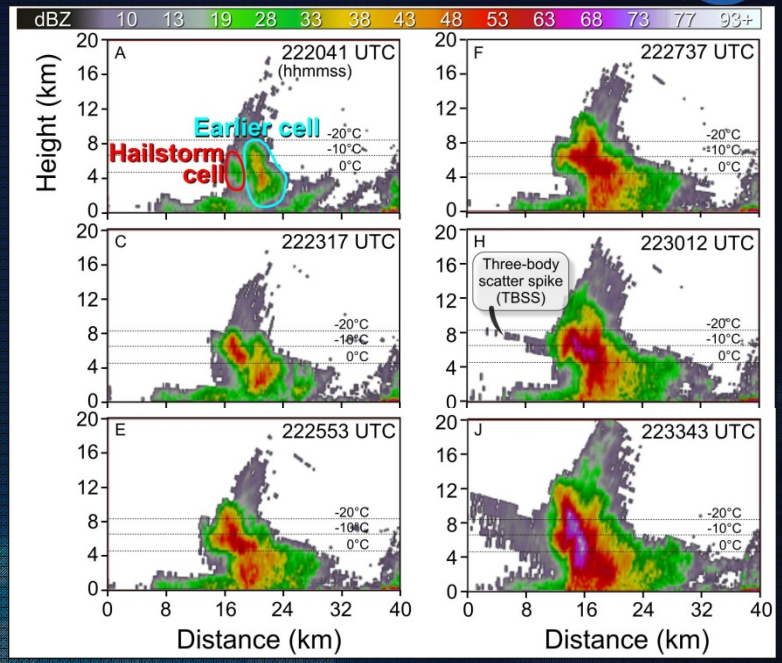
w, dBZ, HID

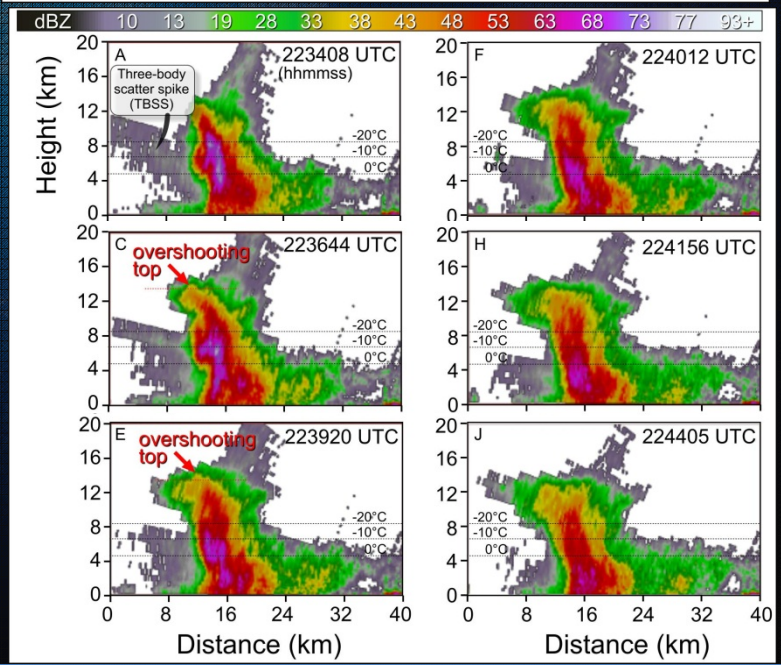


Adapted from Goodman et al, GRL, 1988; Wakimoto and Bringi, MWR, 1988; Kingsmill and Wakimoto, MWR,1991, Zeng et al., 2001, Gatlin and Goodman, JTECH, 2010

