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Effect of ice sheet growth and melting on the slip evolution of thrust faults

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Field investigations suggest that postglacial unloading and rebound led to the formation or re-activation of reverse faults even in continental shields like Scandinavia. Here we use finite-element models including a thrust fault embedded in a rheologically layered lithosphere to investigate its slip evolution during glacial loading and subsequent postglacial unloading. The model results show that the rate of thrusting decreases during presence of an ice sheet and strongly increases during deglaciation. The magnitude of the slip acceleration is primarily controlled by the thickness of the ice sheet, the viscosity of the lithospheric layers and the long-term shortening rate. In contrast, the width of the ice sheet, the rate of deglaciation or the fault dip have an only minor influence on the slip evolution. In all experiments, the slip rate variations are caused by changes in the differential stress. The modelled deglaciation-induced slip acceleration agrees well with the occurrence of large earthquakes soon after the melting of the Fennoscandian ice sheet, which led to the formation of spectacular fault scarps in particular in the Lapland Fault Province. Furthermore, our model results support the idea that the low level of seismicity in currently glaciated regions like Greenland and Antarctica is caused by the presence of the ice sheets. Based on our models we expect that the decay of the Greenland and Antarctica ice sheets in the course of global warming will ultimately lead to an increase in earthquake frequency in these regions.