Replies to Reviewer #1:

We would like to appreciate your time to review this manuscript and all your constructive comments. We have incorporated these suggestions into the latest version of the manuscript. The following are our point-by-point replies.

General Comments:

"This study presents coupled modelling results in which the authors test the effect of several different idealised versions of the world's topography, and show how each can impact the meridional overturning circulation. The authors argue that the combination of the Tibetan Plateau and the Antarctic topography are the most critical factors in determining the present configuration where we have an AMOC, but not a PMOC. The results are interesting, and mostly well presented, but there are some major gaps that have not been addressed in this study."

"Most prominently, the authors do not adequately discuss alternative hypotheses for what drives the modern day AMOC. This includes the work of Maffre et al (2018), who showed convincingly that the presence of the Rocky Mountains in North America can have a decisive impact on the presence of an AMOC and lack of a PMOC. Maffre et al also demonstrated that the river runoff generated by the North American topography has a large impact on the freshwater balance of the North Pacific and North Atlantic. The authors here ignore that line of evidence, and instead leave river runoff unchanged and then claim that only the Tibetan Plateau and Antarctic topography dictates the AMOC/PMOC, which is a rather unbalanced view of the evidence."

Response: Thank you very much for your valuable comments. Our work is inspired by previous studies including Maffre et al. 2018, Sinha et al. 2012, Schmittner et al. 2011 and so on. We are aware of the inadequacy of introducing these papers. And more discussions on the factors that shaping modern-day AMOC are added in the revised paper (Line 90~106).

By removing all the continental orography, all of the work concluded that there's a strong connection between mountains and ocean overturning circulation. Maffre et al.

(2018) emphasized the importance of Rocky Mountain on MOC pattern. They attributed the North Atlantic SSS change to the Rocky Mountain's presence. However, they modified all continental topography in their model experiments, it is hard to conclude the reason for the MOC shift being caused by an individual mountain. A previous work in our research group conducted only Rocky Mountain perturbed experiments and found that Rocky Mountain's existence has a weak effect on AMOC (Jiang and Yang. 2021). In Jiang's experiments, it is possible to analyze the individual contribution of Rocky Mountain by comparing OnlyRocky experiment and Flat experiment, rather than Flat and Real. They found that the net effect of the moisture transport tends to freshen the North Atlantic when Rocky Mountain exists. It is worth noting that the salt content increase in the Atlantic in the presence of global orography (Real-Flat). It represents that other orography may be more important to the moisture transport between the Atlantic and Pacific.

Su et al. (2018) removed the Tibetan Plateau (TP) from the modern topography using CESM, and they found that the AMOC was shut down and PMOC was established finally. The similar conclusion can also be found in Fallah et al. (2016). Actually, we have also shown in our previous studies that it is the flattened TP that leads to the collapse of the AMOC (Yang and Wen, 2020) and also more discussion in this paper.

Maffre et al. (2018) removed all continental orography in their experiments and found the AMOC collapsed in a flat world. They found that the increased freshwater export from the Pacific to the Atlantic through North America in the absence of orography freshens the North Atlantic and weakens the AMOC. And the runoff changes in the tropics contribute to the freshening of the Atlantic. But it is different from Schmittner et al. (2011), which found only small changes in runoff.

We did not change the river routing artificially. The runoff in CESM 1.0 is calculated in Common Land Model (CLM). It includes the liquid water runoff (R) and ice runoff (I). The changes of runoff in the simulations are adjusted according to the River Transport Model (RTM). The RTM uses a linear transport scheme at 0.5º resolution to route water from each grid cell to its downstream neighboring grid cell. The ocean freshwater liquid and ice fluxes are passed to the flux coupler that distributes the fluxes to the appropriate ocean grid cells.

Figure R1 show the runoff flux (units: mSv) anomalies in several experiments relative to Flat. Positive value means that the ocean gains fresh water. In general, the effect of river runoff change on the ocean circulation can be neglected. The magnitude of our river runoff is comparable with that of Schmittner et al. (2011).

