Evaluation of the applicability of multiple drought indices in the core zone of 'westerlies-dominated climatic regime'

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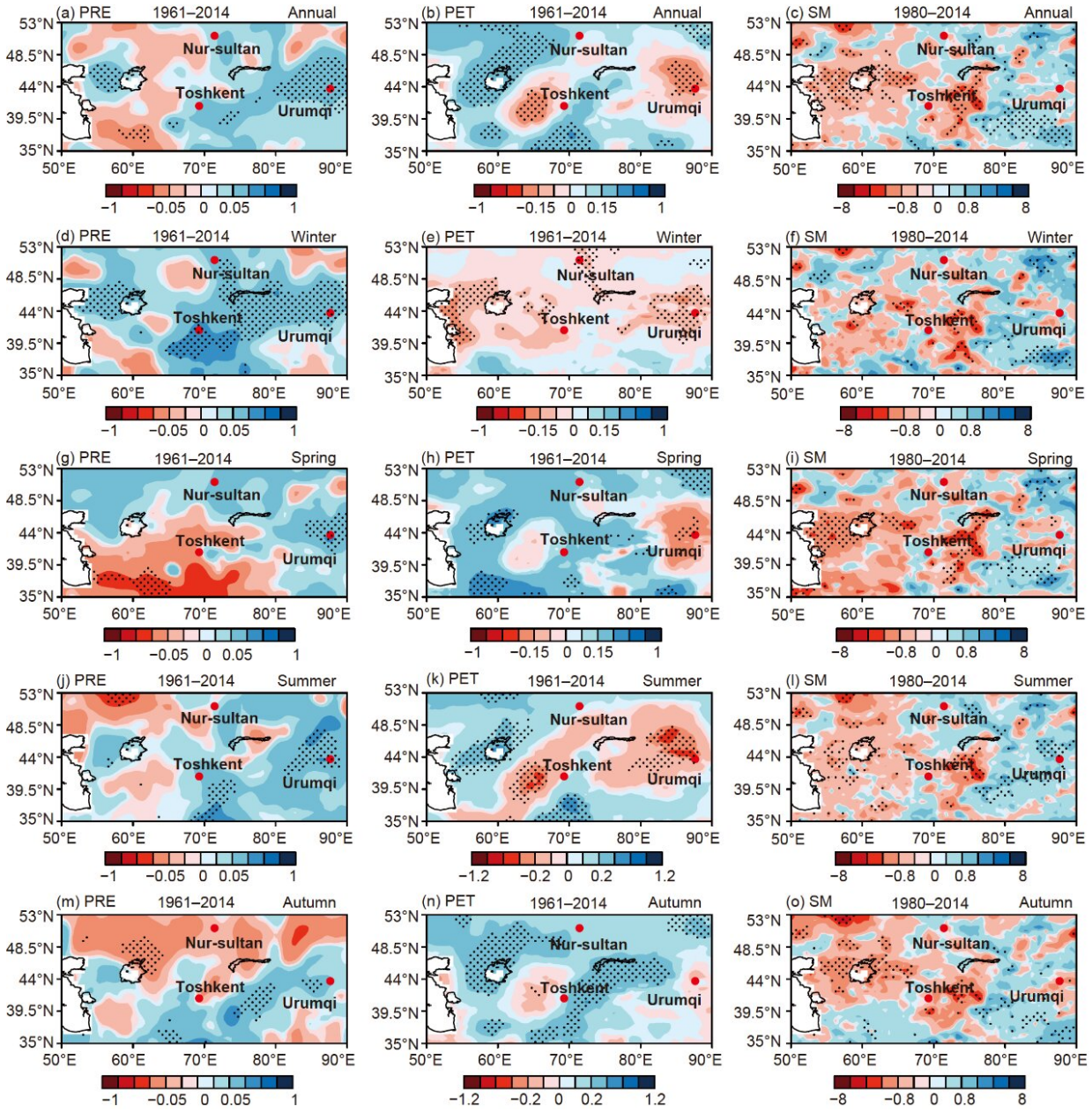


