INFLUENCE OF SCHEMATIZATION DETAILNESS ON THE RESULTS OF RAINFALL-RUNOFF MODELLING IN THE LUBINA RIVER BASIN

VLIV PODROBNOSTI SCHEMATIZACE NA VÝSLEDKY SRÁŽKOODTOKOVÉHO MODELOVÁNÍ V POVODÍ LUBINY

Martin ADAMEC [1], *Lukáš NOSKA* [2], *David VOJVODÍK* [3]

[1] *RNDr. Ph.D., Department of Physical Geography and Geoecology, Faculty of Science, University of Ostrava*
Chittussiho 10, Ostrava, tel. (+420) 59 709 2304
e-mail martin.adamec@osu.cz

[2] *Mgr., Department of Physical Geography and Geoecology, Faculty of Science, University of Ostrava*
Chittussiho 10, Ostrava

[3] *Mgr., Department of Physical Geography and Geoecology, Faculty of Science, University of Ostrava*
Chittussiho 10, Ostrava, tel. (+420) 59 709 2363
e-mail david.vojvodik@hotmail.cz

Abstract

This paper, in a form of a case study, deals with the influence of detailed basin schematization on the results of rainfall-runoff modelling. Three schematizations with dissimilar details were created for the study area and subsequently a rainfall-runoff simulation was carried out by means of the HEC-HMS programme for a precipitation event. Resulting hydrographs were further compared with a real discharge measured in the closing profile of the model basin. The model basin is the Lubina River basin occupying c. 160 km^2, characterized by significant altitudinal articulation and variable land use, so the comparison was not limited to one landscape type. The study also includes statistical evaluation of model accuracy by means of the Nash-Sutcliffe method. Finally, the results are discussed as well as probable reasons for the behaviour of the models.

Abstrakt

Příspěvek zkoumá formou případové studie vliv podrobnosti schematizace povodí na výsledek srážkoodtokového modelování. V zájmovém území byly vytvořeny tři schematizace s rozdílnou podrobností a následně byla provedena pomocí programu HEC-HMS simulace srážkoodtokového procesu pro přívalovou srážkovou epizodu. Výsledné hydrogramy jsou dále srovnávány s reálným průtokem měřeným v závěrovém profilu modelového povodí. Jako modelové povodí bylo použito povodí Lubiny o velikosti cca 160 km^2, které má výraznou výškovou členitost a variabilní využití země, takže srovnání nebylo omezeno na jeden typ krajiny. Také bylo provedeno statistické vyhodnocení přesnosti modelů pomocí metody Nash-Sutcliffe. Na závěr jsou výsledky diskutovány a vysvětleny pravděpodobné příčiny chování modelů.

Key words: rainfall-runoff modelling, HEC-HMS, flash flood, Nash-Sutcliffe coefficient, schematization

1 INTRODUCTION

Rainfall-runoff modelling belongs to dynamically developing branches of modern hydrology. Water management in basins, runoff management, protection against floods and other issues lead to a more frequent application of rainfall-runoff models. Nowadays, there is a wide range of different models that can be applied in almost any sphere of hydrological design. One of such models is the HEC-HMS model that can calculate channel discharge running through a closing basin profile.

The HEC-HMS model represents a close connection between hydrological models and geographic information systems with regard to data preparation. The data preparation for the HEC-HMS model takes place within ESRI programmes, namely in the process of the so-called schematization that can be executed at various levels of detailness. It is just this level of detailness that is one of the key attributes of the very HEC-HMS model and the results it brings. Therefore, the paper in the first place, focuses on the assessment of the influence of data preparation detailness in the schematization process and subsequent influence of the very HEC-HMS model results. In order to support its results, the paper also makes a comparison with the studies focusing on a very similar theme.

 Volume LX (2014), No.1
p. 1-9, ISSN 1802-5420

2 LUBINA RIVER BASIN CHARACTERISTICS

The Lubina River basin is a right-side tributary of the Odra River into which it enters near Košatka nad Odrou (222 m a.s.l.). The river, which belongs to basins of the second order, has a hydrological number 2-01-01-125. The river springs in the Moravskoslezské Beskydy Mts, namely on the north-western slope of the Radhošť Mt at an altitude of 740 m a.s.l. Its upper reach is located in a Beskydian part that is very important from the point of view of water management. [1]

The modelled basin finishes with the Petřvald rain gauging profile at an altitude of 231 m a.s.l. The upper reaches of the Lubina River and its sources are found on the northern slopes of the Beskydy Mts. The Lubina River further flows through the Frenštátská brázda Furrow and Příborská pahorkatina Hillyland. The lower Lubina reach is a part of the Odra River alluvial plain. [2] The Lubina River, as well as other right-side Odra River tributaries, is characterized by a sloping channel and torrential features in submontane zones. [3]

2.1 Hydrographical and hydrological conditions

Hydrographical conditions are necessary for a general idea of the values of the basin parameters that affect the formation and volume of resulting basin runoff.

