THE BLACK SEA AS CONTRIBUTOR TO THE PRECIPITATION AMOUNT ON MOLDOVA REGION

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ABSTRACT

In our study we try to evaluate the contribution of the Black Sea water body to the amount of precipitation across the historical region of Moldova, which encompasses the territory situated between the Carpathian Mountains in West and the Dniester River valley in East. We chose this region for its homogeneity from the point of view of weather circulation types.

We used 8 weather stations from ECAD daily datasets which cover the entire region for 32 years (1961-1992). NCEP/NCAR Reanalysis Maps were used to identify the weather pattern favourable for the humid air masses advection from the Black Sea towards the region of Moldova. According to this analysis just about 4% (around 10-15 days per year) are characterised by these conditions. Generally, these conditions are related to the action of Mediterranean cyclones in South-Eastern Europe, especially those with a backward trajectory. Despite this weak annual frequency, these weather patterns contribute with 15-20% to the total amount of precipitation in Moldova.

Without this contribution Moldova region would be characterised by more pronounced arid climate features. The weather pattern, the annual regime of this contribution, the regional distribution will be presented in detail within the present work.

Keywords: Moldova, Black Sea, precipitation, Mediterranean cyclones, retrograde cyclones.

INTRODUCTION

The influence of the Black Sea on the Romanian climate is defined in the Romanian climatology literature in the form of Pontic influences [1] but are limited to a restricted part of Dobrogea region, based mainly on the thermal mark that this sea generates in the vicinity of the shore. However, Bordei-Ion, 1983 [2], emphasizes the role of the Black Sea as a source of moisture for the Romanian territory, and this work provides a more accurate quantitative assessment of this contribution.

The present work is focused on the geographical area between the Carpathians and the Dniester river valley, area that coincide with the historical region of Moldova, that in most climate classifications corresponds to the limit between transitional climate and the continental one at European level [3]. The hilly relief of the region is marked by the Carpathian orographic barrier in the western part and by south-eastern access into the Black Sea. In the centre of the area, Codrii Plateau from Bessarabia and Bârlad Plateau from Western Moldavia represent a west-east oriented orographic obstacle which is segmented only by the Prut River Valley, with altitudes up to 400-450 m, this being the

main orographic barrier against air masses or weather fronts from the Black Sea that reach the analyzed area during south-east circulation pattern.

