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RADAR CHARACTERISTICS OF RAIN CLOUD WICH CAUSED LANDSLIDE INTO AKHALDABA AND CATASTROPHIC FLOOD IN TBILISI ON JUNE 13-14, 2015

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Summary: *Data on the radar characteristics of a rain cloud that caused a landslide in Akhaldaba and a catastrophic flood in Tbilisi on June 13-14, 2015 are presented. The measurements were carried out using the "METEOR 735CDP10" weather radar located in the village. Chotori of Signagi Municipality of Georgia. The temporal variability of the maximum radar reflectivity of the cloud, precipitation intensity, etc. was studied. It is noteworthy that the cloud did not move much and was over the zone where the landslide descended for more than 5 hours. The consequences of this landslide are well known – the closure of the Vere River, the accumulation of water, the breaking of an artificial dam and the catastrophic flood in Tbilisi.*

This example indicates the possibility of using a radar to predict landslides caused by heavy rains.

Key Words: *Radar monitoring, precipitation, landslide, flood.*

Introduction. Heavy rainfall is often the cause of freshets, floods and flooding [1-3]. Therefore, special attention is paid to a detailed study of the distribution of precipitation intensity in Georgia [4,5]. In connection with the restoration of the anti-hail service in Kakheti equipped with a modern radar [6,7], new opportunities for monitoring of atmospheric precipitation appeared [8,9]. There are several locations in Tbilisi, where from time to time there are floods and flooding as a result of heavy rainfall [1,2]. Catastrophic flood in Tbilisi on the night from 13 on 14 June 2015 – natural calamity, caused by abundant rains in the capital of Georgia on the night 13 on 14 June and by output from the banks of river Vere. As a result of the flood, residential houses and buildings were flooded, roads, infrastructure were damaged, and dozens of predatory animals fled from the zoo. About half of the inhabitants of the zoo died. The most difficult situation was in the area of the Vake-Saburtalo highway, where private residential buildings were flooded. Rescuers took measures to neutralize the predators walking around the city, and their return to the enclosures. The nearby shelter for dogs, in which most of the 450 inhabitants died, was also affected. Precipitation and a landslide destroyed several hundred meters of the section of the Tskhneti-Betania road, which has still not been restored. The total damage amounted to 200 million GEL About 450 residents of the city suffered, 19 people died (https://ru.wikipedia.org/wiki/Наводнение_в_Тбилиси). Preliminary information about the radar characteristics of this process were given in [6,10,11]. More detailed data on the radar characteristics of this process are presented in this paper.

Methods. Meteorological radar "METEOR 735 CDP 10 – Doppler Weather Radar" is established in the village Chotori of the Signagi municipality of Kakheti region of Georgia [6,7]. The products of radar are sufficiently varied [8,9]. In this work two radar products were presented: HWIND(V), MAX(dBZ) and MPPI (dBz). Time designation (Fig. 1-4), for example, 14 hour 33 min – 14:33 h., etc. In Fig. 5 minutes are given in fractions of an hour.

Results and discussion. The results in Fig. 1-7 and Table 1,2 are represented.
As follows from Table 1 and Fig. 1-3 process was intra mass.

Table 1

Prediction of Instability to the Atmosphere
Tbilisi, 13.06.2015
Total Totals Index TT = 49.4
Separate thunderstorm or several thunderstorms
K Index = 35
Probability of thunderstorms:
60-80 %
SWEAT — Severe Weather Threat index = 152
There are no conditions for the appearance of strong thunderstorms