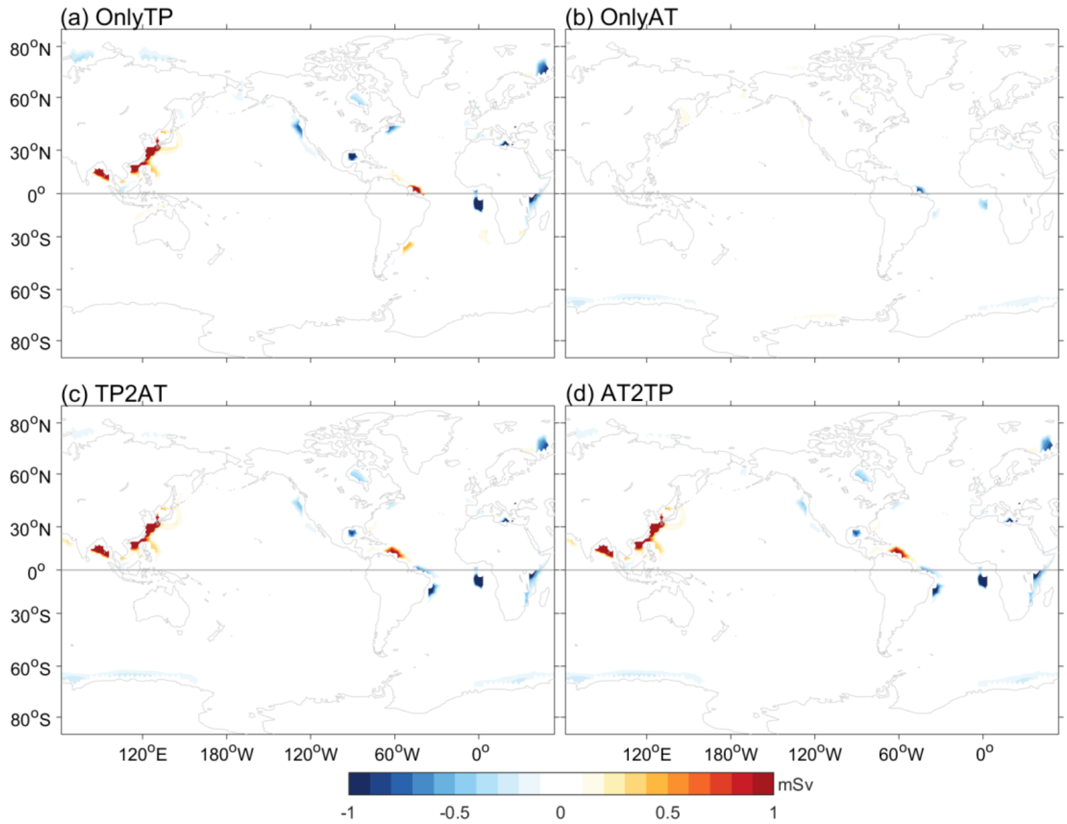

Fig. R1 River runoff flux (units: mSv) anomalies in (a) OnlyTP, (b) OnlyAT, (c)TP2AT, and (d) AT2TP, with respect to Flat. Positive value means freshwater gain by the ocean

"My main problem with their methodology is that they alter topography and ignore the effect that topography has on river routing. River routing maps are inherently set by the prevailing topography, which itself defines the drainage basins that are critical to the return of freshwater from land to ocean. Certainly, the flattening of mountains will change the structure of orographic precipitation, but to do that without considering changes to the river runoff ignores half the reason why the North American continent is important to the modern day AMOC."

Response: Thank you very much for raising this question. In the actual process of topographic uplift, the direction and discharge of river runoff will be changed. We did not change the river runoff artificially, but the direction and discharge of river runoff is adjusted in the simulations due to the topographic change (please see the discussion above). As the figure R1 shows, there is no robust change of river runoff among different topography experiments. Schmittner et al. (2011) also hold the opinion that river runoff is nearly the same for all the simulations without obvious systematic differences between them. Again, we conducted OnlyRocky experiment and we don't think Rocky Mountain matters much in shaping AMOC in our previous work (Jiang and Yang. 2021).

"My other main concern is that the "onlyTP" and "onlyAT" cases were both initiated from the "Flat" earth simulation, which is preconditioned to have a PMOC and not an AMOC. If they had instead initiated their onlyTP and onlyAT experiments with a temperature-salinity distribution from the "Real" experiment, that would test whether an already-established AMOC could continue with either the onlyTP or onlyAT topography. As of now they have not shown that an AMOC cannot form in those topographies. The authors do acknowledge that path-dependent results could exist, but I would argue that the onlyTP and onlyAT setups are the ones that are more likely to support bi-stability (i.e. it is possible they could sustain a PMOC or an AMOC if initiated with one or the other)."

Response: Thank you very much for your suggestions.

First, the reason why we conducted experiments integrated from Flat is that it is more like a natural geological process in the real world. Although we are not doing a paleogeology or paleoclimate research, the results presented here may have some important implications for the fundamental understanding of the AMOC mechanisms and its potential role in paleoclimate. Just as the discussion part has mentioned, the gradual TP uplift led to deflection of the atmospheric jet stream and precipitation over Eurasian continent. The global atmospheric and oceanic circulation will respond more like it did in the past during this process.

We have conducted serial experiments initiated from "Real" experiment before.

Based on Real experiment, we removed the Tibetan Plateau solely. In the equilibrium state of Real, AMOC is already established and would be collapsed immediately after TP is removed (Fig. R2). Combined with the Fig.2. in our paper, TP is essential for forming the AMOC. Besides, we also conducted “NoAT” experiment (Only Rocky Mountain, Andes Mountain, Greenland, and Tibetan Plateau exist), which is integrated from Flat conditions. It shows that Antarctic is important for forming PMOC instead of AMOC. There are also some analyses of NoTP vs. Real in our previous work (Yang and Wen. 2020). The responses of atmosphere and ocean identically distributed but with opposite signs. We did not show all of the serial experiments in our paper due to the journal limitation.

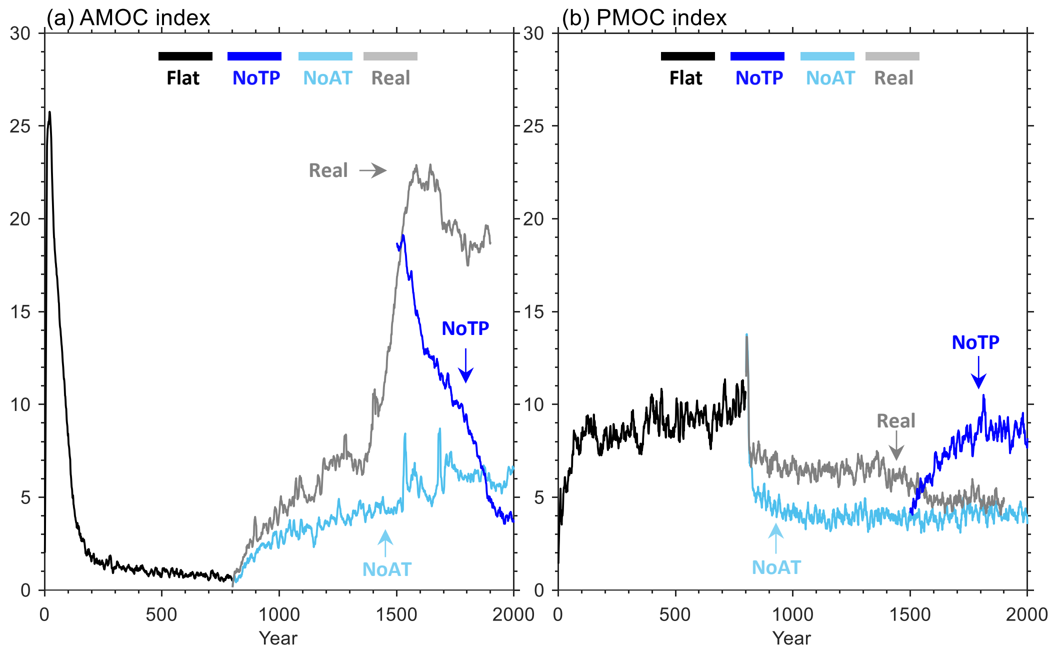

Fig. R2 (a) AMOC and (b) PMOC index (Unit: Sv; 1Sv = $10^6 m^3 Sec^{-1}$) evolution is presented for Flat, NoTP, NoAT, and Real experiment.

