

The Impact of Mesoscale Environmental Uncertainty on the Prediction of a Tornado Supercell Storm using Ensemble Data Assimilation Approach

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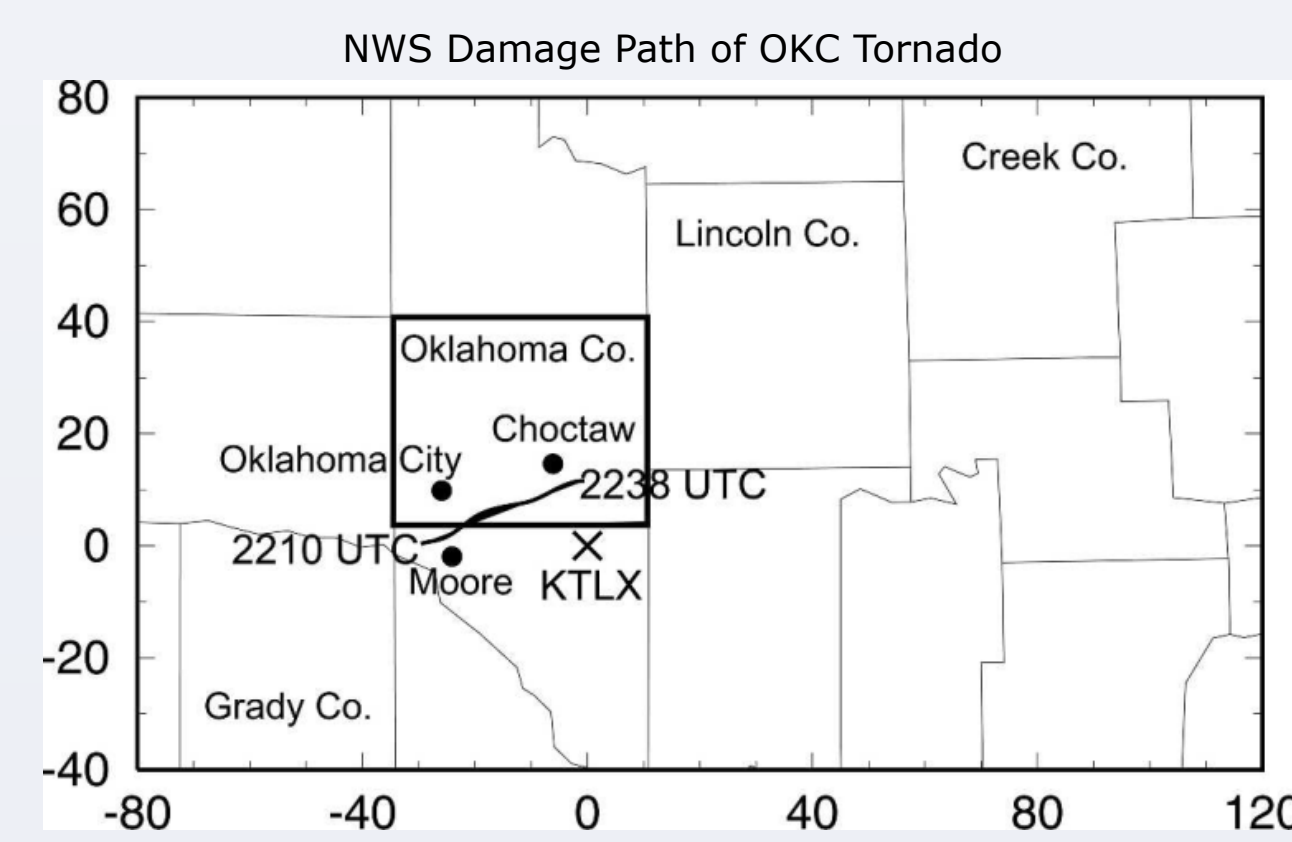
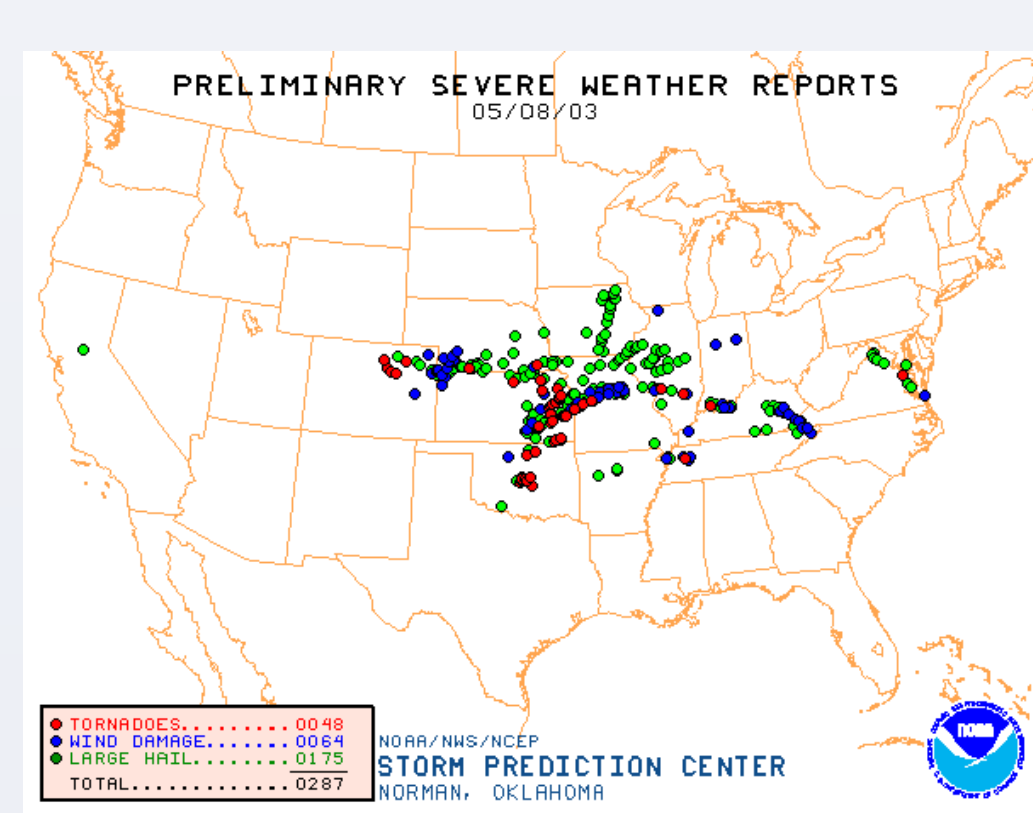
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OBJECTIVES

