

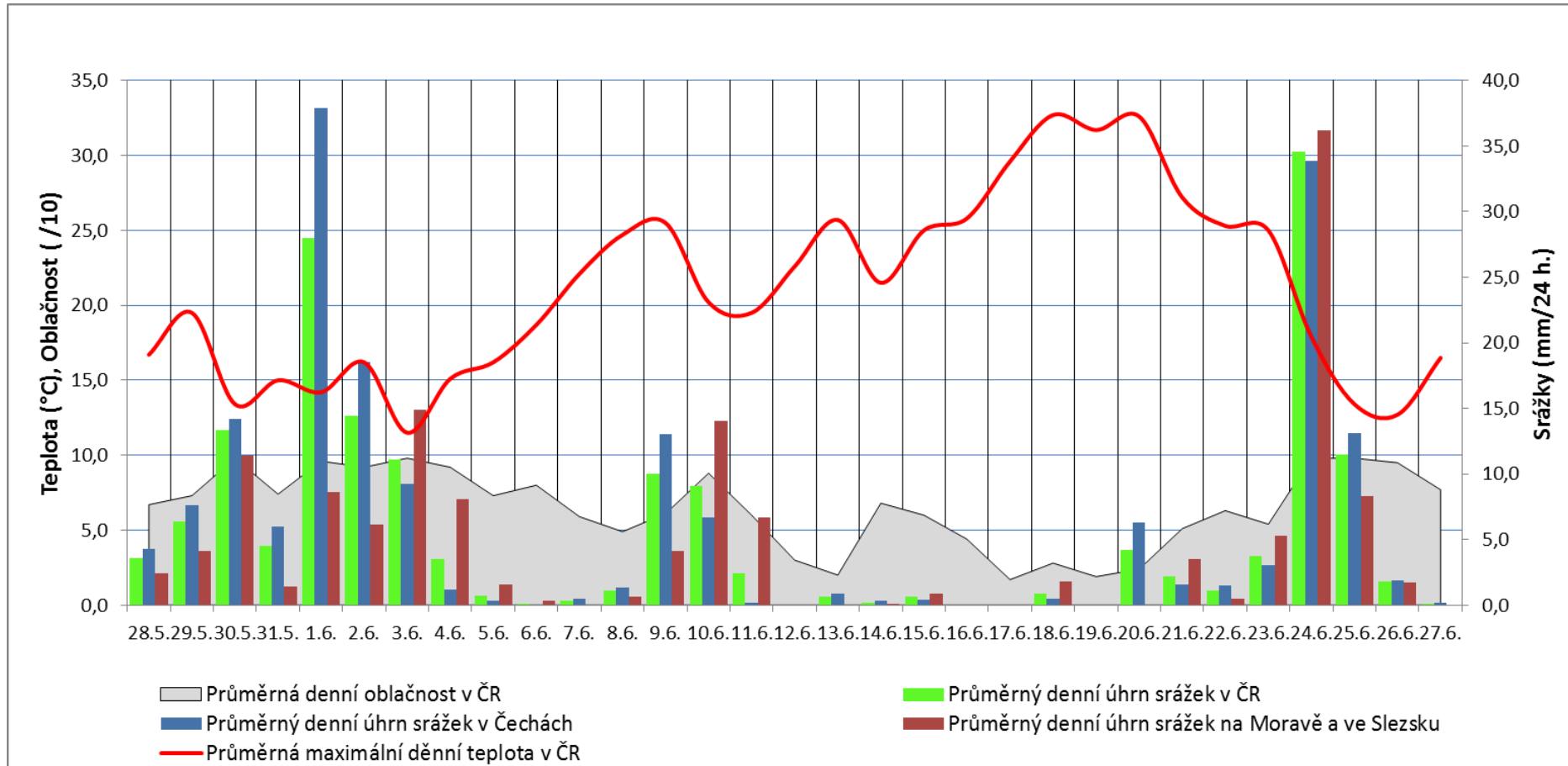
# FLOODS IN JUNE 2013

Jan Kubát

Czech Hydrometeorological Institute

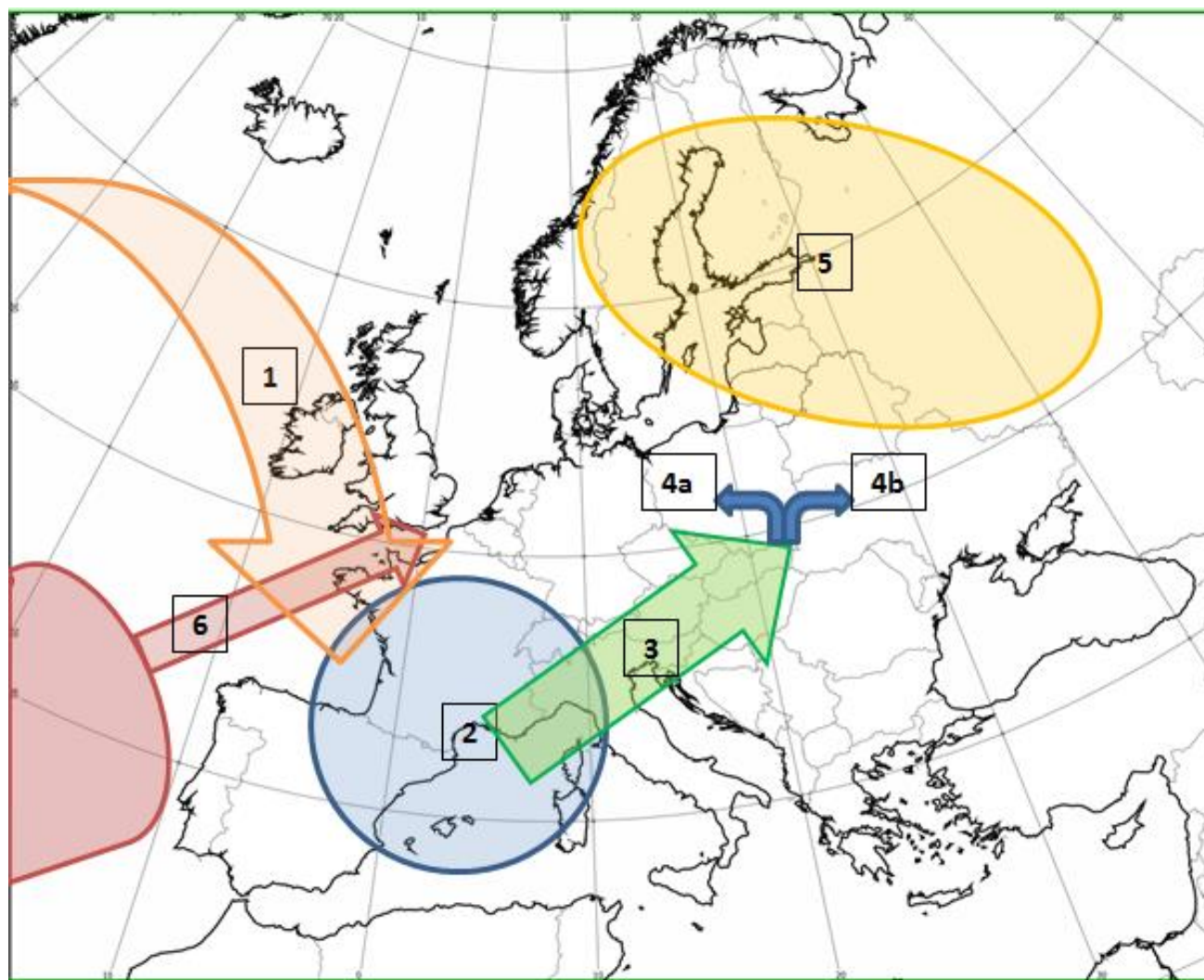


# Meteorological causes of floods



the first episode	29.5. – 3.6.	regional precipitation in Bohemia (mainly 1.- 2.6. > 100 mm on great area)
the second episode	9.6. – 11.6.	flash precipitation in several locations
the third episode	24.6. – 25.6.	regional precipitation in Bohemia and Moravia (mostly less than 100 mm)
		several days with tropical temperatures before

# Mechanism of circulation directing to relevant precipitation in central Europe



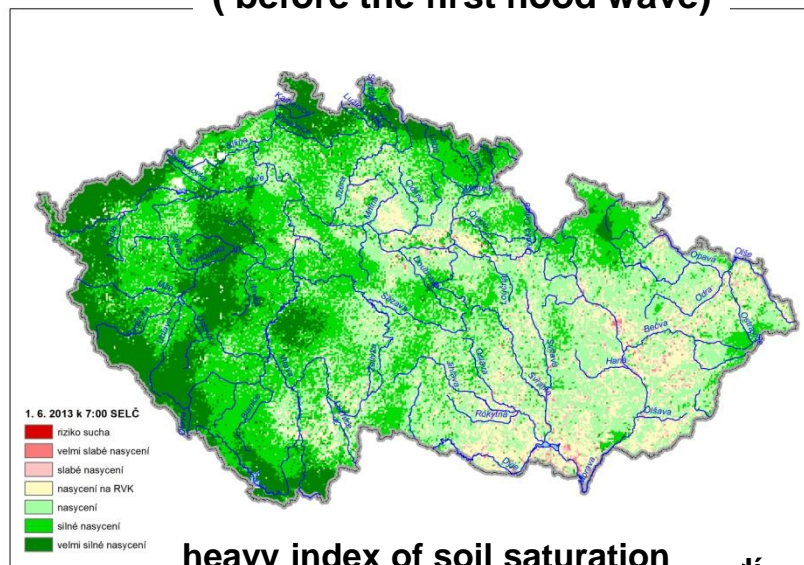
Typical synoptic situation  
before summer floods  
caused by regional rainfalls

