



Pan-European comparison of candidate distributions for climatological drought indices, SPI and SPEI

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Drought indices are vital to objectively quantify and compare drought severity, duration, and extent across regions with varied climatic and hydrologic regimes. The Standardized Precipitation Index (SPI), a well-reviewed meteorological drought index recommended by the WMO, and its more recent water balance variant, the Standardized Precipitation-Evapotranspiration Index (SPEI) both rely on selection of univariate probability distributions to normalize the index, allowing for comparisons across climates. The SPI, considered a universal meteorological drought index, measures anomalies in precipitation, whereas the SPEI measures anomalies in climatic water balance (precipitation minus potential evapotranspiration), a more comprehensive measure of water availability that incorporates temperature. Many reviewers recommend use of the gamma (Pearson Type III) distribution for SPI normalization, while developers of the SPEI recommend use of the three parameter log-logistic distribution, based on point observation validation. Before the SPEI can be implemented at the pan-European scale, it is necessary to further validate the index using a range of candidate distributions to determine sensitivity to distribution selection, identify recommended distributions, and highlight those instances where a given distribution may not be valid. This study rigorously compares a suite of candidate probability distributions using WATCH Forcing Data, a global, historical (1958-2001) climate dataset based on ERA40 reanalysis with 0.5×0.5 degree resolution and bias-correction based on CRU-TS2.1 observations. Using maximum likelihood estimation, alternative candidate distributions are fit for the SPI and SPEI across the range of European climate zones. When evaluated at this scale, the gamma distribution for the SPI results in negatively skewed values, exaggerating the index severity of extreme dry conditions, while decreasing the index severity of extreme high precipitation. This bias is particularly notable for shorter aggregation periods (1-6 months) during the summer months in southern Europe (below 45° latitude), and can partially be attributed to distribution fitting difficulties in semi-arid regions where monthly precipitation totals cluster near zero. By contrast, the SPEI has potential for avoiding this fitting difficulty because it is not bounded by zero. However, the recommended log-logistic distribution produces index values with less variation than the standard normal distribution. Among the alternative candidate distributions, the best fit distribution and the distribution parameters vary in space and time, suggesting regional commonalities within hydroclimatic regimes, as discussed further in the presentation.