

Influence of Solar Activity and Large-scale Climate Phenomena on Extreme Climate and Hydrological Events in an Arid-Semiarid Region of China

Lin Zhang¹, Menggui Jin², Hongbin Zhan³, Xing Liang¹, and Yanfeng Liu¹

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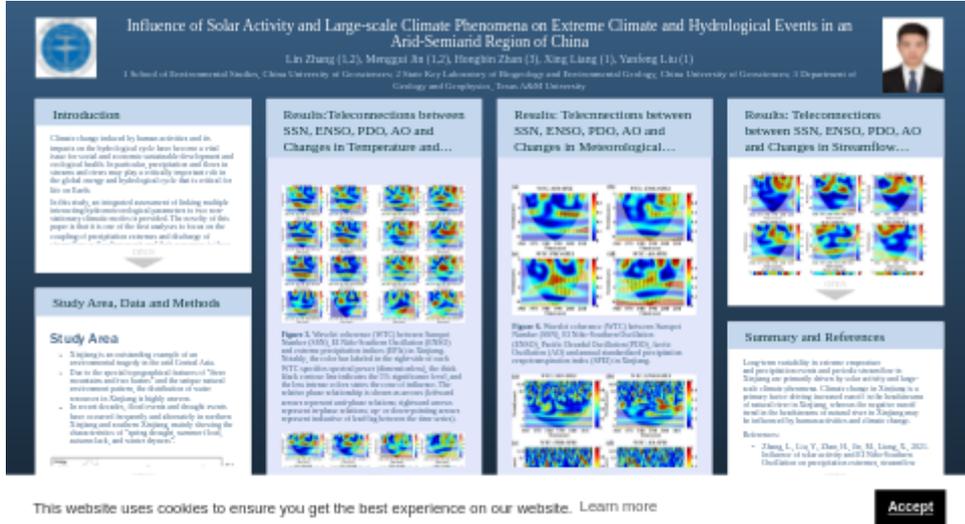
³Texas A&M University

November 23, 2022

Abstract

With a warming climate, solar activity including Sunspot Number (SSN) and large-scale climate phenomena including El Niño-Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO) and Arctic Oscillation (AO) have induced changes in climate extremes and changes in the hydrological cycle in arid-semiarid regions of the world, thus a detailed investigation of climate variability can play a key role in water resources management, drought monitoring, ecological restoration and sustainable development. In this study, we used wavelet coherence (WTC) based on continuous wavelet transform (CWT) to assess the impacts of SSN, ENSO, PDO and AO on multiple interacting hydrological processes and identify the teleconnection patterns and lead-lag relationships between the four principal modes and changes in extreme temperature and precipitation events, meteorological drought, and streamflow variability in Xinjiang, an arid-semiarid region of China. The results indicated that solar activity and climatic oscillations were viewed as the primary drivers for periodic variation of extreme temperature events and the evolution of drought in Xinjiang. For instance, the ENSO positively affected warm extremes with intermittent coherence in the 2–6-year band during 1984–2000 and had negative correlations with cold extremes in the 2–6-year band at the interannual scale. Compared with warm extremes, variability in cold extremes was much more sensitive to the activity pattern of AO. It was clear that the coherence of temperature variables in Xinjiang with PDO was weaker than that with ENSO and AO, and there was a nonsignificant covariance between PDO and extreme temperature events. In addition, the WTC spectra showed that teleconnection factors including solar activity and three large-scale climate phenomena had significant impacts on annual and monthly drought evolution, and AO had the strongest influence on annual standardized precipitation evapotranspiration index (SPEI) values. In general, compared with SSN, ENSO, PDO and AO all showed clear leading effects on precipitation extremes variability and annual streamflow variability for a specific time and frequency, and solar activity's influences might be transferred by ENSO to precipitation extremes or streamflow variability at the 2–7-year band. Overall, the warming and wetting trend in Xinjiang may be a local manifestation of global multivariate climate change. Thus, our findings will have important implications for designing best practice strategies for water resource management and ecological restoration in similar arid-semiarid basins around the world.

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Accept

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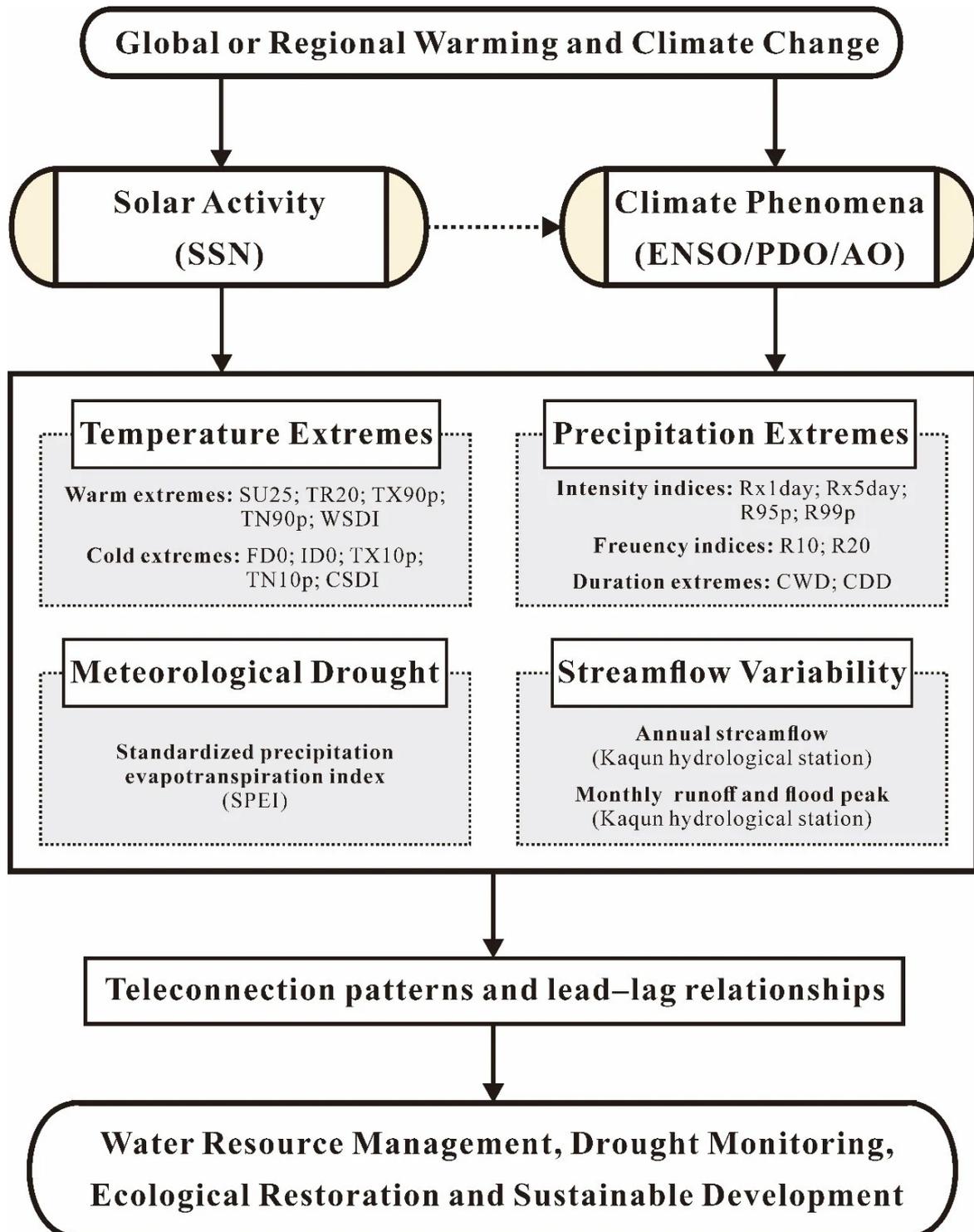


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INTRODUCTION

Climate change induced by human activities and its impacts on the hydrological cycle have become a vital issue for social and economic sustainable development and ecological health. In particular, precipitation and flows in streams and rivers may play a critically important role in the global energy and hydrological cycle that is critical for life on Earth.

In this study, an integrated assessment of linking multiple interacting hydrometeorological parameters to two non-stationary climatic modes is provided. The novelty of this paper is that it is one of the first analyses to focus on the coupling of precipitation extremes and discharge of streamflow or flooding events and their responses to these non-stationary climate modes, such as Sunspot Number (SSN), El Niño-Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO), and Arctic Oscillation (AO).



STUDY AREA, DATA AND METHODS

Study Area

- Xinjiang is an outstanding example of an environmental tragedy in the arid Central Asia.
- Due to the special topographical features of “three mountains and two basins” and the unique natural environment pattern, the distribution of water resources in Xinjiang is highly uneven.
- In recent decades, flood events and drought events have occurred frequently and alternately in northern Xinjiang and southern Xinjiang, mainly showing the characteristics of “spring drought, summer flood, autumn lack, and winter dryness”.