As for the “path-dependent” concern, there is no AMOC in many topography experiments, most of which we did not show in this paper. It is discussed thoroughly in Yang et al. (2024). AMOC strength is nearly unchanged in OnlyAM (Andes Mountain), OnlyGL (Greenland), and Only RM (Rocky Mountain). In OnlyAT experiment, AMOC is enhanced slightly. PMOC is very strong in Flat experiment, and TP itself can destroy it and induce a see-saw pattern in the Pacific and Atlantic. With the cooperation of AT, the AMOC can be as strong as in the Real experiment. We think this is not the “path-dependent".

AMOC indeed has the bistable characteristic, with two stable states—strong "on" and weak "off". Stommel raised this concept for the first time in 1961 and verified it in simple models (Stommel. 1961). Hawkins et al. (2011) also examines such bistability of AMOC by simulating the impact of varying freshwater inputs on the North Atlantic. Our study aims to explain the topography impacts on AMOC's "on" state, and the bistability is not our topic in this paper. We may consider to explore this in our future research.

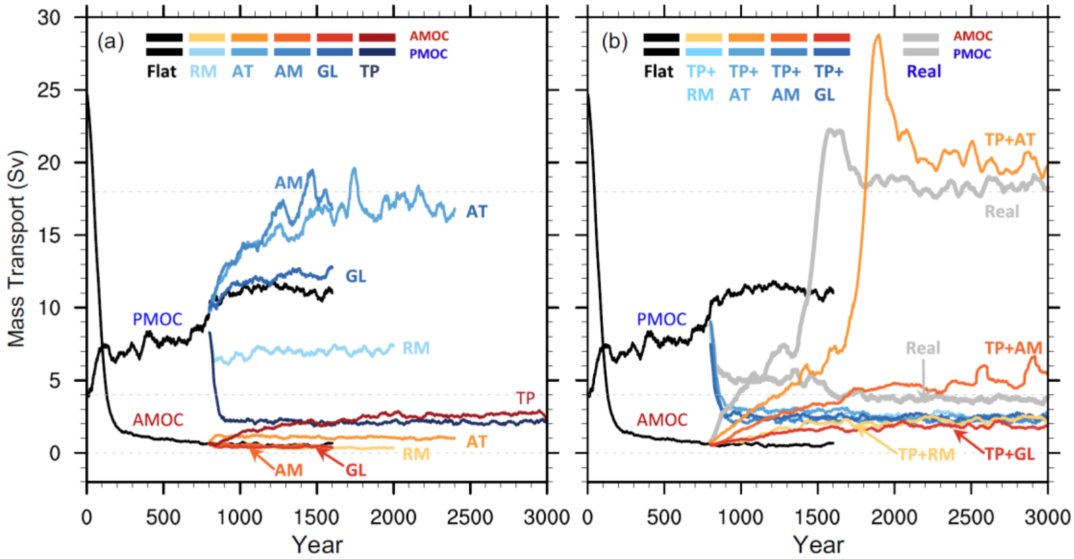

Fig. R3 Temporal evolution of the (a) Atlantic meridional overturing circulation (AMOC) and (b) Pacific meridional overturning circulation (PMOC) in different topography experiments. This figure is Figure 2 in Yang et al. (2024).

"Finally, there are some issues with the writing style that could be improved, with further comments below. I also found that the bibliography was incomplete, e.g. L241 refers to Yang et al (2015) and L353 refers to Yang et al (2016). These are not in the references."

Response: Thanks for your suggestions. The references have been revised.

"The authors also do not provide an adequate Data Availability statement."

Response: Thank you for pointing out this. We noticed that "data available upon request" statements need to be avoided according to the new data policy of *Journal of Climate*. We have collected all of the model output data in this paper into a zipped file, which can be downloaded at *****.

Detailed comments

"L31-33. "The combined influence of the TP and the Antarctica is the key driving factor". This statement ignores important evidence on the impact of North American topography and river runoff, as noted in my General comments."

Response: Thank you very much for this suggestion. TP and AT play a vital role in driving AMOC is a conclusion from Yang et al. (2024). Our work is based on that paper and try to explain the mechanism in details. It is also obvious in Fig. R3(b) that the AMOC can be very strong only when TP and AT exist together. Other topographies also play a role but not as important as TP and AT. For example, as Fig. R3 shows, AMOC is hardly changed in OnlyRM experiments and slightly enhanced in TP+AM experiment. The existence of RM does not significantly alter the global atmospheric circulation, and RM has very limited impacts on the AMOC and PMOC. Please refer to our responses to your general comments above.

"L49: "a hot topic is in climate research": grammar is wrong here."

Response: Sorry. Revised.

"L58: Why the word "Indeed"? I suggest to delete filler words like this."

Response: Thanks for the suggestion. Deleted.

"L70-71: The wording here "only the Antarctic has the capability to complement the TP's influence" is not true when you consider the major role of North America as shown in Maffre et al (2018)."

Response: Thanks for pointing out this. As we discussed before, we think such expression is believable in our experiments. When considering the individual effects of North American topography, such as Rocky Mountain, it plays a trivial role in Northern

Hemisphere deep-water formation (Jiang and Yang. 2021).

“L91: "collaboratively" is a little too anthropomorphic. Please use a more neutral term.”

Response: Thanks for your suggestion. Replaced “collaboratively” by “jointly”.

“L97: "[check]" incomplete editing of the manuscript.”

Response: Sorry. Deleted.

