GOES-R Geostationary Lightning Mapper (GLM): Convective Initiation, and Severe Storms

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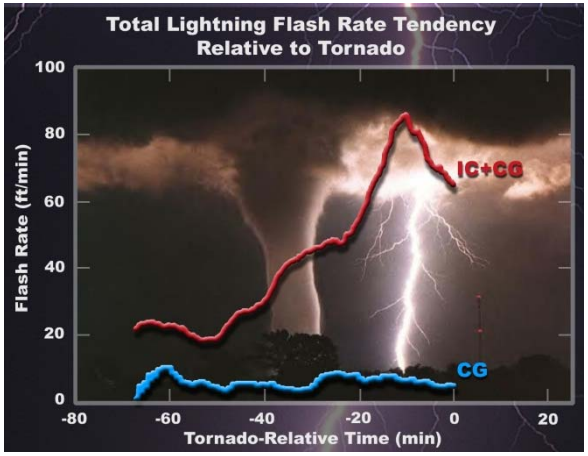
Prague, Czech Republic

27-30 March, 2012

GLM Key Driving Requirements, Mission Objectives, and Performance

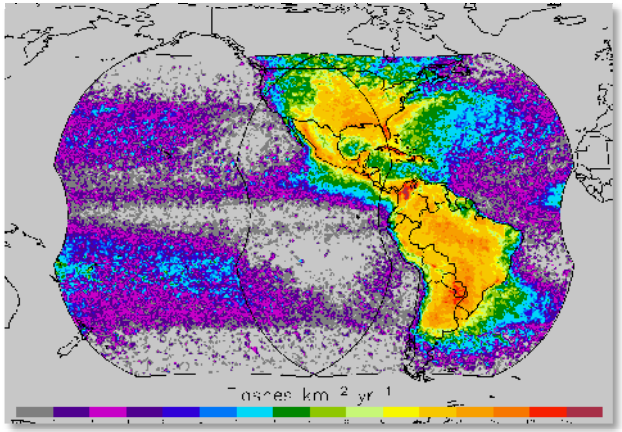
- Top-Level Requirements
  - Capture 70% of the lightning flashes
  - False alarm rate less than 5%
  - Severe storm detection, lightning climatology

Longer tornado warning time



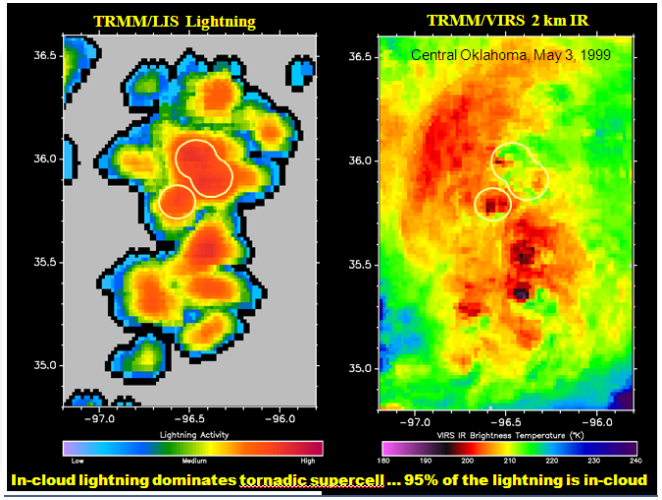
Lightning jump- IC rapid increase

Decadal lightning data



GOES E, W coverage

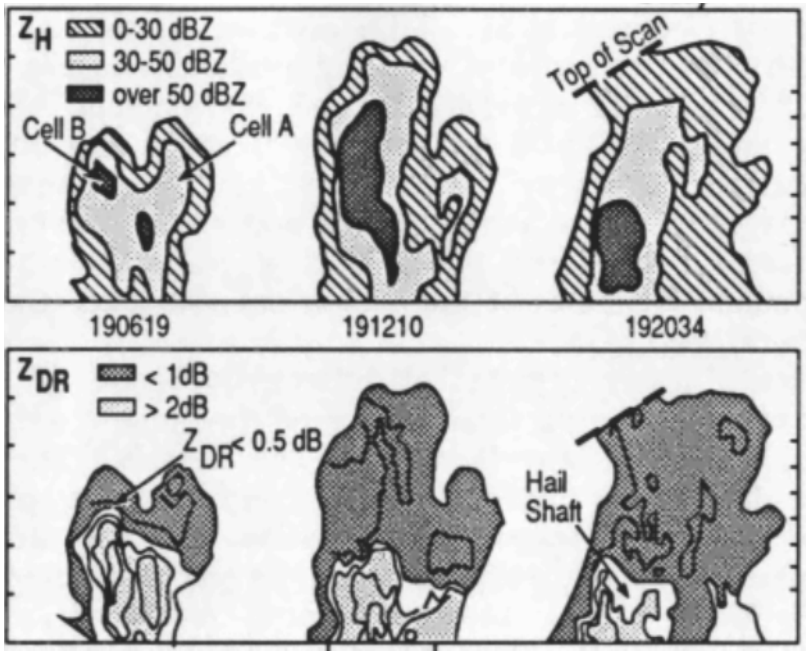
Storm cell ID



Total Lightning (left), 2 km IR (right)

