KEY ASPECTS OF GLOBAL AND REGIONAL ECOLOGY IN THE CONTEXT OF THE OUTLOOK FOR REMOTE SENSING

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The priorities of global ecology and associated requirements for the observational data on the environment and biosphere are discussed. Development of an optimal global observational system of monitoring of the biosphere and environment dynamics aimed at early detection of dangerous trends becomes of critical importance for ensuring the ecological security. Considerations applied to the methodology for the optimization of the observational system are also given.

Ecological problems being aggravated all over the world have become of deep concern. They determine the top urgency of substantiation of the priorities because these problems are numerous and diverse whereas the means for their solution are limited in number. In this connection particular attention has attracted the ecological problems manifesting themselves on global scales and (in certain cases) threatening to the human life.[1,2] The consideration of the ecological priorities is of fundamental importance for planning the outlook for remote sensing.[3]

The life on the Earth depends on a complex interaction of physical, chemical, and biological processes occurring in the environment and in the biosphere under condition of increasing impact of the economic activity on the nature. No doubt that the main external factor governing the natural processes is the incoming solar radiation determined by the solar constant, because it is practically the sole source of energy for the natural processes. The favourable (from the viewpoint of distance to the sun) position of our planet within the Solar System has created the unique conditions for the advent of life on the Earth and formation of specific heat budget of the planet. Clearly, the Earth's heat budget (the difference between the absorbed solar radiation and the heat losses due to outgoing long–wave radiation) is zero in the average (otherwise, the catastrophic warming or cooling of the planet would have happened). The variations of the fine structure of the spectral distribution of the solar radiation are of vital importance for the life evolution.[4]

As for the internal trends in the processes on the planet, they are related first of all to the energy and matter cycles.[2,3]

1. Heat budget of the Earth. There are two immediate problems of the dynamics of the heat budget of the Earth: (1) the variation of incoming solar energy, i.e., the solar constant which is defined as the integral (over spectrum) flux of the solar radiation at the upper boundary of the atmosphere at the average distance between the Earth and the Sun and (2) anthropogenic redistribution of the components of the heat budget of the Earth's surface and the atmosphere, manifesting itself first of all in the intensification of the greenhouse effect of the atmosphere due to the enhanced content of the so–called greenhouse gases (GG), i.e., the optically active minor gas components of the atmosphere.

As to the variations of the extra–atmospheric insolation which are primarily important as a climate formation factor, though they are relatively significant (reach several percent) in the ultraviolet region of the solar spectrum, the value of the solar constant varies (as the analysis of the satellite observations has shown) only within 0.2%. However, such variations should be also taken into account in the study of the reason for the global climate changes. Because of the short–run satellite observations (of the order of 10 years), the long–time trends in the behavior of the solar constant still remain obscure, although there are some grounds to think that such trends exist (as is well known, over the period of a few milliards of years of the Earth's evolution the solar constant increased by 30–35%). On the scales of hundred, thousand, and more years the role of global redistribution of the extra–atmospheric insolation caused by variations of the orbital parameters is unquestionable. The bulk of experimental data pointing to the impact of solar activity on climate is increasing now; however, we failed to achieve the noticeable progress in understanding the mechanisms of impact so far.[1]

From the viewpoint of monitoring of the dynamics of the Earth's heat budget the satellite observations of the extra–atmospheric spectral distribution of solar radiation, solar constant, and components of the Earth's radiation budget (ERB) remain the urgent problem. Of great significance are the observations of the RB of the underlying surface and the atmosphere using ground–based, shipborne, airborne, and balloon means of observation. The immediate problems of extraordinary complexity are the investigations of the totality of anthropogenic variations of water and energy cycles. The burning problem of distinguishing the greenhouse effect from the climate changes calls for the corresponding integrated observational experiments. The important contribution to the solution of the above–mentioned problems must be given by the Global Energy and Water Cycle Experiment (GEWEX).[1,5]

The 20th century is completed by the aggravation of a number of ecological problems. The problem of climate warming due to enhanced concentrations of the greenhouse gases such as carbon dioxide, methane, nitrous oxide, tropospheric ozone, etc. in the atmosphere attracts considerable attention. As was correctly noted in the report of the Intergovernmental Panel on Climate Change (IPCC) favoured by the participants of the Second International Conference on Climate[1] held in Geneva from October 29 to November 7, 1990; however, the problem still remains unsolved to what extent the global climate warming observed during the last 100 years is determined by the natural variability of the climate system "atmosphere–hydrosphere–lithosphere–cryosphere–biosphere" and by the increase in the GG concentrations. The available results of numerical modeling of climate do not contradict to the theory of anthropogenic warming; however, they cannot be considered as the evidence.

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Undoubtedly, more considerable attention must be paid to the fact that the main GG is the water vapor. The problem is that the water exists on the Earth in three phases and this leads to the great difficulties of taking account of the changes of state of water and their effect on the climate theory. Thus, for example, the problem of parametrization of formation and evolution of the cloud cover and its interaction with radiation remains unsolved. No less important is an account of the climate formation role of the atmosphere–ocean interaction.[2,5] The serious attention attracts the analysis of the possible aerosol impact on climate which largely compensates for the contribution of the greenhouse effect.[1]

2. Biosphere dynamics. It should be noted that the climate changes are only a part (and even not the major part despite their undoubtedly great practical importance) of the global change problem. Most acute problems of the global ecology are associated with the anthropogenic impact on the biosphere, which manifests itself in deforestation, change of the soil fertility, and bioproductivity of the world's ocean resulting in disturbance of the closed global biogeochemical cycles of the elements such as carbon, nitrogen, sulphur, etc. The considerable disturbances of the carbon cycle happened at the end of XIX and beginning of XX centuries.

