Bank of meteorological and aerological data for solution of applied problems

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We present the bank of meteorological and aerological data, compiled at the Institute of Atmospheric Optics. The databank is intended for systematization and storage of results of many-year measurement data on the surface values and profiles (up to 300 hPa level) of pressure (or geopotential), temperature, dew point, and wind at a particular mesometeorological polygon.

As known, meteorological and aerological data on limited areas are necessary in constructing local climate and atmospheric models. Such models are very important for increasing the effectiveness of remote sensing optical systems and solving atmospheric optics problems as well as for studying and evaluation of reliability of the spatiotemporal prediction of mesoscale meteorological fields.

Therefore, there emerged an urgent need for backup and systematization of the initial meteorological and aerological data obtained for specified mesoscale areas with horizontal dimensions up to hundreds kilometers and top boundary height of 8–10 km (hereinafter referred to as mesometeorological polygon[1]).

Solution of this problem evidently requires organization of storage and processing of all the many-year environmental data collected at stations of a particular mesometeorological polygon.

Within the framework of the above problem, methodology of creating the database (DB) of meteorological and aerological information was developed at the Institute of Atmospheric Optics. Such a database is a part of a bank of long-term measurement data on the surface values of meteorological quantities as well as on their vertical profiles. It is intended for systematization and effective organization of data storage, data search and retrieval (by user's request), as well as for filing measurement data in a required format, well-formed and easy-to-use for solving different scientific and applied problems.

Remind that a databank is one of the state-of-the-art information system types, which includes computer system, database management system (DBMS), one or more databases, and a set of application programs (DBn applications).[2]

In this paper we describe the structure, configuration, and main functions of a meteorological and aerological DBn containing a set of vertical profiles of wind, thermodynamic parameters, and characteristics measured at a number of synoptic stations and radiosondes, which make up a typical mesometeorological polygon centered near Moscow.

Decoded and processed KN-04 standard bulletins were used as input data for the meteorological and aerological DB containing coded data on temperature and wind. The decoding and processing were performed with the automated meteorological system (AMS) described in Ref. 3. Also the KN-01 bulletins were used for the above database; these bulletins contain data on surface values of the meteorological quantities, they were transformed to a required type using the specific software package of the AMS software.

Meteorological and aerological data files used in the DB include many-year 8-term (0, 3, 6, 9, 12, 15, 18, 21 h GMT) meteorological and 2-term (0 and 12 h GMT) radiosonde data (since 2000 until 2004) on pressure (P, hPa) or geopotential (H, gpm), temperature (T, °C), dew point (T_{d}, °C) as well as zonal (U, m/s) and meridional (V, m/s) wind components. In addition, all radiosonde data are reduced to two systems of altitude coordinates, i.e., a system of isobaric levels with ground data and data for constant-pressure surfaces of 975, 950, 925, 900, 875, 850, 825, 800, 700, 600, 500, 400, and 300 hPa and a system with physical heights: 0, 0.2, 0.4, 0.8, 1.2, 1.6, 2.0, 2.4, 3.0, 4.0, 5.0, 6.0, and 8.0 km.

In recent years, radiosonde measurements of the atmospheric parameters have not been performed in full measure because of poor funding of Hydrometeorological Service; only some of aerological stations carried out launches of radiosondes at two principal synoptic hours (00 and 12 h GMT) while many other aerological stations performed single measurements (either at 00 or at 12 h GMT).

Now consider a structure and main functions of meteorological and aerological DB using Fig. 1, which shows the DB block-diagram. Let us emphasize, that first two blocks ("Input data" and "Data origin") are parts of the AMS software and were described in Ref. 3. For these reasons, the AMS is the integral part of the presented databank. In addition, only mention the KN-04 and KN-01 bulletins with sounding data on atmospheric temperature and wind profiles and on surface values of the meteorological

