Vztah mezi extremitou atmosférické cirkulace, srážek a povodní

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Seminář z FG 8-4-2015

Motivace

"Extreme events are generally easy to recognize but **difficult to define**."

(Stephenson, 2008, p. 12)

http://snehulakvparnemlete.wordpress.com/

"When scanning peer-reviewed literature on weather extremes and its impacts, it is noticeable that many different methods are used to make inferences. However, discussions on these methods are rare. Such discussions are important since a particular **methodological choice might substantially influence the inferences** made. "

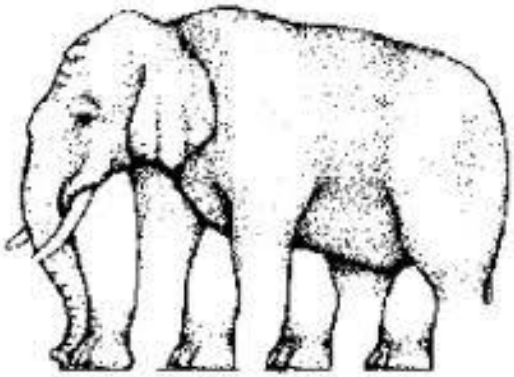
(Visser and Petersen, 2012: Clim. Past, 8, 265–286)

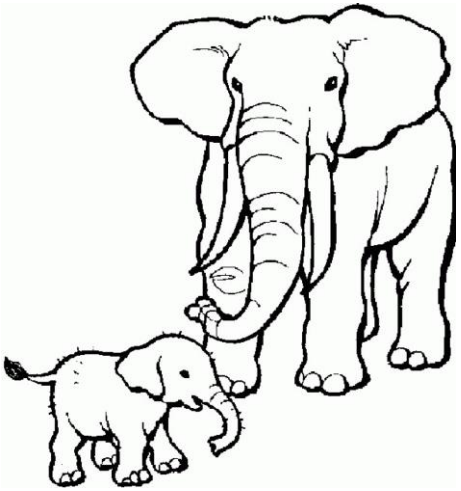
Osnova

- Extremita
- Extremita srážek
- Extremita povodní
- Extremita atmosférické cirkulace

Seminář z FG 8-4-2015

Extremity

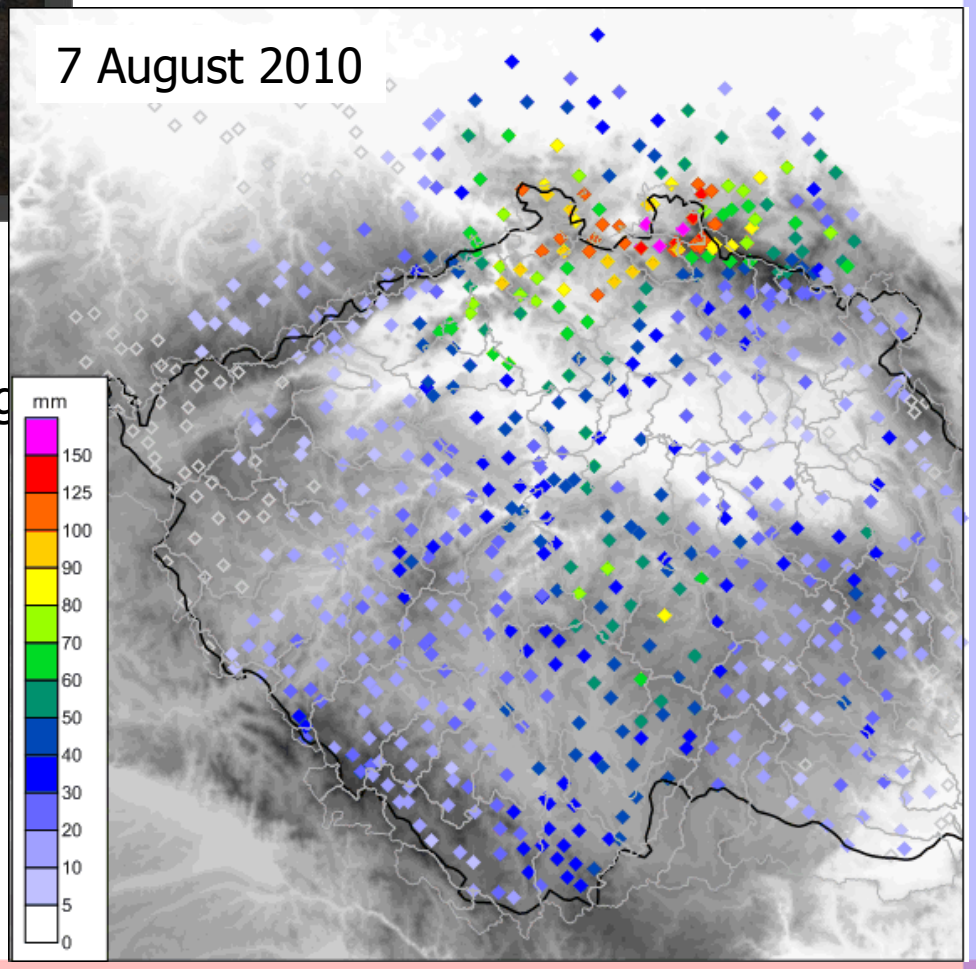


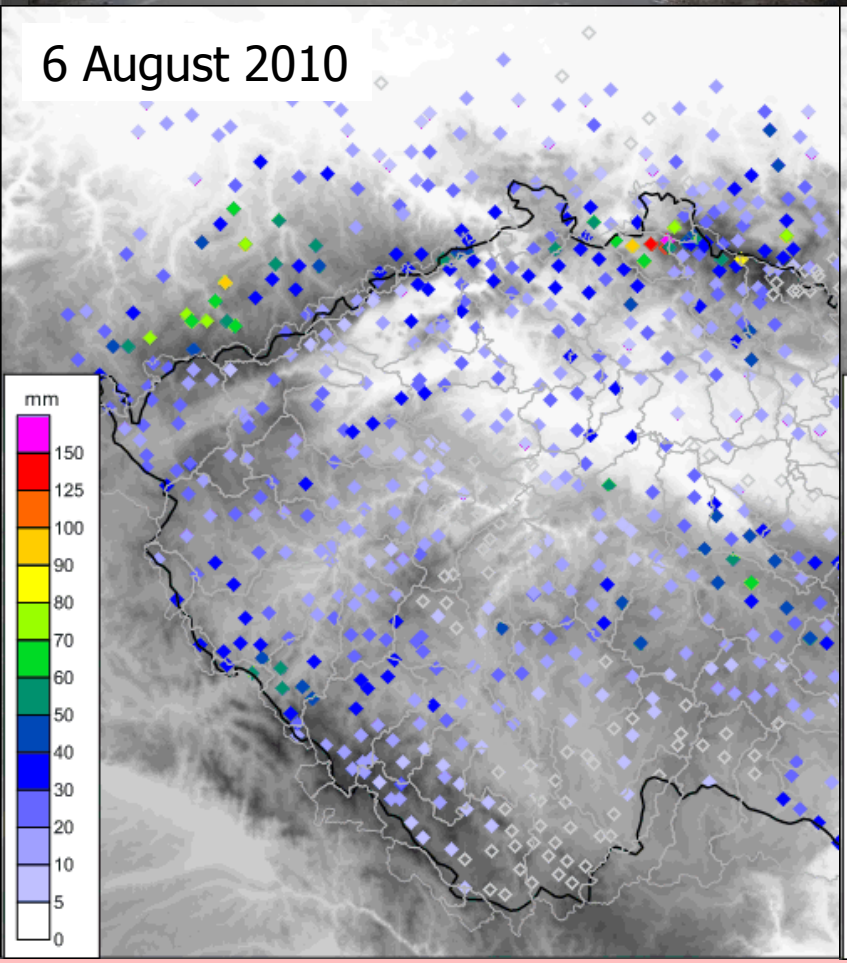


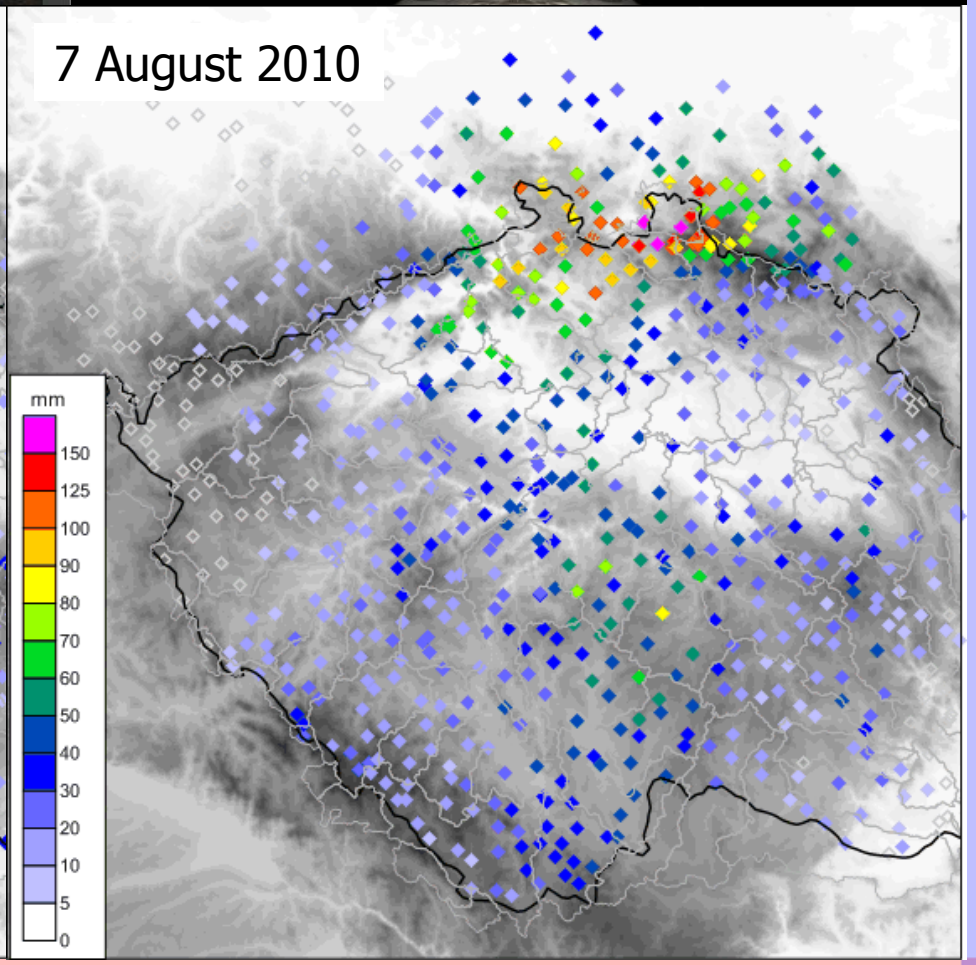
Beniston et al. (2007)

Aspects

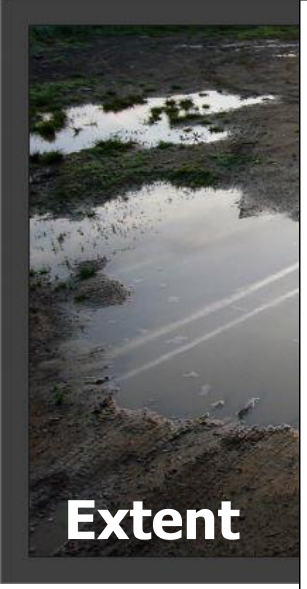
Hejnice, 7 Aug



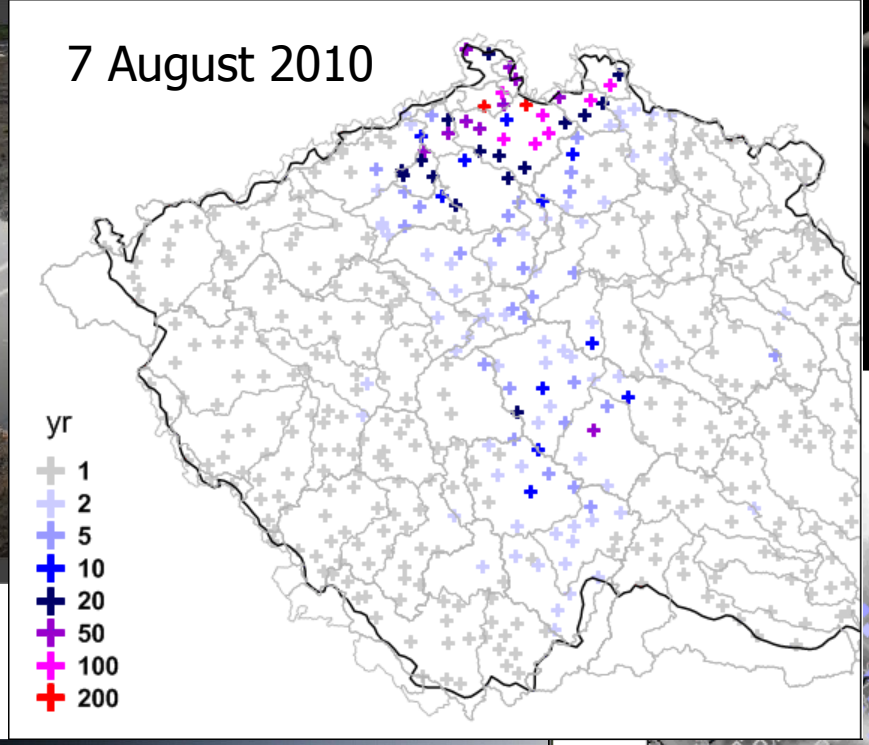




Kašpar et al. (2013)

