Response to Reviewer #1:

In the paper, Su and co-authors demonstrate that the uplift of TP leads to the weakening of AMOC, but the intensification of PMOC. The paper is well written. If the authors can address or discuss the two fundamental weaknesses below, I think the revised version will be largely improved.

(1) Why removal of TP leads to the intensified westerlies over the North Atlantic and weakened subtropical anticyclones and trade winds over the Pacific? Are these changes a direct atmospheric response of TP removal, or including feedbacks of SST? In the revised version, the authors should explain why these atmospheric changes appear in their simulations. This explanation is helpful to judge if the weakening of AMOC is an amplified result due to feedbacks of ocean circulations and SST.

First, the intensified westerlies over the North Atlantic in response to the TP removal is due to the absence of barrier effect from the TP allowing the atmospheric jet stream and associated low-level winds to become more zonal. Besides, the standing waves in association with the TP removal are also absent, leading to less orographic gravity wave drag and stronger winds (Palmer et al., 1986; Sinha et al., 2012). As shown in the revised version, the intensified surface westerly winds over the upstream of TP are clearly simulated (Fig. 2c on page 22).

Meanwhile, both theoretical studies and numerical simulations have demonstrated that the TP uplift strengthens the Asian summer monsoon and in turn diabatic heating over the Asian monsoon region, which provides a critical role in the formation and maintenance of the summer North Pacific subtropical high (Ruddiman and Kutzbach, 1989; Rodwell and Hoskins, 2001; Kitoh, 2004). In particular, during the summertime, the upper-level divergence associated with strong monsoonal ascending motion is located over the Asian region and adjacent oceans, while the upper level convergence circulation related to the descending motion is observed over the middle and lower latitudes of eastern Pacific (Please see the following Fig. S1a).

Comparatively, this circulation cell in the NTP is not as strong as in the MTP, indicating the weakening of both the North Pacific subtropical high and Asian monsoon (Please see the following Figs. S1b and S1c).

