

Flood Frequency and Seasonality in the Sázava River Catchment Based on Historical Cases

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Abstract

The paper gives an overall report on historical floods in the Sázava River Basin, focused on the pre-instrumental period in particular. Documentary sources, flood marks as well as measured data were made use of. The longitudinal profile of the Sázava River from 1933, containing the maximum amount of factual information, represented the main tool. Field investigation was carried out especially on water mills and weirs, power plants, ferries, footbridges, bridges and other buildings and settlement parts around the Sázava River, which were located within the reach of floods and to which the upper reaches were related.

The paper presents the first more detailed chronology of flood events on the Sázava River within the time limits of the years 1515 and 1891. Quotations from chronicles and other documentary sources are expanded by brief description of a flood's process on the Vltava River (and/or in the Vltava and Elbe River Basins) so that the chronicle record is verified according to the overall context. Each individual flood also includes a classification according to time occurrence and, at the end, a discussion on seasonality of all documented events. The most important event, from July 1714, is dealt with in the most detailed way. It is especially this event – often reflected in historical literature – that not only belongs to the really extraordinary events of the basin under review, but generally to the most remarkable extremes recorded in the written history of the Czech Lands.

Key words: flood works, historical floods, Sázava

Introduction

Practically no attention has been paid to historical floods of the pre-instrumental period on the Sázava River yet. Reasons for that are partially of a historical nature and they are, among others, related to the low flood activity of the Sázava River in the 20th century. This paper aims at presenting at least a rough overview of the topic so that it is possible to evaluate the last 2002 and 2006 flood events in a balanced way.

Besides documentary sources, documenting of perished and existing epigraphical sources along the Sázava River stream is being carried out, as well as documenting of historical buildings having an important relation to floods. In terms of historical events, the catastrophic flood event on the Sázava headstream in July 1714 is described.

1. Materials and Methods

1.1 Use of Documentary Sources

In our context, documentary sources – chronicles, annals, personal and business records, period press or expert papers (see e.g. Brázdil et al., 2005) – have been the most effective tool to study hydro-meteorological extremes within the pre-instrumental period so far. However, accessibility of such sources for the river basin in question varies. The accessibility may be regarded relatively satisfactory for the Sázava mid and headstream where larger Sázava towns Zruč nad Sázavou, Ledec nad Sázavou, Světlá nad Sázavou and especially Havlíčkův Brod are located.

1.2 Field Investigation

The field investigation focused on visual inspection of structures with historical flood marks (using the Sázava River longitudinal profile PP-SAZ1933) or structures mentioned in documentary sources in relation to floods. The greatest attention was paid to the 1714 and 1862 floods. Owners of the structures with assumed marks or respective organizations were asked to cooperate: for instance the museums in Světlá n. S. and Havlíčkův Brod, District State Archives in Havlíčkův Brod, Světelsko Geographical Club, Ledec nad Sázavou Information Center, Municipal Authority and Museum in Zruč nad Sázavou, Municipal Authority in Kácov, Povodí Vltavy company /Vltava River Basin Company/, etc. Specifying information and photo documentation were and still are being obtained this way. If necessary, geodetic measurements of the 2006 flood reaches on places of historical flood mark occurrences and/or check measurements of points measured before were carried out.

1.3 Extremity scale

A suitable scale is a tool necessary for the comparison of hydrological data in pre-instrumental period. For example Bariendos et al. (2003) used for documentary sources three levels, based upon hydrological criteria and the impact level directly occasioned by the flooding:

- a) ordinary rise
- b) extraordinary flooding
- c) catastrophic flooding.

For the purpose of this paper I use more detailed scale 1–4, to differ the extreme and extraordinary floods (close to PMP flood) as follows:

- $1/2$ = flood only on a tributary
- 1 = flood with no damage, or not closer specified
- 2 = serious flood
- 3 = extreme flood
- 4 = an absolutely exceptional event.

For the instrumental period the above scale would correspond as follows: grade 1 corresponds to a flood up the Q_{10} level; 2 up to Q_{20-Q30} , and 3 corresponds to $Q_{30}-Q_{100}$.

1.4 Seasonality scale

For assessment of flood seasonality and its possible changes I introduce several categories. Brázdil et al. (2005), used for the Vltava river decadal frequencis of winter and summer floods. In this paper I use more detailed classification to indentify dangerous periods of the year. The categories are established as folows:

1. W_{DE} : 15/12–10/01
2. W_{JF} : 10/01–turn $1/2$
3. W_{F2} : 10/02–09/03
4. W_{M2} : 10/03–05/04
5. W_{AP} : 06/04–25/04
6. S_{MA} : 26/04–09/06
7. S_{JU} : 10/06–10/07
8. S_{JL} : 11/07–05/08
9. S_{AS} : 06/08–10/09

2. Results

2.1 Field Investigation

Field measurement results have been arranged within a topography (Dragoun, 2007). The field investigation confirmed the assumption on disappearance of most flood marks. Literature proves that the oldest flood mark on the Sázava River was on St. Catherine's church building in Havlíčkův Brod and dates back to 1714. However, it was destroyed during its renovation in the 19th century (Sochr, 1993). Neither the