Lightning Connection to Thunderstorm Updraft, Storm Growth and Decay

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



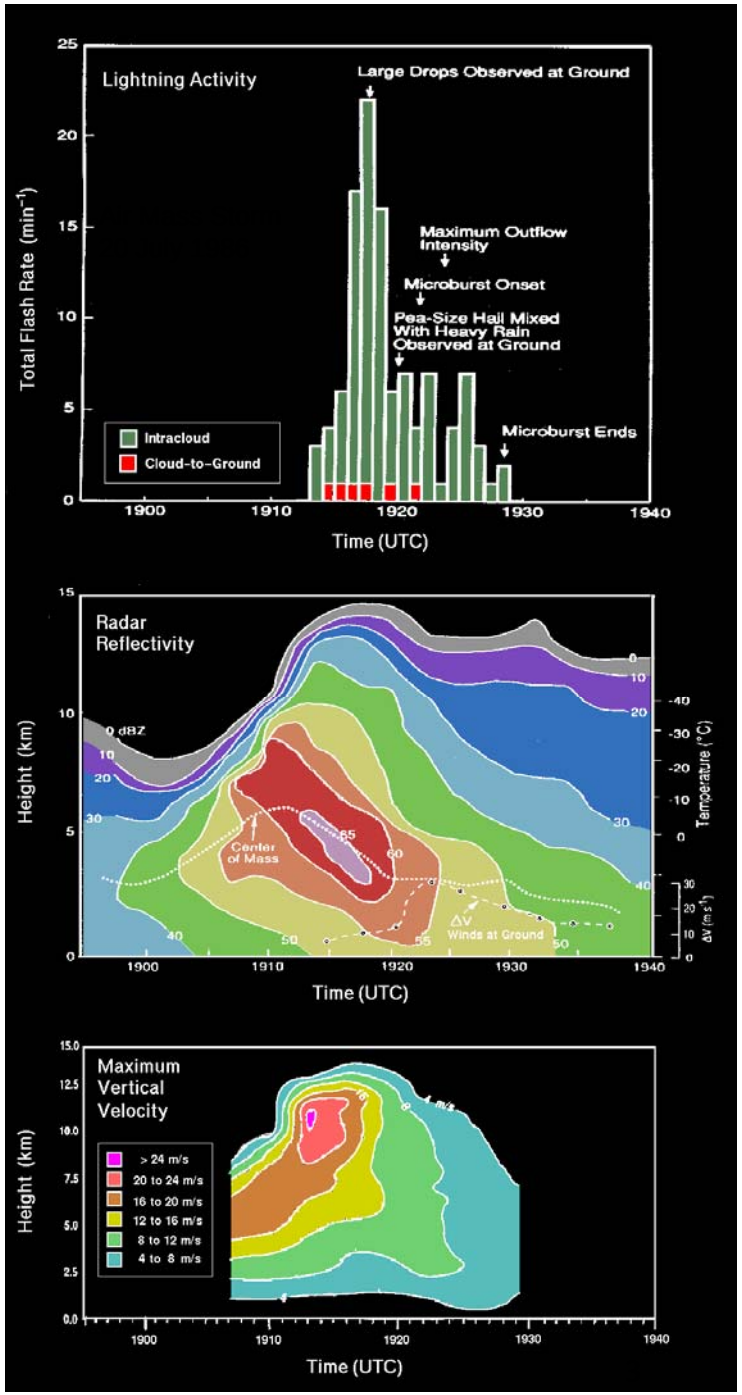


Figure from Gatlin and Goodman, JTECH, Jan. 2010- adapted from Goodman et al, 1988; Kingsmill and Wakimoto, 1991

Huntsville Microburst Storm, 20 July 1986

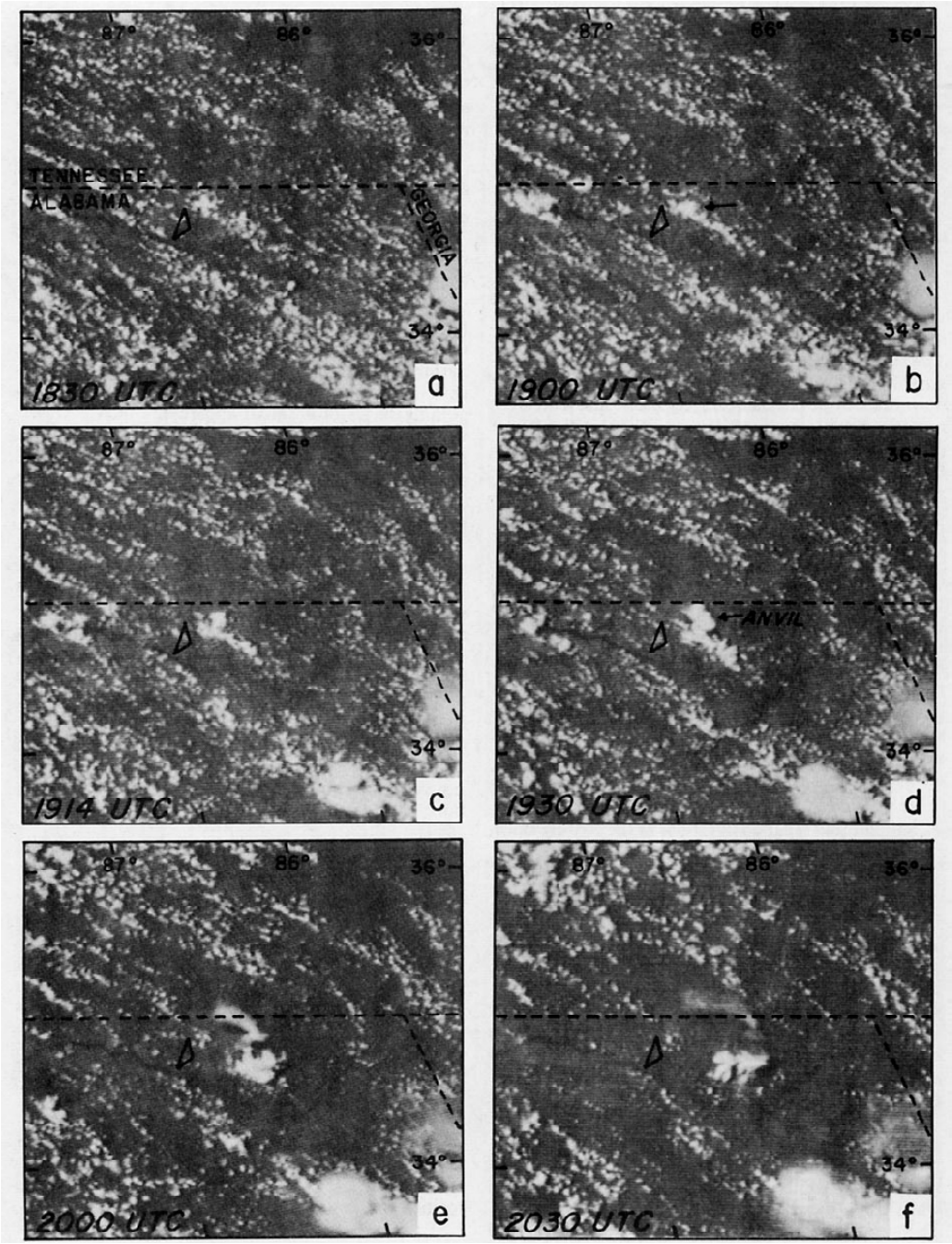
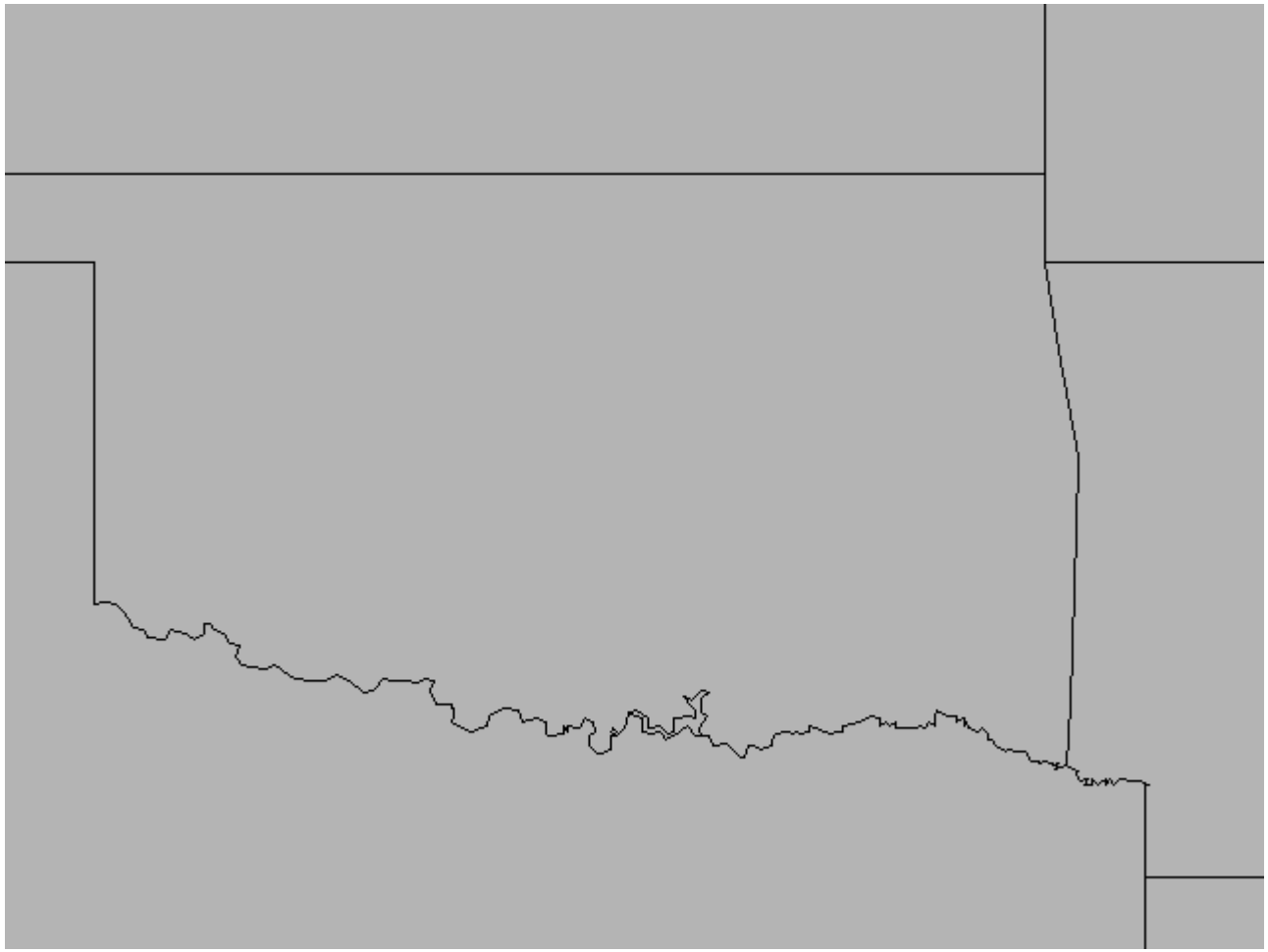


