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Optimal locations for absolute gravity measurements and sensitivity of GRACE observations for constraining glacial isostatic adjustment on the northern hemisphere

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Detailed knowledge of the Glacial Isostatic Adjustment (GIA) process is indispensable in advancing our understanding of mantle rheology and dynamics, ice sheet thickness history and climate change. In order to improve our GIA model, there are 4 parameters that need to be better constrained from geodetic observations and relative sea-level data - they are ice thickness, lithospheric thickness, radial viscosity profile (background viscosity profile for 3D modeling), and lateral viscosity contrasts. To this end, new geodetic data needs to be acquired at optimal locations so that these 4 parameters can be better resolved. Wu et al. (2010) studied the optimal locations for GPS measurements. Here, our focus will be on terrestrial and space-born gravity data in northern Europe and North America.

Since adding new absolute gravity (AG) stations is costly and since taking the measurements is time-consuming, a key question is to find the optimal locations for new observations that are most sensitive to the 4 GIA parameters above. An optimal location is defined by where sensitivity lies above the observational accuracy of the AG measurements. A further study analyses the sensitivity of data from the Gravity Recovery and Climate Experiment (GRACE) twin-satellite mission to the 4 GIA parameters. Here, the accuracy of GRACE depends on the filtering and the time span of measurements and also on the various solutions provided by different processing centres. Furthermore, in both the AG and GRACE observations, the GIA signals are affected by hydrological and/or recent deglaciation effects. All these are investigated in this study.

We show locations of prospective AG sites that are sensitive to all 4 parameters and locations that are sensitive to only one, two or three parameters. Thus, the results are useful for the inversion of one individual parameter or for the separation of the effects of two or more parameters in inversions. We further present a detailed analysis of GRACE data and discuss their reliability in the determination of the 4 parameters.