# Climatic Hazards Phenomena of the Warm Semester of the Year in the South-West Development Region. Romania

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**Abstract.** The South-West Development Region is exposed to several climatic hazards with major impact upon the environment. The paper emphasizes the occurrence and the amplitude of the hazard phenomena characteristic of the warm semester of the year within the study area based on processed annual, monthly and daily extreme climatic values (temperature, precipitations, wind, dangerous atmospheric phenomena) from all the meteorological stations involved (1961-2007) in order to establish the main vulnerability classes (mixed, very high, high, medium and low). On the basis of this survey a climatic hazard map was realized in order to emphases the main threats of these hazardous phenomena (*heat waves and positive thermal singularities, dryness and drought, heavy rainfall, thunderstorms, hail storms, strong winds, acid deposits and fog*) to the environment. Thus, certain areas have been identified with different vulnerability classes: *mixed*, *high* and *very high*, *medium* and *low* to the above mentioned climatic hazards.

## 1. Introduction

The South-West Development Region is situated in the south-western part of Romania covering 12.3 % (29,010 km$^2$) of the national territory and 10.7% of its population (2,301,833 inh.) [Figure 1 A]. The region expands from the heights of Southern Carpathians and Banat Mountains in the north and north-west to the hilly, plain areas and Danube floodplain in the centre and south. The genesis of specific climatic types (mountain, hill-tableland and plain) is mainly determined by the amphitheatre-like distribution of the relief units. The climatic influences (submediterraneean in the south-western extremity, oceanic in the north and transitional to arid in the east), filling the temperate-continental climate of the South-West Development Region (Romania. The Environment and the Electric Transportation Network. Geographical Atlas).

These major climatic traits are completed by the multitude of factors related to the local geographical environment (orographic barrier of the mountains situated in the north, exposure, massiveness and fragmentation, vegetation, soil and water bodies as well as the man-made changes) determining a wide range of local climatic features and exposing it to several climatic hazards with major impact upon the environment (Figure 1).

## 2. Methodology

Natural risk assessment studies have often been elaborated based one criterion determining a one-sided approach of the involved phenomena. In 1991, E. Bryant developed one of the most complex classifications based on multiple criteria, which inspired Croitoru and Moldovan (2005) in approaching the hazardous meteorological phenomena specific to Romania's territory. They identified for the southern part of the country droughts, heat waves, cold waves, strong winds, blizzards, frontal and convective rainfall, hail, thunderstorms, glazing, fog and dust/sand transportation as dangerous phenomena (Bryant, 1991, Croitoru, Moldovan, 2005). Starting from these complex classifications and yet adapted to the particularities and to the scale of the study-area, a regionalization of the main climatic hazards could be done, based on the annual occurrence and the amplitude of the main thermal, pluvial and mixed phenomena.

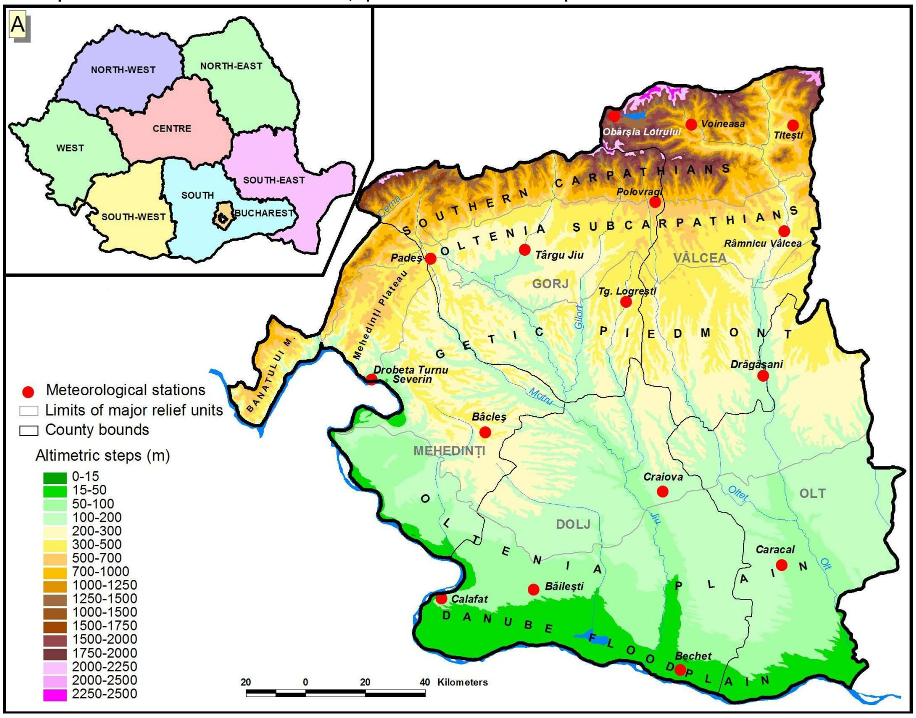


Figure 1: The position of meteorological stations according to relief units in the South-West Development Region and its location within the Romanian territory (A)

Thus, these could be grouped into two main categories: climatic hazards within the cold semester of the year (October - March) and climatic hazards within the warm semester of the year (April-September), revealing with accuracy the two periods in the year where the emergence and development of the extreme climatic phenomena have the greatest impact on the environment. Due to the representatively of the dangerous meteorological phenomena of the warm semester of the year by means of intensity, effects and the covering surface, the present paper analyses in detail the environmental vulnerability to climatic hazards occurring during this time span.

