Responses to Reviewer 6's comments

Summary:

This study examines the effect of Atlantic multidecadal variability on the ENSO-fire weather relationship. A strong modulation is identified using observational data and this is explored further using model simulations.

Overall, the study provides important insights but I think would benefit from some further sensitivity testing to ensure results are well understood and robust.

Reply: We thank this reviewer for the insightful and critical 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. The analysis is limited by data availability back to only 1981 which makes assessing the effects of longer-timescale climate variability, like the AMO, challenging. The authors do an admirable job though (including use of other, longer datasets), but could more explicitly acknowledge the limitation of data length.

Reply: We appreciate your insightful suggestions and have endeavored to evaluate the influence of the AMO using extended datasets, such as the ERA5 dataset spanning from 1959 to 2019. However, we must acknowledge the constraints imposed by data time span availability in our analysis. It is worth noting that longer time span data may be subject to increased unreliability due to suboptimal observation quality. To address this limitation, we have incorporated the discussion in Lines 318-320 and cited it here:

Admittedly, our analysis is constrained by the FWI data time span availability, and longer time span data may be less reliable due to inadequate observations.

2. There is surprisingly little discussion of the effect of AMO on ENSO itself. Elaboration on the relationship and mechanisms would be useful (e.g. Levine et al., 2017).

Reply: Thanks for your helpful suggestions. Indeed, the interplay between the AMO and ENSO has been extensively examined in prior research, encompassing aspects such as ENSO's amplitude, flavor, and predictability. Concerning amplitude, the AMO has been demonstrated to induce alterations in the Walker circulation within the tropical Pacific Ocean (Levine et al., 2017), modulating ENSO's intensity by affecting the equatorial thermocline depth and the thermocline's positive feedback effect (Geng et al., 2020). With respect to flavor, the positive AMO phase enhances the zonal sea surface temperature gradient in the central Pacific, thereby strengthening zonal advective feedback and promoting the development of extreme and CP El Niño events (Gan et al., 2022; Yu et al., 2015). Lastly, ENSO predictability is influenced by the Atlantic mean state bias and systematic errors arising from inter-basin interactions (Chikamoto et al., 2020).

We have broadened our discussion on the AMO's impact on ENSO in Lines 274-281.

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).*

3. The analysis is primarily based on linearly detrended data over 1981-2019. Given the high decadal variability in Australian precipitation, for example, I would be slightly concerned that detrending could accidentally reduce natural variability in the data as well. Sensitivity tests where precipitation is not detrended may be useful.

Reply: We appreciate your thoughtful considerations. Given the potential for detrending to inadvertently diminish natural variability in data, we have analyzed the composite map, which includes Fire Weather Index (FWI) and Total Precipitation (TP), as presented in Figure R1. The responses of FWI and TP exhibit greater intensity during the positive phase of the AMO compared to its negative phase. This finding is in strong agreement with Figure 2 in the manuscript, thereby further validating our conclusions.

Nevertheless, in light of the influence of global warming, all physical quantities in the manuscript have been detrended to minimize the impact of global warming on our analysis.

