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METHODS OF PROCESSING HYDROMETEOROLOGICAL DATA BASED ON TINOASA – CIUREA REPRESENTATIVE BASIN

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Abstract. This paper summarizes the data processing methods derived from observations and measurements at Tinoasa Ciurea Representative Basin for the year 2013. This basin was chosen as a case study in this paper because it uses both classical and modern equipment (sensors for recording water level, solar radiation sensors and sensors for determining evaporation) in order to monitor hydrometeorological phenomena. Also, this basin is considered to be representative to all of the eastern plateau areas in Romania. The study aims at analyzing monitored meteorological parameters during the year 2013 within the basin and their influence on the formation of runoff, highlighting the main aspects of the flow and their role in the propagation and warning of dangerous hydrological phenomena. The methodology was based on the use of GIS technology and on numerical flow simulation models. Using GIS technology for characterizing and analyzing the study area brings forth its main software packages such as ArcGIS and the modalities for the implementation of this technology in small river basins. Equipping this basin with an automatic weather station (including all types of radiation sensors) and sensors for level determination makes it a warning basin in the case of dangerous hydrological phenomena occurrence. In conclusion, the study targets the influence that physico-geographical and generator factors have on the formation of runoff in small river basins.

Key words: Tinoasa-Ciurea Representative Basin, hydro-meteorological equipment, data accumulated in 2013

Objectives

The objective of this paper is the adduction of the data collection within a representative basin and their processing methods, in order to capitalize them as useful. Also, it emphasizes the role that own representative basins in the knowledge of the runoff formation process on the small rivers and on the slopes to provide hydrological parameters with high accuracy in warming of dangerous hydrological phenomena.

General geographical features of the Tinoasa-Ciurea Representative Basin

Tinoasa-Ciurea Representative Basin is located in the eastern part of Romania, in Moldova Plateau, at the contact between the Moldavian Plains and the Central Moldavian Plateau. The site under study constitutes the upper part of the Nicolina river catchment area, which is part of Bahlui river basin, a tributary of the Prut river. Tinoasa-Ciurea Representative

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Basin (Figure 1), placed in the catchment area of Bahlui river, was established in 1969. The basin has a catchment area of 4.17 km^2 and its elevation ranges between 192 and 410 m.

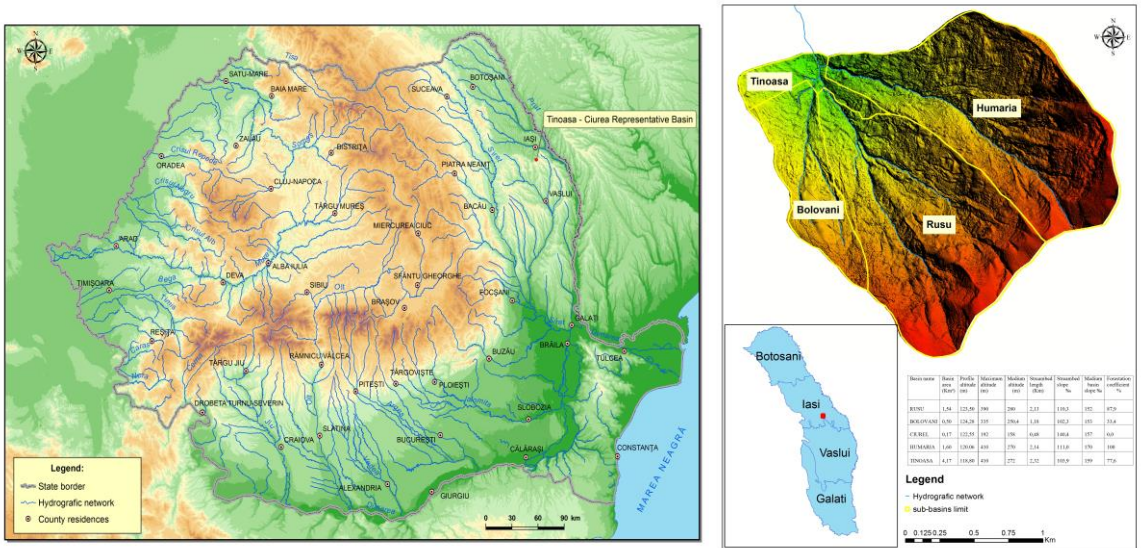


Figure 1: The geographical position of the Tinoasa – Ciurea Representative Basin in Romania

The average slope is of 15.9%, with a predominantly northern orientation. The basin is monitored trough 5 control sections located on Rusu, Bolovani, Ciurel, Humaria and Tinoasa (closing section) rivers, whose reception areas are between 0.17 km^2 and 4.17 km^2 (Table 1).