July 1997  
August 2002  
August 2005  
May/June 2010  
July 2011  
June 2013



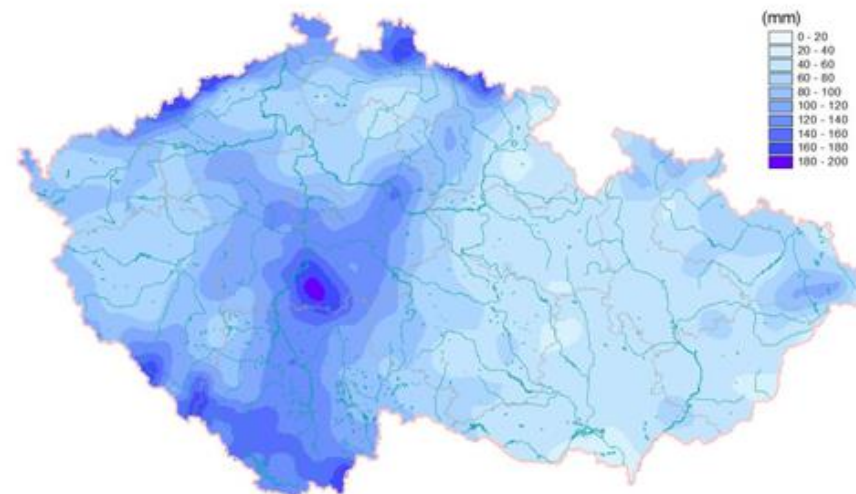
# Hydrological assessment of floods

**Situation at the end of May  
( before the first flood wave)**



**heavy index of soil saturation  
(due to long winter and wet May)**

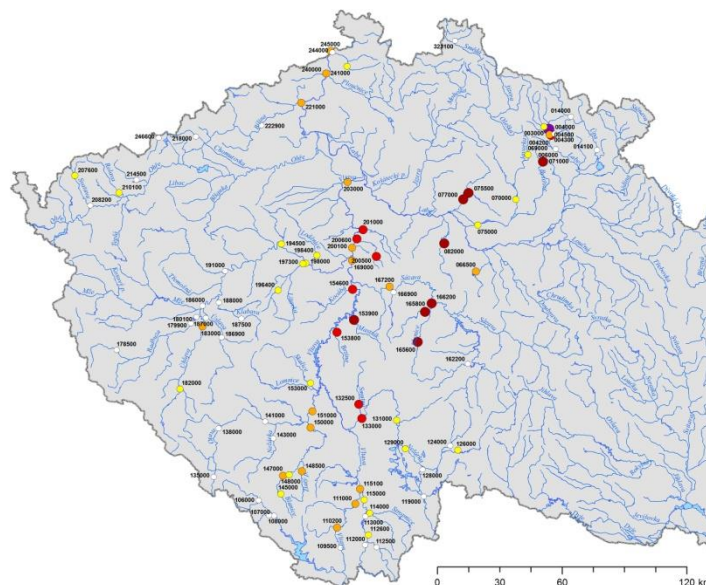
**Precipitation total from 29.5. to 5.6.2013**



**space mean nearly 100 mm in Bohemia (the Labe basin)  
about 150 mm in the centre south of Prague**



**=**

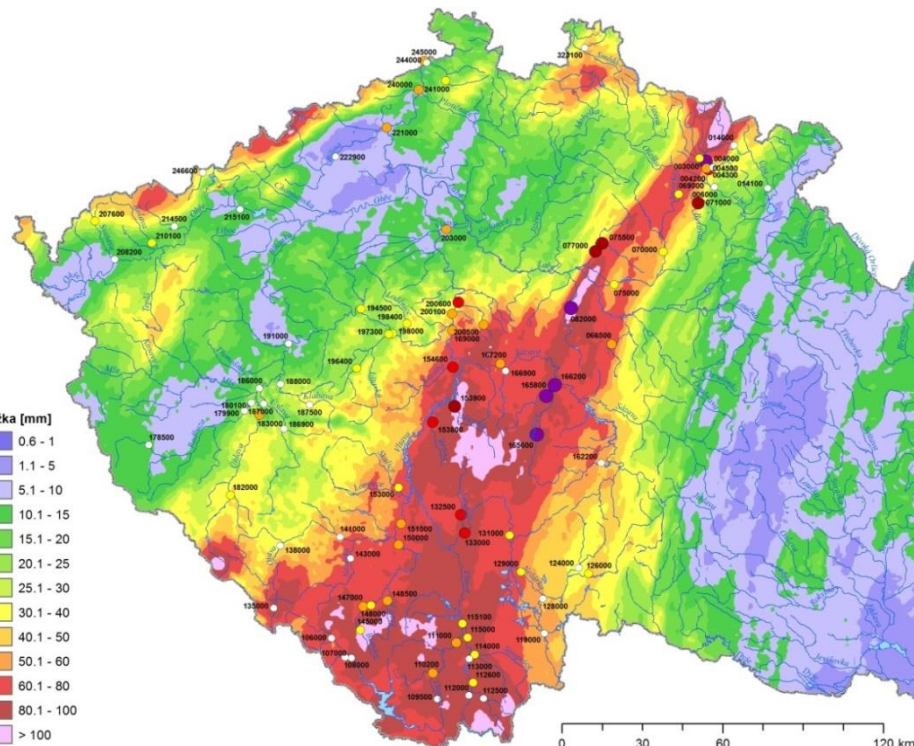
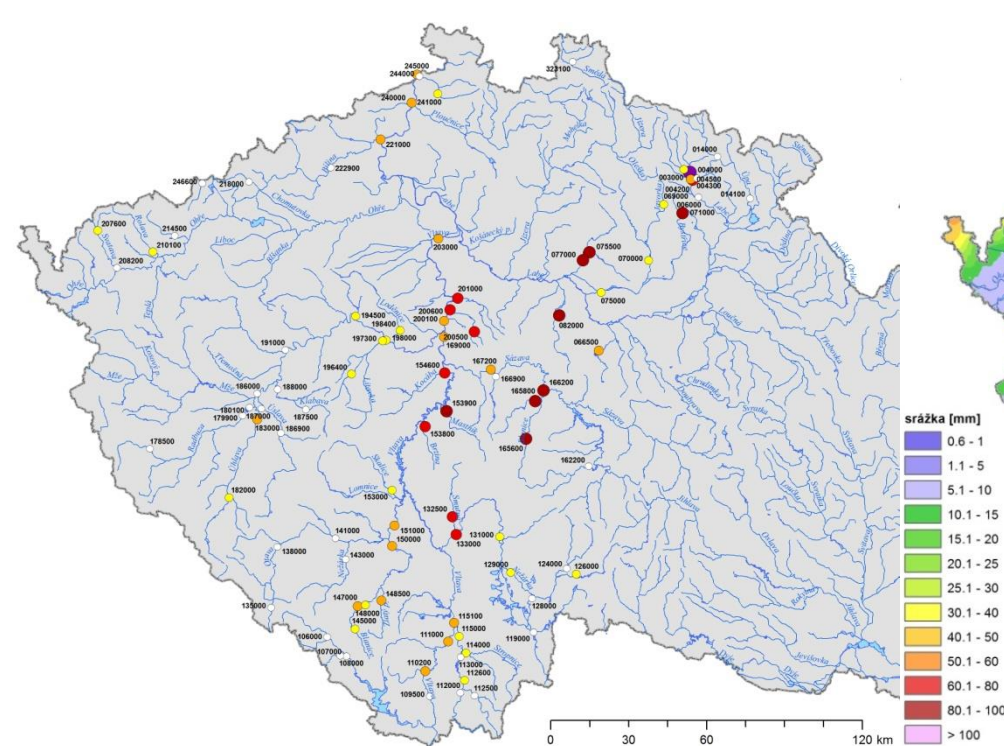


**extreme and quick floods  
on small rivers in upper Labe basin  
(under Krkonoše mountains)  
on small Vltava tributaries  
(in the central Bohemia)**

**great regional floods in Vltava basin  
(also start very quickly)  
continuing along the lower Labe**



# Rivers with the biggest discharges



**Floods with return period 500 years**

- Čistá (small stream) in Hostinné

**Floods with return period 100 years and more**

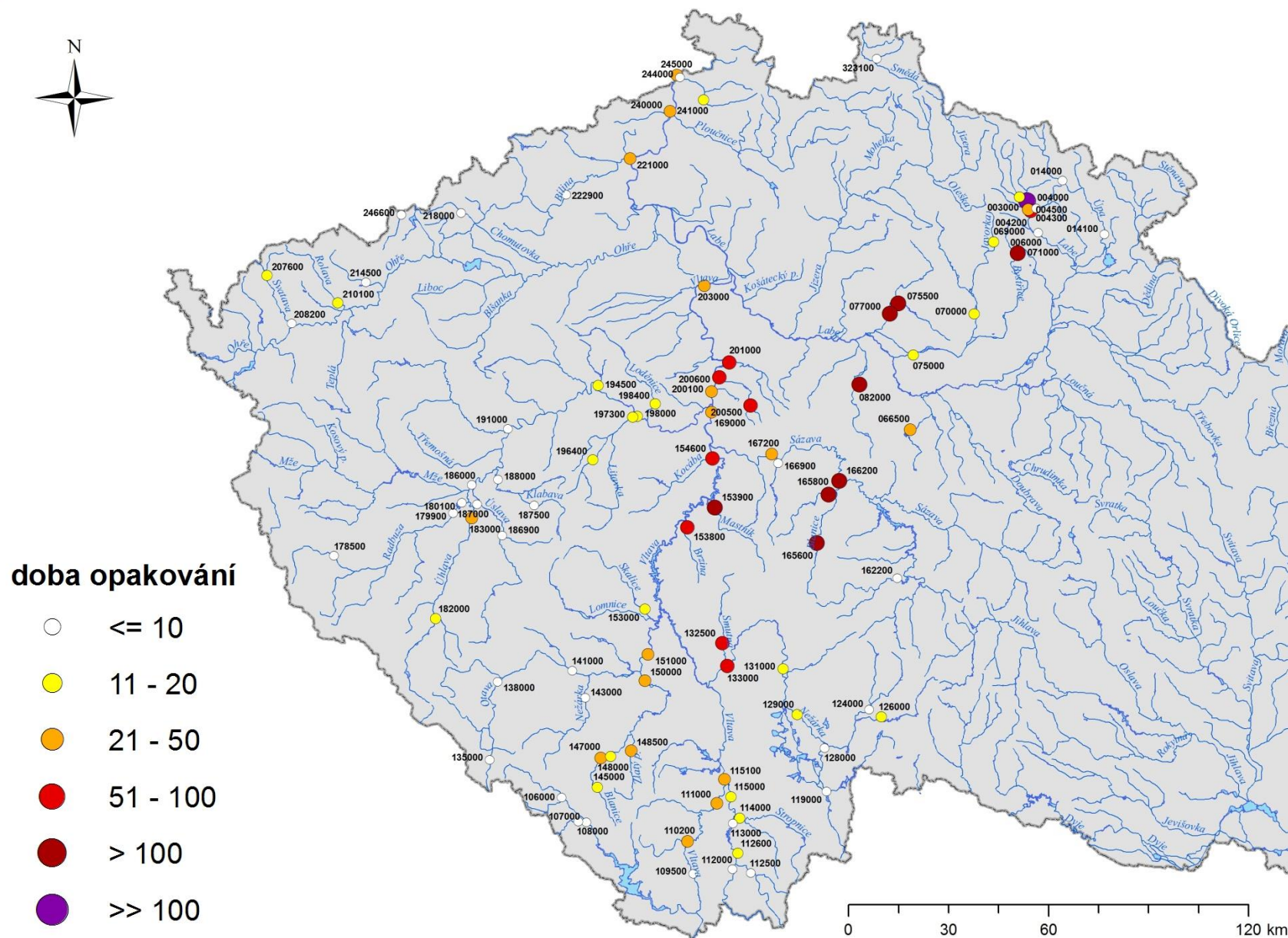
- upper Labe, Bystřice, Mrlina, Výrovka
- Vlašimská Blanice, Chotýšanka, small tributaries of Vltava (Mastník, Brzina, Kocába, Botič)
- lower part of Lužnice, Smutná, Vltava below Lužnice (inflow into Orlick reservoir)

