POSSIBLE SPACE ORIGINE OF 6-YEAR EARTH OSCILLATIONS

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Abstract: *Six-year cycles of the pseudo-periodical oscillations are discovered in the series of astrometrical observations of the latitude and universal time, gravity measurements and Earth rotation series. The six-year cycles consist of several oscillations with close periods from band 5 to 7 years. The separation of the oscillations with close frequencies need long observational series, so some solutions for the Universal Time UT1 and Length of Day LOD with centennial duration are convenient for the analyses of the 6-year Earth cycles. The main problem of 6-year Earth cycles analyses is to determine the origin of their excitation sources. A model of 6-year Earth cycles based on Moon and Solar excitation is proposed. This model includes the 3-rd harmonics of 18.6-year cycle of the Moon node and 3-rd and 4-th harmonics of 22-year solar magnetic cycle. The model is applied to LOD and Mean Sea Level Variations (MSL). The effect of the liquid Earth core on the 6-year cycles of the Earth rotation is determine by excluding the Moon and solar harmonics from the LOD oscillations with periods from band 5-7 years.*

Introduction

Six-year cycles of the pseudo-periodical oscillations are discovered in the series of astrometrical observations of the latitude and universal time, tidal observations and Earth rotation series(Chapanov et al., 2005). The variations of the latitude with period about 6 years are due to oscillations of the local vertical. At observatory Washington 6-year oscillations of the vertical for the period 1919-1953 are with amplitude 20÷30 mas (Fig.1). The observations of the universal time UT at observatory Washington consist of several oscillations with variable amplitudes about 0.1ms and periods between 5 and 7 years (Fig.12). The 5.5-year oscillations of the vertical at observatory Plana are with amplitude about 10 mas for the period 1987.5-2005 (fig.3). The last oscillations are highly correlated with the 5.5-year cycles of nontidal changes of the gravity at observatory Brussels with amplitude 50 nm/s**2, determined from superconducting gravimeter measurements (Chapanov, 2005). In the case of even distribution of the gravity effects, due to the six-year oscillations of the Earth, the corresponding depth of the resulting central force of the disturbances (pendulum model) will be about 600 km.

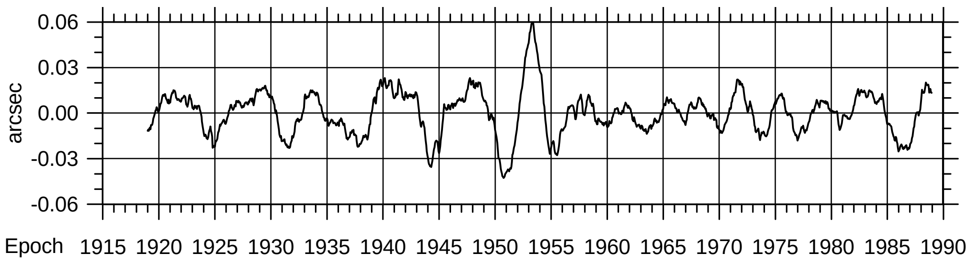

Figure 1. 3-year and 6-year cycles of the vertical at Washington

An explanation of the 6-year cycles of the Earth gravity and rotation is given by a theoretical model (Mound and Buffett, 2003) of the core-mantle system that includes a combination of gravitational and electromagnetic couplings, transferring of the angular momentum between the solid inner core, fluid outer core, and mantle of the Earth This model is involving to explain namely the 6-year variation in the length of day (LOD).

Gorshkov (2010) discovers a partial correlation between 6-year LOD and MSL oscillations.

A new model of 6-year Earth cycles based on Moon and Solar excitation is proposed in this paper in order to improve the consistency between the MSL and Earth rotation variations. This model includes the 3-rd harmonics of 18.6-year cycle of the Moon node and 3-rd and 4-th harmonics of 22-year solar magnetic cycle.

