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PRELIMINARY COMPARISONS OF TROPICAL CYCLONE SIMULATIONS IN THE GFDL AND WRF MODELS

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1. INTRODUCTION

The Weather Research and Forecast Model (WRF) is a next-generation, regional, nonhydrostatic model of the atmosphere presently under development by a number of agencies involved in atmospheric research and forecasting (NCAR-MMM, NCEP-EMC, FSL-FRD, AFWA, UOK-CAPS), along with a number of university scientists. Two of the major goals of this project are to develop a model which successfully bridges cloud-resolving and mesoscale dynamics, and is sufficiently flexible to be used for both operational forecasting and research.

WRF is being considered by NOAA as an eventual replacement to the GFDL Hurricane Prediction System as the operational model for hurricane forecasting. Here, we present preliminary results of comparisons of WRF forecasts with those of the GFDL model. In each case, the WRF simulation was performed with a geometry (grid spacing, vertical levels) very similar to the GFDL model; however, the WRF model physics packages chosen were only from those presently available from the model developers. In particular, we show here results using the following physical parameterizations: for microphysics, the Lin et al. (1983) scheme; for cumulus parameterization, the Kain and Fritsch (1990) scheme; and for the boundary layer, the MRF planetary boundary layer scheme (Hong and Pan, 1996). Other physical parameterizations will be considered as this research progresses. For the moment, our work addresses the question, how well does a straightforward application of the presently available WRF model forecast hurricanes?

2. AN IDEALIZED CASE

The GFDL model has been used to simulate idealized tropical cyclone development for a number of purposes, most recently to study the impact of climate change on cyclone intensity (Knutson et al., 2001). The GFDL domain is 75x75 degrees, with grid spacings of 1, 1/3, and 1/6 degree on three nested grids. The model was initialized with a weak, axisymmetric tropical storm (maximum windspeeds 19 ms^{-1}) embedded in an easterly flow of 5 ms^{-1}.

As grid nesting is not yet available with WRF, the WRF domain is 60x60 degrees with 1/6 degree resolution (approximately, as WRF uses a cartesian grid with map scale factors). The WRF vertical levels were also engineered to be similar to the 18 GFDL model levels. The WRF model is initialized with the same initial conditions and ocean temperatures as the GFDL simulation; boundary data are also derived from the GFDL simulation as time evolves.

Figure 1 shows the basic results. The motion of the storm in both cases was quite similar, with the WRF storm moving slightly farther north and slightly faster to the west. The GFDL storm intensified very rapidly and began to stabilize after 36 hours; the WRF storm developed much more slowly, but matches the GFDL intensity by 72 hours and appears to still be intensifying rapidly. While analyses of these results are still ongoing, a cursory study indicates that the WRF model develops more slowly because of the time necessary for the microphysics to develop (as the fields are initialized with water vapor only), in contrast with GFDL's cyclogenic convective adjustment scheme.

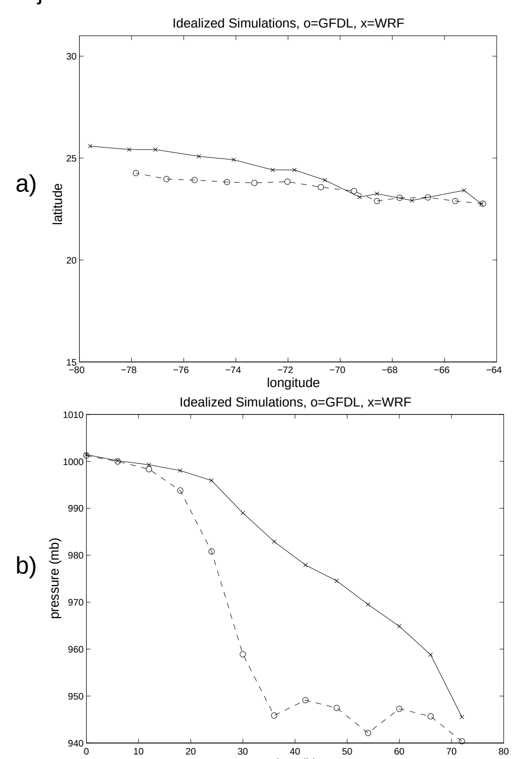

Figure 1: Storm location and minimum surface pressure in the GFDL (o) and WRF (x) idealized simulations, every six hours. Longitude values are arbitrary.

