# Reviewer Response 'Minimal influence of future Arctic sea ice loss on North Atlantic jet stream morphology' submitted to Weather and Climate Dynamics

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January 2025

We thank the Editor for taking the time to review the paper and for providing this additional feedback. Comments are in black and author responses are in blue.

## Editor Comments

### Comment 1

I believe there is an opportunity to enhance the manuscript by further exploring the mechanisms of sea ice impact on the wind speed response in Fig.2. Specifically, you mention in the text that the change in sea ice leads to alterations in the temperature gradient, but how it varies across different models is not shown. I suggest exploring how the atmospheric temperature and gradients in the lower troposphere (around 850 hPa) change in response to SIC changes in each of the six models. This would provide further insight into the differences in jet response, particularly why the response is much weaker in MIROC6 and AWI-CM-1-1-MR compared to other models. I am particularly interested in whether the weakening of wind speed on the poleward side of the jet is related to changes in the local temperature gradient around the Greenland coastline, or if it reflects an equatorward shift of the jet due to changes in the large-scale equator-to-pole gradient that alter the meridional circulation.

Figure R1 shows the atmospheric temperature response to sea ice loss in the lower troposphere. For each model we calculated the ensemble mean difference in 850 hPa air temperature between present and future simulations. All models show significant positive air temperature anomalies between 50-70 °N including AWI-CM-1-1-MR and MIROC6, which showed the weakest zonal wind response.
We define a low and high latitude temperature gradient to explore whether changes in temperature gradient with sea ice loss are related to the zonal wind speed response. The low latitude air temperature gradient is calculated by selecting air temperature anomalies in two boxes at 20-30°N and 40-50°N. We then take the mean across the North Atlantic region (0-60°W) or the whole hemisphere (0-360°) in both boxes and take the difference between the boxes. Likewise, the high latitude temperature gradient is calculated between boxes at 44-54°N and 64-74°N. Air temperature gradients were compared to the wind response at low and high latitudes. The latitude bands are chosen to correspond to the temperature gradient across the low (30-39°N) and high (54-63°N) latitude nodes of the zonal wind response index shown in Fig 2.

