Study Of The 6-Year Oscillations Of LOD

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***Abstract* — The subject of this research is 6-year oscillation of LOD. The main stages of work are studying of the uneven rotation of the Earth about axis, extracting 6-year oscillations from statistical data and studying them, study and accounting of OAM (ocean angular momentum) and AAM (air angular momentum). All oscillations are extracted by using a Panteleev bandpass filter. And after that, graphs were built according to the information received. The charts have been analyzed and compared with the results of the work of scientists, who studying the 6-year oscillation of length of the day. The charts have been analyzed and compared with the results from the existing reserch papers, which deal with the problem of the 6-year oscillation of length of the day.**

INTRODUCTION

The uneven rotation of the Earth around its axis was predicted back in the 18th century by Immanuel Kant, who believed that the Earth was slowing down due to tidal friction, as a result of which the length of the day should increase. Later, Pierre-Simon Laplace revealed that earthquakes, winds, tides, volcanic eruptions and other mass movements around the world cause the planet to rotate unevenly (according to the laws of mechanics). Such deviations were then impossible to measure, the reason for this was the lack of accurate instruments.

In the 19th century, the appearance of high-quality astronomical telescopes in various observatories around the world, for example, in London, Washington, Paris, Pulkovo, whose resolution reached tenths of an arc second, made it possible to collect data on the passage of stars through the meridian with their exact moments and coordinates. And over time, the data became more accurate and accurate.

In the last decade, a great interest among various variations in the Earth's rotation has been caused by a weak 6-year LOD signal. The estimations of variability of the amplitude and phase became a challenging question among researchers. So, in [1], a continuous decrease in the amplitude of the 6-year LOD oscillation was shown. According to this it was concluded that it is freely damped and the characteristics of the core – mantle boundary were estimated. In our work, we analyze the observational data and check how this oscillation behaves, consider the angular momenta of the OAM ocean and the AAM atmosphere, and subtract their contributions to the LOD. Oscillations with a period of 6, 20 or more years, for lack of reliable explanations, are usually attributed to processes in the bowels of the Earth, information about which is not directly available. Recently, the assumption that the 6-year oscillation is associated with the oscillation of the Earth's core has been greatly developed. This 6-year oscillations in the length of the day, as will be shown, has a varying amplitude, which sometimes fades, and sometimes reaches 0.25 ms.

The remainder of the paper is organized as follows. The Literature Review section reviews the results of Chinese scientists who studied the 6-year fluctuation in the length of the day and tells about what we changed when studying in data processing. Further, it is described in detail about the method that we used, the obtained graphs are described, and their correspondence to each other is analyzed. Following are the intermediate results obtained at this stage of the study. The article ends with a brief overview of the progress and results of the work, and describes the steps that can be taken in the future based on the results.

LITERATURE REVIEW

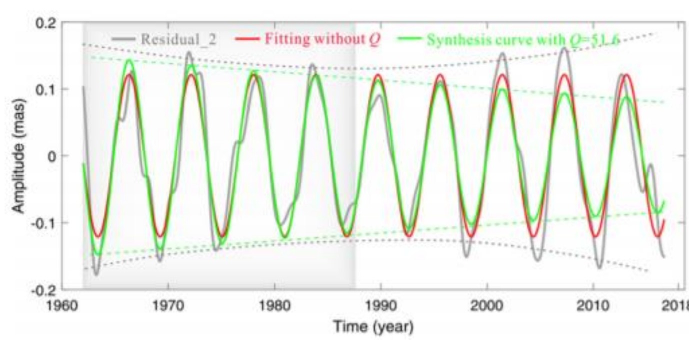

Fig. 1.The graph of the amplitude of the 6-year oscillation in the length of the day, obtained in [4] (green color).

The graph shows that the amplitude decreases over time, from which it is concluded that the oscillation is damped. The difference between our calculation method and the results of the Chinese of 2019 is that we filter LOD, AAM, OAM, and then subtract LOD- (AAM + OAM), Pengshuo Duan immediately subtracts the effects of the ocean and atmosphere, does not apply a band-pass filter, but uses only a harmonic model, and does not analyze the centuries-long series (ECMW). That is, without using a band-pass filter to isolate the oscillation, it distorts the picture of the amplitude change.

METHODS

In the course of this work, a single-band Panteleev filter was used (bears the name of the Russian astronomer and gravimetrist V. L. Panteleev), with it 6-year fluctuations were identified. The impulse response is given by:

$$h(t) = \frac{\omega_0}{2\sqrt{2}} e^{-\left(\frac{\omega_0|t|}{\sqrt{2}} - 2i\pi f_c t\right)} \left(\cos\frac{\omega_0 t}{\sqrt{2}} + \sin\frac{\omega_0 |t|}{\sqrt{2}}\right),$$

with parameters f_c determining the center frequency and $\omega_0 = 2\pi f_0$, determining its width. The transfer function is given by:

$$L_h(f) = \frac{f_0^4}{(f-f_c)^4 + f_0^4}.$$

To isolate the 6-year oscillation, we set f_c=1/d, where d is the period, that is, 6 years, which means the central frequency value is f_c=0.167 and the width parameter is f_0=0.04 year^{-1}.

