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ANALYSIS OF TORRENTIAL RAINFALL AND AUTOMATIC MONITORING OF THE RAINFALL REGIME IN THE CATCHMENT OF THE SLĂNIC RIVER, BACĂU COUNTY

BY

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Abstract. The present paper intends to analyze the precipitation from the catchment of the Slănic river, a tributary of the Trotuș river from the Siret catchment. This analysis is of interest because the catchment of the Slănic river has a pronounced torrential character, causing floods that bring great social and economic damage in that area. As a result, automatic monitoring of the rainfall regime in the area is necessary; this is done through the automatic stations in the Siret river basin through the DESWAT and WATMAN programs. The final aim of these projects was to modernize the hydrological monitoring network in Romania, using the latest technology and creating products for the adequate information / alarm of the public in case of floods. Finally, the aim is to reduce the impact of floods by forecasting the floods through modeling and modernizing the appropriate infrastructure.

Keywords: rainfall; automatic monitoring.

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1. Introduction

1.1. General Framework

The Slănic river's catchment is located on the territory of Bacău county and drains the south-east slope of the Nemira mountains, with an area of 123 km^2.

The main watercourse is represented by the Slanic river that springs from below the top of Șandru Mare mountain, from a an altitude of 1640 m and has a length of 30 km, through the deep valleys of the basin (Fig. 1) and the rugged relief, duged in rocks, which determined the torrential character of the catchment.

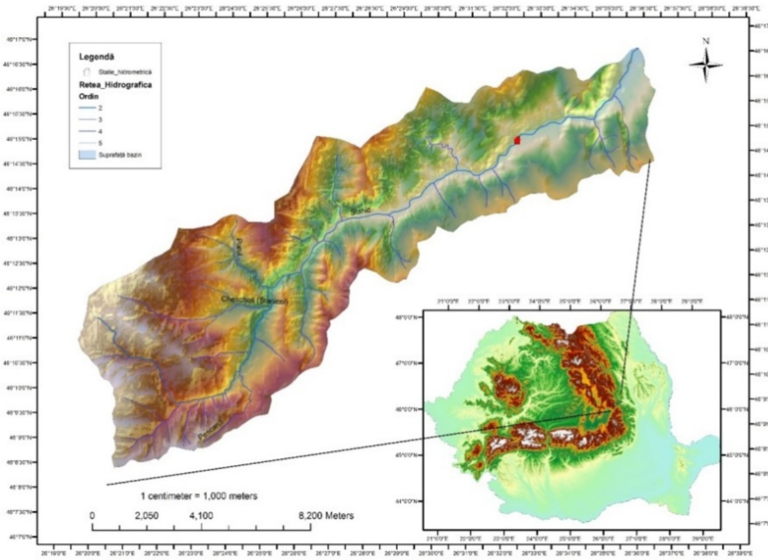

Fig. 1 − Geographic location of Slănic catchment.

1.2. Hypsometry of Slănic Catchment

At the depression's entrance was developed the tourist resort Slănic Moldova, on both sides of the river, passing also along the mineral springs, continuing the route until its discharge in the Trotus river, at the foot of the Măgura mountain, being one of the main tributaries from the right side.

According to the specialized G.I.S terms, hypsometry represents the map that illustrates the relief through the altitude and the configuration of a territory. According to surveyors and cartographers, the hypsometric map illustrates the relief through a series of conventions, such as level curves, shading, hatches or color scale, etc. (Duggal, 2004).

The relief is determined by high altitudes and it is strongly fragmented, represented by higher peaks at the basin's top (Șandru Mare-1640 m), which decrease in altitude to the middle and lower sector: Pufu (936 m), Petrarul (847 m), Cireşoaia (770 m) on the left side and Dobru (1139 m), Păltiniş (1019 m), Cerbu (985 m) and Cernica (954 m), on the right side of the river (Fig. 2).

Engraved on a strongly carved and serrated structure, belonging to the flysch mountains, on hard rocks (Tarcău sandstone, Lucăceşti sandstone, marl, clay shale, etc.) the relief presents a certain massiness and height.