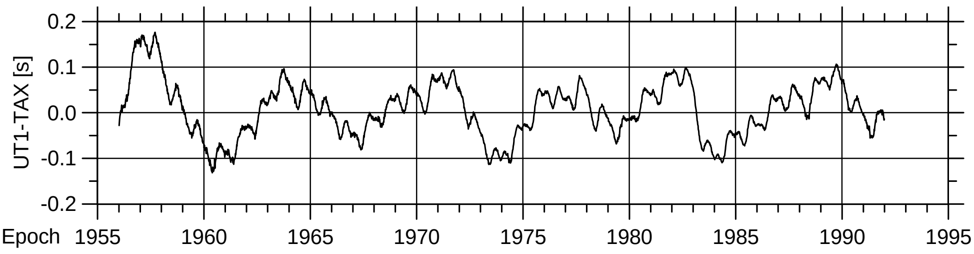

Figure 2. 3-year and 6-year cycles of the Universal Time UT1-TAX

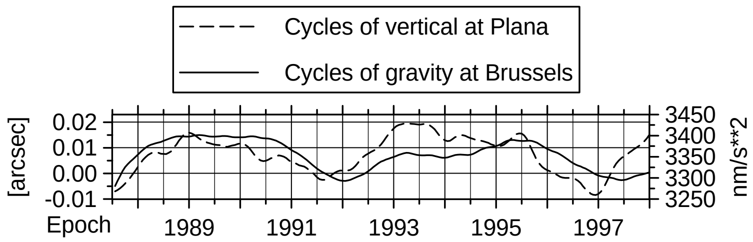

Figure 3. Common 5.5-year cycles of gravity at Brussels and Plana Observatories

A model of 6-year oscillations

The 6-year Earth oscillation may contain several frequencies, whose periods are rather close and proper determination of their parameters need observational interval greater than the beat period between the two closest frequencies. It is possible to use time series of UT1 and LOD solution for the period 1623-2006, determined by star occultation (Stephenson and Morrison, 1984) plus modern determinations (Fig.1). The quality of LOD time series allows determination of 6-year oscillations after 1850. The variations of Earth rotation are close connected with global MSL changes, so time series of MSL variations determined at Stockholm tide gauge station are used, too (Fig.6, top graph).

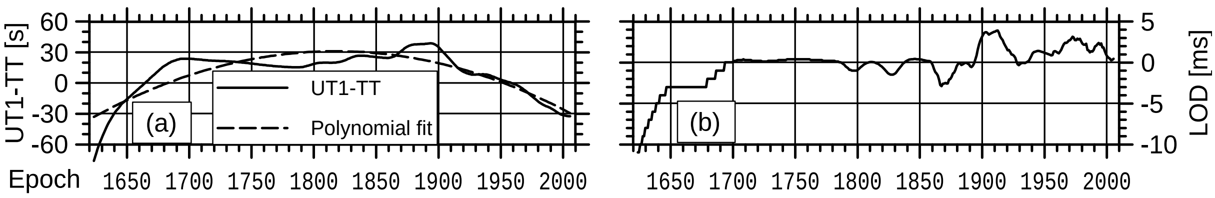

Figure 4. UT1 and LOD variations for the period 1623-2006

The six-year oscillations of MSL and LOD from period bands 5a-7.5a and 5a-8a are determined by partial Fourier approximations of their time series and superposition of 10 (12) harmonics (Fig.5). The comparison of the resulting time series in Fig. 5 shows a significant phase and frequency discrepancy between LOD and MSL cycles, where the case of 6-year oscillations with periods from band 5a-7.5a seems more realistic. Thus, some of the oscillations from this band are not common in MSL and LOD variations. To create adequate models of common 6-year oscillations of MSL and Earth rotation will be used a model with 3 oscillations with fixed phases and amplitudes.

The new model of 6-year Earth oscillations is based on solar and lunar effects on Earth systems. It includes 3 main oscillations the 3-rd harmonics of 18.6-year cycle of the Moon node with period 6.2a and 3-rd and 4-th harmonics of 22-year solar magnetic cycle with periods 7.5a, 5.6a. The last two periods are determined from the mean value of about 22.5 years of solar magnetic cycle for the period 1850-2006, according 22-year solar index $W_{n/22a}$ in Fig.6.

