Integrated Observations for Probabilistic Severe Storm Prediction

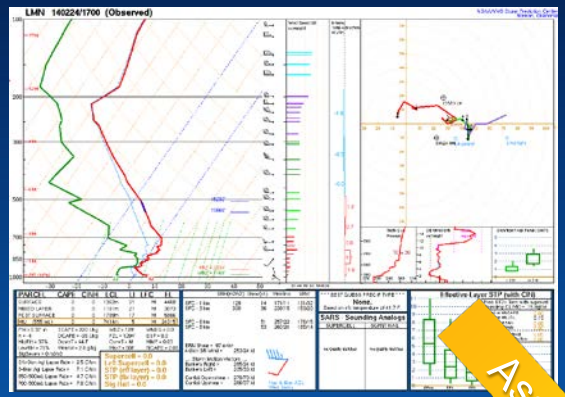
Mike Pavolonis[1], John Cintineo[2], Justin Sieglaff[2], and Dan Lindsey[1]

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

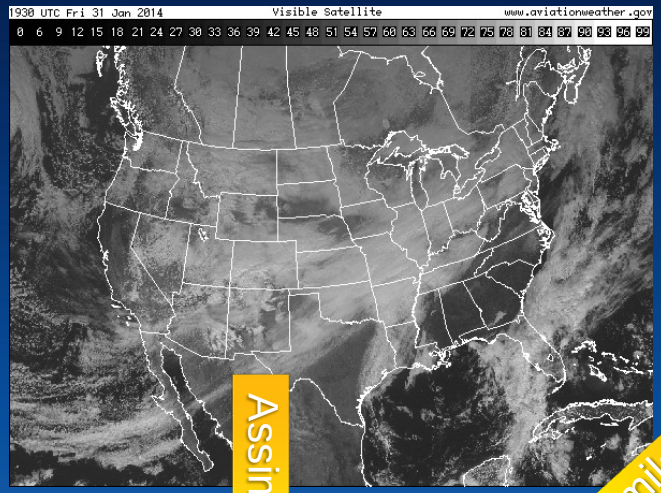
Torrent of data available to forecaster

Leverage existing and future data sources to provide concise, comprehensive information to forecasters

Balloon soundings



Satellite



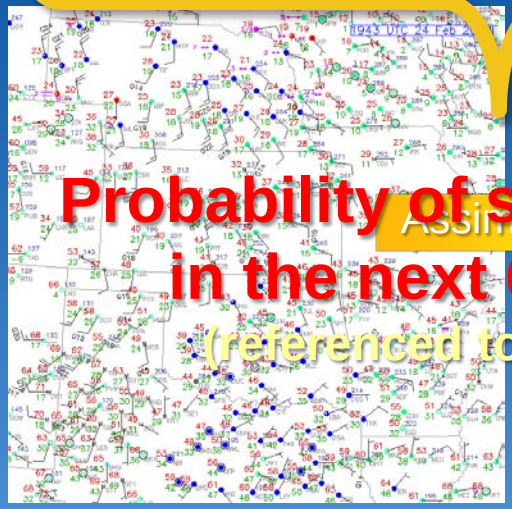
Radar

Assimilated

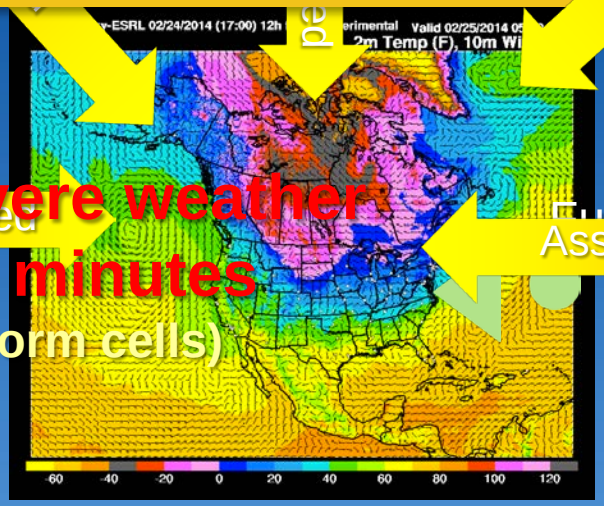
Assimilated

Assimilated

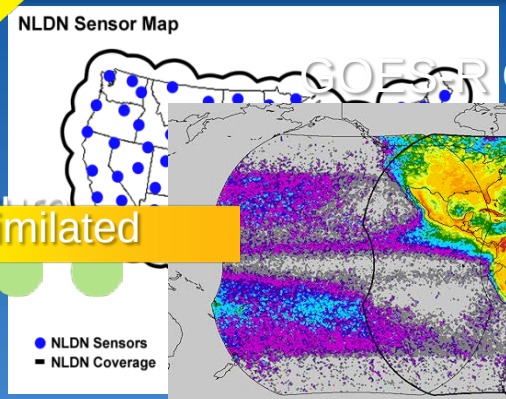
Surface stations



High-res rapid refresh NWP



Lightning



GOES-R GLM

Assimilated

Assimilated

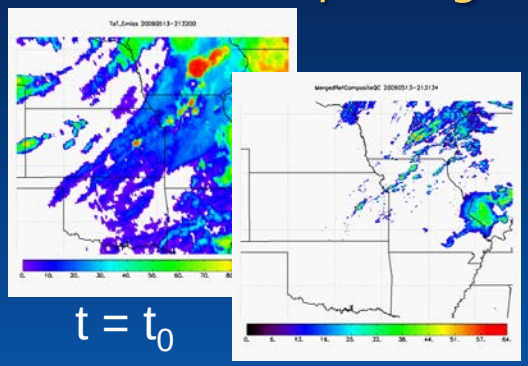
Probability of severe weather in the next 60 minutes

(referenced to storm cells)

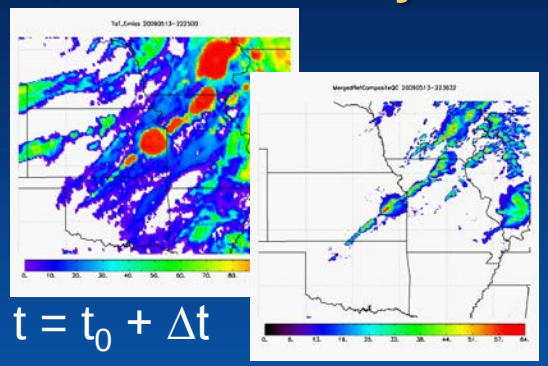
Images are from NOAA, NASA, and NCAR

Observation-driven – Object-centric

1. Identify and track storm-objects in satellite *and* radar imagery
2. Extract data from spatial grids (satellite, radar, NWP) from within objects