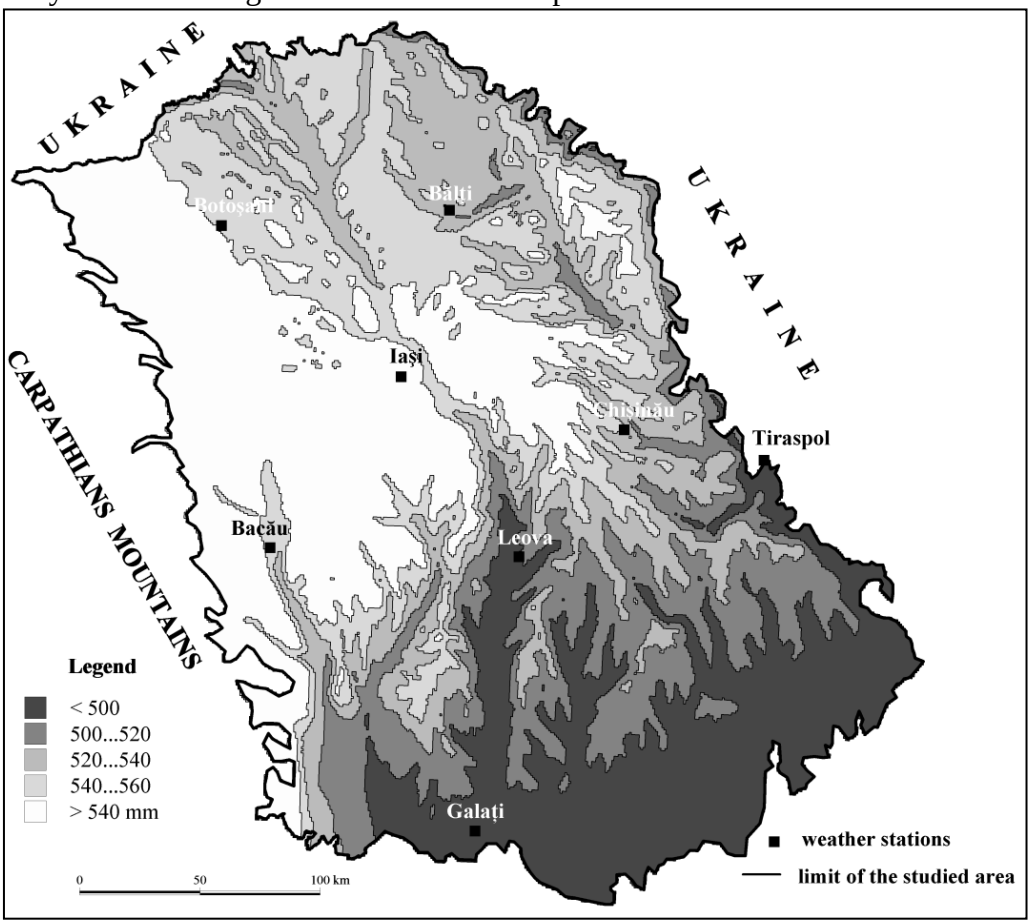

Figure 1. - Distribution of annual precipitation (mm) amount in Moldova

From a pluviometric point of view, excepting the *mountainous areas*, the multi-annual precipitation amount in the analyzed area is not exceeding 500 mm in the extreme southern part of the area, along the Danube and even Black sea coast. For the most part of the area the precipitation mostly amounts are between 500 and 550 mm (Fig. 1), and in the central hilly part slightly exceeds 550 mm [4], being over 650 mm in the subcarpathian and *mountainous* area.

The annual precipitation regime is marked by minimum precipitation in February and the maximum amount of precipitation is recorded in June and lately, for many weather stations, in July. The variation curve of multiannual average amounts of precipitation is very high, often prolonged sequences of weather, have placed Moldova, located between the Carpathians and the Dniester River valley in a scenery specific to maritime or oceanic climate. We are referring to the well-known severe weather intervals from a pluviometric point of view, as the events occurred in 1970 and 1991, of the analyzed period, when in Moldova the annual precipitation amounts were close to 1000 mm in the lower parts of its territory. Excessive precipitation events occurred during these intervals, are associated with either retrograde cyclones moving towards the Black Sea or with south-east circulation patterns. This work contains a quantitative evaluation of this situations.

DATA AND METHODS

The procedure used in the identification of the precipitation activity over the Black Sea is done manually [5], and consisted in analysing the diurnal maps of barometric pressure at sea level and at 500 hPa level and relative humidity at 700 hPa. When the atmospheric circulation is oriented from Black Sea at a 500 hPa level it was accounted for a contribution rate of 100% in the production of daily amount of rain or snow.

When the atmospheric circulations caused by the air masses above the Black Sea were distributed on the surface and on the inferior troposphere, it was considered that a part of the precipitation occurred in Moldova was determined by the moisture supply from the Black Sea, and another part by the circulation in the medium troposphere (500 hPa). Therefore, against this background, it was accounted that only 50% of the precipitation received are produced from the Black Sea moisture. The analysis of circulation patterns of concern was completed by the consultation of the summary of synoptic meteorological observations data NCEP/NCAR that include: geopotential height at 500 hPa, 700 hPa and 850 hPa, temperature at 850 hPa and 500 hPa, relative humidity at 700 hPa, and sea level pressure [6]. All these parameters were analysed at continental level with a special focus on the study region.

At regional scale, we have used daily precipitation amount for 8 weather stations from the whole region on the basis of daily precipitation from ECAD data base for the 1961-1992 period [7]. The mountain area was excluded from this analysis due to its complexity from the point of view of precipitation distribution.

