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Estimation of Vertical Dynamics on the Territory of Austria and the Czech Republic Based on Results of Historical Levellings

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Estimation of Vertical Dynamics on the Territory of Austria and the Czech Republic Based on Results of Historical Levellings

Kurt Bretterbauer, Wien und Antonin Zeman, Prag

Zusammenfassung

Der Artikel gibt eine Abschätzung der vertikalen Bewegung der Erdoberfläche auf dem Gebiet nahe der Grenze zwischen Österreich und der Tschechischen Republik, abgeleitet aus Nivellements, die ursprünglich auf dem Staatsgebiet des ehemaligen Österreich-Ungarischen Kaiserreiches und später auf den Territorien der beiden individuellen Staaten durchgeführt worden waren. Nach ungefähr 100 Jahren, in den Neunzigern unseres Jahrhunderts, war es neuerlich möglich, beide Nivellementnetze durch direkte Beobachtungen zu verbinden. Rückschlüsse auf die gegenwärtigen Beziehungen beider Netze zum Einheitlichen Europäischen Nivellementnetz (UELN) werden gezogen.

Abstract

The paper gives an estimation of the vertical dynamics of the Earth's surface on the territory close to the border between Austria and the Czech Republic from levelling observations originally carried out on the territory of the former Austro-Hungarian Empire and thereafter on the territories of the individual states. After approximately 100 years, in the nineties of this century, it again was possible to connect both networks directly by observations. Conclusions are drawn on the present relation of both networks to the Unified European Levelling Network (UELN).

1. Reconstruction of the Levelling Network on the Territory of the Former Austro-Hungarian Empire

From the data of the Austro-Hungarian Military Geographic Institute (MGI) stored in the archives of the Federal Office of Metrology and Surveying (BEV) the western part of the former Austro-Hungarian levelling network, originally established in the eighties of the last century, was reconstructed by forming and adjusting closed loops. The only constraint for the adjustment was to retain the original height of the datum point of the network at Trieste (3.3520 m above the Adriatic sea level). Adjusted normal orthometric heights were compared with archieved original heights. The new adjustment aimed on checking the values computed 100 years ago. In the case of the fundamental levelling point Liov it served for checking the height value, which is used since that time without changes. The results of the adjustment of the network mentioned are presented in Table 1 in the form of heights of junction points and their rms-errors. In this Table the original heights and their differences to the newly computed heights also are given. For better demonstration, the values of the height differences of both adjustments and the values of the rms-errors of the newly computed heights are represented by isolines in Figs. 1, and 2 resp.

The height differences of both adjustments based on identical input values give no information on some more significant errors of the original adjustment. The differences, however, are increasing systematically with growing distances from the initial point of the network, and at some distinctly limited localities they reach rather large values, but due to the rms-errors of the adjustment of the network (see Fig. 2) those values are not really significant.