Hydrographical characteristics: [1, 4]

- river length as far as the Petřvald closing profile: 33.3 km
- basin extent as far as the closing profile: 166.2 km²
- valley length: 35.8 km,
- average altitude: 487 m,
- basin shape coefficient: $\alpha = 0.15$,
- basin shape: elongated,
- river network density: 1.91 km/km²,
- mean channel gradient: 1.4°,
- forested areas: 30%.

Hydrological characteristics are given in Tab. 1. All data are related to the Petřvald gauging station which at the same time represents the modelled basin closing profile.

Tab. 1 Hydrological characteristics related to the Petřvald closing profile [5]

Average discharge Q_a	1-year discharge Q_1	10-yr discharge Q_{10}	50-yr discharge Q_{50}	100-yr discharge Q_{100}
2.36 m³/s	37 m³/s	140 m³/s	226 m³/s	260 m³/s

The average yearly precipitation height within the basin reaches the value of 906 mm, the average yearly runoff is 384 mm. The runoff coefficient is 0.42 and the specific runoff reaches 12.18 l/s/km². [5]

2.2 Precipitation event

Our aim was to simulate a rainfall-runoff process for a selected precipitation event at three levels of the schematization detailness in order to study the influence of the schematization detailness on the result. We used a real precipitation event from June 2009 to be able to compare a simulated hydrograph with a measured discharge in the Petřvald closing profile gauging station.

The event, which took place on 19 – 26 June 2009, corresponded to a flash flood coming from convective precipitation. The event affected individual parts of the basin with a various intensity, which induced various time distributions of culminations in individual basin parts. The biggest precipitation total was measured in those parts of the Lubina River that were identified using the method of Thiessen polygons as belonging to the Kozlovice station. [6]

An unequal spatial distribution of total precipitation is often marked with variability in the hydrograph shape. If the area close to the closing profile is exposed to a relatively big precipitation total, the resulting hydrograph is then characterized by a rapid increase, sharp culmination and rapid decrease. On the other hand, if the identical situation appears in the upper basin parts, the hydrograph is then marked with a relatively small increase, a wider culmination and a small decrease. [7]

3 USED SOFTWARE TOOLS

The rainfall-runoff modelling and data preparation were based on the following software tools.

3.1 ArcGIS 10

This ESRI product (Environmental Systems Research Institute) is one of versions of geographical information systems (GIS). Nowadays, GIS represent a very efficient tool used to create maps and geographical data analyses. In this programme, a digital terrain model was created by means of contour interpolation using the Topo to Raster method. The Topo to Raster method starts from the ANUDEM algorithm that calculates a raster digital elevation model (DEM) with shapes and runoff structures from a set of topographic data of any size.

3.2 ArcView GIS 3.2

Using two extensions (HEC-GeoHMS and HEC-GeoHMS Add-In), this programme is able to create basin schematizations calculating physical geographic data and generating an export set for the HEC-HMS programme.

3.3 HEC-GeoHMS and HEC-GeoHMS Add-In Extensions

The extensions represent an advanced and relatively intuitive tool for the schematization of lumped, semi-distributed and distributed model for the HEC-HMS rainfall-runoff model. The HEC-GeoHMS extension is used to create basin models. Additional information (effective precipitationin basins, unit hydrograph creation, proposed hyetograph and hydrograph creation, concentration time determination) is obtained by means of the HEC-GeoHMS Add-in extension.

3.4 HEC-DSSVue 2.0.1

The Hydrologic Engineering Centre-Data Storage System Visual Utility Engine (HECDSSVue) is a programme or a manager for the import and management of hydrometeorological data and other time series. Same as the HEC-HMS rainfall-runoff model and the HEC-RAS hydrodynamic model, the programme was developed by the HEC-USACE: Hydrologic Engineering Centre-U.S. Army Corps of Engineers. Its advantages comprise tabular and graphic data visualization and communication with the HEC-HMS and HEC-RAS programmes.

