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Satellite gravity gradients linking the crust to the upper mantle

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When studying the structure of the crust and upper mantle, the geoid and gravity field are typically used and integrated with seismological and electromagnetic studies. In addition to that, satellite gravity gradients are now available, which overcome some limitations of the vertical gravity component and geoid. The ongoing GOCE satellite mission measures gravity gradients at a perigee height of 255 km. These new data can provide a global gravity field with increased resolution of 80 km. Furthermore, GOCE provides gravity gradients in addition to the vertical gravity component. We will show that the use of gravity gradients increases the sensitivity to the shape and orientation of large-scale density structures. Especially the horizontal components are helpful to delineate different density domains and can be used to complement seismological imaging. Another beneficial attribute of the satellite gravity gradients is that they are very sensitive to the density structure from 150 km depth to the Moho level, but not very sensitive to the upper crustal or the sub-lithospheric density distribution. In comparison, the geoid is more sensitive to the overall lithospheric structure and thickness, and the gravity field more sensitive to the crustal setting, especially if near-surface gravity data are used. In addition, both fields often show a long-wavelength component that is associated with sub-lithospheric density anomalies, and must be removed by filtering of spherical harmonic degrees or by simply removing a mean trend. This is not needed for the satellite gravity gradients. Yet another application is the joint inversion with seismological data: Most teleseismic tomographic methods have relative low resolution above 100 km depth, where the gravity gradients are very sensitive. This implies that these data sets can complement each other. We demonstrate this with an example of the North Atlantic, where different upper mantle density distributions have been defined. We integrate modelling of mantle composition, upper mantle velocities and gravity and gravity gradients to show how the lateral varying upper mantle architecture can be resolved with increased confidence with respect to studies that do not incorporate satellite gravity gradients.