Progress and Challenges with Warn-on-Forecast

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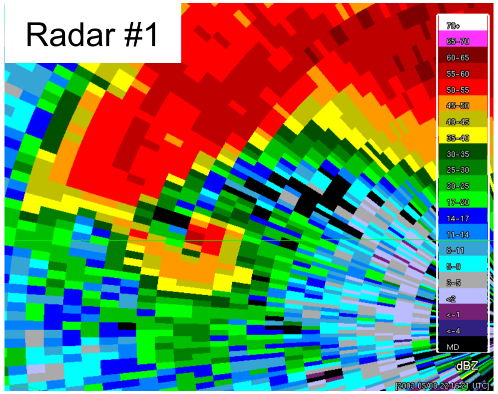
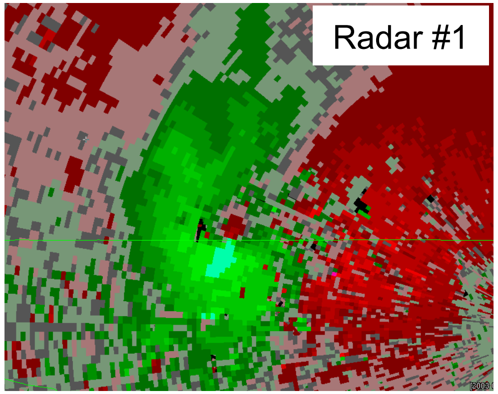
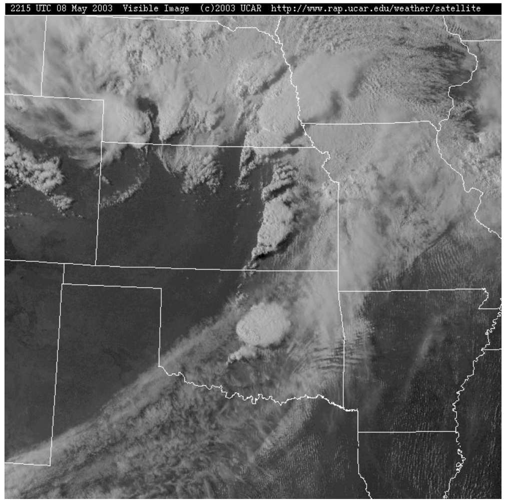
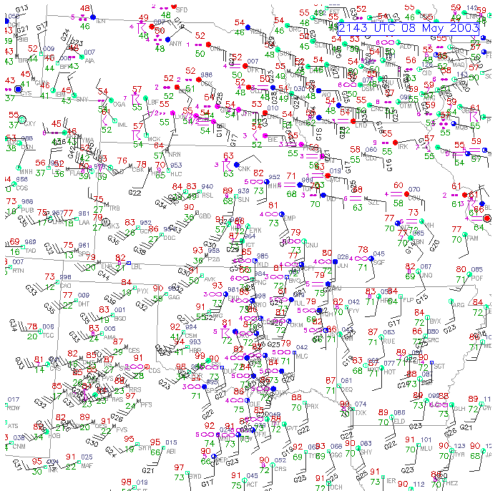
Current warning paradigm

