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THE BELGRADE Z-TERM FOR THE PERIOD 1949-1985 AFTER NEW REDUCTION OF BLZ LATITUDE DATA

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Abstract. The values of the parameters (the amplitude, the period and the phase) of the annual and semiannual wobbles and the secular movement of the Z - term were computed from the homogenised series of the Belgrade latitudes in the interval 1949 - 1985. The Belgrade latitude observations were made according to the Talcott method with ASKANIA zenith - telescope (D=11 cm; F=128.7 cm).

The annual wobble of the Z - term is conspicuous, with the amplitude $0\overset{''}{.}041$ found by the Fourier transforms (DFT), but the semiannual one is with the amplitude $0\overset{''}{.}009$ (DFT also) and the secular movement is $0\overset{''}{.}0004$ per year found by the least – square (LSQ) method. These results are in good agreement with the results of the former analysis of the Belgrade latitude data (Grujić, Djokić, Jovanović 1989) and with the new ones obtained by independent analysis of BLZ data (Vondrák, Pešek, Ron, Čepek, 1998).

1. INTRODUCTION

The Belgrade latitude data were denoted by BLZ in the list of Bureau International de l'Heure (BIH) and they were obtained by of two observation programs in the period 1949 - 1985 : the old one - OP (Djurković, Ševarlić, Brkić 1951), until the end of 1960, and the new one - NP (Ševarlić and Teleki 1960), from the beginning of 1960 and onwards.

The BLZ data were reduced to the FK5 reference frame during the new reduction (Damljanović, Pejović 1995) by using the PPM Star Catalogue (Röser and Bastian 1991) and in line with MERIT standards (Melbourne et al. 1983). The analysis of the BLZ latitudes was necessary because of some systematic instrumental, personal, refraction and star position errors. Then, the systematic errors were removed from the data if they were confidently determined (Damljanović 1994, 1995).

The raw Belgrade latitudes were averaged by using the "normal points" (the average values of 49-58 Talcott pair latitudes) to get approximately equal weights points suitable for interpolation by the cubic spline method to obtain the equidistant data (the lag was 0.1 yr and the total number $N = 369$ of the latitude data φ).

2. CALCULATION OF THE Z - TERM

The values of Z - term were calculated by using the relation (Kulikov 1962)

$$\varphi = \varphi_o + \Delta\varphi + Z$$

where: φ are the equidistant Belgrade latitude values with the lag 0.1 yr,

φ_o are the values of the mean Belgrade latitude, with the lag 0.1 yr, obtained by applying Vondrák (V) method of smoothing the values φ with the parameter of smoothing (Vondrák 1969, 1977) $\varepsilon = 10^{-12}$,

$\Delta\varphi$ are the values of the latitude changes, for the BLZ point and with the lag 0.1 yr, from the international data by using Kostinski formula (Kulikov 1962) $\Delta\varphi = x\cos\lambda_{BLZ} + y\sin\lambda_{BLZ}$, with the BLZ longitude $\lambda_{BLZ} = 339.^{o}5$ (in W direction from the zero - meridian) and the coordinates of the instant pole (x, y) of the Earth's rotation (ILS and BIH, in this case).

The linear trend was removed from φ_o.

The necessary changes of x - coordinate in ILS data were introduced in line with BIH (1978) to bring (x, y) into the quasi 1979 BIH system of the coordinates of the pole. We used (x, y) from the ILS series (Yumi and Yokoyama 1980) for the period 1949.0 - 1962.0 and from the BIH or IERS (1993) for the period 1962.0 - 1986.0. The IERS (1993) series of (x, y) are in the system which is close to those of the 1979 BIH one and the BIH Terrestrial System - BTS (BIH 1984).

3. THE SECULAR CHANGES OF THE Z - TERM

The LSQ method was used. The equation of condition was

$$Z = a + b(T - 67.5)$$

where a, b were unknown, and T was the year minus 1900 . The linear trend of the Z - term was

$$b = +0\overset{''}{.}0004/yr \pm 0\overset{''}{.}0007/yr$$

meaning that b is in accordance with the value $0\overset{''}{.}041$/cy (which is the secular trend of BLZ latitude due to tectonic EURA plate motion) calculated from NUVEL - 1 NNR geophysical model (Vondrák et al. 1998). This linear trend was removed from the Z - term values to prepare the data in applying the DFT for the spectral analysis.

4. THE ANNUAL AND SEMIANNUAL VARIATIONS OF THE Z - TERM

In Fig. 1. the curves of the BLZ latitude variation during the year is presented. It is evident that Z - term contains the seasonal component. There are some discrepancies between the OP and NP curves, also.

