Physics AUC, vol. 23, 63-78 (2013)

Fog forecast in Oltenia

Şerban-Eugen Iordăchescu, Magdalena Iordăchescu

Regional Meteorological Center Oltenia, Weather Service Forecast Craiova
105 Calea Bucuresti, Craiova, Dolj, Romania
e-mail: sebi_iordachescu@yahoo.com, magda_iordachescu@yahoo.com

Abstract

In this paper we present some aspects of the fog classification and forecasting possibilities in autumn - winter in the Oltenia.

To obtain significant results in terms of climatological, study of this phenomenon is necessary for a number of years, but this work is limited to the analysis of 2010, which, in winter there were 55 days with persistent fog Oltenia, representing the 21 cases.

The analysis of synoptic situations in which the phenomenon was produced has been able to establish a number of baric structures that generate persistent fog and its type (inside the air masses and frontal), resulting in that warm anticyclones type determines fog advection-radiation and depressions occur in a front fog type, two physical processes are essential in producing this phenomenon: air cooling and evaporation. Finally we analyzed the case of advection-radiation fog type in the region of Oltenia, taking into account parameters and factors that proceeded kept phenomenon which led to its dissipation.

Introduction

The purpose of this paper is to provide an overview of the synoptic situations that allow the production of fog in the Oltenia, addressing this phenomenon on synoptic scale, mesoscale and the radiosonds scale. Particular case shown refers to the production of fog in the area of Craiova.

The analysis synoptic periods of fog was carried out taking maps from the archives of the German meteorological cases during the year 2010 and for the period 18-20.01.2011, the case specifically analyzed, we used real maps for Europe, Romania and Oltenia (maps of sea level pressure, absolute topography maps at 500 mb - gives information about the evolution of synoptic air mass at the 700 mb - more useful in winter due to reduced vertical development of air masses and the 850 mb - allows the analysis of thermal advection in the lower troposphere) [3], imagery, upper air charts (Here have been used diagrams aerological soundings made in Bucharest, which ,generally, are not conclusive for Oltenia, but in this case, persistent fog affected the south entirely and could be used for the concrete case study in the area of Craiova), graphs of temperature and pressure [4]-[5].

For each period of persistent fog during 2010 the synoptic structures were followed for the entire period highlighted and the synoptic situation resulted in the generation and persistence of fog.

Results regarding the types of fog and associated synoptic regimes are presented in Part I and Part II (case study).

Part I. Types of fog and associated synoptic regimes

I.1. Fog – General definition

According to international standards, the fog is a phenomenon that reduces visibility horizontally less than one kilometer. This phenomenon consist of small droplets of water suspended in the air. The fog is formed when the humid air is cooled and reaches its dew point, vapors in the air becomes saturated and condense to form water droplets.
The principle is the same as the fog formation and cloud formation, only that it is a cloud that touches the ground.
When forming fog droplets are large, wet mist touching objects, and if their size continues to grow, then turns to drizzle.
The opacity of the mist is a remarkable fact, with regard to the total weight of the water particle, which is very small. Maximum distance visibility of objects during fog is proportional to the droplet radius and inversely proportional to the mass of one cubic meter of water. Mist intensity is characterized by the maximum distance at which objects are seen, hence the name mist: 100 m, 50 m, 20 m etc.
Fog has a whitish color due to air cooling, forms generally very fast but dissipates extremely slowly. General fogging conditions are extremely high humidity and a wind that blows not too weak (when the temperature is below 0 gr. resulting droplets freeze frost) or too strong (in this case we can not speak about mist) [6].
Fog forms when the air layer near the ground state reached saturation with water vapor for a longer duration (the temperature falls below the dew point). The water content of the liquid mist is smaller in the case where the temperature is low than high. Two factors are essential for producing the mist: the cooling air and the conventional evaporation, two factors act simultaneously on the weight of the one or the other [7].
At the same time, depending on the synoptic situation the mist can be:

1. Fog in air masses

This category includes radiation fog, advection fog and radiation fog, advection.

1.1. Radiation fog – occurs under clear skies and little wind, following an intense radiation of the soil surface, which entails cooling the surrounding of air layers. Because of this, the mist of the radiation is always linked to the formation of a thermal inversions. An important factor in the formation of this type of fog is the specific moisture distribution in the layer of air near the ground. Increase of its value in first 100 m is an indication that there will be fog, if the other conditions are met. The existence of a little wind up to 3-4 m / s, it is necessary to maintain thermal inversion that acts as a barrier to the development of intense turbulence unfavorable development mist. Typically, radiation fog occurs during the night or early morning, especially in less mobile continental anticyclones. Being subject to decrease of nocturnal temperature, radiation fog can not generate over large stretches of water where the temperature does not show diurnal variations. Radiation fog occurs in baric dorsals and saddles with moist marine air. Fogging temperature can be calculated , Tc, i.e. temperature which will air on the emergence of fog. Tc can be expressed according to the value of the dew point temperature Td of sunset graphics, but this (Td) can be approximated very well with the value at 20 for one in the summer and 17 in winter time. Then the minimum Tm temperature value will be calculated, value that reaches the air during the night and if $Tm-Tc < 0$, there will be fog
1.2. Advection fog – is formed in case of movement of warm air over a cooler surface, where the temperature is below the dew point of hot air. Favorable conditions for advection fog

formation reduces essentially to: large difference (> 0) between the air temperature and the surface temperature of the underlying low velocity wind on land. Air to get closer to the saturation state before its intrusion on the cold surface, stable thermal stratification. In most cases, advection fog is formed under conditions of a thermal inversion layer of air near the ground and wind speeds do not exceed 5-6 m / s. For provision of the advection fog firstly the air mass will move in the region will be determined or the point when the forecast is elaborated, which are its initial properties and then with an intensity with which it is cooled in the process. Mist is expected when the moving air temperature falls below the value the dew had point from the place where the air mass comes If the wind speed exceeds 6 m / s, the fog clears ground with the character of stratiform low clouds [1].
1.3. Advection-radiation fog – is a mixed fog that occurs during the night when we add the action of terrestrial radiation.

2. Frontal fog

2.1. Prefrontal fog - Fog in the front of the warm front and occluded warm nature) that forms especially in spring and autumn. The prefrontal cold air determines a thermic reversal of the process due to evaporation and it is saturated with water vapor mist allowing the production of. This type of fog is formed when the temperature of the hot air from the top of the inversion layer is between -4 and 4 wt. and 3 to 8 wt. higher than the temperature of the soil. To the condition that the wind speed in the weathercock not exceed 6 m/s will be added. Cooling of soil also contributes to the formation of prefrontal mist due to nocturnal radiation. The provision of this type of fog is based on analysis of the synoptic situation and especially on the warm and occluded fronts characteristics [1].
2.2. Fog on the front line – is produced by lowering the frontal cloud to the ground due to turbulent mixing in the lower layers moisted by prefrontal strong rainfall. Radiation and adiabatic cooling of night air also contributes when the front moves on mountain slope exposed to wind. The provision of this type of fog, especially common in areas with rough terrain is made by the same principles as in the prefrontal fog. This type of fog has a short duration (one to two hours).
Fog dissipation occurs due to a warming that allows evaporation of water droplets or dry air mixture due to increased wind [1].

