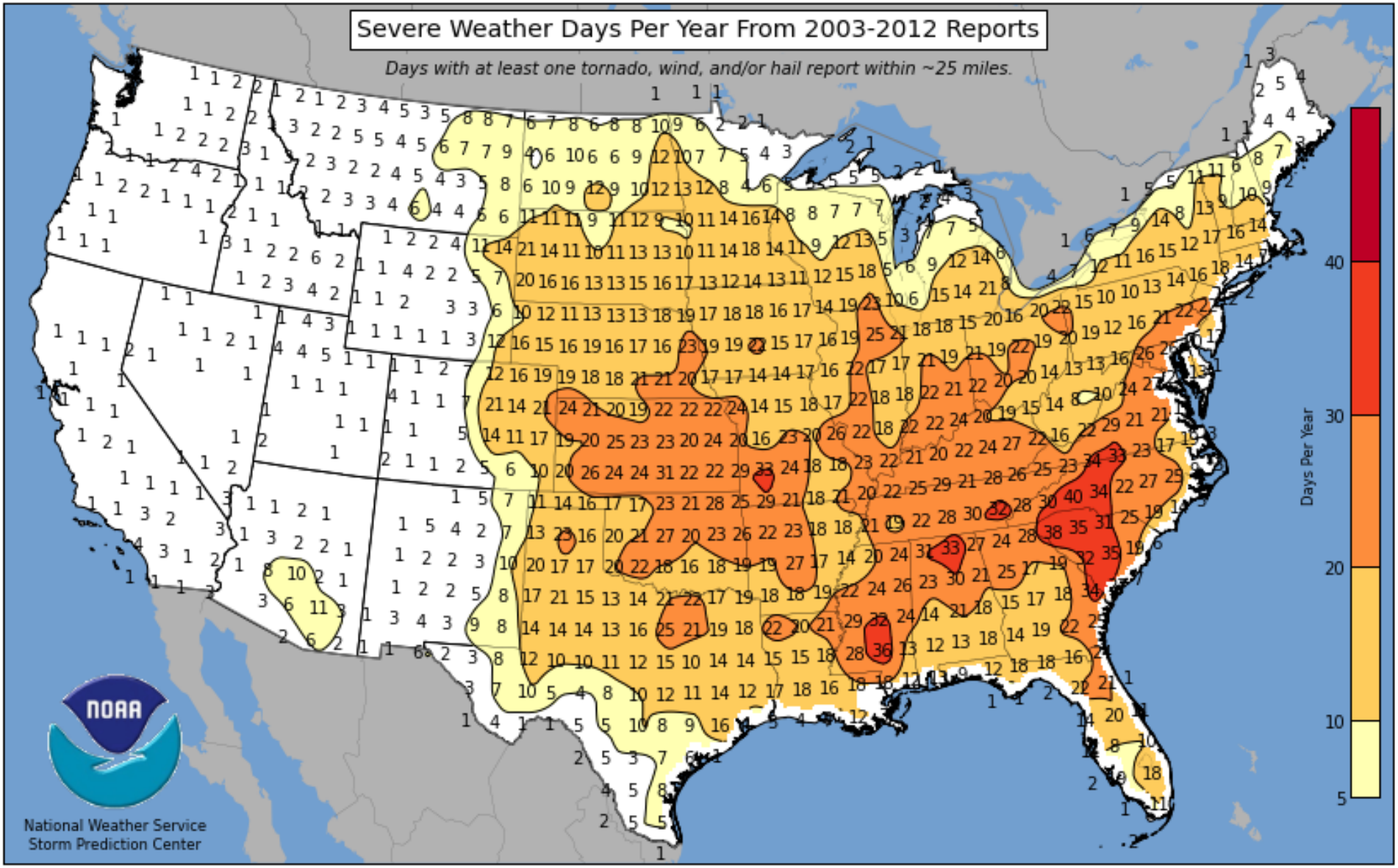
Integrated Observations for Probabilistic Severe Weather Prediction

Mike Pavolonis[1], John Cintineo[2], Justin Sieglaff[2], and Dan Lindsey[1]

[1]NOAA/NESDIS; [2]University of Wisconsin – CIMSS/SSEC


Severe Weather Days Per Year From 2003-2012 Reports
Days with at least one tornado, wind, and/or hail report within ~25 miles.
Days Per Year
40
30
20
10
5
NOAA
National Weather Service
Storm Prediction Center

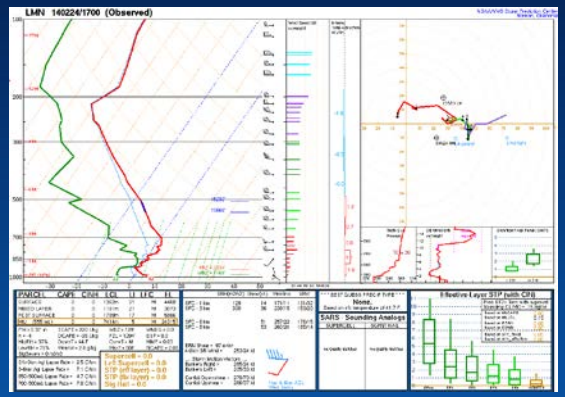
Wind gusts of 58 mph or greater or structural wind damage

Wind gusts of 58 mph or greater or structural wind damage

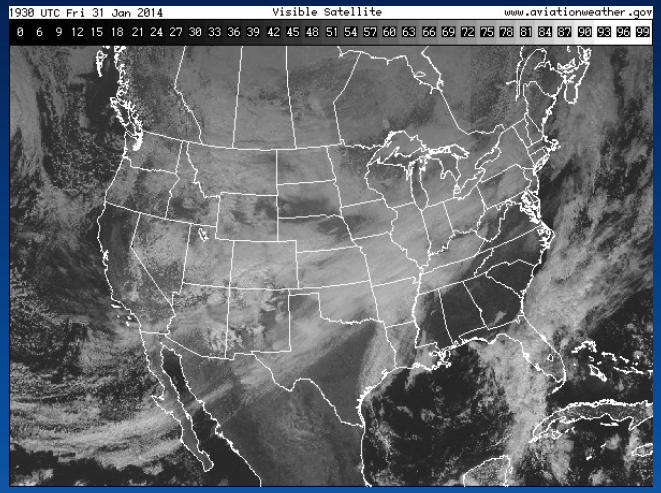
Hail 1 inch in diameter or greater

Torrent of data available to forecaster

Balloon soundings

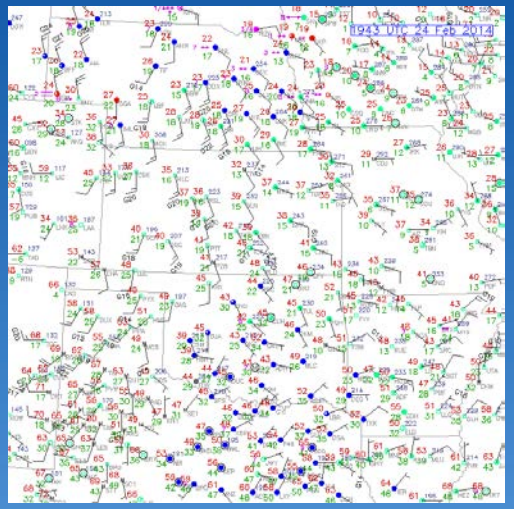


Satellite

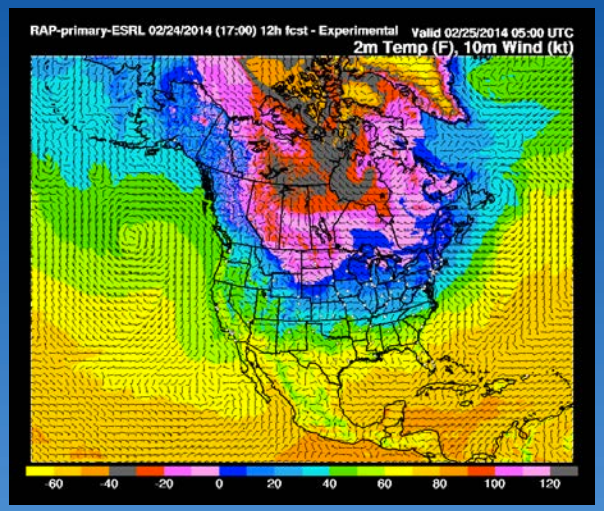


Radar

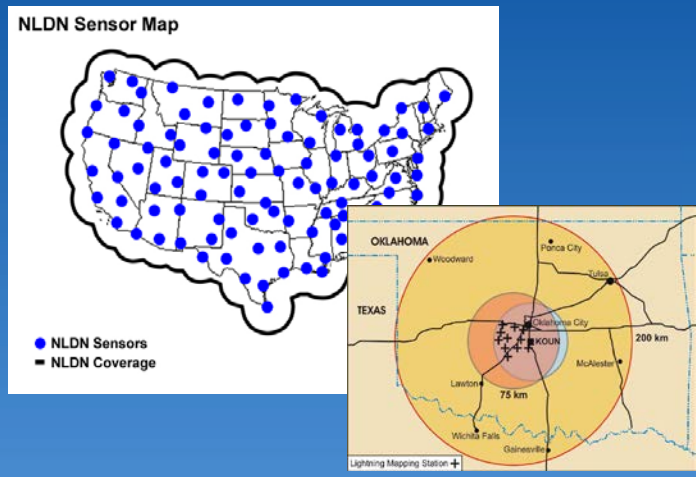
Surface stations



High-res Numerical Models

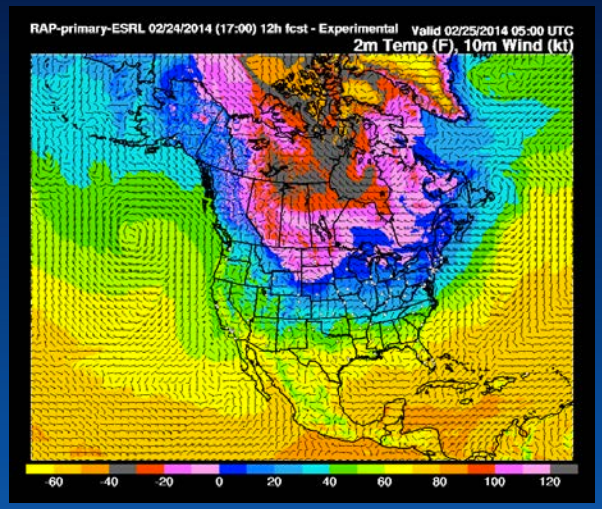


Lightning



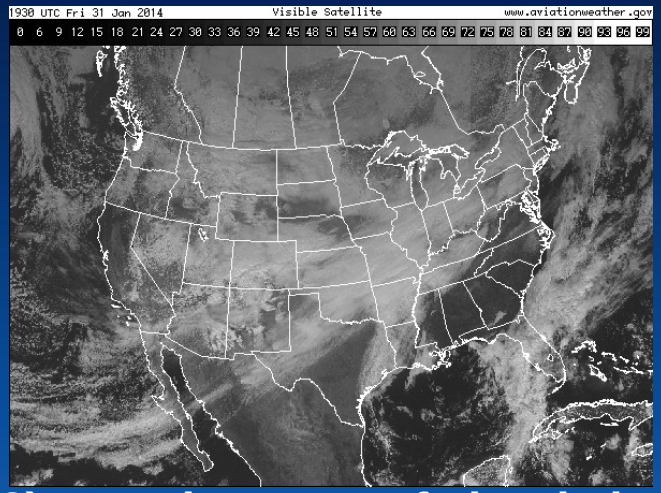
Converting "Big Data" to Information

High-res Numerical Models



1). Storm Environment
(Energetics of atmosphere)

Satellite



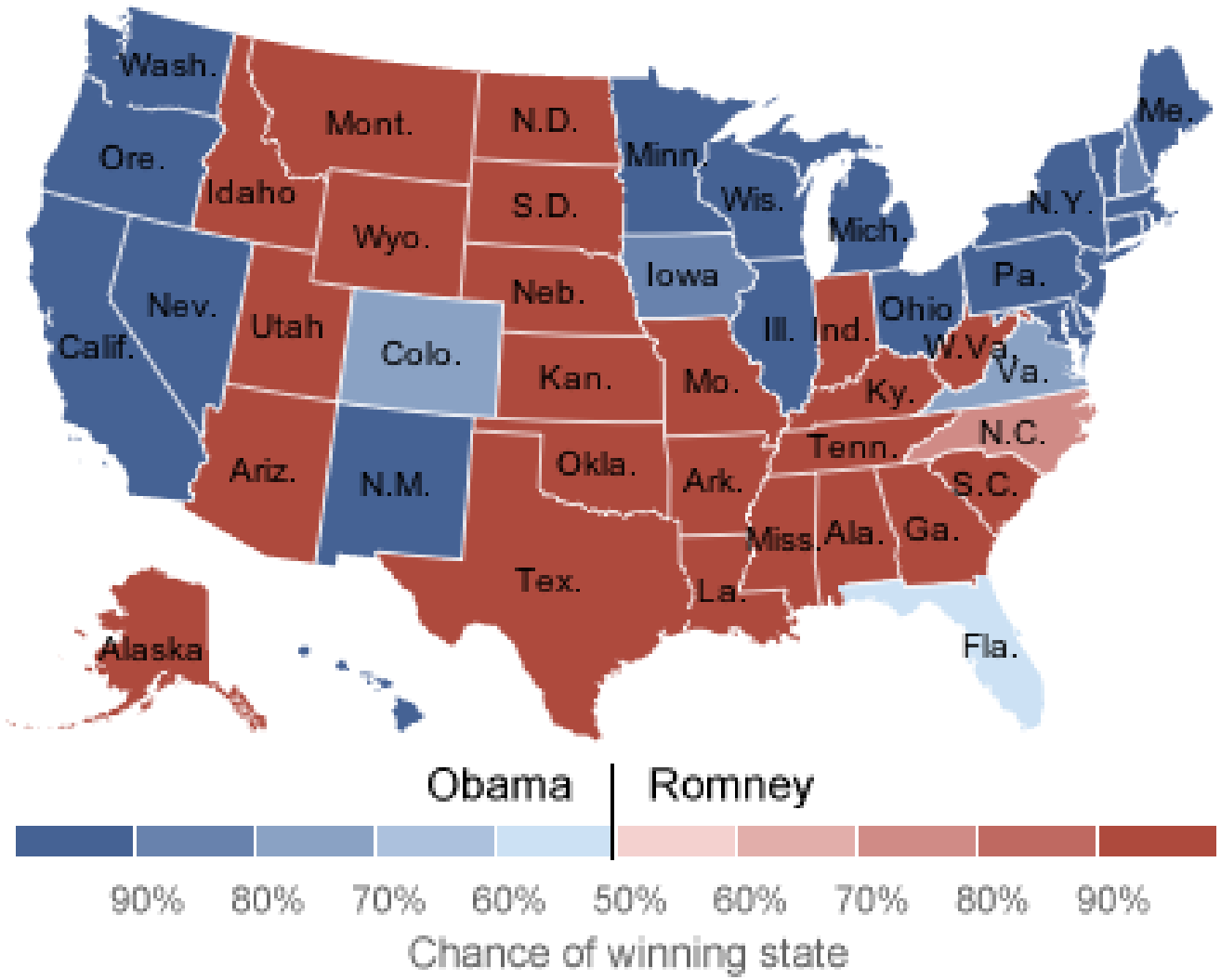
2). Development of clouds in time captured by GOES

