

# Design flood estimation in ungauged basins: Probabilistic extension of the design storm approach

European Geoscience Union – General assembly 2016

Precipitation: from measurement to modelling and application in catchment hydrology

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# The design flood problem in ungauged basins

**Problem:** Determining design floods  $q_T$  of specific return periods  $T$

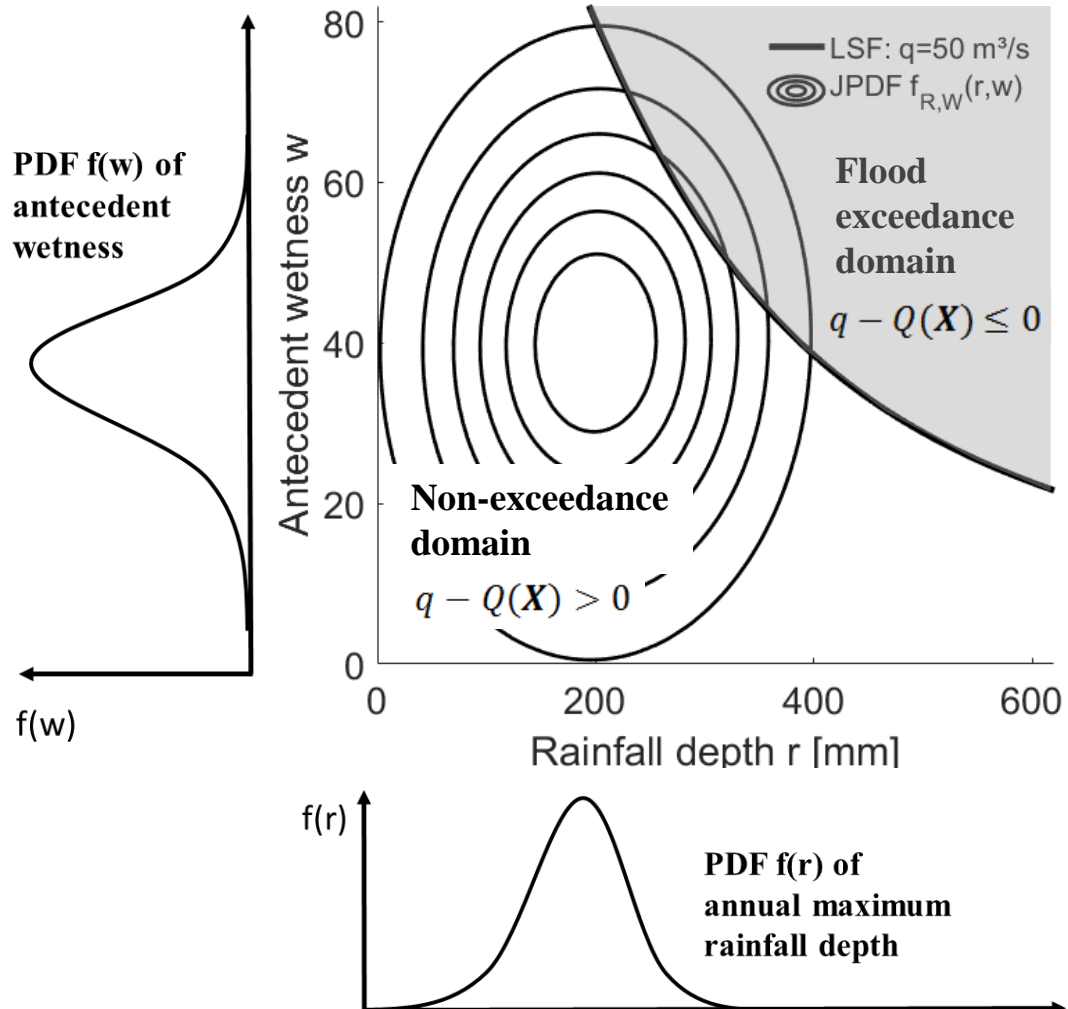
# Including additional parameter uncertainties

