Referee#1:

This manuscript is well written and tires to clarify the role of the Himalaya uplift, Iranian Plateau (IP) uplift and atmospheric CO2 on SASM evolution in the mid-Miocene. They suggest IP uplift to be the main factor causing enhancement of SASM. Overall, I do recommend this study for publication after some revisions. Some suggestions and comments are listed below.

Response: We appreciate this suggestion very positive, below we account for all the comments from the referee.

1. There are several uncertainties in the Middle Miocene paleogeographic boundary conditions (Frigola et al., 2018) used in the simulation, such as the eastern Tethys seaway and Greenland-Scotland Ridge are deep water gateways, and the Bohai Bay and Yellow Sea basins in East Asia are shallow sea environments, which are inconsistent with many geological records (e.g., Sun J.M. et al., 2021, Paleo-3; Tan M.X. et al., 2020, Marine and Petroleum Geology; Stoker M.S. et al., 2005, Marine and Petroleum Geology). Some uncertainties of the boundary conditions are discussed in Section 5.3.

   Response: Thanks for this constructive suggestion. It is important to conduct paleoclimate modeling with "realistic" paleogeographic boundary conditions to improve our understanding of Miocene climate changes and narrow down model-data discrepancies. When we started to perform Miocene simulations in early 2020, a few paleogeographic reconstructions were available, but they presented many differences and uncertainties. We chose the one produced by Frigola et al. (2018; henceforth F18) because it is based on the widely accepted Middle Miocene reconstruction (Herold et al., 2008) and is relatively recent. However, as the referee pointed out, in F18 there are some uncertainties that should be addressed. Following the referee's suggestion, we add and extent the discussion regarding the uncertainties in the IP uplift, the Tethys/Paratethys configuration and the surrounding topographies. The added discussion is the follow (not the final version):

   "Geography, particularly the land-sea distribution, is another important driver for Asian monsoon development (Ramstein et al., 1997; Farnsworth et al., 2019; Sarr et al., 2022; Tardif et al., 2023). The paleogeography used in our Middle Miocene simulations, like other reconstructions (Herold et al., 2008; He et al., 2021, and references therein) inevitably contain uncertainties. For instance, the Bohai Bay and

Yellow Sea basins in East Asia are open in the F18, but they are set as land in a recent reconstruction (He et al., 2021) aligning with regional stratigraphy and lithofacies records (Tan et al., 2020). The Greenland-Scotland Ridge in F18 is set as ~4000 m, significantly deeper than a middle bathyal environment (<1000-m deep) indicated by geological evidence (Stock et al., 2005). Large uncertainties also present in the Tethys/Paratythes configuration. The Tethyan Seaway is open with a depth of over 3000 m in F18, significantly deeper than the geological evidence that indicates the eastern Tethys Seaway intermittently open during ~15-12.8 Ma (Sun et al., 2021). During the Burdigalian to the Serravallian interval, the Paratethys was intermittently connected and disconnected from the global ocean according to geological studies (Rogl, 1999). It is assigned to connect to the global ocean in F18 as in Herold et al. (2008) while it retreats to the Carpathian-Black Sea-Caspian Sea region and is connected with the Mediterranean in He et al. (2021). In short, the land-sea distribution in F18 reflects more the feature of early Middle Miocene geography. As a result, the size of the IP is likely small for the middle-late Miocene, leading to uncertainty in interpreting the effects of the IP on the SASM. The extent to which these uncertainties impact regional climate and global ocean circulations remains unclear, highlighting the need for further investigation in the future."

2. In this study, authors lumped together all the mountain ranges west of the Himalayan, including the Hindu Kush and Pamir as the IP. The uplift history of the Iranian plateau, Hindu Kush, Pamir and East Africa remains controversial. Some studies suggested that the IP and East Africa began to uplift in the late Oligocene–early Miocene and rapidly uplifted in the middle–late Miocene (e.g., Macgregor, 2015, Journal of African Earth Sciences; Mouthereau et al., 2012). Uncertainties of topographic uplift can be appropriately added to the discussion.