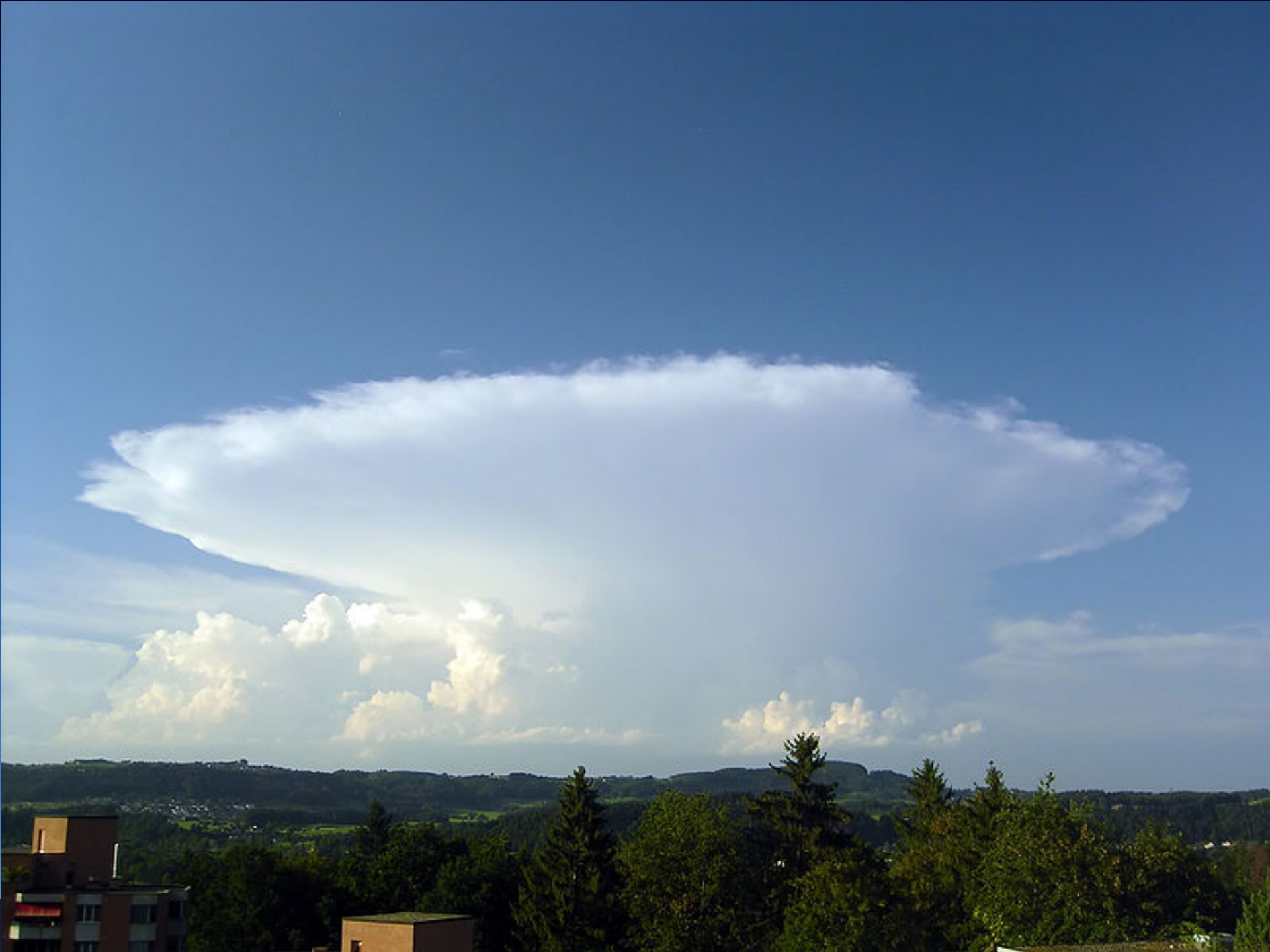
Radar

3). Radar Intensity

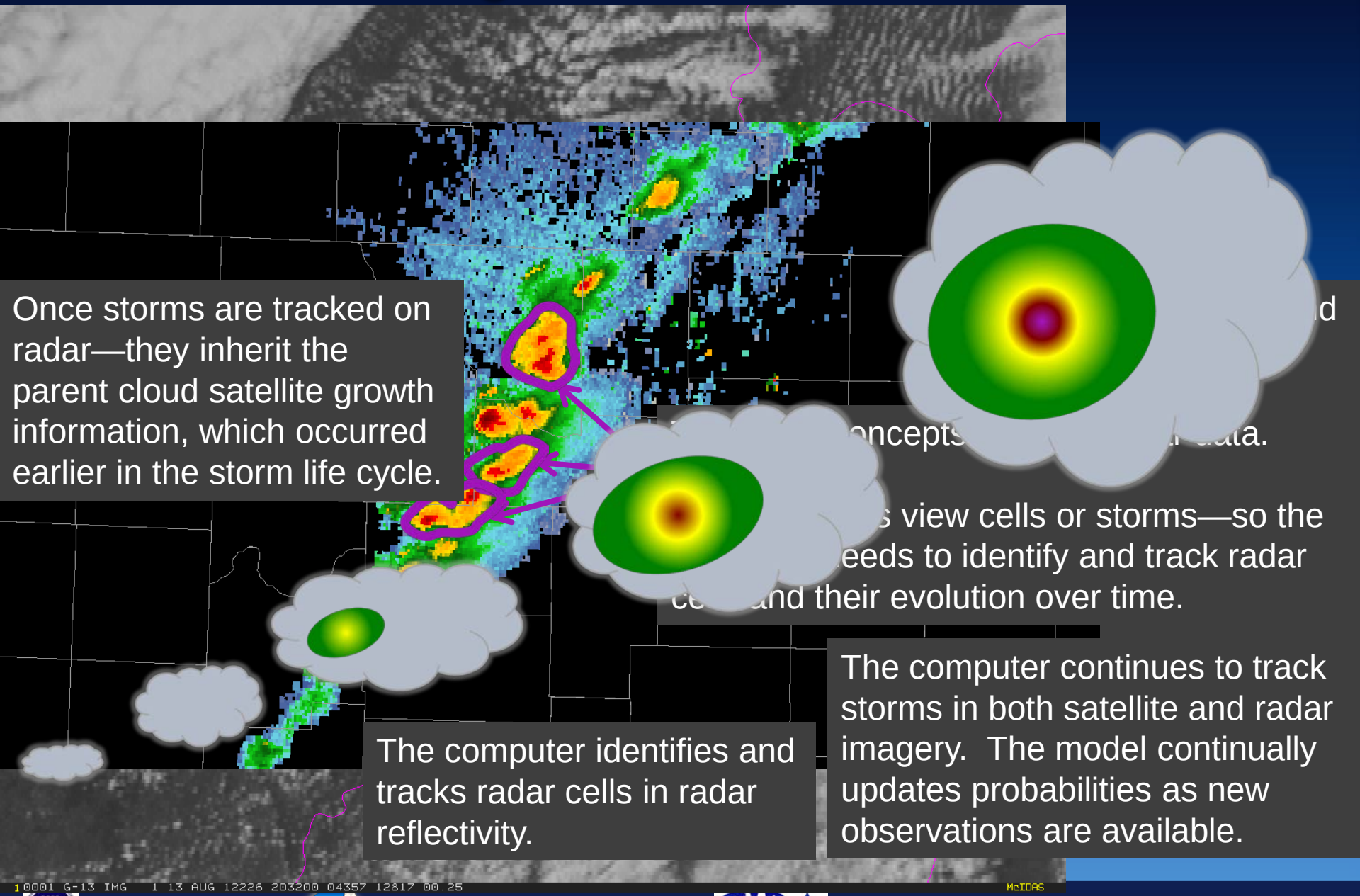
Probability a developing thunderstorm will produce severe weather in the future (up to 60 minutes)

