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Assimilating Southern Hemisphere proxy records into a climate modelling framework

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The assimilation of palaeoclimate proxy records into climate modelling frameworks allows for the reconstruction of past climatic fields. By combining the real-world information recorded by the proxies with the dynamical information encoded within the models, data assimilation (DA) represents an integrated approach whereby climate modelling becomes part of the process of palaeoclimate reconstruction.

Here, the potential of DA is demonstrated by presenting an assimilation of Southern Hemisphere proxy records into a climate model. An offline approach is employed, whereby the model simulations are completed first and the assimilation is performed second. To generate a model ensemble, the CSIRO Mk3L climate model is used to simulate the evolution of the global climate from 801 to 2000 CE. A 50-member ensemble is generated by initialising the model from different years of a pre-industrial control simulation. The ensemble is then forced with best estimates of changes in the Earth's orbit, anthropogenic greenhouse gases, solar irradiance and volcanic eruptions.

The records chosen for assimilation are the temperature-sensitive Southern Hemisphere proxy records synthesised by the PAGES 2k Network. A cost function is defined and used to generate a weighted mean of the climate model ensemble, thereby using the proxy data to constrain the state of the model. The reconstruction generated through this process is shown to have greater skill than any of the individual ensemble members.

A distinct advantage of offline approaches towards DA, such as the one presented here, is that they can be applied to existing climate model ensembles. Thus DA can be performed without performing dedicated model simulations. Further work will extend the assimilation further back in time to span the Holocene. Preliminary results are presented using a three-member ensemble of simulations spanning the past 8,000 years, demonstrating the potential to implement DA over longer timescales.