Application of a WRF mesoscale data assimilation system to severe weather events during springs 2007-2009

4th EnDA Workshop

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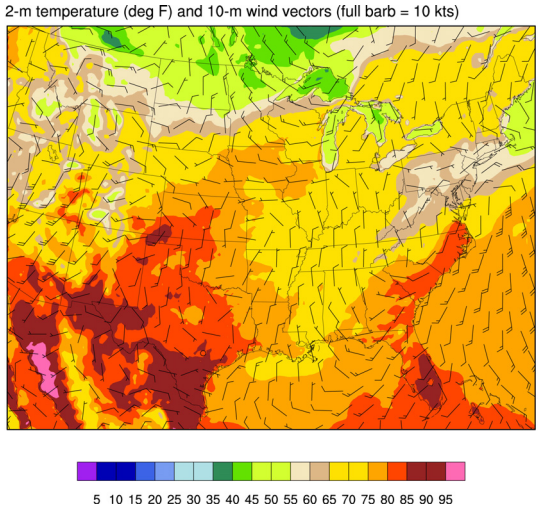
Motivation

- Prior successes with mesoscale surface data assimilation at NSSL
  - Only standard surface observations were assimilated (e.g., see Fujita et al. 2007, Stensrud et al. 2009)
- Results can be used for:
  - Mesoscale analyses/forecasts
  - Multi-scale system



WRF Mesoscale Ensemble System

- WRF (ARW)
  - Eastern two-thirds of CONUS
  - 20-km horizontal grid spacing; 35 vertical levels
  - Mean initial and boundary conditions from the NAM forecast cycle starting at 12Z

WRF mesoscale ensemble system (cont.)

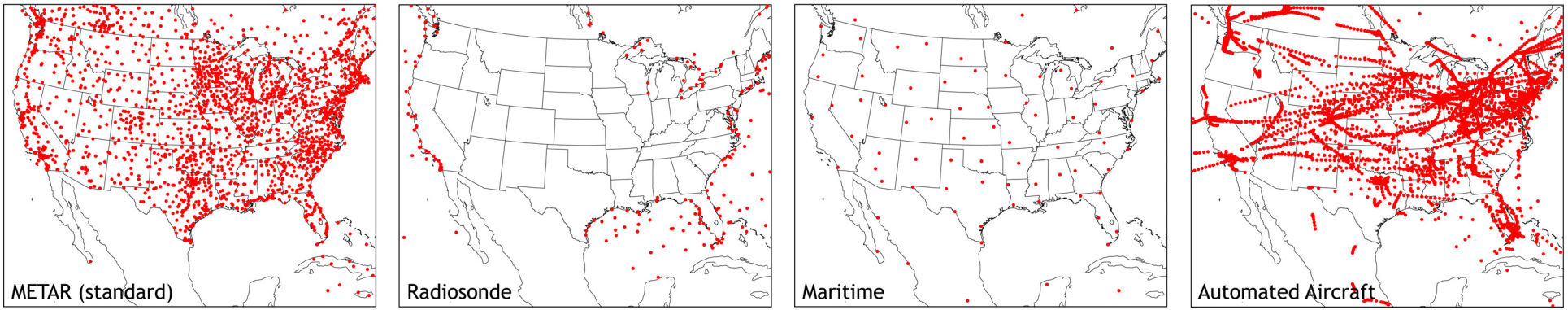
- 30-member ensemble
  - IC/BC perturbations from WRF-Var (see Torn et al. 2006); also, soil perturbations
  - Physics diversity
    - Microphysics: WSM5, Thompson
    - Cumulus: Kain-Fritsch, Betts-Miller-Janjic, Grell-Devenyi
    - Surface layer: Similarity theory (MM5), Similarity theory (Eta)
    - PBL: YSU, MYJ, NCEP GFS
    - Shortwave radiation: Dudhia, Goddard

Mesoscale data assimilation

- *p (land-surface altimeter), T, T_d, u, v*

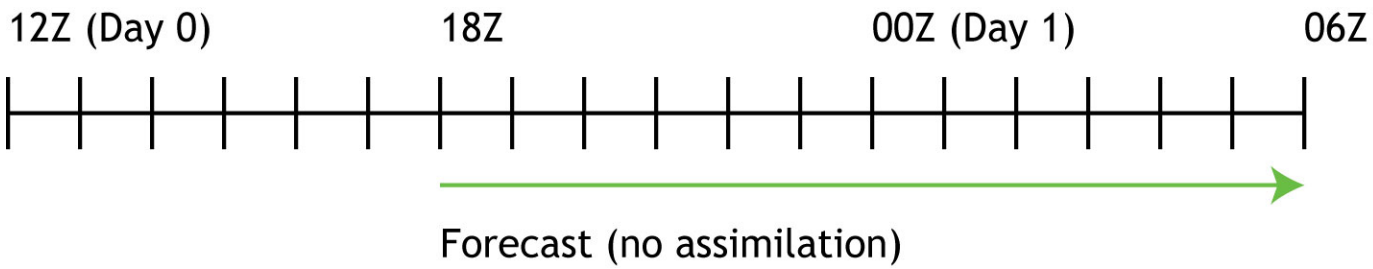
- Data Assimilation Research Testbed (DART)
  - Ensemble Kalman filter (EnKF) approach
  - See http://www.image.ucar.edu/DAReS/DART

