Contrasting Atlantic and Pacific SST Pathways to North China–Huanghuai Drought around 4.2 ka BP

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Significance:

The North China–Huanghuai region is a core cradle of Chinese civilization, and its agriculture, settlement, and societal development were profoundly affected by the 4.2 ka BP event. Our results show that drought in this region was primarily influenced by remote North Atlantic variability through a coherent atmospheric pathway across Eurasia. This finding extends the significance of the 4.2 ka BP event beyond paleoclimate, suggesting that future hydroclimate change over northern China may also depend on long-term North Atlantic variability and its connections to the rapidly changing Arctic and broader polar climate system.

ABSTRACT

The 4.2 ka BP event marks the transition from the middle to late Holocene and was accompanied by widespread but regionally heterogeneous hydroclimatic anomalies. Northern China, particularly the North China–Huanghuai region (NCHH), experienced pronounced drought around this interval. However, the mechanisms responsible for the NCHH drought remain unclear and are still debated. If oceanic variability contributed to the drought, the relative roles of Atlantic and Pacific forcing, and the dynamical pathways through which they affected NCHH hydroclimate, remain unresolved. Here, we combine a transient climate simulation, generalized equilibrium feedback assessment (GEFA), and prescribed-sea surface temperature (SST) experiments to address these questions. The simulated droughts are associated with Atlantic meridional overturning circulation (AMOC)-related North Atlantic cooling and Pacific Decadal Oscillation (PDO)-like North Pacific SST anomalies. Both forcings independently reduce NCHH precipitation, but through contrasting pathways. North Atlantic cooling excites a coherent upper-tropospheric wave train across Eurasia, enhancing moisture divergence and subsidence over NCHH, whereas North Pacific forcing primarily modifies the regional lower-tropospheric circulation. The North Atlantic–forced wave train also extends downstream into the North Pacific sector, suggesting a possible dynamical linkage between the two basins. Our experiments therefore suggest a leading role for North Atlantic forcing in NCHH drought and further imply that low-frequency AMOC variability can affect NCHH hydroclimate through a direct atmospheric teleconnection associated with North Atlantic SST anomalies, without requiring an abrupt AMOC collapse.

Keywords: 4.2 ka BP event; North Atlantic SST; AMOC variability; PDO-like SST; North China-Huanghuai drought; atmospheric teleconnection