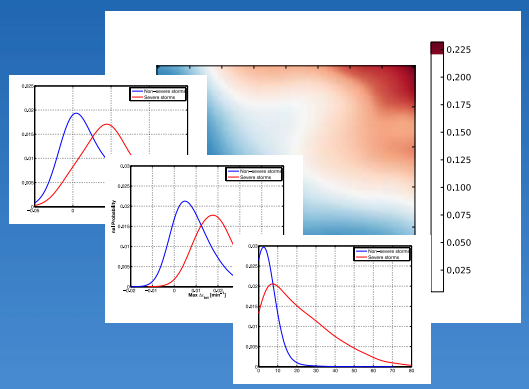


$t = t_0$



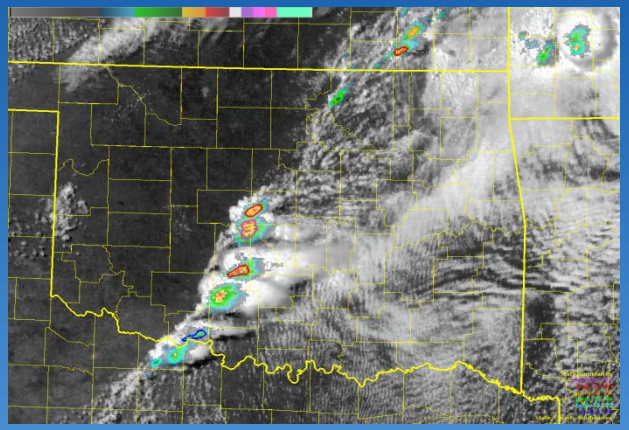
$t = t_0 + \Delta t$

3. Share information from satellite object within overlapping radar object(s)
4. Use trained statistical model to compute probability of severe



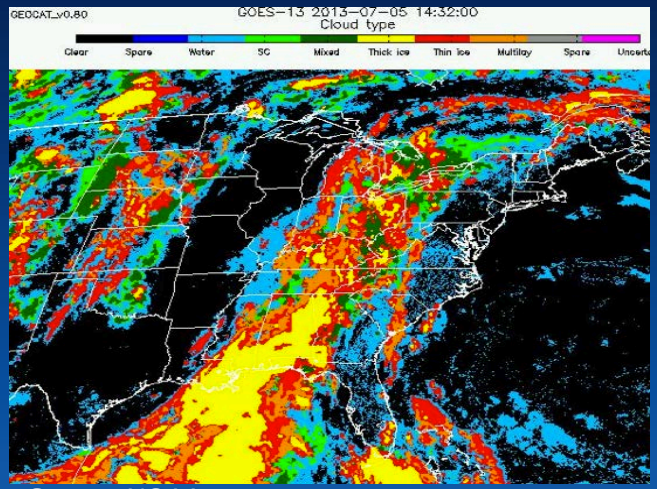
Probability of severe

$$P(C_{severe}|\mathbf{F}) = \frac{P(C_{severe}) \prod_{i=1}^{N} P(F_i|C_{severe})}{P(\mathbf{F})}$$

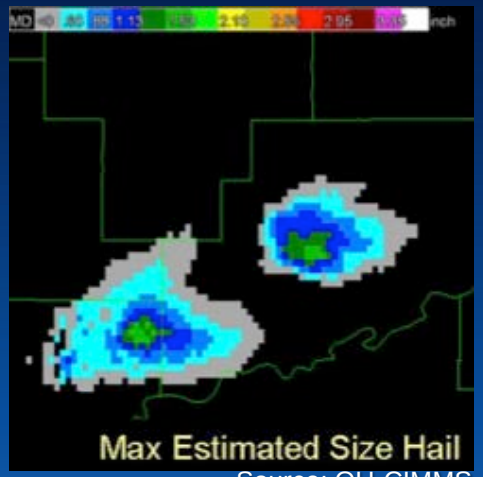


Leverages recent severe weather research

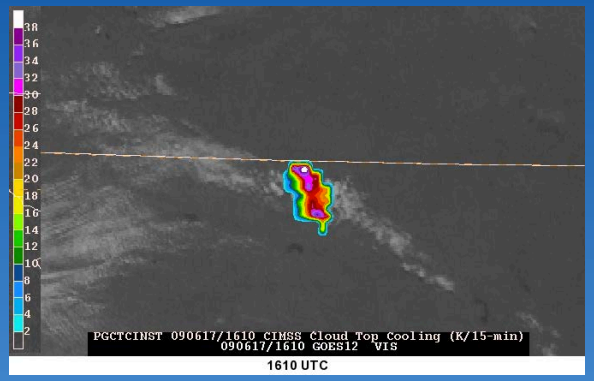
- Satellite and radar object identification and tracking
- RAP-derived fields
- UW-Cloud-top Cooling concept
- GOES-derived cloud-top properties
- NSSL Multi-Radar Multi-Sensor (MRMS) products



