

Correlation between precipitation and orography - key element of the Spatial Decision Support System for Prevention and Management of Floods in the Firiza Basin (Northwest Romanian Carpathians)

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Abstract

Research on the influence of relief on precipitation has been identified in many studies conducted locally, regionally or globally. However, the research on the area analyzed in the present paper is comparatively lacking. The surrounding mountain area we refer to is represented by the Someș and the Tisa watersheds. The present study focuses on analyzing the influence of the relief, i.e. of the altitude, slope orientation relative to the position of the Sun and the movement of air mass as a factor on precipitation and rainfall gradient. For that, datasets of daily precipitation recorded at 62 rainfall stations were used, as follows: 36 rainfall stations in Maramureș County, 19 rainfall stations in Satu Mare County, and 7 rainfall stations in Bistrița-Năsăud County. Precipitation data from rainfall stations located in the neighborhood of the study area were used in order to determine the influence of relief on frontal precipitation. The second purpose of the research was to determine if there is a correlation between precipitation and altitude. To this end, ArcGIS and Microsoft Office software were used. The results seem to confirm the major influence of the relief over the dynamic convection imposed to the air masses on ascending slopes, various average vertical precipitation gradients and differentiated distribution of rainfall. The present analysis and its results will highly contribute as an input element in a Spatial Decision Support System for Prevention and Management of Floods in Firiza Basin (North-Western Carpathians).

Keywords: *relief, rainfall, depression, climate, altitude, SDS System*

Rezumat. Corelația dintre precipitații și orografie - element cheie al Sistemului Spațial de Suport Decizional pentru Prevenirea și Managementul Inundațiilor în Bazinul Firiza (Carpații de Nord-Vest ai României)

Cercetările privind influența reliefului asupra precipitațiilor sunt prezente în multe studii realizate la nivel local, regional sau global. Prin comparație, cercetările privind zona abordată în prezenta lucrare lipsesc. Arealul montan în studiu este reprezentat de bazinele hidrografice Someș și Tisa. Studiul este axat pe analiza influenței reliefului în funcție de altitudine, orientarea pantei în raport cu poziția Soarelui și mișcarea maselor de aer ca factor de influență al precipitațiilor. În analiză au fost utilizate seturi de date referitoare la precipitațiile zilnice înregistrate la 62 de posturi pluviometrice, astfel: 36 posturi din județul Maramureș, 19 posturi din județul Satu Mare și 7 posturi din județul Bistrița-Năsăud. Pentru a determina influența reliefului asupra precipitațiilor frontale au fost utilizate datele de la posturile situate în vecinătatea zonei de studiu. Al doilea obiectiv a fost de a determina dacă există o corelație între precipitații și altitudine. Pentru aceasta s-au folosit software ca ArcGIS și Microsoft Office. Rezultatele par să confirme influența majoră a reliefului asupra convecției dinamice impuse maselor de aer în mișcare ascendentă pe versanți, respectiv diverșii gradienti medii verticali ai precipitațiilor și distribuția diferențiată a precipitațiilor. Întreaga analiză va contribui semnificativ la Sistemul Spațial de Suport Decizional pentru Prevenirea și Managementul Inundațiilor în Bazinul Firiza (Carpații de NV).

Cuvinte-cheie: *relief, precipitații, depresiune, climă, altitudine, Sistem SDS*

Introduction

Flood risk management in watersheds, with tools such as spatial decision support systems, among others, requires spatial and temporal analysis of rainfall to properly represent hydrological processes.

For the mountain areas, topography and elevation affect rainfall and have to be considered for prediction and mapping (Sanchez-Moreno et al., 2014). The influence of elevation on the precipitation, particularly on rainfall, has been studied for decades, for different regions and with various results (Alter, 1919; Bleasdale and Chan, 1972; Lee, 1911; Sindosi et al., 2015). Most of the studies revealed that rainfall amount increases with elevation in a usually linear relationship as it is

connected to orographic updraft (Bleasdale and Chan, 1972; Henry, 1919; Hibbert, 1977; Llasat and Puigcerver, 1992; Weisse and Bois, 2001).

The linear relation is easy and represents an acceptable approximation between rainfall and elevation (Phillipset al., 1992), but for the North-Western Carpathians of Romania the relation is better described by nonlinear functions or it is not clear. However, additional factors influence the rainfall patterns, such as moisture sources or large circulation patterns over a region, which weakens the relationship between rainfall and elevation (Konrad, 1996). For certain areas, such as the Swiss Alps, it has been found that precipitation can decrease with elevation (Blumer, 1994), or elevation is of less

importance when compared to other variables such as exposure or relative distance between rainfall stations, as in Oahu Island (Cheng and Lau, 1970).

In mountain regions, where the nature of rainfall is influenced by orographic lifting, rainfall patterns are complex and not well understood (Prudhomme and Reed 1998). The influence of topography may express itself by changes in precipitation intensity, in the number of precipitation days or in a combination of both factors (Duckstein et al., 1973). For a better understanding and characterization, additional parameters should be considered in the predictions. For Western Colorado, Spreen (1947) found that elevation alone explains 30% of the seasonal variance of rainfall, while the combination of altitude, slope, exposure and orientation explained 88% (Sanchez-Moreno et al., 2014). Basist et al. (1994) found slope gradient, orientation, elevation and exposure as the best mean annual precipitation predictors for ten mountain regions all over the world (Sanchez-Moreno et al., 2014).

An important variable that influences the spatial distribution of rain in mountain regions is the prevailing wind direction (Sanchez-Moreno et al., 2014). Strong winds may redistribute the precipitation, facilitating larger amounts in the valleys and smaller ones on windward slopes (Sanchez-Moreno et al., 2014). The erratic and turbulent nature

of wind makes its characterization difficult (Sanchez-Moreno et al., 2014). The influence of wind can be indirectly described by the orientation and width of the valleys, parameters that can be considered in the analysis in form of additional topographic variables, such as aspect (Daly et al., 1994; Sevruk et al., 1998).

Mountain slopes facilitate the uplift of moisture that results in high rainfall intensities on the windward side of the mountains (Singhet al., 1995), where the rainfall stations tend to be placed. For practical reasons, in mountain areas rain gauges are usually located in valleys, thus biasing the information towards low areas (Prudhomme and Reed, 1998). The position of the rain gauges can be used to describe wind direction and allows a better understanding of the motion path of clouds. For Western Oregon and Washington, Schermerhorn (1967) found that an index for the latitude of the station, combined with terrain elevation and barrier elevation explains most of the variations of annual precipitation during the winter season. Buytaert et al. (2006) explained the monthly variability of rainfall in the Ecuadorian Andes in terms of slope, aspect, elevation and position of the stations.

The present research takes place in the Someș-Tisa Watersheds, NW Romania (the Firiza watershed), as part of the Spatial Decision Support System (SDSS) project (Fig. 1).

