Warn-on-Forecast

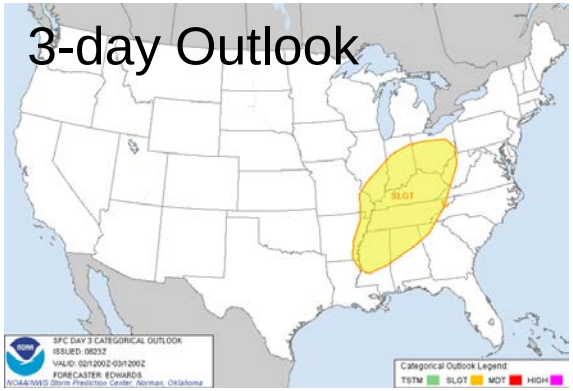
Merging Radar and Satellite Observations

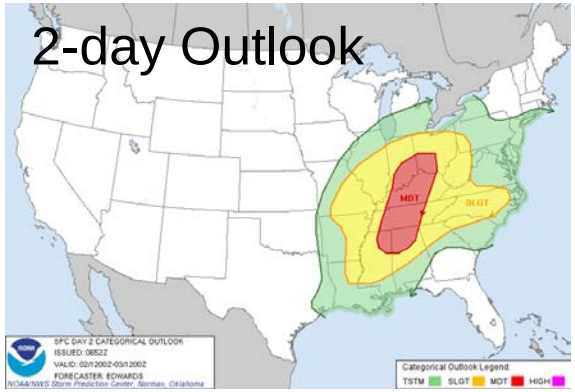
David J. Stensrud and Louis J. Wicker

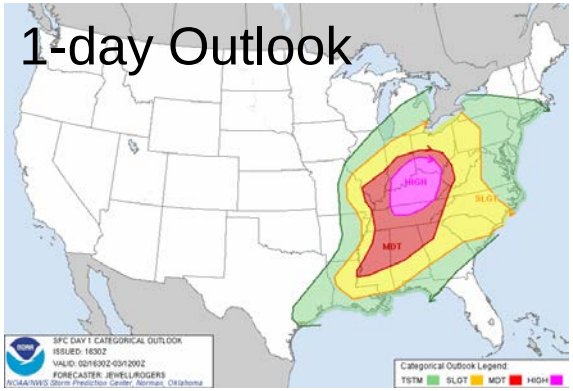
NOAA/National Severe Storms Laboratory

Present Warning System: 2 March 2012

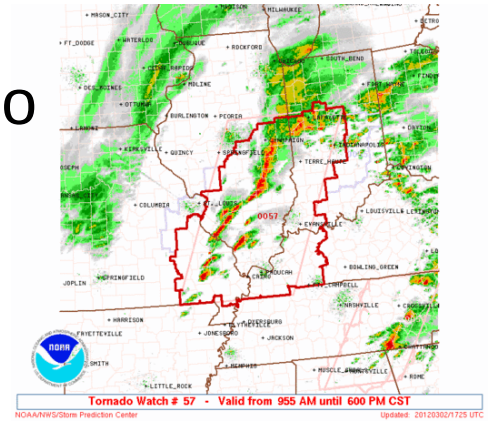
Warning is natural culmination of information distributed over previous days

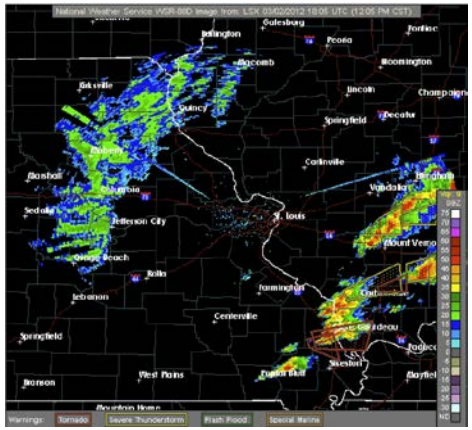






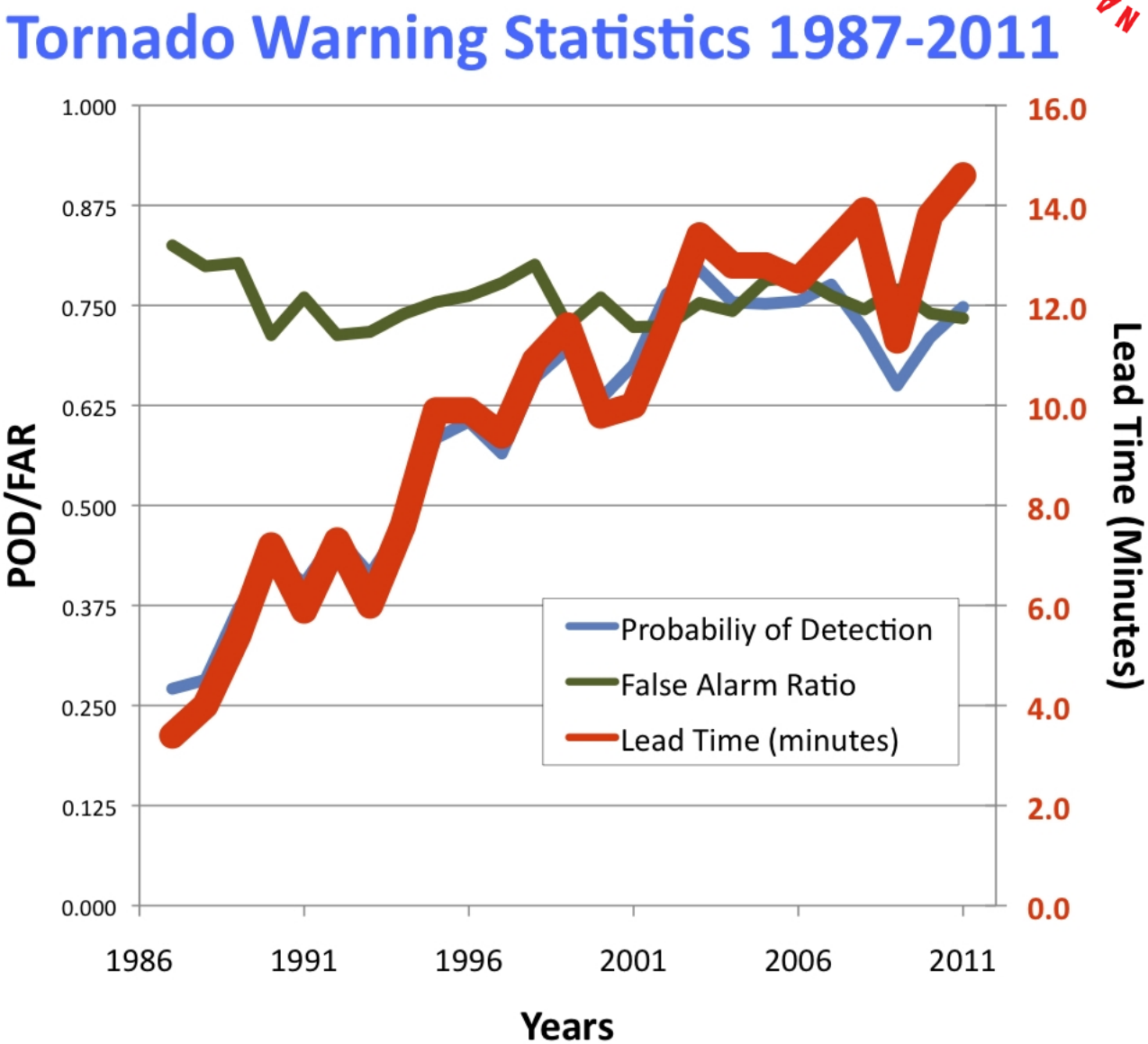
Tornado Watch





Tornado Warning

How well are we doing?

