The Use of Flood Simulator POSIM for Creation Flood Plans

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Abstract: The content of the article is focused on the information support used for the creation of flood area plans. In this article a specific study is realized for the middle reaches of the river Morava, and the lower and middle reaches of the river Becva, including parts of the river Vsetinska Becva. For the flood simulation was selected a flood simulator POSIM from T-Soft a.s.. At present, this flood simulator is used for teaching at the Faculty of logistics and crisis management of Thomas Bata University in Zlin. In the introduction, the justification is described for the use of a flood simulator POSIM. The second chapter describes the characteristics of the POSIM, including minimum technical software and hardware requirements for the operation. The third chapter of this application is indicated from the perspective of the average user in relation to the study of the selected area. In the next chapter is a brief description of the interest area. Five, twenty and one hundred year-flood are displayed from simulations in the discussion and summary of the results. Included in this chapter a comparison of the flood maps was performed by the POSIM with the flood maps by Morava River basin and maps from Digital flood plan of the Czech Republic.

Keywords: flood simulation, floodplains, crisis management, flood plans

1. Introduction

At present, the world is facing threats and impacts of global warming that it has an impact on a wide range of processes and phenomena not only in nature but also on human activity. One of the global warming manifestations is the increasing number of extreme phenomenon occurrence caused by the weather. Between these extreme phenomena include flash floods accompanied by strong thunderstorms with torrential rainfall and hailstorm. These flash floods can cause for a short period on a local section of a small watercourse spilling water. It occurs to spring floods caused by melting snow due to a sudden and steep rise in combination with strong rain precipitation in the Czech Republic. Approximately eight flood situations hit the Czech Republic for the past twenty years. On the basis of the statistics outputs show that the number of these extreme phenomena and situations will continue to increase. It will have a serious impact on all aspects of human activity. [3]

Wide range of software tools for flooding modeling and simulation are used for graphic processing of the flood plans. These software tools are determined to render the surfaces in the graphics section of the floodplains in the flood plans. This is in particular the hydrological and rainfall-runoff models which it contains complex mathematical apparatus. Overwiew of these models is in Table 1:

The name of the model	Status variables	Time series	Input/output	Price
POSIM	river network topology, the parameters of objects	water flow rate, water stocks	graphical and tabular view, Google Maps	According to offer T-Soft Prague http://www.tsoft.cz/posim
MIKE-SHE	river network topology, the roughness factor, cross-section trough, topographic wind vector, object parameters	water flow conditions, the position of the caps, side tributary	graphical and tabular views, browser MIKE View, MIKE GIS, Arc View	According to offer (dhi.cz) Hydroform DHI
HYDROCHECK	river network topology, the roughness factor, cross-section trough, topographic wind vector, object parameters	no	graphical and tabular view, transfer to CAD (AutoCAD), ArcGIS-render flood lines	According to offer Hydrosoft Prague (hydrosoft.cz)
HEC-RAS	the same as for MIKE-SHE,	hydro technical buildings, runoff	graphical and tabular view of	freely available at usace.army.mil

	hydrograph flow, water conditions, depths and the measurement curves profiles	management breakthrough dam, water flow conditions, the position of the caps, side tributary	the HEC-GeoRAS, ArcGIS, ArcView GIS, AutoCAD, the RMS and HEC-HEC-RiverCAD	
FLDWAV	mostly identical to the HEC-RAS	mostly identical to the HEC-RAS	no	freely available at nwsrfs.com
Sacramento (SAC-SMA)	evapotranspiration, bound and free water, horizontal and vertical drainage	hydrological characteristics of soil	Aqualog, binding model SNOW17, trough model TDR, management of reservoirs MAN	unlisted

Table 1: Comparison of parameters POSIM with other hydrological and rainfall-runoff models

Floodplains was simulated by flood simulator POSIM in the framework of the thesis on the topic of "The Simulation and Modeling Use in The Processing of Flood Plans". The simulation was realized at the Faculty of logistics and crisis management in Uherske Hradiste at Tomas Bata University.

The simulation is related to the area of:
- the middle flow of the river Moravia (town Kromeriz – confluence of the river Moravia and Becva),
- the lower and middle reaches of the river Becva (village of Troubky, Prerov – Valasske Mezirici) and
- the lower reaches of the river Vsetinska Becva (village Jarcova).

