Going digital in stormwater management
Polish Atlas of Rains Intensities (PANDa/PARIs)

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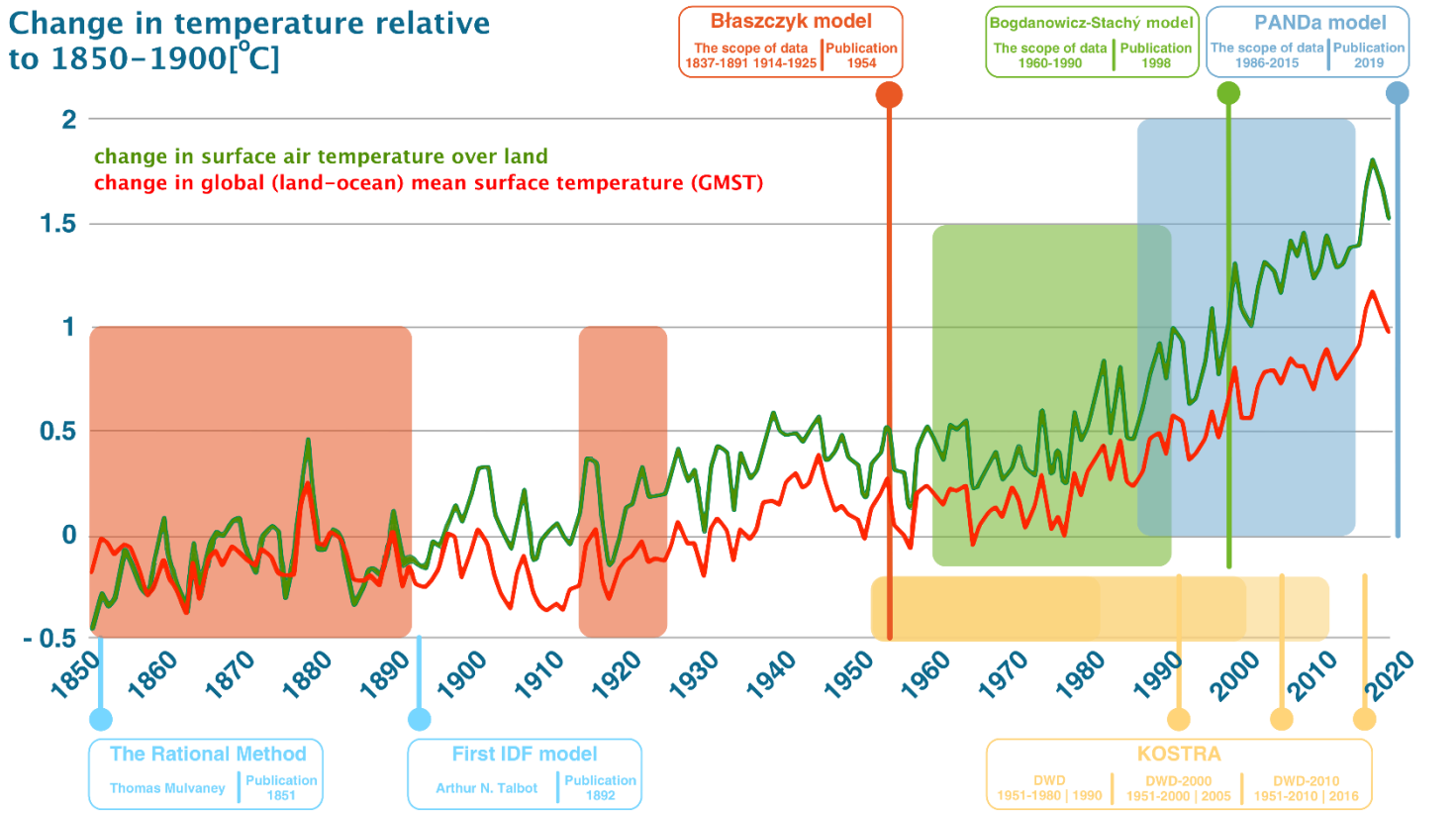
Why to talk about extrems?



Data from "Climate Change and Land" report made by Intergovernmental Panel on Climate Change

Could we make things better?

- ✓ Modern precipitation monitoring: electronic gauges, networks of gauges instead of single devices
- ✓ Alternative rainfall data sources - e.g. C-band weather radar products
- ✓ Fully digital rainfall series processing
- ✓ Geostatistics (geostatistical simulations) – allowance for spatial variability and uncertainty
- ✓ Statistical modeling of extremes – probabilistic DDF/IDF models
- ✓ Digital delivery of extreme precipitation models to end-users

PARIs (PANDa) project

POLSKI ATLAS NATĘŻEŃ DESZCZÓW PANDA

Fundusze Europejskie Inteligentny Rozwój

Unia Europejska Europejski Fundusz Rozwoju Regionalnego

Project title: Development and introduction of the Polish Atlas of Rainfall Intensities (PARIs - PANDa)

Grant number POIR.01.01.01-00-1428/15
Operational Program of Intelligent Development 2014-2020

Narodowe Centrum Badań i Rozwoju

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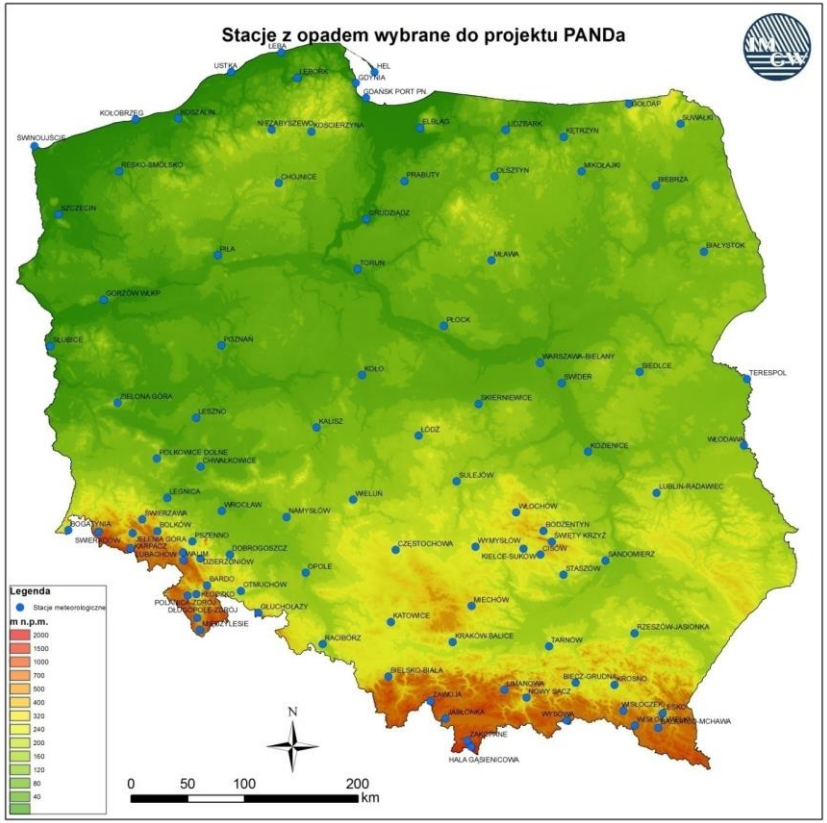
IMGW