I.2. Baric structures associated to the types of fog

Analyzing foggy days during 2010 several baric were identified structures according to the literature, the presence of which occurred persistent fog.

I.2.1. Eastern European Anticyclone

Its development over the Carpathian favor the emergence of persistent fog and stratiform cloud formations in the Carpathian regions because of cold air maintenance and the production of thermal inversions. If the air mass entering is relatively hot and humid due to the higher temperatures of the Black Sea, then the mist will be persistent and affect Carpathian regions.
10 days were identified persistent fog in Oltenia, grouped in four cases, in the presence East European anticyclone (20, 21, 27, 28.01.2010; 8, 9.10.2010; 1, 2, 3, 4.11.2010) (see Fig.1).

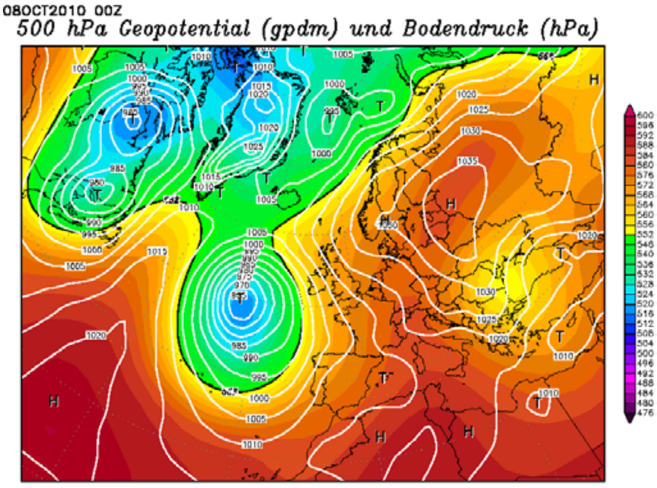


Fig.1. Pressure (hPa) and absolute geopotential (gpdm)
Radiation fog – stable anticyclone, 20.10.2010

I.2.2. Mediterranean Depression in the Adriatic Sea

Mediterranean depressions favor the appearance of mist because of the warm moist air that it carries over our country. The fog that occurs in the presence of this air mass is not persistent, the prefrontal fog type (in front of the warm front) and advection fog in the warm sector of the depression.

Depression relatively stationary over the Adriatic Sea, has a very high moisture, but often carries air into the medium troposphere favoring thermal inversions likely the southern front.

Advection fog occurs when the depression is moving toward the north-northeast and south of the country is in its warm sector.

Rainfall, generally poor, triggers the production of fog which may persist for several days. 21 days with persistent fog in Oltenia were identified, grouped in 8 cases, the synoptic situation (1,6,7,8,9,10,31.01.2010,11,12,13,20.02.2010;26,27,28,29.11.2010;3,4,23,24,25.12.2010;11.03.2010) (see Fig.2 and Fig.3) .

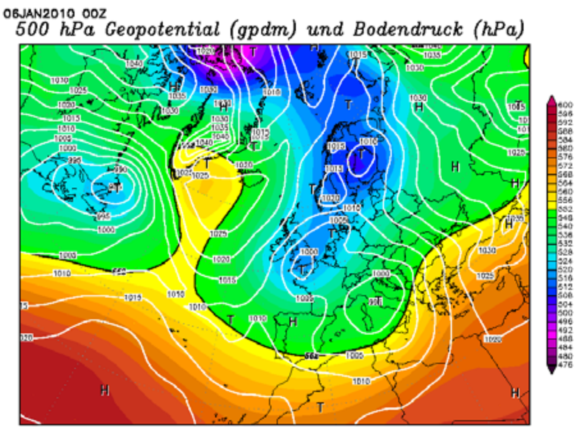


Fig.2. Pressure (hPa) and absolute geopotential (gpdm)
Prefrontal advection fog (06.01.2010)

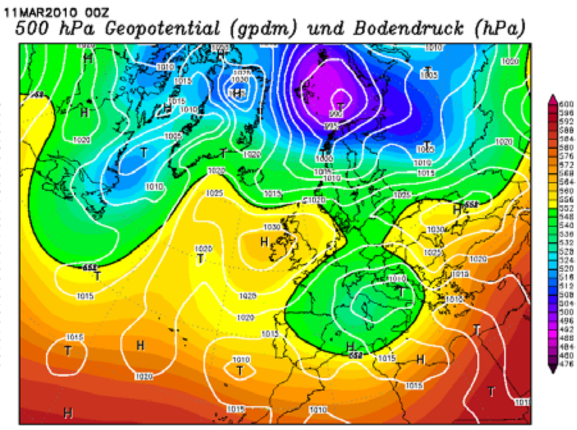


Fig.3. Pressure (hPa) and absolute geopotential (gpdm)
Advection fog in the warm sector (11.03.2010)

I.2.3 Mediterranean Depression in the south of the Balkan Peninsula

These formations, while moving across the peninsula, promote a not to increased circulation from the eastern Black Sea whose surface is warmer than the soil and results, in this situation, in an advection fog type depending on the surface properties of the underlying.

Three days with persistent fog have been identified in Oltenia, representing 3 cases, in the presence of this baric formation. (12.01.2010; 05.03.2010; 19.10.2010) (see Fig.4) .

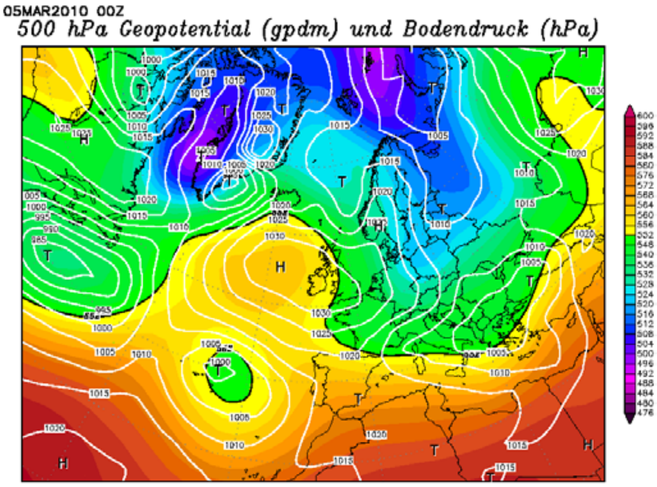


Fig.4 Pressure (hPa) and absolute geopotential (gpdm)
Advection fog on the Black Sea (05.03.2011)

I.2.4 North African Anticyclone

This anticyclone drives tropical warm air masses, over a cold surface and its presence produces a fog advection-radiation. Three days with persistent fog in Oltenia have been identified, representing a case, the presence of the baric formations (29-31.01.2010) (see Fig.5).

