Analogue Geodetic Slip Inversion Technique (AGSIT): Monitoring time-dependent slip distribution along analogue subduction megathrusts

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Abstract

Characterizing the time-dependent slip evolution along subduction megathrusts during seismic cycles is an important process to unfold the recurrence patterns of great earthquakes. Surface displacement measurements made with Global Partitioning System (GPS) and Interferometric Synthetic-Aperture Radar (InSAR) techniques have been applied for modelling slip and its evolution during subduction zone seismic cycles. However, in nature this approach has important limitations: Uncertainty in fault geometry and secondary structure (e.g. splay faults), sparse distribution of data in space (GPS) or time (InSAR), and the general lack of offshore coverage lead to under-determined inversion problems with highly non-unique solutions.
In this study, we have set up scaled analogue megathrust models to develop the "Analogue Geodetic Slip Inversion Technique" (AGSIT), which is inspired by geodesy and remote sensing approaches. We model slip distribution on predefined asperities and forearc crustal faults over many seismic cycles. The model includes all relevant deformation processes from earthquake nucleation and rupture propagation to interseismic locking and accumulation of permanent deformation. To monitor surface displacement at various temporal and spatial resolution a set of four digital cameras with different imaging rates (4Hz stereo, 100Hz and 250Hz) are used to cover the relevant spatiotemporal scales. The recorded image data has been processed using Digital Image Correlation (DIC) techniques in order to retrieve the model surface velocities (incremental displacement) from the forearc to the trench.

For establishing the inverse problem in our models, the surface displacement vectors at different time scales have been considered as virtual two or three-component GPS stations and the pre-defined asperity as a megathrust fault model. The surface trace of crustal faults constrained the geometry of secondary structures (splay fault and backthrust). To tie unit slip on individual patches on the faults to the observed displacement vectors at individual surface points, Green's function for rectangular dislocations in an elastic half-space were computed and applied.

Here we show our preliminary results from AGSIT which enables us to succeed in dealing with constraints of megathrust analogue slip modelling and evaluate seismic cycle-related deformation over a large range of temporal scales (seconds to ka) at laboratory scale.

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