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CURRENT POSSIBILITIES FOR ELABORATING FLASH FLOOD WARNINGS IN ROMANIA. CASE STUDY: THE FLOOD PRODUCED ON 30 JUNE 2018 IN THE TROTUȘ RIVER BASIN

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ABSTRACT. This paper concentrates information on the flash flood produced on 30 June 2018 in the Trotuș River basin. Flash floods are extreme phenomena, caused by torrential rainfall, occurring in a very short time in small hydrographical basins without being hydrometric monitored. These phenomena occur with increasing frequency and severity in the last decades both worldwide and in our country and can be manifested in almost any hydrographic area. Thus, in order to diminish the negative effects caused by floods, an important activity is forecasting and warning in case of dangerous hydrological events. Hydrological warning messages are issued with a certain amount of anticipation time, allowing the officials in the field of emergency management to take the necessary measures to protect people's lives and assets, as well as socio-economic objectives. In the operative procedure for elaborating flash floods warnings, the following informations are used from: national network of hydrometric stations, meteorological radar products, Romanian Flash-Flood Guidance System (ROFFG), South East European Flash-Flood Guidance System (SEEFFG), European Flood Awareness System (EFAS). The purpose of this paper is to present the mail informations used in operative procedure to elaborate flash flood warnings, analyzing the case study on the event produced on 30 June 2018 in the Trotuș River Basin.

Keywords: Flash Floods, Forecasts, ROFFG, SEEFFG, EFAS

1. INTRODUCTION

Climate change and global warming are complex topics of great importance, studied with interest at national and international level (Ardelean, 2008, Solomon et al., 2009, Trenberth, 2007). Climate variability, caused by hot air advections of different origins, is also manifested in the Trotuș River basin, with negative economic and social consequences. The maximum flow is mainly determined due to the abundant precipitation and snow melting water. Among the determining factors can be mentioned: the climate, the surface and shape of the hydrographic basin, the soil, the use / coverage of the land, etc. (Roșu, 1973; Pișota et al., 2005).

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2. GENERAL GEOGRAPHICAL CHARACTERISTICS OF THE TROTUȘ RIVER BASIN

Trotuș is a river with a length of 162 km, which is located in the eastern part of Romania. It springs from the Ciuc Mountains, at an altitude of 1380 m, and flows into the Siret River crossing the Bacău and Vrancea counties. The hydrographical basin, with an area of 4456 km² (Fig. 1) overlaps the central-eastern part of the Eastern Carpathians and the Sub-Carpathians of Moldova.

Fig. 1. Trotuș River basin – hydrographic network

This development influenced the evolution of the Trotuș hydrographical basin by giving it specific morphological and morphometric features (Roșu, 1973). The relief, due to its geomorphometric features (altitude, relief, relief fragmentation density etc.), has a major influence on the formation of water resources and on the reception, accumulation and control conditions of rainfall and snow melting.

Table no. 1 presents some main morphometric data on the analyzed river basin.

Table 1. Morphometric data, Trotuș River
(source: *Atlasul Cadastrului Apelor din România, 1992*)

Length (km)	Altitude (m)			Average slope (%)	Sinuosity coefficient	A (Km ²)	Forest found area (ha)
	Upstream	Downstream	Average				
162	1380	79	706	8	1.54	4456	241737

Note: A = area

From the spring to the confluence with Siret, Trotuș receives the following important tributaries: on the left: Asău, Tazlău and on the right: Sulța, Ciobănuș, Uz, Dofteana, Oituz and Cașin (Fig. 1).

3. DATA AND METHODS

This paper presents an analysis of the current possibilities for elaborating flash floods warnings, using as a case study the flood produced on 30 June 2018 in the Trotuș River basin. The operative procedure for elaborating flash floods warnings is based on:

- Precipitation rates estimated/measured in the National hydrometric and meteorologic station networks registered during the analyzed period, used in the operative activity for real time validation of radar precipitation.
- Weather radar products (precipitation amounts recorded in real time, rainfall accumulations of 1 to 3 hours, predicting the direction of movement of cloud systems which generate heavy rains).
- Romanian Flash Flood Guidance System products (ROFFG).
- South Eastern European System Flash Flood Guidance products (SEFFG).
- European System Flood Awareness products (EFAS).
- Floods recorded at five representative hydrometric stations from Trotuș river basin: H.S. Vrancea, H.S. Onesti, H.S. Tg. Ocna, H.S. Goioasa, H.S. Lunca de Sus.
- Other data used to complete the study are the reports of damages received from the territory.
- In order to process the data, the following software packages were used: GIS, EXCEL and CAVIS - to determine the specific elements of the flood wave.

Data from five representative hydrometric stations within the basin: Lunca de Sus, Goioasa, Tg. Ocna, Onești, Vrancea were analyzed (Table 2).

