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INFLUENCE OF THE SIRET RIVER CORRIDOR ON WIND CONDITIONS

Wpływ doliny Seretu na warunki wiatrowe

Summary. W związku ze specyficznymi warunkami wymuszonymi przez osłonięcie i efekt tunelowy wzdłuż osi północ-południe wiatr istotnie przyczynia się do indywidualności klimatycznej doliny (Korytarza) Seretu. Wpływ topografii znajduje odbicie przede wszystkim w dużej częstości w ciągu roku cisz atmosferycznych przy powierzchni ziemi (35–50% – jest to największa częstość w regionie na wschód i południo-wschód od Karpat), które nadają charakter topoklimatu zagłębienia terenowego. Przedstawione opracowanie pokazuje, jak wiatr staje się elementem topoklimatycznym.

Słowa kluczowe: cyrkulacja zachodnia, efekt Coandy, efekt tunelowy, balonowy sondaż meteorologiczny, cisza atmosferyczna, chmura warstwowa
Key words: westerly circulation, Coanda's effect, funneling, weather balloon sounding, atmospheric calm, stratiform clouds

GEOGRAPHICAL POSITION AND TOPOGRAPHICAL CHARACTERISTICS

The Siret corridor represents a subdivision of the Moldavian Plateau – which occupies the north-eastern part of Romania – located between the Moldavian Subcarpathians (740 m) in the West and Bârlad Plateau (570 m) in the East (Fig. 1). Siret corridor features, especially given by the considerable expansion of the system of terraces, places it as a distinct physical-geographical subunit within of the Moldavian Plateau. The altitude of the Siret floodplain decreases from 230 m in the North of the corridor to 100 m in the south. The region covers approximately 1° in latitude, occupying about 3500 km^2.

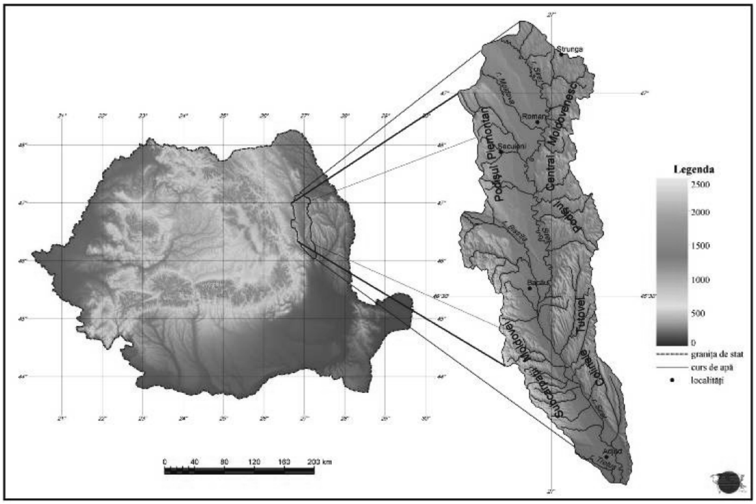

Fig. 1. Geographical position of the Siret Corridor within the Romania's territory
Ryc. 1. Położenie geograficzne korytarza Seretu na obszarze Rumunii

The large development of the terraces in the northern and central sector leads to a considerable enlargement of the valley (12 km at Roman, in the North), which, together with the high slopes gives a strong depressional character to these sectors. The terraces represent a favorable framework for the stabilization of the air masses in the cold season and during the night time, thus emphasizing the atmospheric calm.

The hills that surround the Siret Corridor rise with 300–500 m above the river bed. The biggest contrast are recorded on the West wing, on the contact with the Subcarpathians (740 m). However, the eastern wing, besides the fact that the heights are smaller, is distinguished by its continuity, this is what's emphasizing its depression features. In dynamic conditions, the width of the floodplain and the general north-south orientation of the Siret valley, together with the accentuated slopes of the nearby flanks, lead to the funneling of the air masses, especially in the case of the north and south circulation.

THE MAIN FEATURES OF THE ATMOSPHERIC CIRCULATION ABOVE ROMANIA

According to Grosswetterlagen Europas (Hess, Brezovsky 2005) in Central Europe the annual percentage of the westerly circulation, including North-westerly and South-westerly, is about 35%. Our calculations lead towards a westerly circulation in Romania which doesn't exceed 30%, and despite this represents the dominant direction of atmospheric circulation (Sfîcă 2009).

