Forecast Sensitivity of an April 2012 Southern Plains Convective Event

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Introduction

Ensemble forecast sensitivity seeks to describe the relationship between a scalar forecast—referred to as the response function—and initial or early forecast conditions. This relationship is able to highlight features of the flow that are dynamically relevant to the chosen forecast.

Forecast → ***J***
Initial conditions → ***x***

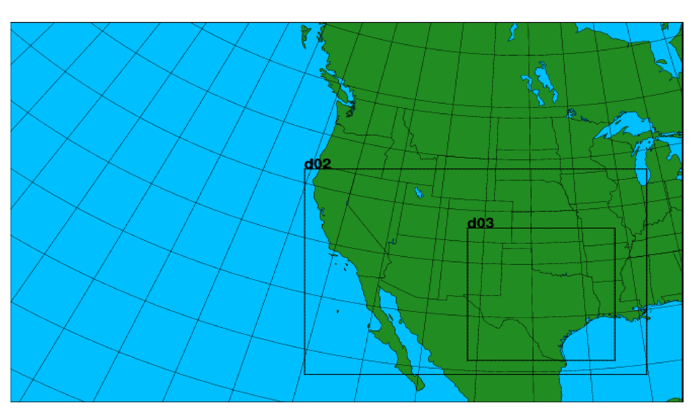
$$sensitivity = \frac{\partial J}{\partial x} = \frac{cov(J, x)}{var(x)}$$

Goals of research

- Explore ensemble sensitivity applied to convection
  - What obvious and non-obvious features are important to a convection forecast?
- Evaluate benefit of a cross-grid sensitivity
  - Will relating a high resolution forecast back to a larger and coarser domain highlight synoptic structure and more coherent features?
- Design unique and appropriate response functions for convection
  - What is the best way to represent convection?
- Integrate sensitivity into NWS forecasting process
  - Can sensitivity be used to increase forecaster awareness?

Model and Method

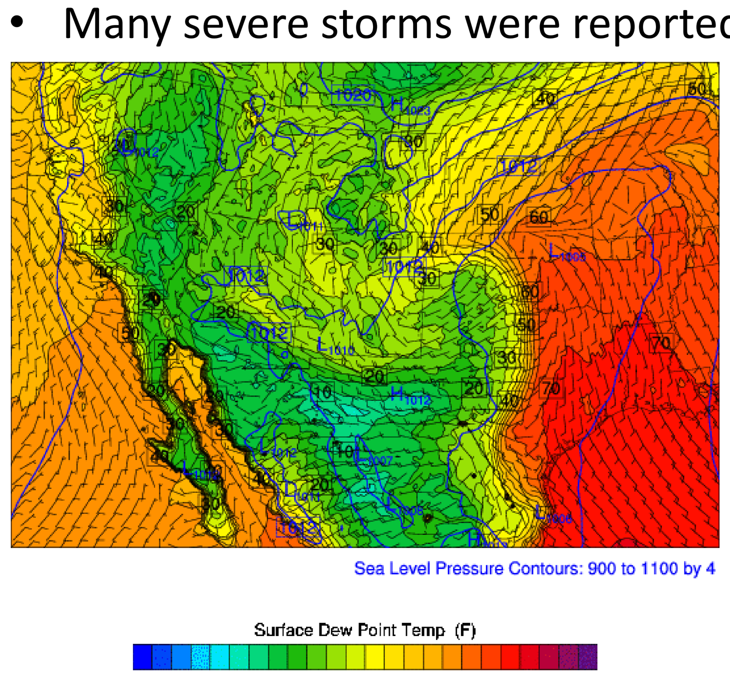
- WRF Version 3.3
- 3 domains: 36, 12, 4 km
  - No cumulus parameterization on 4km domain
- DART EAKF (Anderson et al. 2009; Anderson 2001)
- 50 members
- Configuration reflects TTU Real-time Ensemble *(http://www.atmo.ttu.edu/bancell/real_time_ENS/ttuenshome.php)*
- Ensemble cycled for 2 days to achieve flow dependent spread prior to forecast
- Observations assimilated every 6 hours
  - radiosonde, ACARS, satellite wind, METAR, maritime surface, mesonet
- Ensemble forecast initialized at 00UTC 3 April 2012 and run for 36 hours on all domains