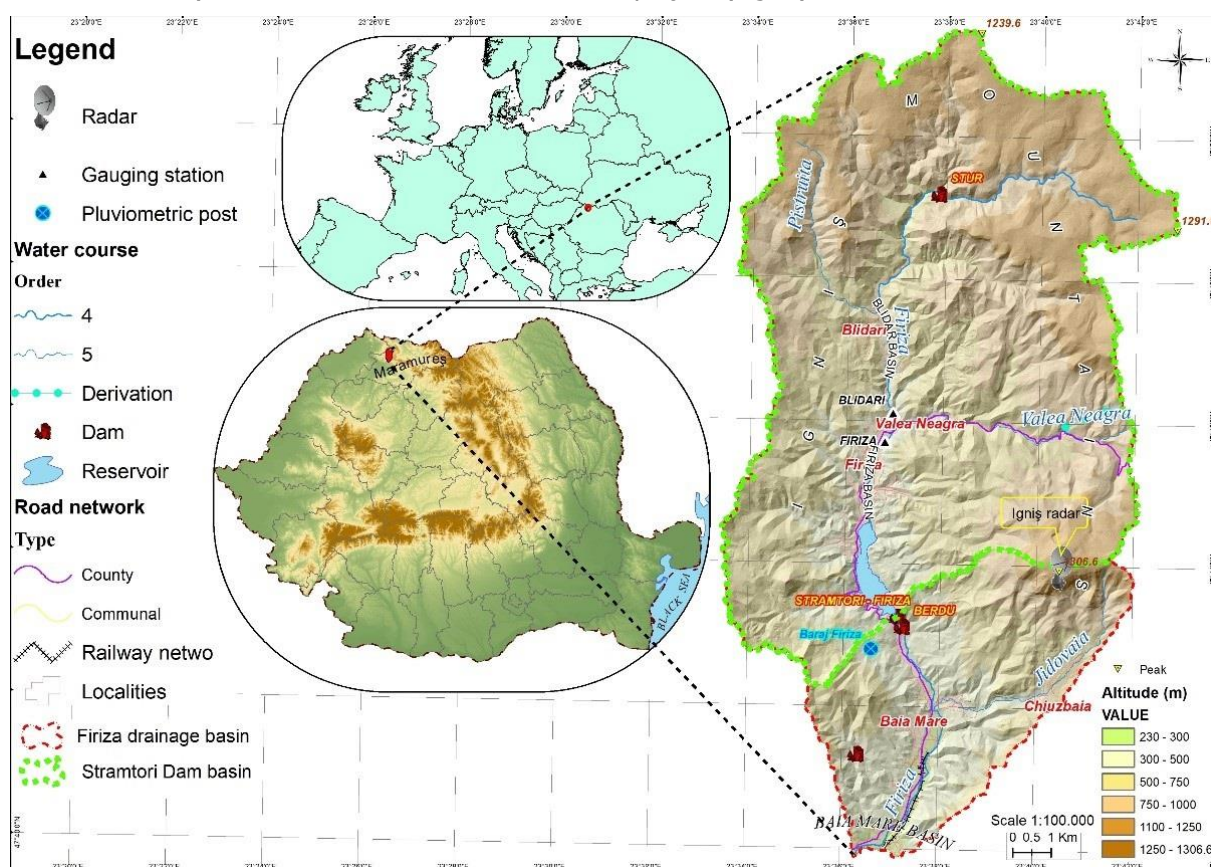


Fig. 1: Location of the Firiza river basin (altitude source: Topo Map RO & PPPDI-DTM, 2014)

The relief and elevation variations in the Firiza watershed and surrounding mountain areas suggest a strong influence of topography on rainfall variability (Sabău et al., 2020); however, this effect has hardly been studied (Bazac, 1983) and without taking into account additional topographic parameters or the position of the rain gauges. Long-term records of rainfall are available for the Firiza watershed and the surrounding mountain area. In this study, the rainfall has been analyzed from low to high temporal periods, to show how the aggregation of rainfall may have an effect in its correlation with topographic parameters.

Within the area, there are few weather stations with disposition that is not appropriate for a spatial analysis, so rainfall data recorded at weather stations and rainfall gauging stations in the complex and surrounding area were used. The reason for choosing this alternative was determined by the numerous rainfall stations within the monitoring system of the Water Administration of the Someș-Tisa Basin.

The book published in 1951 by St. M. Stoenescu - *The Climate of Bucegi* - represents the first Romanian study on mountain climatology and it was very important for the area under study. Its theoretical foundations are still relevant today, as per 1983, Gh. C. Bazac - *Influence of relief on the main features of Romanian climate*.

Between 1960 and 1980, specialists of the Institute of Meteorology and Hydrology have written a number of papers regarding the influence of relief on precipitation, some published and some in the form of manuscripts. The following years registered the publication of several doctoral dissertations on the problems of climatology, such as F. Moldovan – *The role of the Apuseni Mountains in differentiating climate in the north-western Romania. Study of dynamic climatology*, 1986. More recently, in 2008, the National Meteorological Administration published the work - *The climate of Romania*, for the 1961-2000 reference period.

The relief is the main factor influencing the distribution of climatic parameters in the studied area (Bâzâc, 1983), and high intensity precipitation events are frequent throughout the year (Bâzâc, 1983; Climate of Romania, 2008; Vlăduț and Onțel, 2014; Șerban, 2018).

Average annual amounts of precipitation are determined by the evolution of the atmospheric pressure systems, the dynamics of air masses and fronts. The highest amounts of precipitation are generated by cyclonic activity associated with the polar front in the Iceland area, mobile cyclones activity in the thalweg of the Icelandic depression reaching the Maramureș area as well.

The main objectives of this research are: (1) to determine the influence of daily events on the monthly and seasonal rainfall variability, (2) to investigate whether for the Firiza watershed spatial patterns of rainfall can be parameterized, supported

by terrain and location data, and (3) to determine the best strategy to map long-term mean seasonal rainfall in the Firiza using the limited data available.

Data and Methods

Study area

The Firiza river basin holds a special position within Romania (Fig. 1). This assertion no longer needs to be argued if we look at the median area in which it is located: in the northwest part of the country, the short distances from the northwestern border and the favorable exposure to the circulation of the ocean air masses originating in the Atlantic Ocean area, from which it receives a good part of the humidity. Against the background of these climatic-geographical interferences, the spatial development of the Carpathian chain appears as a polarizing element that gives an unmistakable individuality to the neighboring region, up to distances that exceed the limits of the Romanian territory.

Within the Someș-Tisa hydrographic area, the Firiza basin has a northern position and it extends between the latitudes of 47° 52' 00" and 47° 40' 00"; longitudinally, it is located in the north-western part of the Someș-Tisa hydrographic area, between 23° 33' 00" and 23° 43' 00" east longitude.

The features imprinted by the major relief of the Firiza basin over the climate are detached or partially deduced from various studies, but the dynamics of qualitative and quantitative variations in time and space of its various elements, the laws and mechanism that govern and generate as well as maintain them have not yet been deciphered and argued at the scale of current needs.

Given the development of a future SDSS for flood prevention and management, the morphology and position of the Firiza river basin have increasingly required the knowledge of the influence of relief on the variation of precipitation and the distribution of average rainfall.

The subject of the present paper was determined by the desire to know in detail the characteristics of the most important input parameter in the hydrological forecast model, because the quality of the forecast depends equally on the accuracy of input data and the hydrologist's skills (Sabău et al., 2020).

A useful hydrological forecast model for all seasons needs a lot of input data, but the precipitation monitoring network in northwestern Romania does not provide the necessary data for all parameters (Fig. 2). Therefore, we were compelled to investigate the influence of relief on precipitation, in order to determine the laws governing the variation and distribution of precipitation and all associated parameters.

A series of parameters of some climatic elements are treated for the entire Someș-Tisa hydrographic

space. However, due to the distribution of the weather stations necessary for a spatial analysis, most of the parameters were analyzed only for the northern part of the area.

The aim of the paper is to explain the mechanisms of atmospheric phenomena, to highlight and explain the laws according to which they take place when exposed to the influence of major relief. Another goal is to determine the proportion of this influence on the precipitation in the surrounding area.

This approach requires long and homogeneous data sets of observations only within the same sequence. The method allows relative values to be reached on the basis of different strings and intervals, valid for highlighting the legalities underlying the atmospheric processes. By similarity, these laws can be extended, generalized, for similar natural conditions.

