Comparative Analysis of Parameter Optimization of Theoretically Consistent IDF Models of Rainfall Intensity

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Work Flow

1) **Making Use of Full Daily and Hourly Rainfall Records**
   - To effectively taken the dependence into account as without considering it we may underestimate extremes

2) **Merging Both Daily and Hourly Records**
   - To reduce uncertainty of sub-daily rainfall data
   - At larger time scales, daily rainfall series is more reliable

3) **Selecting Distribution for Small and Large Time Scales**
   - Pareto distribution is selected for smaller time scales
   - Pareto-Burr-Feller (PBF) is chosen at larger time scales as it is consistent to the behaviour of rainfall intensity

4) **Estimating Empirical Climacogram**
   - To evaluate the second order dependence structure
   - Pick up climacogram model of type CD or C and obtain first guesses of its parameters

5) **Calculating Empirical Probability Wet/Dry**
   - To deal with intermittence of rainfall occurrences on fine time scales
   - Helps to choose transition time scale k^* from Pareto to PBF distribution

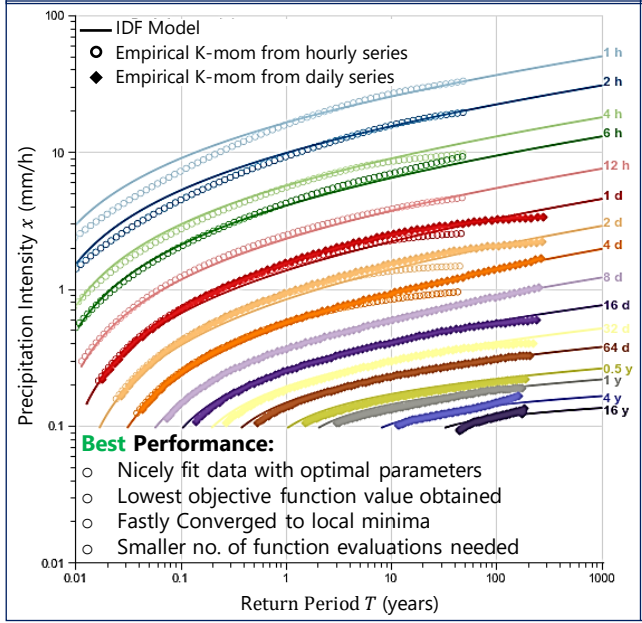
6) **Determining Empirical Knowable-K-Moments**
   - Advanced statistical fitting method for extremes
   - Handles bias due to temporal dependence

7) **Minimizing Error b/w K-Moments and Model Quantiles**
   - Using non-linear optimizing algorithms such as Nelder Mead (NM), Differential Evolution (DE) and Truncated Newton (TNC)

8) **Parameterizing the IDF Model and Visualizing the End Results**
   - Mathematical and physical consistent IDF model that shows good behaviour at all time scales

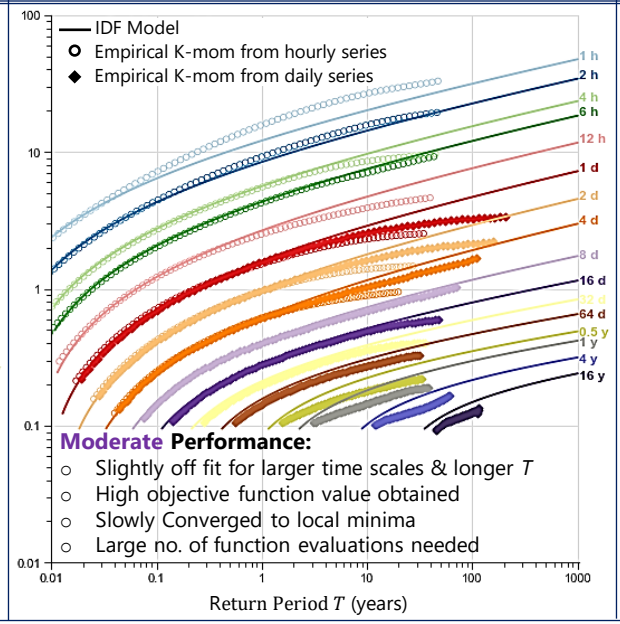
7-Parametric IDF Model Applicable for 1-Hour to 16-years Precipitation in 'Freiburg' (example station)

