UNIVERSITY OF ZAGREB - Faculty of Geodesy
Croatia

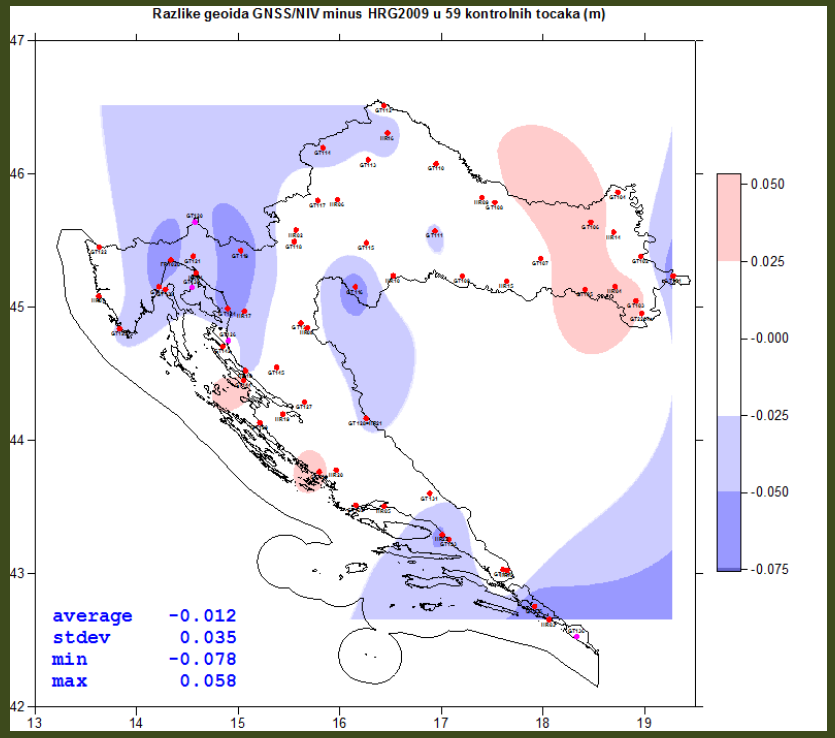
Local applicability of heights obtained by geoid model

Olga Bjelotomic, dipl.ing
Danko Markovinovic, PhD
Tomislav Basic, PhD

Aim of this study

- To test mutual correspondance between measured orthometric heights and the ones obtained from a New Croatian geoid model on the area of the city Zagreb,
- determine accuracy and useness of geoid model heights directly on the field regarding new national vertical datum

