# Long-Term Variability and Distribution of Thunderstorms in Non-Mountainous Regions of Bulgaria (1961 – 2010)

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## I. INTRODUCTION

Thunderstorm power supplies important information about the intensity of atmospheric convection. Lightning activity itself or as a part of severe convective storms are investigated by many authors for different parts of the world (Horvath and Geresdi, 2001; Bielec-Bakowska, 2003; Price, 2008). A great number of studies of the relationships between thunders and precipitation amounts have been presented during the last decade (Kandalgaoncar et al. 2005; Katsanos et al., 2007; Bielec-Bakowska and Lupikasza, 2009; Petrova et al., 2009).

In the last years there have been many studies of the relationships between lightning activity and different precipitation on the limited areas of the territory of Bulgaria. They were connected basically with estimation of different aspects of hail occurrence, intensity and others (Simeonov and Georgiev, 2003; Dimitrova 2009).

Commonly the severe convective storms are not only attended by heavy rain events, but also by hail and thunderstorm activity, which on their own account cause material damages and life loses. According to Bulgarian Agency of Civil Defence the mean annual numbers of victim of thunders increased during the last years and are about 10/per year. So are the thunderstorms over Bulgaria became more often or more violent recently, or both? This study presents a variability and distribution of thunderstorms in non-mountainous regions of the country. Actually it is the first climatological study which concerns the recent annual and monthly lightning and thunders distribution and variations over the whole territory of Bulgaria after the work of Simeonov et al., 1989.

## II. DATA AND INVESTIGATION METHOD

The study was carried out on the basis of meteorological data concerning thunderstorm occurrence for 42 climatological stations from the meteorological network of the Bulgarian National Institute of Meteorology and Hydrology (NIMH) for the period 1961–2010 (Fig.1). These stations are representative of all geographical regions in the country with altitude below 800 m and besides, they were selected according to the quality of observations and data series homogeneity.

The territory of Bulgaria is small, but it is characterised with very diverse relief. Also our country is located on the transition between two climatic zones – moderate continental and Mediterranean. So by the orographic and climatic features we can divide Bulgaria on 6 parts: North-West (NW), North-Central (NC), North-East (NE), South-East (SE), South-Central (SC) and South-West (SW) Bulgaria (Fig.1).

All cases of thunderstorm occurrence at climatological stations during the studied period were investigated. A day with thunderstorm was accepted as a basic index for thunderstorm occurrence. The following criteria were used to define a day with thunderstorm:

- a day when at least one thunderstorm occurs between 00:00 and 24:00 h local time;
- the division into close and distant thunderstorm was not taken into account;
- if thunderstorm occurred at the turn of 2 days, it was included into both days (but these cases occurred rarely).

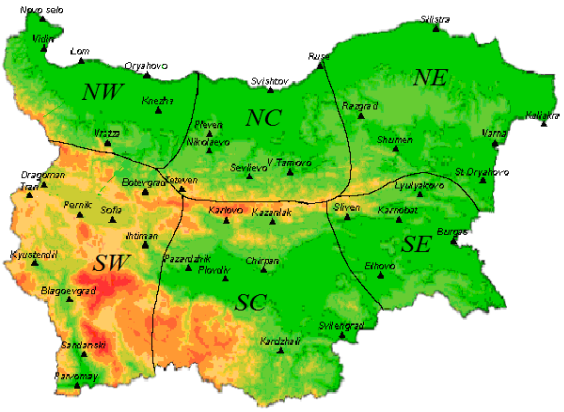



FIG. 1: Climatological stations used in the study.

The data used in the analysis include the daily, monthly and annual number of the days with thunderstorms for every station and year. Part of this information (available only in paper form) was entered into computer-compatible form and the rest of it was taken from the meteorological database of the NIMH. The frequency of thunderstorm occurrence for two periods (1961–1990, 1991–2010), as well as for five 10-years periods for each station were determined by specially developed Transact-SQL store procedures in Climatology and Meteorological Database Division of NIMH. Brief statistical analysis is applied for the assessment of variability and possible differences in the mean number of days with at least one thunderstorm from long-term data series.

