



Deltares
Enabling Delta Life

Salinisation and freshening of the Southwestern Delta & Wadden

A. Case The Netherlands: national
B. Case Zeeland: regional & local
C. Case Wadden

Gualbert Oude Essink

Groundwater in the future

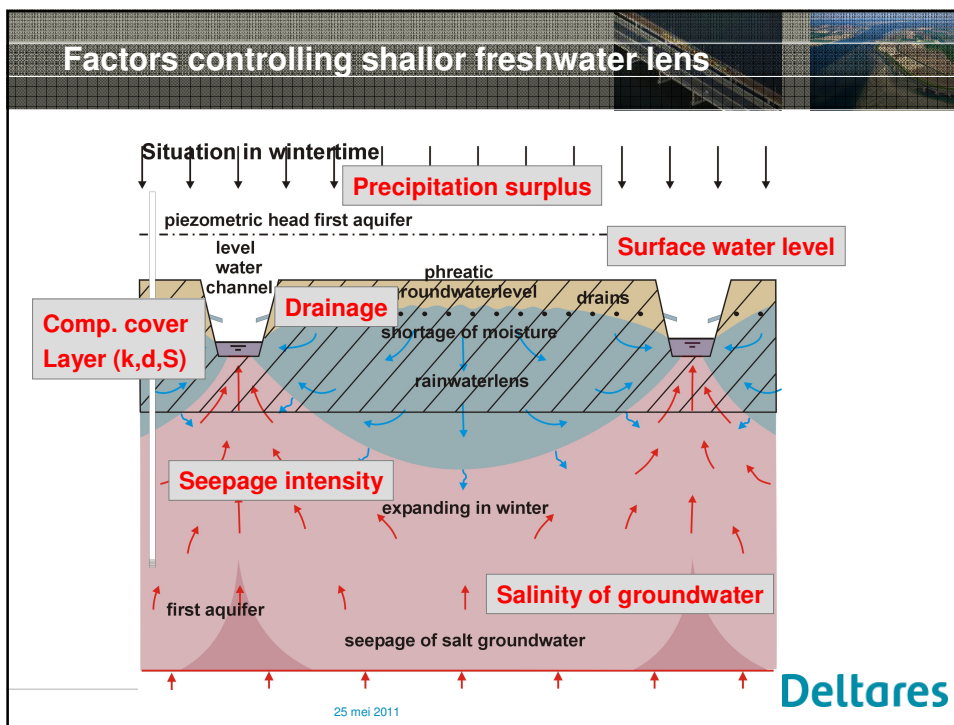
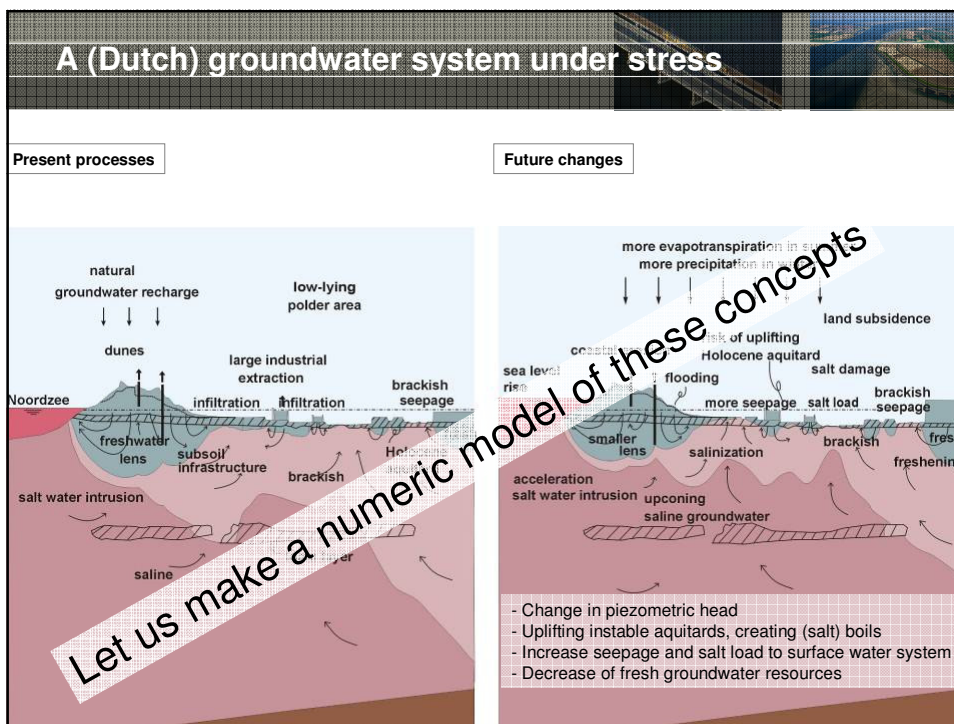
We have to cope with...:

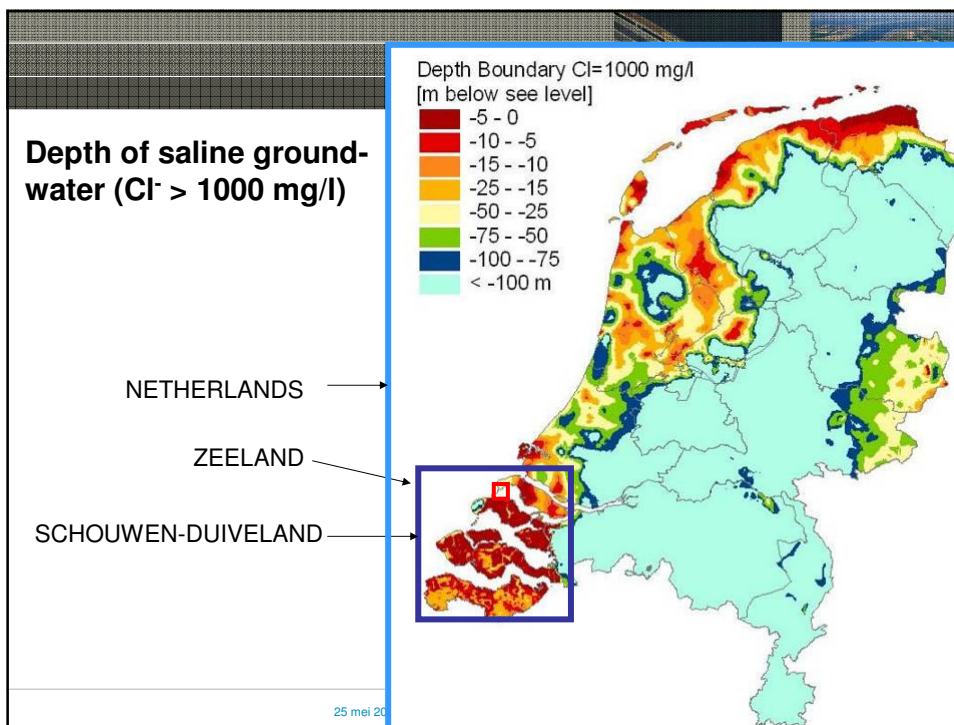
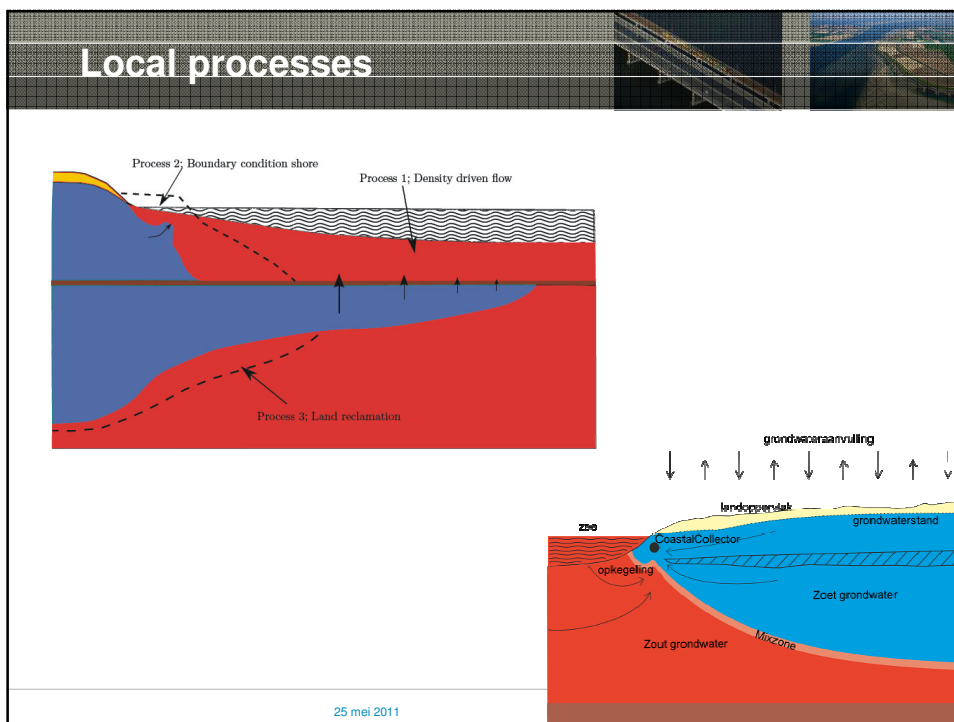
- Climate change
- Groundwater extractions
- Development energy use/production (heat-cold)
- Land subsidence
- Development spatial land use
- **Politics, Policy & Watermanagement**