Figure 1: Buda mill near Zruč n. S.: The floor bar with the engraved 1845 mark (right) was removed from the entrance door (left) during renovation. Photo by: Author

newer 1845 and 1862 flood marks exist any more (still measured in the 1930s). There was an extraordinary case of finding a relocated 1845 flood mark within the Buda mill premises near Zruč nad Sázavou (Fig. 1) thanks to kind help by the mill's owner (the mark was found on a hill of eliminated stone construction units). Compared to the 1930s, fewer than 25% of flood marks or heights evidenced at that time have been preserved (Tbl. 1). Relatively favourable state is only in Nespeky and Chlístov. Near the Žampach ferry, an 1888 mark has been found, and, similarly, there is an 1878 mark (or on the mill no. 33 in Kamenný Přívoz).

The 1845 flood water level (mentioned as reaching the cross on the square) was measured in Zruč nad Sázavou and compared with the 2006 flood level. In general, the level evidenced by chronicles proved to be realistic. The 2006 flood levels were found out based on existing traces, residents' witnesses and the CD application *Flood Marks* by the Povodí Vltavy company.

Table 1: Overview of important profiles with historical flood marks

Structure	Flood Marks Existing in 1933 (currently existing ones are underlined>	Total 1933	Total 2007
Mill in Brodce	1862, 1891, 1926	3	0
Mill in Nespeky	1891, 1909, 1926, + 1940	3	4
Chocerady Bridge	1845, 1862, 1891, 1926	4	0
Sázava Bridge, chapel	1845, 1862, 1891, 1917, 1920	5	0
Mill, Černé Budy	1890, 1926, 1917	3	1
Mill, Č. Šternberk	1862, 1845, 1926	3	0
Soběšín Mill	1891, 1909, 1862	3	0
Kácov Mill	1862, 1891, 1909, 1917, 1920, 1915, 1922, 1923, 1926	9	1
Posadov Mill	1862, 1891, 1926	3	0
Zruč n. S. Bridge	1845, 1862, 1891, 1909, 1926	5	0
Buda Mill	1845*, 1891, 1895, 1909, 1900, 1920, 1922, 1926,	8	1
Ledeč n. S. Bridge	1862, 1891, 1909, 1926	4	0
Chlístov, rail bridge	1876, 1880, 1888, 1891, 1899,	5	5
H. Brod	1845, 1862, 1888, 1891, 1926	5	2
Total		63	14

Notes: + = additionally, * = in other than original position, see Fig. 2

The so far reached field investigation results are schematically shown in Figure 2, comparing the more important 1845, 1862 and 1891 floods with the last 2006 event. The June 1926 flood, which is available in most profiles, was used as comparison level. It is evident that the 1862 flood was not exceeded by the 2006 flood along the whole 160 km long Sázava River section, what mainly applies to the 1891 (with the exception of the Buda mill) and 1845 (with the exception of Č. Šternberk) floods. On Sázava headstream, the evidenced 2006 levels were lower than the June 1926 ones in two cases.

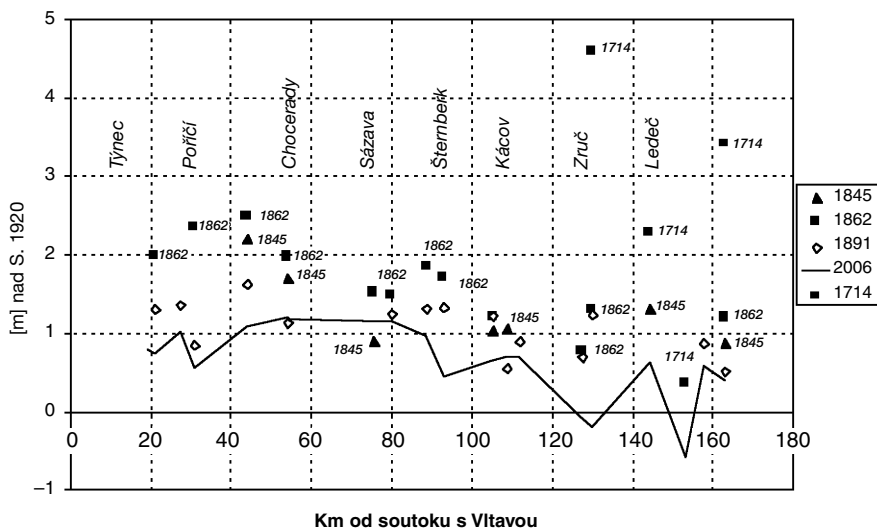


Figure 2: 1714, 1845, 1862, 1891 and 2006 spates according to measured levels (related to the July 1926 flood levels)

The reaches of the extreme July 1714 flood have been verified; they exceeded the highest 1862 levels enormously. That is why the next part contains a – so far brief – reconstruction of this event classified as “an extreme among the extremes”.