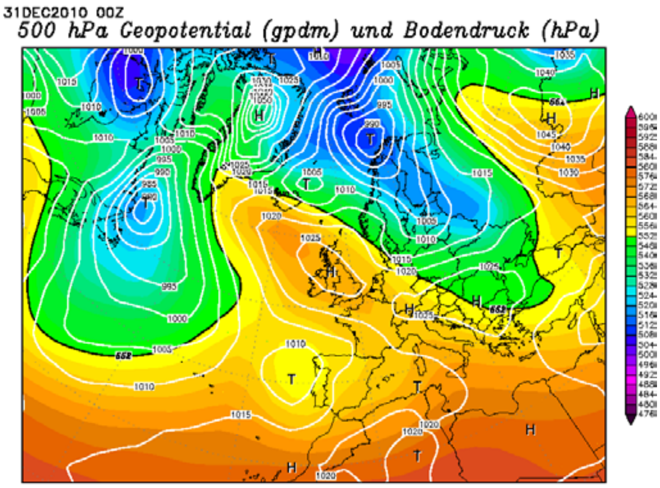


Fig.5 Pressure (hPa) and absolute geopotential (gpdm)
Radiative advection fog (31.12.2010)

I.2.5 Weak pressure field

The characteristic of this baric formation is the weak pressure gradient and a weak circulation and on the inside of this air mass mixed fog is generated, the moisture and weak circulation favoring the persistence of the fog 15 days with persistent fog in Oltenia have been identified, representing 5 cases. (9,17,18,19,24,25, 26.02.2010; 16,17.10.2010; 16,17,18,19,20, 21.11.2010) (see Fig.6).

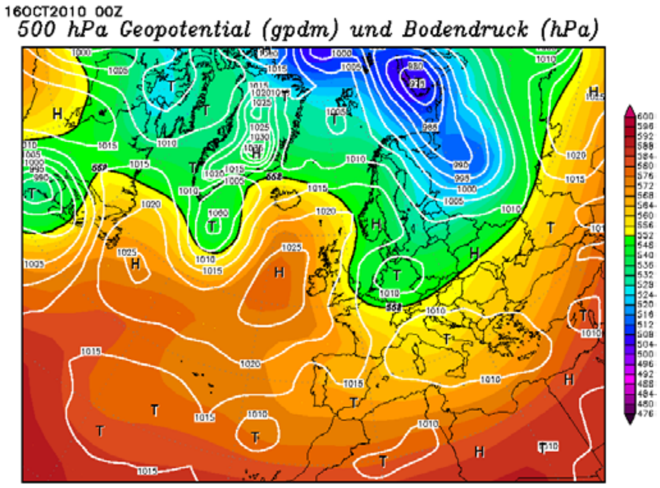


Fig.6 Pressure (hPa) and absolute geopotential (gpdm)
Mixed Fog (16.10.2010)

I.2.6 Azores High Dorsal

This configuration extended up to our country allows the production of the radiative fog type, persistent and dense. The Azores High Dorsal over Europe during the cold season stays above the continent and cools down at the base. We have identified only a foggy day in Oltenia, representing one case (11.10.2010) (see Fig.7).

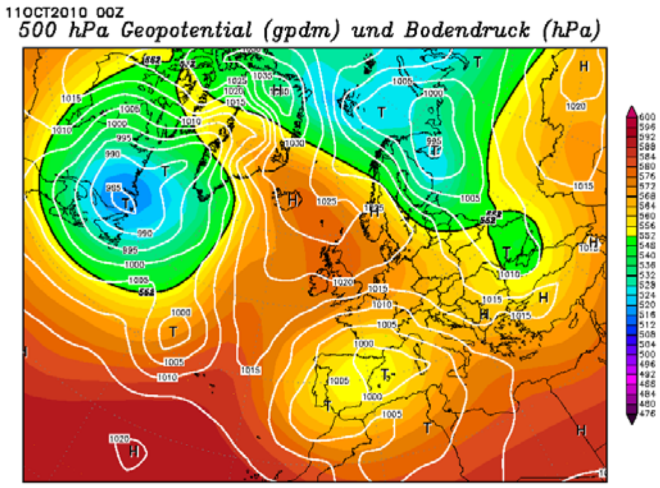


Fig.7 Pressure (hPa) and absolute geopotential (gpdm)
Radiation Fog – Azores High Dorsal (11.10.2010)

All these types of fog were found in Oltenia, in 2010, during the cold season when there were 55 days with persistent fog, corresponding to the 21 cases, so the synoptic situations and atmospheric circulation can be grouped as:

- Blocking regime - in this situation the Mediterranean basin is very active and Eastern European anticyclone is extended to Central Europe. The two baric forms occur together to form the blocking regime in winter. Mediterranean depressions favor the appearance of the fog due to moisture and front activity, and the presence of the Eastern European anticyclone produces radiative fog type.
- Anticyclone regime in Southern and weak Mediterranean cyclonic activity and zonal circulation are at high latitudes. If airflow is intense, there are favorable conditions of producing persistent fog.

Part II. Analysis of a real fogging situation (Case study)

Radiative advection fog; the case 18-20 January 2011

The fog was generated by the presence of a stable anticyclone, which stayed over the continent, centered on Romania with central pressure of 1030 mb and warm altitude advection.

In this situation there was a high density persistent radiation-advection fog that affected the south, including the Oltenia Craiova.

Oltenia with all its five counties, including the city of Craiova, has been affected by this intense phenomenon, local visibility is less than 50 m and relatively large areas, below 200 m. In this regard nine nowcasting fog warnings were issued every 6 hours for the entire region from 18.01.2011 08:00, up to 20.01.2011 02:00.

Synoptic analysis and the mesoscale

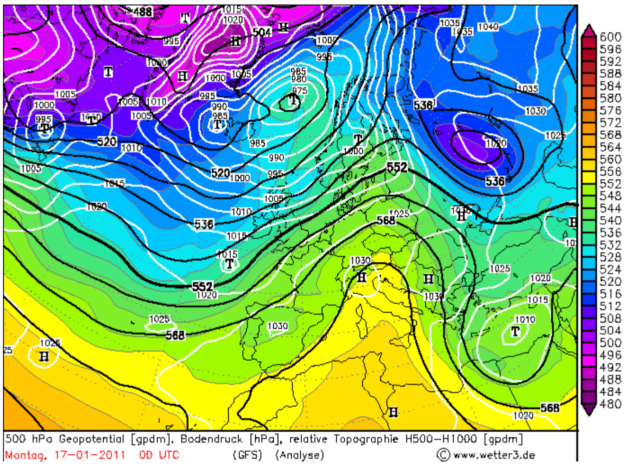
17.01.2011

Ground situation: Almost the entire continent and the central basin of the Mediterranean were in an anticyclone belt consisting of the Azores High and Eastern Europe with a core 1030 mb centered over Romania. The exception is the north-westernmost under the influence of Icelandic depression with a core 980 mb over the Norwegian Sea and the eastern Mediterranean basin, located throughout the field depression. Air circulation at this level was eastern and weak. At this juncture synoptic weather in Romania was beautiful and warm for this time, with mostly clear skies. In **Oltenia**, maximum temperature had values between 3-9 degrees, and minimum between -5 and 0 degrees. In Craiova Maxt=8 degrees, Mint= -4 degrees.

