J10.5: Preparing Users for the Geostationary Lightning Mapper (GLM) on GOES-R

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11th Annual Symposium on New Generation Operational Environmental Satellite Systems
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Acknowledgments

Curtis Alexander (HRRR time lagged ensembles)

GOES-R

Geostationary Operational Environmental Satellite R-Series

Three times greater spectral information

Four times greater spatial resolution

Five times faster coverage of high impact weather phenomena

Real-time mapping of total lightning activity

Real-time monitoring of space weather

… Resulting in more timely, accurate, and actionable information leading to …

Increased thunderstorm and tornado warning lead time

Improved hurricane track and intensity forecasts

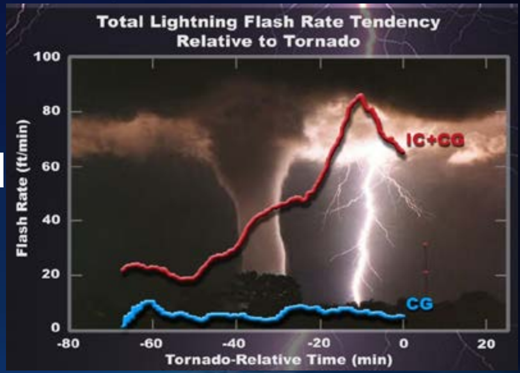
More accurate detection of wildfires and volcanic eruptions

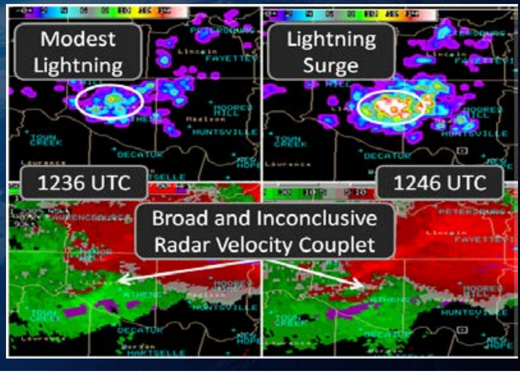
Improved monitoring of solar flares and coronal mass ejections

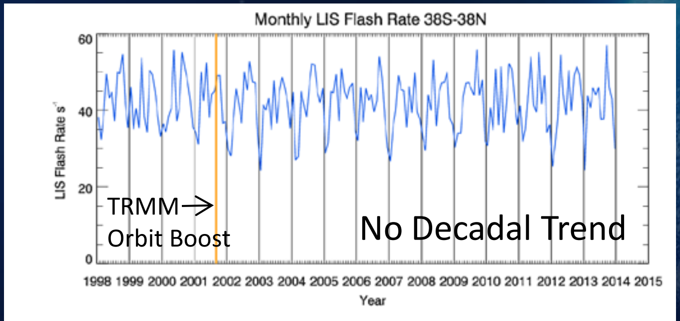
Improved geomagnetic storm forecasting

GLM Mission Benefits

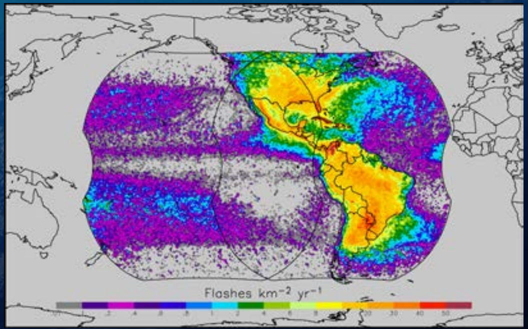
- Improved forecaster situational awareness and confidence resulting in more accurate severe storm warnings (improved lead time, reduced false alarms) to save lives and property
- Diagnosing convective storm structure and evolution
- Aviation and marine convective weather hazards
- Tropical cyclone intensity change
- Decadal changes of extreme weather – thunderstorms/ lightning intensity and distribution
- GLM data latency only 20 sec



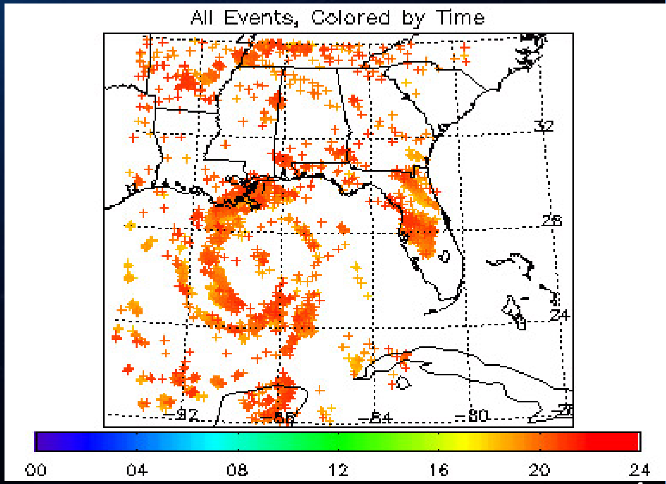




Global flash rate
from LIS/OTD (1995-2014)

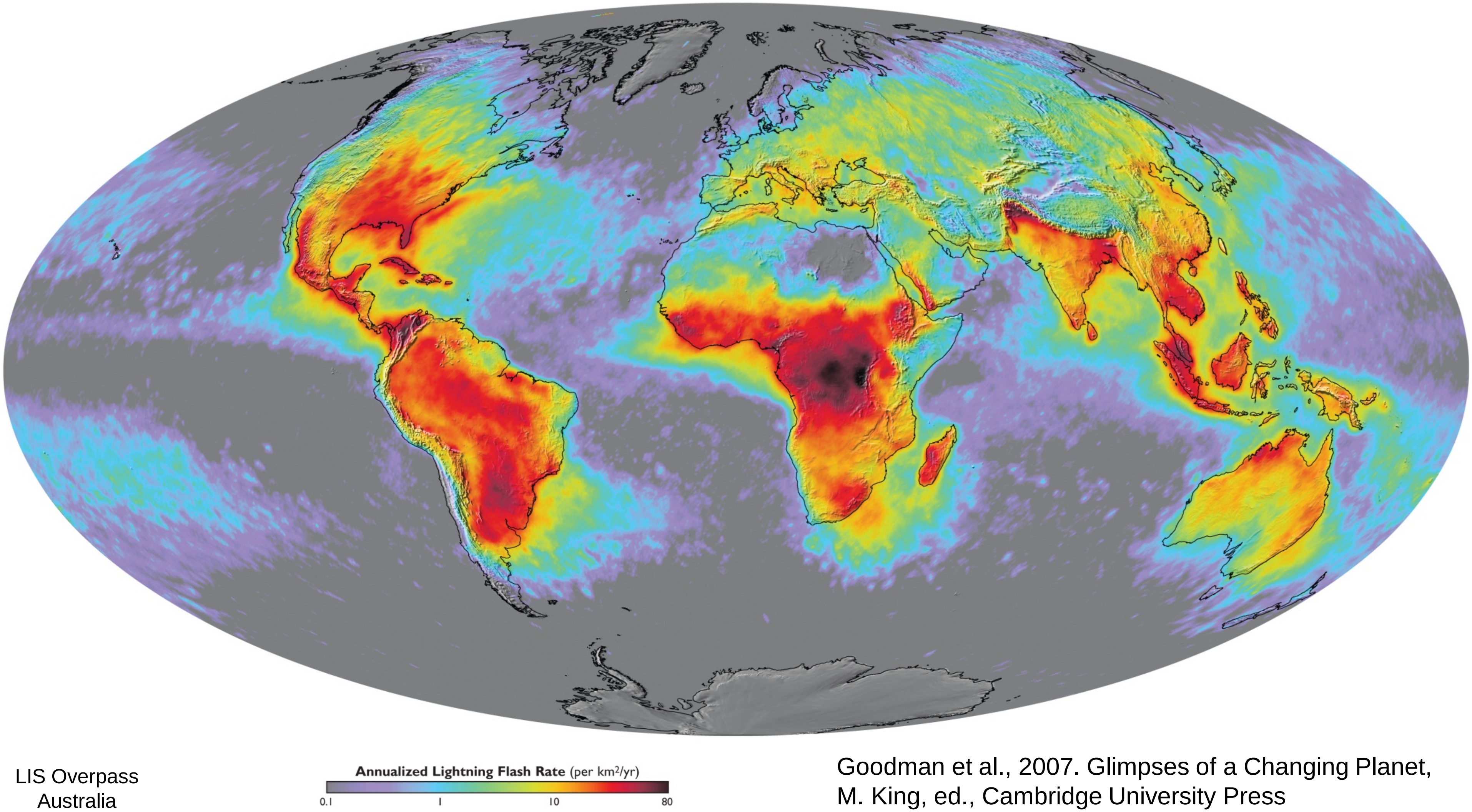


Lightning Climatology



Hurricane Katrina

Global Distribution of Lightning Activity



LIS Overpass
Australia

Goodman et al., 2007. Glimpses of a Changing Planet, M. King, ed., Cambridge University Press

Mean annual global lightning flash rate (flashes km^{-2} yr^{-1}) derived from a combined 8 years from April 1995 to February 2003. (Data from the NASA OTD instrument on the OrbView-1 satellite and the LIS instrument on the TRMM satellite.)

GOES-14 Super Rapid Scan Operations to Prepare for GOES-R (SRSOR)

SRSOR plans for 2015 : May 18-June 12, and August 10-22:

http://cimss.ssec.wisc.edu/goes/srsor2015/GOES-14_SRSOR.html

Data during parts of 2012 (Hurricane Sandy, convection), 2013 (CA Rim Fire, convection) and 2014 (Hurricane Marie, convection):

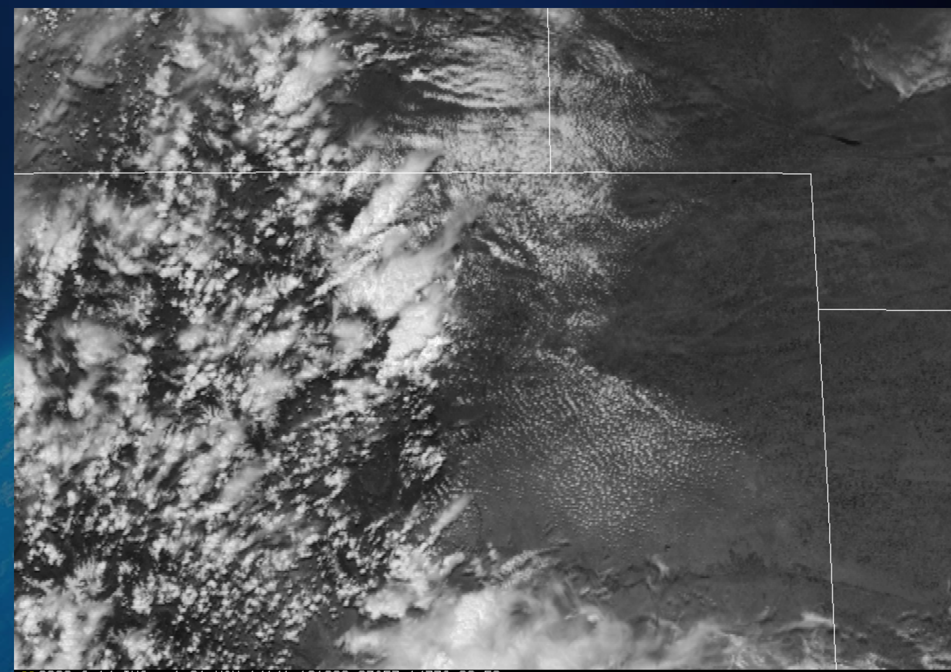
http://cimss.ssec.wisc.edu/goes/srsor/GOES-14_SRSOR.html

