# REGIONALIZATION OF CLIMATIC HAZARD/RISK PHENOMENA AND THEIR ENVIRONMENTAL IMPACT IN BUCHAREST METROPOLITAN AREA

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**_Abstract_**

*By its position within the Romanian Plain (southern part of Romania) both the capital city Bucharest and its metropolitan area are exposed to several climatic hazards/risks with major impact on the environment. The article emphases in detail the occurrence and the amplitude of the hazard/risk phenomena of the cold semester (cold waves, blizzard, snow layer, frost and hoarfrost, glazed frost etc.) and warm semester (heat waves, rainfall, hail storms, strong winds, fog and acid rain etc.) within Bucharest Metropolitan Area.*

*The authors used and processed the annual and monthly mean climatic values within the meteorological stations from the studied area between the years 1961-2005 in order to identify the main hazards/risks with direct impact on the environment quality reflected on the recorded damages which have affected the settlements (roads, houses, agricultural land etc.) and people. At the same time, on the basis of this survey we were able to realize two climatic hazard/risk maps for each semester (cold and warm).*

*The paper also analyses the synoptic conditions which have been generated the main climatic sequences within the studied area, considered as case studies: the heat waves of the summers of 2005 and 2007 and the amount of precipitation fallen in September 2005 as well as their environmental impact.*

**Key words:** *climatic hazard/risk phenomena, environmental impact, Bucharest Metropolitan Area, Romania*.

Bucharest Metropolitan Area is situated in a temperate-continental area, which is specific to the South-East of Romanian Plain, characterized by a continentalization tendency, from the West to the East, as a result of the climatic influences of transition in the West and excessive in the East.

The climate of the metropolitan area, which is determined by natural factors specific to the form of relief it is related to, is completed by the multitude of the local anthropic factors specific to the regions which enclose by the urban and rural areas. The most important factors are:

- the presence of a haze screen which often floats above the city and which modifies the radiation regime and the condensation conditions of the water vapors;
- the specific features of the surface subjacent to the formed areas predominant in roofs (concrete, metal, tiles, wood, etc.) and pavements made of diathermic materials with reduced heat capacity that accumulate heat during the day and release it during the night;
- the alternation of street network with green spaces of different sizes, as well as aquatic surfaces (rivers, lakes, irrigation channels etc.);

- drainage of meteoric waters and industrial waters, through the sewage, which reduces local evaporation and thus the heat consumption;
- the existence of a very rough micro-relief, made up by the network of streets and markets, parks, courts and buildings of different heights and orientations, which modifies the speed and direction of the wind under the conditions of a turbulent air mixture;
- emanation in the atmosphere of the heat resulted from the fuel combustions in industry, transportation, house heating etc.

All these factors, which have a quasi-permanent influence, are modifying the regime of different climatic elements transmitting them to the metropolitan environment along with the extension of the urbanization process.

***Climatic risks/hazards.*** Due to its location and specific particularities, Bucharest Metropolitan Area is exposed to climatic risks of major impact upon the environment presenting a higher vulnerability to *thermic, pluvial* and to the *mixed risks.*

The genetic conditions necessary to the production of ***thermic risks*** are mainly caused by the atmosphere general circulation, solar radiation and by the active subjacent surface.

During cold season, these risks are favored by the advections of cold and dry air belonging to the Grönland, Scandinavian and East-European Anticyclones, which generate high decrease in temperature. Depending on their frequency and intensity, the result is cold waves with different lasting periods, and when they are produced at the beginning of fall or at the end of spring, their effects are even more disastrous.

During the warm season of the year, the advections of marine tropical warm air, subsequently continentalized, or the continental tropical air generated by the continental anticyclones developed in the North of Africa, in the South-East of Europe, in the South-West of Asia etc., determine massive warming and periods of dryness, the longer the period, the higher their frequency and intensity.

***Pluvial risks*** are generated by the activity of ocean cyclones, which are developed by the Mediterranean cyclones with normal or retrogressive evolution as well as by the cut-off cyclonic formations. These risks are likely to take place the whole year.

***Mixed risks*** are determined by the combined action of one or more climatic elements under favorable synoptic circumstances and influenced by the characteristics of the active subjacent surface.

Depending on the production moment, the main thermic, pluvial and mixed phenomena of risks may be divided into: *cold season phenomena of climatic risk* and *warm season phenomena of climatic risk.* Among these phenomena, the ones with a major impact on the environment in Bucharest Metropolitan Area are the following:

**Cold season phenomena of climatic risk,** is represented by the thermic minus tolerances to the normal status, caused by: the position of the baric centers compared to the area of interest, the frequency and intensity of the cooling process and shift speed of the air mass types. These genetic conditions are increased/decreased by the characteristics of the subjacent surface. The main cold season climatic risks existing in Bucharest Metropolitan area are the following:

- Polar or arctic cold waves;
- Heat waves during the winter, which cause floodings;
- Blizzard;
- Snow cover;
- Frost and rime;

- Glazed frost;
- Icing on the aerial conductors etc.

Because of the developed technical-urban infrastructure in the city areas the effects of these climatic risks are much mitigated.

The air masses direction of motion from the position of baric centers, which are constant during cold season, as well as the frequency and intensity of some massive cooling processes of the frosty and dry air waves lead to the occurrence of *cold waves*. The estimation of their intensity *(Bogdan, Niculescu, 1999)* is calculated depending on*:*

- the average monthly air temperatures (≤ -10 $^0$C);
- the minimum air temperature (≤ -30 $^0$C).

