The conceptual - methodological evolution of the research on the föehn with special reference to the Cotnari area

Lidia Maria APOPEI[1]*, Dumitru MIHĂILĂ[1] and Petruț Ionel BISTRICEAN[2]
[1]Department of Geography, Faculty of History and Geography, Stefan cel Mare University, Suceava, Romania
[2]Regional Meteorological Centre of Moldova, National Meteorological Administration, Suceava, Romania

* Correspondence to: Lidia Maria Apopei. E-mail: plmaria31@yahoo.com.

Vol. 30 / 2020, 116-136

ABSTRACT: Given the increasing vulnerability of environmental components to the variability of weather and climate elements, studies of the föehn manifestations are a topical issue both internally and externally. This article aims to highlight the main advances in geographical studies and especially climate dynamics that have marked steps in the knowledge of the föehn, specific wind in parameters that must be quantified in more detail for the climate subregion of Cotnarilor. The clearest possible capture of the dynamic peculiarities of the Cotnari subregion will allow us to detail aspects from its topoclimatic context.

Published:

22 December 2020

KEY WORDS: föehn, Coandă effect, dry adiabatic gradient, adiabatic compression.

1. Introduction

In order to highlight the complementarity of the physical-geographical factors reflected in a perfect natural environment, Bucur and Barbu (1954) analyze the climate and microclimate of Dealul Mare-Hârlău, emphasizing the following types of microclimates: the shelter microclimate (Cucuteni, Cârjoaia, Băiceni, Bahlui) and the exposure and transition microclimate from steppe to forest (Măgura, Cotnari, Deleni, Rădeni, Zagavia, Stroieşti).

Gugiuman (1960, 1961) adds the contribution of the föehn effects of the air, a certain radioactivity from the bottom of the earth and a certain caution of the local vineyards, because "only in conditions of rock, soil, hydrology and climate specific to this area" superior quality of Cotnari wine. Gugiuman realizes a climatic region based on the climatic observations and the morphological and morphometric particularities of the relief, identifying in the Cotnari area the following climatic subunits:

- climatic subunit of the high coast (air temperature 9 °C, rainfall over 500 mm / year and moderate winds);

- the climatic subunit of the contact depression with the Moldavian Plain (temperature inversions, winter frost and large number of foggy days.

Tâștea and Rogojanu (1965) based on the values of air temperature (minimum, maximum), frost-free interval, average daily temperature ≥ 10 °C, ≥5 °C and characteristic time intervals in the morning before and after sunrise every 10 minutes 1 hour and 2 hours at noon) in the spring and autumn of 1963, at 15 observation points located at different altitudes and landforms, concludes that the highest thermal potential has slopes with altitudes between 30 and 150-200 m with southern and south-eastern exposure, where the autumn frost settles late and disappears in early spring. Cotea (2006) evokes the lines of the writer Mihail Sadoveanu "… namely the dust of the dust, the height of the places, the balance of the heat, the dryness of the air, the shelter of the winds, the shelter of the vines..."they are the essence of harmony viticulture with nature in Cotnari.

The regional research papers published by Erhan (1983, 1986, 1990), Băcăuanu (1980), Mihăilă (2006) include the analysis of climatogenic factors and the characterization of meteo-climatic elements, in which Cotnariul is distinguished by the great variability of hydro-meteorological phenomena (dew, fog, late autumn frosts) attributed to the western and north-western circulation: "the air of the ocean suffers, processes of supply while descending from the Suceava plateau". Climatic references for the Cotnari area are found sporadically in regional and national works, but there are no concrete concerns of scientific research on the peculiarities of air dynamics in this area. Through this paper we will highlight the progress made by scientific research and controversies related to the föehn circulation, going from the international level European, extra-European, national and local, regarding the study of the föehn. Clarification of some problems related to: the types of föehn depending on the trigger mechanism, functional and the consequences of these winds in topoclimatic and microclimatic plan.

2. Study area

In this study we will analyze the results of research conducted for land use planning in which a global area is manifested and in Romania, we will specify mechanisms and certain spatio-temporal conditions for a base or a comparison with the föehn in the climate subregion Cotnari.

The Cotnarilor area is located in the northeast of Romania, predominantly in the northern half of Iaşi county, being framed by us in a rectangle that in longitude has the extreme coordinates between 26°25' long. It's 27°35' long.E between the Siret valley to the west and the Prut valley to the east. In latitude the study area is between 47 ° 05 'wide. N and 47 ° 30' lat. N (Fig. 1).

The absolute altitudes are between 30 m in the Prut valley and 587 m Dealul Mare-Tudora. Previous studies show that the territory in question falls within the area of the temperate climate of transition from moderate to central European of the Suceava Plateau to the Eastern European one of the Moldavian Plain, with the transit line between 300-350 m altitude (Cotea, 2006) and is individualized as a climatic subregion (Mihăilă, 2006) of the climatic district of the Moldavian Plain. The geomorphological units of the study area are represented by: The Siret Corridor-part of the middle course of the homonymous river; Dealul Mare-Hârlău Plateau and Cotnarilor Coast subdivisions of the Suceava Plateau; the Frumuşica-Hârlău-Hodora depression gorge and the Iaşi Plain subdivisions of the Jijia-Bahlui Lower. The Siret Valley, due to its geomorphological peculiarities, favors the formation of temperature inversions, resulting in the installation of cold air in the lower valley corridor, over which the warm air slides at high altitudes, so that then on the eastern slope of the Mare-Hârlău Hill, it meets favorable conditions for the production of the föehn (Sfîcă, 2015).

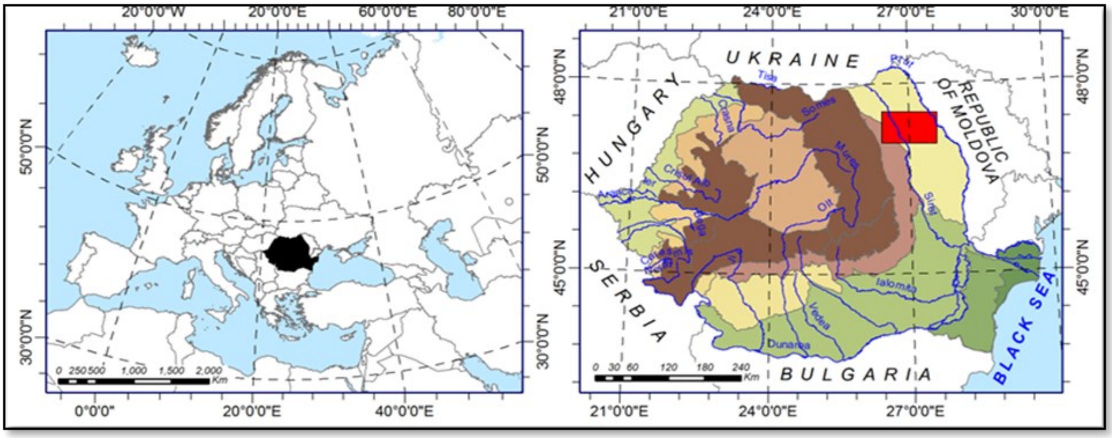

Figure 1 Location of the study area for foehn in Cotnari and surroundings.

3. Methods, data and sources of information used

In order to carry out this study to review the literature on our topic of interest, we consulted similar climate studies on the föehn circulation ordered according to the following algorithm:

- clarification of some aspects related to the terminology used in the specialized literature;

- analysis of studies explaining the origin of the föehn and the specific mechanism of the föehn;

- or which addresses the complex climatic researches of the föehn-type movement at the level of some territories in Europe or in the extra-European space with all the genetic peculiarities, of the manifestation and consequences of such a dynamic mechanism;

- analysis of some studies carried out on the Romanian territory regarding the föehn circulation (genesis, manifestation, consequences) with a special attention on the dynamics around Cotnarilor.

4. Results and discussion

4.1. Clarification of some aspects related to the terminology used in the specialized literature

The föehn, as defined by Brikmann (1971) and the World Meteorological Organization (1992), is "the wind heated and dried by the downward movement, generally on the sheltered slope of a mountain." Therefore, it is as ubiquitous as mountain ranges. The origin of the name "föehn" comes from the Latin "favonius", which means "westerly wind" - "for the Romans, the most important feature of the favor was not the direction from which it struck, but its warmth".

As it reached the northern slopes of the Alps, ... and became a warm wind, the Romans believed that it was a favonius from the Mediterranean. Thus, the name was specific to a warm, dry wind descending on the northern slopes of the Alps ”(Atkinson, 1981).

