Initial Results from Pre-Launch Algorithm Development and Testing for the GOES-R Geostationary Lightning Mapper (GLM)

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http://www.goes-r.gov

(with acknowledgments and thanks to our many partners and contributors)

Eighth Annual Symposium on Future Operational Environmental Satellite Systems
New Orleans, LA
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Outline

- Algorithm Development and Validation
  - Lightning Cluster Filter Algorithm (L2 algorithm)
  - Proxy Data
  - Testing and Validation
- User Readiness Demonstrations
  - GOES-R Proving Ground
  - Forecaster Feedback
  - Lightning Jump Algorithm Demonstration
- Forecaster Training
- Summary

Selected GLM Related Presentations

Sponsor: **Eighth Annual Symposium on Future Operational Environmental Satellite Systems**

2.5 (Oral), Geostationary Lightning Mapper (GLM), Geostationary Operational Environmental Satellite R-Series (GOES-R)
Karen Gheno, Lockheed Martin, Palo Alto, CA; and S. Edgington and E. Aamodt

3.1 (Oral), Overview of GOES-R Level-2 Products
Jaime M. Daniels, NOAA/NESDIS, Camp Springs, MD; and M. Goldberg

492 (Poster), GOES-R AWG Product Processing System Framework
Walter Wolf, NOAA/NESDIS/STAR, Camp Springs, MD; and S. Sampson, R. Garcia, G. D. Martin, X. Liu, T. Yu, W. Straka III, S. Qiu, A. Li, J. Daniels, E. Schiffer, and M. Goldberg

501 (Poster), Evaluation of NASA Sport's Pseudo-Geostationary Lightning Mapper Products in the 2011 Spring Program
Geoffrey T. Stano, ENSCO/SPoRT, Huntsville, AL; and B. Carcione, C. W. Siewert, and K. M. Kuhlman

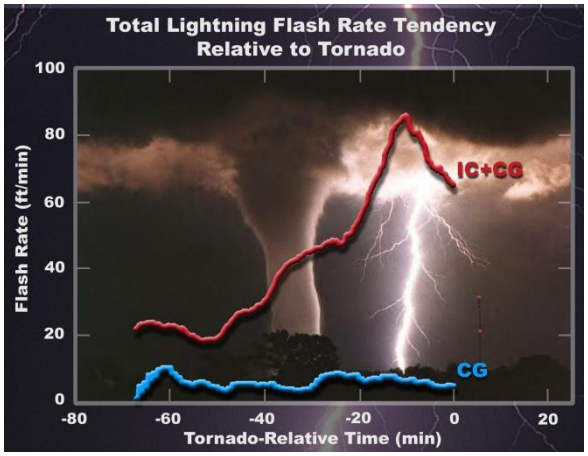
5.5 (Oral), GOES-R Proving Ground - Demonstrating GOES-R Products in 2011
Bonnie Reed, NOAA/NWS, Silver Spring, MD; and M. DeMaria, S. J. Goodman, J. Gurka, D. Reynolds, and C. W. Siewert

TJ15.4 (Oral), The GOES-R Proving Ground: 2012 Update
James J. Gurka, NESDIS GOES-R Program Office, Greenbelt, MD; and S. Goodman, T. J. Schmit, M. DeMaria, A. Mostek, C. W. Siewert, and B. Reed

GLM Key Driving Requirements, Mission Objectives, and Performance

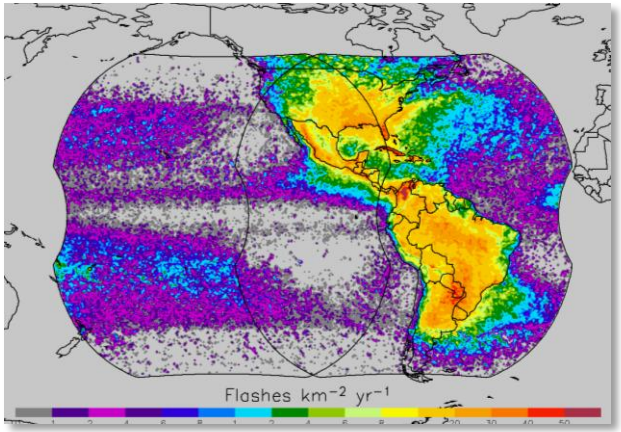
- Top-Level Requirements
  - Capture 70% of the lightning flashes
  - False alarm rate less than 5%
  - Severe storm detection, lightning climatology