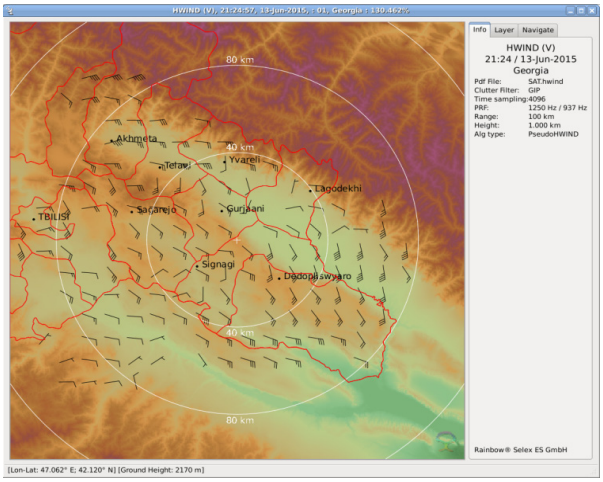


Fig. 1. Distribution of Wind Speed and Direction Above the Territory of Eastern Georgia.

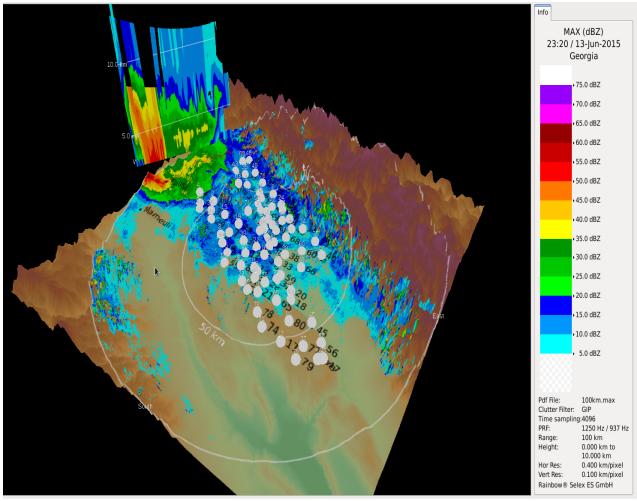


Fig. 2. 3D Picture of the Radar Reflectivity of Cloud Above the Location of Landslide on 13 June 2015 in 23:20 h.

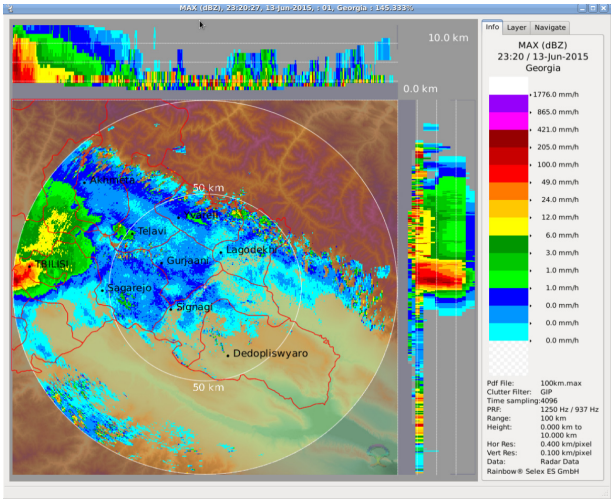
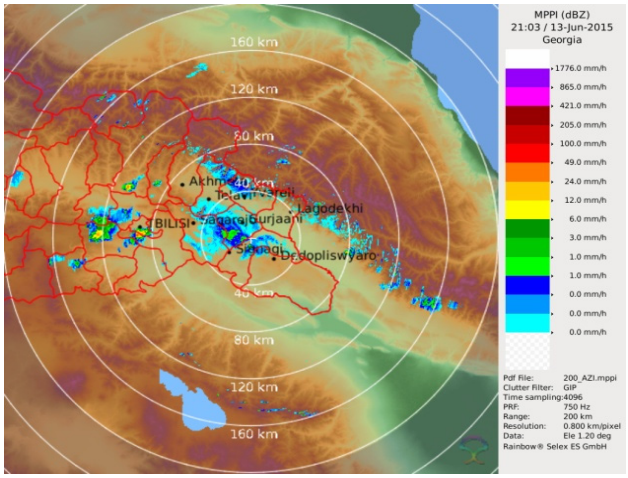
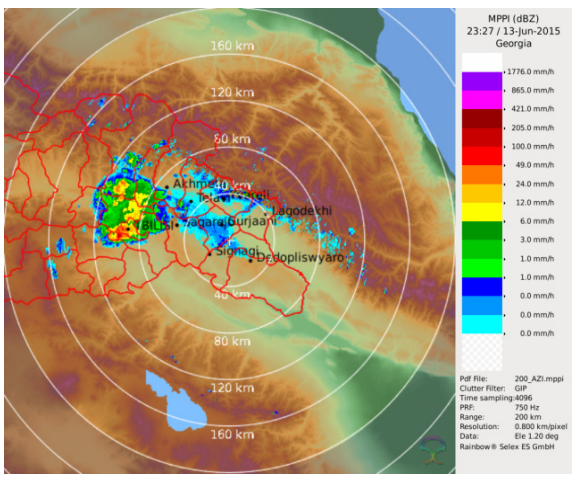


