Review of the GMDD Manuscript: Adaptive Cartesian Meshes for Atmospheric Single-Column Models, a study using Basilisk 18-02-16

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The manuscript describes a prototype Single-Column Model (SCM) that employs dynamic grid adaptation in the vertical direction. The adaptations are guided by error estimators which increase the resolution where needed for accuracy, and remove grid points if additional accuracy is not needed. The method is tested in the atmospheric boundary layer based on the two GABLS intercomparison cases. In particular, the GABLS cases test the fine-scale diurnal variations of the planetary boundary layer (PBL). In general, the PBL structures in the two test cases are reasonably well captured in the adaptive SCM. The authors conclude that the adaptive-grid algorithm is able to dynamically coarsen and refine the numerical grid whilst maintaining an accurate solution.

Overall, the manuscript is interesting and well written, but the application area is rather narrow and it is difficult to judge the performance of the model based on two test cases. Therefore, it is difficult to draw more general conclusions concerning 3D General Circulation Models (GCMs). However, this is not the focus of this manuscript, which only addresses a prototype 1D adaptive model. The main criticism is that the description of the adaptive method is rather short which makes it difficult to understand the methodology even at a fundamental level. The main methodology is described in Van Hooft et al. (Boundary-Layer Meteorol., 2018) and the reader is referred to this paper. I recommend expanding the description of the Adaptive Mesh Refinement (AMR) algorithm somewhat in this paper, especially with respect to the error estimation technique. This will help make this a stand-alone paper. In addition, this review lists some clarifying questions that need to be addressed in a revised version.

Specific comments:

Page 2, line 23: In which way does your work depart from the work by Van Hooft et al. (2018)?
Page 3, line 17: Define the Richardson number. There are many variants, so please provide the equation.
Page 4, lines 5-10: Provide more details how the error estimator works. What makes it second-order-accurate?
Page 4, line 12 onwards: Clarifying questions concerning the refinements:

1) Is the grid only refined if both error criteria are fulfilled, or is it enough if one error indicator is flagged?
2) How often do you adapt (e.g. every time step)?
3) How are newly-created grid points initialized, and how are coarsened grid points merged?
4) Is the initialization (interpolation, merging) algorithm mass-conserving with respect to dry air mass & water mass and/or energy conserving?
5) Does the interpolation/merging technique observe the hydrostatic balance? If not, one might expect a lot of gravity waves in 3D versions of this algorithm.
6) Do you interpolate with respect to a height or pressure coordinate in the vertical direction?
7) What is the order of the interpolation technique? If linear, are oscillation-free high-order

interpolation techniques available?

8) How many ghost cells are used?
9) Typical GCMs work with stretched grids and not equidistant grids. Can your algorithm be applied to stretched grids? The algorithm seems to rely on the fact that the grid spacing differs by exactly a factor of 2 (also refers to Fig. 2).
10) Have other error estimators (variables) and error thresholds been tried? If yes, comment on the pros and cons of these alternative choices.

Page 4, Eqs. (4)-(6): Since all operators are 1D, I suggest using partial derivatives with respect to z instead of the Laplacian operator in Eqs. (4) – (6)
Page 4, line 29: The time steps are extremely short. Can the adaptive method also be applied to more usual physics time steps on the order of minutes to half an hour?
Page 5, line 10: the geostrophic flow cannot be described as a 'forcing' mechanism. A forcing term needs units of m/s^2.
Page 5, line 17: should read 'physical closures for K'
Page 5, line 19: is this the potential temperature or virtual potential temperature? Fig. 1 shows the potential temperature, Fig. 3 show the virtual potential temperature. Is this difference intentional (provide some reasoning)?
Page 5, line 23: should read 'turbulent transport coefficient'
Page 5, line 28: should read 'on the order'
Page 6, Fig. 3: explain the meaning of the gray shading
Page 6, line 22: should read 'Fig. 5'
Page 6, line 27, should read 'presented a one-dimensional'
Page 7, line 15: explain acronym RANS
Page 8, Appendix: what is the equation that is solved here?
Page 8, line 10: provide the values for gamma, U_{geo}, the Coriolis parameter f, and the density rho
Page 8, line 19: Start sentence with 'The adaptive' instead of 'Were'.
Page 10, line 32: Update the Van Hooft et al. reference
Page 14, Table 1: State 'Number of time steps' instead of 'Solver timesteps'
Page 14, caption of Fig. A1: explain that the slope of the dashed line shows the second-order accuracy