REGIONAL QUASIGEOID DETERMINATION: AN APPLICATION TO ARCTIC GRAVITY PROJECT (AGP) AREA

A. Marchenko [1), B. Dzhuman [1)

[1) Institute of Geodesy, Lviv Polytechnic National University, Karpinsky St. 6, 79013 Lviv, Ukraine, (march@pancha.lviv.ua), (teojuman@gmail.com)

Investigation the quasigeoid determinations based on the AGP regional gravimetric data and different types of non-orthogonal base functions was assessed to be important. The construction of high-precision quasigeoid heights can be carried out in the frame of the model or operational approaches to physical geodesy. In the model approach an order of inverted matrix is much smaller and equal to the number of parameters to be determined. In this case different sets of base functions are usually used, which are preferred in local gravity field modeling due to the large number of processed data. For example, the sequential multipole analysis was developed for the approximation of disturbing potential and implemented using radial potential multipoles (Marchenko et al., 2001), which are derived from the radial base functions of J.C. Maxwell type.

When measurements are given from restricted only regions of the Earth surface, the global spherical harmonics loose their orthogonality in such limited regions. So the determination of the coefficients of the model (as a rule by means of the least squares method) is unstable numerically. However, in spite of this fact there is a special solution for Laplace equation when the boundary conditions are appropriate for the case of spherical cap. This approach represents the so-called spherical cap harmonic analysis (SCHA) which are based on the associated Legendre functions of the integer degree and non-integer order (Haines, 1985). These functions represent two orthogonal subsets. In every set corresponding functions are mutually orthogonal over the spherical cap. However in general these functions are not orthogonal and it is quite difficult to compute eigenvalues and norms for their high orders (Hwang & Chen, 1997). For that reason it is possible to use a special model approach of the adjusted spherical harmonic analysis (ASHA) (de Santis, 1992; De Santis & Falcone, 1995) for the approximation of the local gravity field (Jiancheng et al., 1995; De Santis & Torta, 1997). The ASHA technique provides the projection of initial data from a segment of sphere to hemisphere and leads to the spherical functions of integer degree/order. This paper focuses on this modified ASHA method to the gravity field approximation (as the addition to the SCHA approach) within the procedure of ,,Remove - Restore”.

The gravimetric quasigeoid determination was based on the gravity anomalies Δg in the Molodensky sense within the working area [65°N, 90°N] that leads to the quasigeoid heights in the Arctic area cap. The National Imagery and Mapping Agency (NGA) collects the Δg sets in the frame of the Arctic gravity project (AGP) (NGA, 2008) in order to build a high-precision quasigeoid heights in the Arctic area including the construction of gravity anomalies grid with resolution of (5' × 5') using data of airborne gravimetry, satellite altimetry and gravimetric data from nuclear submarines (SCICEX).

Thus, in our solution the gravity anomalies in the Arctic area were taken from the Arctic Gravity Project (AGP). The method applied on this data set is adjusted spherical harmonic analysis (ASHA). Computation of the quasigeoid heights was performed by the ,,Remove - Restore" procedure in the three steps. In the first stage the free air gravity anomalies of the EGM 2008 model (Pavlis et al., 2008) up to degree/order 360 were subtracted from the initial gravity anomalies of the AGP to eliminate the low frequency gravity field content. In the second step the approximation of the residual gravity anomalies was based on the ASHA method. The construction of the normal equations matrix may lead to the time consuming procedure (Marchenko, Dzhuman, 2014). Hence, the discrete orthogonality property in longitude (Sneeuw, 1994) for the chosen base system was taken into account and has led to the significant decrease of the computational time for the residual coefficients $\bar{a}_{km}, \bar{b}_{km}$.

In the last step the residual quasigeoid heights (high frequency components of the gravity field plus EGM2008 constituent) were restored. Thus the gravity field model was constructed and compared with AGP gravity anomalies with the resulting Std. Dev. about 5 mGal. Besides the developed modification of ASHA method makes possible a significal accelerate the process of computing the unknown coefficients of regional gravity fields. This allows to process the gravity fields data up to higher orders.

In summary we can conclude:

- The approximation of the regional gravity field in the frame of the Arctic Gravity Project was considered based on the non-orthogonal functions of the SCHA and ASHA methods.
- Among these approaches we prefer the ASHA method that has a certain advantage caused by the possibility of representation of the base functions in the form of a finite hypergeometric series in contrast to the SCHA technique. It is evident that ASHA technique gives the opportunity of the construction of the ASHA-model in the analytical or/and gridded forms. The combination of different approaches for the determination of optimal degree/order of the model is also discussed; The modified ASHA technique provides a good accordance in terms of standart deviation between initial and model gravity anomalies.
- ASHA approach allows to avoid in the computations of geodetic functionals a time consuming procedure. That is why the approximation by ASHA technique can be reccomended especially for fast computations of regional gravimetric fields with high orders.

Keywords: gravity anomalies, quasigeoid heights, adjusted spherical harmonic analysis, spherical cap harmonic analysis

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