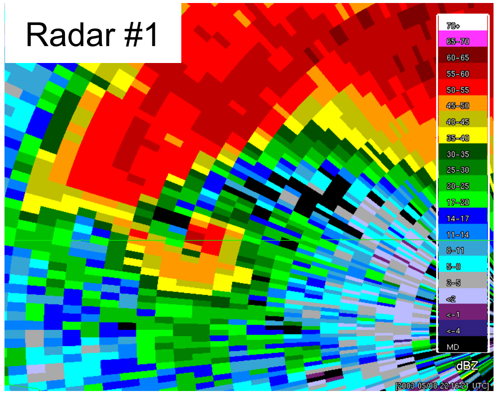


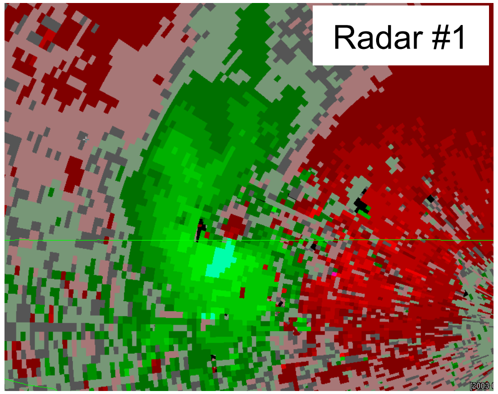


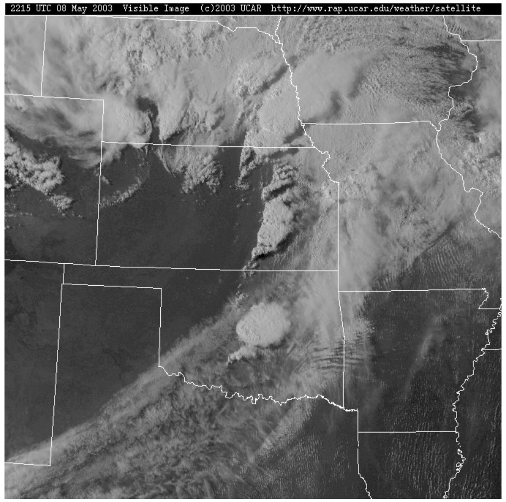


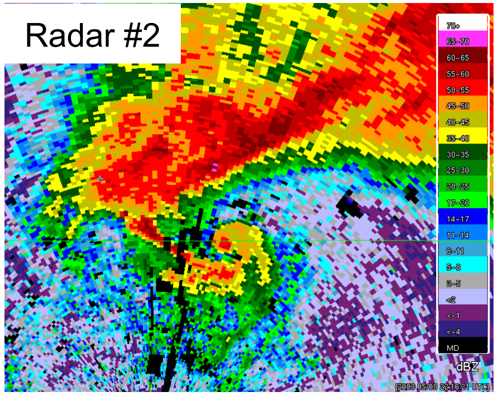


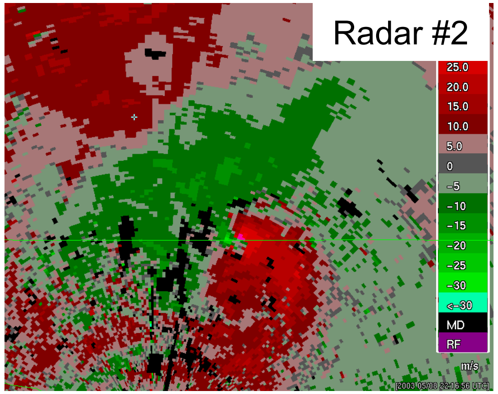
Current paradigm in some locations

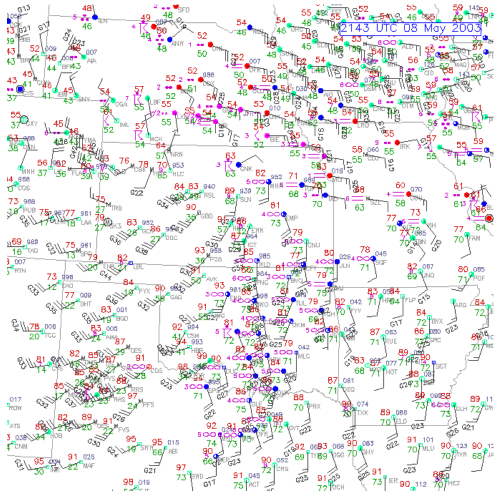




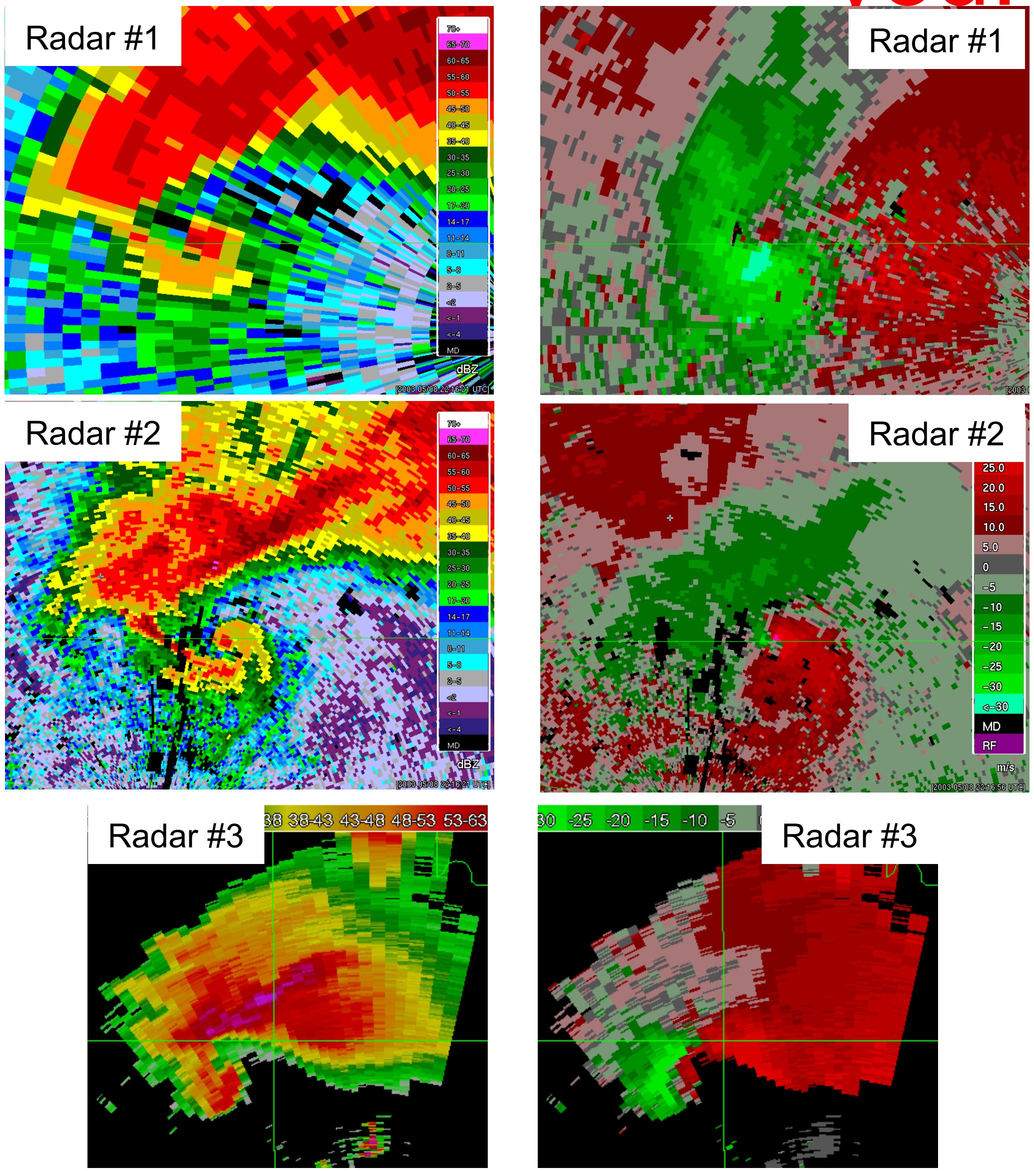




