

EGU paper: Global shifts in mountain wave turbulence within high resolution climate models.

Round two of reviews

Comments from Reviewer 1:

The authors have addressed all of my original concerns. My final comment is related to Appendix B. I suggest that the thresholds be included here, as it is useful for other authors to see how these vary with model and index. Having this as 'please contact the authors' may not be useful in a few years and it would be much better if this were included in the permanent manuscript record.

A – We thank the reviewer for their reply, and we are very glad we addressed their original concerns. Regarding the thresholds comment, the thresholds are model-dependent (not least because of the different numerical grid resolutions) and are therefore not useful to other authors. Future users should recalculate the thresholds based on their own models, rather than using our values, as to do so would be scientifically incorrect. With the CMIP7 data being released in the next few months, thresholds calculated from CMIP6 data will become obsolete.

Reviewer 2:

Overall comments: I appreciate the authors' efforts in revising the manuscript. However, there are still several major issues that remain unclear, as well as some minor points. These are detailed below.

A - We thank the reviewer for their comments, and we hope we have now addressed all their concerns in detail with our replies and within the manuscript.

Major comments:

1) Specified MWT (mountain wave turbulence) prone regions (Figure 1): Compared with Figures 1 and 3 of Kim et al. (2019) and Figures 1 and 3 of Park et al. (2016) over the CONUS, Figure 1 of the revised manuscript appears to miss a substantial portion of the major mountainous regions in the western US. Only parts of the western mountain margins are chosen, which raises concern that key MWT-prone regions may have been omitted relative to those previous studies. In addition, I do not think it is necessary to adopt the same threshold as in Sharman and Pearson (2017) or Kim et al. (2023), since the appropriate thresholds are likely to vary depending on model configuration and spatial resolution. The important point is whether the selected regions meaningfully capture MWT-prone areas within current selected GCMs. In this regard, the authors' response (Reviewer #2, Major Comment #3) is not sufficient.

- J. Kim et al., (2019, WAF): Improvement of mountain-wave turbulence forecasts in NOAA's rapid refresh (RAP) model with the hybrid vertical coordinate system.

- S. Park et al., (2016, GRL): Update of upper level turbulence forecast by reducing unphysical components of topography in the numerical weather prediction model.

A: This is probably because the studies by Kim and Park use regional (not global) models with a very high resolution of 13 km, whereas our global analysis uses models with lower resolutions of 25-36 km. We have added this into our limitations and suggestions for future work. We have also added a

statement before the Rocky mountain section so it's clear for readers on this limitation. In terms of the thresholds, we follow suit using the 98th percentile but of course all thresholds are dependent on our own models and configuration used within our paper.

Lines in text: 268 -272

2) Figures in Section 3.2: I still find it excessive to present seven figures (Figures 3–9), each containing 18 panels, in a repetitive, enumerative format (Reviewer #2, Major Comment #5). I understand that the authors aim to highlight variability across MWT indices, regions, and models. However, presenting a total of 630 plots (18 x 5 x 7) seems overwhelming. I believe a more concise set of figures that clearly conveys the main message would be more informative and accessible to readers.

A: We agree with your comments, it does get very repetitive. We have decided to just include North and South America and Asia in the main text and move the remaining continents to the appendix, as you say we don't mention the figures very much in the text, so its movement doesn't change too much of the main block. We have kept the tables, so we still do discuss all continents in the manuscript.

Lines in text: edited in section 3.2

3) Specified Asian regions in Figure 11: The regions are simply labeled as Asia1–Asia 8. However, these areas encompass very different meteorological characteristics (e.g., the Maritime continent). In addition, Asia 8 appears to include parts of Australia (as authors mentioned in the revised manuscript), which can raise questions about whether the regional definitions are physically meaningful and consistently applied.

A: It is an interesting point, we chose the locations based on regions within the continents that on average over model and indices had similar trends in time, so we could really see if these trends were apparent in the contributions we average over. For future work, looking at the zones in relation to meteorological characterises could be the next step, and may break down some uncertainty in our results, we have mentioned it in future work and give our reasoning for picking these zones in the methodology.

Lines in text: 117 & 367-369

Minor comments:

1) As pointed out in Reviewer #2 (Major Comment #2 and Minor Comment #17), Kim et al. (2023) used low-level horizontal wind speed, rather than vertical wind, to compute ds. The authors' response to this point is missing.

A – Apologises, we should have replied. We also used low-level wind speed and edited the methodology to highlight this and included the word horizontal when discussing Kim et al. (2023) work.

Lines in text: 93

2) Line 5: I am not convinced that stating that MWT changes vary depending on the climate model and indices is an appropriate key message for the abstract. Instead, it would be beneficial to focus on the main consolidated findings.

A – We see what you mean, edited it to say due to uncertainty on continental averages a sub-continental zone approach was developed.

Lines in text: 4-7

3) Line 17: The phrase “this breakdown can develop” sounds awkward to me and could be rephrased for clarity.

A – Edited to sound less awkward.

Lines in text: 17-20

4) Line 28, typo: “cam” should be corrected to “can”.

A – fixed.

Lines in text: 28

5) Lines 52-53: Please ensure consistent usage of “PIREPs” (avoid mixing “PIREPS” and “PIREPs”).

A – fixed.

Lines in text: 51-52

6) Line 62: Please consider revising “101-study period” to “101-year study period” for clarity.

A – fixed.

Lines in text: 61

7) Line 106: I suggest using “PODN” instead of “PDON”.

A – fixed.

Lines in text: 106

8) Line 125: The verb ‘is’ should be used instead of ‘are’.

A – fixed.

Lines in text: - 123

9) Lines 127, 139, 142, and elsewhere: ‘Fig.’ 2i instead of ‘fig.’ 2i.

A – fixed.

Lines in text: Fixed throughout text.

10) Lines 129, 308, 325, and elsewhere: Please use “et al.” instead of “et. al”.

A – fixed.

Lines in text: Fixed throughout text.

11) Lines 134–135: maybe “Fig” is missing in front of 2g and 2h.

A – fixed.

Lines in text: Fixed throughout text.

12) Figures 3–9: The labels shown in gray are difficult to distinguish.

A – Yes so the key idea is to ignore them as they are insufficient and not used within the analysis or write up but they are included to highlight which seasons had the greatest uncertainty associated.

13) Line 244: I am sorry if I have overlooked this. It would be helpful to clarify the criteria for defining the 28 regions.

A – We should have clarified this; thanks for bring it up. It is now included at the end of the methodology. Our approach was to look at a continent and put a zone over a region in which MWT was picked up, and if this zone had a wide range of variation, we would spilt it up further to have

zones which suggested a negative trend and vice versa.

Lines in text: 117 – 119 and 367-370

14) Line 265: “Lane et al, 2009” should be corrected to “Lane et al., 2009”.

A – fixed.

Lines in text: 255 and 265

15) Please ensure consistent spacing between numbers and units throughout the manuscript.

A – fixed.

Lines in text: Fixed throughout text.

16) Line 273: This should likely be written as “Wilms and Henrike (2020)”. Also, this reference is missing from the reference list.

A – fixed.

Lines in text: Wilms and Henrike should be Wilms et al. (2020), they has ben edited

17) Line 310, typo: A period should be used instead of a comma.

A – fixed.

Lines in text: 308

18) Lines 366, 486, reference typo: Sharman and “Pearson” should be used instead of Sharman and “Pearsons”.

A – fixed.

Lines in text: 364

19) Line 368, typo in year of reference: Wilms and Henrike (2020) should be used instead of (20220).

A – fixed.

Lines in text: 365