On the manifestation of resonant effects in climatic fluctuations

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Abstract. Under the influence of large planets (Jupiter, Saturn, Uranus, Neptune), the Sun moves in outer space along a certain trajectory around the common center of mass of the solar system. Earth follows the sun. It is assumed that part of the barycentric rotation moment is transmitted to the Earth's rotational moment and zonal currents of the World Ocean. The aim of this work is to obtain estimates of the possible impact on the climate system of additional rotation forces arising on the Earth during the barycentric movement of the Sun around the common center of mass of the Solar system. The climate system is considered as an oscillatory system, which can resonantly perceive external repetitive effects at its own frequencies. The index of the dynamic influence of barycentric rotation on the speed of the axial rotation of the Earth, on the surface temperature of the ocean and on El Nino is proposed. An asynchronous correlation analysis is performed. It is shown that the influence of the dynamic forces of barycentric rotation describe 31% of the total variability of the Earth's rotation speed with a delay of 5 years, 66% describes the variability of the average annual temperature of the ocean surface in the circumpolar Antarctic current with a delay of 32-37 years. The contribution of the moment of inertia to the total SST variability along other ocean currents is from 25 to 50% with the same delay. It was found that the El Nino phenomenon is a consequence of variations in the circular circulation of oceanic waters in each of the hemispheres of the Pacific Ocean. One of the engines of these variations are perturbations of the ocean circulation in the region of the Antarctic current. The contribution of changes in SST in the Antarctic Current to changes in the NINO3 index is 31%.

1. Introduction

Initially, climate is an astronomical concept. The axial rotation of the Earth creates daily changes in meteorological data, the orbital rotation of the Earth creates seasonal changes. But there is still the motion of the Earth, which is not taken into account in any calculations. It is associated with the barycentric movement of the Sun and planets around their common center of mass. In a climate system, usually all dynamic processes are considered in a geocentric coordinate system, which is accepted as an inertial system. In this case, additional forces arising on the Earth during the barycentric movement of the Sun in outer space cannot be taken into account. In the geocentric reference frame these forces are not, but they can be estimated in the barycentric coordinate system.

As follows from the amended 1st law of Kepler according to A. Khlystov and etc. [1]. The earth moves around the sun, participating with it in motion around the barycenter of the solar system. Large planets (Jupiter, Saturn, Uranus, Neptune) create the conditions under which the sun moves in outer space along a certain trajectory around the common center of mass of the solar system. The distance from the center of the sun to the center of mass depends on the location of large planets in orbits. The center of mass can extend beyond the Sun by more than two radii of the Sun in years when several large planets gather in one sector of their orbital rotation. Earth is a small planet that cannot affect the movement of the Sun, on the contrary, the Earth is in the power of the Sun and always follows the Sun. The entire orbit of the Earth, as a whole, makes movements in space along with the barycentric
movement of the Sun. It is assumed that part of this moment of barycentric rotation is transmitted to
the Earth's rotational moment and zonal currents of the World.

When discussing the reality of external influence, researchers usually confine themselves to
comparing the enormous energy of the observed processes in the climate system with the additional
small variable energy coming from space. With this comparison, the answer about the reality of
cosmic-terrestrial connections is always negative. Variable energy is really small, but the comparison
does not take into account the most important well-known property of the climate system, which
determines another mechanism of perception of external influences, in which this energy may well be
enough to form the observed climate fluctuations. The aim of this work is to obtain estimates of the
possible impact on the climate system of additional forces arising on the Earth during the barycentric
movement of the Sun around the common center of mass of the Solar system.

2. Materis and Methods

The work used daily data on the coordinates of the planets (heliocentric longitude and distance from
the Sun) in the heliocentric reference frame and planet masses: Jupiter, Saturn, Uranus, Neptune.
According to astronomical data on the position of the planets for every day, the moment of inertia $J$ of
the barycentric movement of the Sun was calculated:

$$J = \sum_{i=1}^{n} m_i r_i^2,$$

where $m_i$ - the mass of the planet (i), $r_i$ - the vector distance from the Sun to planet $i$, taking
into account the direction (heliocentric longitude of the planet).

A more detailed calculation procedure is given in [2]. The daily weather values of the heliocentric
longitudes of the planets and the distances from the Sun to the planets were obtained from the Institute
of Applied Astronomy of the Russian Academy of Sciences (St. Petersburg). They are calculated with
obviously great accuracy over the interval of several centuries. The distances to the planets were
expressed in astronomical units, and the masses of the planets in fractions of the mass of the Earth.
Based on daily values, a number of average annual values of $J$ for 1700-2018 were calculated. Over
an interval of 350 years, in the changes in the moment of inertia of rotation $J$, distinctive cycles of
about 12–13 and 37–39 years are clearly distinguished.

