

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

C. B. de Wet¹, D. E. Ibarra², B. K. Belanger¹, J. L. Oster¹

¹Department of Earth and Environmental Sciences, Vanderbilt University, Nashville, TN, USA.

²Earth, Environmental, and Planetary Sciences, Brown University, Providence, RI, USA.

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Tables S1 and S2

Introduction

This file includes maps of annual average precipitation ($\% \Delta P$) and runoff anomalies ($\% \Delta P - ET$) from PIMP4 model simulations and moisture sensitive proxy networks for the mid-Holocene (MH) (Figure S1 and S3) and Last Interglacial (LIG) (Figure S2 and S4). It also includes information about the proxy records included in our MH (Table S1) and LIG (Table S2) networks and about the PMIP4 models used in our analyses (Table S3). Finally, it includes the calculated agreement coefficients (Gwet's AC2, Cohen's kappa, and Gwet's AC1) for categorical comparison between the PMIP4 models and the MH (Table S4) and LIG (Table S5) proxy networks, as well as for the western US proxy network from Hermann et al. (2018).

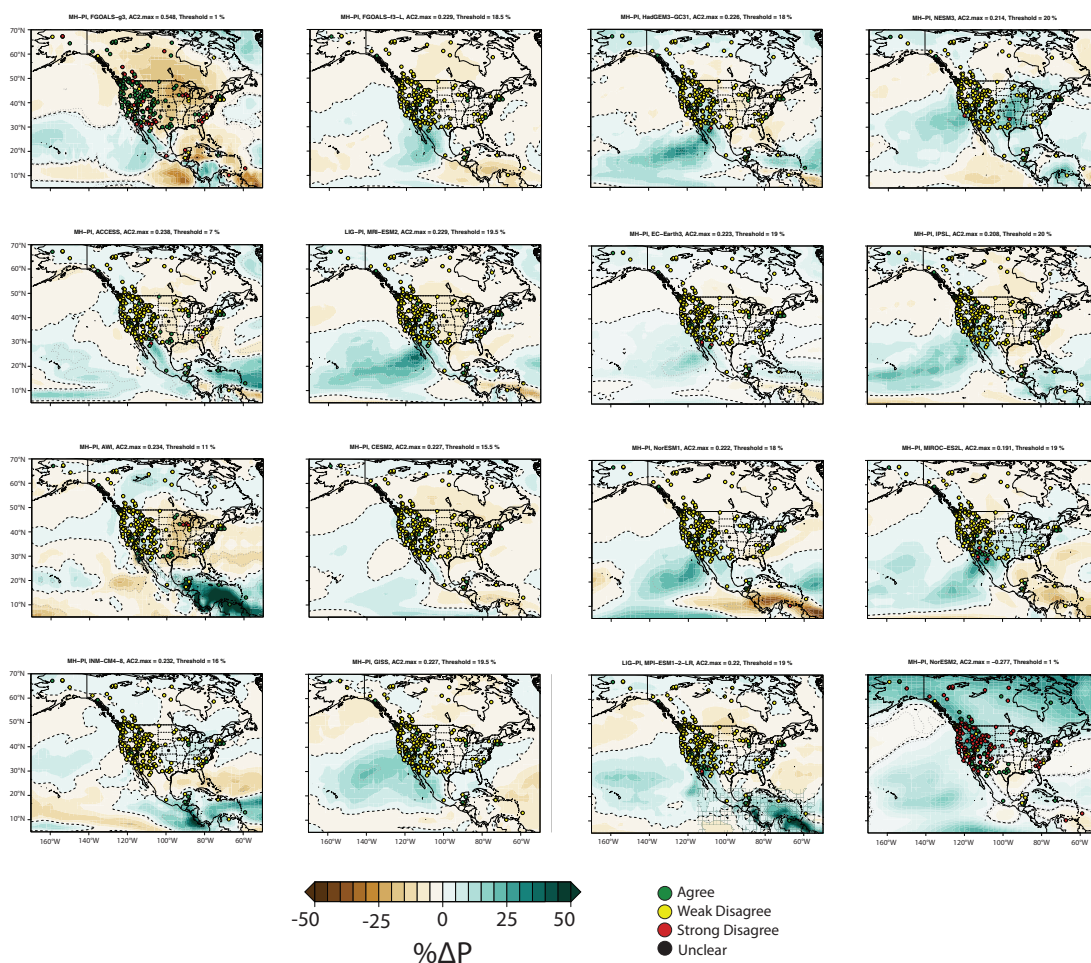


Figure S1. Annual MH-PI precipitation anomaly (% ΔP) for PMIP4 models with MH proxy network plotted based on agreement with ensemble climatology. Dark gray dashed lines denote the boundary between positive and negative precipitation anomalies. Light gray dotted lines denote the threshold for the change in precipitation to be considered

