TOR-STATION FOR MONITORING OF ATMOSPHERIC PARAMETERS

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The paper describes the TOR-station created for monitoring of atmospheric parameters including gas and aerosol air composition. Geographic characteristics of its location are given. Some of the results of the monitoring performed are presented.

The problem of research of climatic factors and their variability is of particular interest when studying the spatiotemporal dynamics of meteorological parameters, gas and aerosol components of air over extended period. The above-mentioned parameters mainly determine the radiation regime of the atmosphere. At the available network of stations for monitoring, the meteorological values are monitored according to the programs confirmed by the World Meteorological Organization.

The problem of monitoring of gases and aerosols has not yet been solved. On the one hand, for this purpose we have no mass inexpensive measuring instruments. On the other hand, educational institutions do not train workers in this field. As a result of which, in the field of atmospheric sciences the data on gases and aerosol do not occupy a proper place.

Since 1991 the Institute of Atmospheric Optics (SB RAS) has become a coexecutor of the project TOR (Tropospheric Ozone Research) of the programme EUROTRAC (European Experiment on the Transport and Transformation of Environmentally Relevant Trace Constituents in the Troposphere over Europe). The city of Tomsk has been chosen as a reference point for researchers from Europe due to its geographic position, especially the fact that Tomsk is located in the boreal forest zone.

The TOR-project research programme proposes to organize the stations for monitoring of ozone and ozone cycle components.

In 1993 the station for ozone monitoring has been constructed at the Institute of Atmospheric Optics. The station is located in the northeastern outskirts of the Tomsk Akademgorodok and, depending on wind direction, the measurements can be carried out both under background conditions and under conditions of the industrial center influence.

This paper describes the above-mentioned station and the results obtained during its work. This station are named as the TOR-Station.

1. TECHNICAL CHARACTERISTICS OF THE TOR–STATION

The station for measurement of the atmospheric aerosol characteristics, meteorological values and some gases has been put into operation at the end of December, 1992 and since that moment has been persistently operating. The schematic diagram of the station is shown in Fig. 1, the technical characteristics are given in Table I.

TABLE I.

Device	Parameter measured	Range	Error, %	Time constant, s
GIAM–15 gas analyzer	CO, mg/m^3	0.1...100	5	1
GIAM–15 gas analyzer	CO_2, ppm	1...1000	10	1
ozonometer 3–02 P	O_3, μg/m^3	1...1000	15	1
Aerosol counter AZ-5	$N(r)$ 12 channels	0...1000 0.2...5 μm	20	1
Meteorological system	t, s	–50...+50	0.1 s	1
	f, %	10...100	7	1 s...5 min
	d, deg	0...360	10	1
	V, m/s	0...40	10	1
Photoelectric nephelometer	a (0.55 μm)	0.001...1 km	7	1
Mercury gas analyzer	gamma background, μR/h	1...1000	30	1

As is seen from Fig. 1, the station consists of 7 measuring units. The information from the units through the crate-CAMAC comes to a DVK-3M computer, where the data are normalized and recorded to a magnetic data medium.

Since all the meters, being the part of the station, are contact, the control system is one of the units of the station intended for turning on the flow stimulators of the gas analyzer, aspiration devices of meteorological system, switching of measuring and calibration regimes of the devices. Switching on and off of the system occurs based on the corresponding computer command.

The work of the station is organized as follows. During 5 minutes before the measurement the control system brings into operation the flow stimulators and aspiration units of devices for scavenging the supply service lines. Then the calibration characteristics are taken. The measurement process after carrying out the above preparative operations continues during 10 minutes. At the same time, a reading of each parameter with 1 Hz frequency is taken. The final result, recorded by a computer, is obtained by averaging of 600 values and calculating the root-mean-square deviation on their basis for every measured value. This is necessary for

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control of serviceablility of primary converters (zero drift, bridge unbalance, and so on). The measured at the station characteristics, recording ranges and measurement errors are given in Table I. Except for those, several gases are investigated using the chromatographic technique, synoptic information is constantly received via radiochannels.

