Comparison of Two Forecasts for Tornadoes Associated with Cold Core 500-mb Lows: Surprise and Bust

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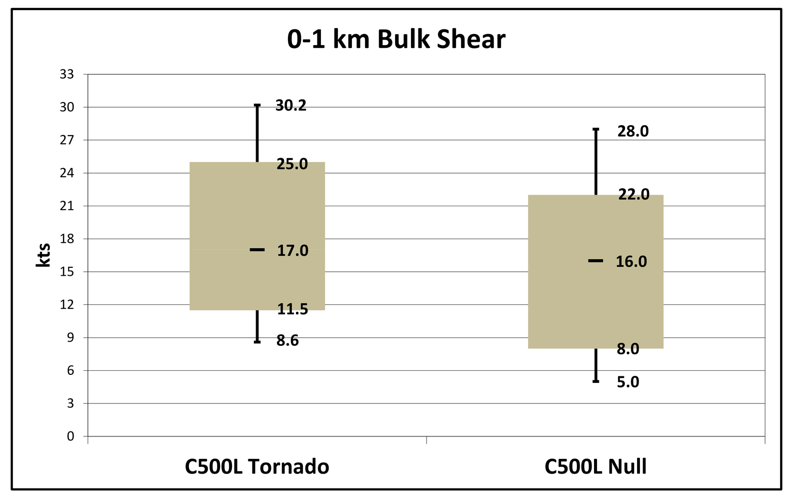
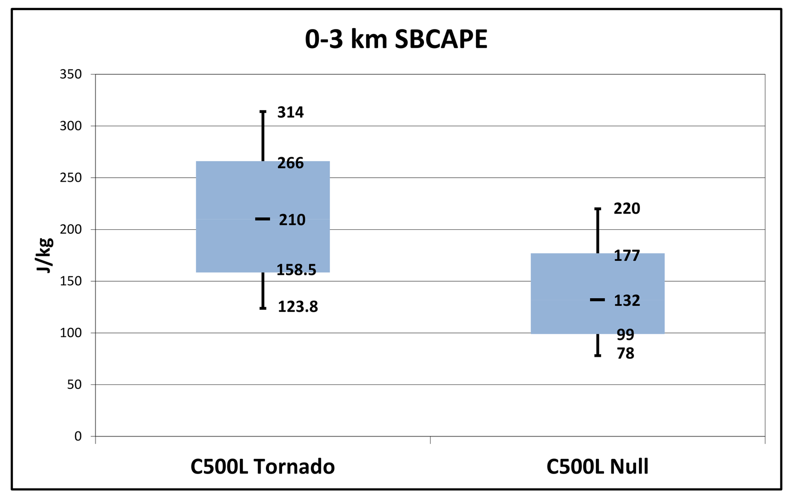
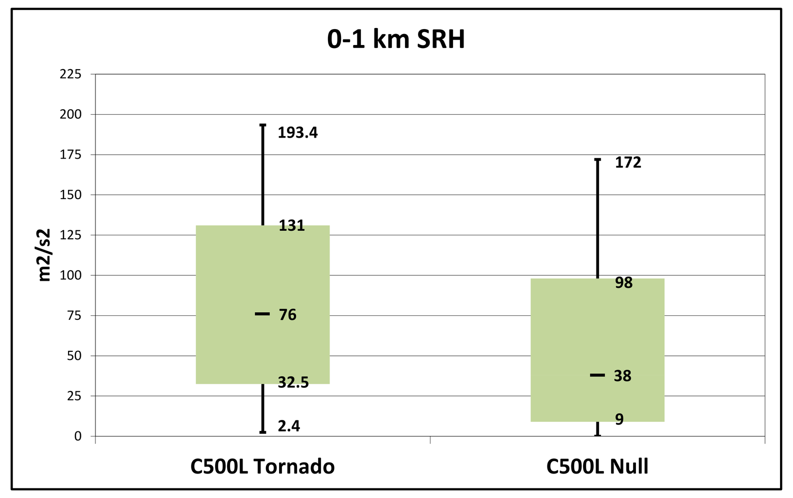
Abstract