One of the main reasons for selecting this specific territory was the fact of frequent occurrence of floods in the past in the area of the confluence of the rivers Morava and Becva. The output of the work was compared to the flood maps from the flood simulator POSIM with data obtained from Morava River basin. For a full extent comparison of floodplains was used digital flood maps from Digital flood plan of the Czech Republic. [4]

2. Characteristics of flood simulator POSIM

Flood simulator (POSIM) is a Web application, which is used for water states and flow rates modeling, and their consequences caused by natural flooding (not intended to simulate flood for example when water burst embankments).

POSIM offers two basic functions:
1) The current (real) status with the actual situation of water stages and flow states in the watercourse map background.
2) Simulation with artificial environment, where we can edit the actual data for the individual water states, and water flow rates. Here we can see the consequences that artificially induced condition causes.

Flood simulator POSIM allows on the basis of these two features:
- Watch the emergence and spread of natural floods,
- Visualize the situation including the prediction of the impacts can be based on:
    - Real state and
    - Artificially induced state.
- Processing data from the individual measuring stations

We can visualize data through a browser Google maps in POSIM or in tables. All the data from hydrometric stations and flood maps were provided by Morava River basin. [1],[2]

2.1. SW and HW requirements

The minimum technical requirements for the operation of flood simulator POSIM are:
- Servers: processor-1 x Intel ® Xeon ® X5260 with dual-core 3.33 GHz X5260, (possibility of mounting two pieces), 4 GB RAM, 4 x.
- Application and database server (SQL database). This software tool supports Czech language mutation.
- Workstation: PC: C2Q N9800GT Q9400/4 GB/1 GB/1000 GB 7.2 k/15v1/BD/WF/A + D TV + to/VIS HP 64 bit. [1]

3. Description of the application in relation to a simulation of the flood on the river Moravia and Becva

In the context of this article, we wanted to point out the use of a flood simulator POSIM focused on study area. First, the user launches the Web browser, where to write the address in the address bar. This address is typically assigned by the application administrator. [1]

In the navigation menu, we have a choice of five essential items:

1) **Home** – we can find a brief description of the application POSIM in this section.

2) **Current status** - we can view the current flood situation on the basis of selected flood maps. These maps are data about water states and flow rates measured on the profiles of the watercourse. Furthermore, we can see the individual crisis management objects which are part of the database information system Emergency Office (EMOFF)[1] Individual objects are identified by shapes and colors according to their danger degree of the flood situation. [1]

3) Two options of flood simulation scenarios are available to choose from the bookmark "**Simulation**":

    a.   *Flood map* is a graphical output parameter of settings on the simulated stations. The advantage of the flood maps is the ability to edit data for each water states and flow rates. After editing we can observe the consequences that this situation causes. It is mainly about the simulation of historical flood maps which varies depending on the change of water states and flow rates.

    b.   *Individual objects* – we can simulate the flood situation and watch submersion of individual objects Crisis Management based on the change parameter of water states and flow rates. These objects are stored in a database system EMOFF. These two objects of Crisis Management were selected in the framework of the simulation for the river Morava and Becva: [1],[3]

        -   HZS ZK-ÚO surroundings of the town Kromeriz

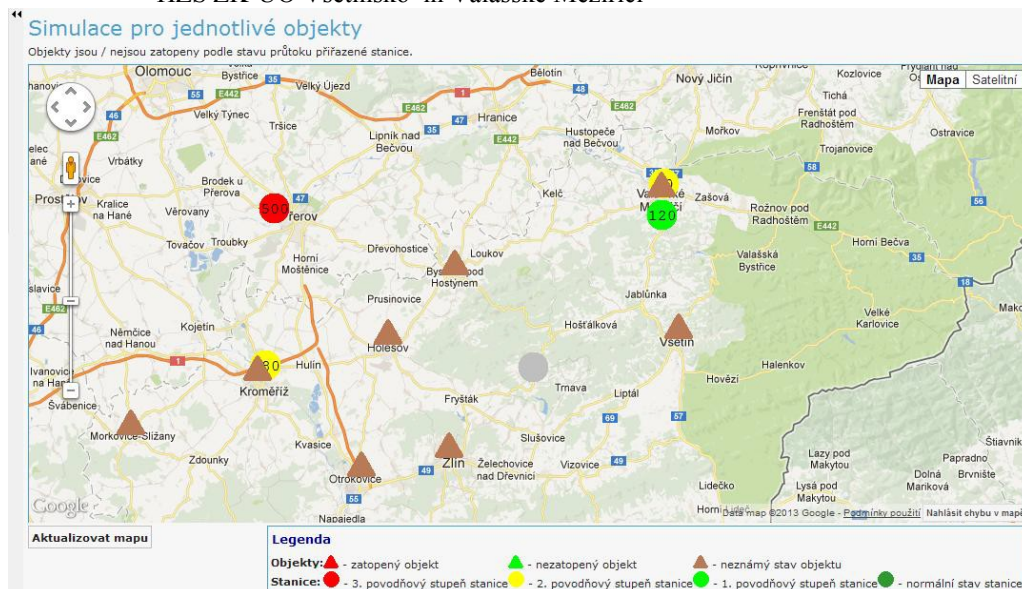   -   HZS ZK-ÚO Vsetinsko in Valasske Mezirici