wetter, drier, or unchanged based on optimized agreement with the proxy network. The precipitation anomaly for NorESM2 is -100 to 100%.

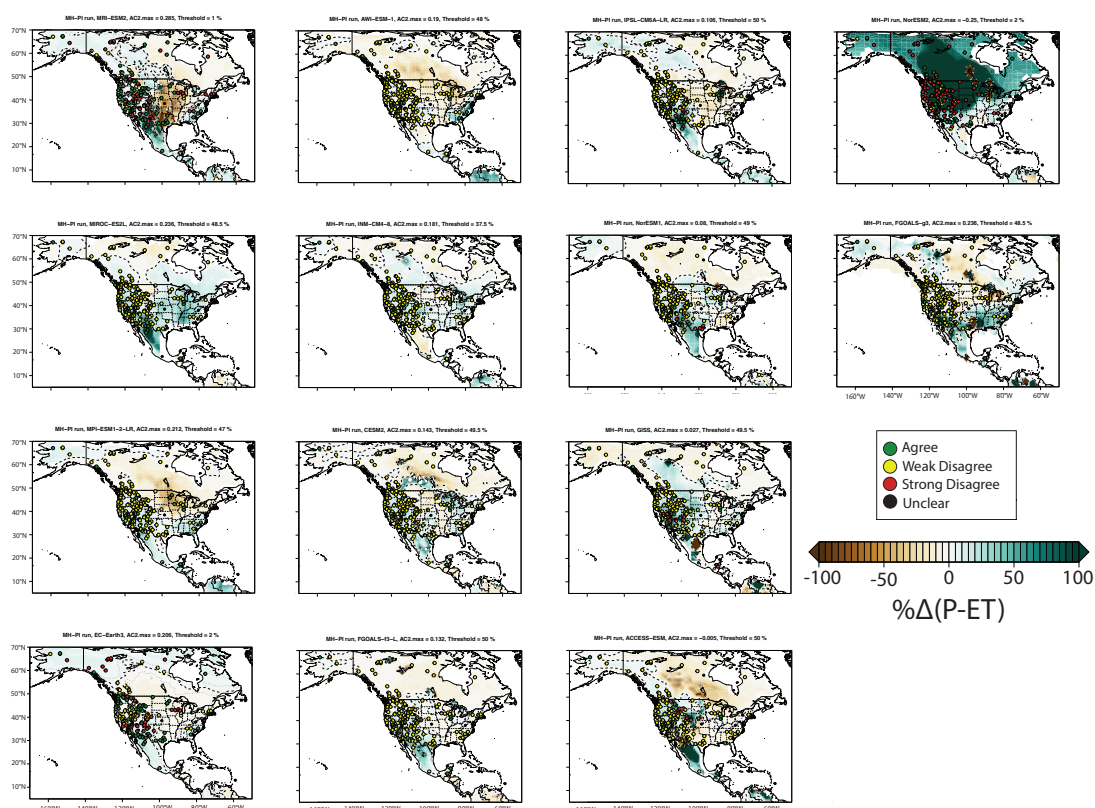


Figure S2. Annual MH-PI runoff anomaly ($\% \Delta P-ET$) for PMIP4 models with MH proxy network plotted based on agreement with ensemble climatology. Dark gray dashed lines and light gray dotted lines same as in Figure S1.

