Answers to Reviewer 1 comments

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General comments

This study investigates how well ERA5 model-level wind speeds at different geometric heights represent 80-m mast observations in complex terrain and coastal/flat sites. The work addresses an important practical question for wind-energy applications: at which ERA5 heights are hub-height conditions best represented, and how does this depend on terrain complexity.

Overall, the paper poses a clear scientific question. The scientific approach is sound and the results are clearly presented. I therefore recommend minor revision, mainly to clarify some key statements, correct small inconsistencies in figures/tables, and explicitly summarize the main uncertainties and limitations in the Conclusions. The manuscript addresses an important and practical question for wind-energy applications and provides useful guidance on the representativeness of ERA5 model-level winds in different terrain types.

Response: We sincerely thank the reviewer for this positive and encouraging assessment of our manuscript. We are very pleased that the reviewer recognizes the importance and practical relevance of our study for wind-energy applications, as well as the clarity of the scientific question, the soundness of the approach, and the clear presentation of the results. We also greatly appreciate the constructive suggestions provided, which helped us improve the manuscript.

Minor comments

1. **In Figure 2, I suggest adding the site elevation in parentheses next to each mast name in the legend (e.g., "M1 (3796 m)", "M2 (3690 m)"), for easier cross-reference with the map.**
   In addition, it would be very helpful to explicitly include the correlations between the mast observations and the ERA5 10-m and 100-m single-level winds for each site (e.g., additional markers or lines). This would make the comparison between single-level and model-level performance more transparent to the reader.

   Response: Both suggestions were included in Figure 4 (originally Figure 2) in the revised version.

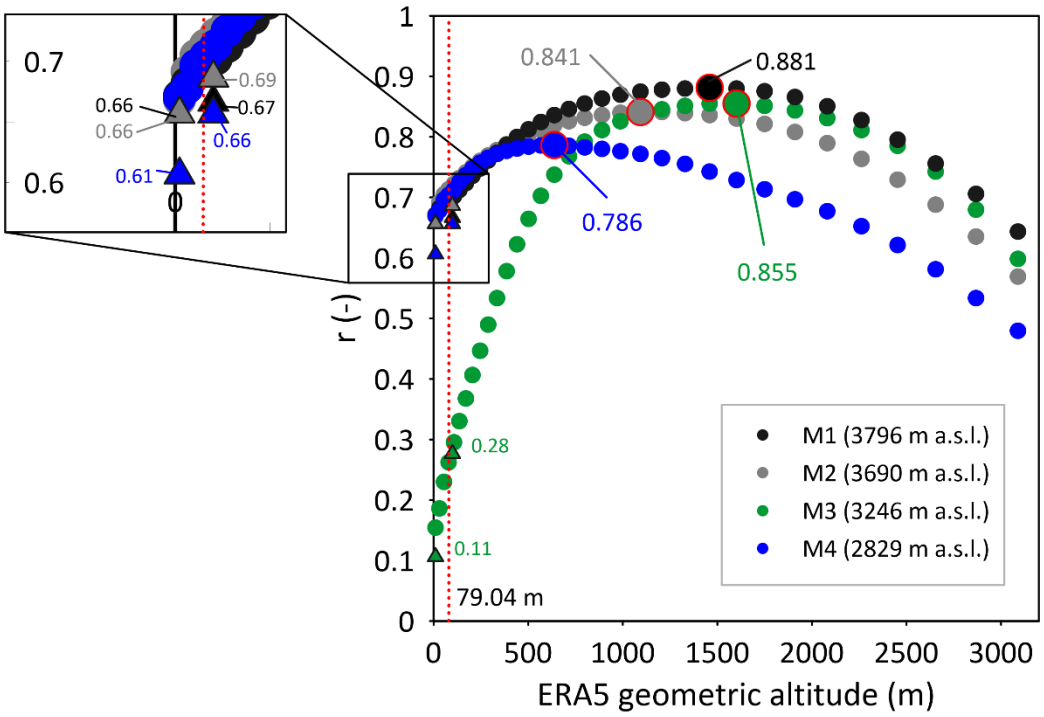

Figure 4. Correlation between observed wind speed at 80 m height at four sites and ERA5 data at different geometric altitudes for the period from January 2021 to December 2023. The 10 m and 100 m wind speeds from the ERA5 single level dataset are indicated by triangles, with their corresponding correlation magnitudes included. For each site, the highest correlation value is indicated by larger circles. The red dashed line indicates the model height closest to the observations. Site elevation is indicated in parenthesis in the legend.

