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Using the full tensor of GOCE gravity gradients for regional gravity field modelling

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With its 3-axis gradiometer GOCE delivers 3-dimensional (3D) information of the Earth's gravity field. This essential advantage – e.g. compared with the 1D gravity field information from GRACE – can be used for research on the Earth's interior and for geophysical exploration.
To benefit from this multidimensional measurement system, the combination of all 6 GOCE gradients and additionally the consistent combination with other gravity observations mean an innovative challenge for regional gravity field modelling. As the individual gravity gradients reflect the gravity field depending on different spatial directions, observation equations are formulated separately for each of these components. In our approach we use spherical localizing base functions to display the gravity field for specified regions. Therefore the series expansions based on Legendre polynomials have to be adopted to obtain mathematical expressions for the second derivatives of the gravitational potential which are observed by GOCE in the Cartesian Gradiometer Reference Frame (GRF). We (1) have to transform the equations from the spherical terrestrial into a Cartesian Local North-Oriented Reference Frame (LNOF), (2) to set up a 3x3 tensor of observation equations and (3) finally to rotate the tensor defined in the terrestrial LNOF into the GRF. Thus we ensure the use of the original non-rotated and unaffected GOCE measurements within the analysis procedure. As output from the synthesis procedure we then obtain the second derivatives of the gravitational potential for all combinations of the xyz Cartesian coordinates in the LNOF.
Further the implementation of variance component estimation provides a flexible tool to diversify the influence of the input gradiometer observations. On the one hand the less accurate xy and yz measurements are nearly excluded by estimating large variance components. On the other hand the yy measurements, which show systematic errors increasing at high latitudes, could be manually down-weighted in the corresponding regions.
We choose different test areas to compute regional gravity field models at mean GOCE altitudes for different spectral resolutions and varying relative weights for the observations. Further we compare the regional models with the static global GOCO03S model. Especially the flexible handling and combination of the 3D measurements promise a great benefit for geophysical applications from GOCE gravity gradients, as they contain information on radial as well as on lateral gravity changes.