Reviewer 2

Dear referee,

Thanks a lot for your thorough and insightful review. The following is a point-to-point reply. The answers are in blue.

The authors investigated the multidecadal atmospheric bias teleconnections caused by the TIO SST bias and their impacts on the simulated atmospheric variability using an intermediate-complexity atmospheric model. The authors found that the atmospheric circulation biases caused by the TIO SST bias have a Gill-Matsuno-type pattern in the tropics and a Rossby wave-train distribution in the extratropics. They also showed that the TIO SST bias could influence interannual variations in the tropical Indo-West Pacific region, Australia, south and northeast Asia, the Pacific-North America region, and Europe.

It is important to understand how the tropical SST bias in the model could generate atmospheric teleconnection biases. I have read the manuscript with much interest. It was especially interesting to see the response of the teleconnections.

The paper is well-written and well-organized. Thus, I suggest the work be accepted subject to some minor revisions.

L230–235: Focusing on the boreal winter is fine. However, if you want to say "Indeed, the circulation bias in the tropics has the same pattern throughout the year, only with varying magnitude, and the extratropical biases are primarily observed in the Northern Hemisphere during boreal winter and in the Southern Hemisphere during boreal summer, albeit with much weaker intensity", please show it.

Sorry for the inaccurate statement. Figures R1 and R2 give the unbalanced and balanced wave circulation biases, respectively. We can see that the wave circulation bias in the tropics (25°S-25°N) follows a similar pattern throughout the year but with varying magnitude. The unbalanced fields are dominated by the Kelvin mode. The balanced fields are featured as a quadrupole structure in the tropics. The extratropical biases are primarily observed in the Northern Hemisphere during boreal winter and in the Southern Hemisphere during boreal summer. In transition seasons (spring and autumn), extratropical biases exist in both Hemispheres with similar magnitude.

We rephrased the sentences in Lines 235-238:

“Indeed, the circulation bias in the tropics (25°S-25°N) has similar pattern throughout the year but with varying magnitude, and the extratropical biases are primarily observed in the Northern Hemisphere during boreal winter and in the Southern Hemisphere during boreal summer. In transition seasons (spring and autumn), extratropical biases exist in both Hemispheres with similar magnitude.”

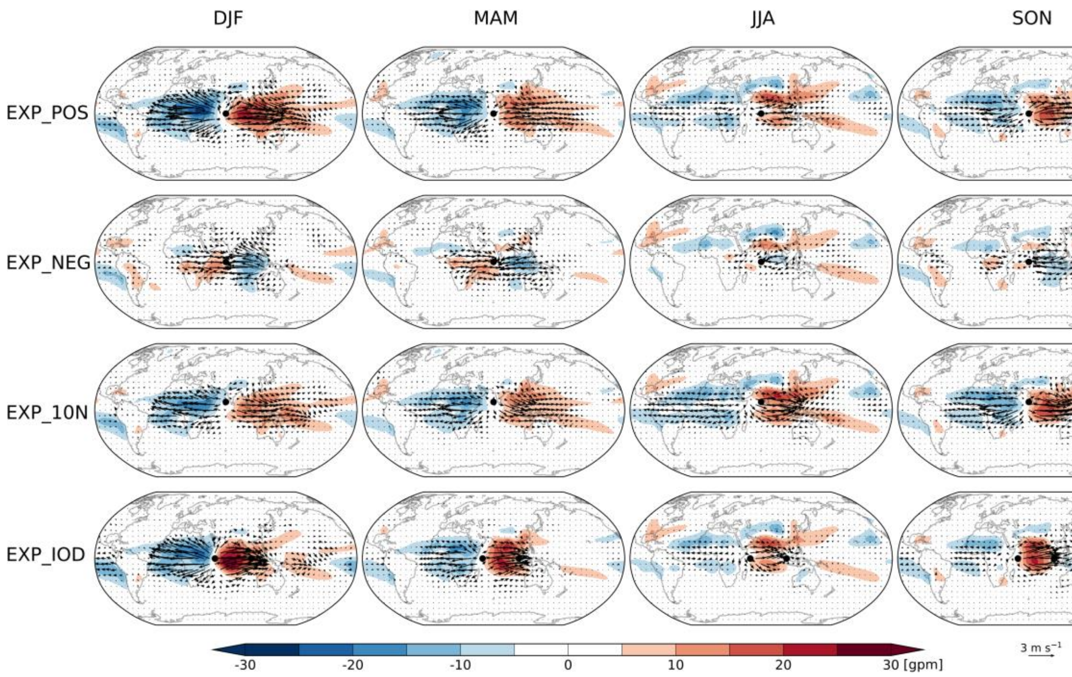

Figure R1. Unbalanced circulation biases at σ = 0.211. Vectors stand for winds (in m s^{-1}) and colors for the geopotential height (in gpm). Black dots mark the SST bias centers.