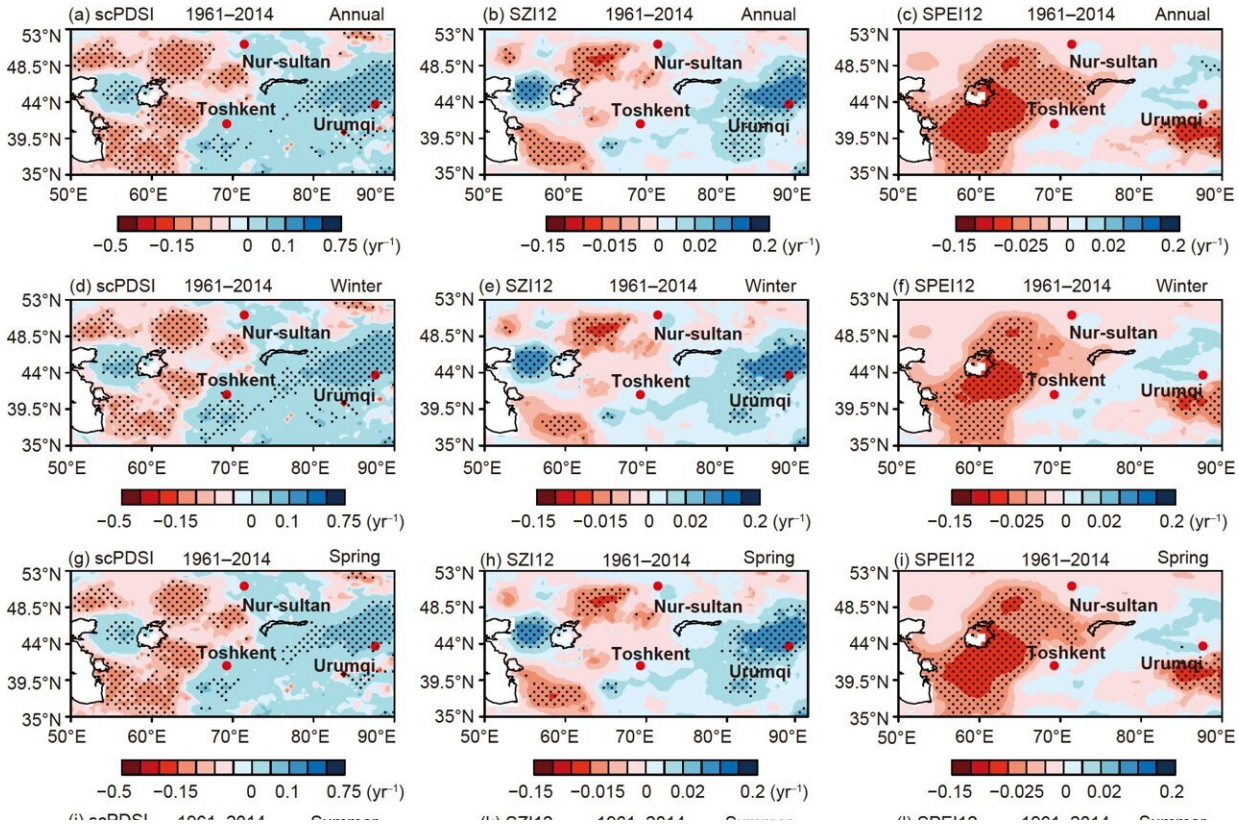
In the 5 subgraphs on the left, spatial distribution characteristics of annual and seasonal variations of precipitation (PRE) during 1961–2014. In the 5 subgraphs in the center, spatial distribution characteristics of annual and seasonal variations of potential evapotranspiration (PET) during 1961–2014. In the 5 subgraphs on the right, spatial distribution characteristics of annual and seasonal variations of soil moisture in whole layer (SM) during 1980–2014. Credit: Science China Press

With the intensification of global warming, different regions are facing constantly changing hydroclimatic conditions, which brings significant uncertainties to the assessment of dry-wet under the backdrop of global warming and the study of drought events. The core zone of "westerlies-dominated climatic regime" primarily includes the five Central Asian countries and China's Xinjiang, located in the heartland of the Eurasian continent and dominated by westerly circulation.

Its climate and hydrological changes differ from monsoon regions and have received widespread attention in recent years. As a key indicator for measuring the variation of dry-wet trend and the change of drought events, the applicability of drought indices also varies across different regions. Therefore, selecting the most suitable index to reflect the changes in aridity and characteristics of drought events in that region forms the basis for unraveling and revealing the hydroclimatic change facts and mechanisms.

To address the above challenges, Professor Wei Huang's research group at Lanzhou University evaluated the ability of three indices: the Standardized Precipitation Evapotranspiration Index (SPEI), the Standardized Moisture Anomaly Index (SZI), and the self-calibrating Palmer Drought Severity Index (scPDSI) to describe the dry-wet characteristics and drought events in the core zone of the "westerlies-dominated climatic regime" from multiple dimensions such as climate, hydrology, and vegetation.

The research findings revealed important insights into the dry-wet trends and drought events in the study area. Over the past 60 years, Kazakhstan had experienced uniform drying, while the four southern Central Asian countries had witnessed drier conditions in the western parts and wetter conditions in the eastern parts.

