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Enabling Delta Life

Combined storm surge – riverine flood events

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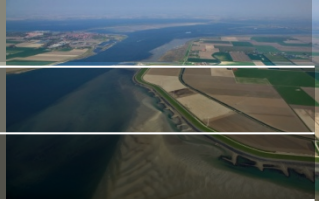
NRC Workshop on PFHA, Rockville MD, January 2013

Outline



- Tidal rivers – combined influence from surge and river
- Challenge for PFHA: need to consider many combinations of surge and river discharge
- Account for correlations
- Example of how this is done for Rotterdam

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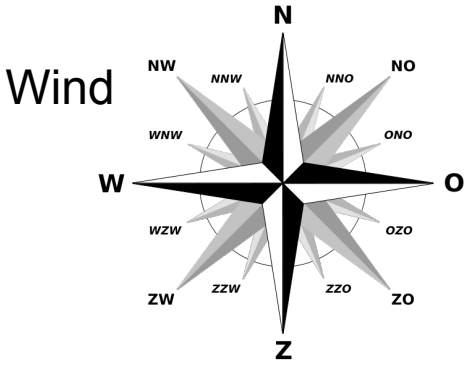
Rhine-Meuse estuary



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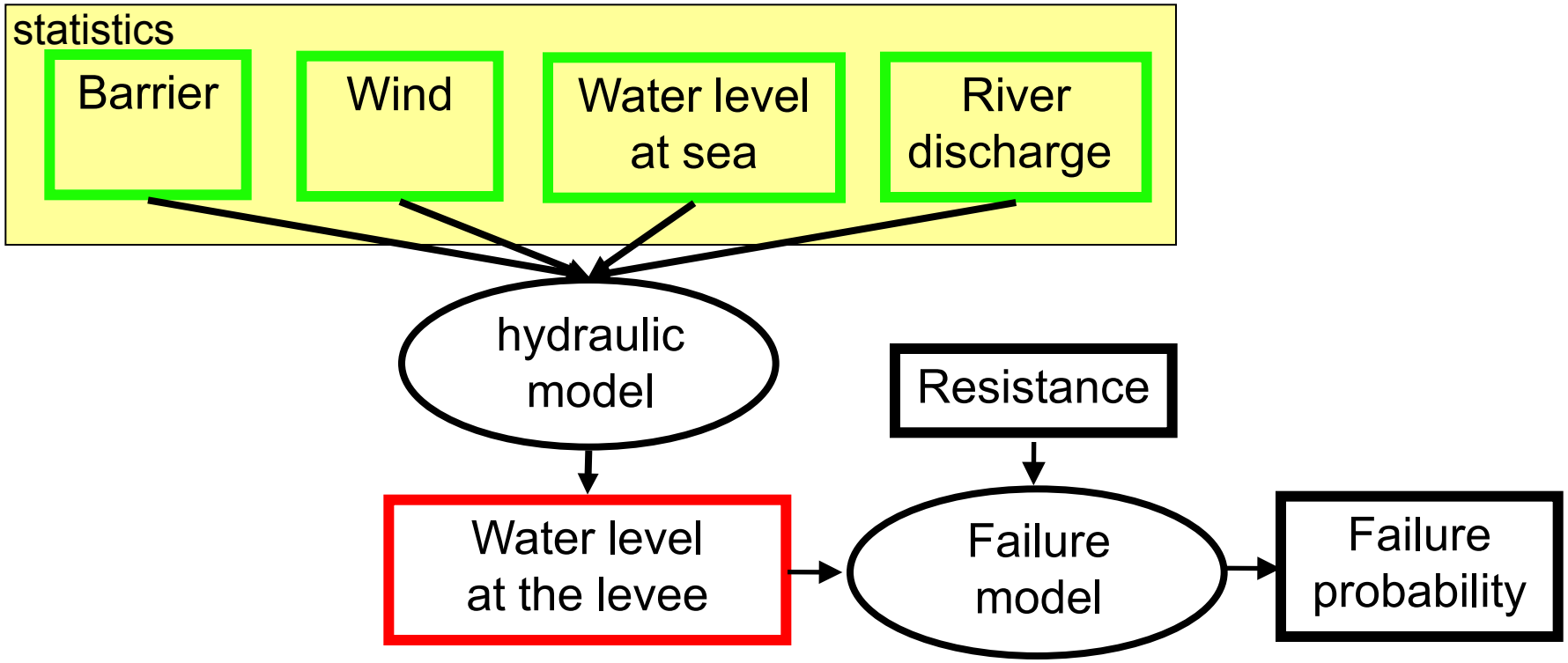
Probabilistic model



To get the exceedance probability of a water level at the levee
- **Consider all relevant combinations of forcing variables**
- **Calculate the water levels at the levee**
- **Determine their probabilities**
- **Integrate probability over all combinations**

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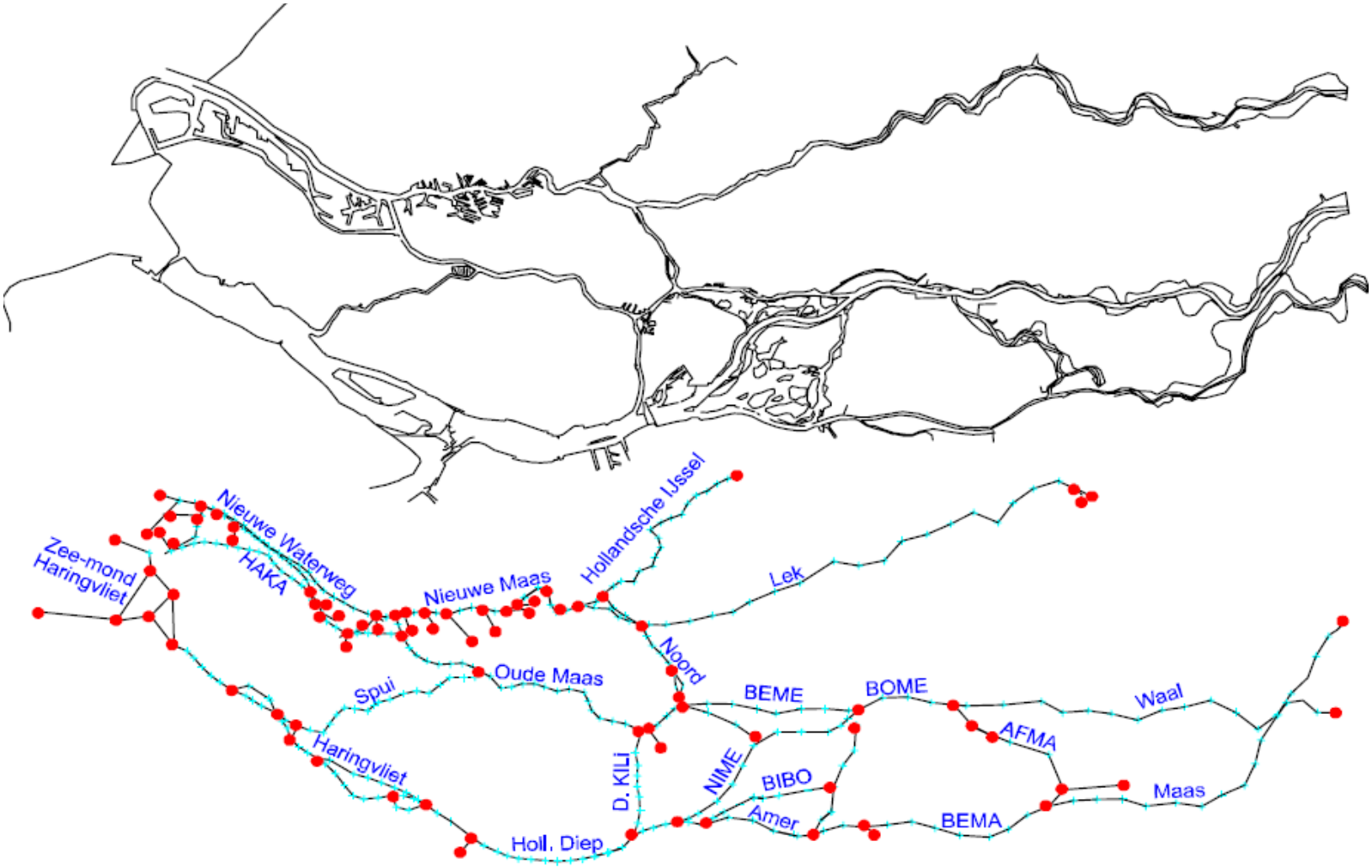
Sobek 1D hydraulic model



