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OF HYDROMETEOROLOGICAL INFORMATION

by

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SOME PROBLEMS IN AUTOMATIC PROCESSING
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Ye. M. Dobryshman

Actual Problems of Automatic Processing of Incoming Hydrometeorological Data

Meteorological reliability in the various areas of human endeavor requires increasing information concerning the state of the atmosphere and the hydrosphere. New methods being developed for observation and study of atmospheric processes and the great potential of computer technology have paved the way for radical reorganization of the entire system of collecting, processing, and distributing hydrometeorological information.

Our primary means of studying the state of the atmosphere is the network of observation stations. This network, which encompasses a significant portion of the earth's surface, is arranged in a very uneven pattern. In order to carefully analyze the actual state of the atmosphere — as of any physical system — it is necessary to collect information from most of the earth's surface over very short intervals. This places a particularly heavy burden on the communication system between the points of observation and on central collection, processing, and distribution of the information.

Until quite recently a great percentage of this incoming information was processed manually. It was only in isolated instances – usually in connection with the results of a radiosonde – that the data is advanced directly to the computer and subjected to primary processing. The ever increasing volume of incoming information, the constantly decreasing rate at which it is processed (as a result of operational demands), the adoption of new methods and observation techniques, such as the unmanned and semiautomatic stations – rockets and satellites – all these factors have created a need for a single system for complex automation of the hydrometeorological service. This complex and many-faceted problem can to a certain degree be represented conditionally in terms of its four nodal parts.

1) technical equipping of observation network;

2) communication throughout the entire system of observing, collecting, processing, and distributing the hydrometeorological information;

3) technical equipping of processing centers – essentially this means a computer pool with a special complex of external units;

4) algorithms for processing information in a common chain, the first link of which is the observation point, the second – finished production output on demand and accumulation of it for modal processing.

Each of these tightly interwoven parts consists in turn of a large number of problems which do not have a one-time solution. As science and technology continue to advance the individual links will change, be brought up to date, or in some cases be entirely eliminated or replaced. In this article we have made an attempt to give some idea of one of the important segments of the fourth unit, namely, the characteristics of the information flow and general principles of constructing algorithms for primary processing of the different types of hydrometeorological information operationally advanced to the large processing centers.

Hydrometeorological information has an extremely wide range of structural characteristics. which can be defined as both meteorological content and the form of the code used for deciphering the individual data. In creating algorithms for primary processing of information on the computer we must consider both the features of the coded information as well as the requirements of operational practice and modal (climatological) processing.

The hydrometeorological information flows in a constant stream in the course of days through the many communication channels, both Soviet and international. Of course these channels are weighted differently. While, for example, we receive in one day through the Murmansk-Moscow channel observations for several aerological telegrams and about 20 synoptical, we receive from Cairo 70-80 aerological and more than 2000 synoptical telegrams with information about the state of the atmosphere above the vast regions of Africa and the Atlantic.

Through the various channels we receive an almost arbitrary sequence about 10 different types of information. The intervals at which this information is received vary from one hour (synoptical reports from the nearest points) to 10 days or a month. In order to give an overall idea of information flowing into the Hydrometeorological Center of the USSR we shall introduce Table 1, which shows the types of information as well as the facilities and codes which are used for deciphering corresponding types of information.

The information is received quite irregularly, in the course of 24 hours or of a year. The different types of information have a very definite yearly pattern – hydrological information, con rning the level of water in rivers and snow reserves, and agrometeorological.

Figure 1 shows the pattern for incoming data of observation taken over days for certain types of information. It is evident that the peaks correspond to information received at certain observation periods.

Table 1. Type and volume of information received at the Hydrometeorological Center of the USSR.

Type of information	Code designation	Arrival intervals	Number of five-digit groups of 10-digit numbers (in thous.)	Note
Terrestrial synoptical observations	KH-01 KH-09	Four basic observation periods per 24 hours and additional periods	300	
Data of aerological sounding	KH-04	Two basic observation periods and additional periods	200	
Hydrological information	KH-15 Kh-24	Daily, five-day periods and ten-day periods	30	
Data from oceanic stations and ships	KH-02 KH-09	Four basic periods and additional periods	80	Part of this information received from foreign ships is coded according to national codes
Agrometeorological information	KH-21	Five-day periods, monthly	20	
Climatic data	KH-19 KH-20	Basically monthly	20 60	
		Total over days	690	

If we reduce the time of transmitting information from observation points to processing centers (by increasing the rate of information transmissions and by automating preparation of data for transmission along communication lines), then the height of the peaks will increase. Furthermore we can create "free" time which can be used in different ways.

