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Interseismic deformation transients and precursory phenomena: Insights from stick-slip experiments with a granular fault zone

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The release of stress in the lithosphere along active faults shows a wide range of behaviors spanning several spatial and temporal scales. It ranges from short-term localized slip via aseismic slip transients to long-term distributed slip along large fault zones. A single fault can show several behaviors in a complementary manner often synchronized in time or space. To study the multiscale fault slip with a focus on interseismic deformation transients we apply a simplified analog experiment using a rate-and-state-dependent frictional granular material deformed in a ring shear tester. The analog model is able to show, the full spectrum of natural slip behaviors including transient creep and slow slip events superimposed on regular stick-slip cycles (analog seismic cycles). Analog fault slip is systematically controlled by extrinsic parameters such as the system stiffness, normal load on the fault, and loading rate. We observe two peculiar features in our analog model: (1) Absence of transients in the final stage of the stick-slip cycle ("preseismic gap") and (2) "scale gaps" separating small slow events from large fast events. Concurrent micromechanical processes, such as dilation, breakdown of force chains and granular packaging affect the frictional properties of the experimental fault zone and control interseismic strengthening and coseismic weakening. Additionally, creep and slip transients have a strong effect on the predictability of stress drops and recurrence times. Based on the strong kinematic similiarity between our fault analog and natural faults, our observations may set important constraints for time-dependent seismic hazard models along single faults.