The small number of stations located on mountain slopes with different orientations limits the possibilities of investigation based on comparative profiles.

In order to highlight or explain some specific characteristics of the precipitation in the studied area, data from the stations located in the areas with the most obvious manifestations of them were used. For example, the catabatic phenomena were studied on transversal profiles (over the Vlădeasa Massif), while in order to highlight their climatic weight, data from weather stations located in the representative areas were used (Vlădeasa 1400, Vlădeasa 1800, and Stâna de Vale for optimal rainfall).

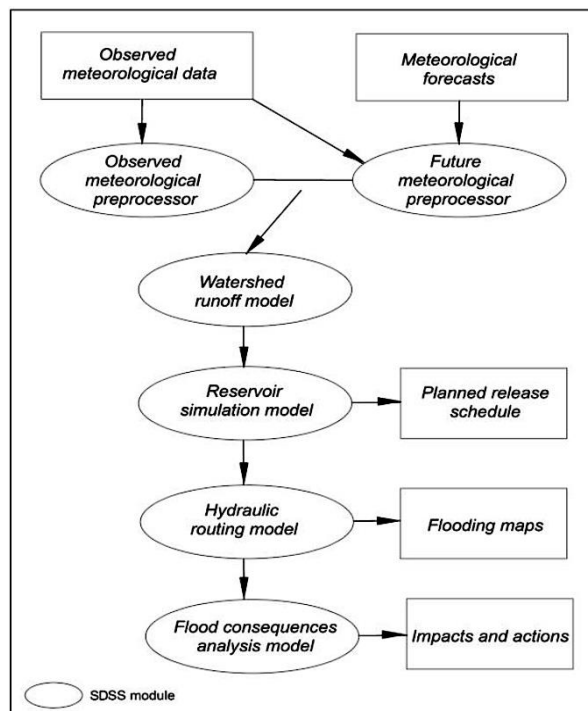


Fig. 2: General schema and components of a SDSS (after Sabău et al., 2020)

Data

Spatial distribution of weather stations within the studied area is not suitable for a spatial analysis (Fig. 3).

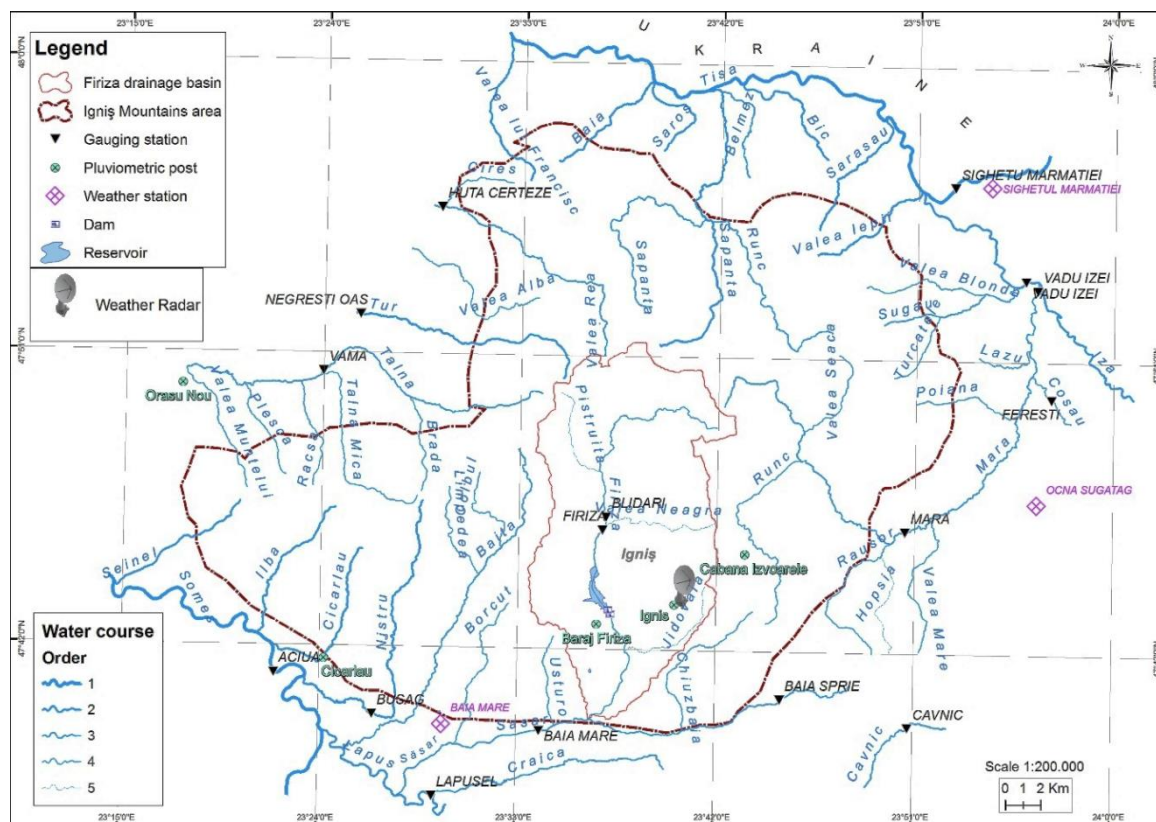


Fig. 3: Hydrometeorological monitoring network in the area under study

Therefore, we also used the precipitation data recorded at the rainfall stations and at the hydrometric stations within and the surrounding area. The authors chose this solution due to the higher density of the stations that measure precipitation and are included in the monitoring system of the Someș - Tisa Water Basin Administration.

Datasets of daily rainfall recorded at 62 rainfall stations were used, as follows: 36 rainfall stations in the Maramureș County, 19 rainfall stations in Satu Mare County, and 7 rainfall stations in Bistrița-Năsăud County. Rainfall stations are part of monitoring network of hydro-meteorological parameters within the Someș-Tisza basin. For the 1961 - 2000 reference period, statistical data from the *Climate of Romania* (2008) were also used.

To perform the analysis, data of numerical and cartographic type were used. The cartographic database contains synoptic maps at European scale, namely the Sea Level Pressure maps, as well as geopotential maps at different pressure altitudes in the troposphere.

For the case study, daily weather data from the European Climate Assessment & Dataset and rp5.ru websites were collected. For the relief analysis and creation of maps derived from the digital model of terrain, we applied the digital terrain model with a spatial resolution of 3 m × 3 m, generated with LiDAR technology within the PPPDI project (*Plan for the Prevention, Protection and Mitigation of Flood Effects*) a national project funded by AXA 5 POS Environment (*POS - Sectorial operational program*).

Methods

For the present paper, elements related to the rainfall characteristics were calculated based on statistical software (Microsoft Office, Statistical Package for the Social Sciences, HEC-SSP) and completed with data retrieved from synthesis and studies of the Someș-Tisa Regional Water Branch. Support for GIS modeling was made up of 1:5000 plans, 1:25.000 topographic maps, orthophotos and other satellite images; coordinates and GPS files from different sources (field trips and references); digital mapping and files conversion were achieved with specific software (GPS Utility, Global Mapper, ArcGIS 10. x).

To establish the atmospheric circulation for the case study, HYSPLIT model was used (Draxler et al., 2012). A simple air parcel 48-hour backward trajectory option was used in order to identify the direction of the influx and the origin of the air masses in the studied area. Based on weather maps provided by wetter.3de archive (Wetter3.de, 2017), temperature and geopotential at 500, 700, 850 hPa levels, moisture at 700 hPa level and Sea Level Pressure were analyzed.