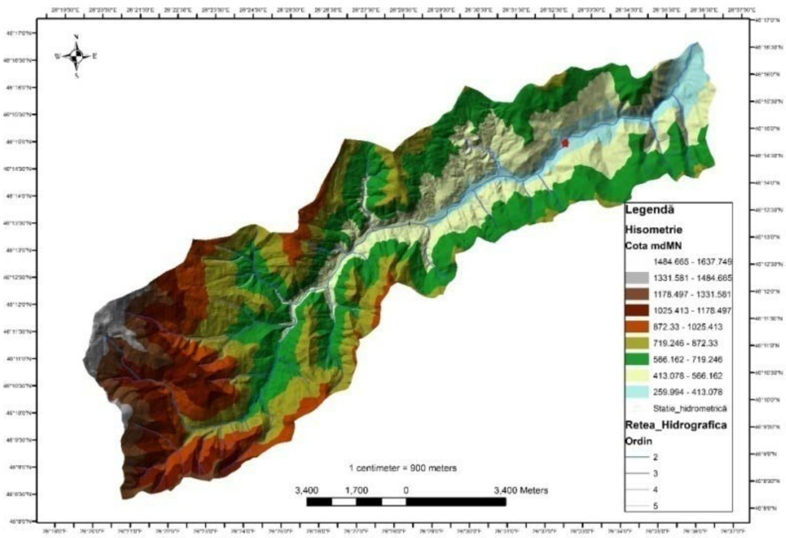

Fig. 2 − Hypsometry of Slănic catchment.

1.3. The Hydrographic Network

In the Slănic catchment, the hydrography is determined by the main Slănic watercourse, respectively its tributaries, which make a significant contribution to the water supply of the main stream, the great majority of the tributaries have a torrential character; this torrential regime of rivers is assigned to the entire hydrographic network, as seen in Fig. 3.

The total length of a hydrographic network is formed by the length of the main watercourse and the length of its tributaries, so that the total length of the hydrographic network of the Slănic River is about 100 km, with the lengths of the hydrographic network segments between 0.123 km - and 30.36 km, the maximum length belongs to the main watercourse, Fig. 4.

The tributaries, in the resort's area, on the left side are: Cheşcheşul stream, Pufului stream, Sasului stream, Ignat stream, Piatra stream, Tudorache stream, and on the right side, Pescaru stream, Sescara stream, Dobru stream, Cerul stream, Pârâul stream and Şurei stream.

The composition of the Slănic waters has been the object of study for many Romanian doctors and scientists, who have highlighted that the action of mineral water is exercised both by the chemical and the physical factor (radioactivity, temperature, osmosis, colloidal state, ion dissociation etc.).

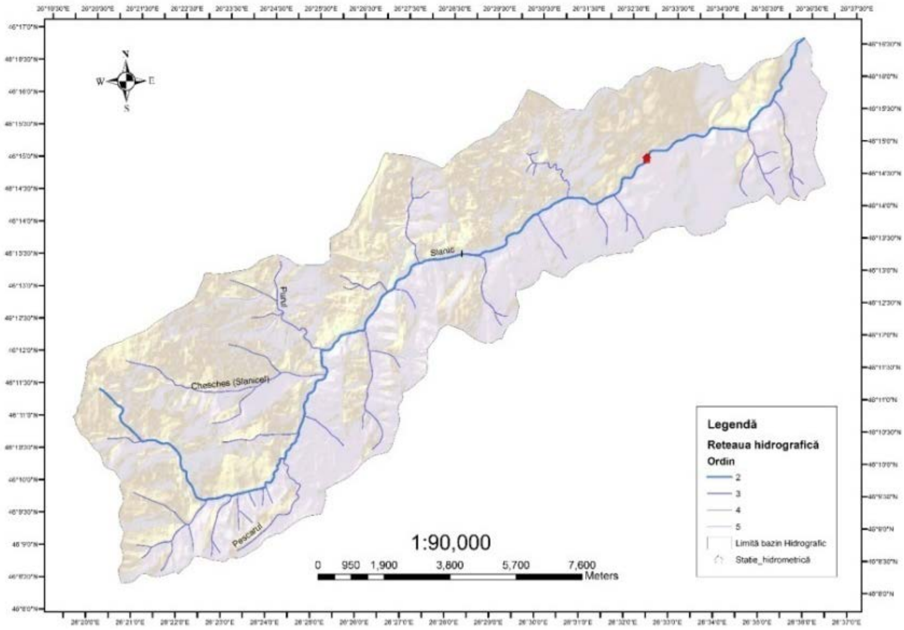

Fig. 3 – Hydrographic network of Slănic catchment (Source: Siret WD).

