PROJECT "AEROSOLS OF SIBERIA", THE FIRST RESULTS

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Atmospheric aerosols play a significant role in many atmospheric processes (formation of clouds and precipitation, transfer of radiation, and visibility). They influence on climate and the quality of the environment.[1–18]

The properties of atmospheric aerosols depend on particle size distribution, concentration, chemical composition, and structure of the particles. The size range of atmospheric aerosols covers about five orders of magnitude and that of concentration includes more than ten orders of magnitude.[19,20]

The composition of aerosols is very complex.[14,21–26] Different projects for the study of atmospheric aerosols have a complex character[27–36] and use special aerosol equipment[19–20] and modern analytical methods.[37–40]

Of the maritime and continental types of atmospheric aerosols,[15,25] the less studied is the continental aerosol. According to the results of the long–term studies performed in the Arctic region, up to 50% of the mass concentration of pollution of this region are caused by aerosols formed above the area of the Urals, Siberia, and Kazakhstan.[26–35] Despite a considerable contribution of aerosols, arising from Siberia, to the global pollution of the atmosphere, they are practically uninvestigated.[11,36,41–52]

Industry and agriculture producing different types of aerosol particles are under intensive development in the Siberian region famed for its various climatic zones. Due to vast territories of Siberia, the monitoring network, typical for Europe and developed western countries is unsuitable for this case. Therefore, most reasonable is the method of "remote sites" in combination with the technique of planned "travels".

AIM OF THE PROJECT

The aim of the project is the investigation of the formation, transformation, and transport of aerosols in Siberian region on the local, regional, and global scales in order to determine the sources and sinks of atmospheric aerosols and to estimate their influence on the quality of atmospheric air, the level of the contamination of vegetation, soil and water, the rate of different substances and elements migration, as well as the impact of various aerosols on the health of people and animals, to study the role of atmospheric aerosols in atmospheric processes and climate.

SPECIFIC GOALS OF THE PROJECT

The following specific goals make up the project.

1. Organization of stationary points for the observation of diurnal and seasonal evolution of the particle concentration, size distribution, and chemical composition near Lake Baykal, in Altai, Krasnoyarsk and Novosibirsk regions, in some industrial cities of Siberia and special expeditions for studies of the atmospheric aerosols of Siberian region.

2. Development and improvement of methods and equipment for complex studies of atmospheric aerosols.

3. Development of the algorithms and programmes for numerical modeling of the processes of aerosol formation, transformation and propagation, for calculation of the levels of contamination of the atmosphere, soil, and vegetation, as well as for optimization of the system of observation and operative control over the quality of atmospheric environment impacted by human activity.

4. Verification of the numerical simulations by sets of experimental data.

5. Creation of the database on the characteristics of the atmospheric aerosols of Siberia.

DURATION AND STRUCTURE OF THE PROJECT

In comparison with the international projects, similar to our, and using the estimations of foreign scientists, the duration of such a project is to be 10–15 years. Therefore, the coordination of all project participants, continuous verification of obtained results and precise formulation of current tasks are required. The project is open and any one who is interested either in joint activity or in using obtained data is welcome.

Annually, the results are reviewed and a concrete program of joint works is adjusted for the next year.

The project, as a whole, and its parts are logically involved in various regional, Russian, and International research programmes. Each of the participants of the project determines himself the forms and duration of cooperation.

The whole project may be organized into 5 blocks.

The 1st block. Field measurements. The organization of basic observation stations near Lake Baykal, in Krasnoyarsk, Altai, Tomsk and Novosibirsk regions, and systematic measurements of atmospheric aerosol in these regions. Within the framework of this block complex expeditions to Siberian regions are assumed.

The 2nd block. Analytical. Here, the methods and equipment for sampling, measuring of size distribution, concentration, and chemical composition of aerosol particles are developed.

The 3rd block. Computer modeling. The development of algorithms and programmes to calculate the processes of aerosol formation, transformation, and transport, the interaction with vegetation, the surface of water or soil, the optimization of the characteristics of measuring equipment and observation system, the estimation of aerosol effect on atmospheric processes, the quality of environment and the health of people, the processing of experimental data.

The 4th block. Indoor studies. The laboratory studies of the elementary stages of aerosol formation, the characteristics of aerodisperse systems as well as the mechanism of the interaction between aerodisperse systems and biological objects and systems.

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The 5th block. Database. The arrangement of databases on the characteristics of atmospheric aerosols, their properties, and the methods for investigation of aerodisperse systems.

At present 16 institutes of Siberian Branch of the Russian Academy of Science (SB RAS), 5 institutes of Environmental Agency of Russia, 4 Russian universities and foreign scientists from the USA, Germany, Belgium, Austria, Sweden, and Hungary are involved into the project.