“L99: "Sdection5": as above”

Response: Done.

“L105: "interaction" should be "interactions"

Response: Revised.

“L107: the label T31_gx3v7 is meaningless unless it is directly linked to an easily findable dataset or configuration which has that marker. It also doesn't tell the reader what is the resolution (which was the point of the sentence).”

Response: Thanks for your suggestion. We have rewritten that part. Check Line 127~134 in the revised paper.

“L110: gx3v7 is meaningless to most readers. Please specify the resolution.”

Response: Thanks. Revised.

“L127-128: The "equilibrium" states are almost certainly not in a true equilibrium. It may be that the MOC is relatively stable, but the deep ocean temperature and salinity are almost certainly not in equilibrium less than 1000 years after a perturbation. Please quote the deep ocean temperature drift for clarity and I suggest using the term "quasi-equilibrium" because it takes much longer timescales to get temperature-salinity equilibria.”

Response: Thanks for your suggestions. We have changed all occurrences of "equilibrium" to "quasi-equilibrium".

"L143: "collaborative" again is an anthropomorphic description. Should be more neutral."

Response: Thanks for pointing out this. Replaced "collaborative" by "combining".

"L148: see comment above on equilibrium"

Response: Revised.

"L148-150: the statement about statistical significance is meaningless because (a) they don't explain properly which data were used to compare significance, and (b) they don't show any of their results. Please remove statements about statistical significance - in my view it is not especially relevant to this study anyway."

Response: Thanks for your suggestion. We agree with that and have deleted this statement.

"L153: "nowadays" is colloquial, please rephrase"

Response: Replaced it by "currently".

"L174: "The presence of the TP is to suppress..." This doesn't make sense, please rephrase."

Response: Sorry. Revised.

"Figure 3-10: In all of the figures with a blue-red colorbar, the colorbar itself appears to be unbalanced at the low end values. The (-0.5, 0) range is light blue, while the (0, 0.5) range is white. The positive low values should have a similar level of shading as the small negative values. Please correct this imbalance throughout the blue-red figures with an improved color scale."

Response: Thanks very much for your suggestion. All of the figures are replotted with a balanced blue-red colorbar now.

“L189: "synergistical" is a corporate buzzword that should be kept out of scientific papers.”

Response: Thanks. Replaced it by “joint”.

“L194: "with a mild freshening occurs": grammar is wrong”

Response: Sorry. Revised.

“L198-200: While the author(s) might have worked on the role of salinity before, they are by no means the first to do so. Perhaps some earlier key references on Pacific-Atlantic salinity would be appropriate here, e.g. the review of Ferreira et al (2018) and many other examples within that paper.”

Response: Thank you very much for this valuable suggestion. We have rewritten this part by adding more explanations and quote Ferreira et al (2018)’s work as well. Please see Line 223~233 in the revised paper.

“L203-204: "surface freshening in the Pacific is hardly changed (Figs 4a3, a4)." This statement is confusing because there are quite strong freshening anomalies shown Figure 4a3 and 4a4 which appear to contradict this statement. Perhaps what the authors meant was that the SSS anomaly is very similar to the OnlyTP case (if so, they should correct the text here).”

Response: Sorry for the misleading statement. We have reorganized this sentence based on your suggestion.

“L220-222: "the TP alone has a controlling influence on the ocean state across much of the Pacific, including both the wind-driven and thermohaline circulations". This statement seems like overreach to me, see general comments about other influences on the AMOC/PMOC.”

Response: Thank you very much for your comments. As we explained above, TP plays a relatively important role in shaping ocean thermohaline circulation in our serial experiments (Yand and Wen. 2020; Yang et al. 2024) and also some previous work (Su et al. 2018; Fallah et al. 2016). But such statement is too strong, we have replaced “controlling” by “important”.

“L226: "synergistic": please avoid corporate buzzwords.”

Response: Sorry. Deleted.

“L227: "dictating the characteristics of global ocean circulations": "dictating" is too strong a word here. "influencing" would be better.”

Response: Thank you. Revised.

“L242: "have significant effects" should be "has significant effects"”

Response: Thanks. Revised.

“L243: The vectors shown in Figure 5 are very unclear over South-East Asia and don't make a lot of sense. Please redraw the figure to make the vectors readable, or even remove them to plot separately.”

Response: Thank you for your suggestion. We have redrawn this Figure.

“L245: [water vapor?]: please fix this”

Response: Sorry. Deleted.

“L246-247: This convergence is not clear because the vectors are unreadable.”

Response: We have redrawn Figure 5. Hope it can be seen clearly now.

“L268: Please explain why Ekman pumping changes are favourable for shutting down PMOC.”

Response: Thanks for your question. The anomalous Ekman upwelling in the Northern Pacific pumps fresh water upward and is forced by the anomalous low-pressure systems above (Fig. R4), which can suppress the vertical mixing and subduction process.

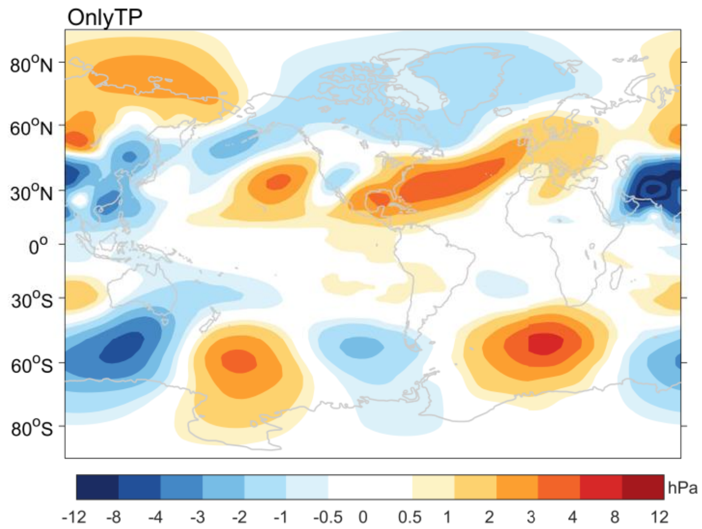

Fig. R4 Changes in sea-level pressure (shading, units: hPa) in the Only TP experiment with respect to Flat.