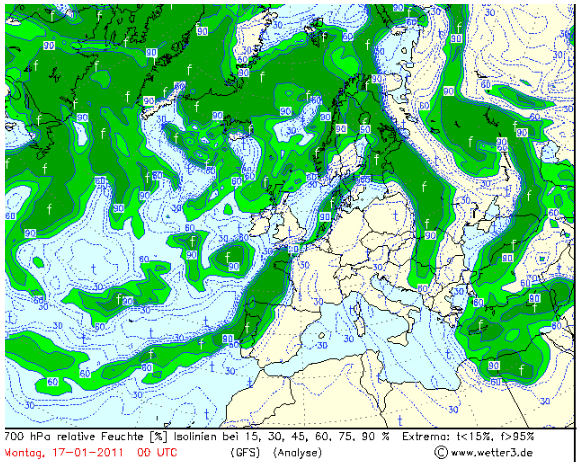
At 500hPa: Continent was under the influence of the geopotential dorsal in the medium troposphere, the characteristic curve of January (545 damgp) being above the Baltic Sea. Romania is located in the dorsal at geopotential values between 572 and 560 damgp in the west to the east. Above Oltenia the geopotential value was 568 damgp. Air circulation at this level was northwester. At **700 hPa:** At this level the geopotential field has the same structure as the dorsal to the top of the Baltic Sea. Romania was in high geopotential field and reduced moisture in the South, and isothermal -5 degrees was over Oltenia. Circulation at this level was north-west and not very fast

At 850 hPa: Geopotential field at this level kept the shape of the dorsal up to the Southern Scandinavian Peninsula, moisture range was extended over Romania, and 0 degree isotherm was above Oltenia.

Circulation of air at this level was maintained north-west but became weaker (see Fig.8).



Ground Pressure (hPa) and absolute geopotential (gpdm)



Relative moisture at the 700 hPa level

Temperature at the 850 hPa level

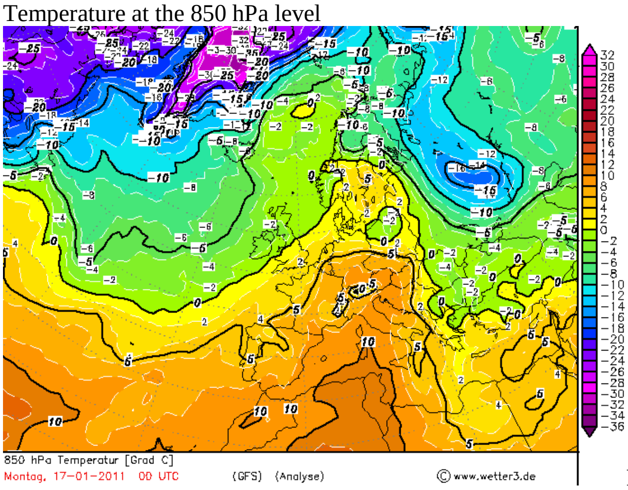


Fig.8. Analysis at a synoptic scale, 17.01.2011 at 00 UTC

18.01.2011

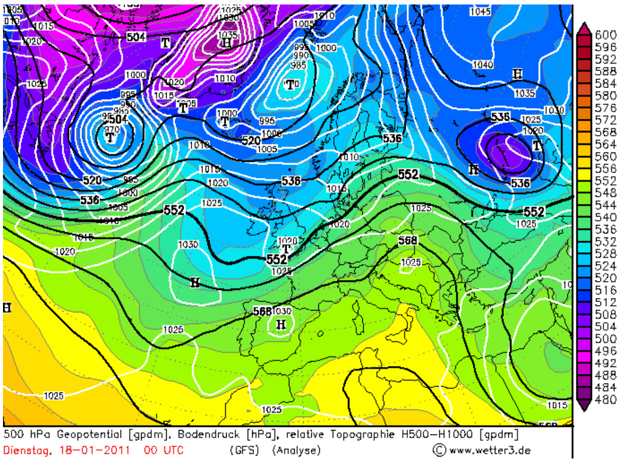
Ground situation: Baric situation remained; almost the entire continent was in an anticyclone field, except the northwest and eastern Mediterranean basin. Romania remained in the anticyclone field with slightly lower pressure (1025-1028 mb) and air circulation at this level was eastern and weak. In Oltenia persistent foggy weather closed a wide area, except highlands of the region. Maximum temperature was between 1 and 10 degrees, and the minimum one between -4 and 0 degrees. In Craiova Maxt=1 degrees, Mint=-2 degrees.

At 500hPa: Geopotential dorsal is maintained in the medium troposphere over the continent, Romania continues to be in the dorsal, the values of the geopotential field ranging between 570 and 564 damgp in the west to the east. Over Oltenia the value of 568 damgp was maintained. Circulation of air at this level was maintained north-west.

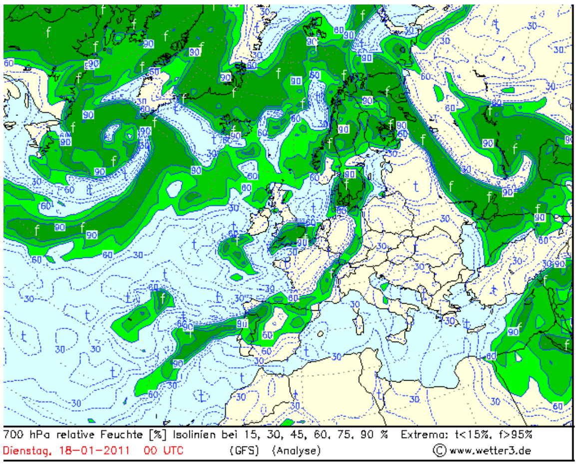
At 700 hPa: In this interval the geopotential field retains the same structure as in the dorsal the previous day. Romania is high geopotential field and low moisture, and isothermal of -3 degrees was over Oltenia.

Circulation of air at this level was maintained north-west but became weaker.

At 850 hPa: Geopotential field at this level kept the shape of the dorsal up to the Southern Scandinavian peninsula, moisture range was extended over Romania, and 5 degree isotherm was above Oltenia and circulation of air at this level was maintained north-west but became weaker (see Fig.9).



Ground pressure (hPa) and absolute geopotential (gpdm)



