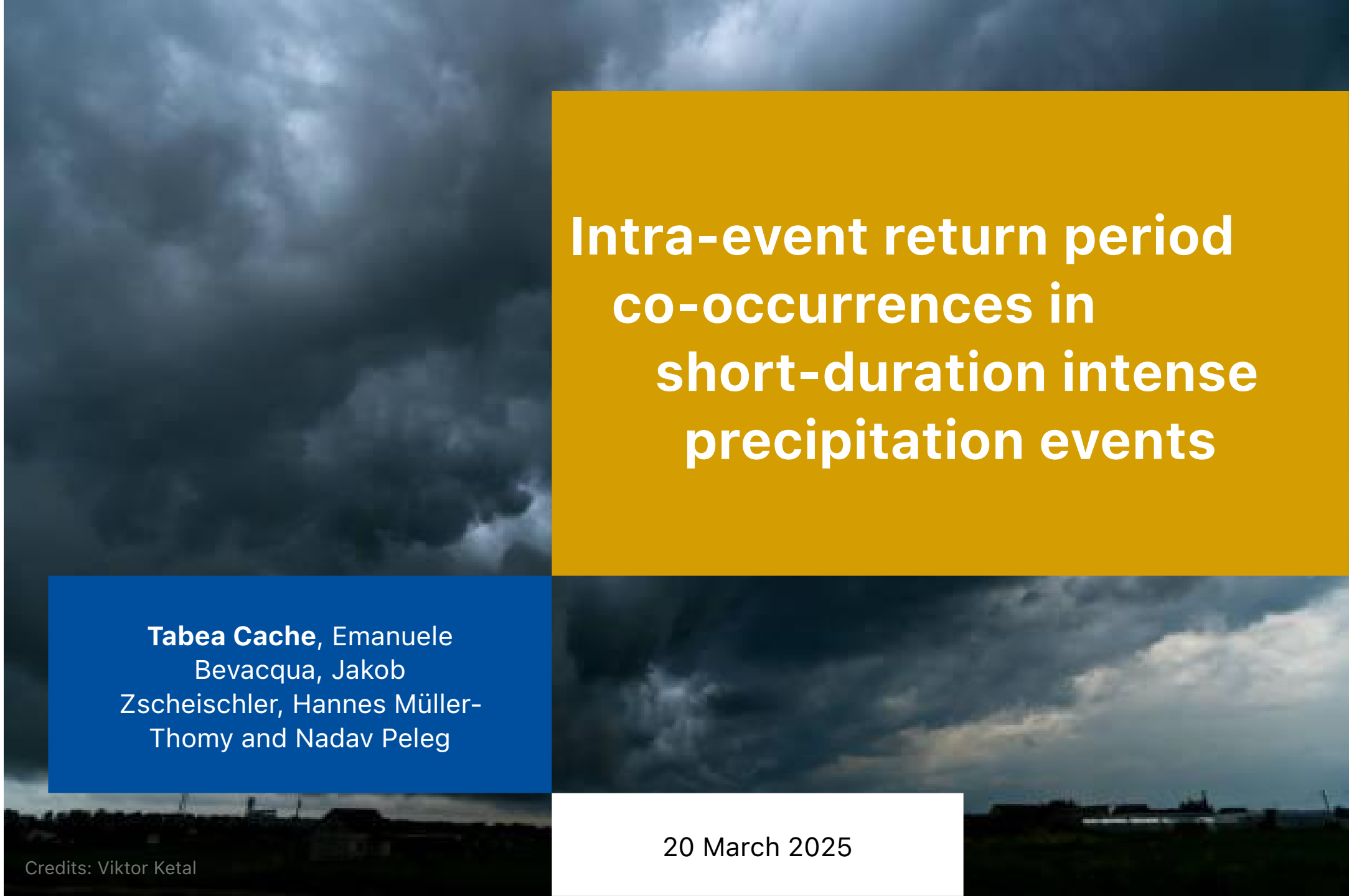


Intra-event return period co-occurrences in short-duration intense precipitation events

Tabea Cache, Emanuele Bevacqua, Jakob Zscheischler, Hannes Müller-Thomy and Nadav Peleg

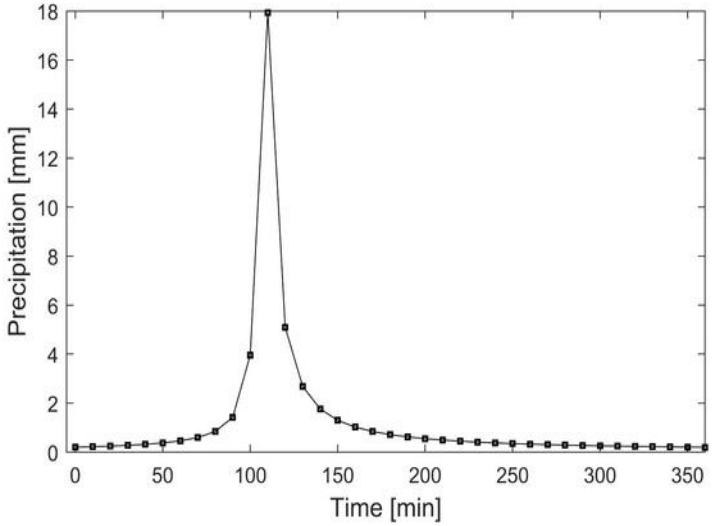
20 March 2025

Credits: Viktor Ketal

PrePEP 2025
Session 5A

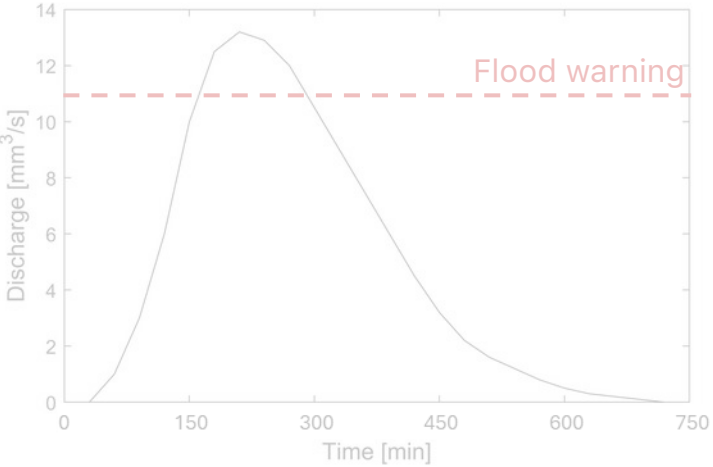
Design Storms

1 Develop a **design storm hyetograph**



2 Route through a hydrodynamic **model**

3 Estimate and manage **runoff**



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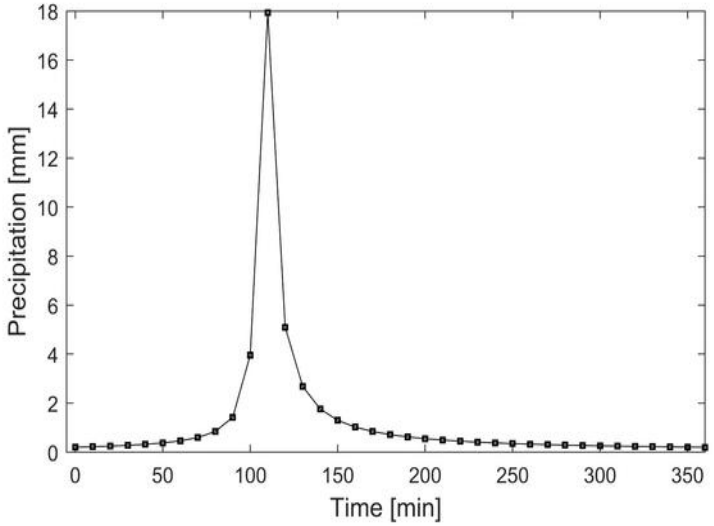

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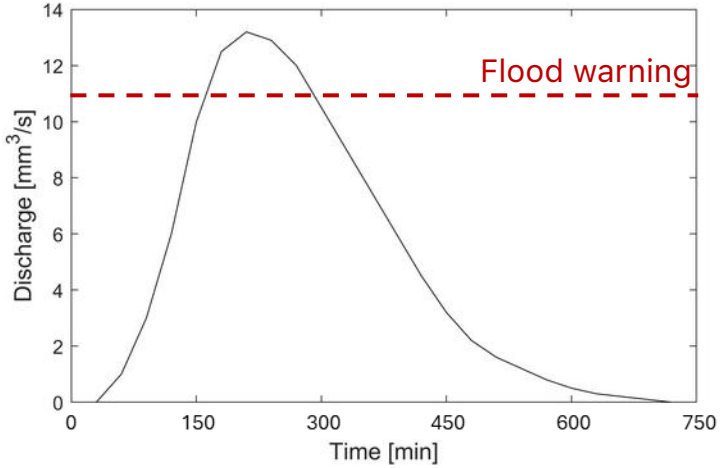


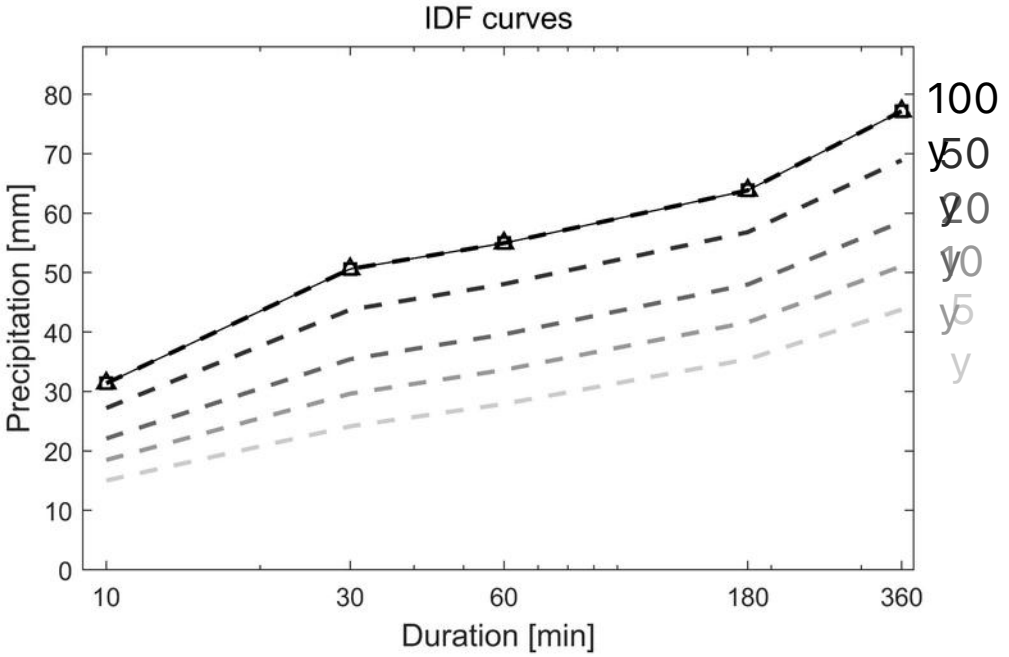
Design Storms

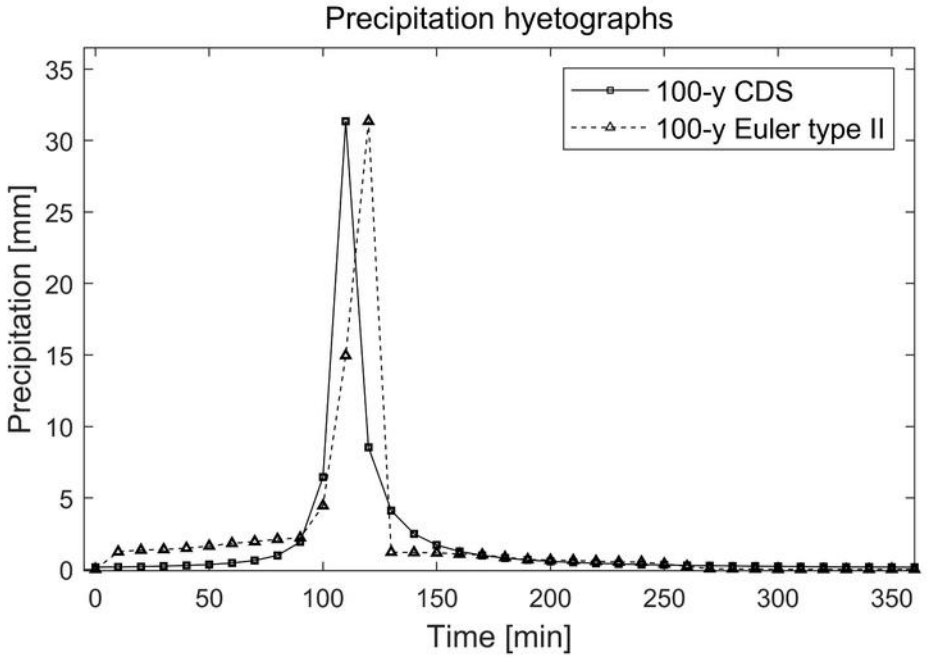
Design storm

Synthetic rainfall event which intensity over a duration is expected to occur with a certain return interval