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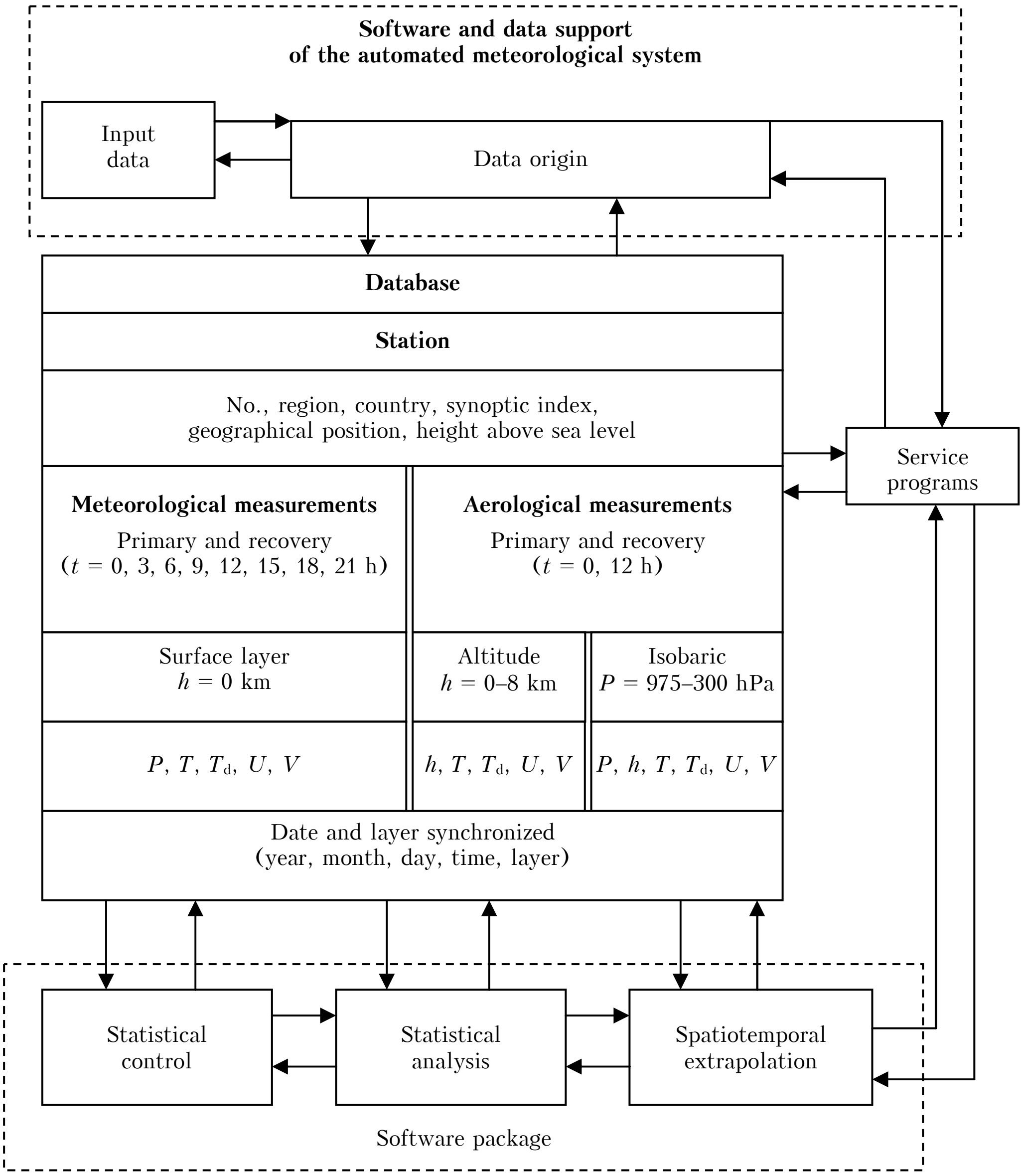


Fig. 1. Block-diagram of meteorological and aerological databank.

quantities as input data. At the same time, the block of data origin provides for decoding the bulletins, interpolation of meteorological parameters (over a particular constant-pressure surface), checking the bulletins' coding by a station operator, and for synchronization of the measurements (year, month, day, time) at the stations.

