Storm-scale NWP Models and Initialization using PAR Data

David J. Stensrud

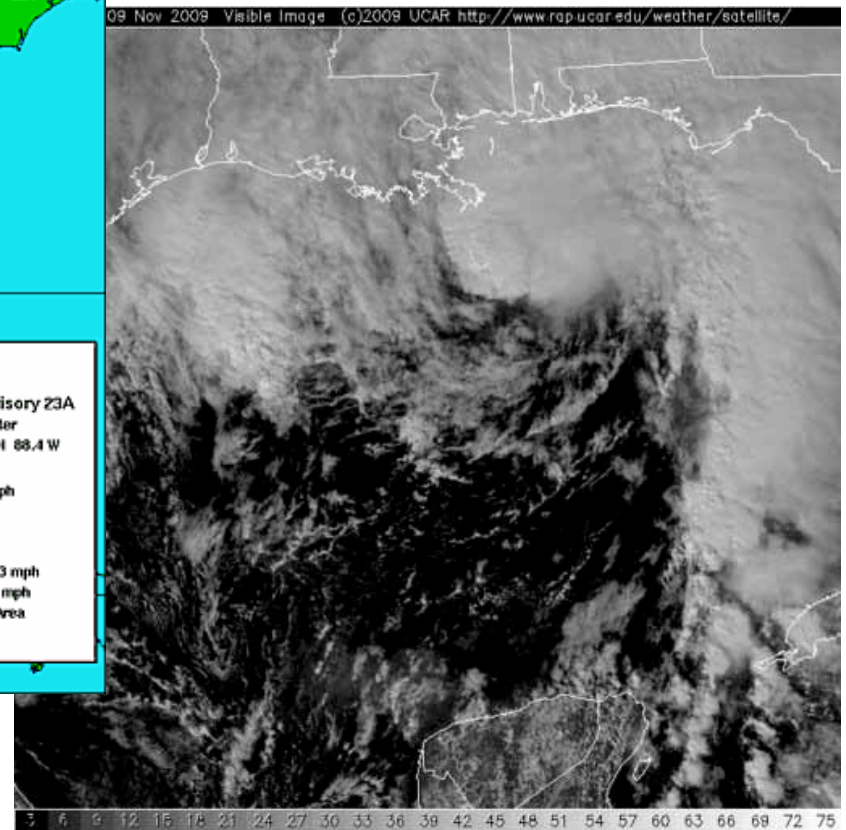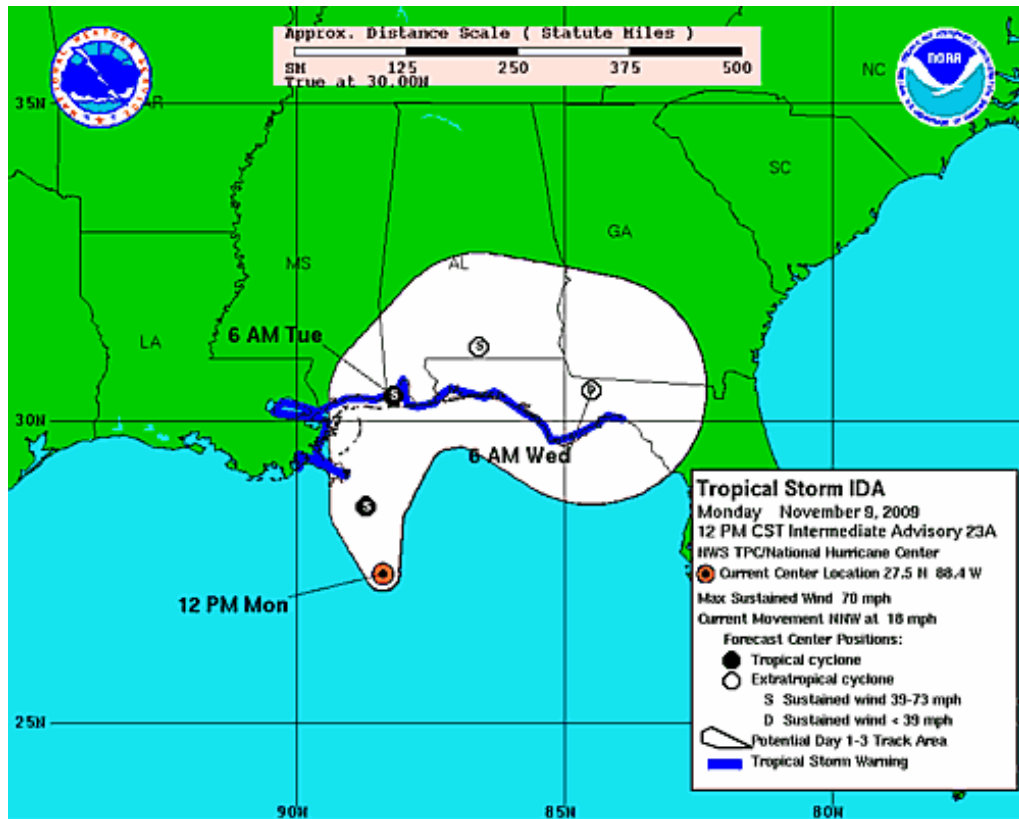NOAA/National Severe Storms Laboratory

Present Warning System
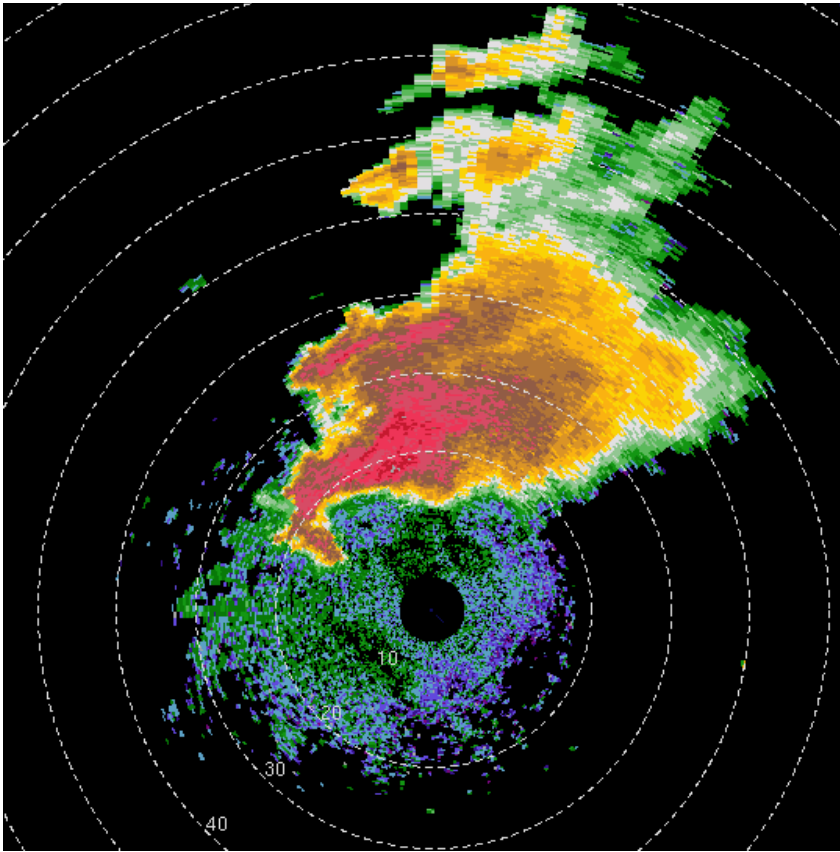
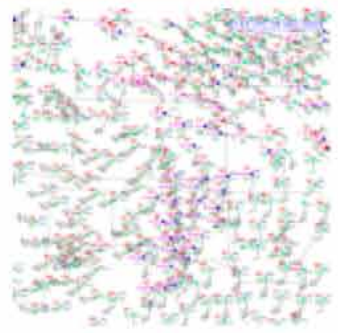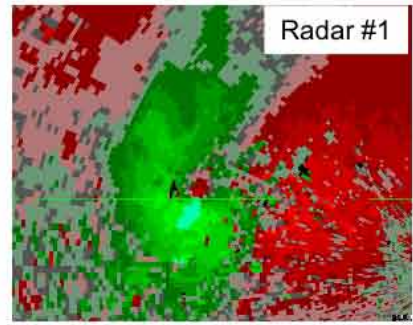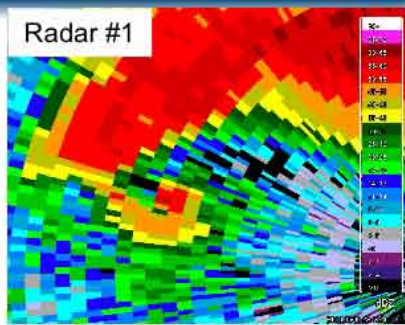- Warning is natural culmination of information distributed over previous days
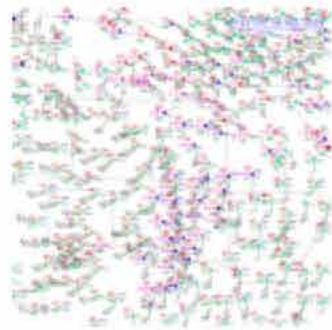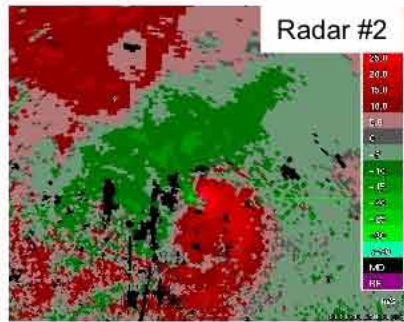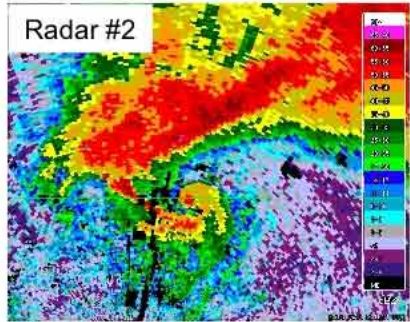
Model Forecasts Used as Warning Guidance