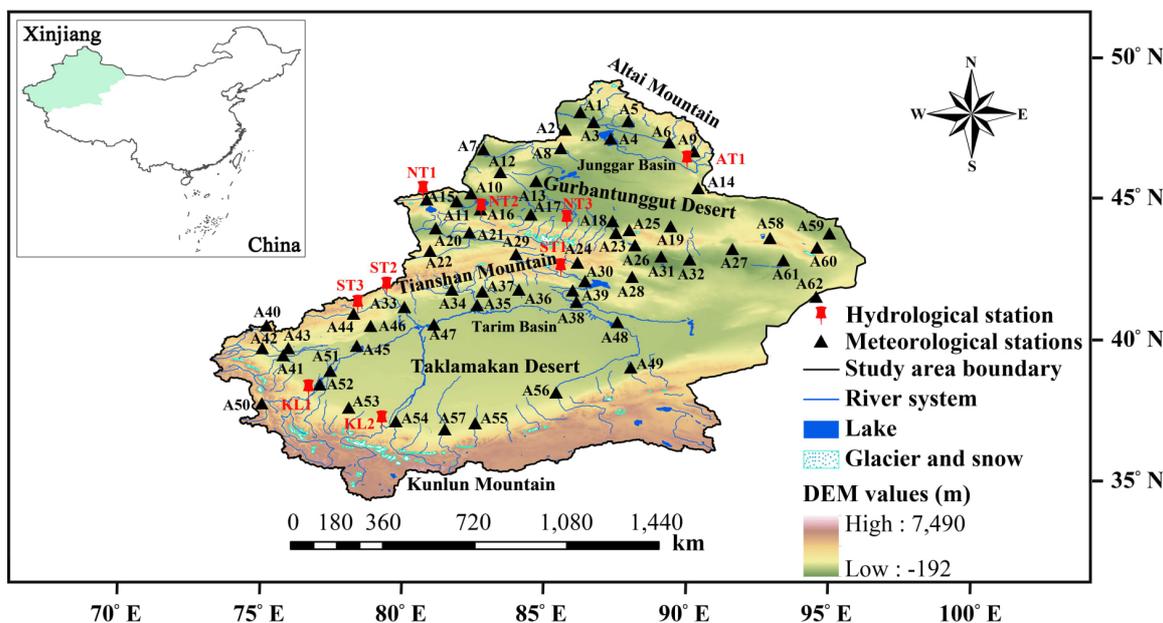


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- Wavelet coherence analysis can be applied to estimate the effect of both solar activity and large-scale climate phenomena on coupling non-stationary hydro-climatic processes.

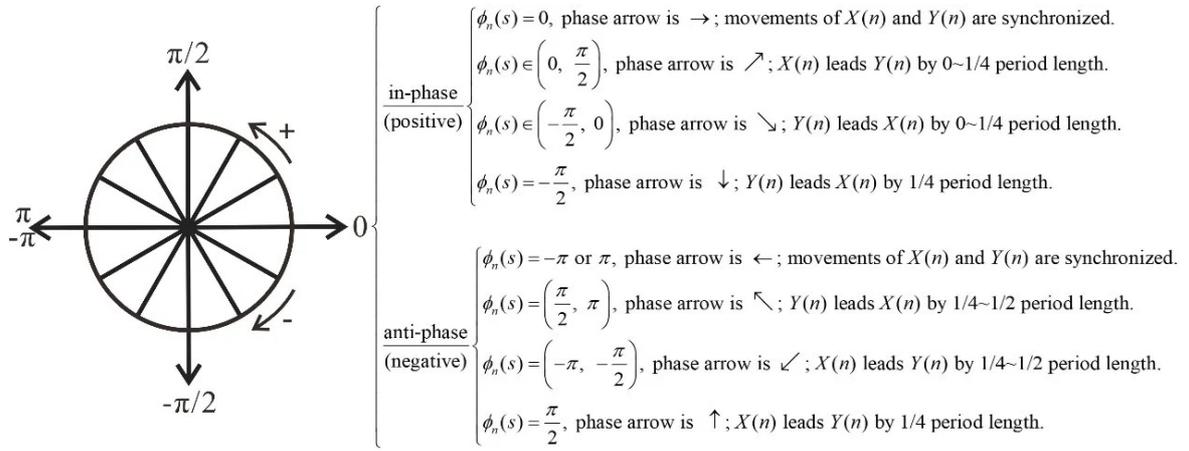


Figure 2. Eight phase angle conditions denoted by the arrows of the WTC spectra and their corresponding lead-lag relationship between the two series $X(n)$ and $Y(n)$.

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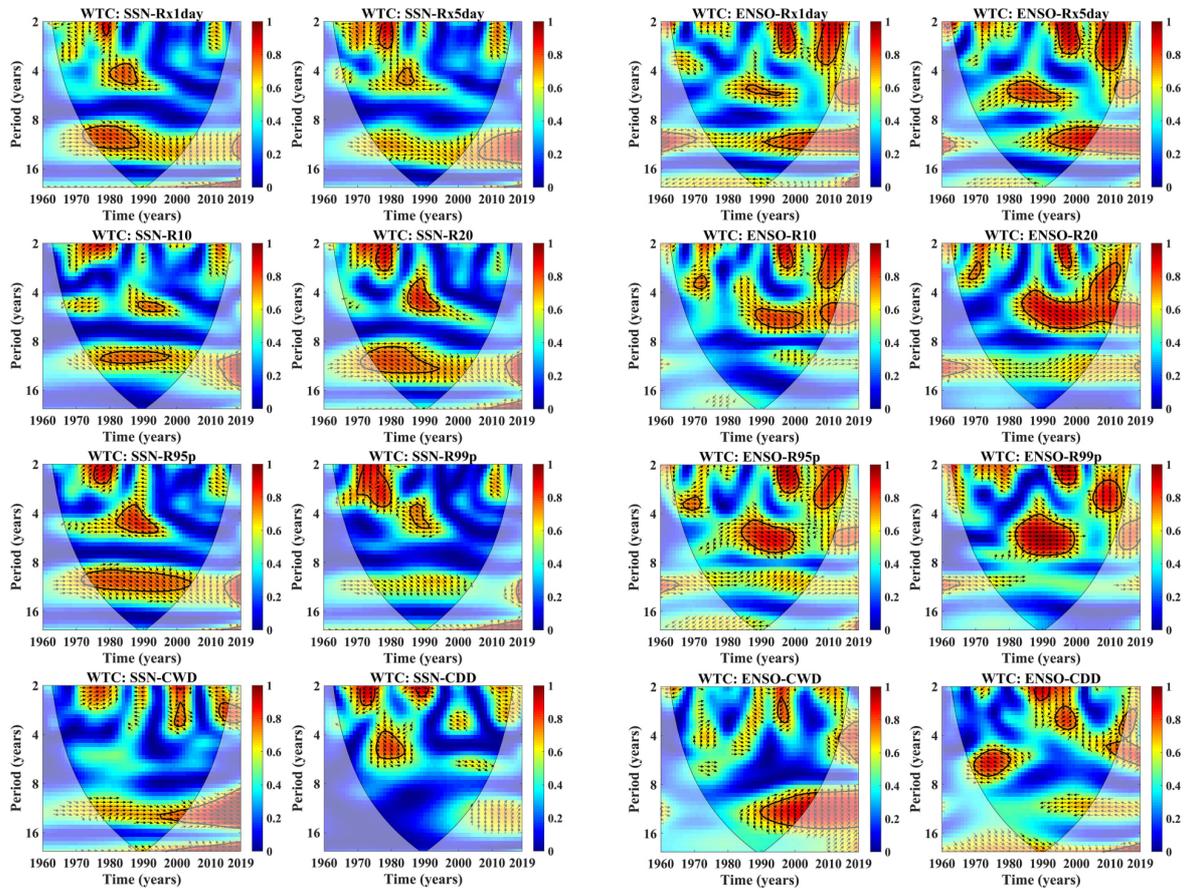