This intermittently received information must be arranged in some manner. This can be done in different ways, depending on equipment. Let us examine one of the simplest methods. If we have the general storage unit which feeds information from all channels, then of course there must a symbol designating the number of the channel to correspond to each code symbol. In this case the problem of arranging the information must be solved through a program in two stages.

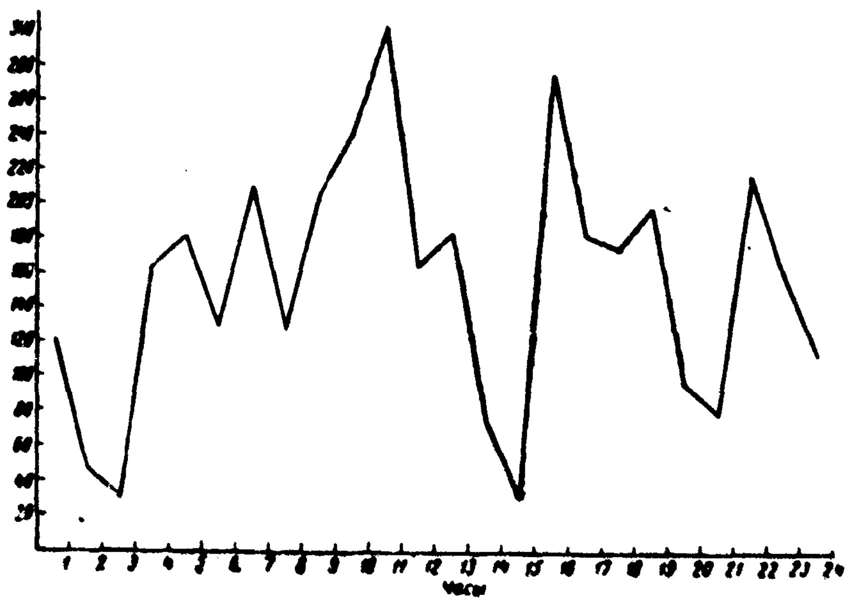

Fig. 1. Summary pattern of volume of information in a 24-hour period (in hundreds of five-digit groups).

First we must collect information from each channel and thus create a storage unit based on the number of existing communication channels. Then from each storage unit we must select telegrams and reports according to the designation of the corresponding meteorological code: synoptical, aerological, hydrological, or agrometeorological. At the end of this phase the information will be prepared for rearrangement for further meteorological processing, and this rearrangement will lead to the creation of a certain information-retrieval system [6]. Such systems must satisfy definite requirements, the most important of which are the following:

1) strict arrangement of information (reports and telegrams) according to given designations: dates, observation periods, geographical observation points, etc.;

2) standardization in arranging the information of all telegrams within reports;

3) distinct demarcation between telegrams, reports, and information retrieval systems;

4) simplicity and uniformity in retrieving necessary data according to their specific designations.

Let us dwell in some detail upon several of the requirements mentioned above.

Arrangement by geographical features is conducted differently, depending on the hydrometeorological meaning of the coded data and the algorithms of further processing.

Such types of reports as synoptical and aerological can, of course, be arranged by the numbers of the regions (two-digit number) according to a given internationally agreed upon numeration. Within a region the data from stations should also be arranged in a definite order, for example, according to an ascending index number of stations in a region (a three-digit number).*

*Such a system is not the only one possible. We could, for example, use Marsden (equal) squares instead of regions, and in each square arrange the data by ascending coordinates. In this case the algorithms of the subsequent processing stations, where it is necessary to switch to actual coordinates, become somewhat complicated.

It is advisable to arrange other types of information according to different geographical principles. We know that for many hydrological calculations related to forecasting the regime of rivers and water reservoirs data received from the stations of a definite basin are used. Therefore it may here appear more practical to arrange telegrams according to a "basin" principle.

In a number of instances, when, for example, in control stations or primary processing centers the reports are assembled according to a definite territorial principle (agrometeorological reports are usually assembled according to administrative divisions) and are transmitted along strictly specified communication channels, they are simpler to compile according to the communication channel. Finally, let us mention one method which we might tentatively call multiple-user. Certain rapidly forming or short-lived features of the atmospheric processes (showers, thunder storms, tornados, atmospherics, etc.) are observed either simultaneously from several points or at different times [7]. Coded data can be received from observation points (or objects - satellites, rockets, buoys, etc.) through different communication channels.

The total data from the points observing these different phenomena (let us call these points a "cluster"), which are received at different times through different communication channels, should be combined into one group according to the "cluster" principle.

Thus the distribution of information according to a geographical principle can be extremely varied depending on the hydrometeorological content of the coded quantities.

