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CHR Workshop on Extreme Discharges
April, 18-19, 2005, Bregenz

Extreme Scenarios and Flood Risk Management

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Contents

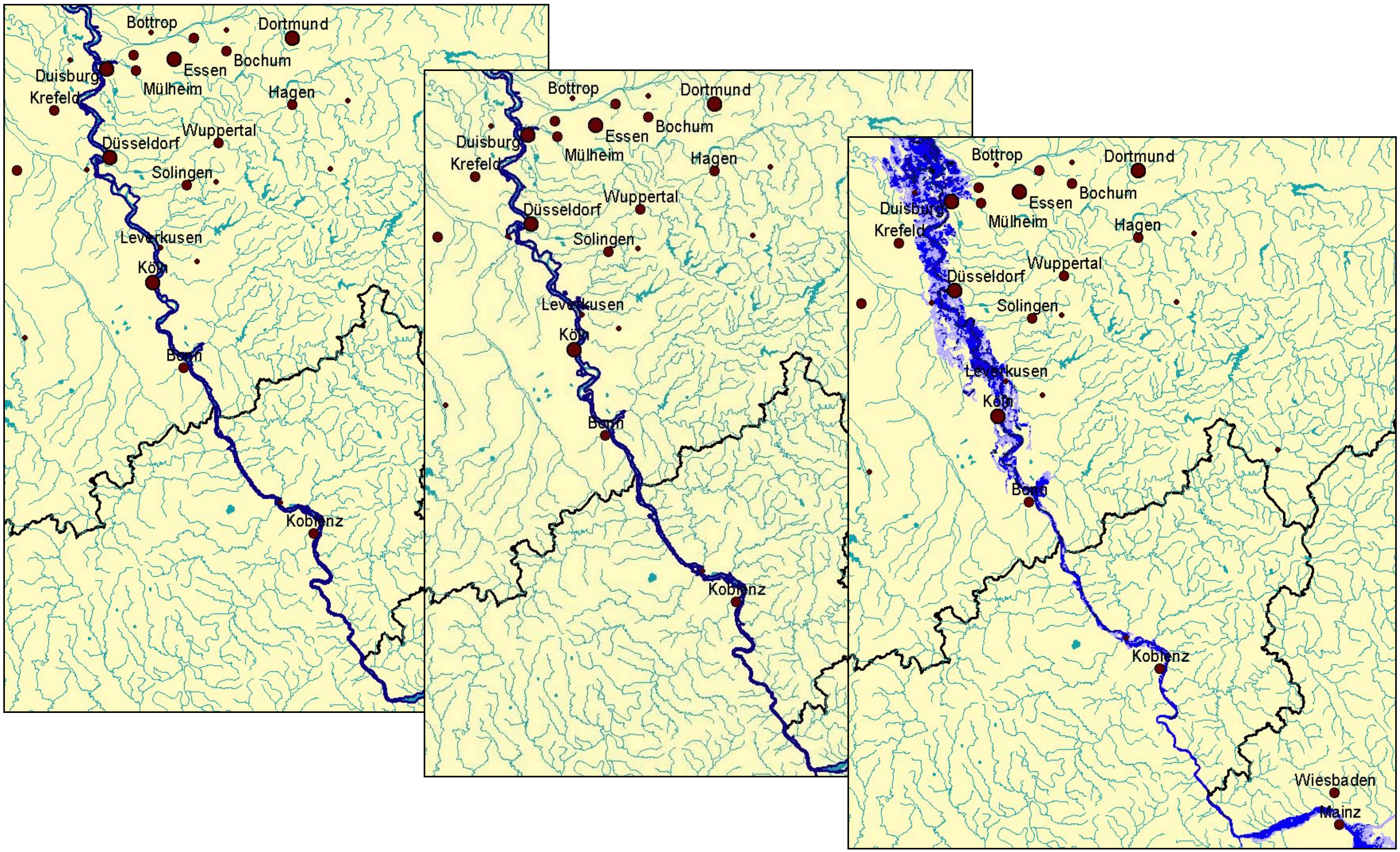
- Which extreme scenarios are of interest ?
- How should extreme scenarios be considered in flood risk management ?
- How can extreme scenarios be quantified ?
- How can extreme scenarios be validated ?

Who needs which (extreme) scenarios ?

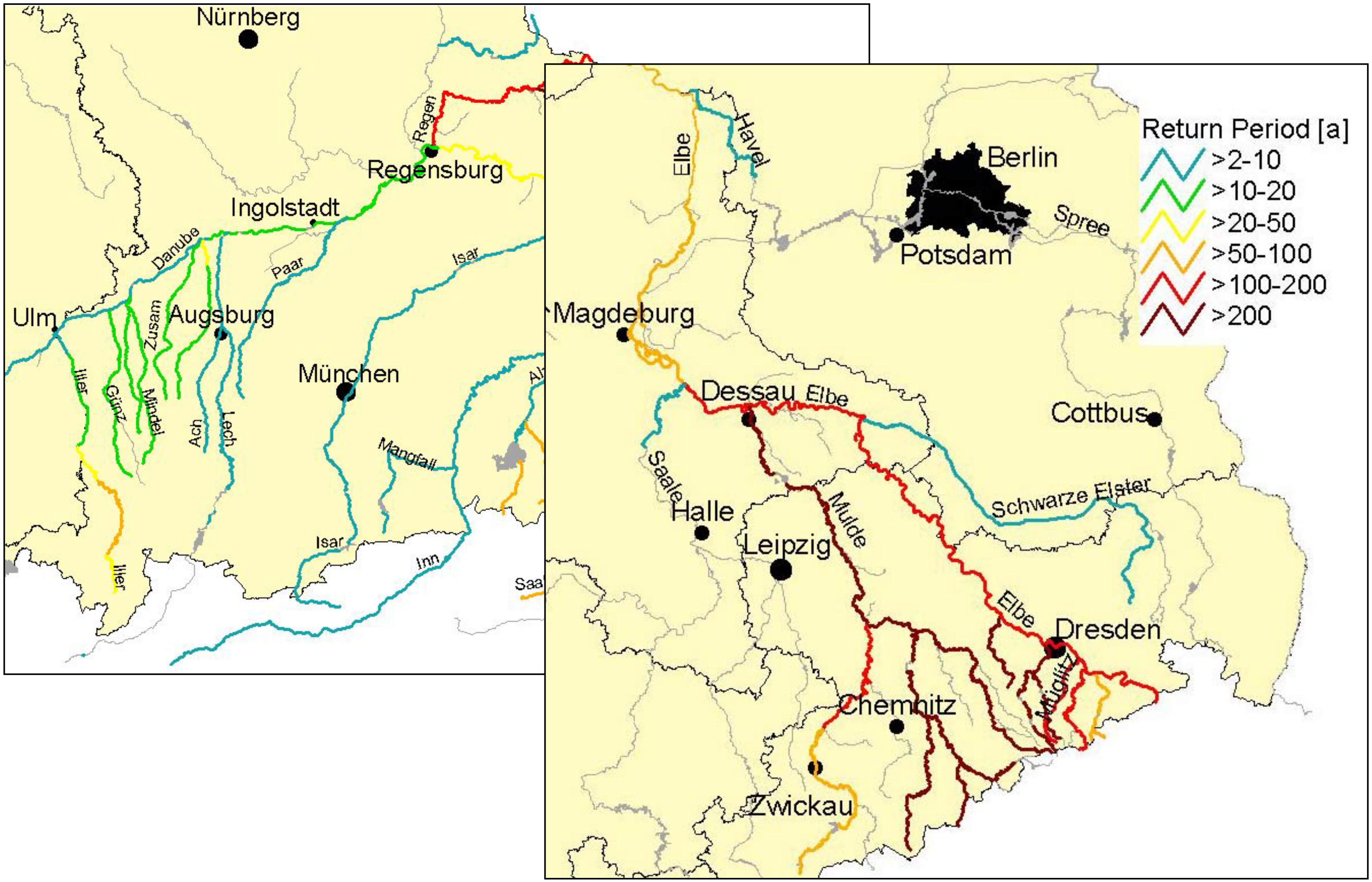
Use	**Required Information**
Flood design for dams	Site-specific statements about extreme discharges / hydrographs, e.g. 10000-year flood
Building insurance	Building-specific statements about flood hazard, e.g. 10 – 200-year floods
Re-insurance	Probable Maximum Flood, large-scale events
Local disaster management	Local scenarios including extraordinary situations and implications for disaster management, e.g. disruption of infrastructure
Federal disaster management	Large-scale, extraordinary scenarios that cannot be handled by regional agencies