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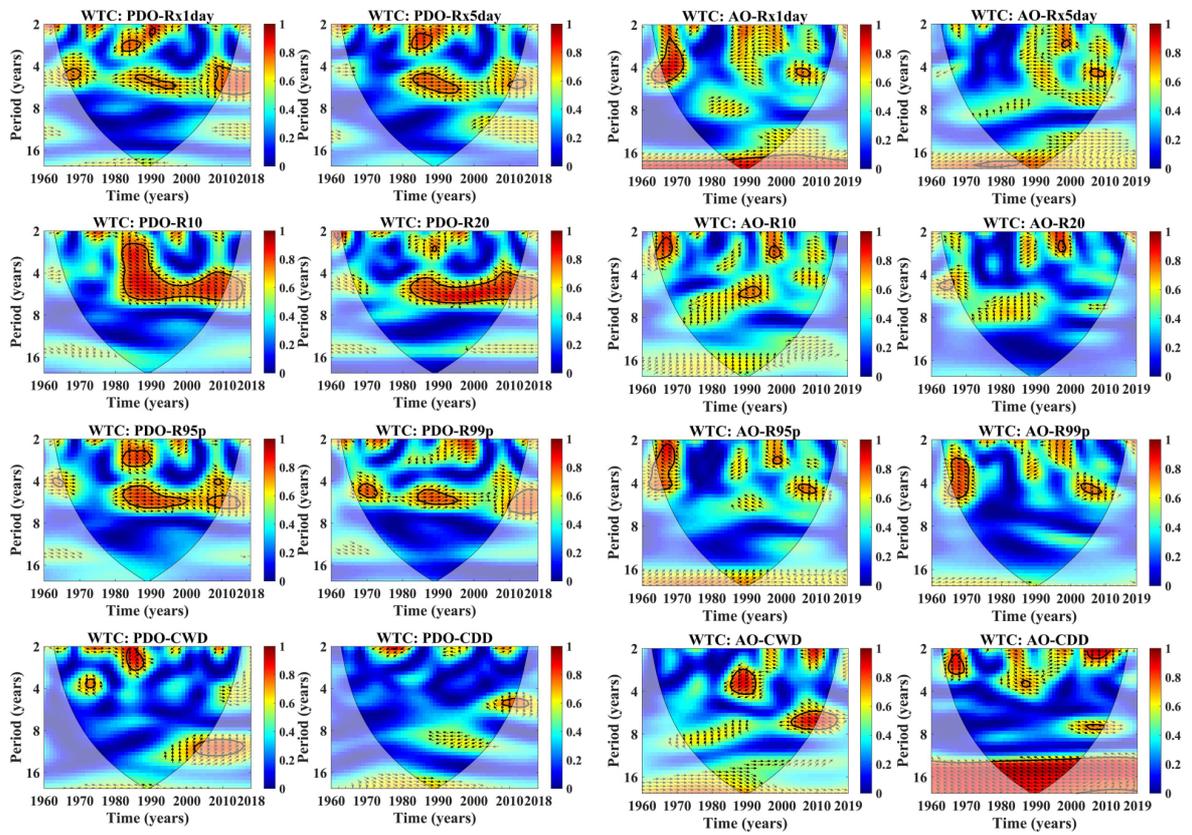


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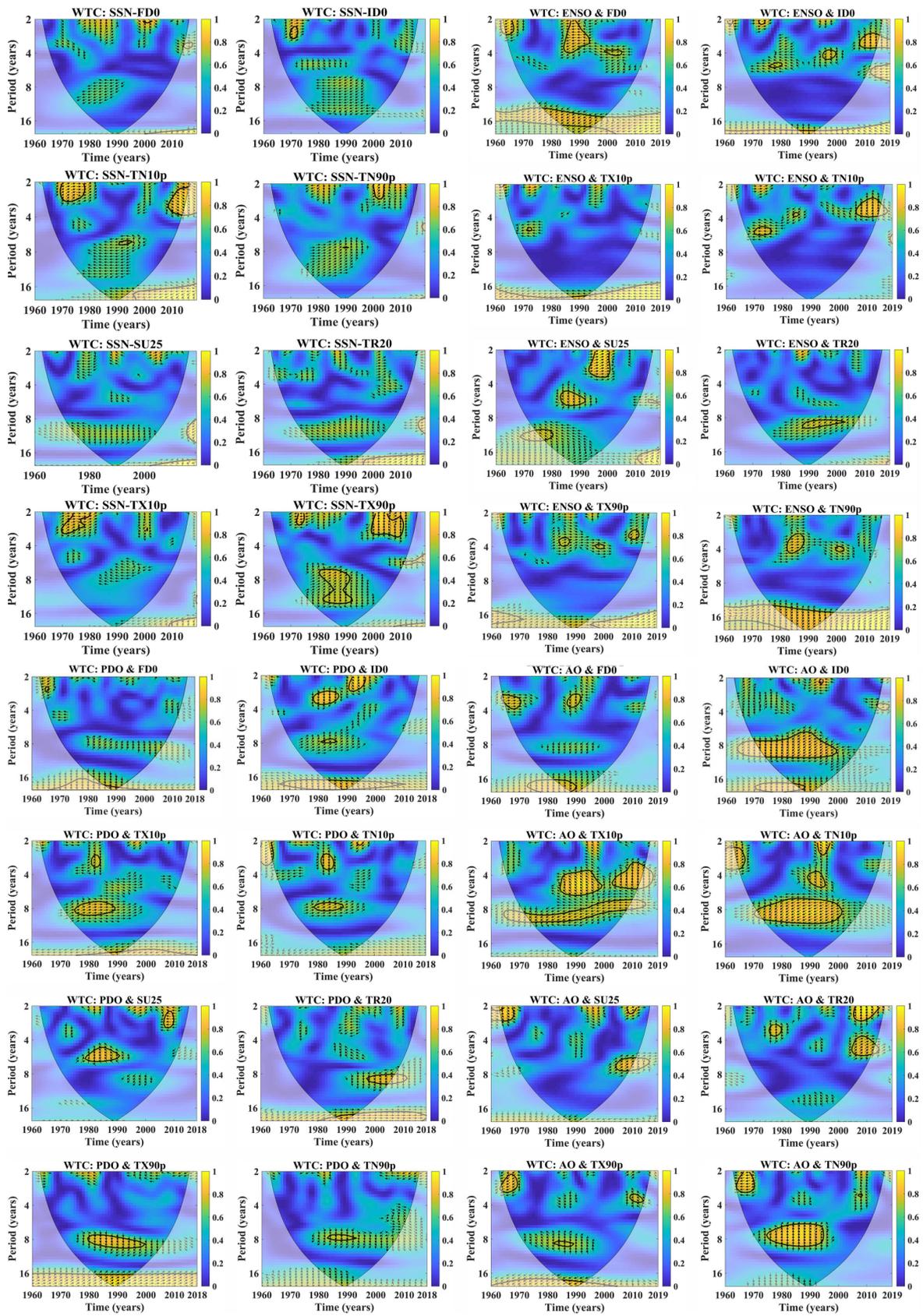


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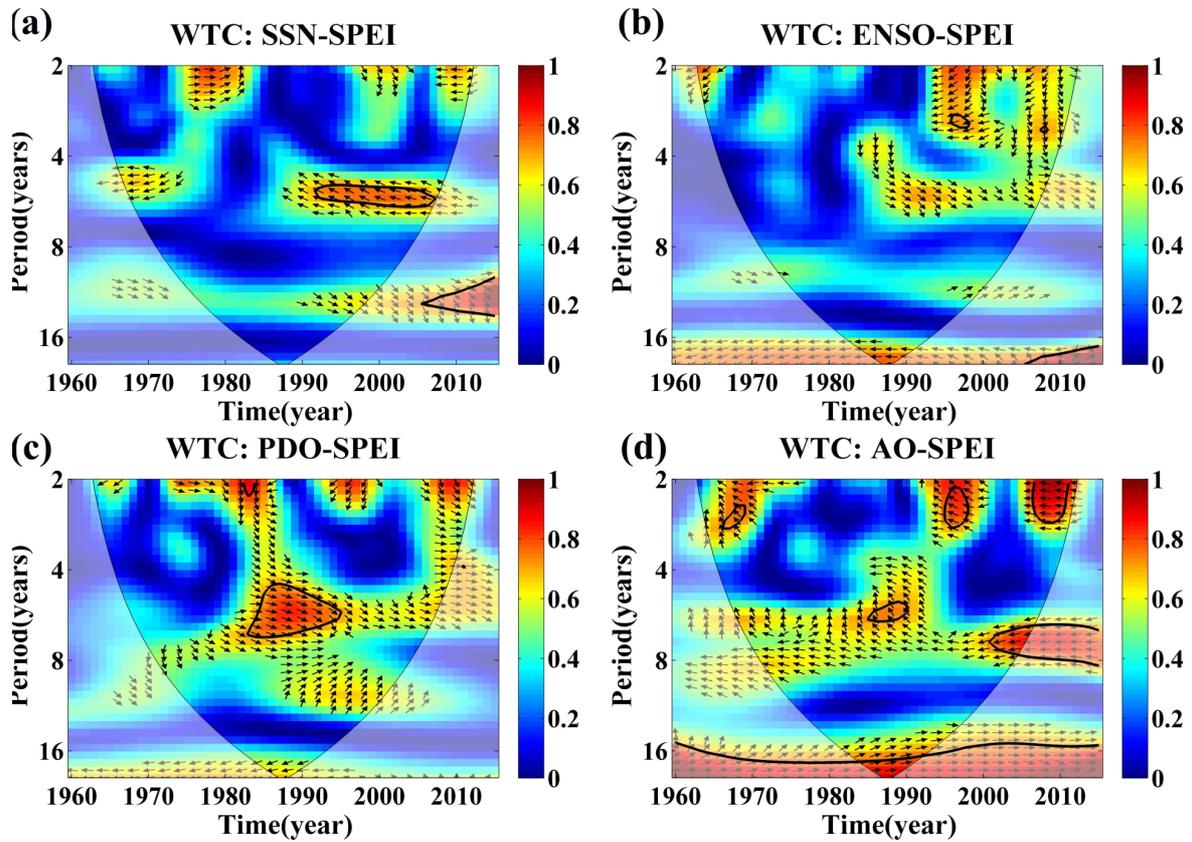