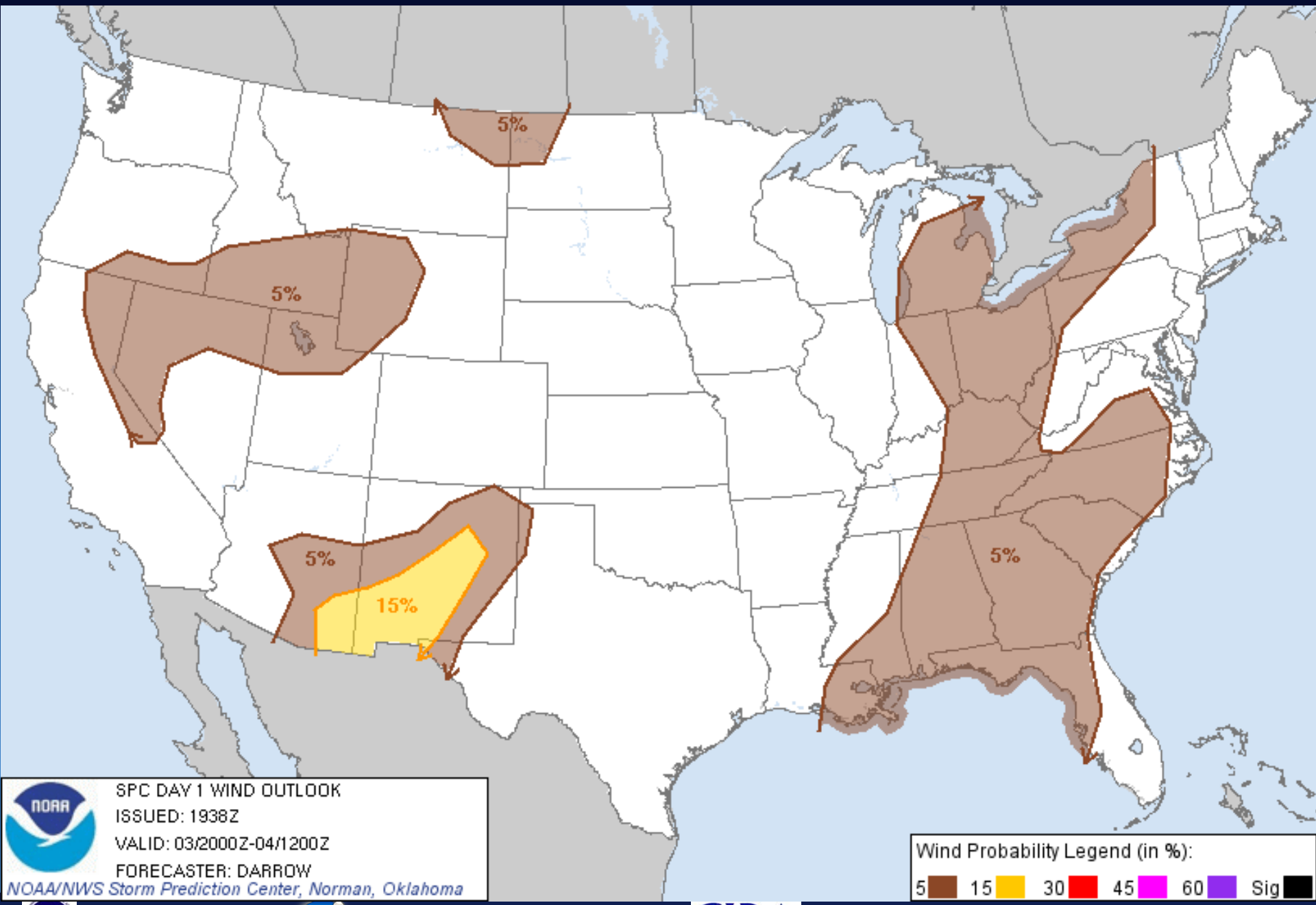
State-by-State Probabilities

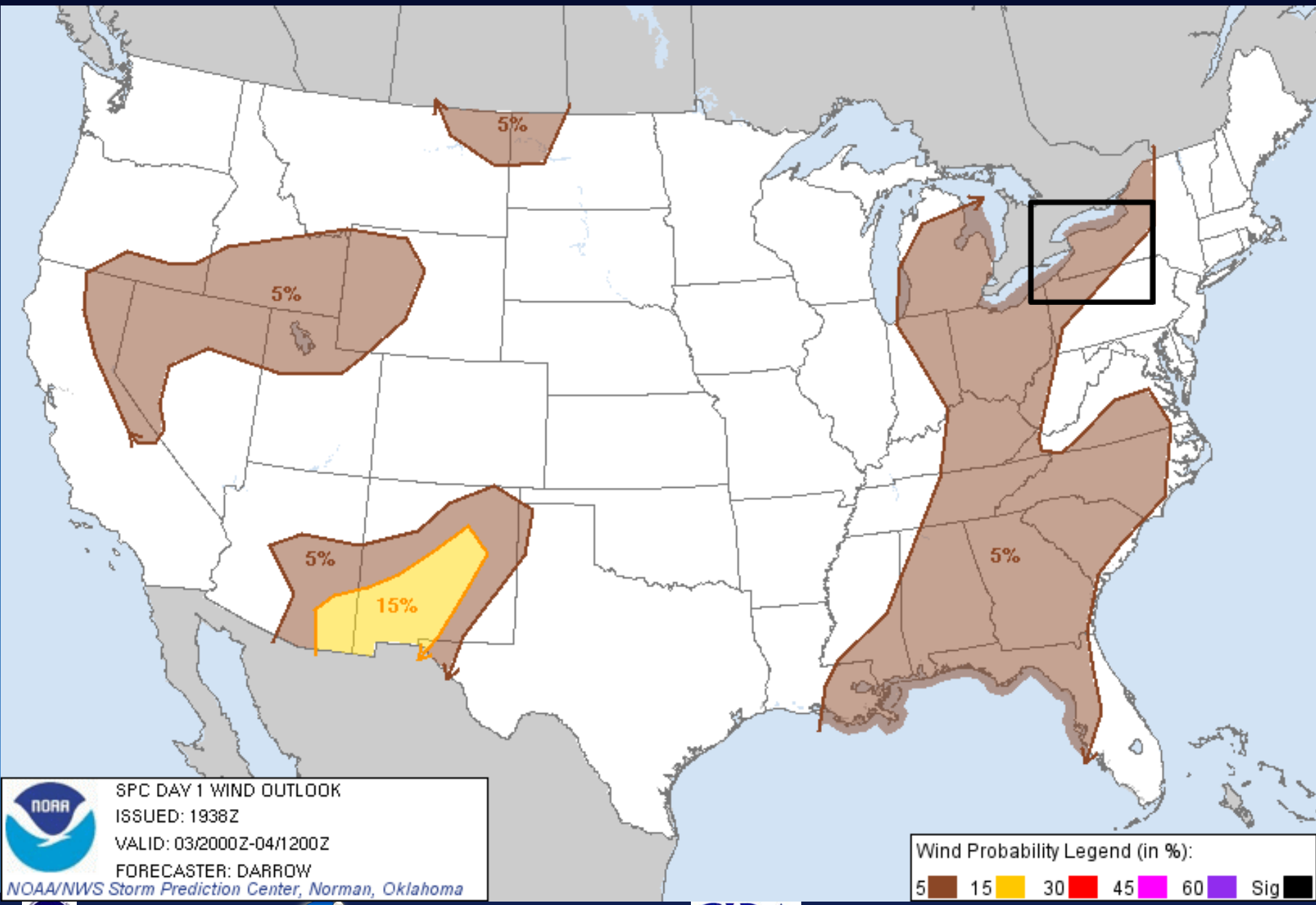




Automated integration of information

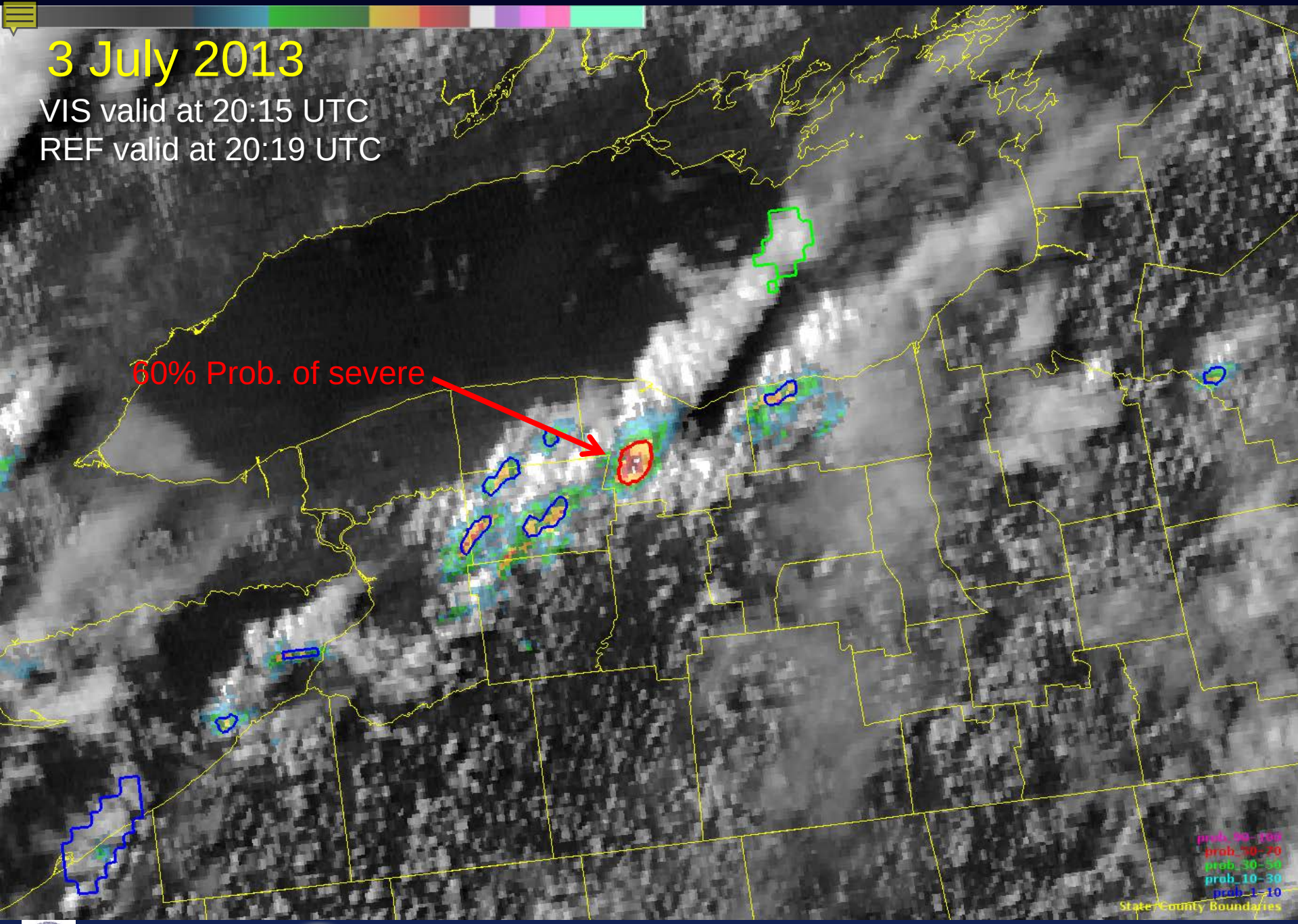



5%
5%
5%
15%
5%
SPC DAY 1 WIND OUTLOOK
ISSUED: 1938Z
VALID: 03/2000Z-04/1200Z
FORECASTER: DARROW
NOAA/NWS Storm Prediction Center, Norman, Oklahoma
Wind Probability Legend (in %):
5 15 30 45 60 Sig


5%
5%
5%
15%
5%
SPC DAY 1 WIND OUTLOOK
ISSUED: 1938Z
VALID: 03/2000Z-04/1200Z
FORECASTER: DARROW
NOAA/NWS Storm Prediction Center, Norman, Oklahoma
Wind Probability Legend (in %):
5 15 30 45 60 Sig

3 July 2013

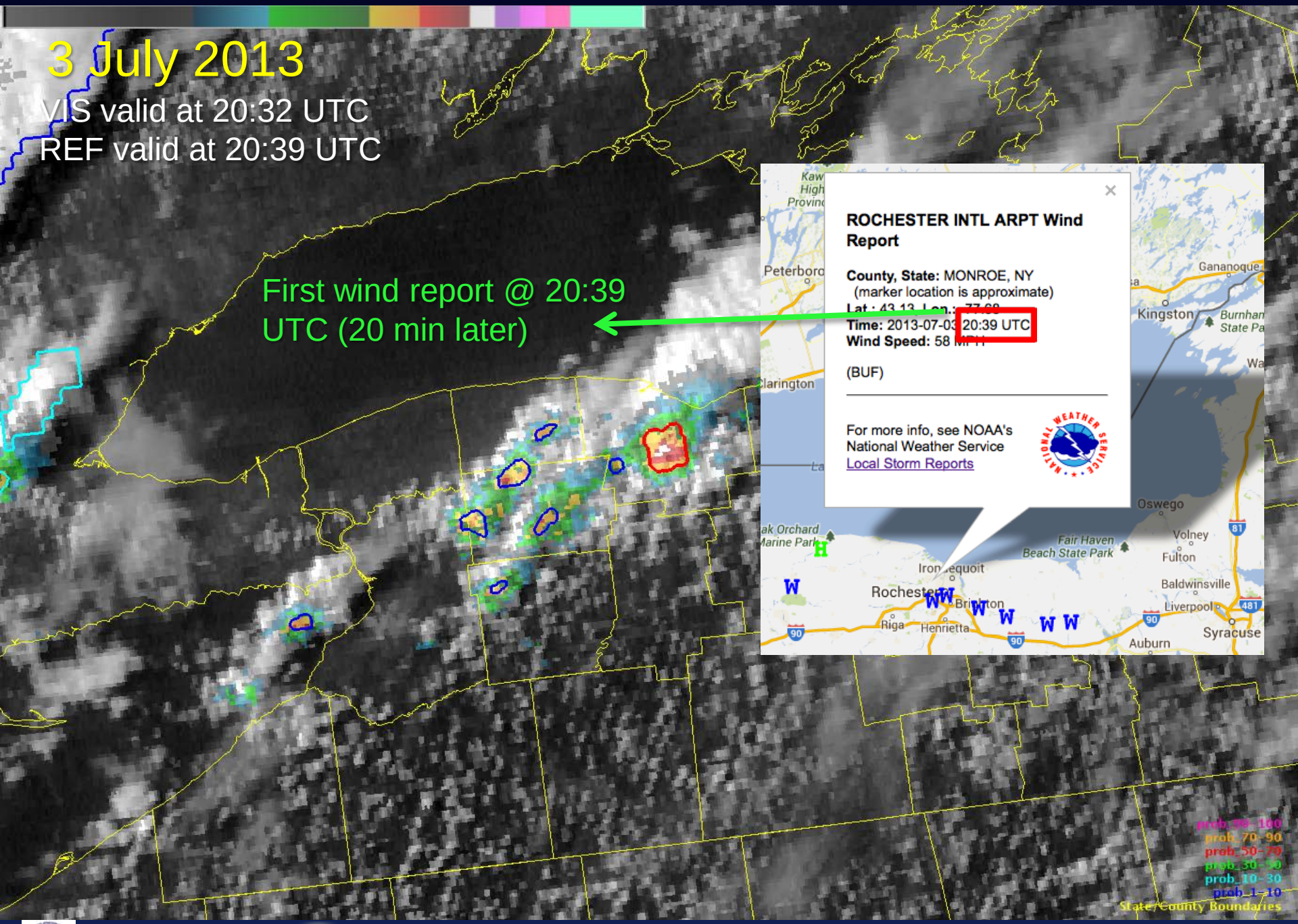
VIS valid at 20:15 UTC
REF valid at 20:19 UTC



3 July 2013

VIS valid at 20:32 UTC
REF valid at 20:39 UTC

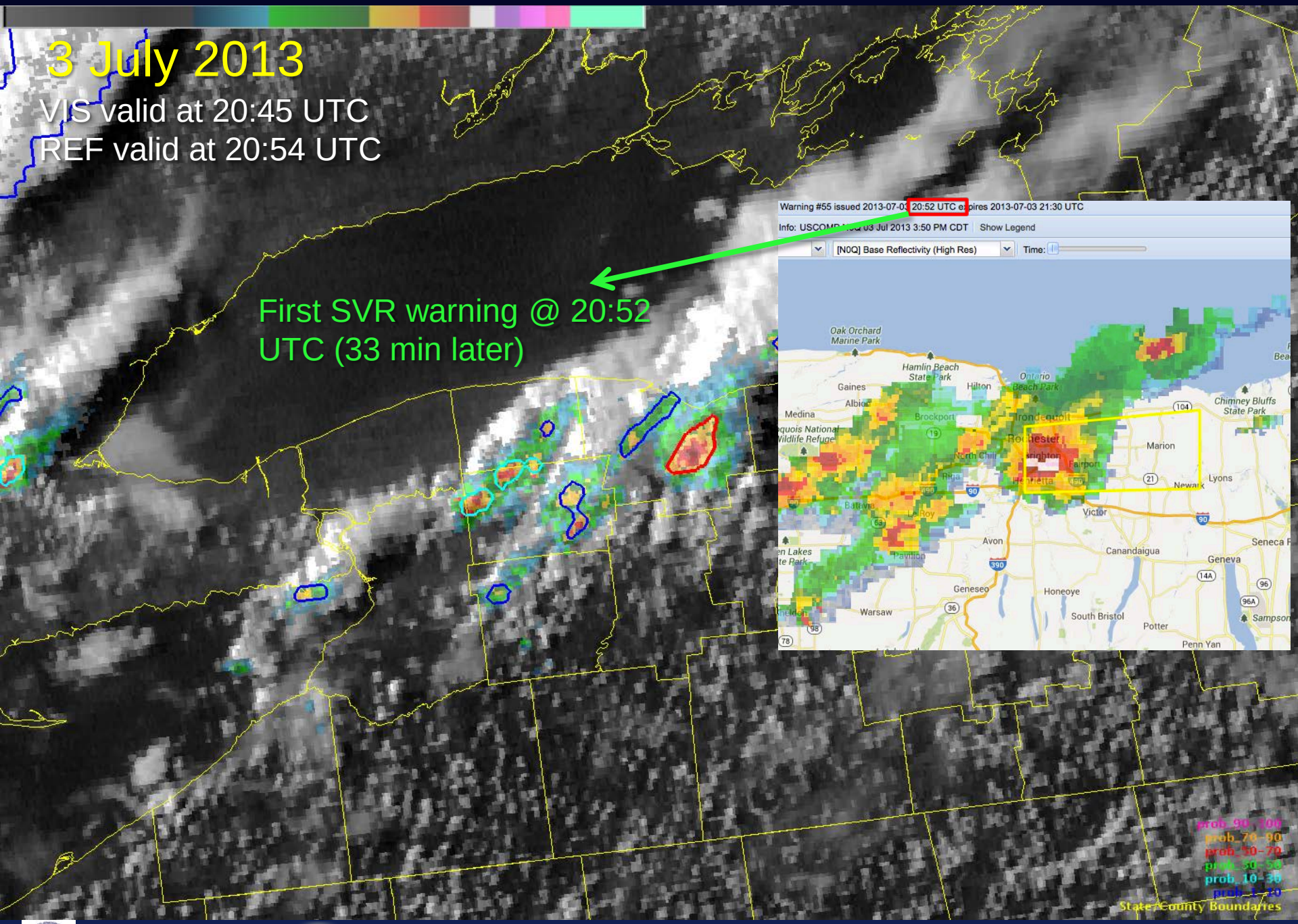
First wind report @ 20:39 UTC (20 min later)



3 July 2013

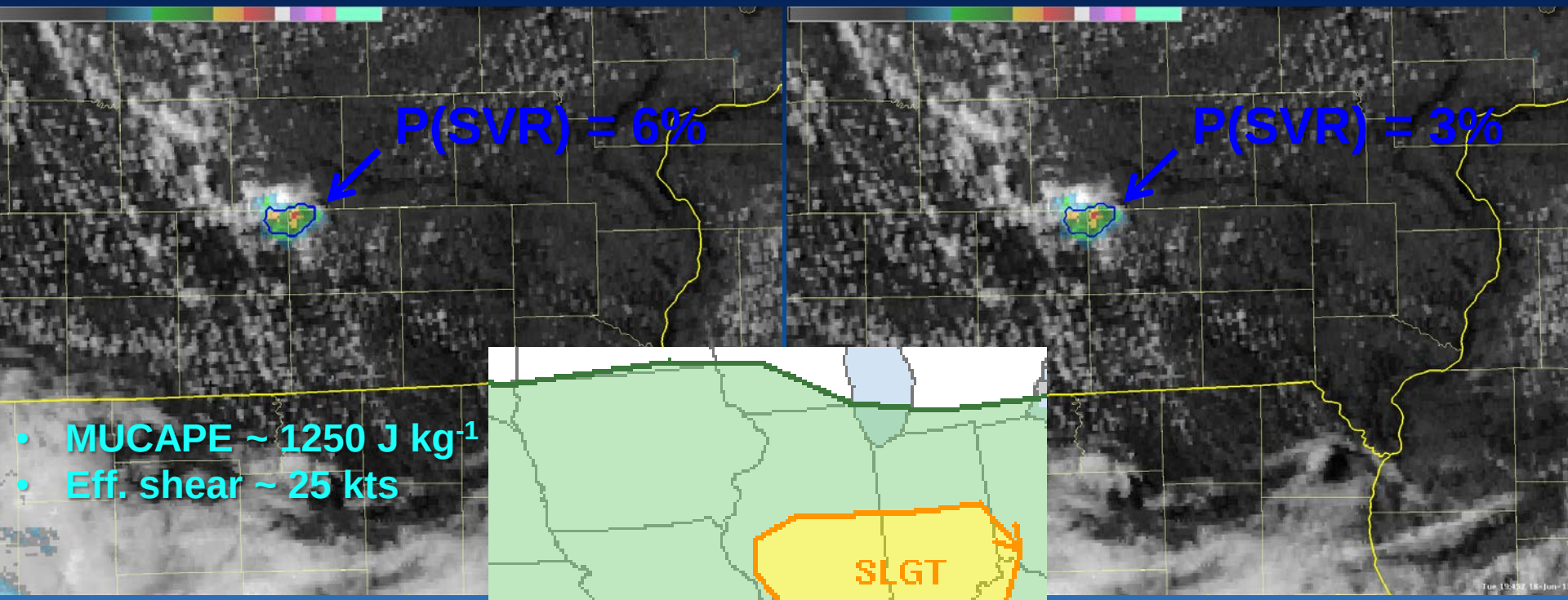
VIS valid at 20:45 UTC
REF valid at 20:54 UTC