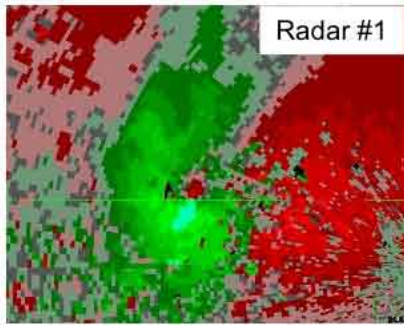# Missing An Opportunity…

Okay...standard warning information input here...

Radar #1

Radar #1
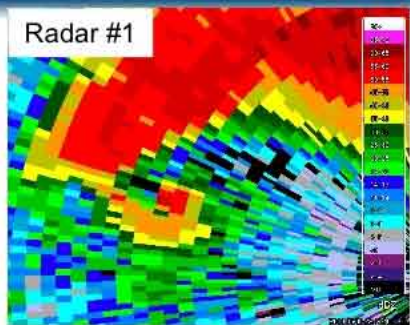
Reached Information Overload?

Radar #2

Radar #2
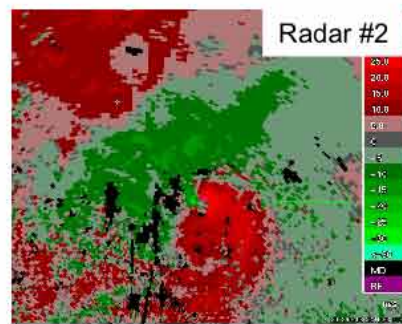
Cool!, hmm...uh, I think....

Radar #1

Radar #1

Radar #2

Radar #2

Radar #3

Radar #3

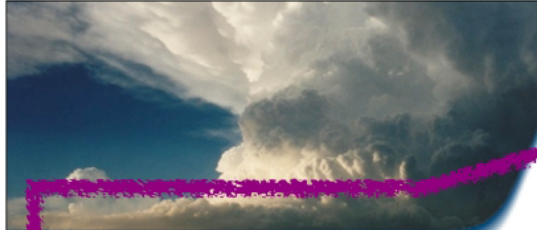*Information Overload!*

NWS Forecaster
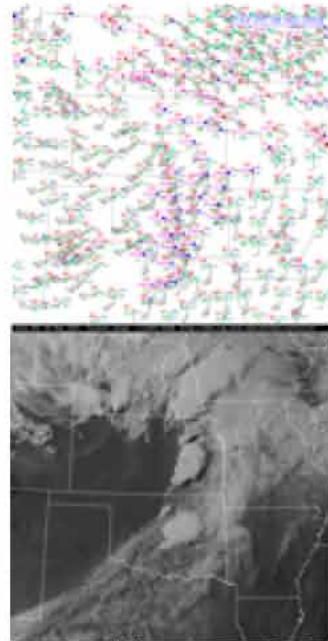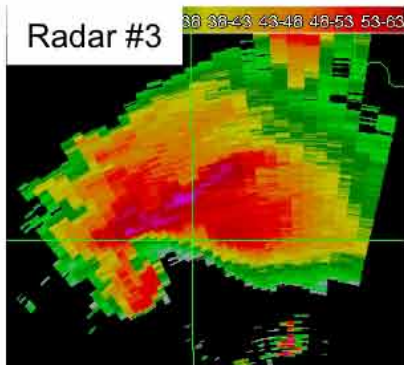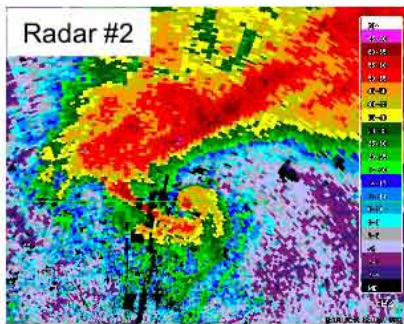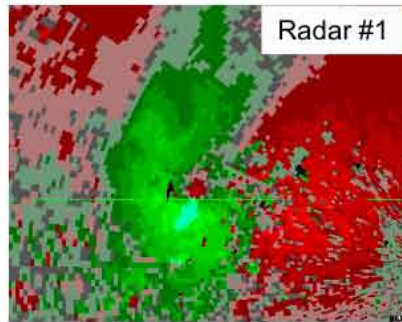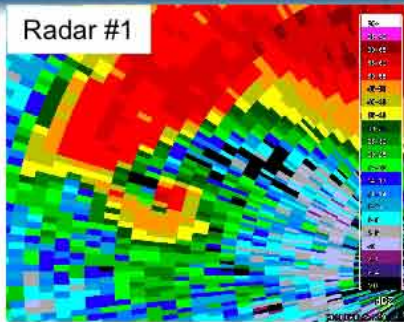
HELP!

"I've tried to tell Stuart he's over-loading himself with too much information but ....."