Point	New height m	rms-error m	Old height m	New-Old m
Triest	3.3520	0.0000	3.3520	–
Sagrado	31.1439	0.0165	31.1450	– 0.0011
Tarvis	732.6575	0.0250	732.6621	– 0.0046
Laibach	296.1452	0.0241	296.1419	0.0033
Adelsberg	553.4171	0.0188	553.4156	0.0015
Sessana	361.2253	0.0118	361.2247	0.0006
Villach	504.9154	0.0281	504.9222	– 0.0068
Klagenfurt	443.3801	0.0294	443.3992	– 0.0191
B.W.H. Nr. 147	270.1808	0.0312	270.1671	0.0137
Kranichsfeld	272.4520	0.0313	272.4392	0.0128
Cilli	240.2568	0.0304	240.2481	0.0087
Spittal	562.1572	0.0318	562.1576	– 0.0004
Radstadt	832.3655	0.0336	832.3591	0.0064
Neuhaus	646.1148	0.0338	646.1106	0.0042
St. Michael	596.8139	0.0327	596.8121	0.0018
Leoben	540.9788	0.0330	540.9770	0.0018
Bruck	491.0868	0.0333	491.0461	0.0407
Graz	365.9120	0.0343	365.9055	0.0065
Bischofshofen	547.1554	0.0344	547.1463	0.0091
Hallein	447.6834	0.0358	447.6787	0.0047
Salzburg	425.8431	0.0358	425.8408	0.0023
Ischl	470.4721	0.0350	470.4692	0.0029
Braunau	352.3579	0.0394	352.3558	0.0021
Schärding	316.6187	0.0396	316.6168	0.0019
Wels	319.2359	0.0365	319.1889	0.0470
Enns	253.9799	0.0368	253.9249	0.0550
Amstetten	276.2173	0.0363	276.1629	0.0544
Penzing	209.4854	0.0386	209.4706	0.0148
Jedlesee	166.5418	0.0390	166.5241	0.0177
Floridsdorf	168.4750	0.0390	168.4573	0.0177
Neu Erlaa	203.1892	0.0387	203.1757	0.0135
Budweis	392.4057	0.0418	392.4019	0.0038
Lišov	565.1526	0.0420	565.1483	0.0043
Znaim	265.3988	0.0411	265.3906	0.0082
Grussbach	193.4157	0.0406	193.4084	0.0073
Laa	186.4545	0.0404	186.4485	0.0060
Lundenburg	162.6457	0.0410	162.6362	0.0095
Gänserndorf	160.6153	0.0407	160.6049	0.0104
Prerau	212.6000	0.0422	212.5848	0.0152
Schönbrunn	216.3427	0.0442	216.3264	0.0163
Okøischko	479.6165	0.0421	479.6066	0.0099
Raigern	200.4925	0.0415	200.4820	0.0105
Wischau	261.5248	0.0421	261.5106	0.0142
Olmütz	217.0176	0.0424	217.0008	0.0168
Troppau	270.5649	0.0451	270.5484	0.0165
Pardubitz	223.7461	0.0436	223.7340	0.0121
Wildenschwert	328.6169	0.0451	328.6033	0.0136
F. J. B. Prag	212.1180	0.0438	212.1078	0.1020
St. B. Prag	196.8853	0.0438	196.8754	0.0099
N. W. B. Prag	191.8407	0.0438	191.8302	0.0105
Turnau	264.8459	0.0462	264.8391	0.0068
Parschnitz	406.9987	0.0479	406.9892	0.0095
Schlancy	347.9448	0.0472	347.9346	0.0102
Sandthor Prag	237.9524	0.0439	237.9398	0.0126
Aussig	146.4951	0.0462	146.4759	0.0192
Bodenbach	135.4079	0.0474	135.3904	0.0175
Zittau	265.4553	0.0484	265.4437	0.0116
W. B. Prag	199.0118	0.0439	198.9994	0.0124

Point	New height m	rms-error m	Old height m	New-Old m
Karlsbr. Prag	193.9985	0.0439	193.9839	0.0146
Horazdovice	434.0422	0.0452	434.0352	0.0070
Eisenstein Mkt.	780.4449	0.0479	780.4360	0.0089
Taus	425.0009	0.0481	424.9898	0.0111
Pilsen	322.7130	0.0451	322.6998	0.0132
Eger	466.4274	0.0499	466.4126	0.0148
Komotau	354.5976	0.0470	354.5811	0.0165
Wr. Neustadt	269.9455	0.0391	269.9351	0.0104
Wörgl	507.8100	0.0419	507.8294	– 0.0194
Franzensfeste	749.1936	0.0421	749.1569	0.0367
Bozen	268.0072	0.0458	267.9822	0.0250
Nauders	1364.6894	0.0483	1364.6914	– 0.0020
Landeck	793.8058	0.0472	793.8182	– 0.0124
Zirl	630.1035	0.0434	630.1317	– 0.0282
Innsbruck	584.0746	0.0421	584.1063	– 0.0317