- Past studies indicate that incorporating environmental variability is crucial for successful very short-range (0-1 h) convective-scale ensemble forecasts.
- The goal is to explore the impact of model physics on the creation of mesoscale environmental variability and its uncertainty.
- A combined mesoscale-convective scale ensemble data assimilation and forecast experiments are conducted for a supercell storm.

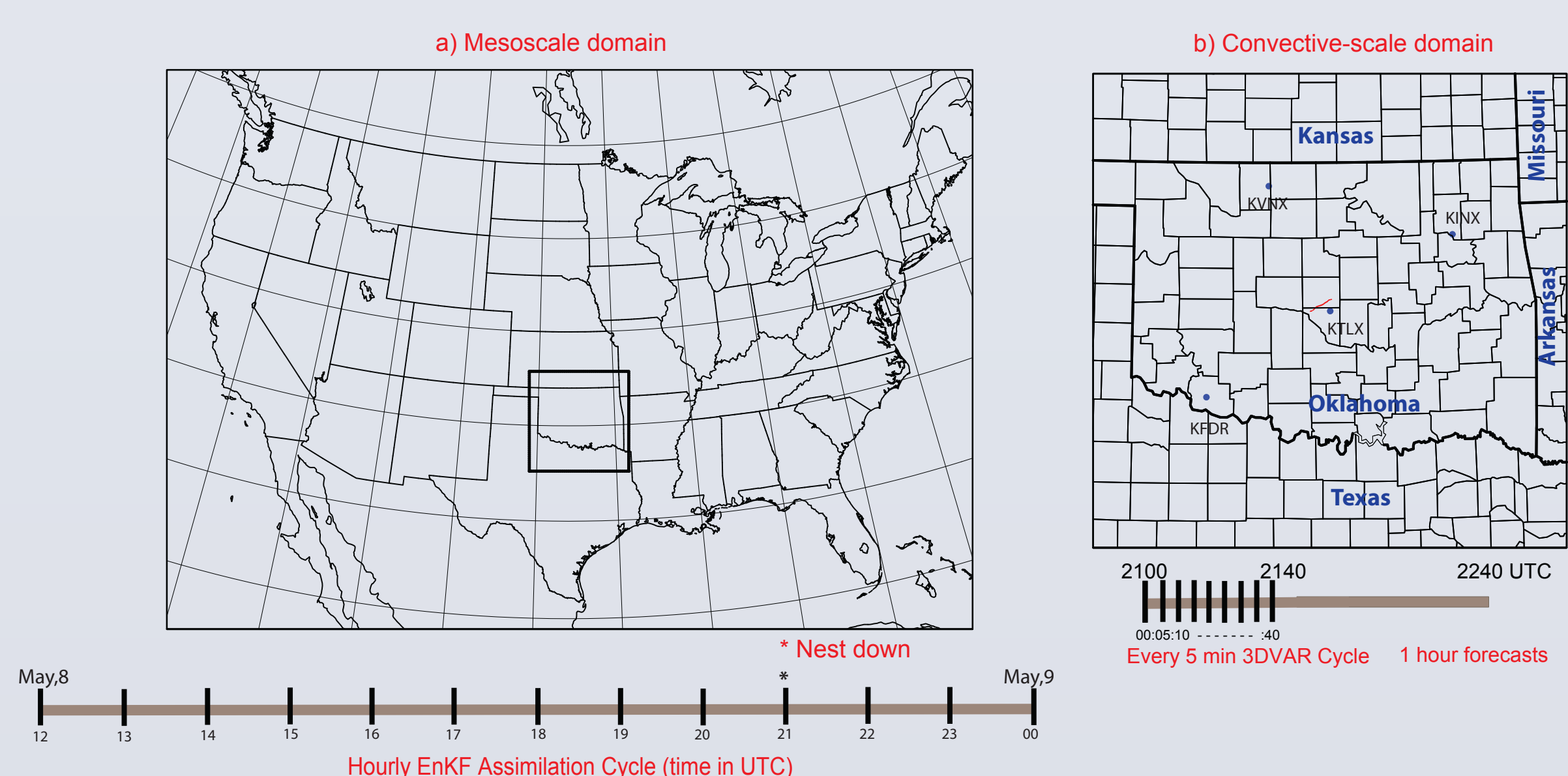
8 MAY 2003 OKLAHOMA CITY TORNADIC SUPERCELL STORM



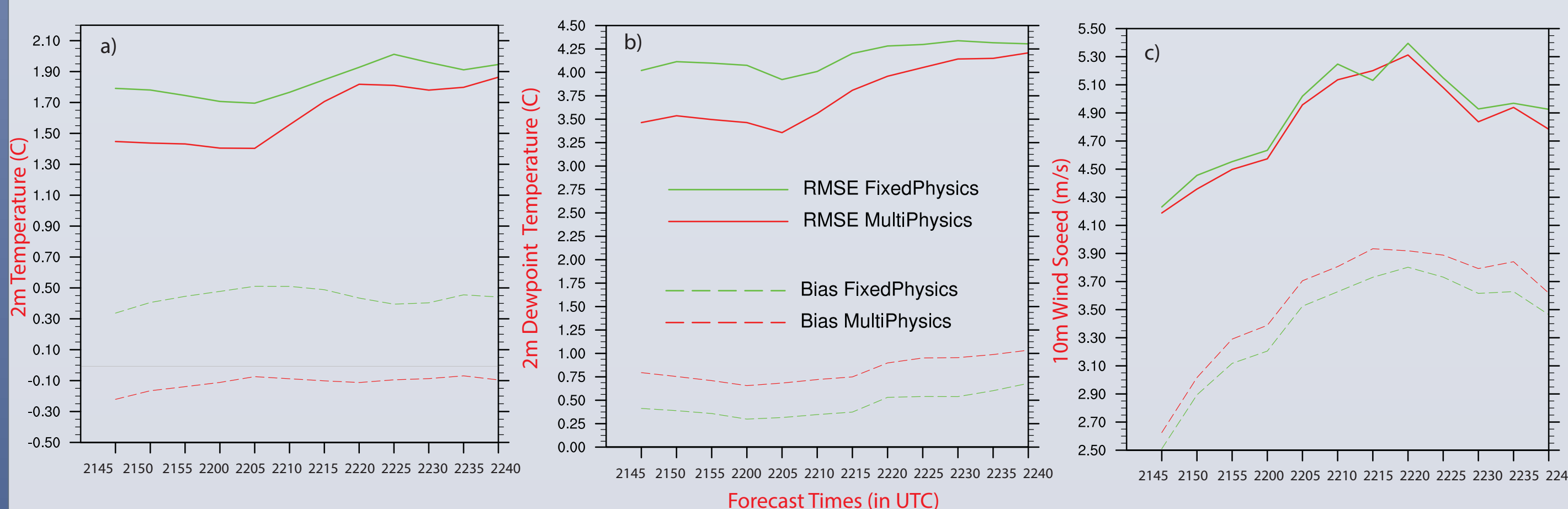
(LEFT) Severe weather reports from NOAA's Storm Prediction Center. (RIGHT) The National Weather Service surveyed damage path.