Radar #1

Radar #1

Radar #2

Radar #2

Radar #3

Radar #3

Available data synthesized into a single 3D analysis

Numerical prediction of severe weather can follow
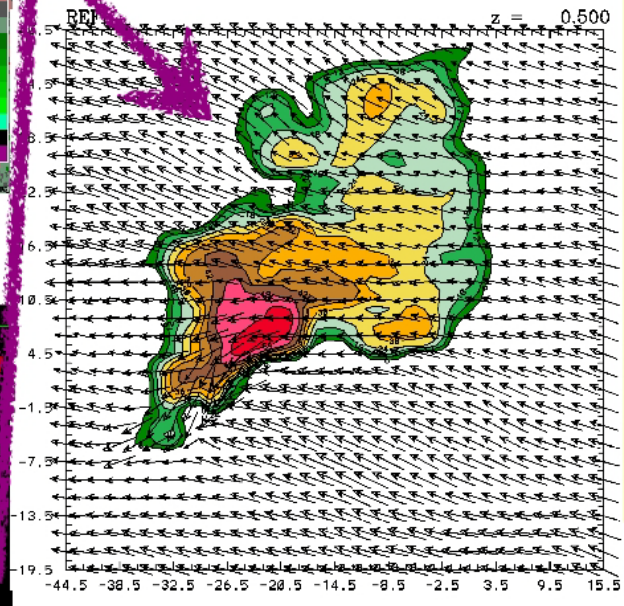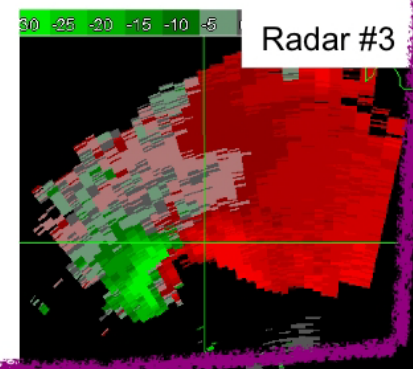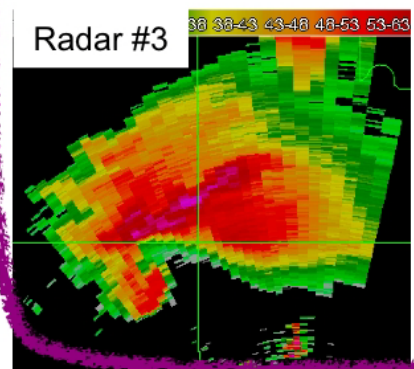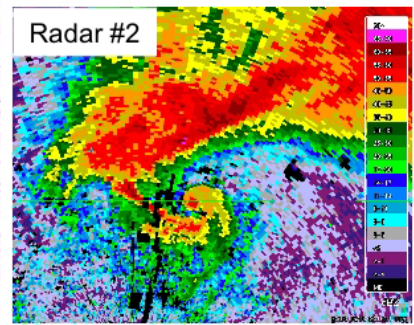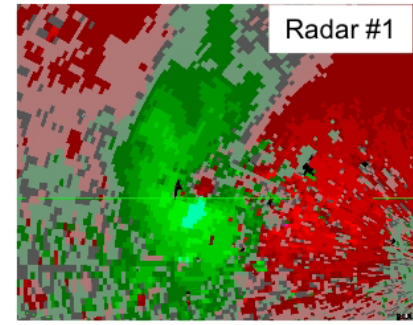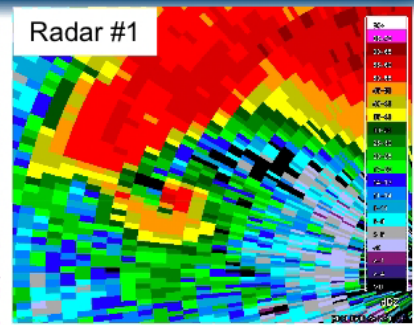
Foundation is Radar Observations
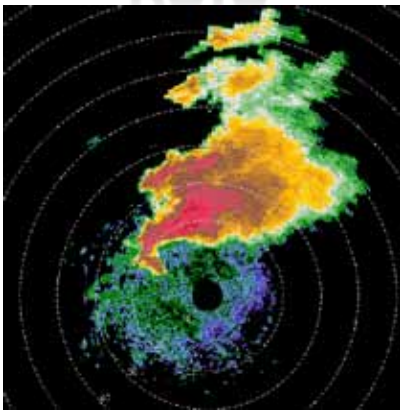
DATA → **MODEL** → **FORECAST**

...but other observations are very valuable

Convective-scale Warn-on-Forecast Vision

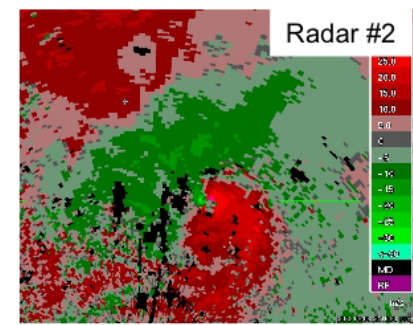Radar and Initial Forecast at 2100 CST

Radar at 2130 CST: Accurate Forecast

An ensemble of storm-scale NWP models predict the path of a potentially tornadic supercell during the next 1 hour. The ensemble is used to create probabilistic tornado guidance.

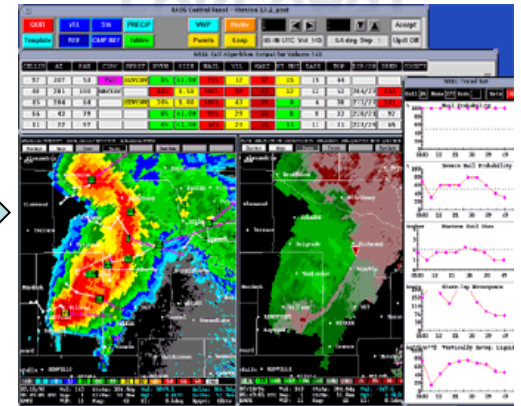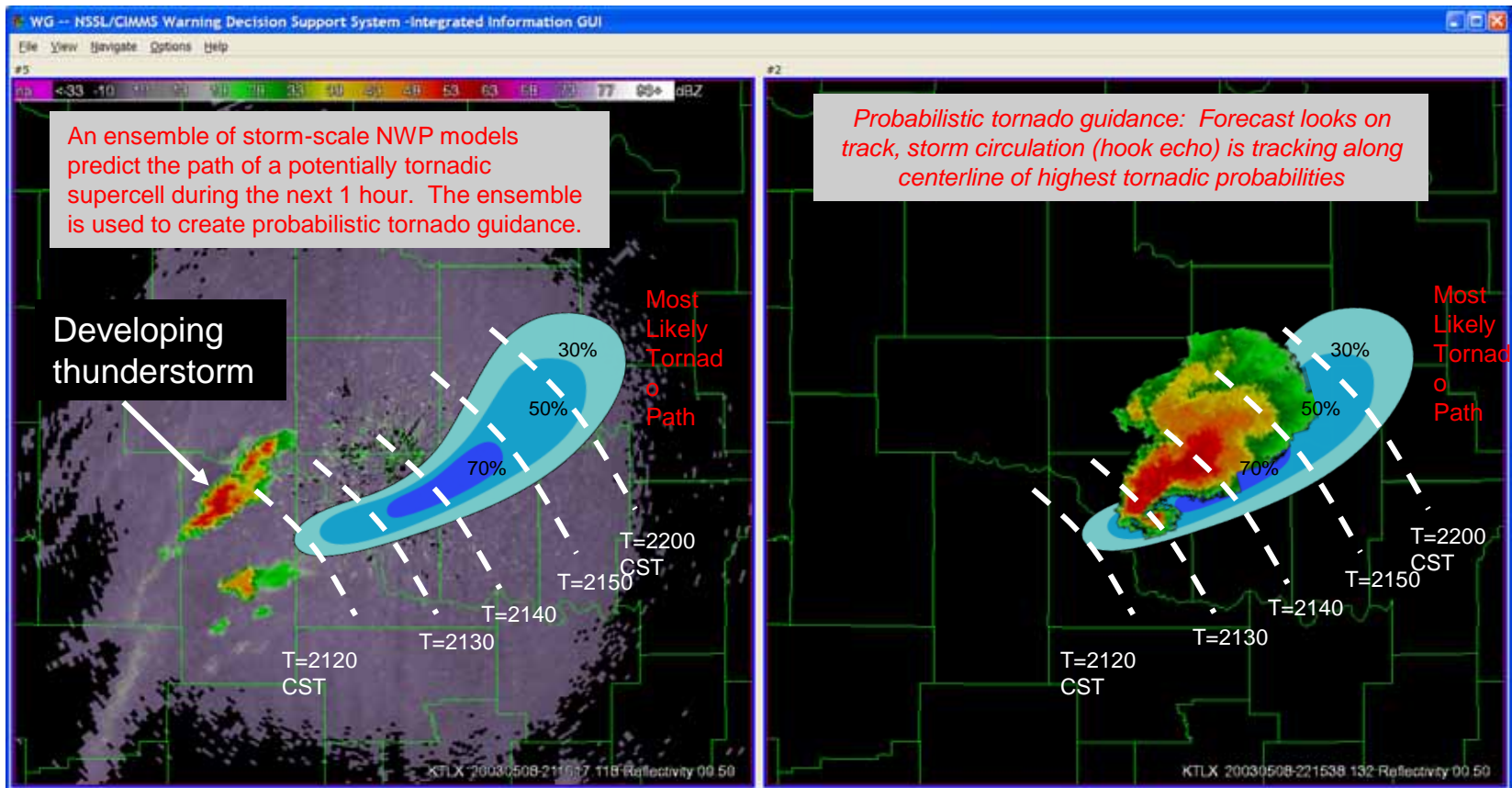Probabilistic tornado guidance: Forecast looks on track, storm circulation (hook echo) is tracking along centerline of highest tornadic probabilities

