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A near finite-volume Eta and a Case of severe Zonda downslope Windstorm

F. Mesinger (1,3), S. C. Chou (2), J. Gomes (2), D. Jovic (3), L. Lazic (4)

(1) Earth System Science Interdisciplinary Center, Maryland, USA, (2) CPTEC/INPE, Cachoeira Paulista-SP, Brazil, (3) NCEP/Environmental Modeling Center, Maryland, USA, (4) Institute of Meteorology, University of Belgrade, Serbia (fedor.mesinger@noaa.gov)

The leading topics of the dynamical core efforts in recent years may have been schemes achieving a near-homogeneous coverage over the spherical earth by using hexagonal/pentagonal or expanded cube grids, and finite-volume schemes. A resurgence of interest in quasi-horizontal (eta, shaved cells, ...) coordinates can be seen as well. Movement in other directions has occurred too, e.g., that of the two Weather Research and Forecasting (WRF) dynamical cores.

Various these and other decisions taken of course involve side benefits or downsides; thus, it was pointed out earlier that choice of the eta or eta-like coordinate results in flux schemes in horizontal being very nearly finite-volume given that vertical sides of the grid cells are very nearly equal. A centered, not-finite volume, Arakawa-Lorenz scheme is however used in the standard Eta model for the vertical advection of momentum and temperature. A problem was recently identified with this scheme in that it enables a false vertical advection from below ground. Used for slantwise advection in a sloping steps Eta forecast this feature led to an instability-like decrease of the lowest model cell temperatures in some of the valleys of the complex western United States topography. Replacement of the scheme by a strictly conserving flux scheme eliminated the problem. This prompted a replacement of the standard Arakawa-Lorenz momentum and temperature vertical advection by the van Leer style finite-volume piecewise linear scheme of Mesinger and Jovic, resulting in a near finite-volume Eta.

Experiments continued with the case of a hurricane-strength downslope “zonda”

windstorm that occurred 11-12 July 2006 at about 31-33˚S in the lee of the Andes. This is a section of the Andes with a mean altitude of about 4500 m, including many peaks of over 6000 m, such as the Aconcagua Peak (6959 m), and a mean width of only 200-300 km. The event was very severe, with for example 2-m temperature and dew point at the San Juan synoptic station within 6 hours changing from 9 and 0, to 33 and –14˚C, respectively! Using a sloping steps 15-km Eta, we obtain downslope winds all along the very steep lee side of the main obstacle, with no flow separation. Using an 8-km Eta, activation of the sloping steps add-on code resulted in an increased foehn-effect warming in the San Juan area, of about 17˚C. A considerably greater warming was obtained by switching to the "near finite-volume" code, just about the same as that observed of about 24˚C, associated with a dew point decrease of 6˚C. Further experiments are in progress using the WRF/NMM code, with one goal being a look at the impact of the of choice of the sigma vs eta.