

Small ungauged basins in the Polish part of the Carpathian Mts. investigated for the maximum discharge during flash floods

Basin characteristics

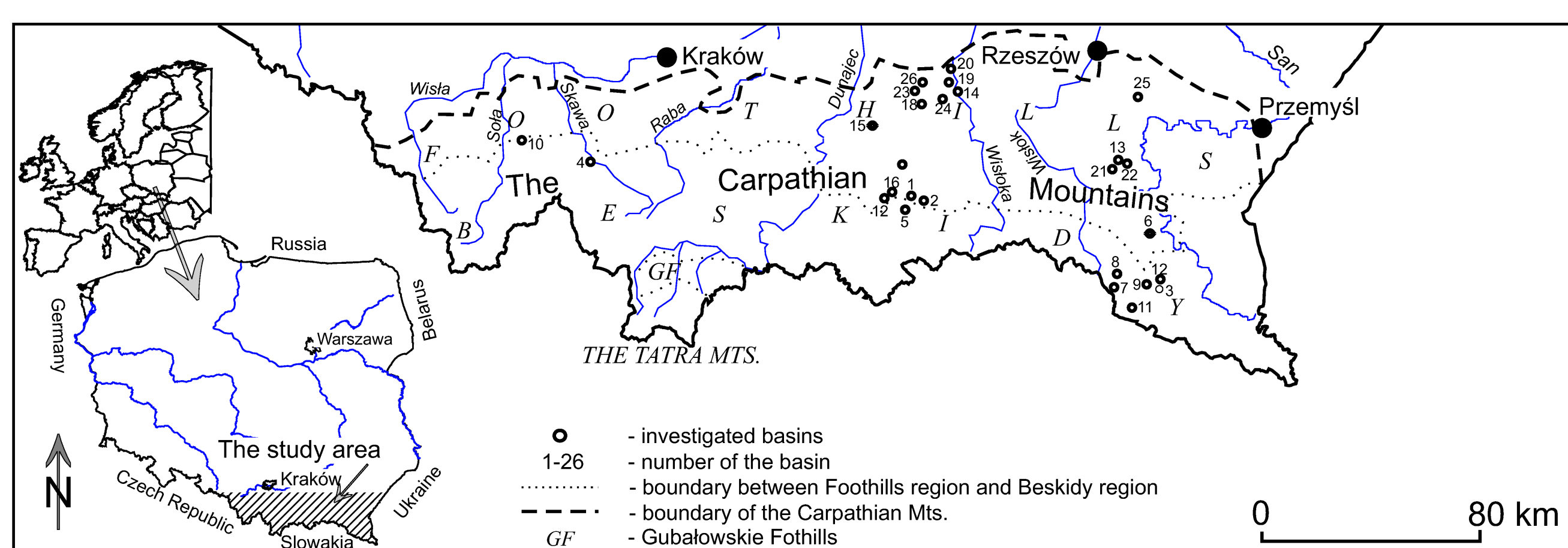
River Basin / River Basin (according EU-WFD)	No.	Basins located in the Beskid region	Basins located in the Foothills region
	1	creek without the name - Szymbark	Ropa river basin/Wisłoka river basin
	2	creek without the name - Siary	Ropa river basin/Wisłoka river basin
	3	Kalniczka - Kalnica	Oslawa river basin/San river basin
	4	Zasyprnica - Sucha Beskidzka	Stryżawka river basin/Skawa river basin
	5	Bielanka - Szymbark	Ropa river basin/Wisłoka river basin
	6	Borowiec - Mokre	Oslawa river basin/San river basin
	7	Dołżyca - Dołżyca	Oslawa river basin/San river basin
	8	Barbarka - Czystochorb	Oslawa river basin/San river basin
	9	Tarnawka - Kalnica	Oslawa river basin/San river basin
	10	Targaniczanka	Wieprzówka river basin/Skawa river basin
	11	Oslawica - Radoszyce	Oslawa river basin/San river basin
	12	creek without the name - Grybów	Biała river basin/Dunajec river basin
	13	creek without the name - Niebocko	Stobnica river basin/Wisłok river basin
	14	creek without the name - Zagórze	Jodłówka river basin/Wisłoka river basin
	15	creek without the name - Gromnik	Biała river basin/Dunajec river basin
	16	Sudół - Biała Niżna	Biała river basin/Dunajec river basin
	17	creek without the name - Błędownka	Chmielnik river basin/Strug river basin
	18	Zalasówka - Zalasowa	Szwedka river basin/Biała river basin
	19	creek without the name - Słotowa	Wisłoka river basin/Wisła river basin
	20	creek without the name - Pilzno	Wisłoka river basin/Wisła river basin
	21	creek without the name - Niebocko-Grabownica	Stobnica river basin/Wisłok river basin
	22	Świnka - Jablonka	Świnka river basin/San river basin
	23	Wątok - Szywnald	Biała river basin/Dunajec river basin
	24	Wolanka - Lubcza	Jodłówka river basin/Wisłoka river basin
	25	Ryjak - Zabartówka	Chmielnik river basin/Strug river basin
	26	Dulcza - Łęki Górne	Wisłoka river basin/Wisła river basin

