Title: Influence of velocity model uncertainty in earthquake source inversions

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Abstract: Earthquake ground motions originate from rupture processes on faults in Earth. Constraints on earthquake source models are important for better understanding of earthquake physics and for assessment of seismic hazard. The source models are inferred from observed waveforms by inverse modeling, which is subject to uncertainty. For large tectonic earthquakes the major source of uncertainty is an imprecise knowledge of crustal velocity model. The research topic of this Thesis is the influence of the velocity model uncertainty on the inferred source models. We perform Monte-Carlo simulations of Green's functions (GFs) in randomly perturbed velocity models to reveal the effects of the imprecise velocity model on the synthetic waveforms. Based on the knowledge gained, we derive closed-form formulas for approximate covariance functions to obtain fast and effective characterization of the GFs' uncertainty. We demonstrate that approximate covariances capture correctly the GF variability as obtained by the Monte-Carlo simulations. The proposed approximate covariance functions are massively tested on moment tensor inversions of synthetic and real data sets. In particular, Bayesian inversion tests show that the posterior probability density provides also realistic estimate of uncertainty of the moment tensors. We apply the method on the case study of foreshocks and aftershocks of the 2016 Kumamoto, Kyushu, Japan, earthquake sequence, where our assessment of the realistic uncertainties of the centroid moment tensors proved to be beneficial for interpretation of the results in seismo-tectonic framework. Further, we develop a new Bayesian parametric fault slip inversion, which accounts for the GFs' uncertainty by means of the approximate covariance functions. Our non-linear kinematic finite-extent source inversion method relies on self-adapting parametrization of slip. Performance of the slip inversion method is demonstrated on the destructive $M_w 7.1$ mainshock of the 2016 Kumamoto sequence. The posterior probability density is sampled by trans-dimensional Markov chain Monte-Carlo algorithm, which results into an ensemble of more than 590k possible finite source models. This allows us to inspect which features of the finite-extent source model are reliable and which are rather artifacts caused by the imprecise knowledge of the velocity model.

Keywords: earthquake source, velocity model, Green's function, Bayesian inversion, 2016 Kumamoto sequence