- Observation platforms…

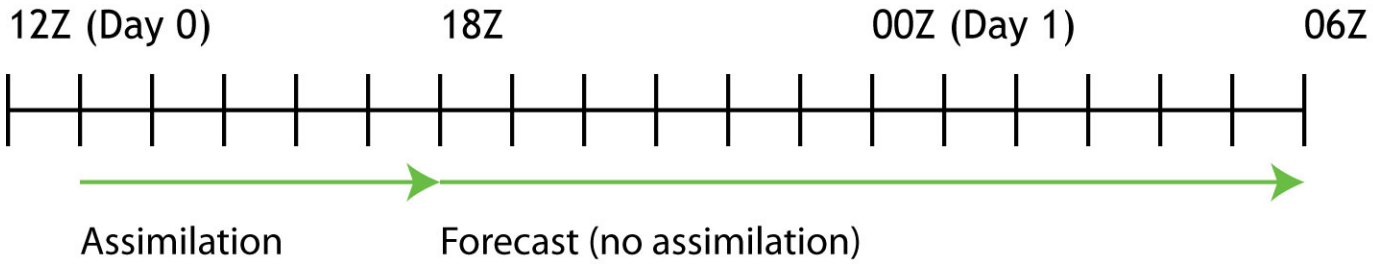


Design of experiments

- Control



- With assimilation

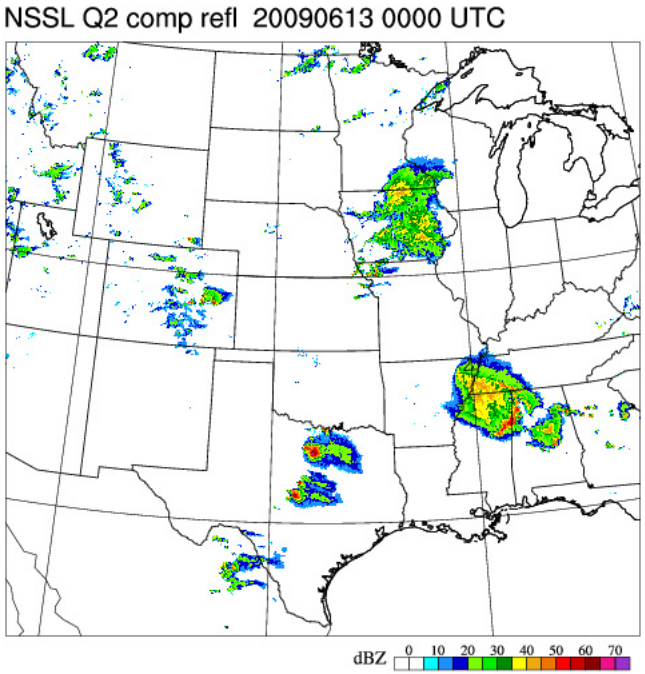


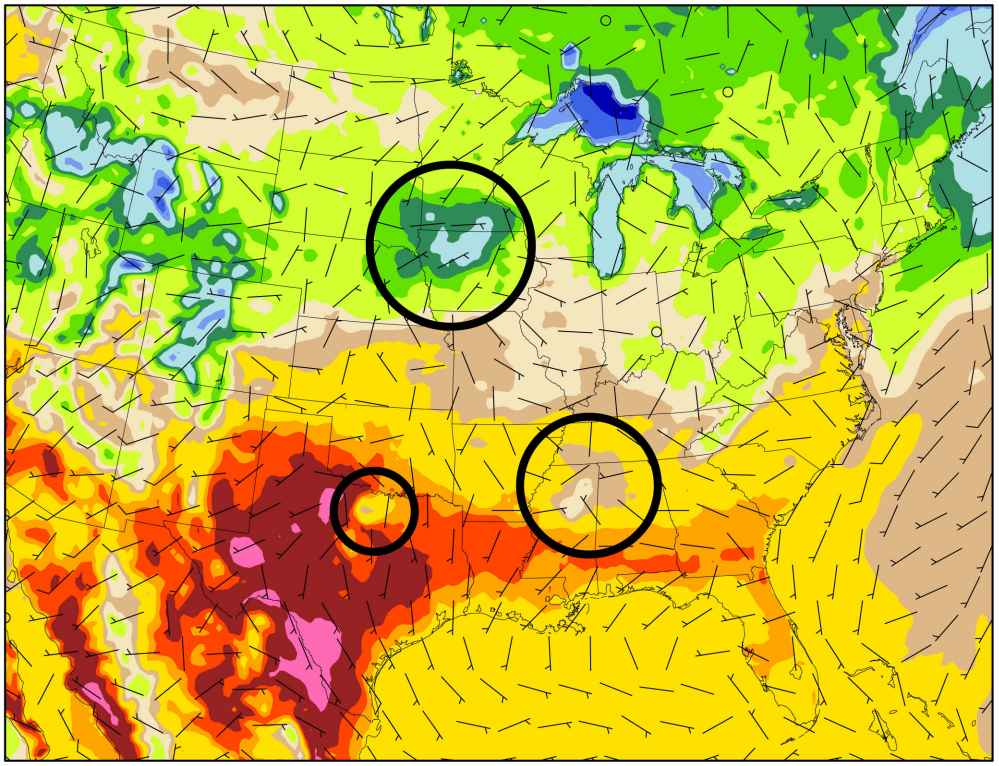
List of events

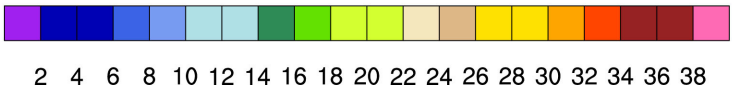
2007			2008			2009	
EVENT	**TYPE**		**EVENT**	**TYPE**		**EVENT**	**TYPE**
23 Mar	T		5 Feb	T, W		23 Mar	T
21 April	T		24 April	T		8 May	W
23 April	T		1 May	T		13 May	T
4 May	T		22 May	T		5 June	T
5 May	T		23 May	T		11 June	W
--	--		29 May	T		12 June	W
--	--		4 June	T,W		18 June	W
--	--		5 June	T		24 June	T
--	--		11 June	T		--	--

