Geoscientific Model Development Discussions

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Comment on gmd-2022-175

Anonymous Referee #2

Referee comment on "Combining regional mesh refinement with vertically enhanced physics to target marine stratocumulus biases as demonstrated in the Energy Exascale Earth System Model version 1" by Peter A. Bogenschutz et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-175-RC2, 2022

Combining Regional Mesh RefinementWith Vertically Enhanced Physics to Target Marine Stratocumulus Biases

Peter A. Bogenschutz, Hsiang-He Lee, Qi Tang, and Takanobu Yamaguchi

This study investigates the ability of improving the simulation of marine stratocumulus by modifying the vertical and horizontal resolutions. Since low clouds are more realistic in global high-resolution simulations, the authors test whether improving only the vertical resolution and /or locally refining the horizontal grid can reproduce this improvement. If so, this would lead to have better simulations with a relatively lower computational cost increase.

For that purpose, the authors analyze 6 global simulations: low, regionally-high, and high horizontal resolution, with and without high vertical resolutions (only for selected processes). They find that, firstly, having a finer vertical resolution for the parameterized processes, and secondly, refining the horizontal grid in the region of interest, significantly improves the simulation of marine stratocumulus (cloud amount and radiative effects).

The authors conclude by advocating the usefulness of their framework for process-oriented analysis and sensitivity tests.

I find the article interesting and well written. The lack of improvement in representing stratocumulus and other boundary-layer clouds remains challenging. Therefore, the focus of the paper is of particular interest. Given the rise of global high-resolution modeling, it is important to provide insight into the effectiveness of improving low clouds with refined resolutions. However, I don't really understand how this happens. Using FIVE, some parameterized processes should be better represented, but it is not explained which of them mostly explains this difference, and how the changes act on the cloud coverage. Is it related to the way some processes are represented at the sub-grid scale and are sensitive to resolution (e.g. scale awareness)? Is it cloud-top entrainment, convective transport, turbulence closure, cloud radiation? This would help clarify why resolutions are so important, and how other climate modeling groups might use this framework.

So I thus suggest that the article be accepted after the minor comments I highlight. I would like to see the authors describe in more detail the reasons why vertical resolution is so important, and which processes are most sensitive to this refinement.

Specific comments:

- Line 59: "panacea": Unclear and not necessary.

- Line 100: "elements": Unclear. Do you mean grid boxes/columns?

- Lines 283-285 + Figure 6b: How do you explain that the RMSE is as high in the HR simulations as in LR? Does this suggest that HR simulations are not realistic in reproducing spatial pattern of low clouds?

- The variability of the COSP low-cloud amount may differ from the model cloud variability

by changes in the high-cloud amount. How much does this influence the biases in the seasonal variability (Figure 12)? Overall, do the authors find the same result (improvement by FIVE, and HR) if using the model low-cloud amount?

- Line 370-371: What is the relative coverage of the SEP-RRM region? This would be a relevant comparison to the 0.05% the authors put forward.