**Task: Determine flood exceedance probability**

$$\Pr(Q(X) > q) = \Pr(q - Q(X) \leq 0)$$

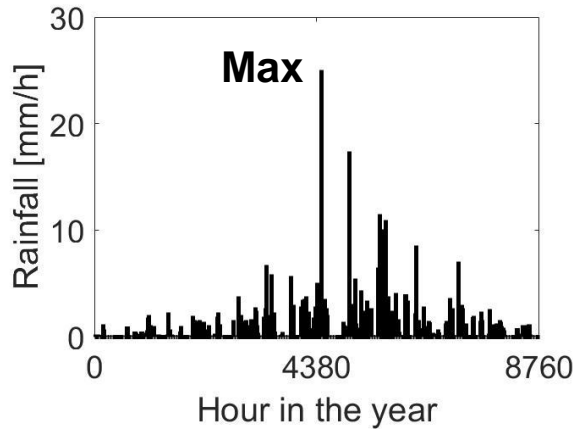
**Limit State Function (LSF):**

$$g(q, Q(X)) = q - Q(X)$$

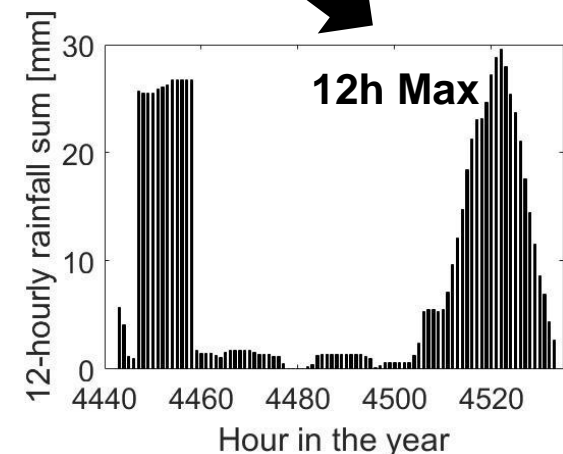
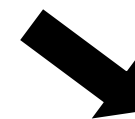
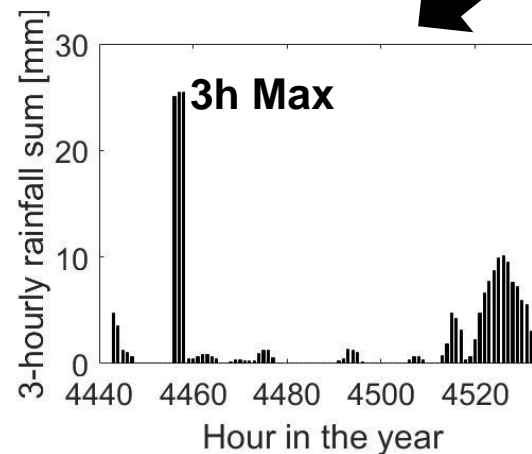
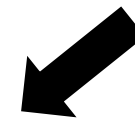
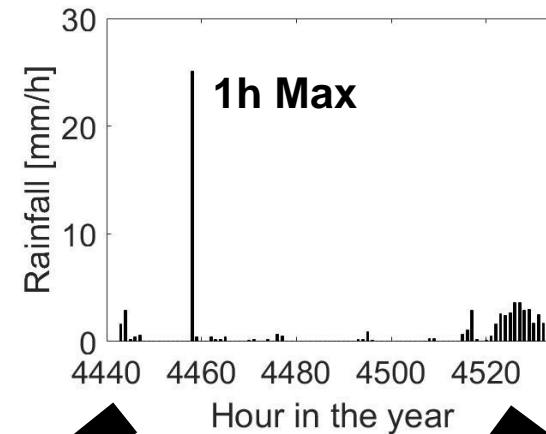