In the literature, *föehn* is the generic term for a warm, dry wind that forms on slopes sheltered by the dominant air circulation. In German it is noted "*föhn*" and in French "*föehn*". The same hot and dry wind has its own names in the world: "*chinook*" on the eastern slopes of the Rocky Mountains, "*zonda*", "*raco*" and "*pulche*" on the western slopes of the Andes Mountains, "*afganet*" and "*ibe*" in Central Asia, "*Kachchan*" in Sir Lanka, "*bohoroc*" in Sumatra, "*koehang*" in Jawa "*koschava*" and "*ljuka*" in Croatia, "*fogony*" in the Pyrenees, "*viento del sur*" in northern Spain, "*terral*" in southern Spain, The “*east*” in Gibraltar, the “*jank*” in Austria and the “*pyrnwind*” at the sources of the Danube (Fig. 2).

4.2. Analysis of studies that explain the origin of the föehn and the specific mechanism of the föehn, or that approach the complex climatographic research of the föehn type at European level and the extra-European space with all the genetic peculiarities, of the manifestation and the consequences afferent to such a dynamic mechanism

Studies that analyzed the circulation of föehn on the European continent

The föehn, identified in the sec. 19th century and researched mainly in the area of European Appliances is currently a topical topic worldwide among climatologists (Seibert 1988, 1990, 2000, 2012). The genesis of the foehn is complex and the theories that explain this wind are varied.

At the end of the 19th century, Hann (1860, 1880, 1891) formulated and expounded *the thermodynamic theory* of the föehn production. According to her, the humid air through adiabatic descent and relaxation, cools (following the humid gradient 0.5 - 0.65°C / 100 m) forms clouds and precipitates on the slope exposed to the dominant circulation. On the opposite side the air becomes dry and is heated initially by the latent heat of condensation and then by adiabatic compression according to the dry gradient (1°C / 100 m). The theory is still valid in current climatological explanations, except that the same author notes in 1880 that condensation for air heating is not mandatory. Air becomes hot by adiabatic compression and "collapse" on the sheltered slope similar to the heating resulting from anticyclonic dependence, a mechanism studied by Billwiller (1899, 1902). Billwiller nuances the föehn forms in: *the northern föehn* on the southern slopes of the Alps, and *the southern föehn is* also called the *anticyclonic föehn*, because it is installed against the background of a baric depression south of the Alps and an anticyclonic air mass north of the Alps. Billwiller evaluates the föehn as a passive wind sucked in by a barricade depression.The twentieth century begins with new scientific answers on the föehn. Ficker (1910, 1931) studied cyclogenesis in the Mediterranean area, emphasizing the asymmetry of air flow on the slopes of the Alps during the föehn. The results were as follows: the warm air on the northern flank of the Alps comes from above, without being part of the dynamics of the air on the southern flank or in the lower layers of the southern Alps. The alpine chain functions as an obstacle that does not allow air from the south to rise to the north; the northern basin is filled with warm air from the high troposphere brought by high-altitude winds whose potentially higher temperature requires heating of the furnace on the northern slopes. These explanations underlie *the theory of the hydraulic jump* or *dry föehn studied* and by Flamant et al. (2002, 2003), Gölm and Mayer (2004), Steinacker (1983, 2006). According to this theory, the hot air that passes over a pool of cold and inert air has its origin in a previous synoptic situation.

Brinkmann (1971) clarifies the definition (see 4.1) and the origin of the wind, but also its location in new regions: Southern California "Santa Ana", Canada "chinook winds", Austria "jank", northern Italy "tramontana", southern France "vent d`Espagne" or "vent du midi" in Lyon.

Klemp and Lilly (1975, 1978) they emit *the linear theory* in the formation of the föehn, based on an atmosphere divided vertically into layers with different properties (two stable layers of air at the active surface and the lower stratosphere between which is the troposphere, a less stable layer). Knowledge of the peculiarities of the upstream atmosphere is necessary to explain the downhill winds, warm, dry winds with accentuated dynamics. Of major importance is the origin of the air mass (which may be an additional factor contributing to the increase in the thermal value of the air) and the topography of the relief. The orographic barriers of over 3000 m altitude exposed to the advection of the sea air in the Cordillera Andes area favor the high speed föehn (named "zonda mare"), on the sheltered slopes there are aridity phenomena, dry vegetation fires and material damages.

Hoinka (1984, 1990, 1991) focuses its climate research activities on the dynamics of the air in the Alps and the surrounding areas (München). Thus, the connections between the types of atmospheric fronts and the change of air currents (direction, speed, air density) at the meeting of orographic obstacles are analyzed. In Europe, cold fronts are significantly changing their speed in the Alps, being distorted, delayed or diminished. North of the Alps, in the prefrontal region, the author observes the production of a moderate wind that leads to the formation of low altitude clouds. The warm air on the southern flank, of subtropical origin, replaces the cold air of polar origin generating clouds and precipitation that were previously transferred on the northern flank, over the Alps. This phenomenon can be observed on the northern flank of the Alps up to 200 km and has a maximum frequency in the first 50 km north of the orographic dam. After the föehn is dismantled, the cold air mass is pushed towards the mountain area behind the previous warm front and blocked between the mountains and the new front alignment. The dynamic mechanism described leads to the formation of frontal precipitation, favored by the high altitude of the Alps (over 3000 m). The author identifies two meteorological-climatic sequences in air dynamics: *off-orography flow* - the flowing air current and *on-orography flow* - the situation of air blockage. In reality, the föehn is generated by a combination of mechanisms explained by various theories, such as the hydraulic theory that best describes the föehn processes (Steinacker, 2006), similar to “shallow waters” in which the atmosphere is characterized by a state of homogeneity and stability of the hydrostatic balance. The potential upstream energy is transformed in to kinetic energy during the crossing of the flank sheltered by air advection (Klemp, Durran 1983; Durran 1990), and its force leads to high air velocities on the slopes and the formation of the föehn.

Based on data sets from a dense network of meteorological observations in the Rhine Valley, Befferey et al. (2004) performed the simulation of föehn flows in different synoptic and topographic conditions, regarding the föehn as *mass flows*, the role of the föehn in the presence of cold air masses and the potential energy budget resulting from two main physical processes involved in air dynamics: *advection* and *turbulence.*

Vergeiner (2004) publishes two case studies of the föehn along the Wipp and Inn valleys. The first study provides information on air flow in three layers that favors the production of *föehn sandwich.* The research was based on Lidar Doppler, two radiosondes, SOP data (Special observation period of the MAP program - Mesoscale Alpine Program, 1999) and data from zonal weather stations. The second case of föehn was studied at the German Aerospace Center (DLR - Deutsches Zentrum für Luft-und Raumfahrt). The classification of *föehn sandwich* layers, proposed by the author is based on: wind direction for hot air flow, valley orientation (Wipp, Inn) and evaluation of relative humidity and potential temperature according to the formula [1]:

$$Q=T \mathrm{\ x\ } (1000/p)^{R/\Phi} \qquad [\mathbf{1}]$$

where

T = temperature in degrees Kelvin,

p = air pressure in hPa,

R/Φ = dry air constant.

Vergeiner (2004) emphasizes the high frequency of *föehn sandwich* and the secondary frequency of *hydraulic föehn* in the researched area and the major role of mountain topography in the föehn manifestations between Brenner and Innsbruk.

Gölm şi Mayer (2006) they researched the föehn in the northern Alps (Brenner Pass region and along the Wipp Valley) arguing *the hydraulic theory* in the formation of the föehn. Climatological analyzes of the Nordic föehn were based on monthly, seasonal and annual meteorological-climatic data from 1991-2003, from five stations in the Po river basin located on the Italian-Swiss borde.

The research results highlighted the föehn manifestations in winter and spring, the phenomenon has a great variability in time and space, influencing the alpine layered environment and the Po river basin. The factors that influence the wind are: the dominant direction of the SE-NW current and the presence of cold air surfaces above the Maggiore Lake basin.

After 2000 complex studies were and are being carried out in South Central Europe (Germany, Switzerland, Austria and northern Italy), where the föehn is characteristic and required the establishment of the MAP service (*Alpine Mesoscale Program, http: //www.map .meteoswiss .ch*). MAP is an international research program dedicated to the study of hydro-meteorological processes in the Alpine region. This program evaluates through mathematical models and IT programs the föehn phenomena in terms of production, duration and wind intensity. MAP included an international field campaign in the Alpine region in 1999 and a period of hydrological forecasting in 2007. MAP has developed institutional links with the World Meteorological Research Program (WWRP) and the World Climate Research Program (WCRP). The city of Zurich hosts the MAP data center which provides activities for observing the Rhine Valley föehn, investigating atmospheric flows, developing high-resolution atmospheric models and using radar data to assess hydro-meteorological events.

