ACTA UNIVERSITATIS CAROLINAE
2003 GEOGRAPHICA, No. 2, PAG. 109–124

Historical Shortening of River Network in the Otava River Basin

JAKUB LANGHAMMER, VÁCLAV VAJSKEBR

Charles University in Prague, Faculty of Science
Department of Physical Geography and Geoecology

Abstract

The article is focused on the historical shortening of the river network as one of the important factors influencing the course and consequences of the floods. The river network shortening is studied at the example of the core zone of the extreme flood in August 2002 – in the Otava river basin. The solution is based on analysis of various data sources – historical maps covering the time period of 150 years as well on the current digital cartographic products. Using GIS analysis there was derived information on spatial distribution of stream shortening intensity as well as on the dynamics of the rectification process in time. The most intensive rectification – up to 40% of the former river length is observed on stream segments situated in the agricultural landscape in lowlands. Major changes on main streams in the Otava river basin were made in the 1st half of the 20th century – the intensive agricultural practices in 1970's and 1980's thus here affected predominantly the small streams. However the river shortening intensity in the study area is in some regions high the analysis did dot prove the stream rectification to be the leading factor of severe consequences of extreme flood in August 2002.

Key words: hydrology; river network shortening; floods; GIS; landuse changes

1. Introduction

In the course of last centuries, watercourses were subject to intensive modifications. With respect to the impact on runoff processes, the most significant role is attributed to river network shortening. Watercourses were and still are rectified to improve transport conditions, to drain agricultural areas, to protect towns and cities from floods, or to leave a wider space for urbanization and industrialization of the landscape (Janský, 2005).

To assess the impact of watercourse shortening on runoff changes mainly in relation to extreme rainfall-runoff events, it is vital to make a precise quantification of the scope and intensity of changes in the hydrographical network. Such data are presently not available in sufficient details for the area of large and medium scale river basins including the Otava river basin where was performed the analysis of human impact on flood extremity. To get detailed information on spatial distribution, intensity and historical evolution of river network shortening there was performed an analysis based on data derived from historical maps. The acquired information helped to explain the process of hydrographical network shortening in the Otava river basin over the last 160 years and its relations with the consequences of the extreme flood in August 2002.

2. Material and Methods

2.1. Data Sources

To analyze changes of the hydrographical network in the Otava river basin, we studied availability and relevance of individual historical map works. To cover the period of initial changes in landscape in the 18th and 19th centuries, we employed the maps of 1st, 2nd and 3rd Military mapping as the data sources with best information value and availability. To study the changes in the 20th century, there were available analogue and digital maps of a good quality from civil and military mapping.
As the main data source for the analysis of hydrographical network changes in the Otava river basin, were used the following map works covering the period from 1844 to presence:

Tab. 1 Map sources applied in the analysis of river network shortening

Source	Map Work	Temporal coverage	Scale
A	Maps of 2nd Military Mapping	1844	1:28 800
B	Maps of 3rd Military Mapping	1869–1887	1:25 000
C	Maps of the Czech Army Headquarters	1952–57	1:25 000
D	Digital Civil Map – ZABAGED	1997–2002	1:10 000

Due to the results of the quality assessment, there was not possible to employ the maps of 1st Military mapping (1764–1783) for further analysis. Although data contained in such maps are very valuable from the historical perspective, the fact that they are not based on a geodetical base and are not represented in a consistent cartographic projection does not allow their effective digitalization and further geoinformatic treatment. Maps of 1st military mapping were be used for assessment of local changes, but due to the above mentioned problems with lack of cartographic projection they were not used for analysis in the whole of Otava river basin.

The historical maps were acquired in the form of a digital raster image. They were consequently georeferenced, digitalized and analyzed in the GIS environment. Processing of individual maps was done in the following sequence:

For the analysis of changes in the Otava river basin, there were selected the major watercourses of the total length of 600 km that corresponded to the extent of mapping of riverbed changes and flood consequences (See Langhammer, 2005b and Engel, Křížek, 2005 in this volume). The assessed river network consisted of 32 streams delimited in 60 partial segments. Longer rivers were divided up to 10 segments allowing the comparison of the changes of the whole watercourse as well as of individual segments. The boundaries of segments were defined by features with minimal historical changes of geographical position – mainly by confluences. Each segment was identified with a unique code allowing identification and database processing.

