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Three-dimensional velocity variations due to ice mass changes in Greenland – Insights from a compressible glacial isostatic adjustment model

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The lithospheric thickness beneath and around Greenland varies from a few tens of kilometres in offshore regions to several tens of kilometres (up to 200 – 250 km) in land areas. But, due to different datasets and techniques applied in geophysical studies, there are large differences between the different geophysical lithosphere models. As an example, lithosphere models from seismological datasets show generally larger values (above 100 km), while models using gravity or thermal datasets tend to be thinner (values mostly below 100 km). To model the deformation associated with the melting of the Greenland Ice Sheet a detailed lithosphere model is required. Nevertheless, seismologically obtained lithosphere models are the ones usually applied in these so-called glacial isostatic adjustment (GIA) models. Besides, GIA models can be used to provide additional constraints on the lithospheric thickness.

Results from most 3D GIA models are compared to observed vertical velocities only, while horizontal velocities are known to be sensitive to the lateral variations of the Earth (e.g., lithospheric thickness). But, horizontal velocities from incompressible GIA models, which are commonly used, are not suitable due to the neglect of material parameter changes related to the dilatation. Compressible GIA models in turn can provide more accurate estimates of the horizontal and vertical viscoelastic deformations induced by ice-mass changes. Here, we use a variety of lithospheric thickness models, obtained from gravity, thermal, and seismological datasets, in a three-dimensional compressible GIA Earth model. The GIA model will be constructed using the finite-element software ABAQUS (Huang et al., under review in GJI) and applying recent ice history models Huy3 and GLAC-GR2a for Greenland in combination with the Little Ice Age deglaciation model by Kjeldsen et al. (2015). We will compare various lithosphere models, including their impact on the modelled 3D velocity field, and compare these against independent GNSS (Global Navigation Satellite System) observations.

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