SEVERE FLASH FLOODS IN SLOVAKIA, JULY 2016

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ABSTRACT

Floods are the most common and widespread of all weather-related natural disasters. Flash floods are the most dangerous floods because of their high speed and unpredictability. In summer they are usually caused by heavy storms, and thus occur in a short time and on small areas, which makes their forecasting challenging. Urban areas, especially, face severe flooding as the impervious surfaces capture all the rainfall and sewer systems have often difficulty to drain water that runs off.

Storms with heavy rainfall occurred in Slovakia at the end of July 2016 causing local flooding of several cities. The extreme precipitations reached the historical maximum in several rain gage stations. There were meteorological and hydrological warnings for intense rainfall and flash floods issued by Slovak Hydrometeorological Institute. Flash floods caused flooding of streets, several family houses and other buildings, gardens, cellars, public sites and roads, and damage of electric supply lines.

This study is focused on hydrological phenomena of flash flood, its causes, forecast, development, and consequences, with a target on events in late July, 2016.

Keywords: Flash flood, rainfall, intensity

1. INTRODUCTION

Flash floods, in comparison to other types of floods, represent a higher risk namely because of its abrupt increase of water level (several meters per hour) and flow speed. Attendant phenomenon to flash floods is often a presence of strong wind and hail, which may result in intensive erosion and mud floods. The crucial factor here is therefore a short time for warning the citizens. A special type of flash floods is an urban flood, where due to very intense precipitation, flooding is not caused by the rise of water level, but by the insufficient capacity of urban sewerage.

The development of floods is influenced by the type of soil and saturation of the basin. In the case of low-permeable subsoil, the soil does not absorb large amount of water, the stream erodes river banks and often carries other objects that can cause obstructions, block the bridge passages and channels.

If flood occurs in lowland areas, as it is in our case in Komárno, where the street rain drains could not drain away extreme volumes of water, the streets and public spaces are flooded. In smaller villages, water gets into yards, floods cellars and, in worse cases, floods houses, reaching a height of several ten centimetres.

2. LOCATION

This article deals with such a situation in three different locations in Slovakia. The first event occurred on July 29, 2016 in the town of Revúca, which lies in the south-eastern part of the Slovak Ore Mountains, at the intersection of the Stolica Mountains and the Revúcka Vrchovina. It is situated on the confluence of the Zdychava and Muráň Rivers. Two days later, on July 31, 2016, the situation occurred from 12 am to 3 pm in the village of Kremnické Bane and the city of Komárno. The Kremnické Bane village is situated in the valley of the Kremnica Mountains, at an altitude of 700 to 800 m a.s.l., and a local Kremnický Creek flows here. The Komárno city is located in the lowlands in the south of Slovakia and the Danube River runs through the city. The different locations of the three events confirm the geographical variability and the unpredictability of the phenomenon that can occur anywhere.

In Komárno on the Danube River there is a gauging station that recorded low water levels during this period and thus did not expect fluvial flooding. In the town of Revúca there is a gauging station, which recorded only a short-term mild water level rise of 20 cm, which is below the 1st degree of flood activity. There is no gauging station in the village of Kremnické Bane.