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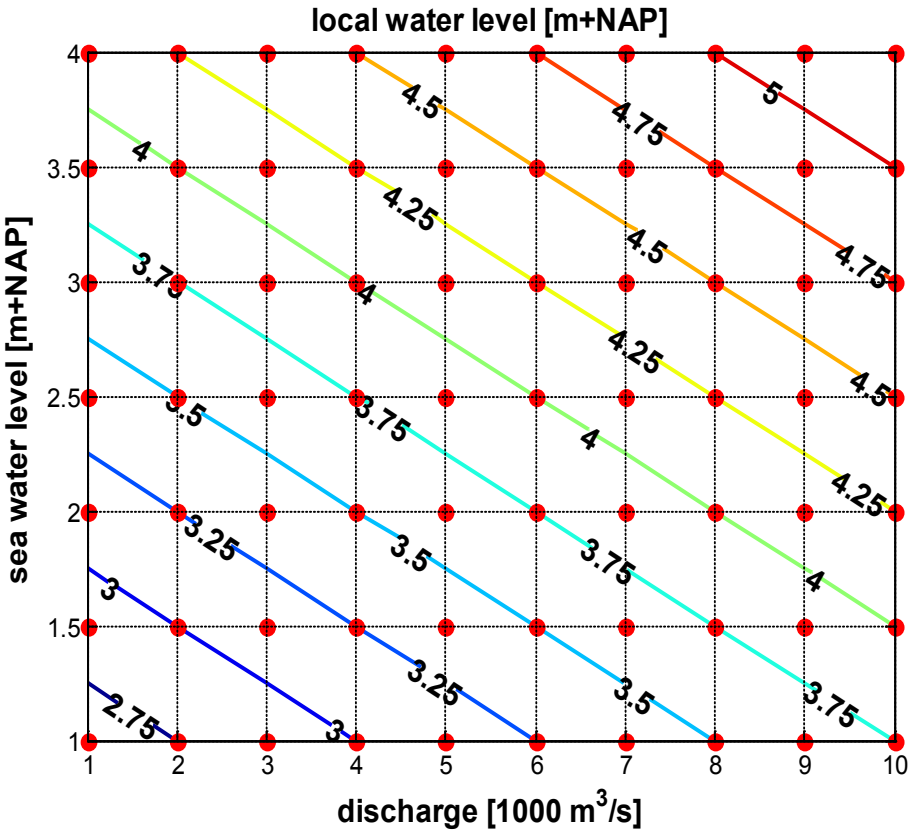
Calculate water levels and draw contours



Water levels at location of interest computed by hydraulic model

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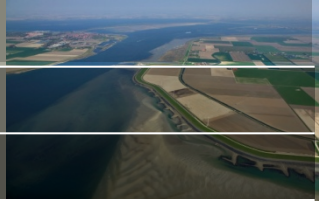
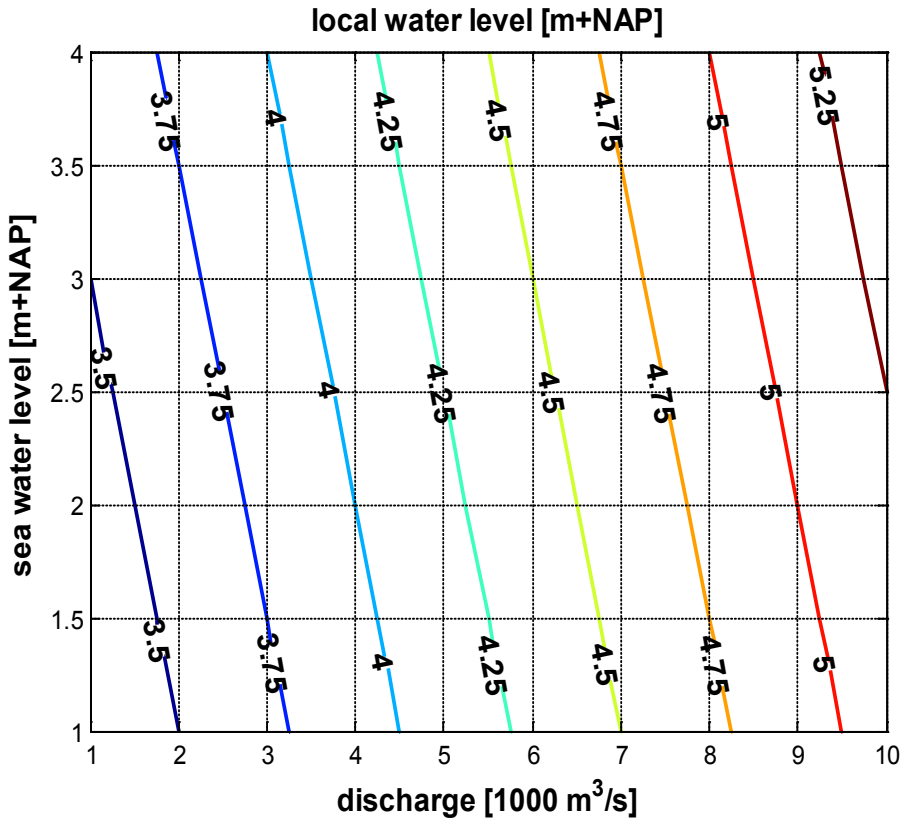
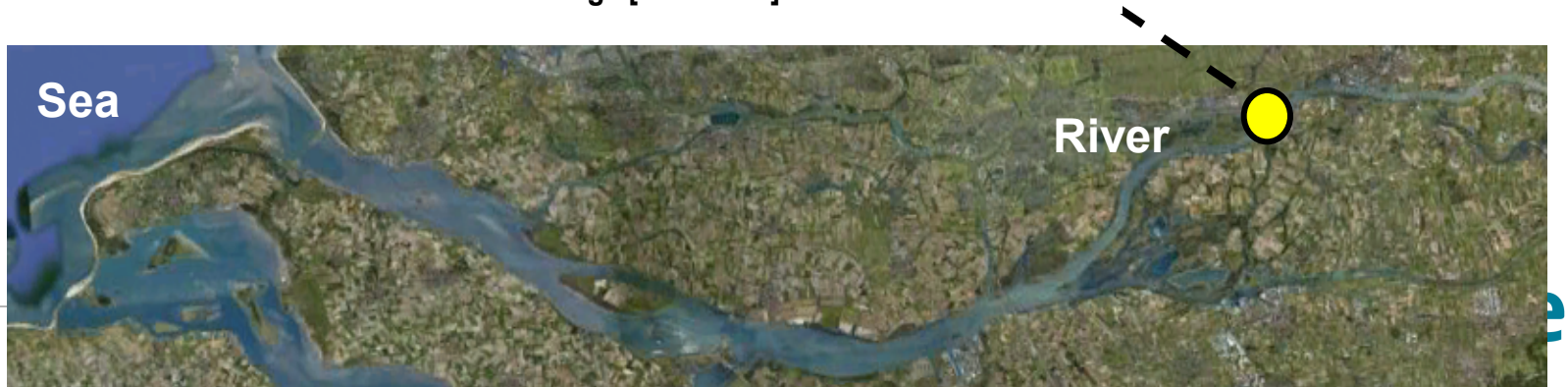
Upstream location

