Digital Zenith Camera for Vertical Deflection Determination: on the Way to 1 cm Precise Quasi-Geoid Model for Latvia

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Abstract

The digital zenith camera VESTA (VErtical by STArs) was designed by the Institute of Geodesy and Geoinformatics (GGI) of the University of Latvia and completed in 2016. Since that more than 300 terrestrial vertical deflection measurements were observed in the territory of Latvia. These observations were post-processed by the GGI developed software and the accuracy was evaluated at 0.1 arc seconds. Terrestrial observations were compared with global geopotential models, e.g. GGM+ and EGM2008. The results show a better correspondence with GGM+ model by evaluating the standard deviation: 0.314 and 0.307 arcseconds for ξ and η components respectively in comparison to 0.346 and 0.358 arcseconds for ξ and η components for EGM2008 model. The comparisons of average and minimum/maximum differences are introduced in this study for better evaluation of the results. Moreover, vertical deflections have been used as additional terrestrial data in DFHRS (Digital Finite-element Height Reference Surface) software v. 4.3 in combination with GNSS/levelling data (B, L, h|H) and global geopotential model EGM2008 for gravity field and quasi-geoid improvement (www.dfhbf.de). The results of the computed quasi-geoid models using different types of data are introduced in this research, representing several solutions, as well as these solutions are compared with the national quasi-geoid model LV'14. In the middle of 2019, the new upgraded version of digital zenith camera was developed by the scientific staff and the accuracy of the measurements of improved camera was evaluated at 0.05 arcseconds, which is two times better than previous one. The improvements of new digital zenith camera are also discussed in this research. It is important to point out that according to our observations the application of digital zenith camera reveals a new capabilities for studies of mass distribution beneath earth.

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DIGITAL ZENITH CAMERA FOR VERTICAL DEFLECTION DETERMINATION: ON THE WAY TO 1 CM PRECISE QUASI-GEOID MODEL FOR LATVIA

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INTRODUCTION

The digital zenith camera VESTA (VErtical by STArs) was designed by the Institute of Geodesy and Geoinformatics (GGI) of the University of Latvia and completed in 2016. Since than 395 terrestrial vertical deflection measurements were done in the territory of Latvia. These observations were post-processed by the GGI developed software and the accuracy was evaluated at 0.1 arc seconds. Terrestrial observations were compared with global geopotential models, e.g. GGM+ and EGM2008. The results show a better correspondence with GGM+ model by evaluating the standard deviation: 0.314 and 0.307 arcseconds for ξ and η components respectively in comparison to 0.346 and 0.358 arcseconds for ξ and η components for EGM2008 model. The comparisons of average and minimum/maximum differences are introduced in this study for better evaluation of the results. Moreover, vertical deflections have been used as additional terrestrial data in DFHRS (Digital Finite-element Height Reference Surface) software v. 4.3 in combination with GNSS/levelling data (B, L, h|H) and global geopotential model EGM2008 for the quasi-geoid improvement (www.dfhbf.de). The results of the computed quasi-geoid models using different types of data are introduced in this research, representing several solutions, as well as these solutions are compared with the national quasi-geoid model LV'14. In the middle of 2019, the new upgraded version of digital zenith camera was developed by the scientific staff and the accuracy of the measurements of improved camera was evaluated at 0.05 arcseconds, which is two times better than previous one. The improvements of new digital zenith camera are also discussed in this research. It is important to point out that according to our observations the application of digital zenith camera reveals a new capabilities for studies of mass distribution beneath earth.