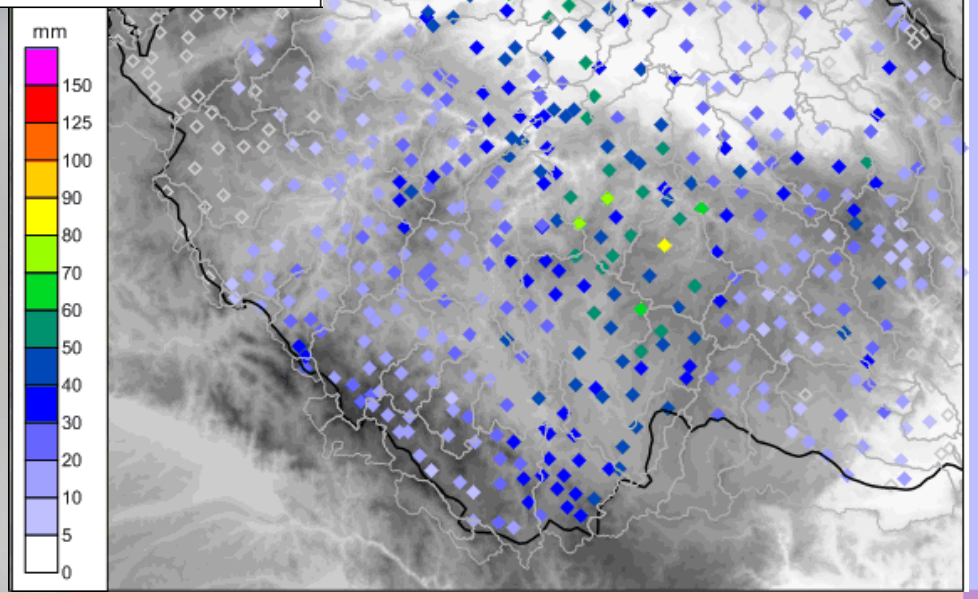


Extent

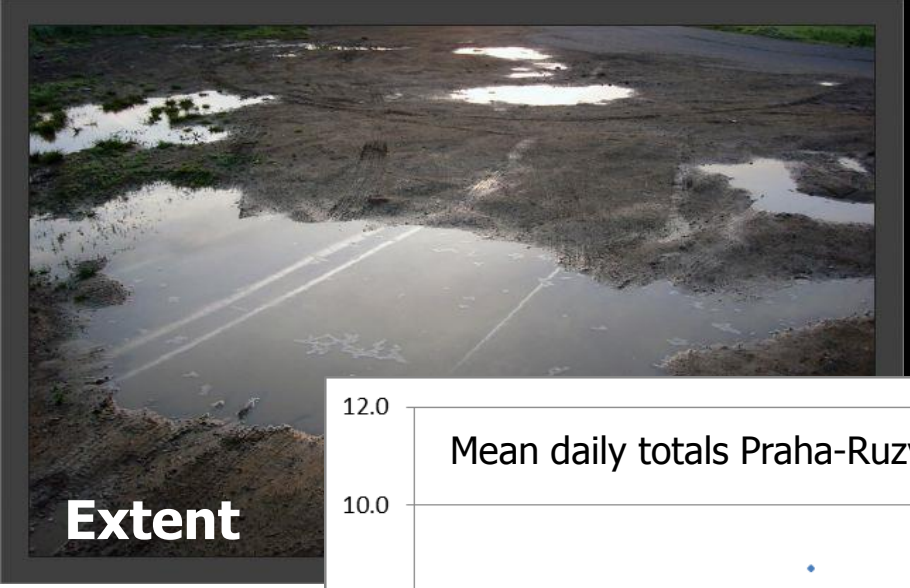


Duration

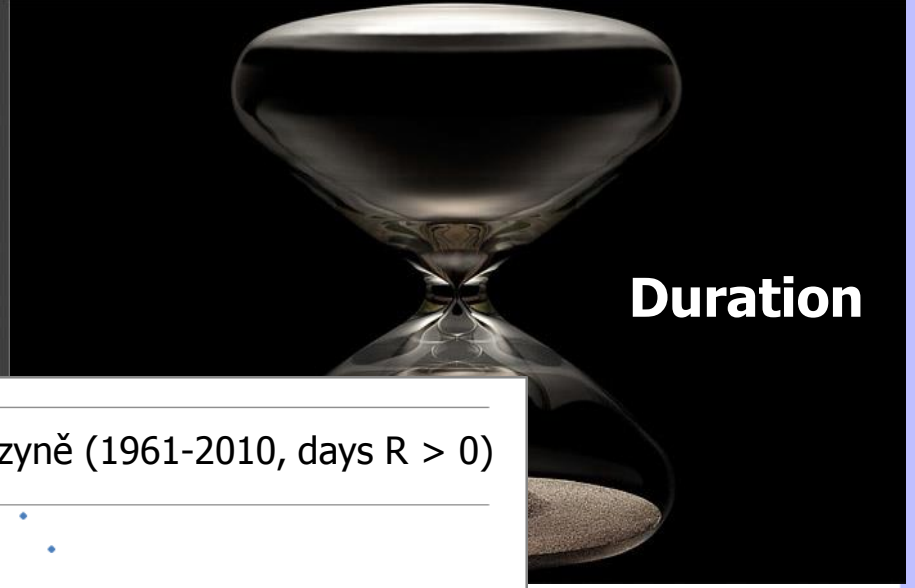
Regionality



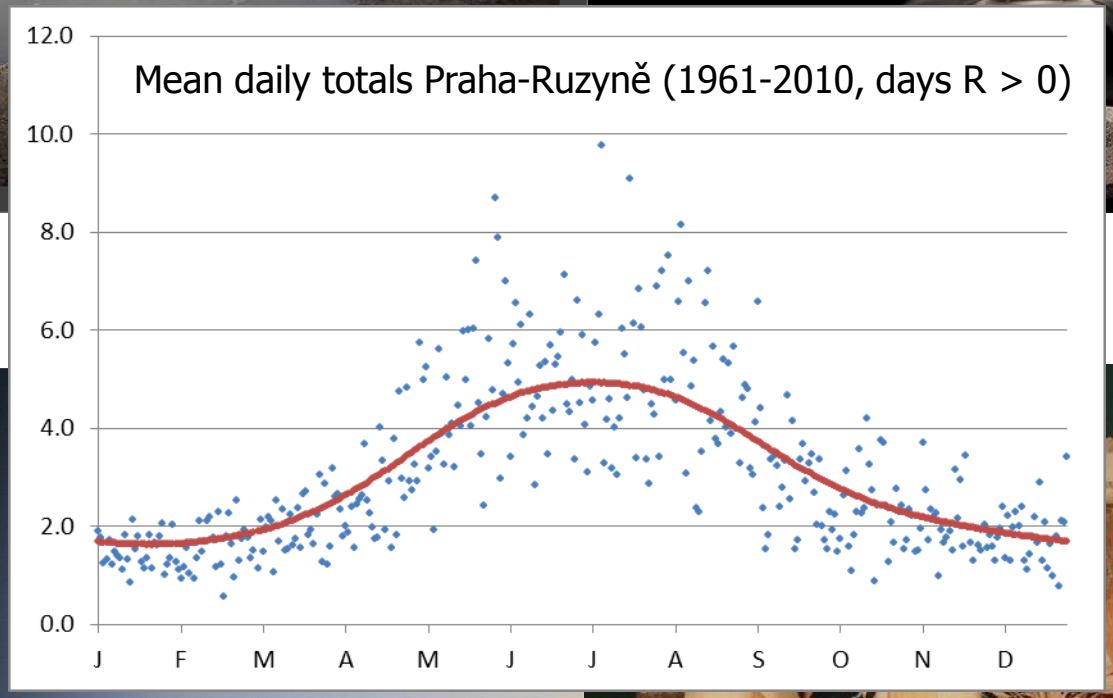
Seminář z FG 8-4-2015



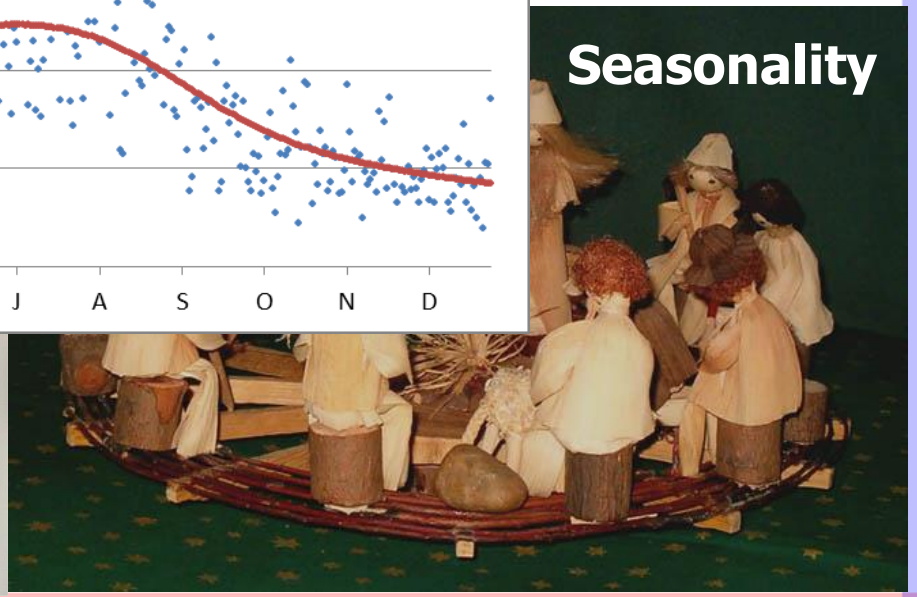
Extent



Duration



Seasonality

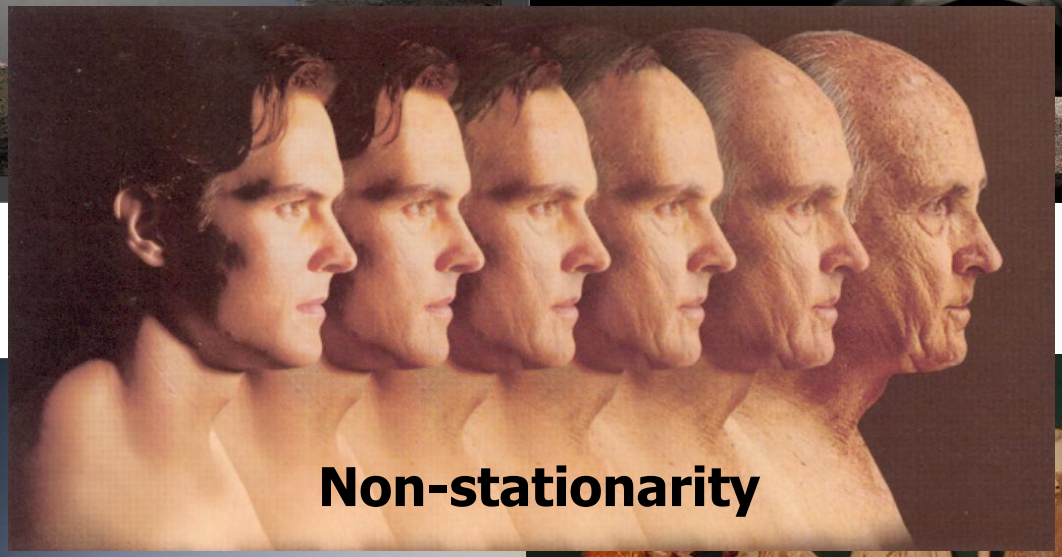


Regionality

Seminář z FG 8-4-2015

Extent

Duration



Non-stationarity

Seasonality

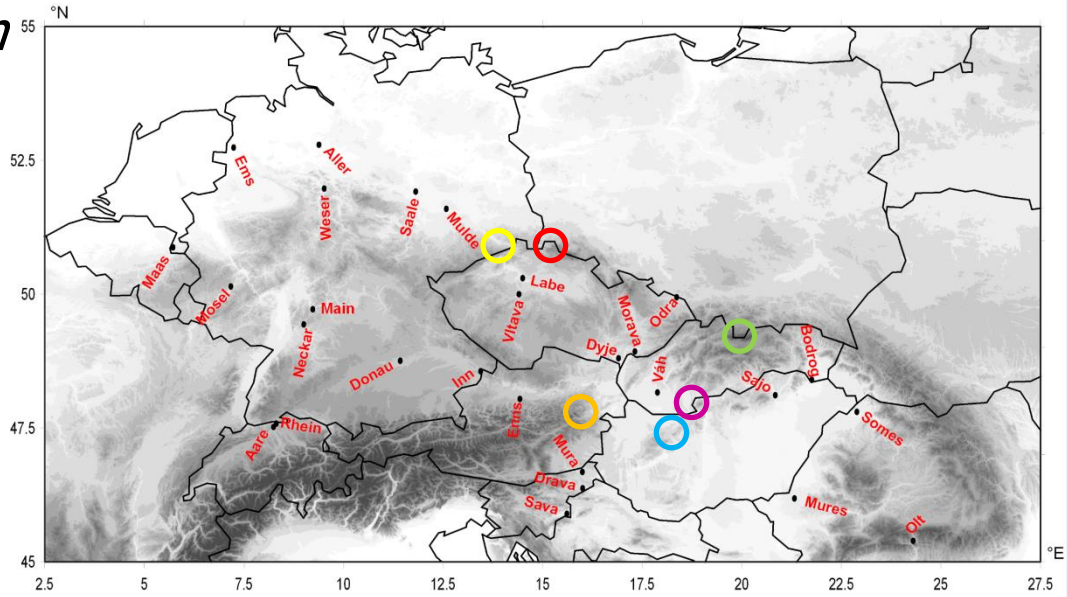
Regionality

Seminář z FG 8-4-2015

Extremita srážek

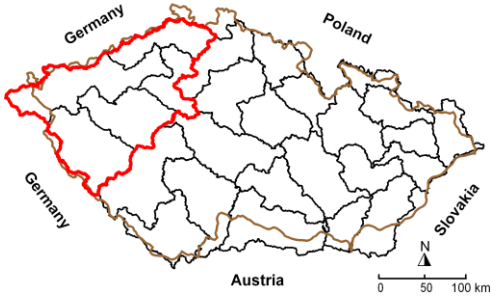
Extremita srážek: nejvyšší bodový denní úhrn

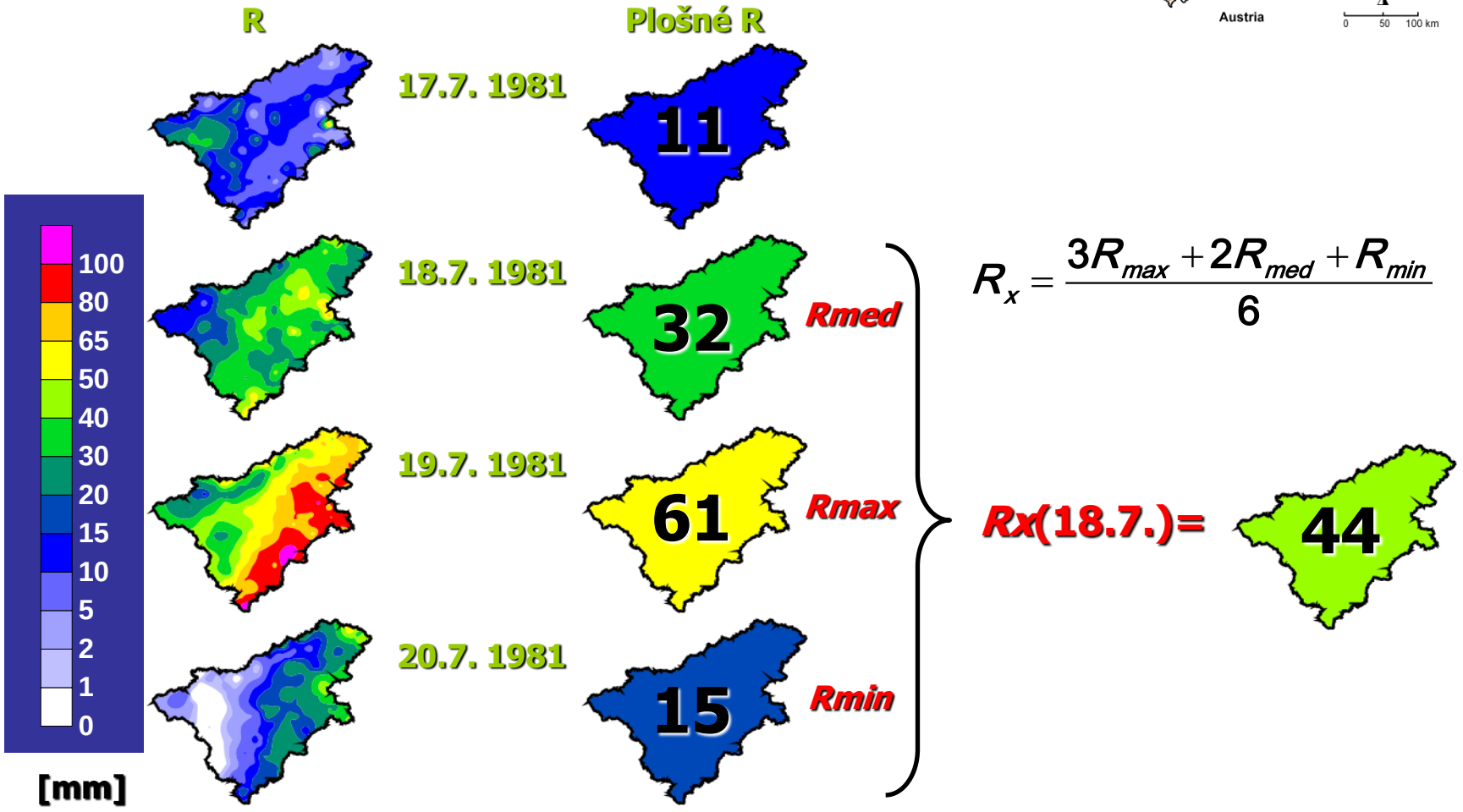
1. Czechia: 345.1 mm – Nová Louka, 29 July 1897
2. *Austria: 323.2 mm – Semmering, 5 July 1947*
3. Germany: 312.0 mm – Zinnwald-Georgenfeld, 12 August 2002
4. Poland: 300.0 mm – Hala Gasienicowa, 30 June 1973
5. *Hungary: cca 260 mm – Dad, 9 June 1953*
6. *Slovakia: 231.9 mm – Salka, 12 July 1957*



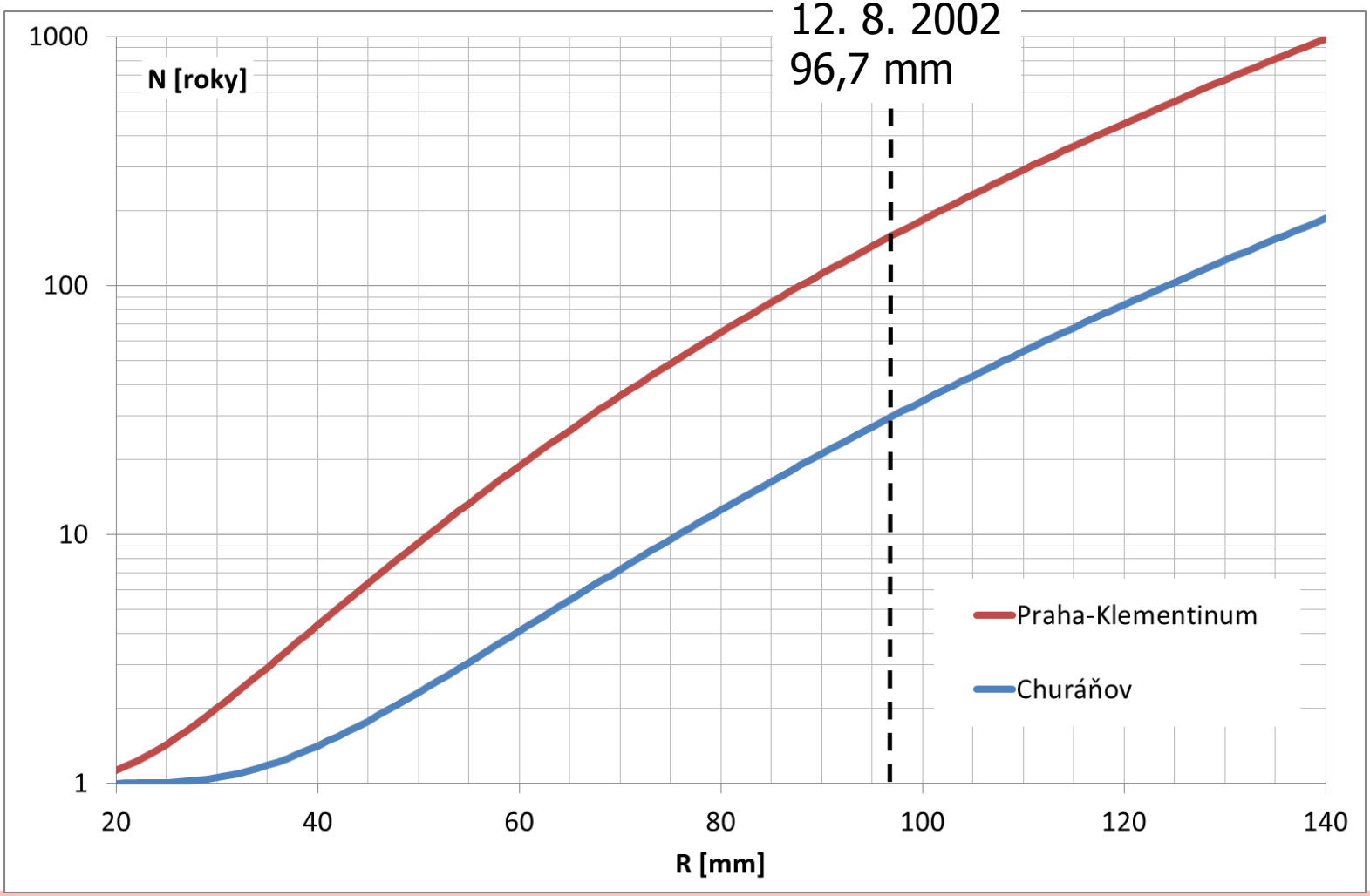
„EDÚS"

