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Toward Systematic and Interdisciplinary Study of Solar-Terrestrial Relations[1]

G.Ya. Smolkov*, Yu.V. Barkin**

**Institute of Solar-Terrestrial Physics*
Siberian Branch of the Russian Academy of Sciences (SB RAS)
ul. Lermontova 126-a, P.O. Box 291, Irkutsk, 664033 Russia
E-mail: smolkov@iszf.irk.ru

***Sternberg Astronomical Institute, Moscow State University (MSU)*
Universitetskij prospekt 13, Moscow, 119234 Russia
E-mail: barkin@inbox.ru

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Abstract. Physics of solar-terrestrial relations is one of fundamental issues for present-day science, because these relations determine the state and variability of the mankind habitat and activity. Unsystematic studying solar-terrestrial relations deprived of the objective account for all primary external causes, without interdisciplinary explaining mechanisms for their effect on the Earth, inevitably results in the forced attributing inexplicable processes and phenomena to "natural anomalies", impedes forecasting variations in the environment. Statement, statistical, and correlation analyses, still widely used, are not accompanied by due interpretation of the studied. Along with solar activity and galactic cosmic ray flows, one should take into account the Earth's endogenous activity caused by an external gravity forcing on the shells of our planet (core, mantle, etc.) including disturbance of the Solar System integrally from outside.

Introduction. Till now, solar irradiance, geoeffective electromagnetic radiation, flows of energetic particles, and solar wind, as well as flows of galactic cosmic rays (GCRs) have been traditionally referred to as environment variability external factors. But recently, a geodynamic concept, according to which the planet's endogenous activity is imposed and dominated by ambient celestial bodies, has been effectively studied and applications. Among them, there are geodynamic, geodesic and geophysical processes, such as excitation and relative displacements of the Earth's shells, their deformations, the Earth's diurnal rotation velocity instability and motion of its poles, the core nutation, as well as tectonics, seismicity, degassing processes, and many other phenomena [1]. Recently, effects of anthropogenic processes (fatal land use, atmospheric emissions of CO_2, and other harmful substances and gases) have been actively investigated. All this testifies to a complicated multifactor character of solar-terrestrial relations and to a necessity of systematic and interdisciplinary study of their manifestations.

Unfortunately, present-day studies in the Earth sciences left with no answer the questions about the activity of natural processes and their observed spatio-temporal properties. Despite

[1]Talk presented at the Interdisciplinatory Colloquium on Cosmic Factors of Evolution of the Biosphere and Geosphere, Moscow, May 21–23, 2014.

numerous endeavors to investigation the space factor of external forcing on the Earth and to study the role of the Earth's gravity interaction with the Moon, the Sun, and the planets, the reasons for the observed Earth's pole centennial drift, Earth's non-tidal acceleration, the planet's deformation, the changes in the magnetic field and climate have remained unexplained. All the available geodynamic models were not able to elucidate many natural phenomena. There was no motivated explanation for the energetics and cyclicity of planetary processes. Prof. Yu. Barkin proposed in 1999–2002 a high-efficiency mechanism for excitation and forced relative swing and rotations of the Earth's shells (as well as those of other planets and their satellites) under gravity attraction of ambient celestial bodies [1]. This mechanism was shown to be an extremely powerful source of the endogenous activity with well-defined cyclic manifestations on different timescales. Endogenous energy of the planet (satellite) is scooped from the gravity effect from external celestial bodies, or, after all, from the energy of translatory-rotary motions of all the interacting bodies and their shells. This mechanism's energetics was shown to elucidate the energy budget of the Earth and of other active celestial bodies. Based on this mechanism, many geodynamic phenomena and planetary geophysical processes have been explained from mechanical and energy viewpoints, as well as the fundamental issues of the Earth and planetary sciences have been solved. Also, owing to the above geodynamic model, estimates for the dissipation power of the Earth's mantle viscous-elastic strains were obtained at the given relative displacements of the core and mantle mass centers. These displacements reflect in the Earth's mass center displacements that have been accessible for present-day observations via space geodesy techniques since 1993. For the revealed oscillation spectrum, the mantle elastic energy dissipation power was determined from observations for each of the oscillations, as well as the integral effect. The dissipation integral power was shown to feature an exclusively large value about 10^{14}–10^{15} W, and it is sufficient to account for the present-day endogenous activity of the Earth [2]. Besides, the century-discussed presentation about cyclic variations in the activity of all planetary natural processes gets its explanation.