Figure from Wakimoto and Bringi, 1987; Vis image at 1830, 1900, 1914, 1930, 2000, 2030 UTC.

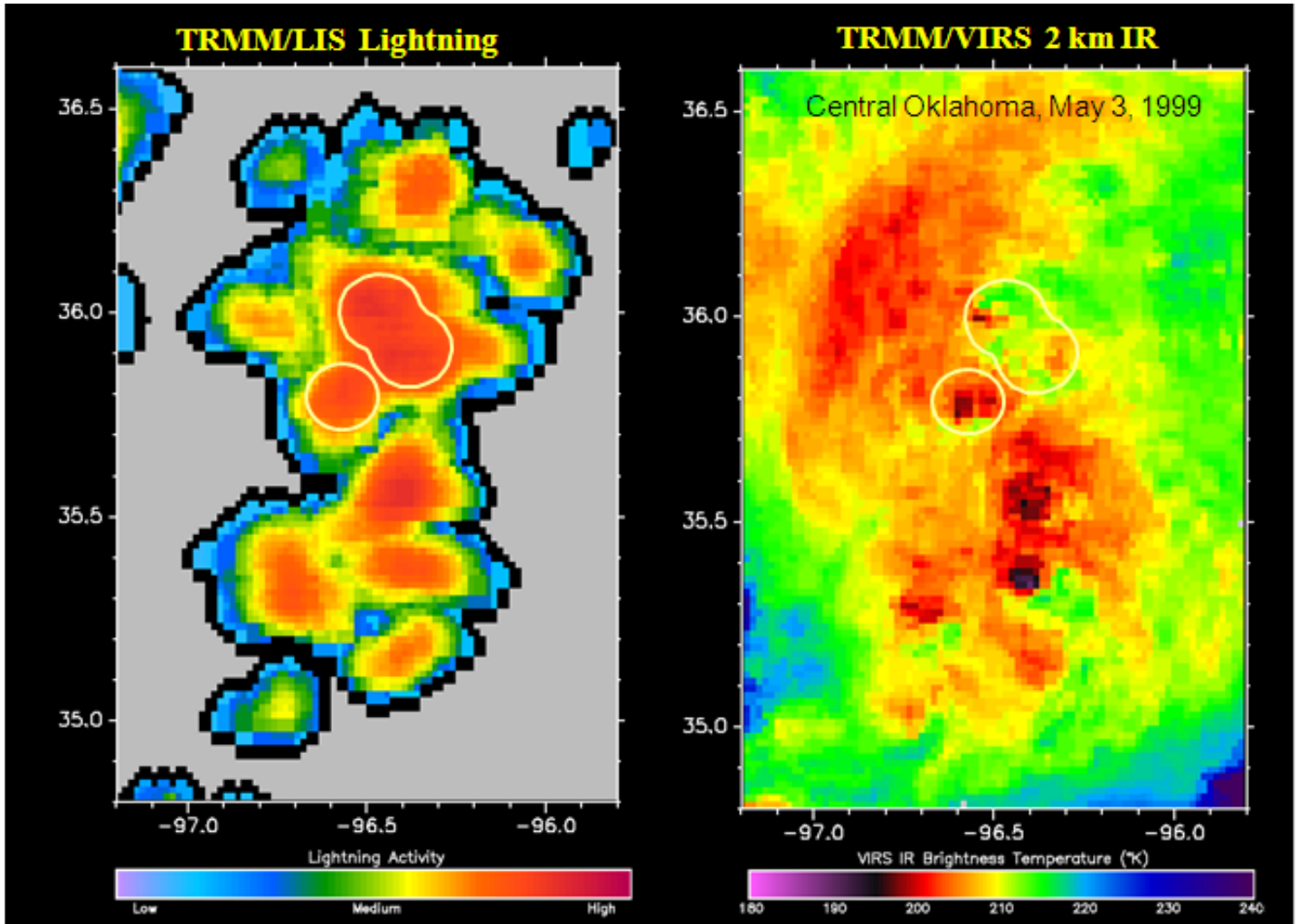
May 3, 1999 Tornado Outbreak



1-minute of observations from TRMM/LIS
Lightning superimposed on TRMM/VIRS IR image

