CLIMATIC CONSIDERATIONS TOWARDS THE MANIFESTATION OF THE PHENOMENON OF SNOWSTORM ON THE TERRITORY OF THE REPUBLIC OF MOLDOVA

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ABSTRACT:

In order to elaborate this article there were processed the weather statistics of the State Meteorological Service of the Republic of Moldova for the 1960-2005 period. There have been analyzed the synoptic conditions of snowstorm genesis on the territory of the Republic of Moldova, its characteristic parameters, snowstorm vulnerability areas and its control.

1. Introduction

For the economy of the Republic of Moldova and for the road and, especially, rail transportation, the cognition of snowstorm phenomena from different aspects is of great importance.

So, ***snowstorm*** *is defined as a snow movement above the Earth surface, caused by an enough strong and turbulent wind, either with or without snowfall* (O. Bălescu, N. Beşleagă, 1962). There are two distinct situations:

- general snowstorm, when snow is strongly drifting, without being noticed whether it snows or not;
- snowstorm with snowfall, when it can be stated if it snows (O. Bălescu, N. Beşleagă, 1962).

Many years there could not be given a distinct definition for this phenomenon. So, for example, in Romania, in different carried researches, having investigated the synoptic conditions in which it is formed the wind known “crivăţ”, there was not specified whether this wind is accompanied or not by drifting snow (O. Bogdan, E. Niculescu , 1999). In other bibliographical sources (A. Puţuntică, 2001; G. Lasse, 1978), the snowstorm is defined as a phenomenon of snowfall accompanied by a more or less strong wind.

The quality of a meteorological hazard is attributed to snowstorm first of all due to the wind speed: it is characterized by strong winds with speeds of over

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11m/s (strong snowstorms) or over 15 m/s (violent snowstorms) and then, due to the heavy snowfall, can form a snow layer of 25-50 cm high, or snow piles of 1-2 metres high, causing numerous damages.

As a hazardous phenomenon, snowstorms occur in mid-winter, especially in January and February. In December and March snowstorm is annually recorded only on open plains and between rivers. The snowstorm occurs more rarely in November, and even more rarely in April. In October the snowstorm is produced only in the northern part of the republic (a case in 10 years) when its effects are associated with frost, and the damage produced to cultures can be greater.

So, snowstorm, as a hazardous phenomenon, must fulfil some qualities:

- high speed wind and especially heavy snowfalls in mid-winter;
- very early and, respectively, very late snowstorms out the season.

2. The causes of snowstorm appearance

Snowstorm is the result of the interaction between the particularities of general movement of the atmosphere over the South-Eastern Europe and the characteristic features of the active surface specific to the Republic of Moldova. This is formed in synoptic situations similar to those of snowfall that results from the meeting of the main European baric centres (East-European Anticyclone, Azoric Anticyclone, Scandinavian Anticyclone and Mediterranean disturbances - Mediterranean cyclones). The difference in this case is the thermal contrast between the cold air mass situated on the ground and the tropical warm one at extremely high altitudes, 20-25ºC horizontally, that forms 4-5 mb/100 km baric gradients şi2-3 ºC/100km thermal ones. The strongest snowstorms are those that appear above the Central and Eastern Europe where a belt of high atmospheric pressure takes action simultaneously with a cyclone family on the Mediterranean Sea (G. Lasse, G. Șevkin, 1974). This belt is determined by the advance of a wedge of the East-European Anticyclone that joins above the Central Europe to another one of the Azoric Anticyclone.

Sometimes the anticyclonic belt can be replaced by the presence of more anticyclones which individually take action: the Azoric, Scandinavian, East-European ones, which are prolonged by a wedge above the territory of the Republic of Moldova and that are in close correlation with the cyclone above the Mediterranean, or above the Black Sea.

In the synoptic practice, the cognition of the situations of or relating to snowstorm genesis is of great importance, creating the possibility of their preventing. Therefore, there was considered useful to classify the snowstorm situations to determine a series of baric types and subtypes. Thus, the classification elaborated by Bălescu O. and Beşleaga (N. (O. Bălescu, N. Beşleagă, 1962), highlights six baric types of snowstorm genesis on the territory of Romania and can also be available for the territory of the Republic of Moldova. Of course, it should be mentioned that between the identified baric types and subtypes there are intermediate baric situations that make their determination more difficult.

