On the Importance of Observations of Tidal Oscillation Effects on the Earth's Rotation Velocity

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Generation of tides

The Earth and the Moon rotate around a common center of mass (known as the barycenter) of the Earth--Moon system with a sidereal period of 27.3 days (relative to the stars). The Earth describes an orbit that is a mirror image of the Moon's, but has a size of 1/81 of the latter. The barycenter always lies inside the Earth at a distance of about 4670 km from its center [2, 4]. The Earth revolves without spinning (translationally) around the "stationary" barycenter (in the Earth--Moon system). As a result of this monthly rotation of the Earth, all terrestrial particles experience the same centrifugal force as at the Earth's center of mass. The sum of the centrifugal force and the Moon's attractive force is called the **tidal force of the Moon**. The tidal force of the Sun is defined in a similar manner.

The magnitude of the tidal force is a function of the declination and geocentric distance of the Moon (or of the Sun). The amplitude of monthly oscillations of Moon's declination varies with a period of 18.61 years from 29° to 18° because of the axial precession (nodal regression) of the lunar orbit. The perigee of the lunar orbit moves with a period of 8.85 years. The declination and geocentric distance of the Sun vary with a period of 1 year. The Earth spins on its own axis with a one-day period. Finally, the oscillation amplitude of lunisolar tidal forces varies with time with periods 18.61-, 8.85-, 6.0-, 1-, 0.5-year, one-month, half-month, one-week, one-day, half-day, and many other less significant periods.

Earth's rotation velocity as an index of tidal oscillations

The lunisolar tides deform the Earth. The Earth's tidal deformations have a noticeable effect on the Earth's daily rotation velocity. Recall that, because of its daily rotation, the Earth has the shape of an ellipsoid of revolution with a flattening of 1/298. The tidal forces stretch the Earth along the line joining its center to the center of the perturbing body---the Moon or the Sun. Moreover, the Earth's flattening increases if the stretching axis lies in the plane of the equator and decreases if the stretching axis is declined toward the tropics. The moment of inertia of the oblate Earth is larger than that of the undeformed spherical planet. Since the angular momentum of the Earth remains constant, the rotation velocity of the oblate Earth is less than that of the undeformed one. Since the Moon's and Sun's declinations and the distances from the Earth to the Moon and the Sun constantly vary, the lunisolar tidal force varies with time. Accordingly, the Earth’s flattening varies as well, which eventually causes tidal oscillations in the Earth's rotation velocity.

The theory of tidal oscillations of the Earth's rotation velocity is based on the theory of the lunisolar tidal potential. In present-day time services, the tidal oscillations of the Earth's rotation velocity are computed using 62 harmonics of the zonal tide with periods ranging from 5 days to 18.6 years [2, 4]. The largest of them are the oscillations with semimonthly, monthly, and semiannual periods (figure).

