Circulation in the troposphere over Europe between 40° and 55° North latitude, with special focus on the western direction

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ABSTRACT: This paper aims to be a contribution to the study of the currents in the upper and middle troposphere over Romania, in the context of European temperate zone, as the influence of the relief upon the western predominant influence, under the planetary boundary layer. Processing database from 19 European aerological stations, two in Romania, one in the intra-Carpathian area, Cluj-Napoca and one in the extra-Carpathian area, Bucharest. Romania is situated in the southern half of the European temperate zone. For this latitudinal area of the Europe, was selected a west-east profile, from the Atlantic Ocean to the Dnieper River. Preliminary analysis carried out for a total of just five years, led to the confirmation of the predominance of western circulation characteristic of temperate zones, in the middle and especially in the upper troposphere, but little to counter clearing, of the backward currents in the upper troposphere, tropopause and lower stratosphere eastward and northeastward, prospective currents of the Ferrel Cell circulation model. It was found discontinuous character of these currents and discontinuous character and increasing of the dominant western direction together with the altitude. From the forces acting on the wind direction, west direction was analyzed in correlation with the altitude and morphology of the relief in the case of the lower troposphere, where these parameters are important, also in the middle and upper troposphere was validated the influence of the Coriolis force.

KEY WORDS: the Coriolis force, prevailing westerlies, isobaric level, radiosounding

1. Introduction

Air movement is the result of the sum of the forces acting upon it. Initially, eulerian wind, gradient baric force generated is amplified by the Coriolis rotation systems and feature modified by centrifugal force and friction, which generates above the planetary boundary layer geostrophical winds. Acceleration of Coriolis force initiated by the Earth's rotation produces Western deviations to direction of air currents (Ahrens, 1985) and is directly proportional to the speed and increasing latitude, with the maximum at the Poles (Apostol, 2000).

Intensifying the speed combined with the deviation direction generates the meandering of the West winds at high altitude (Ștefan, 2004; Kohma & Sato, 2013) and at the upper level of the troposphere, in tropopause, we find the Jet streams, as a true expression of the West's vertical movement (Ciulache ,2004). These currents presents itself as a band of upper-level warms south westerlies (Lewis on Philips, 1998; Wells et al., 2008), characteristic to Ferrel cell, integrated in the scheme of atmospheric movement initiated by Hadley in 1725, Ferrel in 1856,completed in 1941 by Rosby through tricelulare circulation theory and Palmen in 1951.

In the area of study that includes in northern hemisphere aerological stations, between the Parallels of 40° North latitude and 55 atmospheric dynamics are active, accentuated and complex (Mihăilă, 2006), the effect of physical –geographical factors variety, and the ratio of land and water causes a disruption of the Western movement, but also with great frequency in both semesters. Wind direction are major disturbances on the surface of the soil (O'Neill et al., 2010) due to periodic fluctuations generated by thermal – barical differences produced by the relief, as the main factor of influence at regional and diminishes in elevation in response to variations in non-high-circulation (Apostol, 2004).

Table 1. Aerological European Stations located between 40 and 55 North Latitude

Station number	Stations	Altitude (m)	Latitude (Decimal degr.)	Longitude (Decimal degr.)
1	Beograd	203	44.76	20.41
2	Bordeaux Merignac	61	44.83	-0.68
3	Brest	95	48.45	-4.41
4	Bucharest Băneasa	91	44.50	26.13
5	Budapest	139	47.43	19.18
6	Cluj Napoca	413	46.78	23.56
7	Essen	153	51.40	6.96
8	Kryvy Rih	124	48.03	33.21
9	Legionovo	96	52.40	20.96
10	Milano	103	48.03	9.28
11	Muenchen Oberschlsshein	489	48.25	11.55
12	Odesa	42	46.43	30.76
13	Poprad Ganovce	706	49.03	20.31
14	Sofia	596	42.65	23.38
15	Szeged	83	46.25	20.10
16	Wien	200	48.25	16.36
17	Wroclaw I	122	51.78	16.88
18	Zadar	80	44.10	15.35
19	Zagreb	128	45.81	16.03

The analyzed area where the western winds are dominant (the Prevailing Westerlies) is part of the temperate zone, Northern Hemisphere, above Europe, and the area is bounded by the spatial coordinates -4,41° and 33,21° longitude and 42,65° and 52,4 latitude (see table 1).