Relative moisture at the 700 hPa level

Temperature at the 850 hPa level

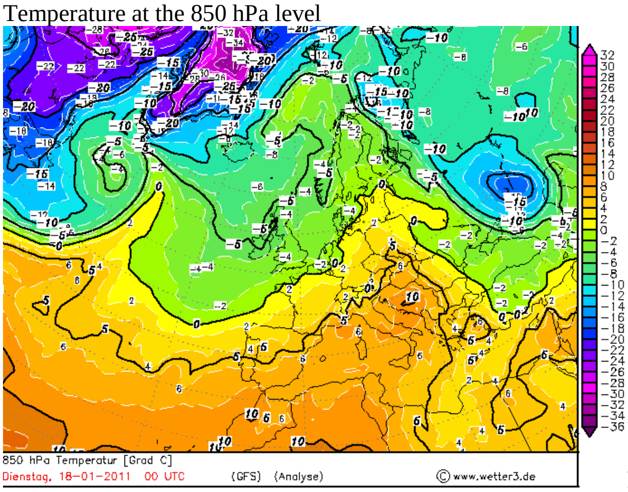


Fig.9. Analysis at a synoptic scale, 18.01.2011 00 UTC

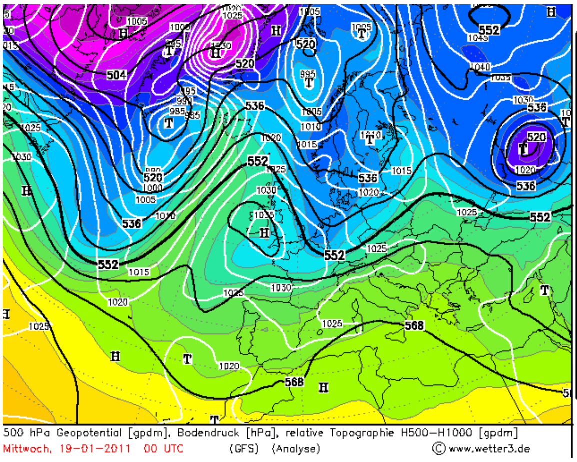
19.01.2011

Ground situation: Azores High has extended a dorsal to the west of Romania and the pressure continued to decline slightly (1022-1026 mb over Romania). Depressionary activity increased in northern Europe, specifically over the Baltic Sea and a valley floor extends with a slightly north-south orientation. Romania remained, in the anticyclone field with weaker pressure. Circulation remained, poor, predominantly eastern. In Oltenia persistent foggy weather closed a wide area, except the highlands area. Max temperatures were -1-9 degrees, and the minimum -2-0 degrees. At Craiova Maxt = -1 degrees, Mint = -1 degrees.

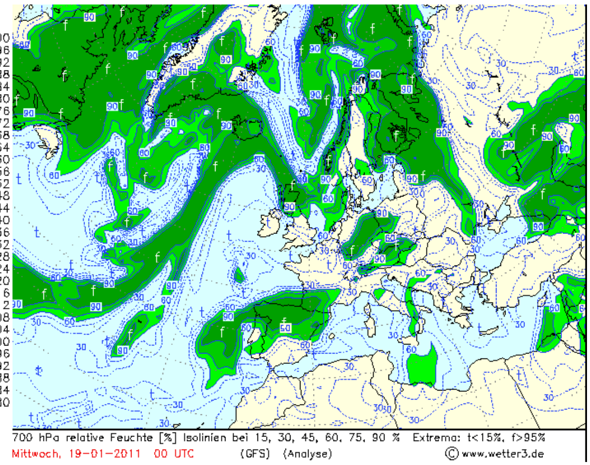
At 500hPa: Western, southern and central Europe remained in geopotential field with high values, but decreasing as against to the previous days, and the north was in a low geopotential field with a valley floor expanding to over Germany, with the axis in the NE-SW. Romania remained in the dorsal, geopotential values between 564 and 560 in the west to the east. Above Oltenia the geopotential value, decreasing, was 564 damgp. Air circulation at this level has become west northwest.

At 700 hPa: In this interval the geopotential field retains the same structure but a flatter dorsal than the previous day. Romania is high geopotential field and low moisture, and an isothermal of -5 degrees was over Oltenia. Circulation became weak west northwest.

At 850 hPa: Geopotential field at this level kept the shape of dorsal slightly flattened in southwestern Romania, moisture spread over the area of Central Europe and the Black Sea, and Oltenia is a 5 degree isothermal; at this level west northwest movement was weak (see Fig.10).



Ground Pressure (hPa) and absolute geopotential (gpdm)



Relative moisture at the 700 hPa level

Temperature at the level of 850 hPa

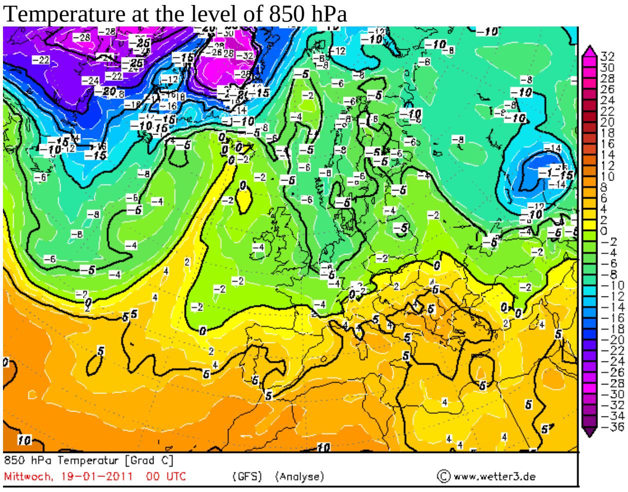


Fig.10. Analysis at a synoptic scale 19.01.2011 00UTC

20.01.2011

Ground situation: The anticyclone belt was broken by a depression corridor with a North-South orientation, including Romania, over which the pressure continued to decline (1018-1020 mb) and a cold front acted west. Under these conditions the stability of the atmosphere has been destroyed, turbulence has accentuated and fog began to dissipate. In Oltenia weather was closed and locally precipitation as rain was predominant. Max temperatures were -1-2 degrees, and minimum -1-1 degrees.

At 500hPa: Thalweg of the previous period spread to the NE-SW direction over the western Mediterranean Basin. It remained shortly in the iberic peninsula an in the southeast. Romania is located in the dorsal, the geopotential values of between 545 and 553 damgp.

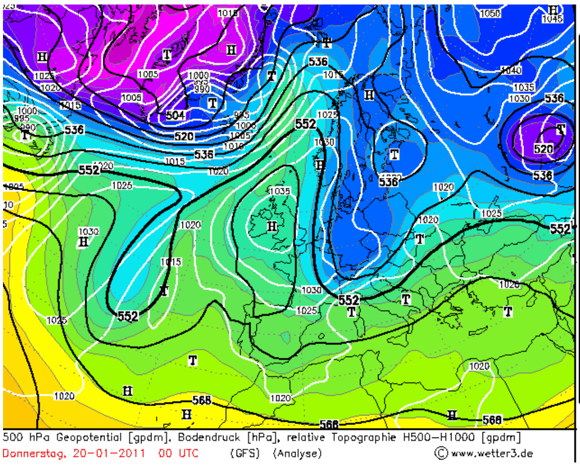
Above Oltenia the geopotential value was 553 damgp, and movement at this level became southwest.

At 700 hPa: The thalweg just outlined in the previous days had expanded over Central Europe and the axis was oriented NE-SW. Romania was the contact between air masses, moisture area expanded to the north, and a isothermal -6 degrees was over Oltenia.

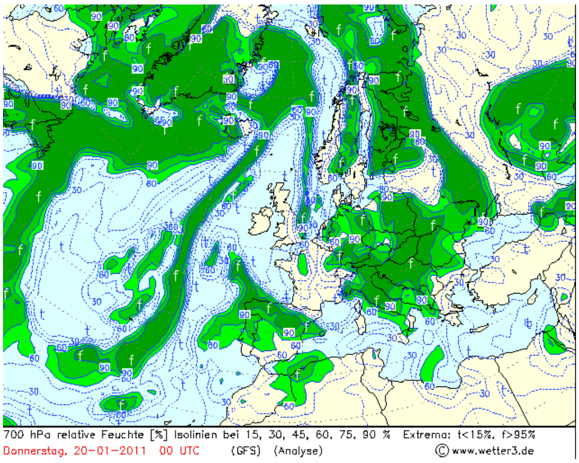
Circulation at this level became southwest.