**Floods with return period 20 – 50 years**

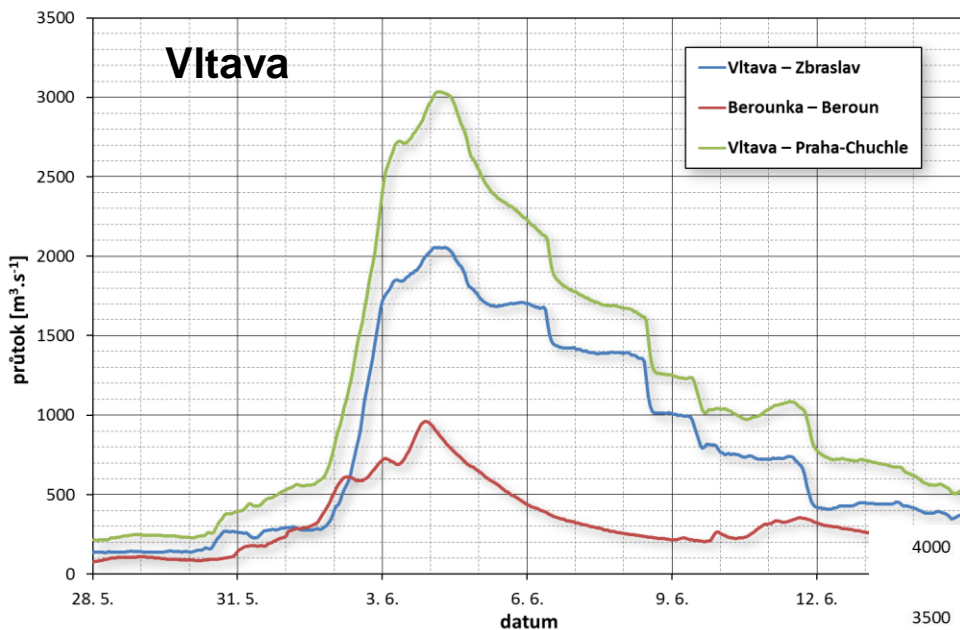
- Vltava from České Budějovice, lower Otava, Berounka, Sázava, Vltava in Prague, Labe under Mělník



# Extremity of top discharges in the first flood waves

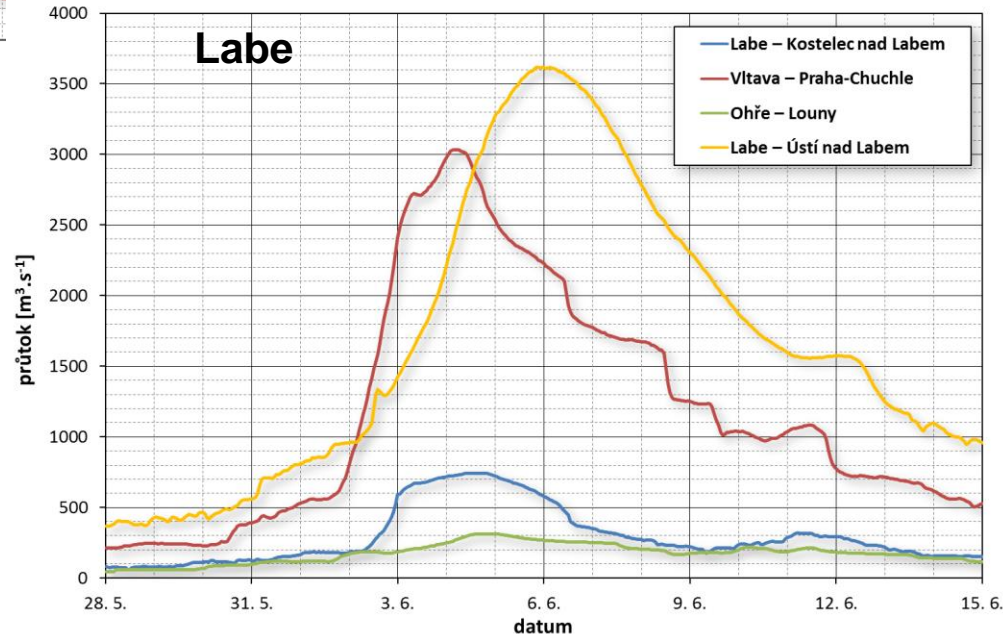


# Composition of flood waves on main rivers



Flood in	6/2013	8/2002
Vltava – Zbraslav	2100	3340 $\text{m}^3/\text{s}$
Berounka – Beroun	960	2170 $\text{m}^3/\text{s}$
Vltava – Praha Chuchle	3040	5160 $\text{m}^3/\text{s}$
ratio Vltava – Berounka	2 : 1	1,5 : 1
ratio of basin area	2 : 1	

Flood in	6/2013	8/2002
Labe – Kostelec n.L.	744	530 $\text{m}^3/\text{s}$
Vltava – Vraňany	3080	5120 $\text{m}^3/\text{s}$
Vltava – Mělník	3640	5050 $\text{m}^3/\text{s}$
Ohře – Louny	314	175 $\text{m}^3/\text{s}$
Labe – Ústí n.L.	3630	4700 $\text{m}^3/\text{s}$
Labe – Děčín	3740	4770 $\text{m}^3/\text{s}$
ratio Vltava – Labe	4 : 1	9,6 : 1
ratio of basin area	2 : 1	



# Measurement of flood discharges

Flood discharges measured during 2013 flood with ADCP flow meter

- measurement on decreasing part of flood wave because of debris in flow during increasing
- maximum discharges in measured gauges
- maximum point in rating curves
- adjustment of rating curves after flood

**Maximum flow** measured in Czech rivers in history  
Labe river – bridge in Děčín  
- velocity field in measured profile

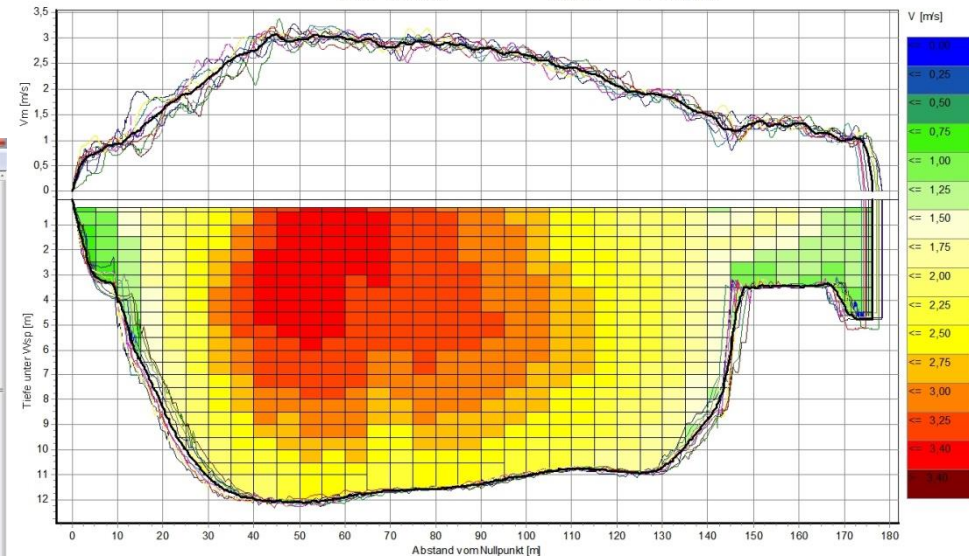
Datum	Time	Profile	River	$Q_{\text{measured}}$ [m <sup>3</sup> .s <sup>-1</sup> ]	Return period [y]
2. 6. 2013	17:40	Hrachov	Brzina	64.5	50
2. 6. 2013	19:30	Louňovice	Blanice	63.0	50
2. 6. 2013	21:50	Nusle	Botič	67.0	50–100
3. 6. 2013	11:25	Nový Bydžov	Cidlina	92.4	20
3. 6. 2013	13:50	Plaňany	Výrovka	54.2	50
3. 6. 2013	15:00	Svínice	Štítarský potok	51.8	50
3. 6. 2013	16:50	Štěnovice	Úhlava	170	20–50
3. 6. 2013	18:45	Písek	Otava	560	20–50
3. 6. 2013	20:30	Štěchovice	Kocába	58	20
4. 6. 2013	11:00	Heřmaň	Blanice	184	20–50
4. 6. 2013	12:50	Praha-Výtoň	Vltava	2830	20
6. 6. 2013	10:20	Děčín	Labe	3700	20–50
7. 6. 2013	18:30	Děčín	Labe	3180	20

Überlagerung von 10 ADCP-Messungen mit AGILA 7

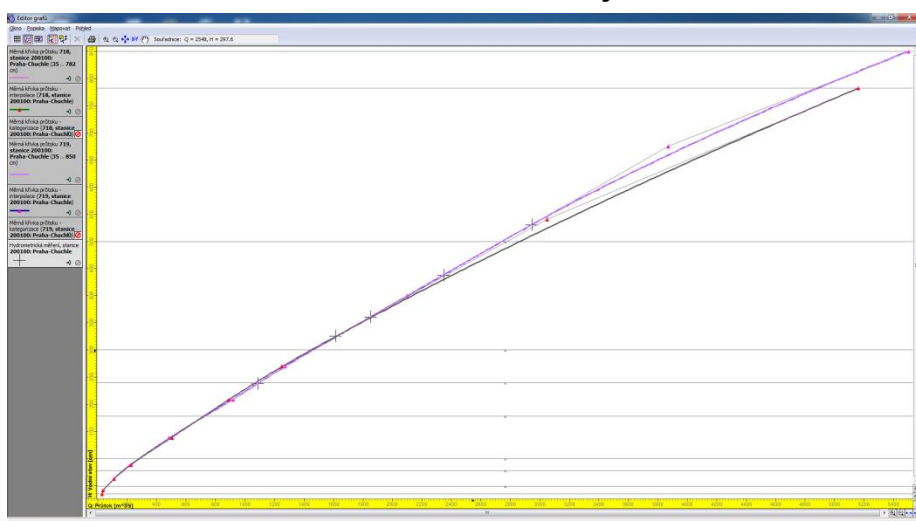
$W = 1065 \text{ cm}$   
 $Q = 3697,84 \text{ m}^3/\text{s}$   
 $A = 1586,38 \text{ m}^2$   
 $b = 176,35 \text{ m}$   
 $V_m = 2,33 \text{ m/s}$   
 $V_{ob} = 2,18 \text{ m/s}$

$h, m = 9,00 \text{ m}$   
 $h, \text{max} = 12,10 \text{ m}$   
 $r, \text{hy} = 8,53 \text{ m}$   
 $P = 5031,70 \text{ m}^2$   
 $C^* \text{Wurzel (I)} = 0,73 \text{ m}^{1/2}/\text{s}$   
 $V_{ob, \text{max}} = 3,62 \text{ m/s}$

mittlere Uhrzeit : 9:16:26



Adjustment of rating curve in Prague gauging station  
maximum discharge 3300 m<sup>3</sup>/s during the event  
3040 m<sup>3</sup>/s after adjustment







Labe – Děčín

max. discharge 3740 m<sup>3</sup>/s 6.6.2013 01:20 – Q20-50

measured discharge 3700 m<sup>3</sup>/s 6.6.2013 10:20





Labe – Ústí nad Labem  
max. discharge – 3630 m<sup>3</sup>/s 5.6.2013 19:50  
measured discharge - smaller





