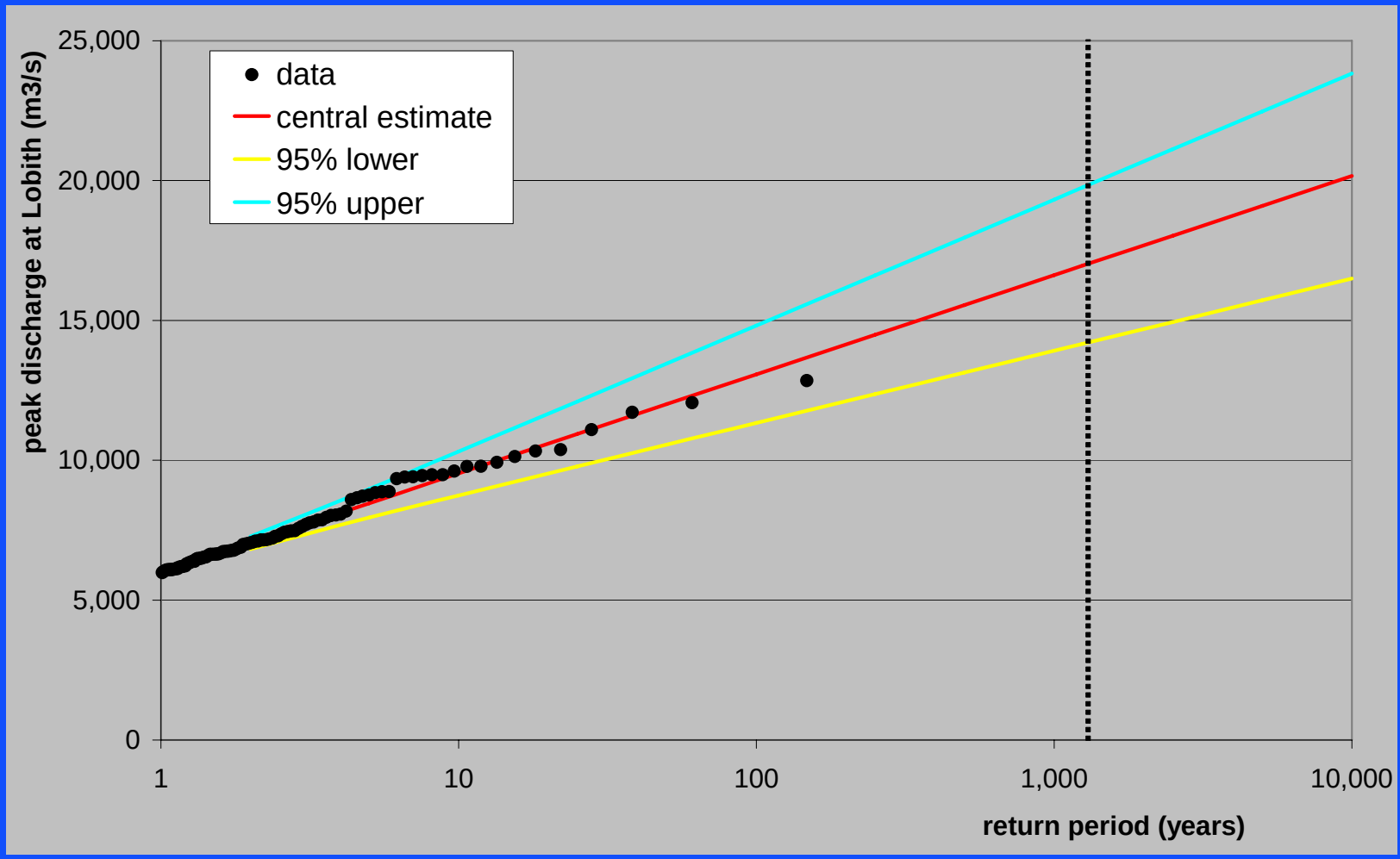
Uncertainty in flood quantiles from basin and river models

Ferdinand Diermanse (Delft Hydraulics)
Henk Ogink (Delft Hydraulics)
Hendrik Buiteveld (RIZA)