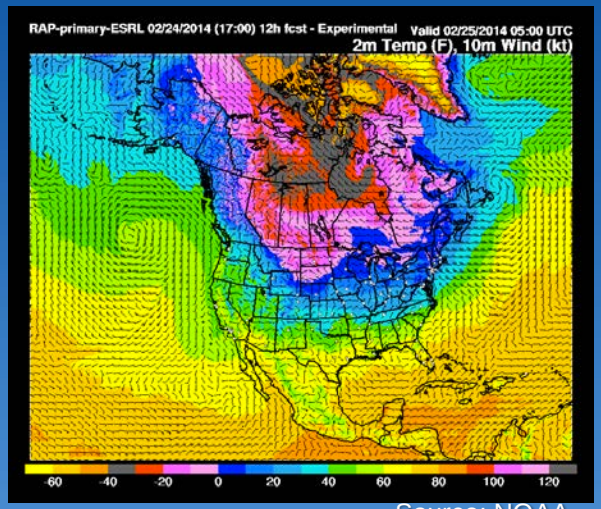
Source: NOAA



Source: OU-CIMMS



Source: UW-CIMSS



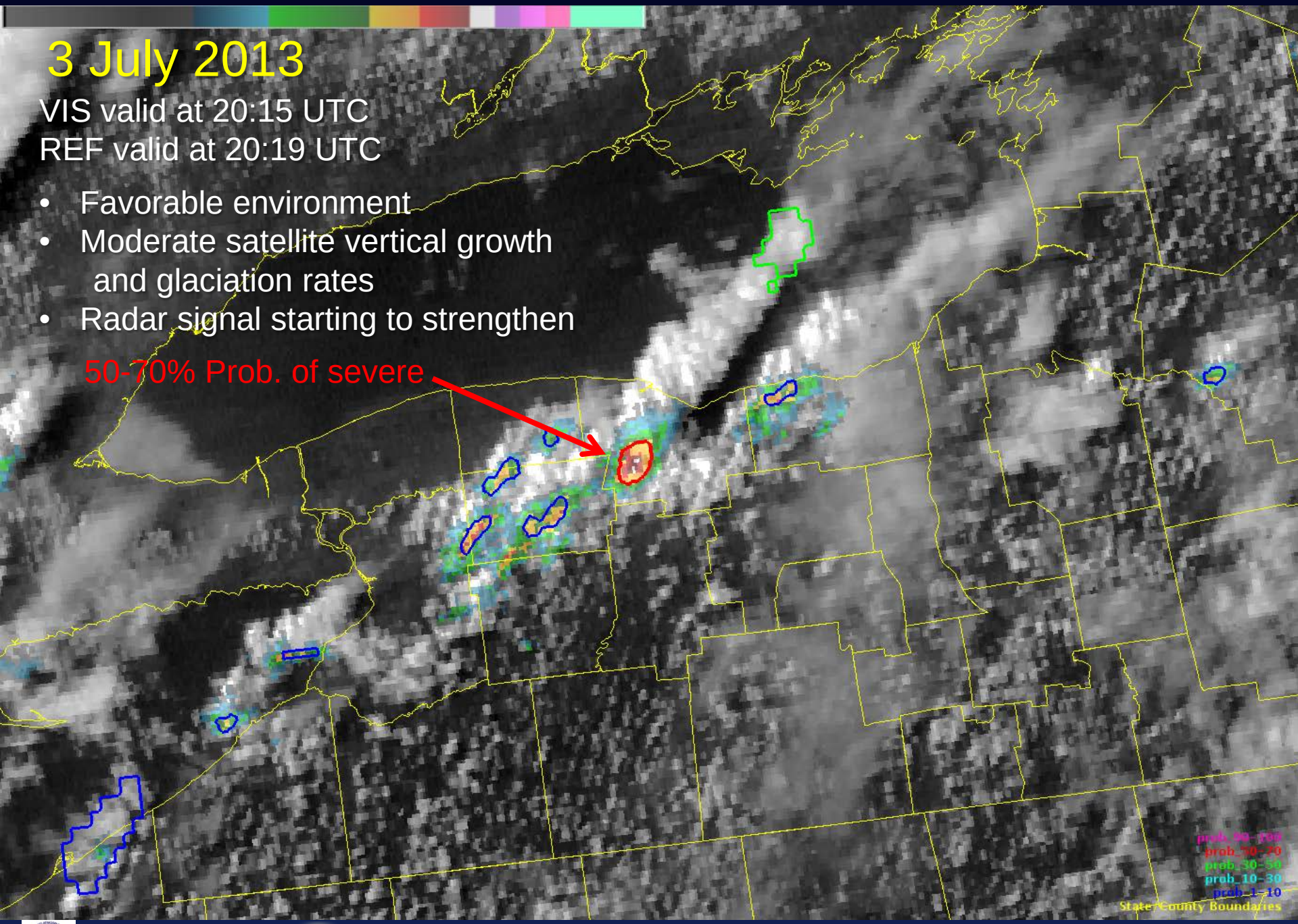
Source: NOAA

3 July 2013

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

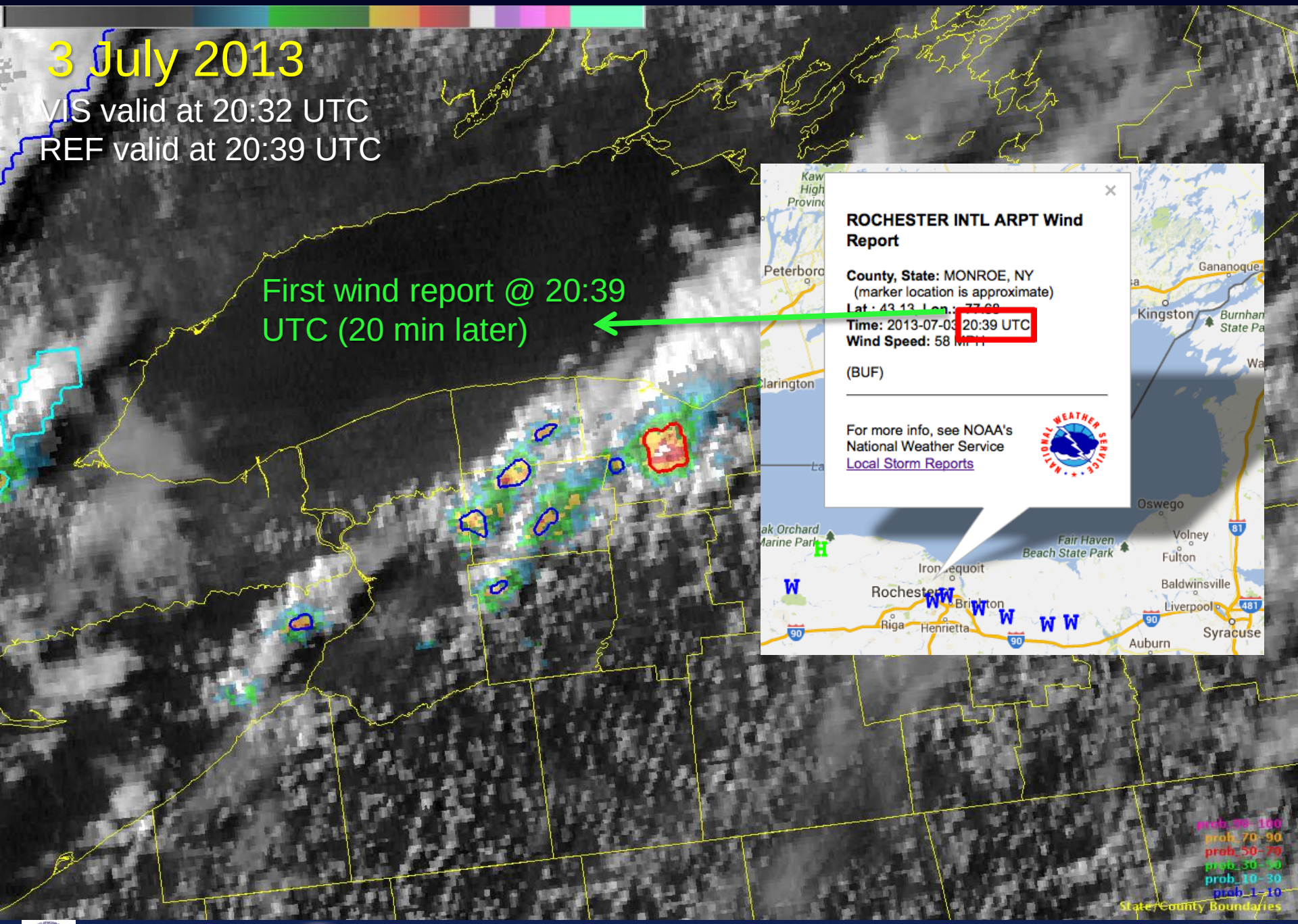
- Favorable environment
- Moderate satellite vertical growth and glaciation rates
- Radar signal starting to strengthen