3.5 HEC-HMS 3.5

HEC-HMS (Hydrologic Modelling System) is a programme designed to model rainfall-runoff processes of dendritic drainage patterns. The programme can cover a wide range of conditions in various geographic zones. Hydrographs produced by this programme can be used directly or in connection with other software, for example in flood predictions, studies on the impact of urbanization, flood damage mitigation or water supply. The present-day programme is a result of more than 30 years of the software research of hydrological simulation. The original HEC-1, HEC-1F, PRECIP and HEC-IFH algorithms were modernized and combined with new algorithms, which led to the creation of a complex library of runoff simulations. Unlike the basic HEC-1 model, HEC-HMS is equipped with a graphic interface. The physical representation of a basin in the model is provided by the so-called basin model whose individual elements (sub-basin, river reaches, water reservoirs or confluences) are connected within a dendritic network in order to simulate the runoff process. Apart from the basin model, basic elements of the user interface comprise a meteorological model and control specifications. Same as HEC-DSSVue, this programme can be downloaded for free. Moreover, it represents an industrial standard in the USA. It is accompanied by a detailed user manual and case studies. The programme can solve the schematization at a level of a lumped, semi-distributed model and partially also at a level of a distributed model. [8]

4 METHODOLOGY

4.1 Lubina basin schematization

Schematization represents one of the steps of the pre-processing stage, which is a series of steps taken in order to derive runoff network and basin parameters or to calculate major physical geographic characteristics of basin. The schematization process is performed by means of GIS tools that ensure a tight connection between a numerical model and geoinformation technologies. It is particularly ArcView that provides in this stage complete basin schematization terminated by the creation of an export set for HEC-HMS that contains data necessary for successful rainfall-runoff modelling. The ArcView schematization requires a raster DEM which thus stands for a basic input data set. [6]

The aim of the study was to determine the influence of a number of sub-basins on the resulting hydrograph based on a rainfall-runoff simulation. Within the pre-processing stage, three levels of schematization detailness are created that divide the Lubina river basin into 4, 23 and 39 sub-basins (Fig. 1). These levels are then combined with a meteorological model based on the above described precipitation event. As a result, the modelled hydrographs are compared with the measured discharges in the closing profile. Within the lowest level of detailness, the basin was divided into 4 partial sub-basins, two of which are found in the upper part of the basin, 1 in the central part and 1 in the lower part of the basin, which also corresponds to the distribution of rain gauging stations. The middle level was intended to be a variant, in which the resulting number of sub-basins was to be found using a default threshold value that is offered in the ArcView GIS 3.2 with the HEC-geoHMS extension. However, this variant failed to be accepted since the number of obtained sub-basins rather corresponded to the last and at the same time the most detailed level of differentiation. Finally, an acceptable solution was proved to be the alternative to divide the Lubina River basin into 23 sub-basins. The last level was to divide the basin into as many partial units as possible, the size and shape of which could correspond to real sub-basins. The original intention to obtain approximately ninety units was then abandoned and the variant containing 39 units was accepted since in some cases the higher number of sub-basins caused that the sub-basin sizes corresponded to one or several DEM cells.

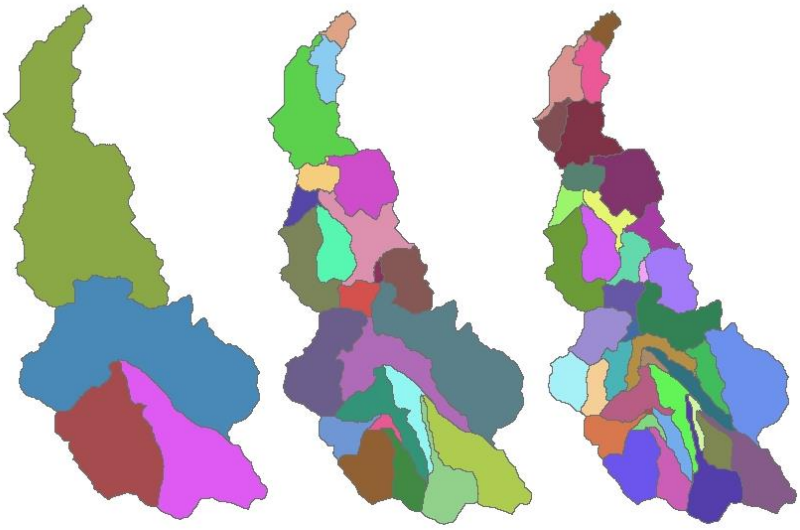

Fig. 1 Lubina River basin division into 4, 23, and 39 sub-basins

4.2 Modelling in HEC-HMS programme

In order to model the selected precipitation event in the Lubina River basin, the following methods of the transformation of atmospheric precipitation were selected in the HEC-HMS programme.

