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Using palaeoclimate data 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. Furthemore, 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 an inherently uncertain exercise. The past evolution of the AIS provides an opportunity to constrain 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 palaeoclimate data can improve our ability to predict the future evolution of the AIS. A 50-member perturbed-physics ensemble is generated, spanning uncertainty in the parameterisations of three key physical processes within the model: (i) the stress balance within the ice sheet, (ii) basal sliding and (iii) calving of ice shelves. 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) to present. Palaeoclimate records are then used to determine which ensemble members are the most realistic. This allows us to use data on past climates to directly constrain our understanding of the past contribution of the AIS towards changes in global sea level. Critically, it also allows us to determine which ensemble members are likely to generate the most realistic projections of the future evolution of the AIS.