The new mobile carriage-laboratory for observations chemical composition of the atmosphere.

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Abstract. A new railroad laboratory intended for observations of the atmospheric chemical composition and environmental pollution is designed and equipped.

Design and goals

A new mobile laboratory was designed in Russia by the A.M.Oboukhov Institute of Atmospheric Physics and Russian Railroad Research Institute. The laboratory consists of two sections, each occupying one specialized railroad carriage. One of the sections is intended for continuous monitoring of the atmospheric parameters (Fig. 1) and the other is intended for chemical analyses of samples.

Figure 1.

Figure 2.

A jeep-laboratory equipped with a sampling system and instrumentation is parked in the latter carriage (Fig. 2). The laboratory, being coupled to a train, moves along electrified railroads of Russia and other countries. It allows accurate measurements of atmospheric aerosol and gas pollutants, solar radiation, meteorological parameters, and soil and water pollutants and meets the requirements imposed on instrumentation of the Global Atmospheric Watch. Principal aims of this laboratory are as follows: monitoring of the chemical composition of the atmosphere over the Eurasian continent, revealing of the anthropogenic and natural sources of pollutants, calibration of the ground-based networks and space instrumentation systems, and detection of natural and man-caused extreme events.

Observations

This laboratory is used to continue the TROICA (Transcontinental Observations Into the Chemistry of the Atmosphere) experiments.

Figure 3 Map of the TROICA expeditions

The recent TROICA-8 experiment performed from March 19 to April 1, 2004 was based on the new mobile laboratory.

The laboratory coupled at the head of a passenger train (immediately after an electric locomotive) passed a back-to-back route between Moscow and Khabarovsk. For thirteen days, it covered about 17000 km under winter conditions, when gas emissions caused by biological processes and forest fires were minimum.

This experiment was the first to provide information on atmospheric pollution of this latitude belt under typical winter conditions. It significantly supplemented the archive of data on the seasonal variations in the atmospheric composition measured in the course of the earlier TROICA experiments. For the convenience of users, a database containing the duty logs and the series of measured parameters, back trajectories, still frames of surrounding, and interface software was developed

The TROICA experiments gave unique information on the distribution of ozone and its precursors over the continent and on the nature and intensity of the processes of transport, photochemical formation, and dry deposition. It was revealed that, even in summer, the ozone concentrations in the atmosphere over Russian towns and in the atmospheric plumes propagating from them are usually lowered. Meanwhile, several regions characterized by intense ozone generation stimulated by high solar illumination and hot weather are identified. The ozone concentration in these regions is much higher than the background one (G.S.Golitsyn et al., 2002).

The variations in the surface ozone concentration are closely related to those in the concentrations of reactive gases, such as NOx, CO, SO_2, and NMHCs. The gas concentrations were continuously measured at 10-s intervals. The NMHC components were individualized through analyses of air samples. Their variability is closely related to the sources of pollutants and to the meteorological conditions. The NOx, CO, and NMHCs emissions caused by biomass burning on Russian or Chinese territories can be clearly identified.

Greenhouse gases CO_2 and CH_4 were analyzed continuously as well as on the basis of air samples (E.A.Oberlander et al., 2002). These analyses revealed large-scale peculiarities in the CO_2 and CH_4 spatial distributions. In particular, high methane concentrations were revealed in eastern Siberia. In the course of the TROICA-5 experiment (1999), the concentrations and isotopic compositions ($\delta^{13}C$, $\delta^{14}C$, δD, $\delta^{18}O$) of these gases were measured on board a river boat that traversed the West-Siberian plain from Novosibirsk 2000 km down the Ob' river. It was shown that, at the southern boundary of the plain, methane is predominantly of biogenic origin. However, as the boat approached regions of natural gas production, the portion of geogenic methane in the excessive CH_4 concentration over its background level increased steadily to more than 50%.

In TROICA-7 and -8 experiments, emissions of gases influencing the stratospheric ozone depletion were studied. The Airborne Chromatograph for Atmospheric Trace Species (ACATS-IV) of CMDL was used. The concentrations of CFC-12, halon-1211, N_2O, and SF_6 and the concentrations of CFC-11, CFC-113, $CHCl_3$, CH_3CCl_3, CCl_4, H_2, CH_4, and CO were measured at 70-s and 140-s intervals, respectively (D.F.Hurst et al., 2004).

Most of these compounds were measured over Siberia for the first time. Following the Montreal Protocol, Russia stopped production of chlorofluorocarbons. Meanwhile, in 1999, emissions of some of these substances were noticeable as a result of the occurrence of old refrigerators, air-conditioners, fire extinguishing agents, etc.

In vegetation growing in some regions of Russia, high concentrations of trichloroacetic acid were found. Its precursors, tetrachloroethene and methylchloroform, are ejected by pulp and paper enterprises. High concentrations of these substances were found in the region of Lake Baikal (L.Weissflog et al., 2003).

Rather comprehensive analyses of microphysical and chemical properties of aerosol in the atmospheric surface layer of size distribution in the range from 3 nm to 10 μm were performed. The natural radionuclids (Po-218, Pb-214, Bi-214, Rn-222) were measured as well.

The spectrophotometric data obtained in the course of the TROICA-8 experiment were used to retrieve the O_3 and NO_2 total contents and vertical profiles in the atmosphere. For sounding the NO_2 emissions from objects located at distances up to 5-7 km from the railroad, the Oriel spectrophotometer was used.

The atmospheric composition measurements were interpreted in combination with the data on the solar radiation (integral, UV-A, UV-B, $J(O_2)$) and on the meteorological parameters, such as the pressure, temperature, humidity, wind speed and direction, and temperature profile in the layer between 0 and 600 m.

Conclusions

The regular TROICA experiments will be continued. The next trip is planning around the center of Moscow and Moscow megapolis in October-November 2004.

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