An analogous curve in the paper of Grujić (1975) displays an amplitude about three times grater than this one.

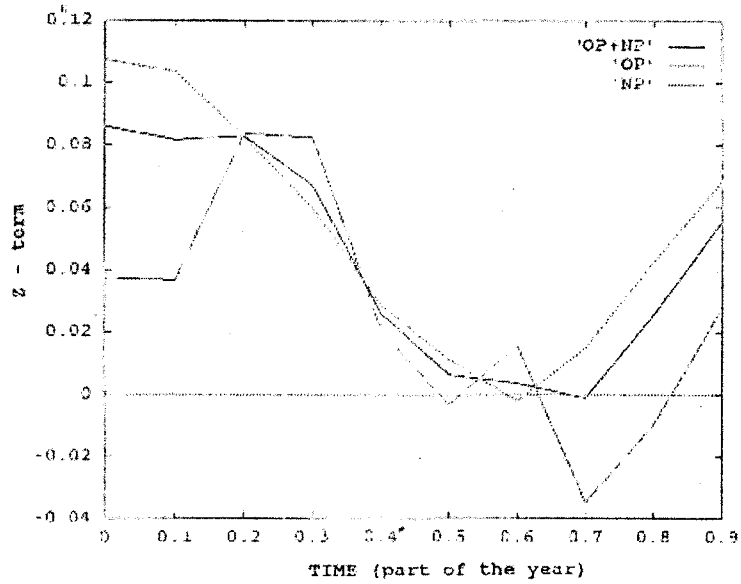

Fig. 1. The seasonal variations of the Z - term

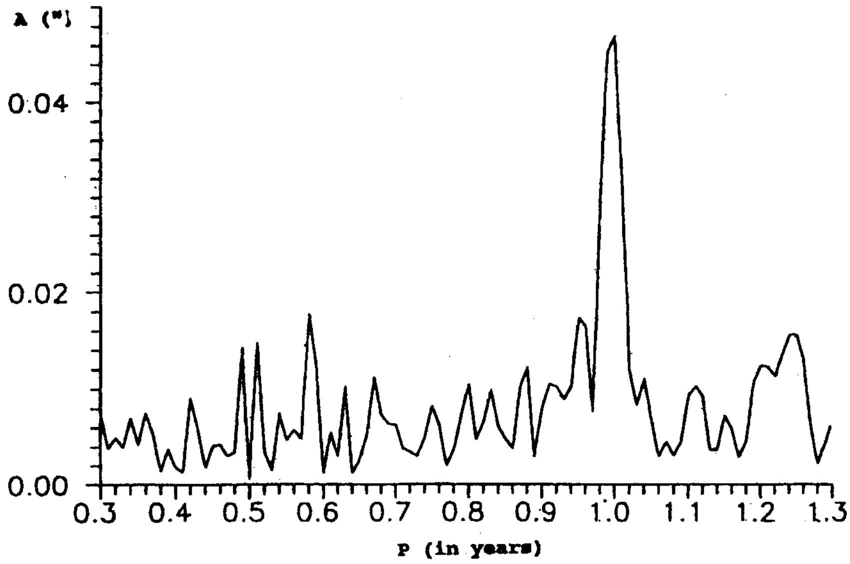

Fig. 2. The amplitude periodogram of the Z - term

After applying DFT method to the values of the Z - term the amplitude periodogram of the Z - term was derived (see Fig. 2.) the form of the harmonic expression being

$$Z = +0\overset{''}{.}043 + 0\overset{''}{.}041\cos(t - 41.^o3) + 0\overset{''}{.}009\cos(2t - 190.^o1),$$

where t is the time (in degrees, $1yr = 360^o$), for the annual wobble ($Pa = 1.00yr$) and semiannual one ($Ps = 0.51yr$). The epoch of the phases was 1949.1 yr, and the white noise correction ΔA was removed from the amplitudes A (but in Fig. 2. ΔA was not removed from A).

The standard deviation of the residuals (the Z - term minus the secular term and two mentioned periodicities) was $\sigma_0 = 0\overset{''}{.}07$. The amplitude standard deviation, the phase and the white noise correction to the amplitude were computed as follows:

$$\sigma_A = \sigma_0\sqrt{\frac{4-\pi}{N}} = 0\overset{''}{.}003$$

$$\sigma_F \approx 57.^o296\frac{\sigma_0}{A}\sqrt{\frac{2}{N}}$$

$$\Delta A = \sigma_0\sqrt{\frac{\pi}{N}} = 0\overset{''}{.}006,$$

where the values of σ_F of the annual and the semiannual terms were $5.^o8$ and $18.^o5$ respectively.