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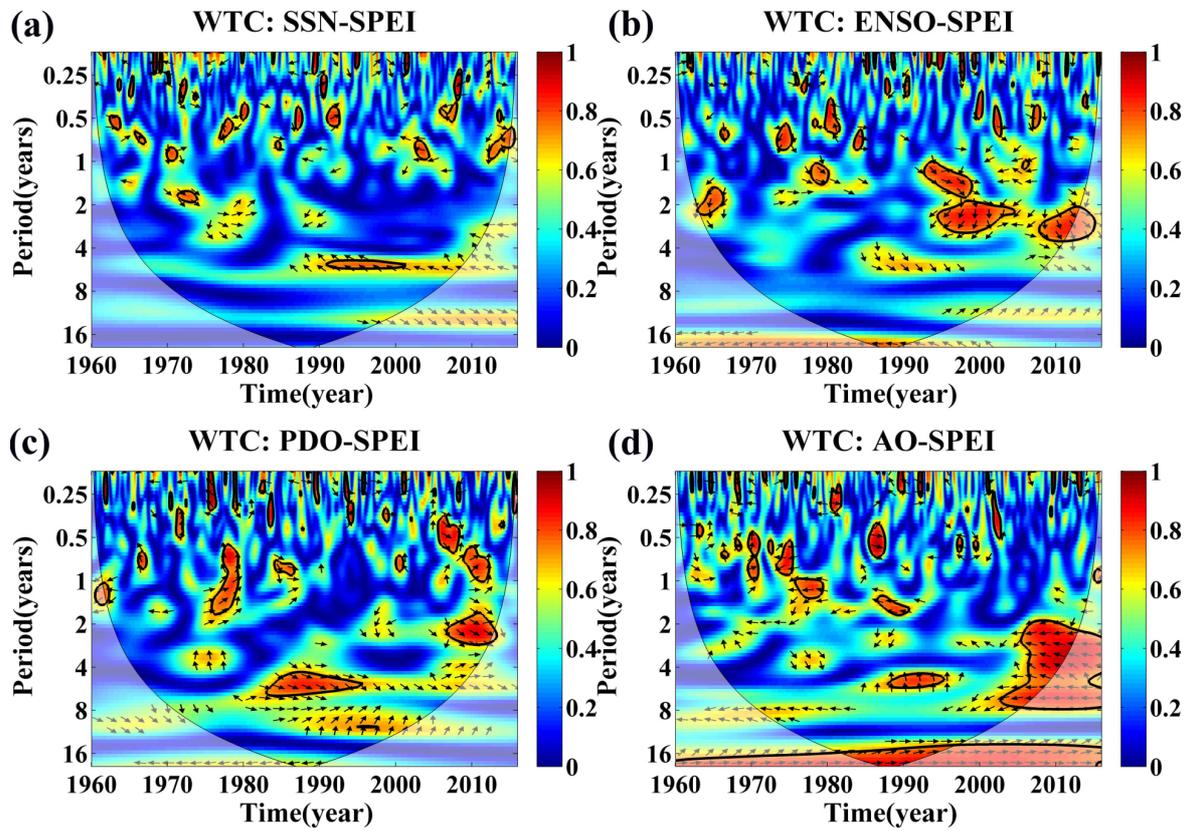


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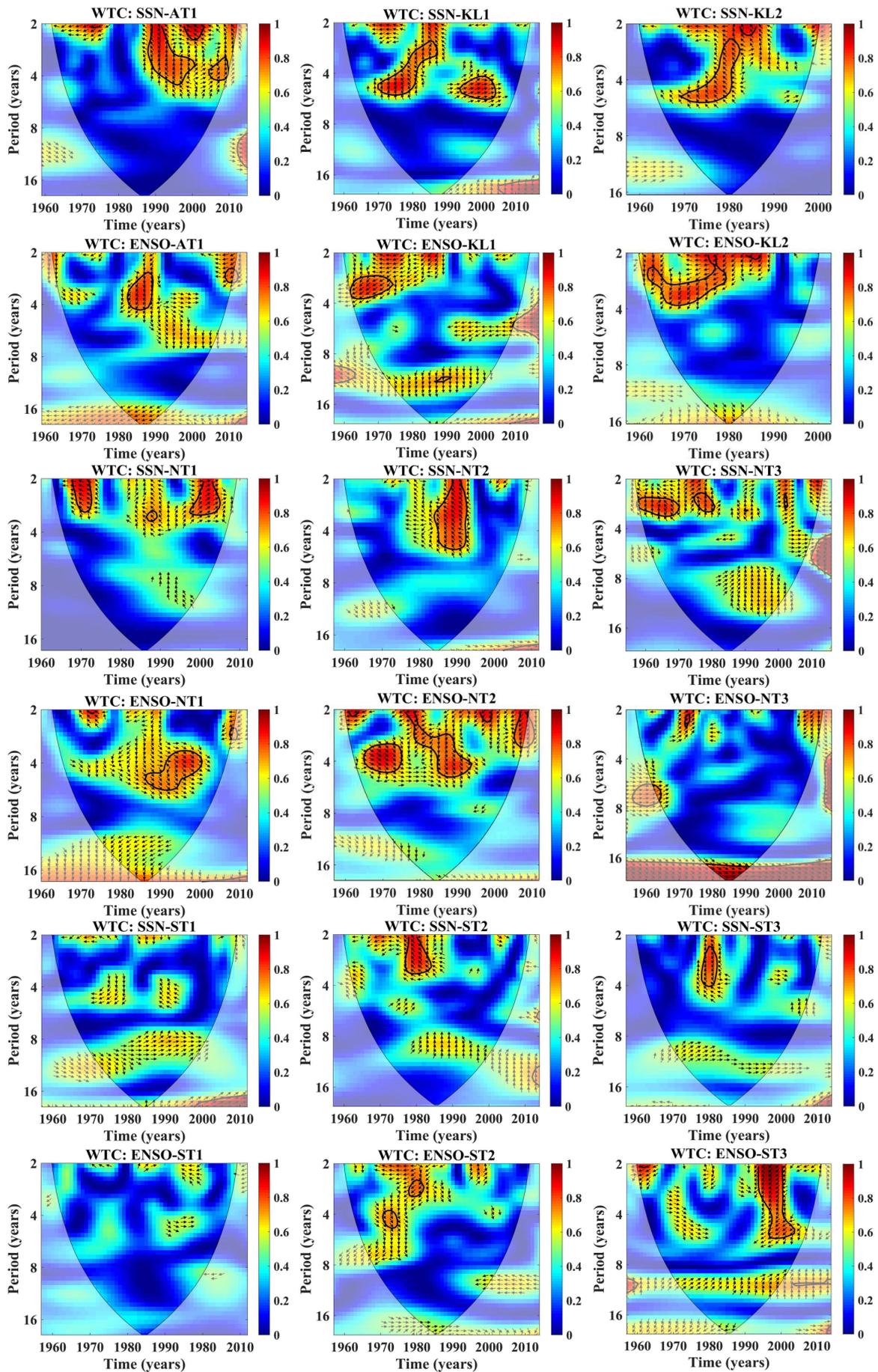


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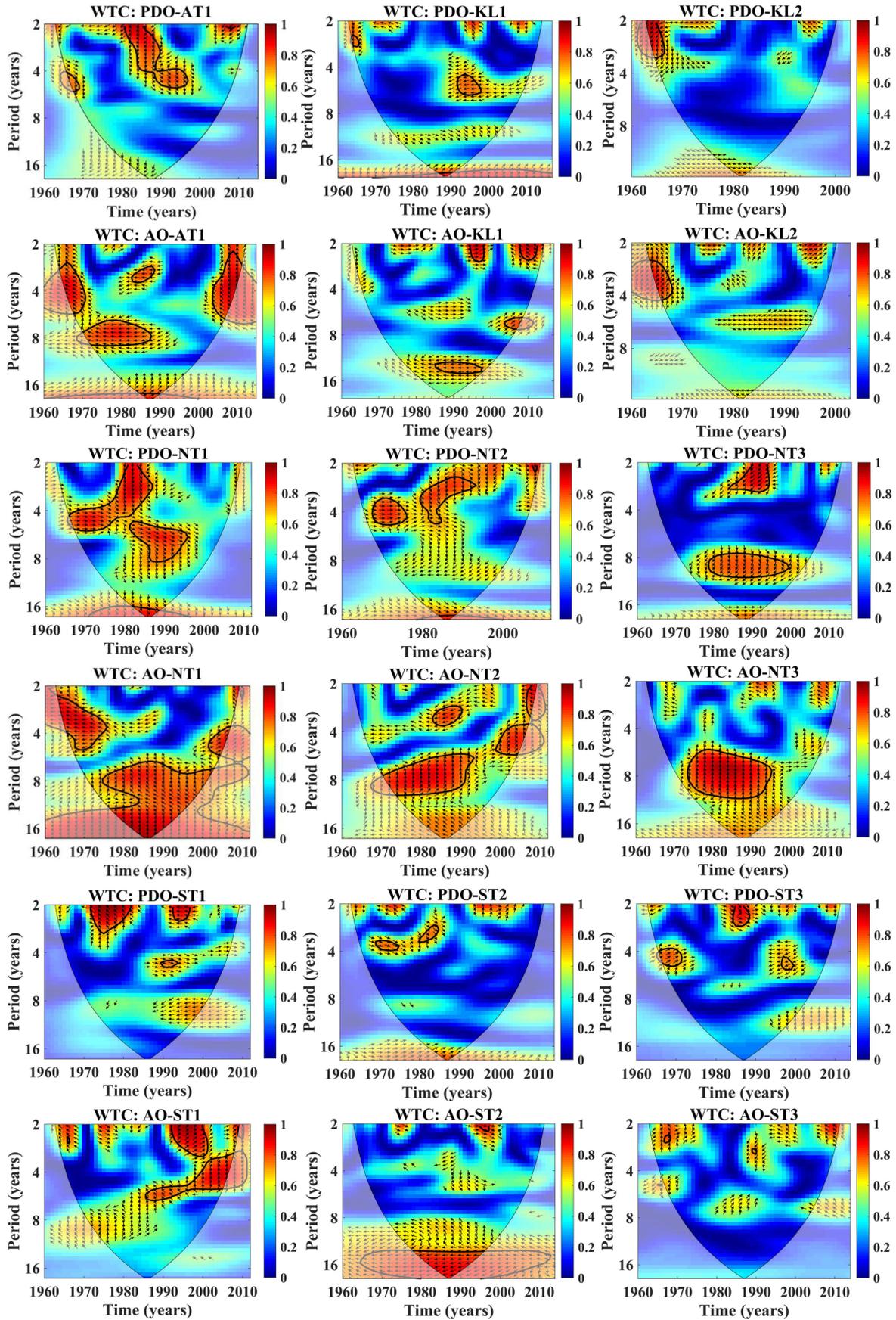


