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Evolution of global mantle convection: mechanical and thermal effects of floating continents

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Numerical models are presented that simulate mantle convection coupled with superimposed continents. Rigid spherical caps floating on the convecting mantle represent the continents and main islands. Non-slip boundary conditions at the bottom of the caps provide mechanical coupling between the convecting mantle and continents. Thermal blanket effect of the continents is investigated by applying the end-member condition reducing heat flux through the caps. Additional repulsive forces prevent overlap of the continents in the case of their collision. The initial temperature distribution in the mantle is calculated based on seismic tomography data. The evolving mantle model implies 25% basal and 75% internal heating. We compare transformations of the mantle convection patterns, which take place after evolution of three different models: free mantle convection model, mantle convection mechanically coupled with floating continents and the convection model with full thermo-mechanical coupling between the convecting mantle and continents. Mechanical coupling leads to near horizontal convection currents under continents and consequently to a noticeable decrease of the mantle temperature under them. By contrast, the thermal blanket effect causes an increase of the sub-continental mantle temperature. The modelling results show that a long-term evolution of the free convection model and model with implemented continents leads to principally different structures. Several common stages of the continental evolution are revealed for the most advanced model. In the final stage of the modelled evolution the convection pattern is reorganized and the main downwellings start to move to the south pulling the continents, which tend to assemble a new supercontinent around Antarctica. Due to the repulsive forces the continents rotate and adjust to each other.