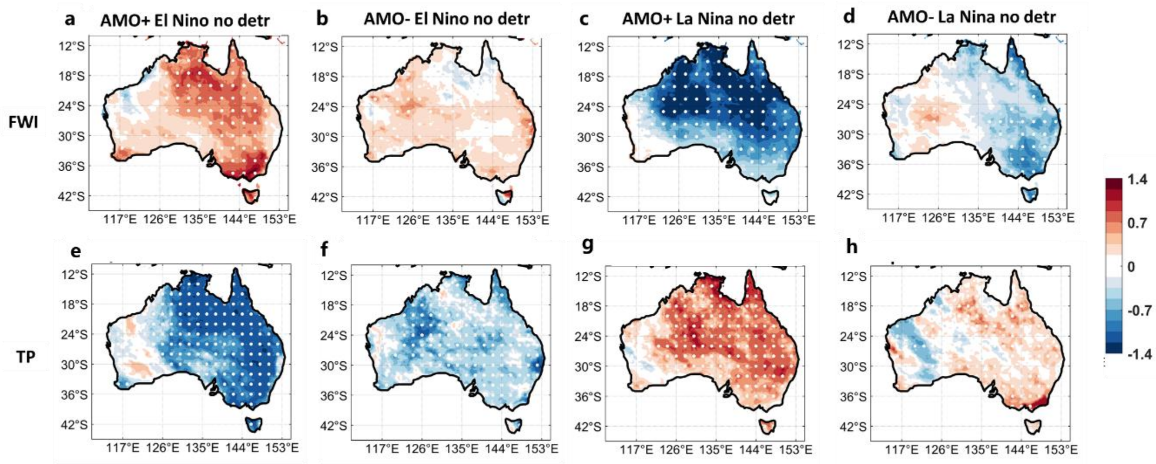

Figure R1. The composite map for the normalized reanalysis SON (a-d) FWI (fire weather index) and (e-h) TP (total precipitation) in (a, e) El Niño events when the AMO indexes are positive, (b, f) El Niño events when AMO indexes are negative, (c) La Niña events when AMO indexes are positive, and (d) La Niña events when AMO indexes are negative from 1980 to 2019. The area with white dots passed the significance test of p-value < 0.05 by Student's *t*-test.

4. Observational datasets are available for some of the variables studied here (e.g. Australian gridded climate dataset (AGCD)). It would be worth comparing ERA-5 against AGCD to ensure ERA-5 is performing adequately.

Reply: Thanks for your helpful suggestions. As suggested, we have employed AFCD for comparing with ERA-5 to ensure that ERA-5 is performing adequately. Moreover, we also compared ERA-5 total precipitation datasets against those from CMAP (CPC Merged Analysis of Precipitation), GPCC (Global Precipitation Climatology Centre), GPCP (Global Precipitation Climatology Project), and PRECL (Precipitation Reconstruction Land) to ensure the reliability of the ERA-5 datasets (Figure R2). In all datasets, the total precipitation responses exhibit greater intensity during the positive phase of the AMO as opposed to its negative phase, which is in strong agreement with Figure 2 in the manuscript. These findings further validate that ERA-5 is performing adequately and substantiate the potential role of the AMO in modulating the ENSO-fire weather relationship in Australia.

