Geophysical Research Abstracts
Vol. 16, EGU2014-4564, 2014
EGU General Assembly 2014

GIA models with composite rheology and 3D viscosity: effect on GRACE mass balance in Antarctica

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Most Glacial Isostatic Adjustment (GIA) models that have been used to correct GRACE data for the influence of GIA assume a radial stratification of viscosity in the Earth's mantle (1D viscosity). Seismic data in Antarctica indicate that there are large viscosity variations in the horizontal direction (3D viscosity). The purpose of this research is to determine the effect of 3D viscosity on GIA model output, and hence mass balance estimates in Antarctica.

We use a GIA model with 3D viscosity and composite rheology in combination with ice loading histories ICE-5G and W12a. From comparisons with uplift and sea-level data in Fennoscandia and North America three preferred viscosity models are selected. For two of the 3D viscosity models the maximum gravity rate due to ICE-5G forcing is located over the Ronne-Filchner ice shelf. This is in contrast with the results obtained using a 1D model, in which the maximum gravity rate due to ICE-5G forcing is always located over the Ross ice shelf. This demonstrates that not all 3D viscosity models can be approximated with a 1D viscosity model.

Using CSR release 5 GRACE data from February 2003 to June 2013 mass balance estimates for the three preferred viscosity models are -131 to -171 Gt/year for the ICE-5G model, and -48 to -57 Gt/year for the W12a model. The range due to Earth model uncertainty is larger than the error bar for GRACE (10 Gt/year), but smaller than the range resulting from the difference in ice loading histories.