TALLINN workshop
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coastal design, extremes and climate change

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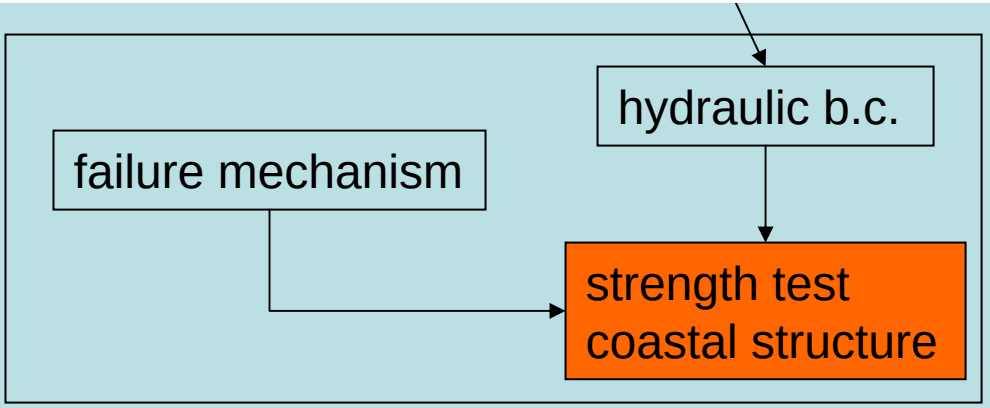
Coastal Design

- design depends on structure; different structures need different design parameters
- relatively high return periods (O(1/4000))

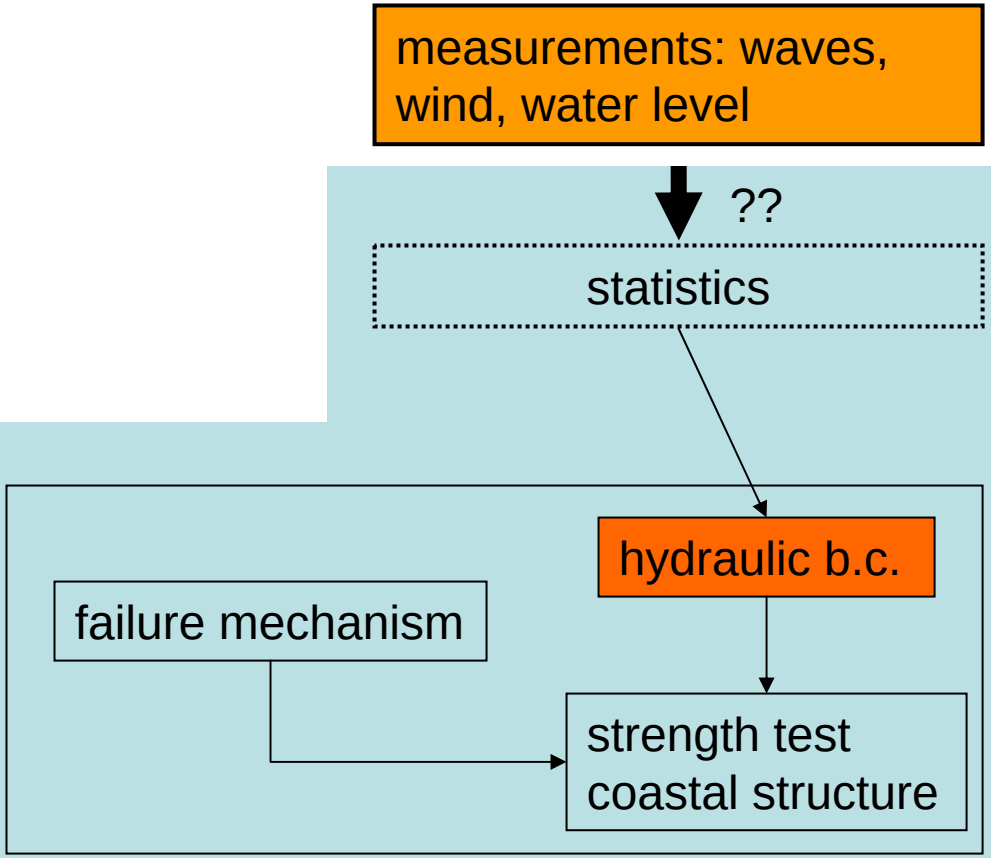

hydraulic b.c.
failure mechanism
strength test
coastal structure

Hydraulic boundary condition

- what kind of information is needed:
  - water level
  - waves: Hs, T, dir, ... spectrum
  - wind
  - ....

Hydraulic boundary condition (cont'd)

