

## METEOROLOGICAL CONDITIONS FOR THE TORNADO FORMATION IN KAKHETI (GEORGIA) ON JUNE 25, 2024

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**Abstract.** The article presents results of studies of the level of atmospheric stability and characteristics of the thunderstorm-hail process that contributed to the formation of a tornado in Kakheti on June 25, 2024.

**Key Words:** natural disasters, hurricane winds, tornadoes, radar monitoring.

### Introduction

The assessment of extreme wind values is especially important from the point of view that such phenomena, as a result of their destructive effects, can cause significant damage to the agro-economic and other infrastructure of the country [1-10]. In particular, article [8] presents information about the tornado in Kobuleti, and also discusses the issue of a more detailed study of these events in Georgia.

In the study [8], as a special case, considered a tornado that took place on September 25, 2021 in the terminal space of the city of Poti, which caused significant damage to one of the cargo terminals.

Some results of an expeditionary study of the tornado distribution area in Kakheti on June 25, 2024 are presented in [10]. The team of researchers visiting the Alaverdi Cathedral, had a meeting with His Eminence, Bishop of Alaverdi, Metropolitan David. The damage to the Alaverdi Cathedral and its surroundings was discussed in detail. Important information has been received regarding this issue. Further research was continued in the area surrounding the Alaverdi Cathedral and in the direction of the villages of Kvemo and Zemo Alvani. The probable place of origin of the tornado and the trajectory and area of its spread were determined. The damage caused by the tornado on the propagation trajectory was studied. This work is a continuation of the study [10]. Results of studies of the level of atmospheric stability and characteristics of the thunderstorm-hail process that contributed to the formation of a tornado in Kakheti on June 25, 2024 are presented below.

### Study area, material and methods

Study area – Akhmeta municipality of Kakheti region of Georgia (Alaverdi Cathedral and surrounding areas, the villages of Kvemo Alvani and Zemo Alvani).

Data on vertical atmospheric sounding [<https://www.ready.noaa.gov/index.php>] for calculated of Indexes of Stability of the Atmosphere [[http://weather.uky.edu/about\\_totl.htm](http://weather.uky.edu/about_totl.htm)].

In this work Total Totals Index (TT) Index stability of the atmosphere is used.

$$TT = T_{850} + T_{d850} - 2 \cdot T_{500} \text{ in degrees C.}$$

where  $T$  represents temperature and  $T_d$  represents dew point temperature at the indicated level (500, 700, and 850 mb).

Data of meteorological radar “METEOR 735 CDP 10 – Doppler Weather Radar” of Anti-hail service of Georgia about the parameters of radar reflectivity of clouds – product MAX (dBZ), max diameter of hailstones D (mm) – product HAILSZ (Size) and the and characteristics of atmospheric phenomena – product ASWLL (ET) – are used [11].

## Results

Results in Table and Fig. 1 – 5 are presented.

**Table. TT Index for study region 25.06.2024.**

Hour.min	TT Index	Stability of the Atmosphere
10.00	51	Scattered Numerous Thunderstorms. Few Scattered Severe. Isolated Tornadoes
13.00	53	Numerous Thunderstorms. Scattered Tornadoes.
16.00	53	Numerous Thunderstorms. Scattered Tornadoes.
19.00	53	Numerous Thunderstorms. Scattered Tornadoes.
22.00	50	Scattered Thunderstorms. Few Severe. Isolated Tornadoes.

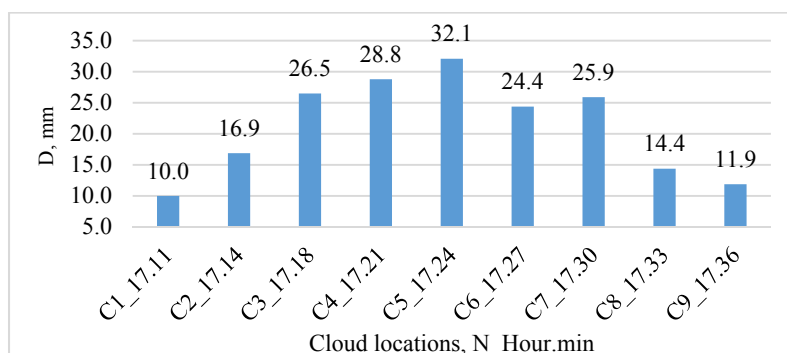
As follows from Table 1, from 10.00 to 22.00, an unstable atmosphere was generally observed over study area. The TT index value varied from 50 (22.00, Scattered Thunderstorms. Few Severe. Isolated Tornadoes.) to 53 (13.00-19.00, Numerous Thunderstorms. Scattered Tornadoes.). That is, throughout the day there were conditions for the formation of intense convective processes and tornadoes.