No.	Basins located in the Beskid region	Basins located in the Foothills region
1	creek without the name - Szymbark 49° 37' 48" N 21° 07' 12" E 289 m. a.s.l.	creek without the name - Grybów 49° 37' 28" N 20° 57' 08" E 323 m. a.s.l.
2	creek without the name - Siary 49° 35' 44" N 21° 12' 48" E 354 m. a.s.l.	creek without the name - Niebocko 49° 40' 33" N 22° 06' 22" E 320 m. a.s.l.
3	Kalniczka - Kalnica 49° 21' 47" N 22° 12' 49" E 475 m. a.s.l.	creek without the name - Zagórze 49° 55' 21" N 21° 18' 28" E 210 m. a.s.l.
4	Zasyprnica - Sucha Beskidzka 49° 44' 09" N 19° 34' 25" E 345 m. a.s.l.	creek without the name - Gromnik 49° 50' 16" N 20° 57' 42" E 240 m. a.s.l.
5	Bielanka - Szymbark 49° 37' 29" N 21° 06' 58" E 310 m. a.s.l.	Sudół - Biała Niżna 49° 37' 36" N 20° 58' 06" E 325 m. a.s.l.
6	Borowiec - Mokre 47° 27' 49" N 22° 09' 50" E 350 m. a.s.l.	creek without the name - Błędownka 49° 58' 10" N 22° 09' 34" E 239 m. a.s.l.
7	Dołżyca - Dołżyca 49° 19' 42" N 22° 01' 23" E 525 m. a.s.l.	Zalasówka - Zalasowa 49° 53' 01" N 21° 08' 12" E 260 m. a.s.l.
8	Barbarka - Czystochorb 49° 21' 22" N 22° 01' 27" E 507 m. a.s.l.	creek without the name - Słotowa 49° 57' 02" N 21° 19' 03" E 210 m. a.s.l.
9	Tarnawka - Kalnica 49° 21' 27" N 22° 12' 15" E 482 m. a.s.l.	creek without the name - Pilzno 49° 58' 33" N 21° 17' 19" E 255 m. a.s.l.
10	Targaniczanka 49° 51' 02" N 19° 20' 21" E 290 m. a.s.l.	Grabownica 49° 39' 16" N 22° 04' 54" E 315 m. a.s.l.
11	Oslawica - Radoszyce 49° 18' 52" N 22° 04' 01" E 486 m. a.s.l.	Świnka - Jablonka 49° 41' 52" N 22° 08' 27" E 275 m. a.s.l.
12	creek without the name - Grybów 49° 37' 28" N 20° 57' 08" E 323 m. a.s.l.	Wątok - Szywnald 49° 57' 53" N 21° 07' 32" E 260 m. a.s.l.
13	creek without the name - Niebocko 49° 40' 33" N 22° 06' 22" E 320 m. a.s.l.	Wolanka - Lubcza 49° 54' 22" N 21° 15' 24" E 230 m. a.s.l.
14	creek without the name - Zagórze 49° 55' 21" N 21° 18' 28" E 210 m. a.s.l.	Ryjak - Zabartówka 49° 57' 12" N 22° 12' 10" E 260 m. a.s.l.
15	creek without the name - Gromnik 49° 50' 16" N 20° 57' 42" E 240 m. a.s.l.	Dulcza - Łęki Górne 49° 58' 27" N 21° 11' 11" E 240 m. a.s.l.
16	Sudół - Biała Niżna 49° 37' 36" N 20° 58' 06" E 325 m. a.s.l.	
17	creek without the name - Błędownka 49° 58' 10" N 22° 09' 34" E 239 m. a.s.l.	
18	Zalasówka - Zalasowa 49° 53' 01" N 21° 08' 12" E 260 m. a.s.l.	
19	creek without the name - Słotowa 49° 57' 02" N 21° 19' 03" E 210 m. a.s.l.	
20	creek without the name - Pilzno 49° 58' 33" N 21° 17' 19" E 255 m. a.s.l.	
21	Grabownica 49° 39' 16" N 22° 04' 54" E 315 m. a.s.l.	
22	Świnka - Jablonka 49° 41' 52" N 22° 08' 27" E 275 m. a.s.l.	
23	Wątok - Szywnald 49° 57' 53" N 21° 07' 32" E 260 m. a.s.l.	
24	Wolanka - Lubcza 49° 54' 22" N 21° 15' 24" E 230 m. a.s.l.	
25	Ryjak - Zabartówka 49° 57' 12" N 22° 12' 10" E 260 m. a.s.l.	
26	Dulcza - Łęki Górne 49° 58' 27" N 21° 11' 11" E 240 m. a.s.l.	