Data were treated with the help of Excel software package and TNT Mips 6.9 was used to generate the maps, the residual kriging method being used for this goal, as a recommended method [8] for the cartographic representation of precipitation amount.

RESULTS AND DISCUSSIONS

Our results are presented at different time level: monthly, seasonal, semestral and multiannual.

Monthly level We evaluate the maximum contribution of the Black Sea to the monthly precipitation amount (Tab.1) for the month of August and September (25-30%). In this period, large convective systems developing throughout Moldova are supplied with moisture from the Black Sea area. They develop either in the warm area of Mediterranean cyclones moving along Trans-Balkan trajectories, either during cut-off low persistence on South-Eastern Europe, one of the important causes for excessive amount of rainfall at european continental scale [9]. The lowest contribution of the Black sea moisture for the monthly precipitation amount is observed generally during Octomber, which is the most arid month of the year in the region, due to the persistence of the anticyclonic conditions. From the spatial point of view, the footprint of Black Sea moisture for precipitation amount grows from west to east and is bigger in the hilly central area of the region. This spatial pattern is explained by the orographic convection which is produced on the eastern slopes of the Carpathian determining a higher discharge of precipitation, but especially also on the southern slopes of the Central Moldavian Plateau. Being known that the end of the summer represents an interval of appreciable aridity, we can underline that the Black Sea saves the Moldavian region from extreme drought in this part of the year.

Table 1. The role of the Black Sea as contributor (%) to the monthly amount of precipitation for 8 weather stations in Moldova (1961-1992)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Botoșani	11,9	9,0	15,1	18,3	21,6	24,3	22,6	24,8	29,7	29,7	8,6	16,1
Iași	8,6	10,5	19,3	23,2	27,0	27,5	20,7	29,9	38,4	38,4	9,6	16,1
Bacău	9,8	11,7	24,0	22,6	28,4	21,9	22,0	33,8	35,3	35,3	6,2	18,7
Galați	8,1	12,8	22,4	21,4	26,5	19,0	18,7	34,2	25,5	25,5	8,1	20,8
Bălți	10,8	10,2	12,4	14,9	17,9	19,2	16,2	21,0	29,1	29,1	8,3	13,7
Chișinău	6,8	10,3	12,3	14,9	20,3	17,9	13,7	21,1	29,3	29,3	9,1	13,1
Tiraspol	4,7	7,7	9,9	13,9	20,0	13,4	8,6	19,7	21,5	21,5	7,1	10,8
Leova	9,2	12,6	16,3	21,7	21,4	19,6	15,8	26,3	28,4	28,4	7,5	16,7
Mean	8,7	10,6	16,5	18,9	22,9	20,4	17,3	26,4	29,7	29,7	8,0	15,7

Also, an important contribution is observed in May and June, the months which concentrate the yearly maximum precipitation amounts representing in absolute values the highest precipitation amount with Black Sea origins.

Seasonal level. More than 65% of the precipitation amounts on the territory of Moldova are accumulated normaly during spring and summer, and within our analysis we estimate that the contribution of the Black Sea to the precipitation amount during this period is maximum being evaluated to approx. 20% (Tab.2), which represents in absolute values approx. 100-150 mm throughout the whole area.

Table 2. The role of the Black Sea as contributor (%) to the seasonal amount of precipitation for 8 weather stations in Moldova (%) (1961-1992)

	Winter	Spring	Summer	Fall
Botoșani	12,3	18,3	23,9	15,4
Iași	11,7	23,2	26	18,1
Bacău	13,4	25	25,9	16,2
Galați	13,9	23,5	24,2	13,1
Bălți	11,6	15,1	18,8	15,3
Chișinău	10,1	15,8	17,6	14,3
Tiraspol	7,8	14,6	13,9	10,3
Leova	12	19,8	20,6	13,8
Mean	11,7	19,4	21,4	14,6

In terms of territorial distribution, the greatest accumulated precipitation products in the Black Sea basin occur in the hilly area from the South-Western Moldova where the mountains border the region. This situation is generated by the patterns in which the weather fronts associated with specific trajectories of Mediterranean cyclones [10] generate significant precipitation amounts as a result of orographic convection that cumulates the fontal lift.

