Floods in the Czech Republic - Peak Discharges Analysis in the Upper Dyje Catchment and the Upper Svratka Catchment

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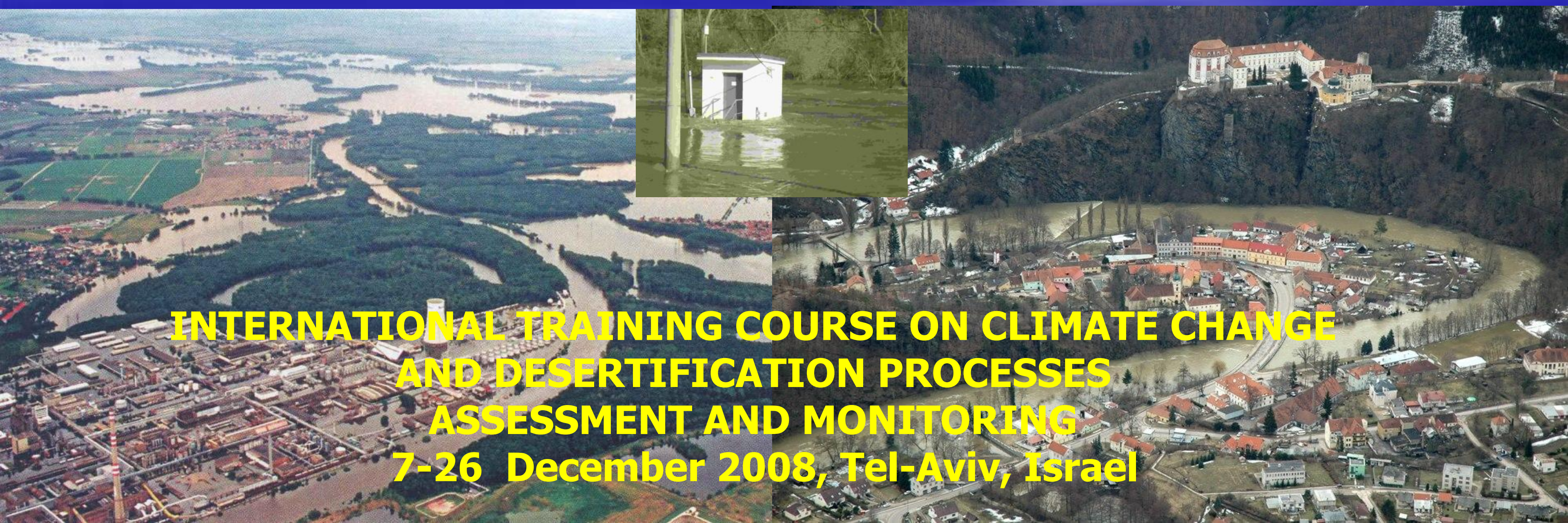


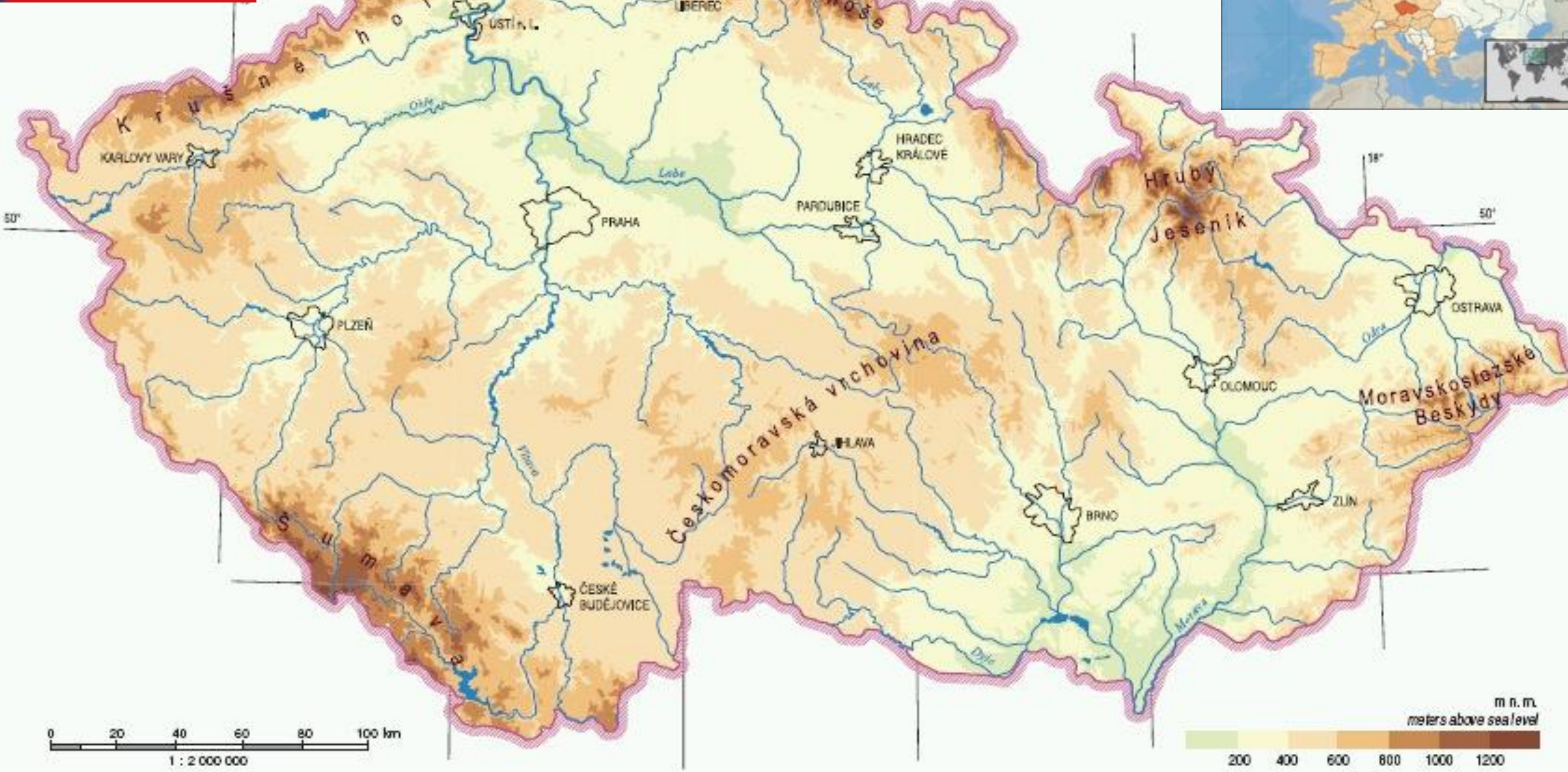
INTERNATIONAL TRAINING COURSE ON CLIMATE CHANGE AND DESERTIFICATION PROCESSES ASSESSMENT AND MONITORING

7-26 December 2008, Tel-Aviv, Israel

Presentation outline

- The Czech Republic
- Masaryk University, Czech Hydrometeorological Institute
- Natural and hydrological extremes in the Czech Republic
- Floods in the Czech Republic -
  - Peak Discharges Analysis in the Upper Dyje Catchment, Station Podhradí nad Dyjí (mean annual runoff distribution, frequency, chronology, seasonality, extremity)
  - Peak Discharges Analysis in the Upper Svratka Catchment, Station Borovnice (frequency, chronology, seasonality, extremity)
- Conclusion

CZECH REPUBLIC



Area :	**78,866 km^2**	**Population :**	**10.3 million (2007)**
The lowest point :	**115 m a.s.l.**	**Build-up areas :**	**2%**
The highest poit :	**1,602 m a.s.l.**	**Agricultural land :**	**54%**
Mean temperature :	**7.5 º C**	**Forest land :**	**33%**
Mean precipitation total :	**668 mm**	**Water area :**	**2%**

Borders : Germany, Poland, Austria, Slovakia

Population density : 130 inhabitants / km^2

Capital: Prague (1.2 million inhabitants)

Specific runoff : $q=6,1\ l.s^{-1}.km^{-2}$, runoff coefficient : $\varphi=28.8\ \%$

MAIN CATCHMENTS

Labe River Catchment : 63%, Morava River Catchment : 27%, Odra River Catchment : 9% of Czechia´s territory, total length of all watercourses :76,000 km, drainage density : 0.96 $km.km^{-2}$

MASARYK UNIVERSITY, FACULTY OF SCIENCE

DEPARTMENT OF GEOGRAPHY

- **The city of Brno is the second largest centre of education in the Czech Republic, Masaryk University is the second largest university (about 36,000 students in 2007) : www.muni.cz**
- **Faculty of Science, Department of Geography – My doctoral studies started in 2007 – physical geography**

EDUCATION :
http://www.geogr.muni.cz/en/studium/

- **Bachelor study** – geography, cartography, applied geography, teaching geography
- **Master study** – physical geography, regional geography, cartography and geoinformatics, teaching geography
- **Doctoral study** – physical geography, regional geography, cartography and geoinformatics