EXPERIMENT DESIGN

- The Advanced Research Weather Research and Forecasting (WRF-ARW core version 3.3.1) model
- Two 36 member mesoscale data assimilation experiments over CONUS at 12 km horizontal grid spacing
 1. Fixed Physics Ensemble
 2. Multi Physics Ensemble
- Observation platforms: METAR, Radiosonde, Maritime and Automated Aircraft from MADIS
- DART EAKF data assimilation system
- Two 36 member convective scale data assimilation experiments nested down at 3 km horizontal grid spacing:
 1. FixedPhysics Ensemble
 2. MultiPhysics Ensemble
- Observation platforms: Operational radar observations from four WSR-88D radars and Oklahoma Mesonet
- ARPS-3DVAR data assimilation system

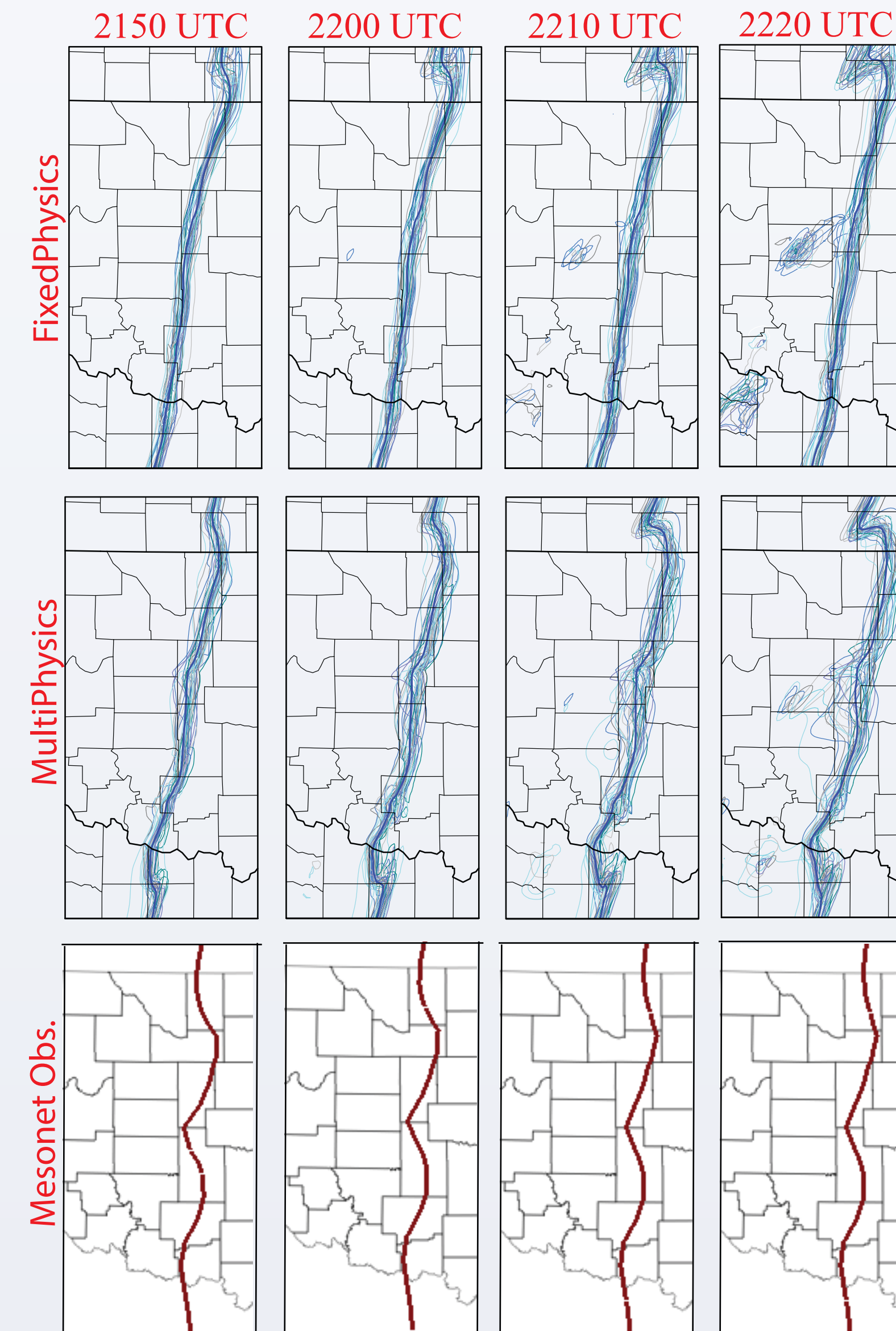


TIMESERIES OF RMSE AND BIAS



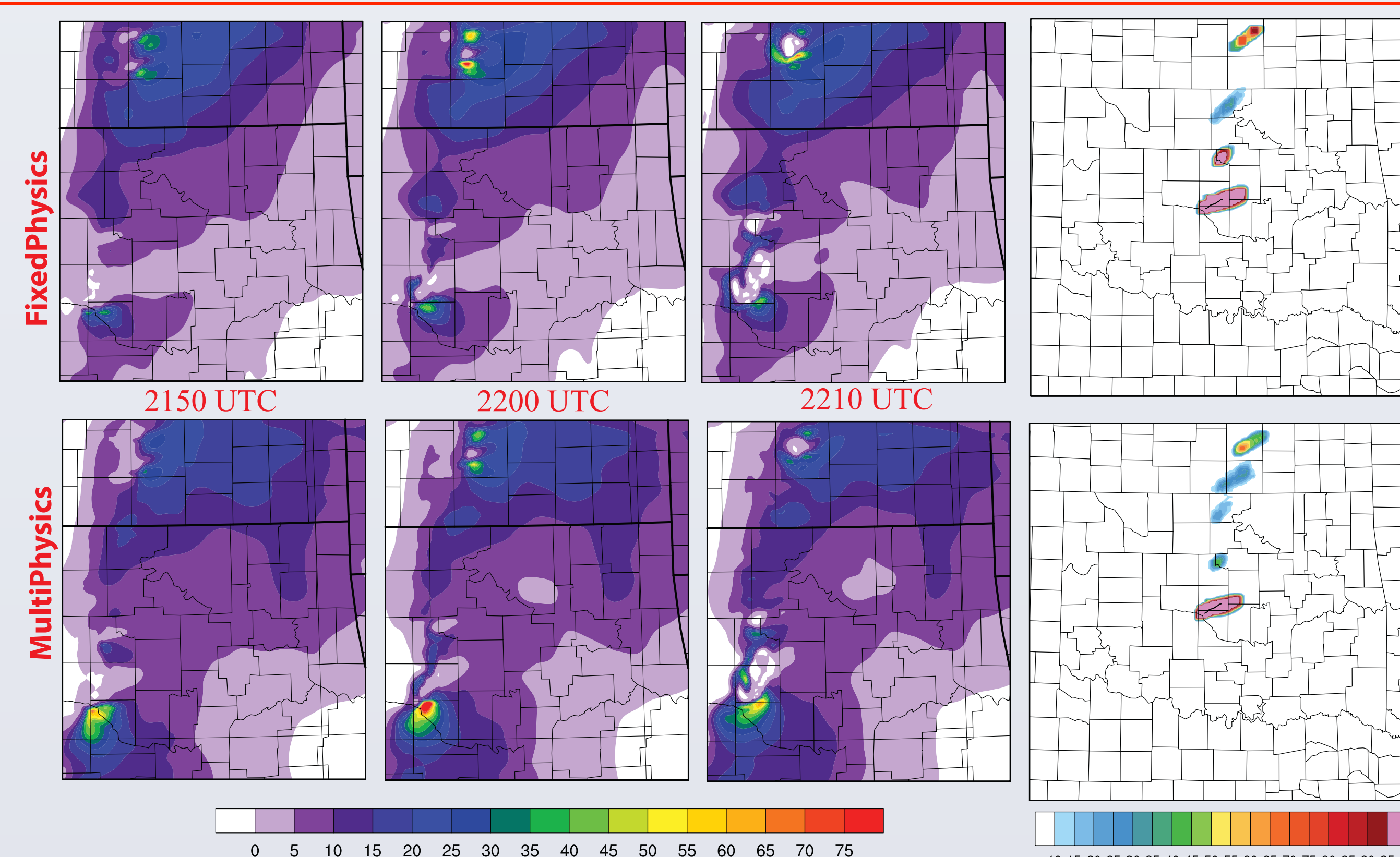
The time series of rmse and bias (forecast - observations) against Oklahoma Mesonet observations during 1-h forecast period for (a) 2-m temperatures (°C), (b) 2-m dewpoint temperature (°C), and (c) 10-m wind speed (m s⁻¹) for convective-scale ensemble system.