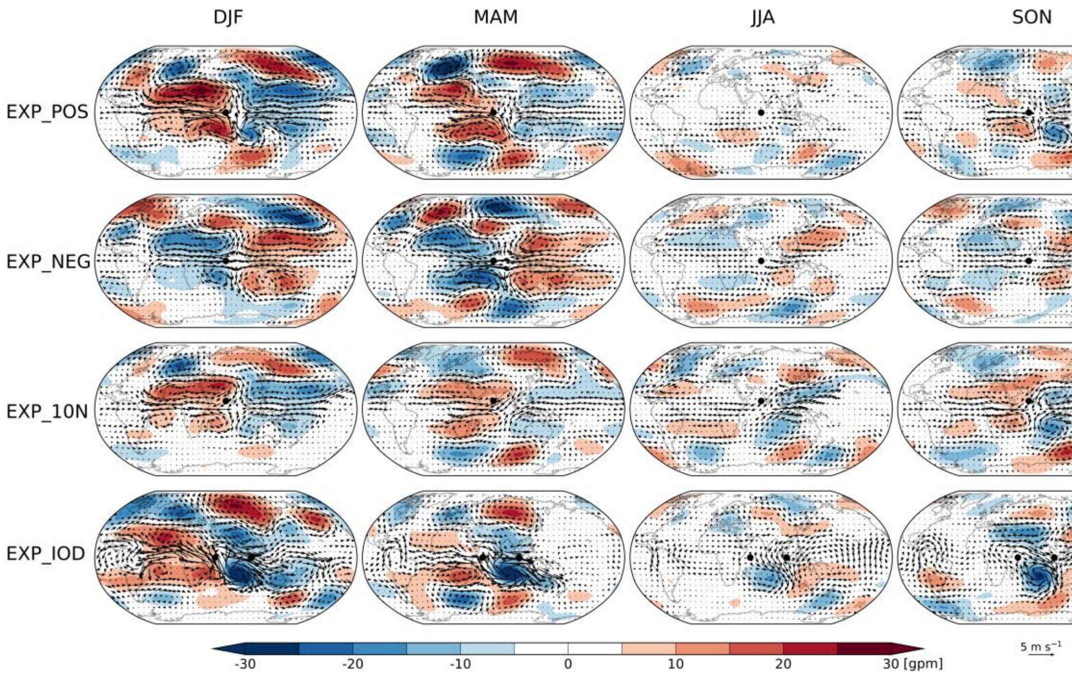

Figure R2. Balanced circulation biases at σ = 0.211. Vectors stand for winds (in m s^{-1}) and colors for the geopotential height (in gpm). Black dots mark the SST bias center.

The IO has strong seasonality. So, I expected the seasonality to be critical. If you focus only on the boreal wintertime, the authors should add "boreal wintertime" in the title.

Agree.

We changed the title to “Atmospheric bias teleconnections **in boreal winter** associated with systematic SST errors in the tropical Indian Ocean”.

The abstract was modified accordingly (Lines 5-6):

“Bias teleconnections **with a focus on boreal wintertime** are researched using …”

L137–145: Please add some references to explain why you set the EXP and EXP_10N as similar to EXP_IOD.

We added an explanation to the choice of the SST bias. See Lines 149-152 in the revised ms:

“These SST perturbations are similar to, but not the same as, the SST biases in the coupled climate models in terms of the center location, spatial extent and magnitude. The ones used in EXP_POS and EXP_IOD have their counterparts in CMIP5 models (see Fig. 4 in Lyon et al. (2020)). Those in EXP_NEG and EXP_10N are primarily used to study the sensitivity of the response to the sign and meridional location of the SST bias, respectively.”