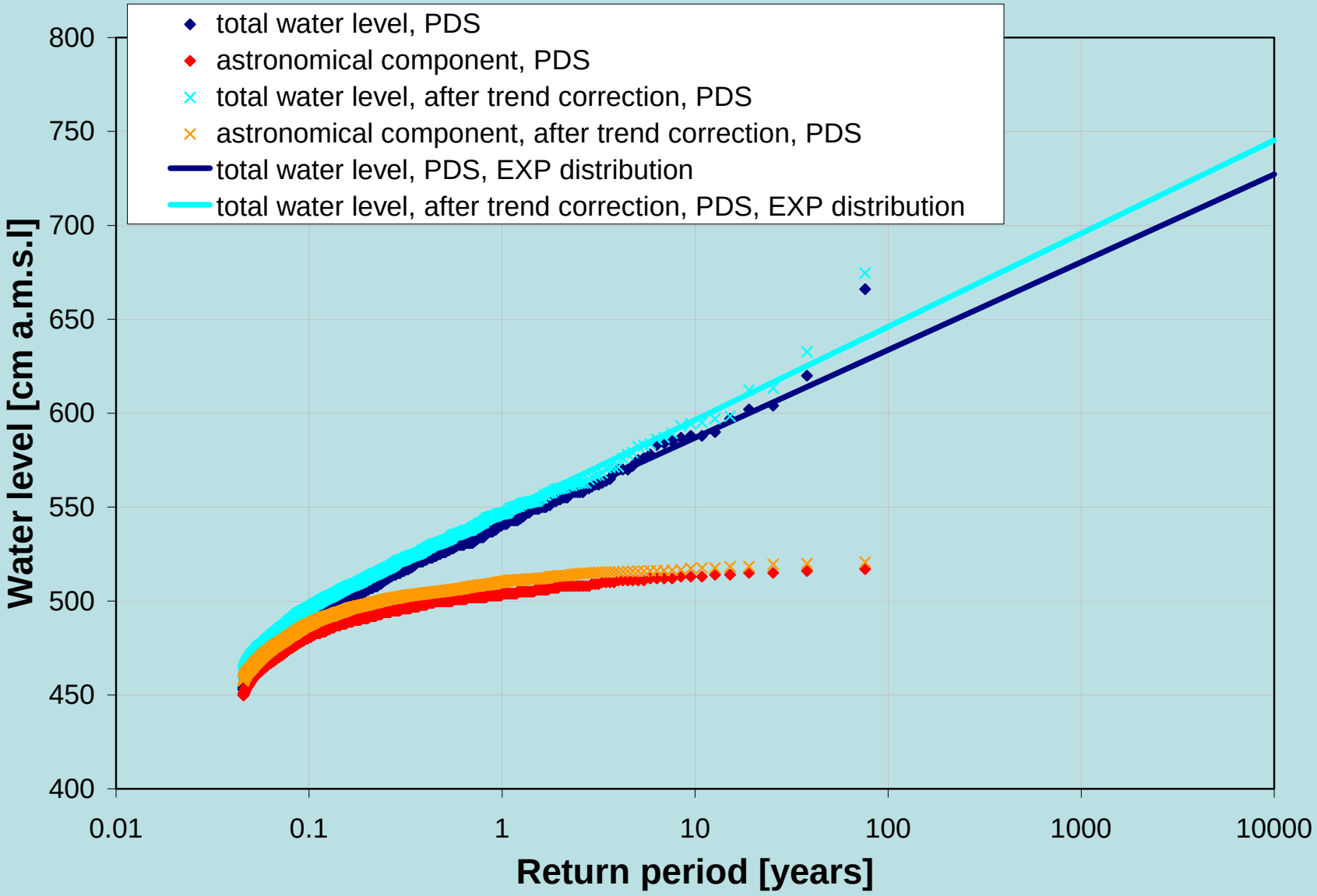
estimation of wave climate & extremes



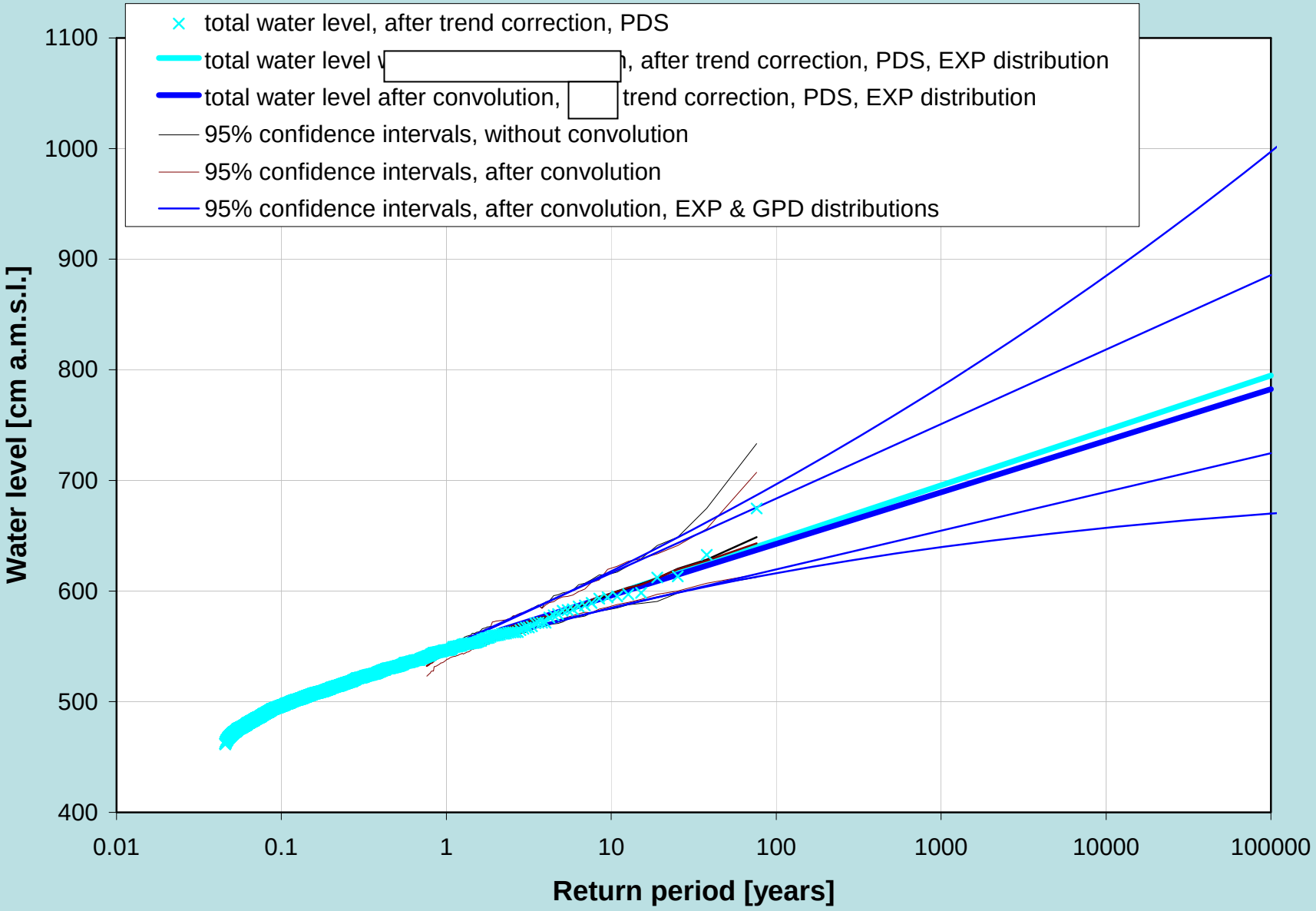
Extreme water level

important/crucial design parameter for many, if not all coastal structures

- study of P. Willems on extreme water levels obtained from convolution of surge levels and astronomical tide levels and from total water levels