Sampling methods

- **Entire IDF curve**





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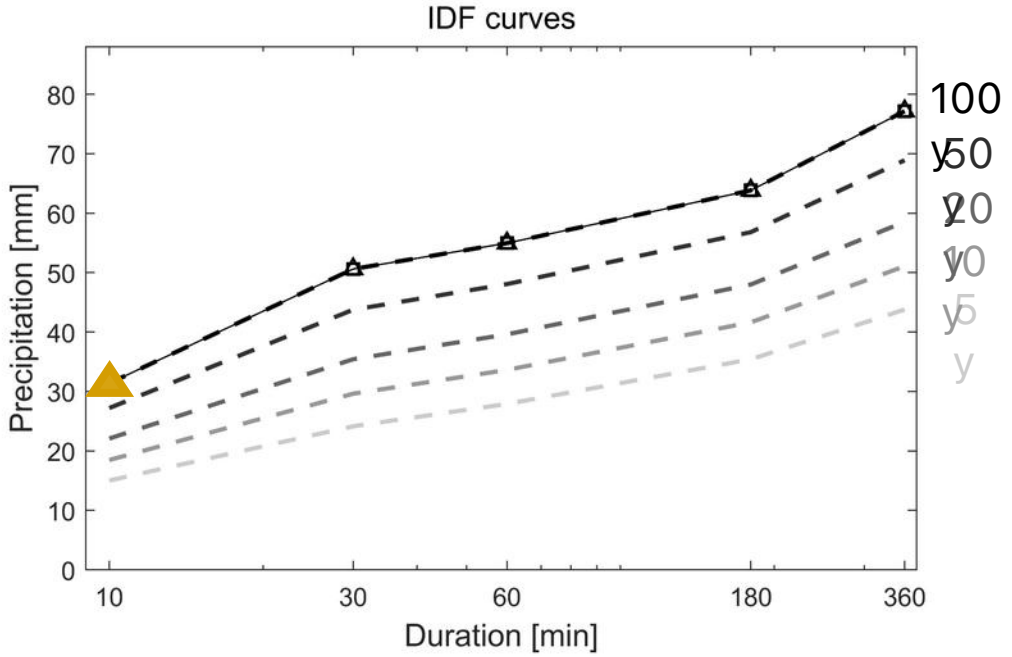

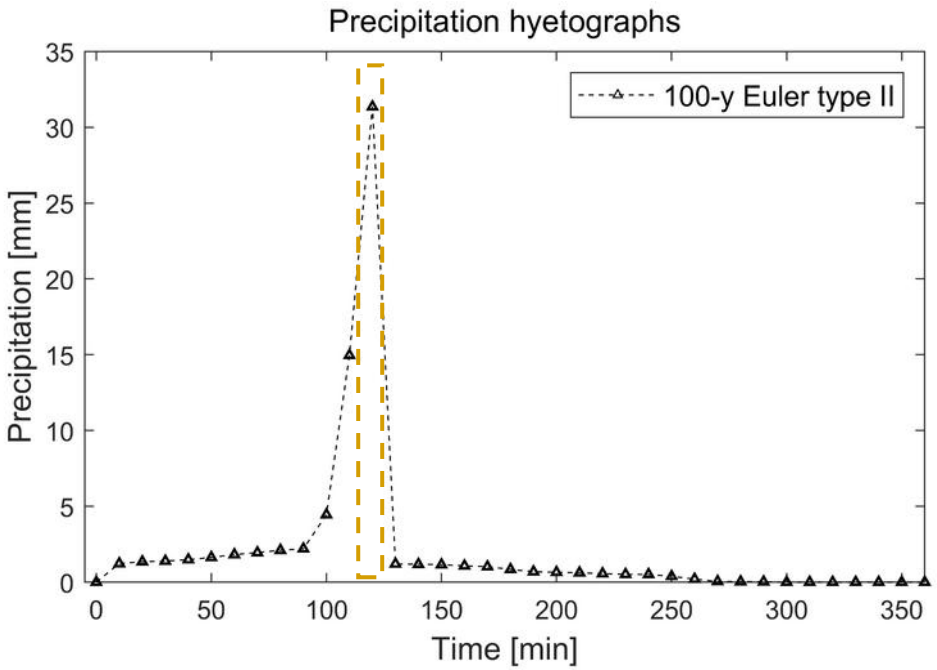

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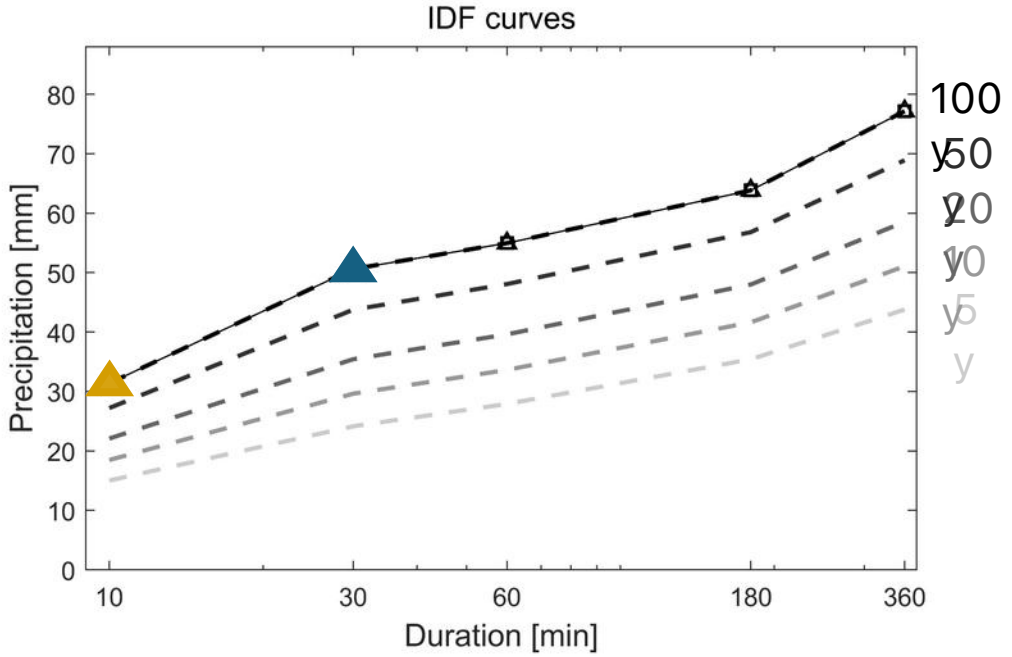

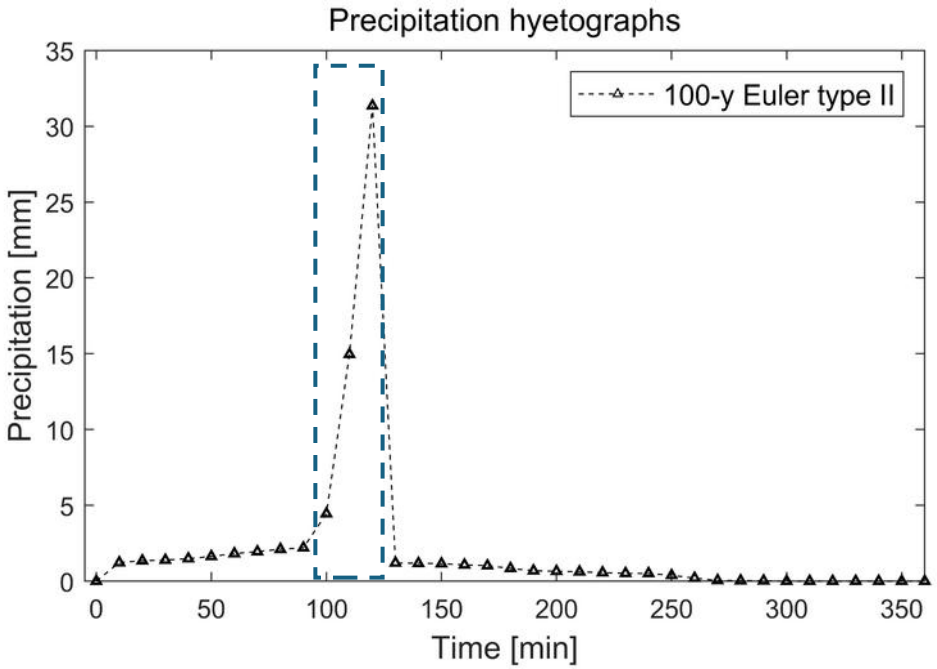

Design Storms

Design storm

Synthetic rainfall event which intensity over a duration is expected to occur with a certain return interval

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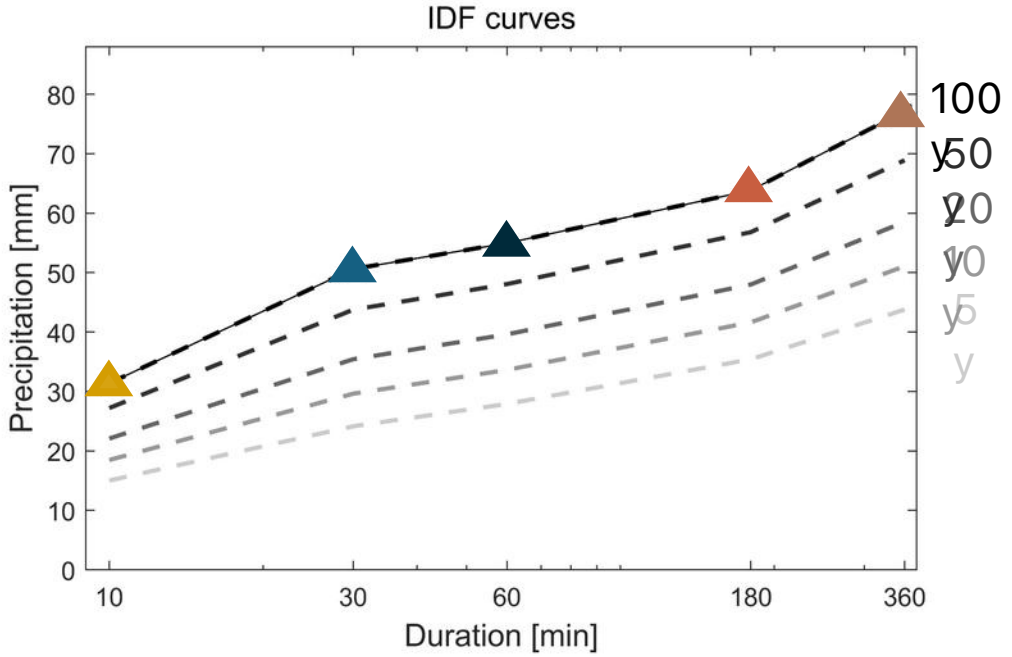
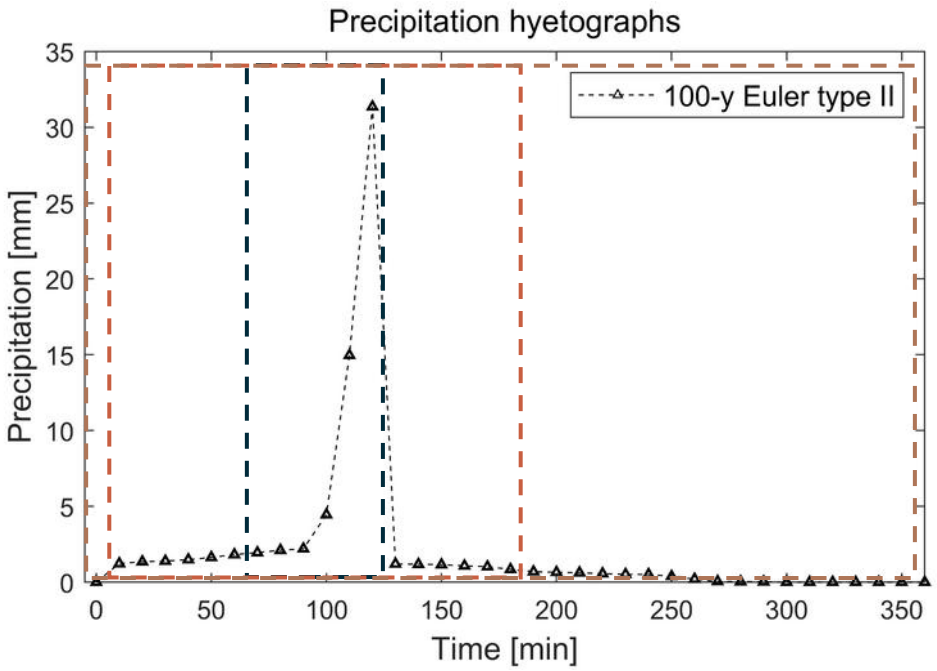
- Single point of the IDF curve
- Simulation from stochastic models