Fig. 3. Vertical and Horizontal Distribution of Intensity of Precipitation Above the Territory of Eastern Georgia on 13 June 2015 in 23:20 h.





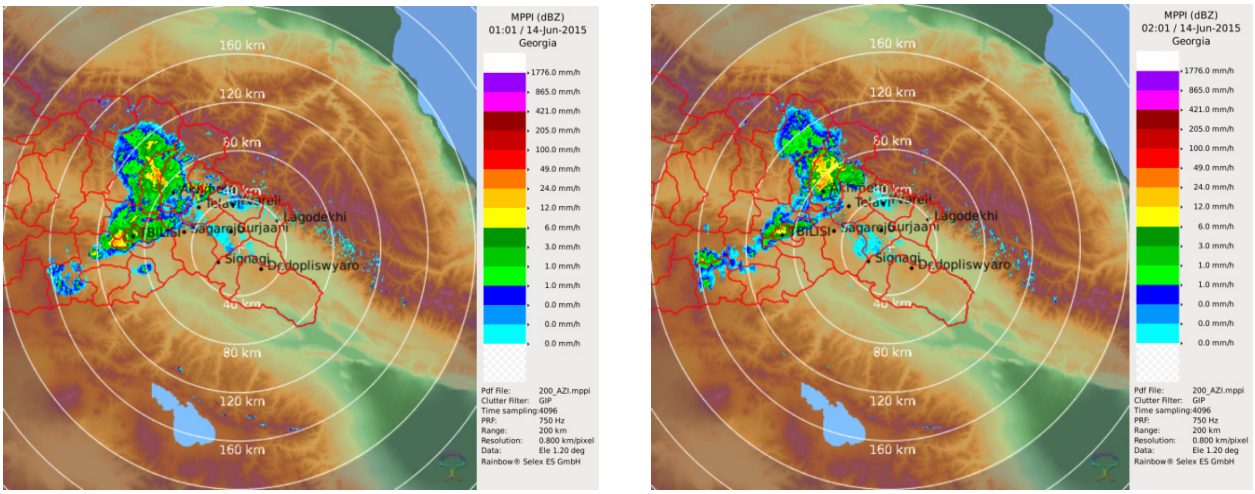


Fig. 4. Data of the Precipitation Intensity in Tbilisi on 13-14 June 2015 in 21:03, 23:27, 01:01 and 02:01 h.

