DATABASE ON THE RESULTS OF ECOLOGICAL SURVEY OF AIR BASINS

B.D. Belan, A.V. Ligotskii, O.Yu. Luk'yanov, M.K. Mikushev, I.N. Plokhikh, A.V. Podanev, and G.N. Tolmachev

Institute of Atmospheric Optics, Siberian Branch of the Russian Academy of Sciences, Tomsk
Received April 5, 1994

The paper presents a description of the database created on the basis of the results of complex survey of the state of air basin over some cities and territories. The database structure is presented, the regions are enumerated where the results were obtained.

As a result of long–standing irrational exploitation of natural resources, there is a very adverse situation in many regions, which calls for performing the well–justified measures for salvaging our environment. However, the information on the present–day state of the environment, in particular, on air quality, mainly is not of systematic and complex character. This hampers the choice and realization of optimal measures for the environmental protection. Therefore, one of the primary tasks is collection, accumulation, and generalization of the data on quality of the environment and its irreversible changes.

In 1981 at the Institute of Atmospheric Optics SB RAS an airborne laboratory was created intended for investigating the concentration and chemical composition of atmospheric aerosol in different regions of the former Soviet Union. In the course of exploitation the onboard measuring complex, the airborne laboratory was constantly modernized and supplemented by new instruments, and by now this measuring complex makes it possible to determine a wide range of gas and aerosol air characteristics. A detailed description of the onboard measuring complex is presented in Ref. 1.

Hereafter, because of worsening of ecological situation, the problem of fair assessment of the degree of urban pollution of atmospheric air is of great importance. And since the airborne laboratory operation corresponds completely to such problems in determinable parameters, in 1989 the first test survey of industrial centers of Russia and Kazakhstan was carried out, during which the technique of sounding was developed.

TABLE I. Parameters of the atmosphere determined with airborne laboratory.

Parameters		Substanses determined after the flight in the samples of air and aerosol
Measured directly	Calculated during the flight	
Height, m Pressure, mm Hg Humidity, % Temperature, °C Aerosol number density, cm^{-3} Aerosol size distribution function Scattering coefficient for an 45° angle, km^{-1} Code of procedure of BAS Direct signal of an external volume nephelometer Reference signal of external volume nephelometer Gamma background, μR/hr Flight course, degree Aircraft drift, degree Aircraft roll, degree Angle of pitch, degree Air speed, km/hr Actual speed, km/hr Overload, g Ozone concentration, $\mu g/m^3$ Carbon monoxide, ppm Carbon dioxide concentration, %	Structural characteristics of temperature fluctuations Wind velocity, m/s Wind direction, degrees Latitude, degrees Longitude, degrees	Gases: ammonia, acetylene, benzine, benzene, xylene, nitric oxide, nitric dioxide, carbon oxide, sulfur dioxide, hydrogen sulfide, toluene, chlorine, oil hydrocarbons, ethyl ether Aerosol: elements: Pb, Mg, Sn, Cr, Mn, Co, B, Zn, Ti, Ca, Si, Fe, Cu, V, Al, Ni, Cd, Ag, P, Mo, Br, W, In, Ba, Ga, Sb ions: Na^+, K^+, Cl^-, Br^-, NO_3^-, NH_4^+, SO_4^{2-}, Hg^{2+}, As^{5+}, Zn^{2+}, Cd^{2+}

By now the survey was made in more than 10 cities in different regions (Ust'–Kamenogorsk, Pavlogar, Nizhniy Tagil, Khabarivsk, Ulan Ude, Nizhnevartovsk, and so on) and territories of Kamchatka, Buryatiya, Pribaikal'e, Samotlor and Megion deposits. The technique of such surveys was completely developed.[2] The system "Gorod" for operative monitoring of air basin[3] is being developed and designed in a lot of industrial centers.

Beginning in 1991 a mobile station mounted in a GAS–66 motor van with advanced cross–country capability has been used for investigating the urban air basins in addition to the airborne laboratory. Its characteristics are analogous to those of the airborne measuring complex.[4]

0235-6880/94/08 585-06 $02.00

In the course of performance of such work a considerable amount of different–type information is accumulated, about 2–3 Mbyte for each city and 5–10 Mbyte for the territory, recorded in a specific format. Special–purpose databases[5,6] are developed, as a rule, to systematize the stored material and to provide operative access to the data. The present paper is devoted to the description of structure and composition of database developed on the base of the results of ecological survey of cities and territories. The structure of such a database is given in Fig. 1.