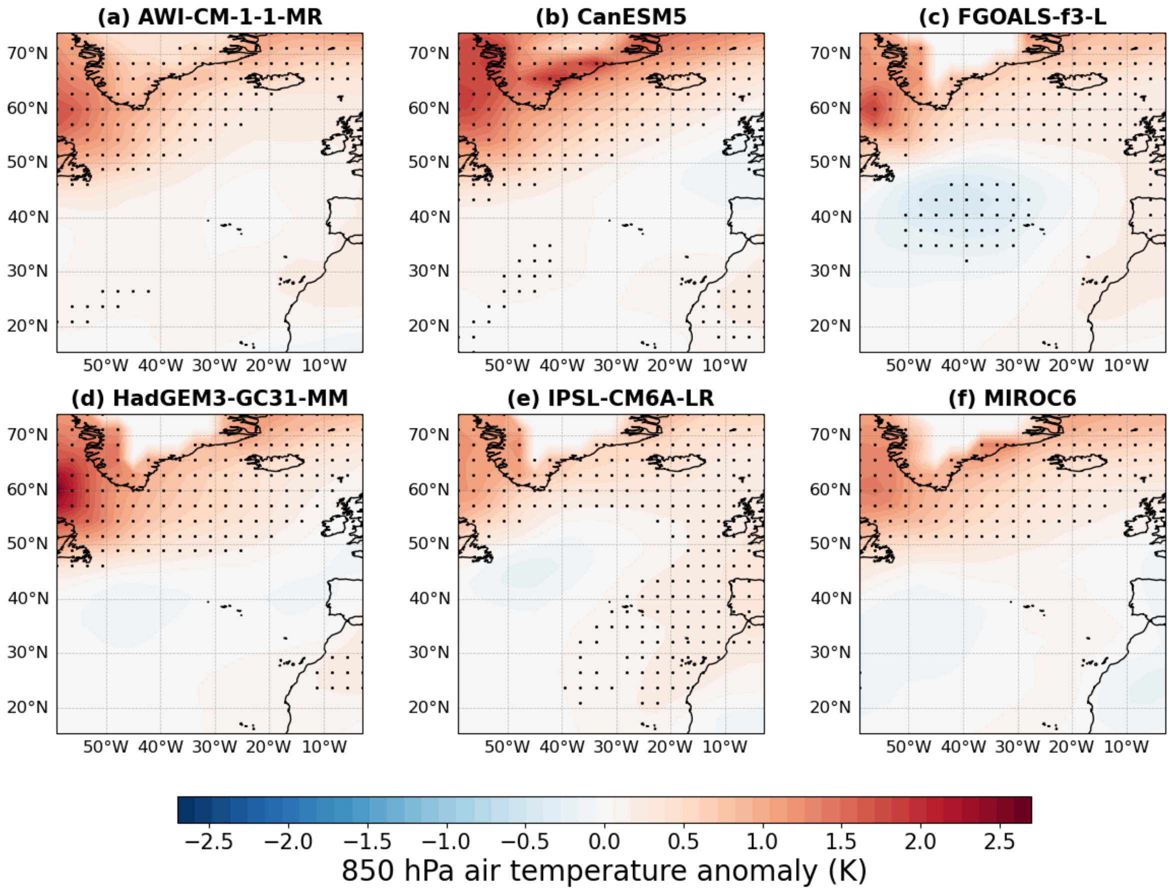


Figure R1: DJF ensemble mean air temperature anomalies at 850 hPa in PAMIP models between simulations forced by present-day and future SIC. Stippling indicates grid points where the difference is significant based on a two-sample Student's t-test at the 95% confidence level.

Figure R2 shows the low latitude temperature gradient plotted against the low latitude wind response to sea ice loss. In the North Atlantic region, the low latitude temperature anomaly decreases in strength from FGOALS-f3-L, MIROC6, AWI-CM-1-1-MR, IPSL-CM6A-LR, CanESM5, HadGEM3-GC31-MM. In the hemispheric zonal mean, the low latitude temperature anomaly decreases in strength from IPSL-CM6A-LR, AWI-CM-1-1-MR, CanESM5, FGOALS-f3-L, MIROC6 and HadGEM3-GC31-MM. There is no clear intermodel relationship between the strength of the low latitude temperature gradient and the low latitude wind response both for the North Atlantic region and the zonal mean.

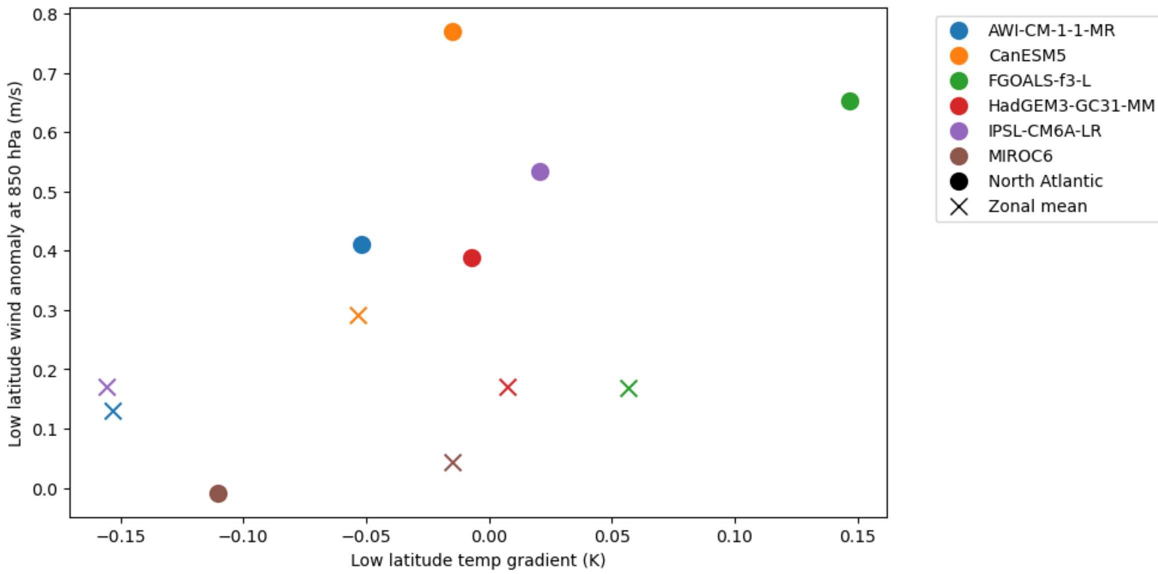


Figure R2: Relationship between low latitude temperature gradient with sea ice loss and low latitude wind response at 850 hPa. Filled circles shows the response in the North Atlantic region, crosses show the response in the hemispheric zonal mean.