Tornadoes associated with closed, cold core 500 mb lows can often be difficult to forecast. This is because these cold core tornadoes are typically associated with weaker magnitudes of instability and shear in comparison to other tornadic environments. Previous studies have determined the values of meteorological parameters that discriminate between cases of cold core tornadic and null events. In these cases, significant overlap exists between the 25-75 percentile ranges of several of the discriminating parameters. This indicates that each event is different, and can prove to be a challenge to both the forecaster and the models. Two cold core cases will be examined and NAM as well as SPC forecasts will be studied in an attempt to determine the extent of forecast accuracy for each case. RUC analyses will be utilized to determine if the accuracy of the NWP guidance improved as forecast lead time decreased.







- Significant overlap exists between the 25-75 percentile ranges when utilizing parameters to discriminate between cold core tornadic and null events as shown in the boxplots by Guyer & Davies (2006).

Methodology

- Two cases were chosen from a list of cold core events (courtesy Jon Davies and Jared Guyer).
- A "surprise" case which was not favorable for tornadoes, but they did occur.
- A "bust" case which was favorable for tornadoes, and none occurred.
- Several points were chosen based on radar that would be analyzed further.
- 00 Z (night before) and 12 Z (day of event) NAM model soundings were acquired and analyzed for each point chosen.
- RUC analysis soundings were also acquired to match the forecast hours of the NAM model.
- 10 parameters used to determine cold core events from typical tornadic events were calculated.

Parameters	SBCAPE	0-3 km SBCAPE	MLCAPE	ML LCL	SB LCL
	ML LFC	0-1 km Bulk Shear	0-1 km SRH	0-1 km SB EHI	0-1 km VGP

Mixed layer values were calculated using the lowest 50 mb mixed layer as suggested via Guyer & Davies (2006).

Overview

Surprise Event (4/18/2009) | **Bust Event (2/20/2012)**

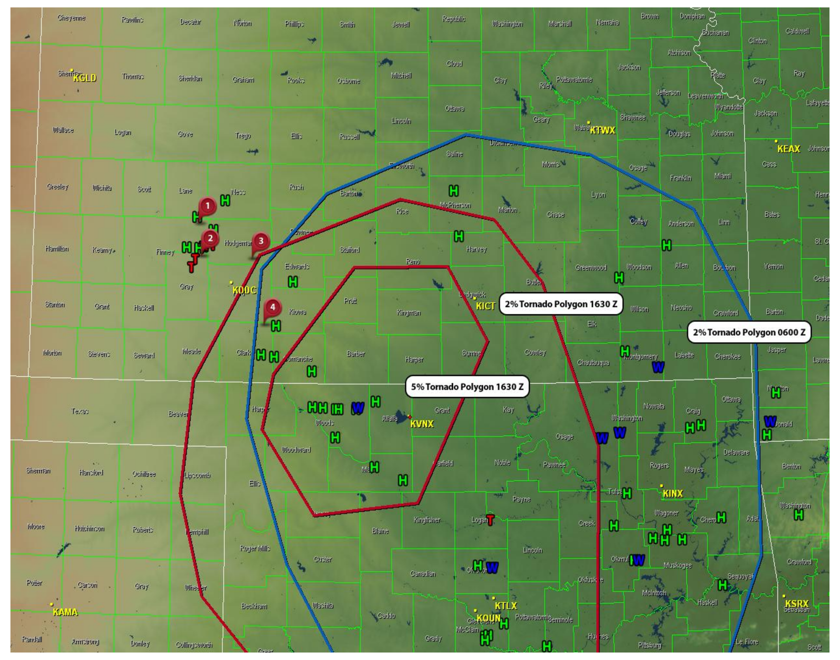


Figure A.

