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Phase relationship between ice volume and oxygen-isotope ratios in seawater and calcite during the last glacial cycle: the role of ocean circulation

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We used combined ice-sheet and ocean modeling to investigate qualitatively the phase relationship between ice-volume variations and the induced changes in the isotopic composition (δ^{18}O) of seawater (δ_w) and foraminiferal calcite (δ_c) during the last glacial cycle. First, we simulated the mean isotopic composition of the North American Ice Sheet (NAIS) during the past 120,000 years with a 2.5-dimensional thermomechanical ice-sheet model including ice δ^{18}O as a passive tracer. This allowed us to estimate the changes in the magnitude and δ^{18}O of the water flux exchanged between the NAIS and the Atlantic Ocean. Then, the water flux was used to force a zonally-averaged model of the Atlantic Ocean, as part of a coupled climate model of reduced complexity. The resulting changes of mean-ocean δ^{18}O, as well as δ_w and δ_c variations at different locations in the ocean, were compared to the modeled NAIS ice volume, in order to investigate the possible phase differences due to the ocean circulation. The simulated NAIS volume variations and the induced mean-ocean δ_w changes over the past 120,000 years indicated no significant phase difference. However, locally the time lag in the ocean could reach up to 2000 years during glaciation, depending on the rate of deep-water formation. In contrast, the deglaciation signal was found to be practically simultaneous.