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Preliminary results on Quasi-geoid of Latvia using Vertical Deflection observations

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Introduction:

In terms of “Development of the high accuracy gravity field model for Latvia including sea territory” project 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., which allowed the combination of GNSS/levelling data together with global geopotential models (e.g. EGM2008 or EGG97). At the moment Institute of Geodesy and Geoinformatics (GGI) is dealing with new kind of measurements – vertical deflection (VD) 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 deflections 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 purposes [2],[3].

Digital-Zenith camera and processing software was developed by GGI and these observations are actively done in Latvia now. The current amount of VD observations is equal to 108 and the precision of these measurements are evaluated as 0,10 arcsec mostly for all observations. In terms of a project, 230 GNSS/levelling points were observed by GGI and 1st and 2nd order levelling data and 147 GNSS/levelling points were provided by Latvian Geospatial Information Agency. Preliminary results show a good tendency of qgeoid improvement and VD measurements are continued in order to cover homogeneously the whole Latvia.

In the DFHRS concept a continuous polynomial surface over of a grid of finite element meshes (FEM) with polynomial parameters p is used as a carrier function for the HRS. The FEM surface of the HRS is therefore called NFEM(p|B,L,h). For some old height systems H a scale-difference factor Δm has to be considered in addition, so that the DFHRS-model of N consists of two parts. The principle of a GNSS-based height determination H requires submitting the GNSS-height h to the DFHRS(B,L,h)-correction N, reading [1]:

$$H = h - N = h - DFHRS(p|B,L,h) = h - NFEM(p|B,L,h)$$

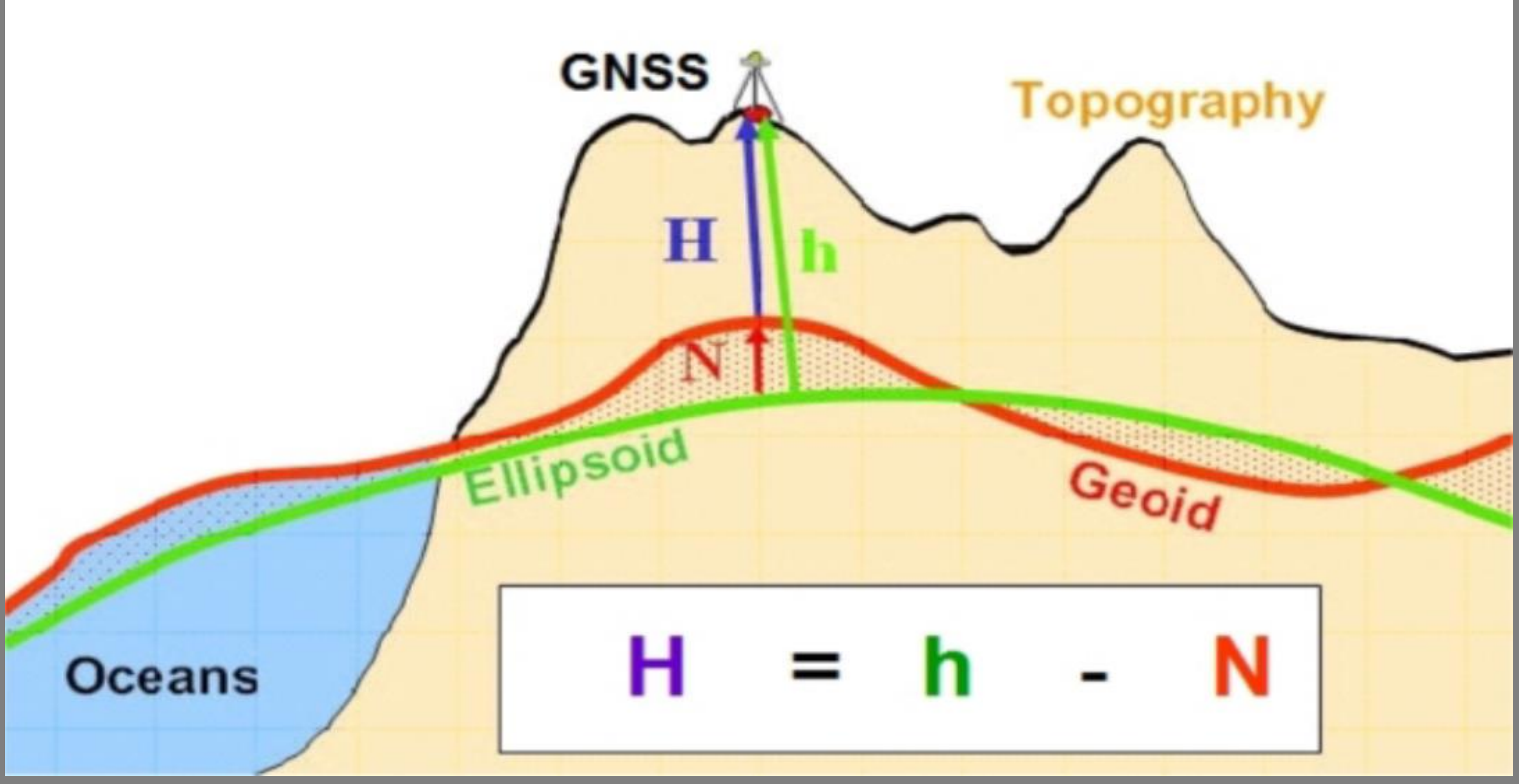

Fig. 1. The principle of GNSS-based height determination

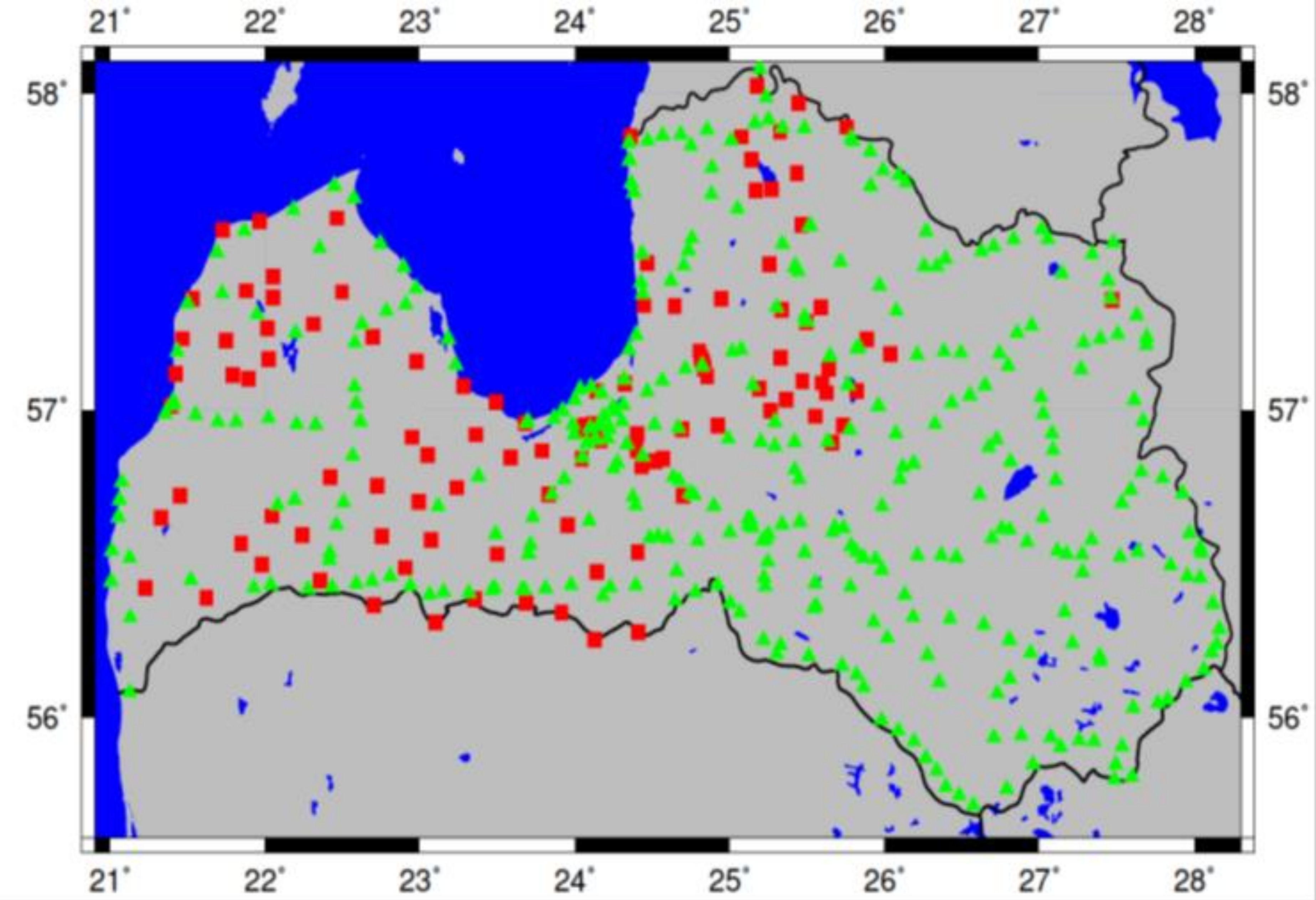

Fig. 2. The scheme of GNSS/levelling points (green triangles) and DoV (red squares)

