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SIMULATION OF HEINRICH EVENTS AND THEIR CLIMATE IMPACT WITH AN EARTH SYSTEM MODEL

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Heinrich events related to large-scale surges of the Laurentide Ice Sheet into the Atlantic Ocean represent one of the most dramatic types of abrupt climate change occurring during the glacial age. MacAyeal proposed a "binge/purge" free oscillatory mechanism, explaining HEs as transitions between two modes of operation of ice sheets: slow movement of ice over a frozen base and a fast sliding mode when the ice bed is at the melting point. This type of self-sustained multi-millennial oscillation has been simulated in simplified 2-D ice sheet models, but in realistic 3-D models such a large-scale instability of the LIS has not so far been reproduced. Here using a coupled atmosphere-ocean-vegetation-ice sheet model, we simulate quasi-periodic large-scale rapid surges from the Laurentide Ice Sheet under typical glacial climate conditions. The average time between simulated events is about 7,000 yrs, while the surging phase of each event lasts only several hundred years, with a total ice volume discharge corresponding to 5–10 m of sea level rise. The crucial factor needed for existence of mega-surges in our model is employment of different sliding laws over hard bed (rocks) and over soft water-saturated sediments, like those in the Hudson Bay and Hudson Strait. The area of deformable sediments served as a geological template for the mega-surges. During each HE, the elevation drops by more than one km over the Hudson Bay, and the Laurentide ice sheet changes from one-dome to a two-dome structure – one dome being located over the southeast of Alberta and another over the southwest of Quebec. In our model the ice surges represent internal oscillations of the ice sheet related to rapid transitions between two metastable modes of ice sheet dynamics over the area covered by deformable sediments. At the same time, we demonstrate the possibility of both internal and external synchronization between in-

stabilities of different ice sheets, as indicated in palaeoclimate records. The maximum ice discharge into the Northern Atlantic during simulated Heinrich events reaches 0.2 Sv (1 Sv=10^6 m^3/s) in freshwater equivalent, which is sufficient to cause a temporal shutdown of the Atlantic thermohaline circulation. This leads to an additional cooling over the Northern Atlantic, and, at the same time, causes gradual warming by several degrees (delayed "seesaw") of the Southern Hemisphere and intermediate water masses, causing an increase of CO_2 concentration in the atmosphere by 10 ppm, which is in an agreement with Antarctic ice core data.