First SVR warning @ 20:52 UTC (33 min later)

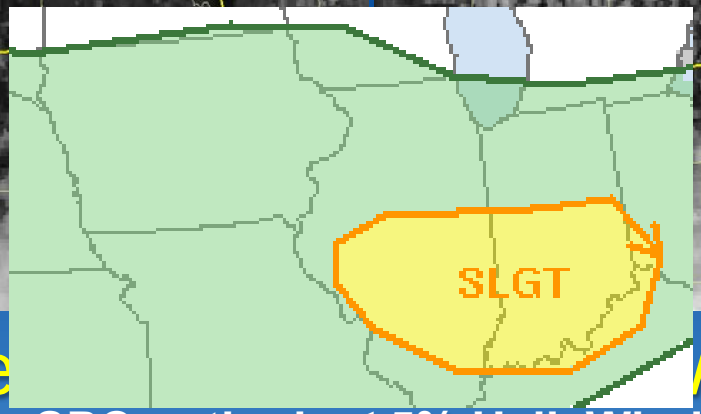


18 June 2013

VIS valid at 19:45 UTC
REF valid at 19:54 UTC



- MUCAPE ~ 1250 J kg^{-1}
- Eff. shear ~ 25 kts



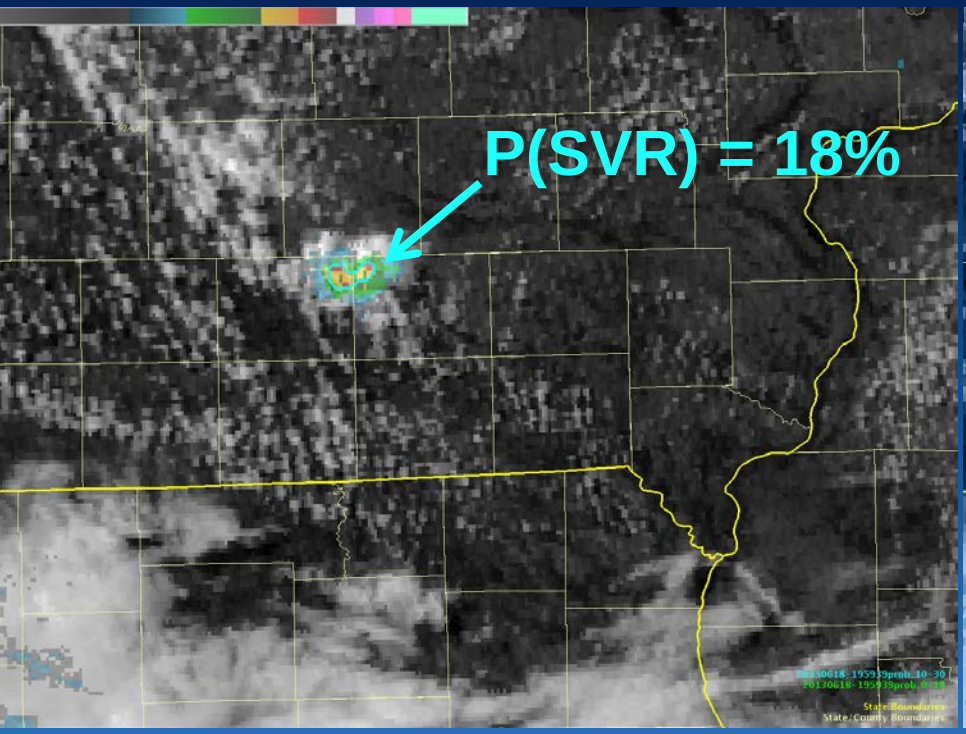
NWP + satellite

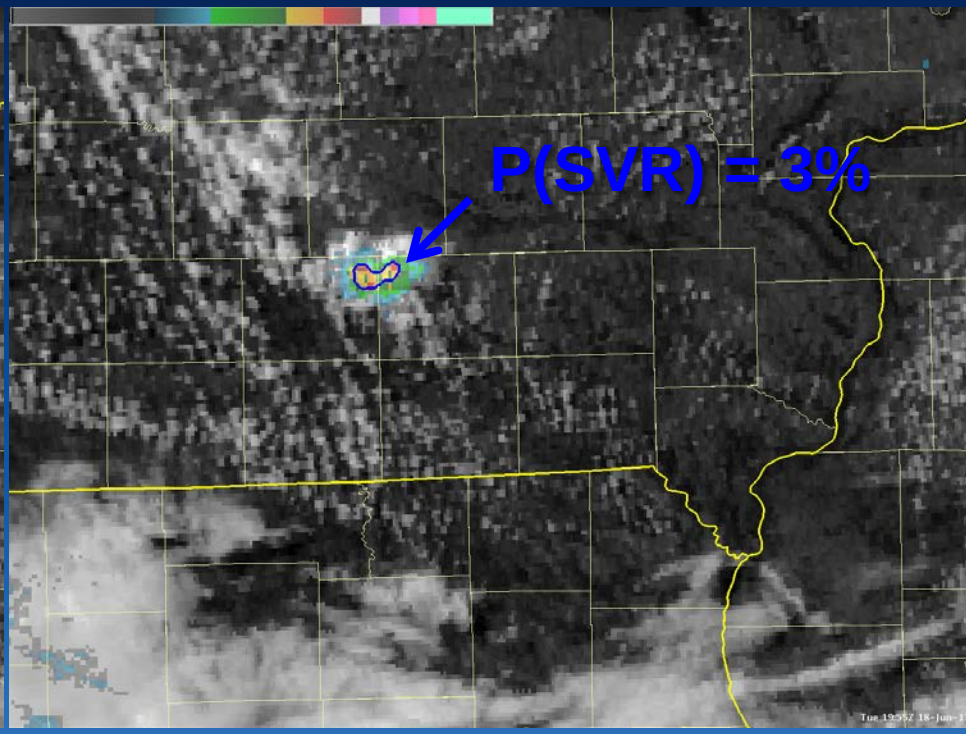
/P + radar only

- SPC outlook: ≤ 5% Hail, Wind, and Tor. in southeast IA
- No watches or MDs issued