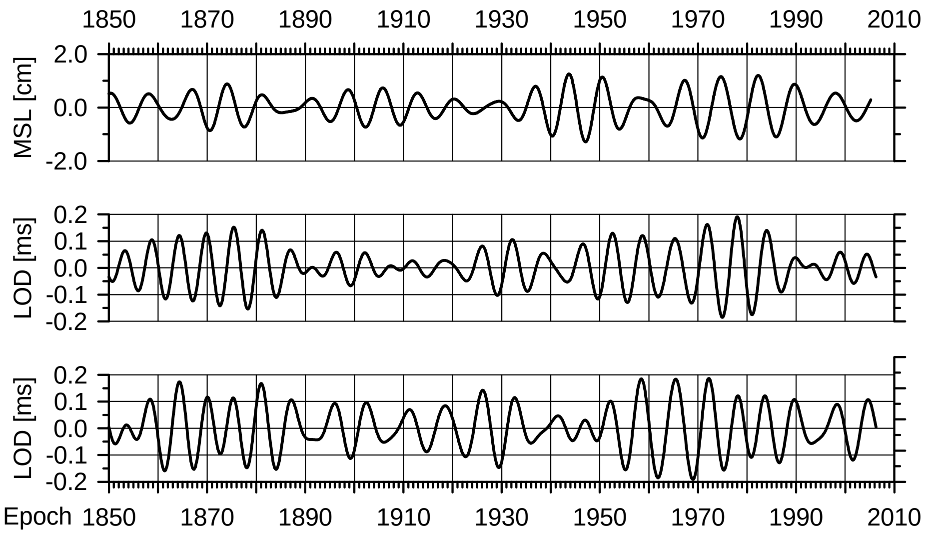

Figure 5. Six-year cycles of MSL and LOD from period band 5a-7.5a (MSL - top graph) (LOD - middle graph) and from period band (5a-8a) (LOD - bottom graph) for the period 1850-2005. Significant phase discrepancy between LOD and MSL is visible

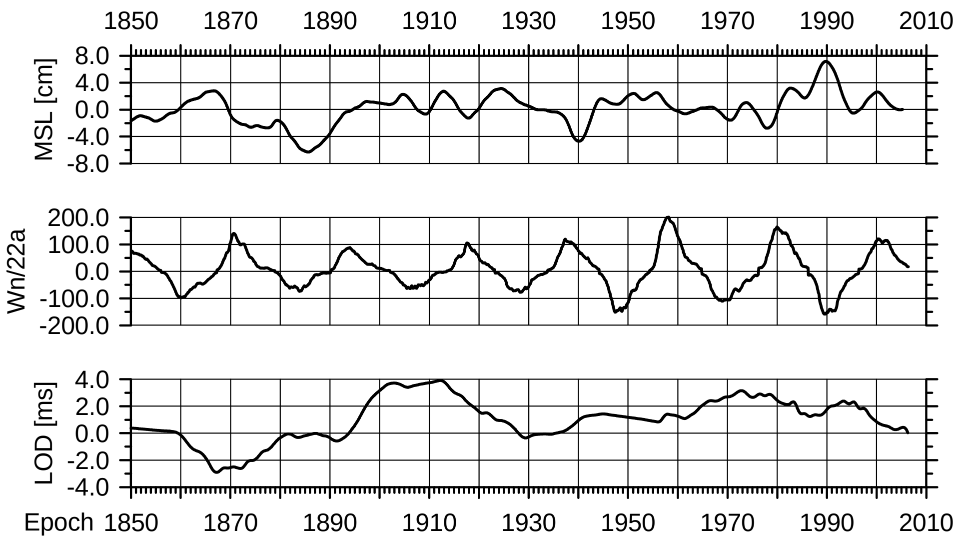

Figure 6. Variations of MSL (top graph) solar magnetic cycles (middle graph) and LOD (bottom graph) for the period 1850-2005

