

First, we would like to thank both the referees and the editor Prof. Dr. Jürg Schmidli for facilitating an open minded and constructive review process. The thoughtful comments and well-minded suggestions of both reviewers helped us to improve the readability and clarity of the text and graphics in the revised version.

In particular, we would like to thank the Reviewer#1 for numerous helpful comments and suggestions. Below, we answer the general and specific comments (reviewer comments in blue, answers in black). All technical comments were modified accordingly.

### General comments

1. Your analysis takes into account regional differences by your separation into "GW hotspots". Since your analyzed period is quite long, it would be awesome if you could also investigate the differences in your GW hotspots of the northern hemisphere in terms of variability between SSW and non-SSW years. In particular, I would be interested in the Himalaya region, as it is hypothesized that strong GW activity in this region might precondition the vortex before an SSW. A climatology of the SSW vs non-SSW periods in this region might shed some light into the role of the Himalaya. Did you have a look into this? For me, it's not necessary to include it in this publication if it's more work than I imagine, however, it would be an interesting point for a short follow up study.

Thank you for the comment. We share your interest in the hypothesis about a possible role of Himalayas for the polar vortex preconditioning. The drag time series computed for this manuscript can certainly be used for this goal, however, we prefer not to include any composite results in the current manuscript nor to disclose any similar results at this point, as we are currently preparing several manuscripts on the dynamical effects of the resolved GW drag, with one study targeting particularly the Himalayan hotspot. That said, we decided to provide the resulting GWD time-series subject to the potential publication of our manuscript (in daily averages and on reduced vertical grid to obtain reasonable size of the data; 10.5281/zenodo.15473685) and we hope that this will be useful for the community for a quick look also on the potential dynamical links like this.

### Specific comments

• I16: '...phenomenon in the terrestrial atmosphere...' GWs are not limited to the terrestrial atmosphere but are also present on other planets with an atmosphere (e.g. on Mars)

Thank you for the correction, the word "terrestrial" was removed.

• I35f: '..., which cannot be to date derived from global-scale observations.' rephrase this sentence. I think you mean that there are nor current observations that allow for this derivation. However, it could be understood as that the methodologies for extracting the GW parameters do not yet exist, which would be wrong [cf. Hindley et al., 2020, Lear et al., 2024, Rhode et al., 2024].

Thanks for pointing this out. Reformulated to "...which cannot currently be derived due to the lack of suitable global-scale observational data."

- I63: When mentioning ERA 5.1, it would be helpful to explain why you are using it. I.e., half a sentence on what ERA 5.1 improves upon compared to ERA 5.

Text modified to: “We base our study on hourly ERA 5 data on model levels with the horizontal resolution corresponding to about 31 km (0.28125 degrees) for the period 1979 – 2023 (Hersbach et al., 2017), combined with ERA 5.1 data, which correct stratospheric temperature bias present in ERA 5 for years 2000 – 2006 (Simmons et al., 2020).”

- I111-113: ‘A perfect match between vertical velocity and horizontal velocity perturbations cannot be expected, as polarization relations indicate that gravity waves with shorter horizontal wavelengths tend to project onto horizontal wind perturbations and vice-versa.’ This sentence is not clear to me and should be rephrased. Do you mean that shorter waves have higher ratio of vertical to horizontal wind amplitudes (which would be the case from the polarization relations) or is it about a direction change (as implied by the word ‘projection’)?

Thanks for the comment and suggestion. We indeed mean the ratio between the amplitudes. We reformulated the text to “A perfect match between vertical velocity and horizontal velocity perturbations cannot be expected, as polarization relations indicate that gravity waves with shorter horizontal wavelengths tend to have higher ratio of vertical to horizontal wind amplitudes and vice-versa.” Further, we added a reference to the polarisation relation in Fritts and Alexander, 2003.

- 179 & Fig. 5: ‘Additionally, we see the...’ this is barely visible. The figure is definitely too small to see all the features well. Consider making it wider. You could gain some width by dropping the y ticks on the middle and right panels, as they are the same(?). Please also add a period axis as top axis for the plots, which would make figuring out the features much easier than counting the dotted lines from left to right. The red line is barely visible. This figure would probably benefit from showing only 2 columns but wider panels.