## III. RESULTS AND CONCLUSIONS

### *Annual distribution*

The results of the analysis of the number of days with thunderstorms at 42 stations all over Bulgaria in the period 1961–2010 show that there are on average 30 days with thunderstorms in non-mountainous part of the country during the year. This number depends on the region and

varies from 11 days in NE Bulgaria to 56 days in NW Bulgaria and its values are typical for thunderstorm occurrence in each region. The comparison of two investigated periods (1961–1990, 1991–2010) for different regions show that the mean number of registered thunderstorm days are increased during the second period for the most part of the regions, but the growth are not statistically significant (Fig.2 and Table I). The statistically significant variation with about 15% is observed only in NE Bulgaria and partially in SC Bulgaria (with about 10%). For eastern and SC part of the country this is connected mostly with the observed changes in atmospheric circulation over the region, especially with the changes in trajectories of Mediterranean cyclones over the Balkans (Marinova et al., 2005). More precise analysis of the synoptic situations, connected with lightning activity is necessary to be done in future investigation.

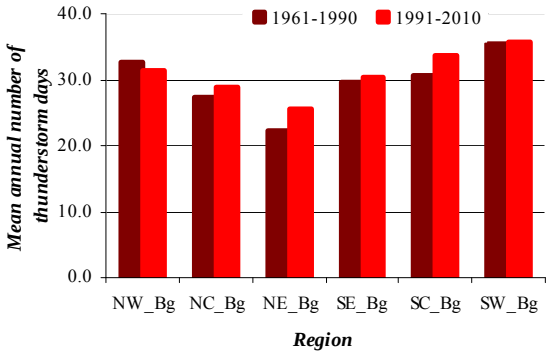



FIG. 2: Monthly distribution of mean number of thunderstorm days for whole territory of Bulgaria

| Region sample № | NW | NC | NE | SE | SC | SW |
|---|---|---|---|---|---|---|
| 1 mean μ1 | 32.7 | 27.5 | 22.3 | 29.7 | 30.6 | 35.5 |
| 1 min | 16.2 | 17.7 | 18.2 | 18.6 | 20.8 | 23.8 |
| 1 max | 53.2 | 39.8 | 29.5 | 42.8 | 48.8 | 53.3 |
| 2 mean μ2 | 31.4 | 28.8 | 25.6 | 30.4 | 33.6 | 35.8 |
| 2 min | 23.5 | 17.8 | 16.8 | 18.6 | 27.9 | 25.1 |
| 2 max | 40.7 | 38.8 | 37.0 | 44.2 | 43.9 | 47.1 |
| 1,2 $\chi^2$ | 0.67 | 0.83 | 5.58 | 0.18 | 3.27 | 0.04 |
| tail probab. P | 0.414 | 0.363 | 0.018 | 0.675 | 0.070 | 0.851 |
| μ1-μ2/μ2, % | -0.04 | 0.05 | 0.15 | 0.02 | 0.10 | 0.01 |

TABLE I: Statistical comparison between two samples of mean regional annual number of thunderstorm days using the Poisson distribution for the 1961–1990 (1) and 1991–2010 (2) data set.

### *Monthly distribution*

The analysis of mean monthly number of days with thunderstorms in all stations and regions confirmed that usually about 75 % of all thunderstorms occur during the period May – August. The maximum of thunderstorm activity is in June (Fig.3) when the mean number of stormy days is about 7 days/per station (maximum 12.0 days for Novo selo in NW Bulgaria and minimum 3.7 days for Varna in NE Bulgaria). Number of days increases in western and south-central part of the country near by the highest Bulgaria mountains: Rila, Pirin and the Rhodope Mountains, because of the preferable orographic conditions for convective initiation. In particular years the maximum number of thunderstorm days in June reaches 18 – 20. The mean number of stormy days in May and July are almost equal during the first period (1961–1990), but during the second one (1991–2010) in July increases more rapidly (with about 16%) – Fig.3. The growth in thunderstorm occurrence recently is mostly due to the rise in observed stormy days in the second part of the summer (from July to September) and the most significant is this increment in September – with about 27%.

