METHODS OF GRAVITY DETERMINATION FOR CALCULATION OF PHYSICAL HEIGHTS IN THE SLOVAK NATIONAL LEVELING NETWORK

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INTRODUCTION

The National Vertical Reference System in the Slovak Republic is realized by the National Leveling Network (1. and 2. order) and it uses normal heights according to Molodensky based on the Kronstadt vertical datum. National Leveling Network is administered by Geodetic and Cartographic Institute in Bratislava. Until now, the "classical method" is used for the practical determination of reference heights in this network. The "classical method" uses components of gravity correction which are based on interpolation of Simple Bouguer Anomaly for leveling points. Currently, new realization of the height reference system is founded on geopotential numbers (combination of precise leveling and gravity measurements on leveling points). Advantage against previously used method is direct connectivity to EVRS and the possibility of transformation into actual realization of EVRS.

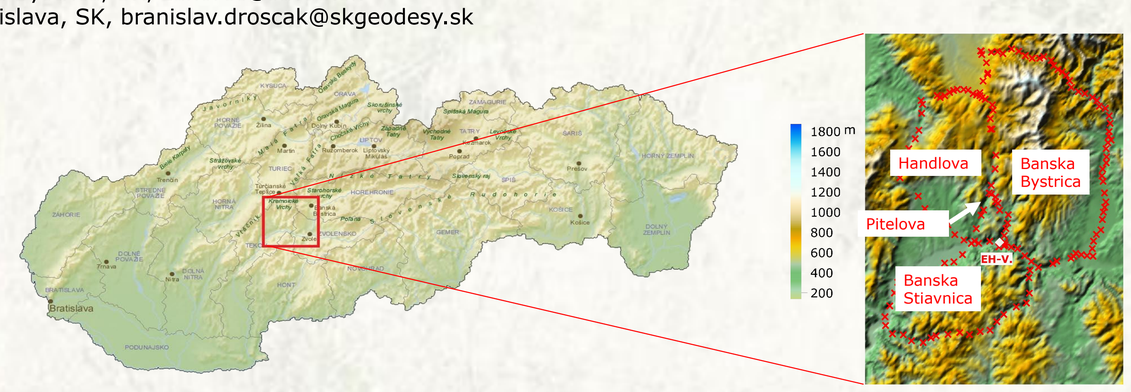


Fig. 1 Location of the selected leveling lines around the EVRF2007 datum point EH-V. Pitelova with marked four leveling rounds

METHODS OF GRAVITY DETERMINATION

Modern method of determination of the physical heights is based on the geopotential numbers, where is necessary to know value of the gravity at the leveling points. Since a most of the leveling pointsthis information is missing, it is necessary to look for alternative possibility of its determination. One of the methods is to use gravity from the map of Complete Bouguer Anomaly from detailed gravimetric mapping in the Slovak area. Next option uses gravity from model EGM2008 (Earth Gravitational Model). The last options is computation gravity from model EGM2008, which is refined by RTM (Residuals Terrain Model). The calculated gravity was used to determine normal Molodensky's heights in parts of the leveling lines (area 30x30 km) around the EVRF2007 datum point EH-V. Pitelova (UELN- 1905325). Results are tested by directly measured gravity values on the leveling points (Fig. 2).

