Comparing trigonometric determining of height differences (TDHD) and GPS (Global Positioning System) in local networks

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Atmospheric influence, primarily problem of the refraction has indispensable influence on measuring accuracy in geodesy, which especially effects quality of measuring results for trigonometric determination of altitude. We tried to eliminate its influence on measuring sets from extreme different conditions in the mild climate zone (Czech republic, Jeseníky) and in the tropical climate zone (Ghana, New Bortianor). Part of our work was idea to verify the theory determination of refraction influence in practice in extreme conditions.

Primary importance of precision and effectiveness when establishing local networks in respect of demand of practice, and on combining terrestrial and celestial determining height differences inspirited us to possibility of comparing trigonometric determining of height differences (TDHD) and GPS (Global Positioning System). Therefore, the adequately investigated method TDHD with which we can partly eliminate atmospheric influences to minimum when keeping specific measuring and counting methods, and the method GPS which suits demand of current practice in aspect of economy, precision and speed of measuring and calculation.

Character of the local networks

For studying of the problem we used local networks J-97 in Jeseníky (see figure 1) and G-99 in New Bortianor (see figure 2). We were concentrated for needs of establishing of local networks; for sides lengths up to 2 km. Main attention is given to hilly areas.

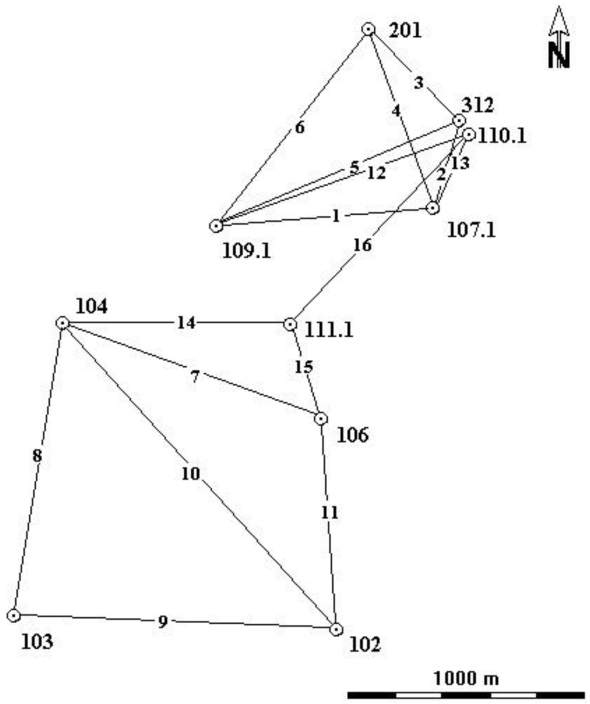

Fig. 1 Local network J-97

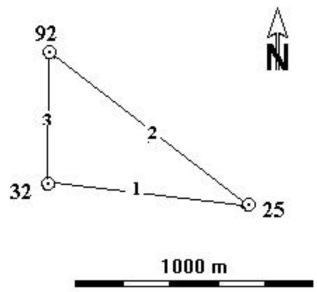

Fig. 2 Local network G-99

Network J-97

In 1980 was established our New Research Network in the Czechs mountains Jeseniky. Average sides length is approximately 1,5 km. Height differences are from 2 m till

125 m. For our experiment we call selected part of the New Research Network J-97 and measured data “Jeseniky 97”.

In September 1997 was made measurement TDHD on 10 points of the J-97. In September 1999 was file of measurements completed by measuring GPS method on 8 points (on 2 points was unable observe by GPS method). Observation contains: 32 vertical angles, 40 horizontal directions and 8 GPS observations (lengths were counted from coordinates S-JTSK, which is Czech National Coordinate System and were also taken from GPS observation).

During the measurement was temperature from 8°C to 20°C and pressure was from 959hPa to 962hPa. It were sunny-cloudy days with light wind.

Network G-99

For our purpose was used the Ghana National Network in region Great Accra. Average sides length in the local network is approximately 200 m, some points has a height. Height differences are max. 40 m. Selected 4 points of the Ghana National Network we call G-99 and measured data “Ghana 99”.

In February 1999 we measured by TDHD method and by GPS method. Observation contains: 6 vertical angles, 6 horizontal directions, 3 slide lengths and 4 GPS observations.

During the measurement was temperature from 34°C to 37°C and pressure was from 991hPa to 993hPa. It were sunny-cloudy days with impulse wind.

Observation data

- For vertical angles we used method of reciprocal simultaneous measuring. Every vertical angle includes 48 pointing and readings – method LU – laboratory unit. 1LU = 12 pointing and every surveyor measured vertical angles in 4 LU.
- Measuring of the temperature and the pressure was made to describe atmospheric condition during the measurement.
- Horizontal directions were used to central vertical angles (we measured out-of-center).
- Total stations for determining of distances were used just in G-99. For J-97 were taken from GPS observations.
- Measuring GPS was made by rapid static method (1/2 hours observations) and it was chosen to keep demand of current practice (economy, precision and speed).

Mathematics model of compering – functional model (FM)

GPS method was taken as a compared method with TDHD method. Values of the TDHD measurement were taken as fixed.

We used mathematics model of compering – FM. From MSS adjustment (method of smallest squares) of TDHD method were found ‘average errors in measurement of height differences’ m_h^T , which we take afterwards as a known parameters for FM.

For FM is TDHD measurement as given and GPS data as measured. Than we can take greatest m_h^T =3.6mm from MSS adjustment as fixed to which was found ratio λ ($l = \frac{s_G^2}{s_T^2}$, where s_T^2, s_G^2 are dispersion of measurement TDHD and GPS), which was an unknown parameter of FM.

Consequently by experimental induction of s_T^2, s_G^2 was found ratio λ, so that suits to the greatest 'average error of measured height difference' m_h^T =3.6mm of TDHD.

Computing of FM finds the value of the greatest 'average error of measured height difference' by GPS m_h^G =7.0mm which suits to m_h^T =3.6mm by TDHT. Results shows advantage to determinate height difference by TDHT method to GPS method – 2:1.

("Ghana 99" was too small file of measurement to apply FM).

Conclusions

Part of our work, which is not presented here, was study of atmospheric influences. For the measuring file "Jeseniky 97" are daily values of refraction coefficients from 0,02 to 0,38. Which shows relatively big changes of refraction during measuring. Average value refraction coefficient from 7 days of measuring is 0,23 and comparing to Gauss average value k=0,13 we can take condition of our measurement as normal. In case of experimental measurement in extreme condition "Ghana 99" is complicated to say about the reason of disparities results values. Daily values of refraction coefficients from –0,91 to 0,10.

It is evident that using Gauss refraction coefficient for a file of data, which would be equal to measurement in condition as "Ghana 99", than results would be greatly devaluated.

Result of compering methods GPS and TDHD shows that for establishing local networks for demand determining heights in accuracy equal to the levelling with the extreme variance $40\sqrt{R}$ (R – length of the traverse), we can use method GPS effectively.

Each of height determining is important to analyse. Of course it depends on given situation, type of work, demand accuracy and speed of work, on character of terrain for establishing of a local network and on atmospheric condition. In our project we present two examples of height determination in local networks in hilly areas, where using of technical levelling is very difficult.

There is no goal in this project to say which method is better to use. The goal is to compare different ways of measuring and choose from possible alternatives of adjustment and an assignment of suitable characterisations of accuracy. Our work follows up needs on accuracy and economy of measurement and computing, which has current practice.