Usually, these cold waves are caused by non-periodical disturbances favored by their casual occurrence, by the different intensity of the cooling processes and by the period of manifestation. These thermic singularities become more obvious when the absolute minimum temperatures are registered during different periods of time and on surfaces more or less extended (Fig. 1).

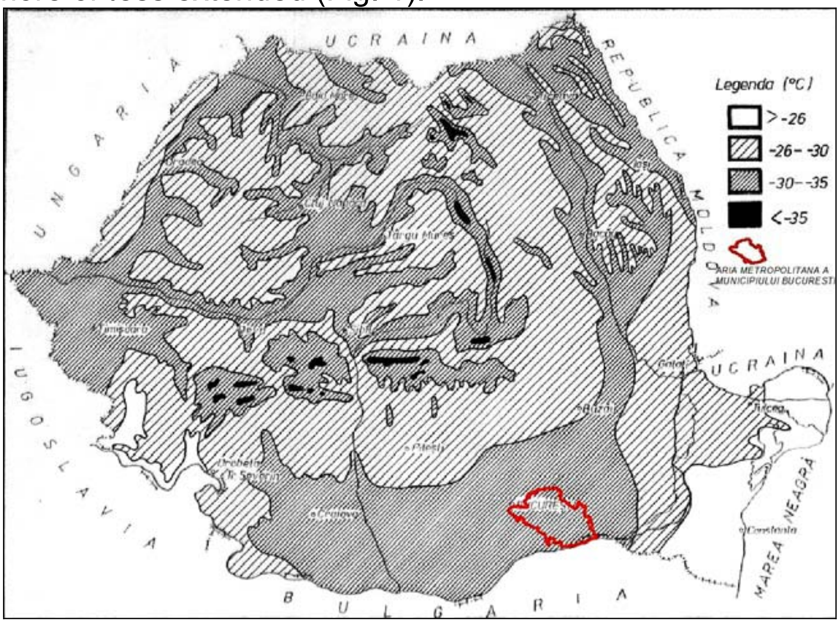


*Figure 1. Territorial distribution of the yearly absolute minimum temperatures (Source: ANM)*

Bucharest Metropolitan Area is exclusively included in the temperature range of – 30... -35 $^0$C generating a major climatic risk, with a negative impact on the environment and on the human body (table 1).

***Table no. 1.*** *The absolute minimum temperatures recorded on the meteorological stations in Bucharest Metropolitan Area*

| Meteorological station | Absolute minimum temperature ($^0$C) | Date |
|---|---|---|
| Baneasa Bucharest | -32,2 | 25.01.1942 |
| Filaret Bucharest | -30,0 | 25.01.1942 |
| Afumati Bucharest | -30,2 | 06.02.1954 |
| Budesti | -27,4 | 06.02.1954 |
| Fundulea | -26,5 | 14.02.1985 |
| Oltenita | -25,0 | 31.01.1987 |

*Source: National Meteorology Administration database*

***Blizzard*** represents a climatic risk of whose genesis is complemented by two elements: wind speed and the thickness of the snow cover. When the speed of the wind exceeds 15 m/s, the blizzards become violent, and when the speed of the wind is associated with thickness of the snow cover that exceeds 25-50 cm, it causes great damages and environmental disequilibria. The Center, the West and the East of the Metropolitan Area of Bucharest City are vulnerable to blizzard, having a yearly maximum frequency of 4 to 9 days, while in the North and in the South this climatic risk is of 2 to 3 days, indicating an average vulnerability (*Romania. Environment and Electricity Transmission Grid. Geographical Atlas*, *2002*).

The transport infrastructure suffering the most because of the blizzard are the ones oriented perpendicularly to the direction of the crivetz: Bucharest – Giurgiu; Bucharest – Lehliu – Constanta; Bucharest – Ploiesti; Bucharest – Alexandria and Bucharest – Buzau – Suceava. We also have to mention the national roads accompanying the arteries, but the blizzard remains a singular hazardous meteorological phenomenon of whose effects are dictated by the quality of the technical-urban infrastructure.

***Snow cover*** is considered a hazardous winter meteorological phenomenon and it is present in the Metropolitan Area of Bucharest City almost every year. The first snow is usually produced at the end of November and the last one during the third decade of March. Although the possible snow interval (between the earliest and the latest day of manifestation of the phenomenon) is of approximately 100 days; the yearly average snow days is only 53 in Bucharest-Filaret, 54 in Bucharest-Afumați and 46 in Bucharest-Baneasa.

The average decade values of the snow cover thickness varies around 10 cm in Bucharest-Baneasa, 8 cm in Bucharest-Afumați and 12-13 cm in Bucharest-Filaret meteorological stations. The urban areas register higher values, visibly influenced by the urban-technical development and more decreased values in open filed because of the snowdrifts, blizzard to the soil and in altitude. The absolute thickness of the snow cover reaches 120-175 cm in the center of the Metropolitan Area of Bucharest during the exceptional years, while the snow cover in the rest of the area decreases under 120 cm. Under the action of wind, especially the crivetz, the snow cover varies and the snow is blown and withered.

The atmospheric calm or the wind with a speed under 2 m/s, as well as the particularities of the active surface, generates important snow beddings. In return, the wind with speed over 15 m/s, affects the stable snow layer generating snowdrifts on all arteries located perpendicularly to the crivetz direction, especially on national roads which start circularly from the city of Bucharest, and particularly along the roads accompanied by skirts, forest plantations, forests etc.

In case of total or partial absence of snow covers, the soil-freezing phenomenon is likely to appear, which causes important damages to the autumn crops and to vegetation in general.