Longer tornado warning time



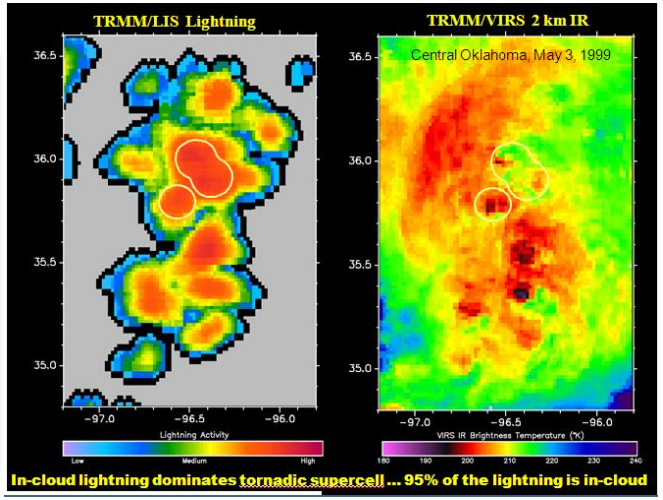
Lightning jump- IC rapid increase

Decadal lightning data



GOES E, W coverage

Storm cell ID

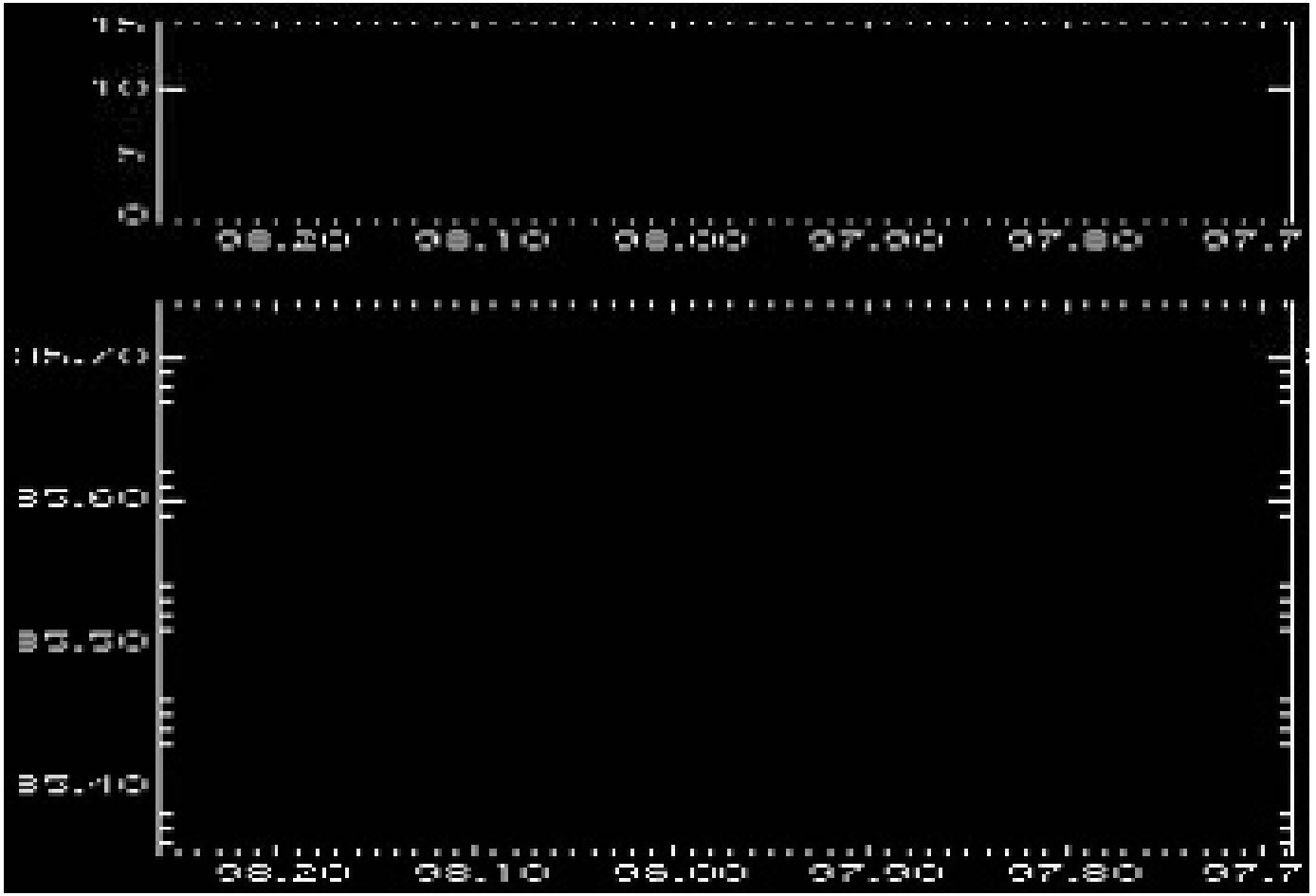


Total Lightning (left), 2 km IR (right)

A Single Lightning Discharge:

What GLM Sees (OU-CIMMS/NSSL OKLMA)

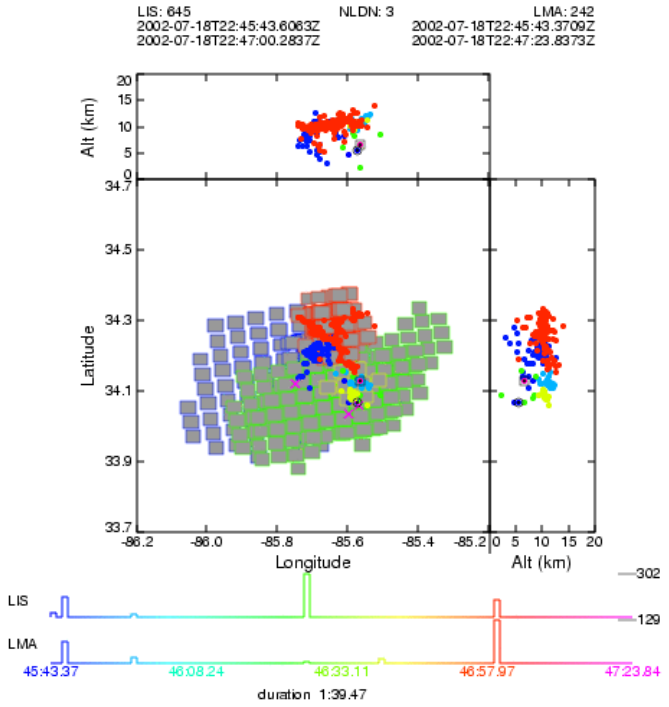
VHF Lightning Mapping Array (dots) and TRMM/LIS proxy (sq pixels)



Proxy Data Motivation

- Total lightning flash rate trends have demonstrated value for forecasting high impact weather and are well observed by VHF systems like the Northern Alabama Lightning Mapping Array (NALMA)
  - > 90% flash detection efficiency within about 100-150 km
  - Fine spatial resolution (< 1 km) at those ranges
  - Maps the lightning channel and its propagation (not simply denoting a strike point at the earth's surface)

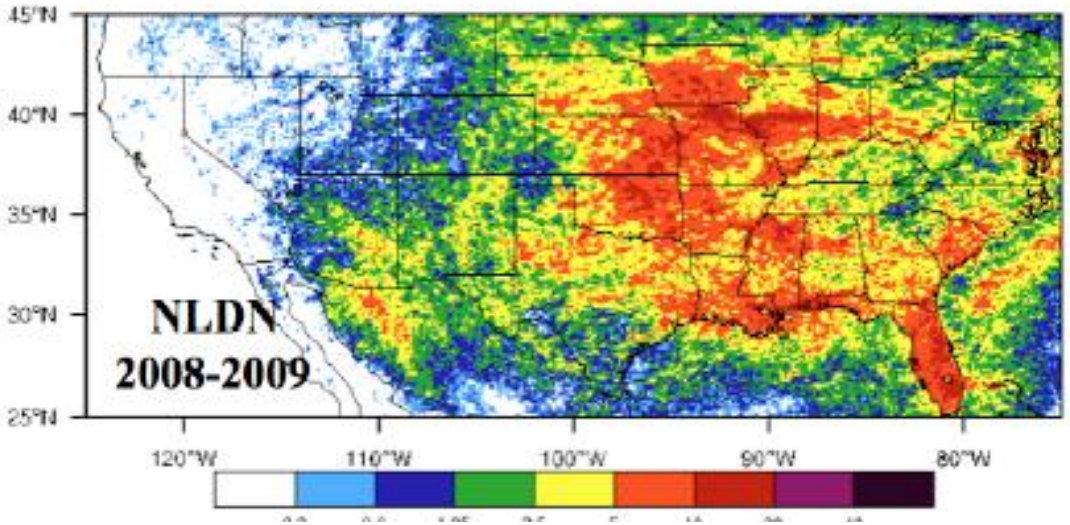
- To expand GOES-R GLM (Geostationary Lightning Mapper) proxy applications for high impact convective weather (e.g., severe, aviation hazards) research, it is desirable to investigate utility of additional sources of *continuous* (total) lightning
  - that can serve as suitable GLM proxy over **large** spatial scales (order 100's to 1000 km or more)
  - including typically data denied regions such as the oceans