# Statistical analysis of rainfall data: Moving window

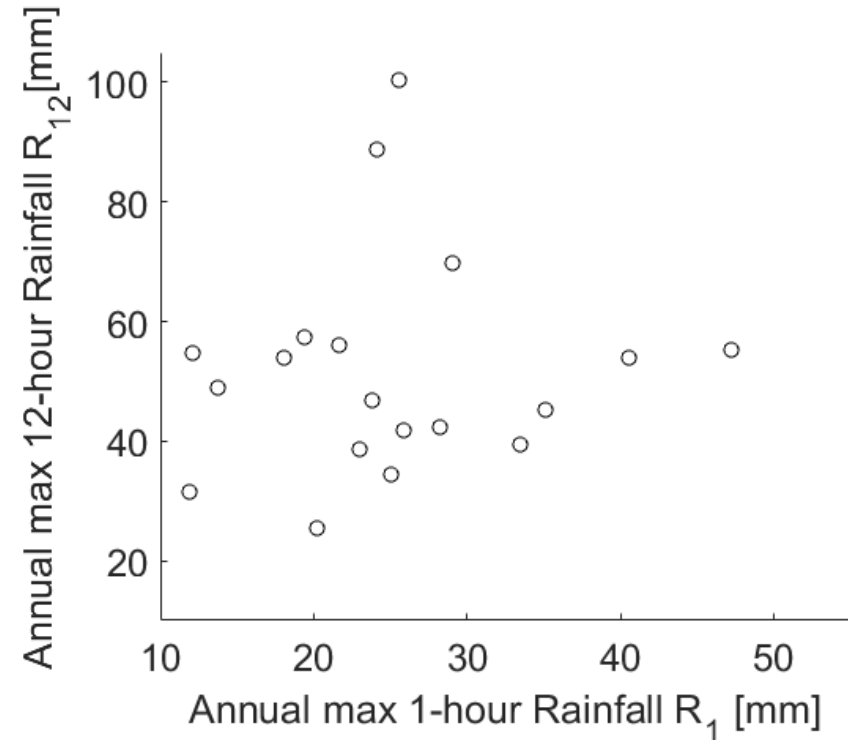
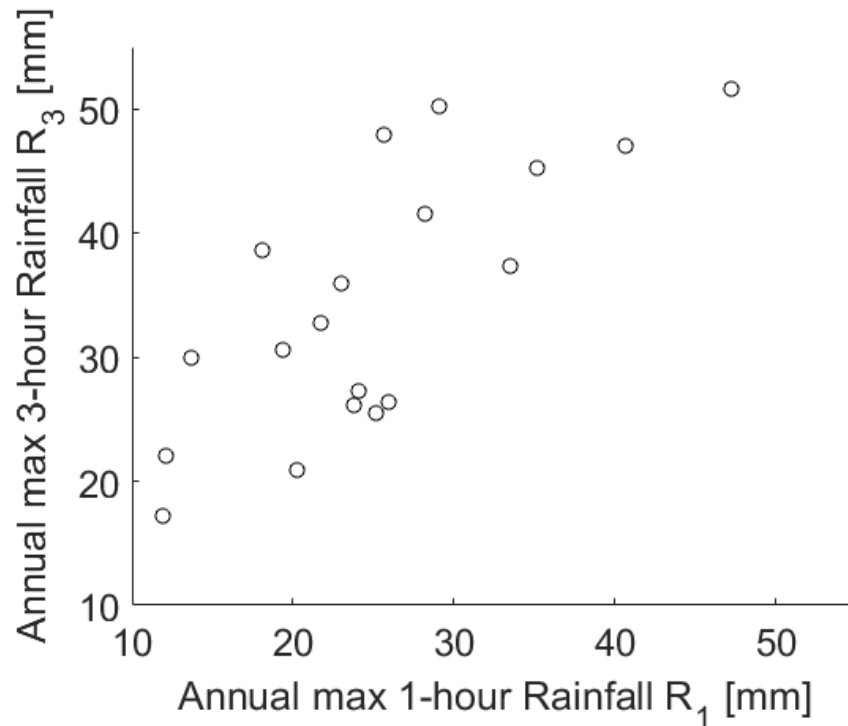
Hourly rainfall data for one year



