SEASONAL OSCILLATIONS OF THE POLAR MOTION DURING THE LAST FORTY YEARS

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Variations of seasonal oscillations of the polar motion during the last forty years are shown and discussed. Seasonal oscillations of the geodetic excitation functions of the polar motion were computed from the EOP (IERS) 97 C04 set of data together with their time variable spectra and correlations with the atmospheric excitation functions of the polar motion.

INTRODUCTION

Geophysical sources of amplitude variations of seasonal oscillations, *e.g.*, annual, semiannual and 120 days period of the polar motion are still not sufficiently known at the present level of accuracy of their determinations submiliarcseconds.

Variations of the polar motion are correlated with variations of the Effective Atmospheric Angular Momentum (EAAM) excitation function, but not so strongly as variations of length of day (LOD). Correlation coefficients between atmospheric and geodetic excitations of seasonal oscillations of the polar motion for the years of 1985–1996 to be equal to 0.5–0.6 were computed by Ponte [8]. This correlation coefficient is higher after considering the total atmospheric and oceanic angular momentum (OAM) [6, 8], but the models of the OAM are available only for the last few years.

The new improved reanalyses of EAAM data computed by the NCAR/NCEP (National Centers for Environmental Prediction/National Center for Atmospheric Research) for the last fifty years [9] enables studies of the correlation between geodetic and atmospheric excitation functions of the polar motion in such long period of time.

In the paper, the correlations of the EAAM and geodetic excitation functions of seasonal oscillations of the polar motion computed for the last forty years are discussed.

ANALYSES

Variations of seasonal oscillations of the polar motion

Applied here the EOP (IERS) 97 C04 pole coordinates data were divided by using the Butterworth band pass filter into two spectral bands, namely annual frequencies (500–300 days) and semiannual frequencies (250–150) days.

The Chandler, annual and semiannual oscillations were filtered from these data by the Fourier Transform Band Pass Filter (FTBPF) with the parameter λ giving a high frequency resolution [3, 5] (Figs. 1, 2). Variations of the amplitude of the annual oscillation are not so big as of the Chandler one; anyhow they are of the order of several tens of miliarcsecond (Fig. 1).

Semiannual oscillation of the polar motion is beating with the semi-Chandler one with the period of about 6–7 years. This combined oscillation achieves the maximum amplitude of the order of 10 mas [4]. They are separated by using the narrow FTBPF [3, 5] (Fig. 2). The amplitude of the semiannual oscillation itself is of the order of 6 mas in maximum. Slow variations of its amplitude are of the order of 1–2 mas. The amplitude of semi-Chandler oscillation is changeable.

Amplitudes of the 120 days oscillations are strongly variable reaching 4–5 mas in maxima [1, 2].

Geodetic and atmospheric excitation functions

The commonly used technique for comparing the polar motion excitation function with EAAM excitation function is as through determination of the so-called geodetic polar motion excitation function χ_1, χ_2 using time domain deconvolution formula [10]. The EOP (IERS) 97 C04 set of polar coordinate data were applied

