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Experiment for the radar estimation of precipitation in Serbia

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Abstract. In Serbia are in operational use 10 meteorological radars MITSHUBISHI RC 34-A and 3 GEMATRONIC radars in hail suppression system. Usage of this powerful and expensive technical means only for single purpose is not economic and now is preparing an experiment for radar estimation of precipitation quantity. In this job will be presented design of the experiment with methodology and targets.

1 Introduction

By its nature, precipitation is very variable meteorological element concerning spatial and time distribution. This fact requires a very dense station network and short observation intervals. Such a network exists (network of precipitation stations), but it is inaccurate, unreliable, limited and without any perspective. In a meteorological and hydrological observing system, the biggest actual problem is the lack of information concerning the precipitation intensity and quantity in real time. Researches connected to the application of weather radars in meteorology have quickly shown that they could be used to monitor the development and moving of weather storms producing storm winds, rain showers and floods, sometimes delivering hail. It has also been proved that weather radars can measure with high accuracy the intensities and quantities of precipitation over a certain area.

In the late seventies, the Republic Hydrometeorological Service of Serbia acquired twelve RC34A Mitsubishi weather radars for the needs of hail suppression. Lately, significant measures have been taken in order to upgrade the radar network in Serbia. Digitalization and automation of Mitsubishi radars was performed. There is a plan to network all the weather radars, three new latest Doppler radars Gematronik 400 SLP 13 were acquired, one of them with a dual polarization (see Fig. 1). All these fulfill the necessary conditions to create the radar network that up to now was used in hail suppression only. Now, this network can become the basis of a modern multi-purpose informational meteorological system. Such a system will be able not only to present a variety of significant information in real time, but also to improve the weather forecast and issue warnings on all dangerous meteorological and hydrological events on the territory of Serbia.

The first step to realize this important goal refers to the radar measurement of precipitation intensities and quantities. The methodology used has been studied all over the world and is operationally used in many countries. These studies and experience acquired in practice have shown that methodology of radar measurements of precipitation cannot be applied in all areas. Besides technical characteristics of the radar, the methodology depends on circulation dynamics and raindrop spectrum, as well as the topography of the terrain, cloud types and evaporation of drops delivered from the cloud. An experiment has been planned that will enable radar measurements of precipitation in Serbia with satisfactory accuracy.

2 Design of the experiment

The primary goal of this experiment is to establish and make necessary researches in the areas with different geographic and physical conditions. Successful accomplishment of this goal will enable to establish a system of radar measurements of precipitation over the whole territory of Serbia and get the data on intensity and quantities of precipitation in real time, for the whole territory of Serbia.

To perform necessary researches, three typical areas were chosen and described in details. Then, a classification of clouds was proposed with different drop spectra in order to get the most accurate algorithms. The precipitations were classified in corresponding categories in accordance to the types of precipitation clouds.

2.1 Criteria for the choice of experimental areas

From previous investigations of radar measurements of precipitation performed in the world, it has been concluded that the coefficients in radar equation for the same type of the

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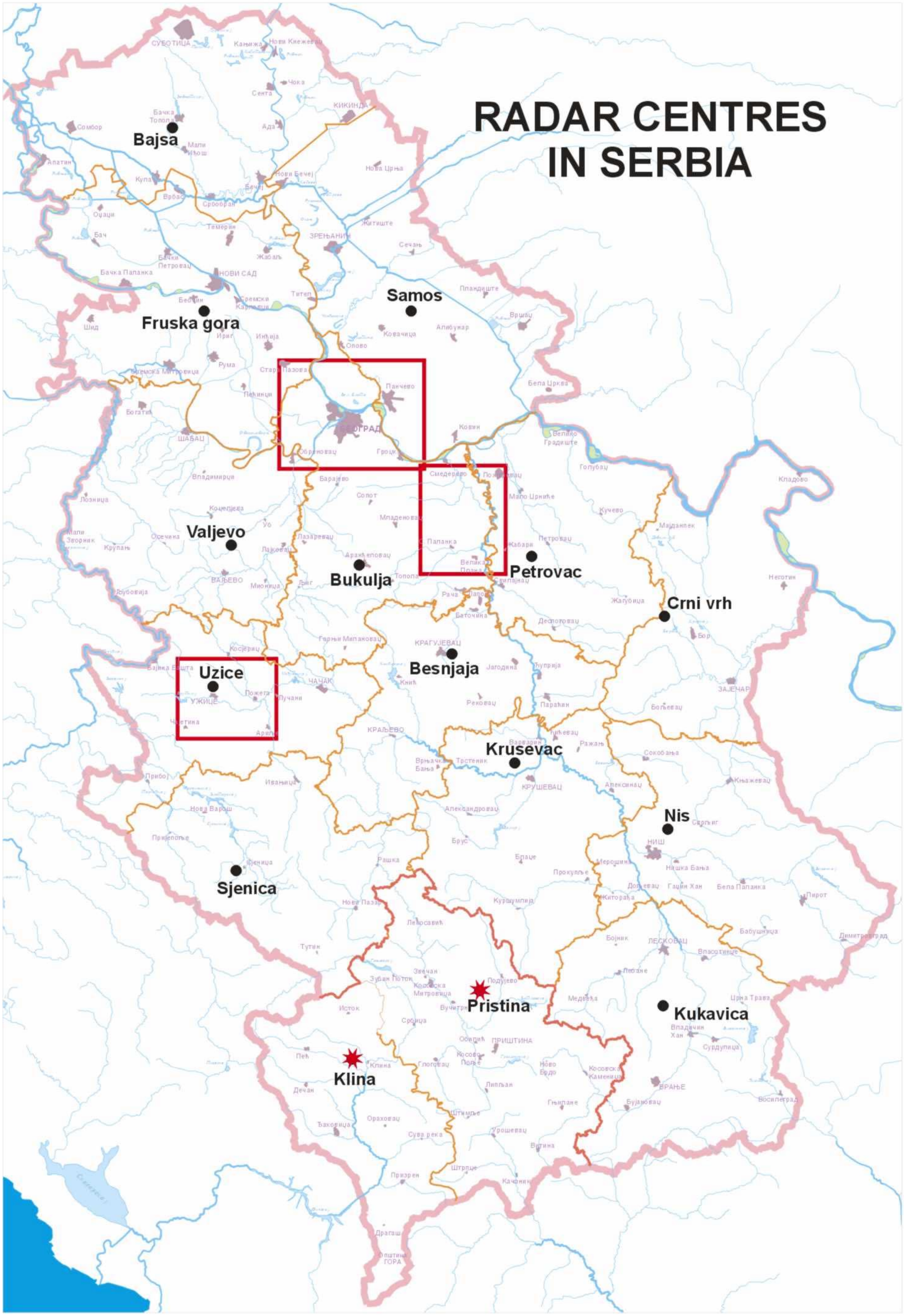