2.2 Chronology of 1515–1891 Historical Floods

Documentary sources concerning e.g. floods on the Vltava River include – in better cases – just a one-word reference to a Sázava River floods, without any details. The only exception is the catastrophic flood in July 1714, which is even mentioned in the Saxon flood chronology by K. G. Pötzch (mentioned e.g. by Kynčil, 1982). One of the most important primary sources relating to this event is a chronicle by Jelínek (a teacher from Havlíčkův Brod), which also records several previous Sázava River floods. A special place and an exceptional position as a source has a paper using the Světlá Farm Archive (Světlá nad Sázavou) (Seidler, 1887). Seidler obtained information on the period until 1850 from older chronicles (Lupáč, Beckovský, Schaller, 1874) and especially from Světlá Archives records. Nowadays, this source is dispersed in various archives of the CR (District State Archives in Děčín, Regional State Archives in Zámorsk, Brno, etc.). Information on the period after 1850 represents the Seidler’s personal records including also e.g. annual summaries of meteorological measurements (he was a volunteer observer). Further, regional sources from the Sázava Midstream region concerning stream regulation, such as Štědra, M. (2004), and web sources, such as ... etc., have been used.

The flood chronology (see Tbl. 2) incorporates floods – if possible – into broader context of the Elbe River Basin and/or Central Europe. The overview contains a simple typification based on date (Type), as well as a four-grade evaluation of extremity. If no

date is stated, an estimate of flood occurrence time has been carried out according to other floods (e.g. in 1698 according to reliable information on an Elbe Midstream spill at the end of March). The list starts with 1515 and ends with the period of regular monitoring of water stage on the Sázava River in the stations Havlíčkův Brod and Poříčí nad Sázavou (in the 1880s). That is why the chronology is completed by a serious 1891 flood, the course of which was already recorded instrumentally. A total of 54 floods were identified, only 6 out of them have not yet been identified timewise, not even by means of mentions of other floods. Floods on the tributaries (Blanice, Trnava, Konopišský Brook, etc.) are marked.

Table 2: Chronology of floods on the Sázava River and its Basin in pre-instrumental period

Date	Type, I	Place, description, (other basins affected)	Source
1515–08, (01 st *)	S _{JL} , 2	[S], (Berounka, Vltava Basin 1.8.*: HSP)	HPDLV-SLČ, HSP
1582–06, (?)	S _{MA} , 1	[Sv], torrent. & reg. rains (Lužnice, Otava, Vltava Rivers 13.–15./06: 1582 rek)	HSP
1596–02?, (?)	W _{F2} , 1/2	-Tr.: Blanice River: [VI], town hall torn down, (??)	Wertika
1616–03, (+24 th)	W _{M2} , 1	[Ka], (??)	(MDzH Memoirs)
1633–01, (20 th)	W _{JF} , 3	[HB], water reachable from the bridge, Nmm, (Dr-Elbe 09/01: Potzch, Je-Saale River 15/01: Cli-Koch)	Macek (1999)
1635–03, (17 th)	W _{M2} , 3	[HB], severe winter, ice run, bridge torn down (Me-Elbe Rv. datume?: Potzch)	Macek (1999)
1655–02, (15 th)	W _{F2} , 2	[Sv], snowy winter, thaw, strong wind (Vltava, Elbe Q ₅₀ –Q ₁₀₀ , 14.–15.2.: HSP)	(HSP- -Kozmancius)
1675–06?, (?)	S _{JU?} , 1	[Sv], (Vltava River-Q ₁₀₀ , Elbe River, 23.–24./06: HSP)	Seidler
1698–03?, (?)	W _{M2?} , 3	[Le], bridge torn down, (Elbe Midstream, 29/03–02/04: Zelenka)	Pleva (1997)
1700–04?, (?)	W _{AP?} , 1	[Ty], the statue from Ledeč drifted in by flood, (??)	(Žižala, 2007)
1712–04, (+ 20 th)	W _{AP} , 3	[Sv], (Vltava, Elbe Rivers, 24/04, Q ₂₀ –Q ₃₀ , HSP)	Seidler
1713–04, (2 nd)	W _{M2} , 1	[Sv], (Elbe Midstream: Pišl, datume ??)	Seidler
1714–07, (31.)	S _{JL} , 4	[Př to Ledečko], torrential rain, ponds (Vltava-Pr: 31/07, Potzsch)	See Part 3.4
1715–02,?	W _{F2?} , 1	[Ka], ice run, bridge damaged, (gale on 12/02: Cli)	Světozor 1872/ 44
1731–?, (?)	W _{M2?} , 3	[Le], severe winter, bridge torn down, water on the square, (Wisla Rv., 28/03: Cli, Elbe-Magdeburg 01/04: Magd)	Pleva (1997)
1734–05?, (?)	S _{JU?} , 2	[Ka], bridge torn down, (Doubrava, Chrudimka Rivers, 21/06: Žleby, Šulc)	Světozor 1872/ 44
1736–07, (17 th)	S _{JL} , 3	[Sv], torrential rains, (Berounka, Vltava, Odra Rivers: HSP)	Felíř (HSP)
1740–12, (21 st)	S _{De} , 2	[Sv], snow, gale, strong precip., (Elbe Upstr.-Q ₁₀₀ , Vltava Rv. up to Q ₂₀ , 22/12, HSP)	Seidler
1750–06, (15 th)	S _{JU} , 2	[Sv], (Vltava River, ca. Q ₁₀₋₂₀ , 17/06: HSP)	Seidler