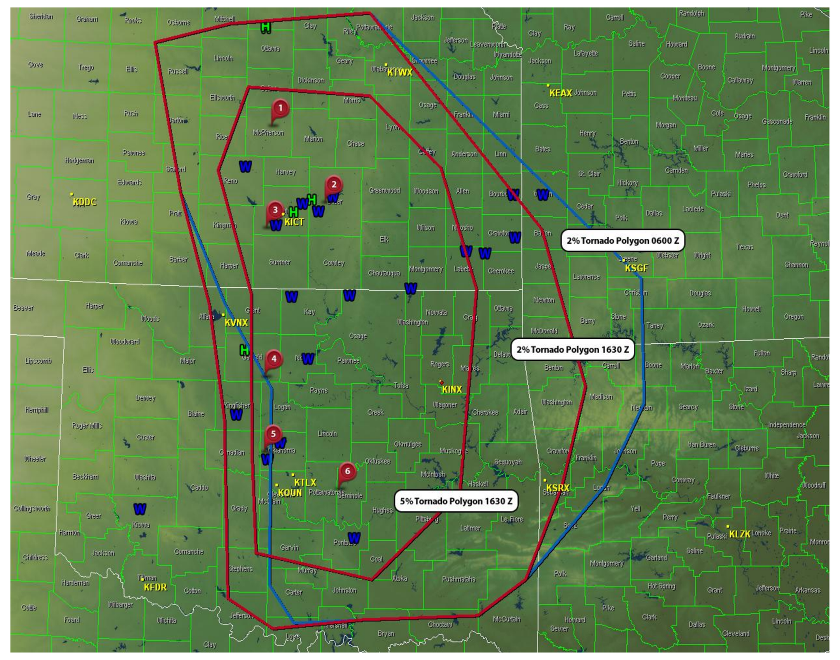


Figure B.

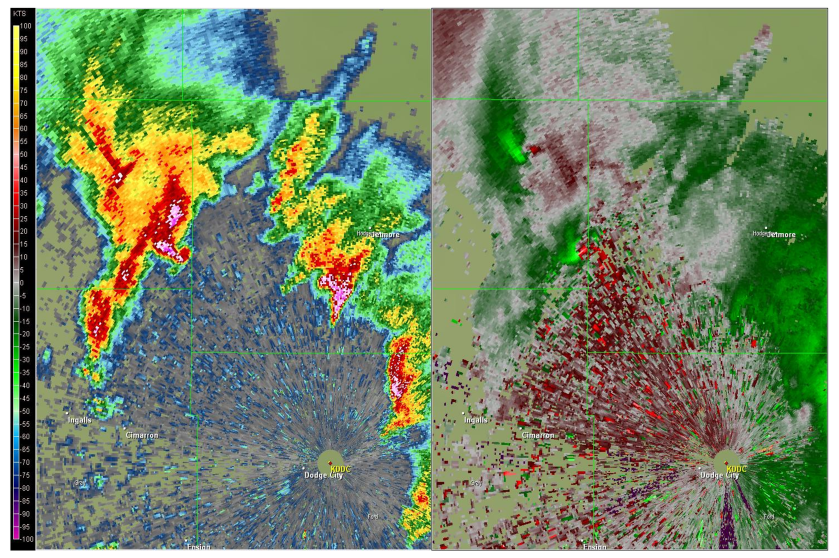


Figure C.

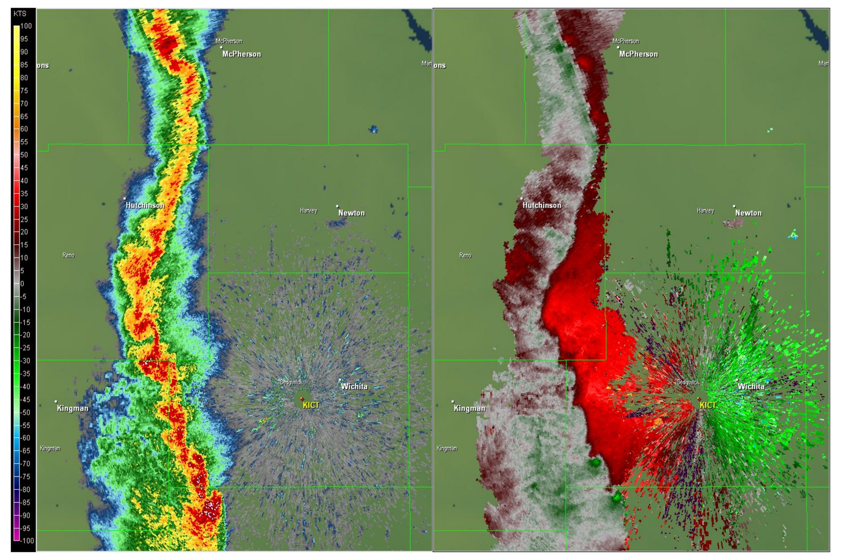


Figure D.