4.2.1 SCS CN method

The SCS CN method is one of the most known and used methods to calculate runoff loss within a basin. The method was originally designated for the calculation of the total infiltration during a storm event. The programme can calculate incremental precipitation during a storm event by recalculating the infiltration volume at the end of each interval. The infiltration during each time interval is then the difference in volumes at the end of both neighbouring time intervals. [8] The principle of this method consists in joining key land cover parameters (or land use parameters) and hydrological characteristics of soils into a single CN number that expresses runoff loss within a basin. Generally, the method solves the surface runoff in the dependence of the intensity of precipitation impulse, antecedent moisture conditions (antecedent precipitation index) and the very values of CN curves. Indisputable advantages of the method include the possibility of raster representation of CN values for a fully distributed solution of the model. [9]

4.2.2 Hydrological transformation – Clark Unit Hydrograph Method

This method represents one of many variants of the classic unit hydrograph method (UH) whose theory was originally developed by Leroy Sherman in 1932 and defined as ‘basin runoff resulting from one centimetre of direct runoff occurring uniformly over the basin area and caused by rainfall of uniform intensity for a specified duration’. [10] The unit hydrograph method can be used to derive flood wave characteristics if we dispose of at least short ombrographic measurements of precipitation and corresponding hydrographs. The method is based on the hypothesis that given basin rainfalls of uniform duration but various intensity give rise to hydrographs of very similar shapes. Physical geographic characteristics of a basin (terrain topography,

Volume LX (2014), No.1
p. 1-9, ISSN 1802-5420

geological and soil conditions, gradient, land use within the basin or hydrographical network) are supposed to be practically invariable. The assumption also includes uniform time and spatial distribution of precipitation and a uniform state of antecedent basin saturation. [9]

4.2.3 Kinematic wave approximation

The method of kinematic wave approximation solves channel runoff or hydraulic precipitation transformation within a basin. The hydraulic transformation is more complex and accurate than the hydrological transformation and it is based on solving the continuity and momentum equations for constant flow in open channels. These differential equations, which are solved on computers either explicitly or implicitly by means of numerical methods, are known as the so-called Saint Venant equations that were derived for the first time in 1871. [10] In the HEC-HMS model, the Saint Venant equations are substituted by the kinematic wave approximation for 1D and 2D flows, while the continuity equation is left in a differential form and the momentum equation is then an algebraic equation. The method of kinematic wave approximation is one of the most spread methods that solve the so-called overland flow (2D) or channel flow (1D) and can thus be expressed by the Saint Venant equations that respect the laws of conservation of mass, momentum and energy. The method neglects the action of pressure and inertial forces. There is also an assumption that the total energy does not change (it is identical at the upper and lower parts of slope). Therefore, this method is well applicable for almost steep slopes. It is also convenient for urbanized areas where natural channels were regulated. [8]

4.2.4 Seasonal recession method

For its simplicity, the recession method is used for subterranean runoff. Except for the initial Q parameters, this method does not start from hydrogeological conditions of area, but it is basically a method of hydrograph separation. Within this approach, the hydrograph is divided into direct runoff segments which are components represented by surface (Horton) and subsurface (hypodermic) runoff, and subterranean or baseflow. The recession curve becomes a hydrograph component starting from a threshold value that is expressed either as an absolute Q value or proportionally to the value of the hydrograph total culmination discharge. The initial discharge value can be used as a total value for basin closing profile or as a value expressed by recalculation to km^2 (analogy to specific runoff). [6]

5 RESULTS

The output of the HEC-HMS programme simulation is a hydrograph in a graphic or tabular form. The graphic output allows tocompare the simulated hydrograph with the hydrograph measured in the closing profile, in this case in Petřvald.