FORECAST LOCATIONS OF DRYLINE



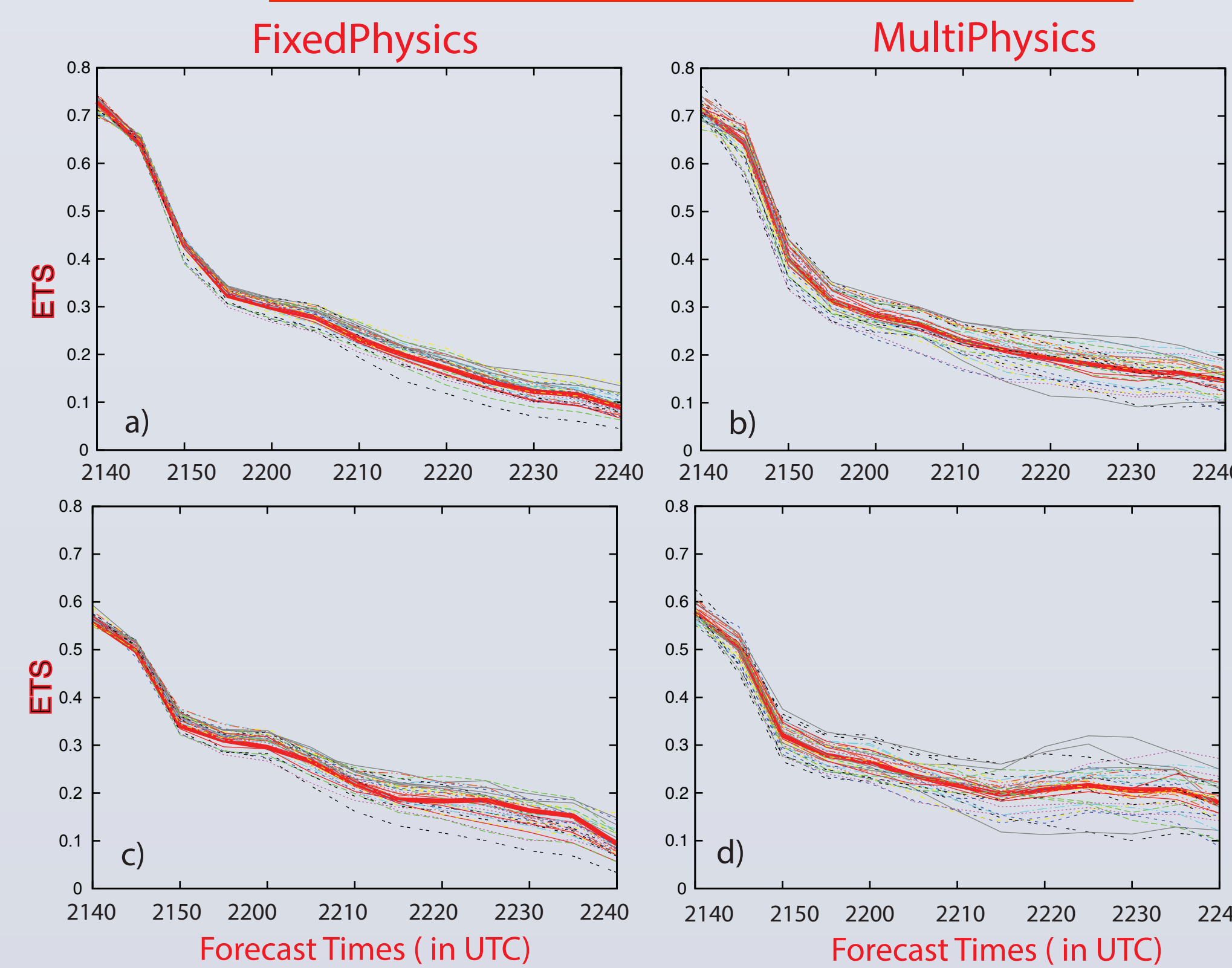
Isolines of 10° C 2-m dewpoint temperature forecasts from FixedPhysics and MultiPhysics convective-scale ensemble members (thin blue lines), ensemble mean (thick blue lines) and Oklahoma mesonet observation (red line). The portion of the domain shown here is 201 x 435 km wide.

