COMPARISON OF STATIC GPS DETERMINATIONS OBTAINED WITH THE POZGEO SERVICE AND GPS LOCAL NETWORK ELABORATION

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ABSTRACT

On the terrain of LGOM, the geodetic measurements aimed at deformation monitoring investigations began in early 60-ties. Exploitation of copper ore on the area of LGOM started in early 70-ties of the XX century. Since that time the deformation process is monitored with the best possible geodetic techniques available. In 1992 the classical measurements have been compiled with results of GPS positioning. GPS campaigns are performed once per year or at least every two years since that date. They comprise the whole control GPS point network of LGOM and some chosen points of the detailed shaft networks.

The Polish part of the EUPOS network, called ASG-EUPOS, started to work in 2008, and a question arose how it can be used for the purpose of LGOM terrain deformation monitoring. One of suggestions was to take advantage of the automatic computations of static GPS sessions, which is possible within the ASG-EUPOS network through one of its services, called POZGEO.

The main aim of this paper is to check what are the obtainable accuracies within this service and whether they are good enough to be applied in deformation monitoring. Results of comparisons of POZGEO coordinates with the coordinates computed using older GPS methods are given.

1. INTRODUCTION

The Polish Copper Basin (LGOM) is located in south-western part of Poland, between Lubin and Glogow. It covers an area of about 800 km^2. Since the very beginning of mining activity in this area (i.e. since 1960) investigations and measurements aiming at discover of factors shaping the deformation of rock mass and terrain surface processes have been carried out there. On the basis of such a long observation period two kinds of influences of the mining exploitation on the surface as well as on the rock mass there can be distinguished: direct and indirect influences. The first have been caused by

displacement of the rocks towards the post-exploitation free space, while the second are an effect of water escape (draining effects) from the rock mass.

Detailed analysis of leveling measurement results from the period of 1960-71 proved that there exists, and even in a higher degree than it was supposed, the indirect influence of the copper ore exploitation on the terrain surface caused by rock mass drainage. The vertical movements which followed the drainage process, began to extend and cover bigger area, considerably overrunning the area of the direct influences. Nowadays, all mining plants are within these influences, and even areas out of LGOM borders are also affected by the influences. The greatest subsidence, caused by direct influences, are located along Tertiary outcrops. Interpretation of the subsidence caused by direct and indirect influences was carried mainly on the basis of precise leveling measurements of vertical network of the second class established on this terrain specially for these purposes.

The vertical network covers terrain of area of about 400 km^2. Distances between bench-marks of the network amount to 1.5-2 km. The first measurements date from early sixties, the next measurements were performed in 1967, 1971, 1975 and after then every 2-3 years. The measurements proved that deformations resulting from mining activities were bigger than expected on this terrain. Thus the time span between successive measurements was shortened to 1-1.5 month and the network was expanded.

Nowadays, the leveling network covers an area of about 2300 km^2, it consists of over 1200 km of leveling polygons. Measurement accuracy of the network amounts to 0.75 to 1.2 mm per 1 km.

The horizontal control classical network on the area of LGOM was established in 1973 and then extended in 1975. It consisted of 38 points. Also in 1975 a local system of coordinates named "Pieszkowice" was introduced on this terrain. Mostly, points of the network were over-built with wooden triangulation towers. First measurement of the network was performed in 1973, and then repeated in 1975. They were performed with very high accuracy, the mean position errors were estimated to 5 cm in 1973 and to 2 cm in 1975. The next measurements were performed in 1980-ties but the situation of geodetic classical measurements was becoming more and more difficult on this terrain, because of lack of stable points near the mining area, and very bad technical condition of the wooden towers (signals of geodetic points in wooden area).

Looking for a solution of this problem it was decided that GPS technique should be applied in this region. In 1992 first GPS experiment aiming at checking the possibility of application of GPS technique to study of this region stability was performed by Olsztyn University of Agriculture and Technology, in cooperation with Polish Copper Mining Inc. and Geodetic Office from Wroclaw. The results obtained confirmed this possibility. New GPS network, precisely tied to the old one, exists on the terrain of LGOM since 1996. Since then it has been measured with GPS technique every two years. The last campaign was performed in October, 2010 by KGHM Cuprum Ltd.

Because the Polish part of the EUPOS network, called ASG-EUPOS, started to work in Poland in 2008, a question arose how it can be used for the purpose of LGOM terrain deformation monitoring. One of suggestions was to take advantage of the automatic computations of static GPS sessions, which is possible within the ASG-EUPOS network through one of its services, called POZGEO.

The main aim of this paper is to check what are the obtainable accuracies within this service and whether they are good enough to be applied in deformation monitoring.