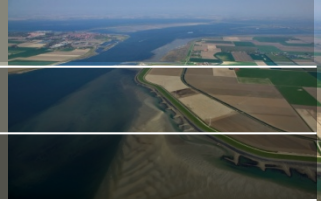


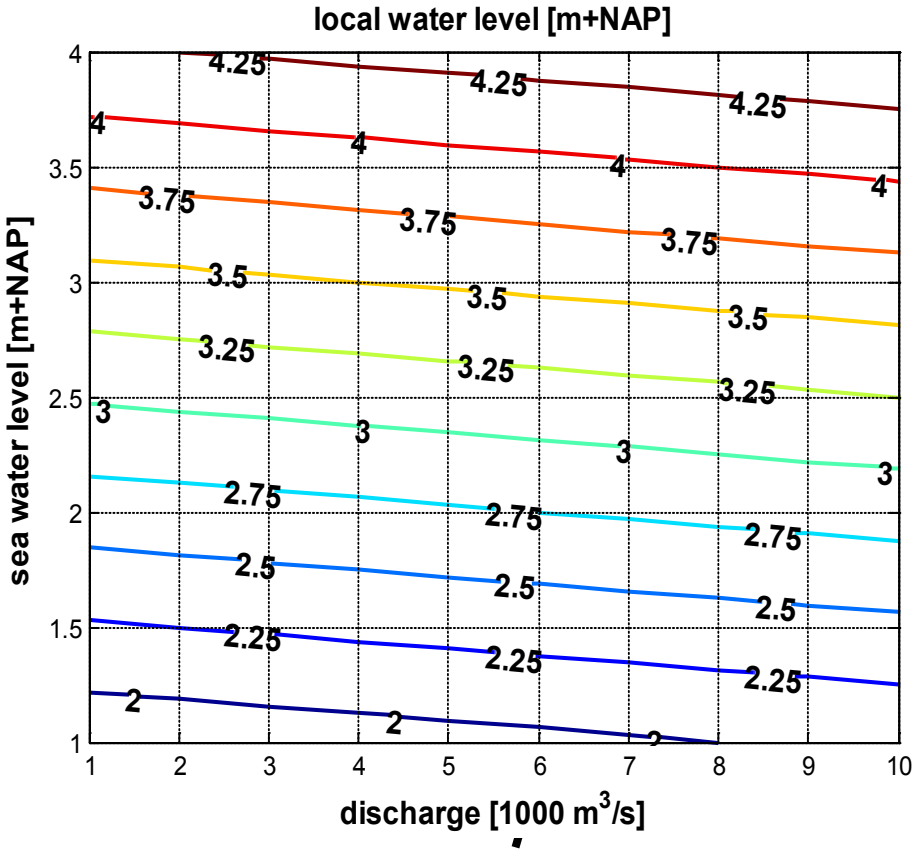


Water levels mainly determined by river discharge



Downstream location





Water level mainly determined by sea water level

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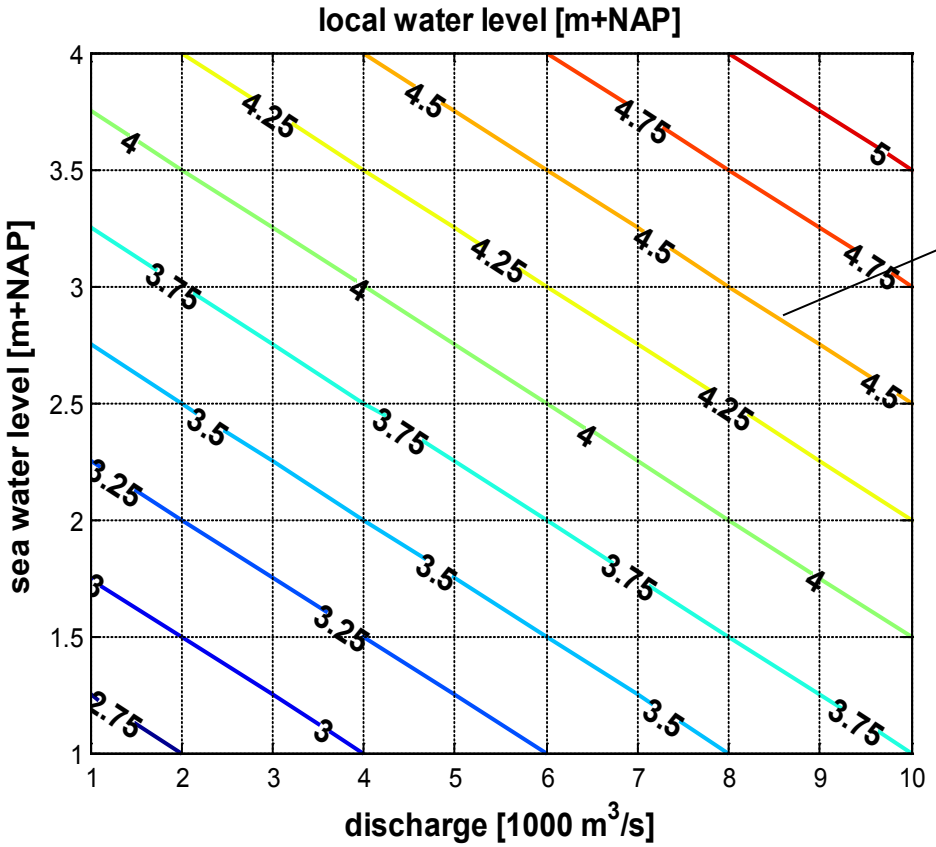
Compute exceedance probability