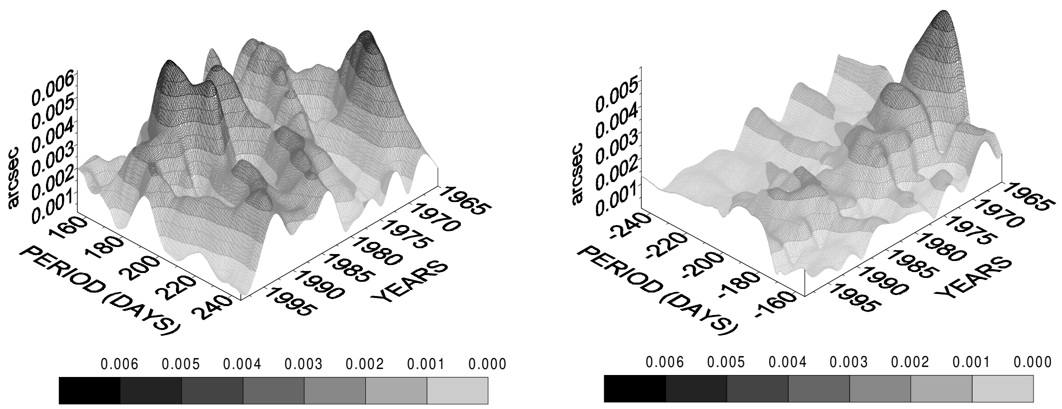

Figure 2: Semi-Chandler and semiannual oscillations of the EOP (IERS) 97 C 04 set of polar motion filtered by the FTBPF with $\lambda = 0.0005$

for computations of the geodetic polar motion excitation function for the period of 1962–1999. The Chandler period of 435 days and the dumping coefficient Q to be equal 100 were adopted for those determinations. The mentioned above reanalyses data EAAM of excitation functions were averaged over 1-day for consistency with the geodetic ones. The geodetic and atmospheric excitation functions for polar motion were divided by the use of the Butterworth band pass filter into three spectral bands, namely annual frequencies (450–230 days), semiannual frequencies (230–150 days), and 120 days oscillations frequencies (150–90 days).

The time variable spectra of the geodetic polar motion excitation functions of seasonal oscillations computed by the FTBPF are shown in Fig. 3. In the case of the annual oscillation a retrograde part of the spectra indicate ellipticity of the annual oscillation. The amplitude of the annual oscillation reached the maximum in the late of seventies and since this time it has been diminished. The amplitude of semiannual oscillation of the geodetic excitation function of polar motion, which is ten times weaker than annual one, is also elliptical (Fig. 3) what is proved by the retrograde part of this spectrum. There are three maxima of the amplitude of the semiannual oscillation around 1970, 1985–1987 and 1993–1995 years. They can be caused by El Nino phenomena.120 days oscillation of geodetic excitation function of polar motion is a very weak. High amplitudes of seasonal oscillations in the retrograde parts of the geodetic excitation function of polar motion in sixties and at the beginning of seventies are probably caused by the low accuracy of the considered data at this time.

Variations of time variable spectra of seasonal oscillations of the EAAM excitation functions of polar motion (not shown here) have a very similar character to the variations of the geodetic excitation functions [7]. The similarity of variations of geodetic and EAAM excitation functions of seasonal oscillations of polar motion is shown by computations of their correlations.