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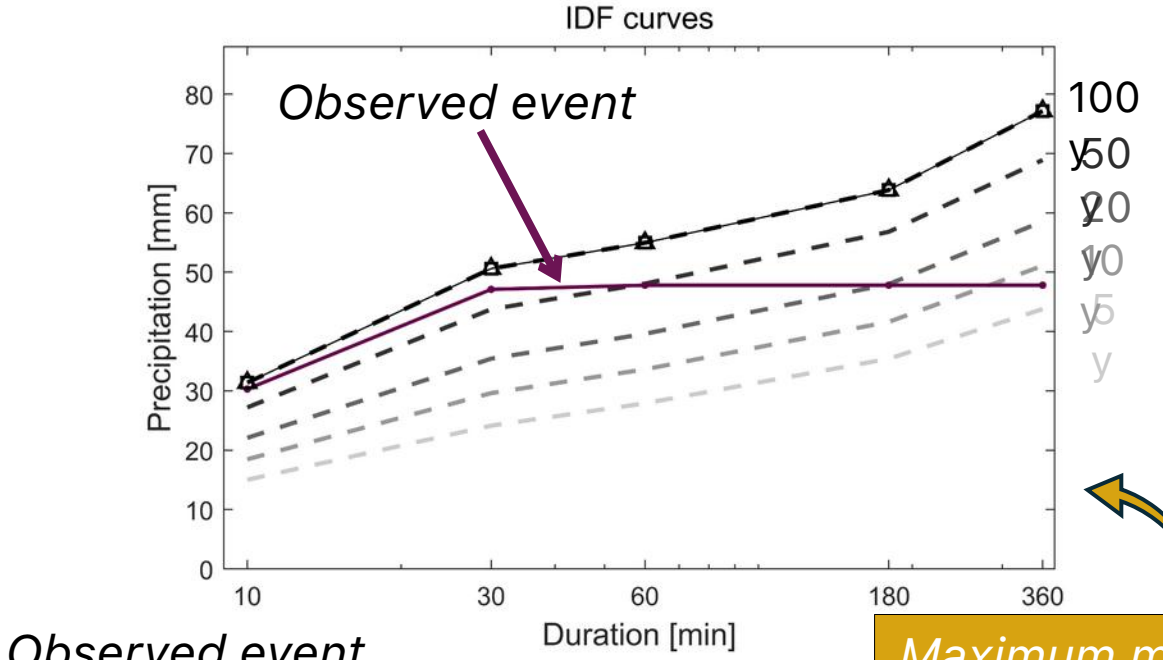

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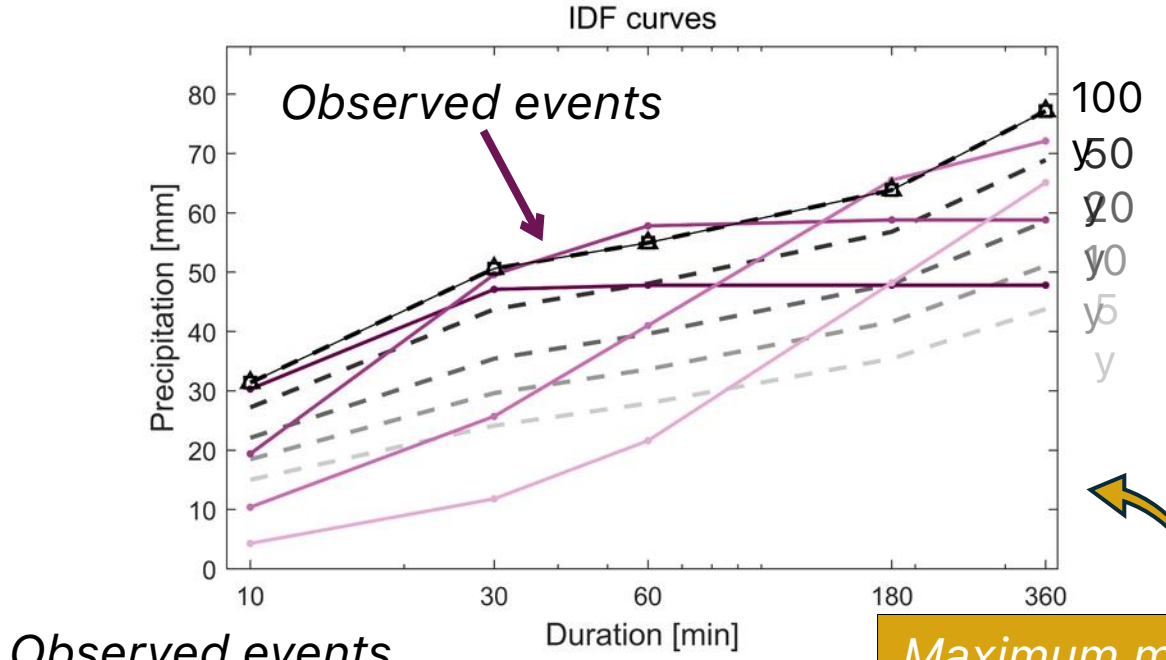
How are intensities across the different duration intervals correlated?



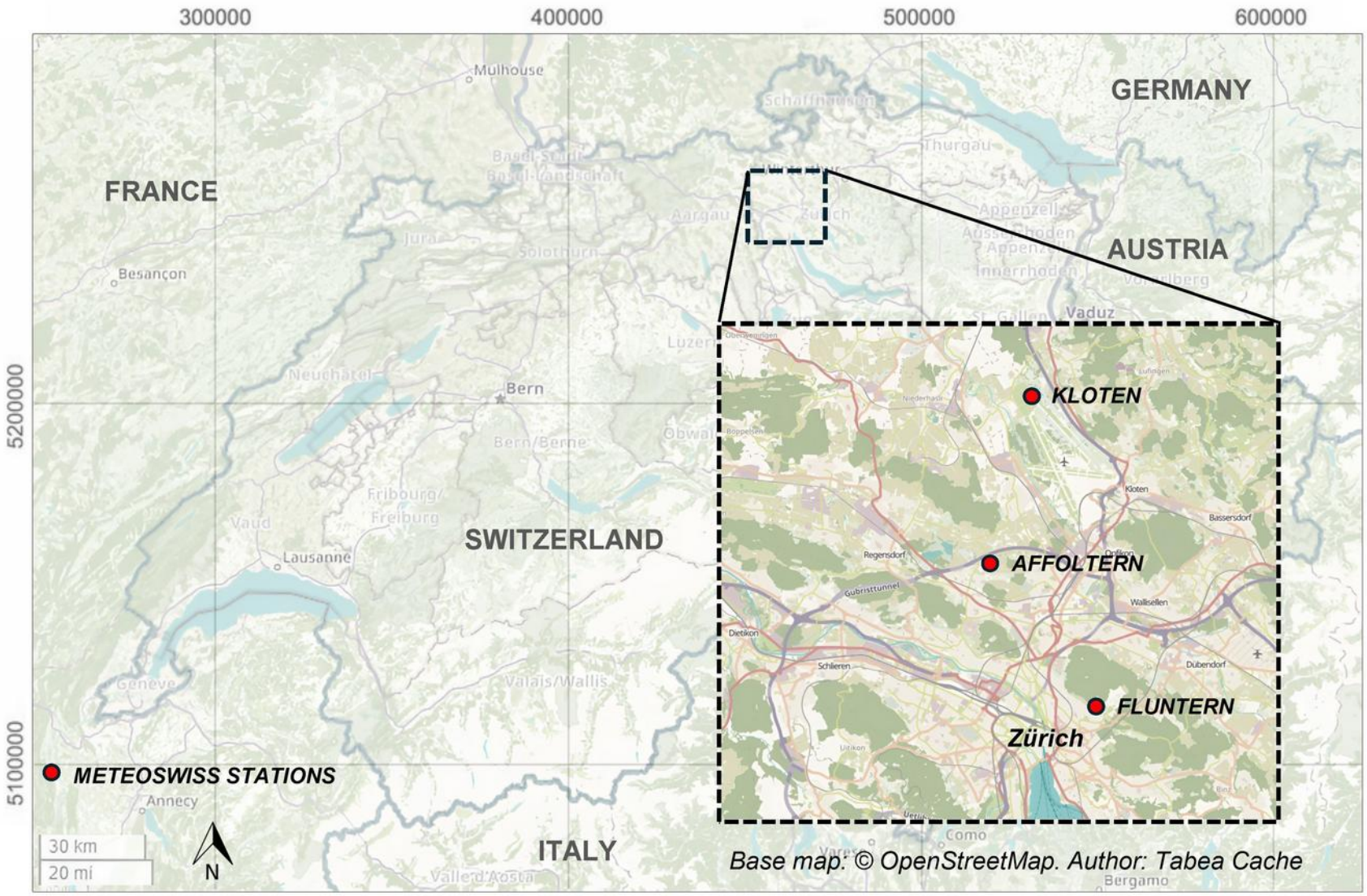
CASE STUDY: ZURICH

126 years at 10-min resolution

- Pooling 42 years of data from 3 stations

Short-duration intense precipitation events

- 360-min window maximum
- Return period > 1.1 year
- 537 events (3.5% of all events)



Duration-Frequency Dependencies

How are intensities across the different duration intervals correlated?

- Dependence structure between maximum accumulated precipitation volumes over different duration intervals:

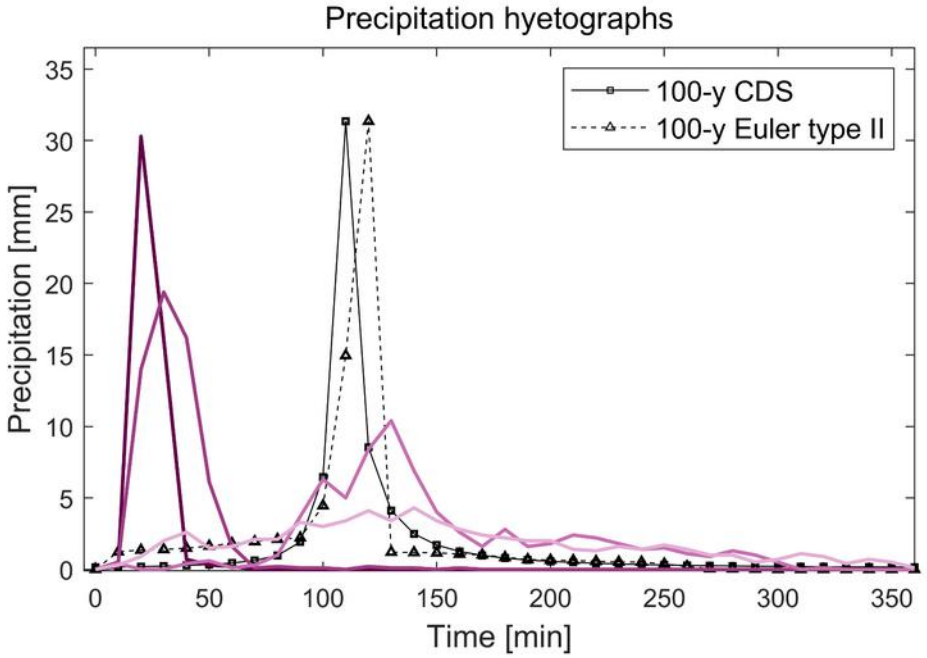
  10-min

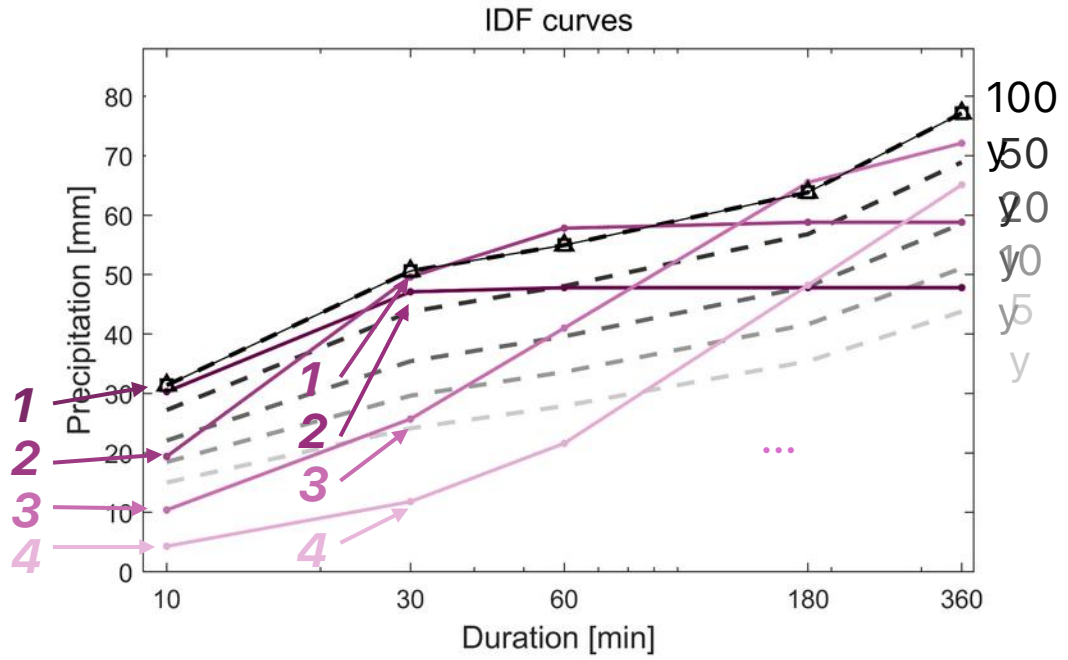
  30-min

  60-min

  180-min

  360-min





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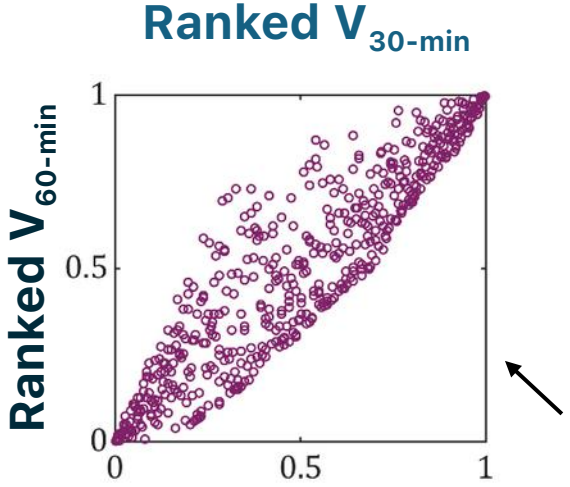
*Kendall's τ rank correlation coefficient**

$$\tau_{30,60} = 0.76$$



*Normalised **ranks** of accumulated precipitation volumes*

* | τ| = 1 ⇒perfect correlation, | τ| = 0 ⇒absence of

Duration-Frequency Dependencies

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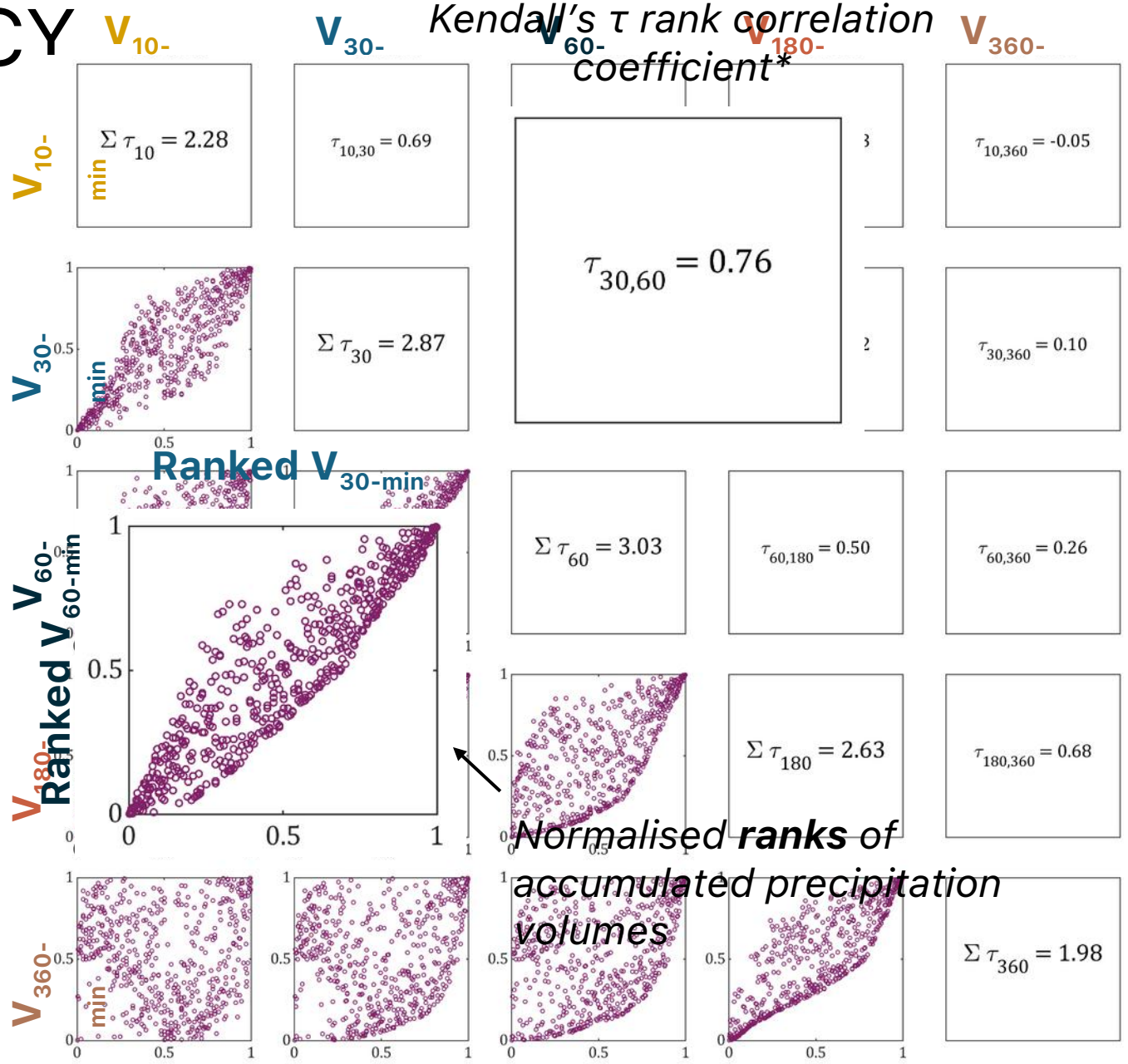

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Duration-Frequency Dependencies

How are intensities across the different duration intervals correlated?

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Highest correlation

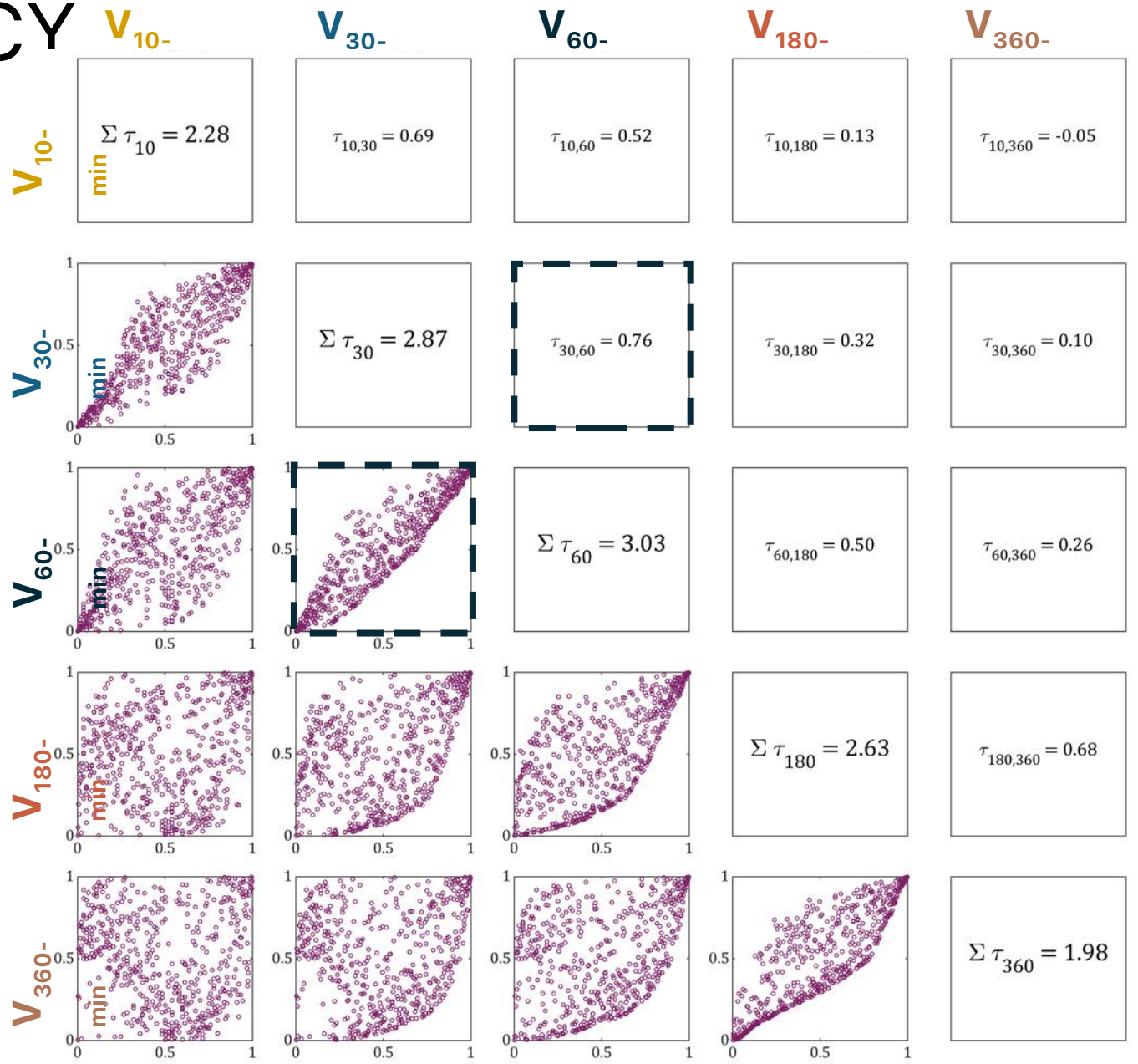
10-min

30-min

60-min

180-min

360-min



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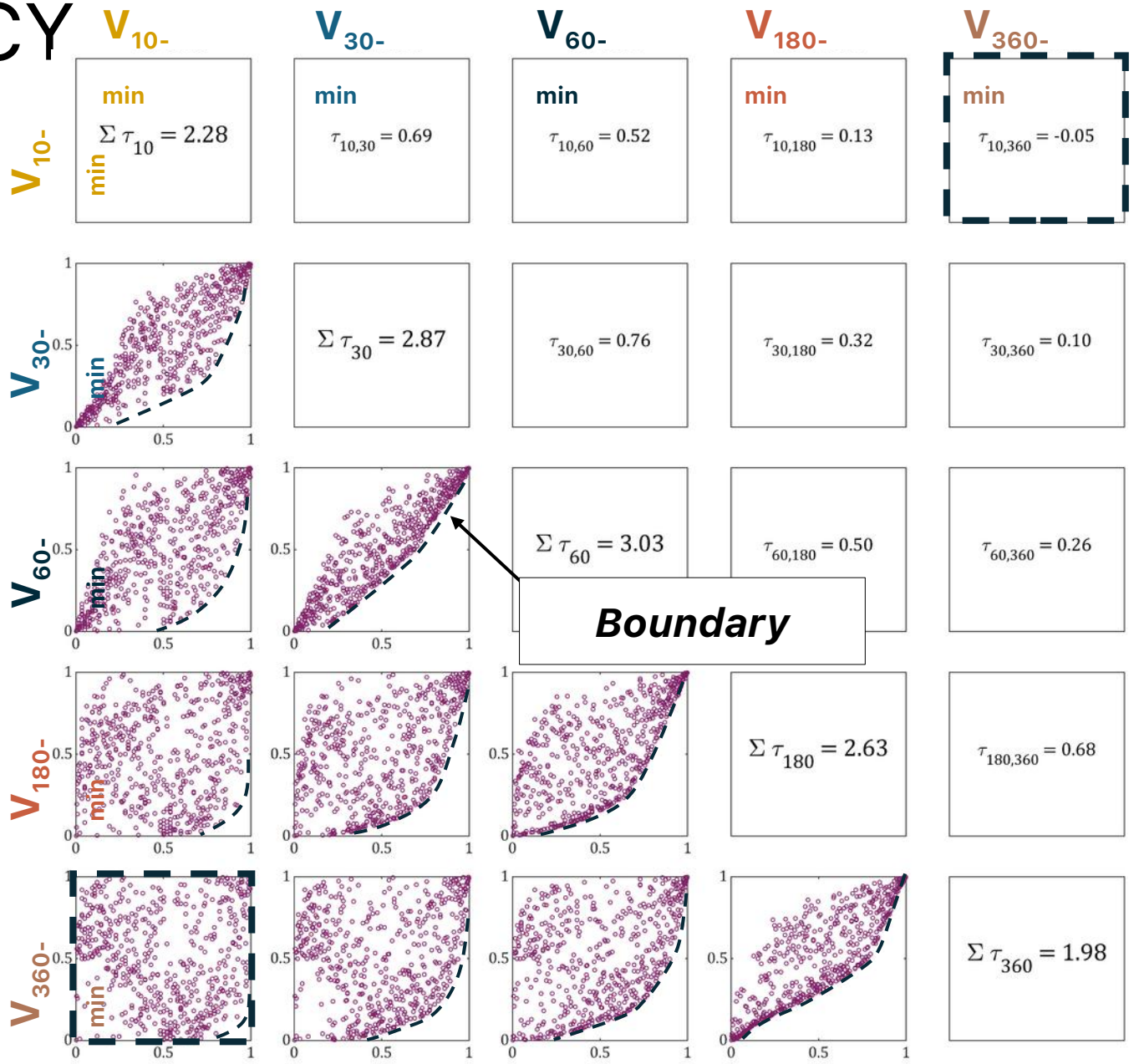
Lowest correlation