Example: flooding occurs if h>4.5 m+NAP

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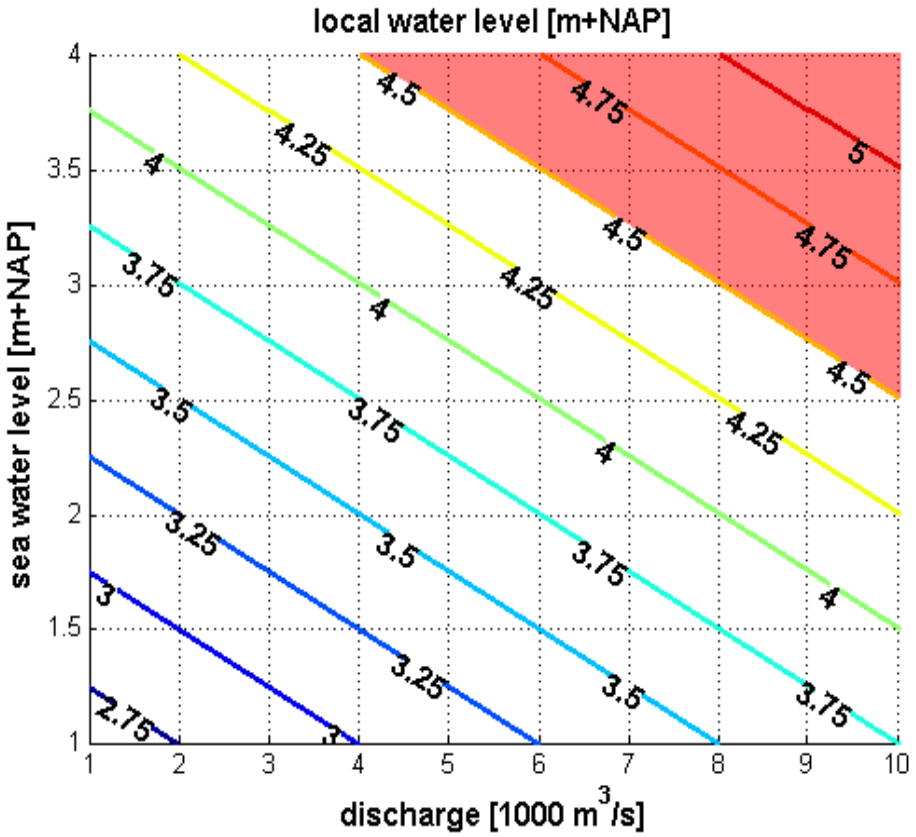
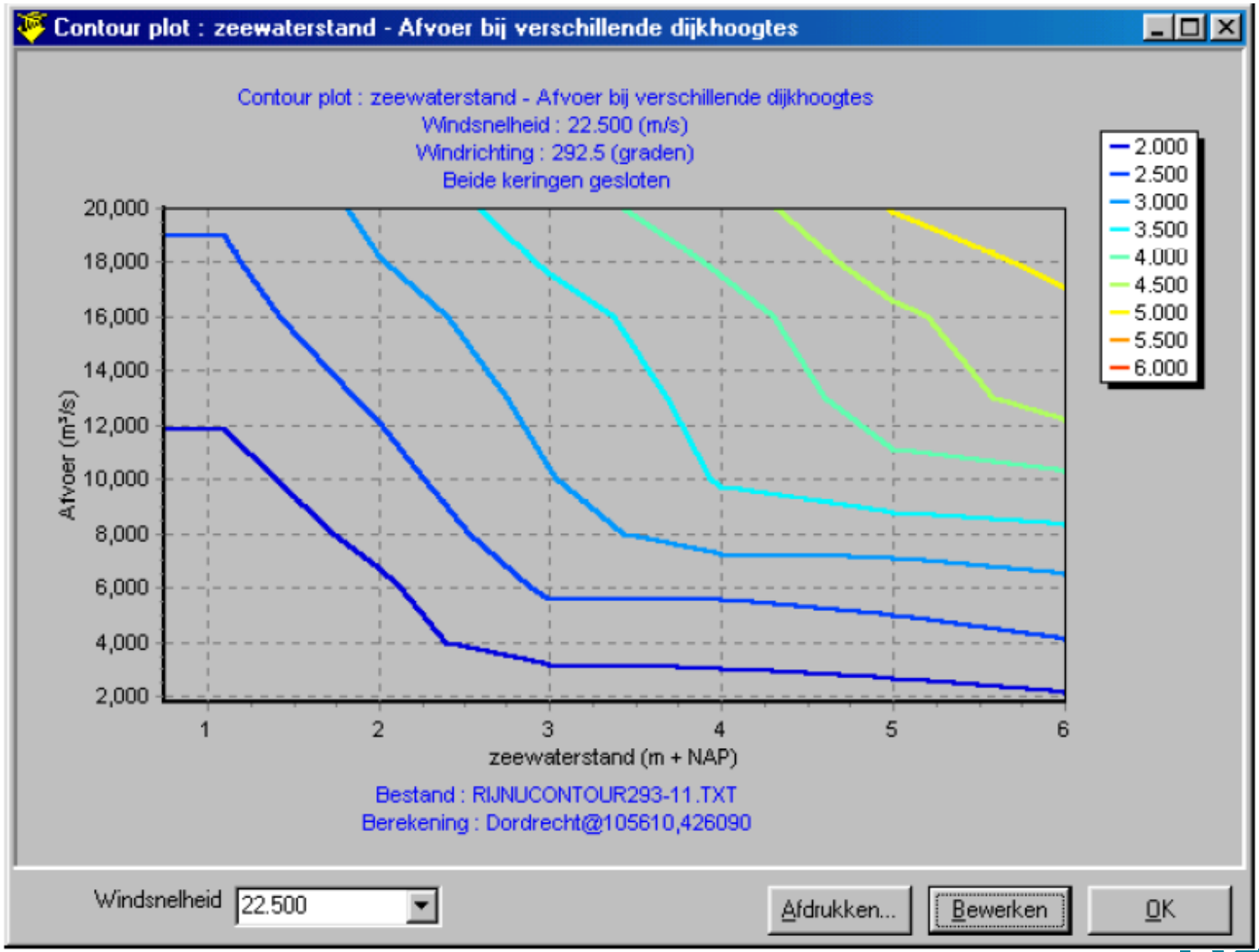
Compute exceedance probability



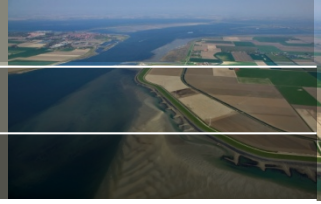
Failure domain

Integrate probability over failure domain

Results Rotterdam – contour plot



Forcing variables for Rotterdam



Variables:

❑ North Sea water level (1,2,3,4,5,6m)	6 values
❑ Rhine and Meuse discharge (2 times 9)	18 values
❑ Wind direction	16 wind sectors
❑ Wind speed	5 values
❑ Open/closed storm surge barrier	2 possibilities

