Supporting Online Materials

Does drought show a significant decreasing trend from 1961 to 2017 in northern China?

S1 Computation of SPEI

According to previous studies (Vicente-Serrano et al. 2010; Wang et al. 2020; Wu et al. 2020; Beguería et al. 2014), the computation of the SPEI is as follows:

Firstly, based on precipitation and potential evaporation, Penman-Monteith equation has been successfully applied in both humid and arid climates around the world. The formula of potential evapotranspiration is:

$$PET = 16K(\frac{10T}{I})^m \quad (1)$$

where T is the monthly mean temperature (◦C); I is a heat index, which is calculated as the sum of 12 monthly index values; m is a coefficient depending on I, m $=6.75\times10^{-7}I^3-7.71\times10^{-5}I^2+1.79\times10^{-2}I+0.492$; and K is a correction coefficient computed as a function of the latitude and month.

Secondly, based on climatic water balance, SPEI is determined by standardizing difference between precipitation (P) and PET for the month i:

$$D_i=P_i-PET_i \quad (2)$$

where P_i and PET_i denote the aggregated precipitation and PET for the given month i. The difference $X_{i,j}^k$ in month j and year i depends on the different time scale k. For instance, the accumulated difference for 1 month in a particular year i with a 12-month

time scale is calculated as follows:

$$X_{i,j}^{k} = \sum_{l=13-k+j}^{12} D_{i-1,l} + \sum_{l=1}^{i} D_{i,l}\,, if\ j < k,$$

$$X_{i,j}^{k} = \sum_{l=j-k+1}^{j} D_{i,j}\,, if\ j \geq k \tag{3}$$

where $D_{i,l}$ is the difference between P and PET in the first month of year i.

Thirdly, after standardized $X_{i,j}^{k}$ data sequence, the log-logistic probability distribution is selected to obtain the SPEI series. The cumulative function of this distribution is expressed as:

$$f(x) = [1 + (\frac{\alpha}{x - \gamma})^{\beta}]^{-1} \tag{4}$$

where α, β, and γ are scale, shape, and origin parameters, respectively.

Thus, SPEI is given by the standardized values of f(x):

$$SPEI = W - \frac{C_0 + C_1 W + C_2 W^2}{1 + d_1 W + d_2 W^2 + d_3 W^3} \tag{5}$$

where $W = \sqrt{-2ln\,(P)}$ for P ≤ 0.5, P is the probability of a defined $X_{i,j}^{k}$ value and $P=1-f(x)$. If P > 0.5, then P is replaced by 1−P and the sign of SPEI is reversed. Other constants are C_0 = 2.515517, C_1 = 0.802853, C_2 = 0.010328, d_1 = 1.432788, d_2 = 0.189269, and d_3 = 0.001308.

S2 Definition of drought duration

According to Wu et al. (2020), the drought duration of the i-th drought event (DDi) was calculated as the difference between the end time of the i-th drought event (TEi) and the start time of the i-th drought time (TSi). In this study, the total drought duration (DD) is defined as the sum of all DDi over different period (Fig. S1).

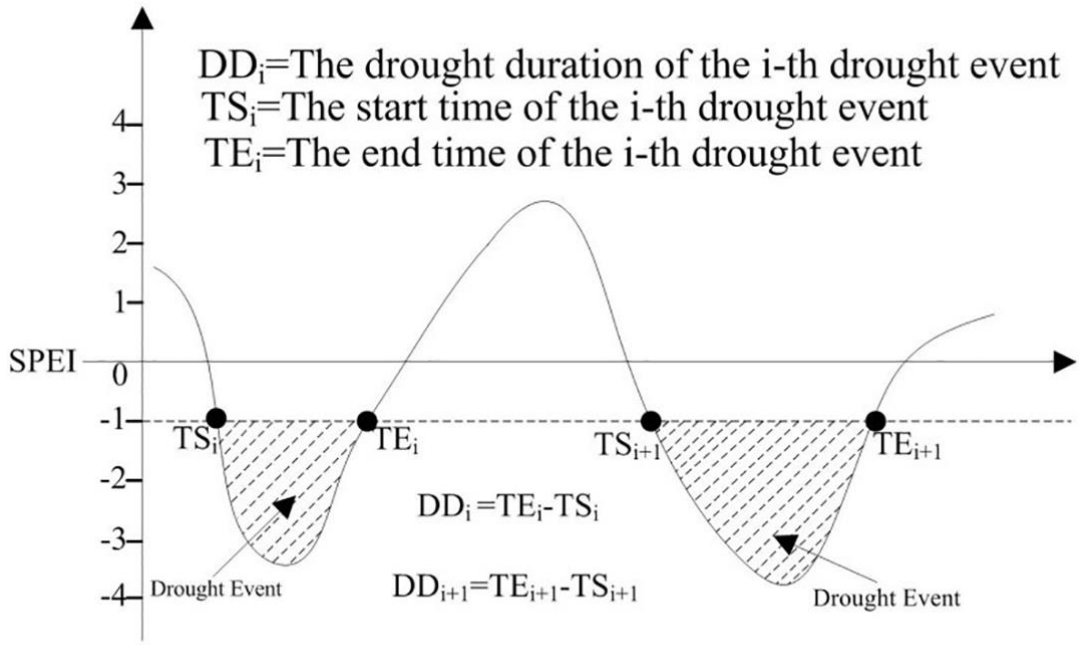

Fig. S1 Definition of the drought duration for i-th drought event

References

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