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3D GIA-modelling of northern Europe with varying lithospheric thickness

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We study Glacio-Isostatic Adjustment (GIA) in northern Europe using a recently developed dynamic ice sheet model of the Weichselian glaciation and the commercial finite element program ABAQUS. The GIA models where implemented using the technique by Wu (2004) with adjustments to allow for the inclusion of non-horizontal layering. This allows us to model the increase in lithospheric thickness, going from west (off the coast of Norway) to east (Finland) in the modeled region. The topography of the lithosphere-asthenosphere boundary is modelled using gravity based elastic thickness estimates, combined with seismology and heat flow based trends in litospheric thickness. Given the differences in the time-scales between the underlying physical principles in these data and the GIA-process, we rescale the topography model to an average lithospheric thickness of 100 km. The results are evaluated against GPS data obtained and analyzed in the BIFROST project. In addition, we assess the models using Relative Sea Level (RSL) data. Since our finite element model does not implement the sea-level equation we only use RSL indicators from the area under the central part of the former ice sheet, adjusted for a constant eustatic sea-level rise of 2 mm/yr.

The simplest model using horizontal layers in the lithosphere and a uniform mantle shows a good fit to both horizontal and vertical GPS displacement rates. Both the density structure and viscosity of the mantle is found to affect the uplift rates whilst the stiffness of the lithosphere is found to be of lesser importance. On the other hand, the stiffness is found to be of greater importance for the stresses in the lithosphere. The overall best-fitting model uses a 100 km thick lithosphere on top of a uniform mantle with a viscosity of 1×10^{21} Pa s. A less good fit is found for the models incorporating varying lithospheric thickness, with a westward shift of the present day center of uplift and increased velocities, especially for the horizontal components. The deterioration in the fit may partly be related to using a flat-layered Earth when constructing the ice-model.