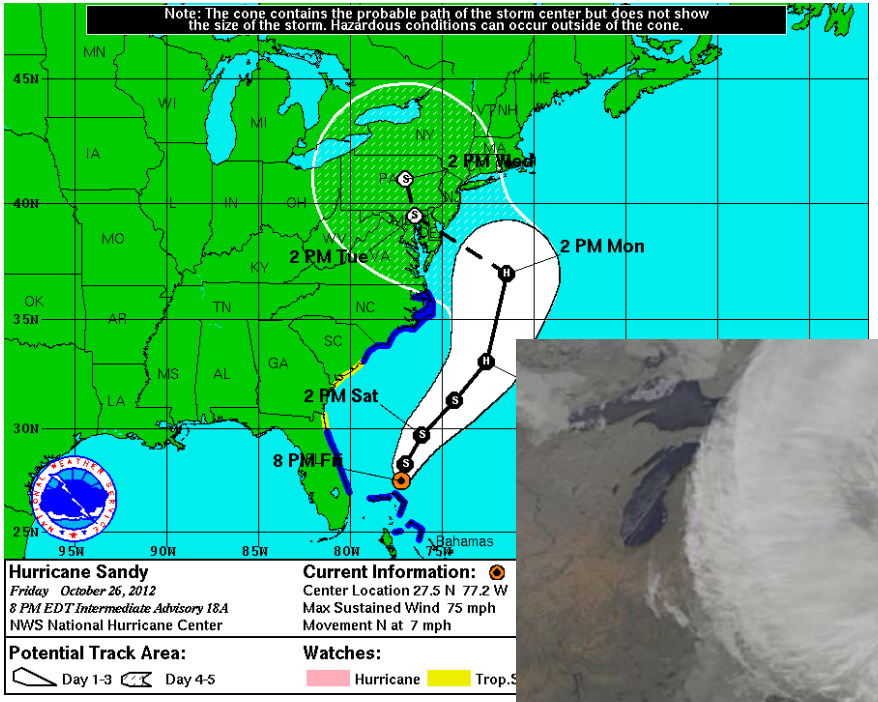


CHIEFS

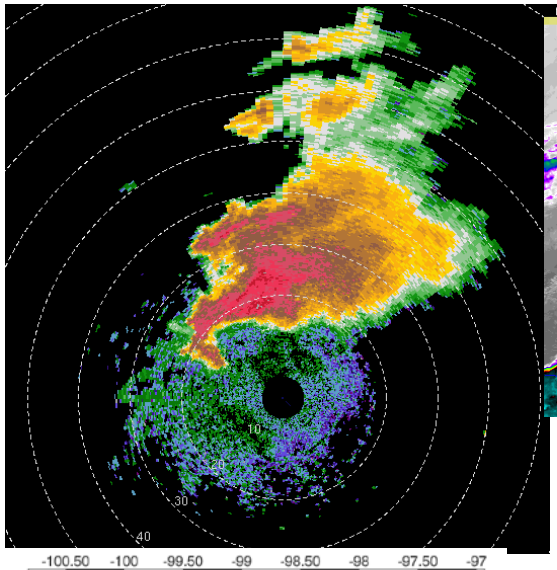
AMBULANCE

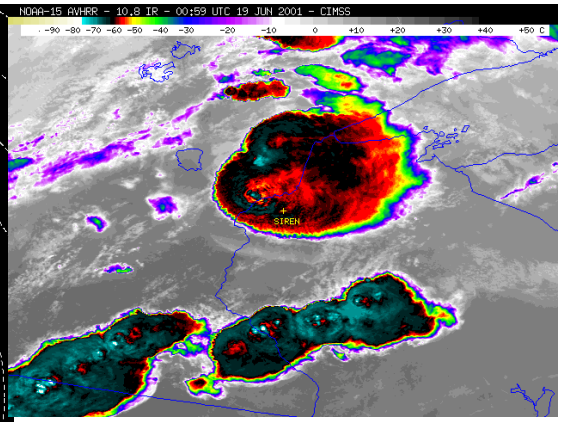
LOWE'S
48

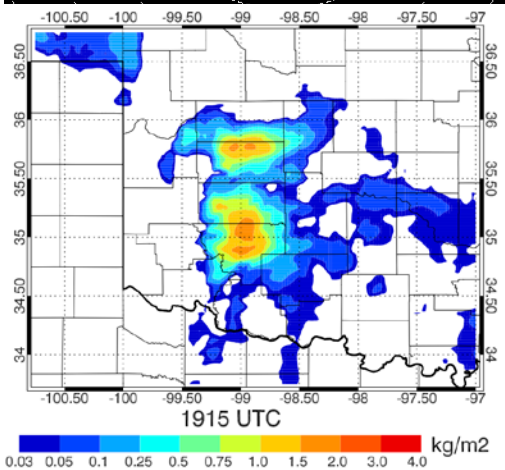
Model Forecasts Used as Warning Guidance