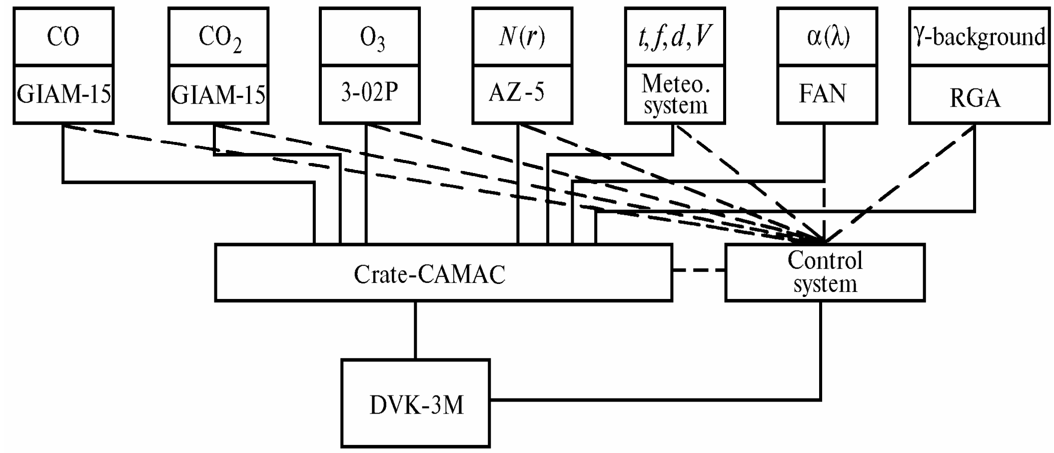

FIG. 1. Schematic diagram of station for atmospheric monitoring (TOR–station).

The measurement of the values enumerated in Table I is carried out every hour over day. The station operates in this mode since December, 1992 to the present day. Few errors occurred only because of unreliable work of DVK–3. However, because of deficiency of means it is impossible to change it in the near future.

The output data from the station are registered in the special database, which except for the measurement results includes also synoptic characteristic of observation periods using the technique previously developed by the authors.

2. GEOGRAPHIC POSITION OF THE STATION

The geographic position of the station for monitoring of atmospheric parameters is of great practical importance since it determines the representativity of the data obtained. The TOR project proposes the research into ozone both in the background and in the industrial regions. For example, the described below station *1* (Fig. 2) under several conditions is able to perform the both functions.

At the southwest northward wind the TOR–station is affected by the air passing through the Tomsk territory. It is evident that in this case the results of measurements are affected by the presence of motor transport exhausts and industrial emissions.

At the wind from northeast to south, the air comes to the TOR–station from the background regions made up of forests. At the same time, there are no any factories at the territory of settlements located in the above-mentioned sector.

The TOR-station is arranged in a building of the high-altitude lidar sensing station of the Institute of Atmospheric Optics (SB RAS) located at the northeastern periphery of Tomsk Akademgorodok as is seen in Fig. 2. There are no enterprises and highways adjacent to the station that excludes the presence of gas and aerosol local sources. There are some small forest areas of broad-leaved trees and conifers around the station, the ground is covered with grass.

The meteorological sensors of the station are located as follows. The temperature and humidity data units are mounted at the rod placed at 12 m distance from the building, at 15 m altitude from the Earth's surface. The data unit of wind velocity and direction is mounted at the 10 m hight meteorological mast at the building roof, so that it appears to be located higher than the trees surrounding the station. The air intake pipes for gas analyzers and aerosol devices are made of Teflon tube and are placed on the outside. The air intake is performed at 15 m altitude. Thus we consider that the station building does not affect largely the unit readings. Nowadays in the framework of State Scientific Technical Programme "Sibir'" the work is proceeding on organizing the climate-ecological monitoring of Siberia. The goal and the problem of this monitoring are in close agreement with the EUROTRAC Programme. Therefore, the TOR-station described here fit naturally into its system. However, this monitoring requires the preparation of a large number of such stations.

For this purpose the station analogous to the TOR-station should be organized at the scientific base of the Institute of Atmospheric Optics (SB RAS) on the river Ob' shore near the Kireevsk suburban estate. The arrangement of stations is shown in Fig. 3.

Taking into account the fact that in the atmosphere the west transfer of air masses predominates, it is believed that the station *1* on the river Ob' will be the background one with reference to the TOR-station (*2* in Fig. 3). Moreover, at several wind directions the air, passing through the station *1*, will arrive at the station *2*. In this case we can evaluate the degree of the Tomsk–city influence on the change of the gas and aerosol air composition.

