Replies to Editor:

Thank you very much for your constructive suggestions. We have revised the manuscript carefully based on these suggestions. The followings are our point-to-point replies.

1. *The manuscript needs to be carefully revised based on the very constructive comments of both reviewers. Further details about the model setup in the sensitivity experiments and model validation results for the study region with available in-situ observations should be provided.*

Responses: Thank you very much for your suggestions. In terms of further details about the model setup, we add in Line 92-93: "*Except for topography, all other boundary conditions, including vegetation, soils and other surface characteristics remain the same as that in CTRL.*"

As for model validation, please see our replies to Q#2 of Reviewer #2. We compared model results with observations and discuss it in Fig. S2 and Line 100-103: "*Figure S2 shows the winter precipitation, surface winds and surface air temperature from our Control simulation and observations (GPCP data and ERA5 reanalysis). It is clearly shown that our Control run can well simulate the mean climate in China.*"

Replies to Reviewer #1:

Thank you very much for these constructive comments. We have revised the manuscript carefully based on these suggestions. Please see our replies below.

1. *According to your descriptions, the land surface model is included in the selected Earth System Model, which may be coupled with atmospheric module. In your control experiments named "Flat" and "NoTibet" by completely removing the topography and landforms, I was wondering whether the interactions between land surface processes and atmospheric circulations affect the following comparisons.*

Responses: Thank you very much for this comment. The land-atmosphere interaction includes the energy and material exchanges between the land surface and the atmospheric boundary layer. This interaction is influenced by vegetation amount and type, soil moisture and other surface characteristics. However, we only change the topography height in our experiments. Except for topography, all other boundary conditions, including vegetation, soils and other surface characteristics remain the same as that in CTRL.

In this work, we would like to directly examine the influence of such an extensive orography on large-scale atmospheric circulation from a physical perspective, without considering the detailed interactions between the atmosphere and land at smaller scales. Although this is a highly idealized modeling study, it can provide guidance regarding how the presence of the TP impacts winter climate in China from the perspective of dynamics of atmospheric circulation. We do agree the land-atmosphere interactions may have some influence on snowfall response; but this point is beyond the scope of our current manuscript. This question warrants future studies through more detailed models.

2. *No verification has been found to state the availability and efficiency of the model and set-ups, thus the feasibility of the chosen spatial scale and other processes in the study area is suspected. In my opinion, several in-situ observations like precipitation and wind can be collected for model validation.*

Responses: Thank you very much for this suggestion. For the availability and efficiency of model, we have compared the model results with the observations in the study area. Fig. R1 shows the precipitation, surface wind and surface air temperature averaged between December and February from our CESM control simulation and the observations. We can see that they are mostly consistent. Although the model simulated winter precipitation (Fig. R1a) over ocean is slightly stronger than the GPCP's (Fig. R1b), the precipitation over China land is well simulated. The pattern of surface winds and surface air temperature from CESM1 (Fig. R1c) shows an excellent agreement with that from the ERA5 reanalysis (Fig. R1d), including the large-scale anticyclonic circulation around China, and low temperature in northern China and Tibetan Plateau. What's more, the pattern of winter winds and geopotential height at 700 hPa (Fig. R2a) from CESM is similar to that from the ERA5 reanalysis (Fig. R2b). Therefore, CESM1 can well simulate the mean climate in our study area.

We have included Fig. R1 in the supporting material (new Fig. S2) and discussed it in Line 100-103 of the revised manuscript: "*Figure S2 shows the winter precipitation, surface winds and surface air temperature from our Control simulation and observations (GPCP data and ERA5 reanalysis). It is clearly shown that our Control run can well simulate the mean climate in China.*"

Our previous studies have also used CESM1 to investigate the TP's role on global climate (Yang et al., 2020; Wang et al., 2023) and regional climate, for example, the precipitation in North Africa (Chen et al., 2021) and North America (Wen et al., 2021), which support the availability and efficiency of our model. Furthermore, we think the influence of the model bias can be neglected. The results we present are differences between the control run and topography perturbation experiment, and the model biases in these runs are comparable, so most of the model biases should not be in the difference field.

