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The measured kinetic energy of hailstone by radar and hailpads

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Abstract. In this paper we compared hailstone kinetic energy measured by hailpads and weather radar over seeded and unseeded territory. Isocontures of radars reflectivity measured in db (each step of 10 db) transformed in dbz, vere used. Horizontal cross – section of the cloud was measured at the level of 0° C isoterm, over two hailpads networks for the purpose of comparison. The agreement of kinetic energy of hailstone measured by radar and hailpads is 92% in average for selected data.

1 Introduction

A hailpad network has been working in the two province Bosna and Pocerina during the period 15 May – 15 August 1985. One network consists of 49 hailpads distributed homogeneously in an area of 500 km^2. The detailed description of the network, the calibration and the analyses of the pads, as well as some of the results obtained have already been published (Pavlovic Berdon, 1999). The protected area refers to the Pocerina territory, and un protected area is the territory of Bosna. The hailstorms over our territory frequently come from west and northwest direction, and because of that, the hailpad network on the unprotected territory is located in front of the protected area. The other reason is to protect this area against agent contamination. These two areas were hailpads are located, are climatologically similar and relatively near in order to compare the relative data.

The experiment with hailpads network on two different areas was established to verify to hail suppression efficiency.

2 Instruments and methods

The experiment with hailpads was to identify the differences in hail kinetic energy and hailstone spectra on protected and non-protected areas being the estimation of the hail suppression effects. In this paper S-band radar and hailpad data are compared over the both territory.

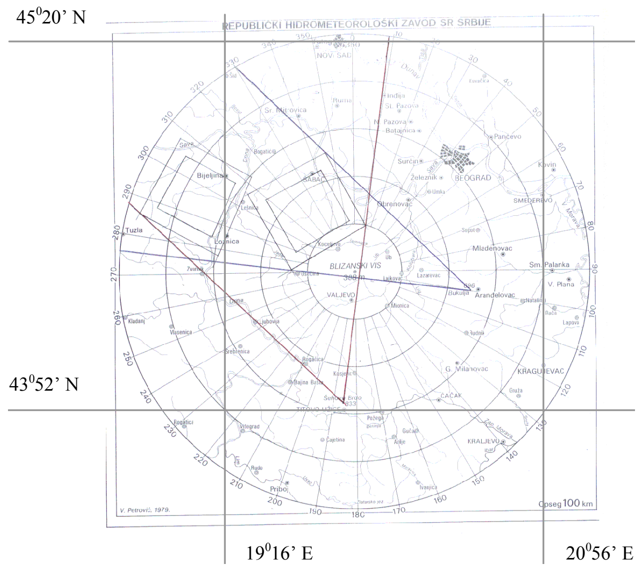

Fig. 1. The location of radars.

Republic Hydrometeorogical Service of Serbia started its hail suppression activity in Serbia from 1967. year. During 1985. the hail suppression system covered 96% (37 610 km^2 of the agricultural area in Serbia (except the north part called Vojvodina). There was a network of 13 hail suppression centers equipped with MITSUBISHI RC-34A weather radars. There were 1415 launching stations on the protected area, from which hail suppression rockets were launched, depending on radar and aerological criteria. We used hail suppression rockets with vertical range of 8 km, and 5 km, which carried 20% AgI seeding material having the efficiency of 10^{12}–10^{13} of active particles, per gram of Silver Iodide, and the quantity of 400 g of agent.

The hailpads consist of a foam rubber plate. The dimensions of the pads are 0.20 m × 0.20 m × 0.02 m. The hail-

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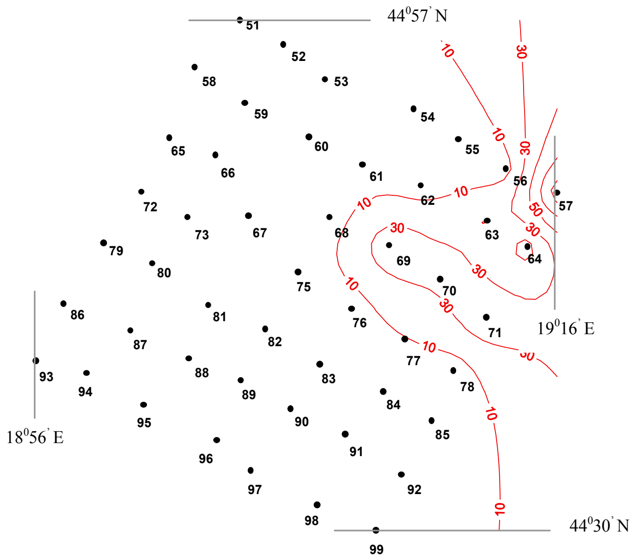

Fig. 2. BOSNA, Kinetic energy (J/m^2) measured by the hailpads on 8 June 1985.

