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Drought monitoring using water deficit index for Huaihe River Basin, China

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Drought is one of natural disasters in agricultural production. As a commonly used indicator for drought monitoring, soil moisture is intensively studied using remotely sensed images. One important technique of soil moisture estimation is to calculate some index reflecting soil moisture status based on the relationship between land surface temperature and vegetation index. In the present study, we use the water deficit index (WDI), which is estimated on the basis of the trapezoidal relationship between remotely sensed land surface temperature and vegetation index, to monitor the drought process for Huaihe River region. The water deficit index (WDI) used in this paper is calculated based on the surface temperature (Ts) $\sim$ vegetation index (VI) trapezoid which is the simplification of vegetation index $\sim$ temperature (VIT) trapezoid proposed by Moran et al. (1994). An iterative algorithm based on energy balance equations is developed for calculate the Ts at four vertices of the trapezoid, which represent four extreme conditions, i.e. saturated bare soil, dry bare soil, water-stressed vegetation and well-watered vegetation. The calculation of the Ts$\sim$VI trapezoid is conducted for each grid separately, and requires MODIS remote sensing data (including MOD11A1 surface temperature, MOD13A2 vegetation index and MOD09A1 surface albedo and digital elevation model, etc.) and meteorological data (air temperature, wind speed, relative humidity) at each pixel. To accomplish the calculation of WDI, a series of data pre-processing is proposed, including de-striping bad pixels, the denoising of vegetation index, correcting the topographic effects for air temperature data and interpolating the meteorological data to each grid. By comparing the WDI values with ground-based precipitation and streamflow observations, we find that the WDI values can reflect the temporal variation of drought conditions very well, and spatial pattern of WDI can reveal more details of the spatial variability of drought than meteorological observations and streamflow observations. We also compared the performance of WDI with that of a popular drought index —- temperature and vegetation dryness index (TVDI). The result indicates that WDI has a better performance than TVDI according to their correlation with antecedent precipitation and runoff depth. Therefore, WDI has a great potential to well monitor drought using satellite data and limited requirement of ground-based meteorological observations.