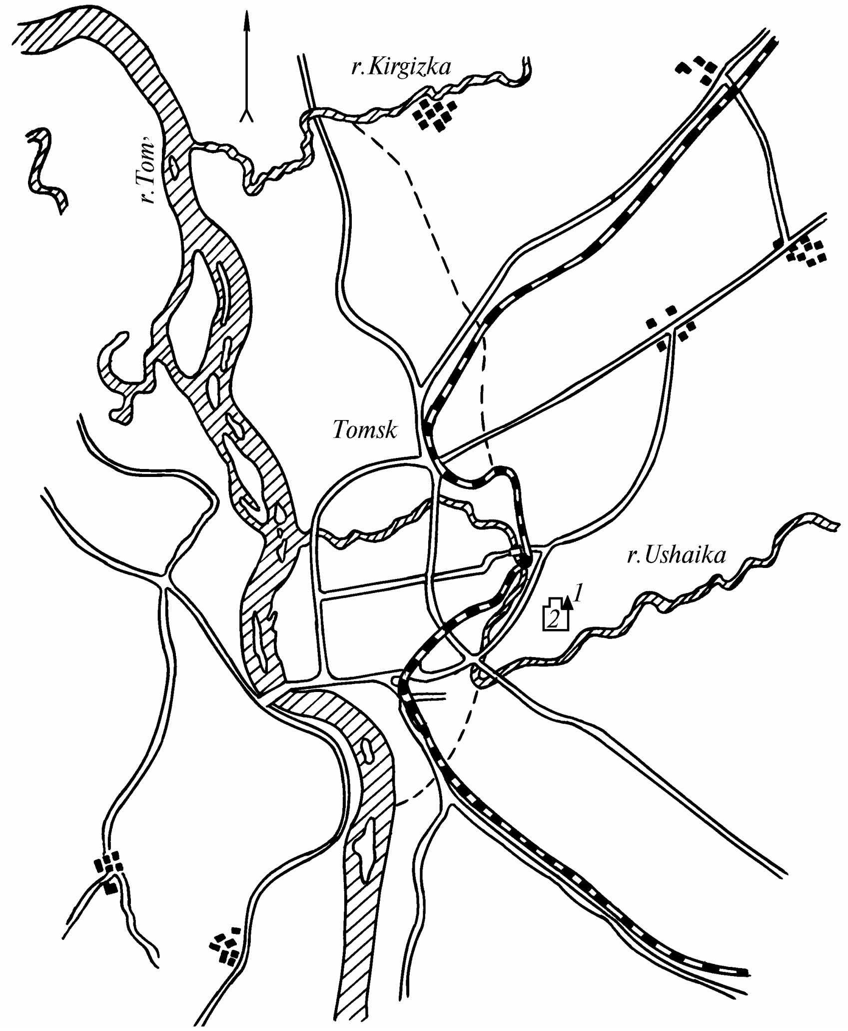

FIG. 2. Geographic location of the TOR–station: the TOR station (1), Akademgorodok (2), the dashed line denotes the boundary of urban areas.

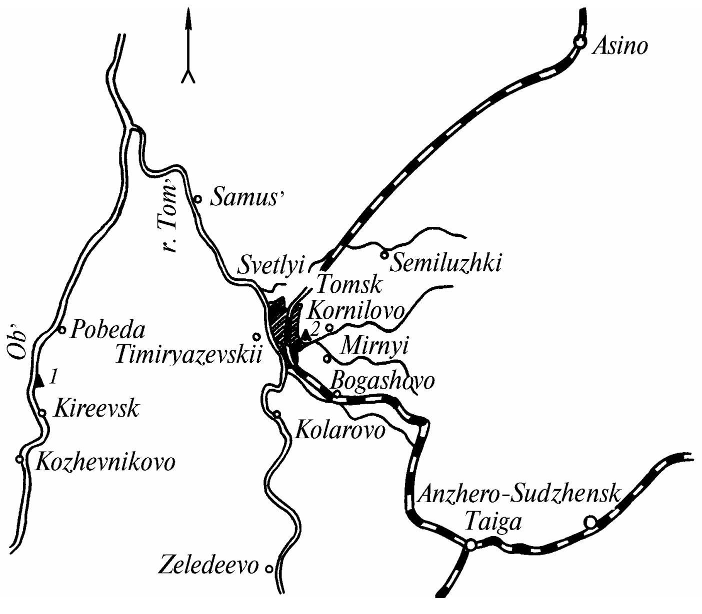

FIG. 3. The arrangement of stations for the climatic and ecological monitoring.

3. RESULTS OF THE MONITORING PERFORMED

By the time of preparation of this paper the data arrays for processing of the results over the whole period of measurements have not yet been formed in the database. Therefore the paper presents only the data obtained in the course of this station operation or the analysis of previous experiments. Figure 4 shows the time dynamics of variability of average daily concentrations of ozone, carbon monoxide and dioxide over a period from February 1 to May 15, 1993.