Table 1: Morphometric data and afforestation coefficients in Tinoasa – Ciurea Basin

Crt. no.	Basin name	Basin area (Km^2)	Average elevation (m)	Maximum Elevation (m)	Streamed lenght (Km)	Average basin slope (%)	Forestation coefficient (%)
1.	Rusu	1,54	280	390	2.13	15.2	87.9
2.	Bolovani	0,50	250,4	335	1.18	15.3	33.4
3.	Ciurel	0,17	158	192	0.48	15.7	0.0
4.	Humaria	1,60	270	410	2.14	17.0	100
5.	Tinoasa	4,17	272	410	2.32	15.9	77.6

From the geological point of view, marls and clays exceed, but gravel, sand and loess can also be observed. Regarding the soil cover, it is represented by the aluviosol and cambiosol class, in which brown soils, reddish – brown by forest and pseudorendzina soils prevail (Figure 2). The vegetation in Tinoasa-Ciurea basin is represented mainly by deciduous forests, but also by meadows, pastures and hayfield. Knowing the considerable influence that the coverage with vegetation exerts on the runoff, one of the purposes of this representative basin is to study the phenomenon, considering that in the area there are sub-basins with a 100% afforestation and sub-basins completely deforested. Forests cover the largest part of the surface of the entire basin (77.6%) and contribute to the diminishing of surface runoff quantity. Tinoasa – Ciurea basin has an excessive continental climate which is characterized by annual precipitation quantities of 600-650 mm. The distribution of precipitations is uneven during the year: minimum precipitations of 30 mm monthly are recorded between August and

October, almost half of the annual quantity falls between May and August with greatest precipitation quantities recorded in July, often having torrential character. The annual temperature average of around 9°C (the hottest month is July - 21.3^{0}C and the coldest month is January with a mean temperature of -3.6°C; the temperature drops below 0^{o}C starting with the second decade of December). This type of climate generates great amplitude between the values of runoff.

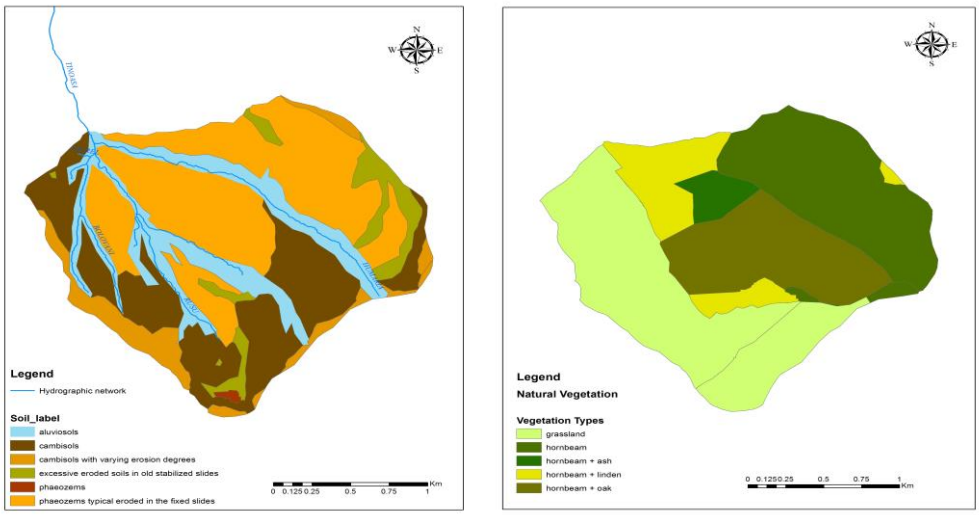


Figure 2: Soils map (left) and vegetation map (right) from Tinoasa-Ciurea Representative Basin

Data and processing methods

The program of observations and measurements of Tinoasa-Ciurea representative basin includes a basic hydrometric program established to determine the main parameters of the runoff (liquid and solid) and the meteorological ones, as well as a program of measures to monitor specific issues that concern the knowledge of the hydrological role of forests (the program, in this case includes measurements of the rainfall fallen in open field, under the canopy of the trees and on the tree trunk), the determination of the snowmelt runoff (measurements of the snow thickness and density), the discharge on the slope and radiometric observations and measurements on the evaporated water layer. In all the 5 sections of the basin we performed the level read, fluid and suspended silt flows determination and water temperature.