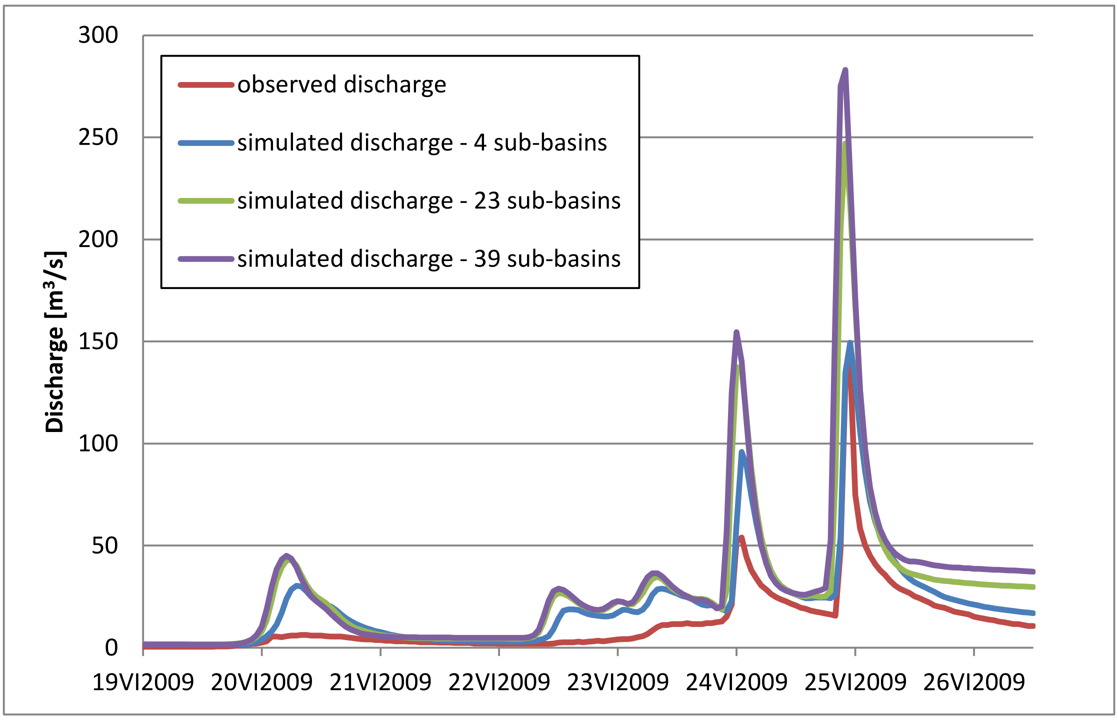

Fig. 2 Comparison of hydrographs in case of various detailness of schematization before calibration

Fig. 2 and Tab. 2 show the biggest correspondence with measured discharge in the non-calibrated hydrograph of the schematization with 4 sub-basins. On the contrary, other two schematizations showed substantial overestimation of culmination discharge (higher in the schematization with 39 sub-basins than in the schematization with 23 sub-basins). Moreover, in both cases, the time of culmination discharge moved 1 hour forward towards the measured discharge.

Tab. 2 Comparison of parameters of modelled non-calibrated hydrographs (the discharge measured at the Petřvald station showed the culmination discharge value equal to 139.2 m^3/s at 11:00 p.m. on 24 June 2009)

Schematization level	Culmination discharge	Time of culmination discharge
4 sub-basins	149.4 m^3/s	23:00, 24 June 2009
23 sub-basins	247.0 m^3/s	22:00, 24 June 2009
39 sub-basins	283.1 m^3/s	22:00, 24 June 2009

5.1 Model calibration

The model calibration represents an inseparable part of rainfall-runoff modelling. Its necessity arises from the fact that no model, including its combination of methods and schematization parameters, is able to work universally for any rainfall-runoff episode and topical conditions in the basin.

The most common calibration method in case of the rainfall-runoff model is the calibration of measured hydrograph values. However, in our case using this method would make it impossible to compare models with different levels of schematization detailness since such calibration directly affects the derived parameters regardless the original data. That is why we calibrated the values of average CN values and the value of initial loss within the basin (Initial Abstraction) in accordance with antecedent moisture conditions (AMC) or more precisely the antecedent precipitation index (API) for 5 previous days (Tab. 3). The AMC index is a dimensionless coefficient adjusting the basic relation of surface runoff according to the precipitation totals during antecedent days. The initial state of soil saturation has an influence on the potential retention value and thus also on the CN value derivation. The AMC values can be divided into three groups and derived based on the antecedent precipitation index (API). [6].

Tab. 3 Antecedent precipitation index for individual rain-gauge stations

Station	Petřvald	Kozlovice	Veřovice	Vlčovice
API [mm]	9	6	13.4	4.9

Fig. 3 and Tab. 4 show that in case of the 4 sub-basin schematization, the model calibration led to the underestimation of culmination discharge. On the other hand, the decreasing hydrograph branch corresponded to the decreasing branch of the measured hydrograph. Moreover, at this level of schematization, the time of culmination discharge was fully identical with the real culmination. The highest culmination discharge correspondence was observed for the 23 sub-basin schematization, whereas the lowest level of correspondence was observed in the case of 39 sub-basin schematization that, despite the calibration, showed a significant culmination discharge overestimation.