RESEARCH ACTIVITIES

CZECH HYDROMETEOROLOGICAL INSTITUTE (CHMI)

- CHMI BASIC PURPOSE :
  - carry out the function of the Czech Republic´s governmental institution for the fields of hydrology, meteorology, climatology and air quality
  - monitoring, acquisition, processing of hydrometeorological data **www.chmi.cz**
- DIVISION OF HYDROLOGY
  - providing specialist services to state administration
  - serving as centre of the Flood Forecasting Service
  - producing of standard hydrological data
  - providing official discharge measurements in water streams
- FOUNDER : Ministry of the Environment of the Czech Republic

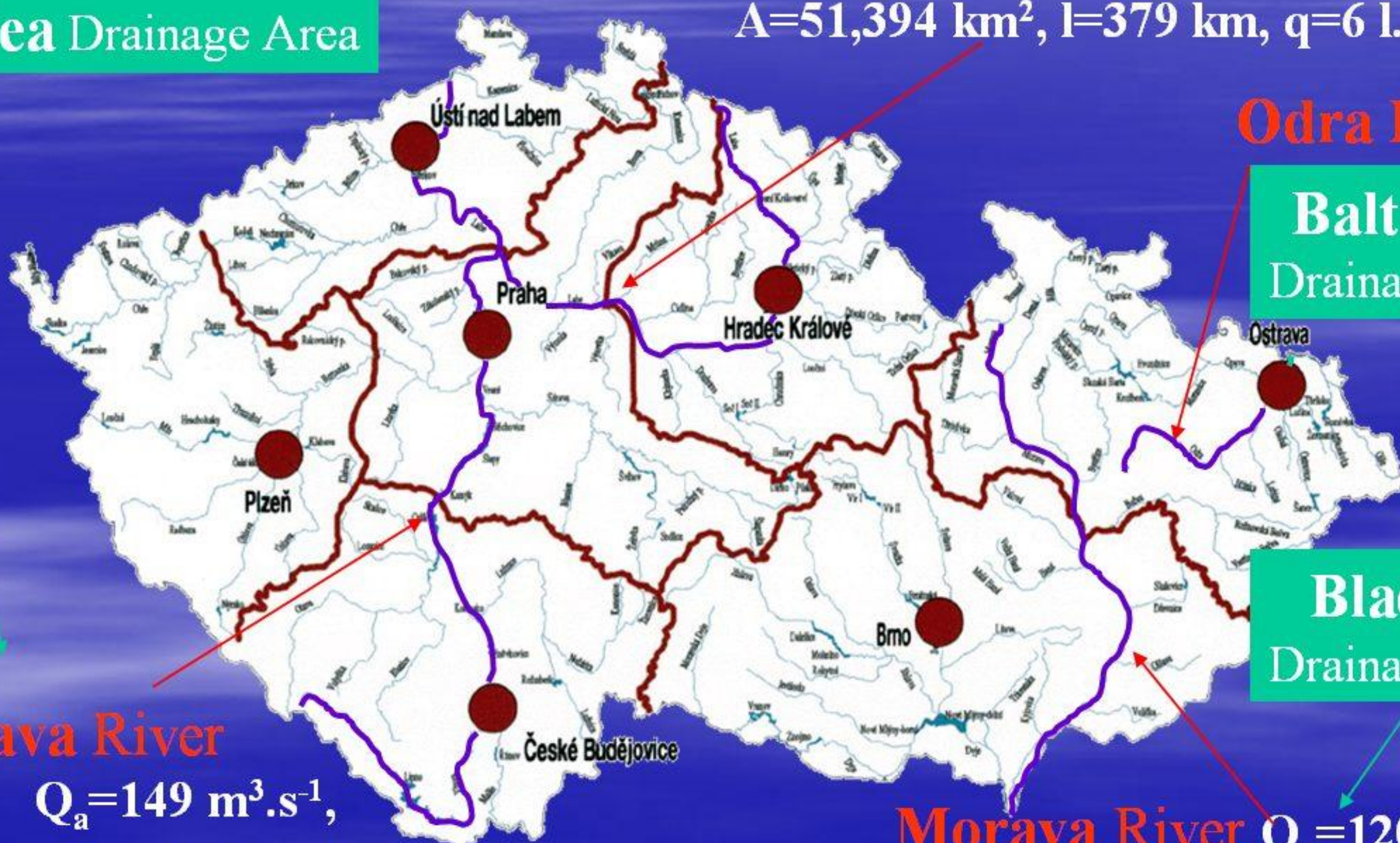
MAIN RIVERS IN THE CZECH REPUBLIC

Labe River, Q_a=308 $m^3.s^{-1}$, A=51,394 km^2, l=379 km, q=6 $l.s^{-1}.km^{-2}$

North Sea Drainage Area

Odra River

Baltic Sea Drainage Area



Black Sea Drainage Area

Vltava River Q_a=149 $m^3.s^{-1}$, A=28,098 km^2, l=440 km

q=5.3 $l.s^{-1}.km^{-2}$

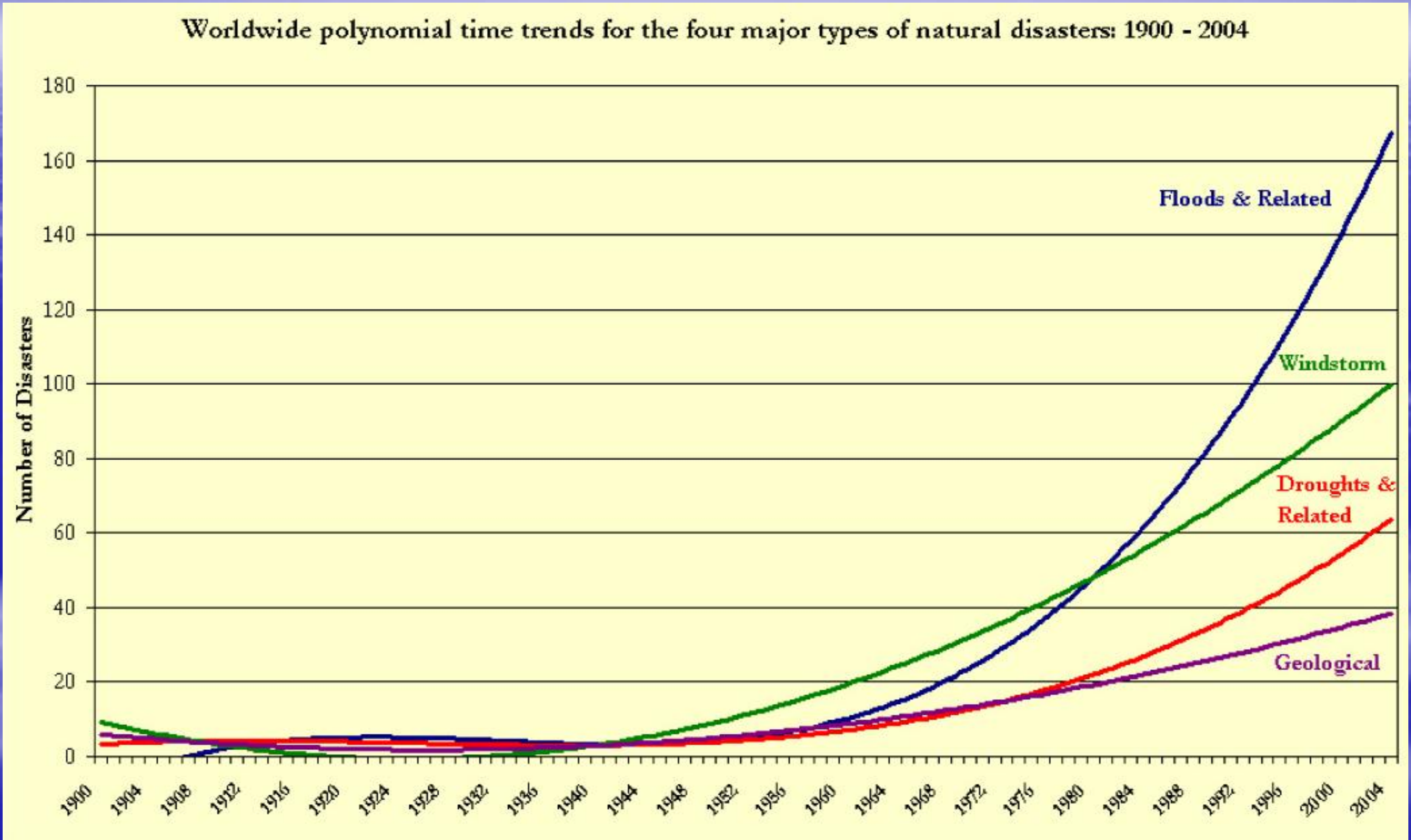
Morava River Q_a=120 $m^3.s^{-1}$, A=23,580 km^2, l=358 km - tributary of Danube River

q=4.5 $l.s^{-1}.km^{-2}$

NATURAL AND HYDROLOGICAL EXTREMES

- Impacts of climate change on water recources and hydrological regime are evident
- The recent period of global warming is characterized by the increased occurrence of natural extremes
- It is also valid for watercourses with the occurrence of hydrological extremes - DROUGHTS and FLOODS
- Problem not only in the Czech Republic and in Europe but all over the world

