Responses to Reviewer 4's comments

Summary:

The manuscript "Atlantic Multi-decadal Oscillation Modulates the Relationship Between El Niño-Southern Oscillation and Fire Weather in Australia" studies the relationship between AMO and ENSO-Australian fire weather. This work advances our understanding of the interactions between different climatic phenomena. After carefully revising several issues, I consider this work interesting, relevant, and worth publication in this journal.

Reply: We thank this reviewer for the helpful suggestions, which have greatly helped us improve the manuscript. We have studied the comments carefully and made revisions, which we hope will meet the journal standards. Our responses to each of the comments and suggestions are as follows. The referee's original comments are shown in blue. Our replies are shown in black. The corresponding changes in the manuscript are shown in *Italic black*

1. In general, the manuscript could be enhanced by extending the discussions about the atmospheric teleconnection mechanisms by means of Rossby wave trains. Although the authors do a great job explaining the Rossby wave trains argument, I think the discussion about the Rossby wave source anomalies in Figure 4 (c-d) could be improved to clarify this point to the readers.

Reply: We appreciate your valuable input and have incorporated the suggested changes to enhance our manuscript. In our revised discussion, we have delved deeper into the atmospheric teleconnection mechanism facilitated by Rossby wave trains. This has led to a more comprehensive analysis of the stream function, providing further validation of the underlying processes at play. Consequently, Figure 4 (Figure

R1 here) in the manuscript has been modified to better reflect these findings.

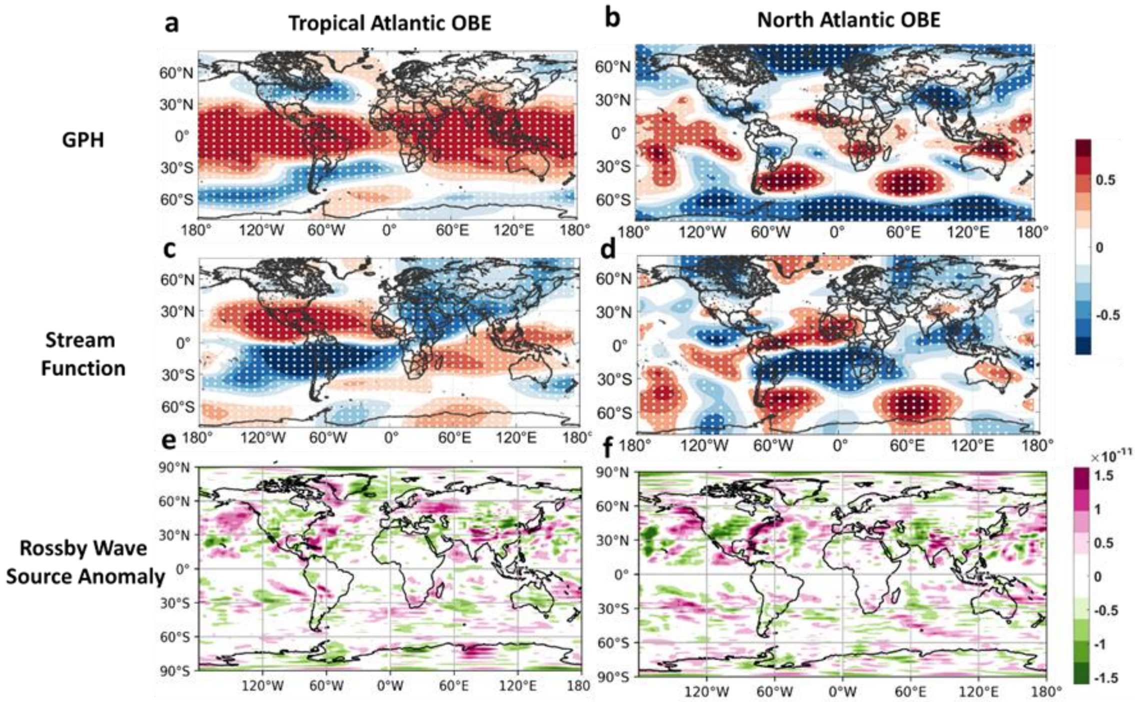

Figure R1. (a-d) Regression coefficients of detrended and normalized SON 200 hPa (a-b) GPH and (c-d) stream function onto detrended and normalized SON (a, c) Tropical Atlantic (10°-60°W, 0-20°N) and (b, d) North Atlantic (10°-60°W, 25-45°N) SST in the OBE. (e-f) 200hPa Rossby wave source anomaly in (e) Tropical Atlantic OBE, and (f) North Atlantic OBE. The area with white dots passed the significance test of $p \leq 0.05$ by Student's *t*-test.