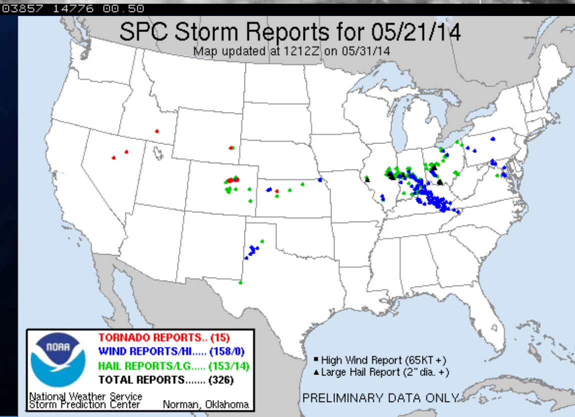
http://cimss.ssec.wisc.edu/goes/srsor2013/GOES-14_SRSOR.html

http://cimss.ssec.wisc.edu/goes/srsor2014/GOES-14_SRSOR.html

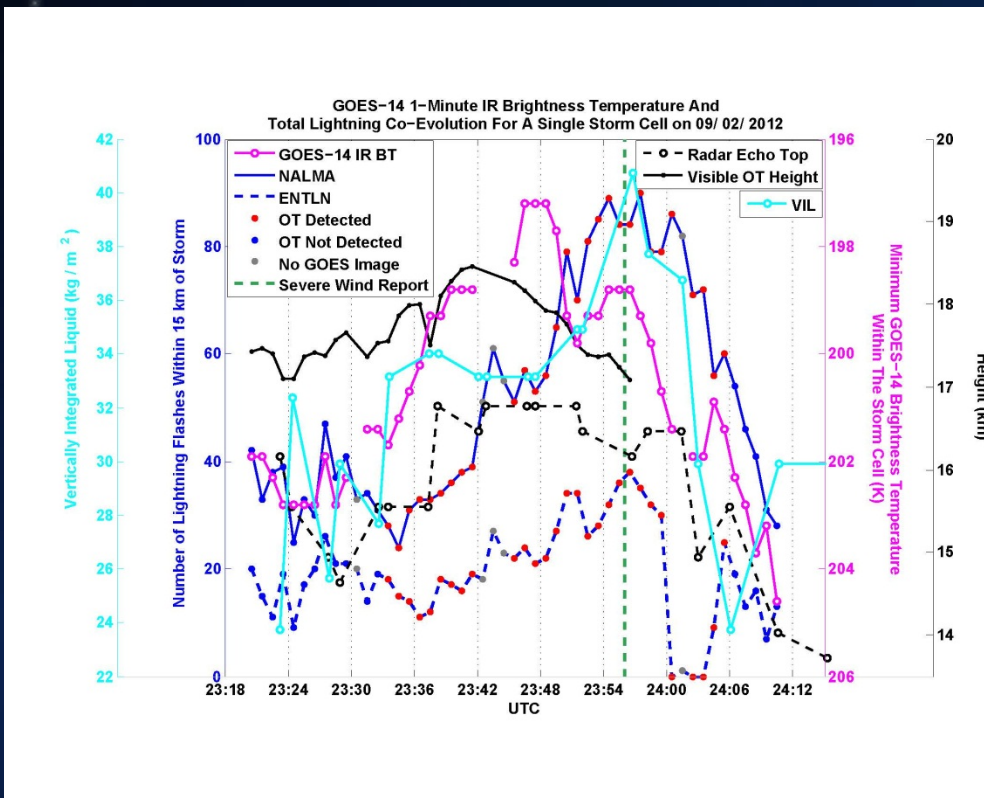
GOES-14 provided very unique data and offered a glimpse into the possibilities that will be provided by the ABI on GOES-R in one minute mesoscale imagery

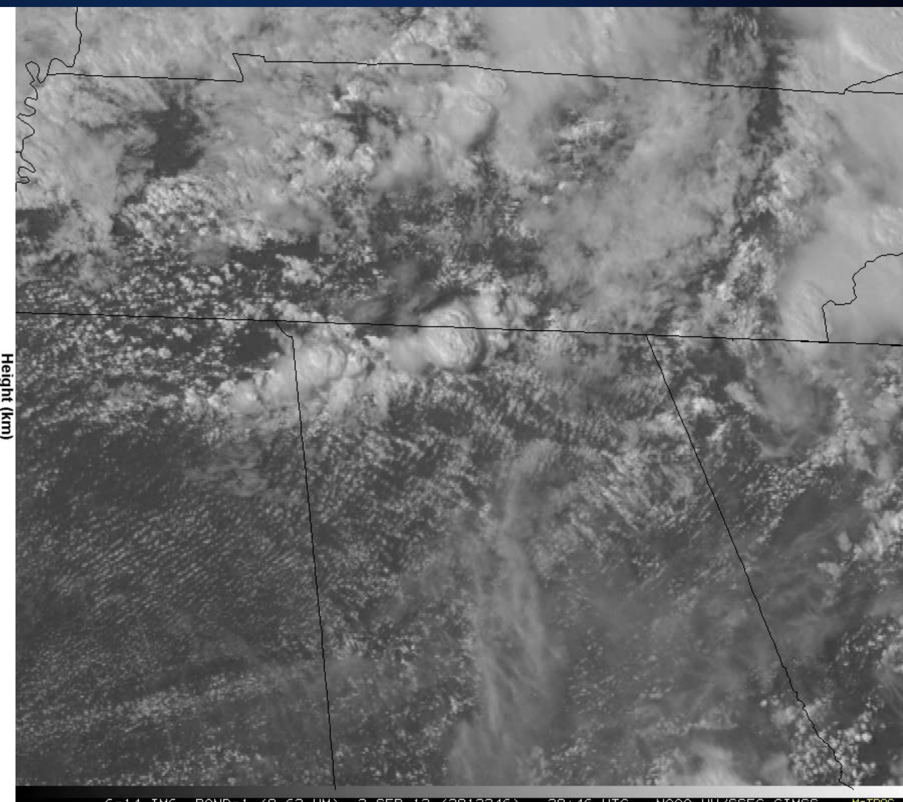
DIA Tornadic Storm





GOES-14 Super Rapid Scan 1-min Imagery to Prepare for GOES-R





GOES-14 IR brightness temperature, GOES-R overshooting cloud top (OT) detection algorithm output, cloud-top height derived from the length of shadow produced by OT penetration above the surrounding anvil, WSR-88D derived vertically-integrated liquid (VIL) and precipitation echo top height, and total lightning from the Northern Alabama Lightning Mapping Array (NALMA) and Earth Networks Total Lightning Network (ENTLN).

Forecaster Demonstration of 1-min Imagery

- Blog posts with SPC examples/comments on Satellite Liaison Blog: http://satelliteliaisonblog.wordpress.com/
  - *"Post-storm initiation, the high-resolution data allowed for careful analysis of overshooting and collapsing tops, the character of the storm anvils (ie. health of the storm) and the identification of convectively generated outflows."* - SPC forecaster
  - *Using cloud character and trends to diagnose boundary locations and motion, and nowcast their potential for either CI or influences on upshear storms to interact therewith."* – SPC Forecaster
  - ***"Satellite imagery at 1-min temporal resolution needs to become the new standard for severe weather operations." – SPC Forecaster***
- Comments from HWT
  - All EWP survey respondents agreed that the 1-minute imagery provided additional value compared to 5- or 15- minute imagery.
  - *"It allowed you to see so much more structure/trends. You could easily see areas of subsidence as cu were squashed or boundaries where things were being enhanced.* – Forecaster in EWP
  - *"Around great lakes looking at advection fog, I wish we had 1 minute updates so we could see how much fog is spreading inland."* – Forecaster in EWP
  - *"Cumulus clouds growing into thunderstorms on the 1 minute imagery definitely provided lead time to when storms might develop, which is great for timing watch issuance's before the storms become severe. This is not easily observed with the 5 minute or longer visible imagery."* - EFP

Lightning Jump Algorithm (LJA)

Weather and Forecasting (Proof Only)

JOBNAME: WAF 00#00 2015 PAGE: 1 SESS: 8 OUTPUT: Tue Dec 9 20:39:00 2014 Total No. of Pages: 15
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Exploring Lightning Jump Characteristics

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ABSTRACT

This study is concerned with the characteristics of storms exhibiting an abrupt temporal increase in the total lightning flash rate [i.e., lightning jump (LJ)]. An automated storm tracking method is used to identify storm "clusters" and total lightning activity from three different lightning detection systems over Oklahoma, northern Alabama, and Washington, D.C. On average and for different employed thresholds, the clusters that encompass at least one LJ (LJ1) last longer and relate to higher maximum expected size of hail, vertical integrated liquid, and lightning flash rates (area normalized) than do the clusters without an LJ (LJ0). The respective mean values for LJ1 (LJ0) clusters are 80 min (35 min), 14 mm (8 mm), 25 kg m^{-2} (18 kg m^{-2}), and 0.05 flash min^{-1} km^{-2} (0.01 flash min^{-1} km^{-2}). Furthermore, the LJ1 clusters are also characterized by slower-decaying autocorrelation functions, a result that implies a less "random" behavior in the temporal flash rate evolution. In addition, the temporal occurrence of the last LJ provides an estimate of the time remaining to the storm's dissipation. Depending on the LJ strength (i.e., varying thresholds), these values typically range between 20 and 60 min, with stronger jumps indicating more time until storm decay. This study's results support the hypothesis that the LJ is a proxy for the storm's kinematic and microphysical state rather than a coincidental value.