Fig. 1. Radar centers in Serbia and experimental areas: urban area (A), the flat terrain area (B) and the hilly area (C).

cloud differ significantly in flat and hilly regions (Harrold et al., 1974). There are two basic reasons for that: (1) In hilly regions, there is a special dynamics of updraft, downdraft and eddy circulation influencing the change of drop spectrum and precipitation distribution on the ground; (2) Distance between cloud base and the ground is often much lower in hilly than in flat regions, so the raindrop evaporation in hilly regions is significantly lower.

From the above-mentioned reasons, there are two extreme characteristics of precipitation distribution in hilly terrains.

The first characteristic represents the increase of precipitation quantities with height and the second one is significantly higher precipitation quantity on the lee side of the mountain at the same altitude above sea level.

Recent studies of urban climate have shown significant differences in precipitation quantities between the cities and their surroundings. Thus, for example, it has been concluded that annual precipitation quantities in Belgrade are 17% higher in average than the quantities in its surrounding (Unkasevic, 1994). The main reason for increased precipitation quantity in cities might be the incomparably higher number of condensation nuclei than in the city surrounding.

From before said reasons, it results that it should be necessary to make the researches in three experimental areas in order to establish the algorithms for radar measurements of precipitation. These areas are: urban, flat and hill regions. In numerous researches performed up to this moment, the areas with different values were used in the world. However, Browning (1978) showed that the optimal and most rational way is to use the area of 1000 km^2 with two precipitation stations to do the calibration. The most favorable range of the area location to the radar location is 20 to 100 km. The network of precipitation stations should be as dense as possible and to perform reliable 24 hours precipitation measurements. Automatic pluviometer stations that are used for calibration of radar measurements should record 5-minutes and hourly precipitation quantities.

Finally, when choosing the criteria for the choice of experimental area, it should be taken into consideration the fact that the area should be located in the range of at least two radar centers that would simultaneously perform the measurements.

2.1.1 Urban experimental area

Belgrade is the largest urban area in Serbia and it should be used in these researches. This area of about 1000 km is limited by the meridians 20° 15′ E and 20° 43′ E (about 36 km) and parallels 44° 42′ N and 44° 57′ N (about 28 km). In city network, there are two principal meteorological stations with pluviographs and hourly observations performed by the professional observers. These are: the Meteorological Observatory in Belgrade (132 m above sea level) and the Meteorological station at Belgrade Airport in Surcin (96 m above sea level), outside the urban settlement. These two stations should be contemporary the calibration stations for the radar precipitation measurements in this experimental area. Comparison of the coefficients in the radar equation for the $Z-R$ relation should indicate the effect of the urban area to the precipitation.

The Radar Center Samos should be the authorized radar center for the radar precipitation measurements for the urban experimental area Belgrade. It is about 40 km far from this area. The Radar Center Fruska Gora is the other radar that should perform the measurements in this urban experimental area. It is considered the auxiliary radar center for this area and is about 60 km far from this area.

2.1.2 The flat terrain experimental area

One of the most convenient areas in Serbia to become the flat terrain experimental area is the lower course of the river Velika Morava. This area is limited by the meridians 20° 50′ E and 21° 10′ E (26 km) and parallels 44° 20′ N and 44° 40′ N (37.5 km). The competent radar center for the precipitation measurements in this region would be the Radar Center Petrovac (about 20 km far from this experimental area), and the auxiliary one would be the Radar Center Samos (about 70 km far from the target area).

