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Joint inversion of gravity data together with Pg traveltimes from shots and Pg/Sg onsets from earthquakes in the Western Bohemia/Vogtland swarm region

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Inverse problems in geophysics exhibit many attributes of complexity: among others, instability, non-uniqueness, non-linearity, big data and model spaces or time consuming forward modelling. Technical difficulties can be solved by applying robust inverse or optimizing algorithms. On the other hand, instability and non-uniqueness are of principal nature. Both these aspects can be efficiently overcome by simultaneous inversion of more qualitative different data sets. In a favourable case, such joint inversion results in a smaller model space involving acceptable solutions compared to analogous model spaces obtained by using single inversions separately dealing with only individual data sets. Solutions reached by joint inversions are therefore more stable and better conditioned.

We performed joint inversion of gravity, seismic and seismological data characterizing the seismoactive region of Western Bohemia/Vogtland (11.65E 13.10E x 49.65N 50.86N) in a depth range of 0-20 km. Gravity data are represented by Bouguer anomalies measured in 1371 points in a grid of 2 x 2 km. Seismological data are represented by (i.) a set of 3022 Pg traveltimes obtained from recorded shots (with known locations and shooting times) and (ii.) Pg/Sg arrival times from 733 local earthquakes (with readjusted origin times and hypocenters during computations) recorded at 10 seismic stations, on average. In total, there were 15829 seismic rays representing the counterpart to gravity data.

In order to find density and velocity distributions we applied several uniform 3D block-gridded models with different box's dimensions (from 10 x 10 x 5 km to 2 x 2 x 2 km). Normally, the velocity and density models should be completely independent. In order to efficiently apply the joint inversion of independent forward methods, we tested two types of artificial constraints applied in model space: (i.) density and seismic velocity were linked by simple empirical rule (ii.) the similarity of both models (i.e. density vs. velocity) was quantified on a statistical basis ("cross-gradient technique"). Our approach is confirmed by inverting not only the real data sets but also the synthetic data.