Total number of combinations: 7000

Several weeks on a single PC, some days on a 10 PC cluster

Store in a database. Next, determine their probabilities

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Statistics and dependencies

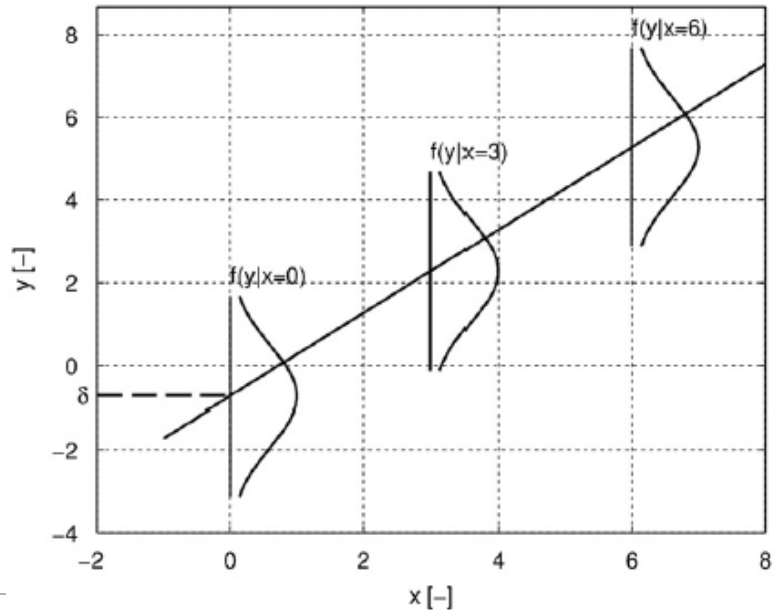
Consider 16 wind sectors:

- **Separate sea water level statistics for each wind sector**

  Probabilities of all wind sectors should add up to onmidirectional

- **Separate wind speed statistics for each wind sector**

  Correlated with sea water level:



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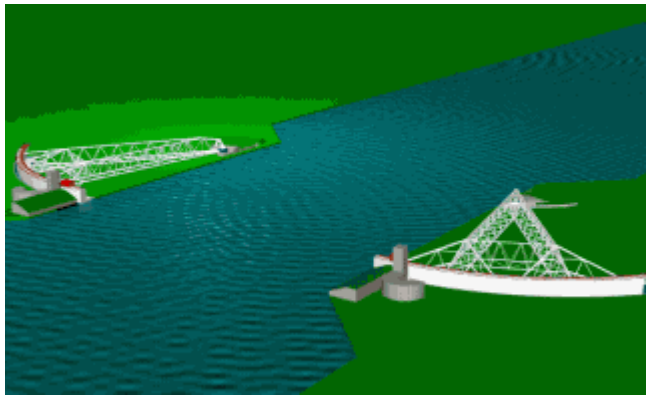
Statistics and dependencies (2)

- Open/closed storm surge barrier:
  - Open due to erroneous forecast
  - Additional 1% probability of failure



- Rhine and Meuse discharge
  - mutually dependent
  - independent of other variables

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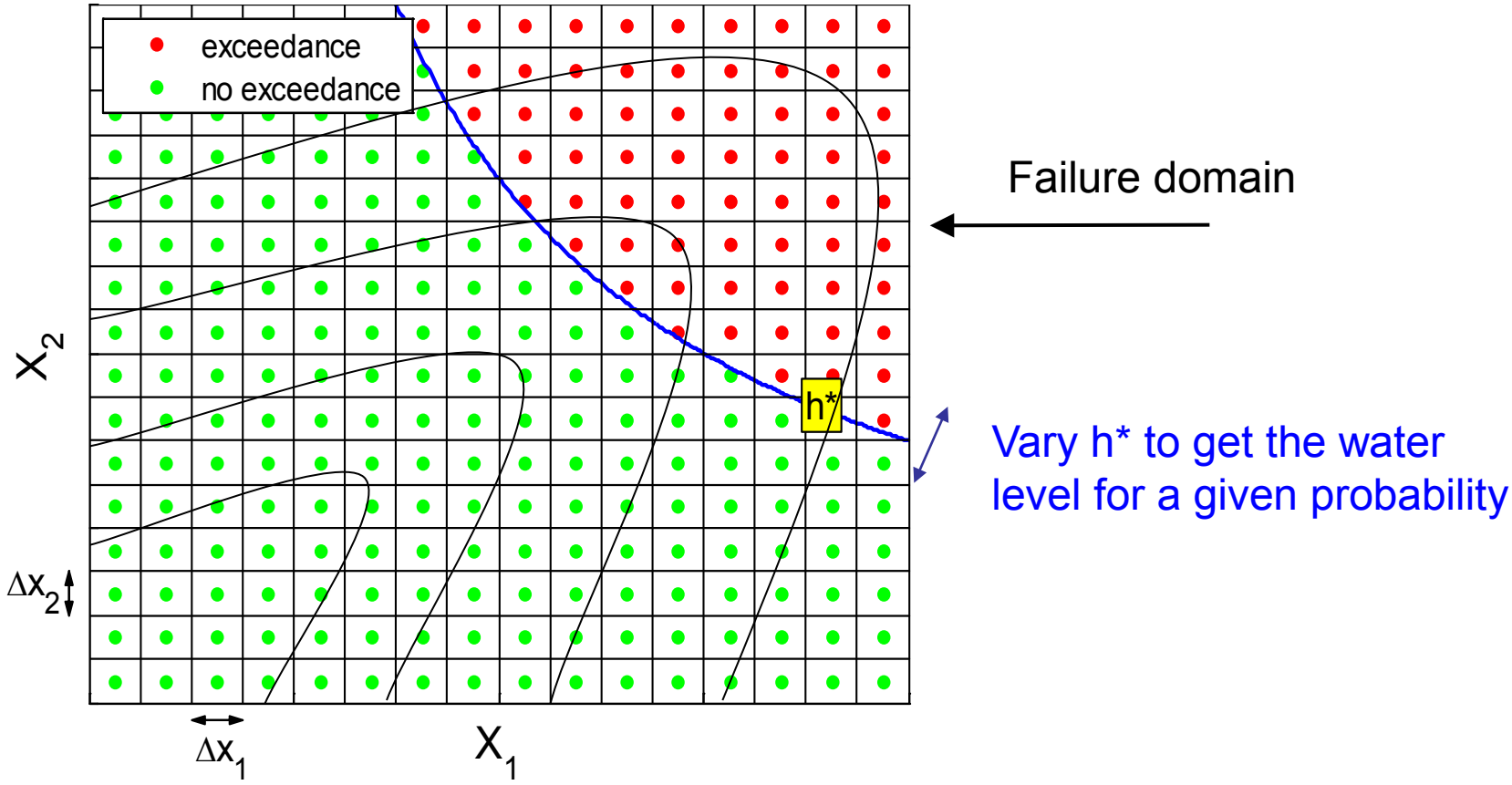
Numerical integration of probability

