

Review of “Global MPAS-A Simulations with a Constant Pressure Upper Boundary

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This is a follow-up paper to the first two authors’ constant pressure surface upper boundary condition paper (KS22). KS22 developed and implemented the proposed BC in a 2D version of MPAS using a 2D diurnal heating/cooling test. The current paper extends the BC to 3D MPAS and tests using a 3D analog of the diurnal heating/cooling test and a real data forecast with a 70 km upper boundary (model top). As mentioned in the last paragraph of the conclusions, the goal of this work is to use the proposed BC in the high-altitude model WACCM-X, where the model top is in thermosphere.

While this effort is sufficient for publication in GMD, the organization and presentation could be improved (see major comments). There are also some minor details that need to be fixed (see minor comments). I hence recommend publication pending minor revisions.

1 Major Comments

1. Organization: A brief recap of constant pressure boundary condition is given in Sec. 2 “Diurnal heating test case”, including Eqs. (3) and (4). This is confusing. A separate short section recapping the BC preceding the Diurnal heating test case would be easier to follow.
2. The diabatic heating/cooling for a 70 km nominal height forecast is insignificant compared to the heating/cooling in the thermospheric, where temperature swings of 400 K are possible. Hence the forecast in Sec. 3 does not represent the problem discussed in the Introduction. Indeed, the authors note that the constant pressure height BC and the rigid lid BC yield comparable results. Are there any numerical advantages to using the new BC with a 70 km nominal lid?

2 Minor Comments

1. Author List: Second Author’s first name is not spelled correctly.

2. Introduction, page 1: A more recent high altitude NEPTUNE/NUMA paper has been published:
 Kelly, James F., Felipe AV De Bragança Alves, Stephen D. Eckermann, Francis X. Giraldo, P. Alex Reinecke, and John T. Emmert. "A nonhydrostatic mass-conserving dynamical core for deep atmospheres of variable composition." *Journal of Computational Physics* (2026): 114683.
 Unlike Kelly et al. (2023), this more recent paper describes the dynamical core and a broader range of idealized tests, similar to Klemp and Skamarock (2021).
3. Page 2, Line 31: The authors claim that proposed BC "maintains exact conservation of scalar mass", but no numerical evidence is shown, either in this paper or KS22. A plot or table to back up this claim would strengthen this claim.
4. Page 3, Line 66: "taper" should be "tapers".
5. Page 4, Eq. (4): You have assumed a constant specific gas constant and constant gravitational acceleration in this expression. Neither of these assumptions are valid in the thermosphere: the specific gas constant increases as the atmospheric composition transitions to lighter elements, and gravity decreases according to the usual inverse square law. I'm guessing you could relax these assumptions with minimal effort. At any rate, please warn the reader of these limitations.
6. Page 8 line 156: "can't" should be "cannot".
7. Page 8, lines 164-165: The instability of a global diurnal test with a rigid lid was also observed in Sec. 4.4 of Kelly et al. (2023).
8. Page 14, Figure 7: In panels a and c, why does the colorbar extend to 76 km when the largest height is about 72 km?