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Correcting for Glacial Isostatic Adjustment in the static gravity field in northwestern Europe

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Around 20,000 years ago, large ice sheets covered the surface of the Earth. In the late-Pleistocene large parts of these ice sheets melted, causing the crustal surface of Earth to relax. This process is called Glacial Isostatic Adjustment (GIA) and can be observed by sea level indicators, GPS uplift rates, and gravity changes. Several studies have tried to observe GIA in the static gravity field; however, they used simplistic models for the lithosphere. This study has two aims: i) to find out if it is possible to retrieve the GIA gravity signal with current knowledge of the density distribution of the lithosphere and ii) to see what the effect is on geophysical models that are constrained by gravity after correcting for the GIA gravity signal.

To remove lithospheric density anomalies from the static gravity field, a spherical harmonic forward gravity field model is used, which calculates the gravity signal of a layered Earth. We found that is not possible to separate the GIA gravity effect from the uncertain density anomalies and boundary geometries in the crust and upper mantle. Therefore, we propose to correct the static gravity field with results from a numerical GIA model. Unknown upper mantle and lower mantle viscosities in such a model are estimated using local GIA observations, and using the global ice loading model history, ICE-5G. The best fitting models produce a free-air gravity anomaly of -28.4 +/-1.5 mGal (peak) and a remaining uplift of 240 m.

When gravity observations and topography are corrected for GIA in geophysical modeling, this results in significant changes in the geometry or density of lithospheric structures, up to 30 km for a lithospheric model in Fennoscandia. The correction will also have an impact on the understanding of density anomalies of the lithosphere in other areas where GIA gravity anomalies are significant, such as North America, Greenland, and Antarctica.