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SUMMARY AND REFERENCES

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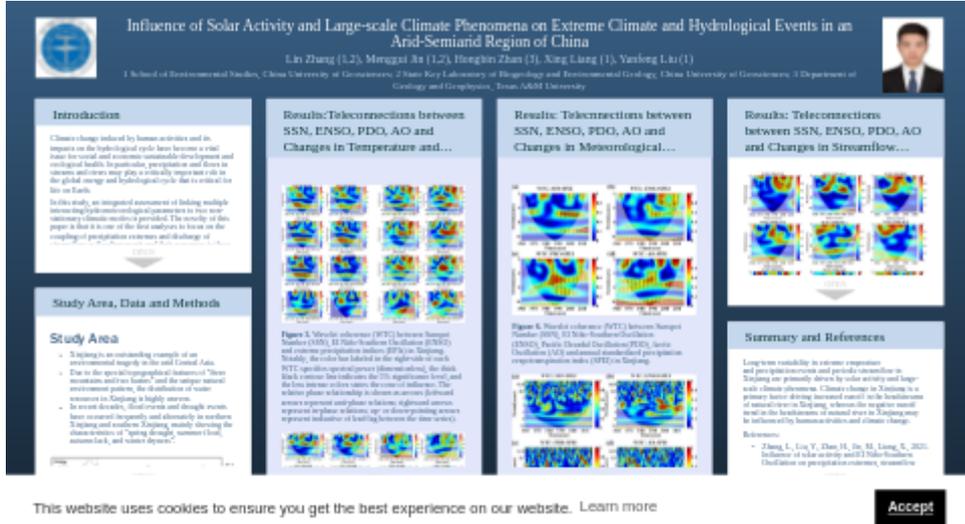
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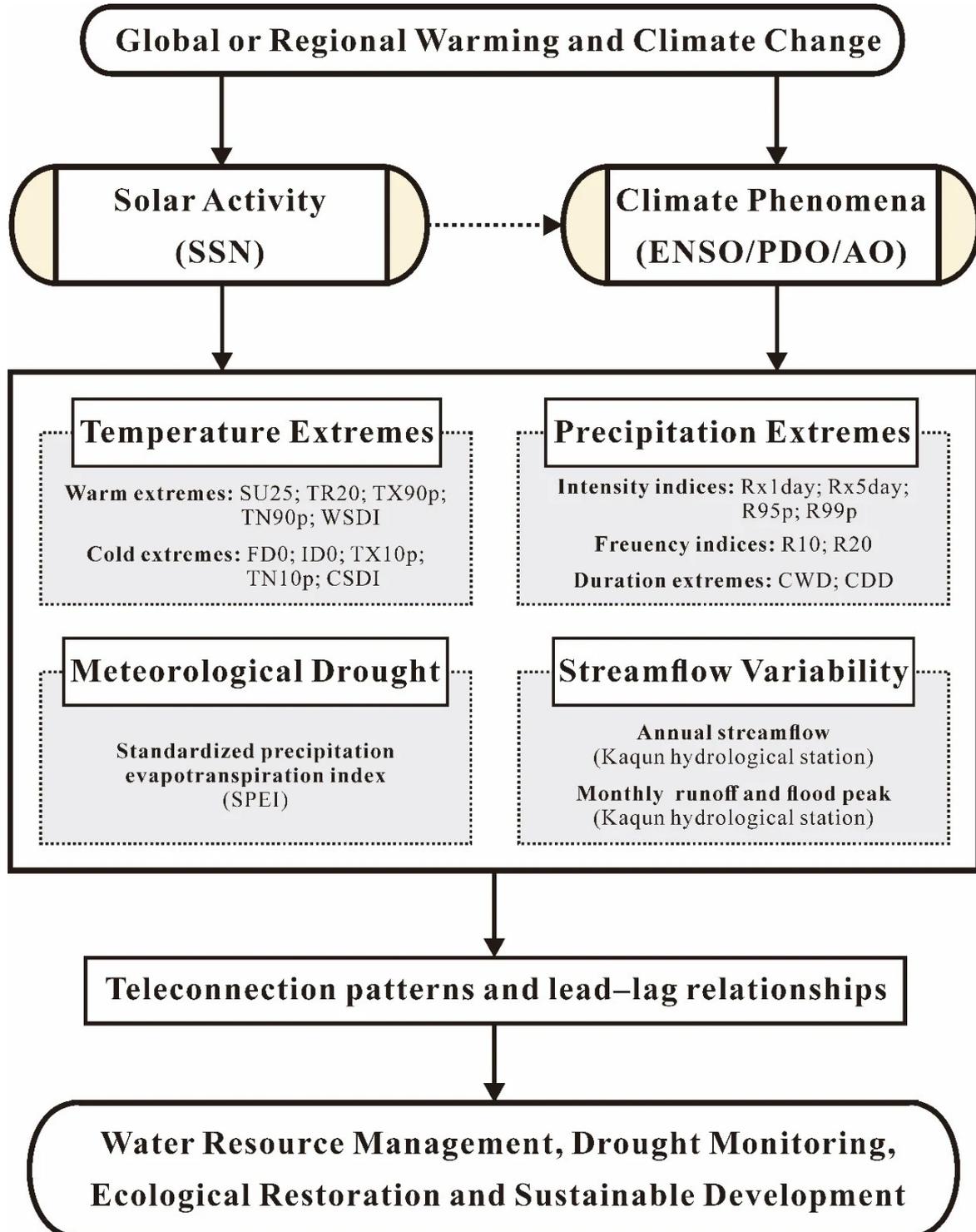
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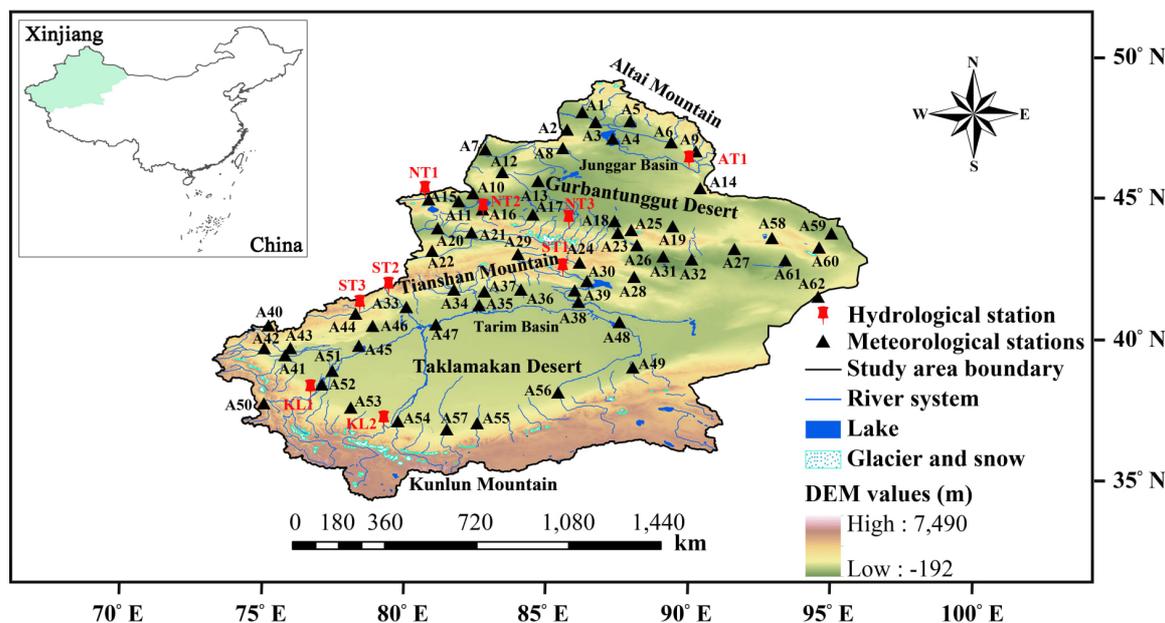