OKLMA Total Lightning and MPAR



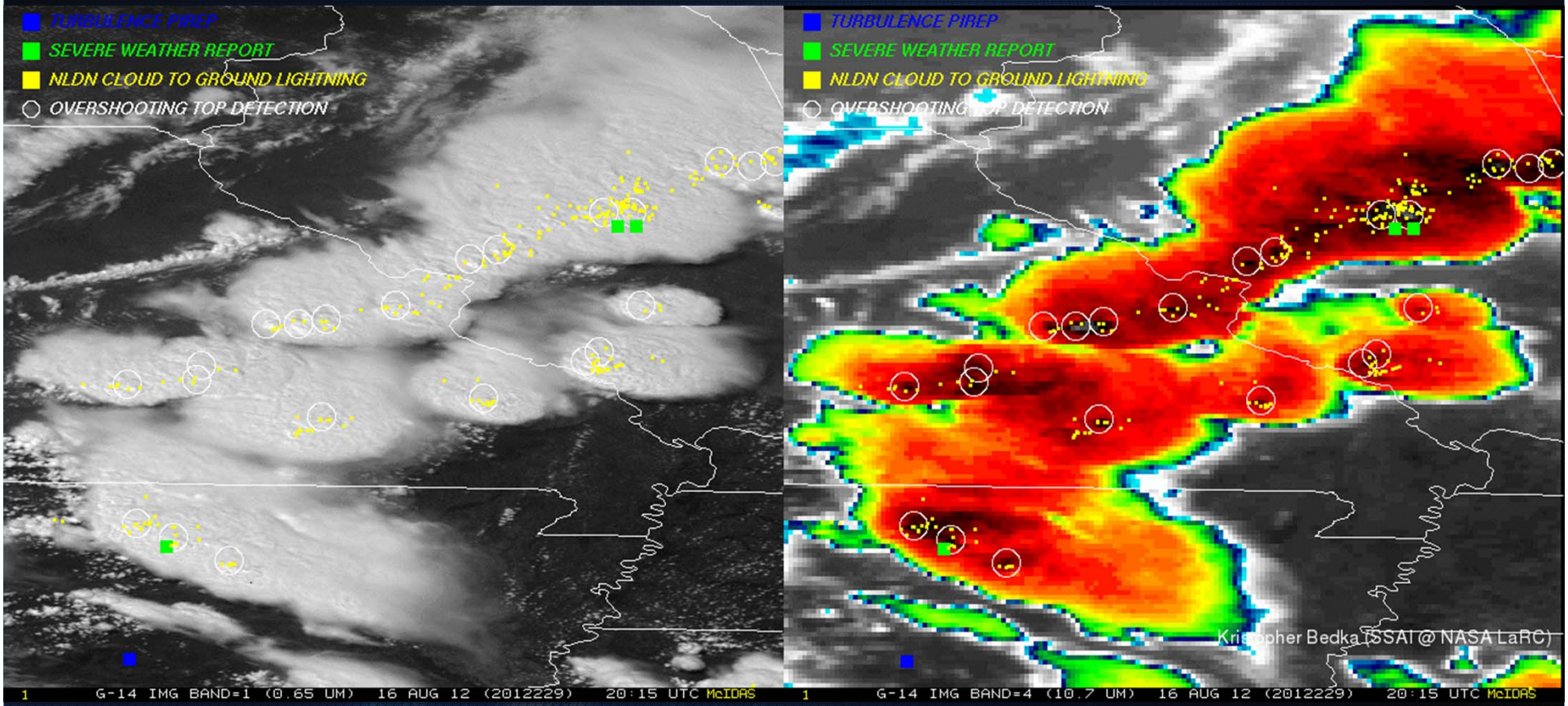




D. MacGorman/NSSL

GOES-14 SRSOR Experiment :