Volume LX (2014), No.1
p. 1-9, ISSN 1802-5420

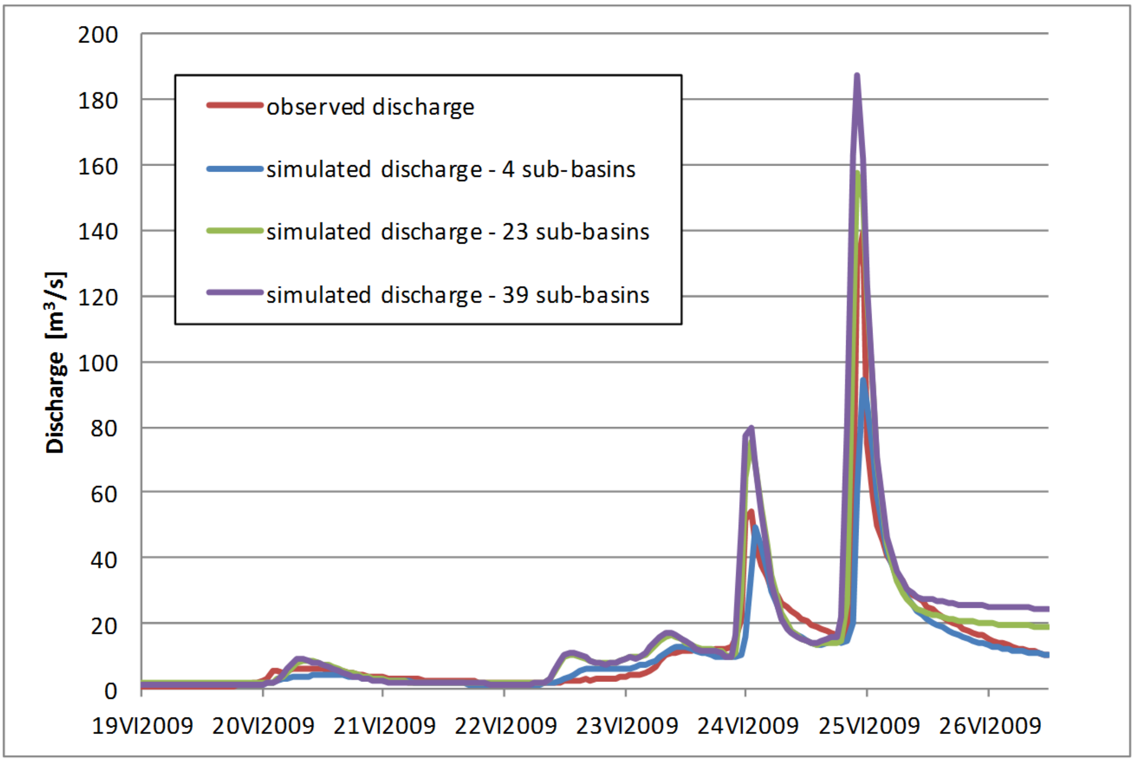

Fig. 3 Comparison of hydrographs at different levels of schematization after calibration

Tab. 4 Comparison of parameters of modelled calibrated hydrographs (culmination discharge value measured at the Petřvald gauge station equalled to 139.2 m^3/s at 11:00 p.m. on 24 June 2009)

Schematization level	Culmination discharge	Time of culmination discharge
4 sub-basins	94.1 m^3/s	24 June 2009, 23:00
23 sub-basins	157.8 m^3/s	24 June 2009, 22:00
39 sub-basins	187.2 m^3/s	24 June 2009, 22:00

6 MODEL ACCURACY ASSESSMENT

As one of the most known and used methods, the Nash-Sutcliffe coefficient was selected in order to assess the model accuracy. Despite the fact that the method is primarily designated for the evaluation of model accuracy in various basins, in this case it was used to assess the model in one basin but with various levels of schematization detailness. The coefficient can reach values ranging from $-\infty$ to 1. The value 1 stands for absolute model correspondence and accuracy. This value is practically unattainable under real conditions. The values higher than 0.5 can be considered satisfactory, and the values higher than 0.7 express excellent model performance as a predictive tool. The negative values then express unsatisfactory model performance as a predictive tool.

