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Reconstructing the surface temperature fields of the Last Glacial Maximum using climate models and data.

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We present a new reconstruction of global climatological temperature fields for the Last Glacial Maximum, which improves on our previous work in several important ways.

The method combines globally complete modelled temperature fields, with sparse proxy-based estimates of local temperature anomalies. We use a localised Ensemble Kalman Smoother, which ensures spatially coherent fields that both respect the physical principles embodied in the models, and are also tied closely to observational estimates.

We use the full set of PMIP2/3/4 model simulations, but perform some filtering of the simulations to remove duplicates and closely related models. We also de-bias the ensemble and show via sensitivity tests that this can be an essential step in the process, although it has little effect in this particular application. Specifically, any bias in the prior ensemble leads to a significant bias (which may take roughly 70-80% of its initial magnitude) in the posterior estimate. Thus we recommend that this step is taken in similar reconstructions unless the researcher is confident that the bias in the prior ensemble is low.

We combine the prior ensemble with a wide range of proxy-based SST and SAT estimates of local temperature to ensure the best possible global coverage. Our reconstruction has a global mean surface air temperature anomaly of -4.5 +- 0.9C relative to the pre-industrial climate, and thus is slightly cooler than the estimate of Annan and Hargreaves (2013), but rather less cold than the estimate of Tierney et al (2020). We show that much of the reason for this latter discrepancy is due to the choice of prior.