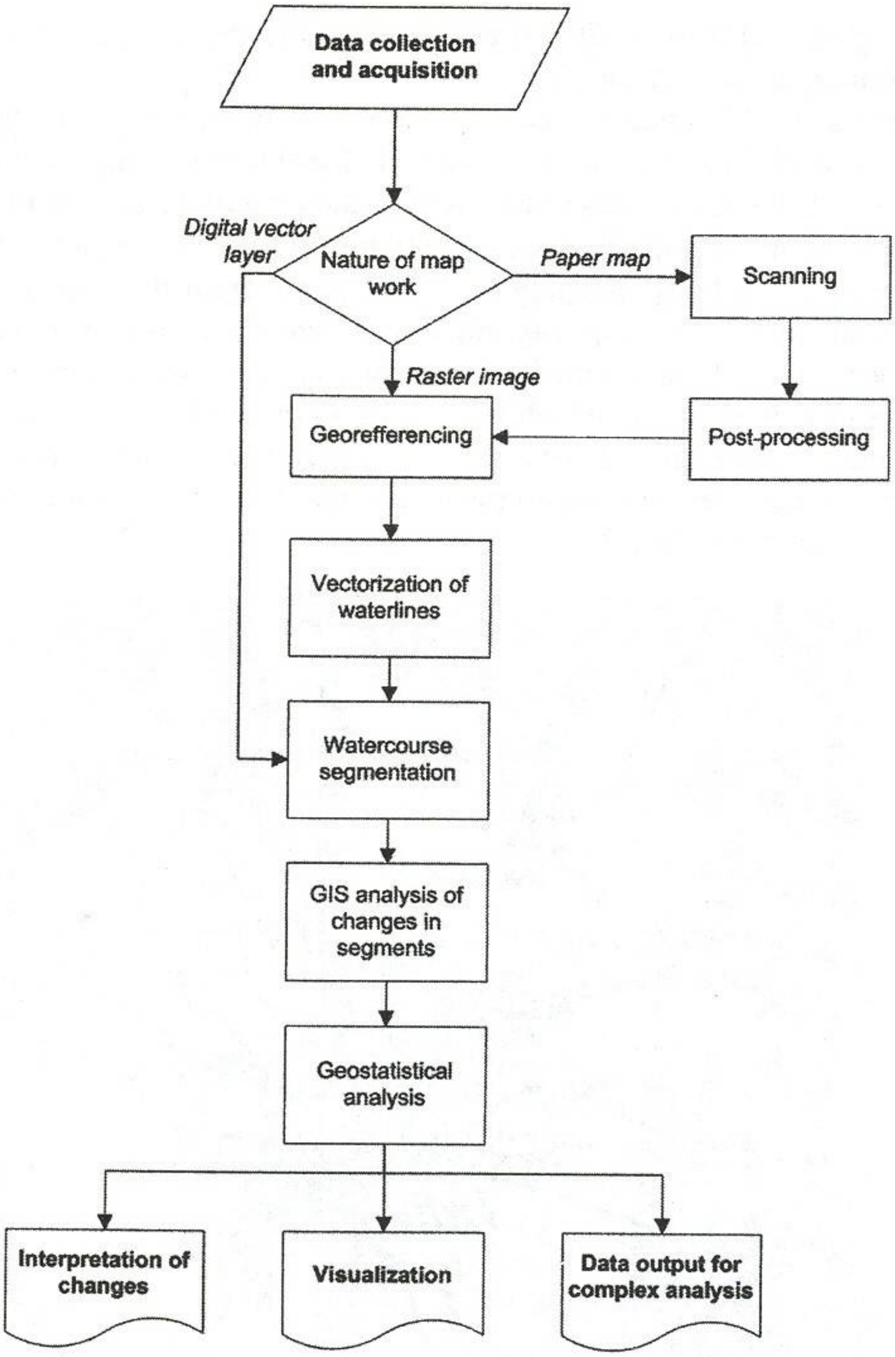

Fig. 1 Methodology of analysis of the historical map sources

2.2. Data Treatment

Available data had different levels of precision due to varied scales, different generalization rates, and quality of the transformation from analogue paper map to digital raster image.

The results of analysis of the historical maps and their digitalization were affected by differences in quality of data sources and imprecision resulting from differences in primary data characteristics – the scale and generalization level, cartographic projection and visualization, and precision of map elaboration. The input data quality was decreasing inversely to the age of maps.

The digital civil map (ZABAGED) reflecting the current state of the river system was the source of the best quality.

The maps of 3rd military mapping (1869–87) and the maps of the Czech Army Headquarters (1952) proved to have optimal balance between quality, processing needs and file size. The original paper maps were scanned with resolution of 300 dpi which with respect to the map size was adequate to the purpose of analysis.

The maps of 2nd military mapping (1844) acquired from the Czech Ministry of the Environment were of worst quality due to the technical quality of the raster image as well as because of the inaccuracies in the original map work. The resolution of the map raster images is 200 dpi which resulted in decrease of precision in positioning and measurement on the map. For accuracy of digitalization is however more important the initial level of generalization of original maps that leads to the underestimation of the resulting river network length.

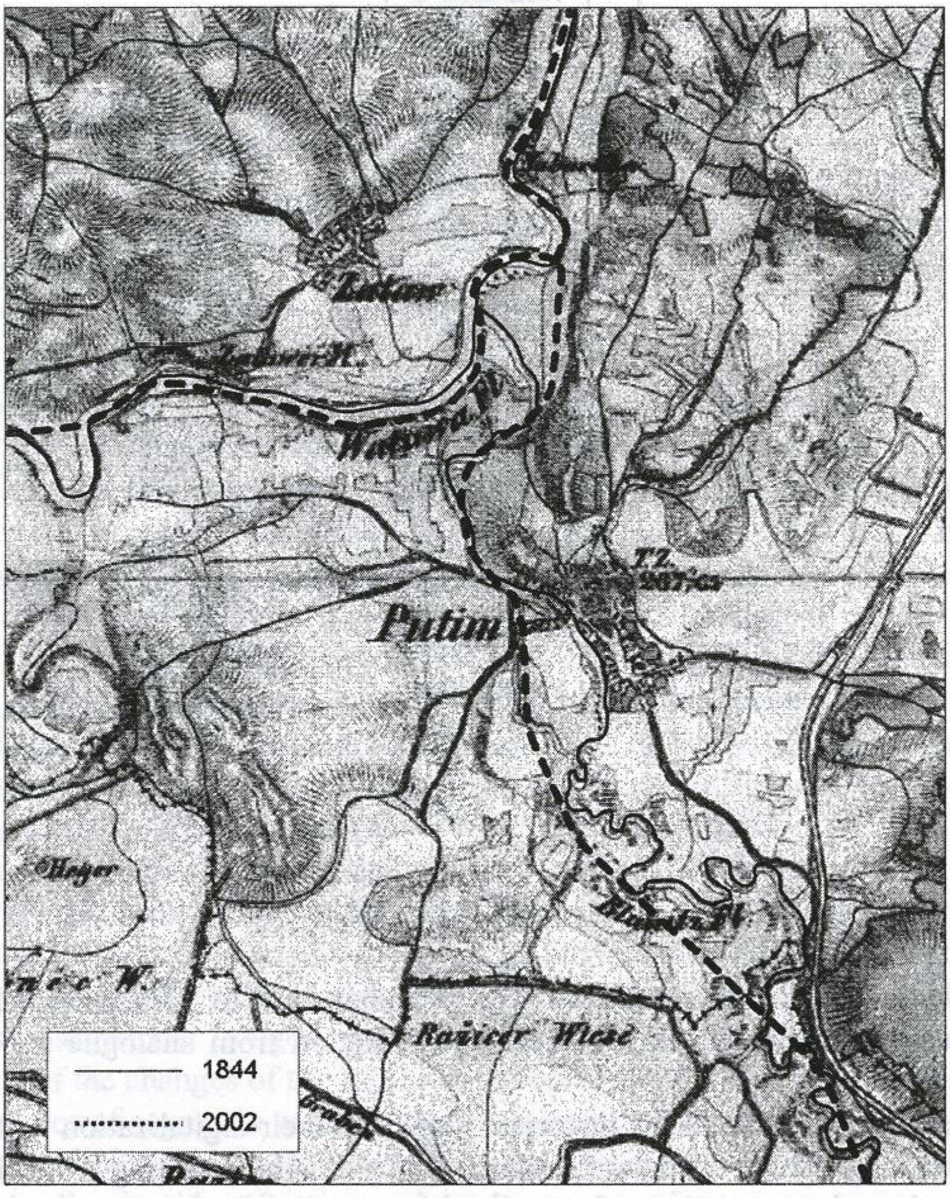

Fig. 2 Overlay of waterlines of Digital civil map (2002) on the map of 2nd military mapping at the confluence of Blanice and Otava rivers pointing to the extreme rectification of the down course of Blanice river since the 19th century

The different accuracy levels of individual map works result in unstable delimitation of the individual river segments. To eliminate these inaccuracies and to improve output precision and therefore the obtained results there was performed post processing of primary data affected by underestimation or overestimation of measuring results.

