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

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Why to talk about extrems?

Change in temperature relative to 1850–1900[°C]

- The Rational Method
  - Thomas Malthus
  - Publication 1811

- First IDF model
  - Arthur N. Talbot
  - Publication 1892

- Błaszczysz model
  - The scope of data 1827-1890; 1914-1935
  - Publication 1954

- Bogdanowicz-Stachy model
  - The scope of data 1903-1960
  - Publication 1981

- PANDa model
  - The scope of data 1960-2015
  - Publication 2019

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

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

- 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
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
### 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...

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### Dates are important for verification...
Verification of maximum rainfall intensities

1) Independent records of daily gauges
2) Synoptic records (e.g. Climate Forecast System (CFS) wetter3.de/Archiv)
Verification: gauge vs radar series

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 ($\chi^2$) 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:

\[
X(\mu, p') = \begin{cases} 
\frac{\sigma (1 - (1 - p')^{-k}}{-k} + \mu, k \neq 0 \\
-\sigma \log(1 - p') + \mu, k = 0
\end{cases}.
\]
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

E-mean

Sym 1

Sym n

Sym n+1

E-mean

Q1

Q3

24 h, 1-year
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

- **p=10%**
- **p=20%**
- **p=50%**
- **p=100%**

**Intensity (dm/3/s∙ha)**

- Shorter duration indicates more violent events.
- Less confident with higher p-values.
Selected (5km x 5km) pixel – IDF confidence intervals

- p = 1%
- p = 10%
- p = 20%
- p = 50%
- p = 100%

Duration, min

Intensity, dm^3/(s-ha)
https://portal.atlaspanda.pl/login
Thank you for your attention