ON SIMILARITIES BETWEEN THE EARTH ROTATION AND TEMPERATURE CHANGES

L.V. Zotov

Sternberg Astronomical Institute of Moscow State University, Russia, *tempus@sai.msu.ru*

ABSTRACT. Earths rotation reflects processes in the atmosphere, ocean, Earths interior. The similarities between the global temperature oscillations and Earths rotation speed changes are well known, but still are not explained. We also have found similarities between $\sim$ 20-year temperature oscillations, Chandler excitation envelope and cycle of regression of the Moon orbital nodes. In this short article we want to attract attention to this fact.

Key words: Earth rotation: Chandler wobble: Climate Change.

1. Introduction

In recent decades huge amount of data upon the Earth was obtained by space and ground-based means of observations. Information retrieval requires developing of new processing techniques. Interpretation needs understanding of the Earth on a planetary scale.

Earth rotation variations can be considered as an index of activity of different processes in atmosphere, ocean, crust, and other parts of Earth system. Among the most discussed problem in Earth sciences today is the Climate Change. Its footprint is evident everywhere: the atmosphere temperature is rising, ocean level is increasing, ice sheets are melting all over the globe. Can this processes be reflected in the Earth rotation? It is known for decades, that correlations exists between the Earth rotation velocity and long-scale temperature changes. For this fact there is lack of explanations, or, better to say, there are many hypothesis, and none of them is preferable.

Below we present some comparisons and propose a new factor, whose influence could be underestimated. Particularly – the response of the Earth system to the Moon orbital precession cycle.

2. Chandler wobble excitation

Since S.C. Chandler discovered in 1981 one of the main component of polar motion, carrying his name, more then a century has passed, but the changes of the amplitude of this oscillation, which reaches 0.2 arcsec, remain enigmatic. The Earth is the viscous-elastic body and Chandler wobble should have been damped with the characteristic time of 50 years, but it does not happen. It is believed, that it is maintained by the hydro-atmospheric excitation (Yatskiv Y., 2000).

Have been studying polar motion, the author (Zotov, 2010c) developed several methods of reconstruction of the Chandler wobble causes – the excitation function. The Chandler excitation reconstruction from observations is tricky, because this excitation is very small in comparison with the nearby annual one and others. In (Zotov, Bizourad 2012) the Panteleev corrective filtering was proposed for solving this ill-posed problem (Zotov, Panteleev, 2012). The inverse operator is corrected in frequency domain to remove annual, low-frequency and other noise components.

In result the 18.6-year amplitude modulation of Chandler excitation, synchronous with the tidal variations caused by the lunar orbital nodes regression cycle was revealed. The excitation is shown on Fig. 3 together with the tidal harmonic, extracted from the IERS LOD zonal tide model and represented along the abscissa. We can trust the reconstruction only inside the 1870-1990 yrs interval because of the 20-yr border effects.

Study of atmospheric and oceanic angular momentum has shown the response of atmosphere and ocean to 18.6-year cycle of the tide (Zotov, Bizourad 2012). The amplitude increase is especially well seen in Ocean Angular Momentum changes, related to the mass redistribution. In this way the influence of the Moon on atmosphere and ocean can be transferred to the Chandler wobble excitation.

3. SSA of GMSTA

Singular Spectrum Analysis (SSA) is one of the useful techniques for signal study. This method is based on SVD decomposition of a trajectory matrix, what allows to decompose the time series into trend, oscillations of different periods and to remove noise. Initial time series splits into principal components (PC). The first one represents the most energetic part of the signal, the second – less intensive part and so on in decreasing

order. Several first components together usually represent the most of signal variability. Here we will not describe the technique, which can be found in Golyandina, 2004; Zotov, 2010a, 2010b.