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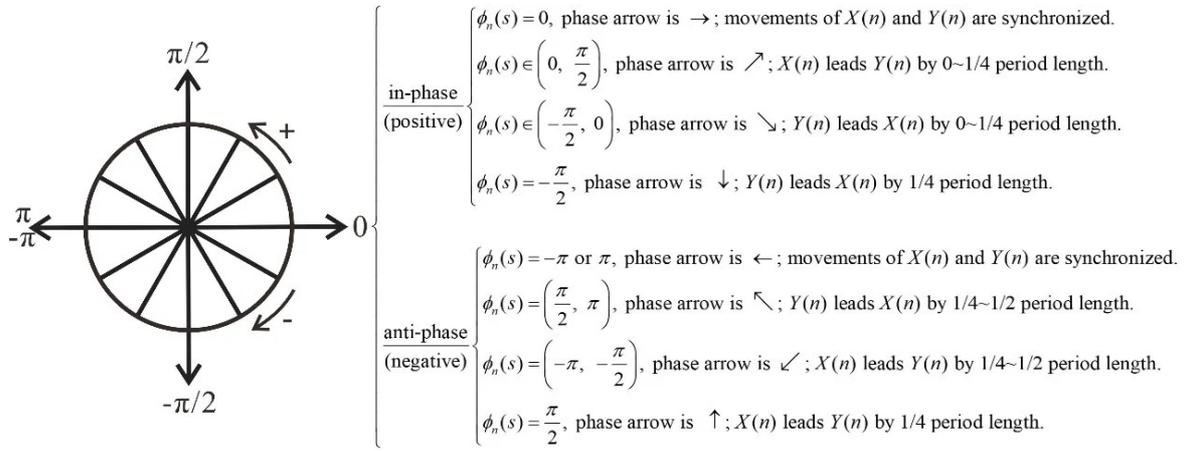


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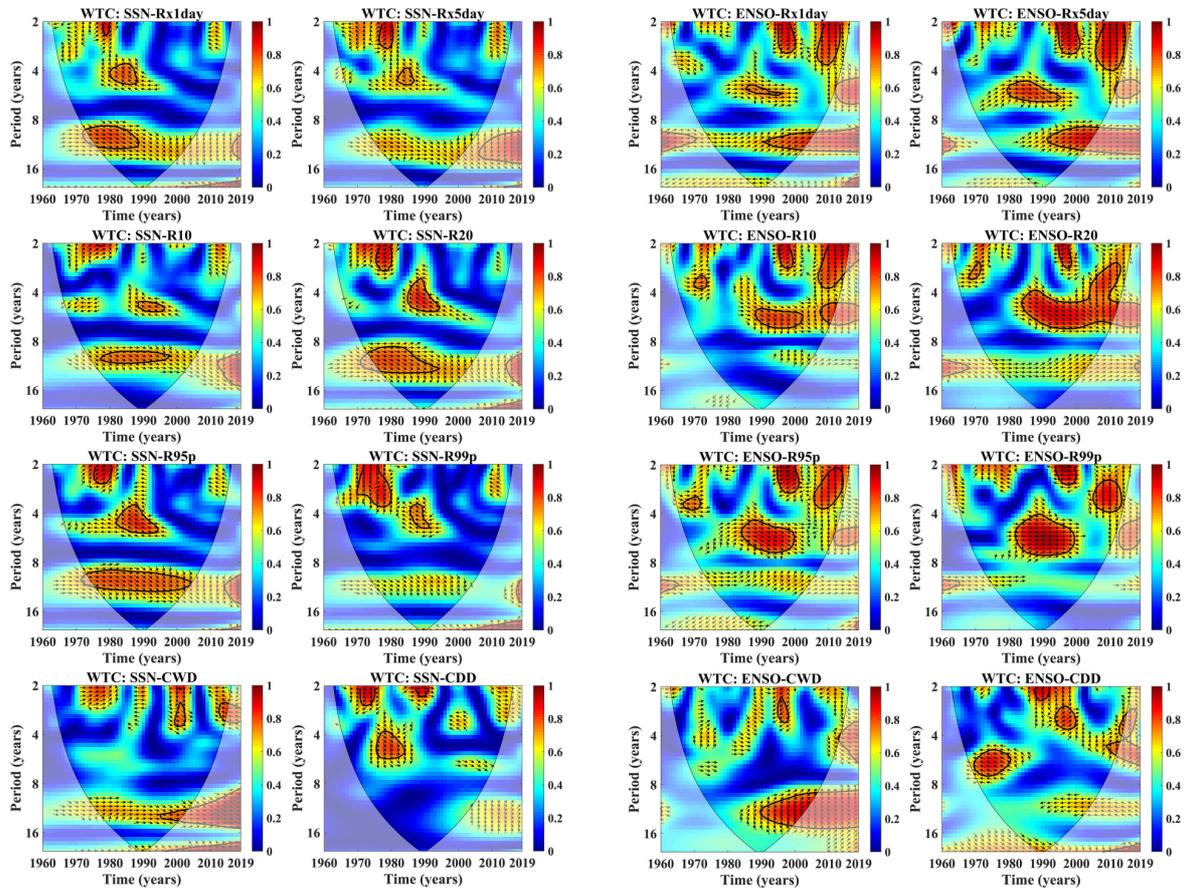


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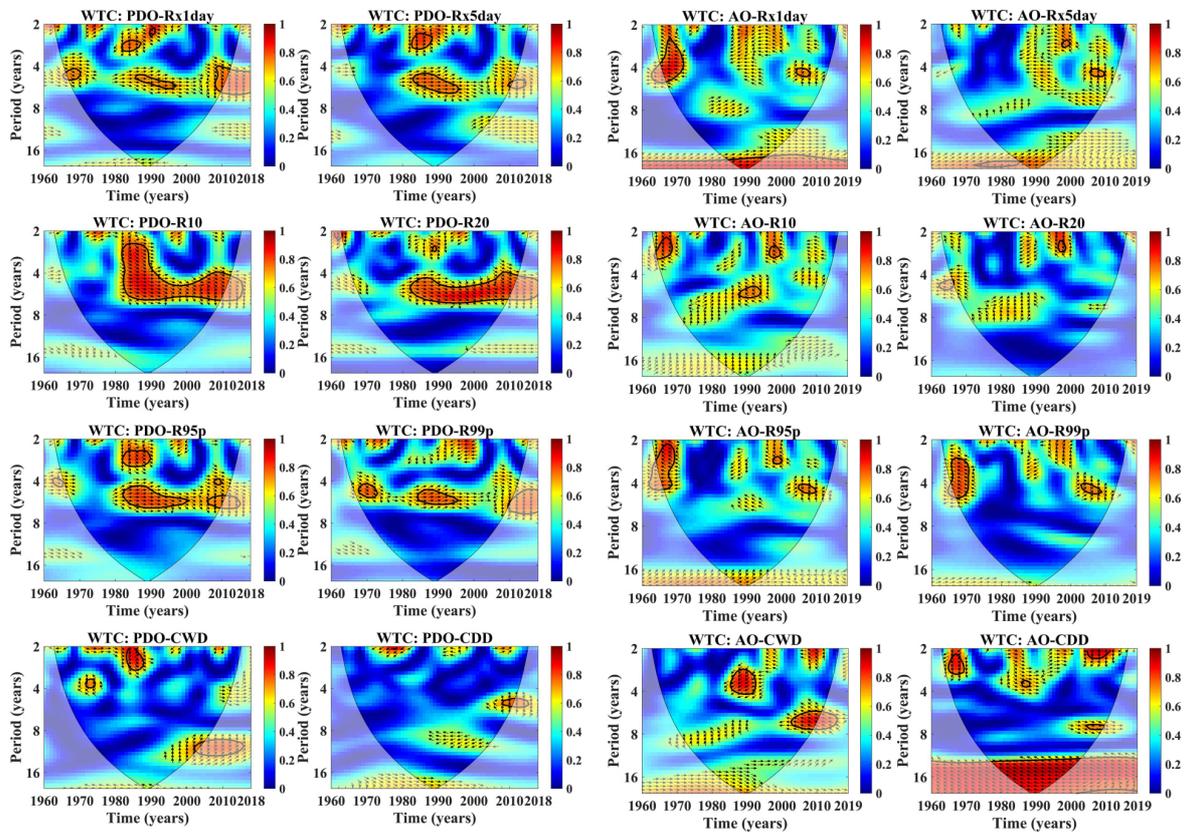