***The freeze and hoar*** are hazardous meteorological phenomena which occur during transition seasons, conditioned by the shift of the air minimum temperature on the soil bellow the level of 0° C. These processes become phenomena with climatic risk under two circumstances: if they occur much sooner or much later than the average date of the first, respectively the last frost and in the situation of extremely frosty winters, in the absence of snow cover or if it is blown away by the wind.

Almost the entire part of the area under study shows a great vulnerability to frost (165 days/year) under the conditions of average temperatures in January, between -2 and -3 $^{o}$C, and the rest of the territory corresponding to Danube riversides and terraces are characterized by an average vulnerability (140 days/year) under the conditions of some average temperatures for the month of January between $-1^0$ and $-2\ ^0C$.

High vulnerability to hoar (over 70 days/year) occurs in the central part of the area under study, while in the rest of the metropolitan area the vulnerability to this meteorological phenomenon is medium (50-70 days/year) (fig. 2).

***Glazed frost*** is a meteorological phenomenon which consist in a thin layer deposit of dense ice, mat or transparent, on the ground and objects, especially on the side exposed to the wind, as a result of the water drops become frozen in contact on a very cold surface. Glazed frost occurs at temperatures between $0^0$ and $–3^0C$ and it is one of the most hazardous phenomena, having a negative impact upon all means of transportation (road, air, cable).

***Table no. 2*** *The average monthly and yearly number of glazed frost days (1961-2000)*

| Meteorological station | Months | | | | | | | | | | | | Yearly |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | |
| Bucharest-Baneasa | 1.2 | 0.6 | 0.3 | - | - | - | - | - | - | 0.1 | 0.5 | 1.3 | 4.0 |

*Source: National Meteorology Administration database*

Generally, the most of the days with glazed frost are registered in plain areas (between 15-20), while in the Metropolitan Area of Bucharest City the maximum frequency is recorded during the months of December and January (tab. 2). In the last years, as result of warmer winters, with positive temperatures for long periods of time, the number of glazed frost days decreased even in the months with maximum manifestation of the phenomenon.

Because it has the greatest density (0,40-0,95 g/cm$^3$), glazed frost may cause additional weight of the conductors, generating cable, relay, etc. tightening or even breakage.

***Ice deposits on aerial conductors*** is a result of overcooled water freezing (under the form of fog, foggy air, drizzle, rain), through the sublimation process and through the adherence and freezing of snowflakes or of rain and snow. Depending on the way of formation, ice deposits may result from glazed frost, hard or soft rime, rain and snow, and freezing snow. The deposits may be simple (as a result of one phenomenon) or compound (formed as a result of two or more simple deposits). The specific parameters for these deposits are: large and small diameters, weight, type of deposit, density and duration of deposits (tab. 3). Icing on aerial conductors modifies the electricity supply conditions, generating disturbances in regular functioning (Corona effect), causing wire tightening, vibration and even breakage under windy weather. Regarding plain areas, the periods with the most frequent icing phenomenon are at the end of autumn and beginning of spring.

***Table no. 3*** *Maximum icing values and their characteristics*

| Meteorological station | Maximum weight (g\mg) | Density | | | Type of deposit | Number of cases | Maximum duration of a case (ore) |
|---|---|---|---|---|---|---|---|
| | | D | d | g/cm | | | |
| Bucharest-Baneasa | 32 | 14 | 14 | 0,24 | Hard rime | 1 | 51-100 |

*Source: National Meteorology Administration database*

The most powerful phenomena in terms of climatic risk characteristic to the cold semester of the year that have the biggest impact on the environment and on the state of health of the population in the metropolitan area of Bucharest Municipal town are: the blizzard, the frost and the white frost. At the scale of Romanian territory certain areas have been identified with a low or high degree of vulnerability to the mentioned above three weather phenomena that are the grounds on which critical environmental areas have been reginalized from a climatic point of view in such a time of the year (fig. 2)

