Applycation of data assimilation to paleoclimate

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Knowledge of past climate conditions is crucial to understand the climate system and to predict the future. Historically, two approaches have been used to reconstruct paleoclimate: one based on the empirical evidence contained in proxy data, and the other based on simulation with physically-based climate models. Here, proxies are not the direct record of climate variables such as temperature, winds and pressure, but natural records representing climate such as tree-ring width and isotopic composition in ice sheets. Recently, an approach combining proxy data and climate simulations through data assimilation (DA) has emerged. DA has long been used for forecasting weather and is a well-established method. However, the DA algorithms used for weather forecasts cannot be directly applied to paleoclimate due to the different temporal resolution, spatial extent, and type of information contained within the observation data. The temporal resolution and spatial distribution of proxy data are significantly lower (seasonal at best) and sparser than the present-day observations used for weather forecasts. Therefore, DA applied to paleoclimate is only loosely linked to the methods used in the more mature field of weather forecasting. Several DA methods have been proposed for paleoclimate reconstruction, and paleoclimate studies using DA have successfully determined the mechanisms behind the past climate changes. In the previous studies, the variables used for DA have been data reconstructed from proxies (e.g., surface air temperature) because physical models for proxies have not been readily available. Recently, proxy modelers have developed and evaluated several forward models for stable water isotopic proxies. In this study, we attempted to assimilate proxy data directly for the first time, and demonstrated that the new method can reconstruct paleoclimate more skillfully.

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