CHANGE OF THE EARTH MOMENT OF INERTIA DURING THE OBSERVED UT1 RESPONSE TO THE 11-YEAR SOLAR VARIATION

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ABSTRACT. The observed oscillation in UT1 with the period 10.47a and amplitude of 60 ms, are highly correlated with the delayed variations of smoothed Wolf's numbers. These oscillations are connected with corresponding changes of the principal Earth moment of inertia C, due to the conservation of angular momentum. The necessary changes of the Earth moment of inertia, during the solar maxima, are considered in two cases - first by an axial-symmetric deformation and uniform decrease of the mean earth equatorial radius, simultaneously with the solar cycles, and second - by a decrease of mean sea level, due to additional water evaporation, and corresponding increase of polar ice thickness, due to the global water redistribution. The observed 11-year UT1 oscillation, due to changes in the Earth moment of inertia, is connected in the first case with the earth equatorial radius variations with an amplitude of about 2 mm, and in the second case - with mean sea level oscillations with mean amplitude of about 5 mm. The only climatic reason of the first case is adequate variations of atmospheric temperature and pressure over the equatorial regions, but according the matter term of the atmospheric angular momentum AAM, no such atmospheric variations exist. The second case is confirmed by a 11-year mean sea level oscillation in some maregraph stations. The necessary energy of additional sea water evaporation during the solar cycles is connected with the total solar irradiance changes with mean magnitude of about 1 Watt per square meter.

ANALYSES. The decadal variations of the Earth rotation are strongly affected by the 11-year cycle of the solar activity and the UT1 response to these cycles is delayed by $1.5a$ with amplitude of about 60 ms (Chapanov and Gambis, 2008). The explanation of the delayed UT1 response to the sunspot cycles is the appropriate change of the axial Earth moment of inertia, due to climatic variations, connected with the total solar irradiance change. Let us consider a homogeneous sphere with radius $R = 6364km$, density $5.6g/cm^3$, inertial moment C, angular velocity ω and constant mass M. From the conservation of angular momentum, any change of inertial moment ΔC is compensated with a corresponding change of angular velocity $\Delta\omega$ according the following expression

$$\Delta C\omega + C\Delta\omega = 0 \tag{1}$$

The variation ΔC depends on the variation of the radius ΔR according the formula

$$C + \Delta C = 1/2(R^2 + 2R\Delta R + \Delta R^2) \tag{2}$$

and from (1) and (2), after neglecting the second order term ΔR^2, we obtain

$$2\Delta R\omega + R\Delta\omega = 0 \tag{3}$$

The formula (3) expresses the relationship between the variations of the radius and the angular velocity of an ideal elastic homogeneous sphere without external moments, hence the necessary change of radius ΔR, which corresponds to the observed variation of time angle ΔUT for time interval P is

$$\Delta R = -\frac{1}{2}R\frac{\Delta UT}{P} \tag{4}$$

In case of periodical variations of time angle ΔUT with observed amplitude A_{UT} and period P, the necessary amplitude A_R of the periodical oscillations of the radius is

$$A_R = \frac{1}{2} R \frac{A_{UT}}{P} \quad (5)$$

In case of a sunspot cycle with $A_{UT} = 0.06 sandP = 10.47a = 3.3 \times 10^8 s$, we obtain $A_R = 0.6mm$. The corresponding deformation of the real Earth is represented by oscillations of the equatorial and polar Earth radii with opposite phases and amplitudes of about 2 mm. The only possible reason of such oscillation is climatic, due to adequate variations of atmospheric temperature and pressure over the equatorial regions, but according the matter term of the atmospheric angular momentum AAM, no such atmospheric variations exist. Another source of Earth inertial moment oscillations, without significant deformations of the Earth crust, are the periodical variations of the mean sea level, followed by polar ice thickness changes, due to global water redistribution. The free global ocean surface is approximately 68% of the Earth surface and the mean density of sea water is $1.025 g/cm^3$. Thus, the necessary change of the Earth axial moment of inertia during a sunspot cycle is provided by mean sea level oscillation with 8 times higher mean amplitude A_{MSL} than A_R, which yields $A_{MSL} = 4.8mm$. The change of inertial moment of polar caps, due to the ice thickness variations during a single sunspot cycle is approximately 5% of ΔC, which need to increase A_{MSL} by 2.5% to the value $4.9mm$. The necessary energy to evaporate a $9.8mm$ thin layer of sea water with surface of $1m^2$, salinity 3.5% and mean temperature 15°C is $9.8l \times 0.989kg \times 2440kJ/kg = 23.6MJ$, collected for time interval of $1/2 \times 10.47a$, or $1.65 \times 10^8 s$. The corresponding deviation of the total solar irradiance is $0.14W/m^2$ only, which is 7 times less than the total solar irradiance variations due to the solar activity. The mean amplitude of the 11-year oscillations

Table 1: Amplitudes A_{MSL} of the 11-year oscillations of the mean sea level for some maregraph stations.

Station	Period	$A_{MSL}[mm]$	Station	Period	$A_{MSL}[mm]$
Fremantle	1897–1990	16.6	Kabelvag	1880–2005	9.6
Sydney	1886–1994	8.1	Barencburg	1948–2006	14.1
Stockholm	1774–2001	7.3	Honolulu	1905–2006	14.7
Port Adelaide	1941–2005	9.0	Mumbay	1878–1994	6.8
Prince Rupert	1909–2006	10.5	Genova	1884–1998	11.8

of the mean sea level, determined from 10 maregraph stations (Table1), is $11 \pm 3mm$. We may conclude that:

1. The 11-year solar activity cycles strongly affect earth climatic variations by the variations of the total solar irradiance with mean magnitude of about $1W/m^2$. These variations provide additional amount of energy ($1.7 \times 1017MJ$ for the whole Earth and $165MJ$ per square meter on the equator) during a single sunspot cycle. This energy is capable of the evaporation $66l$ of water from 1 square meter equatorial ocean surface and $25l$ of water from 1 square meter ocean surface from the north latitudes.

2. The necessary change of the Earth axial moment of inertia during the 11-year cycle of the $UT1$ with an amplitude of about $60ms$ is provided by synchronized global mean sea level oscillations with mean amplitude of about $5mm$ and corresponding change of the ice thickness at the polar caps, due to the global water redistribution.

3. The observed 11-year oscillations of the mean sea level at 10 maregraph stations are with mean amplitude about 11 mm and opposite phase relative to the sunspot oscillations with a delay of about 1.5a. The reason of these oscillations is the additional evaporation due to the variations of the total solar irradiance during the solar activity cycles and next global water redistribution. The greater part of evaporated water (60–80%) returns back to the ocean. The rest part of the evaporated water is periodically redistributed over the continents and polar caps. A minor part of redistributed water (about 40%) periodically changes snow and ice cover over the polar caps and causes the observed $UT1$ response to the sunspot cycles.

REFERENCES

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