Tab. 5 Statistical evaluation of schematization accuracy after calibration according to Nash-Sutcliffe coefficient

Schematization level	Nash-Sutclife coefficient
Division into 4 sub-basins	0.824472711
Division into 23 sub-basins	0.801420197
Division into 39 sub-basins	0.46563365

7 DISCUSSION

Although the results are in contradiction with a general concept of semi-distributed models, they after all do not seem too surprising. In this case, the total area of individual sub-basins plays rather a more important role than just the representativeness of parameters entering the model. Also, a study of M. R. Kousari et al. (2010) in basins of Iran is in agreement with this fact. [11] According to this study, the range of input parameters influencing the volume of culmination discharge is dependent on the basin area. For example, short concentration time indicates a small basin, which leads to a lower potential for infiltration, smaller precipitation loss, higher gradient and short river reaches. Any of these factors or their combination results in an increased discharge value flowing through the closing profile. In other words, water runoff is higher where there is no possibility for its accumulation. On the contrary, increased concentration time results in a small gradient of river reaches, lowered basin gradient, higher precipitation loss for a basin etc., which leads to a smaller water runoff through the closing profile.

In order to confirm this study, we calculated concentration time average values of three levels of schematization detailness, while the concentration time shortened with the increasing level of schematization detailness.

The fact that the results of this study are not unique is also proved by the study carried out by G. Aronic and M Cannarozzo (2000), focusing on the effect of spatial representation of input precipitation and spatial discretization. Within the spatial discretization, the study area was divided into 10, 18, and 32 sub-basins while 4 different spatial representations of input precipitation were simulated. [12] Their results then, to a certain extent, correspond to this study since in a half of the cases the lowest discharge values were reached at the lowest level of detailness. However, when compared with the measured discharges, these values were rather underestimating and better results were reached within a more detailed area schematization.

The cause of the results can be clarified by the study of Kousari et al. (2010). The key factors of the basin runoff volume using the SCS CN method are the CN values and precipitation volume. The CN value was evaluated as a parameter with the biggest influence on the volume of culmination discharge. An increased CN value increases the culmination discharge volume, but at the same time it decreases the concentration time. The effect of precipitation also increases with increasing CN value. [11]

That is where probably the cause of the results of this study lies. Calculating average CN values for the whole basin at individual schematization levels on the basis of the distribution of CN values in individual sub-basins, the highest CN value was reached with the most detailed schematization. This could be one of the causes of high simulated discharge values along with a low value of concentration time. The distribution of CN values in individual sub-basins also played an important role. With regard to the fact that precipitation totals were assigned to individual sub-basins on the base of Thiessen polygons, the following situation occurred in this particular basin: A basin with overvalued CN value was matched with a high precipitation total, which led to the increase in simulated runoffs from individual sub-basins and consequently to the increase in the total runoff itself. In this case, a problem was observed in insufficiently detailed input data for the derivation of CN values and spatial distribution of precipitation totals within the basin.

In conclusion, the level of detailness plays a key role in the case of a semi-distributed model, however, depending on distinguishing input data. If a quality simulation needs to be produced, it is necessary to start on the side of the input data and their representativeness and subsequently determine the level of schematization detailness.

8 CONCLUSION

The results of graphic representation of the June 2009 precipitation episode before calibration show that the main culmination discharge was overvalued at all levels of detailness. Dividing the Lubina River basin into 4 units contributed to exceeding the discharge by 7%. Dividing the basin into 23 sub-basins increased the overvalued culmination by 77%. The worst results were reached at the highest level of schematization detailness when the culmination discharge was exceeded by 103%.

The calibration for antecedent moisture conditions significantly influenced initial results. After the calibration, the culmination discharge at the lowest level of schematization detailness was undervalued by 32%. Only 13% exceeded at the middle level of detailness. The worst results even after the calibration were reached in case the basin had been divided into 39 sub-basins when the culmination discharge was overvalued by 34%.

The statistical assessment of the accuracy of calibrated model schematization according to the Nash-Sutcliffe coefficient revealed that the schematization with 4 and 23 sub-basins reached the value above 0.8, which stands for an excellent value for the prediction of basin water runoff. However, the most detailed schematization (39 sub-basins) only reached an average value of 0.47 (after rounding).

The accuracy of the resulting model and its correspondence with the parameters of a real basin is particularly influenced by the level of schematization detailness (distributiveness). The aim of the study was to prove the hypothesis that if the basin is divided into a different number of sub-basins for rainfall-runoff modelling, the resulting parameters are more representative and affected by a smaller error provided that the input data are of a sufficient quality. The results are in a contradiction with the original hypothesis. Most probable reasons for this are discussed in the Discussion chapter.

