IMMERSE Final conference: Regional climate adaption investigation by use of numerical modelling

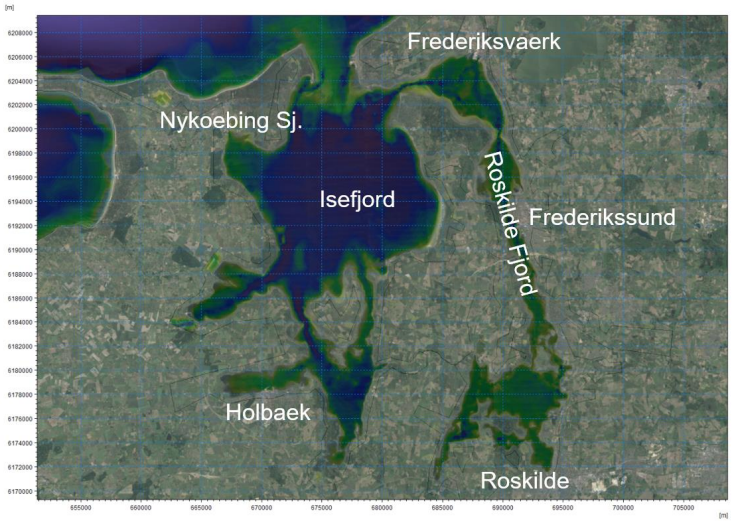
by Lotte Meldgaard Pedersen, Sweco

March 2022

Interreg North Sea Region IMMERSE
European Regional Development Fund
EUROPEAN UNION
SWECO

Presentation:

1. Screening of project area
2. Potential methods
3. Numerical modelling
4. Stakeholders
5. Transfer of knowledge to other estuaries



1. Screening of project area

The project area in IMMERSE:

Complex in many ways!

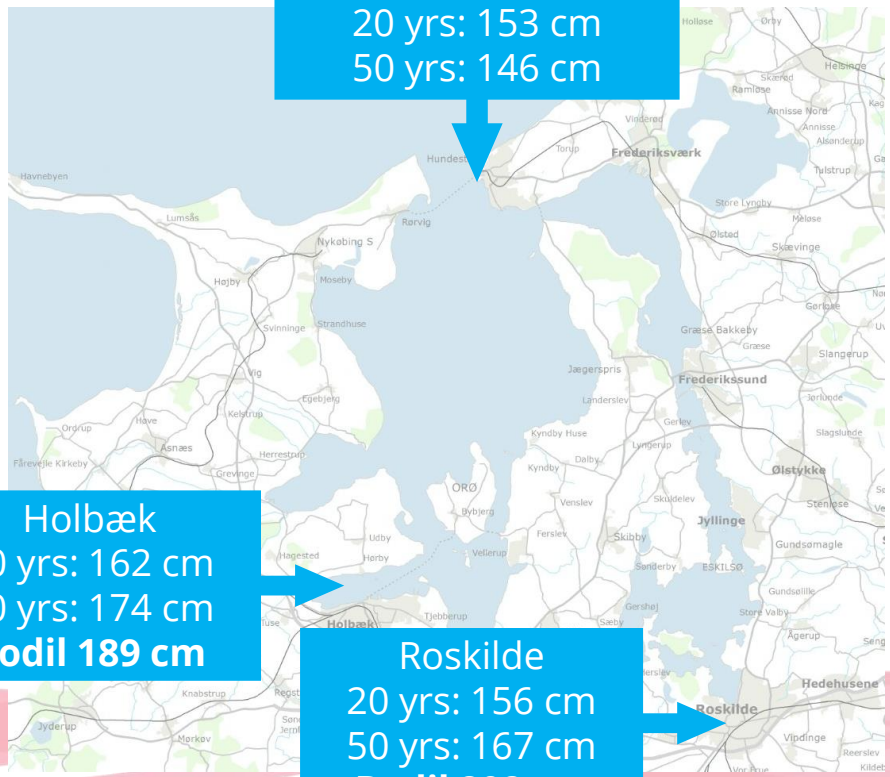
1. Screening of project area

Pressures:

1. Sea level rise
2. More frequent extreme storm surges
3. Cloud burst
4. Rising groundwater

⁂ Storm surge statistics (Kystdirektoratet 2017)

