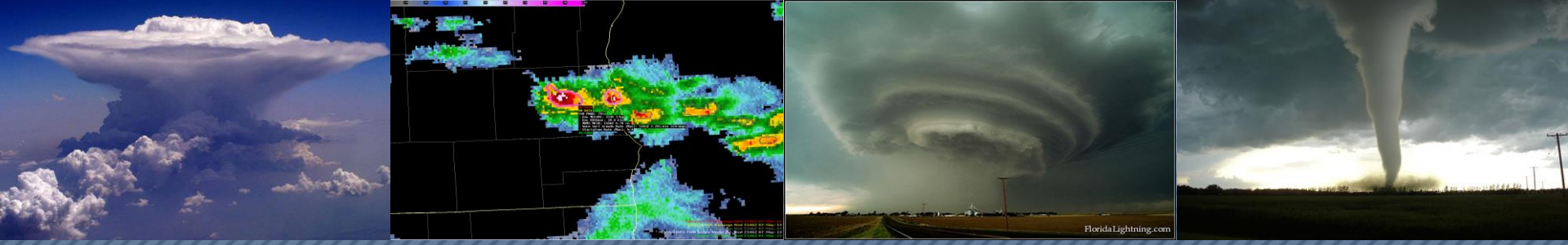
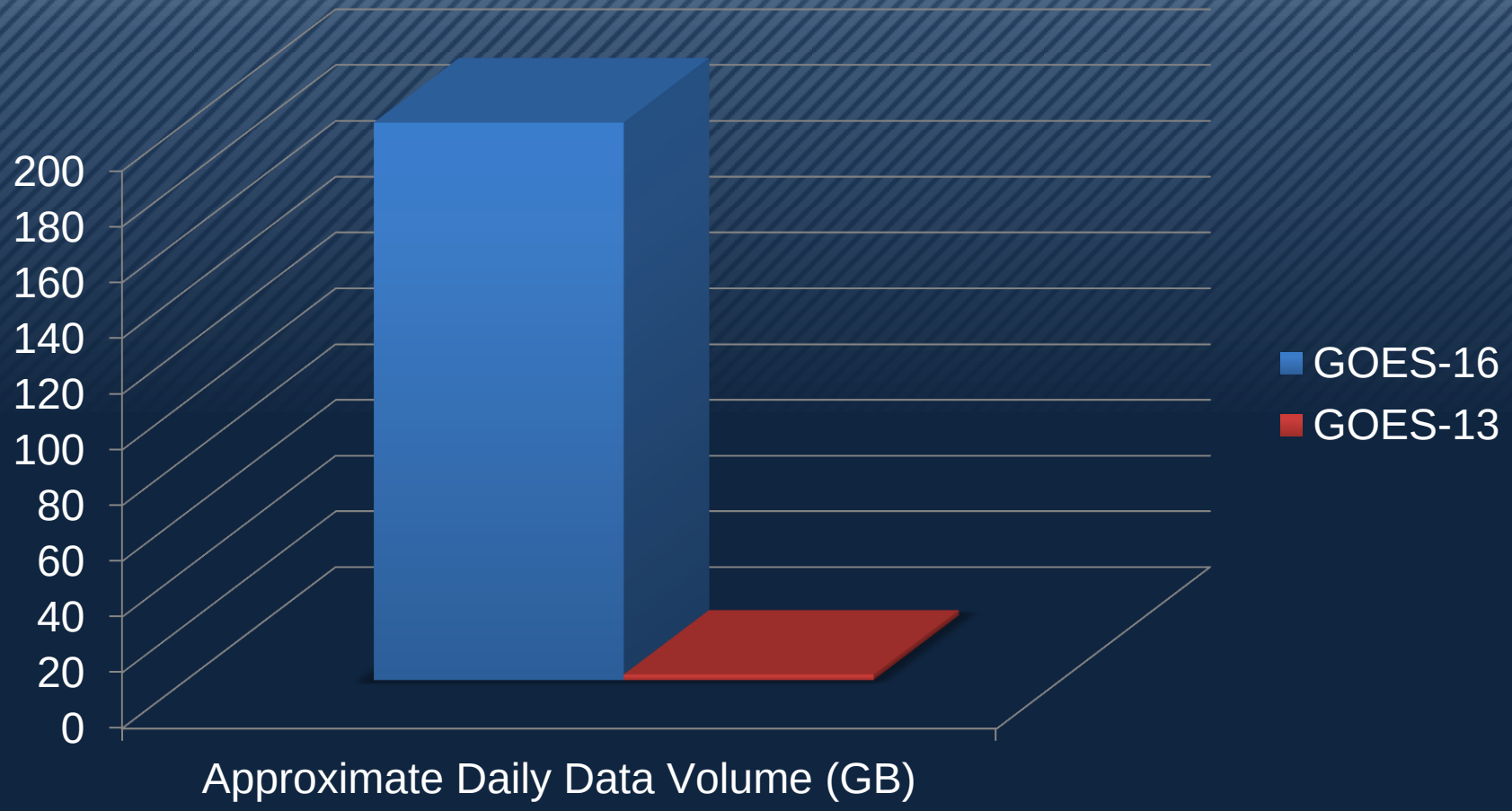
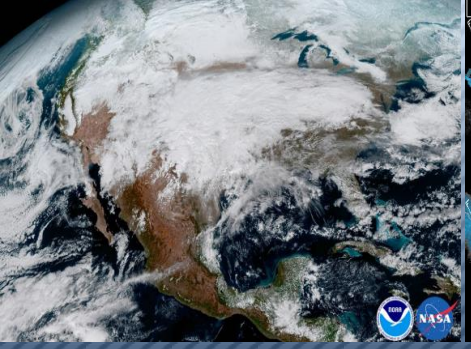


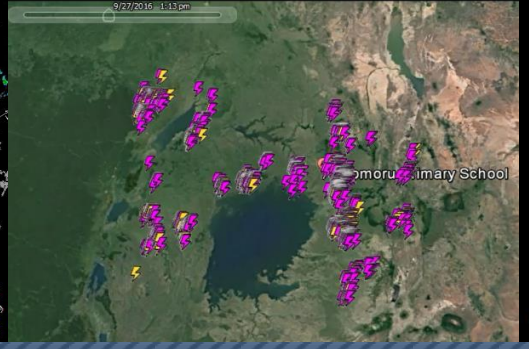
ProbSevere – A New Tool for NWS Severe Weather Warning Operations

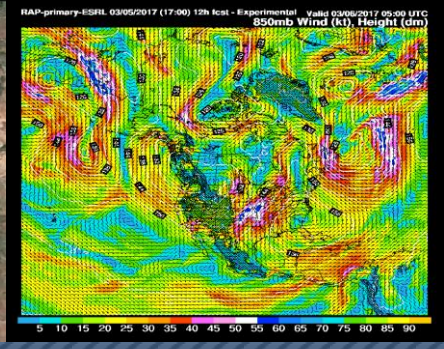
Michael J. Pavolonis (NOAA/NESDIS)
John Cintineo (UW-CIMSS)
Justin Sieglaff (UW-CIMSS)
Dan Lindsey (NOAA/NESDIS)
Chad Gravelle (UW-CIMSS)

Research is critical for transforming "Big Data" to information

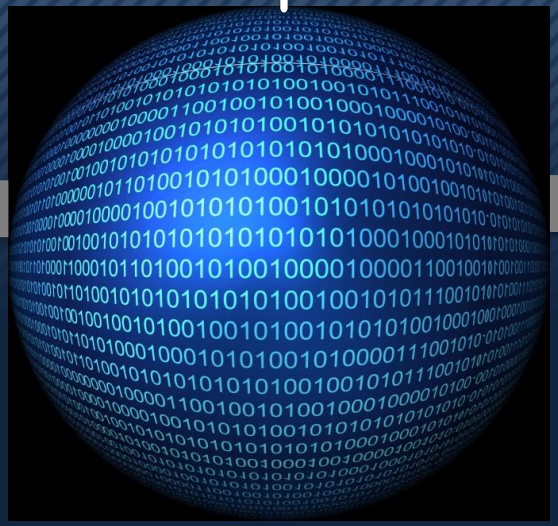




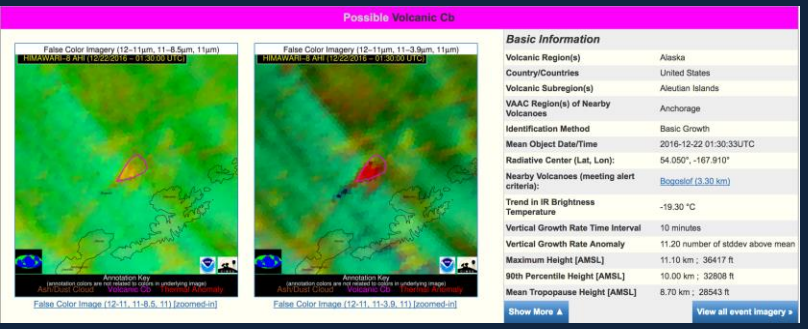




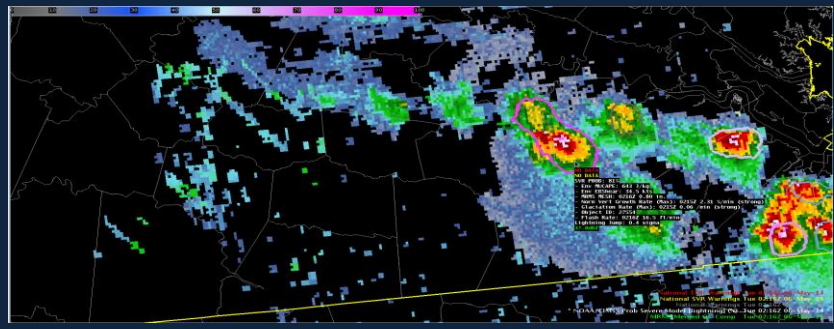
Operational applications require "Big Data" to be automatically transformed into information and insight for decision making



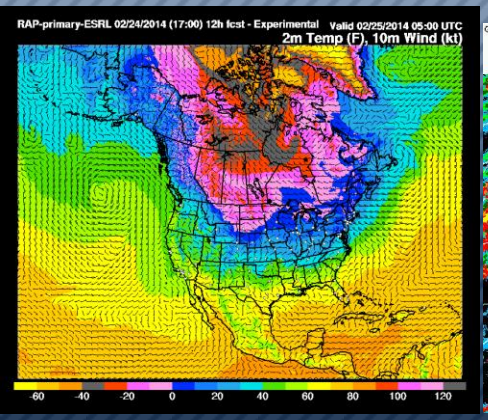
Volcanic Eruption Detected!

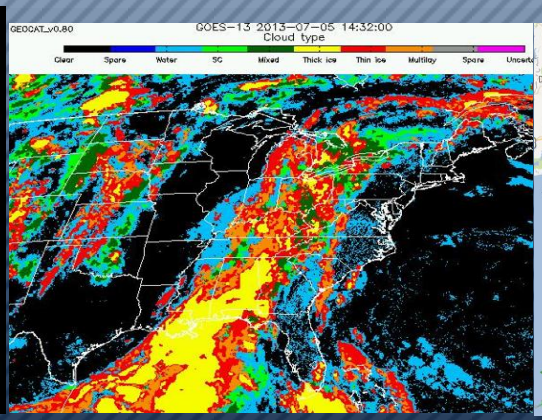


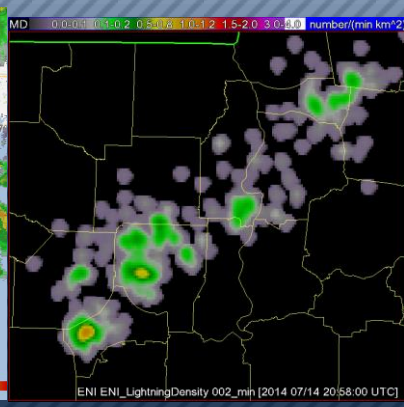
Severe Weather Likely



"Big Data" to Environmental Intelligence







High-resolution NWP Data → **Storm Environment**

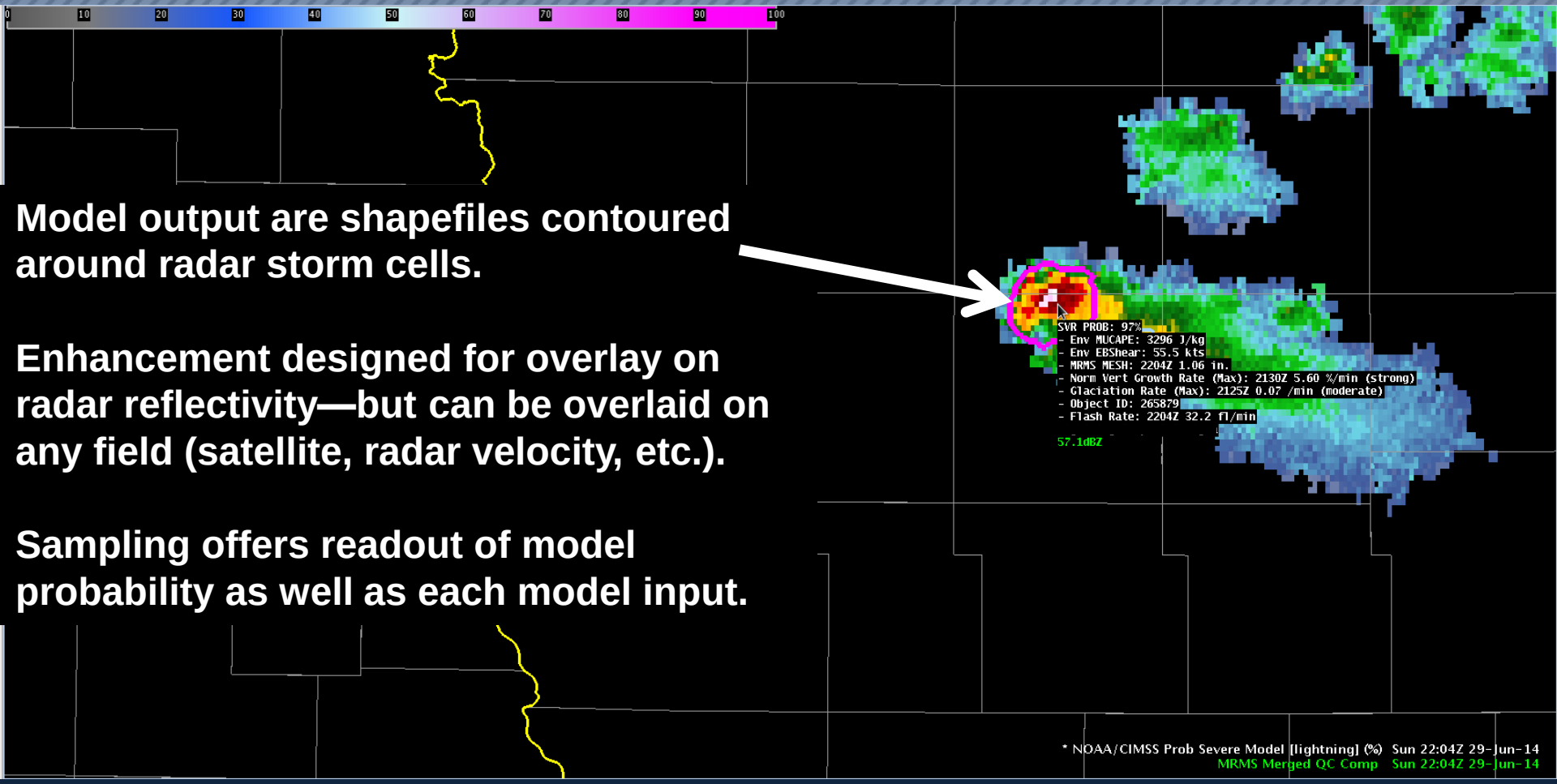
Satellite Imagery and Derived Products → **Evolution of Cumulus to Cumulonimbus**

Radar Imagery and Derived Products → **Storm Tracking and Hydrometeor Properties**

Total Lightning → **Storm Electrification**

Probability a thunderstorm will produce severe weather in the future (up to 60 minutes)

ProbSevere Model AWIPS-II Display

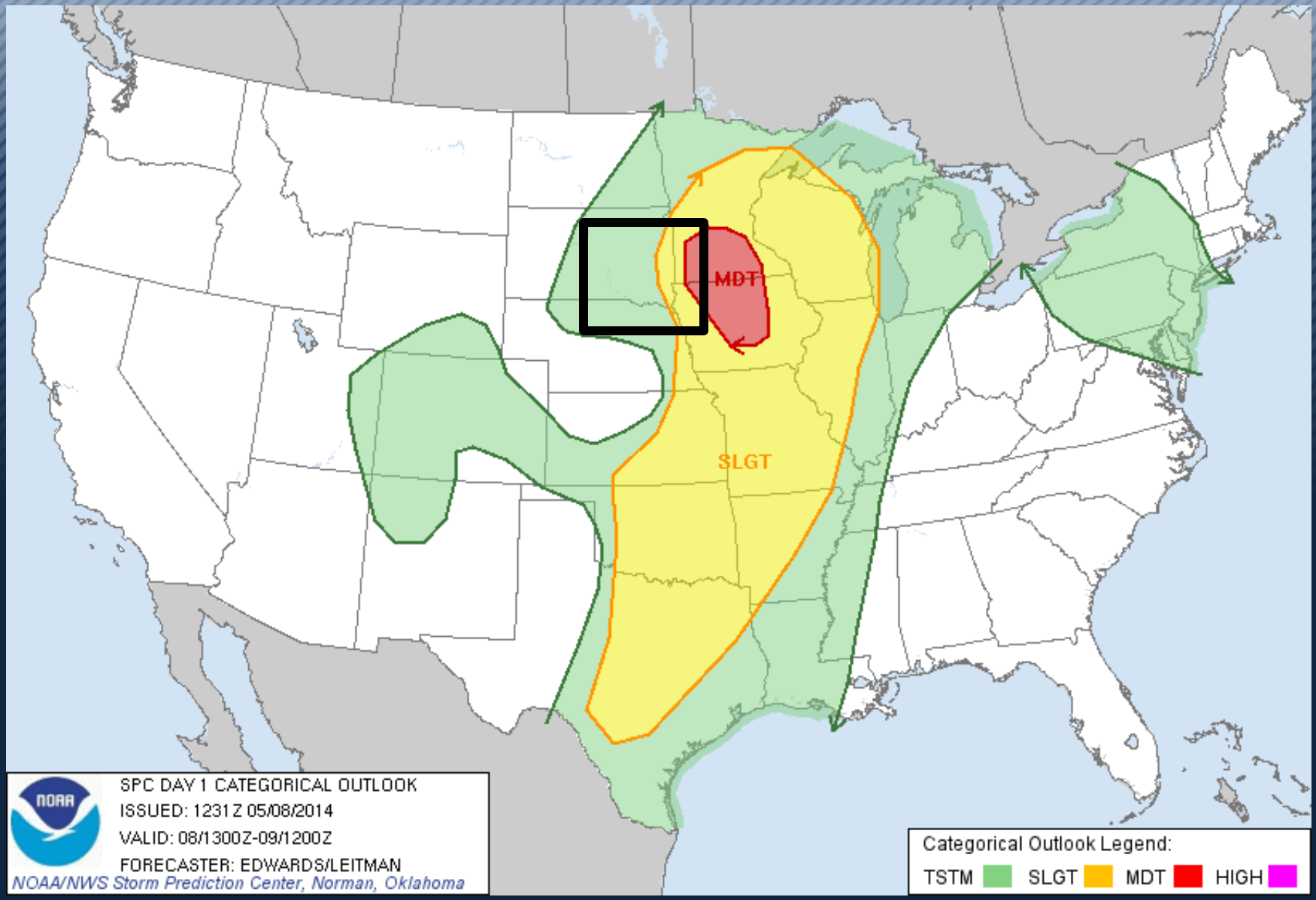


Model output are shapefiles contoured around radar storm cells.

Enhancement designed for overlay on radar reflectivity—but can be overlaid on any field (satellite, radar velocity, etc.).

Sampling offers readout of model probability as well as each model input.