Table 2. Morphometric and hydrological data on the maximum flow of the Trotuș River at five hydrometric stations (data source: INHGA database)

River	H.S.	A Km ²	H med m	Q.A. m ³ /s	Q.I. m ³ /s	Q.P. m ³ /s	Q max 30.06. 2016	Hmax 30.06. 2016	Obs.	C.A. cm	C.I. cm	C.P. cm
Trotuș	Lunca de Sus	89.2	1140	6	15.6	34	25	150	+30 C.I.	80	120	200
	Goioasa	765	1052	168	246	416	133.5	175	-	200	250	350
	Tg. Ocna	2091	924	305	590	740	512	324	+74 C.A.	250	350	400
	Onești	2836	830	457	641	1256	959	460	+60 C.I.	350	400	500
	Vrancea	4077	734	797	1175	2220	2402	520	+20 C.P.	350	400	500

Note: H.S. = hydrometric station, A = area; H med = the average altitude of the river basin; Q.A. = flow of attention; Q.I. = flood flow; Q.P. = risk flow; Q max = maximum flow; H max = maximum level; C.A. = attention level; C.I. = flooding level; C.P. = danger level.

Data on the precipitations recorded during the analyzed period were, also, studied (Table 3).

Table 3. *The amounts of rainfall accumulated during 28-30.06.2018 in Trotuș River basin (data source: INHGA)*

Hydrometric station	Precipitations l/sqm	Recording period	Mean precipitation in Siret basin – Bacau county (l/sqm)
Gura Văii	105,5	28-30.06.2018	125,3
Lucăcești	167		
Scorțeni	148,5		
Asău	123,5		
Cireșoiaia	137,8		
Haloș	140,7		
Măgura	134,7		
Bacău (Bâmat)	51,6		
Cremenea	121,9		
Ferăstrău	121,7		

The montly amount of precipitations in Romania, in June 2018 is shown in the map below (Fig. 2).

Fig. 2. *Precipitation amount in Romania – June 2018 (data source: ANM)*

The total rainfall in June 2018 (Fig. 2) had values greater than 100 mm in most regions of the country. The largest quantities, more than 150 mm, were recorded mainly in hill and mountain areas.

4. RESULTS

Hydrology International Dictionary defines "flood" as an increase, in a relatively short time, of the water level of an river to a peak, where the water level returns to a slower pace (WMO, 2011). The flow variation of the Trotuș River at the five analyzed hydrometric stations are plotted as graph (Fig. 3) and also the characteristic elements of the flood waves produced on 30 June 2018 are shown below.

Fig. 3. Characteristic elements of the flood waves produced on 30 June 2018, Trotuș River basin, at five hydrometric stations (data source: INHGA)

Based on increased atmospheric instability and high soil moisture conditions, indicated both by the Radar products of the used systems and by the dedicated products for flash floods, significant quantities of precipitation were recorded in the hydrographic basin of Trotuș River on 30 June 2018, with cores of approximately 100 mm (Fig. 2).

These have led to the exceeding of the danger level on the Trotuș river at Vrânceni hydrometric station (CP + 20 cm) and of the flood level at the Onești hydrometric station (CI + 60 cm) and Lunca de Sus hydrometric station (CI + 30 cm) (Fig. 3). Following the occurrence of this event, significant damage was recorded.

The radar products of the SEEFFG system and the national ROFFG system indicated the possibility of accumulation of significant amounts of precipitation in the study area and the imminence of flash flood discharge in small hydrographic basins related to it (Fig. 4 and Fig. 5).

Fig. 4. SEEFFG products – national level (data source: INHGA)

Fig. 5. ROFFG products – Siret River basin (data source: INHGA)

At that time, the specific products provided by the EFAS system indicated the possibility of floods in the Trotus River basin, as shown in Fig. 6 and Fig. 7.

Fig. 6. Flood probability > 48hr (26-27.06.2018 - 12 utc) (data source: INHGA)

Fig. 7. Flood probability < 48hr (28-29.06.2018 - 12 utc) (data source: INHGA)

4. CONCLUSIONS

Floods are dangerous hydrometeorological events, resulting from excess rainfall, being considered natural disasters, that affect society and the environment, causing direct or indirect economic damages (Stănescu, V., Drobot, R., 2002)

The event produced on 30 June 2018 in the Trotuș River basin was anticipated by all three forecasting systems used in the operative activity. The radar product of the ROFFG and SEEFFG system reported uniform precipitation amounts over the entire surface with cores of approximately 35-50 mm/24 hour for the study area. Also, FFG, the main product of the ROFFG system, indicates the total volume of rainfall over the given duration which is just enough to cause bankfull flow at the outlet of the draining stream. indicates low values. At the same time, the product of

estimating the possibility of producing rapid floods – FFT (Flash flood threat) indicates high values. With regard to the EFAS system, both products dedicated to flash floods suggest a great potential for producing a rapid flood in the Trotuș catchment area. Consequently, based on this information, INHGA issued orange code warning messages on 29 and 30 June 2018, at national level (Fig. 9) and local level (Fig. 10) targeting this high-risk area, and then this event would be confirmed on the basis of damage reports received from the territory.