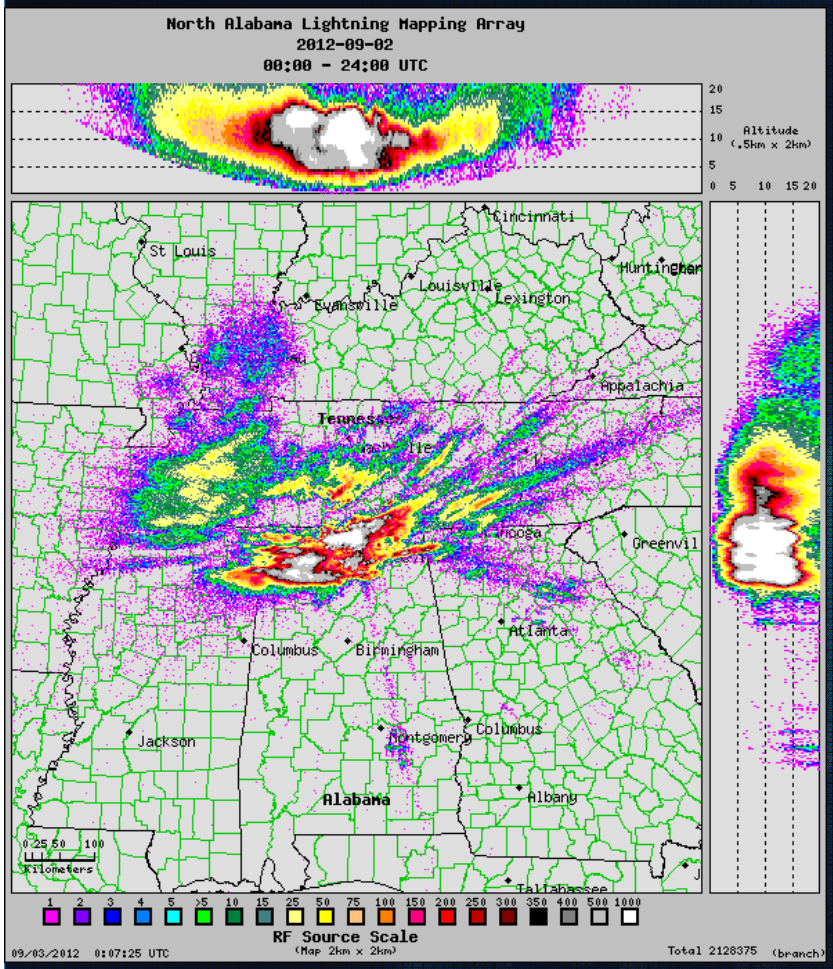
Overshooting Top Detection

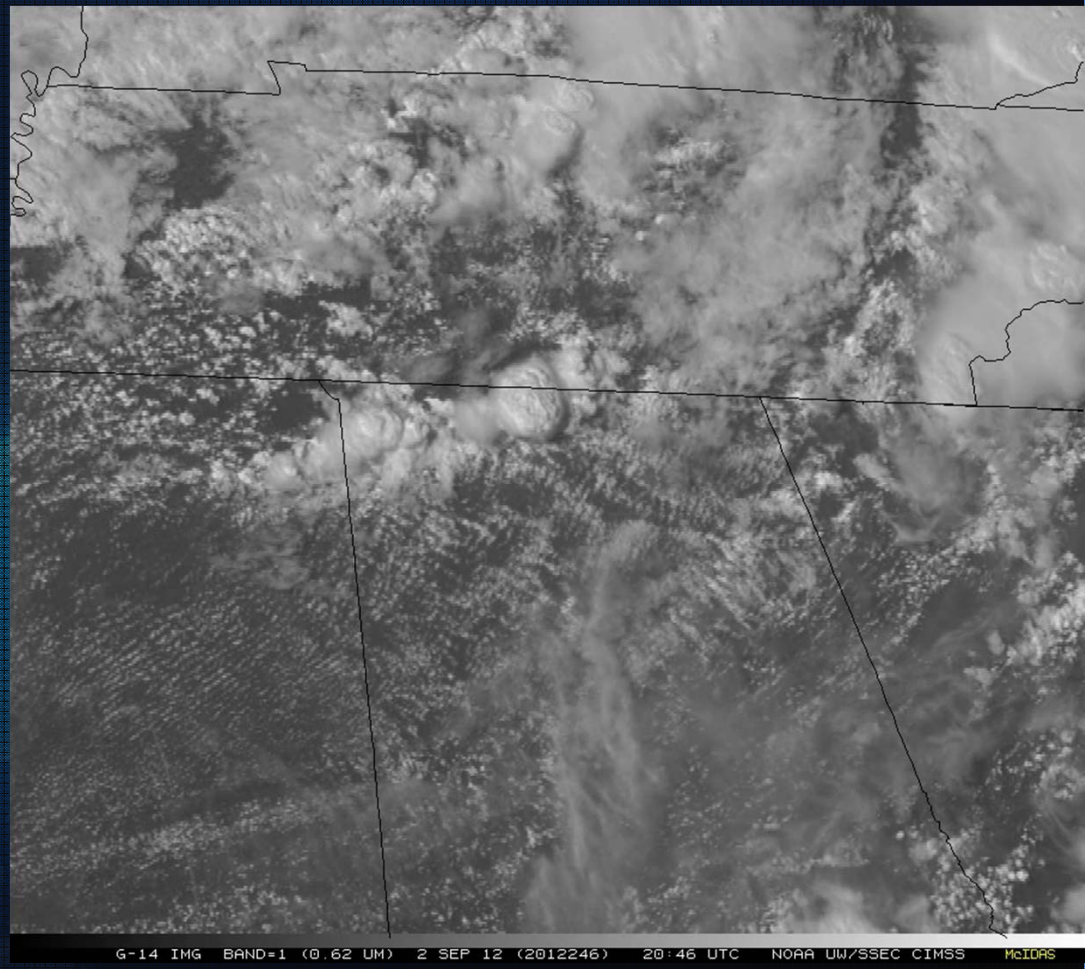


Kristopher Bedka (SSAI @ NASA LaRC)