- ✓ 100 gauges
- ✓ a 30-year time series (1986-2015)
- ✓ high resolution time series (single minutes)

PARIs (PANDa) project milestones

1) Rainfall digital database
2) Selection of maximum precipitation depths and best fitting distributions
3) Geostatistical simulations and digital platform on web

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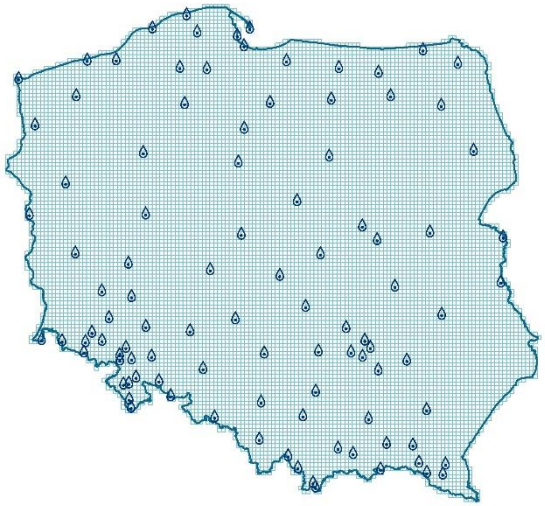
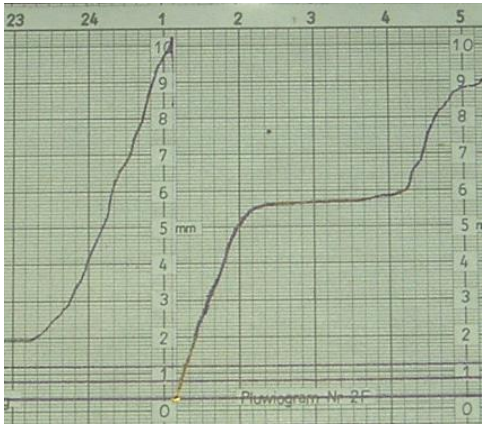
2016

