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Combining the deep Earth and lithospheric gravity field to study the density structure of the upper mantle

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Global gravity field data obtained by dedicated satellite missions is used to study the density distribution of the lithosphere. Different multi-data joint inversions are using this dataset together with other geophysical data to determine the physical characteristics of the lithosphere. The gravitational signal from the deep Earth is usually removed by high-pass filtering of the model and data, or by appropriately selecting insensitive gravity components in the inversion. However, this will remove any long-wavelength signal inherent to lithosphere. A clear choice on the best-suited approach to remove the sub-lithospheric gravity signal is missing.

Another alternative is to forward model the gravitational signal of these deep situated mass anomalies and subtract it from the observed data, before the inversion. Global tomography provides shear-wave velocity distribution of the mantle, which can be transformed into density anomalies. There are difficulties in constructing a density model from this data. Tomography relies on regularisation which smoothens the image of the mantle anomalies. Also, the shear-wave anomalies need to be converted to density anomalies, with uncertain conversion factors related to temperature and composition. Understanding the sensitivity of these effects could help determining the interaction of the deep Earth and the lithosphere.

In our study the density anomalies of the mantle, as well as the effect of CMB undulations, are forward modelled into their gravitational potential field, such that they can be subtracted from gravity observations. The reduction in magnitude of the density anomalies due to the regularisation of the global tomography models is taken into account. The long-wavelength region of the density estimates is less affected by the regularisation and can be used to fix the mean conversion factor to transform shear wave velocity to density. We present different modelling approaches to add the remaining dynamic topography effect in lithosphere models. This results in new solutions of the density structure of the lithosphere that both explain seismic observations and gravimetric measurements. The introduction of these dynamic forces is a step forward in understanding how to properly use global gravity field data in joint inversions of lithosphere models.