2. POZGEO SERVICE

A widely cited and commonly admitted definition of the ASG-EUPOS network is formulated as „ASG-EUPOS – is a multifunctional precise satellite positioning system in Poland“ (Bosy et al., 2008). This network started to operate in Poland in June 2008 and since that time it is possible to use it for both the real-time and post-processing applications. There are 5 services available, suitable for various users. For real-time applications one can choose from three services, namely NAWGIS, KODGIS (for GIS purposes) and NAWGEO (for geodetic real-time measurements). Two remaining services are designed for post-processing techniques, these are POZGEO and POZGEO D. The POZGEO D service enables to get required raw data recorded at chosen reference stations of the system in chosen time periods. The computations are then performed by the user.

On the other hand, the POZGEO service is dedicated for automatic computations. Thus the raw observational data, in RINEX ver. 2.x format, are sent to the service via its web page by the user, the position is determined relatively the six nearest reference stations. The processing of the data is carried out by *Automatic Postprocessing Software for Trimble Application (APPS).* The six vectors are then adjusted to give coordinates of the unknown station in the ETRF 2000 frame *)* (www.asgeupos.pl). Also, in the report generated, the user can find these coordinates recomputed to the Polish cartographic systems 2000, 1992 and 1965. What type of data are used to determine satellites orbits needed in the computational process depends on availability of IGS-rapid or IGS-final orbit, eventually the broadcasted navigational data is used. The required number of observational epochs is 720, as a minimum, it is equivalent with e.g. 12 minutes of observation session with recording interval equal to 1 sec or 2.0 hours for data with 10 sec interval. The files containing data that does not fulfill this condition are rejected and not even a trial is undertaken to process them.

For preliminary estimation of POZGEO capability, a computational experiment was performed. 24-hours data were taken from 6 stations: WLBR, JLGR, LEGN (Lower Silesia region, located near LGOM) and ILAW, DZIA, OLST (Mazury region) for two days, autumn and spring: 10 Oct. 2010 (date of the last GPS LGOM campaign), and six months later, 10 Apr 2011. Each of 12 file was divided, using TEQC program, into eight 3-hour parts. In this way, 96 files were obtained. They were sent to the POZGEO service on 12 May 2011. Unfortunately, for these 96 files, only 39 were elaborated, while 57 were rejected, in this number all the files with data dated from October 2010, and all the files from the OLST station. The message given in the processing reports, in all cases of the rejected files, was as follows: „At assumed number of sufficiently close stations, it was impossible to perform calculations“. Thus the first remark may be given on the POZGEO service, that it is very demanding in its requirements and conditions, and the user must reckon with such circumstances that many files can be left without elaboration. But the remaining 39 processed data files gave quite good results, as can be seen in Fig. 1. To assess the quality of the results, they were compared in ENU frame to the official system coordinates of the reference stations. The biggest differences are encountered for WLGR: the maximum are about 3 cm in up-down direction and about 2 cm in east-west direction. The smallest differences are in north-south direction, they do not exceed 5 mm. It can be stated that the discrepancies between the reference and computed with POZGEO positions amount to 1 cm on average.

It seems that the APPS program had easier task then normally, because the distance to one of six references used for computations was equal to zero. Therefore, it can suggest,

that if one of ASG-EUPOS stations is located near the terrain measured, the results may be good, under 3 cm, instead of 10 cm declared in the system.