Zoom at maximum



## Scatter of annual maximum rainfalls of different durations

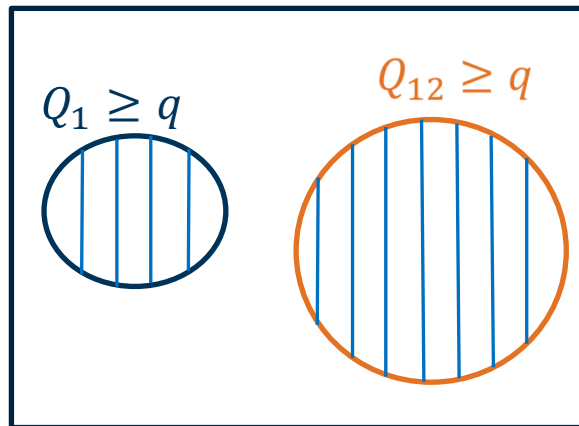


Annual max 1- and 3-hour rainfall: Strong correlation

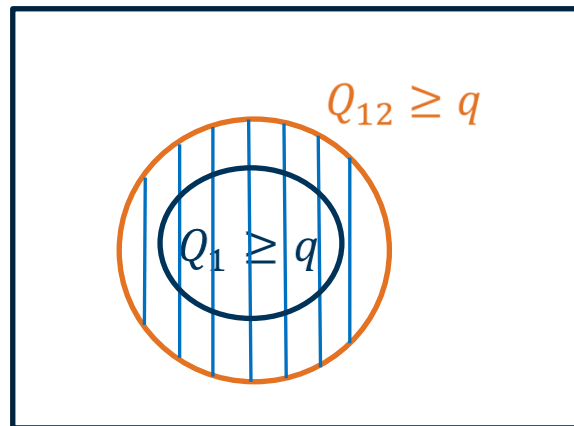
Annual max 1- and 12-hour rainfall: Weak correlation

# Influence of rainfall correlation on flood probabilities

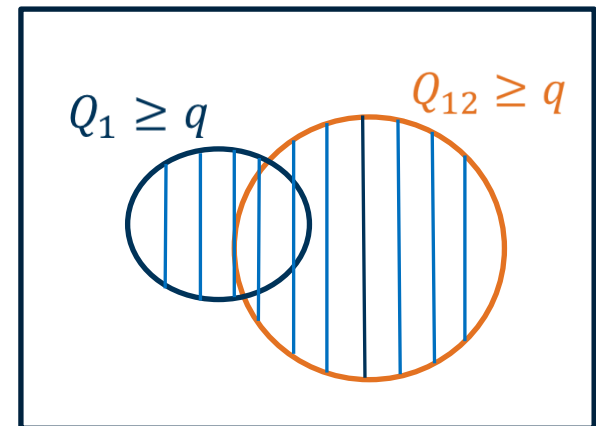
Transformation of rainfall into discharge:  $R_1 \rightarrow Q_1, R_3 \rightarrow Q_3, R_{12} \rightarrow Q_{12}, \dots$