TREND IN DISASTER OCCURENCE 1900-2004



Source: EM-DAT : The OFDA/CRED International Disaster Database.
http://www.em-dat.net, UCL - Brussels, Belgium

DROUGHTS – THE CZECH REPUBLIC - impact on watercourses

- Dry periods occurred in the Czech Republic, for example, 1983, at the beginning of the 1990s (1989-1992), 1994, 2000, 2003 – Morava River Catchment

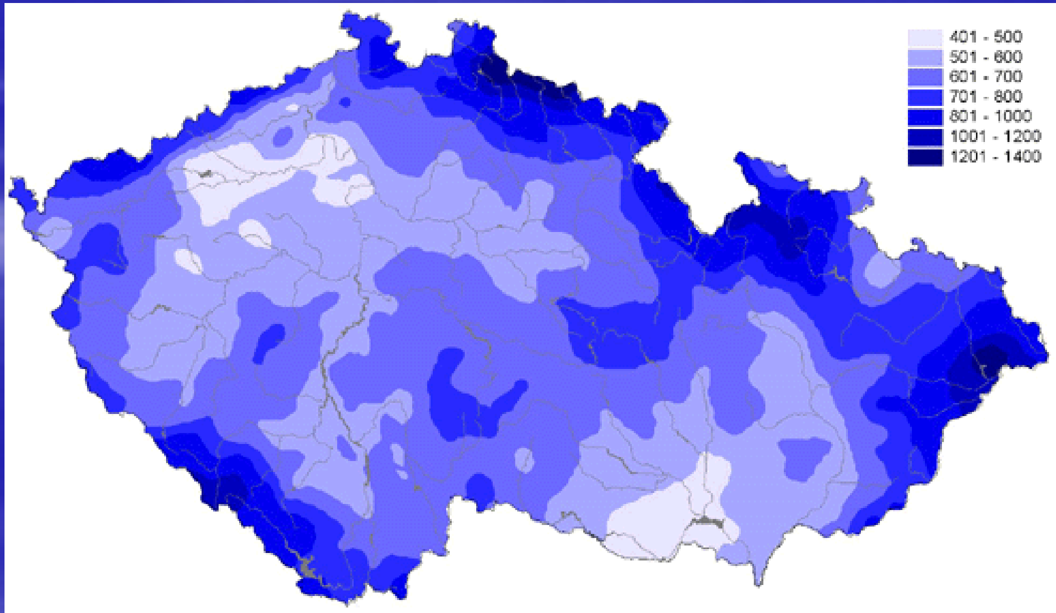
Lanžhot, Morava River August 2003

Vranov Water Reservoir, Želetavka River inflow into Dyje River, September 1992 (5-6% of Q_a)

FLOODS – THE CZECH REPUBLIC

- Location of the landlocked country in the temperate climate in central Europe and diverse orography affect to a considerable degree flood regime of the Czech watercourses
- Floods can most often occur during snowmelt on majority of watercourses, usually from December to April, the summer floods can prevail in Odra River basin and on some watercourses originating in mountains, BUT
- Floods can appear several times a year in any season of the year
  - The lead-time ranges between few and 36 hours

MEAN ANNUAL PRECIPITATION



TYPES OF FLOODS – THE CZECH REPUBLIC

With respect to meteorological causes, floods can be devided into :

- RAIN FLOODS, SNOW FLOODS, MIXED FLOODS, ICE FLOODS (Brázdil, R. et al.,2005)

With respect to the combination of causes and seasonal occurence :

- SUMMER TYPE of floods due to
  - Short storm rainfall (flash floods)
  - Regional rainfall – duration up to several days
- WINTER and SPRING TYPE of floods due to
  - Snow melt or combination of snow melt and rainfalls
  - Occurence of mass of ice in the river channel
- FLOOD FROM OTHER SPECIFIC REASONS
  - Blocking of the flow (e.g. by landslide, avalanche)

(Matějíček, J.-Hladný, J., 1999)

FLOODS – THE CZECH REPUBLIC

- The disastrous floods in the Czech Republic in July 1997 (Moravia, 52 victims) and in August 2002 (Bohemia, 17 victims) reached peak discharges with the return period exceeding 100 years and more (also spring 2006)

Prague, Vltava River
August 2002, Q_{500}

Podhradi nad Dyjí, Dyje River, spring 2006 Q_{100}, summer 2006, cca Q_{500}

VLTAVA RIVER IN PRAGUE

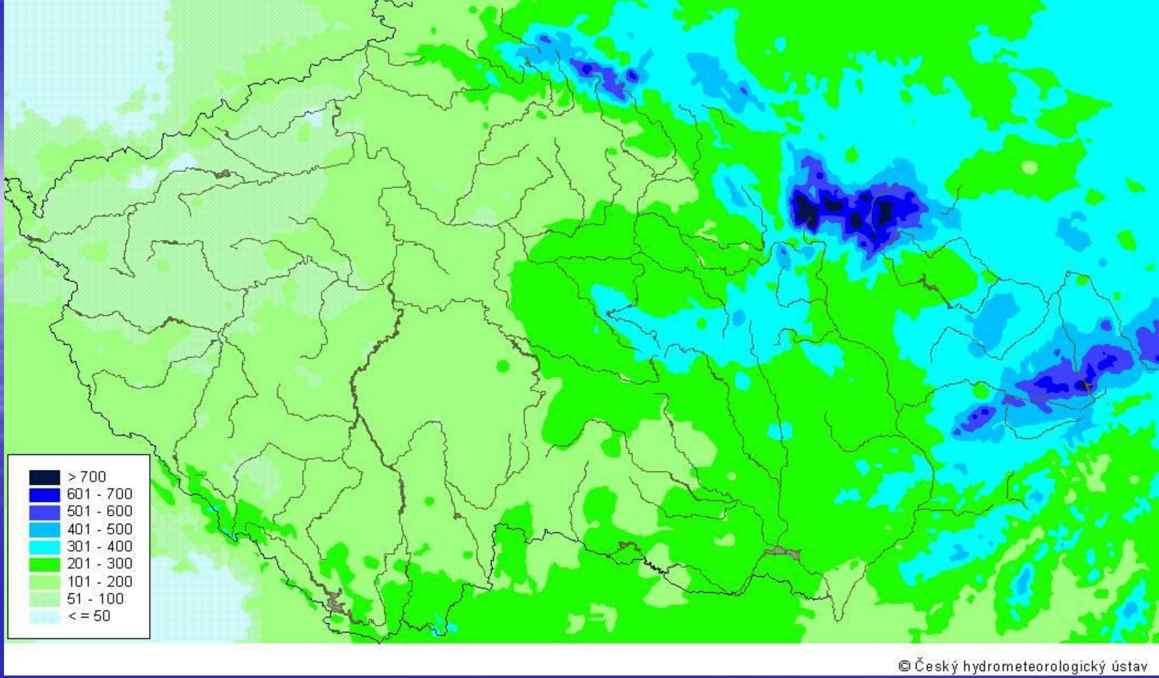
H_a=74 cm, Q_a=149 $m^3.s^{-1}$, 14 August 2002 - water level H=782 cm
peak discharge Q_{500}=5,160 $m^3.s^{-1}$

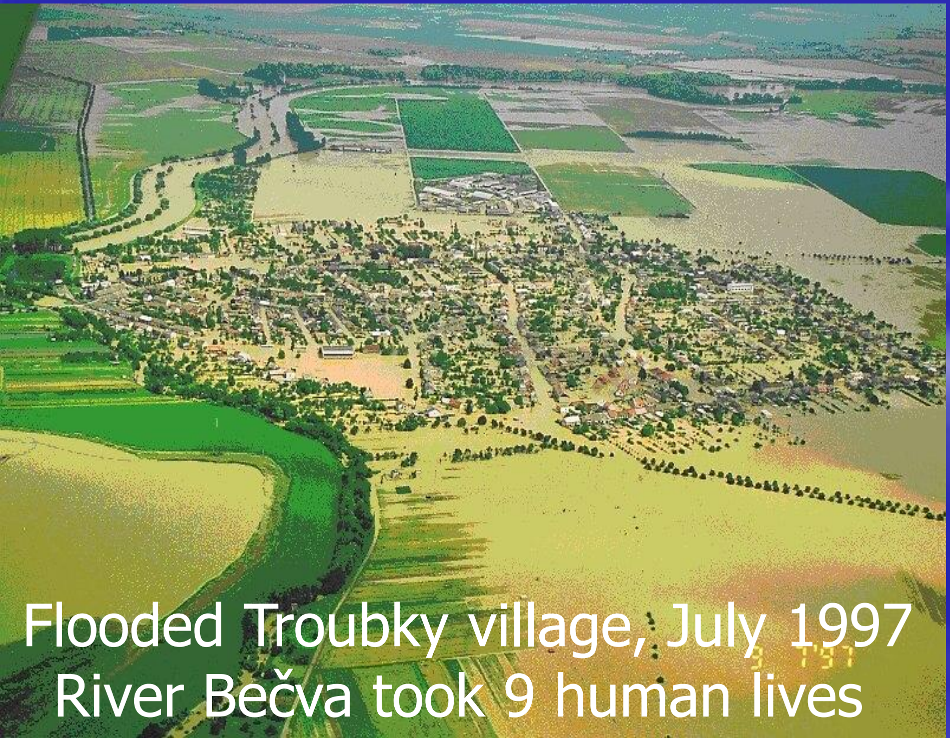
VLTAVA RIVER IN PRAGUE

H_a=74 cm, Q_a=149 $m^3.s^{-1}$, 14 August 2002 - water level H=782 cm
peak discharge Q_{500}=5,160 $m^3.s^{-1}$