Fig. 1: Flood simulator POSIM – Flood simulation for individual objects [3]

4) Bookmark **The Station** provides two databases of measuring stations:

    a)   *The real station* - Overview of the real measurement stations in selected watercourses in the tables showing the names and IDs of the stations, the height of the surface watercourses and flow rates for each water state flood activity (0, 1, 2, 3, and unknown status). These data cannot be edited for the actual stations.

    b)   *Simulated station* - Overview of artificial (virtual) measurement stations on the watercourses. We can edit data for simulated stations so that we take the values from the actual stations. [1],[3]

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[1] EMOFF (Office) - Web application is designed for:

    -   Analysis – determination of the type of threat and the impact on infrastructure and population

    -   Planning – technical personnel and security, planning, operational plans for dealing with emergencies

    -   Emergencies – monitoring of persons and their tasks to the extraordinary event and the implementation of solutions to a predetermined set of procedures and measures, reporting on the state of development of a given situation, etc. **Chyba! Nenalezen zdroj odkazů.**]

The name of the station	The name of watercourse	Region/Municipality	Zero gauge	Q_1	Q_5	Q_{10}	Q_{50}	Q_{100}
Kromeriz	Moravia	Zlin/Kromeriz	184,14	341	512	589	776	860
Prerov	Becva	Olomouc/Dluhonice	200,7	239	466	564	792	892
Valasske Mezirici	Roznovska Becva	Zlin/Valasske Mezirici	0	66.5	161	214	364	441
Jarcova	Vsetinska Becva	Zlin/Vsetin	293,88	151	274	333	479	547

Table 2: The data of water flow rates for simulated station [3]

N-year flood	Kromeriz (h-cm/Q-m^3)	Prerov (h/Q)	Valasske Mezirici (h/Q)	Jarcova (h/Q)
5-year flood	550/380	600/500	240/80	250/120
the 20-year flood	550/380	900/800	400/250	320/170
100-year flood	700/600	900/900	500/350	400/250

Table 3: Data about the water height levels and flows rates for simulated station and 5,20 and 100-year floods[3]

The measurement date varies depending on when the Moravia River basin will supply information about the water states and flow rates. The most important variable parameter is the flow rate (in m^3) by which can change the flood map N-year floods. Mostly, we set it from ten units higher than the flow rate of the N-year floods. It is important that the flow rate does not depend on the degree of flood activity, although from a mathematical and physical principle is dependent. However, in this application is not dependent, and this fact must be taken into account, since the big then we are not able to correctly set the parameters so that they are correctly displayed the floodplain.

First, we choose one station from the interest area of the river Moravia and Becva (in our case Dluhonice in Prerov), where we set the flow rate in higher values when the desired flow rate of N-year floods. We have on the choice five, twenty and one hundred-year flood maps. We change flow rate dependent on the choice of N-year flood. Then we set the size of the levels and flow for the other stations depending on what you want to choose the degree of flood activities. The level of water at N-flood level (e.g. n = 1, 2, 3 flood stage) for fixed parameters corresponds the level of water flow setting in variables parameters. Likewise, this is also true for the flows in variables and invariable parameters. The parameters are always set as well as for the setting up of the N-year flood at least ten units.

