RECENT SEVERE RAIN/HAIL STORMS AND SEVERAL TORNADO EVENTS IN BULGARIA (2001-2008)

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1. INTRODUCTION

This research contains two parts. The first one is an extended study of rain/hail/wind –severe convective storms (SCS) classified as Small-Scale Weather Phenomena (SSWP) that normally occur in the warm half of the year (April-September). The study covers the period 2001-2008. The second part consists of analysis and classification of five tornado events that occurred between 2006 and 2009. The research approach for the analysis of the tornado cases is similar to that used in Simeonov and Georgiev, 2003. The aim is to contribute to the country's long-term set of tornado events like in Dessens, 1989; Dotzek, 2001; Sioutas, 2003, and to enrich the European tornado data base (Dotzek, 2003).

II. RESEARCH APPROACH

In this work the analyzed SCS are selected on the basis of criteria defined and used in Simeonov et al., 2009. They are applied for the identification of extreme values and space-dissemination of database of the NIMH and are as follows:

- total precipitation amount $Q \geq 30$ and $Q \geq 60$ mm/24 h;
- thunderstorm/hailfall events, registered at least in 4 or more provinces;
- wind speed ≥ 20 m/s.

Meteorological data from for 131 meteorological and 244 precipitation stations were processed by program procedures. They are from the warm half of the year for the period 2001-2008.

The selected convective storm days are separated into five classes:

A - days with $Q \geq 30$ mm and thunders (Ts), with or without hailstorm (Hs);

B - days with $Q \geq 30$ mm and thunders (Ts), with hailstorm (Hs);

C - days with $Q \geq 30$ mm and thunders (Ts), with or without hailstorm (Hs), and wind ($w \geq 20$ ms^{-1});

C2 - days with $Q \geq 30$ mm in ≥ 8 stations, Ts in all stations, hail in more than 4 station, $w \geq 20$ ms^{-1} (with or without tornado), sup severe events.

D – as C2 but days with $Q \geq 60$ mm.

The frequency of the days with torrential rainfall ($Q \geq 60$ mm/24h), extended Ts and hailfall, and $w \geq 20$ ms^{-1} have been analyzed separately.

Case-study analyses on five stormy days with six tornado events were carried out. The work required the use of meteorological, synoptic and aerological data, radar records, expert inquiry, and media information. The set of environmental parameters describing the state of the troposphere is calculated using the same method as in Simeonov and Georgiev, 2003. The sounding data most representative for the storm location have been used. The radar records from suitable position (Gelemenovo, airports-Sofia and Varna) are used for the analysis of the storm characteristics and structure.

An attempt for tornado classification according to Fudjita scale is made. The tornado's environment characteristics have been used. The synoptic analysis suggests there is one typical structure that favors the development of tornados. It is a deep trough or a detached cyclone system to the west of the Balkans so that the frontal jet goes through Bulgaria from southwest to northeast. Thus the generated convective systems are forced to migrate rapidly northeastward and this provides the Coriolis effect to take place and strengthen the tornados below the convective clouds. This is the type of events 1, 3, 5, and 6 from TABLE 1 and to some extend event 4. Event 2 develops in the context of a detached cyclone centered to the south of Bulgaria. The dominant flow over the country therefore is from the northeast.

III. RESULTS AND CONCLUSIONS

The statistics of the thunder/rain/hail/wind storms divided into 5 classes is presented on Figure 1. The maximum occurrence among all 473 stormy days was in 2005 (81 days). The number of severe storm days (class C2) is 15 and heavy rain days (class D) is 7. In the summer of that year there were floods which caused damages and victims. One can notice some increase of the days in categories C2 and D in the recent 4 years compared to the previous 4 years.

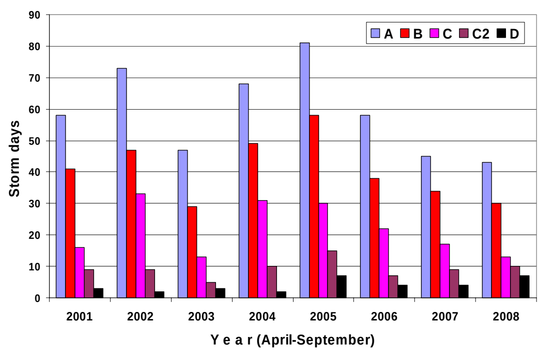

FIG. 1: Statistics of the clasified stormy days from 2001 to 2008.

