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Exploring the properties of shallow slip on surface rupturing faults: Evidence from instrumental monitoring and fault gouge thickness

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Surface rupturing earthquakes occur in a wealth of plate tectonic settings and pose important hazard to nearby cities and infrastructure. Nevertheless mechanical models to describe the slip behavior and displacement accumulation pattern of the shallow fault zone are contradictory. Recent observations suggest that, despite low confining pressure and phyllosilicate rich fault gouges at shallow crustal levels, faults can exhibit velocity weakening behavior all the way to the surface. We use continuous time series from the IPOC Creepmeter Array (www.ipoc-network.org/observatory/creepmeter/creepmeter-at-ipoc/) in N-Chile, monitoring 4 segments of the Atacama Fault System, to investigate the slip mode of the different fault segments.
This instrumental dataset covers a time span of 8 years at 11 monitoring sites and comprises both triggered shallow slip events and creep signals. The recorded shallow slip events range from μm to mm scale in fault parallel displacement. Slip velocities for these events range between 1 -2000 mm/year therefore representing slow slip events. In fact, the current sampling rate of 2 samples/min does not allow for the detection of seismic velocities for the size of the so far recorded slip events.
Decomposing the time series at the different monitored fault segments we are able to differentiate between slow creeping fault segments not accumulating displacement by triggered shallow slip events and others which are accumulating displacement solely by triggered shallow slip events. Comparing these observations with the fault gouge thickness at the monitored sites, we find a strong correlation of segments exhibiting 10 cm thick fault gouge at the monitoring site and creeping fault behavior. Whereas these fault segments, accumulating displacement only via triggered shallow slip events, do not have a fault gouge developed. Instead those fault contacts are developed in a strongly fragmented basement/basement contact zone or show a submillimeter thin sharp contact in alluvial fan sediment. These first results demonstrate the ability to extract fault frictional behavior from time series collected with the IPOC Creep Observatory, that match fault gouge properties studied in the field directly at the monitoring sites.