1. Introduction

The advent of ground-based lightning detection networks in recent decades has made real-time retrieval of total lightning activity [cloud to ground (CG) and intracloud (IC)] available in both high spatial and temporal resolutions. Although there are uncertainties in the details (Takahashi 1978; Saunders 1993), it is known that rebounding collisions between graupel and ice crystals in the presence of supercooled water is the primary process for thunderstorm electrification (MacGorman and Morgenstern 1998; Saunders et al. 2006; Emersic and Saunders 2010). Several studies have documented a temporal covariability between updraft mass flux, precipitation ice mass, and overall storm depth with the respective total lightning activity (e.g., Goodman et al. 1988; Carey and Rutledge 2000; Chronis et al. 2007; Deierling and Petersen 2008; Bruning and MacGorman 2013). Hence, it would be reasonable to suggest that an

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DOI: 10.1175/WAF-D-14-00064.1

Radar Observable	Average Correlation Coefficient (ρ)	Average Normalized Standard Error (NSE)	Average Absolute Normalized Bias Error (|NBE|)
Graupel Echo Volume	0.81	0.70	0.25
Graupel Mass	0.80	0.71	0.33
30 dBZ Echo Volume	0.79	1.24	1.56
Updraft Volume > 5 m s^{-1}	0.74	1.10	0.39
Maximum Updraft Velocity	0.66	1.51	2.21

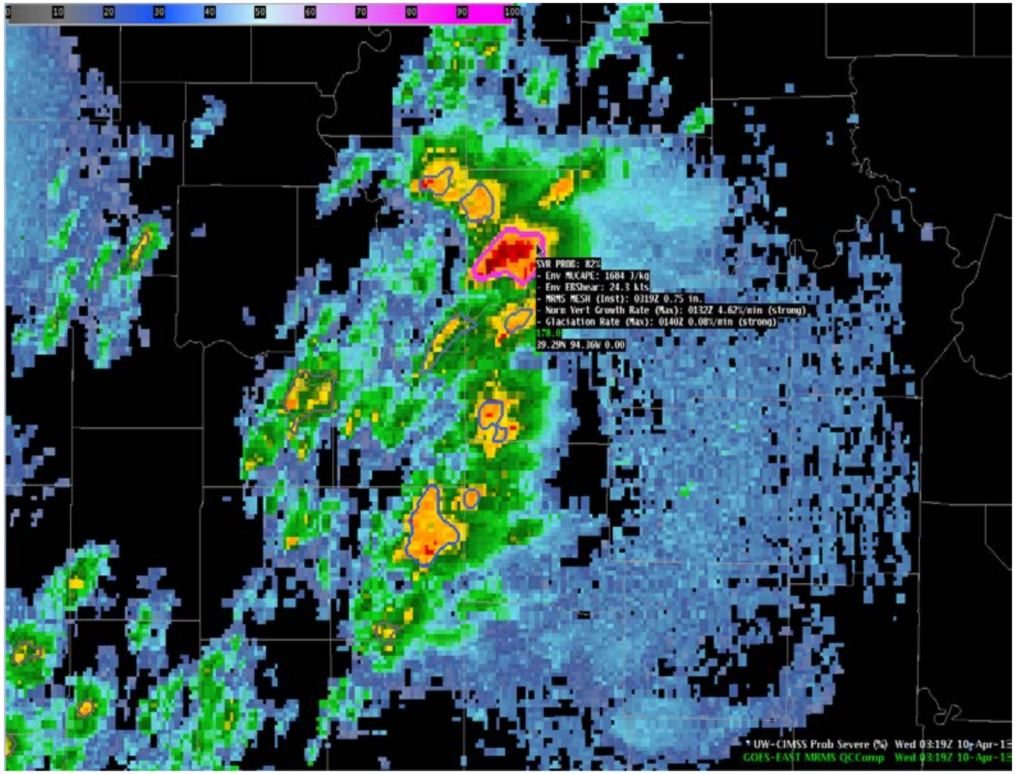
Carey et al., 2014, Vaisala International Lightning Meteorology Conference, Tucson, AZ

Schultz et al., 2015 (this Conference)

- During early growth 88% of jumps occur when both 10 m s^{-1} updraft volume and mixed phase graupel mass growth occur

Probabilistic Forecasting of Severe Convection through Data Fusion

- GOES-derived cloud growth rates, NEXRAD-derived products, and NWP-derived fields are used as input into a statistical model to compute the probability that a storm will first produce severe weather in the near-term
- Satellite and radar object-tracking are used to keep a history of storm development
- FY15-16 R3 project will investigate total lightning data and additional NWP sources, as well as advantages to be gained using super-rapid scan data
- The product display will complement NWS warning operations
- The product will be evaluated in testbeds and proving ground experiments

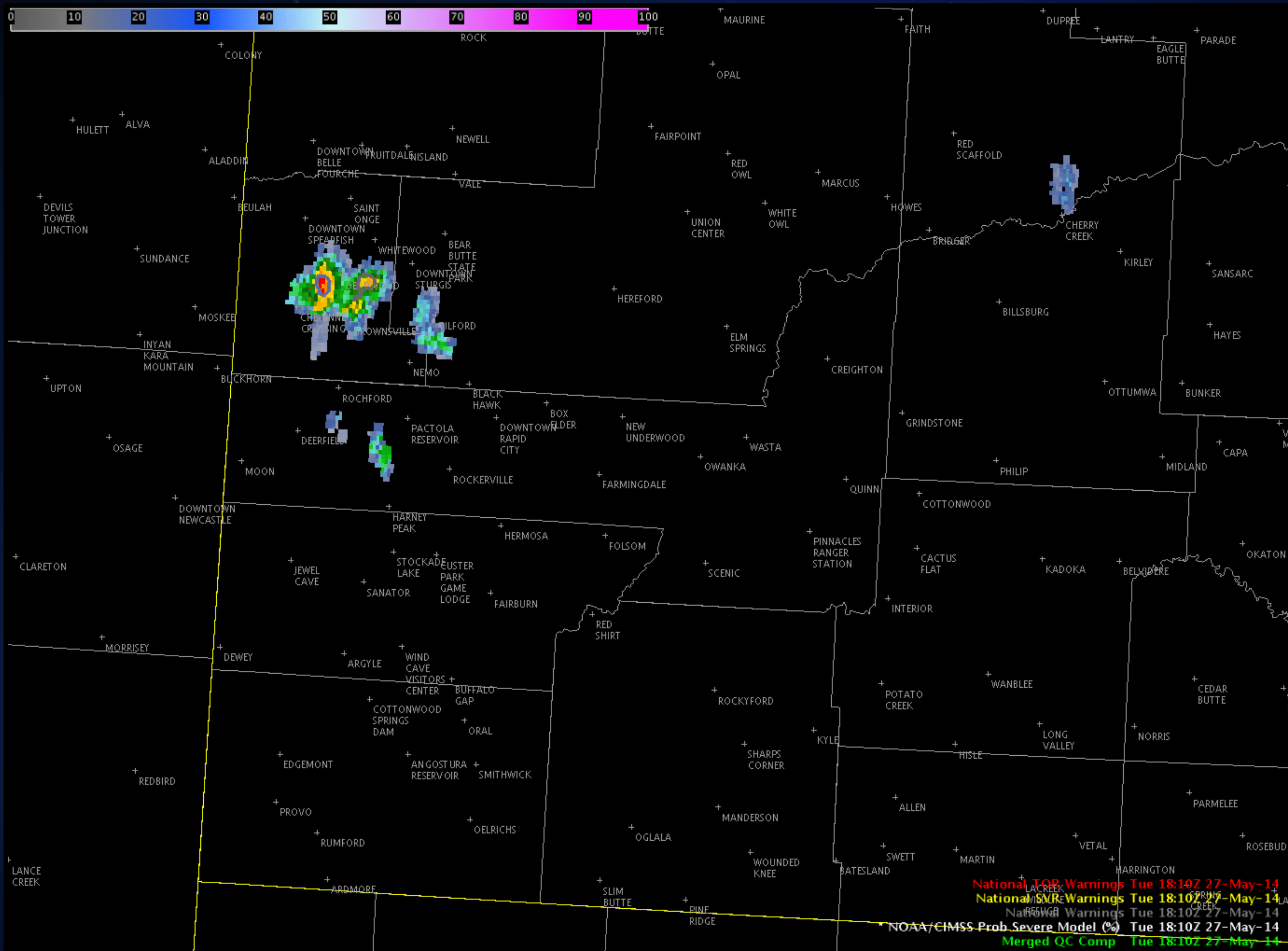


Merged radar reflectivity with model probability of severe contours. The highlighted storm had strong satellite growth rates, contributing to a high probability prior to severe hail occurrence. No warning was issued.

Help NWS forecasters skillfully increase warning lead time to severe hazards

M. Pavolonis (STAR/ASPB) and J. Cintineo (UW-CIMSS), J. Sieglaff (UW-CIMSS), D. Lindsey (STAR/RAMMB), D. Bikos (CSU-CIRA)

Probability of Severe Convection



NHC Tropical Cyclone Cristina Discussion June 10, 2014

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CZC MIATCDEP3 ALL
TTAA00 KNHC DDHHMM

TROPICAL STORM CRISTINA DISCUSSION NUMBER   6
NWS NATIONAL HURRICANE CENTER MIAMI FL       EP032014
800 PM PDT TUE JUN 10 2014

Cristina is intensifying this evening.  The compact central dense
overcast has become more circular, and hints of an eye have been
apparent in geostationary satellite images.  The initial
intensity is increased to 55 kt, in agreement with unanimous Dvorak
classifications of 3.5/55 kt from TAFB, SAB, and UW-CIMSS ADT.

Although the curved bands beyond the inner-core region remain
fragmented, a considerable amount of lightning has been occurring
in a rain band located about 120 n mi to the south-southwest of the
center.  Recent research has documented that lightning in the
outer bands of the tropical cyclone circulation is often a precursor
of significant intensification.  The only apparent factor that could
limit strengthening during the next couple of days is mid-level dry
air, which has been an issue for Cristina during the past day or so.
In about 3 days, Cristina is expected to move into an environment of
stronger southwesterly shear and over cooler waters, which should
end the strengthening trend and cause the cyclone to weaken.  The
NHC intensity forecast is slightly higher than the previous one and
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HRRR Model Fields - Expe ×

rapidrefresh.noaa.gov/HRRR/Welcome.cgi

HRRR Home Info Page

Current and Forecast Graphics

NCEP HRRR 30-day Evaluation:

NCEP HRRR Parallel Hourly

NCEP HRRR Parallel Subhourly

Experimental ESRL HRRR:

ESRL HRRR Hourly

ESRL HRRR Subhourly

ESRL HRRR (alternative)

ESRL HRRR-Aviation Hourly

ESRL HRRR-Aviation Subhourly

ESRL HRRR Soundings

ESRL HRRR-chem-fire (W US)

ESRL HRRR Reflectivity Matrix

HRRR Configuration Info

CONUS-HRRR domain parms

HRRR static fields inc lat/lon (NetCDF-952 MB)

