Tropical Hydroclimate Change during Heinrich Stadial 1: An Integrative Proxy-Model Synthesis

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We explore the response of tropical climate to abrupt cooling of the North Atlantic (NA) during Heinrich Stadial 1 (HS1) combining paleoclimate proxies with model simulations. We assessed a total of 146 published paleoclimate records from tropical locations and categorized whether HS1 was wetter, drier, or unchanged relative to the LGM. Our synthesis reveals large-scale patterns of hydroclimate change relative to glacial conditions. Overall, the observed patterns of hydroclimate change depart from a southward shift of the Inter Tropical Convergence Zone (ITCZ), particularly outside the tropical Atlantic. We explore mechanisms driving these changes using a multi-model ensemble of "hosing" simulations performed relative to glacial conditions. The best-agreeing models indicate that cooling over the tropical NA and the Caribbean may be essential to communicate the response to the global tropics. This response can induce warming over the tropical South Atlantic via the wind-evaporation-SST feedback, driving wetter conditions in South Africa and tropical South America. Cooling over the Caribbean is communicated to the Pacific over the Central American isthmus resulting in a north-south SST gradient that drives wetter conditions in tropical and Southern Andes (SA). Magnitude of precipitation responses over the SA are model dependent, indicating that cooling of the tropical NA is key to SA rainfall responses. We invoke ventilation of colder mid-latitude air as the mechanism driving the robust weakening of North African and Indian summer monsoons observed in most models. The response over the warm pool is driven by El Niño-like changes in the Pacific initiated by cooling of the Caribbean. Together these results show a dominant role for altered pattern of SSTs driving changes in tropical rainfall, and a lesser role for inter-hemispheric shifts in the ITCZ.