The Earth's rotation velocity is characterized by the relative value

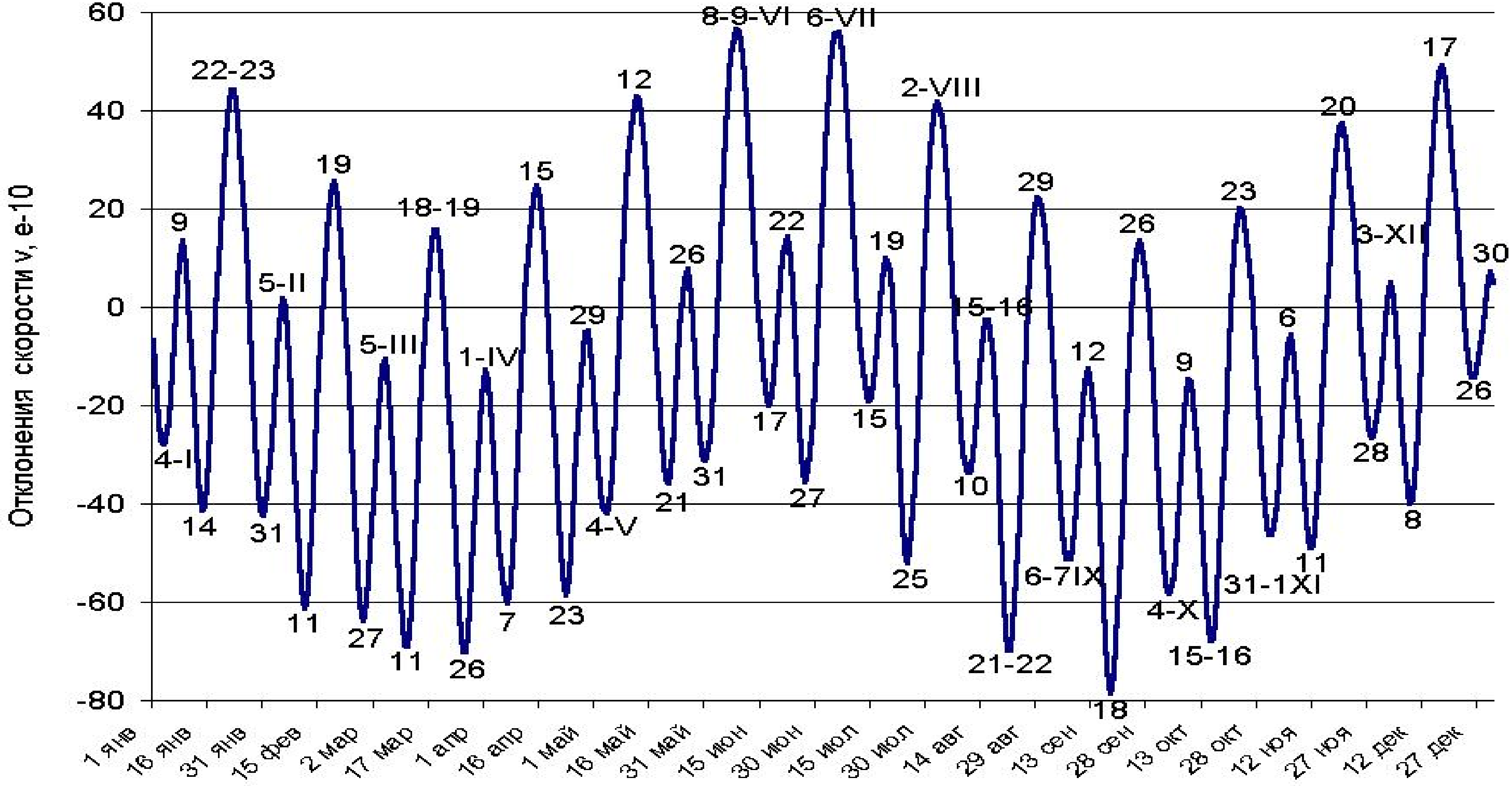
$$\nu \equiv \frac{\delta\omega}{\Omega} = \frac{\omega - \Omega}{\Omega} \approx -\frac{\Pi_з - T}{T} \equiv -\frac{\delta\Pi}{T}, \qquad (1)$$

where $\Pi_з$ is the length of Earth’s day; T is the length of the standard (atomic) day, which is equal to 86400 s; and $\omega = \frac{2\pi}{\Pi_з}$ and $\Omega = \frac{2\pi}{86400}$ rad/s are the angular velocities corresponding to the Earth’s and standard days [2, 4]. Since ω varies only in the ninth or eighth decimal digit, the values of ν are on the order of 10^{-9}–10^{-8}.