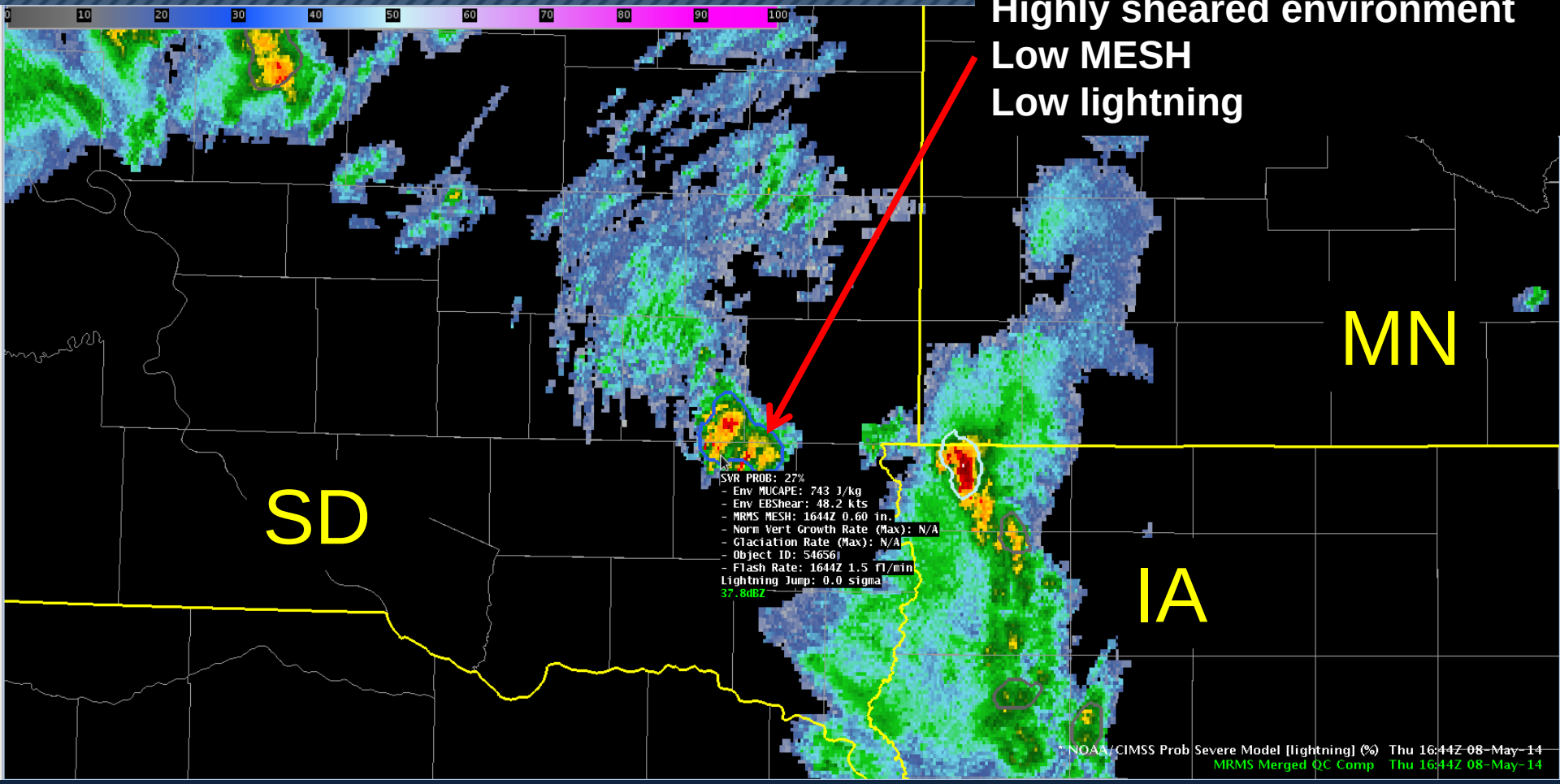
08 May 2014


MDT
SLGT
SPC DAY 1 CATEGORICAL OUTLOOK
ISSUED: 1231 Z 05/08/2014
VALID: 08/1300Z-09/1200Z
FORECASTER: EDWARDS/LEITMAN
NOAA/NWS Storm Prediction Center, Norman, Oklahoma
Categorical Outlook Legend:
TSTM
SLGT
MDT
HIGH

1644 UTC May-08-2014

MUCAPE ~ 750 J kg^{-1}
Eff. shear ~ 48 kts

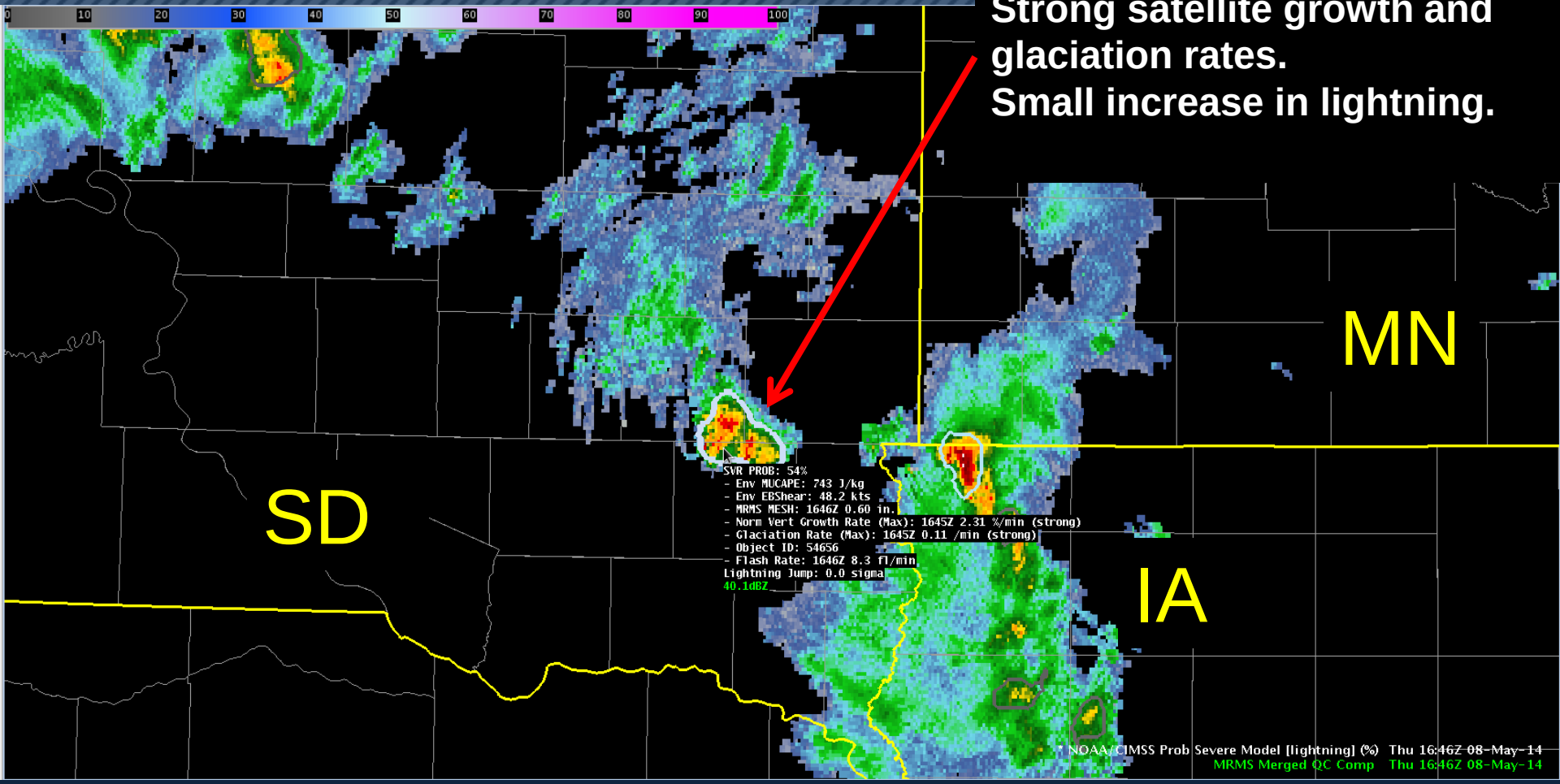
Prob = 27%
Highly sheared environment
Low MESH
Low lightning



1646 UTC May-08-2014

MUCAPE ~ 750 J kg^{-1}
Eff. shear ~ 48 kts

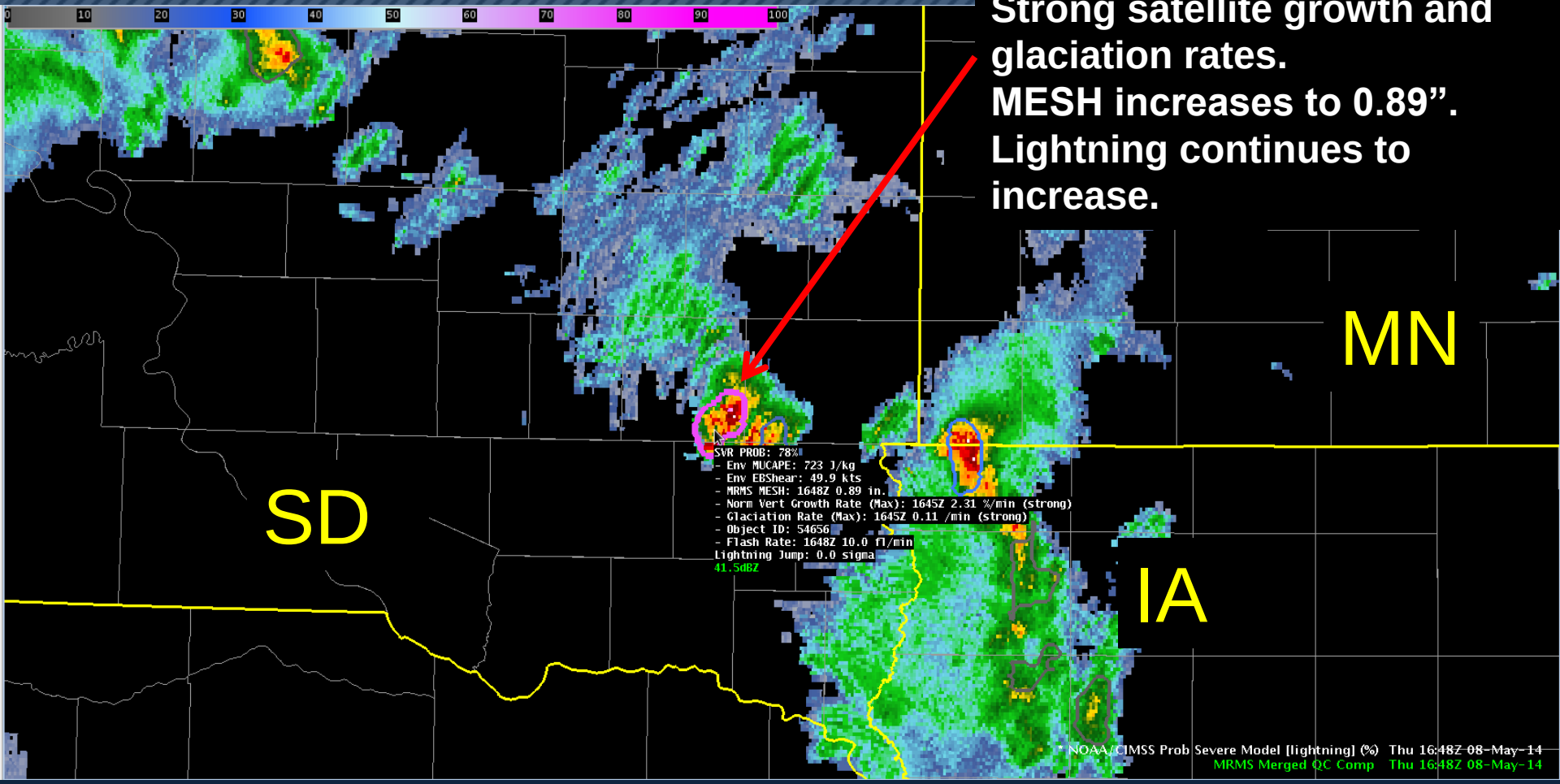
Prob = 54%
Strong satellite growth and glaciation rates.
Small increase in lightning.



1648 UTC May-08-2014

MUCAPE ~ 750 J kg^{-1}
Eff. shear ~ 48 kts

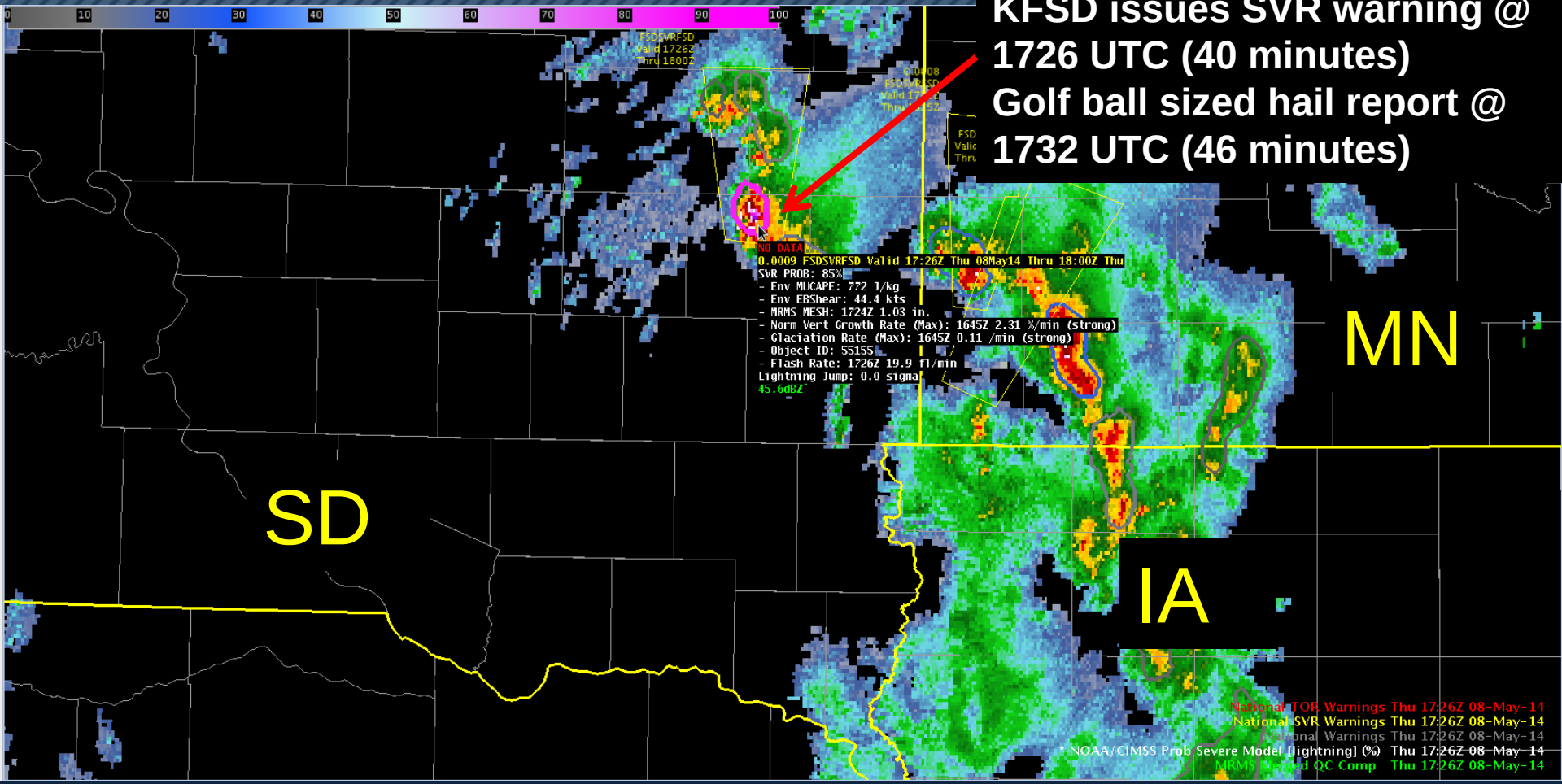
Prob = 78%
Strong satellite growth and glaciation rates.
MESH increases to 0.89”.
Lightning continues to increase.



1726 UTC May-08-2014

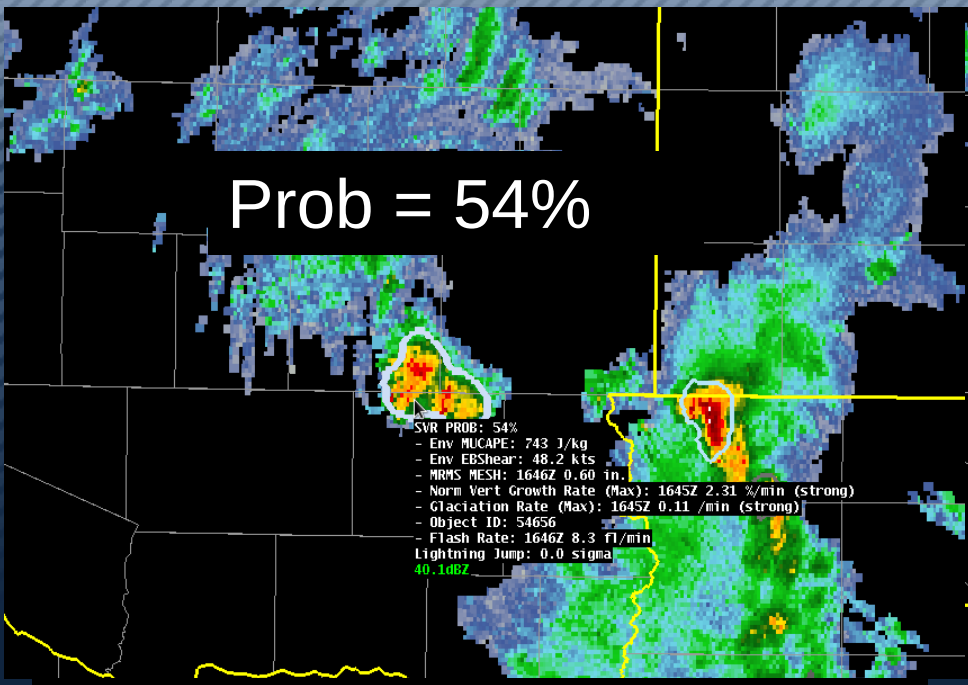
MUCAPE ~ 750 J kg^{-1}
Eff. shear ~ 48 kts

Prob = 85%
KFSD issues SVR warning @ 1726 UTC (40 minutes)
Golf ball sized hail report @ 1732 UTC (46 minutes)

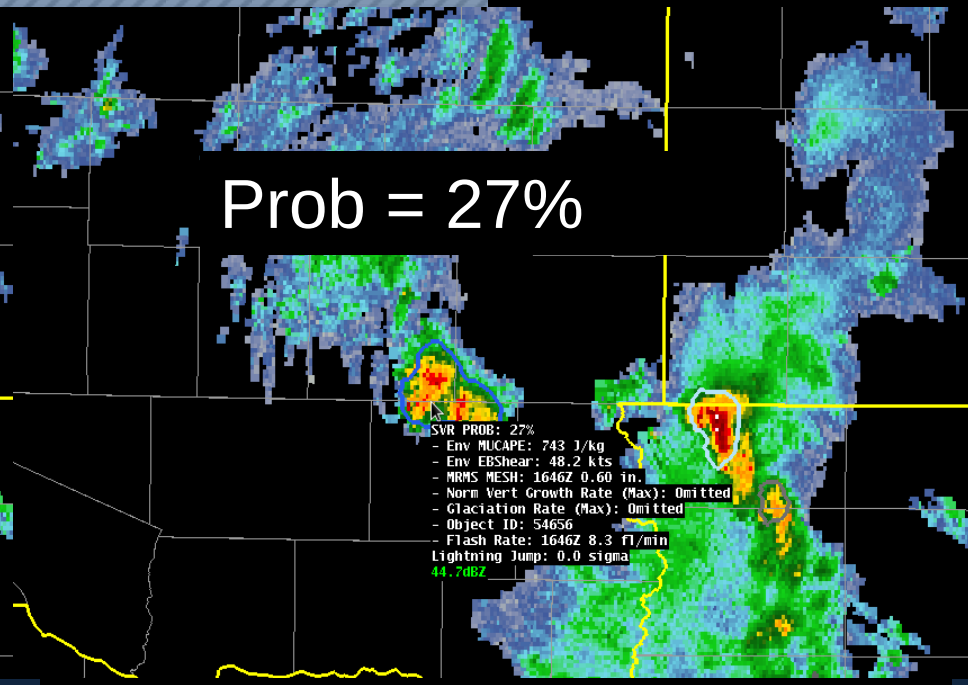


Impact of GOES Data

1646 UTC May-08-2014



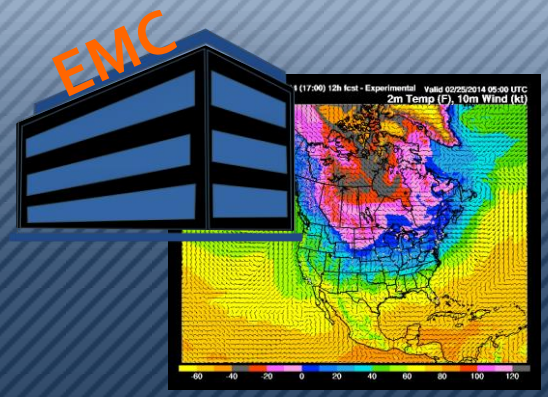
NWP + Satellite + Radar + Lightning



NWP + ~~Satellite~~ + Radar + Lightning

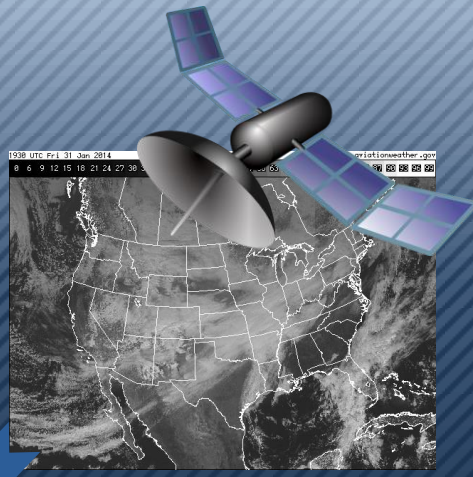
Time (UTC)	With GOES	Without GOES
1644	27% (no sat. growth yet)	27%
1646	54%	27%
1648	78%	54%
1728	85%	65%