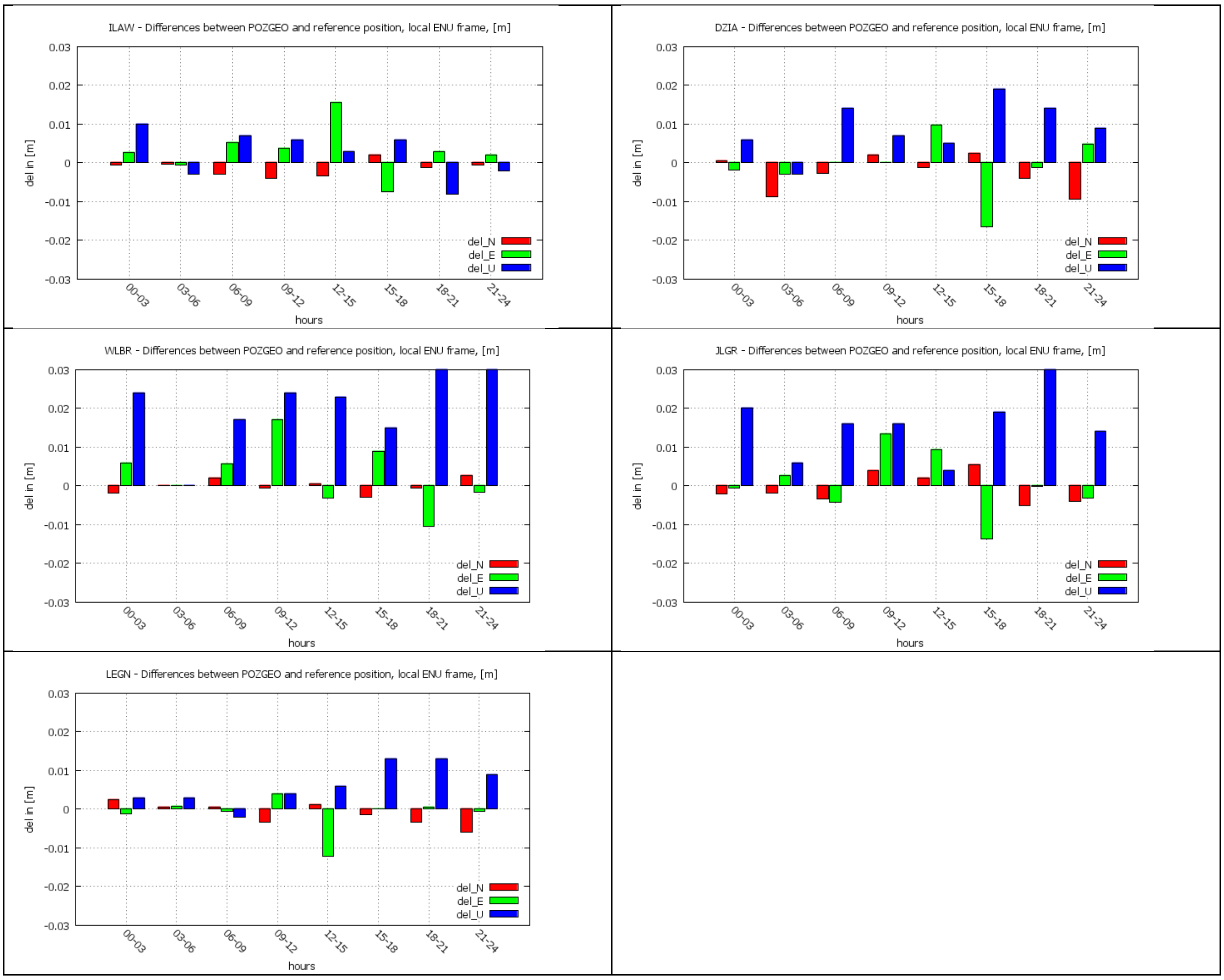

Fig. 1. Differences of the POZGEO and reference positions for 3-hour sessions (raw data taken from POZGEO D service) – stations in order from the top, left: ILAW, DZIA, WLBR, JLGR, LEGN

3. POZGEO RESULTS VERSUS RESULTS DETERMINED WITH OTHER PROCESSING METHODS

The first GPS campaigns performed on the terrain of LGOM, in early 90-ties, were elaborated taking advantage of the GPPS program (Ashtech Inc., 1992) for vector computations, and the GeoLab program (BitWise Ideas Inc., 1992) for network adjustment. Because of obtaining very good results using this method and to ensure repeatability of the coordinates computed, also these program were used later.

In the adjustment of GPS vectors, three POLREF and one EUREF-POL points are kept fixed, thus the results are obtained in ETRF frame (ETRF'89 in our case). After that the results are further transformed into the Polish cartographic system 2000 taking advantage of te TransPol program (Kadaj, 1995). The heights are transformed into Kronsztadt'86 using GPSTRANS program (Gajderowicz, 1993). The accuracies obtained are of the order of several mm.

For the needs of this paper, results of the last two campaigns, from the years 2008 and 2010, were used. In 2008, we got the order to compute some chosen points with the POZGEO service to test how it works, thus some sessions were long enough to be computed by APPS. They could be compared with our own results. About 30 points could be compared, part of them are presented in Fig. 2.a. In 2010 only 15 data files were long enough to be successfully computed in the POZGEO service. Their results of comparisons are given in Fig. 2.b.