2. Methods

The data used is derived from the processing of surveys taken from aerological stations from international data base of the University of Wyoming from 19 European stations. After checking the availability of the data prior to the determination of the period, were elected five years 2008 to 2012, the values being those at 12 noon UTC, and their mediation was done isobaric standard levels used in international meteorological studies, namely: 1000, 925, 850, 700, 600, 500, 400, 300, 200 and 100 hPa.

By using the IF function of Excel, Microsoft Office has been extracted the absolute frequency of the western direction, i.e. values ranging between 225 and 315°, and finally the relative frequencies of brokering that formed the basis for statistical analysis of the results of this study were obtained.

3. Results

The predominant air circulation across Central Europe is the Western (Jacobi, Kürschner, 2006), heading from subtropical anticyclones to the belt of subpolares minimum, variations of the direction being produced and the position of baric centers which resembles with ''spinning eddies in a huge river'' (Ahrens, 1985).

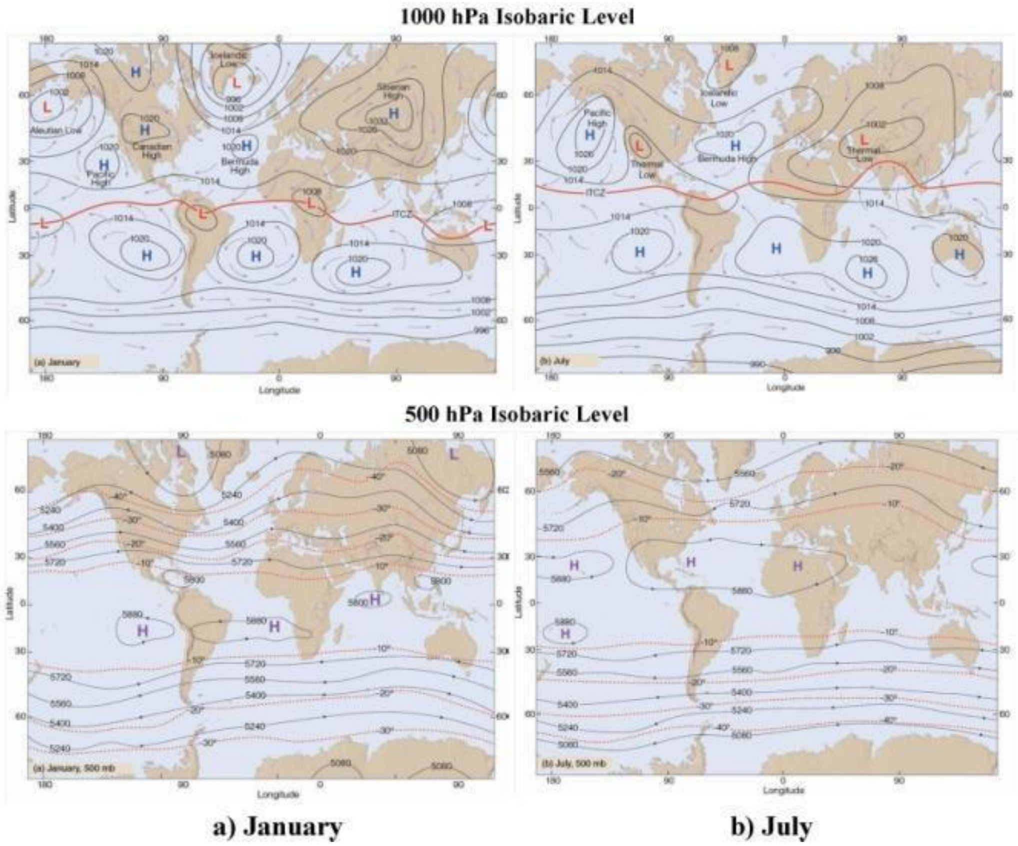

Figure 1. Circulation in the northern hemisphere during the summer (July) and winter (January) at sea level (1000 hPa) and altitude (500 hPa) (from Ahrens, 1985).

A detailed analysis of the main barometric pressure centers on isobaric levels (see figure 1) outlines a higher frequency in January for the 1000 hPa maps. In altitude, at 500 hPa the western winds prevail in both seasons, with the mention that the intensity resulted from the isobars proximity is higher in January.

The Western circulation in our country in the context of intense cyclonic subpolare activity in the northern half of Europe and anticyclonic activity in the South (Ion Bordei , 2008), with the annual manifestation (165 days a year) has an annual rate of about 45 in Romania for the period 1938-1961, analyzed by Topor and Stoica (1965).