"Big Data" to Information: ProbSevere

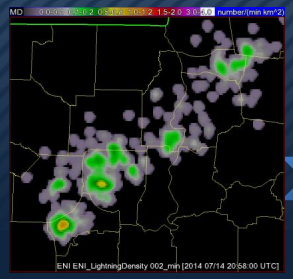


1 set of RAP grids

In one hour…



8 CONUS satellite scans (in rapid scan)



30 lightning files

ProbSevere

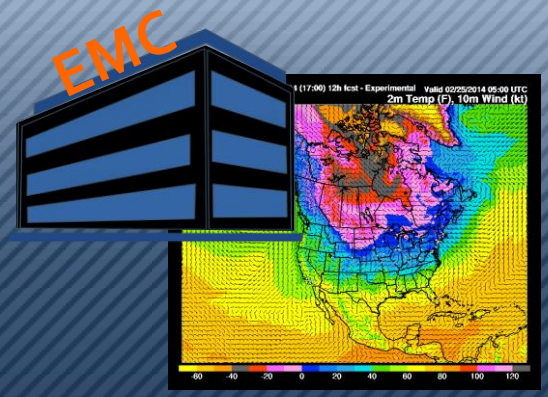
OUTPUT

Input: 1.3 GB
Output: 6 MB

30 CONUS radar scans

File size: 0.2 MB
30 output files

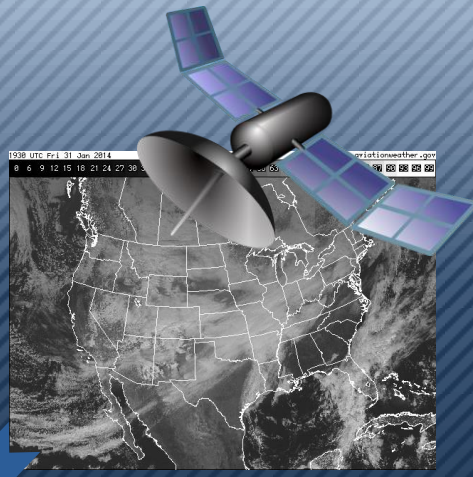
"Big Data" to Information: ProbSevere



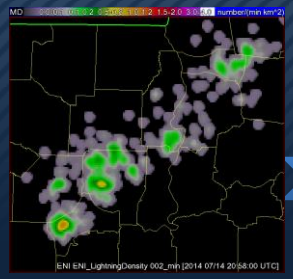
1 set of RAP grids

In one hour…

With 1 GOES-R Series



12 CONUS satellite scans (in rapid scan)



30 lightning files

ProbSevere

OUTPUT

Input: 10 GB

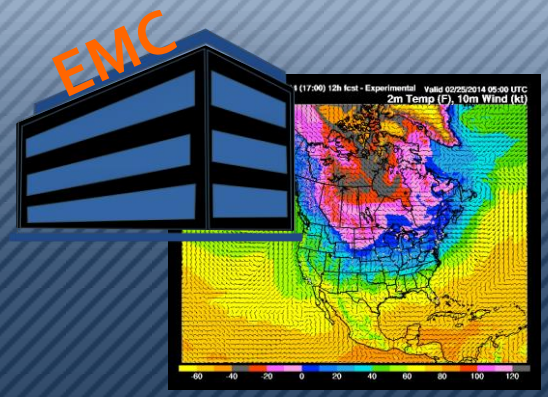
Output: 6 MB

30 CONUS radar scans

File size: 0.2 MB

30 output files

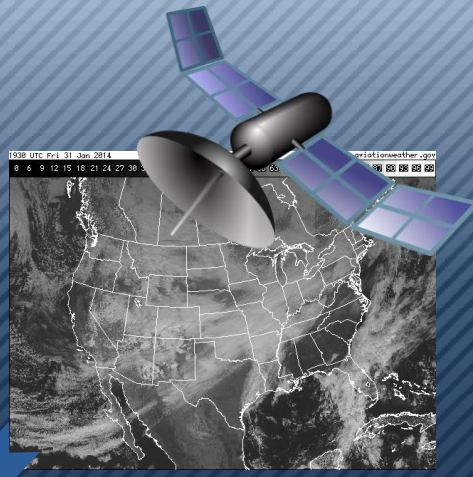
"Big Data" to Information: ProbSevere



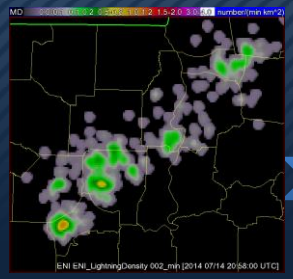
1 set of RAP grids

In one hour…

With 2 GOES-R Series



12 CONUS satellite scans (in rapid scan)



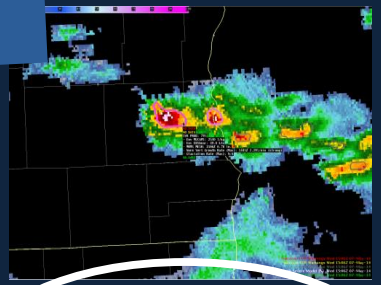
30 lightning files

ProbSevere

OUTPUT

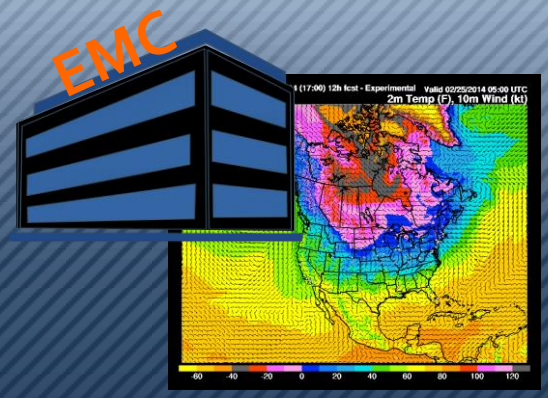
Input: 19 GB
Output: 6 MB

30 CONUS radar scans



File size: 0.2 MB
30 output files

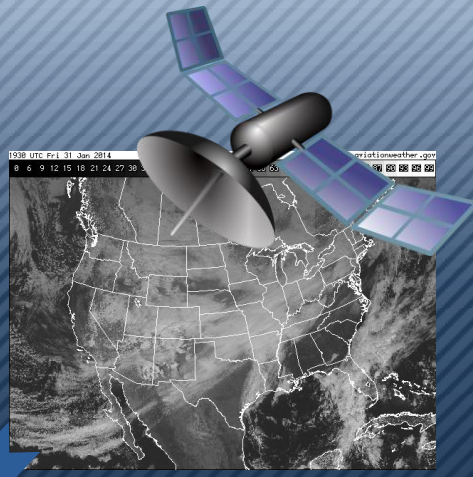
"Big Data" to Information: ProbSevere



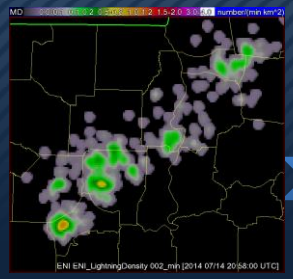
1 set of RAP grids

In one hour…

With 2 GOES-R Series + HRRR



12 CONUS satellite scans (in rapid scan)



30 lightning files

ProbSevere

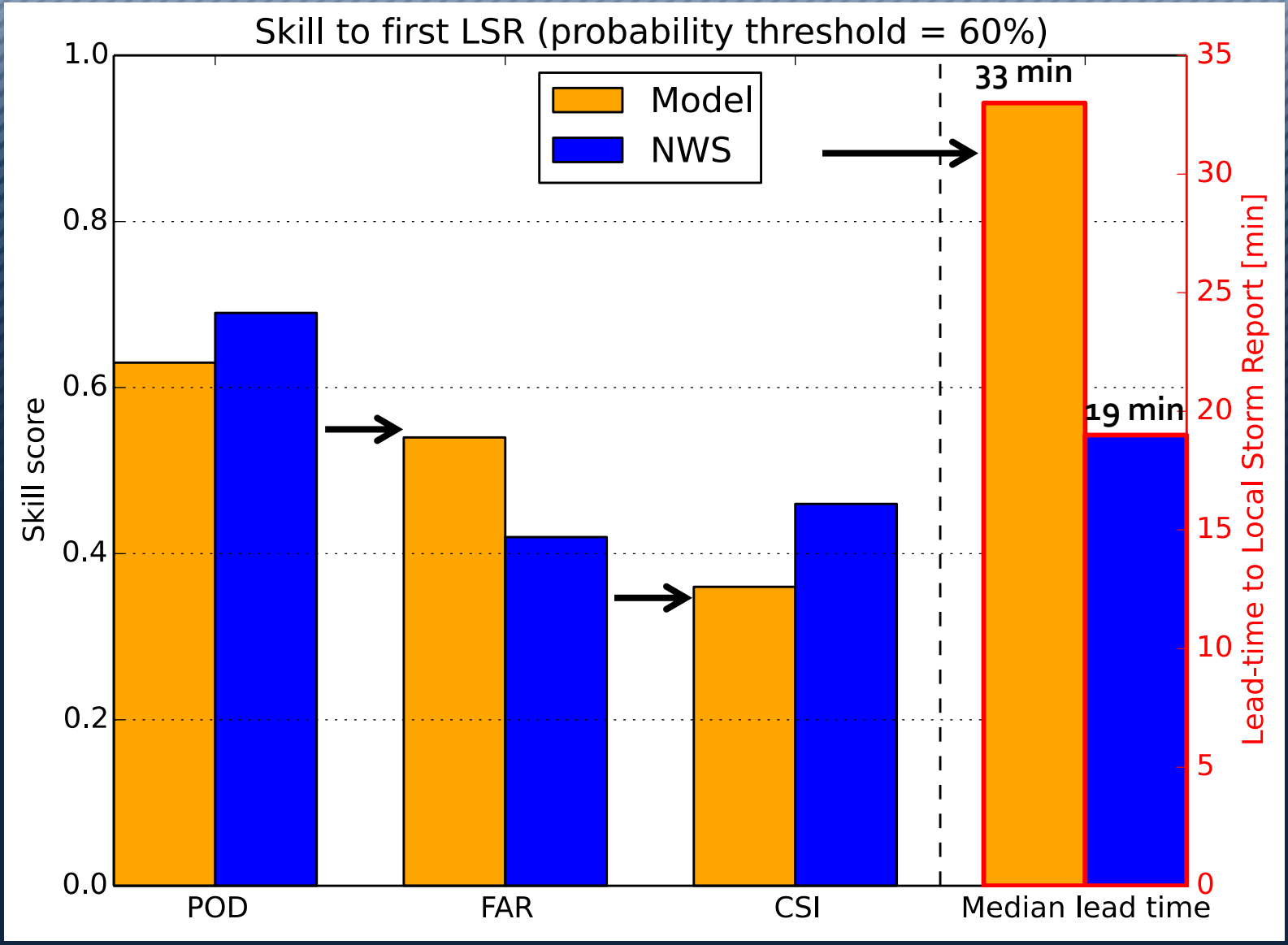
OUTPUT

Input: 22.5 GB
Output: 6 MB

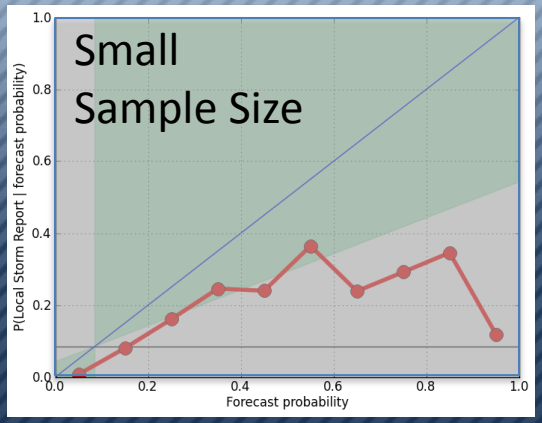
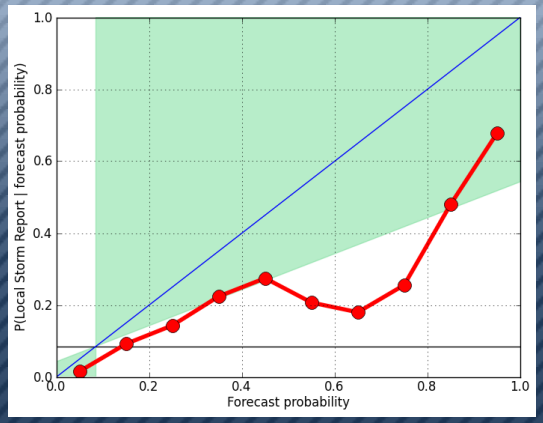
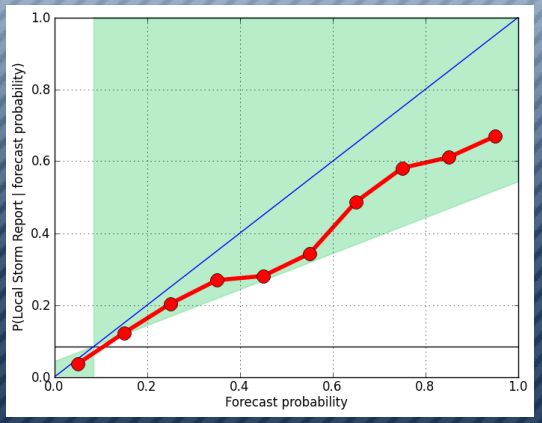
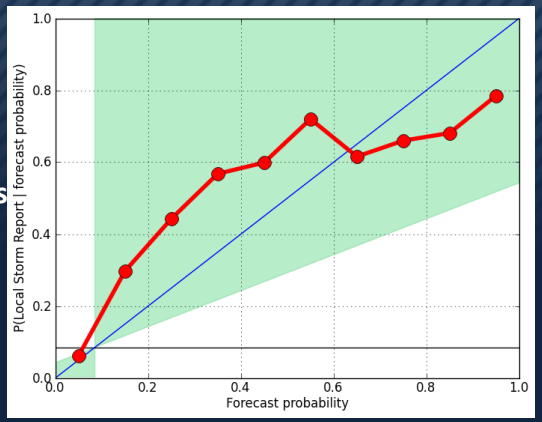
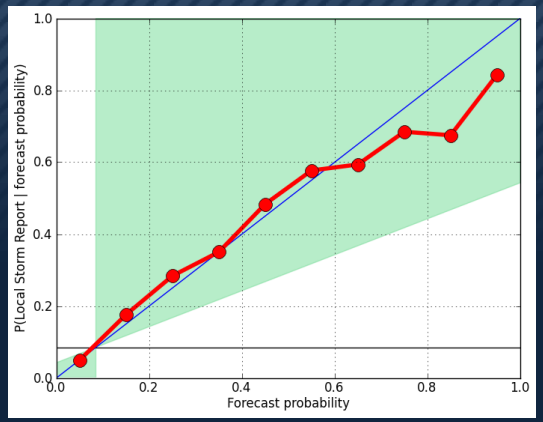
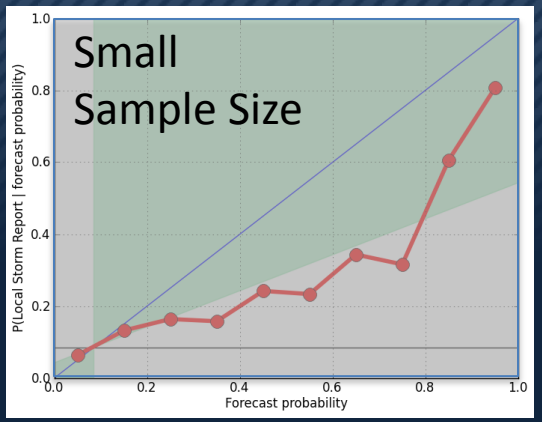
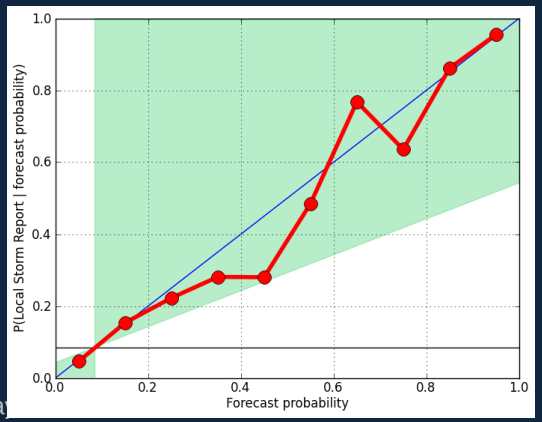
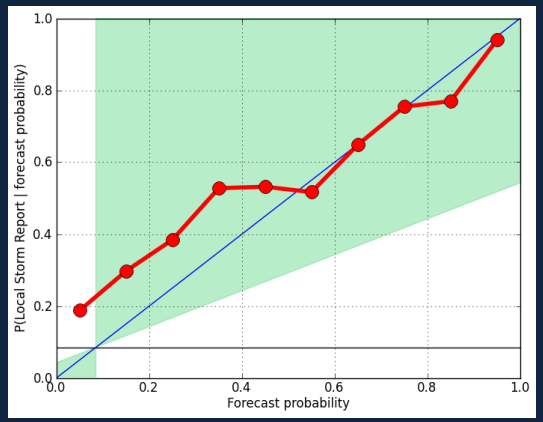
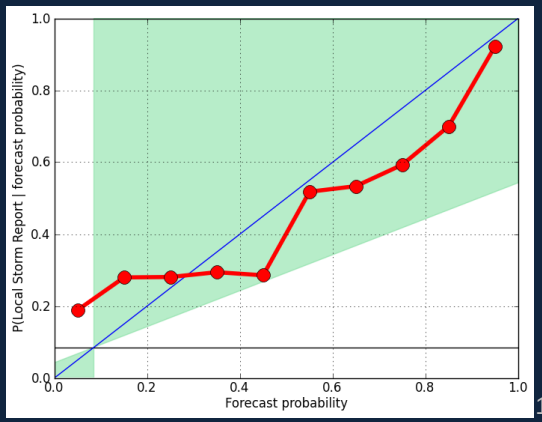
30 CONUS radar scans