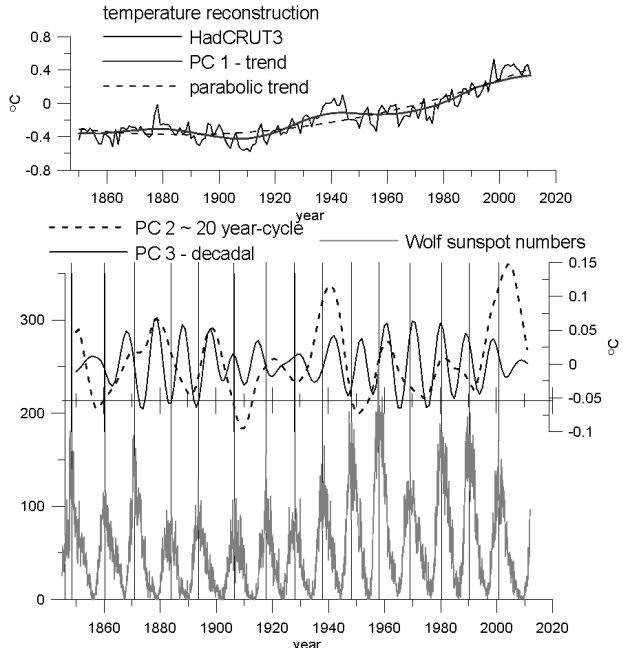

Figure 1: HadCRUT GMSTA and its SSA components compared with Wolf numbers.

By means of SSA we decomposed HadCRUT3 data upon the temperature anomaly on Earth – Global Mean Surface Temperature Anomaly (GMSTA). This time series starts in 1850 and is obtained by combining the sea surface and land surface air temperature records by meteorological and climate centres in UK. The original HadCRUT curve and its SSA-components are shown on Fig. 1. The first component PC 1 represents trend – the temperature rise, especially quick since the mid of XX cent. The total rise of $\sim 0.7^o$, it is believed, is caused by the anthropogenic global warming (IPCC Report, 2007; Zotov, 2010b). The second component PC 2 (Fig. 1 middle plot) has period of $\sim$ 20 years and the third PC 3 is decadal. The existence of this types of variability was also noted by Qian et al., 2010. So that some authors (Schrijver et al., 2011) speculate, that temperature changes are caused by the Sun variability, we show the main characteristic of it – Wolf sunspot numbers on Fig. 1, bottom. It can be seen, that decadal oscillation (PC 3) is not in phase with Wolf numbers curve. On one half of the interval – since 1920 $\sim$ 20-year oscillation (PC 2) can be found more or less in agreement with each second cycle of activity. Still, taking in account that the total solar irradiance changes in the solar cycle are less then 0.1% (IPCC report., 2007), we do not think Sun is responsible for Climate Change.

It was noted long time ago, that temperature anomalies and Earth rotation have similarities. It is mentioned already in Lambeck, 1980 monography, discussed in Sidorenkov, 2009, etc. In particular, it was found the inverse similarity between the length of day (LOD) and temperature. On Fig. 2 the GMSTA after the subtraction of parabolic trend (Fig. 1 top, dashed) is compared with the inverted LOD curve. The correlation coefficient is 0.43, for smoothed GMSTA – 0.55. Though the long-time LOD reconstruction since 1832 provided by JPL from LUNAR97 time series based on eclipses and occultation observations is not very exact for the XIX century, we believe, the similarity is real. When the temperature on Earth increases, the Earth accelerates. One of possible explanations is given in Sidorenkov, 2009, where it is supposed, that ice melting is responsible. The warming, which causes the ice melting in Greenland, Antarctica, etc. changes the Earth moment of inertia, what, together with postglacial rebound, can explain both LOD changes and trend in the Earth polar motion. From the other side, calculations of effect of sea level rise for the scenario of global warming made in (Landerer et al., 2007), give quite a small number: -0.12 ms in LOD for the next 200 years.

The correlation is not yet a proof of cause-effect relationship. Good physical model should be build and tested for this. It could be, that Climate Change does not influence Earth rotation directly, but some other factor exists, which influence them both and leaves similar footprints.

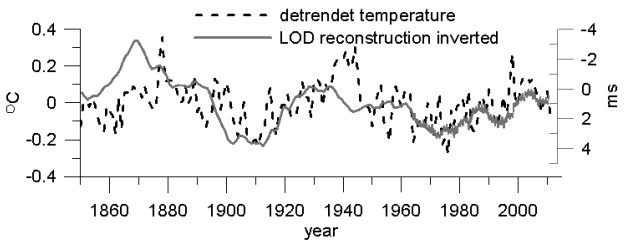

Figure 2: LOD and GMSTA without trend.

We found another interesting similarity. On Fig. 3 we represent Chandler excitation, reconstructed by Panteleev corrective filtering, together with the temperature PC 2 $\sim$ 20-yr component. The plot along abscissa shows 18.6 tidal wave in LOD. The similarity can be well seen everywhere, except the 20-year borders. Envelope of Chandler excitation agrees well with PC 2. The correlation coefficient[1] inside this interval (depicted by rectangle on Fig. 3) is 0.39.

