Model Verification and Analysis of Intense Mesoscale Convective Vortices at the Surface: Simulation of Tropical Storm Erin 2007

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Image compliments of TCS.net. http://tcs.net/photography/photo.php?photoid=000361

Introduction

Although progress has been made in forecasting Mesoscale Convective Vortices (MCVs) as a whole (e.g. Trier et al. 2000), there is still little documentation of the evolution of the environments associated with more intense, surface-based MCVs. Better understanding these environments can improve forecast skill and warning systems for these relatively rare phenomena.

This research studies the ability of the numerical model, Advanced Research WRF(ARW), to accurately forecast the development, intensification, and evolution of this intense MCV.

TC Erin 2007 over Oklahoma

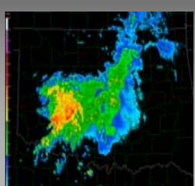

Figure 2: Base reflectivity (0.5° tilt; units: dBz) radar image from Oklahoma City, OK Valid at 0403UTC August 2007

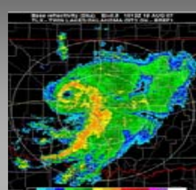

Figure 3: Base reflectivity (0.5° tilt; units: dBz) radar image from Oklahoma City, OK valid at 1013 UTC 19 August 2007.

- Peak winds 25.8 m s^{-1}
- Minimum pressure of 1001.3 hPa
- Eye fluctuated in diameter between 5 to 25 km
- Re-intensified over 500 km inland
- Stronger inland than over water

(*Arndt et al. (2009) and Brennan et al. (2009).*)

Future Work

- Simulate four more intense MCV cases: IOP8, 1-2 May 2008 MCV, 8 May 2009 Derecho, and 21 July 2003 MCV
- Compare what is known about weaker MCVs to their intense counterparts by developing and using composites

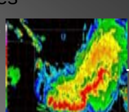

Figure 4. Example of weak MCV

Courtesy of http://www.caps.ou.edu/~nengerer/research/mcs.html

Figure 5. Example of Intense MCV: Tropical storm Erin 2007

Courtesy of http://www.thedailygreen.com/environmental news/blogs/hurricanesstorms/oklahoma-cyclone55041201

Data/Analysis

Vortex Structure

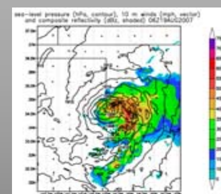

Figure 6. Simulated Vortex Structure, sea-level pressure (hPa, contour), 10 m winds (mph, vector) and composite reflectivity (dBz, shaded) 0600 UTC 19 August 2007.

Figure 7. Observed vortex structure at 0600 19 Aug 2007 images obtained from Arndt et al. (2009)

Figure 8. Base reflectivity Radar imagery from Oklahoma City, OK 0600 UTC 19 August 2007

Thermodynamic Environment

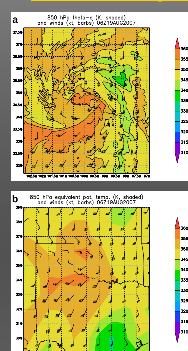

Figure 9. (a) Simulated Equivalent Potential temperature, 850 hPa theta-e (k, shaded), winds (kt; barbs) at 0600 UTC19 Aug 2007. (b) as in (a), except for GFS analysis

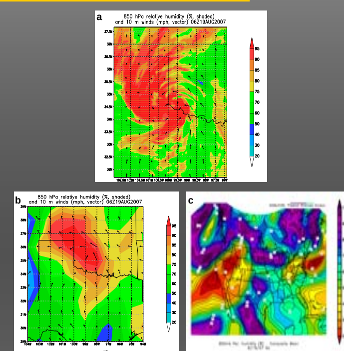

Figure 10. (a) Simulated relative humidity (%; contoured), and 10 m winds (mph; vector) at 0600 UTC 19 August 2007. (b): as in (a), except from the GFS analysis. (c): as in (a), except only 700 hPa heights and from the NCEP/NCAR reanalysis

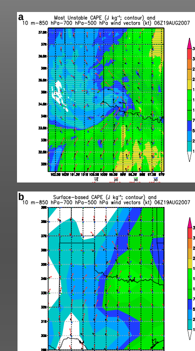

Figure 11. (a) Surface-based CAPE (J kg-1; Contour) and 10 m 850 hPa, 700 hPa, 500 hPa wind vectors (kt) at 0600 UTC 19 Aug 2007. (b) as in (a), except from the GFS analysis.

Dynamic Environment

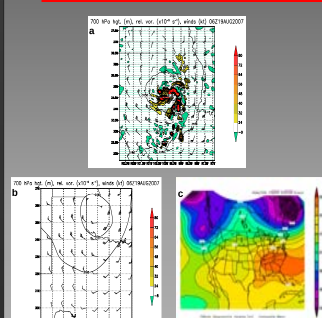

Figure 12: (a) Simulated 700 hPa heights (m; contoured), relative vorticity (x10^5 s^-1; shaded), and winds (kt; barbs) at 0600 UTC 19 August 2007. (b): as in (a), except from the GFS analysis. (c): as in (a), except only 700 hPa heights and from the NCEP/NCAR reanalysis.

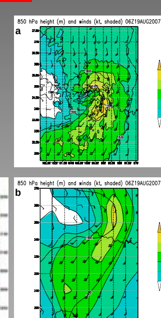

Figure 13. (a) Simulated Low Level jets (850hPa isotachs (m)) and winds (kt, shaded) 0600 UTC 19 Aug 2007 (b) GFS analysis Low Level Jets (850 hPa isotachs (m)), and winds (kt, shaded) 06 UTC 19 Aug 2007

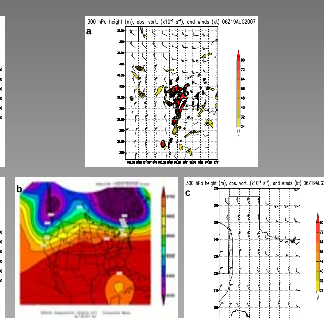

Figure 14. (a) Simulated 300 hPa heights (m; contoured), relative vorticity (x10^5 s^-1; shaded), and winds (kt; barbs) at 0600 UTC 19 August 2007. (b): as in (a), except from the GFS analysis. (c): as in (a), except only 300 hPa heights and from the NCEP/NCAR reanalysis.

Methodology

Simulations are conducted using the Weather Research and Forecasting (WRF) Advanced Research WRF (ARW) v3.2 numerical model (Skamarock et al. 2008). The model domain used in this study covers much of the United States and is depicted in Figure 1 below.

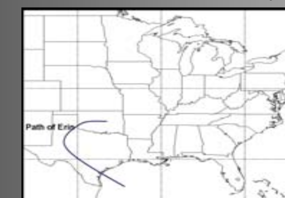

Figure 1. Model Domain and storm track of TC Erin

Model configuration is similar to that used for tropical and severe weather forecasting (e.g. Davis et al. 2008; Weisman et al. 2008):

- 3 km horizontal Grid spacing
- 35 Vertical levels
- Initialization Time: 00 UTC 18 Aug 2007
- Initialization Data 1 degree 6 hourly GFS Operational Analysis
- Forecast Length: 48 Hr; Hourly output

Verification is performed by comparing model output to the observed track and intensity of Erin (e.g. Knabb 2008), observed base reflectivity radar imagery and two model-based products, the GFS (2003) and NCEP/NCAR Reanalysis (Kalnay et al. 1996).

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Acknowledgments

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