Direct anthropogenic influence on groundwater is more important than climate effect

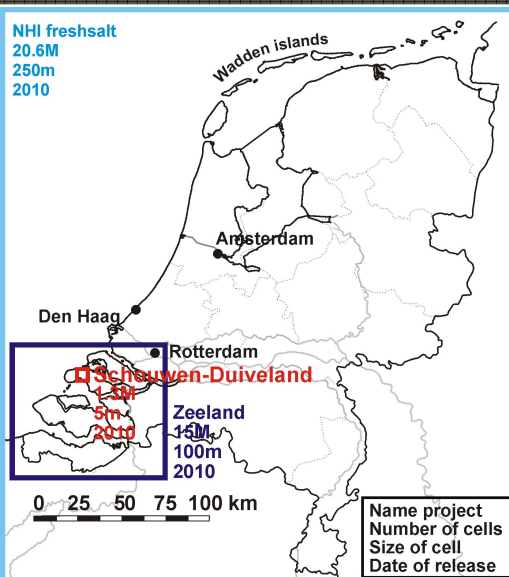
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Three model scales to consider phenomenae



National: NHI freshsalt
cell size=250m²



Regional: Zeeland
cell size=100m²



Local: Schouwen-Duiveland
cell size=5m²

Goal:

Take largest possible scale of relevant salinisation processes to assess impacts of climate and anthropogenic change

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Problem definition and objectives

Salinisation shallow groundwater and saline seepage leads to:

- Salinisation of surface water (salt load)
- Salinisation of root zone (rainwater lenses on agricultural plots)
- Smaller freshwater volumes (drinking water in sand dunes)

Main questions:

- Spatial variation of saline seepage / fresh water bodies
- Dynamics of saline seepage - rainwater lens
- Effects of sea level rise and climatic change
- Robust and feasible mitigation and adaptation strategies

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Modelling effect climate change on fresh-salt groundwater

Modelling:

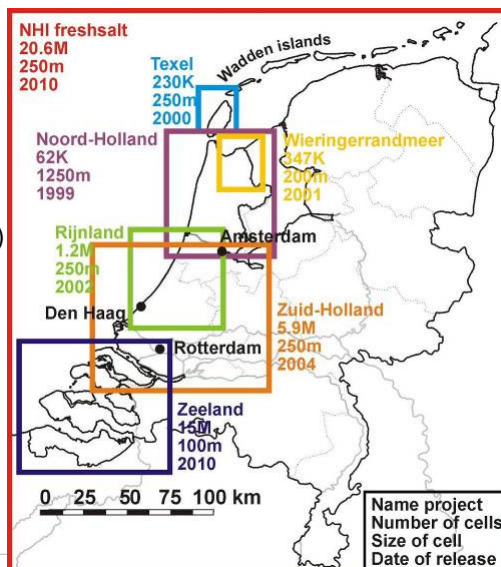
- variable-density
- 3D, non-steady
- groundwater flow
- coupled solute transport

Code:

MOCDENS3D (MODFLOW family)
similar to SEAWAT

Assessing effects:

- autonomous salinisation
- sea level rise
- changing recharge pattern
- land subsidence
- changing extraction rates
- adaption measures

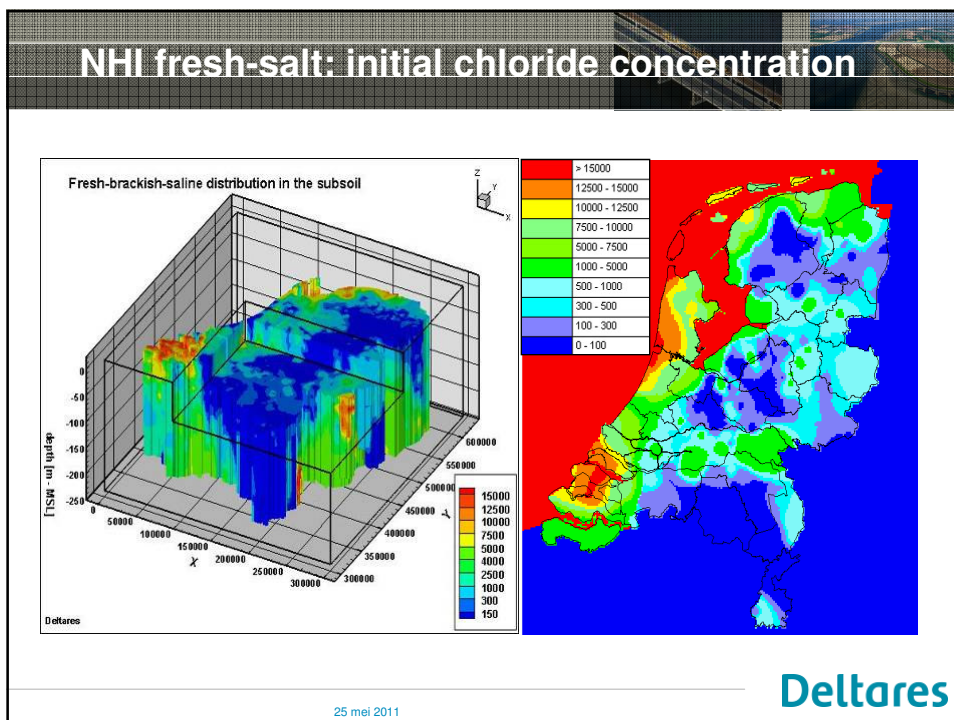
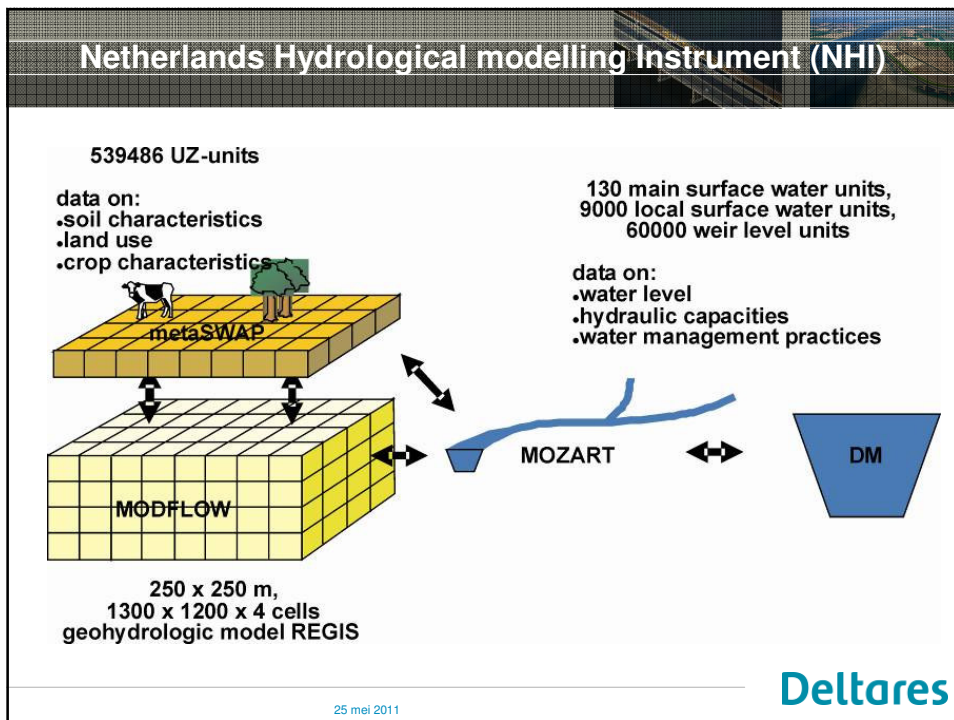