50-70% Prob. of severe



3 July 2013

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



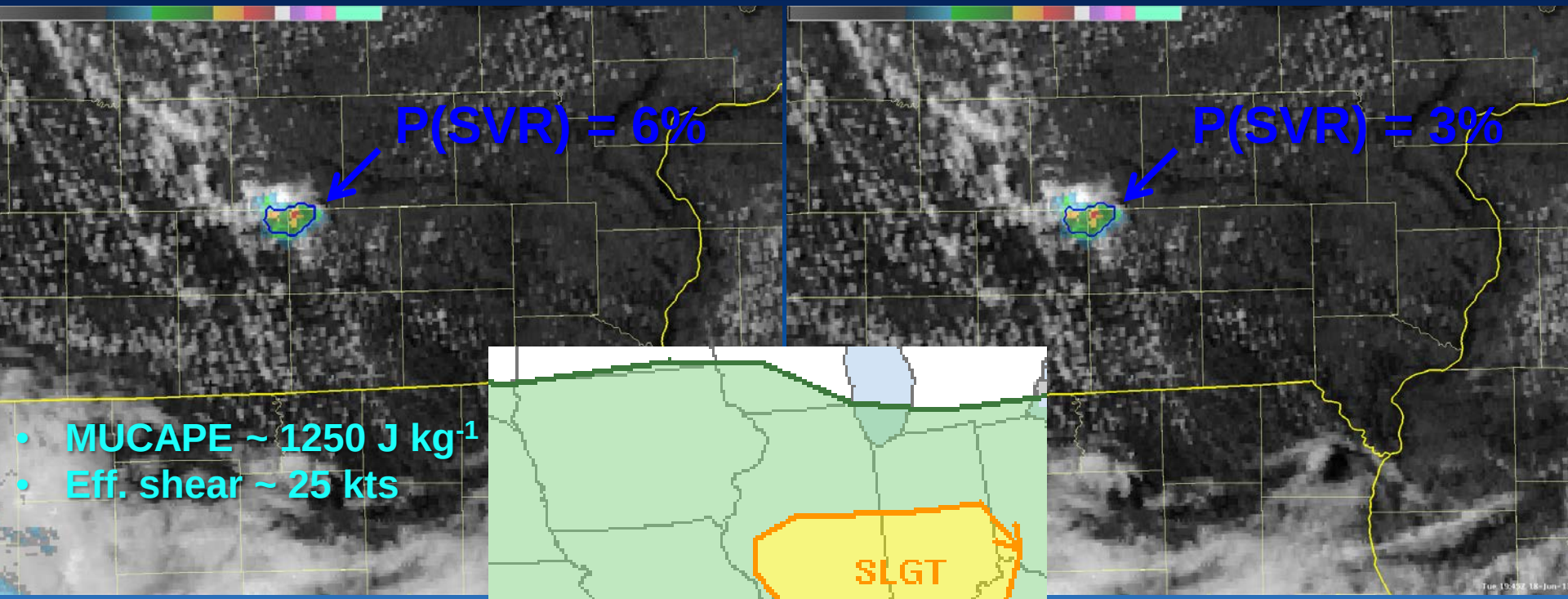
3 July 2013

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

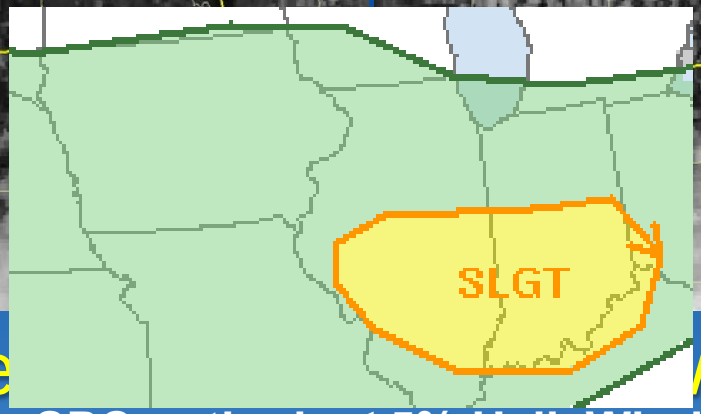
First SVR warning @ 20:52 UTC (33 min later)