Thus, the above mentioned climatic hazards were analysed in a GIS format, based on the processed annual, monthly and daily extreme climatic values for the period 1961-2007 (temperature, precipitations, wind, and dangerous climatic phenomena) from all the meteorological stations involved and on the climatic hazard elements identified within the study-area (Figure 1).

In a first stage, main meteorological elements' distribution maps (temperature, rainfall, wind) which fit into the area of interest have been analyzed by drawing the variability lines of the climatic parameters. Later on, the main meteorological phenomena specific to the warm semester of the year with different degrees of vulnerability have been analyzed and establish the main vulnerability classes (mixed, very high, high, medium and low). The identified vulnerability categories were underlined by the mean and maximum frequency, duration and intensity of hazardous meteorological phenomena, as well as by the periods in the year affected by these phenomena.

Each climatic hazard was represented by a layer in GIS format comprising of the spatial distribution of the environmental vulnerability to the main climatic hazards which are affecting the studied area in order to emphasize the main threats of these hazardous phenomena to the environment. Following the layers' superposition and correlation, a complex climatic hazard map for the warm semester of the year for the study-region has resulted.

The significance of the chosen dangerous climatic phenomena characteristic for the warm semester of the year within the studied area was also emphasized through the analyses of the most significant extreme climatic sequences, considered as case-studies.

## 3. Results

Based on the methodology described above, the regionalization of the main hazardous meteorological phenomena that take their toll on the South-West Development Region between April and September could be performed in order to make the climatic hazards map for the warm semester of the year.

Climatic hazards occurring during the warm semester of the year are caused by the exceeding of the multi-annual mean values in correlation with the general circulation of the atmosphere combined with solar radiation and with the nature of the subjacent surface or by the frequency and intensity of extreme climatic phenomena related to the global warming. Within the South-West Development Region, the meteorological phenomena with great impact on the environment during this period of the year are related to the action of heat waves and positive thermal singularities, dryness and drought, heavy rainfall, thunderstorms, hail storms, strong winds, acid deposits and fog (Figure 3).

Heat waves and positive thermic singularities are generated by the tropical air advections and the criteria according to which they are classified are as follow (Bogdan, Niculescu, 1999):

- mean monthly temperatures of the hottest months (July, August) $\geq 25^0$ C;
- maximum daily temperatures that exceed $35^0$ C (extremely hot days);
- minimum nightly temperatures $\geq 20^0$ C (tropical nights).

Heat waves and positive thermic singularities are enabled by the complex interaction of different genetic factors such as: the intensity of the heating process, the relief's characteristics (orographic barrier of the surrounding hills/mountains, exposure, massiveness and fragmentation), the vegetation cover, the physical and chemical characteristics of soil layer, the man-made related changes etc.

The penetration of tropical heat waves in favourable synoptic situations has lead to excess values in the South-West Development Region which have reached the state of climatic record. Due to the persistence of anti-cyclonal baric formations for several days in a row, local heat-strike phenomena intensify which leads to en increase in the degree of aridity and drought, emphasizing the value of the positive thermic singularities.

It ought to be noticed the presence of an extended area in south-east Oltenia, between Jiu River, the Danube and the Oltenia hills where massive heating processes are worthy of comparison with those in Bărăgan Plain, very well known in Romania for its increases aridisation process. The absolute maximum value in this area is only one degree lower than that of the entire country, and, in addition, the massive heating processes can be seen here earlier ($35.5^0$ C in Bechet on 04.10.1985) and later ($43.5^0$ C in Strehaia on 08.20.1946 and on 09.08.1946), than in the rest of the country. Thus, Oltenia is the first area of the country struck by heat waves the earliest (in spring), but also the latest (the first decade of September). This area could be considered the second epicentre of extreme heat in Romania (Marinică, 2006).

Due to heat waves, as well as positive thermic singularities, the Oltenia Plain is affected by drought, a phenomenon which can be seen all the more often and which has repercussions on the environment by the severe reduction in phreatic waters, changes in the structure and texture of the soil, phenological changes in vegetation etc. In the past decades, the southern part of the South-West Development Region has been struck by extreme heat. Such alterations have occurred during the heat waves of July 1916 and 1936, August 1946 and 1951, June-July 1994 etc.