FORECAST LOCATIONS OF SIGNIFICANT TORNADO PARAMETER



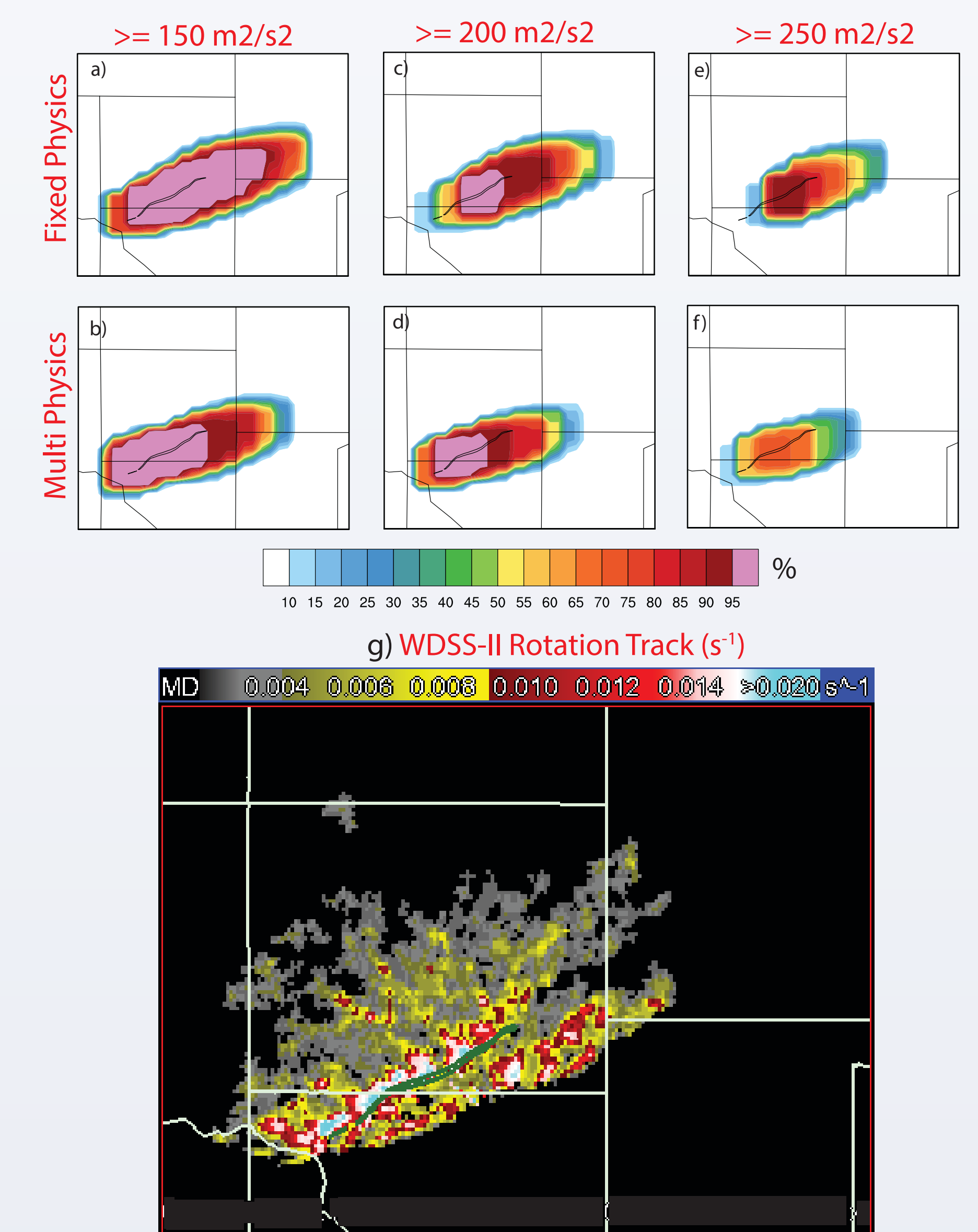
(LEFT) Ensemble-mean forecasts of STP parameter (colorfill, 5 increment) from FixedPhysics and MultiPhysics convective-scale experiments. (RIGHT) Neighborhood ensemble probability forecasts of 0-3 km updraft helicity from FixedPhysics and MultiPhysics convective-scale ensembles exceeding thresholds of 50 m² s⁻² starting at 2200 UTC and ending at 2240 UTC over the entire convective-scale domain. Overlaid in each panel is the NWS observed tornado damage track (black outline) that starts at 2210 UTC and ends at 2238 UTC.