Kocába – Štěchovice  
max. discharge 101 m<sup>3</sup>/s 2.6.2013 – Q<sub>100</sub>  
measured discharge 58 m<sup>3</sup>/s 3.6.213 20:30







Vltava – Praha

max. discharge 3040 m<sup>3</sup>/s 4.6.2013 4:50  $Q_{20-50}$

measured discharge 2830 m<sup>3</sup>/s 4.6.2013 12:50





# Project on Assessment of June 2013 Flood

Government resolution No. 533 from the 3. July 2013

## Project coordinator

CHMI

## Causes and hydrological course of the floods

1.1 Meteorological causes of floods

CHMI

1.2 Hydrological assessment of floods

CHMI (CTU, DHI)

1.3 Anthropogenic influence of flood regime

CHMI (Aqualogic, DHI)

## Function of flood protection systems

2.1 Activities of Flood Committees, Integration Rescue System and other subjects involved in flood protection

WRI TGM

2.2 Flood forecasting service

CHMI (Aqualogic)

2.3 Analyses of public media information

Bison & Rose

## Function of water structures and flood protection structures

3.1 Function and security of dams and water reservoirs

River Boards, Dams TSS

3.2 Function of flood protection structures

WMDC

3.3 Extent and documentation of flooded areas

River Boards

## Documentation of flood consequences

4.1 Social and health consequences

WRI TGM

4.2 Economical consequence

WRI TGM

4.3 Documentation of landslides

CGS

4.4 Environmental consequences and water protection

CEI

## Conclusion and proposed measures

Terms: 30. 11. 2013 preliminary report for Czech Government

31. 3. 2014 partial reports (except tasks 1.3)

30. 6. 2014 final summary report for Czech Government



# Function and safety of water structures (dams)

**Assessment of – 52 significant water structures (dams reservoirs)**

**100 small water structures (ponds, small reservoirs, polders)**

**Max. inflow – Q100 and more – Kořensko, Orlík, Les Království, Hostivař**

**Q50-Q100 – Lipno, Kamýk-Vrané, Husinec, Soběnov, Vrchlice**

**Q20-Q50 – Hněvkovice**

**Outflow decreasing – 50% and more - Lipno, Nýrsko, Želivka, Žlutice, Seč, Rozkoš, Újezd**

**20-50% - Římov, Hracholusky, Husinec, Labská, Les Království,**

**Pařížov, Vrchlice, Nechanice, Jesenice, Dalešice, Vír, Vranov**

**Situation before flood – flood protection space was free in all reservoirs**

**significant part of water supply storage was free – Orlík, Nýrsko,**

**Římov, Husinec, Hracholusky, Žlutice, Labská, Les Království**

**– precipitation in May and high water saturation of basins**

**Reservoirs operation – according to operational rules (except Hostivař dam in Prague)**

**Extraordinary manipulations – Lipno, Orlík, Slapy, Římov, Husinec,**

**Labská, Les Království (ordered or approved by flood authorities)**

**Permitted max. water level exceeded – Kořensko, Slapy, Štěchovice, Vrané, Hostivař (1,01 m)**

**max. water level reached – Husinec, Orlík (2 cm)**

**Security of dams in all cases**

**Security of small structures (ponds) – 24 damaged and 5 destroyed**





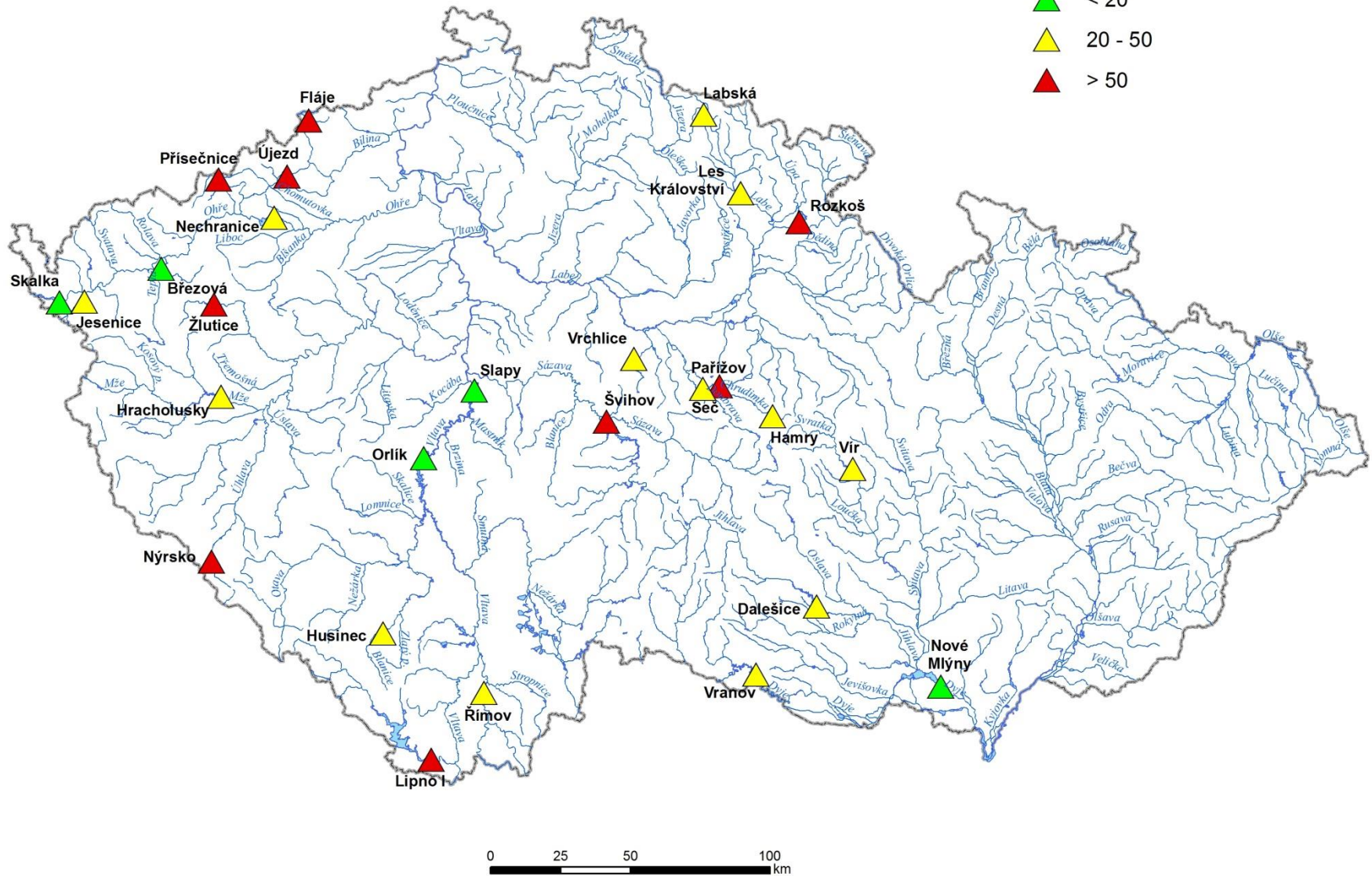
# Reservoirs with significant transformation effect during flood in June 2013

decreasing of max. discharge in %

▲ < 20

▲ 20 - 50

▲ > 50



# Flood course at the Lipno I reservoir

**Inflow:**  
simple flood wave  
top discharge 340 m<sup>3</sup>/s  
Q50 – Q100

**Situation before flood**  
retention space empty  
+ 35 cm of storage room free

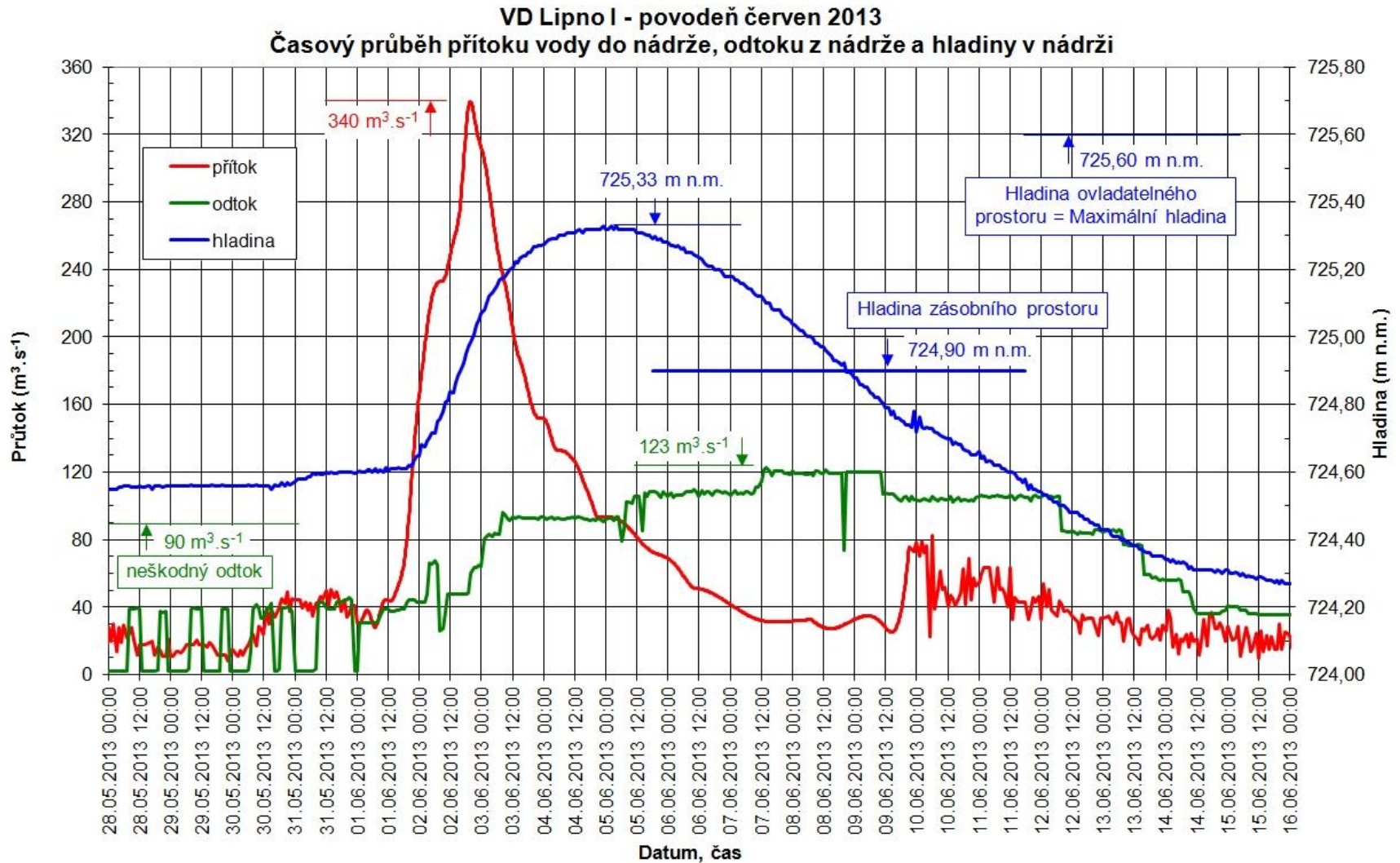
**Function:**  
max. outflow 123 m<sup>3</sup>/s  
culmination decreasing by 64%  
culmination postponing 5 days  
harmless outflow 90 m<sup>3</sup>/s was exceeded  
outflow in time of flood culmination was 60 m<sup>3</sup>/s only