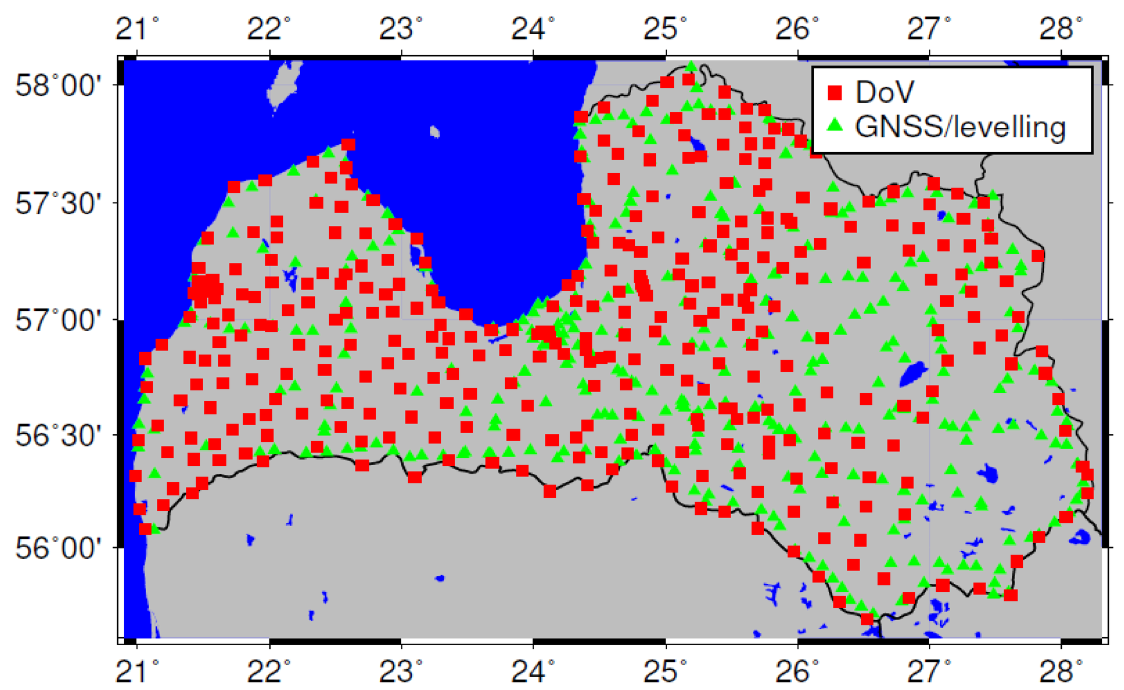

Fig. 3. The location of GNSS/levelling points and DoV

Table 1.The evaluation of Quasi-geoid (m)

	min	max	Avg	Stdev
Quasi-geoid	-0.032	0.031	0.012	0.014

MEASUREMENT CONTROL

- All observation functionality within single interface window,
- Automatic mode supported,
- Measurement sequence specified in scenario script,
- 16 bit image intensity preserved,
- Support of uneven background intensity distributon analysis, improving twilight performance,
- GPS coordinates recorded for each session