From Fig. 2. evident is the annual peak of the Z - term of BLZ data but the semiannual one is neglected. The value of the amplitude of this annual wobble ($0\overset{''}{.}041$) is in line with the values of the coefficients b and c ($b = 0\overset{''}{.}038$, $c = -0\overset{''}{.}014$) of the BIH function $S(T)$ for BLZ data (T is in years) from the paper of Vondrák et al. (1998). It is the same for the semiannual wobble ($0\overset{''}{.}009$) and the BLZ coefficients d and e ($d = 0\overset{''}{.}002$, $e = -0\overset{''}{.}020$) of the $S(T)$. In the paper of Vondrák et al. (1998) the BLZ data are re–calculated into the Hipparcos system and the Earth orientation parameters are done in the ICRS based on the HIPPARCOS reference frame. Our own new reduction of the BLZ data (Damljanović 1994, 1995) is in the FK5 reference frame and the MERIT Standards, using the PPM Star Catalogue, and in our case the $S(T)$ describes the systematic discrepancies (Feissel 1972) between our BLZ series and the quasi system 1979 BIH (we calculated $b = 0\overset{''}{.}04$, $c = 0\overset{''}{.}03$, $d = 0\overset{''}{.}01$ and $e = -0\overset{''}{.}01$). Our values of the coefficients b, d and e are in accordance with the ones from the paper (Vondrák et al. 1998), the exception is the value of the coefficient c.

These results are in accordance with that ones from the paper (Grujić, Djokić, Jovanović 1989) where the former analysis of the BLZ data was done.

The results of the amplitudes and the phases of the annual (A_a and F_a) and the semiannual (A_s and F_s) periodicities (of the Z - term) obtained by applying LSQ method on the independent three years subintervals of the BLZ data are presented in Table 1.

Table 1. The values of the amplitudes and the phases of the annual (A_a and F_a) and the semiannual (A_s and F_s) wobbles obtained by LSQ on the independent BLZ three years subintervals

	subint. (1900+)	A_a (")	F_a (°)	A_s (")	F_s (°)
1	49.1-52.0	0.0270	90.3	0.0477	167.1
2	52.1-55.0	0.0467	55.3	0.0145	208.9
3	55.1-58.0	0.0699	81.8	0.0214	13.6
4	58.1-61.0	0.0449	44.2	0.0290	324.7
5	61.1-64.0	0.0778	24.5	0.0457	12.9
6	64.1-67.0	0.0385	2.4	0.0082	359.5
7	67.1-70.0	0.0343	20.6	0.0133	203.9
8	70.1-73.0	0.0761	43.3	0.0238	168.7
9	73.1-76.0	0.0575	34.6	0.0093	230.2
10	76.1-79.0	0.0481	18.5	0.0028	223.6
11	79.1-82.0	0.0506	46.5	0.0074	3.2
12	82.1-85.0	0.0387	38.0	0.0059	22.7
mean value		0.0508 ± 0.0047	41.7 ± 7.3	0.0191 ± 0.0043	161.6 ± 35.6

The epoch of the phases is 1949.0 yr.

It is evident that A_a increases during OP, mostly stable during NP (exempt during the subintervals 1961.1 - 1964.0 and 1970.1 - 1973.0), and successively decreases after 1970.1 . At the other hand, F_a is mostly stable. The semiannual amplitude A_s mostly decreases (exempt for the subintervals 1961.1 - 1964.0 and 1970.1 - 1973.0, as in the case of A_a), and the values of A_s are small after 1973.1 . The semiannual phase F_s is very changeable.

The LSQ results are in good agreement with the DFT ones.

The same method (LSQ) on the independent BLZ six years subintervals gives the results presented in Table 2. The epoch of the phases is 1949.0 yr, also. The LSQ results presented in Table 2. are in good agreement with the DFT ones, too.

Table 2. The values of the amplitudes and the phases of the annual (A_a and F_a) and the semiannual (A_s and F_s) wobbles obtained by LSQ on the independent BLZ six years subintervals

	subint. (1900+)	A_a (")	F_a (°)	A_s (")	F_s (°)
1	49.1-55.0	0.0353	68.0	0.0297	176.5
2	55.1-61.0	0.0545	67.2	0.0230	345.2
3	61.1-67.0	0.0572	17.2	0.0269	10.9
4	67.1-73.0	0.0543	36.3	0.0178	181.1
5	73.1-79.0	0.0523	27.3	0.0061	228.7
6	79.1-85.0	0.0446	42.8	0.0066	11.8
mean value		0.0497 ± 0.0034	43.1 ± 8.5	0.0184 ± 0.0041	159.0 ± 52.9

5. CONCLUSION

The more detailed discussion will be given elsewhere (Damjanović and Pejović, 2000)

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