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AN INVESTIGATION OF THE IMPACT OF INCLUDING CAMEX-3 DATA ON HIGH RESOLUTION HURRICANE BONNIE SIMULATIONS

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1. INTRODUCTION

High resolution measurements within Hurricane Bonnie were obtained during the 1998 CAMEX-3 field campaign. The object of this study is to gauge their impact on numerical simulations carried out with a model which explicitly resolves convective clouds. Control simulations are initialized with National Centers for Environmental Prediction (NCEP) data and a prescribed vortex in gradient wind balance. One simulation is initialized on August 22 0Z to capture the development phase of Hurricane Bonnie and a second simulation is initialized on August 24 0Z when it is already a mature hurricane. Sensitivity experiments are carried out to investigate the impact of winds and moisture from dropsondes and LASE water vapor profiles on storm track and intensity prediction.

2. MODEL DESCRIPTION

A two-way interactive, nested-grid version of the Colorado State University Regional Atmospheric Modeling System (RAMS) is employed (Pielke et al. 1992). Three grids are used with horizontal grid increments of 60 km, 15 km, and 5 km with (x, y, z) dimensions of $76 \times 68 \times 26$, $66 \times 66 \times 26$, and $89 \times 89 \times 26$, respectively. A Kuo-type convective parameterization scheme is employed in the two coarser mesh domains, as well as an explicit microphysics scheme. In the fine mesh domain the grid increment is just about capable of resolving large convective clouds so only the explicit microphysics scheme is used. The scheme contains prognostic equations for cloud water, rain water, pristine ice, snow, aggregates and graupel (Walko et al. 1995). The model has an analysis package which interpolates NCEP data and any additional sounding data to the model grid points which provides the initial fields for the simulation. Since the NCEP data only poorly resolves the tropical cyclone a vortex is prescribed and the moisture content is modified.

3. PRESCRIBED VORTEX

A vortex is prescribed which is in hydrostatic and gradient wind balance. The perturbation form of the hydrostatic equation is,

$$\frac{\partial \pi'}{\partial z} = B \tag{1}$$

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where π is the non dimensional pressure given by $C_p(p/p_r)^k$ with C_p the specific heat at constant pressure, p_r a reference pressure and $k = R/C_p$, with R the gas constant. $B = g\theta'/\theta_0^2$ with θ_0 the initial state potential temperature and g the acceleration due to gravity. Primed quantities are perturbations from the initial state. The function B is specified as

$$B = B_0 \frac{a^2}{(a^2 + r^2)} \left[\sin\left(\frac{\pi z}{H}\right) - \alpha \sin\left(\frac{2\pi z}{H}\right) \right] \tag{2}$$

where r is radius, a is a specified constant and H is the height of the vortex. For this study α is taken to be 0.25 which has the effect of shifting the warm core to upper levels. Specifying B rather than θ' allows Eq. (1) to be easily integrated with respect to z to obtain an analytical expression for π'. If θ' were specified, the dependence of θ_0 on z makes the integration more complicated. An analytical expression for tangential velocity is then calculated from the gradient wind equation, which gives

$$v = \frac{-rf}{2} + \sqrt{\left(\frac{rf}{2}\right)^2 - r\theta_0 \left(\frac{\partial \pi'}{\partial r}\right)} \tag{3}$$

where f is the Coriolis parameter.

4. RESULTS

The location of the dropsonde data for both initialization times was quite asymmetrical with respect to the center of the tropical cyclone and not capable of resolving the vortex properly. Simulations initialized with this data in the absence of a prescribed vortex began with very asymmetrical winds which were much stronger in regions of good data coverage and consequently the resolved vortex was far from gradient wind balance. Therefore, for these preliminary simulations using CAMEX data it was decided to use the prescribed vortex and only use dropsondes outside of a 200 km radius of the storm center. Figure 1 shows the pressure minimum for the August 22 0Z initialization case. The pressure minimum for the control simulation which only uses NCEP data, does not decreases initially as fast as observations, but by 48 hours is only 4 mb higher than the observed value. Addition of CAMEX data outside of the 200 km radius of the storm center does not improve the prediction of minimum pressure. However, as can be seen in Fig. 2, which shows the distance of the simulated hurricanes from the observed position, it does improve track prediction considerably. Figure 3 compares minimum pressure for the August 24 0Z control simulation with observations. A CAMEX data case was not run for this case since there was very sparse dropsonde data outside of 200 km radius of the circulation center. The simulated pressure minimum compares very favorably with observations. The track error shown in Fig. 4 is fairly large, so it is unfortunate that dropsonde data does not exist to provide a more accurate steering current.

