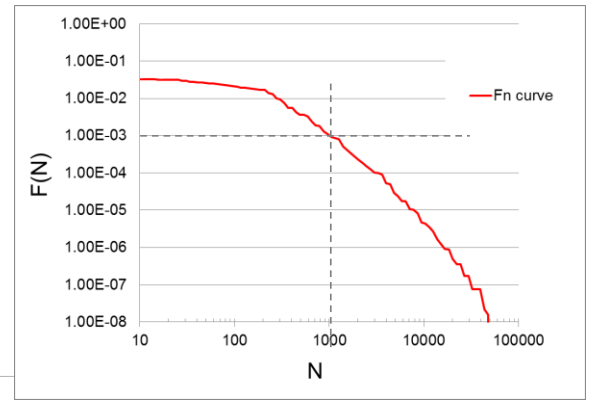
Deltares
Enabling Delta Life

Societal risk assessments for Flood Risk Management in the Rhine-Meuse Delta

Karin de Bruijn, Ferdinand Diermanse, Herman van der Most

Why societal risk? What is it?

- **Flood fatality risk plays an increasingly important role in FRM**
- **Both from individual & societal perspective**
- **Societal risk ~ disrupting events with large numbers of fatalities**
- **Societal flood risks:** probability of events with more than N fatalities



Aim & approach

Aim: ***To assess societal risks for the Rhine Meuse Delta in a way that is meaningful for FRM***

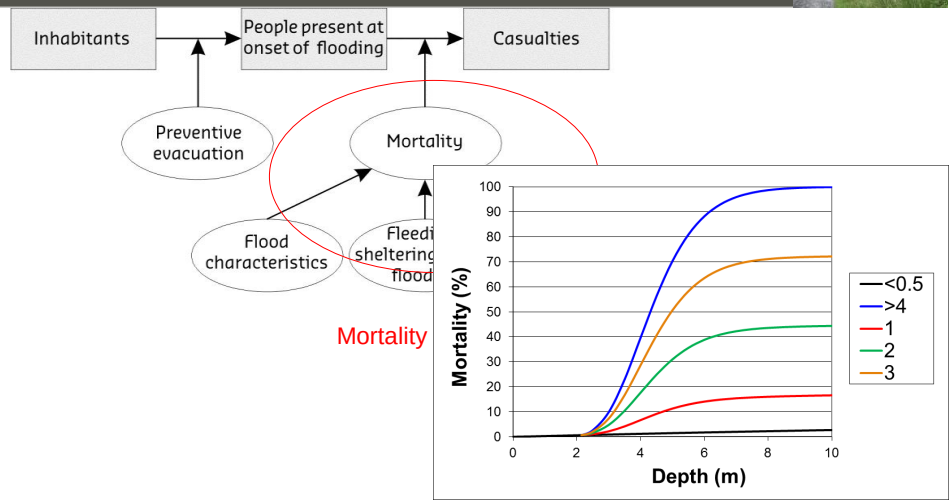
1. Assess societal risk – reference situation
2. Compare with tolerable levels

If too high

3. Develop strategies to reduce societal risk
4. Evaluate these
5. Flood protection standard proposals from societal risks