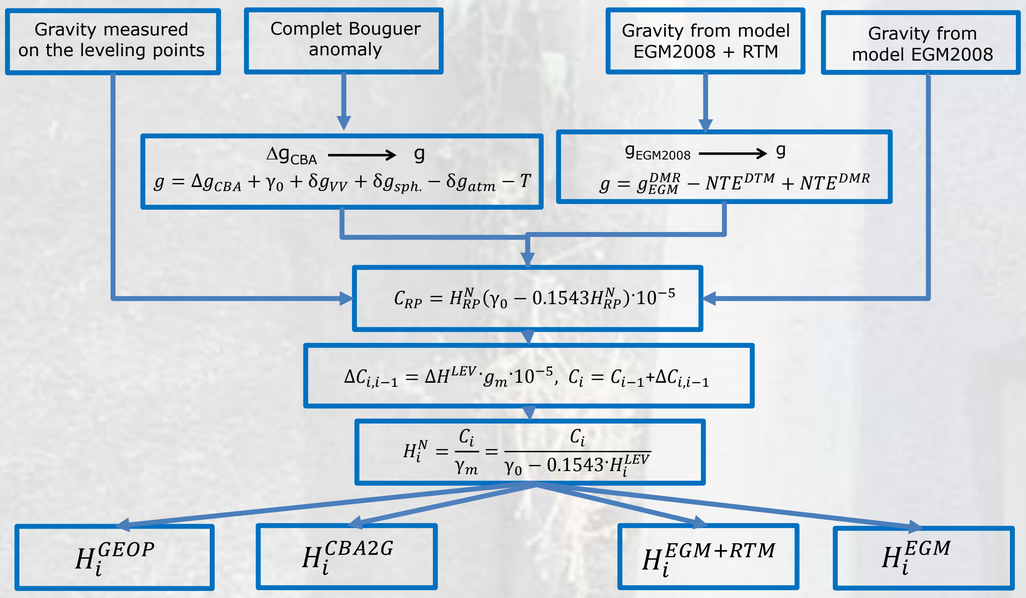
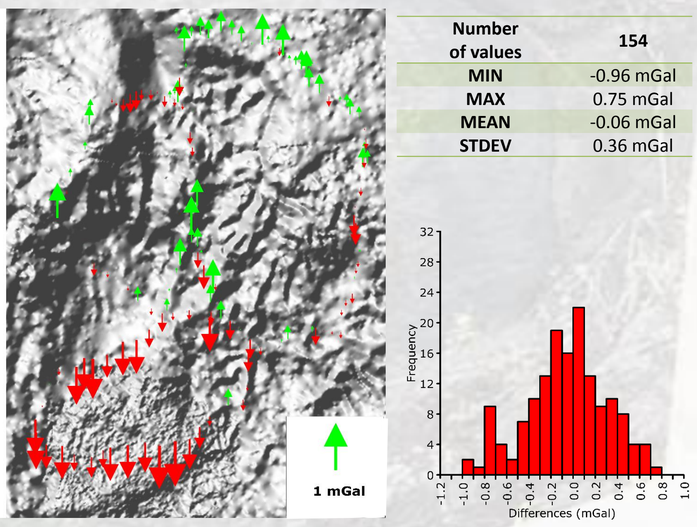


Fig. 2 The scheme of computation normal heights according to Molodensky with four different methods of gravity determination

GRAVITY FROM COMPLET BOUGUER ANOMALY

For calculation gravity from values of Complete Bouguer Anomaly on the leveling points was used the software cba2g_SK (Marušiak et al., 2012). Topographic corrections T1 (0-250 m), T2 (250-5240 m), T31 (5240-2880 m) and T32 (2880-166735 m) are calculated by using known formulas with most recent digital elevation model – DEM (zone T1 – DMR-3, zone T2 – DMR-3_30, zone T31 – SRTM_3 and zone T32 – SRTM_30). The output file contains complete Bouguer anomaly, topographic corrections, free air anomaly, simple Bouguer anomaly and gravity. The graphical interface of this software is on the Fig. 4.