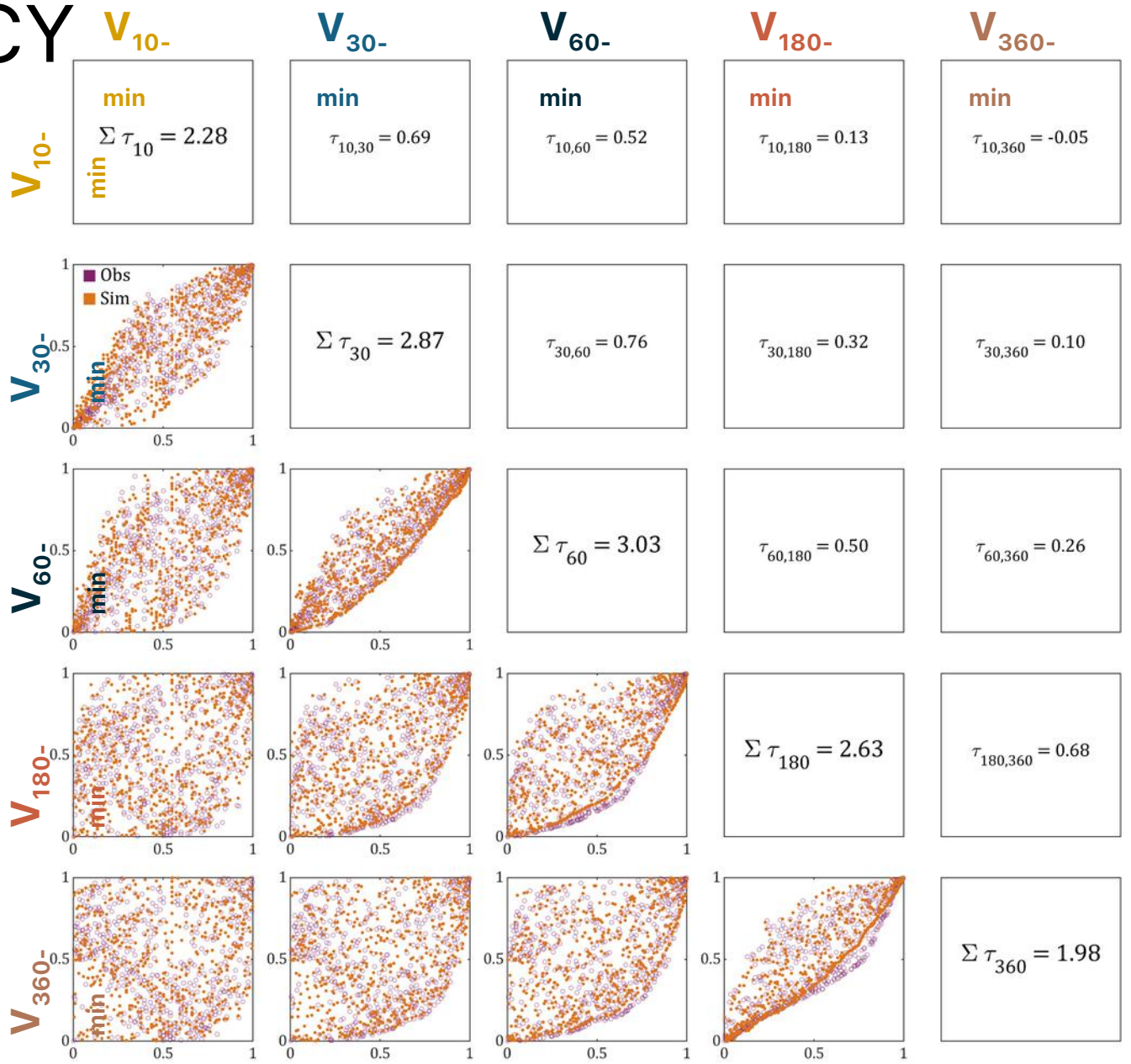


Duration-Frequency Dependencies

How are intensities across the different duration intervals correlated?

- Dependence structure between maximum accumulated precipitation volumes over different duration intervals:

  Modelled with copula



Simulating Duration-Frequency Samples

Can we simulate precipitation samples that satisfy the observed duration-frequency dependencies?

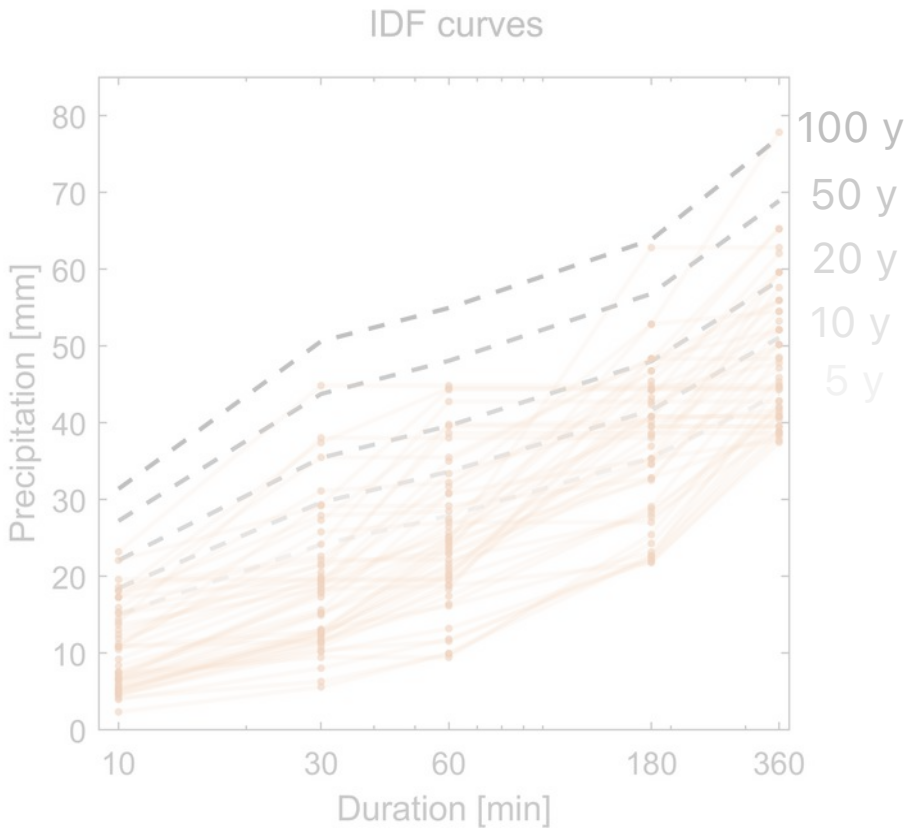
Multivariate joint distribution of precipitation volumes over different durations

- Dependence structure between different durations (modelled by copula)

AND

- Univariate distribution

Example: *IDF profiles for 100 random events*



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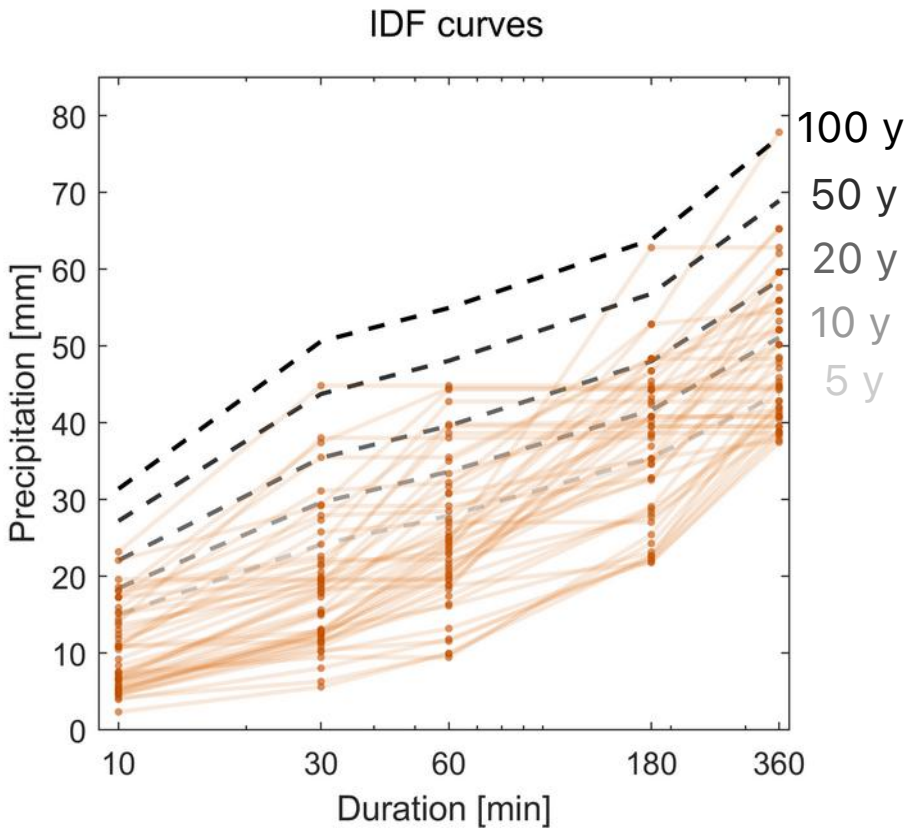

Simulating Duration-Frequency Samples

Can we simulate precipitation samples that satisfy the observed duration-frequency dependencies?