Foto 1: Section for monitoring the liquid and solid flow on Bolovani River (left) and the closing section (right)

Tinoasa-Ciurea representative basin is equipped with plots of discharge, namely a plot with free runoff, two plots concrete in open field and a concrete plot in the woods, where can be performed measurements of drained flows on the slopes. For the observation and measurements of the groundwater regime, the basin has hydrogeological drilling alignments.

In Tinoasa-Ciurea representative basin, the observations and measurements program is performed with classical devices and automated stations which include level, water temperature and precipitation sensors to determine evaporation, maximum and average speed, direction of the wind, atmospheric pressure, relative humidity and solar radiation (net, diffuse, reflected and direct). Data transfer from the automatic station is done using *HYDRAS 3 software* which is based on a high-performance database application which comes with a variety of functions: downloading data, management of master data, incorporating map or graphic material, graphical evaluation, multiple graphics, graphical editor, correlation analysis, numerical display of measured data, importing measurement data, exporting measurement data.

Cartographic representations and spatial analyses have been based on GIS techniques**,** extensions of the ArcGis 10.2 software. The spatial distribution of rainfall was performed using the interpolation method by weighting according to the inverse distance (IDW - Inverse Distance Weighted) with the aid of ArcGIS Spatial Analyst extension. For IDW values interpolation were used data from the vicinity of the estimate point, measurement points had in the interpolation, an influence that decreases with the distance (*Johnston et al., 2001*).

Based on the IDW method and using as an input the measured and observed data in Ciurea – Tinoasa representative basin, and also data from the close area, we obtained successive maps with the evolution in time and space of the water equivalent from the snow layer. The water equivalent of the snow values determined in the basin were compared with the numerical values of the isohyets which resulted from the use of the spatial interpolation method. Thus, the quality of the data provided by Tinoasa-Ciurea representative basin was verified. The spatial interpolation method was used to determine the amount of rainfall by sub – basins, which were necessary to define the parameters of the 2013 floods.

Results

The data obtained in 2013 from the observations, measurements and automatic records in Tinoasa-Ciurea representative basin were processed in order to obtain the hydrometeorological analysis and characterization of the main parameters:

✓ the annual average temperature was slightly higher (10^0C) compared to the multiannual mean values (9.6^0C); extreme values of temperature reached 32.7^0C, -17.9^0C respectively; this parameter was recorded by automatic station at a time step of 10 minutes (Figure 3).

✓ the rainfall regime of Tinoasa – Ciurea basin in 2013 (Figure 4) was close to the climatic averages, characteristic to the studied area, namely the annual amount was 581.2 mm, a slightly higher value than the multiannual one for this area (545 mm/year); between the rainfall values measured with classical devices (623.9 mm) and the records made automatically (581.2 mm), in this case there is an error of 7%; during 2013 in the basin the rainfall had an uneven distribution, in the summer being recorded the highest amounts (125.5 l/m^2 in June, 109.5 l/m^2 in July), while during

October – December there were small rates of precipitation, for example in October there were 4.2 l/m^2;

