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Assessing the Impact of Non-Stationarity on Drought Assessment: A Comparative Analysis of SPI and SPEI Across IPCC Regions

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Understanding drought dynamics in a changing climate is crucial for developing effective adaptation strategies; however, significant uncertainties persist regarding global drought trends and the impacts of climate change on drought patterns. The existing drought indices assume that the climate system is stationary. That is, they are calculated based on a reference climatology, which raises concerns about their applicability to regions that have experienced climate change. In this study, we aim to evaluate the applicability of stationary versus non-stationary methodologies in IPCC regions for assessing droughts based on the Standardized Precipitation Index (SPI) and the Standardized Precipitation-Evapotranspiration Index (SPEI) over the period 1901–2023. This study explores possible limitations of traditional drought indices that assume climatic stationarity. Results demonstrate that non-stationary approaches have a minimal impact on event-based drought characteristics (intensity and duration) in most regions, with notable exceptions in limited regions, such as the Mediterranean and Western Central Asia regions, from the 12-month SPEI timescale or longer. Furthermore, we find that longer accumulation periods (SPI-12, SPEI-12) exhibit greater uncertainty and regional variability in trend detection, while short-term drought trends (SPI-3, SPEI-3) are substantially reduced under non-stationary methodologies. These findings indicate that although stationary methods remain adequate for drought event-based analysis, non-stationary approaches are essential for robust trend analysis in the context of climate change impacts on drought risk assessment.

Keywords: Climate Change, Stationary and Non-Stationary Drought