Thanks for pointing this out. The figure was re-shaped, the red line was changed from dotted to dashed and we added labels with the period to the dotted line.

- Fig. 6: Consider adding a running mean and limit the y axis to Jan-Jan. West America is not visible at all, maybe the visibility could be improved by adding transparency to the high resolution data shown here and a solid-colored running mean (e.g. 7 days).

Thank you for the tip – the plot was adjusted to show the transparent lines and the running mean and the x axis was limited to Jan-Jan.

- Fig. 7 & 8: Why are you using transparency in panel f? Is this for color blindness? If so, make sure that Fig. 6 is also accessible for color blind people.

Thanks. We used the transparency in Fig. 6 as you suggested in the previous comment. Additionally, we checked the figures in a colorblind simulator to be sure that the selected colors are accessible for people with the common types of color blindness.

- ‘A possible reason for this can be that the horizontal scales and background flow of the Himalaya hotspot favor sourcing of longer orographic GW modes that propagate mostly vertically.’ This could be misunderstood as “GWs with longer horizontal wavelengths

propagate mostly vertical” which would be false in general. I think, you mean something like: In the Himalaya region, the longer horizontal GWs seem to show faster vertical propagation. The reason for this, however remains unclear (do they also have longer vertical wavelengths? why is this only the case in the Himalaya region? are the winds different here than in other orographic GW regions?). Please rephrase in a way that states what you mean more clearly.

Reformulated to “A possible reason for this can be that the horizontal scales and geometry of the Himalaya orography together with its orientation with respect to the predominantly zonal background flow favor sourcing of longer orographic GW modes that propagate vertically more efficiently compared to longer GWs for other hotspots.”

#### Technical comments

- I18: ‘...GWs exist at and...’

Modified.

- I21: ‘on a leading order’ → at leading order

Modified.

- I46, 48: consider adding Lear et al. [2024] to the listed citations.

Added.

- I66: drop ‘the’ in ‘using the linear interpolation’

Removed.

- I68: drop ‘the’ in ‘above the 10 hPa’

Removed.

- I71: Consider changing ‘. The details of the filtering are described in the following subsection.’ to as described in Sec. 2.1

Modified to “horizontal velocity perturbations due to GWs are separated, as described in Sec. 2.1”.

- I131: Consider dropping ‘the years’.

Removed.

- I160: Add a comma: ‘In their work, the meridional...’

Added.

- I167: Maybe: 'The zonal mean meridional drag component has by more than a half smaller magnitude...' → The magnitude of the zonal mean meridional drag component is by a factor of more than 2 smaller than the zonal component.?

Changed to "is by a factor of more than two smaller".

- I189f: 'For Southern Andes, based on the definition of the hotspot, two opposite yearly cycles can be derived.' is not too clear. Maybe something like: For the Southern Andes regions (as shown in Fig. 1), two opposing yearly cycles can be derived.'

Modified.

- I193: 'overlaying' → overlapping

Modified.

- I200: 'maximum is not'

Corrected.

- I217: 'which is asymmetrical around'

Corrected.

- I218: 'The probability distributions in Fig. 9 for two cut-off ranges also reveal' is not clear, please rephrase. E.g.: he probability distributions for different scale-separation cut offs in Fig. 9 also reveal.

Changed to "The probability distributions for different scale-separation cut-offs in Fig. 9 also reveal"

- I268: Maybe: 'The last column...' → The rightmost column...?

Modified.

- I292: '...ozone depletion and recovery...'

Corrected.

- I322 & 327: drag instead of 'drags'

Modified.

- I339: no brackets around citation

Changed to a citation with e.g. in the bracket.

- I353: '...GW fields...'

Corrected.

- I354: 'dedicated to this effort'

Corrected.

- I358: Maybe globally observe local GW parameters and induced GW drag

Modified.