Figure R3 shows the relationship between the high latitude temperature gradient and the high latitude wind response. In the North Atlantic region, the high latitude temperature gradient is always negative, as expected, and decreases in strength from CanESM5, FGOALS-f3-L, MIROC6, IPSL-CM6A-LR, AWI-CM-1-1-MR and HadGEM3-GC31-MM. In the zonal mean, the high latitude temperature gradient is always negative and strongest from HadGEM3-GC31-MM, CanESM5, AWI-CM-1-1-MR, MIROC, IPSL-CM6A-LR and FGOALS-f3-L. There is no clear relationship between the strength of the high latitude temperature gradient and the high latitude wind response at 850 hPa.

From this analysis, the weaker zonal wind response in MIROC6 and AWI-CM-1-1-MR cannot be explained by differences in 850 hPa air temperature gradient. We then explored the relationship between the air temperature gradient at 850 hPa and wind anomalies at 500 and 700 hPa (Figures R4-7), to assess whether the wind shear is related to the temperature gradient. However, we see no clear relationship between the temperature gradient and wind response at these different levels. Given the inconclusive findings, we have not added this further analysis to the manuscript as we do not feel it strengthens the results.

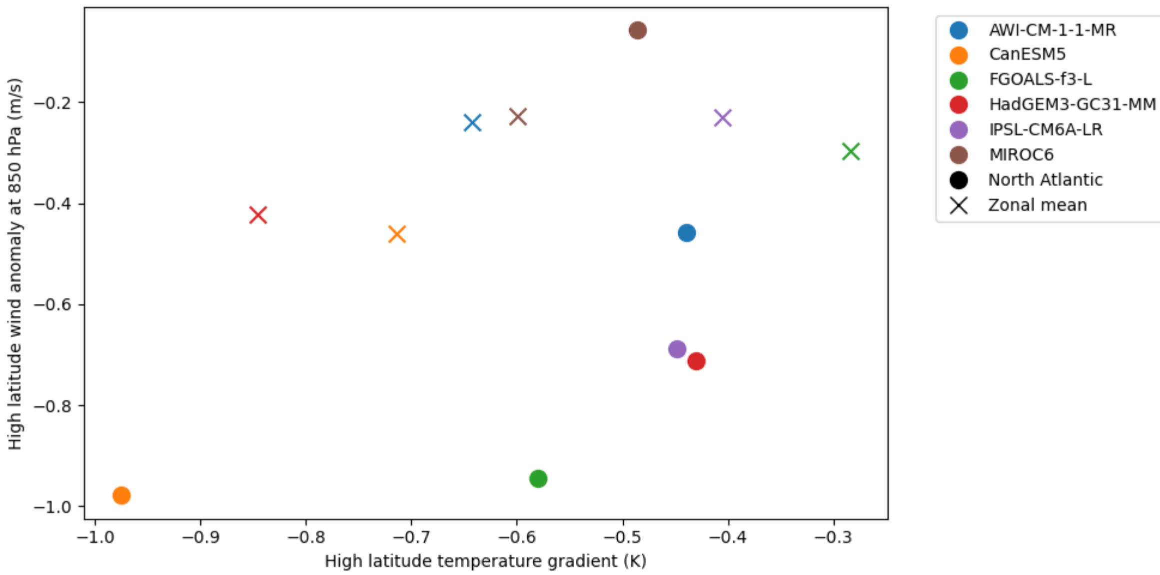


Figure R3: Relationship between high latitude temperature gradient with sea ice loss and high latitude wind response at 850 hPa. Filled circles shows the response in the North Atlantic region, crosses show the response in the hemispheric zonal mean.