Additionally, we have clarified the Rossby wave source anomalies depicted in Figure 4e & f for our readers, ensuring a more coherent understanding of the presented data. The expanded discussion, now encompassing Lines 245-281, not only strengthens our argument but also bolsters the overall quality of the manuscript. We trust that these revisions will prove beneficial in conveying the intricacies of the ENSO-AMO-fire weather relationship.

In the case of the Tropical Atlantic, thermal forcing in this region drives changes *to the zonal Walker circulation. These alterations may result in upward vertical motion and localized convection over the Atlantic, with corresponding low-level convergence and upper-level divergence subsequently producing an intensification of the local Hadley circulation (Li et al., 2014; Li et al., 2015). This process enhances upper-level convergence at the descending branch of the Hadley cell (Simpkins et al., 2014), leading to an intensification of the local Hadley circulation and the generation of a significant source of Rossby waves that propagate eastward with the climatological mean flow in the Southern Hemisphere (Figure 4e). This Rossby wave source is evident over the South Atlantic (30 °S, 20 °W in Figure 4e), and the corresponding Rossby wave will propagate toward Australia, intensifying high pressure in the region (Figure 4a). The regression coefficients of the 200 hPa stream function further corroborate this Rossby wave propagation from the South Atlantic to Australia (Figure 4c). With sea surface temperature (SST) warming in the tropical Atlantic, the response of the stream function in the upper level above Australia corresponds to a high-pressure center with descending airflow in this region (Figure 4c). In summary, anomalous deep convection in response to increased SST in the Tropical Atlantic drives anomalous divergence of the large-scale flow that extends away from local heating by modulating the Hadley and Walker circulations. This process has been discussed in detail by Simpkins et al. (2014).*

Regarding the North Atlantic, warmer Atlantic temperatures heat the air above, forming a local high-pressure center in the upper troposphere. This signal generates the Rossby wave source over the North Atlantic (Figure 4e), with the corresponding Rossby wave train propagating from west to east, featuring alternating high and low-pressure centers that culminate in a high-pressure anomaly in Australia (Figure 4b). This high pressure corresponds to descending motions over Australia, characterized by drier and hotter air that is unfavorable for cloud and rain formation. It is worth noting that stationary Rossby waves can cross the equator under the influence of meridional background wind, and their direction and tilt structure depend *on the meridional background wind (Li et al., 2015). Furthermore, the responses of the stream function are in strong accordance with those of GPH, with a high-pressure center above Australia. These responses lend further support to the cross-equator propagation under the influence of North Atlantic SST forcing (35 °W, 30 °N in Figure 4d). The patterns of regression coefficients (Figure 4 a-d) also correspond well to the equatorial windows and wave guides for Rossby wave propagation in the upper troposphere as identified in previous studies (Li et al., 2019). The southward propagation of Rossby waves originating from the Atlantic is also supported by previous works (Miller et al., 2007; Zhao et al., 2019), which form the basis of the teleconnection between the North Atlantic and Australia. Previous studies also indicate that the Atlantic Multidecadal Oscillation (AMO) can modulate El Niño – Southern Oscillation (ENSO) effects through similar Rossby wave dynamics (Lin and Li, 2012; Nagaraju et al., 2018). The impact of AMO on ENSO itself has been widely discussed in previous studies, encompassing aspects including its influence on ENSO's amplitude, flavor, and predictability. The AMO is known to force changes in the Walker circulation in the tropical Pacific Ocean, affecting ENSO's amplitude (Levine et al., 2017) by impacting the depth of the equatorial thermocline and the positive feedback effect of the thermocline (Geng et al., 2020). For ENSO's flavor, the positive AMO enhances the zonal sea surface temperature gradient in the central Pacific, strengthening zonal advective feedback and favoring extreme and Central Pacific (CP) El Niño development (Gan et al., 2022; Yu et al., 2015). Regarding ENSO predictability, it is modulated by the Atlantic mean state bias and systematic errors in inter-basin interactions (Chikamoto et al., 2020).*

2. LN 61-62. I suggest rewriting as: "WND10 is calculated using the zonal (U10) and meridional (V10) components of the wind vector to represent the intensity of the 10 m wind."

Reply: Thanks for your suggestions. We have rewritten this sentence as suggested.