Number of values	154
MIN	-0.96 mGal
MAX	0.75 mGal
MEAN	-0.06 mGal
STDEV	0.36 mGal

Fig. 3 Differences between the gravity directly measured on the leveling points and gravity calculated by software cba2g_SK

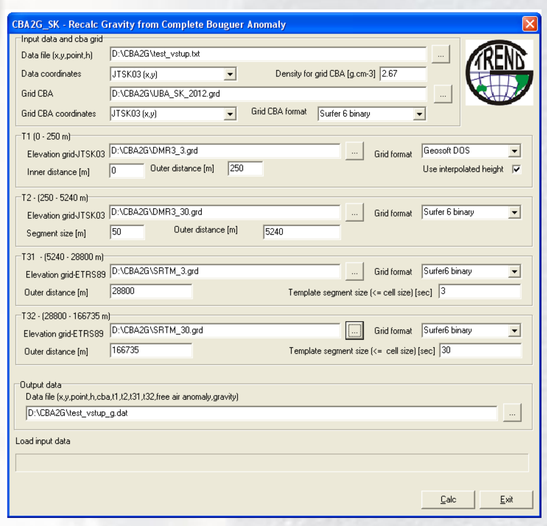
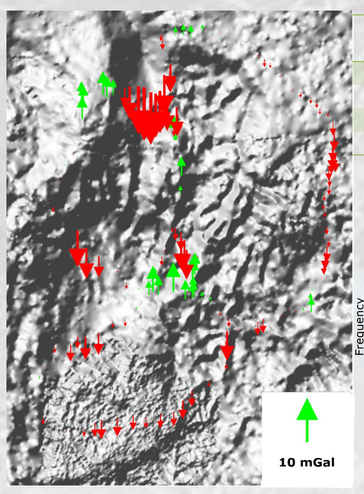


Fig. 4 Graphical interface of the program cba2g_SK (Marušiak et al., 2012)

GRAVITY FROM EGM2008+RTM

Another method how to determine the gravity at the levelling pointsis the use of gravity from the model EGM2008 with the topographic effect of Residual Terrain Model (RTM). The topographic effect was calculated using software TopoSK (Marušiak, Mikuška, 2013) in zones T1, T2 and T31.



Number of values	154
MIN	-12.04 mGal
MAX	6.74 mGal
MEAN	-1.29 mGal
STDEV	3.71 mGal

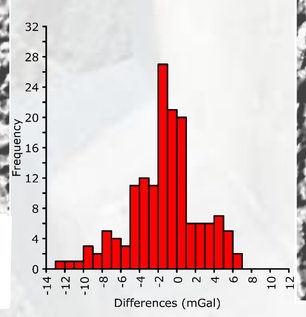
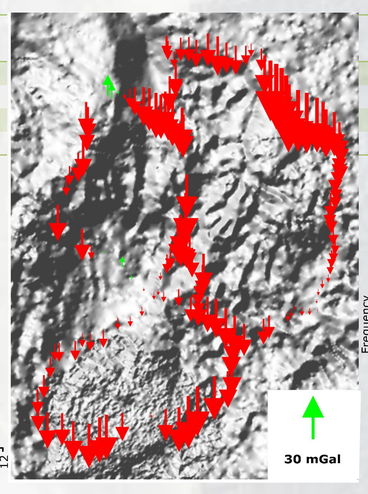


Fig. 5 Differences between the gravity directly measured on the leveling points and gravity calculated by model EGM2008+RTM



Number of values	154
MIN	-48.27 mGal
MAX	14.25 mGal
MEAN	-19.08 mGal
STDEV	11.58 mGal

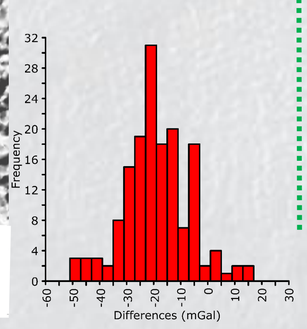


Fig. 6 Differences between the gravity directly measured on the leveling points and gravity calculated by model EGM2008

DETERMINATION OF PHYSICAL HEIGHTS

Finally the results of both gravity tests were transferred by calculating of normal Molodensky's heights of several leveling rounds: Banská Bystrica, Handlová, Banská Štiavnica, Pitelová. (Fig. 1) around the EVRF2007 datum point Pitelova (EH-V.). The aim was to determine the effect of different approaches to compute gravity for the determination of normal heights as well as to analyses the differences between the heights computed using directly measured gravity and the one estimated employing various approaches.
These leveling lines obtain the directly measured value of gravity, so it was possible to calculate approaches described the exact normal Molodensky's heights with geopotential numbers.