A special situation is the massive heating in the summer of 2000 when the intensity of the heat coincided with the year of maximum solar activity of a secular type, resembling the one in 1946, only much more intense.

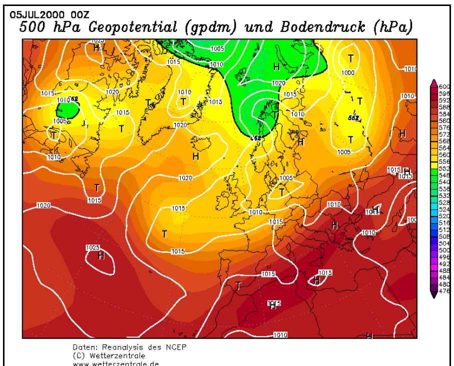


Figure 2: Baric configuration in Europe on July 5th 2000 (www.wetterzentrale.de)

The weather heating process began on July 2nd, 2000 when the Icelandic depression west of Great Britain up to the northern seas interacted with the Greenland Anticyclone above the Atlantic Ocean towards Northern

Africa. In this synoptic context the rapid advection of warm air over south-western area of Romania favoured a south-western circulation of air in the whole of the inferior troposphere (Figure 2).

The final stage of the extreme heat reached its peak in the interval of July 4th-5th of 2000 when it affected the southern half of the country and the temperature-humidity index (ITU) exceeded the threshold of 80 units, which lead to an extremely high thermic hazard.

In the South-West Development Region the hottest summer day in 2000 was the 4th of July, which also holds the record in the past 84 years for the hottest day of any July (Table 1).

Subsequently, within the same synoptic context, the tropical heat waves have hit repeatedly and in addition with the scarce quantities of rainfall, completed the massive heating aspect characteristic for the summer of 2000 in the South-West Development Region.

As to the impact maximum daily temperatures have on the environment, exceeding the $35^0$C threshold has a negative impact on the environment. Taking into consideration the fact that temperatures are measured in meteorological shelter, its equivalent at soil level has 10-$15^0$C more, which amplifies the thermic discomfort. Positive thermic singularities in the warm semester of the year have higher values that the critical threshold of $35^0$C in the southern part of the area under discussion, even exceeding $41^0$C in Oltenia Plain along the Jiu Valley, up to Filiaşi town. These thermic singularities are upheld by the frequency of days when characteristic maximum temperatures are registered of $\geq 30^0$C (tropical days), $\geq 35^0$C (extreme heat) and when minimal temperatures of $\geq 20^0$C (tropical nights) are also taken into account (Table 1).

| Meteorological Station (selection) | Absolute maximum temperature ($^0$C)/date | $\geq 30^0$C | $\geq 35^0$C | Relief unit |
|---|---|---|---|---|
| Obârşia Lotrului | 29.0/5. July | 0 | 0 | Southern Carpathians |
| Voineasa | 36.7/4. July | 11 | 2 | |
| Tg. Jiu | 40.6/4. July | 18 | 6 | Getic Subcarpathians |
| Polovragi | 39.2/4. July | 15 | 4 | |
| Rm. Vâlcea | 40.6/4. July | 17 | 5 | |
| Apa Neagră (Padeş) | 41.8/4. July | 17 | 6 | Getic Piedmont |
| Tg. Logreşti | 40.0/4. July | 14 | 5 | |
| Drăgăşani | 40.7/4. July | 18 | 7 | |
| Vânju Mare | 42.4/4. July | 17 | 9 | Oltenia Plain |
| Băileşti | 43.1/4. July | 19 | 11 | |
| Caracal | 42.3/4. July | 19 | 10 | |
| Calafat | 43.2/4. July | 18 | 12 | Danube Floodplain |
| Bechet | 42.0/4. July | 16 | 12 | |

Source: National Meteorological Agency Database

Table 1. Absolute extreme temperatures and the frequency of days when characteristic maximum temperatures are registered in July 2000, in the South-West Development Region

Heat waves have a special impact on vegetation by underlying physiological and phenological changes and on humans by increasing the risk associated diseases or even death. Thus, following the heat wave in the summer of 2000, the Romanian Government issued the Government Ordinance 99/2000, regarding protection measures taken by the population in the case of extreme climatic phenomena.

In the South-West Development Area the degree of vulnerability to heat waves and positive thermic singularities increases from north to south, revealing an area of very high vulnerability in Oltenia Plain, along Jiu Valley, up to north of Filiaşi. Within this space, an area of a very high degree of vulnerability to aridity and drought can be found. This degree increases as we approach the Danube Floodplain.

The Southern and Eastern slopes of Almăjului Mountains, the southern part of Mehedinţi Tableland, Mehedinţi Piedmont, Bălăciţei and Motrului Piedmont, central and southern part of Olteţ and Cotmeana Piedmont, as well as the Olt valley up to the Râmnicu-Vâlcea – Ocniţa Depression displays a high degree of vulnerability to these climatic hazards.