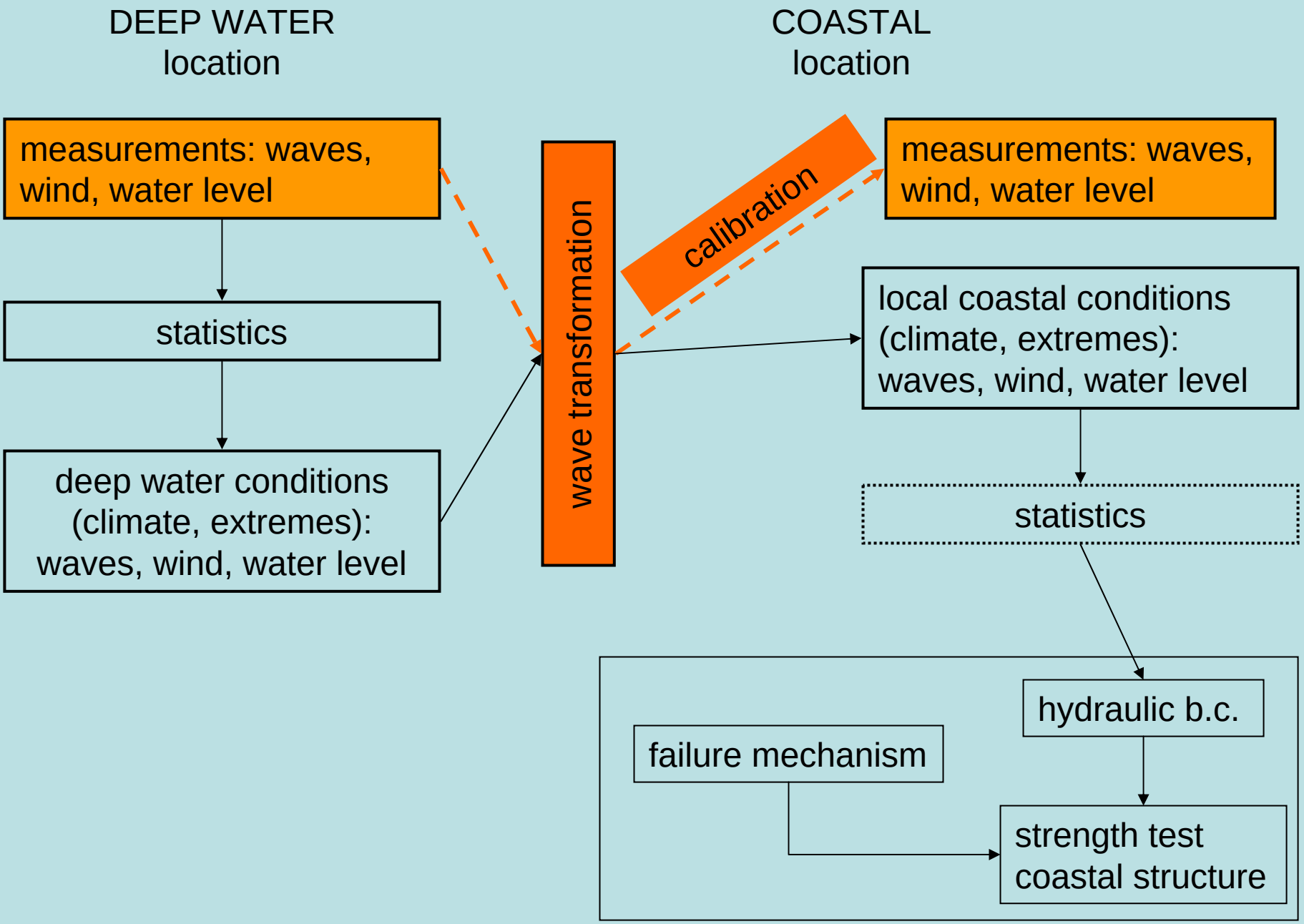
from P. Willems



from P. Willems

Extreme waves

- extreme waves
  - long term measurements seldom available at coastal location but often at off-shore location
  - off-shore can also be obtained from wave model output (hindcasts)


DEEP WATER
location
COASTAL
location
measurements: waves, wind, water level
statistics
deep water conditions (climate, extremes): waves, wind, water level
wave transformation
calibration
measurements: waves, wind, water level
local coastal conditions (climate, extremes): waves, wind, water level
statistics
hydraulic b.c.
failure mechanism
strength test coastal structure

wave transformation / calibration

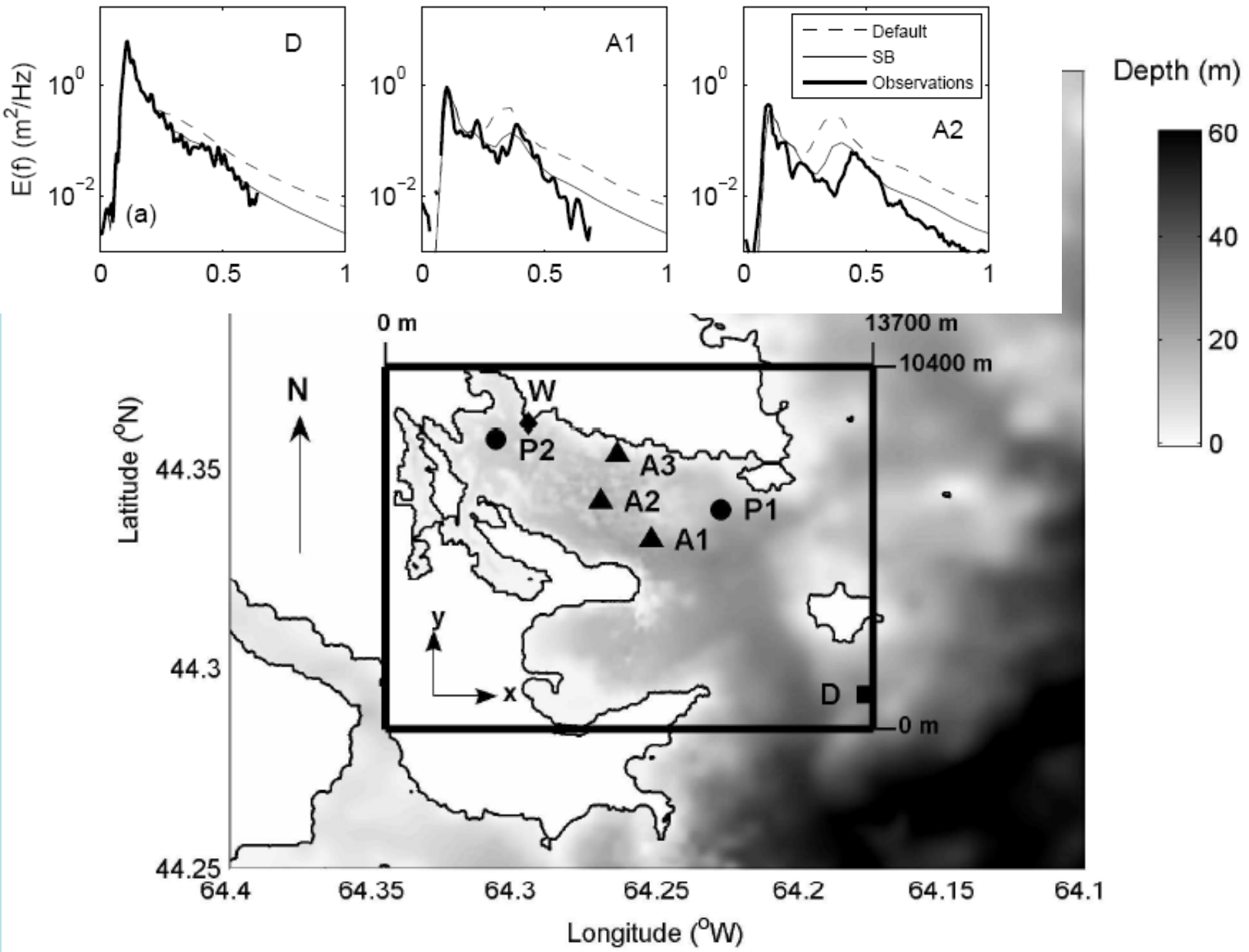
- wave transformation model?
  - phase averaged model (e.g. SWAN)
  - phase resolving model
  - other ...??

wave transformation / calibration (cont'd)

- problems:
  - calibration conditions: usually storm events but seldom extreme
  - are the physics involved in the transformation well represented in my model

Extreme waves at structure

- translation from off-shore to nearshore
  - swell penetration
  - depth limitation -> influence on statistics (cf Dutch studies)
  - wave direction
  - integrated parameters and/or full spectrum?
  - which wave height -> duration!
  - stability of coastal morphology



from Ph.D. A. Van der Westhuysen (T.U.Delft, 2007)

swell penetration?