For your concern about the spatial scale, in one of our previous papers (Yang et al., 2015), we used the same CESM model with a higher resolution (1.9x2.5_gx1v6, i.e., the atmosphere model has the finite volume nominal 1.9°×2.5° in the horizontal). We compared the mean climate states of high-resolution model and low-resolution model, and found no significant differences between them, including the mean global SST and SAT, the mean meridional heat transport, and so on. Considering the limited computing resources, we chose the low resolution in this study.

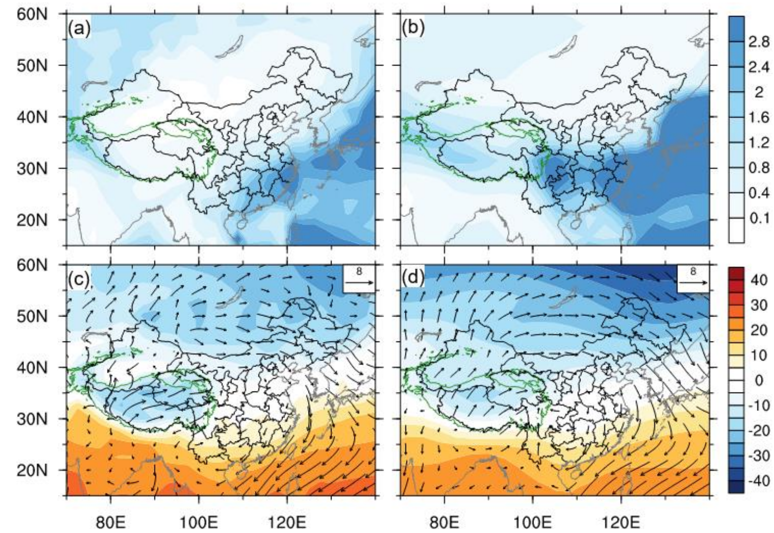

Fig. R1 Precipitation (units: cm/year) from (a) GPCP data and (b) CESM control run. Surface wind (vectors; units: m/s) and surface air temperature (shading; units: °C) from (c) ERA5 reanalysis and (d) CESM control run. All variables are averaged over boreal winter (DJF). Observations are averaged between 1979 and 2020. CESM control run is averaged over the last 100 model year.

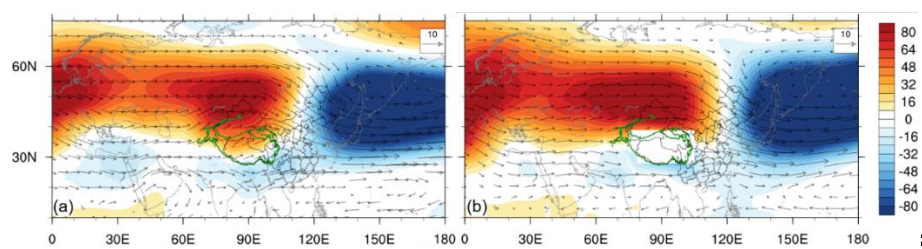

Fig. R2 Spatial patterns of winter wind (vector; m/s) and geopotential height (shading; m) at 700 hPa from (a) ERA5 averaged between 1979 and 2020 and (b) CESM control run averaged over the last 100 model year. The geopotential height is obtained by subtracting its zonal-mean value.

References:

Yang, H., X. Shen, J. Yao and Q. Wen, 2020: Portraying the impact of the Tibetan Plateau on global climate. J. Climate, 33(9), 3565-3583, doi: 10.1175/JCLI-D-18-0734.1.

Wang, L., Yang, H., Wen, Q., Liu, Y., and Wu. G., (2023): The Tibetan Plateau's Far-Reaching Impacts on Arctic and Antarctic Climate: Seasonality and Pathways. J. Clim., 36(5), 1399-1414, doi: 10.1175/JCLI-D-22-0175.1.