Extremita srážek: plošný průměr

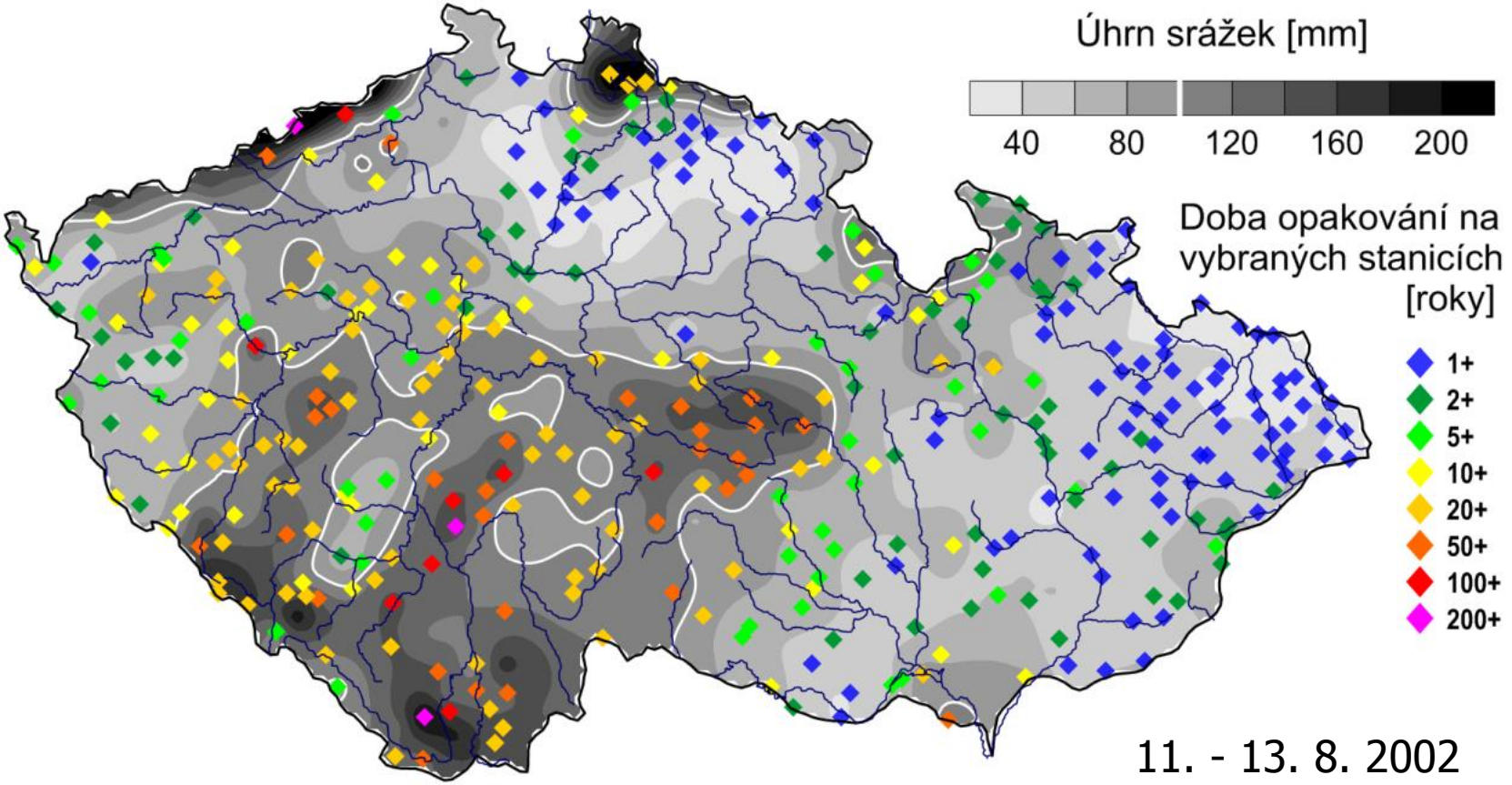




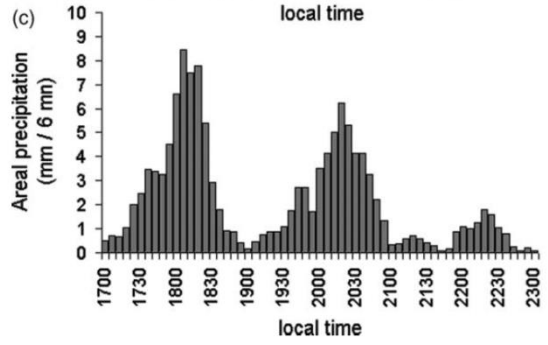
Extremita srážek: doby opakování

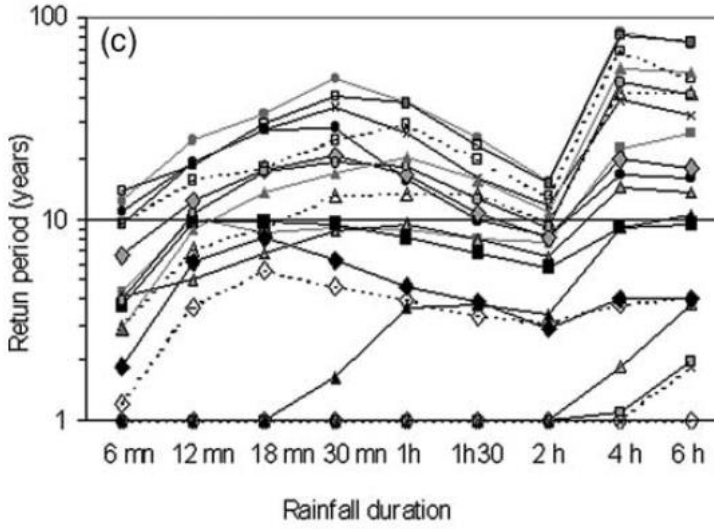


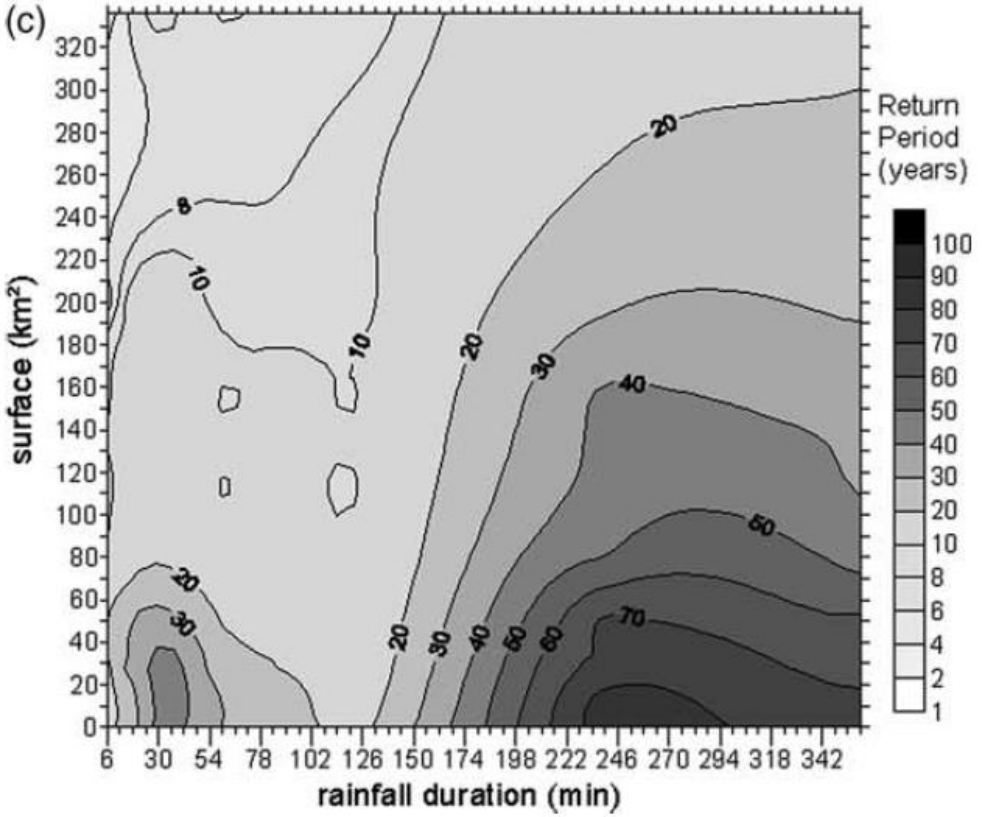
Extremita srážek: doby opakování



Extremita srážek: severity graphs and diagrams



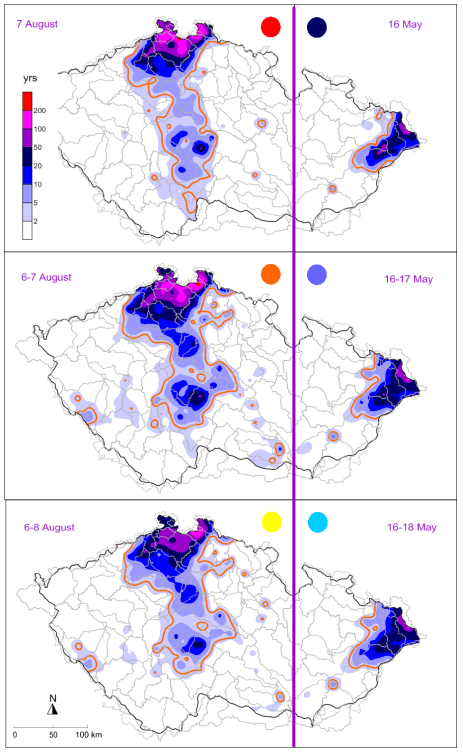


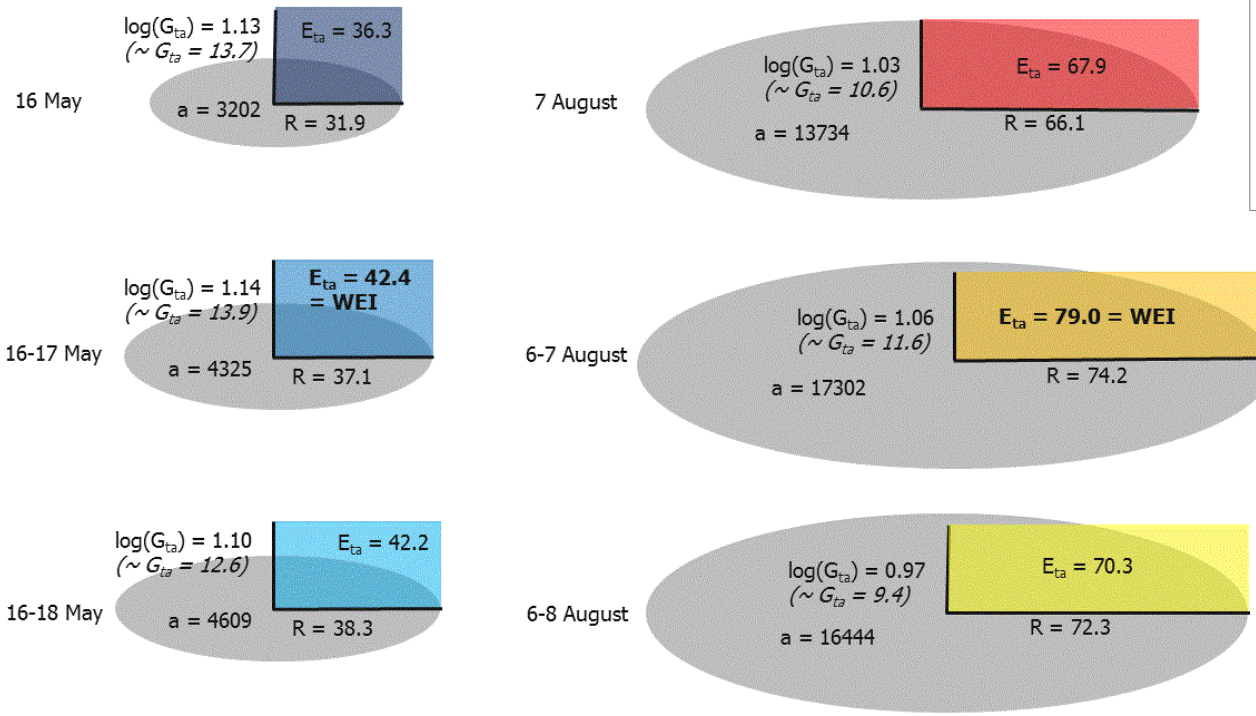


Ramos et al. (2005)

Extremita srážek: Weather Extremity Index

$$E_{ta} = \log(G_{ta})R = \frac{\sum_{i=1}^{n} \log(N_{ti})}{n} \frac{\sqrt{a}}{\sqrt{\pi}}$$

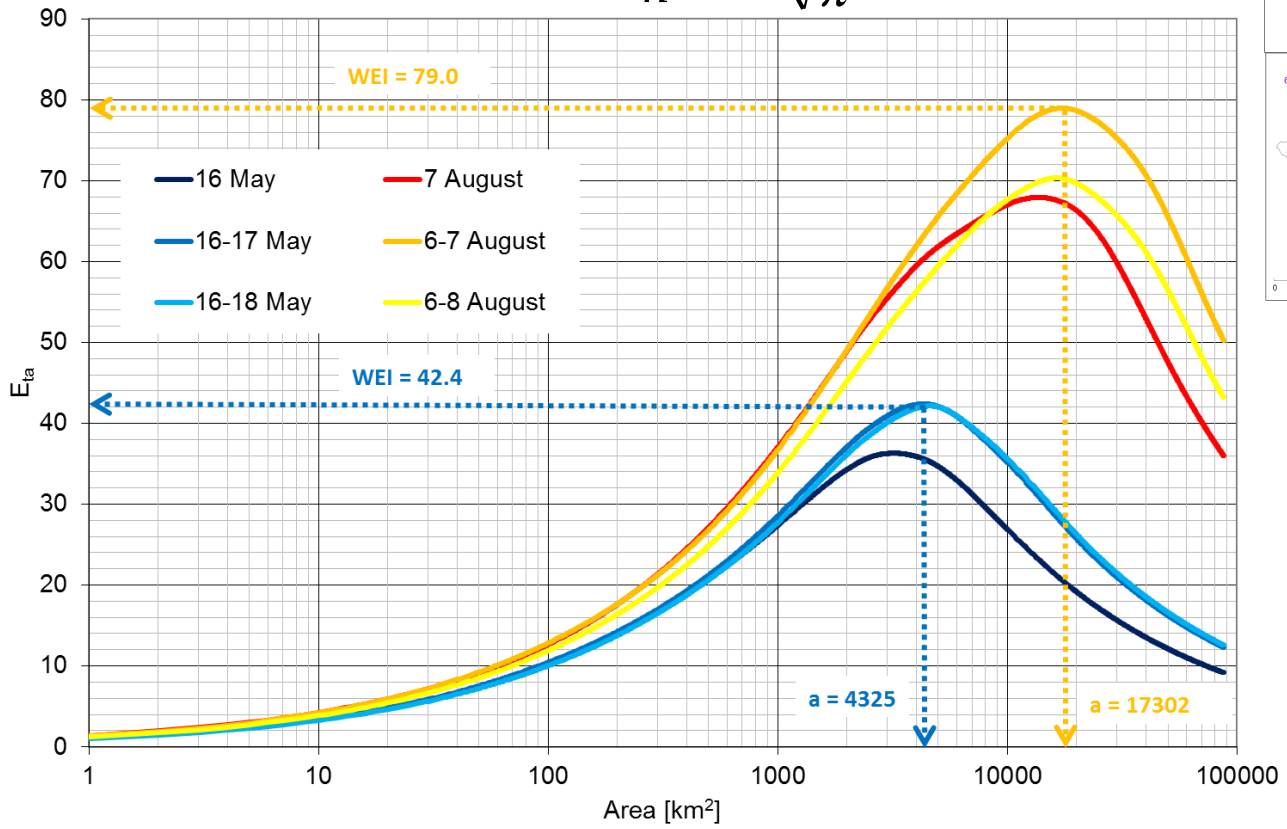


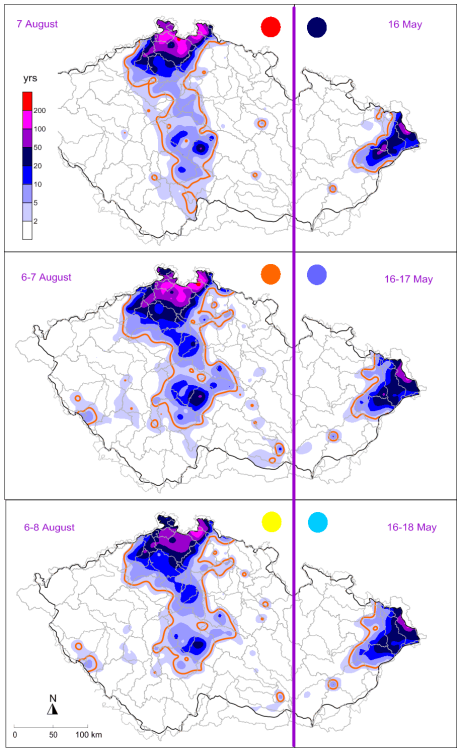


$$WEI = \max(E_{ta})$$

Extremita srážek: Weather Extremity Index

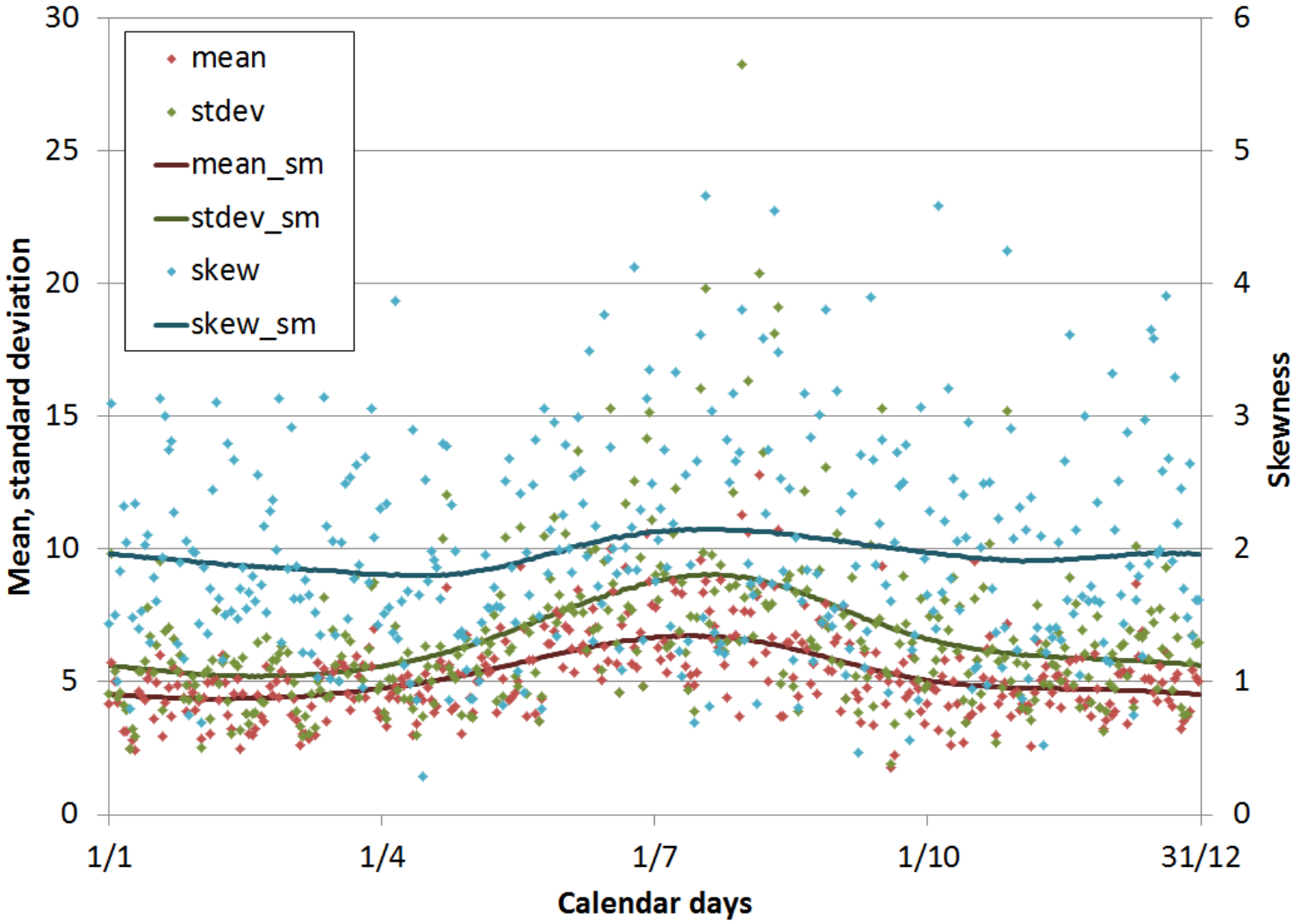
$$E_{ta} = \log(G_{ta})R = \frac{\sum_{i=1}^{n}\log(N_{ti})}{n}\frac{\sqrt{a}}{\sqrt{\pi}}$$