As is seen from Fig. 1, the data obtained as a result of ecological survey of the urban air basin are subdivided into four groups reasoning from the problems of subsequent processing.

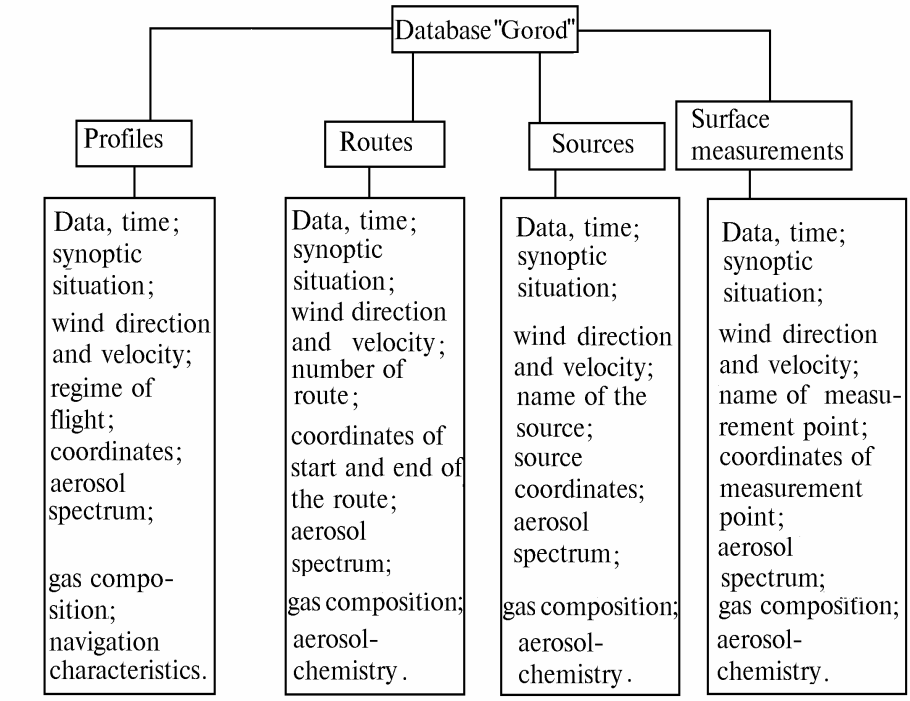

FIG. 1. Structure of database.

The first group "Profiles" represents the data obtained during the climb or descent of the airplane. Here the vertical distribution of concentration of aerosol particles, gases, and meteorological values as well as navigation characteristics are recorded. The measurements are carried out from the earth's surface (beginning of the airplane run) with the 100–m step up to maximum height of 6 to 8 km. An example of printout of the data on the altitude profile is given in Fig. 2. Here the height is given in hundreds of meters, and the other characteristics are given in absolute units.

The second group "Routes" presents the data obtained with the airborne laboratory along various routes at fixed heights. Here the spatial distribution of aerosol, gases, and meteorological values are recorded as well as sampling of air and aerosol is performed for subsequent ground–based analysis. The recording rate for average characteristics equals 1 Hz providing the space resolution of 80–100 m.

These data are used for construction of concentration fields and calculation of balances and gradients of pollutants over the city, as a whole. Figure 3 shows the record sample along the routes.

The third group "Sources" represents the data obtained from the measurements of the airborne laboratory, but, as opposed to the routes, the measurements are carried out in the plumes of emissions (stack cuts, large industrial centers, and so on). Table II presents the sample of data obtained. The data on synchronous measurements of the wind make it possible to calculate the volume of specific pollutants and their total mass.

And finally, the fourth group of data includes the results of ground–based measurements obtained with the use of the mobile station. In their structure they are analogous to the data of the third group. The data of ground–based measurements are used as reference ones for the first three groups.

The database "Gorod" has been realized using a computer IBM PC/AT under the control of an operation system MS DOS. A relational DBMS Fax Pro was used as an instrumental media for developing the database. The archive copy is stored on the magnetic–tape subsystem of "Strimmer" type.

Record No. 10542.263 *Airport: Irkutsk; Regime: landing; Date: September* 20, 1991; *Time:* 06:12.