For the post processing the maps of 3rd military mapping and maps of the Czech Army Headquarters from 1950's were selected as a base because of their identical scale and the same manner of production. Thus it was necessary to correct measuring results from the maps of 2nd military mapping and from the Digital civil map representing the current state.

Because of above stated technical weaknesses and cartographical specifics the maps of 2nd military have higher rate of generalization which led to relative shortening of watercourses length in comparison with maps of 3rd military mapping. These values were therefore subject to an adjustment by coefficient $k = 1.01$ calculated as an average of relative negative deviations of river segment lengths between values gained form maps of 3rd and 2nd military mapping and consequently corrected to eliminate the spatial disproportions of the results.

At the contrary, in comparison with the maps of the Czech Army Headquarters from 1950's, the results obtained from the Digital civil map vector layer overestimate the values of river length. It results in "prolongation" of the river system between 1952 and 2000. As such a phenomenon could only be explained by different level of quality, precision, and resolution of the source datasets the results were generalized by the coefficient $f = 0.981$ calculated as an average of relative differences in the watercourse length between 1952 and 2000 at unmodified segments.

However, application of the correction coefficients is problematic because it leads to a general distortion of all watercourses length including the correctly represented ones. The solution of the problem is different for the individual map works.

Concerning the layer reflecting the current state, the problem could be solved by cartographic generalization adjusting the final values in a more sensitive way. The most efficient way seems to be the use of data from a map work based on the same scale as the maps of the Czech Army Headquarters and maps of 3rd military mapping – the DMU-25 digital military geodatabase.

Concerning the maps of 2nd military mapping, their further improvement is difficult. The technical problems are possible to overcome by rescanning of the original maps at the higher resolution. The key problem with high rate of shortening of waterlines is however caused in higher rate of generalization of the original maps.

The lack of precision of primary data may result in lower values of relative changes in watercourse length. Short watercourse segments are more prone to show greater errors of relative changes. The assessment of individual river basins based on absolute values has a good informative value for a comprehensive interpretation of the river system changes spatial distribution because partial extremities are eliminated.

3. Results

3.1. River Network Shortening in the Otava River Basin

The analysis of the hydrographical network historical changes was performed on the basis of data derived from historical maps of 2nd and 3rd military mapping, maps of the Czech Army Headquarters, and the Digital civil map. The result of analysis indicated significant historical changes in the river system length in the Otava river basin and important regional variations of this process.

Over the last 160 years, the hydrographical network in the Otava river basin has undergone a significant shortening that is strongly spatially differentiated. Changes in the total length are important. In the course of the last 160 years, the backbone of the river network in the Otava river basin lost 9.1% from is original total length – from 611.6 km to current 555.9 km. In absolute Figs., the Blanice river has been shortened by more than 17.7 km, the Otava river by almost 6 km, other watercourses have suffered minor cuts.

The intensity of river network shortening shows important spatial differences in individual parts of the river basin. The maximum observed shortening rate is reached at downstream areas on small watercourses in agricultural landscape. The most intensive shortening was found on the downstream Blanice river – river segment between Protivín gauging station and the confluence with Otava river was shortened up to 39% of the original length (38.8%) while the rate of the river network shortening in preceding river segments reaches 30%.

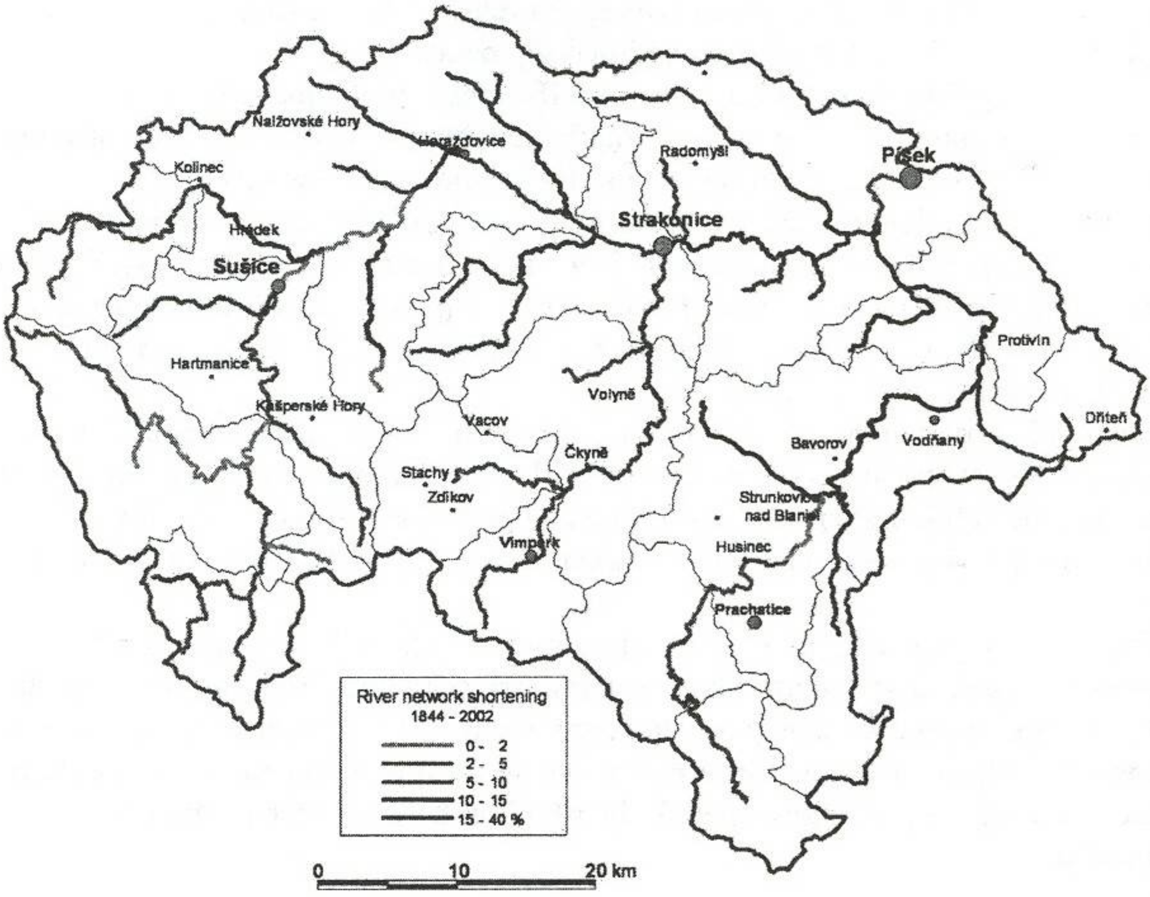

Fig. 3 Spatial differentiation of river network shortening in the Otava river basin since the 2nd military mapping