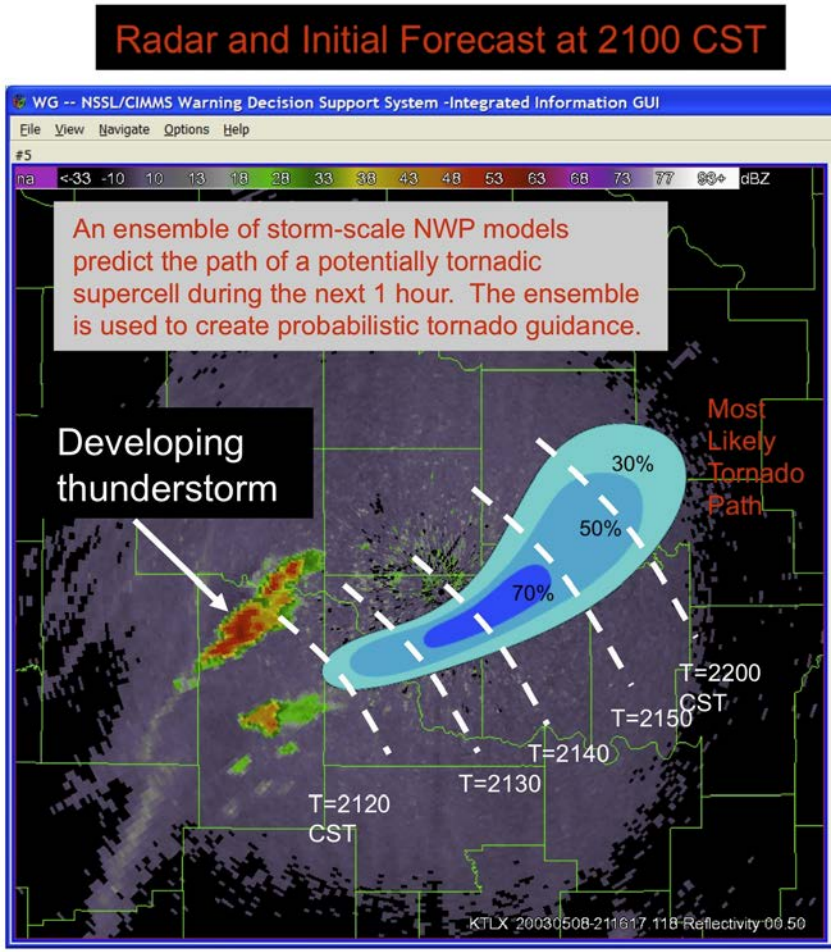
Missing An Opportunity…







Warn-on-Forecast Vision

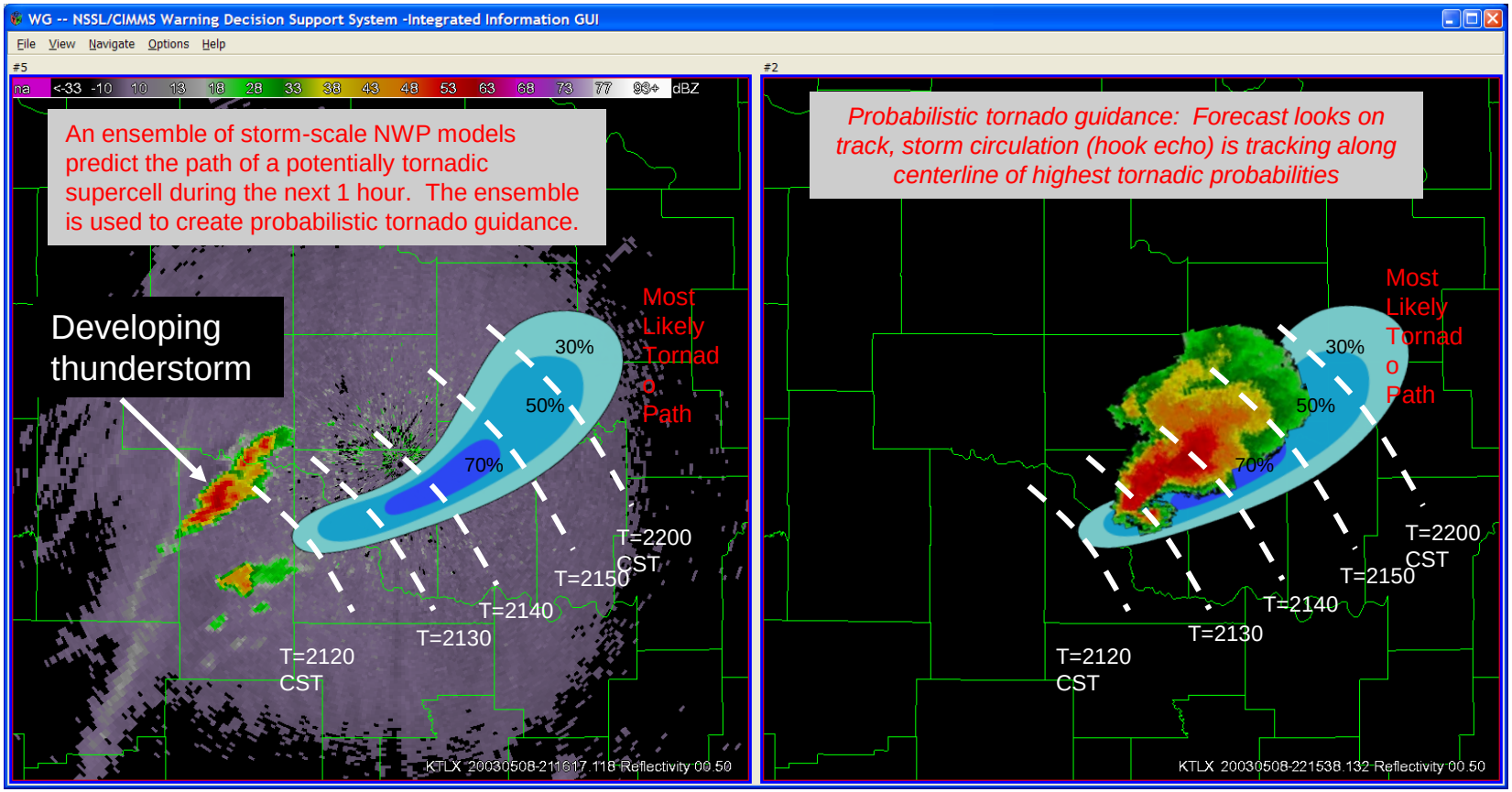


Stensrud et al. 2009 (October *BAMS*)

Warn-on-Forecast Vision

Radar and Initial Forecast at 2100 CST

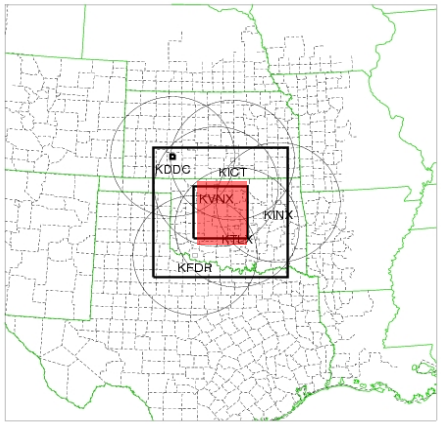
Radar at 2130 CST: Accurate Forecast



Stensrud et al. 2009 (October *BAMS*)

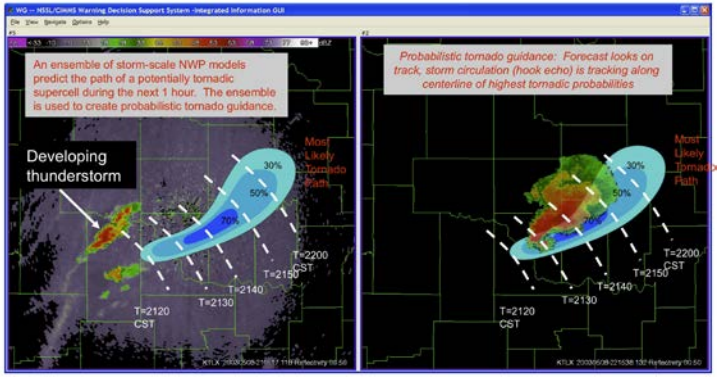
Two major research activities:

- Demonstrate value of a single *three-dimensional variational (3DVAR) analysis* for warning activities

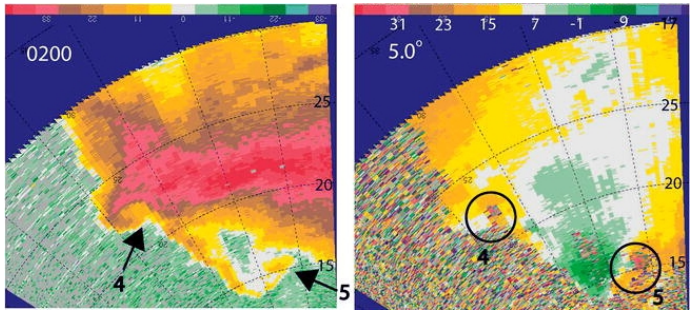


Gao et al. (2013)
Smith et al. (2014)