At 850 hPa: Geopotential field values at this level decreased, over the western basin of the Mediterranean a depression emerged, west, northwest, north and east of the continent remained at high values of geopotential. Moisture area spread over all of Europe, except the west.

Romania is located at the contact between air masses, moisture area was extended over them, and an isothermal of 0 degrees was above Oltenia; at this level circulation became southwest (see Fig.11).



Ground Pressure (hPa) and absolute geopotential (gpdm)



Relative moisture at the 700 hPa level

Temperature at the 850 hPa level

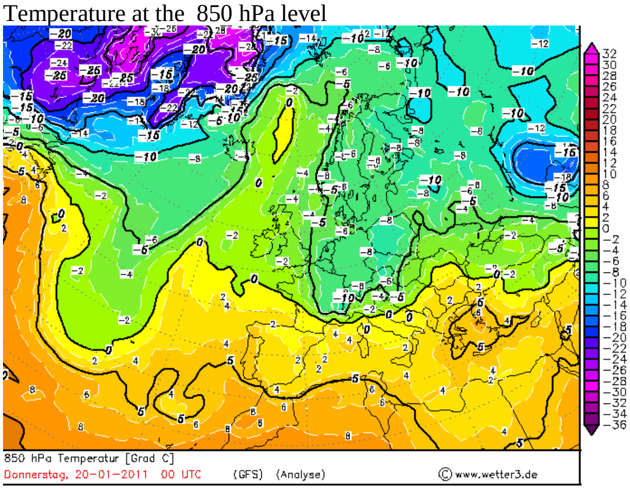


Fig.11. Analysis at a synoptic scale 20.01.2011 00UTC

17.01.2011 during the day there has been a warm advection, thermal and Geopotential dorsal entering in southwestern Romania (from Oltenia) as seen from developments in the maps of Fig.8.

The sky was released, radiative cooling was favored in the night, and when the warm air came over the cold surface condensation produced generating a persistent haze.

The phenomenon occurred between 23 and 00 o'clock at -1.3 degrees (Craiova station), when the air temperature was equalized with that of the dew point (see Fig.12). The wind pressure was weak and had a slight decrease (1025-1028 mb). The state of saturation and poor circulation led to the emergence and intensification of fog across the region Oltenia.

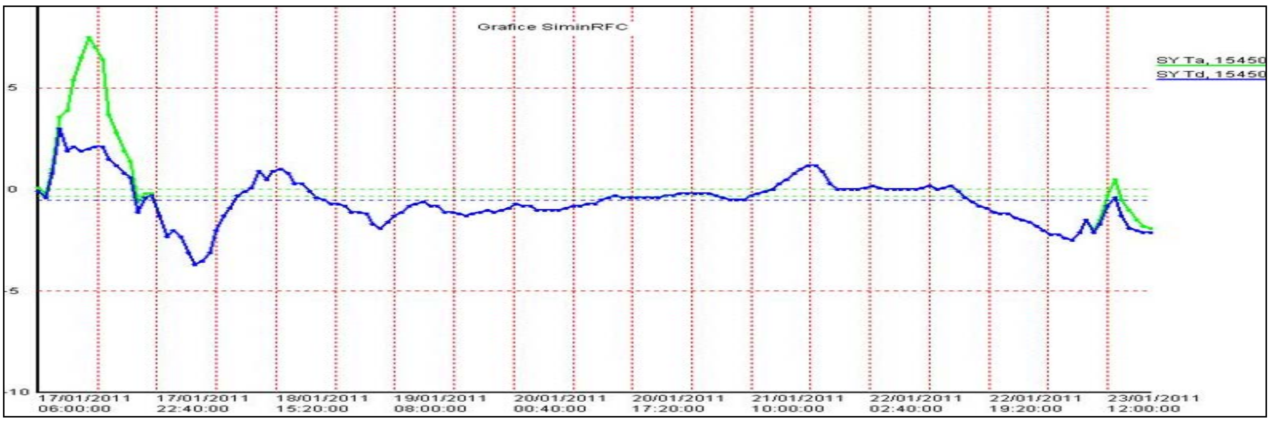


Fig.12. Graph of air temperature and dew point at the Craiova weather station during 17-21.01.2011(graphics RFC)

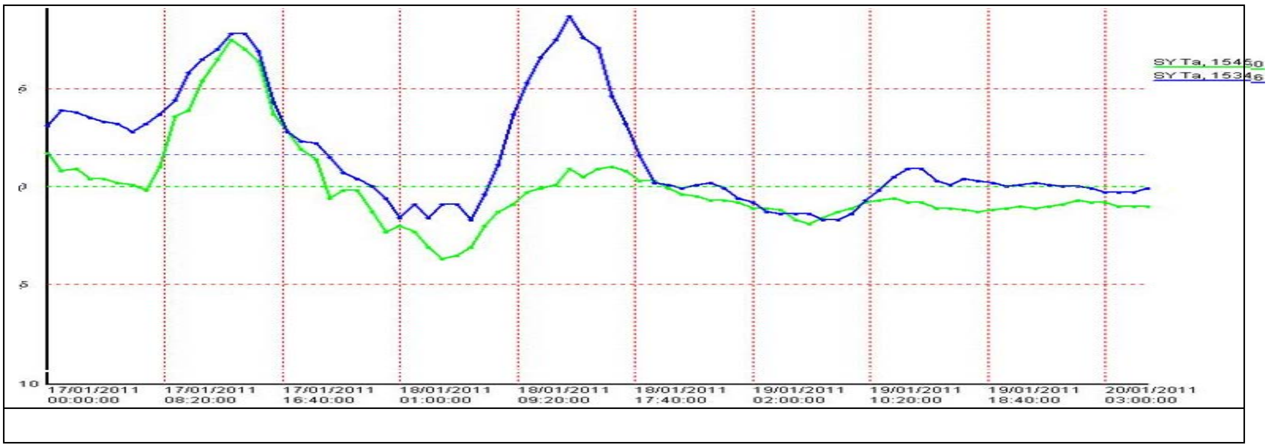


Fig.13. Air temperature chart at the Craiova Station and at the Ramnicu Valcea station (RFC graph) during 17-21.01.2011

During the day of January 19 eastern poor circulation and dorsal ground altitude, allowed the maintenance and persistence of fog. Pressure, temperature and humidity were quasi-stationary and the fog persisted and became stable in the whole region, except small areas of Valcea (see Fig.13) where it is noted that the air temperature in Rm.Vâlcea is much higher than in Craiova.
The activity of low pressure air mass from northern Europe (depression above the Baltic) intensified and expanded a N-S oriented valley floor to the west of Romania (see Fig.10).

Since January 20, pressure began to decline (1018-1020 mb) and in the west is felt a cold front. The average troposphere develop a thalweg over Central and NE-SW oriented extension favored by increasing flow at all levels and colder advection (see Table 1). The fog dissipated increasing the degree of turbulence in the layer of fog. The clouds prevented the radiative cooling at night and cold advection in the troposphere average dissipation led to the existing temperature inversion.