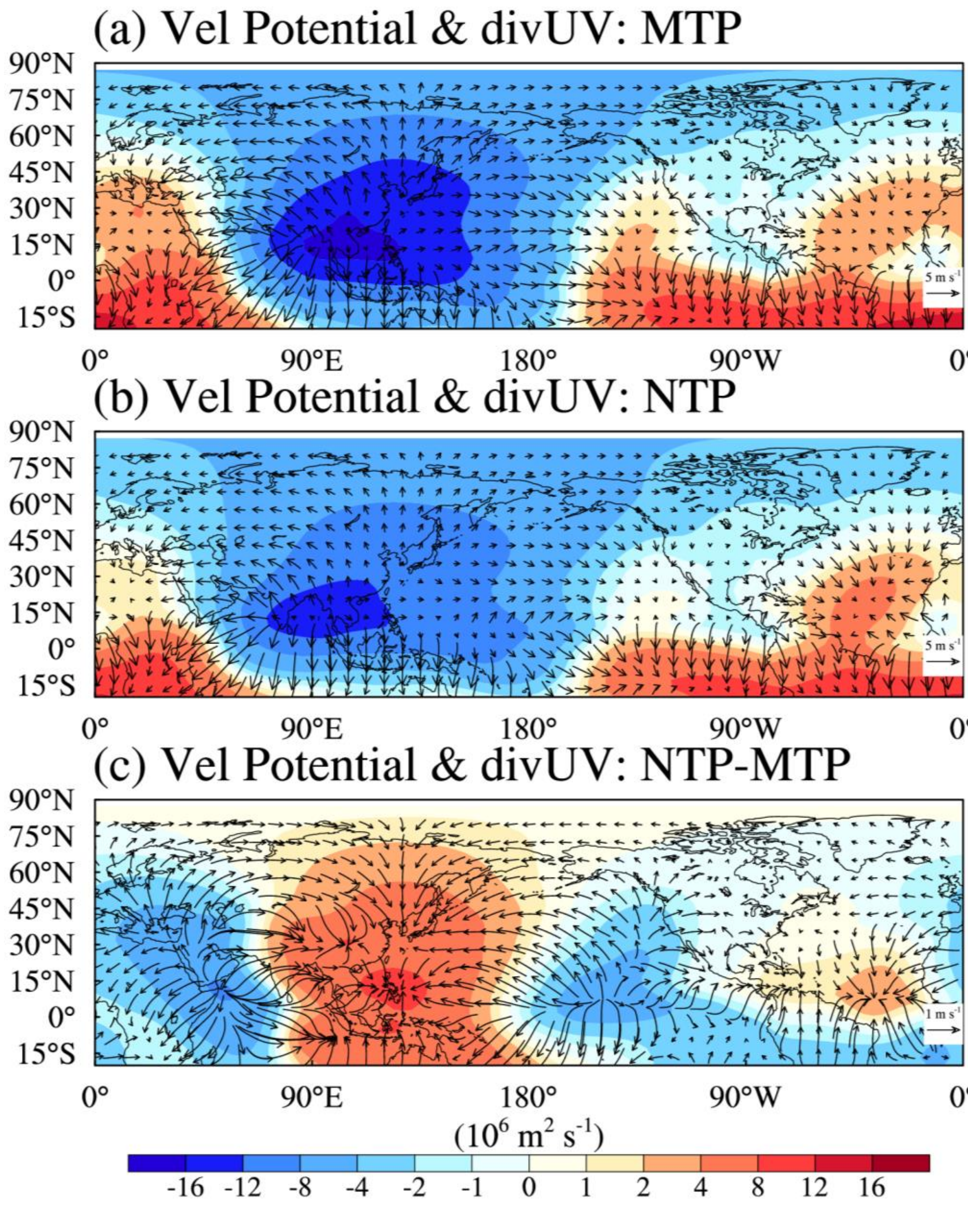

Figure S1. The Northern Hemisphere summertime mean velocity potential (contour) and divergent wind (vectors) at 200 hPa for the (a) MTP, (b) NTP, and (c) the differences between NTP and MTP.

Second, following your comment, we have supplemented a set of experiments with and without TP undertaken by the atmospheric general circulation model (AGCM) of CESM version 1.0.5, aiming to examine the feedback originating from the sea surface temperature changes. The 200-year climatologically averaged sea surface temperature prescribed in both the AGCM experiments is obtained from the MTP experiments undertaken by coupled atmosphere–ocean general circulation model (CGCM, CESM version 1.0.5). Both AGCM experiments are integrated for 50 model years, and the further analysis is performed based on the results of the last 30-year simulations.

In the CGCM experiments, the removal of the TP significantly causes a weakening of the North Pacific subtropical high and an overall weakening of the low-level tropical trade winds (Please see the following Fig. S2a). Similar changes are seen in the AGCM experiments, but with an overall weaker intensity (Please see the following Fig. S2b). Relative to the results of AGCM experiments, there is a clear decrease of tropical trade winds over the North Pacific and an increase of low-level westerly over the North Atlantic in the CGCM experiments (Please see the following Fig. S2c), indicating that the changes of sea surface temperature and oceanic circulations further amplify atmospheric circulation anomalies due to the TP uplift. Thus, we believe that the decrease of AMOC in our simulations is primarily attributed to the direct response of atmospheric circulation to the removal of the TP, and the oceanic feedback further amplifies this response. Considering the aforementioned atmospheric responses in association with the TP uplift have been addressed by many AGCM and CGCM simulations, we do not describe them in detail. Alternatively, we have added a short description on these processes in the revised version (L149–154).

