"Inferring the role of Interdecadal Pacific Oscillation phase dependencies and extratropical internal variability on the tropics" ref[egusphere-2025-3948]

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1 Overall response to reviews

Authors: We thank the reviewers for their comments, time and effort. In considering and responding to their feedback we are confident that the revised manuscript is much improved.

2 Response to reviewer #2

Reviewer #2 This study uses Bayesian structure learning to examine causal relationships between major tropical and extratropical climate modes and identifies notable regime-dependent differences in climate dynamics. The work offers an interesting perspective on how these relationships may vary across regimes. However, in its current form, the manuscript would benefit from clearer calarify, and stronger justification of methodological choices. I therefore recommend further revision before the study can be considered for publication.

Authors: We have made substantive efforts to improve the clarity and readability of the manuscript. Particular effort has been directed at the figures incorporating much of the reviewers suggestions.

Reviewer #2 While the Introduction provides substantial background on IPO, ENSO, and causal discovery methods, the core scientific question is not stated sharply enough. For example, it is unclear whether the primary objective is to demonstrate that causal network structures differ between IPO phases.
Authors: Thanks. We have revised the title and content to better clarify our objectives.

Reviewer #2 Several inferred links, particularly involving the MJO, SAM, and NAO, are described descriptively (e.g., as edges in the graph), but their physical interpretation remains vague. The manuscript would benefit from deeper discussion on what lagged statistical causality implies in the context of

atmospheric teleconnections and how these findings relate to established mechanisms.
Authors: Agreed. We have included appropriate discussion of physical interpretations in the revision.

Reviewer #2 The classification of IPO phases is based on a 30-year moving window and manual selection (Table 2), but the specific criteria and sensitivity of this approach are not well explained. Similarly, the choice of a 6-month maximum lag in the structure learning is not justified in terms of known climate dynamics. Both choices are critical to the causal analysis and should be more clearly motivated and discussed.
Authors: The application of a moving window applied to the IPO tripole index is a standard approach to isolate multi-decadal variability and for identifying the respective phases of the IPO. Here we have chosen a 30-year window as we are primarily interested in the timing of the phase transition if present in the data. The most common choices of window range from 13- to 30-years. Henley et al. [2015] point out that results are qualitatively consistent across three SST reanalysis datasets (HadISST1, HadSST.3.1.0.0, ERSSTv3b) for moving windows of length varying between 10-40 years. We apply the same approach to CMIP model data to augment the number of possible alternate cases of phase transitions beyond the observed historical single case of transition between positive and negative multi-decadal regimes.

Authors: The choice of for networks based on monthly indices, i.e., $\tau_{max} =$ 6 months, corresponds to the approximate e-folding time of the MEI and we argue this is an appropriate timescale for tropical variability. This choice also allows direct examination of the influence of IPO phase on the causal relationships between the internal modes relative to their annual and seasonal climatological DAGs recently reported by O'Kane et al. [2024] in their examination of CMIP5 models where the IPO was not absent from the parent set.

On a technical note, longer lags can necessitate requiring increased sample sizes. For each sampling method, we run multiple chains, discarding the first half of each sample as burn-in - currently 250,000 sample burn in. For the samplers considered, as sample size increases, approximate convergence of the chains to the target distribution as assessed using the χ^2 and Kolmogorov-Smirnov tests may become prohibitive in terms of computation times.

Reviewer #2 Several figures (e.g., Figures 1b–d, 3, 4, 5) are difficult to interpret due to visual overloading and unclear encoding. Posterior probabilities are represented solely by line width, which is hard to distinguish visually, especially without a legend or clear thresholding. Some axes and labels are inconsistent or missing. I suggest using line styles or colors to improve clarity.
Authors: Agreed. This is a fair point. Figures have been redrawn for clarity with additional line styles incorporated..

Reviewer #2 The manuscript mixes data, methods, and results in ways that make it difficult to follow. For instance, Section 2 presents results (e.g., posterior causal networks in Figures 1b–d) before the causal inference method is properly introduced in Section 3. Figure 1a, showing IPO phase identification, also appears abruptly without a clear explanation of the smoothing/filtering methods or its connection to the subsequent analysis. I recommend reorganizing the manuscript so that methods are presented before results, and separating Figure 1 into more coherent units with clearer captions and contextual framing. **Authors**: Some reorganization has been made and figure 1 broken up and completely revised for clarity. Additional explanation of the filtering and contextual framing has also been incorporated.

References

B. J. Henley, J. Gergis, D. J. Karoly, S. Power, J. Kennedy, and C. K. Folland. The Tripole Index for the Interdecadal Pacific Oscillation. *Clim. Dyn.*, 45: 3077–3090, 2015. doi:10.1007/s00382-015-2525-1. URL `https://psl.noaa.gov/data/timeseries/IPOTPI/`.

T. J. O'Kane, D. Harries, and M. A. Collier. Bayesian Structure Learning for Climate Model Evaluation. *Journal of Advances in Modeling Earth Systems*, 16:1–33, 2024. doi:10.1029/2023MS004034.