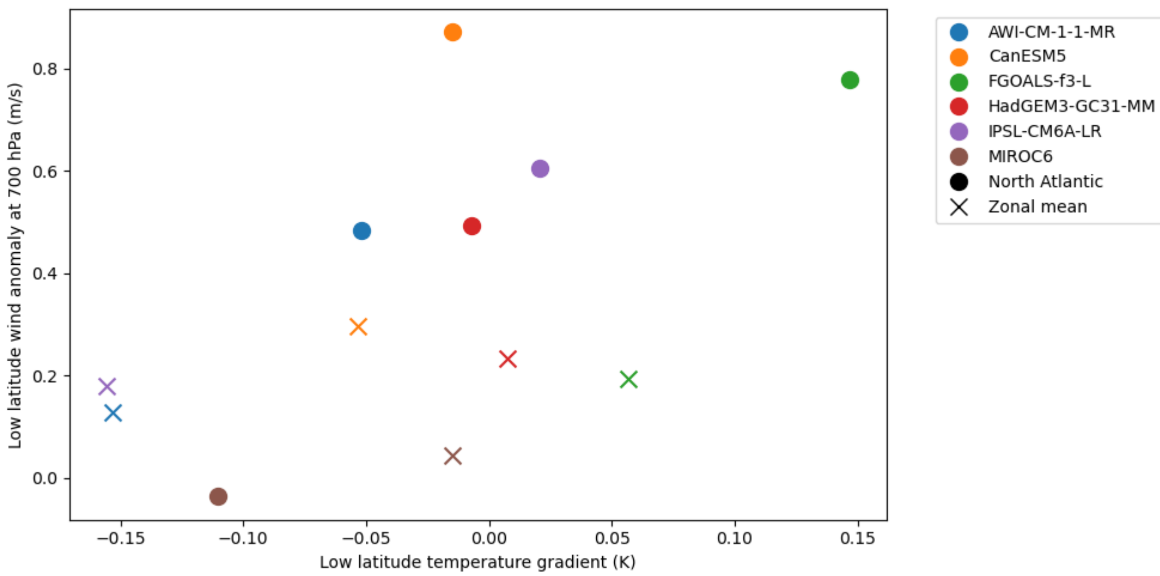


Figure R4: Relationship between low latitude temperature gradient at 850 hPa and low latitude wind response at 700 hPa. Filled circles shows the response in the North Atlantic region, crosses show the response in the hemispheric zonal mean.

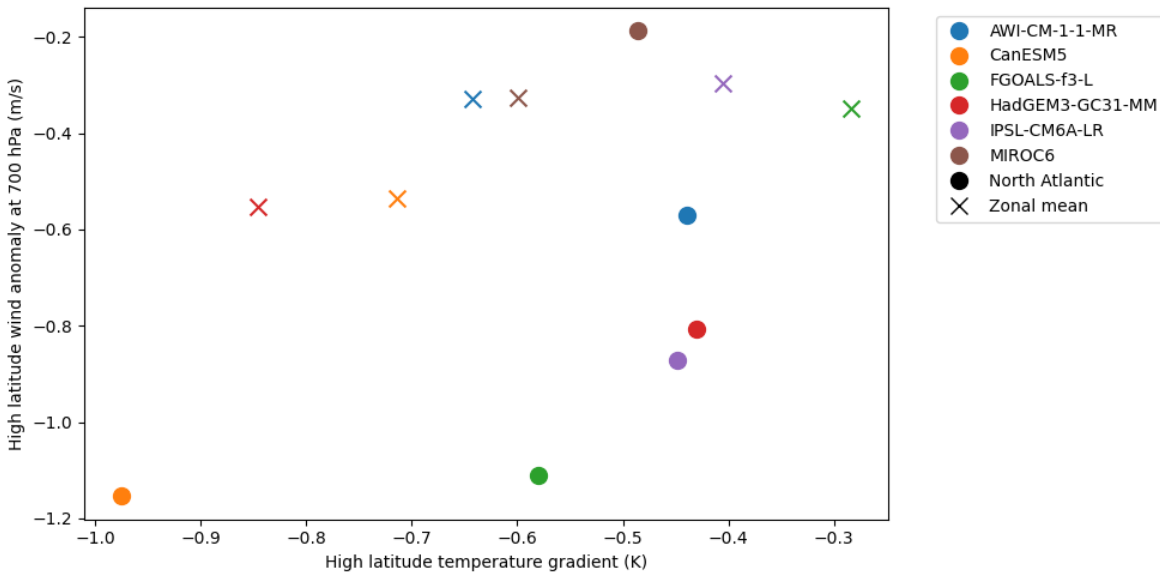


Figure R5: Relationship between high latitude temperature gradient at 850 hPa and high latitude wind response at 700 hPa. Filled circles shows the response in the North Atlantic region, crosses show the response in the hemispheric zonal mean.

