A Preliminary Gravimetric Geoid Model for the Territory of Bulgaria

E. Peneva
Department of Geodesy, University of Architecture, Civil Engineering and Geodesy, Sofia, Bulgaria

Abstract. A computed model of the quasigeoid for the territory of Bulgaria is presented. To obtain the local model remove-restore technique is applied, based on the global geopotential model EGM96 and the topographic model DTED Level 0. To make a digital model of gravimetric data are used the maps of Bouguer anomalies for Bulgaria in scale 1:200000. Scanned images of maps are processed with programs from Intergraph to obtain digital model with spacing 1 arc minute. To compute the quasigeoid model and to prepare data for processing are used programs from package GRAVSOFT. The work area is from 41° to 44.5° North latitude and from 22° to 28.5° East longitude.

Keywords. Geoid, Quasigeoid, Height anomalies, Remove-restore technique

1 Introduction

Gravimetric method is applied for the geoid determination of Bulgaria as the most rational one. The choice is based on the specific features of the country - physical geography, geology, availability of geodetic data, the political and economic conditions etc.

Some important features: Bulgaria is a small country – about 4 degrees and 6 degrees respectively in geographical latitude and longitude, with approximately a rectangular form. The landscape is multiform – plains in the North and in the South, a mountain chain in the middle from West to East direction, high mountains in Southwest part and mountain peaks reaching 3000 m above sea level. Geological structure of the crust is heterogeneous, there is isostatic decompensation of some parts.

For the gravimetric and topographic data available one should take into account, that there are state gravimetric nets, surveyed and developed predominantly by geodetic services. The topography is well studied - there are maps and digital model too. It should be stated that there was a government restriction till recently in use of hypsometric and gravimetric data, and because of the lack of publications it is difficult to judge their suitability for practical use.

Previous determinations of geoid

There have been many attempts of calculating the geoid in our country in the past and nowadays. It is essential that the first two - in1963 and 1972, were based on the astro-gravimetric levelling. Thus only the form of the geoid could be achieved. In 1989 a team formed from Geodetic Department of University of Architecture, Civil Engineering and Geodesy, Sofia and Military Topographic Service calculated the surface of quasigeoid using positional determinations. Doppler geoid is obtained, but lack of data evidently affected the accuracy of the result. This new approach could bring much more reliable results if there were available more observed data. As a conclusion there has not been made any successful attempt of using all data available in our country (gravimetric, hypsometric, levelling, positioning etc.) and are not used data from countries nearby. Therefore it would be unreliable to use derived geoid models for comparison because of their low accuracy. Considering the used normal heights since 1950 it is more appropriate to talk of determination of quasigeoid surface.

Presented in this paper quasigeoid was computed by remove-restore technique, using the following data: 1) Global Geopotential Model EGM96, 2) subset of global terrain model DTED Level 0, 3) 1 x 1 arc minute gridded model of Bouguer gravity anomalies for Bulgaria. Method of analytical continuation of first order is applied with the FFT technique for calculation of height anomalies from residual gravity anomalies. The model of the quasigeoid could be yelled without applying of topographic reductions, and this scheme is chosen for practical application.

2 Gravity data

Source gravity data are from the maps of Bouguer gravity anomalies for Bulgaria (based on terrestrial measurements) in scale 1: 200 000. Anomalies in the maps are presented with contours in 20 $\mu m/s^2$ (2 mgal). Maps are scanned

and processed with application programs from Intergraph in order to reduce deformations from scanning procedure and to present the images in working coordinate system WGS84. Automatic vectorization of the contours is applied. Final 3D digital model consist of the irregular distributed point gravity data with spacing 100 m by contours.

To be able to apply FFT technique there must be a rectangular data grid. To fill the missing data outside the boundaries of Bulgaria data from the neighborhood countries are necessary. But the gravimetric data in some of them are limited of use or they are not of sufficient density. There were two possible approaches to complete a rectangular grid. First of them is to use the gravimetric data from a geopotential model, and the second is, to interpolate data in the missing areas. The second one is chosen as a more appropriate, and so the working area is limited to 41 – 44.5 degrees by latitude and 22 – 28.5 degrees by longitude, with spacing of grid data 1 x 1 arc minute.

Free air gravity anomalies are calculated restoring the Bouguer gravity reduction to the gridded Bouguer anomalies. Bouguer reduction is obtained from used topographic model and constant density of topographic masses 2.67×10^3 kg/m^3.

3 Remove – restore technique

3.1 Residual anomalies

To obtain the model of the quasigeoid, free air local gravity data must be reduced for the long wavelength variations of the gravity field. This corresponds to the first step in remove-restore scheme. Residual anomalies are calculated as from the free air anomalies are subtracted geopotential anomalies from the EGM96 model.

3.2 Height anomalies

Height anomalies are calculated using the method of analytical continuation. This is the well-known gradient solution (Heiskanen and Moritz (1967)). Calculations are presented with the program Geofour from the package GRAVSOFT.

As input files are used grid models with the residual anomalies and the topographic data.

3.3 Final model

Final model of the quasigeoid is calculated restoring the effect of the global geopotential model. The geoid heights from EGM96 model are added to the received height anomalies.

4 Conclusions

The gravimetric method is preferred than GPS/leveling for the determination of the quasigeoid as easier to apply from practical point of view at this moment. As for applying the GPS/leveling method, taking into account the mountain areas and the lack of precision in the normal heights, a higher accuracy is not expected. Nevertheless, the advantages of the method are obvious: there are simple relations between the searched quantity (height anomaly) and given quantities (geodetic and normal height). Besides, GPS/leveling would be inevitable near the frontiers, if no gravimetric data from the neighborhood countries are available. Therefore a combination of the gravimetric and GPS/leveling would be useful for the next stage of calculations. The calculated quasigeoid model is a preliminary one and could serve, as a basis for more precise models, when there will be more correct data.

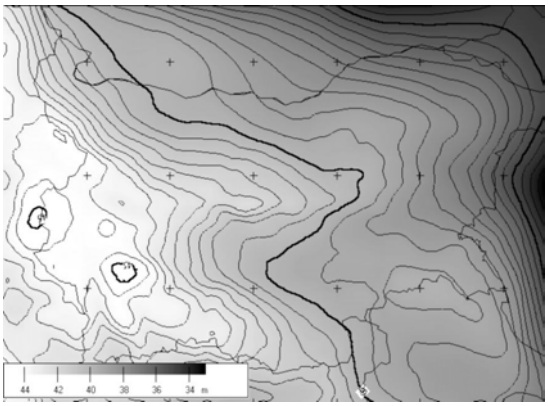

Fig. 1 Preliminary quasigeoid model (contours 0.5 m).

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