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Numerical approach to inverse problems in geodynamics: Application to lithosphere subduction

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To restore mantle thermal structures and convective flow in the geological past, mathematical and computational techniques for inverse retrospective problems should be employed to constrain the initial (in the past) conditions for the temperature and velocity in the mantle from present seismic, heat flow, geodetic and some other observations. The basic principle of inverse retrospective problems in geodynamics is to consider the initial temperature as a control variable and to optimise the model temperature and flow in order to minimize the discrepancy between the present observations and the solution to a model of the inverse thermo-convective mantle flow. Our model is based on the set of the Stokes, heat flux and continuity equations at the extended Boussinesq approximation and at the appropriate initial and boundary conditions and incorporates mantle phase transformations. We use a quasi-reversibility technique (Ismail-Zadeh et al., GJI, 2007) for assimilation of the present data and discuss applicability of this technique to restoration of a descending lithosphere. A sensitivity analysis has been performed to clarify the influence of the model boundary conditions and the model viscosity on model results. We apply the methodology to study the evolution of the Pacific and Philippine plates subducting beneath the Japanese islands and present several scenarios for the evolution of the descending lithosphere.