The first calibration station in this area should be the principle meteorological station in Smederevska Palanka (121 m above sea level) and the second one, the meteorological station in Pozarevac. Beside these two stations, all precipitation and other meteorological stations within this area should be included.

2.1.3 Hilly experimental area

Major parts of the territory of Serbia are the hills and mountains, so it is necessary to study radar precipitation measurements in order to get the corresponding algorithms for such areas. Having in mind the locations of the radar centers, as well as the location of principle meteorological stations and the configuration of the terrain, it seems that the most suitable area will be the one near the mountain Zlatibor.

The hilly experimental area will be limited by the meridians 19° 44′ E and 20° 10′ E (33.5 km) and parallels 43° 44′ N and 44° 00′ N (30 km). The calibration stations will be the principle meteorological station at Zlatibor (1029 m above sea level) and the principle meteorological station in Pozega (311 m above sea level). The difference in altitude should indicate to the change of radar equation coefficient with height. It should also be indicated that the stations on the flat terrain with the similar altitude above sea level, such as Pozega, Smederevska Palanka, Pozarevac and Surcin have approximate coefficient values in case some other geographic, climatic and dynamic factors do not play a significant role.

Hilly experimental area in the region of the mountain Zlatibor should be under the control of the Radar Center Besnjaja and the auxiliary radar center will be Sjenica. Both radar centers are about 7o km far from this experimental area.

2.2 Classification of clouds and precipitations

From previous investigations of radar measurements of precipitation performed in the world, it has been concluded that the coefficients in radar equation differ significantly for different drop size distribution. Drop size distribution is related with type of clouds. From the above-mentioned reasons the precipitations were classified in corresponding categories in accordance to the types of precipitation clouds.

2.3 Methodology of the experiment and data processing

Methodology of performing the experiment, as well as the data processing, is presented in the paper (Radinovic and

Kostic, 1997). During the experiment three base type of data will be collected: intensity of the radar reflectivity Z, echo top of clouds and rate of precipitation on the ground. These data will be processed by statistical methods for each experimental area and for each type of clouds. The results will be tested with corresponding statistical tests.

3 Conclusion

The main objective of these researches was to establish the algorithms for radar measurements of precipitation in different areas and different clouds through a well-planned experiment and performed studies. These algorithms should enable to determine the intensities and precipitation quantities on the ground by using the radar parameters. It is expected that all necessary organizational and technical preparations in order to realize this experiment will be finished during 2002 and the experiment itself will start in 2003.

References

Battan, L.J., 1973: Radar observation of the atmosphere. The University of Chicago Press, Chicago, III, 324 pp.

Browning, K.A., 1978: Meteorological application of radar. Rep.Prog.Phys., 41 pp.

Clift, G.A., 1981: Report on meteorological radars. Instruments and observing methods. Report No.8, WMO, Geneva.

Collier, C.G., 1977: Radar measurements of precipitation. Papers, WMO Tech.Conf. on Instr. and Methods of Observation, 202-207.

Collier, C.G. and P.R.Larke, 1978: A case study of the measurement of snowfall by radar; an assessment of accuracy. Quart. J. Roy. Met. Soc., 104, 615-621.

Collier, C.G., P.R. Larke and B.R. May, 1983: A weather radar correction procedure for realtime estimation of surface rainfall. Quart. J. R. Met.Soc., 109, 589-608.

DWRP (Dee Weather Radar and Real-Time Hydrological Forecasting Project), 1977: Final Report. Central Weather Planning Unit. Dept. of the Environment, Reading.

Gorgucci, E. et al., 1995: Radar and surface measurment of rainfall during CaPE: 26 July 1991 Case Study. J. Appl. Meteor., 34, 1570-1577.

Harrold, T.W., E.J. English and C.A. Nicholass, 1974: The accuracy of radar derived rainfall measurement in hilly terrain. Quart. J.R. Met.Soc., 100, 331-350.

Radinovic, Dj. and M. Curic, 1985: O mogucnosti racionalnijeg organizovanja, efikasnijeg funkcionisanja i visenamenskog koriscenja sistema odbrane od grada RHMZ Srbije.

Radinovic, Dj. and A. Kostic, 1997: Studija Radarsko merenje padavina u Srbiji, RHMZ Srbije Beograd.

Siegel, S., 1959: Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Company, Inc., New York, 312 pp.

Stepanenko, V.D., 1966: Radiolokacija v meteorologii. Gidrometizdat, Leningrad, page 350.

Unkasevis, M., 1994: Klima Beograda. Naucna knjiga, p. 122.

Wilson, J.W. and E.A. Brandes, 1979: Radar measurement of rainfall-a summary. Bull. of Amer. Met. Soc., 60, 1048-1058.

WMO, 1985: Use of radar in meteorology.Tech.Note No.181, 90 pp.

Zrnic, D.S., 1996:Weather radar polarimetry-Trends toward Operational applications. Bull. Amer.Meteor.Soc., 77, 1529-1534.