WFIP-HRRR domain

CONUS-HRRR terrain info

HRRR WPS Namelist

HRRR WRF Namelist

HRRR GRIB2 Table 2-D Hourly

HRRR GRIB2 Table 2-D 15 min

HRRR GRIB2 Table Native

HRRR GRIB2 Table Press

HRRR-NCEP GRIB2 Table 2-D Hourly

HRRR-NCEP GRIB2 Table 2-D 15 min

HRRR-NCEP GRIB2 Table Native

HRRR-NCEP GRIB2 Table Press

HRRR/RAP diagnosis of output fields

Rapid Refresh web page

RUC GRIB viewer

HRRR FAQ page

HRRR Forecast Fields

HRRR Model Fields - Experimental

Model: HRRR-primary Area: Full Date: 13 Aug 2014 - 12Z

Model: HRRR-primary ▼ Domain: Full ▼ Date: 13 Aug 2014 - 12Z ▼

			Valid Time																
			Wed 12	Wed 13	Wed 14	Wed 15	Wed 16	Wed 17	Wed 18	Wed 19	Wed 20	Wed 21	Wed 22	Wed 23	Thu 00	Thu 01	Thu 02	Thu 03	
	All times	Loop	Forecast																
			00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	
all fields																			all fields
1 km agl reflectivity																			1 km agl reflectivity
composite reflectivity																			composite reflectivity
ensemble comp reflectivity																			ensemble comp reflectivity
max 1 km agl reflectivity																			max 1 km agl reflectivity
surface CAPE																			surface CAPE
surface CIN																			surface CIN
mixed CAPE																			mixed CAPE
most unstable CAPE																			most unstable CAPE
most unstable layer CAPE																			most unstable layer CAPE
best LI																			best LI
LCL																			LCL
0-1 km shear																			0-1 km shear
0-6 km shear																			0-6 km shear
0-1 km helicity, storm motion																			0-1 km helicity, storm motion
0-3 km helicity, storm motion																			0-3 km helicity, storm motion
2-5 km updraft helicity																			2-5 km updraft helicity
1-6 km updraft helicity																			1-6 km updraft helicity
2-5 km max updraft helicity																			2-5 km max updraft helicity
1-6 km max updraft helicity																			1-6 km max updraft helicity
ensemble updraft helicity																			ensemble updraft helicity
convective activity 1																			convective activity 1

HRRR Forecast Fields

HRRR Status

- HRRR Status
- HRRR Status (Past 24 hrs)
- HRRR Dev1 Status
- HRRR Dev1 Status (Past 24 hrs)
- HRRR Dev2 Status
- HRRR Dev2 Status (Past 24 hrs)
- RAP-ESRL (HRRR Parent)
- RAP Dev1 (HRRR Dev1 Parent)

HRRR Convective Probabilities

- HCPF

Soundings

- Interactive (Java) (beta--restricted)

Verification

- Composite Reflectivity
- Composite Reflectivity Status
- 24 Hour Precipitation
- 24 Hour Precipitation Status

Other Products

- NCEP Model Products (GFS,etc.)

Organization

- AMB Staff
- Sponsors
- ESRL/GSD

Description

- HRRR Changes Apr 2014
- HRRR Home Page
- NWS Discs Using HRRR
- RUC/RR/FIM Pubs
- HRRR ChangeLog
- HRRRdev ChangeLog

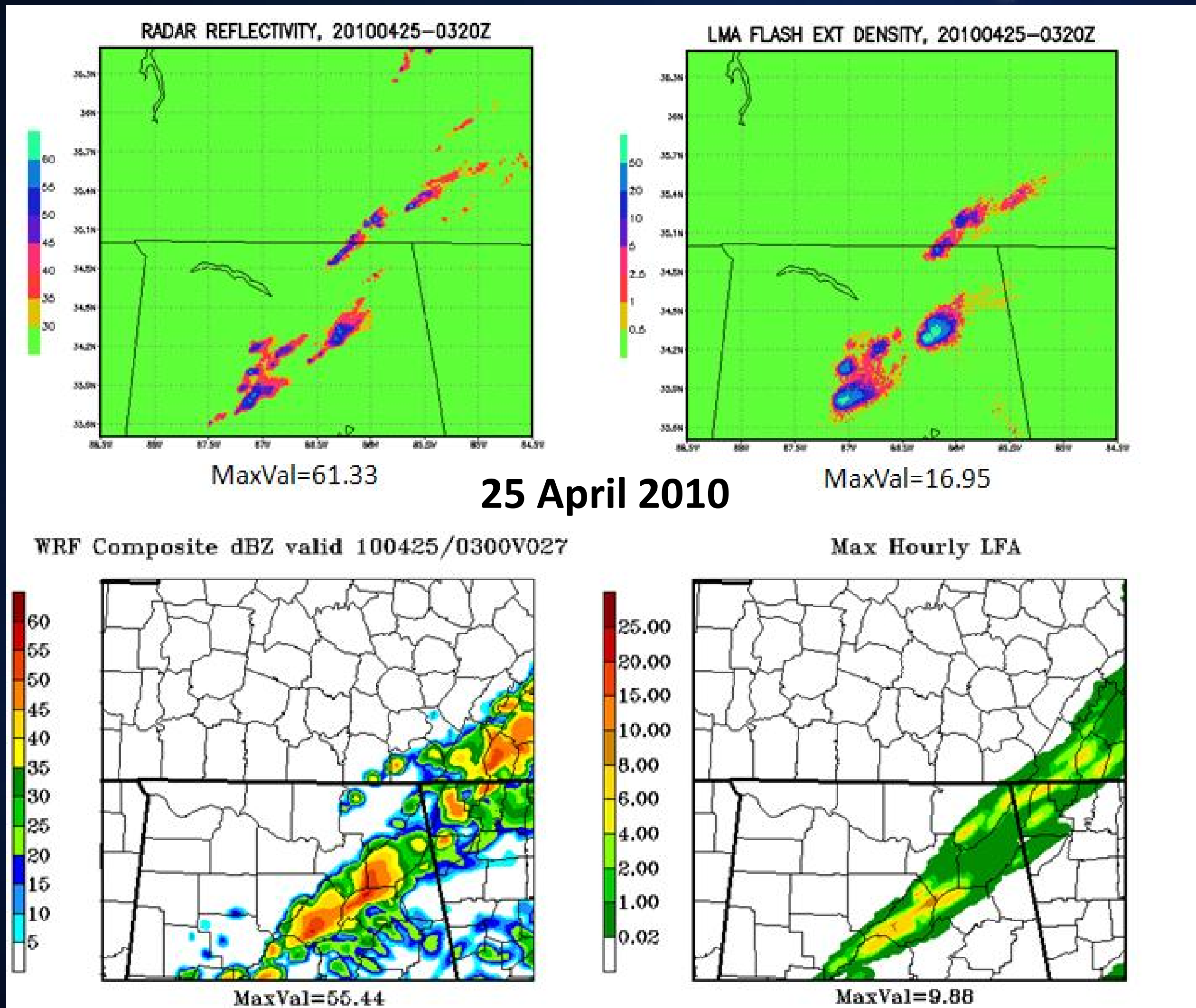
Other Information

- NCEP product status
- NCEP obs processing
- NCEP status messages

convective activity 2		convective activity 2
convective activity 3		convective activity 3
convective initiation 1		convective initiation 1
convective initiation 2		convective initiation 2
convective initiation 3		convective initiation 3
lightning threat 1		lightning threat 1
lightning threat 2		lightning threat 2
lightning threat 3		lightning threat 3
max vert int graupel		max vert int graupel
max 10m wind		max 10m wind
10m wind		10m wind
10m wind gust		10m wind gust
80m wind		80m wind
1h 80m wind speed change		1h 80m wind speed change
ensemble 1h 80m wind speed change		ensemble 1h 80m wind speed change
skin temp		skin temp
2m temp		2m temp
2m potential temp		2m potential temp
2m temp - skin temp		2m temp - skin temp
2m dew point		2m dew point
2m RH		2m RH
surface pressure		surface pressure
3h pressure change		3h pressure change
precipitable water		precipitable water
snow water equiv		snow water equiv
max updraft		max updraft
max downdraft		max downdraft
500mb temp		500mb temp
500mb vort		500mb vort
250mb wind		250mb wind
visibility		visibility
total cloud cover		total cloud cover
low-level cloud cover		low-level cloud cover
mid-level cloud cover		mid-level cloud cover
high-level cloud cover		high-level cloud cover
cloud top height		cloud top height
ceiling		ceiling
echotop height		echotop height
VIL		VIL
RADAR VIL		RADAR VIL

Lightning Threat 3 used for Prob LTG forecast out to 9 hours

Short-range NWP Forecasts of Lightning with NSSL WRF



Lightning Forecast Algorithm (LFA) Methodology

- Compare WRF forecasts of graupel flux (GFX) at -15C (main neg charge region) to LMA observations of peak FRD within storm outbreaks
- Find best linear fit of peak WRF proxy to LMA peak FRD
- Generate additional WRF LTG proxy using vertically integrated ice (VII), and rescale its peak value to match that from GFX
- Threshold GFX to zero where GFX < 1.5
- Create a blend of GFX and VII threats to achieve correct threat areal coverage

  (0.95) GFX + (0.05) VII

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Graupel Echo Volume	0.81	0.70	0.25
Graupel Mass	0.80	0.71	0.33
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Updraft Volume $> 5\ m\ s^{-1}$	0.74	1.10	0.39
Maximum Updraft Velocity	0.66	1.51	2.21

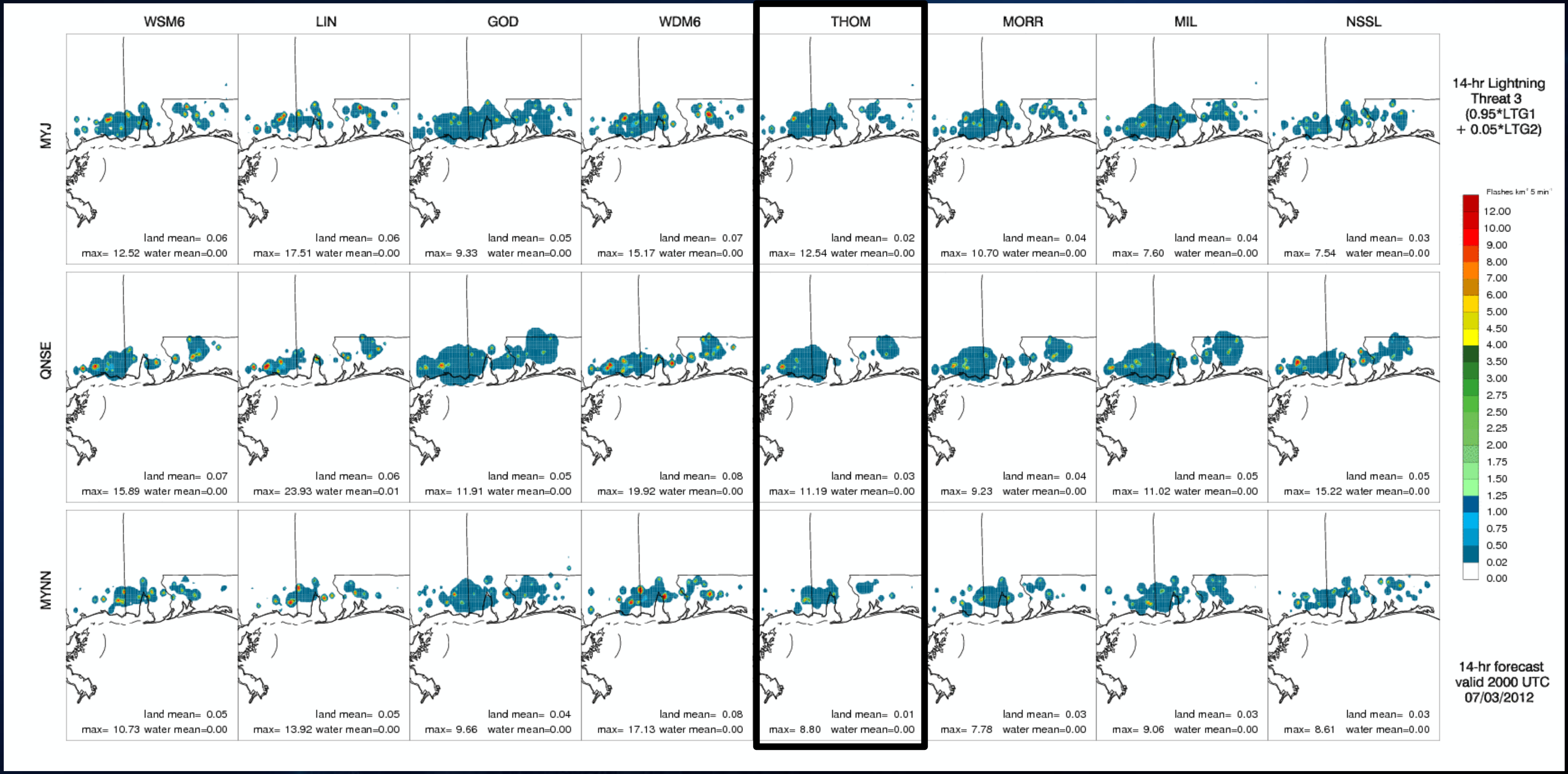
Carey et al., 2014, Vaisala International Lightning Meteorology Conference, Tucson, AZ