"L294: "The TP alone can affect" The wording is too strong, there are other factors that can affect the Rossby wave train. Please moderate."

Response: Thanks for your suggestion. We agree that other topographies can also affect the Rossby wave train. What we wanted to express is that TP can have remote effects on the Antarctic circumpolar current and the Agulhas leakage through Rossby waves in the OnlyTP experiment. We have rewritten this sentence to avoid the confusion.

"L299: Please delete "It is seen that"."

Response: Thank you. Done.

"L308: "in term" should be "in terms"."

Response: Done.

"L310-313: While these points are interesting, I think it would be a better test to see if the OnlyTP or OnlyAT topographies can sustain an AMOC when initiated from the "Real" topography initial conditions rather than the flat topography ICs. Because

here they must overcome an initial state that is pre-conditioned to have a PMOC, whereas if the temperature and salinity were initialised from an AMOC state, the results might be different."

Response: Thank you very much for your valuable suggestions. Due to the limitation of computational resource, we didn't conduct OnlyTP or OnlyAT initiated from "Real" topography. But we have conducted the experiment called "NoTibet" as mentioned above, which is initiated from "Real" scenario. AMOC is strongly reduced and PMOC is enhanced after TP is introduced (Fig R2).

"Figure 7: The continent outlines in the left column plots are a bit faint, and could be made stronger. Especially 7a1, where the continents are almost invisible."

Response: Thank you for pointing out this. Figure 7 has been redrawn.

"L332-333: "as zonally integration": fix grammar."

Response: Thanks. This sentence has been revised as follows: "The meridional water mass transports are calculated by integrating the meridional velocity zonally over the depth range of 2000-3000 m across 30°S in the Atlantic and Indo-Pacific basins, respectively".

"L345-346: "sea ice after year 3200 (3600) in TP2AT (AT2TP)": Please don't use this bracketed form to combine two separate statements into a single phrase. See the opinion piece by Robock (2010) for an explanation of why this should be avoided.

Response: Thank you very much for the recommendation of Robock (2010). We have read this short paper and realized that parentheses should only be used for clarification and references. We have separated the original sentence from two parts in the revised paper.

"L347: "over there" is a colloquial expression. Please specify the basin instead."

Response: Thank you. Revised.

“L349-351: "after year 3200 (3400) in TP2AT (AT2TP) (Figs. 350 2a, 9a, b), with the AMOC (and correspondingly, sea ice) reaching its maximum (minimum) within approximately 200 years". Here is an example where brackets are used both as an "opposite" and as a "clarification" and then an "opposite" all in the same sentence. It's exactly the confusion that Robock (2010) identified should be avoided.”

Response: Thanks for pointing out this writing problem. We have reorganized this sentence to make it clearly in the revised paper.

“L381: "The only existence of the TP." Grammar”

Response: Revised.

“Figure 10: The colorbar is absent.”

Response: Thanks for your careful tip. Figure 10 is the schematic diagram, which aim is to show simple concept of TP and AT’s joint role in regulating AMOC and PMOC. Subplots with shading patterns are the same as Figure 3 in the paper, so, we did not show the colorbar.

“L407: "over Eurasian" should be "over the Eurasian"”

Response: Thanks. Done.

“L429-430: "There is no doubt that these two colossal topographical features have shaped the fundamental structure of the global climate." This is a rather lyrical statement that I think does not add much to the scientific argument, and in any case, ignores some important features such as the North American continent, among other things. I suggest to delete it.”

Response: Thanks for your suggestion. We have deleted this sentence.

“L439: This is not an appropriate data availability statement. All model data presented in the manuscript should be available in an open access data repository, as

per the journal's guidelines."

Response: Thank you for the reminder. We have collected all of the model output data in this paper into a zipped file, which can be downloaded at *****.

References

Maffre, P., J.-B. Ladant, Y. Donnadieu, P. Sepulchre, and Y. Goddéris, 2018: The influence of orography on modern ocean circulation. *Clim Dyn*, **50**, 1277–1289, https://doi.org/10.1007/s00382-017-3683-0.

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Fallah, B., U. Cubasch, K. Prömmel, and Coauthors, 2016: A numerical model study on the behavior of Asian summer monsoon and AMOC due to orographic forcing of the Tibetan Plateau. *Clim. Dyn.*, **47**, 1485–1495, https://doi.org/10.1007/s00382-015-2914-5.

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Stommel, H., 1961: Thermohaline convection with two stable regimes of flow. *Tellus A*, **13**, 224–230.

Replies to Reviewer #2:

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

"In this manuscript, the authors studied the effect of rising Tibet Plateau and Antarctic on the AMOC and PMOC using a set of specially designed experiments run by the low resolution CESM1. They found that with a globally flat mountains, AMOC collapses and PMOC establishes. With a rising Tibet Plateau, PMOC weakens and AMOC start to establish, and by adding a rising Antarctic, PMOC collapses and AMOC establishes. Thus they concluded that it is essential to have the Tibet Plateau in order to have AMOC, and the Antarctic boosted the AMOC strength. I found this result is very interesting and the authors have demonstrated their findings thoroughly. I would like to suggest this manuscript being accepted for publication after some minor revision."

Response: Thank you very much for your encouraging comments.

Comments:

"1. It is not totally clear how the AMOC and PMOC are defined in the manuscript. Usually with our community, we define AMOC as the maximum of the Atlantic meridional streamfunction below 500m depth. Doing so is to avoid the effect of the subtropical cell (STC). At the same time, we also define PMOC in the same way if there is a PMOC. So my question is if the authors define AMOC and PMOC this way, does the result change?"