18 June 2013

VIS valid at 19:55 UTC
REF valid at 19:59 UTC





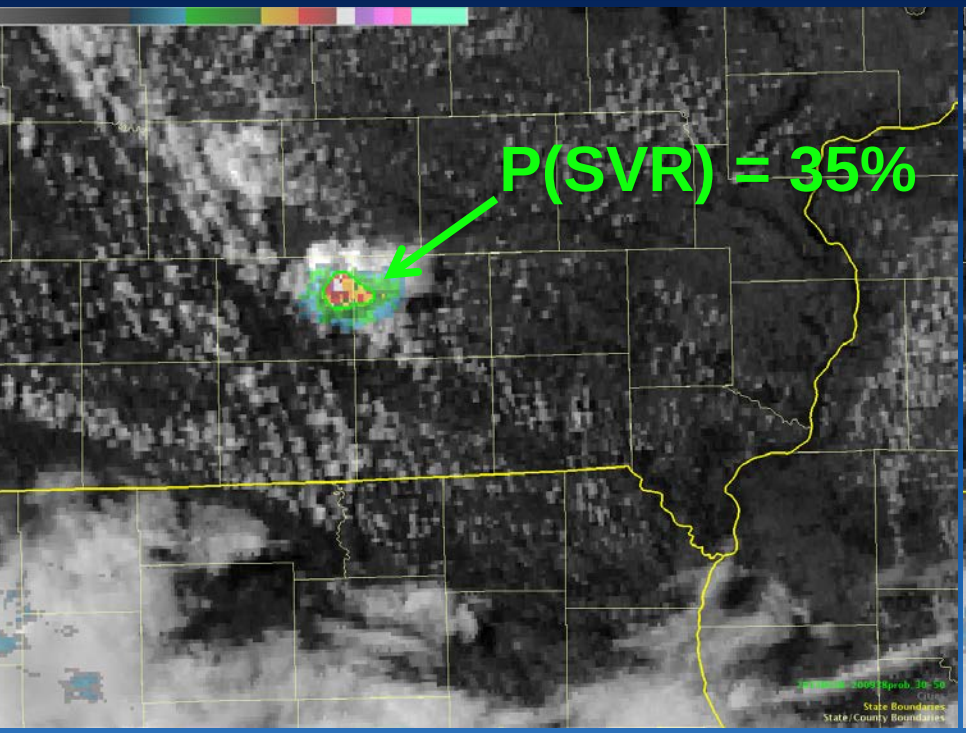
NWP + satellite + radar

- **Strong satellite growth rates by 19:40 UTC**

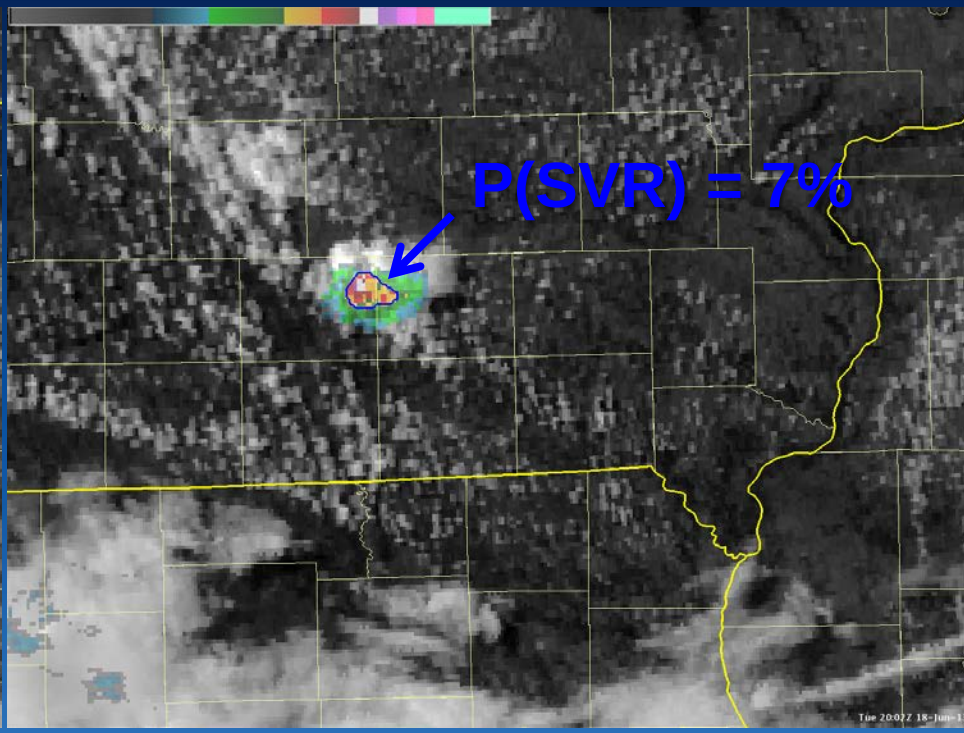
NWP + radar only

18 June 2013

VIS valid at 20:02 UTC
REF valid at 20:09 UTC



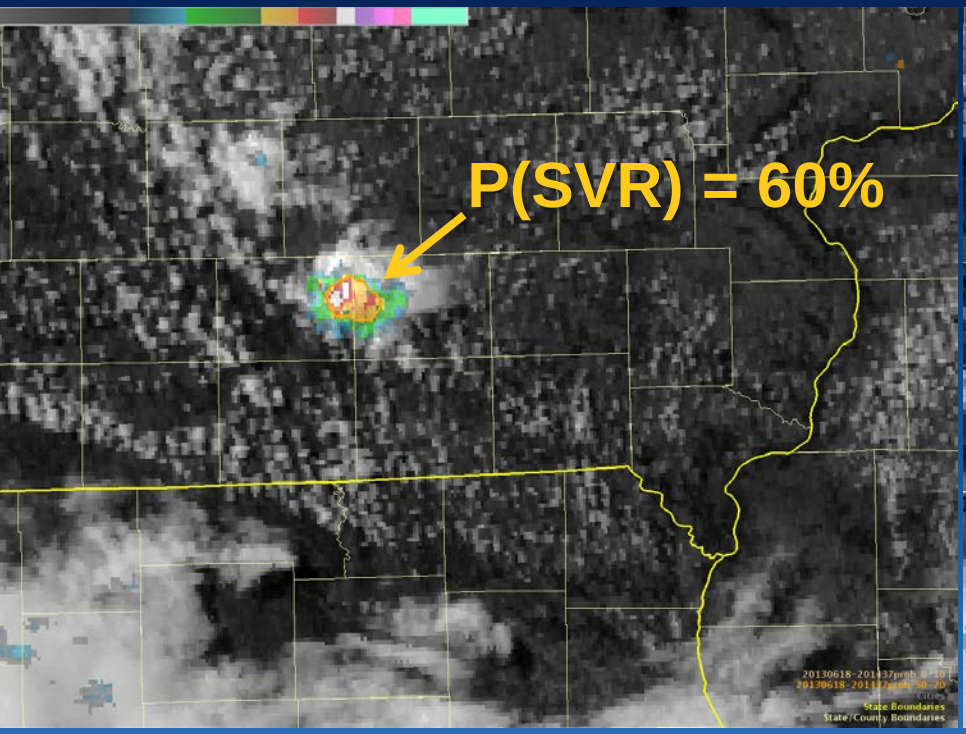
NWP + satellite + radar



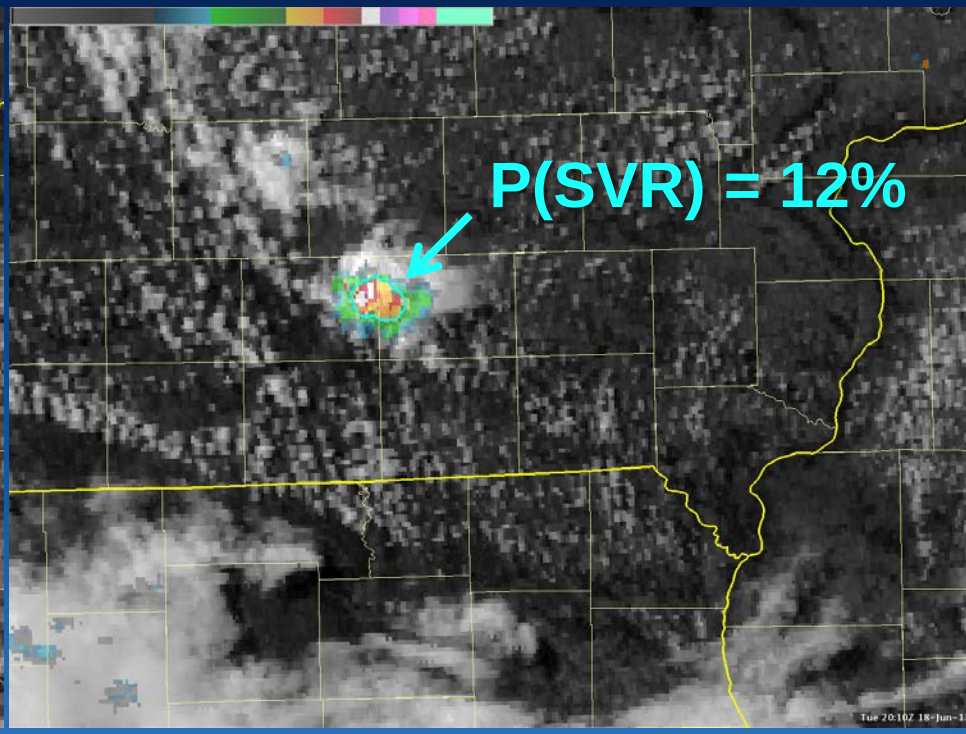
NWP + radar only

18 June 2013

VIS valid at 20:10 UTC
REF valid at 20:14 UTC



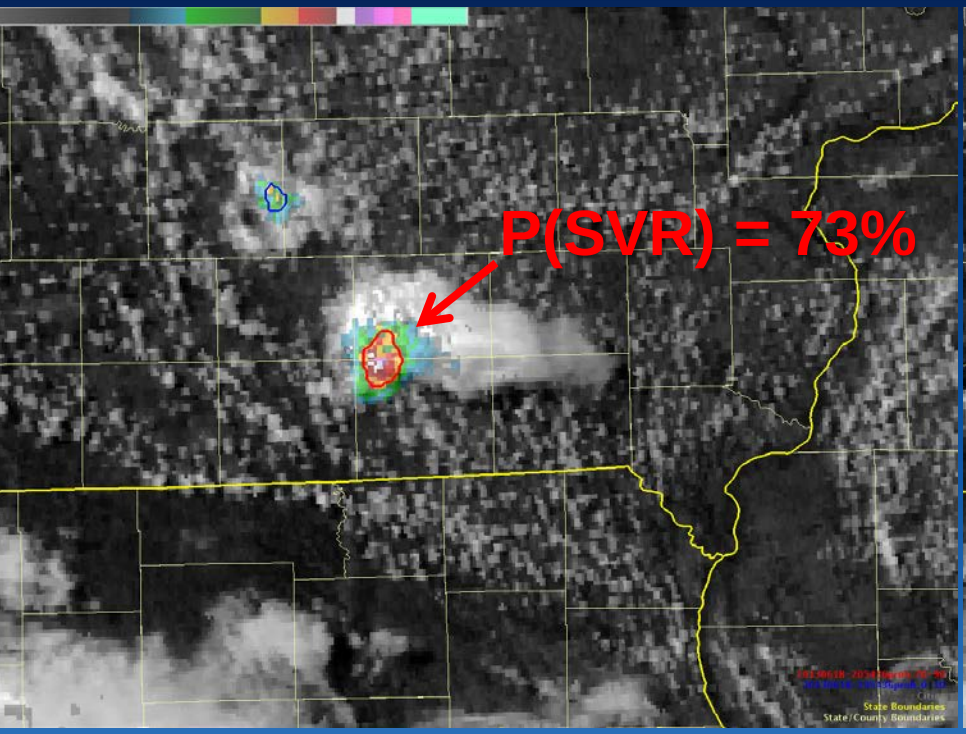
NWP + satellite + radar



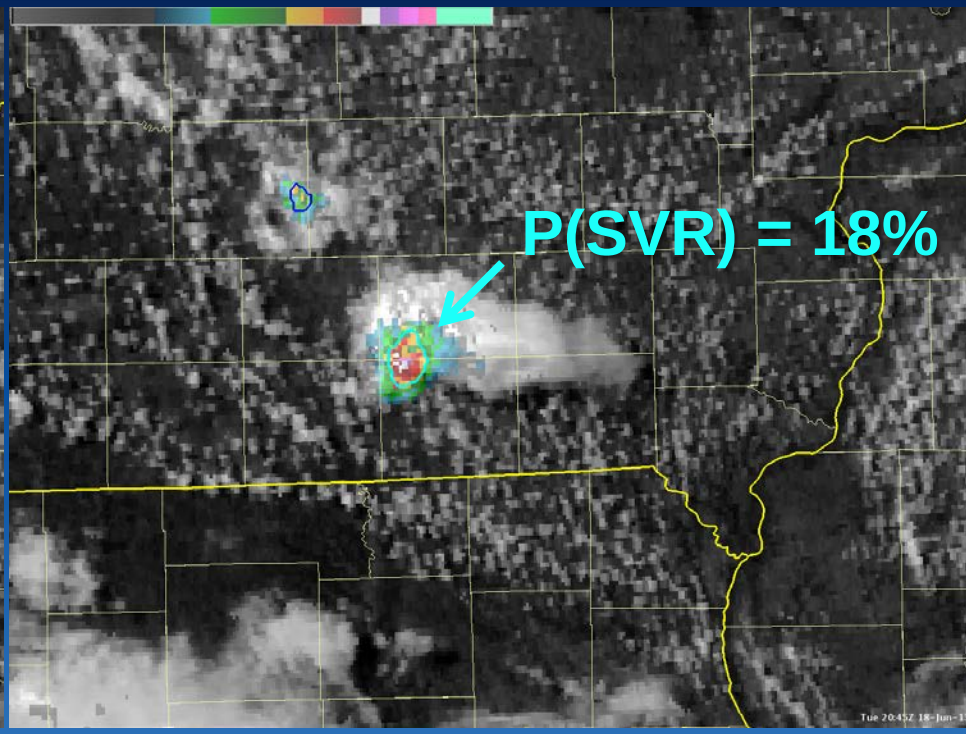
NWP + radar only

18 June 2013

VIS valid at 20:45 UTC
REF valid at 20:54 UTC



NWP + satellite + radar



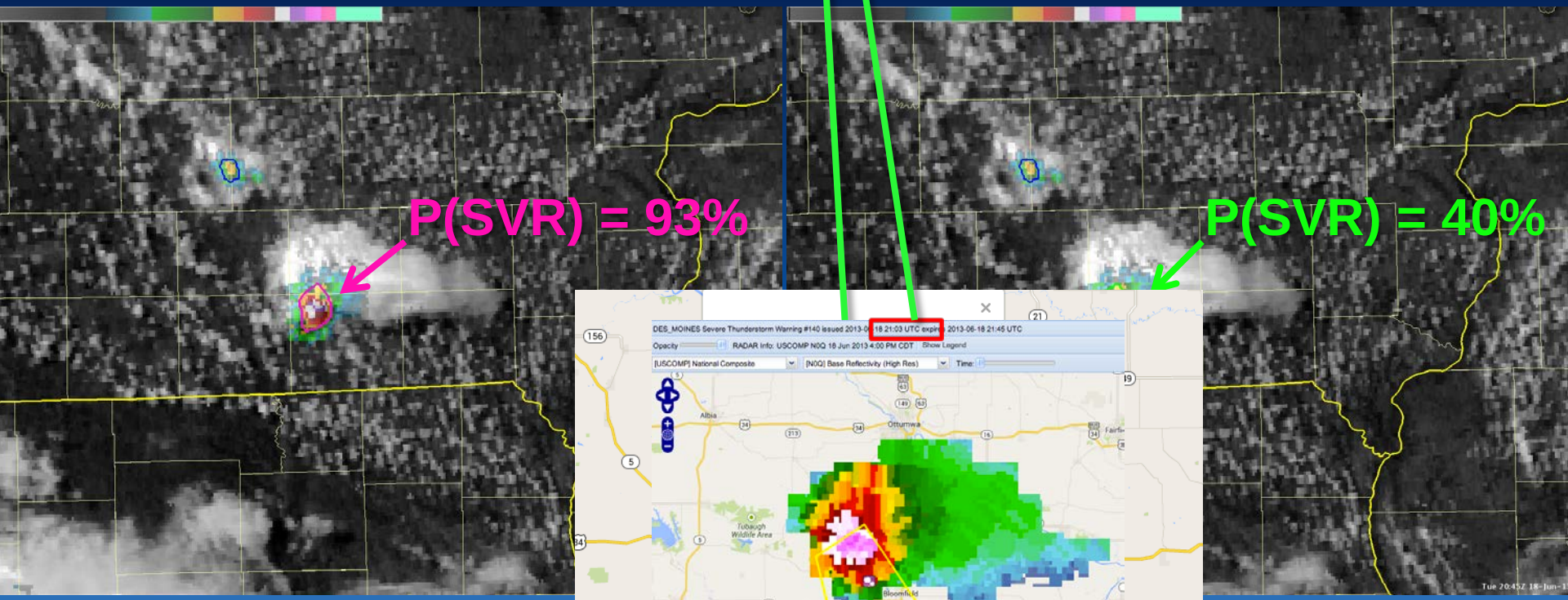
NWP + radar only

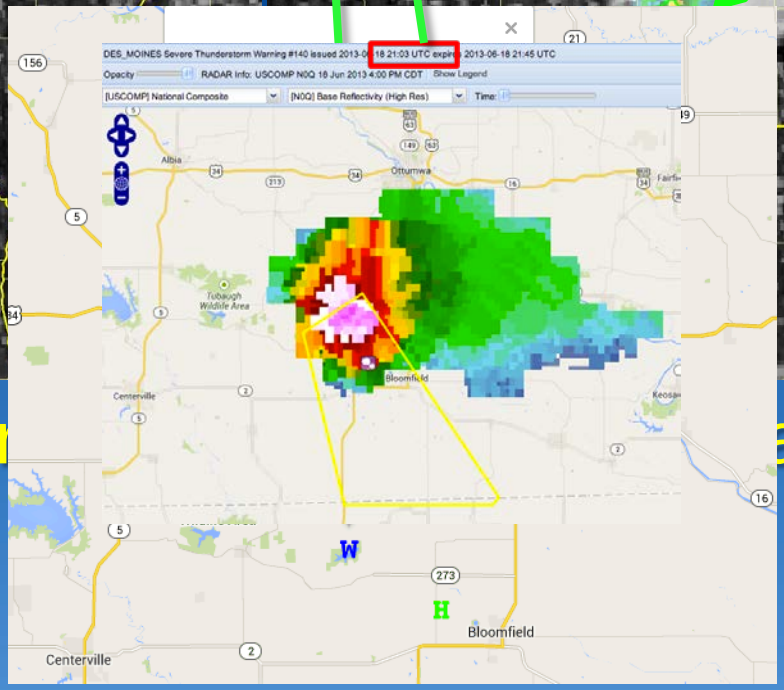
18 June 2013

VIS valid at 20:45 UTC
REF valid at 20:59 UTC

First SVR warning at 21:03 UTC (50 min later)

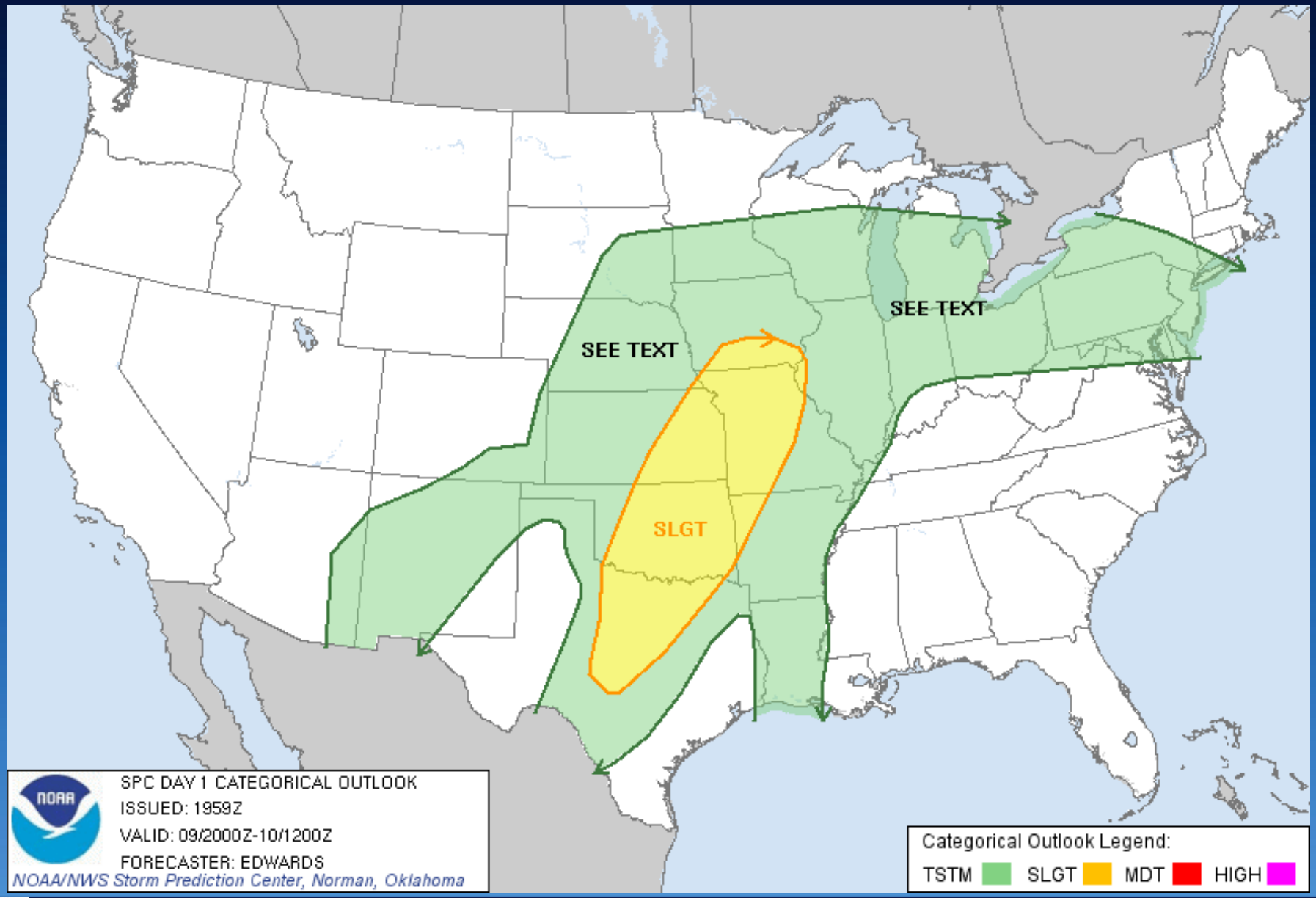
Wind and hail reports at 20:59 UTC (45 min later)