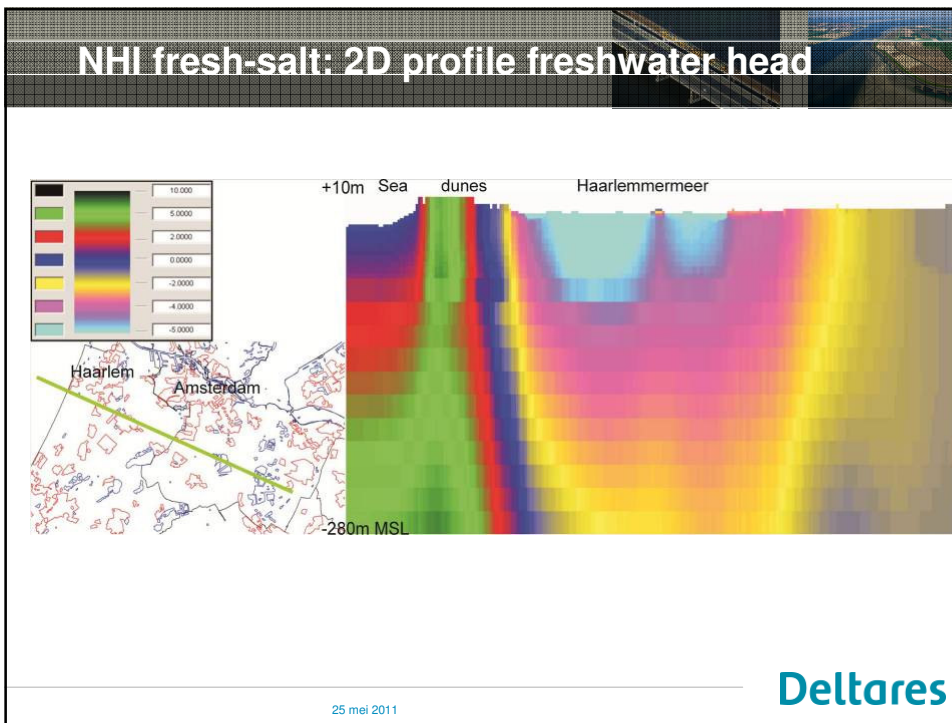
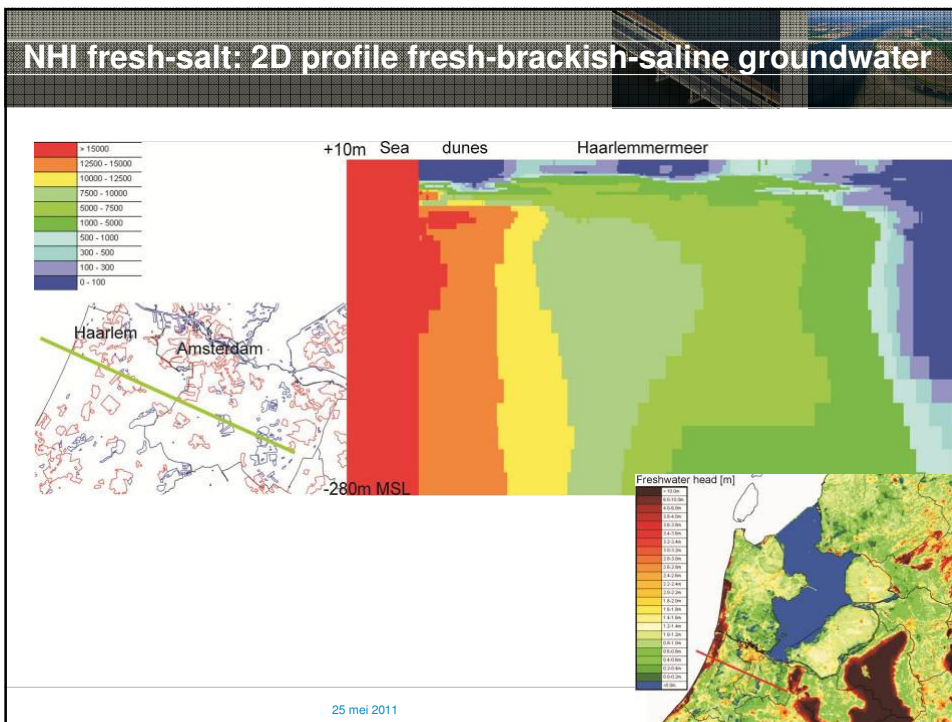
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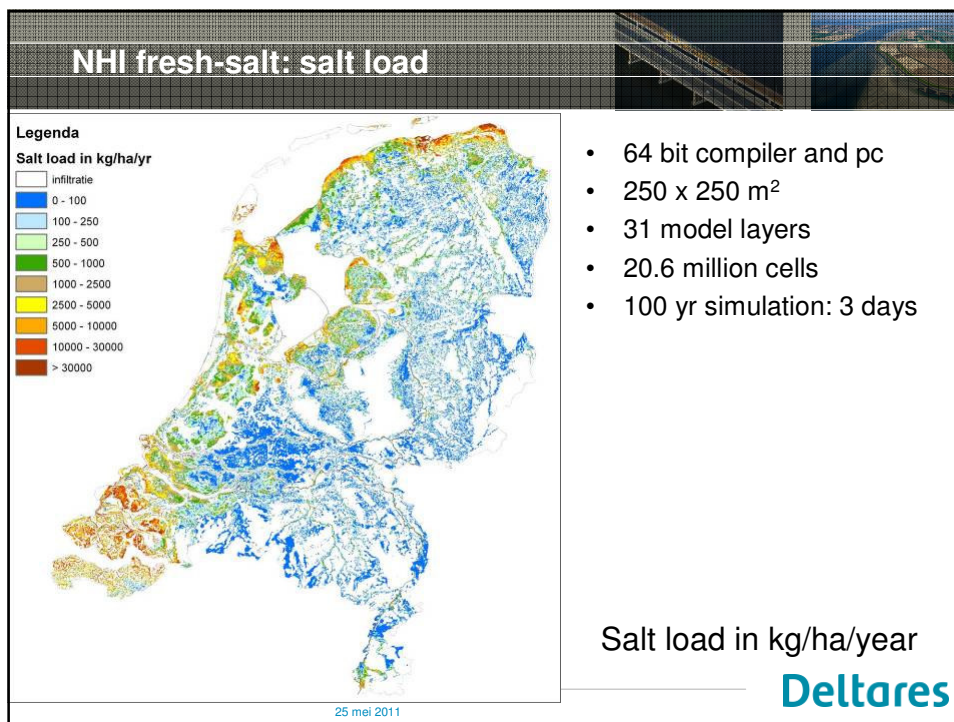
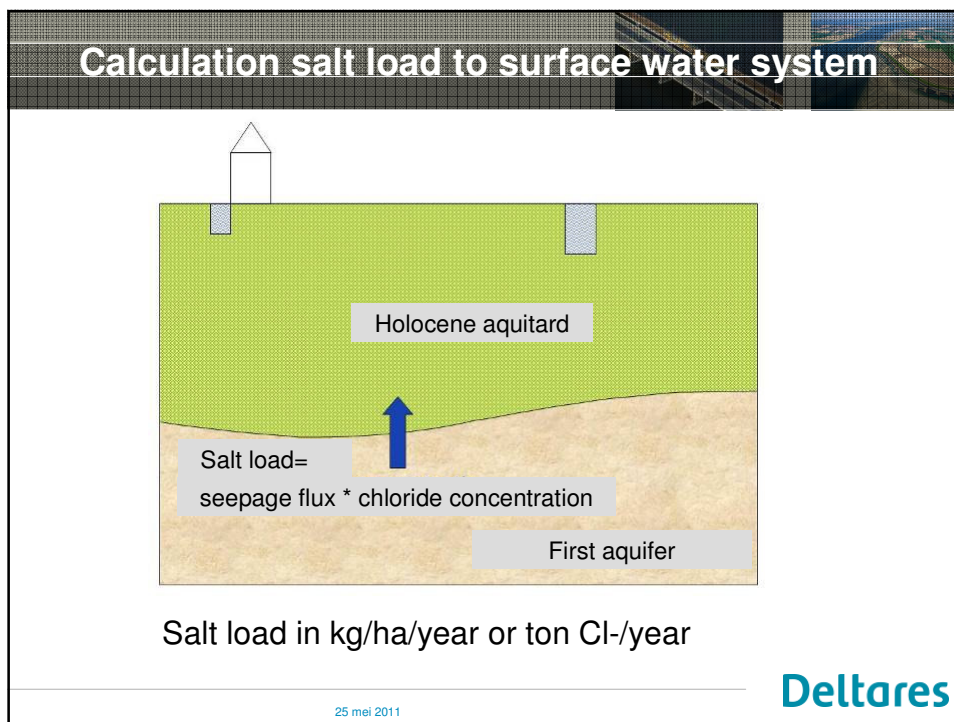
National scale