3. The main parameters to characterize snowstorm

The favourable period of time for snowstorm appearance is comprised between the average dates of its producing from the beginning to the end of the cold semester of the year. The analysis of these average dates allows us to realize when snowstorm becomes a climatic hazard, all the more as this does not occur every cold semester of the year or every month of this one. On the basis of long periods of observation at the meteorological stations on the territory of the country it could be specified what is the favourable period of its producing regarding to the altitude and the geographical position towards the invasion of the cold air from the North and the North-East of the East European Plain.

The average date of the first snowstorms occurring in the Republic of Moldova is placed in December-January, and those of the last snowstorms occurrence is placed towards the end of February. The annual average period favourable for snowstorm producing is comprised between these average dates, between the first snowstorm (December-January) and the last one (the end of February) that means 2 – 2.5 months per year (Г. Лacce, 1978).

Regarding the average date of snowstorm occurrence, this one can take place earlier or later in out-season when it can obtain the character of a climatic hazard due to its consequences which it unleashes on the environment, society and economy.

The earliest snowstorms take place in October but these are recorded only on the North Moldova's Plateau (1case in 10 years) and on the Central Moldova's Uplands.

The earliest snowstorms usually took place in November (e.g. in Kisinev in 1948 there were 2 cases, in 1948 – 2 cases; in 1954 – 1 case; in 1975 – 4 cases; in 1989 – 1 case). More recent dated November snowstorms are those from 1993, 1995, 1998. The first one from November, 1993, was recorded in Corneşti on the 21st; lasting for 1 hour (from 3.20 p.m. to 4.20 p.m.), the height of the snow layer being insignificant (2 cm). The second case in November, 1993, took place in Ştefan-Vodă, on the 30th. The height of the snow layer reached 2 cm. Apparently, we could say that these snowstorms are not so dangerous, but analysing more complex the situation, we can see that the sudden fall of temperatures during their occurrence lead to the freezing of the last autumn crops, especially there where the wind blows away the protective snow layer.

The snowstorms in 1993 and 1998 occurred in the third decade of November. But that one in November, 1995, took place in the first decade of this month (Corneşti, on 6-7 November between 9.20 p.m.-03.15 a.m., length 6 hours; Bălţata, the same date, between 9.15p.m - 0.40 a.m. due to the earth baric differences between the Central Europe (1035mb) and the South-Eastern Europe (1005 mb), that facilitated the accentuated growth of the wind speed, visible aspects in the analysis of the ground atmospheric pressure (Europe) and geo-potential at the level of 500 mb) (figure 1).

The latest spring snowstorms noticed on the territory of the Republic of Moldova were in March (1947; 1962; 1971; 1973; 1988; 1993). Very rarely snowstorms were recorded in April (Briceni 0,2 days, Corneşti – 0,3 days (cases).

The periods between the average dates and the extreme ones of the snowstorm producing, at the beginning of the cold semester and, respectively, at its end, contains the periods of climatic hazards for the snowstorms that occur in out-season and can cause numerous damage for the national economy, especially, agriculture. The snowstorms produced out the specific winter season, on the background of negative temperatures and sweeping of the snow layer, can determine the freezing of field crops on the field, especially, of those at the beginning of their vegetation period.