Multivariate joint distribution

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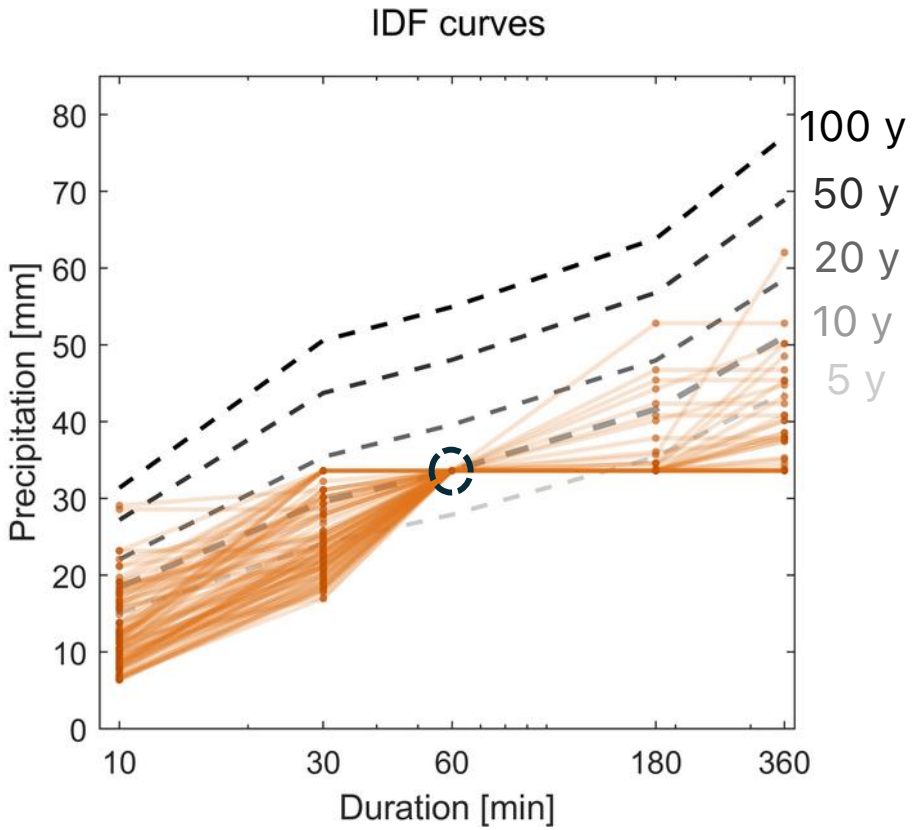
- Univariate distribution

Conditional sampling

- 'Pivot point'

Example: *IDF profiles for 100 events with 10-y return period on the 60-min duration interval*



Simulating Duration-Frequency Samples

How does the standard method compare with design storms that reproduce the observed duration-frequency

Relative difference in the total storm volume

- Average: +30%
- Ranging from +34% to -22%

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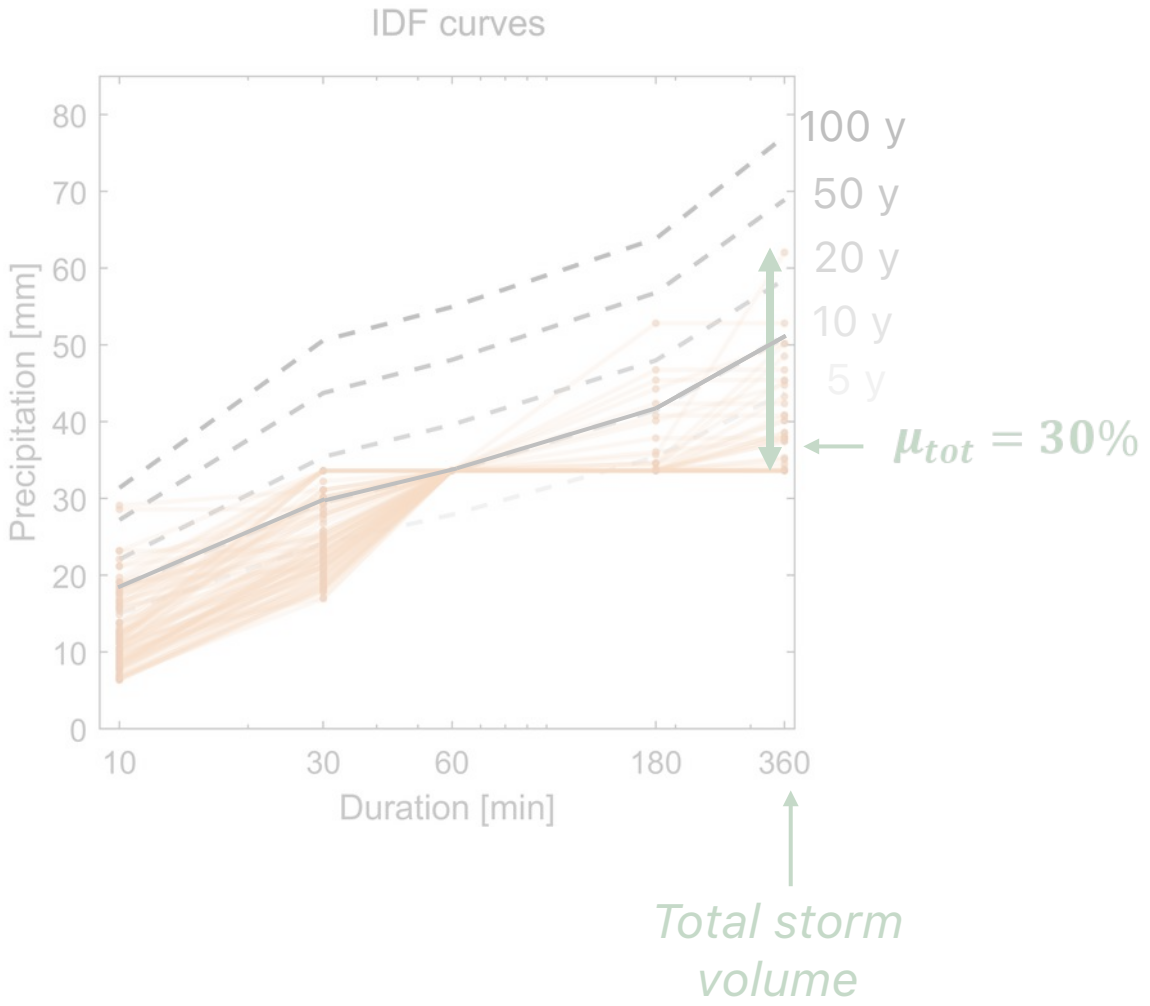


Simulating Duration-Frequency Samples

How does the standard method compare with design storms that reproduce the observed duration-frequency

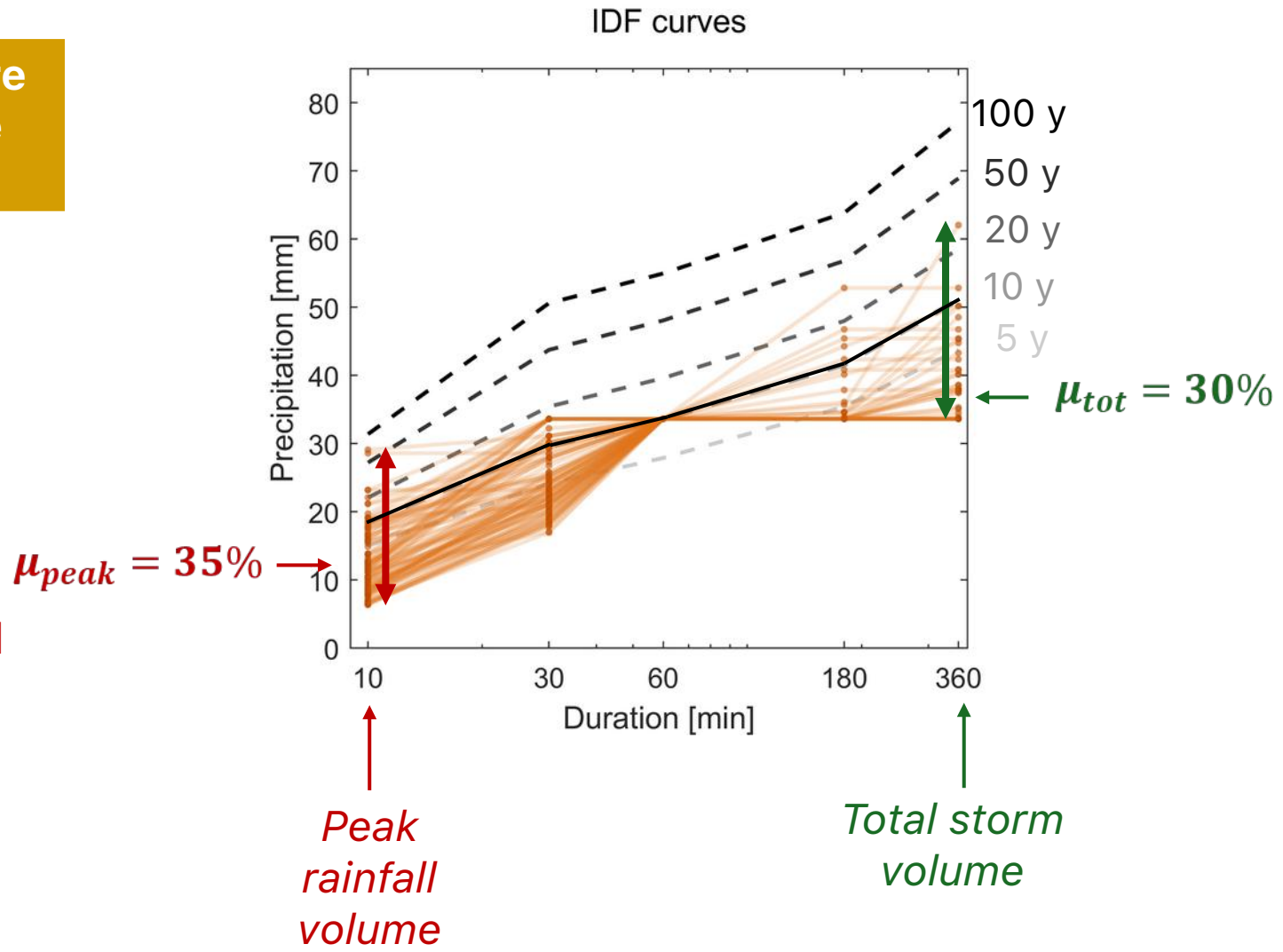
Relative difference in the total storm volume

- Average: +30%
- Ranging from +34% to -22%

Relative difference in the peak rainfall volume

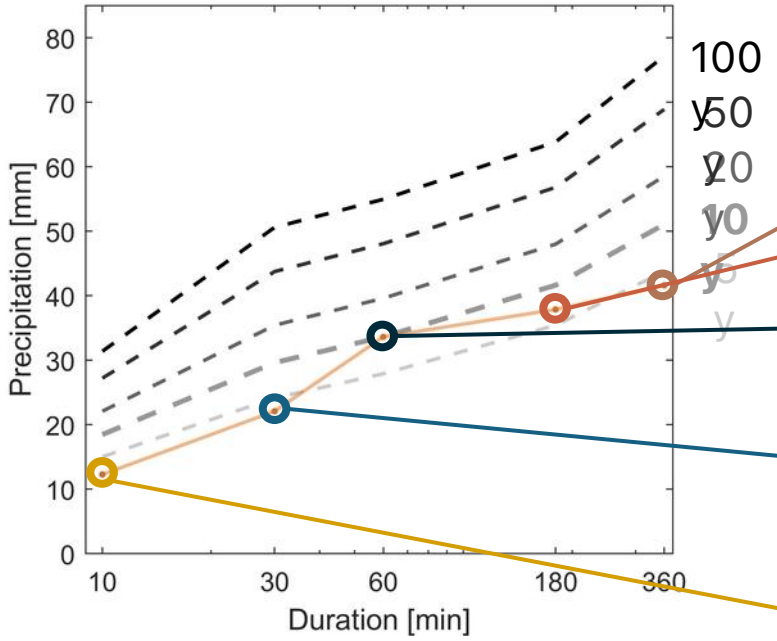
- Average: +35%
- Ranging from +66% to -43%

Example: *IDF profiles for 100 events with 10-y return period on the 60-min duration interval*