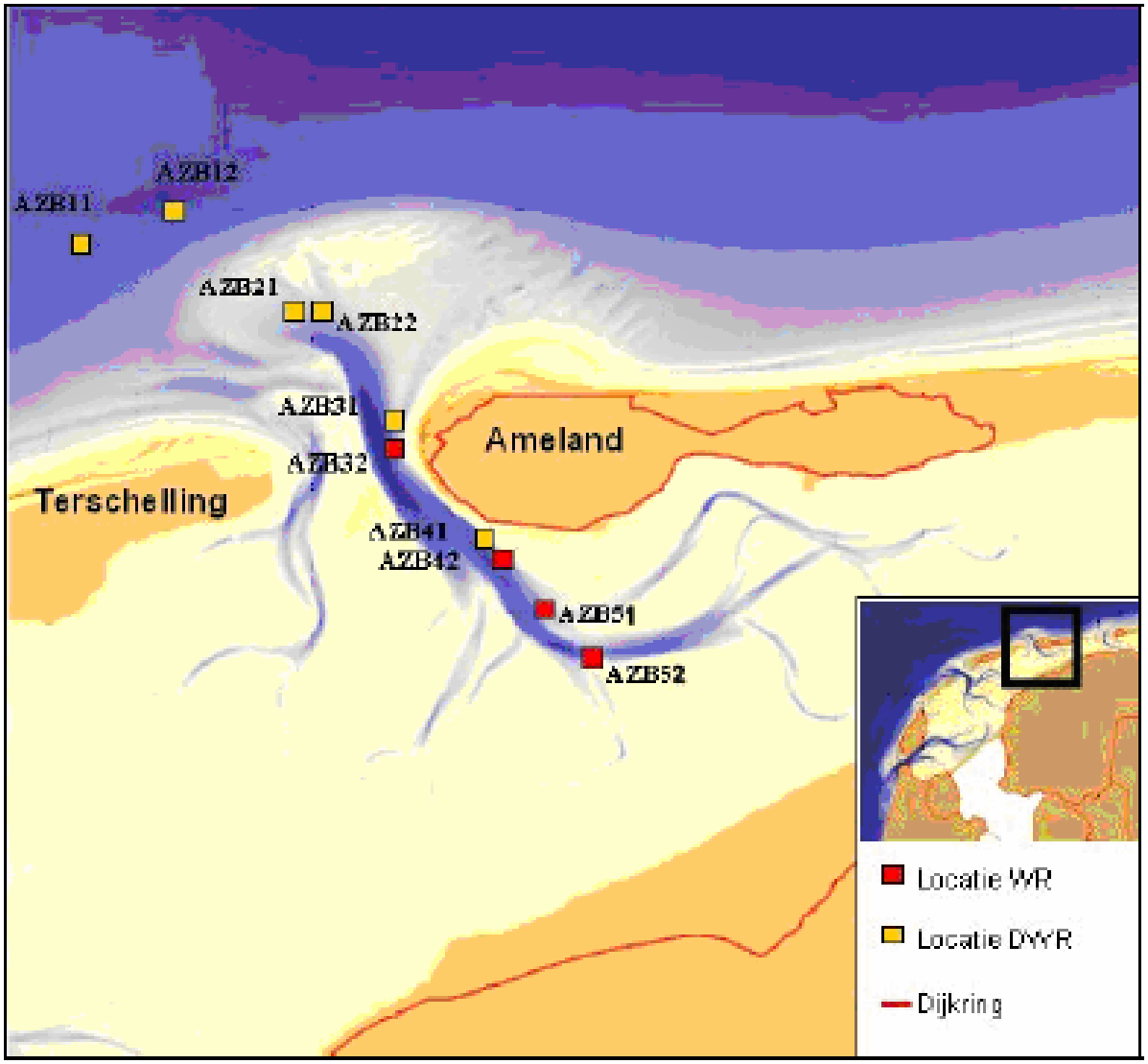


Figure 2.1: Wave measurement locations tidal inlet of Ameland 2004-2005

from Svasek 2005 report for RWS "Measurement report tidal inlet Ameland"

depth limitation?

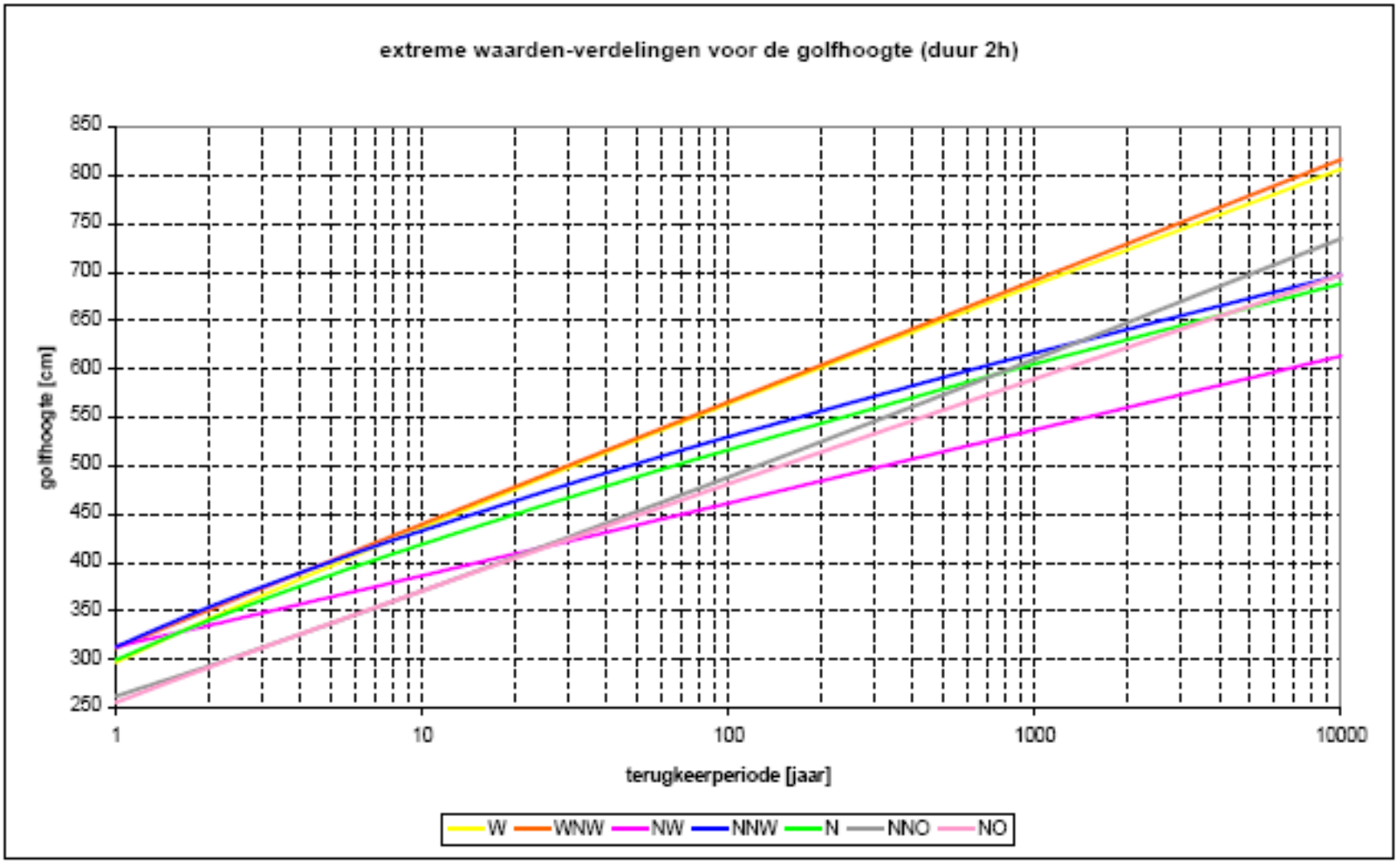
- comparisons between these and the corresponding POT/GPD upper bound estimates in terms of absolute and relative biases.