Miltenberger et al. (2013) Lagrangian analysis identifies two types of föehn in the Swiss Alps. On the side exposed to advection, the air reaches by a dynamic ascent to altitudes of over 2000 m, gives rise to adiabatic-humid processes that explain the change of thermodynamic and microphysical parameters of the air with the formation of clouds and precipitation. It is *föehn with precipitation* upstream. Then, in its offspring on the protected slope, the air heats up and becomes drier. The second type is *the föehn without precipitation*, characterized by the air rising to lower altitudes on the slope exposed to advection (1700-2000 m) and then adiabatic heating of the air on the protected slope. The same author studies the föehn in terms of spatio-temporal variability, intensity and frequency in the southern Alps, the Provinces of Lombardy and Piedmont. The research results indicate the high frequency of föehn in March, during the afternoons. The speed and frequency of the wind is high near the alpine ridges and on the north-south oriented valleys. The wind is warm and dry, favoring a high horizontal visibility induced by the mixing of the air in the lower layers. The Alps develop in normal conditions of south-north circulation, *the southern föehn* where the clouds are evident on the southern slope, an area known as *Muro del Föehn.*

Studies that have analyzed the föehnal circulation at extra-European level

On the American continent, föehn is found as a subject of scientific research in the works of Brinkmann (1970), who describes *the chinook* on the eastern slopes of the Rocky Mountains and in the Calgary area (Canada). Raphael (2003), Mayr et al. (2002, 2004) studied the influence of diurnal heating air flow on the slopes of the Sierra Nevada Mountains (California) along the Owens Valley (3 km).

An atypical case *of evening föehn.* The study shows the warming of the air in the afternoon with an average speed of 8 m/s and the unnatural succession of air until noon : at ground level a layer of cold air over which warm air accumulates at altitude, while in the evening the situation is reversed.

Gaffin (2009) analyzes the frequency of strong descending winds with a speed of over 20 m/s on the eastern slopes of the Central Appalachians in the USA. *The zonda* wind (strong, hot and very dry wind from the Cuyo region - frequently on the eastern slopes of the Years), has been the subject of climate research since 1950 due to negative effects (air pollution, road accidents, disruption of air transport) on the cities of Mendoza and San Juan. Detailed research on this wind (onset time, area of manifestation, duration, intensity, time of wind cessation) is another major challenge for researchers and regional forecasts (Seluchi, Norte, 2003).

On the Asian continent, the föehn is the subject of many scientific papers. In China, *the föehn sandwich* (identified and described in the Aples to Vergeiner, 2004) amplifies air pollution in Urumqui, a city located north of the Tianshan Mountains and in the provinces of Xinjiang and Sichuan (Li et al., 2015). The atmospheric structure highlights the northwest wind at the upper level, the föehn between 500-200 m altitude and the cold, inert air basin at the level of the active surface. The same author identifies in Taiwan - a mountainous island frequented in the west and northwest by strong typhoons, and on the east-southeast coasts of hot and dry winds of the föehn type that negatively influence the propagation of radar waves near cyclones (Typhoon Krossa 2007, 2009).

In Japan, föehn effects are highlighted (Kusaka et al., 2000) by increasing the air temperature on the ground, mixing with turbulent diffusion and strong winds in Tohoku District, in response to record temperatures above 40°C in the Kanto Plain. in the summer of 2007. and in the Osaka-Kobe metropolitan areas.

In Israel, föehn was studied in the Jewish Mountains (1000 m) and the Dead Sea Tectonic Depression (-427 m) and its effects marked March 22, 2013 with a high degree of pollution and record temperatures of over 42° C (Kishcha et al., 2018). The föehn is manifested in 72 % of summer days on the eastern slope of the Judean Mountains, a phenomenon demonstrated by Lidar observations and analysis of meteorological and climatic elements, identifying two types of foehn: *type I* with a duration of 2-3 hours, a maximum average speed of 5.5 m/s and does not propagate far into the valley; *type II* which affects the entire valley, as it propagates along the valley to the eastern part with speeds of over 11 m/s and has a duration of 4 -5 hours.

Scientists' concerns about the high temperatures and low number of foggy days in eastern Tasmania and southeastern Australia, the high frequency of fires near Hobart associated with warm winds blowing down the Australian Alps, were reasons for analytical research in field. The areas affected by the fires coincide with those in which the föehn has an appreciable area of manifestation: eastern Tasmania, northern New South Wales, southeastern Queensland and east of the Flinders Ranges. The föehnal mechanism is a combination of thermodynamics and mechanics and meets the conditions to reach high frequencies in late autumn, winter and spring (Sharples, 2010).

Wind föehnal are often responsible for warming the air on the outskirts of Antarctica and melting ice blocks. In the dry valleys of Mc. Murdo, the correlation between the pressure gradient and the surface wind speed leads to the formation of mountain winds through adiabatic heating and the descending transport of hot air (Steinhff et al., 2013). Valea Mc. Murdo and the Taylor Valley in eastern Antarctica (4800 km) impress by the seasonal melting of ice on the surface of lakes located in closed basins. The Transantarctic Mountains block the flow of cold air from the south and generate the existence of liquid water in a climate with valley thermal environments between -14.8°C to -30°C. In summer, positive temperatures favor early melting of the ice, but average annual thermal values are low enough to maintain the basal ice sheet throughout the year. Although rare, summer föehn has a major impact on the hydrological balance along the Antarctic Valley, being responsible for the occasional melting of ice on the surface of lakes and increasing the number of days with freeze-thaw temperatures. The intensification of major events in recent years in Antarctica is also due to rising synoptic air pressure above the continent's neighboring ocean waters. Appearance confirmed by Xun Zou et al. (2018), which demonstrates the contribution of the föehn by 2°- 4°C to the increase of air temperature on the surface of the coastal zone in the Marie Byrd Land area and by about 1°C in the Edward peninsula.

Figure 2 Areas with foehn on the Glob *(Data source map: https://mapswire.com/world/physical-maps/ - with minor changes).*

4.3. Analysis of some studies carried out on the Romanian territory regarding the föehnal circulation (genesis, manifestation, consequences) with special regard to the dynamics around Cotnari

Studies on föehn with reference to the territory of Romania

Among the climatic processes determined by the atmospheric circulation influenced by the relief, by the orientation of the peaks, the exposure of the slopes and altitude with an important role in the distribution of air temperature and humidity, nebulosity, sunlight duration, wind speed and atmospheric precipitation regime, are also found föehnization of the air.

In the Romanian specialized literature there are references on the phenomenon of föehn. Climatologists' studies outline two research directions: some authors (Stoenescu, 1951; Ciulache, 1987; Bordei 1979, 1980 1988, 2008; Pop, 1983; Bogdan 1993) have studied both the mechanism of production and the effects of the hair dryer), others (Teodoreanu, 1979; Bogdan, 1986, 1990; Erhan, 2004; Irimescu, 2014; Sfîcă, 2014) studied the effects of föehn in various regions of the country: in the Eastern Carpathians (east of the volcanic mountains and Giurgeu-Ciuc depressions), in the Apuseni Mountains, in the south - the west of the Banat Mountains ("*Coşava*"), in the north of Făgăraş ("*Vântu Mare*"), on the northeastern slope of the Piatra Craiului Mountains ("*Pietrarul*"), in the south of Oltenia, in the east of Romania or in the climatic subregion Cotnari Stoenescu (1951) analyzed the föehn effect and the "*cascading winds*" that affect forests through tree felling on the mountain floor. In *The Forest Magazine,* Baroncea (1963) describes the characteristics and the way of formation of the two cases of föehn in the winter 1947-1948 and their violent influences with the destructions on the forests located in the northern part of the Eastern Carpathians. We find the same concerns in Marcu (1969) regarding the causes of cutting down trees in the mountainous area of the Carpathians from the cold period of 1964-1965-1966.

Macarov takes the research idea of the föehn from the mountain floor and in 1976 demonstrates on the basis of the distribution of air temperature, relative humidity and wind parameters, the existence of the mentioned phenomenon in the area of Harghita and Covasna counties.

In 1976 Tilinca et al. demonstrates that by compression and descent, the air is heated according to the dry adiabatic gradient (1°C / 100 m). The author attributes to the föehn the particularities of a *pseudo-dynamic process* that presupposes the ascent of the humid air on the slope of the relief in front of the wind with its adiabatic relaxation. The same meticulous research on the meteo-climatic elements determined by the föehnale phenomena is the basis of the work published by Teodoreanu (1979) in which are presented therapeutic references induced by föehn in the Banat Plain and Hills, noting that the föehn of Banat does not have a high intensity and frequency (holding between 1 and 5 % of the air dynamics), the manifestation period is spring, and in autumn and summer the föehna processes are attenuated. The thermal variations do not exceed 2°C, the humidity loses between 13-14 % and the wind is not a medical motivation for the cure in Buziaş.

