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Analysis of a strong thunderstorm process observed in the eastern part of the Republic of Azerbaijan on June 1, 2017

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Abstract

The article is devoted to a comprehensive analysis of severe flood events that took place on the southern slope of the Greater Caucasus, including in the Gobustan region, on June 1, 2017. As a result of heavy rain and hail, farms and other facilities were seriously damaged in this area, and mudflows led to traffic stop on the section of the main Baku-Shamakhi Road, called the Jeyrankechmez valley. The influence of the dynamics of the development of thunderstorm clouds, as well as other factors on the formation of a strong flood, is analyzed. Based on the data of radar and satellite observations, as well as the analysis of aero synoptic material, considering the physical and geographical conditions of the given region, appropriate proposals were made for more reliable forecasting of such processes using radar data.

1. Introduction

As it is known, on the territory of Azerbaijan, thunderstorm processes and related mudflow phenomena are associated with high contrasts of surface temperatures and the influence of invading air currents (Climate of Azerbaijan). In recent years, due to global warming in various regions of the world, including in the territory of Azerbaijan, the intensity and frequency of such phenomena has increased. In some cases, these phenomena reach the level of a natural disaster by the intensity and scale of the damage. In most cases, heavy rainfall, hail, mudflows, and floods cause serious damage to certain sectors of the economy, including agriculture. From this point of view, a comprehensive study of such phenomena is of the greatest scientific and practical interest.

Ground-based radar and meteorological observations conducted on the territory of the Republic show that in recent years there has been an activation of the above-mentioned dangerous phenomena (Safarov et al. 2017).

From this point of view, the spring-summer period of 2017 was not an exception. Hazardous hail and storm events observed during this period, as well as mudflows and floods associated with them, are distinguished by great intensity and the scale of the damage caused.

Hazardous hail and storm events observed during this period, as well as mudflows and floods related with them, are distinguished by great intensity and the scale of the damage caused. The most powerful processes were noted on April 30, on May 16, 21, 27, 28, 31, on June 1, 10, 12, 13, 15, 20, 30 and on September 7, 16, 25, because of which serious damage was caused to crops and livestock, transport infrastructure, power lines and communications, residential and social facilities, as well as flora and fauna. The hailstorm process observed on June 1, 2017 in some places of the southeastern slope of the Greater Caucasus, by features of the dynamics of development, intensity, and amount of precipitation, as well as the scale and extent of damage, is of interest. The purpose of this article is a radar analysis of this process.

2. Material and Method

Radar data of automated MRL-5 of Shamakhi and Geygel radar stations and satellite data of the platform GPM were used in the work. The heights of the terrain, where both radar stations are standing, are about 1000 m. Automated MRL-5 was created based on meteorological incoherent radar MRL-5 with the introduction of the corresponding software and hardware complex. This system allows within a radius of

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250 km at any time and at any point in space to quickly assess the intensity, quantity, and other characteristics of precipitation. MRL data on the presence, location, direction, and speed of displacement of the centers of showers are the most operational and complete. Automated MRL-5 allows to monitor the dynamics of development and the cellular structure of the thunderstorm processes and determine the type of such processes. Other features of this system are described in detail in (Safarov, 2012). We also used synoptic maps and ground observation data.

3. Results and Discussion

According to synoptic maps, by 00 o'clock (GMT) on this day, the meteorological situation in Azerbaijan was determined by a local cyclone that formed over the Black Sea and deep baric hollows at different altitudes. This situation created a condition for the invasion of moist air masses from the Black Sea and cold air from the north, which allowed the development of intensive convective processes.

According to synoptic maps, by 00 o'clock (GMT) on this day, the meteorological situation in Azerbaijan was determined by a local cyclone that formed over the Black Sea and deep baric trough at different altitudes. This situation created a condition for the invasion of moist air masses from the Black Sea and cold air from the north, which allowed the development of intensive convective processes.

According to the radar data of the Shamakhi and Geygel radiometeorological stations, on this day, beginning from noon, the formation of a cumulonimbus clouds was observed on the territory of Gabala, Ismayilli, Guba, Shamakhi and Gobustan regions. At the initial stage, the process of precipitation wore a disordered nature, and in some places local showers were noted. Starting from 15 o'clock, precipitation intensified on the territory of Gusar, Zagatala, Gakh, Oguz, Gabala, Ismayilli, Shamakhi, Shabran and Khyzi districts in some places led to a descent of mudflow and floods (Fig. 1).

