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Evaluation of height network in Latvia

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Evaluation of height network in Latvia

OUTLINE

1.Levelling campaigns in Riga city

2.Height determination of levelling benchmarks

3.The control measuring campaign using *EUPOS*® – *Riga* and LATPOS RTK network

3.1. The daily result distribution during two month period (Jan-Feb, 2008)

3.2. The LATPOS base station OJARS. Hourly result distribution during 6 day period September 2010

3.3. Preliminary results

3. 4. The 1st order levelling benchmark monumentation in Latvia

3.5. The control measuring campaign using *EUPOS*® – *Riga* and LATPOS RTK network

3.6. Results

4.Conclusion for RTK

5.The analysis of precise levelling and Earth's crust vertical movement

6.Selection of zero point (reference point with zero vertical motion)

7.The reference points of geodetic heights

8. Interoperability of height systems

9.Additionally re-measured EUVN points

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1. Levelling campaigns in Riga city

Last 2nd order levelling campaign in Riga city was performed at **1975-77**. Mainly negative vertical movement was discovered at several places comparing with levelling results of **1949-54**. There were no levelling networks neither controlled nor developed in Riga city after **1977**. However, the high accuracy levelling network is still important for many civil engineering tasks and for geodetic and geophysical research purposes.

The deformation of Riga levelling network may be caused by:

-the vertical movement of local earth surface;

-the tectonic continental and intercontinental movement of the earth core is available as well.

-there are several effects of vertical movement in urban environment.

-development of the new building construction;

-increase of traffic intensities and

-both the geologic and hydro geologic conditions in upper layers of ground are additional sources of the up or down movement of earth surface.

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2. Height determination of levelling benchmarks

The vertical movement could be controlled by height determination of levelling benchmarks.

Application of **Global Navigation Satellite Systems (GNSS)** in geodesy discovers a powerful tool for the verification and validation of the historically long time ago established geodetic levelling benchmarks. **The differential GNSS and RTK methods** appear very useful to identify the vertical displacement of landscape by means of inspection of the deformation of levelling networks.

The criteria of Mean Sea Level not always is highly useful. **The mean Baltic Sea level has risen by 26 cm during 100 years** according the records of Riga tide gauge station. It is placed near the Daugava river estuary where the water level changes depending of the work regime at the Riga hydroelectric power station placed on the Daugava river at a distance of about 20 km. Therefore it is rather difficult to fix the real value of mean sea level near Riga. It is influenced by the artificially changing water level of river Daugava.

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2. Height determination of levelling benchmarks

Additional tool for the independent height determination is the **application of Satellite Laser Ranging System (SLR)** recently developed at the University of Latvia. The SLR is located at the centre of *EUPOS*® – *Riga* base station network at a distance of 20 m from GNSS antenna (in the centre of our capital).

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2. Height determination of levelling benchmarks

The relevant volume of **SLR ranging data** will be collected and the proper height determination tests will be performed.

The laser ranging **accuracy** of LAGEOS and other LEO satellites appears at the **subcentimeter level**.

LAGEOS (d=60 cm)

LAGEOS visible in SLR telescope guide at a distance of 7000 km

	Date	Satellite	RMS cm	RMS cm	NP	RMS cm
1	2009.04.13	Ajisai	661	3.1	9	0.64
2	2009.04.16	Jason2	752	4.0	9	0.54
3	2009.04.16	Ajisai	631	4.7	6	0.62
4	2009.10.06	Ajisai	1894	4.2	13	0.70
5	2009.10.06	Jason1	9	1.7		
6	2010.04.13	Lageos1	33	1.9	2	1.01
7	2010.04.19	Lageos2	58	2.1	3	0.66
8	2010.04.19	ERS2	368	2.7	11	1.0
9	2010.04.20	Lageos1	97	3.4	2	0.54
10	2010.04.26	ENVISAT	1212	2.7	16	0.70
11	2010.04.26	ERS2	1539	2.3	17	0.41
12	2010.04.27	Jason2	210	3.1	10	0.65

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3. The control measuring campaign using *EUPOS® – Riga* and LATPOS RTK networks

EUPOS®-Riga

- 5 base stations
- distance between stations ~12 km

Riga's GeoMetrs Ltd. and Institute Of Geodesy and Geoinformation /University of Latvia/

LATPOS

- 19 base stations
- distance between stations ~70 km

Latvian Geospatial Information Agency
www.latpos.lgia.gov.lv

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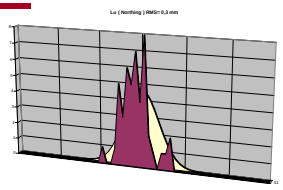
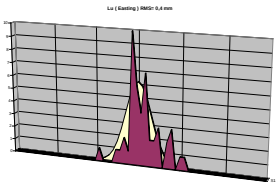
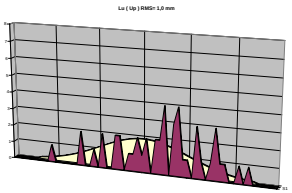
3.1. The daily result distribution during two month period (Jan-Feb, 2008)

EUPOS-Riga antennas calibrated

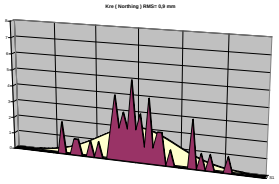
Centre (LU)
N, E, U: $STDV_{mm}$={0.3, 0.4, 1.0}

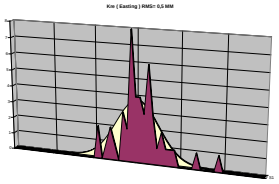


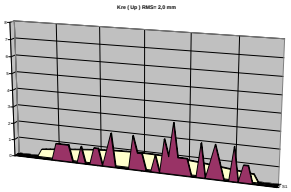




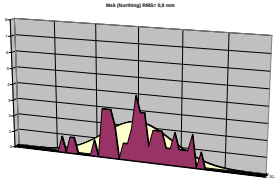
North (Kre)
N, E, U: $STDV_{mm}$={0.9, 0.5, 2.0}

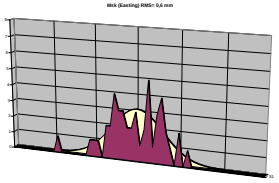


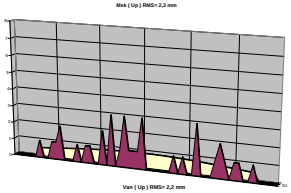




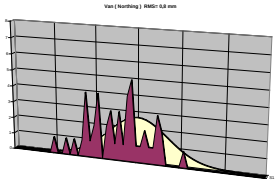
South (Msk)
N, E, U: $STDV_{mm}$={0.9, 0.6, 2.3}

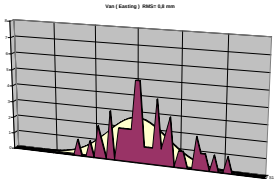


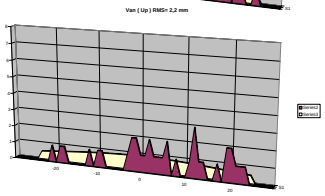




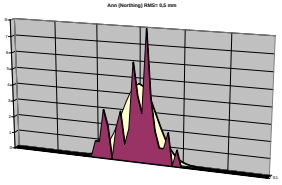
East (Van)
N, E, U: $STDV_{mm}$={0.8, 0.8, 2.2}

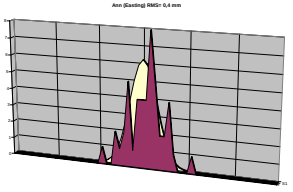


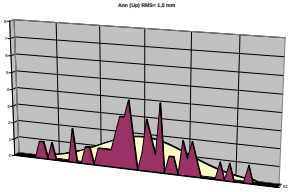




West (Ann)
N, E, U: $STDV_{mm}$={0.5, 0.4, 1.0}







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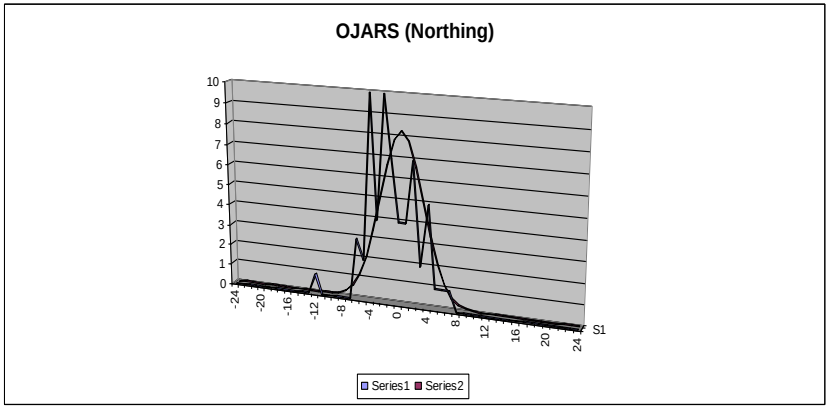
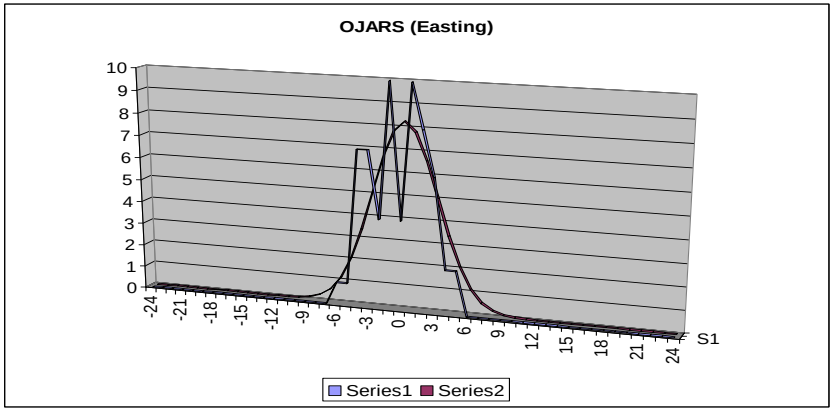
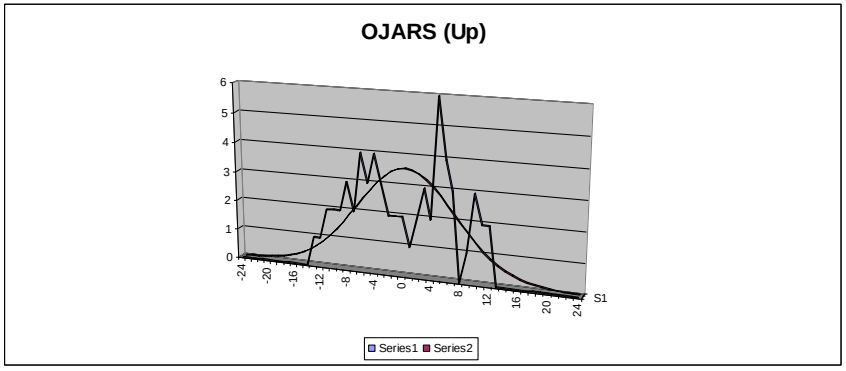
3.2. The LATPOS base station OJARS. Hourly result distribution during 6 day period September 2010

