ANALYSIS OF THE PRELIMINARY RESULTS OF GPS OBSERVATION SERIES AT THE POLTAVA GRAVIMETRICAL OBSERVATORY

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The first results of researches of GPS observations in Poltava are submitted. Linear trend, annual, semi-annual terms as well as a number of additional terms are marked out on each coordinate. It is shown that the annual term considerably prevails above semi-annual one. Numerical values of parameters of these components are determined. Comparison of the obtained results with results of the similar researches at the Kyiv Station has been carried out.

INTRODUCTION

Since September 2001 regular GPS observations within the EPN (the EUREF GPS Permanent Net) have been started at the Poltava Gravimetrical Observatory (POLV is the acronym used by the EPN). The first GPS data have been analyzed with the goal of studying some local effects (stability of the observational place coordinates, local Earth's crust deformation, *etc.*).

The GPS data analysis was divided into two stages. Such approach to processing of observation results is explained by the absence of a priori data on structure of the researching series at the initial investigation phase that complicated the choice of optimum length of series for realization of the analysis. On the other hand, the available period of supervision is not long enough for studying the structure of series based on the spectral analysis on multiple harmonics. The high frequency band is limited to rather big interval of discretization (averaged week values). Presence of signals in this frequency band will result in the effect of aliasing. The big interval of discretization also reduces resolution on the periods in the low frequency band. As the results of GPS observations are unequivocally not in statistical balance, the non-stationary part was originally filtered in the initial series of observations. The size of linear trend on a two-year interval of observations for the POLV Station amounted for coordinate $x = -36.3$ mm, $y = 25.3$ mm, and $z = 16.3$ mm.

METHOD OF ANALYSIS

At the first phase of research we applied the spectral analysis method which is widely used for researches of latitude observations [4]. The spectrum estimation is calculated based on Fourier discrete transformation of the unbiased correlation function. For suppression of narrow-band casual process which may be present in the observation lines, the Tucker window was used [3].

At the first stage of calculations based on application of the spectral analysis the frequency-response characteristics of the series components were obtained. At the second stage the determination of these components was carried out on the maximal value of spectral capacity.

As amplitude, period and phase were included in the determined parameters at component determining, we came to non-linear model of the data [2]. For estimations of the parameters of the times series component, the phased least squares adjustment was applied [1, 2]. Such approach is explained by the fact that the specific task of studying of internal physical essence of processes inherent in GPS observation series was set, as well as studying of the formation dynamics of these processes at the researched period.

THE RESULT OF ANALYSIS

In Fig. 1 sample spectrum changes of coordinates for GPS observations at the POLV Station are submitted. The spectral analysis results proved that the annual and semi-annual terms are the factors that mainly contribute to the variations of the observational place coordinates, the annual term being substantially predominant over the semi-annual one. In all spectra the contribution of annual components forms about 50% of average power.

Estimations of harmonious component parameters for each coordinate of the GPS observations, obtained at the second stage of calculations are given in Table 1. Comparing the results of the spectral analysis with the results of phased least squares adjustment, we see that some additional harmonics not discovered at the first stage were marked out. To compare the analysis results with the observations performed at the other stations the similar research was carried out at the Main Astronomical Observatory (GLSV) in Kyiv. Comparison of the observation analysis results at the POLV and GLSV stations shows good correlation in coefficients of linear trends (for GLSV $x = -28.6$ mm, $y = 31.2$ mm, and $z = 23.1$ mm), annual and semi-annual terms, the other harmonics being close in amplitude and period may differ in phase (Table 1).