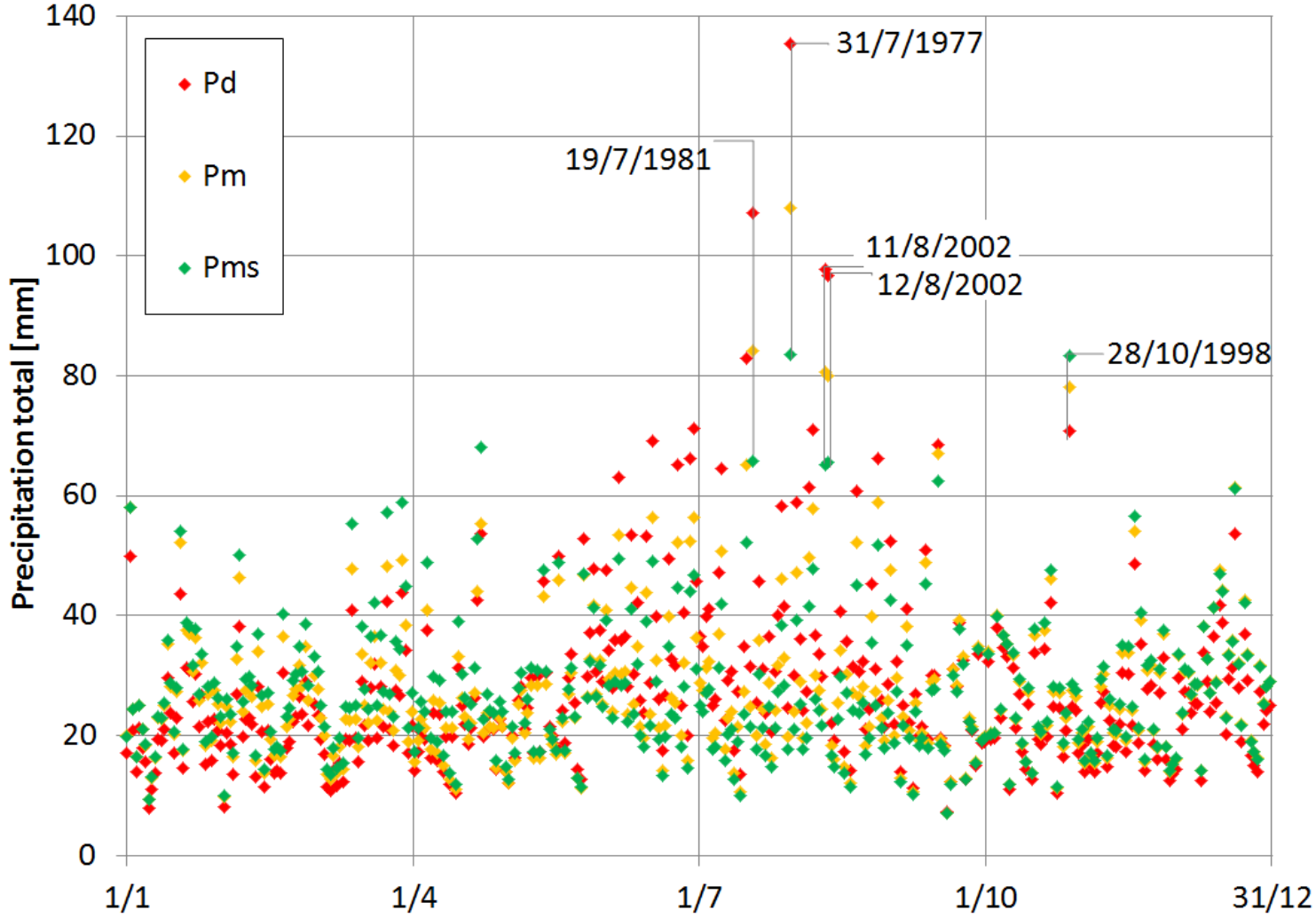
$$WEI = \max(E_{ta})$$

Abnormalita srážek



Abnormalita srážek

$$P_{ms} = \overline{P}\left(\frac{P_d}{\mu_{dG}}\right)^{\frac{\bar{\gamma}}{\gamma_{dG}}}$$



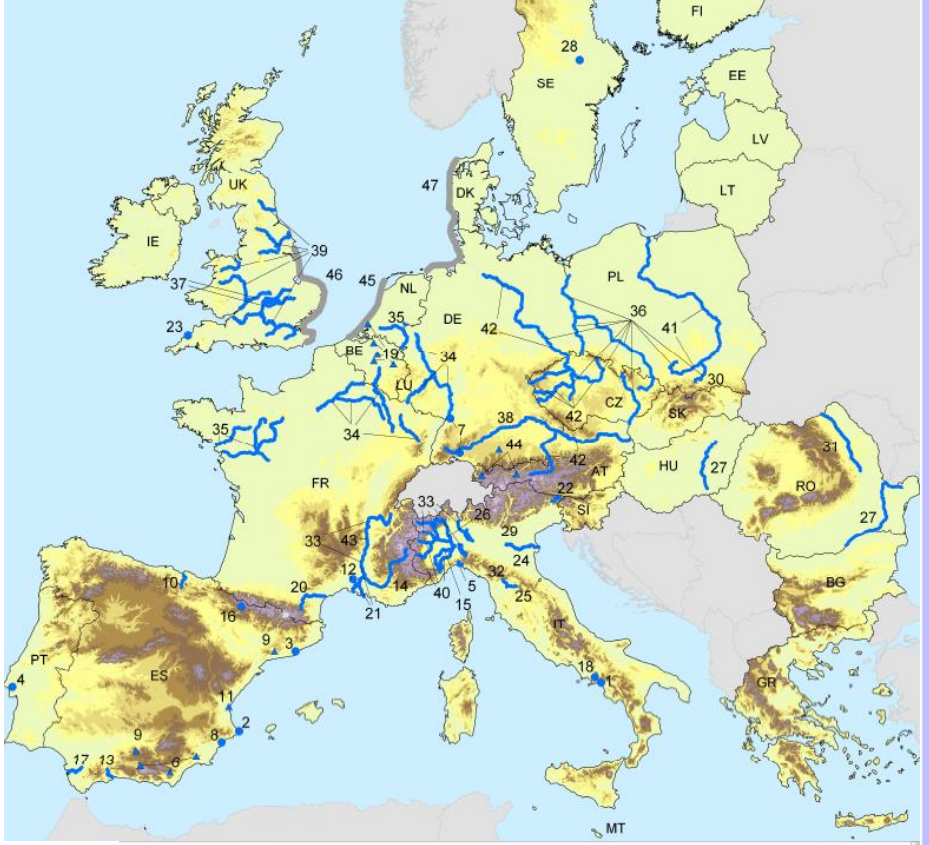
Müller and Kašpar (2014)

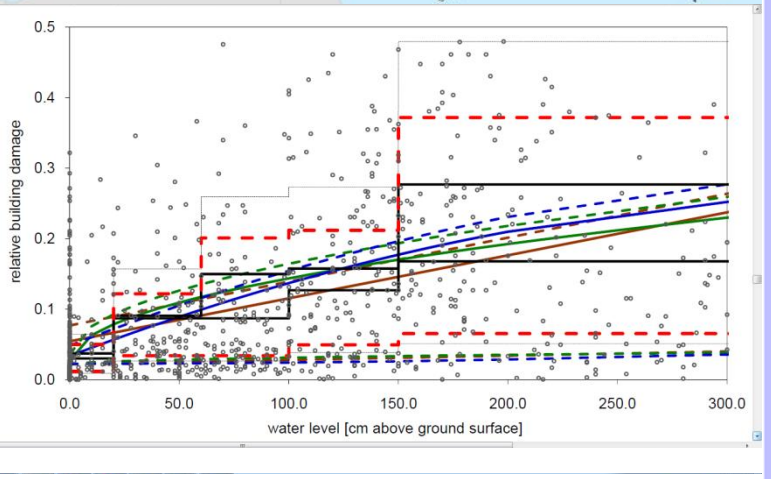
Extremita povodní

Extremity of floods: Severity

Barredo, 2007: Nat Hazards, 42, 125–148.

- EU + Bulgaria and Romania
- 1950 – 2005
- **70+ casualties or 0.005% of EU GDP**
- 23 flash floods + 21 river floods



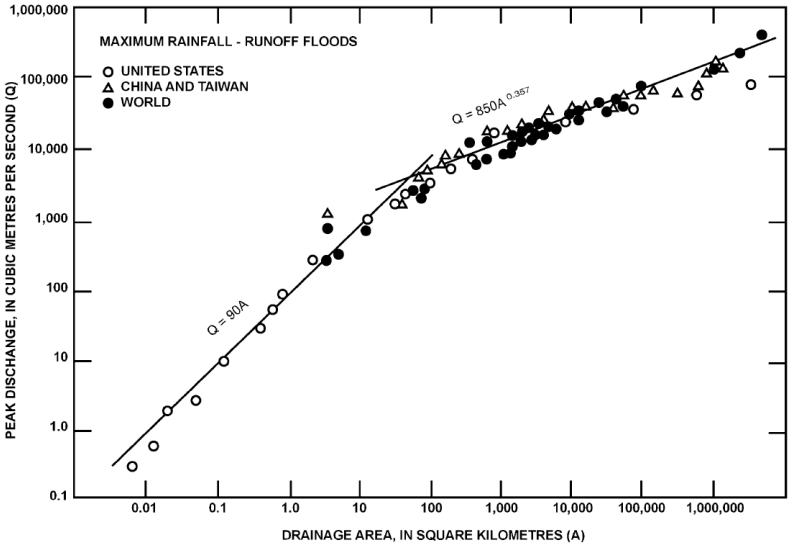


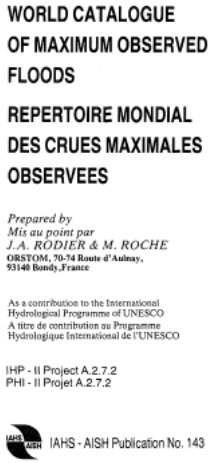
Elmer et al. (2010)

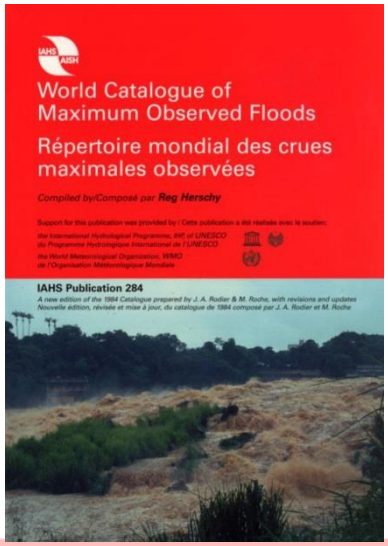
Extremity of floods: Intensity

World Catalogue of Maximum Observed Floods.

- Rodier, J. A., Roche, M. J., 1984: IAHS Publ. no. 143.
- Herschy, R. (ed.), 2003: IAHS Publ. no. 284.







Francou index:

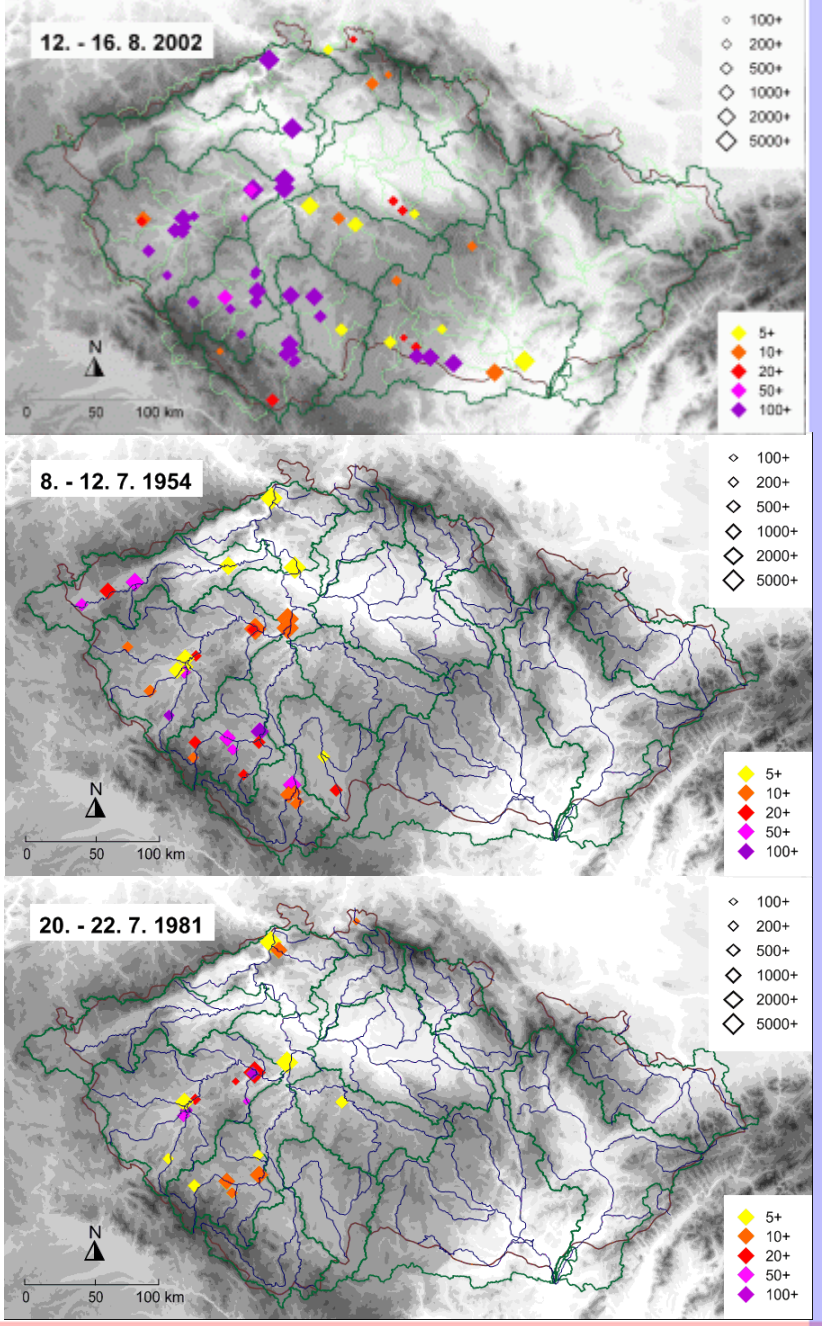
$$k = 10\left(1 - \left[\log(Q) - 6\right] / \left[\log(A) - 8\right]\right)$$

Extremity of floods: Rarity

- Kvantily
- Doby opakování

	Q_{kulm} [m^3s^{-1}]	N [yrs]
VIII 2002	4770	100
IX 1890	4450	100
VI 2013	*3740*	20-50
VII 1954	3180	10
VII 1981	3170	10
V 1896	3100	10