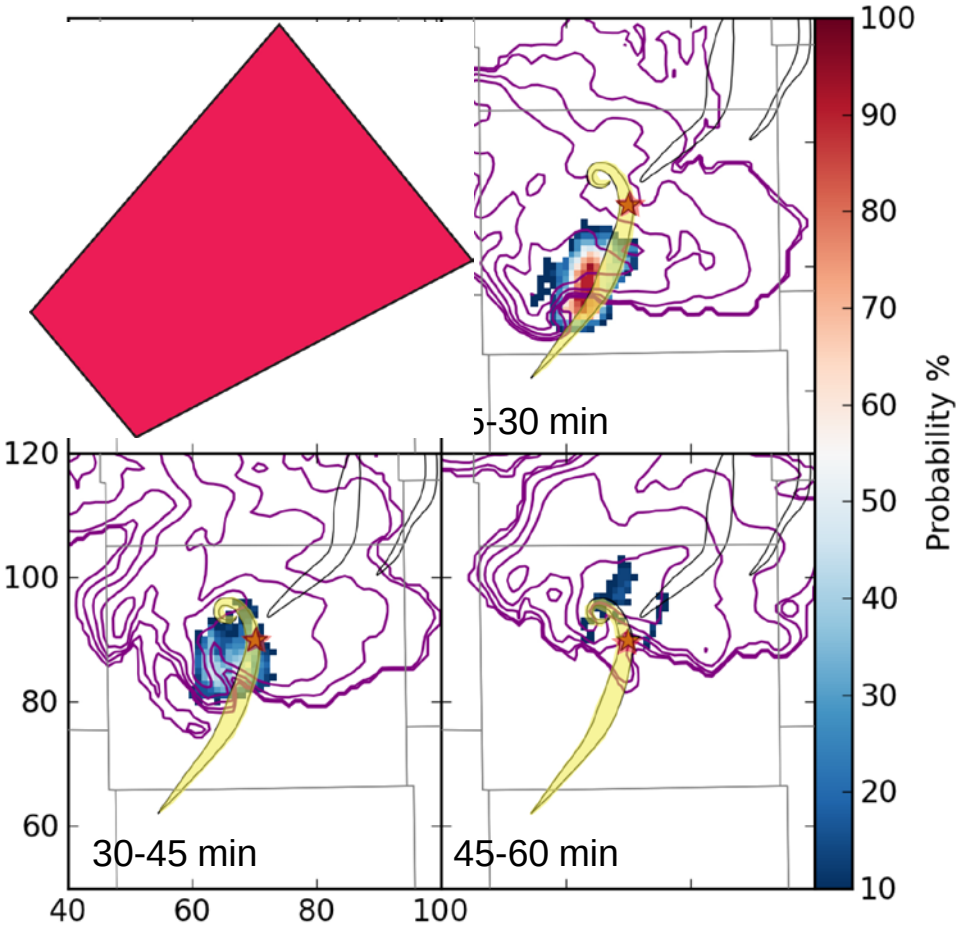
- Research to make Warn-on-Forecast *forecast* vision a reality



Warn-on-Forecast: 4 May 2007 Greensburg, Kansas, Tornado

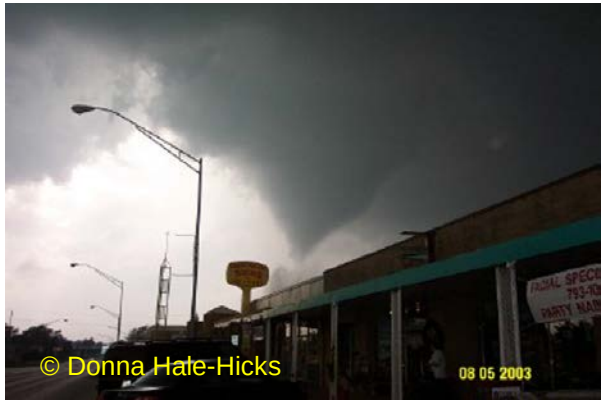


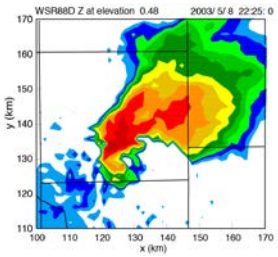
Mobile radar observations of Greensburg storm from Bluestein (2009)

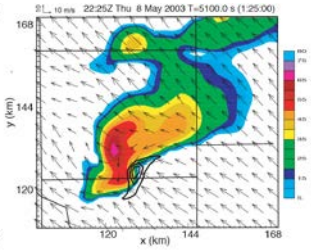


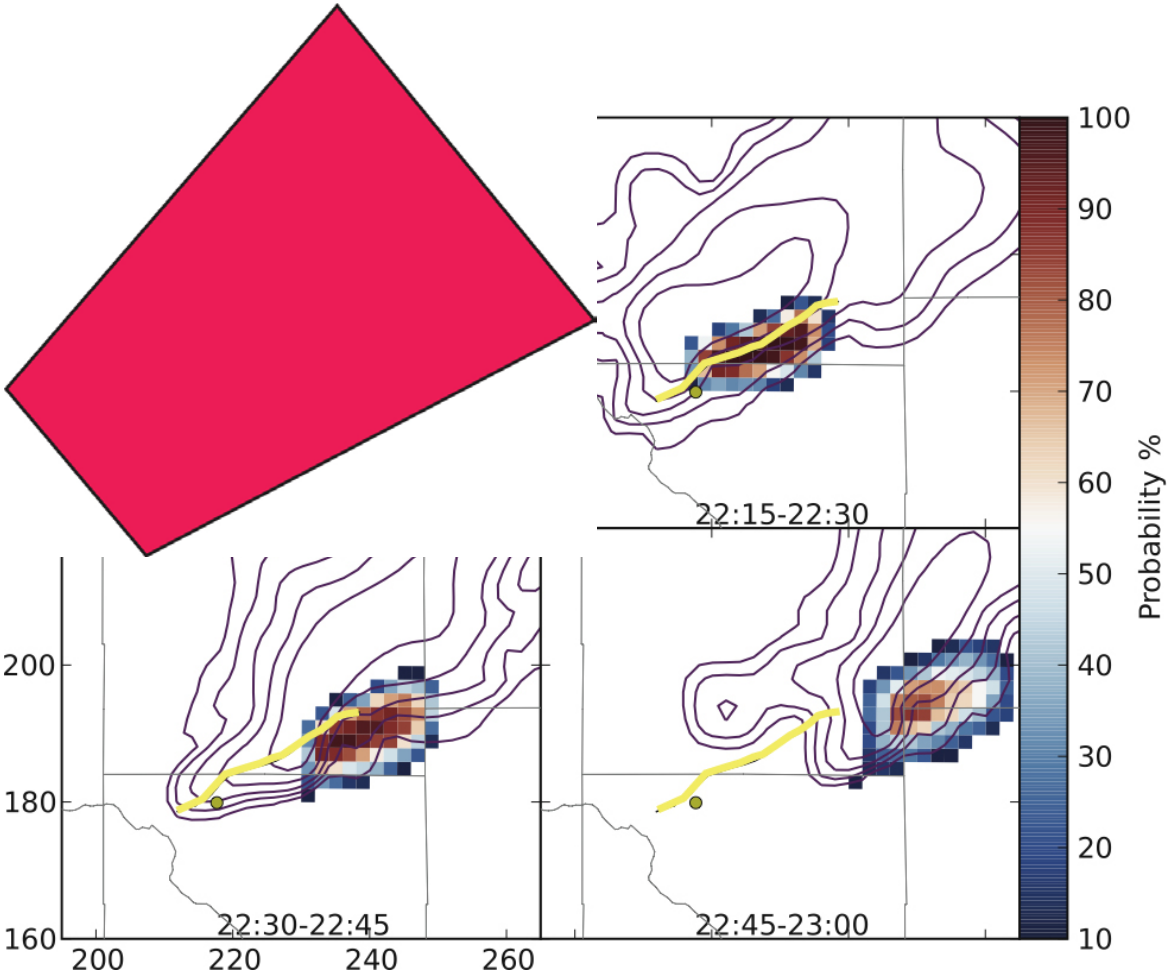
Dawson et al. (2013)

