MM5 Simulations of Precipitation and Mesocyclone Dynamics Associated with TC Gabrielle (2001) Using High Resolution Data of East Central Florida

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1. Introduction

Much has been studied in the past 50 years about the tornadoes spawned by outer rainbands of landfalling Tropical Cyclones (TCs), as they represent potential damage to the life and property of the public. Doppler radar has enabled meteorologists to understand the characteristics of mesocyclones that spawn tornadoes and is proven to be helpful in nowcasting these events (see Spratt *et al*. 1997; and Rao *et al*. 2003). Numerical modeling of these mesoscale phenomena was difficult in the past due to the non-availability of data in fine resolutions. Now, simulating these events has improved due to the development of mesonets, and other conventional and non-conventional observations that provide data over smaller horizontal extents.

2. Objectives

In the past using MM5 Gallagher (2002) simulated the mesoscale features of the mesocyclones produced by TC Earl in September 1998 in the vicinity of Tampa, Florida and in the vicinity of Charleston, South Carolina. That simulation was performed using FNL data in the coarse domain and interpolating it to finer domains. The principal objective of the current study is to utilize a nonhydrostatic version of the PSU-NCAR MM5 numerical model, initialize High Resolution analysis data from a different model in the warm start mode and make short-range predictions. Advanced Regional Prediction System (ARPS) Data Assimilation System (ADAS) (see Case 2002) was used to generate the High Resolution Data. The secondary objective is to explore the dynamics of mesocyclone formation and evolution through analysis of the vorticity, streamlines, and other relevant fields. The influence of high-resolution data in the model is compared with the cold start run.

3. Methodology

TC Gabrielle (2001) was chosen for this study because of the availability of conventional observations, mesonet, radar data, and high-resolution analysis data (4-km) over central Florida. A total of four domains, with two-way nesting, were used in this simulation. The mother domain covered most of the United States, at a 54-km resolution. Grids of 18-km, 6-km and 2-km were nested to resolve successively finer scales, the last domain covering a high-resolution data rich area over east central Florida. NCEP Final Analyses (FNL) were obtained from NCAR and used to initialize the MM5 integrations in cold start mode. FNL data is initialized into the model on 00 UTC 14 September 2001. Then the model is integrated forward on cold start mode for 24 hours until 00 UTC 15 September 2001. The finer (6-km) and finest (2-km) domains are run only for 4 hours starting from 1000 UTC 14 September in order to resolve the dynamics of the mesocyclones that produced tornadoes. Output was written every three hours for the two largest domains (54-km and 18-km), every 30 minutes for 6-km and every15 minutes for 2-km domains. Since an objective was to examine the forecast products with and without high-resolution data the dense data set was assimilated into the model in a warm start mode intermittently for the finest domain (2-km) at 1000 UTC 14 September. The model was then integrated forward as described above.

4. Simulations

Experiments are made to test the sensitivity of several modeling schemes. The sensitivity of two different cumulus parameterization schemes, Betts-Miller and Grell for Tropical Cyclones were examined in two independent runs. Also, the sensitivity of two different Planetary Boundary Layer (PBL) Schemes, ETA PBL (Mellor-Yamada), and Blackadar, were tested. These schemes were used in every domain, with the exception of the fine domain, which was simulated explicitly.

The Grell scheme for cumulus parameterization worked well for the TC dynamics. The location of TC center coincided with the observed for the run with Grell scheme. This will be discussed in the conference. Even the precipitation over the 54-km and 18-km domains was simulated well with the Grell scheme. The dynamics of mesocyclones, the location of vorticity maxima matched well with the observation during the run with the Betts-Miller scheme.

5. Conclusions

Preliminary results show the special data affects other domains within 4 hours.

The Grell scheme was found to work well for the TC location, but the Betts-Miller scheme worked best for the mesocyclone dynamics.

The runs without the high-resolution data (see Fig. 1) underestimated the rainfall, suggesting that supplemental high-resolution data can be utilized to achieve more accurate mesoscale forecast guidance.

A 24-hr simulation of accumulated rainfall (convective and non-convective) within the 18-km domain (Fig. 2) using the high-resolution data over east-central Florida (beginning 0000 UTC 14 September 2001) agreed well with the observed precipitation pattern over the region.

The location of the vorticity regions were displaced well north and west of reality in the cold start run and were also much less pronounced.