Tab. 2 Major streams affected by shortening in the Otava river basin since the 2nd military mapping

River	Shortening 1844–2002 [m]
Blanice	17710
Otava	5903
Novosedelský p.	3235
Ostružná	3021
Dubský p.	2994
Volyňka	2718
Březový p.	2647
Skalský p.	1853
Nezdický p.	1580
Mlýnský p.	1408
Zlatý p.	1367
Rojický p.	1339
Radomilický p.	1295
Brložský p.	1162

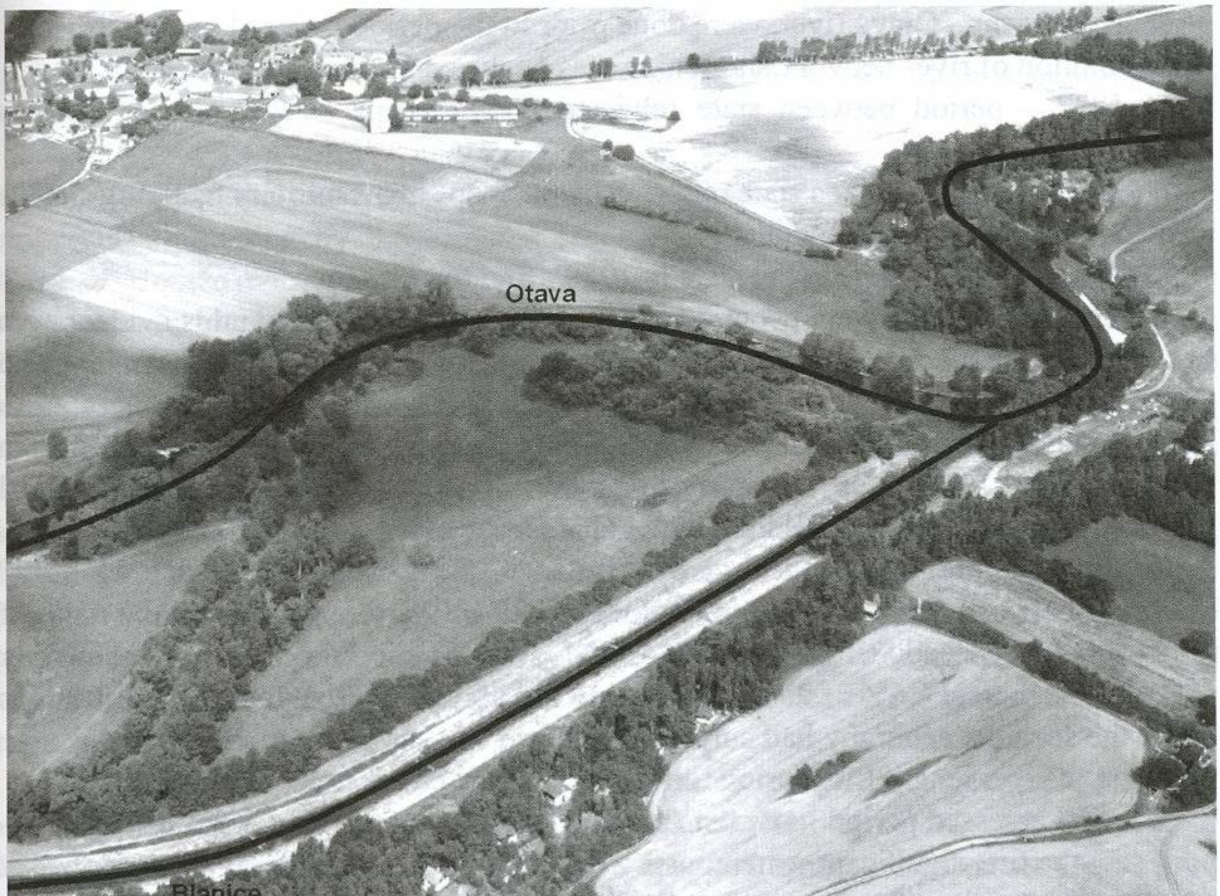

Fig. 4 Geometrically modified route of the Blanice river at the confluence with the Otava river (Photo J. Langhammer, 2003)

Other important shortenings have been made on the Dubský stream (loss of 19% of the former river length) and on many small tributaries of the Otava river at its midstream area. Here the rate of shortening reaches up to 10% of the original stream length. These watercourses are located in agricultural landscape and were rectified due to agricultural activities intensification and flood protection purposes.

The central part of the river basin in the area of Šumava foothills – Volyňka catchment and its tributaries as well as the Otava tributaries have been affected only to a limited extent. The average shortening rate reaches approximately 5%, i.e. less than the average in the whole Otava river basin and less than are average values for the whole Czech Republic. This is due to a lower anthropogenic stress in such areas and less intensive urbanization and agricultural activities.

The lowest average rates of shortening were found on upstream tracks in mountainous areas. Due to the prevailing forestall character of the river basin; almost no significant modifications have been introduced. Watercourses in the central Šumava area thus remain virtually unmodified with some exceptions. This geographically concerns the headstream areas of the Blanice, Křemelná, Ostružná, and Vydra rivers.

3.2. Historical Evolution of Stream Shortening in the Otava River Basin

The shortening of river network in Otava river basin is result of intensive and long-term human activities in the landscape. First modifications of the main watercourse of the river basin – Otava river, were done prior to the period covered by the project. The evolution of river network shortening was analysed in three stages:

1844–1887 – period between state reflected by the maps of 2nd and 3rd military mapping,

1887–1952 – period between state reflected by the maps of 3rd military mapping and the maps of Czech Army Headquarters,

1952–2002 – period between the state in 1950's and the presence.