Chen, Z., Wen, Q. and Yang, H (2021): Impact of Tibetan Plateau on North African precipitation. Clim. Dyn., 57, 2767–2777, doi: 10.1007/s00382-021-05837-2.

Wen, Q., Han, Z., Yang, H. et al (2021): Influence of Tibetan Plateau on the North American summer monsoon precipitation. Clim. Dyn., 57, 3093–3110, doi: 10.1007/s00382-021-05857-y.

Yang, H., Q. Li, K. Wang, Y. Sun and D. Sun (2015): Decomposing the meridional heat transport in the climate system. Clim. Dyn., 44, 2751-2768, doi: 10.1007/s00382-014-2380-5.

Replies to Reviewer #2:

This study conducted comparative experiments to simulate winter snowfall in China with or without TP by CESM1.0 model. The findings can deepen our understanding of the impact of TP on winter climate in China. It concluded that previous results of winter snowfall in China are overestimate over the area north of 40°N, and the estimates from this study is closer to the real situation. The topic/contents are interesting to broad audience in relevant fields. The methods used are robust, and the results are comparable to the previous works using different models. However, some issues need to be taken cared to improve this work.

Responses: Thank you very much for your constructive comments. We have revised the manuscript carefully based on these suggestions. The following are our point-to-point replies.

1. *The method section is need to supplement and strengthen, how is the water vapor flux calculated? The regional division of China should be placed in this section. The data of temperature, wind, sea-level pressure, moisture, relative humidity, geopotential height and vertical velocity are lack of specification.*

Responses: Thank you very much for the suggestions. We have added the calculation of water vapor flux in Method Section (Lines 108-121):

"Moisture content is the total column water vapor, representing the precipitable water. It can be written as:

$$Q = \frac{1}{g} \int_{1000\,hPa}^{300\,hPa} q\, dp \qquad (1)$$

where q is the specific humidity and g is the acceleration of gravity. It is vertically integrated from 1000 hPa to 300 hPa, as the water vapor above 300 hPa is negligible.

Moisture transport is calculated as follows (Trenberth 1991):

$$MT = \frac{1}{g} \int_{1000\,hPa}^{300\,hPa} (\vec{V} q)\, dp \qquad (2)$$

where $\vec{V}$ = (u, v) is the horizontal wind. The divergence of moisture transport can be divided into two terms (Huang 1998):

$$\nabla \cdot MT = \frac{1}{g}\int_{1000\,hPa}^{300\,hPa} \nabla \cdot \left(\vec{V}q\right) dp = \frac{1}{g}\int_{1000\,hPa}^{300\,hPa} \vec{V} \cdot \nabla q \; dp + \frac{1}{g}\int_{1000\,hPa}^{300\,hPa} q \cdot \left(\nabla \cdot \vec{V}\right) dp \quad (3)$$

The first term on the right is the moisture advection and the second term on the right represents the contribution of wind divergence. The divergence (convergence) in the wind field, like an anomaly anticyclonic (cyclonic) circulation, corresponds to the divergence (convergence) in the moisture transport field, which contributes to less (more) moisture (Schmitz 1996)."

We have relocated the description of China's regional division from Lines 192-194 to the Method section, specifically in Lines 122-126: "*To have a more comprehensive understanding of the TP's contribution on the winter climate in different regions of China, we divide China into five regions: northeast China (110°-132°E, 40°-53°N), north China (110°-120°E, 34°-40°N), northwest China (73°-110°E, 34°-45°N), southeast China (110°-120°E, 21°-34°N), and southwest China (97°-110°E, 21°-34°N).*"

The variables we use are monthly data directly outputted from the model. We have added the specification in Lines 99-100: "*We use the monthly model outputs including temperature, wind, sea level pressure, relative humidity, geopotential height and vertical velocity.*"

References:

Trenberth, K. (1991), Climate diagnostics from global analyses: Conservation of mass in ECMWF analyses, J. Clim., 4, 707–722, doi:10.1175/1520-0442 (1991)0042.0.CO;2.