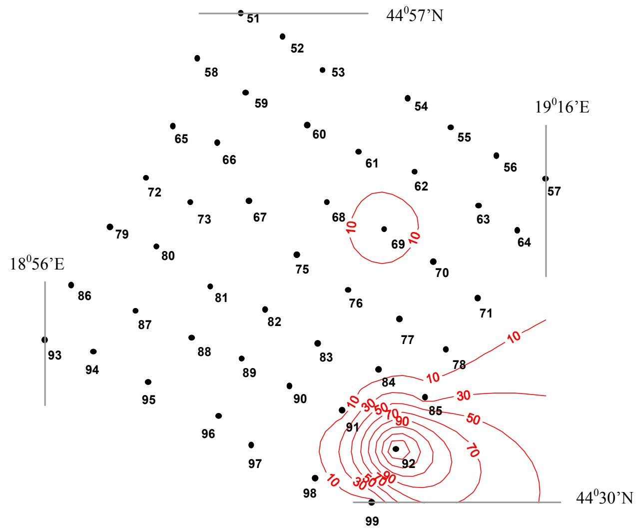

Fig. 4. BOSNA, Kinetic energy (J/m^2) measured by the hailpads on 17 July 1985.

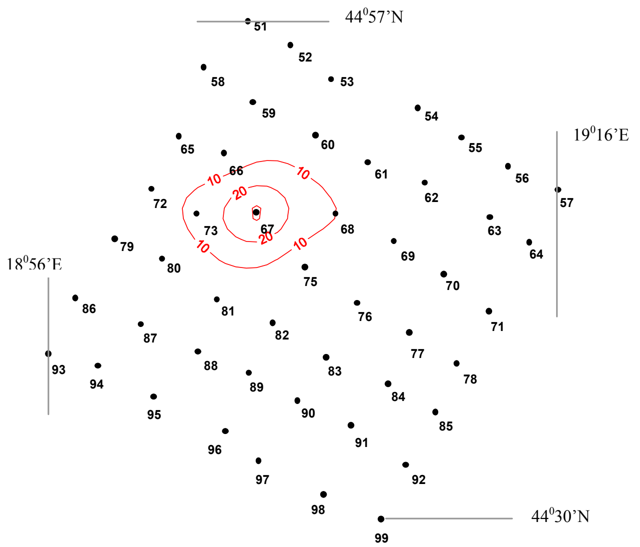

Fig. 3. BOSNA, Kinetic energy (J/m^2) measured by the hailpads on 23 June 1985.

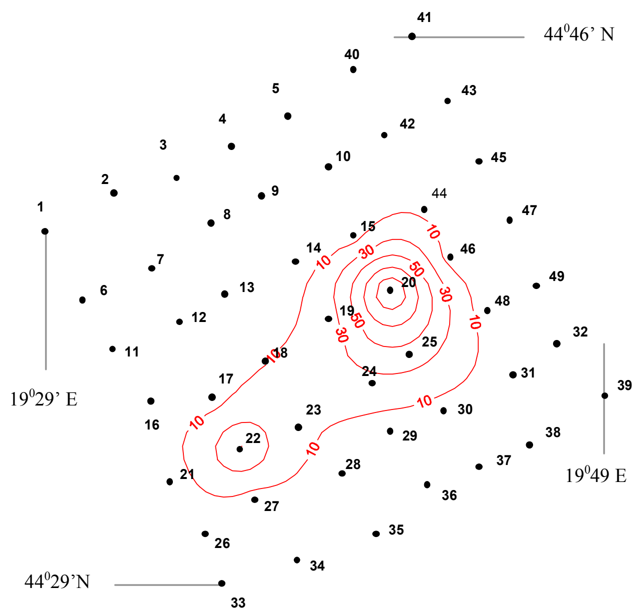

Fig. 5. POCERINA, Kinetic energy (J/m^2) measured by the hailpads on 17 July 1985.

