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Using past changes to improve models of the Antarctic Ice Sheet

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Ice sheet models are the most descriptive tools available to simulate the future evolution of the Antarctic Ice Sheet (AIS), including its contribution towards changes in global sea level. However, our knowledge of the dynamics of the coupled ice-ocean-lithosphere system is inevitably limited, in part due to a lack of observations. Furthermore, to build computationally efficient models that can be run for multiple millennia, it is necessary to use simplified descriptions of ice dynamics. Ice sheet modelling is therefore a poorly constrained exercise. The past evolution of the AIS provides an opportunity to improve the description of physical processes within ice sheet models and, therefore, to constrain our understanding of the role of the AIS in driving changes in global sea level.

We use the Parallel Ice Sheet Model (PISM) to demonstrate how past changes can be used to improve our ability to predict the future evolution of the AIS. A large perturbed-physics ensemble is generated, spanning uncertainty in the parameterisations of key physical processes within the model. A Latin hypercube approach is used to optimally sample the range of uncertainty in parameter values. This perturbed-physics ensemble is used to simulate the evolution of the AIS from the Last Glacial Maximum (∼21,000 years ago) until 5,000 years into the future. Records of past ice sheet thickness and extent are then used to determine which ensemble members are the most realistic. This allows us to use the known history of the AIS to constrain our understanding of its past contribution towards changes in global sea level. Critically, it also allows us to determine which ensemble members are most likely to generate realistic projections of the future evolution of the AIS. This enables us to use past changes in the AIS to reduce uncertainty in projections of future sea level rise.