Under this project, the scientific potential and equipment belonging to the project participants is mainly used. The project is organizationally, logistically and financially supported by the SB RAS. From organizational point of view, SB RAS plays a big role in creation of various international centers and developed networks of sampling sites in different regions of Siberia.[53,54]

The project "Aerosols of Siberia" started in 1990 with the organization of joint workshops, visits of foreign scientists to the institutes of SB RAS, and joint measurements of atmospheric aerosols of Siberia near Lake Baykal and in Novosibirsk region.

THE FIRST RESULTS AND DEVELOPMENT OF THE PROJECT

The primary results on Siberian aerosols, obtained during measuring expeditions in 1990 and 1991 were discussed at the First International Workshop on the project "Aerosols of Siberia", which was carried out at Wien University in August 1991.[45] At this workshop the international validity of the project was declared and joint interests and research programmes for future were discussed. Based on these agreements, the complex expeditions near Lake Baykal and in Novosibirsk region were arranged in 1992. In Tomsk region the measurements of atmospheric aerosols were performed for many years at the Institute of Atmospheric Optics, SB RAS. In Altai, the studies of atmospheric aerosols were started in 1991 in connection with the investigation of impact of nuclear tests near Semipalatinsk. These studies are done by the Institute of Water and Ecological Problems, SB RAS, and Altai State University. Because of poor ecological situation in the city of Kemerovo, the studies of atmospheric aerosols are performed by the Institute of Coal, SB RAS.

In spring 1993 the Institute of Forest and the Institute of Chemical Kinetics and Combustion, SB RAS, prepared a project on aerosols, formed by forest fires in Siberia. In July 1993 in Krasnoyarsk region the first complex expedition for investigation of forest fires in Siberia was arranged. Samples of aerosol particles from forest fires were collected during this expedition. In summer 1993 regular observations of diurnal and seasonal variation in characteristics of aerosols in Novosibirsk region were started. In summer 1993 joint experiment of Central Aerological Observatory with German scientists using the IL–18 airborne laboratory was performed. In this experiments the spatiotemporal structure of atmospheric aerosols in Arctic and Novosibirsk region was studied.

In spring and fall 1993 the research expeditions over Lake Baykal were continued. The scientists from the USA, Belgium, and SB RAS participated in these expeditions.

In September 1993 in Novosibirsk the Second International Workshop was held on the project "Aerosols of Siberia". The specialists from Novosibirsk, Irkutsk, Kemerovo, Krasnoyarsk, Barnaul, Tomsk, Moscow, and also the USA, Germany, Belgium, Austria[55] participated in this workshop. The data obtained during the expeditions of 1990–1992 were summarized, and the programmes of studies for the year 1994 and further years were corrected.

Some of the papers concerning the questions, discussed at the workshop, are presented in this issue.

THE MAIN RESULTS OBTAINED UNDER THE PROJECT "AEROSOLS OF SIBERIA"

1. A complex of instrumentation for measuring of aerosol concentration and size distribution from a few nanometers to 100 μm particle diameter has been developed.[46]

2. The methods and equipment for ion and element analysis of aerosol particles of different size fractions and also method for determination of size distribution and multi–element composition of individual aerosol particles were developed.[47–52]

3. It was shown, that the size distribution for Siberian aerosol is three–modal, typical for remote continental aerosol. The parameters of each mode were determined and the nature of different modes was clarified. The smallest size fraction is formed due to photochemical gas–to–particle conversion. The residence time for this size fraction is only few hours. Therefore, the presence of small particles reflects processes of a local scale.[44–46] The largest aerosol particles are produced by soil erosion. This conclusion is supported by elemental composition of this size fraction. Under normal conditions the appearance of such particles is caused by processes of local and regional scales. The most stable size fraction is formed by the aerosol particles in the size range of 0.1–1 μm diameter. These particles are mainly produced by aging of the smallest aerosol particles, produced by photochemical gas–to–particle conversion and combustion of different types of fuels. This conclusion is drawn from the results of element analysis of aerosols of different size fractions.[47–52]

4. A semiempirical model was proposed to describe the diurnal evolution of aerosol number density. This model takes into account the rate of photochemical transformations and the diurnal evolution of thickness of boundary layer. This model describes well the results of field measurements.[46]

5. The method for solution to Smolukhovski's equations for calculating of aerosol formation kinetics under conditions of high supersaturation (photochemical aerosol formation, combustion) is developed.[56] A comparison of suggested model with the results of indoor experiments on photochemical aerosol formation in haloidbenzenes mixture was performed.[57] The results of computer simulations well agree with the results of experimental research.[57]

6. The algorithms and programmes for calculation of the concentration and deposition fields using different types of aerosol sources for local scale modeling were developed. The proposed methods may be used for optimizating the observation systems and pollution control.[58–60]

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