In addition, we used a series of average annual values of the surface temperature of the oceans,
the ERSST v3b massif at the nodes of the geographic grid $2^\circ$ at $2^\circ$ latitude and longitude for 1960–
2018 [3]. Linear trends at each node of the geographic grid were subtracted from the source data of the
surface temperature (SST).

The data on the average annual length of day for 1960-2018 were used. A linear trends were
subtracted from the annual length of day data (LOD). LOD is the inverse of the axial rotation speed
of the Earth.

The average annual values of the NINO3 index for 1982-2018, which characterizes the classical
El Nino in the eastern Pacific, were used [4]. A linear trends were subtracted from the NINO3 data.

The asynchronous correlation coefficients between the J and LOD indices, as well as between the
SST in the region of the circumpolar Antarctic current and the NINO3 index, were calculated.

The method of correlation analysis is used to obtain estimates of the correlation of SST at the
nodes of the geographical grid of the World Ocean with changes in the moment of inertia $J$ of the
barycentric movement of the Sun. Asynchronous correlation coefficients were calculated between a
data of average annual values of $J$ and a series of average annual values of SST in each geographical
node for 1960-2018. The calculations were carried out at a temperature delay of 1 to 60 years.
Considering that the $J$ series has been calculated since 1700, in the calculations of asynchronous
correlations when the temperature series shifts to the past, there was no decrease in the number of
members of the series. Data on SST for earlier years are excluded from the analysis. In the high
latitudes of the southern hemisphere, they are not reliable. Of all the asynchronous coefficients in
the node, one maximum modulus correlation coefficient was selected and the delay (number of years) of
SST changes was recorded. The results were mapped.

3. The Result and Discussions.
The assumption was verified that a change in the moment of inertia of the movement of the Sun+Earth
pair around the center of mass of the Solar system can create additional rotational moment for the
axial rotation of the Earth, and can also create additional movements of the oceans along latitudinal
circles. Previously, the influence of barycentric motion on the climate was considered by many
authors, but always the mechanism erroneously was reduced to a change in the Sun-Earth distance and
to a change in insolation [5-10].

3.1. The relationship of the axial rotation speed of the Earth with external dynamic action.
The change in the moment of barycentric rotation of the Sun+Earth pair can be partially transmitted to
the solid, liquid, and gaseous shells of the Earth. According to observations, the reality of such an
assumption was verified. The correlation coefficients between the $J$ index and the LOD index were
calculated for LOD delays from 0 to 10 years. The best correlation coefficient $r = -0.56$ was found
when the LOD was delayed by 5 years.

Figure 1 shows long-term fluctuations in the moment of barycentric rotation (with the opposite
sign) and changes in the length of the day with a shift of 5 years to the past. An increase in the
moment of inertia corresponds to an increase in the speed of the axial rotation of the Earth with a
delay of 5 years. A significant correlation confirms the initial assumption that part of the moment of
inertia of the barycentric rotation is transmitted to the moment of axial rotation of the Earth. The
change in the Earth's rotation speed is associated with changes in the moment of inertia of the
barycentric rotation. The forces arising from a change in the moment of inertia of rotation affect all the
layers of the Earth. A delay of 5 years is supposedly associated with the inertia of the upper viscous
mantle of the Earth.

![Figure 1](image-url)

**Figure 1.** Change in the moment of barycentric movement $J$ (with the opposite sign) and change in the
length of the day LOD with a shift of 5 years.

3.2. The connection between changes in SST and changes in the moment of inertia of the motion of the
Sun+Earth pair.
Using the maximum asynchronous correlation coefficients between changes in SST at the nodes of the
geographic grid and changes in the moment of inertia $J$ of the barycentric movement of the Sun, it was
found that the best connections are observed when the SST series is shifted by 32-37 years into the
past. The changes in SST are behind the changes in J. A map of the best statistically significant coefficients is shown in Figure 2. The correlation coefficients modulo $r = 0.4$ are significant.

The realism of such a delay is confirmed by other researchers. By analyzing the asynchronous covariance structure of climate indices [11] describes the propagation of a signal of temperature change throughout the Northern Hemisphere through a sequence of multiple transformations of asynchronous atmospheric oceanic long-distance bonds. According to the estimates of the same authors, the initial signal of temperature change in the North Atlantic, propagating, reaches the remote regions of the hemisphere about 30 years later. In the work [12]. Based on other approaches, it is shown that the response of the state of the atmosphere to external influence occurs with a delay, which is determined by the necessary relaxation time characteristic of the entire climate system. The optimal values of this relaxation time in [12] received 25.1 - 27.5 years. Close estimates of the delay were also found for other cyclic external influences on the ocean. For example, in [13]. The effect of cyclic changes in solar activity on the North Atlantic Oscillation with a delay of 40 years as a result of a shift in the zone of tropical convection in the Pacific Ocean was discovered.