Buoy	bed level (m NAP)	SWAN		POT/GPD	bias (m)	relative bias
		wind direction (°N)	upper bound (m)	upper bound (m)		
SON	20.8	330	10.25	11.91	-1.66	-0.14
ELD	28.0	330	11.81	9.71	2.10	0.22
YM6	23.4	300	10.83	14.37	-3.54	-0.25
EUR	32.4	360	13.08	9.10	3.98	0.44
SCW	12.9	330	7.62	4.90	2.72	0.56

Table 4.2 Estimates of the physical maxima of significant wave height based on SWAN-2D computations and their absolute and relative biases with respect to the estimates obtained using the POT/GPD

from Delft Hydraulics 2006 Report “Extreme wave statistics: methodologie and applications to North Sea wave data (projec97)t RKZ-16

extreme values per direction



Figuur 2-2 Extreme waardeverdelingen van de golfhoogte

from IMDC 2004 report “Hydraulisch randvoorwaardenboek Vlaamse kust 2004”

use integrated parameters?

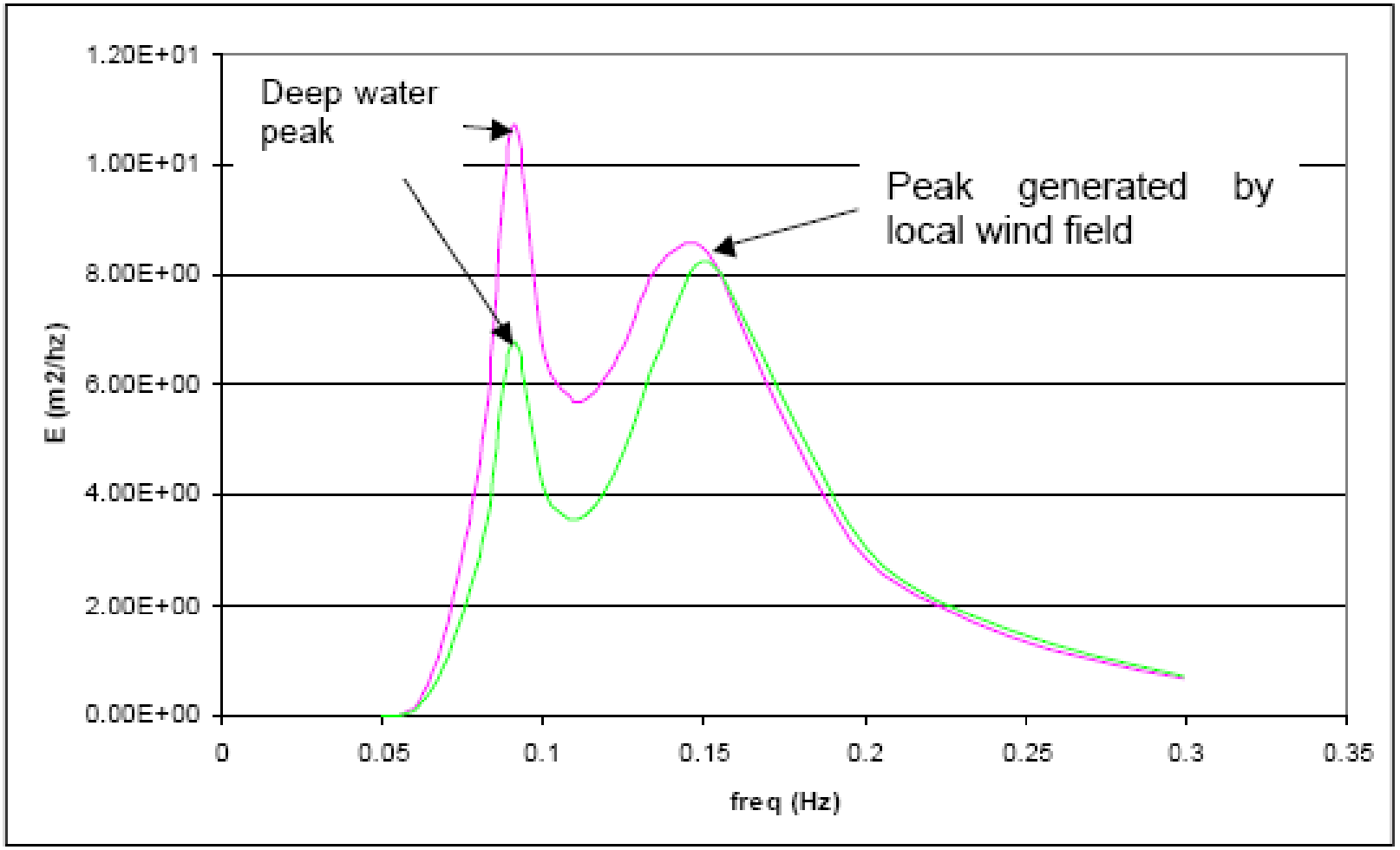


Figure 25: Spectra to the east of Zeebrugge

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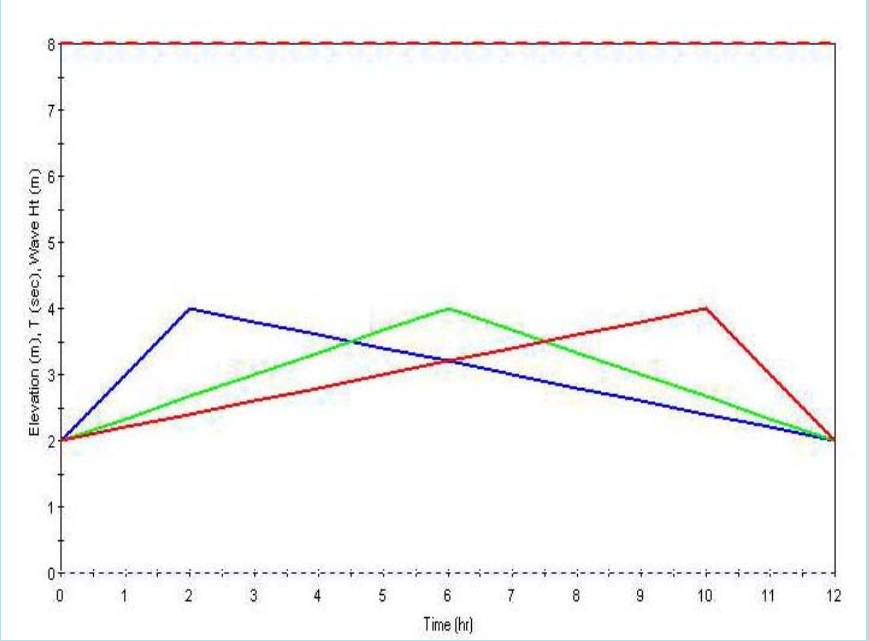
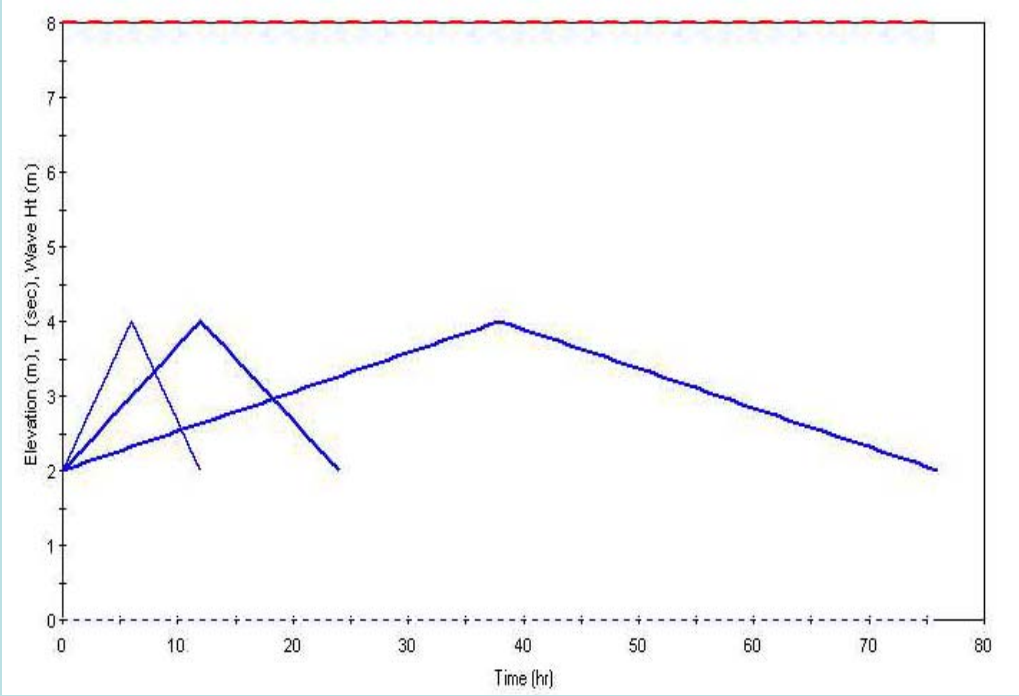
Storm shape and duration

Threshold of 2.0m.





Storm Duration 12 ,24, 76,100 & 160 hrs)

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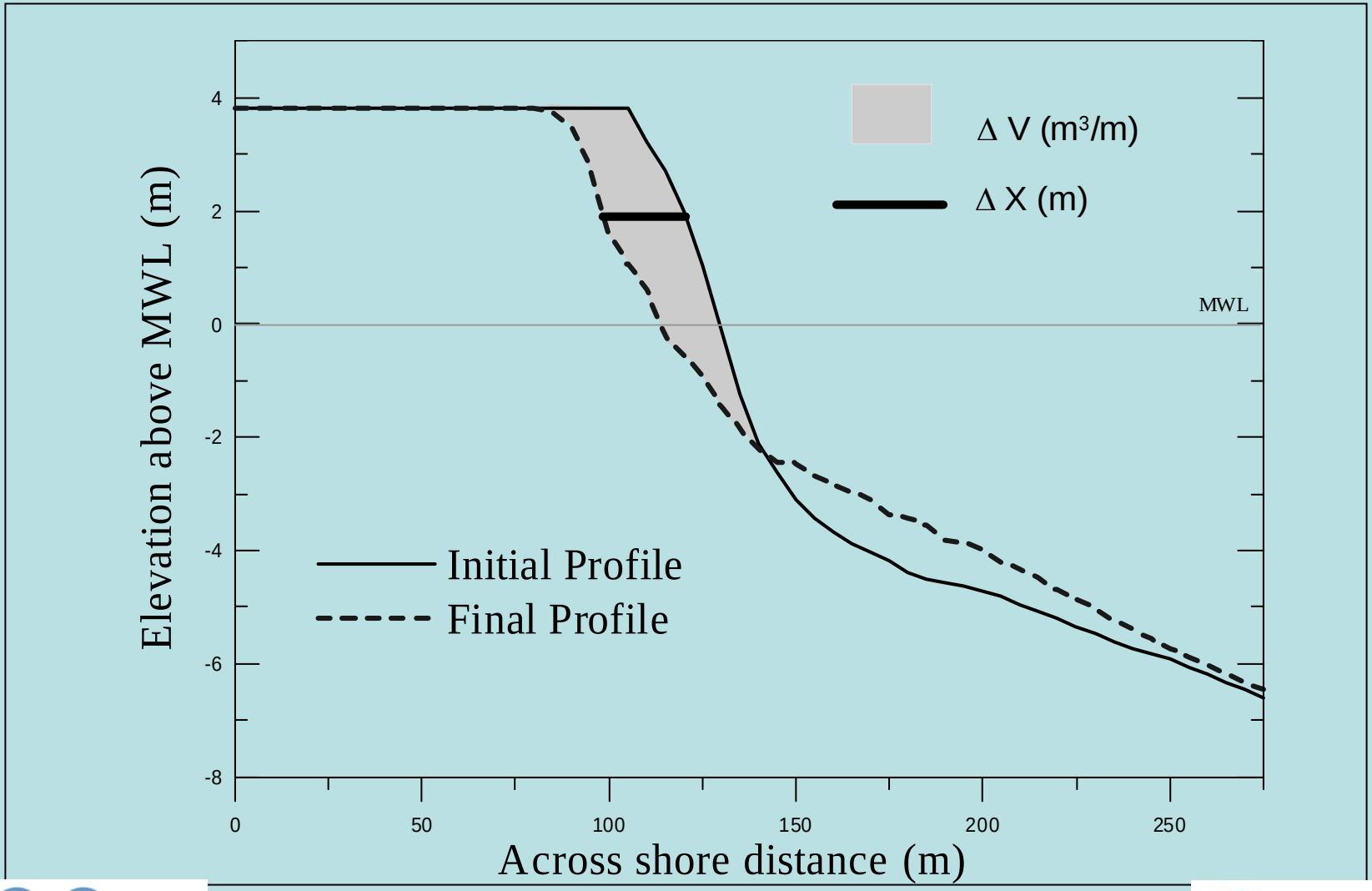
Beach erosion using SBeach (reflective beach type)