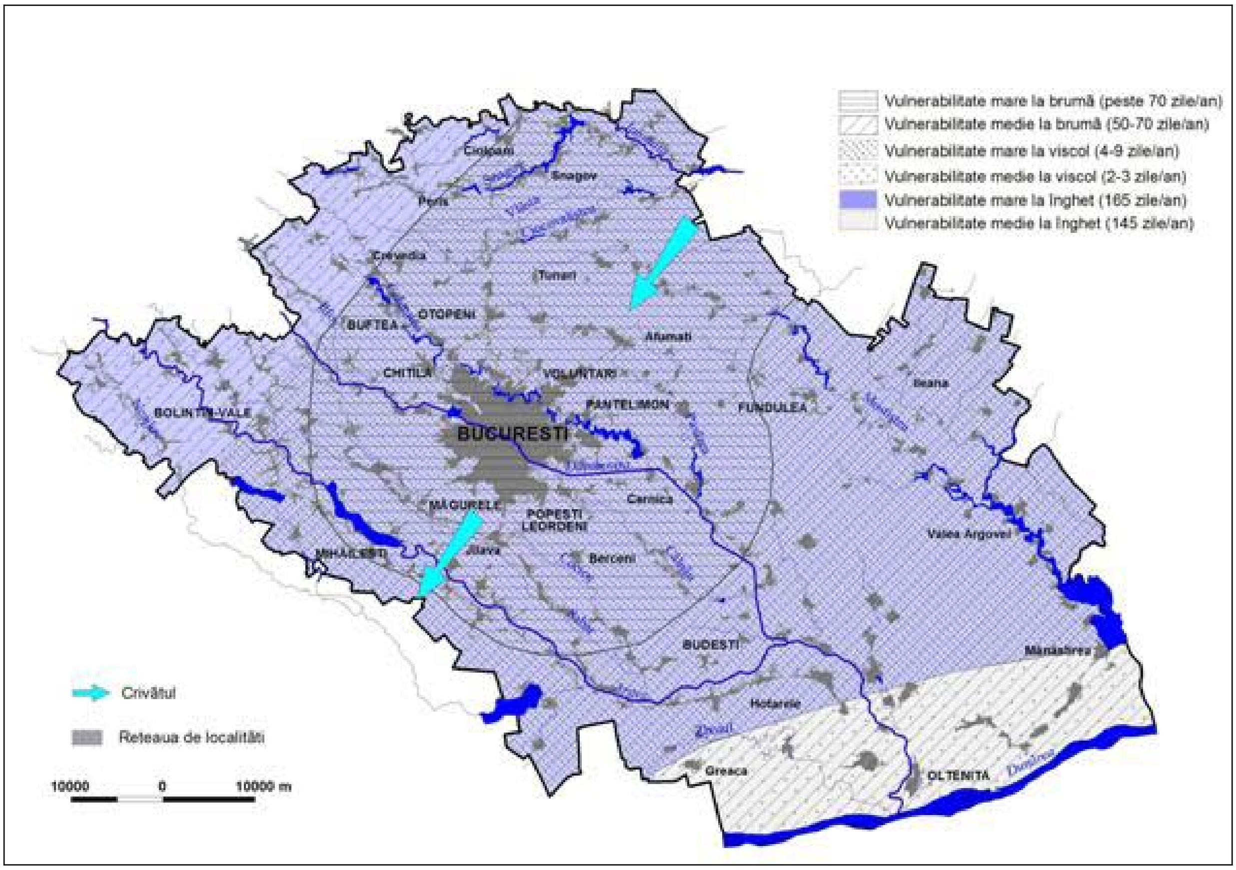


*Figure 2. Climatic risks/hazards within the warm semester of the year in Bucharest Metropolitan Area*

**Climatic risk phenomena within the warm semester of the year** are influenced by the fact that the multiannual medium degree is highly overrun with pozitive degrees, which are brought about by the general movement of the atmosphere in correlation with solar radiation and with the nature of the subadjacent surface. These types of climatic risk include:

- heat waves and pozitive thermic singularities;
- heavy rainfall;
- hail storms,
- thunderstorms,
- fog and acid deposits;
- manifestations of wind at a speed of 15m/s.

***Heat waves and pozitive thermis singularities*** are generated by the adventions of warm, topical air, and the criteria after which they are classified entail (*Bogdan, Niculescu, 1999*):

- the monthly medium temperatures of the hottest months (Jully, August) ≥ 35° C
- highest daily temperatures that exceed 35° C (extremely hot days)
- lowest nocturnal temperatures ≥ 20° C (tropical nights)

Regarding the impact that highest temperatures have on the human body, the exceeding of the 35°C thermic threshold is acutely felt and it has a negative effect on human confort as well as on the normal development of the phenofazes of different type of vegetation. Taking into consideration the fact that the 35° C temperature is measured inside meteorological shelters, 10-15°C can be added at the soil level, which renders the thermic doisconfort even more acute. Absolute maximal values of the air temperature in the area opf interest have exceeded 40°C, reaching even 44°C (tab. 4) and having a major impact on the environment and on the general state of health of the population, pointing a maximum degree of vulnerability to this thermic risk.

***Table no. 4***

*Absolute maximal temperature on values classes within Buharest Metropolitan Area*

| **Value clases** | | | | |
|---|---|---|---|---|
| **40.0 – 40.9 $^0$C** | **41.0 – 41.9 $^0$C** | **42.0 – 42.9 $^0$C** | **43.0 – 43.9 $^0$C** | **≥ 44 $^0$C** |
| Bucharest Afumati 40.0/5.VIII.1998 | **Bucharest Afumati 41.1/5.VII.2000** | **Bucharest Baneasa 42.2/5.VII.2000** | - | Valea Argovei (Argova Valley) 44.0/10.VIII.1951 |
| Bucharest Băneasa 40.0/16.VIII.1963 | Fundulea 41.3/16.08.1963 | **Bucharest Filaret 42.4/5.VII.2000** | - | - |
| Bucharest Filaret 40.4/5.VIII.1998 | Budesti 41.4/16.VIII.1963 | **Fundulea 42.4/5.VII.2000** | - | - |
| Bucharest Filaret 40.8/7.VIII.1896 | Bucharest Filaret 41.1/20.VIII.1945 | **Oltenita 42.7/5.VII.2000** | - | - |
| Snagov 40.0/10.VII.1945 | Bucharest Baneasa 41.1/20.VIII.1945 | - | - | - |
| Gurbanesti 40.5/3.VII.1938 | **Budesti 41.5/20.VIII.1945** | - | - | - |

*Source: National Meteorology Administration database*

A particular situation is the ***massive warming in the Summer of 2000*** when the intensity of the heat coincided with the *year of maximum salar activity*, just like in the year 1946, only more intense.

The warming process began on the 2$^{nd}$ of Jully 2000 when the islandic depression located in the West of the UK up to the nordic seas came into contact with the Greenland Anticyclone, over the Atlantic Ocean towards Northern Africa. In such a synoptic context the swift advection of the warm air over South-Western Romania has favourised a South-Westward circulation in the inferior troposphere (fig. 3). The peak of the heat was in the interval 4-5$^{th}$ of Jully and it affected the Southern half of Romania when the temperature and moisture index exceeded 80 units which led to a *highly elevated thermic risk*.