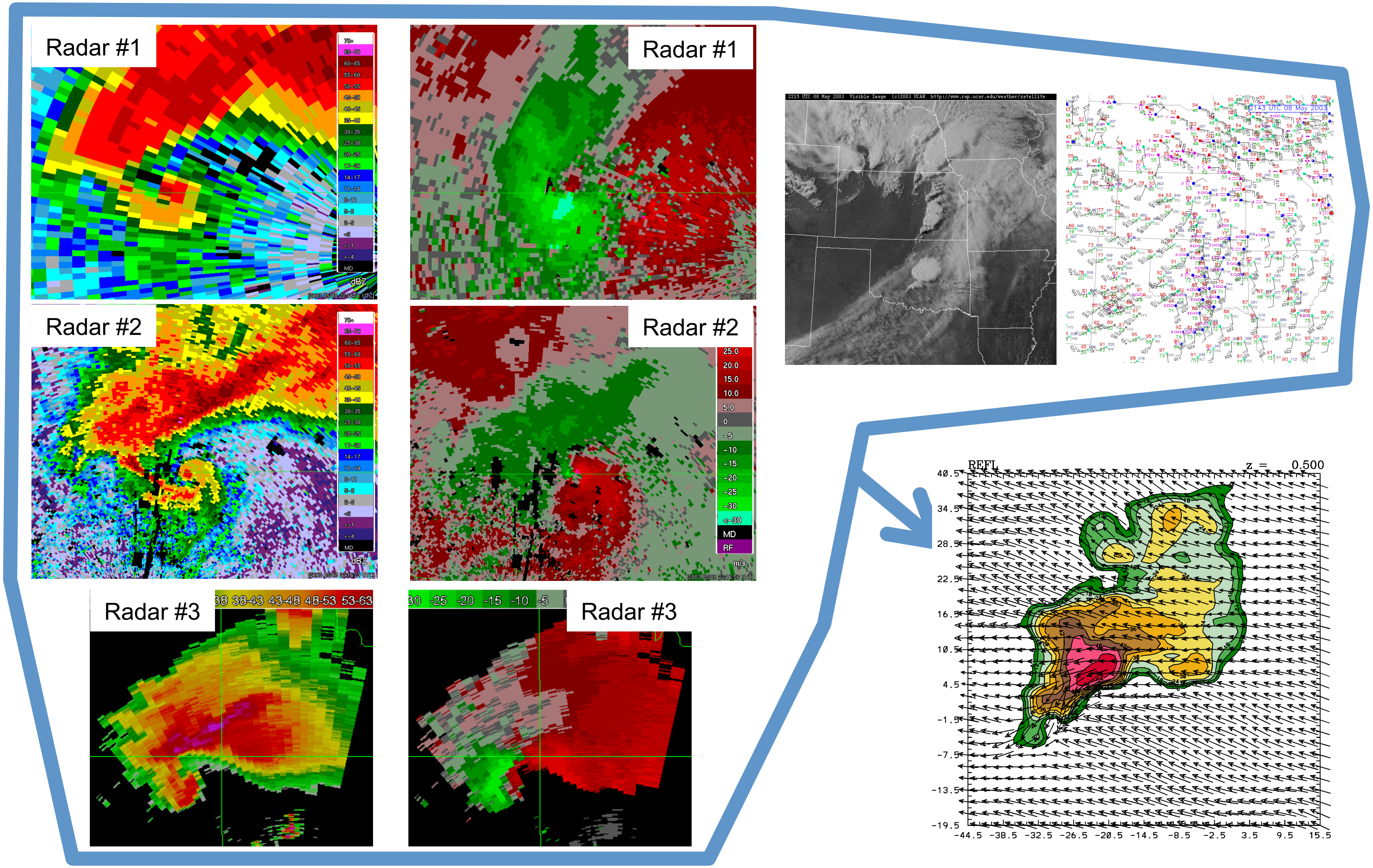




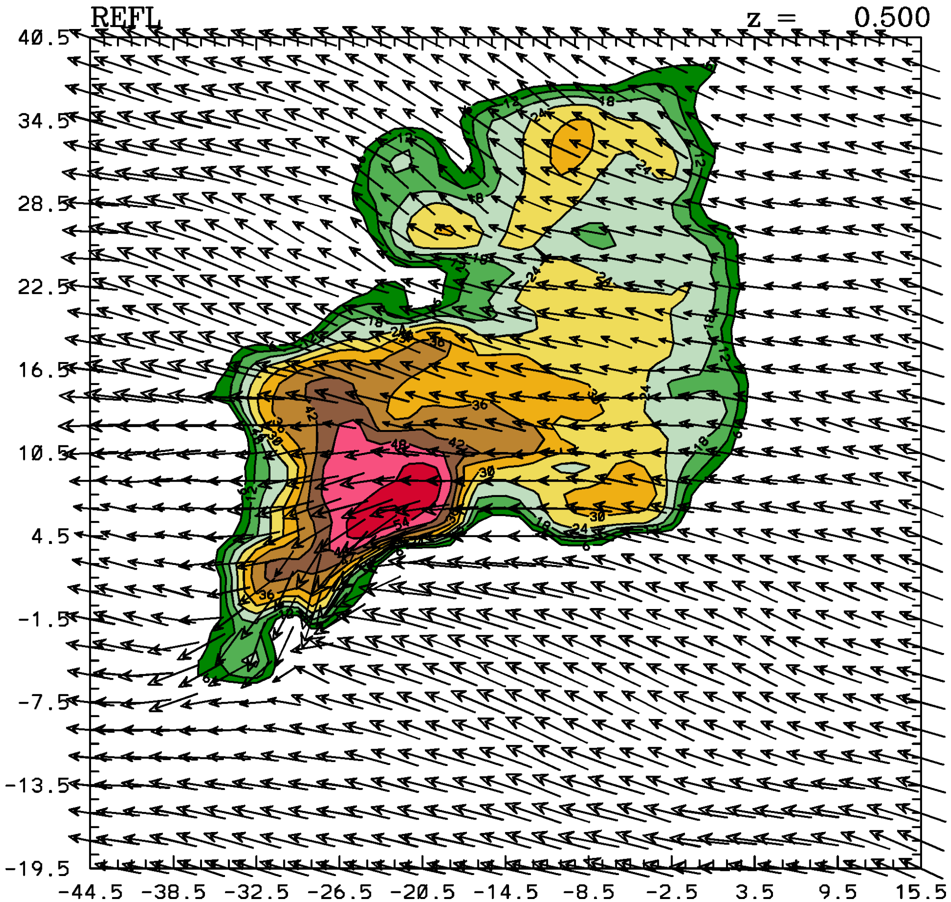
Coming soon to a weather office near you!



A better alternative?

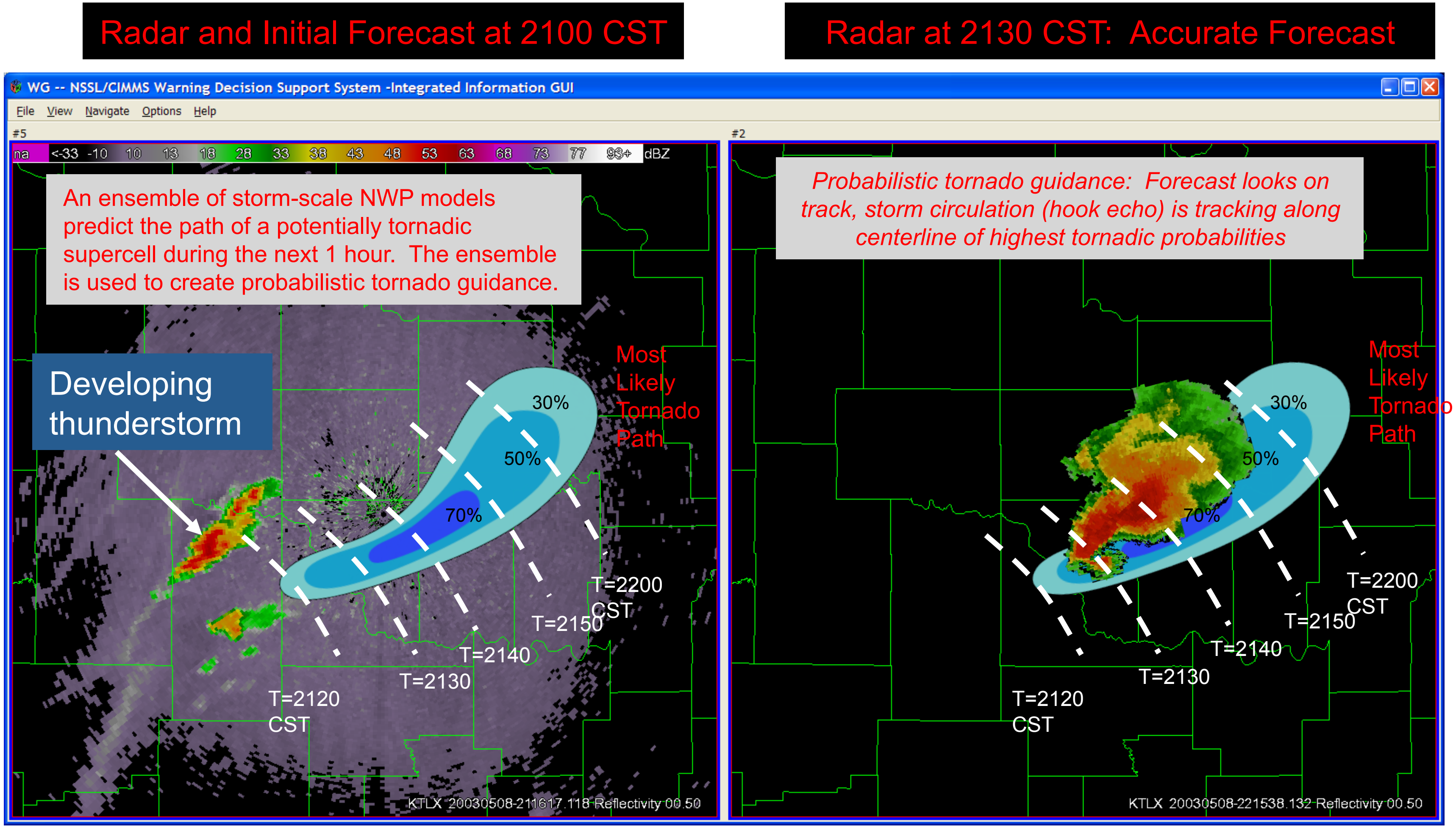


Single analysis



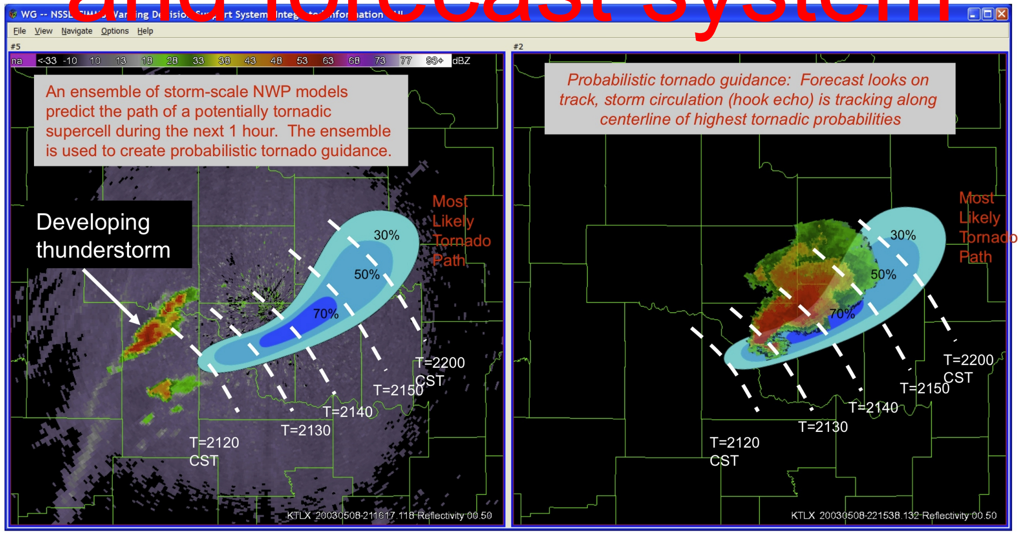
that can also be used to initialize storm-scale ensemble forecasts for Warn-on-Forecast

