ON THE ANNUAL EARTH'S ROTATION

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ABSTRACT

A number of works have presented evidence that the seasonal terms of the Earth's rotation are variables from year to year. In this paper, introducing a parameter associated to a mean seasonal kinetic energy we show evidence of about 4 year and 7 yr periodicity. This result is briefly discussed.

The importance of the study of the Earth's annual motion in astronomy and geophysics has been outlined by Lambeck (1980) in his recent book: The Earth's variable rotation. The problem can also be considered important for the definition of a reference system. Because of fluctuations in the Earth's rotation, in fact, the astronomical scale of Universal Time is not uniform. To reduce it, at least in part, UT2 was introduced to take into account the apparently regular annual and semi-annual variations. But,owing to the evidence that also seasonal variations are variable, the suppression of UT2 has been recently proposed (Guinot, 1979) at the IAU S. Fernando Symposium n. 82.

Attempts to explain and analyze the variation of seasonal fluctuations were made by several authors. Since seasonal terms are generally attributed in the largest part to the zonal wind circulation, also their variability is assumed to being originated by the same causes. The results of the approaches are not, however, entirely satisfactory. Lambeck and Cazenave (1973) found an increasing amplitude of the semi-annual term and a decreasing amplitude of the annual term. Okazaki (1975) made in greater detail an analysis of the amplitude changes of the annual component and suggested that it varies with a repeating period of 6 yr correlated with the westerly zonal winds at the 500-mb in the zone 35°-55° N. Variations of the amplitudes and phases of the components with periods of 1, 0.5 and 0.33 yr have been also investigated by Korsun and Sidorenkov (1974) for the interval 1956.5-1972.8 . They found several periods and explained them as being the result of the amplitude

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modulations of the seasonal waves; in particular a 6-7 yr period was emphasized and attributed to "polar tides".

Sidorenkov (1979) himself suggested an "intermisphere engine" as the responsible mechanism of the seasonal variation. In this case the form of the function describing the seasonal variation should be different from the classical Stoyko formula. Starting from this point of view we have shown that the mean seasonal kinetic energy has a fairly regular variation (Poma and Proverbio, 1980). We shall discuss this point in the next section.

Finally a complete study of the Earth's motion should also include the annual polar motion but, because of its proximity to the Chandler resonance, such an investigation is a more difficult task.

2. THE SEASONAL FUNCTION

Let us describe the seasonal variations of the Earth's rotation as a quite general periodic function having fundamental period T equal to one year and the mean annual value equal to zero. Then we can represent this "seasonal function" S as a trigonometric series

$$S = \Sigma_k (a_k \cos 2k\pi t + b_k \sin 2k\pi t) \qquad (1)$$

where t is a fraction of a year and k = 1,2,3,...

According to the observational evidence the Fourier coefficients of the harmonics of order $k > 3$ can be neglected, with a high degree of approximation. Let us introduce the mean amplitude A defined by

$$A^2 = P = 2T^{-1} \int_0^T S^2 \, dt \qquad (2)$$

and related to the Fourier coefficients a_k and b_k by the Parseval equation

$$P = \Sigma_k (a_k^2 + b_k^2) \qquad (3)$$

We assume the quantity P, which is proportional to a mean kinetic energy, as a parameter representative of the seasonal variation of the rate of the Earth's rotation.

In order to evaluate this parameter we have used the values of the rotational velocity m_3, derived from the 5-day data of UT1 - IAT, published by the BIH, for the period 1962.0 - 1979.0. The values of the fun-

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ction S have been obtained from those of m_3 after filtering the long term variations by the use of running means (Korsun and Sidorenkov, 1974). Another method which led to equivalent results was used and described by us in the above mentioned paper.