The same procedure is repeated when setting up parameters for other N-year flood, thus the output incured by three flood maps with flood plain territory with different degrees of flood activities. The essence of the simulation in POSIM is the possibility of an optional set parameters depending on the degrees of flood activity and in particular the setting of flow rates parameters, where the application can use the database flow rates and levels to identify and render the flood plain territory area of the N-year floods. [3]

5) **Flood maps** the entire surface serves as a graphical application. Here we can choose a specific flood map for specified water flow N-year floods (5-year, 20-year and 100-year floods) [1]

4. Characteristics of interest area

Interest area was simulated through a flood simulator POSIM:
- the river Morava – the city of Kromeriz (Zlin region),
- the confluence of the Morava and Becva – between the villages Tovacov and Troubky (Olomouc region),
- the river Becva – the town Prerov, Lipník upon Becva, Hranice and Valasske Mezirici (Olomouc and Zlín region) and
- the river Vsetinska Becva (Valasske Mezirici- village Jarcova) [3]

Among the floodplain may include six areas on the river Morava and Becva:

1) *The area around the town Kromeriz to the river Morava-* in this lowland area is most affected by the left side of the river Morava in the eastern part of town Kromeriz. Floodplain one-hundred flood extends to the western edge of the town Hulin. The width of the floodplain at the one hundred-year flood is about 5-7 kilometers.

2) *The area between the towns Kojetin and the Chropyne* — this area is large and very flat floodplain twenty and five year-floods, which extend from the northern edge of the town Kromeriz to Lobodice. The width of the floodplain achieves up to 10 kilometers. This area has a lowland character, where extensive areas of fields and on the left bank of the river Morava are a floodplain forest.

3) *The area at the confluence of the river Morava and Becva between the villages Tovacov and Troubky* -in the lowland area occurs many lakes along the right bank of the river Morava in Tovacov where can take advantage of these ponds for flood waves mitigation. The width of the floodplain twenty and hundred-year-floods can reach up to 9 kilometers.

4) *The area of town Prerov on the lower reaches of the river Becva* – the width of the floodplain here is of such width (about a couple of kilometers) as the preceding areas in the Moravia River basin. However, in the case of hundred-year floods would have occurred to flooding two-thirds of the city Prerov.

5) *The area of the middle reaches of the river Becva* – this area relates to the towns Lipnik upon Becva, Hranice and Valasske Mezirici. To the city Hranice has mainly lowland character; in the area Valasske Mezirici is hilly, mountainous terrain with valleys to streams of subcritical type. The width of the floodplain here does not exceed more than 3 kilometers.

6) *The area of the lower flow the Becva* – in this area with Vsetínska Becva connects with the Roznovska Becva in Valasske Mezirici. Vsetinska Becva also flows through the municipalities of town Vsetin and village Jarcova and around it is spread over a large area of the highlands Hostynsko-Vsetinsko. Vsetínská Becva has the valley flow character and inflow streams of subcritical character. The width of the floodplain twenty and hundred-year floods reach 300-1000 meters. [3]