Height, km	Aerosol	Particle size, μm												Radiation background, μR/h	T,°C	Humidity, %	T, °C	Pulsation T	P, mm Hg	O_3, μg/m³	CO, ppm	Heading, degree	Drift, degree	Roll, degree	Pitch, degree	V_{air}, km/hr	V DWM, km/hr	Overload	V_{wind}, m/s	Wind direction
		0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.5	2.0	4.0	7.0	10.0																	
0	1447	858	336	48	29	15	12	35	17	18	2	0	0	8	10.7	77	11.0	0	727	22	31	293	−1	0	0	139	170	0	8	107
0.1	1435	840	330	50	30	18	14	41	22	27	6	0	0	4	9.8	79	10.0	0	720	23	30	294	0	0	−3	208	206	0	2	294
0.2	1444	858	341	48	28	16	10	36	23	26	6	0	0	4	8.9	80	9.2	0	714	22	28	294	−1	0	−3	207	200	0	3	329
0.3	1440	855	340	55	27	16	12	36	20	25	5	0	0	12	8.3	80	8.6	0	706	22	27	294	1	0	−4	209	203	1	3	259
0.4	1436	851	333	58	28	17	11	36	23	26	4	0	0	12	7.3	80	8.1	0	699	22	26	292	0	0	−3	208	221	0	2	112
0.5	1524	896	360	67	37	20	13	37	16	14	1	0	0	8	6.5	78	8.0	0	692	22	25	290	−3	0	−3	204	202	1	4	341
0.6	1496	898	366	73	34	16	11	27	8	7	1	0	0	8	6.5	73	8.3	0	685	23	24	295	2	0	−3	199	203	1	2	235
0.7	1163	791	267	37	4	0	0	1	0	0	0	0	0	3	7.5	70	9.0	0	676	30	23	286	−4	0	0	210	209	0	5	339
0.8	1173	815	277	39	4	1	0	1	0	0	0	0	0	13	9.8	65	9.8	0	668	39	23	295	−1	0	−1	303	301	1	6	329
0.9	1198	814	279	50	12	2	1	4	2	2	0	0	0	12	9.5	64	9.4	0	660	36	23	294	−1	0	−1	310	305	1	7	327
1.0	1198	815	284	49	11	1	1	4	2	3	0	0	0	11	8.8	61	9.0	0	654	35	23	294	0	0	−1	310	313	1	5	294
1.1	1186	811	283	50	8	0	0	3	1	3	0	0	0	6	8.1	57	8.3	0	647	32	22	293	0	0	−1	308	310	1	6	293
1.2	1181	820	277	44	6	0	0	2	1	2	0	0	0	16	7.6	57	7.8	0	640	32	22	289	−1	0	−2	308	313	2	5	323
1.3	1140	796	266	37	3	0	0	3	1	1	0	0	0	13	7.4	57	7.5	0	633	30	21	291	0	0	−1	312	331	1	2	291
1.4	1128	794	264	31	3	0	0	2	1	3	0	0	0	14	6.8	59	7.0	0	629	29	20	291	0	0	−1	325	337	1	4	291
1.5	1120	794	251	38	5	0	0	2	1	4	0	0	0	12	6.1	60	6.4	0	618	29	20	289	0	0	−1	327	342	1	4	289
1.6	1116	788	255	34	3	0	0	1	2	1	0	0	0	12	5.5	62	6.0	0	614	29	19	289	0	0	−1	325	340	0	4	289
1.7	1141	793	261	41	5	0	0	3	3	4	0	0	0	8	5.0	62	5.4	0	606	30	19	293	0	0	0	319	345	1	2	293
1.8	1137	789	257	34	3	0	0	3	2	2	0	0	0	17	4.6	61	5.1	0	599	30	19	291	0	0	−1	318	342	1	3	291
1.9	1156	796	267	44	6	0	0	3	2	3	0	0	0	9	4.0	59	4.6	0	593	29	17	290	0	0	−1	318	340	1	4	290
2.0	1173	810	265	45	5	0	0	3	2	4	0	0	0	13	3.4	59	4.1	0	585	29	17	293	1	0	−1	318	342	1	4	256
2.1	1207	818	274	48	9	0	0	2	4	5	1	0	0	20	3.0	59	3.7	0	578	28	17	292	0	0	−1	319	342	1	5	292
2.2	1178	797	272	47	6	0	0	4	3	6	1	0	0	14	2.0	55	3.1	0	570	27	17	292	0	0	0	318	347	1	3	292

FIG. 2. An example of output listing on profiles data.

