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Constraints on upper mantle rheology from a 3D GIA model for Fennoscandia

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GIA models with 3D rheology can incorporate information from laboratory experiments and seismology. With that, the number of parameters greatly increases and GIA modeling can not offer unique constraints anymore, but only test the information from the other sources. Our goal is to see if GIA models can offer robust contraints on olivine rheology given the laboratory and seismology results.

We use a finite element model for Fennoscandia with 3D rheology parameters and a creep law which takes into account the main deformation mechanisms of olivine. Particular attention is paid to temperatures in the top 400 km underneath Fennoscandia by using estimates derived from surface heatflow data and seismology. Because lithospheric thickness is implicit in our model, it is possible to test if the lithospheric thickness found in GIA studies is consistent with the input temperature field. Grain size and water content are kept as free parameters. We use an ice model that is created from ice margin data and simple ice physics.

Sea level data show a slight preference for wet upper mantle. However, uplift rate data require slower relaxation and hence a dry rheology. Varying ice model does not reduce this conflict, and also using more reliable temperature values underneath Fennoscandia does not have a large effect. Neglecting dislocation creep is shown to worsen the fit.
Finally, we vary diffusion and dislocation creep parameters in the lower mantle to investigate whether the best-fitting creep parameters in the upper mantle are sensitive to such variations.