Some priorities in the interdisciplinary climatic and ecological research in Siberia

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Climate changes in Siberia especially in the last decade are far ahead of the global tendencies in the climate warming. For this period the mean temperature in Siberia increased by 0.7'C. It should be noted that in the previous 90 years it increased only by 0.4°C. That noticeable warming in Siberia necessarily causes anxiety and calls for more intense research in this field. The question on the role of the anthropogenic factor in this warming is still open. In the former USSR and in now Russia, Siberia is considered as a raw-material region, so the vast expanses of Siberia turned out too polluted. Practically all Siberian ecosystems proved to be under the technogenic impact, especially, in the second half of the 20th century. The influence of some factors, for example, emission of highly toxic or radioactive pollutants manifests itself almost immediately and therefore can be easily detected. The consequences of such emissions can be very harmful but, as a rule, not irreversible. Other factors cause slow changes in the environment and the biosphere. The influence of the anthropogenic factor, which has far lower power than some natural factors, can become a key one as the initiating, if it affects the starting mechanisms of ecologically dangerous irreversible natural processes.

Such processes can hardly be controlled and predicted because of a wide variety of direct relations and feedbacks that exist in the permanently interacting "space – atmosphere – hydrosphere – lithospere – cryosphere – biosphere" system. A particular example of complex relations in the chain of climatic events mentioned above is the problem of pollution of the Arctic regions of Siberia with aerosols of anthropogenic origin, first of all, from industrial regions of oil and gas production in Samotlor and Urengoy and from Norilsk copper-nickel plants. The aerosols generated there, including the soot ones, are dispersed over vast territories due to trans–boundary transport. It is deposited on snow and ice covers and thus decreases their albedo and significantly distorts the radiative and temperature conditions in the "atmosphere – underlying surface" system. The surface pollution and blackening of ice and snow covers initiate their melting. Thawing water becomes the medium for active development of microorganisms from this aerosol as a biogenic raw material. The products of vital activity of microorganisms add to ice and snow melting. The decrease in the volume of ice and in the area of surface covered with ice intensifies, in its turn, climate changes, in particular, the hydrological cycle having the principal effect on the hydrosphere, lithosphere, and certainly biosphere. As seen, only one factor – technogenic aerosol in the Arctic regions can give rise to changes in absolutely all links of the long chain of climate events in the "space–atmosphere–hydrosphere–lithosphere–cryosphere–biosphere" system. If we mention that the increase of the surface temperature causes the reduction of the greenhouse gas methane from its hydrate state at permafrost melting and thus additional warming, then it becomes clear that the development of this chain includes all prerequisites for irreversibility of the above-described processes.

In analyzing such multifactor phenomena, one should take into account the prevailing role of biotic regulation. As known, the stability of ecosystems is provided for, according to the Le Chatelier – Braun principle, by the law that all random natural perturbations of the environment are compensated for by the corresponding changes in functioning of the natural biota. The huge potential of the natural biota in synthesis and decomposition of organic matter allows it to rapidly compensate for any geophysical and space fluctuations every time returning the environment to its initial state for tens years. Biologically active chemical elements (biogens) are consumed or released in the processes of synthesis and decomposition in a certain stoechiometric relations different for different organisms. This allows the biota to change the concentration of biogens in the environment in the needed direction. In the first approximation, the stoechiometric relations can be considered constant, what gives the quantitative characteristics of the Le Chatelier – Braun principle for carbon – the most abundant biogen in the biota. Any changes in the natural biota necessarily distort the state of the environment. Therefore, the stability of the environment is conserved, if the biota is kept unperturbed. The stable biosphere is such a state of the biota and the environment, in which the anthropogenic perturbation does not exceed the threshold of violation of the Le Chatelier – Braun principle.

Based on the above-said, we can formulate some priorities in the climate studies in Siberia taking into account limiting funding typical of the Russian science nowadays. It is clear that these studies should be of multidisciplinary character. They should generalize paleoclimatic, atmospheric and hydrospheric physical and chemical and biospheric studies. Note that the ecological state and climate changes at the territory of Siberia are strongly connected with the floodplain ecosystems of great Siberian rivers. The floodplains of the rivers Ob, Yenisei, and Lena cover the whole territory of Western and Eastern Siberia like the blood system. The lower reaches of these rivers lie in the Arctic latitudes, and they empty to the Arctic Ocean. Therefore, the vast expanses of Siberia can be studied with an instrumented vessel of the "river–sea" class. Such a vessel could carry a multidisciplinary research team able to study almost the whole variety of problems.

One of the steps in this direction was the International Mission Poima – 99 on a shipborne laboratory moving from Tomsk to Khanty-Mansiisk. The mission was organized by the Institute of Atmospheric Optics SB RAS. Specialists from 12 organizations, including eight institutes of the Siberian Branch of the Russian Academy of Sciences: Institute of Atmospheric Optics, Institute of

0235-6880/00/06—07 655-02 $02.00

Optical Monitoring, Institute of Petroleum Chemistry, Affiliate of the V.N. Sukachev Institute of Forest, and Affiliate of the Institute of Gas and Petroleum Geology (Tomsk), Institute of Water and Ecological Problems (Barnaul), Institute of Chemical Kinetics and Combustion (Novosibirsk), Limnological Institute (Irkutsk), as well as Tomsk Polytechnical University, Institute of Atmospheric Physics (Moscow), and Max Plank Institute of Chemistry (Mainz, Germany) joined this mission. This mission favored organization of the regular Inter-regional Meeting on Ecology of Floodplains of Siberian Rivers and Arctic. The first meeting was successfully held in Tomsk at the Institute of Atmospheric Optics in November 1999.

The discussions at this meeting covered the following research areas. Among the existing methods of paleoclimatic studies, most interesting are dendrochronology and paleoglaciology. In atmospheric studies, emphasis should he placed on aerosol, in particular, its biogenic components. The priority gases for gas analysis are such greenhouse gases as ozone, methane, carbon dioxide and carbon monoxide. Measurements of UV-0 fluxes of solar radiation are also needed. This is caused, on the one hand, by the role of UV-B solar radiation in photochemical transformations determining the aerosol–gas relations in the troposphere and, on the other hand, by its possible effect on the water biosphere at destruction with the growing temperature of dissolved organic matter absorbing UV-B radiation. Chemical analysis of the hydrosphere allows the technogenic load on water medium to be estimated. In the biospheric studies, the problems of biological variety keep their priority. In this case, it should be kept in mind that all biospheric communities are based on the communities of plants and single-cellular microorganisms, which fully control the number of large animals, as smell as the concentration of biogens in the environment. For example, lichen and phytoplankton are indicators of such communities in the Arctic regions.

In conclusion, let us note the unquestionable fact that the key link in the long chain of climate events in the "space – atmosphere -hydrosphere – lithosphere–cryosphere–biosphere" system must certainly be the noosphere. We would like to hope the results of our studies in Siberia will significantly contribute to it.