Extraordinary manipulation 2.6.2013 evening ordered by Regional Flood Authority  
increasing of outflow above harmless outflow  
but considering situation in Český Krumlov (Vltava culmination at noon 225 m<sup>3</sup>/s)  
increasing of outflow was compensated by decreasing of flow from basin under reservoir



# Flood course at the Lipno I reservoir



Inflow is calculated by water balance in reservoir (in 1 hour time step)



# Flood course at the Orlík reservoir



**Inflow:**  
flood wave with secondary hill  
top discharge  $2160 \text{ m}^3/\text{s} - Q_{100}$

**Situation before flood:**  
retention space empty  
part of storage room free  
2 times more free space than  
given by operational rules

**Function:**  
max. outflow  $1950 \text{ m}^3/\text{s}$   
culmination decreasing by  $210 \text{ m}^3/\text{s}$   
culmination postponing by 18 hours  
max. water level 253,58 m n.m.  
2 cm below permitted level  
entire using of retention capacity

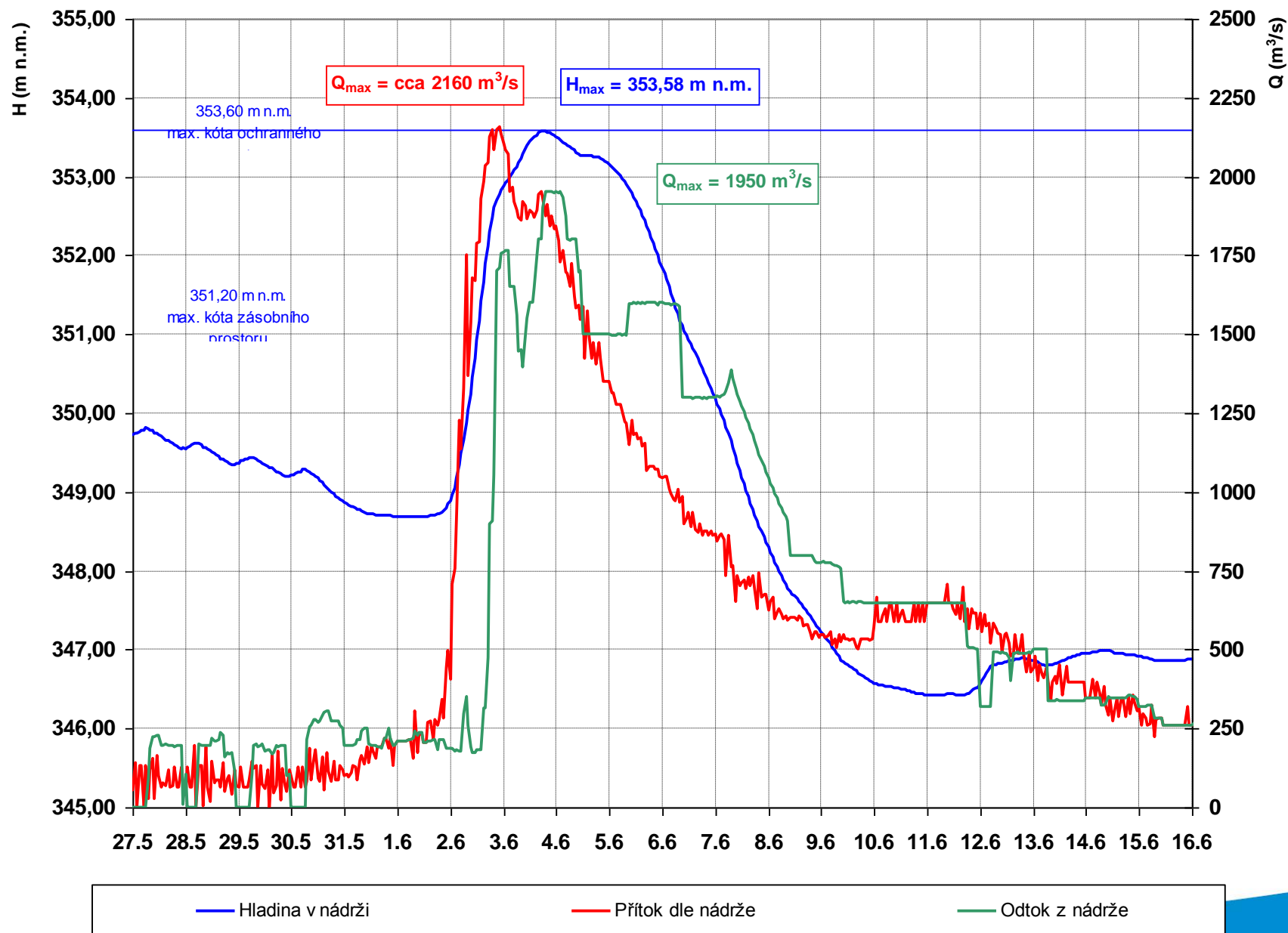
**All manipulations according to Operational rules**

- outflow from the cascade was delayed  
to have time enough for safety works  
and building of mobile barriers in Prague
- extraordinary manipulation according to resolution  
of Supreme Flood Authority from 7.6.2013  
emptying of storage room for possible next flood wave

**Questions ???**

**reservoir influence downstream:**  
culmination decreasing in Prague  
culmination decreasing in the Labe

# Flood course at the Orlík reservoir





# Comparison of the Orlik effect in different flood situations

June 2013- quick start of flood wave

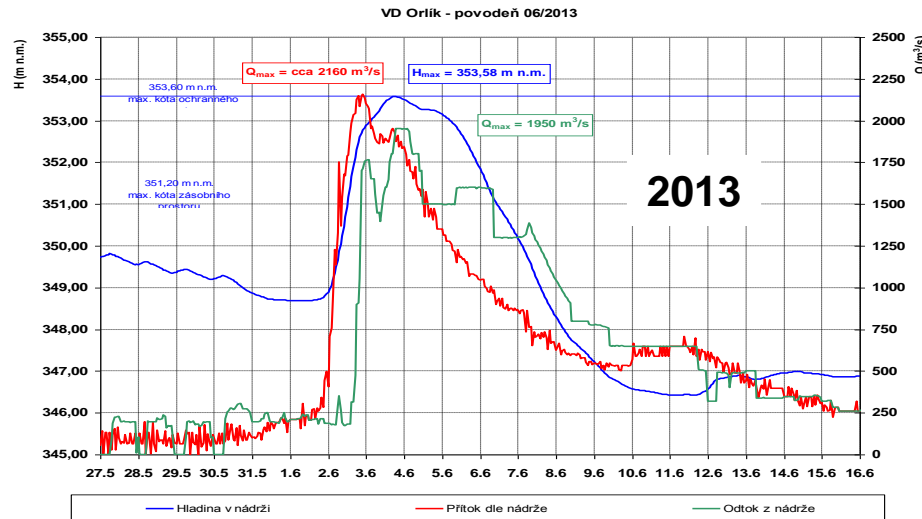
$$dQ = 210 \text{ m}^3/\text{s}$$

$$\max H = 353,58 \text{ (2 cm below max level)}$$

August 2002 – two flood waves in short time

$$dQ = 800 \text{ m}^3/\text{s} \text{ ( - 600 m}^3/\text{s power plant)}$$

$$\max H = 355,17 \text{ (+ 157 cm above max level)}$$

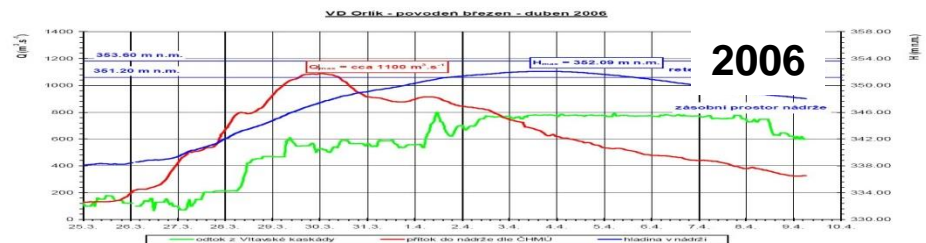
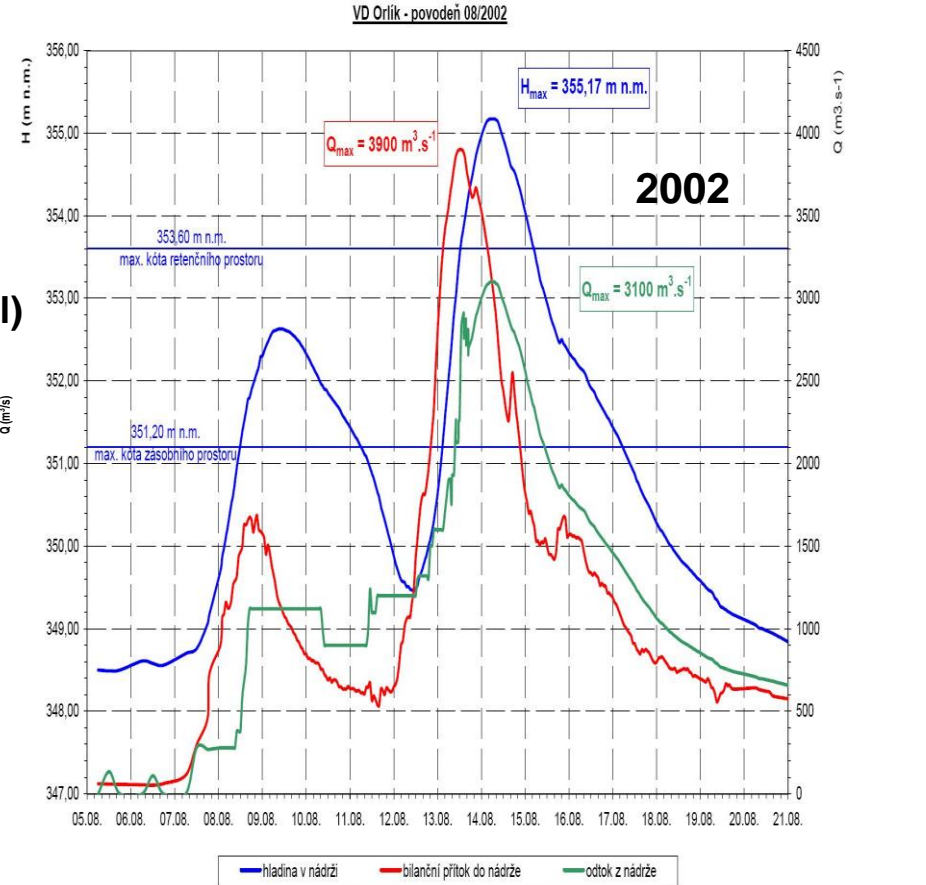