File size: 0.2 MB
30 output files

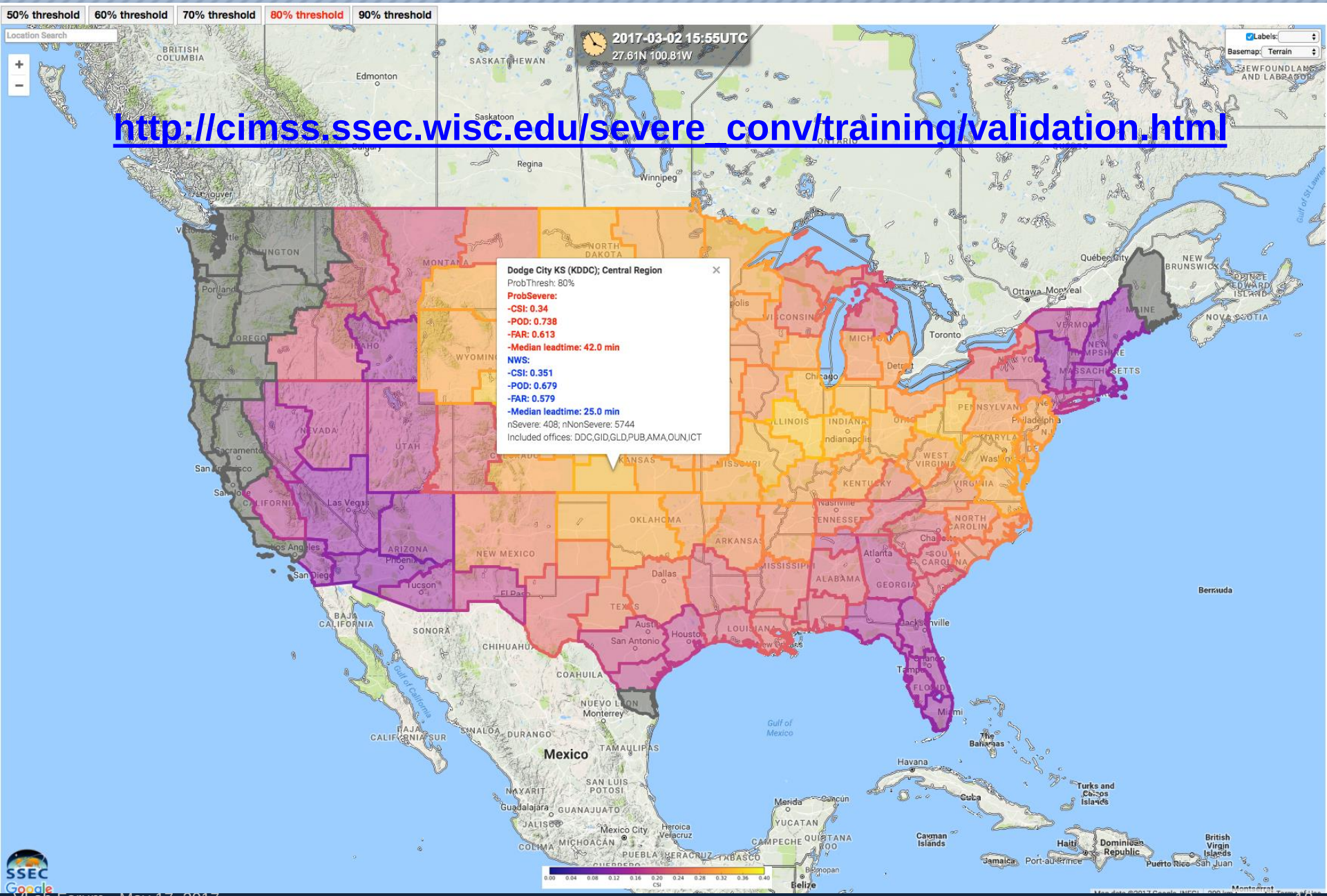
ProbSevere Verification



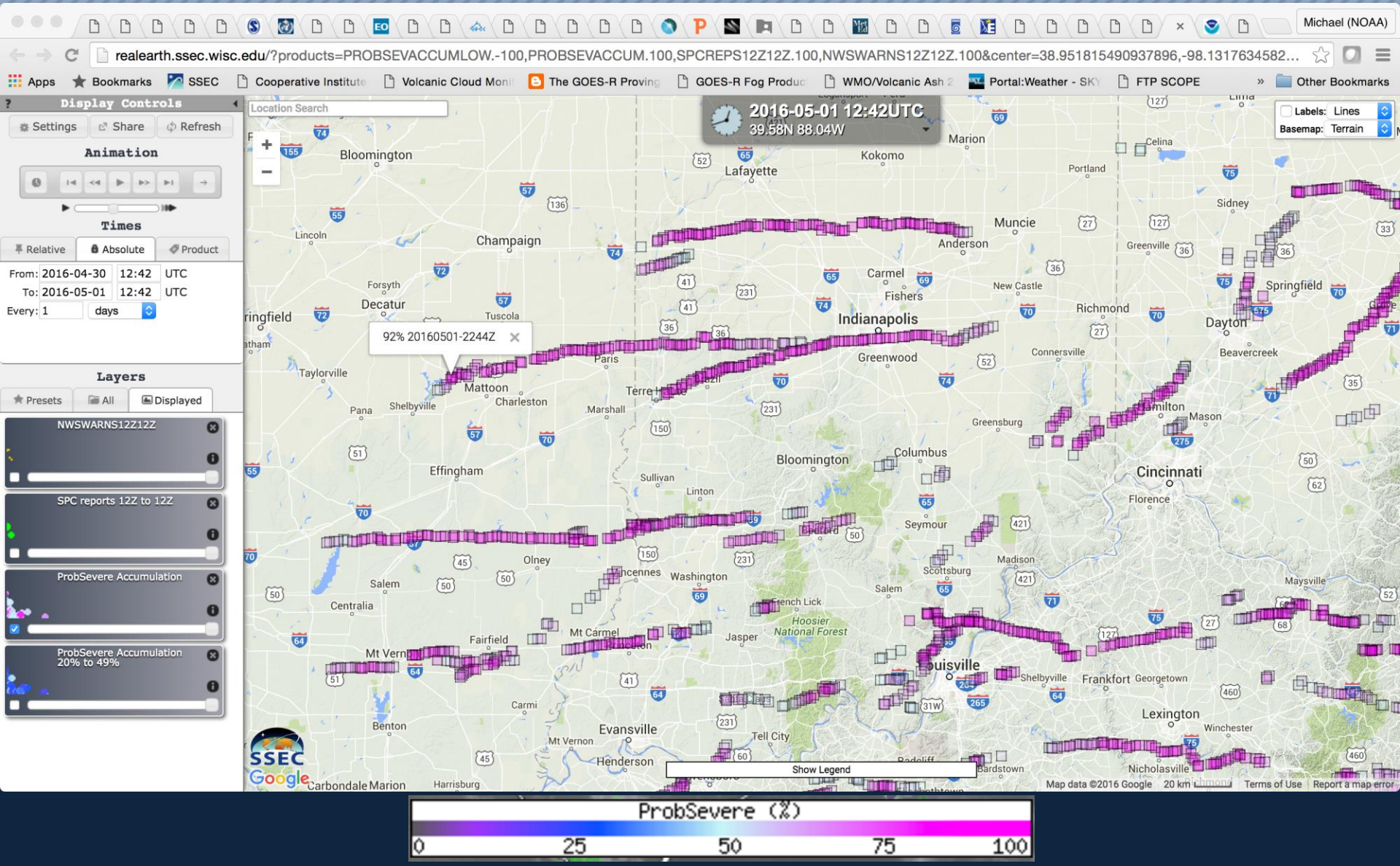
ProbSevere Calibration

	CAPE 0-1500 J/Kg	CAPE 1500-2500 J/Kg	CAPE 2500+ J/Kg
EBS 0-10 m/s			
EBS 10-15 m/s			
EBS 15+ m/s			

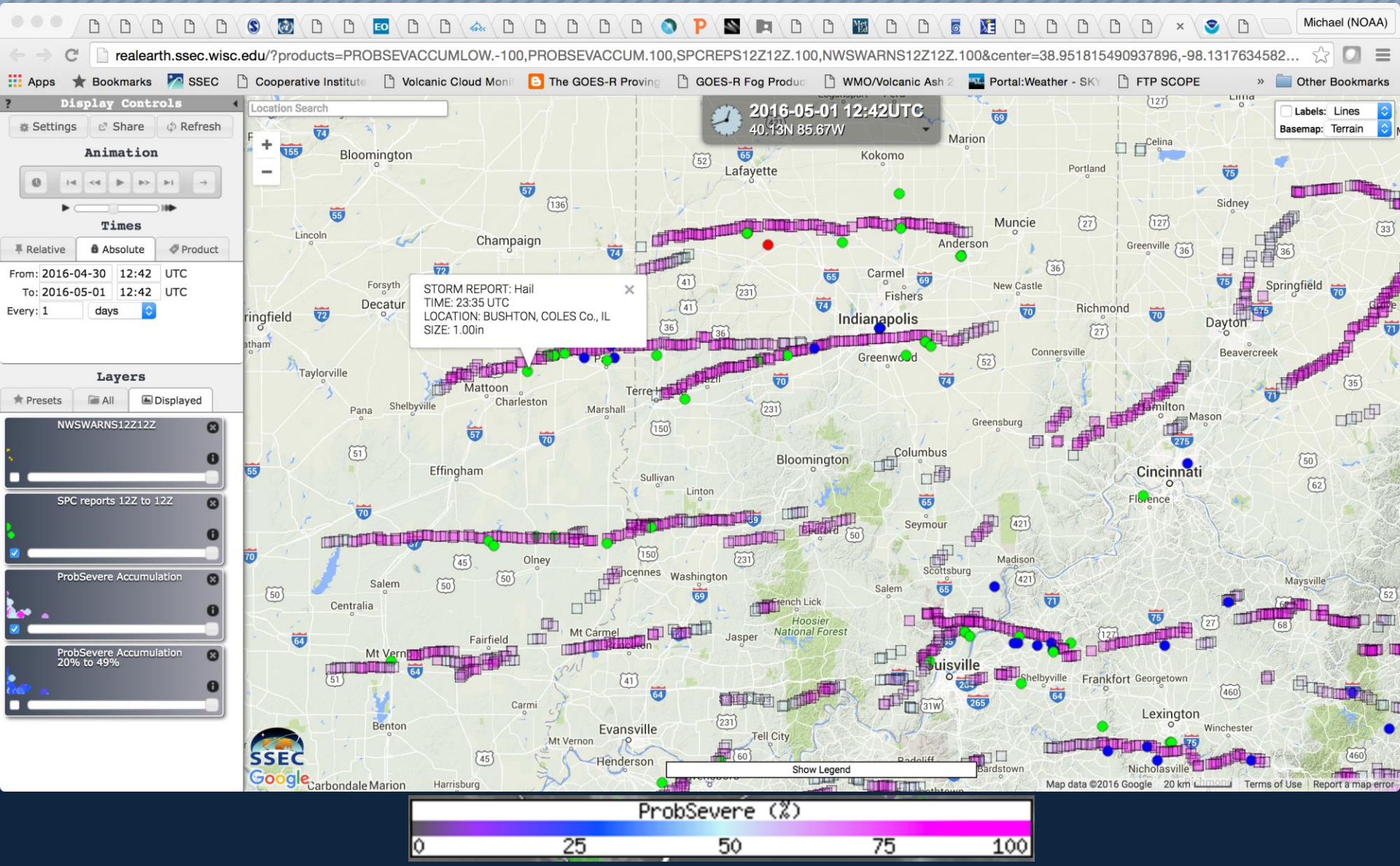
ProbSevere Verification by WFO



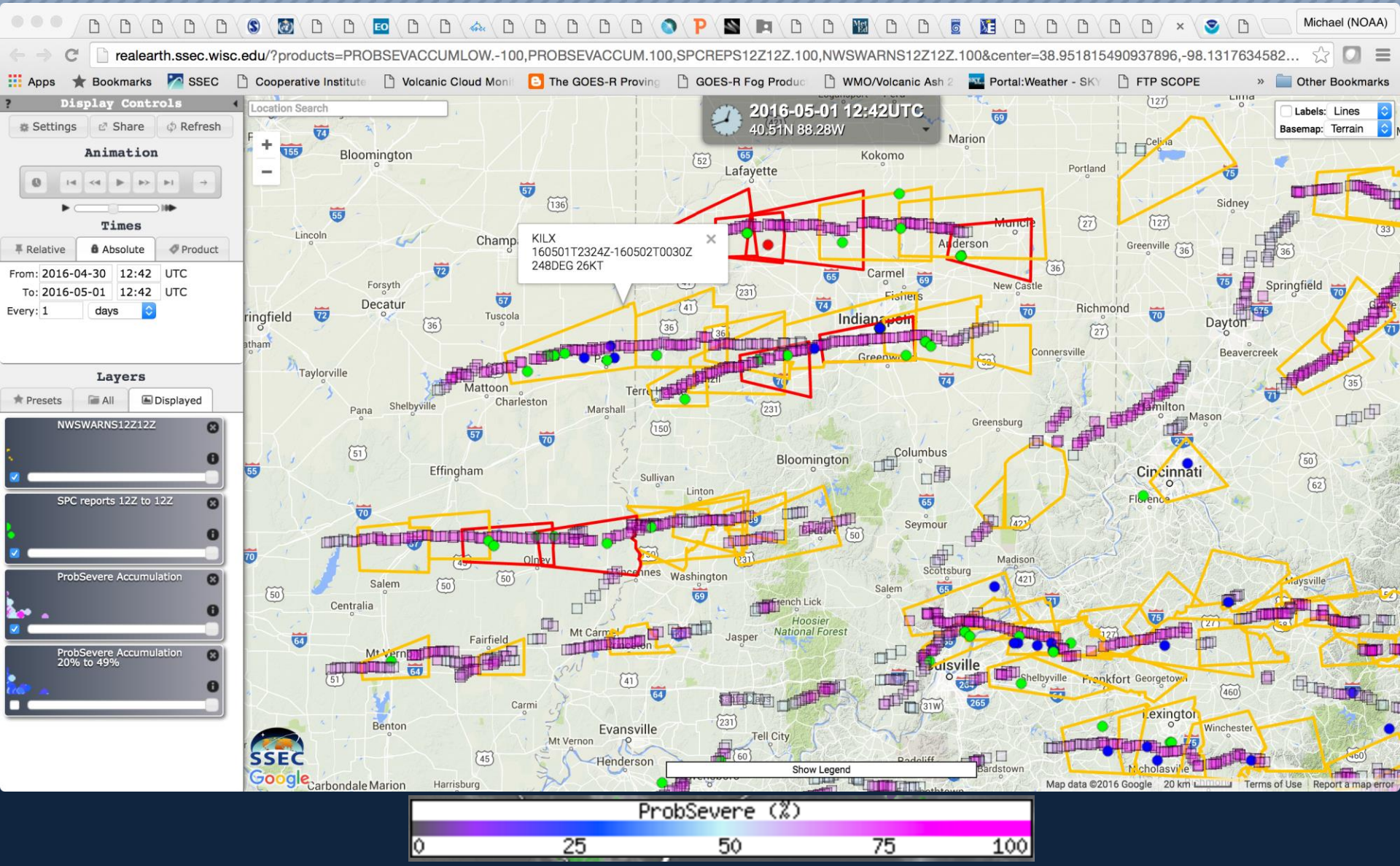
ProbSevere Verification - Daily Storm Tracks



ProbSevere Verification - Daily Storm Tracks



ProbSevere Verification - Daily Storm Tracks



Hazardous Weather Testbed (HWT)

http://goesrhwt.blogspot.com

The GOES-R Proving Ground at the Hazardous Weather Testbed

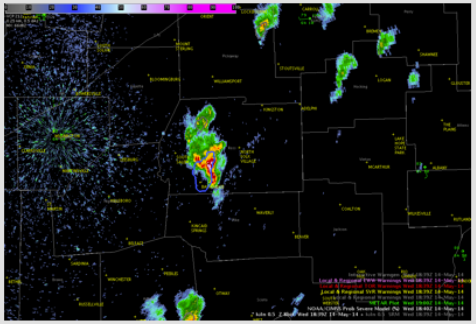
Wednesday, May 14, 2014

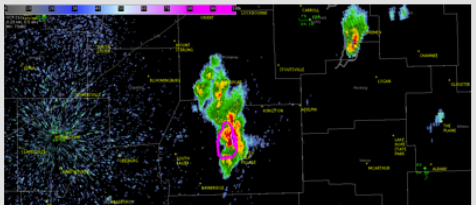
CIMSS Prob Severe Product Increases Warning Confidence in South Central OH

CIMSS Prob Severe Product did a great job illustrating a developing severe storm over South Central Ohio. The SVR PROB increased from 32% at 1840 UTC, 94% at 1856 UTC, then decreased to 69% at 1920 UTC. The MESH increased from 0.64 in. at 1840 UTC to 1.78 in. at 1856 UTC, then decreased to 0.95 in. at 1920 UTC. Normal Vertical Growth Rate rose from 0.87%/min at 1840 UTC to 1.00%/min at 1856 and 1920 UTC. The Glaciation Rate went from 0.02/min at 1840 UTC, 0.03/min at 1856 UTC, to 0.03/min at 1920 UTC.

The MUCAPE was around 1500 J/kg and ENShear ranged between 38 and 43 kt. The change in colors from blue to red and expansion in width of the outlined area depicting the reflectivity core provides warning forecasters valuable information for making warning decisions. A Severe Thunderstorm Warning was issued for this storm in the HWT.

Michael Scotten





Links

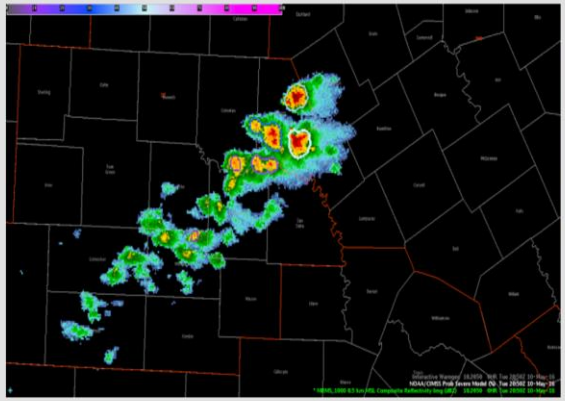
goesrhwt.blogspot.com/2016/05/first-severe-warning-issued.html

The Satellite Proving Ground at the Hazardous Weather Testbed

Tuesday, May 10, 2016

First severe warning issued!

I issued my first severe thunderstorm warning ever...what a thrill! The Prob severe product as well as lightning jump product aided my decision. Sadly it seems to have been a bit hasty as storms have weakened quite a bit, as they move into region of lower cape...



Links

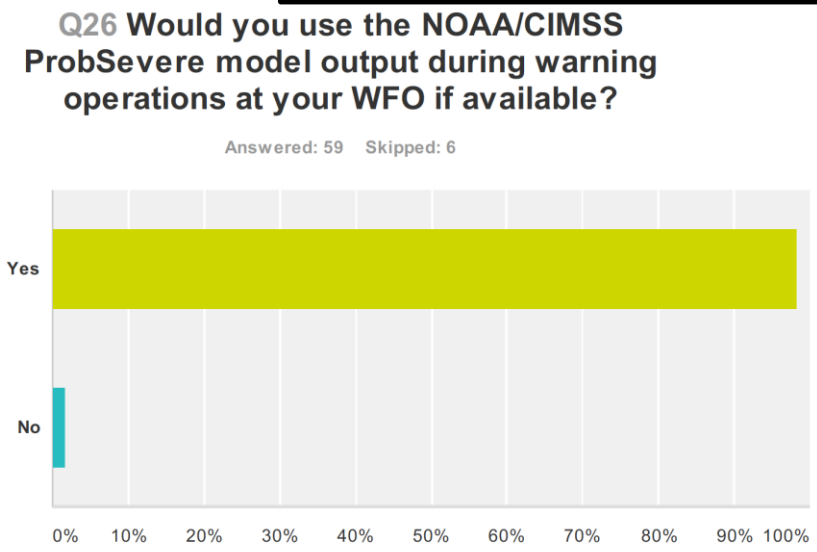
- GOES-R Homepage
- GOES-R Proving Ground
- JPSS Homepage
- NOAA Storm Prediction Center
- NOAA Hazardous Weather Testbed
- Experimental Warning Program
- Experimental Forecast Program
- EWP Blog
- EFP Blog
- NSSL Realtime WRF model forecasts
- RAMMB GOES-R Proving Ground Blog
- UW-CIMSS Satellite Blog

Blog Archive

▼ 2016 (482)

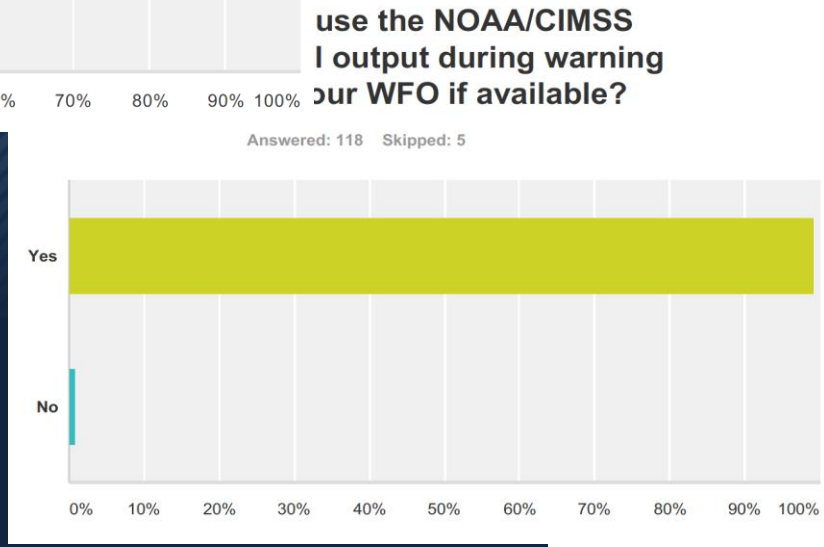
Downward Trend

HWT (2014)

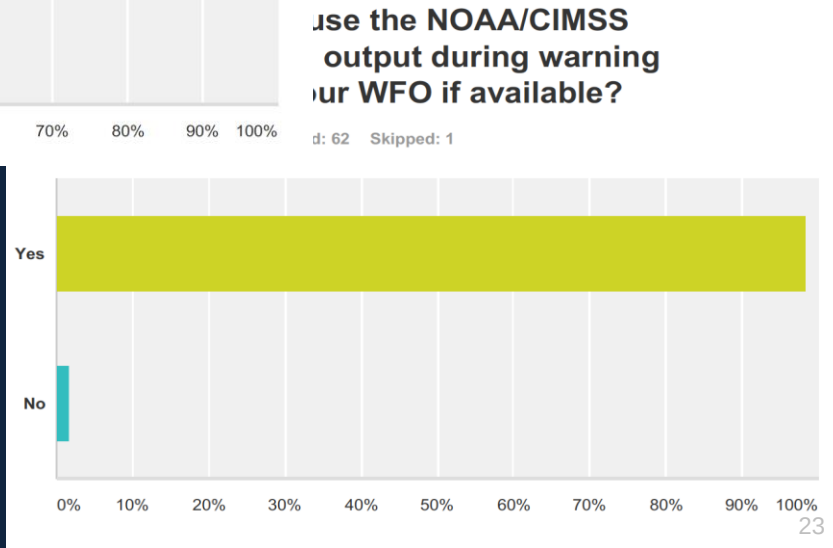


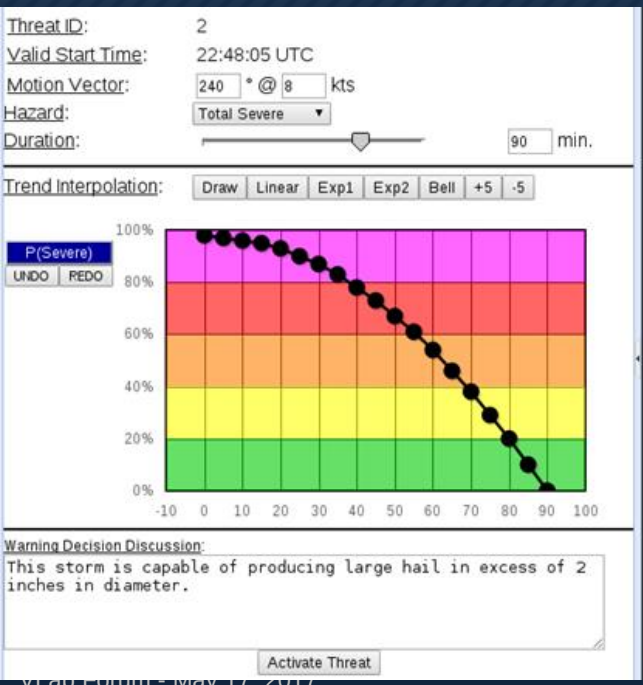
"Would you use NOAA/CIMSS ProbSevere model output during warning operations at your WFO if available?"