2018



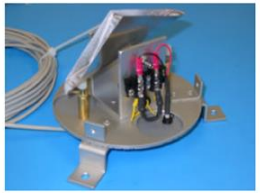
2019

Raingauges yesterday and today



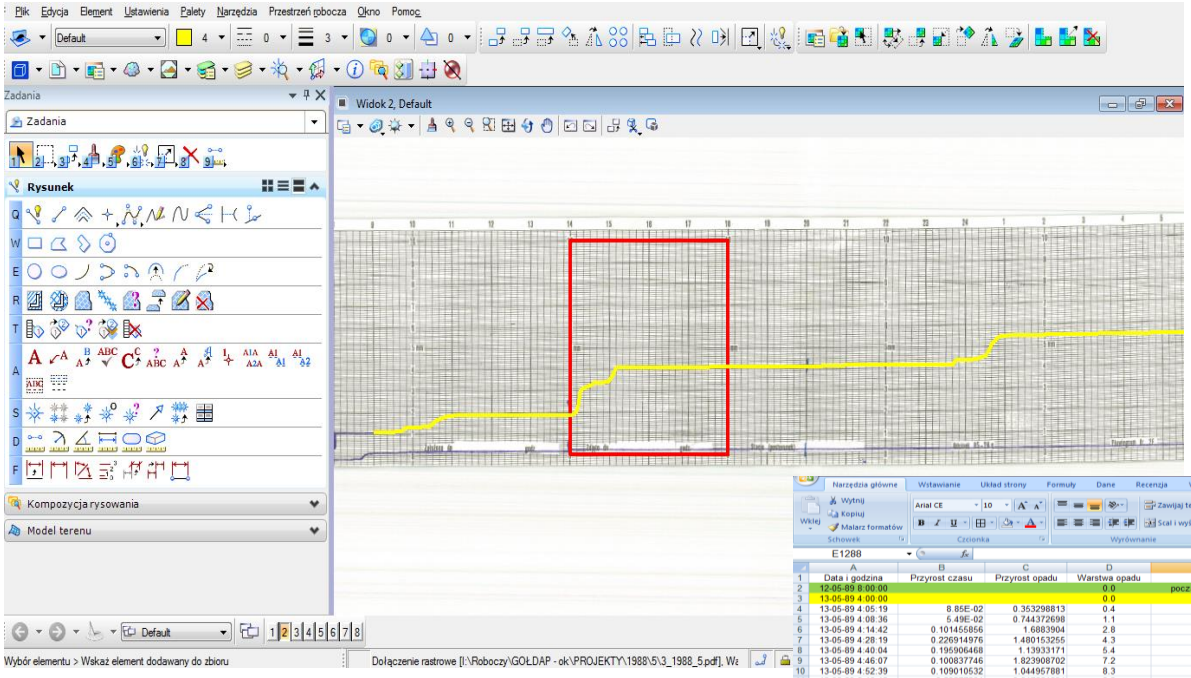
Pluviograph

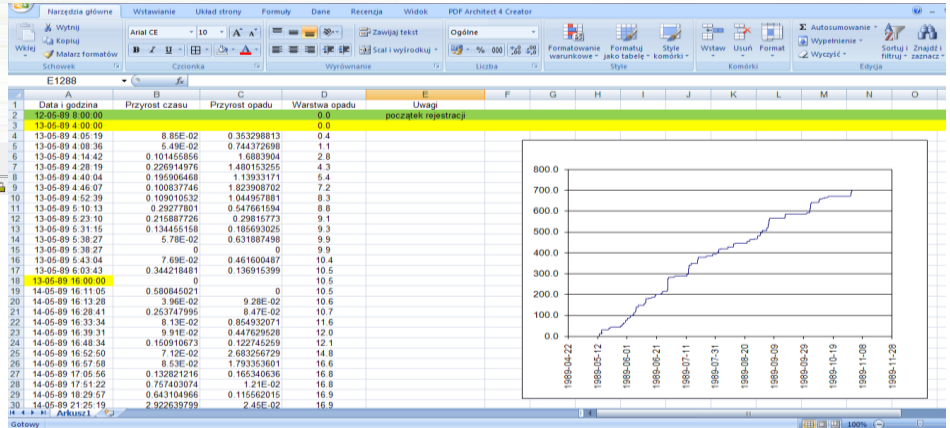
RG-50 SEBA



Met One Instruments 60030

Digitalization of rainfall records





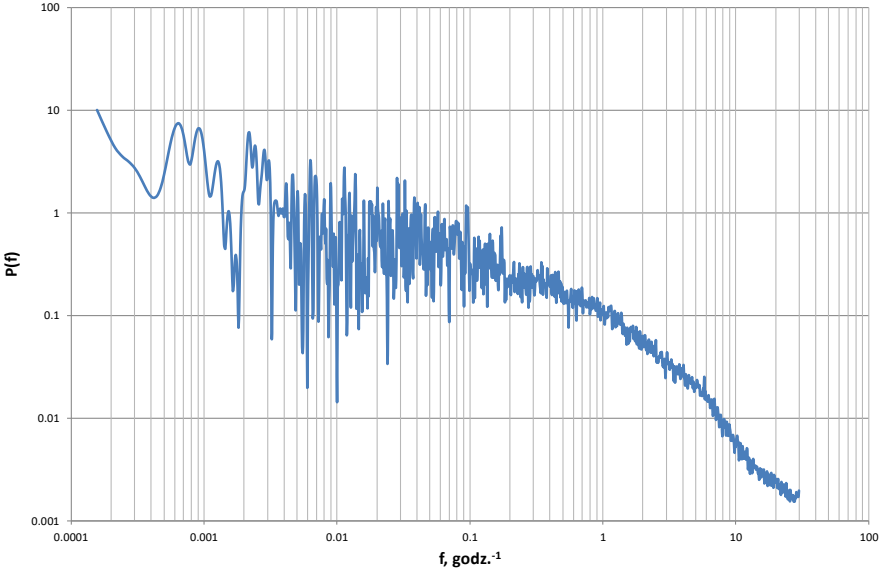
59% of database

1782 out of 3000 years

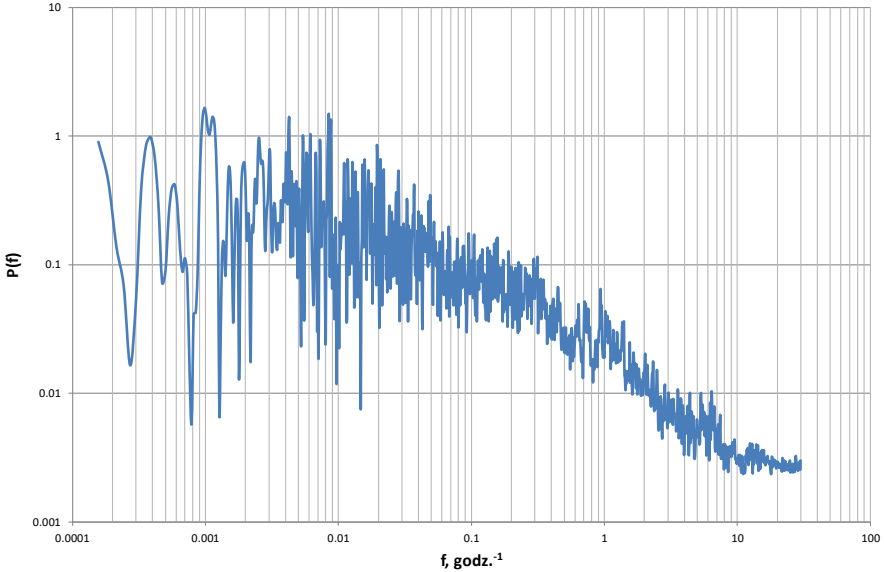
Verification of rainfall series structure

Fast Fourier Transform (FFT)

$$P(f) = f^{-\beta}$$

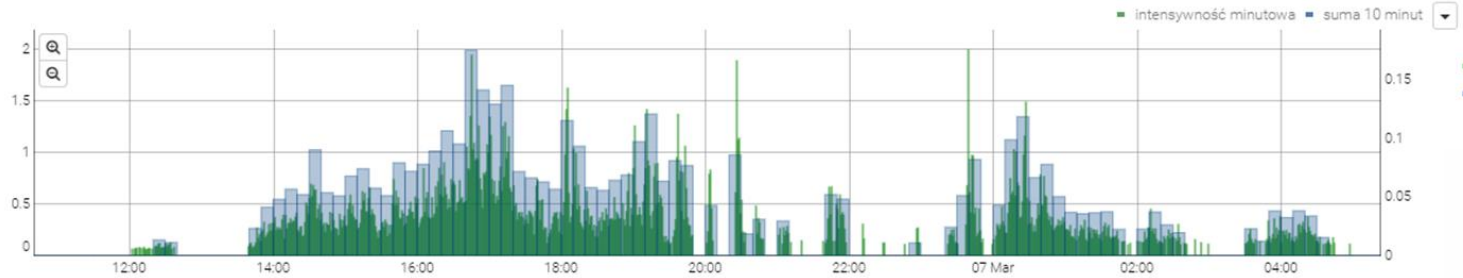


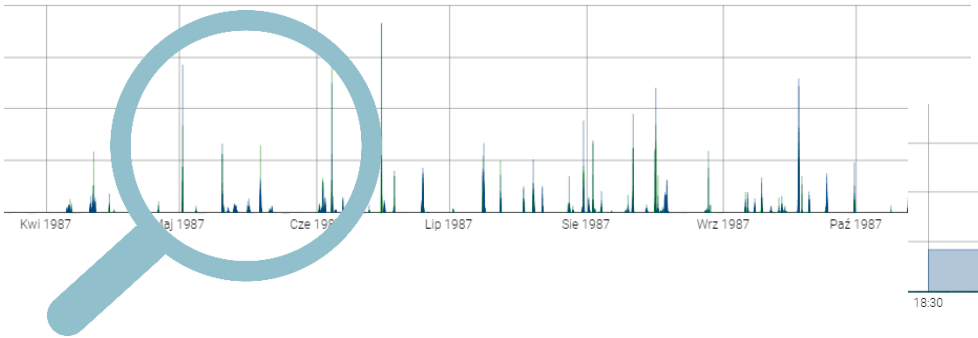
Digitized annual time series

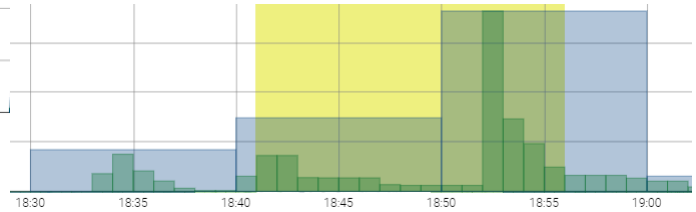


Tipping bucket annual time series

Digital rainfall series processing - RAINBRAIN database

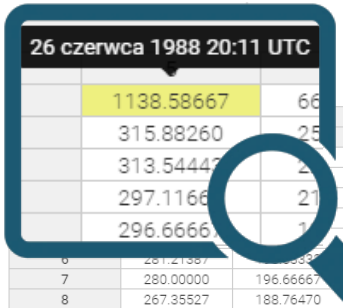






Years:	1986																												2015
AMS method:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
POT method:	1	1		1			3				1		3	3		2	1		1	2	1			1	5	4				