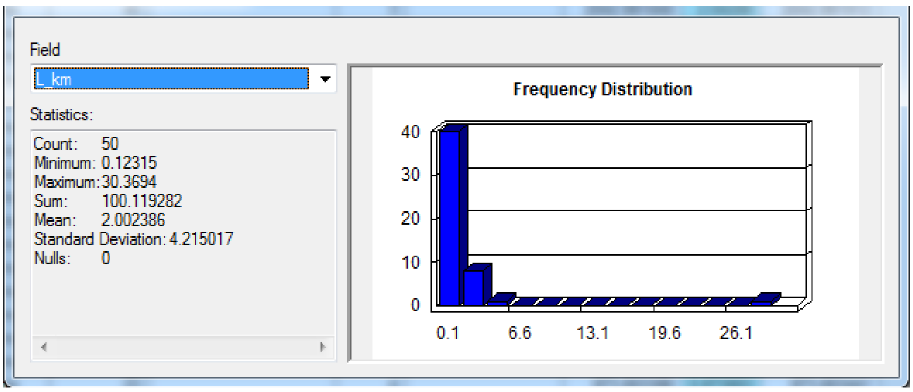

Fig. 4 – Graph on the watercourses distribution according to their length - shapefile generation on the rivers length (Source: ArcGIS - ArcMAP 10.1).

Cireșoaia hydrometric station controls an area of 105 km^2 with an average altitude of 775 m, located on the Slănic River where the hydro-meteorological phenomena are monitored (Table 1, Table 2) by both manual and automatic measurements.

Table 1
The Monthly Distribution of the Multiannual Average Flows According to the Historical Data from the Cireșoaia Hydrometric Station (Q in m^3/s) (Source: Siret WD)

Months / Section	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Cireșoaia	0.45	0.59	1.29	2.54	2.34	1.80	1.50	0.98	0.79	0.60	0.52	0.52	1.16

Table 2
Maximum Flows with Different Exceedance Probabilities (Source: Siret WD)

Exceedance probabilities (%)	1	2	5	10
Maximum flows (m^3/s)	185	146	100	68.5

1.4. Climate of the Catchment

The climate is temperate-continental of the mountain type, with slight shelters. The average annual temperature of the air varies between 2°C - 4°C on the high peaks and 7°C - 8°C in the valleys, and the values of precipitation amounts between 800-1000 mm. At the Slănic Moldova rainfall station, the norm (multiannual precipitation average) is 825 mm.

1.5. Analysis of the Rainfall Regime

The annual rainfall amounts have values of over 800 l/sqm on the higher mountain parts and 800-850 mm in valleys. In Slănic Moldova, the average multiannual rainfall amount is 825 mm. It should be noted the torrential nature of rainfall, which is also reflected in the water flow regime, by the high frequency of large floods and flash floods (Giurma, 2009; Giurma *et al*., 2009).

From the analysis carried out over a 10 years period, as shown in Fig. 5, the multiannual rainfall recorded at the rainfall station Cireșoaia resulted in a maximum volume in 2016 of 921 mm.

2. Monitoring of Hydrometeorological Phenomena with the Help of Automatic Stations Mounted Through DESWAT and WATMAN Projects

With the implementation of Deswat (Fig. 6) and Watman national projects in the water domain, the hydrometeorology phenomena monitoring systems have been modernized through implementation of automatic transmission stations (Giurma and Crăciun, 2010).

The DESWAT project (Destructive Water Abatement and Control) to reduce the impact of floods by ensuring continuous hydrological vigilance on rivers and forecasting floods had as main objectives:

- improving the capabilities and forecasting speed;
- improving forecasting accuracy;
- use of the SIMIN facilities (National Integrated Meteorological System) project;
- assessment of potential damages - costs, in case of floods.

