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Gravity Field and Quasi-Geoid Determination based on a Zenith Camera as Intelligent System for Vertical Deflection Determination

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Qgeoid determination for Latvia

In terms of the project on high accuracy gravity field model for Latvia the main task is to compute gravity field and precise quasi-geoid model up to 1 cm accuracy using all available data. In the year of 2016 quasi-geoid model for Eastern part of Latvia has been computed using Karlsruhe University of Applied Sciences developed DFHRS (Digital finite-Element Height Reference Surface) software v.4.2. (Jäger 2000-2017), which allowed the combination of GNSS/levelling data together with global geopotential models (e.g. EGM2008/EGG97). But some inconsistencies were found by comparing the use of different geopotential models as input data. At the moment Institute of Geodesy and Geoinformatics (GGI) is dealing with new kind of measurements – vertical deflection observations – which are possible to use in DFHRS v.4.3. Updated version of DFHRS allows to use GNSS/levelling data together with geopotential models and field vertical deflection measurements or/and vertical deflections derivatives from geopotential models. Vertical deflections measurements allow to check independently the places that have inconsistencies and improve qgeoid model. Digital-zenith camera is used for this purpose. Test measurements were done in Riga region and proved the improvement of qgeoid twice (Morozova et al 2017). Digital-Zenith camera and processing software was developed by GGI (Zarins et al 2016) and these observations are actively done in Kurzeme region now. The current amount of points is equal to 108 and these measurements are evaluated as 0,10-0,15 arcsec accuracy. Preliminary results of qgeoid of Latvia using GNSS/levelling points, EGG97 model and vertical deflection observations give a standard deviation of 0,012 m in comparison to 0,018 m standard deviation without using vertical deflection observations. So, in this case qgeoid is improved by 30%. In the result of the project the whole country will be homogeneously covered with vertical deflection observations, and it is planned to make about 200 observations (see Fig. 1).