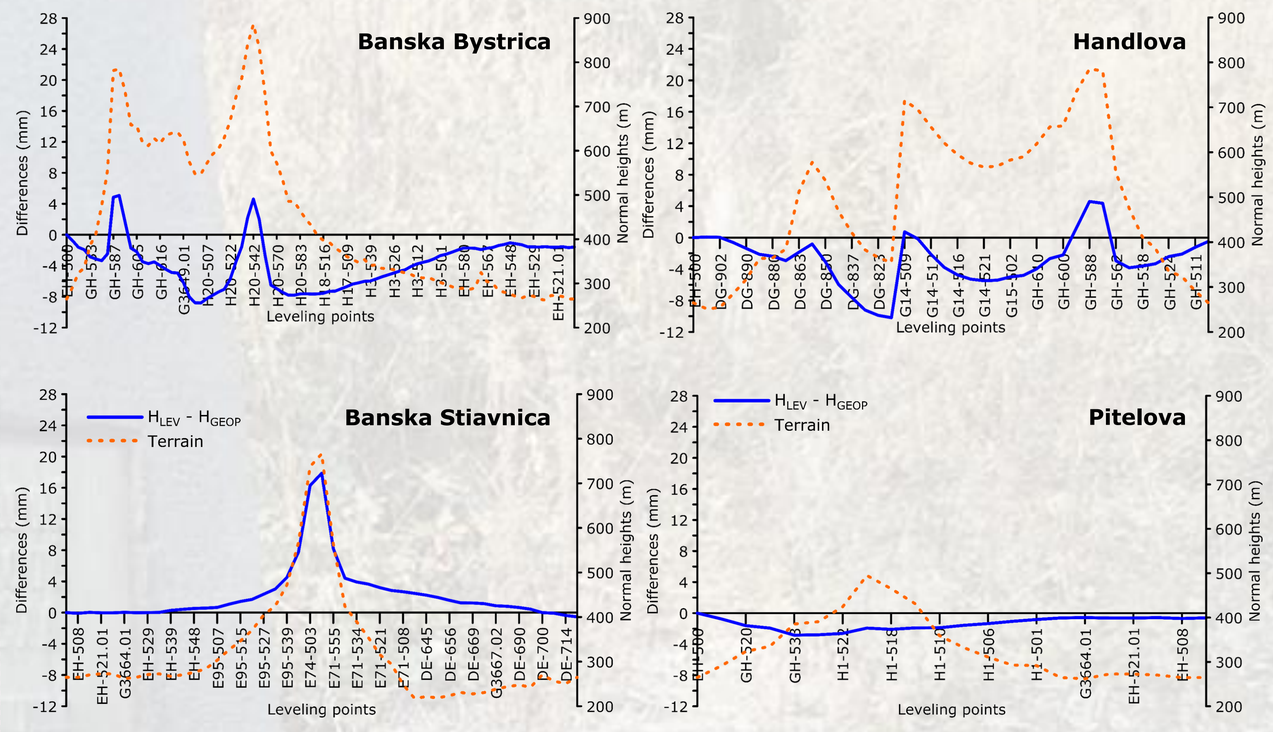


Fig. 7 Differences between leveling height (H_{LEV}) and normal Molodensky's height determinated from directly measured gravity on the leveling points (H_{GEOP}).