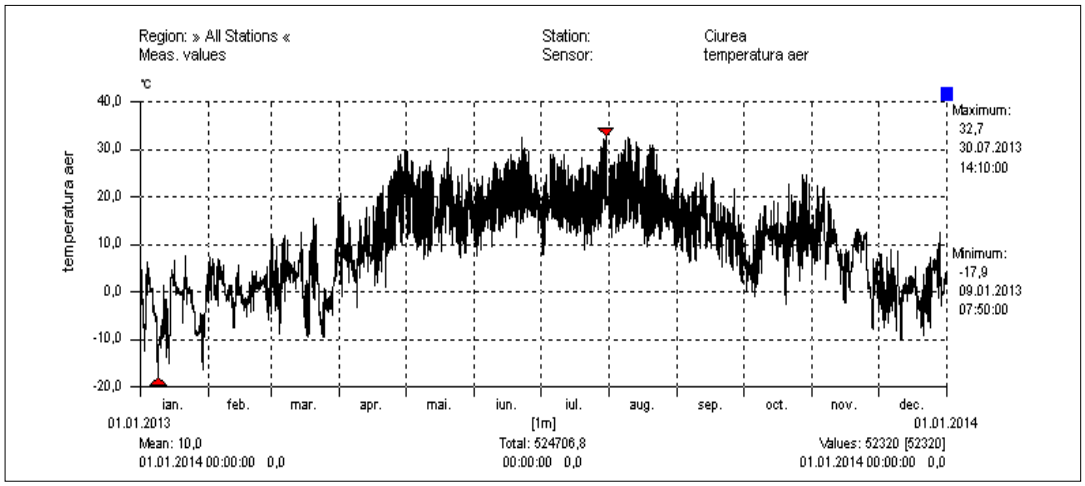


Figure 3: Variation of air temperature (2013) in Tinoasa – Ciurea Representative Basin

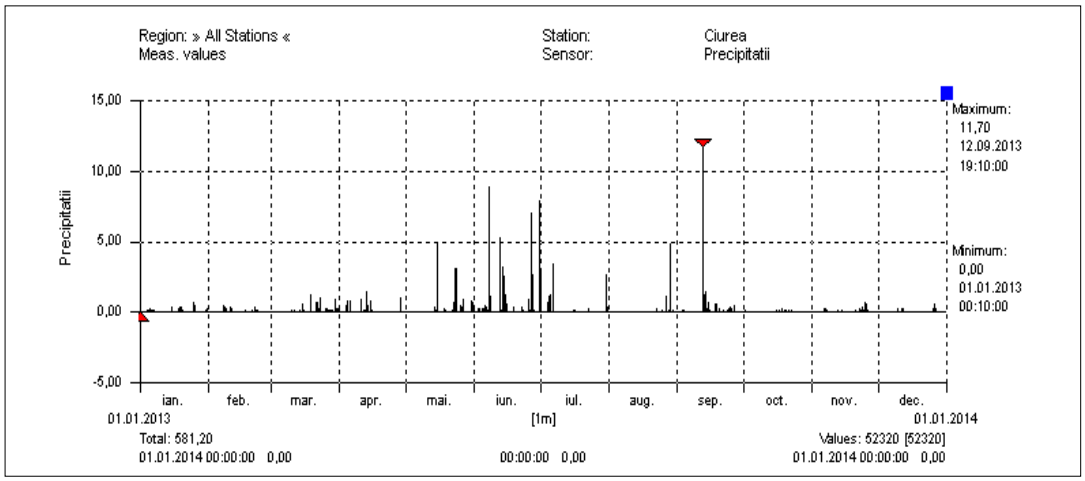


Figure 4: Rainfall distribution in Tinoasa – Ciurea Representative Basin in 2013 year

✓ the richest rainfall amounts were recorded in the following periods: 21.03. – 23.03., 4 – 6.04 and 30.06 – 2.07. Although precipitation amounts were high for this area, they have not generated significant water runoff due to the existence of the excessive drought, which was installed on the lack of rainfall in the previous year; from June 30 to July 2 there were recorded the highest amounts of rainfall, which reached 105,8 mm (Figure 5), the rain having an average intensity of 0.1mm/min.

Amid the precipitation amounts recorded in this interval, maximum flow in the monitored sections climbed up to 6000 l/s on the Rusu River and 13068 l/s in the closing section from Tinoasa.

Another period with high amounts of rainfall started on March 21 untill March 23, when they reached 29 mm (Figure 7 a). The rainfall recorded in this period overlapped with

high air temperatures that favored the rapid melting of the snow fallen in the previous months, thus causing a small flood, the maximum flow at the closing station reaching 703 l/s. Another rich rainfall period was April 4 - 6, during which they exceeded 20 mm. Based on the records, the isohyets map and the generated flow chart were made (Figure 7 b.).

