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Preliminary results on qgeoid for Western part of Latvia using Digital-Zenith camera and DFHRS software

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Introduction:

This research represents quasi-geoid (qgeoid) model for Western part of Latvia based on parametric modelling of continuous polynomial surface by DFHRS (Dgitial Finite-element Height Reference Surface) software v.4.3. developed by Hochschule Karlsruhe – University of Applied Sciences [1]. Apart from standard observations for qgeoid determination: GNSS/levelling points and Global Geopotential Models (GGMs), new kind of measurements – vertical deflection observations provided by Digital-Zenith camera [2], [3] are used. This instrument has been developed by Institute of Geodesy and Geoinformatics, University of Latvia and provides the accuracy of about 0.10 arcsec, what equivalent to 0.5 mm error in elevation for 1 km length and it gives twice better accuracy than 1st order levelling in Latvia respectively. As input data 58 1st order GNSS/levelling points were used (12 points were excluded from the processing, because of gross errors in reproductivity) and 63 points of terrestrial vertical deflection observations. The poster represents the results on different solutions of qgeoid in Kurzeme region, using different types of data. The common principle of DFHRS software and Digital-Zenith camera is included.

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 [1]. 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:

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

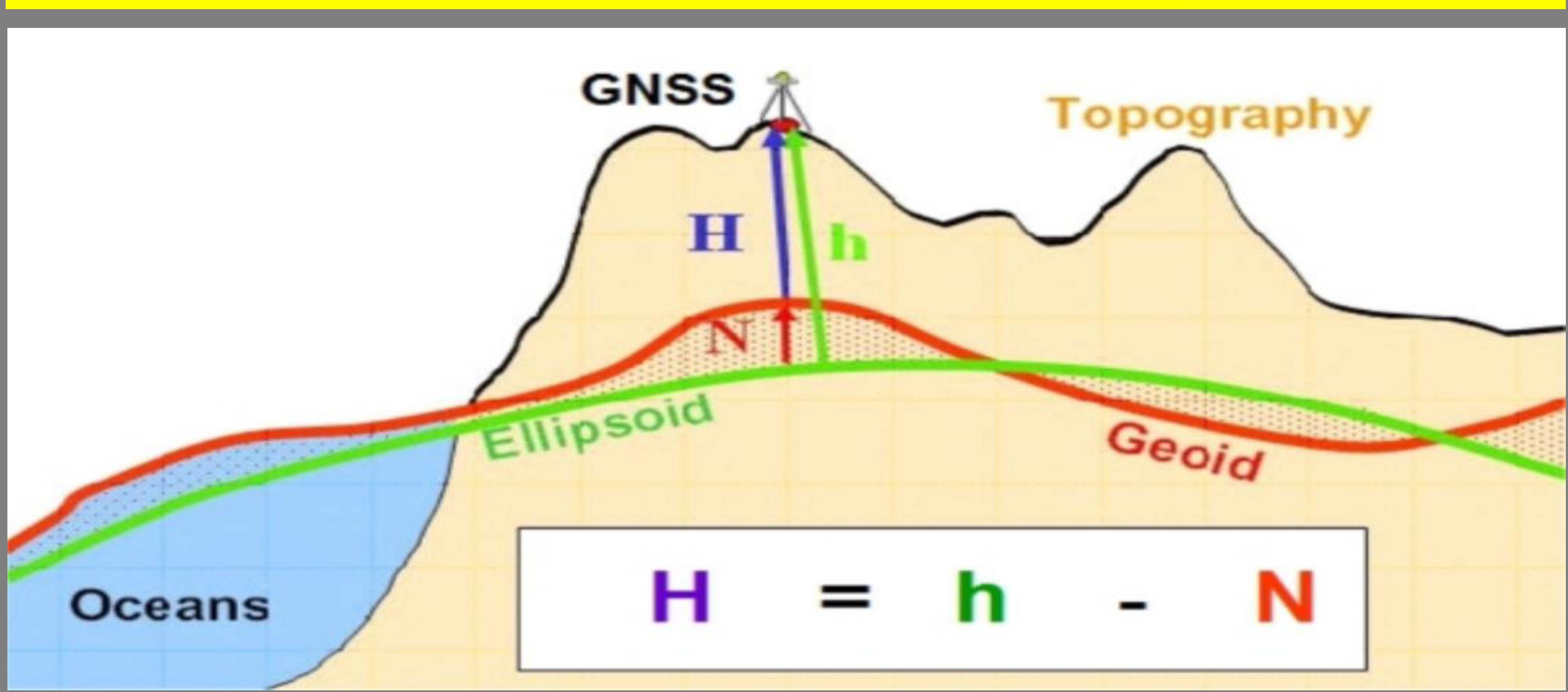
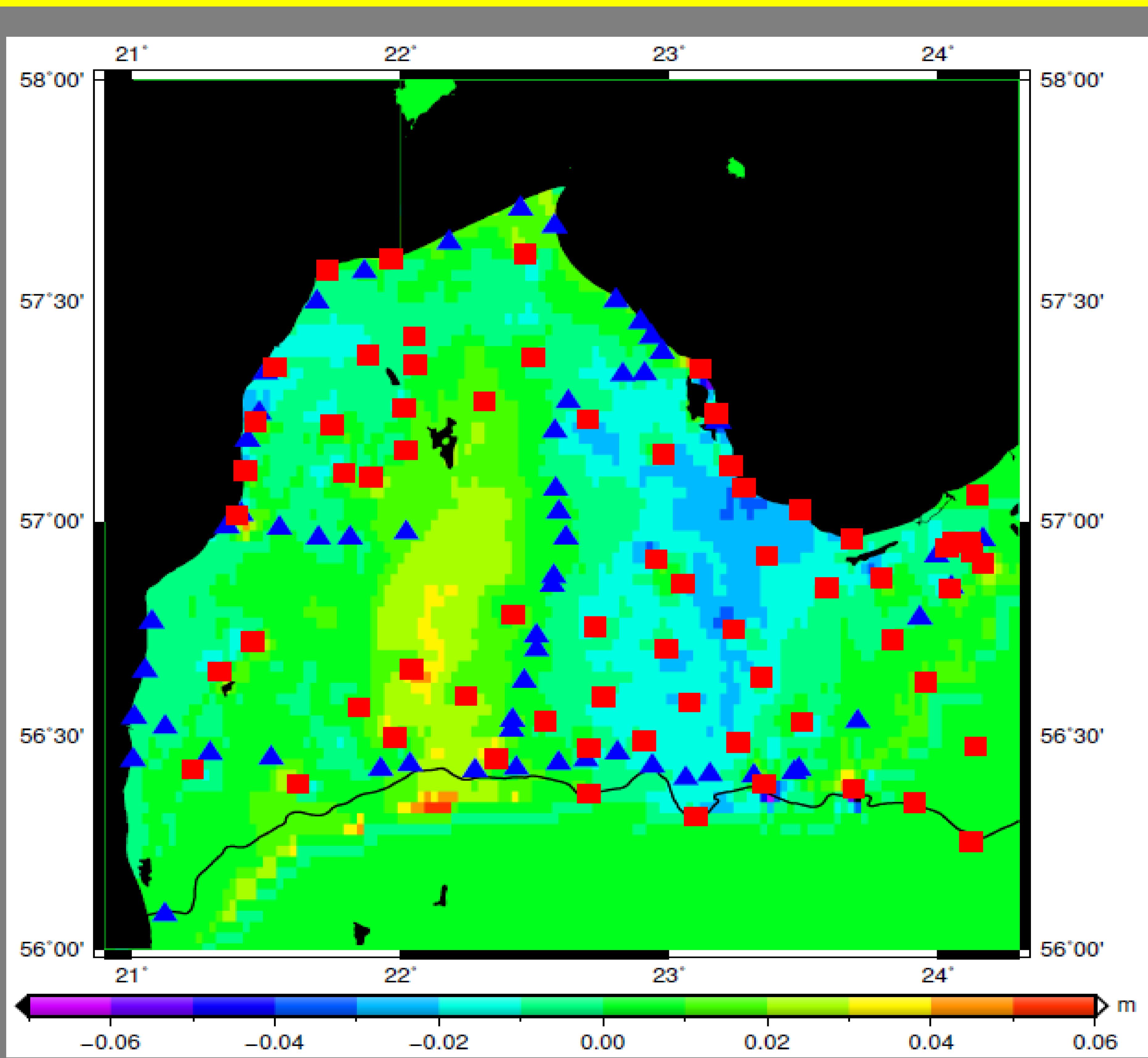