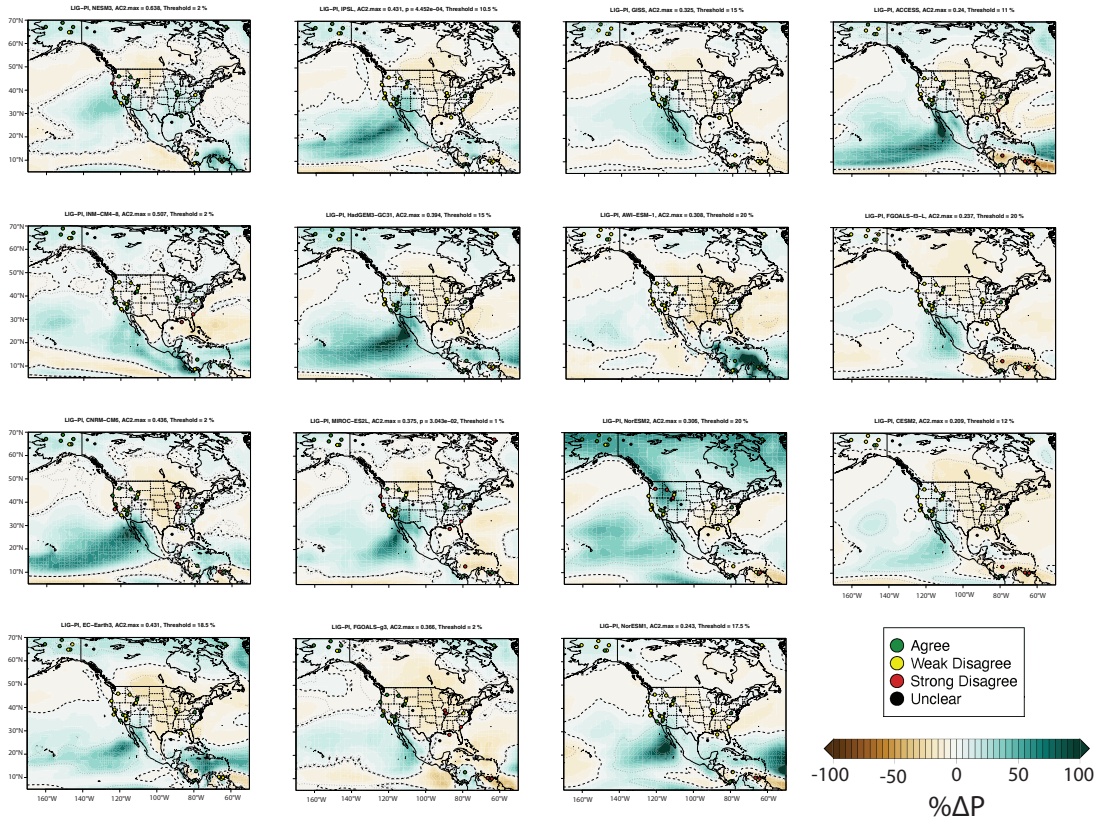


Figure S3. Annual LIG-PI precipitation anomaly (% ΔP) for PMIP4 models with LIG proxy network plotted based on agreement with ensemble climatology. Dark gray dashed lines and light gray dotted lines same as in Figure S1.