Convective-scale Warn-on-Forecast Vision



Stensrud et al. 2009 (October *BAMS*)

Probabilistic convective-scale analysis and forecast system

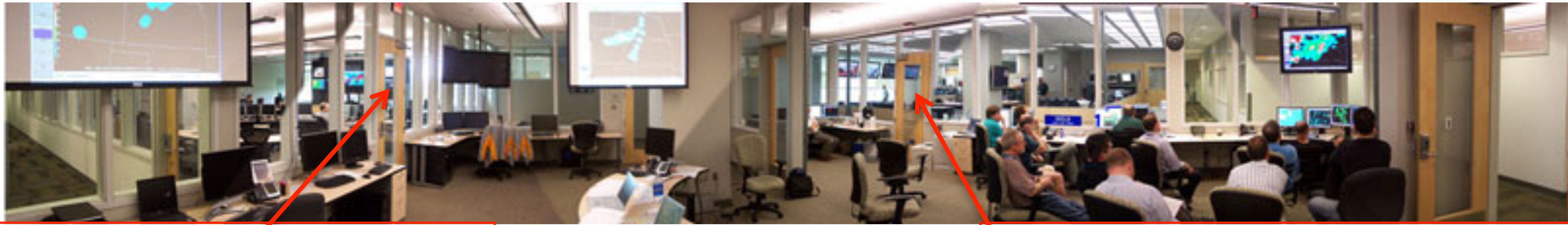


Two near-term goals:

- Demonstrate operational value of a single analysis
- Show progress toward Warn-on-Forecast forecast vision

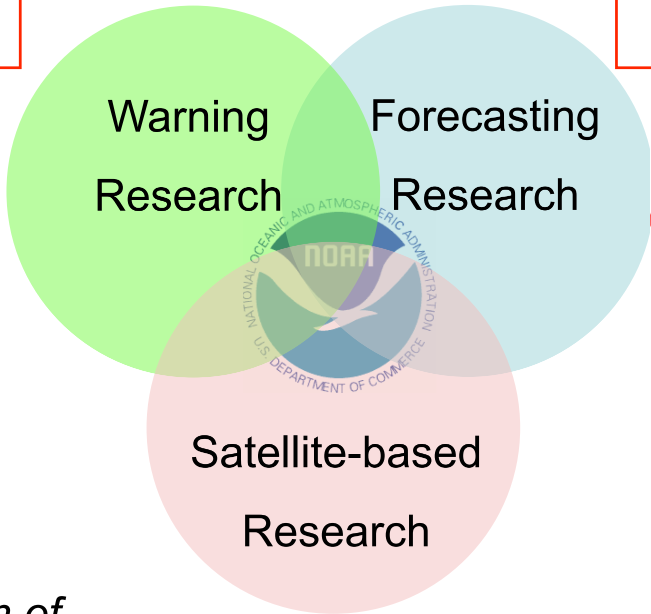
NOAA Hazardous Weather Testbed

Where practitioners and researchers work together…



Local NWS forecast office:
Regional responsibility

Storm Prediction Center:
Nationwide responsibility



Experimental
Warning
Program

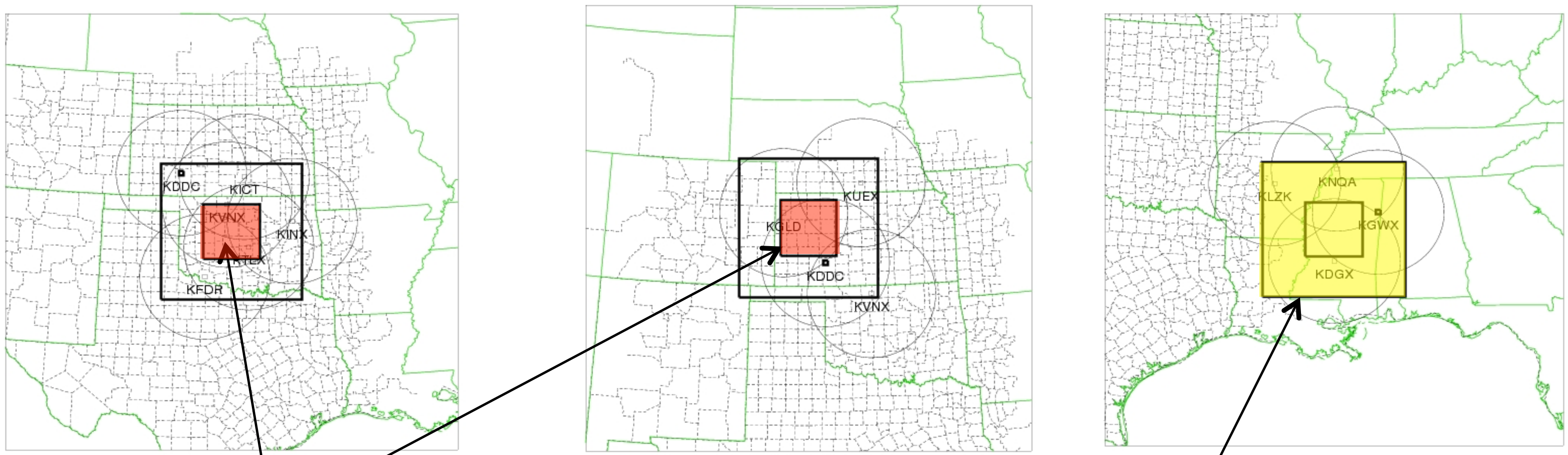
Detection and prediction of hazardous weather events ***up to several hours in advance***

Experimental
Forecast
Program

Prediction of hazardous weather events from ***a few hours to a week in advance***

Current Real-time Capabilities in the HWT…

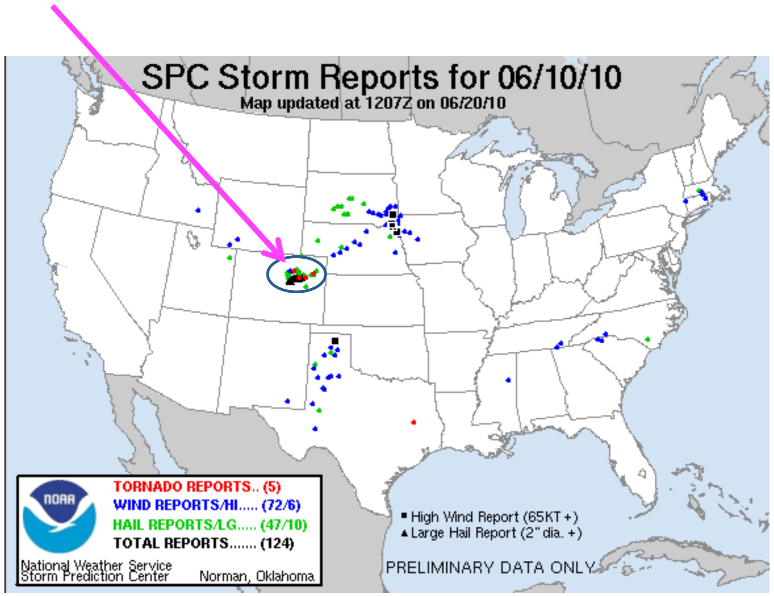
Creating 3D variational (3DVAR) analyses so forecasters can determine if the additional information provided by a single analysis has value

