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Lithospheric structure of the Arabian peninsula from modeling of satellite gravity gradients

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To understand the interplay between mantle and lithosphere dynamics requires an integrated approach to estimate the physical properties. For example, in recent years, it has become evident that the thermal structure and composition of the upper mantle have a large influence on topography. Lithospheric structures are affected by large-scale tectonic processes and are, in turn, expected to influence the amount, localization and style of surface deformation. For example, the gravity gradients from the GOCE mission data have a depth sensitivity that makes them a useful tool to study the density distribution in the uppermost mantle. The characteristic of the gradients is that they are not sensitive to the sub-lithospheric regional trend (unlike terrestrial gravity and the geoid), but especially sensitive to the uppermost 150 km of the lithosphere.

We show an example how to use satellite gravity gradients from the GOCE satellite mission to improve modeling of the lithosphere for the Arabian Peninsula. Pre-existing information about the crustal structure is very sparse. Conventional crustal thickness models are based on inversion of near-surface gravity data constrained by few seismic data points. These models do however not fit with the gravity field observed by the GOCE satellite mission. To overcome this misfit, we optimize the model for isostasy, gravity and satellite gradients. Inversion of crustal thickness using satellite gravity gradients shows that a satisfying fit to the observed data can only be given by introducing lateral variations in crustal composition in addition to varying crustal thickness.

The model is further tested against near-surface gravity data and tested for its isostatic state. From the latter, we estimate the base lithosphere, which is defined as the 1315°C isotherm. Hence, the lithospheric model can be used to estimate the regional heat-flow component. This is more realistically done using GOCE data than by just using conventional gravity data sets.