

Impact of model resolution and turbulence scheme on the representation of mountain waves and turbulence (egusphere-2025-4308)

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Authors' response to the editor

We thank the editor for the careful, independent reading of the revised manuscript and for recommending publication subject to technical corrections. Two of the eight points below require a new or modified figure rather than a wording change alone: the vertical-resolution sensitivity (paragraph L264–268, referenced again at L350) and Fig. 11. We address our plan for each in place below. The remaining six are wording edits, given in full below.

Editor comments are in black, followed by our replies in blue. Line numbers refer to the editor's line-numbered PDF of the revised manuscript (submitted as the second revision).

1. L193 ...consistent with vertically propagating gravity waves. – if the GWs were just propagating vertically, w' would increase with height. But as you nicely disentangle in the revision, GWs are trapped in your case explaining the decreasing w' . Please reflect the new findings here.

Response: Agreed, and thank you for catching this. We have revised it to attribute the amplitude decrease with height to partial wave trapping rather than free vertical propagation, with a forward reference to the Scorer-parameter analysis:

“It is stronger in the troposphere (4 and 8 km) than in the lower stratosphere (11 km). This decrease in amplitude with height reflects partial wave trapping rather than free vertical propagation, consistent with the Scorer-parameter analysis in Sect. 3.2 (Fig. 7). Note the dominant waves also increase in horizontal scale between 4 and 8 km.”

2. Paragraph L264-268 – the sensitivity to vertical resolution is also discussed and highlighted on a prominent place of the Conclusions, hence it is absolutely necessary to show the underlying results in the manuscript.

Response: Agreed. We have placed the requested figure in a new Appendix C (“Sensitivity to vertical resolution”), following the precedent already set by Appendix B: it gets only a brief pointer in the main text and does not require renumbering Figs. 7–11. Appendix C contains one figure (Fig. C1), in the same format as Fig. 6 (vertical cross-section of w along the southern transect at 18:00 UTC), for the 400 m / 200 m / 100 m runs. The Sect. 3.2 sentence now reads “...indicating near-convergence at 200 m (Fig. C1)”, and the Conclusions sentence at L349 now also references Fig. C1.

3. L275 ..appear questionable..→ ..appear questionable given the previously identified trapping mechanism being the likely cause for the amplitude weakening..

Response: Done. The sentence now reads:

“The elevated TKE values above the ABL and outside regions of strong gravity-wave activity appear questionable, given the wave-trapping mechanism identified above (Sect. 3.1, 3.2) as the likely cause of the amplitude weakening aloft, rather than turbulent dissipation, and warrant further investigation.”

4. L286 ..in regions without strong wave activity..→ ..in regions without obvious wave breaking?

Response: Agreed, wave breaking is the more precise term. Large TKE can coincide with strong, non-breaking wave activity, which is the artifact this section documents. Changed to:

“The occurrence of large TKE values in regions without obvious wave breaking suggests a breakdown of the empirical horizontal-shear parameterization at km-scale resolution.”

5. around L350 – this important statement and finding needs to be supported by results presented in the manuscript – see my comment for the paragraph L264-268.

Response: Covered by our response to the L264–268 comment above: the vertical-resolution figure has been added (Appendix C, Fig. C1), and the Conclusions statement at L349–350 now points to it rather than resting on the unsupported Sect. 3.2 sentence.

6. Fig. 11 – Consider replacing the figure with a vertical divergence (drag), which should make the differences more clear. However, to disentangle the trapping, probably the full Reynolds stress tensor would need to be computed. This is maybe also the reason, why LES appears to have the smallest MF, because only vertical flux is computed and majority of the waves is trapped in LES.

Response: Agreed, and this is a good catch. We have extended Fig. 11 to a two-row figure: the top row shows the momentum flux as before, and a new bottom row shows its vertical divergence (the wave drag), $|\partial\tau/\partial z|$, computed component-wise from the flux vector before combining into a magnitude. We have revised the Sect. 3.4.2 text accordingly: the momentum flux itself is closely matched between the 1 km and 500 m simulations only at 17:00 UTC, with a significant difference emerging in the layer below 3–4 km by 18:00 UTC and growing further by 19:00 UTC; the drag already differs between the two resolutions at 17:00 UTC. We have amended the corresponding statements in the Abstract and Conclusions accordingly.

On the Reynolds-stress-tensor point: we agree that isolating the trapped-wave contribution, and thus the LES’s comparatively small area-averaged flux, would potentially require the full stress tensor rather than the vertical flux alone. We have not attempted this decomposition, which is a substantially larger undertaking than the present analysis and is better left for future work; we note this here rather than in the manuscript itself, to keep the manuscript text concise.

7. L420-421, A5 – please define the notation for a non-local and a local estimate of the flux Richardson number (Ri_f^{TE} and Ri_f^{GR} ?).

Response: Agreed, the superscripts were never spelled out. We now state, immediately after Eq. (A5):

“...where Ri_f^{TE} denotes the non-local estimate, calculated from the two prognostic turbulence energies (TKE and TTE), and Ri_f^{GR} denotes the local estimate, based on the turbulent Prandtl number and the local gradient Richardson number (see Eqs. (21) and (22) in Bašták Ďurán et al., 2022). This nonlinearity and non-locality help suppress the oscillatory behavior often encountered in classical TKE closures.”

8. Appendix B – Somehow the figures appear only after the other sections and references.

Response: This was a LaTeX artifact. The manuscript sorts all figures inline into their sections (the Copernicus template’s “Option 1”), but Appendix B still carried the `\appendixfigures /`

`\noappendix` pair, which is the Copernicus template's mechanism for the alternative workflow ("Option 2") where all figures are collected after the reference list. We have removed both commands; Figs. B1 and B2 are now plain figure environments inside `\section{Additional horizontal cross sections}`, and we have confirmed by recompiling that both figures now appear inline in Appendix B, correctly numbered.