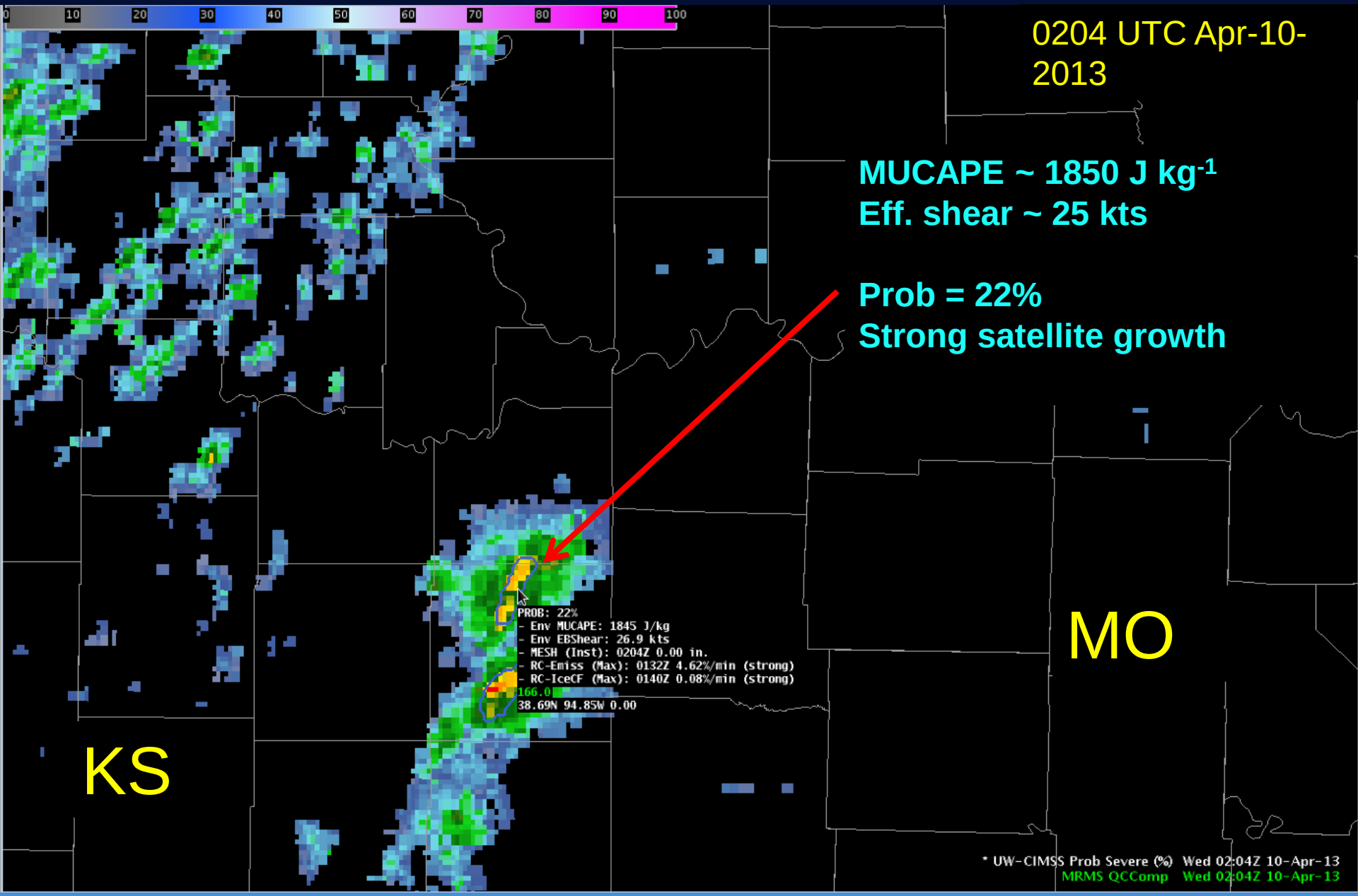


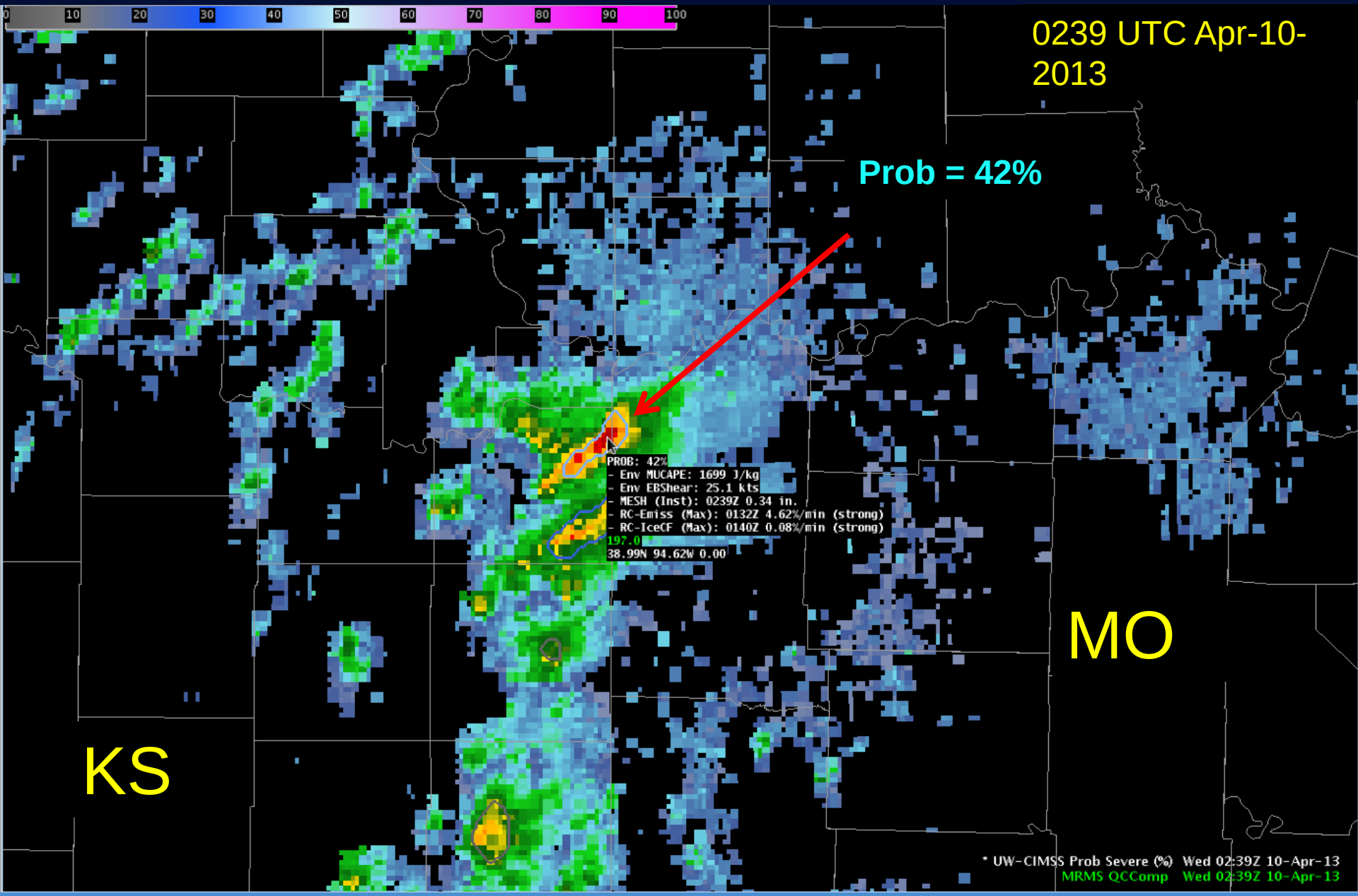


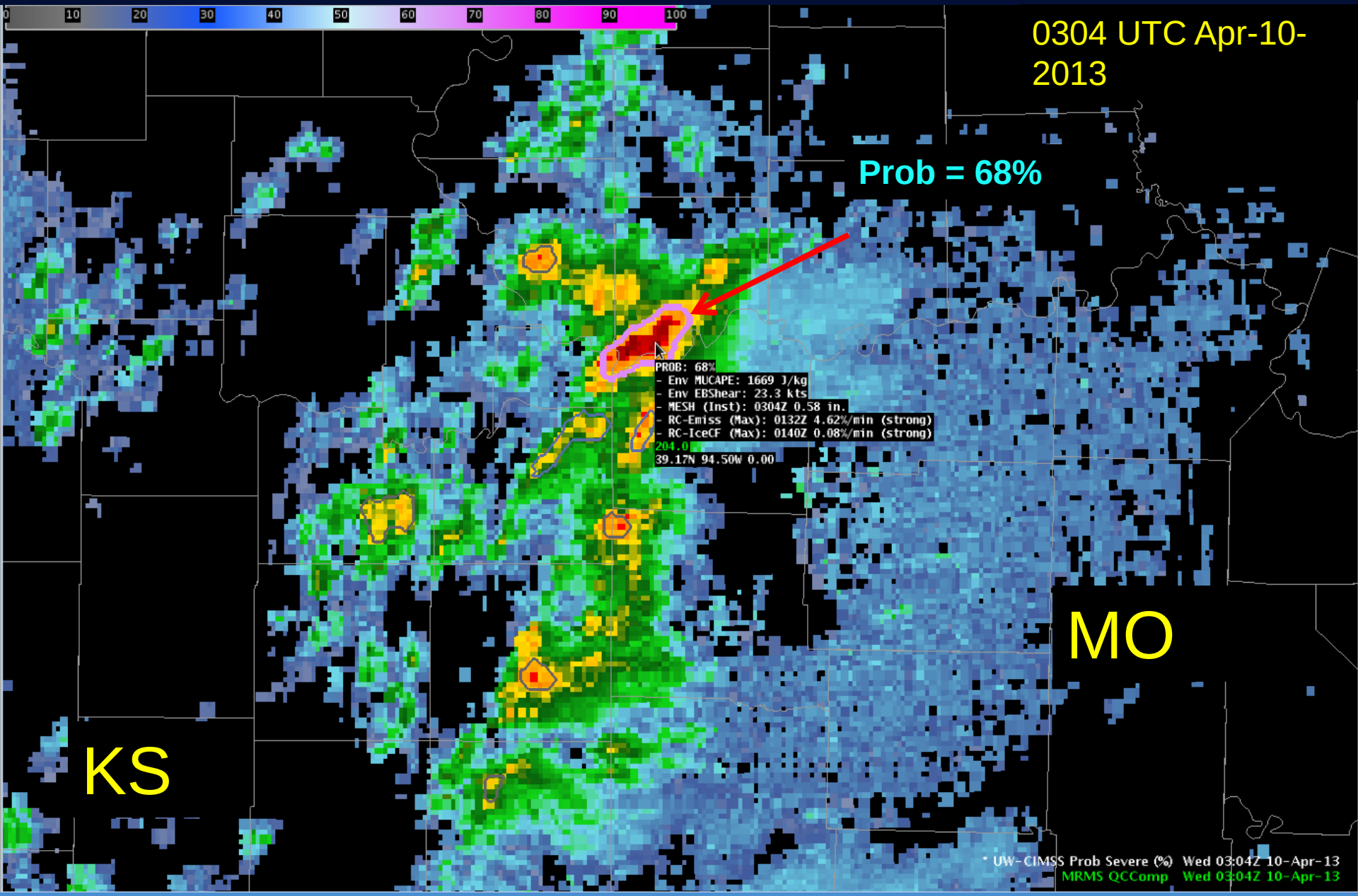
NWP + satellite + radar only

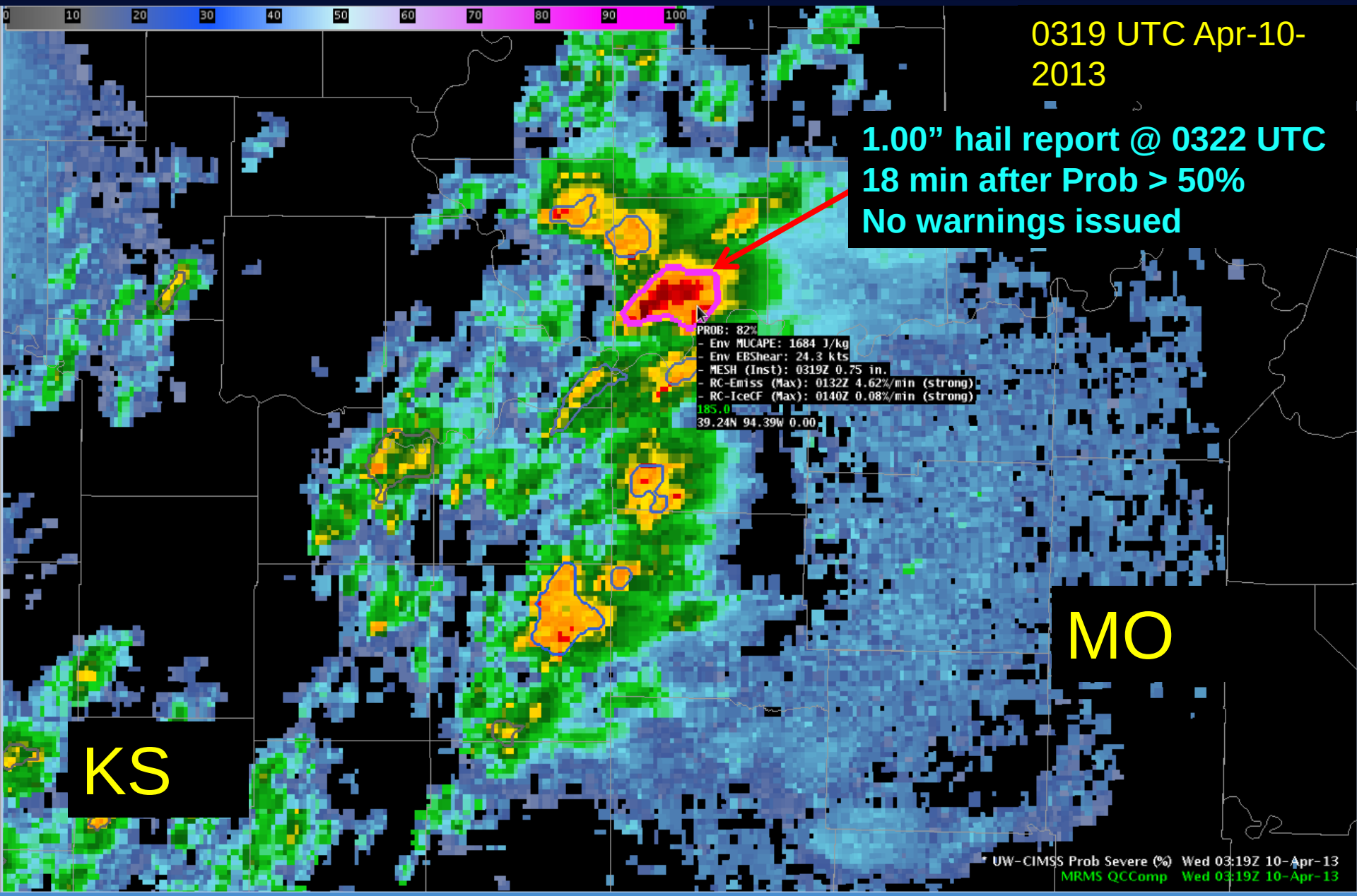
09-10 April 2013




0204 UTC Apr-10-2013
MUCAPE ~ 1850 J kg-1
Eff. shear ~ 25 kts
Prob = 22%
Strong satellite growth
PROB: 22%
- Env MUCAPE: 1845 J/kg
- Env EBShear: 26.9 kts
- MESH (Inst): 0204Z 0.00 in.
- RC-Emiss (Max): 0132Z 4.62%/min (strong)
- RC-IceCF (Max): 0140Z 0.08%/min (strong)
166.0
38.69N 94.85W 0.00
KS
MO
* UW-CIMSS Prob Severe (%) Wed 02:04Z 10-Apr-13
MRMS QCComp Wed 02:04Z 10-Apr-13