Probability of exceedance of critical water level h*



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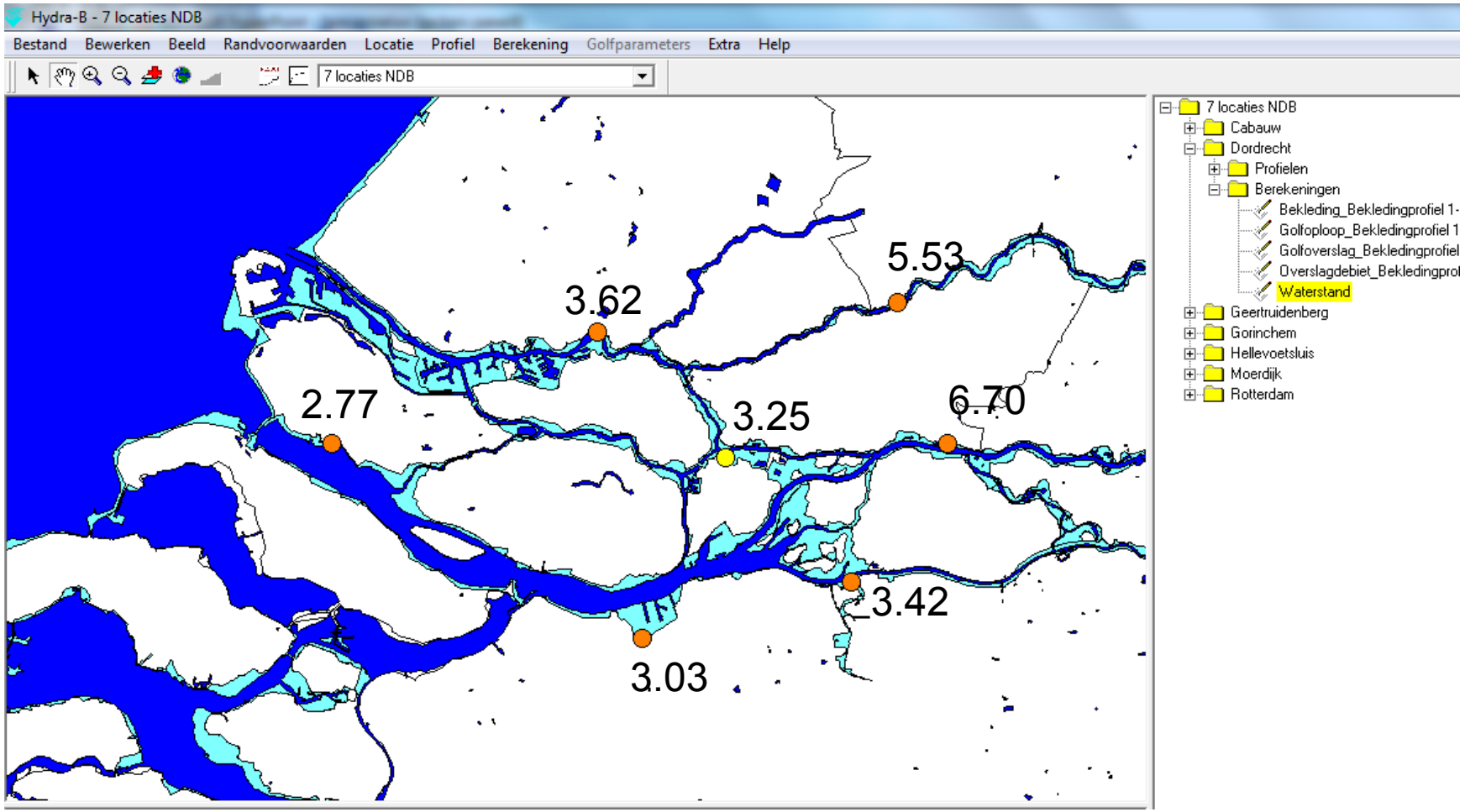
Results: 1/10,000 year water levels



Large contribution from combinations of less than extreme surges and discharges and of ‘open barrier’ situations to exceedance probability

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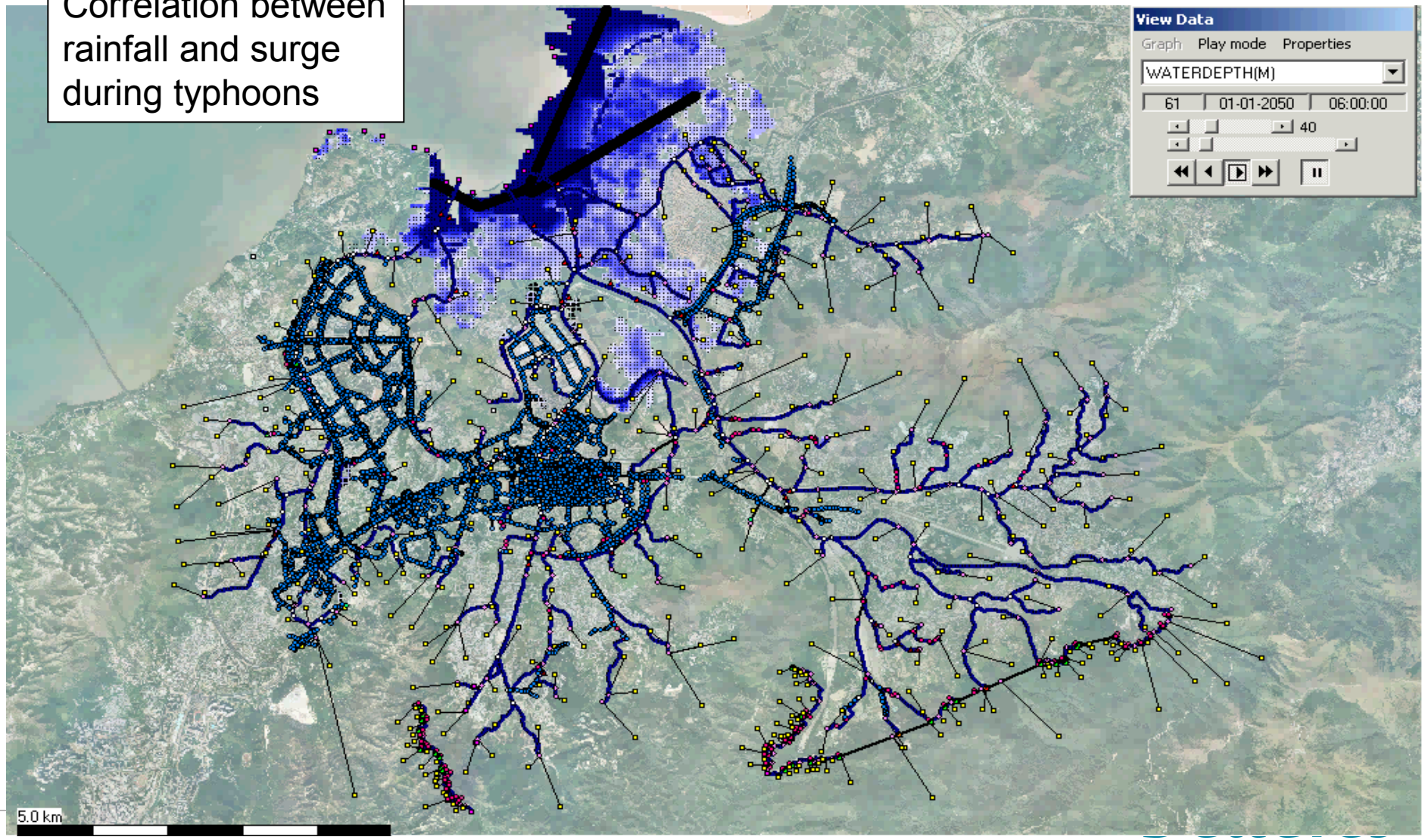
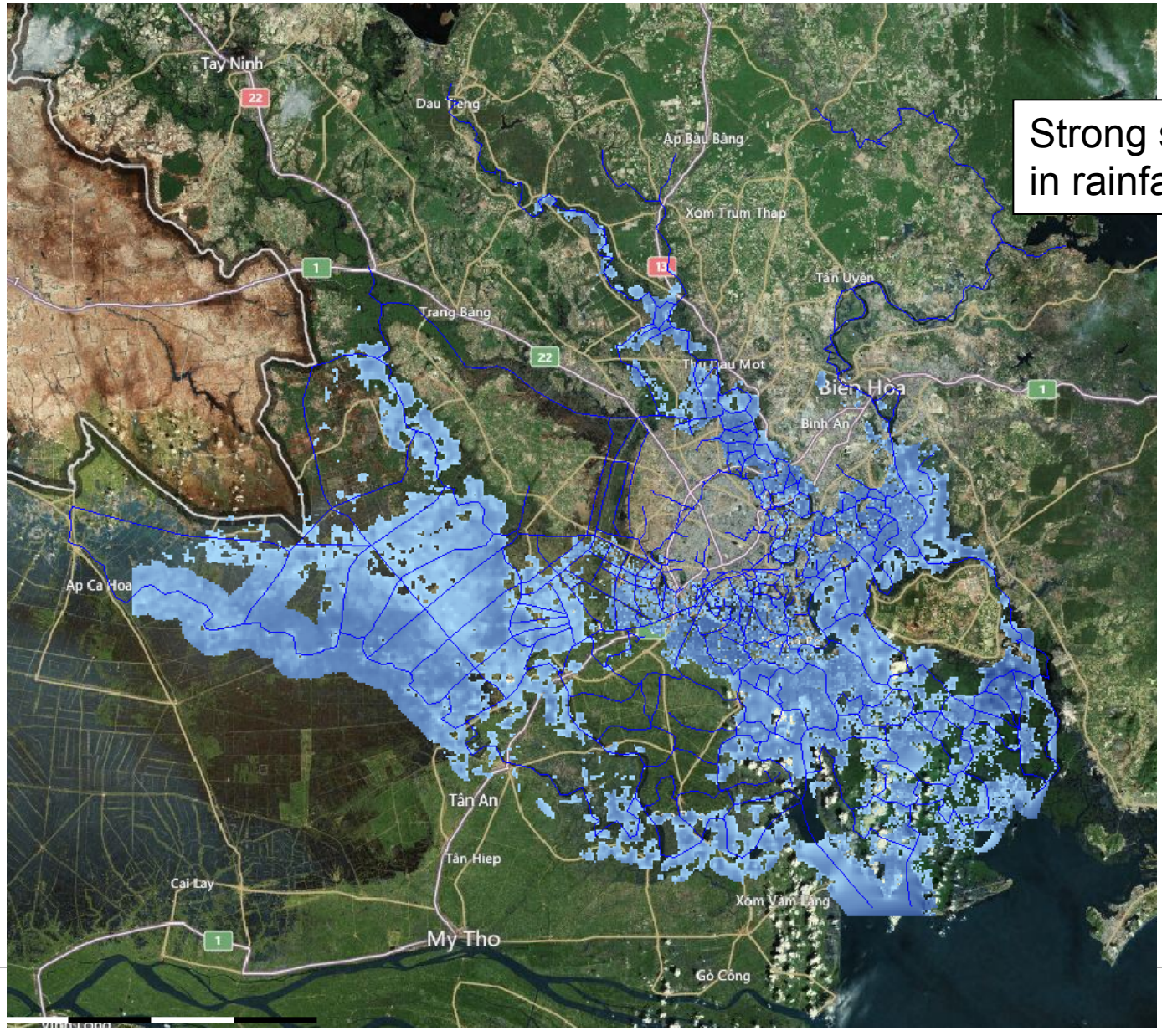
A few other examples: Hong Kong