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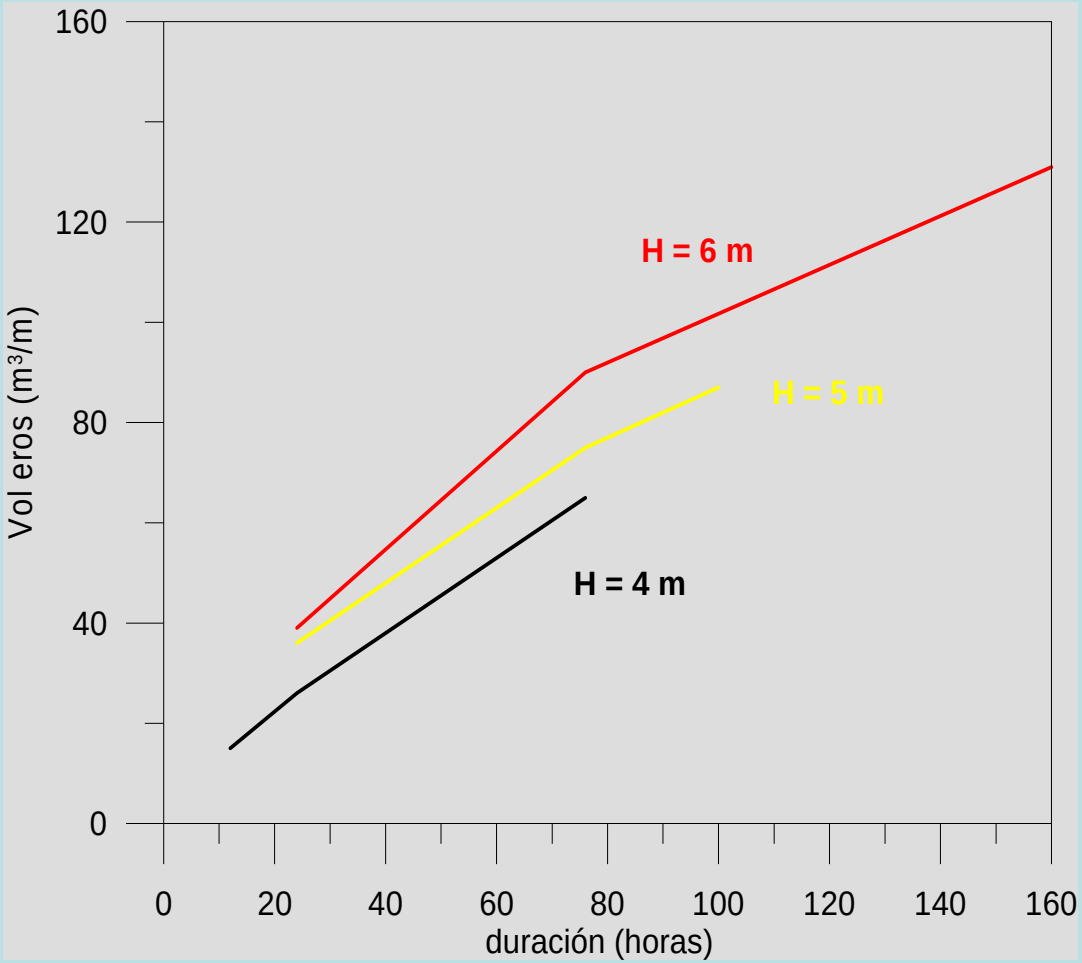
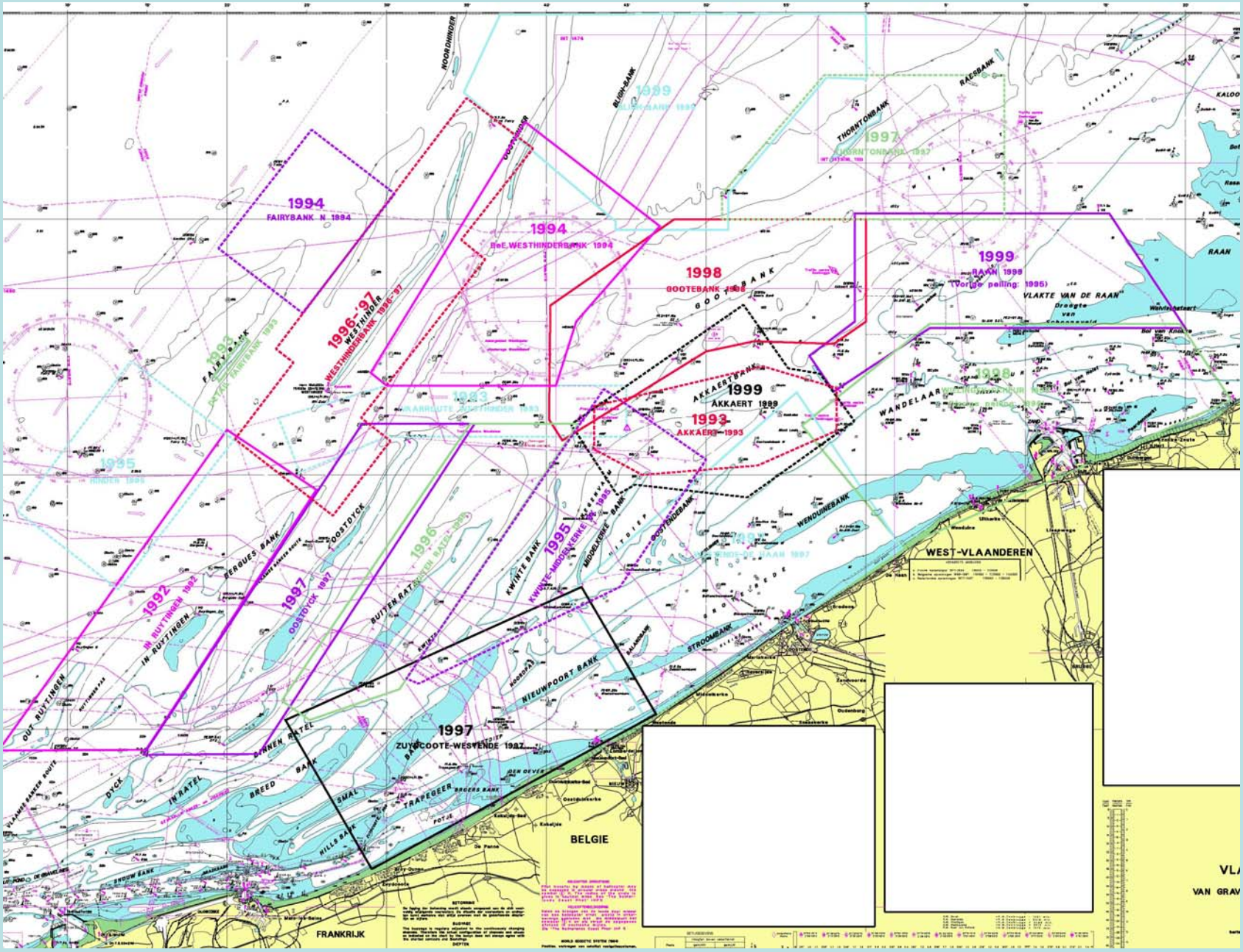


stability in time of bottom topography



Climate change

- what can we do to estimate impact?
  - example: UK initiative

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Future Wave Climate Modelling for Tyndall Coastal Simulator project