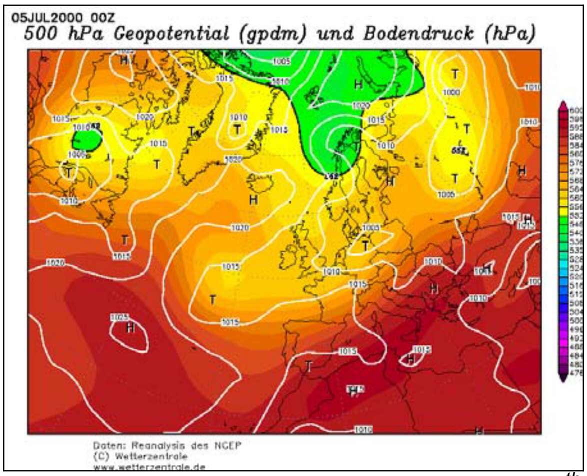


*Figure 3. Baric configuration in Europe on Jully 5$^{th}$ 2000*

On the 5$^{th}$ of Jully 2000, at all the meteorological stations within the Bucharest Metropolitan Area absolute maximum temperatures exceeded 41° C (tab. 5). Afterwards, in several consecutive sequences spreading over August as well, tropical heat waves came one after another and were produced in the same synoptic context, completing the massive heating situation. These temperatures along with minimum precipitations resulted in droughty weather made even worse by extreme heat. This situation was characteristic for the Summer of 2000.

***Table no. 5*** *Absolute maximum temperatures of over 40°C recorded in the Bucharest Metropolitan Area in Jully 2000*

| Meteorological Station | Absolute Maximum Temperatures ($^0$ C) | Date |
|---|---|---|
| Bucharest Afumati | 41.1 | 5. VII |
| Bucharest Baneasa | 42.2 | 5. VII |
| Bucharest Filaret | 42.4 | 5. VII |
| Fundulea | 42.4 | 5. VII |
| Oltenita | 42.7 | 5. VII |

*Source: National Meteorology Administration database*

Heat waves have a great impact on plants in general and especially on crops, leading to physiological and phenological changes (the drying of leaves and plants), and on the human body it leads to an encrease in the risk of getting ill and even to the death of people exposed. Thus, following the heat wave in the Summer of 2000, the Romanian Government has issued the 99/2000 Emergency Order, which was published in the 304 Official Monitory of 04.07.2000, regarding protection measures for the population in the case of extreme climatic phenomena.

***Heavy rainfall***. Through their characteristic parametres (intensity, length, quantity), heavy rains are dependant on altitude, relief formes, solar radiation and on the role that is played by the orographic damn in connection to the moist air advections. The highly active dynamics of the moist tropical air or that of the polar maritime air on Romanian territory, as well as the different levels of warming of the earth's surface determine, during summertime, the fall of heavy rains, represents a climatic risk for the environment because of the flooding it produces.

As to the lowlands (Bucharest Metropolitan Area is located in the lowlands), floodings are conditioned by a certain quantity of water coming from precipitations (*Milea et al., 1972*):

- in the case of dry soil a 50 l/sqm quantity of water is needed within a 24 hour period;
- for moist or soaked soil a 15-30 l/sqm quantity of water is needed within a 24 hour period.

Given the context, the ***heavy rainfall of September 2005*** have a special significance within the Bucharest Metropolitan Area, in terms of the environmental impact. The 2005 warm semester was a period of thermic extremes, of especially unstable atmospheric elements and of unususaly intense phenomena which are linked to them. In terms of rainfall, this period of time was an exceptional situation for the South of the country, and especially for Bucharest Metropolitan Area.

During this month, an Azoric air mass had spread over western and central Europe, the baric configuration being the one that determined the contact between polar cold air and moist masses of air from the Mediterranean Sea where an intense cyclogenesis took place. At high altitudes, above the Mediterranean, between the 13$^{th}$ and the 23$^{rd}$ of September a cyclonic nucleus was isolated, which determined unusual precipitations in the South-East of the Continent.

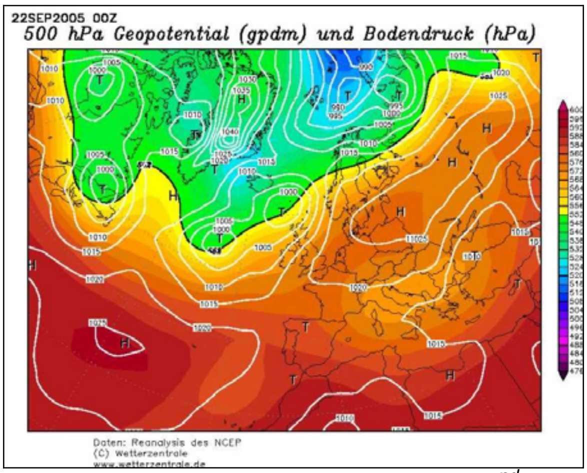


*Figure 4. The baric configuration in Europe for the 22$^{nd}$ of September 2005*

Given the sinoptic context, the full monthly amount of precipitations in the warm semester of the year 2005, as well as those that fell within a 24 hour period, were completely exceptional, enhancing more than one time the aspect that it was a historical record for the entire period of time when rainfall measurements took place in Romania.