Date	Type, I	Place, description, (other basins affected)	Source
1750–07, (12 th)	S _{JL} , 2	[Sv], (Vltava River, ca. Q ₁₀₋₂₀ , 12/07: HSP)	Seidler
1756–07?, (?)	S ² , 1/2	-Tr.: Konopišský Br.: [Po], bridge torn down (T. Orlice R. 02/07: Orlicko)	Klempera (2000)
1770–04, (?)	W _{M2?} , 1	[Sv], snow thaw, flood (Pr-Vltava River 04/04: HSP)	Seidler
1771–03, (17 th)	W _{M2} , 3	[Sv], water up to sick house, (Pr-Vltava, ca. Q ₃₀ 17/03: HSP)	Seidler
1776–02, (5 th ?)	W _{JF} , 2	[Ty], bridge torn down, (Dr-Elbe, 06/02–11/02, ice run: Pötzsch)	Klempera (2000)
1784–02, (28 th)	W _{F2} , 2	[Sv], bridge washed away, [Le], water on the square, (Vltava-Pr, Q ₁₀₀ , 28/02, HSP)	Seidler
1784–03, (28 th)	W _{M2} , 3	[Sv], flood, (Elbe Ma, 04/04: Magd)	Seidler
1789–04, (4 th)	W _{M2} , 2	[Sv], bridge damaged, (Pr-Vltava 04/04, Clem)	Seidler
1795–07 or 08	S _{JL} , 2 (S _{AS?} , 2)	[Sv], torrential rains, (??)	Seidler
1799–02, (22 nd ?)	W _{F2} , 3	[Sv], part of the bridge washed away, (Vltava-Q ₁₀₀ , Elbe, 23/02: HSP)	Seidler
1814–03, (?)	W _{M2?} , 2	[Sv], bridge damaged (Vltava, Elbe ice, 24.–28./03.: HSP)	Seidler
1815–08?, (?)	S _{AS?} , 1	[Sv], floods, (Vltava River 09–10/08: HSP)	Seidler
1821–03?, (?)	W _{M2?} , 2	[Sv], bridge torn down, (Vltava, Elbe, 09–11/03: HSP)	Seidler
1830–02/03?, (?)	W _{M2?} , 1	[Sv], bridge torn down after flood**, (Vltava, Elbe: 01/03, HSP, Danube: KGE)	Seidler
1834–05, (?)	S _{MA} , 1/2	-Tr?-[Pf], downpours, mill flooded, (??)	Půža (1914)
1835–spring, (?)	W _{JF} ?, 3	[Sa], mills up to the ceiling, Nmm, (Jizera, 05/02, Dlak)	Sázava Dictionary
1844–06, (25 th)	S _{JU} , 1/2	-Tr-, [Sv], L, (thunderstorms on different places, DBK)	Seidler
1845–03, (?)	W _{M2} , 3	[Sv], park and sick h. flooded (Elbe, Vltava, Danube, Rhine, 29/03–05/04: HSP, Cli)	Seidler
1845–06, (?)	S _{JU} , 2	-Tr?-[HB], damaged ponds, damage on roads, (??)	Krolmus (1845)
1847–02, (?)	W _{F2} , 2	[Sv], bridge, weir damaged by ice run (Elbe, 19/02: HSP)	Seidler
1858–07, (+28 th)	S _{JL} , 1	-Tr.: Trnava, [Pa], threatened ponds, mills, (Elbe Upstr. & tributs -Q ₁₀₀ , 02/08, Vltava-Pr. 03/08, Q ₂ , HSP)	PN 1858/ č.189
1860–03/04, (?)	W _{M2} , 1	[Zr, Sa], (Pr-Vltava 31/03, Q ₅ : HSP)	Janatová, Radil (2005)
1862–01/02, (?)	W _{JF} , 3	[Sa, KP, Za Sa2], damaged mills, (Pr- Vltava, 02/02 = Q ₁₀₀)	PN, Bo
1868–02, (29 th)	W _{F2} , 1	[Zr], snow thaw, no damage, (Elbe Midstr. 28/02–07/03: Bo)	Janatová, Radil (2005)
1869–02, (?)	W _{JF} , 2	[Sv], ice accumulation, water near château gate (??)	Seidler
1876–02, (?) ***	W _{F2?} , 1	[Ch], flood mark, (Vltava, Prague ca. Q ₂₀₋₅₀ , 20/02: HSP)	Flood Mark
1881–03, (?)	W _{M2} , 1	[Sv], park, sawmill flooded, (Vltava, Prague ca. Q ₅ , 10/03: HSP)	Seidler

