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QUALITY ANALYSIS OF THE CROATIAN HEIGHT TRANSFORMATION MODEL: CASE STUDY CITY OF SLAVONSKI BROD

INTRODUCTION

The Republic of Croatia, throughout the history to the present day, is using two height reference systems:

- old height reference system (Trieste, Mol Sartorio) – *HVRS1875*

- new height reference system (Dubrovnik, Split, Bakar, Koper and Rovinj) – *HVRS71*

Croatian height transformation model – *HTMV*

- the aim of this research is to examine and analyze the external quality of the Croatian height transformation model

- urban area (*Slavonski Brod*)

CROATIAN HEIGHT TRANSFORMATION MODEL

- elevation data of the same bench marks contained in the old and the new height reference system in the Republic of Croatian and Bosnia and Herzegovina

Differences between height coordinates of bench marks H_Δ were determined by the expression:

$$H_\Delta = H_S - H_N$$

- transformation model, is mathematically modeling the differences variability of absolute height H_Δ by using two different components that are contained in them - the datum $H_{\Delta D}$ and distortion $H_{\Delta d}$ components

Fig. 1: Surface od Croatian height transformation model – realisation *HTMV08v.1*
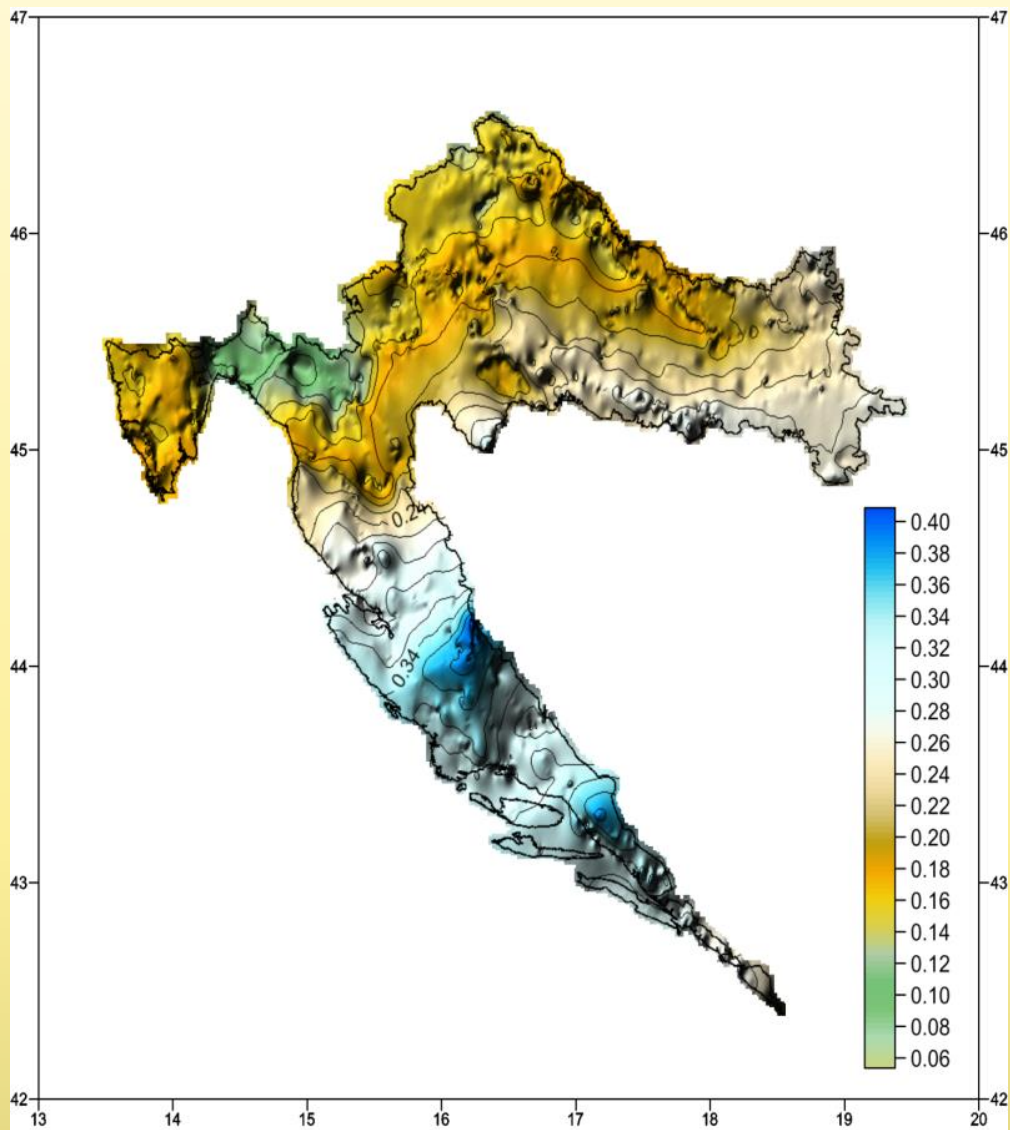
- grid transformation model
- transformation of height with an accuracy of 1 cm