A significant interest exists also to the study of factors forcing directly the Solar System, and there are grounds for that. The Voyager 1 data showed the circumstances of interaction between the Solar System and the interstellar medium. Academician V. Ambartsumyan reported such an external forcing at the AS SB Presidium Meeting already in 1956, which NASA confirmed in its News in 1999–2013 [3]. Thus, the fundamental and applied researches of solar-terrestrial relations for the benefit of many present-day industries should be conducted with the account for all the above [4].

Approaches to studying solar-terrestrial relations. In fact, most distressingly, there has been no uniform (conventional) opinion about all the initial factors and their contributions to variations in geophysical and geodynamic processes and phenomena (for instance, in geodynamics, geology, geodesy, oceanology, climatology, etc.) till now, even with the global cooperation of endeavors of the stakeholder countries, with a number of international research organizations, and international engineering projects. Despite these endeavors, till now there has been a large divergence in studying the STR nature by specialists of various occupations, an incomplete account, confusion, and even distortion of the initial causes of the investigated variations in the environmental parameters, endeavor to explain them only through the concepts of a narrow professional field. As a result, there are approaches to studying STRs similar to "The Surface Description of the Earth's Surface", and sometimes simply erroneous approaches, for instance, when studying the increase in the ocean level

through altimetry techniques, when interpreting the warming processes, the role of postglacial retreat [5, 6], and others.

Mechanism for activation of the Earth's seismic and volcanic activities. Earthquakes and volcano eruptions are the brightest and sensitive indicators of the present-day Earth's geodynamic activity. V.E. Khain and E.N. Khalilov [7] explain it only qualitatively, using established correlative peculiarities, and the principle of cause-and-effect relations among various natural processes proposed by them, as well as comparatively weak energy mechanism for the tidal effect on the Earth, the cyclicity of volcanism manifestations, its chronological structure, and probabilistic characteristics. They fairly noted a necessity to understand possible physical mechanism for the process, deeper analysis of the Solar System planets' gravity fields' effect on the Earth's natural processes. A correlation of compared ground phenomena may and should occur at the common initial causes or the factors causing variations (disturbance) in natural processes. But, upon establishing correlations (for instance, of earthquakes and volcano eruptions with other processes), one should find out the physical mechanism for their couplings or for each of the compared processes. Without this, the results of the study appear superficial, with the assumptions or conclusions being unconvincing. The mechanism for forced oscillations of the Earth's core and mantle [1] that allowed one to explain centennial, cyclic, and spasmodic changes in seismic and volcanic activities in their unity with many other natural planetary processes on the Earth is proposed for such a mechanism. Activation of seismic planetary process is associated with the storage and fault of the elastic energy in the mantle layers. Activation of volcanic process is associated with changes in the Earth's heat flux, and with reallocations of magmatic masses. But the basic power source driving the indicated processes is the mobile oscillating core.

Climate changes and their mechanism. The problems of change in regional and global climate are rather topical. The presence of global warming has been finally recognized doubtless by the Intergovernmental Panel on Climate Change (IPCC), but greenhouse gases are still considered its principal cause, i.e., the anthropogenic factor (IPCC Report, 4 April 2014) [8]. Various scientists in a search for the warming cause have tried, indeed, all possible factors, sometimes rather far by their nature from climate changes. For instance, V.E. Khain and E.N. Khalilov indicate as the causes of global climate change the following: drifts of the Earth's geographic and geomagnetic poles, variation in the Earth's rotation, and growth in the endogenous, particularly, volcanic activity [7]. Comparison of growth in greenhouse gases in the atmosphere and the Earth's volcanic activity may be an indirect evidence of a certain association between these processes. Based on different correlation methods of studies, they erroneously admit a possibility of the solar activity effect on geodynamic processes, in particular, on volcanic and seismic activities. The authors recognize that their conclusions, by far, are not indisputable, and may undergo additions or changes when conducting further investigations, and also as a result of other scientists' studies.