Since the beginning of that month, periods of time with heavy rains on vast areas could be identified throughout the country, only hours apart. We have singled out those that took place in the Southern part of the country (*Grigorescu, Dragota, 2006*):

- 1-2 September – Central and Eastern Muntenia, Banat and Oltenia;
- 13-14 September in Northern Oltenia and in Central and Northern Muntenia;
- 14-15 September in Banat, Oltenia, Central and Western Muntenia;
- 18-19 September in the North-West of Oltenia;
- 20-21 September in Central Muntenia, North-Eastern Muntenia and South-Eastern Dobrogea;
- 21-23 September in the Southern half of Romania and especially in South-Eastern Dobrogea.

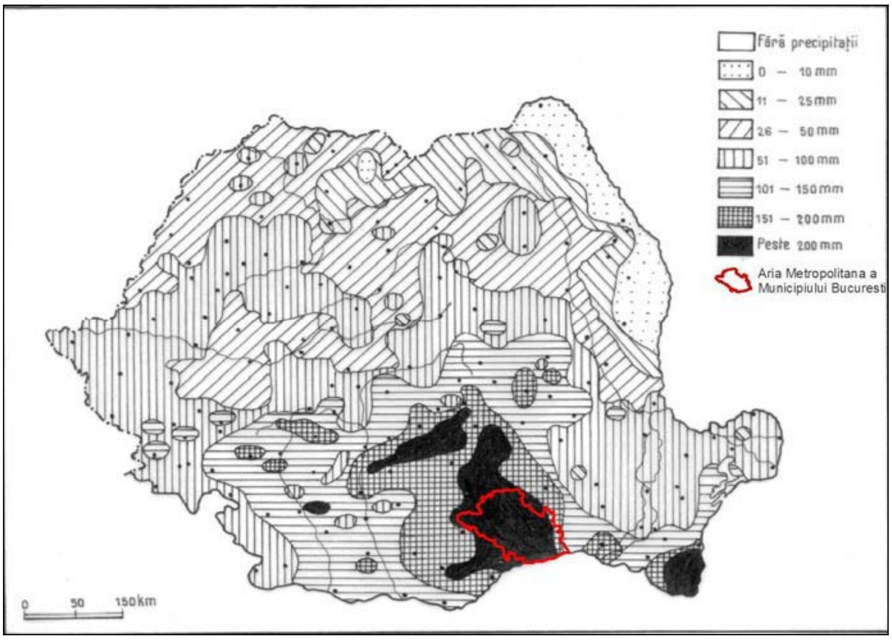


*Figure. 5 The display of precipitations in September 2005*

Water quantities accumulated in September 2005 have exceeded 100 mm in vast areas in the southern half of the country (except Northern Baragan and Central and Northern Dobrogea). Thus positive recordings are registered in regards to the monthly average spanning over several years and are comprised in the interval of 45-80 mm in weather stations within the analysed area. In Central Muntenia and South-East Dobrogea quantities of over 200 mm were registered. These precipitations have affected, in that particular month, especially the Bucharest Metropolitan Area (fig. 5)

Maximum amounts fallen in a 24 hour period of time are an indicator of the heavy rain – character of atmospheric precipitations and have developped in September 2005 extra-ordinary values that exceeded absolute maximum amounts of precipitations previously registered which in coparison with the entire month and with the entire year (tab. 6)

***Table no. 6*** *Maximum amounts of precipitations (in mm) fallen in a 24 hour period within the Bucharest Metropolitan Area.*

| **Meteorological station** | **Absolute maximum amounts (until 2005)** | **Maximum Average (September)** | **Maximum amounts (September)** | |
|---|---|---|---|---|
| | | | **Absolute maximum amounts (until 2005)** | **2005** |
| BucharestAfumați | **107,0<br>20.VIII.1949** | 20,8 | **94,5**<br>11/2003 | **152,3<br>20/2005** |
| Bucharest Băneasa | **107,7<br>15.VII.1954** | 20,1 | **94,0**<br>11/2003 | **126,4<br>20/2005** |
| Bucharest Filaret | **136,6<br>7.VI.1910** | 19,9 | **100,3**<br>11/2003 | **161,4<br>20/2005** |
| Fundulea | **103,2<br>22.VII.1959** | 19,6 | **24,8**<br>22/1998 | **106,4<br>20/2005** |
| Oltenita | **102,8**<br>12.VII.2005 | 32,6 | 86,1<br>4/1999 | **-** |

*Source: National Meteorology Administration database*

Exceeding precipitations that have resulted from man-engineered floodings affect crops, economical infrastructure (roads, bridges, railroads, electrical energy transport networks, sewage pipes and water and gas pipes), houses, and it projected itself both directly and indirectly into people's lives.

The main effects of precipitations fallen in September 2005 in Bucharest Metropolitan Area resulted in the flooding of aproximately 2,500 houses and households in Ilfov County alone and over 190 people were evacuated. The most troubled cities were Pantelimon, Domnesti and Buftea.


*Figures 6 and 7 – Broken damn on Lake Buftea (September 2005)*

On the 22nd of September, Lake Buftea broke through the damn and the water kept flowing towards Mogosoaia village as a result of the fact that the waterflow rose from $3m^3/s$ to $20m^3/s$ (fig. 6 and 7)

On Lake Mogosoaia peers made out of sand bags were erected in order to stop the waters moving forward. In Comana, Giurgiu County, the earth flooring that most poor families in the village had turned into genuine swamps (fig. 8) and the local train station was flooded (fig. 9).


*Figures 8 and 9 Flood effects in Comana Commune, Giurgiu County*

The amounts of water that supply the lakes around Bucharest have grown about ten times within a 24 hour period reaching record waterflows, and in Domnesti town Ciorogarla river burst its banks flooding many a house.