Large-scale flood scenarios
Example ICPR Rhine Atlas

T = 10 a | T = 100 a | extreme flood event



Spatial heterogeneity of flood events
Example August flood 2002



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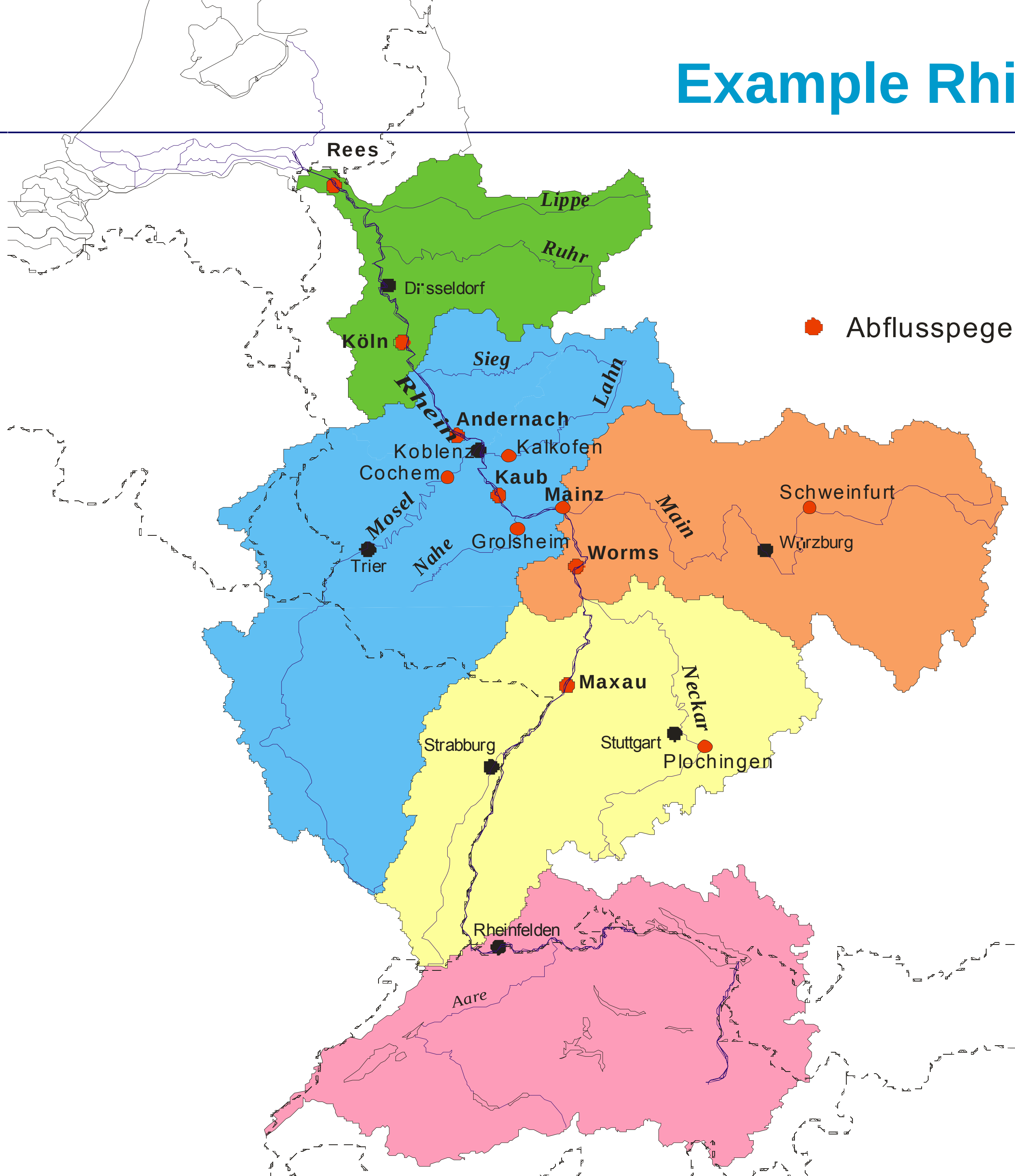
Example Rhine basin



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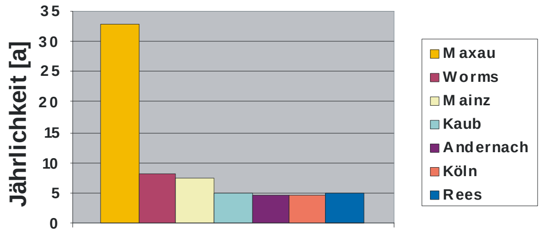
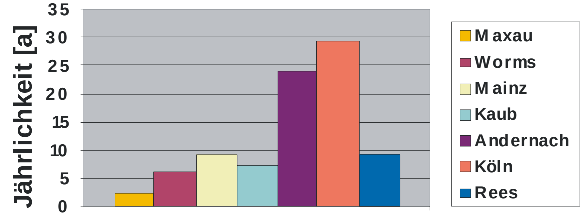
Variation of return period