The 6-year fluctuation was distinguished from the corresponding LOD time series of the bulletins C02 and C04 of the Earth Rotation Service [2], which begin from 1830 and from 1962, respectively. Data processing and graphing were carried out using a service developed by the French scientist Christian Bizouard, as well as Matlab tools.

Let us consider a filtered signal of a 6-year fluctuation in the length of the day in the interval from 1830 to 2016 according to the bulletin of the Earth rotation service center EOP C02, obtained based on star coverings and lunar eclipses.

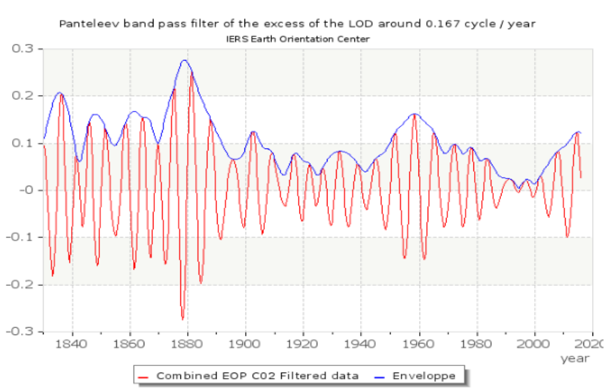

Fig. 2. The filtered signal of a 6-year fluctuation in the length of the day in the interval from 1830 to 2016, vertically is milliseconds.

The graph clearly shows that in the 1880s the amplitude rapidly increased to almost 0.3 ms, and by 1930 it had dropped to 0.05-0.07 ms, but by 1960 it had again increased to 0.15 ms and by 1995 it had again decreased to 0.01-0.02 ms, after which it began to increase again.

Consider a filtered signal of a 6-year fluctuation in the length of the day in the interval from 1962 to 2016 according to the EOP C04 data, which are more accurate (obtained by comparison with an atomic clock), but less long.

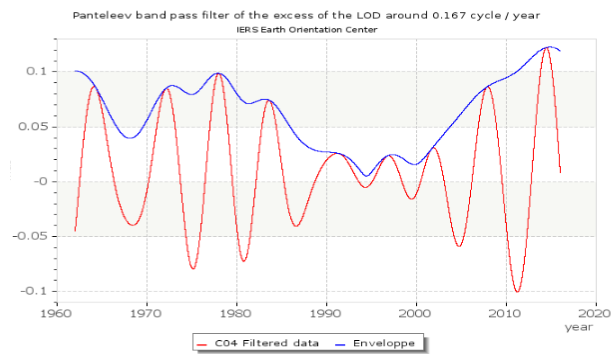

Fig. 3. The filtered signal of a 6-year fluctuation in the length of the day in the interval from 1962 to 2016, vertically is milliseconds.

Next, we consider the 6-year-old signals identified by the Panteleev filter at angular moments of the AAM atmosphere according to the NCEP, ECMWF and GFZ data and the OAM ocean according to ECCO and GFZ data.

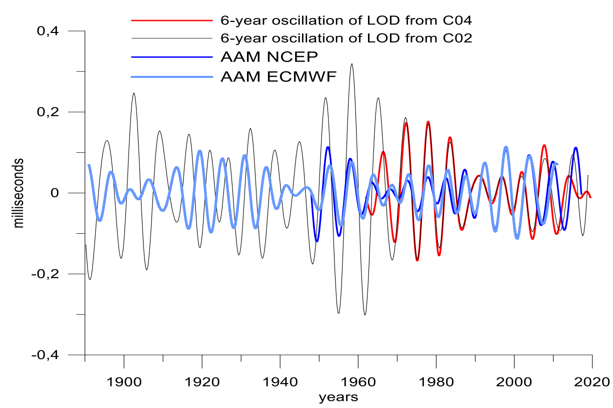

Fig. 4. 6-year LOD oscillations allocated by the Panteleev's filter in comparison with the signal extracted from the atmospheric angular momentum data AAM NCEP (National Centers for Environmental Prediction of the USA) and ECMWF (European Center for Medium-Range Weather Forecasts).