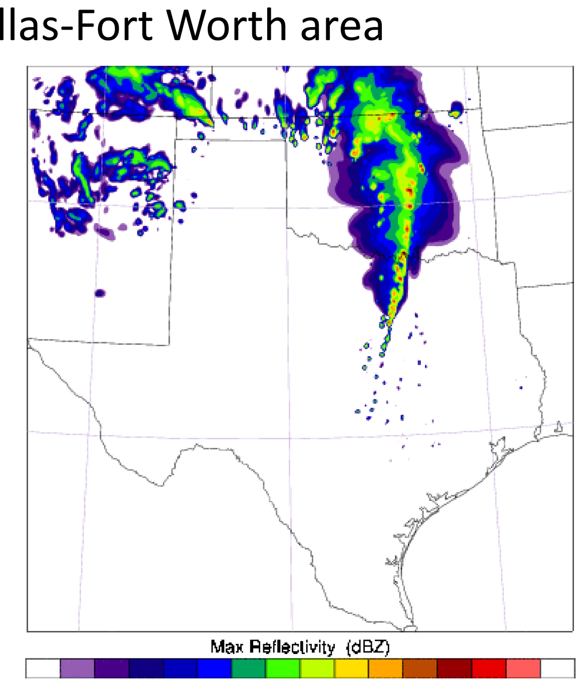
Model domains

3 April 2012 Case Overview

- Convection focused along frontal boundary in Oklahoma and Texas
- Many severe storms were reported in the Dallas-Fort Worth area

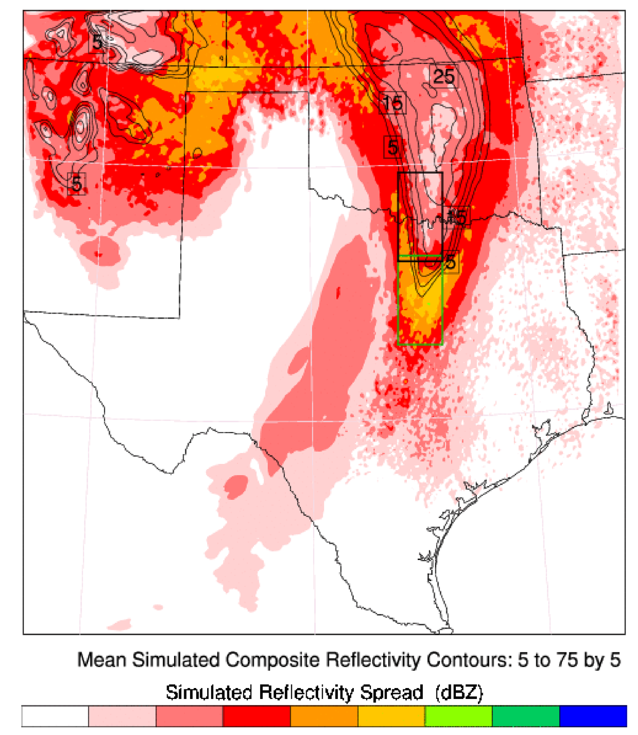


21 UTC (21 hr forecast) ensemble mean SLP and 2m Dewpoint



Simulated reflectivity from one of the ensemble members

Results



Mean and spread of simulated reflectivity at time of response function (21 UTC)

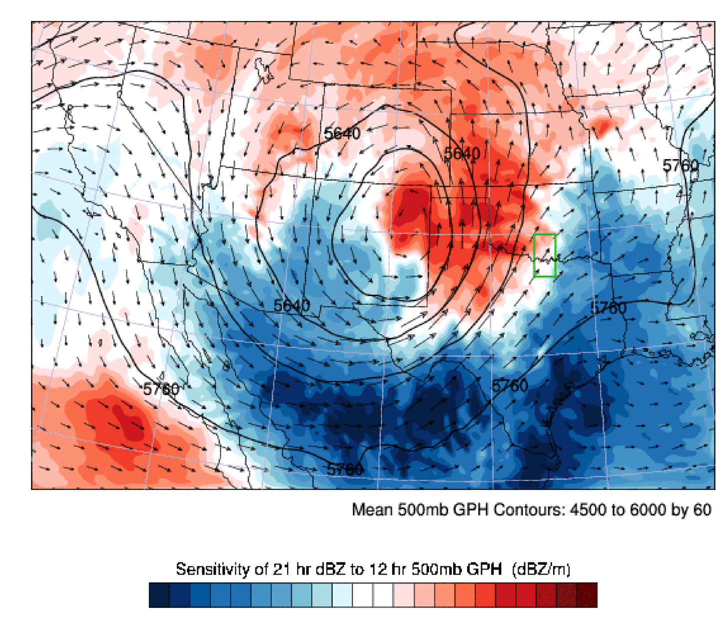
Two response function areas were chosen. The first (black) is farther north and located in an area of less spread. The second (green) is positioned in an area of greater ensemble spread. The response function is the area-averaged simulated reflectivity in the box.