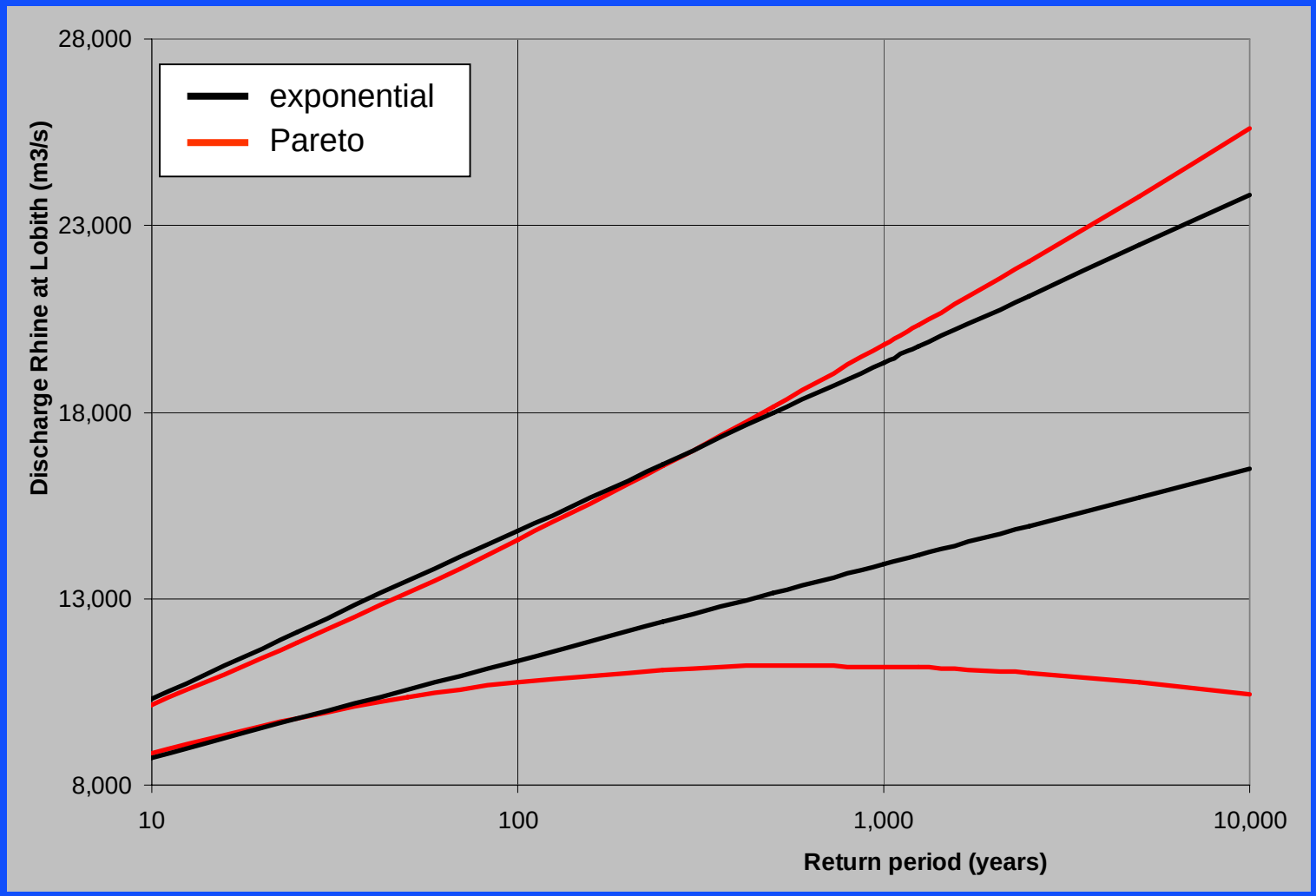
Background

- Current situation: flood frequencies of river discharges in the Netherlands derived by fitting extreme value distributions on observed discharges
- New (physically based) approach inititisated by RIZA (part of the Dutch Ministry for Transport, Public Works and Water Management)
- Contributions from other institutes, such as:
  - KNMI (Dutch meteorological Institute)
  - BfG (Bundesanstalt fur Gewasserkunde)
  - WL | Delft Hydraulics

Frequency distributions and uncertainties



Uncertainties in the uncertainties !!