Antenna not calibrated







OJARS

N, E, U: $STDV_{mm}$= {3.0, 3.0, 7.0}

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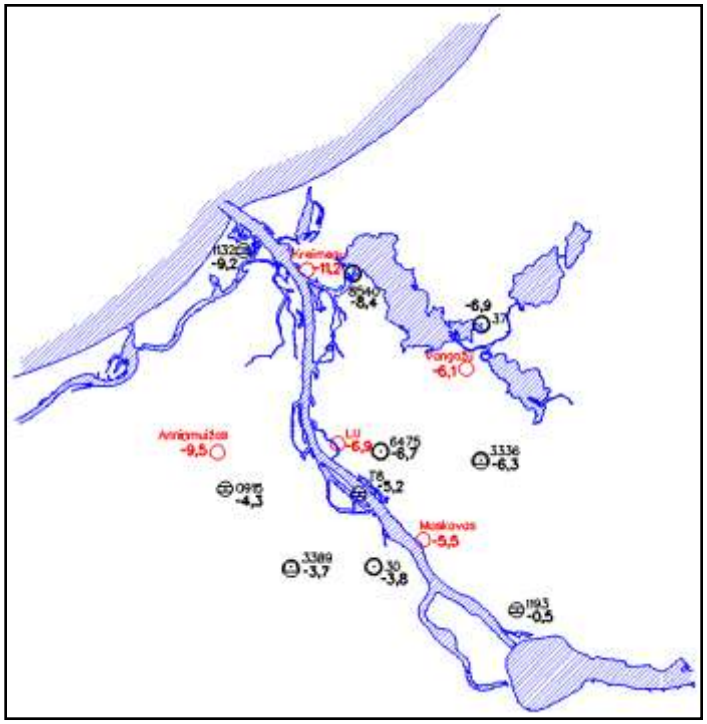
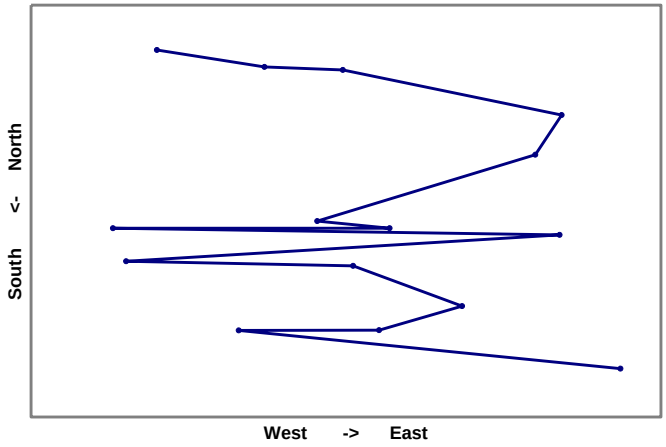
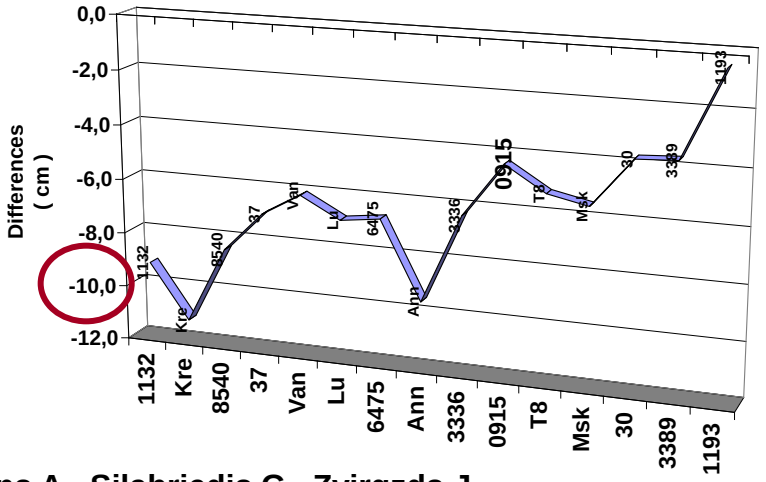
3.3. Preliminary results



Arrangement N -> S





Epoch precision and reliability

Rp 0915 one measurement RMS=1,8 cm
(62 measurements)
result RMS=2,3 mm

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3.3. Preliminary results

Preliminary results have discovered **a land down lift** at the bank of Riga Bay

THEREFORE

Further measurements and research was performed during summer 2010.

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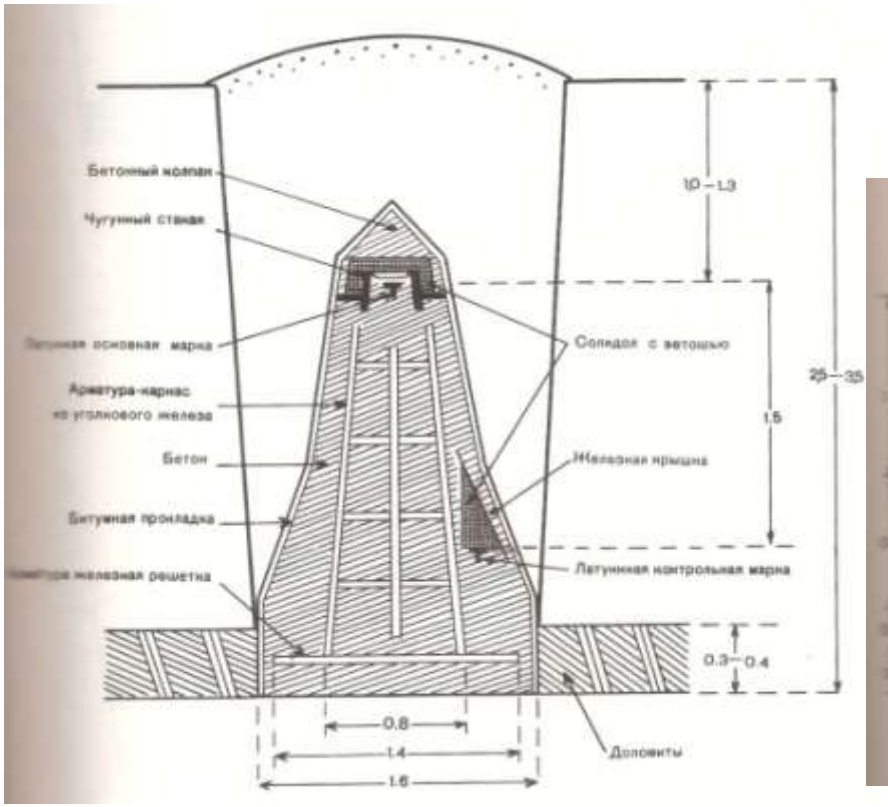
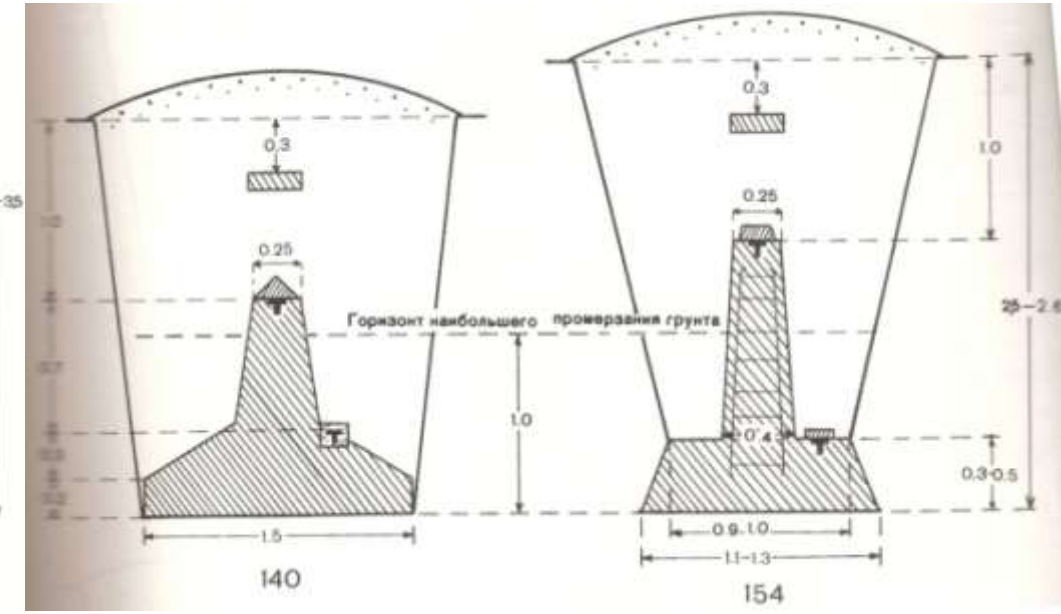
3. 4. The 1st order levelling benchmark monumentation in Latvia