Bogdan and Mihai-Niculescu (1990) highlight the areas with hair dryer in Romania (Fig.no.3) and support the thermodynamic theory with the mention that the air that is rising just like a stream of air propelled upwards cools, condenses and precipitates at altitudes of saturation on the exposed slope, releasing in the condensation process the latent heat, so that up on the peaks the ascending air flow is warmer than the surrounding air. Then, by virtue of the inertia, the ascent into the void continues for a while, after which it flows on the sheltered slope.

Stăncescu, Damian, Şerbu (1982); Bogdan, Niculescu (1986) and Bogdan (1993) deepen the knowledge of the mechanisms and effects of the mountain föehn, realizing also the conceptual model of its production (Fig. 4). The schematic model of the föehn production mechanism takes into account: 1. the formation conditions; 2. the thermodynamic mechanism it-self; 3. meteorological consequences; 4. subsequent changes to the landscape.

The conclusions of the paper lead to:

- the individualization of the curvature subcarpathians as an area of maximum intensity of the föehn with direct influences in the northeast of the Romanian Plain and in the south of the Modova Plateau.

- the case study from the winter of 1988-1989 highlights the föehn in 7 out of 10 cases with wind,

especially at night.

- föehn contributes to the shaping of a mild topoclimate in the Curvature Subcarpathians, with the development of sub-Mediterranean biogeographic elements (Călinescu et al., 1966).

Bogdan (1993) supports the elementary conditions for the production of föehnale phenomena:

- the presence of an orographic dam and a mass of cold and humid air in advection with the dam;
- you can only talk about föehn when the orographic obstacle is overcome and the air begins to descend;
- the föehn genesis is characterized by a thermodynamic mechanism itself which is triggered at the moment of impact of the air mass with the orographic dam;
- meteorological phenomena bring weather and long-term climate change on both mountainsides.

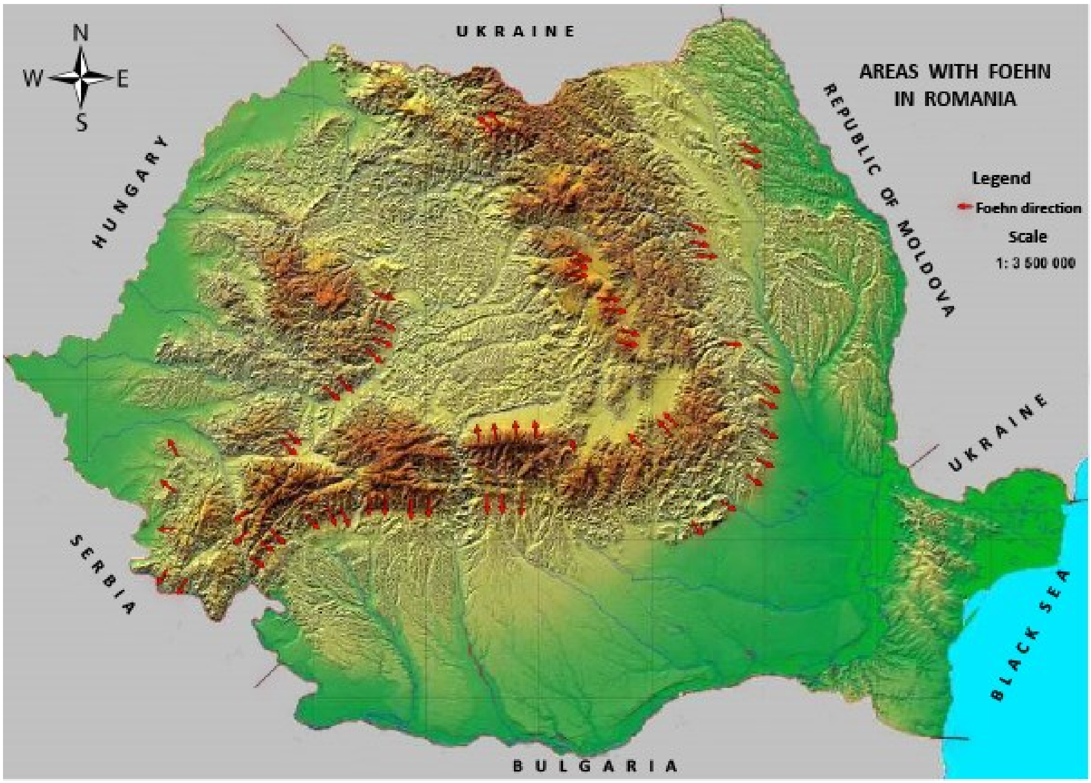

Figure 3 Areas with föehn in Romania *(Data source map: SRTM - www.nasa.gov - with minor changes).*

Bogdan (1993) emphasizes the role of the Carpathian arc which benefits from the production of föehnal phenomena in the extra-Carpathian area in different types of circulations: the Carpatho-Balkan interior curvature (Oltenian sub-Carpathian sector, Mehedinți plateau, Getic plateau), north of the Rodna Mountains (Maramureş Depression), north-west of the Piatra Craiului Mountains ("Pietrarul"), east of the volcanic mountains (Giurgeu and Ciuc Depressions), southwest of the Banat Mountains ("Coşava"), east of the Eastern Carpathians, east and southeast The Apuseni Mountains, in the Făgăraş depression, are called "Vântul Mare" and it can extend to the Târnavelor Plateau, with an average speed of 10 m/s for days on end, in winter the snow melts quickly, causing floods and in summer it accelerates the ripening of field crops.

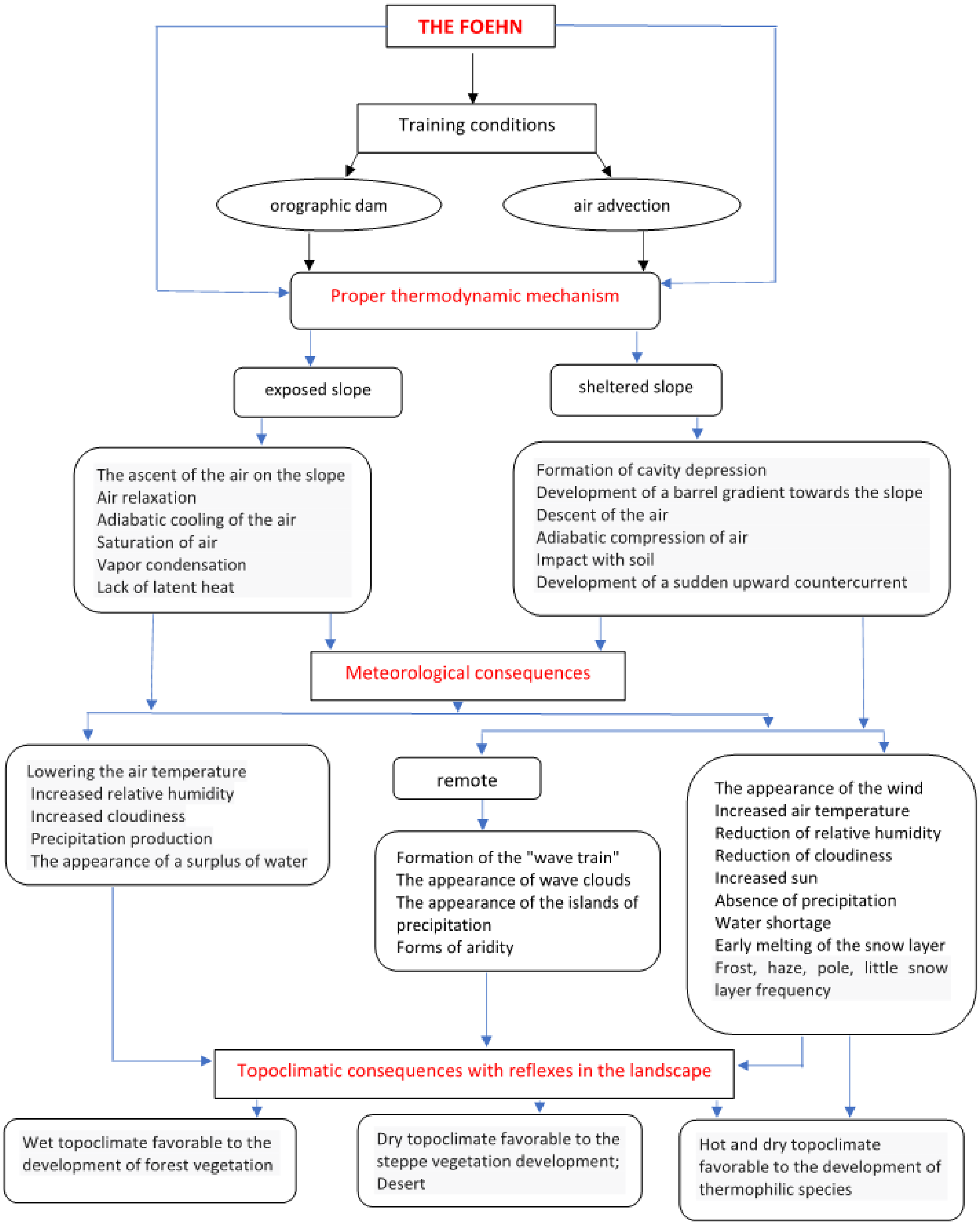

Figure 4 The conceptual model of föehn production (Bogdan, 1993; Bordei, 1988).