18 June 2013

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



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



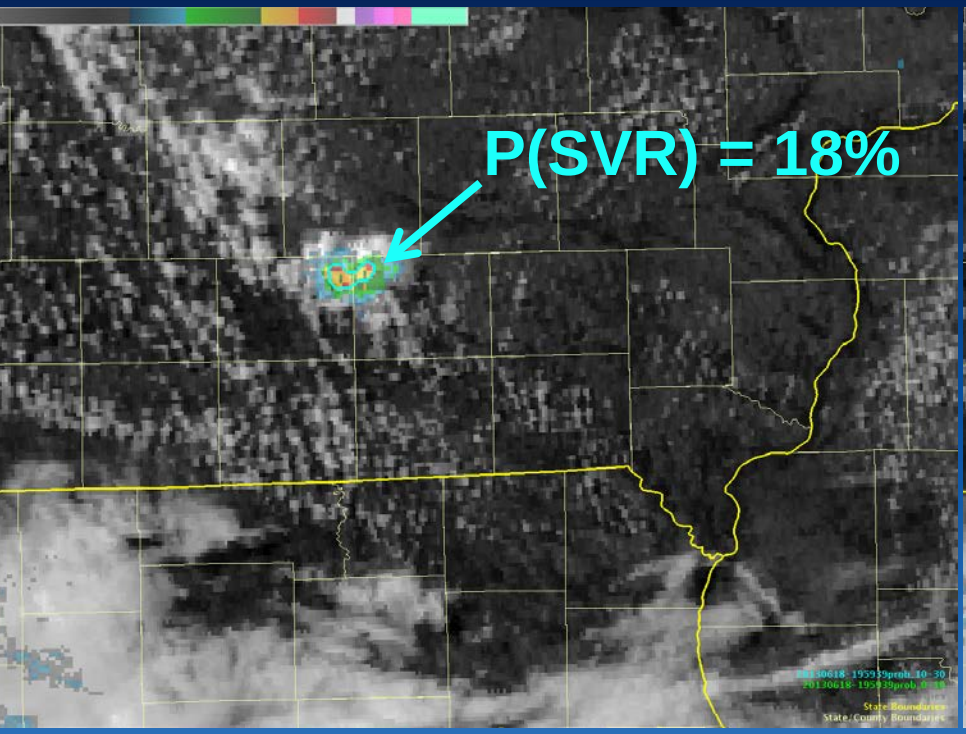
NWP + satellite

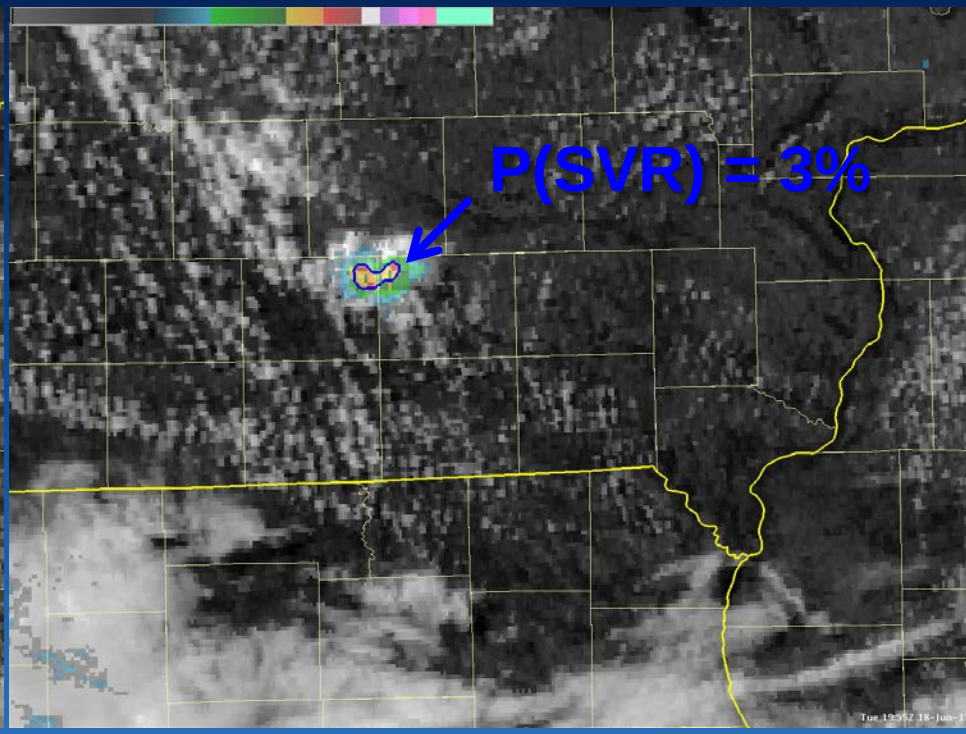
/P + radar only

- 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





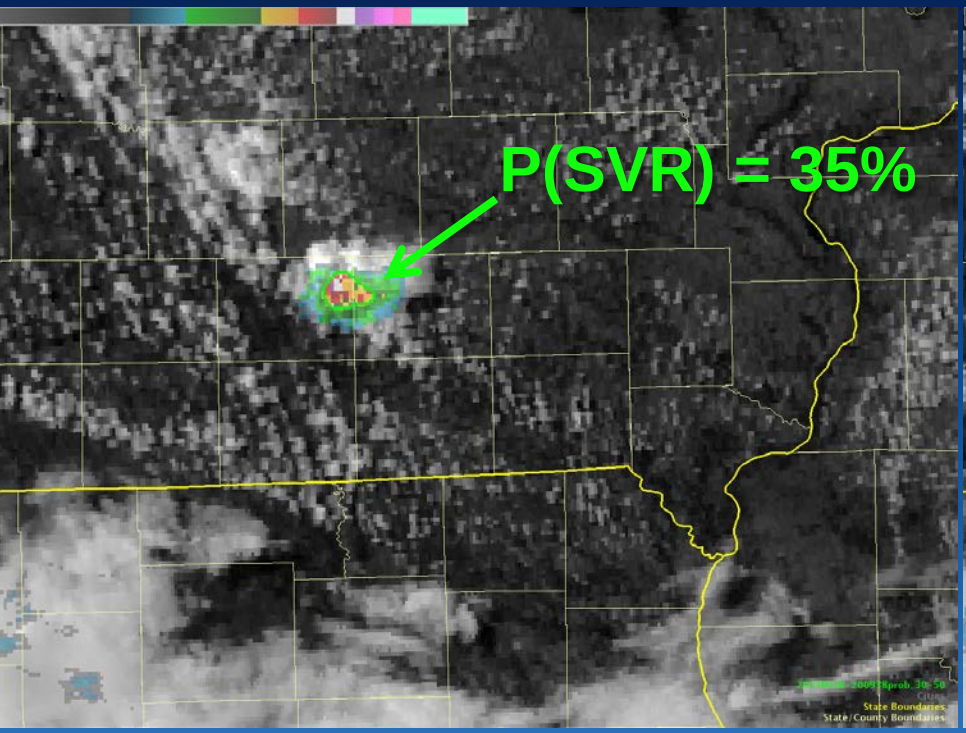
NWP + satellite + radar

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

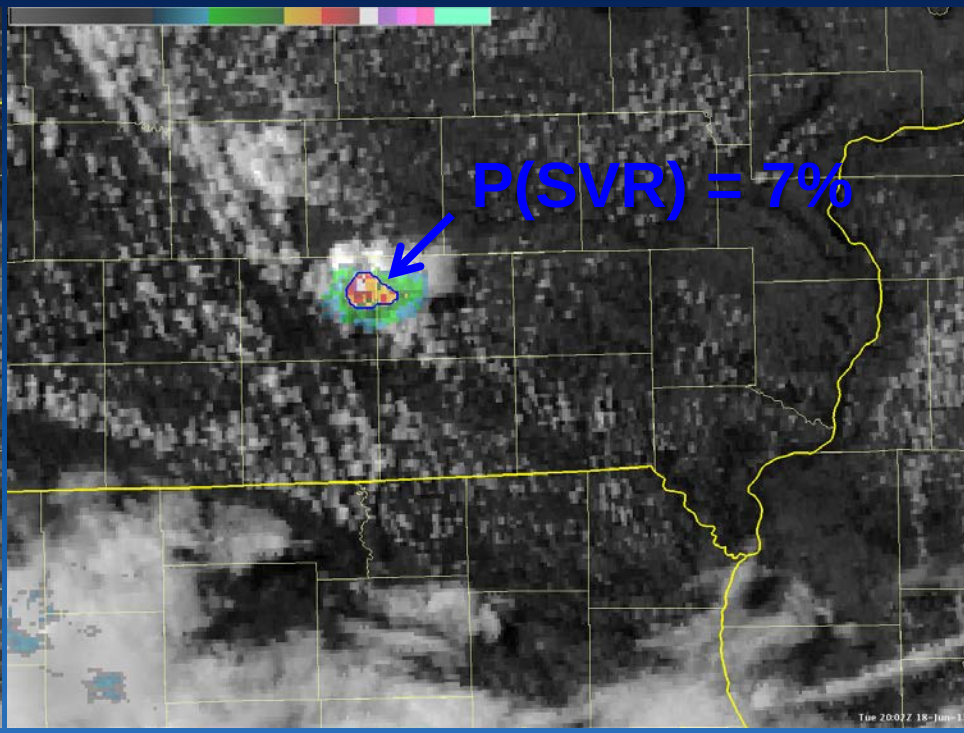
NWP + radar only

18 June 2013