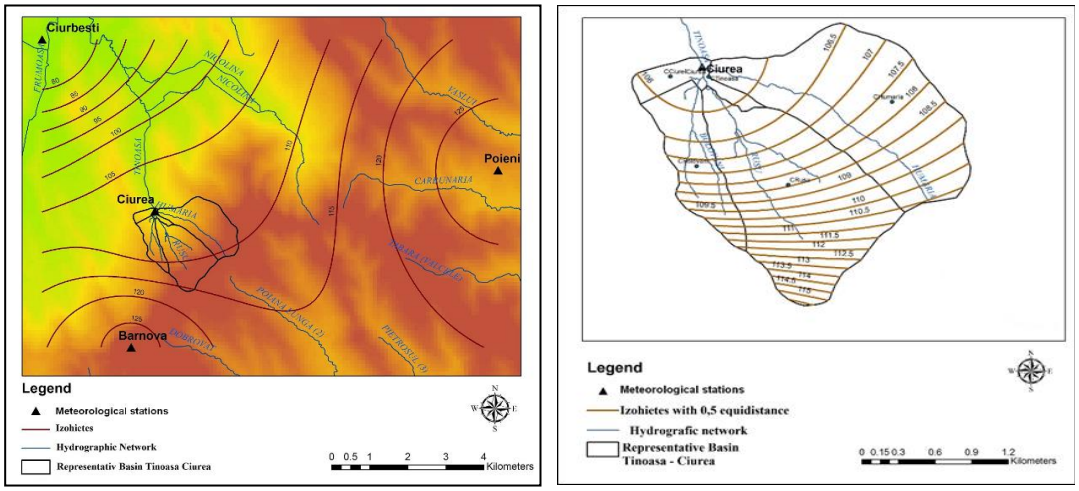


Figure 5: The map with isohyets in the range June 30 – July 2, 2013 (detail on the right)

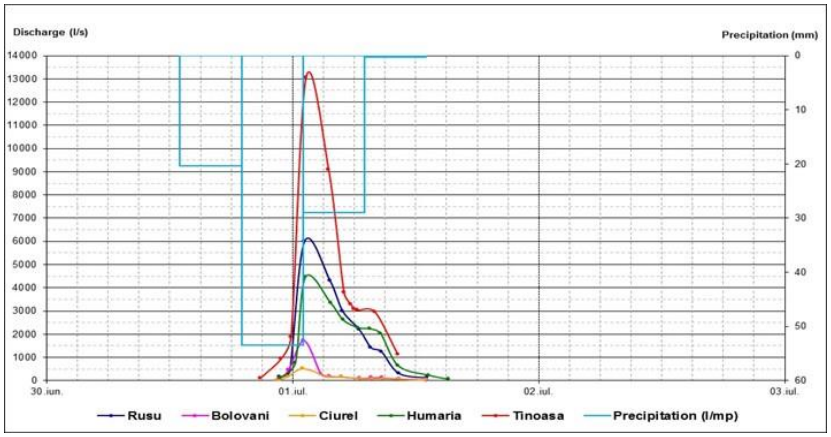
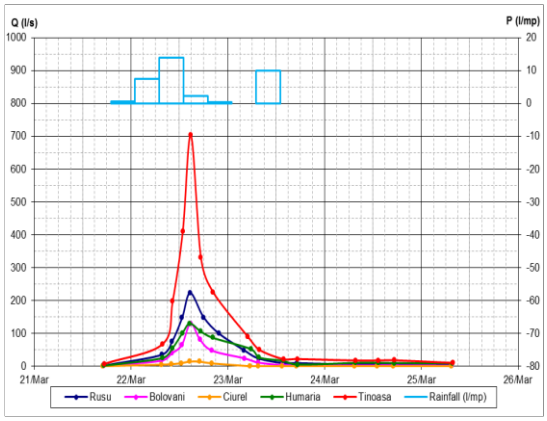
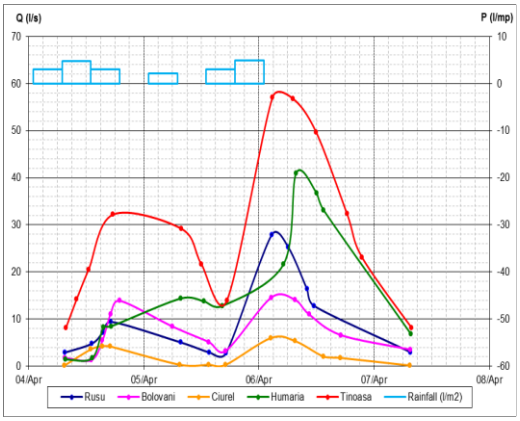


