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Supplement of

Testing the reliability of global surface temperature reconstructions of the Last Glacial Cycle with pseudo-proxy experiments

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S1 Introduction

This supplement contains additional plots that present:

- the results of the *Full PP at random location* and *bioturbation* pseudo-proxy experiments.
- the locations of records at the LGM related to the temperature anomaly field of each simulation.
- a comparison of the scaling factor in Snyder (2016), Clark et al. (2024), and the simualtions.
- the coherence between GMST and mean SST timeseries

S2 Further results from the PPEs

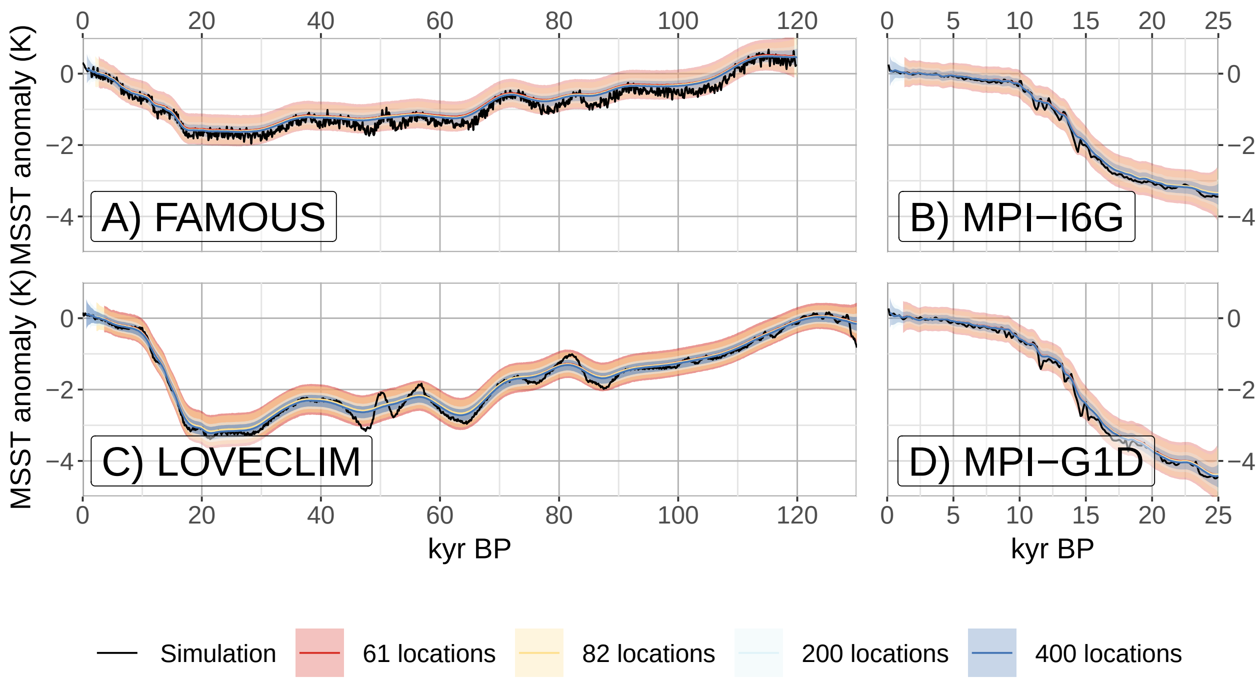

Figure S1: Effect of different numbers of proxy locations randomly distributed in space. The coloured lines are the 60°S-60°N mean SST (MSST) reconstructions based on the *full PP at random locations* experiments. The black line corresponds to the simulated MSST. The shading corresponds to the 90% confidence interval of the reconstruction, which only includes the effect of latitudinal band configurations and location resampling. We find that the random locations do not exhibit biases compared to the simulated MSST. The number of records mostly impacts the uncertainty range.