Date	Type, I	Place, description, (other basins affected)	Source
1882–05, (?)	S _{MA}	-Tr.-[Sv], Závítkovce (??)	Seidler
1883–06, (19 th ?)	S _{JU} , 1	[Sv], frequent rains, (Chrudimka, Q ₁₀₀ , 20/06, Šulc)	Seidler
1886–06, (22 nd)	S _{JU}	[Po], Q ₅ , (Pr-Vltava, 23/06: Q ₅ : HSP)	CHMI
1888–03, (11 th)	W _{M2} , 1	[Po], Q ₅ , (Pr-Vltava, 12/03: Q ₅ : HSP)	CHMI
1888–05, (20 th)	S _{MA} , 1	-Tr.: Blanice River [VI], extreme spills (??)	Vlašim History
1891–03, (3 rd)	W _{F2} , 3	[HB-Po], Q ₃₀ -Q ₅₀ , (Elbe Midstream, 03/03, NL)	Seidler

Notes: I = grade of extremity, Type = see methodology or Tbl.3, [xx] = place on the Sázava river where xx = Pf = Přibyslav, HB = Havlíčkův Brod, Ch = Chlístov, Sv = Světlá n. S., Le = Ledeč n. S., Zr = Zruč n. S., Pa = Pacov, Ka = Kácov, Sa = Sázava, Po = Poříčí nad Sázavou, Ty = Týnec n. S., KP = Kamenný Přívoz, Za = Žampach, SA2 = Sázava u Davle, Pr = Prague, Dr = Dresden, Je = Jena, Me = Meissen, Ma = Magdeburg, -Tr = Tributary, ? = date unknown, + after the stated date, () = flood also in another basin, Nmm = does not have an eyewitness, bold = extreme cases.

* = datume converted from Julian to Gregorian calendar

** = the bridge pulled down in 1830, after a flood, maybe as a result of serious damage

*** = in 1876, date not determined, the flood may have occurred in February

2.3 Sázava River Flood Seasonality and Frequency

Despite the necessary simplification, the significant prevalence of W_{M2} (15 events) and W_{F2} (7 to 10 events) types is apparent, i.e. the end-of-winter period. The date between April 1 and 4 repeats ca. 5 times. Both types W_{JF} and W_{M2} concentrate the highest number of extreme events, but the absolutely exceptional winter extreme occurred in the W_{JF} period and the summer one in the S_{JL} period.

Flood frequency then grows from May to June S_{JU} (4–8 events); the S_{JL} category (4–5 events) includes also the 1714 event discussed. The S_{AS} type, typical for the Vltava River floods, occurs only rarely on the Sázava River (2 events). It was confirmed also by the 2002 event (also S_{AS}), during which only the Q₅–Q₁₀ levels were reached (Nespeky).

Table 3: Frequency overview of individual extreme flood types

Type	N	Period	Years
W _{DE}	1	15/12–10/01	1740
W _{JF}	3–5	10/01–turn 1/2	1633 , 1776, (1835) , 1862 , (1869)
W _{F2}	7–10	10/02–09/03	(1596), 1655 , (1715), 1784_{II} , 1799 , 1830, 1847, 1868, (1876), 1891
W _{M2}	15	10/03–05/04	1616, 1635 , 1698 , 1713, 1731 , 1770, 1771 , 1784 _{III} , 1789, 1814, 1821, 1845_{III} , 1860, 1881, 1888 _{III}
W _{AP}	1–2	06/04–25/04	(1700), 1712
S _{MA}	1–3	26/04–09/06	(1582), (1734), 1888
S _{JU}	4–8	10/06–10/07	(1675), (1734), 1750 _{VI} , (1756), (1795), (1844), 1845 _{VI} , 1883, 1886
S _{JL}	4–5	10/07–05/08	1515, 1714 , 1736 , 1750 _{VII} , (1795)
S _{as}	2–3	05/08–10/09	(1795), 1815

Note: () = tributary or not sure, bold: extreme cases; underlined: absolutely exceptional

Fig. 3 presents chronology of floods summarized in Table 2. An accumulation of floods on the turn from the 17th to the 18th century, around 1735, is obvious. Within the period 1770 to 1870, for the Sázava River up to 1891, frequent winter floods are typical, which also corresponds with the Vltava River floods analysis. The flood inactivity period in the 20th century is typical for the majority of river basins in Central and Western Europe; it is therefore not surprising in the case of the Sázava River.

Evaluation of flood extremity has been complicated by subjective allocation of grades on the 1–4 scale, based on water reaches, e.g. in Světlá n. S., or damage on bridges, e.g. in Světlá, Ledec or Kácov. Pre-instrumental flood evaluation has been rather based on the course of floods on the Sázava River head section above the Želivka and Blanice Rivers. Nevertheless, we can state that the floods marked with grade 3 were – with the highest probability – more serious than the 2006 flood. A total of 13 events represent on average a bit more than one event for a period of 50 years.