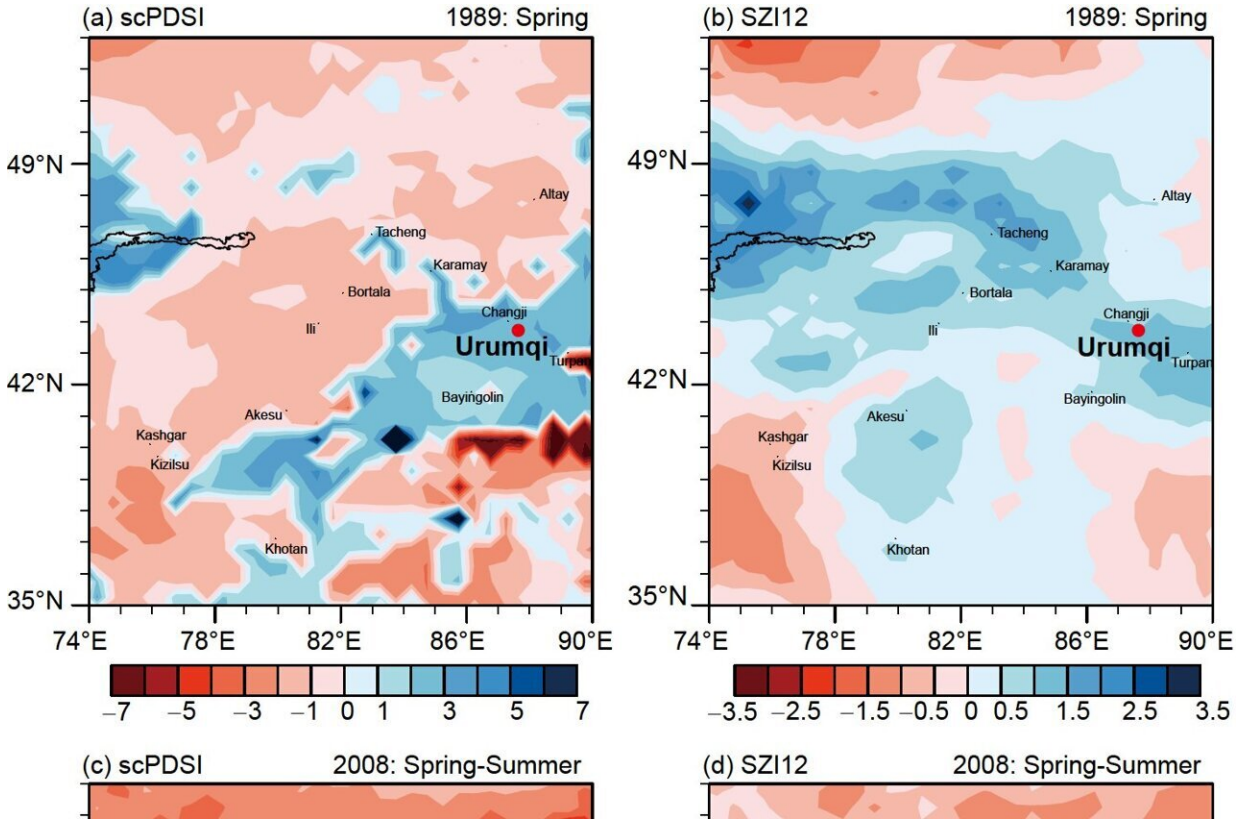


In the five subgraphs on the left, spatial distribution characteristics of annual and seasonal variations of scPDSI. In the five subgraphs in the center, spatial distribution characteristics of annual and seasonal variations of SZI. In the five subgraphs on the right, spatial distribution characteristics of annual and seasonal variations of SPEI. Credit: Science China Press

This aligned with the observed slight increase in precipitation in Kazakhstan and the four southern Central Asian countries, accompanied by a significant rise in potential evapotranspiration, ultimately leading to drier conditions. In Xinjiang, the hydroclimatic variables, SZI and scPDSI indicated a trend towards increased humidity, particularly in summer. However, the SPEI demonstrated an opposite pattern of change.

The researchers noted that the SPEI, being more sensitive to potential evapotranspiration alterations, exacerbated the severity of regional drought in arid and semi-arid regions due to rising temperatures. Consequently, it is not applicable to the study of drought in the core zone of the "westerlies-dominated climatic regime."

The team also evaluated the capability of the index to identify different degrees of drought events in the study area. The SZI employed a standardization approach based on a nonlinear three-parameter probability cumulative distribution function to enhance the representation of drought conditions. However, actual climate change often deviates from the normal distribution, leading to the underestimation of severe and extreme drought events by SZI.



The two subgraphs above (a) and (b), the severe drought in 1989. The two

subgraphs below (c) and (d), the continuous drought in spring and summer in 2008. Credit: ©Science China Press

On the other hand, the scPDSI primarily focused on assessing the severity of regional drought to provide a better reflection of the overall drought situation in the area. As a result, it could effectively reproduce the occurrence of drought events in most parts of Xinjiang during the corresponding period. In summary, the scPDSI is better suited for monitoring and identifying the characteristics of drought, including extreme drought events, in the core zone of the "westerlies-dominated climatic regime."

These research findings provide a valuable theoretical foundation for the utilization and improvement of drought indices, as well as the monitoring, attribution, and prediction of drought events in arid areas. They will significantly contribute to the estimation and understanding of climate and environmental risks in the future, as the impacts of human activities continue to increase in arid regions.

More information: Huiwen Guo et al, Evaluation of the applicability of multiple drought indices in the core zone of "westerlies-dominated climatic regime", *Science China Earth Sciences* (2023). DOI: 10.1007/s11430-022-1097-0

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