Developing thunderstorm

Most Likely Tornado Path

Stensrud et al. 2009 (October *BAMS*)

The Time is Right
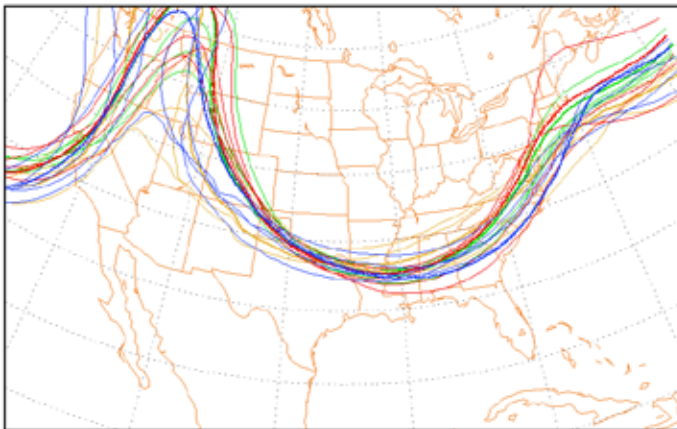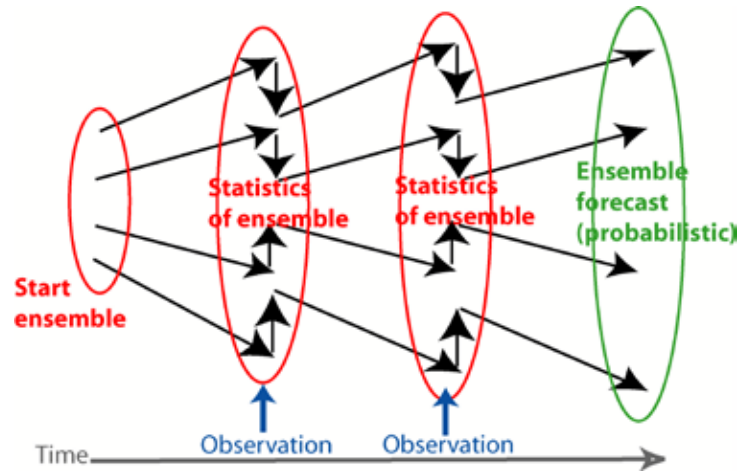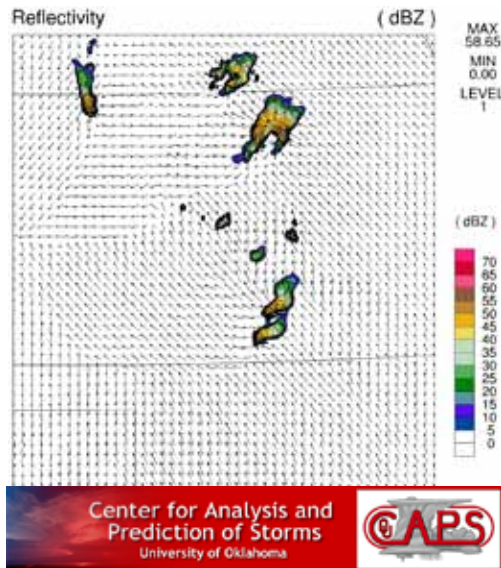
Conceptually Simple, Scientifically Difficult

- pushes limits of modeling capabilities
– pushes limits of data assimilation
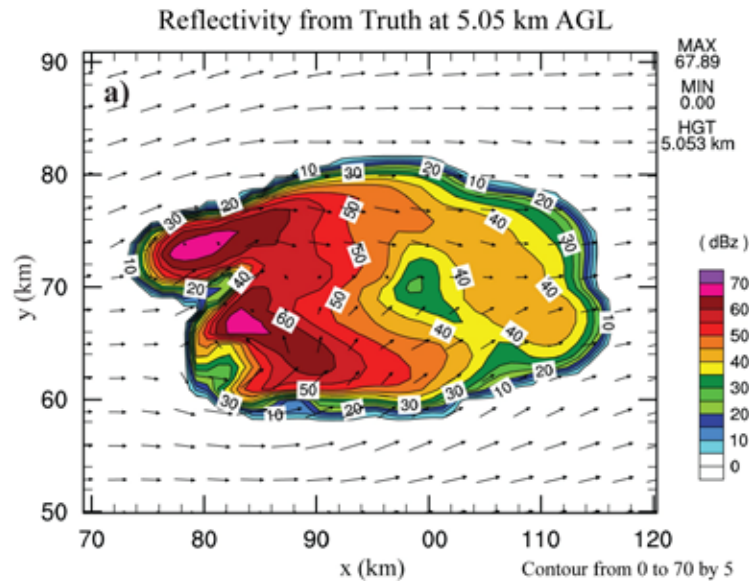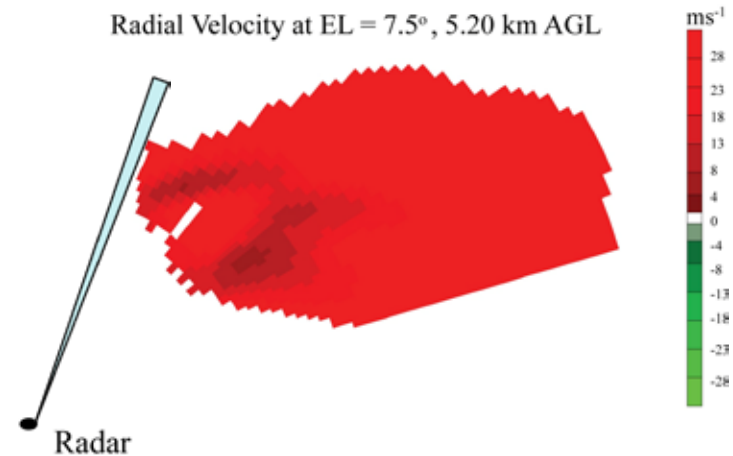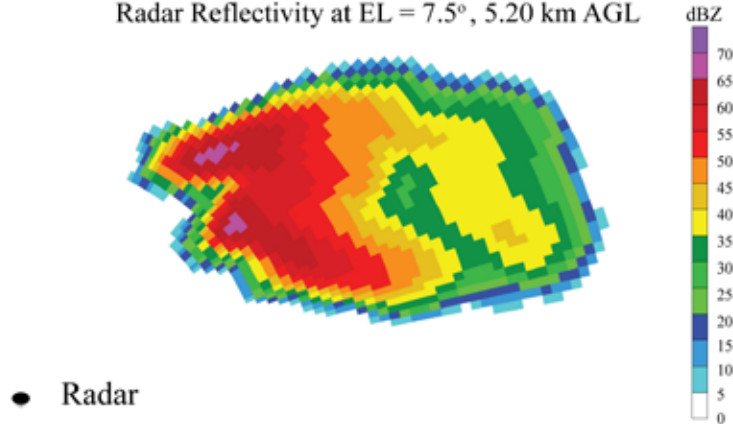– pushes limits of computer power (today)