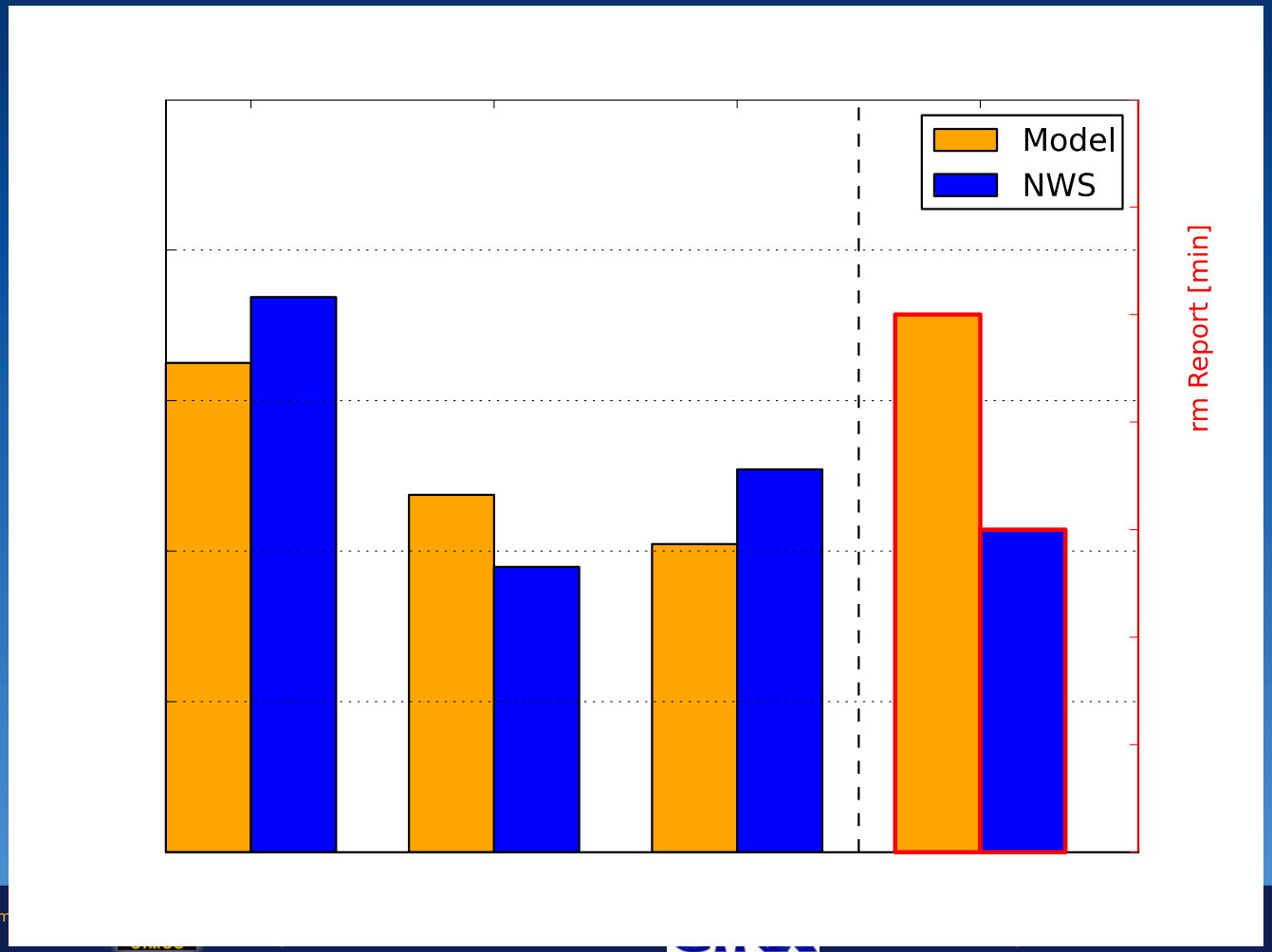

0239 UTC Apr-10-2013
Prob = 42%
PROB: 42%
- Env MUCAPE: 1699 J/kg
- Env EBShear: 25.1 kts
- MESH (Inst): 0239Z 0.34 in.
- RC-Emiss (Max): 0132Z 4.62%/min (strong)
- RC-IceCF (Max): 0140Z 0.08%/min (strong)
197.0
38.99N 94.62W 0.00
KS
MO
* UW-CIMSS Prob Severe (%) Wed 02:39Z 10-Apr-13
MRMS QCComp Wed 02:39Z 10-Apr-13


0304 UTC Apr-10-2013
Prob = 68%
PROB: 68%
- Env MUCAPE: 1669 J/kg
- Env EBShear: 23.3 kts
- MESH (Inst): 0304Z 0.58 in.
- RC-Emiss (Max): 0132Z 4.62%/min (strong)
- RC-IceCF (Max): 0140Z 0.08%/min (strong)
204.0
39.17N 94.50W 0.00
MO
KS
UW-CIMSS Prob Severe (%) Wed 03:04Z 10-Apr-13
MRMS QCComp Wed 03:04Z 10-Apr-13


0319 UTC Apr-10-2013
1.00” hail report @ 0322 UTC
18 min after Prob > 50%
No warnings issued
PROB: 82%
- Env MUCAPE: 1684 J/kg
- Env EBShear: 24.3 kts
- MESH (Inst): 0319Z 0.75 in.
- RC-Emiss (Max): 0132Z 4.62%/min (strong)
- RC-IceCF (Max): 0140Z 0.08%/min (strong)
185.0
39.24N 94.39W 0.00
KS
MO
UW-CIMSS Prob Severe (%) Wed 03:19Z 10-Apr-13
MRMS QCComp Wed 03:19Z 10-Apr-13

Model Evaluation

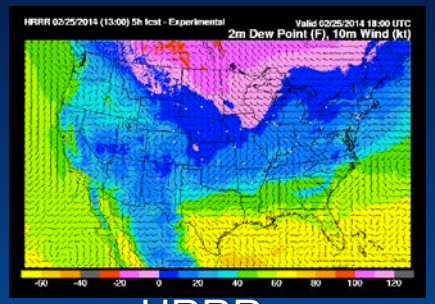
- Model is not as skillful as NWS warnings (but comparable)
- Model median lead-time is 25 min vs. 15 min for NWS



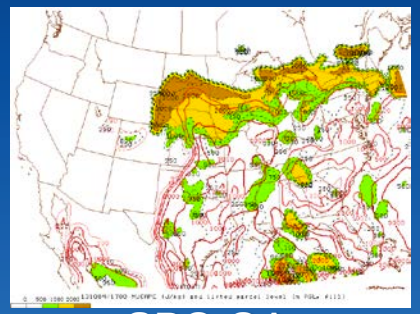
Future Data Integration

- Flexible system can include current state-of-the-art and future data sources

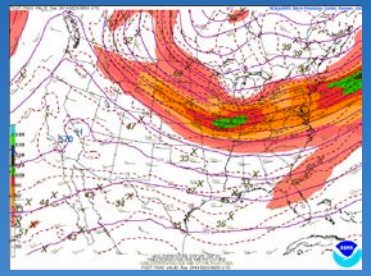
NWP / near-storm env.



HRRR



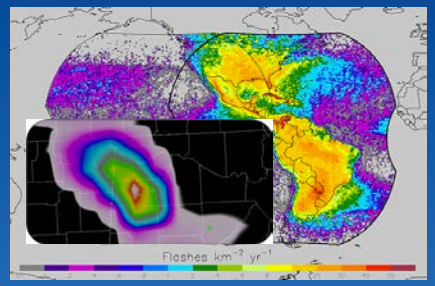
SPC-OA



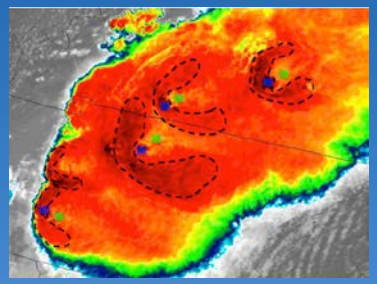
SREF

GOES-R

Super-rapid scan

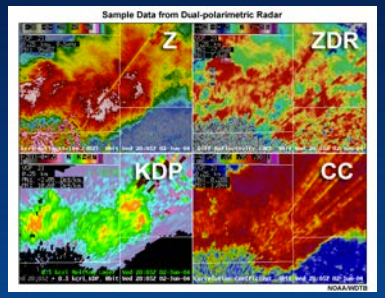


GLM

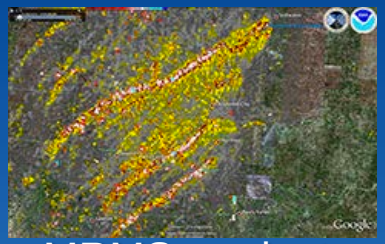


OT detection

NEXRAD



Dual-pol products

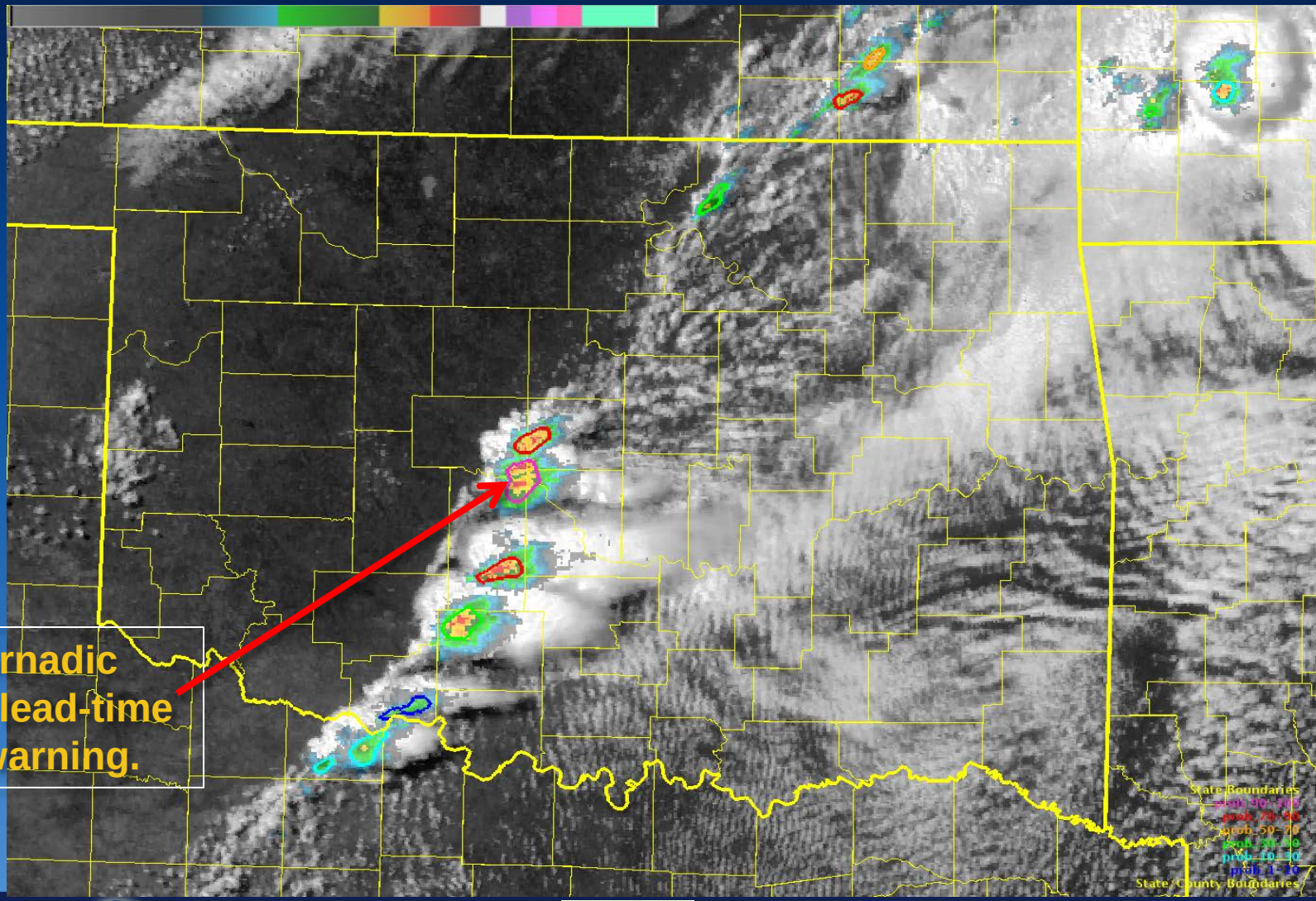


MRMS products

Create more refined and specific forecasts of severe weather (tornado, hail, wind)

