AUTOMATED ARCHIVE OF DATA OF AIRBORNE SOUNDING OF THE ATMOSPHERE

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Structure and composition of the automated data archive is described based on the results of airborne sounding of the atmosphere which comprises data on the concentration and chemical and gaseous composition of the atmospheric aerosols over different regions. Towns are listed for which the data are available.

Since 1981 the systematic airborne measurements of concentration and chemical composition of the atmospheric aerosol have been performed practically over the entire territory of the former USSR at the Institute of Atmospheric Optics of the Siberian Branch of the Russian Academy of Sciences. Since 1988 the measurements of ozone and since 1990 the measurements of other gaseous constituents have been started. The instrumental complex[1] developed at the Institute made it possible to accumulate vast experimental material. However, due to periodic updating of the measuring complex, the airborne sounding data were recorded on different data media (magnetic tapes, magnetic discs, diskettes, and listings). In addition, since the experiments differed in their character, the information was recorded in different formats. Therefore, to make better use of the accumulated experimental material it was necessary to develop the unified form of data representation and to organize them so that to ensure the on–line data retrieval. This was one of the objectives in developing the automated data archive. The problem was solved as part of the integrated program SATOR and the developed archive provided the basis for optimal experimental design.

A number of "industrial" databases (DB) have been developed for mini– and microcomputers.[2–5] However, in our case the use of such a DB is difficult because the heterogeneous data representation substantially increases the number of null records.

Previously at the Institute of Atmospheric Optics (IAO) the work on systematization of airborne sounding data was performed based on the ideas used in developing the present archive. But this work covered only a part of the accumulated experimental data both in time and in the number of involved parameters.[6–7] The automated archive presented in this paper includes all the data of airborne experiments and is open for further enhancement and add–in.

The description of the structure and composition of the data in the archive is the purpose of this paper.

We start with the description of airborne measurements of the parameters.

The IL–14 (since 1981 till 1988) and AN–30 (since 1988 up to now) aircrafts were used for airborne sounding. It is natural that the airborne measuring complexes underwent permanent modernization. These complexes were described in detail in Refs. 8–12. Table I lists the parameters which were measured with the use of the last modification of the complex.[1] The parameters calculated directly in flight and determined with the use of the air samples under laboratory conditions are also included.

The procedure of airborne sounding is based on two flight regimes, that is, "profile" and "area". In the profile regime (gaining altitude or descending the aircraft) the vertical distribution of concentrations of the atmospheric aerosol, gases, meteorological parameters, and navigation characteristics were determined. The measurements were conducted from the Earth's surface (from the beginning of the aircraft take–off) up to the maximum flight altitude (8100 m) with 100 m spatial step.

Along the horizontal portions of the flight line, that is, in the area regime, the spatial distribution of aerosol, gases, meteorological parameters, and navigation characteristics were determined as well as air and aerosol sampling was performed. The mean characteristics were sampled with a frequency of 1 Hz, thereby ensuring 80–100 m spatial resolution, while fluctuations were sampled with a frequency of 10–100 Hz. The measurements in the area regime were performed within 100 – 8100 m altitude range.

The information obtained in flight was stored on the external memory of a microcomputer in the form of specially organized files. In addition to the experimental data, filing of the information about the experimental conditions was performed.

As has already been noted, measurements were performed over almost all regions of the former USSR in different years and various seasons. To illustrate the obtained data set, the information about the measuring regimes and time and region of flights was tabulated (see Table II).

It can be seen from Table II that the most part of measurements was performed over the Western Siberia. The measurements over the other regions were periodic. Below we list the towns and settlements, the information about which is available from the archive (see Table III).

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TABLE I. Atmospheric parameters measured from the aircraft–laboratoty.