T = Torn; W = Wind

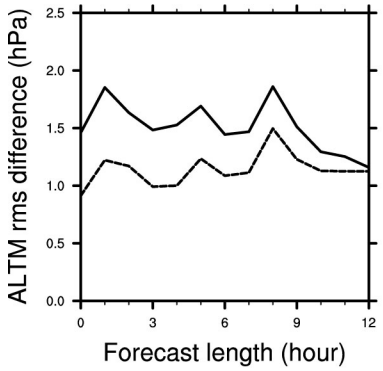
0000 UTC 13 June 2009

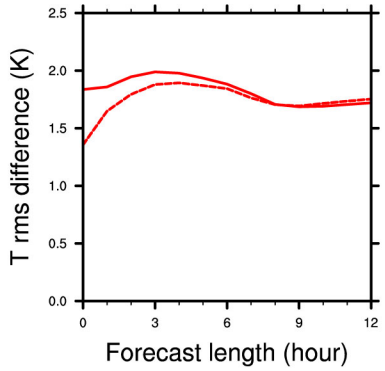


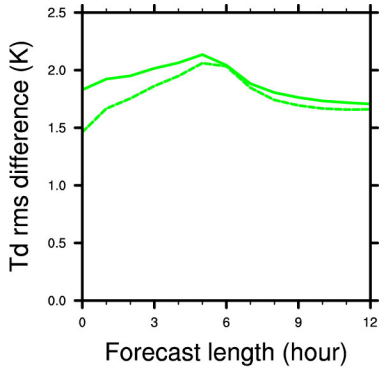


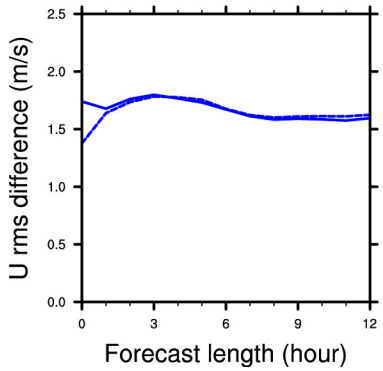


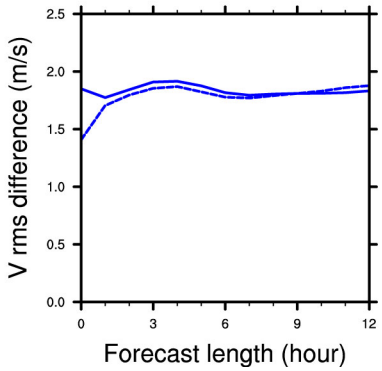
Associated cold pools reproduced in ensemble mean 2-m temperature











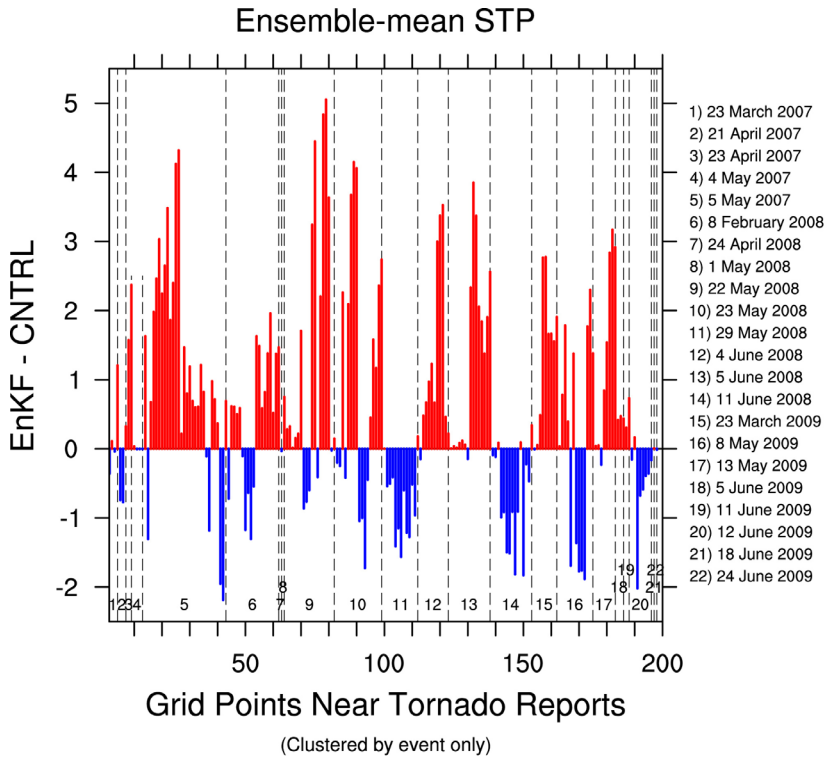
- RMS differences between the ens. mean and surface obs.
- Averaged over all the obs. locations, across all events