CAPS 2011 Experiments

Model	IC (arw_cn+)	BC	micro-Physics	LSM	PBL
S4cn	+00zARPSa	00zNAMf	Thompson	Noah	MYJ
S4m4	+em-p1 pert	21zSREF em-p1	Morrison	RUC	YSU
S4m5	+em-p2 pert	21zSREF em-p2	Thompson	Noah	QNSE
S4m6	+nmm-p1 pert	21zSREF nmm-p1	WSM6	RUC	QNSE
S4m7	+nmm-p2 pert	21zSREF nmm-p2	WDM6	Noah	MYNN
S4m8	+rsm-n1 pert	21zSREF rsm-n1	Ferrier	RUC	YSU
S4m9	+eKF-n1 pert	21zSREF eKF-n1	Ferrier	Noah	YSU
S4m10	+eKF-p1 pert	21zSREF eKF-p1	WDM6	Noah	QNSE
S4m11	+eBMJ-n1 prt	21zSREF eBMJ-n1	WSM6	RUC	MYNN
S4m12	+eBMJ-p1 prt	21zSREF eBMJ-p1	Thompson	RUC	MYNN
S4m13	+rsm-p1 pert	21zSREF rsm-p1	M-Y	Noah	MYJ
S4m14	+em-n1 pert	21zSREF em-n1	Ferrier+	Noah	YSU
S4m15	+em-n2 pert	21zSREF em-n2	WSM6	Noah	MYNN
S4m16	+nmm-n1 pert	21zSREF nmm-n1	Ferrier+	Noah	QNSE
S4m17	+nmm-n2 pert	21zSREF nmm-n2	Thompson	Noah	ACM2
S4m18	+rsm-p2 pert	21zSREF rsm-p2	WSM6	Noah	MYJ
S4m19	+rsm-n1 pert	21zSREF rsm-n1	M-Y	Noah	MYJ
S4m20	+rsm-n2 pert	21zSREF rsm-n2	M-Y	RUC	ACM2

LFA Findings

Sample snapshot of output from MOB 20120703 run shows variability of LFA flash rate densities



HRRR Time-Lagged Ensemble Technique

1. Determine hazard field "predictor" and threshold
-- multiple and conditional thresholds possible
-- diurnal and other dependence for bias correction

2. Select appropriate search radius (kernel)
-- regional, diurnal, forecast length, other dependencies

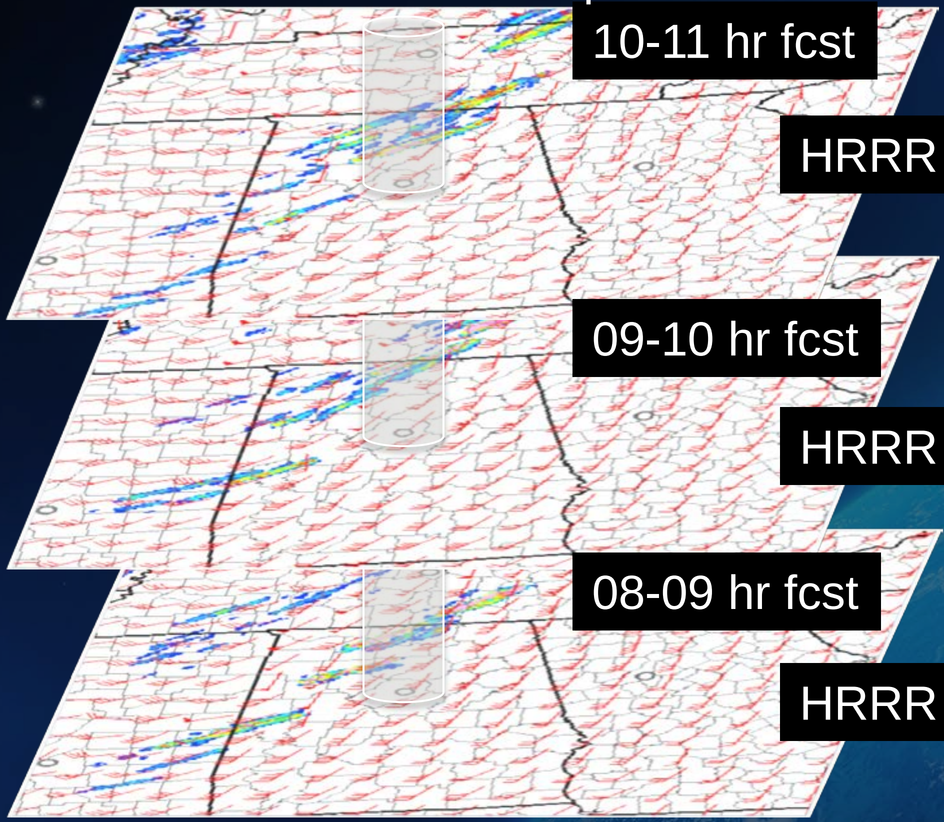
3. Select number of time-lagged ensemble members
-- typically use "hourly summed" fields and two bracketing hours from each forecast (accounts for timing errors)

4. Tally over neighborhood points among ensemble members, with adjustment to ensure reliability

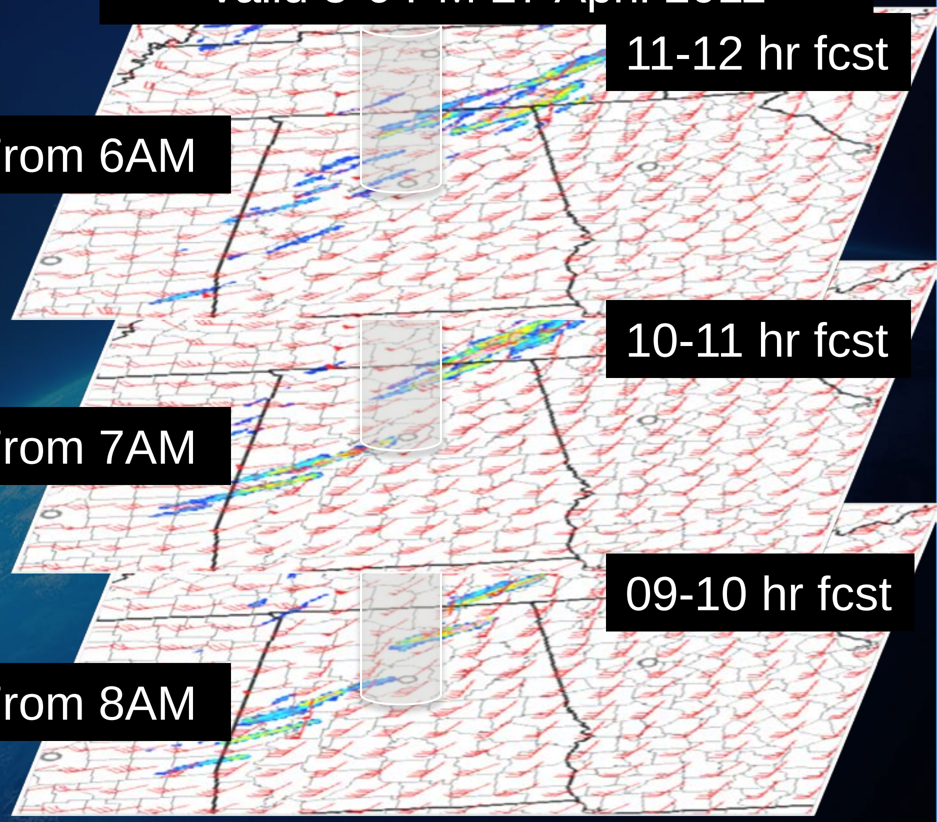
5. Forecast horizon out to 9 hours

HRRR Time-Lagged Ensemble Example

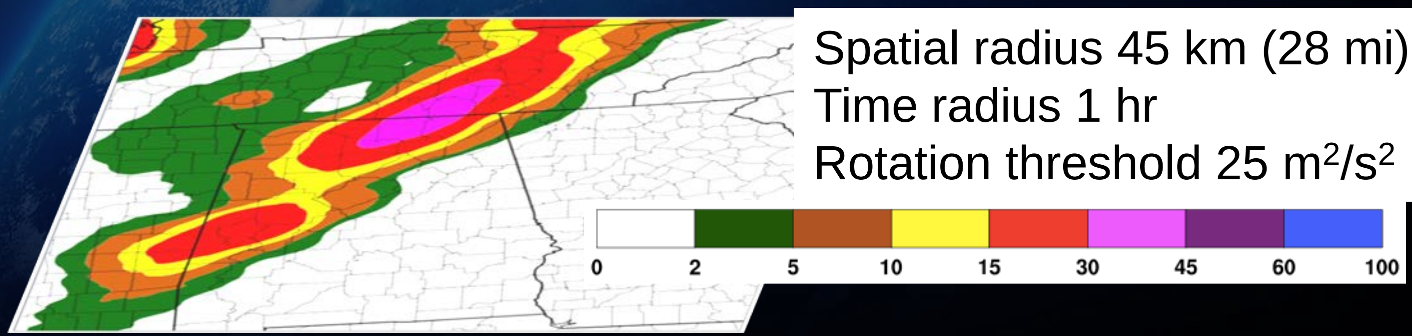
Thunderstorm Rotation Forecasts
valid 4-5 PM 27 April 2011