A Good Place to Begin
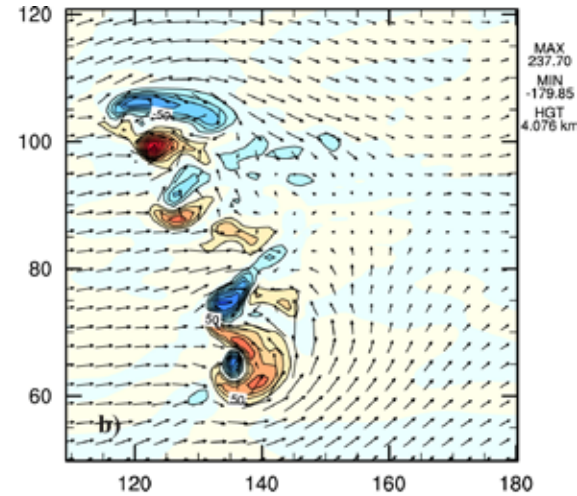

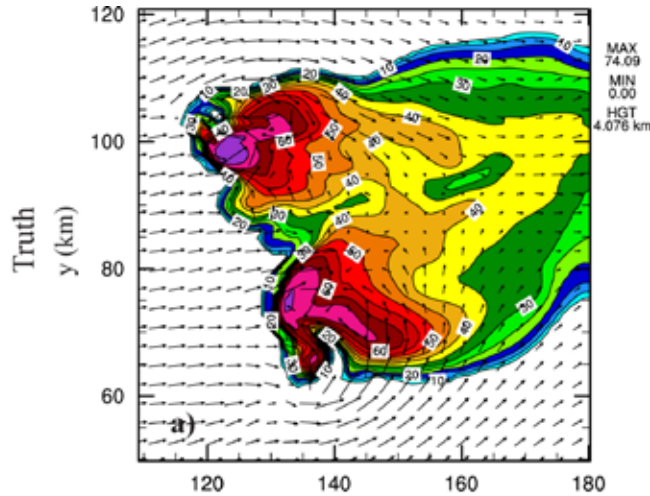Reflectivity from Truth at 5.05 km AGL

Radial Velocity at EL = 7.5°, 5.20 km AGL

Radar Reflectivity at EL = 7.5°, 5.20 km AGL

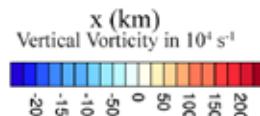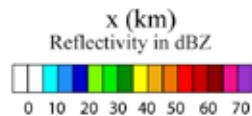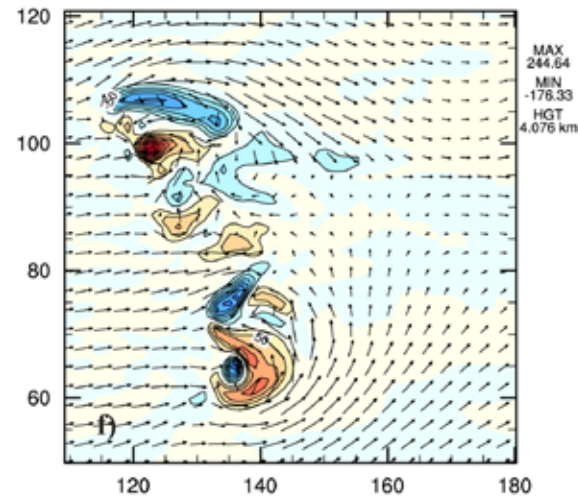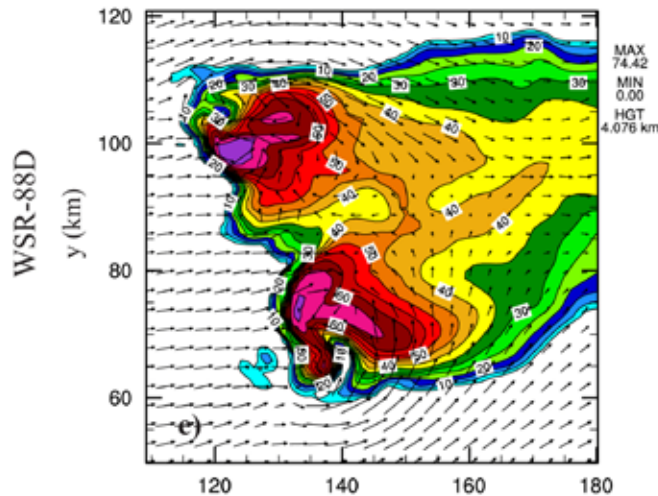Observing System Simulation Experiments (Yussouf and Stensrud 2008)

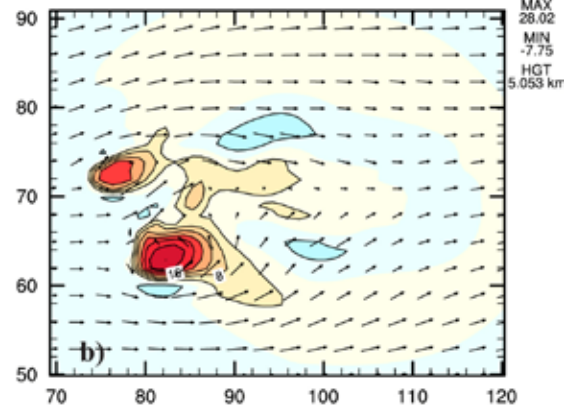# After 1 hour of Assimilation

Yussouf and Stensrud 2008

Under-determined Problem

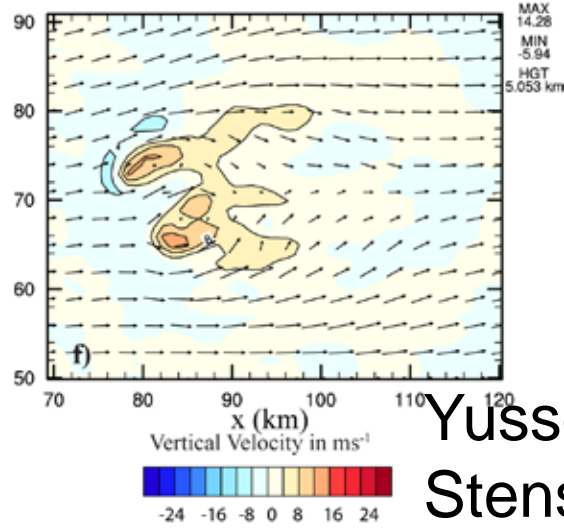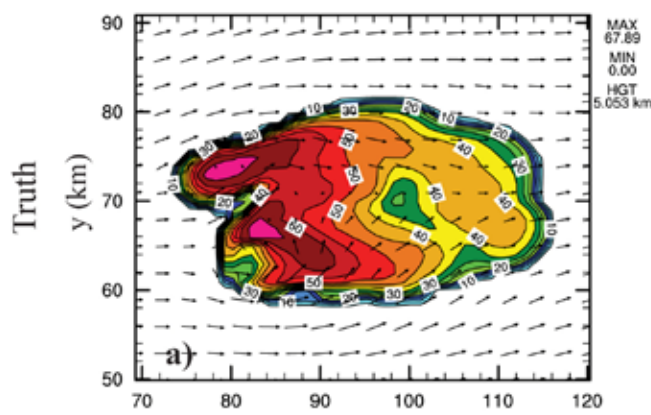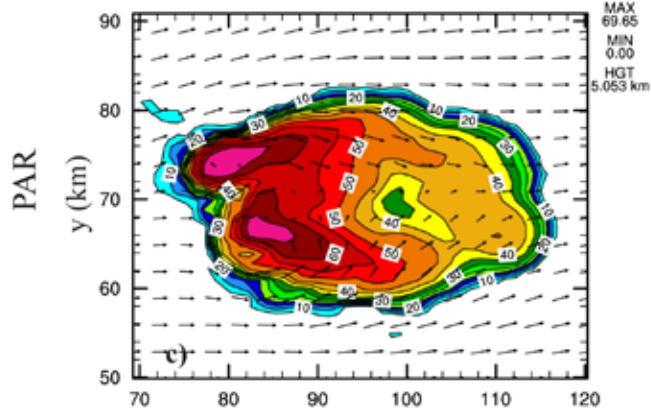- General consensus is that it takes 8-10 volume scans to obtain accurate analyses (~40 min for WSR-88D)
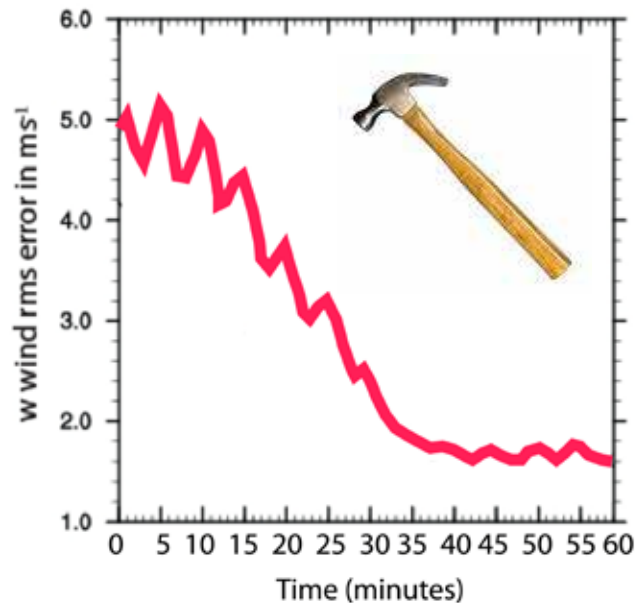
Benefits of PAR
15 minutes of assimilation