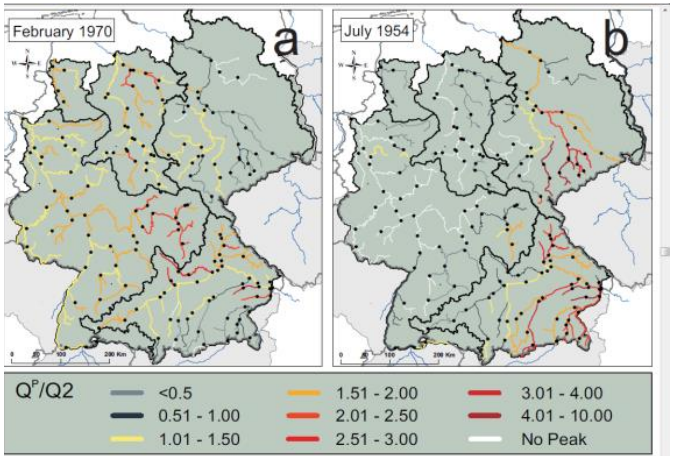
Labe (Elbe) in Děčín, MJJASO

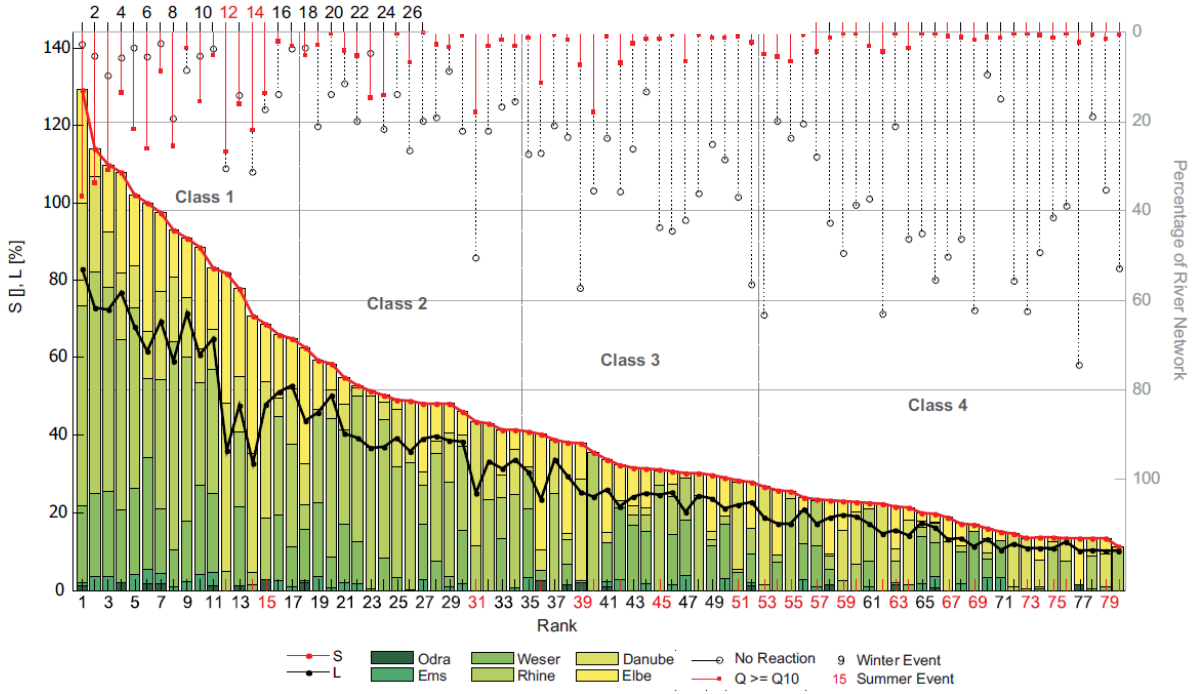


Extremity of floods: Trans-basin floods

Uhlemann et al., 2010:
Hydrol. Earth Syst. Sci., 14, 1277–1295

- Weighted cumulative discharge index

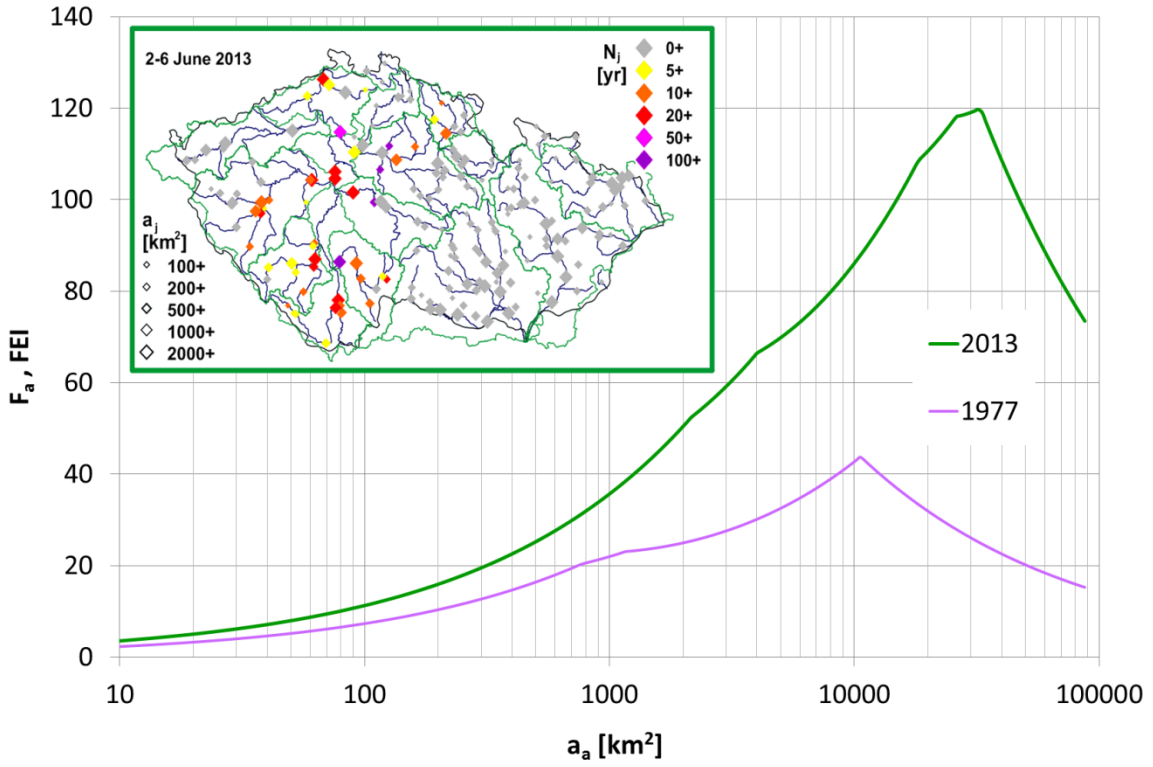




Extremity of floods: Flood Extremity Index (FEI)

$$F_a = \frac{\sum_{j=1}^{h}\left(\log(N_{ti})a_j\right)}{a_a}\frac{\sqrt{a_a}}{\sqrt{\pi}}$$

$$FEI = \max(F_a)$$



Müller et al. (2015)

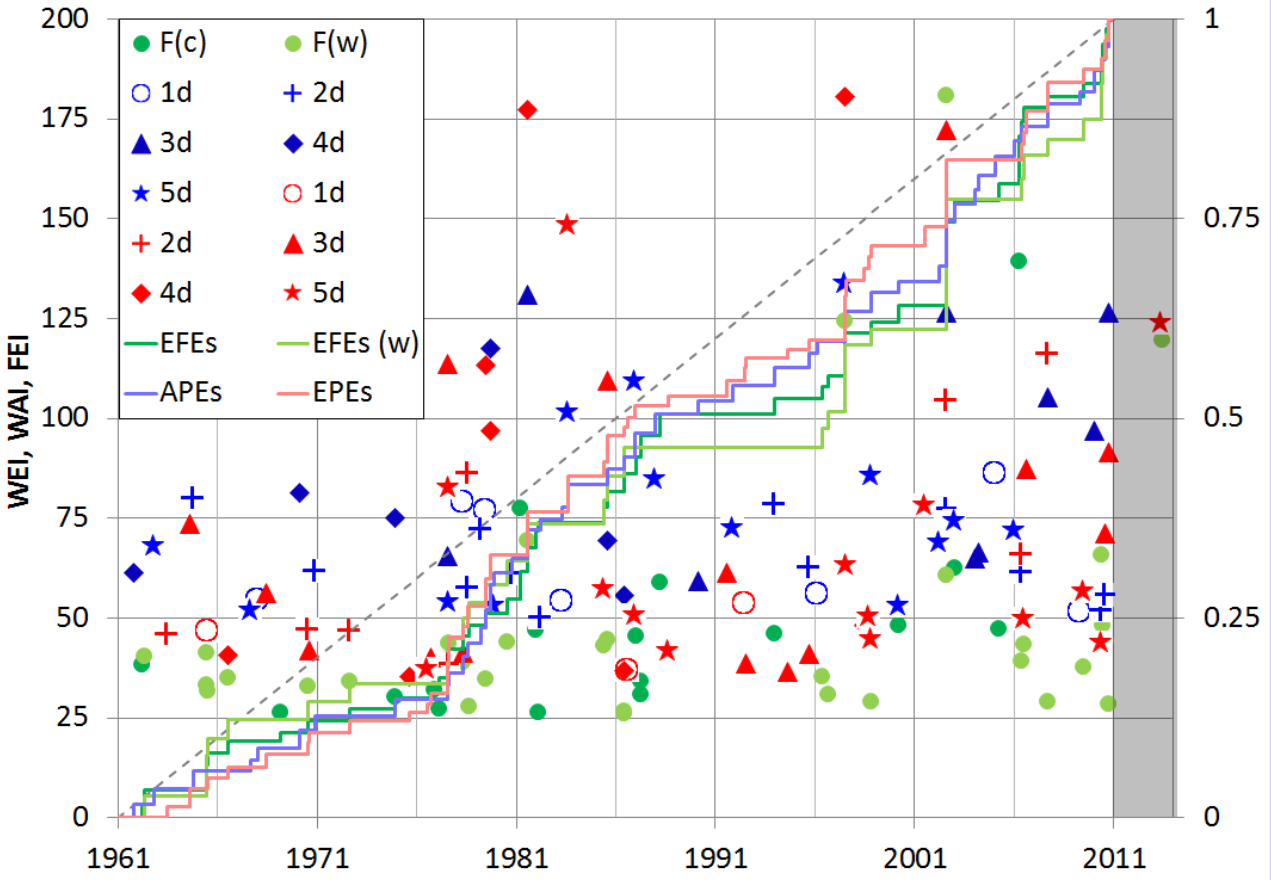
Vzájemný vztah povodní a srážek

	EPEs					APEs					EFEs		
	EPEs + APEs												
						APEs + EFEs							
	EPEs + APEs + EFEs												
Rank-ings	First day [yyyy-mm-dd]	Duration [days]	WEI	Area [10^3 km^2]	C_e [%]	First day [yyyy-mm-dd]	Duration [days]	WAI	Area [10^3 km^2]	C_a [%]	First day [yyyy-mm-dd]	FEI	Area [10^3 km^2]
1	1997-07-04	4	180.6	37.9	69	1997-07-03	5	133.6	28.4	93	2002-08-12	180.9	35.8
2	1981-07-17	4	177.1	45.0	39	1981-07-18	3	130.9	31.0	53	2006-03-28	139.4	48.2
3	2002-08-11	3	172.3	55.2	105	2010-09-25	3	126.4	29.1	22	1997-07-07	124.3	20.2
4	1983-08-01	5	148.3	39.6	8	2002-08-11	3	126.3	43.0	143	1981-03-10	77.5	19.5
5	2007-09-05	2	116.0	35.5	25	1979-09-21	4	117.6	33.1	0	1981-07-20	69.4	16.7
6	1977-07-31	3	113.5	44.2	35	1986-12-28	5	109.0	42.1	42	2010-05-17	65.9	7.6
7	1979-06-15	4	113.4	33.1	31	2007-09-05	3	105.2	27.0	28	2002-12-30	62.4	18.5
8	1985-08-06	4	109.3	35.6	41	1983-08-01	5	101.2	32.2	12	2002-08-07	60.8	9.1
9	2002-08-06	2	104.2	20.7	58	2010-01-08	3	96.8	33.5	0	1988-03-26	59.0	16.9
10	1979-09-21	4	97.0	37.9	0	2005-01-20	1	86.1	45.6	0	2010-06-02	48.2	8.2
11	2010-09-25	3	91.6	31.4	31	1998-10-28	5	85.5	48.3	34	2000-03-09	48.1	6.7
12	2006-08-05	3	87.3	34.6	21	1987-12-16	5	84.7	37.7	9	2005-03-17	47.3	11.1
13	1978-08-07	2	86.2	26.0	32	1970-02-20	4	81.3	47.6	23	1982-01-06	47.0	9.9
14	1977-08-18	5	82.5	53.3	53	1964-10-08	2	79.9	18.0	0	1993-12-21	46.0	5.9
15	2001-07-16	5	78.0	38.1	11	1978-05-07	1	78.9	17.9	49	1986-12-30	45.5	10.4
16	1964-08-08	3	73.6	18.2	22	1993-12-19	2	78.5	34.3	59	1985-08-07	44.7	8.3
17	2010-08-05	3	71.2	22.3	62	2002-08-06	2	77.3	14.3	79	2010-08-07	44.2	4.9
18	2006-05-26	2	65.7	17.6	60	1979-06-17	1	76.8	17.0	45	1980-07-21	43.9	6.2
19	1997-07-17	5	63.0	43.8	31	1974-12-05	4	75.0	19.0	40	1977-08-22	43.8	10.6
20	1991-07-31	3	61.2	30.8	22	2002-12-29	5	74.3	42.4	84	2006-06-30	43.3	4.0
21	1985-05-17	5	57.1	9.9	75	1991-11-16	5	72.3	32.4	0	1985-05-20	43.0	5.9
22	2009-06-22	5	56.5	14.8	67	1979-03-29	2	72.1	17.8	0	1965-06-05	41.3	5.7
23	1968-06-08	3	56.2	16.1	28	2005-12-30	5	71.8	17.6	0	1962-05-14	40.5	7.4
24	1992-06-23	1	53.5	10.5	8	1985-08-06	4	69.3	27.6	64	1977-08-01	39.6	5.1
25	1986-12-28	5	50.6	19.2	90	2002-03-19	5	68.9	19.0	23	2006-05-27	39.3	5.8

Müller et al. (2015)

Meziroční variabilita

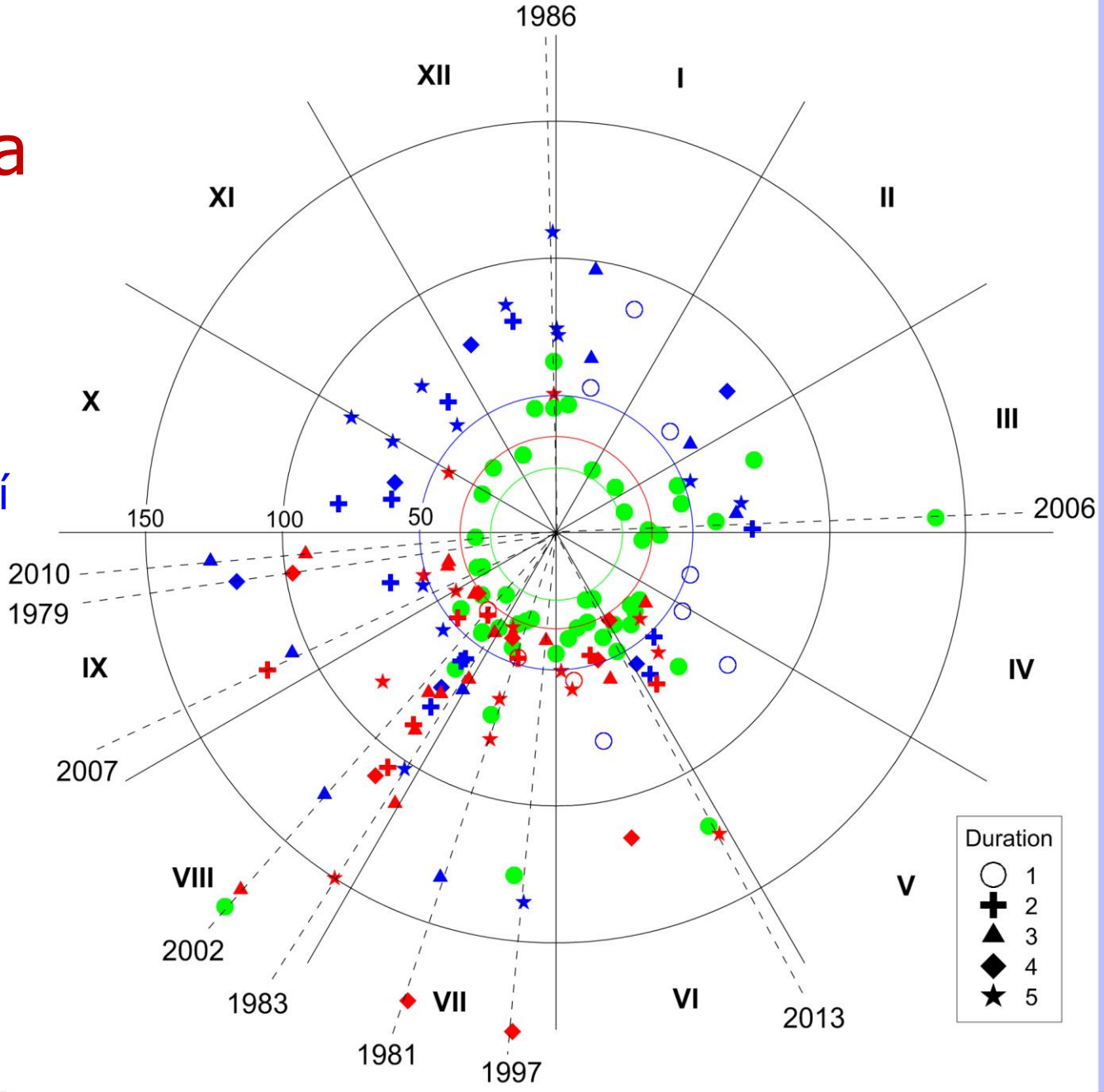
- Extrémní srážky
- Abnormální srážky
- Extrémní povodně



Müller et al. (2015)

Sezonalita

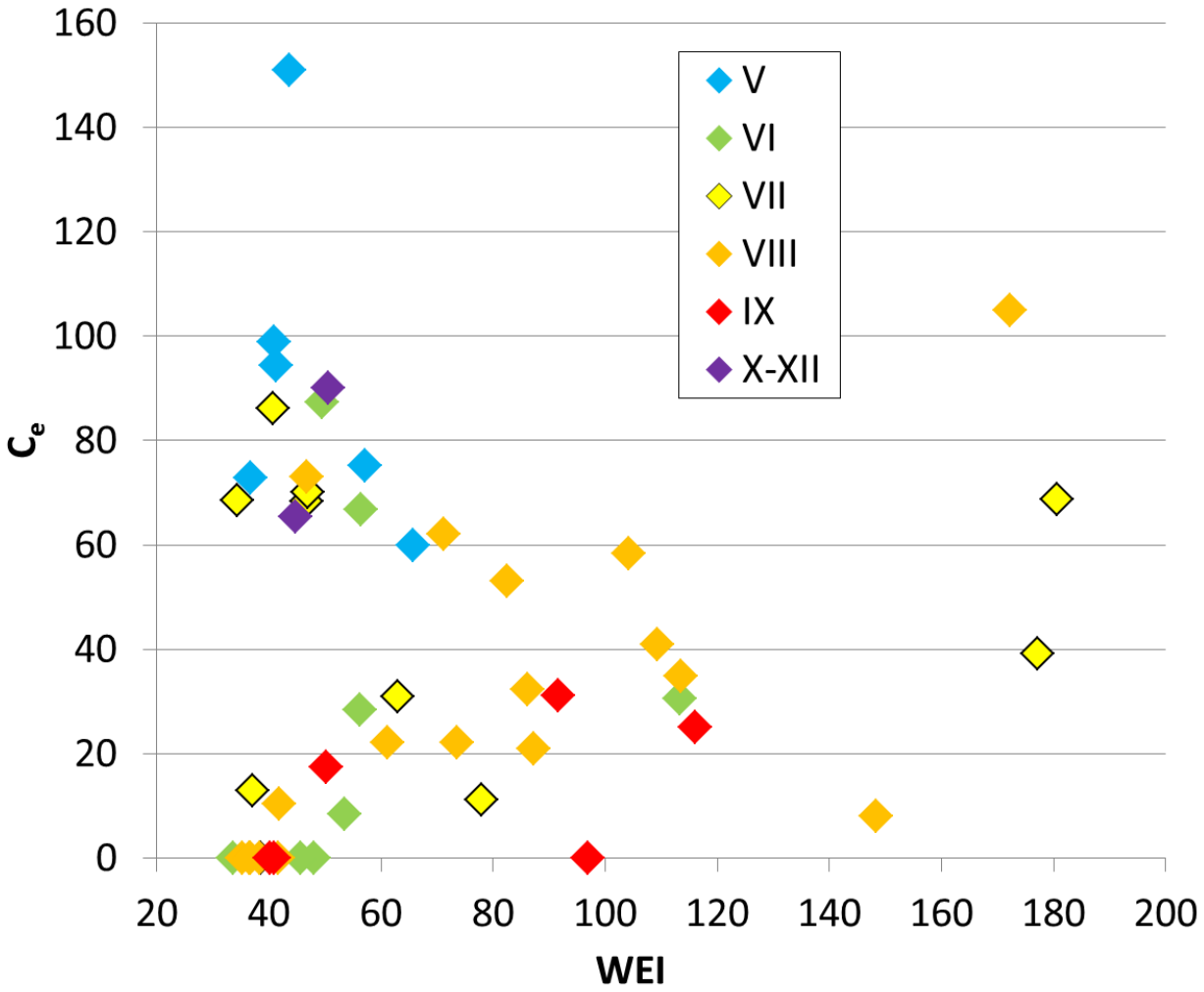
- Povodně
- Extrémní srážky
- (Abnormální srážky)



Müller et al. (2015)