No.	Basin name	Catchment area km ²	Elevation range m. a.s.l.	Climatic parameters	Land use %	Soils ^c	Geology ^d
				Basis type Temperature (1950-1980) °C ^a Precipitations mm ^b	Forest Settlement areas Arable areas		
Basins located in the Beskid region							
1	creek without the name - Szymbark	1.8	289 - 635	6	77% pine, beech	2	21
2	creek without the name - Siary	3	354 - 635	6	93% fir, beech	2	5
3	Kalniczka - Kalnica	4.3	475 - 782	6	65% fir, beech	1	34
4	Zasyprnica - Sucha Beskidzka	6.2	345 - 871	5	58 spruce, fir	4	38
5	Bielanka - Szymbark	6.5	345 - 871	5	70% beech, fir	2	28
6	Borowiec - Mokre	9.2	350 - 663	5	77% fir, beech	1	22
7	Dołżyca - Dołżyca	9.7	525 - 837	5	83% fir, beech	1	16
8	Barbarka - Czystochorb	13.4	507 - 806	6	40% fir, beech	1	59
9	Tarnawka - Kalnica	13.7	482 - 997	6	81% fir, beech	0	19
10	Targaniczanka	23	290 - 883	6	48% spruce, beech	6	46
11	Oslawica - Radoszyce	31.0	486 - 735	6	31% hornbeam, pine, fir	50	1
Basins located in the foothills region							
12	creek without the name - Grybów	1.4	323 - 535	7	17% spruce, beech	31	52
13	creek without the name - Niebocko	3.6	320 - 474	7	0%	8	92
14	creek without the name - Zagórze	4.1	210 - 389	7	5% riparian forest	9	85
15	creek without the name - Gromnik	4.6	240 - 402	6	32% pine, beech	9	59
16	Sudół - Biała Niżna	4.8	325 - 562	6	29% spruce, beech	8	63
17	creek without the name - Błędownka	5	239 - 366	6	1% riparian forest	3	97
18	Zalasówka - Zalasowa	5.2	260 - 367	6	4% pine, oak, hornbeam	3	92
19	creek without the name - Słotowa	6.0	210 - 391	6	6% riparian forest	11	82
20	creek without the name - Pilzno	7.5	205 - 379	6	21% pine, oak	4	75
21	creek without the name - Niebocko-Grabownica	8.6	315 - 527	6	50% fir, beech	6	44
22	Świnka - Jablonka	9.3	275 - 447	7	45% pine, beech	6	49
23	Wątok - Szywnald	10.0	260 - 387	7	20% fir, beech	6	74
24	Wolanka - Lubcza	13.1	230 - 370	7	18% beech, fir	6	76
25	Ryjak - Zabartówka	14.5	260 - 377	7	81% beech, pine	2	17
26	Dulcza - Łęki Górne	16.6	240 - 409	7	16% fir, beech	3	81