New Croatian geoid model *HRG2009*

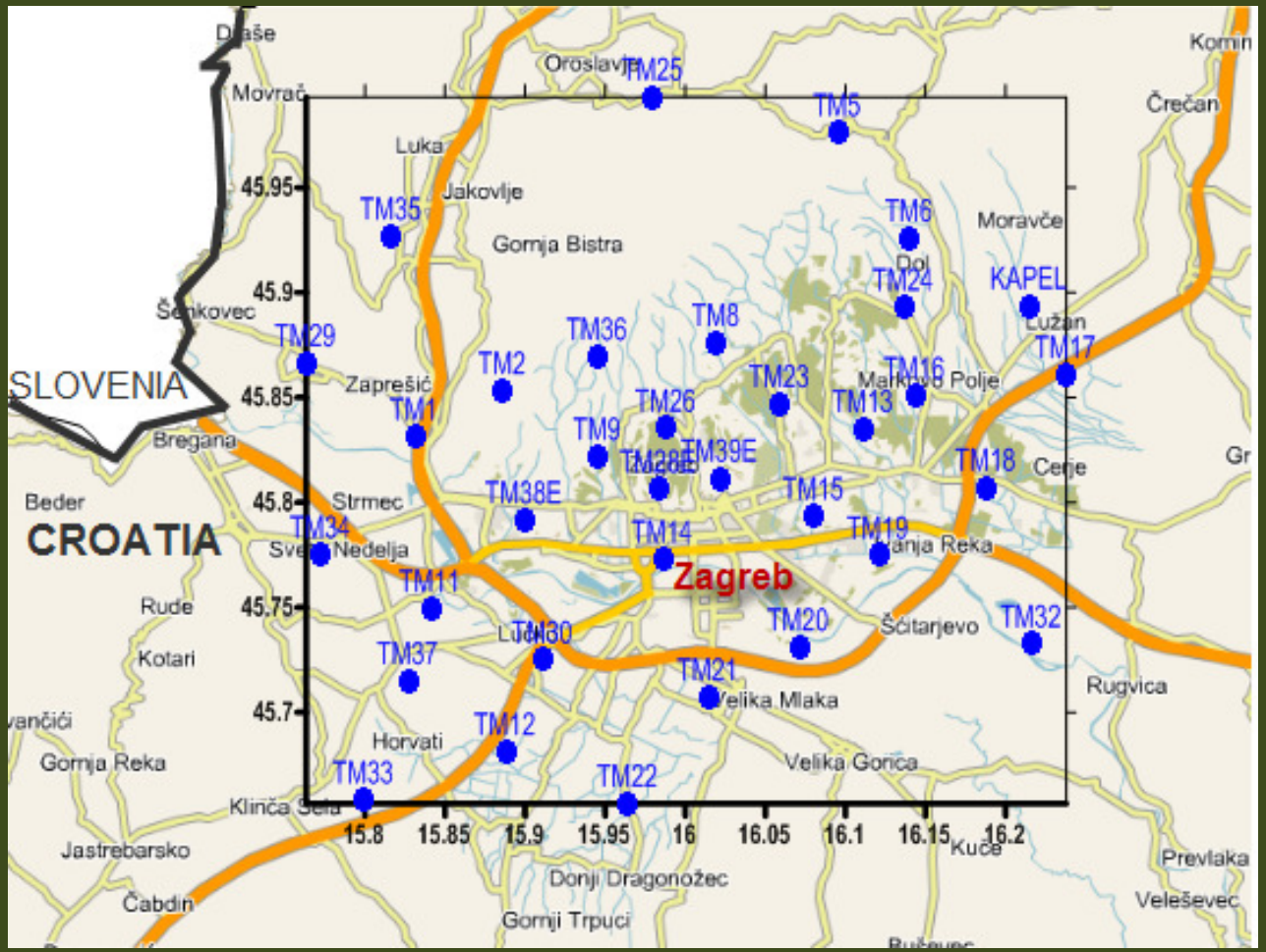


- **derived from the Earth's gravity field data used**:

- point free air anomalies (over 30000),
- discrete geoid undulations obtained by GPS/leveling on the mainland (495) and by satellite altimetry in the Adriatic Sea (400),
- long– and medium–wave field structures taken from the latest detailed global geopotential model EGM2008 (to the maximum degree and order of development 2160),
- high frequencies field structures modeled with the help of 3"x3" Shuttle Radar DEM's
- with implementation of least squares collocation calculation technique.