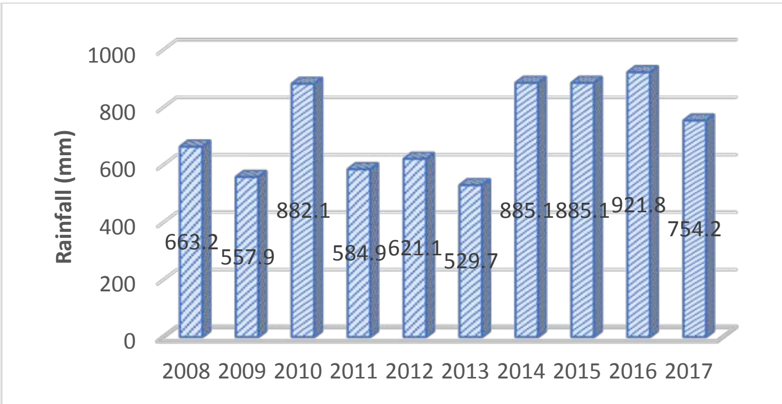

Fig. 5 – Chart regarding the multiannual rainfall at the Cireşoaia rainfall station (Source: Siret WD).

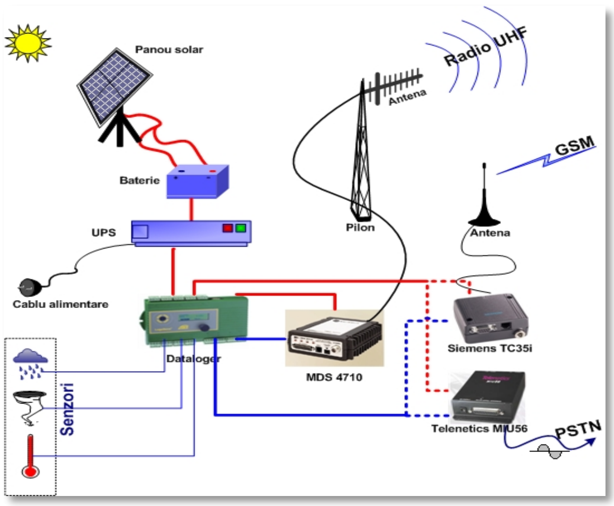

Fig. 6 – Principle scheme for data collection and transmission (Source: DESWAT project).

In the Siret catchment were installed through the DESWAT program a number of 83 automatic HPT stations (AHSS) and 35 automatic rainfall stations (APSS). The Cireşoaia hydrometric station has a DESWAT station with automatic transmission of hydrometric data (AHSS) and rainfall data (APSS) (Fig. 7).

The final aim of this project was to modernize the hydrological monitoring network in Romania, using the latest technology and creating products for the adequate information / alarm of the public in case of floods.

a) *b*)

Fig. 7 − DESWAT automatic station (Cireșoaia) *a*) hydrometrical data; *b*) rainfall data.

WATMAN Project - Information System for Integrated Water Management - Stage I

It is a project whose final objective is to protect the population, by modernizing the appropriate infrastructure to prevent floods in order to mitigate their destructive consequences.

Within this program at national level the following were pursued:

- Optimizing the security and efficiency of the existing hydrotechnical infrastructure;
- Computerization of the collection system with data from the automatic stations;
- Remote real-time monitoring of the hydrotechnical constructions behavior;
- Refurbishment of the intervention means;
- Integration of all information at electronic level and real time communication.

The investments in Objective I - made for modernization, include automatic sensors and complementary equipment, as for example, at the national level were installed:

- 89 automated stations with sensors to increase the dams safety;

- 233 automatic stations with sensors for measuring the snow layer and hydrometric stations for tributary flows, sockets and bypasses;
- 89 dams equipped with software and hardware for the control and coordination of the hydrotechnical constructions exploitation;
- Equipment and means for flood intervention

In the Slănic catchment was installed an automatic meteorological station for measuring the following parameters near the existing hydrometric station:

- rainfall;
- the snow layer;
- air temperature.

Rainfalls are automatically measured (Fig. 8) using the RG50 rain gauge - a high precision transducer, with pulse output, on relay contact, for the data logger (Antohi and Telişcă, 2004). The rain gauge has a 2cm3 tilting cup which, when filled, tilts and causes an electrical contact. The filling and tipping of the cup corresponds to a rainfall amount of 0.1 mm.