Fundamental ground benchmark

Ground benchmark

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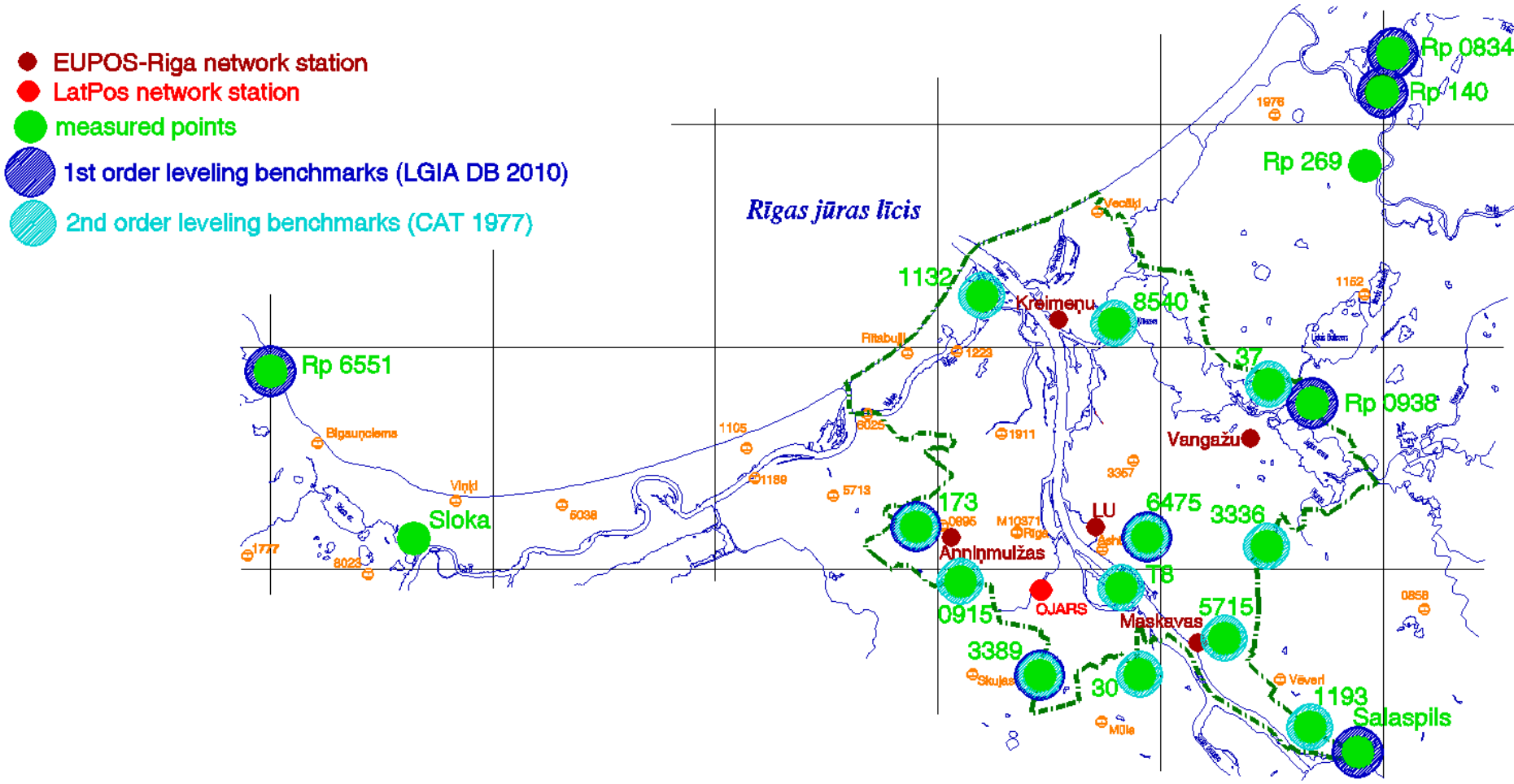
3.5. The control measuring campaign using *EUPOS® – Riga* and LATPOS RTK networks



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Evaluation of height network in Latvia

3.6. Results

•**17** points **(1st order and 2nd order levelling benchmarks)** were measured using LEICA and TOPCON GPS receivers

•The sequence of **50** results of RTK 10 sec long sessions were collected

and/or

•The sequence of **160** results of RTK 10 sec long sessions were collected

Evaluation of height network in Latvia

Collecting **160** results of RTK 10 sec long sessions in Riga at the Rainis monument

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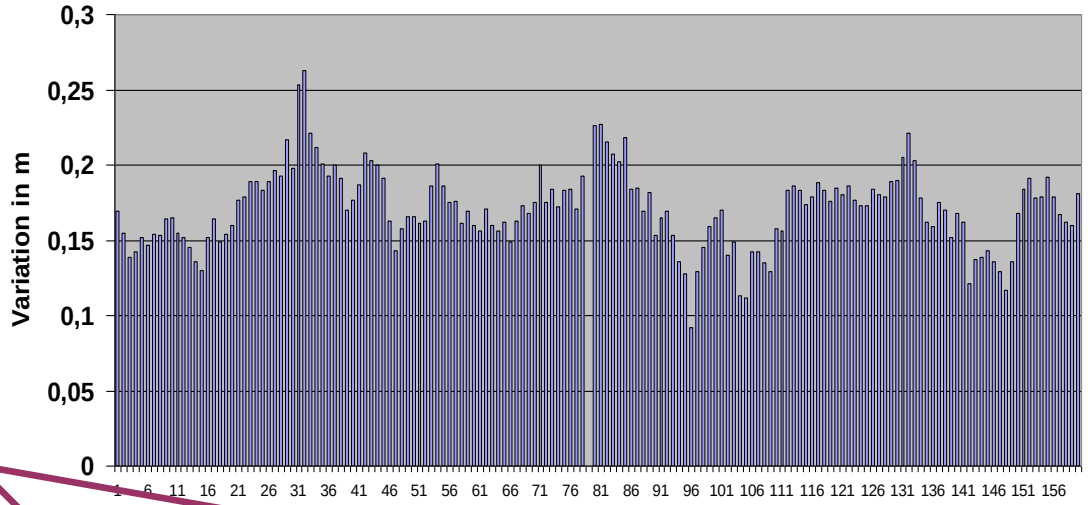
3.6. Results

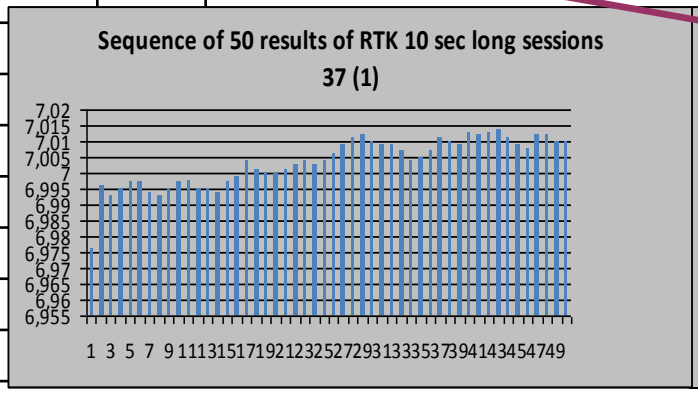
Evaluation of height network in Latvia

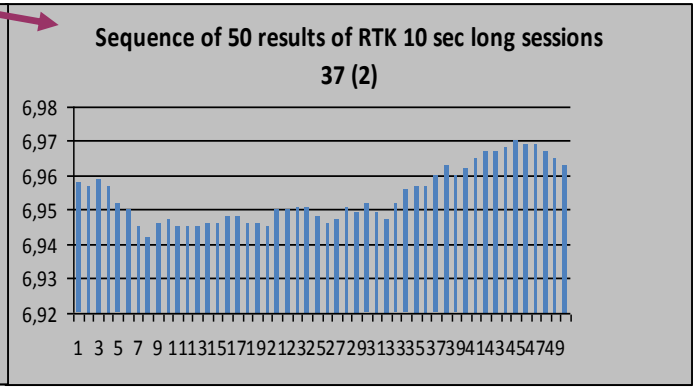
STDV= $\sqrt{\frac{\sum(x-\bar{x})^2}{(n-1)}}$ RMS= $\sqrt{\frac{\sum(x-\bar{x})^2}{n\,(n-1)}}$

	Results	STDV	RMS	STDV	RMS
#	H	mm	mm	mm	mm
5715	11,805	9,0	1,3	5,7	0,6
1193	10,590	7,2	1,0	11,6	1,3
915	11,792	3,0	0,4	7,2	0,7
173	9,011			5,4	0,5
1132	0,984			13,0	1,3
30	9,065	13,0	1,8	8,5	1,2
3389	12,292	10,0	1,4	10,9	1,3
8540	9,619	3,2	0,5	14,0	1,9
37	7,037	7,7	1,1	8,3	1,2
938	13,317	9,4	1,3		
140	6,226	24,7	3,5		
834	8,220	17,0	2,5		
6475	15,222	3,6	0,5		
3336	9,404	14,3	2,0		
SALA	10,503	11,6	1,6		
T8	4,719	6,0	0,9		
6551	4,135	31,5	3,1		

Sequence of 160 results of RTK 10 sec long sessions, probably influenced by ionosphere fluctuations







