Historical Hydrology in Central Europe

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1 Recent floods

The flood in Moravia and Silesia in July 1997
52 victims - material damage 63 billions of Czech crowns

The flood in Bohemia in August 2002
19 victims - material damage 73 billions of Czech crowns

The flood in Bohemia and Moravia in March-April 2006
10 victims - material damage 5.5 billions of Czech crowns
Floods in Moravia and Silesia (Bohemia) in June 2009 - 15 victims - material damage 8.5 billions of Czech crowns

(www.seznam.cz)
Instrumental data: The variation of floods with at least two-year peak discharge rates ($Q_2$, m$^3$.s$^{-1}$) in 1825-2003: 1 - winter synoptic type, 2 - summer synoptic type
2 Historical hydrology

Relatively short periods of instrumental hydrological observations requires to look on the pre-instrumental period – historical hydrology as a research field occupying the interface between hydrology and history using mainly man-made documentary evidence with the objectives:

• to reconstruct temporal and spatial patterns of river flow and in particular extreme events (floods, ice phenomena, hydrological droughts), mainly for the period prior to the creation of national hydrological networks (systematic observations)

• to investigate the vulnerability of past societies and economies to extreme hydrological events

(Brázdil - Kundzewicz - Benito, HSJ, 2006)
3 Documentary evidence about floods

Newspapers and special prints

Narrative written sources

Pictorial evidence

Watermarks
a) sources of the narrative character

annals, chronicles, memories etc.

The Prague canon Cosmas

The first record about a flood in Prague (Kosmas's chronicle - September, 1118):

"In the year of our Lord 1118 in the month of September, there was such a flood as, I think, has not been on the Earth since the Deluge. This river of ours, the Vltava, suddenly breaking out of its bed, how many villages, how many houses in the suburbia, huts and churches did it take away! At other times, although it happens rarely, the water reaches only the floor of the bridge, but this flood raised to the height of ten ells over the bridge."
b) economic records

Books of accounts of Louny (on the Ohře river)

Information about regular Saturday payments of wages for agricultural and other municipal work (relation to floods - e.g. reparation of bridges after floods, flooded fields and meadows, removing of ice barrier on the Ohře river)
c) pictorial evidence

Shooting target (1826) depicting the flood on the Dyje (southern Moravia) in February 1799 and the effort of a crew of Russian Cossacks to save villagers drifting on ice floes and the debris of houses in Starý Šaldorf.

The Litoměřice bridge, destroyed during the Elbe flood on 24 March 1814.
d) occasional prints

e) correspondence

f) newspapers

g) early scientific papers and communications

(Description of a terrible flood on the Vltava River in Prague in September 1890)
h) epigraphic sources - watermarks

The Mosel River – Cochem water-gauge

The Danube River - Ybbs a. d. Donau
### Classification of flood intensity based on documentary evidence (completed according to Sturm et al., 2001)

<table>
<thead>
<tr>
<th>Level</th>
<th>Classification</th>
<th>Primary Indicators</th>
<th>Secondary Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>flood</td>
<td>no additional information</td>
<td>no additional information</td>
</tr>
<tr>
<td>1</td>
<td>smaller, regional flood</td>
<td>little damage, e.g. fields and gardens close to the river, wood supplies that were stored close to the river are moved to another place</td>
<td>short flooding</td>
</tr>
<tr>
<td>2</td>
<td>above average or supra-regional flood</td>
<td>damages on buildings and constructions related to the water like dams, weirs, footbridges, bridges and buildings close to the river like mills etc.; water in buildings</td>
<td>flood of average duration, severe damages to fields and gardens close to the river, loss of animals and sometimes people</td>
</tr>
<tr>
<td>3</td>
<td>above average or supra-regional flood on a disastrous scale</td>
<td>severe damages on buildings and constructions related to the water i.e. dams, weirs, footbridges, bridges and buildings close to the river like mills etc, water in buildings; in part, buildings are completely destroyed or torn away by the flood</td>
<td>flood of longer duration, several days or weeks; severe damages on fields and gardens close to the river, extensive loss of animals and people; morphodynamic processes like sand sedimentation cause lasting damages and change the surface structure</td>
</tr>
</tbody>
</table>

Classification of flood intensity based on documentary evidence (completed according to Sturm et al., 2001)
Chronology of floods in the pre-instrumental period based on documentary evidence for the Vltava (AD 1501-1824) and the Elbe (AD 1501-1850)
The synthesis series of flooding derived from documentary evidence and water-gauge measurements - the River Vltava in Prague during AD 1500-2002
Decadal frequencies of floods 1501-2000: 1 - winter synoptic type, 2 - summer synoptic type, 3 - without specification, ↓ - beginning of instrumental measurements
The stone figure of Bradáč (a bearded man), located in the fortification of the right bank of the River Vltava in Prague (close the Charles Bridge)
Levels of greatest floods on the River Vltava in Prague with the projection to the position of Bradáč (missing watermarks for July 1432 and February 1862)
Floodmarks of the Elbe River on Castle Rock at Děčín
5 Floods of the 1783/1784 winter

• typical winter of the Little Ice Age: very cold, much snow (after the 1783 Lakagígar eruption in Iceland)
• three flood waves in Europe (December-January, late February, late March)
• important social and economic consequences

The flood of the Vltava at Prague on 27-28 February 1784 due to ice damming - the highest known water mark up to August 2002, the Charles bridge damaged (estimated discharge rate 4,560 m³.s⁻¹)

(Brázdil et al., TAC, 2010)
A flood hydrograph of the Vltava River in Prague at the Monastery of the Knights of Cross reconstructed from documentary data for 27 February – 1 March 1784 (corrected after Brázdil et al., 2005)
Late February – early March 1784
Fluctuations of daily mean temperatures and the Seine water levels measured at the bridge de la Tournelle in Paris from 1 December 1783 to 14 April 1784: 1 – water level, 2 – temperature, 3 – day with snowfall

(Brázdil et al., TAC, 2010)
Rivers in Central Europe and Mediterranean used for the study of floods in the past 500 years (Glaser et al., Climatic Change, 2010)
Time series of 31-year running flood frequencies (black line) of selected Central European rivers with respect to their causes (the colored background displays the underlying climatological causes differentiated into convective rain, long-lasting rain, ice break up and snow melt; grey background — no information about the triggering climatic causes) (Glaser et al., Climatic Change, 2010)
7 Concluding remarks

• from the mid-19th century the **drop in the number and intensity of floods** in the Czech Elbe River Basin has been observed - mainly due to decrease of floods in February to April, related to a later onset of winters and a lower accumulation of snow cover

• **documentary evidence** is an important source of high-resolution data about floods in the pre-instrumental period - frequency, seasonality, causes and impacts of floods

• the **most disastrous millennial floods** in the Czech Elbe River Basin: **September 1118**, March 1272, February 1342, **July 1432**, August 1501, March and August 1598, February 1655, June 1675, February 1784, March 1845, February 1862, May 1872, September 1890, July 1897, **August 2002**

• floods of February 1784, March 1845, February 1862 (all winter synoptic type) - the **end phase of the Little Ice Age**?
• since May 1872 **floods of the summer synoptic type** (from rainfall) prevail

• **long-term flood records may reduce uncertainty** in hydrological analyses and contribute to reducing losses of human lives and property – **floods in the current and future global warming?**

Thanks for your kindly attention!