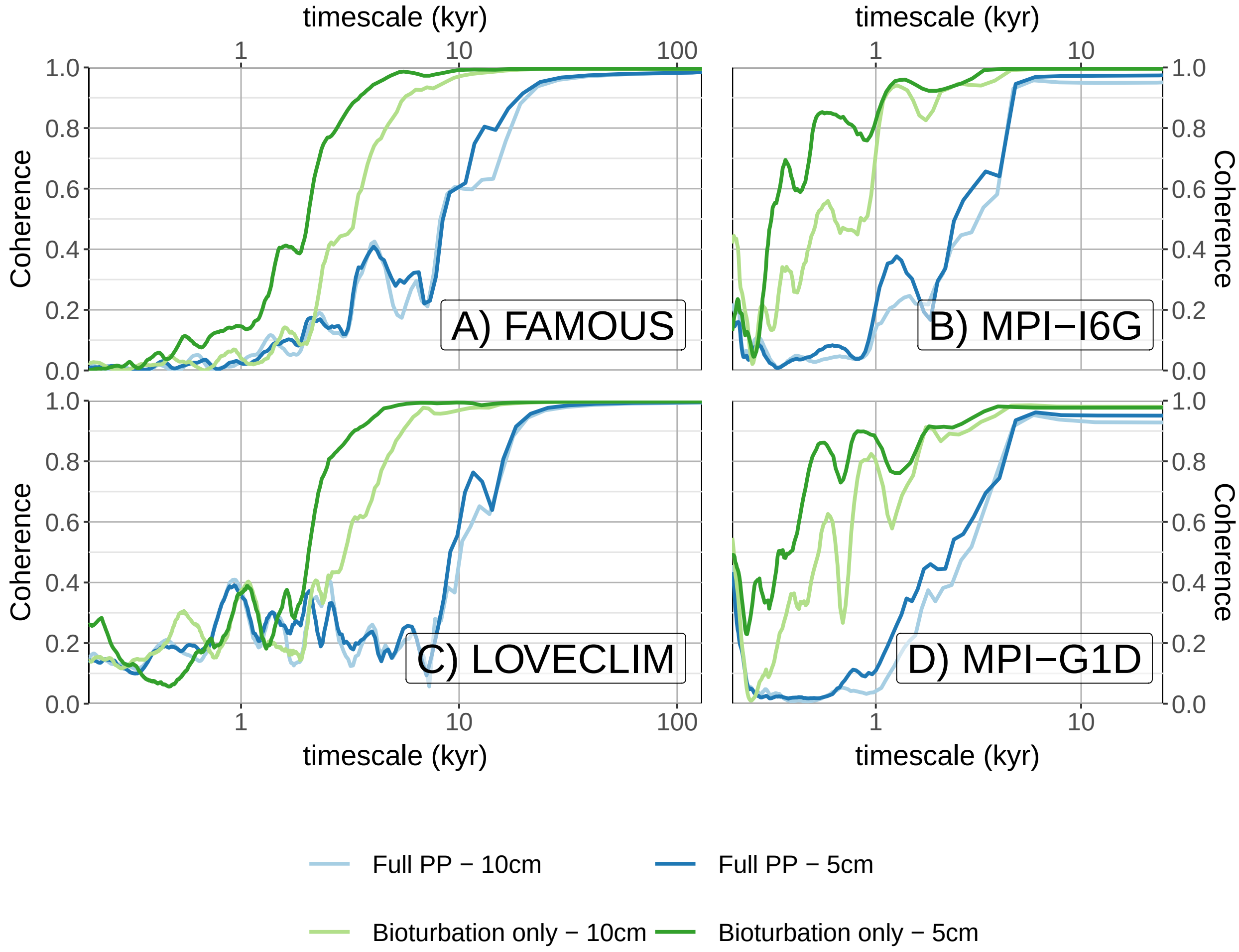

Figure S2: Impact of bioturbated layer width on the coherence of the signal. We test two configurations. The first one (light colours) corresponds to the *bioturbation* experiment (green) and the *full PP* experiment (blue) described in the manuscript. For both experiments, we use a bioturbated layer width depth of 10 cm. The second configuration (dark colours) uses the same set-up, but both experiments are re-computed with a 5 cm layer width. The impact of the reduced layer width on the *full PP* experiment is limited, suggesting this does not influence significantly our results.