a - on the basis of Atlas Republic of Poland, Part II Natural Environment, Główny Geodeta Kraju, Warszawa 1994
b - on the basis of Geographic Atlas, PRWK, Warszawa-Wrocław 1999
c - on the basis of Soil Map of Poland 1:300 000
d - on the basis of Geology Map of Poland 1:200 000

Map of the research basin



Instrumentation and data

The maximum discharge was calculated using velocity-area method. The velocity was computed using Manning's equation.

No. Name of the river - Name of discharge profile	A km ²	Q _{max} m ³ /s	q _{max} m ³ /s/km ²	No. Name of the river - Name of discharge profile	A km ²	Q _{max} m ³ /s	q _{max} m ³ /s/km ²
Basins located in the Beskid region				Basins located in the Foothills region			
1 creek without the name - Szymbark	1.8	16.29	9.1	12 creek without the name - Grybów	1.4	10.2	7.3
2 creek without the name - Siary	3	15.6	5.2	13 creek without the name - Niebocko	3.6	16.5	4.6
3 Kalniczka - Kalnica	4.3	28.8	6.7	14 creek without the name - Zagórze	4.1	6.3	1.5
4 Zasyprnica - Sucha Beskidzka	6.2	11.7	1.9	15 creek without the name - Gromnik	4.6	5.5	1.2
5 Bielanka - Szymbark	6.5	75	11.5	16 Sudół - Biała Niżna	4.8	24	5.0
6 Borowiec - Mokre	9.2	9.3	1.0	17 creek without the name - Błędownka	5	32	6.4
7 Dołżyca - Dołżyca	9.7	42.6	4.4	18 Zalasówka - Zalasowa	5.2	10.2	2.0
8 Barbarka - Czystochorb	13.4	67	5.0	19 creek without the name - Słotowa	6.0	10.2	1.7
9 Tarnawka - Kalnica	13.7	37.8	2.8	20 creek without the name - Pilzno	7.5	35	4.7
10 Targaniczanka	23	43	1.9	21 creek without the name - Niebocko-Grabownica	8.6	14.3	1.7
11 Oslawica - Radoszyce	31.0	84.5	2.7	22 Świnka - Jablonka	9.3	15.8	1.7
				23 Wątok - Szywnald	10.0	20.8	2.1
				24 Wolanka - Lubcza	13.1	14	1.1
				25 Ryjak - Zabartówka	14.5	31.3	2.2
				26 Dulcza - Łęki Górne	16.6	13.2	0.8

A - basin's area
Q_{max} - the maximum discharge
q_{max} - the maximum specific discharge

Applied models

Equations enabling calculation of the maximum discharge in the basins smaller than 100 km² in area.

$$Q_{max} = 100 \cdot A^{0.8} \text{ Rodier, J. A. Roche, M. (1984) Word Catalogue of Maximum Observed Floods. IAHS Press, Wallingford UK. IAHS Publications 143.}$$

$$Q_{max} = 85.7 \cdot A(A+1)^{-0.3667} \text{ Ciepielowski, A. (1973) Przegląd wzorów empirycznych do określenia maksymalnych przepływów letnich (En overview of the empirical equations to calculation of the maximum summers floods). Zeszyty Naukowe AR w Warszawie, Melioracje Wodne, 12.}$$