LEVELLING NETWORK DATA OF SLAVONSKI BROD

- the total number of available bench marks, according to levelling forms no. 3 is 198

- unavailability of bench marks planar position of destroyed bench marks

- based on the bench marks known planar position and medium length levelling side data, bench marks planar coordinates that were originally unknown were defined

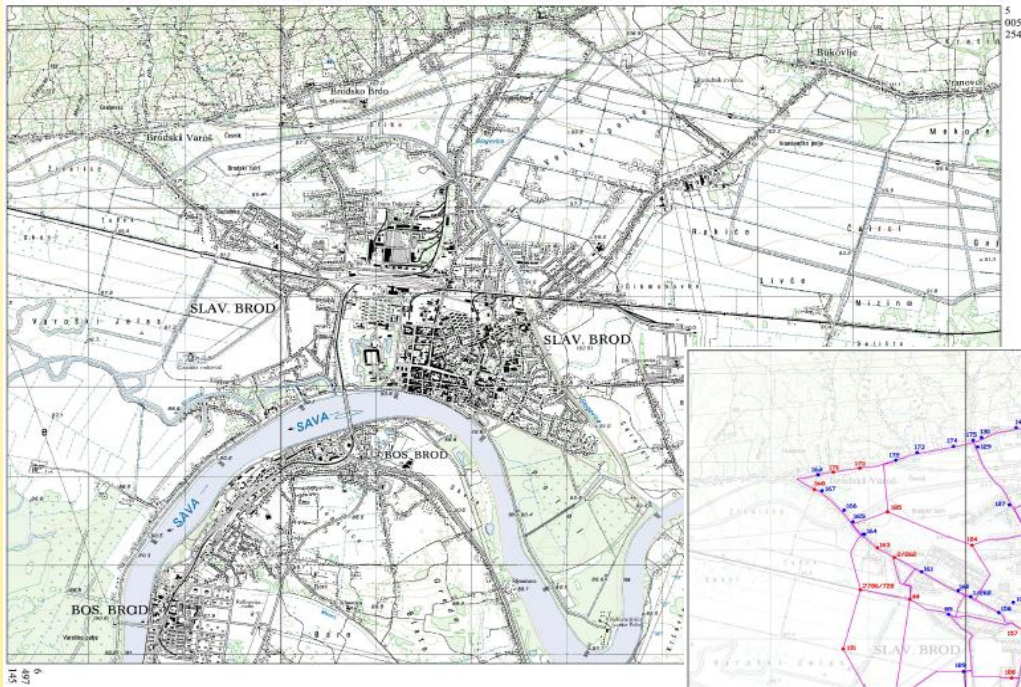- total number of bench marks potentially suitable for testing the quality of the model is 54
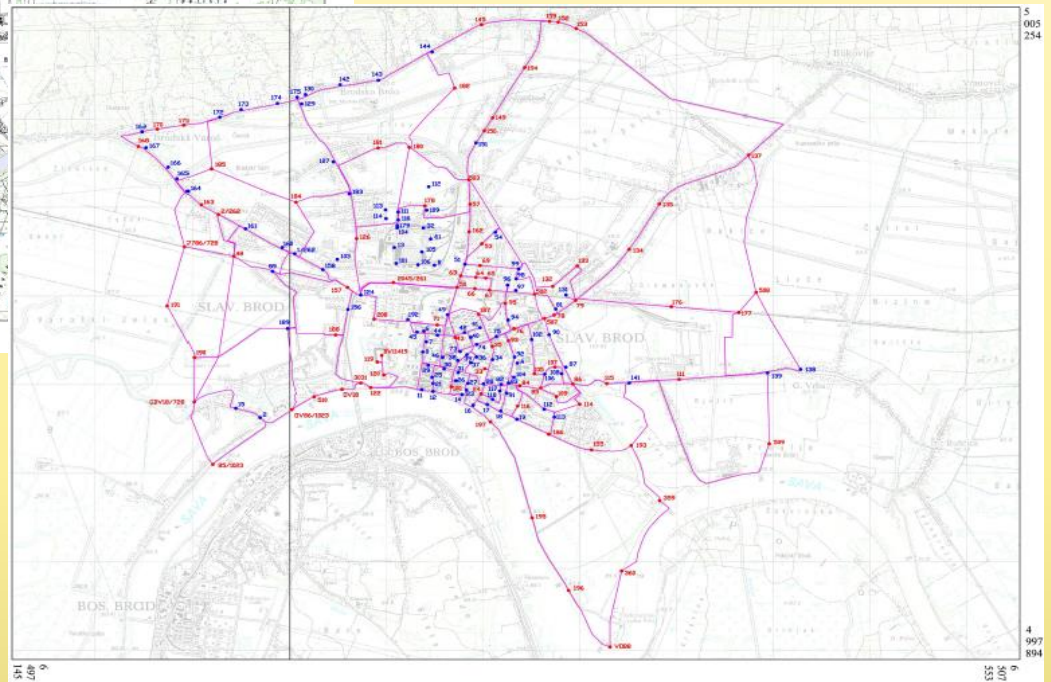
Fig. 2: Map with topographic base of Slavonski Brod

