Geophysical Research Abstracts, Vol. 9, 04209, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-04209

Viscosity structure of the shallow Earth from GOCE

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In recent papers we have shown the effect of crustal and asthenospheric low-viscosity zones (LVZs) on geoid heights and gravity anomalies, as predicted by models of glacial isostatic adjustment. We have also shown that ESA's upcoming satellite gravity mission GOCE is sensitive to the properties of these LVZs. In these studies, the governing equations were solved analytically in the spectral domain, which makes the method accurate and fast. However, it does not allow for lateral variations in Earth parameters, which are expected in for example Northern Europe, and non-linear rheologies, which are predicted from laboratory experiments. Therefore we have developed a finite-element model based on Abaqus. We use a regional (flat-3D) model, as global (spherical-3D) finite-element models are currently not capable of providing high-resolution predictions, which we expect due to the shallowness of the LVZs.

We compute gravity field perturbations from predicted displacements at density boundaries by solving Laplace's equation in the Fourier-transformed domain, and show that the method is very accurate for shallow LVZs. We will compare predictions computed from different power-law rheologies and geotherms with existing estimates of the viscosity structure for Northern Europe. Finally, we will investigate if GOCE can discriminate between linear and non-linear rheologies, and laterally homogeneous and heterogeneous structures in the shallow Earth. We will use different ice-load histories to test the sensitivity of our conclusions.