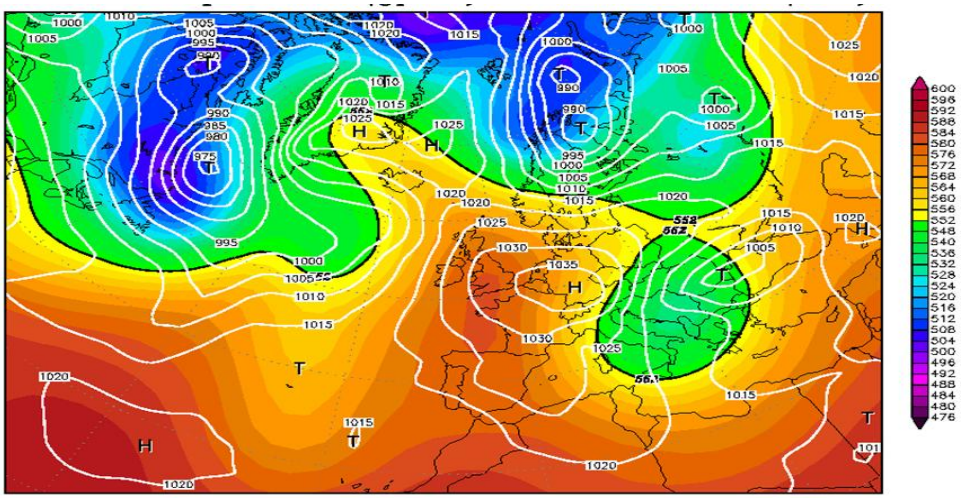

Fig. 1. Atmospheric pressure at ground (mb - in isobars) and geo-potential at the level of 500 mb (gpdm - in colours), Europe, 6.11.1995, hour 00, (snowstorm at Cornești and Bălțata), (from www.wetterzentrale.de).

Also, the snowstorms produced in the period between the average date of the first snowstorm at the beginning of the cold semester and that of the last snowstorm at the end of it can have especially serious consequences, if we take into consideration their violence, and the snow layer as well as the character of their falling.

Though the length of the possible snowstorm period is rather long, sometimes being equal to the whole length of the cold period of the year, the annual average number of snowstorm days is relatively small (table 1).

Annually, the fewest number of snowstorm days occur in the field regions (Bălți 5.2 days) and also in the urban topo-climatic regions (Chișinău-4.4 days), where the high density of the high buildings diminish the snowstorm occurrence (G. Lasse, 1978).

Unlike these in the upland regions of the North and the Centre of the Republic of Moldova the annual number of snowstorm days is doubled (Briceni – 9.6 days, Cornești – 10.8 days). The increase of snowstorm days in the southern part (Cahul – 7.2 days) might be explained by the physical and geographical

position of this station, at the entrance in the Romanian Plain, "watched" in the North by the Carpathian Curvature and in the South by the Massif of the Northern Dobrogea, which determine an orientation of the cold air masses of arctic origin from the North and North-East of Europe, in the same time with their interaction with the warm ones of tropical origin from the above the Mediterranean Sea.

Table 1. Annual average number of snowstorm days (G. Lasse, 1978).

No.	Station	X	XI	XII	I	II	III	IV	SUM X-IV
1.	Briceni	0.1	0.8	1.6	3.2	2.3	1.5	0.1	9.6
2.	Soroca	0.0	0.4	1.2	2.7	2.5	1.4	0.0	8.2
3.	Camenca	0.0	0.4	1.4	3.1	3.2	1.9	0.2	10.2
4.	Bălți	0.0	0.2	0.7	1.5	1.8	1.0	0.0	5.2
5.	Vărăncău	0.0	0.5	2.5	3.8	3.8	2.7	0.05	13.4
6.	Bravicea	0.05	0.1	0.8	2.2	1.8	0.5	0.0	5.4
7.	Cornești	0.05	0.5	1.3	3.6	3.1	1.9	0.3	10.8
8.	Dubăsari	0.0	0.4	1.6	2.9	2.9	1.8	0.2	9.8
9.	Bălțata	0.0	0.2	1.3	3.3	2.7	1.4	0.1	9.0
10.	Kisinev	0.0	0.1	0.6	1.6	1.3	0.8	0.0	4.4
11.	Tiraspol	0.0	0.2	1.0	2.3	1.9	1.0	0.1	6.5
12.	Cărpineni	0.0	0.2	0.5	1.2	0.8	0.4	0.0	3.0
13.	Olănești	0.0	0.1	1.2	2.2	1.7	0.7	0.0	5.9
14.	Leova	0.0	0.2	0.8	2.2	1.5	0.7	0.0	5.4
15.	Comrat	0.0	0.4	1.1	2.1	1.4	1.1	0.0	6.1
16.	Cahul	0.0	0.4	1.1	2.3	2.3	1.1	0.0	7.2

The maximum number of snowstorm days of a winter records the highest values in the regions where the average number of days with this phenomenon is higher (Briceni – 23 winter cases in 1946-1947; Camenca – 31 winter cases in 1963-1964; Cornești – 21 winter cases in 1967-1968; Cahul – 24 winter cases in 1968-69).