Míra hydrologické odezvy

$$C_e = 100 \frac{FEI}{WEI}$$



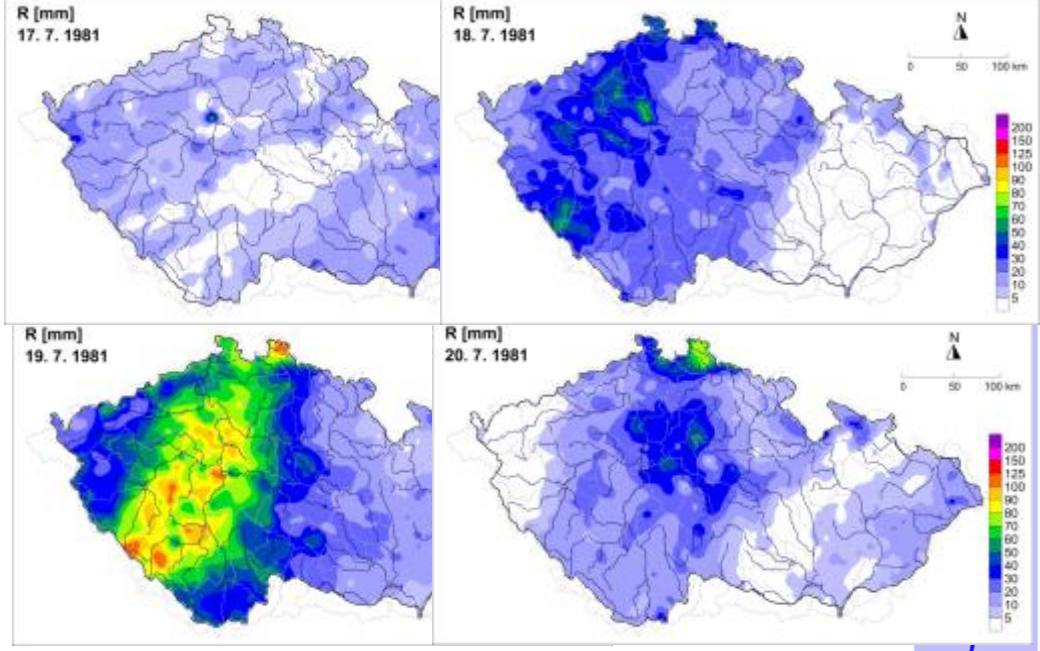
Müller et al. (2015)

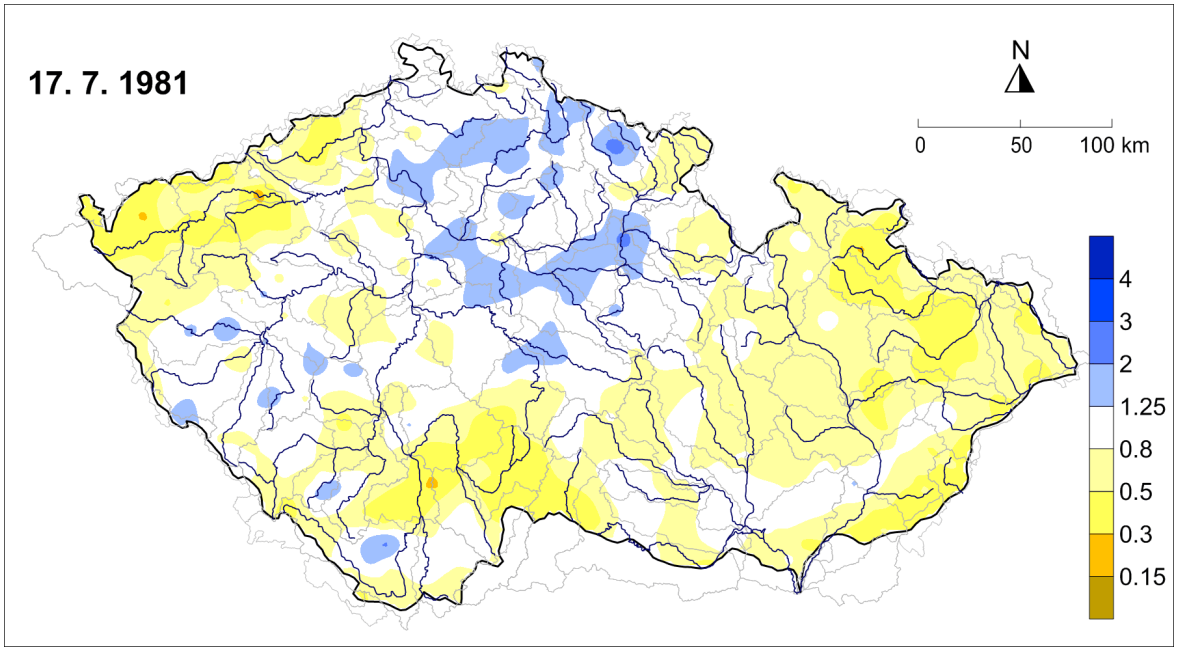
Vliv předchozí nasycenosti

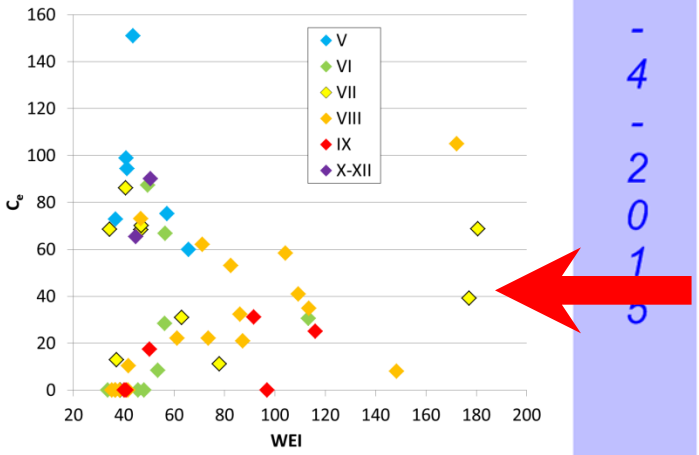
Köhler and Linsley (1951):

Antecedent Precipitation Index

$$API_n = \sum_{i=1}^{n} P_i \, k^{n-i+1}$$







FG 8-4-2015

Vliv předchozí nasycenosti

Köhler and Linsley (1951):

Antecedent Precipitation Index

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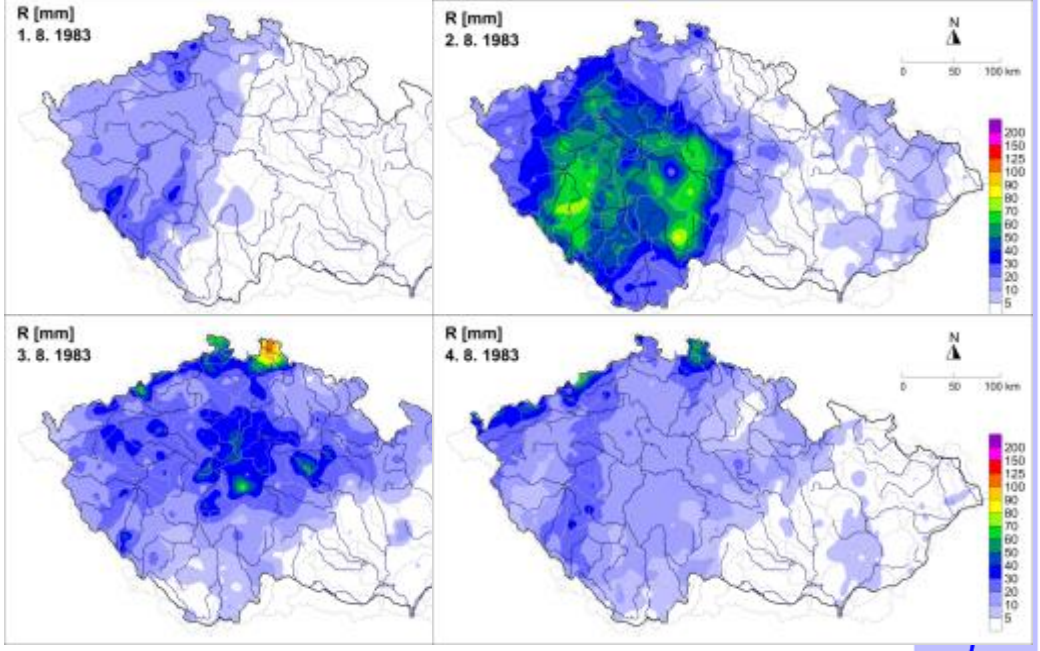

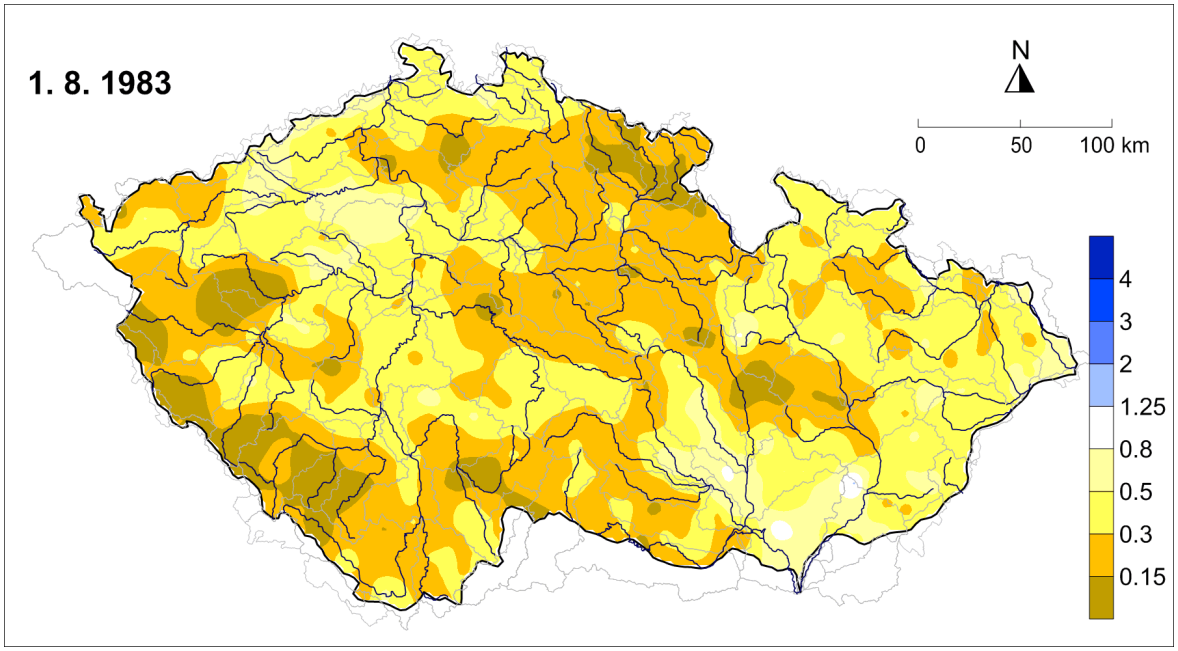

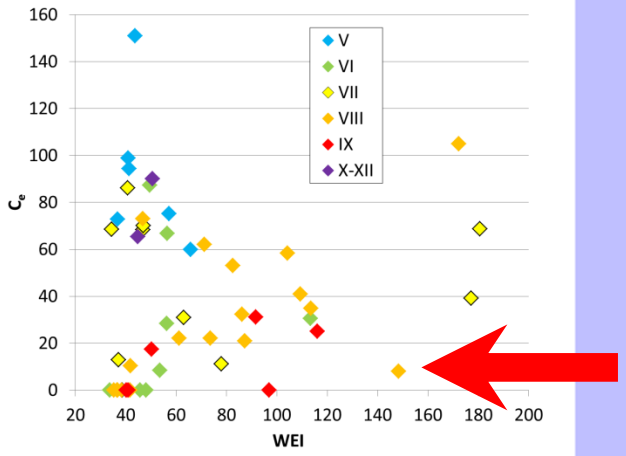

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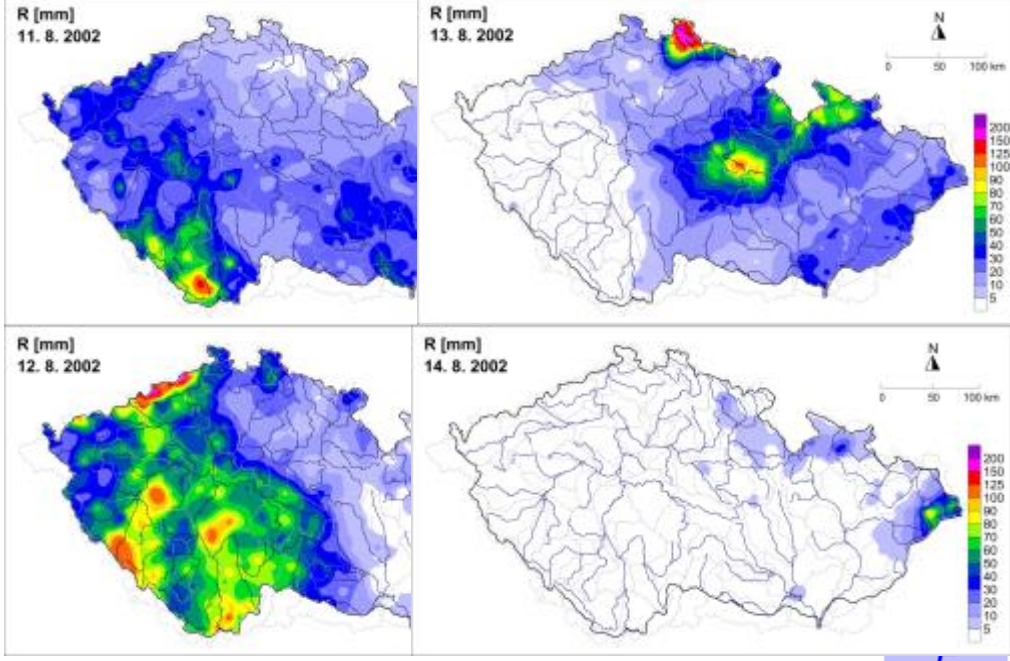
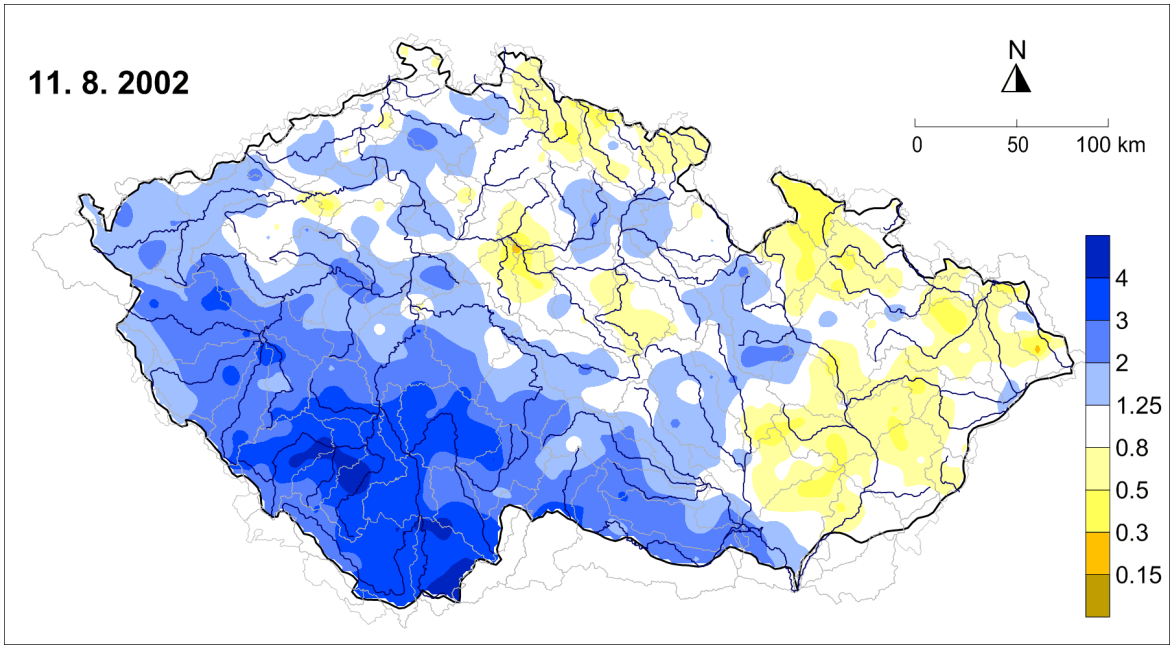
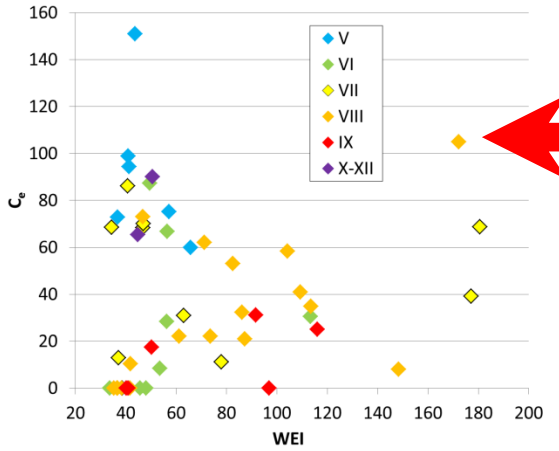






IG 8-4-2015

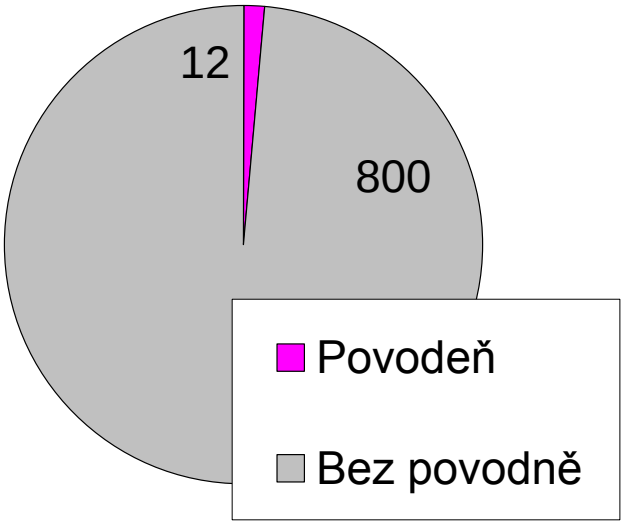
Extremita atmosférické cirkulace

Atmosférická cirkulace: Typy povětrnostních situací

	Typ ČHMÚ	Qk [$m^3.s^{-1}$]	Datum
1.	NEc	2160	8. 7. 1997
2.	NEc	1050	9. 8. 1985
3.	C	936	22. 8. 1972
4.	C	890	26. 7. 1960
5.	B	818	12. 5. 1951
6.	C	765	4. 8. 1977
7.	Ec	718	26. 7. 1966
8.	B	697	8. 9. 1996
9.	B	687	19. 7. 1970
10.	NEc	608	3. 7. 1949