Extremes – maximum depths and rainfall intensities



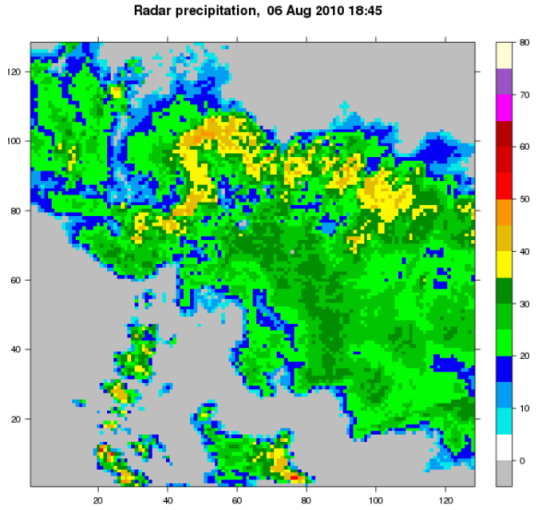
			60. maksymalnych średnich natężeń **I, l/s/ha** dla okresu (w min):													
			15	30	45	60	90	120	180	360	720	1080	1440	2160	2880	4320
			443.81112	222.42811	148.32376	111.27159	75.43173	57.53217	38.69501	20.23148	10.11574	7.28395	5.99537	5.30864	4.03935	2.92438
			190.59347	143.60547	108.51852	88.33333	65.92593	55.13889	36.85185	19.39367	9.89871	6.59914	5.17704	4.50617	3.98727	2.65818
			183.67849	131.11111	107.77778	82.22222	60.55556	45.97222	31.66667	16.86027	9.49120	6.58273	4.97685	4.08060	3.12962	2.12787
			182.22222	122.77778	98.45736	74.66036	52.69380	42.63778	29.53704	16.25350	9.21211	6.42540	4.94936	3.82781	2.90143	2.04307
			170.00000	116.73533	90.50576	69.14689	49.88281	39.16667	29.50611	16.15741	8.19444	5.98765	4.81905	3.69067	2.76800	1.95851
6			154.44444	107.31244	77.82758	66.28815	49.29897	38.40005	28.97992	16.15741	8.10185	5.75617	4.36343	3.59568	2.71412	1.90972
7	280.00000	196.66667	154.44444	100.55556	75.41428	58.96970	47.81608	37.66211	28.42593	15.46296	8.07870	5.46296	4.31713	3.49700	2.64749	1.90771
8	267.35527	188.76470	150.33533	97.77778	69.62963	58.37370	45.37263	37.44056	26.57407	14.92519	7.73148	5.40123	4.25127	3.42684	2.57245	1.89043
9	266.66667	188.33333	148.15452	90.72777	67.83803	55.83333	43.52467	36.44177	26.52827	14.72391	7.51842	5.33788	4.23611	3.21270	2.40953	1.85059
10	263.00883	184.68713	146.66667	89.44444	67.40741	54.16667	41.11111	35.83144	26.45331	14.58333	7.50000	5.15432	4.16971	3.09115	2.32639	1.84534
11	258.91683	178.90732	146.66667	88.33333	65.74626	53.70603	39.97937	34.58333	26.02508	14.42858	7.48262	4.99433	4.13290	3.04327	2.28296	1.72941
12	249.50907	177.03235	145.68718	86.30810	64.89285	53.44930	39.83198	34.39080	25.80620	13.53161	7.37299	4.94765	4.05093	3.02165	2.26624	1.71296
13	246.66667	175.45258	145.66872	86.18534	61.85185	52.25586	38.91982	33.25167	25.08207	13.42593	7.29678	4.93870	3.91204	2.96462	2.25113	1.60645
14	240.00000	173.61222	131.77646	84.14216	61.17591	51.76271	38.19681	31.60282	24.96357	13.06050	7.13445	4.92269	3.89521	2.96126	2.24926	1.60214
15	239.12033	171.66667	131.34774	83.88889	60.37037	51.11111	37.77778	29.19288	23.91094	13.00926	7.05254	4.90973	3.86574	2.90895	2.22095	1.58433
16	231.81207															1.55093
17	230.00000															1.54707
18	220.66653															1.52963
19	220.41387															1.52531
20	213.89200															1.52392
21	210.00000															1.52197
22	210.00000															1.51572
23	206.66667															1.50076
24	203.33333	148.33333	117.55423	76.19233	55.40645	44.19598	32.77778	26.38889	18.98148	10.41667	6.46402	4.51054	3.62269	2.65432	2.06019	1.47948
25	201.97167	146.04348	117.38598	76.15031	55.37494	43.54666	31.81938	25.97222	18.81123	10.12275	6.43519	4.47679	3.62143	2.57716	2.02546	1.45833
26	201.80233	141.66667	114.44444	71.69184	55.20281	42.50000	30.98238	25.56821	18.24074	10.11863	6.40699	4.47531	3.61111	2.56903	2.01736	1.45361
27	197.63667	141.66667	113.33333	69.21354	55.18519	42.19388	30.74074	25.30796	18.16021	10.04164	6.38889	4.45988	3.56648	2.50043	2.01389	1.44775
28	196.66667	138.90081	112.28709	69.21109	53.51678	41.66667	30.37037	24.68541	18.14815	9.95370	6.37076	4.43460	3.54852	2.46405	1.99074	1.43133

Maximum rainfall intensities (years 1986-2015) for time durations:
5, 10, 15, 30, 45, 60, 90, 120, 180, 360, 720, 1080, 1440, 2160, 2880, 4320 minutes

Dates are important for verification…

Verification of maximum rainfall intensities

1) Independent records of daily gauges
2) Synoptic records (eg. Climate Forecast System (CFS) wetter3.de/Archiv)
3) Weather radar data (2007-2015)