The '80s and' 90s open the page of research concerns of the mechanism of hair dryer production from the perspective of the authors Bordei (1979, 1988, 2008) and Ceobanu (1998).

Bordei (1980) explains in detail the mechanism of the föehn formation by the presence of a mountainous or hilly obstacle and the advection of a humid air mass that crosses perpendicularly the orographic obstacle. In the author's conception „the descent is not a free descent, but a forced descent, on canvas, to the base of the slope, due to a cavitation depression that forms immediately below the ridge, as a dynamic effect of air circulation on a mountain range [...].The phenomenon of deviation is in this case in a high degree of similarity and the Coanda effect [...]. In regions with strong winds, downstream of the cavitation depression there is an impact sector, where the air current hits the slope. There may be a more pronounced deflation than the rest". The air mass reaching the ridge would thus be forced to enter under the colder air mass on the sheltered slope and to drain to the base. This explains the high intensity of the wind towards the base of the slope, a wind that can reach very high speeds, and in the forest regions the trees can be felled.

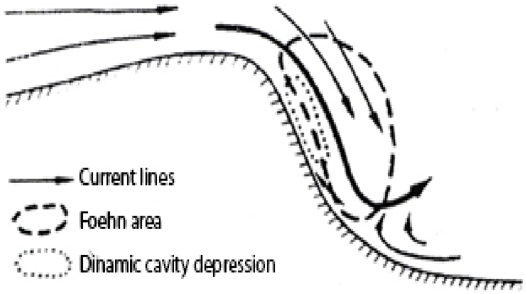

Figure 5 Air circulation on the leeward slope of the mountain (Bordei**,** 1988).

Bordei demonstrates that the violent impact is produced downstream by a counterfoehn that comes into contact with the föehn on the slope sheltered at the interface of the two air currents (Fig. 5). The formation *of wave clouds* and *remote precipitation islands* in the Bărăgan Plain are the meteorological and climatic consequences of the föehn extra-Carpathian, considered a *major föehn*, in contrast to the *minor föehn* felt in the eastern, south-eastern circulation on the western and north-western slopes of the Carpathian Curvature.

Ceobanu (1998) explains the formation of the föehn considering the chemical composition of the atmosphere and its properties. Wet air (with a high volume of water vapor) has a lower density than dry air (which contains more nitrogen (Ciulache, 1985). The relationship between the density parameter of wet and dry air is given by the formula [2]:

$$\rho v / \rho a = 0.622 \quad [\mathbf{2}]$$

where
ρv = density of humid air,
ρa = density of dry air.

Under conditions of constant temperature and pressure, when an obstacle is encountered, the humid air tends to rise mechanically and, depending on the amount of vapor, the clouds formed may or may not precipitate. On the sheltered slope, the dry air becomes even heavier and the downward movements are faster. Adiabatic compression processes occur and the air heats up.

Other scientific papers come with explanations on the mechanism of the föehn formation derived from the field of aeronautics and atmospheric physics (Isaia, 2005) or in the field of synopsis (Irimescu, 2014). In the last study, the information is analyzed about: the altitude of the air layer affected by the föehn, the meteorological elements and processes that indicate the föehn, the types of clouds and how the air flow is directed when crossing an orographic obstacle. To demonstrate the production of the föehn, the author used three basic criteria: changing the wind direction and increasing its speed, increasing the air temperature by more than 2°C and reducing the relative humidity. o identify the föehn in vertical section, Irimescu used METEOSAT 8 satellite images (which provide infrared temperature data) and analyzed 5 case studies from the cold period of 2008-2009. The conclusions of the paper pointed out that: föehnale manifestations are possible in northern Oltenia throughout the year with the maximum frequency in winter and spring, the wind intensity is shaped by the height of the orographic dam that opposes the dominant circulation, the synoptic situation that favors the production of föehn is given by the presence of an anticyclonic belt oriented west-east over Central Europe (Azores anticyclone in the west and Eastern European anticyclone in the east) and Mediterranean cyclones to the east-southeast of Europe. Irimescu made the catalog of föehn situations for the territory between the Danube-Olt between 1961-2000.

In 2014, Pandi et al. studies the föehn in the eastern Apuseni Mountains based on the hourly values of air temperature, relative air humidity, wind direction and speed, the daily average values of the three meteorological parametersand maximum air temperature values in 12 and 24 hours, offering three east-west profiles over the mountain area that highlight the incidence föehn on the eastern slopes of the Apuseni Mountains.The synoptic context was represented by the dominance of the western circulation over the whole of Romania and by the post-frontal advection of the hot air that replaced the cold air from the low eastern areas of the Apuseni Mountains.

Studies on föehn with reference to the territory in the vicinity of Cotnari

Gugiuman (1960) emphasized that "the climatic nuance of the territory around the Cotnari vineyard is defined by the föehnization processes, due to the frequent winds from the north-west, west and south-west direction".

Pantazică (1974) showed that the ocean air suffers, a process of foahnization while descending from the Suceava Plateau. These are the landmarks that define the depression area in northeastern Moldova.

Mihăilă (2006) in the *Moldavian Plain-climate study*, includes study territory in the *climate sector with arid influence, the climatic support of the low hills, the climatic sub-region around Cotnarilor*.

This territory is affected by the föehnization processes that introduce in the south of the Moldavian Plain obvious east-west differences: hot summers and mild winters, higher temperature, relative humidity and lower atmospheric pressure, reduced snow cover and shorter annual duration, dominance of air advections in the north-northwest and south-east sector favoring warm winds as an effect of föehnization on the eastern and south-eastern slopes with cloudiness, humidity and lower atmospheric precipitation than in the surrounding territories.

Erhan (2004) analyzes the föehn based on daily air temperature (maximum and minimum) data from 1990-1998, from nine meteorological stations in Moldova arranged on the alignment of some profiles, starting from north to south as follows: Rarău-Dolhasca-Cotnari; Ceahlau-Toaca- Piatra Neamt; Brusturoasa-Tg. Ocna; Tulnici-Paşcani and the temperature values from 7.00 - 9.00 for the Paşcani and Cotnari meteorological stations from January, April, July and October. Calculating the average thermal gradients with the help of day and night maximums and observing the significant deviations from the average vertical thermal gradient (0.5-0.6°C / 100 m) he concluded that the air from the west is forced to climb the peaks of the massifs. Giumalău and Rarău and then descend föehnizing towards the Suceava Plateau and the Siret Valley. In the Siret valley, one part can stay forming temperature inversions, and the other part can climb the western slopes of the Great Hill (587 m) and then descend föehniziz on the east-southeast slopes. The observations of this paper show that in such conditions at Cotnari (289 m) the maximum temperatures are higher compared to those at Pașcani and Dolhasca (located at lower altitudes).

According to Erhan (2004), air conditioning processes can take place *throughout the year, more frequently in spring and summer.* The most frequent cases of föehnization are of low intensity, being masked by the relief configuration, the author emphasizing that *not every thermal increase* *is the consequence of fönehnization* and that a major contribution to the generation of these thermal differentiations has a and the higher degree of insolation of the east-southeast slopes.

By analyzing daily synoptic maps, observations and data from radio surveys and monitoring the air temperature and humidity in the cold season 2013-2014 in 12 points in the Cotnari-Valea Siretului area, Sfîcă et. al. (2014) demonstrate the frequency of the hydraulic föehn (20 % of the hourly observations), by the presence of the cold air basin along the Siret Valley. Recording of negative temperatures (during the interval 22. Dec. 2013 at 05:00, 23 Dec. 2013 at 09:00) of -3.9°C at Paşcani and positive temperatures of + 4.9°C at Deleni and 6.6°C at Cotnari and in the neighboring territories denotes the advection over the hilly peak Tudora-Hârlău of a mass of hot air that intensifies its heating and by adiabatic compression (1°C / 100 m) so that the thermal differences exposed slope - slope sheltered by advection) to which is added the lack of precipitation on the slope exposed to the dominant western circulation, lead to *the theory of hydraulic föehn.*

The persistence of warm, western air flows, corroborated with previous synoptic situations, which favored the stagnation of cold air in the Siret corridor, reinforces the conclusion of the development of the mechanism that favors large-scale hydraulic föehn in the eastern Eastern Carpathians, both in the Moldavian and Subcarpathians of Curvature.