Evaluation of height network in Latvia

3.6. Results

	Levelling	Year	dH (m)	Levelling	Year	dH (m)
#	1st order		1st order	2nd order		2nd order
5715				11,797	1977	0,008
1193				10,570	1977	0,020
915				11,816	2000	-0,024
173	9,024	2005	-0,013	9,012	2000	-0,001
1132				0,948	1977	0,036
30				9,136	2000	-0,071
3389	12,314	2000	-0,022	12,303	1977	-0,011
8540				9,617	1977	0,002
37				7,047	2000	-0,010
938	13,328	2001	-0,011			
140	6,237	2001	-0,011			
834	8,226	2001	-0,006			
6475	15,212	2008	0,010	15,186	2000	0,036
3336				9,425	1977	-0,021
SALA	10,491		0,012			
T8				4,746	1977	-0,028
6551	4,128	2002	0,007			

The coherence of results (1st and 2nd order of benchmarks; year 1977, 2000, 2001, 2002, 2005) **is within 3 cm**

Mainly the values with negative sign have been observed

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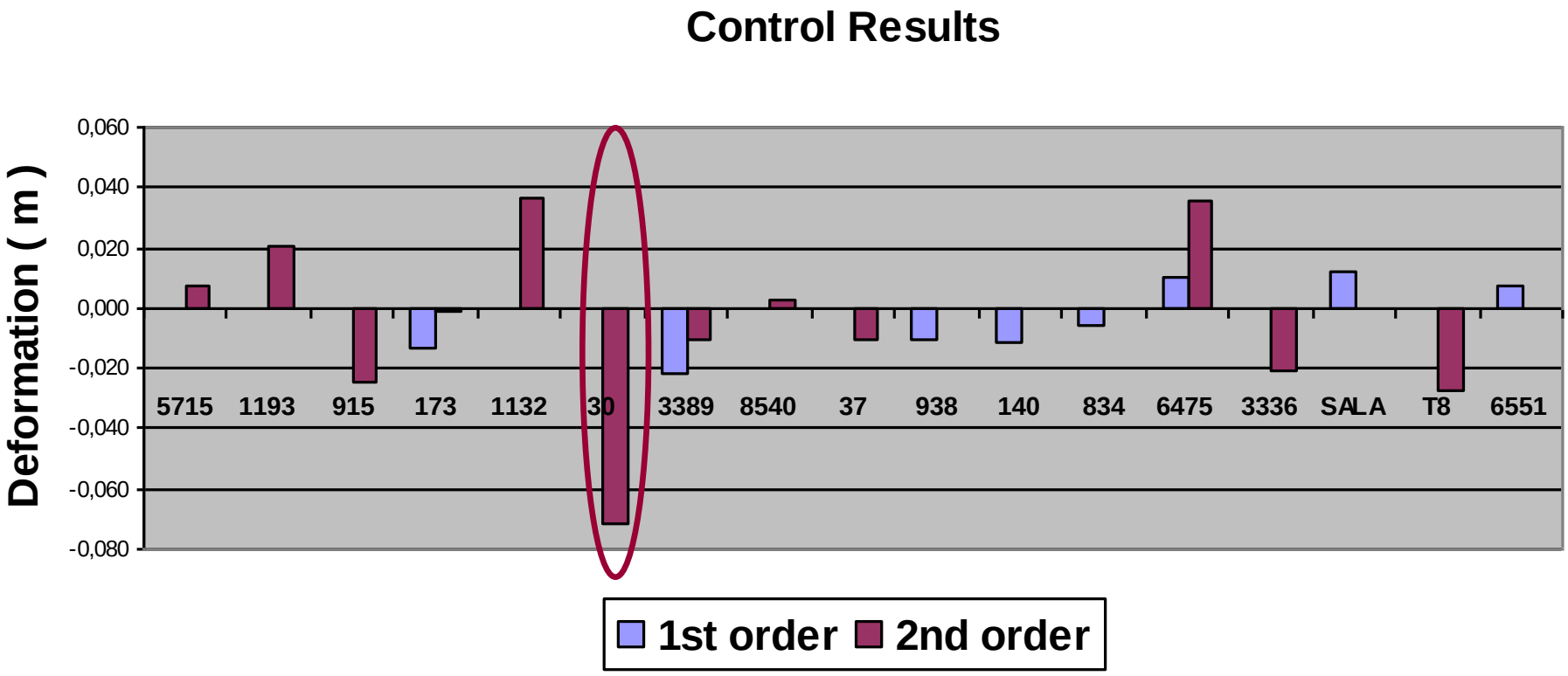
Evaluation of height network in Latvia

3.6. Results



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Evaluation of height network in Latvia

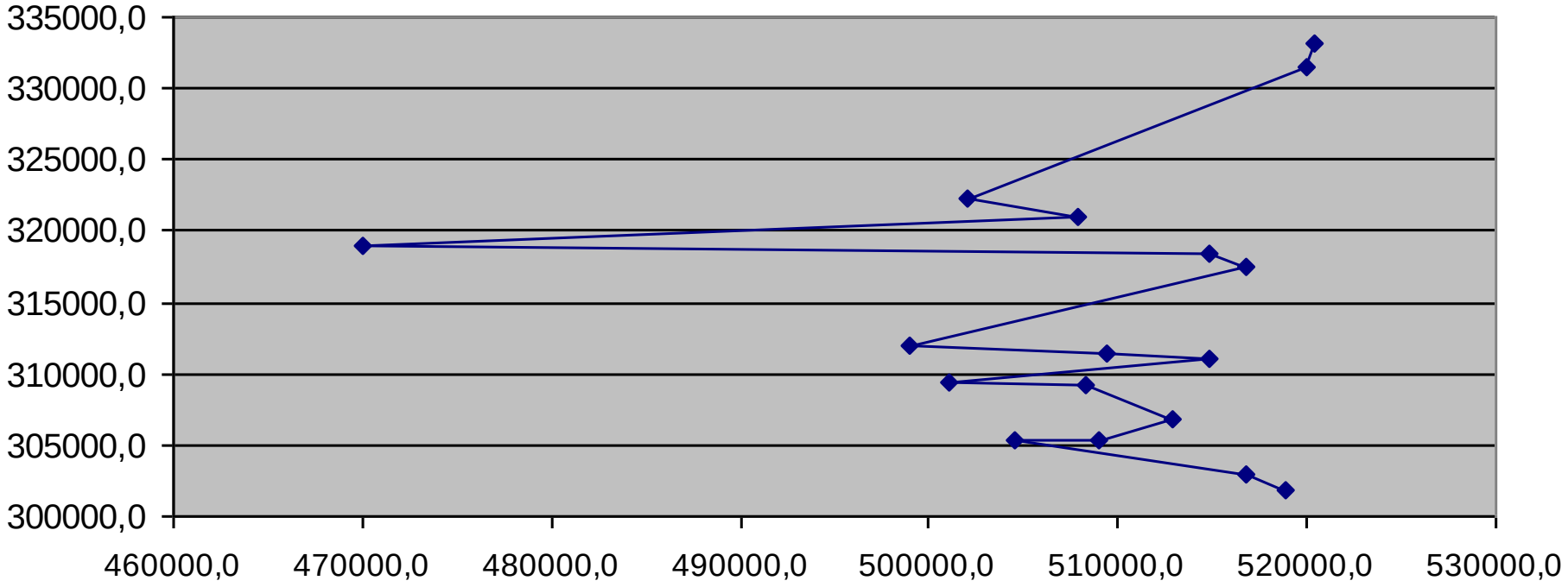
4. Conclusion for RTK

LEVELLING

using traditional methods
~200 km;
50 days work of levelling team

/

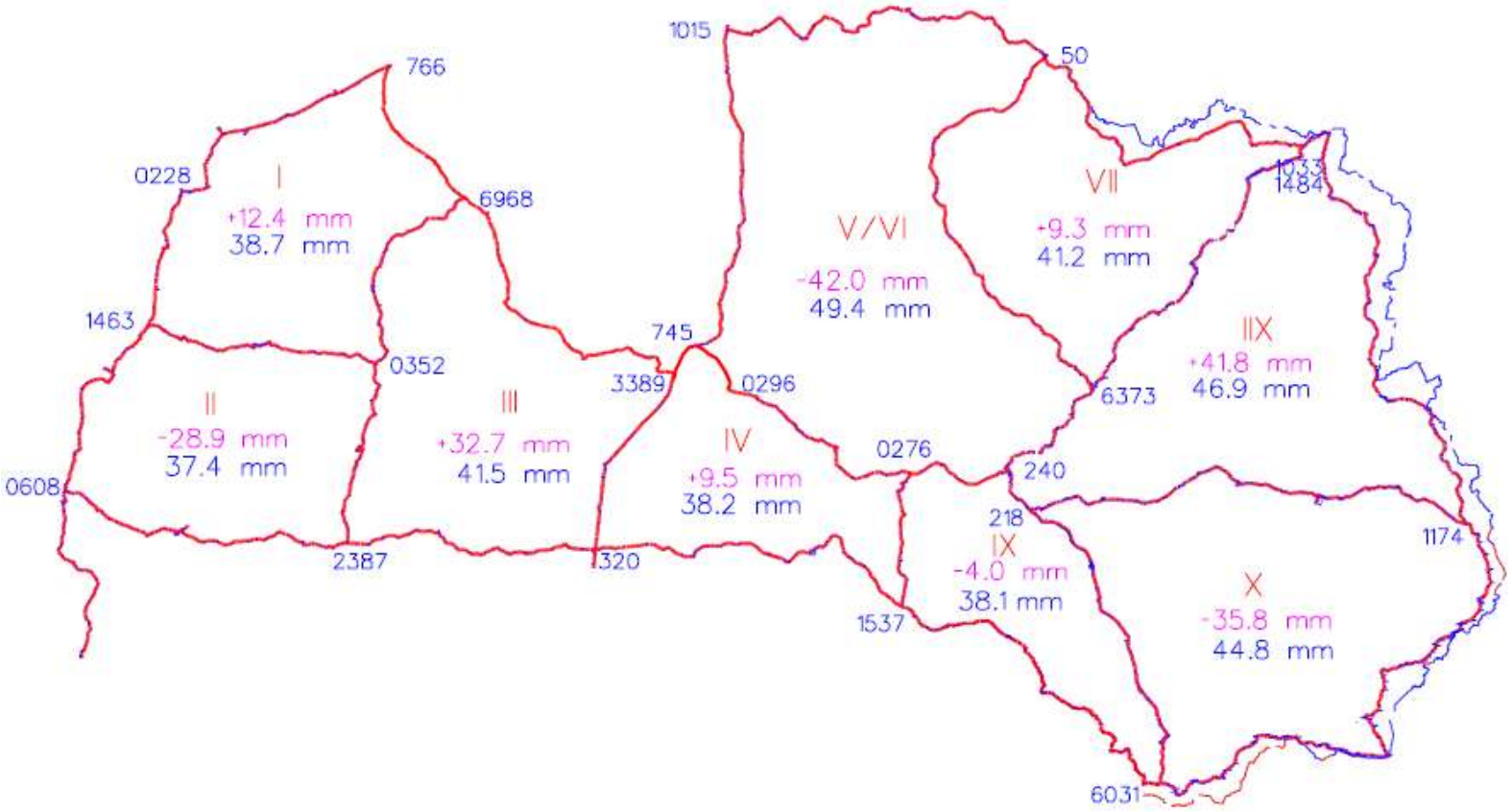
using RTK application
~200 km;
1 week work