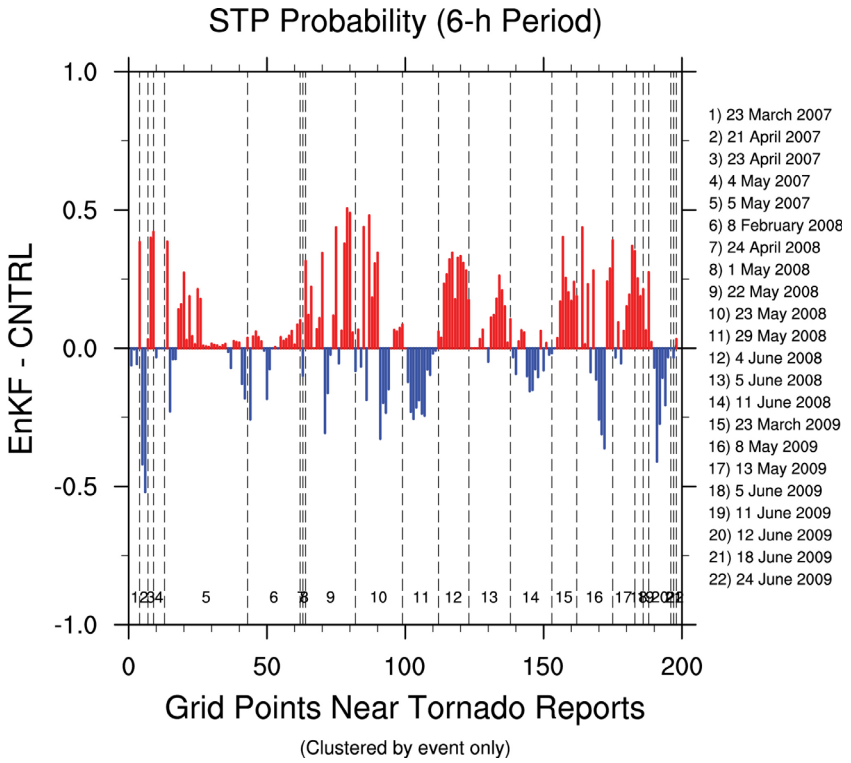
Improved short-term forecasts?

- *SIGNIFICANT TORNADO PARAMETER*

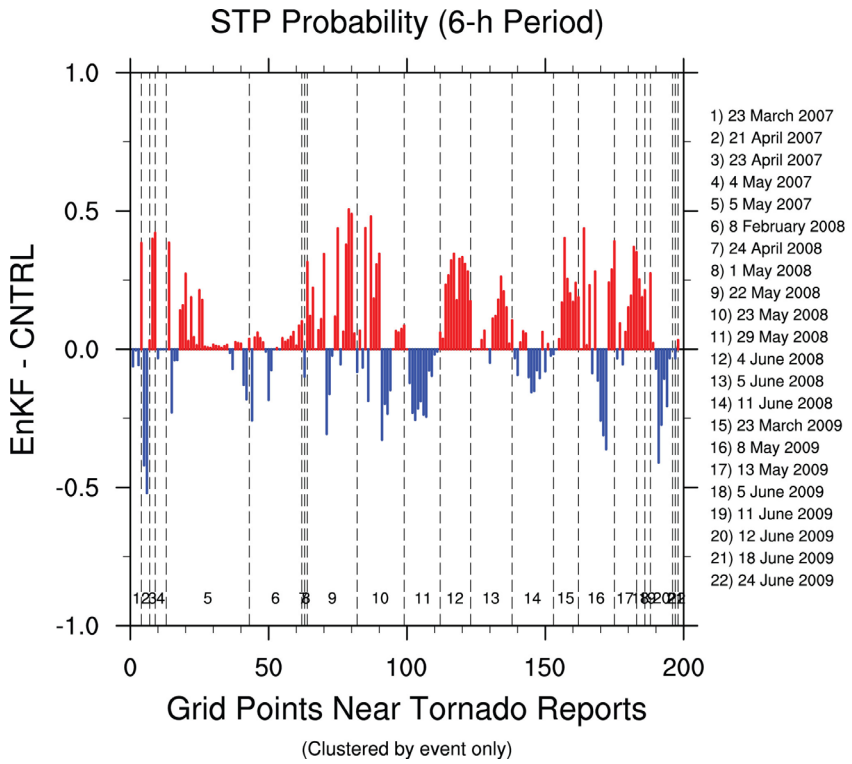
- Discriminates between significantly tornadic and nontornadic supercell environments