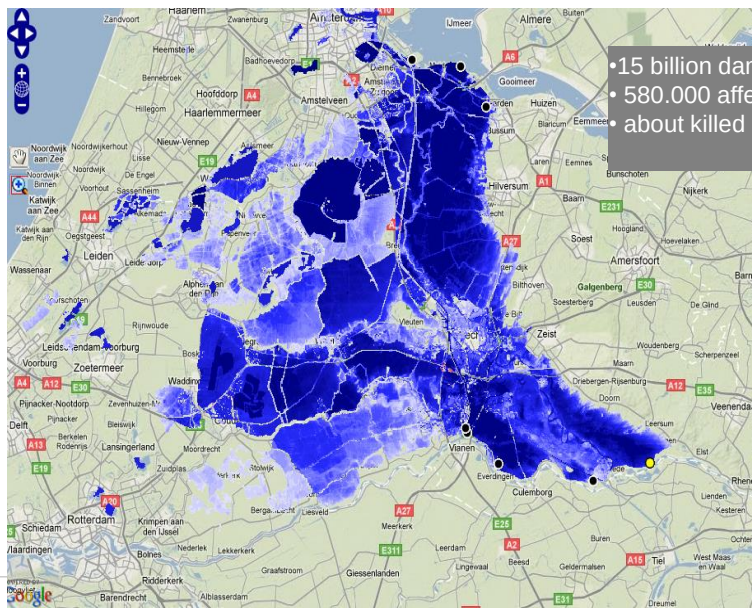
Deltares

Method: Number of fatalities



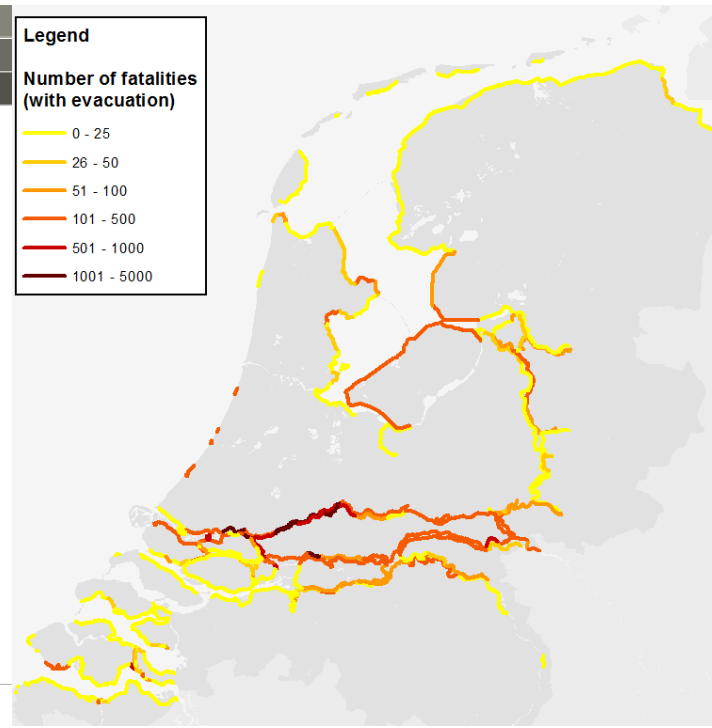
Deltares

Flood patterns



- 15 billion damage
- 580.000 affected
- about killed 280

eltares

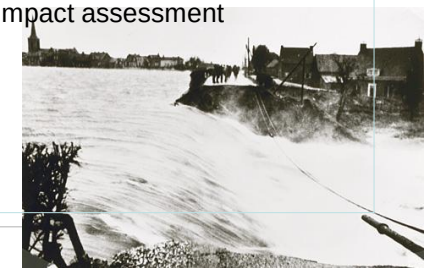


From fatalities to societal risk

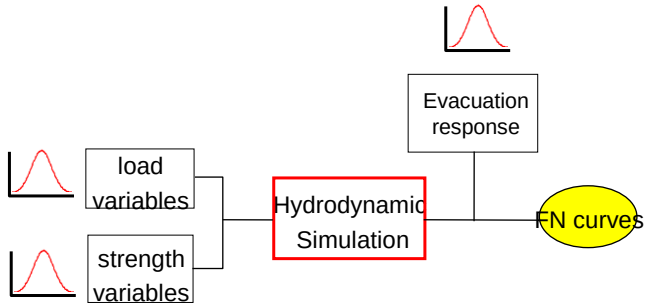
How many breaches occur in one *event*?

- Flood hazards: Storm surges & peak discharges on Rhine & Meuse
- Storm surge barrier, failure probability 1/100 per closure
- NL high protection standards 1/1250 to 1/10.000 a year.
- If a breach occur, other areas may become a little safer

Integrated approach of river discharges & storm surges
And river modelling - breach modelling – impact assessment