Results and Discussion

The influence of the Carpathian mountain system on the air masses continentalization

The main features of the relief, such as altitude, extension and spatial arrangement in relation to the main directions of the air masses advection generate a decisive influence on the amount and type of precipitation. Thus, if the mountain ranges are oriented perpendicularly to the direction of the atmospheric fronts movement, they force the air masses to escalate, determining the intensification of the atmospheric processes. During these processes, a large part of the moisture load falls in the form of precipitation on exposed slopes.

In order to determine the rate of the relief influence on the continentalization processes and, therefore, on the rainfall potential of the air masses that transport moisture from the Atlantic Ocean over the northwest of Romania to the east, the precipitation data from a series of stations located along three profiles were used. The three profiles that cross the Someș-Tisa hydrographic area are: from west to east; from northwest to southeast, and from north to southwest. The first two profiles start from the western border of Romania, cross the mountain ranges of the Carpathians and reach the edge of the area. The third profile has a north-south orientation, which was extended in the Criș rivers basin to capture the exceptional mountain profile offered by the two stations located on the Vlădeasa Massif (Fig. 4).

The variation curve analysis of the three profiles shows, on one hand, the increases in precipitation on the western slopes of the Carpathians, exposed to the ocean air masses circulation, and on the other hand, the gradual decrease of their rainfall potential as they move eastward.

As a consequence of their westerly position, the Oaș-Igriș-Gutâi mountain range and the western branch of the Apuseni Mountains take priority of the moisture load of the ocean air masses, thus achieving important amount of precipitation. The mountains, located in the background (sheltered), reactivate atmospheric processes, but the rainfall potential of the ocean air is reduced by the mountain range over which they have already passed.

In order to analyze the relief influence on the precipitation, three profiles of the average annual amount of precipitation are presented in Fig. 5, 6 and 7.

Average annual amounts of precipitation are determined by the evolution of the atmospheric pressure systems, the dynamics of air masses and fronts. The highest amounts of precipitation are generated by cyclonic activity associated with the polar front in the Iceland area, mobile cyclones activity in the thalweg of the Icelandic depression reaching the Maramureș area as well.

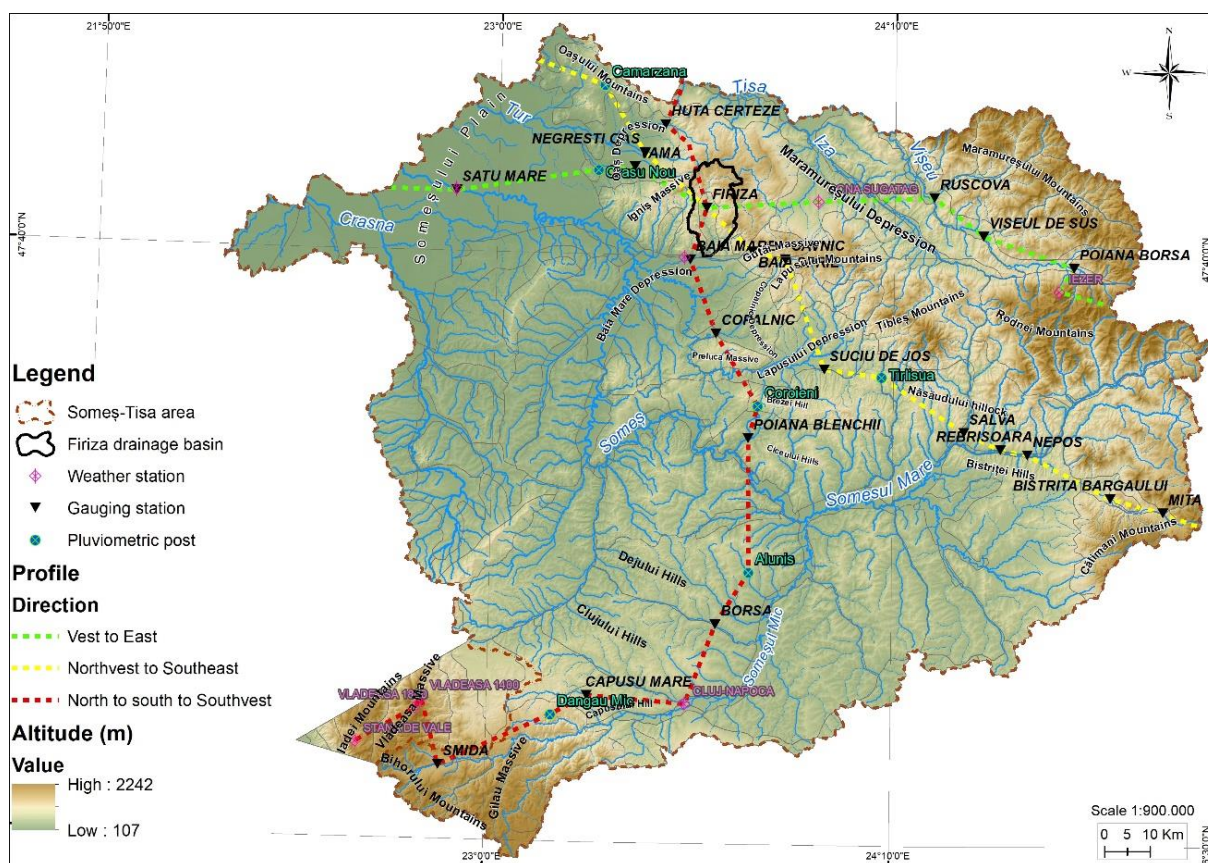


Fig. 4: The position of the three profiles that cross the Someș-Tisa hydrographic space

The climate, specificities, influences

The climate of the Firiza basin is of temperate continental-moderate type and it is subdivided into two areas: 1) mountain and 2) hills and plateau, with

a subtype of depression in the Baia-Mare Depression. The analyzed basin is characterized by the type of moderate continental temperate climate, with the specificity created by the mountainous floor of the middle and low mountains (800-1300 m altitude).

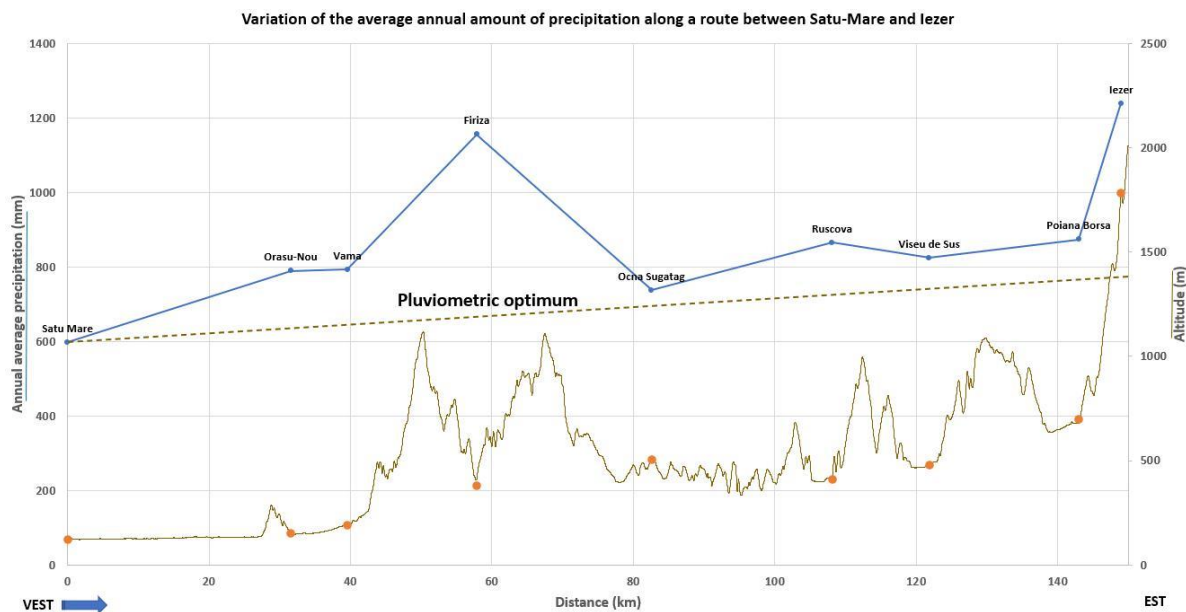


Fig. 5: The variation of the average annual amount of precipitation, along a V-E route