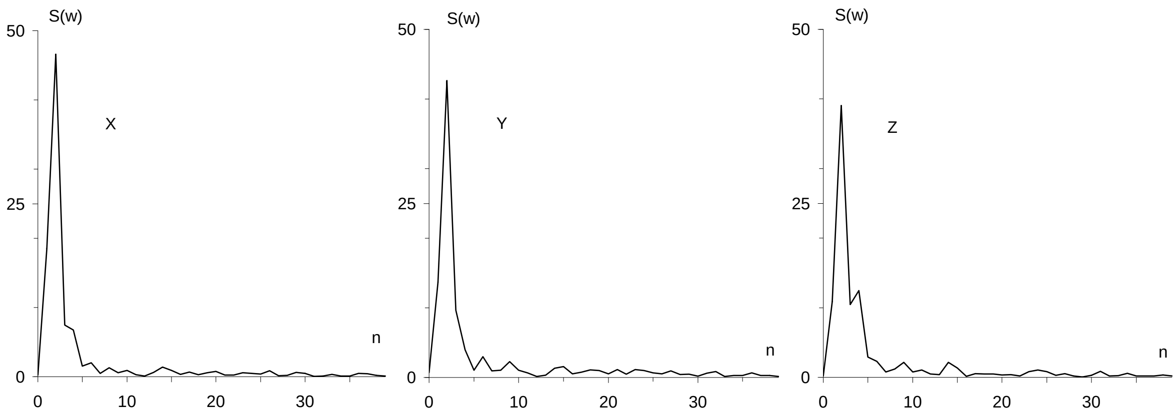

Figure 1. The sample spectrum for observations at the POLV Station

Table 1. Harmonic amplitudes (in mm), periods (in days) and phases (in degrees) coordinate variations of the POLV and GLSV stations

POLV			GLSV		
Amplitude	Period	Phase	Amplitude	Period	Phase
	Coordinate X			Coordinate X	
5.35 ± 0.44	362.40 ± 8.29	167.51 ± 0.27	5.98 ± 0.49	362.97 ± 8.38	155.61 ± 0.28
2.07 ± 0.34	177.46 ± 1.99	281.57 ± 0.60	2.86 ± 0.36	176.62 ± 1.52	257.01 ± 0.47
1.04 ± 0.33	124.88 ± 1.24	34.35 ± 1.12	1.33 ± 0.35	118.47 ± 0.89	301.95 ± 0.90
1.00 ± 0.32	87.83 ± 0.45	154.87 ± 1.12	1.05 ± 0.32	86.40 ± 0.43	165.27 ± 1.14
0.97 ± 0.30	47.31 ± 0.07	280.21 ± 1.12	1.42 ± 0.29	47.23 ± 0.05	286.35 ± 0.74
	Coordinate Y			Coordinate Y	
3.70 ± 0.32	354.75 ± 6.86	139.61 ± 0.30	4.20 ± 0.27	355.13 ± 6.03	138.22 ± 0.22
1.06 ± 0.29	196.74 ± 4.14	33.95 ± 0.92	0.67 ± 0.22	189.26 ± 4.54	332.32 ± 0.52
0.89 ± 0.28	112.04 ± 0.94	171.31 ± 1.14	0.84 ± 0.21	109.80 ± 0.70	138.11 ± 0.30
	Coordinate Z			Coordinate Z	
5.91 ± 0.57	354.37 ± 8.97	142.47 ± 0.33	7.34 ± 0.59	365.17 ± 8.47	170.09 ± 0.29
2.98 ± 0.45	180.01 ± 1.84	306.66 ± 0.53	3.17 ± 0.44	176.31 ± 1.64	272.82 ± 0.50
1.59 ± 0.42	141.91 ± 1.56	326.10 ± 0.92	1.58 ± 0.44	149.33 ± 1.87	118.74 ± 0.96
1.30 ± 0.39	114.02 ± 0.98	202.46 ± 1.12	1.40 ± 0.34	111.94 ± 0.82	180.37 ± 1.00
1.25 ± 0.38	85.63 ± 0.40	107.03 ± 1.07	1.55 ± 0.36	87.03 ± 0.33	183.12 ± 0.85
1.32 ± 0.36	50.14 ± 0.07	284.01 ± 1.14	1.06 ± 0.35	47.41 ± 0.07	303.11 ± 1.18

ADDITION ANALYSIS

For additional result verification of comparison of the initial series of GPS observations at the POLV and GLSV stations the cross-correlation analysis was applied. Cross-correlation functions $K_{pg} = (\tau)$ for series of GPS observations at POLV − GLSV are shown in Fig. 2. The cross-correlation maximum for all diagrams accounts for displacement ($\tau = 0$) and lies within the limits of $0.91 \div 0.93$. If the average radius of correlation is designated as r_k ($K_{pg}(\tau) = 0$ for $\tau > 0$) then it is possible to receive the general model of cross-correlation function $K_{pg}(\tau)$ as

$$K_{pg}(\tau) = \delta_{pg} \exp(-\alpha\tau) \cos(\pi\tau/2r_k). \quad (1)$$

Thus, the characteristics of cross-correlation functions, as well as the results of determination of harmonious components point out that the change of station coordinates is caused by the same physical process acting inphasely at the POLV and GLSV stations.