Overview of the method

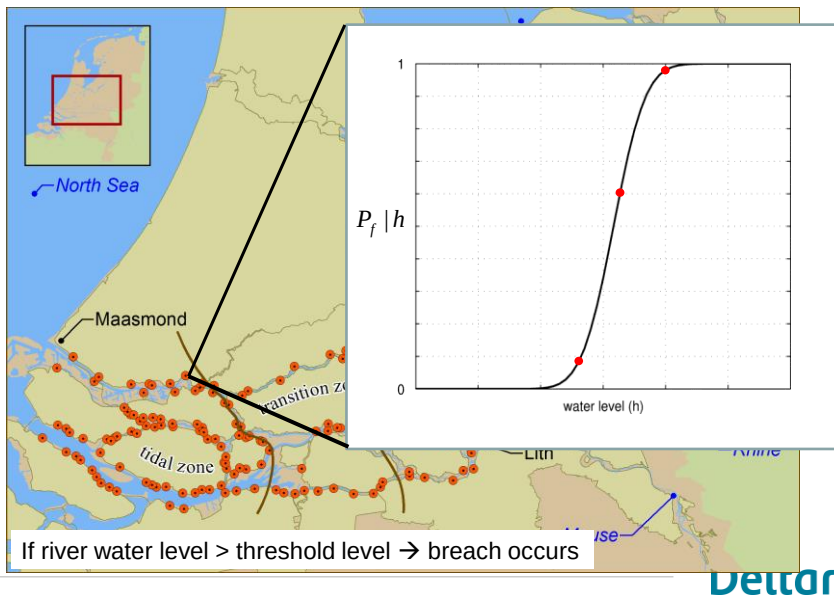


Components:

- Define characteristics of: Hazard, strength, response parameters
- Sample many events from hazard, strength & response parameters
- Hydrodynamic modelling: Run samples → obtain breach locations
- Translate results to fatality figures per event
- Make FN curve + indicator values

Deltares

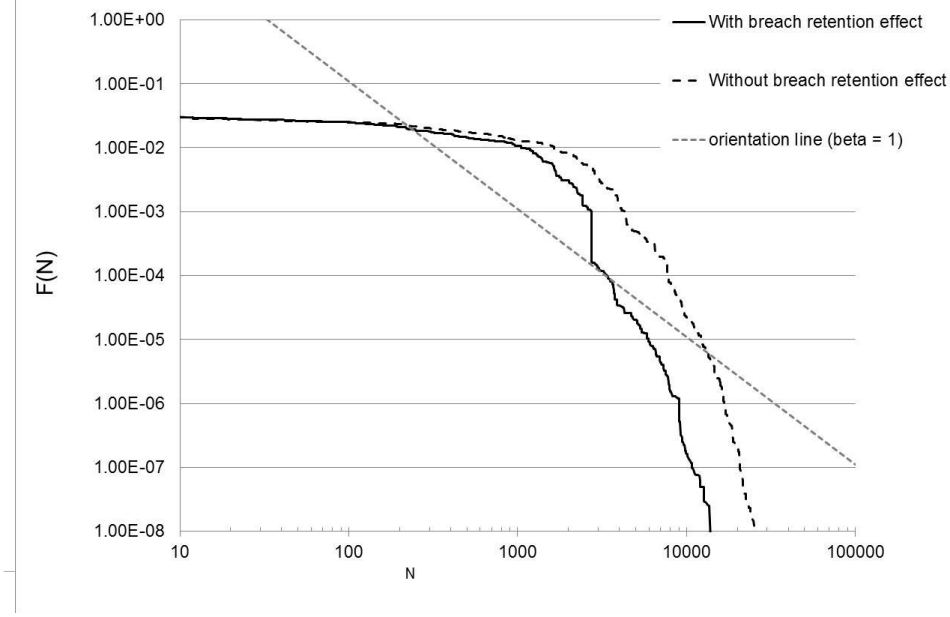
Rhine Meuse Delta



If river water level > threshold level → breach occurs

Deltares

Resulting FN reference situation



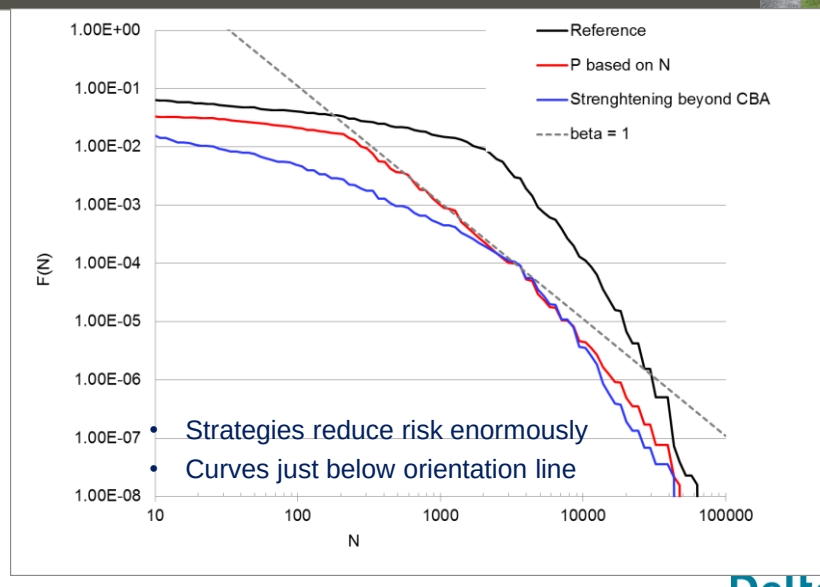
Alternative strategies

Strategies: Flood *protection* standards based on:

- Fatalities per potential breach location
- Strengthening those stretches which contribute most to societal risk
- Same but starting from CBA

N	P (1/year)
>1000	1/100.000
300-1000	1/30.000
100-300	1/3000
<100	1/300

Results strategies for the NL



- Strategies reduce risk enormously
- Curves just below orientation line

Deltares

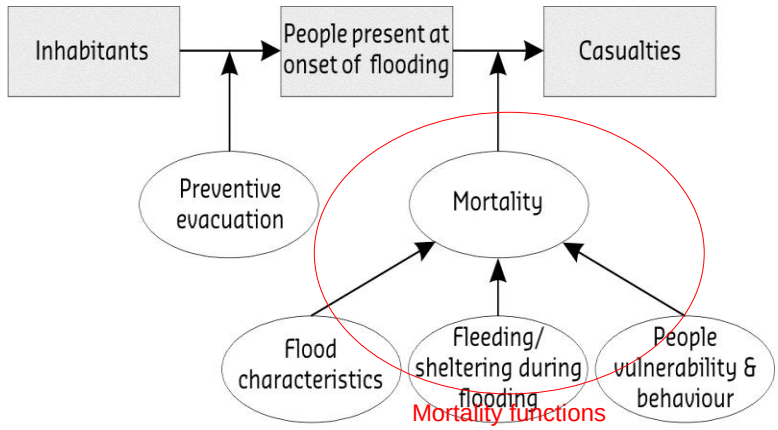
eltares

Conclusions & discussion

- Societal risk: the probability of events with more than N fatalities
- Societal risk assessment requires integrated approach. A method was developed which includes:
  - The whole system (Rhine-meuse delta),
  - Both hazards (storm surges & peak discharges & combinations)
  - The hydrodynamic interaction between areas
- Method provides insight into most important scenario's, contribution of subareas
- Outcomes were used in Delta Programme next to CBA outcomes and individual risks.