Figure 6: Flood from 30.06 to 2.07. in the Tinoasa – Ciurea Representative Basin



a)



b)

Figure 7: Flood from 21.03 to 23.03. a) and the flood from 4.04. to 06.04. b) in Tinoasa – Ciurea Representative Basin

The purpose of presenting these intervals with high rainfall, correlated with the graphs of flow variation recorded on the same period, was to emphasize the rapid response that this small basin had on this trigger. Except for the three periods mentioned, when rainfall was quantitatively significant and generated the richest runoff on the rivers, the basin faced in 2013 with low water periods. Thus, there were very long periods of time with „dry" on Rusu, Bolovani, Humaria şi Tinoasa Rivers, the second decade of July until the end of the year,with the exception of a few days in September. On Ciurel river the fluid flow was recorded only for short intervals in January and April, for few days in June and July and throughout March, and for the rest was „dry". Reduced discharge is highlighted during the runoff curve made based on the average daily flow from the closing station, Tinoasa. The easement flow (with the probability of 95 %) decreases to a value of 0.024 l/s/Km^2.

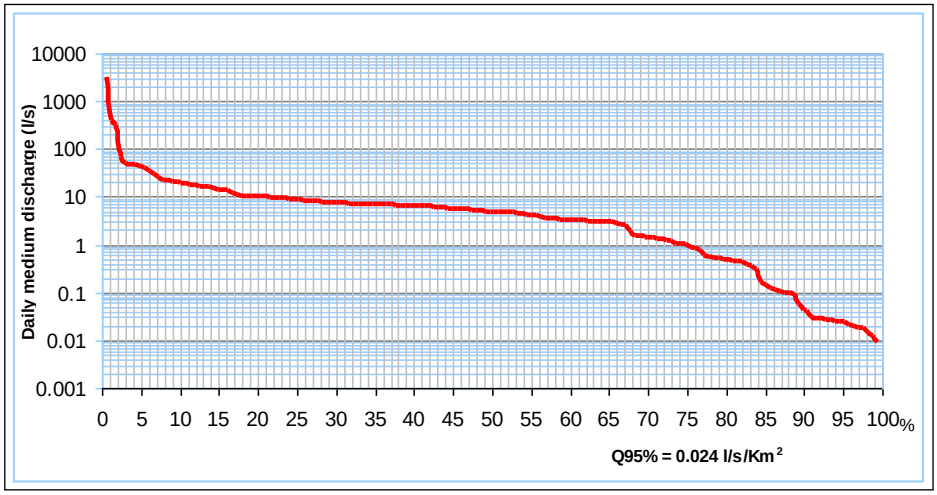


Figure 8: Flow duration curve in 2013 at the closing station in Tinoasa – Ciurea

Given the low liquid flow rates to all the five rivers in the catchment area, the solid flow was insignificant. The highest quantities of alluvial material were transported in July, which is attributed to the large amounts of rainfall during this period of the year, precipitation which presented a torrential character, causing the transfer of the material from the slopes in the riverbed. The average amount of the slit were between 1.1 g/l on Ciurel River until 199 g/l on the closing section.

Regarding the water level equivalent of snow, which is made based on density measurements carried out pentadic and nivometric profiles, its graphical representation revealed the role of slope exposure on the water reserve from the snow layer and on the molten layer of snow (Figure 9). The highest values of the layer of water derived from melting snow was recorded on the slopes with a north – eastern exposure, compared with north – western exposure and in the sub-basins with higher slopes. The maps with water equivalent from the snow layer at different times of 2013 highlighted the vertical zoning of snow, or solid precipitation increase with the growth in altitude. The values for this parameter were quite low. The highest values of the water equivalent from melting snow was recorded on NE exposed slopes in relation to NV exposed ones and in sub-basins with a higher slope.