First part of a study:
Fundamental Network of Zagreb

- 25 points



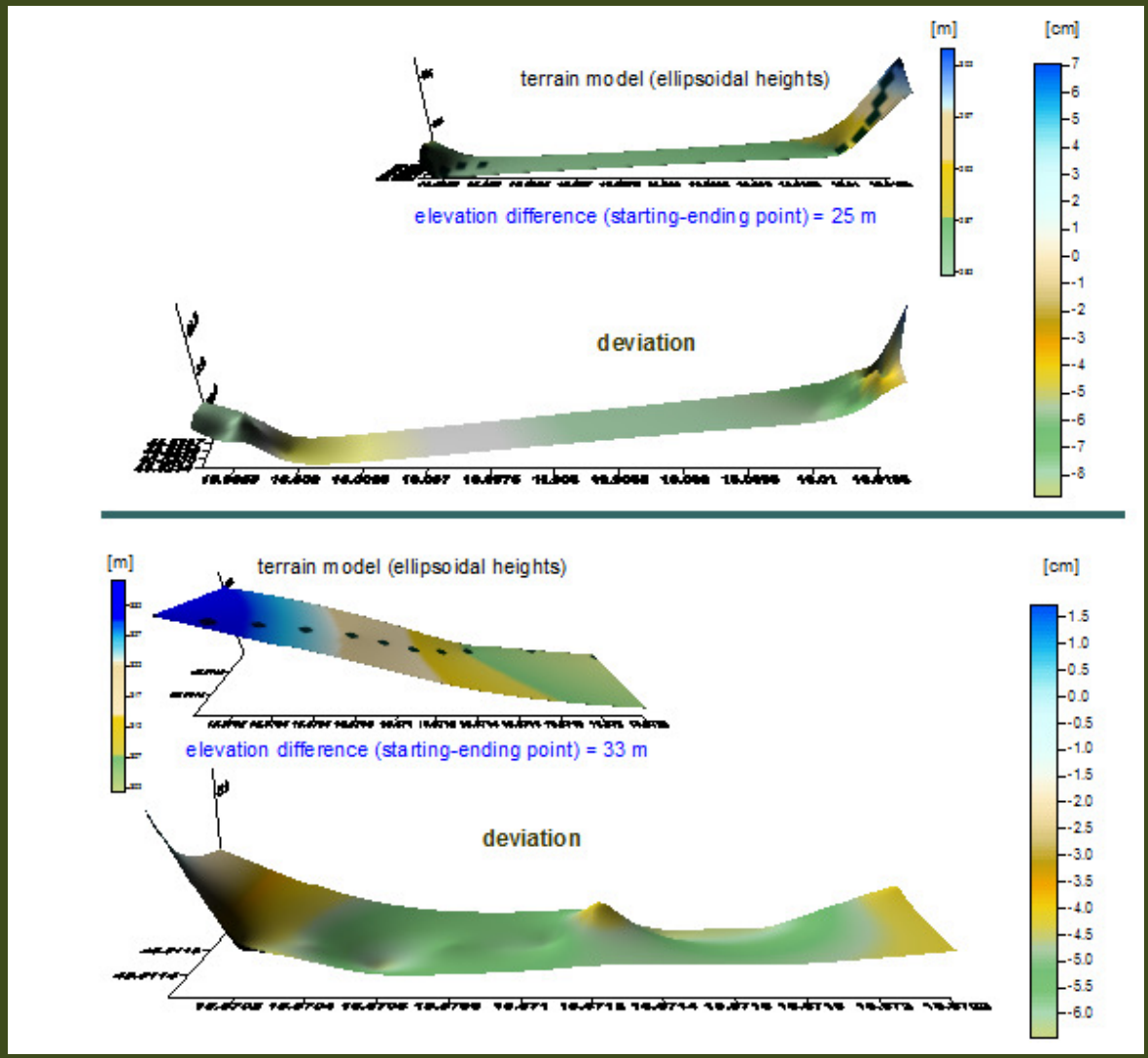
First part of a study: Fundamental Network of Zagreb