River network shortening occurred in all of the assessed phases and is evident even from the oldest maps of 1st and 2nd military mapping particularly in the midstream Otava area.

The Otava midstream and downstream river basin areas were intensively used from the mid of the 19th century. Floating of timber, transport of goods, and agricultural production significantly marked the face of landscape even in the 19th century.

The most important changes were recorded in the period of 1st half of the 20th century – between state recorded in the maps of 3rd military mapping and the maps of the Czech Army Headquarters from the 1950's. In this period the whole assessed river network lost in total 6.6% of its length. The period of intensive landscape modifications under the socialist economy had surprisingly lower impact on river rectifications – the total rate of river length loss during the second half of 20th century is only 3%.

The first assessed period **between the issue of maps of 2nd and 3rd military mapping** saw the first significant watercourse modifications in agricultural areas. However the overall intensity of river network modifications is generally low. The whole river network in the Otava river basin was shortened by 7 km. The majority of rectifications are situated to the midstream of Blanice river and its confluence with Zlatý stream

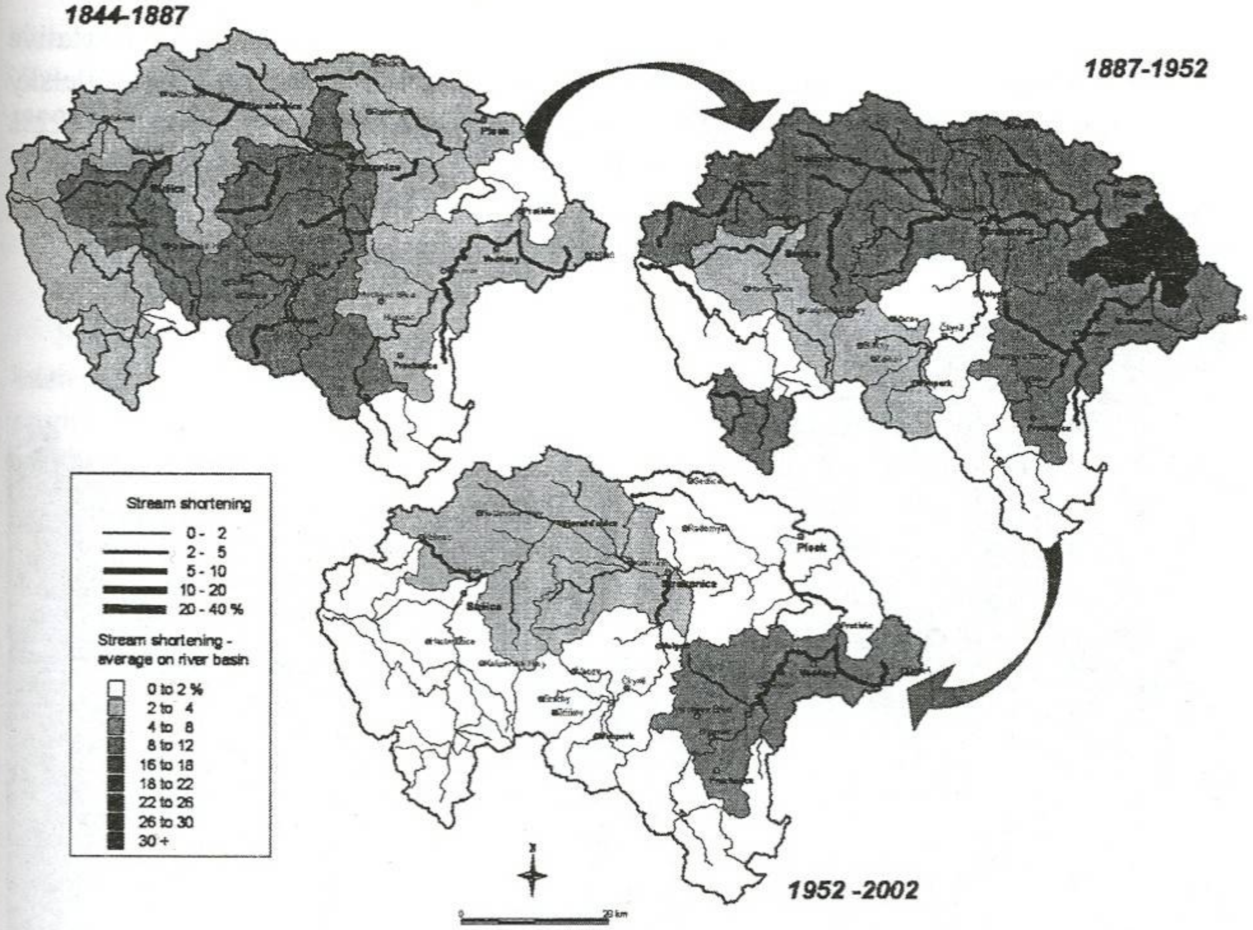

Fig. 5 Main stages of the river network shortening in the Otava river basin. The most intensive stream rectification is observed in the first half of the 20th century

near the Prachatice town – the total shortening here accounted for 3.1 km. Further important shortening by 0.8 km was recorded on the Otava midstream track near town of Horažďovice. The modifications during this period hit mainly the smaller watercourses located in midstream hilly parts of Blanice, Volyňka and Otava river basins. Watercourses in mountainous areas didn't undergo any modifications at all; the changes at the downstream areas reached were minimal.

The most significant changes of hydrographical network in the Otava river basin occurred **in the first half of the 20th century**. Differences between the watercourse length indicated by maps of 3rd military mapping (1869–87) and the maps of the Czech Army Headquarters (1952–7) amount to 39.8 km, i.e. 6.6% of the overall river network length. This period covers the time of radical changes in the structure of society and landscape – beginning in the era of the Austro-Hungarian Empire and starting industrialization and ending after two world wars at the beginning of era of communist regime.

The most important modifications during this period hit the midstream and downstream tracks of Blanice and Otava rivers. Shortening of only one segment of Blanice river in this period even exceeded the total amount of rectifications of the whole river network in the previous period. This segment, located between town of Protivín and the confluence with Otava lost more than 38% of its original length. In total, the Blanice river lost 13.6 km of its length in this period.

The Otava river lost more than 5 km of its length in this time. With respect to relative changes, significant cuts affected mainly smaller watercourses. The Novosedelský stream was shortened by 35%, the downstream track of the Březový stream by 22% and further segments of the Březový, Řepický and Rojický streams by 16% of their original length. Cuts affected mostly so far unmodified or even previously modified watercourses, e.g. the Blanice river below the confluence with the Zlatý stream.