***Hail*** is a climatic risk phenomenon which takes place in the warm semester of the year. It has major repecussions on the environment. Usually, hail il associated with heavy raining and lightning. In the northern sector of Bucharest a rather large island-like area can be identified as having great vulnerability to such a climatic risk (the maximum amount of days with hail per year is 5-10). The rest of the area has a fairly moderate vulnerability (4-5 days per year) and the South-East has a low degree of vulnerability (under 4 days per year) (*Romania. The environment and the Transportation Electrical Network, Geographical Atlas, 2002*)

***Thunderstorms*** fall into the category of electrometeors and are defined by sudden electrical discharges in the atmosphere. They appear as an intense and short-lived ray of light (lightning) accompanied by a loud thud (thunder). Thunderstorms are often associated with convection clouds (Cumulonimbus) and are usually accompanied by heavy precipitaions.

***Table no. 7*** *Medium and maximum amount of days with thunderstorms per month and per year* (1961-2000)

| Meteorological station | | Month | | | | | | | | | | | | Annualy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | |
| Bucharest-Băneasa | med. | 0.2 | 0.2 | 0.3 | 2.1 | 6.2 | 9.2 | 7.8 | 5.8 | 2.3 | 0.8 | 0.2 | 0.1 | 35.2 |
| | max/ yr | 3 | 2 | 3 | 6 | 13 | 16 | 16 | 10 | 5 | 4 | 1 | 2 | 54 |
| | | 1962 | 1970 1971 | 1967 | 2000 | 1975 | 1970 | 1972 | 1966 | 1967 | 1980 | 1966 | 1975 1969 | 1975 |

*Source: National Meteorology Administration database*

On a yearly basis, in Romania the average number of days ranges between 30-35 in plain regions, and 35.2 days at the Bucharest-Baneasa weather station. All through the year, thunderstorms take place mainly in the warm semester. The maximum amount is reached in Jully when the heaviest amount of precipitations also fal. (tab. 7).

***Fog and acid deposits*** are a heavy source of atmosphere pollution. Due to to the mecanic effect (fog) and the chemical one (acid deposits) it has a great negative impact on the environment.

Fog is basically atmospheric suspension in the form of microscopical drops which cause a diminished visibility in distances of under one kilometre. Fog, in whichever form it may come, has a negative impact on transportation activities (road transport, water transport, air transport, sewage transport) and on the general state of health of the population.

***Table no. 8 The monthly and annual number of foggy days*** *(1961-2000)*

| Meteorological station | Month | | | | | | | | | | | | Annualy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | |
| Bucharest-Băneasa | 10.9 | 8.0 | 3.8 | 1.3 | 0.9 | 0.5 | 0.2 | 0.4 | 1.0 | 4.3 | 9.5 | 11.4 | 52.2 |

*Source: National Meteorology Administration database*

The highes monthly frequence of fog in a one year period of time can be registered during Winter (December- January), and the lowes in Sumer months (Jully- August).

When fog is associated with various polluting substances, its effect on the environment increases alongside these substances's level of concentration, and the intensity and the length of the parametres characteristic to this weather phenomenon increase or diminish the amounts of polluting substances that exist in the given miro-climatic space. The fact that Romania is exposed to this kind of climatic risk involved six levels of vulnerability depending on the number of days with such a phenomenon per year (*Romania. The Environment and The Electric Transportation Network.*

*Geographical Atlas, 2002*) Bucharest Metropolitan Area is set entirely in a high level of vulnerability lasting between 36 to 50 days per year.

Precipitations associated with polluting substances increase the fog's negative impact on the environment as well. In some polluted areas like some different regions within Bucharest Metropolitan Area, 5% of polluting substances that can be found in the atmosphere can adhere to precipitations that fall on the earth (wash-out). In the case when precipitation come from a dirty cloud, highly polluted (rain-out), the polluting substances reach the earth alongside the precipitations at very long distances from their source.

*Acid precipitations* or *acid rain* that have a pH value lower than 5.6 involve the process of dry or moist depositing on the earth of acid material coming from the atmosphere. Without rainfall or some other form of precipitations, atmospheric polluting substances are shifted from the atmosphere by the gravitationnal force that attacts them to the earth's surface and through direct contact with the soil, the vegetation and the buldings. The rate of dry sedimentation of polluting substances varies between 0.1 and 1.0 cm/sec (tab. 9)

***Table no. 9*** *Dry sedimentation speed*

| Poluanți | Viteza (cm/s) |
|---|---|
| $SO_2$ | 0,1 – 1,0 |
| $NO_2$ | 0,2 – 0,5 |
| Sulfați | 0,1 |
| Azotați | 1,0 |

*after Fărcaş, Croitoru, 2003*

Dry deposits can have a very important contribution to increasing acidity levels in both dry and moist deposits. Thay bear the name of *acid deposits* (*Farcas, Croitoru, 2003*) which  take place along with fog risk and within the topoclimatic conditions of the area known as the Island of Hat of the Bucharest Metropolitan Area. After 1989, as the industrial activities of chemical plants decreased, the number of areas with vulnerability to such a climatic risk has also diminished, maintaining the consequences of productive years. Due to the fact that road traffic has increased, the mobile pollution sources have also risen in numbers which, associated with risk weather phenomena (fog, acid deposits, dense and heavy fog) have amajor impact on the environment and on the general state of health of the population.

