Geophysical Research Abstracts
Vol. 20, EGU2018-10557, 2018
EGU General Assembly 2018

Estimating lithospheric density structure using probabilistic joint inversion of satellite gravity gradients and topography

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Lithospheric mantle density anomalies contribute to the gravity field and isostatic compensation of topography. Determining these density anomalies from seismic velocities is challenging, because seismic velocity mainly reflects temperature variations and is less sensitive to different chemical composition. However, such chemical variations have a strong effect on rock density.

We use gravity gradients to directly invert for a two-layered model of the lithosphere consisting of a crust and mantle part. Within each layer density is laterally variable. In addition, we fit the Earth's topography, requiring our models to be in isostatic equilibrium. However, we do not require the model to be strictly in isostatic equilibrium but allow for a long-wavelength contribution from the deep mantle. Starting values crustal thickness and density are based on kriging interpolation of a catalogue of active seismic experiments. This approach also gives an estimate of the uncertainty of the starting values.

Since we expect strong trade-offs between the different model parameters, we use a Bayesian Monte-Carlo-Markov-Chain (MCMC) approach to generate ensemble of possible model solutions. In addition, we use hyperparameters to describe the magnitude and wavelength of the contribution from the lower mantle to gravity and topography.

We will first apply our algorithm to the United States, which is a well-studied region, to assess the sensitivity of satellite gravity gradients and topography to lithospheric structure. Then, we will test our algorithm in a frontier region with sparse data and compare the reliability of obtained results in the two test areas.