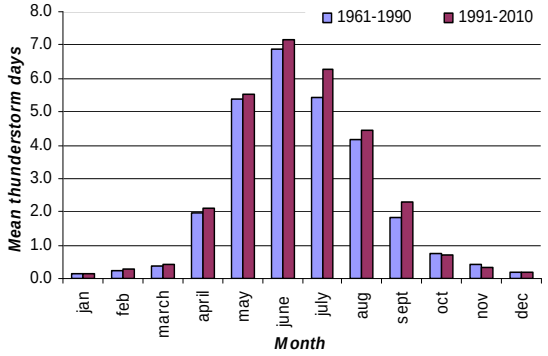
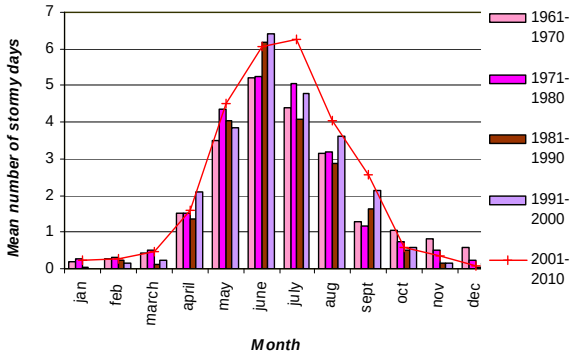
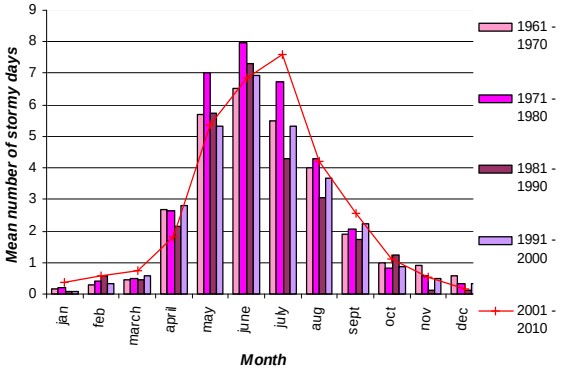



FIG. 3: Monthly distribution of mean number of thunderstorm days for whole territory of Bulgaria.

Monthly distribution of thunderstorm days in different regions in Bulgaria is the same for two investigated periods.




a) NE Bulgaria




b) SE Bulgaria

FIG. 4: Monthly distributions of 10-years mean number of thunderstorm days.

The detailed examinations of monthly distribution of 10-years mean number of thunderstorm days for each region present that the typical for the climate of Bulgaria maximum

in lightning activity in June, is moved to July now, during the last decade 2001–2010, for stations from eastern part of the and near by the Black Sea (Fig.4 a, b). Besides that the long-term variability of monthly distribution of thunderstorm days is very similar to those observed for torrential precipitation events (daily precipitation sums which exceeded the limits of 60-100 mm/24 hours) for the same regions and periods (Bocheva et al., 2009, 2010). Probably it is an indicator that now-a-days severe convective storms, connected with more powerful thunderstorms and torrential precipitation events become more frequent in eastern part of the country and during the months July and September.

***Concluding remarks and prospects***

During the analyzed period (1961–2010), no statistically significant tendency was found in the annual and monthly distribution of number of days with thunderstorms in Bulgaria. The values in different parts of the country are typical for the climatic – geographical region in which Bulgaria is situated.

For different regions of Bulgaria the comparison of distribution of thunderstorm days during the two periods (1961–1990 and 1991–2010) show statistically significant increase in NE Bulgaria (15 %) and in SC Bulgaria (about 10%). Monthly frequency of mean number of stormy days for the two investigated periods does not differ much from each other. More remarkable are the observed growth in second part of the warm half of the year and especially in September – about 27 %. For eastern part of the country and the Black Sea coast the maximum in lightning activity during the last 10 years (decade 2001–2010) is moved from June to July.

The changes in monthly regional distribution of thunderstorm days, particularly during the last 10 years, coincide with observed significant increase of torrential precipitation in NE and SE Bulgaria (Bocheva et al., 2009). It is in the further authors' plans to investigate the relationship and correlation of precipitation events with thunderstorm activity in different regions of Bulgaria.

## IV. ACKNOWLEDGMENTS

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