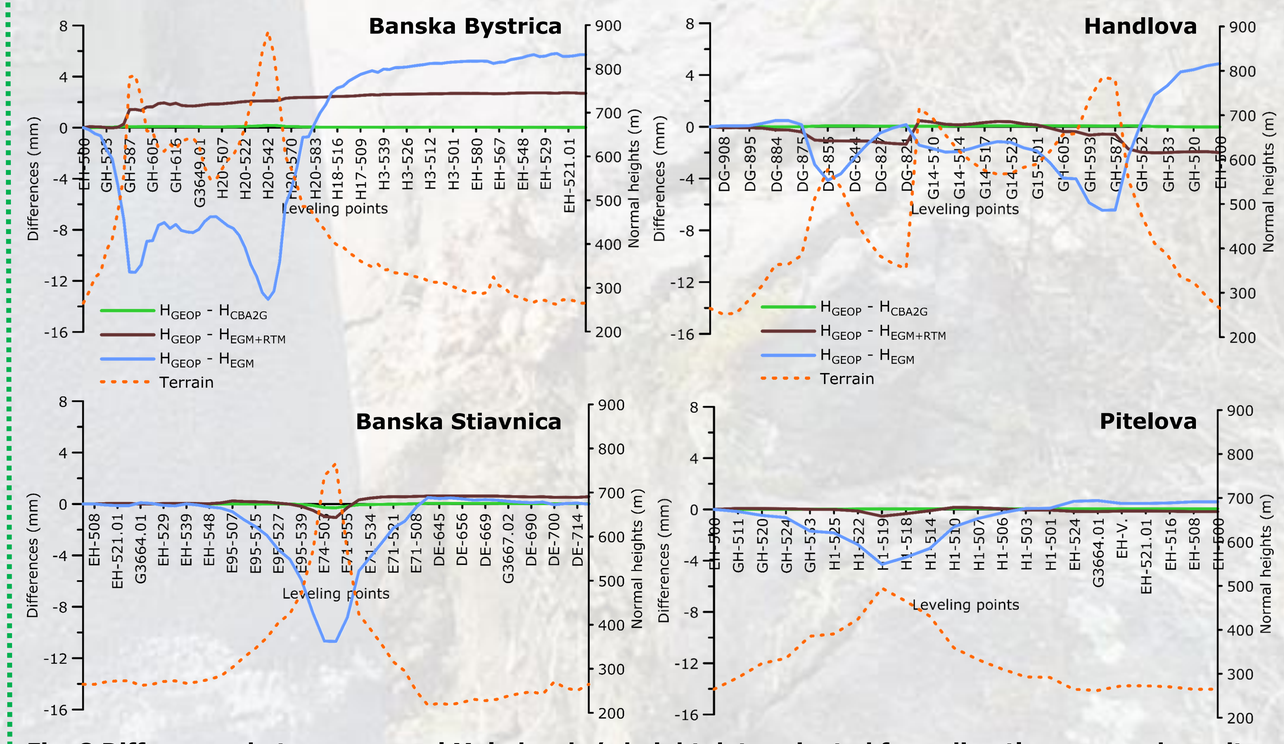


Fig. 8 Differences between normal Molodensky's height determinated from directly measured gravity on the leveling points (H_{GEOP}) and normal Molodensky's height determinated from gravity computated by cba2g_SK (H_{CBA2G}), by EGM2008+RTM ($H_{EGM+RTM}$) and by EGM2008 model (H_{EGM}).

CONCLUSION

The main aim of the article was to test alternative options of the determination of the gravity and application these alternative options in modern methods of calculating normal Molodensky's heights in the National leveling network in Slovakia. In this article two approaches of calculating the gravity were used, namely the calculation by the program CBA2G_SK using the values of Complete Bouguer Anomaly and the calculation using the EGM2008 corrected by the topographic effect RTM.

- Test cba2g_SK – minimal differences and indicating a very good quality of the gravimetric mapping (Kubeš et al., 2001) and its subsequent processing; normal heights in leveling lines were proved the minimal differences in comparison with determination, where the directly measured gravity are used
- Test EGM+RTM – Compared to the direct measured gravity reached the maximum differences 6.74 mGal, the quality is dependent on accuracy of availability GGM ands RTM

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