Evaluation of height network in Latvia

5. The analysis of precise levelling and Earth's crust vertical movement

Acquired and allowed (in blue color) **discrepancies of polygons**



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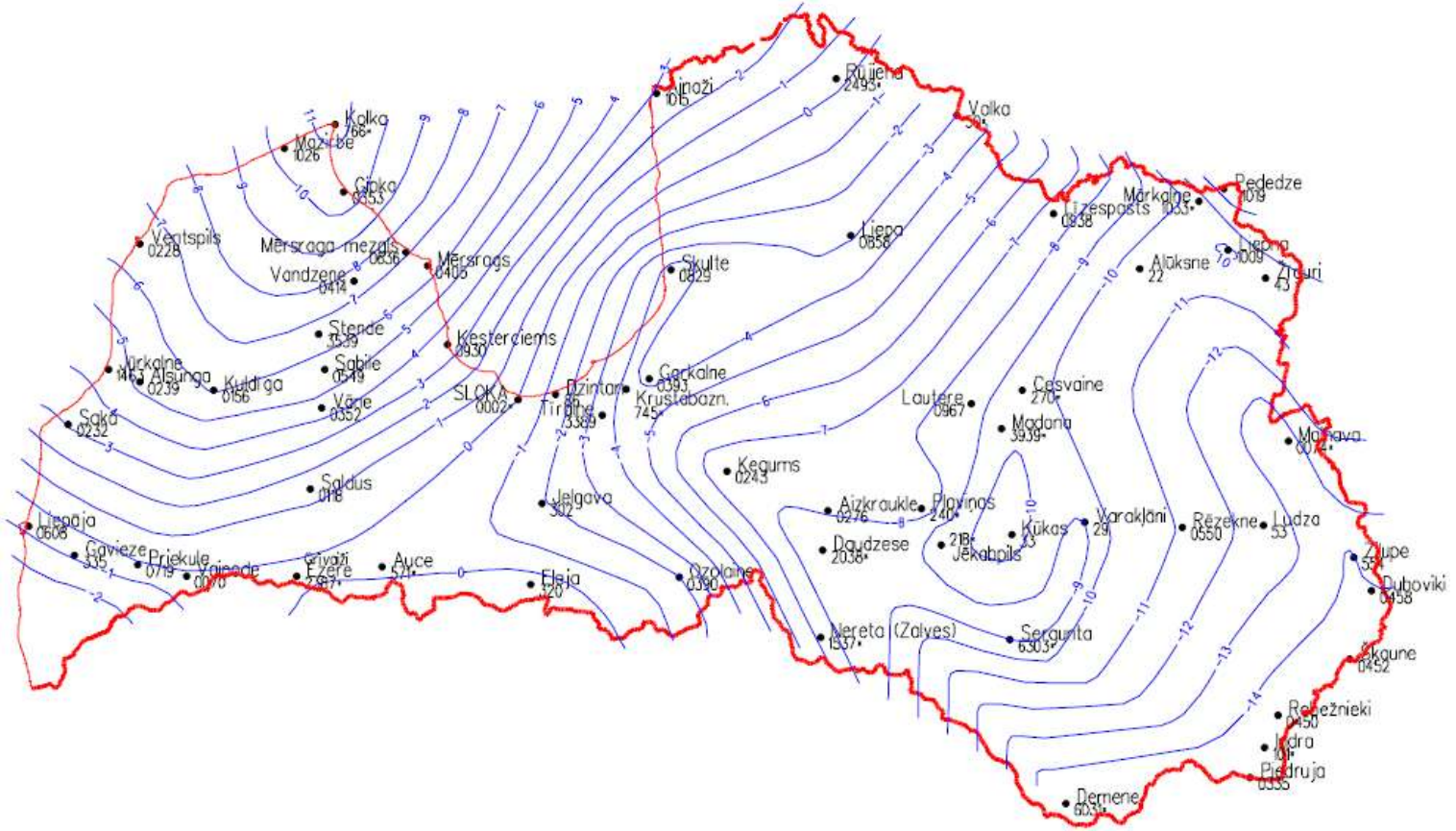
Evaluation of height network in Latvia

5. The analysis of precise levelling and Earth's crust vertical movement

Earth's crust vertical movements in a 10 year period in [mm] (represented with isolines)



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Evaluation of height network in Latvia

6. Selection of zero point (reference point with zero vertical motion)

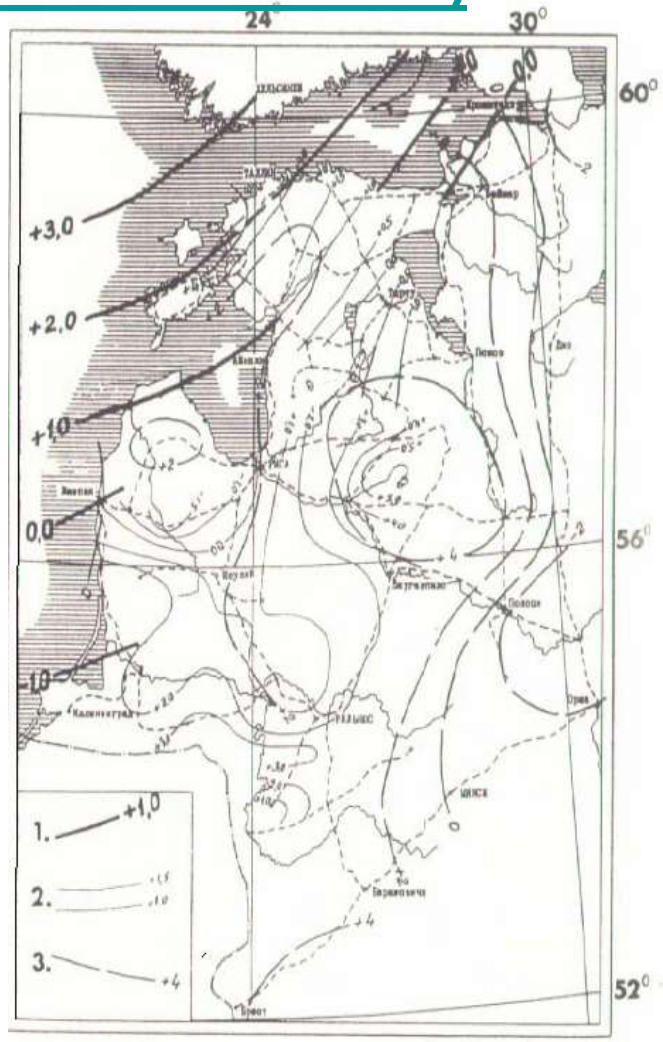
Scientific and historical motivation

Earth's crust movement in Baltic states
(O. Jakubovskis, G. Žeļņins, I.Liešs un V. Matskovs)

1. The results from levelling materials (1889 – 1979) tied with sea level observation data (research of O. Jakubovskis)

2. The data of precise levelling in the territory of Latvia and Lithuania (1872 - 1954) (research of G. Zelnins and I. Liess)