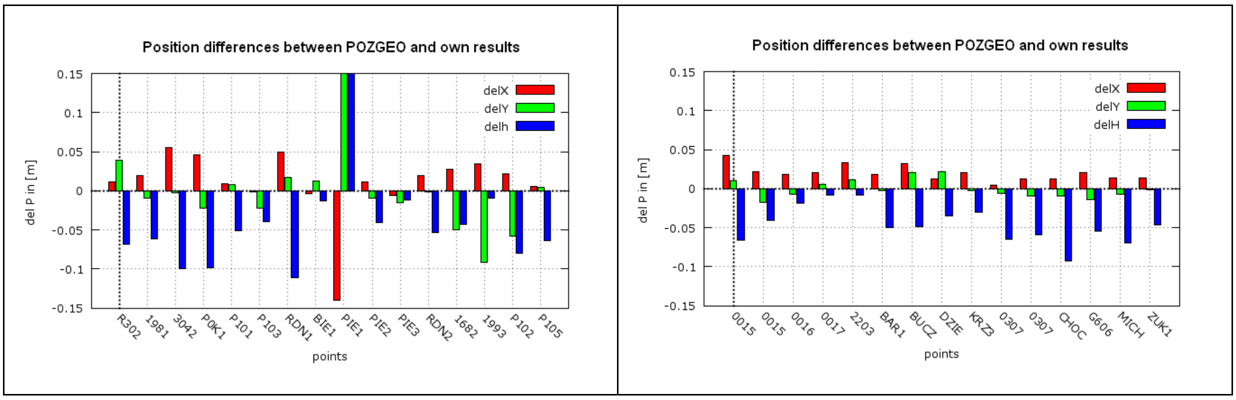

Fig. 2. Differences between POZGEO and own results obtained for chosen points measured in 2008 (left) and 2010 (right) campaigns.

It can be notice that the results from 2010 fit each other better than those from 2008. The biggest differences are obtained for heights, the smallest for Y, for the X coordinate they reach 5 cm in some cases. For the point PIE1 in 2008 there seems to be a gross error.

Unfortunately, there had not been many data to compare independently of our own results. Only two points were computed with POZGEO in both the year 2008 and 2010, therefore only for them it was possible to check repeatability. The differences are given in Fig. 3.a. For the point 0307 (EUREF Studnica) they are within 1 cm for all coordinates, but for point 0015 (I class of Polish triangulation network) the discrepancies reach 3 cm for Y and h coordinates.

Two points regarded as fixed in own elaboration were computed with POZGEO, thus it was possible to compare the coordinates obtained with those given in catalogues of the POLREF control network. The results of comparison are given in Fig. 3.b. Discrepancies in heights are over 6 cm, and in the X coordinate they reach 3 cm.

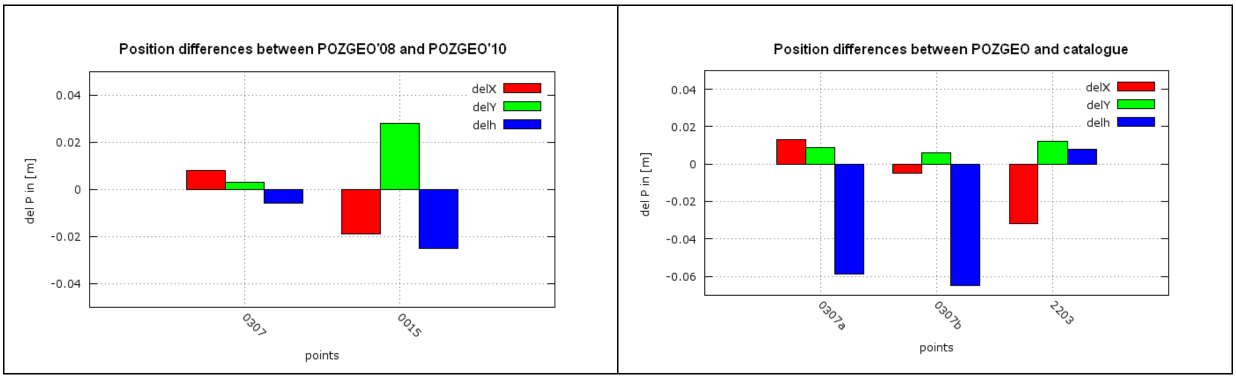

Fig. 3. Left (a): differences between positions computed with POZGEO on the basis of 2008 and 2010 data; right (b): differences between positions computed with POZGEO and coordinates given in catalogue of POLREF points.

4. CONCLUSIONS

On the basis of the computations performed, the following conclusions and remarks can be derived:

a) **In many cases it is impossible to compute the POZGEO positions, it may be caused by insufficient good observational epochs. This can be influenced by the user – it should be remembered the sessions to be long enough. But the next reason encountered, that the condition of good results from 6 nearest stations was not fulfilled, it cannot be influenced by the user, and it is nothing to be done by the user in future to avoid such situations.**

b) **The POZGEO service gives results within the system declaration, the differences never exceed 10 cm.**

c) **It seems that close vicinity of one of the system reference stations helps to get much better results, but since the data were taken from these same stations which later took part in the POZGEO computations (resulting in zero-length of one of the vectors), more studies, with independent data, are needed. If this suggestion is confirmed, perhaps it will give a reasonable argument for building a new permanent station close to this mining area**

d) **For deformation monitoring, and other precise applications, it is recommended to use non-automatic methods of data processing, although the automatic methods may be very convenient in other situations.**

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