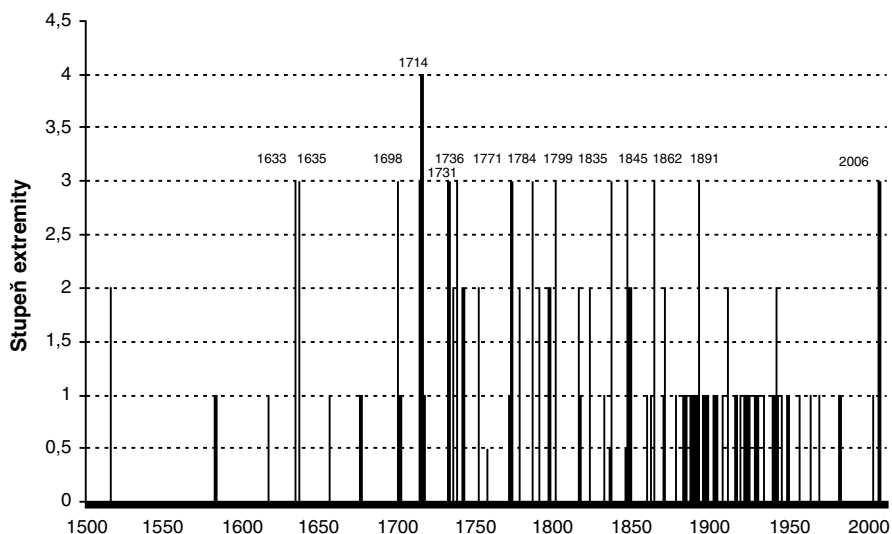


Figure 3: Flood regime on the Sázava River on the following scale: 1 = regular, 2 = serious, 3 = extreme, 4 = absolutely exceptional

2.4 Flood in July 1714

Despite the fact that the July 1714 flood belongs to the absolutely exceptional events, specialized hydrological or meteorological sources only mention its economic losses caused in the neighboring Svatka River Basin (Brázdil & Valášek, 2003), or they just generally state that the flood occurred. Therefore, at least a brief description of – the so far traced – causes as well as the process and impact of the flood disaster is mentioned in the following part.

Torrential rain in hilltop regions of the Českomoravská Vysočina uplands around Žďár n. S. and the Polensko region was the intermediate cause. It resulted in

a catastrophic flood of the streams heading in the area of the Žďárské Vrchy hills, i.e. not just a flood of the Sázava River, but provably also a flood of the Svratka River (the Jimramov town Chronicle), the Doubravka River (the Šabak Chronicle) and the Chrudimka River. There is no doubt that it was an event of an even wider framework: Brázdil (2005) also mentions the flood of the Morava River headstream (Kroměříž).

The situation on the Sázava River worsened when the ponds on the Šlapánka River and the Sázava River headstream burst open. The flood process, material damage and number of casualties surpass any comparisons until today. Table 4 shows a brief time sequence in the Sázava Headstream Basin, based on its records in documentary sources. Reports on the number of casualties (several hundreds; persons often stated by names) and on the highest reaches (see hereinafter) suggest an extraordinary event. Data have been derived from the following sources: Jeníček (1907), Petr (1931), Hasičská stráž /Fire Patrol/ (1938), Sochr (1993), Macek (1999), Klempera (2000), Janatová, Radil (2005), Janatová (2006), Vála (2007), Valchář, etc. According to the above mentioned sources, flood damage can be traced from Příbyslav to Leděčko near Český Šternberk where, according to Klempera (2000, p. 185), a mill was destroyed on 1 Aug. 1714 and built again by the lords.

Based on a measurement in Havlíčkův Brod, the flood extent corresponds to the distance of today's Riegrova Street and 97 Dolní Street (see also Tbl. 5). The unusually fast water level rise was accompanied by devastation of the river bank town part where, rather coincidentally, only St. Catherine's Church (Fig. 4) remained saved.



Figure 4: On the left: Havlíčkův Brod; on the left St. Catherine's Church flooded up to ca. 3 m in 1714; on the right 97 Dolní Street; sidewalk height under the "Bearded Man" sculpture corresponds to the flood reach. Photo by: Author and Havlíčkův Brod Museum's archive.

Table 4 implies that the water level rise stopped 11 hours after the start of causal precipitation, i.e. on 31 July 1714. Flood surface in Havlíčkův Brod and Leděč n. S. (data for Okrouhlice and Světlá n. S. area less accurate and correspond to the lower estimation limit) reached 2 to 3 m higher than during the largest flood of the instrumental period (1862). Table 5 contains basic information we so far have based on measurements of available heights (with respect to St. Catherine's Church, three options have been assumed: maximum (A), probable (B), and minimum (C). The abundance and specificity of data, mentioning that flood water rose incredibly high, imply that the catastrophic

depictions of the flood are realistic, e.g. the impressive inscription on St. Peter and Paul's Church's memorial arch in Ledeč: *"this temple of God, almost tumbled down through waters, has been restored into the original state thanks to the warmth of the highborn duchess Eleonora de Liechtenstein"*, Pleva (1997).

Table 4: Time sequence of the events

Time	Havlíčkův Brod & Zruč n. S.
31/07 15 h	Probable beginning of causal precipitation
31/07 16 h	Flood beginning
31/07 24 h	Flood stages
31/07 2 h	Peak
01/08 2–12h	Constant stage and then decline
02/08	New, smaller rise; peak in Zruč n. S.