2. **In Figure A3, I only see three coastal sites, while the caption refers to "four Coast sites". Please check and correct the caption and/or the figure.**

   Similar to Figure 2, I recommend also indicating the correlations between the mast observations and the ERA5 10-m and 100-m single-level winds for each coastal site, to facilitate comparison.

   Response: There was a mistake in the caption. We considered only three coastal sites, as shown in the figure. The caption of Figure A2 was corrected in the revised version.
   In addition, correlations between the mast observations and the ERA5 10-m and 100-m single-level winds for each coastal site were included in Figure A2 in the revised version to ensure consistency with Figure 2.

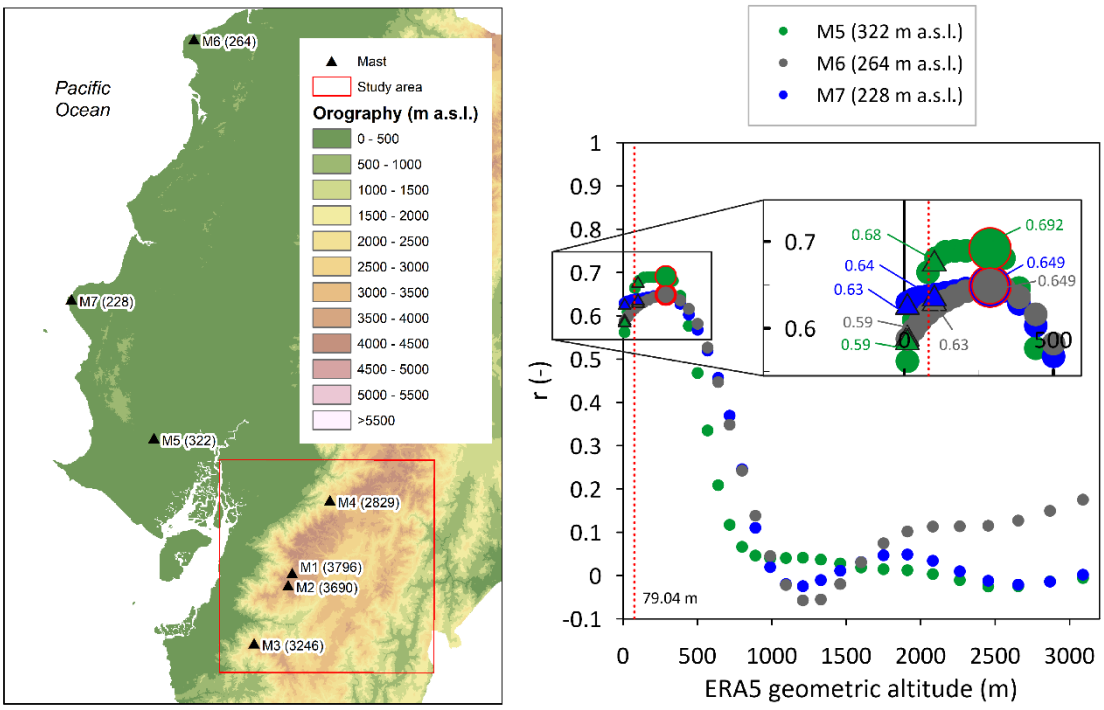

Figure A2: Correlation between observed wind speed at 80 m height at three Coast sites and ERA5 data at different geometric altitudes for the period from January 2021 to December 2022 (different analysis period compared with the mountain sites due to data availability constraints). On the left, the map shows the location of the sites, with the actual elevation of each site indicated in parentheses (m a.s.l.). On the right, the highest correlation value for each site is indicated by larger circles. The 10 m and 100 m wind speeds from the ERA5 single-level dataset are indicated by triangles, with their corresponding correlation magnitudes. The red dashed line indicates the model height closest to the observations. Site elevation is indicated in parenthesis in the legend.

3. **Lines 303–305: I suggest explicitly emphasizing in the Conclusions that, in complex terrain, better correlations are obtained at well-exposed locations (e.g., ridge-top sites) than at sites strongly affected by local flow behaviour (e.g., sheltered hillslopes or valleys).**

   In addition, the important findings stated in Lines 444–445 ("higher underestimations would be expected for sites with high frequencies of low wind speed") and in Lines 289–292 ("wind speeds over flat terrain are representative of hub-height conditions at coastal and inner flat sites but are not representative in mountainous areas") could also be briefly restated in the Conclusions section so that the main messages are more clearly visible to the reader.