Problem statement

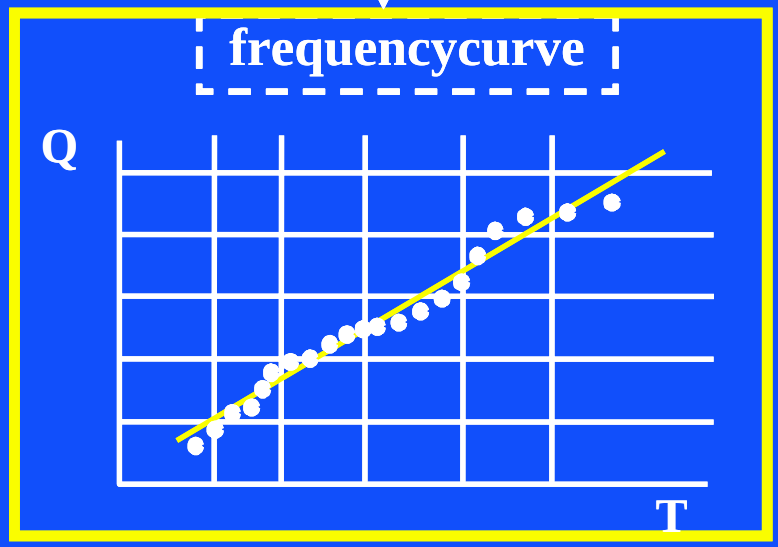
- Both underestimation and overestimation of flood dangers are very costly
- Therefore the existing uncertainties (confidence intervals) in the design flood are much larger than desired.
- Even the estimated uncertainties are uncertain
- Can this be improved, using a more physically based approach ???

Model instrumentation Rhine (initiated by RIZA)

Stochastic rainfall generator (KNMI)

Hydrological model (HBV; BfG)

Hydraulic model (SOBEK)



Reasons for building the instrumentation

- Generate (very) long series of discharges so extrapolation in frequency analysis won't be necessary

- More information on:
  - Effects of upstream physical limitations on flood frequencies
  - Flood hydrograph characteristics
  - Confidence intervals of relevant statistics

- Offers options for impact studies on:
  - Climate change
  - Human interventions

So, many potential advantages, but...

First, if possible, we need more information on:

- The validity of the concept
  - How to calibrate the models for extreme conditions?
  - Are the models capable of simulating extreme conditions?

- The reliability and uncertainties …
  - Of the rainfall generator
  - Of the rainfall-runoff and routing model
  - Of the resulting flood frequencies

Problem

There are no observations of of extreme events with return periods of 1000 years or more, so …

- How to calibrate the models for extreme conditions?
- How to validate the models for extreme conditions?
- Are the models capable of simulating extreme conditions?

1. Rainfall generator

- Impossible to validate for extreme events
- Reliability of the model depends on reproduction of observed statistical features
- KNMI has done extensive research on this

