

Lightning Activity in Rain and Hail Bearing Thunderstorms over Bulgaria

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I. INTRODUCTION

Several studies show that there is an apparent relation between lightning activity and microphysical and dynamical characteristics of thunderstorms. However the conclusions based on the investigations conducted in different geographical regions are often contradictory (e.g. Soula et al, 2004).

The aim of the present work is to study if there is a correlation between evolution of CG flash rate and radar reflectivity related to hail and rain producing clouds. The work is directed to reveal whether measurements of lightning activity over Bulgaria provide useful information for an improvement of nowcasting of occurrence of large hail caused damage on the ground.

II. PRESENTATION OF RESEARCH

The results of the combined analysis of lightning activity and radar data as a function of time in three multicell and one supercell thunderstorms developed over Bulgaria are presented. The analysis is carried out for different type of precipitating convective clouds: producing rain, small and large hailstones. Two thunderstorms that developed on 1 June 2008 are analysed. One of them denoted by MCR produced rain and the other denoted by MCH produced small hailstones (size up to 0.5 cm) on the ground. On 30 May 2009 a supercell thunderstorm, denoted by SSCH and on 02 June 2009 a multicell thunderstorm, denoted by SMCH produced heavy rain and hailstones with diameter reaching 6 cm. The lightning parameters (location, polarity, flash rate, FR and peak current) are taken from the LINET network. Radar information (maximum radar reflectivity, Max ref (dBZ); heights of 15 dBZ and 45 dBZ - H15 and H45 respectively; height of Max ref, Hmax ref) is obtained by radar MRL5-IRIS (λ 10cm) observation from Hail Suppression Agency in Bulgaria. The height of zero isotherm H0°C, of -10°C, H-10°C, and -20°C H-20°C are taken from aerological sounding.

III. RESULTS AND CONCLUSIONS

The analysis shows (Table 1) that the mean and maximum values of the flash rate (number of flashes for 5 min), FR is lowest for rain producing thunderstorm MCR and it is highest for severe multicell thunderstorm SMCH. The higher lightning activity in more intense multicellular thunderstorms is in agreement with the results in other studies and can be linked to the intensification of the updraft which favours both electrification of the cloud and the probability of severe weather (Williams, 2001). However the average and maximum values of FR in severe supercell storm SSCH are similar to FR in MCH. There is no significant difference in mean values of peak current in the four studied thunderstorms (see Table 1), while the max

values of peak current is highest in SMCH and it is lowest in MCR.

	Flash rate (5min)		Peak current [kA]	
	mean	max	mean	max
MCR	2.9	7.0	22.7	56.8
MCH	7.5	24.0	23.7	96.8
SMCH	57.2	143.0	12.8	141.2
SSCH	10.0	26.0	18.7	80.0

TABLE 1: Mean and max values of FR and Peak current for the studied thunderstorms

Fig. 1 gives an idea for the evolution of FR and radar information for the studied thunderstorms. The FR in the severe storms during period of intensive large hail on the ground is denoted by darker columns on Fig.1.

The FR in the multicell storm MCR producing only rain is highest when the maximum radar reflectivity is 35 dBZ, while in hail multicell storms the maximum values of FR are reached at higher radar reflectivity – 45 dBZ for MCH and 60 dBZ for SMCH. In the supercell thunderstorm SSCH FR is highest at Max ref between 45 and 50 dBZ. In the four studied storms FR achieves max values after the time of maximum radar reflectivity, i.e. when Max ref starts to decrease. It seems that the more intensive is a multicell storm the higher is the Max ref at which FR reaches maximum values. From Fig. 1 it is also visible that the flash activity period is longer at higher flash rate. This result coincides with conclusion in Baughman and Fuquaay, 1970. The established in other studies (Williams et al, 1999) high peak in the flash rate prior to the severe weather event is well pronounced approximately 40 and 20 minutes before the first and the second event with intensive large hail on 2 June 2009. There is also a peak in FR 10 minutes prior to large hail from supercell storm on 30 May 2009. It is interesting to note that the highest peak of FR is detected almost 90 min before falling of large hailstones on the ground from SMCH.

In rain MCR (Fig. 2 upper left panel) and severe supercell SSCH (Fig. 2 lower right panel) thunderstorms there are no flashes in the area of maximum radar reflectivity, while in the ordinary hail storms MCH (Fig. 2 upper right panel) and severe multicell storm SMCH (Fig. 2 lower left panel) several lightning were detected in the location of maximum radar reflectivity.