Raw data sources: "Someș-Tisa" Water Branch, Cluj

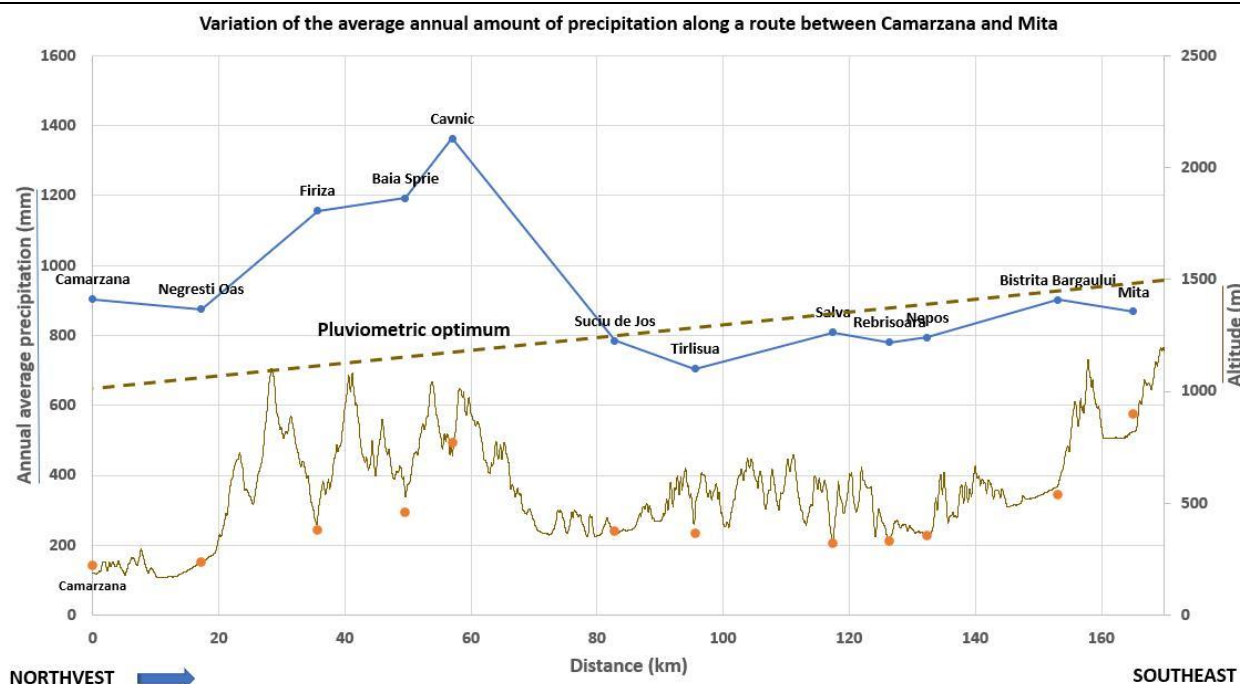


Fig. 6: The variation of the average annual amount of precipitation, along an NV-SE route

Raw data sources: "Someș-Tisa" Water Branch, Cluj

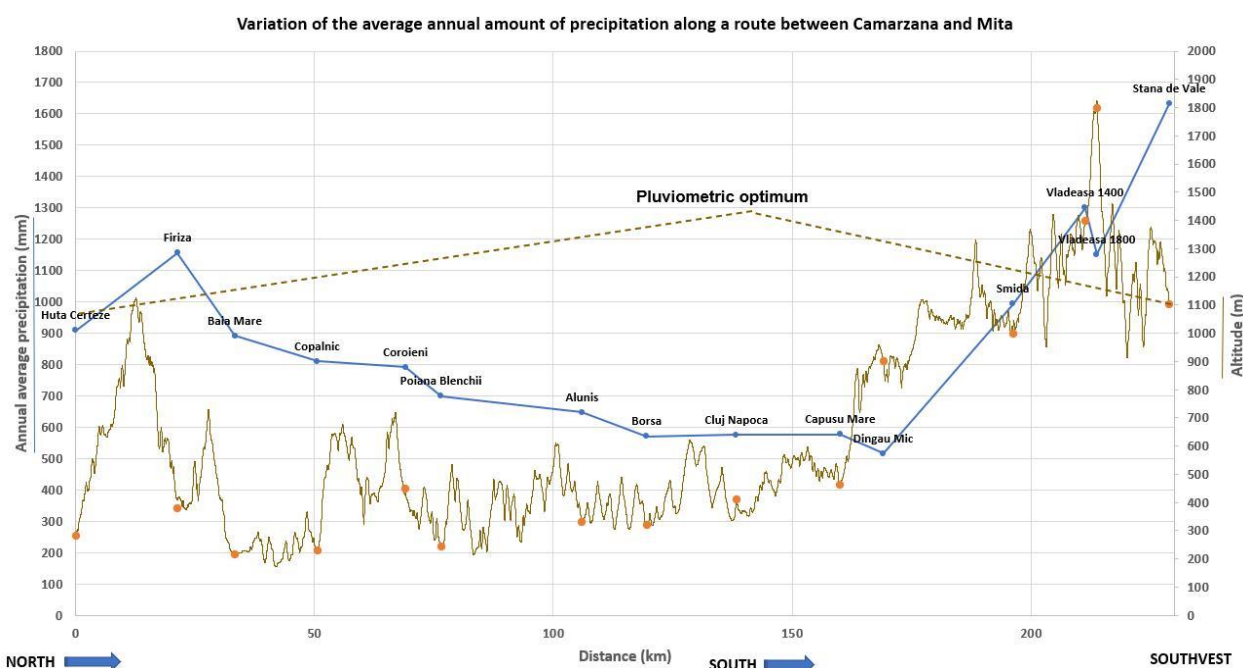


Fig. 7: The variation of the average annual amount of precipitation, along an N-S-SW route

Raw data sources: "Someș-Tisa" Water Branch, Cluj

The area is affected mostly by the western air circulation, with the predominance of maritime-polar or maritime-arctic air advections from the northwest in winter and the advection of the warm air from the southwest of Europe in summer. The values of the climatic parameters depend on the altitude (Fig. 8), the orientation of the slopes towards the general

circulation of the atmosphere, and their exposure (Fig. 9).

The Igniș Mountains represent an orographic barrier of the air masses movement from the west. This causes an uneven distribution of moisture, cloudiness and precipitation, the western slopes recording a higher humidity (of 2 to 4%) and rainfall (by 50 to 100 mm) at the same altitude.