Similarly restricted and, hence, insufficiently valid approach with orientation to the processes and phenomena occurring and accessible to recording only from the Earth's surface is also characteristic of other specialists. They discuss and endeavor to elucidate natural processes via intermediate effects and ground responses, without knowing all of their primary causes. Thus, in the genetic concept of the Earth, the only explanation for the Earth's endogenous activity (as well as for Solar System planets and their satellites) is hydrogenous degassing of their liquid cores [9]; that is only one of the processes in a complex of endogenous activity phenomena, depth geodynamics. There are also other not less extravagant hypotheses

of warming, and the causes of variation in the world ocean level [10, 11]. The authors related the following to the basic possible causes of the present-day global warming: anthropogenic changes in the atmosphere, on the Earth's surface, and in the near-Earth space environment, manifestations of eigenoscillations in the Earth's climate system, joint action of all three enumerated causes. They also admit solar activity as the principal cause of warming. About 97% of scientists are convinced in the anthropogenic character of warming. By the results of the survey done by an international panel, global warming is considered to be caused by human activity (http://ebull.ru/dl/digest-020.pdf). However, R. Wood showed the unessential role of CO_2 in the climate variability already about 100 years ago.

Energy estimates of the contribution to global warming both from cumulative effect of solar-geomagnetic activity centennial variability and various anthropogenic sources, including emissions of greenhouse gases (industrial, fuel, and transport) and the land abiotizaton performed by conversions of energy of solar flares and precipitations of particle fluxes in the ionospheric microwave emission, led to the proposal of a uniform physical (radio-optical) mechanism for monitoring the processes in the lower atmosphere and biosphere (including man) caused by the solar and geomagnetic activity levels associated with ionospheric microwave emission in transitions between optically highly-excited (Rydberg) states of all the upper-atmospheric components [12]. Leading climatologists in the USA have termed the process of occurring global warming "temperature anomaly" till now [13]. The Roskomgidromet has been still using a stochastic model for weather forecast with their about 60% validity. Dependences on many factors are noted, one of them being El Niño phenomenon. Analyzing the effect of different factors on temperature has not revealed a unique, explicitly dominating factor [14].

Addressing long-term variations in solar activity, escaping of energy flows into the space, atmospheric electricity, geomagnetic activity, atmosphere-ocean energy exchange, variations in the brine ice mass and area, river run-off volume led to the judgment that a considerable proportion of the 20th-century observed warming might be caused by the variation in the solar activity level, along with "natural variability of the global climate system, volcanic activity, etc." To estimate the real quantitative contribution of both solar activity, and anthropogenic factors to the climate changes, one is offered to account for the circulation variations in the atmosphere and in the ocean, and the efficiency of energy exchange between the ocean and the atmosphere [15]. The most weighted description of climate changes with the account for all the above considered natural and anthropogenic causes and conditions is briefly stated in [16]. Along with these, there are judgments by scientists fanatically regarding the basic climate changes, including global warming, caused by the effect of only solar activity. We do not think expedient to refer to them.

In [2, 17] the phenomena of warmings and cold snaps, inversions of climate changes on the Earth in the northern and southern hemispheres, their present-day manifestations were addressed and interpreted. The above mechanism for a forced swing of the core and the mantle, and the mantle viscous-elastic strains drives the the Earth's integral heat flux and its reallocation between the hemispheres. Similar phenomena are widely observed on other bodies in the Solar System (including the Sun itself), and the natural process activity inversion (activity alternation between hemispheres) is the most correct signature for the active operation of the mechanism for excitation of celestial bodies' shells [1]. The investigations preformed based on the gravity mechanism for exciting shells allowed one to substantiate such difficult-to-understand phenomena as activation of natural processes, and of geological, tectonic activity in the polar regions of planets and satellites.

Inversion polar changes of the Earth's climate in past and modern epochs. Based on the mechanism for a forced wobble of the Earth's core and mantle, in 2004 Yu. Barkin predicted the phenomenon of "climate swing" for the northern and southern hemispheres that later obtained a complete approval in the data of present-day studies and observations [17]. The proposed geodynamic model naturally elucidates high energetic and dissipation of natural processes on the Earth. But it allows one to explain and interpret other complicated planetary phenomena, for instance, such as polar inversion of natural process activity for which process activity or energy dissipation of these processes increases in one hemisphere (northern) and decreases in the other (southern). Also, hemispheres may change roles cyclical at certain frequencies and periods (in different time scales) or centennially and even spasmodically [18–20]. The hemispheres with contrasting variations in natural processes are not necessarily northern and southern, and their orientation and position are determined by directions of corresponding cyclic radial displacements of the geocenter (or by the core and mantle relative displacements). Here, of course, it goes about all natural processes, as well as about physical terrestrial fields. But we briefly stop on the analysis of inversion climate changes on the Earth. These variations in the climate correspond to the modern epoch. Similar correlations in variations in the Greenland and Antarctica climate were established from the ice cores for the last glacial period [21]. As a result of special procedure in smoothing sharp spasmodic variations in the Greenland climate, the authors managed to reveal a planetary phenomenon of inversion climate changes in the Earth's southern and northern hemispheres. There appeared even a title for this phenomenon, climate swing. This sort of inversion climate change were also found in a comparatively short time scale in the Greenland and Antarctica climate variations in XX century.