Fig. 7: Why not show EXP_10N? I expect that EXP_10N may influence RWS and WAF more than EXP_POS/NEG.

Figure R3 shows the WAF and RWS in each experiment. We can find that the impact of EXP_10N SST bias on the RWS and WAF is not as strong as that of EXP_POS. This is likely associated with the background state. Previous study has shown that SST changes in tropical ascending regions is more efficient at generating global influences (Zhou et al 2017). In DJF, the Hadley cell ascending branch is located slightly south of the equator. (This also explains the south-north asymmetry in the precipitation biases in the TIO region in EXP_POS (see Fig. 3a in the ms).) Therefore, when the SST bias shifts northward away from the ascending region, it becomes less efficient at producing wave sources and therefore the WAF.

Another major difference between EXP_POS and EXP_10N is seen over Asia and north Pacific. In EXP_POS, there are two wave paths in that region. One (the northern path) originates in west and east Asia and propagates northeastward and then eastward, and the other (the southern path) originates in the subtropical North Pacific and propagates northeastward. They merge over the northeast Pacific. In EXP_10N, however, only the north path is visible.

In the revised ms, the EXP_10N has been added to Figure 7. Besides, we added a short discussion in Lines 285-288:

“… albeit with smaller amplitude. Previous studies have shown that SST changes in tropical ascending regions are more efficient at generating global impacts (Zhou et al. 2017). In DJF, the ascending branch of the Hadley circulation is located slightly south of the equator. Thus, as SST bias moves northward away from the equator, it becomes less efficient at impacting the atmosphere."