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



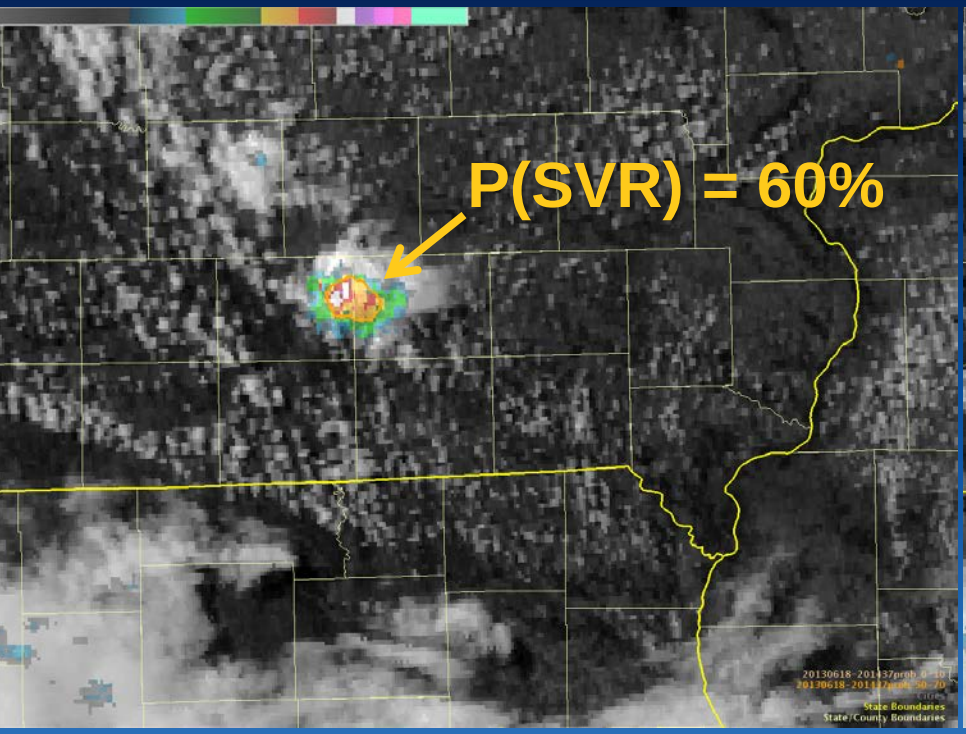
NWP + satellite + radar



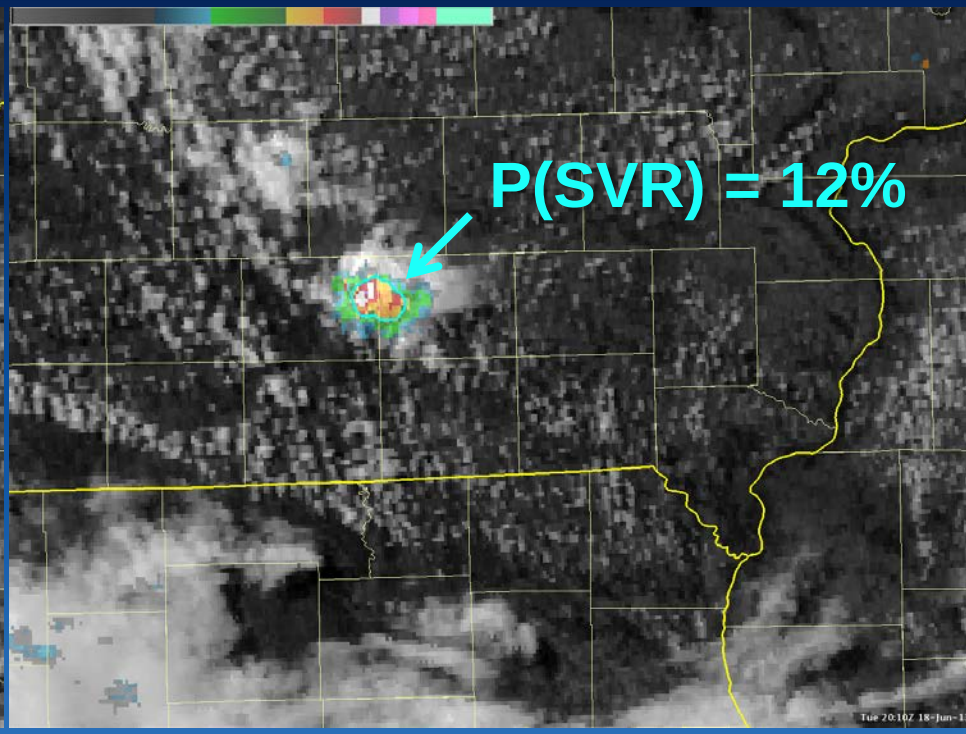
NWP + radar only

18 June 2013

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



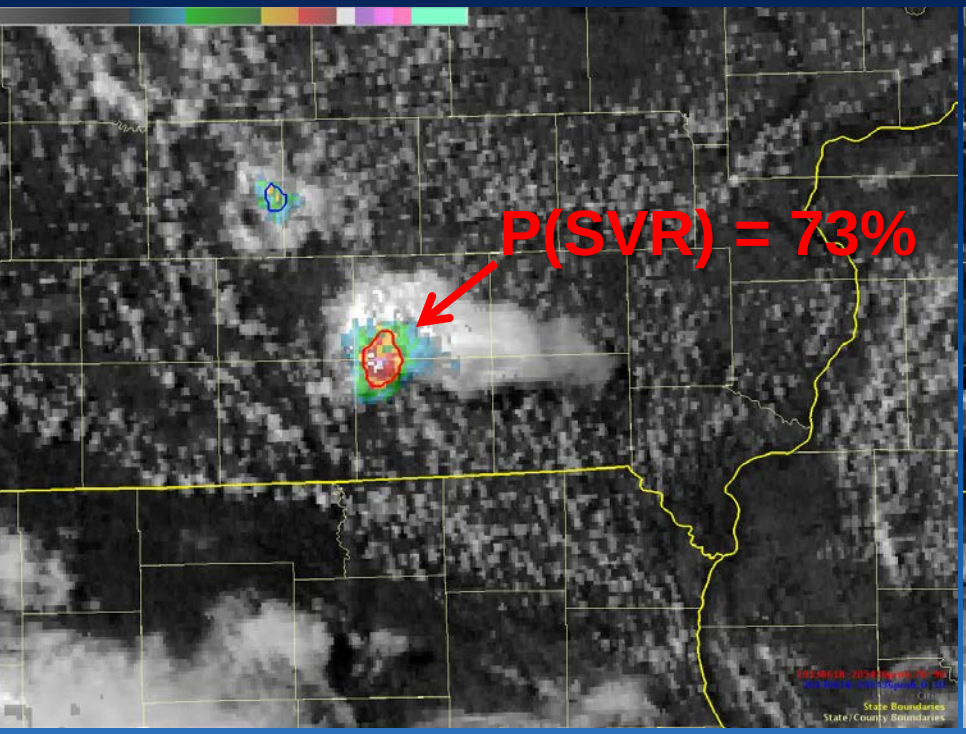
NWP + satellite + radar



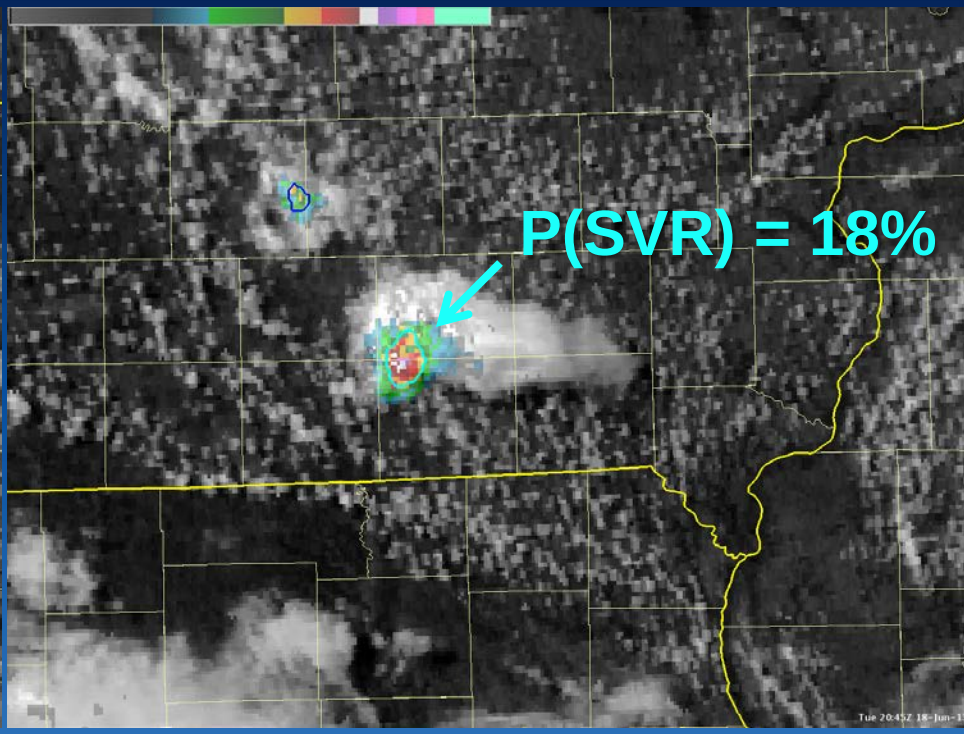
NWP + radar only

18 June 2013

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



NWP + satellite + radar



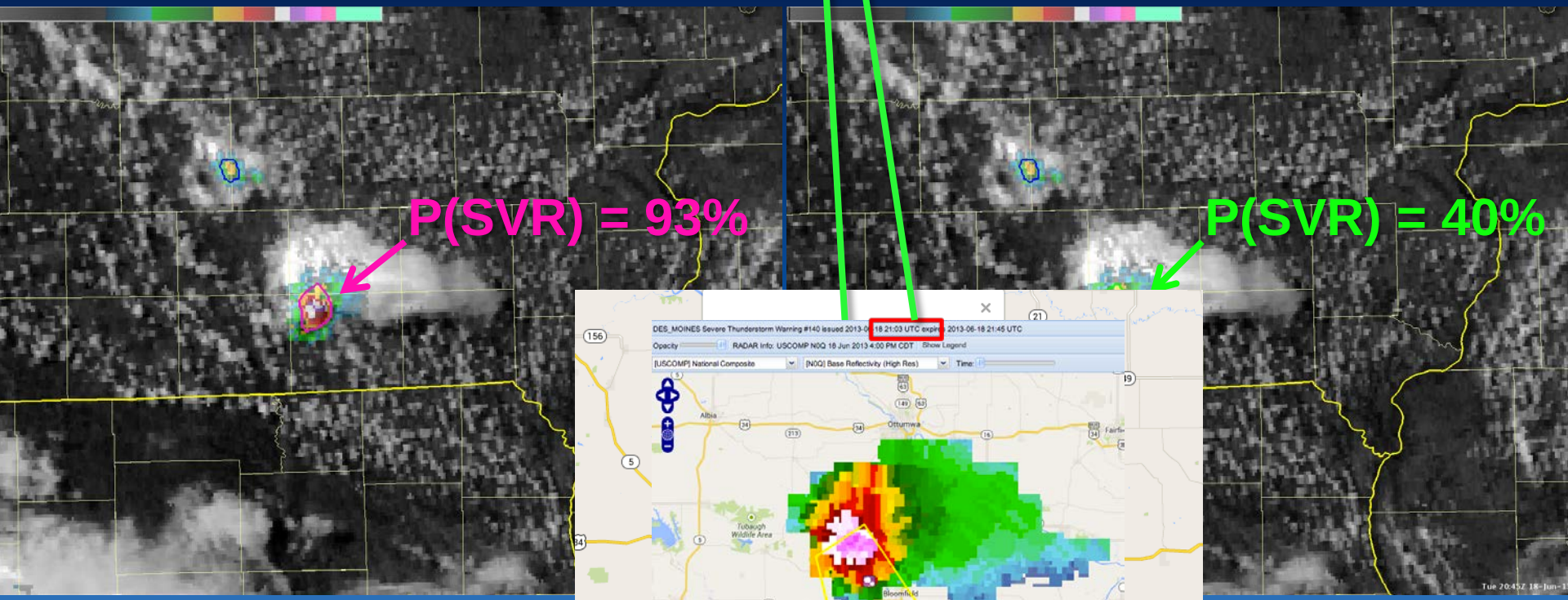
