For Details, Contact:

Dr. David S. Nolan

Department of Atmospheric Science
Colorado State University
Fort Collins, CO 80523
Phone:
Fax:
nolan@chandra.atmos.colostate.edu

Conference on European Tornadoes and Severe Storms

High Reynolds number simulations of axisymmetric tornado-like vortices with adaptive mesh refinement

David S. Nolan, Department of Atmospheric Science, Colorado State University, Fort Collins, Colorado
Ann S. Almgren, John B. Bell, Computing Sciences, Division, Lawrence Berkeley National Laboratory, Berkeley, California

---

Axisymmetric numerical simulations continue to provide new insight into how the structure, dynamics, and maximum windspeeds of tornadoes, and other convectively-maintained vortices, are influenced by the surrounding environment. This work is continued with a new numerical model of axisymmetric, incompresible flow that incorporates adaptive mesh refinement. The model dynamically increases or decreases the resolution in regions of interest as determined by a specified refinement criterion. Here, the criterion used is based on the cell Reynolds number, so that the flow is guaranteed to be laminar on the scale of the local grid spacing.

The power of adaptive mesh refinement is used to investigate the effects of the size of the domain, the location and geometry of the convective forcing, and the effective Reynolds number (based on the choice of the eddy viscosity *n*) on the behavior of the vortex. In particular, the claim that the vortex Reynolds number Γ/ν, which the ratio of the far-field circulation to the eddy viscosity, is the most important parameter for determining vortex structure and behavior is found to be valid over a wide variety of domain and forcing geometries. Furthermore, it is found that the vertical scale of the convective forcing only affects the vortex inasmuch as this vertical scale contributes to the total strength of the convective forcing. The horizontal scale of the convective forcing, however, is found to be the fundamental length scale in the problem, in that it can determine both the circulation of the

more

fluid that is drawn into the vortex core, and also influences the depth of the swirling boundary layer. Higher mean windspeeds are sustained as the eddy viscosity is decreased; however, it is observed that that the highest windspeeds are found in the high-swirl, two-celled vortex regime rather than in the low-swirl, one-celled regime, which is opposite to what had been previously observed.

The conclusions drawn from these results are applied to dimensional simulations with

scales similar to the tornado environment and with a more realistic rotating environment. Tornado-like vortices are reproduced, using a constant eddy viscosity with such values as 20 m^2s^{-1} which have radii of maximum winds and boundary layer depths which are very similar to those recently observed with portable Doppler radar.