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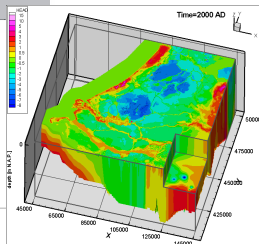
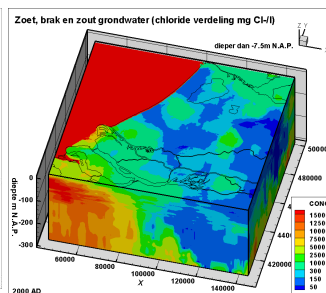
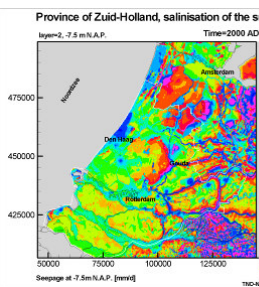
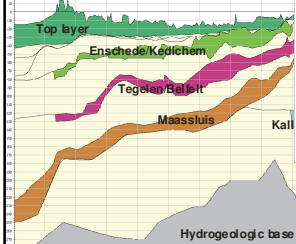
Regional scale



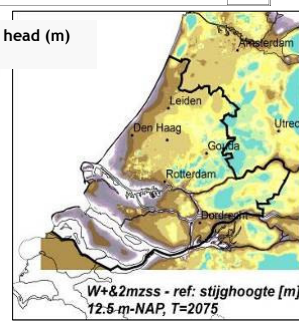
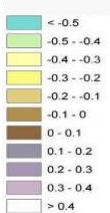
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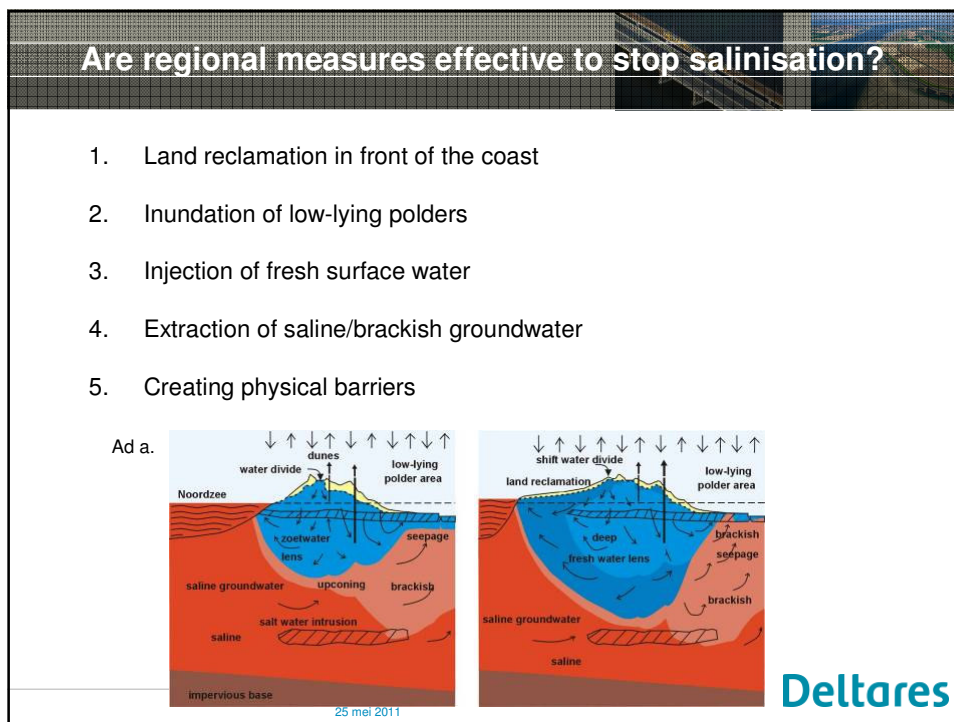
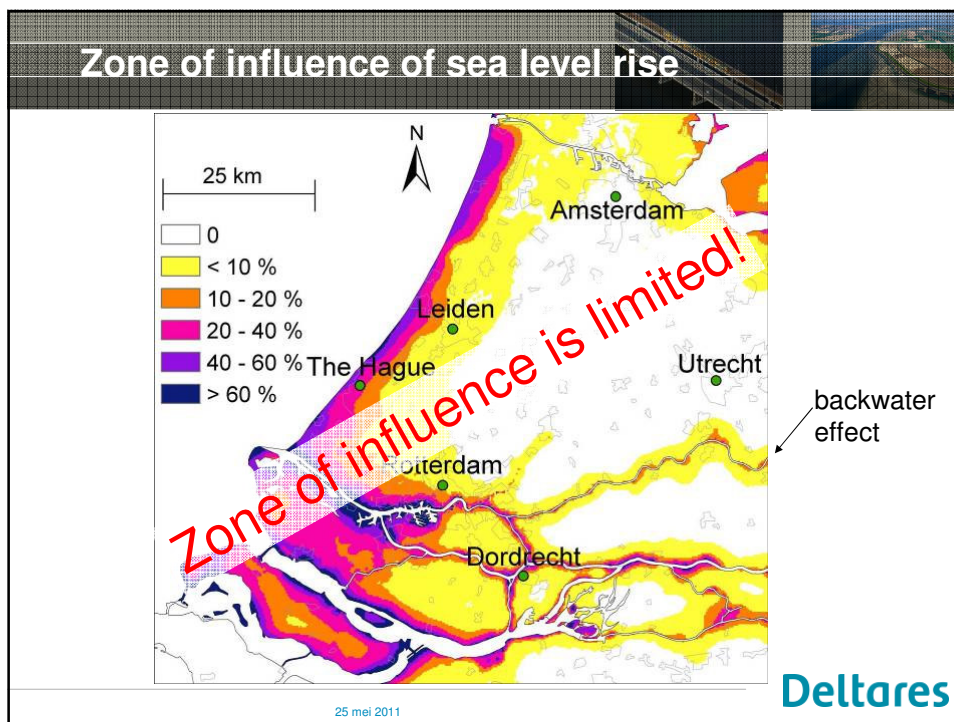
Provincie Zuid-Holland (2004, update 2008, etc.)

