Anonymous Referee #3

This paper investigated the atmospheric response to wintertime cold Tibetan Plateau (TP) bias with CMIP6 multi-model mean (MMM) simulations and idealized SPEEDY experiments. The authors found that the cold bias over Asian orography intensifies the East Asia winter monsoon (EAWM) through enhancing the low-level baroclinity and reinforcing the southern Pacific jet. The EAWM is a three-dimensional climate system and more details should be examined to measure its strength. Thus, I recommend a major and mandatory revision before the paper could be accepted. The details of the comments are listed below.

Major comments:

This study investigated the impacts of the cold bias over Asian orography on East Asia winter monsoon (EAWM). The EAWM is a three-dimensional climate system (e.g., Jhun et al. 2004) and its strength could not be simply measured by the wind at 850hPa. Thus, the authors should carefully check the atmospheric anomaly (e.g., Z500, U300, SLP) to measure the strength of EAWM (Jhun et al. 2004, Wang et al. 2010).

We agree with the reviewer's comment. A new figure (Figure 5 below) detailing the vertical structure of the EAWM, is added to the manuscript in order to address the reviewers' concern. The consistency with East Asia winter monsoon strengthening, with reference to Jhun et al. 2004, is discussed in the Results as in the following:

"Typical features relatable to a strong East Asia winter monsoon are captured by the sea-level pressure and mid-troposphere geopotential height fields in Figure 5, as by comparing e.g. with strong and weak monsoon conditions in Figure 6 of Jhun and Lee (2004). A deeper zonal pressure contrast to the east of the Siberian High (panel (a)) and a lower 500 hPa isobaric surface over the Asian coast (panel (b)), together with a strong 300 hPa jet inland and to the south of Japan (panel (c)) - following the low-level signal (Figure 4(c)), are in conformity with maps describing the atmospheric state associated with an intense monsoon."

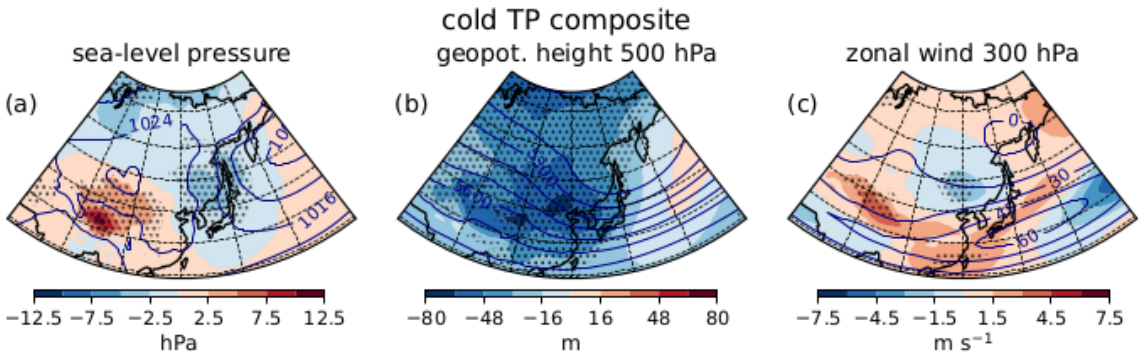

Figure 5. The "cold TP composite" anomalies of (a) sea-level pressure, (b) 500 hPa geopotential height and (c) 300 hPa zonal wind; the respective MMM climatologies in contours. Stippling shows the anomalies exceeding the 95th percentile in a randomly extracted 6-model composite distribution, see Methods

Other comments:

2.1 Line 101: ‘the January and February months are referred to as winter’. Why December is not considered? In general, the boreal winter is referred as “December-January- February” (DJF).

The results of the model compositing do not change if considering JF instead of DJF. See Figures R1 and R2 included below. This will be mentioned in the Methods section of the new manuscript.

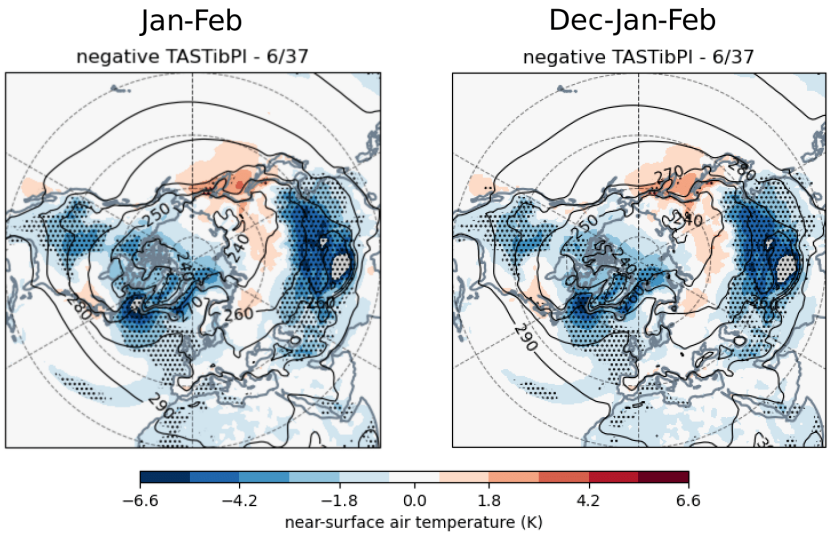

Figure R1: near-surface temperature anomaly in the “cold TP composite”, version JF (left) and DJF (right). Figure on the left is as Figure 2a from the manuscript.

