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Dansgaard-Oeschger oscillations by sea-ice variations: a conceptual model approach

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The last glacial period was characterised by large and abrupt millennial-scale climatic fluctuations, the so called Dansgaard-Oeschger (DO) oscillations. Using an interhemispheric box model of the Atlantic thermohaline circulation (THC) coupled to a moist energy balance model of the atmosphere, we show that the transition from a modern climate state to a colder climate forces the system into DO-like oscillations. The oscillations in our model are characterised by the transition between a strong and a weaker mode of the THC. The oscillations are activated by a southward migration of the sea-ice cover in the North Atlantic in the transition to a colder climate and a weaker THC. The main effect of the southward sea ice migration is the isolation of the surface northern North Atlantic, which reduces the available active surface area where deep sinking and ocean atmosphere heat exchange can occur. In our model approach this effect provides an additional positive feedback on the initial weakening of the THC by cooling. The weaker THC is accompanied by changes in the interhemispheric temperature gradient with cooling in the north and warming in the south in agreement with the bipolar seesaw principle. These interhemispheric temperature changes amplify the north - south density contrast and cause the abrupt recovery to the stronger THC mode. The effectiveness of the oscillations in our model concept suggest that changes in the North Atlantic sea-ice cover may have played a dominant role for DO-oscillations by determining the potential available surface area for deep water formation and the location of deep water formation sites.