Now let us discuss the problem of obtaining the necessary data from an organized information-retrieval system. In operational practice all data in the telegrams are not always used immediately. Thus, for example, for analyzing and forecasting by numerical methods basic meteorological fields - pressure and wind - data concerning the potential, temperature, and wind of all isobaric surfaces is not used. Furthermore, depending on the system, the moment at which the forecast is compiled, and other factors, data received from a limited territory are used.

Analogously data from synoptical hydrological and agrometeorological stations are used. Occassionally here the same data contained in the telegram are subjected to several further processings. If the value of the necessary information relative to our existing information is small, then it is advisable to select it from a general information-retrieval system. Selection of necessary data from each telegram or groups of telegrams should be simple and standard.

Consequently, in an organized information-retrieval system each logical group should be located in a strictly determined place. This place is determined by the "distance" - the number of single bit digit - from the beginning of the telegram or, if the length of the telegram is not standard, from the distinct groups which must make up such telegrams.

After selection of the necessary data their meteorological processing begins, the first stage of which is the so-called objective analysis [3]. In the broad sense of this word we mean a rather wide and diverse program for processing data. This includes verification of observation data, exclusion of erroneous data, the replacement of it by more "suitable" (reliable) values, interpolation into units of the regular grid*, or determination of the location of the object sought - the front or atmospherics [4, 7].

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*Often objective analysis is understood to mean one special problem - the interpolation of observation data from stations into units of the regular grid. Such a narrow interpretation is inaccurate, not to mention incorrect.

The algorithms of objective analysis depend mainly on the nature of analyzed quantities and on the algorithms of subsequent processing.

Note that the methods for objective analysis are developed primarily for smooth fields [3]. Of no less interest, however, is analysis of the features of atmospheric processes – fronts, jets, tropopauses, etc. We are developing methods for objectively analyzing hydrological, agrometeorological, and other data. Solving these problems will make it possible to automate processing of the basic types of hydrometeorological information.

As a result of the objective analysis we should obtain data prepared for further processing – for diagnosis and forecasting of processes, fields, and individual elements.

The algorithms of further processing are determined by many factors, of which the main ones are the physical sense of the quantities studied and the state of scientific methods of diagnosis and forecasting. Thus, for example, modern numerical systems of short-term forecasting are based on the solution of nonlinear hydrothermodynamic equation system [5]. Here arithmetic calculations are very time consuming. Agrometeorological and hydrological forecasts are often based on the use of correlation dependences, and arithmetic calculations here are relatively simple. However, it is often necessary to use a large volume of original information – climatic data, data for past periods, etc. [1, 2].

A model time ratio of the basic stages of processing several types of hydrometeorological information is given in Table 2.

If we consider that one part of hydrological and agrometeorological information requires only several percent of the total volume of information and that the algorithms of final processing are relatively simple, then we come to the conclusion that it is to some degree possible to automate processing of these types of information, just as aerological.

More complex is the problem of synoptical information, even though this results from the fact that we have not yet developed methods of objective analysis for many properties in synoptical telegrams: cloud cover, precipitation, visibility, and other phenomena. For that reason we must for the time being limit ourselves to a partial automatization of treatment. After an information-retrieval system is created selective data – pressure, wind, temperature, tendency, and humidity – can be used for the numerical forecasting methods of the synoptical background and local weather. The telegram as a whole can be used either for publication or for automatic rotation on a weather map.

Table 2. Time ratio of processing in basic stages against total time (in %).

Type of information	I block. Decoding and formation of information-retrieval system	II block. Selection of data and objective analysis	III block. Calculation system of forecasting
Aerological (from geostrophic models)	30	30	40
Aerological (from full equations)	10	10	80
Hydrological	30	40	30
Agrometerological	40	40	20

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13. ABSTRACT

This paper deals with the characteristics of the primary meteorological information and the algorithm of the initial processing. The rate of incoming information to the processing centers varies widely , as are the total number of messages in a given observation period. Nearly ten types of information reach the central stations. The information is initially sorted in accordance with its nature: synoptic, aerological, hydrological, agrometeorological. In the next stage the information is processed in accordance with its other characteristics, such as time, date, geographical point of observation, etc. The second stage can lead to a creation of an information retrieval system. To be fully useful such systems must satisfy the following requirements: ability to sort the data accurately in accordance with a given characteristic; standard sequence of information in all telegrams containing summaries; distinctive separation between the telegrams, summaries, and information retrieval; and simplicity and uniformity of retrieval for the necessary data in accordance with their characteristics. The author considers the algorithm for such a system in considerable detail. Orig. art. has: 1 figure and 2 tables. [AT8013560]

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