The maximum length of snowstorm is recorded in January because in this month it is noticed the largest amounted period of snowstorm hours (15-20 hours).

The average length of a singular snowstorm case varied from 5.6 hours (Cornești) to 9.4 hours (Cahul).

The quantity of fallen snow during a snowstorm fulfils the portray of a climatic hazard of snowstorm. But, naturally, the largest quantity of fallen snow on a snowstorm day is not on the area where the phenomenon is the most frequent. The highest values (5-6 l/m^2) occur in more advantageous falling conditions (less violent snowstorm) and moisture transportation, conditions that are met on Bălți Hillock Plain, Inferior Nistru Plain, South Moldova Plain, due to the Mediterranean cyclones with zone evolution and those with retrograde character. Regarding the duration and intensity of snowstorm the snow layer is of variable height.

The average height of the snow layer fallen during the snowstorm that is measured on the standard meteorological platform with the help of fix snow gauge rulers can vary from 8-10 cm to 50-60 cm, without taking into consideration the height of the snow piles that are formed as a result of the snow accumulation in the sheltered places.

The maximum height of the snow layer formed during a snowstorm is even higher if compared with the average one. During the years the highest (consistent) snow layers were of 6-8 m during the snowstorm on 5-6 January, 1966, and of 5-6 m during the snowstorm on 11-13 February, 1967, both of them more actively occurring in the centre and the south of the republic.

As a hazardous phenomenon, according to the performed evaluation for the 1960-2005 period, the snowstorm occurs in the middle of the winter season, especially in January (probability of 35%) and February (probability of 24%). The probability of snowstorm occurring in the other characteristic months essentially decreases (16-17% in March; below 5% in April, November and December) (figure 2).

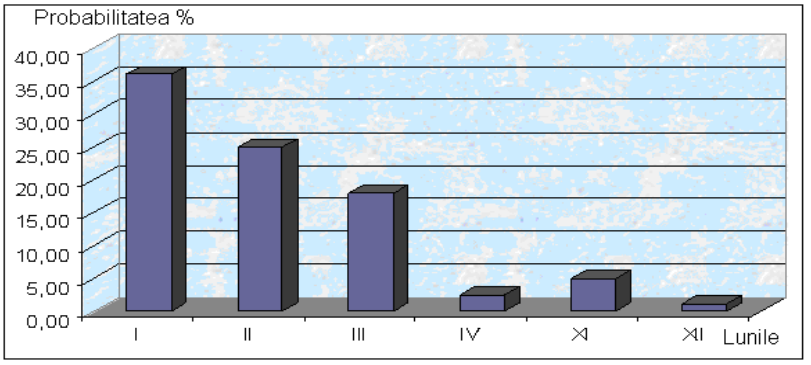

Fig. 2. The probability of snowstorm occurrence in the Republic of Moldova (1960-2005)

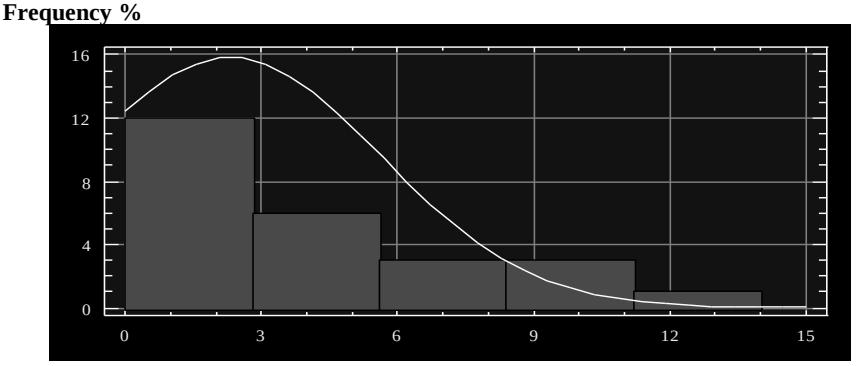

Fig. 3. Annual frequency of snowstorm occurrence on the territory of the Republic of Moldova (1960-2005).

