LONG-TERM CHANGES IN THE VARIANCE OF THE EARTH ORIENTATION PARAMETERS AND OF THE EXCITATION FUNCTIONS

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ABSTRACT. The variability in time of the Earth' Orientation Parameters (EOP) and of the Effective Atmospheric Angular Momentum (EAAM) functions is studied. The initial time series for the analysis are the daily values of the length of day from 1962 to 2005 and also the six-hour values of the EAAM functions: the wind terms χ_1^w, χ_2^w, χ_3^w, and pressure terms χ_1^P, χ_2^P, χ_3^P from 1958 to 2000. The values of variances were calculated for the annual interval that had been continuously slid from the beginning up to the end of the analyzed series. The step of the slide was equal to 1 day.

The obtained graphs of temporal changes in the variances for each analyzed time series are demonstrated. It is shown that the values of variances of the EOP and the EAAM functions change by a factor of several times. The variations are caused by the oscillations of tidal forces in the cycle of the regression of the lunar nodes (18,6 year) and also by the evolution of the phenomena of the El Nino Southern Oscillation and of the Quasy-biennial Oscillation of the atmospheric circulation.

1. INTRODUCTION

It is known that the lunisolar tide has a strong influence on the instability of the Earth rotation. The declination and geocentric distances of the Moon vary in time in a complicated way. The amplitude of monthly oscillations of the Moon declination varies from 29° up to 18° because of the regression of the lunar orbit nodes with a period of 18.61 year. The perigee of the lunar orbit moves with a period of 8.85 year, that causes the variation of the quasy-weekly period from 5 to 9 days (Sidorenkov, 2002).

The tidal oscillations of the Earth rotation have the amplitude and phase modulations due to the oscillations of the Moon declination and geocentric distance. The amplitude of the tidal oscillations varies with a period of 18.61 year, and the phase with a period of 8.85 year.

The variability of the tidal oscillations of the Earth rotation most brightly comes to light if to calculate the variance D_{td} of the tidal oscillations of the Earth angular velocity with a sliding temporal (for example, annual) interval. Figure 1 shows the temporal course of this variance D_{td}. One can see that the magnitude of the variance of the tidal oscillations varies by a factor of three from its minima in 1960, 1979, 1998 to its maxima in 1969, 1988, 2007.

The maximum (minimum) of the variance D_{td} has place when the ascending (descending)

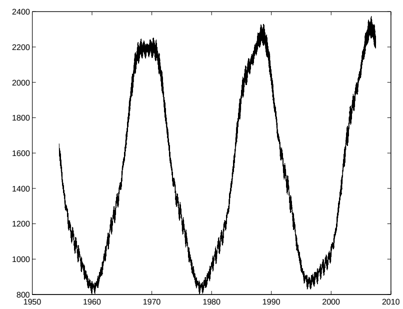

Figure 1: The variance D_{td} of the tidal oscillations of the Earth angular velocity in the sliding interval N=365 days.

node of the lunar orbit coincides with the point of the spring equinox. The long-term (zonal) tides have a strong influence on the meridianal circulation and synoptic processes of the atmosphere. We may expect that the variability of the excitation functions of the atmospheric angular momentum will reflect, along with other causes, the effect of temporal variations of the zonal lunar tides.

2. INITIAL DATA

For the analysis, we used the time series of the Earth orientation parameters C04, which were calculated in the International Earth Rotation and Reference Systems Service (IERS) with the daily discreteness from 1962 to 2005.

Also, we used the time series of the components of the atmospheric angular momentum, which are computed in the Special Bureau for the Atmosphere of the Global Geophysical Fluids Centre of the IERS. They included three wind terms: h_1, h_2 and h_3, and three terms of pressure P_1, P_2 and P_3. The wind terms were computed by integrating the winds from the Earth surface to 10 hPa, that is to the top of the atmospheric model. The pressure terms were calculated in two variants: with and without the account for the effect of the inverse barometer for pressure over the World Ocean. All these series span the period since 1948 till 2005 and have the discreteness equal to 6 hours.

Note that the inverted barometer correction involves the applying of the mean atmospheric surface pressure over the entire World Ocean to every point over the World Ocean (Salstein et al., 1993).

3. CALCULATION FORMULAS

For all series the variances D were calculated in the sliding annual interval

$$D = \frac{1}{N}\sum_{i=1}^{N}\left(x_i - \overline{x}\right)^2,$$

where N=365 for the series with the daily discreteness, or N=1461 for the series with the 6-hour discreteness. The values of the variances were calculated for the annual interval that had been continuously slid from the beginning up to the end of the analyzed series. The step of the slide was equal to 1 day or 6 hours.