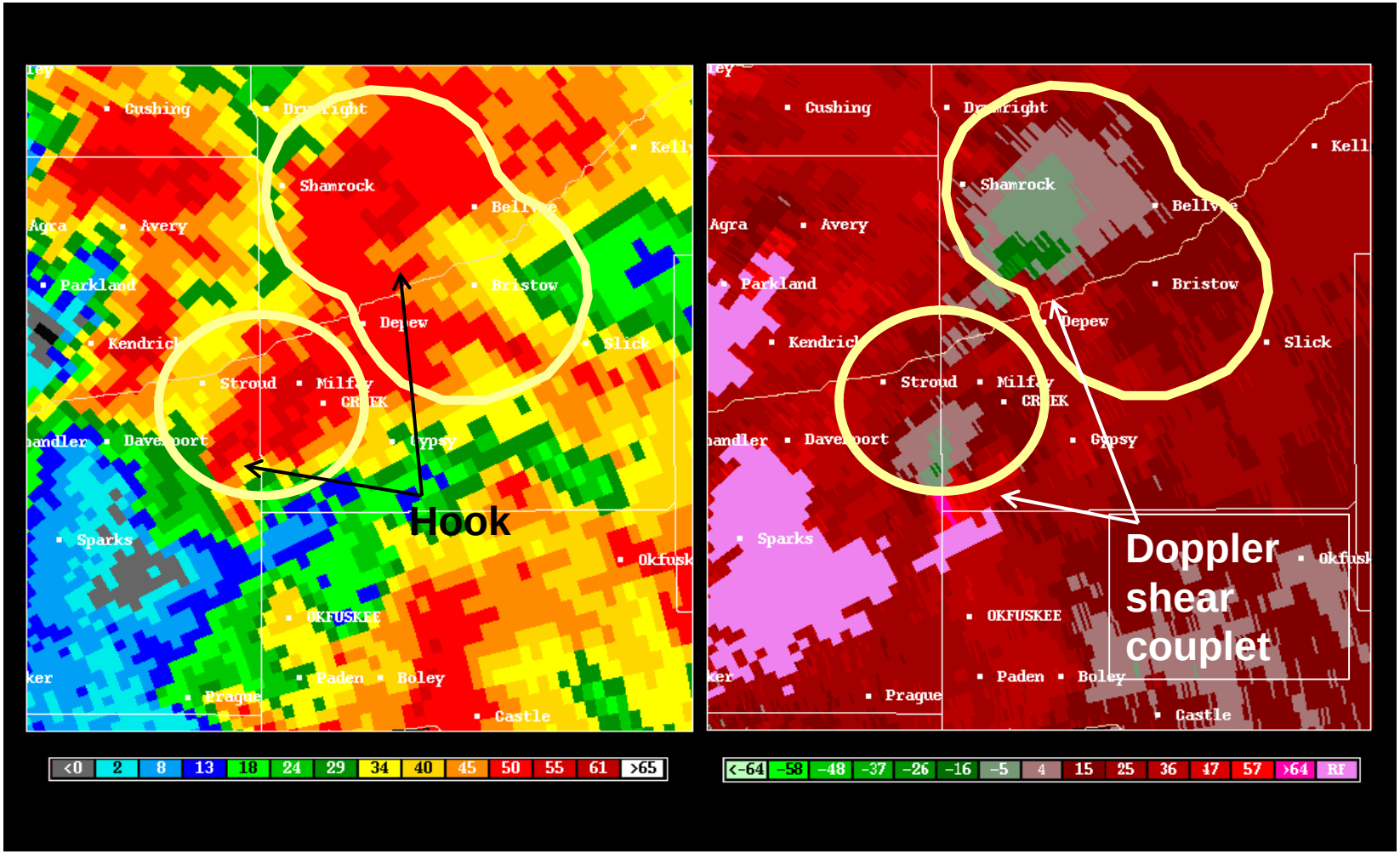
Total Lightning Dominates During OK Tornado: 3 May 1999

GLM and ABI Combined (with radar) characterizes storm intensification and decay)



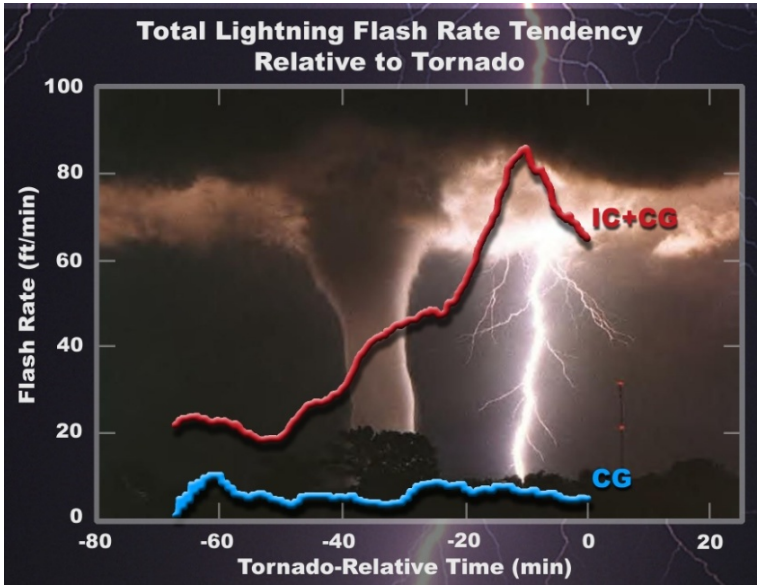
OK Tornado Outbreak 3 May 1999

NEXRAD Reflectivity **NEXRAD Velocity**



Active lightning region in tornadic supercell … correlates with radar hook echo and velocity couplet