EQUITABLE THREAT SCORE (ETS)



Values of equitable threat score (ETS) for reflectivity thresholds of (a, b) 35 dBZ and (c, d) 45 dBZ as a function of forecast times (UTC) from the convective-scale FixedPhysics and MultiPhysics 36-member ensembles (thin lines) and ensemble mean (thick lines). The independent 3DVAR analyses of reflectivity are used as observations.

PROBABILITY OF LOW LEVEL ROTATION TRACK



Neighborhood ensemble probability forecasts of 0-3 km updraft helicity from FixedPhysics and MultiPhysics convective-scale ensembles exceeding thresholds of (a, b) 150 m² s⁻², (c, d) 200 m² s⁻² and (e, f) 250 m² s⁻² starting at 2200 UTC and ending at 2240 UTC. The bottom panel (g) is the WDSS-II generated KTLX radar observed low level (0-3 km AGL) mesocyclone track during 2200-2240 UTC (MD is missing data). Overlaid in each panel is the NWS observed tornado damage track (black outline in a-f and green outline in g) that starts at 2210 UTC and ends at 2238 UTC. The portion of the domain shown here is 120 x 90 km wide

SUMMARY

- The forecast rmse for the near surface temperature, dewpoint temperature and wind variables from the convective-scale MultiPhysics ensemble are smaller than those from the FixedPhysics ensemble, highlighting the positive impact of the MultiPhysics approach.
- More specific forecast features, such as the presence of dryline bulges, environmental sounding structures, values of ensemble mean STP and 0-3 km UH probabilities, all show that the MultiPhysics ensemble better captures the important features on this day than the FixedPhysics ensemble.
- The convective-scale Multiphysics ensemble forecasts high values of STP around the OKC area before tornadogenesis, suggesting an environment that is very favorable for tornadic supercell storms, while the FixedPhysics experiment forecasts much lower STP values in the same area.
- The 0-3 km UH values for both FixedPhysics and MultiPhysics ensembles show high probabilities that correlate well with the observed tornado and low-level rotation tracks. However, the UH track of from the MultiPhysics ensemble better captures the beginning and ending points of the observed tornado track than seen in the FixedPhysics ensemble.
- The convective-scale ensembles with greater diversity in the mesoscale environmental conditions as produced through using multiple physics schemes can provide forecasters with more accurate situational awareness and greater confidence of the tornado threats from very short-range ensemble forecasts.

Questions?

Questions? email: nusrat.yussouf@noaa.gov
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