The national meteorological administration has also issued an orange code warning that targets this area (Fig. 8)

Fig. 8. Meteorological warning at national level no. 44 - 30.06.2018 (data source: INHGA)

Fig. 9. Hydrological warning at national level no. 41 - 29.06.2018 (data source: INHGA)

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Cod PT-01-INH/A

AVERTIZARE HIDROLOGICĂ PENTRU FENOMENE IMEDiate
NR. 2 DIN 30.06.2018

Sursa: INSTITUTUL NAȚIONAL DE HIDROLOGIE ȘI GOSPODĂRIRE A APELOR, BUCUREȘTI		
Ziua/luna/anul: 30.06.2018	Ora: 10:50	Numărul mesajului: 2
Către:		
Ministerul Apelor și Pădurilor, Inspectoratul General pentru Situații de Urgență, Administrația Națională Apele Române, Administrația Bazinală de Apă: Siret, Sistemele de Gospodărire a Apelor: Harghita, Bacău, Covasna, Neamț.		
<p align="center">FENOMENELE VIZATE:</p> <p align="center">Scurgeri importante pe versanți, torenți, pâraie, viituri rapide pe râurile mici cu posibile efecte severe de inundații locale și creșteri rapide de debite și niveluri cu posibile depășiri ale COTELOR DE PERICOL</p>		
<p align="center">Bazine afectate:</p> <p align="center">Trotuș</p>		
<p align="center">MOMENTUL PRODUCERII FENOMENELOR VIZATE:</p> <p align="center">Data: 30.06.2018 ora 11:00 – 30.06.2018 ora 24:00</p>		
<p align="center">COD ROȘU</p> <p>Ca urmare a precipitațiilor înregistrate în ultimele ore, a celor prognozate și propagării, se pot produce scurgeri importante pe versanți, torenți, pâraie, viituri rapide pe râurile mici cu posibile efecte severe de inundații locale și creșteri importante de debite și niveluri cu posibile depășiri ale COTELOR DE PERICOL pe râurile din bazinele hidrografice: Trotuș, județele Harghita, Bacău, Covasna, Neamț.</p> <p>Fenomenele hidrologice periculoase se pot produce cu probabilitate și intensitate mai mare în bazinul inferior al râului Trotuș, aval s.h. Târgu Ocna.</p> <p>În funcție de evoluția fenomenelor hidrometeorologice vom reveni cu actualizarea prognozei hidrologice. Se impune urmărirea evoluției situației hidrometeorologice, în conformitate cu „Regulamentul privind gestionarea situațiilor de urgență generate de inundații, fenomene meteorologice periculoase, accidente la construcții hidrotehnice, poluări accidentale pe cursurile de apă și poluări marine în zona costieră”.</p>		
Intocmit, Nicolae TUDORACHE		Aprobat, Director C.N.P.H. Dr. Marius Mătreacă

COD GALBEN: Risc de viituri sau creșteri rapide ale nivelului apei, neconducând la pagube semnificative, dar necesită o vigilență sporită în cazul desfășurării unor activități expuse la inundații. Depășire COTE DE ATENȚIE;
 COD PORTOCALIU: Risc de viituri majore generatoare de revărsări importante care pot conduce la inundarea de gospodării și obiective social – economice. Depășire COTE DE INUNDAȚIE;
 COD ROȘU: Risc de viituri majore care necesită măsuri deosebite de evacuare a oamenilor și bunurilor, restricții la folosirea podurilor și căilor rutiere, precum și luarea unor măsuri deosebite în exploatarea construcțiilor hidrotehnice. Depășire COTE DE PERICOL.

Fig. 10 - Hydrological warning, Trotuș River basin, no. 2 - 30.06.2018
 (data source: INHGA)

The maximum flow impact on society is primarily reflected in material assets, with the negative effect of even loss of life. During floods the infrastructure (buildings, roads, railways, bridges etc.) is affected, the soil - by washing, erosion

and sliding, water - by contamination. Social and economic activities are also affected, as well as transport and telecommunications.

On the basis of the operational report on the effects of the dangerous hydrometeorological phenomena produced during the analyzed period, there are there are hundreds of households flooded, 8 flooded houses, one isolated village due to a damaged bridge, tens of kilometers of flooded streets, 17 bridges, 34 damaged bridges, 1 destroyed bridge, 30 isolated families, a flooded wastewater treatment plant, 7 persons evacuated, 4 flooded economic targets, 40 dead birds, tens of hectares of flooded land, fountains, etc.

Among the causes that have led to these phenomena are mainly included torrential rainfall, leakage from the slopes, overflows.

Regarding the actions and interventions for diminishing the effects of the dangerous hydrometeorological phenomena undertaken by SGA Bacau it can be mentioned: stopping the floods caused by the Bârnat River, through elevation of banks in certain areas, in Călcâi village (Oituz village) ISU Bacau and CLSU Oituz, have acted for the execution of a temporary bridge.

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