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Depth sensitivity of satellite gravity gradients inferred from a density model of North America

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In addition to seismological and electromagnetic data, for lithospheric scale modeling the vertical gravity acceleration or the geoid are used in most cases. For such investigations, the gravity field is divided into lithospheric and sub-lithospheric parts. Often spherical harmonics degrees 2-9 are identified as the sub-lithospheric gravity field. However, the lithosphere contains significant density anomalies that cause a strong gravity effect at these degrees. Thus the filtered gravity field is contaminated by a considerable crustal effect.
An alternative approach is to strip the total field of the contribution of lithospheric sources by forward calculation, making use of gravity gradient data as available from the GOCE satellite mission. Gravity gradients have a depth sensitivity that is different from conventional gravity. We have determined and compared the relative proportion of signal coming from different depths for all gravity and gravity gradient components. These proportions can be interpreted as an estimate of depth sensitivity. Our first results show that the density contrast at the crust-mantle boundary causes the strongest signal in both the gravity field and the gravity gradients. Gravity gradients have an increased sensitivity to inner-crustal density anomalies, whereas the normal, vertical gravity field better reflects sub-lithospheric anomalies. Furthermore, the non-vertical gradient components do not have the same depth sensitivity as the vertical gradient components.
These characteristics can be used (a) to improve the quality of crustal density models and (b) to better separate the lithospheric and sub-lithospheric parts of the gravity field.
We demonstrate this approach for the North American continent. The starting model is based mainly on the seismological model of the North American Crust NaCr 14. Additionally, we include travel time tomography for the velocity distribution in the upper mantle. This approach gives a sub-lithospheric contribution to gravity of several 100 mGal. It is likely that a significant part of this (supposed) contribution results from errors in the lithospheric models that are projected into the sub-lithosphere. The different sensitivities of gravity and gravity gradients allow distinguishing genuine sub-lithospheric contributions from projected errors of the lithospheric models.