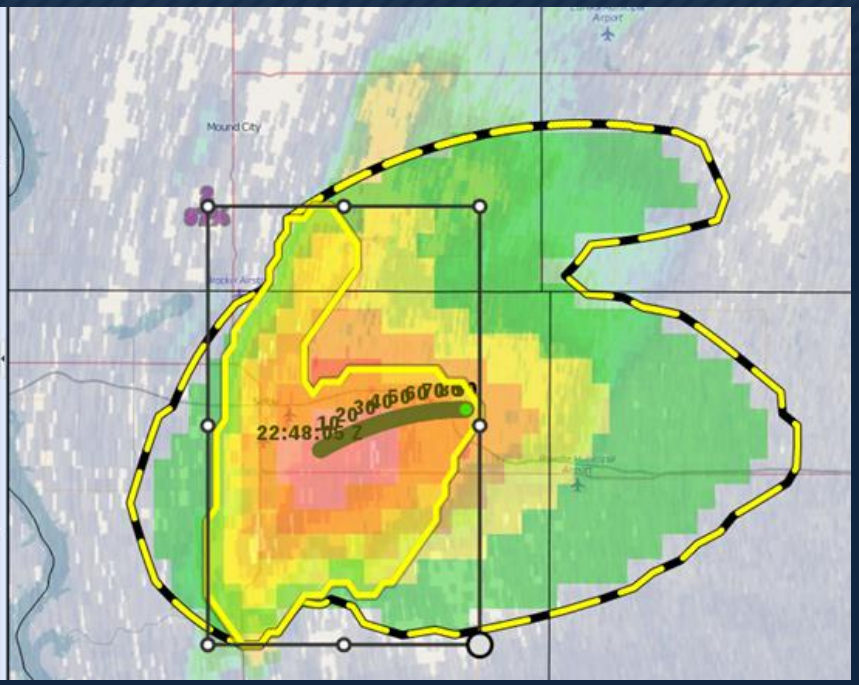
HWT (2015)



HWT (2016)



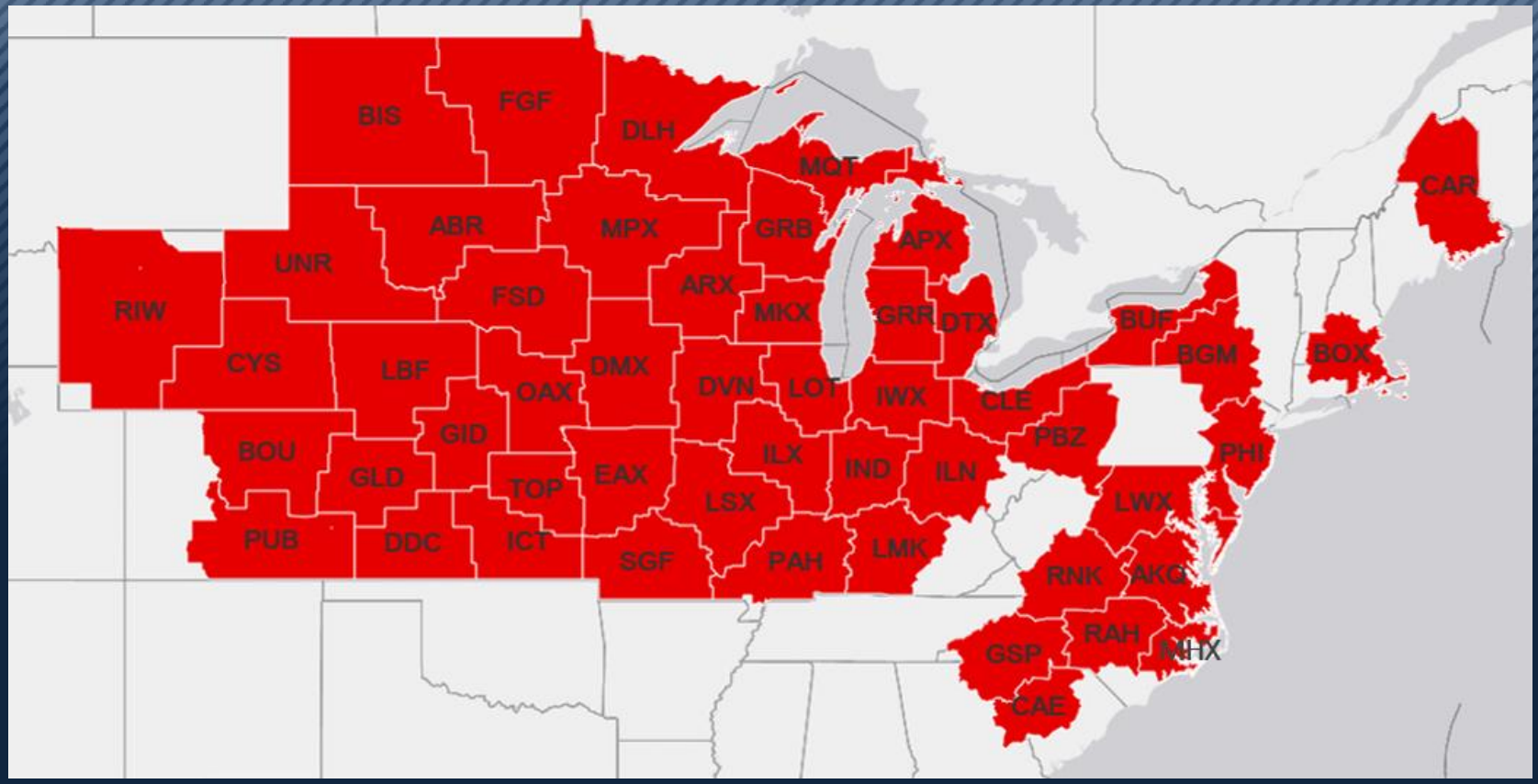




ProbSevere is one of the guidance options available in the PHI tool

Spring/Summer 2016 Central and Eastern Region Evaluation

1 April – 1 October 2016
Participating Forecast Offices…



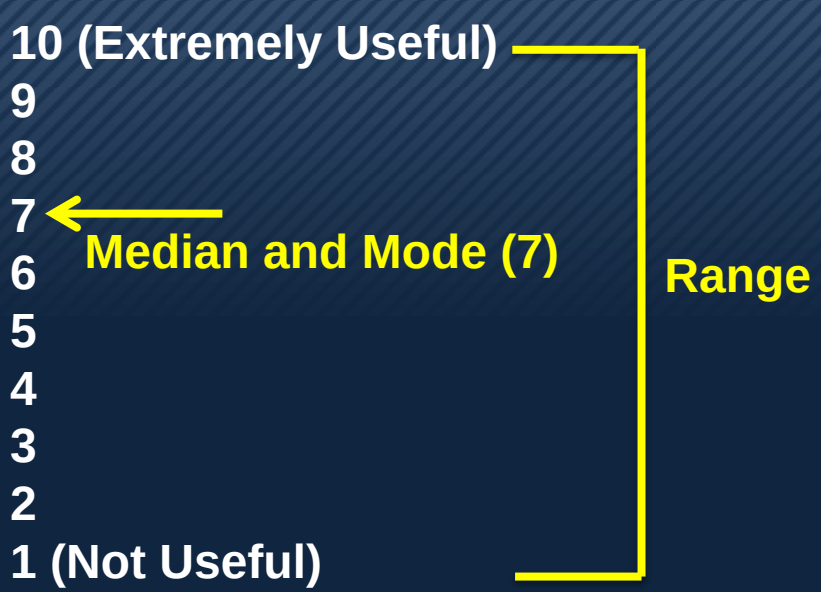
Eastern Region: 15
Central Region: 37

Credit: Chad Gravelle

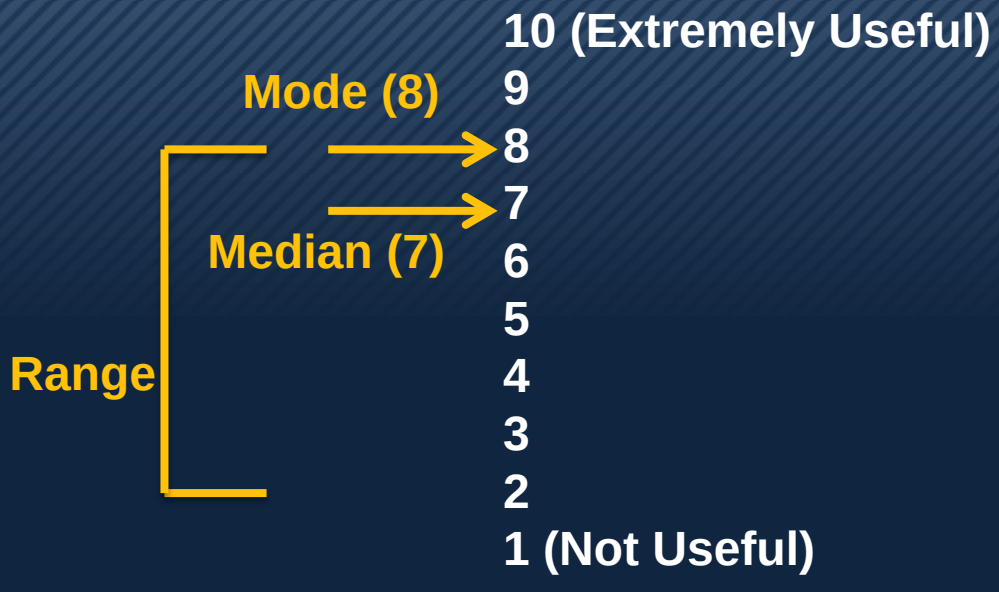
52 offices…18 forecasters (assumptions)…potentially 936 sets of eyes

Spring/Summer 2016 Central and Eastern Region Evaluation

Overall, during the CR and ER ProbSevere Model evaluation, how useful did your office find ProbSevere for providing confidence in issuing or not issuing convective warnings on thunderstorms?

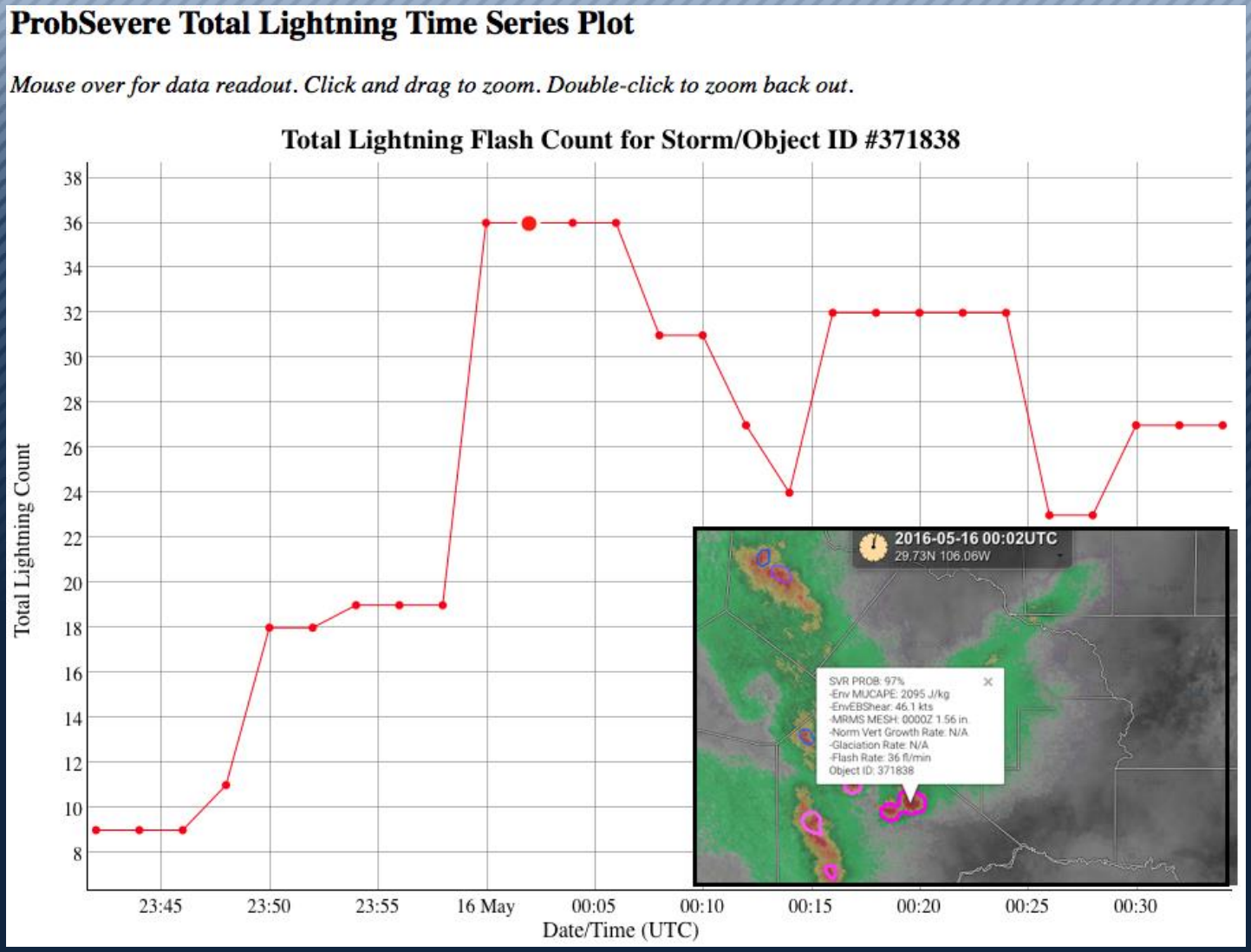


62 forecasters



25 SOO's

Realtime ProbSevere Time Series Analysis



http://hopwrf.info/ProbSevere/PlotLightning.html

ProbSevere – Multi NOAA Line Office Research and R2O Effort

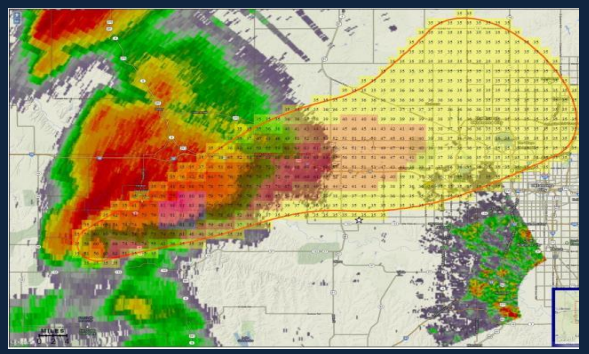
NOAA Satellites (NESDIS)

NOAA Research (OAR)

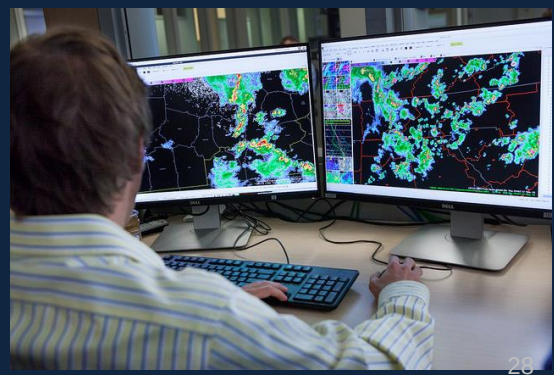
National Weather Service (NWS)

Project lead, satellites, data fusion

MRMS, lightning, PHI

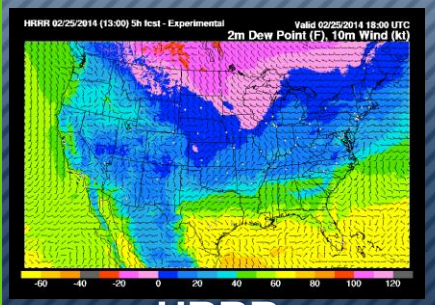


End user, O2R

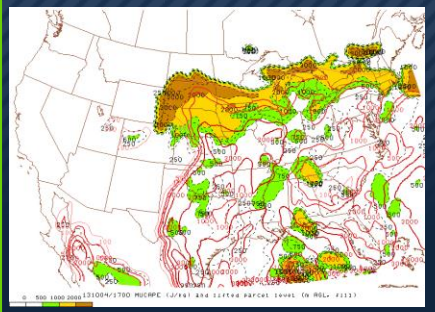


ProbSevere is Expandable

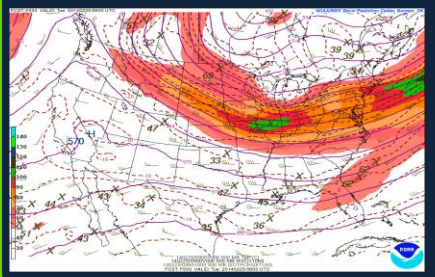
NWP



HRRR



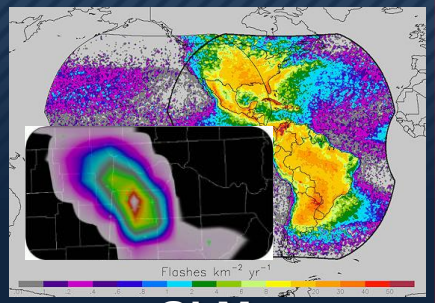
SPC-OA



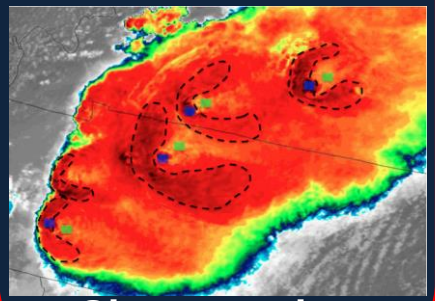
SREF

GOES-R

Super-rapid scan

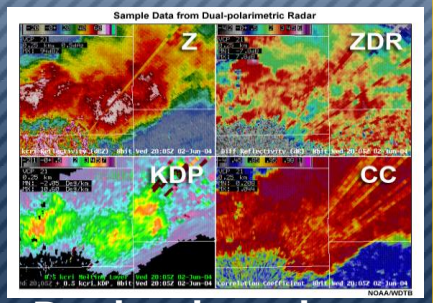


GLM

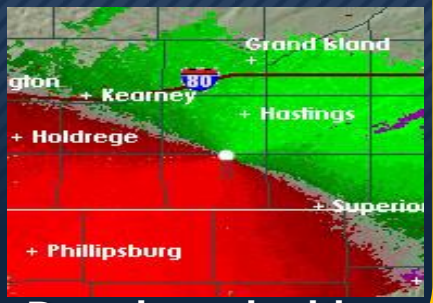


Cb properties

NEXRAD

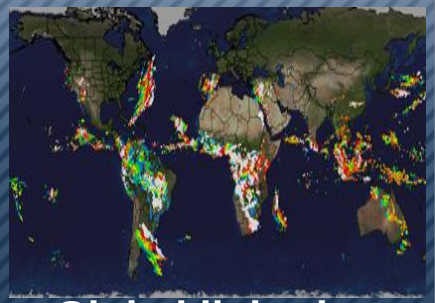


Dual-pol products

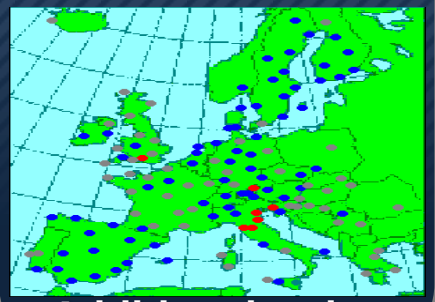


Doppler velocities

Other



Global lightning

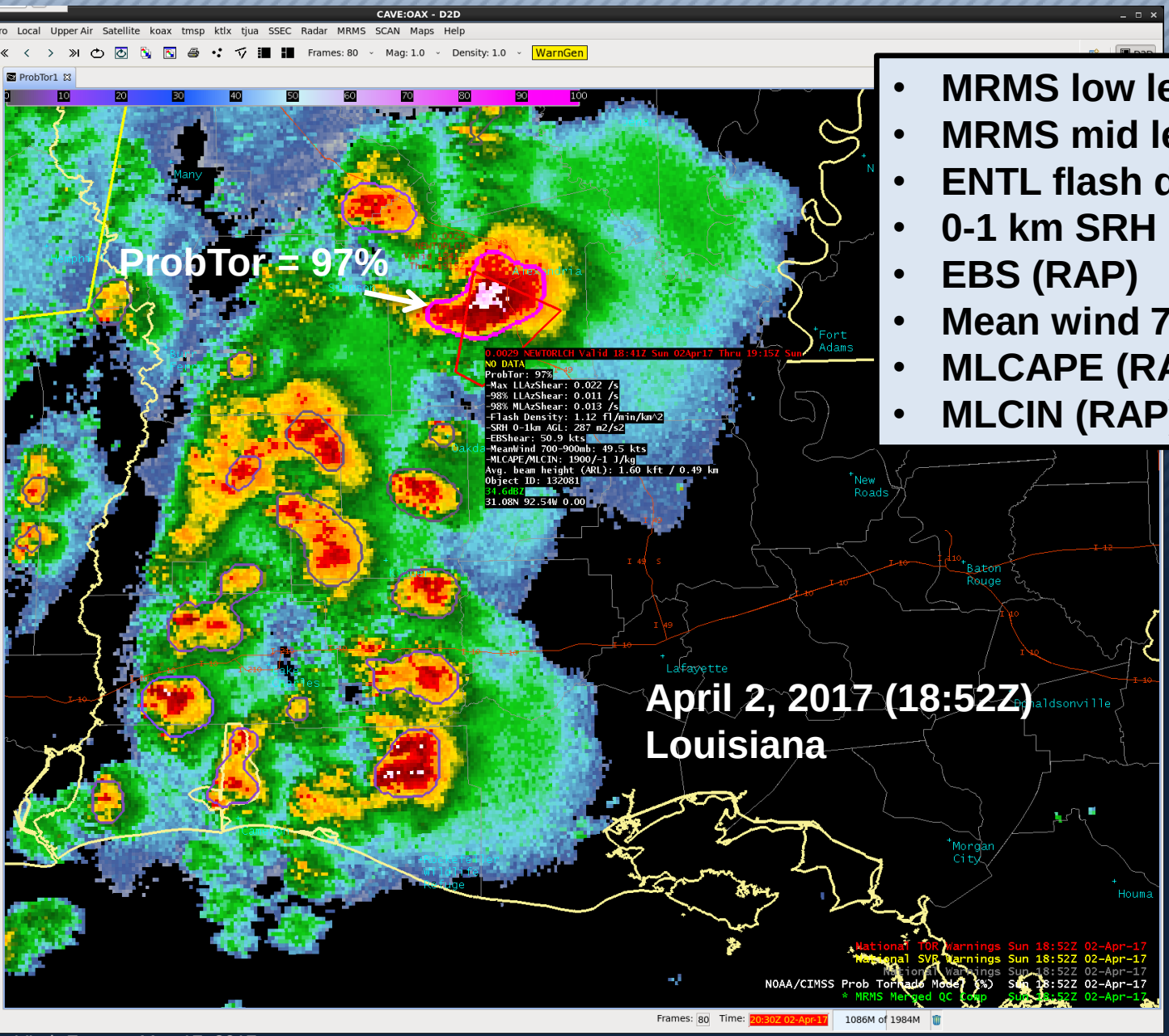


Additional radars

Hazard specific probabilities (tornado, hail, wind) are being evaluated in the 2017 HWT