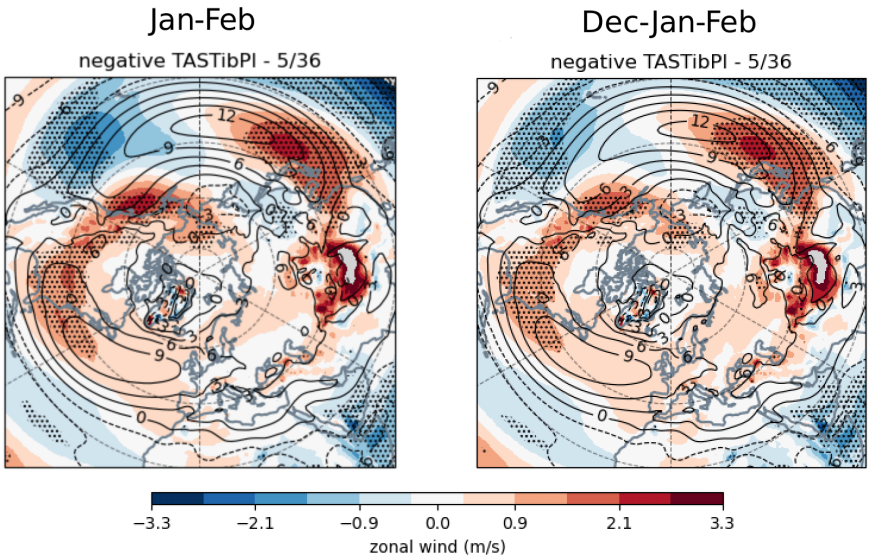

Figure R2: 850-hPa zonal-wind anomaly in the “cold TP composite”, version JF (left) and DJF (right). Figure on the left is as Figure 2c from the manuscript

2.2 Line 37: 40°N could be better.

Correction applied.

2.3 Line 128: As mentioned in line 125, the LST is prescribed in SPEEDY model. However, it is also proposed that the model includes a freely evolving LST scheme. I wonder how the LST is treated in the SPEEDY simulations? Could the LST be affected by upper-level circulation, or it is just prescribed as a model input? Please clarify.

The LST in the freely evolving versions interacts with the upper-level circulation by responding to a surface energy-balance equation, while relaxing towards a prescribed climatology - the relaxation time scale is 40 days. In the prescribed LST case (used here) the LST is simply fixed to the prescribed field, and does not evolve.

A detailed description of the LST scheme is available in Appendix B of

Portal, A., C. Pasquero, F. D'Andrea, P. Davini, M. E. Hamouda, and G. Rivière, 2022: Influence of Reduced Winter Land–Sea Contrast on the Midlatitude Atmospheric Circulation. *J. Climate*, **35**, 2637–2651, https://doi.org/10.1175/JCLI-D-21-0941.1.

Such reference is provided also in the Methods of the manuscript, section 2.2.

2.4 Line 150: '1979-2008' could be better.

The correction has been applied.

2.5 Figure 2: Please check the unit of the heat flux. It could be W m-2.

Correct, we thank the reviewer for pointing out this mistake.

2.6 Figure 2: Positive value means upward or downward heat flux? Please provide the information in figure captions.

The issue has been addressed.

2.7 Line 170: The statement could be misleading. The heat flux change is negative over TP regions.

We specify in the description (Results) that enhanced cooling is present where the turbulent heat fluxes are climatologically negative.

2.8 Line 171: If the heat flux change is not significant over TP and CP, why the authors show the heat flux change here? It could confuse the readers.

From Figure 2b,c (old manuscript numbering) we note that stippling (significant signal) is present over the TP and MP, even if it does not extend uniformly over the region.

2.9 Line 184: The jet stream distributes around 300hPa during winter (Jhun et al. 2004). The statement here could be misleading.

We specify that in this context we are referring to the eddy-driven jet.

2.10 Line 187: Please check the figure captions.

The caption has been corrected.

2.11 Line 190: Increased instability favors acceleration of upper-level zonal winds (e.g., Nie et al., 2016). Please show the zonal wind change of upper troposphere.

The upper-level jet is shown in the new Figure 5(c), shown in response to the Reviewer's major comment.

2.12 Line 214: Please check the figure captions.

The caption has been revised in order to make it clearer.

2.13 Figure 5: Please show the significant information of the changes as in Figure 4.

Stippling to indicate the significant changes has been included in the updated figure.

2.14 Line 199: Please show the surface wind anomaly with vectors. Otherwise, one may not understand the heat flux anomaly.

Following the reviewer's comments, we have inserted in Figure 2c (old numbering) vectors showing significant wind anomalies at 1000 hPa (near-surface wind was unavailable for ~10 models, hence the 1000 hpa pressure level was preferred).

2.15 Line 200: More upward heat flux? Please clarify.

The sentence has been rephrased.

Reference:

Wang, B., Wu, Z., Chang, C., Liu, J., Li, J., & Zhou, T. (2010). Another Look at Interannual-to-Interdecadal Variations of the East Asian Winter Monsoon: The Northern and Southern Temperature Modes, Journal of Climate, 23(6), 1495-1512.