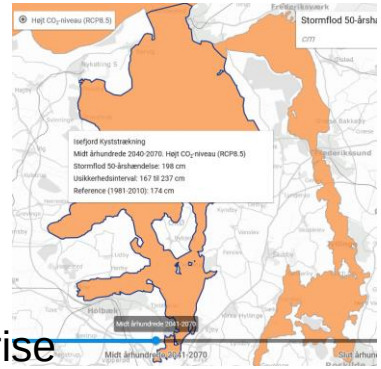
Hundested
20 yrs: 153 cm
50 yrs: 146 cm



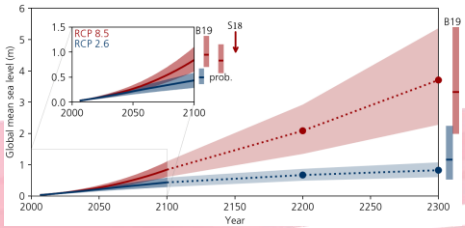
Holbæk
20 yrs: 162 cm
50 yrs: 174 cm
Bodil 189 cm

Roskilde
20 yrs: 156 cm
50 yrs: 167 cm
Bodil 202 cm

⁂ Climate atlas (DMI 2019)



⁂ Global sea level rise (IPCC 2019)



Interreg
North Sea Region
IMMERSE
European Regional Development Fund

EUROPEAN UNION

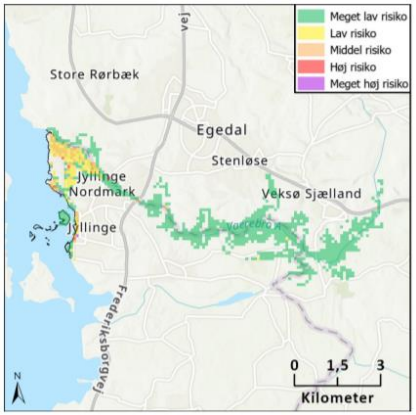
SWECO

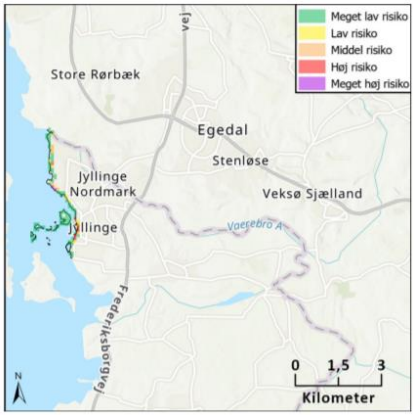
1. Screening of project area

Flooded areas at water level +2 m.

Example of risk evaluation for:

Flooding *Erosion*





1. Screening of project area

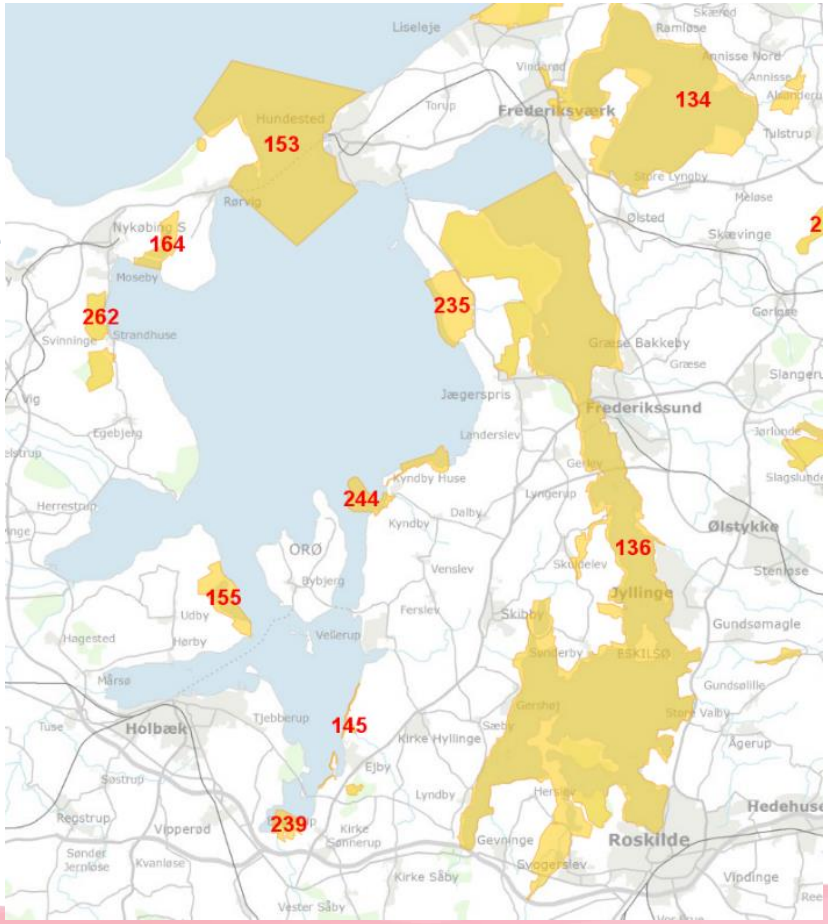
Nature 2000 areas

16 Natura 2000 areas
25.000 acres - of which 11.000 acres are situated in sea and fjord areas.

Meadows, freshwater marshes and saltwater marshes.