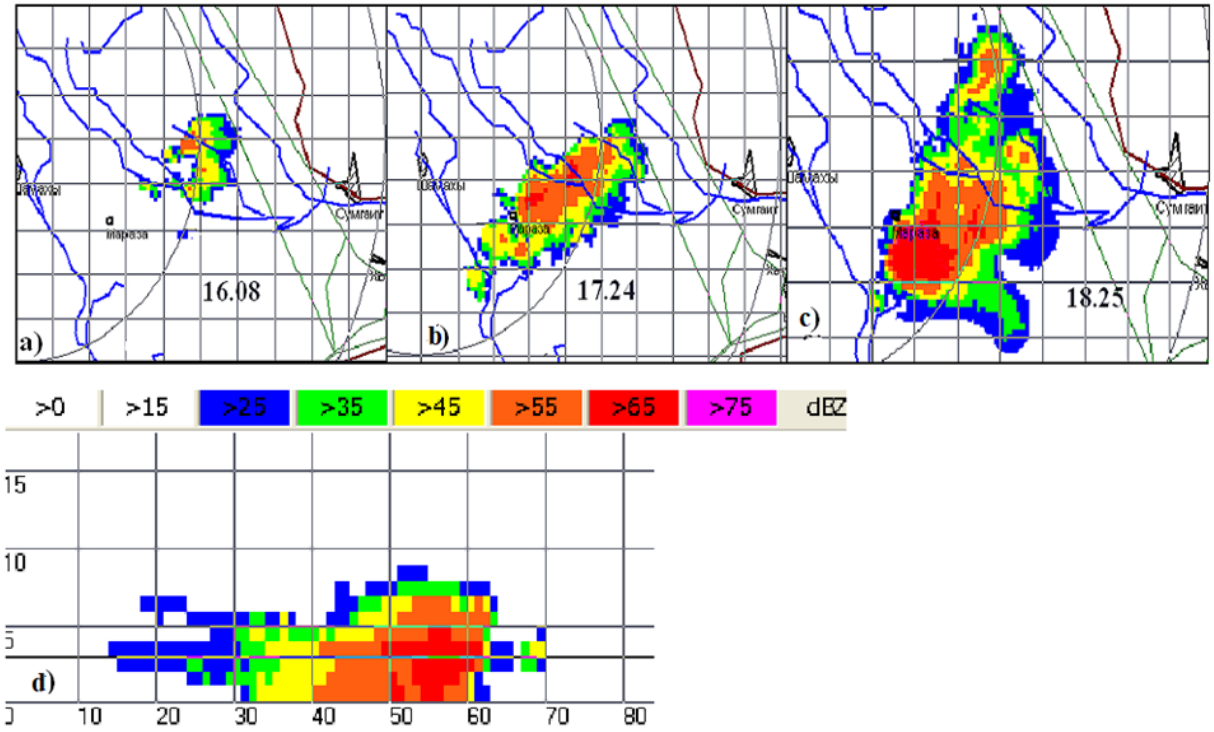

Figure 1. Evolution of the horizontal section of the radio-echo of the thunderstorm process at the level of 5000 m from the sea level observed in the Gobustan region (a, b, c) and the vertical section of the radio-echo to 18.25 (d).

According to radar observations, starting at 4 pm, a more powerful thunderstorm process was observed on the territory of Gobustan region (Fig. 1a).

Cumulonimbus (Cb) cloud rapidly developing by 18.30 turned into a powerful multi-cell thunderstorm process (Fig. 1a, b, c). According to its radar characteristics, (radar reflectivity Z_{10}, dBZ; height of the upper boundary of the radio echo cloud H_u, km; hail area S_h, km^2; duration of the process and hail precipitation; intensity and amount of precipitation) this process turned out to be much more powerful than previous processes (Table 1).

Heavy hail fell in some places and precipitation intensity has reached a catastrophic level. As can be seen from Fig. 2, from 16.00 to 20.00 more than 80 mm of precipitation fell, which is 45 mm more than the monthly norm of the area.

At times, precipitation intensity exceeded 60 mm/hour, which is confirmed by radar and satellite data. The temporal course of precipitation intensity built according to the GPM platform (Global Presipitation Measurement) of the Giovanny portal with a time resolution of 0.5 hours and a spatial resolution of 8 km is shown in Fig. 3. As can be seen from Fig. 3, by about 18:00 (14:00 GMT), the intensity of precipitation increased sharply and exceeded 60 mm/h.