FLOODS

Monthly precipitation totals
July 1997 [mm]





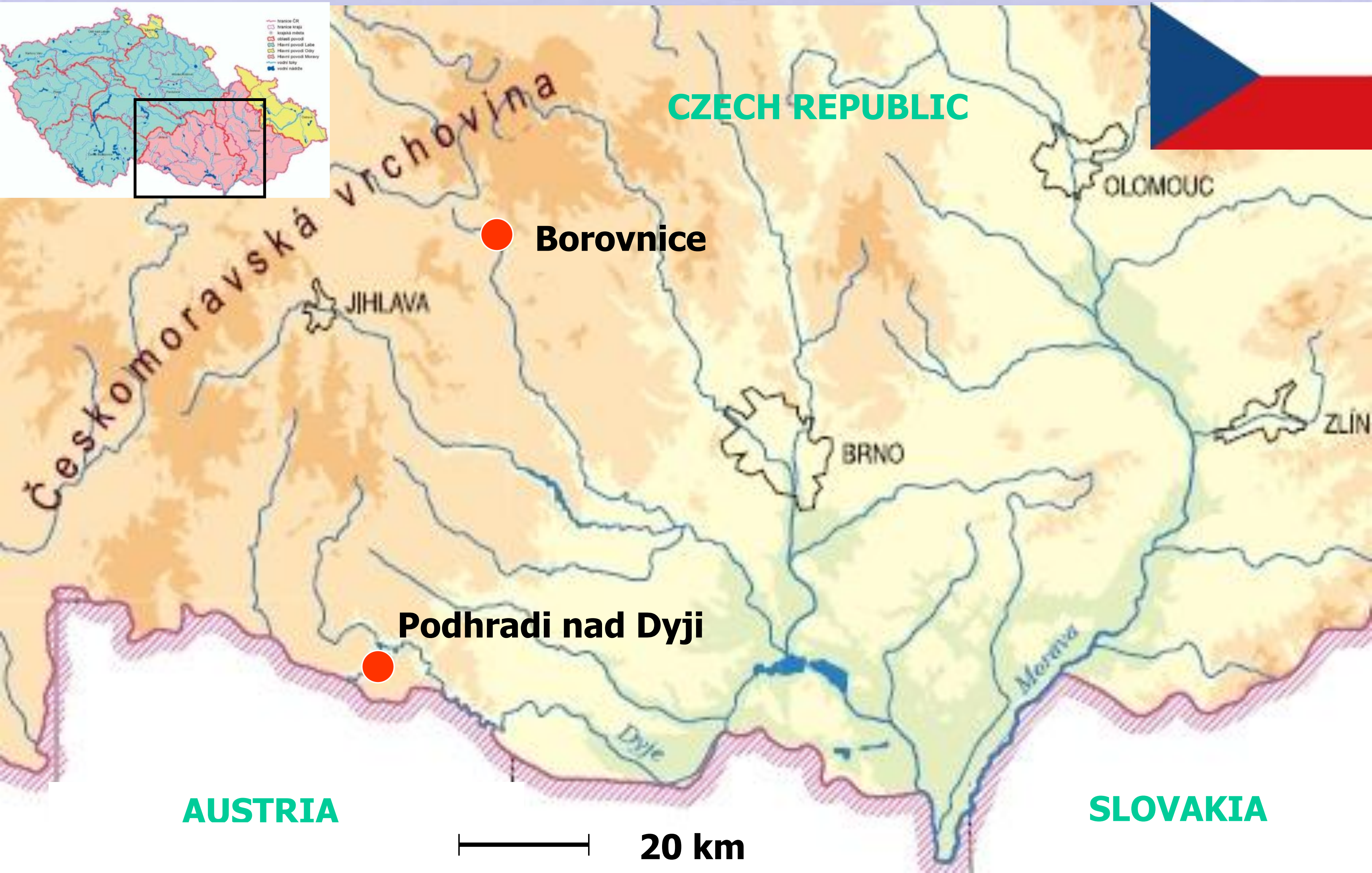
Flooded Troubky village, July 1997
River Bečva took 9 human lives

Morava River, Olomouc
11 July 1997

DATA AND SELECTION OF THE TERRITORY STUDIED

- 2 hydrological stations
- Series of the mean annual and monthly discharges
- Series of the annual peak discharges
- Selected period of assessment :
  - Dyje River, Station Podhradí : 1935-2006
  - Svratka River, Station Borovnice : 1925-2007
- Territory of interest : upper parts of Dyje River Catchment and Svratka River Catchment
- Located in the south part of the Czech Republic (South Moravia)

SELECTED HYDROLOGICAL STATIONS



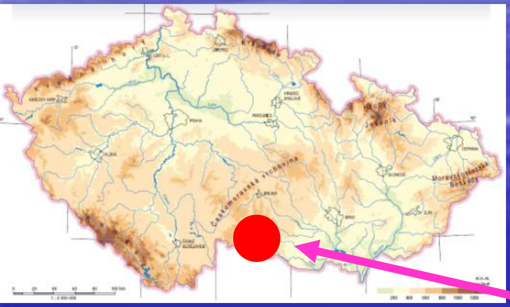
METHODOLOGY

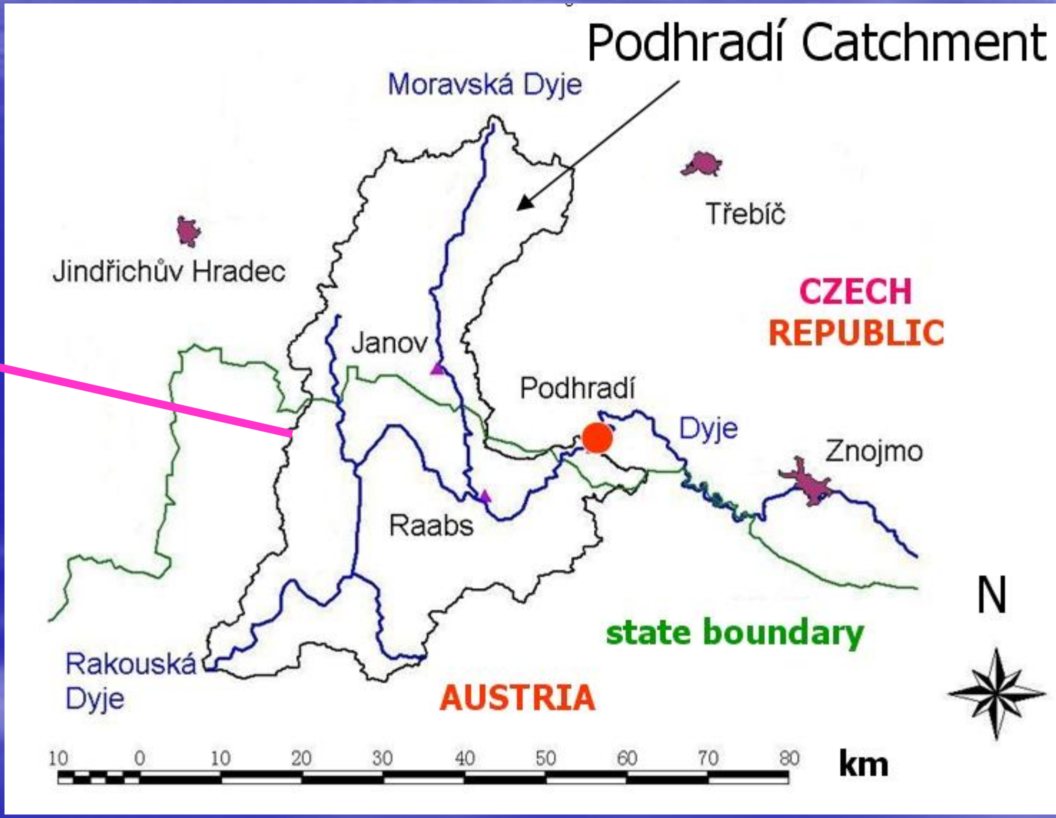
- In the period of systematic hydrological observations, floods exceeded the value Q_2 (peak discharge with the return period of 2 years) were chosen from the CHMI database
- N-year discharges were applied (for N=2, 5, 10, 20, 50, 100) - derived with accordance to the methodology used in CHMI, calculated from the values of maximum peak discharges from all of hydrological years)
  - data series are sufficiently long
  - discharges are not affected by water reservoirs (geografical location - catchments are located in upper parts of selected rivers)