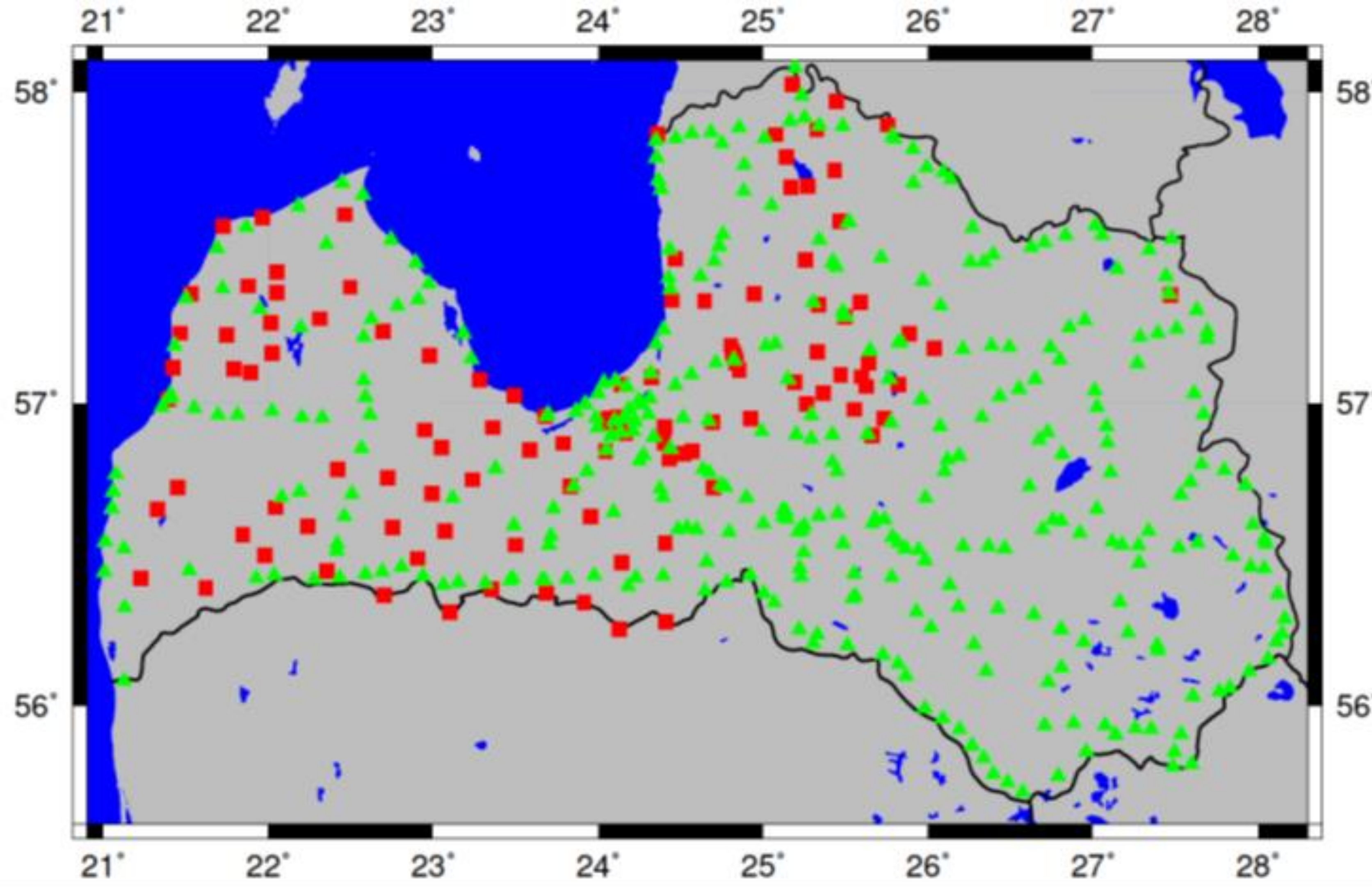

Fig.1. The map of currently measured points: green triangles – GNSS/levelling points, red squares – vertical deflection observations

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Camera design and imaging system

Our design consists of a rotating platform, on it are mounted a small telescope, equipped with imaging device (CCD assembly), tiltmeter, leveling mechanism, rotation gear and control equipment. Similar platform below is used as base of leveling and rotation; it is mounted on a field tripod (Fig. 2). The CCD camera is attached in direct focus, below the telescope. The weight of rotating assembly is about 12 kg; it is easily detachable from tripod with the lower platform, and is transported in a separate case. The total weight of device and it's accessories is less than 30 kg. The camera needs 12v / 3A power supply, it can be either a mains adapter or a battery (possibly, onboard). A 8″ (203 mm) catadioptric telescope equipped with CCD camera is used for image acquisition. The camera has 8 Mpix sensor with 4.5 μm pixels; at 2 m focus distance resulting field of view is 0.5×0.39 dg with resolution close to 0.5″/pixel. We found that for zenith camera purposes 2×2 pixel binning mode (with resolution close to 1″/pixel) is advantageous due to increase of sensitivity and decrease of image file size and download time. Besides, bigger pixels lessen tendency of image fragmentation, caused by air turbulence effects. Loss of image details at decreased resolution only slightly affects resulting coordinate accuracy. Exposure duration of 0.3–0.5 sec proved to be optimal. Image elongation becomes pronounced for longer exposures; shorter exposures result in smaller number of stars and in some loss of accuracy – while star position residual dispersion in a frame is a bit smaller for shorter exposures, estimated zenith position dispersion increases, probably due to lesser extent of averaging of air turbulence effects. At above exposure settings, images of stars up to 13.5–14 magnitude are automatically recognized. That ensures typically 10 to 100 stars per frame; frames with less than 10 stars occasionally can occur only when imaged area is far from galactic plane. Details of recognition and identification of star images are provided in (Zariņš et al. 2014).

The PhD treats the integrated mathematical model - including vertical deflections - and design optimization on different observation types.

Fig. 2. Digital Zenith Camera

References

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