Sensitivity

Both cross-grid and same-grid sensitivities of simulated reflectivity were calculated relative to an early forecast variable (forecast hour 12). Features that are important to the forecast are highlighted by regions of large sensitivity. Positive values indicate that an increase in the early forecast conditions are related to greater values of reflectivity.

Cross-grid

Sensitivity of dBZ to 500mb gph

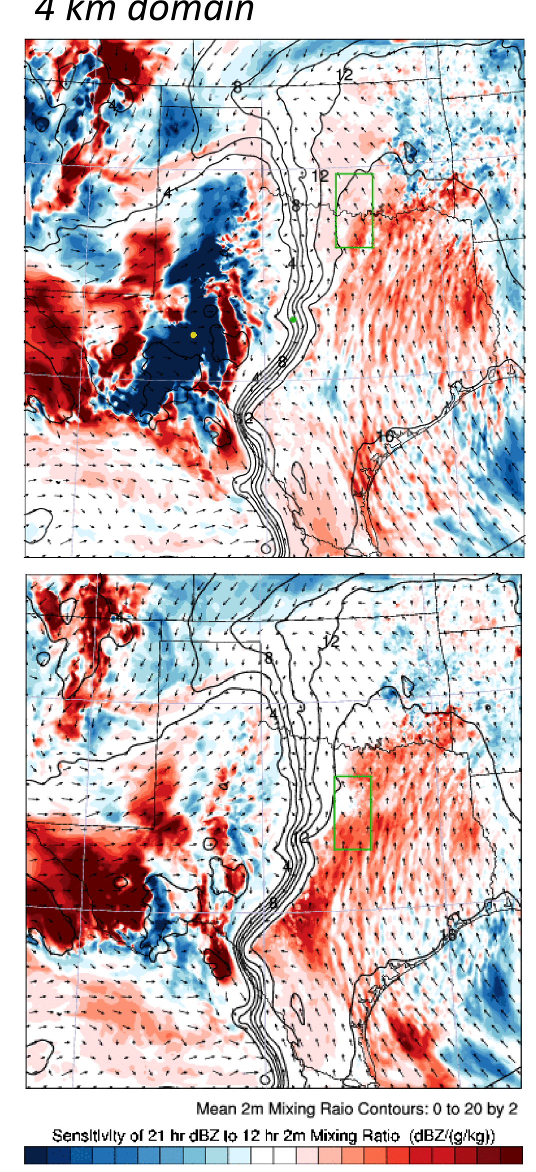


Convection is sensitive to upper-level low position.

