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Reconstructing a new terrestrial water storage deficit index to detect and quantify drought in the Yangtze River Basin

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With the intensification of global climate change, droughts have occurred frequently in the Yangtze River Basin (YRB), which has caused significant impacts on human production, life, and socio-economic development. To reduce the damage caused by drought in the YRB, the drought characteristics must be comprehensively detected and quantified. Here, the spatial and temporal variability of precipitation, runoff, soil moisture, terrestrial water storage, and groundwater in the YRB from the Gravity Recovery and Climate Experiment (GRACE), hydrological and in situ observations were comprehensively estimated by decomposing them into seasonal, subseasonal, trend, and interannual observations. The new weighted GRACE drought standardisation index (WGDSI) was reconstructed using the component contribution ratio and compared with the standardised soil moisture index (SSI), standardised precipitation index (SPI06), and standardisation runoff index (SRI). Additionally, the drought characteristics identified based on observations of the water storage deficit, severity, peak, duration, and recovery time were also quantified using the WGDSI over the YRB. The results indicated that changes in soil moisture, terrestrial water storage, and groundwater in the YRB increased from 2003 to 2019 and mainly based on seasonal and interannual signals. The correlation coefficients between the WGDSI and the SSI, SPI06, and SRI were 0.92, 0.62, and 0.79, respectively, which represented increases of 9%, 14%, and 21% compared to that with the unweighted GRACE drought standardisation index, respectively. The interannual variability of the hydrologic variables was more consistent with drought events in the YRB, which was beneficial for detecting drought. Two serious droughts occurred in the YRB from 2003 to 2019. In 2006, a continuous 7-month-long drought occurred, with a peak at -28.974 km^3, severity of -174.767 km^3month, average drought recovery rate of 0.83 km^3/month, and recovery time of 30 months, while in 2011, a continuous 5-month-long drought occurred, with a peak at -18.384 km^3, severity of -78.106 km^3/month, average drought recovery rate of 0.40 km^3/month and recovery time of 39 months. The above results indicate that the WGDSI can be used to monitor and quantify drought over the YRB. The index proposed in this study can be applied to generate new datasets and methods for detecting and quantifying global drought.