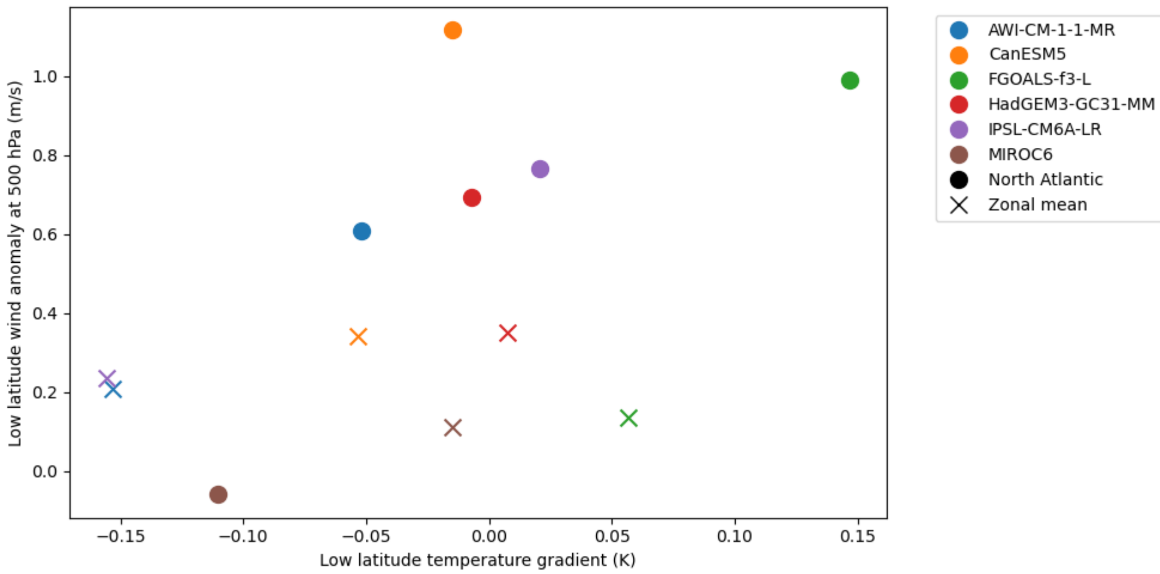


Figure R6: Relationship between low latitude temperature gradient at 850 hPa and low latitude wind response at 500 hPa. Filled circles shows the response in the North Atlantic region, crosses show the response in the hemispheric zonal mean.

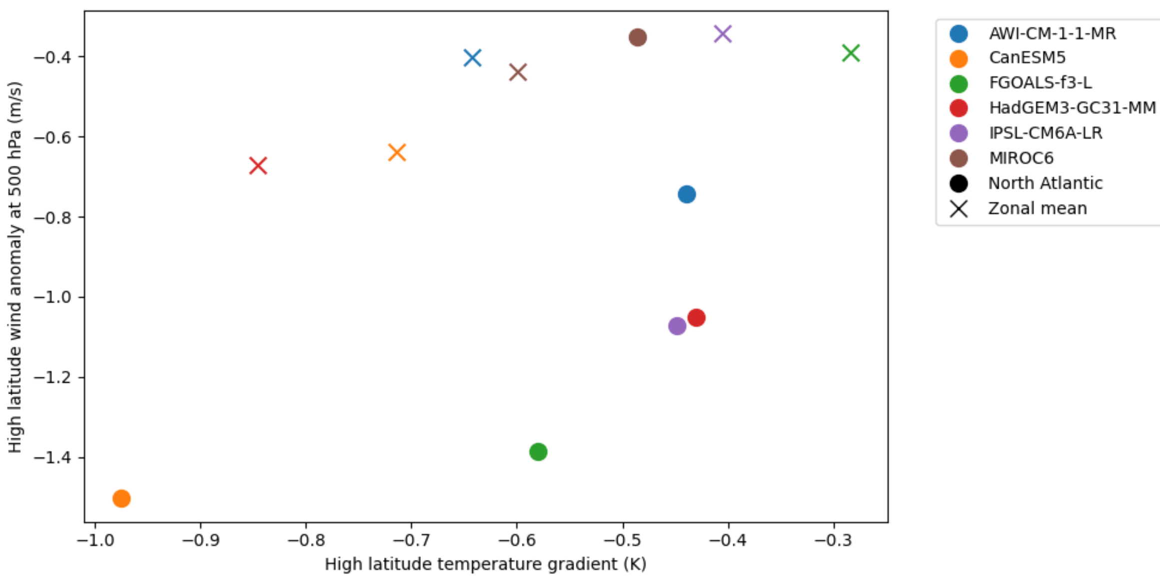


Figure R7: Relationship between high latitude temperature gradient at 850 hPa and high latitude wind response at 500 hPa. Filled circles shows the response in the North Atlantic region, crosses show the response in the hemispheric zonal mean.