The five analized damaging tornadoes developed in 2006-2009 period. FIG. 2, 3, and 4 illustrate them. TABLE I and II give their characteristics and clasification. The radar image presented on Fig. 2 shows bow echo (Oprea and Bell, 2009) in the maximum stage of storm development. The maximum sizes of observed hailstones for the tornado cases were from 1.5 cm for case No.1 to 8 cm for case No.5A.

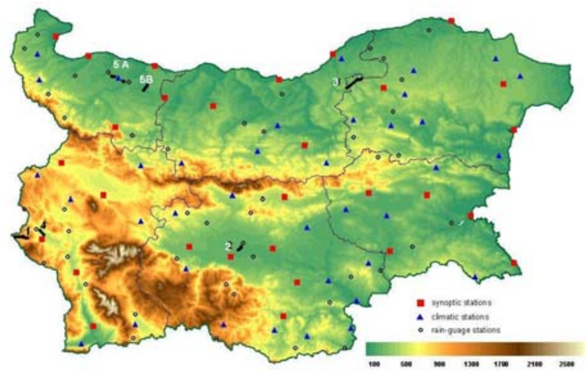

FIG.2. Locations of six tornadoes: 2006 Bobeshino (1); 2007 Kalekovetz (2); April 2008 Kostandenets (3) and July 2008 Kjustendil; 2009 Hayredin (5A) and Tarnava (5B).

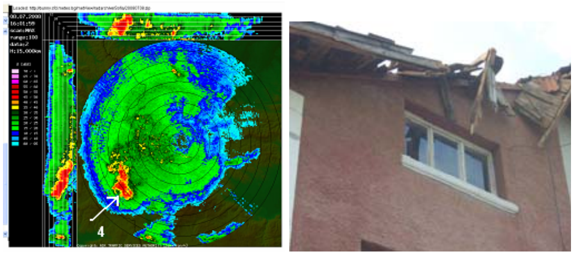

FIG.3. 08 July 2008 1602 UTC CAPI image of Kjustendil tornado (4) produced by Gematronik C-band radar in airport Sofia and the broken roof of NIMH Building.

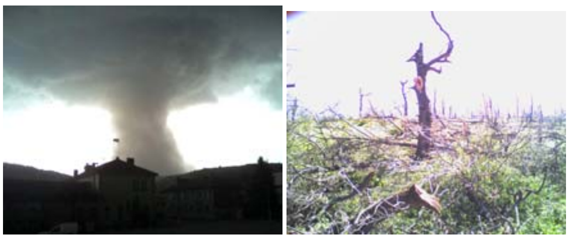

FIG.4. 22 April 2008 1300 UTC: The funnel of tornado (3) near to Konstandenets village and uprooted trees.

TABLE 1: Main tornado characteristics obtained by visual and radar observations in Bulgaria

No	Date	Time UTC	Max radar echo dBZ	Cloud top km	Max. wind speed ms^{-1}	Path L km	Path W m	F-scale
1	2 June 2006	0520	52	12.7	25	6	60	F1
2	21 May 2007	1320	50	11.5	>20	3	450	F1
3	22 April 2008	1355	63	13.1	29	15	30	F2
4	8 July 2008	1602	55	12.8	27	2	40	F0
5	2 June A 2009	1558	62	15.0	>35	14	100	F2
6	2 June B 2009	1335	62	15.1	35	3	80	F2

TABLE 2. Instability charcteristics of the throposhere, obtained by the Sofia sounding which is closest to the 5 tornadic storms location.

Index	Unit	2006 06.02 0000 UTC Belgrad	2007 05.21 1200 UTC Sofia	2008 04.22 1200 UTC Bucha-rest	2008 07.08 1200 UTC Sofia	2009 06.02 1200 UTC Sofia
DTm	°C	7.3	11.1	17.7	19.7	12.6
S_{DT75}	°C	8.4	15.8	19.9	19.8	16.4
S_{DT754}	°C	10.6	26.0	36.1	36.0	28.4
w_{max}	m/s	13.7	19.6	26.0	26.8	19.8
Z_{wmax}	km	4.2	10.0	10.3	10.5	8.4
Z_{EL}	km	9.2	12.0	12.8	13.5	12.6
E_i	J/kg K	1597	3421	5387	5518	3712
R_E	ratio	0.38	0.68	0.77	0.78	0.72
Δv	m/s	25	0	29	15	20
TT	°C	42.5	71.8	54.4	75.4	75.3
K	°C	25.3	48.5	19.5	61.3	54.2

The analyzed cases will enrich the database of severe storm events and can be used for further improvement of techniques and practices for severe weather warning forecasting.

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