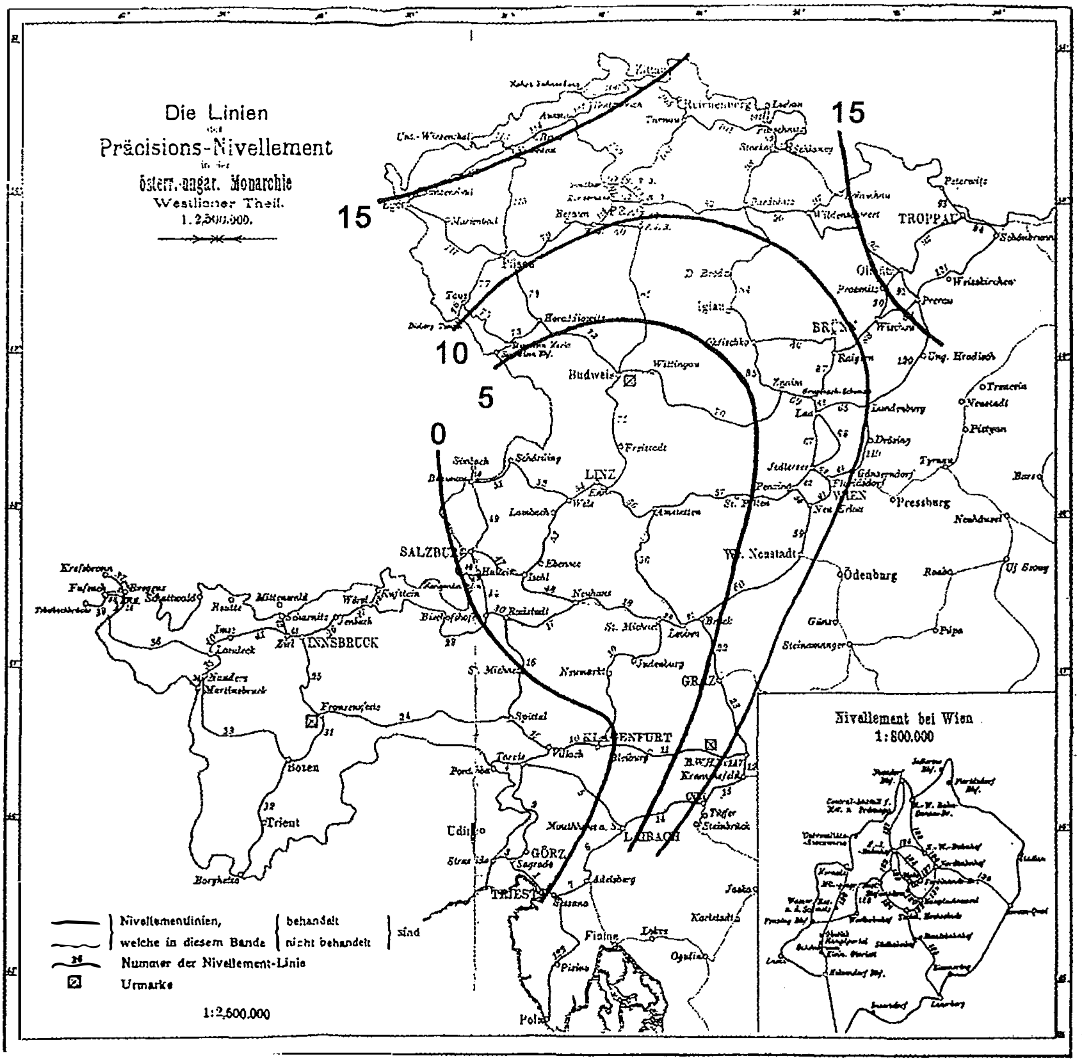

Fig. 1: Height Differences „new minus old adjustment“ in mm

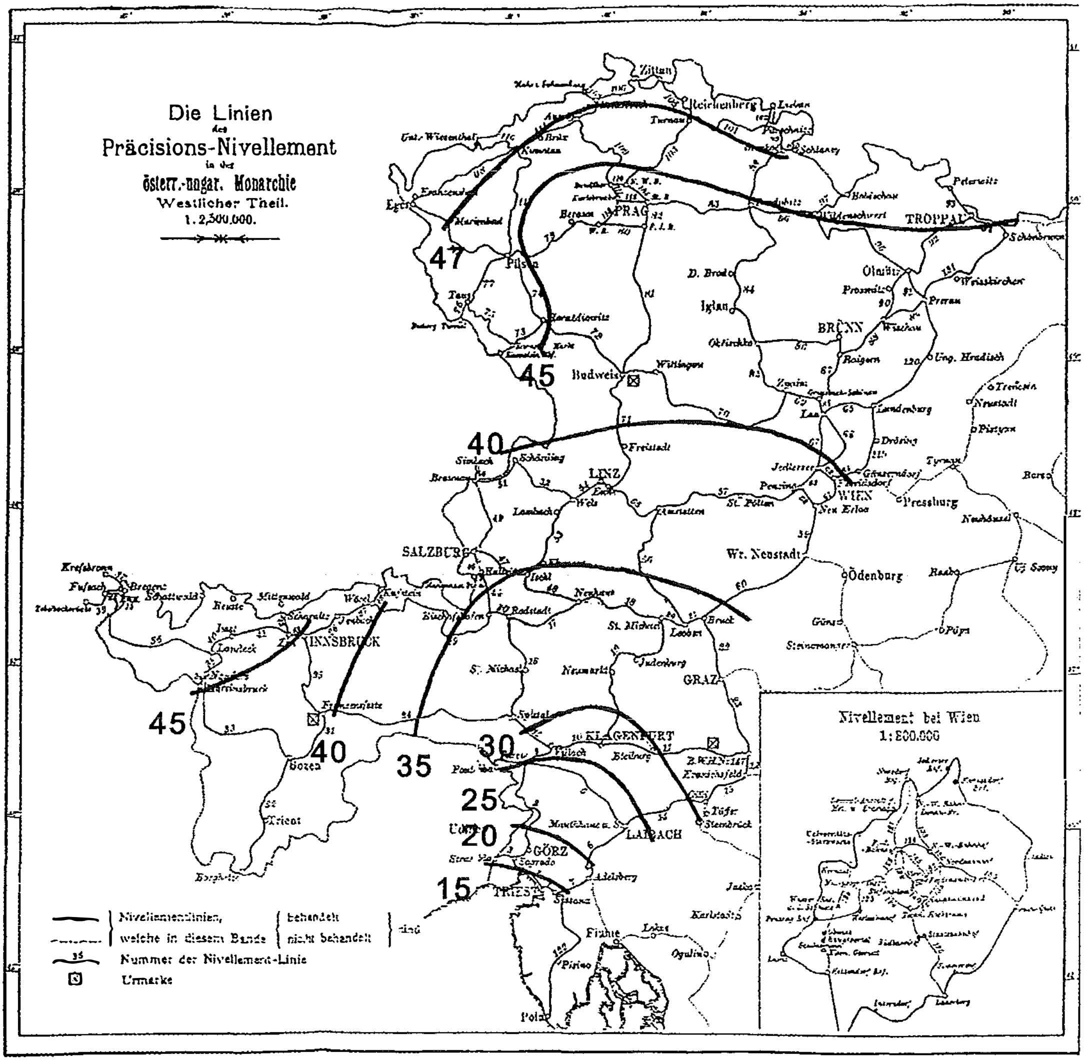

Fig. 2: rms-errors of the new adjustment in mm

An important quality of the new adjustment of the height network on the territory of the former Austro-Hungarian Empire is the determination of rms-errors of the adjustment, characterizing its quality. The second significant result is the verification of the height of the fundamental levelling point Lišov, which is unchanged since the original adjustment and served as a reference height for the system of heights of former Czechoslovakia and of the present Czech Republic for about 70 years. The difference between both adjustments of 4.3 mm for Lišov is due to the rms-error of the adjustment of the whole network, reaching ± 42.0 mm, and appears insignificant, such confirming the original height of Lišov as well determined. This conclusion is important in view of the fact that the reference height of point Lišov could not be verified neither by observation nor by calculations for the whole period of its validity.