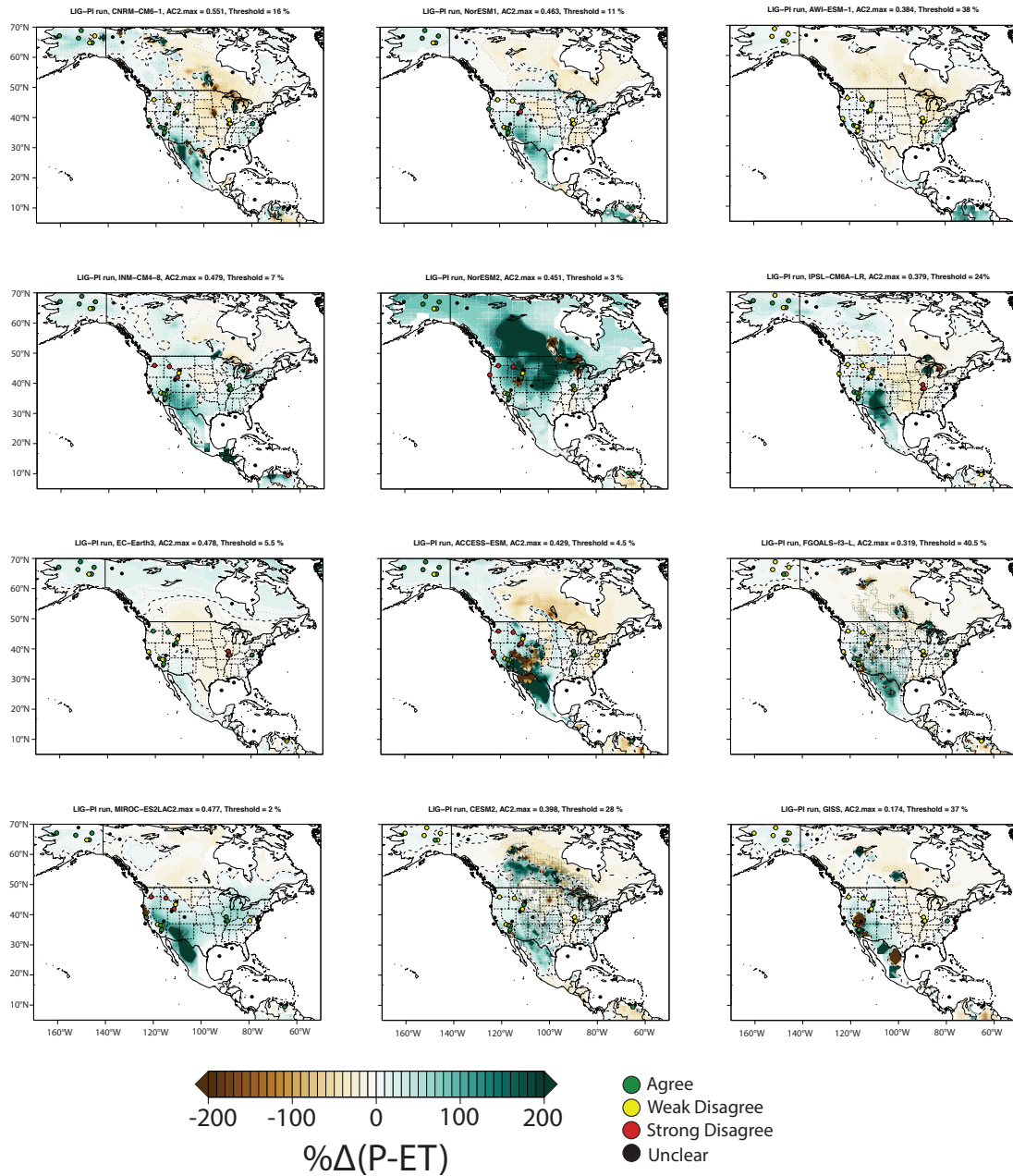


Figure S4. Annual LIG-PI runoff anomaly ($\% \Delta P-ET$) for PMIP4 models with LIG proxy network plotted based on agreement with ensemble climatology. Dark gray dashed lines and light gray dotted lines same as in Figure S1.

Table S1. The mid-Holocene proxy network.

(Uploaded separately.)

Table S2. The Last Interglacial proxy network.

(Uploaded separately.)

Table S3. Description of PMIP4 models used in this study.

