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# A SIMULATION OF HURRICANE DANNY (1997) AT LANDFALL USING AN ARTIFICIAL INITIAL VORTEX

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## 1. INTRODUCTION

Hurricane Danny entered Mobile Bay at 12 UTC on 19 July as a Saffir-Simpson cat. 1 hurricane (Rappaport, 1999). The storm changed from a symmetric storm before entering Mobile Bay, to a highly asymmetric system with greatly increased rainfall rates during its stay in the Bay (Blackwell, 2000). The extreme convection and rainfall rates were concentrated on the *western* side of Danny. Most landfalling storms experience enhanced convection in the right, front quadrant, which would have been the *eastern* side in Danny's case. Precipitation nearly vanished in the eastern half of the storm. The change in rainfall distribution coincided with a change in the distribution of the low-level winds with maximum winds occurring at a lower altitude in the western eyewall than in the eastern eyewall. The reasons for this unusual evolution are unclear and a modeling study is being conducted to shed more light on the issue.

## 2. MODEL CONFIGURATION

The Penn State/NCAR mesoscale model, (MM5) is initialized using GFDL analysis fields. The simulation begins on 18 July at 12Z, when Danny is located over water to the south east of New Orleans, and ends on 20 July at 00 Z when the storm starts decaying over the Florida Panhandle. A more accurate SST field was obtained from the U.S. Navy Fleet Numerical Meteorology and Oceanographic Center. The two-way nested MM5 simulation makes use of two nested domains with horizontal resolutions of 9 and 3 km respectively. Convection is modeled explicitly on both meshes. Micro-physics is modeled using the Reisner graupel scheme and includes snow, super-cooled water, graupel and ice number prediction equations.

## 3. ARTIFICIAL VORTEX CONSTRUCTION

The GFDL analysis includes a bogus vortex to represent Hurricane Danny, which is located about 10 km to the north of the observed center of Danny at 12 UTC on 18 July 1997. This misplacement is most likely a result of interpolating the coarser GFDL fields (approximately 18 km) to the finer resolution MM5 model fields used here. The GFDL vortex is also much larger than the observed Danny. This may be ebcause the coarse resolution of the operational GFDL model cannot resolve an initial vortex with a small (45 km) RMW. In research mode, a much finer resolution can be used, and hence the structure and initial location of the initial vortex can be defined more accurately. For these reasons the GFDL vortex is removed and replaced with a new bogus vortex. Ideally, the vertical and horizontal dimensions of the initial bogus vortex should equal those of the real Hurricane Danny. Unfortunately data giving a detailed enough three dimensional picture of Danny are not available.

An new artificial vortex is constructed using the same technique as described in (Kimball and Evans, 2002), except for the boundary temperature and moisture soundings, and sea level pressure which are taken at 12 UTC 19 July 1997 over the Gulf of Mexico about 500 km east of Hurricane Danny. Also a spherical Earth is used instead of an f-plane. Several vortices, with similar central surface pressure and RMW to the observed Danny, were chosen.

This method is chosen instead of nudging the vortex to the observed wind fields, since no detailed, observed wind fields are available. A vortex constructed in the above manner will have a consistent internal structure (moisture, wind, temperature fields, etc. will be in balance with one another), it will resemble the corresponding real storm, and it will be compatible with the numerical model physics, computational schemes, and grid resolution (Kurihara et al., 1993).

Before inserting the new, Danny-like vortex into the model initial fields, the GFDL bogus vortex will have to be removed. Since this vortex is symmetric, except for the small effect of the β gyres (Kurihara et al., 1993), this will be done by removing the azimuthally averaged meteorological variables in a circular region twice the radius of gale (17 $ms^{-1}$) force winds, following Davidson and Weber (2000). The center of the vortex often differs for each vertical level and meteorological variable, and hence will be determined separately for each case (Davidson and Weber, 2000).

## 4. RESULTS

The storm track and intensity are found to be highly sensitive to the initial structure of the initial bogus vortex. The results of the best simulation to date are discussed. At the conference the results from future simulations will be presented.

Figure 1 shows the tracks (starting at 00 UTC on 19 July and ending at 00 UTC on 20 July 1997) of the simulated and observed cases. As the model storm approaches Mobile Bay, its position is about 20 km removed from the observed storm. Just before entering the bay, at 12 UTC on 19 July, the storm comes within 9.5 km of the observed position. After this, the observed storm recurves to the east, while the model storm

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recurves to the west to make landfall on the opposite side of Mobile Bay.