The snowstorm being an unfavourable phenomenon that rarely occurs has the highest frequency of 2 days per year. The analysis of data range for the 1960-2005 period for 7 meteorological stations in the republic allowed the building of the theoretical repartition curve which presents an obvious asymmetry, a fact that is determined by numerous cases when the snowstorm phenomenon is missing, statistically getting the value of 0 (zero) days/year (figure 3).

4. The vulnerability of the territory towards snowstorm

The character of hazardous climatic phenomenon that we attribute to snowstorm is highlighted very well by the means of its consequences. Due to the high speed of the wind and the quantity of snow fallen during the snowstorm there are numerous, sometimes very serious, consequences on environment and economy.

The snowstorm violence causes the snow-swept and the uncovering of the cultures that are later frozen, the formation of snow piles at the shelter of wind obstacles (in the villages outskirts, along the transportation ways, on the river meadows etc.). Having its part, the piled up snow interrupts the road and rail circulation, destroys the walls and roofs of the houses and stables (both due to its weight and quantity of moisture absorbed by them); due to its mechanical action on the ground objects, the snowstorm causes the breakage of the young branches, electric and telephone cables, uncovering of houses, etc.

The main circulation arteries that suffer most, because of the snowstorm are those situated perpendicularly on the snowstorm direction like the following rail roads:

- ✓ *sector Corneşti-Ungheni;*
- ✓ *sector Bălți-Făleşti;*
- ✓ *sector Basarabeasca–Iargara;*
- ✓ *sector Căuşeni-Căinar*i.

The same happens to some national and international roads like:

- ✓ *sector Ungheni-Corneşti-Călăraşi (nr. E581; A273);*
- ✓ *sector Bălți-Floreşti (A-280);*
- ✓ *sector Rîşcani-Drochia-Soroca (A-281; P8);*
- ✓ *sector Comrat-Vişniovca-Cociulia (P46);*
- ✓ *sector Kisinev-Hînceşti (A276) and others*.

Nearly there is no snowstorm that would not affect these circulation arteries, a fact that imposes the adoption of some prompt measures of snow removal and restoring their function.

But there are recent situations as November, 1993, or November, 1995, when the snowstorm at the beginning of the cold season kept the circulation interrupted for 3-5 consecutive days, because of the non-intervention with much promptness and firmness for snow and ice removal (maybe there were produced late interventions due to the economic crisis the system of road management of the republic had to face – the lack of fuel, the poor financial situation etc.).

Other serious consequences that appear as a result of the melting of the snow piles caused by snowstorm often are the floods, phenomena dependent on

the quick rate of warming up at the end of the winter and the level of soil moisture from the previous autumn period.

From the above presented it results that the snowstorm, both due to the intensity of the genetic conditions and the resulted consequences, can be considered one of the most aggressive meteo-climatic hazards.

The average frequency of snowstorm days on the territory of the Republic of Moldova and their consequences allow a global evaluation of the snowstorm affected areas at different levels. According to the annual average number of snowstorm days and the resulted consequences the territory of the Republic of Moldova is exposed at, the map of exposed areas to snowstorm hazard presents three levels or steps of vulnerability as it follows:

- *Territories with low vulnerability (1-1,55 days);*
- *Territories with average vulnerability (1,55-2,1 days);*
- *Territories with high vulnerability (>2,1 days).*