In [17, 20], a mechanism was proposed, and a scenario for forming the Earth's glaciations and warmings, and their inversion and asymmetrical manifestations was described. These planetary thermal processes are related to gravity forced excitations of and variations in the Earth's core-mantel system that control and guide heat delivery into the high layers of the mantle and onto the Earth's surface. The operation of this mechanism is shown to be manifested on different timescales. In particular, significant climate changes are to occur at thousand-year periods, with the periods of tens and hundred thousands of years. The excitation of the core-mantle system is caused by planetary centennial orbit disturbances and disturbances of the Earth's rotation that are known to feature significant amplitudes. But on a short timescale, climate variations with interannual and decadal periods should also be observed like dynamic implications of the Earth's core-mantle system swing at the same periods. The core and mantle oscillations result in viscous-elastic strains of all the mantle layers, in cyclic heat release, and in forming a heat flux, which affects the oceanic and atmospheric activity, and, generally, all synoptic processes. After all, the core participates most actively in forming and changing the planet's climate both globally, and in the northern and southern hemispheres of the planet. However, the core oscillations and displacements are controlled by the Moon, Sun and other planets. This is a manifestation of the relationship and unity, domesticity and interconnection of all the Solar System bodies, generality of variation styles, and synchronism of their natural processes. The systems of the Sun's and planets' shells also experience excitation, and synchronously. This is one of the major features of solar-terrestrial and, generally, solar-planetary relations. The stated is corroborated, for example, by that jumps in natural process variations on the Sun, Moon, Earth, and other bodies of the Solar System occurred synchronously in 1997–1998 [22]. The cores of these

bodies were excited and had a gravitational forcing on all the shells and natural processes. Shells' relative displacements, rotations and strains scoop their energy from a vast energy "big kettle" of the reciprocating and rotating motion of all the Solar System bodies.

Available geophysical, geodynamic data, and the data on space geodesy convincingly testify to that, in present period (last decades), there is a centennial drift of the core northward at slowly increasing speed. The Earth's mass center, and, according to our model, the Earth's core mass center, displaces to Taimyr Peninsula. This process may continue over the nearest decades and centuries, which conceals a great threat for civilization. The number of catastrophes and disasters, including those at nuclear power stations, will intensify; climate conditions will be more and more severe and hard for the biosphere, on the whole. The problem and difficulty of the situation is in that the indicated geodynamic phenomena do not depend and are not able to depend on man's will. What depends on man is only not to create additional hazards and difficulties for life on Earth. It is Russia that is subject to the effect of the discussed mechanism for directional climate changes on the planet at the greatest degree. Hence, the northern regions of Siberia (and whole Russia) are subject to most intensive impacts of gravity from the core, which, after all, leads active climate changes and general warming compared with any other regions of the planet. The present-day observational data corroborate this. Slow changes and other geodynamic and geophysical implications of dynamics of the Earth's shells' forced relative dynamics may play an important role in the national economy and should be taken into account in the plans for its future development.

If one follows the conventional views of the STR nature, one may note that the contribution of solar radiation (SR) with which, first of all, one correlates geophysical variations, for instance, climate ones, dramatically depends on a time interval due to the differential character of solar-terrestrial relations on different time scales. Standard approaches to studying STRs cited as most indicative suffer from insufficient systemacy, absence of cooperation among specialists of necessary profiles. No wonder that at such a difference in judgments about initial factors and approaches to studying STRs, it is impossible to present logically and physically their reasoned essence, global and regional spatio-temporal picture, reliable forecasts of their variations. Certainly, this affects scientific and economic aspects of the modern times already critical without the above. A forced reference of the processes and phenomena (due to impossibility to elucidate them) to "natural anomalies" initiates searching for an external factor not taken into account, which the Earth's endogenous activity driven by external gravity effect appeared to be.