Fig. 1. The Digital Zenith Camera

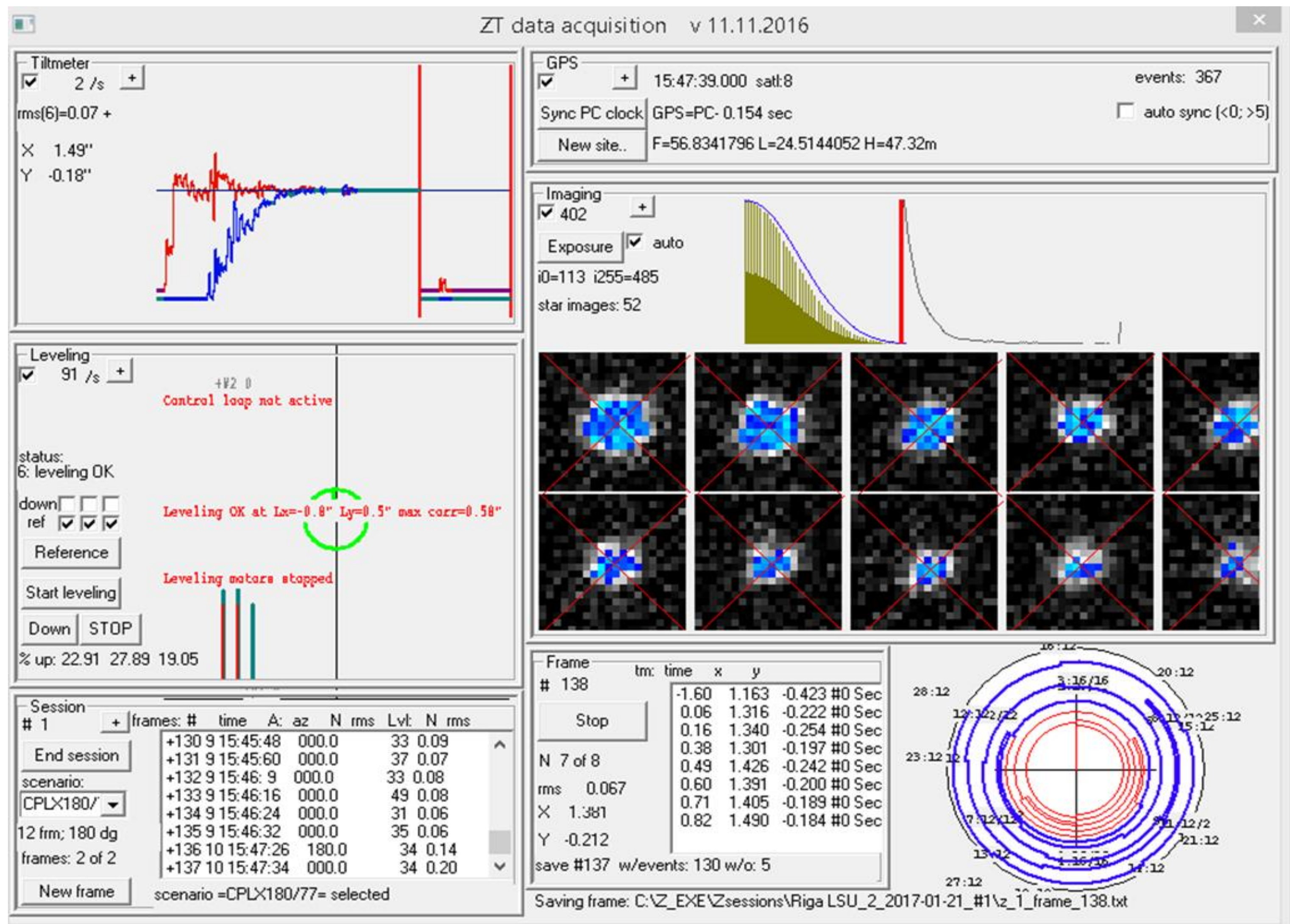

Fig. 2. The interface of the VD processing software

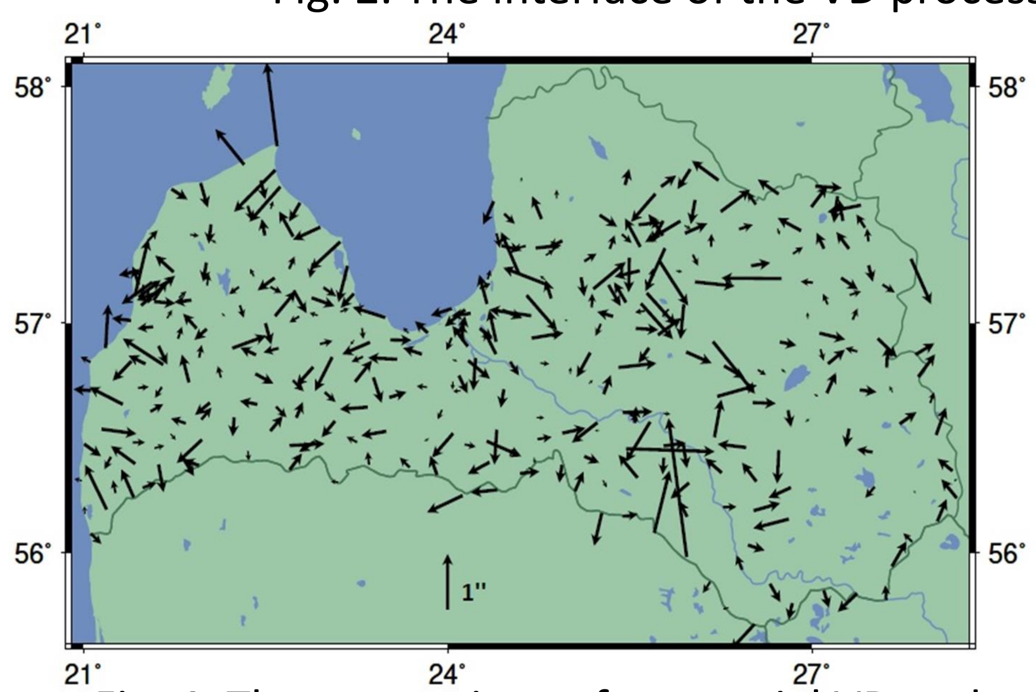

Fig. 4. The comparison of terrestrial VD and VD derived from EGM2008

Fig. 5. Upgraded DZC

Table 2. The comparison of field VD with derived VD from DFHRS and EGM2008 (arcsec)

	Min		Max		Avg	
	Xi	Eta	Xi	Eta	Xi	Eta
DFHRS	-0.190	-0.348	0.162	0.216	0.033	0.041
EGM2008	-1.128	-0.939	1.669	2.491	0.256	0.252