The run with the high-resolution data produced pronounced vorticity maxima over east-central Florida during the time of the tornadoes. The time and location of the vorticity maxima also correlated fairly well with the mesocyclones observed via radar.

Acknowledgements

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References

Case, J. L., J. Manobianco, T.D. Oram, T. Garner P.F. Blottman and S.M. Spratt, 2002: Local data integration over east central Florida using the ARPS data analysis system. *Wea. Forecasting*, **17**, 3-26 pp.

Gallagher, D.G., 2002: Low-level structures of environments bearing mesosyclones with tornadoes spawned by Tropical Cyclone Earl (1998) as revealed by MM5 integration. *M.S. Thesis.* Dept. of Earth and Atmos. Sci., Saint Louis University, 137 pp

NOAA, National Oceanic and Atmospheric Administration, 2001: *Storm Data*, **43,** 161 pp.

Rao, G.V., K. Santhanam, D. Gallagher, J.W. Scheck, R. Edwards, J.T. Schaefer, S.M. Spratt, and B.C. Hagemeyer, 2003: Radar characteristics and mesocyclones associate with Tropical Cyclones (TC) and simulation of the mesocyclonic characteristics using MM5. Preprints, 10th *Conference on mesoscale processes,* Portland, Oregon, Amer. CD ROM, P 2. 10.

Spratt, S.M., D.W. Sharp, P. Welsh, A. Sandrik, F. Alsheimer, and C. Paxton, 1997: A WSR-88D assessment of tropical cyclone outer rainband tornadoes. *Wea. Forecasting,* **12**, 479-501 pp.

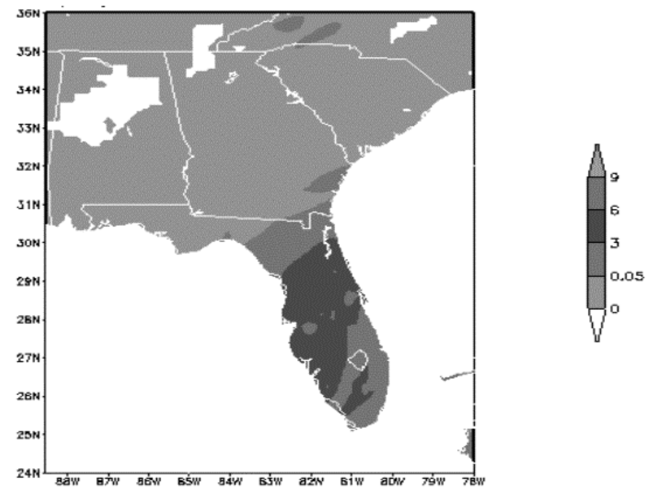

Figure 1. 24-h simulation of accumulated precipitation (convective and non-convective) in inches at 18-km grid beginning 00 UTC 14 September 2001. The initial data for this simulation is the routine FNL available from NCAR.

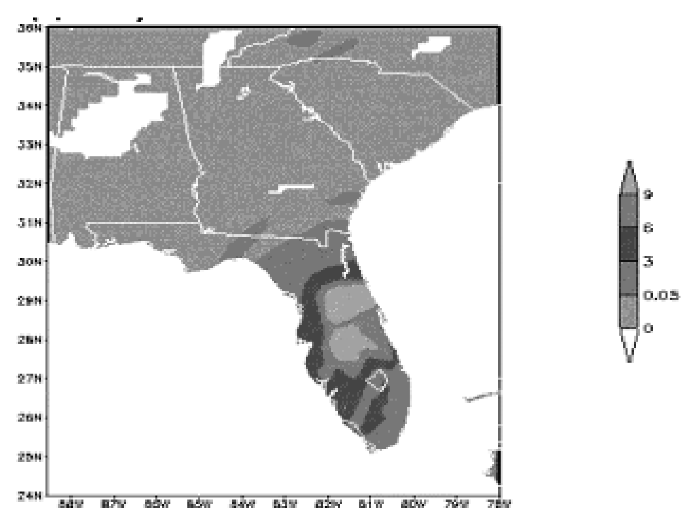

Figure 2. 24-h simulation of accumulated precipitation in inches at 18-km grid beginning 00 UTC 14 September 2001. At 1000 UTC 14 September high-resolution data, based on the ARPS Data Analysis System over central Florida was used in 2-km domain. A 4-hour influence of the special data exists on this result through the feed back from two-way nesting.

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