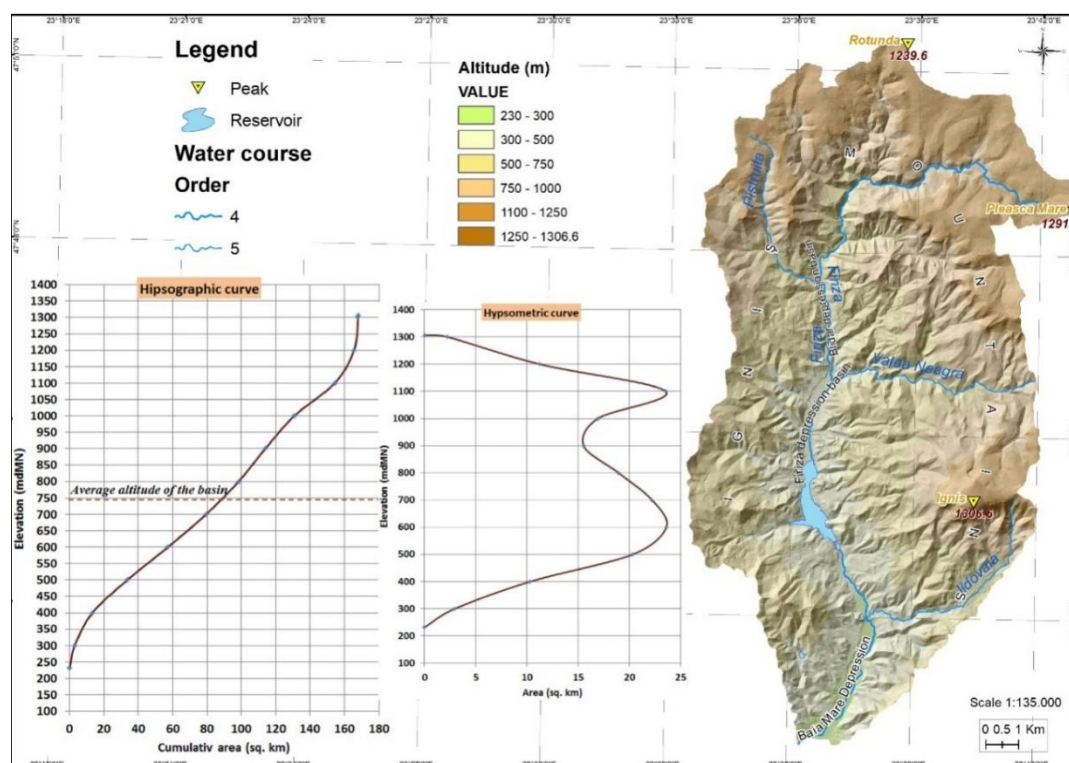


Fig. 8: Hypsometric map with characteristic curves

(altitude source: Topo Map RO & PPPDI-DTM, 2014)

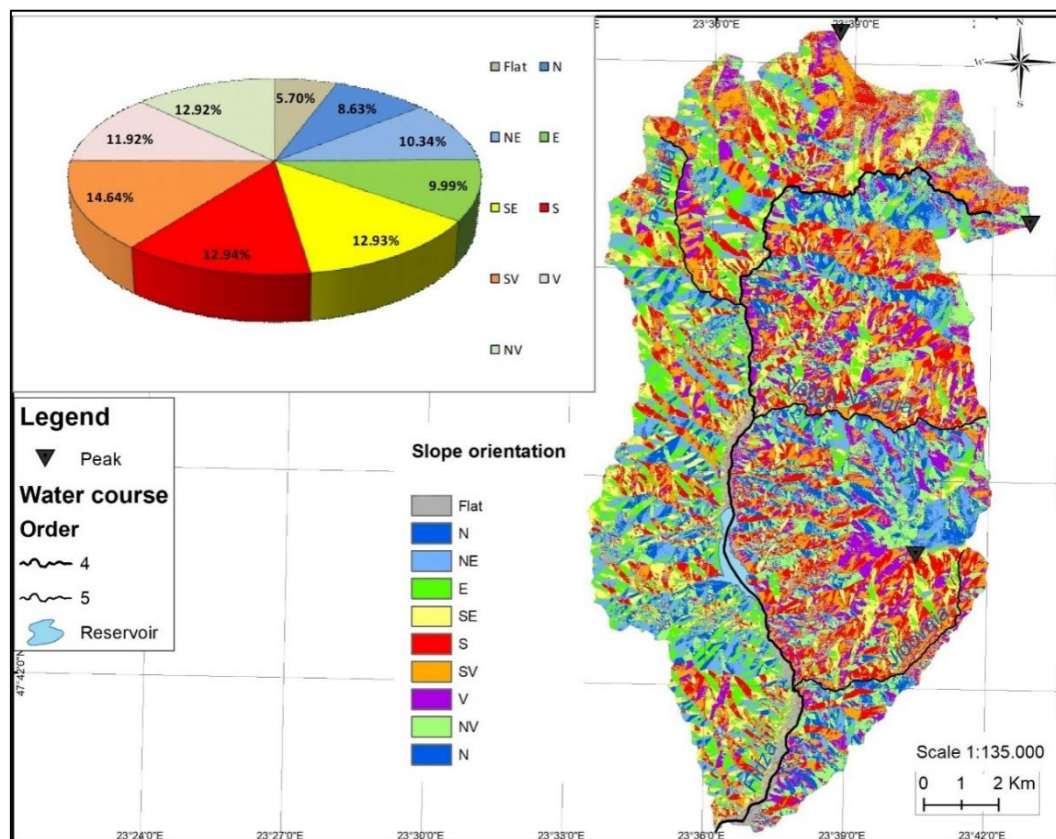


Fig. 9: Aspect (slope direction) map

Precipitation regime

The average annual precipitation is characterized by significant variations, caused especially by the relief configuration, by the exposure to the dominant atmospheric circulation (in the west) and by elevation. While the average annual value of

precipitation in the Baia-Mare Depression is situated at about 892 mm, in the high mountain areas, on the slopes exposed to the oceanic air masses; it reaches at about 1400 mm, (due to favorable exposure to dominant circulation, Fig. 10). For Baia Mare weather station, the monthly and annual average amount of precipitation have the following values (Table 1).

Table 1. Average monthly and annual rainfall (mm) at Baia Mare weather station

Station	J	F	M	A	M	J	J	A	S	O	N	D	Year
Baia Mare	65.7	52.4	50.3	63.1	84.2	103.5	92	77.8	63.5	58.1	72.3	90.1	872.9

Source: N.M.A – National Meteorological Administration

The average annual number of days with precipitation ≥ 0.1 mm is high, correlating with the annual quantities of rainfall. Yearly, the number of days with precipitation ≥ 0.1 mm is of 110-160 days in the lower hilly areas exposed to dominant western circulation, 120-140 days in the higher hilly areas, 150-200 days in the lower mountain regions and $150 \geq 170$ days at the highest altitudes. On average, at Baia Mare weather station, 156.5 days with rain per year are recorded (*Climate of Romania*, 2008).

Spatial distribution of average rainfall

The altitude correlated with the average amount of precipitation highlights the laws of spatial rainfall

distribution (Cocuț, 2008; Șerban et al., 2020). Air masses circulation is predominantly from NW to SE, which determines the peculiar spatial distribution of rainfall. The correlation between average multi-annual rainfall and altitude is shown in the Fig. 10.

Regarding the atmospheric precipitation, an increase with altitude to a certain height, known as the rainfall optimum is observed, followed by decrease. In the Someș-Tisa hydrographic area, the rainfall optimum is around 1100 m, so that within the Firiza basin, the amount of precipitation increases with altitude, up to the rainfall optimum.

For the study area five distinct exponential links are highlighted - each one corresponding to a different rainfall gradient (Fig. 10).