5. Results and discussion
5.1. Simulation of flooding for interested area
Flood maps were drawn up for each N-year floods on the basis of the flood simulation for the middle reaches of the river Morava and Becva. Blue areas are displayed for each floodplain; green triangles are objects of crisis management. Green, red and yellow circles represent the degree of flood activities depending on the set parameters. [3]
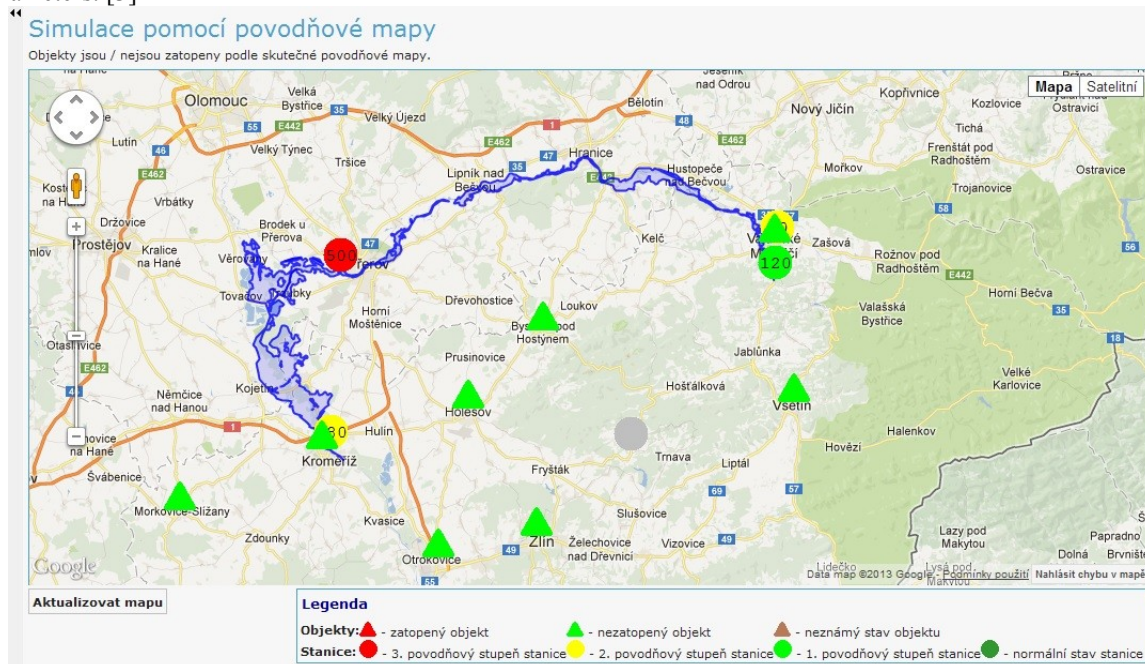

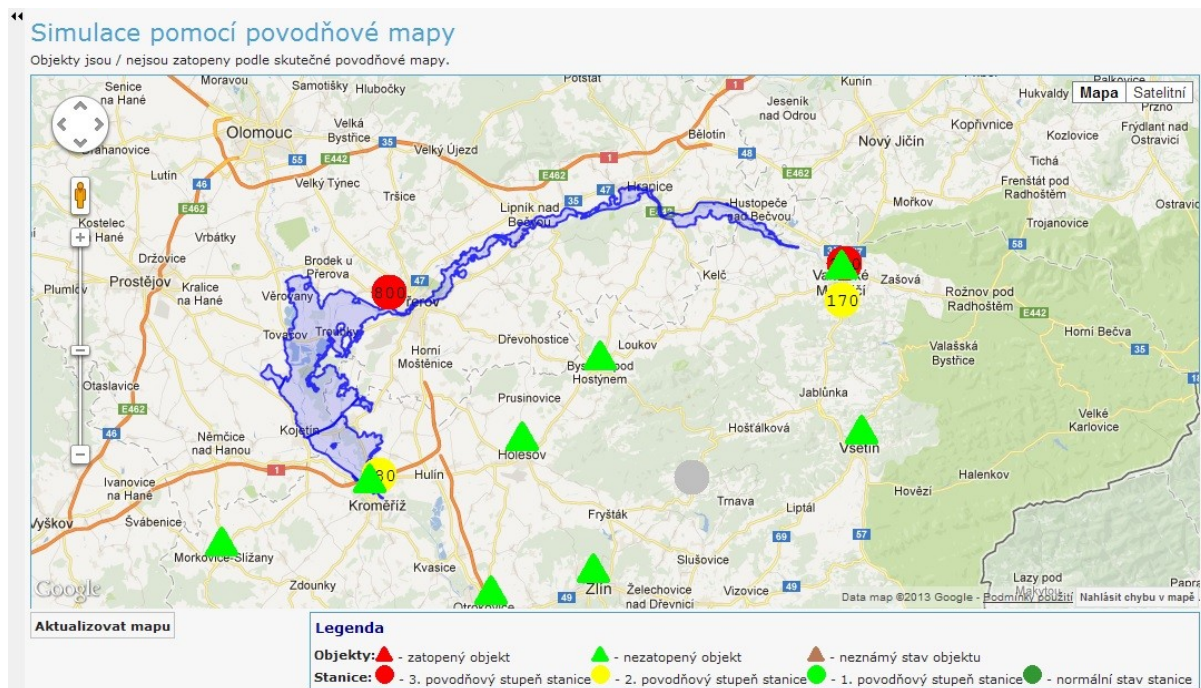Fig. 2: POSIM - Flood map five-year flood of the river Morava and Becva [3]