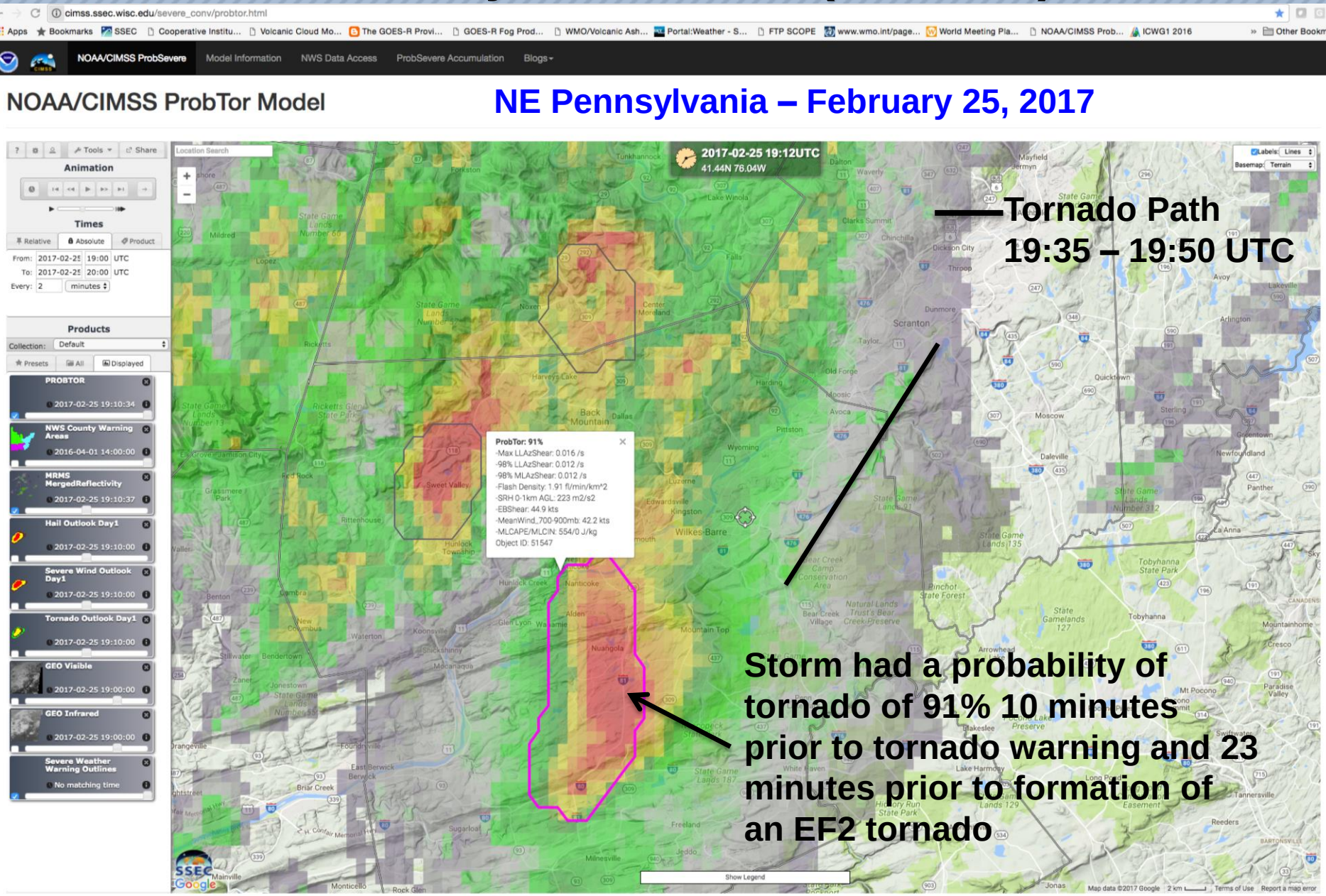
Images are from NOAA, NASA, UW-CIMSS, and OU-CIMMS

Probability of Tornado (ProbTor)

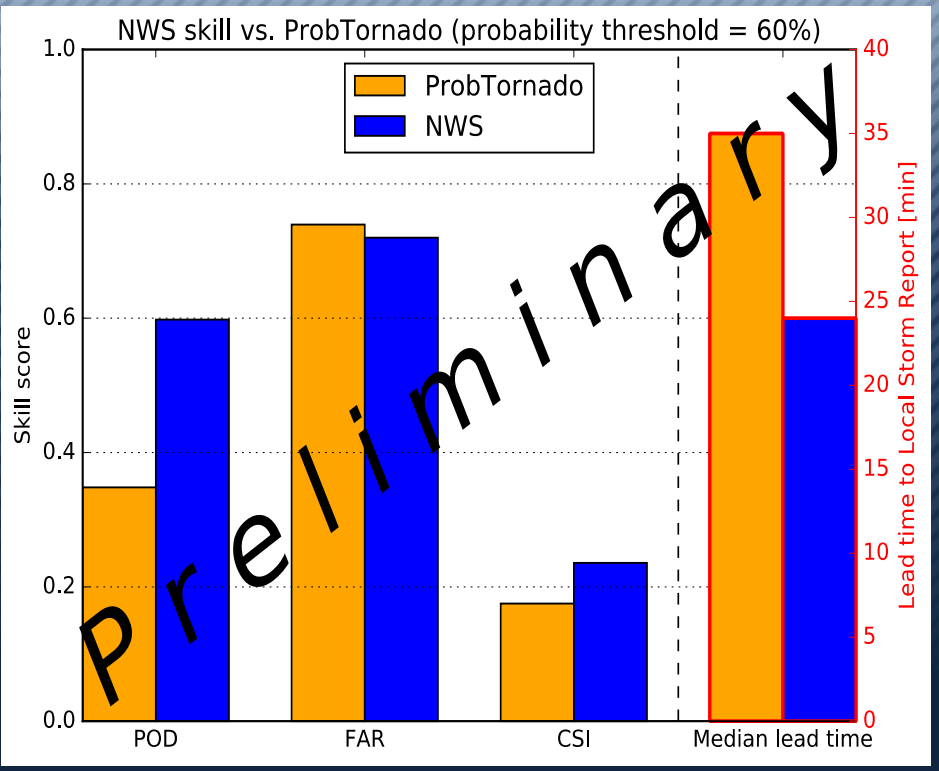


- MRMS low level az. shear
- MRMS mid level az. shear
- ENTL flash density
- 0-1 km SRH (RAP)
- EBS (RAP)
- Mean wind 700-900 mb (RAP)
- MLCAPE (RAP)
- MLCIN (RAP)

Probability of Tornado (ProbTor)

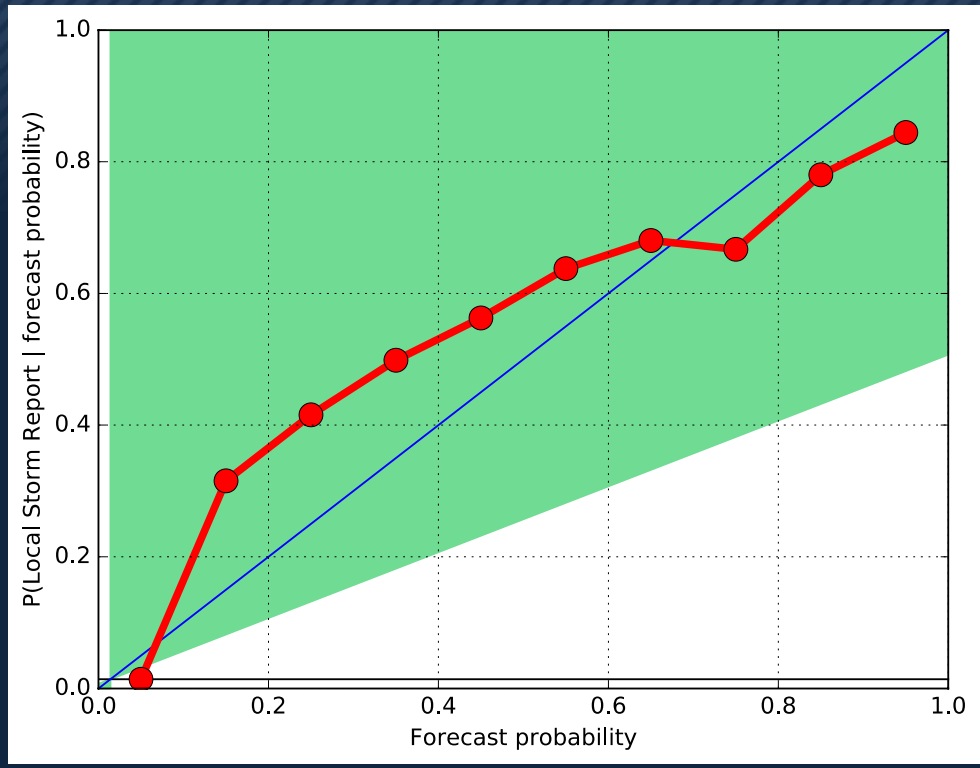


Storm Centric ProbTor Verification



ProbTor shows promise, but there are some known issues that are being worked:

- **Radar artifacts**
- **RAP limitations**

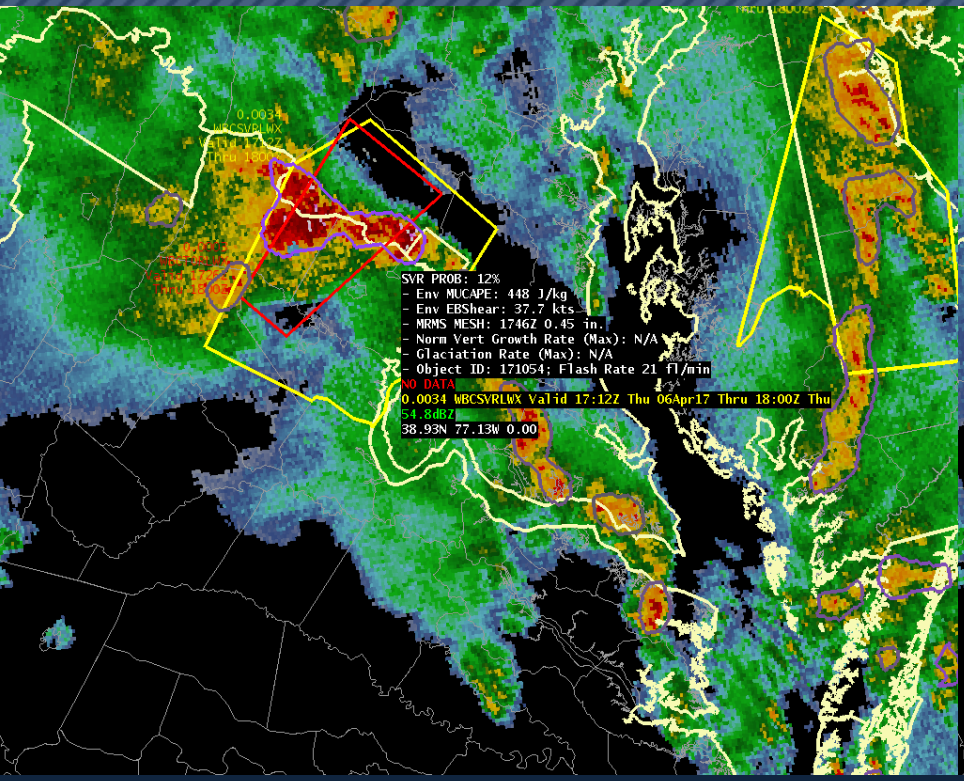


Human experts will always add value!

“All Hazards” ProbSevere

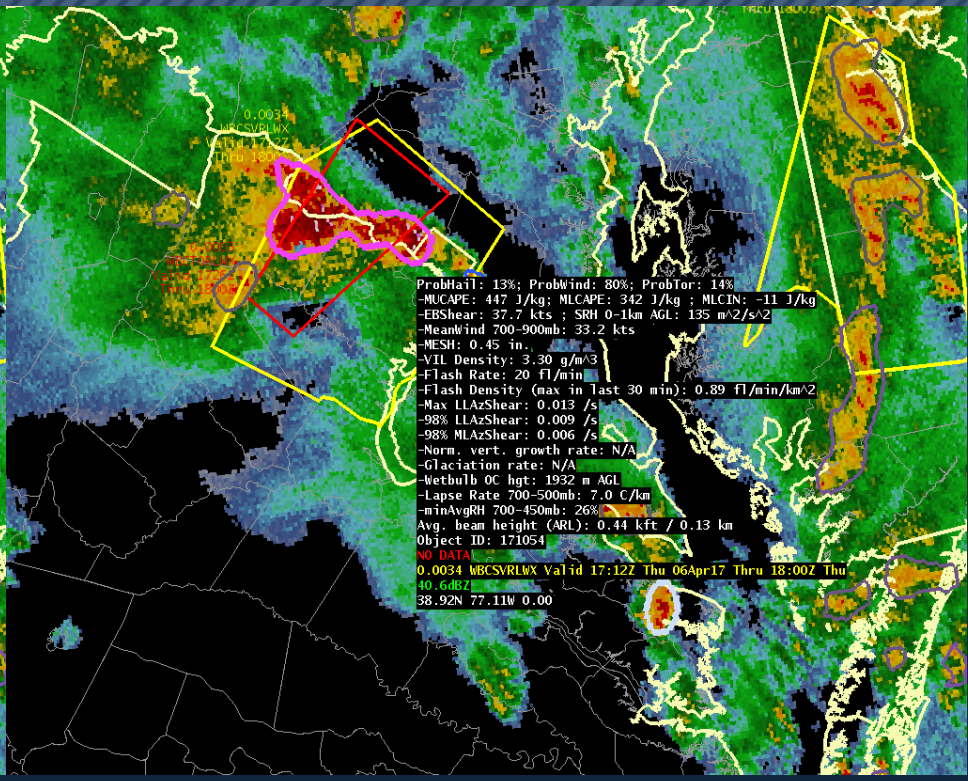
April 6, 2017 (17:48Z) – Washington D.C. Area

Legacy ProbSevere



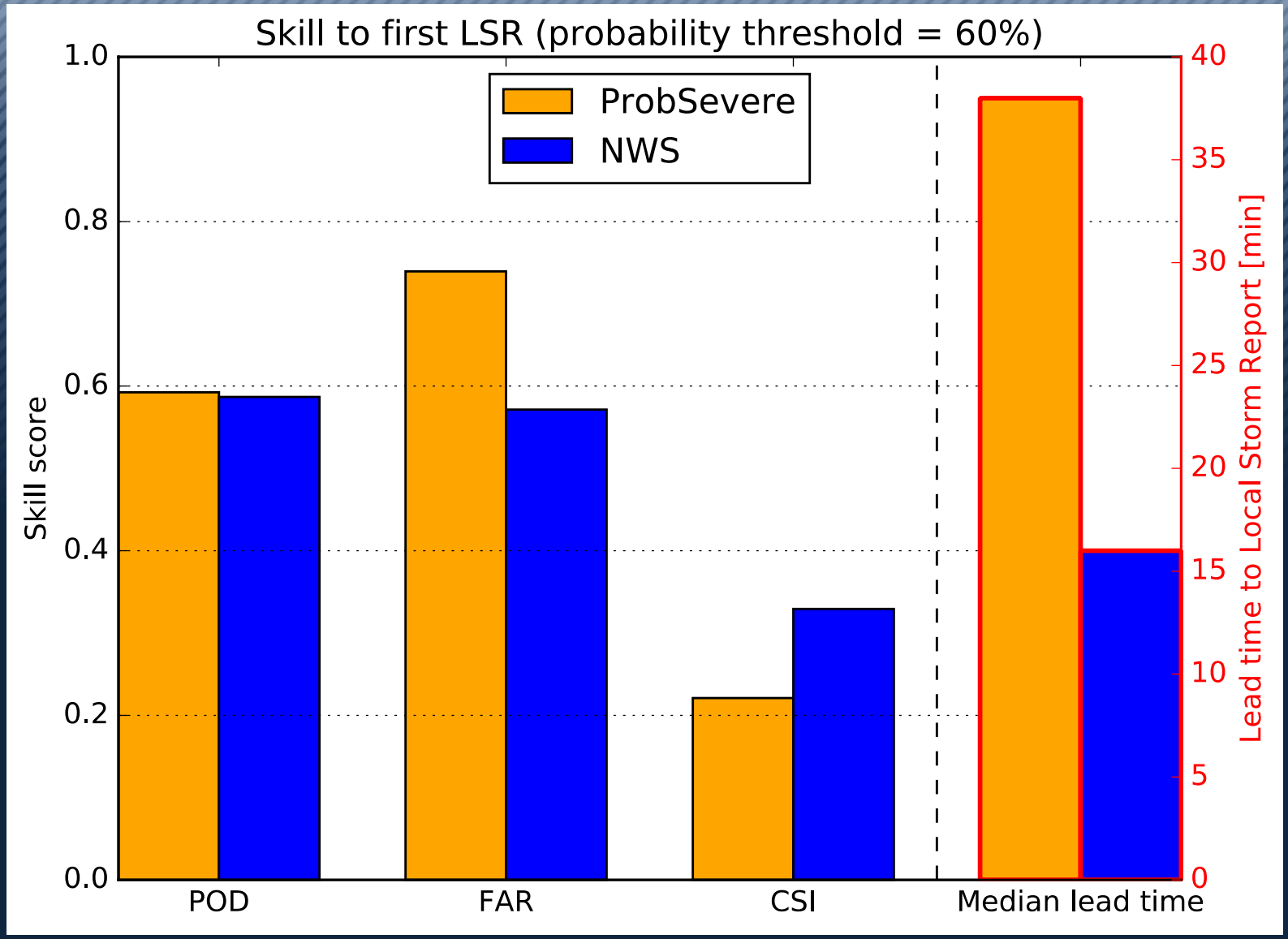
ProbSevere = 12%

“All Hazards” ProbSevere

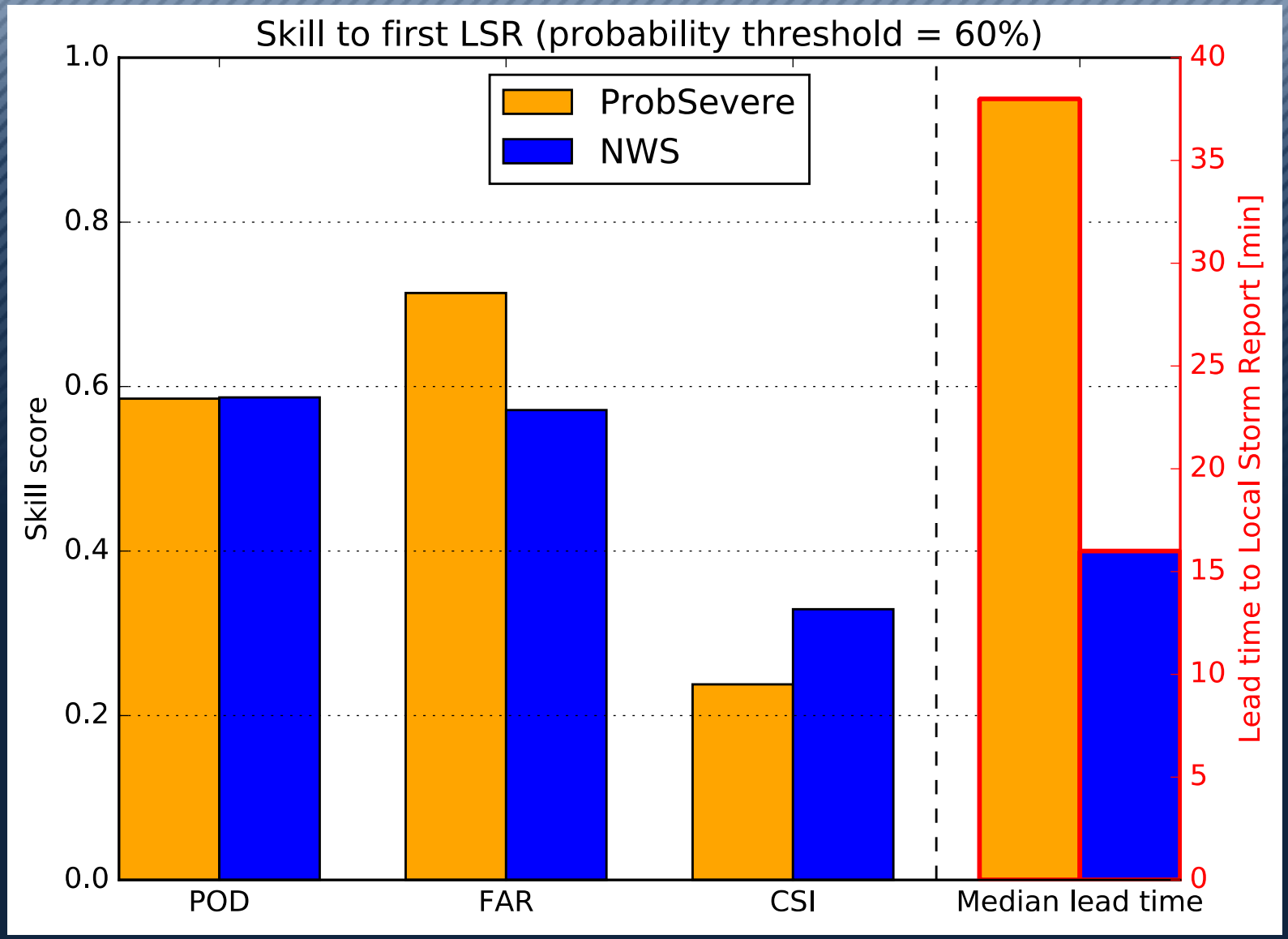


ProbHail = 13%
ProbWind = 80%
ProbTor = 14%

Legacy ProbSevere wrt First LSR



“All Hazards” ProbSevere wrt First LSR



Summary

Goal: ProbSevere is designed to directly support NWS severe weather warning operations through data fusion