Areas with a medium degree of vulnerability are in the north of Mehedinţi Tableland, the Getic Subcarpathians (except Târgu-Jiu and Râmnicu-Vâlcea – Ocniţa Depressions) expanding towards the Olt Valley in the mountain sector, to the northern part of Olteţ and Cotmeana Piedmonts. This area also displays a medium degree of vulnerability to aridity and drought phenomena.

The mountain area subscribed to the South-West Development Region is not affected by these thermic hazards and is, thus, characterized by a low degree of vulnerability.

By way of their characteristic parameters (intensity, duration, quantity), heavy rainfall are dependant on altitude, relief, solar radiation, and on the role as a orographic barrier the Carpathian Mountains play to the humid air advections. The highly active dynamics of the humid tropical air or of the polar-maritime air over Romania's territory, as well as the unequal heating of the terrestrial surface generates heavy rainfall during summer unleashing flood-waves.

When taking into consideration the South-West Development Region, the evolution of the meteorological factors, aside from topographic particularities of riverbeds and fundamental features of the water system, plays a decisive role in the occurrence of floods most often brought about by heavy rainfall. From the point of view of the synoptic situations, heavy rainfalls within the area belong to certain types (Milea et. al., 1976):

- ***Type 1*** – heavy rainfall determined by the Mediterranean cyclones;
- ***Type 2*** – heavy rainfall determined by the cyclones centred in the Pannonia Plain;
- ***Type 3*** – heavy rainfall inside the depression corridor formed by an Icelandic anti-cyclone and a cyclone from the eastern area of the Mediterranean Sea;
- ***Type 4*** – heavy rainfall brought about at the limits of an anti-cyclonic field;
- ***Type 5*** – heavy rainfall of a thermo-convective nature.

As a moment when heavy rainfall occur after being generated by such weather situations, a greater frequency during spring and summer comes forwards when talking about the South-West Development Region, due to the more frequent surging of warm and humid oceanic or Mediterranean air above the Romanian territory. During summer, the thermo-convective type 5 is prevalent.

Within the analyzed area, floods are determined by a certain quantity of water coming from precipitations (Milea et. al., 1976):

- in plain areas:
  - in the case of dry soil, a quantity of water of 50 l/m$^2$ or more is required in a 24 hour period;
  - in the case of humid or soaked soil, a quantity of water of 15 – 30 l/m$^2$ or more is required in a 24 hour period;
- in hill or mountain areas:
  - in the case of dry soil, a quantity of water of 30 l/m$^2$ or more is required in a 24 hour period;
  - in the case of humid or soaked soil, a quantity of water of 10 – 20 l/m$^2$ or more is required in a 24 hour period.

In the South-West development Region, the maximum monthly precipitation amounts of a year is registered in the months of June – July. One sector where heavy rainfall are registered is that of the sand dunes at Ciuperceni – Calafat, where the underlying sand surface is rapidly heated and the frequency of unstable moist and tropical air is very high. Another sector greatly affected by heavy rainfall is that of the Subcarpathian Depressions of Oltenia, where the orographic barrier of the relief plays a major role in the increase in value of rain intensity, on the background of Mediterranean cyclones evolving on the classical south-west north-east axis. In such situations, in plain, hill and tableland areas, rainfall of a torrential character have mean intensities of 4 mm/min or even higher. The greatest pluvial intensities determined during torrential rain have been registered at:

| Meteorological station | Date of occurrence | Mean intensity (mm/min) | Duration (minutes) | Total quantity of water (mm) |
|---|---|---|---|---|
| Ciupercenii Vechi | 28.06.1945 | 6.15 | 2 | 12.3 |
| Târgu Jiu | 30.07.1941 | 5.60 | 6 | 33.6 |
| Tismana | 27.06.1934 | 0.50 | 240 | 120.0 |

After Marinică, 2006

Table 2. Maximum quantity of heavy rainfall in Oltenia

As the altitude increases, the intensity of torrential rains drops under 3 mm/min due to the increase in air humidity which quells air temperature values thus preventing thermo convection.

The destructive aspects of torrential rainfall depend on the intensity, duration and on the water quantities, as well as on the numerous characteristics of the active area: lithology, the presence/absence of the vegetal layer, the declivity rate, the moment when they occur during the year (after long drought periods, when the soil is very dry and its cohesion is reduced and the rain's force of erosion is higher, but also after a period of heavy rainfall, or after snow meltdowns when the soil is oversoaked). In such conditions, heavy rainfalls trigger geomorphological processes, affects crops, economic infrastructure (roads, bridges, railroads, networks of electrical energy transportation sewage systems and water/gas pipelines) and houses determining a negative impact on the environment.

The environmental vulnerability to this climatic hazard takes into consideration especially the pluvial intensity, which, in the south and the centre of the area under discussion becomes one of the highest. It is worthy of mentioning the special role of meteorological phenomena associated with heavy rainfall (strong winds, hailstorms, floods etc.), which usually complete the aspects that make up the climatic hazard in the warm semester of the year.

