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Mihai-Florin Necula
,,Al. I. Cuza" University,
Faculty of Geography and Geology
700506 Iasi, Romania, Bulevardul Carol I, nr 11
e-mail: necula_mihai_florin@yahoo.com

MAIN CLIMATIC ELEMENTS THAT DIFFERENTIATE THUNDERSTORM ACTIVITY IN THE BÂRLAD PLATEAU, ROMANIA

Główne elementy klimatyczne wpływające na zróżnicowanie aktywności burzowej na wyżynie Bârlad w Rumunii

Streszczenie. Wyżyna Bârlad[1], chociaż wydaje się jednorodnym obszarem geograficznym, wykazuje zaskakujące zróżnicowanie jeśli chodzi o aktywność burzową. W artykule zbadano charakterystyki sezonu burzowego, liczbę burz, ich czas trwania i rozkład uderzeń pioruna w celu rozpoznania czynników, które wywołują silne zróżnicowanie powstawania i ewolucji burz na badanym terenie.

Słowa kluczowe: aktywność burzowa, sezon burzowy, piorun, cyrkulacja atmosferyczna, wyżyna Bârlad
Key words: thunderstorm activity, thunderstorm season, lightning, air circulation**,** Bârlad Plateau

INTRODUCTION

While there are many studies of the climatic parameters of thunderstorms done at a national level (Iliescu 1989, Changery 1981, 1983), and many case studies that analyze in detail specific (but local) convective severe weather events (tornadoes, downbursts, torrential precipitations event, hailstones), especially those that resulted in casualties or significant property damage, there is a big gap in the understanding of thunderstorm distribution especially on two spatial scales:

[1] Południowa część Wyżyny Mołdawskiej.

- On the global level this phenomena is studied only by the means of remote sensing the actual cloud to ground lightning strikes by satellite and radio wave triangulation;
- The regional distribution of thunderstorm is usually derived from the few national level maps and averages, failing to take into account the specific characteristics of the studied area which can influence the initiation and manifestation of thunderstorms.

There is a double challenge involved in studying thunderstorms at a regional scale, the first being that the geographical unit selected may induce such small variations in the studied characteristics that will render useless the results of the study, and secondly because the analyzed phenomena is very poorly represented in the Romanian literature.

Besides the very detailed work of Iliescu (1989), only hailstone (Erhan 1986) was studied on more reduced spatial scale while even the most recent papers describing cloud to ground climatology analyze the phenomena, again on the national level, with limited detail despite the use of the latest technology (Antonescu, Burcea 2010)

The geographical region selected for this study, The Bârlad Plateau, is located in the eastern part of Romania, and represents 2/5 of the Moldavian plateau (~ 8000 km^2).

Broadly speaking, the air circulation in this region is greatly influenced by the presence of neighboring features (Bâzâc 1983, Bordei 1988): Eastern Carpathians (west); Eastern European Plain (north and east); Romanian Plain (south) and Black Sea (south-east) (Fig. 1).

The areas with higher altitudes are generally located in the north-west and the central part of the Bârlad Plateau and the lower altitudes being generally found in the south-east.

Between the higher areas of plateau, the Bârlad valley represents a major feature that clearly defines this plateau while it is bordered to the east and west by other significant low area, the Prut and Siret river valleys which represent additional features that influence the air circulation.

Because the active surface is grafted on homoclinal ridges (cuestas):

- the most impressive slopes in this rather monotonous area are facing north and west;
- the very gentle slopes can be usually found facing a south-eastern direction.

The orientation, altitude and gradient of these slopes directly influence not only the air circulation but also the amount of solar radiation received per sq meter and in the end the specific situation of the active surface:

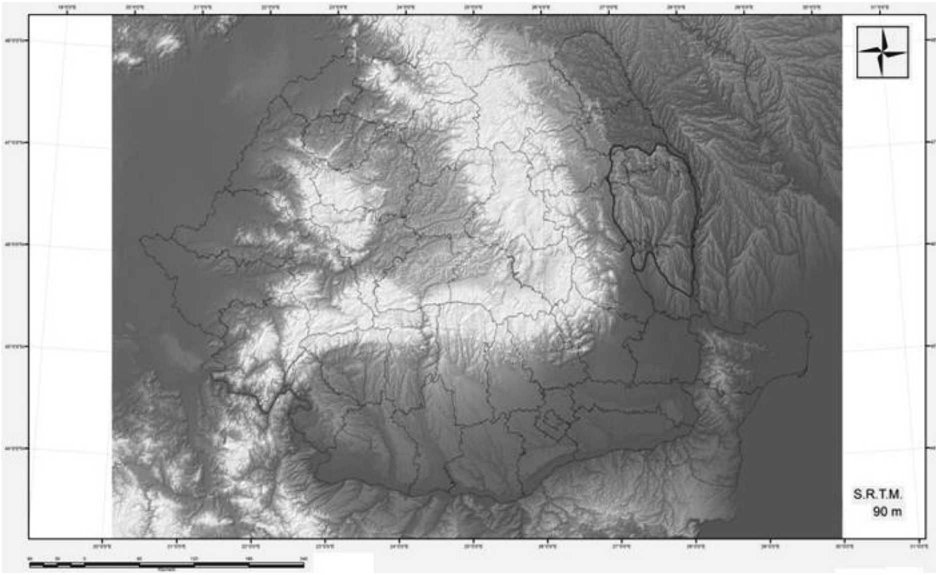


Fig. 1. Geographical position of the Bârlad Plateau within the Romania's territory
Ryc. 1. Położenie geograficzne wyżyny Bârlad na obszarze Rumunii

METHODS

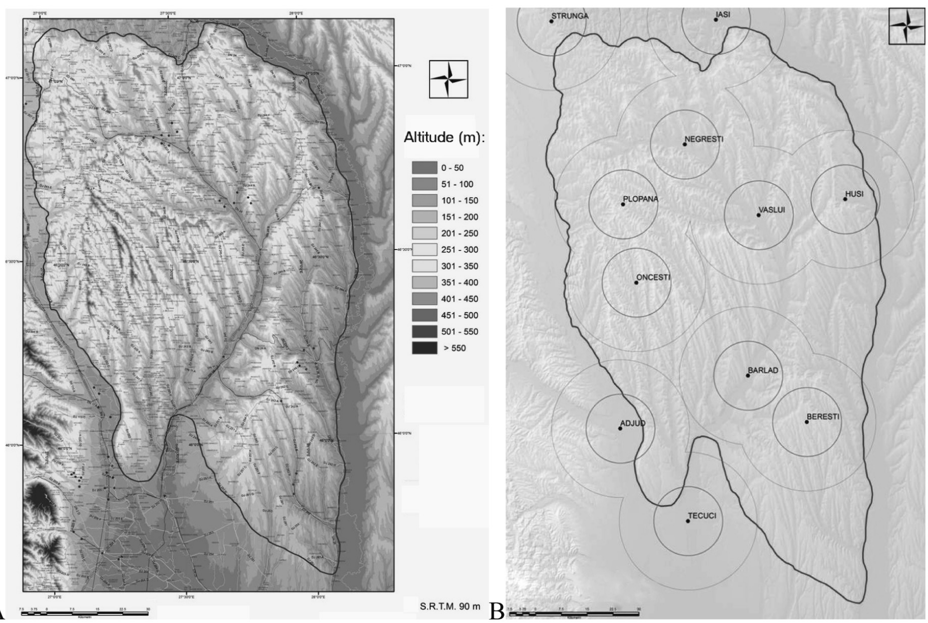
The characterization of the active surface was done by using GIS (*Geographical Information Systems*) methods, the main data sources used being SRTM (*Shuttle Radar Topography Mission*) and CORINE (*Coordination of Information on the Environment*) Land cover 2000. The results were used to determine the main feature influencing air circulation and thunderstorm activity: altitude, slope orientation, gradient, solar radiation and land-use.

Besides the ultimate goal of computer modeling of severe weather phenomena, the characterization of the active surface was also done to properly assess the relevance of the meteorological stations that provide information for the area recorded between (full data sets):

- 1961–2009 for the: Tecuci, Adjud, Bârlad and Vaslui meteorological stations;
- 1966–2009 for the Negrești meteorological station;
- 1961–1999 for the Oncești and Huși meteorological stations;
- 1964–1999 for the Plopana meteorological station;
- 1961–1983 for the Bălintești meteorological station;
- 1981–1999 for the Berești meteorological station.

Because of the movement of the Bălintești meteorological station to a better location in the nearby town of Berești (some 5 km away) and also because many of the rural stations operated with full staff and equipment only between 1980 and 1989, we have a common set of data for all the meteorological stations of only 20 years for most parameters (1980–1999) and some 10 years for thunderstorm durations (Fig. 2).

To properly assess the direction of the air circulation and the synoptical features for each thunderstorm recorded between 1980 and 1999 the study also used archive satelliteimagery and synoptic charts. Where available data from weather radars (classic and Doppler) and lightning detectors was also used.