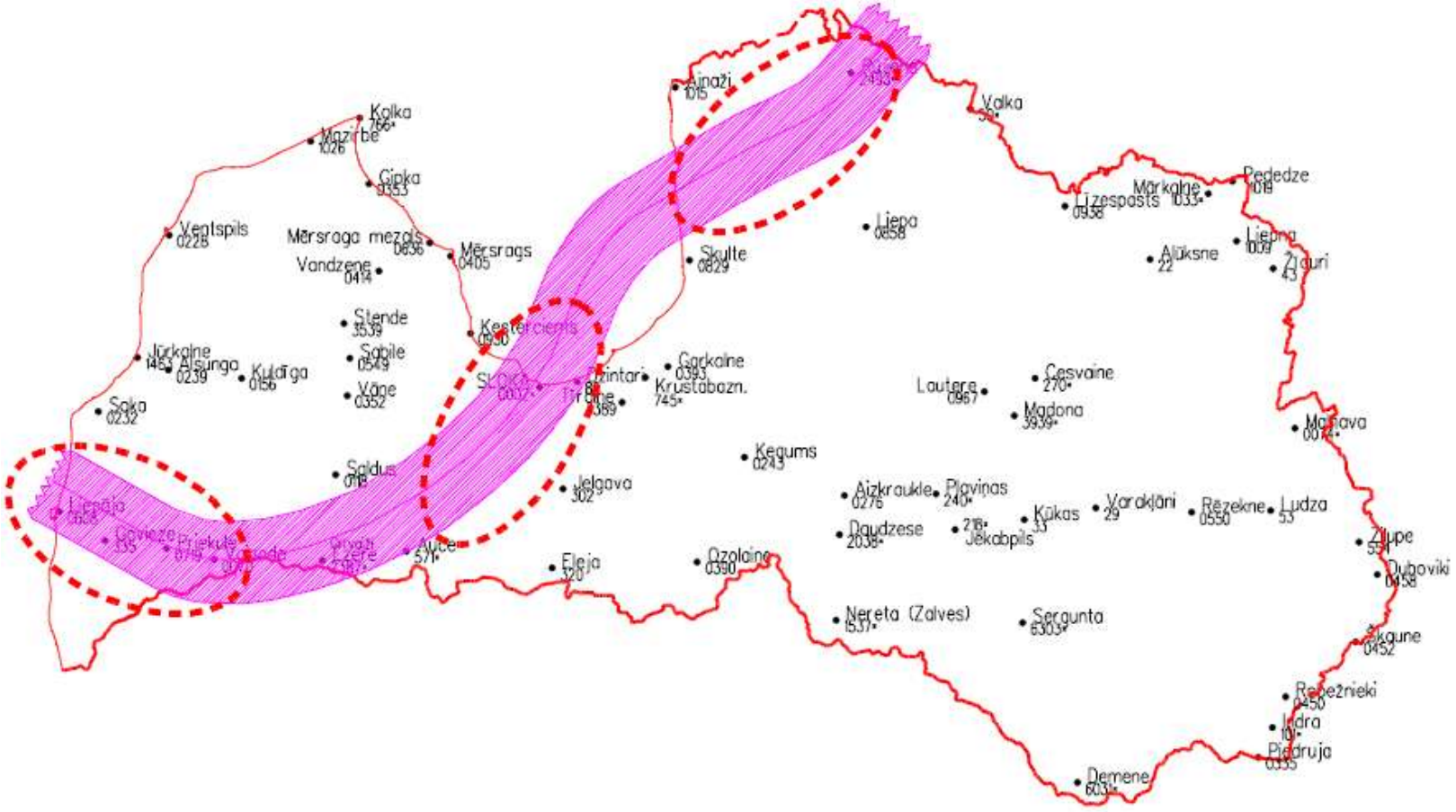
3. The isolines of Earth's vertical movement for a 1 year period (research of V. Matskovs)



Evaluation of height network in Latvia

6. Selection of zero point (reference point with zero vertical motion)

Zero line of Earth's crust vertical movement



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6. Selection of zero (reference point with zero vertical motion) point

The fundamental benchmark is determined as the most suitable height zero point,

Fr 002, in Sloka, its height is 2.125 m (BHS77) and 2.281 m (EVRF2007)

Difference 15,6 cm between systems

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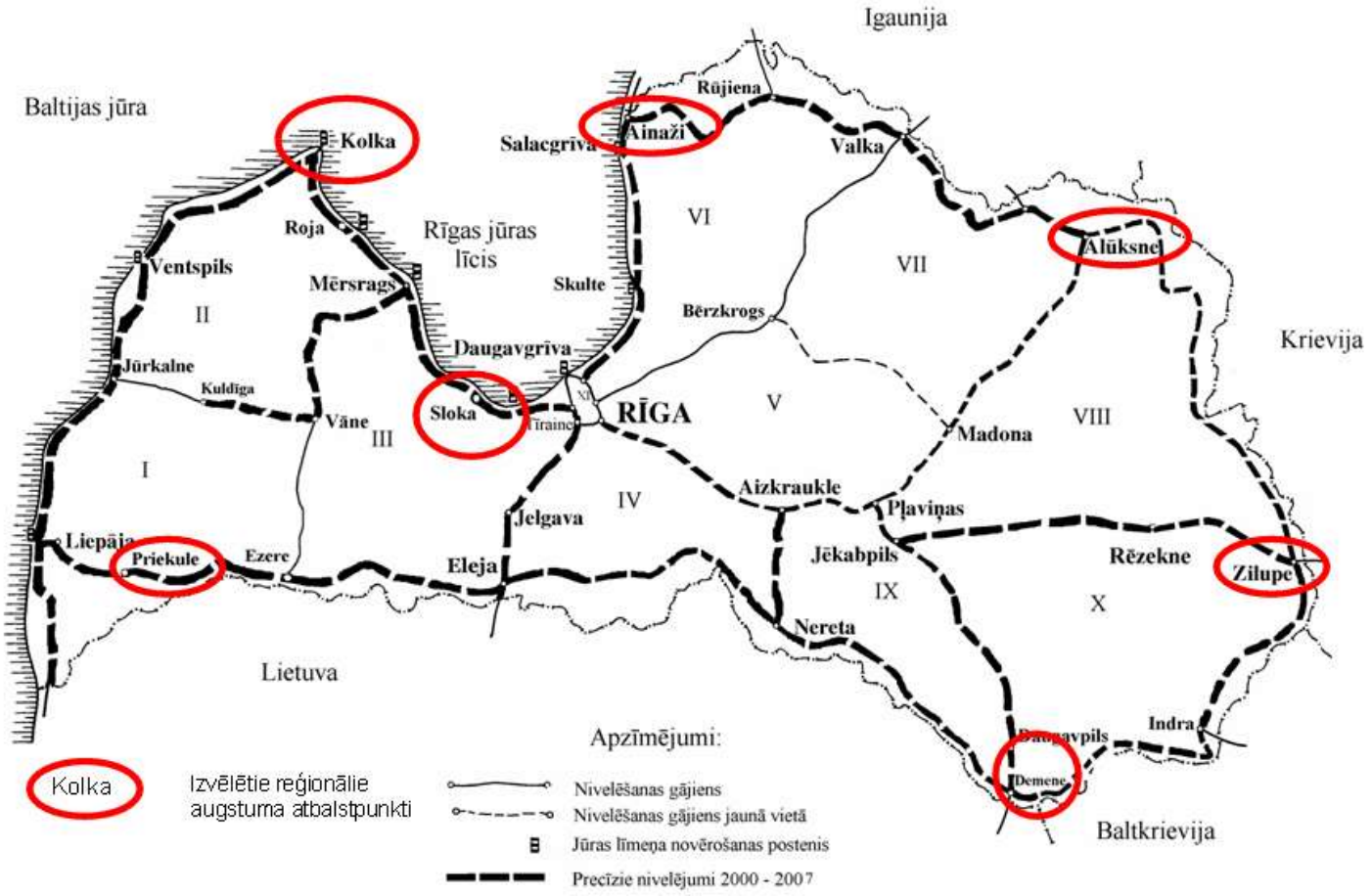
7. The reference points of geodetic heights



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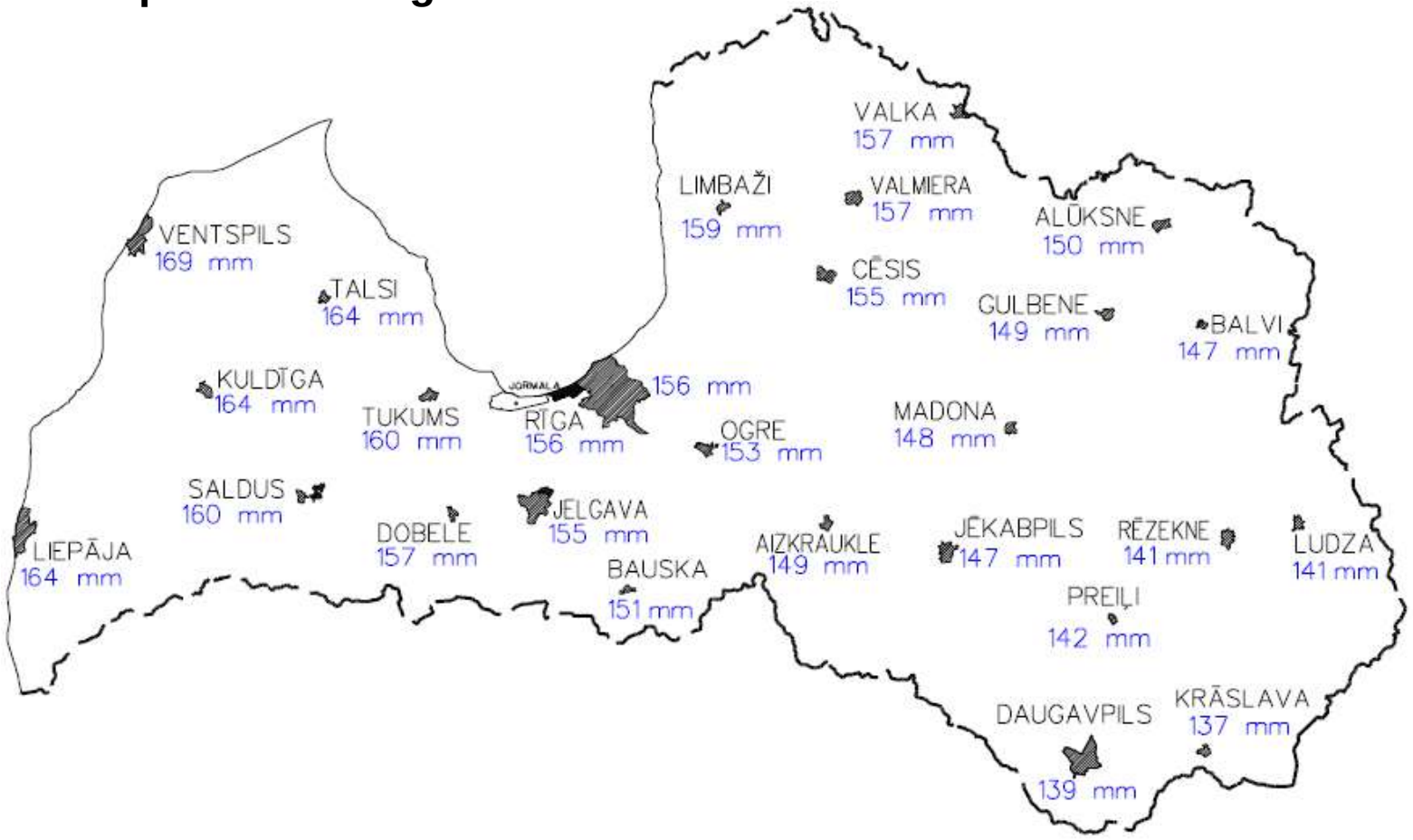
8. Interoperability of height systems