March/April 2006 – spring flood, great volume

$$dQ = 400 \text{ m}^3/\text{s}$$

$$600 \text{ m}^3/\text{s} \text{ in time of culmination}$$

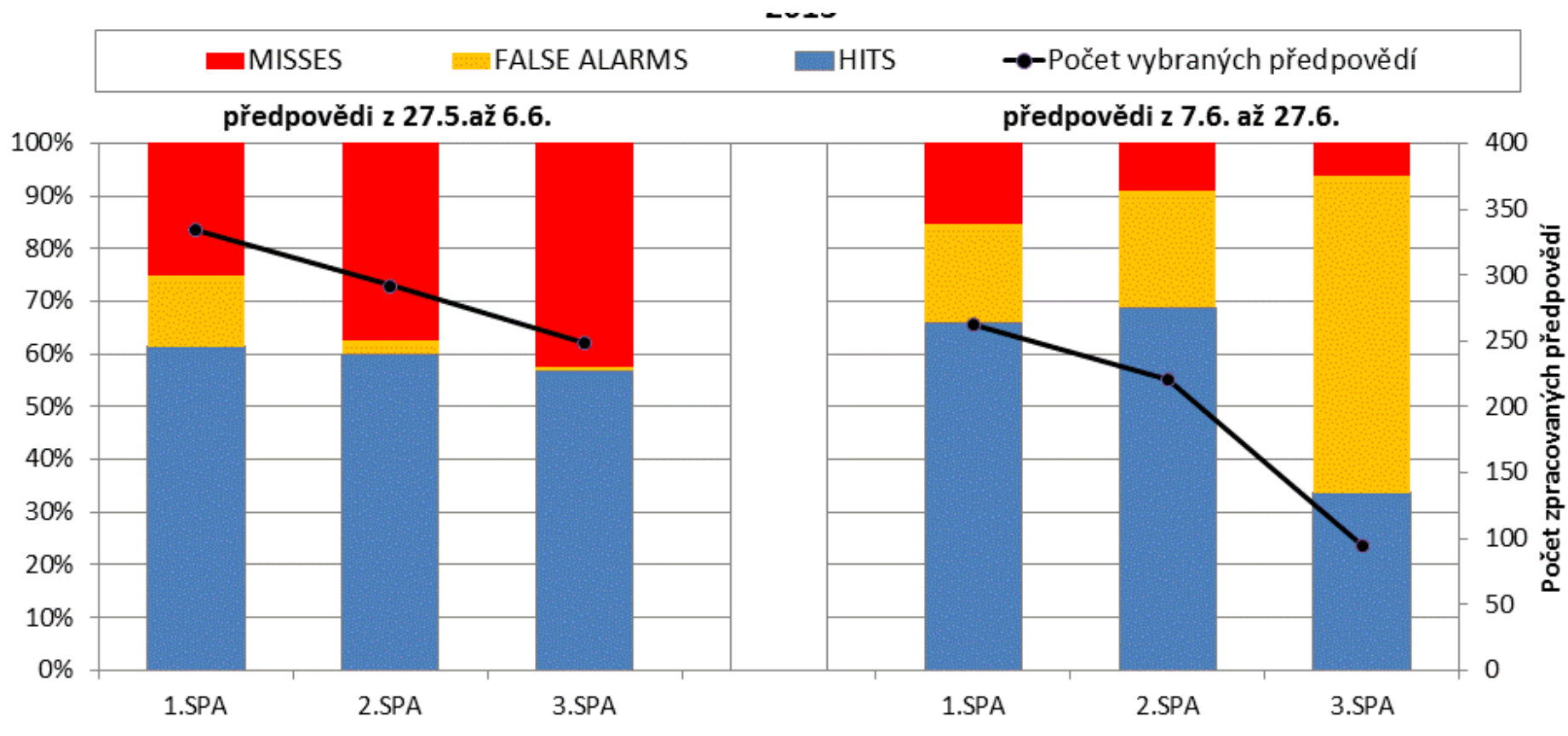
$$\max H = 352,09 \text{ (51 cm below max level)}$$



# Assessment of hydrological forecasts success

Achievement or over achievement of flood danger levels (1.SPA, 2.SPA, 3.SPA)

Category – successful forecast – phenomenon was forecasted and occurred – HIT  
 unsuccessful forecast - phenomenon wasn't forecasted but occurred – MISS  
 unsuccessful forecast - phenomenon was forecasted but didn't occur – FALSE ALARM

