

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

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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). 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 losses. According to Bulgarian Agency of Civil Defence the annual number of victims 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 climatologic 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. The study was carried out on the basis of meteorological data concerning thunderstorm occurrence for 42 climatologic stations from the meteorological network of the Bulgarian National Institute of Meteorology and Hydrology for the period 1961–2010. 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.

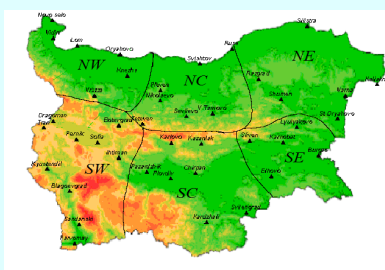
All cases of thunderstorm occurrence at climatologic stations during the studied period were investigated. A day with thunderstorm was accepted as a basic index for thunderstorm occurrence. The following criteria were used to define a day with thunderstorm:

- 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).

The data used in the analysis include the daily, monthly and annual number of the days with thunderstorms for every station and year. 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. 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.

## Distribution and variability of thunderstorms occurrences

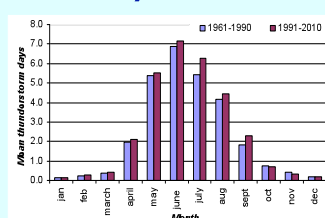
### Annual distribution of thunderstorm days



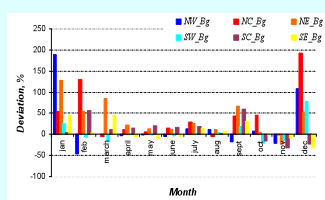
The territory of Bulgaria is small, but it is characterised with very diverse relief. Also our country is located on the transition between two climatic zones – moderate continental and Mediterranean. By the orographic and climatic features we divide Bulgaria on 6 parts: North-West (NW), North-Central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

No. of sample	1	1	1	2	2	2	1, 2	tail	
Thunderstorm	mean	min	max	mean	min	max	$\chi^2$	probability	$(\mu_2 - \mu_1)/\mu_1$
	$\mu_1$			$\mu_2$				p	%
NW Bulgaria	32.7	16.2	53.2	31.4	23.5	40.7	0.67	0.414	-0.04
NC Bulgaria	27.5	17.7	39.8	28.8	17.8	38.8	0.83	0.363	0.05
NE Bulgaria	22.3	18.2	29.5	25.6	16.8	37.0	5.58	0.018	0.15
SE Bulgaria	29.7	18.6	42.8	30.4	18.6	44.2	0.18	0.675	0.02
SC Bulgaria	30.6	20.8	48.8	33.6	27.9	43.9	3.27	0.070	0.10
SW Bulgaria	35.5	23.8	53.3	35.8	25.1	47.1	0.04	0.851	0.01

### Monthly distribution of thunderstorm days



- About 75% of all thunderstorms occur during the period May–August. The maximum of thunderstorm activity is in June 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).

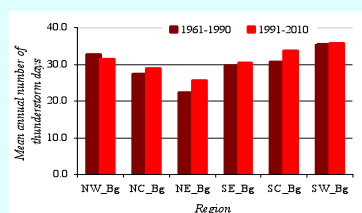


- Number of days increases in western and south-central part of the country near by the highest Bulgarian mountains: Rila, Pirin and the Rhodope Mountains, because of the preferable orographic conditions for convective initiation.

- The mean number of stormy days in May and July is almost the same during the first period (1961–1990), but during the second one (1991–2010) in July increases more rapidly (with about 16%).

- The growth in thunderstorm occurrence recently is mostly due to the rise in observed stormy days in the second part of the warm half of the year (the most significant is this increment in September – with about 27%).

➤ The percentage deviation of mean monthly number of thunderstorm days during the 1991–2010 period towards 1961–1990 period, increases more rapidly in North Bulgaria, especially in December and January – not typical for winter convective storms becomes more frequent at the present time.

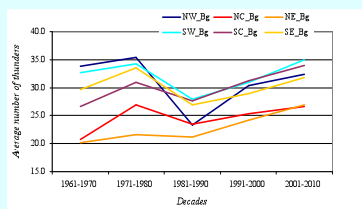


The comparison of two investigated periods (1961–1990, 1991–2010) for different regions shows:

- Mean number of thunderstorm days is increased during the second period for the most part of the regions (the growth is statistically insignificant).

- 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).

There are on average 30 days with thunderstorms in non-mountainous part of the country during the year. The mean decadal number of stormy days depends on the region and varies from 20.3 days in NE Bulgaria to 35.3 days in NW Bulgaria and it's values are typical for thunderstorm occurrence in each region.

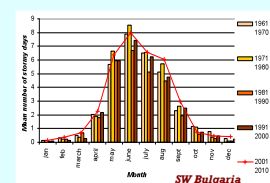
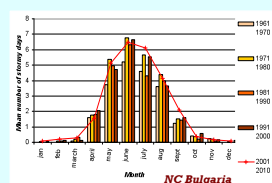
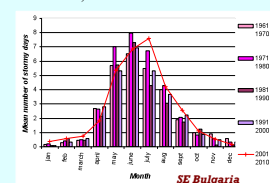
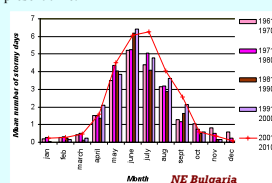


## Concluding remarks and prospects

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.



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. 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).

## References

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