pads are installed on a pole 1m above the ground. The kinetic energy E (J/m^2) measured by a hailpad is obtained from the number of hailstones n_i (m$^{-2)}$ in the diameter intervals ΔD_i with mean diameter D_i (mm) according to

$$E = 4,58 \times 10^{-6} \sum_{i=1}^{p} n_i D_i^4$$

where index p denotes the number of diameter intervals used. The global kinetic energy Eg of a hailfell is defined as the sum of all the kinetic energies measured by hailpads hit by one hailfell. In hailpad network at each point, besides the hailpads, there were rain gauges and observers in order to record rainfall and hailstones on the ground, as well the time of occurence of these events quantities and intensities. The hailpad data were analyzed later on, and compared with radar data.

In this project we have weather radar MITSUBISHI RC-34A production in solid state tehnology S-band. It is used for the detection hail clouds. It is equipped with PPI,RHI and A/R displays indicating angular and vertical cut and the target distance for the amplitude of reflcted signals. It has several types of light markers and operational ranges. The beam width is 2 degrades, output power 400 kW, anntena rotation speed is 6 revolutions per minute, ranges are 25, 50, 100 and 250 km and the azimuth, elevation and range readout is digital.

In this project we used 3 radars lounted at the Vljevo,

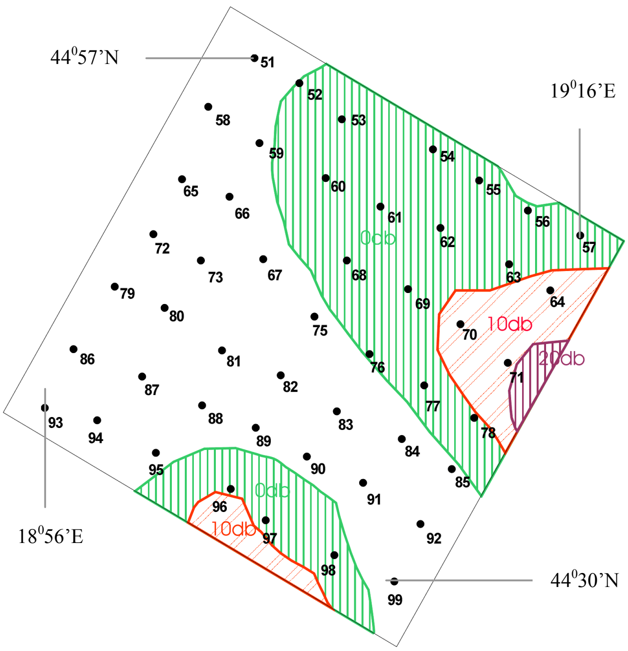

Fig. 6. BOSNA, Radars reflectivity in db on 8 June 1985.

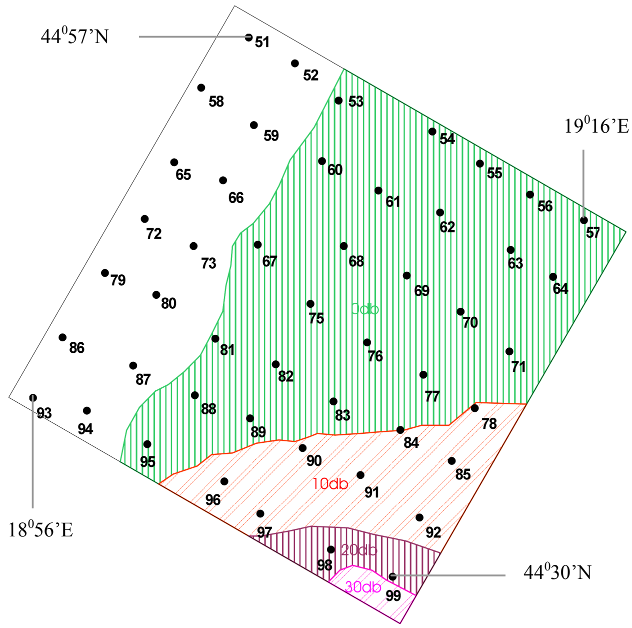

Fig. 8. BOSNA, Radars reflectivity in db on 17 July 1985.