Table 5: Measured maximum water levels of 1714 flood

Havlíčkův Brod	
House 97 Dolní Street	Water level reached the doorstep. Until 1894 the place had been identified by the so called Bearded Man of Havlíčkův Brod (Fig. 43). The sculpture was placed ca. 3 m higher, at the butment of the street vaulted arch (simultaneously, water probably reached to house no. 153). According to the measurement, the level reached ca. 413 m a.s.l., i.e. roughly 200 to 240 cm higher than the 1862 flood.
Former Rosmarkt	Up to house no. 77 (former Trčkova St.) – whole neighborhood torn down while building a new condominium neighborhood. Original state cannot be measured.
St. Catherine's Church	A/ Position under the ceiling (ca. 10 cm); B/ Position ca. 3 m above the floor (up to half of the altar; paintings were not damaged), approximately corresponds with the level stated for house no. 97; C/ minimum height 90 cm (mud accumulation thickness).
Okrouhlice	
Chateau wall	Foot of chateau wall is at a height of 400.37 m a.s.l. (allegedly, water spilled up to the chateau wall) $HW_{2006} = 399.76$ m ASL, $HW_{1714} = >$ at least 60 cm higher than 2006.
Světlá nad Sázavou	
Above the river	Water rose up to 14 cubits, i.e. cm, probably above the stilling pool water level (Kostecký-b). He states the same figure as Jelínek in Ledeč, which is suspicious (Macek, 1999), see Ledeč.
Sick House	Water reached to groundfloor rooms of the sick house (Kostecký, Dějiny špitálu); today's doorstep at 392.18 m a.s.l., i.e. at least 180 cm higher than HW_{2006} ; measured a height of 390.36 m a.s.l. (according to mill owner's witness).
Pách Periphery	A total of 23 houses torn down in this part of the ford's forefront on the right bank.
Ledeč n. S.	
St. Peter and Paul's Church	According to Ledeč n. S. history (Ledeč n. Sázavou – dějiny), 3.5 m of water, i.e. 6 cubits (exact conversion is cm), (Hasičská stráž, 1937); $HW_{1714} = 355.93$ m a.s.l. (ca. 270 cm higher than HW_{1862}).
Generally	Water level 14 cubits, i.e. (Macek, 1999).
Square	Flooded

Notes: HW = High Water (level), a.s.l. = altitude above sea level (Baltic Vertical Datum after adjustment)

3. Discussion of Flood Marks and Traces

Besides the frequently mentioned antropogenous factors (changes in agriculture and forestry; stream adjustments; and construction of dams) having an impact on passage of floods through river basins, another important aspect of flood hazard should be mentioned. The practical non-existence of flood marking (Part 3.1) and/or its continuing disappearance lead to decreasing sensibility of the citizens towards such danger. Practical local knowledge cannot be always substituted in a fully successful way by expert institutions that are in charge of floods. As for significance of (specifically the Sázava River) marks for experts, e.g. the unique 1876 mark in Chlístov should be mentioned, as well as the 1878 mark in Kamenný Přívoz and the 1890 one in Sázava; as measured series start in Poříčí nad Sázavou in 1880, in Havlíčkův Brod in 1884, in Sázava nad Sázavou in 1891, in Čerčany in 1893, in Ledeč nad Sázavou in 1893 to 1895, and in Kácov in 1898. To sum up: for the respective sections of the Sázava River, there is no other information on the level of some older floods. Also some structures which the flood reaches used to be related to play an important role. To compare levels of serious floods, we can use e.g. the former sick house building or the castle park in Světlá n. S. that were repeatedly reached by floods in 1714, 1771, 1799 or 1845, or flooding of the square in Ledeč (1714, 1731, 1784, 1862, 2006 – lower part). Similarly, literature mentions the cross on the square in Zruč nad Sázavou, the mills in Kam. Přívoz or Žampach and other structures, which have become part of the Sázava River flood history.

Unfortunately, disappearance of flood marks is often unnecessary rather than unavoidable. Some of the causes include façade repairs or disrepair stages. Today's situation can be related to disappearance of trades impacted by fluctuating water stages (ferrying, miller's). Nevertheless, it can be also related to the general withdrawal of the man from landscape and, thus, to decreasing interest in and knowledge about processes occurring there. A number of already destroyed marks used to be fixed by geodetic measurements (carried out by T. G. Masaryk Water Research Institute in the 1920s and 1930s) so their information was rescued at least for experts. Also other European countries, sometimes with incomparably richer resources of that type, have to deal with similar challenges. An inspirational example may be the Directions régionales de l'environnement (DIREN) project in the Loire-Bretagne area. It aims at searching, but also at restoring flood marks. The Sázava 21 Project (The Sázava River for the 21st century), supported among others by the senator prof. Bedřich Moldan, the Kácov townlet center and moved forward by the mayor of Kácov, could bring hope and a step forward not only towards a clean Sázava River, but also to renewal of its historical memory.