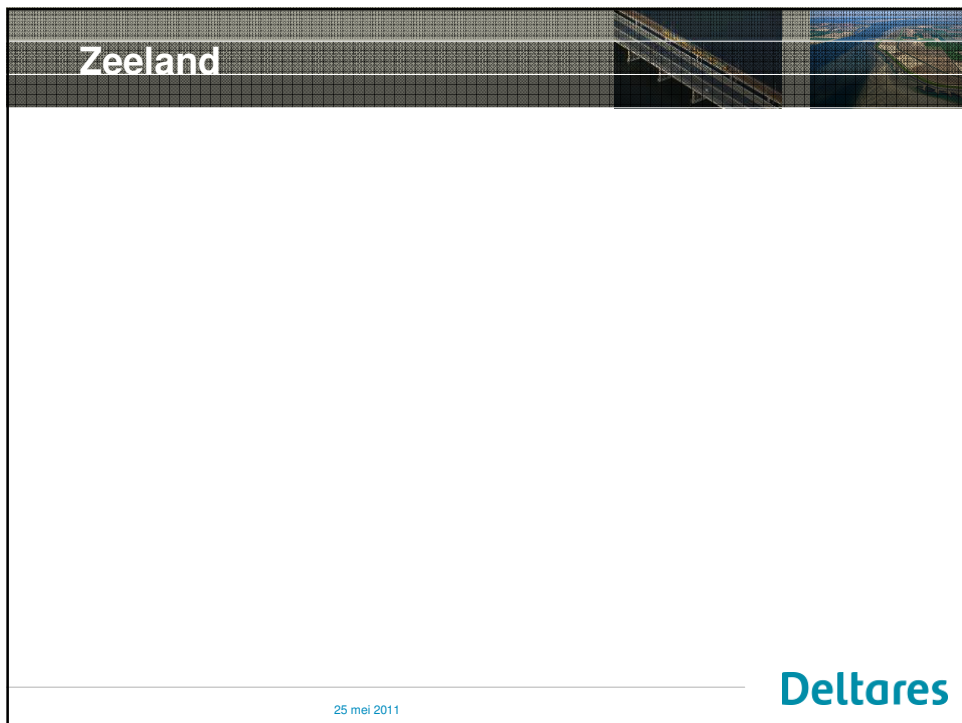
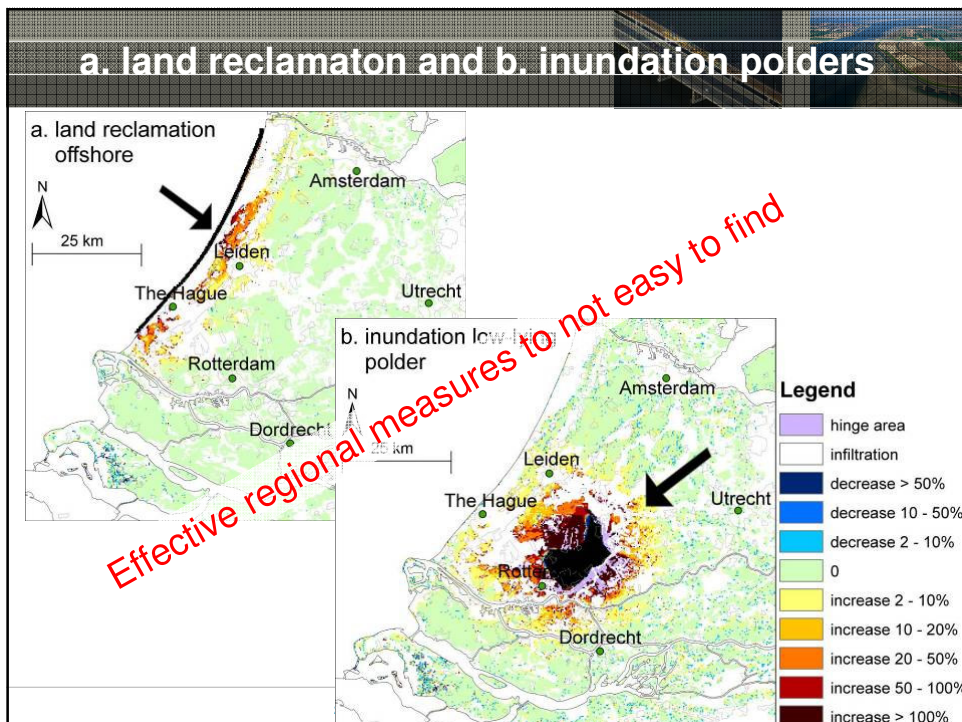
- Land subsidence
- Sea level rise
- Change in recharge