Correlation between rainfall and surge during typhoons



Ho Chi Min City (Saigon)



Strong seasonal effects in rainfall and tide

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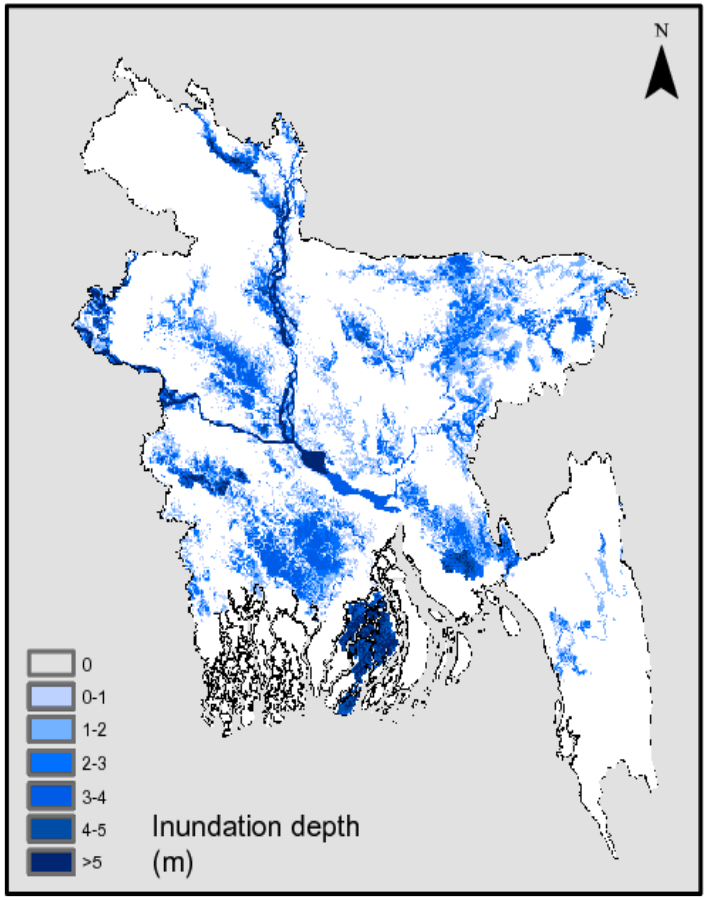
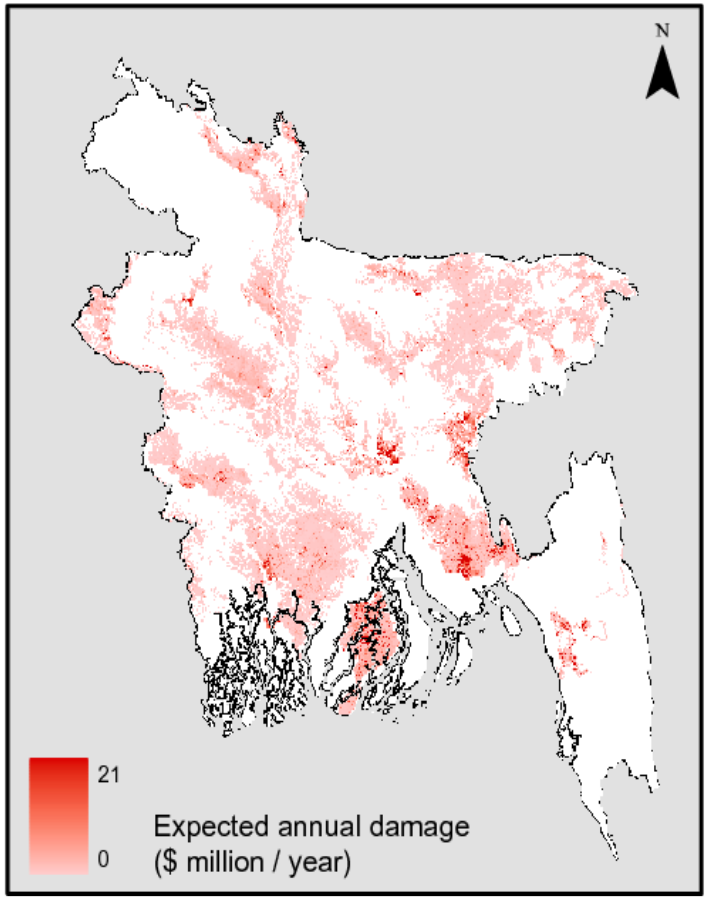
Bangladesh