RESULTS

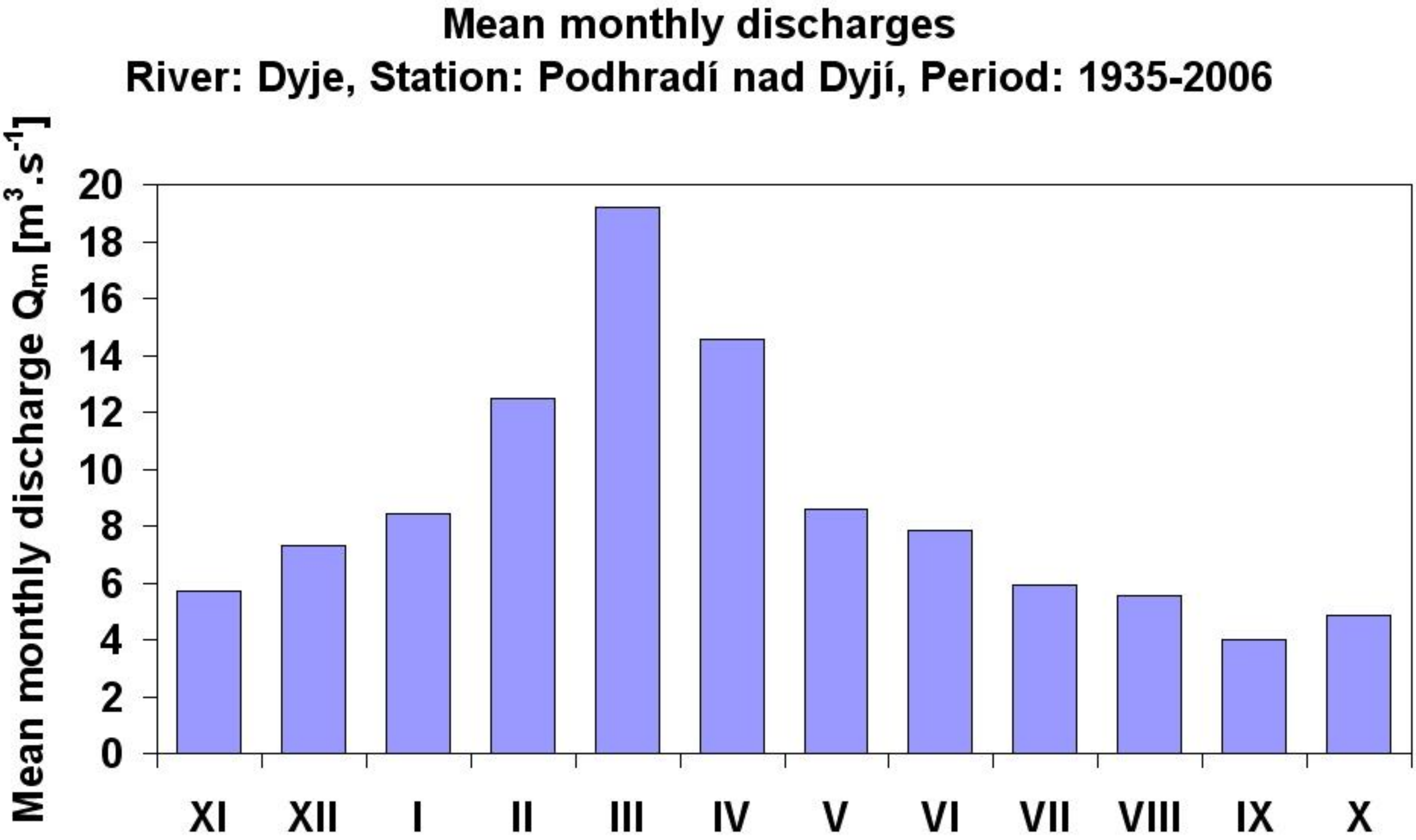
1. River Dyje, Station Podhradí, Period 1935-2006

Basic hydrological characteristics



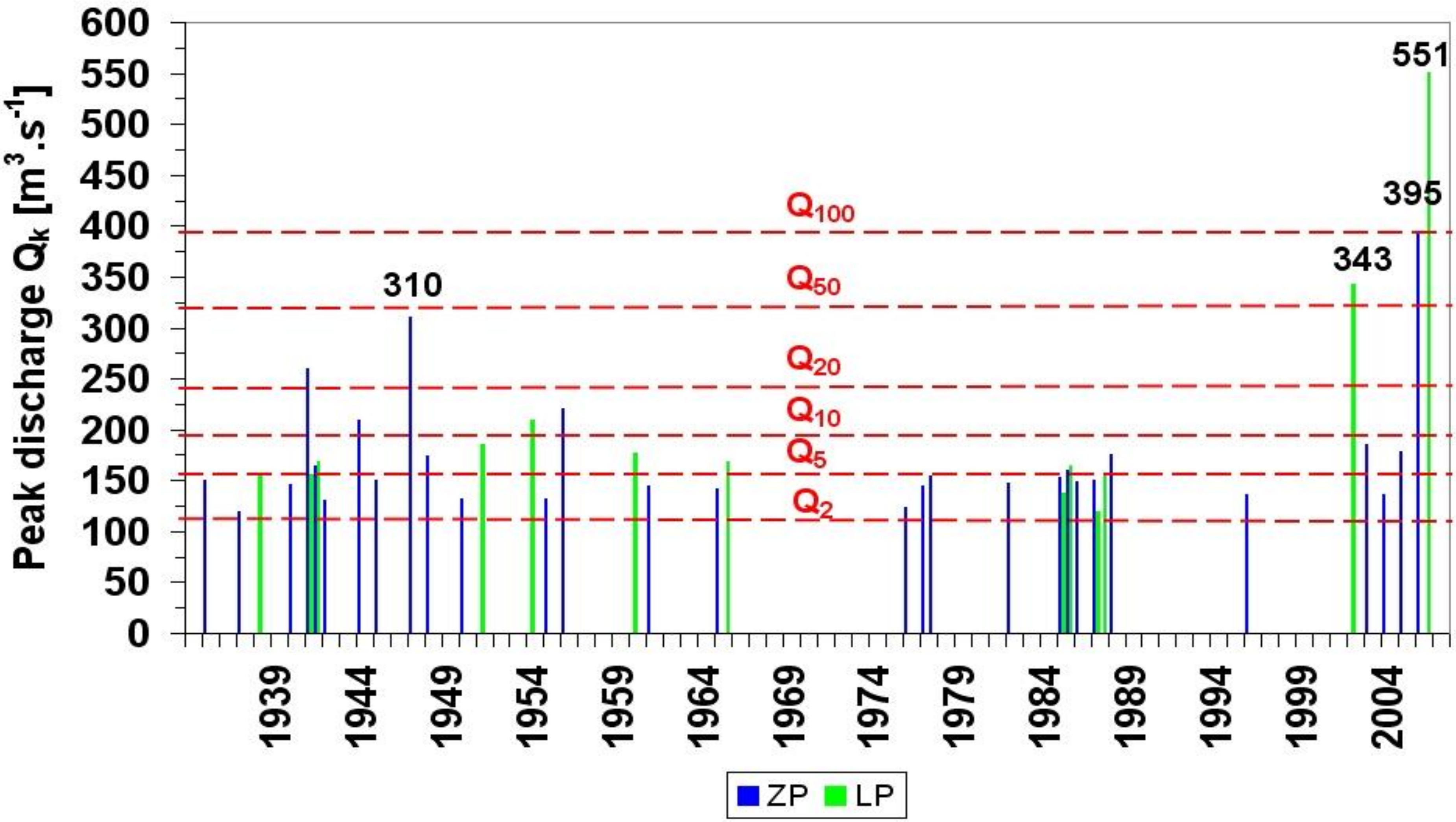


- Catchment area
  $A=1,755.95\ km^2$ (i.e. 13.1% of the total area of the Dyje catchment)
- Mean annual long-term discharge $Q_a=8.5\ m^3.s^{-1}$
- Mean area precipitation
  $P_a=632\ mm$
- Absolute maximum of 551 $m^3.s^{-1}$ achieved during the flood of 30 June 2006



the heighest monthly discharges - March (18.4% of Qa) and April (14.0%), the lowest monthly discharges in Semptember (3.8%) and October (4.7%)

