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North American rainfall patterns during past warm states: A proxy network-model comparison for the Last Interglacial and the mid-Holocene

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The Last Interglacial (LIG) period (~129,000–116,000 years BP) and the mid-Holocene (MH) (~6,000 years BP) are the two most recent intervals with temperatures comparable to low emissions scenarios for the end of the 21st century. During the LIG and the MH differences in the seasonal and latitudinal distribution of insolation led to enhanced northern hemisphere high-latitude warmth relative to the pre-industrial, despite similar greenhouse gas concentrations, marking these intervals as potentially useful analogs for future change in regions like North America. Further, the inclusion of both LIG (127 ka) and MH (6 ka) experiments in the CMIP6-PMIP4 effort provides an opportunity to better understand the regional hydroclimate responses to radiative forcing during these two intervals. The dense coverage of paleoclimate proxy records for North America during the MH (N=260 sites) reveals a pattern of relative aridity in the Pacific Northwest and Western Canada and wetness in the southern Great Basin and Mexico. However, the seasonality and driving mechanisms of rainfall patterns across the continent remain poorly understood. Our understanding of terrestrial hydroclimate in North America during the LIG is more limited (N=39 sites), largely because the LIG is beyond the range of radiocarbon dating.

Here we present spatial comparisons between output from 14 PMIP4 global circulation models and LIG and MH networks of moisture-sensitive proxies compiled for the North American continent. We utilize two statistical measures of agreement – weighted Cohen's Kappa and Gwet's AC2 – to assess the degree of categorical agreement between moisture patterns produced by the models and the proxy networks for each time-slice. PMIP4 models produce variable precipitation anomalies relative to the pre-industrial for both the LIG and MH experiments, often disagreeing on both the sign and magnitude of precipitation changes across much of North America. The models showing the best agreement with the proxy network are similar but not identical for the two measures, with Gwet's AC2 values tending to be larger than Cohen's Kappa values for all models. This pattern is enhanced for the much larger MH proxy network and is likely related to the fact that Gwet's AC2 is a more predictable statistic in the presence of high agreement. Overall agreement is lower for the mid-Holocene than for the LIG, reflecting smaller MH rainfall anomalies in the models. The models with the highest agreement scores during the LIG produce aridity in the Rocky Mountains and Pacific Northwest and wetness in Alaska, the Yukon, the Great Basin, and parts of the Mid-West and Eastern US, although spatial coverage of the proxies in these latter two

regions is poor. The models with the highest agreement score for the mid-Holocene tend to produce aridity across Canada and the northern US with dry conditions extending down the US Pacific coast and increased wetness in the American Southeast and across the North American Monsoon region. Our analyses help elucidate the driving mechanisms of rainfall patterns during past warm states and can inform which models may be the most useful for predictions of near-future hydroclimate change across North America.