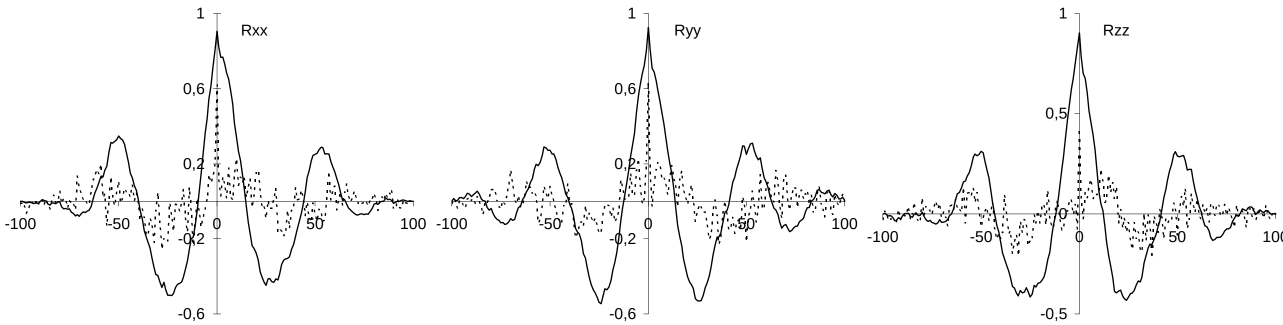

Figure 2. Cross-correlation functions of the initial series of observations (solid) and the remainders (dotted) for POLV – GLSV stations

After removal of the determined components (Table 1) from the initial observation lines, we received remainders $z_p(t)$ and $z_g(t)$ for the POLV and GLSV stations. respectively. In Fig. 2 cross-correlation functions $K^z_{pg}(\tau)$ of the remainders $z_p(t)$ and $z_g(t)$ in the series of GPS observations at POLV – GLSV stations are submitted. We see that interdependence of the remainders reaches its maximum only for displacement $\tau = 0$ and matters for $K^z_{xx}(0) = 0.62$, $K^z_{yy}(0) = 0.63$, $K^z_{zz}(0) = 0.42$. And for other z displacements estimation $K^z_{pg}(\tau)$ does not exceed $|K^z_{pg}| < 0.25$ on module practically meaning that the dependence between the lines is absent.

Hence, after determination of periodic components the remainders can be considered as correlated casual processes $z(t)$ and $z(t')$ with dispersions σ^2_p and σ^2_g and cross-correlation function

$$K_{pg}(\tau) = \sigma_{pg}\delta(t - t'), \quad (2)$$

where $\delta(t - t')$ is delta-function.

The method of comparison of integrated spectral functions of the remainders with spectral function of white noise is applied for judgement about internal structure of the $z_p(t)$ and $z_g(t)$. We tested the remainder research method at statistical analysis of latitude observations in high-frequency band [5]. In Fig. 3 the data on accident of the remainders for $z_x(t)$ and $z_y(t)$ for the POLV Station are submitted, as well as 75% and 99% confidential intervals for white noise, and for the remainders $z_z(t)$ the intervals at level of 75% and 95% are given.