Analyzing the character of the evolution of this hailstorm process using the patterns of distribution of the radar reflectivity and their animation, it is possible to explain the reason for the precipitation that is too abundant. As in most of the highly hazardous regions of the world, the thunderstorms processes observed on the territory of Azerbaijan, according to their cell structure and development dynamics, are mainly divided into single-cell, multi-cell, and supercell.

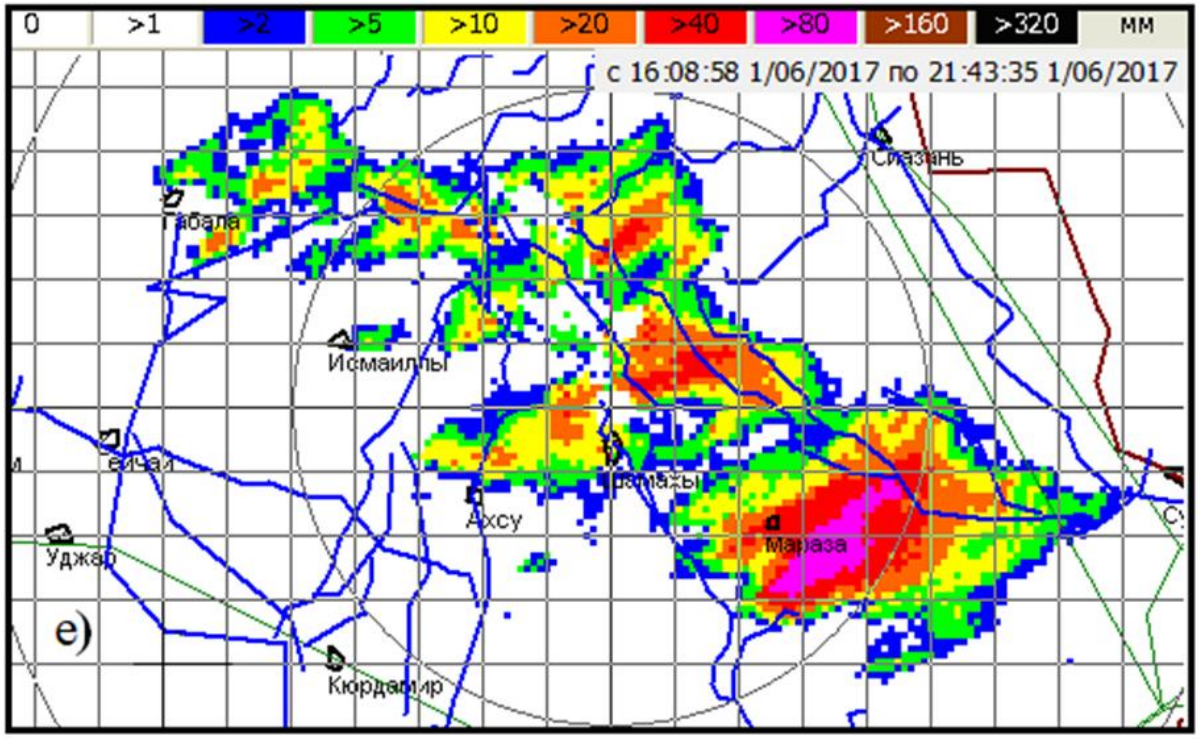

Figure 2. Distribution of precipitation over the territory in the thunderstorm process on June 1, 2017 from 16:08 to 21:43

