Bridging Geodesy and Seismology to study fault slip behavior in space and time

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Finite rupture models of past large earthquakes provide insights to rupture physics and the gained information feeds into rupture simulations and simulated ground-motion. An obstacle are the commonly high uncertainties corresponding to hazard-relevant rupture characteristics like precise fault location, rupture dimension, slip or moment rate and rupture velocity. More robust inferences of rupture models with reduced uncertainties can be achieved through a combination of near-field and far-field data such as strong-motion, GPS and InSAR surface displacement data and broadband teleseismic data, respectively. Because GPS and strong-motion observations depend on dense local instrument networks, a global coverage of onshore crustal earthquakes is realized only by combining space-borne InSAR data and broadband seismic waveform observations.

Additionally, InSAR time series data can be used to measure interseismic fault loading and stress-releasing aseismic fault slip, like fault creep or postseismic afterslip. Taken together these observations reveal slip deficits and earthquake potential at fault systems. The consideration of the latter is important in strain-based earthquake forecasts.

We present our ongoing work in the German young researcher group project “Bridging Geodesy and Seismology” (www.bridges.uni-kiel.de) to facilitate the combined use of InSAR data and seismic waveforms to model seismic finite rupture processes in a harmonized modeling framework. To do so we extend the existing open-source seismology community toolbox pyrocko (www.pyrocko.org) by modules that allow for the additional use of near-field static offsets in combination with far-field seismic waveforms for finite rupture modeling.

The relationship between fault slip at depth and surface displacement is highly non-linear and the fault continuation at depth is not precisely known. As a consequence, best-fit model solutions are often highly ambiguous. For studying the coseismic slip, fault afterslip, creep and/or interseismic fault loading we therefore need to explore a large model parameter space and estimate model parameter trade-offs, e.g. between fault geometry at depth and slip potential, and uncertainties of model parameters. To do so as realistically as possible we use Bayesian modeling approaches which includes the propagation of correlated data error. We are working on also propagating the medium model uncertainties that have been shown to significantly bias the estimation of rupture parameters.

Our goal is to facilitate combined-data finite rupture modeling for more robust earthquake source estimations, to find best-practice modeling standards and to provide examples for enriched earthquake catalog data of finite sources with their model probabilities. We want to use these to better understand the resolution limits on earthquake source characteristics from surface data and possibly strengthen source scaling relations. Furthermore, we are interested in the properties of aseismic slip and loading to

improve the knowledge the seismic potential.

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