The model $F(t)$ of 6-year Earth oscillations with 3 fixed frequencies is given by

$$F(t) = f_0 + f_1(t-t_0) + \sum_{k=1}^{3} a_k \sin\frac{2\pi}{P_k}(t-t_0) + b_k \cos\frac{2\pi}{P_k}(t-t_0),$$

(1) $$A_k = \sqrt{a_k^2 + b_k^2},$$

$$\psi_k = \arctan\frac{b_k}{a_k},$$

where t_0, *is* the first epoch of observations, f_0, f_1, a_k and b_k are coefficients, determined by the Least-Squares Method, A_k is the amplitude, Ψ - the phase, and the periods P_k , k=1, 2, 3 take values equal to 5.6a, 6.2a, 7.5a.

The estimated Amplitudes and phases of the modeled 6-year oscillations of MSL and LOD are given in Tables 1 and 2. The time series of 6-year models of LOD and MSL variations are compared in Fig.7, where four piece wise parts have good agreement by no phase differences

Table 1. MSL model of 6-year oscillations

Period [a]	Amplitude [cm]	Phase [deg]
7.5	0.340 ±0.02	36.3
6.2	0.206 ±0.02	-82.8
5.6	0.055 ±0.02	110.4

Table 2. LOD model of 6-year oscillations

Period [a]	Amplitude [ms]	Phase [deg]
7.5	0.065 ±0.01	-171.4
6.2	0.050 ±0.01	146.5
5.6	0.026 ±0.01	-60.8

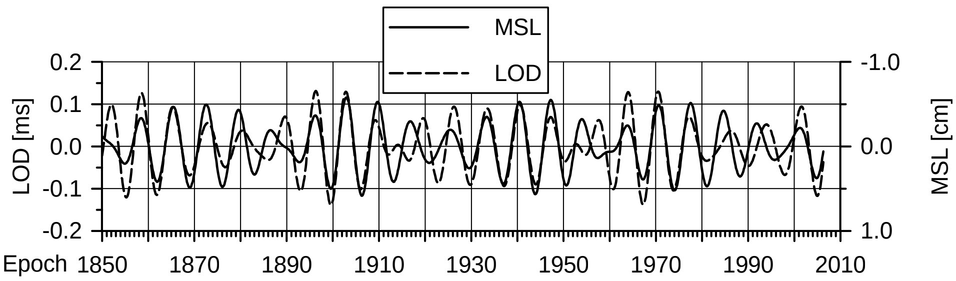

Figure 7. Comparison between the time series of 6-year models of LOD and MSL variations

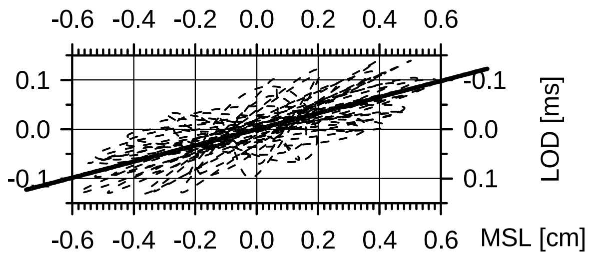

Figure 8. Linear regression between LOD and MSL variations according their 6-year models

The linear regression between LOD and MSL variations according their 6-year models is expressed by the formula

(2) LOD [ms] = –0.1637 * MSL [cm]

The difference between the time series of 6-year models of LOD and MSL variations (Fig.9) is calculated in LOD dimension by means of the linear regression (2). This difference is mostly due to the local variations with the model frequencies of the sea level at Stockholm, whose source are local weather changes, winds and atmosphere pressure. The Fig.10 presents the difference between the time series of total LOD variations from band 5a-7.5a and 6-year model of MSL. These residual variations are combination of the local MSL variations and the liquid Earth core influence on the 6-year LOD cycles. The proper determination of 6-year core oscillation needs preliminary to determine all local sea level changes.