$$1/\text{Log}Q = 0.248 + 0.483 \cdot \exp[-\text{Log}(A)] \text{ Bartnik, A. Jokić, P. (2007) Odpływy maksymalne i indeksy powodziowości rzek europejskich (Maximum runoff and flood's index of the European rivers). Gospodarka Wodna 1, 28-32}$$

$$Q = 230A^{0.43} \text{ Herschy, R.W. (2002) The word's maximum observed floods. Flow Measurement and Instrumentation 13, 231-235}$$

$$Q_{max} = 22.4 \cdot A^{0.727} \text{ Fal, B. (2004), Maksymalne przepływy rzek polskich na tle wartości zaobserwowanych w różnych rzekach świata. (Maximum discharge in the polish rivers compared to values observed in in different rivers of world). Gospodarka Wodna 5, 188-192.}$$

$$Q_{max} = 361A/12.2 + A \text{ Dębski, K. (1969) O potencjalnym najwyższym odpływie z krótkotrwałych deszczów nawalnych. (Potential maximum outflow induced by rainstorms). Rozprawy Hydrotechniczne 23, 51-63.}$$

SCS-CN GIUH

Main scientific results

- In the Polish part of the Carpathian Mts., flash floods in small basins are induced by short-duration convective rainstorms. Precipitation vary from 80 to 120 mm, whereas time duration is usually lower than three hours.
- Small basins affected by local floods are ungauged and information about hydrological parameters of flash floods in small basins is superficial. These phenomena should be investigated in more detail.
- Hydrological data should be collected immediately after the flood event. The data allows for evaluation of the maximum discharge and maximum specific discharge in the basins suffering from local floods.
- Data collected after flood events usually constitutes the only source of the information about the maximum discharge in small basins.
- In the Polish part of the Carpathian Mts. twenty six basins affected by flash flood were investigated for the maximum discharge. Results indicated that the maximum discharge varied from 5 to 85 m³/s, whereas maximum specific discharge ranged from 0.8 to 11.5 m³/s/km².
- In the basins smaller than 10 km² in area the maximum discharge and maximum specific discharge ranged from 5 to 21 m³/s and from 1 to 9 m³/s/km² respectively.
- For the basins larger than 10 km², the maximum discharge varied from 14 to 85 m³/s whereas maximum specific discharge ranged from 0.8 to 5 m³/s/km².
- In the mid-mountain part of the Carpathian Mts. (Beskid region) maximum discharge varied from 9 to 85 m³/s and maximum specific discharge reached almost 12 m³/s/km². In the basins located in the Carpathian Foothills the maximum discharge varied from 5 to 35 m³/s and the specific discharge was lower and reached 6.5 m³/s/km².
- The maximum discharges recorded during flash floods in the Carpathian Mts., were significantly lower than those which were calculated using the models mentioned above. Therefore, based on the Pagari formula assumptions and using collected hydrological data equation: $Q_{max} = 87A/1.07A$; where Q_{max} - maximum discharge (m³/s), A - basin's area (km²) enabling the calculation of the maximum discharge in the small Carpathian basins was created. The equation is valid for basins smaller than 32 km² in area.
- SCS-CN and GIUH models indicated that transformation from rainfall into outflow in the basins affected by flash flood is similar what was conformed by maximum specific discharge.

Key references for the basin

- Bryndał, T. (2006) Natural and anthropogenic causes of small-scale flooding in Poland. PhD. Thesis, Pedagogical University, Kraków, Poland, 1-196.
- Bryndał, T. (2007) Transformacja opadu w odpływ w karpaccich zlewniach przy wykorzystaniu GIUH. (Transformation of rainfall into runoff in Carpathian drainage basins using GIUH), (In) Badania hydrograficzne w poznaniu środowiska (Hydrographic research in environmental science), Tom (Vol.) VIII Obieg wody w środowisku naturalnym i przekształconym (Water circulation in natural and transformed environments), Z. Michalczuk (Ed.), UMCS, Lublin, 117-126.

Contact

Tomasz Bryndał
Pedagogical University of Kraków, Institute of Geography,
Podchorążych 2 Str.
30-082 Kraków
Poland

tbrinda@ap.krakow.pl