S3 Record locations at LGM

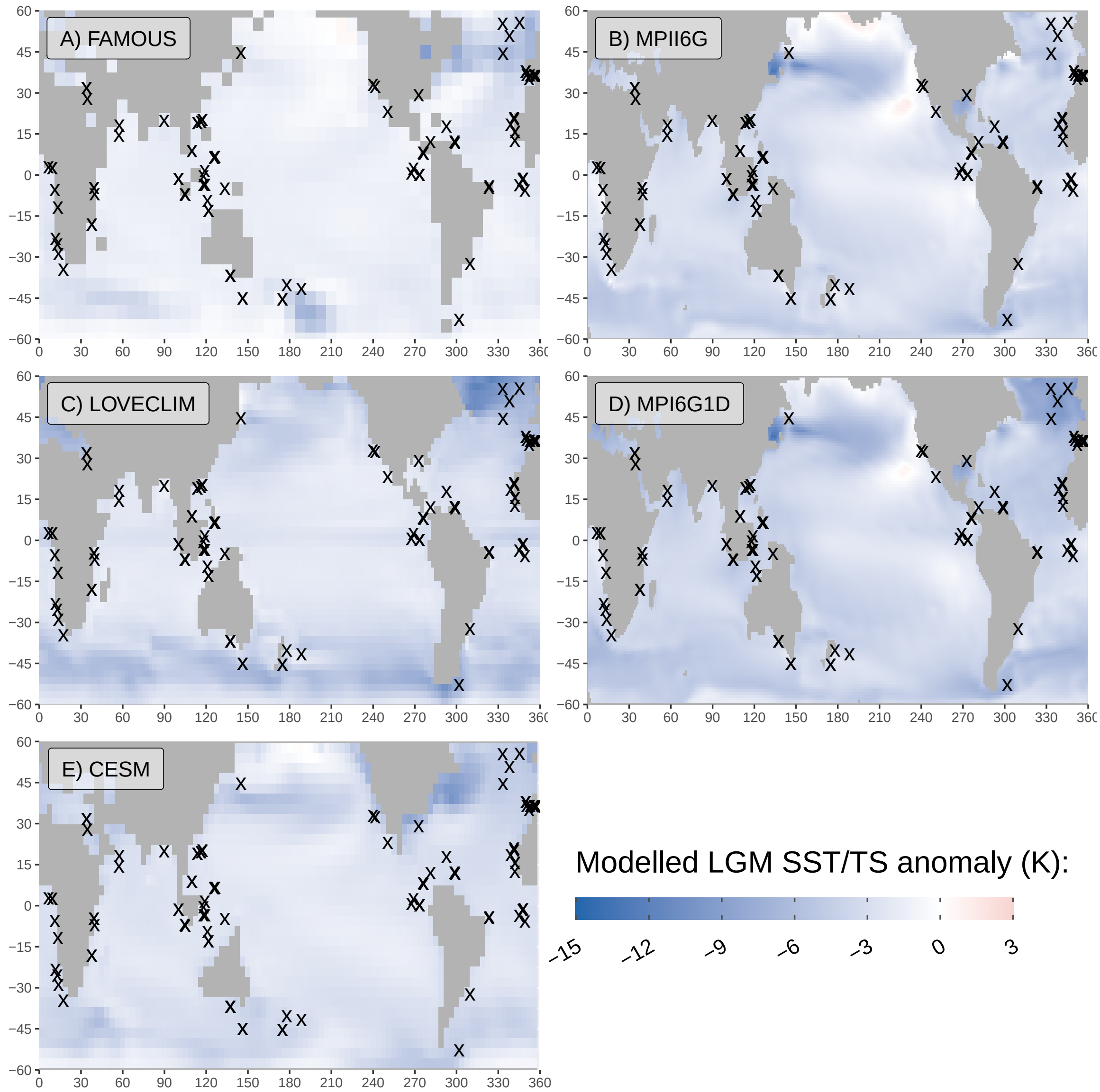

Figure S3: LGM temperature anomaly (19 to 23 kyr - 0 to 5 kyr) for the five simulations with proxy locations. These are the temperatures used in the pseudo-proxies (SST or TS with the proper land mask). The crosses correspond to the record locations with at least one value during the LGM (19-23 kyr) and one during the reference time period (0-5 kyr). The distribution of records is heterogeneous and tends to over-represent areas of strong cooling, such as the North Atlantic, to the detriment of the less cool Pacific.