Table 1 with ground temperature and 850hPa level between 17-21.01.2011 in Oltenia

Interval	Tmax	Tmin	T850hPa (for Oltenia)
17-18.01.2011	3....9	-5...0	0
18-19.01.2011	1....10	-4...0	5
19-20.01.2011	-1....9	-2..0	3
20-21.01.2011	-1....2	-1...1	0

In Figure 15, represented by maps phenomena across the country, where we have defined Oltenia highlighted the fog present between 18-20.01.2011.

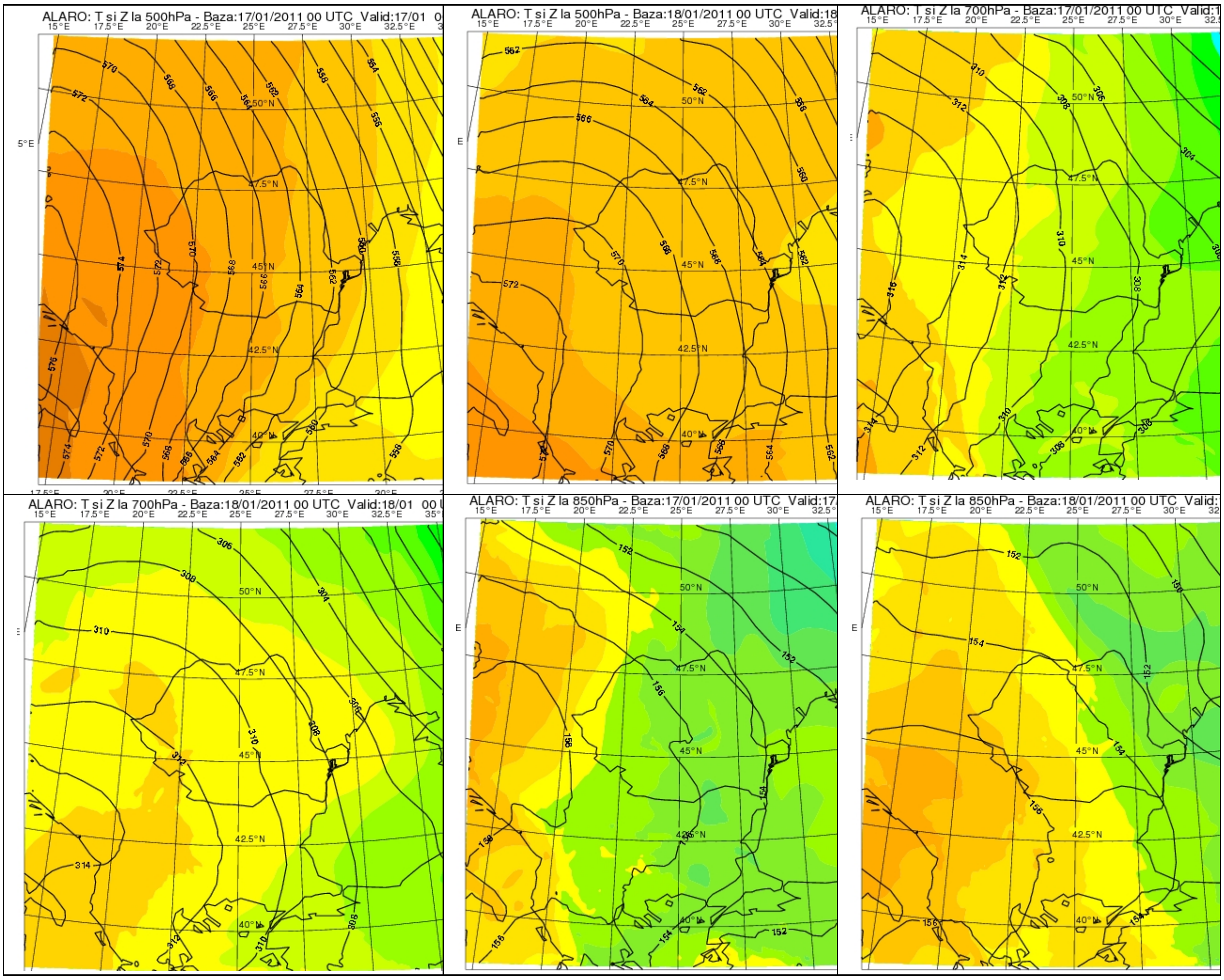


Fig. 14 Evolution of the mesoscale during 17-18.01.2011 (pressure and geopotential)

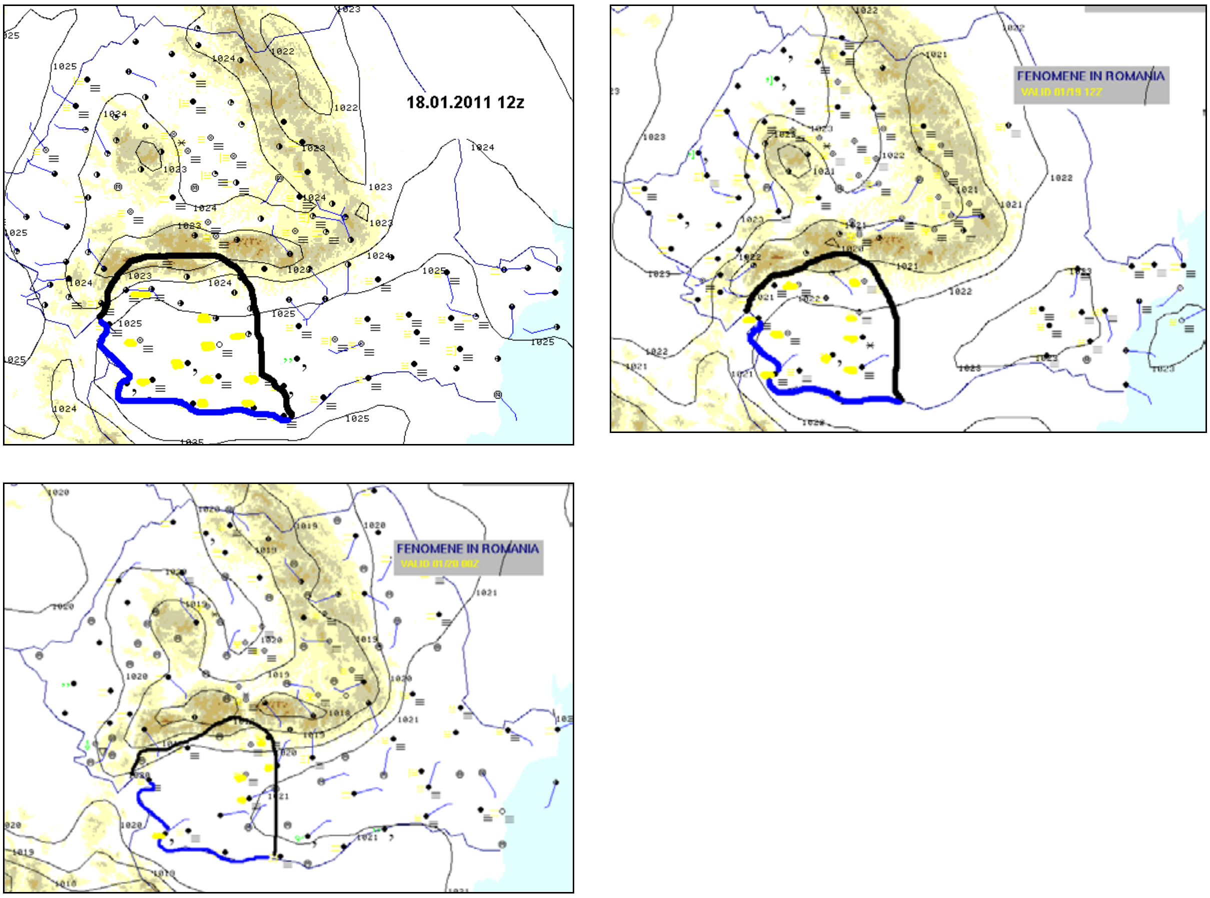


Fig.15 Maps phenomena in Romania (Oltenia region delineation and highlighting mist) (NIMS maps) between 18-20.01.2011

