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Efficiently constraining climate sensitivity with ensembles of paleoclimate simulations

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We use a recently-developed efficient probabilistic estimation technique to estimate the sensitivity of the Earth's temperature to a doubling of atmospheric carbon dioxide. The method is based on the ensemble Kalman filter which we apply to the CCSR/NIES/FRCGC AGCM (the atmospheric component of MIROC3.2) at T21L20 resolution coupled to a slab ocean. The method combines prior beliefs about the model, with observational data, to simultaneously estimate 25 model parameters in an efficient manner. We perform a sensitivity analysis to investigate the effect of different assumptions regarding model error, since this is a necessarily subjective input which has not yet been well characterised. We therefore attempt to validate the resulting ensembles against out-of-sample data by comparing their hindcasts of the Last Glacial Maximum (LGM) to paleoclimate proxy data, and demonstrate through this that our ensembles of simulations are probably biased towards too high a sensitivity. Within the framework of our single-model ensemble experiment, we show that climate sensitivity of much greater than 6C is hard to reconcile with the paleoclimate record, and that of greater than 8C seems virtually impossible.