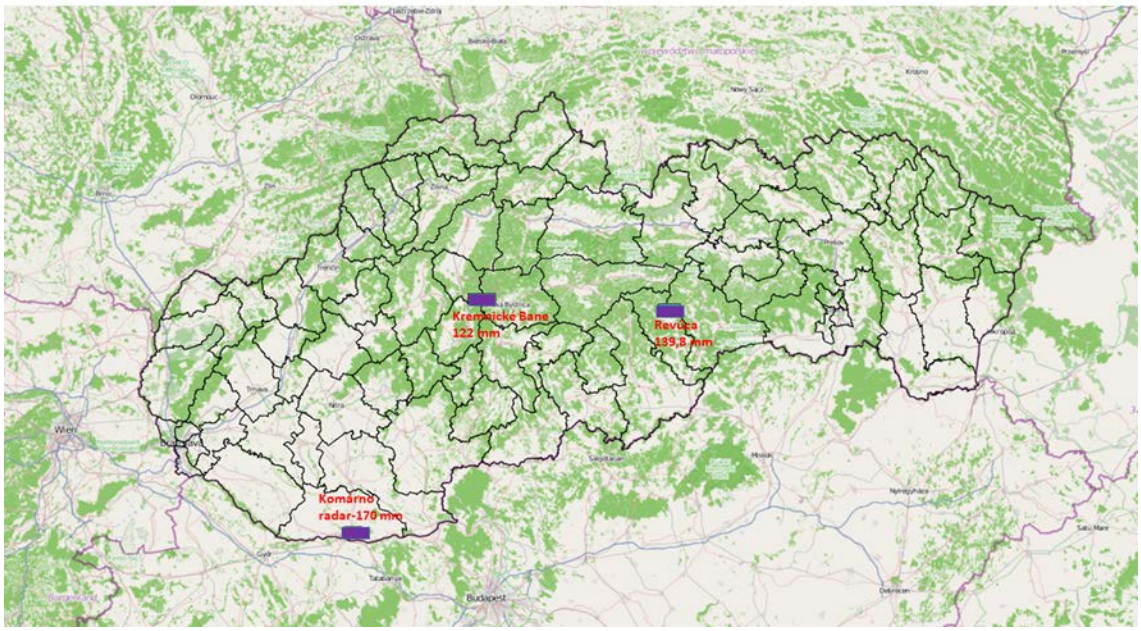

Fig. 1: Location – Komárno, Kremnické Bane, Revúca.

3. SYNOPTIC SITUATION

The territory of Slovakia was from July 25th to 31st in a damp and warm air mass. On Thursday, July 28, a cold front moved through our territory further east. In Friday, July 29, the cold front crossed the territory of Poland and by its southern border influenced the weather in our territory (initiated the formation of storms). On Sunday, July 31, another distinctive front moved to our territory from west. During the whole period, only a slight flow of air was in our area, which resulted in a very slow movement of storms, difficult to predict. The formation and further development of storms was

mostly linked to orthogonal obstructions, or cold air flow, which triggered the occurrence of another gust fronts in the vicinity.

4. PRECIPTATION

As the cold front has passed along, humid air stood in the south of the middle and southeast Slovakia on Friday, July 29. Conditions for the formation of intensive storms in our territory continued, supported by the cold front passing through Poland to the east. The intense and heavy rainfall that began in Revúca on July 29 at 15:48 and ended at 18:48 CEST was preceded by a stormy activity in the north-eastern part of the Stolica Mountains and the Revúcka Vrchovina as well as in the Volovské Mountains. There are data from two rain gauging stations in Revúca. The automatic precipitation station on the northern part of Revúca measured 112 mm of rainfall in three hours. At the rain gauging station located in the city centre, near the Zdychava stream, up to 139.8 mm in three hours (141 mm/ 24 hours) were recorded. The course of the rainfall event in Revúca is in Fig. 2, showing one minute precipitation totals. This represents the highest daily total in July in this locality since 1951, and corresponds to approximately 200 to 500 annual rainfall sums.

