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Direct modeling of oxygen isotopes in the ocean during abrupt climate change

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The oxygen-18/oxygen-16 ratio in water is a fundamental tracer of the hydrologic cycle. The direct modeling of this ratio in deep-sea sediments is a critical test for the fluxes of heat and fresh water (and hence density) at the atmosphere-ocean interface of a coupled climate model. This makes the oxygen-18/oxygen-16 isotope ratio in calcite shells of fossil planktic and benthic foraminifera ideally suited for the "assimilation" into a coupled climate model. To this end we suggest to combine a "forward" model and an objective function, e.g. the sum of root-mean square (RMS) differences between model and data, which depends on observations (or proxy data), model output and the model parameters.

In our illustrative example, we focus on the large negative anomalies in the Atlantic Ocean between Heinrich event 1 (H1, 15.4-16.8 kyr BP) and the Last Glacial Maximum (LGM). We argue that they are caused by the slow-down and subsequent recovery of the meridional overturning circulation (MOC) in the Atlantic Ocean, in response to meltwater input mainly to high northern latitudes. To test our hypothesis, we used a climate model of reduced complexity with active hydrological and isotopic cycles and the LGM and H1 oxygen isotope data from 30 planktic and 27 benthic proxy records.

According to our model-data comparison, a large warming ($\approx 5^{\circ}$C) dominated the change in the oxygen isotopic composition of foraminiferal calcite in the Central and Antarctic Intermediate Water of the Atlantic Ocean.