Response: Thanks for this valuable input. We insert the development history of the East Africa in the texted in Section 5.1, aligning with previous modeling studies and our simulation results:

"This aligns with geological evidence indicating that the East Africa began to uplift in the late Oligocene–early Miocene and rapidly uplifted in the middle–late Miocene (Macgregor, 2015)."

We also add text regarding the evolution history of the IP as the follow (not the final version):

"The evolution history of the IP uplift remains hotly debated (Agard et al., 2011; McQuarrie et al., 2003; Mouthereau, 2011; Ballato et al., 2017). Nevertheless, most studies suggest a Miocene age for the uplift of most landforms. Geological evidence indicates that in the northern sectors of the IP, the uplift likely occurred between 16.5-10.7 Ma (Ballato et al., 2016), particularly accelerated after 12.4 Ma (Mothereau, 2011) while in regions bordering the IP to the south between 15 and 5 Ma (Mouthereau, 2011). The Zagros orogen, a significant part of the IP, developed in three distinct pulses within the last ~20 Ma (Agard et al., 2011; Mouthereau, 2011). Our IP relevant sensitivity experiments reflect the possible range of IP uplift during the Middle Miocene. However, the configuration of Tethys/Paratethys in our simulations leads to small size of the IP. As a result, the effect of the IP uplift on the SASM is possibly underestimated."

3. Table 2: there are some errors and inappropriate references. For example, Zhuang et al. (2017) interpreted the late Miocene (11–10 Ma) ocean cooling as representing the establishment of monsoonal upwelling in the western Arabian Sea, which may not be suitable as evidence for the enhancement of SASM in the Middle Miocene. Betzler et al. (2016): "deposit" changes to "sedimentary and geochemical record". Bialik et al. (2020): "Precip" changes to "wind"; Ai et al. (2021): "Precip" changes to "wind". In these papers, authors mainly talked about wind/monsoonal upwelling, not precipitation.

   Response: Thanks for these notices and suggestions. We correct Table 2 as suggested. We also remove the reference Zhuang et al. (2017) as the evidence of SASM intensification during the Middle Miocene, which has no essential impact on our conclusions and discussions.

4. Table 2: "sample" changes to "proxies".

   Response: Thanks for this correction.

5. Lines 507 and 523: "geography" changes to "land-sea distribution".

   Response: Thanks for this suggestion. While we indeed emphasized the importance of land-sea distribution as demonstrated by the following cited studies, we add a discussion on the uncertainties in Greenland-Scotland Ridge which is bathymetry rather than land-sea distribution. Therefore, we maintain the term “Geography” but append a half sentence “particularly the land-sea distribution” to underline this aspect.

References:

Agard, P., Omrani, J., Jolivet, L., Whitechurch, H., Vrielynck, B., Spakman, W., Monié, P., Meyer, B., Wortel, R., 2011. Zagros orogeny: a subduction-dominated process. Geological Magazine 148, 692–725. https://doi.org/10.1017/S001675681100046X

He, Z., Zhang, Z., Guo, Z., Scotese, C.R., Deng, C., 2021. Middle Miocene (~14 Ma) and Late Miocene (~6 Ma) Paleogeographic Boundary Conditions. Paleoceanography and Paleoclimatology 36, e2021PA004298. https://doi.org/10.1029/2021PA004298

McQuarrie, N., Stock, J.M., Verdel, C., Wernicke, B.P., 2003. Cenozoic evolution of Neotethys and implications for the causes of plate motions. Geophysical Research Letters 30. https://doi.org/10.1029/2003GL017992

Mouthereau, F., 2011. Timing of uplift in the Zagros belt/Iranian plateau and accommodation of late Cenozoic Arabia–Eurasia convergence. Geological Magazine 148, 726–738. https://doi.org/10.1017/S0016756811000306