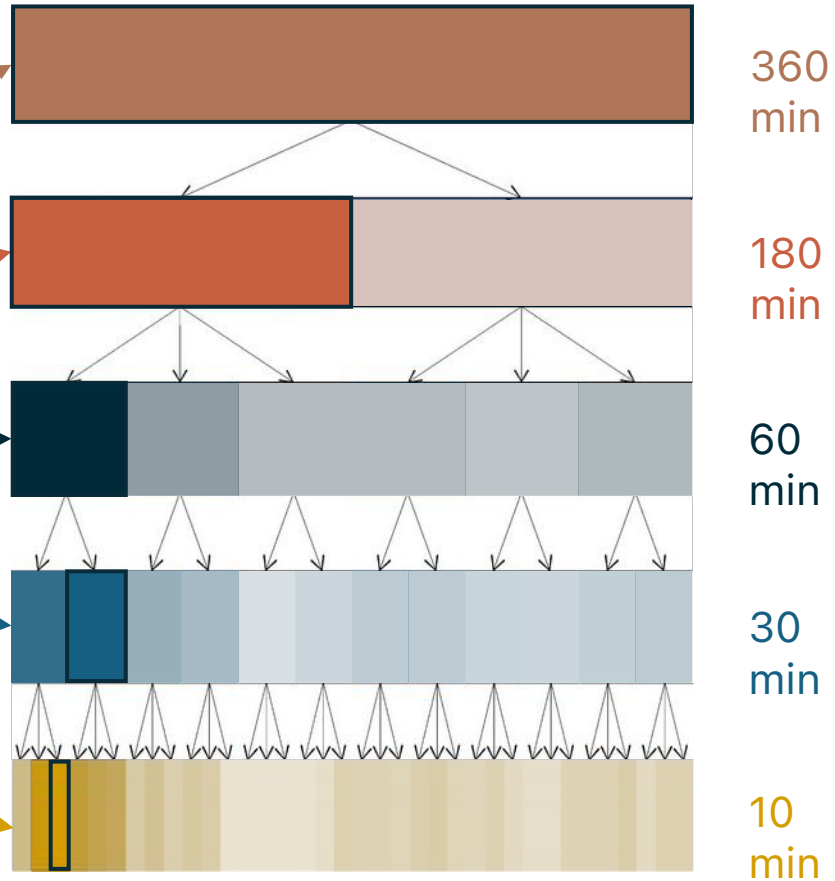
Simulating Design Storms

1 **Copula-based approach for IDF profile sampling**



2 **Temporal disaggregation of rainfall**

Constrained micro-canonical cascade model



Müller-Thomy, 2020

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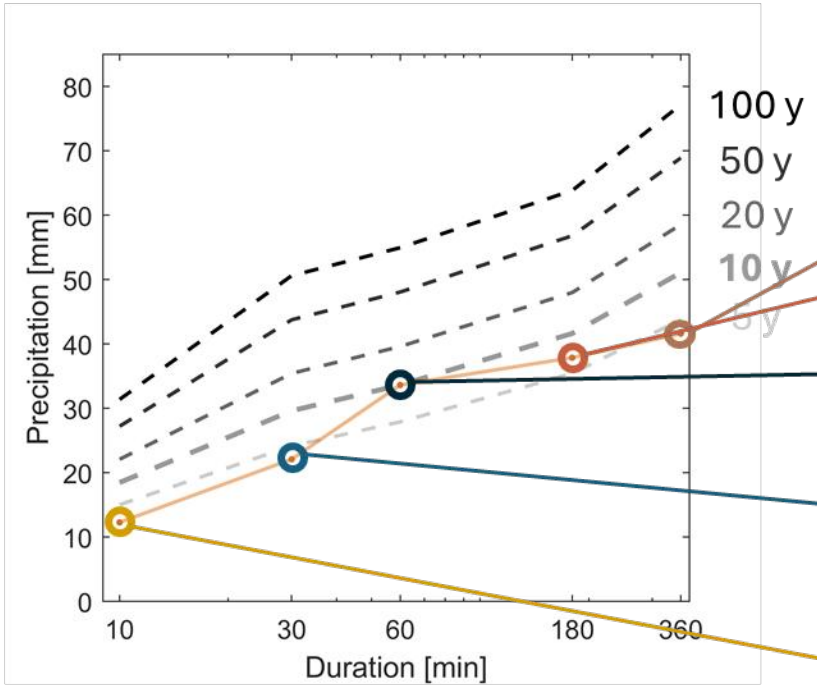

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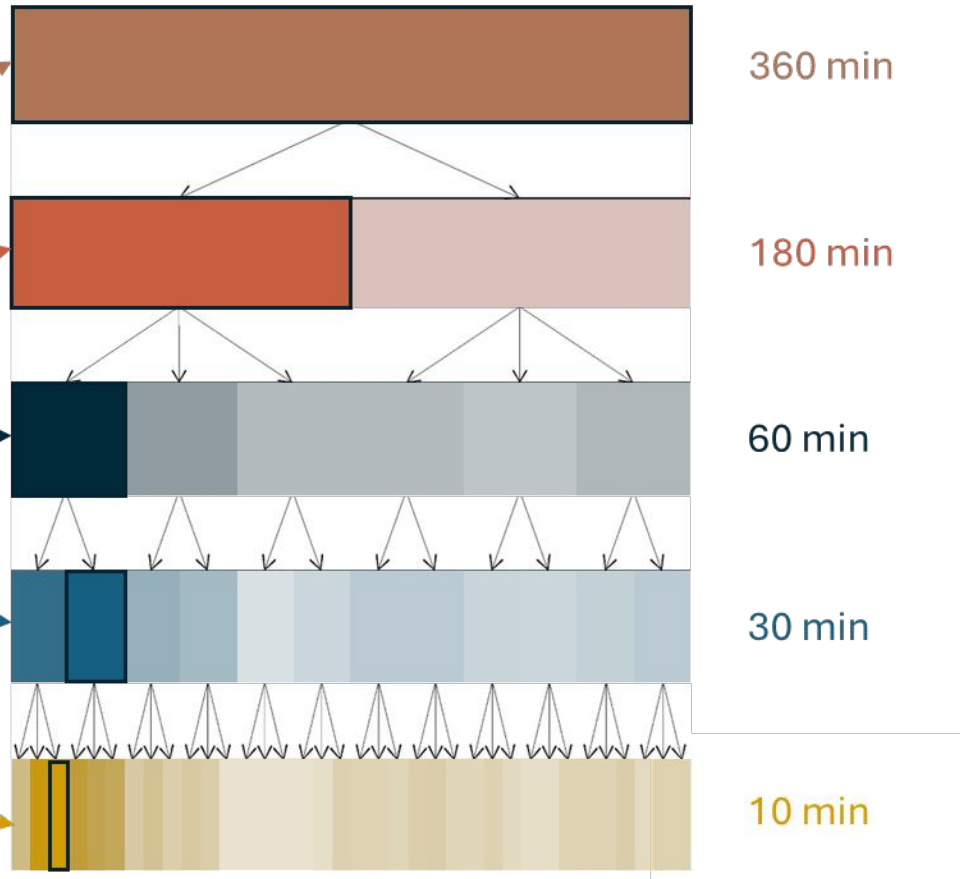

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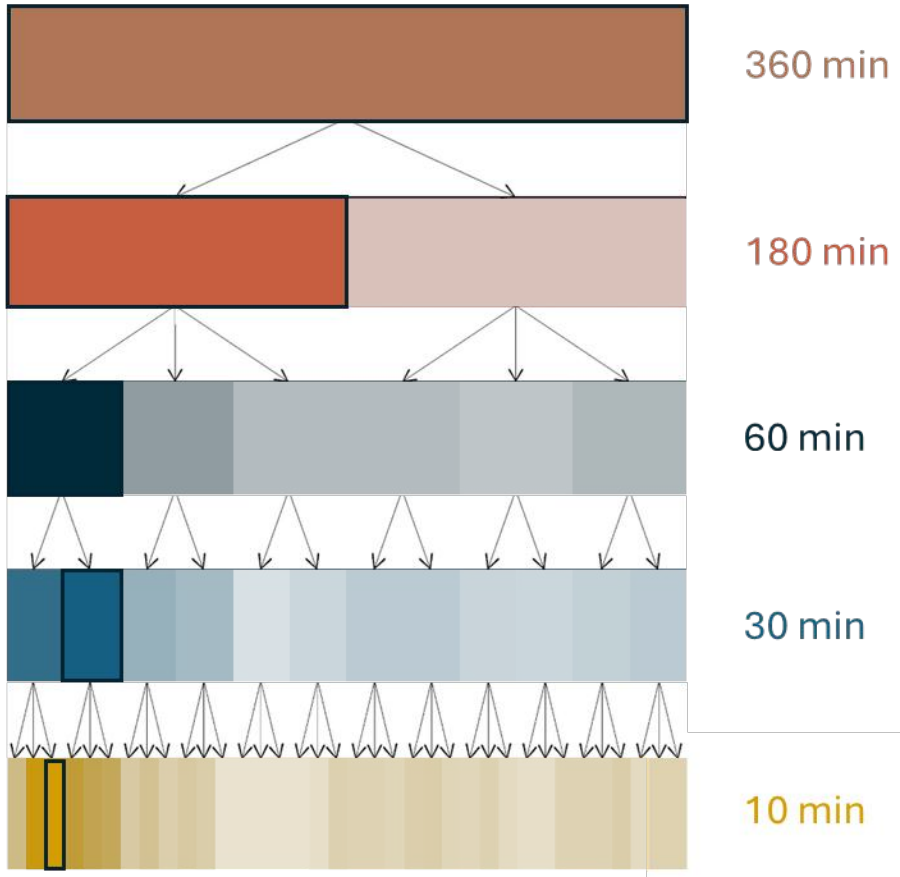
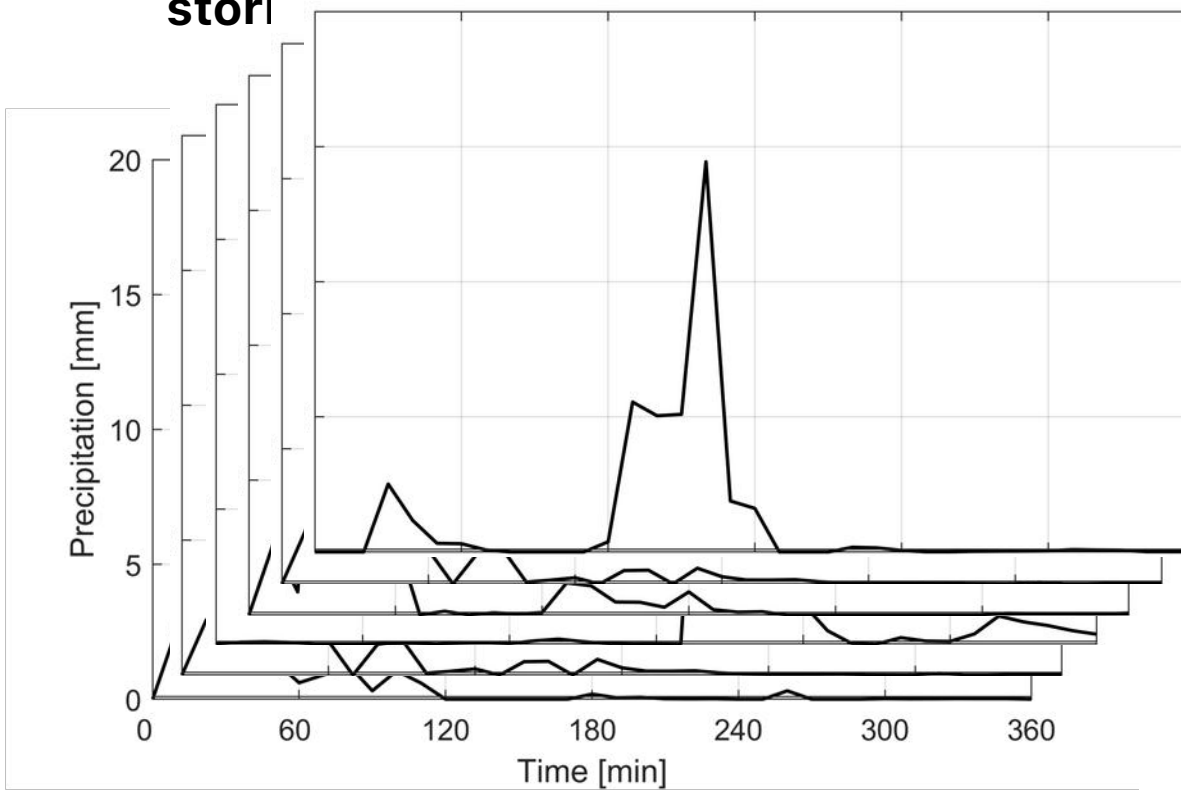


Müller-Thomy, 2020

3 **Ensemble of realistic design stor**



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Summary

- Model generates storms that account for the joint return periods over different durations
- High variability in possible duration-frequency profiles
- Model highlights the overestimation of total precipitation volumes by the common design storm sampling methods

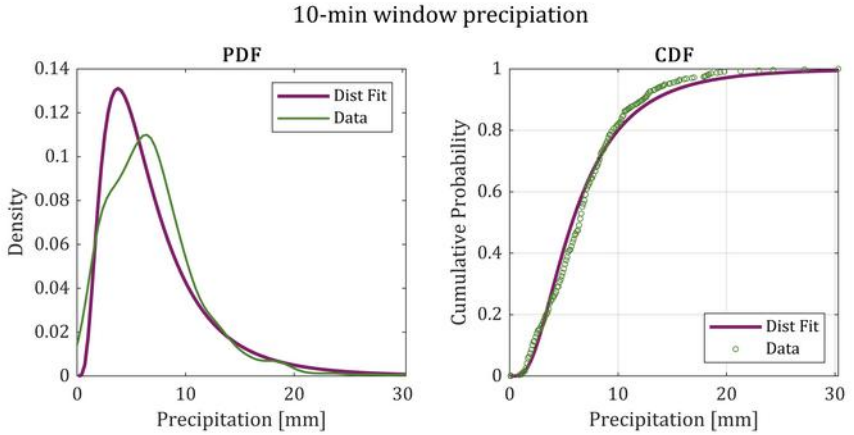
Thank you!