Total Lightning Activity:
Can it add value to Tornado Lead Time



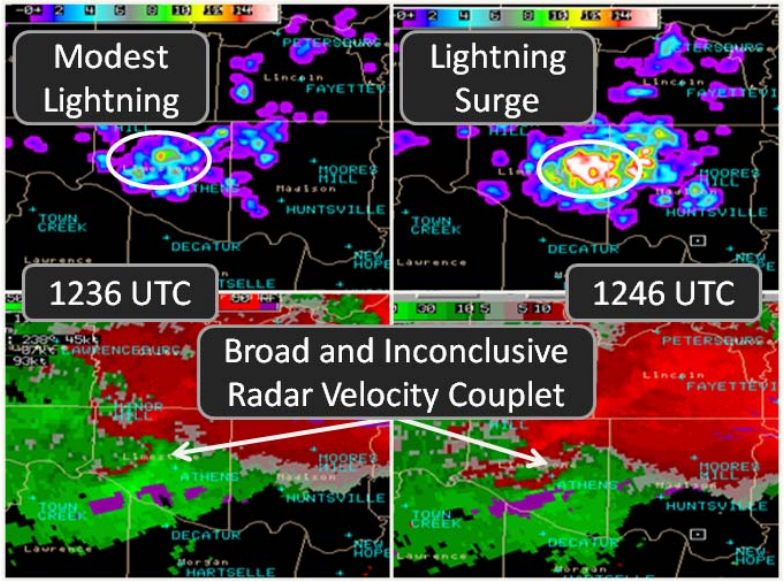


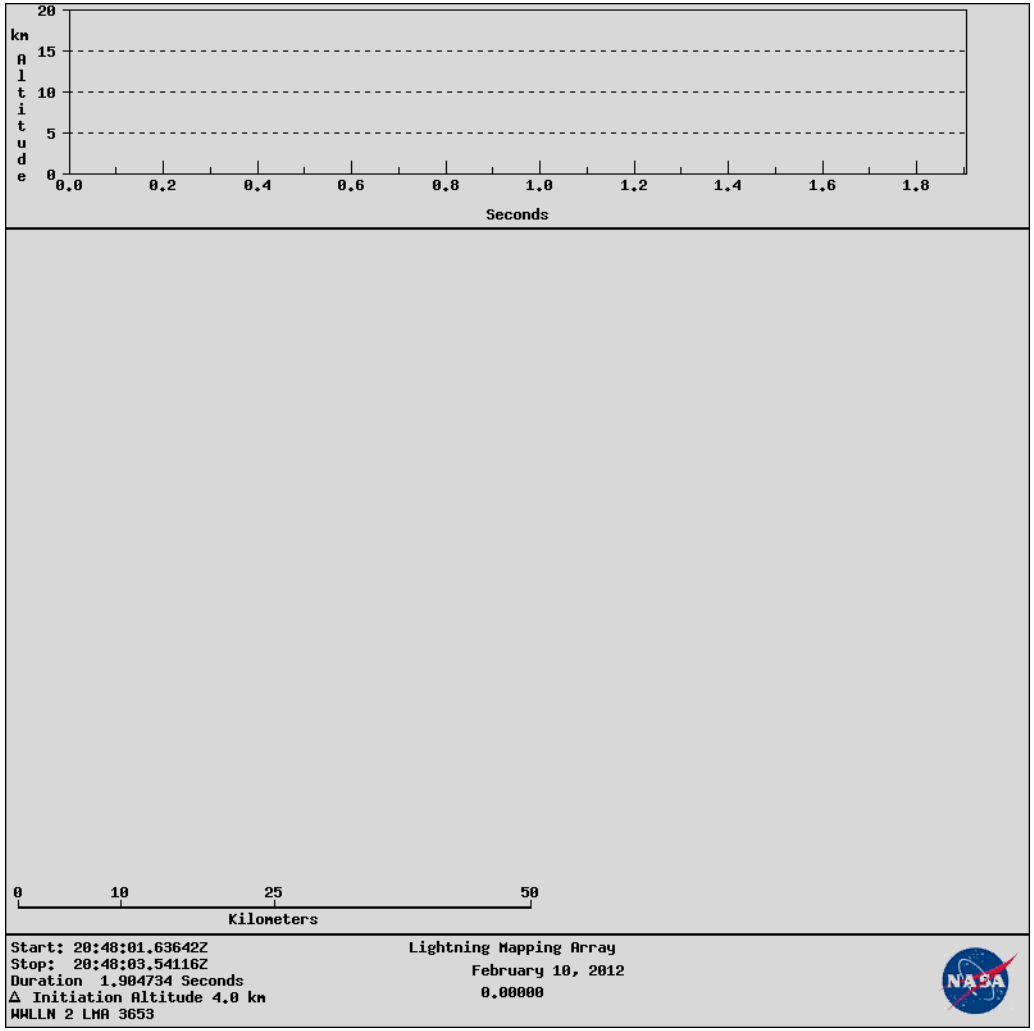
TABLE 3. Skill scores and average lead times using the sample set of 711 thunderstorms for both total lightning and CG lightning, correlating trends in lightning to severe weather.

	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 13 minutes

National Experiment for an operational demonstration of the total lightning algorithm at the Hazardous Weather Testbed (at request of NWS) begins April 1

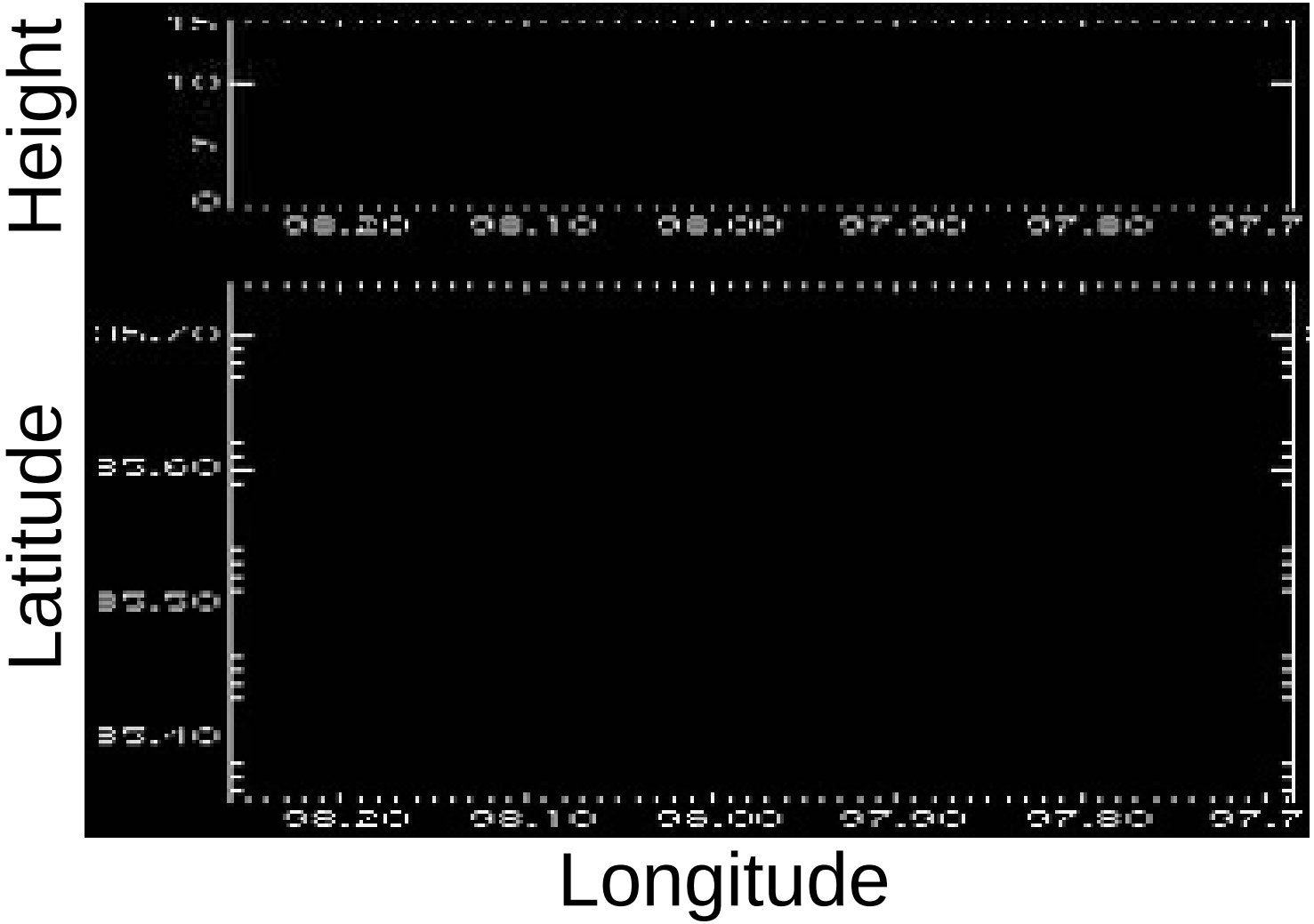
SPLMA Flash During TRMM Overpass: CHUVA 10 Feb 2012



A Single Lightning Discharge:

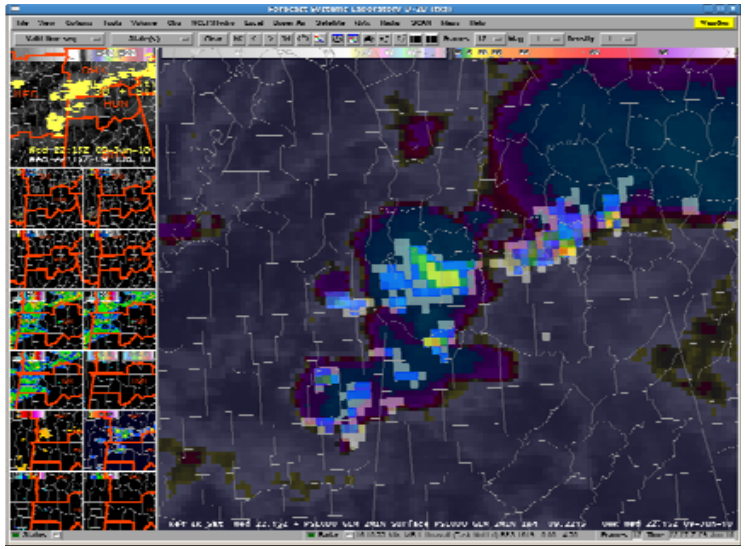
What GLM Sees (OU-CIMMS/NSSL OKLMA)

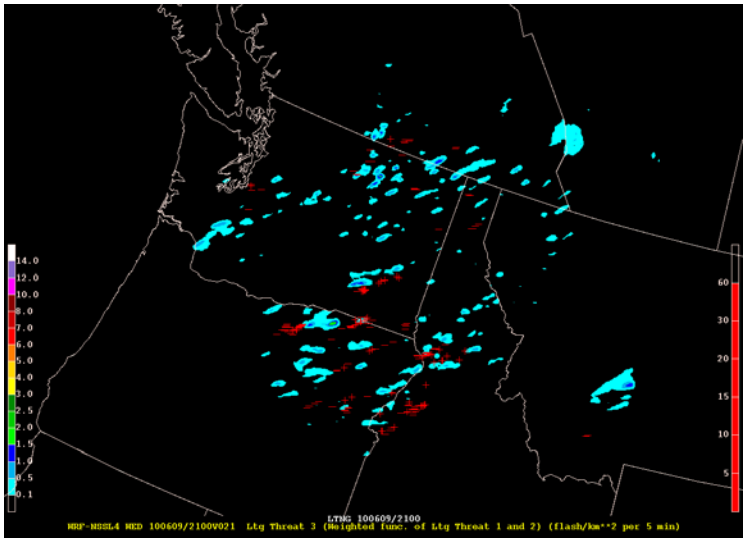
VHF Lightning Mapping Array (dots) and TRMM/LIS proxy (sq pixels)



Total Lightning Detection

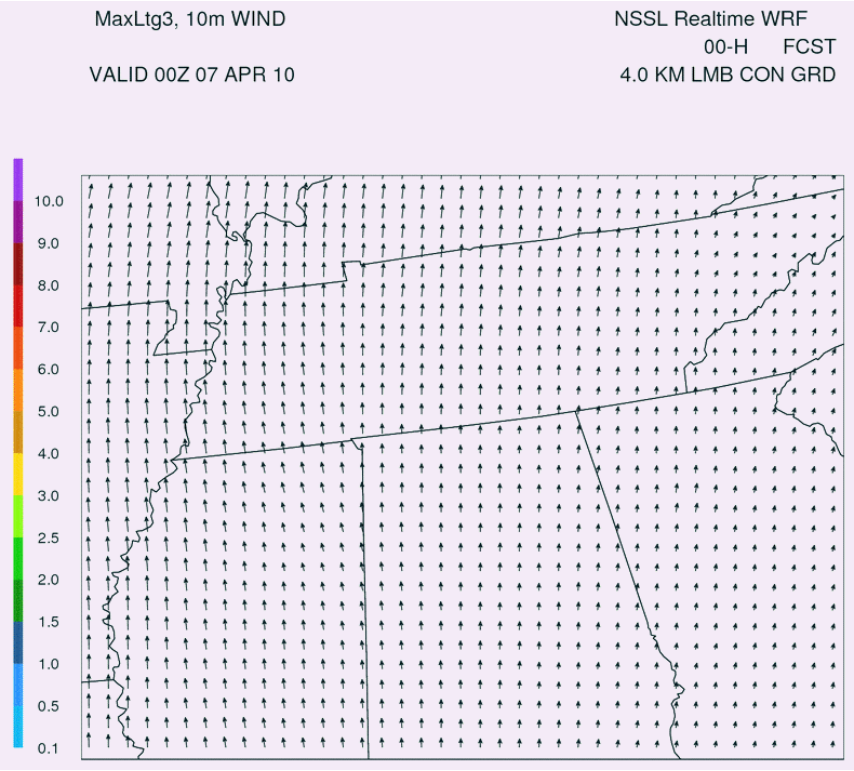
- Pseudo-GLM
  - Data from ground-based total lightning detection networks
    - Huntsville, AL; Washington, DC; Melbourne, FL; and Norman, OK
  - Raw data sorted into flashes and interpolated to an 8km grid
  - Running 2-minute average
- Simulated lightning threat
  - Implemented in NSSL-WRF, OU/CAPS ensemble, and High Resolution Rapid Refresh (HRRR)
  - Estimates total lightning from vertical ice content and flux within cloud objects (see McCaul et al., 2009)