Chronology of floods exceeding the two-year maximum peak discharge $Q_2 = 118.5\ m^3.s^{-1}$ in the period 1935-2006, taking into consideration their N-year return period and occurence during the winter (ZP : November-April) and summer (LP : May-October) hydrological half-years River : Dyje, Station : Podhradí nad Dyjí



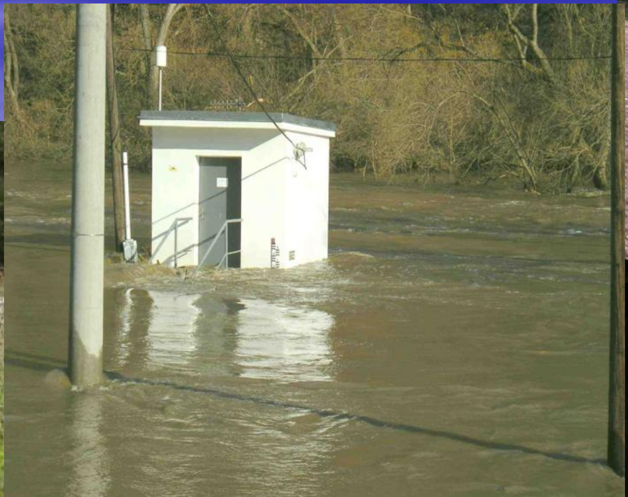
Frequencies of floods according to the N-year return period of their maximum peak discharge Q_k on the Dyje River at Podhradí nad Dyjí in the period 1935-2006

Period/Q_k	$Q_2<Q_k<Q_5$	$Q_5<Q_k<Q_{10}$	$Q_{10}<Q_k<Q_{20}$	$Q_{20}<Q_k<Q_{50}$	$Q_{50}<Q_k<Q_{100}$	$Q_k>Q_{100}$	Total
ZP	18	6	2	2	0	1	29
LP	5	5	1	0	1	1	13
Total	23	11	3	2	1	2	42

30 June 2006
cca Q_{500}

30 March 2006
Q_{100}

August 2002
> Q_{50}



Monthly frequencies of floods (exceeding the two-year maximum discharge $Q_2 = 118.5\ m^3.s^{-1}$) according to the N-year return period of their maximum peak discharge Q_k during the winter (ZP - November-April) and summer (LP - May-October) hydrological half-years

<table>
<tr><th>Month/Q_k</th><th>$Q_2<Q_k<Q_5$</th><th>$Q_5<Q_k<Q_{10}$</th><th>$Q_{10}<Q_k<Q_{20}$</th><th>$Q_{20}<Q_k<Q_{50}$</th><th>$Q_{50}<Q_k<Q_{100}$</th><th>$Q_k > Q_{100}$</th><th>Monthly frequency</th><th>Frequency ZP/LP</th><th>Total frequency</th></tr>
<tr><td>XI</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td rowspan="6">29</td><td rowspan="12">42</td></tr>
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<tr><td>VI</td><td>2</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td>4</td></tr>
<tr><td>VII</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>VIII</td><td>1</td><td>2</td><td>0</td><td>0</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td>IX</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>X</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
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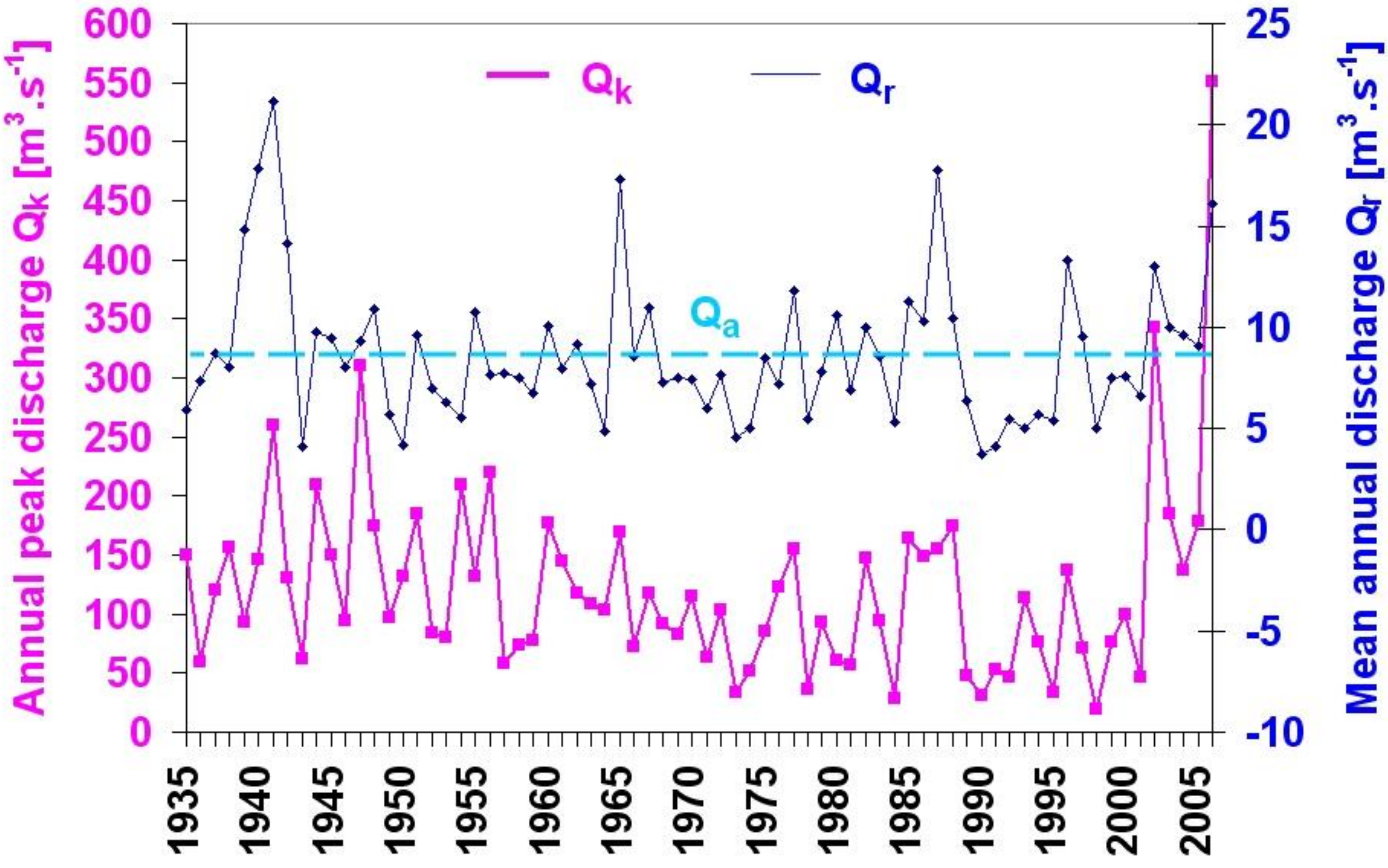
Mean annual discharges Q_r and annual peak discharges Q_k on the Dyje River at Podhradí nad Dyjí station in the period 1935-2006



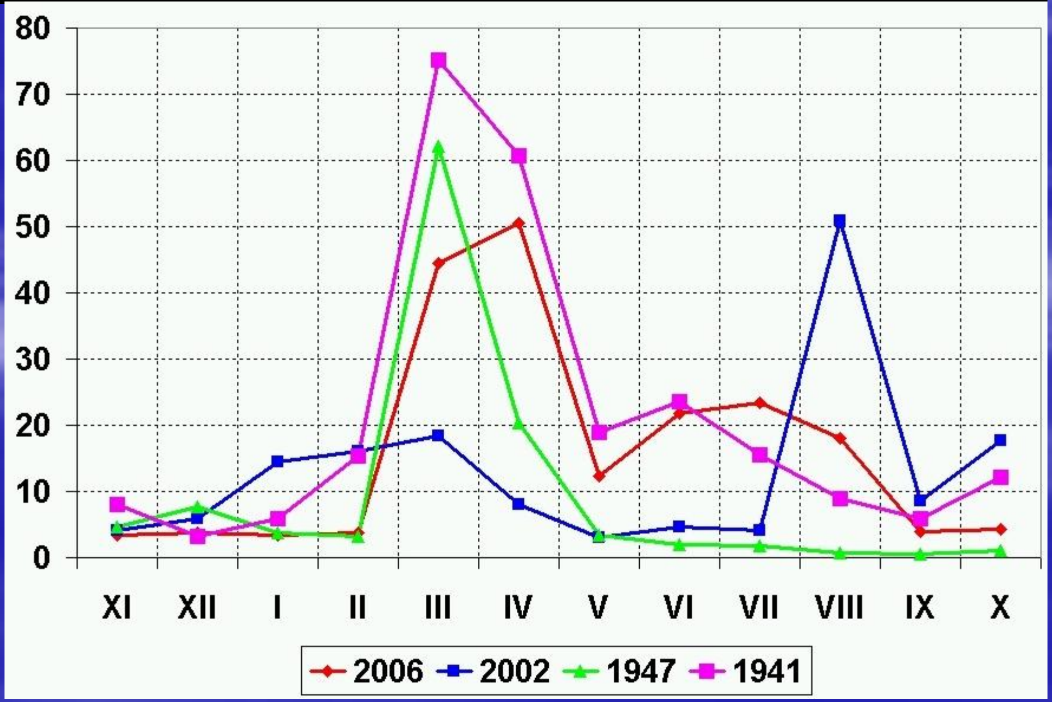
Rate of runoff during hydrological years including maximum peak discharge Q_k, mean annual discharge Q_r and N-year return period of the maximum annual peak discharge Q_k, Station : Podhradí