| Model | Experiments and outputs | Number of grid cells (lat.) | Number of grid cells (lon.) | Citation for model description | Notes |
|-----------------|--|-----------------------------|-----------------------------|---|--|
| ACCESS-ESM1-5 | <i>piControl - pr, evspsbl;</i> <i>midHolocene - pr, evspsbl;</i> <i>lig127k - pr, evspsbl</i> | 145 | 192 | Ziehn et al. (2017, 2020) | Fixed vegetation with interactive leaf area index, prescribed aerosols |
| AWI-ESM-1-1-LR | <i>piControl - pr, evspsbl;</i> <i>midHolocene - pr, evspsbl;</i> <i>lig127k - pr, evspsbl</i> | 96 | 192 | Sidorenko et al. (2015) | Interactive vegetation |
| CESM2 | <i>piControl - pr, evspsbl;</i> <i>midHolocene - pr, evspsbl;</i> <i>lig127k - pr, evspsbl</i> | 192 | 288 | Danabasoglu et al. (2020) | Prescribed potential vegetation (crops and urban areas removed), interactive phenology, simulated dust |
| CNRM-CM6-1 | <i>piControl - pr, evspsbl;</i> <i>lig127k - pr, evspsbl</i> | 128 | 256 | Voldoire et al. (2019), Decharme et al. (2019) | PI atm. GHGs, prescribed vegetation and aerosols |
| EC-Earth3-LR | <i>piControl - pr, evspsbl;</i> <i>midHolocene - pr, evspsbl;</i> <i>lig127k - pr, evspsbl</i> | 160 | 320 | Zhang et al. (2020) (for lig127K) | Prescribed vegetation and aerosols |
| FGOALS-f3-L | <i>piControl - pr, evspsbl;</i> <i>midHolocene - pr, evspsbl;</i> <i>lig127k - pr, evspsbl</i> | 180 | 288 | Zheng et al. (2020) (for lig127K) | Prescribed vegetation and aerosols |
| FGOALS g3 | <i>piControl - pr, evspsbl;</i> <i>midHolocene - pr, evspsbl;</i> <i>lig127k - pr, evspsbl</i> | 80 | 180 | Zheng et al. (2020) (for lig127K) | Prescribed vegetation and aerosols |
| GISS-E2-1-G | <i>piControl - pr, evspsbl;</i> <i>midHolocene - pr, evspsbl;</i> <i>lig127k - pr, evspsbl</i> | 90 | 144 | Kelley et al. (2020) | Prescribed vegetation |
| HadGEM3-GC31-LL | <i>piControl - pr; midHolocene - pr; lig127k - pr</i> | 144 | 192 | Kuhlbrodt et al. (2018), Williams et al. (2017) | Prescribed vegetation and aerosols |
| INM-CM4-8 | <i>piControl - pr, evspsbl;</i> <i>midHolocene - pr, evspsbl;</i> <i>lig127k - pr, evspsbl</i> | 120 | 180 | Volodin et al. (2018) | Prescribed vegetation, simulated dust and sea salt |
| IPSL-CM6A-LR | <i>piControl - pr, evspsbl;</i> <i>midHolocene - pr, evspsbl;</i> <i>lig127k - pr, evspsbl</i> | 143 | 144 | Boucher et al. (2020) | Prescribed vegetation, interactive phenology, prescribed aerosols |
| MIROC-ES2L | <i>piControl - pr, evspsbl;</i> <i>midHolocene - pr, evspsbl;</i> <i>lig127k - pr, evspsbl</i> | 64 | 128 | Hajima et al. (2020) | Prescribed vegetation and aerosols |
| MPI-ESM1-2-LR | <i>piControl - pr, evspsbl;</i> <i>midHolocene - pr, evspsbl</i> | 96 | 192 | Giogetta et al. (2013) | Interactive vegetation, prescribed aerosols |
| MRI-ESM2 | <i>piControl - pr, evspsbl;</i> <i>midHolocene - pr, evspsbl</i> | 160 | 320 | Yukimoto et al. (2019) | |
| NESM3 | <i>piControl - pr; midHolocene - pr; lig127k - pr</i> | 96 | 192 | Cao et al. (2018) | Interactive vegetation, prescribed aerosols |
| NorESM1-F | <i>piControl - pr, evspsbl;</i> <i>midHolocene - pr, evspsbl;</i> <i>lig127k - pr, evspsbl</i> | 96 | 144 | Guo et al. (2019) | Prescribed vegetation and aerosols |
| NorESM2-LM | <i>piControl - pr, evspsbl;</i> <i>midHolocene - pr, evspsbl;</i> <i>lig127k - pr, evspsbl</i> | 96 | 144 | Seland et al. (2020) | Prescribed vegetation and aerosols |

Table S4. Gwet's AC2, Cohen's kappa (K_w), and Gwet's AC1 values with associated statistical significance and optimized precipitation threshold for comparisons between

the mid-Holocene proxy network and annual precipitation from PMIP4 mid-Holocene simulations.