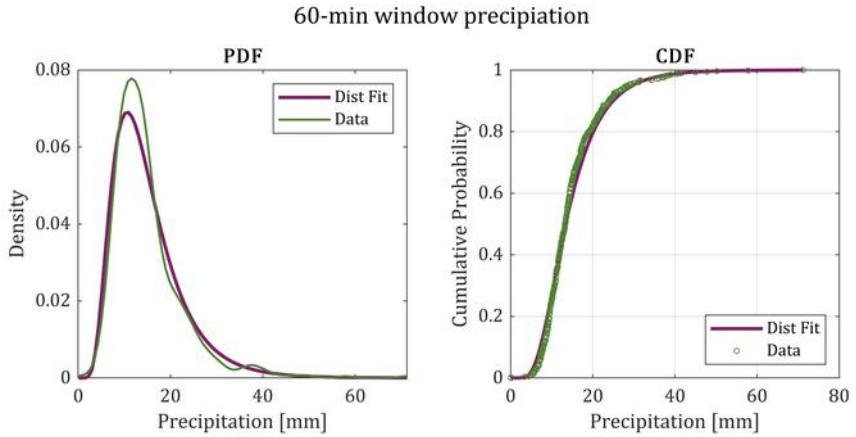
tabea.cache@unil.c
h

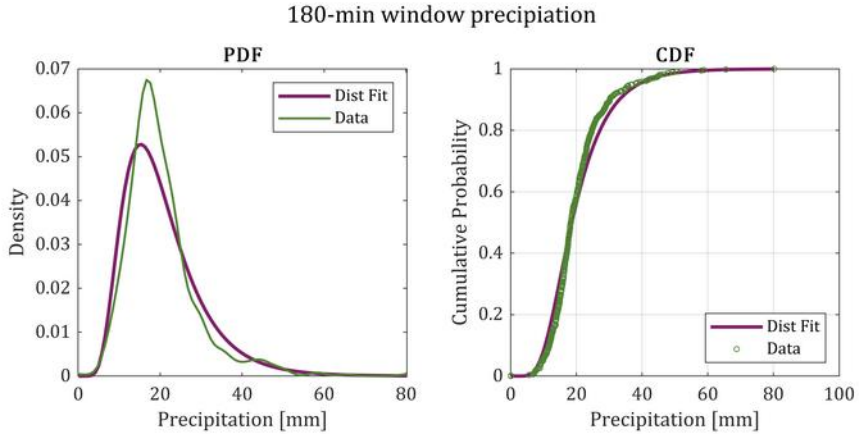
Credits: Viktor Ketal

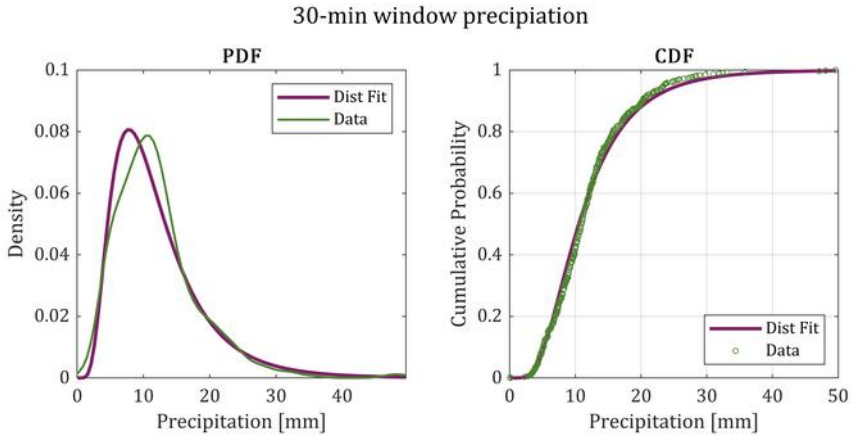
Supplementary material

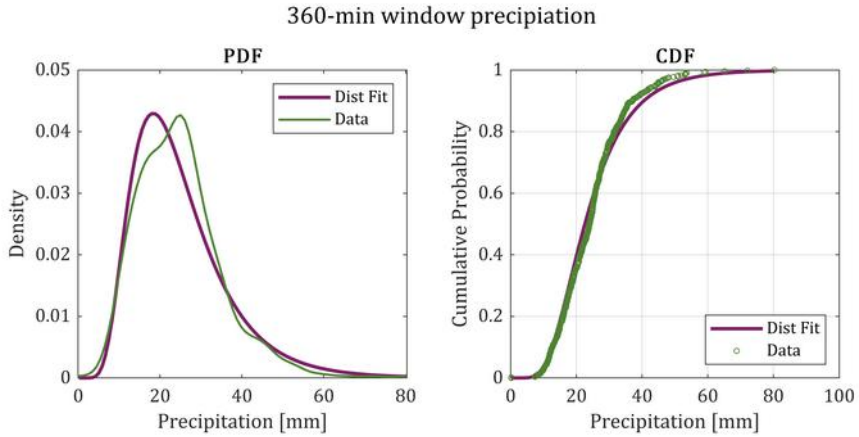
Marginal distributions



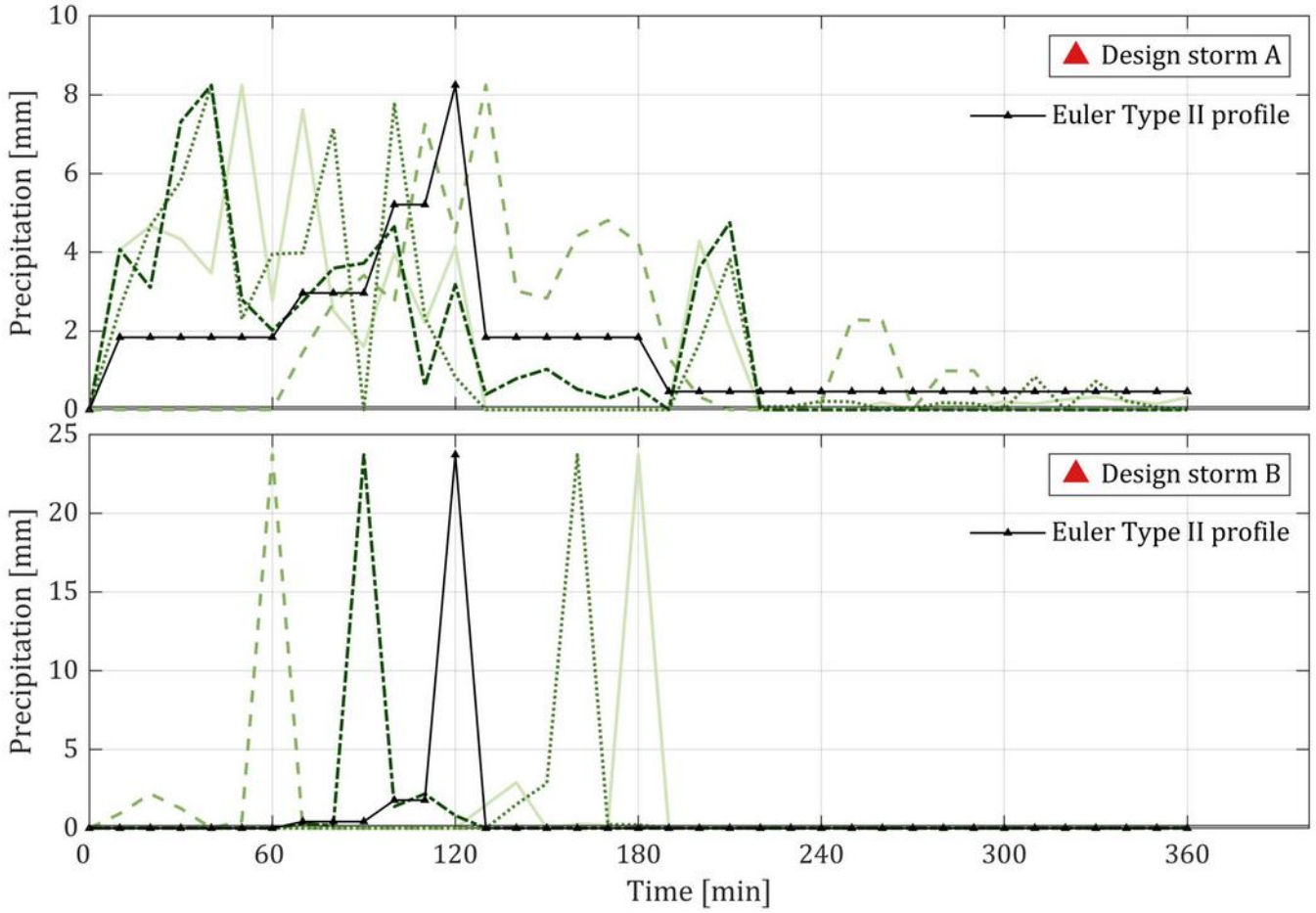




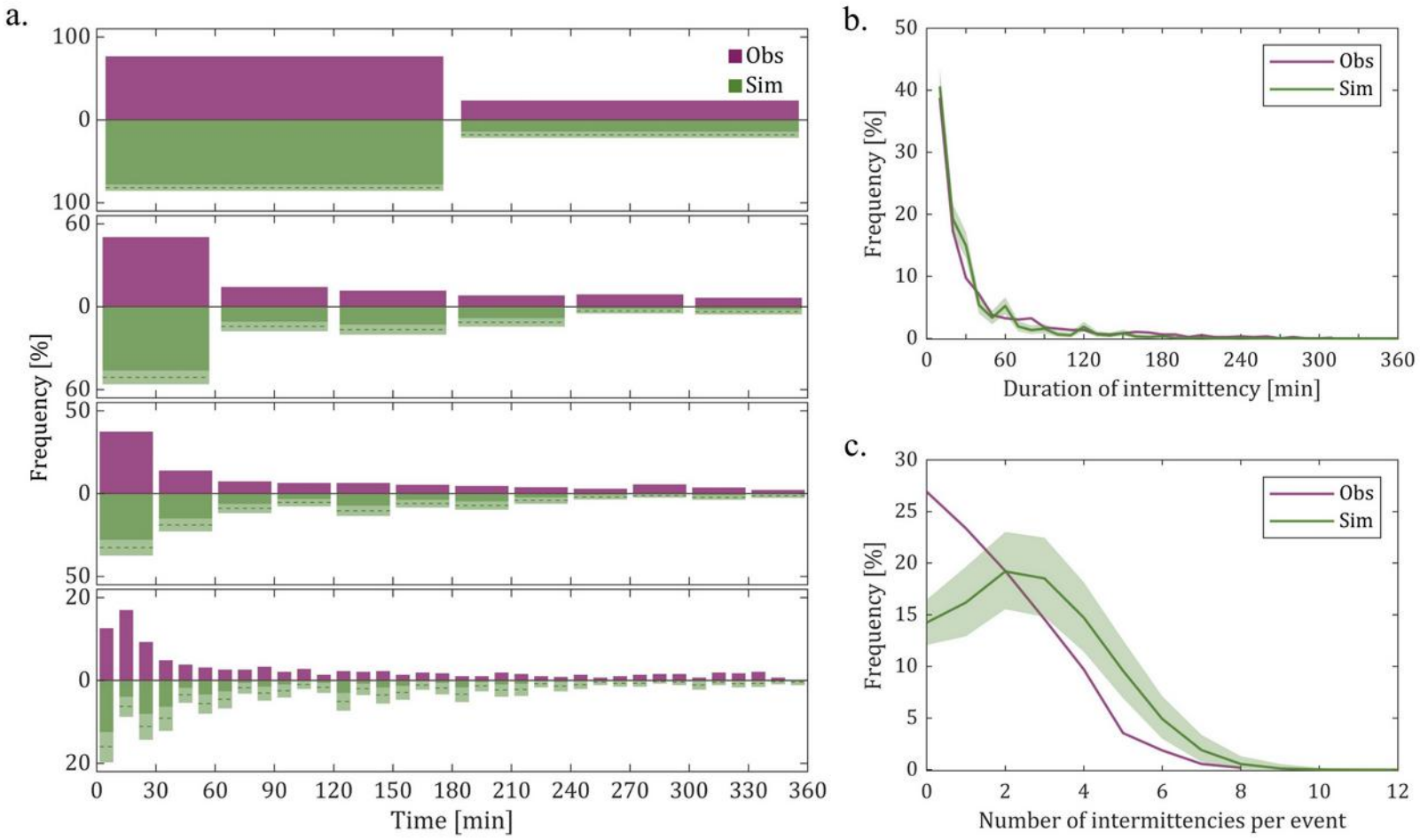




Euler Type II



Model validation



Relative difference of the total storm volume

	5-y			10-y			20-y			50-y			100-y		
	q_1	$\boldsymbol{\mu}$	q_{99}	q_1	$\boldsymbol{\mu}$	q_{99}	q_1	$\boldsymbol{\mu}$	q_{99}	q_1	$\boldsymbol{\mu}$	q_{99}	q_1	$\boldsymbol{\mu}$	q_{99}
10 min	-32	**42**	66	-13	**48**	62	-2	**52**	62	16	**56**	61	23	**56**	59
30 min	-36	**31**	45	-22	**34**	42	-7	**35**	39	7	**35**	36	15	**34**	34
60 min	-42	**26**	36	-22	**30**	34	-2	**31**	32	16	**30**	30	20	**29**	29
180 min	-32	**16**	19	-17	**17**	18	-6	**17**	18	5	**17**	18	15	**17**	17
360 min	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0