**Fig. 1. Trajectory and speed of movement of the thunderstorm-hail process over the study area.**

Points C1÷C9 – location of the cloud zone with the maximum diameter of hailstones.

Point 0 – center dome of the Alaverdi Cathedral, point 13 – approximate location of tornado formation, all other points – locations of the tornado distribution area in Kakheti [10].



**Fig. 2. Max diameter of hailstones in different time.**

As follows from Fig. 1 and 2, the thunderstorm-hail process moved over the territories of Zemo Alvani, Kvemo Alvani and Alaverdi from 17.11 to 17.36. The speed of this process varied from 9 km/h to 30 km/h. At the same time, according to the radiosonde data at 16.00, the direction of the leading flow was 273°, the speed was 46.8 km in the altitude range of 5.06-6.61 km, the maximum diameter of hailstones varied from 10.0 to 32.1 mm.

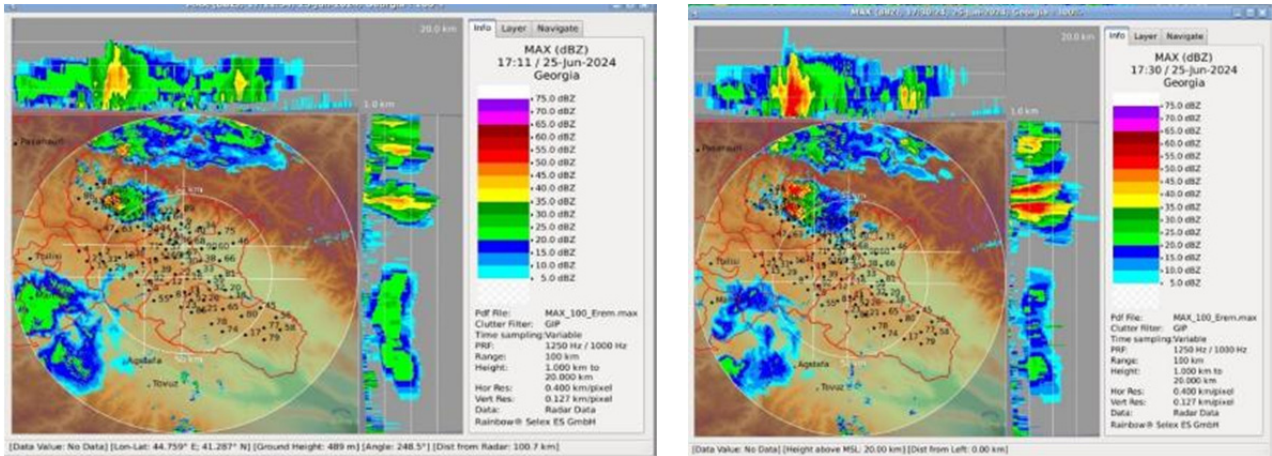


Fig. 3. Examples of distribution of radar reflectivity of clouds over the study area at 17.11 and 17.30.

