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Slip modes and interaction in a simplified strike-slip fault system with increasing geometrical complexity

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The release of elastic energy along an active fault is accommodated by a wide range of slip modes. It ranges from long-term slow slip events (SSEs) and creep to short-term tremors and earthquakes. They vary not only in their characteristic duration but also in their magnitude, spatial extent and slip velocities. The exact relationship is unclear, as in some regions many slip modes occur simultaneously (e.g. Tohoku-Oki) and in others certain slip modes are completely absent (e.g. Cascadia).

One of the driving factors in the generation of this large variety of slip modes is the interplay of fault heterogeneity and geometrical complexity of the fault system. We test various settings in terms of fault heterogeneity and geometrical complexity with a scaled physical model. The experimental results are then validated and benchmarked through multi-scale numerical simulations. We describe the system using a rate-and-state frictional framework and introduce on-fault heterogeneity with variable frictional properties. All properties are the same for analogue and numerical simulation as far as they can be determined or realized experimentally (a-b, v_{load}, S_{hmax}, S_{hmin}, etc...). As analogue material we use segmented, decimetre sized neoprene foam blocks in multiple configurations (e.g. biaxial shear at forces <1 kN) to simulate the elastic upper crust. The contact surfaces are spray-painted with acrylic paint to generate velocity weakening characteristics in between the blocks which is similar to the frictional behaviour of natural faults. We add heterogeneity to the fault surface by varying the fault area that is velocity weakening using grease. Geometrical complexity is implemented using conjugated or parallel sets of additional faults with the same characteristics.

We are able to reliably generate frequent stick-slip events of variable size and recurrence intervals. The slip characteristics, such as slip distribution, are in good agreement with analytical solutions of fault slip in elastic media. In a geometrically simple strike-slip model the recurrence behaviour and magnitude follows straightforward scaling relations in accordance with existing studies. If geometrical complexity is added to the model we observe clustering and variable recurrence that differ from the simpler geometry. Additionally, we are going to give an outlook on the interaction behaviour of multiple faults in dependence of their geometric configuration and the generation of power-law type magnitude scaling relations.