Wetlands and moist natural areas outside the Natura 2000 areas rely on the water ecosystems in the river basin.

About 30 bird species breed on the vacated islands of Roskilde Fjord.

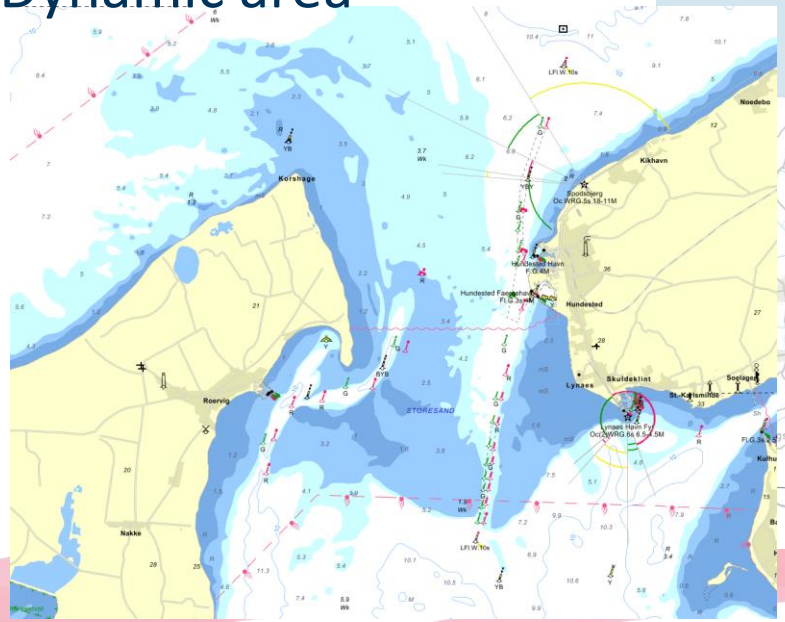


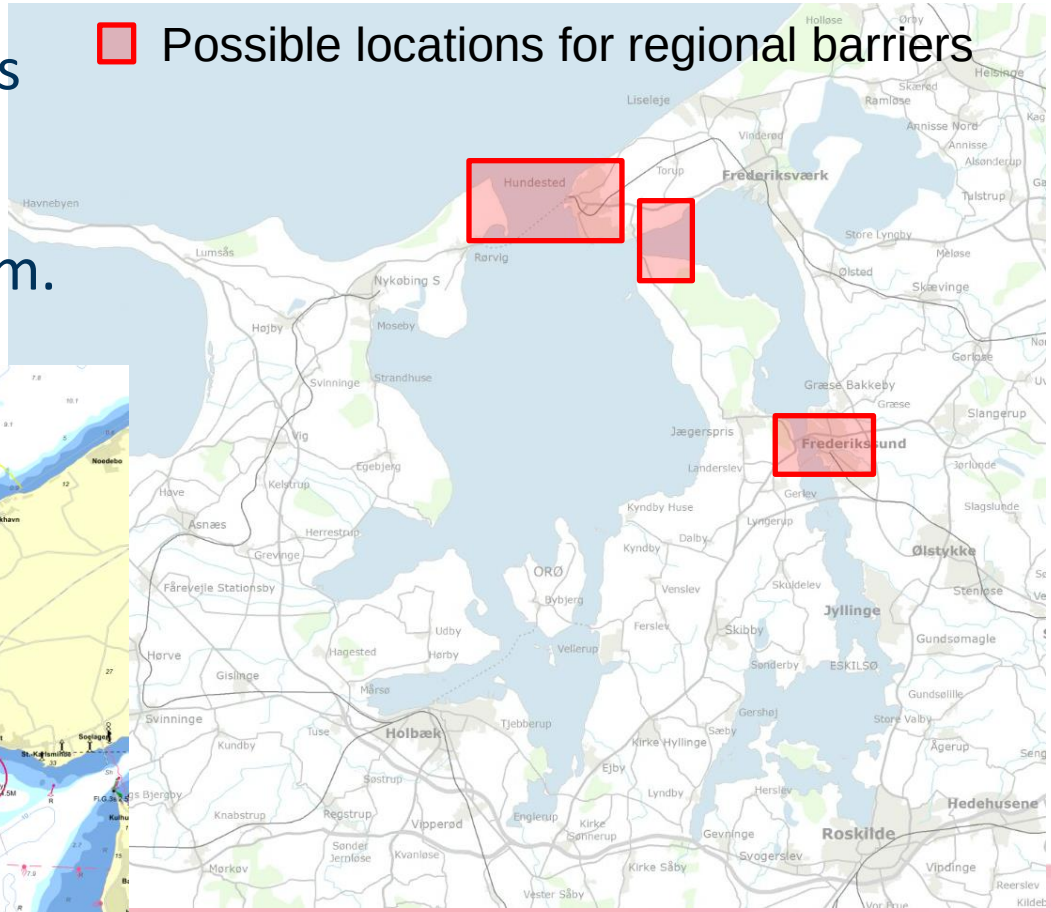
1. Screening of project area

Local >< Regional options

Water depth to app. -15 m.