Judith Wolf and James Leake
Proudman Oceanographic Laboratory (POL), Liverpool, U.K.

http://www.tyndall.ac.uk/research/programme5/task_5.1.html

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Tyndall Wave Climate project

- We aim to simulate the effect of climate change on waves using atmospheric forcing data provided by the Hadley Centre and wave modelling expertise provided by POL. The outputs will be:
  - 30-y simulations (using WAM) based on one present and two future UKCIP02 scenarios
  - 30-y simulations based on one present and two future UKCIP08 scenarios
  - Wave forcing for Tyndall Coastal Simulator (Norfolk coast pilot project) driving wave transformation and cliff/foreshore evolution models for coastal management

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Tyndall Wave Climate project (cont'd)

Present and future climate scenarios, are being run using the ProWAM wave model of NW European Shelf on 12km grid, driven by Hadley Centre RCM winds (~50km)

- Boundary conditions are provided by whole Atlantic wave model on 1-deg grid driven by HadCM3 global model winds

Example of Atlantic model wave height (m) showing NW European shelf model extent (box)

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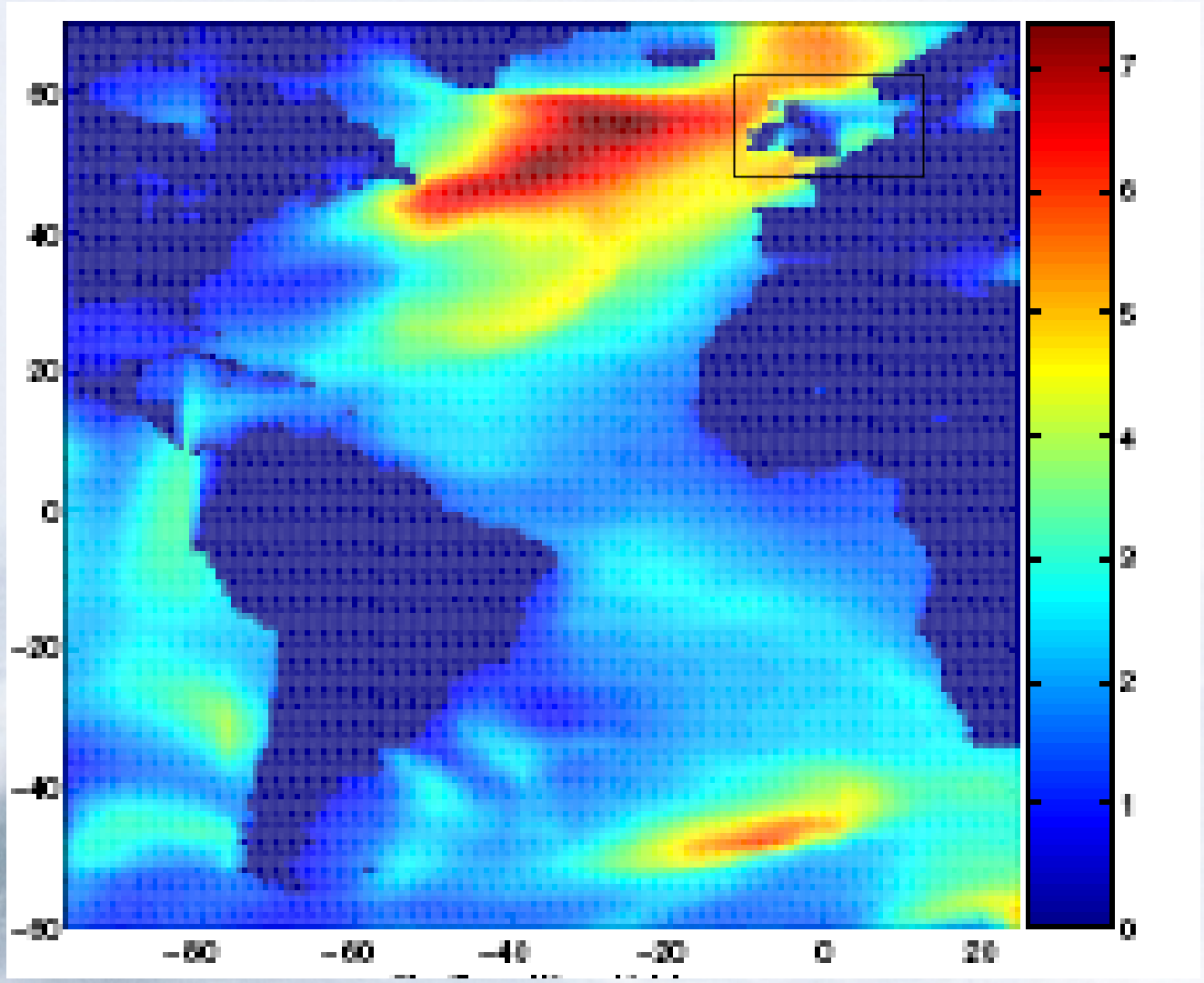

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UKCIP02 and UKCIP08 scenarios

- UKCIP02
  - Present-day, A2 and B2 scenarios (medium-high and medium-low emissions)
- UKCIP08
  - Select 2 examples from the 17-member ensemble of climate model forcing to cover range of variability
  - Run Atlantic and NW European Shelf models for 3 3-year time-slices

First Results

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- Atlantic runs, present and future climate, for UKCIP02, are complete
- NW European Shelf model UKCIP02 runs are nearly complete
- Tests of statistical agreement with ERA40 reanalysis results for recent 30-year time-slice (1960-1990) have been carried out
- A suite of statistical analysis methodology for model output has been developed

Extreme hydraulic boundary conditions

- joint probabilities for water level, wave conditions, wind conditions, morphological conditions, climate change ...

coastal design, extremes and climate change

Defining hydraulic boundary conditions is complex with many uncertainties :

- from purely statistical origin (data limited in time)
- from modeling
  - hindcast deep-water conditions (if used)
  - wave transformation
  - climate change scenario’s

At the end coastal engineer needs design values (including uncertainty bounds)