Figures A. and B. display the sounding locations and tornado outlooks valid at 1630 Z and 0600 Z for both events as well as SPC storm reports. Figure C. is radar from KDDC at 1916 Z in Hodgeman, Gray and Finney counties in Southwest Kansas. An EF-2 tornado was on the ground at this time near Kalvesta, KS. Figure D. displays radar from KICT at 2135 Z in Sedgewick, Kingman and Reno counties in South central Kansas. Multiple mesocyclones can be noted along the advancing line.

Procedure

- The 10 parameters were calculated from the soundings using the Rawinsonde Observation Program (RAOB).
- Values for the parameters were recorded every 3 hours for RUC analyses, 00 Z NAM, and 12 Z NAM soundings starting at 12 Z until storm initiation occurred.
- Values were averaged among all the points for each event.
- The change in percent error over successive NAM model runs were evaluated to determine if they improved or deteriorated.
- A RUC analysis time was selected that best represents the environment before storms initiated.
- The selected hour and its 10 parameters were used to determine if the successive NAM model runs were trending toward tornadic or null cold core events.

$$\textbf{Change in Percent Error} = \left(\left| \frac{\text{NAM 12 Z} - \text{RUC Analysis}}{\text{RUC Analysis}} \right| - \left| \frac{\text{NAM 00 Z} - \text{RUC Analysis}}{\text{RUC Analysis}} \right| \right)$$

Equation 1. The equation above was used to calculate the change in percent error among the NAM model with respect to the RUC analyses.

Results

- Overall statistics showed general improvement of the NAM model in both cases as forecast lead time decreased.
- Some of the parameters were more discriminatory than others for both cases based on Guyer and Davies (2006); see boxplots in left column.

4/18/2009 (Surprise)	0-3km SBCAPE (J/kg)	0-1km Bulk Shear (kts)	0-1km SRH (m2/s2)
RUC 18 Z Avg	169.25	7	-8.25
NAM 00 Z (F018) Avg	74.25	6.25	12.75
NAM 12 Z (F06) Avg	151	7.25	-14
NAM 12 Z (F06) Change in % Error	**45.3%**	**7.10%**	**184.40%**
Trend: N: No Tornado, T: Tornadic	**T**	**T**	**N**
2/20/2012 (Bust)	**0-3km SBCAPE (J/kg)**	**0-1km Bulk Shear (kts)**	**0-1km SRH (m2/s2)**
RUC 21 Z Avg	50.17	19.33	176.33
NAM 00 Z (F021) Avg	83.5	15.33	128.5
NAM 12 Z (F09) Avg	52.17	17.5	145.5
NAM 12 Z (F09) Change in % Error	**62.5%**	**11.20%**	**9.60%**
Trend: N: No Tornado, T: Tornadic	**N**	**T**	**T**

- Low level CAPE appears to play a bigger role in tornadogenesis than vertical shear in cold core environments. This is likely due in part to increased acceleration and associated stretching among parcels.

