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The increasing risk of future simultaneous droughts over the Yangtze River basin based on CMIP6 models

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Drought projection is critical for water resource planning and management, as well as disaster prevention and mitigation. As a strategic national water source for China, the Yangtze River Basin (YRB) plays a vital role in the connectivity of rivers and economic development, flowing through 11 provincial administrative regions and is injected into the East China Sea, with a total length of 6,397 km. The watershed covers an area of 1.8 million square kilometers, accounting for about 1/5 of China's total land area. However, frequent droughts have caused water shortages in the YRB in recent years. Based on observed meteorological and hydrological data, the CMIP6 model and SPEI (standardized precipitation evapotranspiration index) drought models were used to elucidate the risk of future simultaneous droughts in the upper and mid-lower reaches of the YRB from 2015 to 2100. SRI has been used based on SWAT model to study the transfer process of meteorological drought to hydrological drought. The results indicated that, (1) The average of 10 CMIP6 models showed a good verification of historical precipitation and temperature for drought predictions. The MMK and Sen's slope demonstrated consistency for historical and future droughts in the YRB. From a historical perspective (1961–2019), the middle reaches of the YRB experienced intensifying drought frequency with the highest total drought (Moderate and above drought events) frequency (> 17%); (2) In the future (2020–2100), the higher emission signifies higher moderate and total drought frequency, intensity, and scope of the YRB in FF, lower in NF. The ratio of autumn severe and extreme droughts would increase in mid-twenty-first century; (3) Severe drought risk encounters were projected in the upper and meanwhile in the middle-lower reaches in YRB, especially in the 2030–2040 period. Under all three scenarios, severe droughts occurred more frequently with SPEI close to − 2. The middle-lower reaches of the YRB are forecast to witness the largest scope and highest intensity of drought under the SSP1-2.6 scenario.; (4) The future runoff in the YRB during the dry period varied less, but in May and June during the main flood season the runoff under SSP1-2.6 would be the largest. Maximum decrease in runoff in the mid-lower reaches under the SSP2-4.5 scenario would be 2045, reaching 13.9%. Extreme flooding events and extreme meteorological droughts would happen accompanying with hydrological droughts would occur more frequently and severely under different scenarios. More attention and improved strategies should be brought to bear to address future simultaneous droughts in the upper and mid-lower YRB.