Fig. 3: POSIM - Flood map twenty-year flood of the river Morava and Becva [3]
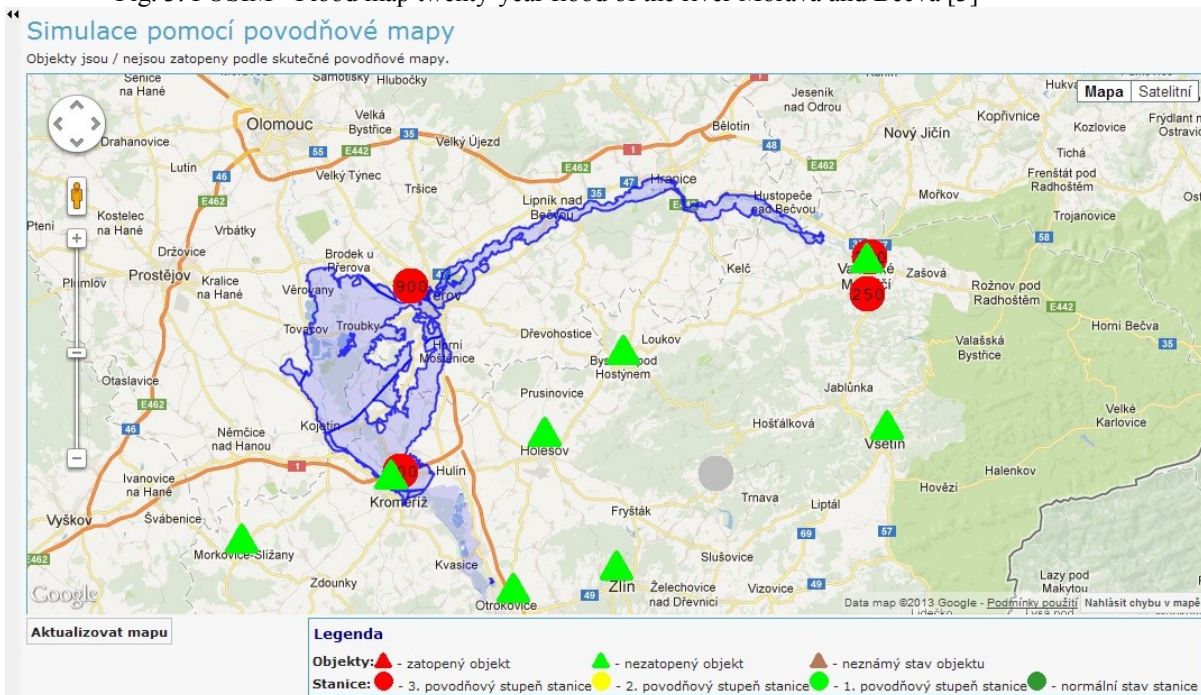

Fig. 4: POSIM - Flood map hundred-year flood of the river Morava and Becva [3]

Change the size of the increase in floodplain is seen depending on the number of years N-year flood. The most affected area is the middle flow of the river Morava from Kromeriz to the confluence of the Morava and Becva (village Troubky). Floodplain reaches widths of ten kilometers due to the low landed area characters. For twenty-years and the hundred-year flood is missing the rendering for the floodplains of town Valasske Mezirici and village Jarcova, because the programmers and the creators of applications from T-Soft did not have available information to program the rest of the floodplains. [3]

5.2. Comparison of flood maps

The digitization of the flood maps was carried out in the past years, including the digitization of the entire flood plans. The year 2013 was an important year to update flood maps, and due to we decided to create a flood simulation of the selected territory on the basis agreement with Ing. Iva Jelinkova from hydroinformatics and