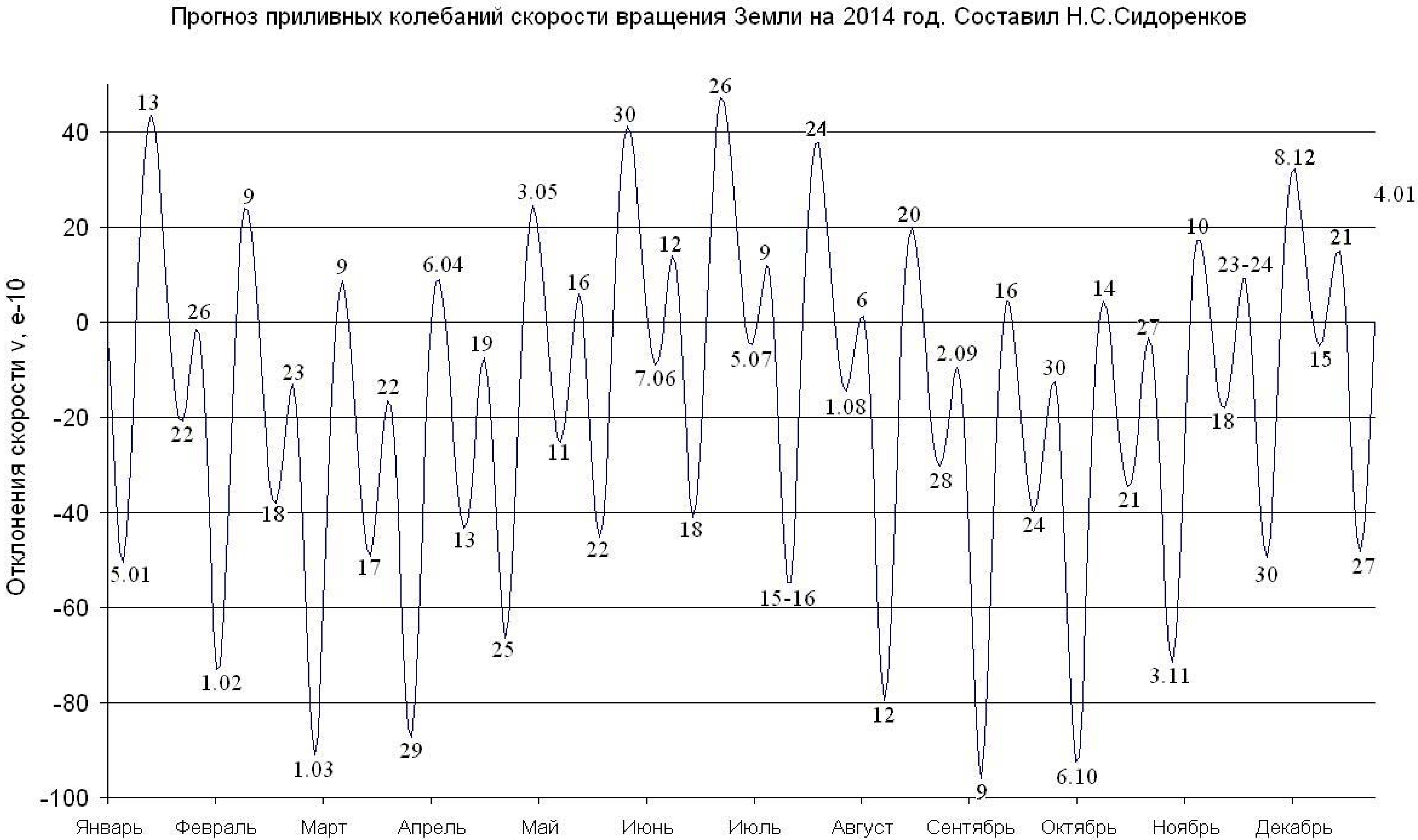
According to the figures, which show the calculated tidal oscillations of the Earth's rotation velocity in the years 2012, 2013, 2014 and 2015, the Earth’s rotation over the lunar month exhibits four regimes of different lengths: two acceleration periods of lengths m_1 and m_3 and two deceleration periods of lengths m_2 and m_4. On average, the regimes change every m $\approx$ (27.3)/4 = 6.8 days. However, because of the slow motion of the lunar orbit perigee and nodes, this period varies from 4 to 9 days. For example, in 2012 we can see acceleration from May 2 to 8, deceleration from May 8 to 13, acceleration from May 13 to 22, and deceleration from May 22 to 30; the lunar month was composed of the intervals 6+5+9+8 days. Within a month, any combinations of m_i ranging from 4 to 9 days are possible.

The Earth's rotation velocity ν varies primarily within the sidereal month (27.3 days). Over this time interval, the Moon moves from its extreme position in the Northern Hemisphere, where its positive declination is maximal, to a minimum negative declination in the Southern Hemisphere and then again returns to its maximum declination in the

Predicted tidal oscillations of the Earth's rotation velocity *v* in 2012. The vertical axis represents the relative deviations of ν multiplied by 10^{10}. Numerals indicate the dates when maxima and minima of *v* occurred.