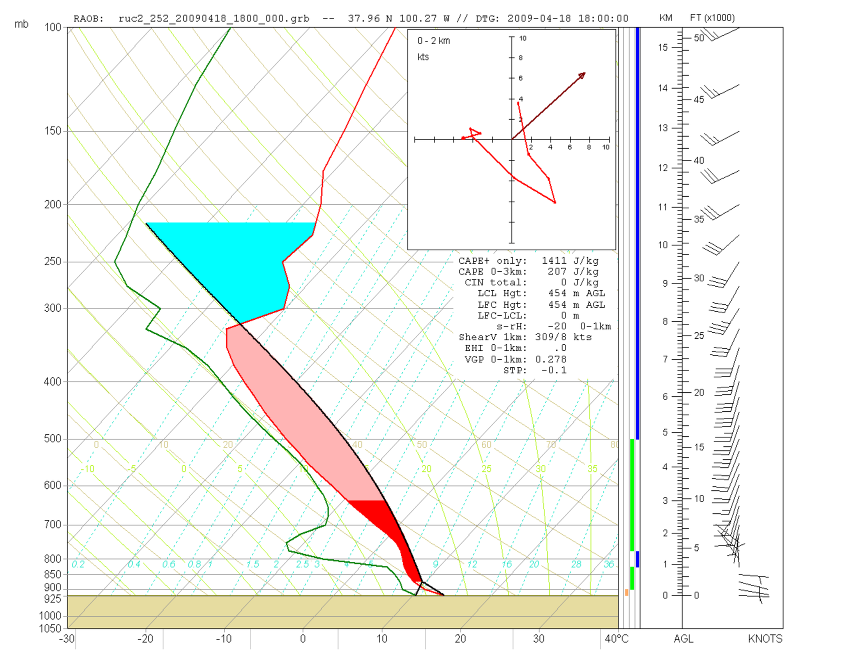


Figure 1.

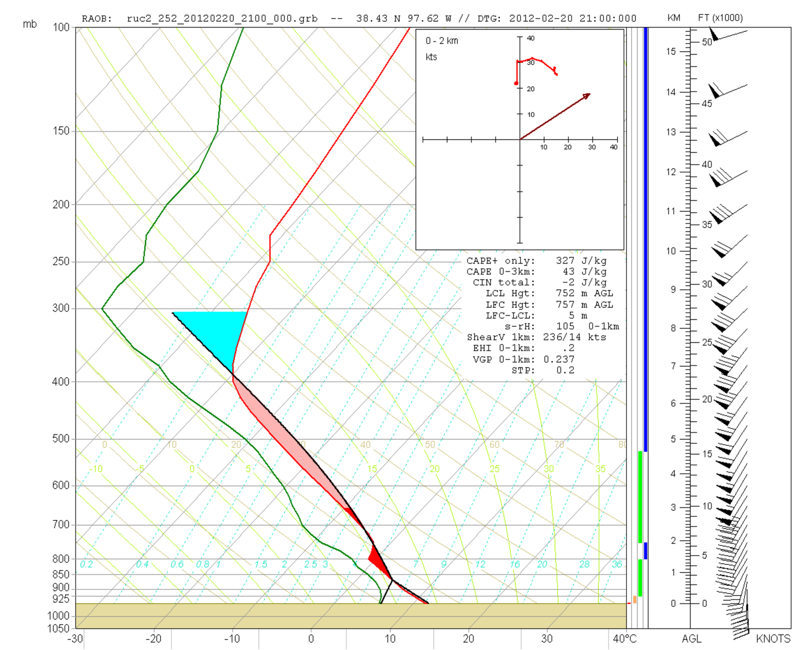


Figure 2.

Figure 1 is a RUC sounding from the tornadic case which displays 4 times as much low level CAPE (0-3 km) as Figure 2. The tornadic case also displays half the amount of 0-1 km shear than the null case.

Conclusions

- NAM 12 Z guidance improved overall with most, but not all parameters.
- One of the most discriminating parameters: 0-3 km SBCAPE , dramatically improved from 00 Z to 12 Z with respect to the RUC values and trended towards the actual outcome of each case.
- This suggests that mesoscale and even microscale processes play a dominant role in maintaining these low topped supercells responsible for tornadoes which the 12 km NAM model cannot resolve.

Future Work

- Further analysis to determine the cause of the improvement of 0-3 km SBCAPE within the NWP guidance.
- Current ensemble prediction systems such as the 16 km SREF are likely too coarse for any benefit.
- Further research would investigate cases utilizing a ≤ 4 km non-hydrostatic ensemble prediction system.

Acknowledgements

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