Nr.	Hydrological year (HR)	Mean annual discharge Q_r [$m^3.s^{-1}$]	Exceedance probability p [%]	Maximum annual peak discharge Q_k [$m^3.s^{-1}$]	Rate of runoff during hydrological year	Return period N	Number of floods during hydrological year
1	1941	21.165	0.97	260	extremely wet	>20	4
2	1940	17.857	2.35	146	extremely wet	>2	1
3	1987	17.784	3.73	155	extremely wet	>2	3
4	1965	17.306	5.11	169	extremely wet	>5	2
5	2006	16.100	6.49	551	extremely wet	>100	2
6	1939	14.821	7.87	93	extremely wet	<1	1
7	1942	14.153	9.25	130	extremely wet	>2	1
8	1996	13.279	10.64	137	wet	>2	1
9	2002	13.037	12.02	343	wet	>50	1

Floods exceeding the twenty-year maximum peak discharge of $Q_{20} = 242.9\ m^3.s^{-1}$
Station : Podhradí

Nr.	Maximum annual peak discharge Q_k $[m^3.s^{-1}]$	Hydrological year	Month	Number of floods during hydrological year	Return period N	Rate of runoff during hydrological year
1	551	2006	VI	-	> 100	extremely wet
2	395	2006	III	-	> 100	extremely wet
3	343	2002	VIII	1	> 50	wet
4	310	1947	III	1	> 20	wet
5	260	1941	III	4	> 20	extremely wet

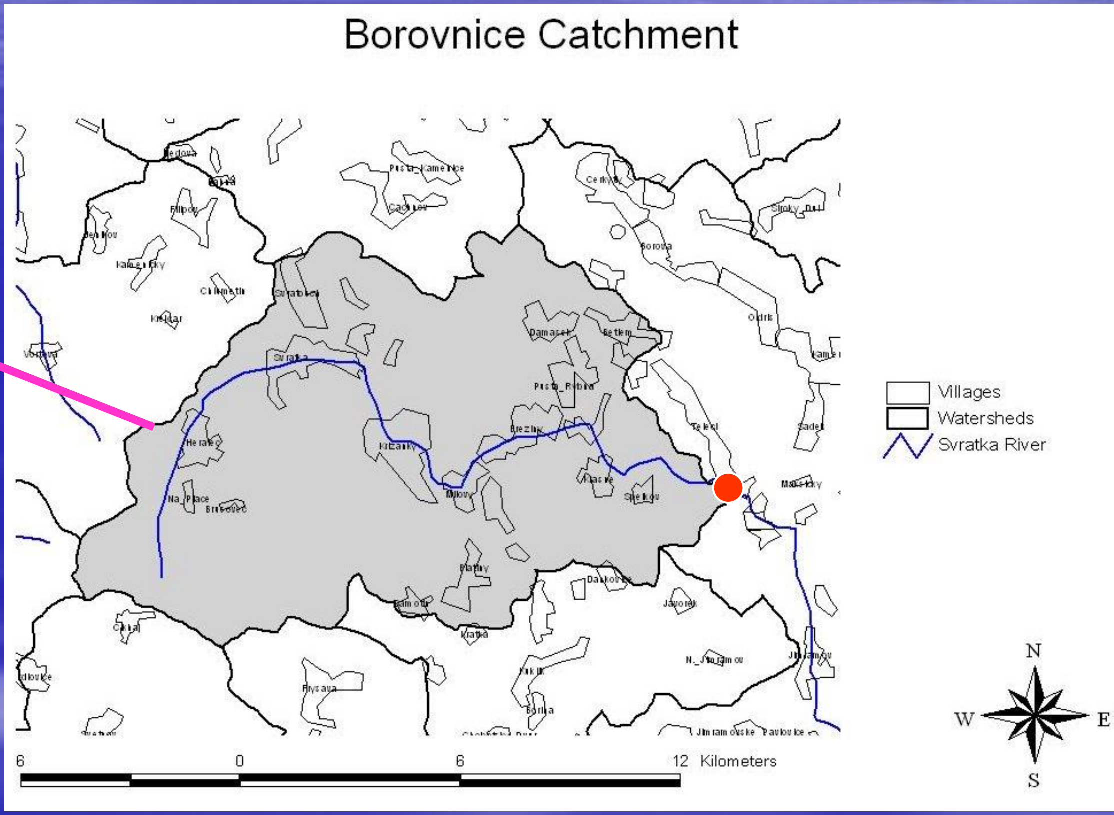
Mean monthly discharges Q_m $[m^3.s^{-1}]$ in hydrological years with floods exceeding Q_{20}



RESULTS

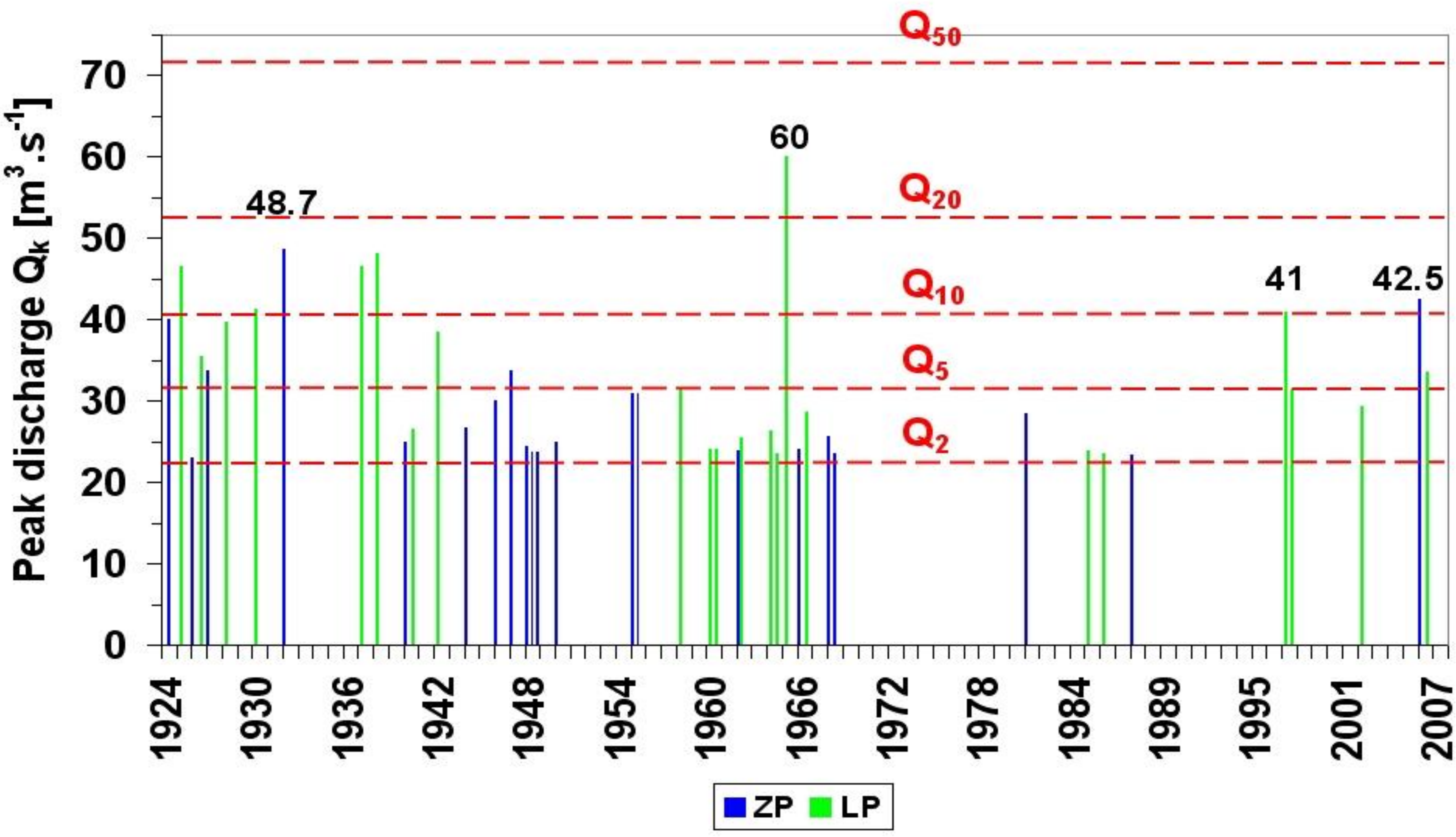
2. River Svratka, Station Borovnice, Period 1925-2007