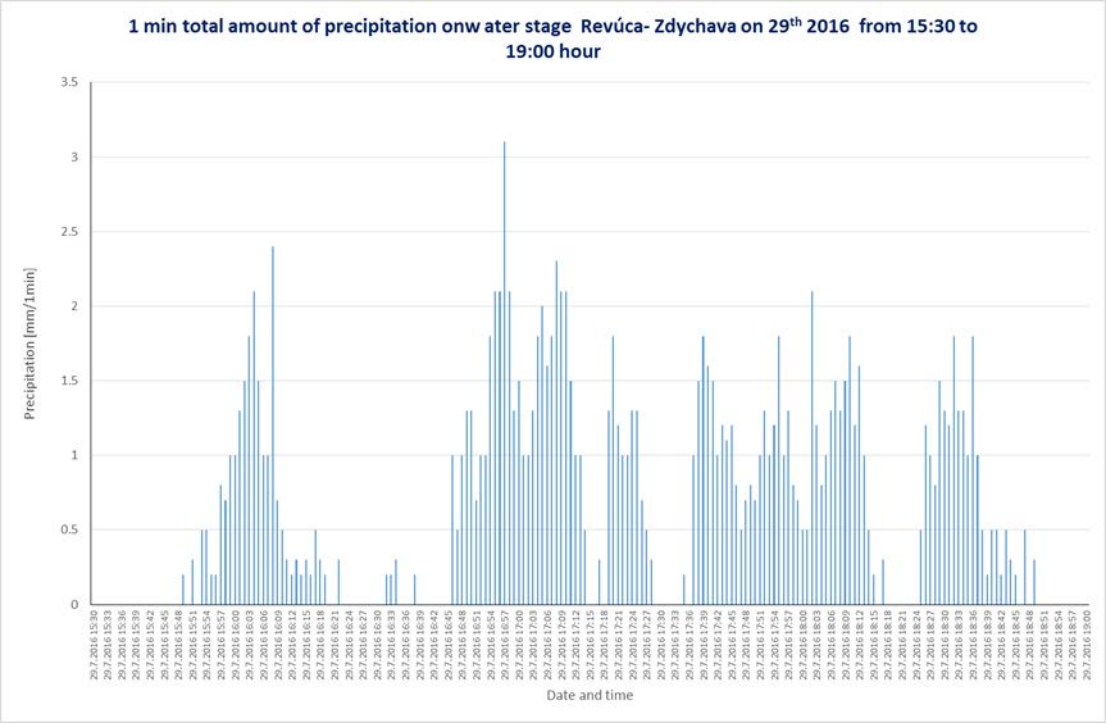

Fig. 2: Total amount of precipitation on July 29, 2016, Revúca-Zdychava.

Warm and humid air was moving thorough our territory on Sunday, July 31. On the last day of July, the cold front passed through the middle east of Europe to the east, thus creating convenient conditions for the development of intensive storms in several places. The most extreme was the stormy activity in mountains of Kremnica and also in the city of Komárno. An intense rain hit also the meteorological station in Kremnické Bane. The whole rainfall event began at 12:38 and ended at 14:44 CEST, with an

intense rainfall precipitation lasting until 13:57 (Fig.3). During this time four shorter rainfall periods occurred, during which precipitation reached the intensity of storm rainfall (> 2 mm/ min). Daily rainfall at this station reached 122 mm (72 mm per hour). Again, this is an extremely high daily precipitation, which has not occurred since 1951 in this area (Fig.4).