3. LN 62. The authors compared their results with other NCEP-NCAR and MERRA-2 reanalyses "In order to verify the robustness of our results." I am not sure that this comparison ensures the robustness of their results. I would suggest saying instead: "In order to compare LN 63. Please indicate the resolution of the NCEP-NCAR and MERRA-2 reanalysis in the text. Do you use the data in the original grids, or do you regrid to use the same grid as ERA5?

Reply: We appreciate your attention to detail and have incorporated the suggested revisions in our manuscript. The resolution of the NCEP-NCAR and MERRA-2 reanalysis datasets has been explicitly mentioned in the text, ensuring transparency and reproducibility of our methods. Furthermore, we used NCEP-NCAR and MERRA-2 reanalysis in the original grids without regriding.

We modified the expression in Lines 73-79 and cited it here:

To compare results from various datasets, we also employ the same variables from the NCEP-NCAR Reanalysis 1 datasets with a spatial resolution of 2.5°×2.5°, MERRA-2 datasets with a spatial resolution of 0.625°×0.625° (Global Modeling and Assimilation Office, 2015a; Global Modeling and Assimilation Office, 2015b; Kalnay et al., 1996), and re-gridded and interpolated ERA5 reanalysis datasets with a spatial resolution of 0.1 °×0.1 ° (Hersbach, 2019) for the period 1959-2019. It is noted that the native spatial resolution of the ERA5 reanalysis dataset is 9km on a reduced Gaussian grid. The data used here has been regridded to a regular lat-lon grid of 0.1x0.1 degree by the Climate Data Store (CDS).

4. Figure S2. Caption: "...and (e,j) Kaplan Extended SST v2 datasets"

Reply: Thanks for your suggestions. We have revised as suggested.

5. LN 115-117. The authors could also mention that the correlations are strengthened even with the analysis of detrended time series. If Global warming alone were the cause, the correlations would disappear.

Reply: Thanks for your helpful suggestion. We have added the explanation as suggested in Lines 153-154 and cited it here:

Moreover, the strengthened correlation persists even when analyzing detrended time series, further undermining the attribution of this correlation shift to global warming.

6. LN 140-145. Please improve the explanation of Figure 2.

Reply: Thanks for your helpful suggestions. We have improved the explanation and added more related details of Figure 2 as suggested in Lines 178-186.

We cited them here:

In our investigation, we first juxtapose El Niño-associated meteorological responses in Australia during positive (Figure 2d-f) and negative AMO phases (Figure 2g-i). Our findings reveal that temperature increases and precipitation decreases are more pronounced during El Niño events coinciding with a positive AMO phase. This intensified response is particularly evident in central and southern Australia, where the predominant vegetation comprises grasslands and shrublands, *which are highly susceptible to ignition and wildfire propagation. Furthermore, SLP and WND10 responses are markedly more robust during positive AMO phases compared to negative phases (Figure 2f & i). Specifically, El Niño events in the positive phase of AMO are characterized by elevated SLP and intensified surface winds. The elevated SLP corresponds to descending airflow, consequently exacerbating hot and dry conditions in biomass-rich regions of Australia. Collectively, these observations suggest that AMO may potentially amplify the relationship between ENSO and FWI.*

7. Figure 2 Lowercase i in Caption ".... and (c,f, i, l) Sea Level Pressure ..."

Reply: Thanks for your suggestion. We have revised as suggested.

8. Figure 2. It is not clear how you do the significance test on these figures. I recommend enhancing the manuscript (or in the supplementary material) on how you do your significance test.

Reply: Thanks for your suggestions. We have clarified more details in the significance test in section 2.3. We also cited them here (refer to Lines 123-135):

The assessment of the differences between ENSO composites with positive AMO (AMO+) and negative AMO (AMO-) was conducted using Student's t-test to ascertain the statistical significance of these differences. This robust analytical method facilitated the evaluation of the potential impacts of AMO phases on the ENSO-Australian fire weather relationship.

The Student's t is calculated as

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sigma\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

where $\bar{x}_1$ *and* $\bar{x}_2$ *are sample means,* n_1 *and* n_2 *are sample sizes for different samples, and σ is the pooled standard deviation, which is calculated as*

$$\sigma = \sqrt{\frac{n_1 s_1^2 + n_2 s_2^2}{n_1 + n_2 - 2}}$$

where s_1 *and* s_2 *are standard deviations for different samples. The test statistic under the null hypothesis has Student's t distribution with* $n_1 + n_2 - 2$ *degrees of freedom.*