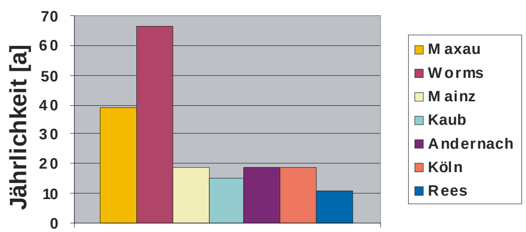
November 1944



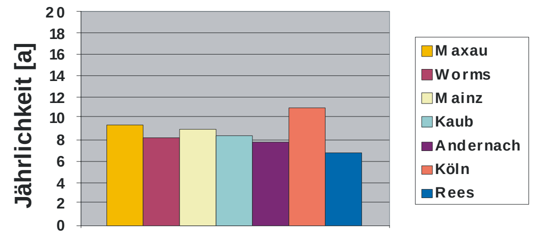
Januar 1948



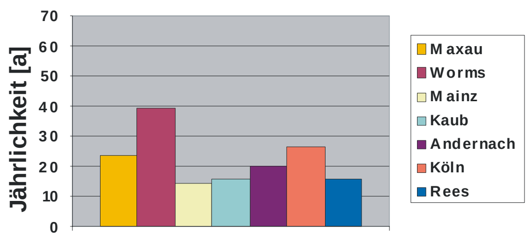
Januar 1955



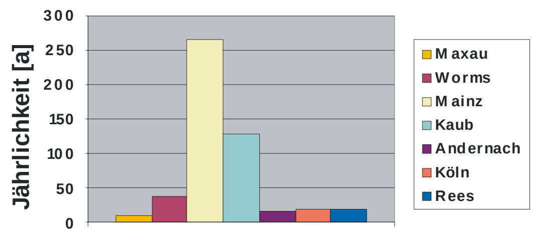
Februar 1980



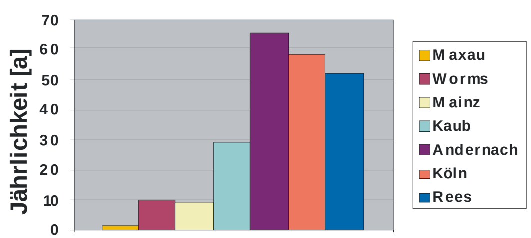
Mai 1983



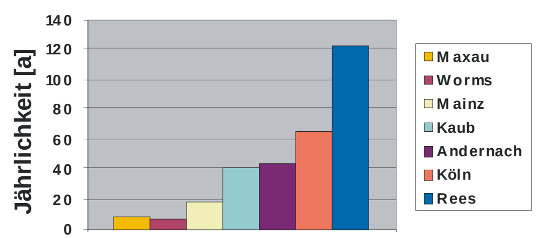
März 1988



Dezember 1993



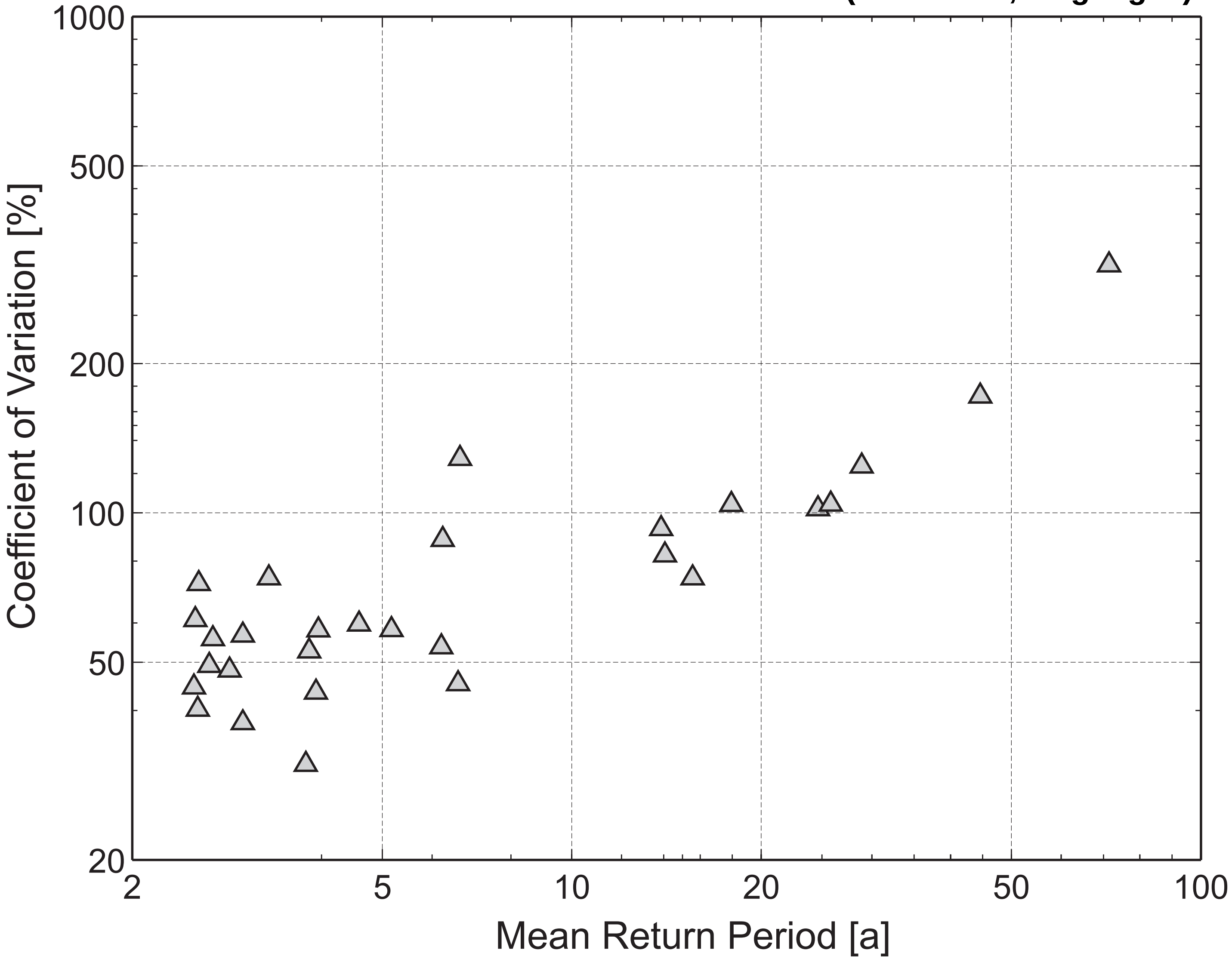
Januar 1995



Fluss	Pegel	Zeitreihe
Rhein	Maxau	1922-1999
Rhein	Worms	1937-1999
Rhein	Mainz	1931-1999
Rhein	Kaub	1931-1999
Rhein	Andernach	1931-1999
Rhein	Köln	1880-1999
Rhein	Rees	1931-1999
Neckar	Plochingen	1919-1999
Main	Schweinfurt	1845-1999
Nahe	Grolsheim	1845-1999
Lahn	Kalkofen	1936-1999
Mosel	Cochem	1901-1999

Variation of return period and „severity“ of floods

Data: 29 floods in the Rhine basin
(1940-1999, 12 gauges)



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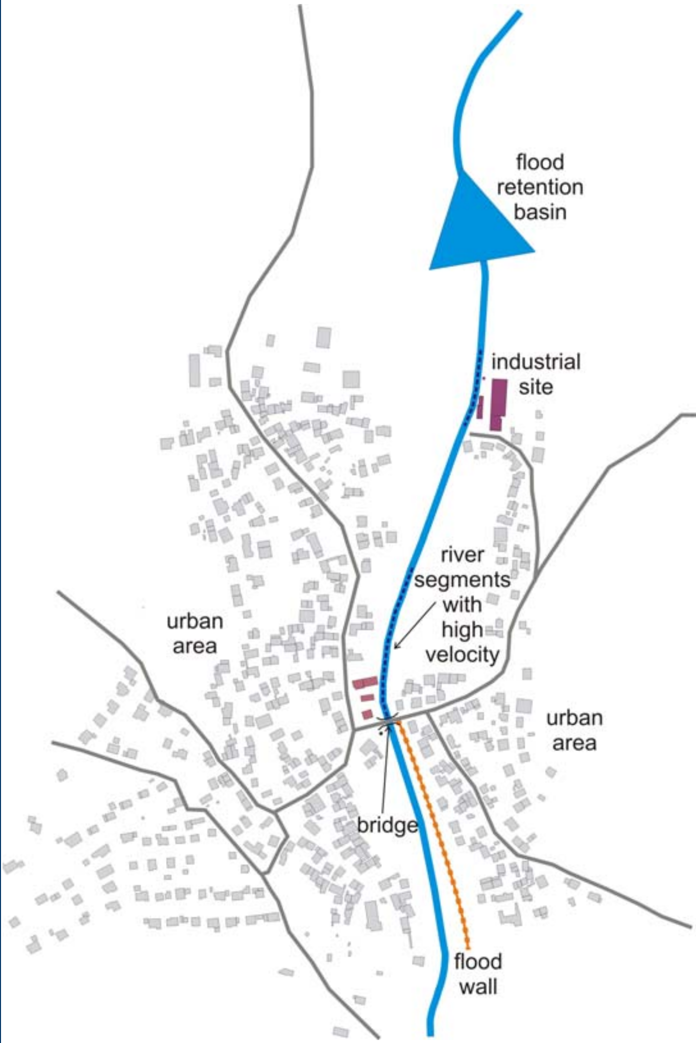
Unusual events, failure situations



Failure Modes and Effects Analysis (FMEA)