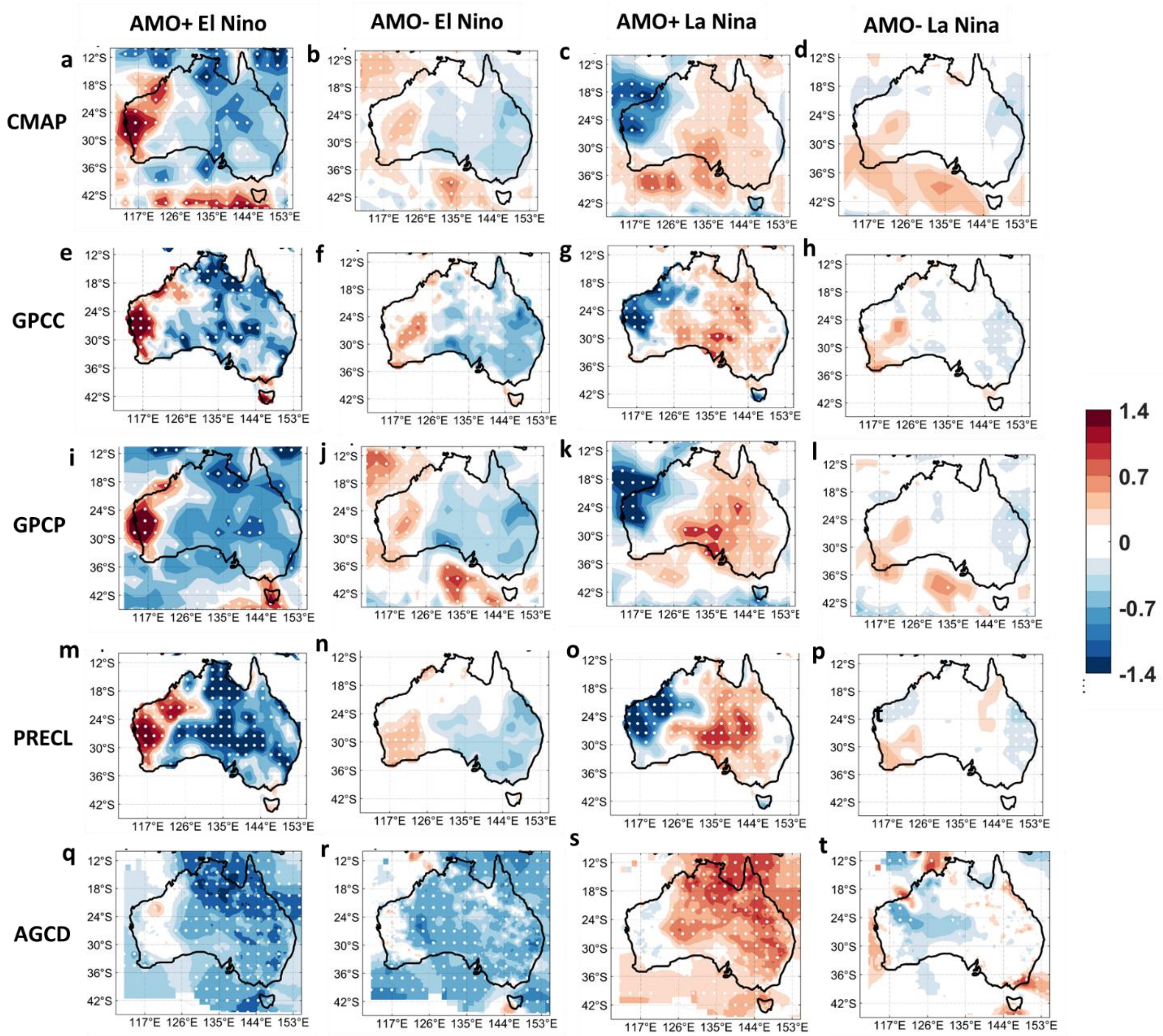

Figure R2. The composite map for the normalized reanalysis SON total precipitation (TP) applying (a-d) CMAP (CPC Merged Analysis of Precipitation), (e-h) GPCC (Global Precipitation Climatology Centre), (i-l) GPCP (Global Precipitation Climatology Project), (m-p) PRECL (Precipitation Reconstruction Land), and (q-t) AGCD (Australian Gridded Climate Dataset) in (a, e, i, m, q) El Niño events when the AMO indexes are positive, (b, f, j, n, r) El Niño events when AMO indexes are negative, (c, g, k, o, s) La Niña events when AMO indexes are positive, and (d, h, l, p, t) La Niña events when AMO indexes are negative from 1980 to 2019. The area with white dots passed the significance test of p-value < 0.05 by Student's t-test.

5. L22: Suggest changing “climate” to “global”

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

6. L32-33: This sentence seems redundant.

Reply: Thanks for your suggestions. We have deleted this sentence to avoid redundancy.

7. L38-39: Better as “shifted from negative to positive phase” I think.

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

8. L104-105: Worth adding a qualifier in here such as “typically”.

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

References

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Gan, R., Liu, Q., Huang, G. Hu, K. M. and Li, X. C.: Greenhouse warming and internal variability increase extreme and central Pacific El Niño frequency since 1980. Nat. Commun. 14, 394, https://doi.org/10.1038/s41467-023-36053-7, 2023.

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