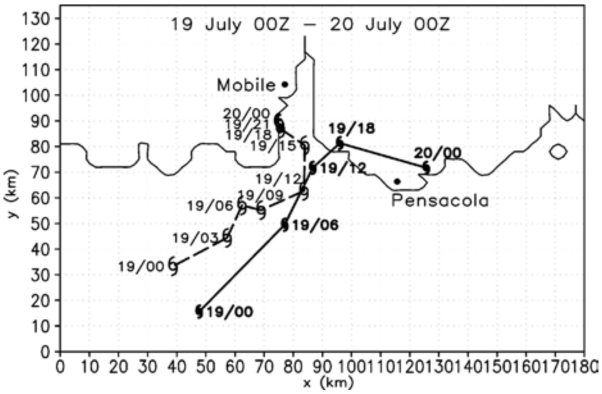


Figure 1. Actual (solid) and simulated (dashed) tracks of Hurricane Danny from 19 July 00 UTC to 20 July 00 UTC.

The central surface pressures of the modeled and real storm are compared in Figure 2. The model storm is slightly more intense than the real Danny, except after landfall has occurred (just before 18 UTC on 19 July).

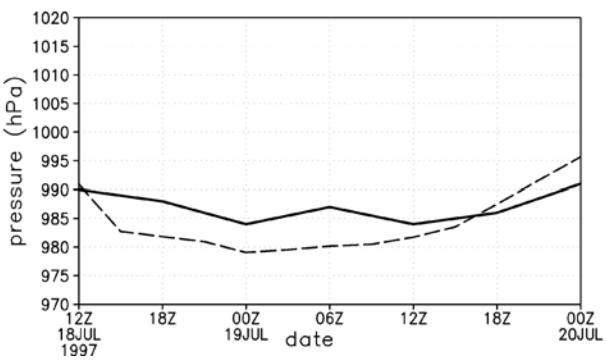


Figure 2. Actual (bold) and simulated intensity of Hurri cane Danny from 18 July 12 UTC to 20 July 00 UTC.

While out over the open water the modeled Danny is an axisymmetric storm, just like the real Danny. This changes, in both cases, when the storm enters the bay at 15 UTC on 19 July. As in the observed case, convection diminishes in the eastern half of the storm, but remains strong in the western half, Figure 3. Figure 4 shows the wind vectors, terrain, and divergence field of the model storm at 15 Z on 19 July. The convergence (Figure 4) and rain water fields (Figure 3) correlate well. The region of strong convergence on the western side of the bay seems to be forced by the terrain. The northerly winds on the north-western and western sides of the storm are funneled down the valley. The rotational winds to the immediate north of the eye, flowing down the eastern shore bluffs, come together with these northerlies. Hence, directional convergence occurs. Strong upward motion (not shown) occurs in the same location, forcing condensation of moist air and the formation of cloud and rainwater in the western half of the storm.

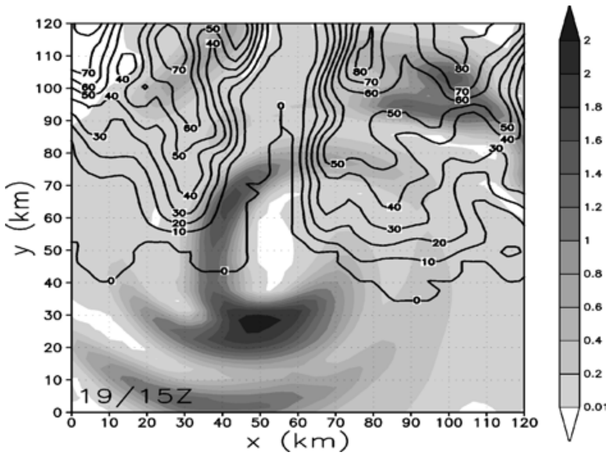


Figure 3. Rain water concentration (shaded in g $kg^{-1}$) of the modeled hurricane Danny at 15 UTC on 19 July 1997. The black solid lines are the model terrain height.

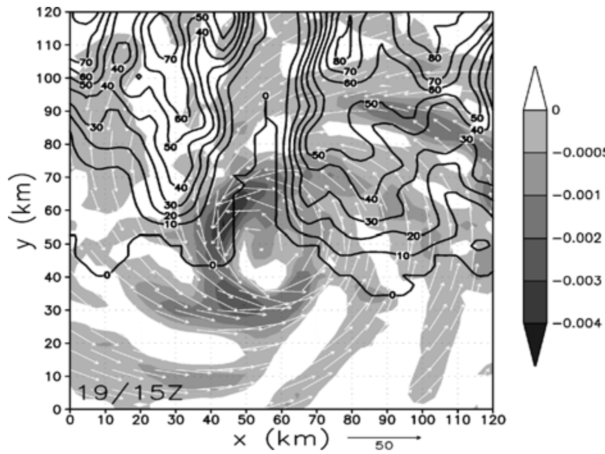


Figure 4. As Fig. 3, but for divergence (shaded, $s^{-1}$) and wind vectors (white arrows).

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