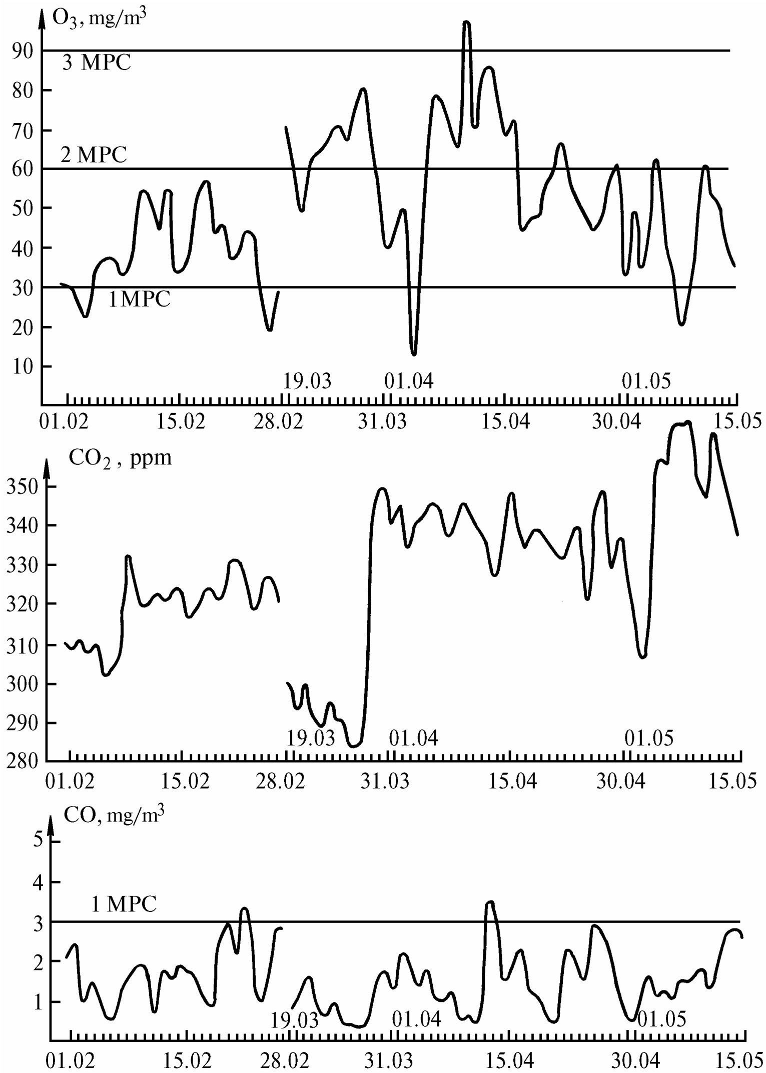

FIG. 4. Time behavior of the average daily gas concentration in Tomsk based on the TOR–station data.

As is seen from the figure, the concentrations of all gases are subjected to variations with periodicity typical for passing of synoptic objects. As it takes place their behaviors correlate weakly. It is well known that the gases indicated are the pollutants of the air, for the two of those the corresponding standards have been determined. In the upper and lower parts of Fig. 4 the horizontal lines denote the average daily maximum permissible concentrations (MPC) of ozone and carbon oxide determined by the state standards.

From the figure we notice that already in February the ozone concentration in the vicinity of the station exceed the MPC at regular intervals. In March and April this excess was 2 MPC and on separate days it was even 3 MPC. It should be noted that the measurements were carried out in the vicinity of Akademgorodok where there are no industrial emissions and intense streams of motor transport, which could provide formation of industrial photochemical smog. The latter confirms the time dependence of the carbon monoxide concentration (at the bottom of Fig. 4). As is seen from Fig. 4, the MPC for a period under study was exceeded only twice over a short period of time. The subsequent analysis of the material should reveal: Is a such time dependence the result of the influence of Tomsk industrial center on the measurement region, or this is the process of formation of natural photochemical smog due to the proximity of large forest area, which liberates the phytoncides being the basis of ozone generation.

Before creating the monitoring station at this place since September, 1989 continuous monitoring of the surface ozone concentration has been carrying out. When comparing the previous data with the results of measurements in 1993 (Fig. 5) the following peculiarities are revealed. Thus, if in the preceding years the ozone concentration varied by the classical principle, that is, it had one maximum in spring over a period from March till May, then in 1993 one can separate out the two distinct maxima in March and July. This is explained by the fact that the intense spring rise in temperature started in March and then it was changed by the continuous relatively cold period up to the middle of June.

As a result of such process there are two waves of phytoncide emission from the forests around the station.