Fig. 6 Žižka's Bridge. Due to rectification of the Březový stream in the 1920's the original medieval bridge was left off the current river stream (Photo J. Langhammer, 2003)

Watercourse modifications in the second half of the 20th century didn't reach the same intensity as in the previous period. Overall, absolute shortenings amounted to 8.8 km and the most intensive modification were made again in the Blanice river basin and newly also in the Volyňka and Ostružná river basins, and on small tributaries in agricultural areas. Reductions of individual watercourses didn't exceed 2 km – the most intensive rectification activities were performed on the Radomilický stream (1.8 km), the midstream and downstream Blanice (1.5 km and 0.9 km), and on the Ostružná river (0.9 km). In relative terms, shortening affected particularly the midstream areas of the Otava and Blanice leading to a loss of 11%, respectively 10% of their original length. With the exception of the Křemelná, the midstream Blanice and the Novosedelský stream that lost approximately 6% of their length, the remaining assessed segments were in average shortened only by 2–4%.

The low rate of river network shortening in period of massive landscape modifications during the decades marked by collectivization and industrialization of agriculture is related to the level of detail of the performed assessment. As the main streams were during the 2^{nd} half of the 20^{th} century already rectified the most intensive changes were done on small streams draining the agricultural areas. Such streams are often under the limit of resolution of the source maps due to different level of generalization and thus they were not included into the assessment.

3.3. Impact of Stream Shortening on Consequences of the Flood in August 2002

Spatial relationships between the watercourse modification rate in the Otava river basin and flood consequences indicated by field mapping were analyzed in the GIS environment (see Křížek, Engel, 2004 and Langhammer, 2004 in this volume). The analysis was focused on spatial coincidence of river network shortening of varying intensity with recent fluvial accumulations, river bank derogation, landslides, and occurrence of destroyed bridges or river structures.

To identify segments showing spatial relations between rectification and flood consequences and to separate them from other segments, there was applied a rule-based classification. We grouped individual segments into categories according to parameter values on the basis of selected threshold criteria. The main parameters comprised stream shortening intensity in the period between the 2^{nd} military mapping and the present time and flood consequences in the segment buffer zone found during the field mapping performed after the 2002 flood. Such a classification was applied to the whole river network.

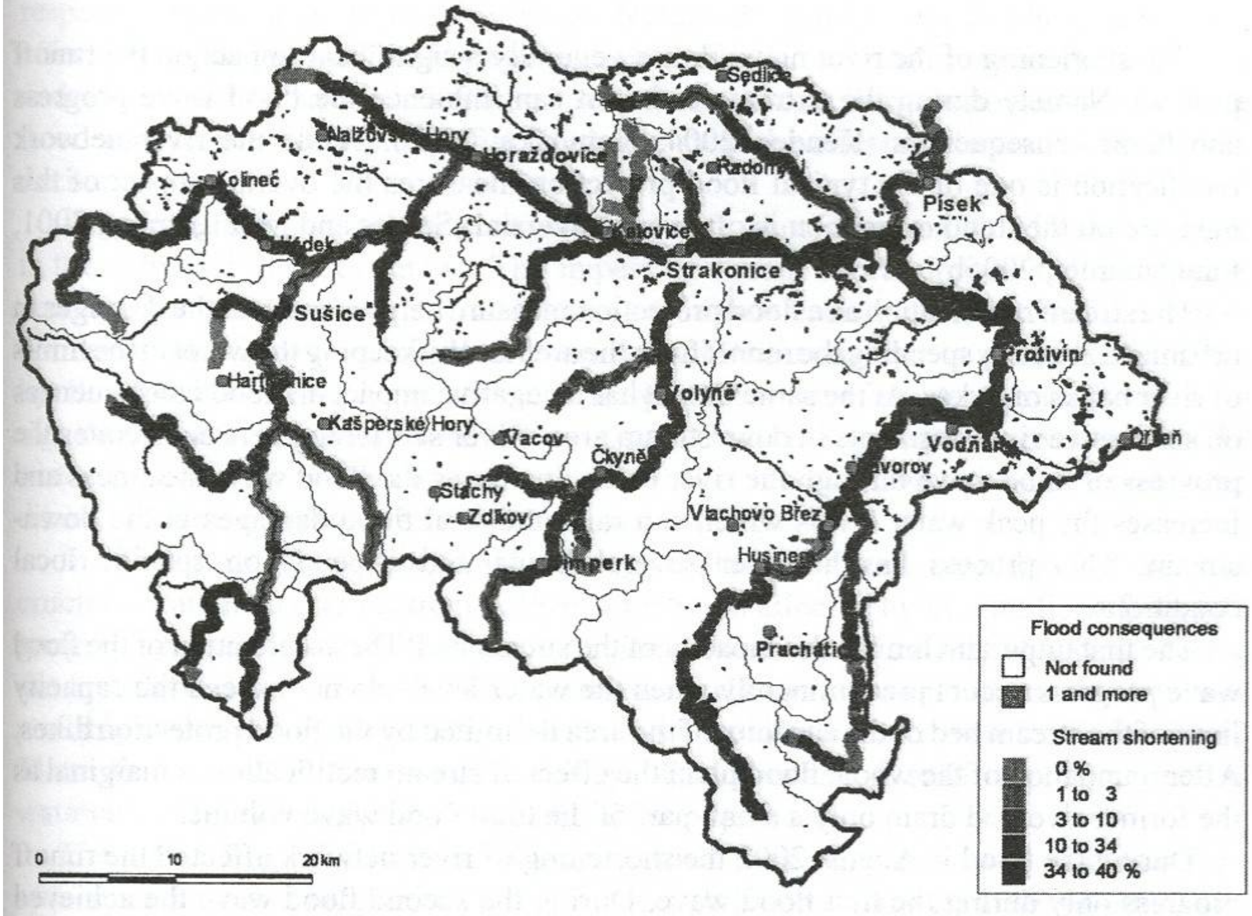

Fig. 7 Spatial coincidences between stream shortening and the consequences of the flood in August 2002

The threshold value of watercourse rectification affecting the runoff process was defined as 5% shortening. Applying such a limiting factor, we selected segments where we found more than one of indicated flood manifestations after the 2002 flooding. Thus we separated segments showing relations between anthropogenic shortening and flood consequences from those that despite intensive rectification weren't affected by any flood consequences. Unmodified segments with flood consequences were classified into a different category. The last group comprised segments free of any shortening or flood consequences.