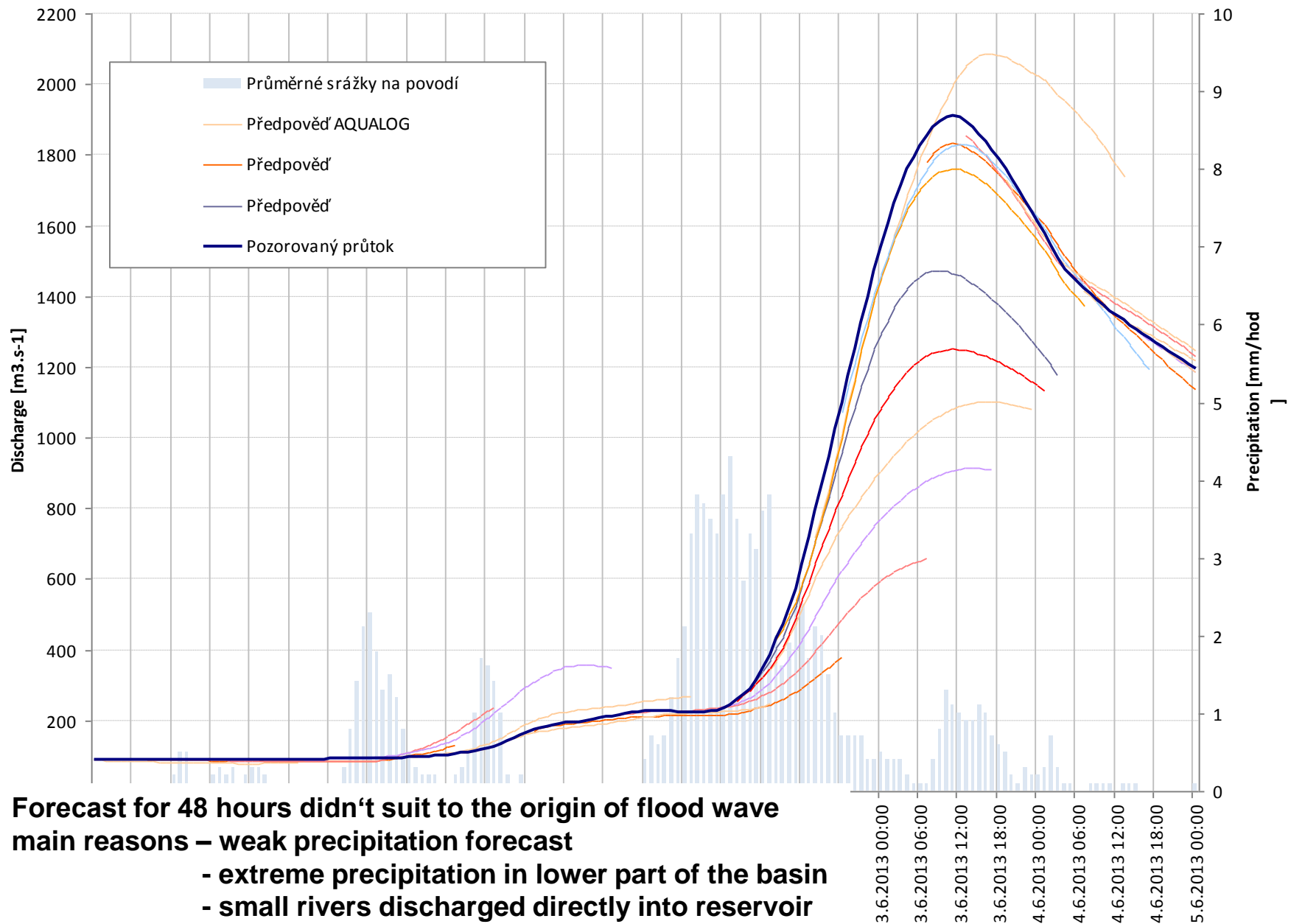


Difference in forecasts success between the first and the second flood wave

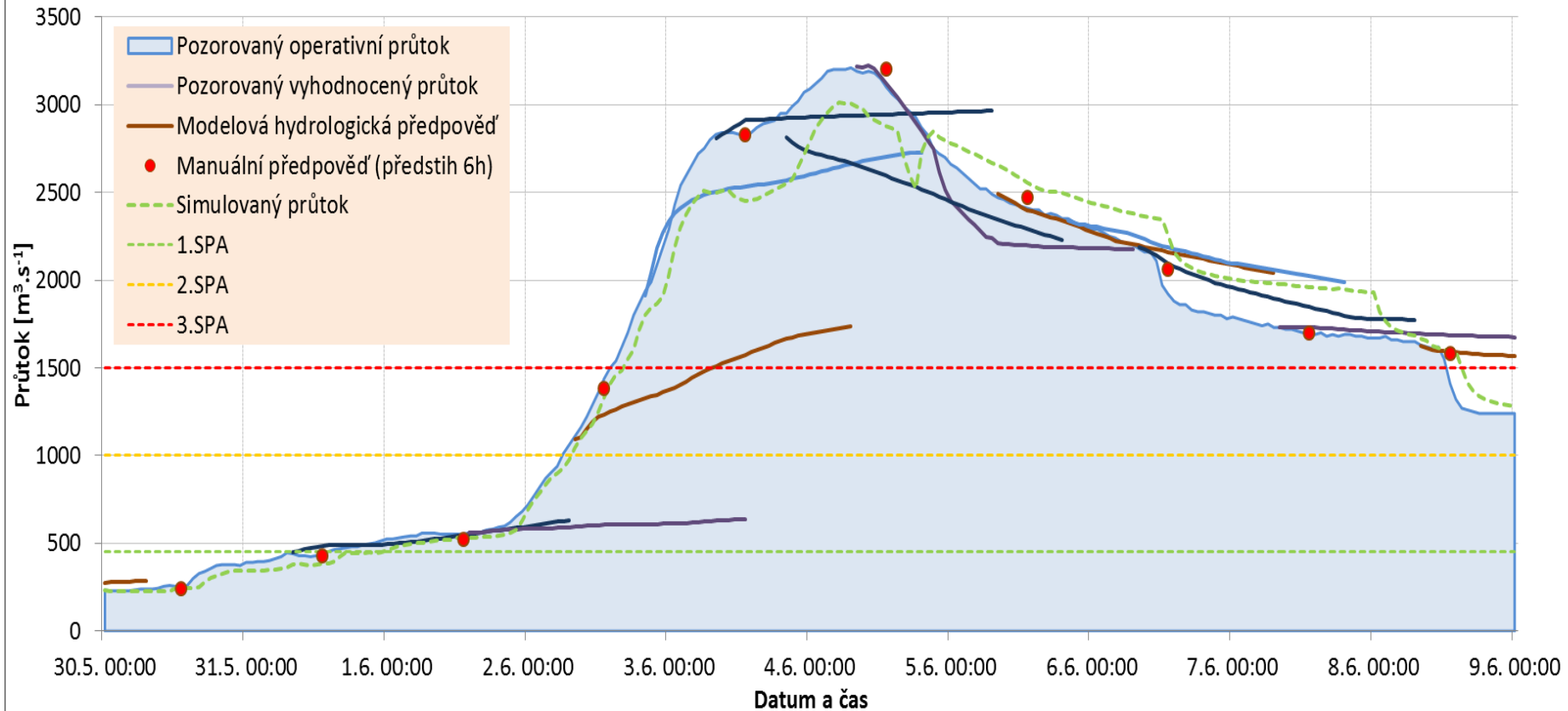




# Hydrological forecast of inflow into Orlick reservoir



# Hydrological forecast for Vltava river in Prague



**Forecast for 48 hours didn't suit to the origin of flood wave**

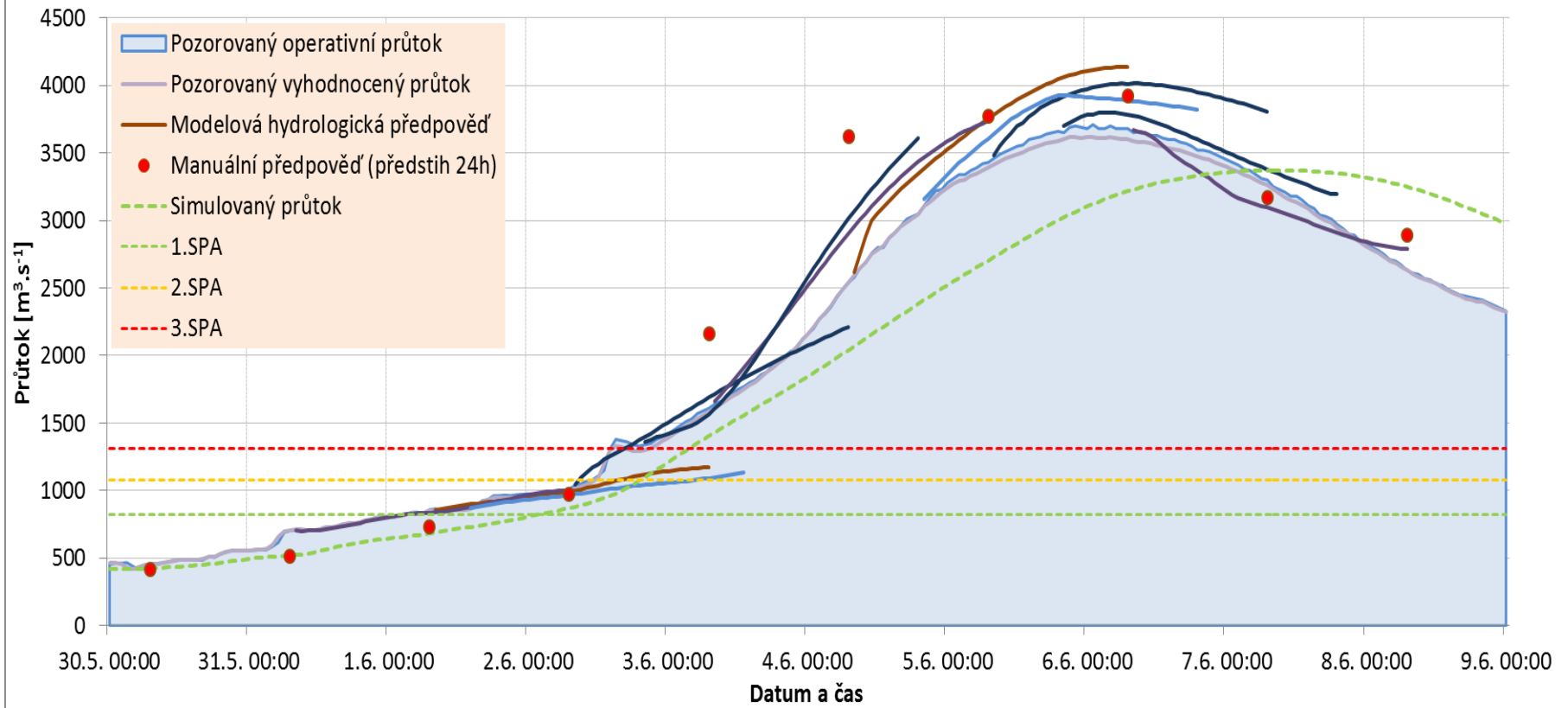
**main reasons – weak precipitation forecast**

- weak hydrological forecast for Berounka and Sazava rivers
- reports on outflow from the Vltava cascade (2/3 of flow in Prague)

**green line – resimulation of hydrograph according to real outflow from the Vltava cascade**



# Hydrological forecast for Labe river in Ústí n.L.



**color lines – 48 hours forecasts by hydrological model**

**red circles – 24 hours manual according to flood course in upper sites**

**didn't suit during the main part of flood wave**

**main reasons – doesn't depend on precipitation forecast**

- underestimated influence of large inundations (Mělník and Litoměřice areas)
- wrong information from upper gauging station (mainly from Prague) because of rating curve currently use during flood (difference about  $250 \text{ m}^3/\text{s}$ )

# Assessment of flood protection structures

**Structures designed and built after 2002 flood (including structures under construction)**  
**Mainly longitudinal structures (river beds construction, protection dikes, mobile barriers)**

River Basin Company	Number of structures	Structures affected by flood	Protection aim fulfilled	Protection aim not fulfilled		Structures under construction
				Flood over design parameters	Partial effect with problems	
Labe	54	22	11	2	2	7
Vltava	54	44	32	1	4	7
Ohře	27	3	2	0	0	1
Together	135	69	45	3	6	15







## Mobile protection structures

Frequently used component: Praha, Děčín, Ústí n.L., Lovosice, Mělník, České Budějovice,

Bechyně, Jaroměř, Mnichovo Hradiště, Benátky n. Jizerou

Problem is building of system on time in case of quick coming of the flood (Bechyně, Praha)



Bechyně – situation in June 2013





# Flood protection system in Prague

8 phases 17,5 km longitudinal structures

6,4 km mobile barriers

design level - flood 2002 + 30 cm





# Flood protection measures in Prague - Libeň

**Problem of flood occurrence  
in Vltava river and Rokytká river  
in the same time**

**top discharge in Rokytká 45 m<sup>3</sup>/s  
capacity of pumping station 20 m<sup>3</sup>/s**



# Documentation of flooded areas

## Documentation of flooded areas is done by River Basin Companies

**Vltava River Basin Company** – compile 239 km of rivers – 95,7 km<sup>2</sup> of flooded areas

**Labe River Basin Company** – 252 km 156,1 km<sup>2</sup>

**Ohře River Basin Company** – process 6 km 26,5 km<sup>2</sup> (2 pilot reaches only)

**Processing according to** – aerial photos (ensured by Vltava River and Labe River Basin Company)

- field survey after flood

- flood marks (1460 pc pointed and measured, 510 fixed by metal plate)

- satellite pictures as complement only (GMES/Copernicus)





## Flood marks at confluence of the Labe and Ohře rivers





## Flooded area at confluence of the Labe and Ohře rivers

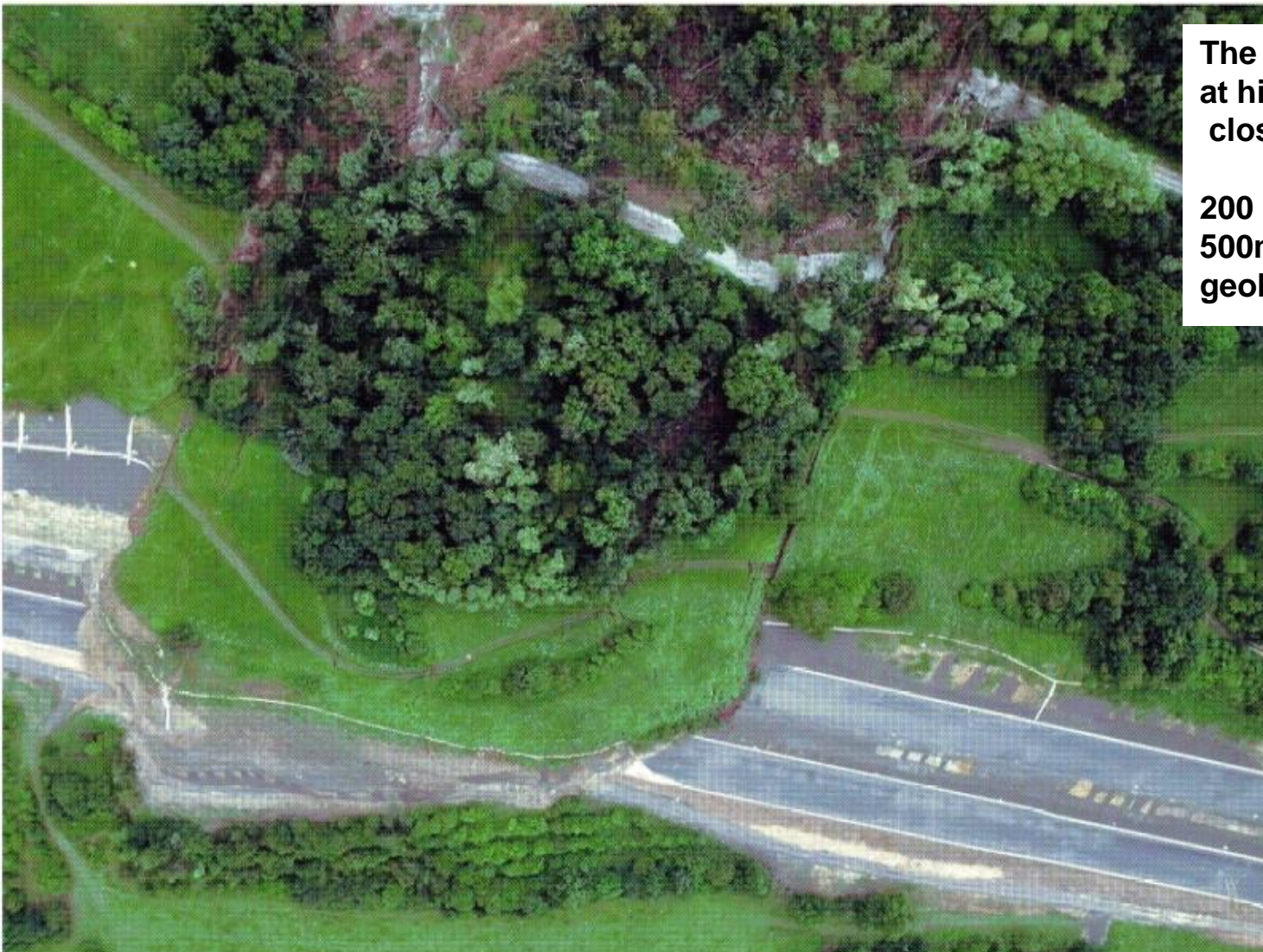




# Documentation of landslides

(Czech Geological Service)

Together 124 landslides were detected, from that 19 slides with high risk of continuation (III. category) most of slides were detected in Middle Czech region and Ústí region



The greatest landslide  
at highway D8 building site  
close to Dobkovičky village

200 m width  
500m long on slope  
geological survey is done

# Activities of Flood Authorities and others

Water Research Institute assessed according to reports from regional and municipal offices, river basin companies, Fire Rescue Service and others.

