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RADAR STUDIES OF FORMATION AND DEVELOPMENT OF HAIL CLOUDS

***Liev K.B., *Kushchev S.A., **Anischenko E.A.**

[*]High-Mountain Geophysical Institute, Nalchik, Russia
[**] Kabardino-Balkarian State University named after H. M. Berbekov, Nalchik, Russia
Stasuk6@mail.ru

Summary: *The results of analysis of long-term radar observations of hailstorms are presented. The dynamic characteristics of formation and development of hail cores in severe convective clouds are studied. The statistical sample of radar data included 764 hail cells; for each cell the temporal distributions of measured and computed major radar parameters were constructed using the automated system of acquisition, processing, and presentation of radar data. The most informative time characteristics of hail cores development and the interrelation between them were identified. The natural variability of hail core volume is demonstrated.*

Key Words: *First hail storm echo, hail core, hail core volume, radar reflectivity, dual-wavelength hail detection method.*

Introduction. The researching of the processes of hail initiation and growth by radar methods has become more popular during last years because of the development and improvement of automated systems of collecting and processing of radar data on hailstorms. With the help of these programs researchers can calculate parameters of hailstorms and track their change. The radar studies of the dynamic characteristics of the formation and development of hail sources in powerful convective clouds in the area of Kabardino-Balkarian Republik are the purpose of this work.

Methods. The authors has collected the results of complex radar studies of hailstorm processes which were made on scientific proving ground of High-Mountain Geophysical Institute from 2003 to 2018. The statistical sample included 801 cases of registration of hail cells. The researching were made with the help of two-wave meteorological radar MRL-5, automated systems of collecting of radar data MeteoX and the database of radar characteristics of hail clouds [1]. The radar observations were carried out continuously from the moment the first radio echo appeared to the complete dissipation of the cloud. The period between the observations was about 3 minutes. For the researching were built temporal allocations of the main radar parameters (fig.1) both measured and calculated within the framework of the used automated system for collecting and processing information. Further analysis included the construction of distributions of four parameters which characterizing the process of formation and development of hail sources in powerful convective clouds [2]:

— dT^1 — the period from the registration of the first radio echo of the hail cloud to the indication of hail in the cloud;

— dT^2 — the period from the indication of hail to the maximum volume of the hail focus is reached in the cloud;

— dT^3 — the total time of the existence of the hail hearth;

— dT^4 — the period from the reaching the maximum volume of the hail source in the cloud until the indication of hail in the cloud stops;

— V — the maximum value of the volume of a hail chamber in a cloud for the entire time of its existence.

As we can see on Fig.1 the hail in the cloud appeared at 17:41 and its volume was 0.5 km^3; the period from the registration of the first radio echo of the hail cloud to the indication of hail in the cloud (dT^1) was 11 minutes. At 18:50, the maximum value of the volume of the hail source in the cloud (V) 84 km^3 was reached; the period from the indication of hail to the achievement of the maximum volume of the hail source in the cloud (dT2) was 80 minutes. At 19:17, the volume of hail in the cloud became equal to 0, and the total lifetime of the hail focus was 96 minutes.

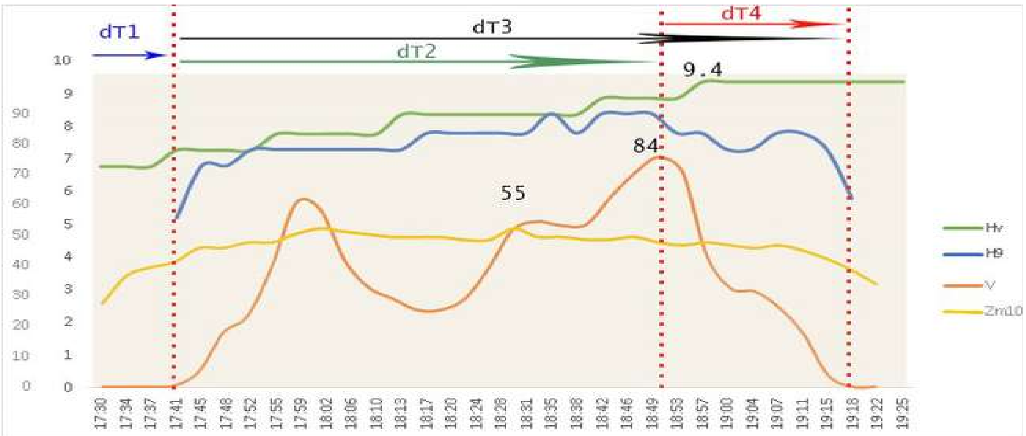

Fig.1. Time distributions of the main radar parameters.

With the help of method, 764 hail cells were analyzed. For each of the above time parameters dT_1, dT^2, dT^3, dT^4 characterizing the process of formation and development of hail sources, distributions were constructed showing the range of variation of each parameter.

Results and discussion. Both of the parameters on Fig.2 depends on the nature of the course of certain different microphysical processes at different stages of the development of the hail cloud.