Response: Thanks for your question. The AMOC and PMOC index are defined as the maximum streamfunction in the range of 400~2000m of 20°~70°N in the North Atlantic and North Pacific, respectively. The definition of this calculation is based on and improved from Jiang and Yang's work (Jiang and Yang. 2021). We have added how we calculate AMOC and PMOC into the revised paper at Line 194. And we also tried the calculation of the "maximum of the Atlantic meridional streamfunction below 500m depth". As Figure R6 shows, the different definition of MOC index doesn't bring any changes here.

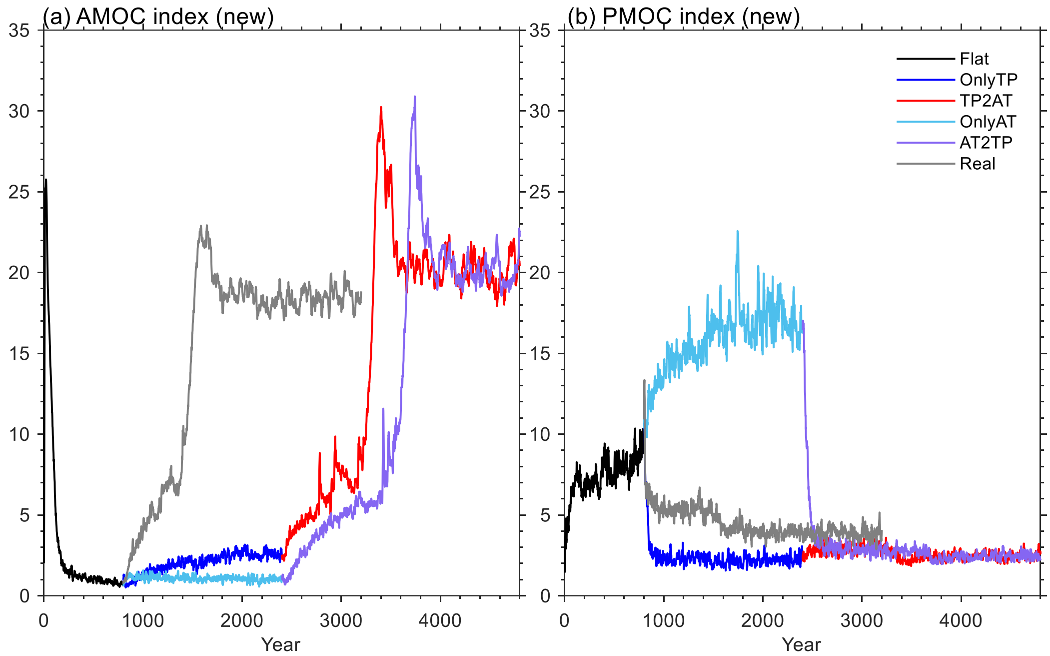

Fig. R5 Temporal evolutions of (a) the Atlantic meridional overturning circulation (AMOC) and (b) Pacific meridional overturning circulation (PMOC) in different topography experiments (units: Sv; 1 Sv = $10^6 m^3 s^{-1}$). Noted that this figure is the same as Figure 2 in the paper, but using a new definition of MOC index as suggested.

"2. From Fig. 3b1, the deep convection in the subpolar North Pacific is very weak. There are a portion at least of the PMOC related convection is in the subtropics. So in this sense, how much of the PMOC is in the sense as AMOC, a thermohaline driven circulation? and how much of PMOC is more wind driven?"

Response: Thank you very much for your question. Similar to the AMOC, the PMOC has an interhemispheric structure, suggesting its remarkable thermohaline component. So, the MOC is composed of two main components: a wind-driven component and a thermohaline component (Weaver et al. 1993; Toggweiler and Samuels 1995). The wind-driven MOCs, particularly the shallow ones known as Subtropical Cells (STCs), are primarily confined to the tropical regions.

As Figure 3 shows, the wind-driven circulation parts are indicated by boxes located in the upper 300m between 30°N and 30°S (Fu et al. 2022). Nearly little changes of wind-driven circulation have been found in different topography experiments. And when we calculate the MOC index, we consider it as the maximum streamfunction in the range of 400~2000m of 20°~70°N in the North Atlantic and North Pacific, respectively. In other words, we only consider the thermohaline part in the analysis, which has a more obvious difference among the experiments.