4. RESULTS AND DISCUSSION

The variance of the angular velocity ω of the Earth rotation has minima in 1962, 1979, 1999; in other words they are near to the minima of the values D_{td} of the tidal oscillations. The maxima of the variance of the angular velocity are recorded near 1969, 1988, and 2006; in other words, they coincide with the maxima of the variance D_{td} of the tidal oscillations. A sharp peak of the variance of the angular velocity near 1998 is caused by a significant acceleration of the Earth rotation at this time. The reason of such anomaly of the angular velocity ω is, probably, the El Nino phenomenon of 1997-1998. It is known that during El Nino the zonal circulation and the angular moment of the atmosphere amplify. This disturbs the usual seasonal course of the angular velocity ω. In Figure 2 it is possible to see the peaks, which are excited by the El Nino phenomenon. Smaller peaks of the variance are caused by the quasy-biennial oscillations of the atmospheric winds in the equatorial stratosphere. They conceal the course of the curve D. To suppress the quazy-biennial cyclicity, we have calculated the variances D of the angular velocity with the sliding interval N=850 days. Figure 2 shows the change in the variance D in this case. Here, oscillations D due to of the lunisolar tides (the minima in 1979 and 1998 and maxima in 1969 and 1988) are more pronounced. The peaks in 1983, 1988, and 1997 are associated with the El Nino events.

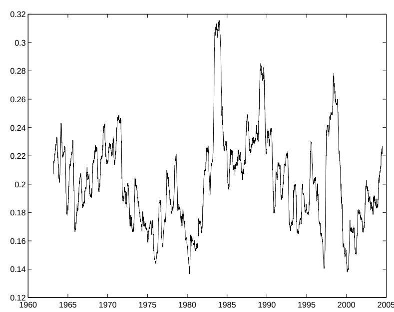

Figure 2: The variance D of the Earth angular velocity in the sliding interval N=850 days

The variances of the coordinates of the pole x and y have, apart the 6-year cyclicity, a small modulation, which is likely to be due to the phenomena of the El Nino-Southern Oscillation. Maxima of the variance of the coordinates x and y nearly coincide in time with three most strong El Nino of 1982-1983, 1987-1988, and 1997-1998. In 2003, the El Nino was developed only slightly; therefore, the variances of the coordinates x and y was minimal.

The variance of the axial component AAM h3 has peaks during the El Nino events. Thus in 1951, 1957, 1969, 1977, 1982, 1988, and 1998 there observed the El Nino phenomena and the peaks of the variances of the component AAM h3. The variance axial component AAM h3 is due to the evolution of the El Nino Southern Oscillation phenomena. Smaller peaks are caused by the quasy-biennial oscillations of winds in the equatorial stratosphere. Figure 3 shows the course of the variance of the component AAM h3 in the case of using the sliding time interval N=850 days. In this case the effect of the El Nino events became more pronounced.

The variances of the equatorial components AAM h1 and h2 had maxima in 1952, 1969 and 1982. The reason of a considerable damping of the variance in the last 20 years is not clear.

Long-term (zonal) tides have a strong influence on the meridianal circulation and the synoptic processes of the atmosphere. At increasing (decreasing) of the value D_{td} the variability of the atmospheric and oceanic processes increases (decreases).

The maximum of the lunisolar tidal forces variability in 2005 has initiated many extreme processes. For example, the catastrophic earthquake and devastating tsunami took place in December 26, 2004, i.e. they occurred exactly at the time of the winter maximum of tidal forces

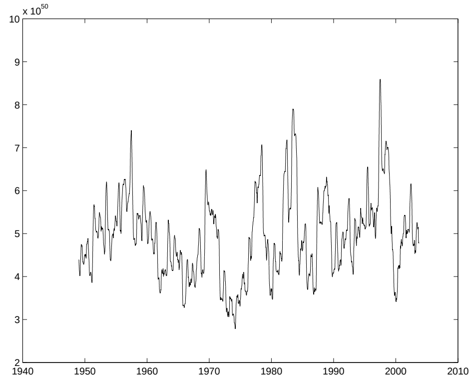

Figure 3: The variance of the atmospheric angular moment component h3 in the sliding interval N=850 days

in 2004 and of the 18.6-year maximum of tidal forces.

In 2005, the extreme activity of the tropical atmosphere was observed. Thus, the amount of hurricanes in the Atlantic Ocean in 2005 was so great that there were no enough names for them. Indeed, the name of each tropical cyclone begins with the particular letter of the Roman alphabet. According to the climatic norm, in Atlantic, in span since June till November, 9 hurricanes form, and there were 27 of them in 2005. Over the whole history of instrumental observations, such amounts of the Atlantic hurricanes were not observed.

In 2005, the blocking atmospheric highs of extremal duration were observed: in February - April - in the region of Iceland, and in September - November - over the European part of Russia. They gave rise to many extremal weather events in Europe and adjacent regions.

The statistics of hazardous hydrometeorological phenomena, which is being carried out in the Hydrometcentre of Russia, clearly reveals an increase (decrease) in their frequency with the increase (decrease) in the variance of the tidal forces.

Thus, the increased frequency of extreme natural processes in the last years, which is usually attributed to the global warming, is to a greater extent caused by the maximum variability of the tidal forces, which is presently observed.

5. CONCLUSION

The variances of the EOP and the EAAM functions changes by a factor of several times. The variations are caused by the oscillations of tidal forces in the cycle of the lunar nodes regression (18,6 years), as well as by the evolution of the El Nino Southern Oscillation and of the Quasy-biennial Oscillation phenomena of the atmospheric circulation.

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