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Assimilation of the present crust-mantle temperature to the geological past

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Recent high-resolution teleseismic body-wave tomography data image the mantle beneath the south-eastern Carpathian mountains. Using the tomography data we obtain a model of the present mantle temperature beneath the region. The temperature in the crust is constrained from measured borehole temperature and corrected for paleoclimate changes and the effects of sedimentation. A thermo-convective flow in the mantle is described mathematically by the Stokes, quasi-heat, and continuity equations.

To estimate temperature and mantle flow in the geological past, we develop a 4D quasi-reversibility method (4DQuaR). Data assimilation using this method is based on a search of the best fit between the forecast model state and the observation by minimizing over space and time the regularization parameter, entering the quasi-heat equation. We employ 4DQuaR to assimilate the present temperature into the past and to restore the prominent thermal features of the crust-mantle structures in the study region. Early Miocene subduction beneath the Carpathian arc and subsequent gentle continental collision transported cold and dense lithosphere into the hotter mantle. The present day sinking lithosphere (slab) has roots down to at least 350 km. The restored mantle structures show prominent features of the slab in the shallow mantle as well as the evolution of another portion of the sinking lithosphere which is practically invisible in the present mantle images. The data assimilation in problems of mantle dynamics opens new perspectives in better understanding of the solid Earth evolution.