## Comment 2

My other suggestion is minor, and it could simply reflect my limited understanding of the PAMIP experiments, but I think it would benefit the manuscript to provide a bit more description of the experimental design to avoid any confusion for readers. From my understanding, in PAMIP1.6, SSTs are set to present-day conditions, while SIC is set to reflect a future warming of 1.4°C relative to present-day climate. I am wondering, though, whether SIC is the same for all models, regardless of their climatology, or if the SIC anomalies are added to each model's baseline climatology, so the actual SIC field would differ across models. For those who are less familiar with the setup, it might be helpful to clarify this point further in the text. I did look at Smith et al. (2019), but I was still unsure, as they showed SIC anomalies in Fig. 5-6c,f, but the text implied that SIC forcing was the same for all models, regardless of their individual climates. Additionally, following this line of thought, it may be worth revising the legend in Figures 6-7 to change the label from 'future' to 'future SIC'. This would help clarify that these PAMIP1.6 experiments are forced by SIC changes only, and do not incorporate other climate changes (e.g., GHGs) if that is correct.

We thank the Editor for their suggestion of clarifying this section about the datasets and methods. Each model simulates their own present-day and future SIC fields, however the final SIC forcing applied in the experiments is constrained by observed present-day SIC values. Firstly, global mean temperatures for pre-industrial, present-day and future time periods are defined as 13.67°C, 14.24°C and 15.67°C, respectively. For each model, the 30 year period where the average global temperature matches these values is then determined. The average SIC during those periods is then calculated to give pre-industrial, present-day and future SIC fields. At each grid point, linear regression is calculated between simulated future and present-day SIC. The point where the regression line intersects the observed present-day value is taken as the future SIC estimate. The outcome is a single, consistent SIC forcing field applied to all models, rather than one that reflects the unique climatology of each model. This information can be found in Smith et al. (2019), Appendix A.

We have clarified this point in Section 2.1 of the manuscript as follows: "Taking the ensemble mean SIC for CMIP5 simulations results in a poor representation of the ice edge. To address this issue, future SIC projections are constrained by present-day observations to ensure a more accurate representation. For each model, linear regression is calculated between simulated future and present-day SIC at each grid point. The future SIC estimate is taken as the point where the regression line intersects with the present-day observed SIC value. The outcome is a single, consistent SIC forcing field applied to all models, rather than one that reflects the unique climatology of each model. Additionally, in regions where the difference between present-day and future SIC is greater than 10%, present-day SSTs are replaced by future SSTs in experiment 1.6."

To address your second point, the authors agree that revising the legend in Figure 6-7 to specify "future SIC" is helpful. This change will clarify that the PAMIP 1.6 experiments are forced by changes in SIC only.

## Final reviewer comments

Thanks for clarifying the ZWRI index. I'd like to suggest a minor further revision to this sentence: "However, changes in zonal wind in other regions may not reflect the local North Atlantic eddy-driven jet response." I think something like this is even more clear (at least to me): "However, changes in the

hemispheric zonal winds may not reflect the local North Atlantic eddy-driven jet response". In the sentence just prior to this you could also add "hemispheric", so "based on the hemispheric zonal mean zonal wind". The point being that writing "zonal mean" with no comment does not automatically mean readers will infer that you are talking about all longitudes, as opposed to just in a particular region (which is why I was confused in the first place).
In L348 there's a word missing ("the to the").

The authors thank the reviewer for their additional feedback and agree that this clarification will be helpful. The manuscript has been updated to include 'hemispheric' to further clarify the definition of the zonal mean zonal wind.

# References

Smith, D. M., Screen, J. A., Deser, C., Cohen, J., Fyfe, J. C., García-Serrano, J., Jung, T., Kattsov, V., Matei, D., Msadek, R., Peings, Y., Sigmond, M., Ukita, J., Yoon, J.-H., and Zhang, X.: The Polar Amplification Model Intercomparison Project (PAMIP) contribution to CMIP6: investigating the causes and consequences of polar amplification, Geosci. Model Dev., 12, 1139–1164, https://doi.org/10.5194/gmd-12-1139-2019, 2019.