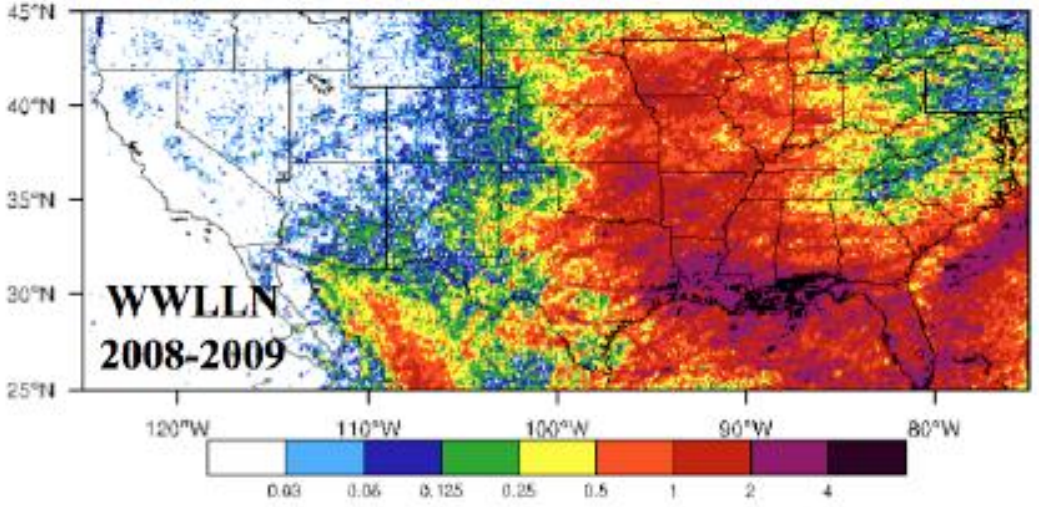


Tool developed for inter-comparing LIS (squares), LMA (dots), and NLDN (Xs) for Proxy Data Development.

Data Inter-comparison for RF Networks

- **Need to understand performance of each system**
- **NLDN and WWLLN primarily detect CG flashes- <u>6% IC detection</u>**





Year	2006-2007	2007-2008	2008-2009
All WWLLN flashes	2,732,366	3,228,444	6,154,394
All (CG) NLDN flashes	29,614,920	27,567,606	24,839,997
Coincidences	1,147,815	1,346,692	2,558,809
CG DE [%]	3.88	4.89	10.30
IC DE [%]	1.78	2.28	4.82
CG + IC DE [%]	2.31	2.93	6.19

Courtesy Bob Holzworth

Testing and Validation

Demonstrating Algorithm Performance

- Truth data
  - Ground-based lightning networks, in-situ
  - Ancillary data
  - Field Campaigns
  - Hazardous Weather Testbed- Huntsville, AL and Norman, OK
- Algorithm Test plan
  - Use proxy/simulated data cases
  - Perform verification using truth data above in conjunction with proxy/simulated data cases to perform verification

Testing and Validation

Proxy and Simulated Data…

- TRMM LIS/OTD- resampled to GLM resolution
- VHF total lightning- remapped to GLM resolution
- SEVERI, MODIS as ABI proxies concurrent with LIS and ground-based lightning data- for merged ABI-GLM products

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

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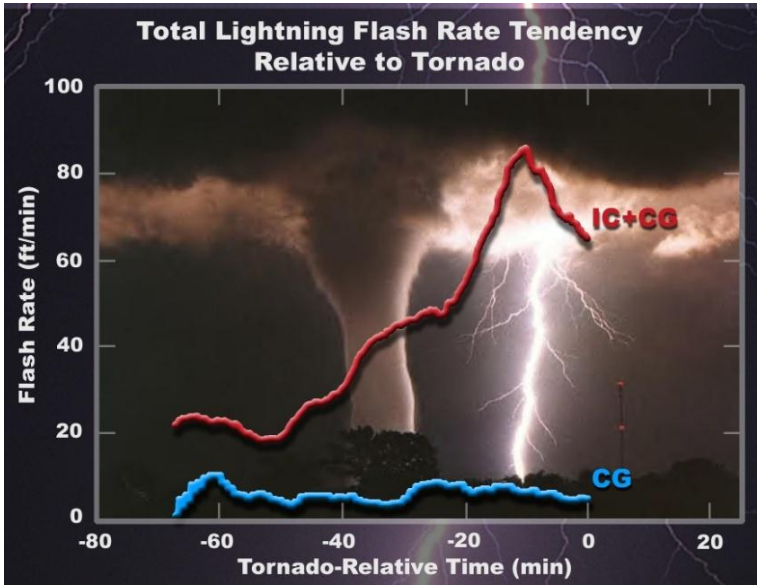
Can it add value to Tornado Lead Time



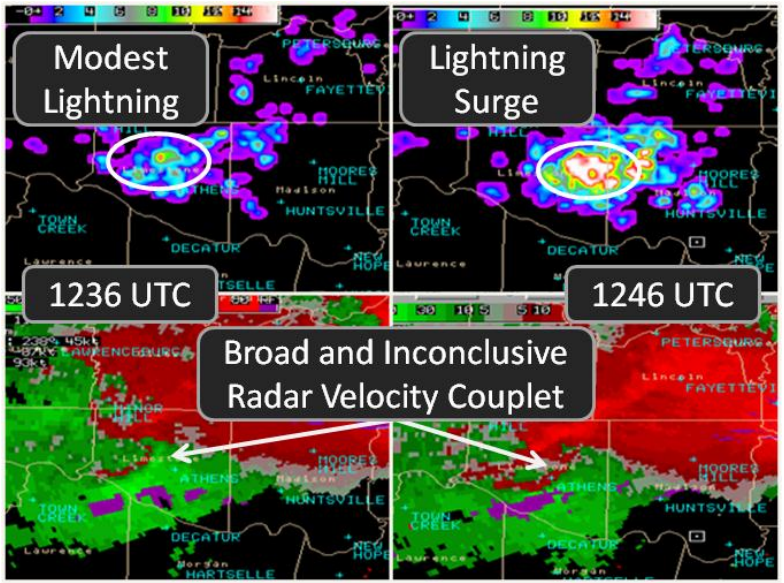


TABLE 3. Skill scores and average lead times using the sample set of 711 thunderstorms for both total lightning and CG lightning, correlating trends in lightning to severe weather.

