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

Michael Rudolf¹, Joscha Podlesny², Matthias Rosenau¹, Ralf Kornhuber², and Onno Oncken¹
¹Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Lithosphere Dynamics 4.1, Potsdam, Germany (michael.rudolf@gfz-potsdam.de)
²Department of Mathematics and Computer Science, Numerical Analysis of Partial Differential Equations, Freie Universität Berlin, Berlin, Germany

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 extend and slip velocities. As all slip modes are related to earthquakes, the understanding of the relationships between the different slip modes and the underlying mechanisms is crucial to assess earthquake hazards in various regions. The exact relation 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. Using a scaled physical model we test various settings in terms of fault heterogeneity and geometrical complexity. The experimental results are then validated and benchmarked using multi-scale numerical simulations. We describe the system using the rate-and-state frictional framework and introduce the on-fault heterogeneity with variable frictional properties. All properties are the same for analogue and simulation as far as they can be determined or realized experimentally (a-b, v\text{load}, S_{\text{max}}, S_{\text{min}}, \text{ 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. The major advantage of using neoprene over other materials, such as gelatine or polyurethane foams, is that it has closed pores and thus exhibits a more favourable Poisson's ratio in comparison with rocks and shows better elastic strain propagation in the block. Furthermore, all used materials are inert and do not change their properties over time.

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 this contribution we will highlight the material properties, experimental results and used methodologies to monitor and process the experimental data. 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.