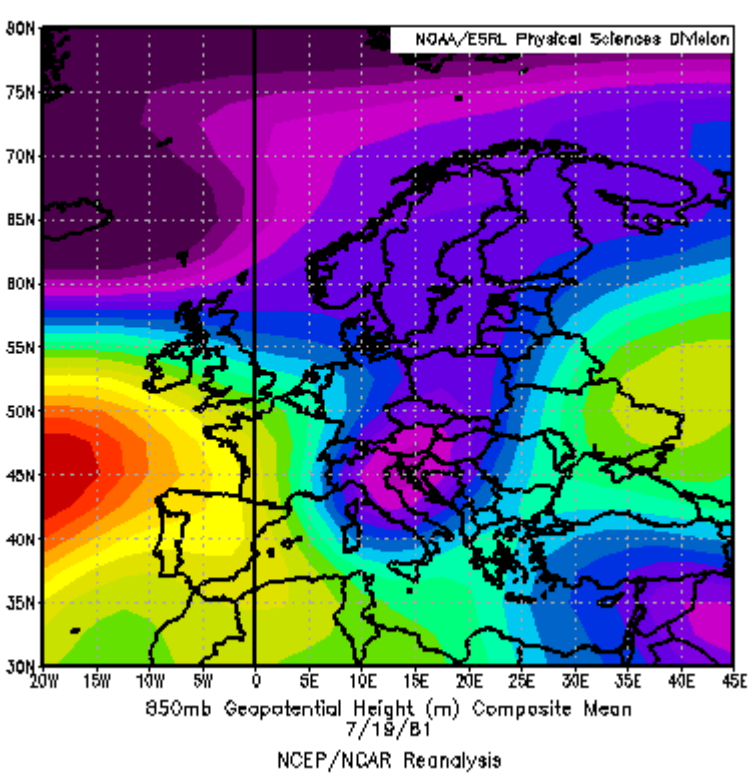
Brázdil a kol. (2005)
www.chmi.cz / historická data / počasí / typizace

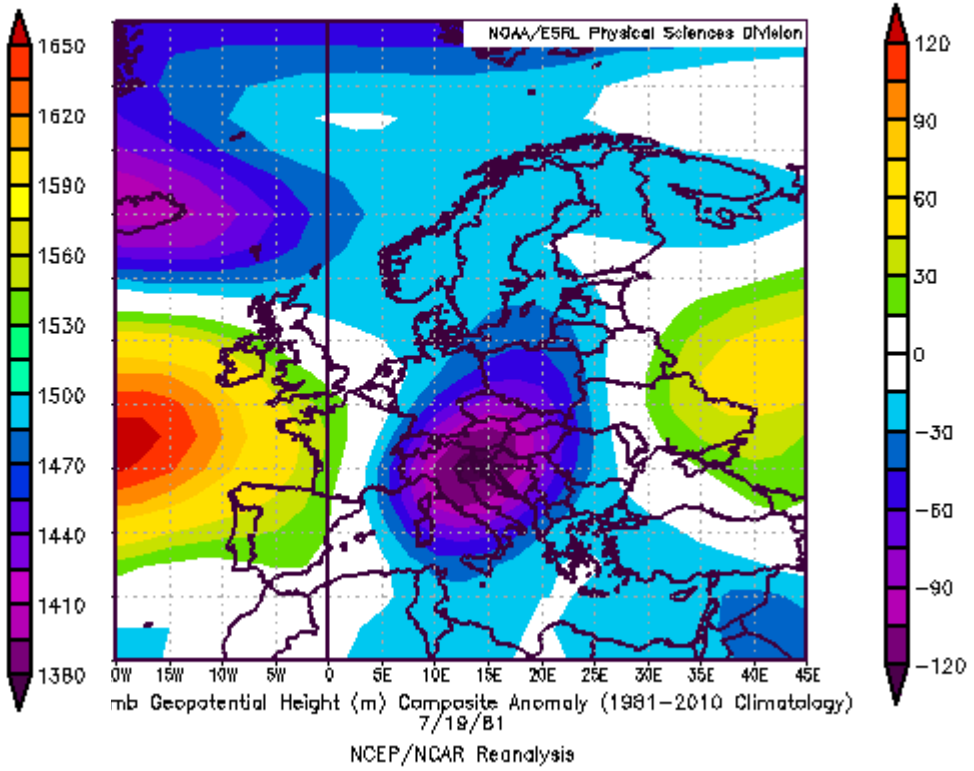
Odra v Bohumíně (1946 – 2000)
Dny D-1 při Q > Q_2 (MJJASO)



1946 – 1965, LHP,
Brádka (1967), Kakos (1974)

Extremita cirkulace:
Absolutní odchylky od normálu

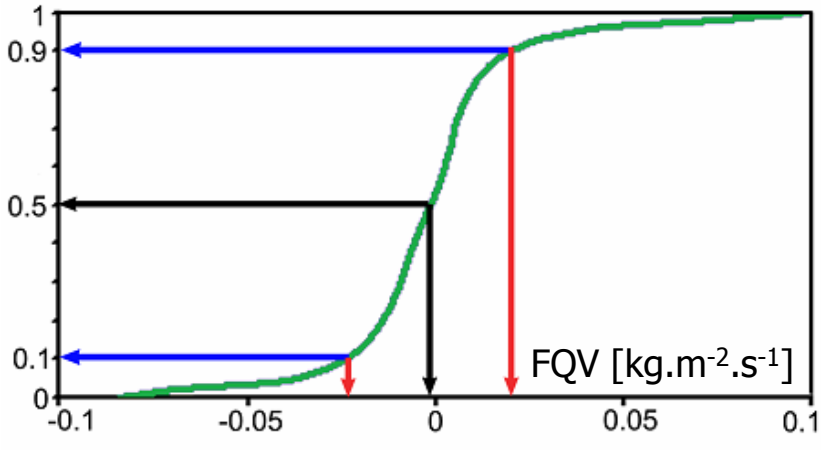


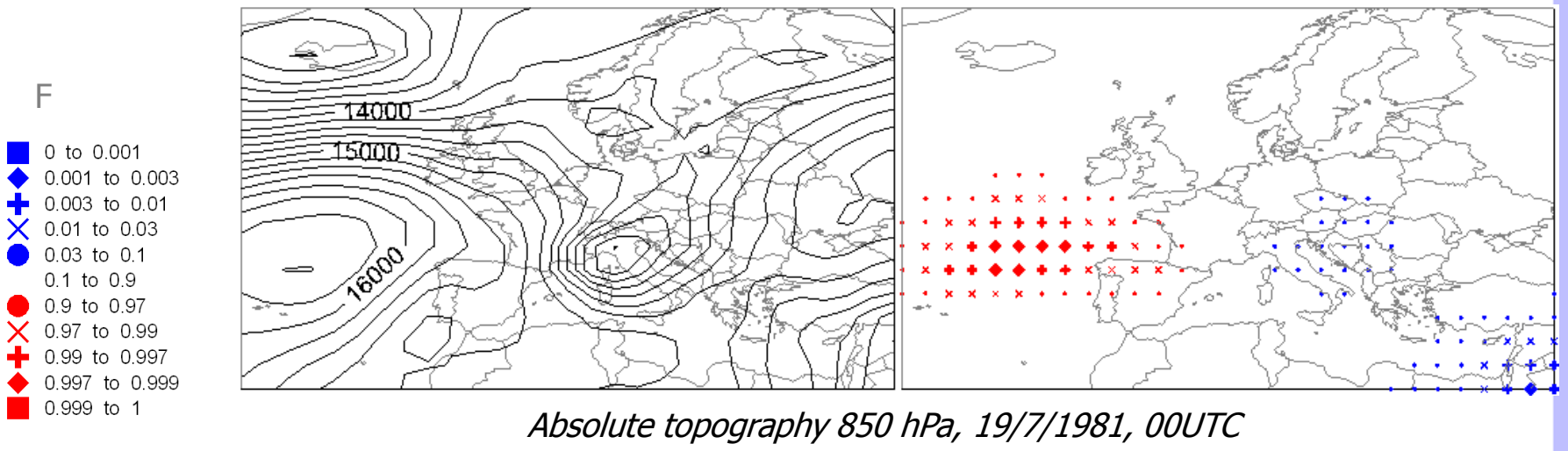


http://www.esrl.noaa.gov/psd/cgi-bin/data/getpage.pl

Extremita cirkulace: Kumulativní distribuční funkce

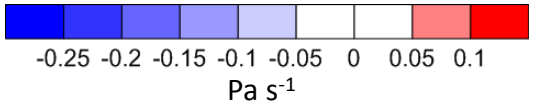
$$F(x_i) = \frac{i}{n+1}$$





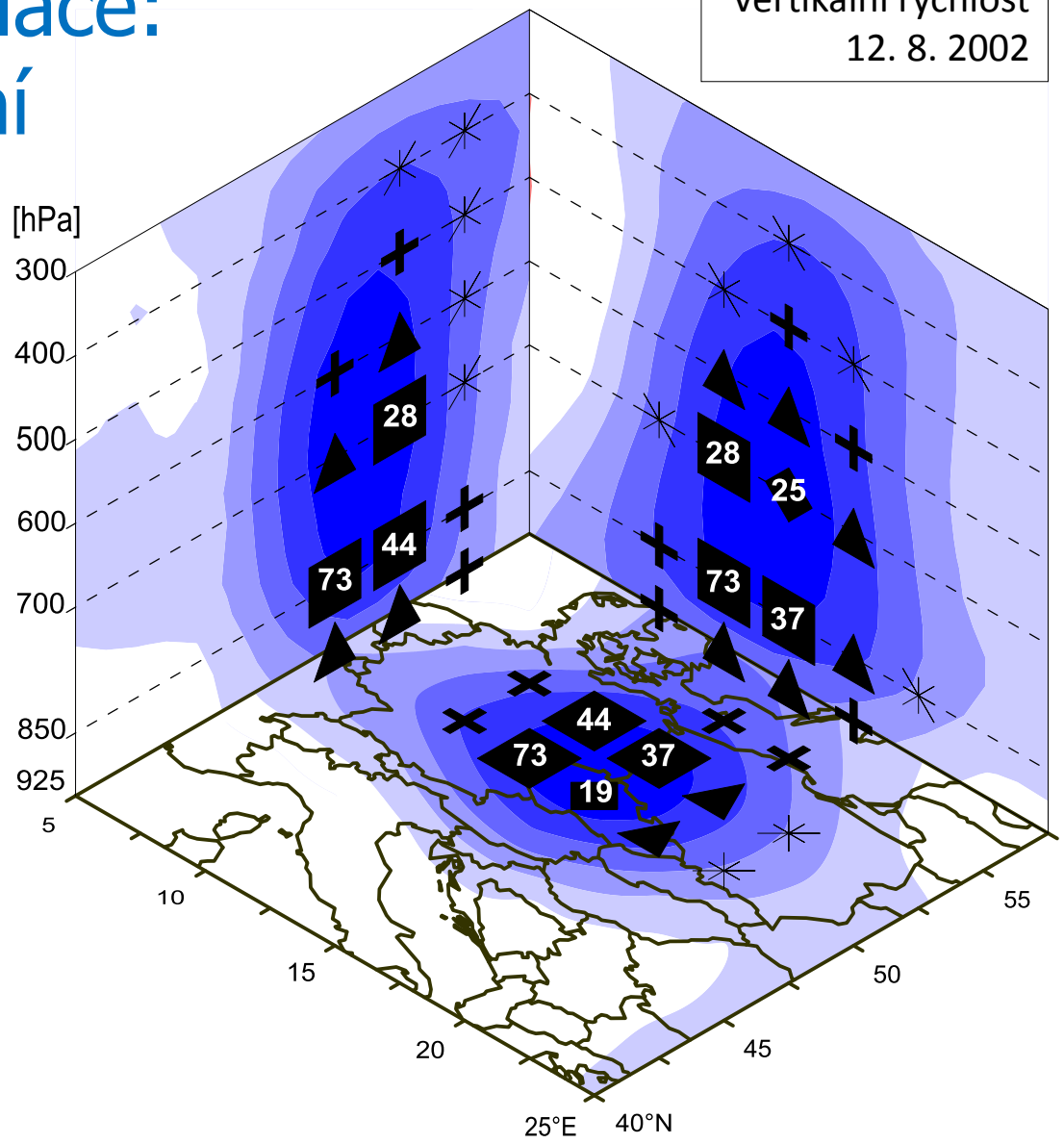
Absolute topography 850 hPa, 19/7/1981, 00UTC

Extremita cirkulace: Doby opakování

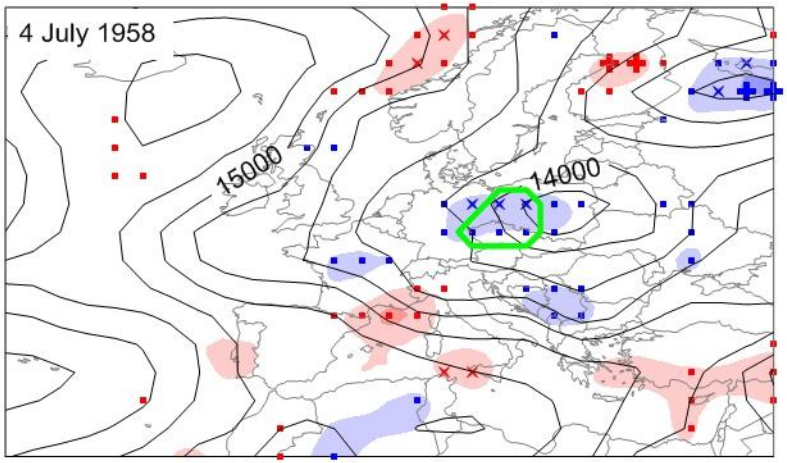


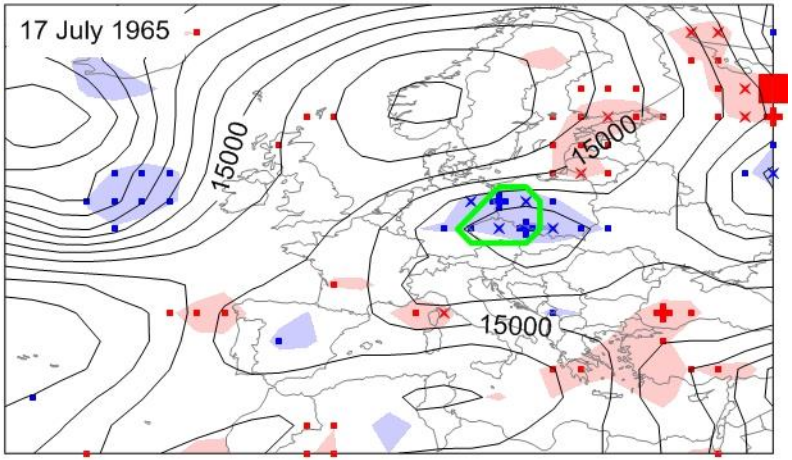
Pravděpodobnost překročení velikosti výstupné rychlosti

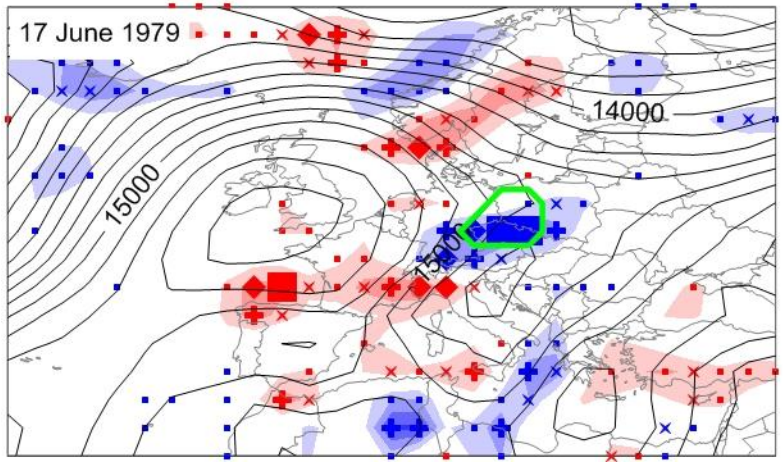
- 0 až 0.0001
- 0.0001 až 0.0003
- 0.0003 až 0.001
- 0.001 až 0.003
- 0.003 až 0.01

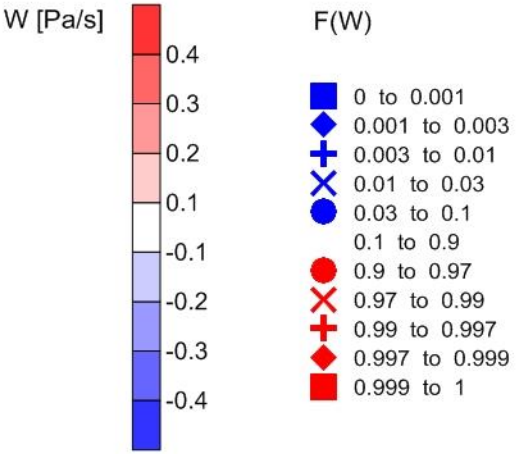


Extremita cirkulace: Anomálie meteorologických veličin







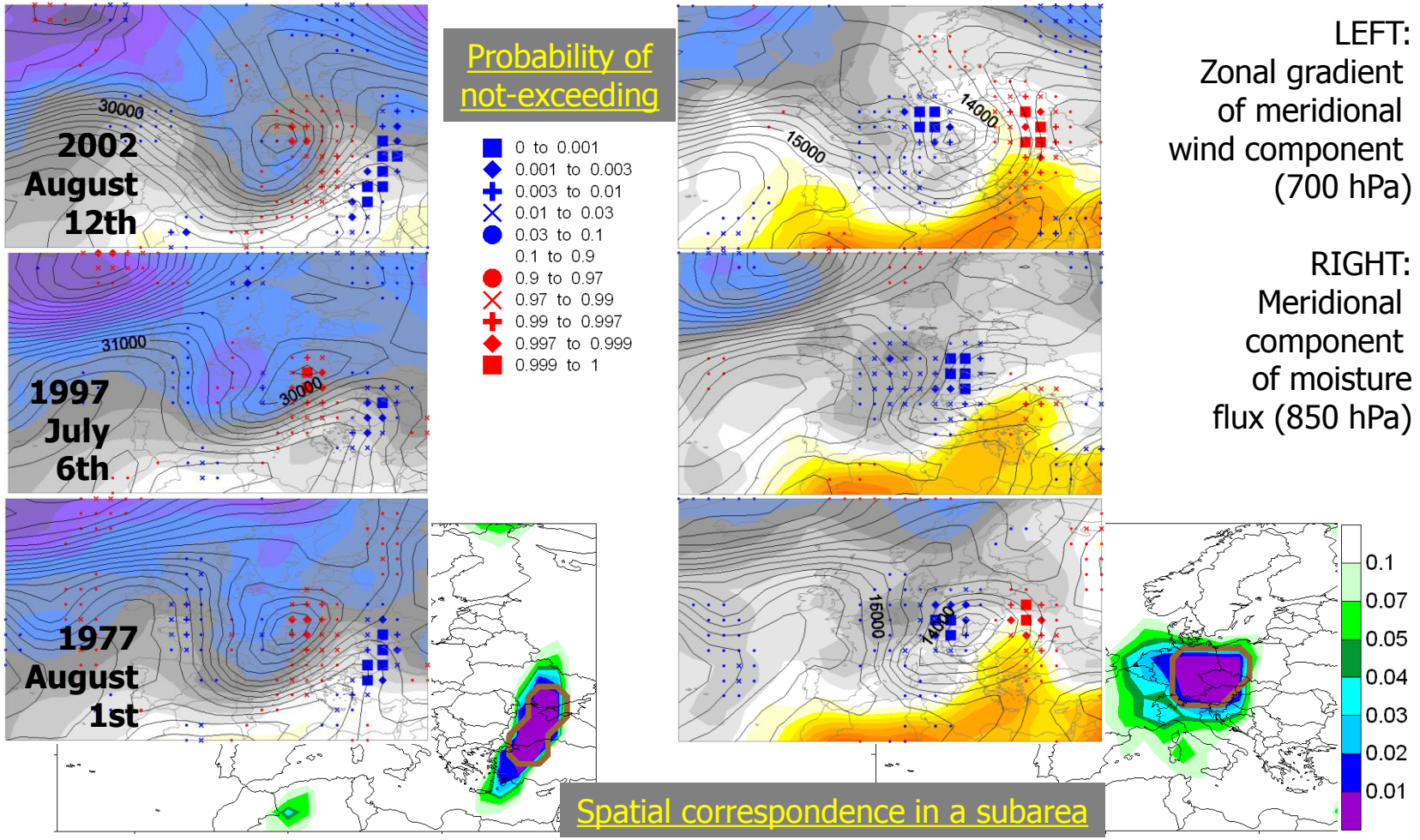


$$E_a = \sqrt[B]{\prod_{j=1}^{B} F_j}$$

Kašpar and Müller (2014)