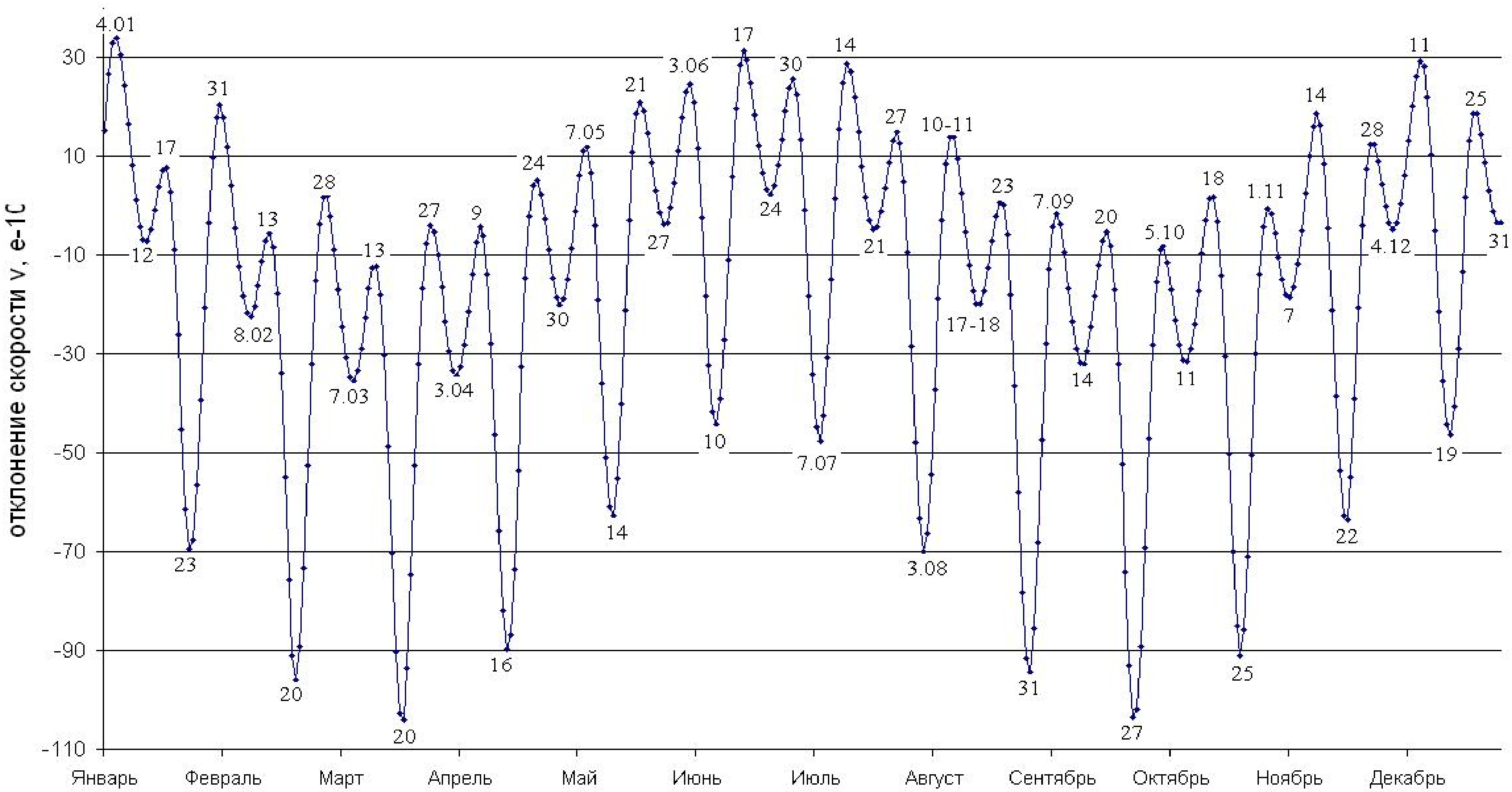


Predicted tidal oscillations of the Earth's rotation velocity v in 2013. The vertical axis represents the relative deviations of v multiplied by 10^{10}. Numerals indicate the dates when maxima and minima of v occurred.



Predicted tidal oscillations of the Earth's rotation velocity ν in 2014. The vertical axis represents the relative deviations of ν multiplied by 10^{10}. Numerals indicate the dates when maxima and minima of ν occurred.

Прогноз приливных колебаний скорости вращения Земли на 2015 год. Составил Н.С.Сидоренков



Predicted tidal oscillations of the Earth's rotation velocity ν in 2015. The vertical axis represents the relative deviations of ν multiplied by 10^{10}. Numerals indicate the dates when maxima and minima of ν occurred.

Northern Hemisphere. The Earth's rotation velocity exhibits two semi-monthly oscillations with maxima occurring when the Moon is at the maximum distance from the Earth’s equator in both Northern and Southern hemispheres and with minima occurring when the Moon crosses the equator. The Earth's rotation velocity is also influenced by the solar tides, which vary because of the variations in the Sun’s declination and geocentric distance. The solar tides generate oscillations with semiannual (182.62 days) and weak annual (365.25 days) periods.