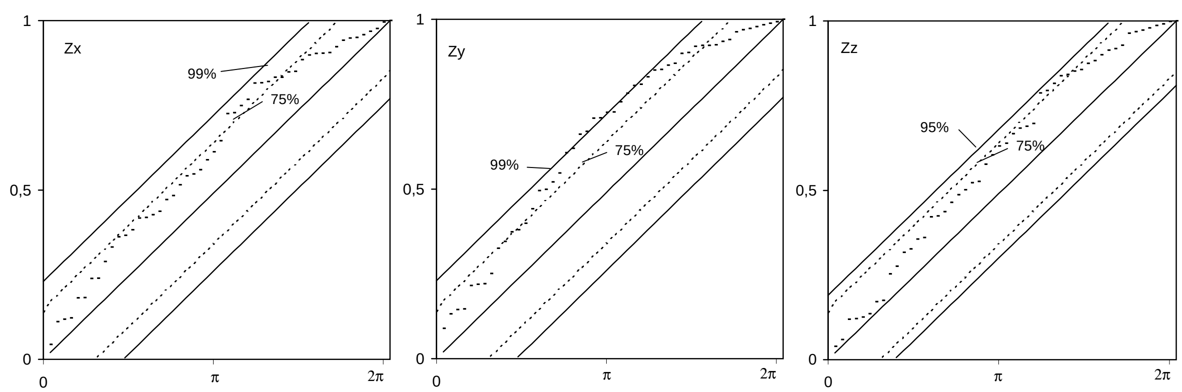

Figure 3. Integral spectral functions of the remainders and confidential intervals for white noise obtained at the POLV Station

As given in Fig. 3, in the low frequency band all the three spectral functions do not leave 75% confidential intervals of white noise. For the remainders $z_x(t)$ the increase of the dispersion role is only registered in the high frequency band. For the remainders $z_y(t)$ the insignificant overstep of the 99% limit of white noise only takes place in the medium frequency band. The series $z_z(t)$ is close to white noise in the best way at all the interval of low and medium frequencies.

As a rather short interval of observations was used for the analysis, it seemed expedient to carry out some additional researches on stability of component estimations at this interval. In Fig. 4 the diagrams of amplitude, period and phase formation of annual and semi-annual term for x coordinate at the POLV and GLSV stations are submitted as an example. There is a change of parameter estimations of composite series at this interval; the phase estimation has particularly small stability. Some distinction in phase estimations for the annual wave of coordinate x and z for the POLV and GLSV stations may be explained by this fact. The results of cross-correlation analysis (Fig. 2) indicate the phase synchronism of the processes. Therefore, the available interval of observations is still insufficient for determination of the exact parameter estimations of the components, and it is necessary to consider parameter estimations (Table 1) as preliminary ones.

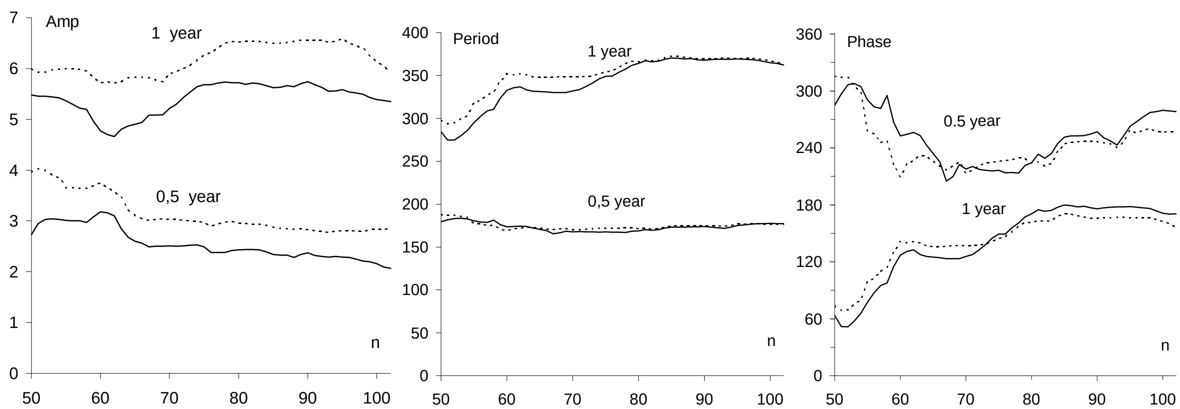

Figure 4. Verification on stability of parameter estimation of harmonics in process of increase of the observation period for the POLV (solid) and GLSV (dotted) stations

CONCLUSION

The analysis of observation series by various methods at two stations by the same technique has allowed to research series components and to estimate their contribution to changeability of station coordinates. The analysis results of the first years GPS observations at the POLV Station have not revealed important local effects. The mean value of post-fit residuals σ_0 for the period of research after determination of components for the POLV Station amounts 2.1 mm – (x), 2.0 mm – (y), 2.5 mm – (z); for the GLSV Station amounts 2.1 mm – (x), 1.5 mm – (y), 2.5 mm – (z).

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