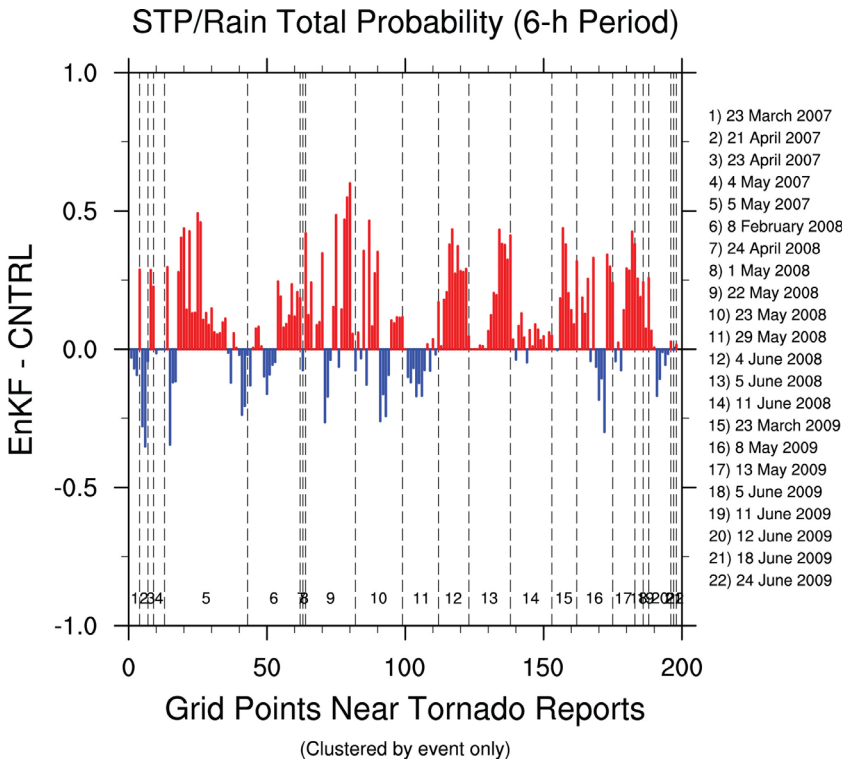
  - CAPE/CIN
  - Lifting condensation level height
  - 0—1-km storm relative helicity
  - 0—6-km vector shear magnitude



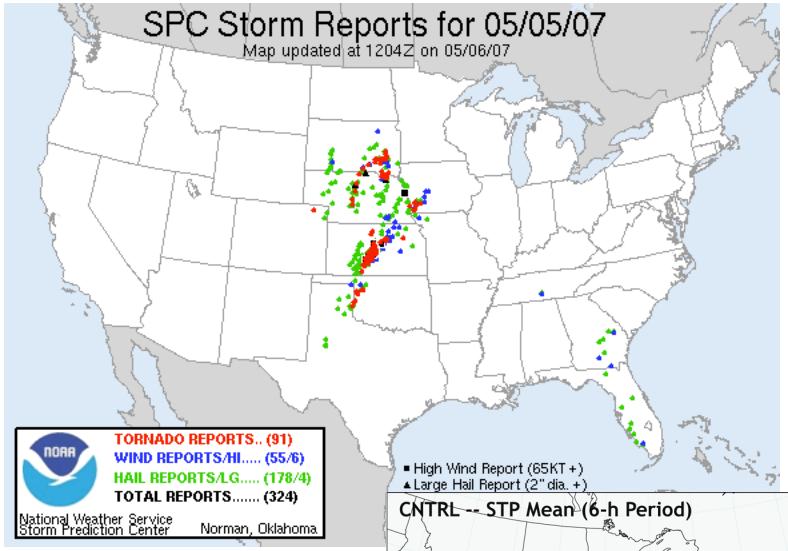


- Tornado reports from 1800-0000 UTC
- Diagnosed quantity extracted from nearest model grid point

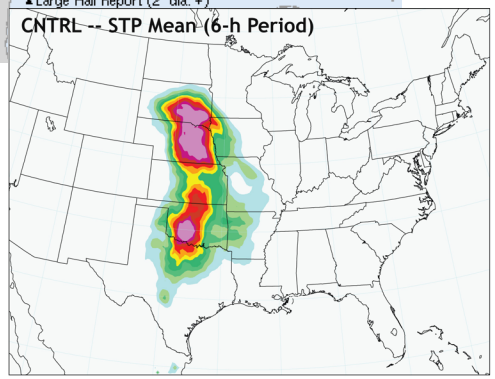


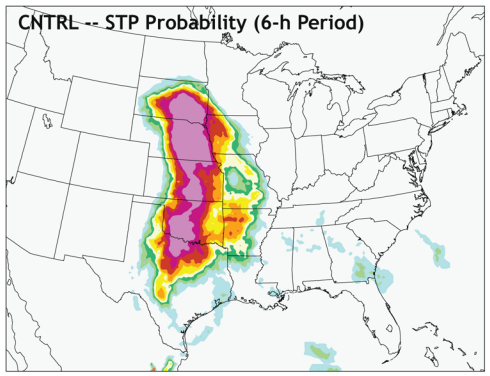


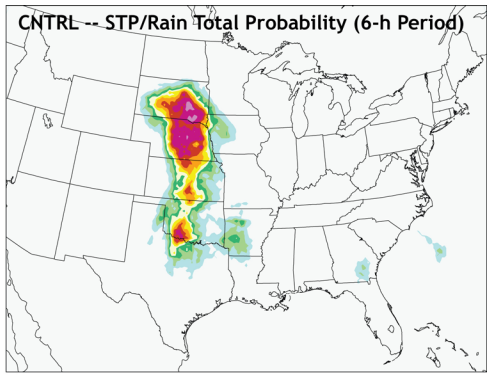
- Include probability of precipitation (right)

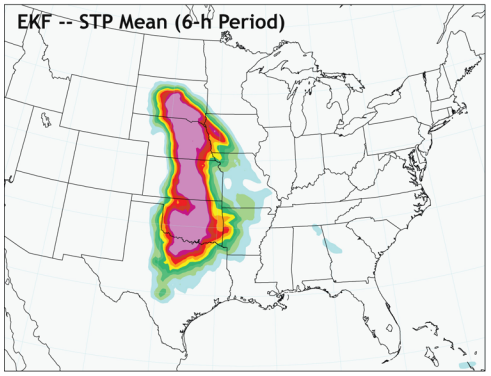

SPC Storm Reports for 05/05/07
Map updated at 1204Z on 05/06/07
TORNADO REPORTS.. (91)
WIND REPORTS/HI..... (55/6)
HAIL REPORTS/LG..... (178/4)
TOTAL REPORTS..... (324)
National Weather Service
Storm Prediction Center
Norman, Oklahoma
■ High Wind Report (65KT+)
▲ Large Hail Report (2" dia.+)