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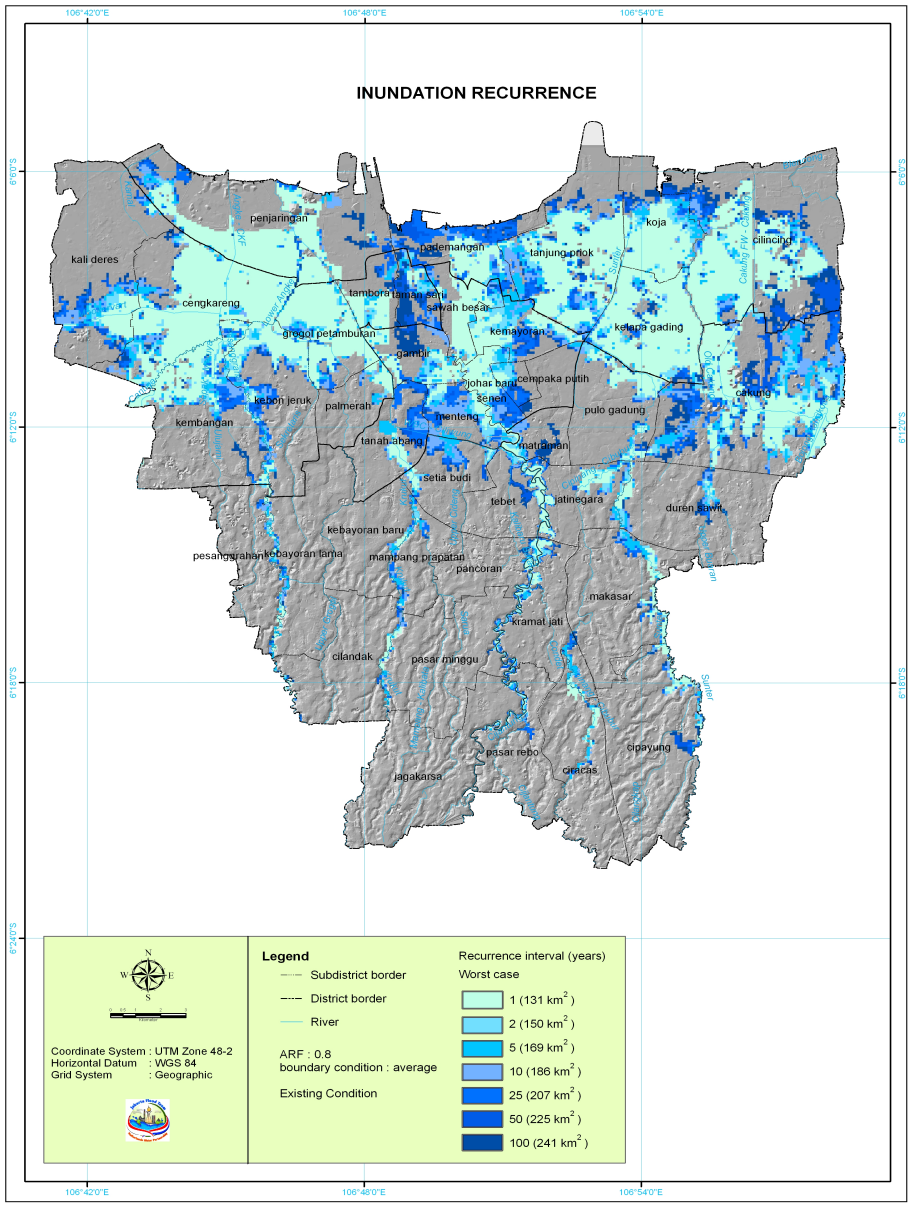
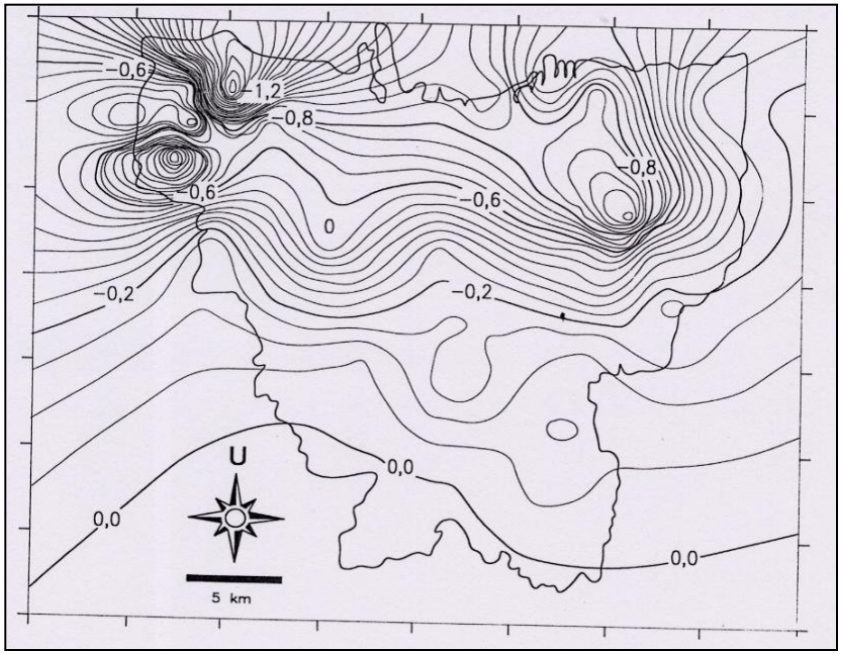
Jakarta – Indonesia





Land subsidence of several cm per year

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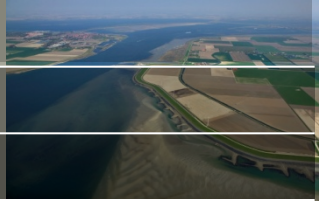
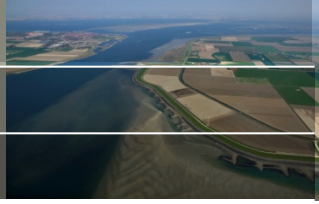
Conclusions



- Number of combinations of forcing variables in tidal river systems poses a computational challenge to PFHA
- Specific model is required for each situation (forcing variables and correlations)
- In the transition zone, often a large contribution from combinations of less than extreme values of the individual variables

Thanks for your attention



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