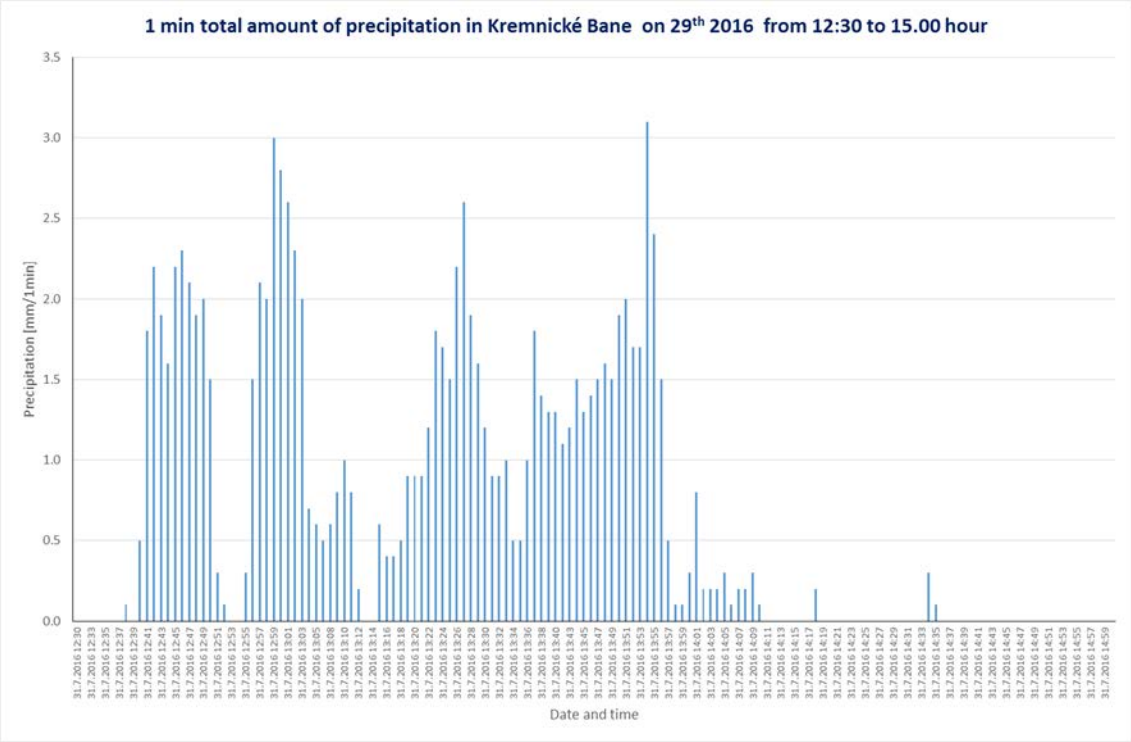

Fig. 3: Total amount of precipitation on July 29, 2016, Kremnické Bane.

An intense precipitation, hail, but also a strong wind went along with a storm in Komárno and nearby surroundings. The rainfall gauging station in Hadovce (northwest of the Komárno city) recorded a total precipitation of 47 mm per hour. In the evening and during the night, a cold front passed through our territory, on which a significant line of storms was created and hit Komárno. The total 24-hour precipitation reached 79.1 mm at this station. This is the highest daily precipitation in this locality since at least 1951. At the same time, much higher precipitation totals were recorded on the Hungarian side, in the Komárom city [4]. According to operational information from the INCA system, the daily precipitation total high exceeded 170 mm (probably more than 200 mm) (Fig.4).

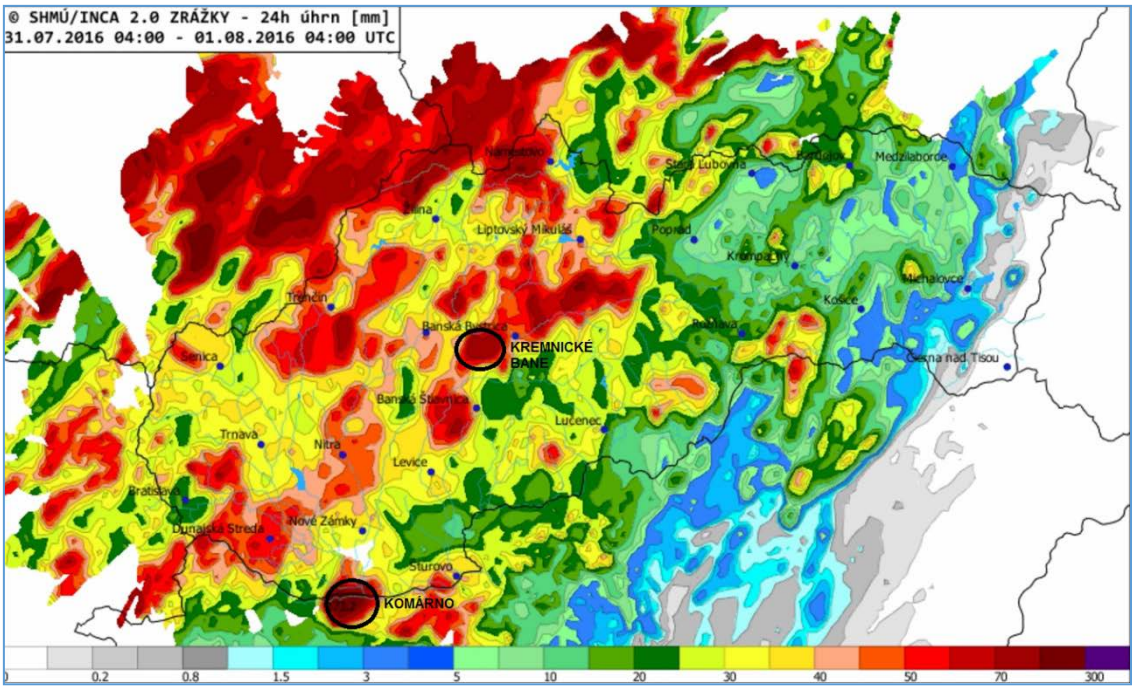

Fig.4: 24-hour precipitation totals in Slovakia on August, 1st, 2016 at 4 am UTC.

Difficulties in the localities were not caused by the precipitation totals, but by the short-term intensity of rainfall, when the land was not able to absorb the extreme volume of water, or flow away through the sewage system and nearby river.