The concept of the Earth's endogenous activity, and the geodynamic model of the planet developed on its basis deserve urgent popularization and insistent recommendation to account for them when studying STRs. They have been developed under favorable informational conditions that had emerged due to man's exit into the space, use of orbital technologies that allow one to almost globally monitor the Earth (meteorologically, geodetically, gravimetrically, seismotomographically, altimetrically, etc.). This allowed us to directly and globally trace the Earth's deformation, the behavior of geodynamic and geophysical parameters, temperature modes of the land and oceans, etc., to avoid untestable assumptions and other constraints. Already first studies based on the new geodynamic model corroborated its competency and efficiency when studying the cyclicity and energetics of the processes, when elucidating centennial variations in gravity, when explaining slow growth in the ocean levels, both global and mean, in the northern and southern hemispheres, spasmodic changes in the natural process activity, increased and contrasting activity of the planet's polar regions, centennial

and cyclic variations in seismic activity, when studying the planet's tectonics plus tectonics and supercontinental cyclicity in geology, and many other processes and phenomena in the Earth and planetary sciences [18].

One may state that the Earth is simultaneously under the forcing of continuously changing Sun radiation, solar wind, GCRs, and also gravity forces from the Moon, Sun and other planets. According to Barkin's concept, the shells represent the system of interacting celestial bodies. The shells are excited by gravity forces from external celestial bodies. The endogenous energy is spent cyclicly, and in a strict dependence on the peculiarities of external celestial bodies' orbital motions. The phenomena of natural processes' cyclicity and their inversion are universal and observed in all the time scales, from hours through geological periods. The gravity forcing on the Earth is implemented both directly by every, and integrally by all bodies of the Solar System during their motion relative to the barycenter (its mass center), and, generally, under the influence of the Galaxy. This forcing results in small relative displacements, rotations, deformations and other changes in the the Earth's core, mantle, and other shells. These relative displacements of the core lead to variations in its shape and, in particular, to forming a "pyriform" shape. Therefore, the STR essence is not confined to the concepts quite customary when studying and accounting for space weather caused by responds to SR and GCR flows. Short-period and decadal variations in natural processes are dictated by relative displacements of the Earth shells under the influence of gravity attraction from the Moon, Sun, and other planets. Natural process activity possesses the property of a planetary asymmetry. The phenomenon of reflectivity or inversion of natural processes is caused by polar changes in the stressed state in the opposite hemispheres of the Earth. These changes are determined by the direction of the relative displacement of the shells. Similar phenomena of cyclicity, reflectivity, and inversion of natural processes are observed on other planets and satellites.

From the positions of geomodel for the Earth's core and mantle forced oscillations, spasmodic changes in the activity of diverse geophysical and geodynamic phenomena were scrupulously investigated in [19, 22, 23]. These changes were addressed like implications of the fundamental phenomenon, a jump of the core mass center relative to the mantle mass center. This phenomenon was referred to as "core galloping". The 2010 reports of the GEOCHANGE (International Committee on Problems of Global Variations in Geological Medium, a scientific organizations and scientists from more than thirty countries) and of the Global Flood Detection System (experimental system aiming at providing alerts for flood disasters) noted the above spasmodic changes in some natural processes, and some new were added [24]. Cumulatively, the authors termed these synchronously occurred changes in natural environment "energy jump" of the processes in all the Earth's shells: lithosphere, hydrosphere, atmosphere, and magnetosphere. The authors relate the global "energy jump" onset to 1998. Also, there is a hypothesis that the jump might be caused by the external forcing on the entire Solar System. Thereupon, even the 1987 Feb 23 explosion of supernova SN1987A in the Large Magellanic Cloud (a satellite of our Galaxy) was also mentioned. However, the authors do not discuss at all a possible physical mechanism for excitation of the Sun and the Solar System planets.

Our mechanism for forced oscillations and displacements of the Sun's, its planets', and their satellites' shells under the gravity effect of all the Solar System bodies allows us to propose a similar explanation. And, in particular, to interpret a phenomenon of the jump synchronism on different bodies in the Solar System. Due to celestial-mechanical interaction

among the Solar System bodies, the shell systems of the Sun, planets, and satellites are excited synchronously, which is reflected in the synchronous variations in their natural processes [22]. As a result, one obtains a certain interpretation for spasmodic change in the Sun's mean radius, in the amplitude of solar radiation, in the CME propagation velocity, and in the longitudinal distribution of all the eruptive prominences in the microwave emission, in the sunspot production.