The map in Fig. 2 shows that all significant correlations turned out to be in the nodes of the geographical grid located along the main ocean currents. The contribution of the moment of inertia to the total SST variability along the ocean currents is about 50%. In the Southern Ocean, a positive correlation of J and SST is observed in the cold circumpolar Antarctic currents in the Pacific, Atlantic, and Indian oceans at a latitude of about 60°S.

![Figure 2](image-url)

**Figure 2.** Fields of significant asynchronous positive and negative correlation coefficients between J and SST with shifts of 32–37 years. Gradation of coefficients on the map: 1) $<= -0.70$; 2) $-0.60 - 0.69$; 3) $-0.50 - 0.59$; 4) $-0.40 - 0.49$; 5) $-0.39 + 0.39$; 6) $+0.40 + 0.49$; 7) $+0.50 + 0.59$; 8) $+0.60 + 0.69$; 9) $>= +0.70$. Arrows indicate oceanic currents: 1 - Antarctic circumpolar; 2 - Peruvian; 3 - South Passatnoe; 4 - East Australian; 5 - California and North-Passat; 6 - Kuroshio and the North Pacific; 7 - North Atlantic; 8 - Norwegian.

Figure 3 shows a graph of the change in the moment of inertia of the barycentric motion of the Sun and SST (with a shift of 36 years) in the region of the Antarctic current in the Pacific Ocean at a node with coordinates of 226°E 54°S. The correlation coefficient between them is $r = 0.81$. The contribution of external impact to the total variability of SST in the Antarctic Current was 66%.
Figure 3. The surface temperature of the ocean in the Antarctic current, smoothed over three years (SST_A) and the moment of inertia of the barycentric movement of the Sun (J) with a shift of 36 years.

This confirms the initial assumption of the transfer of torque from the barycentric movement of the Sun + Earth pair to the zonal ocean current. The Southern Ocean is the only place on Earth where the continents do not interfere with the circular ocean current along the latitudinal circle. The west-east flow of the circumpolar current of the Antarctic is a unifying link for the exchange of water masses at all depths between the main oceanic basins of the world [14]. In different parts of the Antarctic course, the contribution of J changes to the SST changes is from 25 to 50% of the total SST variability. In the South Pacific, the field of positive correlations from the Antarctic current extends to the region of the cold Peruvian current (arrow 2) and then spreads along the South Passat current (arrow 3). In the northern part of the Pacific Ocean, the field of positive correlations is located exactly on the trajectory of the cold California current (arrow 5) and then extends to the region of the North Passat current. The field of negative correlations in the South Pacific Ocean is located near the warm East Australian Current and extends east to the islands of Polynesia (arrow 4), and in the northern Pacific Ocean - near the warm currents of Kuroshio and the North Pacific (arrow 6). In the Atlantic Ocean, the field of negative correlations coincides with the trajectory of the warm North Atlantic (arrow 7) and the Norwegian currents (arrow 8). High correlations of SST with J in places of the main ocean currents show that a change in the moment of inertia in the movement of the Sun+Earth pair creates in the World Ocean previously unaccounted for external forces that affect the dynamics of currents in the Great Ocean Conveyor [15]. This result coincides with the conclusion [12]. That the heat transfer of the Great Ocean Conveyor is a primary physical phenomenon that directly responds to variations in astronomical parameters.

Changes in SST in the region of ocean currents are presumably the result of dynamic changes in these currents, including vertical mixing. Correlation fields show that when changes the moment of inertia of the barycentric motion of the Sun, in the Pacific the SST changes in the region of circular circulation of warm and cold currents in the southern hemisphere counterclockwise. In the Northern Hemisphere in the Pacific Ocean, on the contrary, when the moment of inertia changes, the SST changes in the region of circular circulation of warm and cold currents clockwise. In the northern part of the Atlantic Ocean, when the moment of inertia of the barycentric movement of the Sun changes, changes in the characteristics of the warm North Atlantic and Norwegian currents occur, which possibly affect heat transfer to the Arctic.
3.3. El Nino’s relationship with SST in the Antarctic Current

A striking manifestation of SST fluctuations in the equatorial part of the Pacific Ocean is El Nino. It is associated with the Passat oceanic currents, and the Passat currents are part of the circular oceanic circulations in each hemisphere. According to our assumption, the Antarctic current is the main driver of changes in the circular circulation in the southern half of the Pacific Ocean, therefore, an assessment of the relationship between the NINO3 index and SST in the Antarctic current was further obtained. Figure 4 shows the changes in SST in the node 214°E 68°S in the Antarctic Current and synchronous changes in the NINO3 index for 1982-2018. The correlation coefficient between them is \( r = 0.56 \). The contribution of changes in SST in the Antarctic Current to changes in the NINO3 index is 31%.