Finally, by using as input data the values of S thus obtained, both sides of equation (3) have been calculated over an annual period sliding by quarterly intervals. The integral of the (2) has been numerically computed and the coefficients a_k and b_k ($k = 1,2,3$) have been determined by the least squares method starting from equations of conditions (1). The results for A^2 and p agree fairly well with one another; a_k and b_k of the annual, semi-annual and quarterly components are also in discrete agreement with those found by Korsun and Sidorenkov (1974). This should confirm the validity of the method and the reliability of results. The values of P expressed in $(ms/day)^2$ are plotted in Fig. 1. The annual values for the period 1956-1961 have been carried out using relatively few data and must be considered less precise and homogenous. It can be clearly seen from the diagram that P varies apparently in a regular manner. It must be first emphasized that the variation of P appears to be more regular than the above mentioned fluctuations obtained, analysing separately the amplitude of the annual or semi-annual components, by the above mentioned authors.

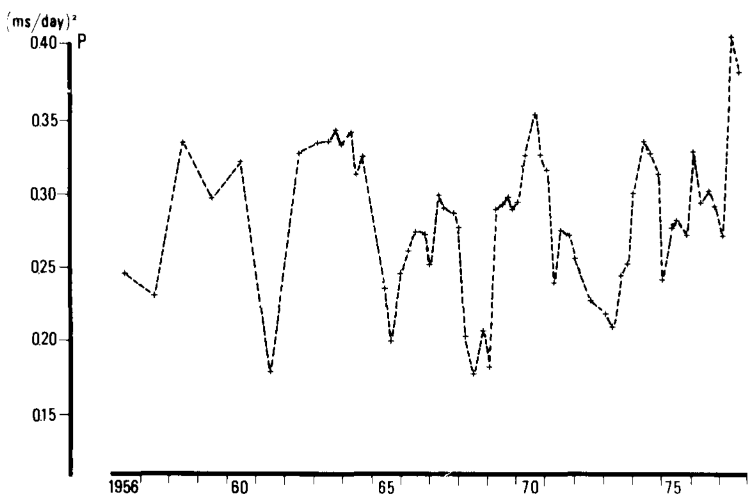

Figure 1. Variation of P, square of the mean seasonal amplitude

These results seem suggestive of a modulation of the seasonal variation in the rate of rotation with periodicity of about 7 yr and, less definite, of about 3,5 year. If this latter is removed an interesting result is obtained. The residuals are very well fitted by a sine curve of period 7 yr and amplitude 0.022 $(ms/day)^2$. (Fig. 2)

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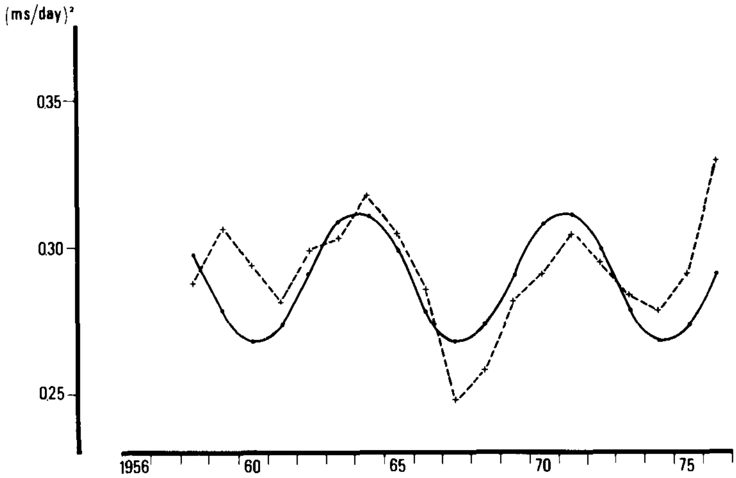

Figure 2. 4-yr running means of P (dashed line); the sine curve, with 7-yr period, has been computed by the least square method.

CONCLUSIONS

The existence of periodical fluctuations in the seasonal variation of l.o.d. of a period of about 3.5 and 7 yr are suggested by our results.

The assumption that the modulations found in the seasonal variations of l.o.d. could have different causes cannot be disregarded. The periodicity of about 7.5-yr discovered in the spectrum in the atmospheric mass distribution by Dickman (1977) and the global oscillation of the ocean having about a 3.5 year period showed by Kakuta and Onodera (1972) could explain the results found. The origin of both modulations might also be explained by the same external or internal excitation function. So there still remain difficult problems concerning the physics and energy flux engaged in the same modulation phenomena. We are indebted to to Dr. L.V. Morrison for the critical reaching of the manuscript.

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