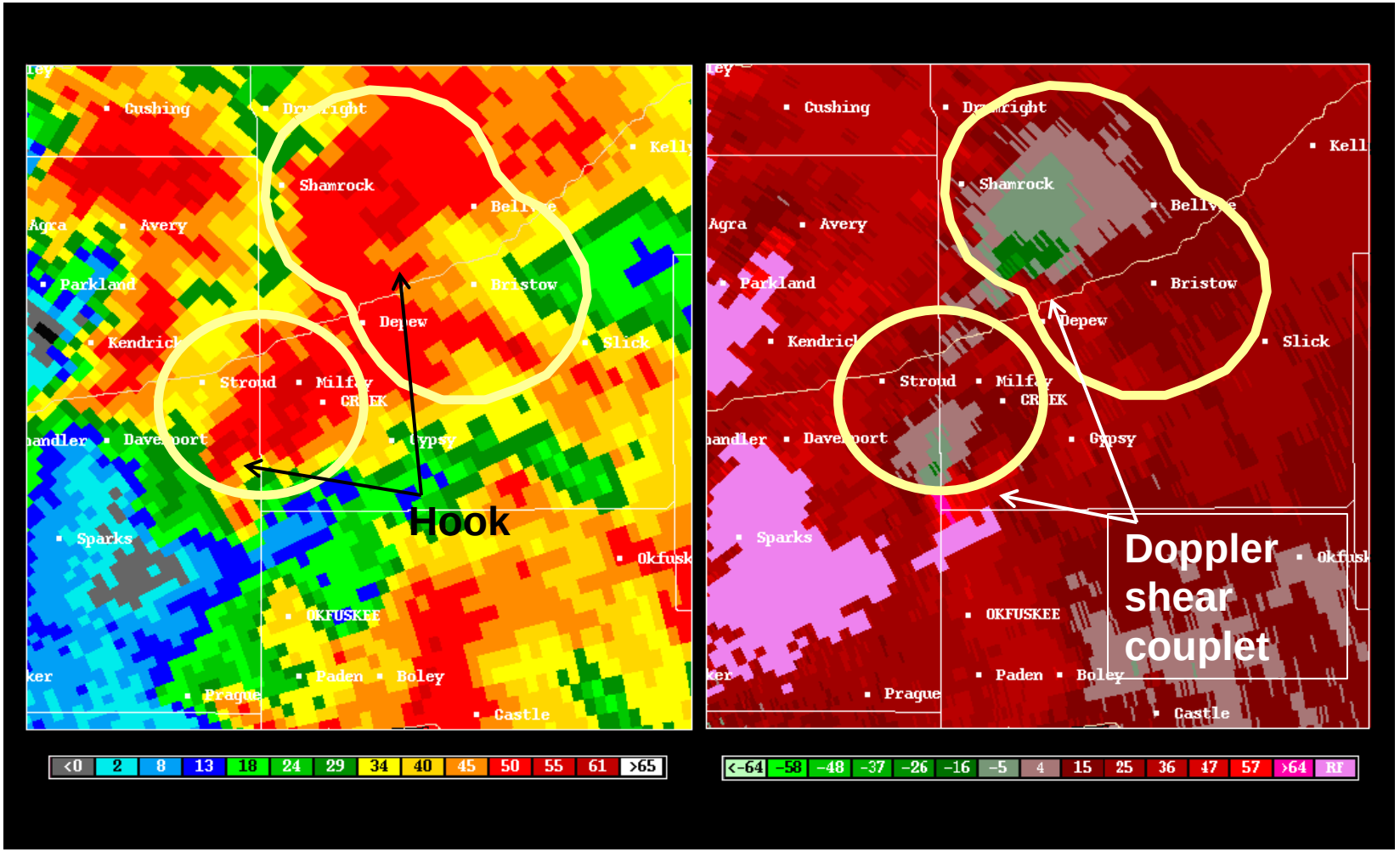
	POD	FAR	CSI	HSS	lead time (all)	lead time (tornado)
Total lightning	79%	36%	55%	0.71	20.65 mins	21.32 mins

National Average for Tornado warning lead-time is only 13 minutes

Experiment Design developed for an operational demonstration of the total lightning algorithm at the Hazardous Weather Testbed (at request of NWS)

OK Tornado Outbreak 3 May 1999

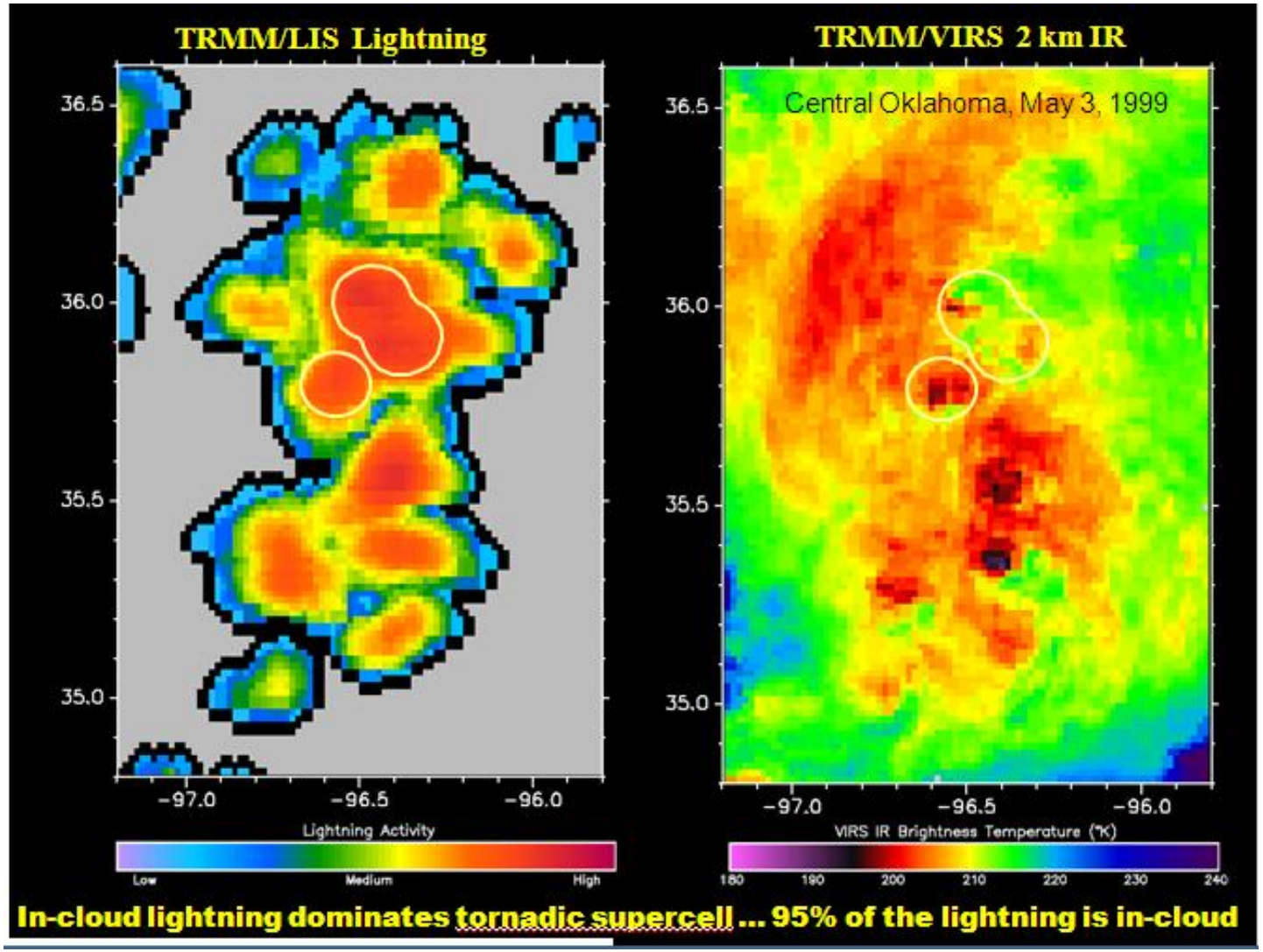
NEXRAD Reflectivity **NEXRAD Velocity**



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

Total Lightning Dominates During OK Tornado: 3 May 1999

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



Physical Basis:

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
- Microwave Radiometer — responds to concentration, size, phase, and type of hydrometeors — integrated over depth of storm (85 GHz ice scattering)
- VIS / IR — cloud top height/temperature, texture, optical depth

