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On the challenges of high resolution forecasting with the Global Environmental Multiscale (GEM) atmospheric model

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High resolution forecasting at the sub-kilometer scale with the Global Environmental Multiscale (GEM) atmospheric model leads to a number of challenges. The three-dimensional elliptic problem resulting from vertical discretization imposes severe restrictions on the vertical resolution and the time-step size in order to maintain vertical separability that permits the use of a direct solver. Although iterative solvers do not depend on vertical separability, readjusting the contributions of the nonhydrostatic pressure perturbation is found to circumvent the separability issue for the direct solver.

In addition to the vertical-separability problem, at sub-kilometer resolutions the model currently exhibits strong instability particularly over complex orography where the model may encounter mountains with steep slopes. Off-centered averaging in the semi-Lagrangian scheme as well as the explicit high order numerical diffusion scheme – available within the GEM model to control high wave number noise – are found to be inadequate in addressing this strong orography-induced instability. Increasing the level of off-centering for the equations attributable to the non-hydrostatic aspects of the atmospheric flow is found to improve model stability during preliminary tests. Furthermore, as the existing hyperdiffusion schemes in GEM does not conserve angular momentum a new Smagorinsky-type diffusion scheme is currently being developed that will be compatible with the conservation laws. The improved diffusion scheme coupled with the modified off-centering of the non-hydrostatic equations is expected to have a more meaningful impact on the orgography-induced instability. Pertinent results will be presented at the conference.