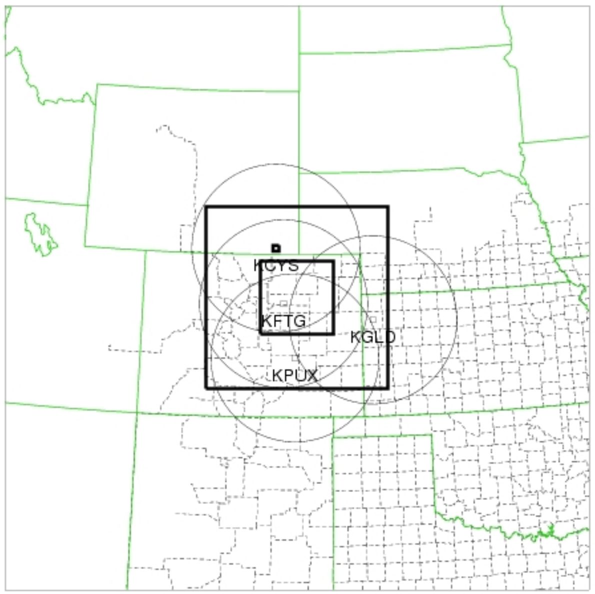


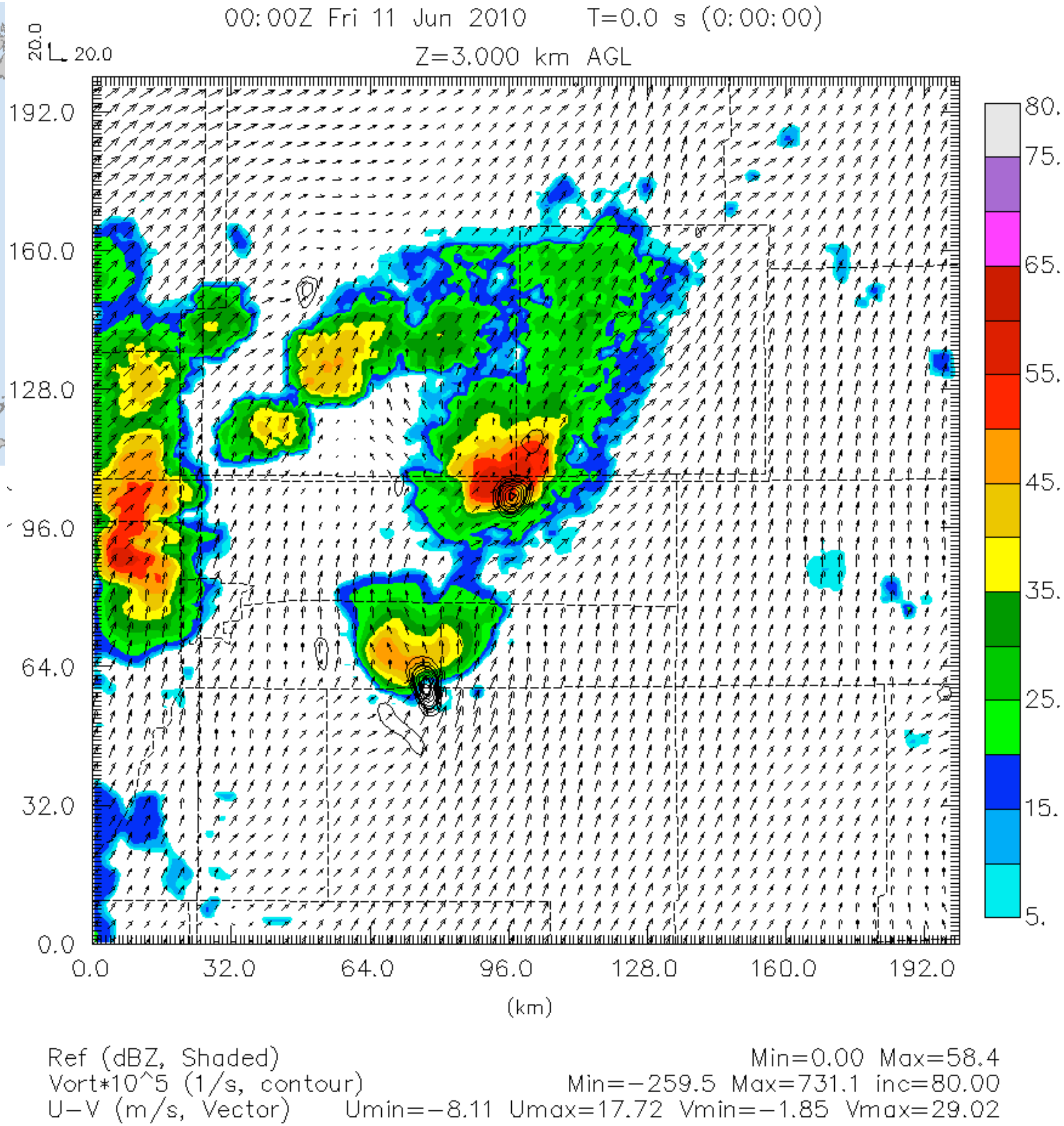
Inner domain of 200x200 km is used for 3dvar analysis