A B

Fig. 2. The altitude map of the Bârlad Plateau (A) and location of the relevant meteorological stations (B)

Ryc. 2. Mapa hipsometryczna wyżyny Bârlad (A) i położenie uwzględnionych stacji meteorologicznych (B)

AIR CIRCULATIONS FAVORABLE TO THUNDERSTORM DEVELOPMENT

The analysis of the synoptically features and air circulations for each thunderstorm recorded in the plateau between 1980 and 1999 resulted in the identification of some common characteristics for a large number of event (Tab. 1). Cold frond situations (including the pre and post frontal activity) are responsible for most of the thunderstorm especially in NNW-N circulations. Occlusions

Table 1. The frequency (%) of air circulation directions for the synoptical features that generated at least one thunderstorm in the Bârlad Plateau (1980–1999)
Tabela 1. Częstość (%) kierunków cyrkulacji w różnych sytuacjach synoptycznych, przy których wystąpiła przynajmniej jedna burza nad wyżyną Bârlad (1980–1999)

Sinoptical features \ Directions	NNW-N	NE-E	SE	S-SW	W	Stationary low pressure	Stationary high pressure
pre-Cold Front	43	7	0	7	14	14	14
Cold Front	64	4	1	2	22	4	4
post-Cold Front	48	7	3	14	14	0	14
pre-Warm Front	0	0	0	0	0	0	0
Warm Front	5	5	14	59	11	3	3
post-Warm Front	0	0	17	33	0	0	50
pre-Occlusion	0	0	0	50	50	0	0
Occlusion	19	16	24	10	29	3	0
post-Occlusion	23	23	23	15	8	0	8
pre-Stationary Front	0	0	0	0	0	0	0
Stationary Front	13	13	13	25	38	0	0
post-Stationary Front	0	100	0	0	0	0	0
Local thunderstorm	36	10	1	23	8	10	12
Other features	56	0	11	22	0	11	0

produce thunderstorms no matter the direction of the circulation. Warm front situations come third with thunderstorms appearing mostly on S-SW and W circulations. Local (pulse) thunderstorms are more frequent in NNW-N types of circulations.

MAIN THUNDERSTORM PARAMETERS

The characteristics of the thunderstorm season (beginning, end and duration – tables 2–4) represent one of the parameters most likely to be influenced by air circulation.

Table 2. The average and extreme dates marking the beginning of the thunderstorm season
Tabela 2. Średnia i skrajne daty burz rozpoczynających sezon burzowy

Meteo-rological station	Average annual date of the first thunderstorm (full data set)	Average annual date of the first thunder-storm (common pe-riod 1980–1999)	The most early first thunder-storm the season	The most late first thun-derstorm the season
Strunga	20 IV	20 IV	17 III	23 V
Iaşi	17 IV	20 IV	26 II	25 V
Negreşti	25 IV	26 IV	24 II	20 V
Plopana	20 IV	20 IV	17 II	20 V
Vaslui	13 IV	19 IV	12 II	28 V
Huşi	27 IV	1 V	24 II	2 VI
Onceşti	26 IV	26 IV	3 I	28 V
Bârlad	13 IV	17 IV	3 I	30 V
Bereşti	19 IV	19 IV	15 II	21 V
Tecuci	20 IV	22 IV	10 II	16 VI
Adjud	19 IV	19 IV	15 II	30 V

The first thunderstorm of the year occurs earlier in the south-western low areas of the plateau, but the beginning of the thunderstorm seasons is generally delayed in the areas which are the most shadowed to this SW circulation (eastern depressions, internal areas of the plateau.

Because of the presence of the Black Sea to the SE, thunderstorms are possible even in January in the southern extremity of the plateau, while in the northern extremity the earliest thunderstorm ever recorded occurred only in the second half on March. Surprisingly in some low areas of the plateau which are bordered by the surrounding plains it is possible (in some dry years) to have the first thunderstorm of year happening as late as the second half of June.

The end of the thunderstorm season occurs on average earlier in the NW extremity of the plateau, and latest in the SW extremity, the difference of 17 days being extremely significant for such a small area. The last thunderstorm of the year may appear as early as 15th of August in the NE areas of the plateau and as late as the second decade of December in the S and SW.

