Geophysical Research Abstracts
Vol. 15, EGU2013-5973-2, 2013
EGU General Assembly 2013

Eta or eta-like vs sigma coordinate: A review of available evidence

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During the time of the operational use of the Eta model at NCEP numerous tests were made of the impact of the eta coordinate by comparing results against those obtained with the model's sigma switch turned on. These tests invariably showed an advantage of the eta, with the advantage persisting as the resolution kept being increased over the years. Yet, a NOAA-wide announcement in the summer of 2002 of the operational implementation of the NMM at NCEP, using terrain-following coordinate, stated that "This choice [of the vertical coordinate] will avoid the problems . . . with strong downslope winds and will improve placement of precipitation in mountainous terrain." In spite of the NCEP's operational Eta being "frozen" since the summer of 2003, an about a 5-month parallel in 2006 showed the latter not to have been confirmed, since the Eta kept its advantage in precipitation placement scores. Similar results, albeit at a lower resolution, came from tests with a NASA GISS eta-like model (Russell, Mon. Wea. Rev., 2007).

The Eta developments within its user community continued with the major novelty being the introduction of "sloping steps", somewhat of a simplified version of the shaved cells of Adcroft et al. (Mon. Wea. Rev., 1997). Simulation of a major downslope windstorm over the Andes using thus and in other ways upgraded Eta code is shown in (Mesinger et al., Meteor. Atmos. Phys., 2012). For tests of the impact of the discretization change in more general situations a ten year experiment was ran, driving the Eta with the ERA-Interim Reanalysis of 1990–1999, over a large South American domain, at 50-km resolution. Compared to CRU data, monthly precipitation values were improved in the majority of months, while not decreasing in accuracy in the remaining ones. The 2-m temperatures improved quite considerably in three months in which the errors of the standard Eta were the largest, to the extent that the errors were reduced by more than a half; again with little change in accuracy in the remaining months.

Another set of experiments ran recently is that of Veljovic et al. (Meteor. Z., 2010) in which the Eta driven by 26 ECMWF 32-day ensemble members achieved overall a higher accuracy in placing the strongest 250 hPa winds than its driver ensemble members, in spite of absorbing the unavoidable LBC errors. A conspicuous feature of these results we here focus upon is the improvement in the two sets of Eta scores relative to those of the ECMWF driver members at lead times of 11–12+ days, persisting for quite a while afterwards. This we have identified as due to a statistically significant number of Eta members' more accurate forecast of the tilt of a deep upper tropospheric trough as it was crossing the Rockies; a property reminiscent of the outcome of several eta-sigma experiments done earlier. Results of a study of the accuracy of the positions of major lows as forecast by the Eta relative to GFS for two earlier winter seasons are consistent with this Eta ensemble's feature. It is felt that the implementation of finite-volume or near finite-volume schemes as used in the Eta, requiring less of an effort because of the quasi-horizontal eta coordinate surfaces, could also be making a significant contribution to the Eta advantages summarized.