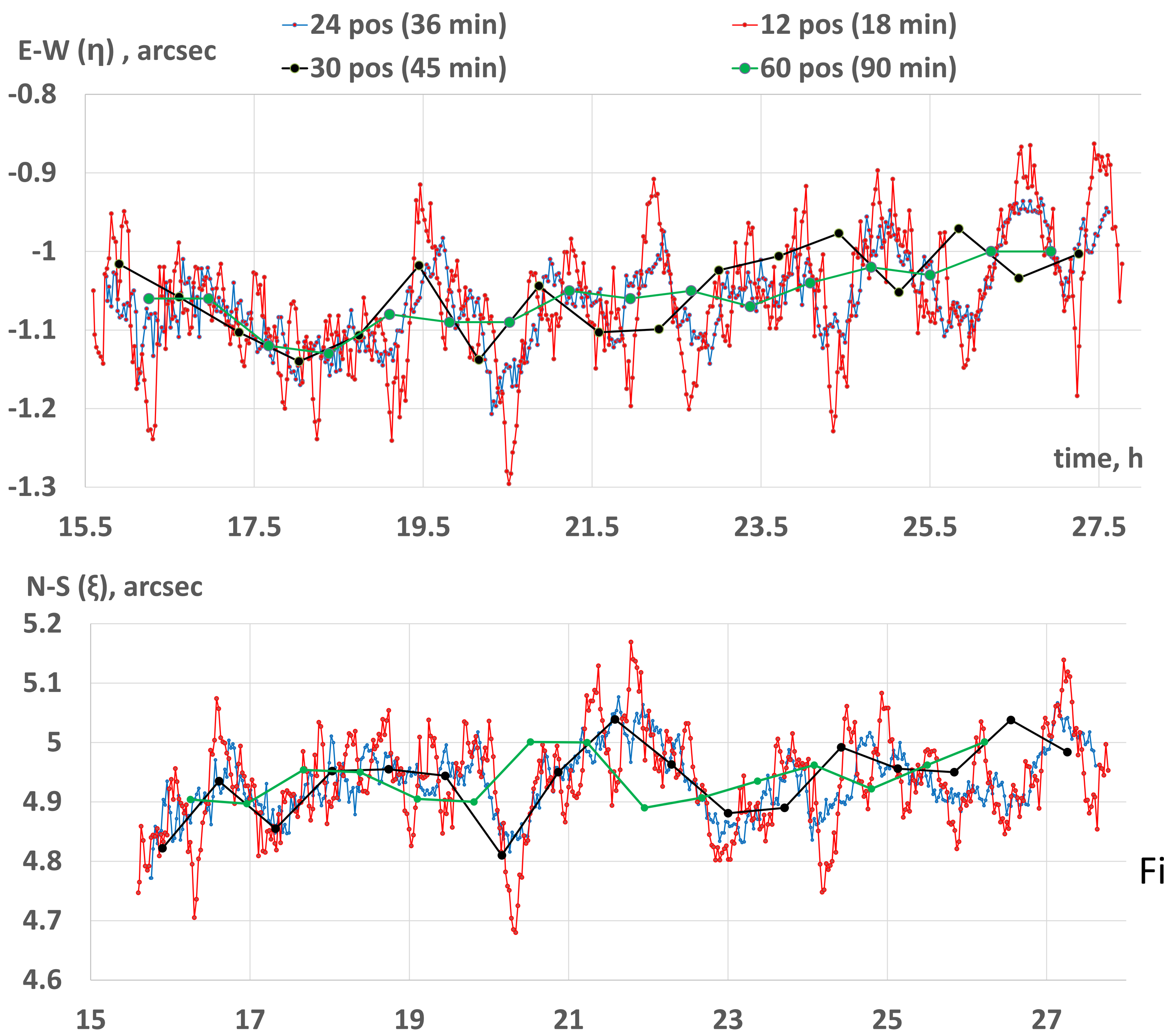

Fig. 6, Fig. 7. Variations of xi and eta component estimated using moving time windows of different width (12 h measurements)

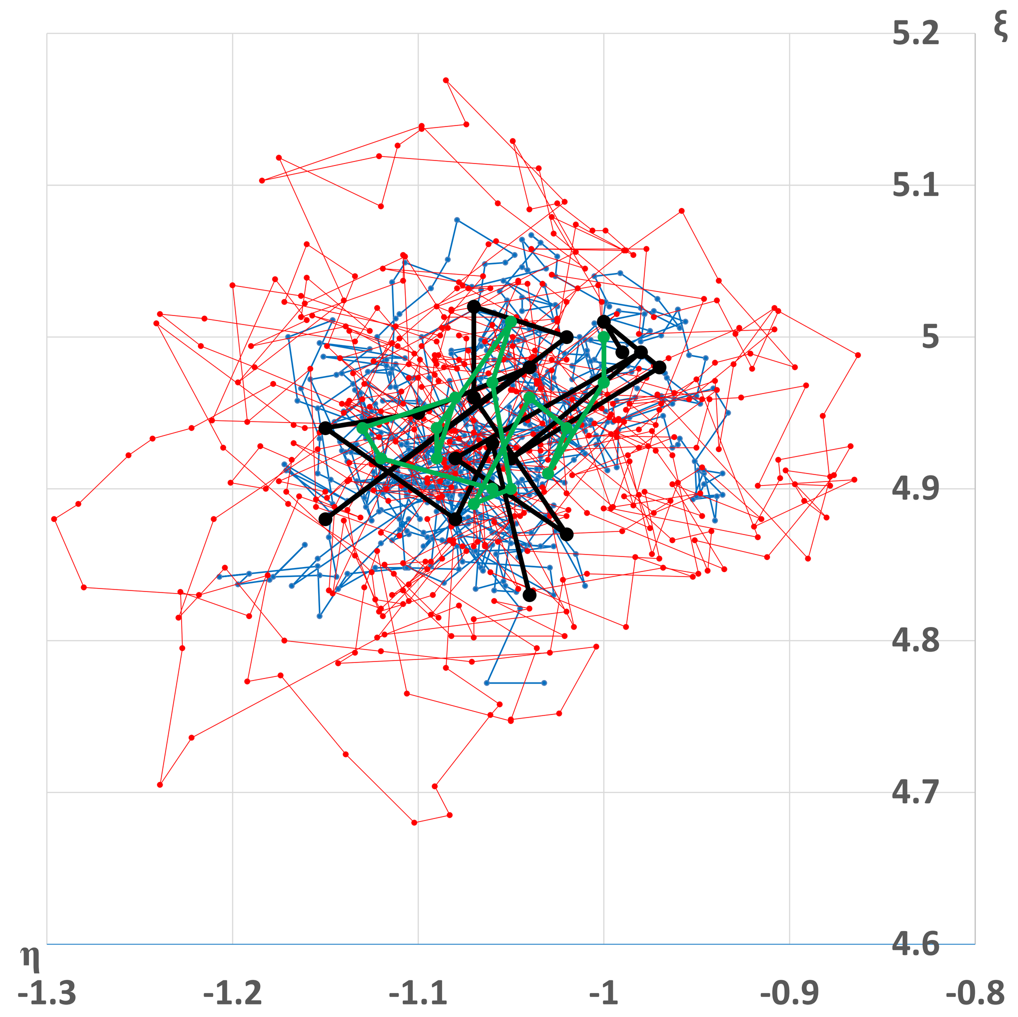

Fig. 9. VD variations for different width of moving time window

$$X = x0 - \sin A \times \xi + \cos A \times \eta + dT \times X',$$
$$Y = y0 + \sin A \times \eta + \cos A \times \xi + dT \times Y'.$$

DIGITAL ZENITH CAMERA CONSISTS OF:

- 20 cm Telescope;
- Rotating assembly with levelling system;
- High resolution tiltmeter;
- On board GNSS receiver;
- CCD camera;
- On board control computer;
- Wireless data transmission equipment;
- Data processing software.