The tidal oscillations in the Earth's rotation velocity represent a perfect index for the features of the Earth’s monthly rotation around the barycenter and time variations in the lunisolar tidal forces. They correlate with quasi-weekly and semimonthly variations in atmospheric processes and with local anomalies in the air temperature, pressure, cloudiness, and precipitation amounts depending on those variations. Tidal oscillations in the Earth's rotation velocity are also correlated with weather disasters, geomagnetic variations, and geophysical processes [4, 5]. N.S. Shapovalova has found that industrial disasters, people’s behaviors, disease courses, and mortality correlate with quasi-weekly extrema of tidal oscillations in the Earth's rotation velocity.

It is widely believed that the effects of gravitational tides must be certain on global scales. The author’s long-time experience suggests that, at the time when the tidal forces exhibit extrema, variations in the terrestrial shells are observed almost everywhere, but their signs and values are everywhere different. The effects of the lunisolar tides on the atmosphere have **local in character**. The cause is that, while propagating in the atmosphere, the tidal waves (for which up to 28 000 components are involved in modern expansions of the tidal potential) are perturbed, reflect from terrain obstacles and baric and thermal inhomogeneities, and interfere to produce a varied interference pattern. This pattern has not been previously analyzed. As suggested by the study of ocean tides, in the atmosphere, there may exist nodal amphidromic points, where the tidal height is always zero, and crests, where the tides are amplified by tens of times.

In oceanology the time lag between the moon passing across the meridian and the next high water is called the lunitidal interval. The average lunitidal interval is known as the establishment of a port, or high water full and change. Shokal’skii [3] notes that the high water full and change cannot be found analytically and is derived only from observations, since for each port it depends on local factors that cannot be taken into account theoretically; even if they could, it would not be possible to find the moment when the Sun and the Moon during a syzygy are both on the equator and at their average distances.

The author calls for natural science researchers to monitor events of interest (weather variations, geophysical processes, human-caused disasters, medical characteristics, social disturbances, etc.) and compare them to the course of tidal oscillations of the Earth's rotation velocity aimed at searching for local features of their interrelation.

As an example, weekly plots are presented for variations in meteorological elements (atmospheric pressure (mmHg) and/or air temperature) in Moscow and Vladivostok near extrema of tidal oscillations in the Earth's angular velocity of rotation. All plots were downloaded in an operational mode from the weather forecast site http://hmn.ru . The skips resulted from holidays or conference visits.

An analysis of these plots shows that, in the overwhelming majority of the cases, deviations in the behavior of meteorological elements in both Moscow and Vladivostok are observed near the moments of extrema of the Earth's rotation velocity. Thus, weather varies not only at random, but also correlates with oscillations of lunisolar tides. Natural synoptic periods discovered by Multanovskii a hundred years ago [1] are caused by the oscillations of lunisolar tides.

The basic meteorological and geophysical consequences of tidal weather variations are considered in the author's publications [5].

1. B. P. Multanovskii, *Basic Principles of Synoptic Method for Long-Range Weather Forecasts* (TsUEGMS, Moscow, 1933) [in Russian].
2. N. S. Sidorenkov, *Atmospheric Processes and the Earth's Rotation* (Gidrometeoizdat, St. Petersburg, 2002) [in Russian].
3. Yu. M. Shokal'skii, *Oceanography* (A.F. Marx's Publishing House, Petrograd, 1917) [in Russian].
4. N. S. Sidorenkov, *The Interaction between Earth's Rotation and Geophysical Processes* (Weinheim, WILEY-VCH Verlag GmbH and Co. KGaA, 2009).
5. See the papers at http://www.geoastro.ru

In this presentation, weekly plots are given for meteorological elements (atmospheric pressure (mmHg) or air temperature (degrees)) in Moscow and Vladivostok near extrema of tidal oscillations in the Earth's angular velocity of rotation. The plots were taken from the weather forecast site http://hmn.ru. The skips resulted from holidays or conference visits. The goal of comparisons is to show that weather varies not only at random, but also correlates with oscillations of lunisolar tides.

The details can be found in N.S. Sidorenkov's publications (see http://www.geoastro.ru).

The plots were last updated on August 5, 2015.