Parameters measured directly		Parameters calculated in flight		Parameters determined after the flight termination with the use of air and aerosol samples
Name	Symbol	Name	Symbol	Name*
Altitude, m	*W*	Structure characteristics of		Gases: ammonia, acetylene,
Pressure, mm Hg	*PR*	the temperature fluctuations	*PUS*	gasoline, benzol, xylene,
Relative humidity, %	*WL*	Wind speed, m/s	*SV*	nitrogen oxide, nitrogen
Temperature, °C	*TE*	Wind direction, deg	*NV*	dioxide, carbon oxide,
Aerosol number density, cm^{-3}	*AS*	Latitude, deg	*SF*	sulphur dioxide, hydrogen
Aerosol particle size distribution function	$AS(i)$	Longitude, deg	*SL*	sulphide, toluene, chlorine,
Scattering coefficient at an angle of 45°, km^{-1}	$P(1)$			oil hydrocarbons, ethyl ether
Code of the PAN (Photoelectric Aerosol nephelometer) operation	$P(2)$			Aerosol elements: Pb, Mg,
Direct signal of the external nephelometer	G_1, G_2			Sn, Cr, Mn, Co, B, Zn, Ti,
Reference signal of the external nephelometer	G_3			Ca, Si, Fe, Cu, V, Al, Ni,
Gamma background, μR/h	*RD*			Cd, Ag, P, Mo, Br, W, In,
Flight direction, deg	*KU*			Ba, Ga, Sb
Aircraft drift, deg	*SN*			Ions: Na^+, K^+, Cl^-, Br^-,
Aircraft bank, deg	*KR*			NO_3^-, NH_4^+, SO^{2-}, Hg^{2+},
Pitch, deg	*TN*			As^{5+}, Zn^{2+}, Cd^{2+}
Relative speed, km/h	*SP*			
Absolute speed, km/h	*SD*			
Overload	*PG*			
Ozone concentration, $\mu g/m^3$	*OZ*			
Carbon oxide concentration, ppm	CO			
Carbon dioxide concentration, %	CO_2			

*Name corresponds to the symbol

It is obvious from the list of towns and settlements that airborne sounding encompasses practically all geographical zones of the territory of the former USSR. The towns, the information about which is available, may be under not only clear (background) atmospheric conditions but also under severely polluted ones. In the latter case a separate archive has been created.

All data in the developed archive have been clustered in the regime of operation and time of experiment and stored on the external memory of a microcomputer in the form of separate files. These data files represent two–dimensional digital arrays containing the time series of numerical values corresponding to every measured parameter for the area regime and the time series of numerical values with altitude quantization for the profile regime.

Data on the chemical composition of aerosol and gases represent one-dimensional arrays of concentration of the measurable parameters spatially averaged and related to a geographical site.

Information about the address of the data files (the serial number of a magnetic tape) is catalogued. In addition to the file name the key information about the date, time, area, and region of flight; the formalized description of meteorological conditions; and, the list of the parameters recorded in a given experiment are catalogued.

The parameters used for a formalized description of meteorological conditions during the experiment are tabulated in Table IV.

In fact the table of the archive is formed by several databases set in the standard of the RTK MICRO technological complex and linked by the program ARCHIV. This program makes a query in the interactive mode, performs the data retrieval, and then prints the data in the form convenient for the user. Any parameter entering into the catalogue may be used as a criterion (or criteria) for data retrieval.

Archive copies of the data files are stored on the magnetic tapes. Operating archive catalogue is stored on the SM 5400 magnetic disk.

The list of the recorded parameters must be catalogued due to the fact that depending on the purposes of experiment and the permanent modification of measuring complex the set of the recorded parameters changes considerably (see Table II). In fact this problem was solved in such a way: every data file was associated with the so–called file format which comprises the parameters being recorded in the experiment. Application of the file format made it possible to eliminate the null records from the archive. A general idea of the hierarchy of the format files can be understood from the list of notation in Table II. The structure of the archive is shown in Fig. 1.