Record No. 10835.331 *Date: November,* 27, 1991; *Time:* 08:40; *Region: Tomsk. Coordinates: initial, finite; Longitude:* 85.09; 85.10; *latitude* 56.15; 56.18.

t, s	H, m	Aero-sol	Particle size, μm												Radiation backround, μR/hr	T, °C	Humi-dity, %	T, °C	Pulsa-tion T	P, mm Hg	O_3, μg/m³	CO, ppm	Hea-ding, degree	Drift, degree	Roll, degree	Pitch, degree	V_{air}, km/hr	V DWM. km/hr	Over-load	V_{wind} m/s	Wind direc-tion
			0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.5	2.0	4.0	7.0	10.0																	
1	170	158	61	35	11	16	6	6	10	7	6	0	0	0	3	−23.8	84	−22.7	0	723	27	14	228	−9	0	1	295	263	2	13	290
2	170	145	48	42	8	7	7	4	12	8	9	0	0	0	3	−23.8	84	−22.7	0	723	30	14	228	−10	0	1	295	263	11	14	292
3	165	127	60	22	10	4	5	6	8	10	2	0	0	0	3	−23.8	84	−22.7	0	723	29	14	228	−10	−4	1	298	260	27	15	286
4	170	122	41	35	12	8	5	2	9	4	4	1	1	0	4	−23.8	84	−22.7	0	723	28	15	228	−10	−8	2	295	260	0	14	289
5	170	157	62	32	12	14	6	10	8	7	3	1	2	0	4	−23.8	84	−22.7	0	723	28	15	228	−10	−12	1	295	260	2	14	289
6	170	120	50	25	7	11	2	5	9	2	8	1	0	0	0	−23.8	84	−22.7	0	723	30	16	228	−11	−12	1	304	260	4	17	283
7	170	161	55	38	9	16	14	7	7	10	5	0	0	0	4	−23.8	84	−22.7	0	723	30	15	228	−11	−14	2	304	260	11	17	283
8	170	137	48	35	14	6	8	5	3	8	9	0	1	0	3	−23.8	84	−22.7	0	723	28	14	228	−11	−14	1	304	260	2	17	283
9	170	248	96	68	20	18	16	8	6	7	8	0	1	0	9	−23.8	84	−22.7	0	723	30	14	228	−11	−15	1	298	260	27	16	288
10	170	141	43	39	15	11	8	4	9	7	4	1	0	0	1	−23.8	84	−22.7	0	723	26	14	228	−11	−15	1	298	260	2	16	288
11	170	175	58	42	12	14	7	7	10	10	12	2	1	0	0	−23.8	84	−22.7	0	723	27	15	225	−11	−12	1	298	260	6	16	285
12	195	100	41	22	5	4	7	9	6	2	3	1	0	0	4	−23.8	84	−22.7	0	723	31	14	225	−11	−7	1	298	260	1	16	285
13	204	134	49	42	8	10	7	2	6	6	3	0	1	0	1	−23.8	84	−22.7	0	723	29	14	222	−11	−3	1	298	263	27	16	284
14	204	145	54	43	6	8	5	7	9	7	4	2	0	0	4	−23.8	84	−22.7	0	723	32	14	222	−11	0	1	298	260	1	16	282
15	234	96	36	19	3	9	6	4	5	6	6	2	0	0	0	−23.8	84	−22.7	0	723	26	15	222	−11	4	1	303	260	0	17	278
16	234	151	63	35	12	5	8	3	10	6	9	0	0	0	1	−23.8	84	−22.7	0	723	29	15	222	−11	11	1	303	260	8	17	278
17	234	148	50	25	4	17	8	18	5	10	11	0	0	0	3	−23.8	84	−22.7	0	723	32	15	222	−11	14	1	303	270	27	16	287
18	234	145	48	35	13	9	11	8	4	9	4	4	0	0	4	−23.8	84	−22.7	0	723	26	15	222	−11	18	1	303	270	5	16	287
19	234	137	47	39	5	15	5	2	9	6	7	1	1	0	6	−23.8	84	−22.7	0	723	33	15	222	−11	19	0	303	270	9	14	287
20	234	172	54	40	10	17	14	10	12	7	6	2	0	0	3	−23.8	84	−22.7	0	723	27	15	222	−10	20	0	303	280	27	14	296
21	234	147	59	38	13	11	3	3	7	10	2	1	0	0	3	−23.8	84	−22.4	0	723	30	15	226	−10	19	0	308	280	2	14	295
22	234	140	60	35	6	8	4	8	8	3	8	0	0	0	6	−23.8	84	−22.4	0	723	29	14	229	−10	19	0	304	280	1	14	302

FIG. 3. An example of output listing on routes data.

TABLE II. Data containing in the third group "Sources".

