Weather Clim. Dynam. Discuss., referee comment RC1
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Comment on wcd-2022-41

Anonymous Referee #1

Referee comment on "Increased vertical resolution in the stratosphere reveals role of gravity waves after sudden stratospheric warmings" by Wolfgang Wicker et al., Weather Clim. Dynam. Discuss., https://doi.org/10.5194/wcd-2022-41-RC1, 2022

The study by Wicker et al. investigates the effect of improved representation of gravity wave propagation and breaking in the stratosphere due to increased vertical resolution on the stratospheric model evolution following SSW events. In particular, they find a significant reduction of a pronounced stratospheric polar cap cold bias and a correspondingly prolonged recovery phase of the polar vortex when increasing their model resolution from 91 to 198 vertical levels. As the authors show, this bias reduction is mostly due to changes in resolved gravity wave drag.
I think low vertical resolution is an interesting and often under-discussed issue, and hence this study forms a useful contribution to the existing literature. The findings of the paper are overall convincing and well presented. Language and structure of the manuscript are clear and the scientific analysis is overall sound. All I have is a few minor questions and remarks:

General points:
- I like the concept of using the 2018/19 SSW as primary case, but also including additional analyses (2 more SSWs and S2S diagnostics) to ensure the robustness of your results.

- I am wondering a bit about the 198 levels; do you think the gravity waves are sufficiently resolved at this resolution or should the observed bias decrease further with more levels? If the drag has converged, is there any argument why this should be a suitable resolution (eg would this be generally consistent with estimations based on Eq. 3 or so)? Of course, this is generally discussed in the paper (eg Figs. B1/B2 and Sec. 5) but can you give any estimate of at what resolution you would expect convergence?

- Can you say something about differences in tropospheric gravity wave forcing? I think your results are generally convincing (especially since you find robust signals for 3 different SSWs), but I guess generally differences/biases in wave drag could in principle result from changes/biases in wave forcing? Did you look at corresponding

signals/correlations for your 3 SSWs or maybe within your S2S dataset?

Specific points:
L58-59: Maybe specifically include the estimation “scale height/Rossby radius” in equation 1?
L71: model experiments
L75: This might be a personal preference, but I was never a fan of the word “confirm” in a scientific context. Maybe just say that you find a corresponding bias in S2S data?
L81: It is clear from the plots later, but maybe clarify here specifically if you mean 2017/18 or 2018/19 since both winters had a SSW.
Fig. 2: Just for clarification: is the initial bias a result of the way you construct your climatology from different hindcasts?
L193-194: Most wave theories are based on linear and other crude assumptions and the applicability of inferred quantitative values to the real atmosphere is always a bit limited. I am not sure if it is useful to state a specific quantitative range for your critical wind lines here since you don’t actually use it anywhere else in the paper.
Fig 5 and some others: I think the figure would be much easier to read if you only include one colour bar and distinguish the different panels with panel headings.