Dynamic area





1. Screening of project area

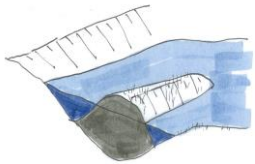
Solution catalogue based on:

Regional solutions

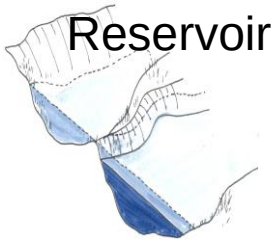
- Storm surge barrier, sluices, minimizing inlet, storage etc.

Local solutions

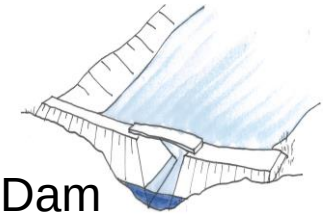
- Dikes, mobile solutions, walls etc.
- Leave the area! ...



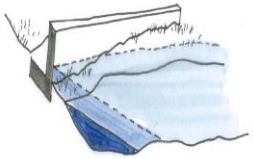
Artificial island or dam to delay flooding

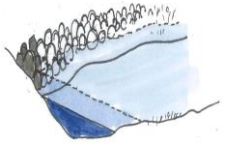


Reservoir



Dam



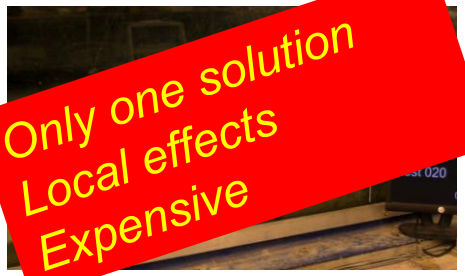


Local solutions

2. Potential methods

Possible options to test measures:

Physical model tests (flume)



Only one solution
Local effects
Expensive

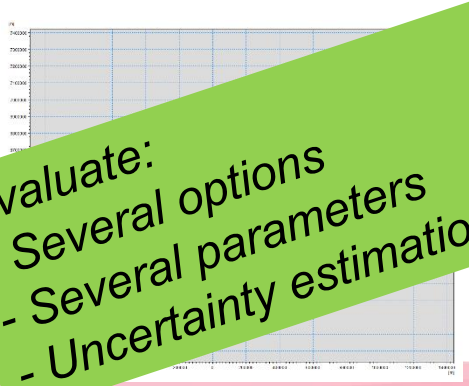
Empirical calculations

$$(x+a)^n = \sum^{n} (n)$$

$$\max_{0 \le x \le 1} xe^{-x^2}$$

Complexity!!!