The flare neutrino radiation was recorded at several laboratories. But several seconds prior to recording the first neutrino impulses, a gravity wave antenna in Italy was triggered. The recorded energy flux was unusually high. If the energy flux carrier was a scalar wave (along with the gravity one), then the flux might correspond to a supernova flare. This is a possible time correlation, for which we cannot indicate any physical mechanism, and it should be considered as a hypothesis.

Noting a substantial increase in the geodynamic activity of our planet since 1998, the GEOCHANGE International Committee is still guided by the external forcing of only solar activity, basing on just correlations without any explanation of their physical mechanisms, without accounting for the contribution of gravity effect on the Earth. Global changes in some geophysical parameters and high correlation of the "spasmodic increase" in natural cataclysms are noted only in the lithosphere, hydrosphere, and atmosphere. These changes testify to releasing an unusually high-level additional endogenous and exogenetic energy without knowing and, consequently, accounting for variations in the depth geodynamics. The role of which was rather clearly and illustratively shown earlier in Yu. Barkin's studies, including those for spasmodic changes in the process activity. From our investigations, it follows that jumps occur systematically enough (not only in 1998). For instance, they occurred for different natural processes, for instance, in 1975–1976, 1986–1987, 1997–1998, 2010–2013, on different bodies of the Solar System and in a strict correlation to variations in the cyclic solar activity (in particular, with the 11.1-year known period). But the solar radiation does not play the leading part here, and remains as though apart. Thereby, there are signatures and reliable observational data evidencing that the oscillations in the basic shells of the Sun and planets occur synchronously and are interconnected [22]. Some discord and specificity in the shells' relative oscillations (for instance, jumps) are introduced by boundary conditions between the shells (for instance, the cores and the mantle), and the interaction is energetic. Naturally, the shells oscillations are dictated by gravity interactions in the Solar System and by these bodies' motions. We pay a special attention to the non-inertial property of the shells' motion in the Solar System barycenter reference system. The Sun's mass center motion in the barycentric reference system dramatically correlates with the geodynamic and geophysical processes. These phenomena and dynamic factors should be studied in greater details in the near future.

Conclusion. The results of studying the environmental variability cannot be considered as satisfactory and, moreover, complete. They only evidence that the physics of solar-terrestrial relations is at the search stage. To overcome the latter, one should: (1) account for the implications of gravity forcing on the Earth from the Moon, Sun, and other planets during the barycentric motion of the Solar System as a whole in the Galaxy gravity field, along with the solar activity and GCR flows and with a possibility of external forcing on the Solar System in general; (2) recognize as mandatory conducting systematic study of solar-terrestrial relations with interdisciplinary revealing physical mechanisms for disturbances, (3) adopt target programs for interdisciplinary coordinated further studies of solar-terrestrial

relations.

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К системному и междисциплинарному изучению солнечно-земных связей

Г.Я. Смольков*, Ю.В. Баркин**

**Институт солнечно-земной физики*
Сибирского отделения Российской академии наук
ул. Лермонтова 126-а, а/я 291, Иркутск, 664033 Россия
E-mail: smolkov@iszf.irk.ru

***Государственный астрономический институт имени П.К. Штернберга*
Московский государственный университет имени М.В. Ломоносова
Университетский проспект 13, Москва, 119234 Россия
E-mail: barkin@inbox.ru

Резюме. Физика солнечно-земных связей является одной из важнейших проблем современной науки: эти связи в конце концов определяют степень стабильности образа жизни и деятельности человечества. Бессистемное изучение солнечно-земных связей без принятия в расчёт их фундаментальных механизмов, без объяснения на междисциплинарном уровне их воздействия на Землю приводит к тому, что необъяснённые процессы списываются на "природные аномалии", и прогноз изменений в окружающей среде оказывается сильно затруднён. До сих пор результатам широко используемых для изучения этой проблемы статистического и корреляционного анализа не даётся должная интерпретация. На самом деле, следует учитывать не только солнечную активность и галактические космические лучи, но и процессы внутри самой Земли, обусловленные внешним гравитационным воздействием на геосферы (ядро, мантию и т.д.), включая внешние возмущения, испытываемые Солнечной системой в целом.