The role of the altitude in the production of precipitation from the moisture supply provided by the Black Sea during summer season (Fig. 2c), against the background of occurrence of convective precipitation, increases.

In this regard, within our cartographic models is enhanced in particular the Valley of Prut, but along Dniester River valley also, whose general aridity is also attributed to the descendant movement of the atmosphere that prevent the formation of convective systems.

Alternatively, in the spring season, when atlantic frontal rain bands are more important as frequency, the role of altitude in the contribution of Pontic filtering, as regards the amount of precipitation, decreases significantly (Fig. 2b).

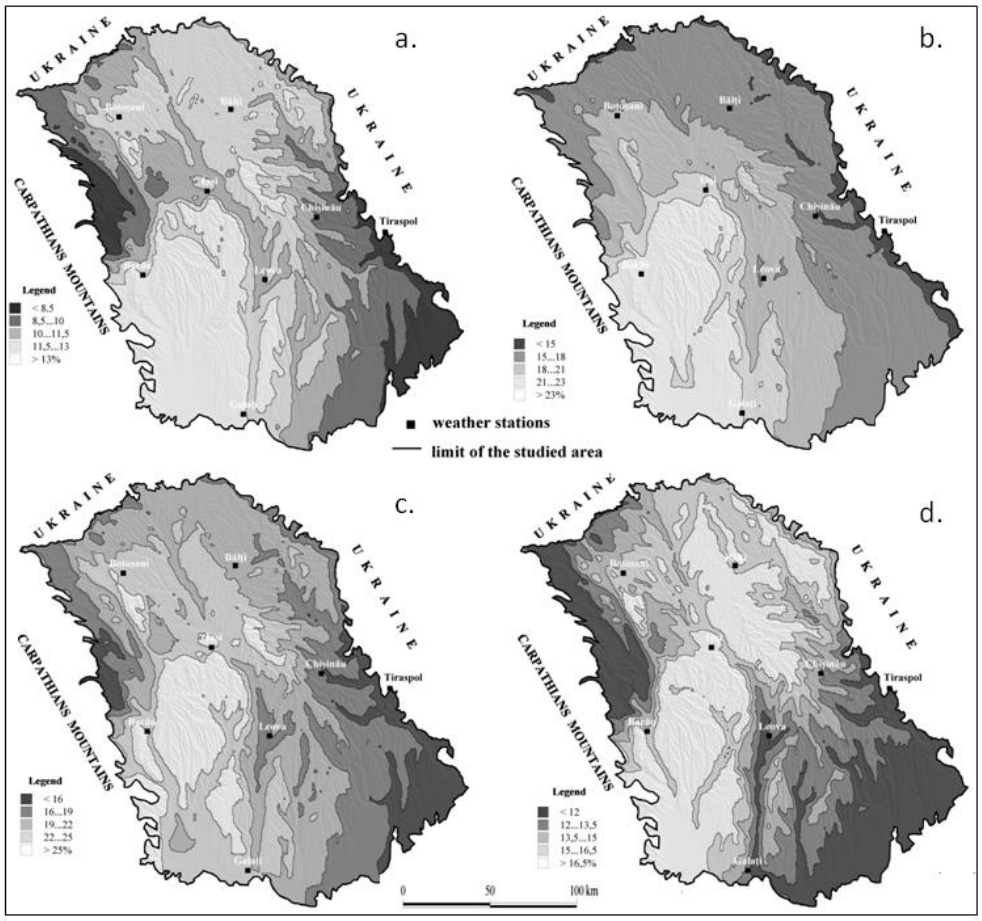

Figure. 2 - The contribution (%) of the Black Sea to the annual regime of precipitation in Moldova region for winter (a), spring (b), summer (c), fall (d)

The Pontic pluviometric input is the most reduced very close to the Black Sea and to the northern part of the region due to the atmospheric stability induced by the broad aquatic surfaces, as we depart from the moisture source.