3. REAL DATA CASES

Here we present results on two tropical cyclones from the 2001 hurricane season: Humberto, which formed south-southeast of Bermuda on September 21,

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and Michelle, which formed in the Western Carribean on October 29. AVN model output in Grib format was obtained for 72 hour forecasts beginning on the relevant dates, and processed through the WRF Standard Initialization to generate initial and boundary conditions for the WRF model. The WRF grid again had approximately the same 18 levels as the GFDL model, with 15 km grid spacing on 180x180 grid points.

Figure 2 shows a 72 hour forecast of Humberto from 2001-09-22-12Z. The WRF forecast track is quite similar to that of the GFDL, both showing significant improvement over the AVN. The WRF intensity forecast also shows a noticeable improvement over GFDL.

a)

b)

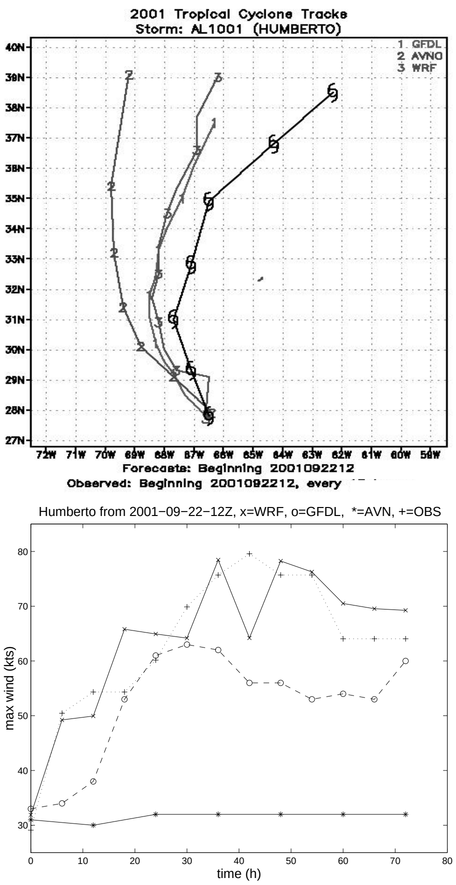

Figure 2: Track (a) and intensity (b) comparisons for Hurricane Humberto among the WRF, GFDL, and AVN models.

Results from a 72 hour forecast of Hurricane Michelle from 2001-11-03-12Z are shown in Figure 3. In this case, the forecast is very close to the observed track (and the AVN), whereas this was an unusually poor forecast for the GFDL. For storms which are already fully developed, the WRF model cannot yet hope to have good intensity forecasts for short times, as the storm must intensify from the highly smoothed AVN analysis with undeveloped microphysics.

4. CONCLUSIONS

A straightforward application of the presently available WRF code has been shown to produce reasonable forecasts with moderate skill in both track and intensity. Our development of the WRF model for hurricane forecasting and research is ongoing, and more detailed results regarding storm structure and dynamics will be presented in the near future.

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a)

b)

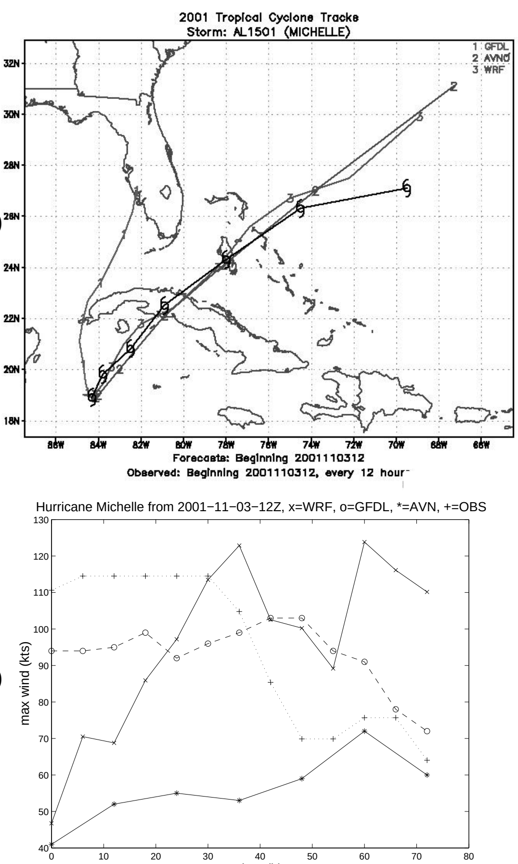

Figure 3: As in Figure 2, for Hurricane Michelle.