| | AC2 | p value | Precip. threshold (%) | Kw | Significance | Precipitation threshold (%) | AC1 | p value | Precip. threshold (%) |
|-----------------|-------|----------|-----------------------------|-------|--------------|--------------------------------|-------|----------|-----------------------------|
| FGOALS-g3 | 0.55 | 0 | 1 | 0.13 | Not Sig | 5 | 0.51 | 0.00E+00 | 1 |
| ACCESS-ESM | 0.24 | 8.47E-11 | 7 | 0.08 | Sig | 6 | 0.00 | 1.04E+00 | 1 |
| AWI-ESM-1 | 0.23 | 6.42E-11 | 11 | 0.07 | Not Sig | 7 | 0.06 | 2.40E-01 | 1 |
| INM-CM4-8 | 0.23 | 2.95E-11 | 16 | 0.03 | Not Sig | 10 | 0.17 | 1.32E-03 | 1 |
| FGOALS-f3-L | 0.23 | 6.01E-11 | 18.5 | 0.08 | Not Sig | 2 | 0.20 | 1.10E-04 | 1 |
| MRI-ESM2 | 0.23 | 6.01E-11 | 19.5 | 0.19 | Sig | 1 | 0.15 | 2.29E-03 | 1 |
| CESM2 | 0.23 | 8.45E-11 | 15.5 | 0.02 | Not Sig | 6 | -0.01 | 1.18E+00 | 1 |
| GISS-E2-1-G | 0.23 | 8.45E-11 | 19.5 | 0.04 | Not Sig | 2 | -0.06 | 1.84E+00 | 1 |
| HadGEM3-GC31-LL | 0.23 | 2.44E-10 | 18 | 0.11 | Sig | 5 | 0.01 | 8.40E-01 | 1 |
| EC-Earth3-LR | 0.22 | 8.62E-10 | 19 | 0.16 | Sig | 2 | 0.20 | 1.18E-04 | 1 |
| NorESM1-F | 0.22 | 5.04E-10 | 18 | 0.08 | Sig | 7 | -0.03 | 1.54E+00 | 1 |
| MPI-ESM1-2-LR | 0.22 | 9.81E-10 | 19 | 0.15 | Sig | 6 | 0.04 | 4.40E-01 | 1 |
| NESM3 | 0.21 | 4.20E-09 | 20 | 0.09 | Sig | 4 | 0.05 | 2.70E-01 | 1 |
| IPSL-CM6A-LR | 0.21 | 3.48E-09 | 20 | 0.11 | Sig | 3 | 0.04 | 3.50E-01 | 1 |
| MIROC-ES2L | 0.19 | 3.18E-07 | 19 | 0.07 | Not Sig | 4 | 0.01 | 8.00E-01 | 1 |
| NorESM2-LM | -0.28 | 2.00E+00 | 1 | -0.04 | Not Sig | 1 | -0.09 | 1.96E+00 | 1 |

Table S5. Gwet's AC2, Cohen's kappa (K_w), and Gwet's AC1 values with associated statistical significance and optimized precipitation threshold for comparisons between the Last Interglacial proxy network and annual precipitation from PMIP4 Last Interglacial simulations.

| | AC2 | p value | Precip. threshold (%) | Kw | Significance | Precipitation threshold (%) | AC1 | p value | Precip. threshold (%) |
|-----------------|------|----------|-----------------------------|------|--------------|--------------------------------|------|----------|-----------------------------|
| NESM3 | 0.64 | 1.42E-05 | 2 | 0.4 | Sig | 2 | 0.55 | 2.00E-04 | 2 |
| INM-CM4-8 | 0.51 | 1.50E-03 | 2 | 0.35 | Sig | 2 | 0.42 | 5.90E-03 | 2 |
| CNRM-CM6 | 0.44 | 7.70E-03 | 2 | 0.35 | Sig | 2 | 0.42 | 4.60E-03 | 2 |
| EC-Earth3-LR | 0.43 | 2.00E-04 | 18.5 | 0.31 | Sig | 8 | 0.34 | 2.25E-02 | 4 |
| IPSL-CM6A-LR | 0.43 | 4.00E-04 | 10.5 | 0.19 | Not Sig | 4 | 0.32 | 2.64E-02 | 1 |
| HadGEM3-GC31-LL | 0.39 | 2.30E-03 | 15 | 0.14 | Not Sig | 19 | 0.21 | 1.45E-01 | 11 |
| MIROC-ES2L | 0.38 | 3.04E-02 | 1 | 0.19 | Not Sig | 1 | 0.39 | 9.00E-03 | 1 |
| FGOALS-g3 | 0.37 | 3.24E-02 | 2 | 0.36 | Sig | 2 | 0.4 | 6.60E-03 | 2 |
| GISS-E2-1-G | 0.32 | 2.50E-03 | 15 | 0.17 | Not Sig | 4 | 0.21 | 1.64E-01 | 2 |
| AWI-ESM-1 | 0.31 | 1.10E-02 | 20 | 0.15 | Not Sig | 3 | 0.2 | 1.69E-01 | 2 |
| NorESM2-LM | 0.31 | 4.78E-02 | 20 | 0.09 | Not Sig | 20 | 0.21 | 1.38E-01 | 20 |
| NorESM1-F | 0.24 | 8.38E-02 | 17.5 | 0.11 | Not Sig | 12.5 | 0.17 | 2.39E-01 | 1 |
| ACCESS-ESM1-5 | 0.24 | 1.38E-01 | 11 | 0.14 | Not Sig | 11 | 0.15 | 2.99E-01 | 3 |
| FGOALS-f3-L | 0.24 | 9.16E-02 | 20 | 0.13 | Not Sig | 1 | 0.16 | 2.76E-01 | 1 |
| CESM2 | 0.21 | 1.70E-01 | 12 | 0.05 | Not Sig | 12 | 0.13 | 3.77E-01 | 1 |