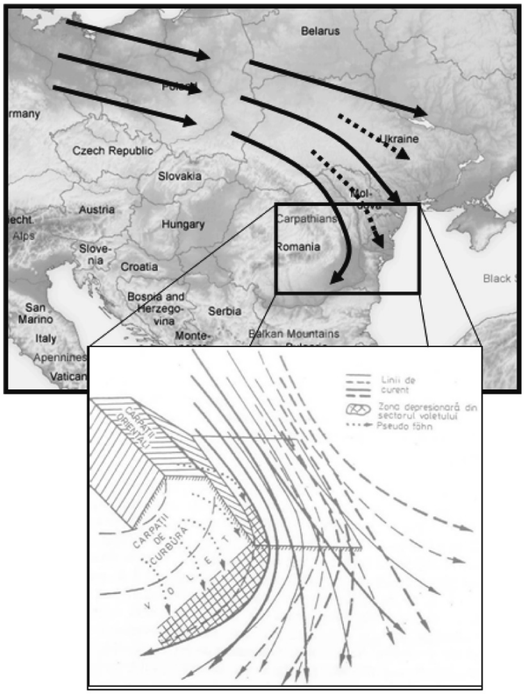

Fig. 2. Spatial distribution of the wind streamlines at the East of the Carpathians as a deviation of the predominant western circulation in the German-Polish Plain. Detail: streamlines distribution at the bend of the Carpathians in the territory of Romania (Bordei-Ion 1988)
Ryc. 2. Rozkład przestrzenny linii prądów wiatru na wschód od Karpat jako odchylenie przeważającej cyrkulacji zachodniej nad Niziną Niemiecką i Polską. Mała mapka – rozkład linii prądów za łukiem Karpat na obszarze Rumunii (Bordei-Ion 1988)

Another characteristic of the atmospheric circulation is the high frequency of anticyclonic conditions (cca. 20%), Romania being situated at the intersection of the Azoric anticyclone with the anticyclons of continental and Scandinavian origin. All this leads to Romania occupying a point of maximal atmospheric pressure inside the continent (Bâzâc 1983).

An important factor in the atmospheric circulation derives from Romania's positioning on one of the main paths of the Mediterranean cyclones (Vc) and adjacent to one of the important paths of the Atlantic cyclones (III a), according to van Bebber cyclonic path in Europe (van Bebber 1891).

The treats of the general atmospheric circulation are deeply transformed by the form of the major relief. For NE of Romania a very important role plays the bending of the wind stremlines in the outer Carpathic sector. This bending was demonstrated for the first time in 1988 by Nicolae Ion-Bordei for the Great Carpathians Curvature from Romania. He explained this process through „the

Coandă effect" meaning the modification of the direction of a fluid which flows freely at the contact with a surface. When the surface is curved, a part of fluid continues this direction, forward, and a part has a tendency to keep the curvature direction. Between these two directions is made a dispersion of the current lines. This effect was demonstrated by Henri Coanda in 1910 and patented in 1934.

In this study we considered (for the first time) that the same process of bending occurs also in the case of the westerly circulation throughout the German-Polish Plain in the Carpathian Curvature imposed by the Beskid Carpathians in the Ukrainian territory (Fig. 2). This bending may explain the dominant NW-SE elongation of the wind roses in Moldova, beyond the local funneling processes. In these conditions, in the regions at the East of the Carpathians, the wind diagrams are elongated on the NW-SE direction. This situation is further accentuated at the East of the Carpathians, by the identical orientation of the valleys with the dominant atmospheric circulation. But, on the heights of the hills, above 350 m, between Carpathians and Prut River, the predominant direction is North. At high altitudes, above 1000 m, where the effects of the Carpathians fade, the wind blow mainly from the North-West, and above 2000 m, from the West.

