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A 3D multi-observable probabilistic inversion method for the compositional and thermal structure of the lithosphere and sublithospheric upper mantle

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High-resolution imaging and characterization of the thermal and compositional structures of the lithosphere and sublithospheric upper mantle represent the basis for understanding the formation and evolution of the lithosphere and the interaction between the crust-mantle and lithosphere-asthenosphere systems. Unfortunately, such imaging and characterization using available geophysical-geochemical methods still are unsolved and technically challenging problems.

In this contribution we present a new full 3D multi-observable inversion method particularly designed for high-resolution (regional) thermal and compositional mapping of the lithosphere and sublithospheric upper mantle. Ambient noise tomography, multiple plane wave earthquake tomography, magnetotelluric, thermal, thermodynamic, and potential field modelling are all combined in a single thermodynamic-physical framework and appraised within a general probabilistic (Bayes) formulation. This circumvents the problems of strong non-linearity involved in traditional inversions, provides highly refined seismic information, eliminates the trade-off problem between temperature and composition in wave speeds, offers critical insights into incompatibilities between traditional stand-alone methods, and takes advantage of a priori local geochemical information. Both synthetic models and preliminary results in real-case examples will be used to discuss the benefits, robustness, and limitations of this method.