Truth

PAR
Analysis

WSR88D
Analysis

Reflectivity in dBZ

Vertical Velocity in ms⁻¹
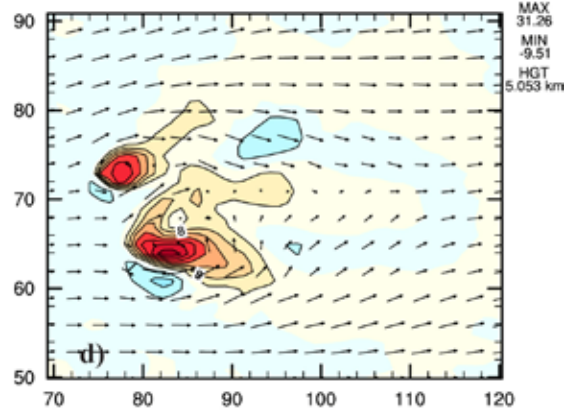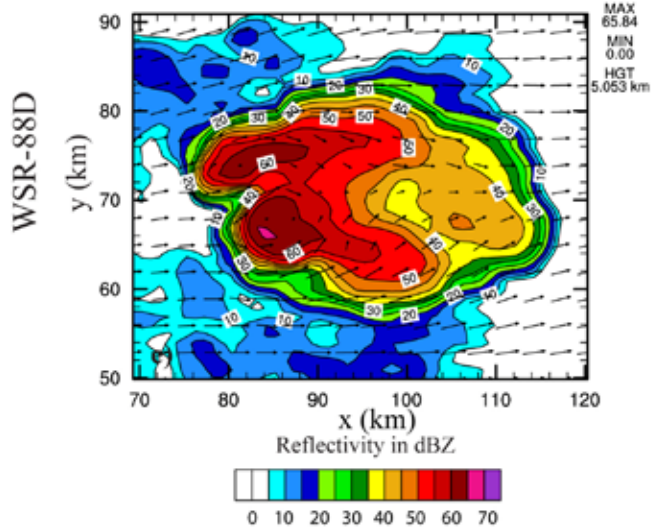
Yussouf and
Stensrud 2008

Real Data Impact Phased Array Radar

29 May 2004
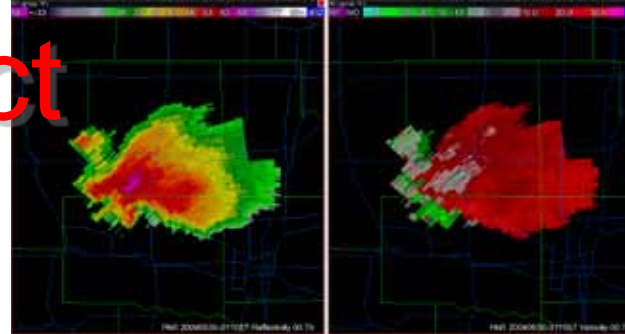
After 20 min of PAR Data Assimilation (20 volumes)

After 20 min of WSR-88D Data Assimilation (5 volumes)

Thompson and Wicker
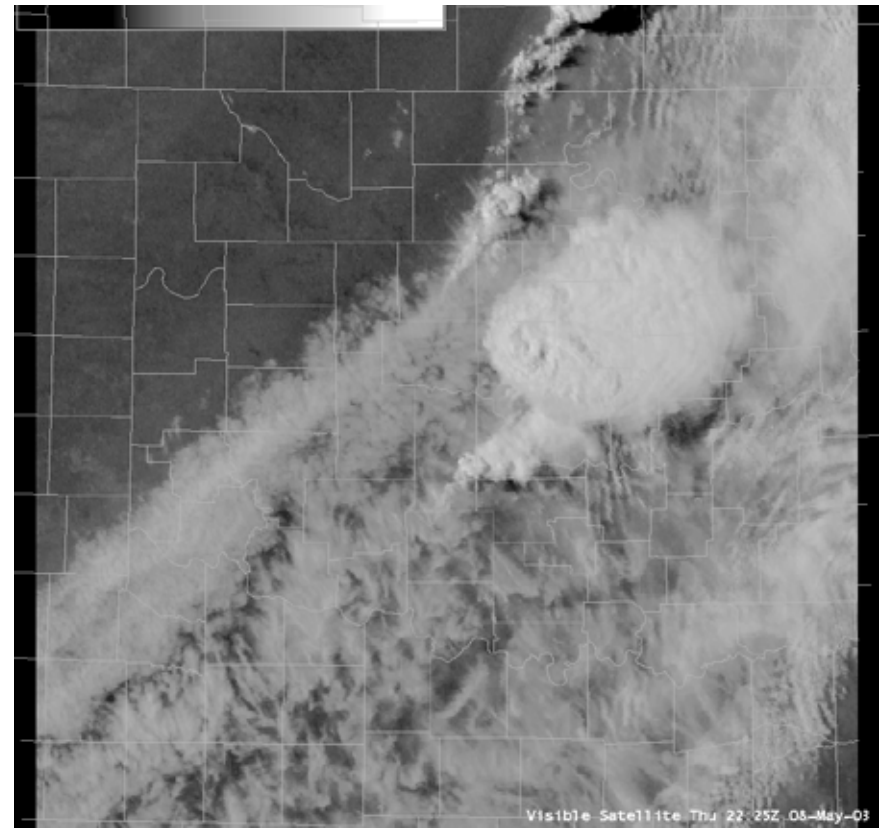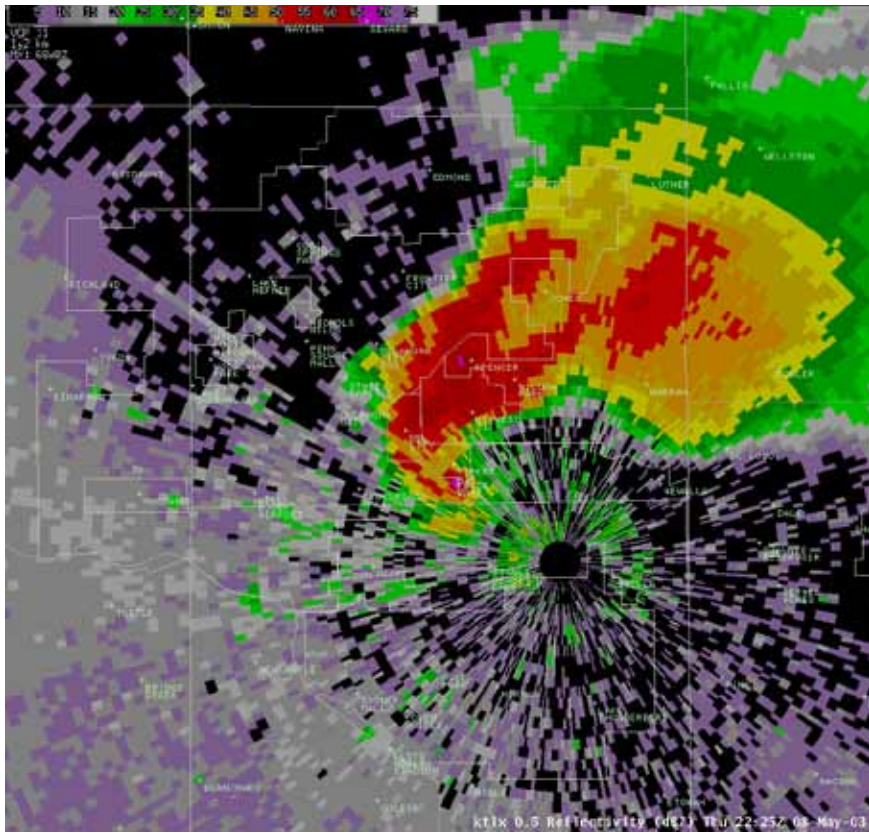
8 May 2003