2. Hydrological model

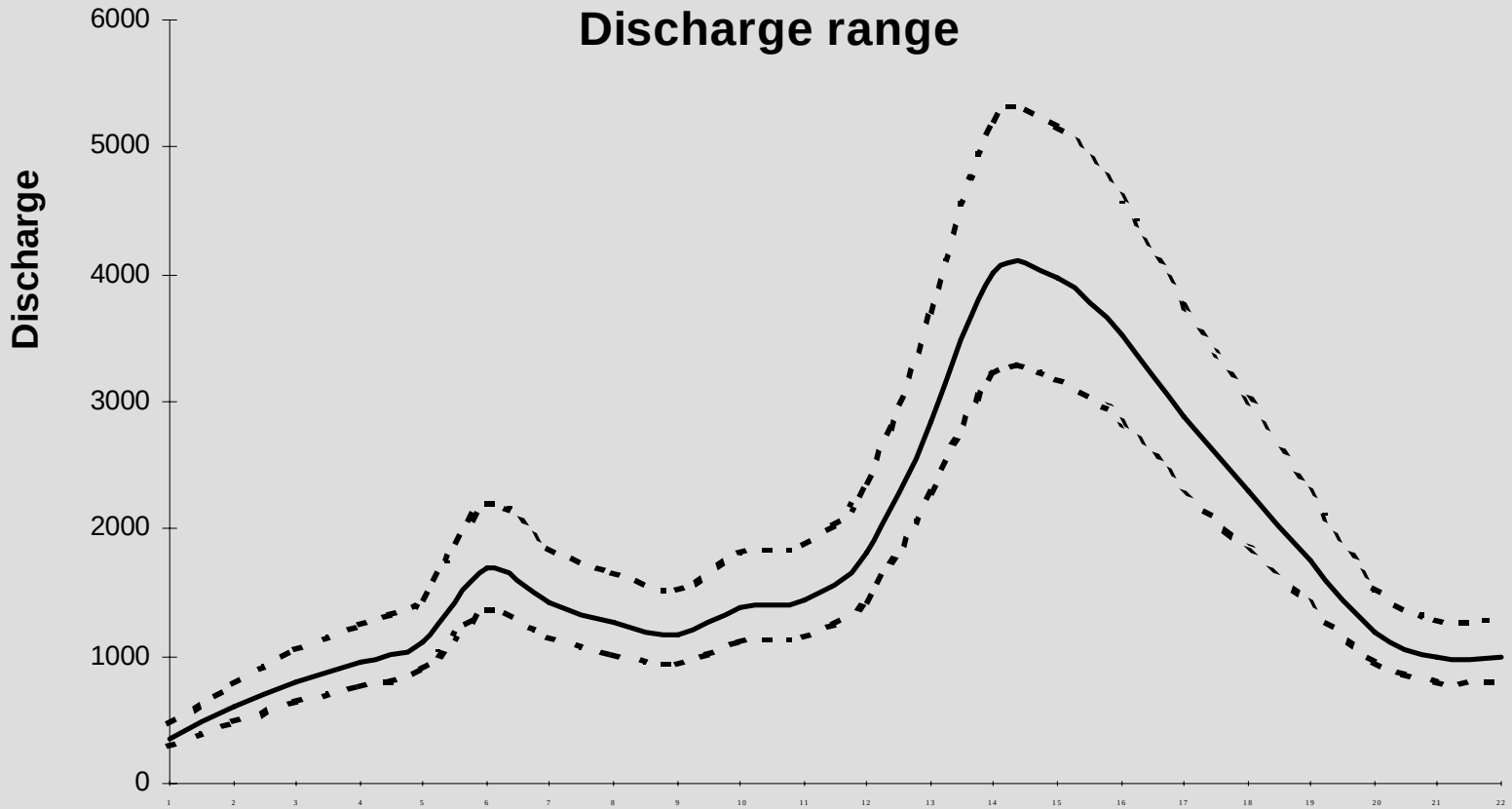
- **Good possibilities for validation of extreme events …**

River	highest observed discharge
Oberrhein (incl. Neckar)	5,600
Main	1,980
Nahe	1,150
Lahn	840
Mosel	4,170
Nette und Wied	202
Ahr	194
Sieg	1,053
Wupper	181
Erft	55
Ruhr	907
Emscher	200
Lippe	370
total:	**16,902**

Methods for estimating uncertainty HBV

- Calibration and subsequent validation with “optimal parameter set”
- Validation with multiple satisfactorily parameter set
- GLUE-procedure: Derive model uncertainty by a Bayesian method for estimating parameter uncertainty

Uncertainty in discharge-prediction



3. Hydraulic model

- Design flood conditions are far more extreme than observed conditions
- However, physical processes are quite well-known
- Necessary to have detailed information on cross-sections, dikes and floodplains along all major stretches
- Physical limitations (maximum flow capacity) may well reduce the uncertainties of the model instrumentation as a whole

To conclude

- Existing uncertainties in the design flood of the Rhine are much larger than desired.
- New model instrumentation may help reduce these uncertainties, especially if physical limitations are relevant.
- Instrumentation not necessarily a replacement of the existing method, i.e. combination of both methods is probably most beneficial