The first wave of phytoncide emission from conifers was observed early in spring and the second wave was observed in the beginning of summer (broad-leaved forest).

In conclusion we dwell on one more aspect. Since in future the complex analysis of the material should be performed, then as the first approximation we consider the relation of variability of different physical characteristics of air during this year, represented by the correlation coefficients in Table II.

As is seen from Table II, the sufficiently large correlation couplings are observed between the variations of different meteorological values and gas concentrations. In most cases the correlation couplings vary during a year, sometimes even in sign, as, for example, between the air temperature and ozone, ozone and water vapor pressure.

This fact counts in favour of multiconditionality of the factors of each of them. It is evident that the character of couplings depends on the seasonal conditions. However, to draw final conclusions we should consider the data of measurements for several seasons. It seems likely that the role of circular processes is also important, judging from large correlation coefficients between wind velocity and another meteorological values and gases.

Table II does not include the data on carbon monoxide since any considerable correlation coefficients were not observed over the given period. The reason of such a carbon monoxide concentration behavior should be determined in future.

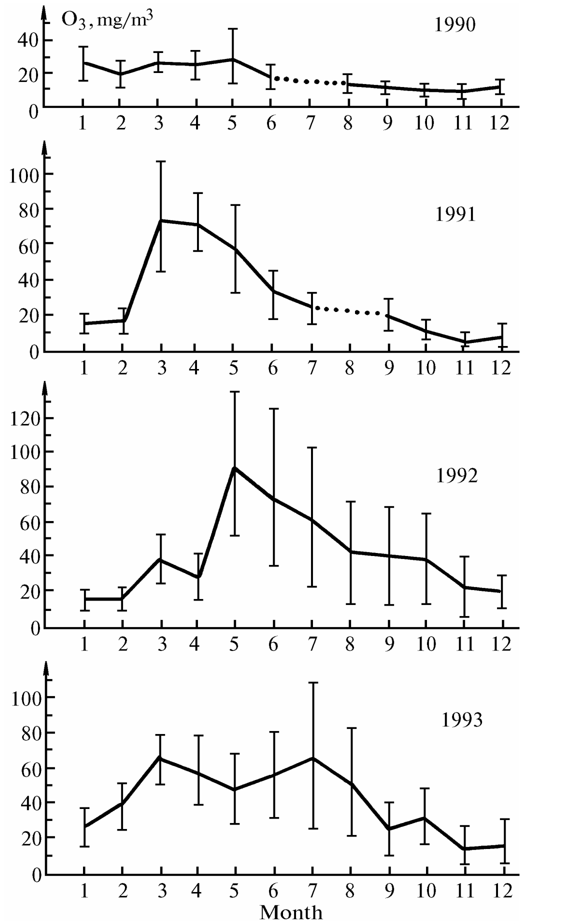

FIG. 5. Annual variation of ozone concentration in the air near the ground.

TABLE II. Correlation coefficients between different meteorological values.

Month	T, e	T, CO_2	T, O_3	CO_2, O_3	N, O_3	e, O_3	T, V	V, O_3	N, V	e, N
I	0.96	–0.60	0.84	–0.70	–0.66	0.83	0.49	0.48	–0.24	–0.09
II	0.91	–0.35	–0.08	0.01	–0.14	–0.15	0.48	0.06	–0.47	–0.20
III	0.56	–0.16	–0.60	0.08	0.46	–0.62	0.63	–0.68	–0.54	–0.25
IV	0.66	–0.12	0.56	0.17	0.10	0.28	–0.06	0.11	–0.07	0.14
V	0.48	–0.19	0.91	–0.19	0.16	0.55	0.00	0.01	–0.09	0.14
VI	0.38	–0.50	0.46	–0.37	–0.27	–0.18	0.43	0.34	–0.24	–0.05
VII	0.68	–	0.65	–0.07	–0.05	0.31	0.04	0.08	–0.19	0.50

Note: T is the air temperature, CO_2 is the carbon dioxide, O_3 is the ozone, N is the aerosol number density; e is the water vapor pressure, V is the wind velocity.

In conclusion it should be noted that the present paper describes only the first phase of the TOR-station project. In what follows we would like to enlarge the set of measured values at the station described. The measurements should be performed in two directions by means of inclusion direct and total solar radiation, radiation balance, to be measured with data units and also a diffusion battery. This will make it possible to extend the measured particle size range (up to 2 nm) and thus to study the processes of gas–aerosol transformation. The work is in progress on extension of operation of the station for chromatographic determination of ozone cycle gas concentration as well as gases of anthropogenic origin.