Geophysical Research Abstracts
Vol. 12, EGU2010-13639, 2010
EGU General Assembly 2010

Tailoring a global finite element model for GIA to Fennoscandian rheology

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One of the uses of GIA models is the inference of deformation parameters of the solid Earth. Most GIA models use simplified rheological models (radially symmetric, linear rheology, or both). However, GIA models should move towards using a rheological model in agreement with other knowledge of Earth structure, in order to provide more useful constraints on Earth rheology. Here we attempt to create a rheological model for Scandinavia that is based on laboratory derived flow laws, exposed mantle rocks and xenoliths. Our aim is to see if such a model can provide a reasonable fit to global relative sea level observations, and GPS data in Scandinavia.

We use the coupled Laplace finite element method with combined diffusion and dislocation creep (composite rheology) in a 6-layer Earth model with elastic parameters derived from PREM. Experimentally derived flow laws are used for the upper mantle and lithosphere below Fennoscandia. We use grain sizes derived from exposed mantle rocks and xenoliths. We showcase examples for various geotherms, a wet and dry rheology. In the composite rheology the contribution of dislocation and diffusion creep to the effective viscosity is governed naturally by the time-varying stress distribution and depth-dependent flow law parameters. Composite rheology is shown to provide a significantly better fit to global sea-level data than a rheology with only diffusion or dislocation creep, but it results in too low uplift rates.