Component	Damage Cause	Consequences	Possible Countermeasures
Flood retention basin	Volume of flood > available retention volume	Spillway discharges; moderate inundations downstream (industrial site, urban area)	Monitoring and early warning; damage-reducing measures downstream, e.g. mobile flood walls for particularly vulnerable objects
Flood retention basin	Volume of flood > available retention volume Flood peak > spillway capacity	Overtopping of dam; possibly dam break; severe inundation downstream	Monitoring and early warning; damage-reducing measures downstream, e.g. evacuation
Flood retention basin	Obstruction of the outlet due to sediment, driftwood etc.	Spillway discharges; moderate inundations downstream	Monitoring and clearance operations during floods
Industrial site	Inundation causes release of chemicals	Pollution downstream of chemical release	Flood proofing of chemical storages
Bridge (urban area)	Obstruction of the profile due to driftwood etc.	Backwater effects; local inundation in urban area	Monitoring and clearance operations during floods
Flood wall (urban area)	River water level > height of wall	Inundation in urban area	Damage-reducing measures in the urban area
Private households (urban area)	Leakage of flooded oil fuel storages due to buoyancy	Contamination in the respective household and in its neighbourhood	Flood proofing of oil fuel storages
River segments with high velocity in case of flood (urban area)	Erosion of river bed	Damage to foundation of buildings; loss of structural stability	Protection of erosion-prone river segments

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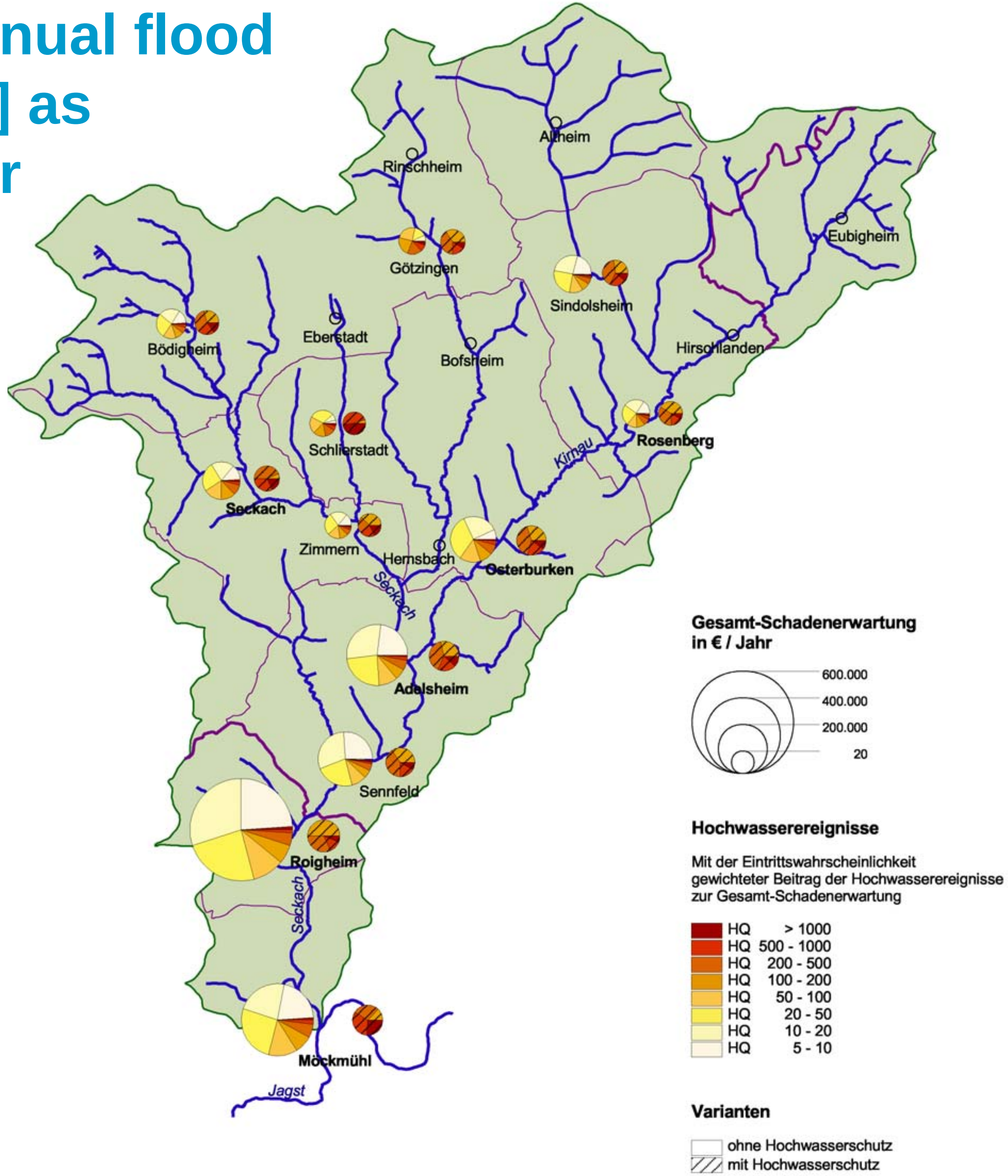
Expected annual flood damage [€/a] as risk indicator



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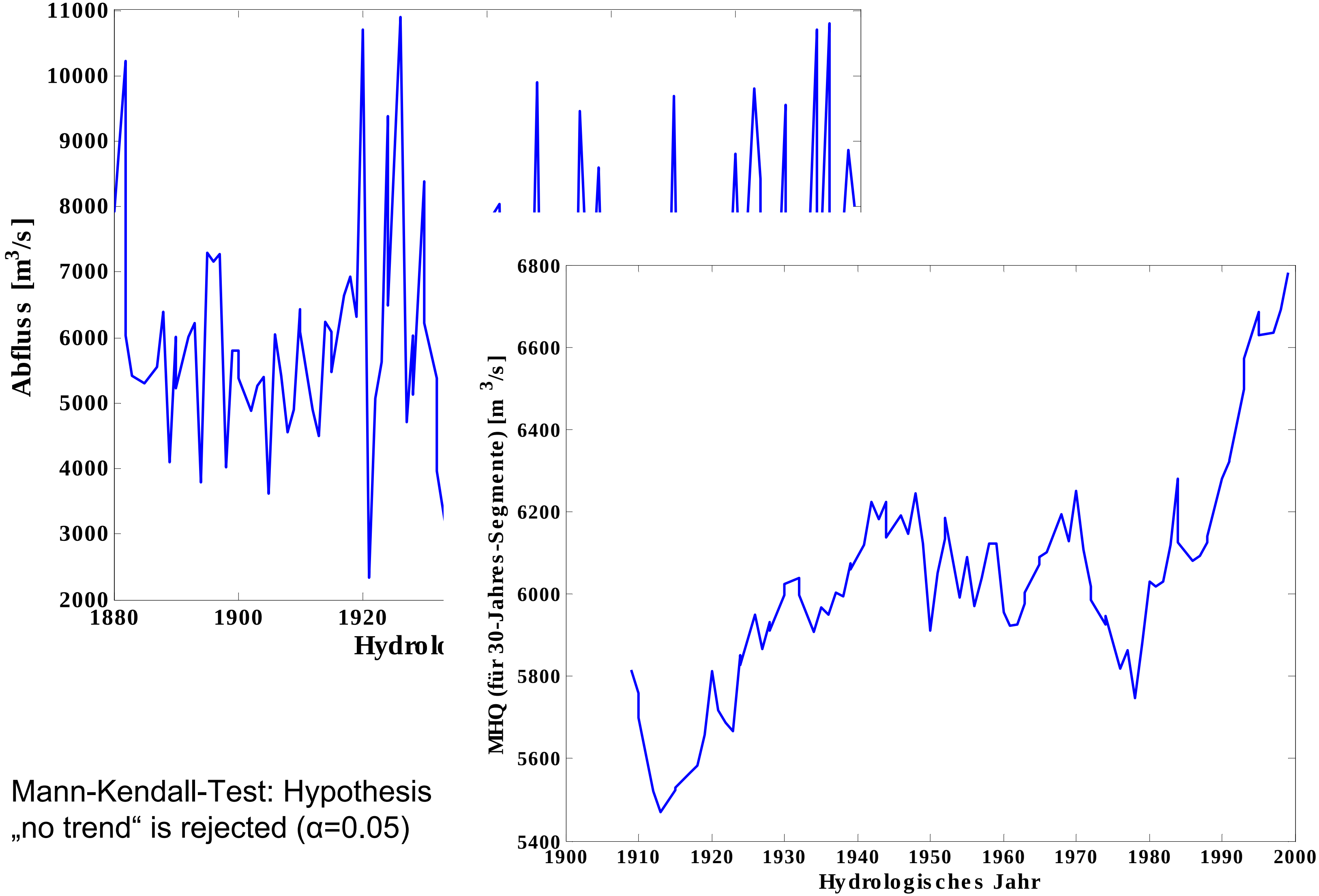
Flood frequency analysis and uncertainty