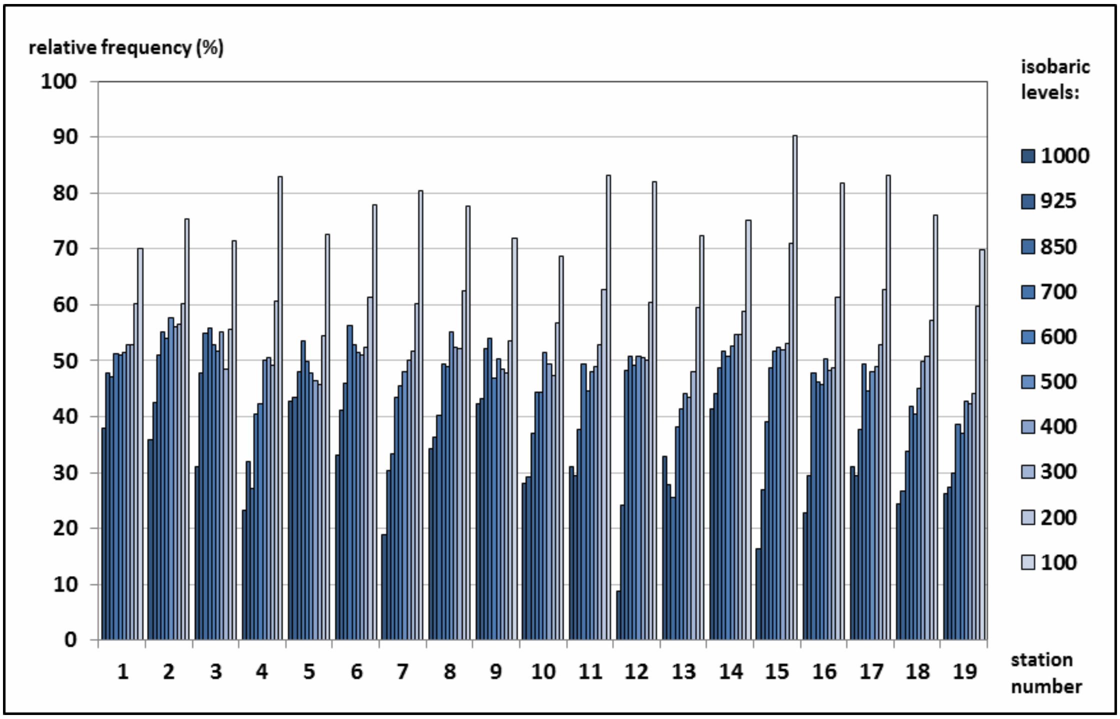

Figure 2. Average annual frequency distribution of the wind's direction of isobaric levels in Europe, between 40 and 55 ° North latitude, from 2008 to 2012.

In the lower and middle troposphere (850hPa, 700 hPa and 500 hPa) the dominant wind direction is from the West and intensify as the increase in altitude (Clima României, 2008), and latitude**.** In the layer in which acts the friction force, the theoretical zonal circulation is difficult to be perceived as there occur disturbances generated by relief (Topor, 1965), the area of interference fades above 3000 m for the Carpahian area. Western direction analysis over Europe was achieved on two spatial dimensions: vertically from ground stations up to 100 hPa and isobaric horizontal from -4,41° (Brest) to 33,21° longitude (Kryvy Rih).

Vertically the frequency of the western winds increases in altitude, the maximum being associated to the high troposphere, respectively to the high isobaric levels of 200, 100 hPa and the amplitude between ground level and 100 hPa grow towards east, inland, the maximum belonging to Poprad and Sofia stations (see figure 2).

In the case of the lower troposphere, the underlying active surface, represented by orographic natural dams put its mark on the frequency of western direction by posting small values above aerological stations positioned in the middle of them, namely: Milan, Zagreb, Poprad, Sofia, and Bucharest-Băneasa. The breakdown of the quantifiable western wind component in months reflects two periods with maximum frequency for all analyzed stations, March-April and July-August, when the barometric configuration of Europe is disturbed by the large extent of the Azores High favoring advections from the west.

The lowest frequencies, under 20 %, grow towards east, in the interior of the continent, and the characteristics altitudes are those of the lower troposphere, with the exception of the East area looked when this class of values occurs and to higher altitudes (see figure 3). The distribution of classes of securities from West to East reflects a great variability in the center of the continent, the active surface roughness imposed with high relief again. The uniformity of the relief from the North and West of the ocean influences the homogenization of their prints.

