Meteorological database using in developing of empirical (physical and statistical) hail storm cloud models

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Abstract. The paper presents the use of a meteorological database for a complex study of storm clouds on the example of a single-cell cloud. The database is presented in the form of a structure, including meteorological, radar, lightning and satellite information.

Methods and results of research
Information systems can bring great benefits to researcher by automating tasks that previously were solved manually. The use of a database (DB) provides a significant increase in the efficiency of processing a large amount of data [1,2]. The results of comprehensive studies of thunderclouds at the SMP HMGI (Scientific measuring point of High Mountain geophysical institute) in the spring-summer period annually replenish the relevant tables of the meteorological database [3]. Below is a general scheme for organizing the storage of information on thunder-gravest processes (Figure 1). Each rectangle in the diagram represents a separate table. Relational relationships are indicated by lines with an arrow.

Figure 1. Scheme of construction of heterogeneous information storage about hail storm processes
The database receives information about lightning from the thunderstorm total lightning detector LS8000, which sensors are located in four points of the North Caucasus (Cherkessk, Kyzburun, Stavropol and Zelenokumsk).

Information about lightning discharges obtained with the help of low-frequency and high-frequency sensors is used as thunderstorm data. In this case, we can talk about two data sources represented by the tables ls8000lf and ls8000vhf. All types of stored information according to the location of the measurement instrumentation in a geographical point can be divided into two groups.

The gridding is not used for a model of storing lightning detection data of the LS8000 system, satellite images and weather forecasts transmitted to hail suppression service. The Figure 2 shows the general pattern of access to this data. The description of some table fields is marked with markers.

![Figure 2. The general scheme of access to the no gridded data](image)

Each entry in the table with information has a time field that allows you to link different entries with each other. For the correct installation of communication is used either the CUT standard (coordinated universal time), or the time is indicated according to the time zone. Each lightning detection record provides lightning discharge information obtained with the help of low-frequency (table ls8000lf) or very high-frequency sensors (table ls8000vhf), satellite data with reference to the photo location (table satellites), and the weather forecast includes, in addition to the forecast itself, some radiosonde measurements (table forecast).

The data access scheme becomes something more complicated in the case of geo-referenced data (Figure 3). The table of stations is formed indicating the name and identifier of the object and taking into account the coordinates of radar and meteorological stations.
Figure 3. General data access scheme taking into account the geographical location of the stations

The active mode of operation of radar and automatic meteorological stations is not continuous. The datasets table is used to record the working time of measuring equipment, each entry on the table contains station codes (from the stations table) and data source (from the sources table), start and end times of the continuous measurement period, as well as some additional parameters associated with this period (depending on the data model, this may be the radar constant, the meteorological parameters collection period, etc.).

Information about the amount of precipitation by ground-based meteorological stations was allocated in a separate precipitation table, because it is time-bound not only at the time of the readings, but also the duration of data collection. The table of total precipitation is formed in the context of fragments of continuous measurements (datasets table) and includes only non-zero (non-empty - for synoptic meteorological stations) values, which can significantly reduce the number of records.

All other information is stored in the tables of meteorological parameters of network of synoptic weather stations (synopraw, synopdaily, metar) and hydroposts (hydropost), automatic weather stations DavisVantagePro (wlkar, wlksum) and MAWSVaisala (maws10, maws1h, maws24h) or in the form of references (mrldata) (access to which is possible either via an ftp server or via http using GET and POST requests).

Secondary radar data processing consists of processing and visualization of incoming information. At the same time, in parallel, in the automatic mode, a number of problems are solved by spatial mapping of a particular cloud characteristic.

The method for determining cloud parameters is performed in semi-automatic mode and consists in the following: the operator selects a convective cell with the mouse and assigns a sequence number to
it. Then, according to the program for calculating cloud parameters, the machine calculates their values in the selected area and automatically enters the received data into the radar data table. You can see the results of the calculations in the parameters window, either in the parameters table, which contains data of each selected cell for all the time of its existence, or on the graphs of parameters corresponding to observation time. The radar parameters of convective cells that are recorded in the database and displayed on the screen are shown in the table (Figure 4).

Figure 4. Fragment of the table “Radar parameters of cells”

In addition, the graphical image corresponding to meteorological objects in the radar environment at this time is also recorded in the database (Figure 5).

Figure 5. Scheme of recording of radar parameters and graphic image to the database in operational mode

The algorithm for replenishing the database with radar parameters in operational mode is shown in Figure 6.
The next logical step after the implementation of the database is the creation of a physical data model. At this step, by querying the database, the necessary information is displayed in the systematized on various features form.

To search hail processes of different types in the database is necessary to form queries to the base of meteorological and synoptic data in order to select days with hail and select among its days that meet the criteria for development of hail storms of required type. Figure 6 shows the search algorithm for single cell hail clouds using the query system of the radar and meteorological databases.

![Flow chart of searching for single-cell hail clouds using databases](image)

**Figure 6.** Flow chart of searching for single-cell hail clouds using databases

The sequence of actions is as follows.

1. Selection of days with hail is made from the DB of meteorological data according to the following criteria that determine the conditions with danger of hail:
1.1 Updraft velocity $W > 10 \text{ m/s}$;
1.2 Air temperature during the day $t > 25 \text{ °C}$;
1.3 Air humidity $\varepsilon > 45\%$.

2. Selection of days that meet the criteria for single-cell processes:
2.1 Days with mass development;
2.2 Driving speed $v < 30 \text{ km/h}$;
2.3 Wind shear in the 1-4 km layer $< 10^{-4} \text{ s}^{-1}$.
3. Selection into the radar database.
3.1 Cell displacement velocity less than 20 km/h;
3.2 Cell lifetime less than 40 minutes;
3.3 Cell radar structure having one local maximum reflectivity.

Summary
The storage of heterogeneous information collected as a result of complex studies of hail storm clouds is made in separate tables combined into a single weather data database.

Rules for finding each table in automatic, semi-automatic or manual modes are developed.

For further practical use of the information received, a remote user can connect his local MS Access database to the PostgreSQL DBMS located on the server.

Queries to identify patterns that link the various parameters collected in the database are developed.

A database search method for hail processes of various types is considered.

References
[1] Aksenov S A, Inyukhin V S 2006 Spatial comparison of radar and other information (Proceedings of the VII Conference of Young Scientists, KBNC RAS, Nalchik - Presidium of the KBNTs) 12-16.
[2] Inyukhin V S 2001 Principles of building a radar database. Abstracts of reports at the All-Russian (Conference on Cloud Physics and Active Impacts on Hydrometeorological Processes Nalchik).
[3] Bazlova T A, Bocharnikov N V, Brylev G B and others 2002 Meteorological automated radar networks (SPB, Gidrometeoizdat).
[4] Studies of macro- and microstructural characteristics of hail clouds based on radar, satellite, lightning, ground and aero-synoptic data 2015 (Research report (Intermediate): 1.6.4.2/ Federal State Institution High-Altitude Geophysical Institute, Nalchik) 169.
[5] Berezinsky I N, Inyukhin V S, Kuschev S A and others 2017 Certificate of state registration of database No. 2017620749 “Radar characteristics of hail clouds” (In the database registry July 10, 2017).