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

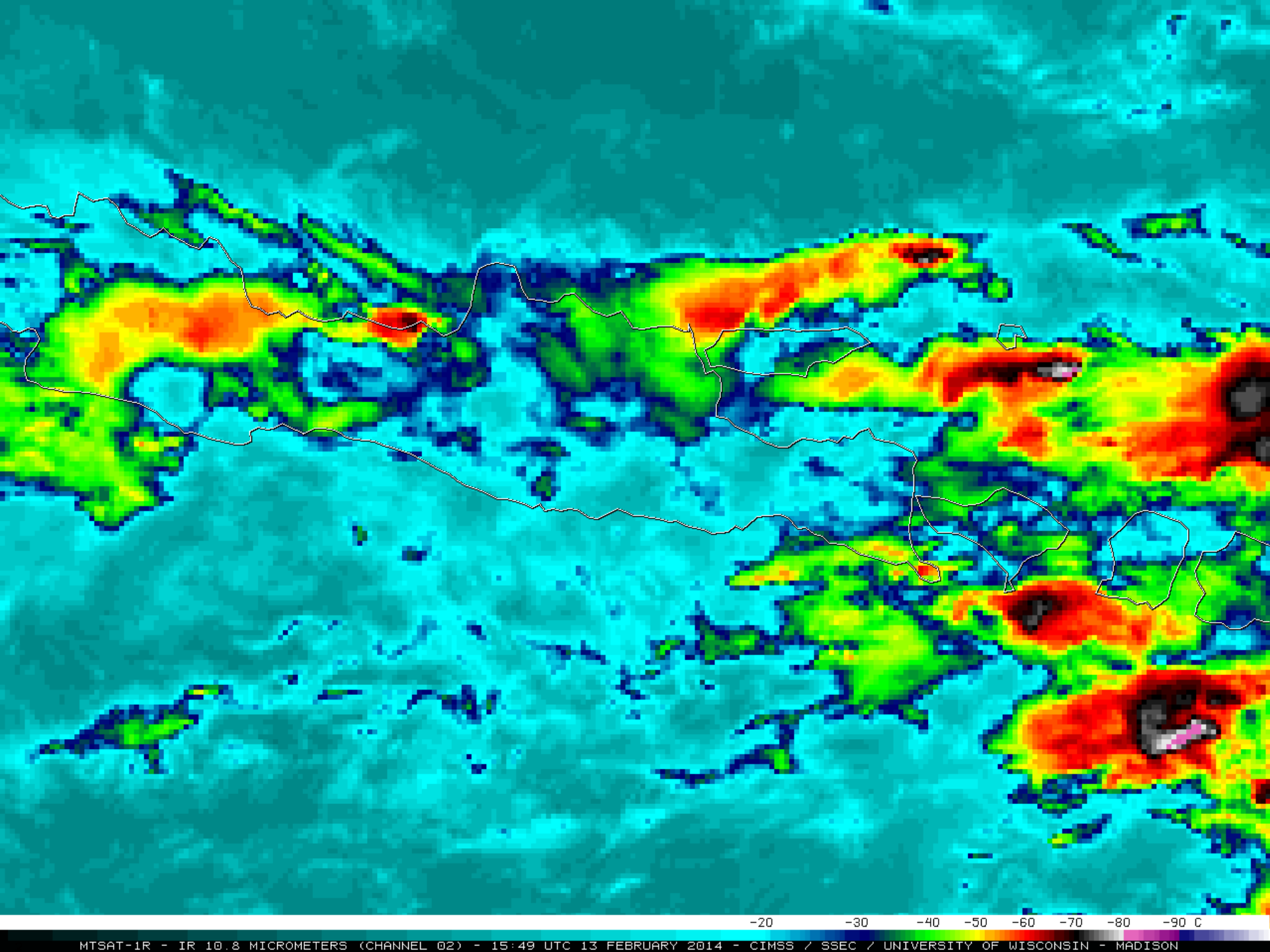
The model coverts GB of input data into kB of information that can be used to help extend severe weather warning lead-times



Moore, OK tornadic storm; 8 min lead-time to first SVR warning.

Erupsi Kelud
@hilmi_dzi | 00:30 am
Nglegok, Blitar

University of Alaska-Fairbanks


-20 -30 -40 -50 -60 -70 -80 -90 C
MTSAT-1R - IR 10.8 MICROMETERS (CHANNEL 02) - 15:49 UTC 13 FEBRUARY 2014 - CIMSS / SSEC / UNIVERSITY OF WISCONSIN - MADISON

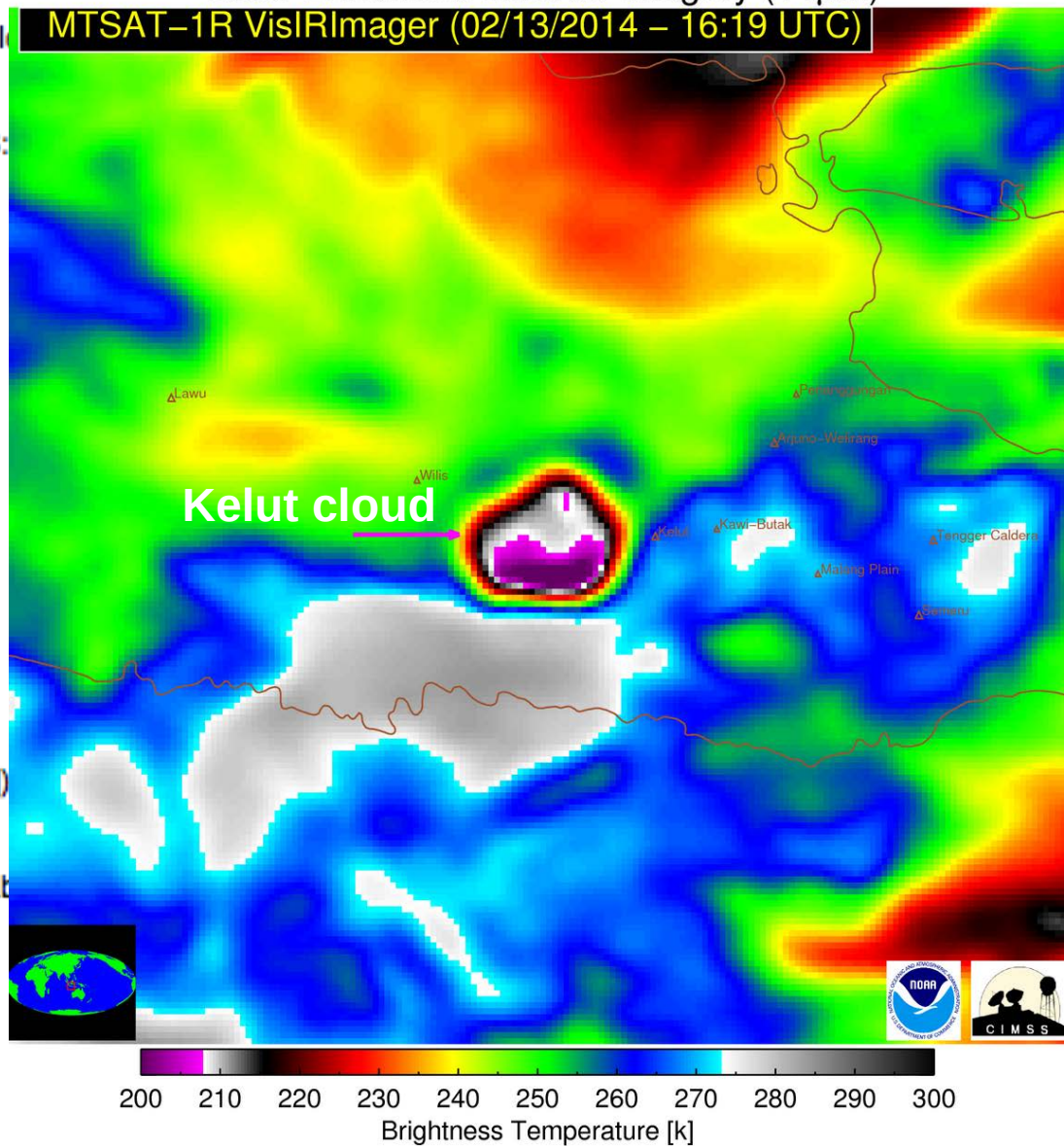
@**********VOLCANIC ALERTS**********
STARTING DATE/TIME OF IMAGE: 2014-02-13 16:19:00 [UTC]
PRODUCTION DATE/TIME OF ALERT: 2014-02-14 16:49:44 [UTC]
PRIMARY INSTRUMENT: MTSAT-1r Vis/IR_Imager
WMO SPACECRAFT ID: 171
LOCATION/ORBIT: GEO
L1 FILE: mtsat01_1_2014_044_1619.area.gz
VOLCANO DATABASE: /data/common/VOLCAT_DATA/al
NUMBER OF ASH CLOUD ALERTS: 0
NUMBER OF VOLCANIC Cb ALERTS: 1
NUMBER OF VOLCANIC THERMAL ANOMALY ALERTS:
NUMBER OF SO2 CLOUD ALERTS: 0

REPORT WITH IMAGES:
http://volcano.ssec.wisc.edu/alert/report/12238

POSSIBLE VOLCANIC ERUPTION DETECTED
Alert Status: New Alert Object
Latitude of Radiative Center: -8.012 [degrees]
Longitude of Radiative Center: 112.265 [degrees]
Mean Viewing Angle: 33.92 [degrees]
Mean Solar Zenith Angle: 157.44 [degrees]
Nearby Volcanoes (meeting alert criteria):
Kelut(9.99 km)
Kawi-Butak(23.00 km)
Maximum Height [AMSL]: 21.2 [km] (69649.79 [ft])
90th Percentile Height [AMSL]: 19.2 [km] (62995.20 [ft])
Mean Tropopause Height [AMSL]: 16.4 [km] (53783.42 [ft])
Trend in IR Brightness Temperature: -53.16 [K]
Vertical Growth Rate Time Interval: 10 [minutes]
Vertical Growth Rate Anomaly: 24.75 [number of stddev at
Total Area: 1270.01 [km^2]

Geographic Regions of Nearby Volcanoes: Java
VAAC Regions of Nearby Volcanoes: Darwin
FIR Regions of Nearby Volcanoes: Unknown

Color Enhanced Infrared Imagery (11μm)



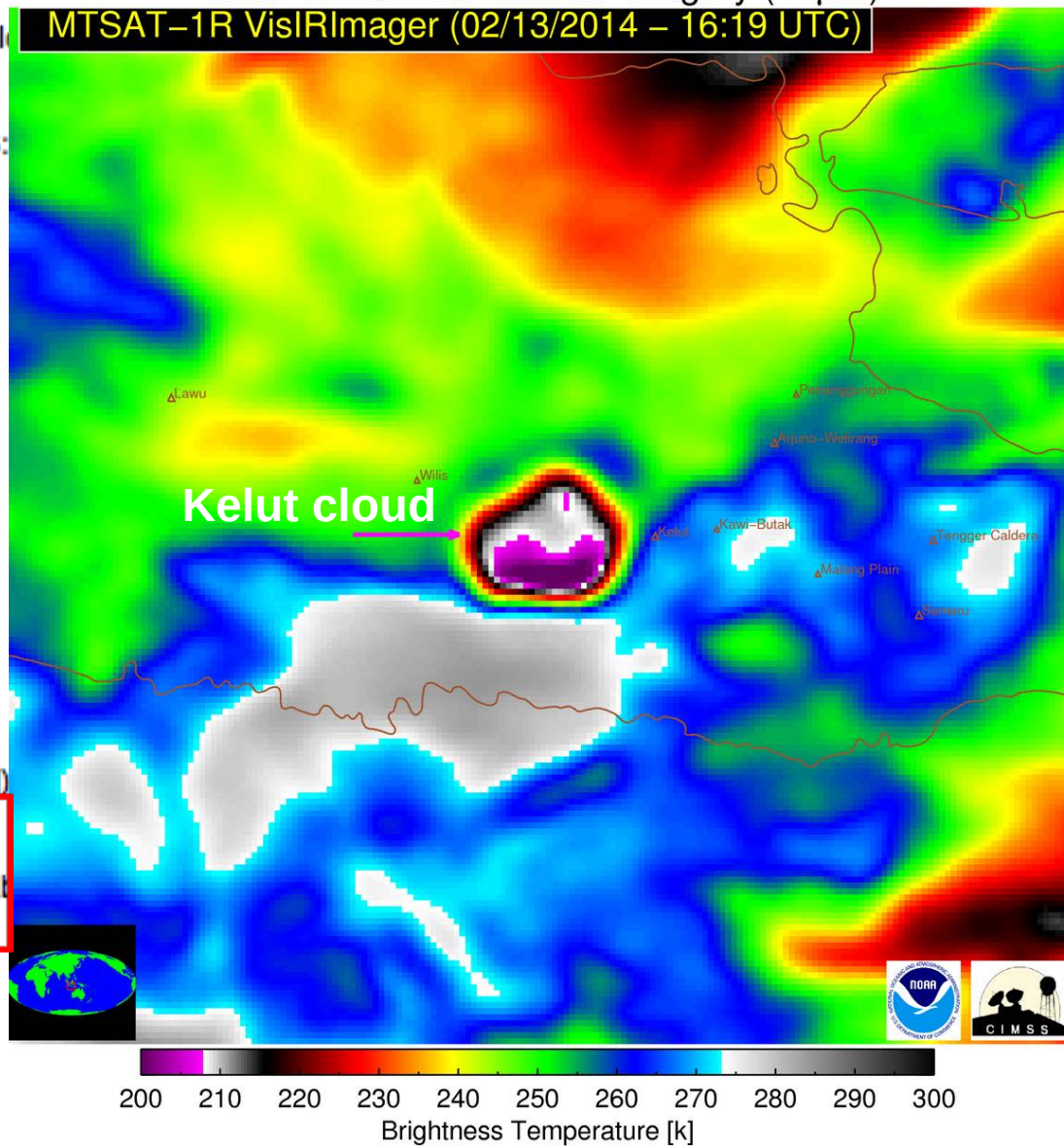
@**********VOLCANIC ALERTS**********
STARTING DATE/TIME OF IMAGE: 2014-02-13 16:19:00 [UTC]
PRODUCTION DATE/TIME OF ALERT: 2014-02-14 16:49:44 [UTC]
PRIMARY INSTRUMENT: MTSAT-1r Vis/IR_Imager
WMO SPACECRAFT ID: 171
LOCATION/ORBIT: GEO
L1 FILE: mtsat01_1_2014_044_1619.area.gz
VOLCANO DATABASE: /data/common/VOLCAT_DATA/al
NUMBER OF ASH CLOUD ALERTS: 0
NUMBER OF VOLCANIC Cb ALERTS: 1
NUMBER OF VOLCANIC THERMAL ANOMALY ALERTS:
NUMBER OF SO2 CLOUD ALERTS: 0

REPORT WITH IMAGES:
http://volcano.ssec.wisc.edu/alert/report/12238

POSSIBLE VOLCANIC ERUPTION DETECTED
Alert Status: New Alert Object
Latitude of Radiative Center: -8.012 [degrees]
Longitude of Radiative Center: 112.265 [degrees]
Mean Viewing Angle: 33.92 [degrees]
Mean Solar Zenith Angle: 157.44 [degrees]
Nearby Volcanoes (meeting alert criteria):
Kelut(9.99 km)
Kawi-Butak(23.00 km)
Maximum Height [AMSL]: 21.2 [km] (69649.79 [ft])
90th Percentile Height [AMSL]: 19.2 [km] (62995.20 [ft])
Mean Tropopause Height [AMSL]: 16.4 [km] (53783.42 [ft])
Trend in IR Brightness Temperature: -53.16 [K]
Vertical Growth Rate Time Interval: 10 [minutes]
Vertical Growth Rate Anomaly: 24.75 [number of stddev at
Total Area: 1270.01 [km^2]

Geographic Regions of Nearby Volcanoes: Java
VAAC Regions of Nearby Volcanoes: Darwin
FIR Regions of Nearby Volcanoes: Unknown

Color Enhanced Infrared Imagery (11μm)



Publications

- Cintineo, J., M. Pavolonis, J. Sieglaff, and D. Lindsey, 2014: An Empirical Model for Assessing the Severe Weather Potential of Developing Convection. *Wea. Forecasting*. doi:10.1175/WAF-D-13-00113.1, in press.

- Cintineo, John L., Michael J. Pavolonis, Justin M. Sieglaff, Andrew K. Heidinger, 2013: Evolution of Severe and Nonsevere Convection Inferred from GOES-Derived Cloud Properties. *J. Appl. Meteor. Climatol.*, 52, 2009–2023.