Numerical simulations



Evaluate:
- Several options
- Several parameters
- Uncertainty estimation

Full scale

Not really possible

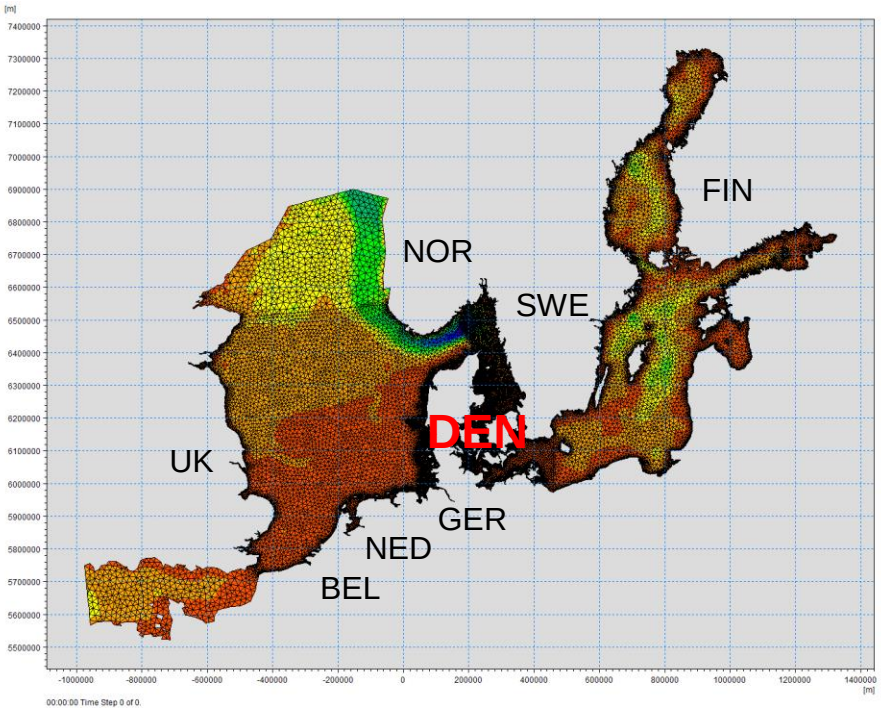
3. Numerical modelling

Most suitable option – what to study:

+ Permanent measures at different locations:
  - Sea dike / Barrier (partly blocked inlet)
  - Submerged dike
  - Flood storage channel
+ Flexible/mobile measures:
  - ‘Gate’ structure
+ Response to climate change:
  - Sea level rise
  - Storm peak >< Tidal peak
  - Storm track / Extreme wind
  - Sedimentation at inlet / Morphodynamics
+ Robustness of measures (incl. sea level rise)

3. Numerical modelling

Regional model

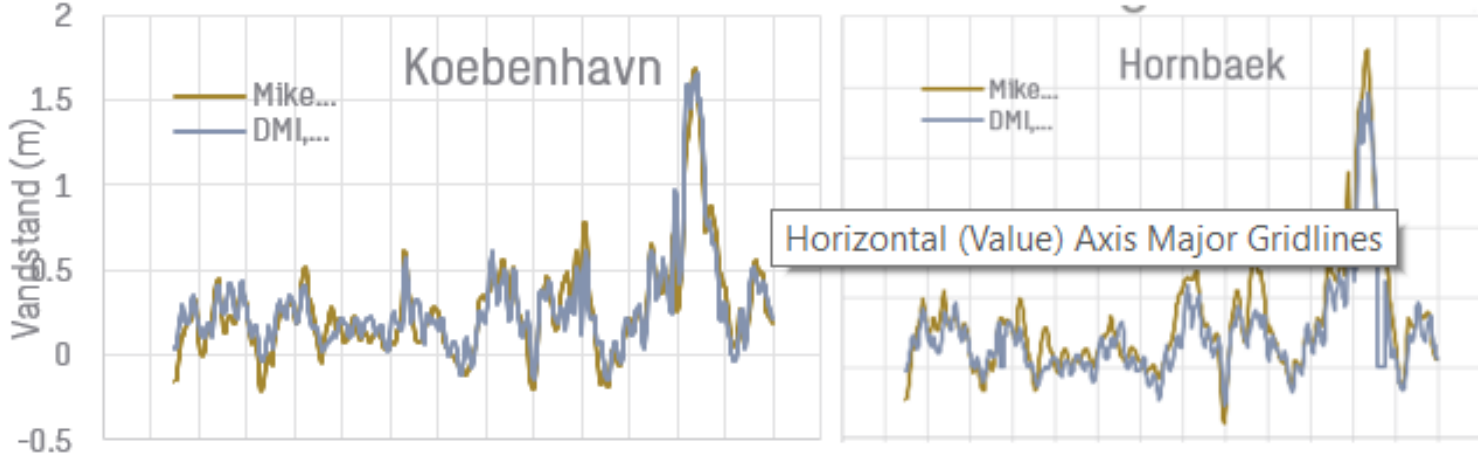


Regional model covers North Sea, all Danish waters and the waters to the Botnian Bay.

Based on available weather data from 1979-2019. Include wind, rain, evaporation, rivers.

3. Numerical modelling

Calibrated against available water level data in the regional model area.