Department of geodetic information Morava River basin in the city Brno. This simulation has to serve as a possible basis for a comparison of how the current flood maps, as well as for the processing of updated maps.
We received updated flood maps in the shapefile format from the Ing. Iva Jelinkova from Morava River basin. To this data format can open, it was necessary to download freeware version of ArcGIS Desktop and learn how to work in an environment of ArcGIS geographic information system. Then we opened these maps in ArcMap and could use the information obtained for the comparison with the flood maps generated by POSIM. [3]
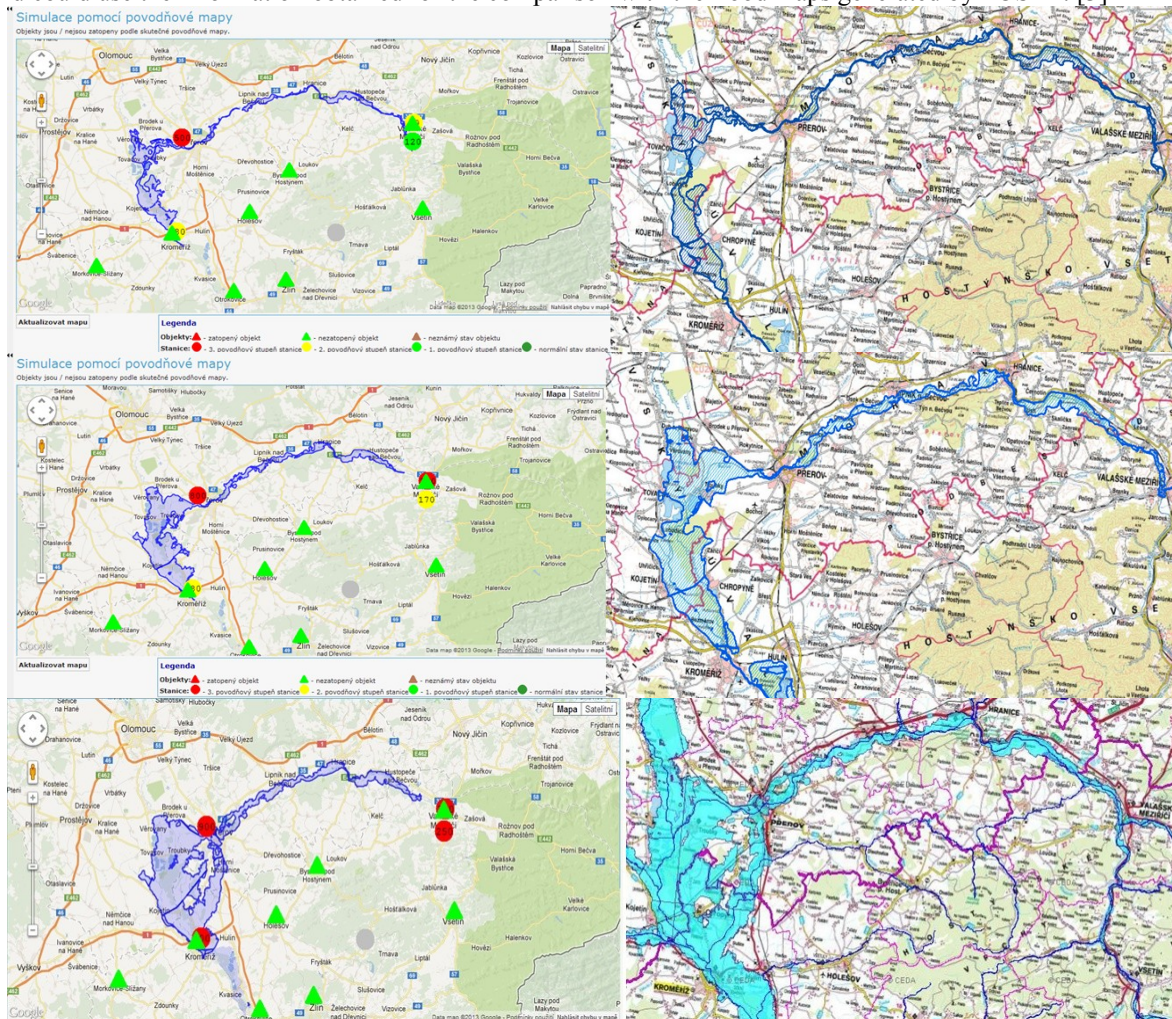

Fig. 5: Comparison of floodplain from POSIM and digital flood maps for flow rates Q_5, Q_{20} and Q_{100} [3]

