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GIA model for Antarctica with 3D viscosity estimates based on seismology and gravity

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3D GIA models need a 3D viscosity distribution as input. However, viscosity estimates based on seismic models have a large uncertainty. Better estimates can only be obtained by combining multiple sources of information on the Earth's interior. Here we use a 3D temperature distribution derived from lithospheric modelling based on gravity gradients, seismic models and isostasy constraints. The resulting temperature maps are combined with flow laws for dislocation creep and diffusion creep in olivine to produce viscosity estimates for the upper mantle beneath Antarctica.

The viscosity maps show that the mantle in East Antarctica is effectively elastic down to depths of 150 km, whereas viscosity is around 1018 Pa s for parts of West Antarctica at depth of 100 km. After predicting uplift curves in a GIA model, relaxation time constants can be determined by fitting an exponential curve to the uplift curve. Relaxation times are in the order of centuries, which makes clear that for large parts of West Antarctica, the most important ice loading occurred in the last millennium. Also, the relatively small relaxation times are shown to have a stabilizing effect on the ice sheet in West Antarctica as it decreased from its Last Glacial Maximum (LGM) size. This means that the LGM ice sheet in most of West Antarctica was smaller than simulated by models that do not take into account spatial variations in relaxation time.