   Response: All these findings were highlighted in the Conclusions section in the revised version in Lines 541-544: *"This finding indicates that while near surface and hub-height wind speeds over flat terrain are representative of observed hub-height conditions at coastal and inner flat sites, they are not representative in mountainous areas. Particularly, better correlations between ERA5 and observed winds were obtained at well-exposed locations (e.g., ridge-top sites) than at sites strongly affected by local flow behaviour (e.g., sheltered hillslopes or valleys)."*; and in Lines 549-552: *"In the latter site, higher underestimations would be expected due high presence of low wind speeds and the challenges of the RF models to predict the frequency of extreme low values (0-1 m s-1); however, these values showed no*

major impact in AEP estimates as wind turbines considered here operate at higher wind speeds (>2.4-4 m s-1).".

4. **In the caption of Table 4 it is stated that "The best-performing models … are highlighted in bold", but no boldface appears in the current version of the table. Please either apply the bold formatting or adjust the caption accordingly.**

   Response: The caption was modified in the revised version by deleting the phrase "… are highlighted in bold" to avoid confusion.

5. **Lines 369–371: M1 shows the smallest discrepancies, whereas M2 exhibits the largest. It would be useful if the authors could briefly discuss the possible reasons for this difference (e.g., differences in exposure, local flow features, representativeness of the ERA5 grid point, or data quality), as this may help readers understand how site characteristics affect model performance.**

   Response: Thanks to the reviewer for this helpful observation. We clarified this point by adding topographic contour lines to Figure 1c, which helps readers better interpret the results in relation to the site characteristics. The revised figure shows that M1 is located on a high plain, with no higher surrounding mountains, making it a well-exposed site to the prevailing easterly winds. In contrast, M2 is located on a mountain foothill and is closely surrounded by higher terrain (≥4000 m a.s.l.), which likely produces a more sheltered environment and promotes local flow effects.

   The following text was included in Lines 441-447 of the revised version: *"This higher underestimation is mainly related to the underestimation of the frequency of wind speeds above 16 m s^{-1} compared with the other sites (Fig. 4). It should be noted that the M1 and M2 sites are located within the same ERA5 pixel. Thus, the larger error at M2 may be attributed to the limited representativeness of the ERA5 pixel in capturing the local flow conditions at this site. As shown in Fig. 1c, M1 appears to be more representative of the dominant topographic characteristics within the ERA5 pixel, whereas M2 is surrounded by higher mountains, which likely influence the local flow conditions.".*

6. **In the Conclusions section, I recommend adding a short paragraph summarizing the main sources of uncertainty and limitations of the study. For example, this could include:**

   – the limited number of masts and regions considered;

   – the representativeness of individual masts for complex terrain;

   – the dependence on the chosen ERA5 grid point and the computation of geometric heights from model levels;

   – and the relatively short analysis period (2021–2024).

   Such a paragraph would help frame how far the results can be generalized to other complex-terrain regions.

   Response: Thanks for this valuable recommendation. The following paragraph describing the uncertainty and limitations of the study was included in the revised version in Lines 554-567: *"Despite these promising results, some limitations are acknowledged for interpreting*

and generalizing the findings. The analysis was based on a limited number of masts located in a specific region of the tropical Andes, and most sites correspond to well-exposed locations with relatively high wind potential. Therefore, additional observations from other complex-terrain regions, including more sheltered hillslope or valley sites, would be needed to assess the broader applicability of the results. Moreover, the representativeness of individual masts may vary according to their local exposure and surrounding terrain characteristics. Such results may also depend on the selected ERA5 grid point, particularly where the reanalysis topography differs from the real terrain. Alternatively, future studies could employ the weighted-pixel extraction approach proposed by Gualtieri (2021), which considers neighbouring pixels to improve the spatial representativeness of the sites. Finally, although the sensitivity analysis showed no major interannual changes in the selected optimal height levels, the relatively short analysis period considered here (2021–2024) may not fully capture longer-term climate variability or periods with anomalously high or low wind speeds. Extending the analysis to longer periods and additional sites would help to better evaluate the robustness and transferability of the proposed approach."

Gualtieri, G. (2021). Reliability of ERA5 reanalysis data for wind resource assessment: A comparison against tall towers. Energies, 14(14), 4169.