Annual maximum flood, 1880-1999, gauge Köln/Rhine



Mann-Kendall-Test: Hypothesis
„no trend“ is rejected (α=0.05)

Consideration of uncertainty

- **2 time periods:**
  1880-1999, 1960-1999

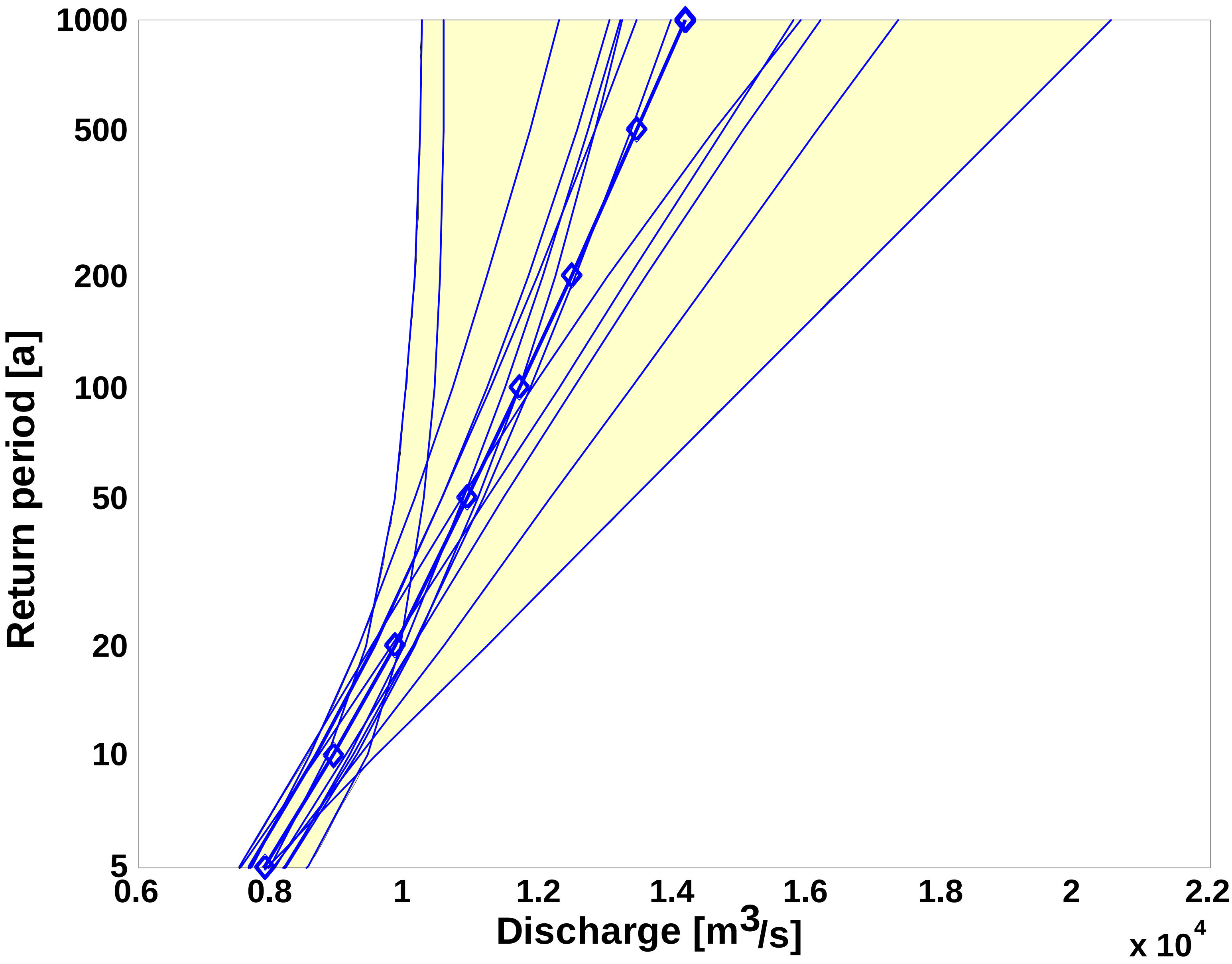
- **7 distribution functions:**
  Generalised Extreme Value, Gumbel, Log Pearson Typ 3, 3-parametric Lognormal, General Logistic, Exponential, General Pareto distribution

- **goodness-of-fit test:**
  Kolmogorow-Smirnow (α=0.05)

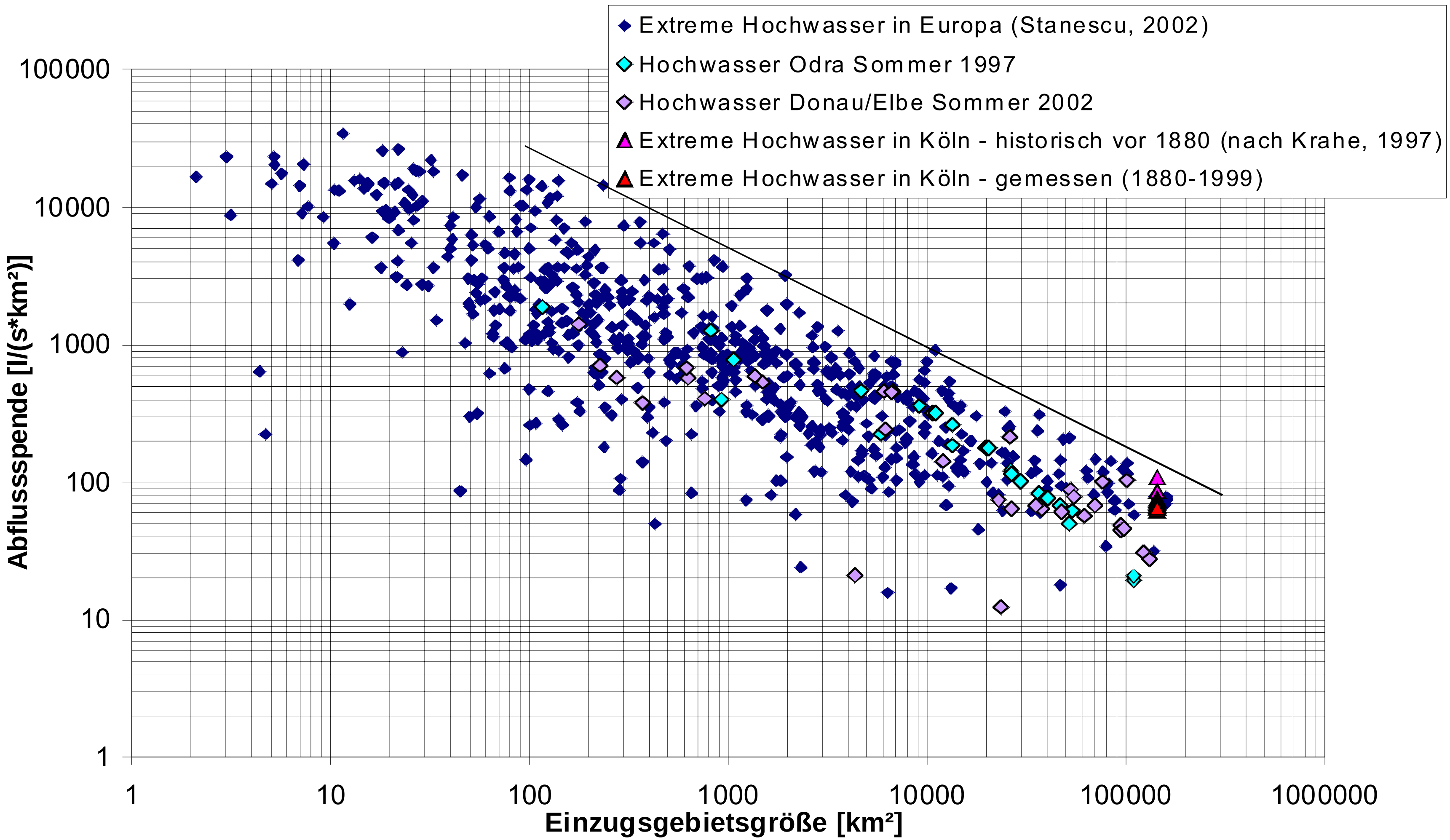
- **Probability bounds as uncertainty estimation:**
  Envelope, including all cdf that are not rejected