Fig. 3: Map with topographic base with the city levelling network

BENCHMARK DATA ANALYSIS FOR THE PURPOSE OF DISCLOSURE OF GLOBAL AND LOCAL SPATIAL OUTLIERS

- dataset of bench marks suitable for testing the quality of the transformation model has to be tested in order to detect the presence of so-called spatial outliers

- spatial outliers - global, referring to the entire collection of spatial data and local, relating to a part of spatial data from their immediate environment

- software program Geoda

- **boxplot** (fig. 4), the **histogram** (fig. 6), **spatial scatter diagram** and **standardized scatter diagram** (fig. 5) for the purpose of detection of **global spatial outliers**, and **Moran dispersion diagrams** and **Voronoi diagram** (fig. 7) for the purpose of detection of **local spatial outliers**

Analysis of spatial data for the purpose of detection global outliers are identified bench marks values: 53, 54, 122 and OV86/1023.
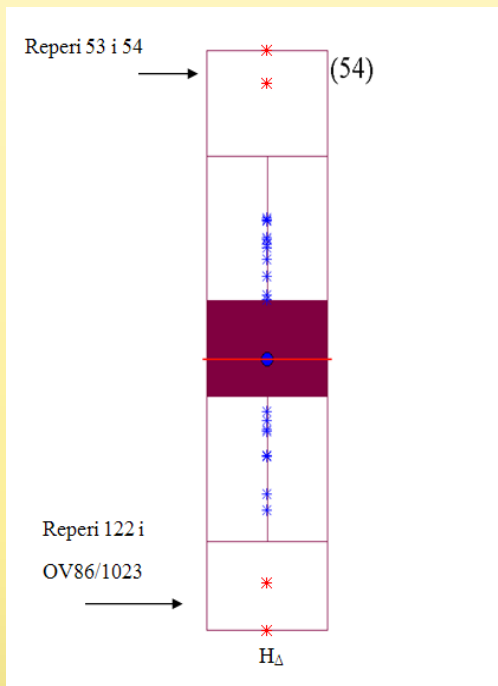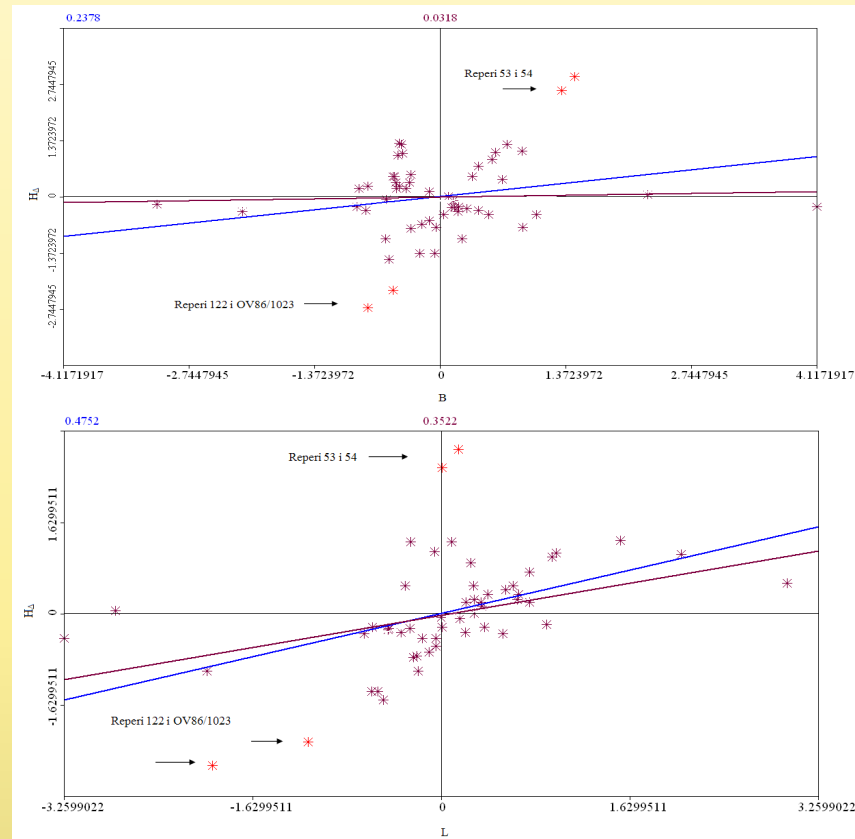