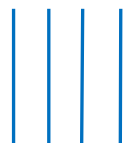
Mutually exclusive events



Fully dependent events

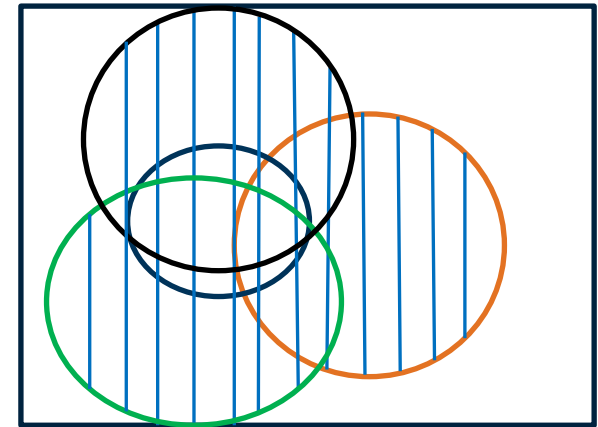


Reality is in between

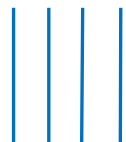


$$\Pr(Q \geq q) = \Pr((Q_1 \geq q) \cup (Q_{12} \geq q))$$

# Influence of rainfall correlation on flood probabilities

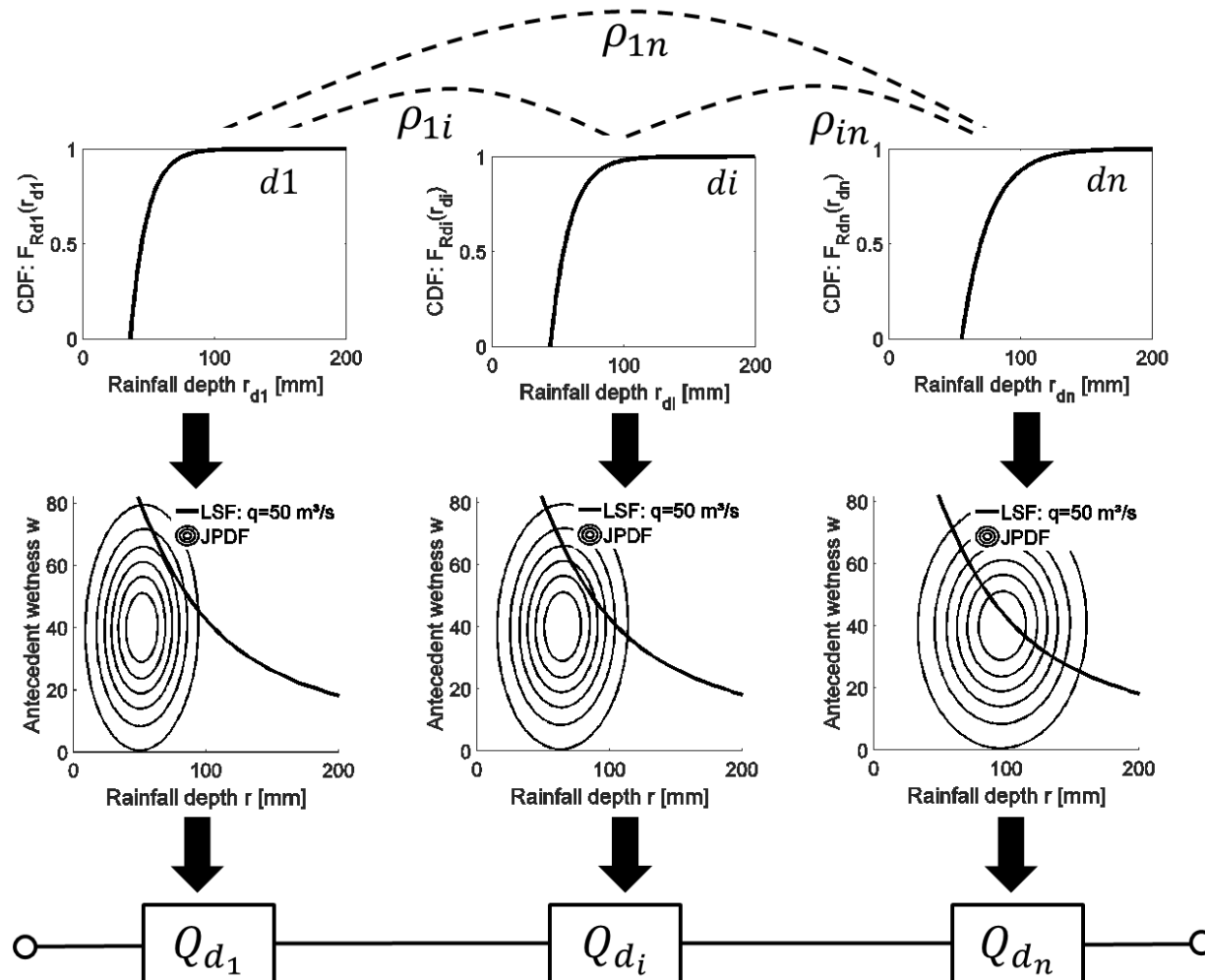


Multiple rainfall durations