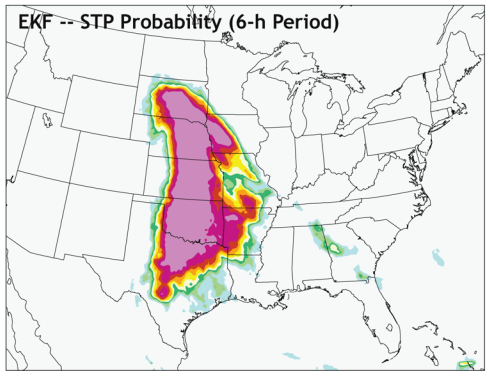
5 May 2007


CNTRL -- STP Mean (6-h Period)
.5 1 1.5 2 2.5 3 3.5 4 4.5 5


CNTRL -- STP Probability (6-h Period)
.1 .2 .3 .4 .5 .6 .7 .8 .9


CNTRL -- STP/Rain Total Probability (6-h Period)
.1 .2 .3 .4 .5 .6 .7 .8 .9


EKF -- STP Mean (6-h Period)
.5 1 1.5 2 2.5 3 3.5 4 4.5 5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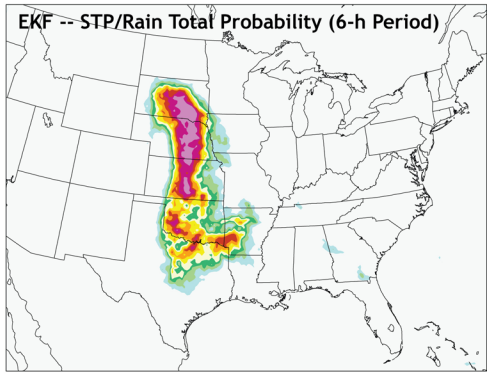
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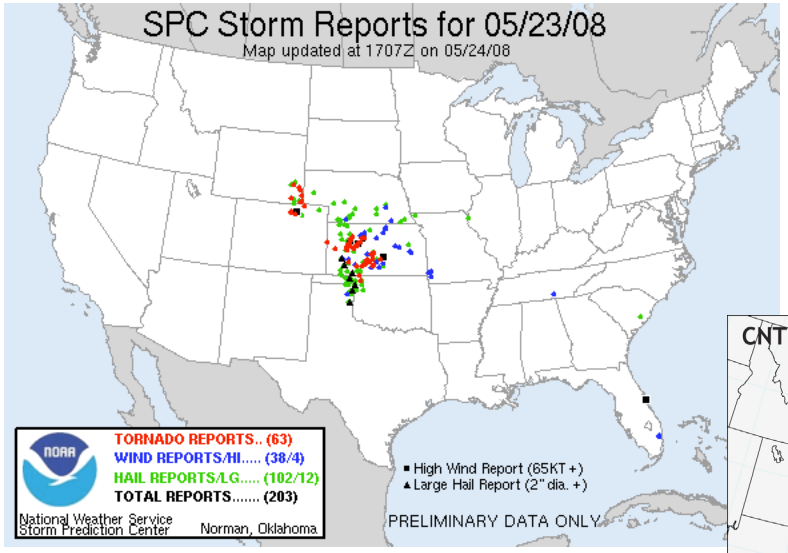
23 May 2008