Table. 3. The role of the Black Sea as contributor (%) to the semestral amount of precipitation for 8 weather stations in Moldova (1961-1992)

	Cold	Warm
Botoșani	11,4	23,6
Iași	11,7	27,8
Bacău	12,9	27,3
Galați	13,0	24,3
Bălți	10,6	19,7
Chișinău	9,3	19,5
Tiraspol	7,1	16,2
Leova	11,3	22,2
Mean	10,9	22,6

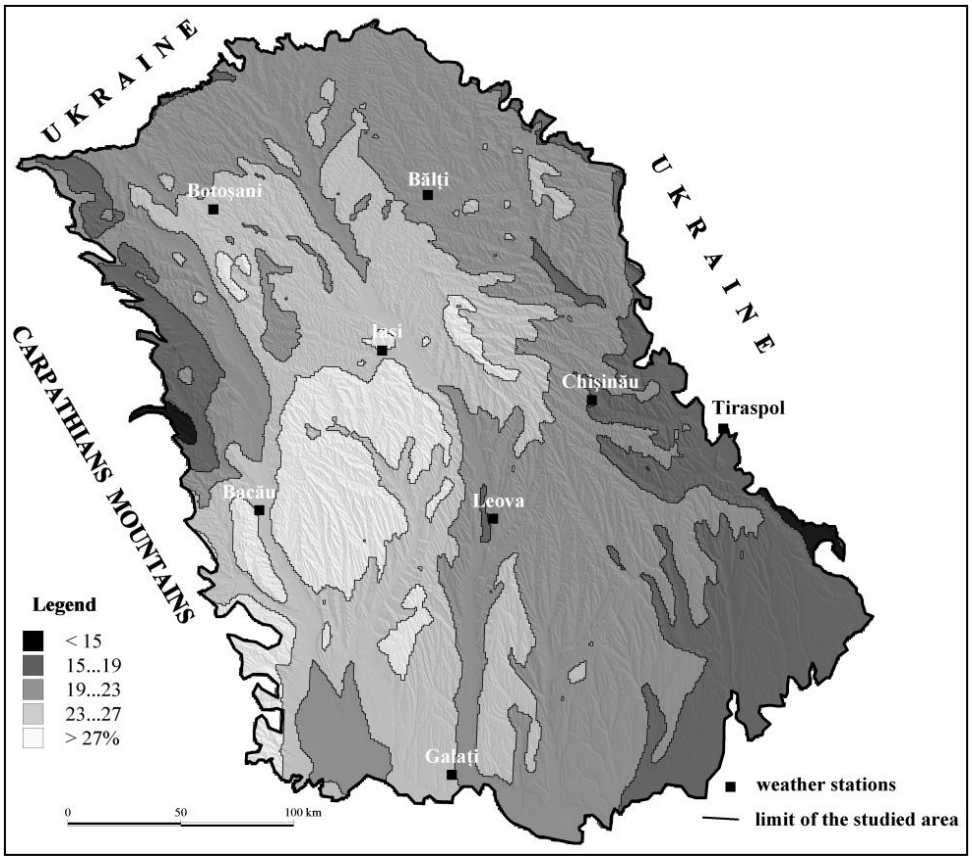

Figure. 3 - The contribution (%) of the Black Sea to the semestral amount of precipitation in Moldova region during the warm semester

Semestral level. The convective mechanism of producing precipitation that originates from Pontic moisture is better observed due to large amounts of precipitation in the warm season (April-September). Moreover, large amounts of rain fall over hilly areas of Western Moldova (Tab. 3, Fig. 3) where convective mechanism are also maintained by the orographic environment.

Eastern and South-Eastern part of the analysed region, along Dniester River valley and South-Eastern Basarabia, are deprived of Pontic input (<20%) mainly because of the low relief plains.

