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Mechanisms and time scales of glacial inception simulated with an Earth system model of intermediate complexity

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Abstract. We investigate glacial inception and glacial thresholds in the climate-cryosphere system utilising the Earth system model of intermediate complexity CLIMBER-2, which includes modules for atmosphere, terrestrial vegetation, ocean and interactive ice sheets. The latter are described by the three-dimensional polythermal ice-sheet model SICOPOLIS. A bifurcation which represents glacial inception is analysed with two different model setups: one setup with dynamical ice-sheet model and another setup without it. The respective glacial thresholds differ in terms of maximum boreal summer insolation at 65° N (hereafter referred as Milankovitch forcing (MF)). The glacial threshold of the configuration without ice-sheet dynamics corresponds to a much lower value of MF compared to the full model. If MF attains values only slightly below the aforementioned threshold there is fast transient response. Depending on the value of MF relative to the glacial threshold, the transient response time of inland-ice volume in the model configuration with ice-sheet dynamics ranges from 10 000 to 100 000 years. Due to these long response times, a glacial threshold obtained in an equilibrium simulation is not directly applicable to the transient response of the climate-cryosphere system to time-dependent orbital forcing. It is demonstrated that in transient simulations just crossing of the glacial threshold does not imply large-scale glaciation of the Northern Hemisphere. We found that in transient simulations MF has to drop well below the glacial threshold determined in an equilibrium simulation to initiate glacial inception. Finally, we show that the asynchronous coupling between climate and inland-ice components allows one sufficient realistic simulation of glacial inception and, at the same time, a considerable reduction of computational costs.

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