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Inversion of multi-level gravity data to improve lithospheric modelling – A case study for the North Atlantic region

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Modelling of the structure of the lithosphere is often affected by uncertainties in the sub-lithospheric mantle structure. For example, in the North Atlantic region both the gravity field and geoid are strongly affected by a regional component, which reflects the presence of density changes associated with the Iceland plume and the thermal structure of the upper mantle. Typically, the ultra-long wavelengths are therefore omitted in density modelling, but with a high degree of uncertainties of which wavelength to ignore. Satellite gravity gradient data are less affected by such a regional trend, and are mainly sensitive to intra-lithospheric sources. Due to their orbit height they are on the other hand little sensitive to near-surface structures. This makes them a useful addition to optimize model parameters and to increase confidence in the modelled structures. In addition, the isostatic state of the lithosphere can be evaluated to verify the model.

For the North Atlantic region different crustal thickness compilations exist, which we can evaluate with the use of multi-level data. Such data sets are based on compilation of previous studies and/or interpolation between seismic profiles. For example in areas where no seismic profile exists, the uncertainty of such compilations can be up to 8 km. The combined use of gravity field and satellite gradients helps to evaluate these seismic compilations and to optimize the compilations within their error bounds. Furthermore, the oceanic crust and mantle have densities that are strongly temperature-dependent and vary with distance from the spreading ridge. This is a challenge for conventional gravity modelling, but we show how the non-vertical gravity tensor components can be used to estimate the density contrast between the lower crust and upper mantle.