TABLE II. Classification of the airborne data set

Year	Western Siberia	Eastern Siberia	European part of the USSR	Kazakhstan	Ural	Kamchatka	Chukotka	Far East	Uzbekistan	Turkmenistan	Tajikistan	Number of che-mical composi-tion samples	Total flight time in hours
1981	*P*1, *C*	*P*1, *C*	–	*P*1,*C*	–	–	–	–	–	*P*1, *C*	–	108	130
1983	*P*1, *C*, *X*1	*P*1, *C*, *X*1	–	*P*1, *C*, *X*1	–	–	–	–	–	–	–	136	190
1984	*P*1, *C*, *X*1, *A*1	*P*1, *C*, *X*1	*P*1, *C*, *X*1	*P*1, *C*, *X*1, *A*1, *P*2	*P*1, *C*, *X*1	–	–	–	*P*1, *C*, *X*1	–	–	121	420
1985	*P*1, *C*, *X*1, *A*1	*P*1, *C*, *X*1	*P*1, *C*, *X*1	*P*1, *C*, *X*1	*P*1, *C*, *X*1	–	–	–	–	–	–	508	860
1986	*P*2, *X*1, *A*1	*P*2, *X*1, *A*1	*P*2, *X*1, *A*1	*P*2, *X*1	*P*2, *X*1	–	–	*P*2, *X*1, *A*1	–	–	–	470	1160
1987	*P*1, *C*, *X*1	*P*1, *C*, *X*1	*P*1, *C*, *X*1	*P*1, *C*, *X*1	*P*1,*C*, *X*1	–	–	–	–	–	–	670	1020
1988 a	*P*1, *A*2/1, *P*3/1, *C*, *X*2	–	*P*3/1, *A*2/1, *X*2	–	*P*3/1, *A*2/1, *X*2	–	–	–	–	–	–	49	320
1988 b	*P*1, *A*2/2, *P*3/2,*C*, *X*2	*P*3/2, *A*2/2, *X*2	*P*3/2, *A*2/2, *X*2	*P*3/2, *A*2/2, *X*2	–	–	–	–	*P*3/2, *A*2/2, *X*2	*P*3/2, *A*2/2, *X*2	–	249	520
1989	*P*3/3, *X*2, *A*2/2	*P*3/2, *X*2, *A*2/2	*P*3/2, *A*2/2, *X*2	*P*3/2, *A*2/2, *X*2	*P*3/2, *A*2/2, *X*2	*P*3/2, *A*2/2, *X*2	–	*P*3/2, *A*2/2, *X*2	*P*3/2, *A*2/2, *X*2	*P*3/2, *A*2/2, *X*2	*P*3/2, *A*2/2, *X*2	563	420
1990	*P*4, *A*3, *X*4	*P*4, *A*3, *X*4	*P*4, *A*3, *X*4	*P*4, *A*3, *X*4	*P*4, *A*3, *X*4	–	*P*4, *A*3, *X*4	*P*4, *A*3, *X*4, *G*	–	–	–	244	320
1991	*P*4, *A*3, *X*4, *G*	*P*4, *A*3, *X*4, *G*	–	–	*P*4, *A*3, *X*4, *G*	–		*P*4, *A*3, *X*4, *G*	–	–	–	356	145

Note: *P*1 refers to the profiles of the parameters *W*, *WL*, *TE*, and *AS*;
*P*2 stands for *P*1 +*G*1,*G*2, and *PUS*; *P*3/1 is for *P*1 + *AS* (0.4–10 μm), *P*(1), *P*(2), *PG*, and *SP*;
*P*3/2 is for *P*3/1 + *KU*, *SN*, *SD*, and *PUS*;
*P*4 is for *P*3/2 + *SV*, *NV*, *KR*, *TN*, *OZ*, *CO*, *and* CO_2;
*X*1 refers to the chemical composition of aerosol including the following chemical elements and ions: Al, Ca, Si, Fe, Ni, Mg, Mn, Sn, Pb, Ag, B, Cr, Ti, Na, K, Cu, Cl, SO_4^{2-}, NH_4^+, NO_3^-
*X*2 is for *X*1 + Br, P, and Zn;
*X*3 is for *X*2 + Cd, Co, V, Mo, Ba, and W;
*X*4 is for *X*3 + F, Hg, As, In, and Be;
C is for the aerosol particle size distribution (0.4–10 μm) + *W*, *WL*, and *TE*;
*A*1 is for the area regime *W*, *WL*, *TE*, *PUS*, *AS*, G_1, G_2, and G_3;
*A*2/1 stands for *W*, *WL*, *TE*, *PUS*, *AS* (0.4–10 μm), *P*(1), *P*(2), *SP*, and *PR*;
*A*2/2 is for *A*2/1 + *KU*, *SN*, *SD*, and *PUS*;
*A*3 is for *A*2/2 + *SV*, *NV*, *KP*,*TN*, *OZ*, CO, and CO_2;
G denotes gases.

TABLE III.

