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Inverse retrospective thermo-mechanical modeling of lithosphere subduction

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Present temperature in the crust and in the mantle provides a clue to deciphering lithosphere subduction at present and in the past. The present temperature can be estimated from seismic tomography models, laboratory experiments on properties of minerals and rocks and through the extrapolation of surface heat flow observations. We map the thermal state of the mantle beneath the Japanese islands by inverting P-wave velocity anomalies of the high-resolution global seismic tomography model. The effects of anharmonicity, anelasticity, and partial melting on seismic velocities are considered in the forward modeling of synthetic seismic velocity anomalies. We analyze a sensitivity of the temperature model to dry and wet solidus.

The developed temperature model together with geodetic observations and plate motion reconstructions are assimilated in the Early Miocene times to constrain the dynamics of the Pacific and Philippine plates subducted beneath the Japanese islands. Our inverse retrospective model is based on the set of thermal convection equations using the extended Boussinesq approximation and appropriate initial and boundary conditions and incorporates mantle phase transformations. To restore mantle structures and flow in the geological past, the quasi-reversibility data assimilation technique is employed to determine the initial conditions for the temperature and velocity in the geological past from the present data and models. We will present several scenarios for the evolution of the descending lithosphere beneath the islands depending on the presence of phase changes at the depths of 410 and 660 km and on the rigidity of the lithosphere.