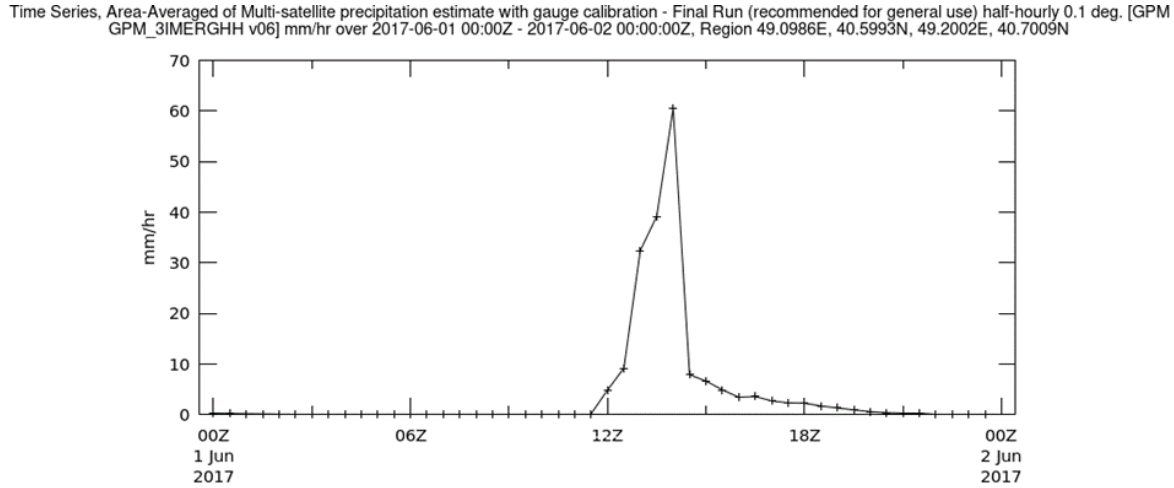

Figure 3. Time course of the precipitation intensity in the thunderstorm process on June 1, 2017, built by the data of GPM

Table 1. The maximum radar characteristics of the multi-cell hailstorm process 01.06.2017

Area	Horizontal sizes of hail area, km major axis	minor axis	Duration of the process, min	Length of hail strip, km	Amount of precipitation, mm	**Z_{10},**dbz	Horizontal section area, km ^{2}	H_u km	H_h, km
Gobustan district	11	8	340	42	> 80	73	107	10	6
Nearby areas	7	4	125	23	45	68	65	9,2	5,8

Notes: 1. Z_{10}-radar reflectivity at a wavelength of 10 cm;
2. H_u - the height of the upper boundary of the radio echo of the cloud from sea level;
3. H_h - the height of the upper boundary of the hail cloud from sea level.

The characteristic features of these types of processes are described in more detail in (Safarov, 2012). Ordered multi-cell processes, in turn, are divided into normal and anomalous subtypes. In normal processes, due to the fact that new convective cells are formed on the right flank of the cloud system, to the right and slightly ahead of the previous cell, the stripes of precipitation of individual cells are almost parallel to each other.

In normal processes, due to the fact that new convective cells are formed on the right flank of the cloud system, to the right and slightly ahead of the previous cell, the stripes of precipitation of individual cells are almost parallel to each other. And with abnormal subtypes, new cells form at the back of the previous cell, relative to their direction of movement (Safarov, 2012; Safarov, 2018; Safarov 2019)

A detailed analysis of the radar material of the considered thunderstorm process has shown that it can be classified as anomalously ordered. Thus, new powerful convective cells periodically appearing behind the previous one (relative to the direction of their movement), moving along practically identical paths on the territory of the Gobustan district, led to long and intense rainfall, sometimes accompanied by dropping of large hail.

Despite the fact that individual convective cells moved from the south-west to the northeast at a speed of 15-20 km/h, the thunderstorm process as a whole and the corresponding cloud system stood still and did not move. All this led to heavy precipitation in the local territory, the amount of which exceeded 80 mm.

The disaster caused serious damage to the infrastructure of the territory, power lines and communications, bridges, and to a greater extent agriculture. In rivers, especially in the course of the Pirsaat River, water sharply increased, and the water level rose. In some places, intense precipitation led to the collapse of mudflows, as a result of which part of the Baku-Shamakhi main road in the area of the Dzheyrankechmez valley was flooded. Due to accumulated mud and flooding, more than 500 cars were stuck in transit and traffic in this part of the road was temporarily stopped.

It should be noted that in the territory of Azerbaijan, such anomalously ordered multi-cell processes are often observed, and in most cases, they lead to the loss of dangerous and sometimes catastrophic rainfall, sometimes accompanied by intense hail. For example, on June 20, 1985, on the territory of Shamkir district, in one and the same places, strong precipitation was observed three times in one evening [4] . On May 21, 2014, an abnormally orderly process led to dangerous flooding in the Tovuz region. In some places of the region, the amount of precipitation was more than 100 mm [5].

4. Conclusion

Thus, radar detection of abnormally ordered multi-cell lightning-hail processes in any part of the territory of the Azerbaijan Republic, taking into account the relief and other terrain features, can be a reliable predictor of long-lasting heavy rainfall and associated mudflows and floods

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