R2O: Optimistic that ProbSevere will be added to MRMS product generation suite at NCO in coming years

User Readiness: Most NWS forecasters have taken the ProbSevere training and have experience using it at WFO's or the HWT

Development: An "all hazards: version of ProbSevere will be evaluated in the 2017 HWT EWP and PHI experiment (future availability in baseline AWIPS depends on HWT results and AWIPS development schedule)

GOES-16 Status: Work is underway to re-train ProbSevere with on-orbit GOES-16 data by the Fall 2017 (improvements in lead-time and accuracy are expected)

Additional Resources

- Mike Pavolonis – NOAA/NESDIS/STAR (michael.pavolonis@noaa.gov)
- John Cintineo – UW/CIMSS (john.cintineo@ssec.wisc.edu)
- Justin Sieglaff – UW/CIMSS (justin.sieglaff@ssec.wisc.edu)
- Dan Lindsey – NOAA/NESDIS/STAR (dan.lindsey@noaa.gov)

ProbSevere training modules and supplemental training material:
http://cimss.ssec.wisc.edu/severe_conv/training/training.html

ProbSevere blog posts:
http://goesrhwt.blogspot.com/search/label/ProbSevere

Realtime ProbSevere on the web:
http://cimss.ssec.wisc.edu/severe_conv/probsev.html

Realtime "All Hazards" ProbSevere on the web:
http://cimss.ssec.wisc.edu/severe_conv/probsevtest.html

Realtime ProbTor on the web:
http://cimss.ssec.wisc.edu/severe_conv/probtor.html

Realtime ProbSevere time series:
http://hopwrf.info/ProbSevere/PlotLightning.html

References

Pavolonis, M. J., 2010: Advances in Extracting Cloud Composition Information from Spaceborne Infrared Radiances-A Robust Alternative to Brightness Temperatures. Part I: Theory. Journal of Applied Meteorology and Climatology, **49**, 1992-2012, doi:10.1175/2010JAMC2433.1 ER.

Cintineo, John L.; Pavolonis, Michael J.; Sieglaff, Justin M. and Heidinger, Andrew K. Evolution of severe and nonsevere convection inferred from GOES-derived cloud properties. Journal of Applied Meteorology and Climatology, **52 (9)**, 2013, 2009–2023.

Cintineo, John L.; Pavolonis, Michael J.; Sieglaff, Justin M. and Lindsey, Daniel T. An empirical model for assessing the severe weather potential of developing convection. Weather and Forecasting, **29 (3)**, 2014, 639–653.

Questions?

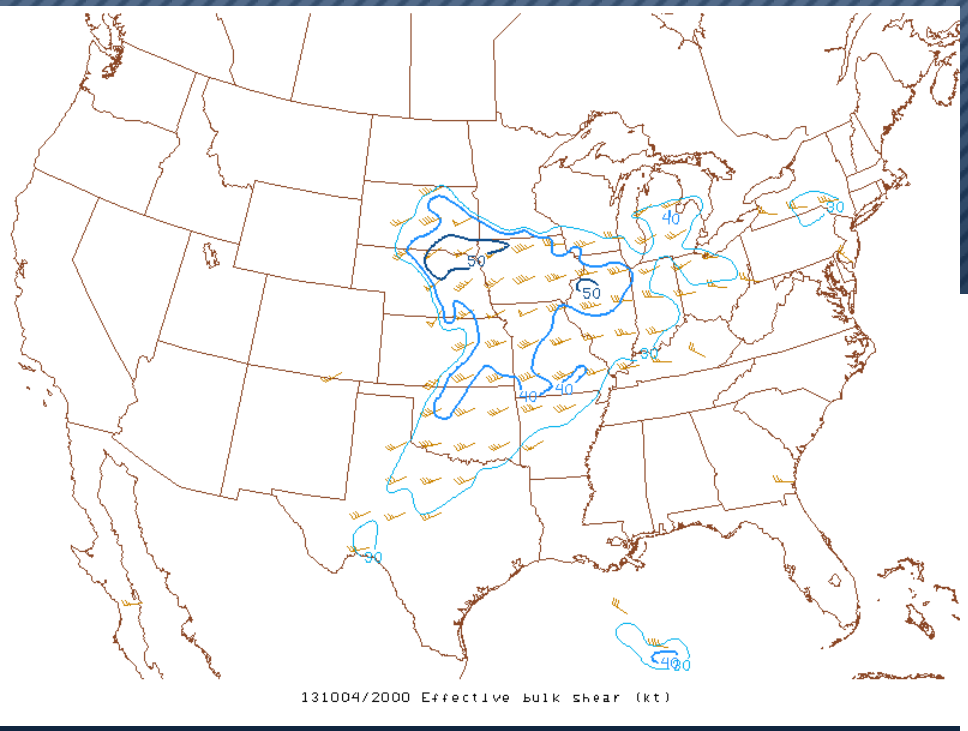
BACKUP SLIDES

"Big Data" to Environmental Intelligence

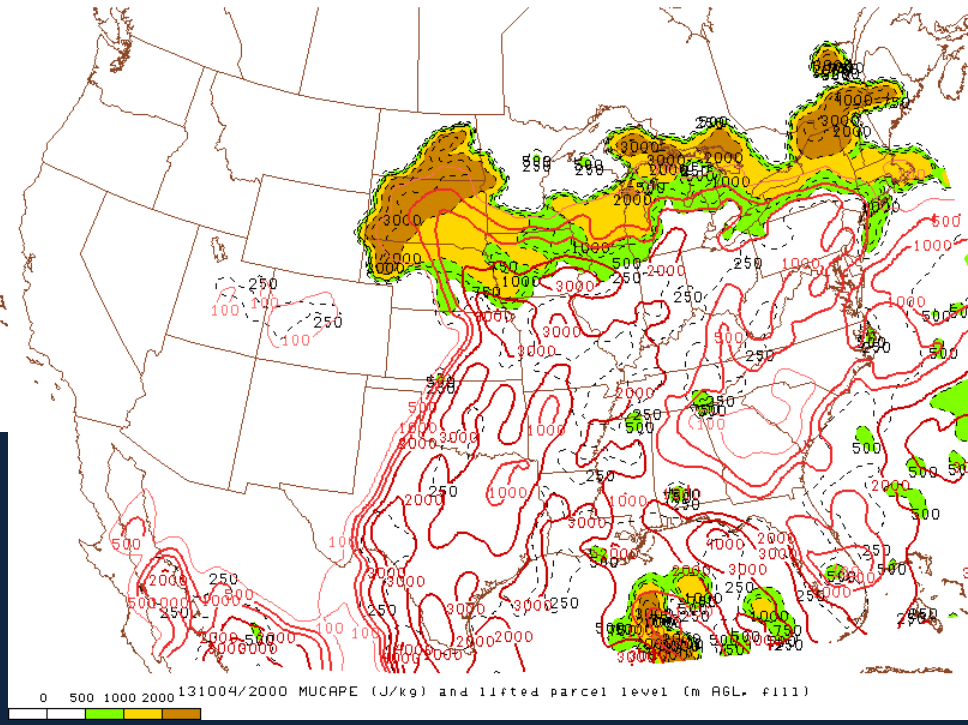
1). Mesoscale NWP

Short-term forecasts from the Rapid Refresh NWP model are used to characterize the dynamic and thermodynamic environment.

Effective Bulk Shear



Most Unstable CAPE

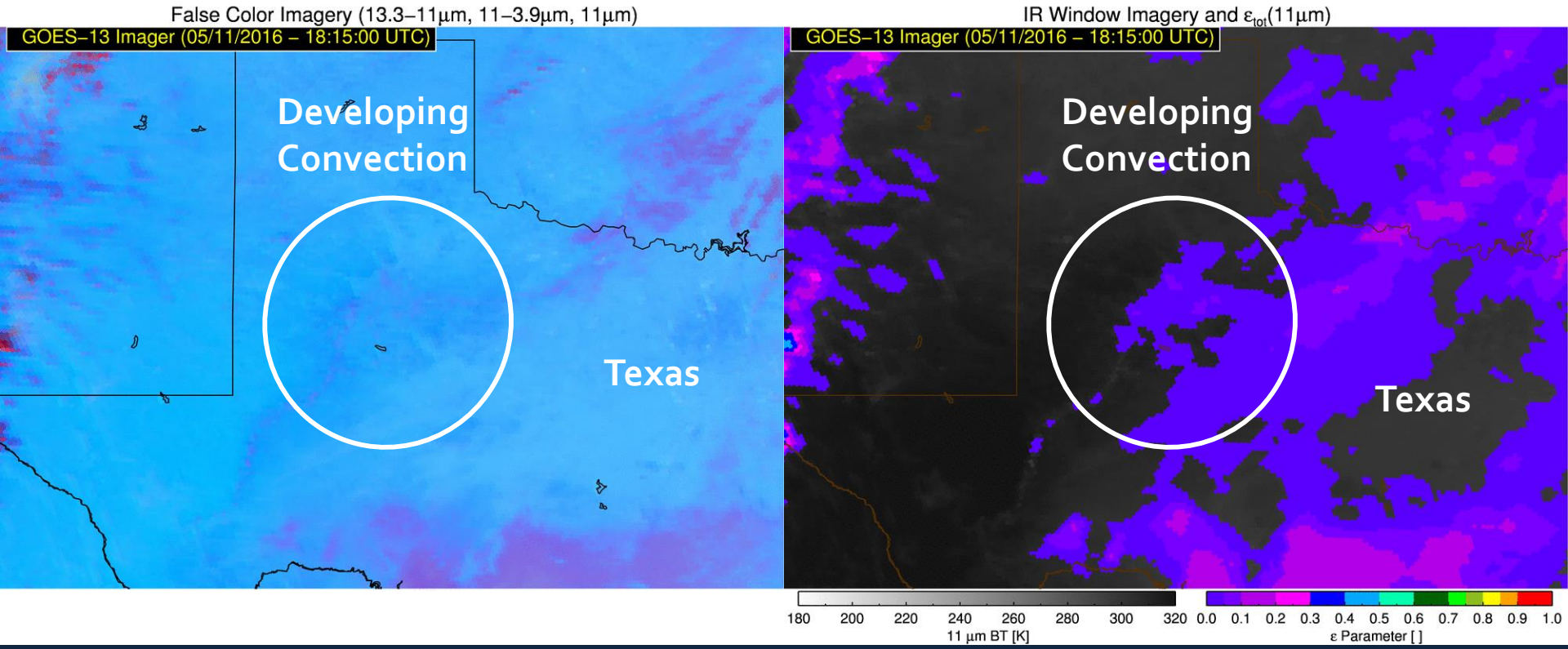


"Big Data" to Environmental Intelligence

2). Geostationary Satellite Data

False Color Image

Top of Troposphere Emissivity (Pavolonis, 2010)

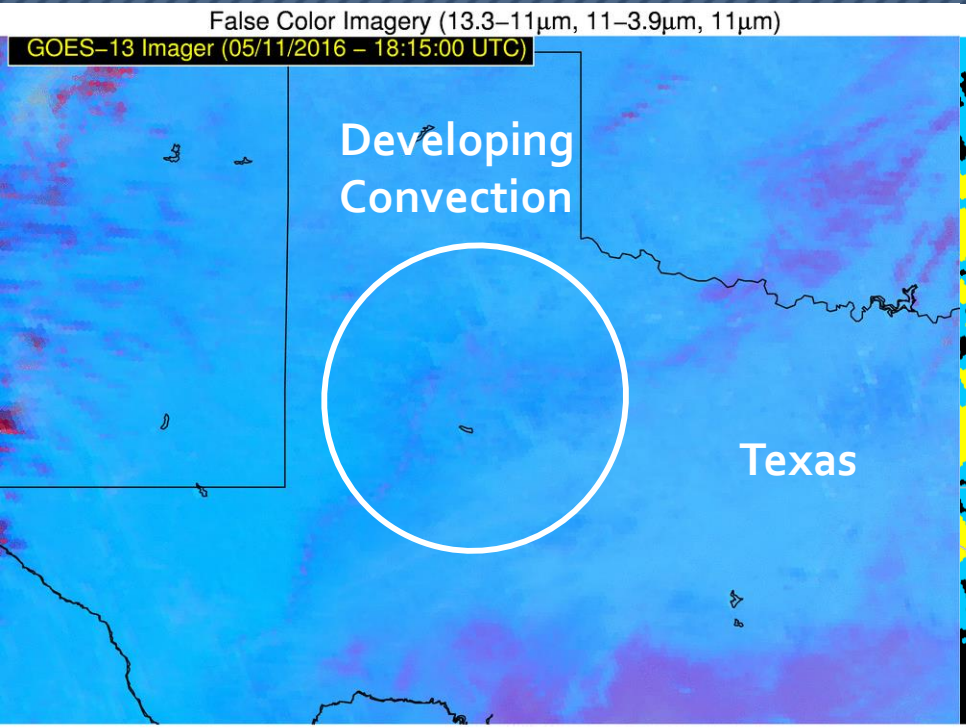


Object are extracted from ε_{tot}(11μm) and are tracked in time (Lakshmanan et al. 2003). Time trends in the maximum value of ε_{tot}(11μm) are utilized.

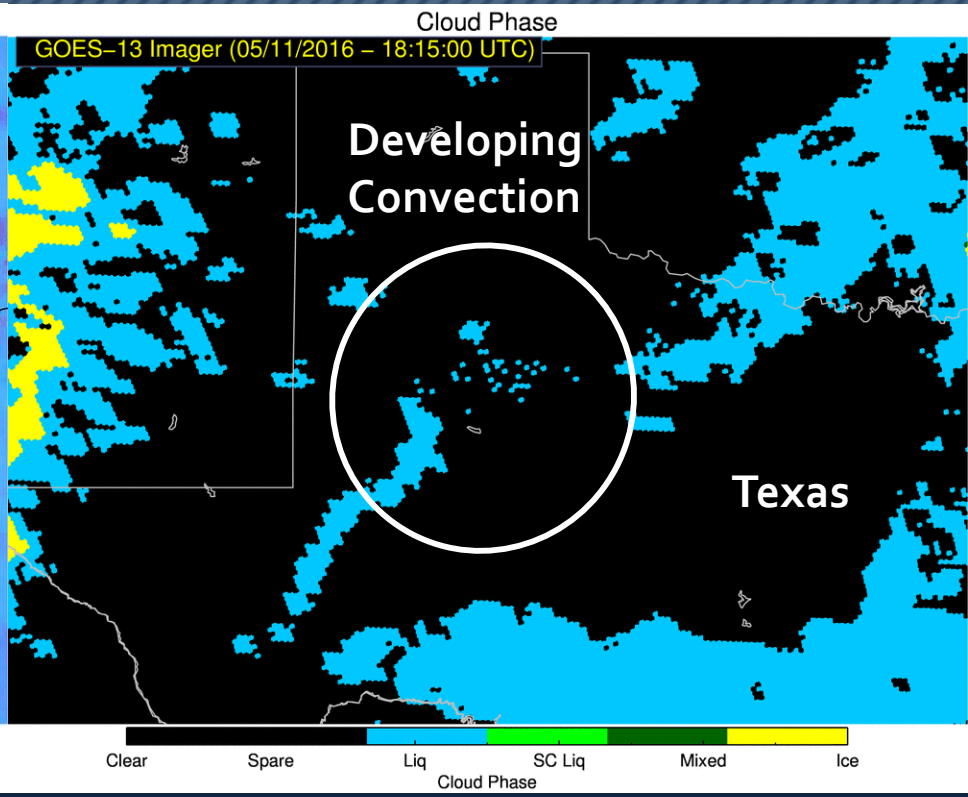
"Big Data" to Environmental Intelligence

2). Geostationary Satellite Data

False Color Image



IR-derived Cloud Top Phase (Pavolonis, 2010)

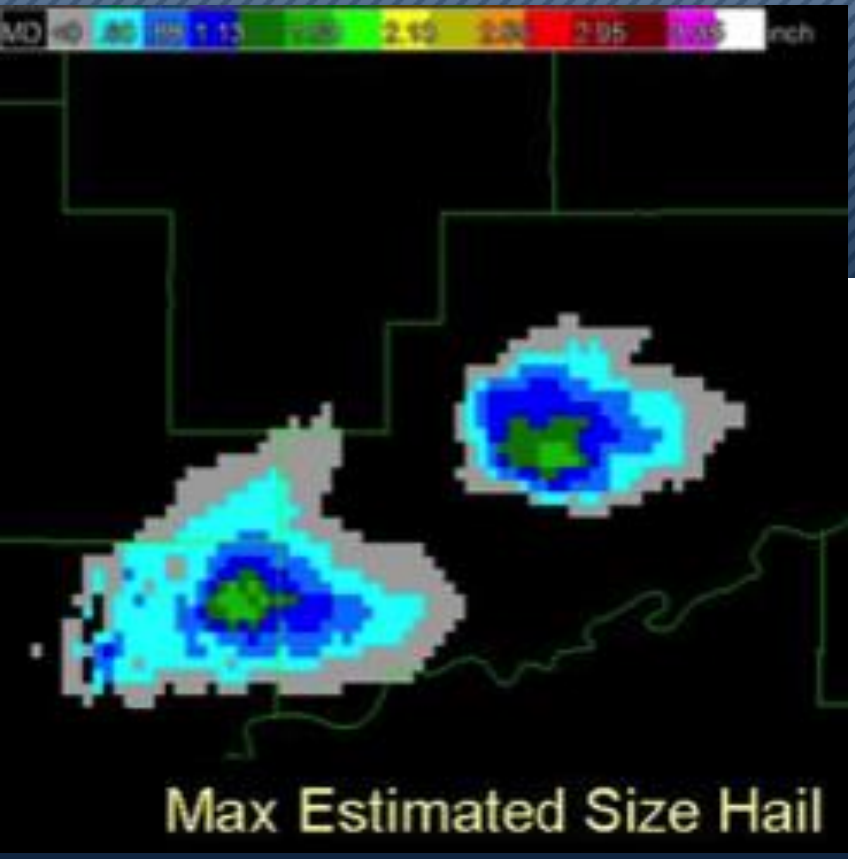


The time trend in the fraction of glaciated pixels within each object is also utilized.