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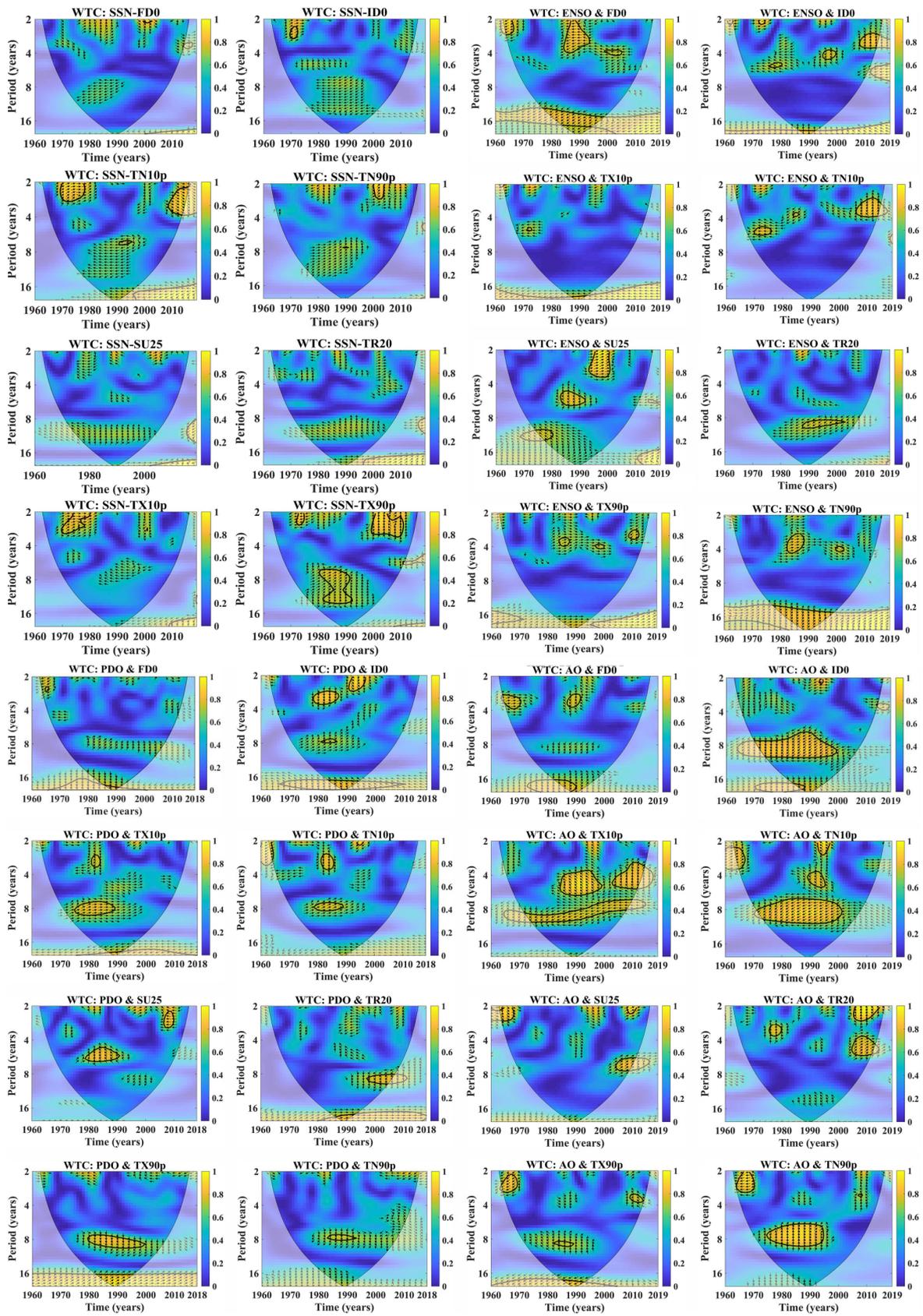


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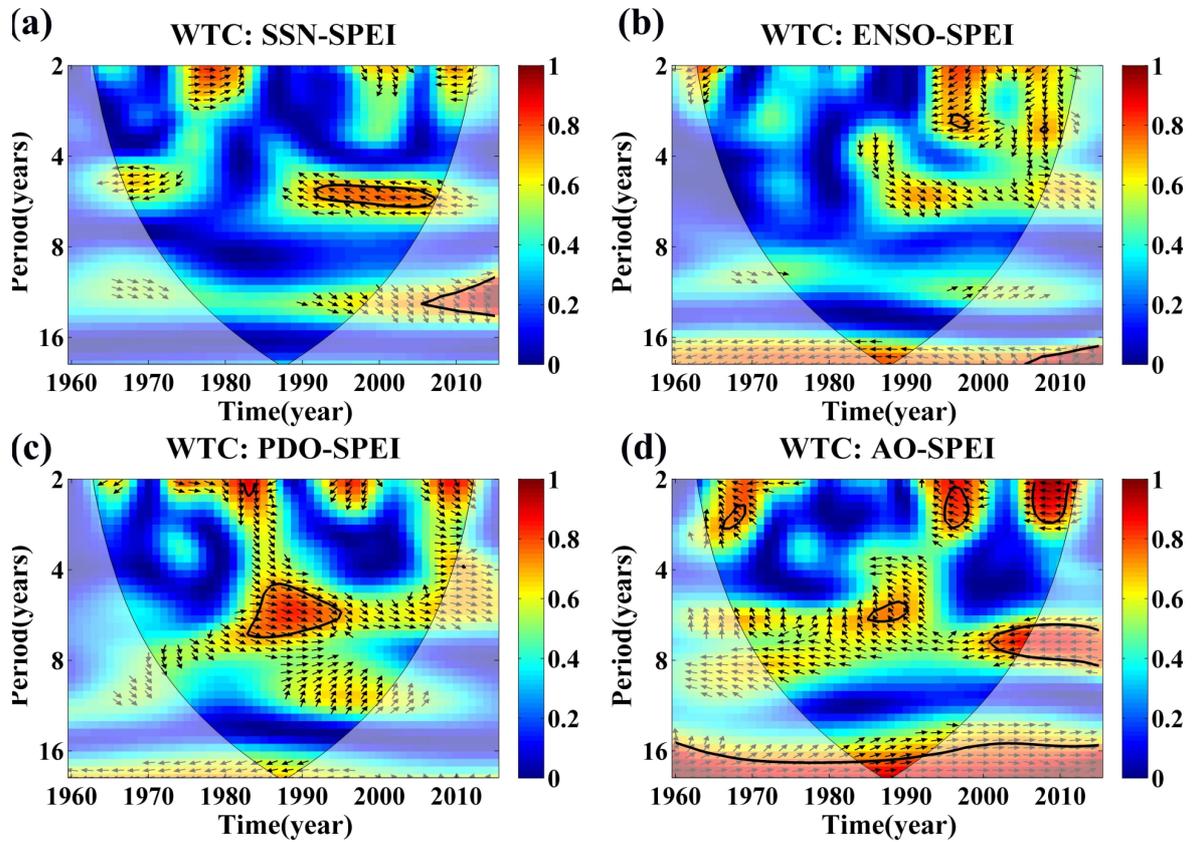


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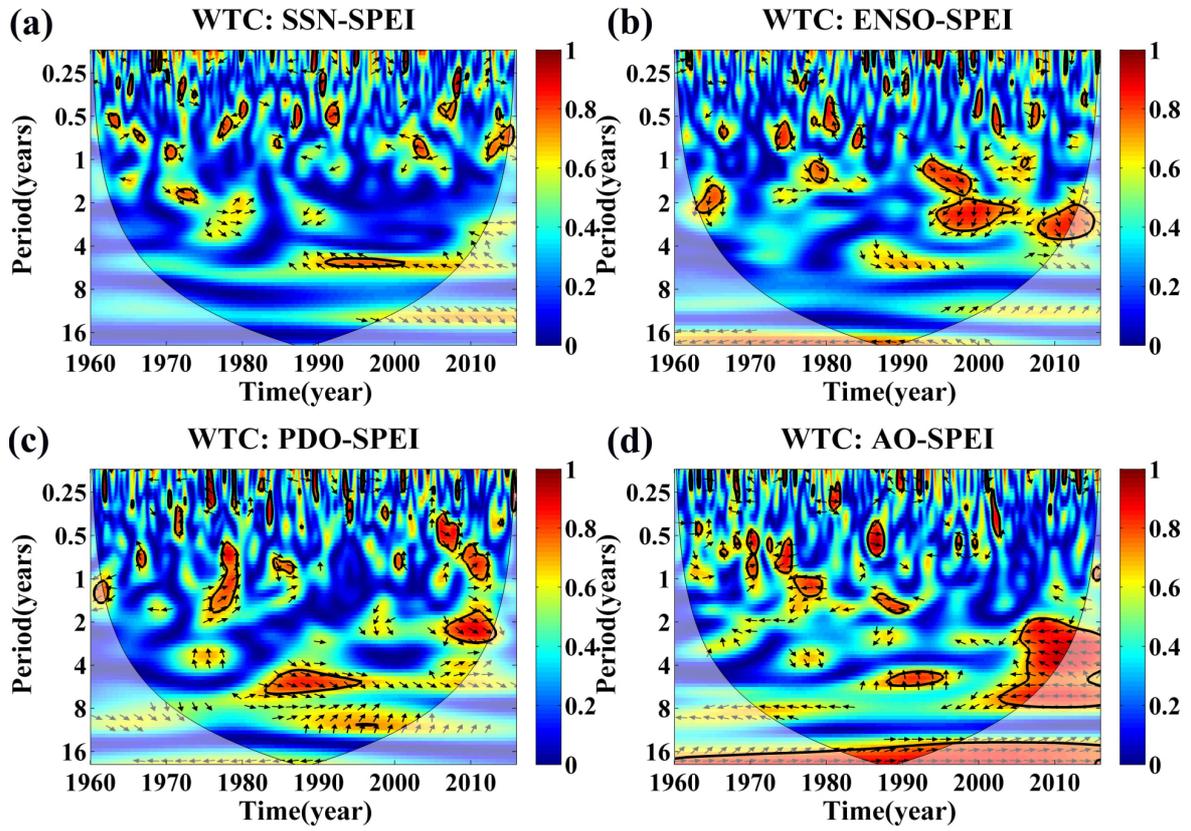


