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Models and observations of plume-ridge interaction in the South Atlantic and their implications for crustal thickness variations

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Mantle plumes are thought to originate at thermal or thermo-chemical boundary layers, and since their origin is relatively fixed compared to plate motion they produce hotspot tracks at the position of their impingement. When plumes reach the surface close to mid-ocean ridges, they generate thicker oceanic crust due to their increased temperature and hence higher degree of melting. Observations of these thickness variations allow estimates about the buoyancy flux and excess temperature of the plume. One example is the interaction of the Tristan plume with the South Atlantic Mid-Ocean Ridge, however, conclusions about the plume properties are complicated by the fact that the Tristan plume track has both on- and off-ridge segments. In these cases, where a plume is overridden by a ridge, it is assumed that the plume flux has a lateral component towards the ridge (the plume is “captured” by the ridge). Additionally, sea floor spreading north of the Florianopolis Fracture Zone did not start until $\sim$112 Ma – at least 15 Ma after the plume head arrival – while the Atlantic had already opened south of it. Therefore, the plume is influenced by the jump in lithosphere thickness across the Florianopolis Fracture zone.

We present crustal thickness and plume tracks of a three-dimensional regional convection model of the upper mantle for the Tristan-South Atlantic ridge interaction. The model is created with the convection code ASPECT, which allows for adaptive finite-element meshes to resolve the fine-scale structures within a rising plume head in the presence of large viscosity variations. The boundary conditions of the model are prescribed from a coarser global mantle convection model and the results are compared against recently published models of crustal thickness in the South Atlantic and hotspot tracks in global moving hotspot reference frames. In particular, we investigate the influence of the overriding ridge on the plume head.

Thus, our comparison between models of plume-ridge interaction and observations of crustal thickness in the South Atlantic can improve the estimate about the buoyancy flux and excess temperature of the Tristan plume over time. Moreover, it provides an estimate about the quality of the employed global plate reconstructions and hotspot track models.