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Behavior of Active Faults during Glacial-Interglacial Cycles: the Effect of the Spatial Distribution of the Glacial Surface Load

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Paleoseismologic data show that many active faults experience short-term variations in their slip rates (e.g. Friedrich et al. 2003, Ferry et al. 2005). Previous two-dimensional models of normal faults suggest that glacial-interglacial changes in surface loads may trigger such slip rate variations on a 10 ka timescale (Hetzel & Hampel 2005). Here we present three-dimensional finite-element models of normal and thrust faults to systematically investigate the effect of the spatial distribution of the glacial load on fault behavior. The model was set up as a lithospheric block consisting of an elastic upper crust, a viscoelastic lower crust and a viscoelastic lithospheric mantle. To account for isostasy, a lithospheric pressure and linear springs and dashpots, representing the asthenosphere were applied to the bottom of the model. A 70-km-long fault was implemented in the center of the upper crust. By applying a velocity boundary condition, the model is either extended or shortened for 1 Ma so that the fault develops as a normal or thrust fault, respectively, and achieves a steady-state slip rate prior to loading. Afterwards, the surface load is applied along-strike of the fault, to its footwall or hanging wall or both. The pressure applied represents lakes of 250 m depth or ice of 270 m thickness. The loading history in the model mimics the last glacial period, i.e. loading starts at 35 ka, linearly increases to the maximum at 22 ka, which is maintained until 18 ka before a linear decrease to zero until 16 ka. The experimental results show that the changing load on the model surface causes variations in the slip rate of both normal and thrust faults. Depending on the location of the load with respect to the fault, the fault experiences a decreased slip rate during loading and an increased slip rate during unloading or *vice versa*. For example, the slip rate of a normal fault decreases during loading and increases during unloading if the load is located on the footwall,

both on footwall and hanging wall or along strike of the fault. In contrast, loading of the hanging wall causes an increase of the slip rate during loading and a decrease during unloading before a return to the steady-state rate. The slip rate of the thrust fault decreases during a simultaneous loading of footwall and hanging wall or during loading on the hanging wall and increases during unloading. A load on the footwall or along strike of the fault causes an inverse slip pattern. Additional preliminary experiments, in which we varied the rheologic parameters of the lithospheric layers, further suggest that the slip pattern may not only be influenced by the distribution of surface load but also by the ratio between the viscosity of the lower crust and the lithospheric mantle.