Warn-on-Forecast: 8 May 2003 Oklahoma City Tornado





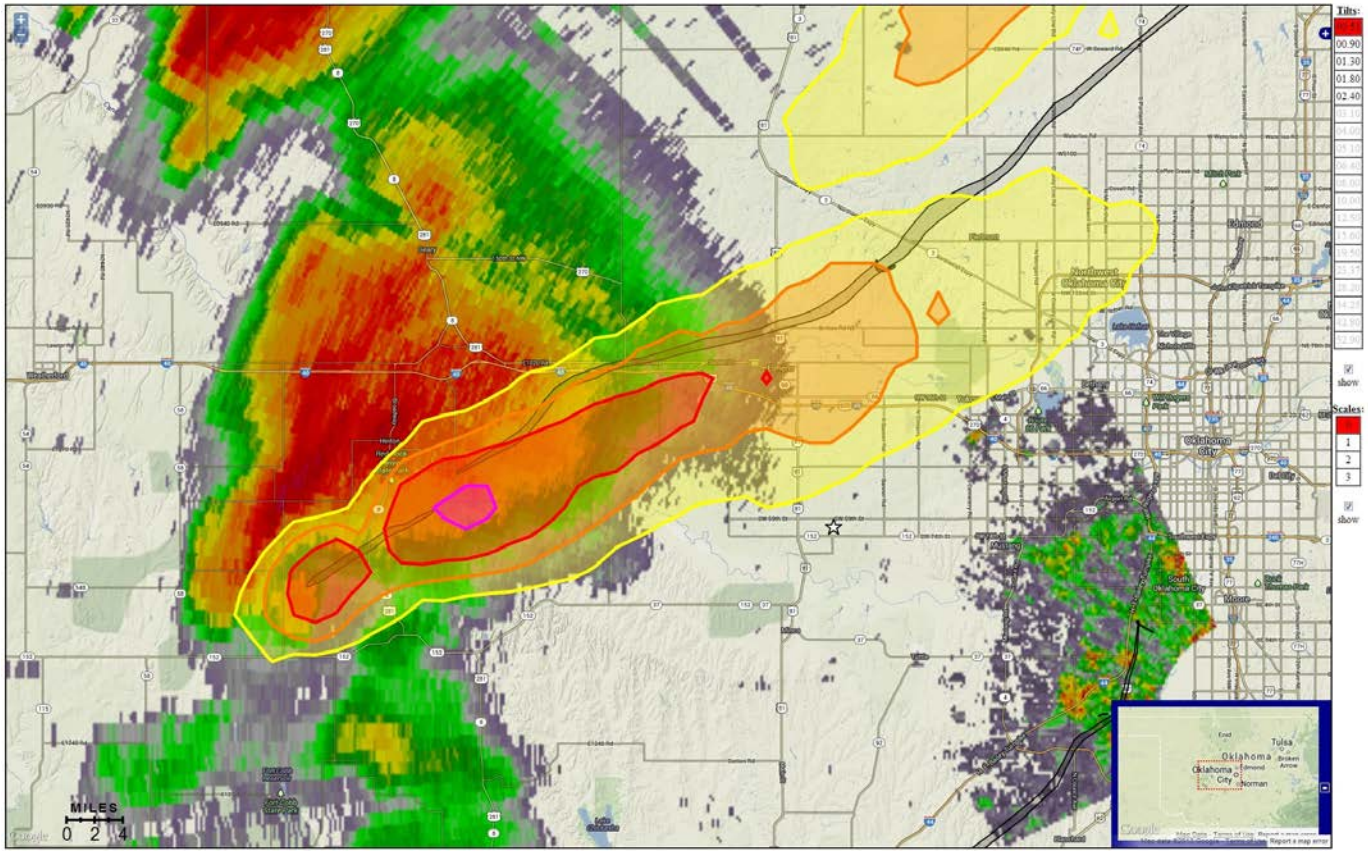




Yussouf et al. (2013)

Warn-on-Forecast: 24 May 2011 El Reno, Oklahoma,Tornado

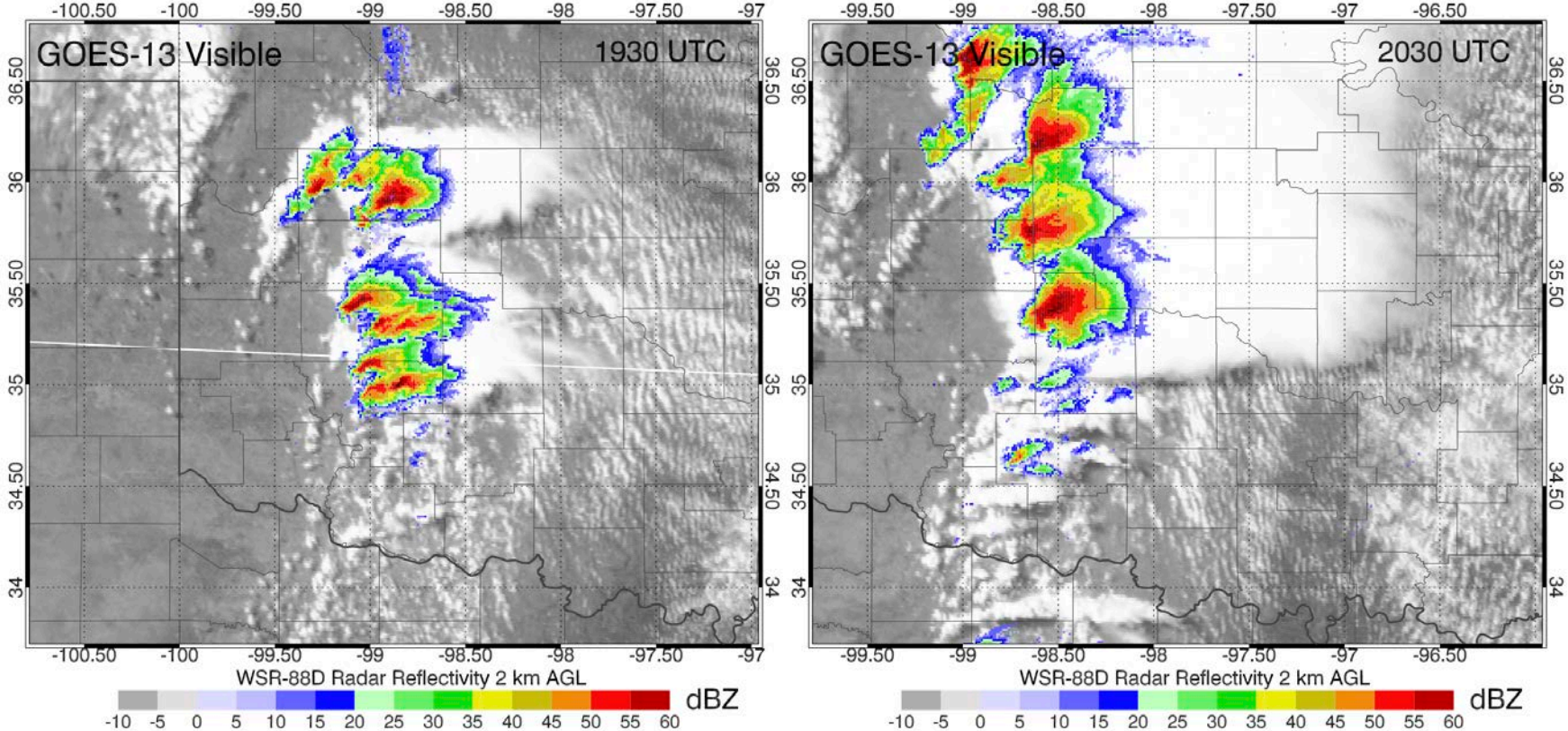
Vorticity swaths shown to improve when using 1-minute Doppler observations from a phased array radar



Courtesy Chris Karstens, CIMMS and Louis Wicker, NSSL

Case Study: 24 May 2011

- High instability, high shear environment in which several tornadic supercells formed in central OK