Basic hydrological characteristics



- Catchment area
  A=127.95 km^2 (i.e. 1.8% of the total area of the Svratka catchment)
- Mean annual long-term discharge Q_a=1.52 $m^3.s^{-1}$
- Mean area precipitation
  P_a=764 mm
- Absolute maximum of 60 $m^3.s^{-1}$ occurred in July 1965

Chronology of floods exceeding the two-year maximum peak discharge $Q_2 = 22.3\ m^3.s^{-1}$ in the period 1924-2007, taking into consideration their N-year return period and occurence during the winter (ZP : November-April) and summer (LP : May-October) hydrological half-years River : Svratka, Station : Borovnice



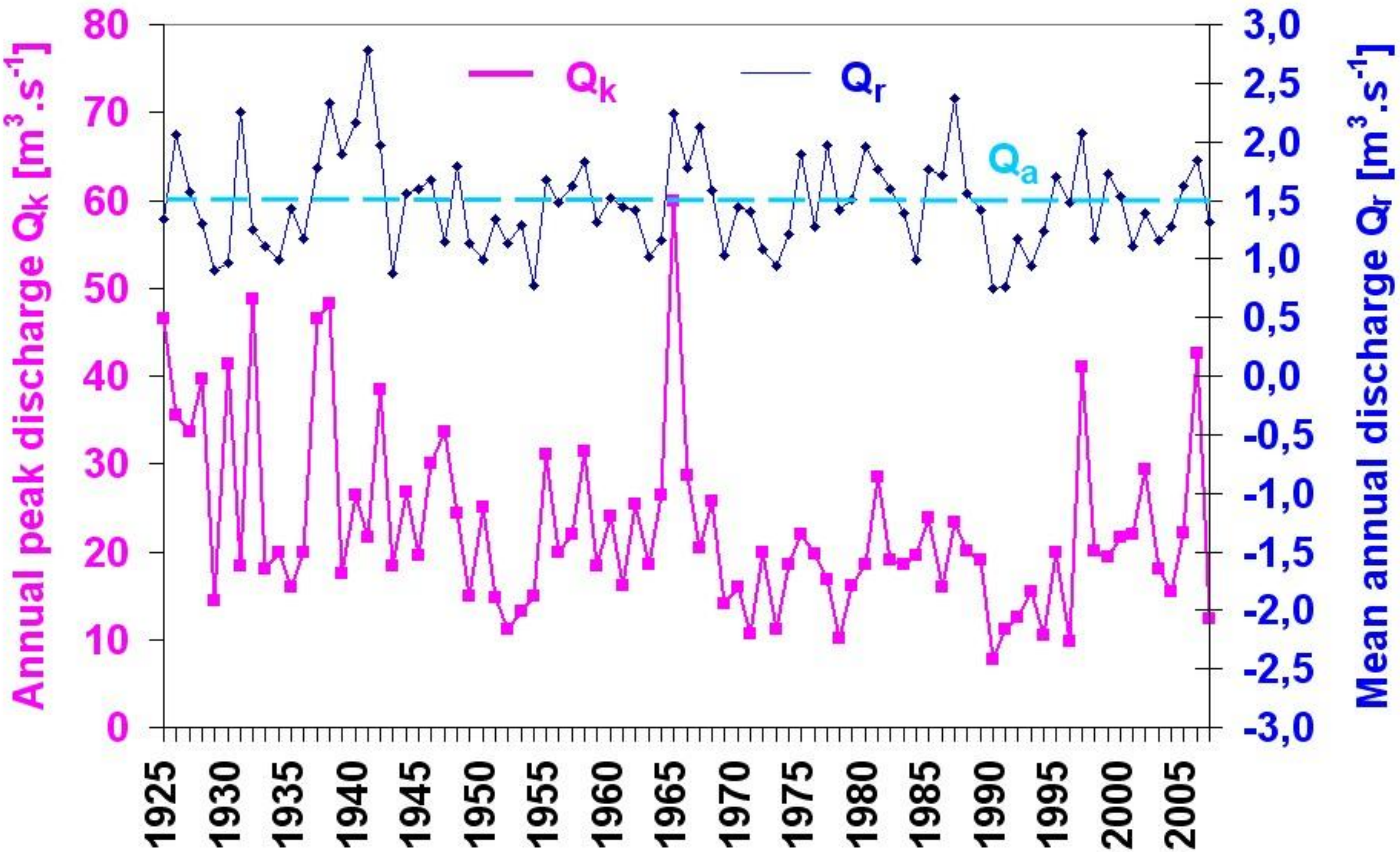
Frequencies of floods according to the N-year return period of their maximum peak discharge Q_k on the Svratka River at Borovnice Station in the period 1925-2007

Period/Q_k	$Q_2<Q_k<Q_5$	$Q_5<Q_k<Q_{10}$	$Q_{10}<Q_k<Q_{20}$	$Q_{20}<Q_k<Q_{50}$	$Q_{50}<Q_k<Q_{100}$	$Q_k>Q_{100}$	Total
ZP	16	3	2	0	0	0	21
LP	10	6	5	1	0	0	22
Total	26	9	7	1	0	0	43

Monthly frequencies of floods (exceeding the two-year maximum discharge $Q_2 = 22.3\ m^3.s^{-1}$) according to the N-year return period of their maximum peak discharge Q_k during the winter (ZP - November-April) and summer (LP - May-October) hydrological half-years

Month/Q_k	$Q_2<Q_k<Q_5$	$Q_5<Q_k<Q_{10}$	$Q_{10}<Q_k<Q_{20}$	$Q_{20}<Q_k<Q_{50}$	$Q_{50}<Q_k<Q_{100}$	$Q_k>Q_{100}$	Monthly frequency	Frequency ZP/LP	Total frequency
XI	1	0	0	0	0	0	1	21	43
XII	4	0	0	0	0	0	4		
I	3	1	1	0	0	0	5		
II	4	0	0	0	0	0	4		
III	3	2	1	0	0	0	6		
IV	1	0	0	0	0	0	1		
V	3	2	0	0	0	0	5	22	
VI	2	1	0	0	0	0	3		
VII	0	2	2	1	0	0	5		
VIII	4	1	2	0	0	0	7		
IX	0	0	0	0	0	0	0		
X	1	0	1	0	0	0	2		

Mean annual discharges Q_r and annual peak discharges Q_k on the Svratka River at Borovnice station in the period 1925-2007



Rate of runoff during hydrological years including maximum peak discharge Q_k, mean annual discharge Q_r and N-year return period of the maximum annual peak discharge Q_k, Station : Borovnice

Nr.	Hydrological year (HR)	Mean annual discharge Q_r [$m^3.s^{-1}$]	Exceedance probability p [%]	Maximum annual peak discharge Q_k [$m^3.s^{-1}$]	Rate of runoff during hydrological year	Return period N	Number of floods during hydrological year
1	1941	2.775	0.84	22.0	extremely wet	>1	1
2	1987	2.372	2.04	23.3	extremely wet	>2	1
3	1938	2.327	3.24	48.2	extremely wet	>10	1
4	1931	2.259	4.44	18.3	extremely wet	>1	1
5	1965	2.243	5.64	60.0	extremely wet	>20	1
6	1940	2.166	6.83	26.5	extremely wet	>2	2
7	1967	2.120	8.03	20.5	extremely wet	>1	1
8	1997	2.075	9.23	41.0	extremely wet	>10	2

Table of floods exceeding the ten-year maximum peak discharge $Q_{10} = 40.7\ m^3.s^{-1}$ Station : Borovnice

Nr.	Maximum annual peak discharge $Q_k\ [m^3.s^{-1}]$	Hydrological year	Month	Number of floods during hydrological year	Return period N	Rate of runoff during hydrological year
1	60.0	1965	VII	1	> 20	extremely wet
2	48.7	1932	I	1	> 10	drought
3	48.2	1938	VIII	1	> 10	extremely wet
4	46.6	1925	VIII	1	> 10	mean
5	46.6	1937	VII	1	> 10	wet
6	42.5	2006	III	2	> 10	wet
7	41.3	1930	X	1	> 10	extremely drought
8	41.0	1997	VII	2	> 10	extremely wet

CONCLUSION

- Floods are important natural extremes which are affected by climate change
- Despite their negative human impacts, floods should be considered as natural phenomena and a part of water cycle in the nature
- The absolute protection is not possible, it is possible to reduce the harmful impacts of floods only
- Therefore, the research, monitoring and assessment of floods remain an up-to-date topic

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THANK YOU FOR YOUR ATTENTION

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