6C.4

LOW-LEVEL STRUCTURES OF ENVIRONMENTS BEARING MESOCYCLONES WITH TORNADOES SPAWNED BY TROPICAL CYCLONE (TC) EARL (1998) IN FLORIDA AS REVEALED BY MM5 INTEGRATIONS

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1 INTRODUCTION

This study focuses on an outer rainband of TC Earl that affected west-central Florida on 2 September 1998, before Earl made landfall. See Fig. 1 for the complete track of Earl. In total, two outer rainbands associated with TC Earl were responsible for eight tornadoes in Florida, and six more in South Carolina before Earl was classified as extra-tropical at 0000 UTC 4 Sept 1998. Three mesocyclones that developed tornadoes 100 km north of Tampa, FL, where WSR-88D data was available, will be included in this study.

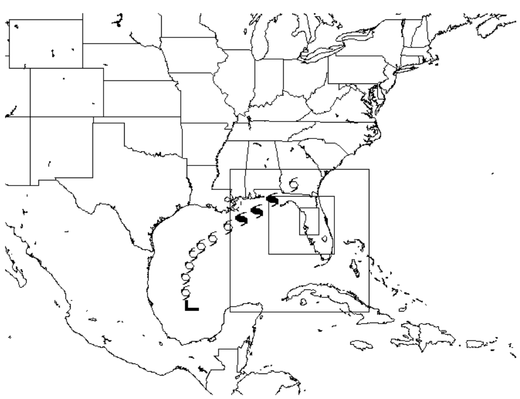

Figure 1: Smoothed track of TC Earl beginning at 1200 UTC on 31 August 1998. The entire map represents the 81-km mother domain of the MM5 simulation, while the boxes, from largest to smallest represent the 27, 9, and 3-km domains.

Recent advances in modeling capabilities and computing power have made mesoscale modeling an appealing choice as an additional research and forecasting tool. Studies conducted by Braun et al. (2000) have utilized the Pennsylvania State University- National Center for Atmospheric Research (sponsored by NSF) (PSU-NCAR) fifth-generation Mesoscale Model (MM5; Dudhia 1993; Grell et al. 1995) to help understand the kinematic and thermodynamic structures of Hurricane Bob (1991) at a fine resolution. More recently, Davis and Bosart (2001) used the MM5 to run high resolution simulations of the inner core of Hurricane Diana (1984) while at the same time running a domain large enough to study the influence of synoptic-scale flow on cyclogenesis. This study at Saint Louis University (SLU) utilizes the MM5 model to simulate the TC environments bearing mesocyclones that produce tornadoes. The goal of this research is to test the feasibility of using MM5 forecast fields, such as vorticity, CAPE, and surface temperature fields to highlight areas where mesocyclones with rotation are more likely to occur, so that forecasters may have another tool at their disposal in making quality forecasts and reducing the number of false tornado watches and warnings.

2 DATA/METHODOLOGY

The nonhydrostatic MM5, version 3.4, was used to conduct a 24-h simulation of TC Earl. Four two-way interactive nested grids (with spacings of 81, 27, 9, and 3 km) were employed to simulate the environment that developed the mesocyclones in the outer rainband, given an initial map time 6-h prior to the mesocyclone initiation. The initial data was the NCEP Global "FNL" Analysis for 1200 UTC 2 September 1998. The fine domain covers an area 150 km to the north of Tampa, where radar data showed that mesocyclones had occurred. Because the 3 km domain is computationally expensive, it is run only from hours 6 to 12 of the simulation, when most of the tornadic activity had occurred. Physics options in the forecast model include the Betts-Miller cumulus parameterization, a Mixed-Phase (Reisner) microphysics, the Eta (Mellor-Yamada) boundary layer parameterization, and a simple-cloud radiation scheme. However, the fine-mesh domain was explicitly resolved as opposed to using a convective parameterization scheme.

Model results are verified with information from Storm Data (1998), WSR-88D data from Tampa (KTBW), and conventional observations, such as upper air soundings, surface analyses, and others. The radar imagery for TC Earl was obtained from Scheck (2001). The WSR-88D Algorithm Testing and Display System (WATADS) software and level II data were used in computing and visualizing the radar results.

MM5 results were visualized using the Grids Analysis and Display System (GrADS) software, version 1.8, provided for free by the Center for Ocean-Land-Atmosphere Studies (COLA).

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3 RESULTS

Preliminary model results of streamlines show an area of confluence at 925 hPa north of Tampa on the 27-km domain, as illustrated in Figure 2. The location and orientation of this area agree with the initial location and subsequent propagation of the observed mesocyclones from Doppler radar. It is believed that low-level convergence ahead of an outer rainband helped to produce the mesocyclones to the north of Tampa. This confluence was evident between 1800 and 2000 UTC, agreeing with the time of occurence of the mesocyclones.

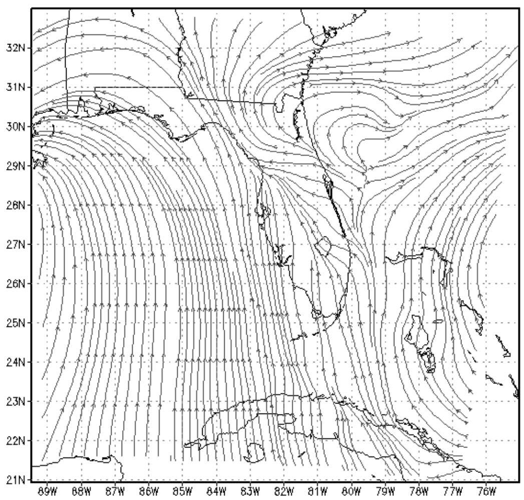

Figure 2: 925 hPa streamlines from 27 km domain run at 1900 UTC on 2 Sept 1998. A confluence zone is well-defined at this time in the area north of Tampa.

Streamlines at 925 hPa in the 3-km domain also exhibited the confluence and additionally a cyclonic circulation at 2000 UTC 2 Sept 1998. The cyclonic circulation persisted through three 15 min time frames. KTBW radar showed mesocyclones approximately 5 km in diameter at both 0.5 and 1.5° elevations at these times and locations. Although the short-term forecast products are available at fifteen minutes apart, it is notable that propagation of the model circulation follows that of the observed mesocyclones.

A model sounding showed that CAPE (1629 J kg^{-1}) in the TC tornado environment is comparable to that found in studies by McCaul (1991, 1993), Suzuki et al. (2001), and others. Rao et al. (2000, 2002) and Scheck (2001) found the CAPE for TC Earl at Tampa was 2091 J kg^{-1} at 0000 UTC 3 Sept 1998. The model soundings also showed mid-level dry air (which was also present in the observed data previously associated with a mid-level trough). The dry air entrainment also assisted in increasing CAPE. [1]

Finally, the normal component of vorticity showed large values (10 s^{-3}) in the vorticity of the observed mesocyclone locations, although a small northeastward displacement was noted.

[1] A Powerpoint presentation of this material is available at *http://www.eas.slu.edu/Comet/trop.html*.

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