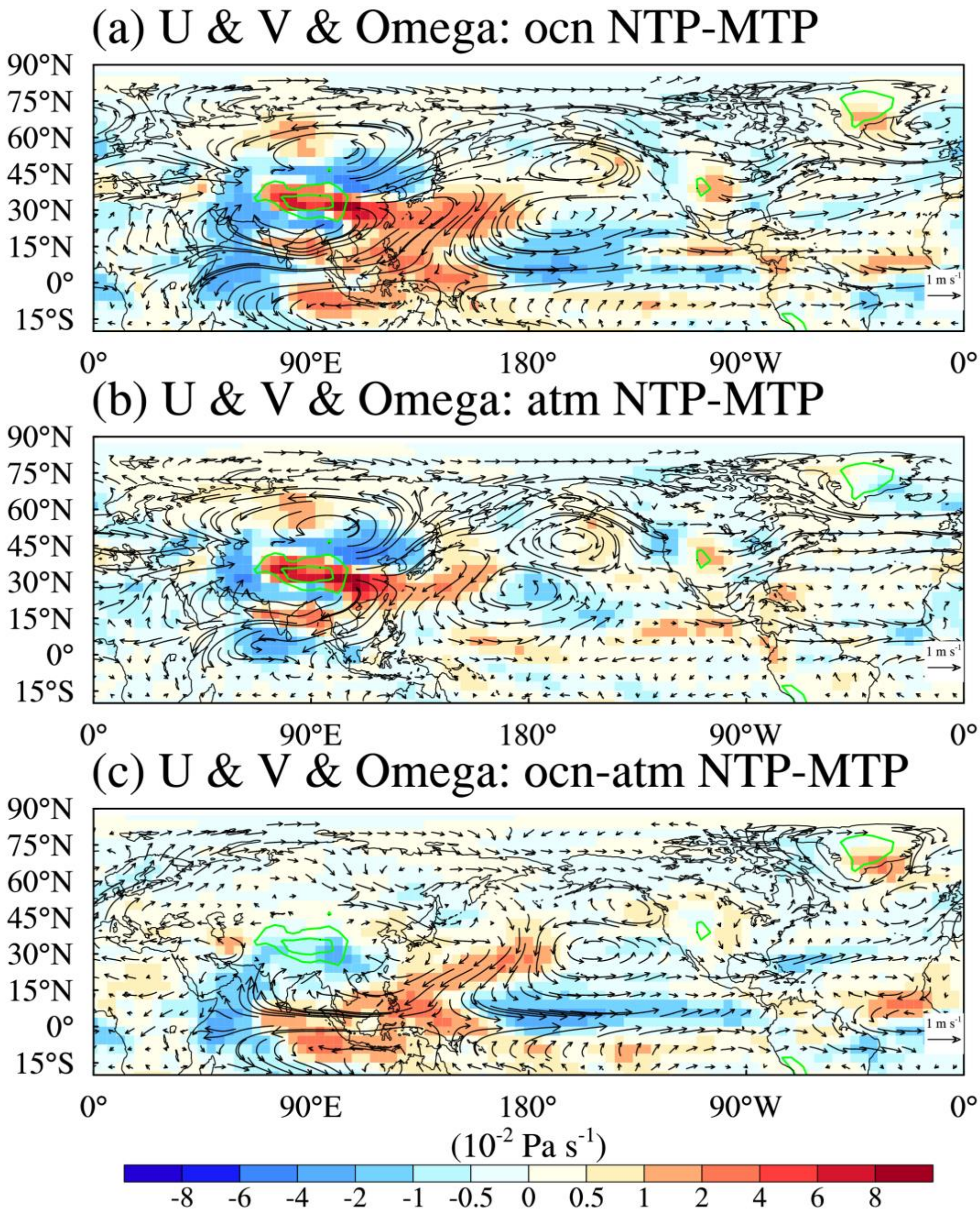

Figure S2. Changes of annual mean 500 hPa vertical velocity and 850 hPa wind in NTP relative to MTP for the (a) CGCM, (b) AGCM, and (c) differences between CGCM and AGCM. Green contours surround the areas with topography higher than 2000 m and 4000 m, respectively.

(2) In the NTP experiment, the net freshwater flux increases by 0.005 Sv at the initial stage, but by 0.025 Sv at the final stage. The author should discuss a little bit in the revised version, if fresh water flux of 0.005Sv is strong enough to trigger the weakening of AMOC. Is the model too sensitivity to a small change in fresh water flux?

We have compared the magnitude of net freshwater flux in our simulations with two earlier simulations, although there exists difference in the experimental configuration. Sinha et al. (2012) indicated a final net precipitation flux anomaly of approximately 0.02 Sv across the Atlantic basin (30–60 °N). Maffre et al. (2017) indicated that the net freshwater flux anomaly over the North Atlantic (22–60 °N) is approximately 0.0446 Sv and 0.097 Sv at the beginning and final stages, respectively. First, it should be noted that these two previous simulations with respect to the freshwater flux anomaly are obtained from simulations with and without global mountains, rather than the TP alone in our experiments. As such, the atmospheric circulation responses to the topographic modification in their experiments might be stronger than ours. Second, the area that they calculated the freshwater flux is over the North Atlantic at 22–60 °N, and the grid mesh is greater in size than ours at 40–70 °N. Third, Maffre et al. (2017) emphasized the net freshwater flux over the tropical Atlantic could play an important role in the AMOC weakening. We do not exclude the importance of the net freshwater flux over the tropical–subtropical Atlantic, since it has been well revealed that the warm and salty waters of the tropical–subtropical North Atlantic circulate north to the sub-polar regions of the North Atlantic via the Gulf Stream, and evaporation causes the surface waters to cool and thus the formation of North Atlantic Deep Water. Even though the net freshwater flux in our simulations is less than that in Maffre et al. (2017), it is difficult for us to determine the sensitivity of AMOC in response to the net freshwater flux in our simulations. Because we have identified the important role of wind-driven sea-ice process in initially triggering the AMOC weakening in our simulations. Thus, to answer the abovementioned question, a series of sensitivity experiments with the modification of the net freshwater flux are necessary to be performed. However, this topic is beyond the scope of this study and needs to be investigated in the future.

Reference

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