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Interactive comment on "Vertically nested LES for high-resolution simulation of the surface layer in PALM (version 5.0)" *by* Sadiq Huq et al.

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Review of Huq et al., "Vertically nested LES for high-resolution simulation of the surface layer in PALM (version 5.0)."

This is a very good paper on an oft-neglected topic and should be published. The issue of how to handle the vertical dimension on a nested grid is rarely addressed in the literature and this paper is a welcome addition that should help spur further discussion and development in this area. Many times in this article the authors either posed solutions to issues arising during grid refinement that I have myself encountered or gave excellent descriptions of technical details that relatively few papers on grid refinement address.

There are two particularly commendable components to the "anterpolation" (an excellent term!) from the fine to the coarse grid, both of which ensure that the nesting preserves appropriate physical quantities. The first is in Eq. 7, that the velocity components are averaged only over the faces shared between the nested and coarse grids and thereby ensuring that the volume-mean (non-)divergence is conserved by the anterpolation. (This idea is also used in Harris and Lin, 2013, MWR, although that paper uses a different grid staggering and thereby conserves a different cell-mean quantity.) The other is the "Germano Identity" of Eq. 8, which recognizes that resolved components on the nested grid may indeed be sub-grid on the coarse grid. I am unaware if other two-way nested LES models make this identification.

There are a few minor issues with this paper that I would like the authors to address before it is published.

The 5x refinement is quite aggressive and that the nesting artifacts are minimal shows how well the method works, at least for the problems considered here. The improvement to the profiles well above the grid interface is a particularly strong indication of how well the method works to improve the solution. However it is often hard to see artifacts in a snapshot such as Fig. 4. Would a time-averaged spatial plot show more artifacts? As seen in Fig. 6 there are some artifacts seen in the averaged profiles of the velocity variances, especially in the v variance. Why might v have larger shift in the variance between the two grids? Would these appear if a time-average of the variance were plotted as in Fig.4?

The issue of reflections of vertically-propagating gravity waves at the top boundary of a vertically-nested grid was considered by Clark and Farley (1984, JAS). In this model the nested upper boundary condition is relatively simple, which is OK for the Boussinesq LES problem presented here in which there are no sound waves and any vertically-propagating gravity waves would be very well-resolved. Do the authors expect that at coarser resolutions ($\sim$ 1 km) or if compressible equations are used that the form of the upper boundary condition used here would still yield acceptable results?

I found it strange that the two grids use the same timestep, which could introduce a significant computational burden. Furthermore the communication is done every single timestep, which also introduces substantial overhead due to the amount of message passing needed for the antepolation. Has any consideration been given to a longer communication timestep, or to use a longer timestep on the coarse grid?

Other comments:

- Sec 2.2: Quadratic interpolation is used for scalars. Does this introduce new extrema or negative values into the interpolated fields?

- Table 2: It seems strange that the SA-F run is more than 2000x more expensive than SA-C despite having only 125x more grid cells. Is this correct?

- Sec 3.1: The potential use of a sponge layer is briefly discussed. Do the authors plan to look more into this in future work to alleviate some of the artifacts at the upper boundary?

- The lines in Figures 5–7 are difficult to distinguish because they overlap so much. Perhaps thicker background lines for the SA simulations overplotted by thinner lines for the two grids of the nested grid would work better.

- Sec 3.4: The authors recommend an odd refinement ratio. Why would this be? The sort of averaging anterpolation used should be able to handle even refinements as well. Also it is said that the first five gridpoints in an LES are unreliable; why is this, and in which direction?

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