One has to mention the impact of the precipitation registered during short periods of time, of which those cumulated in 24 hours play a very important role. These amounts of rainfall that fall during the warm semester of the year, genetically juxtaposed to thermo convective and frontal processes subscribe themselves to the Azores circulation of air which prevails, and reach the highest values in the whole year. The months during which the most abundant day precipitations are registered, are June, July and August, followed by the autumn months, and then by spring months (especially May). From the perspective of quantity, they exceed the mean values and quantities of the entire month, and in some cases they grow near to the annual mean. In the South-West Development Region, among the most representative such amounts are the following:

| Meteorological station | Maximum amount of precipitations/24 h (mm) | Date of occurrence |
|---|---|---|
| Bîcleş | 110.1 | 31.07.1980 |
| Calafat | 194.0 | 4.06.1940 |

Dragotă, 2006

Table 3 Absolute maximum quantities of precipitations registered in 24 hours

One of the most significant examples of precipitation fallen in short periods of time and in large areas that generate floods in the South-West Development Region is represented by the ***1st-3rd of July heavy rainfall***.

The year 2005 stands out through the long list of meteorological observations conducted since 1874, as an exceptional year in terms of the quantity of monthly rainfall, but especially during the warm semester. In Romania, this has generated, from April until November, seven flood waves with catastrophic results, since material damage of over one billion Euros, and 62 human casualties were registered (Dragotă, 2006).

The synoptic context favourable to the unfolding of the climatic hazard in July 2005 started off on the 30th of June 2005, due to vast depression areas north of Romania, in Ukraine and Poland that merged with the Icelandic depression above our country. The Azores Anticyclone had extended over the western and central areas of Europe and led to the contact of cold, polar air with the humid masses of air coming from the Mediterranean, thus generating an intense cyclic genesis best displayed by the synoptic situation on the 2nd of July 2005 (Figure 3).

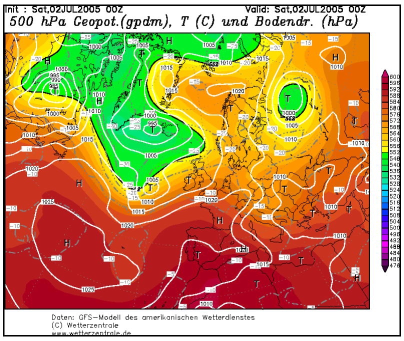


Figure 3: Baric configuration in Europe on July 2nd 2005 (www.wetterzentrale.de)

The evolution of the synoptic context has led to the development of a strong associated cloud system, and in the southern part of the country, especially in Oltenia, rainfall has been signalled associated with strong winds. The rainfall of three days equalled, and even exceeded, the multi-annual monthly mean within the interval 1901-2007 (Table 4), flooding wide areas in the South-West Development Region.

A similar synoptic context stands out for the 11th - 13th of July 2005 when heavy rainfall seriously damaged Jiu and Olt rivers catchments. Thus, due to the damage inflicted (11 human causalities and 839,415 mil. Ron), the month of July 2005 has been deemed to have been the month with the most serious floods in the past 50 years for the area under analysis (Dumitraşcu, Dumitraşcu, 2001, Dumitraşcu, 2006). The largest part of the South-West Development Region displays a medium vulnerability to climatic hazards generated by torrential rain overlapping with the central and northern part of the Oltenia Plain and with the entire piedmont area.

| Meteorological station (selection) | Precipitation amounts (mm) | | | | Relief unit |
|---|---|---|---|---|---|
| | Registration date | | | | |
| | 1.07.2005 | 2.07.2005 | 3.07.2005 | Total (1-3.07 2005) | |
| Runcu | 30.8 | 87.5 | 1.8 | 120.1 | Getic Subcarpathians |
| Balta | 49.7 | 92.7 | 0.9 | 143.3 | Mehedinţi Plateau |
| Rovinari | 66.2 | 93.1 | 2.8 | 162.1 | Getic Piedmont |
| Potcoava | - | 191.5 | 2.9 | 194.4 | |
| Scorniceşti | - | 137.0 | 2.0 | 139.0 | |
| Slatina | 18.6 | 109.4 | 30.0 | 158.0 | Oltenia Plain |
| Breasta | 55.0 | 75.0 | 26.0 | 156.0 | |
| Mărunţei | 27.3 | 143.0 | 21.5 | 191.8 | |
| Corbu Buzeşti | 3.0 | 164.0 | - | 167.0 | |
| Văleni | 1.0 | 168.0 | 4.9 | 173.9 | |

After Marinică, 2006

Table 4. Rainfall amounts registered between the 1st and the 3rd of July 2005

To the South, in the Danube Defilee, Blahniţa Plain, Desnăţui Plain and in the southern part of Romanaţi Plain, as well as in the insular area that covers Mehedinţi Plateau and the depressions in the Oltenia Subcarpathians, the degree of vulnerability to this climatic hazard is high. In the mountain area, the vulnerability to torrential rain is low (Figure 4).