Same-grid

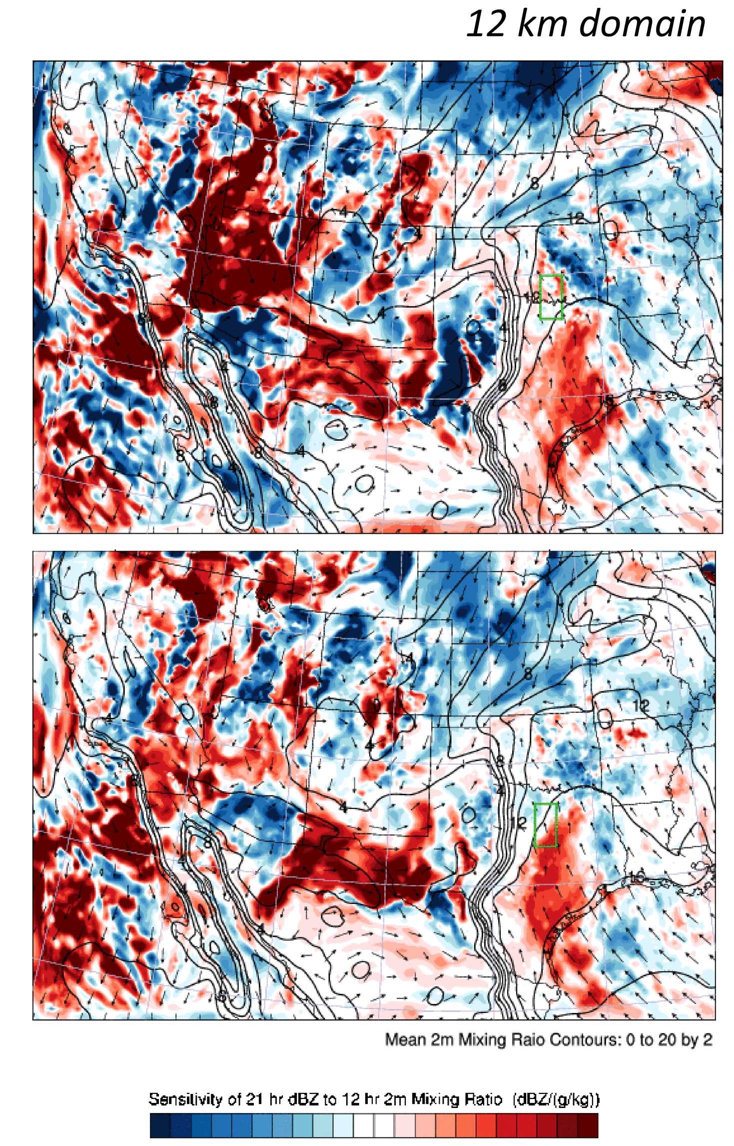
Sensitivity of dBZ to 2m Mixing Ratio

4 km domain



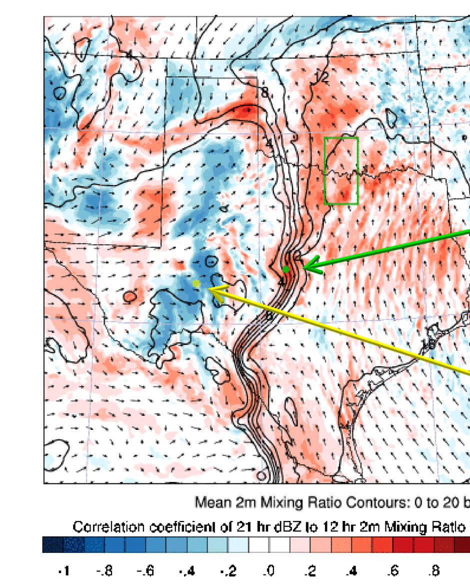
The same and cross-grid sensitivities seem to be highlighting similar features. Two clearly sensitive regions are the warm, moist Gulf air and the dry air behind the boundary.

12 km domain



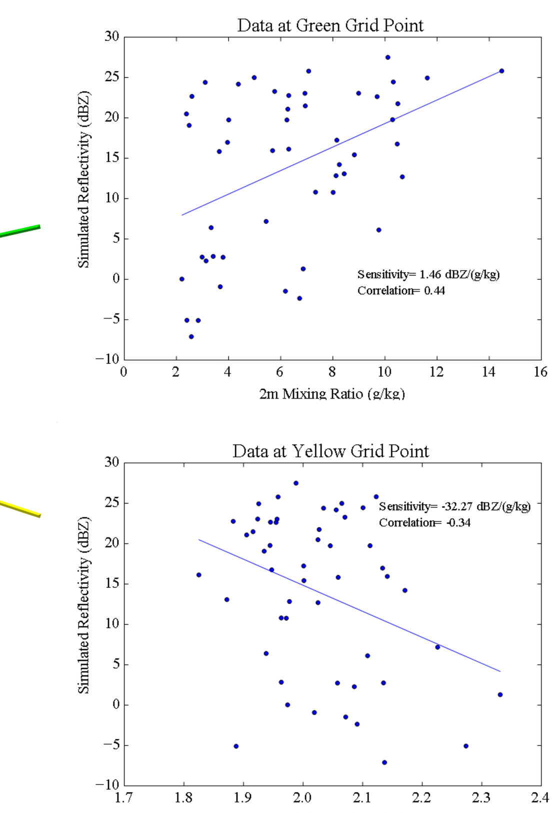
Correlation

To see the strength of the linear relationship, correlation coefficient is plotted for the top-left sensitivity plot. Two points were chosen to create scatter plots of the data: one in an area of high sensitivity and moderate correlation, and one in an area of low sensitivity but higher correlation.



Correlation coefficient

The correlation shows areas that have a stronger linear relationship with the forecast.



Scatterplots of ensemble members for two model grid points

Conclusions

- Sensitivity to moisture showed strong values in the warm, moist air, which was expected. However, the largest sensitivity values were located behind the boundary in the dry air, suggesting that this area has a greater importance to the forecast.
  - The area of large negative sensitivity behind the boundary for the northern response function could be highlighting the importance of downward mixing of air. The positive-negative dipole can be traced from western New Mexico if sensitivity is animated in time.
  - There are significant differences in the dry air sensitivity region between the two response function locations even though their centers differ by less than 200 km.
  - These could be described as second-order contributors; they do not have a role in the actual convection but may have an indirect influence
- Low sensitivity yet high correlation values were found along the boundary
  - Is its position 9 hours prior not as important as other features?

Future Work

- Continue exploring different response functions
- Perform tests on sensitivity for statistical significance
- Lagrangian perspective of response function
  - Move location relative to specific features such as a front

Acknowledgments/References

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