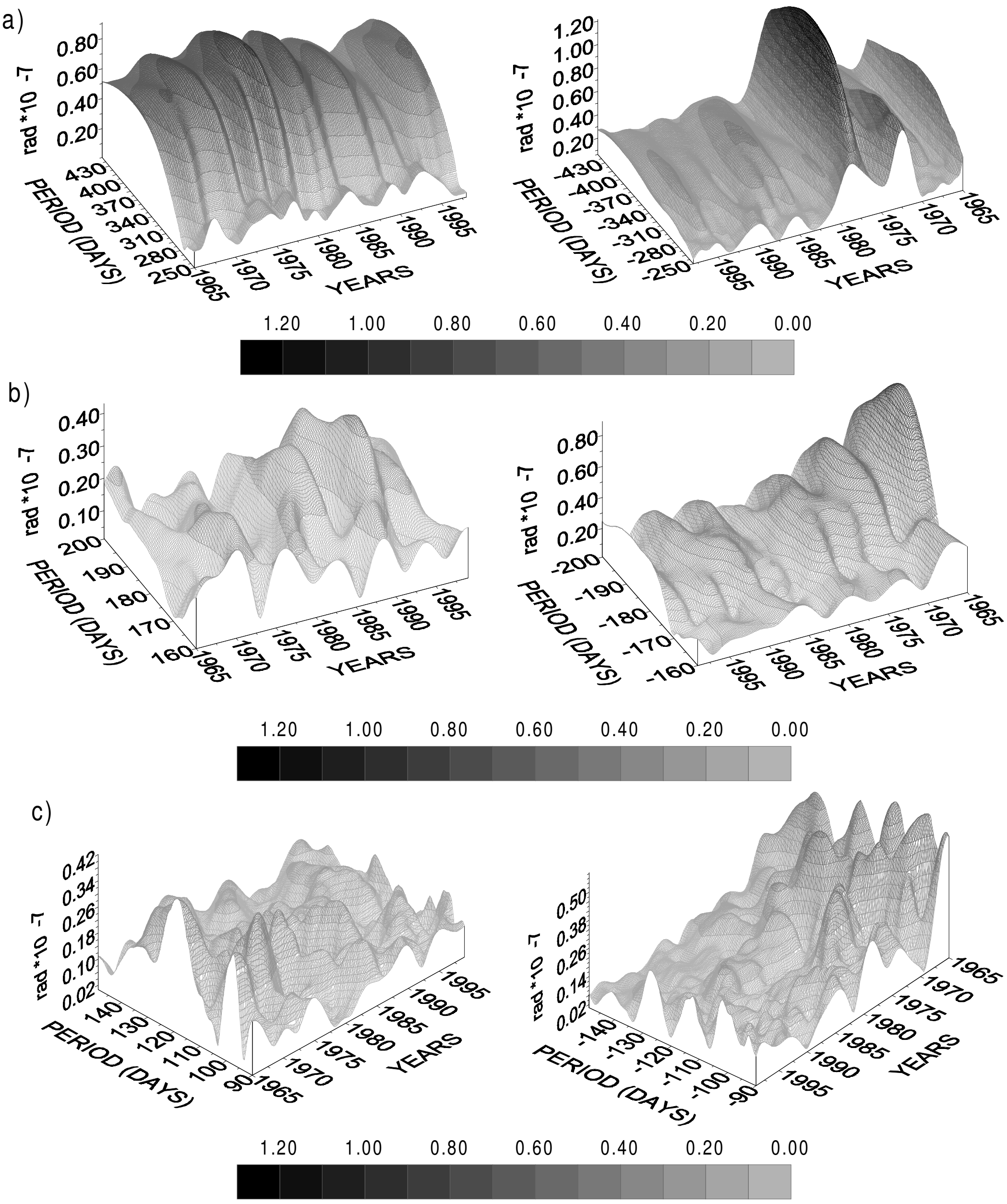

Figure 3: Time variable amplitude spectra of (a) annual, (b) semiannual, (c) 120 days oscillations of complex equatorial components of the geodetic polar motion excitation function filtered by the FTBPF with $\lambda = 0.001$ for the annual and with $\lambda = 0.0005$ for semiannual and 120 days oscillations, for the prograde (positive) and retrograde (negative) parts of spectrum

Correlations

Correlation coefficients between complex-valued components of geodetic and atmospheric functions of polar motion were computed since 1962 over 2190, 1095, 720, 540 days long intervals, with 100 days step for annual, semiannual, 120 days and subseasonal (shorter than 90 days) bands, respectively (Fig. 4). On the basis of the computed autocorrelation functions of all filtered data the estimated numbers of independent points are 33 and 128, for the seasonal and subseasonal bands, respectively. Using the standard Student-table for the 95 per cent confidence level we obtained critical values of the correlation coefficient equal to 0.31 and 0.17, respectively.

It is clear that the correlation has improved since 1970's for annual and semi-annual bands while only since 1980's for the subseasonal one. The correlation coefficient in the case of the annual oscillation is stable and