***Wind at speeds of over 15m/sec*** are generated by thermo-baric contrasts between the different areas characterised by earth horisontal gradients with high values, which can happen at any time during the year. In the cold semester these winds are associated with snowfall. Yet in the warm semester they become climatic risks associated especially with extreme heat periods or with the beginning of heavy rains season. The mecanic effect generated by such winds is twice reinforced by by the large amounts of polluting substances spead into the atmosphere, which generates an increased vulnerability of the environment to such a rosk phenomenon. Taking into consideration the annual frequency of winds with speeds exceeding 15m/sec., one notices that, generally, Bucharest Metropolitan Area has a low vulnerability state (16-20 cases per year). In the South of the MetropolitanArea, along the Danube river plain the degree of vulnerability is average (61-70 cases per year) and the Center and East of Mostistea Plain has an elevated degree of vulnerability (71-100 cases per year).

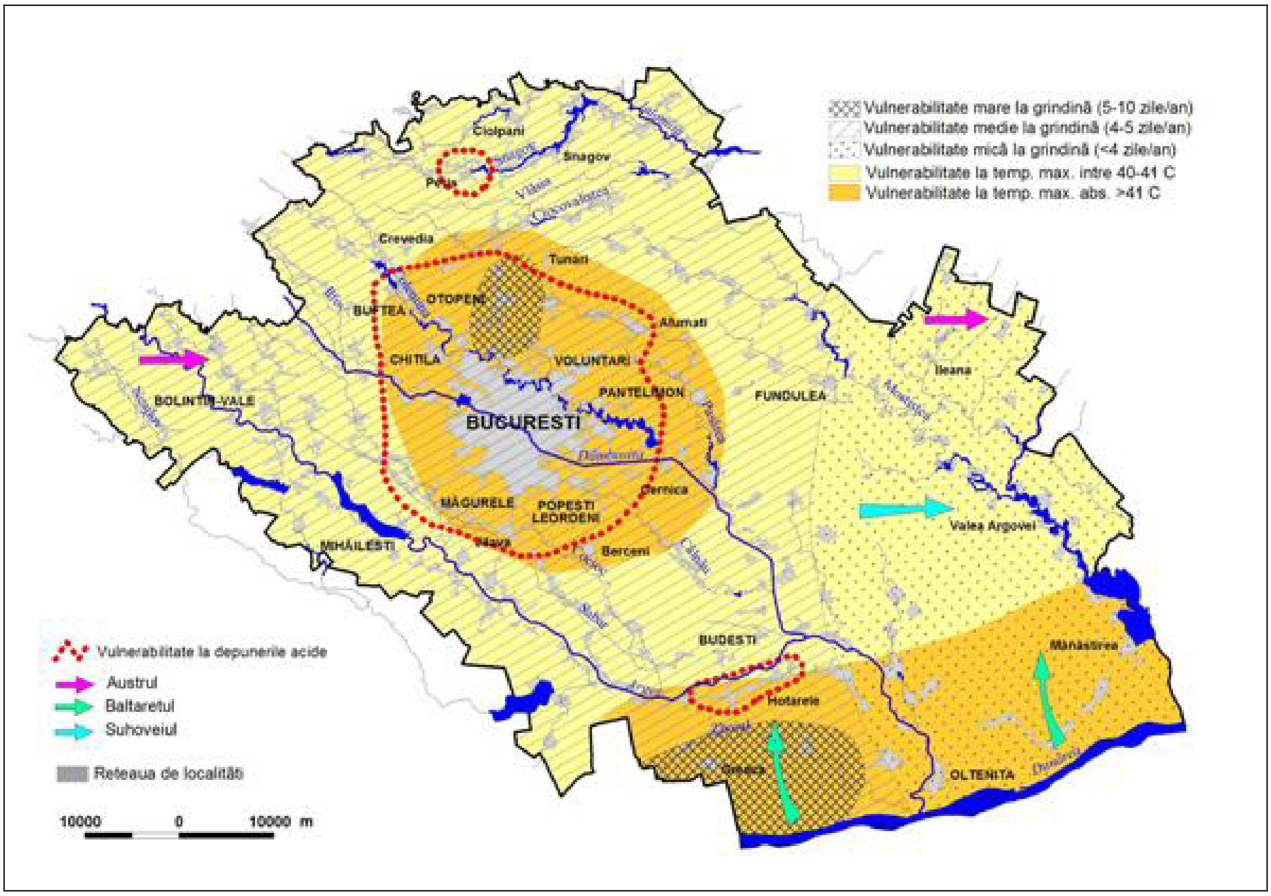


*Figure 10. Climatic risks/hazards in the warm semester of the year in Bucharest Metropolitan Area*

Among the climatic risk phenomena characteristic to the warm semester of the year as to Bucharest Metropolitan Area, those that have a major impact on the environment and on the general state of health of the population were singled out: h***eat waves and positive thermic singularities*** along with ***hail*** (fig 10). Areas with high, average or low vulnerability to hail were identified and areas with high and average vulnerability to positive temperatures were discovered so as to establish with critical environment from a climatic point of view within the warm semester of the year.

Both in Romania, as a country, and within Bucharest Metropolitan Area the rapid shift of certain extreme weather phenomena take place: heavy rain, tornados, sudden temperature rise of over 30-35°C and cold periods of time which subject the human body to adaptation shocks.

Within Bucharest Metropolitan Area, among the climatic risk phenomena, the ones involving thermic and rain risk stand out. As one of these risks, heavy rainfall has the greatest impact on the environment through the extent of the damage it inflicts. Extreme heat and heat waves also represent a major impact due to the fact that human lives are lost.

Because they endure and because they are intense, these climatic risk phenomena within Bucharest Metropolitan Area are either triggering factors of factors that support other categories of natural risks: geomorphological, hydrological, soil related and even ecological ones.

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