1. Aktubisnk
2. Alma–Ata
3. Amursk
4. Arkhangel'sk
5. Astrakhan'
6. Ashkhabad
7. Ayaguz
8. Baku
9. Balkhash
10. Barabinsk
11. Barnaul
12. Biisk
13. Bishkek
14. Blagoveshchensk
15. Bratsk
16. Bugul'ma
17. Vilnius
18. Vitebsk
19. Volgograd
20. Voronezh
21. Gomel'
22. Gur'ev
23. Dzhambul
24. Dikson
25. Dnepropetrovsk
26. Donetsk
27. Dushanbe
28. Ekaterinburg
29. Eniseisk
30. Zyryanka
31. Igarka
32. Izhevsk
33. Irkutsk
34. Karaganda
35. Kargasok
36. Kemerovo
37. Kzyl–Orda
38. Kiev
39. Kirensk
40. Kishinev
41. Kolpashevo
42. Komsomol'sk na Amure
43. Krasnovodsk
44. Krasnoyarsk
45. Krivoi Rog
46. Kurgan
47. Kurgan–Tyube
48. Kustanai
49. Lipetsk
50. Magadan
51. Magnitogorsk
52. Minsk
53. Mirnyi
54. Moscow
55. Muinak
56. Murmansk
57. Nizhnevartovsk
58. Nizhnii Novgorod
59. Nizhnii Tagil
60. Nikolaev
61. Nikolaevsk na Amure
62. Novgorod
63. Novokuznetsk
64. Novosibirsk
65. Nukus
66. Nyurba
67. Odessa
68. Omsk
69. Orenburg
70. Ossora
71. Osh
72. Okha
73. Pavlodar
74. Pevek
75. Penza
76. Perm'
77. Petropavlovsk
78. Petropavlovsk–Kamchatskii
79. Riga
80. Samara
81. St. Petersburg
82. Saratov
83. Semipalatinsk
84. Simferopol'
85. Sobolevo
86. Sovgavan'
87. Strezhevoi
88. Syktyvkar
89. Tambov
90. Tashkent
91. Termez
92. Tiksi
93. Tobol'sk
94. Tomsk
95. Tynda
96. Ulan–Ude
97. Ural'sk
98. Urgench
99. Ust'–Ilimsk
100. Ust'–Kamenogorsk
101. Ufa
102. Ush–Tyube
103. Khabarovsk
104. Khar'kov
105. Kherson
106. Khodzhent
107. Tsimlyansk
108. Chardara
109. Chardzhou
110. Chelyabinsk
111. Chimkent
112. Chita
113. Chokurdakh
114. Shevchenko
115. Ėkibastuz
116. Yuzhno–Sakhalinsk
117. Yakutsk

TABLE IV. The list of the parameters used for a formalized description of meteorological conditions.

Baric field type	Air mass type	Season	Atmospheric phenomena
Cyclone	Arctic	Winter	Haze
Anticyclone	Mid–latitude	Spring	Fog
Zone of small gradient	Subtropical	Summer	Smoke
Contrast zone		Fall	Drifting dust
Ridge			Rain
Trough			Snow
Baric field subtype	**Air mass subtype**	**Cloud cover index**	**Time of a day**
North–East*	Marine	0–10	Morning
North–West*	Continental		Day
South–East*	Old		Evening
South–West*			Night
Axis			
Front			
Rear			
High preassure			
Low preassure			

*Note: The sector of baric field formation is implied.[13]

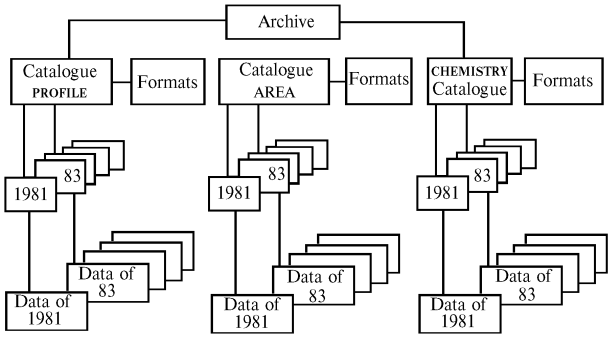

FIG. 1. The automated archive structure.

The work on the storage of the archive in IBM PC is now underway. In the new version the streaming magnetic tape is used as a physical data medium, while the archive catalogue is set in the medium of the relational database management system FOX PRO. In future we plan to attach the program package for the statistical computations and two– and three–dimensional graphics to the archive.

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