Verification: gauge vs radar series

RAINBRAIN

Gauge

Radar PAC

Radar QI

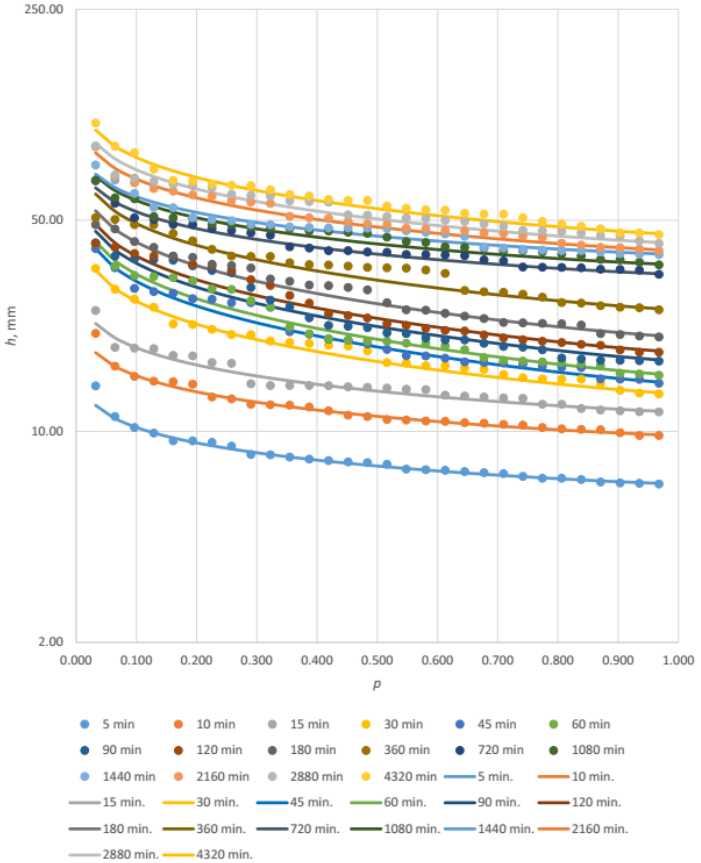
Fitting distributions – selecting the best distribution

16 time durations from 5 to 4320 min (each 30 maximum rainfall depths)

Distributions tested: gamma (Pearsona typ III), Gumbela Max (Fishera-Tippetta typ I max), log-normal, Weibull (Fishera-Tippetta typ III min), generalized logistic, **generalized Pareto**, generalized extreme value (GEV), Wakeby

Statistical tests of Kołmogorow-Smirnow, chi-square (χ2) and Anderson-Darling

Akaike information criterion (AIC)



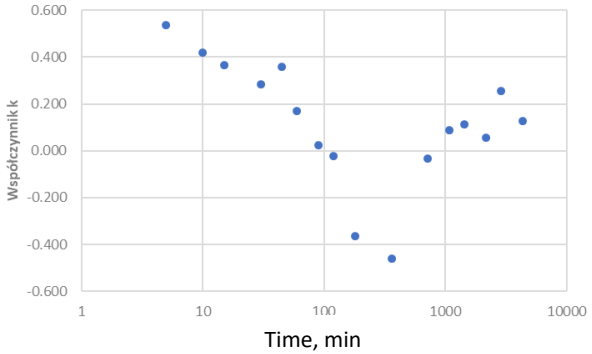
Generalized Pareto distribution

Generalized Pareto density function:

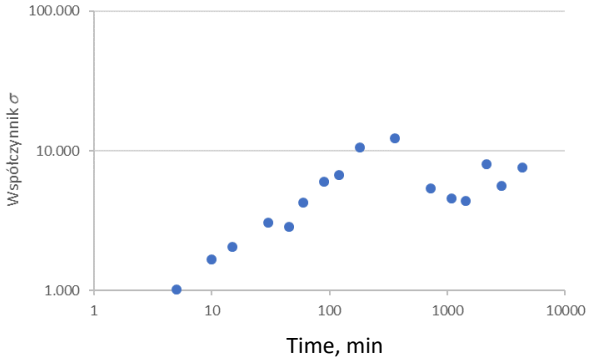
$$f(x;k,\sigma,\mu) = \begin{cases} \frac{1}{\sigma}(1+k\frac{(x-\mu)}{\sigma})^{-1-1/k} & k \neq 0 \\ \frac{1}{\sigma}exp\left(-\frac{(x-\mu)}{\sigma}\right) & k = 0 \end{cases},$$

Generalized Pareto quantile:

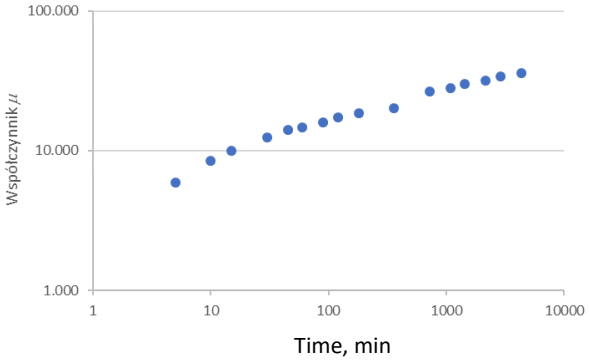
$$X_{(\mu,p')} = \begin{cases} \frac{\sigma(1-(1-p')^{-k}}{-k} + \mu, k \neq 0 \\ -\sigma\log(1-p') + \mu, k = 0 \end{cases},$$