It is beyond question that the changes in the gas composition of the atmosphere have an impact on its greenhouse effect and can have a pronounced effect on the global climate. Closely related with the above problem is the dynamics of the global ozone layer being subjected to the influence of emissions of chlorfluorocarbons. The problem of the tropospheric ozone, i.e., the ozone content in the air which we breath is no less important. It should be remembered in this case that the possible climate warming and the decrease of the total ozone content in the stratosphere will result in the higher rate of the smog photochemical reactions of the ozone formation near the Earth's surface thereby bringing the severe threat to the human health.

Of key importance (from the viewpoint of the climate change problem as well) is the fact that under conditions of an unperturbed natural medium the global biogeochemical cycles of the elements (carbon, sulphur, nitrogen, phosphorus, etc.) are closed to a high degree of accuracy of the order of 0.01% (see Ref. 2). In the last century this closeness deteriorated nearly by an order of magnitude, that (if this tendency remains unchanged) threaten to cause a global ecological catastrophe, i.e., a destruction of the existing biosphere within several centuries.

That is why the problem of the biosphere dynamics has assumed a fundamental importance and should be considered as the priority of the global ecology.[2]

A lot of regional ecological problems (desertification, pollution of the environment, transboundary transport, deforestation, land degradation, etc.) make integral parts of the global ecology.

The coordination of all the efforts is of primary significance. Bearing in mind that the most acute problem of the global ecology is the global security problem,[2] it is appropriate to formulate the problem of creation of a new special–purpose institution of the UNO, i.e., a center or panel on ecological security (CES) which may include some of already existing organizations (for example, UNESCO, UNEP).

Of particular value is the further progress in the numerical imitation modeling of the biosphere dynamics,[2] which is still at the initial stage of its development and is in fact limited by the elaboration and (mainly) implementation of the imperfect climate models. The most promising way is the gradual enrichment of the available climate models by means of interactive account of biogeochemical cycles (first of all, of carbon, sulphur, and nitrogen) and consequently the interactive reconstruction of changes in the chemical composition of the atmosphere, the most important characteristics of the biosphere, and the climate dynamics. The similar approach must be fruitful to provide the deeper insight (and, if possible, the prediction) into the trends in the climate changes and biosphere dynamics.

Implementation of the numerical imitation modeling, processing, and analysis of data of the global observational system is impossible without the high–speed computers and powerful data centers. Therefore, it is extremely desirable to organize (under the auspices of the UNO) several regional international centers of data and of numerical modeling equipped with the most perfect computers. As models of such a center (making some essential provisos), for example, the European Center for Medium–Range Weather Forecasts (Brecknell, Great Britain) and International Institute for Applied Systems Analysis (Laxenburg, Austria) can serve.

3. Observational system. Primariness of the problem of global biosphere dynamics and the distortion of biogeochemical cycles (first of all, of the carbon cycle) determine the urgent necessity of substantiation and design of the optimal global observational system of monitoring of the processes occurring in the biosphere and in the environment that can be realized only on the basis of international cooperation under the auspices of the UNO.

So far lacking substantiation of the optimal (adequate) observational system is possible only on the basis of the data analysis of the numerical imitation modeling aimed at formulation of the priorities and requirements for the observational data.[3] The analysis of the trends in the biosphere dynamics based on the observational data calls for the combined use of both conventional (continental and marine) and satellite observational means. In doing so the emphasis should be placed on the concentration of conventional observational means (especially research vessels) in the regions in which the ecological changes are most pronounced and on the employment of the ecosystem approach to optimal design of the observational systems. Similar situation brings forth the problem of optimal design of the global observational systems as the immediate one including, for example, the optimal design of the systems as part of the program Mission to the Planet Earth.[1,2] This problem was discussed by Kondrat'ev et al.[3] in detail.

As the analysis of the ecological situation on the European continent shows, the most sensitive to the changing environmental conditions are the control of water resources, soil acidification, wood production, and sea level while relatively insensitive are transport and city development. This analysis leads to the conclusion that only the ecologically secure evolution both in Europe and all over the world can ensure the ecological well–being of the mankind.

Among the measures necessary for ecologically stable development are: (1) energy and resource saving in industry and agriculture, (2) decrease of industrial emissions in the environment with the use of low–waste technologies, (3) improvement of the performance of devices of monitoring of the pollutants, (4) impetus to the development of ecologically secure technologies and products, (5) decrease of employment of chemical fertilizers and pesticides in agriculture, etc. The

important means of control over the compliance with proper rules of stable eco–evolution must become the remote sensing methods.

4. Conclusion. From the viewpoint of the outlooks for further researches and developments the immediate problems are: (1) numerical imitation modeling of land use under conditions of increasing anthropogenic loading, (2) investigations of an industrial methabolism (the anthropogenic cycles of substance and energy) for the integrated natural systems and of changes in the chemical composition of natural media (including pollution, acidification, salinization, entrophication, etc.), (3) estimate of the stability limits of ecosystems being subjected to the anthropogenic loading, and (4) substantiation of optimized observational systems with allowance for the specific peculiarities of socio–economical development.[3]

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