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Large-scale interaction between ice sheets and climate during the past 800,000 years

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During the Cenozoic, land ice and climate have interacted on many different time scales. On long time scales, the effect of land ice on global climate and sea level is dictated by large ice sheets on North America, Eurasia, Greenland and Antarctica. The climatic forcing of ice sheets is largely determined by the meridional temperature profile. In their turn, the ice sheets cause an increase in albedo and surface elevation which affects the climate system. To quantify the importance of these climate-land ice processes, a zonally-averaged energy balance climate model is coupled to a one-dimensional ice-sheet model of the four major ice sheets. The benefit of using relatively simple models is that the tested model parameters are easily interpretable. Moreover, the shorter computation time allows for more tests and long transient simulations at geological time scales to be performed. This study focusses on the past 800,000 years, where a high-confidence CO_2-record from ice-core samples is used as input. Simulations of atmospheric temperature, ice volume and sea level are obtained, that are in good agreement with recent proxy-data reconstructions (RMSE=20 m over the last glacial cycle). The climate-ice sheet interaction is studied by a comparison of simulations with uncoupled and coupled ice sheets. By performing runs with CO_2 or insolation held constant, the influence of these variables is assessed. It is found that atmospheric temperature is controlled by a complex interaction of CO_2 and insolation. Finally, we show that the amplification of the climate sensitivity from the long-term ice feedback is a factor 3.