- **Best estimate:**
  weighted flood frequency curve (weights based on agreement between empirical and theoretical values)

Uncertainty of extrapolation



Additional information



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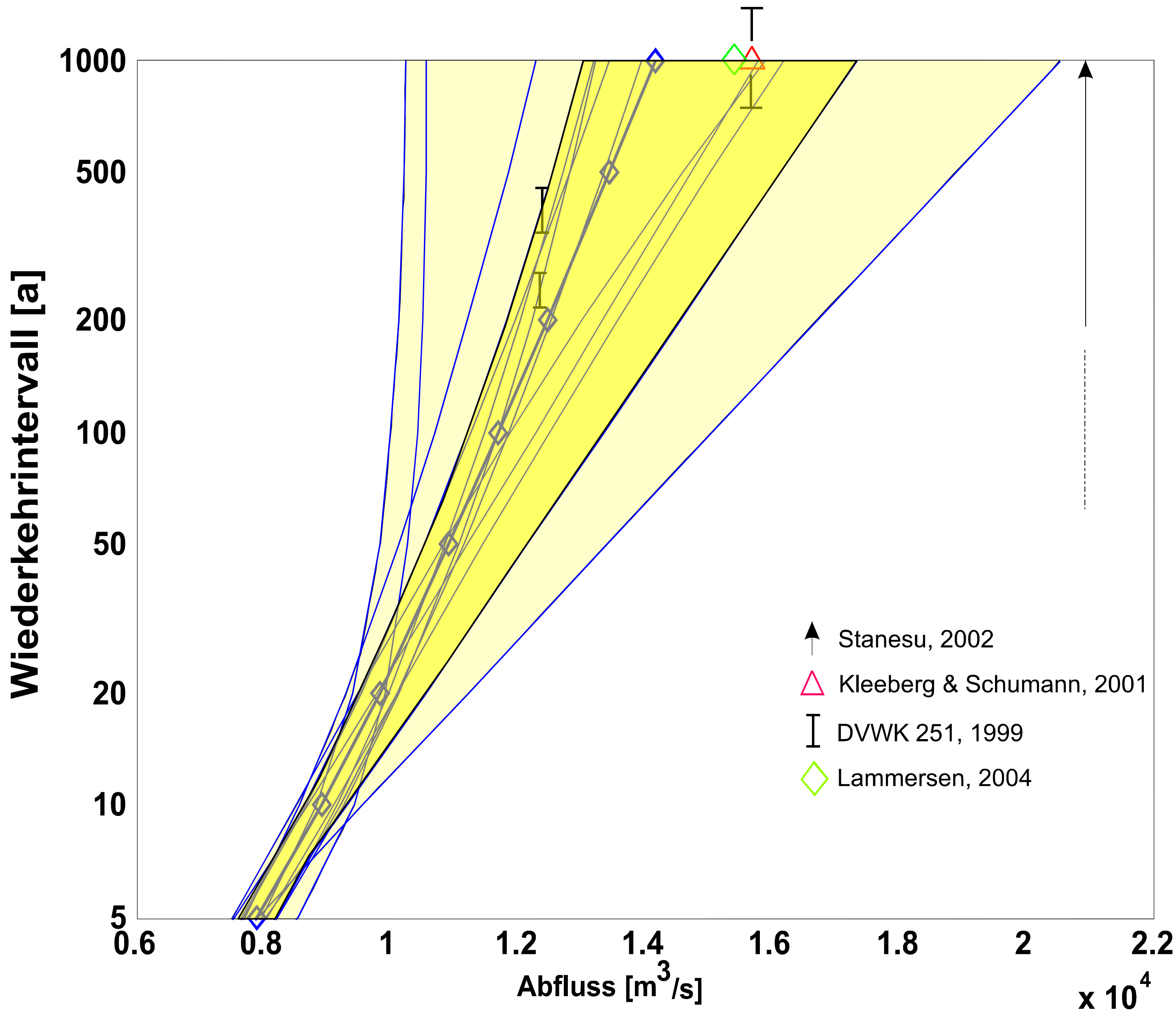
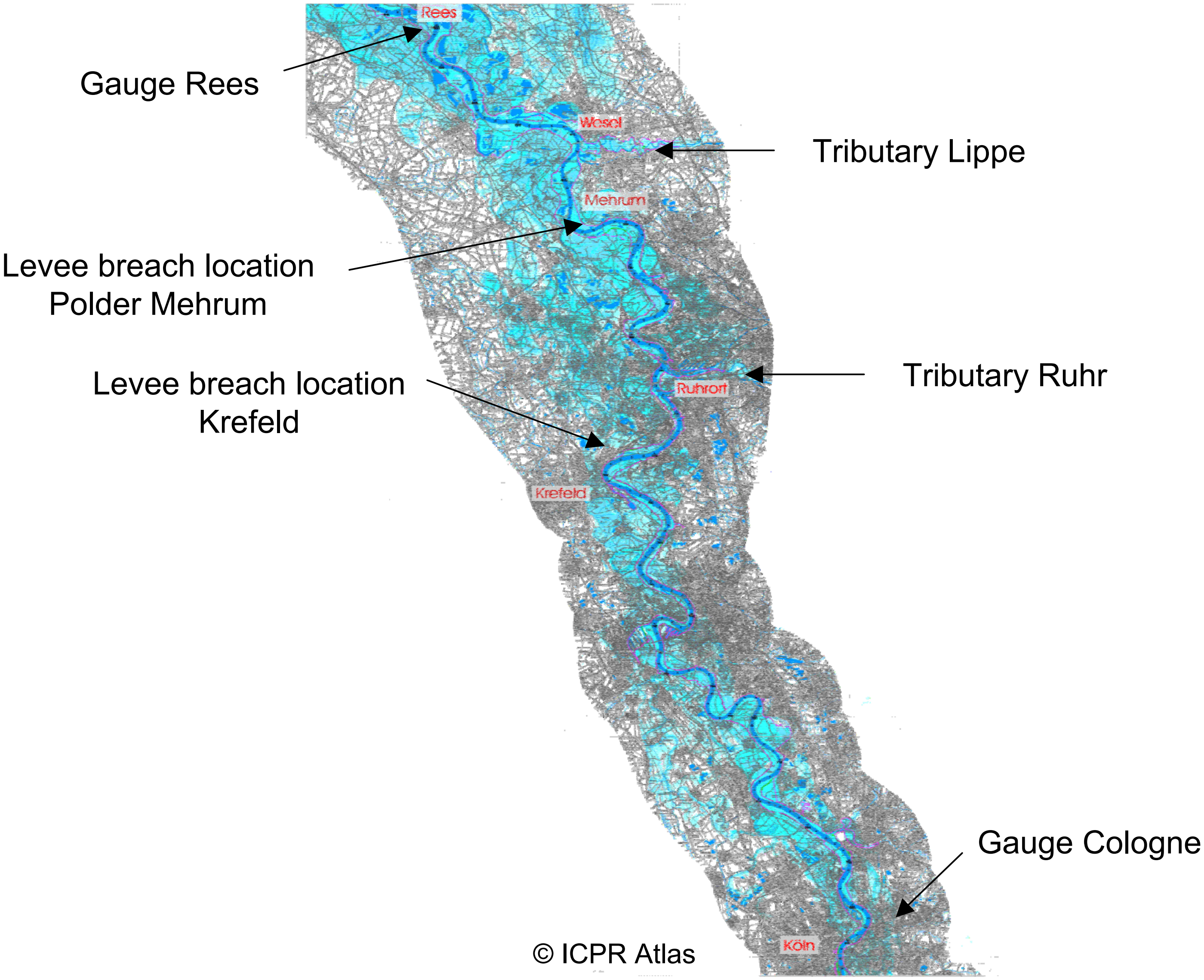
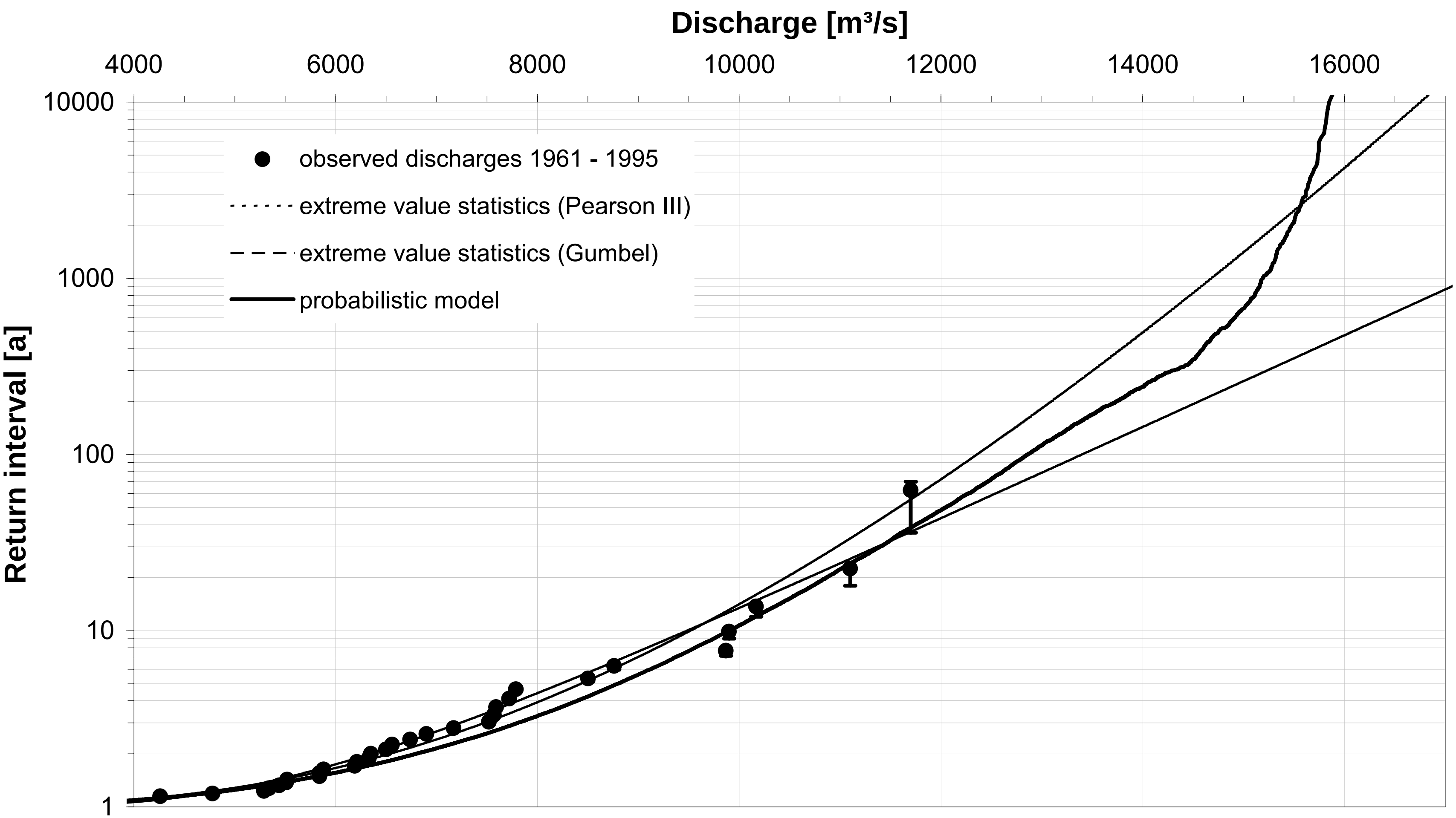
Flood frequency analysis and additional information