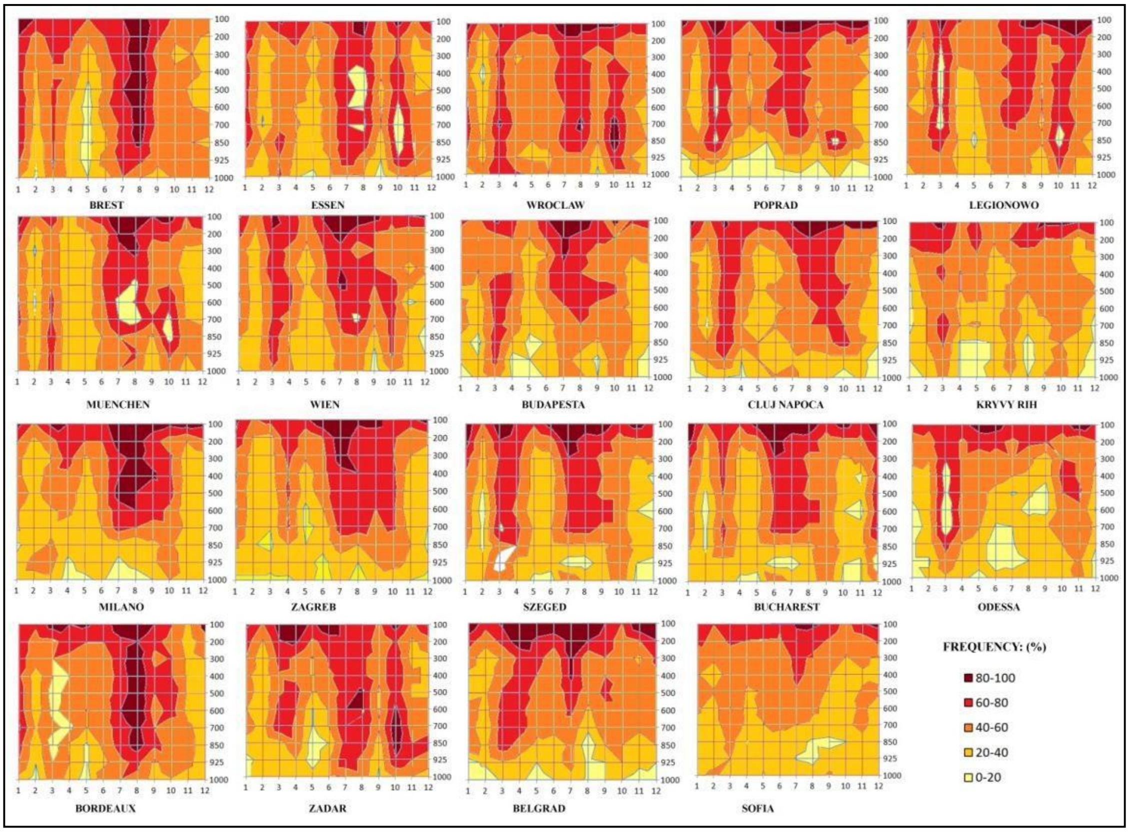

Figure 3. Average monthly frequency distribution of western direction on altitudinal levels above Europe, between 40° and 60 ° N latitude from 2008 to 2012.

Hypothesis analysis aimed at action subject to the Coriolis force deviation over the European continent, between 40 and 55° North latitude, which hypothetically should act through the air currents deviation to the right, an increase of Western direction from South to North, as well as in altitude due to the decrease in the force of friction generated by relief.

For analysis, we used three South-North profiles: One between 5 and 10° longitude East, comprising aerological stations Essen and Milan, the second between 15 and 20° longitude East with stations at Zadar, Zagreb, Vienna and Warsaw, and between 20 and 25° East longitude, between Belgrade, Szeged, Poprad and Legionowo, differences in latitude being 5.97, 7.68°, respectively 7.64°. The values used in the analysis were the differences between the average annual frequency of the period 2008-2009, reflecting an increase in the negative direction from South to West (see figure 4).