5. FORECAST AND FLOOD NOTIFICATION

One of the main tasks of Slovak Hydrometeorological Institute (SHMI) is to alert flood authorities and the general public to flood risk. Time and space localization of possible storm rainfall is not a simple task. SHMI has a dense network of modern monitoring facilities, 4 new radars, meteorological and hydrological models, which make it much easier to predict storm rainfall. At the present, in the POVAPSYS project, a new flash flood forecasting system is being tested, based on the INCA precipitation analysis, ALADIN rainfall forecasts, and taking into account land saturation, geographic and soli properties, as well as land use.

The meteorological and hydrological warnings on affected districts were issued and continuously updated during the mentioned period for the danger of floods from storm rainfall. For the Revúca district, a weather warning of the first degree for storms (with a total of 20 - 40 mm) was issued on July 29, 2016 at 9:35 am CEST. According to the meteorological situation, the warning was increased at 15:10 CEST to the 2nd degree (with a total of 50 - 80 mm) and at 15:55 CEST to 3rd degree (with a total of 50-120mm).

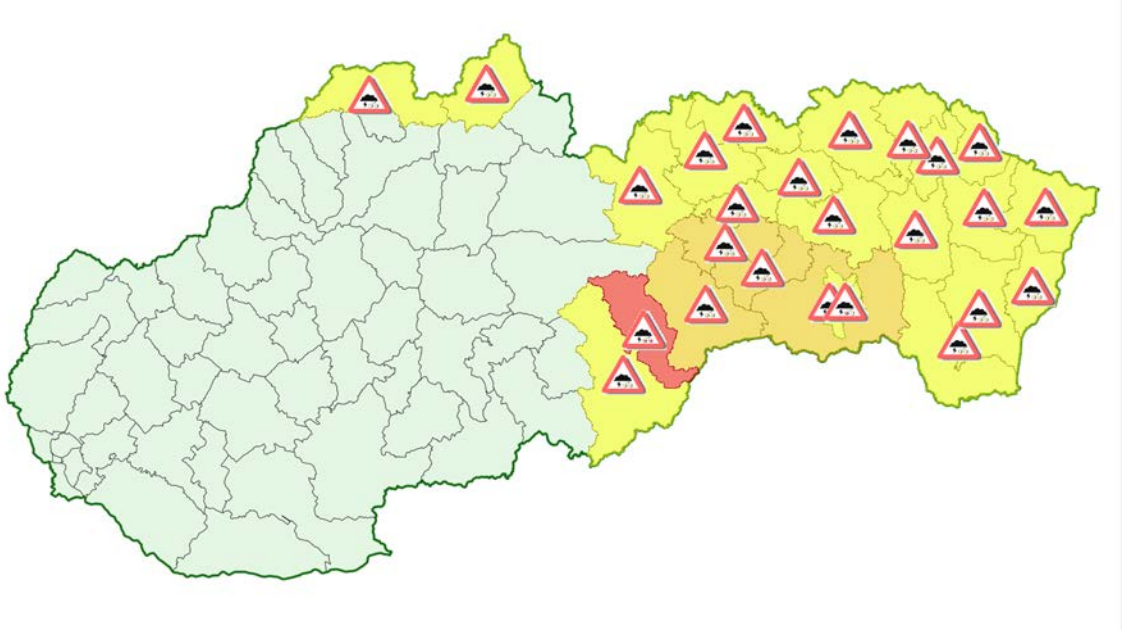

Fig. 5: Meteorological warnings, July, 29, 2016, at 16:00 CEST.

Because of the danger of a flash flood on July, 31, 2016, a hydrological warning of the 2nd degree for the Nové Zámky-South district, with effect from 12:30 CEST, was issued. Considering the development of the weather situation, a warning of the 2nd degree for the Žiar nad Hronom district was issued at 13:45, and a warning of the 2nd degree for the district of Komárno from 2 pm.