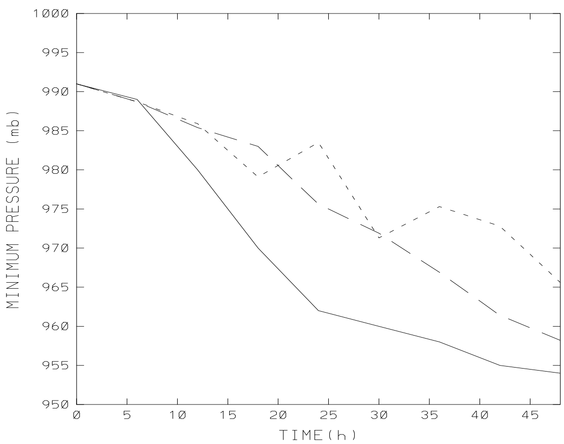

Figure 1: Pressure minimum for the August 22 initialization case. The solid line indicates the observations, large dashed line indicates the control case, and the small dashed line indicates the dropsonde case.

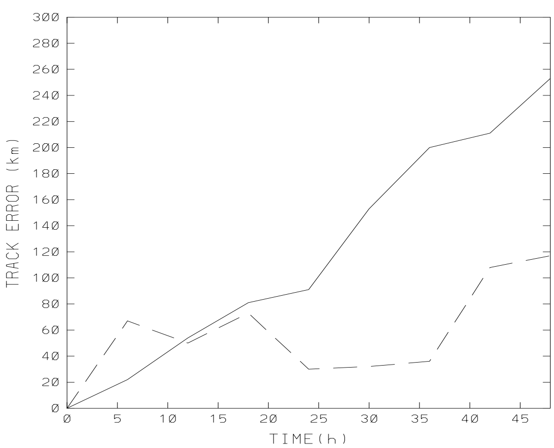

Figure 2: The track error for the August 22 initialization case. The solid line is the control simulation, and the dashed line shows the dropsonde case.

5. CONCLUSIONS

The addition of CAMEX data outside of a 200 km radius from the center improved the track forecast considerably, but the intensity error was larger than for the control case. It is possible that the intensity of simulated hurricanes is dependent on the grid resolution and so future simulations are planned with better resolution. These preliminary simulations did not utilize dropsonde data within 200 km of the storm center and as a next step it is planned to determine the best fit of the prescribed gradient wind balanced vortex to this data for both initialization times. It may also be possible to use this data to determine the radial circulation, which may hasten the development of deep convection and improve the intensity prediction for the August 22 0Z initialization case.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

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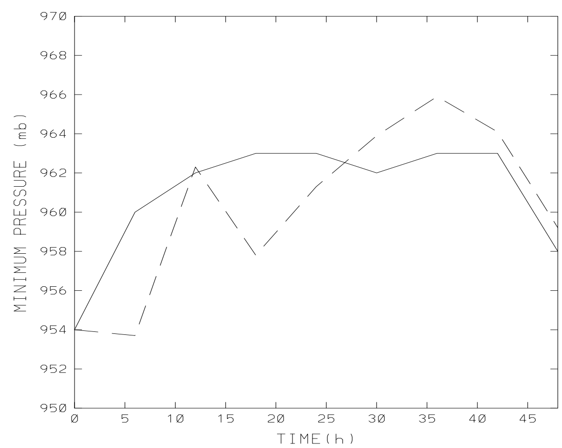

Figure 3: Pressure minimum for the August 24 initialization case. The solid line shows the observations and the dashed line shows the control simulation.

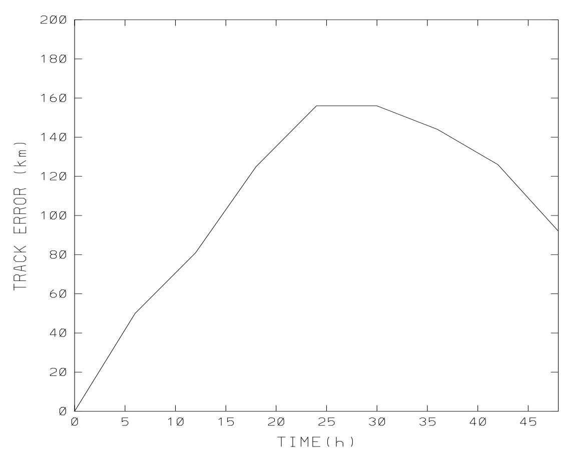

Figure 4: The track error for the August 24 initialization case. The solid line shows the control case simulation.