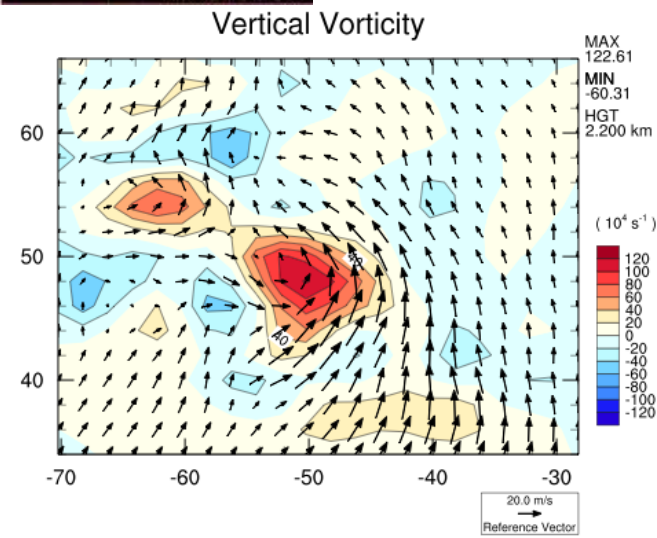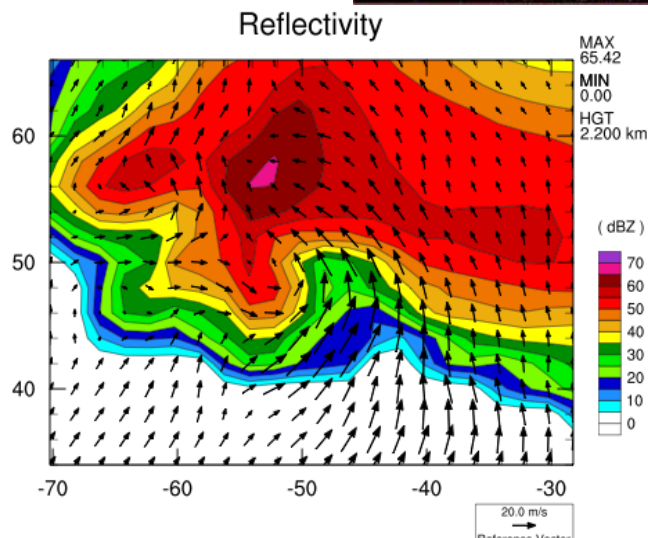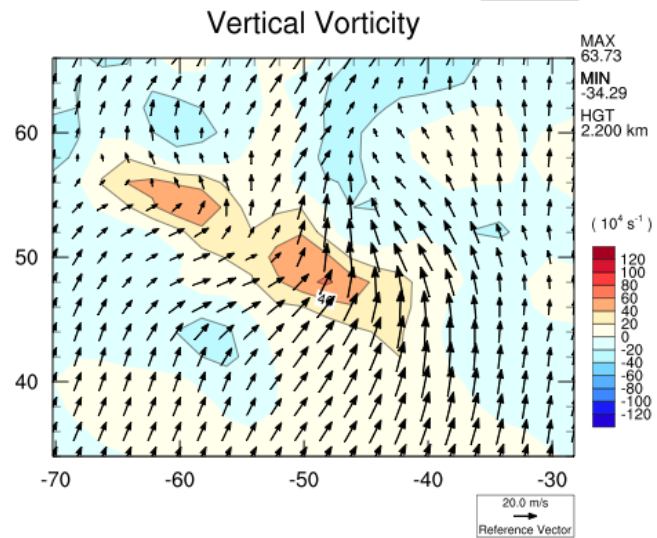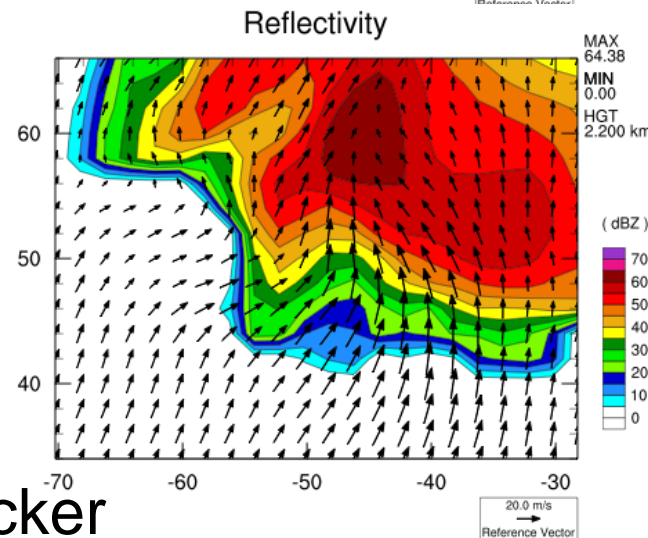**"2nd Moore" OK tornado (F4)**