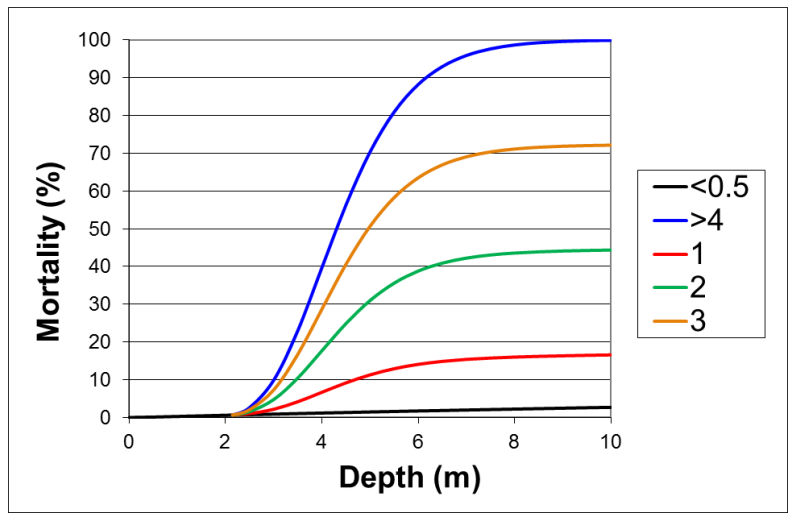
Deltares

Method: Mortality & fatality analysis



Deltares

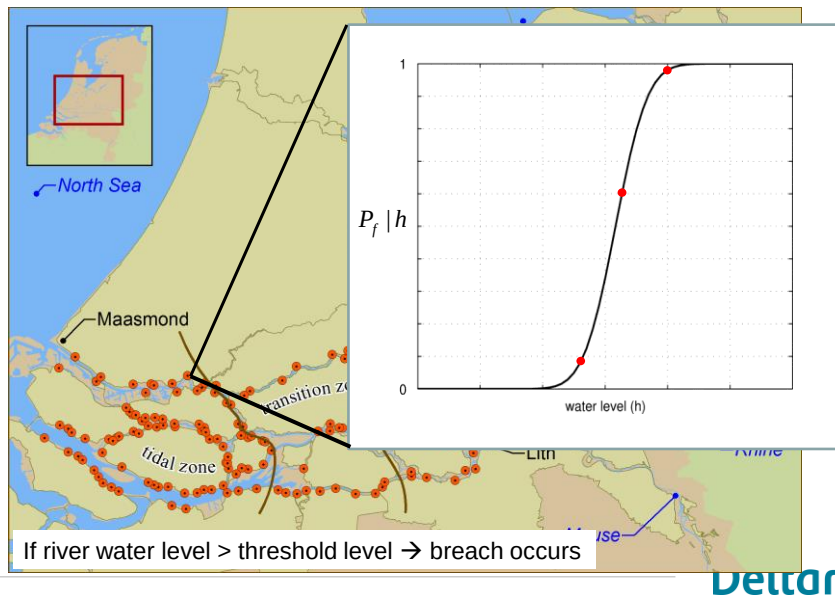
Method: Mortality & fatality analysis



Deltares

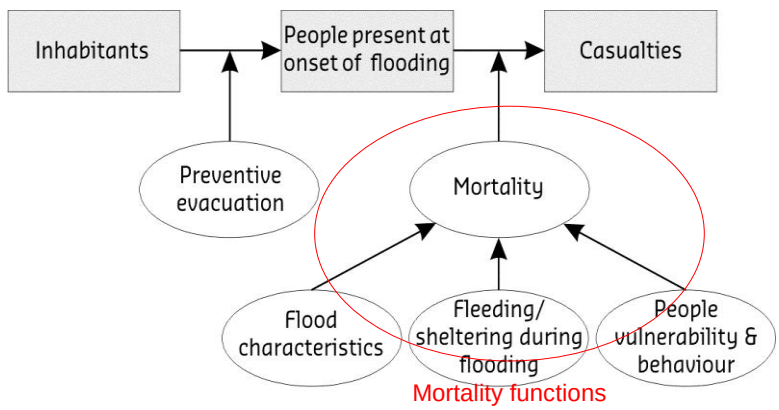
Rhine Meuse Delta

Rhine Meuse Delta



If river water level > threshold level → breach occurs

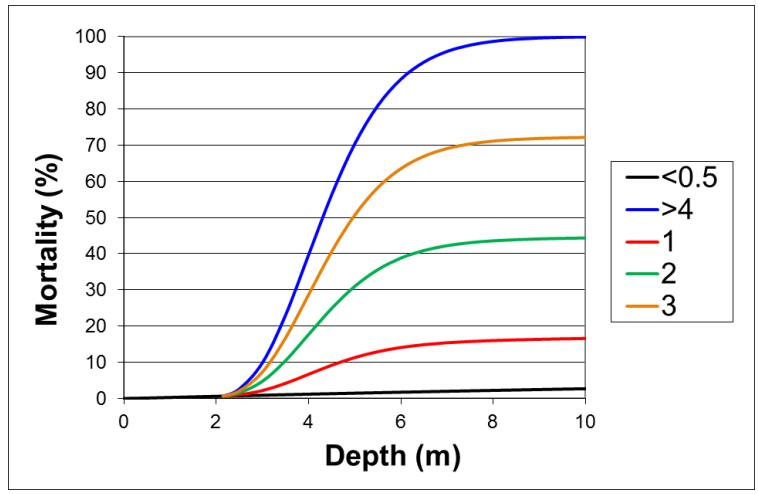
Method: Mortality & fatality analysis



Mortality functions

Deltares

Method: Mortality & fatality analysis



Deltares

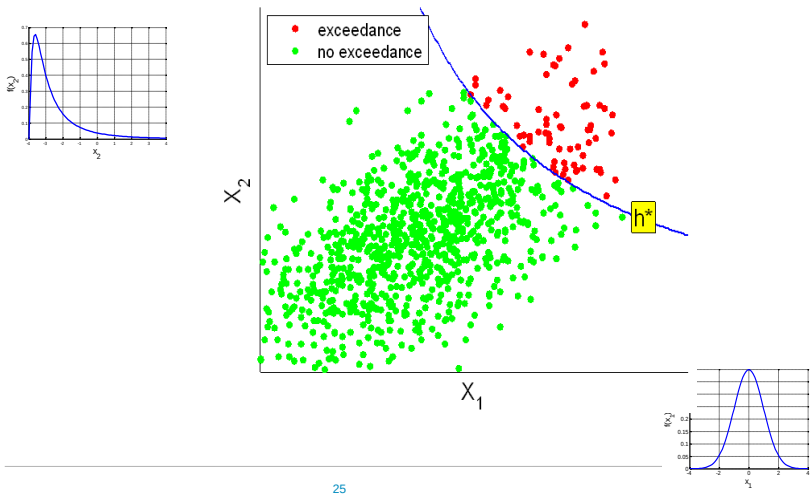
Monte Carlo simulation set-up

- N synthetic years simulated
- For each year 2 events are considered (so 2*N samples):
  1. Annual maximum discharge + co-inciding sea water level
  2. Annual maximum sea water level + co-inciding discharge
- For each event the “barrier functioning” is sampled:
  - 99% correct functioning (closing upon request)
  - 1% malfunctioning (not closing upon request)

Deltares

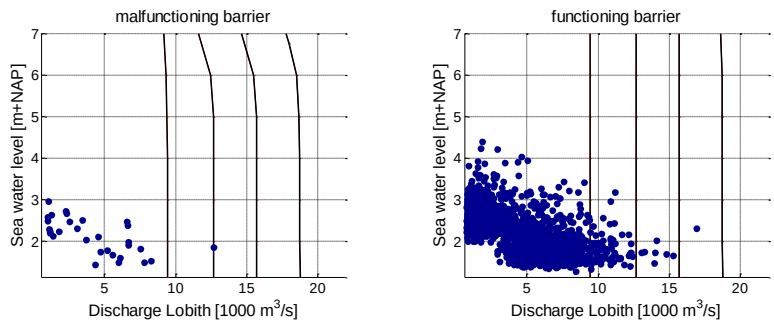
Selected probabilistic method: Monte Carlo sampling

1. Take N random samples of x_1 and x_2
2. Count the number of samples (M) that lead to “failure” or “exceedance”
3. Estimate P_f = M/N

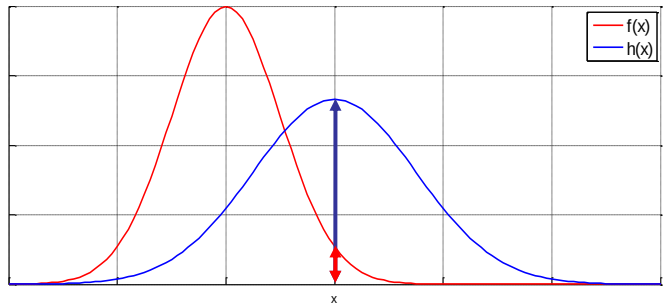


Problem with (crude) Monte Carlo

- Many samples required for reliable probability estimates
- Specifically for extreme events
- Each sample requires simulation time
- If time is limited, this may lead to significant errors



Potential solution: importance sampling

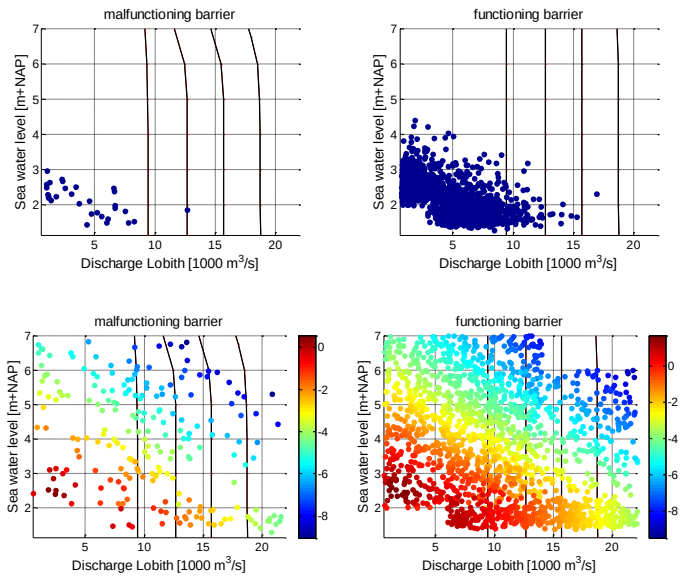


"Manipulation" of probabilities

Allowed if correction is applied: $\frac{f(x)}{h(x)}$

Deltares

Resulting samples



Crude

Importance Sampling

Deltares