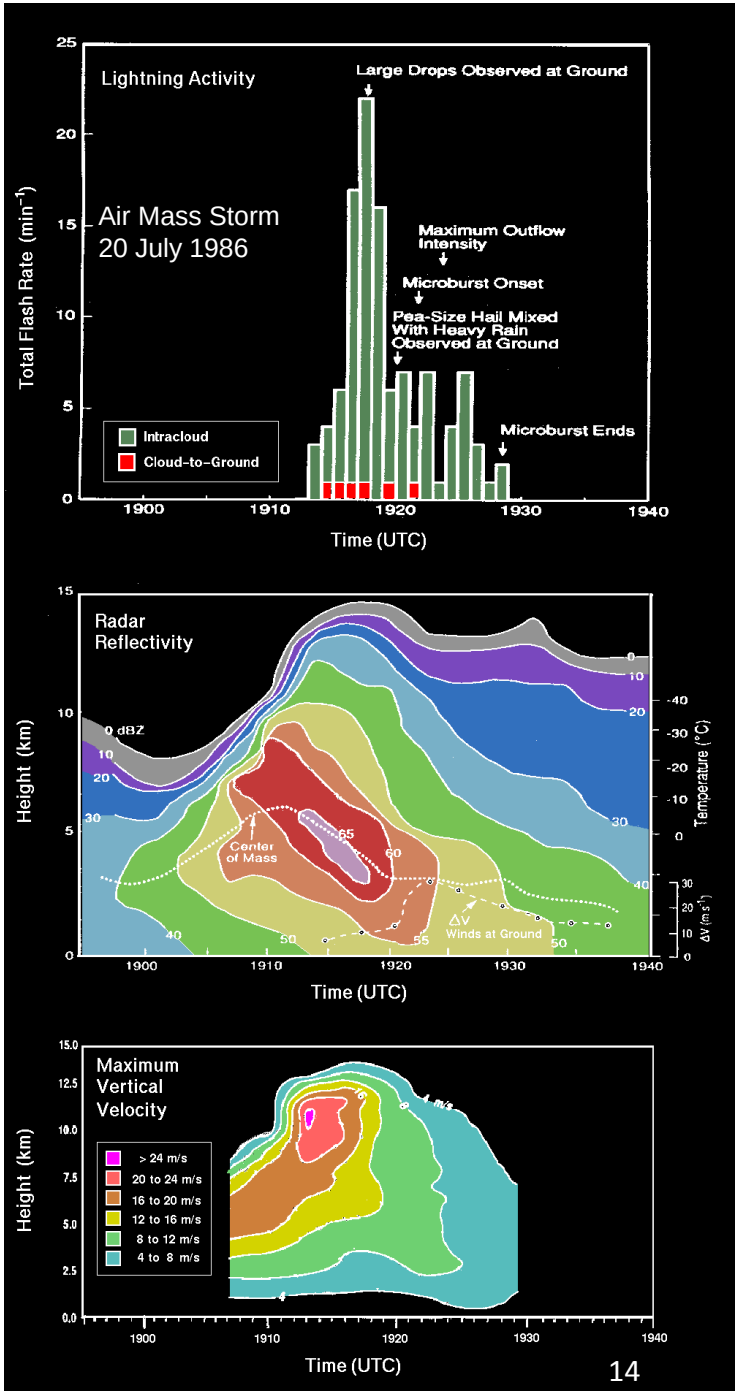
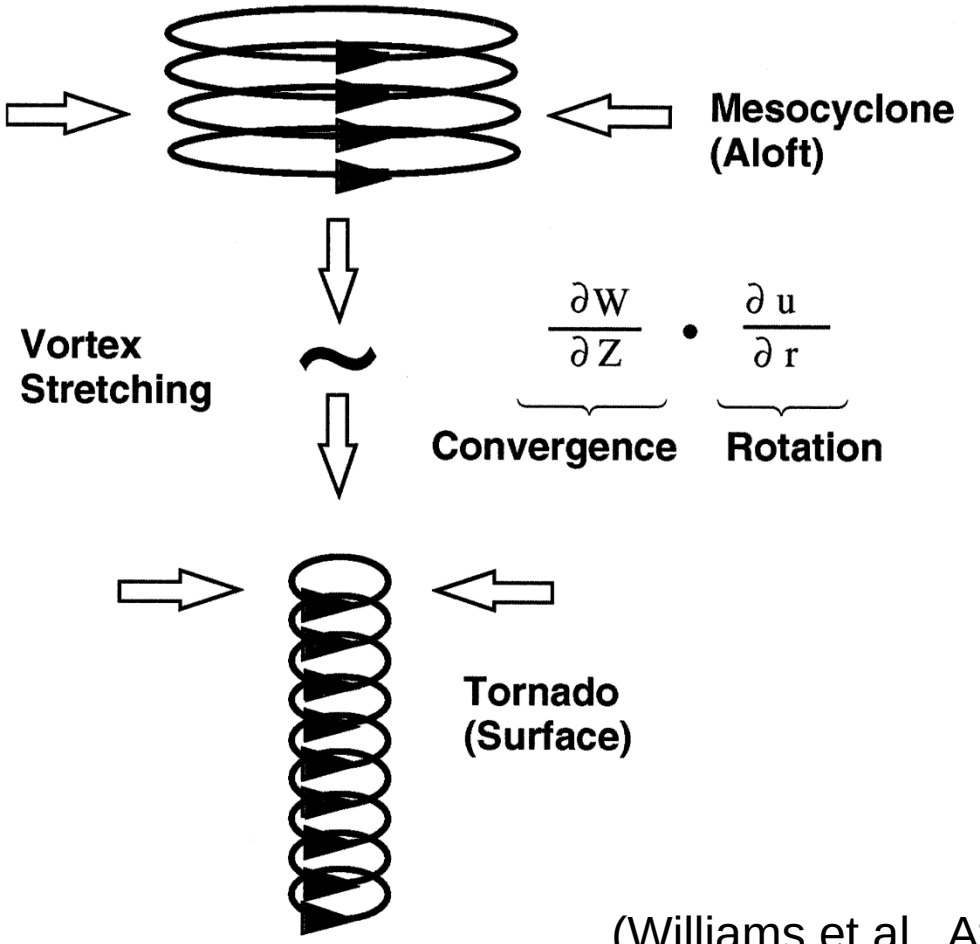
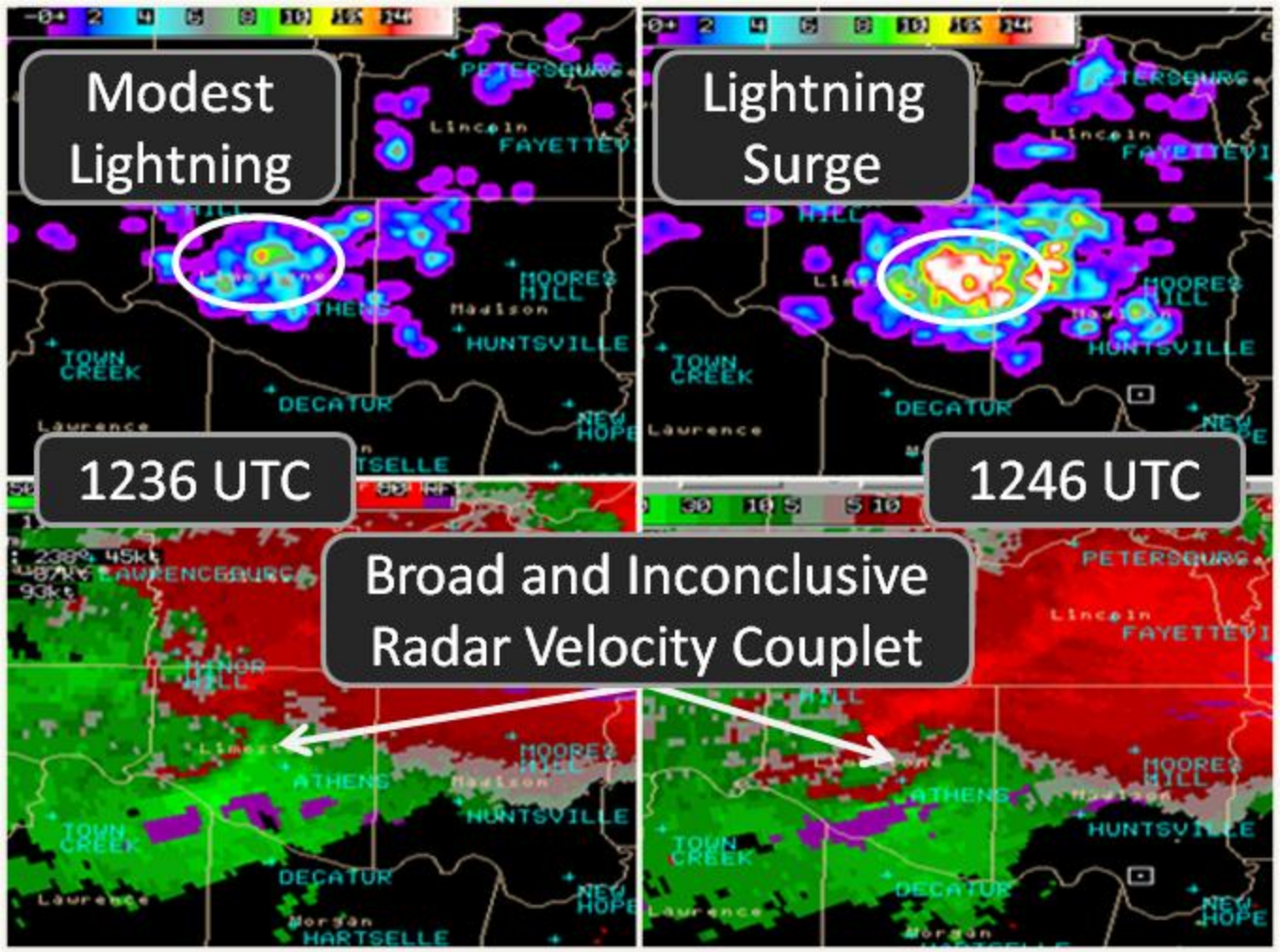