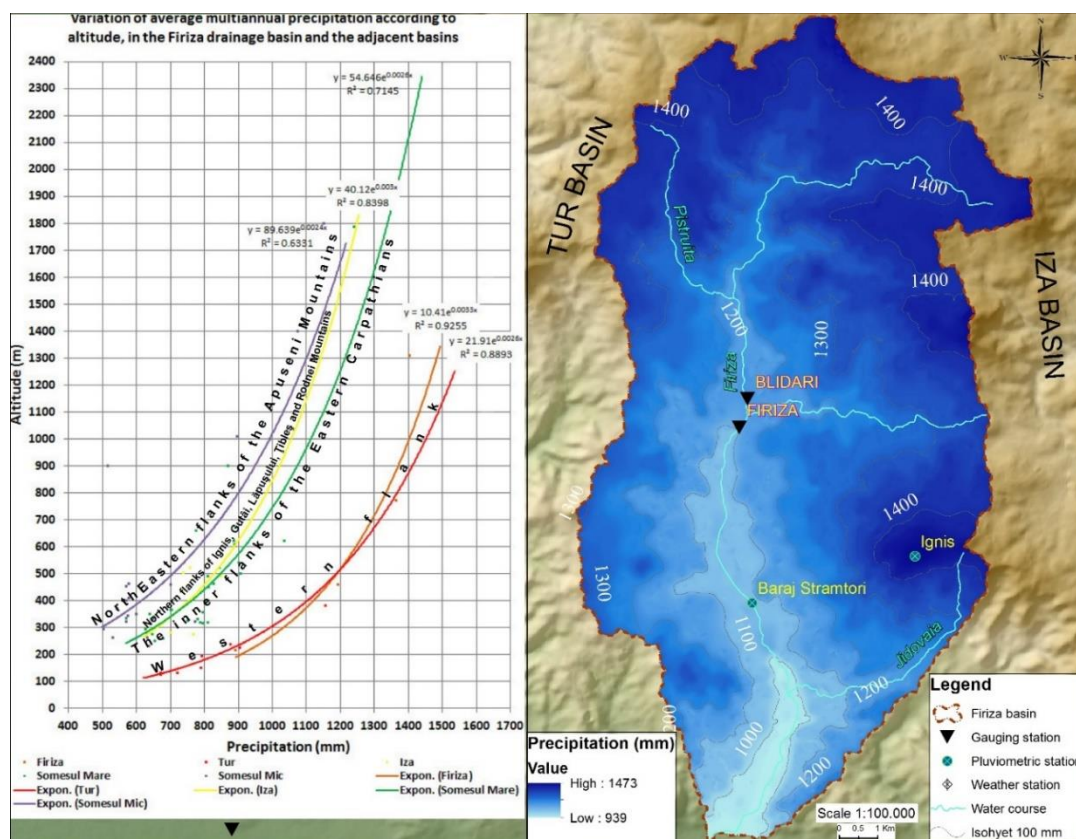


Fig. 10: Average annual rainfall distribution map in the study area and adjacent major basins

Raw data sources: "Someș-Tisa" Water Branch, Cluj

The western flank shows the precipitation gradients with highest values as it is exposed to air masses advections. The central part of the basin is characterized by lower rainfall gradients while the sheltered south-east part of the basin presents the lowest values of precipitation gradients.

The increase of precipitation amount with altitude takes place until a certain height, from which they begin to decrease due to the reduction of the water vapor content of the progressively cooled air in the altitude.

Significant amounts of precipitation are also discharged / also fall over some interfluvies in the central and central-western part of the basin. In the lower sector of the basin, the values are slightly reduced, due to the descent of the air masses towards the depression area of Baia Mare, reaching values below 900 mm.

The spatial distribution of the average multiannual precipitation and of seasonal amounts shows that important concentrations are characteristic on the ridges and plateaus in the eastern and northern part of the basin, where the values can easily exceed 1300 mm.

As compared to the annual average values of precipitation recorded in the Baia-Mare Depression (about 892 mm), the precipitation amounts rise on the slopes exposed to the ocean air masses in the high mountain areas, at about 1400 mm. High intensity rainfall events are frequent throughout the year (Posea, 1980; Bâzâc, 1983; *Clima României*, 2008; Zaharia, 2012; Sabău et al., 2018; Șerban, 2018).

The slight reduction of precipitation amounts at a certain altitude is confirmed by the correlation between the two parameters (Fig. 11).

Case Study: Distribution of rainfall in the study area and neighboring mountain frame

To emphasize the relief influence over the amount of precipitation of frontal origins, the thermal convection was excluded by choosing a case study from the beginning of the cold season. For this, a

north-western air circulation type was analyzed as well as the rainfall distribution in the studied area.

On the 06.11.2016, 00 GMT the geopotential structure at 500 hPa shows that the eastern half of Europe is under the influence of an upper ridge, generating a south-west air circulation. At ground level, the western part of the continent was under the influence of an Atlantic cyclone, moving eastward, associated to an upper trough (Fig. 12, A). This atmospheric structure generates a south-western flow both at ground level as well as in the middle troposphere. In the lower troposphere, the air advection over the south-east of Europe and the study area has its origin over the Mediterranean Sea, generating a warm and humid air influx (Fig. 13, left).

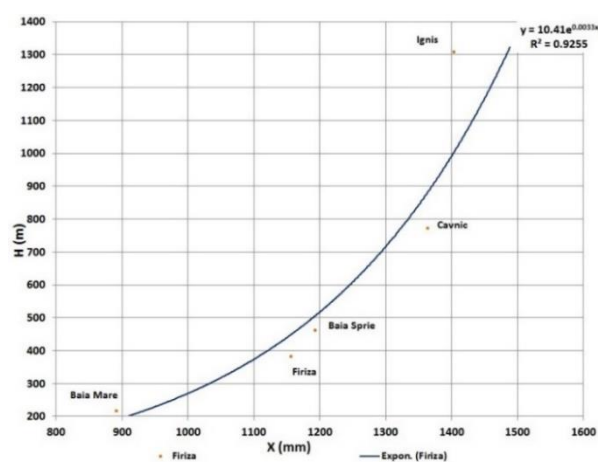


Fig. 11: Relationship between multiannual average precipitation and altitude

The fast movement of the Atlantic cyclone generates precipitation due to its warm and cold fronts over the study area as well as the movement of the upper trough. On the 9th of November, the air circulation becomes western, and on the 10th, north-western (Fig. 13, right), generating a cold air advection from the upper troposphere to the ground level (Fig. 12, B).

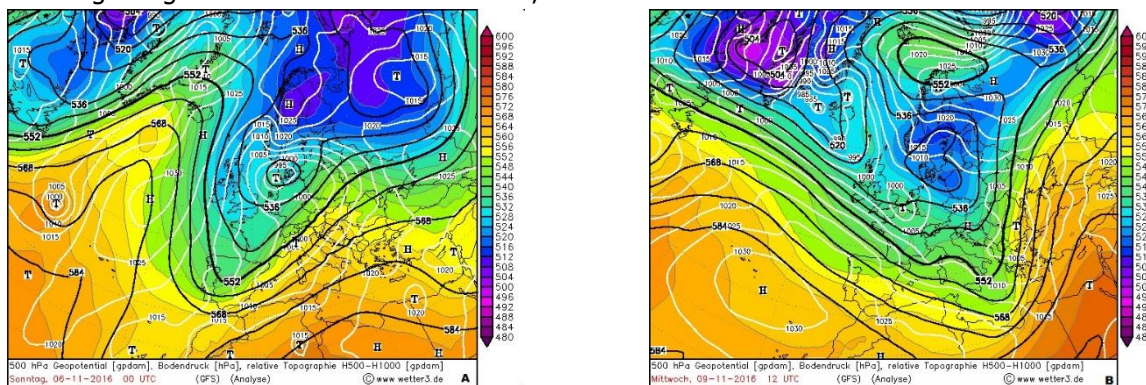


Fig. 12: Sea level pressure (white lines, hPa), 500 hPa geopotential height (black lines, gpdam), and relative topography 500-1000 hPa (colored, gpdam), recorded on 06.11.2016, 00 GMT (A) and 09.11.2016, 00 GMT (B)

Source: <http://www1.wetter3.de/Archiv/>

The spatial distribution of rainfall in the study area, for the 06.11.2016, 04 GMT - 7.11.2016, 04 GMT period and for the 62 rainfall stations shows the highest amount of precipitation on the mountain slopes exposed to air circulation, and the lowest - in the low parts of Maramureș Depression (Fig. 14). For example, the Firiza rainfall station, situated at an

altitude of 423 m, recorded 63.4 mm, Cavnic rainfall station, located at an altitude of 680 m, recorded 42.3 mm, while rainfall stations situated at lower altitude did not exceed 20 mm. This situation emphasizes the role of the relief in generating high amounts of precipitation in the case of humid air masses that cross the area.