The predicted height differences between BHS77 and EVRF007



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9. Additional measured points

N.p.k.	Station name	EUVN_DA identifier 5 char.	ETRFyy lat [deg]	ETRFyy lon [deg]	ETRFyy ellipsoidal height [m] tide free	ETRFyy ellipsoidal height [m] zero tidal	LV98 Geoid model	EGG2008 Geoid model	NKG 2004 Geoid model	normal height of EUVN_DA station EVRF2000	normal height of EUVN_DA station EVRF2007	Remarks
1	Skulte	LV001	57,315894	24,410088	26,418	*26,3505*	19,773	19,589	19,537	6,745	6,805	
2	Liepaja	LV002	56,514942	21,000910	36,271	*36,2059*	24,231	24,004	23,955	12,131	12,203	
3	Ventspils	LV003	57,395897	21,537961	27,954	*27,8863*	21,345	21,028	21,001	6,698	6,774	
4	Irbene	LV004	57,554417	21,851996	40,624	*40,5559*	21,151	20,781	20,754	19,563	19,638	14
5	12302M002	RIGA	56,948619	24,058771	34,714	*34,6476*	20,981	20,852	20,763	13,826	13,885	
6	gp 0782	LV101	56,571683	22,606993	133,742	*133,6767*	23,600	23,413	23,313	110,204	110,267	
7	gp 0800	LV102	57,088583	22,799248	81,674	*81,6072*	21,690	21,468	21,399	60,065	60,132	
8	gp 0833	LV103	56,407852	23,677412	54,761	*54,6962*	23,031	22,829	22,709	31,813	31,870	
9	gr 8742	LV104	56,928926	23,581192	23,685	*23,6187*	21,403	21,175	21,083	2,412	2,474	-3
10	Aloja	LV105	57,772568	24,879732	102,878	*102,8092*	19,669	19,502	19,498	83,307	83,370	
11	Behova	LV106	55,695467	26,617537	201,603	*201,5403*	21,910	21,772	21,712	179,810	179,846	
12	Indra	LV107	55,879104	27,611137	213,625	*213,5617*	20,862	20,672	20,666	192,866	192,898	
13	Jaunjelgava	LV108	56,591562	25,152735	111,041	*110,9756*	21,597	21,514	21,422	89,550	89,601	-14
14	Kangari	LV109	57,094592	27,593663	163,854	*163,7872*	19,701	19,481	19,543	144,254	144,296	
15	Kolka	LV110	57,751916	22,588247	32,269	*32,2003*	20,556	20,191	20,179	11,799	11,872	14
16	Nesaules	LV111	56,960176	26,184897	305,730	*305,6636*	21,515	21,346	21,316	284,310	284,359	
17	Pastari	LV112	56,428242	26,747099	180,745	*180,6801*	20,941	20,798	20,755	159,907	159,949	
18	Pavari	LV113	57,363906	21,519453	52,415	*52,3474*	21,401	21,089	21,061	31,108	31,184	
19	Riga	LV114	56,948462	24,058597	29,337	*29,2706*	20,981	20,853	20,764	8,457	8,516	
20	Slamste	LV115	56,322584	21,226528	44,757	*44,6924*	24,454	24,210	24,139	20,394	20,462	
Mean values					94,905	94,839	21,540	21,328	21,278	73,46095	73,52005	

+21,2 cm +26,2 cm

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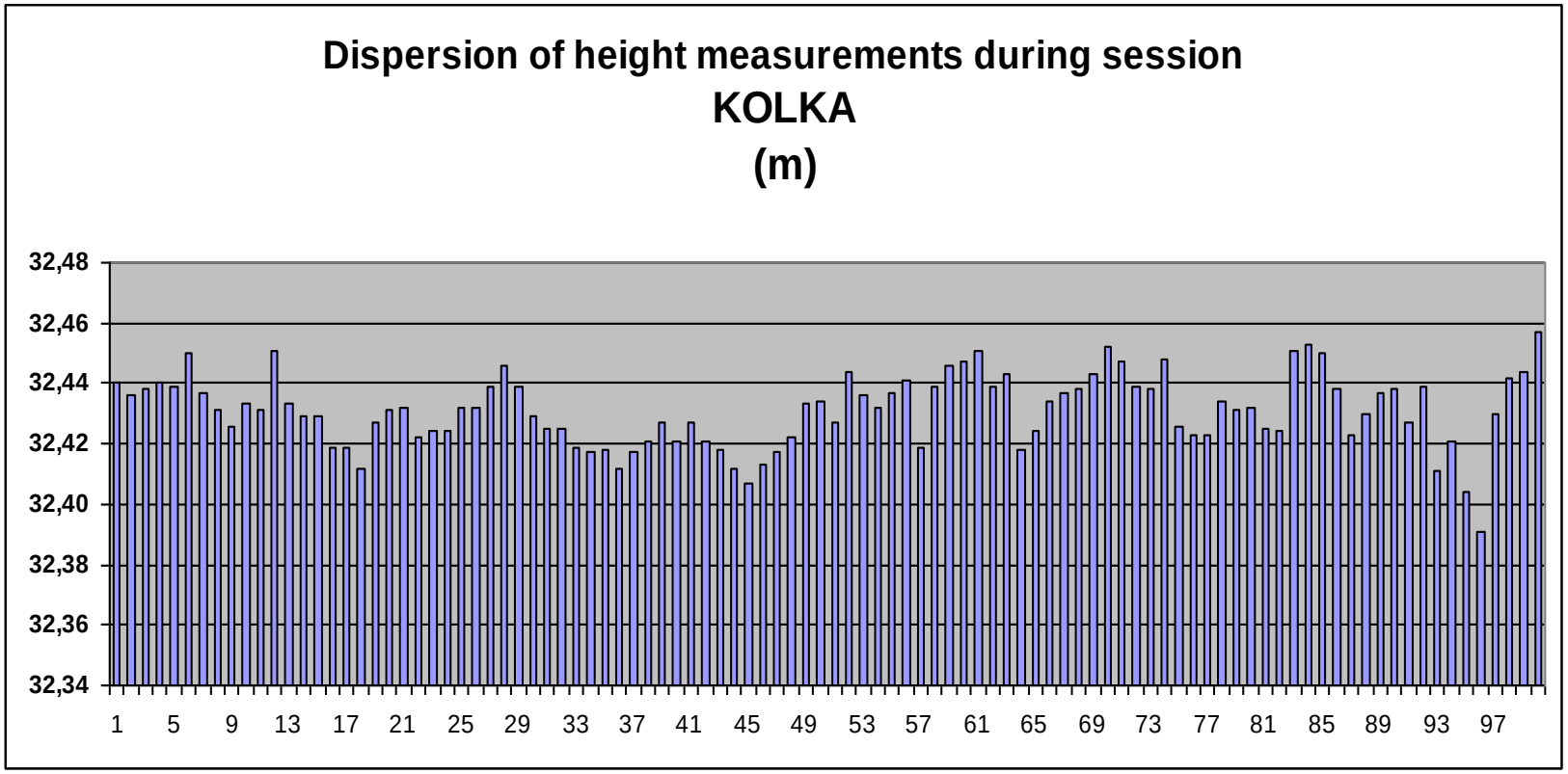
9. Additional measured points