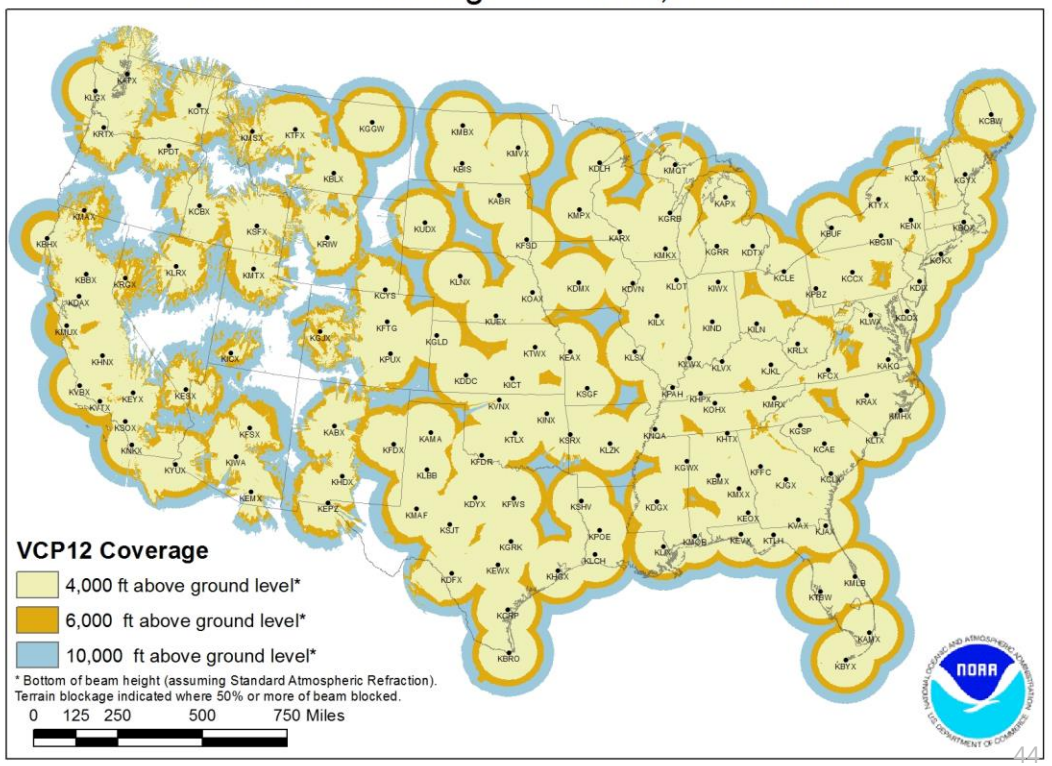
"Big Data" to Environmental Intelligence

3). Precipitation RADAR Data

MESH



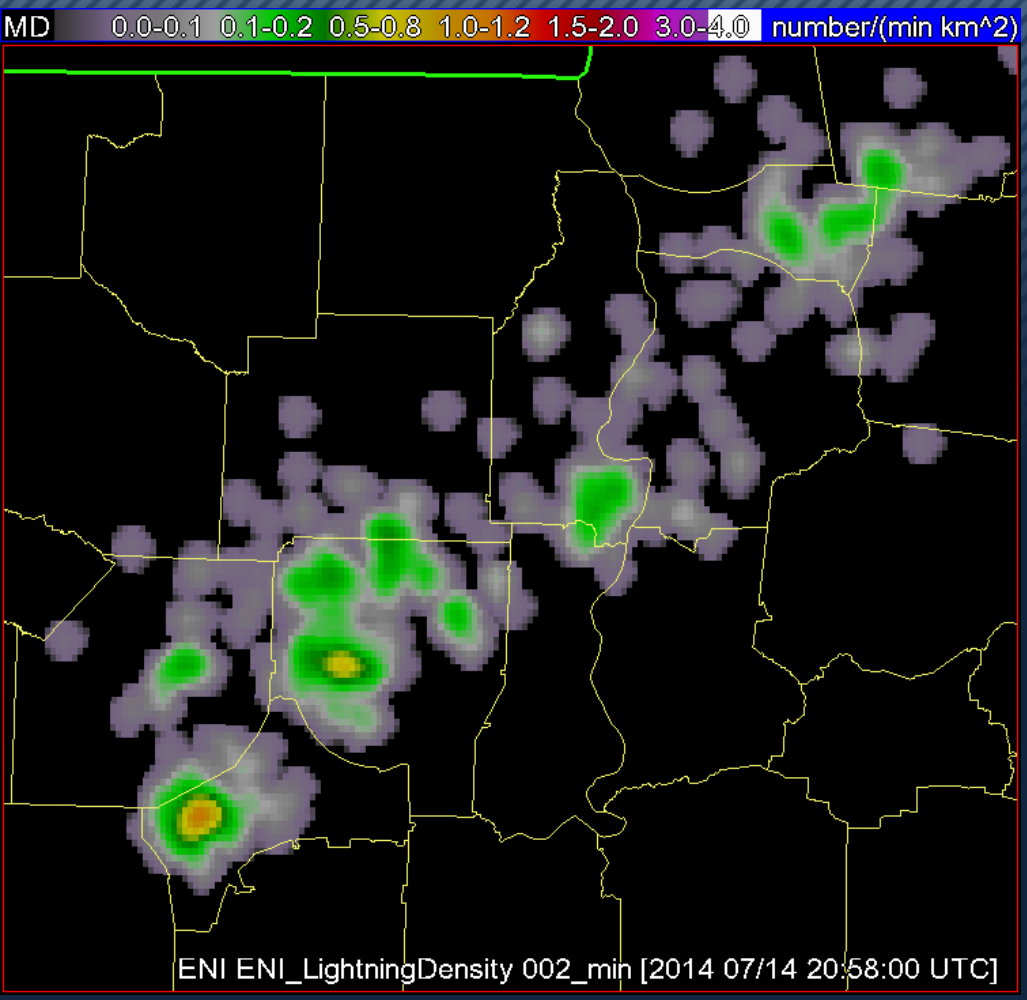
The MESH is taken from the Multi-sensor/Multi-radar System (MRMS) (Witt el al., 1998; Lakhmanan et al., 2006). The composite MRMS reflectivity is used to identify and track radar objects.



"Big Data" to Environmental Intelligence

4). Lightning Data

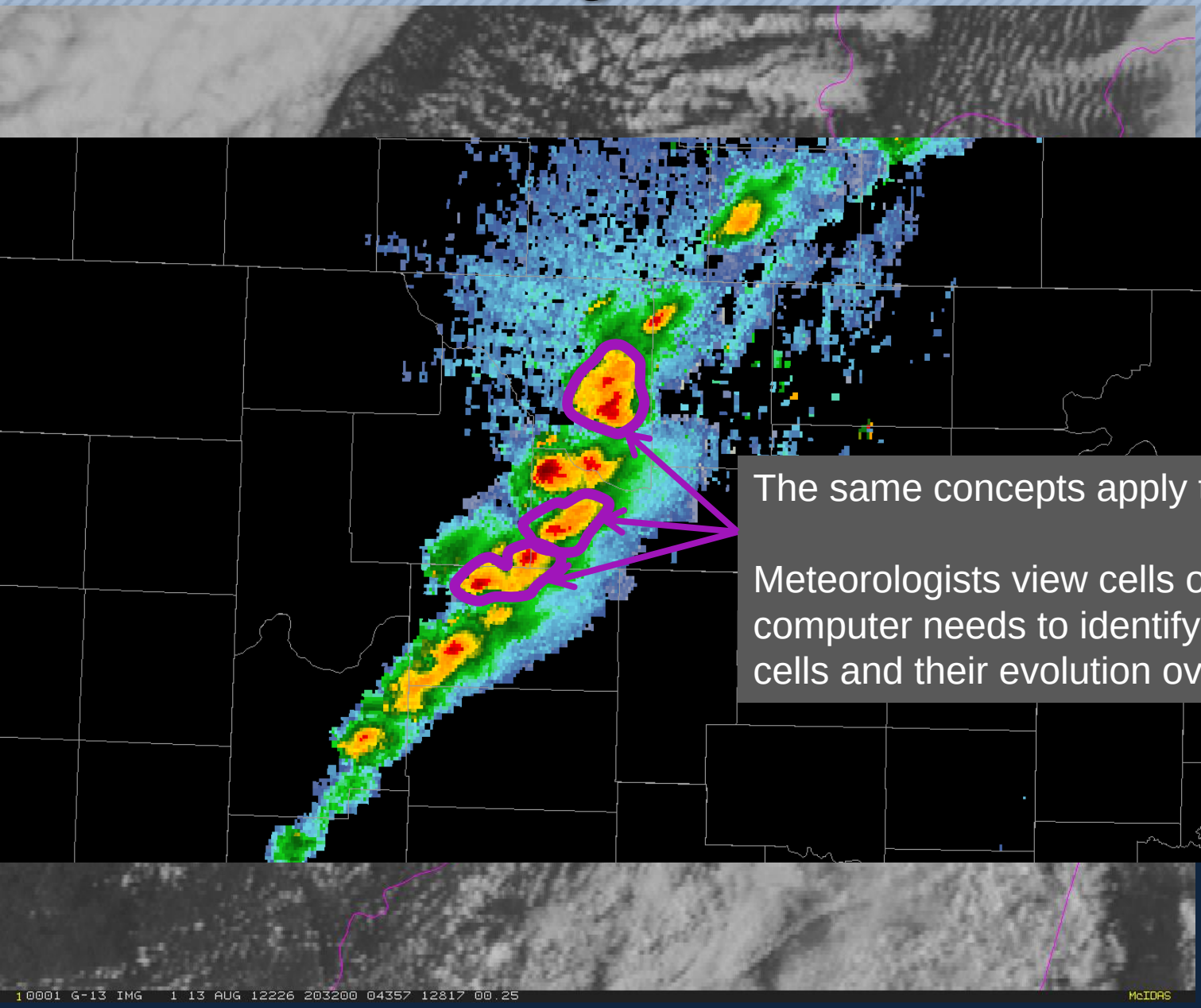
Total Lightning



Total lightning (per minute) within each radar object is utilized. The total lightning data are from Earth Networks.

Liu and Heckman, 2012

Automated integration of information



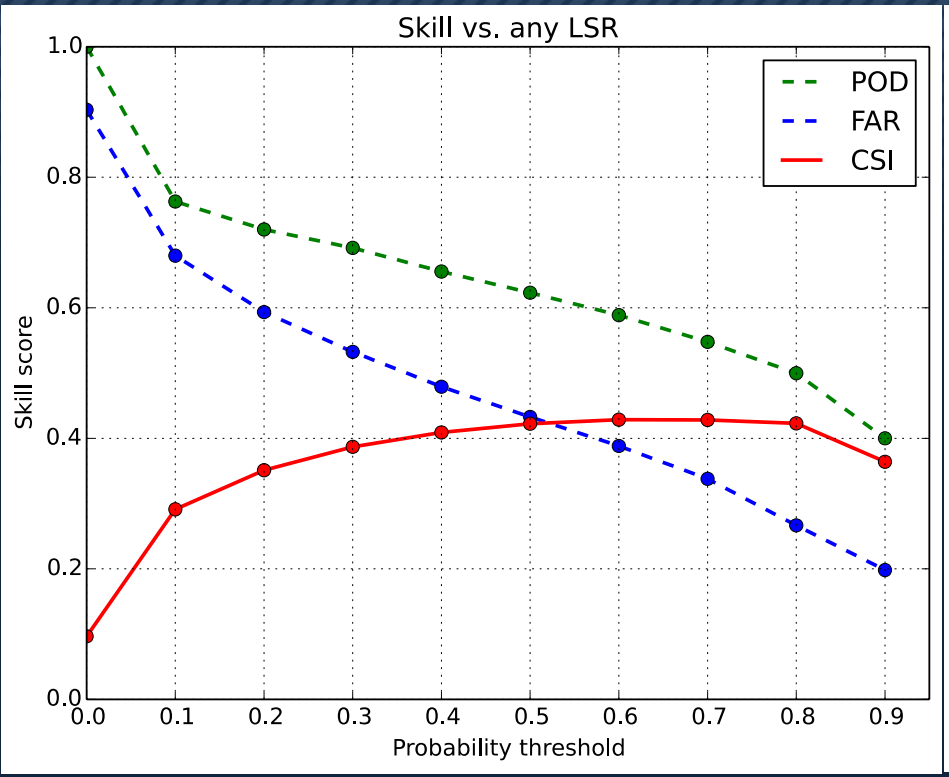
ping storms and
pixels or

The same concepts apply to radar data.

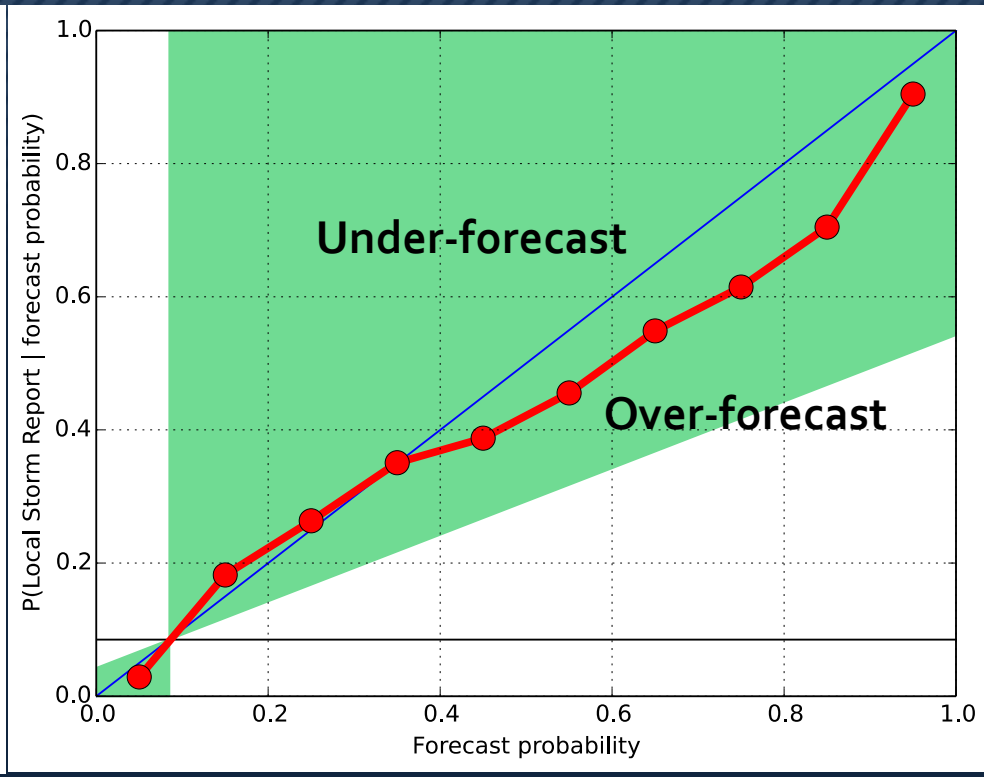
Meteorologists view cells or storms—so the computer needs to identify and track radar cells and their evolution over time.

ProbSevere Verification

Once a 60% probability is achieved, any gain in CSI at higher probabilities is negligible



Overall, the ProbSevere probabilities are well calibrated



Spring/Summer 2016 Central and Eastern Region Evaluation

"It seems that ProbSevere has become a standard display to load up on several of the forecaster's routine procedures during convection, a sign that many of our forecasters have enough experience with the model that they have at least some confidence in the product."

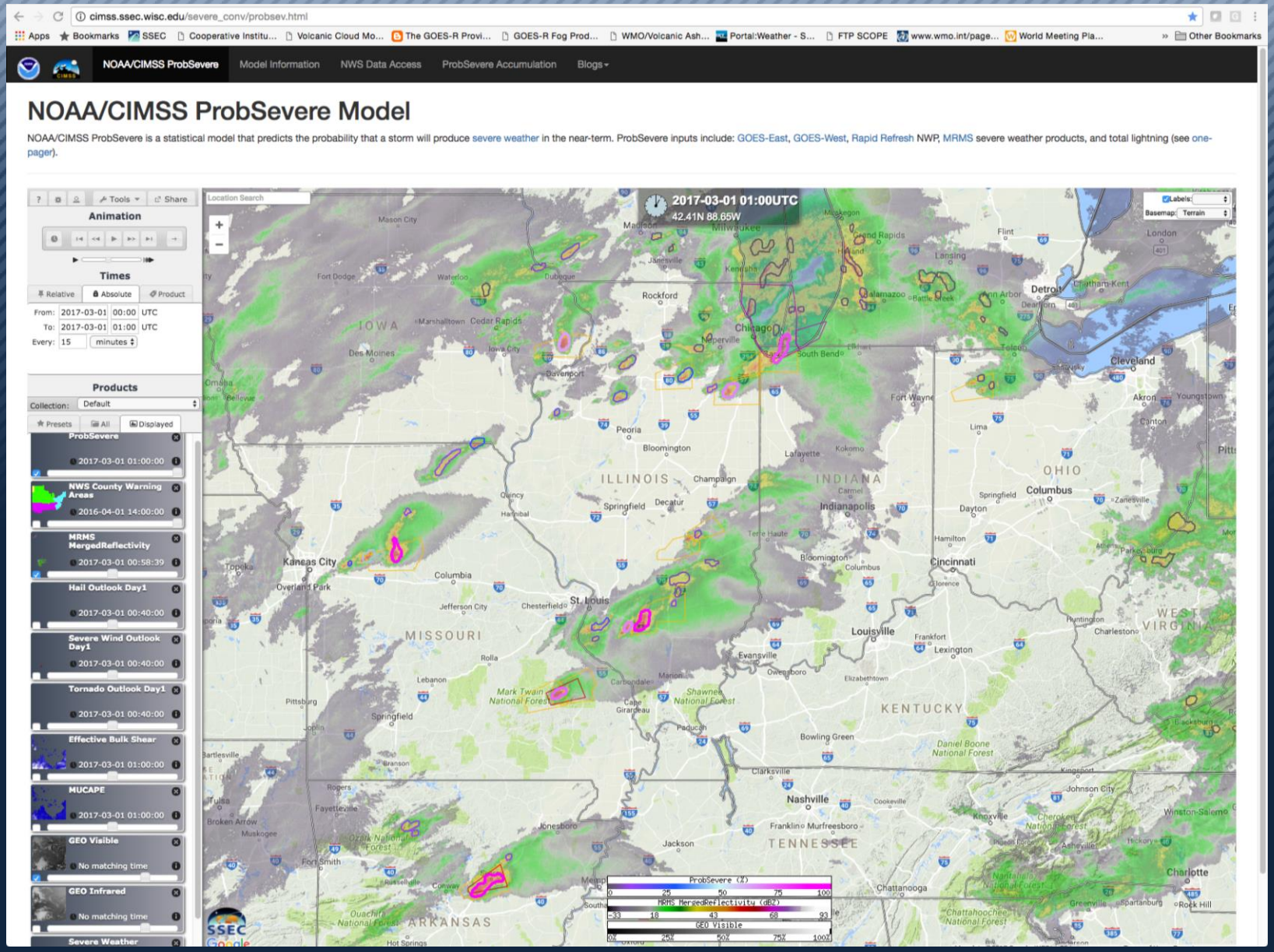
"As people got comfortable using the data it became very useful, especially in marginal cases and when the warning met wanted to issue a warning early in a storms life. We had a supercell event where a storm was quickly building and warnings were issued before a robust core aloft. ProbSevere gave us another piece of data to support the warning decision to our customers before it was apparent on legacy radar techniques."

"I think we all found the best use of ProbSevere to be what storms to NOT focus on as much. In that way, ProbSevere improved radar efficiency on a scope full of storms...guiding us to more detailed interrogation on the higher probability storms."

"ProbSevere was most valuable on days with numerous cells with just one person on radar, helping to quickly determine which cells to focus on and which not to."

"I think those who used the model as a guide to determine what storms to focus a more detailed assessment on generally were pleased. With 4 RPGs in our CWA (3 TDWRs and an 88D) we need all the time/awareness efficiency we can get."

http://cimss.ssec.wisc.edu/severe_conv/probsev.html



ProbSevere History

- 2007: Small exploratory project to utilize GOES Imager derived cloud properties for quantitatively diagnosing and forecasting severe storms begins under NESDIS GIMPAP
- 2011: First version of ProbSevere (GOES + NWP)
- 2012: NEXRAD added to ProbSevere
- 2013: ProbSevere project continues under GOES-R Risk Reduction Program
- 2013: Internal NRT evaluation of ProbSevere at UW-CIMSS
- 2014: ProbSevere successfully demonstrated at HWT EWP
- 2014: ProbSevere evaluated at WFO MKX
- 2015: ProbSevere becomes part of AWIPS II baseline (V14.4)
- 2015: ProbSevere, with improvements, successfully demonstrated in HWT EWP
- 2016: Earth Networks lightning integrated into ProbSevere
- 2016: ProbSevere, with lightning, successfully demonstrated at HWT EWP and PHI experiments
- 2016: Successful completion of NWS Eastern, Central, Southern, and Western Region demonstrations
- 2017: Began testing ProbSevere upgrades for improved forecasting of severe straight-line winds across spectrum of storm type
- 2017: ProbTor model is evaluated in HWT EWP and PHI experiments
- 2017: ProbSevere is assessed in Operations Proving Ground

The Weather Channel

Local Media Coverage: Peoria, IL

https://www.youtube.com/watch?v=493mk5K1pO8