- 25 points

Point number	ETRS'89			ORTHOMETRIC HEIGHTS [m]		GEOID UNDULATION [mg		difference	
	φ	λ	h	leveling	calculating from HRG2009 geoid model	N leveled	N HRG2009	$H_{orth} - H_{HRG2009}$	residuals [m]
TM1	45°.49'51".3022	15°.49'35".2926	325.862	280.1855	280.1495	45.6765	45.7125	0.0360	**0.0182**
TM2	45°.51'10".0969	15°.52'52".7293	518.571	472.8400	472.7489	45.7310	45.8221	0.0911	**0.0733**
TM5	45°.58'33".3847	16°.05'26".0732	478.278	432.4765	432.4893	45.8015	45.7887	-0.0128	**-0.0306**
TM6	45°.55'32".5659	16°.08'07".0621	359.109	313.4466	313.4469	45.6624	45.6621	-0.0003	**-0.0181**
TM8	45°.52'32".9702	16°.00'53".6168	280.589	234.8092	234.7944	45.7798	45.7946	0.0148	**-0.0030**
TM9	45°.49'17".7431	15°.56'26".4957	237.556	191.9299	191.8934	45.6261	45.6626	0.0365	**0.0187**
TM11	45°.44'56".1884	15°.50'10".9073	178.535	132.9797	132.9705	45.5553	45.5645	0.0092	**-0.0087**
TM12	45°.40'51".1028	15°.52'59".4884	180.075	134.5948	134.5820	45.4802	45.4930	0.0128	**-0.0051**
TM13	45°.50'05".4461	16°.06'23".5201	167.801	122.3435	122.3350	45.4575	45.4660	0.0085	**-0.0093**
TM16	45°.51'01".0558	16°.08'19".6541	187.544	142.0921	142.0939	45.4519	45.4501	-0.0018	**-0.0196**
TM17	45°.51'37".2546	16°.13'58".7495	161.778	116.4553	116.4656	45.3227	45.3124	-0.0103	**-0.0282**
TM18	45°.48'24".5744	16°.10'59".6267	149.869	104.5508	104.5595	45.3182	45.3095	-0.0087	**-0.0265**
TM19	45°.46'27".9453	16°.06'57".2099	152.939	107.5780	107.5894	45.3610	45.3496	-0.0114	**-0.0293**
TM20	45°.43'50".3816	16°.03'58".5619	152.002	106.6322	106.6412	45.3698	45.3608	-0.0090	**-0.0268**
TM22	45°.39'22".3975	15°.57'34".5072	231.196	185.7438	185.7211	45.4522	45.4749	0.0227	**0.0049**
TM23	45°.50'47".5913	16°.03'15".7598	191.739	146.1702	146.1551	45.5688	45.5839	0.0151	**-0.0027**
TM24	45°.53'33".7054	16°.07'54".0291	204.839	159.2615	159.2619	45.5775	45.5771	-0.0004	**-0.0183**
TM25	45°.59'34".3483	15°.58'30".9901	327.446	281.7359	281.6828	45.7101	45.7632	0.0531	**0.0353**
TM26	45°.50'06".2211	15°.59'00".3397	253.804	208.1517	208.1389	45.6523	45.6651	0.0128	**-0.0050**
TM29	45°.51'58".3236	15°.45'30".6207	179.559	133.8278	133.8159	45.7312	45.7431	0.0119	**-0.0059**
TM30	45°.43'28".9101	15°.54'23".4561	168.834	123.3404	123.3367	45.4936	45.4973	0.0037	**-0.0142**
TM33	45°.39'28".7595	15°.47'41".0735	196.816	151.3684	151.2970	45.4476	45.5190	0.0714	**0.0536**
TM34	45°.46'28".46	15°.46'05".2401	294.228	248.5823	248.5356	45.6457	45.6924	0.0467	**0.0289**
TM35	45°.55'35".5151	15°.48'42".6073	245.6	199.8756	199.8392	45.7244	45.7608	0.0364	**0.0186**

Second part of a study: particular mountainly rough area

- **2 leveled trains**: 800 and 1200 meters of lenght
- **30 meters of height difference** between start and end point



	deviation [cm]
min	-6.45
max	1.73
average	0.00
st.dev.	2.32

Conclusion

- Results have shown very good accurracy and adaptability of new geoid model *HRG2009* to local changes of relief, observed in detail on a wide area of the city of Zagreb. Its average deviation regard to terrain is around 2 centimeters,
- (?) Stays questionable should terrain defined with leveled orthometric heights be the reference surface because of uncertainty and often poor conditions of benchmarks
- Local adaptability proved to be adequately accurate even in mountanious area with large slopes (tested up to 30 meters in height difference) on the border areas of the city. In this conditions, orthometric heights obtained from a geoid model still reserves absolute provided accuracy and can be used for purposes of land registery because required register accuracy is smaller then accuracy of *HRG2009*.
- It is useful in the precise height definition using modern GNSS tecnology where is more efficient, economic and faster method then leveling but with the same, if not even better, accuracy and exactness.
- New Croatian geoid model *HRG2009* proved to be reliable representation of relief in local appliance, and significant contribution to local engineering tasks.

Conclusion

- Results have shown very good accurracy and adaptability of new geoid model *HRG2009* to local changes of relief, observed in detail on a wide area of the city of Zagreb. Its average deviation regard to terrain is around 2 centimeters,
- (2) Stays questionable should terrain defined with leveled orthometric heights be the
- provided accuracy and can be used for purposes of land registery because required register accuracy is smaller then accuracy of *HRG2009*.
- It is useful in the precise height definition using modern GNSS tecnology where is more efficient, economic and faster method then leveling but with the same, if not even better, accuracy and exactness.
- New Croatian geoid model *HRG2009* proved to be reliable representation of relief in local appliance, and significant contribution to local engineering tasks.

Thank you for attention!