The analysis of the selected data from Polish Active Geodetic Network stations with the view on creating a model of vertical crustal movements

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Abstract

Up to now, the maps and models of the vertical crustal movements on the territory of Poland were created on the basis of data from 1st class precise levelling. Apart from levelling data, the vertical movements can be determined using satellite data. The present system of reference network has been operating in Poland for 6 years. It enables the determination of the model of vertical crustal movements on Polish territory on the basis of satellite data. The high credibility of levelling data is evaluated by a number of control procedures and statistical evaluation before and after adjustment, as well as during the measurement activities. The type of stabilisation allows for certainty as well (secular points, buildings of a specific stability, ground survey markers, above ground survey markers). Reference stations, due to the fact that they require an open horizon, are located on high buildings. The choice is conditioned by a number of factors. Moreover, the very structure of a station may influence the final result. The specificity – advantage or disadvantage – of satellite measuring is a permanent observation of the height changes recorded by a reference stations. All changes are recorded, even the slight ones that are not related to the dynamic changes of the Earth’s crust. The purpose of this article is to evaluate the measuring data, being the periodic (diurnal) changes of the height between the chosen stations of the ASG-EUPOS system. The evaluation was conducted with the use of statistical methods.

Keywords: ASG-EUPOS; vertical crustal movements; statistical tests.

1. Introduction

The maps and models of vertical crustal movements in the area of Poland have been so far developed on the basis of the data from precise first-order levelling. Height differences between nodal points of two repeated levelling campaigns were used as data. In 2012, attempts were conducted to adjust the data from three precise levelling campaigns [1]. On the basis of the tests [1], the precise levelling campaign from 1947–1955 was excluded from the preparations of the model of vertical crustal movements within the Polish territory. The determination of the model of the vertical crustal movements can be based not only on the levelling and tide gauge [2] data, but also on satellite data [3, 4, 5] and interferometry [6]. The combined data was used to create the European Vertical Reference System [7]. In order to unify the data to a common epoch the land uplift model NKG2005LU [8] was utilised. A combination of solutions was used in this model, as presented in [9, 10].

Having various time series and a dense network of permanent stations (~60 km), one can employ the movements calculated between the particular stations to determine the model of vertical crustal movements. On the basis of these movements, one can conduct the process of adjustment of the network by assigning them properly chosen weight functions.

The above approach requires a well-prepared and reliable research material. Various periods when the stations are operational, external conditions and other unidentified factors influence the quality of the data [11].

The purpose of this article is to evaluate the measuring data from North-Eastern part of Poland (Fig. 1), being the periodic (diurnal) changes of ellipsoidal heights between the chosen stations of the ASG-EUPOS network. The evaluation was conducted with the use of statistical methods. Moreover, not adjusted vertical movement between the chosen station was determined with the use of linear trend. Their standard deviation was calculated and the results were analysed.
2. Research material

The research material consists of the diurnal height differences from 35 ASG-EUPOS stations determined in the Military University of Technology EPN Local Analysis Centre (MUT LAC) using Bernese 5.0 software [12]. The height differences were calculated between the stations of the neighbouring countries (Russia and Lithuania) as well. The connections of permanent stations for calculating the height differences were chosen with the use of Delaunay triangulation [13] (Fig. 2).

The calculated height differences were compiled in the files as time series (Fig. 3). Prior to the analysis, outliers influencing the standard deviation were eliminated from the research material using $3\sigma$ criterion. The data from the measurement epochs featured by major variations from the general characteristics of the series was eliminated.
The research material was characterised by a large number of measurement epochs for each defined pair (vector) of permanent stations (Fig. 4).

The number of epochs in the particular pairs of ASG EUPOS stations

![Fig. 3. A sample of the data: the height differences between ASG EUPOS stations (stations: a) GRAJ_SOKL and b) BART_LAMA)](image)

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3. Statistical analyses and evaluation of the results

3.1. Standard deviation of the height differences

A standard deviation of the sample was calculated for particular vectors. At first, the calculated standard deviation of the height differences at particular pairs (vectors) of permanent stations was analysed. In Fig. 5 the distribution of standard deviation for particular vectors is presented.

![Fig. 5. Histogram of the standard deviation of height differences for particular vectors](image)

The calculated standard deviations of height differences at vectors vary from 3.0 mm to over 6.2 mm. In order to verify the evaluation of the compatibility of the above distribution of the standard deviation of height differences at vectors, the values of kurtosis (Fig. 6a) and skewness (Fig. 6b) were calculated.

![Fig. 6. Histograms of pressure kurtosis (a) and skewness (b)](images)

Within the analysed set, the value of kurtosis is negative only in one case. The values are less concentrated than in the normal distribution. Skewness does not exceed 1.0 sets. The distributions of errors do not show any significant skewness.

3.2. Linear trend and the standard deviation of the trend

The linear trend of the height changes in time was calculated at particular vectors. Alongside, the standard deviation of this trend was computed, as well as correlation coefficient of the data to the trend was determined. The obtained values of the standard deviation of the linear trend are presented in Fig. 7.
3.3. Loop misclosures

Another phase constituted the calculation of loops misclosure. Average misclosure is equal to ~0.3 mm/year, while maximum misclosure is equal to ~1.0 mm/year. The distribution of the loop misclosures is presented in Fig. 8.

4. Summary

The analysed material was heterogeneous. The researches aimed at the evaluation of its quality and at giving instructions to prepare material to create a model of vertical crustal movements in the area of Poland out of satellite data. The main criterion of the analysis was an a priori search for an answer to a question whether the analysed material (standard deviation) is consistent with the normal distribution. A number of statistical tools were used in order to achieve that. On the basis of the results of the calculations and analyses, one can claim that not the entire data at the chosen vectors has a symmetrical distribution of standard deviations. There are outliers within the sets (these were eliminated with the use of the 3σ criterion of post fit). Sudden, slight height changes were observed, the reason of which has not been established so far, at this stage of analysis. There are few deviations in loop misclosure.

References