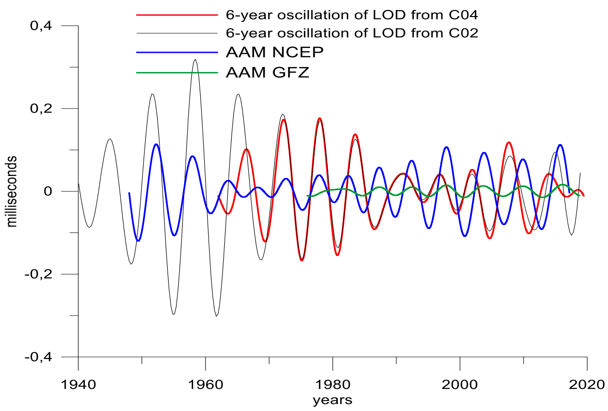

Fig. 5. Highlighted by the Panteleev AAM filter according to NCEP and GFZ(Helmholtz Potsdam Center for Earth Sciences).

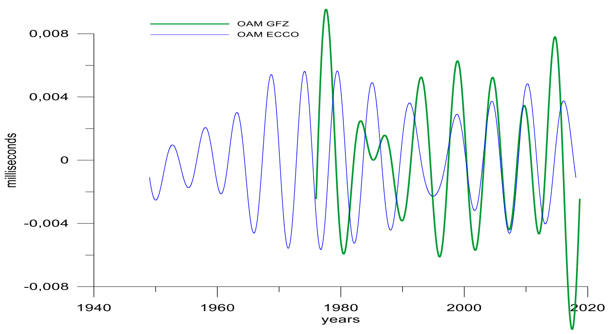

Fig. 6.Highlighted by Panteleev's OAM filter according to GFZ and ECCO ("Estimating the **Circulation** ***and*** **Climate** ***of the*** **Ocean"** ***consortium).***

Note that the amplitudes of the 6-year component of OAM are extremely small, both in comparison with the amplitude of the 6-year oscillation of LOD and AAM, so we can neglect the influence of the ocean. Subtract the 6-year-old AAM component from LOD to get a graph.

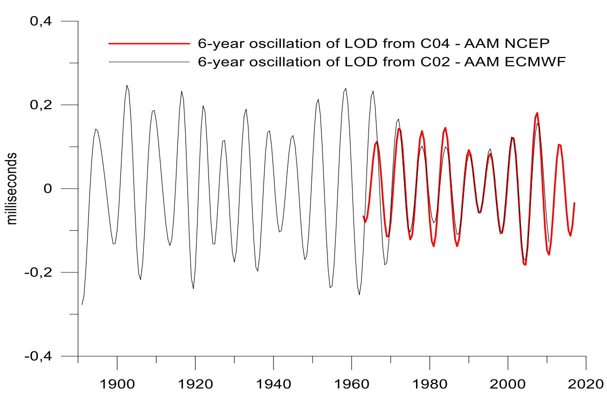

Fig. 7.The filtered signal of a 6-year fluctuation in the length of the day minus the AAM.

It is noticeable that the amplitude of the 6-year oscillation of the LOD, freed from atmospheric influence, became stable. The graph is very similar to the results of Hao Ding [3], in whose work a completely different technique was used. Some residual changes in the amplitude of the 6-year signal may be associated with the presence of some additional fluctuation in the neighboring period of 8 years.

Anticipated Results

A 6-year fluctuation in the length of the day was identified and studied. Significant changes were found in the amplitude of the 6-year oscillation, which varies from 0.02 to 0.3 ms at time intervals of decades. The oscillation is not a free oscillation of constant amplitude or a simple damped oscillation. The angular moments of the ocean and atmosphere are considered, its comparison is made with the amplitude of the variation in the duration of the day. The amplitude of the 6-year component of OAM is extremely small in comparison with LOD and AAM, therefore, when considering the total value of the 6-year component of the day duration, we neglect the influence of the ocean. After subtracting the influence of the atmosphere from the amplitude of the oscillation of the duration of the day, we find that the oscillation is not free of constant amplitude or simply damping, as shown in [4].

Conclusion

In the work, a 6-year oscillation of the LOD day duration was studied, and its envelope was also studied. The data of bulletins C02 and C04 of the center of the Earth's rotation parameters in Paris were used [2]. Changes in the amplitude of the 6-year oscillation from 0.02 to 0.3 ms over long time intervals were revealed. However, after subtracting the influence of the angular momentum of the AAM atmosphere, the range of changes was reduced to 0.1–0.2 ms. Nevertheless, judging by the resulting graph, the oscillation is not free of constant amplitude or damped oscillation, as assumed in [4]. If we assume that it is really connected with the own rotational oscillation of the earth's core, then it should be excited, and the changes in amplitude can reflect changes in the parameters at the core-mantle boundary. However, the characteristic processes in the bowels of the Earth can hardly be noticeable at intervals of less than decades or even centuries.

Our plans for the future work include achieving greater accuracy in the results. Further writing a program to reduce the impact of edge effects, this will also improve the result of the study of 6-year fluctuations in the length of the day. In addition, it is possible to write a program to predict the amplitude of a 6-year oscillation based on available data, and consider oscillations with a slightly different period to clarify the oscillation period, this can be done by studying the phases of such oscillations.

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