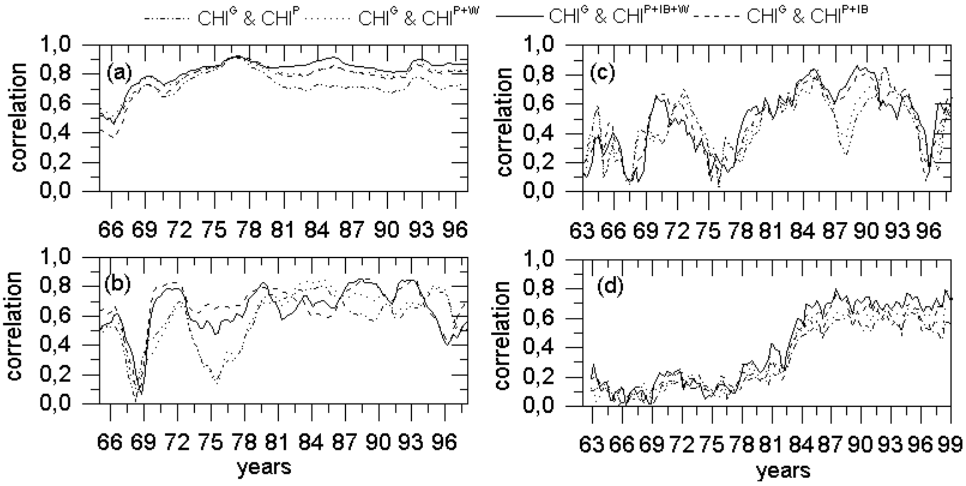

Figure 4: Correlation coefficients between the complex-valued equatorial components of geodetic and atmospheric excitation functions for polar motion separated by the Butterworth band pass filter into (a) 450–230 days, (b) 230–150 days, (c) 150–90 days, (d) 90–10 days bands

quite high, above 0.8, since 1970. In the case of semiannual oscillations these coefficients are changeable in the range of 0.6–0.8 since 1980. In the 120 days oscillation band the correlation coefficient is more stable only in the years 1980–1993. The IB correction, introduced to the pressure term of the atmospheric excitation function, increases the correlation somewhat but does not change a general tendency. Such a behaviour of the correlation coefficients is likely due to less accurate polar motion or atmospheric data before the mentioned years. Thus, the accuracy of estimates of geodetic and atmospheric excitation functions of polar motion before 1970's and 1980's still remains a matter of concern.

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REFERENCES

[1] *Kolaczek B.* Variations of Short Periodical Oscillations of Earth Rotation // Developments in Astrometry and their impact on astrophysics and geodynamics: Proc. 156th IAU Symp., Shanghai, China, Sept. 15–19, 1992 / Eds I. I. Mueller, B. Kolaczek.–Kluwer Academic Publishers, Dordrecht/Boston/New York.–1992.–P. 291–296.

[2] *Kolaczek B.* Short period variations of Earth rotation // Systemes de Reference Spatio–Temporels: Proc. Journees 1995.–1995.–P. 147–154.

[3] *Kosek W.* Time variable band pass filter spectrum of real and complex-valued polar motion series // Artif. Satell., Planetary Geodesy.–1995.–**30(1)**.–P. 27–43.

[4] *Kosek W., Kolaczek B.* Semi-Chandler and Semiannual Oscillations of Polar Motion // Geophys. Res. Letts.–1997.–**24**, N 17.–P. 2235–2238.

[5] *Kosek W., Popiński W.* Comparison between the Fourier transform band pass filter and the wavelet transform spectro-temporal analyses on Earth Rotation Parameters and their excitation functions // IERS Technical Notes.–1999.–N 28.–submitted.

[6] *Nastula J., Ponte R. M.* Further Evidence for oceanic excitation of polar motion // Geophys. J. Int.–1999.–**130**.–P. 469–474.

[7] *Nastula J., Kolaczek B.* Seasonal oscillations in regional atmospheric excitation of polar motion // Adv. Space Res.–2000.–submitted.

[8] *Ponte R. M. Stammer D., Marshall J.* Oceanic signals in observed motions of the Earth's pole of rotation // Nature.–1998.–**391**.–P. 476–479.

[9] *Salstein D. A., Kann D. M., Miller A. J., Rosen R. D.* The Sub-Bureau for Atmospheric Angular Momentum of the International Earth Rotation Service: A meteorological data center with geodetic applications // Bull. Amer. Meteorol. Soc.–1993.–**74**.–P. 67–80.

[10] *Wilson C. R.* Discrete polar motion equations // Geophys. J. Roy. Astron. Soc.–1985.–**80**.–P. 551–554.