Huang, R., Z. Zhang, and G. Huang (1998), Characteristics of the water vapor transport in East Asian monsoon region and its difference from that in South Asian monsoon region in summer (in Chinese), Sci. Atmos. Sin., 22(4), 460–469, doi: 10.3878/j.issn.1006-9895.1998.04.08.

Schmitz J T, Mullen S L (1996). Water vapor transport associated with the summertime North American monsoon as depicted by ECMWF analyses[J]. J. Clim., 9(7): 1621-1634, doi: 10.1175/1520-0442(1996)009<1621:WVTAWT>2.0.CO;2.

2. *The discussion section is relatively weak, the comparison with previous regard to simulation study on the effect of Tibetan Plateau on wintertime snow is less.*

Responses: Thank you very much for this comment. To the best of our knowledge, there are few papers directly examining the TP's impact on wintertime snowfall in Asia. In our study, we demonstrate that the snowfall formation is determined by the low temperature condition and some moisture. Some atmospheric modelling studies show that the presence of the TP leads to a lower air temperature and a higher moisture in southern China, indicating the increasing possibility of more snowfall there, which is in line with our conclusions.

We added the discussion in Line 280-287: "*Previous studies revealed that the uplift of Tibetan Plateau results in a reduced temperature in East Asia (Jiang et al., 2008; Yanai and Wu 2006), which is similar to our studies. Furthermore, some studies using atmosphere model demonstrated that the existence of the TP enhances the winter cold air outbreak to East Asia, as well as the southerly winds towards southern China, which facilitates the transport of moisture, forming persistent rainfall in late winter and early spring over southern China (Liu et al., 2007; Wu et al., 2005; Wan and Wu, 2007). These findings align with our conclusions.*"

References:

Jiang, D., Z. L. Ding, H. Drange, and Y. Q. Gao (2008): Sensitivity of East Asian climate to the progressive uplift and expansion of the Tibetan Plateau under the mid-Pliocene boundary conditions. Adv. Atmos. Sci., 25(5), 709–722, doi: 10.1007/s00376-00.

Liu, Y., Bao, Q., Duan, A. et al (2007): Recent progress in the impact of the Tibetan Plateau on climate in China. Adv. Atmos. Sci. 24, 1060–1076, doi: 10.1007/s00376-007-1060-3.

Wu, G. X., J. Wang, X. Liu, and Y. M. Liu, 2005a: Numerical modeling of the influence of Eurasian orography on the atmospheric circulation in different seasons (in Chinese). Acta Meteor. Sin., 63, 603– 612.

Wan, R. J., and G. X. Wu (2007): Mechanism of the Spring Persistent Rains over southeastern China. Sciences in China (D), 50, 130–144, doi: 10.1007/s11430-007-2069-2.

Yanai, M., and G.-X. Wu (2006). Effects of the Tibetan Plateau. The Asian Monsoon, pp. 513–549, Springer, New York, doi: 10.1007/3-540-37722-0_13.

3. *Line 208-209: "suggesting that a strengthened snowfall climate would not help provide human comfort", this sentence is a little hard to understand, there is no direct relationship between snow*

and human comfort, to my knowledge, human comfort is not only related to relative humidity, but also to temperature.

Responses: Thank you very much for this comment. This sentence in our original manuscript was not clear. We want to demonstrate that the presence of the TP leads to a strengthened snowfall climate, with lower surface temperature and higher relative humidity, which are not favorable for human comfort. We rewritten the sentence to: "*suggesting that the presence of the TP would not help provide human comfort"*

4. *The captions of figure S3 and figure S6 in supporting information are not correct. Please revise . The captions of figure S2 (c): its changes in NoTibet, with respect to Real is there any problem? Please check.*

Responses: Thank you very much for the comments. *Figure S2 (c)* is the snowfall changes due to the presence of the TP ("Real" minus "NoTibet"). We have revised it as "*its changes in Real, with respect to NoTibet*".