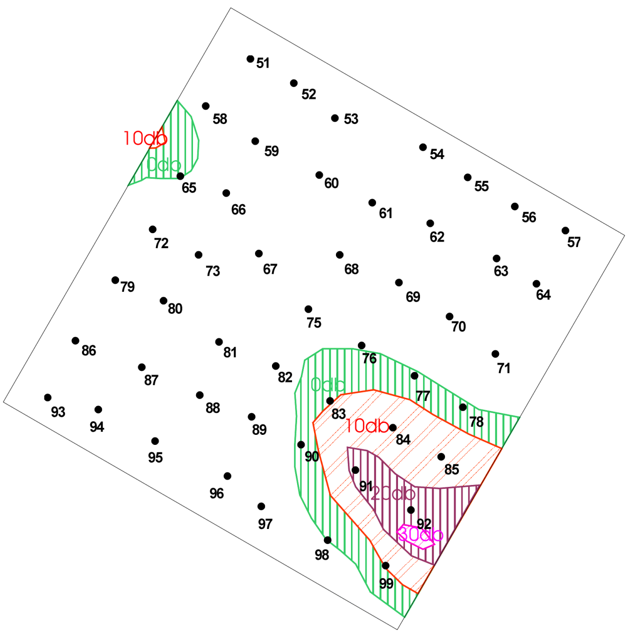

Fig. 7. BOSNA, Radars reflectivity in db on 23 June 1985.

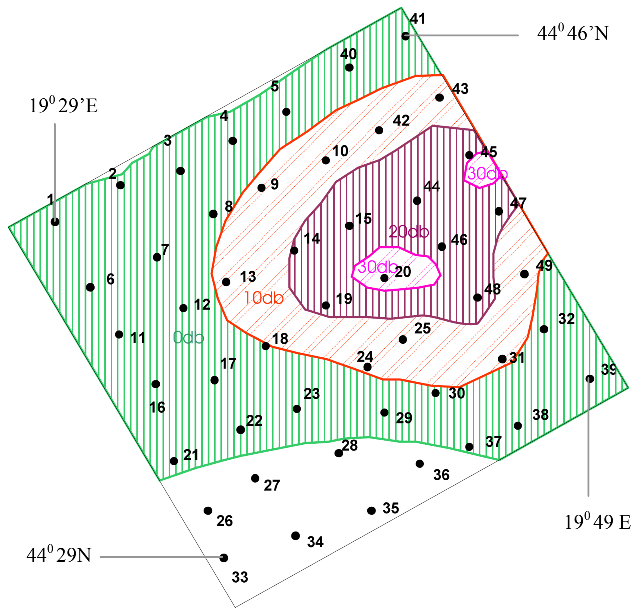

Fig. 9. POCERINA, Radars reflectivity in db on 17 July 1985.

Bukulja and Uzice and the largest distances between the radar and a pad was less than 40 km (Fig. 1).

Radar charts were made mannually and cloud cross sectins were given at the level of 0° C isotherm hight.

The Ze value of the corresponding PPI element was displaed in digital form end manualy drawing togedther with the stopped isoecho contours on the PPI screen on times per 3 min. The radar reflectivity values are transformed into kinetic energies by means of empirical Z-E realations optained from measured time-resolved hailstone spectra (Table 1).

3 Results

The analyses performed in this paper is the first attempt to deal with kinetic energy of hail measured by radar in our country. The data of four severe hailstorms (8 June, 23 June and 17 July 1985) are studied and the following results are obtained: the agreement of data in space, time and the values of kinetic energy of halifells. The agreement in space and time we can see from the Figs. 2 to 9. The Figs. 2 to 5 show kinetic energy calculated by hailpads. On Figs. 6 to 9 we show the radar reflectivity in db for the same data.

Table 1. Comparison of hailpad and radar data

BOSNA						
data	km^2	t (min)	Eg (10^6jM$^-2$)	>dbz	Ec (10^6Jm^{-2})	Eg/Ec(%)
08 June 1985	4.52	5	2,432.79	45	2,768.25	88%
23 June 1985	1.39	3	604.62	55	602.85	100%
17 July 1985	3.77	4	2,078.28	55	2,184.34	95%
POCERINA						
17 July 1985	11.10	2	1,904.67	55	1,607.61	84%

4 Conclusion

In Table 1 we can see the values of kinetic energy calculated by radars measurements and by hailpads data which show the agreements of data in 92%.

We are sure that if we analyzed the more number of data it will be possible find to the boundary between rain and hail measured by radar reflectivity. This is significant as a criterion for successful treatment of hail of clouds. Determination of kinetic energy of hilstone is also important in objective analyzes of plant damage degree.

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