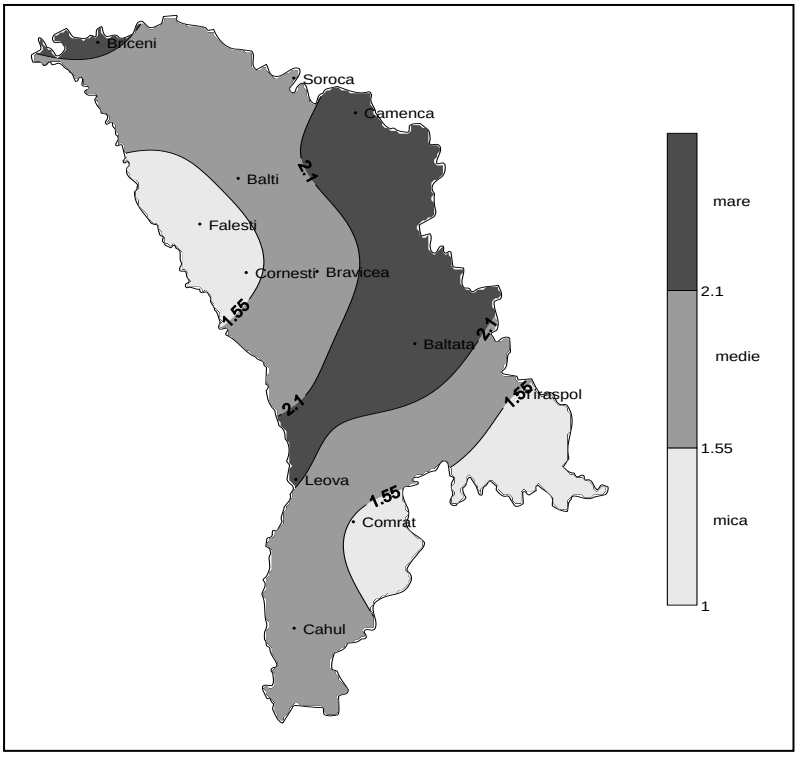

Fig. 4. Snowstorm vulnerability of the territory of the Moldova Republic (1960-2005).

In figure 4, one can notice first of all that the territories in the northern extremity of the Republic of Moldova are the most exposed to snowstorm and, as a consequence, have a very high vulnerability as a result of their position towards the horizontal movements of the cold air that are directed from higher latitudes.

Approximately the same situation is repeated in the central part with the exception of Bălți Hillock Steppe Plain. We remark that the number of snowstorm days increases in the same time with the altitude. The overlapping of the same snowstorm vulnerability maps elaborated for Ukraine and Romania also denote a logical continuation of an axle of maximum intensity of the snowstorm on the territory of the Republic of Moldova. It is connected to the air movement of the Euro-Asian Anticyclone that goes far towards the South-West of Europe, especially towards the area of the curvature of the Eastern Carpathians (Romania). Inside this channel (the anticyclonic wedge), it is felt a narrowing of the cold air current that comes from the North-East, on one side from the North of the Curvature Carpathians and on the other one from the South-East of the Dobrogean horst.

Unlike these regions where the snowstorm reaches the maximum frequency, the territories in the South-East of the country show low vulnerability.

Different from these ones are the valleys and the depressions where because of the shelter offered by the relief (the valley of Răut at Trebujeni, the valley of Țâpova etc.) the snowstorms are very rare, or are missing, and the snow lies relatively uniform copying the relief forms. Due to this the height of the snow layer formed during the snowstorms varies very much being dependent on depth of breaking up.

5. Conclusions

The negative snowstorm consequences are too frequent and too well-known to present them once again. It is obvious, of course, that for diminishing the damage caused by snowstorms the control measures are much more various and efficient than those of proper control.

The control measures are long and short-termed. Among the first group there are mentioned:

- *The planting of protective curtains formed of forestry species that hinder the snow-drifting from the agricultural fields;*
- *The installation of snow fences along the main roads and rail roads to hinder the formation of snow piles and prevent them from being blocked, etc*.

Among the last one are:

- *The sheltering of animals;*
- *The creation of food reserves for these and the adoption of other measures aimed at the outrunning of the snowstorm periods with as few as possible damages.*

It is also recommended to have lanterns and spare batteries, food and water reserves at hand (for example, high energetic food as well as dried fruits, nuts, food that does not need to be refrigerated or thermally prepared, medicine reserves, and first-aid kit). There should be used more thin clothes to prevent sweating. It is necessary to wear caps and hoods because half of the body warmth is lost in the head area. The mouth will be covered with a scarf to protect the lungs against the cold air.

The control of snowstorm consequences or the snow removal is done with more or less efficient means according to the level of endowment and organization of every community.

In conclusion we mention that in spite of knowing the annual snowstorm frequency for every region of the Republic of Moldova and forecasting these hazardous atmospheric phenomena do not present a very difficult problem for the meteorologists, the snowstorms continue to cause numerous damages and even human loss nearly every year.

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