$$\Pr(Q \geq q) = \Pr((Q_1 \geq q) \cup (Q_2 \geq q) \dots \cup (Q_n \geq q))$$

# Series system formulation of the design flood problem

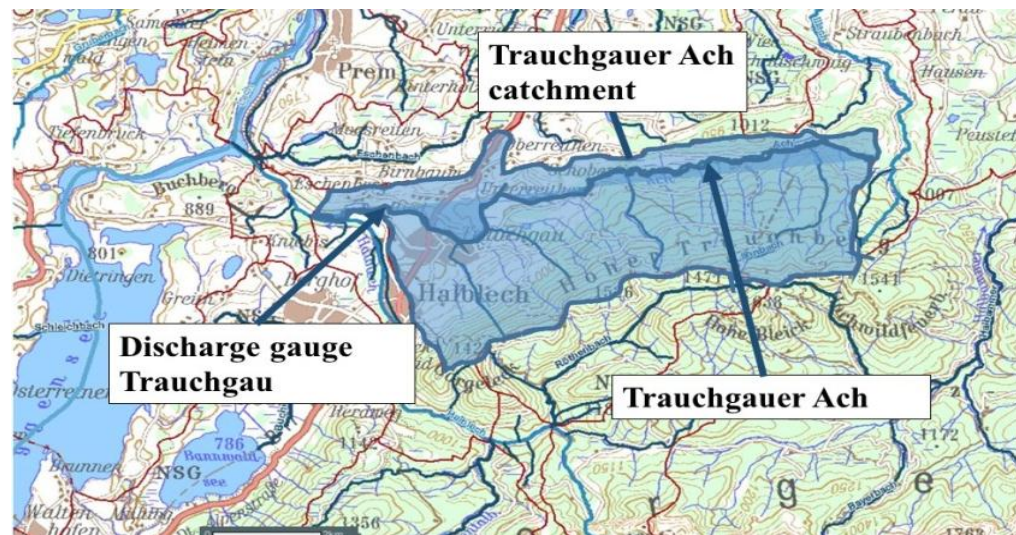




# Case study: Trauchgauer Ach

## Hydrological Models:

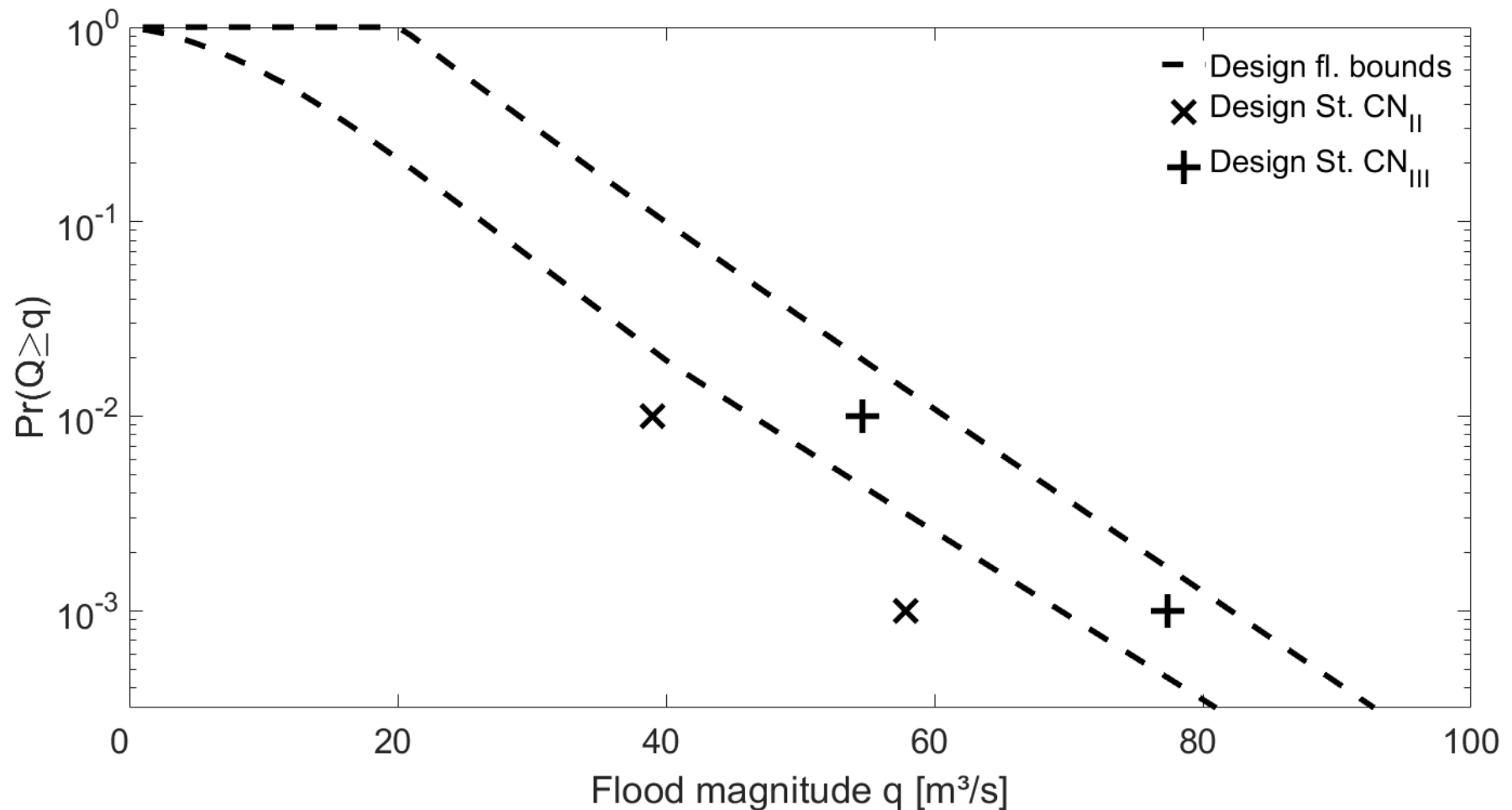
Soil Conservation Service (SCS) Curve Number (CN) approach  
 Unit Hydrograph after Wackermann<sup>2</sup> (1981)