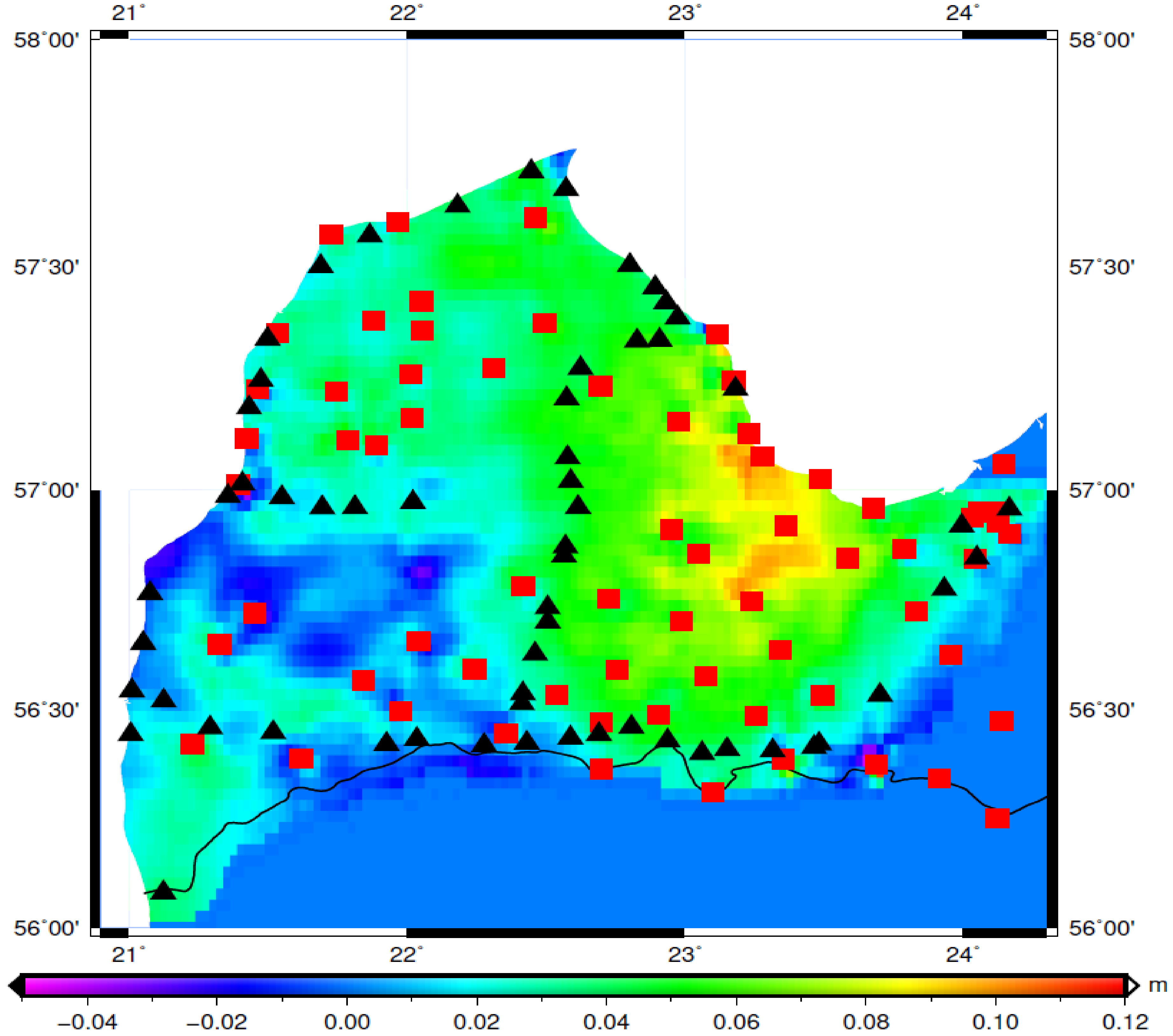

Fig. 3. The difference between the computed Kurzeme qgeoid and LV’14 [5] (GNSS/levelling points – black triangles, DoV – red squares)

Zenith Camera 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. The CCD camera is attached in direct focus, below the telescope. 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.

Fig. 4. Digital Zenith Camera

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 [4].

References:

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