The accuracy of the instrument is ~0,1 arcsec, limited by impact of atmospheric refraction;
Minimum duration of observation session ~30min
Accurate levelling, setting of azimuth and prescribed schedule of observations are done automatically.

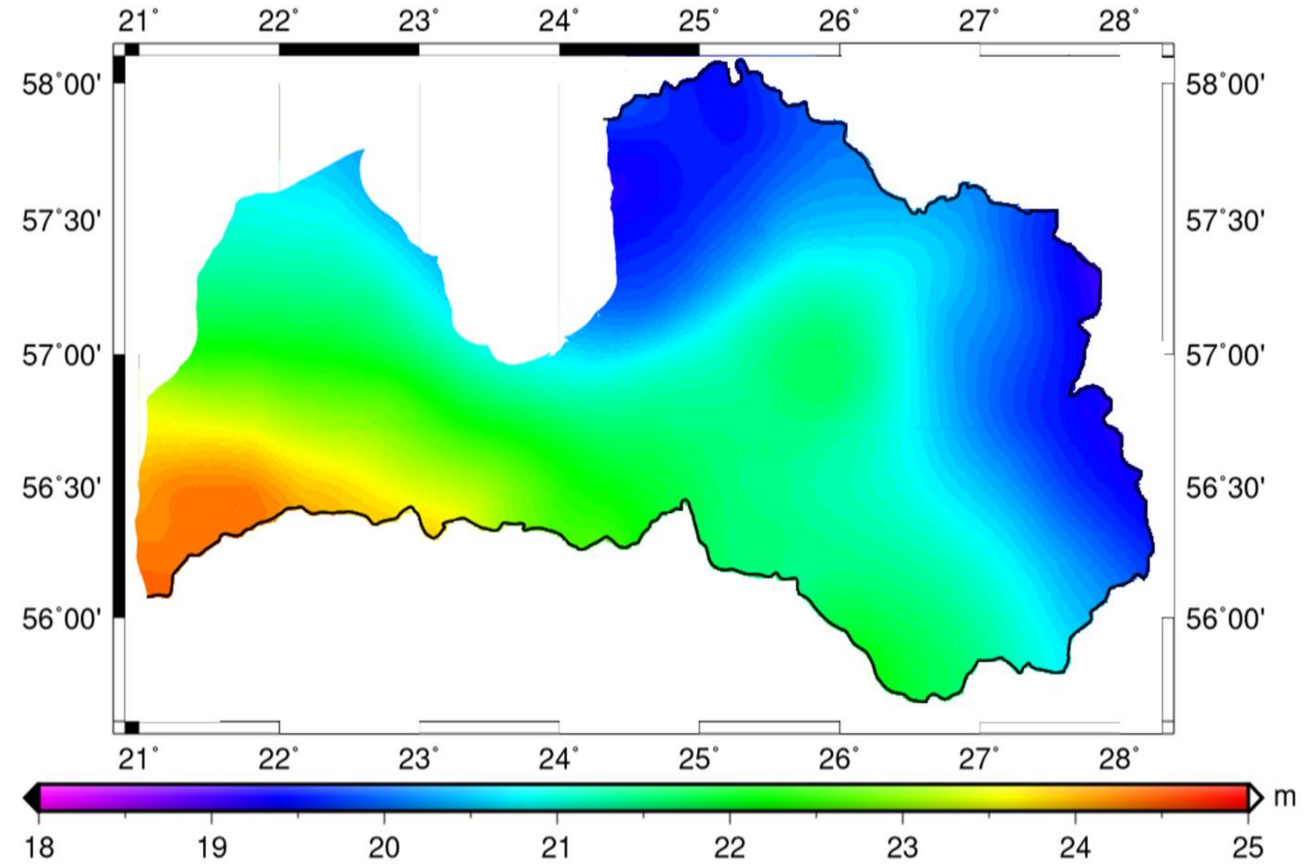

Fig. 10. Quasi-geoid model for Latvia

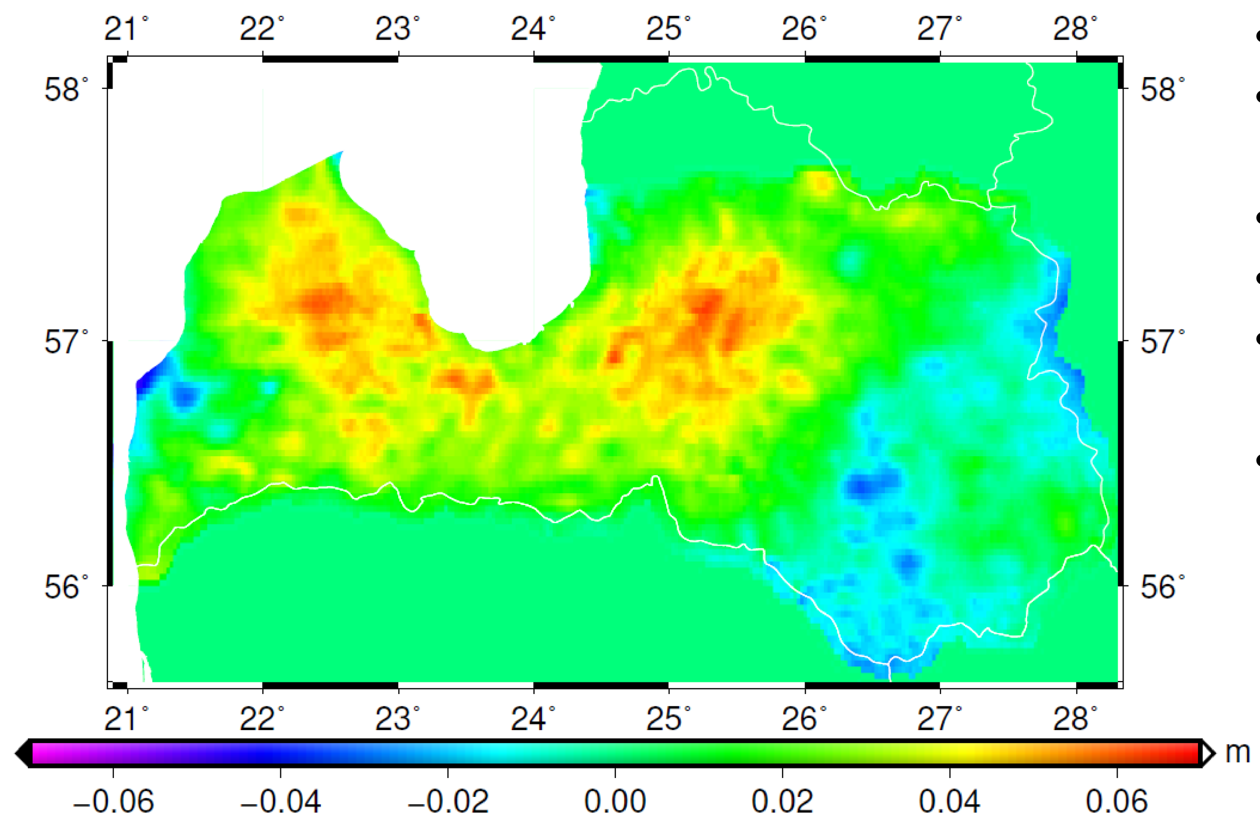

Fig. 8. The comparison of national LV'14 and GGI model

IMPROVEMENTS:

- Elaboration of measurement methodology,
- Measurement control software corrections and complements,
- Data processing improvements and automation,
- Transition to GAIA data release 2 star catalog,
- Revision of mechanical design, development of a new model,
- Currently 4 cameras are manufactured

ACKNOWLEDGEMENT:

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