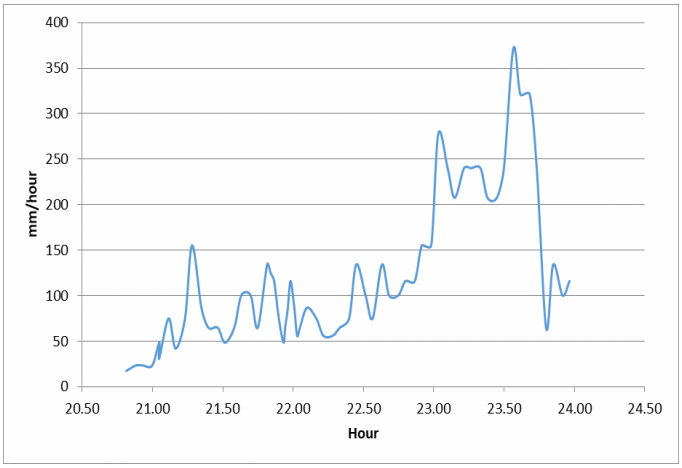


Fig. 5. Change in the Time of Precipitation Intensity Under Zone with the Maximum Radar Reflectivity of the Cloud on 13 June 2015 from 20.82 to 23.97 h.

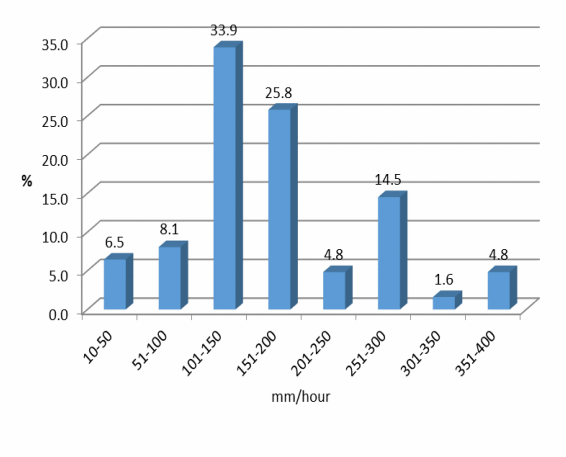


Fig. 6. Repetition of Precipitation Intensity Under Zone with the Maximum Radar Reflectivity of the Cloud on 13 June 2015 from 20.82 to 23.97 h.

Table 2

Statistical Characteristics of the Intensity of the Precipitation of Cloud in the Region of Akhaldaba on 13 June 2015 with 20.82 to 23.97 h. under the Zone with the Maximum Radar Reflectivity (mm/hour).

Parameter	Precipitation	Parameter	Precipitation
Count	62	**St Dev**	81.6
Mean	120.4	**σ_m**	10.4
Min	17.6	**Cv (%)**	67.8
Max	371.4	**As(skew)**	1.2
Range	353.8	**Exc(kurt)**	0.9
Median	100.5	**99% CONF-L**	92.6
Mode	65.0	**99% CONF-U**	148.2

As follows from Table 1 on June 13-14, 2015 are no conditions for the appearance of strong thunderstorms. In Fig. 1. distribution of wind speed and direction above the territory of eastern Georgia at the level 1.0 km according to the radar data on 13 June 2015 in 21:24 h. is presented. In particular, as follows from this figures, over Tbilisi the wind has no definite direction. Accordingly, the cloud is not very mobile (Fig. 2,3).

In Fig. 4 radar data of the precipitation intensity in Tbilisi on 13-14 June 2015 in 21:03, 23:27, 01:01 and 02:01 h. are presented. As it follows from this figures, the rain cloud of almost five hours was located in one and the same place. Precipitation intensity at the separate moments of time was found in the range 17.6-371.4 mm/h. (Fig. 4-6, Table 2). Sum precipitation for 3.15 hour was 379 mm (Fig. 5, Table 2). That's, extreme rain was observed. The prolonged presence of cloud (almost 5 hours) at one and the same place caused catastrophe. Note that in Tbilisi in 1957-2006 the maximum sum of daily precipitation was 130.1 mm [5,11].

Fig. 7. Landslide into Akhaldaba and its Consequences.

In fig. 7 presents images of a landslide in Akhaldaba and its consequences for the infrastructure of Tbilisi city as a result of the subsequent flood.

Conclusion. In addition to anti-hail operations, the radar is planned to be used for monitoring and forecasting hazardous meteorological phenomena. In particular, preparatory work is being conducted on the radar prognostication of landslides caused by intensive precipitation.

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