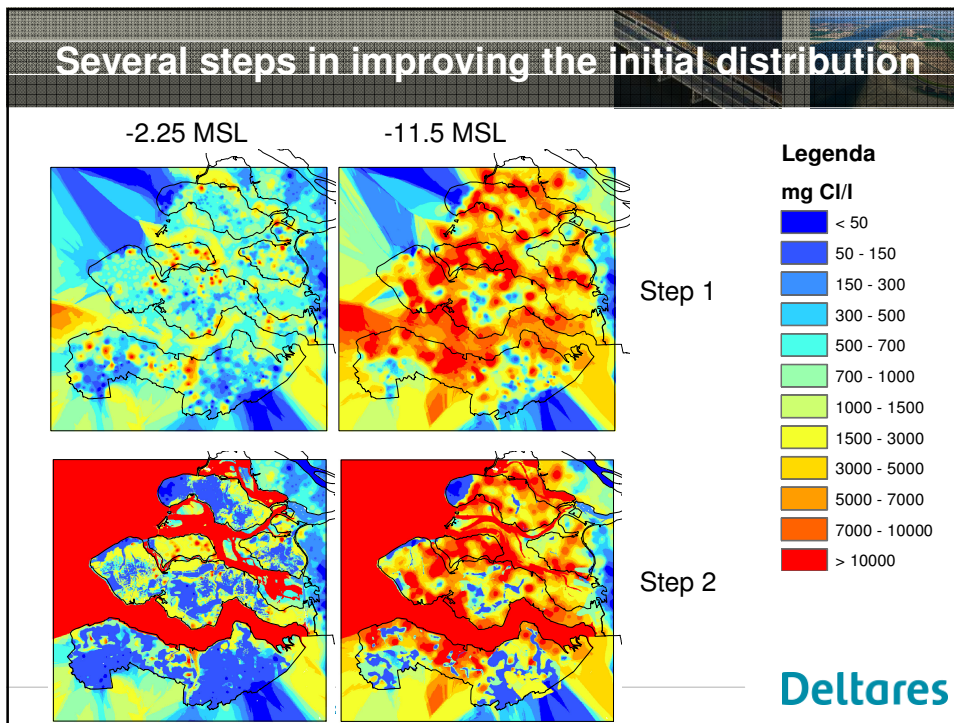
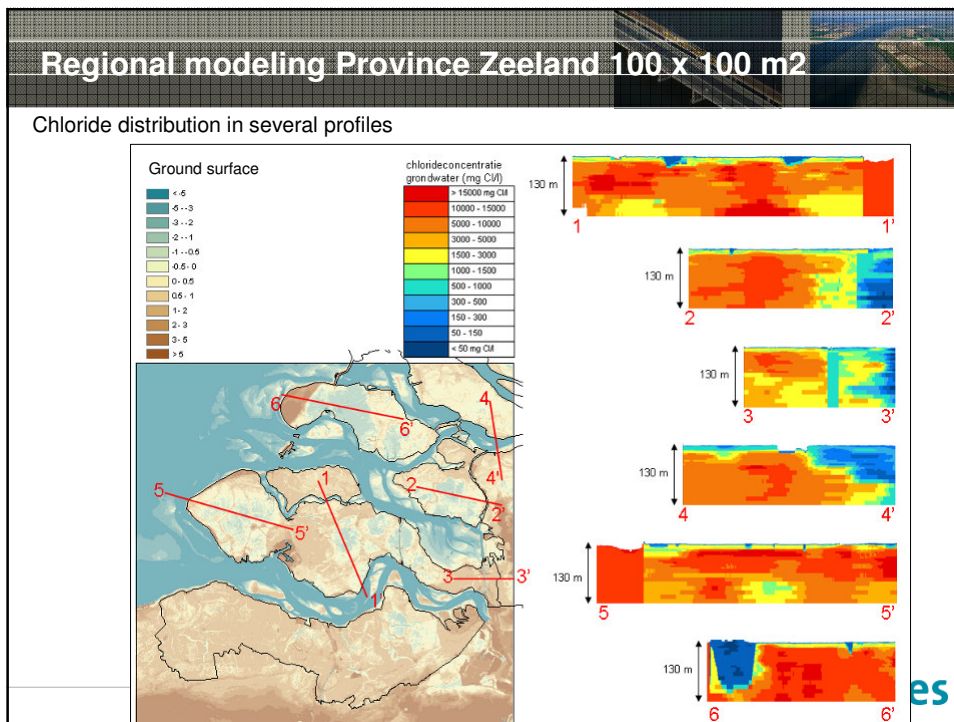


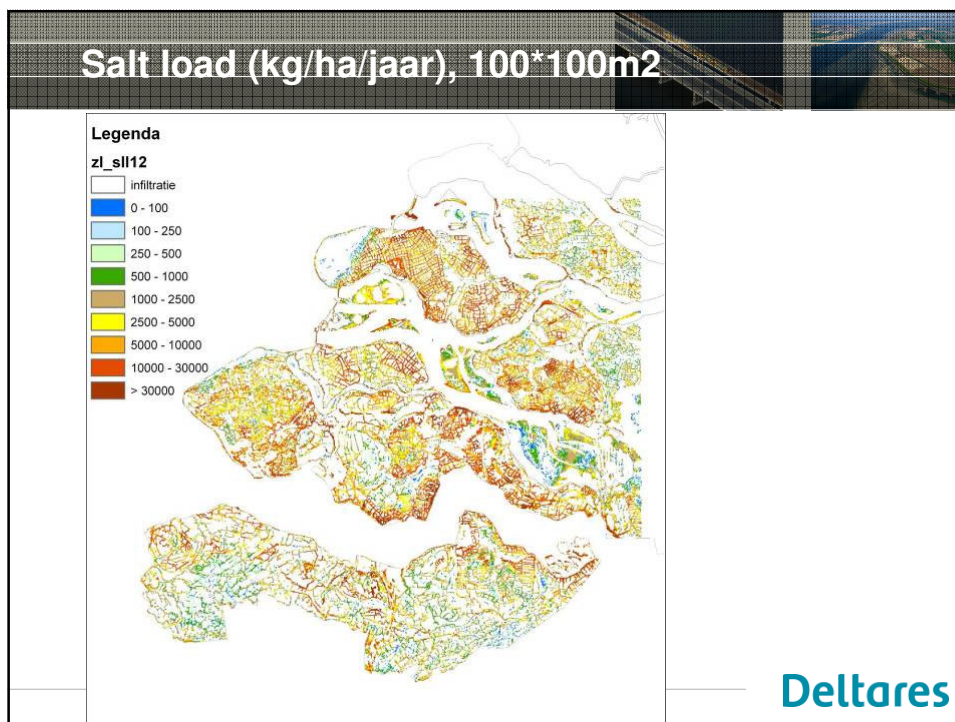
difference in head (m)