SPC Storm Reports for 05/23/08
Map updated at 1707Z on 05/24/08
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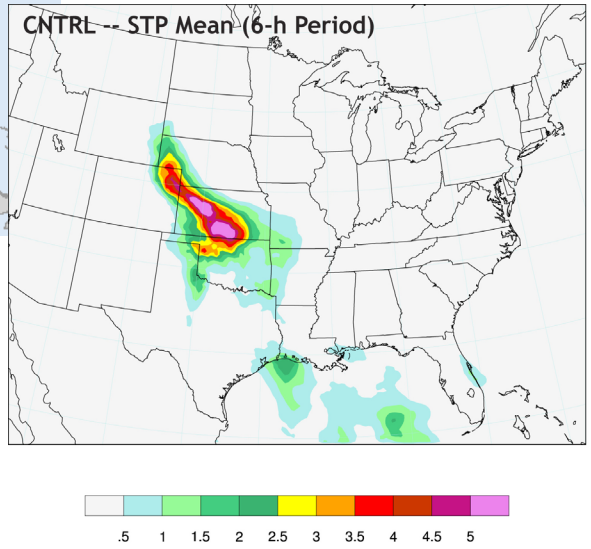
PRELIMINARY DATA ONLY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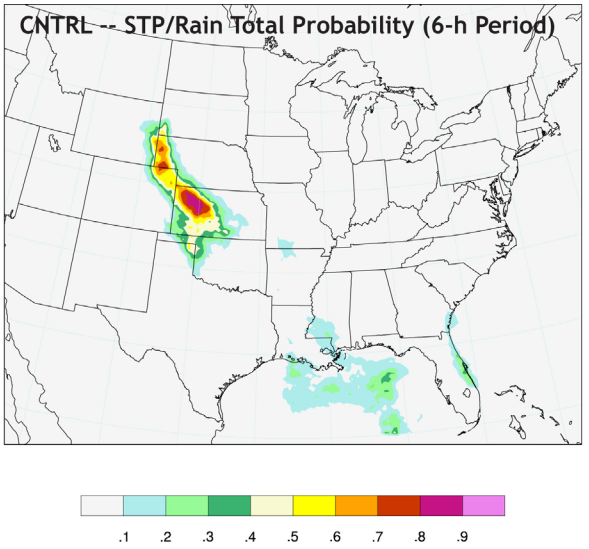
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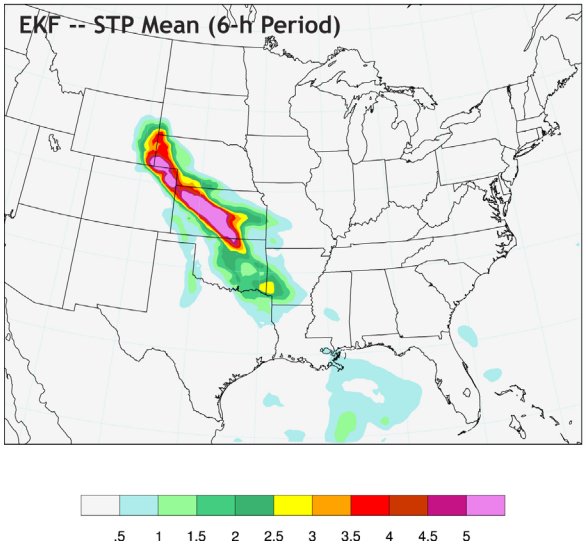
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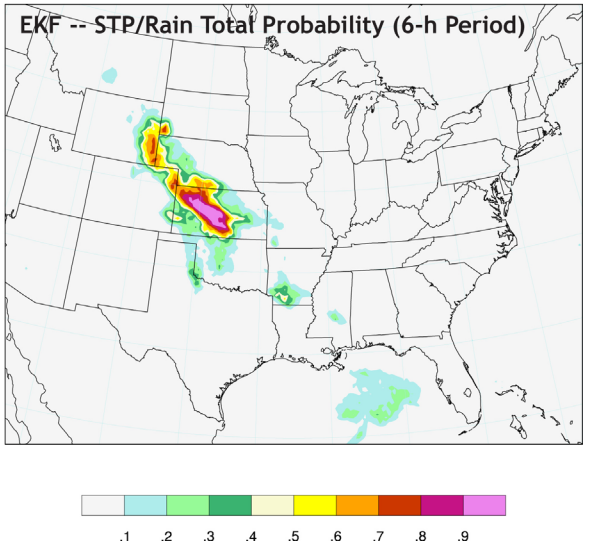
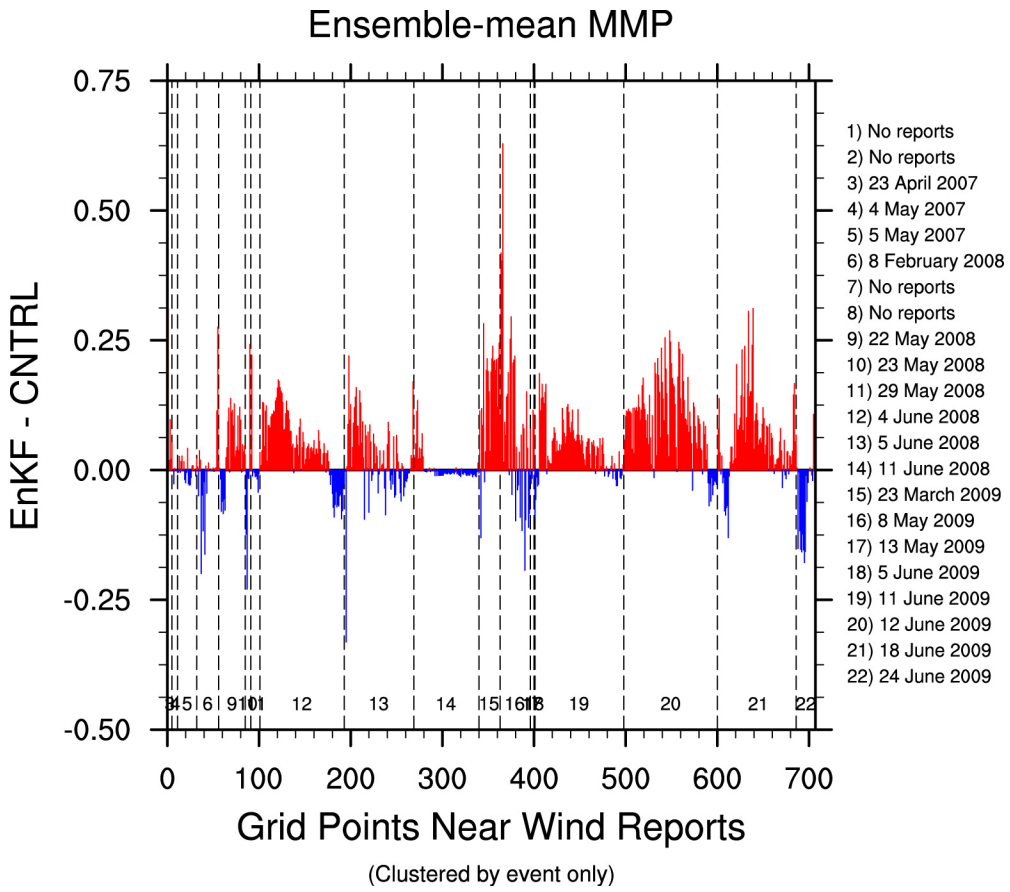

EKF -- STP/Rain Total Probability (6-h Period)
.1 .2 .3 .4 .5 .6 .7 .8 .9

Improved short-term forecasts?