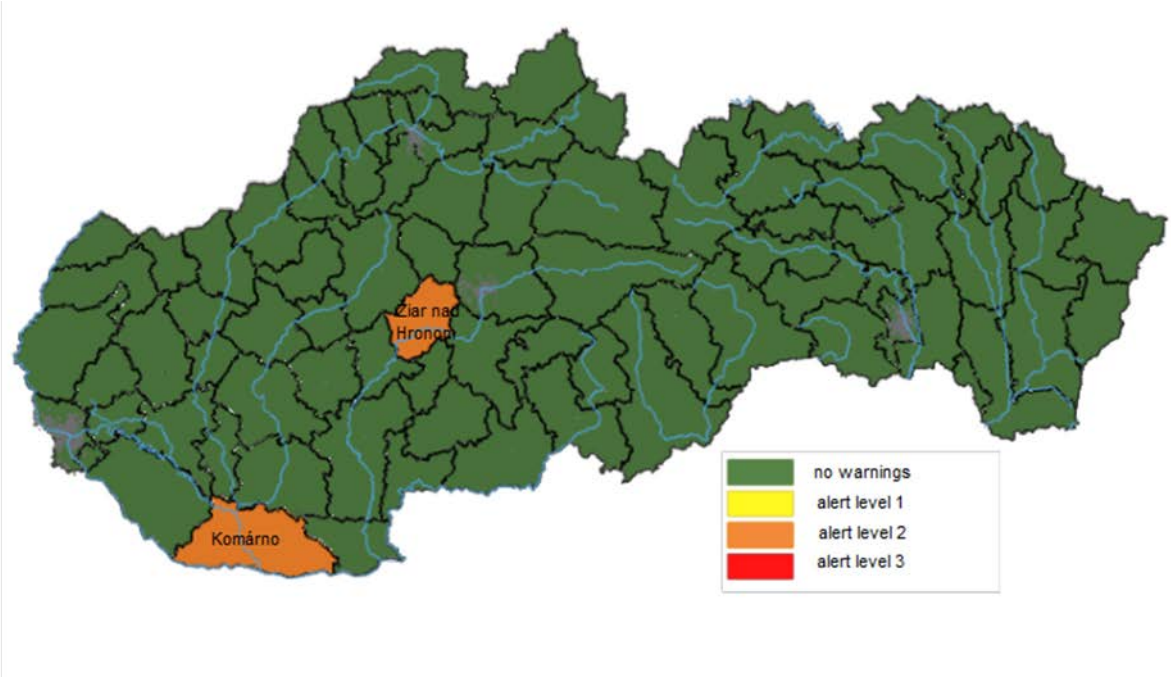

Fig 6: Hydrological warnings July, 31, 2016, 14:00 CEST.

Hydrological alerts of the 1st and 2nd degree for flash floods were issued from 14:00 to 14:30 also for the other affected districts (Turčianske Teplice, Banská Bystrica, Rožňava – 2nd degree and for the districts of Zvolen, Martin, Ružomberok, Brezno, Poltár, Rimavská Sobota - 1st degree).