Table S6. Gwet's AC2, Cohen's kappa (K_w), and Gwet's AC1 values with associated statistical significance and optimized precipitation threshold for comparisons between

the mid-Holocene proxy network from Hermann et al. (2018) and annual precipitation from PMIP4 mid-Holocene simulations.

| | AC2 | p value | Precip. threshold (%) | | Kw | Significance | Precip. threshold (%) | | AC1 | p value | Precip. threshold (%) |
|-----------------|-------|----------|-----------------------------|--|-------|--------------|-----------------------------|--|-------|----------|-----------------------------|
| FGOALS-g3 | 0.62 | 0.00E+00 | 1 | | 0.21 | Sig | 2 | | 0.55 | 0.00E+00 | 1 |
| INM-CM4-8 | 0.28 | 8.40E-10 | 15 | | 0 | Not Sig | 15 | | 0.19 | 3.87E-03 | 1 |
| AWI-ESM-1 | 0.28 | 8.40E-10 | 16.5 | | 0.04 | Not Sig | 7 | | -0.09 | 1.90E+00 | 7 |
| CESM2 | 0.28 | 8.40E-10 | 14.5 | | 0.05 | Not Sig | 5 | | -0.1 | 1.93E+00 | 14.5 |
| EC-Earth3-LR | 0.28 | 1.55E-09 | 19 | | 0.24 | Sig | 2 | | 0.23 | 3.00E-04 | 1 |
| GISS-E2-1-G | 0.28 | 8.40E-10 | 19.5 | | 0.12 | Sig | 2 | | -0.08 | 1.84E+00 | 2 |
| NorESM1-F | 0.28 | 8.40E-10 | 18 | | 0.16 | Sig | 7 | | -0.06 | 1.75E+00 | 7 |
| FGOALS-f3-L | 0.28 | 5.81E-10 | 18.5 | | 0.21 | Sig | 2 | | 0.17 | 9.46E-03 | 1 |
| ACCESS-ESM1-5 | 0.28 | 8.40E-10 | 18.5 | | 0.05 | Not Sig | 6 | | -0.08 | 1.86E+00 | 7 |
| MRI-ESM2 | 0.28 | 5.81E-10 | 19.5 | | 0.23 | Sig | 1 | | 0.13 | 4.41E-02 | 1 |
| NESM3 | 0.27 | 9.69E-09 | 19 | | 0.15 | Sig | 1 | | 0.1 | 9.45E-02 | 1 |
| MPI-ESM1-2-LR | 0.27 | 2.77E-09 | 19 | | 0.17 | Sig | 6 | | -0.05 | 1.66E+00 | 1 |
| HadGEM3-GC31-LL | 0.27 | 3.38E-09 | 17 | | 0.16 | Sig | 6 | | -0.05 | 1.62E+00 | 9 |
| IPSL-CM6A-LR | 0.25 | 6.63E-08 | 20 | | 0.16 | Sig | 7 | | -0.03 | 1.43E+00 | 1 |
| MIROC-ES2L | 0.23 | 2.12E-06 | 19 | | 0.2 | Sig | 3 | | 0 | 1.04E+00 | 1 |
| NorESM2-LM | -0.39 | 2.00E+00 | 1 | | -0.02 | Not Sig | 1 | | -0.18 | 2.00E+00 | 1 |