Conclusion

The paper provides an overall summary of 1515 to 1891 flood event chronology. The overview is used to carry out an evaluation of flood seasonality. The most serious event from 1714 is described in more detail. Based on the frequency of individual flood occurrences, it is obvious that also in previous centuries the flood frequency went up between December and March. The most risky period for big Sázava floods was the end

of winter. The most frequently, floods occurred at the turn from March to April, the frequency was a bit lower at the turn from February to March. As for summer floods, July events were more typical; more serious floods in August and September were rather rare. It has been found out that only one third of the collection of flood marks, still quite rich in the 1930s, currently exists. Historical marks confirm that the latest flood in March 2006 was the fourth most serious event on the section from Davle to Havlíčkův Brod within the period 1845–2007, following the floods in 1862, 1845 and 1891. For the whole period of 1500–2000, 13 floods could be identified that were – highly probably – more serious than the latest significant one from 2006.

Sources and Abbreviations

1582 rek: Elleder, L., Kotyza, O. (2007)

Bo: Bohemia daily

Cl: Climdat, database of the Universität Leipzig (<http://mitglied.lycos.de/mili04/index.htm>), stated as: Cli-primary source

Clem: Hlaváč V., (1977)

CHMI: Database of Czech Hydrometeorological Institute

Dlask: Kutnar, F., ed. (1941)

DBK: Author's database Krolmus

HPDL: Kotyza et al. (1995):

HSP: Brázdil et al. (2005)

Žleby Chronicle: <http://www.ouzleby.cz/index.php?id=kronika.php>

KGE: Glaser, R. (2001)

NL: Národní Listy daily

Magd.: Magdeburk measured series, CHMI's archive

BK Memoirs: Frič, J. J. (1940): Paměti babičky Kavalírové, 1940, Praha, Topič

DzH Memoirs: Paměti – Mikuláš Dačický z Heslova, www.citanka.cz

PP-SAZ 1933: Longitudal profile of the Sázava River from Německý Brod to the mouth. In: Podélné a příčné profily československých řek. Sešit 7. Státní ústav hydrologický T. G. M., Praha 1933

PN: Pražské Noviny

Světozor: Malebné cesty po Čechách: Naše řeky – Sázava: Světazor/1872, s. 522

Seidler: Seidler K. (1887): Kronika města Světlá od roku 1207–1886, překlad A.V. Eichler, náklad vlastní, Světlá, s. 221

Sázava Dictionary: <http://www.mestosazava>

Šulc: Šulc (2007)

Flood Marks, DVD, Hydrosoft Veveslavín, Povodí Vltavy (official web site of the Sázava nad Sázavou municipality) www.ledecns.sz: Z historie Ledecských mostů

Orlicko: www.rodokmeny.kvalitne.cz/povoden.htm: Overview of floods in Podorlicko – A voda se valila

Wertika: <http://wertika.webgarden.cz/>

Zelenka: Brázdil, R. et al. (2001)

R é s u m é

Historické povodně na Sázavě

Článek přináší souhrnnou zprávu o historických povodních v povodí Sázavy se zaměřením zejména na předinstrumentální období. Využity jsou dokumentární zdroje, povodňové značky i měřené údaje.

Základním podkladovým materiálem byl podélný profil Sázavy z roku 1933, který obsahuje maximum věcných informací. Předmětem terénního průzkumu byly zejména sázavské mlýny a jezy, elektrárny, převozy, lávky, mosty a případně jiné stavby a části sídel, které byly v dosahu povodní a k nimž byly maximální hladiny vztahovány. Vyhodnocena je rovněž dostupnost informací o historických povodních, které přinášejí historické povodňové značky. Analýzou dostupných podkladů bylo zjištěno, že v 30. letech ještě poměrně bohatý fond povodňového značení dnes reálně existuje z jedné třetiny.

Článek představuje první podrobnější chronologii historických povodňových událostí na Sázavě. V celém období let 1500–2000 se podařilo identifikovat 13 povodní s největší pravděpodobností významnějších než poslední významná povodeň na přelomu března a dubna 2006. Historické značky potvrzují fakt, že jarní povodeň 2006 byla čtvrtým nejvýznamnějším případem v období 1845–2007, po povodních 1862, 1845 a 1891 a to v úseku toku od Davle po Havlíčkův Brod.

Podle frekvence jednotlivých výskytů povodní je zřejmé, že i v minulých staletích stoupá frekvence povodní od prosince až po březen. Nejrizikovějším obdobím pro velké povodně Sázavy byl historicky konec zimy. Nejčastěji zde docházelo k povodním na přelomu března a dubna, o něco nižší frekvenci měly povodně na přelomu února a března. Z letních povodní jsou typičtější události červencové, významnější povodně v srpnu či září jsou vzácné.

Podrobněji je zpracován nejvýznamnější případ z července 1714. Tento případ, reflektovaný častěji v historické literatuře patří nejen mezi zcela mimořádné případy v právě zkoumaném povodí, ale obecně mezi nejpozoruhodnější extrémy zaznamenané v psané historii českých zemí.

Citace kronikářských a jiných dokumentárních zdrojů je v článku rozšířena o stručnou charakteristiku průběhu povodně na Vltavě (případně v povodí Vltavy a Labe), tak aby dle celkových souvislostí byla kronikářská zpráva ověřena. Každá jednotlivá povodeň obsahuje i kategorizaci dle časového výskytu a sezonality.

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