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Interaction between ocean circulation and sea ice explains Dansgaard-Oeschger events

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Records of oxygen isotope ratios from the North Greenland Ice Core Project (NGRIP) provide accurate proxies for the temperature evolution in Greenland during the last glacial period (12ka to 100ka b2k) [1]. The most distinctive feature of these records are rapid transitions, called Dansgaard-Oeschger (DO) events, during which Greenland temperatures increased by up to 15 K within a few decades. These warming events are consistently preceded by more gradual warming, and followed by more gradual cooling in Antarctica [2].

Several lines of evidence hint at the Atlantic Meridional Overturning Circulation to play a key role [2,3]. Other mechanisms, though, such as variations of sea ice extent [4] or ice shelf coverage [5] may play an important role, too. A comprehensive theory explaining the DO events is thus still lacking.

Here, we introduce a low-order nonlinear model that explains the DO variability by rapid retreat and slow regrowth of ice shelves and sea ice, in combination with changing subsurface water temperatures; the latter is due to insulation by an extensive sea ice cover. Our dynamical model reproduces key observed features of the records, including the sawtooth shape of the DO cycles, average waiting times between DO transitions, and the anti-phase relationship between Greenland and Antarctic ice cores. The warming of subsurface waters is also likely to contribute in triggering the Heinrich events [6], which are characterized by massive iceberg discharges from the Laurentide Ice Sheet. Our model thus helps explain both DO and Heinrich variability in a unified framework.

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