Estimating the Optimum Duration of GPS Static Observations for Short Baseline Length Determination in Greece

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Key words: GPS, Static Observations, recording duration, Greece.

SUMMARY

Cost-effecctiveness is a requirement of most geodetic projects. In order to estimate the minimum duration of GPS static observations to determine an optimum, cost- effective accuracy in baseline length measurements, a statistical analysis of data collected during a 6-day long record, in the framework of the GERCOP project, were analyzed.

Using a random number generator we defined each time 9 sets of observations, 15min to 3 days long from this 6-day record. These sets of data were analyzed on the basis of post-processing static analysis and a commercial software, and the corresponding baseline lengths were computed. The differences between the average and maximum estimated baseline length for each data set from the best estimate baseline length and their standard deviation were subsequently computed. A plot of the obtained result versus time revealed an exponential trend for the decay of the uncertainty of the baseline length versus time.

This analysis reveals that only a slight improvement in the accuracy of the baseline length is obtained after 3 and definitely after 24 hours of observations. This indicates that the optimum duration of GPS static observation for short baseline length measurements in Greece is 3 hours.

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1. INTRODUCTION

Estimation of a baseline length using GPS can be very precise, because of the carrier phase measurements. However the accuracy of the measurement is dependent among others on the constellation of the satellites, the multipath and the troposphere effect (Barnes et al., 2003). The role of these parameters becomes smaller if the duration of observations is long. Various studies have revealed that the duration of the observation is the dominating factor determining the accuracy in baseline length (Eckl et al., 2001). Is there an optimum duration of GPS observations leading to the minimization of this role of the above parameters (satellites, multipath etc)?

In this paper we present an answer to this problem for the conditions in Greece based on a statistical analysis of data collected from a very short (about 20m long) baseline measured during a period of 6 full days in the framework of the GERCOP project (geodynamic investigations of the Balkan region).

2. METHODOLOGY

Our analysis is based on the statistical analysis of GPS data covering a relatively long time period (6 full days) and hence providing a high accuracy estimate of the baseline length. Shorter sets of data of variable duration were produced from this record, and for each set the baseline length and its precision were computed. The difference of the computed baseline length of each set from the estimated baseline length and its standard error were analyzed to investigate the effect of the observation duration on the accuracy and the reliability of the baseline length measurements.

3. DATA COLLECTION AND ANALYSIS

In the framework of the GERCOP project two GPS stations were established on the roof of the Civil Engineering building, in Patras University (Fig.1). The GPS equipment of each station consisted of a dual frequency (L1 and L2) receiver (JAVAD Legacy-H) and an

Figure 1 The two GPS stations during the experiment

antenna (JAVAD JPSLEGANT-E). The two stations defined a short baseline (length about 20 m). Data were sampled every 30 seconds for 6 full days (16-21/06/2003). An elevation mask angle of 15^o was used. The bases of the two GPS stations were fixed on stable ground free of surfaces which would induce multipath error or reduce the satellite availability.

3.1 Data Analysis

In a first step, the whole set of the recorded data was analyzed on the basis of post-processing static analysis and a commercial software (Pinnacle 1.0). Due to the long recording period (6 days) and the large number of observations (more than 17000), the baseline length could be defined with high accuracy, which was considered as the best estimate of the baseline length. A random number generator was used in order to select subsets from this record, with 9 subsets of equal duration defining a set of data, 12 in total. The duration of each subset was varying (15 and 30 minutes, 1,2,3,5,7,8,10 hours, 1,2,3 days). Obviously, there was some overlapping between some of the subsets (Fig.2).

For the 9 subsets of each set we compute the mean value of the baseline length, its standard deviation and its difference from the assumed real value. The last two variables were plotted versus the duration of each subset in Figure 3a. Using the trial-and-error technique, we found that exponential curves can best fit the plotted data, both mean offsets from the baseline length and their 1σ error intervals (Fig.3a).

Also, for each of the 12 sets of data, we identified the value with the maximum offset relative to the baseline length. These values, ranging between 1.7 mm and 0.2 mm for 15 min and 24 hrs observations, respectively, were plotted in Fig.3b.