Source: Kartendienst für Fließgewässer: Bayerisches Landesamt für Umwelt (LFU),  
 Adapted by Berk, M. 17.07.2015

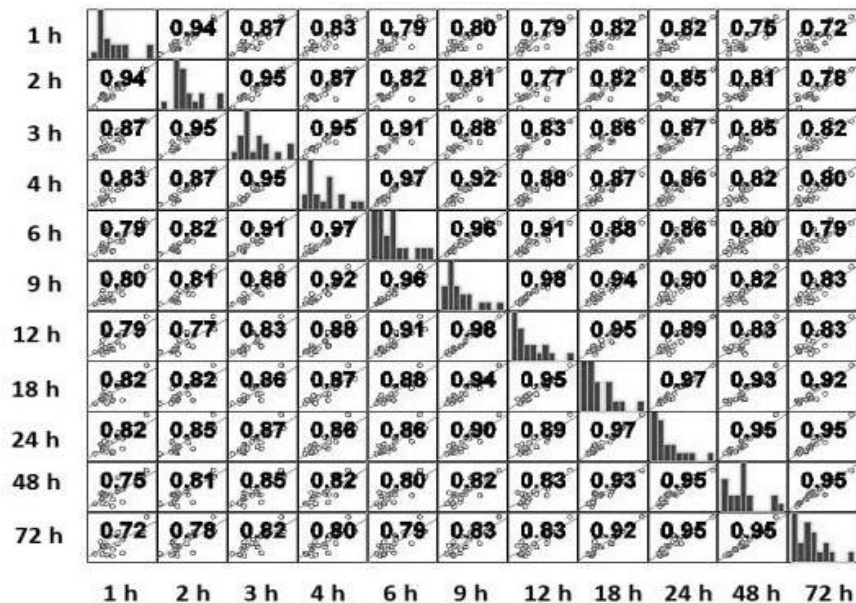
<sup>2</sup>Wackermann, R. (1981): Eine Einheitsganglinie aus charakteristischen Systemwerten ohne Niederschlag-Abfluss-Messungen. In *Wasser und Boden* (H 1), pp. 23–28.

