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Connections between meteorological and hydrological droughts in semi-arid basins of the middle Yellow River

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Differences between meteorological and hydrological droughts could reflect the basin water consumption by both natural elements (such as evaporation) and human water-use. The connections between these two drought types were analyzed using the Standardized Precipitation Evapotranspiration Index (SPEI) and Standardized Streamflow Index (SSI), respectively. In the typical semi-arid basins of the middle Yellow River (Qingjianhe River basin), annual precipitation and annual air temperature showed significantly downward and upward trends, respectively, with the rates of -2.37 mm/year and 0.03 oC/year (1961-2007). Under their synthetic effects, the water balance variable (represented by SPEI) showed obviously downward (drying) trend at both upstream and whole basin areas. For the spatial variability of precipitation, air temperature and the calculated SPEI, both upstream and downstream areas experienced very similar change characteristics. Results also suggested that the Qingjianhe River basin experienced near normal condition during the study period. As a whole, this semi-arid basin mainly had the meteorological drought episodes in the mid-1960s, late-1990s and the 2000s depicted by 12-month SPEI. The drying trend could also be depicted by the hydrological drought index (12-month SSI) at both upstream and downstream stations (Zichang and Yanchuan), but the decreasing trends were not significant. A correlation analysis showed that hydrological system needs a time lag of one or more months to respond to meteorological conditions in this semi-arid region. In addition, the increasing constructions of soil and water conservation measures may intensify the drying trend of this study basin. This finding could be an useful implication to drought research for those semi-arid basins with intensive human activities.