Figure 1. The principle of GNSS-based height determination

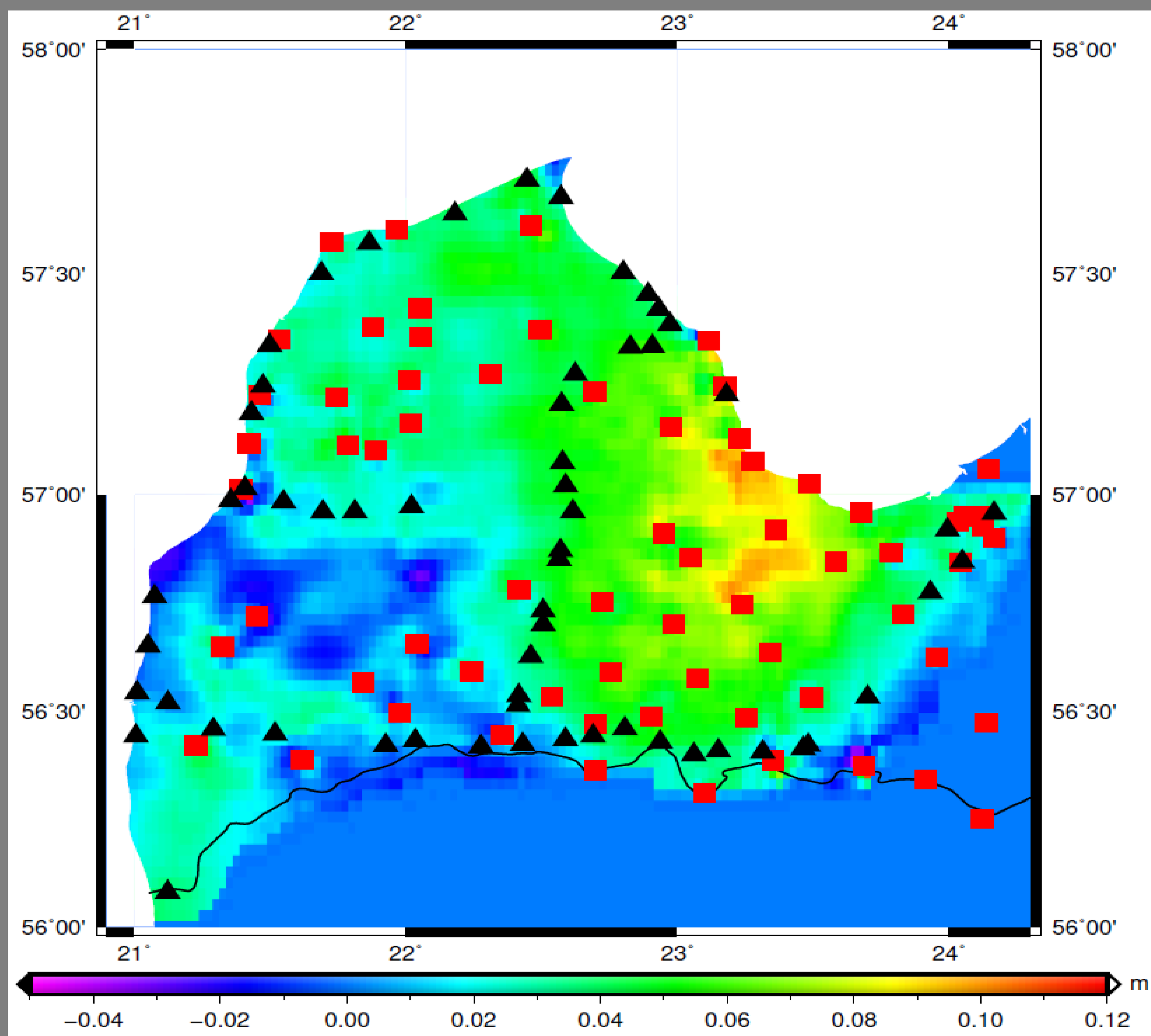
Zenith Camera design consists of a rotating platform, on it are mounted a small telescope, equipped with imaging device (CCD assembly), tiltmeter, leveling mechanism, rotation gear and control equipment. Similar platform below is used as base of leveling and rotation; it is mounted on a field tripod. 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.

Figure 2. 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].



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



The difference between the computed Kurzeme qgeoid and LV'14 [5]

References:

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4. Zariņš, A.; Janpaule, I.; Kaminskis, J. 2014. On reference star recognition and identification, Geodesy and Cartography 40:143–147
5. Latvian Geospatial Information Agency page: http://map.lgia.gov.lv/index.php?lang=0&cPath=2&txt_id=130

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