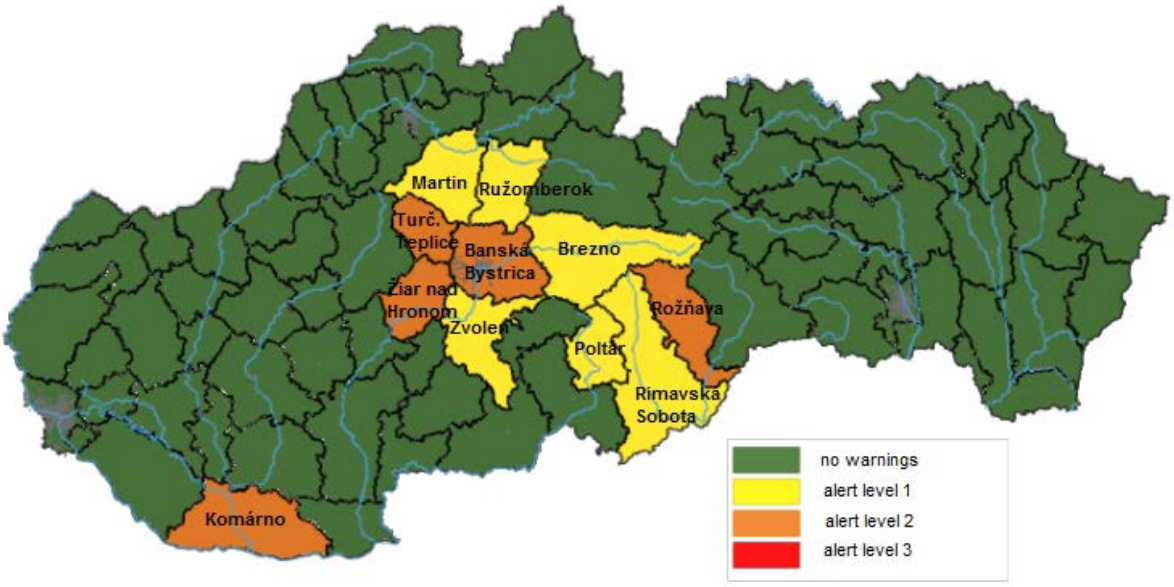

Fig 7: Hydrological warnings July, 31, 2016, 14:30 CEST.

After the evaluation of the Civil Protection reports, it can be stated that the hydrological warnings were issued in advance and the residents of the affected areas aware of the danger in time.

6. CONSEQUENCES

Extreme precipitations became quickly evident in the discussed localities. A report from the Emergency Response Coordination Centre (SVK ERCC) states that after the heavy storm rainfall, which hit the city of Revúca, local roads, cellars of family houses and residential homes were flooded by water and mud from the fields (Fig. 8) [1]. Based on this fact, the Mayor of the town announced 3rd degree of flood activity on July 29, 2016 at 6:30 pm. The city carried out rescue work by its own forces and resources with the help of state and voluntary firefighters. Population was warned by local radio. Water culverts and sewage drains have been clogged with flooded material during the intense rainfall and the streets have changed into water plane. Huge volumes of water flooded streets and public spaces, e.g., parking lot in front of hypermarket Tesco (Fig. 9) [1].

Fig.8: Flooded yard, Revúca.

Fig.9: Hypermarket Tesco, Revúca.

Similar reports were received also from the village of Kremnické Bane, where the Mayor of the village announced the 3rd degree of flood activity on July 31, 2016 at 3:25 pm. There was an overflow of local creek and flooding of streets because of the storm rainfall (Fig. 10, and 11). Rescue works have begun immediately by the forces and means of the municipality [2, 3].

Fig.10: Strong rain undermined the main road that leads through Kremnické Bane.

Fig.11: The first class road between Žiar nad Hronom and Turčianske Teplice, which runs through Kremnické Bane, was closed for several days.

The most serious situation was in Komárno. Mayor of the city announced, together with an extraordinary situation, the 3rd degree of flood activity on July 31, 2016 at 3:35 pm. The storm rainfall caused flooding of streets, underpasses, garages, cellars, courtyards, industrial parks, and family houses (Fig. 12). There was uprooting of trees, a breakdown of the branches, which resulted in the tearing of the electricity lines and failure of the electricity supply. The units of the District Directorate of the Fire and Rescue Corps and the District Police Forces, volunteer firemen of Komárno city and volunteers were engaged.

Fig.12: Streets flooded in the town of Komárno.

Damages by wind were recorded in the Komárno city. Despite the many firefighters, residents had to help as they knew.

7. CONCLUSION

The issue of predicting extreme storms and associated flash floods with precise time and space determination is the task of meteorological and hydrological services. The detection of meteorological and hydrological conditions for the formation of storm rainfall is a common practice, but with respect to the speed of the convective cloud development, precise localization and predicting the duration and intensity of the storm rainfall is almost impossible. It is very difficult to prevent such floods, but to warn the population before the occurrence of such an event by issuing a good and timely warning is the main task of the SHMI flood forecasting service.

The role of the various flood protection authorities is to respond to such a warning in a time and to take all measures that can mitigate its consequences.

The municipalities themselves, in cooperation with the river and sewerage manager, can prepare themselves for such situations by appropriate water management measures, such as cleaning of rills, rain gullies and watercourses, thus maintaining the land in such a condition that the water can flow smoothly and do not block the runoff from the river basin.

Due to various scenarios of a climate change that anticipate an increase in air temperature and a more frequent occurrence of extreme weather events, we can expect more frequent flash floods, therefore it is important for the specialists to pay increased attention to this issue and take such measures, which would mitigate their devastating consequences.

8. REFERENCES

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