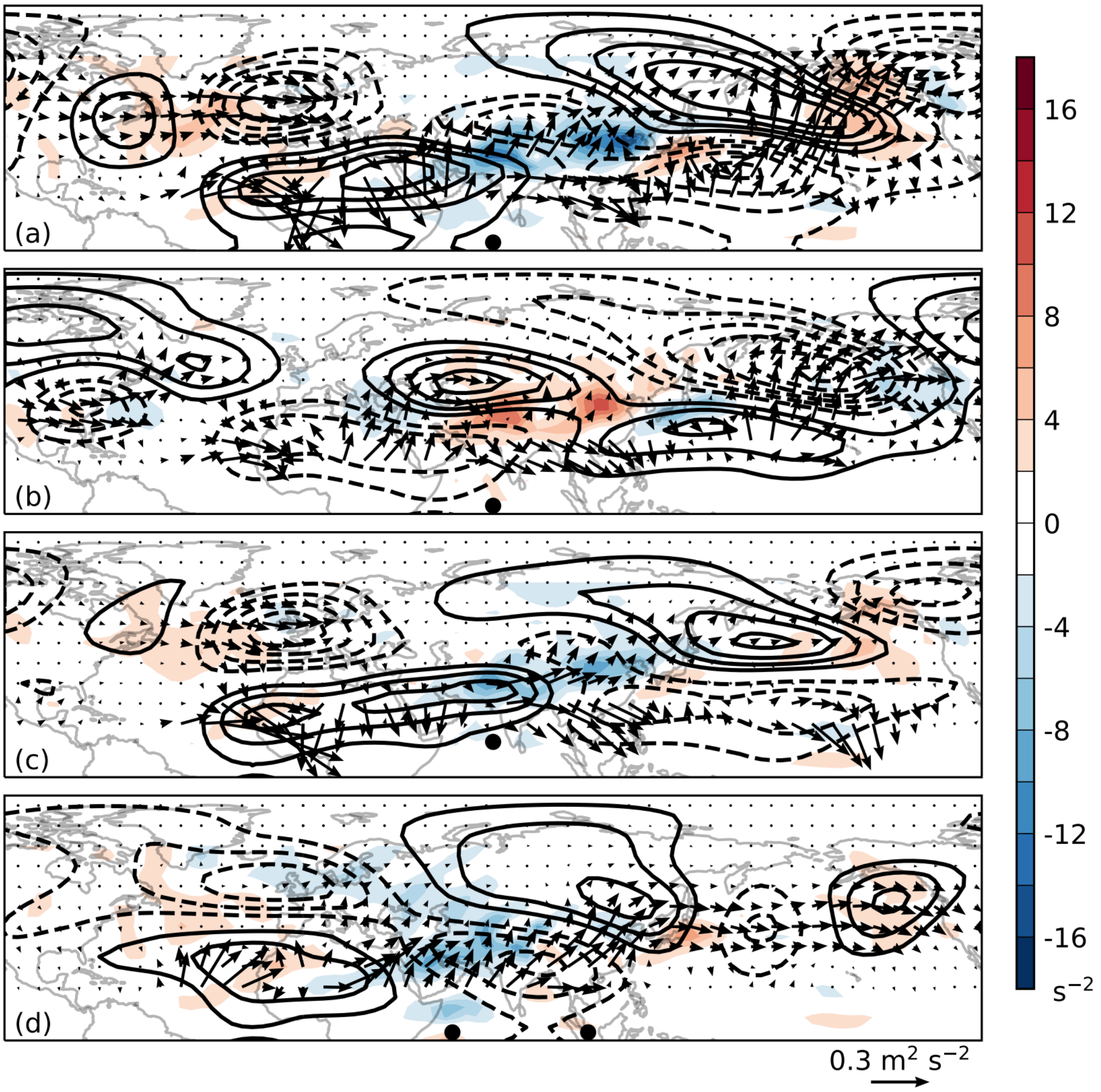

Figure R3. Horizontal distribution of the 250 hPa stationary wave activity flux (vectors, m^2 s^{-2}) and Rossby wave source (colors, 10^{-11} s^{-2}) in DJF: (a) EXP_POS, (b) EXP_NEG, (c) EXP_10N, and (d) EXP_IOD. Black contours show the balanced geopotential height biases. The contour interval is 5 gpm. Negative values are indicated with dashed lines and the zero-line is omitted.

And we rephrased the text in Lines 334-344 accordingly:

"The major feature is the wave propagation indicated by WAF over Aisa and the PNA region. In EXP_POS, there are two wave paths. One (the northern path) originates in Asia and spreads northeastward and then eastward; the other (the southern path) originates in the subtropical North Pacific and propagates northeastward. The two wave paths merge over the northeast Pacific and then propagate eastward across North America and the North Atlantic, and finally terminates over North Africa (Fig. 7a). EXP_NEG has similar wave propagation to EXP_POS, but its northern wave path is very weak (Fig. 7b). In EXP_10N, the northern wave path is similar to that of EXP_POS, but the southern wave path no longer exists (Fig. 7c). The wave-train in EXP_IOD originates in South Asia. It first spreads northeastward and then eastward across the North Pacific (Fig. 7d). The wave route in EXP_IOD is much zonal, which may be due to the wave being trapped by the jet stream (Zhang and Liang, 2022). The termination of the Rossby waves over America in EXP_IOD is probably due to the zonal inhomogeneity of the jet stream, which is very weak to the west coast of North America and does not support Rossby wave propagation."

The authors analyzed the years 1931–2010. As the authors may know, the Indian Ocean has warmed faster than the global average. So I believe that atmospheric bias teleconnections associated with IO SST bias may change. Although the topic is beyond the main scope, it might be better to slightly touch on the problem.

Thank you for pointing out this.

The atmospheric bias teleconnections associated with IO SST bias may have a time evolution with the non-stationary backround SST, but it is beyond the scope of this study. A brief discussion does not help to draw any conclusive results. We plan to study this in a separate paper.

In response to your suggestion, we added the following sentences in Lines 520-522.

"Furthermore, the TIO has warmed faster than any other tropical oceans over the past century (Roxy et al. 2020), and the atmospheric bias teleconnections associated with the TIO SST bias may have a temporal evolution with the non-stationary background SST. While not addressed in this paper, it will be discussed in follow-on studies."

Thanks again for your careful review!

Yuan-Bing Zhao and Coauthors

References:

Lyon, B., 2020: Biases in CMIP5 Sea Surface Temperature and the Annual Cycle of East African Rainfall. *Journal of Climate*, **33**, 8209–8223, https://doi.org/10.1175/JCLI-D-20-0092.1.

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Zhou, C., M. D. Zelinka, and S. A. Klein, 2017: Analyzing the dependence of global cloud feedback on the spatial pattern of sea surface temperature change with a Green's function approach. *J. Adv. Model. Earth Syst.*, **9**, 2174–2189, https://doi.org/10.1002/2017MS001096.