NWP + radar only

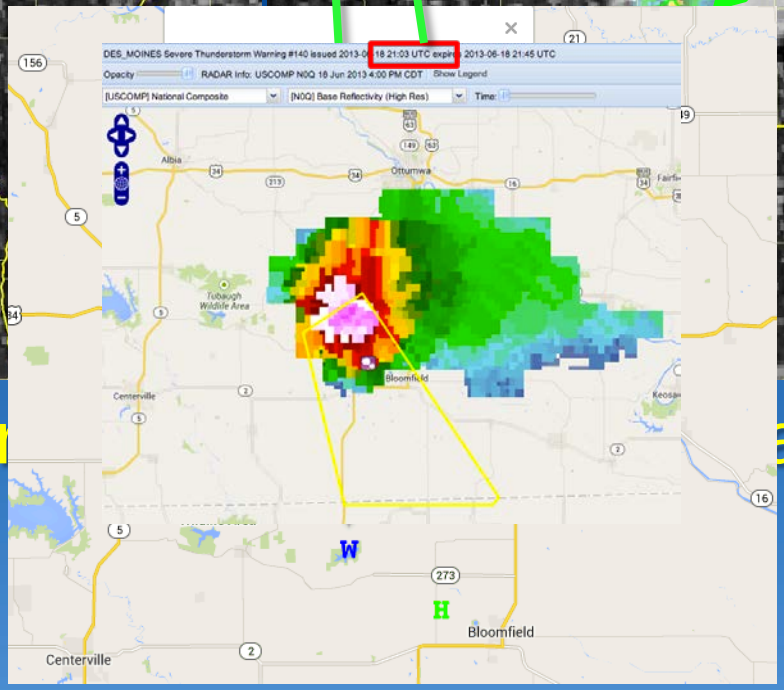
18 June 2013

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)

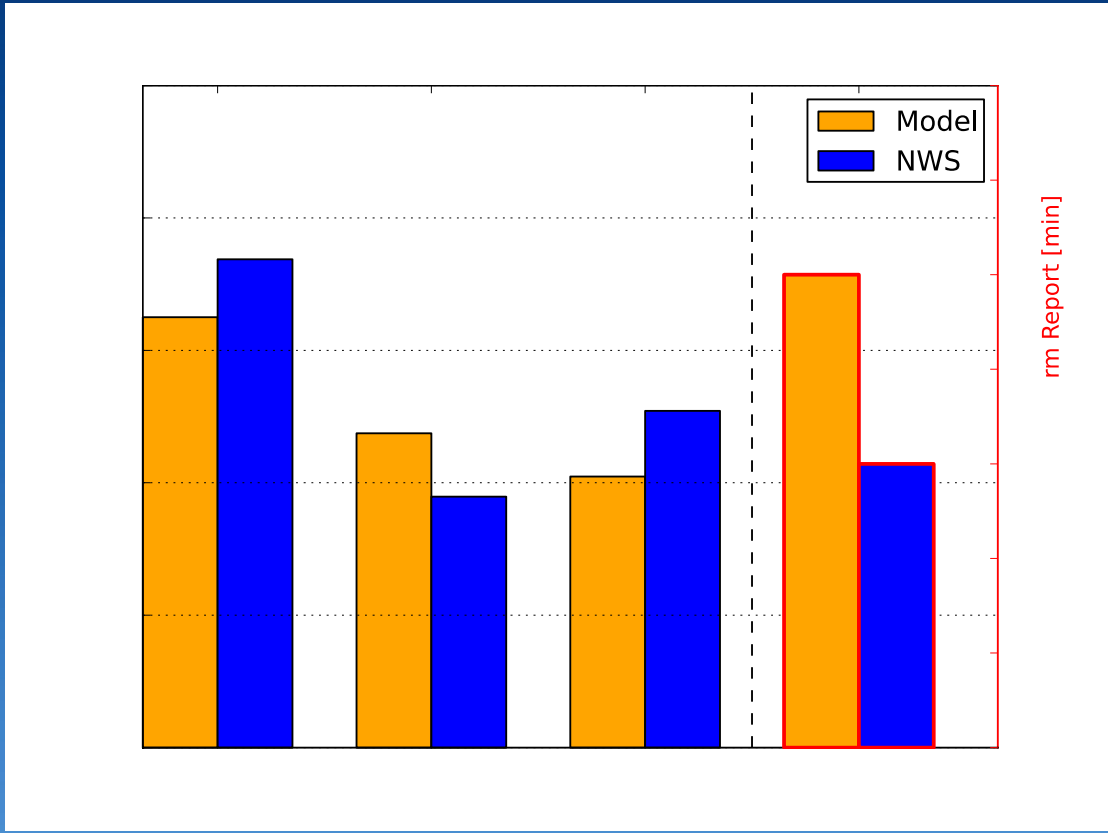




NWP + satellite + radar only

Preliminary Evaluation

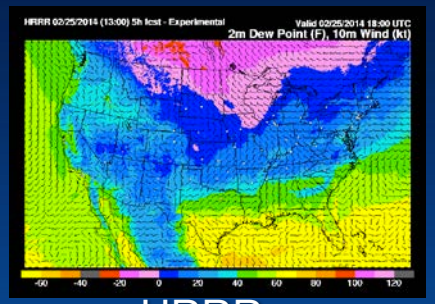
- Model has been running in near real-time since April 2013
- Evaluation based on over 800 storms (severe and non-severe)
- Model is not as skillful as NWS warnings (but comparable)
- Model median lead-time is 25 min vs. 15 min for NWS