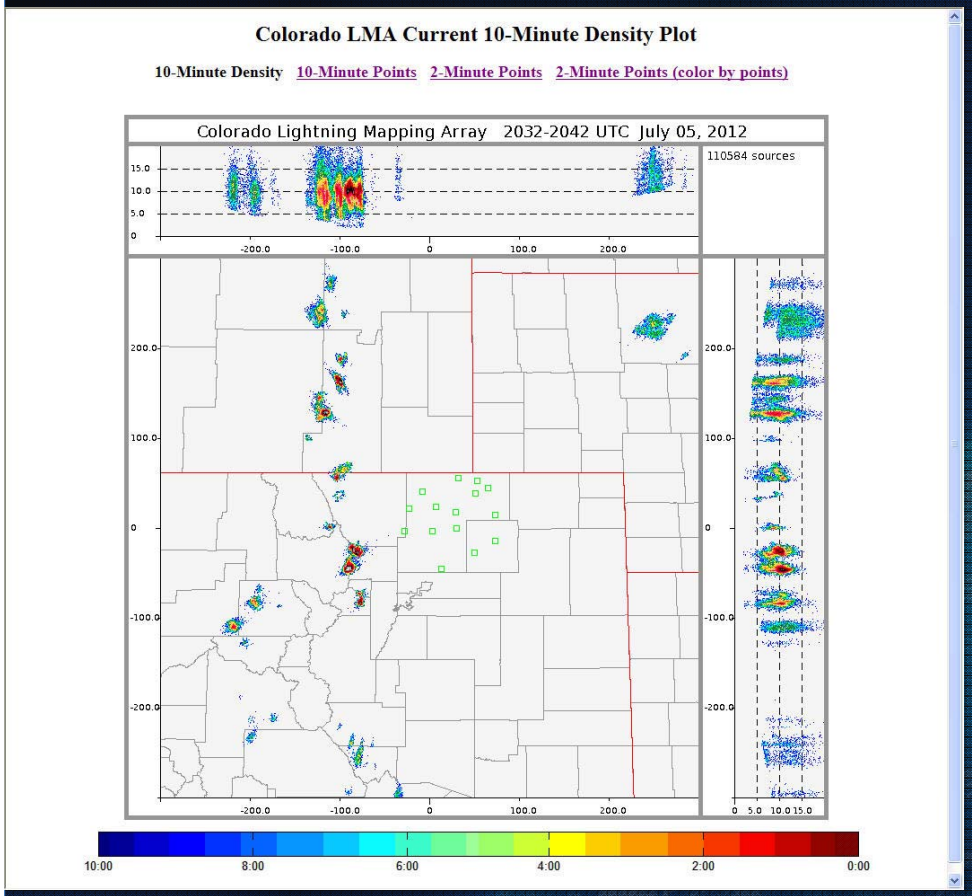
GOES-14 SRSOR Experiment :