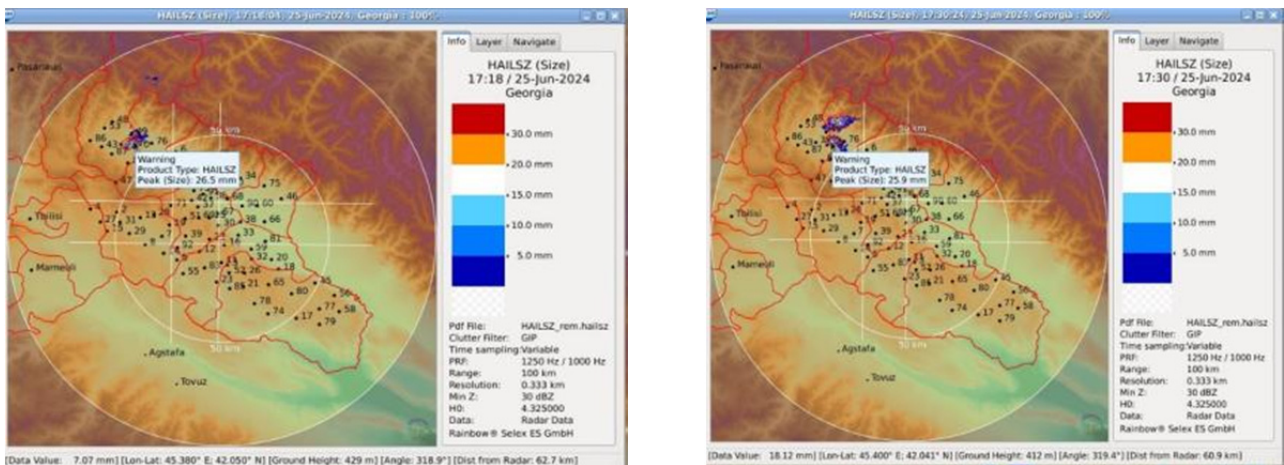


Fig. 4. Examples of distribution of maximum hailstone size over the study area at 17:18 and 17:30.

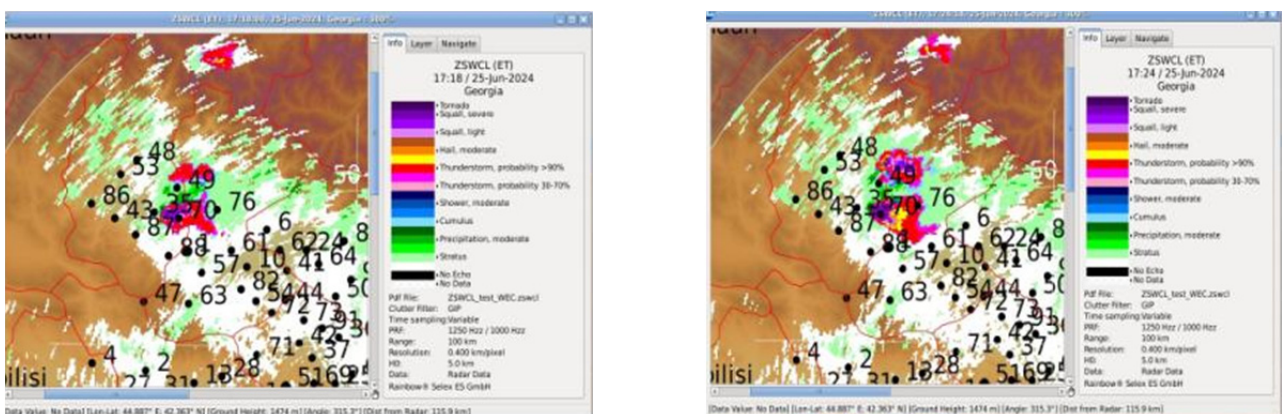


Fig. 5. Examples of distribution of characteristics of atmospheric phenomena over the study area at 17:18 and 17:24.

In Fig. 3-5 are presented some examples data of the radar about the parameters of radar reflectivity of clouds, max diameter of hailstones and the characteristics of atmospheric phenomena, respectively. In these Figures, by numbers are indicated the anti-hail missile points for influencing on clouds. Note that the supposed location of the tornado (point N 13 in Fig. 1) is located near missile point N 35, and the Alaverdi Cathedral (point N 0 in Fig. 1) is not far from missile point N 70.

As the analysis of the radar data showed, from 17.11 to 17.36 the thunderstorm-hail cloud, which was actively attacked by anti-hail missiles to prevent hail, was a two-cell system with max radio echo heights of up to 15 km. The lower cell was more active. The tornado, fueled by it, apparently arose at 17.11-17.14, and reached the territory of the Alaverdi Cathedral at approximately 17.30, having traveled about 5.7 km [10] at an average speed of 18-21 km/h. This corresponds to the average speed of the cloud during the same period of time (Fig. 1). It should also be noted that strong gusts of wind were observed inside the cloud (Fig. 5, designation “Squall severe”), which contributed to the formation of a tornado and its existence for at least 22-25 min.

## Conclusion

In the near future, we plan estimation of the speed of air flows inside a tornado, clarify the strength of the tornado, etc.

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