![Figure 4. SST in the Antarctic Current (SST_A) and NINO3](image)

During the period from 1982 to 2018, 4 cases of El Nino were observed in the eastern equatorial part of the Pacific Ocean and in all cases they occurred with increasing temperature in the region of the circumpolar Antarctic current. Two-thirds of the SST changes in the Antarctic current region are associated with changes in the moment of inertia of the barycentric movement, and one-third NINO3 changes are associated with the SST in the Antarctic current.

3.4. On resonant interactions of oscillatory systems

The main obstacle to the recognition of external climate impacts is the low strength of these impacts, but everything changes when you consider that the climate system has the properties of an oscillating system with its own frequencies. Earth is part of the solar system, in which everything is built on resonances [16]. The oscillating climate system is exposed to weak repetitive effects from space. The question of the sensitivity of the climate system to these weak impacts remains unresolved. The climate system has the properties of an oscillatory system. Repeated external influences on any oscillatory system act on it selectively with frequencies close to the natural frequencies of the system. Resonances can occur not only with a 1:1 ratio of the frequency of exposure and the natural frequency, but also at comparable frequencies, for example 1: 2, 1: 3, 2: 3, 3: 2, etc. According to the theory of vibrational systems [16], the small value of the external forces acting on the vibrational system is not an obstacle to modulation in it of resonant oscillations at comparable frequencies. Recognition of the climate system as an oscillatory system removes restrictions on the minimum effective strength of the external periodic impact. In a nonlinear system, resonances can cause changes in the oscillatory system, which are many times greater in energy than the influx of energy from an external factor. At
the moment of resonance, the oscillations can be amplified due to the release of the internal energy of the system. Such a complex and non-linear climate system is, resonances with the release of internal energy in it are possible. Regardless of their nature, nonlinear oscillatory systems tend to go into a special synchronous mode of motion during dynamic evolution. The collection of objects isolated from each other, making oscillations with different frequencies, when superimposing sometimes even very weak connections, goes into a mode of motion in which the frequencies of the objects become equal, multiple or in rational relationships. [16]. Fluctuations in the characteristics of the climate system cannot affect space, but cosmic repetitive effects on the oscillatory system of the climate are possible. Confirmation of the reality of this influence are the results of the studies described. According to Molchanov [16], when studying the interaction of nonlinear oscillatory systems, weak interaction forces should be taken into account. These forces are aimed at suppressing interacting vibrations that are random with respect to each other. But these same forces lead to resonant amplification of oscillations that are in rational relationships with each other. The results obtained in this study are consistent with the theory of resonant interaction of vibrational systems.

4. Conclusion

Changes in the configuration of the planets in their orbital rotation creates changes in the moment of barycentric rotation of the Sun and the Earth with it. Repeated changes in the moment of inertia resonantly affect changes in the speed of the axial rotation of the Earth and resonantly create a rotational moment along latitudinal circles in the oceans. Part of the moment of inertia of the barycentric rotation is transmitted to the moment of axial rotation of the Earth. The climatic system has the properties of oscillatory systems and is capable of resonantly perceiving weak external repetitive dynamic effects during the barycentric rotation of the solar system. The most favorable conditions for the appearance of an additional zonal component in ocean currents are in the Southern Ocean, where there are no continents that could impede the zonal flow. Therefore, it can be assumed that changes in the circumpolar Antarctic current are modulated as a result of the appearance of additional torque from the barycentric movement of the Sun and the Earth with it. In the Northern Hemisphere, such favorable conditions are formed in the area of quasi-zonal North Atlantic and Norwegian currents. The theory of the interaction of vibrational systems removes the requirement of the need for energy matching of cosmic variations and the observed changes in the Earth's rotation speed and ocean climate change. The ocean responds to dynamic external influences. These effects simultaneously affect currents at all depths of the ocean, but on the surface they manifest themselves in temperature changes along the main oceanic currents with a delay of 32-37 years. The changes in the moment of inertia of the barycentric movement of the Sun are explained by 31% of the total variability of the Earth’s rotation speed, 66% of the total SST variability in the Antarctic current and about 50% of the total SST variability in the main ocean currents. An increase in the moment of inertia of barycentric motion is accompanied by an increase in the surface temperature of the ocean in cold currents and a decrease in temperature in warm currents. One example of the manifestation of such changes is El Nino and its associated climate variations. The presented results are a consequence of the resonant effects of dynamic external influences on the climate oscillatory system.

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