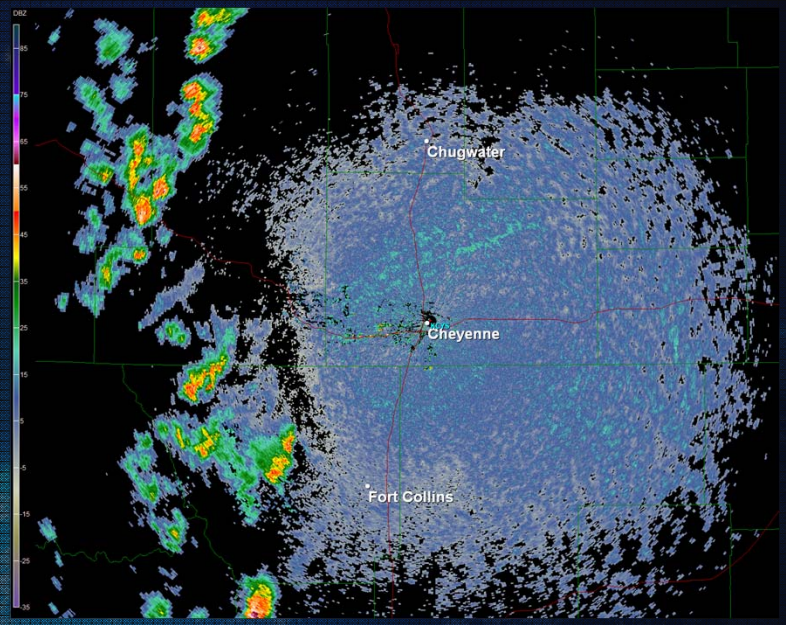
GLM Testbed Lightning Detection

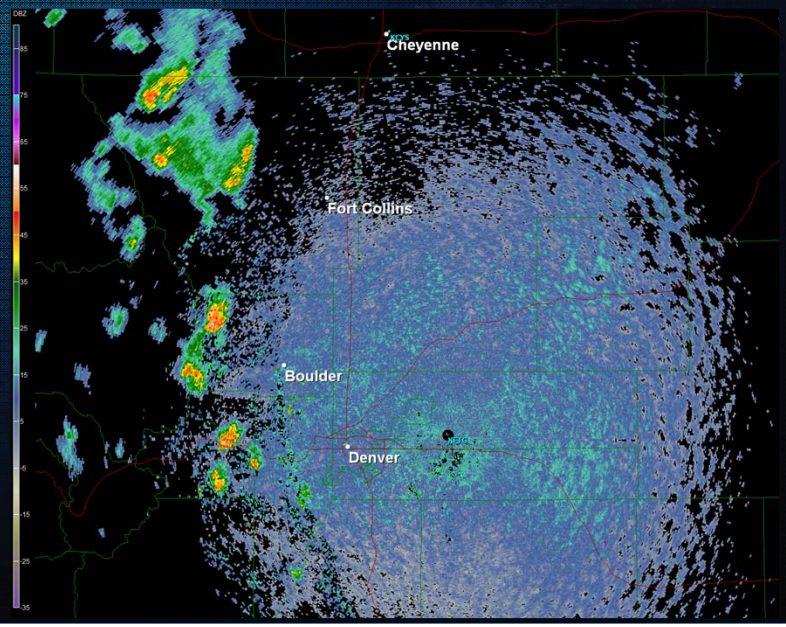




Thunderstorms in Complex Terrain







North Colorado LMA (above) concurrent with KCYS (2037 UTC) and KFTG (2038 UTC) NEXRAD low level scans (right).

VISIT

Virtual Institute for Satellite Integration Training

Additional Live VISIT Training Sessions in 2011, 2012

TROWAL Identification (winter weather satellite application)
UW Nearcasting Product (for severe weather)
Morphed Total Precipitable Water Detection (MIMIC)
POES and AVHRR Data in AWIPS
UW Convective Initiation Products (GOES-based CI Algorithm)
Convective Downbursts
GOES Imagery for Forecasting Severe Weather
Water Vapor Imagery Analysis for Severe Weather
Mesoscale Convective Vortices
Basic Satellite Interpretation in the Tropics
Basic Satellite Principles
Interpreting Satellite Signatures
Satellite Interpretation of Orographic Clouds
Utilizing GOES Imagery to Forecast Winter Storms – Part 1, 2
CIMSS Regional Assimilation System – Forecast Satellite Imagery in AWIPS
Cyclogenesis: Analysis Using Geostationary Satellite Imagery

Currently Available Training

- VISIT CONUS Lightning
- VISIT Lightning Meteorology I
- VISIT Lightning Meteorology II
- COMET Intro to Tropical Met
- COMET Fire Weather Climatology
- COMET GOES-R Benefits
- VISIT GOES-R 101
- SPoRT Lightning Mapping Array
- SPoRT PGLM Training
- VISIT Use of GOES/RSO Imagery w/Remote Sensor Data for Diagnosing Severe Wx

Source, NWS/Brian Motta

The Road Ahead

- 2013 Call for Visiting Scientist Proposals: September, 2012
- AMS 9th Satellite Symposium-6th MALD: January 7-10, Austin, TX
- Joint Session on Total Lightning (no Southern Thunder Workshop)
- WoF-High Impact Weather Workshop: February 6-8, NWC, Norman, OK
- NOAA Satellite Science Week: March 18-22, 2013, Virtual
- NOAA Satellite Conference: April 8-12, 2013, NCWCP, College Park, MD
- CHUVA International Scientific Workshop: May 8-10, Sao Paulo, Brazil
- OCONUS Proving Ground: June 17-21, 2013, UA-Fairbanks, AK
- 2014 LOI/RFP for Risk Reduction Science Program: July-August, 2013
- GLM Science Team Meeting: September 24-26, 2013

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 Ddevelopment 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