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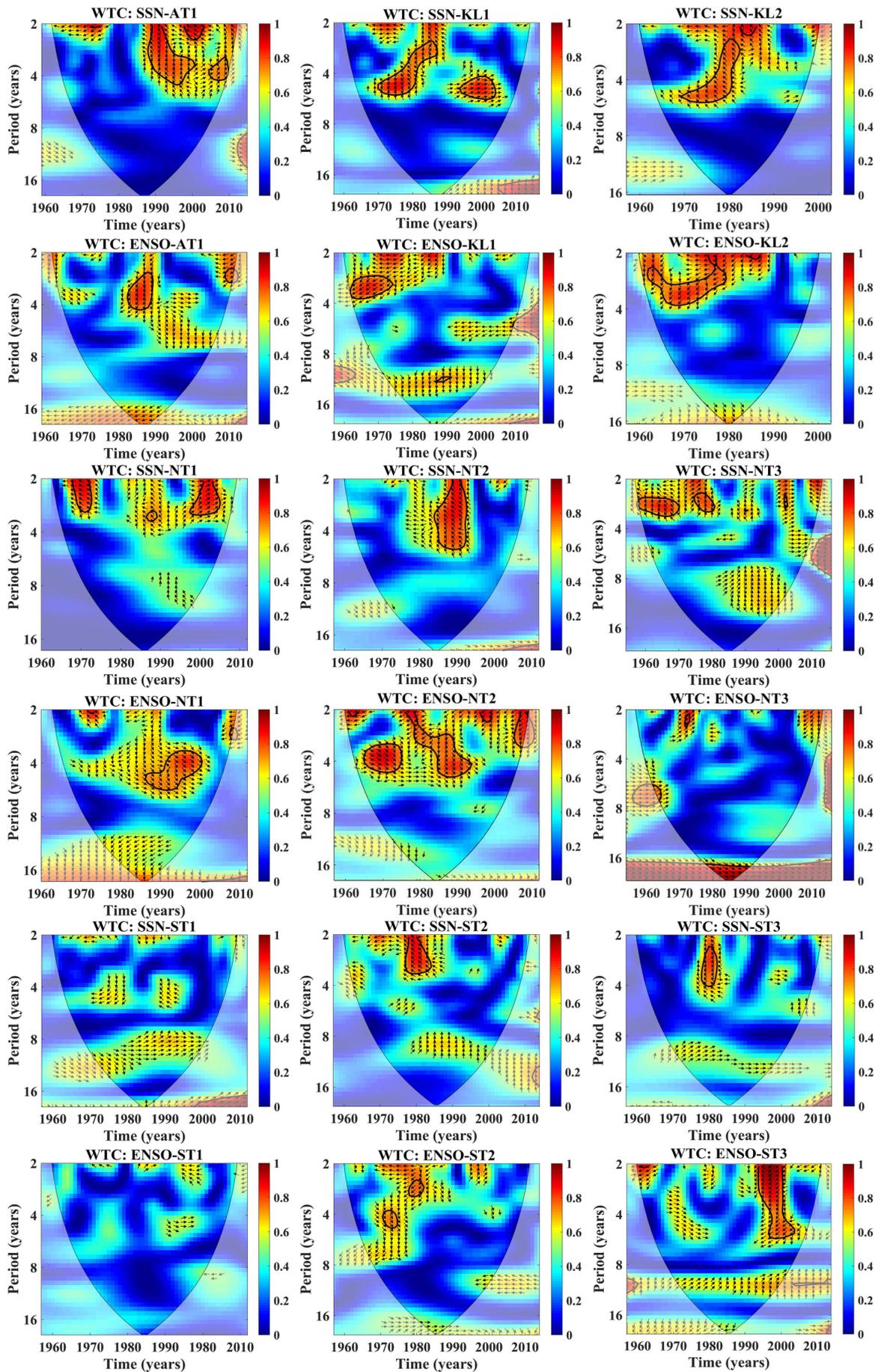


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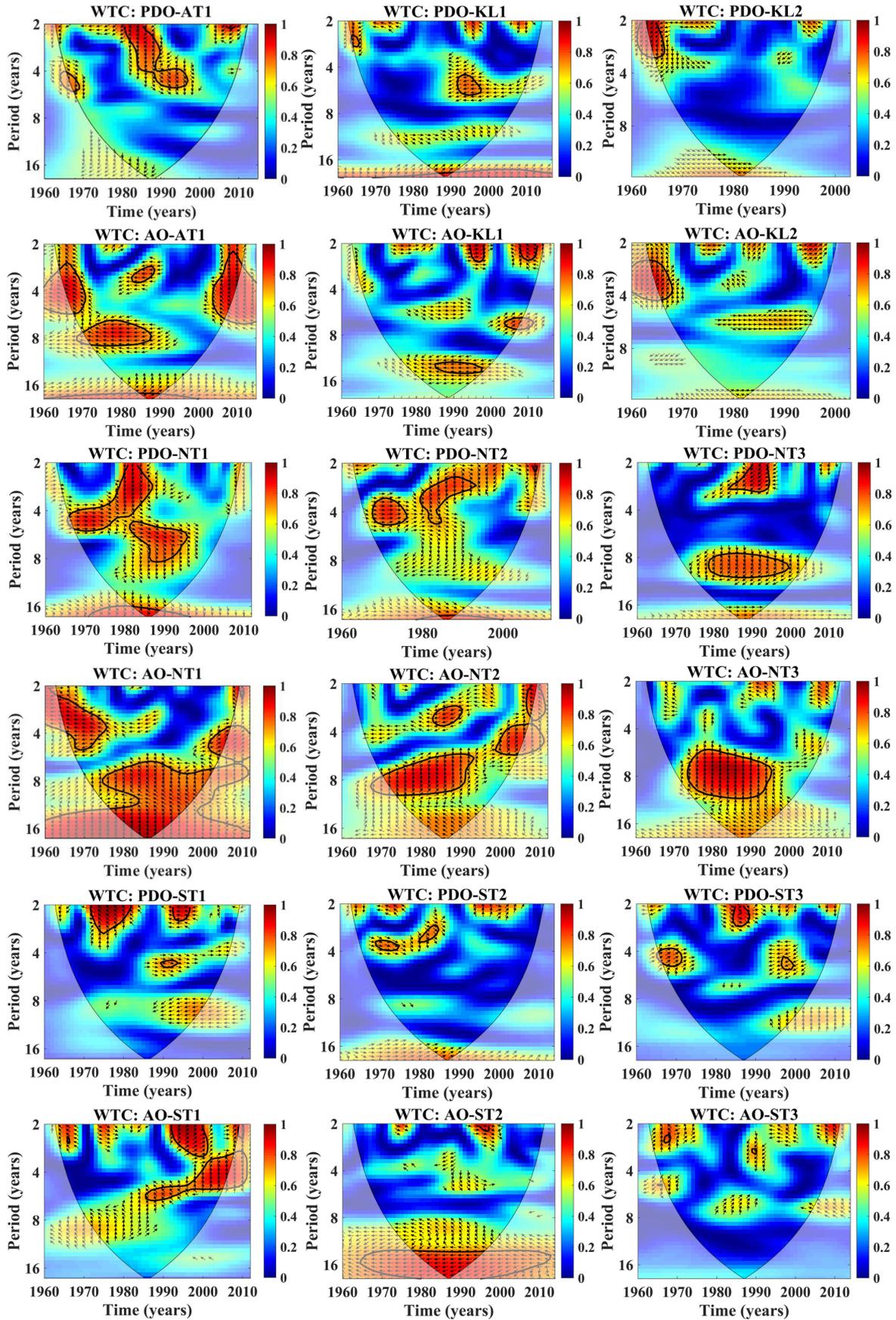


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