S4 Comparing scaling factors

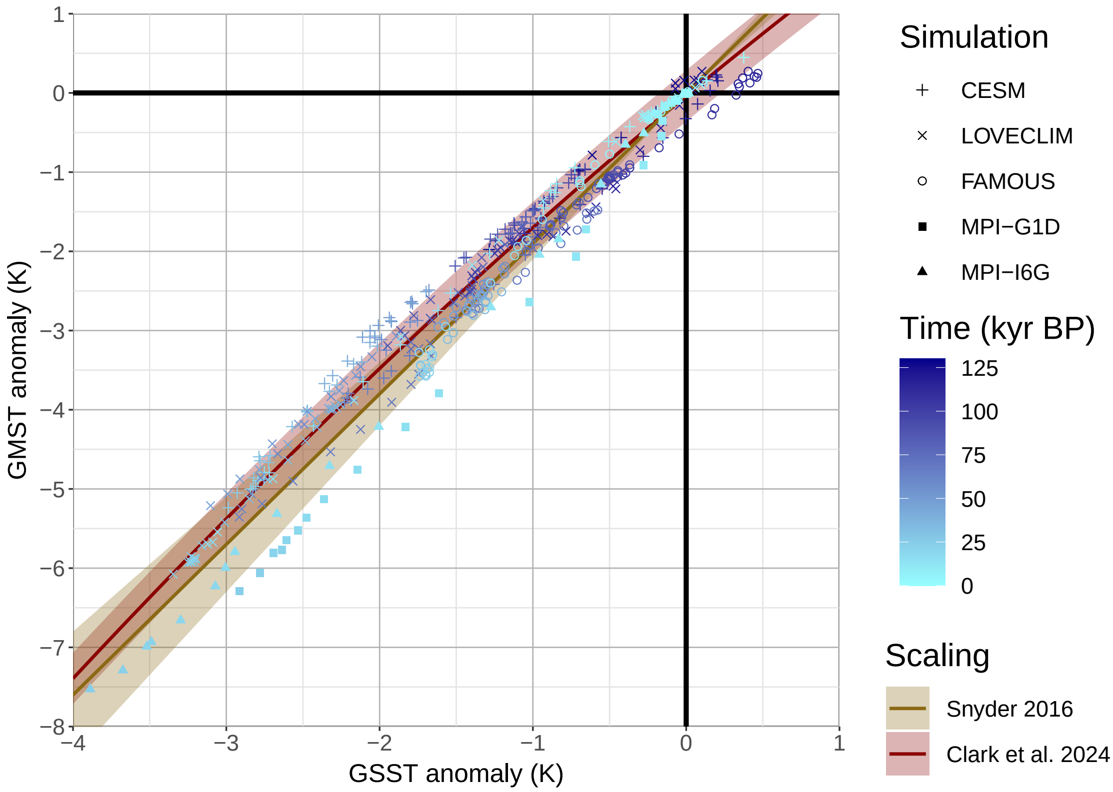

Figure S4: Comparison of the scaling between GMST and GSST anomaly. The points correspond to the various simulations used in the study, with the colour indicating the time period. We compare it to the scaling formula used in Snyder (2016) and Clark et al. (2024). The shading corresponds to 2 times the standard deviation (This is different from the 90% uncertainty range used in the manuscript). The fit used in Clark et al. (2024) mostly follows the shape of the last 20 kyr scaling from the CESM simulation, but does not provide an improvement compared to other time period or simulations, compared to Snyder (2016). In addition, neither the additive (Clark et al., 2024) nor the multiplicative (Snyder, 2016) uncertainty captures the range of modelled value.

