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Approximate global modeling of the gravity potential from observations with non uniform noise

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Improving modelling of GOCE data using reduced point mass or multipole base functions

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Abstract

Spherical harmonic are not the only harmonic functions which may be used when approximating the anomalous gravity field. One of a few other harmonic functions, which may be used as base functions when approximating anomalous gravity field, are point mass or multipole functions. In this study reduced point mass functions are used for the local modelling of GOCE data.

Point mass or multipole base functions may be expressed by closed expressions or as sums of Legendre series. In both cases at least the two first terms must be removed since they are not present in anomalous gravity field. Generally, for local applications the effect of a global gravity model is first removed (and later restored). For calculations discussed here contribution from EGM96 up to degree 36 has been subtracted. In order to improve modelling of gravity data, more terms, than just effect of a global gravity model, need to be removed. In this study for point-mass the terms up to the lowest degree of the reference potential (the global model) have been put equal to zero.

Reduced point masses

Linear combinations of point mass functions or mass multipoles have been used for the representation of the global (***W***) or regional anomalous gravity potential, ***T***. For a point mass base function we have for an approximation to *T*:

$$\tilde{T} = \sum_{i=1}^{I} GM_i / l_i$$

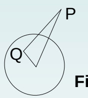

Figure. 1

where G is the gravitational constant, M_i is the mass, I the number of point masses and l_i is the distance from the mass located at the point Q_i to the point of evaluation, P, see Fig. 1. The distance from the origin to P and Q_i is denoted r_P , r_{Qi}, respectively and the first will always be larger than the other. The angle (spherical distance) between the vectors to P and Q_i is denoted ψ.

For the inverse distance we have:

$$\frac{1}{l} = \frac{1}{r_P} \sum_{i=0}^{\infty} \left(\frac{r_Q}{r_P}\right)^i P_i(cos\psi)$$

where P_i are the Legendre polynomials.

Multipole-functions are derive from the inverse distance function by integration or differentiation. We intend to show that in order to make the functions suitable for regional gravity field modeling low-degree terms may be removed or substituted by appropriate weights. From equation for inverse distance, terms of degree zero and one, which are not present in *T*, are removed, simply by subtracting from the closed expressions the first two terms.

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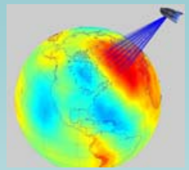

Figure. 2: Point mass method

Example of usage of reduced point masses

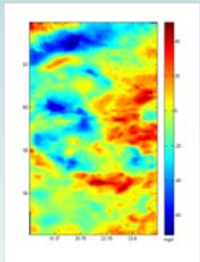

Figure. 4: Fenno-Scandia gravity data

In this study data from GOCE mission have been used. Data includes first two cycles of GOCE data (i.e. from end of October 2009. to mid February 2010.). Data distribution in the form of GOCE ground tracks, in this period and chosen region, is shown in Figure 3..

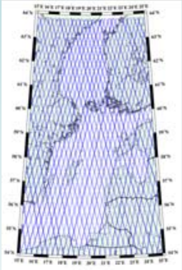

Figure. 3: GOCE ground tracks

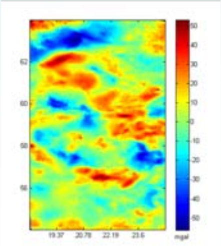

Figure. 5: Differences between gravity data and complete point mass functions

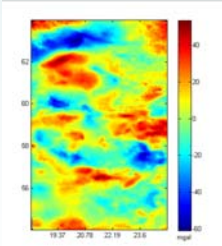

Figure. 5: Differences between gravity data and reduced point mass functions up to degree 36

Data used for comparison with reduced point masses from GOCE solution are gravity anomaly from Fenno-Scandia.

Figure 2 shows solution for reduced masses in selected area from just one GOCE observation

	Observations	Difference 0 deg	Difference 36 deg	Difference Full and Reduced point masses
Mean	-6.46	1.51	0.86	0.51
St. Dev	19.90	16.80	18.46	0.83

Table 1: Statistics of reduced point masses

Similar calculations have been succesfully carried through using collocation (Gravsoft Geocol). Statistic of the results and differences of reduced point masses can be seen in table 1.

Conclusion

In order to improve modeling of gravity data, more terms, than just effect of a global gravity model, need to be removed. Even better solution could be to substitute them by terms that uses small wavelength but also includes information representing the variances of the reference field that was removed. This assures that the model in an appropriate manner weights the regional frequencies with respect to the used global model.

In the future work with point mass or multipole functions it should be tried to use terms representing the power in the frequencies which the global model has not removed, corresponding to error-degree variances, and use them as the terms up to the lowest degree of the reference potential .

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