Shape parameter k

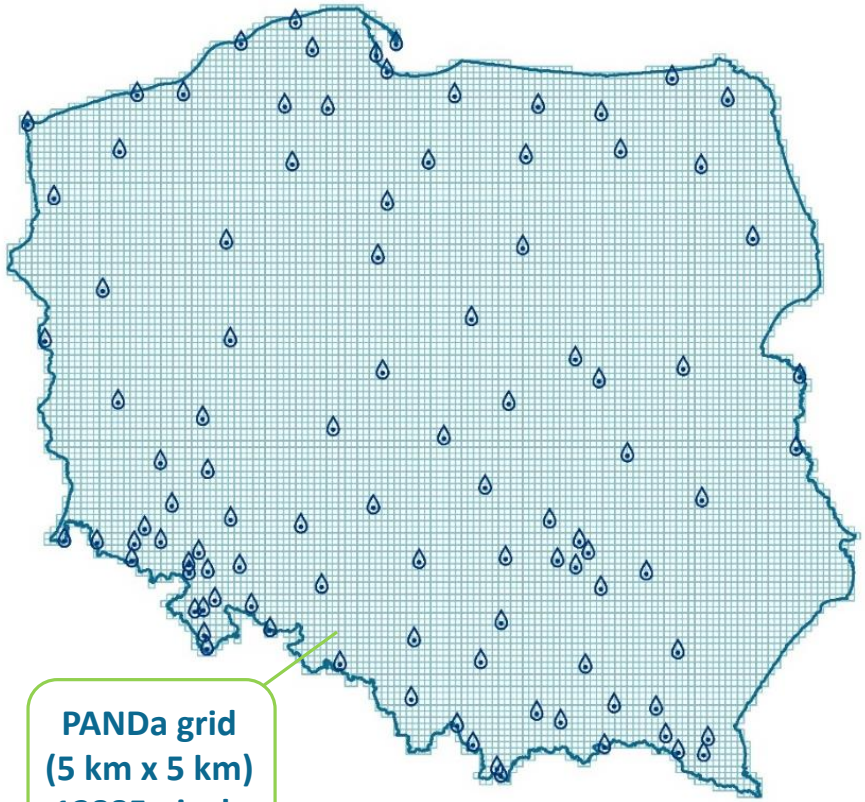


Scale parameter σ

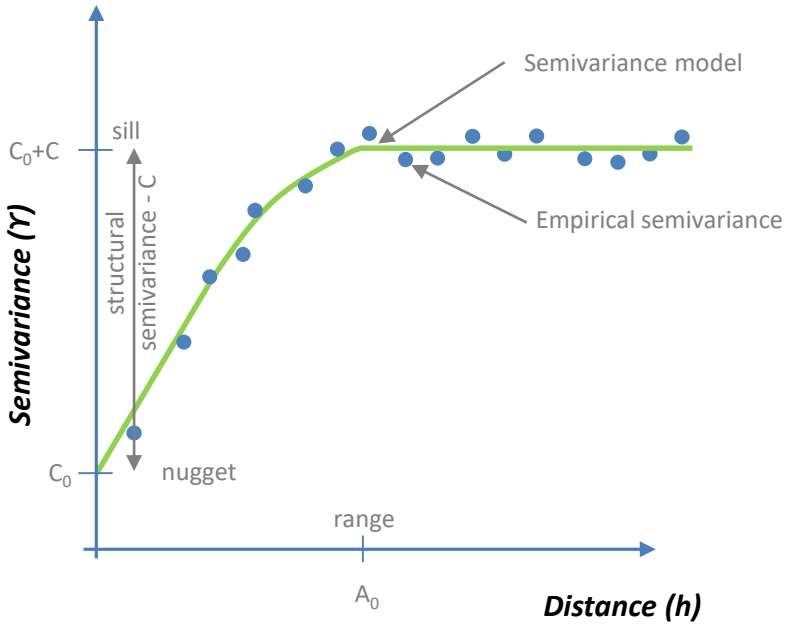


Location parameter μ

Spatial interpolation of extremes – geostatistics (kriging)



PANDa grid
(5 km x 5 km)
12885 pixels



$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [Z(x_i + h) - Z(x_i))]^2$$

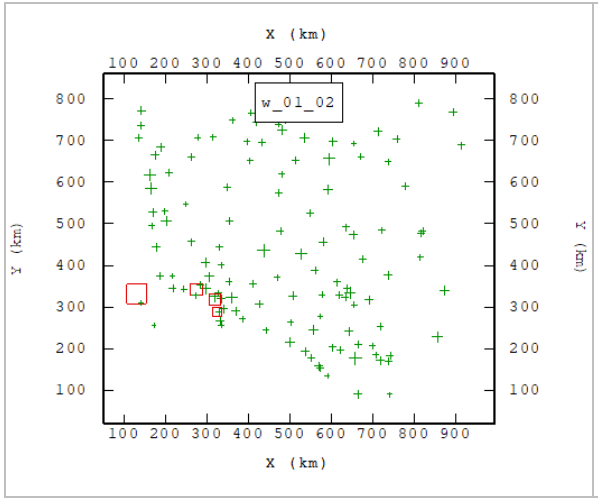
Spatial autocorrelation - semivariograms analysis

Points: 100+25 gauges
480 combinations: 16 time durations times 30 extremes
Example: maximum 10-min duration depths, 2nd maximum

Spatial autocorrelation - semivariograms analysis

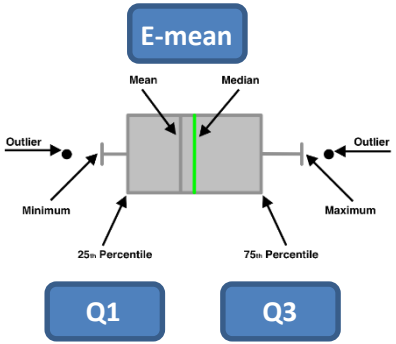
Masking outliers

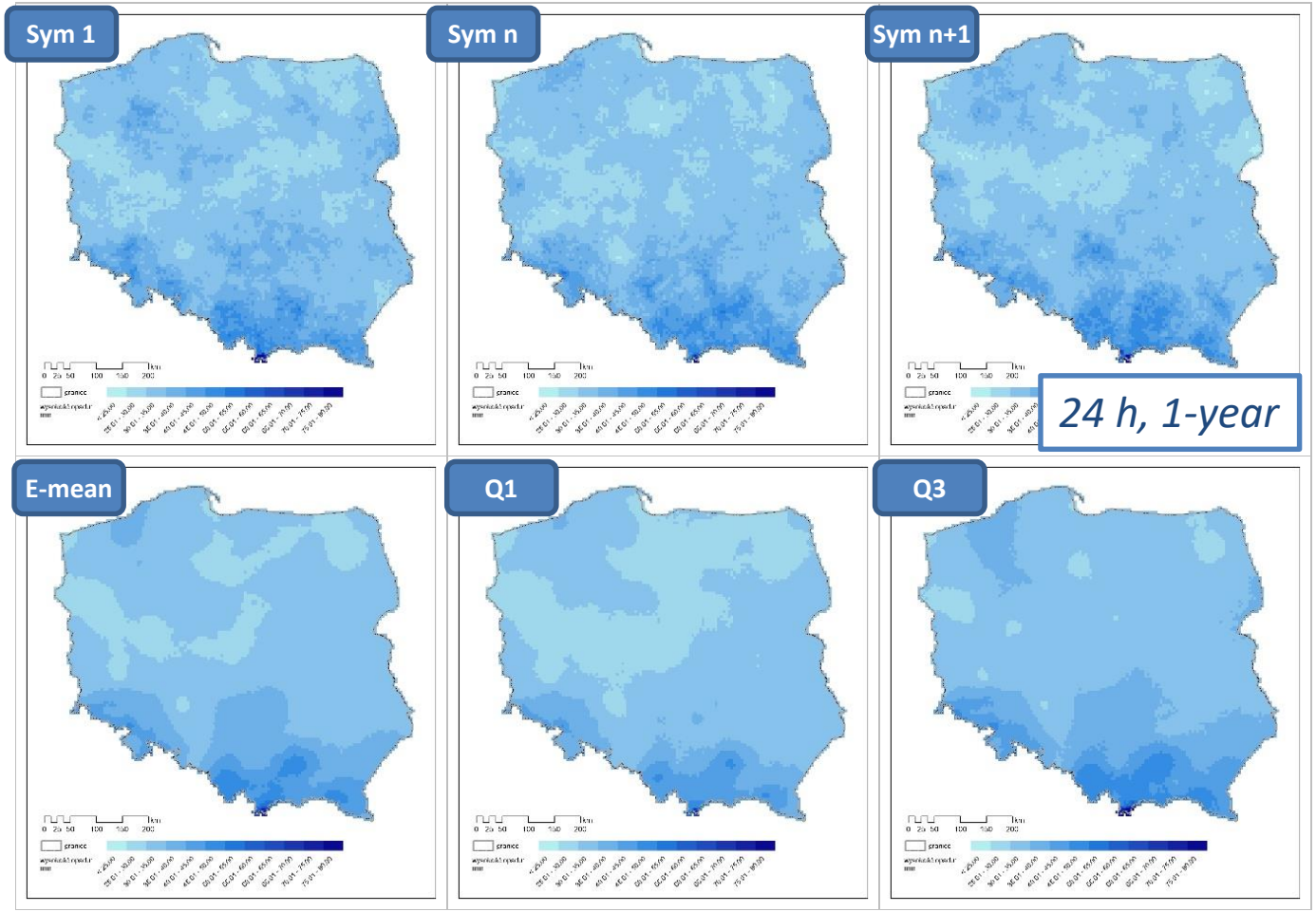
Combining semivariograms models: circular, spherical, exponential, gaussian, nugget – eg. N-S-S



