Response to RC2: 'Comment on egusphere-2023-1465', Anonymous Referee #2, 21 Aug 2023.

We appreciate the comments and references given by the reviewer. We repeat the reviewer's concerns and provide our respective responses in italics.

This study is focusing on the long-term trend of the horizontal wind in the MLT, using multiple radar datasets in high and middle latitudes. The calculation of the trends of horizontal wind is always challenging due to the large variability of the winds. These results will contribute greatly to the community's understanding on the MLT dynamics changes induced by increasing CO2 and climate change in the lower atmosphere. In addition, the author analyzed the radar date during geomagnetic quiet time and active time and revealed the impacts of the geomagnetic activity on the horizontal wind. This is an important topic that has not been studied very much in the community. There are some recent first principle model investigations, using TIME-GCM, on the MLT wind responses to the geomagnetic storms, showing dramatic variations in the MLT wind field during geomagnetic activities (Li et al., 2019, 2023). They could be helpful for the understanding of these results and the discussion section in this paper.

Thanks for the citation, we will include in the discussion of the paper.

One the other hand, the algorithm is quite different to the traditional multi-linear regress approach. I encourage the author to conduct a separate multi-linear regression analysis to look at specifically the geomagnetic effects, and compare them with the current results. Because the wind results of high geomagnetic activity are based on considerably less number of days than those of low geomagnetic activity. It would be very interesting to see if they are consistent with each other.

Indeed it's a different approach, which was our objective. The recommendation is valuable and we would like to explore it in future work, using a more traditional multiple linear regression approach including other regressors such as the geomagnetic activity.

In addition, since there are two types of radar involved in this study (MF radar and MWR for zonal wind data), the author should be aware of the potential bias between the two instruments (MF radar underestimates the winds) and address the possible effects on the results presented. Reid et al (2018) has some insightful discussion on this topic, and the paper could be beneficial for the author to clarify this issue.

Indeed, we are aware of this difference. The PRR winds for high latitudes are corrected based on the Angle-of-Arrival statistics and compared to mesospheric VHF wind measurements (Renkwitz et al., 2018). We will add the comment in section 2. Thanks.

T. Renkwitz, M. Tsutsumi, F. I. Laskar, J. L. Chau und R. Latteck, On the role of anisotropic MF/HF scattering in mesospheric wind estimation, Earth Plan. Space, 70:158, doi:10.1186/s40623-018-0927-0, 2018.

There is not much investigations on the inter-annual oscillations and solar cycle effects in the current manuscript. I suggest removing 4.1 and 4.2, just focusing on wind trends and geomagnetic effects.

We agree that it needs more discussion. We will add more discussion with the proper citations. We find these results interesting since the oscillation in the MLT are highly variable over the years and altitude dependents. We will share this part of the discussion in the following reply.

Minor issues:

The author keeps using the term "velocity amplitude" throughout the paper. This is confusing, since "amplitude" is usually referring to the magnitude of the modulation, such as wave amplitude, but this study is about the mean wind. I think this is due to some writing habit. Please revise.

We will remove the word amplitude.

Page 1, line 4: "…absence of intense planetary wave…". This is incorrect. The QTDW is quite active in the summer hemisphere. But it should not affect the results, since the author is using the sliding 16-day window.

Indeed, although the QTDW starts in July and is not active during the entire summer. As the reviewer mentioned any effect is removed with the 16-day running window. We will add the comment. Thanks.

Page 3, line 78, The MLT height decrease is also revealed by Yuan et al., 2019 on the trend of the mesopause height, a direct evidence of "shrinking" of the upper atmosphere.

We will add the reference.

Page 5, the definition of low and high geomagnetic quiet days seems arbitrary. For high latitude AP >= 15, but for midlatitude AP>=20. I understand that you need stronger geomagnetic activity to see the changes at midlatitudes, but I think the criteria should be consistent. In addition, it is expected to see weaker responses at midlatitudes than at high latitudes.

The AP limit was taken from Jacobi et al. (2021) for middle latitudes. We chose Ap >= 15 following the paper by Renkwitz and Latteck (2017) for the high latitudes. The difference between 15 and 20 at high latitudes, is not significant, but as mentioned by the reviewer, the amount of days used in the statistics decreases for AP>=20. Considering the shorter time series at high latitudes, we found this change better, but we wanted to continue the values for middle latitudes, as a follow-up and extension of the work done by Jacobi et al. (2021).

Page 9, line 198-199, this is expected from the model simulations mentioned above. But the high latitude responses are more complex than those at the midlatitudes due to aurora heating.

We will add the citations.

Page 13, why leaves a gap in each of figure 6a and 6b?

This is to keep the same height format as the high latitude height range (Figures 5a and 5b).

Page 14, I suggest deleting the statement "In addition,…", because there is not much investigation on this topic, just some hypothesis. See my comment above.

We will rephrase it.

Page 15, "… the contribution of planetary waves is ….." see my comment above.

We will rephrase it.

Suggested references:

Li, J., Wei, G., Wang, W., Luo, Q., Lu, J., Tian, Y., Xiong, S., Sun, M., Shen, F., Yuan, T., Zhang, X., Fu, S., Li, Z., Zhang, H., Yang, C. (2023). A modeling study on the responses of the mesosphere and lower thermosphere (MLT) temperature to the initial and main phases of geomagnetic storms at high latitudes. Journal of Geophysical Research: Atmospheres, 128, e2022JD038348. https://doi.org/10.1029/2022JD038348

Li, J., W. Wang, J. Lu, J. Yue, A. Burns, T. Yuan, X. Chen and W. Dong (2019): A modeling study of the responses of mesosphere and lower thermosphere (MLT) winds to geomagnetic storms at middle latitudes, J. Geophys. Res. Space Physics 124. https://doi.org/10.1029/2019JA026533.

Reid, I.M., McIntosh, D.L., Murphy, D.J. et al. Mesospheric radar wind comparisons at high and middle southern latitudes. Earth Planets Space 70, 84 (2018). https://doi.org/10.1186/s40623- 018-0861-1

Yuan, T., Solomon, S. C., She, C.-Y., Krueger, D. A., & Liu, H.-L. (2019). The long-term trends of nocturnal mesopause temperature and altitude revealed by Na lidar observations between 1990 and 2018 at mid-latitude. Journal of Geophysical Research: Atmospheres, 124. https://doi.org/10.1029/2018JD029828.