Sfîcă et al. proposes an individualization of the föehn in two typologies: a *main föehn* specific to the sub-Carpathian territories and a *secondary föehn* specific to the hilly territories, located at appreciable distances from the Carpathian mountain range. The dominance of wine-growing lands in the Cotnari area is also a consequence of the föehnale phenomena produced there. The vines rise to high altitudes avoiding the lower level, where föehn is less intense and temperature inversions generate low temperatures and frequent frosts in the cold season.

Against the background of the intensification of fönehnization phenomena, Ichim (2014) highlights on the eastern slopes of Dealul Mare-Hârlău, values of air temperature higher in winter by 2°C, similar to the urban areas of Iași. Correlating the air temperature with the altitude of the stations, the author mentions *the thermal anomalies* at Tudora-Deleni-Cotnari, attributed to the air conditioning, throughout the year, with the maximums in the morning.

Buruiană (2015) and Sfîcă (2015) in their doctoral dissertations, present tangentially the observation area of the föehnal circulation and identify favorable conditions for the production of föehnal processes on the Siret Corridor, especially on the eastern slopes of Pietricica Peak and Piedmont Hills. Against the background of the western circulation, east of the axis of the Eastern Carpathians, wave clouds develop, the air temperature increases and the relative humidity decreases - indications for the production of föehnization. The concentration of vine areas at altitudes of 250-350 m on the eastern slopes of Pietricica Peak, similar to Cotnariului Peak, are interpreted as a footprint in the landscape of the intensity of air conditioning processes (Sfîcă, 2015).

Table 1 Synthesis of research on the föehn in Romania and Cotnari subregion.

The year	Author (s)	The studied region of Romania	The ideas and conclusions of the study in question
1951	Stoenescu Șt.	Carpathian Mountains - Bucegi Mountains	The general and local winds from the Bucegi Mountains, *the föehn effect* and *the cascading winds* from the bottom of the mountain that affect the forests by cutting down the trees were analyzed.
1960	Gugiuman I., Pleşca Gh., Erhan E.,	Eastern Romania	They individualized the climatic subregion of the Dorohoi-Cotnari-Iaşi hillside characterized by obvious *föehnal manifestations* of the west-northwest winds

	Stănescu I.		between Dorohoi-Târgu Frumos and of the south-southeast winds on the coastal region Tg. Frumos-Iaşi.
1963	Baroncea E.	Eastern Carpathians	*The föehn is a violent and destructive wind* for the mountain forests in the northern part of the Eastern Carpathians (Călimani Mountains).
1976	Macarov P.	The Giurgeu and Ciuc mountain depressions	*The föehn* and thermal inversions *decrease the precipitation amounts* in the area of Harghita and Covasna counties.
1976 **1984**	Tilinca Z., Fărcaş I., Mihăilescu M.	East and northeast of the Apuseni Mountains	The synoptic conditions and the importance of frontal activity in the production of aerial offspring (76.6 % of cases) and the possibility of *identifying föehn* with the meteorological radar were analyzed. The föehn is credited with the qualities of a *pseudoföehn.* The air is heated on the sheltered slope, by adiabatic compression and the contribution of the dry adiabatic gradient of 1°C / 100 m.
1979	Teodoreanu E.	Banat Plain and Hills	*The local föehn* does not have a high intensity, duration and frequency (1-5 % of the air dynamics) and does not constitute a medical motivation for the spa treatment in Buziaş resort.
1982 **1986**	Stăncescu I., Damian D., Şerbu C.	Bordering areas of the Southern Carpathians	*The föehnal manifestations* are a characteristic of the submontane areas both south of the Southern Carpathians and north of them. *The Great Wind* is individualized in the area of the Făgăraş Depression.
1979 **1980** **1988** **2008**	Ion-Bordei N.	Carpathians and Subcarpathians of Curvature	*The föehn mechanism includes:* -the formation of a *depression of dynamic cavitation* on the leeward slope; -highlighting *the counter-föehn, air current opposite the föehn, formed at the base of the sheltered slope, which intensifies the processes of erosion and deflation;* -at a distance from the orographic obstacle, *wave clouds and island precipitation form* (in the Bărăgan Plain, in North Dobrogea and in the south of the Moldavian Plateau); The Carpathian arc and the dynamics of the atmosphere favor *the major föehn*, in contrast to *the minor föehn,* felt in the south-east, east-south-east circulation over the Curvature Carpathians, on the western and north-western slopes.
1990	Bogdan O., Mihai-Niculescu E.	Eastern areas of the Carpathian Mountains (Apuseni Mountains, Eastern Carpathians and Southern Carpathians)	The dominant type of föehn on the eastern slopes of the Carpathian Mountains, territories opposite to the dominant air circulation, is the *classic thermodynamic föehn.* *The classic submountain föehn* is characterized by: -increasing the air temperature by 1-2°C; -reducing the relative humidity of the air by 25 %; -decreasing the air pressure by 1-10 hPa; -reducing the cloudiness; -increasing wind speed (up to 8-10 m/s); -topoclimat specifically gentle.

1993	Bogdan O.	Curvature Subcarpathians (Pătârlagele)	Highlights the areas with föehn in Romania and develops a *conceptual model of föehn production* that includes: -the conditions necessary for the genesis of the föehn, -thermodynamic mechanism, -topoclimatic consequences.
1998	Ciobanu M.	Study of the effect of föehn	*The föehn* is explained by the chemical composition of the atmosphere and its properties . *High density of dry air (water vapor is lighter than nitrogen), causes rapid descent of air on the sheltered slope*. As the air descends, the process of adiabatic compression accelerates the heating of the air and leads to *the formation of the föehn*.
2005	Isaia I.	The föehn and the Coandă Effect	*The föehn* is scientifically analyzed using landmarks in the field of aeronautics and atmospheric physics, namely *the Coandă effect.*
2011	Dima V.	Eastern Eastern Carpathians	Knowing the particularities of the *föehn is important because it influences all the parameters of the meteorological forecasts:* wind direction and speed, air pressure, temperature and relative humidity.
2014	Irimescu A.	Northern Oltenia	The highest frequency of föehn is recorded in *winter* and *spring,* differentiated locally according to the type of circulation. *The synoptic situation* that determines the production of föehn is given by the presence of an anticyclonic belt oriented west-east over Central Europe and the Mediterranean cyclones extended in Eastern Europe.
2014	Paudi G., Moldovan Fl., Vigh M.	East of the Apuseni Mountains	Emphasizes the synoptic context and föehn incidence on the western slopes of the Apuseni Mountains.
2016	Tudose T. Moldovan Fl.	Northeast of the Apuseni Mountains	Western circulation in the context of post-frontal advection with warm air, air temperature increases simultaneously with wind intensification and reduction of air humidity (Huedin Depression, Alba-Iulia Corridor).
		Cotnari	
2004	Erhan E.	Eastern Romania	Föehnization is favored by *the relief configuration*, the *degree of insolation* of *the slopes oriented south-south east-east* and *the anticyclonic regime with clear weather*. Föehnization occurs at any time of the year, especially in *spring* and *summer.*
2014	Sfîcă L.	Vineyard Cotnari	*The hydraulic föehn, also called dry föehn, is characteristic of the Cotnari area (20% of obs.) Lack of precipitation on the western slope of Dealul Mare-Hârlău*. Individualization of two types of föehn: *the main föehn* specific to the submontane area and *the secondary föehn* for hilly areas.
2020	Apopei L. M. Mihăilă D. Bistricean P.I.	Cotnari region	*The föehn at Cotnari there is a local wind with meteorological consequences that cannot be reduced to a minimum*. The consequences of the föehn start from Humosu and fade towards the Jijia-Prut valleys,

			but are stronger at the alignment of Cotnari, Cucuteni, Deleni, Belcești.

