Contribution of glacial-isostatic adjustment to tectonic plate motion

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The horizontal surface motion induced by glacial isostatic adjustment (GIA) is usually considered in formerly glaciated regions only, whereas apart from those regions (far-field) this motion is neglected. The reason for this is (1) the assumption of a moderate viscosity contrast between upper and lower mantle which does not allow for an effective channeling of material flow in the upper mantle and (2) the application of a spherical symmetric earth model which does not allow for the consideration of isolated plates.

In this study, we investigate the effect of GIA on tectonic plate motion assuming the tectonic plates to be elastic and viscously connected along the plate boundaries. The elastic thickness is parameterized according to the thermal state of the lithosphere. Assuming a large contrast of $\eta_{\mathrm{UM}}/\eta_{\mathrm{LM}} = 5 \times 10^{-2}$, we show the motion of the plates as well as the intraplate deformation to be of the order of mm/a which is observable by modern geodetic methods such as GPS. We discuss the mechanism of the GIA induced horizontal motion and the influence of plate boundaries. Figure 1 shows the present-day velocities along a cross-section between Australia and Antarctica. We can see a large change of the velocity field at the mid-ocean ridge, denoted by the triangle, and the channeling of lateral material flow in the upper mantle.
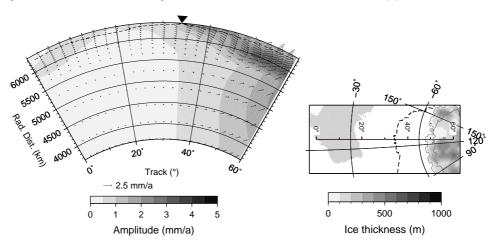

Figure 1: Left: Present-day displacement rates on a cross-section that passes the the Southeast Indian ridge between Australian and Antarctic plates. Dashed line shows the lithosphere considered. Inverted triangle denotes the position of the ridge. Right: Location of the cross-section, the ice thickness relative to present day and its extension (solid line) at the last glacial maximum and the mid-ocean ridge (dashed line).

Numerical model

The material property of the earth's mantle is described by a linear viscoelastic rheology. The driving force is the surface loading due to the last glacial cycle. We use a spectral finite-element code which solves the field equations of a viscoelastic, incompressible, self-gravitating continuum in spherical geometry allowing for lateral variations in viscosity. The filed variables are parameterized by finite elements in radial direction and by spherical harmonics in horizontal direction. The time evolution of the adjustment process is treated by an explicit finite-difference scheme.