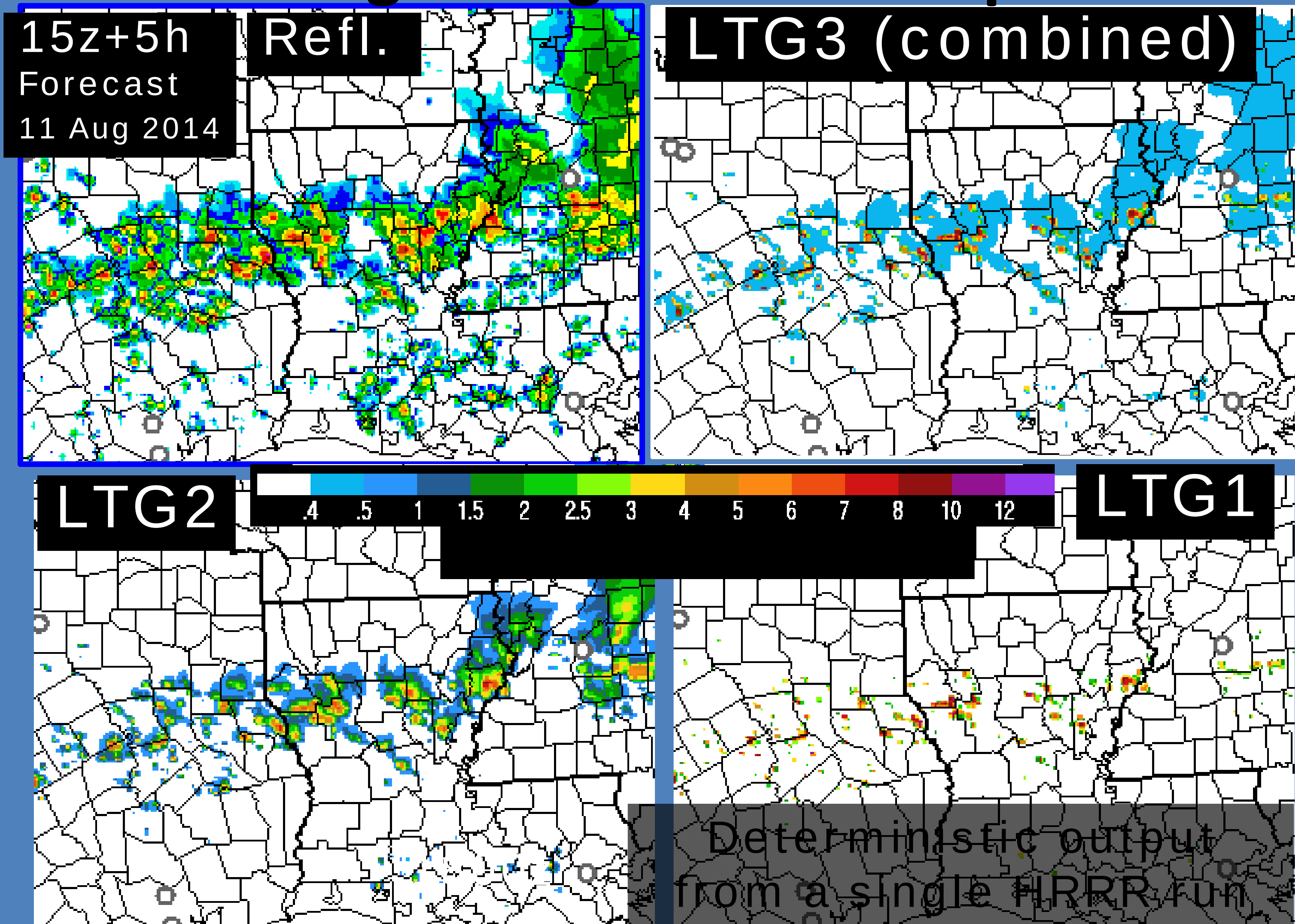
Thunderstorm Rotation Forecasts
Valid 5-6 PM 27 April 2011