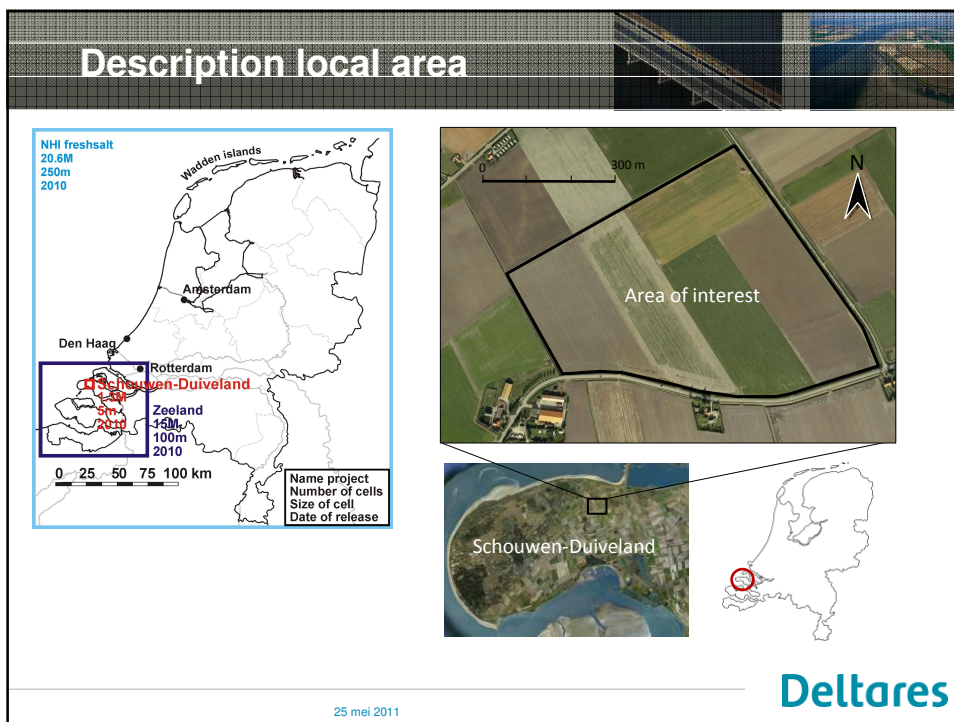
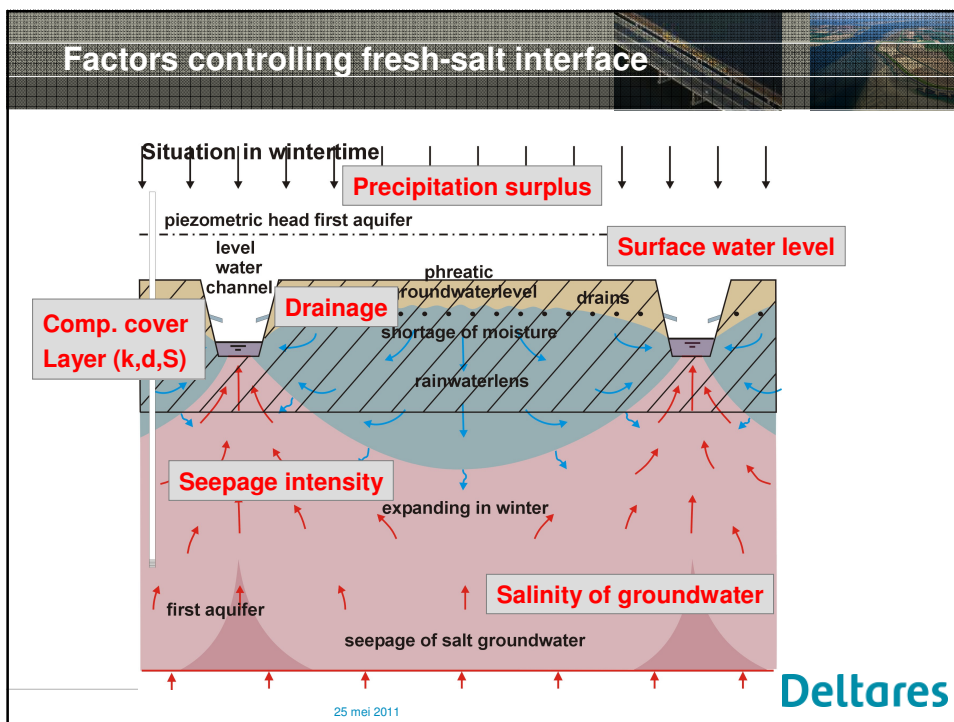


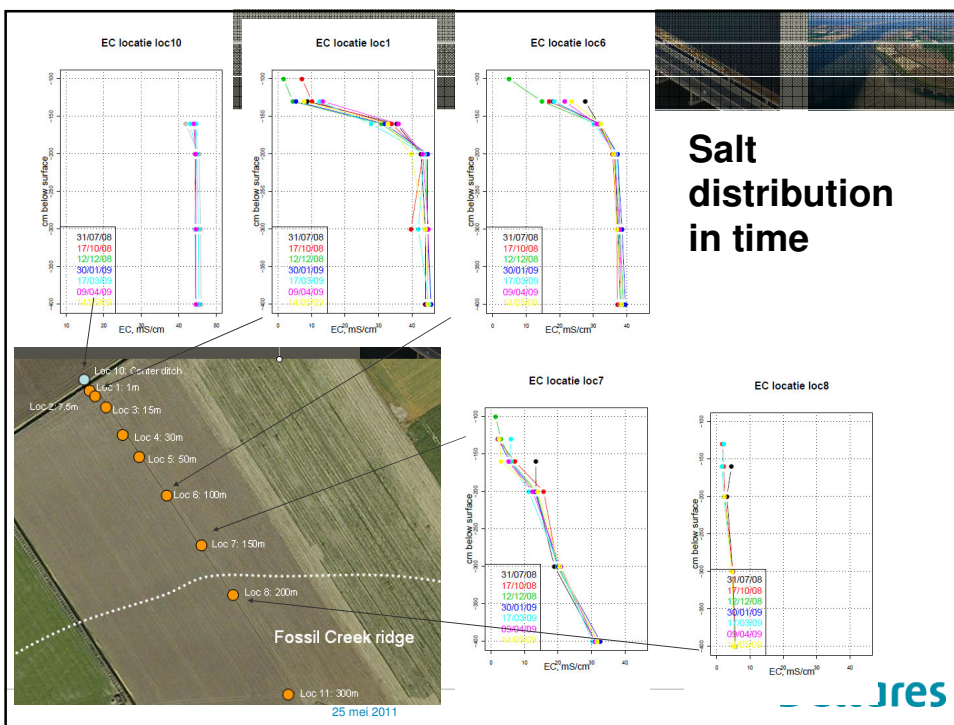


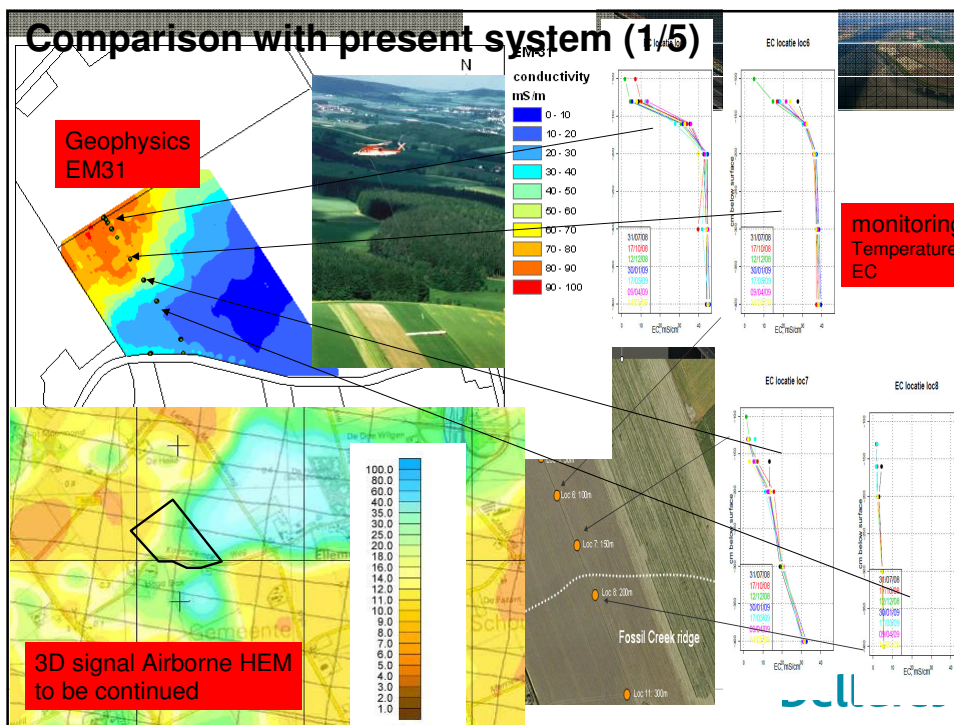
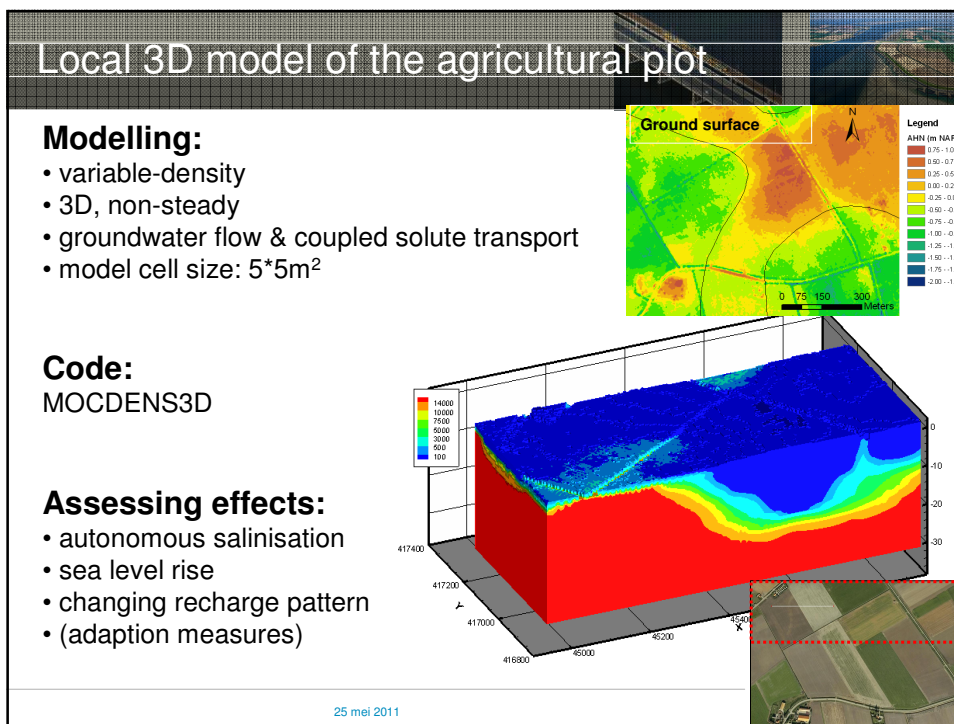
Zeeland: Local scale