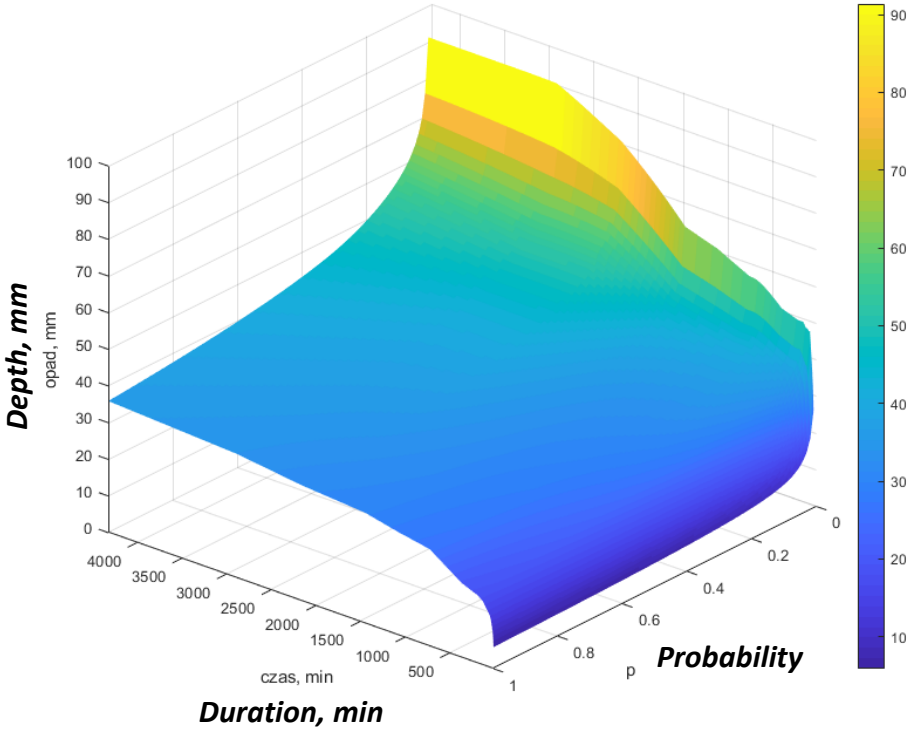
Geostatistical simulations – allowance for uncertainty