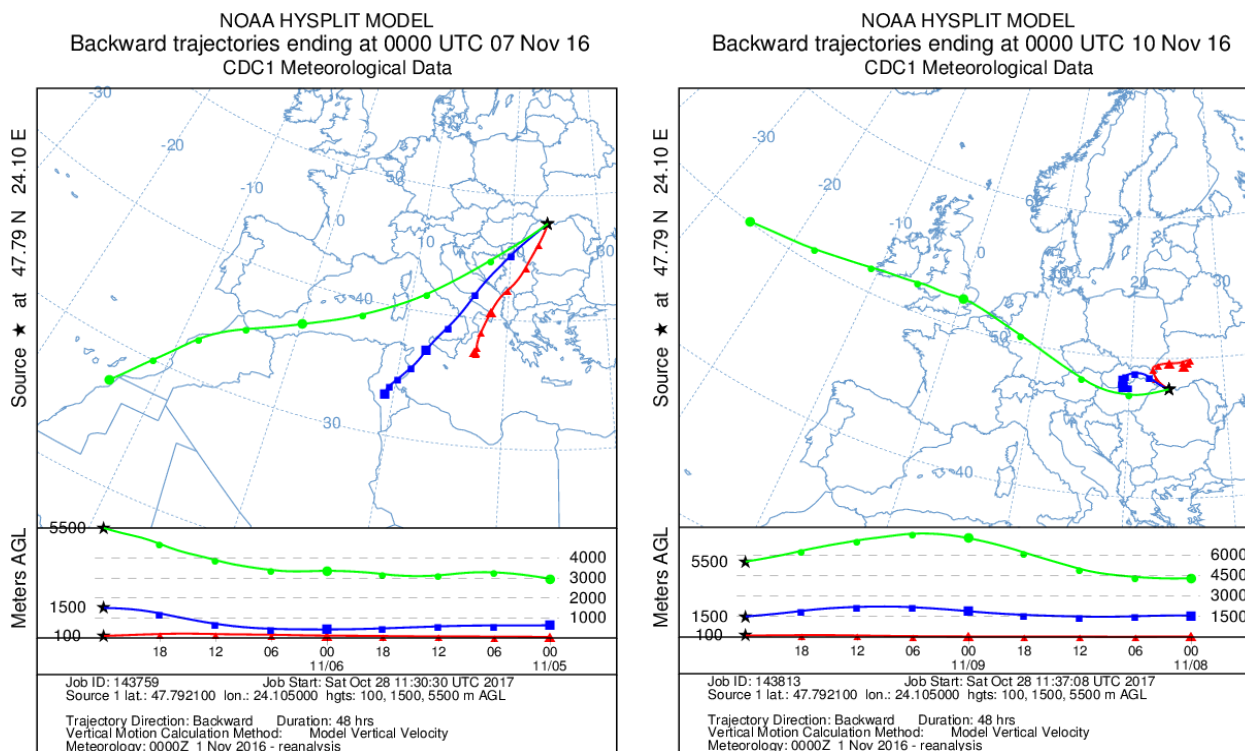


Fig. 13: The backward trajectories computed for air mass movement on 07.11.2016, 00 GMT (left) and 10.11.2016, 00 GMT (right)

Source: <https://www.ready.noaa.gov/HYSPLIT.php>

In the Firiza watershed area, the amount of precipitation is high due to the exposure to oceanic

air masses, the SW-NE alignment and the lower orographic barrier enforced by Oaș Mountains.

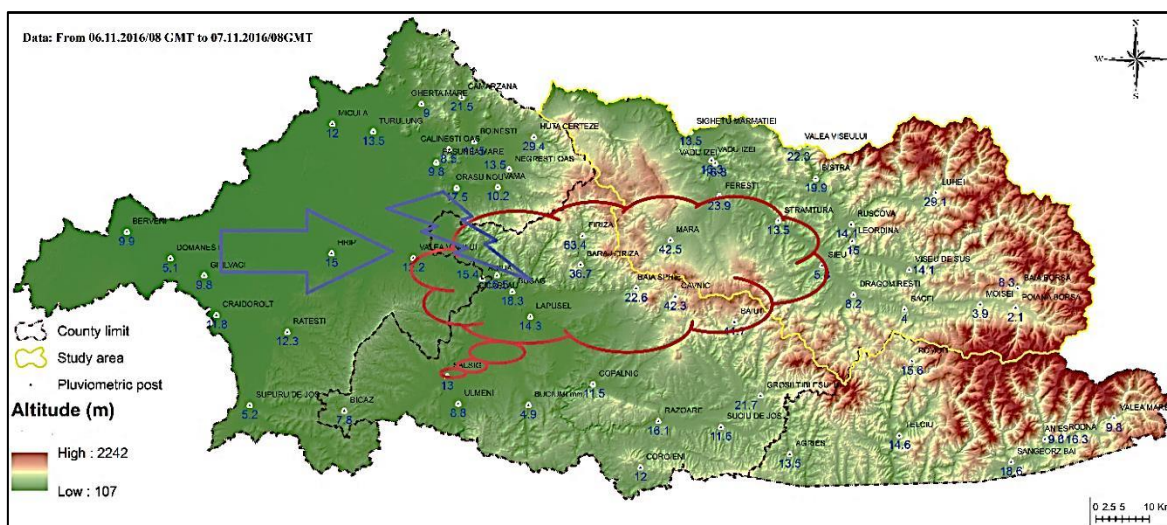


Fig. 14: The precipitation amounts recorded at rainfall stations within the study area for the 06.11.2016, 04 GMT - 7.11.2016, 04 GMT period

Raw data sources: "Someș-Tisa" Water Branch, Cluj

The results confirm the major influence of the relief over the recorded amount of precipitation due to orographic convection generated by the humid air masses ascending exposed slopes of the mountains and different distribution of the rainfall.

Conclusions

In the Firiza watershed area, the amount of precipitation is high due to the exposure to oceanic air masses, the SW-NE alignment and the lower orographic barrier enforced by Oaş Mountains.

Orographic precipitation is generated by the ascent of air masses over the slopes exposed to air masses advection. This process leads to saturation of the air in water vapor and condensation, causing precipitation showers. The characteristics of the orographic precipitation are dependent, therefore, both on the altitude and on the slope, as well as on the orientation of the slopes.

The results confirm the major influence of the relief over the recorded amount of precipitation due to orographic convection generated by the humid air masses ascending exposed slopes of the mountains and different distribution of the rainfall.

Accurate meteorological information is critical to simulating runoff processes within a hydrologic model. All this analysis will highly contribute as an input element in a Spatial Decision Support System for Prevention and Management of Floods in the Firiza Basin (North-Western Carpathians).

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Authors' contribution

All authors have an equal contribution in achieving the present paper.

Conflict of interests

The authors state that they have no conflict of interests.

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