Applying the 5% threshold, the resulting group of shortened segments affected by flood consequences represented 30% out of 725 assessed segments. Increasing the threshold to 10%, the percentage of segments affected by length cuts and flood consequences dropped radically to 9.4%.

The analysis of spatial and statistical relations between observed flood consequences and historical shortening didn't show any significant correlations. The impact of stream shortening on the progress and consequences of the flood in August 2002 in Otava river basin thus seems to be limited. This mechanism is influenced also by other factors – the relief, geographical location and mainly flood extremity and characteristics of the flood wave shaping and progress which played the decisive role during the flooding in August 2002.

4. Discussion

The shortening of the river network has generally a significant impact on the runoff process. Namely during the extreme events it can influence the flood wave progress and flood consequences (Kender, 2004, Konvička, 2003). While the river network rectification is one of the typical flood protection measures the overall impact of this measure on the flood mitigation is often controversial (Stover and Montgomery, 2001, Langhammer, 2005b).

The stream rectification as a flood protection measure helps to prevent the damages in urbanized zones by speeding the runoff from the area and by keeping the water in the limits of river banks or dykes. At the same time it has a negative impact on flood consequences on successive river segments in downstream area. River shortening here accelerates the progress of flood wave through the river basin, increases the flood wave steepness and increases the peak water levels which can raise the total flood damages in the down-stream. This process has however several limits and depends on specific local conditions.

The first important limit is the capacity of the stream bed. The acceleration of the flood wave progress occurs predominantly when the water levels do not exceed the capacity limit of the stream bed or the capacity of the area delimited by the flood protection dikes. After inundation of the whole flood plain the effect of stream rectification is marginal as the former riverbed drain only a small part of the total flood wave volume.

During the flood in August 2002 the shortening of river network affected the runoff progress only during the first flood wave. During the second flood wave the achieved water levels exceeded by several meters the original level of the floodplain and thus the impact of stream shortening on the flood routing was minimal. The effect of stream shortening on the flood progress acceleration is considerable mainly on significantly shortened watercourses, e.g. the downstream Blanice river. Currently, the length of the downstream segment of Blanice equals 13.5 km while in the mid of 19th century it was 21.4 km. This cut by 8 km may result in acceleration of the flood wave progress by more than 1 hour if if we consider the average flow velocity of 1.5 m/s as measured during the flood in August 2002 (see Table 2). The loss of property and lives during floods is a matter of minutes and such a time reserve could be decisive for adoption of the rescue measures. Runoff acceleration plays a significant role mainly during flash-floods when unlike in case of large regional floods there is almost no time gap between the forecast warning and the flooding.

Tab. 3 Measurement of flow velocities during the flood on 9. 8. 2002. Data: CHMI, 2002

Station	**Water level [cm]**	**Discharge [m^3/s]**	**Mean profile velocity [m/s]**	**Max. profile velocity [m/s]**
Blanice – Heřmaň	244	152.0	1.71	2,75
Volyňka – Nemětice	209	55.2	1.46	2.96
Otava – Písek	454	394.0	1.75	2.66

Another important factor is the geographical position and location in the framework of the river system. The impact of hydrographical network shortening differs with respect to the location in the river basin. Stream shortening have the most significant effects on upstream and midstream segments where the flood wave is getting shape and where is still space for its efficient transformation. At downstream areas where the flood wave enters into the large flat floodplain areas the effect of stream shortening can decrease.

Key factor for the influence of river network shortening on flood consequences is the achieved flood extremity. The impact of stream shortening on the flood wave acceleration is critical at floods with lower recurrence period when the flood spill does not reach the whole flood plain and stay locked in channels or in the zone delimited by flood dykes. In such situations, hydrographical network shortening becomes a significant factor raising the total flood damage. Conversely at extreme events when the water levels highly exceed the upper limit of river banks or even the flood protection dikes the effect of stream rectification becomes marginal.

In conditions of extreme flood in August 2002 at Otava river basin there was crucial the attained flood extremity level which was affected by distribution of rainfall, geographical position and flood timing, mainly the effect of two flood waves. During the first flood wave the impact of river network shortening on flood acceleration was possible to determine, from the point of view of the whole flood event it was marginal. These findings thus don't support the hypothesis on the overall negative effect of watercourse shortening on the rise of flood consequences.

The total impact of stream shortening on the course of flood waves and flood consequences shouldn't be generalized. The current high rate of the hydrographic network shortening in cultural landscape significantly affects runoff conditions in individual river basins and may contribute to negative consequences of the floods. However the individual aspects have to be always assessed in relation to specific geographic conditions, the spatial scale, and flood extremity.

5. Conclusion

Anthropogenic modifications of river network including the stream shortening are one of the factors that importantly influence the runoff process mainly during the extreme events. To assess the impact of watercourse shortening on effect of the flood in August 2002 in Otava river basin there was performed analysis of historical evolution of the river network changes. The assessment was based on analysis of historical military maps for a total period covering 160 years. The GIS-based analysis resulted in detailed information on spatial distribution, intensity and historical evolution of river network shortening that was used for further geostatistical assessment.

The results of the analysis of historical shortening of river network in Otava river basin proved important changes on individual streams in the whole river basin. In the course of the last 160 years, the hydrographical network underwent significant rectifications that are in some areas reaching almost 40% of the original river length. The most intensive shortening was found on downstream tracks and on small tributaries in agricultural landscape. The headwater regions in mountain areas remained relatively unspoiled mainly because of geomorphology and the small intensity of the economical activities.

First evidences of stream shortenings are visible already from the oldest map sources. The Otava river was rectified to allow the flowing of wood from the Šumava mountains and to increase of transport capacity. The most intensive changes were however made in the first half of the 20th century and affected all major watercourses of the river basin, mainly the Blanice and Otava on the downstream areas. Surprisingly the intensive activities related with collectivization and industrialization of agriculture under the era of socialism in the second half of the 20th century affected the core hydrographical network only to a limited extent.

The assessment of the course and consequences of the 2002 flood in the Otava river basin shows that the impact of the hydrographical network shortening on flood consequences was limited, while the decisive driving factor were the extreme precipitations and the sequence of two flood waves. Shortening of watercourses may however play a significant role during floods of a lower extremity and it is therefore important to pay a sufficient attention to this phenomenon in the process of flood prevention planning and management.