Ellipsoidal height = 32,431 m → +16,2 cm

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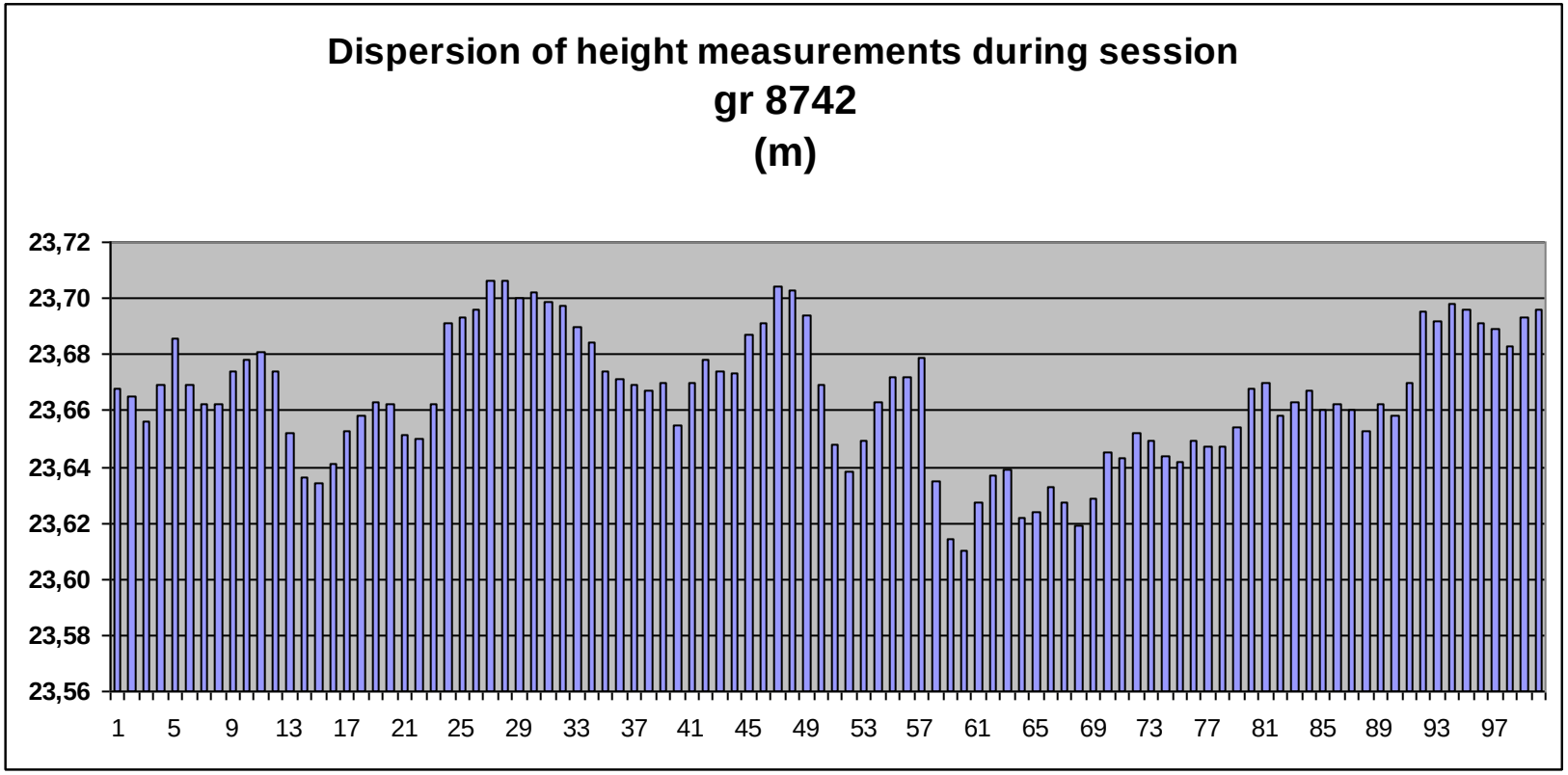
9. Additional measured points



Ellipsoidal height = 23,665 m → -2,0 cm

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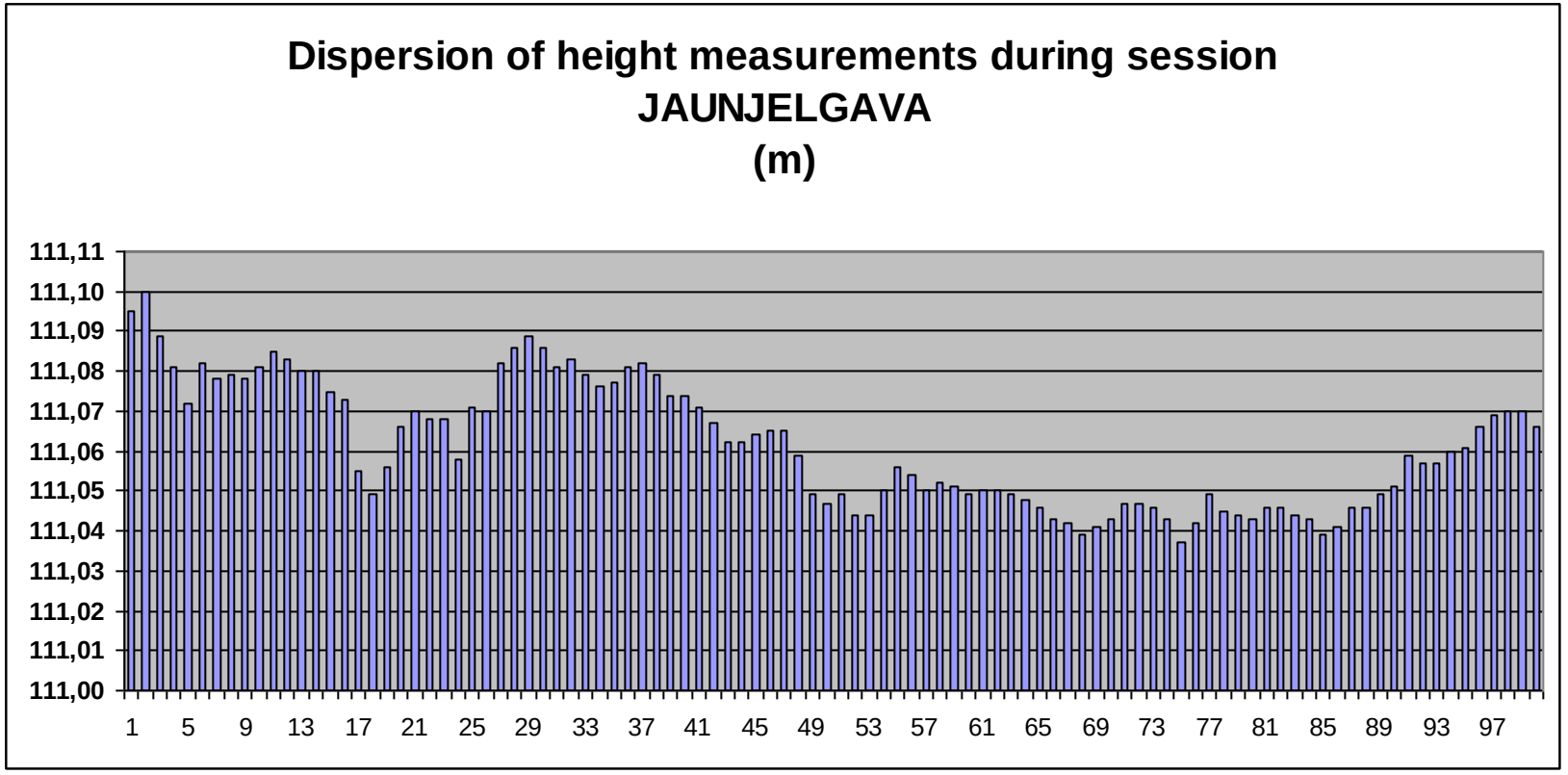
9. Additional measured points



Ellipsoidal height = 111,062 m → +2,1 cm

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9. Additionally measured EUVN points

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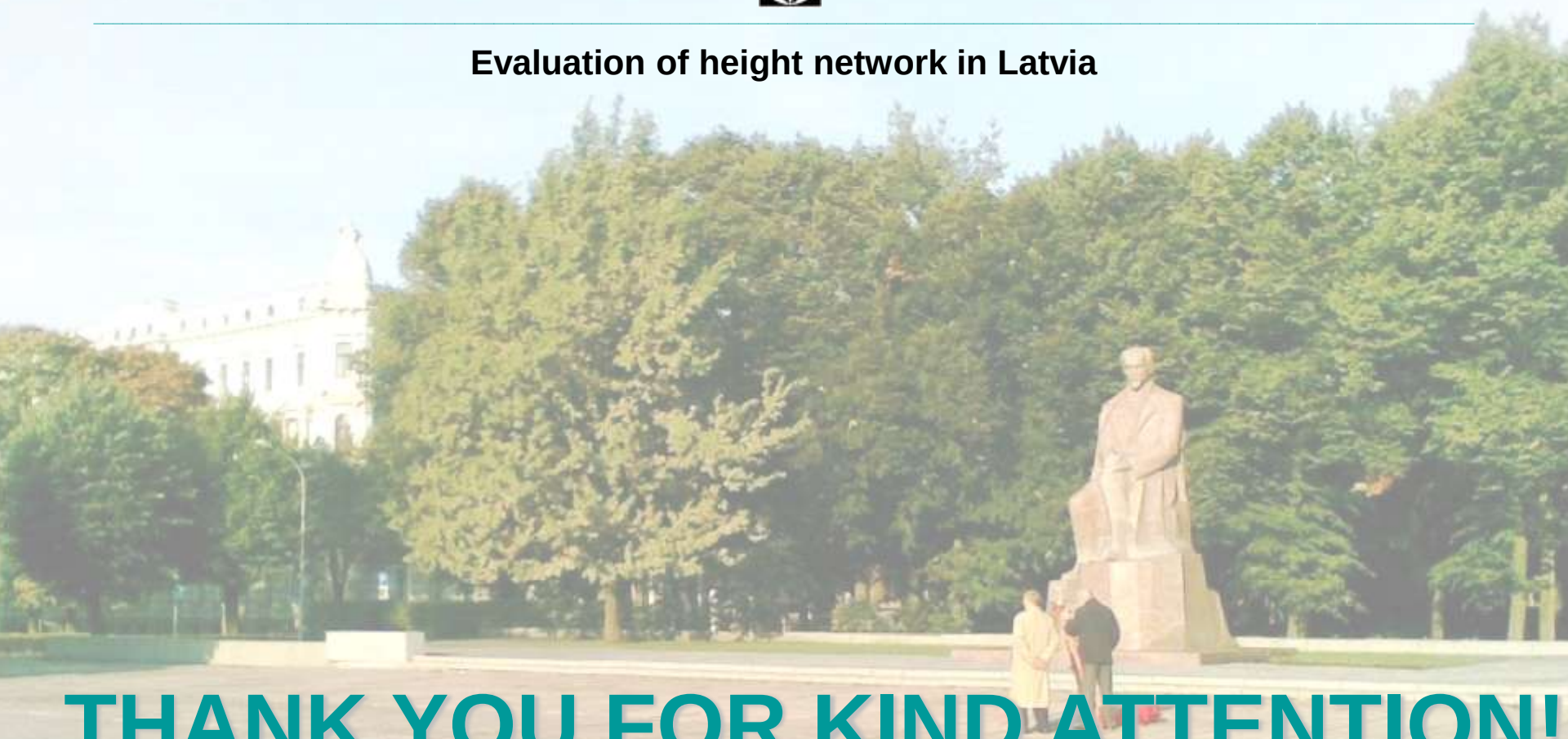

THANK YOU FOR KIND ATTENTION!

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