Source	H, m	Plume width, m	V_{wind}, m/s	Ammonia	Acetylene	Acetone	Benzine	Benzene	Xylene	Ozone	NO	NO_2	CO	SO_2	H_2S	Toluene	Oil–CH	Cl_2	Ethyl alcohol
Lake Samotlor, plume of oil flame.	120	60	8	1.9	< 3.0	< 3.4	31.0	1.8	9.6	2.6	1.24	0.08	3.15	1.8	<0.01	< 0.1	32.0	<0.03	< 12
Lake Samotlor, plume of gas flame.	110	70	5	0.2	< 3.0	< 3.4	2.2	1.2	10.8	4.6	1.32	0.20	3.90	1.6	<0.01	< 0.1	14.6	<0.03	< 12
Khabarovsk heat and power plant	220	120	4	0.2	–	–	–	0.6	–	< 2	7.20	0.10	15.0	0.6	0.20	–	36.2	0.50	–

pH	Na^+	K^+	Cl^-	NH_4^+	SO_4^{2-}	Hg^{2+}	Zn^{2+}	Cd^{2+}	Fe	Mn	Mg	Pb	Cr	Ni	Al	Ti	Cu	V	Mo	Ca	Si	Ba	B
6.37	18.3	<	112.1	<	<	<	<	<	4.4	0.04	4.30	0.14	0.1	0.41	242.5	12.0	0.3	0.03	<	13.8	0.6	1.6	0.1
6.35	5.2	<	–	<	<	0.19	0.1	<	6.1	0.03	<	0.07	<	0.08	3.2	5.3	2.1	<	<	3.5	0.1	<	<
–	153.3	316.7	443.2	346.6	15.2	1.90	22.4	16.7	200	2.50	5.17	2.30	2.7	2.70	333.4	<	0.5	1.05	1.10	1017	1266	0.3	<

Aerosol	Size of particles, μm											
Sum	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.5	2.0	4.0	7.0	10.0
13217	6158	1820	828	646	588	529	1089	979	422	121	34	3
22038	8221	4322	1282	1116	1086	985	2240	1620	876	248	38	4
34112	9836	6374	3159	2832	2483	1978	3081	2847	1057	321	108	36

Note: Concentration of gas constituents (excepting ozone) are given in mg/m^3; *concentration of ozone, ions, and elements are in* $\mu g/m^3$. *Aerosol concentration is measured in* $1/dm^3$.

Most of the data, stored in the database, were obtained as a result of the flight measurements or processing of the samples. The directly measured data are recorded at once, the results of subsequent processing are recorded in the database by means of the console. The latter refers to the characteristic of synoptic situation (see Fig. 1).

To describe the synoptic situation, the authors use the classification developed in Ref. 7. Its application when filling the database is given in Ref. 6.

The described database, in addition the above–mentioned cities and regions, includes the data on the following points:

Alma Ata,	Dushanbe,	Odessa,
Amursk,	Kemerovo,	Petropavlovsk–Kamchatskiy,
Balkhash,	Kolpashevo,	Tomsk, and
Donetsk,	Komsomol'sk–na Amure,	the lake Balkhash

Later on the database should be verified using the models of impurity transfer and, *vice versa,* the calculation accuracy based on these models should be estimated.

ACKNOWLEDGMENTS

The work was performed under the sponsorship of the Special Fund for Financial Support of Young Gifted Scientists (Grant No. A6.02).

REFERENCES

1. V.E. Zuev, B.D. Belan, D.M. Kabanov et al., Atmos. Oceanic Opt. **5**, No. 10, 658–663 (1992).
2. B.D. Belan, *ibid*. **6**, No. 2, 124–135 (1993).
3. Yu.S.Balin, B.D. Belan, A.I. Nadeev, and M.V. Panchenko, *ibid*. **7**, No. 2, 86–92 (1994).
4. B.D. Belan, M.V. Panchenko, and N.P. Soldatkin, in: *Materials of the First School–Seminar "Ecology of Air Basin"*, Kol'tsovo, 1991, pp. 17–20.
5. L.A. Gerasimova, M.V. Panchenko, S.A. Terpugova et al., Atm. Opt. **3**, No. 7, 709–713 (1990.
6. B.D. Belan, O.Yu. Luk'yanov, M.K. Mikushev et al., Atmos. Oceanic Opt. **5**, No. 10, 695–706 (1992).
7. B.D. Belan, G.O. Zadde, and T.M. Rasskazchikova, in: *Forecast and Monitoring of Optical–Meteorological Conditions of the Atmosphere,* Tomsk, TA SB AS USSR, 1982, pp. 21–25.