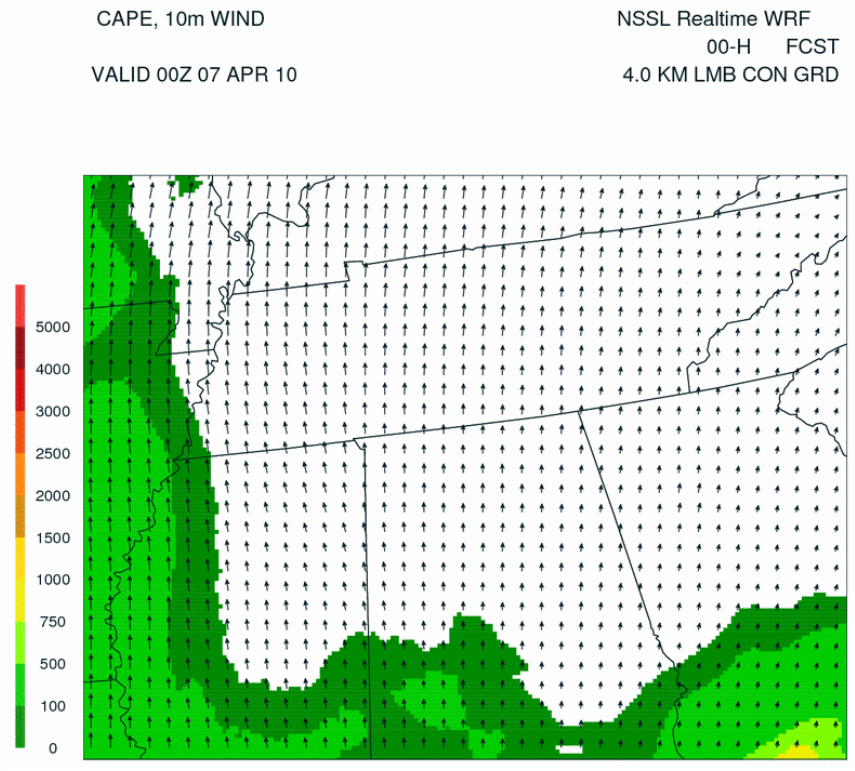




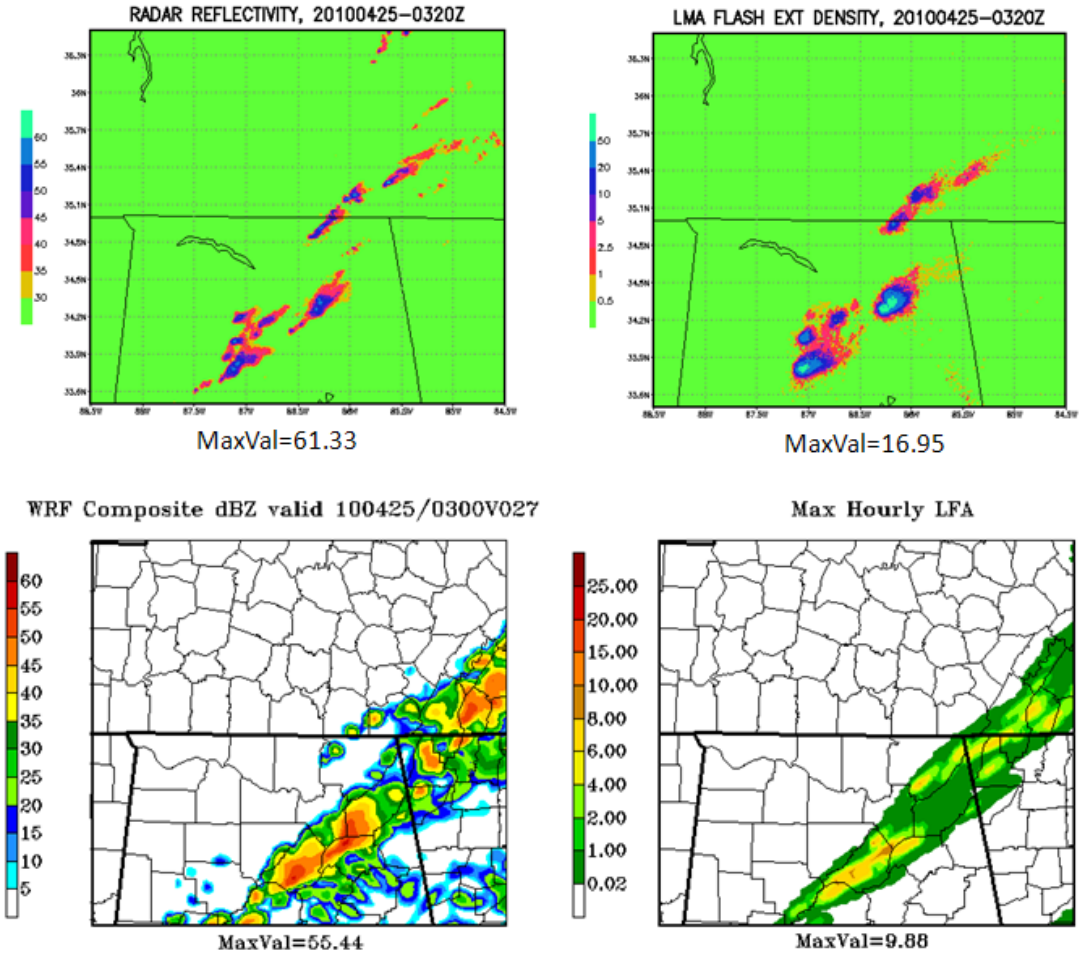
Lightning Forecast Algorithm (LFA) at the NOAA Hazardous Weather Testbed (HWT)

http://goesrhwt.blogspot.com/





WRF Lightning Threat Comparison with NEXRAD and LMA Observations



Direct comparison of the NSSL WRF 27 h forecast at 03Z on 25 April 2010 with the 0300 UTC radar and Lightning Mapping Array (LMA, top row) and model composite reflectivity and max-hourly LFA flash extensity density (bottom row). The LFA in the lower-right shows the tracks of storms in the previous forecast hour. The radar data are a merged composite of HTX,OHX,GWX,BMX and FFC, with the plotted values being the largest of the 5 radars at each pixel.

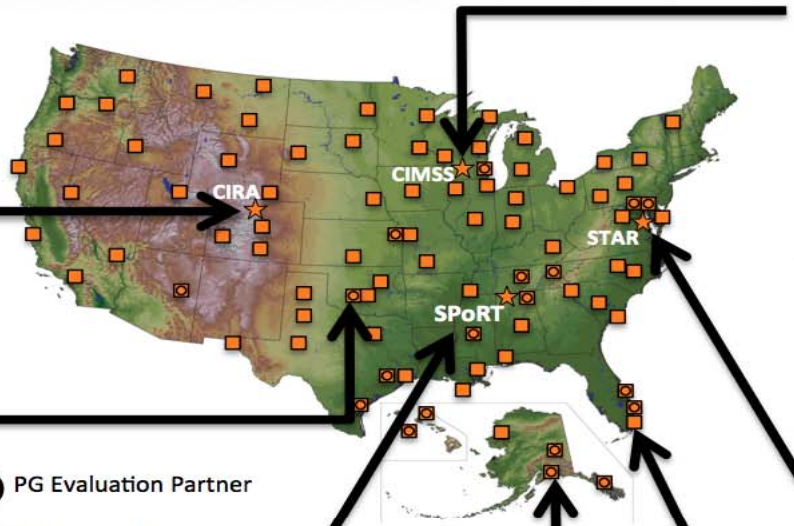
What Is the GOES-R Proving Ground?

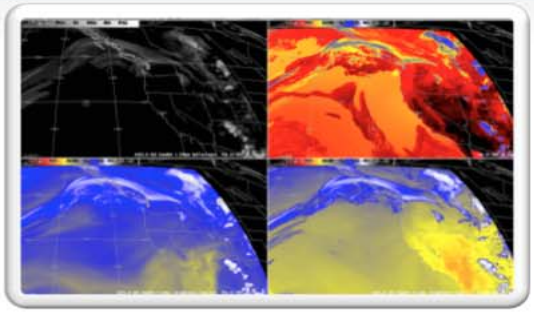
(http://www.goes-r.gov/org/docs/PG_Update_Sept_2011.pdf)

- Collaborative effort between the GOES-R Program Office, selected NOAA Cooperative Institutes, NWS forecast offices, NCEP National Centers, NASA SPoRT, JCSDA, and NOAA Testbeds
- Responsible for user readiness testing of GOES-R baseline products and future capabilities prior to launch
- Where proxy and simulated GOES-R products are tested, evaluated, and integrated into operations before the GOES-R launch
  - Satellite Champions at NWS National Centers
  - Develop training for users
  - Prepare for display within AWIPS/AWIPS-II/N-AWIPS
  - Initial focus on High Impact Weather and warning related products requested by NWS
- A key element of GOES-R User Readiness (Risk Mitigation)
- Proving Ground activities are having an impact **NOW!**