We come to the conclusion, that temperature increases with the increase of Chandler excitation (at these moments Earth decelerates). The governing factor could be the influence of 18.6-yr Moon nodes regression cycle. Thus, the influence of the Moon on

[1]Linear correlation is not quite a good measure here because of different amplitude of oscillations.

atmosphere and ocean can be reflected in Chandler excitation and even in the temperature changes on the planet. The mechanism of this influence is yet to be explained.

4. Conclusion

The purpose of the presented research is to attract attention to similarities between Earth rotation and temperature changes on Earth. By means of SSA and correlation analysis we decomposed HadCRUT3 time series and detected different components of temperature changes – global warming trend, decadal and $\sim$ 20-year oscillation. Comparison with Wolf sunspot numbers did not reveal similarities between the Sun activity cycle and any of the temperature components.

On the other side, our recent result upon the Chandler excitation attracted our attention to the 18.6 yr cycle of the Moon orbital nodes regression, which modulates Chandler excitation envelope. We compared $\sim$ 20-year oscillation in temperature with this envelope and, surprisingly to ourself, found distinctive similarities. Thus we conclude, that the influence of such factor as the Moon orbital regression cycle can be underestimated. Its influence on ocean and atmosphere can be more important, then it was expected theoretically. The presence of Moon's signature in Chandler excitation and GMSTA makes it one of the governing factors of these and, may be, some other processes.

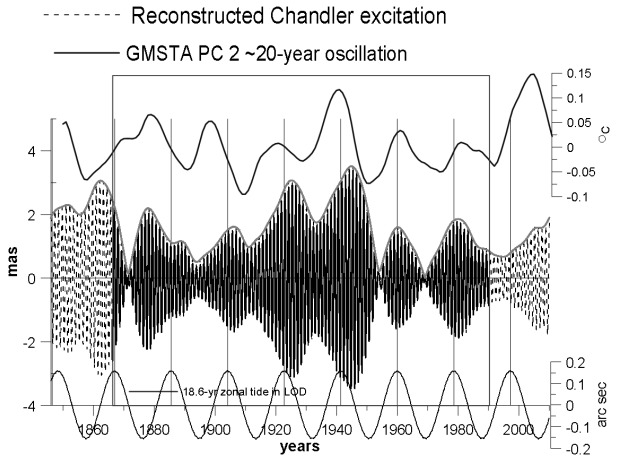

Figure 3: Chandler excitation and $\sim$ 20-year temperature changes.

Acknowledgements. This work is supported by the Russian Foundation for Basic Research grants No 12-02-31184, No 10-05-00215 and Chinese Academy of Sciences grant for Young International Scientist.

References

Golyadina S.A.: 2004, Method "Caterpillar-SSA": analysis of the time series, Snt-Petersburg.

IPCC Fourth Assessment Report: Climate Change 2007 (AR4).

Qian W.H., Lu Bo, Zhu C.W.: 2010, *Chinese Science Bulletin.,* **55**, 19. 1963-1967.

Lambeck K.: 1980, The Earth's Variable Rotation; Geophysical Causes and Consequences, Cambridge University Press.

Landerer F.W., Jungclaus J.H., Marotzke J.: 2007, *GRL*, **34**, L06307, doi:10.1029/2006GL029106.

Schrijver C.J., Livingston W.C., Woods T.N., Mewaldt R.A.: 2011, *GRL*, **38**, L06701, doi:10.1029/2011GL046658.

Sidorenkov N.S.: 2009, The Interaction Between Earth's Rotation and Geophysical Processes, Wiley-VCH Verlag.

Yatskiv Y.: 2000, *ASP Conf. Ser.*, **208**, 383.

Zotov L., Bizourad C.: 2012, *Journal of Geodynamics, special issue "Earth rotation"*, doi: 10.1016/j.jog.2012.03.010.

Zotov L.V., Panteleev V.L.: 2012, *Computational Methods for Applied Inverse Problems* /Ed. by Y.F.Wang, A.G.Yagola and C.C.Yang, De Gruyter & Higher Education Press.

Zotov L.: 2010a, Theory of filtering and time series processing, course of lectures, Moscow State University.

Zotov L.V.: 2010b, *Proc. of the 10th Gamow Odessa Astron. Conf.*, 189.

Zotov L., 2010c, *Artificial satellites*, **45**, N 2, 95.