Linking process simulation and probabilistic methods (Example Lower Rhine)



Flood Frequency Curve Gauge Rees



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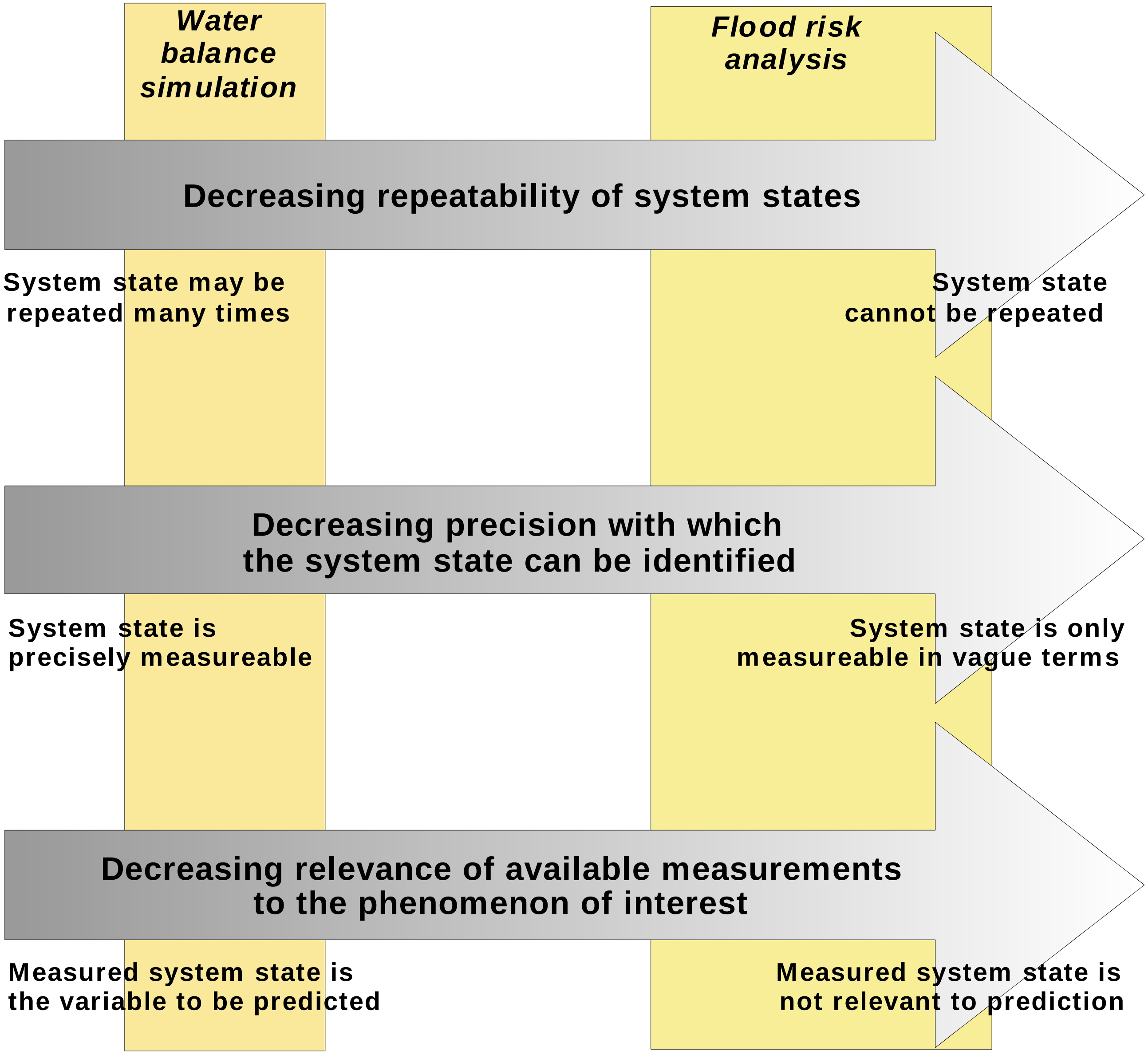
Possibilities for validation