Illustration of the Role of Vertical Drafts in Vortex Stretching

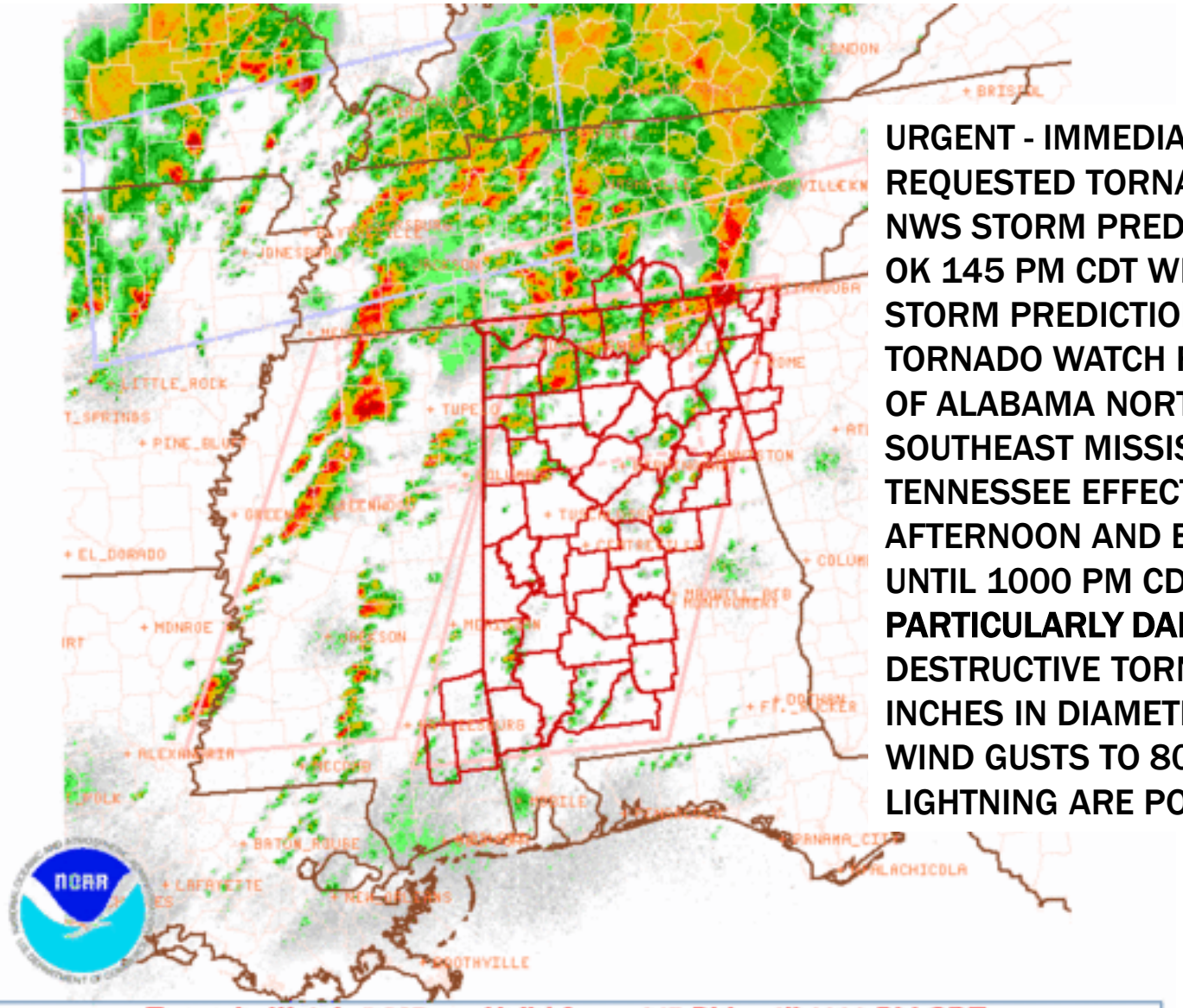


(Williams et al., Atmos. Res. 51, 1999)