In the article *Thermo-hydrometric arguments in the demonstration of föehnal circulation in Cotnari, Romania,* presented in Ohrid, during the International Conference Geobalcanica, Apopei et al. (2020), highlighted the area in the east of Cuesta Cotnarilor, with the greatest thermo-hygrometric impact, on the alignment of Cucuteni, Cotnari, Deleni and Belceşti localities. In the 8 months of research, March-October 2019, the thermal advance was 1.3 - 1.5 °C, the water deficit of 8-9 % and the duration of the föehn covered 4.5 % of the monitored time. The case study from 11.10.2019, the time interval 00: 30: 000-14: 30: 00, with föehnal manifestations, led to the increase of the air temperature by over 3.5°C and the decrease of the relative humidity due to the föehn of 19 %. The western circulation dominated the air dynamics, with an average percentage of 58 %. This circulation, in accordance with the NNV-SSE arrangement of the relief, favors the föehnization of the air in the eastern sector of the study area and argues that the föehn at Cotnari is a local wind with meteorological consequences that cannot be minimized.

5. Conclusion

Despite the large area of manifestation (from cold climatic subzones to the warm zone), but also the local character of production, the multitude of hypotheses and theories of formation, the complex and correct analysis of the mechanism of föehn formation depends on the researcher's knowledge, methods and the means used and the capacity to manage the background of satellite data and images necessary to argue the research.

For the climatic subregion Cotnari, the föehn is mentioned by Erhan (2004) who emphasizes that not any thermal increase in the subregion is the consequence of föehnization and that a major contribution to local warming on the leeward slope induces its behavior in relation to radiative processes during an average year. Sfîcă (2014) justifies the hydraulic theory of the föehn by the advection of the warm air from the west in altitude, over the cold air from the Siret Corridor. The author distinguishes a main föehn specific to the sub-Carpathian territories and a secondary föehn specific to the areas of hilly territories located at a great distance from the mountain range.

The föehnal circulation from Cotnari is a meteorological reality demonstrated by statistical, cartographic and graphical analyzes. Apopei (2020) first confirms that the föehn brings significant changes in the evolution of the values eed to know and clarify the main controversies and ambiguities that still persist in the scientific world related to the production of föehn, so that later, to be able to undertake a good quality monitoring of the meteorological elements of interest, in order to be able to identify the most representative sources of information that will be useful in defining and analyzing the spatio-temporal parameters of the phenomenon in the Cotnari area. The results of the study, in addition to certain purely scientific clarifications, can also contribute to the adoption of the most efficient management measures and the long-term use of natural resources provided by the local geographical area.

Acknowledgements

This work is supported by project POCU 125040, entitled "Development of the tertiary university education to support the economic growth - PROGRESSIO", co-financed by the European Social Fund under the Human Capital Operational Program 2014-2020.

References

Atkinson B.W., 1981, Meso-scale atmospheric circulation, Academic Press, Londra, 494

Baroncea E., 1963, Două cazuri de foehn în Carpaţii Orientali. Rev. Pădurilor nr. 2, pag. 29-35

Băcăuanu V., Barbu N., Pantazică M., Ungureanu Al., Chiriac D., 1980. Podişul Moldovei. Natură, om, economie, Edit. Ştiinţifică şi Enciclopedică, Bucureşti

Beffrey G., Jaubert G. and Dabas A., 2004. Föhnflow and stable air mass in the Rhine valley: the beginningof a MAP Event.Q. J. R. Meteorol. Soc.130, 541–560

Billwiller, R., 1899: Über verschiedene Entstehungsarten und Erscheinungsformen des Föhns. Meteorol. Z., 16, 204–215

Billwiller R. 1904: Der Bergeller Nordföhn. Ann. Schweiz. Meteor. Centralanst., Jahrg. 1902, 56 pp.Bogdan O., Niculescu E., 1986. Particularităţile climatice specifice generate de curbura internă carpato-balcanică ale regiunilor limitrofe româneşti, Terra, XVIII, 2, Bucureşti, 43-48

Bogdan O., Mihai-Niculescu E. 1990. Un caz tipic de foehn în România, Studii şi cercetări de geografie, t.XXXVII, Bucureşti, 95-103

Bogdan O., 1993. Foehnul carpatic, Analele Univ. din Oradea, III, 58-63

Bordei-Ion N., 1979. Foehnul Carpaţilor de Curbură şi distribuţia precipitaţiilor în Bărăgan, Studii şi Cercet.Meteo. 1, IMH, Bucureşti

Bordei-Ion N., 1980. Influenţa Curburii Carpaţilor asupra circulaţiei atmosferice, Teză de doctorat, Institutul de Geografie, Bucureşti

Bordei-Ion N., 1988, 2008. Fenomene meteoclimatice induse de configuraţia Carpaţilor în România, Edit. Academiei R.S.R. , Bucureşti

Brinkmann W.A.R., 1970. The chinook of Calgary (Canada). Arch. für Met., Geoph.und Bioklim., Serie B, 18, 269 -278

Brinkmann W.A.R., 1971. Wat is a foehn?, Royal Meteorological Society, vol. 26, Institule of Arctic and Alpin Rechearch University of Colorado, 230-240

Bucur N., Barbu N., 1954. Complexul de condiţii fizico-geografice din coasta Dealul Mare-Hârlău, în „Probl. de geografie”, I, Bucureşti

Buruiană D., 2015. Atmospheric precipitations, water discchange and inundations in the Moldavian Plain, teza de doctorat, Universitatea ,,Al.I. Cuza”, Iaşi

Călinescu R., Stoenescu Şt.M., Bunescu Al. 1966. Enclava de elemente mediteraneene din Subcarpaţii de Curbură, SGGGG-Geogr., XIII, 1

Ciobanu M., 1998. Studiul efectului de foehn. Aplicaţii în România, teza de doctorat, Facultatea de Fizică, Univ. Bucureşti, 92

Ciulache St., 1987. Vânturile locale, Terrra, XIX, 2, Bucureşti

Cotea V.D., Ciubotaru M., Barbu N.N.,Cotea V.V., Magazin G.P., Grigorescu C.C., 2006. Podgoria Cotnari, Edit. Academiei Române, Bucureşti

Dima V., 2014. Foehn over the Eastern Carpathians, characterised by a western circulation of anticyclonic shade. Case study, 4–6 february, 2011. Rev.Roum.Geogr.,58 (1), 17-27,2014, Bucureşti http://www.rjgeo.ro/atasuri/RR%20Geographie%2058_1/Dima.pdf

Durran D. R., 1990. Mountain waves and downslope winds. Atmospheric Processes over Complex Terrain, Meteor. Monogr. / 45, American Meteorolgical Society, 59-81

Erhan E., 1983. Fenomenul de secetă în Podişul Moldovei, An. Şt, ale Univ.,,Al. I. Cuza”, t XIX, Iaşi.

Erhan E., 1986. Fenomenul de grindin în Podişul Moldovei, An Şt. ale Univ.,,Al. I. Cuza”, Seria B-Gelogie-Geografie, t XXXII, Iaşi

Erhan E. 1990. Particularităţile meteorologice ale anilor 1989-1990 în România, Lucrările Seminarului D. Cantemir / 10, Iaşi, 145-154

Erhan E. 2004. Aspecte ale foehnizării aerului în estul României, Lucrările Seminarului “D. Cantemir”, 23-24, Univ. “Al. I. Cuza”, Iaşi

Ficker H., 1910. Innsbrucker Föhnstudien IV. Weitere Beiträge zur Dynamik des Föhns. Denkschr.Kaiserl. Akad. Wiss., math.-nat.wiss. Kl., 85., 113–173

Ficker H., 1931. Warum steigt der Föhn in die Täler herab? Meteor. Z.,66, 227-229

Flamant C., Drobinski P., Nance L., Banta R., Darby L., Dusek J., Hardesty M., Pelon J. and Richard E2002. Gap flow in an Alpine valley during a shallow south föhn event: Observations, numerical simulations and hydraulic analogue. Quart. J. Roy. Meteor. Soc.128,1173-1210

Flamant C., Drobinski P., Protat A., Benech B., Chimani B., Frioud M., Furger M., Haberli C., Jaubert G., Lothon M., Mitev V., Richner H., Steinacker R., Tschannett S. and Vogt S., 2003. F˙ohn/cold-pool interactions in the Rhine valley during IOP15 of the MAP SOP'. In extended abstracts of theI CAM/MAP2003 conference, Brig, Switzerland

Gaffin D. M., 2009. On High Winds and Foehn Warming associated with Mountain-Wave Events in the Western Foothills of the Southern Appalachian Mountains, Weather and Forecasting, American Meteorological Society, Vol. 24

Gölm A., Mayr G. J., 2006. Hydraulic aspects of foehn winds in an Alpin Valley, Quarterly Journal of the Royal Meteorological Society. University of Innsbruck, Austria

Gugiuman I., Pleşca Gh.,Erhan E., Stănescu I., 1960. Unităţi şi subunităţi climatice din partea de est a R.P.R. An şt. ale Univ. „Al. I. Cuza", Iaşi