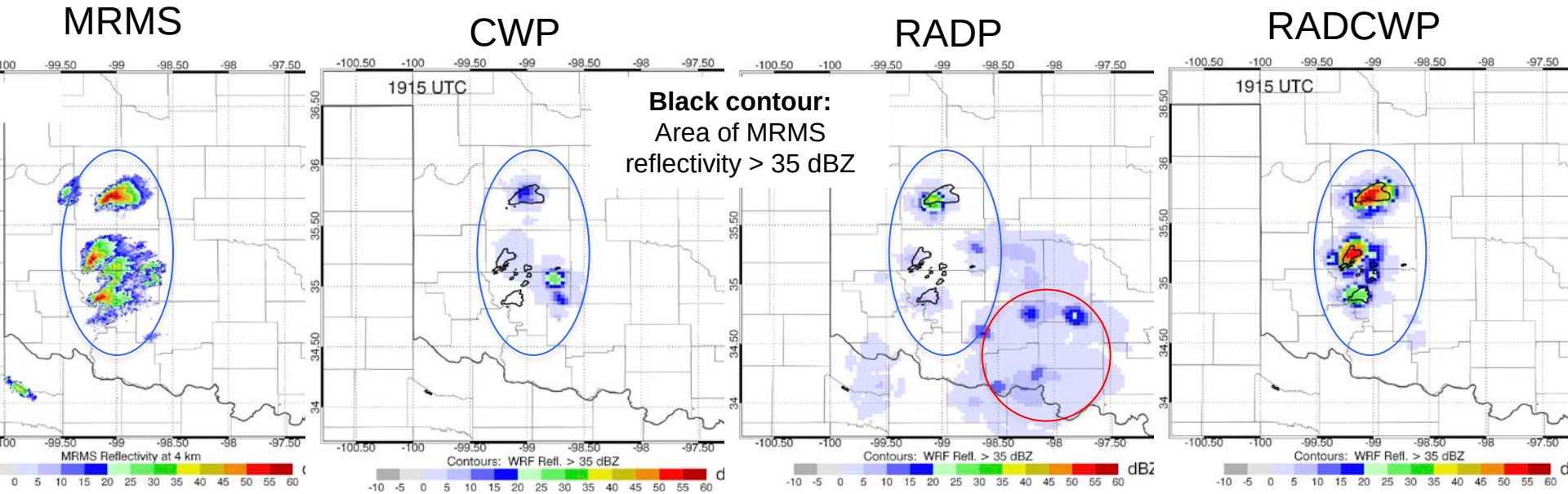


- These experiments focus on the period of initial development and growth of convection into mature and tornadic supercells

Courtesy Thomas Jones, CIMMS, and P. Minnis and R. Palikonda

Early Convection: 1915 UTC

4 km Reflectivity (ensemble mean)



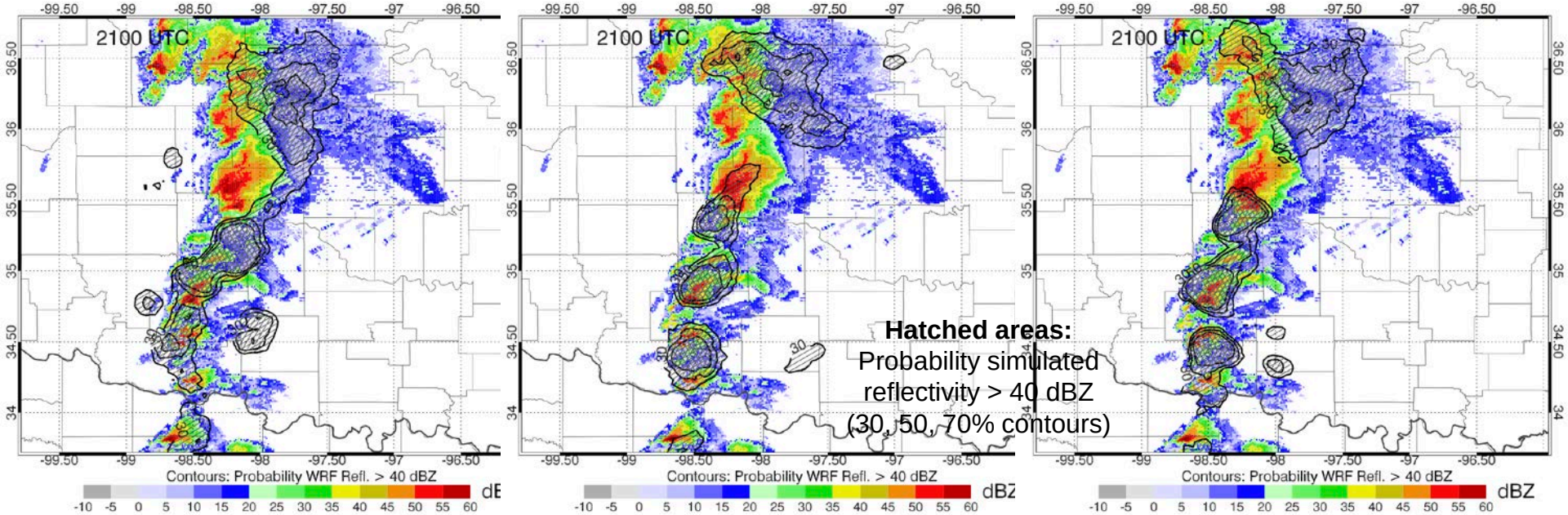
- **CWP** and **RADP** slow to develop high radar reflectivity compared to observations
- **RADP** generates larger area of low reflectivity corresponding to spurious **CWP** seen previously
- **RADCWP** locates convection correctly and generates higher magnitude reflectivity values consistent with observations
- ***Assimilation of both radar and satellite data allows for a faster storm spin-up within the model***

Courtesy Thomas Jones, CIMMS, and P. Minnis and R. Palikonda

1 hour forecast: 2100 UTC

4 km Reflectivity probability

CWP RADP RADCWP

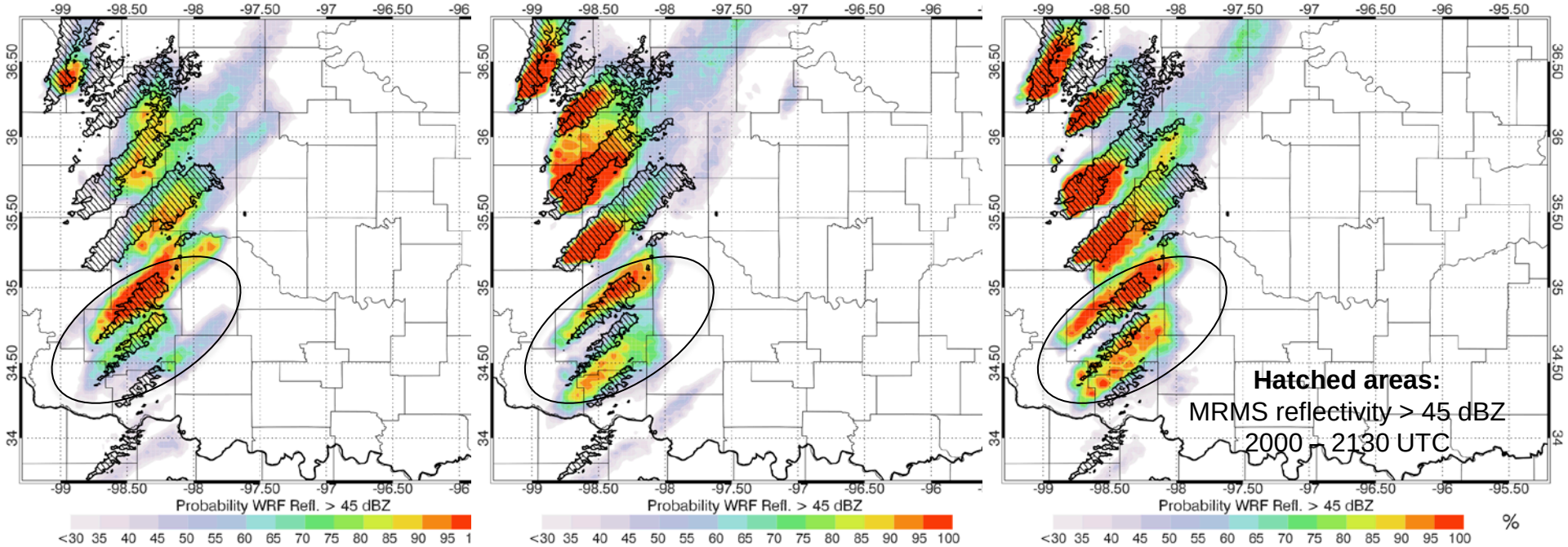


- **CWP**: Eastward bias in northern storms, good location for southern storms
- **RADP**: Similar to CWP, but with a larger break in convection in central OK
- **RADCWP**: Orientation of northern storms similar to CWP, smaller difference in southern storms

