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Combined simulation of carbon and water isotopes in a global ocean model

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Carbon and water isotopes are included as passive tracers in the MIT general circulation model (MITgcm). The implementation of the carbon isotopes is based on the existing MITgcm carbon cycle component and involves the fractionation processes during photosynthesis and air-sea gas exchange. Special care is given to the use of a real freshwater flux boundary condition in conjunction with the nonlinear free surface of the ocean model. The isotopic content of precipitation and water vapor is obtained from an atmospheric GCM (the NCAR CAM3) and mapped onto the MITgcm grid system, but the kinetic fractionation during evaporation is treated explicitly in the ocean model.

In a number of simulations, we test the sensitivity of the carbon isotope distributions to the formulation of fractionation during photosynthesis and compare the results to modern observations of δ^{13}C and Δ^{14}C from GEOSECS, WOCE and CLIVAR. Similarly, we compare the resulting distribution of oxygen isotopes to modern δ^{18}O data from the NASA GISS Global Seawater Oxygen-18 Database. The overall agreement is good, but there are discrepancies in the carbon isotope composition of the surface water and the oxygen isotope composition of the intermediate and deep waters.

The combined simulation of carbon and water isotopes in a global ocean model will provide a framework for studying present and past states of ocean circulation such as postulated from deep-sea sediment records.