- overview on flood danger state issued by municipality and regional flood authorities
- overview on emergency state issued by the Czech government (Prague and 6 regions)
- activities of the Integrated rescue system

Rescue activities were coordinated by Fire Rescue Service (in compliance to Crisis Law)

- 4,5 thousand of Fire Rescue Service staff
- 14,9 thousand other firemen (mainly from voluntary fire brigades)
- 26 thousand of policemen (man/days) from Czech Police and others from municipal Police
- 10,5 thousand of soldiers (man/days) Czech Army

Evacuation – together nearly 26,5 thousand people

- 8 thousand with firemen help
- 12,5 thousand with police help
- 6 thousand themselves or with help of municipality

Lifesaving

- 618 persons were saved (from that 16 people by helicopters)
- 15 people died (from that 5 needlessly – irresponsible canoeists)

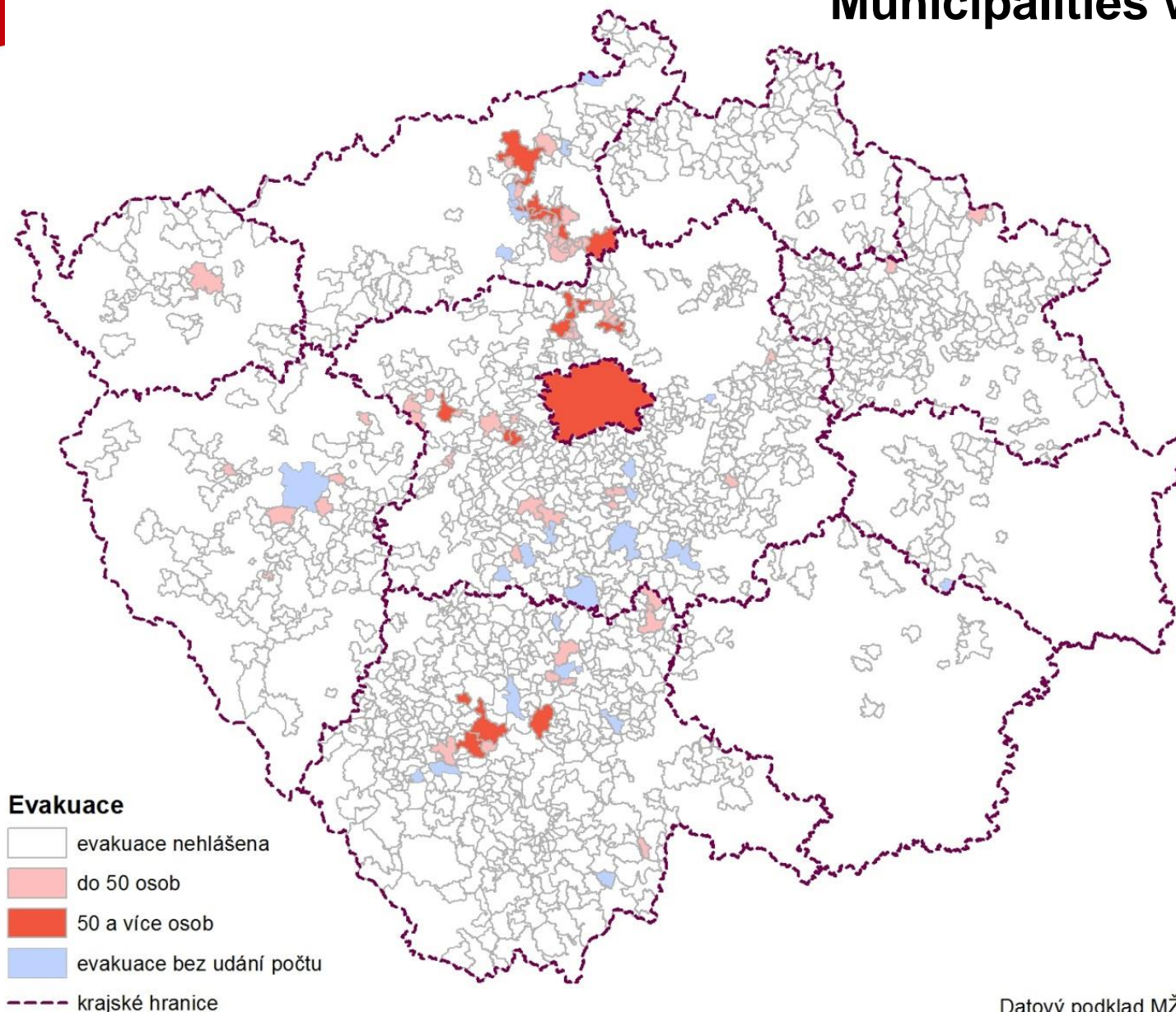
Flood losses – together nearly 15,4 mld. CZK (570 mil. EURO)

- 4,5 mld. CZK traffic infrastructure
- 2,5 mld. CZK water
- 2,3 mld. CZK technical infrastructure (sanitary networks...)
- 1,6 mld. CZK living houses





# Municipalities with evacuation

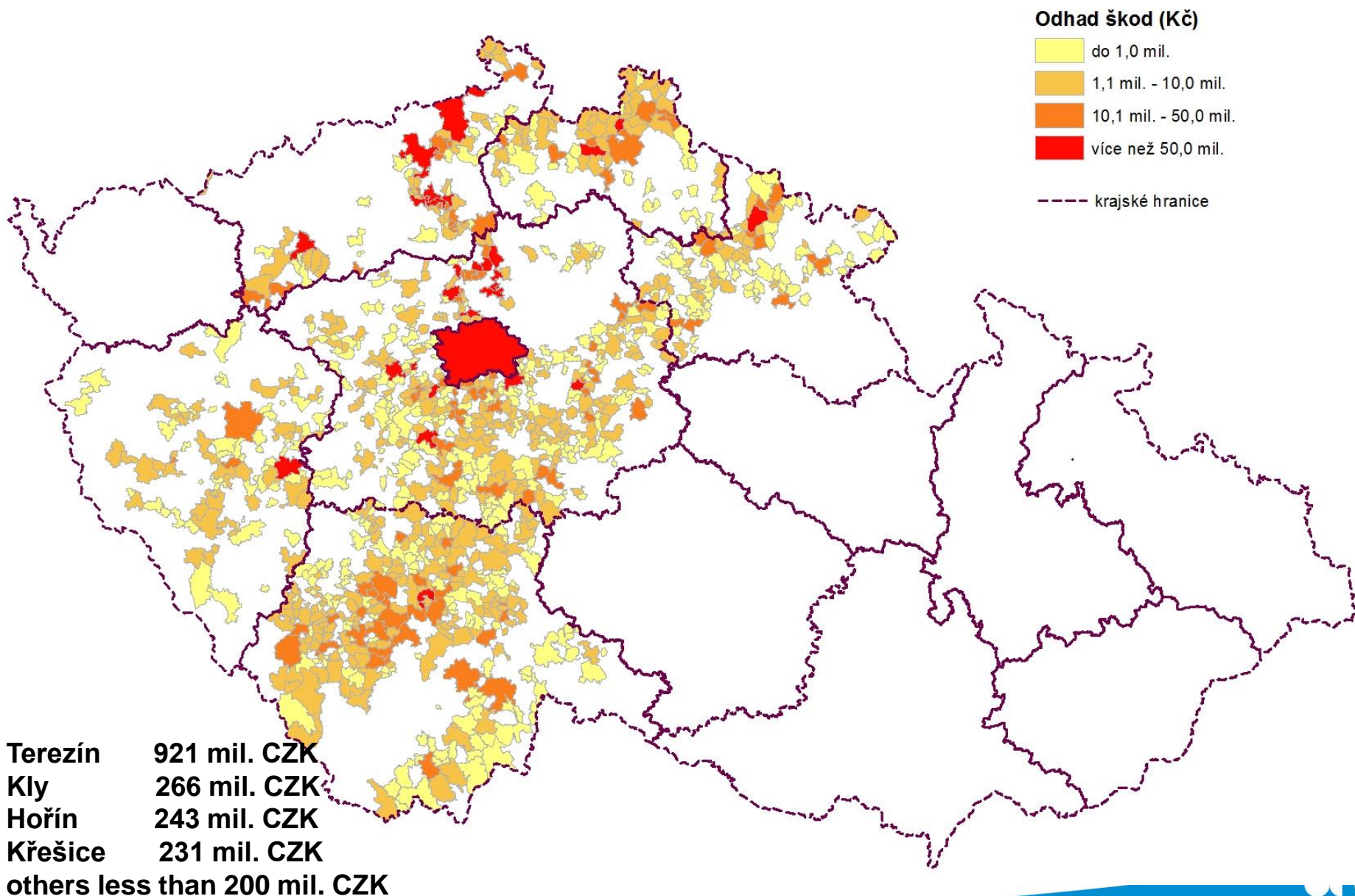


Number in region:

<b>Středočeský</b>	<b>39</b>
<b>Ústecký</b>	<b>34</b>
<b>Jihočeský</b>	<b>20</b>
<b>Plzeňský</b>	<b>7</b>
<b>Královéhrad.</b>	<b>2</b>
<b>Karlovarský</b>	<b>1</b>
<b>Pardubický</b>	<b>1</b>
<b>Prague</b>	<b>1</b>
<b>together</b>	<b>105</b>

Datový podklad MŽP

# Flood losses in municipalities





# Economical and social losses

Flood	Type of flood	Stricken area	Return period N-years	Flood effects
July 1997	summer regional two flood waves	Oder and Morava basins	100 to 500 exceptionally >500	62,6 mld. Kč 50 -60 fatalities
August 2002	summer regional two flood waves	Vltava and Berounka basins, lower Elbe	200 to 1000 someplace >1000	73,1 mld. Kč 17-19 fatalities
June 2013	summer regional two flood waves	Vltava and Berounka basins, Elbe and tribut.	20 to 50 some place >100	15,4 mld. Kč 15 fatalities
August 2010	summer flood with flash flood features	Smědád, Lužická Nisa, Ploučnice and Kamenice basins	50 to 100, >100 exceptionally >1000	10,1 mld. Kč 5 fatalities
June/July 2009	flash flood	Nový Jičín., Jeseníky and Děčín regions	100, > 100 someplace >> 100	8,5 mld. Kč 15 fatalities
March/April 2006	spring flood, thaw and rain	Dyje, Morava, Sázava, Lužnice and others	50 to 100 exceptionally >100	6,2 mld. Kč 9 fatalities
May/June 2010	summer regional two flood waves	Oder and Morava basins	50 to 100 exceptionally >100	5,1 mld. Kč 3 fatalities
March 2000	spring flood, thaw and rain	upper Elbe and Jizera basins	50 to 100 exceptionally >100	3,8 mld. Kč 2 fatalities
July 1998	flash flood	Dědina, Bělá (Orlice basin)	>100	1,8 mld. Kč 10 fatalities



**All partial reports from the Project Assessment of floods in June 2013  
are on web address <http://voda.chmi.cz/pov13> in Czech language**

**Thank you for attention**

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