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Three-dimensional numerical modeling of slip rate variations on normal and thrust fault arrays during ice cap growth and melting

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Changes in the volumes of ice caps considerably alter the stress state of the lithosphere by generating a transient signal that is added to the tectonic background stress field. These stress field changes, in turn, affect crustal deformation and in particular the slip behavior of existing faults. Here we use three-dimensional finite-element models to investigate how arrays of normal and thrust faults near a growing and subsequently melting ice cap are influenced in their slip evolution (Hampel et al., JGR, 2009). The results show that, regardless of fault dip, both types of faults experience a decrease in their slip rate during ice cap advance and an increase in their slip rate during ice cap retreat if they are located beneath the ice cap. In contrast, faults outside the ice cap that are loaded on their footwall or hanging wall only, show the opposite pattern: their slip rate increases during glacial loading and decreases during subsequent unloading. If the load is located along-strike of the fault, i.e. at one of its tips, the slip behavior of normal and thrust faults is different: The normal fault shows a slip rate increase during unloading, the thrust fault during loading. Our results explain the location and timing of deglaciation-induced paleo-earthquakes in Scandinavia and the contrasting slip histories reported from normal faults in the Basin-and-Range Province, which are located at different positions relative to the former Yellowstone ice cap. More generally, our findings imply that a uniform slip behavior of faults in formerly glaciated regions should not be expected.