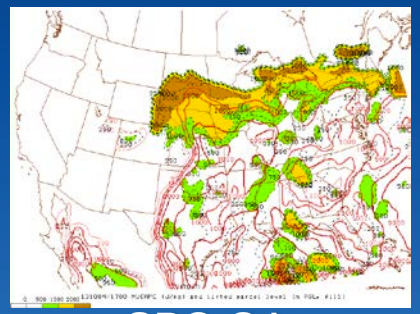
Future Data Integration

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

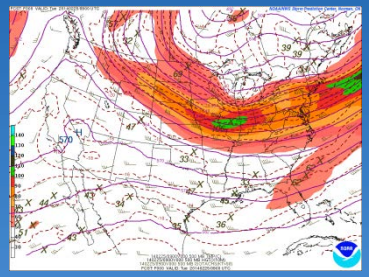
NWP / near-storm env.



HRRR

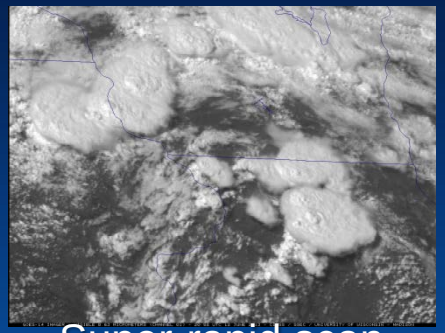


SPC-OA

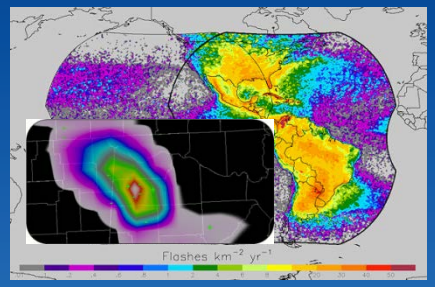


SREF

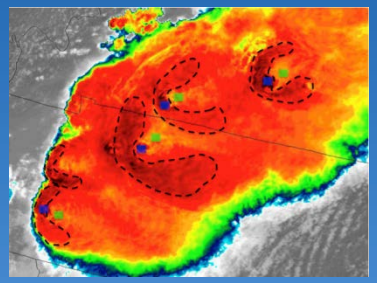
GOES-R



Super-rapid scan

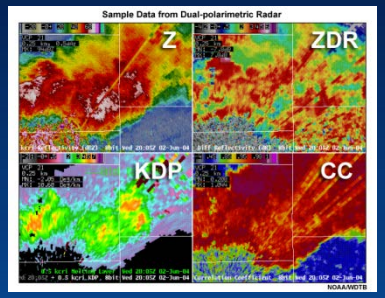


GLM

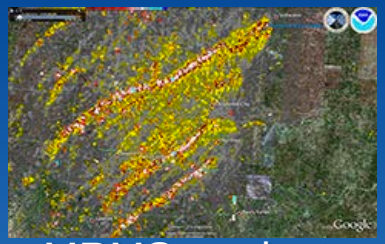


OT detection

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

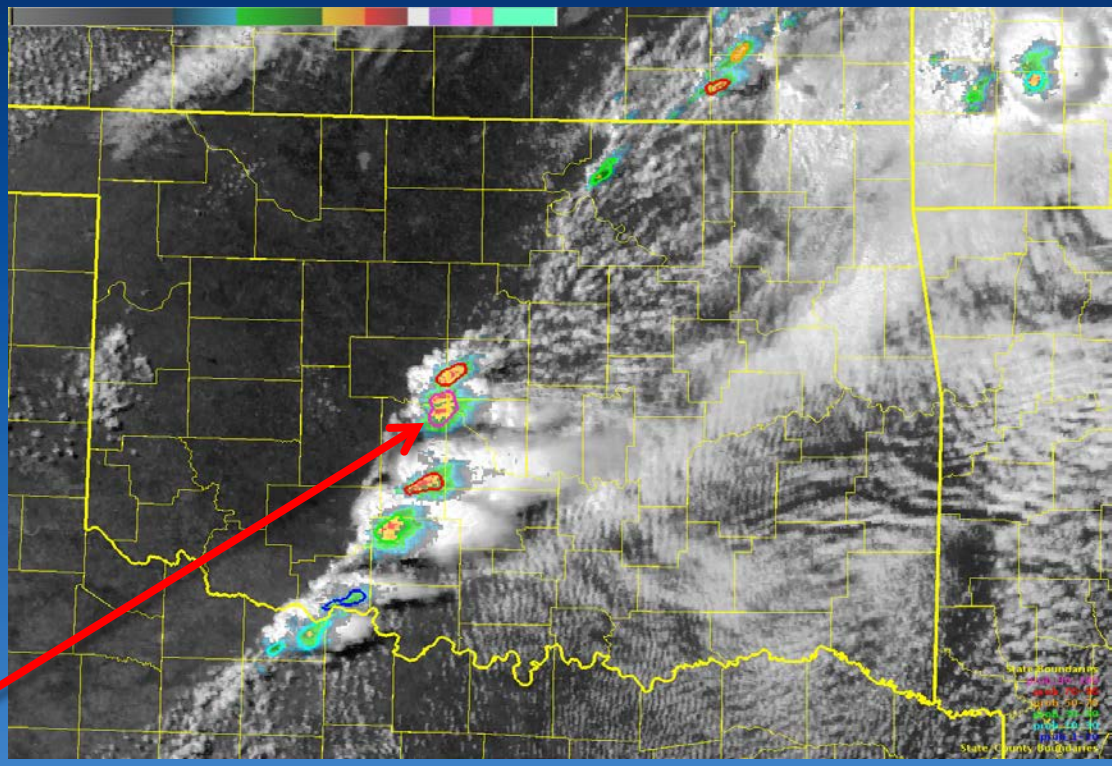
Road ahead (next 2-3 years)

1. Determine best source(s) for near-storm environment
2. Incorporate GLM total lighting
3. Optimize temporal trends in satellite fields from GOES-R super-rapid scan
4. Evaluate potential of NEXRAD dual-pol and other MRMS products for model
5. Generate probabilistic forecasts of specific hazards
6. Forecaster evaluation along the way at proving ground and HWT experiments; internal statistical verification

The model:

- Distills GB of data from the "fire hose" into kB
- Employs a simple yet effective statistical approach (naïve Bayesian)
- Is day/night independent
- Is flexible
- Can associate a satellite object with multiple radar objects

- Operates under cirrus shields
- Integrates recent research
- Has a versatile display format
  - Shapefiles, contoured to objects



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