	Peak current [kA]			
	mean		max	
	+CG	-CG	+CG	-CG
SMCH	12.8	12.8	141.2	82.3
SSCH	25.5	17.4	80	64.5

TABLE 2: Mean and max values of Peak current of +CG and -CG

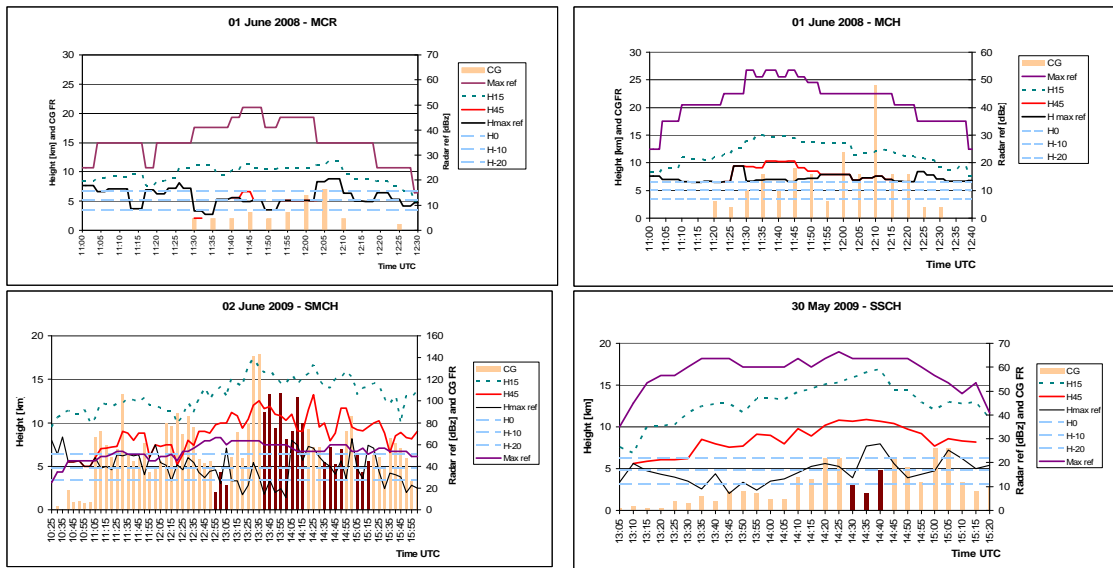


FIG.1 Number of flashes for 5 minutes, **FR** and radar information as function of time for the studied thunderstorms. The **FR** in the severe storms during period of intensive large hail on the ground is denoted by darker columns

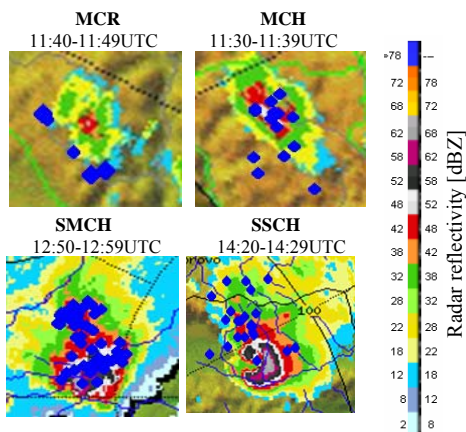


FIG.2 Location of flashes and radar reflectivity during the time of max radar reflectivity

The analysis of lightning polarity in severe supercell storms reveals that the ratio of positive (+CG) to negative (-CG) flashes is less than 0.3, i.e. the negative flashes prevail the positive ones during SSCH life. However the average and maximum values of +CG peak current are higher than those of -CG peak current (Table 2). The SMCH is characterized by abundance of positive flashes with higher maximum values of peak current than of -CG peak current (Table 2). The ratio +CG/-CG varies between 0.5 and 1.5 during the severe events. It is highest ≈ 90 min prior to the first period of intensive hail caused damage on the ground (Fig.3).

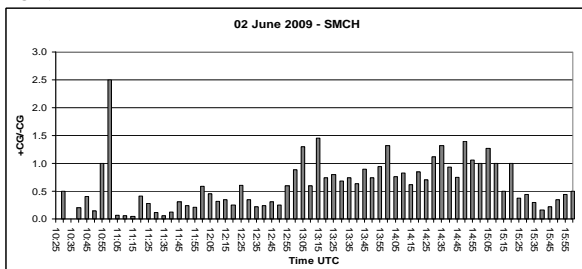


FIG.3 The ratio of positive to negative flashes in SMCH

The present study reveals that most of lightning activity features of thunderstorms developed over Bulgaria is similar to lightning activity in other geographical regions. The established peak in flash rate and the prevalence of positive flashes above negative prior to the severe event indicate that lightning activity information can contribute to improvement of nowcasting of occurrence of intensive large hail from multicell storm. For firm conclusion lightning characteristics in several multicell thunderstorm has to be analysed.

IV. AKNOWLEDGMENTS

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V. REFERENCES

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