Outer domain of 400x400 km is used to identify 88Ds to be used

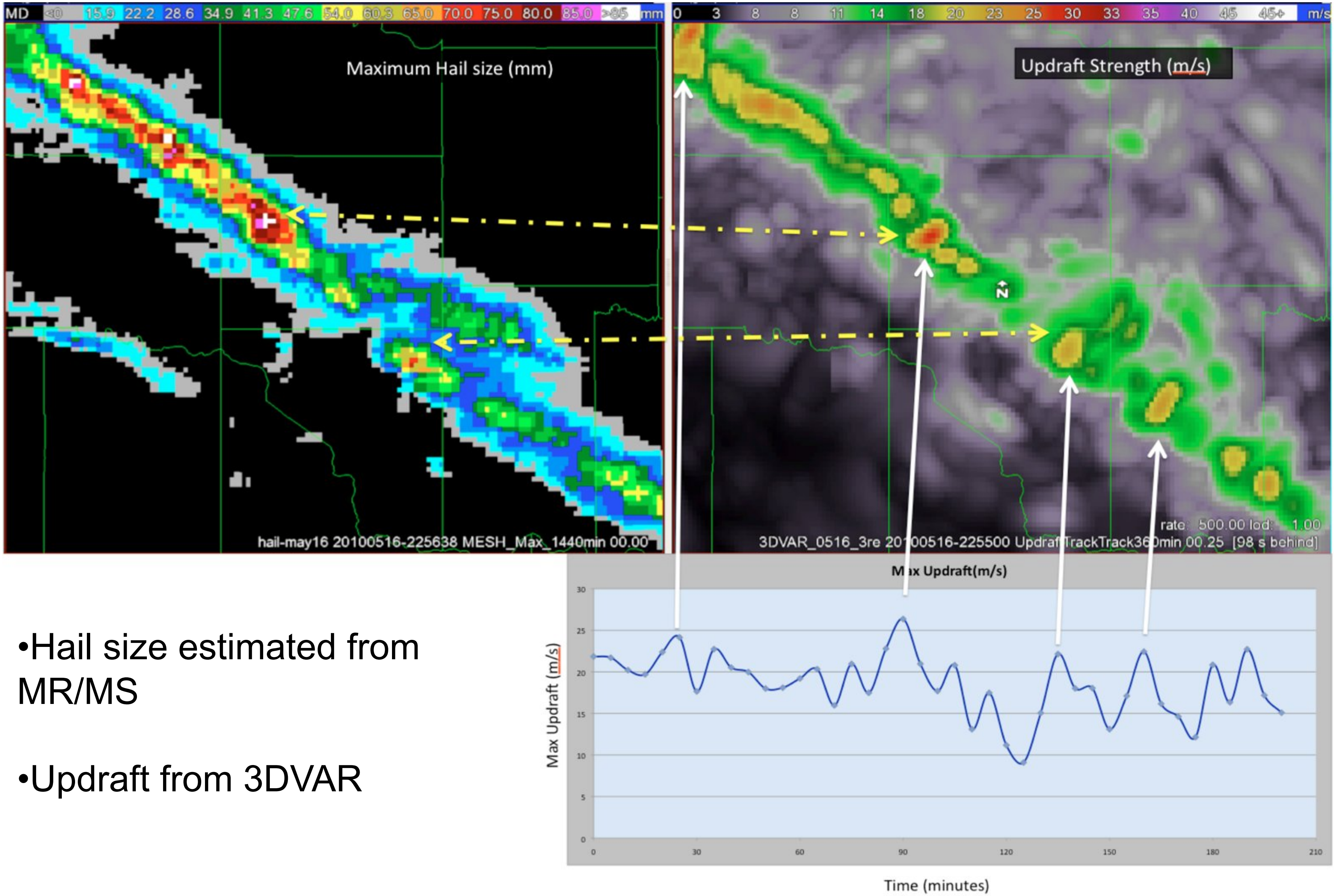
June 10th 2010 Colorado Tornadoes







Hail Size versus Updraft Intensity



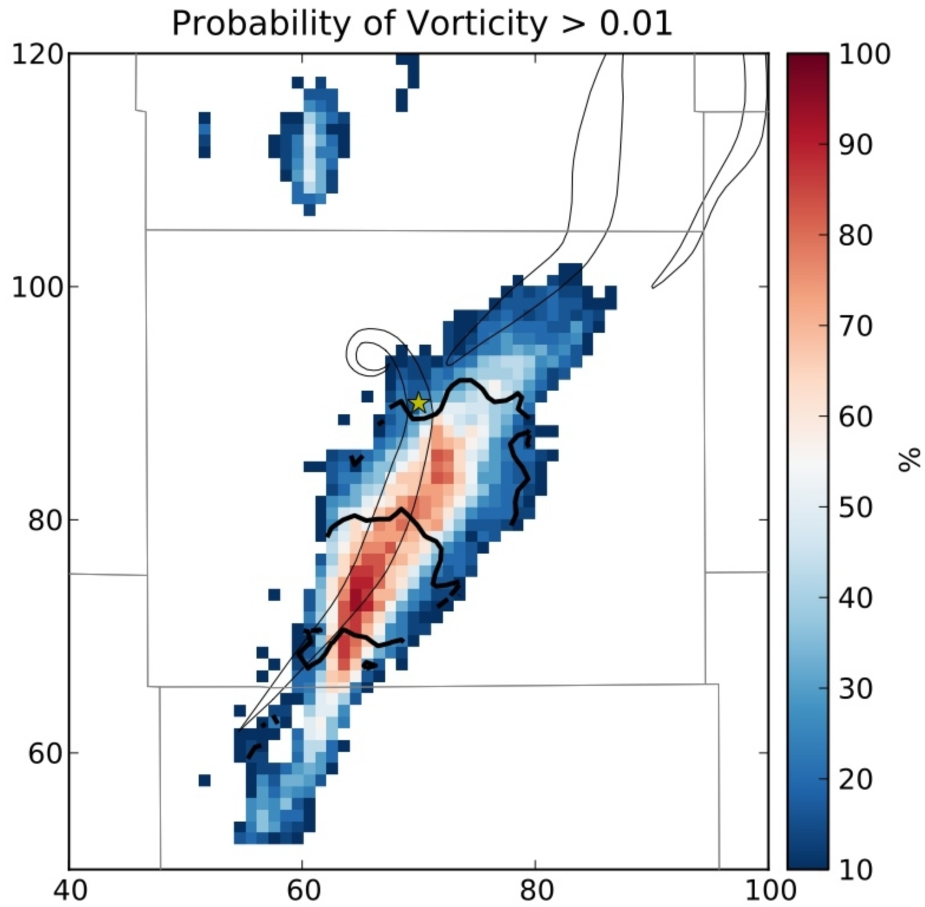
- Hail size estimated from MR/MS

- Updraft from 3DVAR

While HWT activities are ongoing…

– Also conduct research towards the Warn-on-Forecast vision of a probabilistic forecast warning system

Some Successes: 5 May 2007 Greensburg, Kansas



Dawson, Wicker, Mansell and Tanamachi (2011, MWR)

Not all cases are as successful

- Errors in microphysics often viewed as a large source of *model error* for storm-scale
  - *Can a multi-parameter (MP) bulk microphysics ensemble provide improved analyses and forecasts on storm-scale compared to an ensemble with no microphysics diversity?*

Observing System Simulation Experiment (OSSE)

- Produce truth run from a numerical model
    - COMMAS model, 10-ICE microphysics
    - 1-km horizontal grid spacing, 100 km x 100 km domain, homogeneous environment
- Sample truth run just like an operational radar to create synthetic radar observations
- Assimilate synthetic radar data into a slightly different model (using ensemble Kalman filter method)
- Compare ensemble analyses and forecasts to the truth run

Multi- vs. Single-Parameter Ensemble

- Single-parameter (SP) ensemble
  - Constant intercept and density parameters for single-moment LFO microphysics

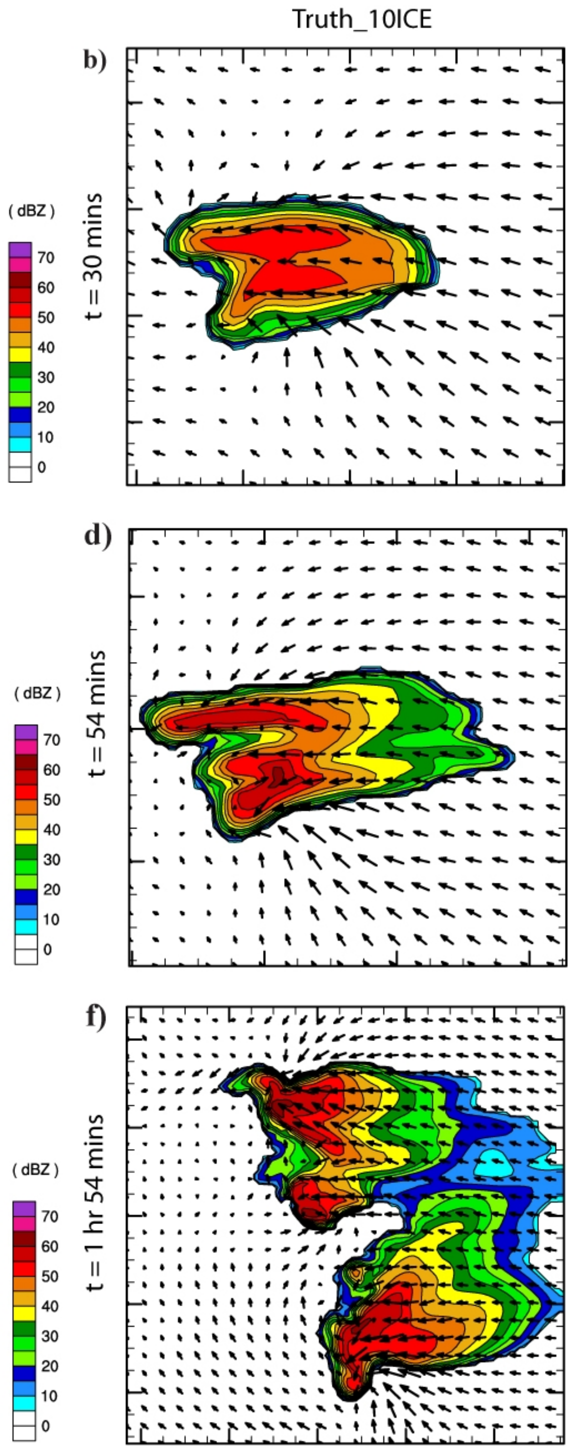
- Multi-parameter (MP) ensemble
  - Variable intercept and density parameters for single-moment LFO microphysics

See Yussouf and Stensrud (2011, MWR) for details.