TOPOCLIMATIC WIND CHARACTERISTICS

a. Influence of the atmospheric circulation on the wind direction. As we could see in table 1, the cyclonal conditions present a well positiv correlation with the maximum wind speeds from NE and E, which is explained by the predominant Mediterranean origin of depressions which move with their center situated in the South-East of our area, in the Black Sea, respectively in South, in the Balcanic Peninsula. On the second place there are the Atlantic Cyclones with trajectories above the German-Polish Plain, on southern variants, in their final phase, when they arrive in the Central Ukraine. In this case, the wind blows from North-East. The atmospheric calm is rare in the cyclonic periods.

Anticyclonal conditions were not so favorabile for wind genesis. They are positively well correlated with northern circulations, which indicate the Atlantic origin of the high pressure dorsal or nuclei, which extend towards Eastern Europe. In this situation, their position are in the West or North-West of Romania. Western circulations are diminuated.

Also, synoptic conditions with an westerly circulation are a well positive correlation with winds from West. Normally, the funneling is not produced. Easterly circulation is transformed under influence of the funneling, of major obstacle of Carpathians, of the predominant northern direction nearer Carpathians, into north-eastern winds. The eastern wind occupied the second place. Normally, for northern and southern circulations, the facts are simple, they manifest very well on the original directions on the Siret Corridor. In the southern circulations, atmospheric calm is very rare.

Table 1. Pearson correlation between types of circulation and wind direction in Bacau region (1991–2002)
Tabela 1. Współczynnik korelacji między typami cyrkulacji i kierunkami wiatru w rejonie Bacau (1991–2002)

Wind direction	Cyclonic	Anticyclonic	Westerly	Northerly	Southerly	Easterly
N	- 0.04	**+ 0.26**	**- 0.21**	**+ 0.31**	**- 0.34**	**+ 0.17**
NE	**+ 0.31**	+ 0.01	- 0.11	**- 0.19**	- 0.01	**+0.21**
E	**+ 0.26**	+ 0.12	**- 0.22**	**- 0.22**	+ 0.04	**+ 0.20**
SE	+ 0.03	+ 0.16	- 0.16	**- 0.17**	+ 0.13	+ 0.05
S	- 0.11	**- 0.17**	+ 0.06	**- 0.37**	**+ 0.48**	- 0.04
SW	- 0.08	+ 0.02	+ 0.14	+ 0.02	- 0.10	- 0.11
W	+ 0.08	**- 0.23**	**+ 0.40**	+ 0.08	- 0.06	**- 0.31**
NW	**+ 0.21**	+ 0.01	- 0.03	**+ 0.19**	- 0.15	- 0.02
C	**- 0.26**	+ 0.02	+ 0.09	**+ 0.18**	**- 0.21**	- 0.03

b. Influence of altitude on wind direction in the Bacău region. For a detailed analysis of the way in which this funneling works, depending on the topographic characteristics of the region being studied, data from observations made on the wind in altitude by weather balloons, during 1957–1965 in Bacau was processed.

At altitudes over 1000 m the predominant wind directions are NW (22.8%) and W (16.6%) at 1500 m, while at 2000 m it is 20.3% W and 23.5% NV (Fig. 3). Even though at these altitudes the direct influence of the local topography of the Siret Corridor is not felt, the high share of the NW direction in Bacau can be the result of the long range effect of the funneling of westerly and even northerly circulations along the Bistrita Valley in its mountain sector.

Beyond the level of the highest peaks in the region, at 800 m above the station, the predominant directions are those specific to the funneling, but the cause is not the morphology of the region, but the presence of the Carpathian Mountain chain to the west. Wind speed grows in altitude until the same altitude after which it becomes uniform (Cristodor 1968).

The elongation wind frequency roses on the N-S direction, as a direct effect of funneling is more emphasized in 200–500 m altitude, where the atmospheric calm frequency is reduced, in the benefit of the related direction of the air funneling. Thus, the north direction has at these altitudes frequencies of 27%, while the frequency from the ground is of 24%. Similarly, the frequency of the S wind direction increases from 16% at the ground level, at 20% between 200–500 m in altitude.

In the lower horizons we find a very rapid reduction in the frequency of the atmospheric calm in altitude in the first tens of meters from land level. If at the vane level the atmospheric calm holds 36.2%, at only 100 m in height the atmospheric calm is reduced to only 0.9% and 0.2% at 500 m.