Fig. 4: Boxplot differences of H_Δ
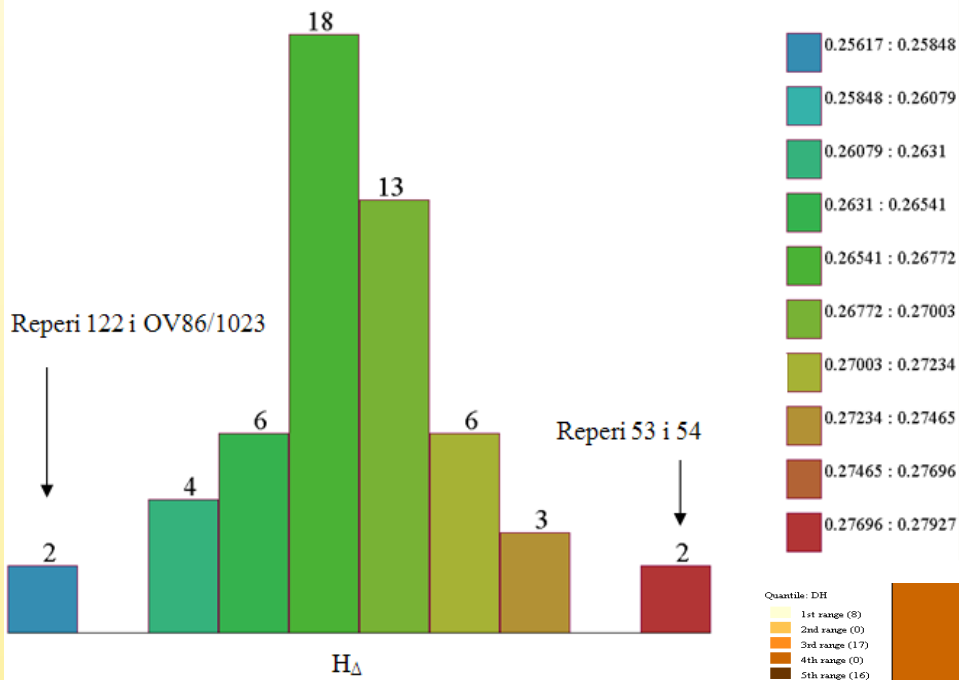

Fig. 5: Standardized scatter diagram

Fig. 6: Histogram differences of H_Δ

The analysis of spatial data for the purpose of detection of local outliers are identified bench marks values: 26, 100 and 196.
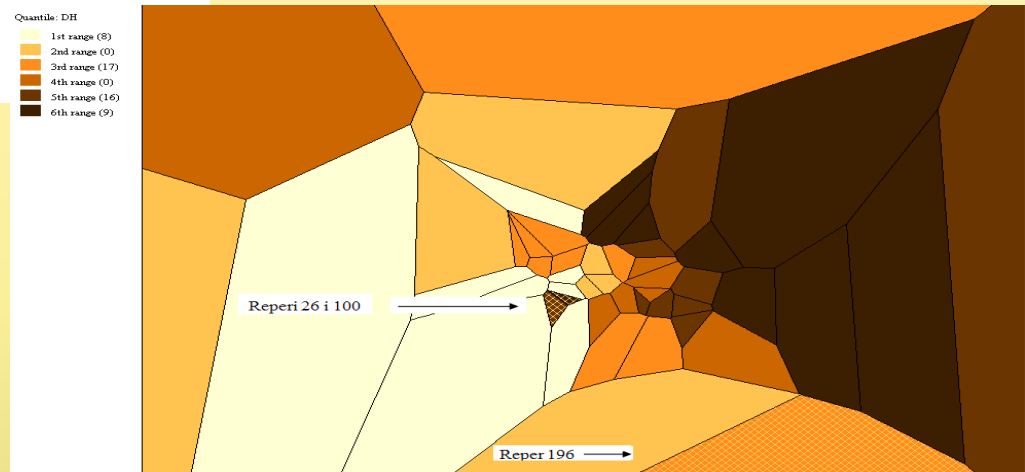

Fig. 7: Voronoi diagram of positional distribution differences H_Δ

DETERMINING QUALITY TRANSFORMATION MODEL INDICATORS

- the final data set for analysis of external quality of HTMV makes a definite set of test data of 20 bench marks presented in the table 1

- bench marks that were originally used in the creation of this model were eliminated

- the extraction part of the transformation grid from the original grid of Croatian height transformational model (HTMV) was performed using Surfer software program

- transformation grid file that contains the modeled values of transformation parameters on the grid nodes was obtained

Tab. 1: A set of test data bench marks for HTMV quality testing

Broj repera	HVRS1875 H_S m	HVRS71 H_N m	$H_Δ$ m
24	92.4517	92.1847	0.2670
43	92.9841	92.7179	0.2662
63	93.2434	92.9792	0.2642
64	94.2854	94.0136	0.2718
67	95.2553	94.9828	0.2725
71	91.9167	91.6506	0.2661
78	96.1389	95.8686	0.2703
79	96.1276	95.8559	0.2717
84	93.3424	93.0737	0.2687
85	94.0721	93.8028	0.2693
86	92.6980	92.4266	0.2714
93	94.9038	94.6365	0.2673
95	96.2847	96.0137	0.2710
111	93.1824	92.9108	0.2716
141	94.6365	94.3639	0.2726
145	114.4034	114.1371	0.2663
185	92.5255	92.2580	0.2675
191	86.5674	86.3019	0.2655
195	88.3967	88.1309	0.2658
502	96.2041	95.9351	0.2690

Considering that for every bench mark from the test set of bench marks is available value differences of height coordinates obtained by direct survey and value differences of bench marks height coordinates obtained by modeling, the conditions for determination the quality of the external transformation model in Slavonski Brod are acquired.

The quality of the transformation model is shown by deviation between directly determined and modeling determined absolute values of differences of bench marks height coordinates, respectively:

$$\varepsilon = H_Δ - \overline{H}_Δ$$

Using the deviation ε the standard deviation is determined as a fundamental indicator of external quality transformation model, i.e.

$$s = \sqrt{\frac{\varepsilon^t \varepsilon}{n}} = 2{,}62 mm.$$

-standard deviation in the area of Slavonski Brod takes a very small amount

-that amount is within the proclaimed tolerance of internal and external quality transformation model HTMV, amounting to 1 cm

CONCLUSION

- indicator or criterion of external quality of Croatian height transformation model was standard deviation

-- the standard deviation obtained for the area of Slavonski Brod is 2.62 mm

-- it shows that the external quality of HTMV is very high

-- standard deviation indicates the model application acceptability to transform the bench marks height coordinates from the old to the new height system, and vice versa, if the bench marks ellipsoidal position are available

THANK YOU ☺

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