Taking into account that the SW circulation is responsible for most of the thunderstorm which appeared during the winter, and that the areas exposed to the N and NE circulations are the ones where thunderstorms appear later during the year and end earliest, we can expect that the thunderstorm season will

Table 3. The average and extreme dates marking the end of the thunderstorm season
Tabela 3. Średnia i skrajne daty burz kończących sezon burzowy

Meteo-rological station	Average annual date of the last thunderstorm (full data set)	Average annual date of the last thunderstorm (common period 1980–1999)	The most early last thunder-storm of the season	The most late last thunder-storm the season
Strunga	13 IX	13 IX	20 VIII	27 XI
Iaşi	21 IX	20 IX	14 VIII	5 XII
Negreşti	18 IX	18 IX	20 VIII	5 XII
Plopana	15 IX	15 IX	26 VIII	5 XII
Vaslui	26 IX	19 IX	16 VIII	4 XII
Huşi	17 IX	14 IX	15 VIII	20 XI
Onceşti	19 IX	19 IX	18 VIII	4 XII
Bârlad	27 IX	17 IX	17 VIII	8 XII
Bereşti	25 IX	25 IX	17 VIII	19 XI
Tecuci	28 IX	22 IX	23 VIII	5 XII
Adjud	1 X	27 IX	23 VIII	13 XII

Table 4. Average and extreme length of the thunderstorm season
Tabela 4. Średnia i skrajne długości sezonu burzowego

Meteo-rological station	Average length of the thunder-storm season (full data set)	Average length of the thunderstorm season (common period 1980–1999)	The shortest thunderstorm season	The longest thunder-storm season
Strunga	146	146	98	222
Iaşi	157	152	90	222
Negreşti	145	144	100	248
Plopana	148	148	106	216
Vaslui	165	153	99	269
Huşi	142	136	110	269
Onceşti	146	146	93	271
Bârlad	166	152	92	294
Bereşti	155	155	106	222
Tecuci	162	153	96	283
Adjud	166	156	106	299

be the longest in the SW area of the plateau and shortest towards the north, east and in the most shadowed (from general air circulations) areas of the plateau. These observations are confirmed by the meteorological data (Tab. 4), where we can also observe that the longest thunderstorm season ever recorded reaches almost 300 days (covering most of the year) in the SW while in the internal areas of the plateau the maximal length of the thunderstorm season is just some 216 days.

The actual number of thunderstorms and their duration (Tab. 5 and 6) seems to be influenced more by the actual characteristics of the active surface (ridges, vegetation, altitude) and exposure to different types of circulations and less by geographical location.

Table 5. Aveage and extreme annual number of thunderstorms
Tabela 5. Średnia i skrajne liczby burz w roku

Meteorological station	Average number of thunderstorms	Maximum number of thunderstorms	Minimum number of thunderstorms
Strunga	30.0	50	15
Iași	38.6	73	24
Negrești	33.8	47	18
Plopana	31.4	56	19
Vaslui	39.2	63	24
Huși	26.5	48	11
Oncești	34.6	57	13
Bârlad	37.5	83	18
Berești	30.7	51	16
Tecuci	30.3	55	18

As a general observation the most numerous thunderstorms appear in the vicinity of cuestas ridges facing N and NW, and less on the gentler slopes and depressions facing S and SE. Also there are more thunderstorms in the Bârlad river valley than in internal areas of the plateau with higher altitudes but more shadowed from all types of air circulation.

On the other hand there is a strict dependency between altitude and the possible duration of thunderstorms, as this phenomena appears more often on lower elevation but for an shorter average duration of 2.2–2.4h, while at higher elevation thunderstorms are less frequent but last longer, reaching an average of 3h or more.

Table 6. Average and extreme annual duration (h) of thunderstorms (*~10 years of data available)
Tabela 6. Średnia i skrajny czas trwania (h) burz w roku

Meteorological station	Average anual lenght of thunderstorms.	Maximal anual lenght of thunderstorms.	Minimum anual lenght of thunderstorms.
Strunga*	91.3	155.4	53.5
Iasi	98.6	209.2	53.1
Negresti	99.2	180.3	61.8
Plopana	85.1	165.0	40.6
Vaslui	81.9	151.5	41.0
Husi*	66.7	93.1	39.3
Oncesti*	79.3	120.7	46.3
Barlad	83.5	248.7	38.1
Beresti*	90.7	103.0	80.0
Tecuci	63.2	141.8	33.1
Adjud	88.6	169.2	45.4

In the Bârlad Plateau there are annually over 150 cloud to ground lightning strikes/100km^2: Vaslui – 153, Tecuci – 130, Barlad – 170. Based on the most up to date research (Antonescu, Burcea 2010) and data from the new lighting detectors we can generally consider that the number of lightning strikes increases with altitude, but at the same time and from north-east to south-west.

CONCLUSIONS

Thunderstorm activity can present significant variations even over small areas and these variations can be determined by local funneling of the general air circulations along river valleys, ridge characteristics or the influence of the greater geographical units nearby. In the case of the Bârlad Plateau the presence of the Carpathian mountains arch, the Romanian Plain, the Black Sea area and the openness of the Eastern European Steppe greately influence thundestorm activity making the Bârlad Plateau look more like an transitional area between the thunderstorm characteristics of the neigbouring area than a region defined by a clear set of thunderstorm characteristics.

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