REFERENCES

[1] VLČEK, V. *Vodní toky a nádrže: zeměpisný lexikon ČSR*. Praha: Academia, 1984. 315 pp.

[2] ADAMEC, M. Vliv použitých výškových dat na výsledky srážkoodtokového modelování v povodí Lubiny. In *Sympozium GIS Ostrava 2010*. Ostrava: VŠB - Technická univerzita Ostrava, 2010. pp. 1-7.

[3] BROSCH, O. *Povodí Odry*. Ostrava: Anagram, 2005. 323 pp. ISBN 80-7342-048-1.

[4] Kolektiv pracovníků Hydrologické služby HMÚ. *Hydrologické poměry ČSSR, Díl 1. – Text*. 1st ed. Praha: Hydrometeorologický ústav, 1965. 414 pp.

[5] Kolektiv pracovníků Hydrologické služby HMÚ. *Hydrologické poměry ČSSR, Díl 3*. 1st ed. Praha: Hydrometeorologický ústav, 1970. 557 pp.

[6] ADAMEC, M. *Vliv rozlišení vstupních geodat na výsledky hydrologického modelování v povodí Lubiny*. DISERTAČNÍ PRÁCE, VŠB-TU Ostrava, 2010.

[7] MISHRA, K., M. & SINGH, V., P. *Soil Conservation Service Curve Number (SCSCN) Methodology*. 1st ed. Kluwer Academic Publishers, 2003. 536 pp. ISBN 1-4020-1132-6.

[8] US Army Corps of Engineers. Hydrologic Engineering Center. Hydrologic Modeling System: *HEC-HMS: User´s Manual*. Version 3.0.1, April 2006. 260 pp.

[9] HRÁDEK, F. & KUŘÍK, P. *Hydrologie*. Praha: Česká zemědělská univerzita v Praze, 2008. 280 pp. ISBN 978-80-213-1744-4.

[10] BEDIENT, P. B. & HUBER W. C. *Hydrology and floodplain analysis*. Reading: Addison Wesley, 1988. 763 pp. ISBN 0-201-12056-9.

[11] KOUSARI, M. R., et al. Sensitivity analysis and impact quantification of the main factors affecting peak discharge in the SCS curve number method: An analysis of Iranian watersheds. *Quaternary International*. 2010, CCXXVI, Nr. 1-2, pp. 66-74. ISSN: 1040-6182.

[12] ARONICA, G. & CANNAROZZO, M. Studying the hydrological responsenext term of urban catchments using a semi-distributed linear non-linear model. *Journal of Hydrology*. 2000, CCXXXVIII, Nr. 1-2, pp. 35-43. ISSN: 0022-1694.

RESUMÉ

Srážkoodtokové modelování představuje matematické řešení složitého přírodního procesu. Význam srážkoodtokového modelování je velice dlouho uznávaný a to je zřejmě i důvodem, proč v dnešní době existují stovky modelů zabývající se touto problematikou.

Na zájmovém území povodí řeky Lubiny (plocha povodí 166,2 km^2) byla provedena pomocí programu HEC-HMS simulace srážkoodtokového procesu pro přívalovou srážkovou epizodu z června 2009. Během procesu schematizace bylo území rozděleno na 4, 23 a 39 subpovodí a spočteny základní fyzicko-geografické charakteristiky a parametry potřebné pro výpočet odtoku z území v závěrovém profilu Petřvald. Cílem bylo zjistit, jak míra podrobnosti ovlivní výslednou hodnotu průtoku. Simulované průtoky byly poté srovnány s měřeným průtokem v závěrovém profilu jak na úrovni grafických výstupu, tak na úrovni statistického zhodnocení metodou Nash-Sutcliffe.

Nepotvrdila se vstupní hypotéza, která vychází z vlastností semidistibuovaného modelu, že největší shody s reálným průtokem bude dosahovat nejpodrobnější úroveň schematizace s 39 subpovodími. U této schematizace se hodnota kulminačního průtoku po kalibraci lišila od měřeného průtoku o 34%. Schematizace s 23 povodími se lišila o 13% a nejméně podrobná schematizace o 32%. Ale po celkovém statistickém zhodnocení, dosáhla nejméně podrobná úroveň schematizace nejlepšího výsledku, naopak nejpodrobnější úroveň výsledku nejhoršího.