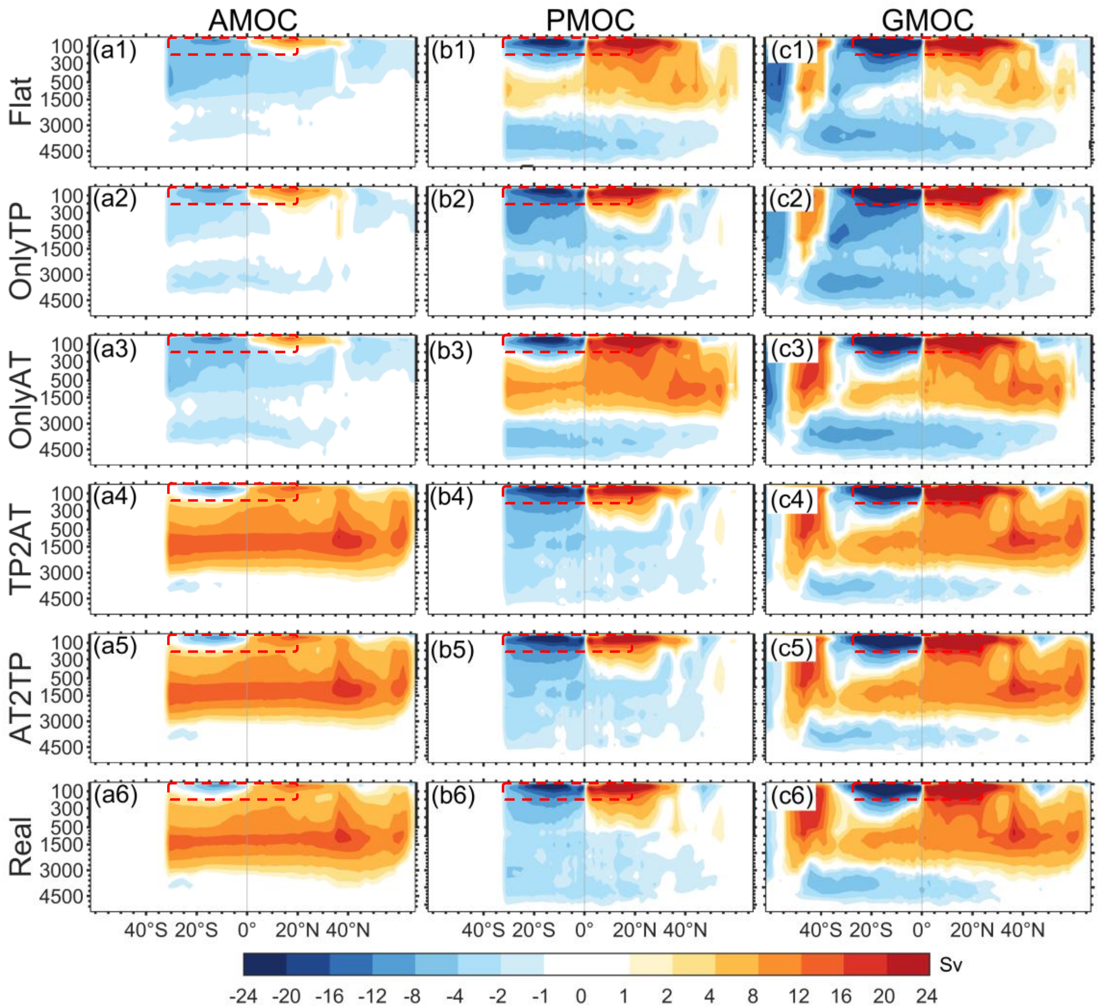

Fig. R6 Patterns of (a) the AMOC, (b) PMOC, and (c) GMOC in different experiments (units: Sv). The same as Figure 3 in the paper but added indication boxes.

"3. Since a low resolution of the CESM is used, is the Bering Strait open or closed. If it is open, by default, it requires to have three grid points at Bering Strait which makes this strait much wider than reality. How this wider Bering Strait will affect your results. If it is closed, how this closed Bering Strait will affect your result."

Response: Thanks for your suggestion. We maintain the modern-day configuration of bathymetry, continental layout, greenhouse gas concentration, incident solar radiation, and orbital parameters in our experimental design (Line 447~449 in the revised paper). The Bering strait is open in our model but it is wider than reality because of the coarse resolution.

The width of Bering Strait may affect the strength of AMOC. Hu et al. (2015) found that the closure of the Bering Strait slows Arctic Sea ice movement, reduces water exchange and sea ice export between the Arctic and North Atlantic, and decreases fresh water in the North Atlantic. These factors increase upper ocean density, which in turn enhance the AMOC (Fig. R6). In other words, the wider Bering Strait in our experiments causes a relatively weaker AMOC.