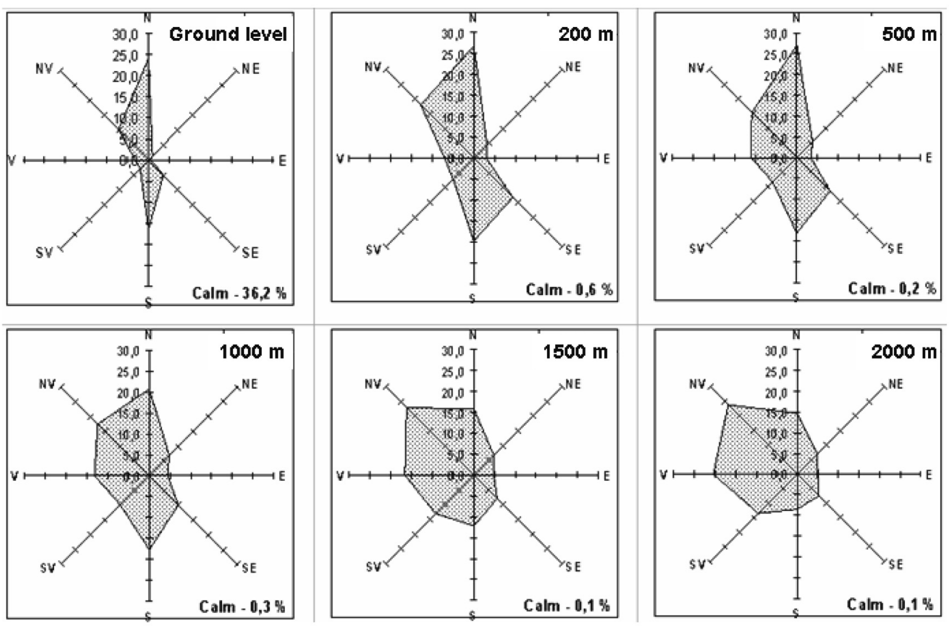

Fig. 3. The annual average frequency of the wind directions in altitude from Bacau, based on weather balloon observations (1957–1965)
Ryc. 3. Średnia roczna częstość kierunków wiatru na wysokości od powierzchni ziemi do 2000 m w Bacau, na podstawie obserwacji balonów meteorologicznych (1957–1965)

c. The annual average frequency of the wind directions. The predominant direction is closely related to the north-south funneling along the Siret valley, but also of the currents funneling along the river valleys of the Carpathian – Trotuş, Bistrita, Moldova – on exit from the Subcarpathians. In the case of the whole region one may speak of a dual funneling. The funneling main direction (N-S) corresponds with the direction of the Siret valley, while the secondary funneling (NW-SE) corresponds to the direction of its principal effluents of Siret river from the Subcarpathian sector. In the southern region, at Adjud, the main funneling is given by changing the valley's direction towards SE (Fig. 4).

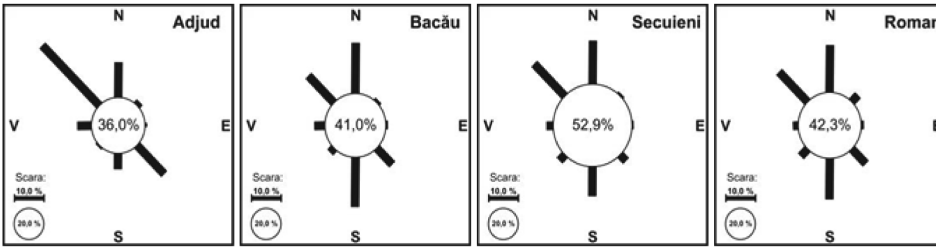

Fig. 4. Roses of the wind directions frequency in the Siret Corridor (1961–2002)
Ryc. 4. Róże częstości kierunków wiatru w Korytarzu Seretu (1961–2002)

The Siret Corridor topography allows – through increasing atmospheric calm – the development of stratiform clouds during the cold semester, only to this region (Fig. 5). The monthly frequency of these clouds can reach 20% in November, being able to form throughout the period from October to March. The presence of these clouds have significant implications in topoclimatic terms in the region (reduce the duration of sunshine, increasing relative humidity in the lower strata of the cold semester of the year, abnormalities in the vertical distribution temperature, high fog frequency phenomena in the region).