At the same time, the convective cells containing Pontic moisture develop in the Eastern part of the region and produce precipitation in the western hilly areas after travelling along general trajectories from NE to SW [10] or from SE or NW. This type of trajectory specific to convective cells provided by the Black Sea represents the main cause of producing precipitation excess in the Subcarpathian region [11] in particular due to the influence of retrograde cyclones originating over the Mediterranean.

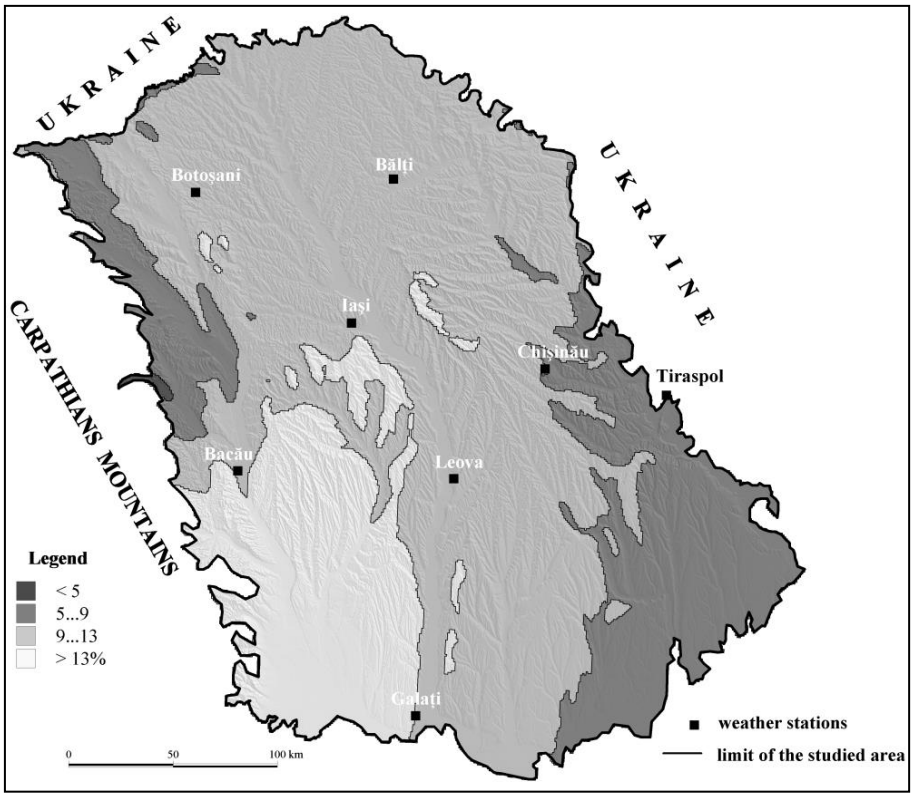

Figure. 4 - The contribution (%) of the Black Sea to the amount of precipitation in Moldova region during the cold semester

During cold season (Octomber-March) the smaller precipitation amounts of Pontic origin do not exceed throughout the region 15%, meaning an absolute value of 30 mm (Fig. 4). In this period the input of Pontic origin is manifested through air advection from the Black Sea with a south-easterly component in the anterior side of some of the Mediterranean cyclones or even under the influence of south-eastern advections under the action of the East-European anticyclone [12].

CONCLUSIONS

The input of Pontic origins precipitation amounts registered in Moldova is higher during warm season dominated by convective pluvio-genetic mechanisms. From the point of view of territorial distribution, the highest input of Pontic origin is distributed on the hilly areas of the western half of the region. Quite often the moisture input from the Black Sea represents the cause of exceptional pluviometric episodes from the Subcarpathian region (1991, 2005).

Black sea as moisture contributor plays a major role in supplying Moldavian region with water in the period of highest monthly precipitation amount, but also saves the installation of severe drought at the end of summer and beginning of autumn. In the absence of the Black Sea the annual precipitation in the non-mountainous areas of Moldova, would not exceed the threshold of 500 mm on an annual average level.

Our evaluation is in line with the previous assessment given by Bordei-Ion (1983) and provides a clearer image on the territorial distribution of this input.

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