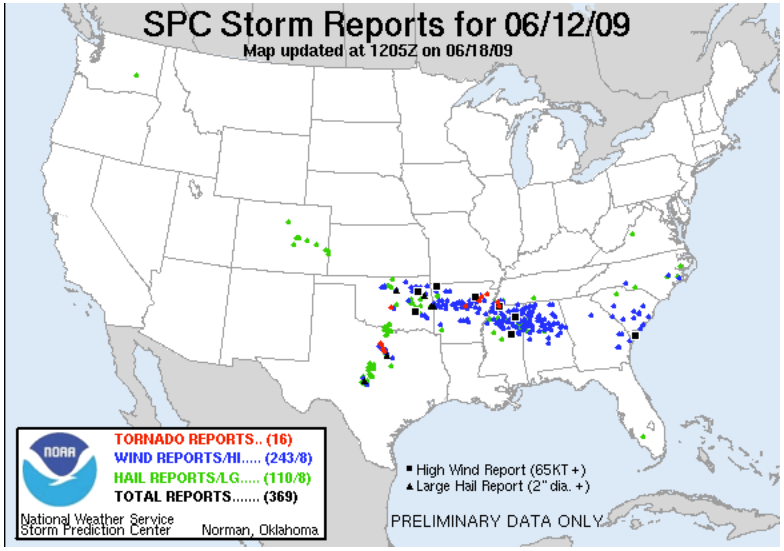
- *MCS MAINTENANCE PROBABILITY (%)*

- Predicts chance that MCS will be strong and be maintained

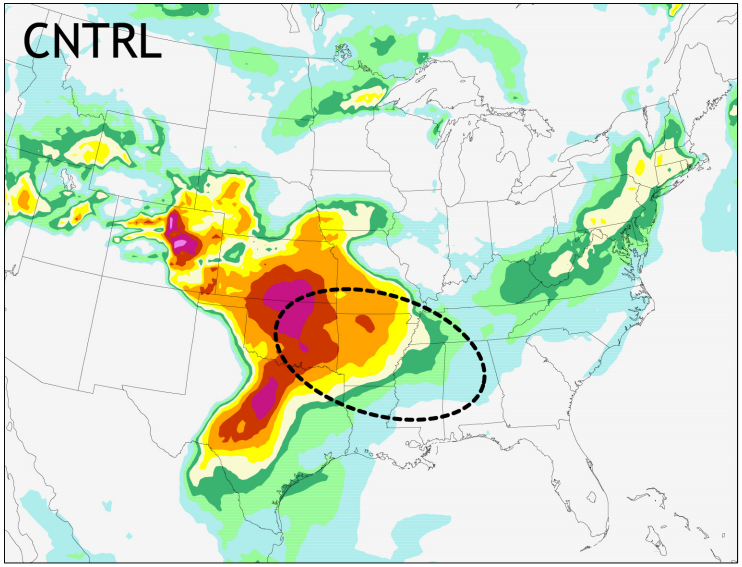
  - Maximum deep shear
  - 3—8-km lapse rate
  - CAPE
  - 3—12-km mean wind speed

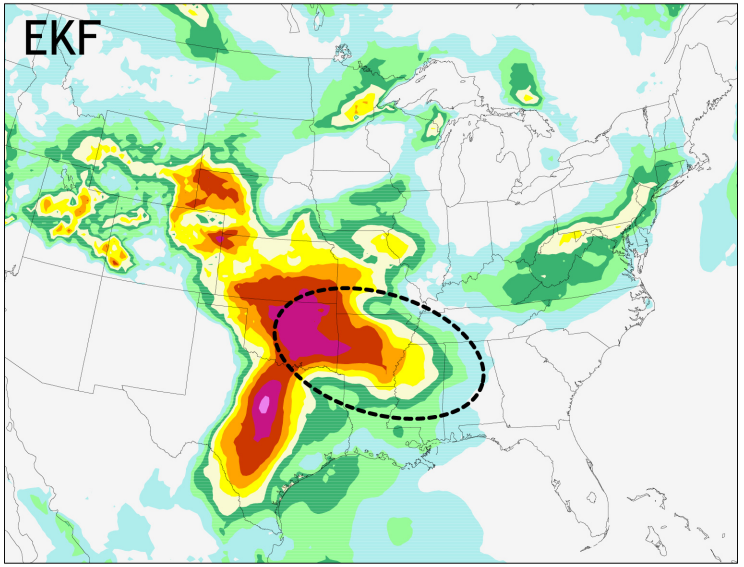


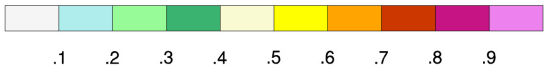
Event #’s 12, 16, 19-20, 21 ← → Long-lived MCS events

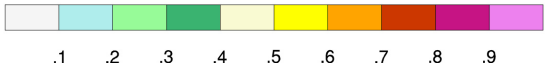


MMP values derived from EKF more clearly delineate MCS trajectory.









Discussion

- With DA: Potentially improved forecasts of various parameters related to severe thunderstorms and tornadoes.
- Unresolved issue (with/without DA): Low-Low-level sounding structure.
- Starting point for multi-scale data assimilation system…