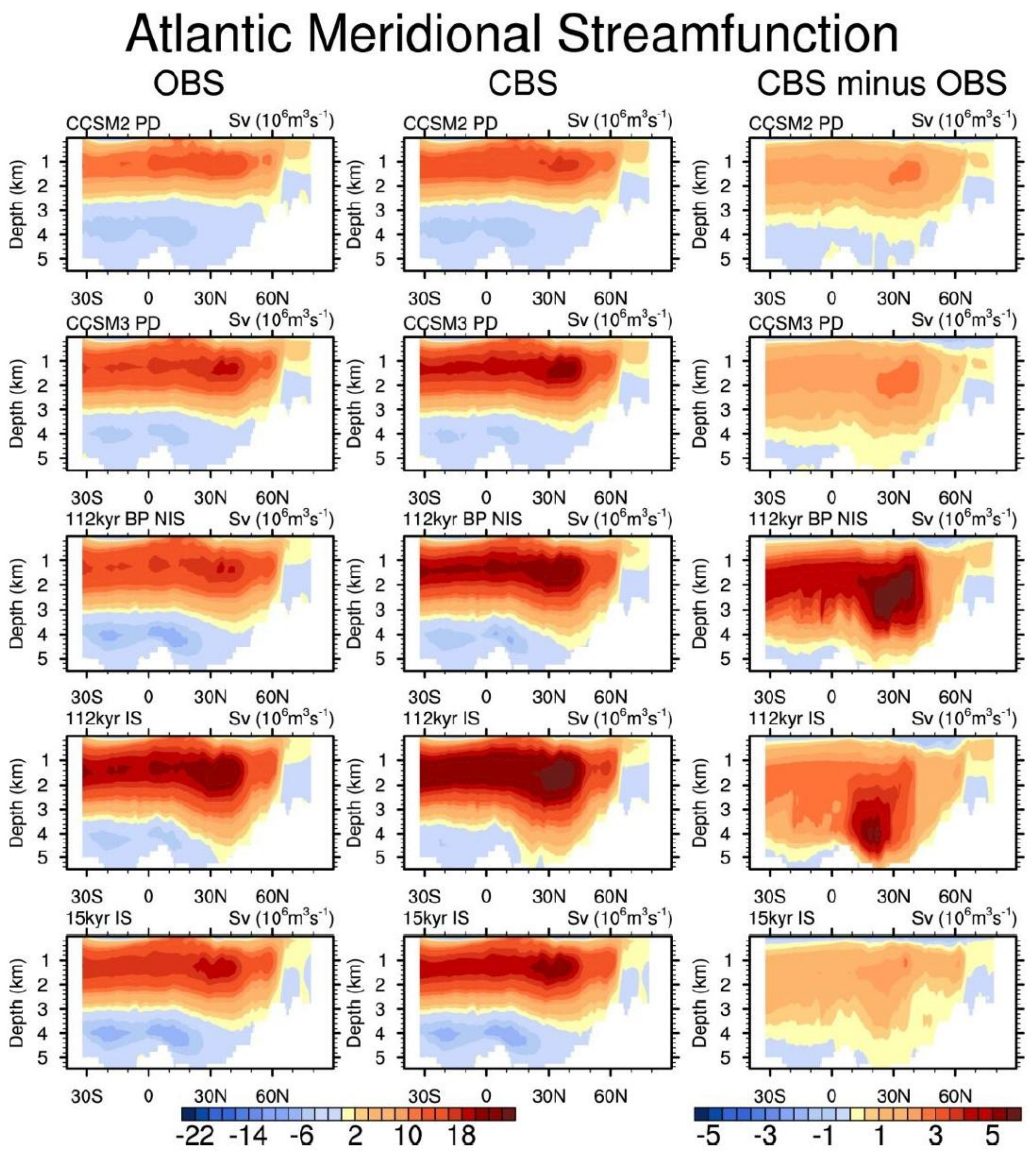

Fig. R7 The Atlantic meridional streamfunction is shown across three panels: the left panels for the open Bering Strait simulation, the middle panels for the closed Bering Strait simulation, and the right panels for the changes between the two. "PD" refers to present day; "kyr BP" to thousand years before present; "NIS" to no North America ice sheets; and "IS" to with North America ice sheets. Simulations labeled CCSM2 PD and CCSM3 PD use present-day climate conditions with CCSM2 and CCSM3 models, respectively. The 112kyr BP NIS simulation uses CCSM3 under 112,000 years before present conditions without North America ice sheets, while the 112kyr IS and 15kyr IS simulations use CCSM3 under 112,000 and 15,000 years before present conditions with North America ice sheets. This figure is adapted from Hu et al. (2015).

"4. From Figure 2, if the TP2AT or AT2TP experiments are directly branched from your flat experiment, the results will be the same? or there will be some changes?"

Response: Thank you very much for your question. The TP2AT experiment is branched from the OnlyTP experiment adding Antarctic terrain to that. And the AT2TP is integrated from the OnlyAT scenario introducing TP to that. The primary distinction between "TP2AT" and "AT2TP" lies in the sequence in which the terrains are incorporated. When we focus on the quasi-equilibrium state of these two experiments, the results are nearly the same with some mild differences.

"5. In Figure 4, the deep convection in the subpolar North Pacific seems very weak. This means that PMOC shown here may not be the counterpart of AMOC."

Response: Thank you very much your comments. In the TP-related experiments, we agree that the deep convection in the subpolar North Pacific is weak. Because TP can suppress the deep-water formation there and contribute negatively to PMOC.

It is noted that Figure 3 in the paper is the original pattern of different topography experiments. But Figure 4 shows the differences between the topography disturbed experiments and the Flat experiment. We consider the thermohaline part of MOCs and calculate them in the same way except for the different regions of AMOC and PMOC. We think they are the counterpart of each other.

"6. Lines 264-271, should this change in westerlies also reduce the evaporation in the Atlantic? On the other hand, the increase of westerlies in SH will increase evaporation there. Is this increased water vapor transported to NH?"

Response: Thanks a lot for your valuable questions. The weakening of mid-latitude westerlies in the Northern Hemisphere also leads to reduce the evaporation in the North Atlantic. Surface latent heat flux is increased over the NADW region due to the removal of TP. In other words, the existence of TP would reduce the evaporation over the North Atlantic region.

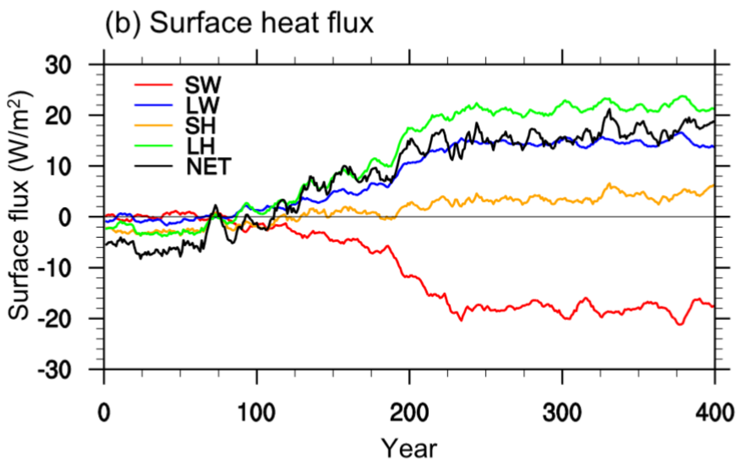

Fig. R8 Temporal evolutions of surface heat flux. The red curve is for shortwave radiative flux (SW); blue is for longwave radiative flux (LW); orange and green are for SH and LH, respectively; and black is for net surface heat flux (NET). All curves are for changes in NoTibet, with respect to Real. This figure is adapted from Yang and Wen. (2020).

In the OnlyTP experiment, the increasing of westerlies in the Southern Hemisphere is not as obvious as that in the Northern Hemisphere. We consider this wind changing effect is mild, especially when compared to the OnlyAT, TP2AT, and AT2TP scenarios. We are not sure if the increased water vapor could transport to the NH. Here we only wanted to emphasize the importance of the strong Ekman upwelling due to the Antarctic. Only in the AT-related scenarios, the Ekman upwelling is increased obviously, which contributes positively to the NADW formation thus enhancing AMOC indirectly.

"7. Figure 8, is there a reason to choose 2000-3000 m? Does this really represent

the southward flow or the lower part of the AMOC or PMOC?"

Response: Thanks for your question. The choice of 2000~3000m is referred to Yang et al. (2024). According to Cunningham et al. (2007), the Intermediate Water, located between 800m and 1100m depth, typically flows northward. And the Upper North Atlantic Deep Water (UNADW), which lies between 1100 and 3000 meters, generally flows southward. Additionally, the Lower North Atlantic Deep Water (LNADW) below 3000 meters also flows southward. It can also refer to our Figure 3 in the paper. The main signal of MOC locates above 3000m. Therefore, the 2000m to 3000m depth range effectively represents a key portion of the southward flow within the AMOC or PMOC.

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