Radar Data Assimilation

FORECAST   2204 UTC

60 km

40 m/s ⟶

Forecast versus Observed Storm Tornado Tracks
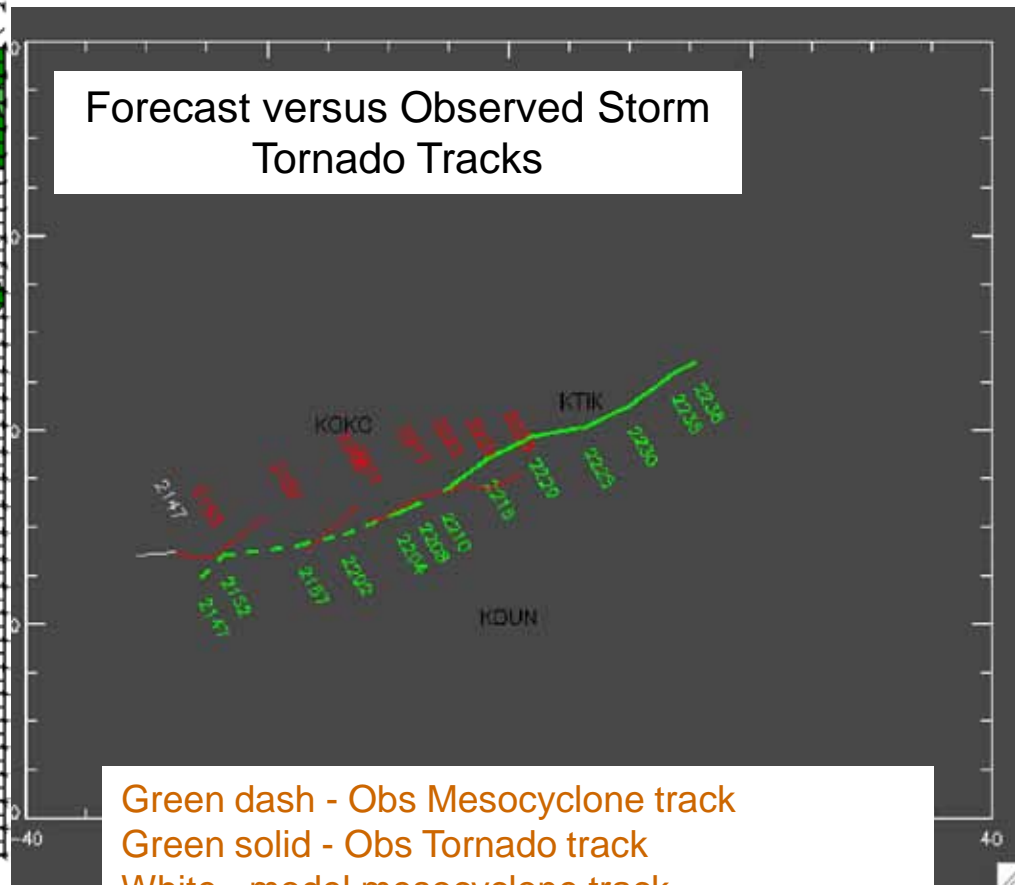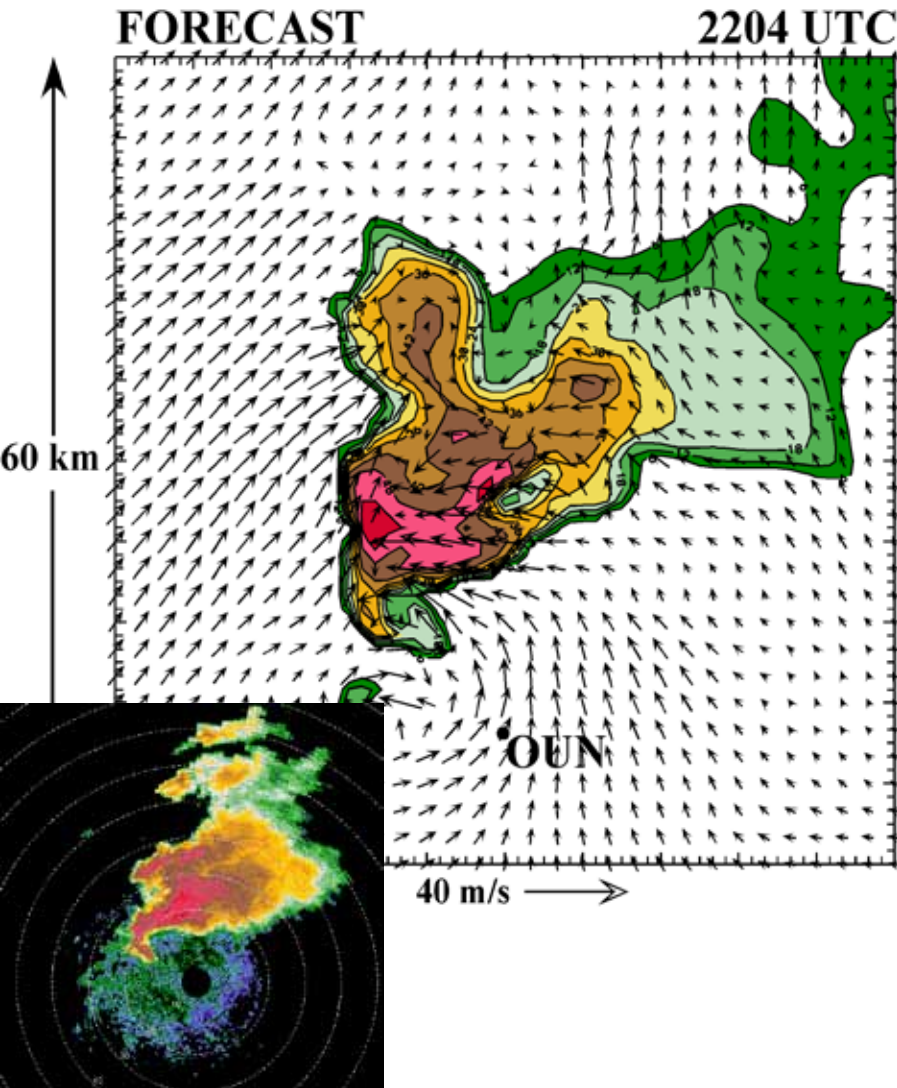
Green dash - Obs Mesocyclone track
Green solid - Obs Tornado track
White - model mesocyclone track
Red - model tornado-cyclone track (z > 0.05 s^{-1})

Dowell and Wicker 2009
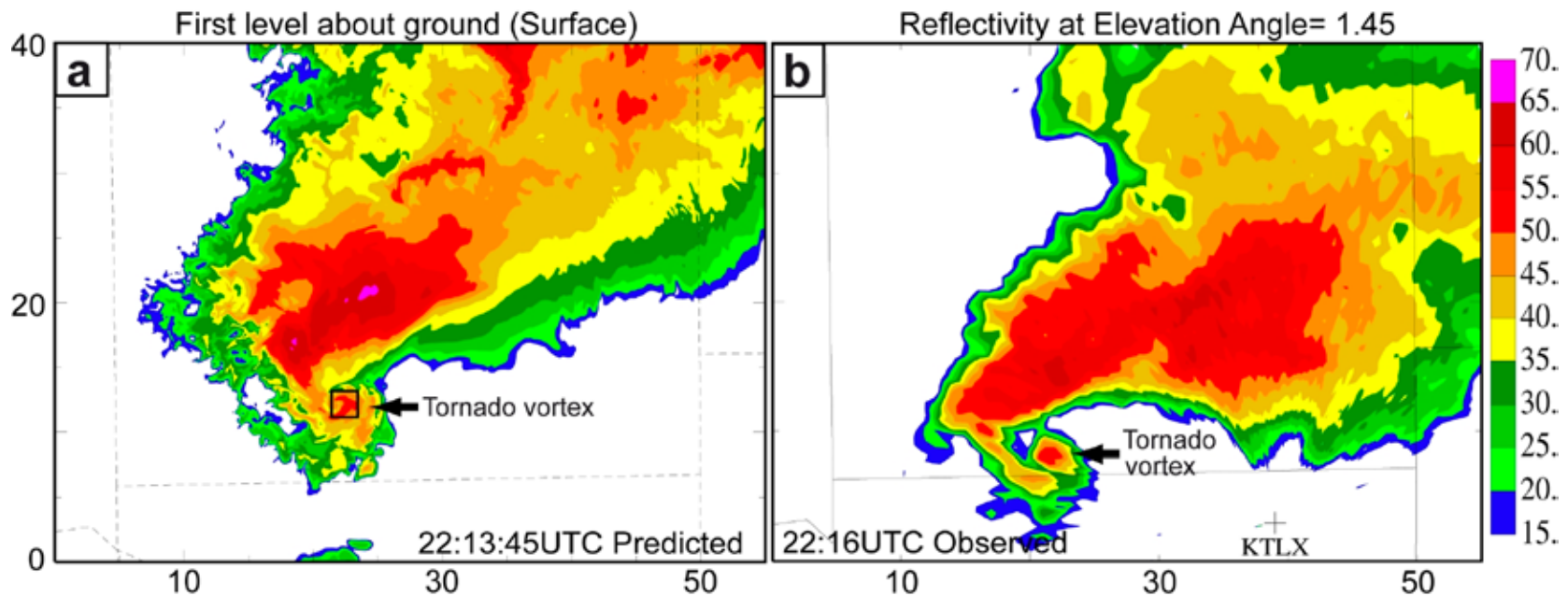
33-min forecast of 8 May 2003 thunderstorm initialized using radar observations (50 m grid spacing)

Xue, Droegemeier, and Weber 2007

Leadership and Partnerships

Challenges

- Rapid and accurate data quality control
- Assimilation method to use?
  - 3DVAR, EnKF, hybrid
- Model error
  - microphysics, boundary layer, turbulence, radiation, land surface
- Sensitivity to errors in environmental conditions
- Ensemble methods for convective-scale