a) Differential Evolution (DE) Optimization



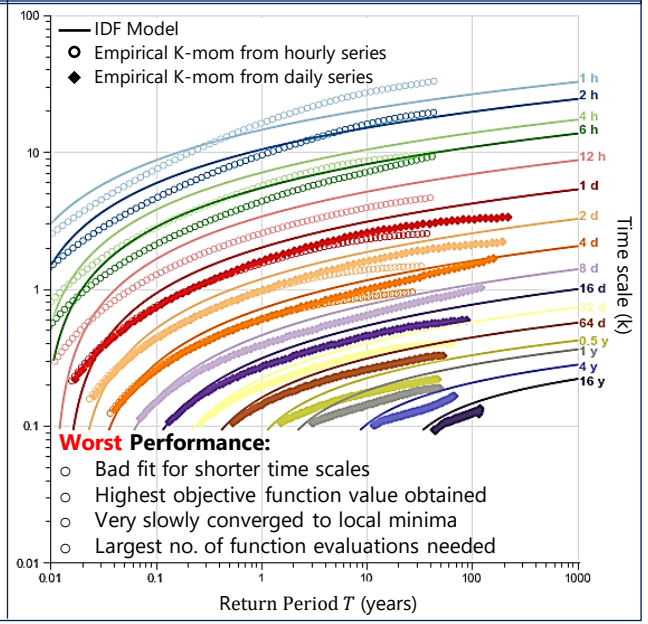
Best Performance:
- Nicely fit data with optimal parameters
- Lowest objective function value obtained
- Fastly Converged to local minima
- Smaller no. of function evaluations needed

b) Nelder Mead (NM) Optimization



Moderate Performance:
- Slightly off fit for larger time scales & longer T
- High objective function value obtained
- Slowly Converged to local minima
- Large no. of function evaluations needed

c) Truncated Newton (TNC) Optimization



Worst Performance:
- Bad fit for shorter time scales
- Highest objective function value obtained
- Very slowly converged to local minima
- Largest no. of function evaluations needed

Parameters	Symbol	Units	DE	NM	TNC
Mean Intensity	μ	mm/h	0.0968	0.0950	0.0935
Exp.of Prob. dry	θ	(-)	0.9634	0.5000	0.8509
1st Intensity scale	λ_1	$(mm/h)^2$	0.0535	0.0078	0.0079
2nd Intensity sacle	λ_2	$(mm/h)^2$	1.9666	1.3539	1.6885
Time Scale	α	hour (h)	0.8454	9.5341	9.2563
Hurst Parameter	H	(-)	0.7889	0.9500	0.9341
Tail Index	ξ	(-)	0.0870	0.1500	0.0067

IDF Model by Koutsoyiannis 2021	Pareto for smaller scales, $k \le k^* \ll k^*_{max}$	PBF for larger scales, $k \ge k^*$
$x\ for\ \xi > 0$	$\lambda(k)\frac{\left(P_1^{(k)}\,T/k\right)^{\xi}-1}{\xi}$	$\lambda(k)\left(\frac{\left(P_1^{(k)}\,T/k\right)^{\xi}-1}{\xi}\right)^{\frac{1}{\zeta(k)}}$
$x\ for\ \xi = 0$	$\lambda(k)\ln\left(P_1^{(k)}\,T/k\right)$	$\lambda(k)\left(\ln\left(P_1^{(k)}\,T/k\right)\right)^{\frac{1}{\zeta(k)}}$

- ❑ Hourly time series (1995-2022)
- ❑ Daily time series (1874-2022)
- ❑ Transition time scale (k*): 96h
- ❑ Climacogram type: CD for complex structures

Purpose: Regional Modeling of precipitation extremes based on the parameter values extracted from the Intensity Duration Frequency (IDF) Model

Importance: To provide predictions for urban storm waters and floods at both sampled/unsampled sites

Future: To deal with spatial variability of extremes by effectively handling data discrepancies