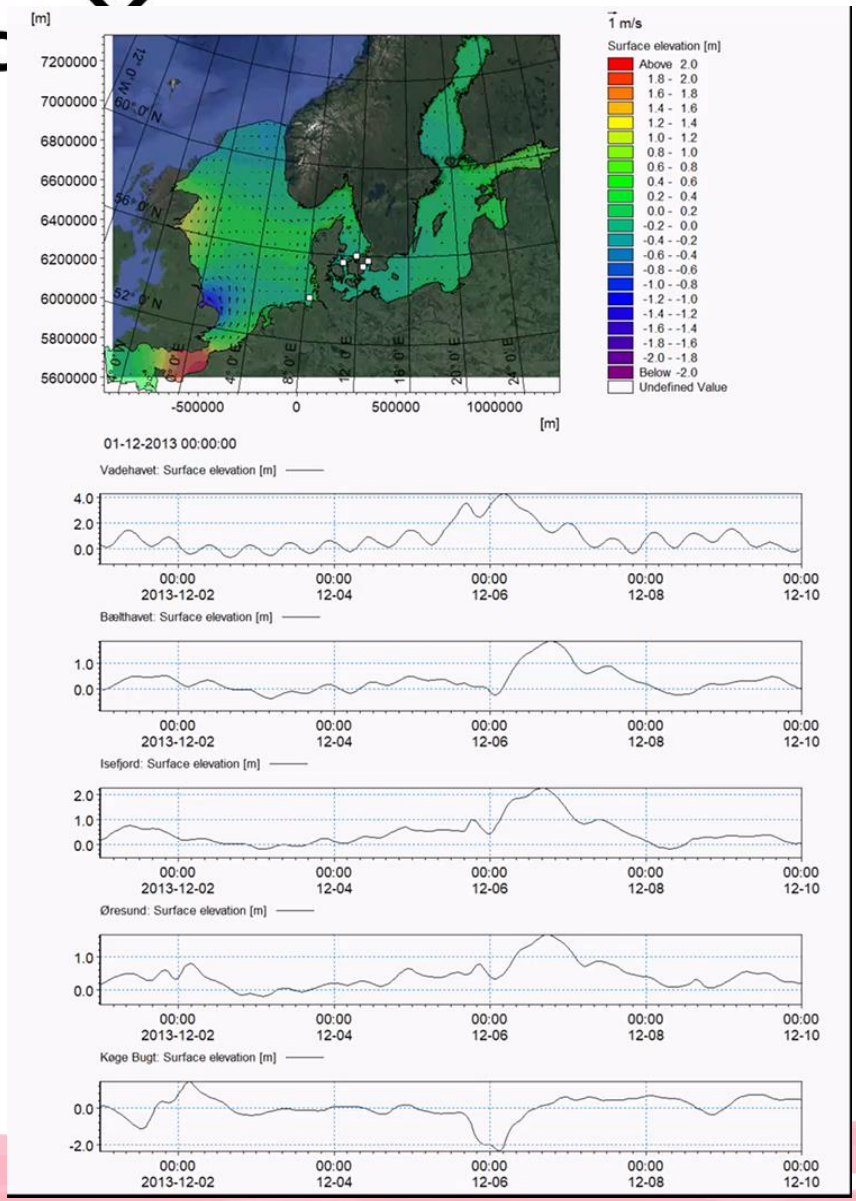


Interreg
North Sea Region
IMMERSE
European Regional Development Fund

EUROPEAN UNION

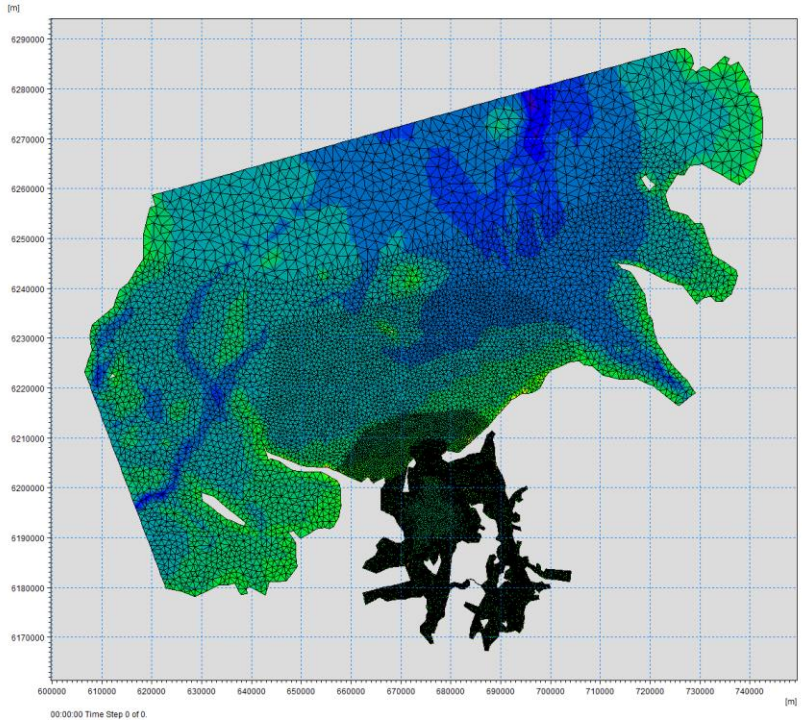
SWEC

Simulation of Bodil Dec. 2013



3. Numerical modelling

Local model



Swecos local Isefjord/Roskilde Fjord model.

High resolution in narrow straits and along coastline. Coast have been added to +3 m.

Effect of regional solutions on storm surge levels (**time scale** and **extreme level**).

