QGEOID COMPUTATION OF WESTERN PART OF LATVIA, PARAMETER ESTIMATION AND OPTIMIZATION CONCEPTS FOR GRAVITY FIELD DETERMINATION

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Introduction:

In the era of modern technologies and GNSS developments the precise quasi-geoid (QGeoid) model is necessary as geodetic infrastructure for GNSS services in different engineering needs, as it allows the determination of normal height much faster in comparison to levelling and directly from GNSS. This poster represents the DFHRS (Digital Finite-element Height Reference Surface) software for QGeoid determination based on parametric modelling, as well as further version based on Adjusted Spherical Cap Harmonics (ASCH) modelling. The example of the QGeoid model for Western region of Latvia (Kurzeme) and preliminary computation results are introduced. The theory of Deflections of Vertical measurements by digital zenith camera is also included.

Computations of Kurzeme qgeoid:

In order to compute the DFHRS_DB for Kurzeme 71 Identical points (ellipsoidal h and normal heights H in EVRS system) together with the EGM2008 geopotential model data were used. Additionally terrestrial 63 DoV observations were included. EGM2008 is a spherical harmonic model of the earth's external gravitational potential in degree and order of 2160, with additional spherical harmonic coefficients extending up to degree of 2190 and order of 2160 that offers a spatial resolution of 9 km [1]. For meshing the area, mesh size of 5x5 km was chosen. Total amount of meshes – 969. The total number of patches is 6.

Digital Zenith Camera [7]

Zenith camera and determination of DoV:

$$\mathbf{R}^{LAV}_{LGV} = \mathbf{R}^{LAV}_{LGV}(B,L,\eta,\xi) = \begin{pmatrix} \sin B\sin\Phi\cos(\Lambda-L)+\cos B\cos\Phi & \sin B\sin(\Lambda-L) & \cos B\sin\Phi-\sin\phi\cos\Phi\cos(\Lambda-L) \\ -\sin\Phi\sin(\Lambda-L) & \cos(\Lambda-L) & +\cos\Phi\sin(\Lambda-L) \\ \sin B\cos\Phi-\cos B\sin\Phi\cos(\Lambda-L) & -\cos B\sin(\Lambda-L) & \cos B\cos\Phi\cos(\Lambda-L)+\sin B\sin\Phi \end{pmatrix}^T$$

where R^{LAV}_{LGV} rotation matrix between LAV and LGV systems;

With the star coordinates at the observation time t_UTC have: $\mathbf{r}^{LGV}_{SI} = \mathbf{R}^{LGV}_{e}(B,L)\cdot\mathbf{r}^{e,s}\ (1)$

The general model for the vertical surface deflections determination the equation reads:

$$\mathbf{r}^{LGV}_{SI}(1) - \mathbf{r}^{LGV}_{SI}(2a,b) = \mathbf{0}$$

$$\mathbf{r}^{LGV}_{SI} = \mathbf{R}^{LAV}_{LGV}(B,L,\eta,\xi)^T\cdot\mathbf{R}^{LAV}_{b}(r=0,p=0,y)\cdot\mathbf{r}^{b}_{SI} = \mathbf{0}\ (2a)$$

$\mathbf{r}^{LGV}_{SI}$ –direction vector from sidereal place; $\mathbf{r}^{b}_{SI}$ - direction vector of the body system;

$$\mathbf{R}^{LAV}_{b} = \begin{pmatrix} cospcosy & sinrsinpcosy-cosrsiny & cosrsinpcosy+sinrsiny \\ cospsiny & sinrsinpsiny+cosrcosy & cosrsinpsiny-sinrcosy \\ -sinp & sinrcosp & cosrcosp \end{pmatrix}\ (2b)$$

DFHRS software HSKA/IAF[3)]© further developments in the PhD of the first author are:

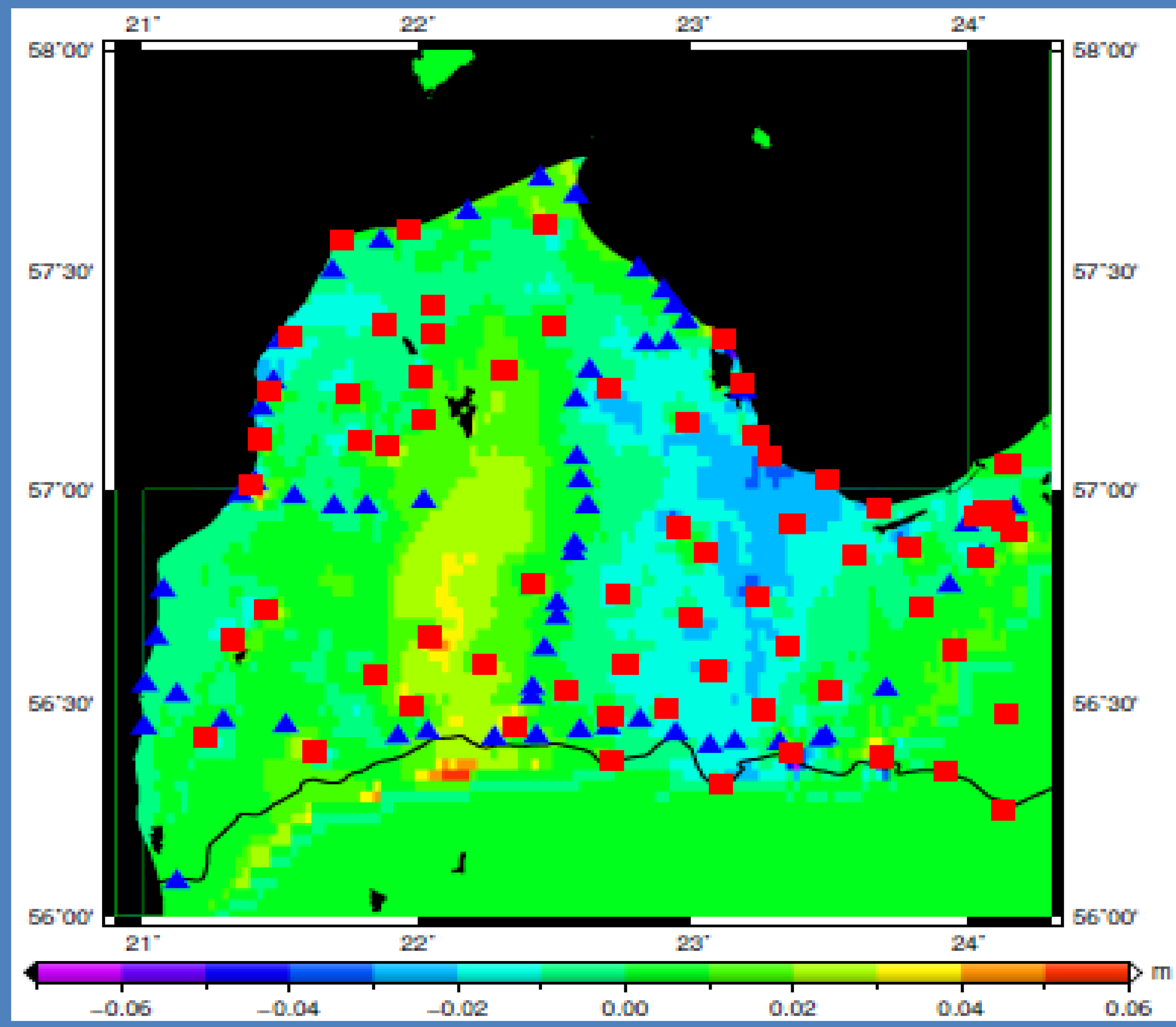
The extension of DFHRS concept and software to physical observation types – such as terrestrial and space-borne gravity measurements and prior information related directly to the parameters of global geopotential models, e.g. EGM 2008 – is based on a regional adjusted spherical cap harmonic parameterization (ASCH) of the Earth’s gravitational potential (V) [3,4,5]. Optimal design of combined networks is another topic of the PhD.

$$V(r,\lambda',\theta') = \frac{GM}{R}\sum_{k=0}^{k\,max}\left(\frac{R}{r}\right)^{n(k)+1}\sum_{m=0}^{k}(C'_{nm}cosm\lambda' + S'_{nm}sinm\lambda')\bar{P}_{n(k),m}(cos\theta')$$

By introducing the disturbance potential applied to the Bruns theorem and Molodenski’s theory, we obtain the observation equation for fitting-points converted to quasi-geoid heights $N_{QG.}$ Vertical deflections $(\xi,\eta)_p$ at point P reffering to W without normal potential U and norm. curvature [3],[5],[6]:

$$h - H = N_{QG} = \frac{T_p}{\gamma_Q}$$

$$\xi P = -\frac{1}{\gamma_Q\cdot(M+h)}\cdot\left[\left(\frac{\partial W}{\partial B}\right)_P - B\right)\right] \qquad \eta P = -\frac{1}{\gamma_Q\cdot(N+h)\cdot\cos B}\cdot\left[\left(\frac{\partial W}{\partial L}\right)_P - L\right)\right]$$



The difference between the solution with only GNSS/levelling (blue triangles) data and GNSS/levelling + DoV (red squares)

Computation results of Kurzeme qgeoid:

The present DFHRS was calculated on the basis of the EGM2008 [2] model and 59 identical reference points. 12 first order levelling/GNSS points were excluded from the computations because of Gross errors in the DFHRS, which could reach up to 9.6 cm. Some of these points were located along the shore of Gulf Of Riga and were replaced by DoV observations (see fig.2). The results of 2 solutions are depicted in table 1.

Table 1. STDEV of 2 solutions

Used data	Stdev of residuals	Stdev of repro
GNSS/levelling	0.007m	0.015m
GNSS/levelling +DoV	0.008m	0.024m

Conclusions:

The quasi-geoid model for Kurzeme region has been computed with evaluated accuracy of 1-3 cm. ASCH modelling in terms of integrated geodesy allow the combination of both geometrical and physical data, moreover this method is much faster in comparison to SH. Implementation of vertical deflections observations in terms of ASCH gives additional improvement of quasi-geoid and gravity field determination.

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