Total Lightning Increases with Storm Growth and Updraft Intensification

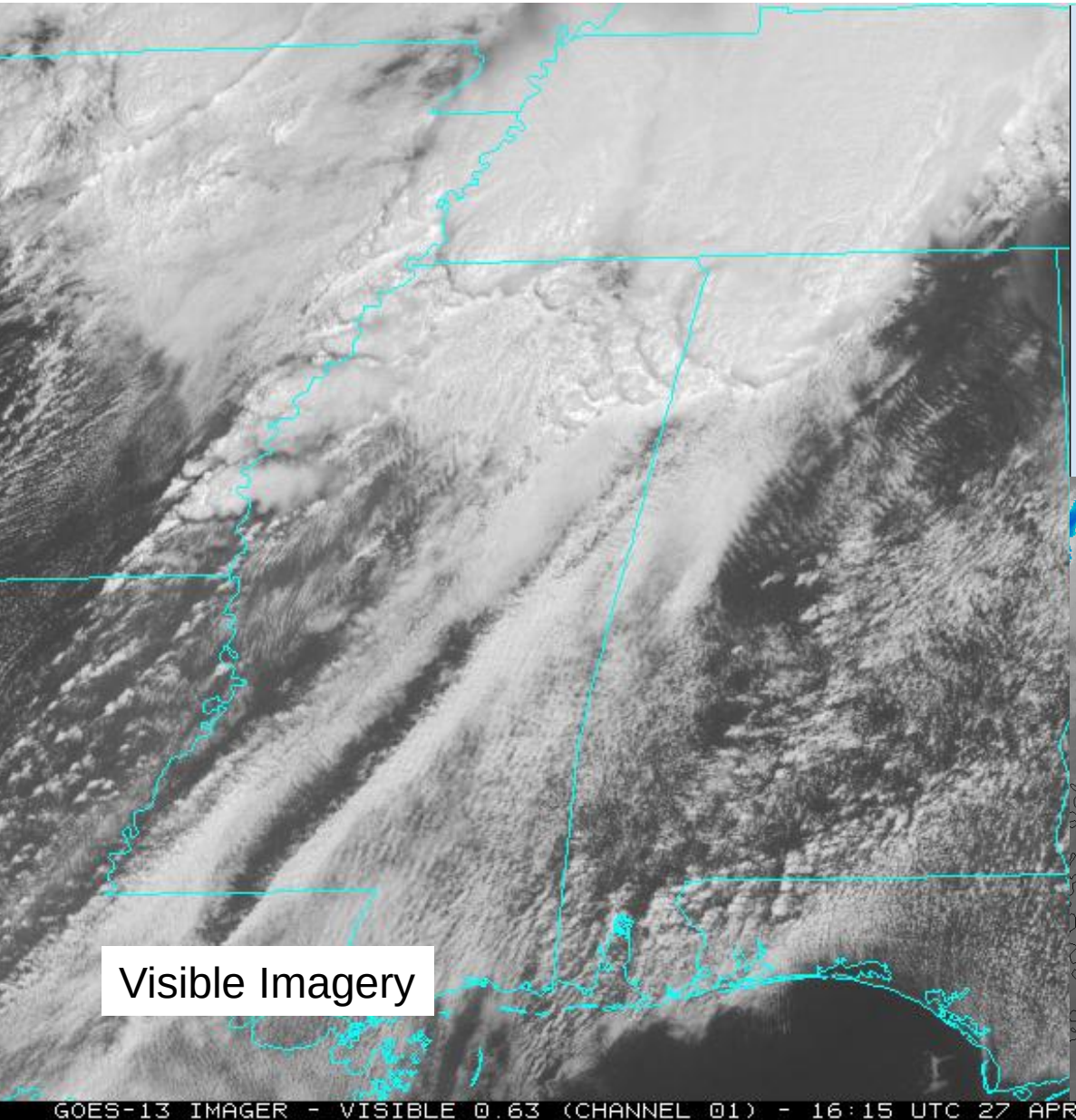


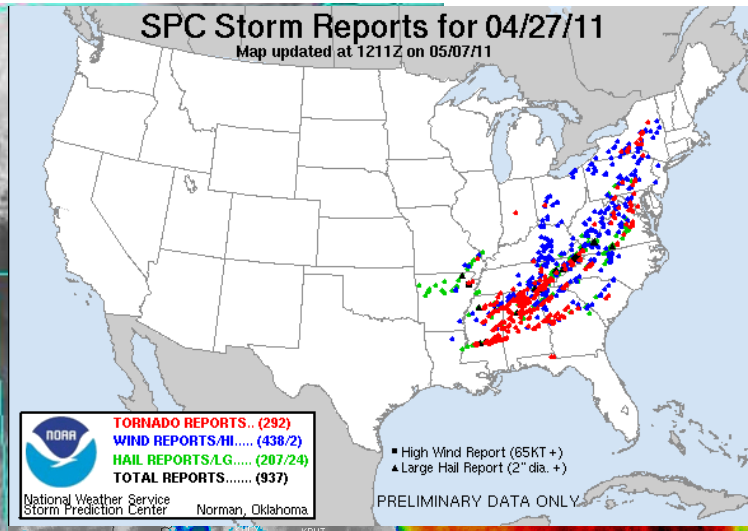
Tornado Watch Issued April 27

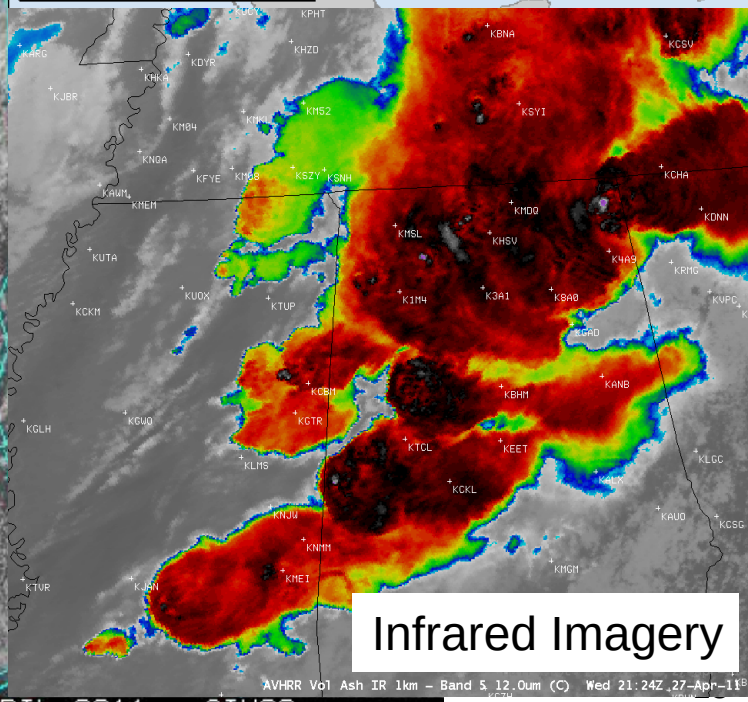


URGENT - IMMEDIATE BROADCAST REQUESTED TORNADO WATCH NUMBER 235 NWS STORM PREDICTION CENTER NORMAN OK 145 PM CDT WED APR 27 2011 THE NWS STORM PREDICTION CENTER HAS ISSUED A TORNADO WATCH FOR PORTIONS OF MUCH OF ALABAMA NORTHWEST GEORGIA SOUTHEAST MISSISSIPPI SOUTHERN MIDDLE TENNESSEE EFFECTIVE THIS WEDNESDAY AFTERNOON AND EVENING FROM 145 PM UNTIL 1000 PM CDT. **...THIS IS A PARTICULARLY DANGEROUS SITUATION...** DESTRUCTIVE TORNADOES...LARGE HAIL TO 4 INCHES IN DIAMETER... THUNDERSTORM WIND GUSTS TO 80 MPH...AND DANGEROUS LIGHTNING ARE POSSIBLE IN THESE AREAS.