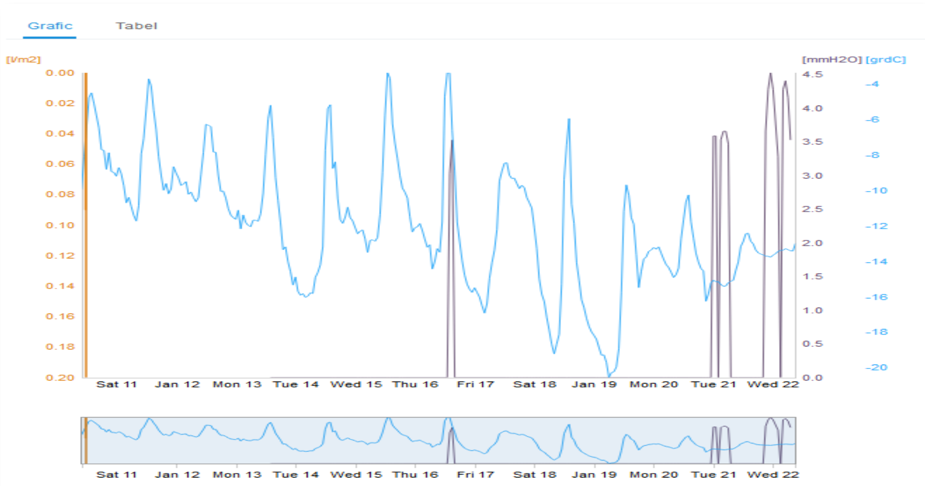

Fig. 8 − Automatically generated graph in the e-sensor software, based on the automatically collected data.

The snow platform (Fig. 9) measures the water equivalent of the snow layer in mm (Giurma, 2003). This value is identical to the weight of the snow on the surface, in Kg/sqm. The transducer works based on the conversion of the weight of the snow layer into an electrical signal.

The TaCTH01 temperature transducer is intended for continuous measurement of indoor or outdoor air temperature.

The data acquisition and transmission is done with the help of CATD-CTH equipment, intended for the automatic retrieval, processing and transmission of the data from the field translators. The operating principle is to retrieve information by scanning the sensors, storing this information in an internal buffer and transmitting the memory contents through the GSM network.

Fig. 9 − Automatic weather station (Cireșoaia) for measuring rainfall, temperature and snow layer mounted by WATMAN project.

3. Conclusions

From the analysis of rainfall in the Slănic catchment, tributary of the Trotus river from the Siret catchment, recorded at the Cireșoaia station, was found that the ratio between multi-annual flow Qmed and maximum flow Qmax with 1% exceeding probability above the value of 1/100 thus indicating the torrential character of this catchment.

The strong torrential character in the Slănic catchment creates floods that can cause great social and economic damage in that area.

As a result, in addition to the classic equipment used in the hydro-meteorological measurements, it is necessary to automatically monitor the rainfall regime in the area to prevent floods in order to mitigate their negative consequences.

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ANALIZA PRECIPITAȚIILOR TORENȚIALE ȘI MONITORIZAREA AUTOMATĂ A REGIMULUI PLUVIOMETRIC ÎN BAZINUL HIDROGRAFIC AL RÂULUI SLĂNIC, JUDEȚUL BACĂU

(Rezumat)

Prezenta lucrare intenționează să analizeze precipitațiile din bazinul hidrografic al râului Slănic, afluent al râului Trotuș din bazinul hidrografic Siret. Această analiză prezintă interes, deoarece bazinul hidrografic al râului Slănic are un caracter torențial pronunțat, provocând inundații care aduc mari pagube sociale și economice în acea zonă. Ca urmare, este necesară monitorizarea automată a regimului de precipitații în zonă; acest lucru se face prin stațiile automate din bazinul râului Siret amplasate prin programele DESWAT și WATMAN. Scopul final al acestor proiecte a fost modernizarea rețelei de monitorizare hidrologică din România, utilizând cea mai recentă tehnologie și creând produse pentru informarea adecvată / alarmă a publicului în caz de inundații. În cele din urmă, scopul este de a reduce impactul inundațiilor prin prognozarea inundațiilor în urma modelării și modernizării infrastructurii adecvate.