Since 20.01.2011 Oltenia weather remained closed, but the grounds of cloud and precipitation areas were relatively large predominantly as rain and cold advection gradually destroyed existing thermal inversion previous days and the fog dissipated.

In Figures of satellite (Fig.16, Fig.17 and Fig.18) below can be seen fog located in southern Romania on 18 and 19.01.2011 and of 20.01.2011 cloud system development, leading to dissipation of fog and rainfall occurrence.

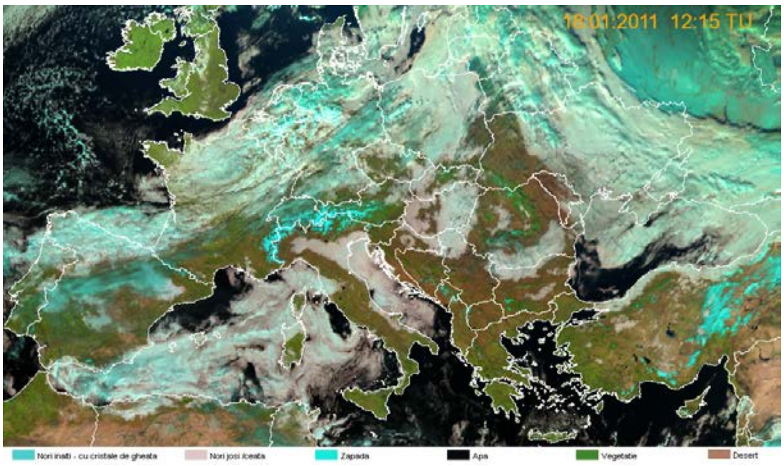


Fig.16 Satellite images from 18.01.2011 (fog)

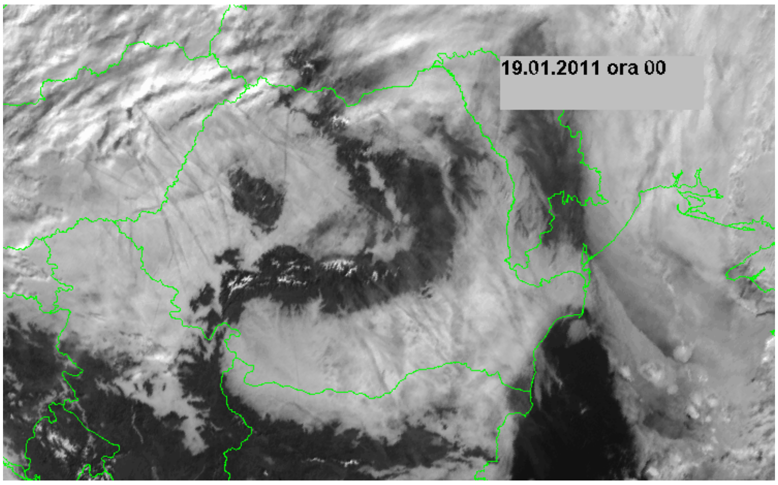


Fig.17 Satellite images in the visible (fog)

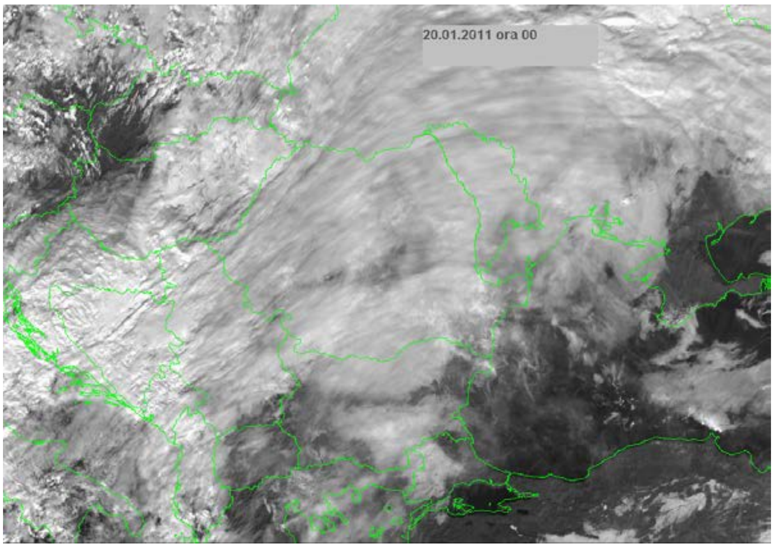


Fig.18 Visible satellite image system (clouds)

Conclusion

1) This persistent fog was a typical case of radiative-advection fog, the triggering factor process was nocturnal radiation and persistence was due to warm advection average troposphere and poor circulation predominantly east (from the Black Sea).

2) Factors that led to the dissipation of fog were intensification of movements from the southwest sector and development at the same time of the cloud formations, high from the beginning and then the increasingly lower as well as cold mass intrusion into the troposphere average (see Table 1) which has led to destruction of existing thermal inversion. The weather continued to be closed, but now because of cloud cover and precipitation.

The importance of forecasting of fog

Impact of that phenomenon on the society in general has often serious consequences, ranging from delays in surface and air transport (people or goods), to major disasters.

It is important to decide when Weather Forecast elaborates, whether it will produce fog, which will be the effects on the economy or will be endangered lives. The decision in this sense is based on the data assimilation, the use of the numerical instruments and mesoscale tools and meteorologist own experience.

References

[1] Beşleaga şi Doneaud, Synoptic Meteorology and Aeronautics, Ed Teaching and Pedagogical-Bucharest, 1966

[2] Topor, N., Stoica, C., Types of movement and action centers barometric air over Europe, CSA, IMBucureşti 1965

[3] Bell, A. Instructions for making the analysis of mesoscale.

[4] http://www.wetter3.com

[5] http://www.Wetterzentrale.de , alaro, Satellite, charts

[6] http://www.meteolafleche

[7] Instructions for observing, identifying and codifying clouds and weather phenomena (meteors), INMH-Bucureşti, 1986

[8] Popa, Ghe., Course of aeronautical meteorological Military Schools, Military Schools Aviation Typography-Bucharest, 1928