2. Evolution of Heights on the Northern Part of the Austro-Hungarian Levelling Network up to the Nineties of this Century

The newly established levelling network on the territory of former Czechoslovakia after 1918 was based on levelling lines completely independent of the configuration of the original network. During the period of observations, mainly in the 30ies and 40ies, however, some points of the original network were connected to and their heights computed in the newly established height system, which was called CSULN (Czechoslovak Unified Levelling Network). The heights were still defined as normal orthometric heights and the reference point of this network was again the point Liov with its height taken from the original adjustment.

In order to find suspected height changes during the period between the mean epochs of the original Austro-Hungarian Levelling Network (1881.2) and CSULN (1943.2) 62 common points were identified in both networks. Preliminary tests proved 14 of them to show anomalous height changes being completely out of trend limits displayed by the other points. This can be explained by instability of objects bearing the relevant bench marks. Values of height changes are represented by isolines as interpolated between the remaining 48 points (Fig. 3).

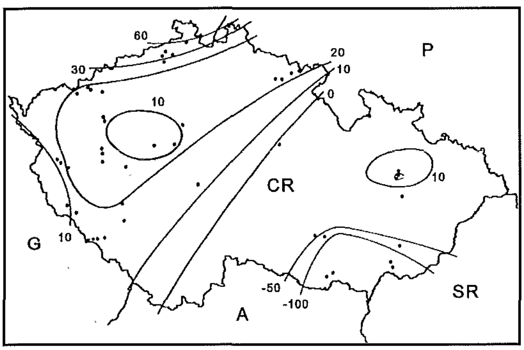

Fig. 3: Height-differences of identical points (epoch 1943 minus epoch 1881) in mm

Fundamental conclusions from Fig.3 are the distinctly negative height changes in the south-eastern part of the territory and the more or less systematically increasing changes in north-west direction.

The northern part of the network on the territory of former Czechoslovakia such analysed was remeasured (mean epoch 1976) in the course of the complete East-European network with the aim of obtaining information on so-called recent vertical crustal movements. Independently of that the levellings on the territory of former Czechoslovakia were adjusted in the system of normal orthometric heights and based on the Adriatic Sea Datum (i.e. relatively to the height of Lišov). This new heights were compared with the epoch 1943 (period = 1976 minus 1943). Isolines of the same height differences are presented in Fig. 4. The principal trends are very similar to those previously shown.

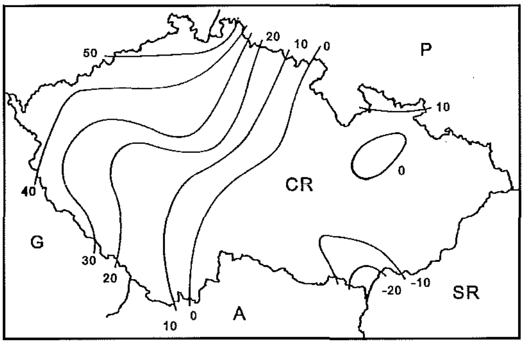

Fig. 4: Height-differences of identical points (epoch 1976 minus epoch 1943) in mm

Results of relevellings from the seventies were further used for the comparison of the two original fundamental bench marks Lišov and Nadap (Hungary). The Austro-Hungarian levelling network then had been processed in three separate parts. At first the western part was adjusted, including point Lišov directly connected to the Adriatic Sea at Trieste. The eastern and south-eastern parts were connected to the western part as supplements. Point Nadap was the main bench mark of the south-eastern part of the network. Clearly, the whole network had to be very inhomogeneous. Geodetic Surveys of former Czechoslovakia and Hungary decided to confirm previously determined height differences using results of relevellings from the seventies of this century. The resulting height difference between Lišov and Nadap, computed from their original normal orthometric heights and referring to the Adriatic Sea Datum, amounted to 270 mm. This value represents the constant difference between the two parts of the former network and simultaneously had been the constant difference between Czechoslovakian and Hungarian heights before the introduction of the common Baltic Sea Datum (Kronstadt).