Direct Sequential Simulation – DSSIM

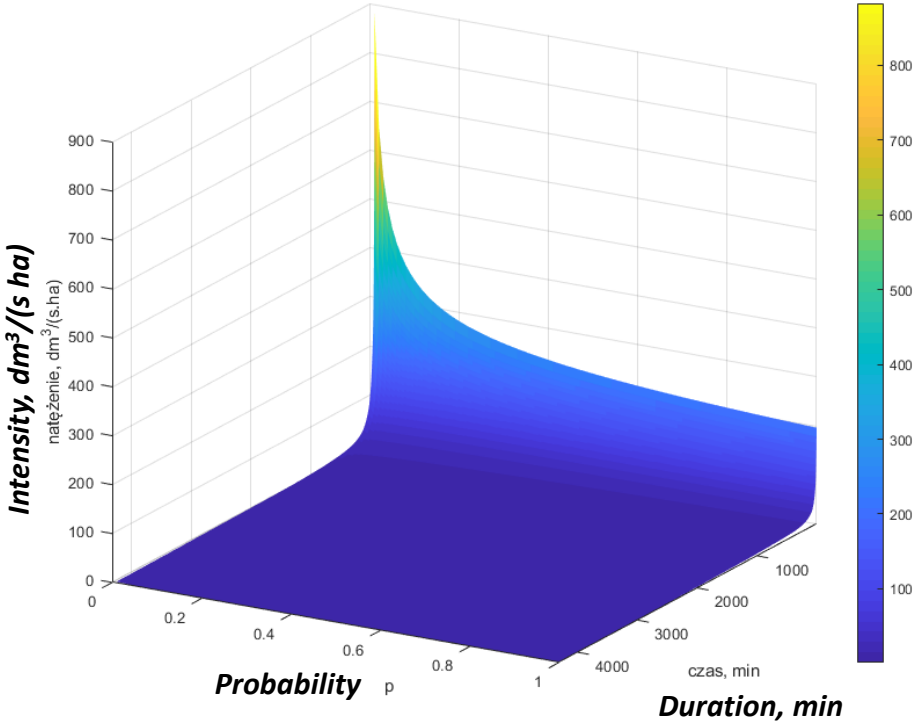




Probabilistic DDF/IDF models

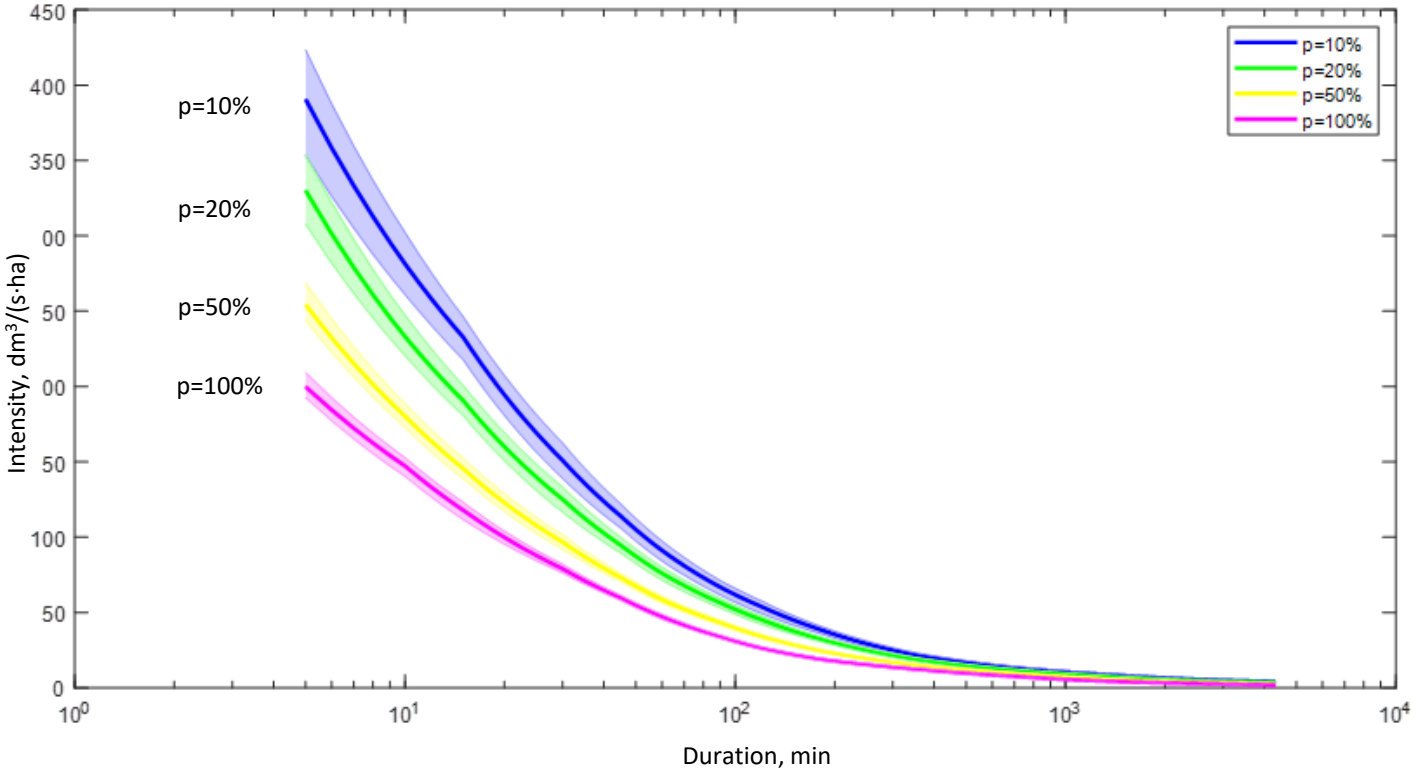


DDF model based on E-mean and generalized Pareto distribution (GPD)



IDF model for frequencies from C=1 year (p=1) to C=100 years (p=0,01) and time duration from 5 to 4320 min

Selected (5km x 5km) pixel – IDF confidence intervals



shorter more violent

Less confident

Selected (5km x 5km) pixel – IDF confidence intervals

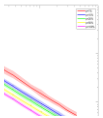
p= 1%

p=10%
p=20%
p=50%
p=100%

More extreme

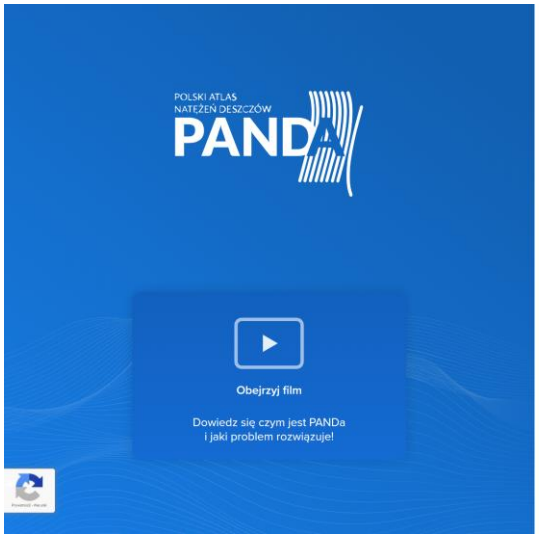
Less confident

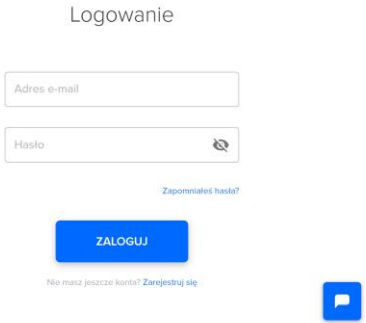
Intensity, $dm^3/(s \cdot ha)$

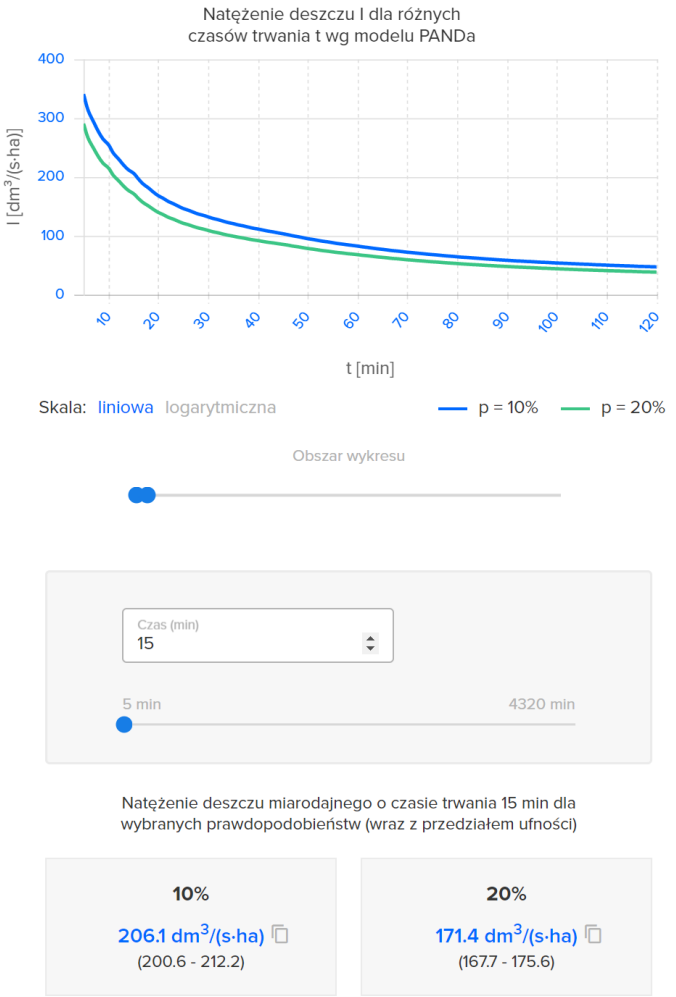


Duration, min

https://portal.atlaspanda.pl/login








Thank you for your attention