

Geosci. Model Dev. Discuss., referee comment RC3
<https://doi.org/10.5194/gmd-2021-82-RC3>, 2021
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Comment on gmd-2021-82

Anonymous Referee #3

Referee comment on "Topography-based local spherical Voronoi grid refinement on classical and moist shallow-water finite-volume models" by Luan F. Santos and Pedro S. Peixoto, Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-82-RC3>, 2021

This paper investigates the usage of topography based local refinement of a Voronoi grid using the Model for Prediction Across Scales (MPAS) with the TRSK method for the classical and moist shallow-water equations.

The main motivation is a better representation of the Andes mountain topography in the South American continent, which plays a key role in the weather patterns of the region, while maintaining a coarser grid for the rest of the globe to reduce the computational cost of the model.

The authors propose a density function with parameters that can be tuned to specify the approximate ratio between the coarse and fine grid resolution areas; the refinement level specifically to the Andes region; and the refinement level of the larger South America region.

This density function is used to generate a series of locally refined grids with an increasing number of Voronoi cells, which are used in different test cases where the results are compared to solutions using uniform resolution grids.

The test cases show that when the grid with local refinement is used spurious numerical waves are produced, an artifact not present with the uniform grids, and that adding artificial diffusion to the simulation mitigates this issue.

Although the issues produced by the local refinement can be mitigated, the classical shallow water model test cases show that the results obtained are not improved when compared to a solution using a uniform grid with the same number of Voronoi cells.

With the moist-shallow water model using the locally refined grid lead to improved cloud representation, nevertheless, spurious precipitation was also present.

The paper is well written and well organized and provides useful information for the scientific community.

I recommend publication but also suggest a few potential revisions to further improve the paper:

- One addition that I believe would greatly improve the paper is the inclusion of a set of grids with a greater coarse to fine cell ratio, that is, a grid generated with a greater value for γ in the density function (For example, $\gamma=6$). How the results would compare

to those with $\gamma=1$ and $\gamma=3$? Are the spurious waves magnified? If so, linearly with gamma or following a higher order? Would errors start developing at earlier times? Would the inclusion of the same amount of artificial diffusion still mitigate the problem?

Some minor suggestions/questions to be discussed in the paper are:

- In the steady geostrophic flow analysis, do all VR1 to VR7 results follow the same pattern of developing spurious waves? Figure 6 might suggest that is happening only for the VR6 and VR7 grids.
- Figure 7c shows the alignment index for the VR7 grid. What it looks like for a uniform grid, such as UR7 or UR8?
- Still regarding figure 7c, I'd expect the bad alignments would happen in the transition of refined/coarse cells region. Is there an explanation for the bad indices in the mostly uniform region of the grid?
- For the Flow over the Andes mountain test case, besides the figures with the error, it would be interesting to also include figures of the actual final solution for the velocity magnitude and height fields, since there is no similar simulation in the literature. It would also give the reader a better sense of how big the error is compared to the actual solution.
- On page 15, line 300 of the manuscript, it is written "Despite that, the magnitude of the does not increase...", I believe it should be "Despite that, the magnitude of the **error**...".
- In figure 10, for comparison purposes, it would be better if the same colormaps ranges were used for all plots, with colors cropped at a minimum of $-1.8e-8$ and a maximum of $1.8e8$ and different colors could be used for data outside that range.