Vzájemný vztah srážek a cirkulace

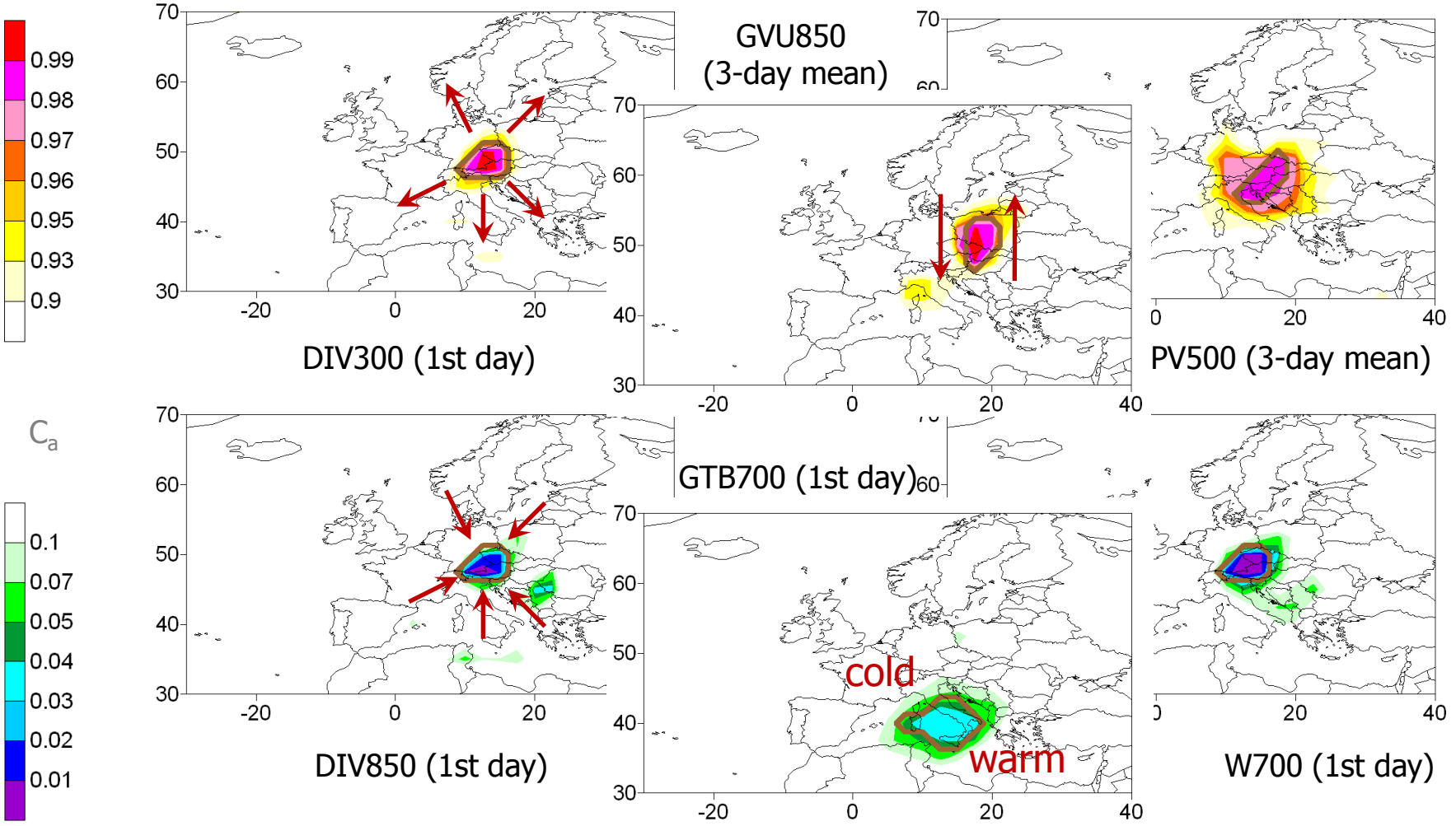
Anomálie charakteristické pro silné srážky



LEFT:
Zonal gradient of meridional wind component (700 hPa)

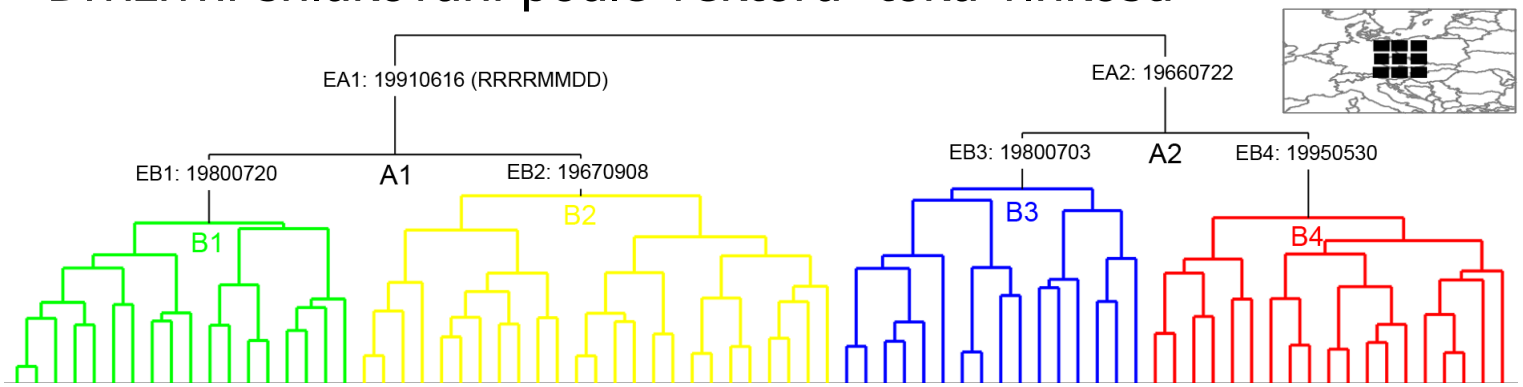
RIGHT:
Meridional component of moisture flux (850 hPa)

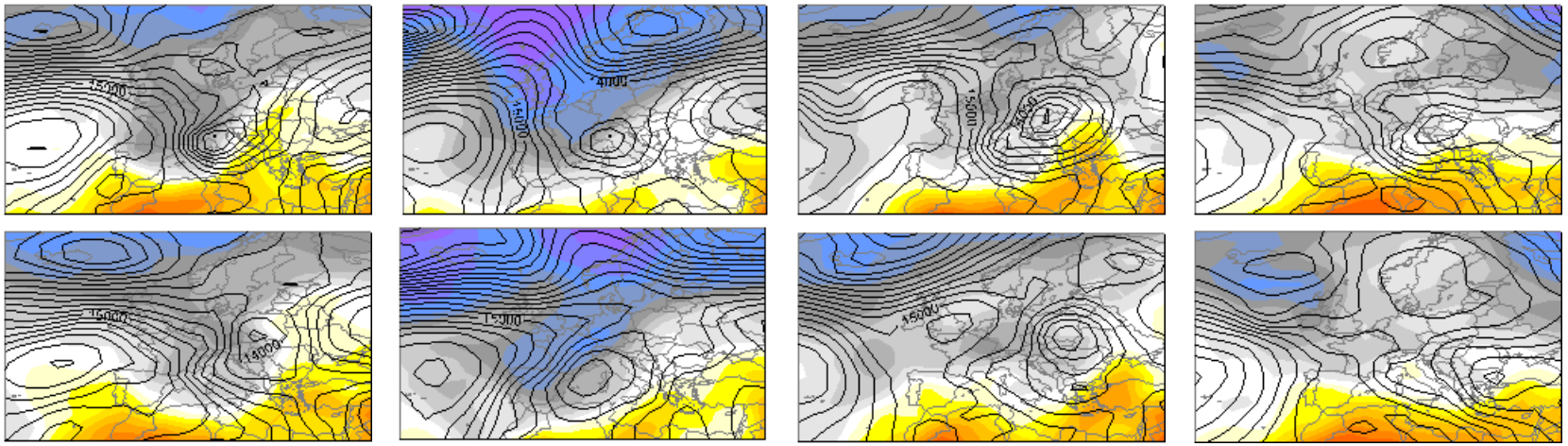
Anomálie charakteristické pro silné srážky



Cirkulační varianty srážkových událostí

- Divizivní shlukování podle vektorů toku vlhkosti





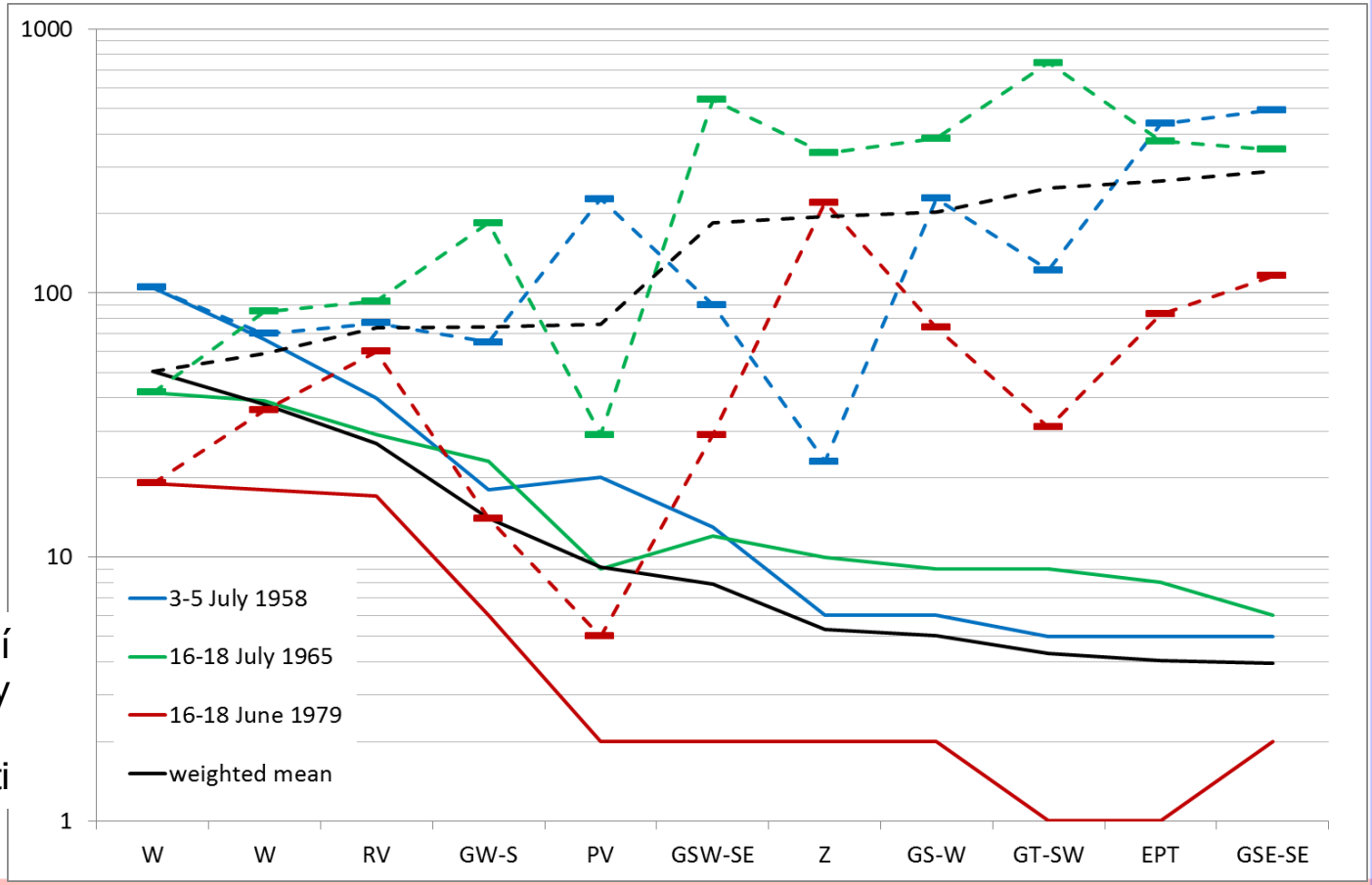
18–20/7 1981 | 22–24/9 1979 | 31/7 – 2/8 1977 | 6–8/8 2002

Kašpar and Müller (2010)

Extremita cirkulace při silných srážkách: Circulation Extremity Index

- Optimalizovaná kombinace většího počtu typických anomálií

$$CEI = \frac{\sum_{k=1}^{n} E_k W_k}{\sum_{k=1}^{n} W_k}$$

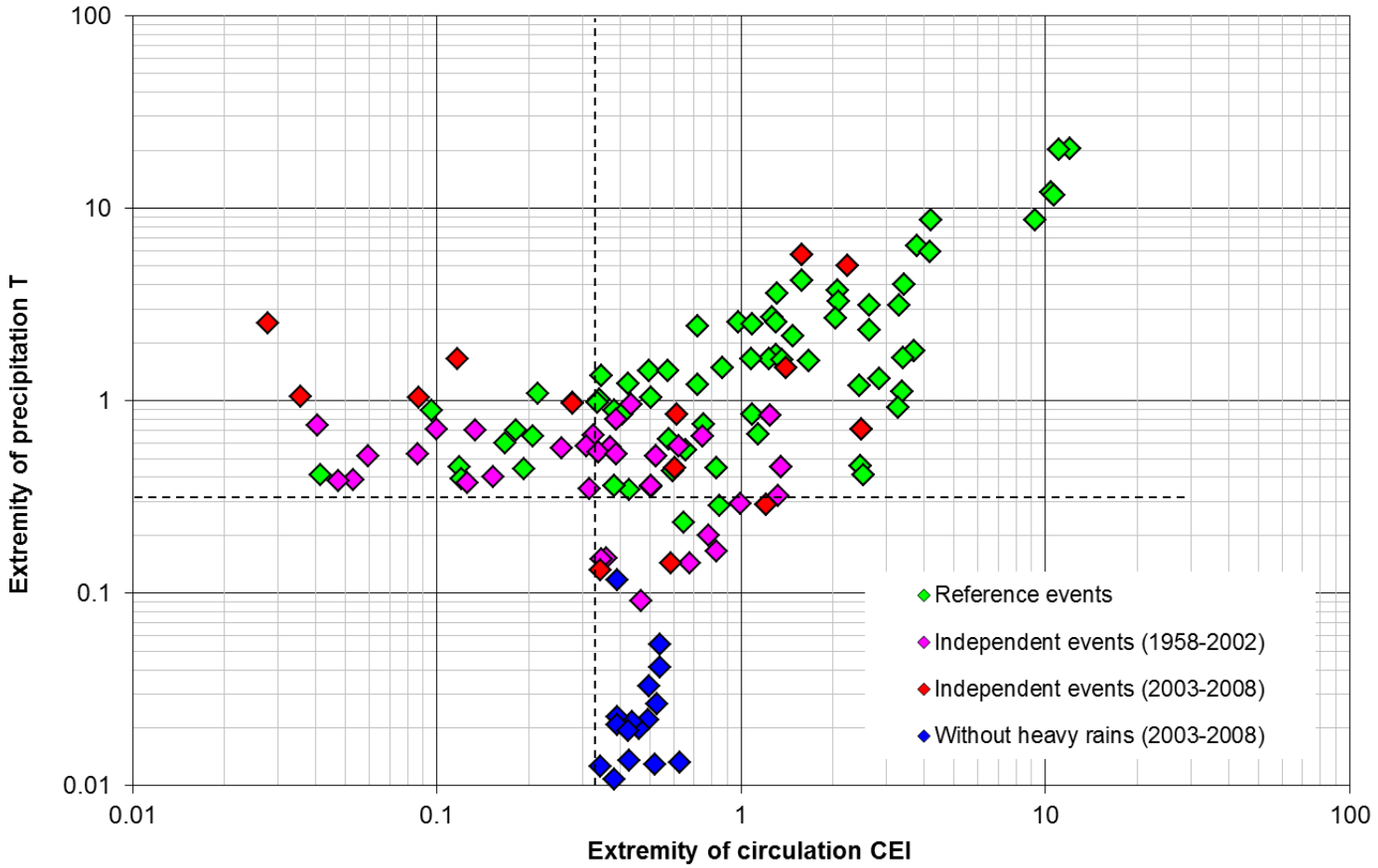


pořadí hodnoty podle velikosti

Kašpar and Müller (2014)

Podmíněnost srážek cirkulací

$$CEI' = \frac{1}{28} \sum_{i=1}^{28} \frac{45}{z_i}$$



Kašpar and Müller (2014)

Závěr

- Extremita cirkulace: anomálie charakteristické pro silné srážky, několik synoptických variant

- Extremita srážek: aspekty intenzity, plošného rozsahu, doby trvání atd.

- Extremita povodní: dána intenzitou příčinných srážek, vliv předchozí nasycenosti i roční doby

Literatura

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Děkuji za pozornost