Tools for Bayesian earthquake source inversion from heterogeneous geodetic and seismological observations

Marius Paul Isken*[1], Henriette Sudhaus[1], Sebastian Heimann[2], Rongjiang Wang[2], Hannes Vasyura-Bathke[3], Simon Daout[4], and Andreas Steinberg[5]

[1]Kiel University (CAU) – Otto-Hahn-Platz 1 24118 Kiel, Germany
[2]GeoForschungsZentrum - Helmholtz-Zentrum Potsdam – Telegrafenberg, D-14473 Potsdam, Germany
[3]University of Potsdam – Am Neuen Palais 10, House 914469 Potsdam, Germany
[4]Kiel University (CAU) – Germany
[5]Kiel University (CAU) – Otto-Hahn-Platz 1 24118 Kiel, Germany

Abstract

Robust characterization of earthquake sources from diverse geodetic observations requires elaborate forward modeling techniques and efficient inversion strategies which can deliver expressive model uncertainties.
We present a flexible software framework for forward modeling displacements and seismic wave forms in layered media. Our approach is based on adaptable Green's function databases which provide predictions of near-field geodetic data (InSAR, GNSS and gravity) together with synthetic seismic waveforms at all distances.

We show first results of immediate forward models of gravity potential change at GRACE orbit height (which corresponds to Level-1 data products). We show that GRACE Level-1 data allows to unveil the gravity change signal imposed by large earthquake events, exemplarily we investigate the 2010 Maule Earthquake.

Together with this extensible forward-modeling framework, we present the toolkit kite to prepare and analyze satellite InSAR data: The software eases the spatial quadtree data reduction and calculation of data error covariance to facilitate the use of realistic error margins for the optimization. Alongside we present talpa, a graphical tool to interactively manipulate different kinds of displacement sources while visually comparing observed and modeled data. Combining the above frameworks, we show a Bayesian bootstrap-based probabilistic inversion scheme for heterogeneous data. It realizes an efficient strategy to explore the full model space together with uncertainties and parameters trade-offs for the earthquake source model. The program is highly flexible with respect to the adoption to specific problems, the design of the objective functions, and the diversity of the measurements.

*Speaker