# Results of flood frequency estimation

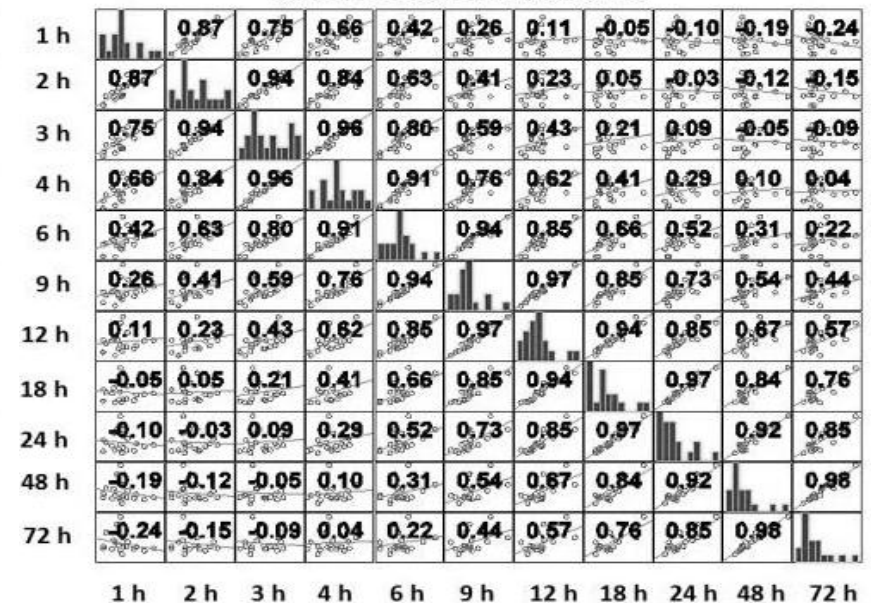


# Correlation Analysis: Rainfalls of different durations

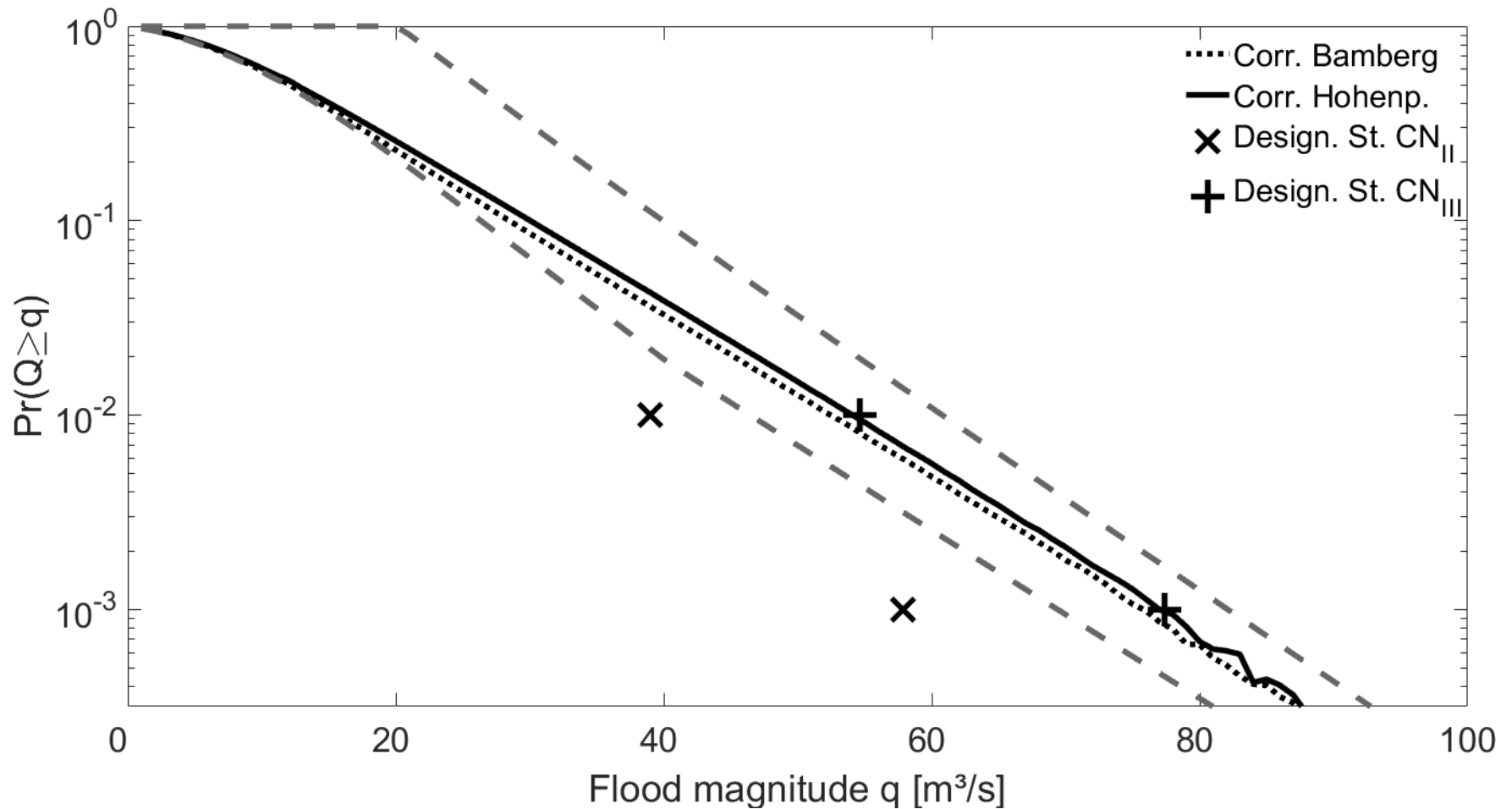
## Bamberg



## Hohenpeißenberg



# Results of flood frequency estimation



## Conclusions

- Methodology accounts for additional parameter uncertainties
- The effect of multiple rainfall durations is incorporated
- Influence of different rainfall durations depends on correlation
- Traditional design storm method underestimates design floods when using  $CN_{II}$
- To be submitted: Berk, M.; Špačková., O; Straub, D.: Design Flood Estimation in ungauged catchments Including Parameter Uncertainties And Multiple Rainfall Durations

# Thank you for your attention!

## And now: Questions...

Design flood estimation in ungauged basins: Probabilistic extension of the design storm approach

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