Meteorological and aerological database is one of the basic functional blocks of the block-diagram (Fig. 1) and consists of three main files: "Station," "Meteorological measurements," and "Aerological measurements." "Station" file includes the data on the region number and region name (e.g., Europe, Asia, etc.), country (France, Austria, Russia, etc.), and its code, synoptic index, and name of a station, its geographical position (latitude and longitude), and the height above sea level. Station retrieval is carried out by user's request.

"Meteorological measurements" file contains arrays of meteorological data from stations of a particular mesometeorological polygon (in our case, it is the polygon centered near Moscow) synchronized by years, months, days, and hours. This file includes both primary and reconstructed meteorological parameters (pressure, temperature, dew point, zonal and meridional wind components) at the ground level. "Station" database is realized using Delphi visual programming system (Version 6).

"Aerological measurements" file includes aerological data, i.e., data collected with radiosondes from the aerological stations of the same mesometeorological polygon, synchronized by years, months, days, and hours. There are both primary and reconstructed meteorological parameters (pressure or geopotential, temperature, dew point, zonal and meridional wind components) at the ground level and constant-pressure surfaces or physical heights (they are listed above). DBMS Access controls "Meteorological measurements" and "Aerological measurements" databases.

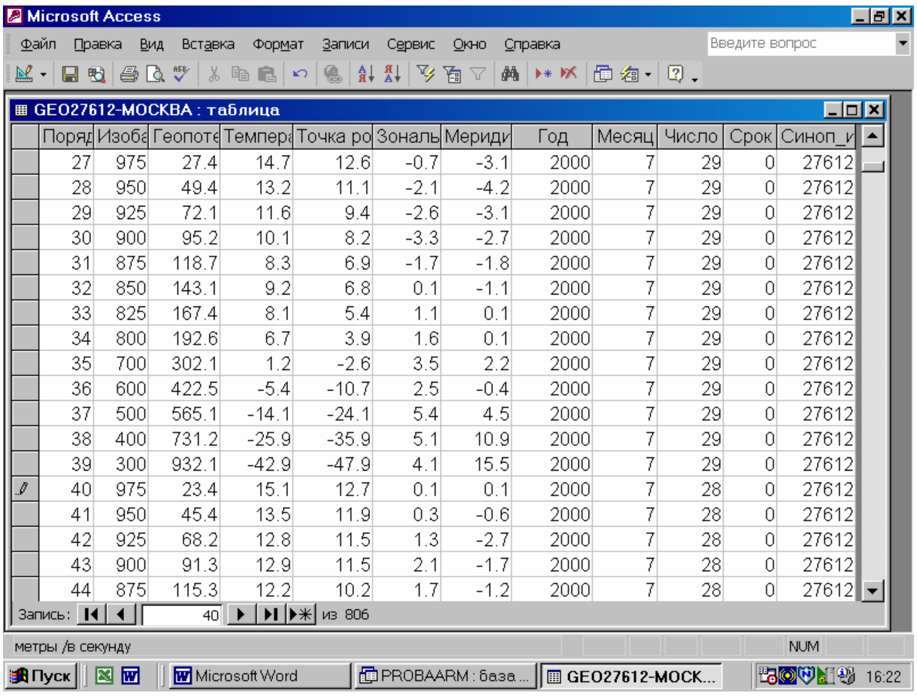
Besides the meteorological and aerological databases, the databank includes a software package composed of three blocks: block of statistical control of meteorological data, statistical analysis, and block of spatiotemporal extrapolation. The last block in the DBn is the block of service programs.

Statistical control block monitors abnormal values of meteorological parameters. To validate the input data, the difference between values under control and normal (simple mean) ones is used, as agreed in meteorology,[4] and then modulo-$N\sigma$ compared, where σ is the variance of the meteorological parameter; $N = 3$, as is commonly assumed in the "classical" theory of testing hypothesis. Such N allowed us to reveal errors introduced when acquiring and transmitting meteorological and aerological data to the database.