All six forecasts combined to form probabilities valid 5 PM 27 April 2011



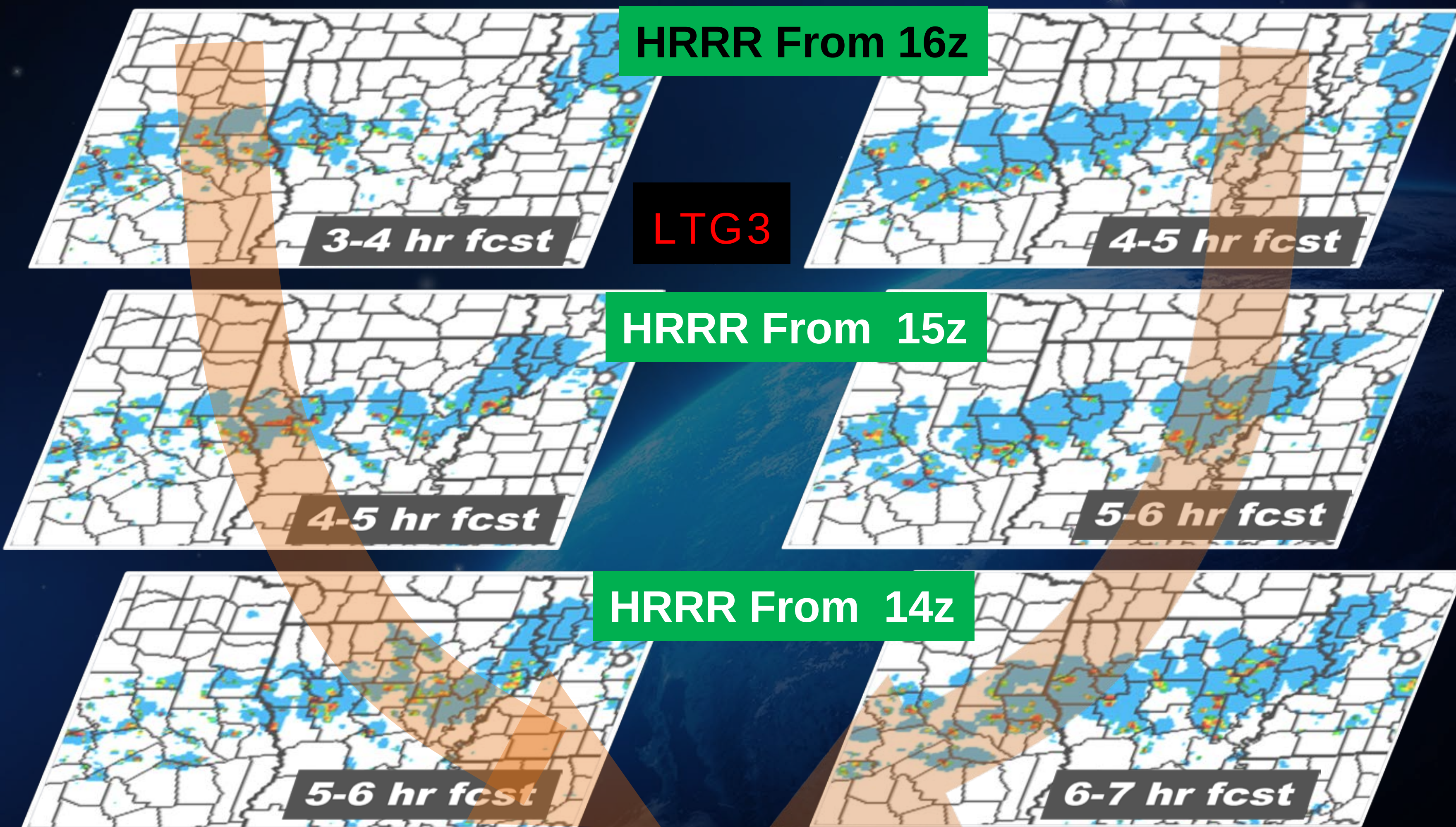
HRRR Lightning Threat Components



HRRR Time-Lagged LTG Ensemble

Combined lightning risk
valid 19-20 z **11 Aug 2014**

Combined lightning risk
valid 20-21 z **11 Aug 2014**

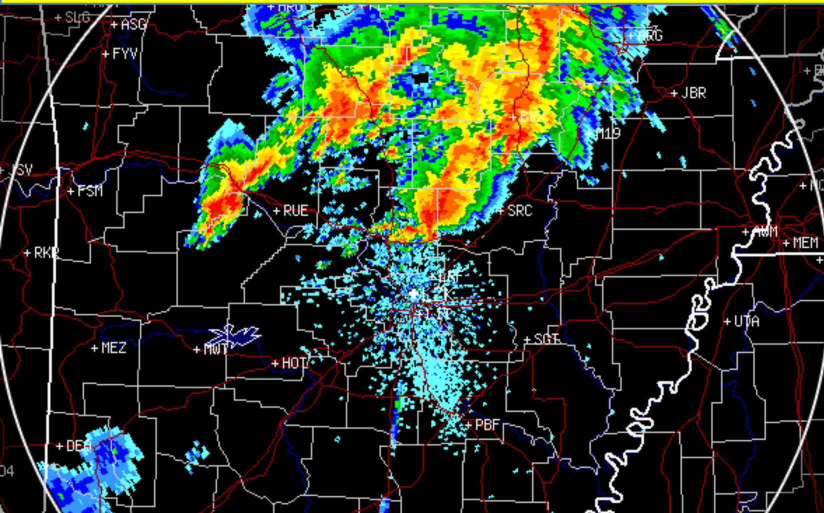


six forecasts combined

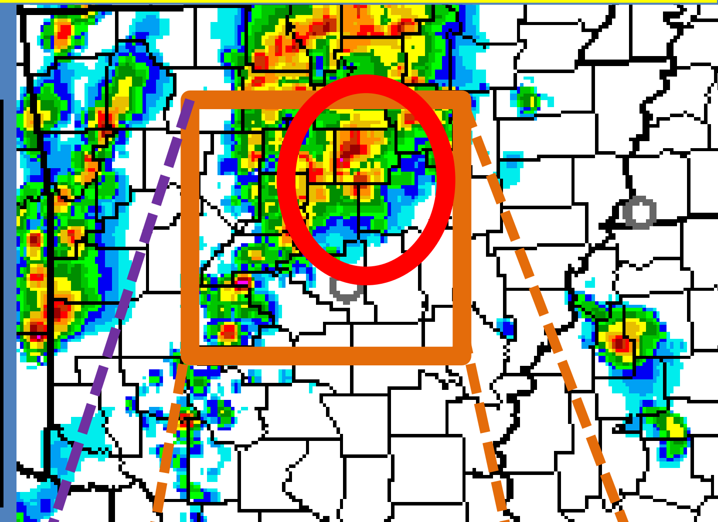
HRRR lightning threat probability

Spatial filter applied to each forecast

Arkansas Tornadoes – Sunday 27 April 2014

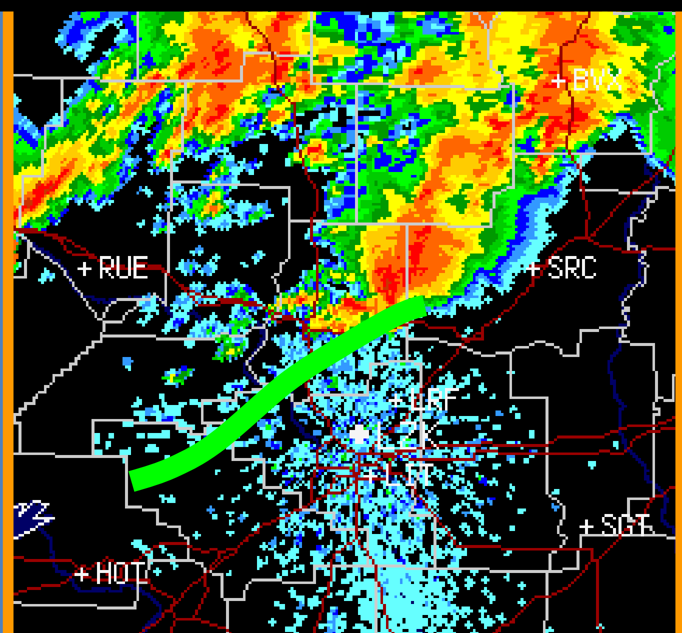


6-h HRRR forecast made at 2 PM for 8 PM



Observed radar

HRRR model

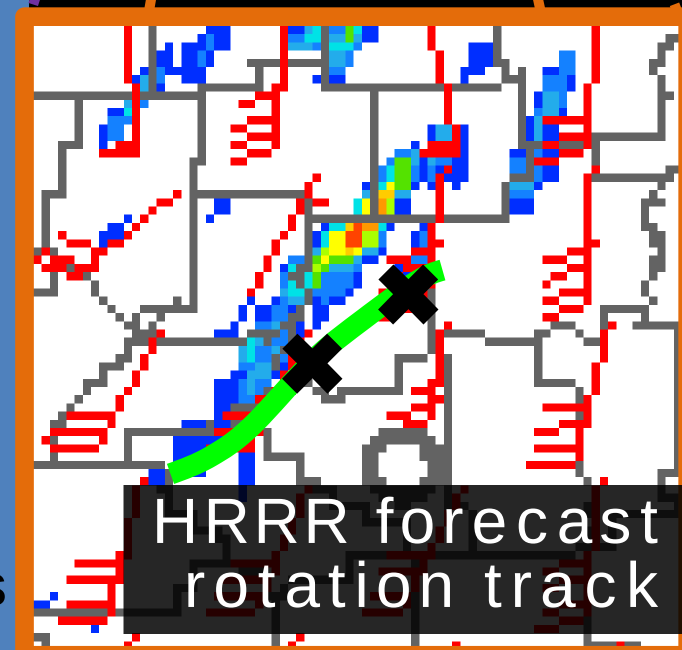


8 PM CDT

Tornadic thunderstorm

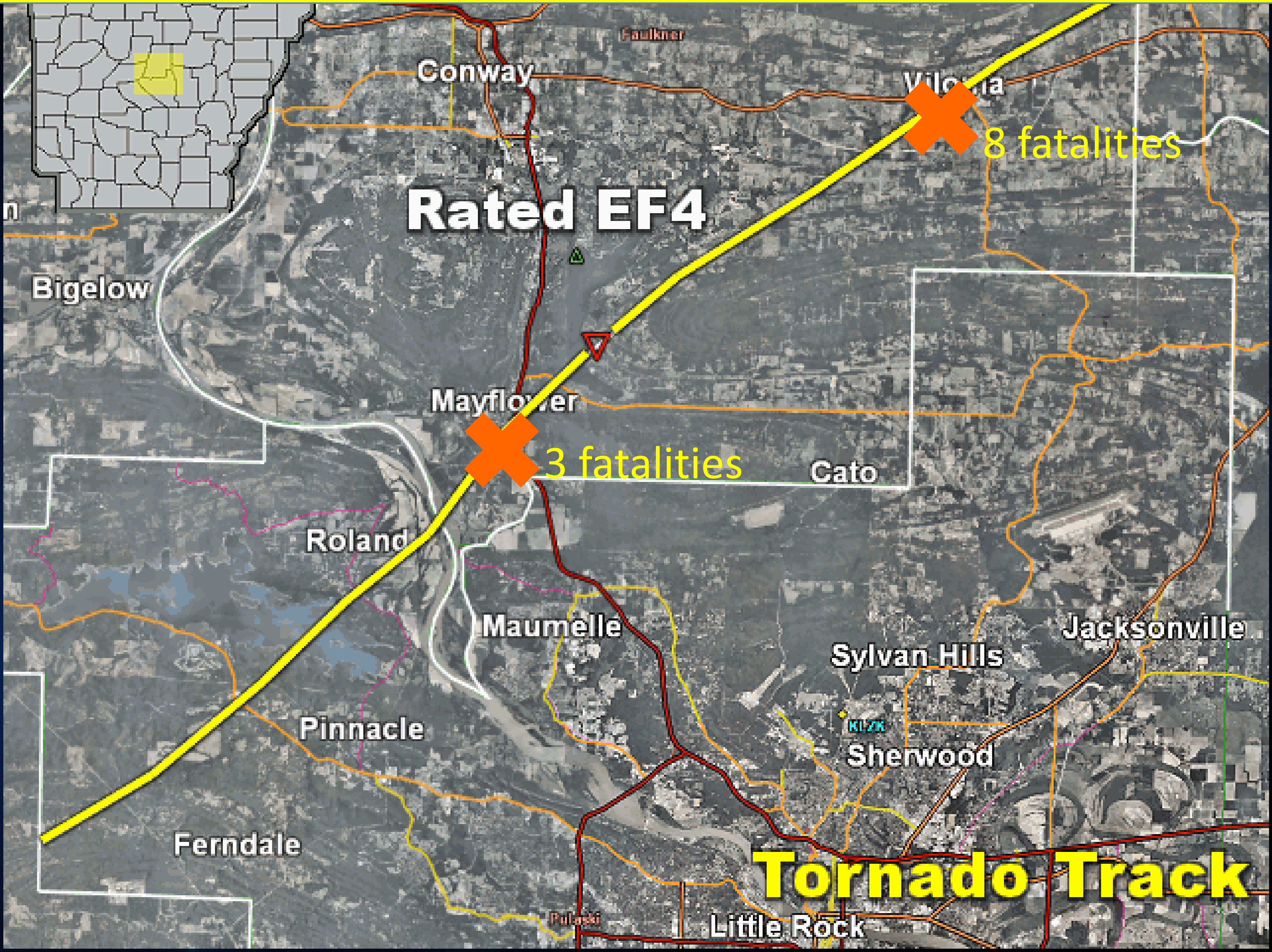
Actual tornado path

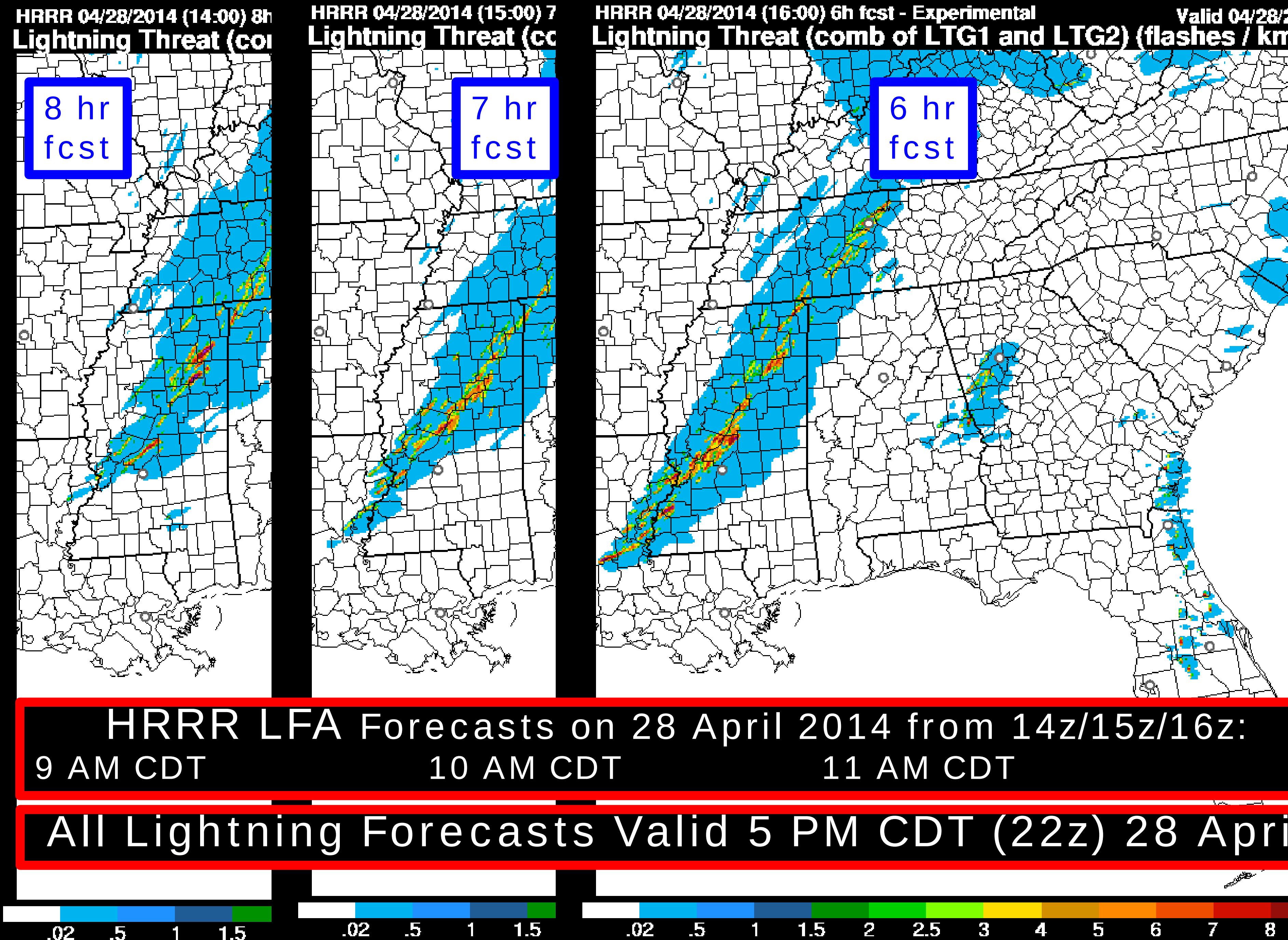
Fatalities



HRRR forecast rotation track

Arkansas Tornadoes – Sunday 27 April 2014





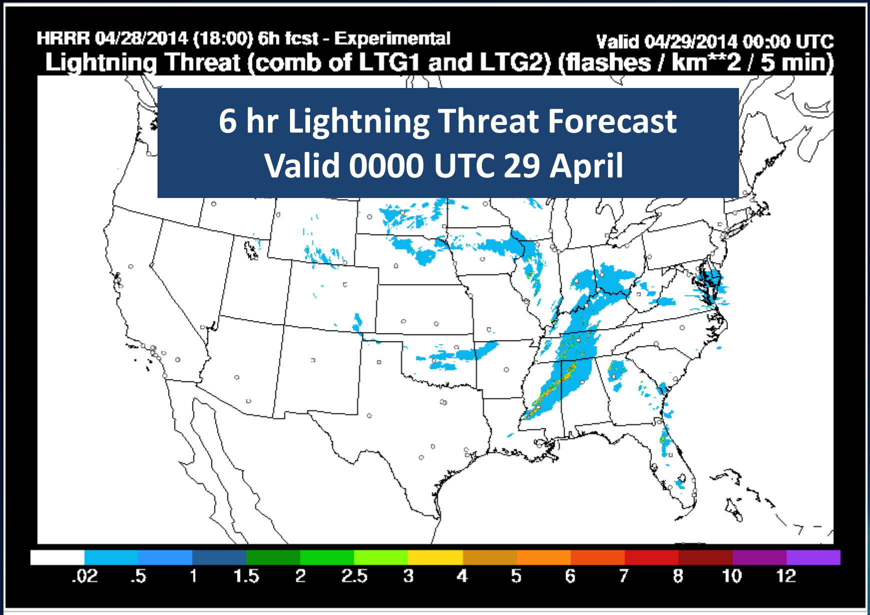
HRRR LFA Forecasts on 28 April 2014 from 14z/15z/16z:

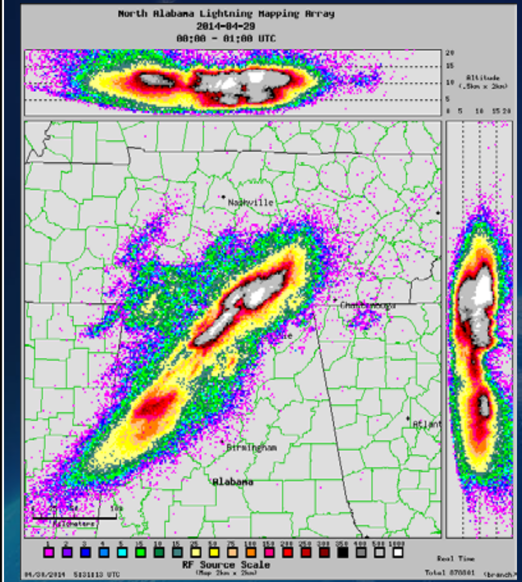
9 AM CDT 10 AM CDT 11 AM CDT

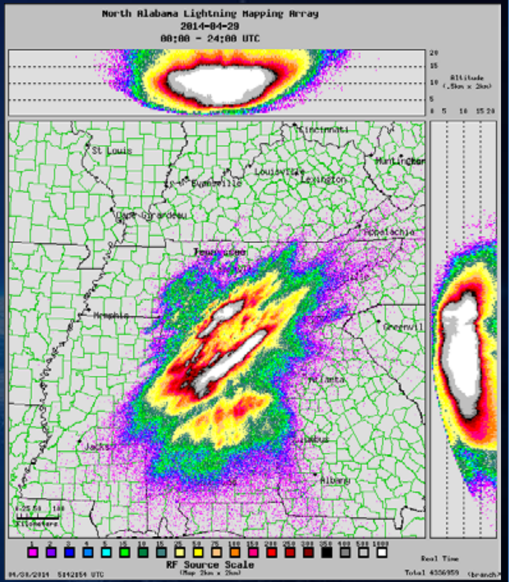
All Lightning Forecasts Valid 5 PM CDT (22z) 28 Apri

Lightning Threat Forecast

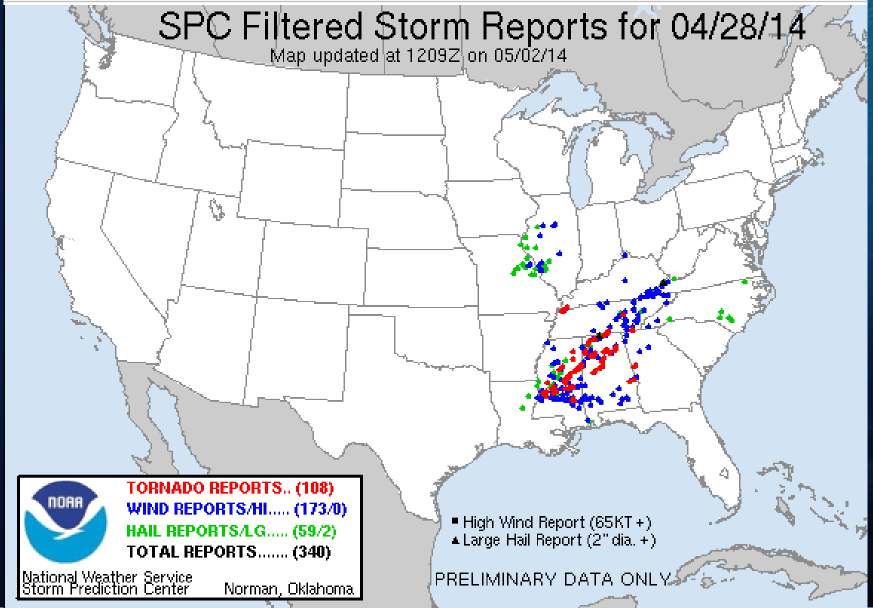
NOAA High Resolution (3 km) Rapid Refresh







Observed Total Lightning (left, 2300 UTC 28 April; right, 24 hr period ending 0000 UTC 29 April)



2056 UTC: EF-1 WITH PEAK WIND SPEEDS OF 110 MPH. PATH LENGTH 3.2 MILES. MAXIMUM PATH WIDTH OF 50 YARDS (NW Alabama).

2305 UTC: TREES AND POWERLINES DOWN (Madison, Alabama).

0000 UTC: TREES DOWN ALONG HIGHWAY 82 JUST EAST OF HIGHWAY 12. WINDS ESTIMATED ABOUT 75-80 MPH. REPORTED BY SPOTTER (NE Mississippi).

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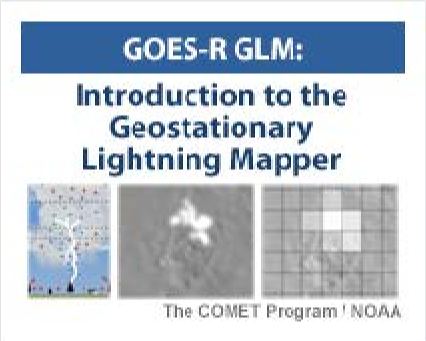
Lesson/Resource Listing » Description

GOES-R GLM: Introduction to the Geostationary Lightning Mapper



Languages: English, Spanish
Publish Date: 2014-09-05
Skill Level: 1
Completion Time: .75 - 1.00 h
Includes Audio: yes
Required Plugins: none
Topics: Mesoscale Meteorology, Satellite Meteorology
Included in Courses: GOES-R Satellites Orientation Course
Reviews:

BEGIN LESSON

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Take the quiz?

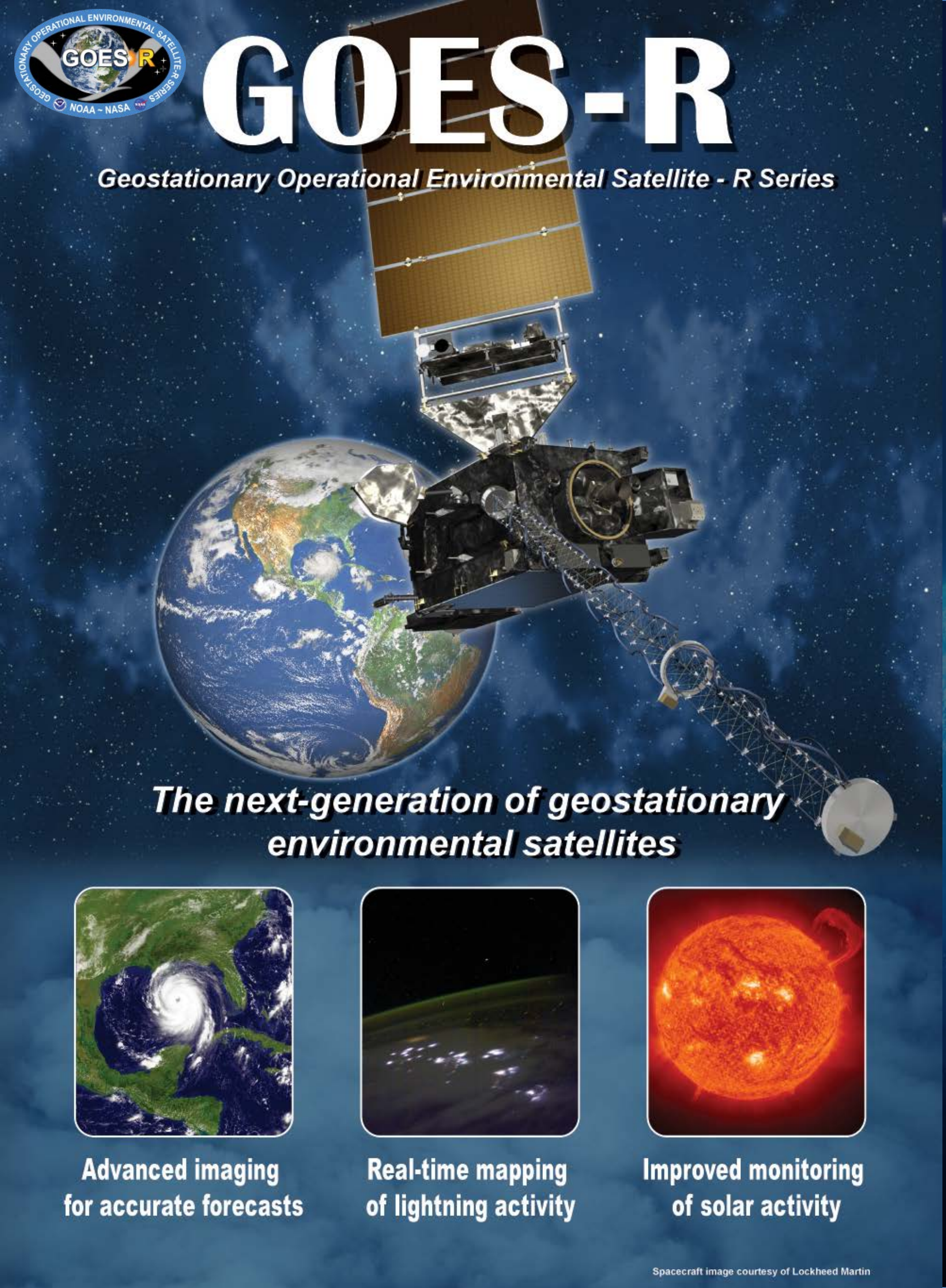
Begin Quiz

Share this resource: 1

- Outline the process of converting GLM observations to a lightning flash product
- Describe how GLM observations will help improve situational awareness and severe weather warning decision support
- Explain how GLM observations will improve warnings of impending lightning hazards
- Describe how GLM observations will benefit various application areas, such as aviation, quantitative

Summary

- GOES-R is coming - Launch early 2016
- New sensors, products, and services will help improve forecasts and increase lead times for warnings and decision makers
- Presents Challenges and Opportunities for model assimilation, data fusion and tools
- Product testing as soon as 2 months post-launch, also available to users for science assessment
- User preparation is essential to take advantage of the advanced capabilities to support a Weather Ready Nation - Hemisphere - World



Thank you!

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