Hail is a dangerous meteorological phenomenon which occurs during the warm semester of the year and has major consequences on the environment. Usually, hail is associated with heavy rainfall and lightning and its character of a climatic hazard is provided by the size of the ice hailstones, the duration, the amount of water, the intensity of the hailstorm and the wind speed that leads to the storm before hail.

The South-West Development Region generally displays the same degree of vulnerability to these meteorological phenomena as those determined by heavy rainfall, which is why on the map for dangerous meteorological hazards distribution concerning the warm semester they are represented by the same symbol.

In the case of a high vulnerability the mean annual frequency is 2-6 days of hail and the absolute annual mean is o 5-10 days. The areas described by this vulnerability step are: the Danube Defilee, Desnăţui Plain and the south of Romanaţi Plain, as well as the insular area covering Mehedinţi Plateau and the Oltenia Subcarpathians' depressions. The medium vulnerability, specific for the centre and north of Oltenia Plain and the entire piedmont area is determined by an average number of 1-2 days and a maximum number of 4-5 days of hail (Bogdan, Marinică, 2007). Areas which show low vulnerability register less than one case of hail in a mean regime and less than 4 cases per year of maximum frequency in multi-annual regime, being representative for the entire mountain area.

The damage caused by this climatic hazard is of a mechanic nature through their destructive effect the hailstones have on crops, as well as through the wind intensifications that accompany or anticipate hail.

Thunderstorms are part of the electro-meteor category and consist of sudden atmospheric electrical discharge which manifest themselves as a short-lived and intense light (lightning) and smothered sounds or loud thuds (thunder). Thunderstorms are associated with convection clouds (Cumulonimbus) and usually come accompanied by rainfalls.

In the South-West Development Region, an average number of thunderstorm days on an annual basis, oscillates from south to north:

- between 30-35 cases/year in the south of Bălăciţa Piedmont and in Oltenia Plain and display a ***low*** vulnerability;
- 40-50 cases per year in the rest of the piedmont area and in the Oltenia Subcarpathians east of Târgu Jiu, leading to an medium vulnerability;
- in Mehedinţi Plateau, the eastern part of the Getic Subcarpathians, as well as in the entire area overlapping the South-West Development Area have, all together, a number exceeding 45 cases of thunderstorms, thus determining a high vulnerability.

All the year round, the maximum number of days/month of thunderstorms is reached in June, when, on a multi-annual regime, the maximum amount of precipitations is registered.

Strong winds (with a frequency and speed of >15 m/s) are generated by the thermo-baric contrasts between the different regions characterised by the high values of horizontal gradients, as they can occur any time of the year. If during the cold semester of the year winds are associated with the snow layer and with snowfall, for the warm semester they are seen as climatic hazards when associated especially with extreme heat or with the begging of heavy rainfall.

The main role in the dispersion of pollutants in the terrestrial atmosphere is that of masses' circulation as well as the relief's configuration. Atmospheric calm associated with the lack of precipitations favours the stagnation of these elements of pollution for long periods of time, usually at lower altitudes and in the same areas where they were generated. The fact that atmospheric precipitations along with strong winds are the most active pair of meteorological elements which influence the geographical environment is very well known. The annual mean of the dominant wind frequency is predominantly west-wards and in the direction of its components.

The aspects of a climatic hazard developed by the wind meteorological factor results in the strong intensification and are characterised by the sudden changes in direction and intensity, resulting in values of 16 m/s. These can be regarded as strong winds and convective thunderstorms associated with the passing of cold fronts of air. The aspect of a climatic hazard induced by strong winds and thunderstorms can produce significant damage, especially in the case of those that hit frontally (due to the large expansion area): the dislodging and destruction of roof-tops, suspended cables and especially electric energy transportation network, knocking down trees in hilly an mountain areas (especially if the front of air comes right after a period of heavy rainfall and the soil is intensely humid), affecting crops etc.

In the South-West Development Region, the average number of days/year with strong winds varry between north (mountain area) where 50-100 cases have been registered, towards south (the Danube Valley and the south of Oltenia Plain) where their frequency drops to 10 cases, exceeding 10 days (Clima României, 2008), and the maximum number of cases possible during the warm semester can go beyond 40. In the north of Oltenia Plain and in the south of the Getic Plateau, due to local orographic factors and to the southern exposure, the number of days with strong winds is 10-25 cases. Within the analysed area, maximum winds speeds registered at the meteorological stations display a variety in value different, in the sense that the lowest value is specific to Blahniţa Plain and to the south of Desnăţui Plain (20-30 m/s) while the Oltenia Subcarpathians east of Tismana River register the lowest maximum speeds (under 20 m/s).