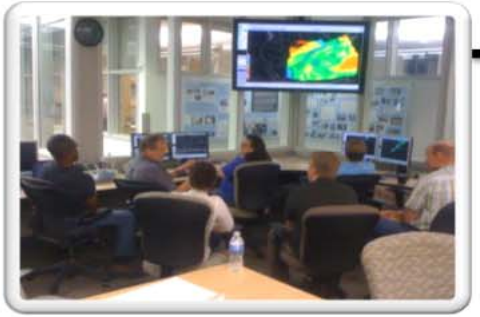
GOES-R Proving Ground Partners

CIRA - Ft. Collins, CO
ABI Simulated Natural Color

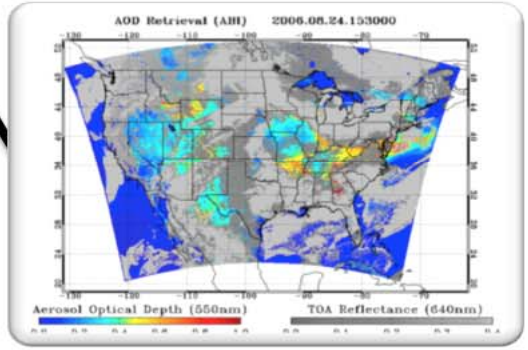




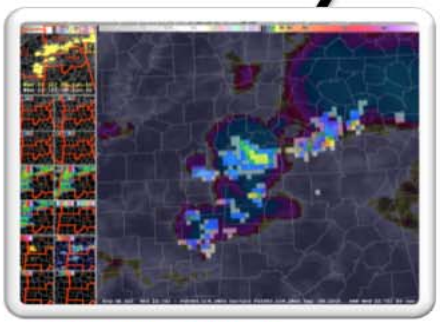
CIMSS – Madison, WI
Simulated ABI Bands



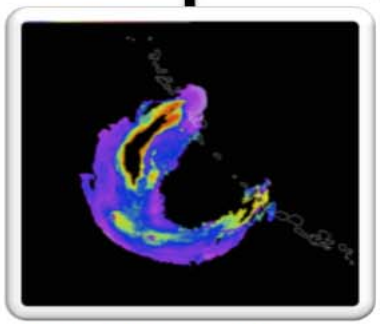
SPC – Oklahoma City, OK
Nearcast Training at the Hazardous Weather Testbed



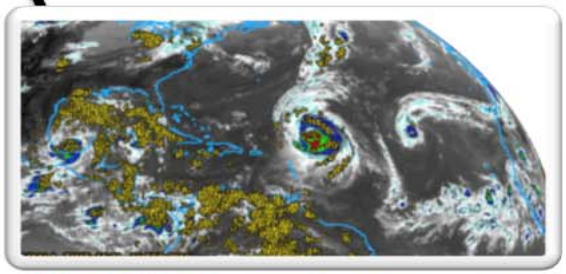
STAR – Camp Springs, MD
Aerosol Optical Depth Product



SPoRT – Huntsville, AL
GLM Lightning Flash Density



AFC – Anchorage, AK
Volcanic Ash Product



NHC – Miami, FL Rapid Intensification Index

July 2011

Visiting Scientists: Satellite Champions

NWS Centers	Visiting Scientist/PI	CI	NOAA Host
SPC/HWT	C. Siewert, K. Kuhlman	OU-CIMMS	Russ Schneider
OPC, HPC, SAB	M. Follmer,	CICS	J. Sienkiewicz, E. Danaher, J. Kibler
AWC	Amanda Terborg	UW-CIMSS	David Bright
NWS Training Center	Chad Gravelle	UW-CIMSS	John Ogren
Pacific Region	Roy Huff	UH-JIMAR	Bill Ward
Alaska Region	T. Heinrichs	UAF-CIFAR	Gary Hufford
Multiple	R. Brummer	STAR/CSU-CIRA	Various
Multiple	W. Feltz	STAR/UW-CIMSS	Various
Multiple	G. Jedlovec	NASA-SPoRT	Various
SwPC	W. Denig	NGDC/CIRES	Steve Hill
NWS HQS	A.Huff/ S. Kondragunta/R. Hoff	STAR/UMBC	Ivanka Stajner

Capturing Feedback

- Real-time blogging http://goesrhwt.blogspot.com/
  - During forecast/warning exercises
  - Participants were also encouraged to blog following forecast/warning exercises
- Web-based surveys
  - Immediately following forecast/warning operations
- Daily post-mortem discussions
  - Between visiting scientists and forecasters

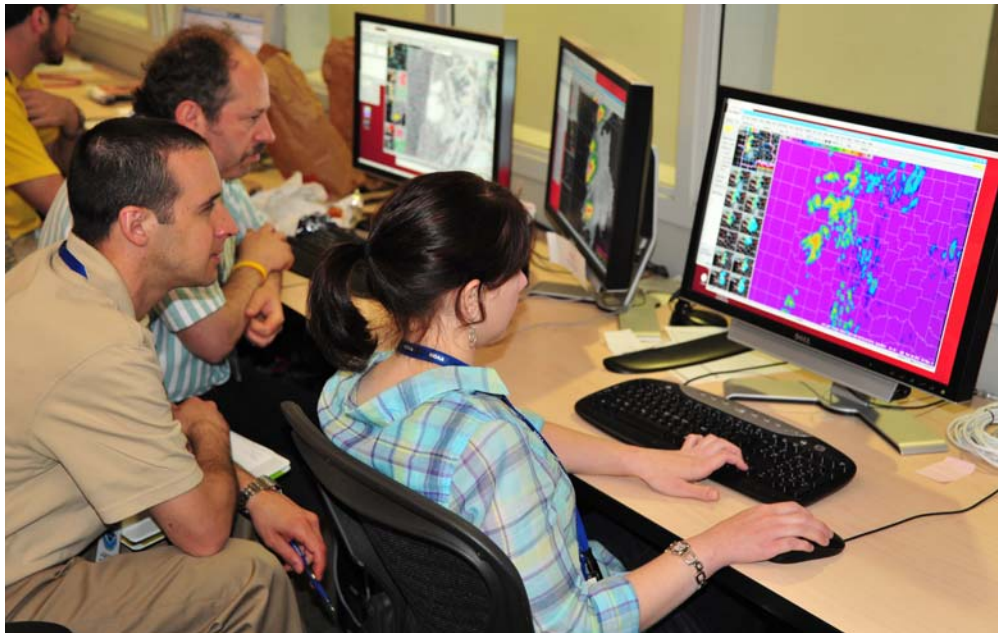
Proving Ground Forecaster Feedback: Lightning Detection

- "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."

"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 lighting statements and potentially lightning based warnings."

-Pat Spoden (SOO, NWSFO Paducah, KY)

HWT: Forecaster Feedback from 2011 Lightning Detection



- "Total lightning data preceded the CG network 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."

Lightning Jump Algorithm Operational Demonstration

- Establish a fully automated processing method using the "2σ" (2-sigma) algorithm (Schultz et al., 2009).
- This includes automated (but ***not*** real-time) verification in order to calculate and evaluate **POD/FAR/CSI** for severe weather forecasts.
- This is expected to produce a large data set, which can be used for various other post-processing elements, yet to be determined.
- Expected Outcome:

  The results of this test are intended to assess the utility of the GLM data from GOES-R to increase warning lead time and reduce FAR.

Summary

- GLM Instrument Development on Track- FM1 2013
- Proving Ground continues to grow and plans are in place for continued demonstrations of new applications/capabilities with forecasters
- Content being developed for forecaster and end user training
- Proxy data and Cal/Val tools in development for monitoring GLM performance