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Eta features, additional to the vertical coordinate, deserving attention

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An experiment reported in Mesinger and Veljovic (JMSJ 2020) and at the preceding EGU General Assembly, showed an advantage of the Eta over its driver ECMWF ensemble members in placing 250 hPa jet stream winds east of the Rockies. Verifications subsequent to 2020 confirmed this advantage. A byproduct of that experiment was that of the Eta ensemble switched to use sigma, Eta/sigma, also achieving 250 hPa wind speed scores better than their driver members, although to a lesser extent. It follows that the Eta must include feature or features additional to the eta coordinate responsible for this advantage over the ECMWF.

An experiment we have done strongly suggests that the van Leer type finite-volume vertical advection of the Eta, implemented in 2007, may be a significant contributor to this advantage. In that experiment, having replaced a centered finite-difference Lorenz-Arakawa scheme, this finite-volume scheme enabled a successful simulation of an intense downslope windstorm in the lee of the Andes.

Another likely and perhaps unique feature of the Eta contributing to that advantage is its sophisticated representation of topography, designed to arrive at the most realistic grid-cell values with no smoothing (Mesinger and Veljovic, MAAP 2017).

While apparently a widespread opinion is that it is a disadvantage of terrain intersecting coordinates that "vertical resolution in the boundary layer becomes reduced at mountain tops as model grids are typically vertically stretched at higher altitudes (Thuburn, 10.1007/978-3-642-11640-7 2011)," a comprehensive 2006 NCEP parallel test gave the opposite result. With seemingly equal PBL schemes, the Eta showed a higher surface layer accuracy over high topography than the NMM, using a hybrid terrain-following system (Mesinger, BLM 2023).

Hundreds of thousands of the Eta forecasts and experiments performed demonstrate that the relaxation lateral boundary condition, almost universally used in regional climate models (RCMs), in addition to conflicting with the properties of the basic equations used, is unnecessary. Similarly,

so-called large scale or spectral nudging, frequently applied in RCMs, based on an ill-founded belief, should only be detrimental if possible numerical issues of the limited area model used are addressed. Note that this is confirmed by the Eta vs ECMWF results we refer to above.

Even so, to have large scales of a nested model ensemble members most times more accurate than those of their driver members, surely requires not only the absence of detrimental techniques, but also the use of a lateral boundary condition (LBC) scheme that is not inducing major errors. The scheme of the Eta is at the outflow points of the boundary prescribing one less condition than at the inflow points (e.g., Mesinger and Veljovic, MAAP 2013), and has for that reason been referred to by McDonald (MWR 2003) as one of "fairly well-posed" schemes.