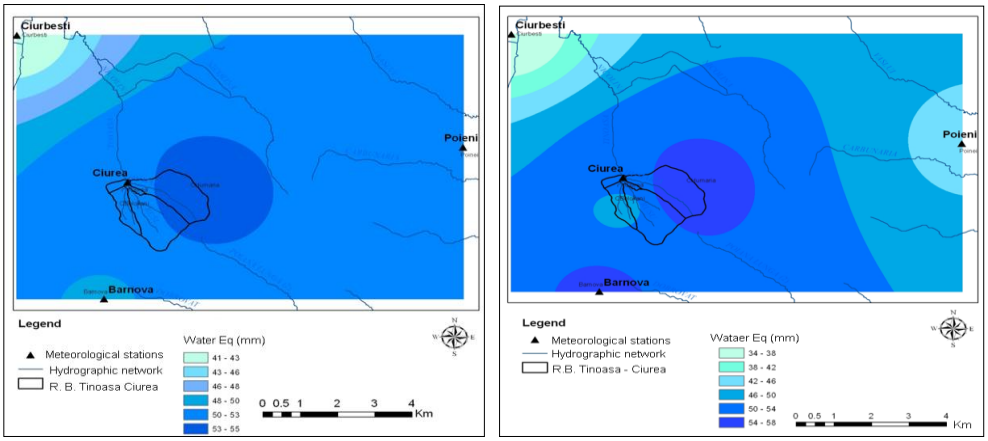


Figure 9: Water equivalent of snow on 20.01 (left) and 25.01.2013 (right) in Prut hydrographic basin which includes Tinoasa – Ciurea R.B.

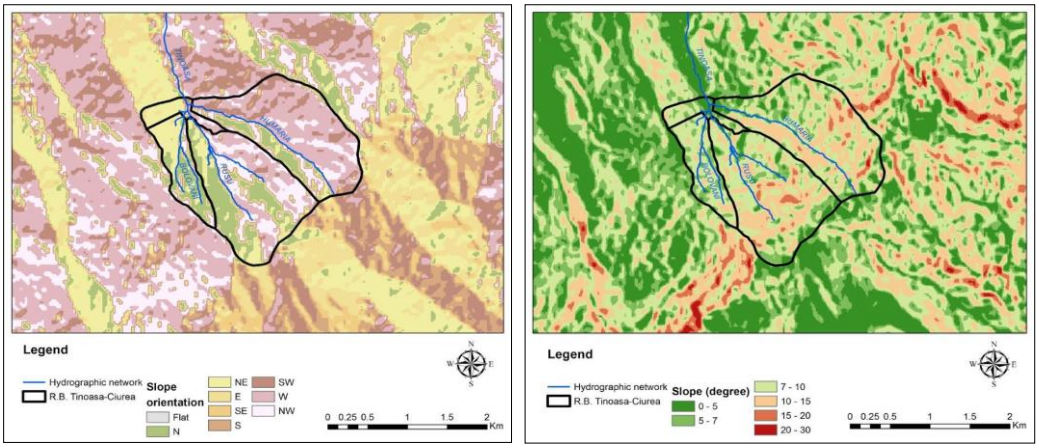


Figure 10: Maps regarding the slope orientation and slope (degree) in Tinoasa – Ciurea R.B.

The maps regarding the water equivalent of snow in different times of 2013 highlighted the vertical zoning of snow, respectively the increase of solid precipitation with the increase in altitude. The values determined in the basin, regarding the water equivalent of snow were compared with the isohyet numerical values resulted from the use of the spatial interpolation method. Thus, the quality of the data recorded at Ciurea RB was verified. The spatial interpolation method was used to determine the sub-basins average amount of precipitation which is needed to determine the parameters of the 2013 floods.

Conclusions

In Tinoasa – Ciurea representative basin, hydrometeorological parameters are obtained from classic measurements and observations and by using automated stations. The data obtained in this basin during 2013 revealed the quick answer of the small catchment areas to

certain triggers, primarily rainfall and then the features of some geographical factors (vegetation, soil cover, geology, topography). Based on the records, we determined with high precision the floods, the drained water layer, the water equivalent of snow layer and the climatic parameters. The hydrometeorological analysis of 2013 showed for the studied area the manifestation of drought having as main cause rather the low rainfall (below 600/year), unevenly distributed during the year, plus the geological constitution which does not allow groundwater storage.

The results of this paper are expected to contribute to studies of land use and climate change, studies of uncertainties and the development of new measuring techniques, besides further hydrological process understanding.

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