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Software Toolbox Development for Rapid Earthquake Source Optimisation Combining InSAR Data and Seismic Waveforms

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We present a modular open-source software framework (pyrocko, kite, grond; http://pyrocko.org) for rapid InSAR data post-processing and modelling of tectonic and volcanic displacement fields derived from satellite data. Our aim is to ease and streamline the joint optimisation of earthquake observations from InSAR and GPS data together with seismological waveforms for an improved estimation of the ruptures' parameters. Through this approach we can provide finite models of earthquake ruptures and therefore contribute to a timely and better understanding of earthquake kinematics.

The new kite module enables a fast processing of unwrapped InSAR scenes for source modelling: the spatial sub-sampling and data error/noise estimation for the interferogram is evaluated automatically and interactively. The rupture's near-field surface displacement data are then combined with seismic far-field waveforms and jointly modelled using the pyrocko.gf framwork, which allows for fast forward modelling based on pre-calculated elastodynamic and elastostatic Green's functions. Lastly the grond module supplies a bootstrap-based probabilistic (Monte Carlo) joint optimisation to estimate the parameters and uncertainties of a finite-source earthquake rupture model.

We describe the developed and applied methods as an effort to establish a semi-automatic processing and modelling chain. The framework is applied to Sentinel-1 data from the 2016 Central Italy earthquake sequence, where we present the earthquake mechanism and rupture model from which we derive regions of increased coulomb stress.

The open source software framework is developed at GFZ Potsdam and at the University of Kiel, Germany, it is written in Python and C programming languages. The toolbox architecture is modular and independent, and can be utilized flexibly for a variety of geophysical problems.

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