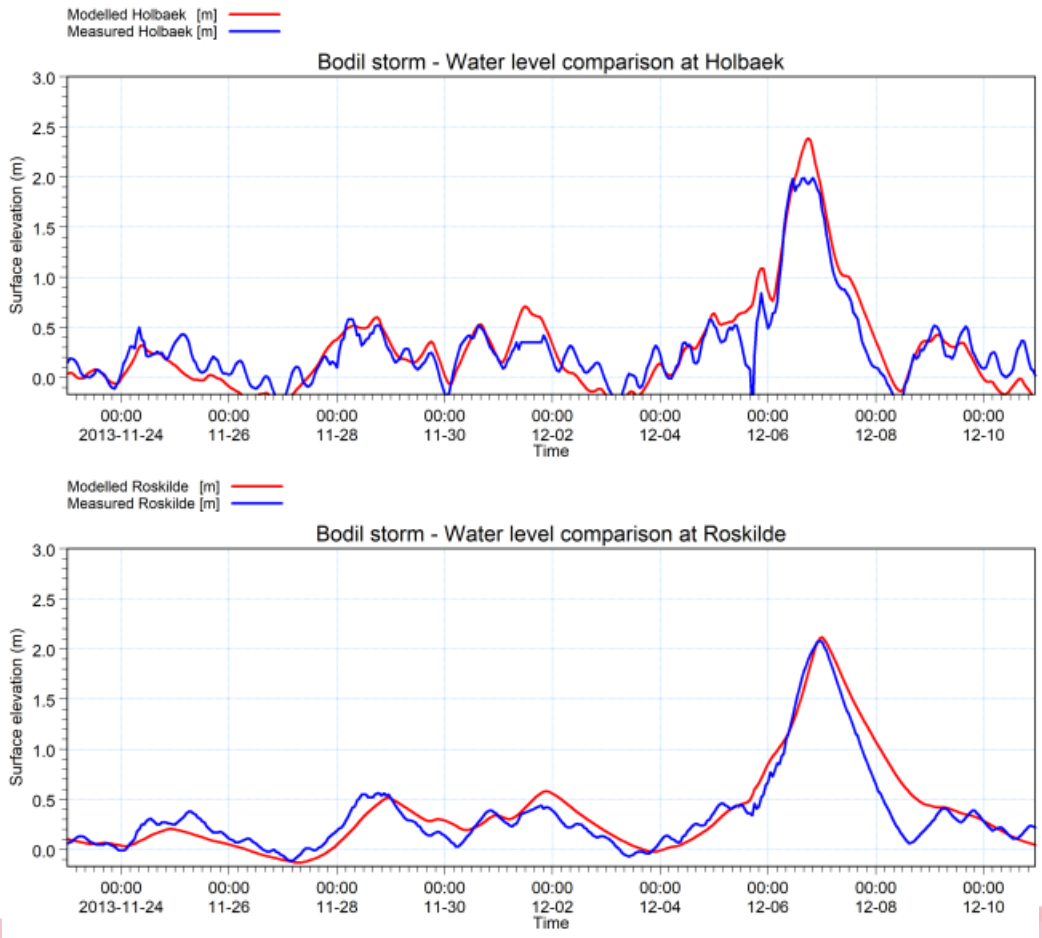
Effect of climate change parameters

3. Numerical modelling

Calibration performed on main parameters:

- Manning number
- Grid size
- Wind distribution

Calibration at storm events
(Bodil December 2013)

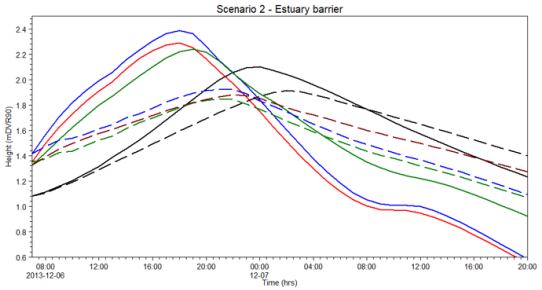


3. Numerical modelling

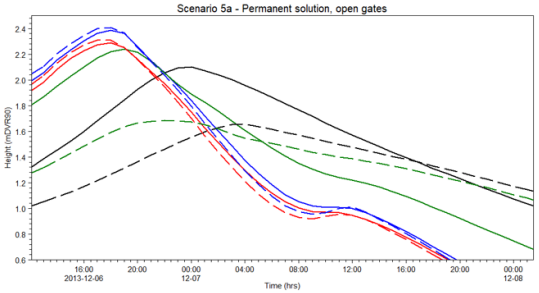
What have we learned so far?