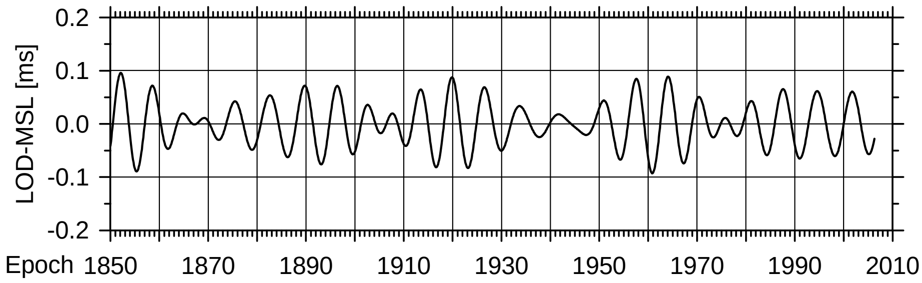

Figure 9. Difference between the time series of 6-year models of LOD and MSL variations, due to the local MSL variations

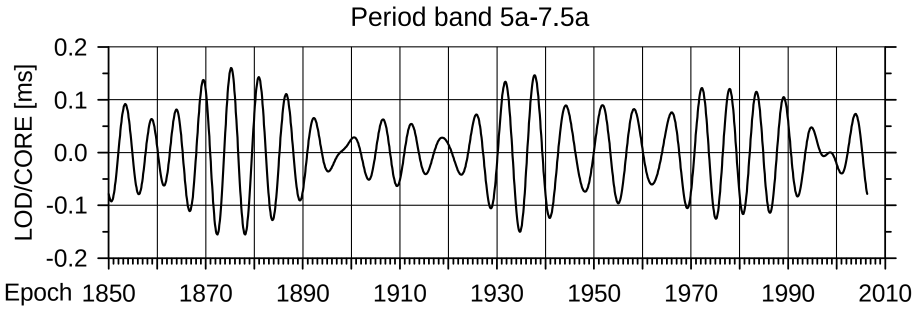

Figure 10. Difference between the time series of total LOD variations from band 5a-7.5a and 6-year model of MSL, due to combined local MSL changes and core effects

Conclusions

The model of 6-year Earth oscillations, based on the 3-rd and 4-th harmonics of the Hale cycle with periods 7.5a, 5.6a and 3-rd harmonic of Lunar node with period 6.2a, applied to MSL and LOD variations, yields time series with synchronous 6-year oscillations during beat maxima and phase discrepancy during the beat minima. The phase discrepancy is most probably due to the local variations of sea level.

The proper model of core influence on 6-year cycles of the Earth rotation needs a remove of all local sea level changes due to local weather, winds and atmosphere pressure, because the residual LOD oscillations from the band 5a-7.5a are combination of the local MSL variations and the liquid Earth core influence on the 6-year LOD cycles. The core effects on the 6-year LOD variations are expected to be with maximal amplitude below 0.1ms and decadal modulation. The models of 6-year Earth oscillation may play important role in complex analyses of number geodynamical, climate, weather and seismological events.

References:

1. C h a p a n o v , Y a., 2005, A global gravity oscillation determined by superconducting gravimetry measurements and astronomical latitude observations, Kinematics and Physics of Celestial Bodies, Suppl. Ser. No5, ISSN 0884-5913, 347-350.
2. C h a p a n o v Y a., J. V o n d r a k, V. G o r s h k o v, C. R o n, 2005, Six-year cycles of the Earth rotation and gravity, on Geodesy, Warsaw University of Technology, No2 (73), ISSN 0867-3179, 2005, 221-230.
3. G o r s h k o v , V. L., 2010, Study of the Interannual Variations of the Earth's Rotation, Solar System Research, Vol. 44, No. 6, ISSN 0038_0946, 487–497.
4. M o u n d a n d B u f f e t t, 2003, Interannual oscillations in length of day: Implications for the structure of the mantle and core, JGR, 108, No. B7, 2334.
5. S t e p h e n s o n, F. R., M o r r i s o n, L. V., 1984, Long-Term Changes in the Rotation of the Earth: 700 BC to AD 1980, Philosophical Transactions of the Royal Society of London, Ser. A, pp. 47--70.