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Diverging trends between meteorological drought indices (SPI and SPEI) in Europe

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Severe European droughts over the last decade and climate change projections of increased regional drought severity for the Mediterranean and eastern Europe make understanding drought events in a non-stationary climate a major scientific and practical concern for Europe. Additionally, the existence of numerous differing drought metrics is a challenge for the robust detection of drought occurrence trends. This research addresses these issues by testing the hypotheses that (a) there have been recent trends in meteorological drought severity across Europe, and (b) that the choice of drought index significantly affects these observed trends. Meteorological drought is quantified in this study using the 6-month Standardized Precipitation Index (SPI-6) and Standardized Precipitation-Evapotranspiration Index (SPEI-6), which are commonly recommended drought metrics that measure accumulated precipitation and climatic water balance (precipitation minus reference potential evapotranspiration), respectively. Climate data are based on the WATCH Forcing Data (WFD) and WFD ERA-Interim (WFDEI) datasets, which together cover the period 1958-2014. Trends in percentage of European land area in drought were calculated for this 56 year period by defining drought as occurring below the 20th index percentile (SPI/SPEI < -0.84). Trends in European SPI-6 and SPEI-6 drought area have been moderate, with a slight decrease in precipitation-only drought (SPI) area and a slight increase in climatic water balance drought (SPEI) area. The observed spatial trends in drought frequency are consistent with climate model output, with increases in drought frequency for southern Europe and decreases across northern Europe. However, the difference between percentage drought area measured using these two indices has steadily increased. Investigating the constituent climate variables shows that the increasing divergence between drought measured by SPI and SPEI is driven by an increase in temperature and thus PET, which is only accounted for in the SPEI. The divergence between drought indices remains nearly constant across Europe, regardless of the overall trend in drought frequency. This suggests that increased temperature and PET have exacerbated the recently intensifying Mediterranean droughts, while also partially counteracting precipitation increases in northern Europe. The drought trends identified are vital for water resources planning, whereas the divergence between trends in the SPI and SPEI highlights the importance of the drought index used in a non-stationary climate.