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The Analog Subduction Earthquake Cycle: Capturing Maximum Information with Minimum Measurement

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Subduction zones are complex dynamic systems hosting two of the most dangerous geo-hazards: mega- earthquakes and tsunamis. The scientific community is making great efforts to instrument and monitor these areas in order to illuminate, with improved resolution, the spatial and temporal features of subduction zone earthquakes. A very important aspect is the spatial relation between the interseismic degree of locking and the co-seismic slip distribution along the subduction interface, and thus the seismic cycle of megathrusts. This is particularly relevant for the intermediate-shallow part of megathrusts, where ruptures can occur and more easily produce devastating tsunamis, as demonstrated by the 2010 Maule and the 2011 Tohoku events. Another significant aspect is the range of transient signals that we might observe as the non-steady state interseismic period evolves towards the next co-seismic rupture. There are numerous examples of late-interseismic transients for recent large ruptures (e.g. Tohoku Mw 9.0, Iquique Mw 8.1, Illapel Mw 8.3), some of which were only subtly recorded by onshore GPS, but captured more clearly with analysis of repeating events.

One major challenge is that interseismic locking is most often estimated using onland GNSS instruments, but the trench is so far offshore that we struggle to obtain enough model resolution in the updip regions of the plate interface. Accordingly, specific efforts are currently dedicated to the configuration and installation of geodetic sensors, specifically on the seafloor.

Here, we use a novel analog model, that is a simplified scale reproduction of a subduction zone, to simulate hundreds of seismic cycles in a reasonable experimental time and observe the seismic behaviour of the megathrust for a given asperities configuration on a timescale of 10-100 kyr. Material properties (both elasticity and friction) and subduction geometry in the model are well defined, whereby specific configurations of asperities can be implemented a-priori. We exploit top-view monitoring with a videocamera and digital image cross correlation analysis to measure the velocity field of the model surface, discretized in a large number (i.e. thousands) of interrogation windows that ideally play the role of a set of homogeneously distributed "synthetic geodetic stations" above the whole model surface.

Our preliminary results analyse the relation between the spatial distribution of geodetic sensors (both offshore and inland) and the resolution to which velocities can be imaged, hence indirectly the slip and interseismic locking and other potential transient signals along the subduction interface.