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Automated assessment of rupture geometry and segmentation based on InSAR data and seismic moment rate functions prior to source optimizations

Andreas Steinberg (1), Henriette Sudhaus (1), Sebastian Heimann (2), Marius Isken (1), and Simon Daout (1)
(1) Institute of Geosciences, Kiel University, Kiel, Germany, (2) GFZ, German Research Center for Geosciences, Potsdam, Germany

The increasing amount of Interferometric Synthetic Aperture Radar (InSAR) surface displacement data of shallow crustal earthquakes calls for increasingly efficient and automated ways of earthquake source analyses using these data.We see a need to update our toolboxes particularly for the combined use of near-field and far-field data towards more efficiency with unsupervised, automated joined-data source inversions.We focus here on more objective ways to assess rupture segmentation prior to any source optimizations, preferably in an automated manner.
Co-seismic ruptures for earthquakes with large moment magnitudes (Mw>7) are commonly segmented with rupture segments separated in space and time and which often contribute differently to the total moment release. However, also the more frequent earthquakes in the moment magnitude range between 5.5 and 7 show segmentation, especially normal or reverse faulting earthquakes. If rupture segmentation occurs, a simple one-source model like a single point source (Double-couple) or a single rectangular source may not represent the rupture process well. A single-source model is often the start of any automated source analysis. However, in some cases a segmented source model might be more appropriate.
Through the combination of near-field data with far-field data we are more sensitive to rupture segmentation than with teleseismic waveforms alone. Still, , often the degree of source segmentation is judged intuitively on appearance from the observables on a case-study basis, for example from the surface displacement pattern in InSAR data or from mapped fault data.

To asses objectively characteristics of the ruptured fault plane from static surface displacements maps, we make use of displacement gradient vectors and image analysis toolslike eedge detection.
Based on that we analyse (1) where the deformation signal is in an InSAR image, (2) if and where surface rupture took place and (3) trace the surface rupture.
We also calculate moment rate functions and create Backprojection images from teleseismic waveform data (from 20 to 50 Hz) to detect possible complexities in the rupture evolution. eThese informations are then combined to calculate the probabilities of rupture segmentation based on rupture probabilities functions from UCERF3.Potentially, this can be used to derive meaningful geometries for start model ensembles in preparation for source optimizations.
We use open-source python-libraries and for data processing and post-processing the modular Pyrocko software package (pyrocko.org), including the Kite software module for handling InSAR datasets. This work is conducted within the project “Bridging Geodesy and Seismology” (www.bridges.uni-kiel.de) funded by the German Research Foundation DFG through an Emmy-Noether grant.