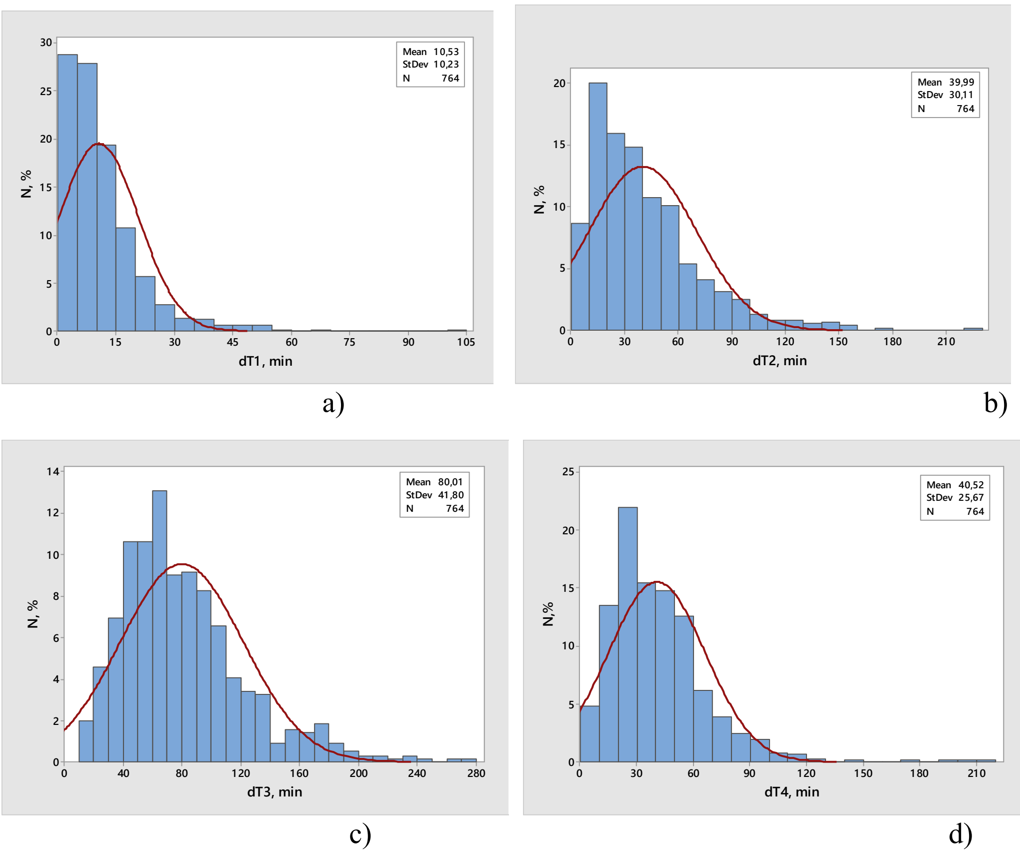

Fig.2. Distribution of temporal characteristics of the formation and development of hail foci dT^1 (a), dT^2 (b), dT^3 (c), dT^4 (d) for 764 hail cells that developed on the territory of the Kabardino-Balkarian Republic from 2003 to 2018.

As we can see on Fig.2 the average time of registration of a hail focus from the moment the first radio echo appears (dT^1) is 10 minutes, the minimum time before the appearance of a hail in the cloud is 3 minutes, and the maximum time is 102 minutes, but this is an isolated case. This stage is preceded by a long time of cloud development before the appearance of the first radio echo.

The time from the moment of the hail indication to the time of registration of the maximum volume of the hail hearth (dT^2).

This parameter is significantly influenced by the rate of the ascending flow and the water content in the hail growth zone, as well as their optimal ratio [3]. As seen in Fig. 2b, the average time of development of the maximum value of the hail focus is 39 minutes, the minimum time is 3 minutes and maximum 229 minutes.

The lifetime of a hail source (dT^3) often depends on the ratio of the energy storage of the atmospheric instability and wind shear. With a low energy of instability, the lifetime of a hail source in most cases is less than 30 minutes. At low wind shear, the cells are also short-lived, due to the suppression of ascending flows by precipitation [4]. As can be seen from Figure 2c, about 7% of such cells are investigated. The maximum time of the existence of a hail focus of 280 min was shown by a supercell hail cloud on July 10, 2003. In total, the average time of existence of a hail focus in a cloud is 80 minutes.

Time from the moment of registration of the maximum volume of the hail focus to its disappearance (dT^4). As we can see in Fig. 2d, the average time of this parameter is 40 minutes, the maximum is 220 minutes.

Conclusion. The analysis of the data gives us an understanding of how rapidly the hail cloud is developing. This information can be especially useful in case of active influence on hail cells, it gives information on how quickly a hail focus can develop. Unfortunately, the dependence of the time of the existence of a hail source dT^3 on the time of the appearance of the first radio echo until the time of the appearance of a hail source in the cloud dT^1 was not found. This regularity would make it possible to estimate the lifespan of a hail cloud based on the first measurements of the cloud parameters. But the correlation between the total time of existence of a hail focus (dT^3) and the time from the indication of hail to reaching the maximum volume of a hail source in the cloud (dT^2) is 0.79.

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