(Hall & Anderson, 2002, Blockley, 1980, modified)

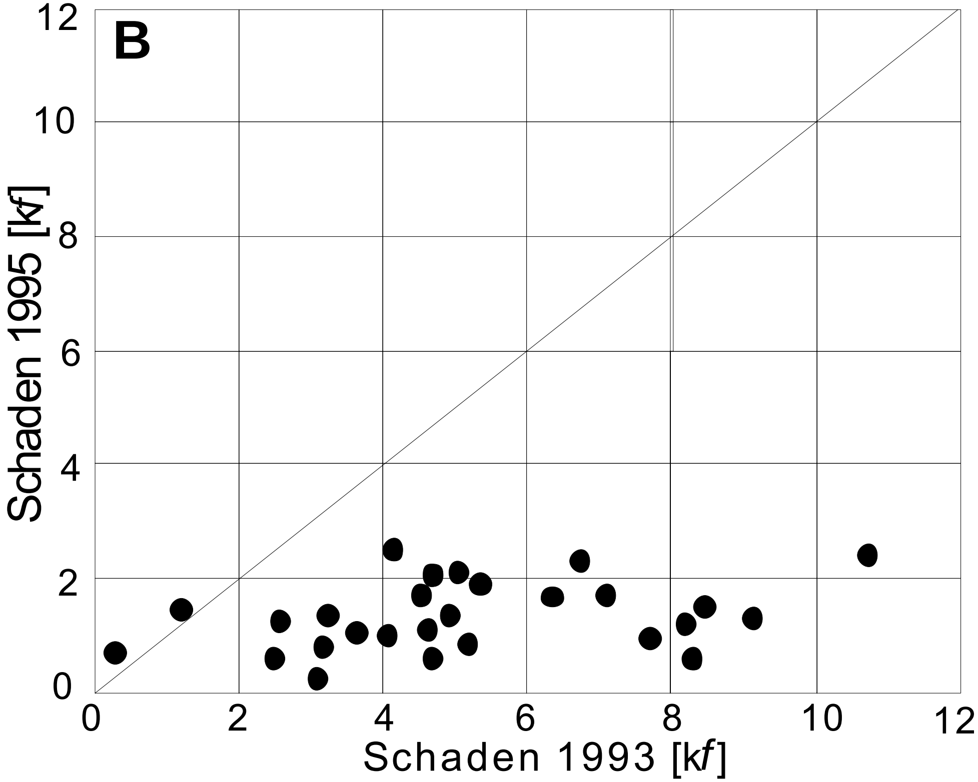
Some aspects concerning model validation for extreme flood scenarios

- Possibilities for “validation”:
  - Sensitivity analysis to identify important input / processes
  - Probabilistic analysis to identify the effects of uncertainty on model results
  - Comparison of alternative models
  - Reporting on model assumptions and uncertainty
- Optimistic models may be dangerous
- Be aware: we tend to overestimate our knowledge

Conclusions

- Lack of certain types of extreme scenarios:
  - Large-scale flood events
  - Unusual events, failure situations (blockage of weirs, human error in emergency management, etc.)
- Use of extreme scenarios in flood risk management:
  - Risk awareness, ‘low frequency – high damage’ events
- Quantification of extreme scenarios:
  - Integration of different sources of information (historical events, formal expert knowledge, etc.)
  - Linking of process understanding and probabilistic methods
- Lack of methods for validation in data-sparse situations

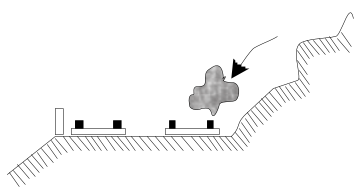
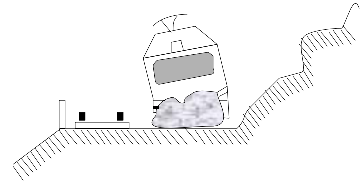
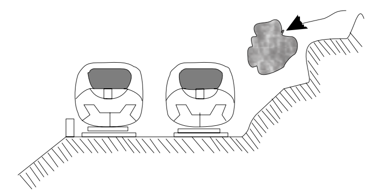
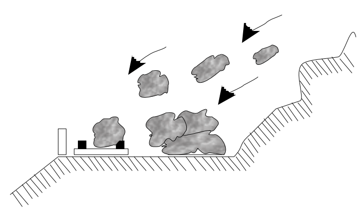
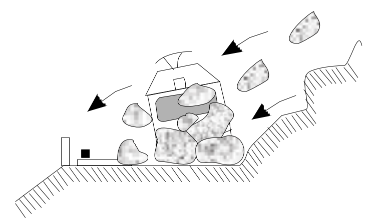
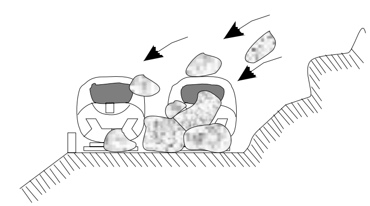
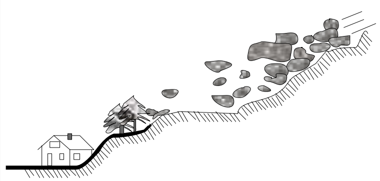
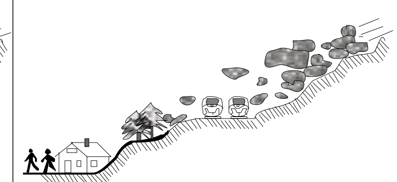
Definition of ‘extreme events‘



Community damage (household inventory) Meuse floods
Wind et al., 1999

- Extreme events are inherently contextual
- Extreme means ‘something rare, big, different’
- ‘Extremeness’ implies an event’s behavior to cause change
  (Sarewitz & Pielke, 2000)

Choice / development of scenarios

	Schweregrad		
Eintretenswahrscheinlichkeit	**Normaler Verlauf (95%)** Prozess verläuft, so wie man es auf Grund von Erfahrungen kennt. Alle Schutzmaßnahmen greifen. Die Einsatzkräfte können optimal eingesetzt werden. Keine Personen im Wirkungsraum.	**Schwererr Verlauf (4%)** Ausbreitung des Schadenprozesses weicht von den Erwartungen ab. Einzelne Schutzmaßnahmen funktionieren nicht. Erschwerte Einsatzverhältnisse. Unglücklich exponierte Personen werden erfasst.	**Katastrophaler Verlauf (1%)** Prozess verläuft sehr unüblich. Schutzmaßnahmen funktionieren nicht oder kommen zu spät. Schwierige Einsatzverhältnisse. Viele Personen exponiert und direkt betroffen (z.B. Direkttreffer)
Häufig Schlimmstes erlebtes Ereignis (einmal innerhalb von 10 bis 50 Jahren: Wahrscheinlichkeit für die nächsten 25 Jahre ca. 100%)			
Selten Schlimmstes Ereignis, an das man sich erinnern kann (einmal innerhalb von 50 bis 200 Jahren: Wahrscheinlichkeit für die nächsten 25 Jahre ca. 25%)			
Sehr selten Schlimmstes vorstellbares Ereignis (einmal innerhalb von einigen 100 Jahren: Wahrscheinlichkeit für die nächsten 25 Jahre ca. 2%)			

Bähler et al. (2001)