First direct levelling connections to the Austrian levelling network, more than 100 years after the original observations, with the aim of obtaining data for including the network on the territory of the Czech Republic into the Unified European Levelling Network (UELN), were carried out in 1991. After computations of the heights, done by both geodetic surveys, significant and rather unexpected height differences were determined (in the sense Austrian Trieste Datum minus Czech Trieste Datum) on average reaching the value of about 100 mm (Fig.5).

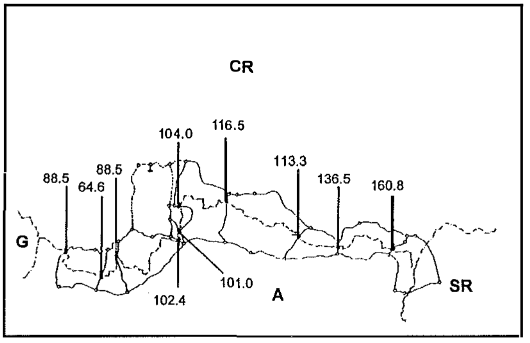

Fig. 5: Height-differences (Austrian minus Czech Trieste Datum) in mm

An explanation of this discrepancies can be based on the following facts:

- The height of point Lišov was determined in the last century with a rms-error of $\pm$ 42 mm and since that time it is used with its original value. This could partly be the source of the differences of height levels. The discrepancies also can partly be explained by the fact that the height difference between the Austrian and the Slovenian networks (taken in the same sense Austrian Trieste Datum minus Slovenian Trieste Datum) reaches the average value of about –100 mm. This difference is especially significant because both networks are territorially close to the reference height at Trieste.
- Increasing values of height differences along the common border of Austria and the Czech Republic in west-east direction are probably caused by different ways of considering the vertical dynamics of the Earth's on the territory along the common border. The fact that in this area the vertical dynamic is very strong is evidenced by Figs. 3 and 4.

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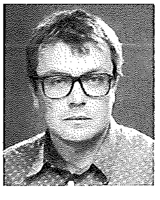

Ausgleichung nach der Methode der kleinsten Quadrate mit der a posteriori Schätzung der Gewichte

Florijan Vodopivec und Dušan Kogoj, Ljubljana

Zusammenfassung

Die a posteriori-Varianzenschätzung ist ein iterativer Process. Die Beobachtungen können sinnweise in Gruppen vereinigt sein. Die annähernde Anfangswerte der Gruppenvarianzen sind ausgewählt. Die neue Werte der Gruppenvarianzen, die eine Eingangsangabe für den neuen Ausgleich darstellen, sind von der Ergebnisse des Ausgleiches kalkuliert. Der Iterationsprozess konvergiert zu den Erwartungswert der Gruppenvarianzen und der unbekannten Parameter. Vier Methoden sind auf praktischen Exemplären der triangulation-trilateration Netze getestet. Die Vorzüge und die Nachbarkeiten der einzelnen Methoden sind auf Grund der Testenergebnisse festgestellt.

Abstract

The a posteriori determination of variances is an iterative process. In a logical sense, observations can be joint into groups. Approximate initial variance values of the groups are selected. New values of variances the groups are calculated on the basis of the adjustment's results, and represent entrance data for a new adjustment. The iterative process converges to the most probable values of unknown parameters and corrections of measured quantities. Four methods have been tested at practical examples of the triangulation trilateration nets. Based on the testing results, the advantages and disadvantages of each individual method were established.