- Well calibrated model.
- We are able to delay and minimize the peak without complete regional blocking.
- Sea level rise and morphodyamics will have an impact on the levels.
- Tidal circle will impact extreme levels.
- Storm track will impact the level.
- Flood storage channel not feasible.
- Ideal method for initial studies of measures – forms the basis for more explicit studies also taking environmental impacts into account!

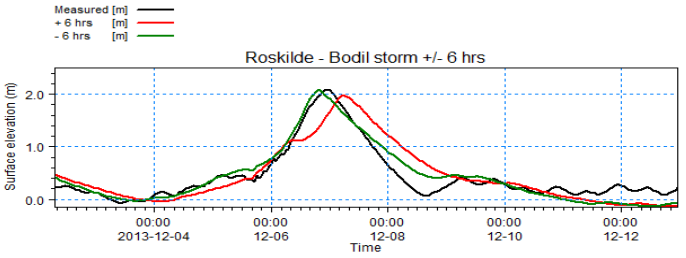
Preliminary results



Black: Roskilde. Blue: Holbaek. Red: Nykoebing Sj. Green: Frederiksvaerk.
Solid: Baseline. Dash: Tested measure.



Black: Roskilde. Blue: Holbaek. Red: Nykoebing Sj. Green: Frederiksvaerk.
Solid: Baseline. Dash: Tested measure.



3. Numerical modelling

Limitations:

- Not all parameters that govern the value of a measure is studied (groundwater rising, more frequent cloud bursts, local solutions etc.)

- '*Garbage in – garbage out*' – deeply depending on reliable input parameters!

3. Numerical modelling

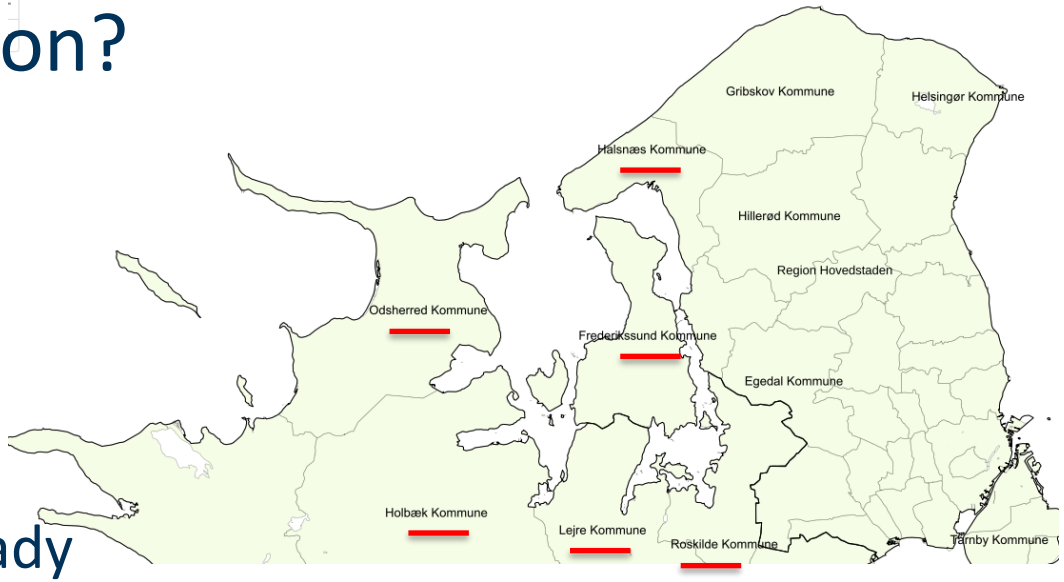
Final project input:

- Elaborating the results
- Prelim. dynamic adaption planning pathway as basis for strategy
  - (regional, local and '*leave*' level)

4. Stakeholders

Why is it difficult to agree on regional solution?

- 6 Municipalities
- 2 Regions
- Diverse use of land
- Risk levels differs
- Local solutions already established (50 yr horizon)
- Nature preservation



4. Stakeholders

Presentation of results to technical / non-technical stakeholders:

- Clear message on the limitations/uncertainties in modelling (e.g. bathymetric data, lack of measurements for calibration, wind pattern input)
- Presentation of results always with an explanation
- Regional solutions >< Local solutions => Stakeholder involvement!!

5. Transfer to other estuaries

Independent on location:

- Creation of measure catalogue (within variations)
- Methodology in simulation
- How to assess the uncertainties in climate change expectations

DISCUSSION

+ Value of simple initial project screening and numerical modelling in your projects?
+ What is more important when looking for the right solution?
    1. Ecology / Nature preservation
    2. Economy (structural cost)
    3. Visual / Architecture
    4. Adaptive dynamic potential due to all uncertainties
    5. Something else

Thank you for your time

LotteMeldgaard.Pedersen@sweco.dk