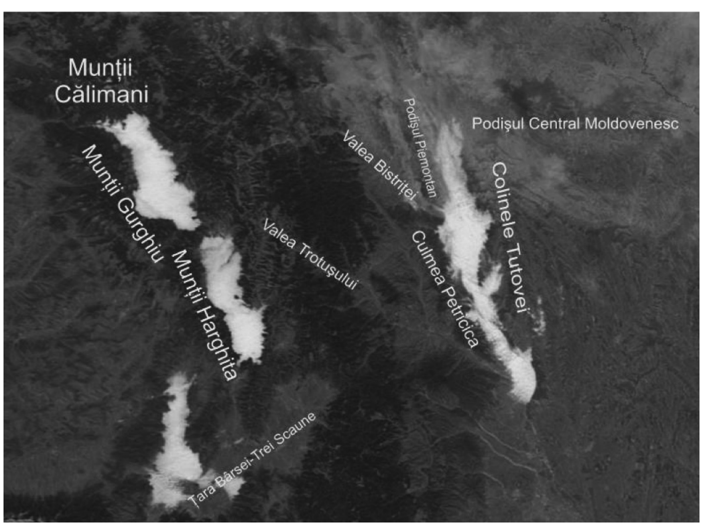

Fig. 5. Development of stratiform clouds upon the Siret Corridor (Modis image, 26 X 2004)
Ryc. 5. Rozwój chmur warstwowych wzdłuż Korytarza Seretu (26 X 2004)

<u>d. The annual average wind speed by directions in the Siret Corridor.</u> The directions with the most important frequencies have also the highest average speeds, while the smallest velocities are characteristic to the directions less

figured (Fig. 6). Thus, in Adjud, on the funneling direction, the average velocity exceeds 5 $m \cdot s^{-1}$ (5.4 $m \cdot s^{-1}$ NW and 5.3 $m \cdot s^{-1}$ on N), and at Roman and Bacau the average velocities exceeds in the same directions 4.5 $m \cdot s^{-1}$.

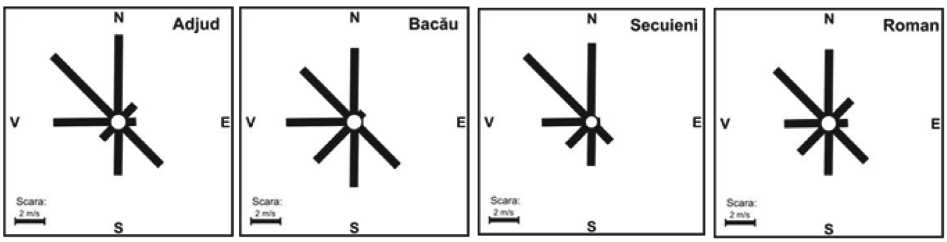

Fig. 6. Speed wind roses in the Siret Corridor (1961–2002)
Ryc. 6. Róże prędkości wiatru w Korytarzu Seretu (1961–2002)

These values are the highest in Moldova, except for mountain peaks of over 1000 m altitude, which induces a considerable eolian energy potential region. This reality underlines the importance of the funneling phenomenon in the Siret Corridor. Another feature implied by the northern circulation funneling, in particular, is given by de increase of wind speed from N to S. It should be emphasized that these potent factor of these high speeds and low roughness of the Siret terraces, which facilitates the amplification of wind speeds in the direction N and NW.

CONCLUSIONS

One of the main climatic feature of the Siret corridor is represented by the funneling of the wind, this process is so strong that it's felt up to 800–1000 m, well above the highest altitude in the region. On the background of the main funneling on the N-S direction, the junctions of the Siret River with the Charpatic effluents induce a secondary funneling character on the NW-SE axis, along these valleys. In this way, the NW direction represents the local correspondent of western circulation and therefore the highest values of frequency and speed are recorded in this direction.

Also, the topoclimatic effects on wind characteristics have as result a series of climatic peculiarities of the regions. In this way, the high frequencies of atmospheric calm leads to the development of the stratiform clouds wich have significant implications in topoclimatic terms in the region (reduce the duration of sunshine, increasing relative humidity in the lower strata of the cold semester of the year, abnormalities in the vertical distribution temperature, high fog frequency phenomena in the region).

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