Statistical analysis block allows computation of vertical profile statistics of a specified meteorological parameter, in particular, ordinary moments, central moments of 2nd, 3rd, and 4th orders, kurtosis, and skewness. This block is used to estimate the distribution of the meteorological parameter frequency of occurrence, its normality, compute normalized autocorrelation (cross-correlation) functions as well as to approximate calculated correlation functions aimed at the following building of an analytical model of meteorological parameter variation. All the calculations are performed using files of primary data for any meteorological parameter (geopotential, temperature, dew point, zonal and meridional wind components) at any height level or constant-pressure surface.

Spatiotemporal extrapolation block includes algorithms for computing meteorological parameters at a specified point within a chosen polygon at specified time. Such algorithms are: optimal interpolation (extrapolation), modified method of clustering of arguments, dynamic stochastic method, polynomial approximation method, and mixed regression stochastic method; the algorithms are described in Ref. 5. The block can be supplemented with newly developed methods. Choice of an algorithm depends on statistical analysis results, i.e., accepted hypothesis on normality of a parameter distribution over the frequency of occurrence. Within the framework of spatiotemporal prediction of meteorological parameters, one may speak about creation of researching workstation (WKS) for debugging and handling of new algorithms and methods.

Block of service programs includes software for data-flow control. As a management system, the DBMS Access with its language tools was chosen; it permits data loading, storage, access, visualization, and data retrieval on request with results filing in a required format. Display of an example of test aerological data from the DB is shown in Fig. 2. Here, the vertical profiles of geopotential, temperature, dew point, zonal and meridional wind components, obtained via temperature and wind sounding near Moscow (Dolgoprudnaya Station, synoptic index 27612) in July 2000, are given in isobaric coordinates.



Поряд	Изоба	Геопоте	Темпера	Точка ро	Зональ	Мериди	Год	Месяц	Число	Срок	Синоп_и
27	975	27.4	14.7	12.6	-0.7	-3.1	2000	7	29	0	27612
28	950	49.4	13.2	11.1	-2.1	-4.2	2000	7	29	0	27612
29	925	72.1	11.6	9.4	-2.6	-3.1	2000	7	29	0	27612
30	900	95.2	10.1	8.2	-3.3	-2.7	2000	7	29	0	27612
31	875	118.7	8.3	6.9	-1.7	-1.8	2000	7	29	0	27612
32	850	143.1	9.2	6.8	0.1	-1.1	2000	7	29	0	27612
33	825	167.4	8.1	5.4	1.1	0.1	2000	7	29	0	27612
34	800	192.6	6.7	3.9	1.6	0.1	2000	7	29	0	27612
35	700	302.1	1.2	-2.6	3.5	2.2	2000	7	29	0	27612
36	600	422.5	-5.4	-10.7	2.5	-0.4	2000	7	29	0	27612
37	500	565.1	-14.1	-24.1	5.4	4.5	2000	7	29	0	27612
38	400	731.2	-25.9	-35.9	5.1	10.9	2000	7	29	0	27612
39	300	932.1	-42.9	-47.9	4.1	15.5	2000	7	29	0	27612
40	975	23.4	15.1	12.7	0.1	0.1	2000	7	28	0	27612
41	950	45.4	13.5	11.9	0.3	-0.6	2000	7	28	0	27612
42	925	68.2	12.8	11.5	1.3	-2.7	2000	7	28	0	27612
43	900	91.3	12.9	11.5	2.1	-1.7	2000	7	28	0	27612
44	875	115.3	12.2	10.2	1.7	-1.2	2000	7	28	0	27612

Fig. 2. Display of an example of test aerological data stored in the DB.

In conclusion, it is necessary to note, that the automated meteorological system together with a large bulk of input KN-01 and KN-04 bulletins, containing meteorological and aerological data, allow the development of a database for any mesometeorological polygon in Russia to be performed using the technique developed. Besides, it is worthy to emphasize, that the described information system is a milestone and provides more precise software choice in future as well as the development of a flexible storage system of primary meteorological and aerological data from other mesometeorological polygons.

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