Tornado Outbreak April 27, 2011

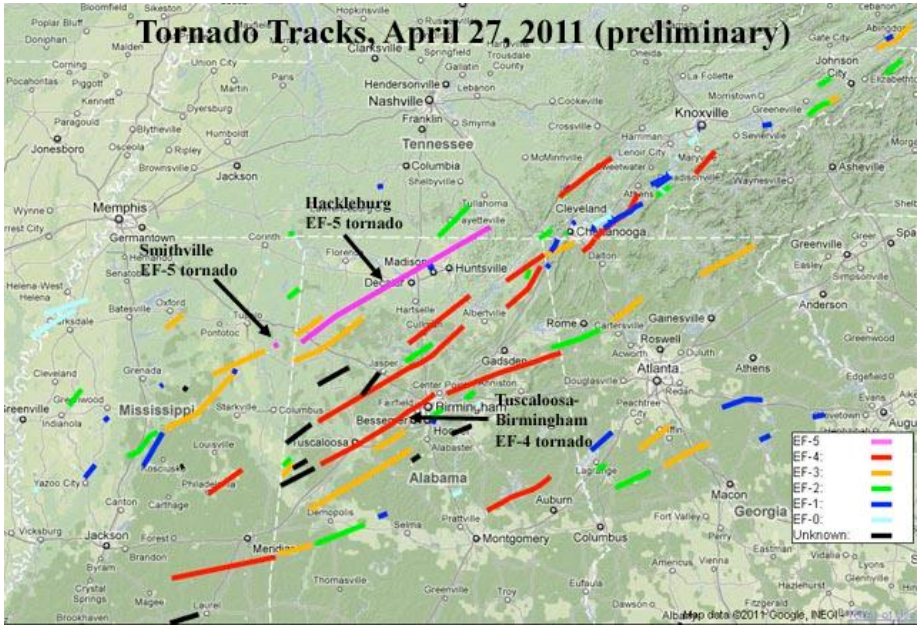




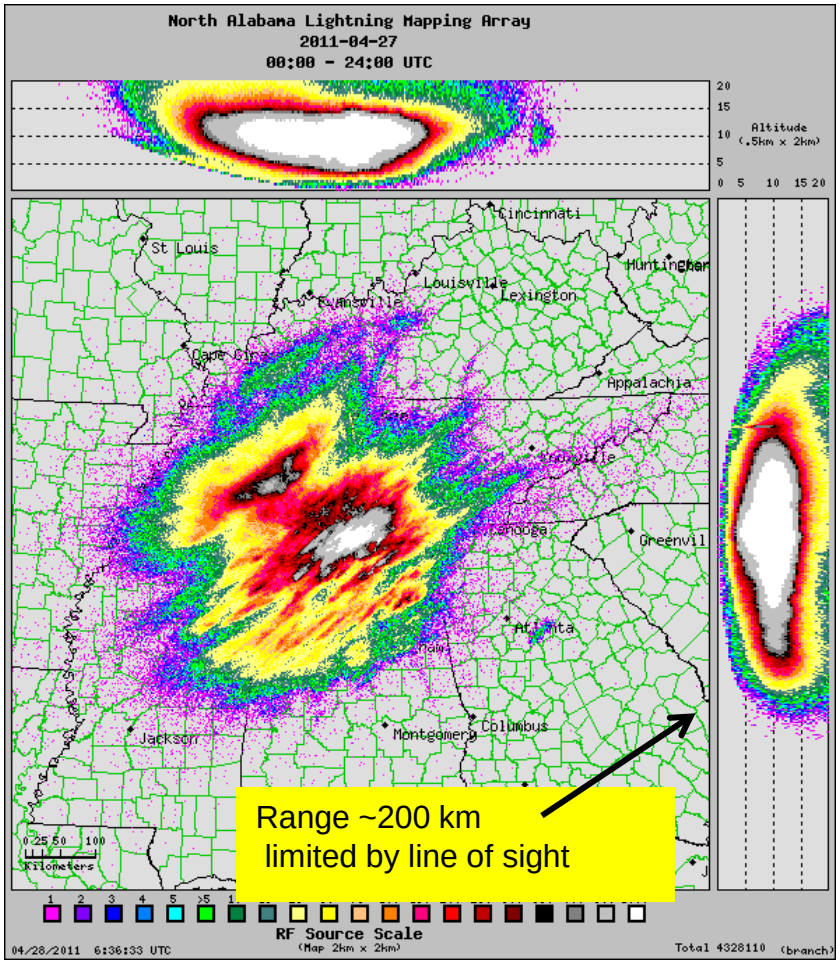


GLM Lightning Testbed 04/27/11
North Alabama VHF Lightning Mapping Array

- GLM proxy for total lightning
- R3 supported research indicates potential to increase severe storm and tornado warning lead-time up to 20+ min
- NESDIS, OAR, NWS coordinating on a national demo field test to assess “lightning jump” algorithm



- 305 tornadoes during the three-day April 25 – 28, 2011
- 3 EF-5s, 11 EF-4s
- 318 fatalities-4th deadliest on record



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 and then kept a watch on my tried and true radar practices to issue the warning. The PGLM data gave me more confidence in my warning.”

Lightning Jump Algorithm Operational Demonstration

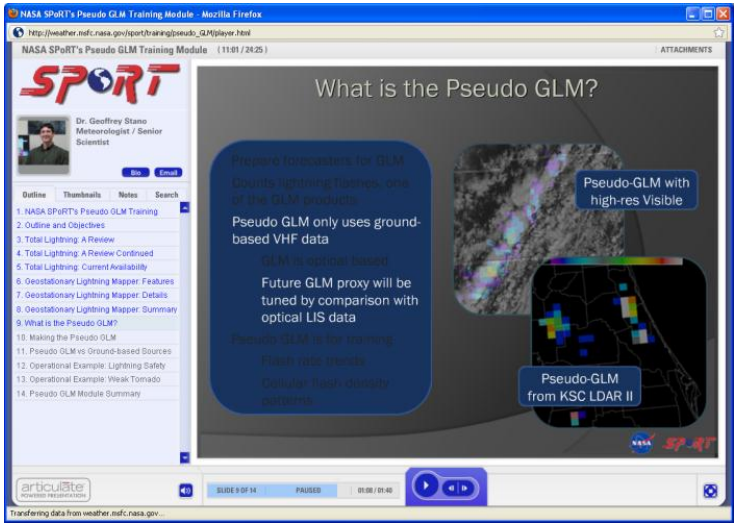
- Establish a fully automated processing method using the "2σ" (2-sigma) algorithm (Schultz et al., 2009).
- This includes automated (but ***not*** real-time) verification in order to calculate and evaluate **POD/FAR/CSI** for severe weather forecasts.
- This is expected to produce a large data set, 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.

Currently Available Training

- **Developed for 2010 & 2011 Spring Program**
- **Described three features**
  - ✓ **Total lightning**
  - ✓ **Geostationary Lightning Mapper (GLM)**
  - ✓ **Pseudo GLM product**
- **Included operational examples**
- **Intended for use before arrival**
- **Available on Learning Management System**
- **Available on SPoRT web page**

http://weather.msfc.nasa.gov/sport/training/



Courtesy Geoffrey Stano

Summary

- GLM Instrument Development on Track
- 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