Time

Assimilate data, create analyses

Make ensemble forecasts

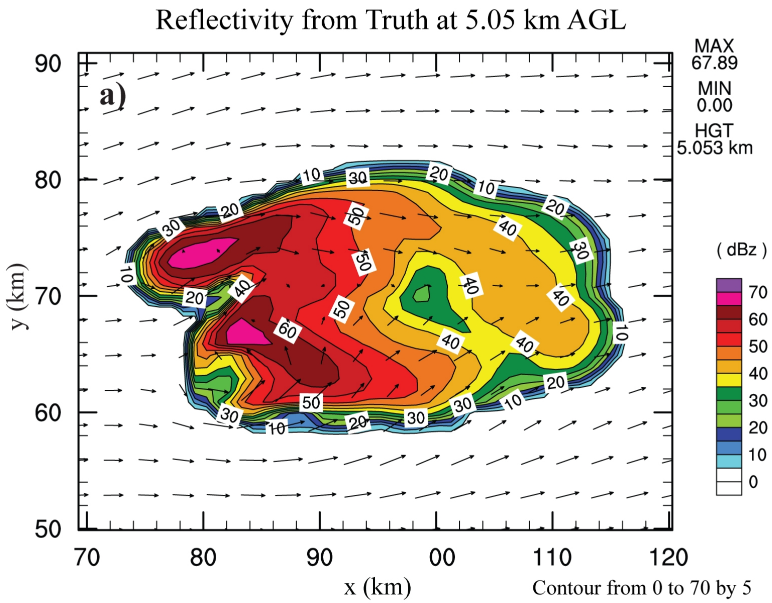


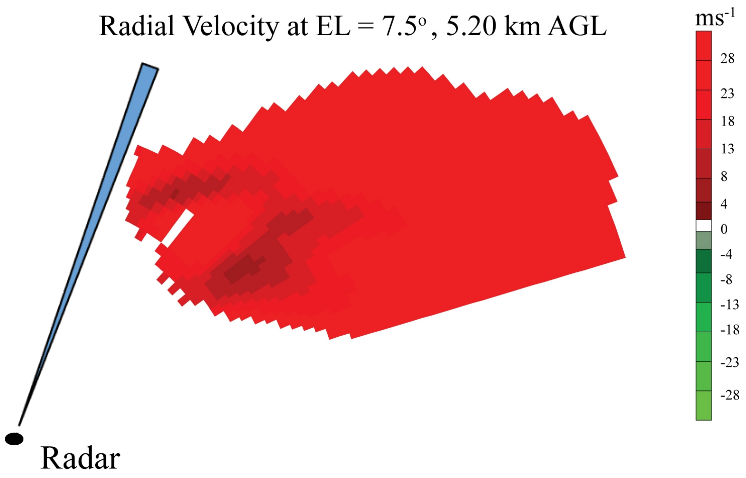
Truth run reflectivity field using 10-ICE microphysics shows splitting supercell thunderstorm.

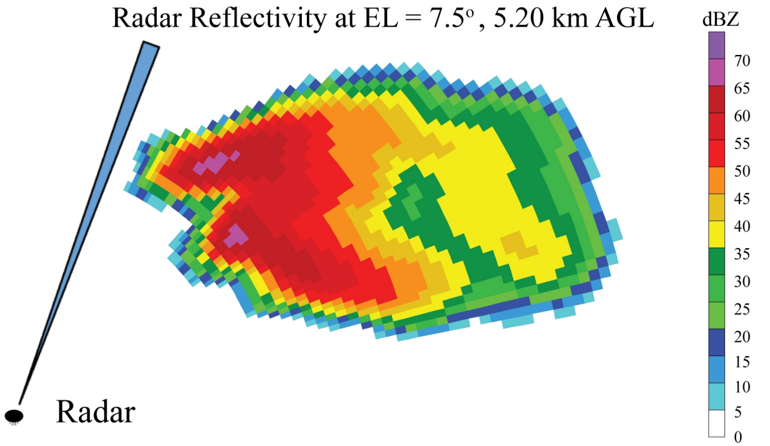
← End time of data assimilation period

← Can we predict this?

Synthetic Observations





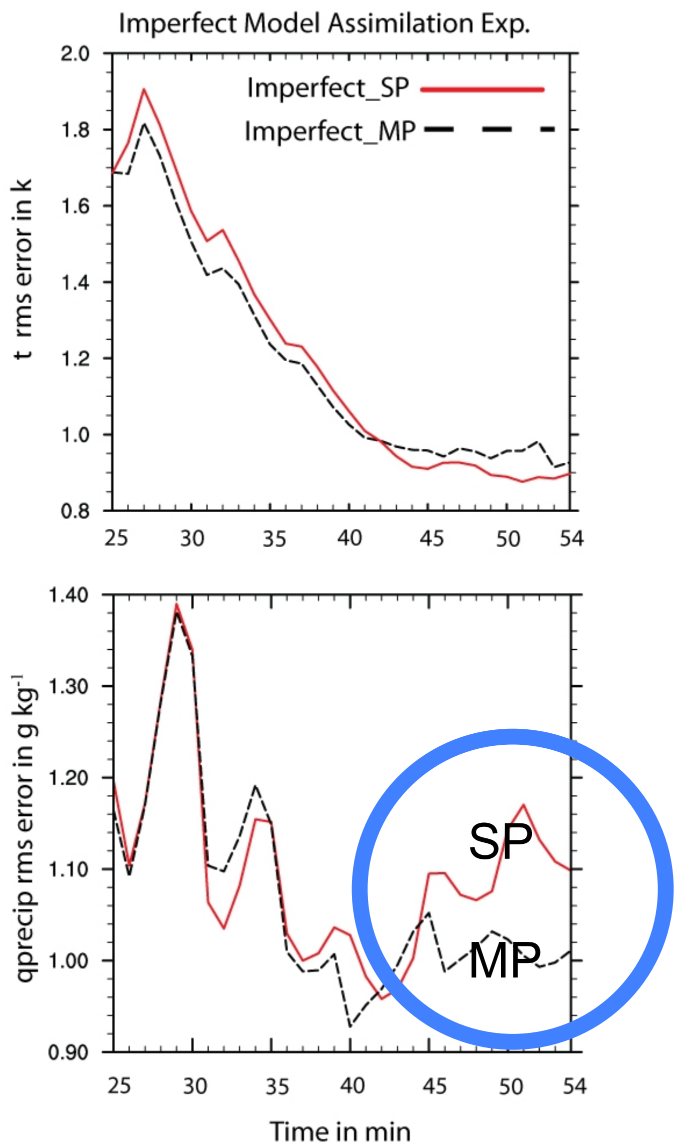


- Mimic current NWS Doppler Radars (WSR-88Ds)