Gugiunan I., Davidescu D., 1961. Clima şi microclimatele podgoriei Cotnari, An şt. ale Univ. „Al. I. Cuza",sectiunea II, tom.VI, fascicolul 4, Iaşi

Hann von Julius, 1860. Zur Frage über den Ursprung des Föhn. Zeitschrift der Österreichischen Gesellschaft für Meteorologie 1, 257–263

Hann von Julius, 1868. Der Scirocco der Südalpen. Zeitschrift der Österreichischen Gesellschaft für Meteorologie 3, 561–574

Hann von Julius, 1880. Der Föhn in den Österreichischen Alpen. Zeitschrift der Österreichischen Gesellschaft für Meteorologie 2, 433–445

Hoinka, K., 1984. Observation of a mountain-wave event over the Pyrenees. Tellus, 36, 369 - 384

Hoinka K., 1990. Untersuchung der alpinen Gebirgsüberströmung bei Südföhn. Forschungsbericht DLR-FB 90-30, DLR Oberpfaffenhofen, Germany, 186

Hoinka K., Clar T., 1991. Pressure drag and momentum fluxes due to the Alps: Comparison between numerical simulation and observation. Quart. J. Roy. Meteor. Soc., 117, 495 - 525

Ichim P., 2014. Studiul inversiunilor termice în aria dintre Prut şi Siret, teza de doctorat, Univ."Al.I. Cuza", Iaşi

Irimescu A., 2014. Foehnul din nordul Olteniei. Geneză şi caracteristici, Edit. Academiei Române, Bucureşti

Isaia Ion, 2005. Foehnul şi efectul Coandă, Teză de doctorat, Facultatea de Fizică, Universitatea Bucureşti

Kishcha P., Pinker T. R., Gertman I., Starobinets B., Alpert P., 2018. Observations of positive sea surface temperature trends in the steadily schrinking Dead Sea, Nat. Hazards Earth Syst. Sci. 18.3007-3018

Klemp J.B., Lilly D. K., 1978. The effects of terrain shape on nonlinear hydrostatic mountain waves. J. Fluid Mech., 95, 241-261

Klemp J.B., Durran D.R., 1983. An upper boundary condition permittinginternal gravity wave radiation in numerical mesoscale models. Mon. Wea.Rev.,111., 430–444

Kusaka H., Kimura F., Hirakuchi H., Muzutori M., 2000. The efects of landuse alteration on the sea breeze and daytime heat island in the Tokyo metropolitan area. J. Meteorol.Soc. Japan 78, 405-420

Li X., Xiangao X., Wang L., Zhao K., 2015. The role of foehn in the formation of heary air pollution events in Urumqi, China: Impact of Sandwich Foehn on Air Quality, Journal of Geophisical Reserch Atmospheres, Univ. Innsbruck, Austria

Macarov P. 1976., Reducerea cantităţilor şi a numărului de zile cu precipitaţii atmosferice din zona depresionară Gheorghieni-Ciuc, efecte ale proceselor föhnale si ale inversiunilor termice, St. cerc., Meteorologie, IMH, Bucureşti, 525-531

Marcu Gh. 1969., Cauzele doborâturilor produse de vânt în anii 1964-1966 în pădurile ţării noastre. Revista pădurilor, 1, anul 84, 23-27

Mayr G.J., Vergeiner J. and Gohm A., 2002. An automobile platform for the measurement of foehn and gap flows., J. Atmos. Oceanic Technol., 19, 1545–1556

Mayr G.J., Armi L., S. Arnold R.M., Banta L.S., Darby D.R., Durran C., Flamant S., Gaberšek A., Gohm R., Mayr S., Mobbs L.B., Nance I., Vergeiner J., Vergeiner and Whiteman C.D., 2004. Gap flow measurements during the Mesoscale Alpine Programme. Meteorol. Atmos. Phys., 86, 99 - 119

Mihăilă D., 2006. Câmpia Moldovei-studiu climatic, Edit. Univ. "Ştefan cel Mare", Suceava

Miltenberger A.K., Pfahl S., Wernli H., 2013. An online trajectory module for the nonhydrostatic numerical weather prediction model COSMO. Geosci. Model Dev., 6, 1989-2004

Pantazică M., 1974. Hidrografia Cîmpiei Moldovei, Editura Junimea, Iaşi

Paudi G., Moldovanun Fl., Vigh M., 2014. The influence of foehn processes on river flows eastern Apuseni Montains, 3rdInternational Conferince-Water resources and wetlands, Tulcea, 113-119

Pop C., 1983. Procesele foehnale-virtuală resursă economică, Hidrotehnica, 28-11, Bucureşti, 321-322,

Raphael M.N., 2003. The Santa Ana winds of California. Earth Interactions, 7

Seibert P., 1988. Föhnprognose in Innsbruck. Wetteru. Meteorol. Atmos. Phys. 40, 31-42

Seibert P., 1990. South foehn studies since the ALPEX experiment. Meteorol.Atmos. Phys. 43, 91–103

Seibert P., 2000. Hann's Thermodynamic Foehn Theory and its Presentation in Meteorological, Institute of Meteorology, University of Natural Resources, Vienna

Seibert P., 2012. The riddles of foeh-introduction to the historic articles by Hann and Ficker, Met. Zet., vol 21/6, 607-614

Seluchi M.E., Norte Frederico A., 2003. Analysis of Theree Situationos of the Foehn Effect over the Andes (Zonda Wind) Using the Eta-CPTEC Regional Model, American Meteorological Society, Weather and forecasting, vol. 18, 481-501

Sfîcă L., 2015. Clima culoarului Siretului şi a regiunilor limitrofe, Ed. Univ. "Al. I. Cuza", Iaşi

Sfîcă L., Ichim P., Patriche C.V., Irimia L., Oană L., 2014. Cotnari vineyard - a gift of hydraulic foehn?, Lucrări ştiinţifice vol.57, Seria Agronomie, Iaşi

Sharples J.J., Milles G.A., McRae R.H.D. and Weber R.O. 2010. Foehn-like winds and elevated fire danger conditions in southeastern Australia. J. Appl. Meteor. Climatol., 49, 1067-1095, doi:10.1175/2010JAMC2219.1

Stăncescu D. D., Şerbu C., 1982. Modificări în evoluţia unor parametri meteorologici determinate de efectul de foehn produs de circulaţia aerului în zonele limitrofe Carpaţilor Meridionali, Hidrotehnica, nr.4, 105-107

Steinacker R., 1983. Fallstudie eines Süd- und eines Nordföhns über den Alpen, OSTIV Paderborn, Aero Revue 8/83, 41-44

Steinacker R., 2006. The Map Sop Man. MAP Newsletter, 12, 2-3

Stenhoff F.D., Bromwich H.D., MonaghanA., 2013. Dynamics of the Foehn Mecanism in the McMurdo Dry Valleysof Antarctica from PolarWRF, J. Roy. Meteor. Soc. 139 : 1615-1631

Stoenescu Ș. M., 1951. Clima Bucegilor, Edit. Tehnică , Bucureşti, 222

Teodoreanu E., 1979. Date preliminarii asupra foehnului de la Buziaş, Lucrările Staţiunii de cercetări biologice geologice și geografice Stejarul, nr. 7, Piatra Neamţ, 311-316

Tilinca Z., Fărcaş I., Mihăilescu M., 1976. Contribuţii la studiul sinoptic al föhnului în Munţii Apuseni, Studii şi Cercetări Meteorologice vol.I/2, I.M.H., Bucureşti, 567-584

Tilinca Z., Moldovan Fl., 1984. The study of foehn in the Apuseni Montains using meteorological radar, I.M.H.,Bucureşti, 135-137

Tudose T., Moldovan Fl., 2016. A special foehn case in nord-eastern Apuseni Montains, Aerul şi Apa- tea D., Rogojanu I., 1965. Unele caracteristici microclimatice in zona podgoriei Cotnari, Culegere de lucrări Inst. Meteor., Bucureşti

Vergeiner J., 2004. An objective foehn clsification scheme general concept an applications to the Wipp Valley. Univ. Innsbruck

Vergeiner J., 2004. South foehn studies and a new foehn classification scheme in the Wipp and Inn valley, Central Institute for Meteorology and Geodynamisc, Univ. Innsbruck, Austria

Xun Z., Bromwich D.P., Montenegro A., Wang S.H., 2018. West Atarctic surface melt event of January 2018 facilitated by fohn warming, J. Roy. Meteor. Soc., http://doi.org/10.1002qj.3460

***http://www.map.meteoswiss.ch (page- Meteorological Alpin Programm)

***https://www.limnology.ro/wrw2016/proceedings/14_Gavril_Pandi.pdf

***http://www.map.ethz.ch/icam2003/418.pdf