In the rest of the plain and piedmont areas on the southern slope of Vulcan-Parâng-Căpăţânii Mountains and in Mehedinţi Mountains and Mehedinti Plateau, maximum speeds range between 30 and 40 m/s. In the mountain area maximum wind speeds of over 40 m/s are registered, providing an elevated frequency of this climatic hazard.

Combining the climatic parameters represented by the maximum speed and frequency of days with strong winds (>15 m/s) that have an impact on the South-West Development Regions's environment; areas displaying vulnerability to strong winds can be individualized. The north area of the analysed region is the most exposed part to this climatic hazard, and overlaps the high-altitude mountain space, thus describing a region with a very high vulnerability. The south-west part of Almăj Mountains, the high-altitude mountain area, the Danube Gorge, Mehedinţi Mountains, the south of the Getic Plateau and the north of Oltenia Plain display a high vulnerability to this climatic hazard.

A medium vulnerability is characteristic for the southern slopes of the Carpathian Mountains, as they merge with the Oltenia Subcarpathians, Olt Valley (mountain sector), the north of the Getic Piedmont, Danube Valley, Blahniţa Plain, Desnăţui Plain, south of Romanaţi Plain.

Areas with a low vulnerability generally overlap the east of Mehedinţi Plateau and the Oltenia Subcarpathians. Within this area, at the lowest altitudes of Târgu Jiu – Câmpu Mare Depression, an insular area stands out within which the degree of vulnerability to this type of meteorological phenomenon is very low.

Acid deposits and fog are a very important source of pollution of the atmosphere, due to the mechanic (fog) and chemical (acid deposits) effects that have a negative impact on the environment.

Fog is basically atmospheric suspension in the form of microscopic drops that reduce visibility to less than 1 kilometre. The presence of fog, in no matter what shape, has a negative impact on transport means (road transport, water transport, air transport, sewage transport) and on population's health.

The highest monthly frequency of fog within a year can be registered during winter (December-January), and the lowest during summer (June-August). The physical and geographical allotment of this hydro-meteor highlights the highest number of foggy days (40-50) in the subcarpathian depressions and down the valleys of Jiu River (Motru – Rovinari coalfield) and Olt River (from the mountain region to the plain region). Isolated, in Târgu Jiu – Câmpu Mare and Râmnicu Vâlcea – Ocniţa depressions up to 60 cases in annual mean regime are registered. In the rest of the analysed territory the number of foggy days decreases, rarely exceeding 40 cases as an average value per year (e.g.: the Danube Valley).

When associated with various polluting substances its effect on the environment increases in direct ratio with their concentration rate, and the intensity and duration of parameters characteristic for this meteorological phenomenon amplify or diminish the content of polluting substances existent in that micro-climatic area.

Precipitations associated with polluting substances enhance the negative impact fog has on the environment. In a polluted area, as in the case of some regions in the analysed area, 5% of the polluting elements present in the free atmosphere can be engulfed in the precipitations that fall on the soil (wash-out). In the case where precipitations come from a dirty cloud that has a high concentration of polluting substances (rain-out), these substances reach the earth's surface at the same time the precipitations do and at great distances from the emission source.

The most important industrial sources for atmosphere pollution are concentrated in the urban ecosystems of: Râmnicu Vâlcea (Oltchim S.A.), Craiova (S.C. Dolj Chim, CET 1 Işalniţa, CET 2 Şimnic), Slatina (Slatina Industrial Platform), Târgu Jiu (Romcin), Drobeta Turnu Severin (Power Plant), Turceni (Energetic Complex), Rovinari (CET Rovinari) etc. These sources also determine the pollution caused by the dusts conditioned during constant exploitation in the Motru-Rovinari coal exploitation, as well as by the toxic substances and polluting emissions in the atmosphere that come from the fuel burns coming out of technological processes, from thermic plants that produce heat and running water, and, last but not least, from road traffic.

These lead to the identification, within the South-West Development Area, of regions that display different degrees of vulnerability associated with sources previously mentioned that manifest themselves even 4-5 km around the affected cities. The direction and the average speed in a multi-annual wind system, imprint the differentiated dispersion also favoured by the local configuration of the relief as well as by the degree of sheltering conveyed by the frequency of the atmospheric calm.