The images in the left side are the flood maps generated by the flood simulator POSIM. The first two images on the right are the updated flood maps with floodplains of five-year and twenty-year- flood. Data were gained from these flood maps from Ing. Iva Jelinkova Morava River basin. Floodplain of hundred-year flood are shown on the last image on the bottom right and are taken from the digital flood maps Digital flood plan of the Czech Republic. The first two images are marked dark blue five-year floodplains flood. The other two images in the central part with the blue color represent floodplains of twenty-year floods and the last two with the cyan color are floodplains hundred-year floods. Table 4 summarizes information on the interest area of the rivers Morava-Becva, giving rise to small regional differences in the extent of flood areas. At five and twenty year-floods are possible to register flood reducing of floodplain compared to the previous state in the town Chropyne. In floodplains with flow rates Q_5, Q_{20} and Q_{100} for the river Becva were not compared the flood maps from Morava River basin, because the floodplains there were absolutely identical to the floodplains of digital flood maps Digital flood plan of the Czech Republic.[3]

The territory of the floodplains	River	Digital flood plan CR	Flood Simulator POSIM	
		The width of the flood area of the 100-year flood	The width of the flood area of the 100-year flood	Flood protection

the area of the town Kromeriz	medium flow of Moravia	to 7 km	to 6 km	Polder Bezměrov, embankment road
the area between Kojetin and Chropyne	medium flow of Morava	within 10 miles	to 8 km	floodplain forests, levees
the area between the villages Tovacov and Troubky	the confluence of the Morava and Becva	o 9 km	to 8 km	levees, channelization
the area of the city Prerov	the lower flow Becva	within 5 km	within 5 km	Polder Teplice, channelization
the area from the city Lipník upon Becva to Valašske Mezirici	the middle flow of the Becva	within 3 km	within 3 km	levees, channelization
the area of village Jarcova u Vsetina	the lower flow Becva	300-1000 m	-	channelization

Table 4: Summary of interest area Morava-Bečva

Conclusion

The output of the work was a flood simulation by flood simulator POSIM for the river Morava and Becva. Flood simulator POSIM was developed for teaching purposes at Faculty of logistics and crisis management in Uherske Hradiste. The output of this article should serve as a manual for students for quick and easy orientation in this application. From the results of the flood maps comparison obtained from Ing. Iva Jelinkova Morava River basin with flood maps generated by flood simulator POSIM shows that recently there has been a reduction in the area floodplains of the one kilometer outside the town Chropyne. In contrast, changes were not in the floodplains simulation on the river Becva. The biggest threat from the perspective of the flooded residential areas in cities and municipalities are primarily floodplains twenty-year and a hundred-year flood. From a historical point of view and the amount of the damage caused is that the worst of the municipality of Troubky at the confluence of river Morava and Becva. There had to be built very expensive comprehensive set of flood protection measures for maximum elimination of floods repetition in the following years. Very important flood alert measures to protect all the lower (town, Prerov) and part of the middle reaches of the river Becva is a proposal to build a polder Teplice.

Flood simulator POSIM is clear and the graphical environment, in which we can watch the current and future development of the flood situation. Its great weakness is a small selection of historical flood maps. It is planned to create flood maps for larger and smaller water flows in the future (e.g. some mountain streams, which are even smaller-scale floods pour into around and threaten the local population).

The historical flood maps from flood simulator POSIM correspond to the updated flood maps from Morava River basin and the digital flood plan of the Czech Republic. Some maps are a slight variation as a result of changes in land use planning. Yet these flood maps from POSIM used without problems in processing and creating the graphical part of the flood plans.

In a chapter summarizing the current and future status of flood protection were given samples of the flood maps from the flood simulator POSIM after the accuracy of the comparison floodplains. Some flood maps are slight variations due to changes in land-use planning. Nevertheless, these flood maps from POSIM used without problems in the processing and graphical creation of flood plans.

In comparison with the current flood maps Morava River basin and the Digital flood plan Czech Republic are not the striking differences in the floodplains of five-year, twenty-year and hundred-year flood. But the biggest changes are in the area of the middle reaches on the river Morava and the confluence of the river Morava and Becva. These changes can be observed for many reasons. One reason is the impact of global warming and with it magnified the increase in extreme phenomena caused by weather, most commonly in the form of torrential rainfall caused by thunderstorms and intense local rainfalls accompanied by the dangerous phenomena, e.g. hail and strong gusts of wind (very strong wind – "hulava"). The second reason is to change the nature of the landscape and its departure from the original landscape (e.g. building of concrete surfaces, cutting down forests, cultivation of unsuitable crops, etc. Therefore, in the future it will be very important to pay attention to this issue in terms of appropriate security flood control measures, in particular in the field of the landscape revitalization and return to the original state of the landscape in the interest area. [3]

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