Courtesy Thomas Jones, CIMMS, and P. Minnis and R. Palikonda

Time Series Probabilities

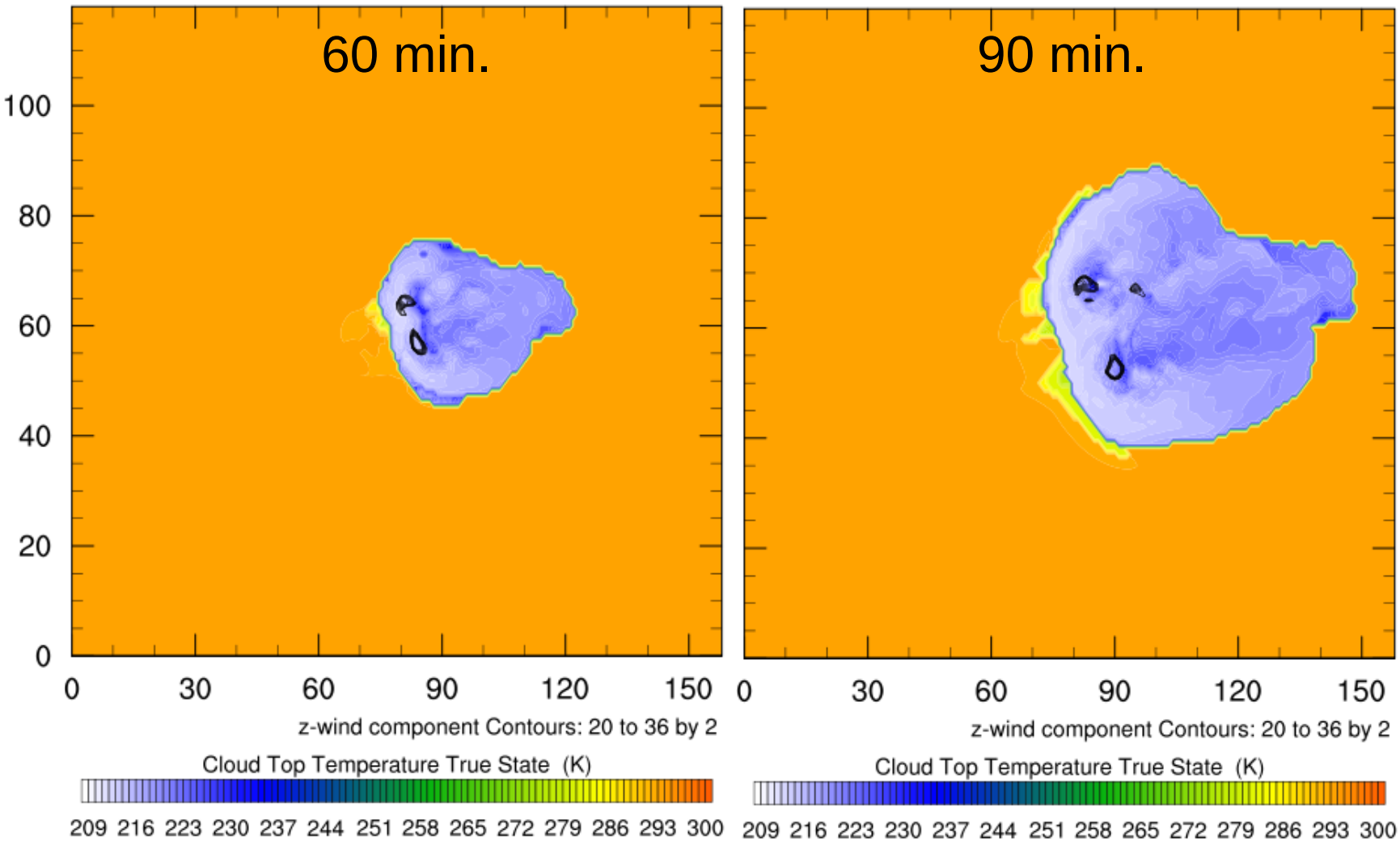
CWP RAD RADCWP



- Integrated probability of simulated reflectivity > 45 dBZ between 2000 – 2130 UTC compared to observations
- **RADCWP** generates stronger southern storms compared to **RADP**
- ***Assimilation of both radar and satellite data yields better ensemble prediction***

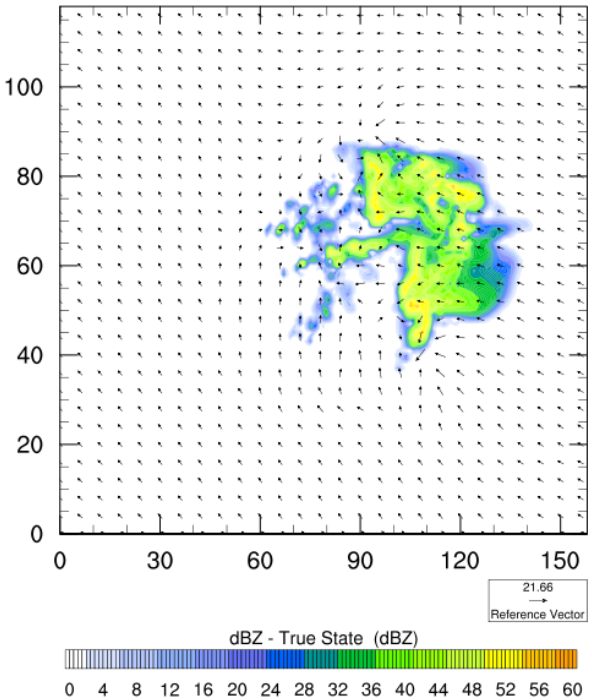
Courtesy Thomas Jones, CIMMS, and P. Minnis and R. Palikonda

