OPTIMAL HURRICANES: THREE-DIMENSIONAL MODELING

John Persing,[1] Mel Nicholls, Michael T. Montgomery,
Colorado State University, Fort Collins, CO

Based on findings from axisymmetric modeling, Persing and Montgomery (2003; PM03) proposed the term "superintensity" for hurricanes that are much more intense than the maximum possible intensity (MPI) suggested by the theory of Emanuel (1995; E-MPI). These ideas are summarized in a companion presentation (OPTIMAL HURRICANES: MOTIVATION, AXISYMMETRIC THEORY, AND OBSERVATIONS). Presented here are results that evaluate the Carnot turbocharger model for a hurricane (PM03) in a three-dimensional modeling context. We use the CSU Regional Area Modeling System (RAMS) model with a 2-km grid spacing on the finest grid. The sophisticated radiation, surface interaction, and microphysical parameterizations employed in the standard RAMS model were simplified in a sequence of simulations until a highly-simplified form was developed to be as close as possible to the simple physical parameterizations of the Rotunno and Emanuel (1987; RE87) model (used by PM03). This RAMS simulation is thus a three-dimensional "analog" of the RE87 model, except the subgrid-scale diffusion and liquid condensation physical parameterizations of the original RAMS model remain.

Shown in Fig. 1 are results from a simulation with only one degree of complexity over the RE87 "analog" simulation described above, the replacement of Newtonian cooling with RAMS longwave radiation. To evaluate superintensity, one must compare the computed E-MPI estimate of maximum winds with the solid curve in the bottom figure. E-MPI is estimated preliminarily here using the known SST and the same (approximate) outflow temperature from PM03 as well as a fixed 80% relative humidity and $C_k/C_D = 1.0$ used in the bulk aerodynamic formulation. There are indications that this simulation had not completed in-

[1] *Corresponding author address:* John Persing, Department of Atmospheric Science, Colorado State University, Fort Collins, CO 80523-1371.
Email: johneady.atmos.colostate.edu

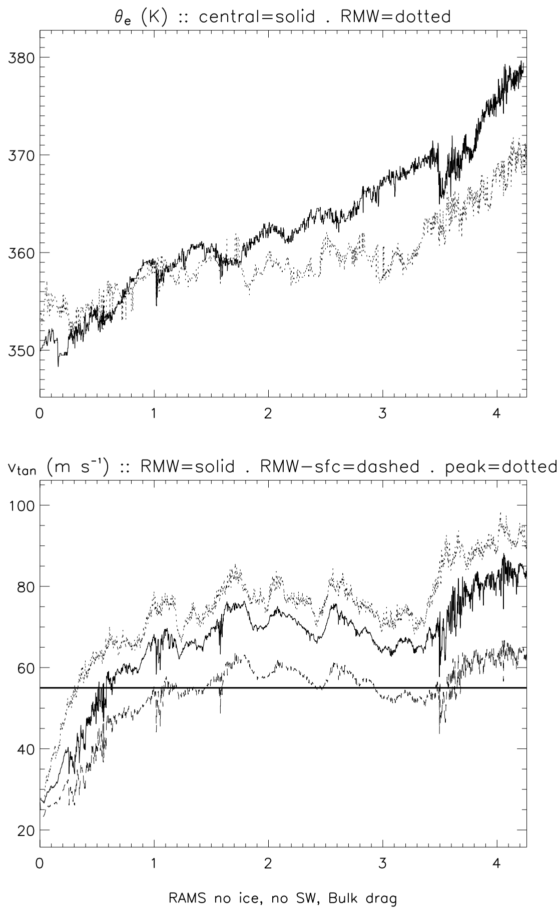

Figure 1: Plots from a 3D RAMS simulation designed to mimick the RE87 model, except for the use of RAMS longwave radiation. Top, θ_e using the Bolton (1980) formula at the first model grid level at hurricane center (solid) and at the radius of maximum mean tangential winds at the first grid level (dotted). Bottom, maximum mean tangential winds at any height (solid, generally at $z = 1$ km and at the first grid level (dashed), and peak tangential winds (dotted). Also plotted is the estimated E-MPI, $V_{E-MPI} = 55$ m s^{-1}. The abscissa is in days.

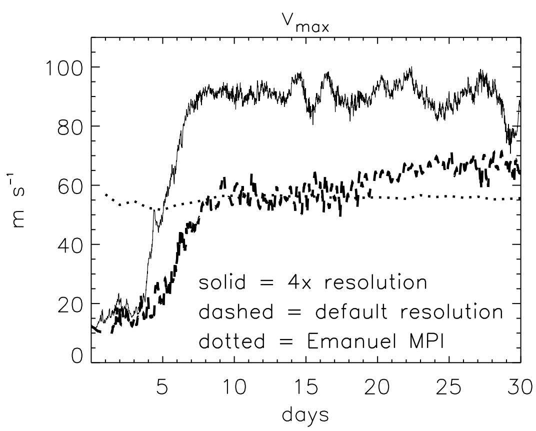

Figure 2: Maximum winds as a function of time found in the 4x simulation (solid) and default simulation (dashed) of PM03, compared to E-MPI estimate of maximum winds (dotted).

tensification. Preliminary analysis shows many of the same characteristics between these RAMS simulations and the RE87 model simulations from PM03 (see Fig. 2), most notably the enhancement in θ_e found at the center of the storm relative to the eyewall (Fig. 1, top, solid curve greater than the dotted curve). The result is not peculiar to the highly simplified physics. As layer-by-layer of the sophisticated physics of RAMS is reintroduced in separate simulations, the basic result of superintensity remains in each, although with varying intensities and structure. Thus, the Carnot turbocharger (a term more general than superintensity since such a eye/eyewall interaction may be present in intensity fluctuations in weaker hurricanes) can plausibly be applied to a context closer to reality. For an application of these ideas to observations, consider the companion presentation OBSERVED VORTEX AND THERMODYNAMIC STRUCTURE OF HURRICANE ISABEL AT MAXIMUM INTENSITY by Bell et al.

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