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Can limited area NWP and/or RCM models improve on large scales inside their domain?

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In a paper in press in Meteorology and Atmospheric Physics at the time this abstract is being written, Mesinger and Veljovic point out four requirements that need to be fulfilled by a limited area model (LAM), be it in NWP or RCM environment, to improve on large scales inside its domain. First, NWP/RCM model needs to be run on a relatively large domain. Note that domain size in quite inexpensive compared to resolution. Second, NWP/RCM model should not use more forcing at its boundaries than required by the mathematics of the problem. That means prescribing lateral boundary conditions only at its outside boundary, with one less prognostic variable prescribed at the outflow than at the inflow parts of the boundary. Next, nudging towards the large scales of the driver model must not be used, as it would obviously be nudging in the wrong direction if the nested model can improve on large scales inside its domain. And finally, the NWP/RCM model must have features that enable development of large scales improved compared to those of the driver model. This would typically include higher resolution, but obviously does not have to.

Integrations showing improvements in large scales by LAM ensemble members are summarized in the mentioned paper in press. Ensemble members referred to are run using the Eta model, and are driven by ECMWF 32-day ensemble members, initialized 0000 UTC 4 October 2012. The Eta model used is the so-called "upgraded Eta," or "sloping steps Eta," which is free of the Gallus-Klemp problem of weak flow in the lee of the bell-shaped topography, seemed to many as suggesting the eta coordinate to be ill suited for high resolution models. The "sloping steps" in fact represent a simple version of the cut cell scheme. Accuracy of forecasting the position of jet stream winds, chosen to be those of speeds greater than 45 m/s at 250 hPa, expressed by Equitable Threat (or Gilbert) skill scores adjusted to unit bias (ETSa) was taken to show the skill at large scales. Average rms wind difference at 250 hPa compared to ECMWF analyses was used as another verification measure. With 21 members run, at about the same resolution of the driver global and the nested Eta during the first 10 days of the experiment, both verification measures generally demonstrate advantage of the Eta, in particular during and after the time of a deep upper tropospheric trough crossing the Rockies at the first 2-6 days of the experiment.

Rerunning the Eta ensemble switched to use sigma (Eta/sigma) showed this advantage of the Eta to come to a considerable degree, but not entirely, from its use of the eta coordinate. Compared to cumulative scores of the ensembles run, this is demonstrated to even a greater degree by the number of "wins" of one model vs. another. Thus, at 4.5 day time when the trough just about crossed the Rockies, all 21 Eta/eta members have better ETSa scores than their ECMWF driver members. Eta/sigma has 19 members improving upon ECMWF, but loses to Eta/eta by a score of as much as 20 to 1. ECMWF members do better with rms scores, losing to Eta/eta by 18 vs. 3, but winning over Eta/sigma by 12 to 9.

Examples of wind plots behind these results are shown, and additional reasons possibly helping or not helping the results summarized are discussed.