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Transdimensional joint inversion of seismic refraction, surface elevation and gravity data for chemical composition of the crust and upper mantle

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Information on chemical composition and thermodynamic state of the subsurface is the ultimate goal of geophysical inversion. To reduce the associated uncertainties, joint interpretation/inversion of heterogeneous datasets is crucial; realistic uncertainty analysis requires probabilistic approach. Here we present a framework for probabilistic joint inversion of seismic traveltimes, surface elevation and gravity data. Primary unknowns of our inverse problem are proportions of mineral phases within the crystalline crust, geometry of the basement surface / Moho and bound water content in the uppermost mantle. Such parameterization allows for consistent integration of the observables: elastic moduli and density are predicted from mixture model and mineral physics at pressure and temperature satisfying the thermodynamical constraints. To sample generally multimodal posterior probability density function of the model parameters efficiently we adapt Markov chain Monte Carlo algorithm with Parallel Tempering. Parsimonious model parameterization is especially important in view of highly nonuniform and nonlinear ray geometry inherent to seismic refraction experiments. To achieve this we apply transdimensional approach, varying number of nodes parameterizing composition. We present results for 2D synthetic and real-world data from wide-angle seismic experiment in the Porcupine Basin (North-East Atlantic).