S5 Coherence between GMST and mean SST

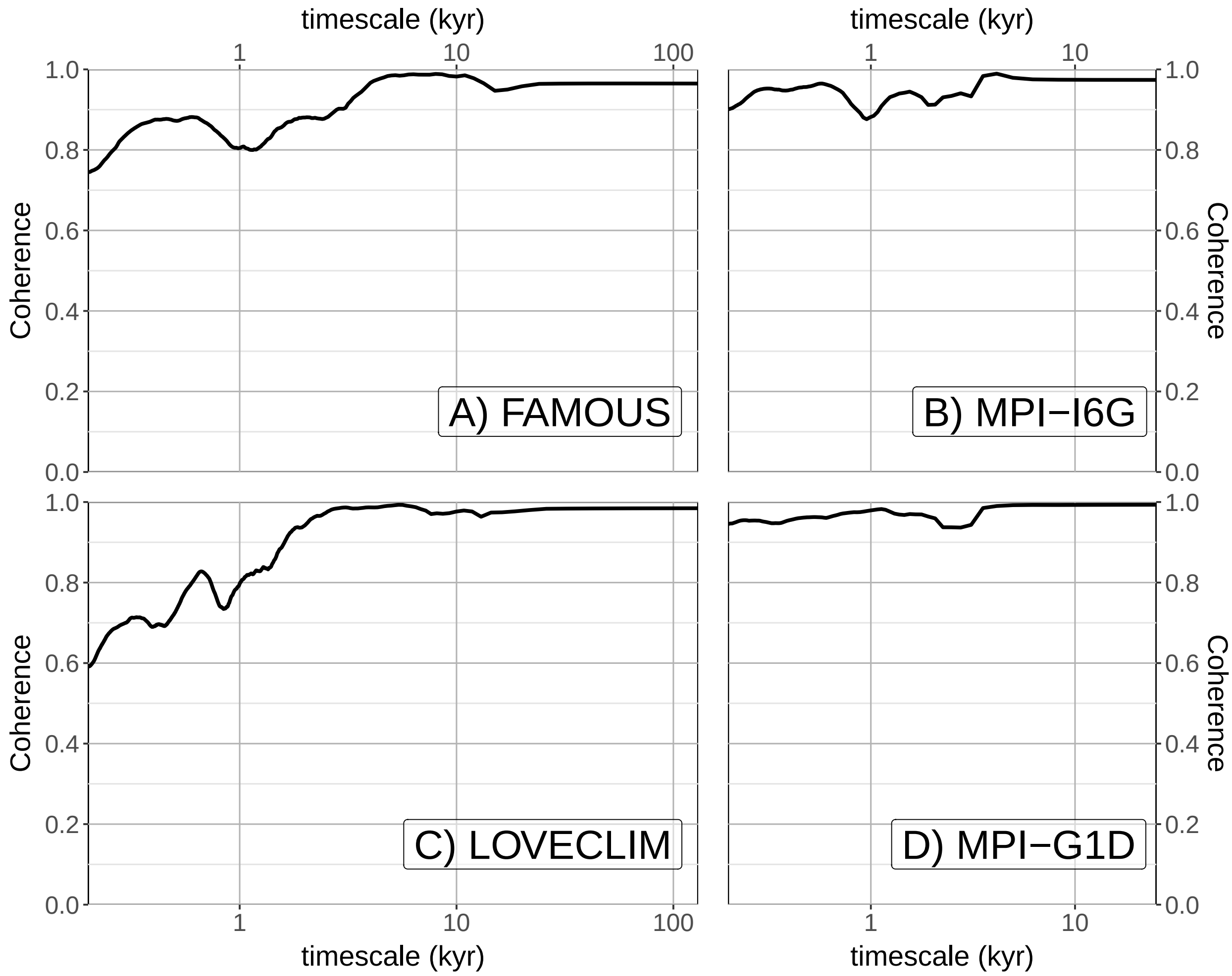

Figure S5: Coherence between the simulated GMST and the simulated 60°S-60°N mean SST.

S6 References

Clark, P. U., Shakun, J. D., Rosenthal, Y., Köhler, P., and Bartlein, P. J.: Global and regional temperature change over the past 4.5 million years, Science, 383, 884–890, https://doi.org/10.1126/science.adi1908, 2024.

Snyder, C. W.: Evolution of global temperature over the past two million years, Nature, 538, 226, https://doi.org/10.1038/nature19798, 2016.