Cloud Top Temperature Assimilation – Imperfect OSSE

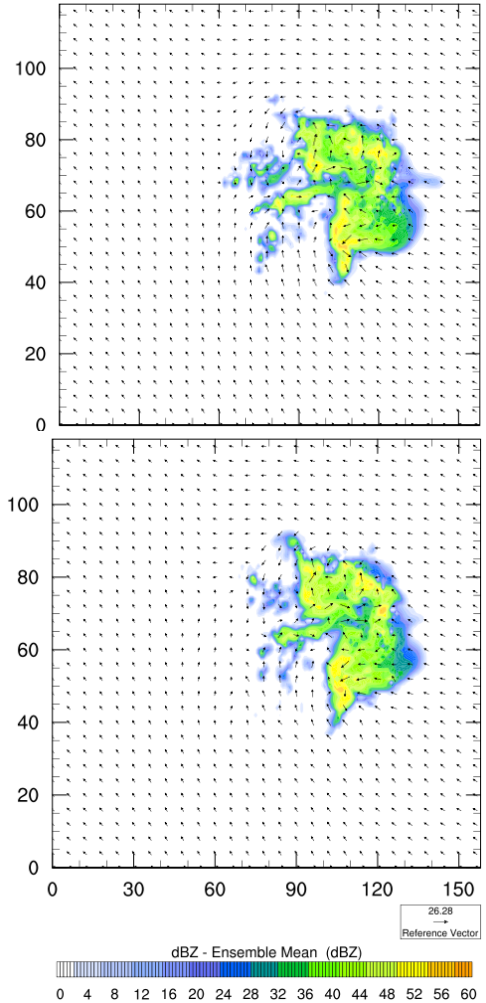


Courtesy Chris Kerr and Xuguang Wang, OU

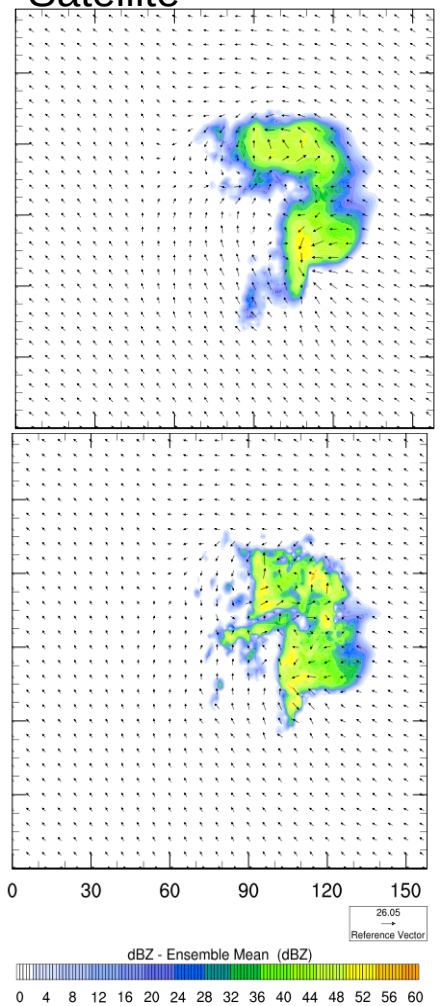
Truth



Radar



Satellite



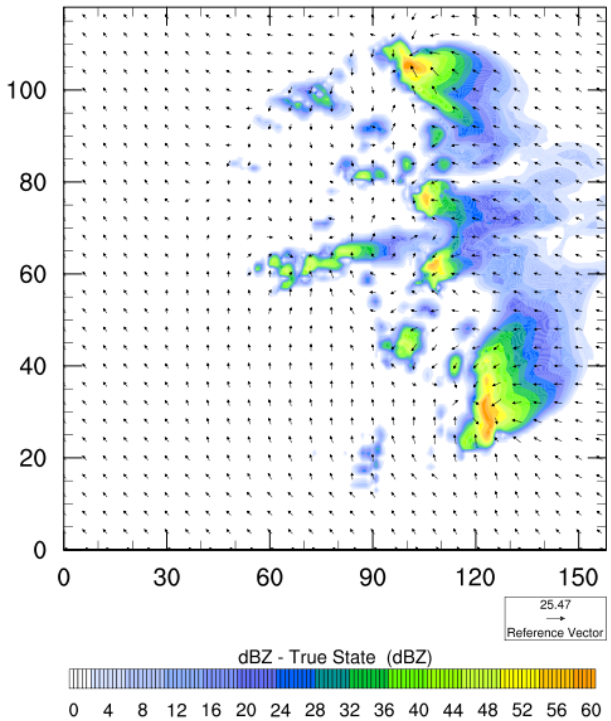
Reflectivity 1.5 km AGL at 2.5 hours or end of assimilation period

Satellite-Radar

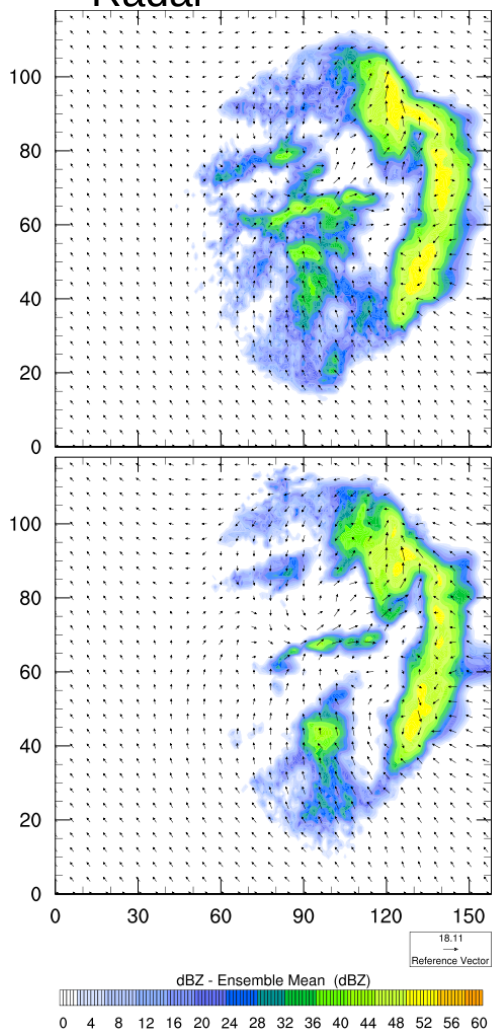
Radar-Satellite

Courtesy Chris Kerr and Xuguang Wang, OU

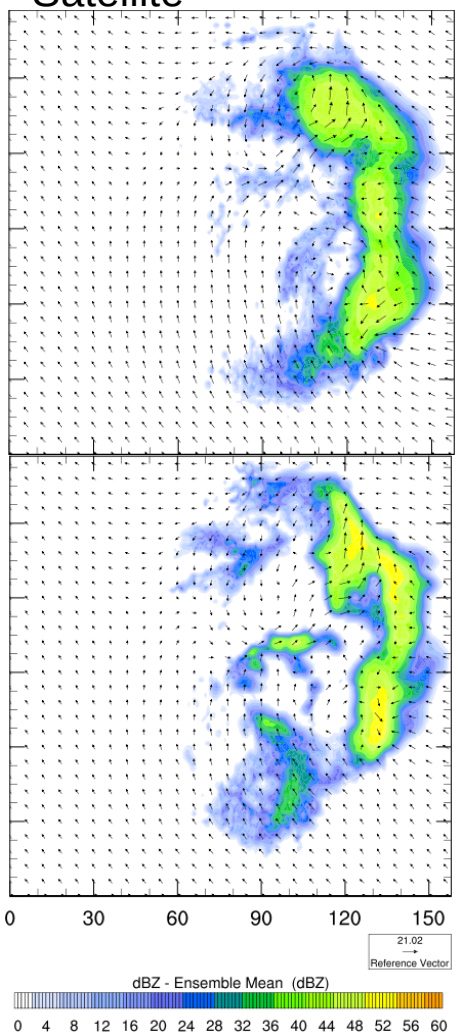
Truth



Radar



Satellite



One hour forecasts; ensemble mean reflectivity 1.5 km AGL

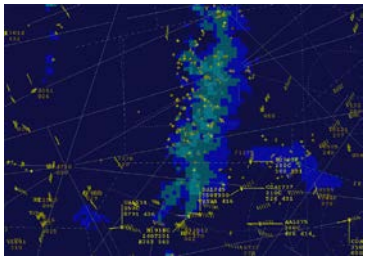
Satellite-Radar

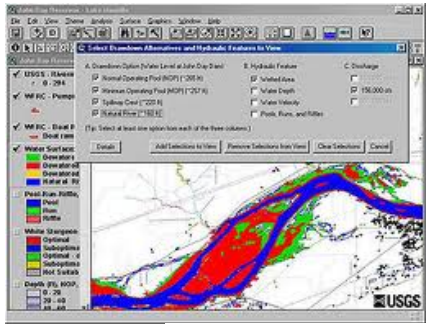
Radar-Satellite

Courtesy Chris Kerr and Xuguang Wang, OU

Communication and Use of Information

Provide high-quality weather warning information to allow people to make the best decisions for their families.





Conclusion

Assimilating radar and satellite observations together has clear value to Warn-on-Forecast as these data sets sample different aspects of storm characteristics

Thanks to everyone on the Warn-on-Forecast team for their hard work and dedication!