P1.26 SENSITIVITY OF THE STRUCTURE OF HURRICANE TO SPACIAL RESOLUTION AND THE IMPACTS ON THE QUANTITATIVE PRECIPITATION FORECASTS (QPFS)

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1. INTRODUCTION*

Despite the improvement of skill at forecasting a tropical cyclone's intensity and track, quantitative precipitation forecasts (QPFs) represent a major challenge. The complexity of the precipitation process makes these forecasts difficult. For example, surface exchanges of heat and moisture play an important role in the evolution of tropical cyclones and thus in determining the precipitation intensity and distribution (Braun and Tao 2000). As computer resource improves, high reolution simulations of tropical cyclones can now be conducted with mesoscale models. Rogers et al. (2003) studied the interactions between Hurricane Bonnie and its environmental vertical shear by using the Penn State University/National Center for Atmospheric Research mesoscale model (MM5) with the finest horizontal resolution of 1.67 km. The question of whether high-resolution simulations can improve the forecast skill has been raised (Mass et al. 2002). Recent studies have focused on the resolution dependence of model simulations. Gallus et al. (1999) found that, with various horizontal resolutions, the Eta model gave markedly different QPF trends among simulations of extreme rainfall events over continental North America.

This study examines the dependence of hurricane evolution, thermodynamic structure, intensity and distribution of precipitation to spatial resolution by conducting numerical simulations of Hurricane Erin with MM5 (Version 3.5). The goal is to explain the variability among simulations by investigating how the physical processes in the model cause the simulations to differ.

The model setup will be described in Section 2. Section 3 shows some of the preliminary results and Section 4 presents a brief summary.

2. THE MODEL DESIGN

The MM5 simulations of Erin cover a 4-day period from 0000 UTC on September 7 to 0000 UTC on September 11. During this period, Hurricane Erin evolved from a tropical depression into a category-3 hurricane at 1800 UTC September 9 with a maximum wind speed of 54 ms^{-1} and a minimum central pressure of 968 hPa (Pasch and Brown 2002) and decayed into a category-1 hurricane at 0000 UTC on September 11 (Fig. 1). The evolution and movement of a surface high-pressure system located near the eastern coast significantly influenced Erin's track. Erin moved northwesterly in this 4-day period and then changed its direction to the east and northeast at 0600 UTC on September 11.

The National Center for Environmental Prediction (NCEP) global analyses on 1^o by 1^o grids are used for the initial and boundary conditions. There are three two-way nested domains with horizontal resolution of 54 km, 18 km, and 6 km. The number of half-sigma layers in the vertical varies from 27 to 35 to 46. For simulations performed here, the physics options are the Burk Thompson planetary boundary scheme, the Betts-Miller cumulus parameterization and the Goddard microphysics scheme. The Betts-Miller cumulus parameterization is turned off for the 6 km resolution domain.

3. RESULT ANALYSES

Substantial differences of hurricane evolution and precipitation distribution are found, especially between the simulation with 27 half-sigma layers and the other simulations. With the increased vertical resolution, the model tends to produce a more intense hurricane with deeper central pressure and higher maximum wind (Fig. 1), which indicates that the model physics schemes perform differently. Few differences are found between simulations with 35 and 46 half-sigma layers.

We also find more isolated precipitation in the simulation with lower vertical resolution (not shown). This feature is not seen in the radar observations of Erin.

4. SUMMARY

Current physics parameterization schemes used in mesoscale models have not been tuned according to spatial and temporal resolution (Jung and Arakawa 2004). The sensitivity of these schemes to model resolution can have significant impacts on model results. Better understanding of these feedbacks is needed to improve model forecast skill. From a series of numerical simulations of Hurricane Erin, it is clear that significant differences exist among simulations with various vertical resolutions. More experiments will be conducted to examine the impact of horizontal resolution of model physics.

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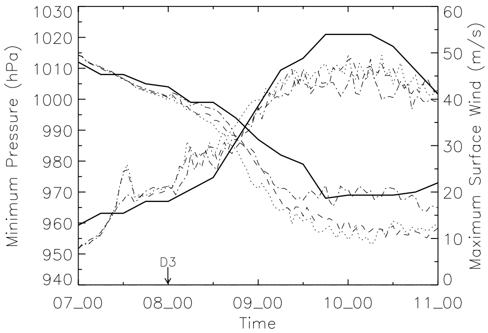

Figure 1: Temporal evolution of minimum sea-level pressure and maximum wind speed from the observation and from simulations with various vertical resolutions between 0000UTC, September 7 and 0000UTC, September 11, 2001. Solid lines represent observations. Dash-dotted lines, dashed lines, dotted lines correspond to simulations with 27, 35 and 46 half-sigma layers, respectively. D3 (Domain 3) indicates the time when 6 km horizontal resolution domain is activated.

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