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Relationship between monthly temperature anomalies and drought frequency

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Meteorological droughts are extreme climate events characterized by a period, of months or years, with below-normal precipitation. The economical and ecological impacts of such events can be catastrophic, having profound effects for agricultural production, water resources, biodiversity, tourism and many other aspects. It is recognized that the cause of meteorological droughts are largely associated with fluctuations on sea surface temperature and atmospheric dynamic processes. Nevertheless, the influence of surface air temperature on the frequency of meteorological droughts is still unclear. The objective of this study was to assess the relationship between temperature anomalies and drought frequency. Records from 50 stations from the Global Historical Climatology Network (GHCN) were analyzed at monthly time scale. The criterion used to select the stations was solely the length of the time series recorded in the stations. Namely, only stations with more than 100 years records, for both precipitation and temperature, were used in this study. In general, the selected stations were distributed along Australia, European countries, Unites States and Canada. Standardized temperature anomalies were calculated taking as baseline the entire dataset recorded at the station. The precipitation anomalies for each month were assessed through the Standardized Precipitation Index (SPI) according to the empirical cumulative distribution at each location. Therefore, both temperature anomalies and precipitation deficits were normalized, allowing a direct comparison of the entire dataset in each station, independent of the season of the year. Next, the monthly SPI were associated with the respective monthly temperatures anomalies. The SPI values were binned based on the temperature anomaly values. The used bin width was 0.5 degC. Finally, for each temperature anomaly bin, the average SPI and the frequency of months with SPI lower than -1 (moderated drought) were calculated. In order to avoid bias, only bins with more than 20 observations were considered.
The results showed that 64% of the stations had a significant inverse relation between average SPI and rising temperature anomalies (at a significance level of 0.05%). All the stations with a significant relation presented a negative slope in the regression, meaning that SPI values declined in average at a rate of 0.185degC-1. A large increase on the frequency of months with SPI lower than -1 was also observed in these stations. While the average frequency of dry months for temperatures anomalies close to zero (-0.5 degC < a >0.5 degC) was about 14% (stdev=2.7), months with temperature anomalies higher than 2degC showed an average incidence of dry months of about 40% (stdev= 12). Therefore, this study shows clear evidences of a direct relation between temperature anomalies (mostly related to heat waves) and the occurrence of meteorological drought events. Nevertheless, the results also indicate that, in some regions, the occurrence of dry events is not necessarily coupled with the variability of air temperature. Further studies are necessary in order to understand the discrepant results among these regions. Additional effects, such as sea surface temperature fluctuations and specific humidity need to be analyzed in order to isolate the effects of surface temperature.