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An upgraded Version of the Eta Model

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Upgrades implemented over a number of years in an open source version of the Eta Model, posted at its CPTEC web site (http://etamodel.cptec.inpe.br/) are summarized and examples of benefits are shown. The version originates from the NCEP's so-called Workstation Eta that used to be maintained at NCEP, and posted on its web site, which differs from the NCEP latest operational Eta by having the WRF-NMM nonhydrostatic option included. Most of the upgrades made resulted from attention paid to less than satisfactory performance noted in one or another aspect of various Eta operational results, and identification of the reasons for the problem. Others came from simple expectation that including a feature that is physically justified but is missing in the code should help.

Within dynamics, a major upgrade is that of the introduction of "sloping steps", or of a discretized version of the shaved cells of Adcroft et al. (1997). This addresses the problem of the insufficient strength of downslope winds in two real data cases, and the Gallus and Klemp simulation of the flow in the lee of the "Witch of Agnesi" topography. Use of the piecewise-linear vertical advection of dynamic variables is another dynamics change. This makes the code approximately finite-volume, given that flux-type schemes are then used for all dynamics variables, and that sides of the cell volumes are very nearly equal due to the use of the eta coordinate. Several refinements having to do with the calculation of exchange coefficients, conservation in the vertical diffusion, and diagnostic calculation of 10-m winds have been made. Vapor and hydrometeor loading in the hydrostatic equation was included. Within physics, efforts in refining the two Eta convection schemes received most attention. The upgrades address the model's well established problem of underdoing the heavy rain thresholds when the Betts-Miller-Janjic convection scheme is used. Momentum fluxes were added to the Kain-Fritsch convection scheme. The molecular sublayer treatment was refined by making the molecular sublayer depth dependent on the roughness Reynolds number, following a suggestion of Brutsaert (1982).

Examples showing improved performance resulting from the dynamics changes include a case of the impossibly cold temperatures in several mountain basins generated by a centered vertical advection finite difference scheme's unphysical vertical advection from below ground, removed by its replacement with a finite-volume scheme; and of increased katabatic winds in the Terra Nova Bay Antarctica region. Successful hindcasts of the severe downslope zonda winds in the lee of the highest peaks of the Andes are also shown. Finally, results of recent tests of the value added by the upgraded Eta in RCM ensemble experiments achieved over its driver ECMWF 32-day global ensemble members (Veljovic et al. 2010) are recalled.