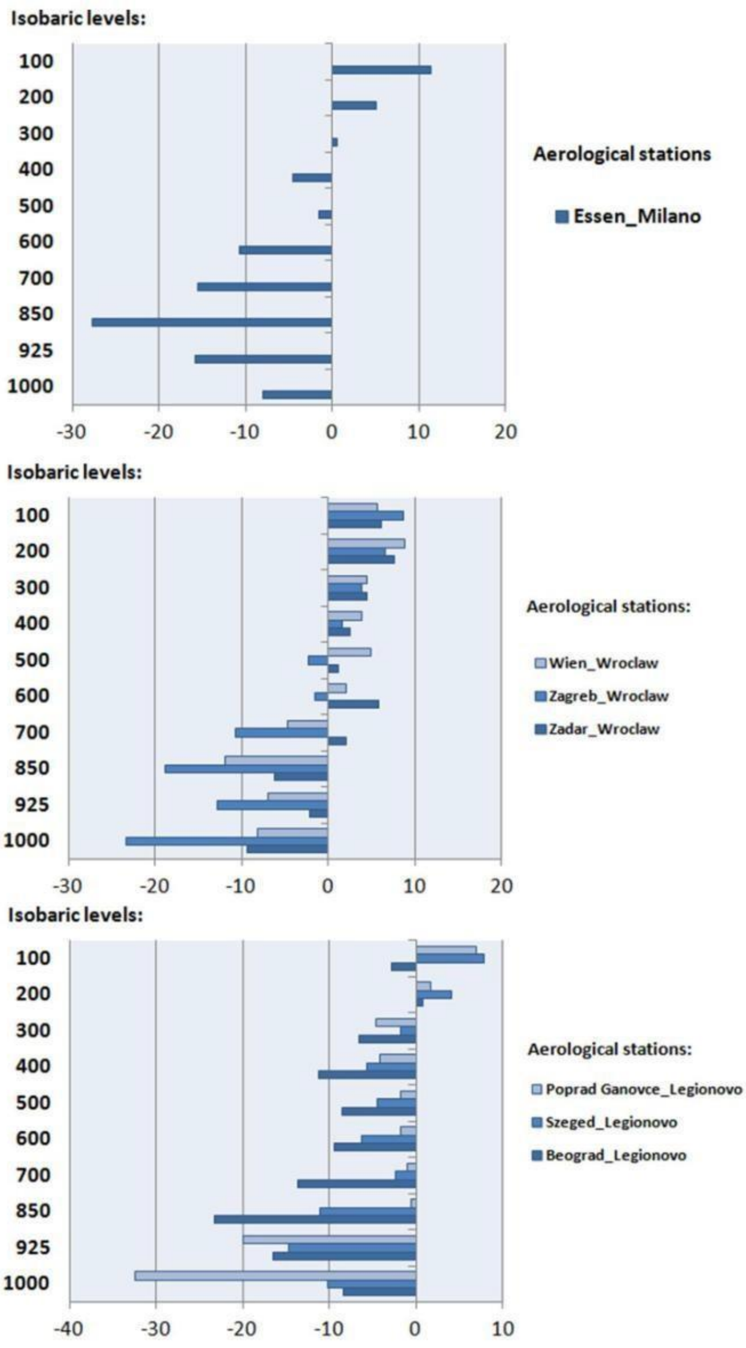

Figure 4. The distribution of differences of wind direction above Western Europe on profiles S-N from 2008 to 2012.

Profile of Wroclaw and Zadar, comprising aerological stations Vienna and Zagreb, expanded on a longitude difference of 7, 68 ° is characterized by negative differences recorded up to 850 hPa between all stations, while to the North, between Zagreb and Wroclaw, and it encompasses the range of up to 500 hPa, defining an intensification of Coriolis deflection. The most eastern profile, Legionowo- Belgrade is distinguished by increasing the frequency of the western direction towards the north up to izobaric level of 200 hPa approximately 11 000 m.

4. Conclusions

Western component increases with the height, confirming the hypothesis that between 40 and 55° North latitude, the prevailing West winds are specific to circulation of Ferrel cell. In the lower troposphere underlying active surface requires changes in the share of its direction, and the continentalism and the influence of the ocean moderates the variability of monthly average frequency distribution.

According to frequency analysis of prevailing westerlies above Europe in the period 2008-2012, we can affirm that the Coriolis force increases the deviation in altitude and latitude, while positive differences recorded between 300 and 100 hPa, the izobaric range of the tropopause takes to the assumption that atmospheric dynamics was intense, including meandering, which alters the frequent strong directions.

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