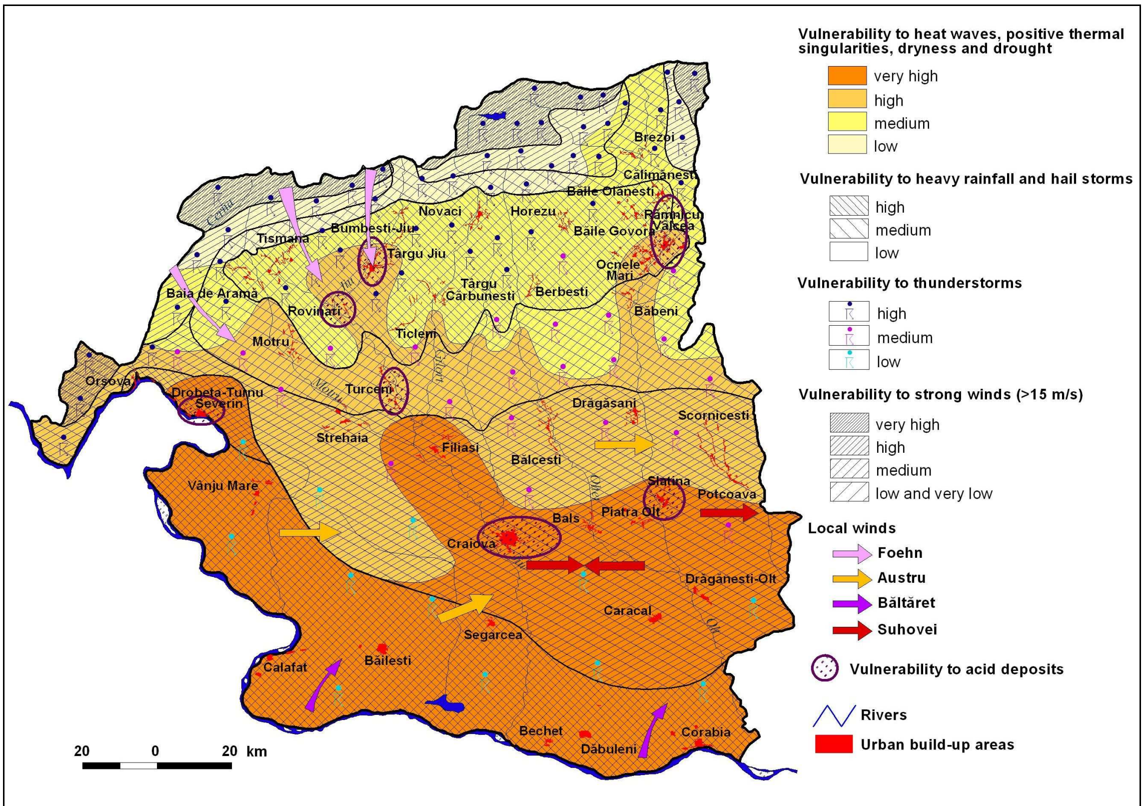


Figure 4: Climatic hazards in the warm semester of the year within South-West Development Region

Acid precipitations or acid rainfall that have a pH value lower that 5.6 refer to the process of dry or humid deposit of the acid materials in the atmosphere on the earth's surface. In the absence of rain or any other sort of precipitations, atmospheric polluting substances shift from the atmosphere by gravitational fall and by direct contact with the soil, vegetation and buildings. The rate for the dry deposit of these polluting substances varies between 0.1 and 1.0 cm/s. Dry deposits can have a great contribution to the increase in acidity, and both types of deposits (dry and humid) bear the name of acid deposits (Fărcaş, Croitoru, 2003) which manifest themselves associated with the risk of fog formation and in the topo-climatic conditions of the heat island of the urban ecosystems affected (Râmnicu Vâlcea, Craiova, Slatina, Târgu Jiu, Drobeta Turnu Severin, Turceni, Rovinari) and increases in direct ratio with these cities' territorial expansion. Due to the fact that road traffic has increased, sources of mobile pollution have also multiplied and, associated with dangerous meteorological phenomena (mist, fog, acid deposits etc.) lead to a major impact on the environment and on the state of health of the population.

Thus, by analyzing the main dangerous meteorological phenomena having different degrees of climatic vulnerability characteristic for the warm semester of the year in the South-West Development Region a complex hazard map with the identified vulnerability areas have resulted (Figure 4).

## 4. Conclusions

The joint effect of hazardous climatic phenomena can be felt gradually depending on how their parameters manifest themselves: according to the altitude (from the plains' level to he mountain areas), but also from East to West. During the warm semester of the year, the central, southern area of the Getic Piedmont, as well as the southern slopes of the Southern Carpathians reveal an area of mean vulnerability to the climatic hazards characteristic for this time of the year. Towards the south, in the Oltenia Plain, an area affected by heat waves accompanied by positive thermal singularities, drought and dryness, heavy rainfall and winds of a regional and local character, the degree of vulnerability is high. In the Subcarpathian depressions and in the northern area of the Getic Piedmont, an area with mean towards low vulnerability stands out, especially regarding heavy rainfall and thunderstorms, which, when confronted with atmospheric polluting sources, favour the existence of insular areas with acid deposits. The mountain sectors exhibit low vulnerability to heat waves, but a high degree of vulnerability to humidity, winds, and thunderstorms.

The importance of making the hazard maps consists in assessing and monitoring the environment vulnerability to different disturbing factors in order to avoid or even diminish their negative impact. Hereby, the maps dictate the delimitation of areas with different vulnerability scales to the analyzed hazards, having a practical importance for the human communities at regional and local level.

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