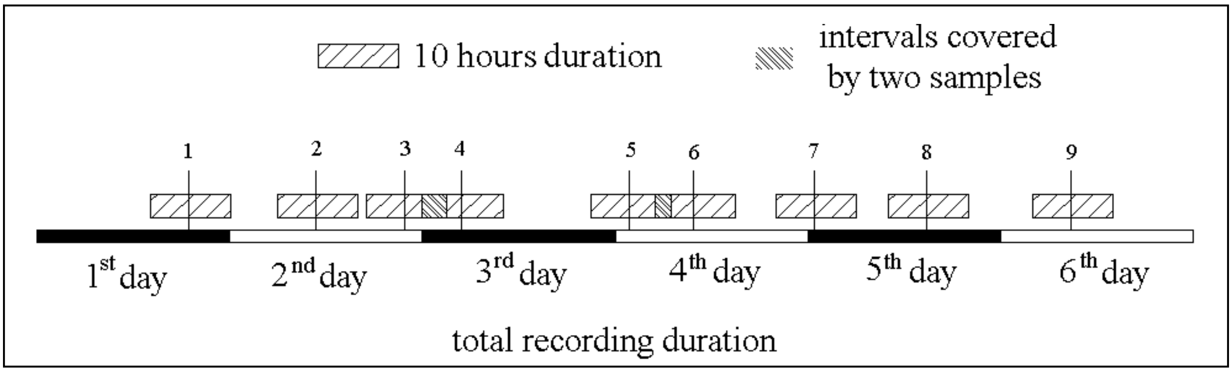

Figure 2: Schematic presentation of a 10-hour long set of data. Numbers 1 to 9 indicate random numbers, at the middle of the 9 subsets composing a whole set. 12 sets of partially correlated data, with subset duration ranging between 15min and 3 days were defined.

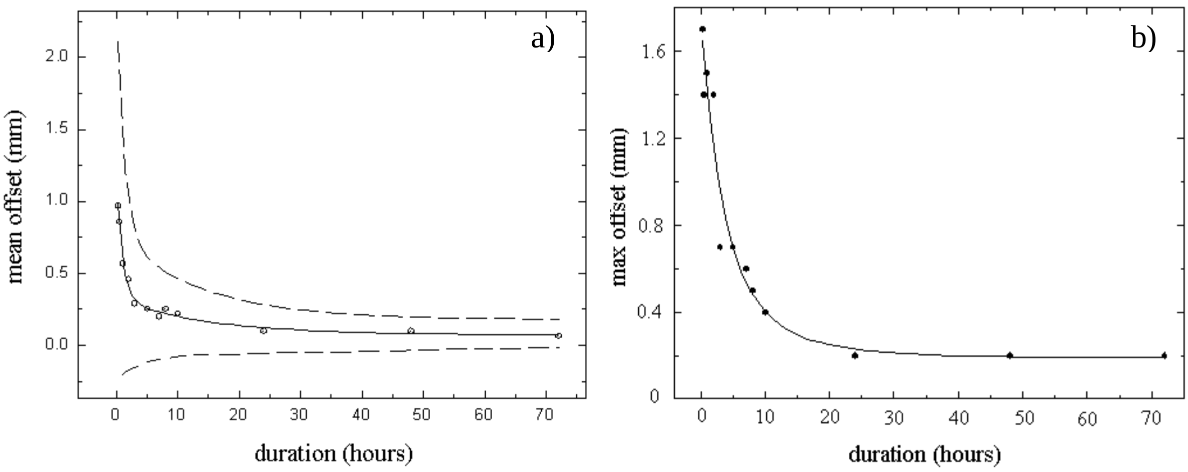

Figure 3: Plot of the mean difference (a) and maximum offset (b) of each data set from the best baseline length estimate (dots) versus duration of recording. Solid and dashed lines indicate exponential curves best fitting to the decay of the offsets and their standard deviation, respectively.

4. DISCUSSION

It is obvious from Figure 3 that there is an exponential decay of the deviation of the computed baseline length of each duration set from the best estimate of the baseline length. The standard deviation seems to fit to exponential trend, as well.

This graph reveals that only a slight improvement in the accuracy and the reliability of the baseline length is obtained after of 3 hours of observations. A slight improvement of the accuracy of the measurements was noticed after of 24 hours of observations. This is probably due to the reduction of the effect of the periodic errors for periods shorter than one day (multipath, troposphere) and also the sporadic effects (signal diffraction, satellite geometry; Hartinger and Brunner, 1998).

A very similar, exponential trend is observed in Fig.3b showing the max difference from the baseline length for each set. Small improvement in baseline length is observed after 10 hours of observations, and practically no improvement after 24 hours.

5. CONCLUSIONS

Our results are consistent with results of previous studies revealing that the duration of observation is the critical factor in the determination of the baseline length (Eckl et al., 2001) For the conditions in Greece, it has been shown that the cost-effective duration of observation for baseline length determination is 3 hours and that after 24 hours no significant improvement in the quality of our estimates can be expected.

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BIOGRAPHICAL NOTES

Panos A. Psimoulis is 5^{th} year undergraduate student of the Dept. of Civil Engineering of Patras University, Greece. His research activities, involve the application of analytical methodologies on reconstruction/ design of structures and application of GPS in monitoring civil engineering structures.

Villy A. Kontogianni, Dipl. Eng. MSc, is PhD candidate of Dept. of Civil Engineering, Patras University, Greece. Her PhD thesis is the analysis of tunnel deformations monitoring data. Her research involves analysis of geodetic data from geotechnical engineering structures (tunnels, dams, ground subsidence) and seismic faults activation.

Anna Nickitopoulou, Dipl. Eng. Msc. Her research activities involve applications of GPS in monitoring of civil engineering structures and analysis of GPS monitoring data.

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