- Assimilate 3 elevation angles every minute

Analyses of Unobserved Variables: SP vs. MP

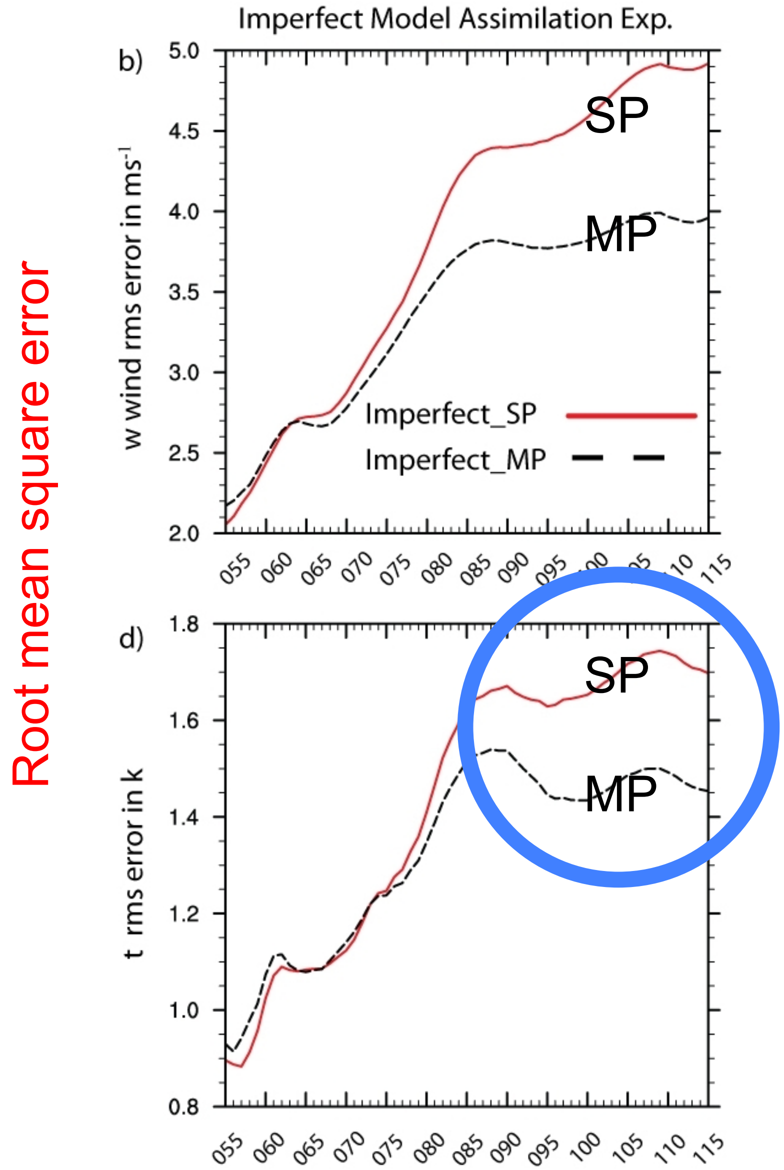
Root mean square error



•rms errors of many unobserved variables are similar for SP and MP ensembles

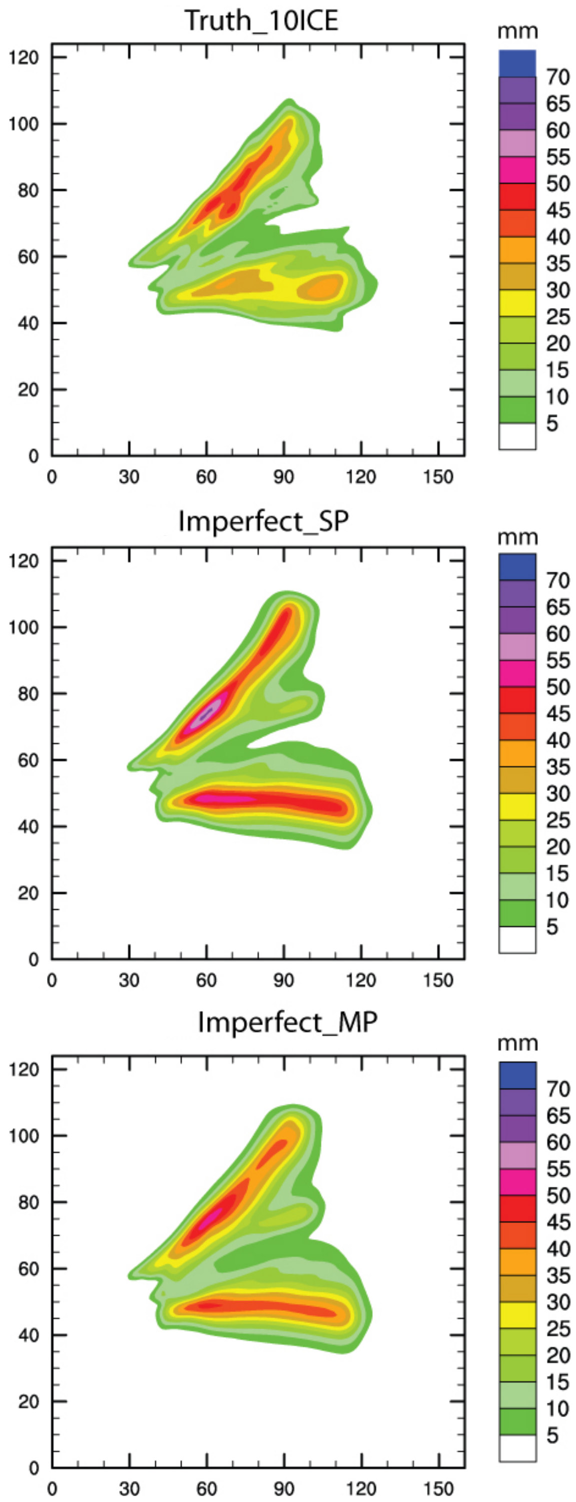
•MP ensemble provides improvement over values from SP ensemble for precipitation variables.

Forecasts of Unobserved Variables: SP vs. MP



•MP ensemble has smaller rms errors than SP ensemble for all forecast variables.

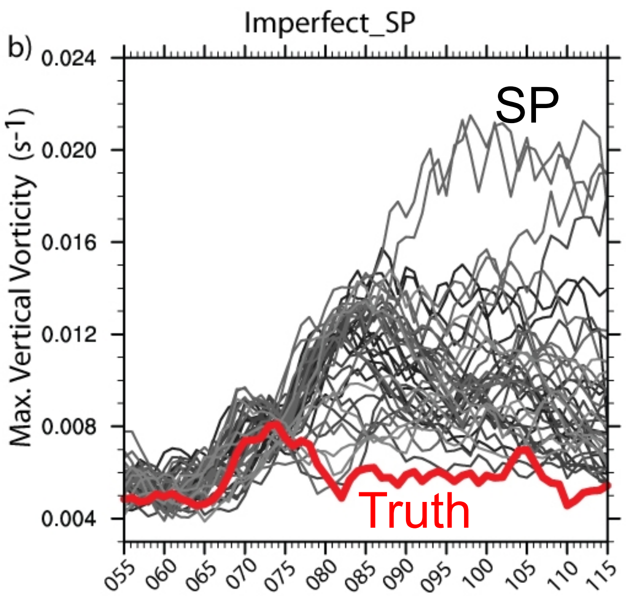
•Similar results found when comparing ensembles using ETS for radar reflectivity and total precipitation mixing ratio.



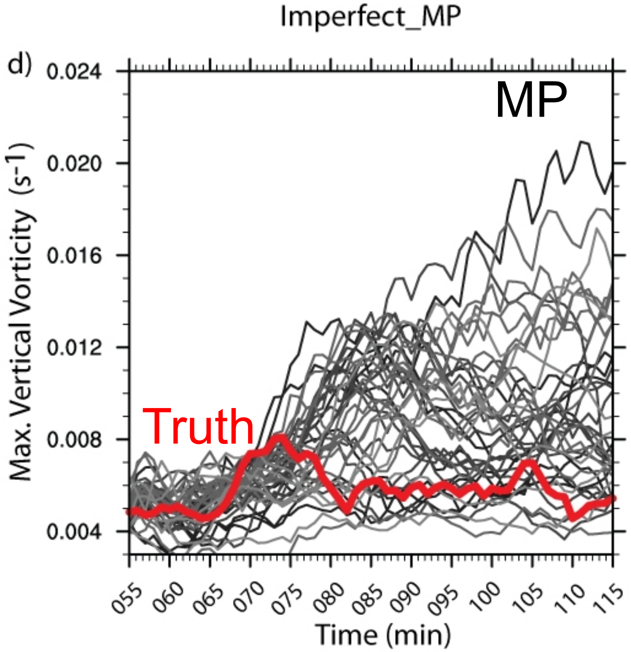
Forecasts of Total Rainfall SP vs. MP

MP ensemble produces improved mean rainfall track and amounts compared to SP ensemble

Maximum Surface Vorticity: SP vs. MP



•SP ensemble yields low-level rotation that is too strong.



•MP ensemble captures maximum near-surface rotation from truth run within ensemble envelope.

Discussion

- Warn-on-Forecast is showing the value of a single analysis, and is making progress on longer-term vision

- For vision, when *model error* is present
  - MP ensemble provides more accurate analyses and forecasts than SP ensemble, with 10-20% larger ensemble spread.
  - Challenge will be correctly predicting the more extreme conditions associated with severe weather.
  - Some amount of microphysical parameter diversity may be beneficial to storm-scale ensemble forecasting. Real data tests are underway.

Challenges

- Best assimilation technique to use
- Radar data quality control; value of other data
- Errors in environmental conditions
- Predictability of severe weather
- Model error
- How to optimize use of storm-scale ensemble data for warning operations and decision-making by public

Questions?