Acknowledgements

The presented research was supported by the Czech Science Foundation project 205/03/Z046 "Assessment of environmental changes impact on the flood course and consequences" and by the Research Plan MSM 0021620831 "Geographical structure and risk processes in conditions of global change and European integration" which is fully appreciated by the authors.

References

BIČÍK, I. et al. (2006): Development of Landuse Structure in the Otava River Basin in 1845–1948–1990. Anthropogenic Transformation of River Network in the Otava River Basin. Acta Universitatis Carolinae – Geographica, 38, 2, 65–78.

CHMI (2003): Hydrological assessment of the catastrophic flood in August 2002, Prague.

CHENG, J. D., LIN, L. L. & LU, H. S. (2002): Influences of forests on water flows from headwater watersheds in Taiwan. Forest Ecology and Management 165, 11–28.

JANSKÝ, B. (2006): Water retention in river basins. Acta Universitatis Carolinae – Geographica 38, 2, 173–184.

JUST, T. (2003): Revitalizace vodního prostředí, AOPK, Praha.

KAKOS, V. (1983): Hydrometeorologický rozbor povodní na Vltavě v Praze za období 1873 až 1982. Meteorologické zprávy 36, 171–181.

KENDER, J. et al. (2004): Voda v krajině, Praha. [Water in landscape, in Czech]

KONVIČKA, M. et al. (2002): Město a povodeň, Brno. [The city and floods, in Czech]

KŘÍŽEK, M. & ENGEL, Z. (2006): Geomorphological Consequences of the 2002 Flood in the Otava River Basin. Acta Universitatis Carolinae – Geographica, 38, 2, 125–138.

LANGHAMMER, J. (2006a): Anthropogenic Transformation of River Network in the Otava River Basin. Acta Universitatis Carolinae – Geographica, 38, 2, 139–156.

LANGHAMMER, J. (2006b): Geoinformatic Assessment of the Consequences of Extreme Flood in August 2002 in Otava River Basin. Acta Universitatis Carolinae – Geographica, 38, 2, 185–202.

ROSGEN, D. L. (1996): Applied River Morphology, Wildland Hydrology Books, Pagosa Springs.

STOVER, S. C. & MONTGOMERY, D. R. (2001): Channel change and flooding, Skokomish River, Washington. Journal of Hydrology 243, 272–286.

HISTORICKÉ ZKRÁCENÍ ŘÍČNÍ SÍTĚ V POVODÍ OTAVY

Résumé

V kulturní krajině se v průběhu posledních několika staletí setkáváme s různě intenzivními úpravami vodních toků, přičemž k nejvýznamnějším z hlediska vlivu na odtokové poměry patří zkrácení říční sítě. Vodní toky v minulosti byly a stále jsou napřimovány zejména kvůli využití pro dopravu, pro odvodnění zemědělských ploch, stejně jako pro ochranu měst a obcí před povodněmi či jako důsledek intenzivní urbanizace a industrializace krajiny.

Pro možnost posouzení dopadu zkrácení říční sítě na průběh a následky povodně v srpnu 2002 na povodí Otavy byla provedena podrobná analýza změn délky říční sítě v povodí v průběhu posledních 150 let, tj. v období nejdramatičtějších změn v krajině, vyvolaných intenzivním osídlením, zemědělstvím a průmyslovou výrobou.

Jako základní datové zdroje byla použita čtyři mapová díla, pokrývající období 150 let s přibližným vzájemným časovým odstupem 50 let:

- mapy 2. vojenského mapování z let 1844 v měřítku 1:28 800 (zdroj: MŽP ČR).
- mapy 3. vojenského mapování z let 1869–1887 v měřítku 1:25 000 (zdroj: Mapová sbírka PřF UK).
- mapa Generálního štábu ČSA z let 1952–1957 v měřítku 1:25 000 (zdroj: Český úřad zeměměřičský a katastrální).
- digitální vektorová vrstva vodních toků ze Základní báze geografických dat v měřítku 1:10 000 (zdroj: AOPK, data: ČÚZAK).

Všechna mapová díla byla nejprve převedena do podoby digitálního rastrového obrazu, následně digitalizována a analyzována pomocí GIS.

Toky byly rozděleny do segmentů, pro které byly pomocí GIS analýzy zjišťovány délky říční sítě zobrazené v jednotlivých mapových podkladech. Segmenty byly voleny tak, aby pokrývaly reprezentativní úseky toků, u kterých v průběhu hodnoceného období nedocházelo k významným změnám hraničních bodů.

Výsledky analýzy historického vývoje říční sítě prokázaly výrazné změny ve vývoji délky říční sítě v povodí Otavy. V průběhu posledních 150 letech říční síť doznala značného zkrácení, které se v některých

úsecích blíží až 40 % původní délky. Největší zkrácení říční sítě je pozorováno na dolních úsecích toků a na drobných přítocích. K nejintenzivnějšímu zkrácení toků došlo v období od konce 19. století do poloviny 20. století, kdy byly napřímeny hlavní úseky významných toků v povodí, zejména dolní Blanice a Otavy. Intenzivní socialistické zemědělství v 2. polovině 20. století se na úpravách říční sítě překvapivě projevilo méně výrazně.

Výsledky analýzy zkrácení říční sítě byly následně využity pro navazující geostatistické hodnocení souvislostí mezi zkrácením říční sítě a charakterem následků povodně v srpnu 2002. Při hodnocení průběhu a následků povodně v srpnu 2002 na povodí Otavy zkrácení vodních toků se ukázalo, že, vliv zkrácení hydrografické sítě na povodňové následky byl omezený zejména na první vlnu povodně, kdy přispěl k podstatnému urychlení postupové doby povodně na napřímených úsecích. Rozhodujícím činitelem pro celkový rozsah a výši škod povodně v srpnu 2002 však byly extrémní srážkové úhrny a především časový sled dvou povodňových vln. Zkrácení říční sítě hraje významnou roli zejména pro méně extrémní povodňové události, kde ovlivňuje postup povodňové vlny povodí, stejně jako tvar a časování souběhu povodňových vln a proto je tomuto fenoménu zapotřebí věnovat patřičnou pozornost.

Authors' full address:
JAKUB LANGHAMMER, VÁCLAV VAJSKEBR
Charles University in Prague, Faculty of Science
Department of Physical Geography and Geoecology
Albertov 6, 128 43 Prague 2
Czech Republic
langhamr@natur.cuni.cz
spruce@natur.cuni.cz