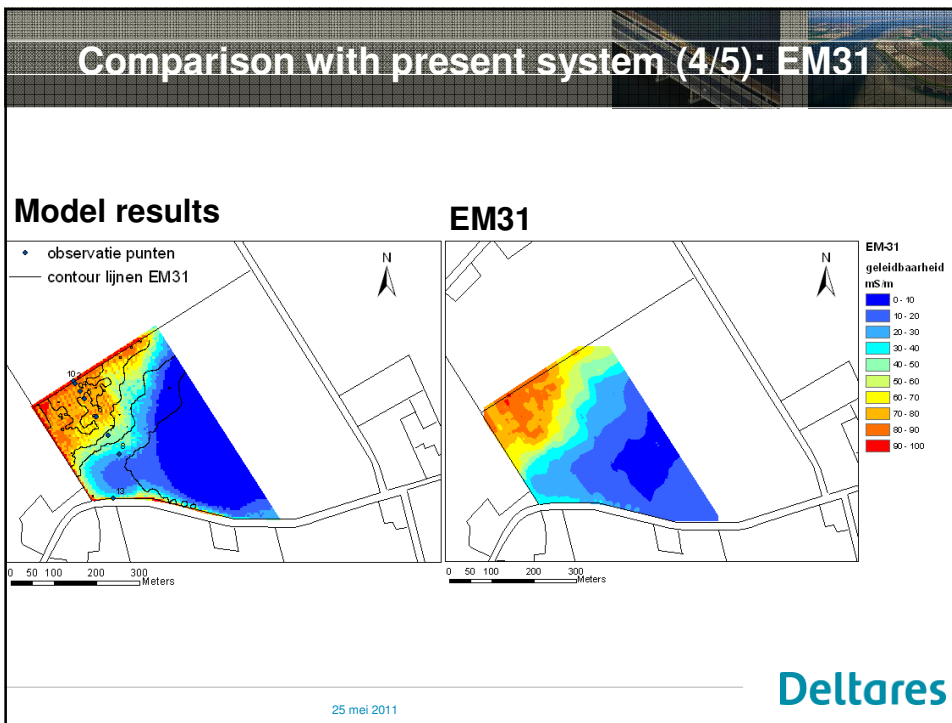
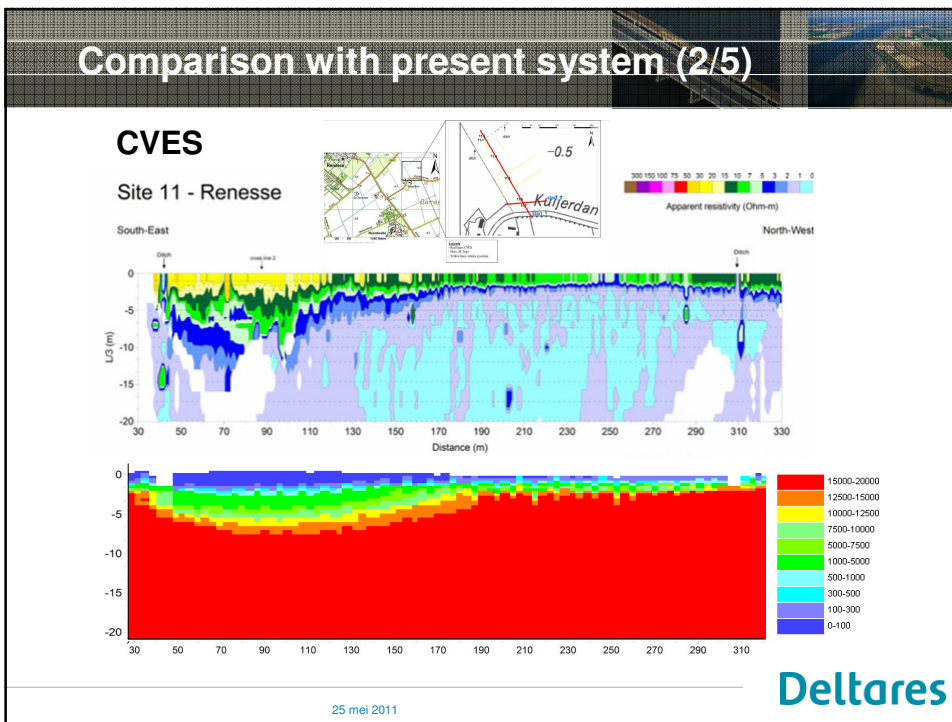
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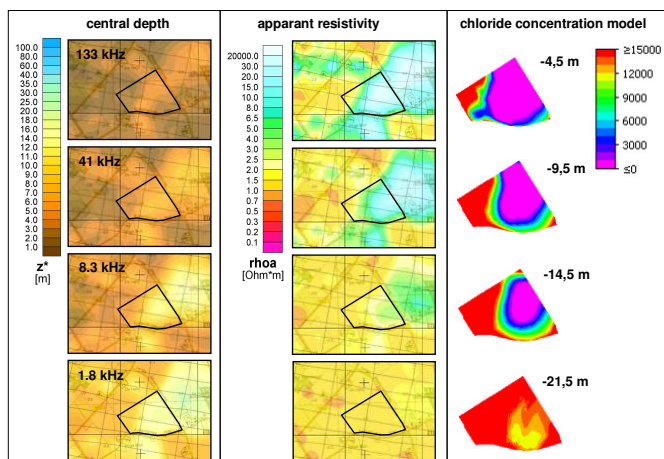








Comparison with present system (4/5): HEM

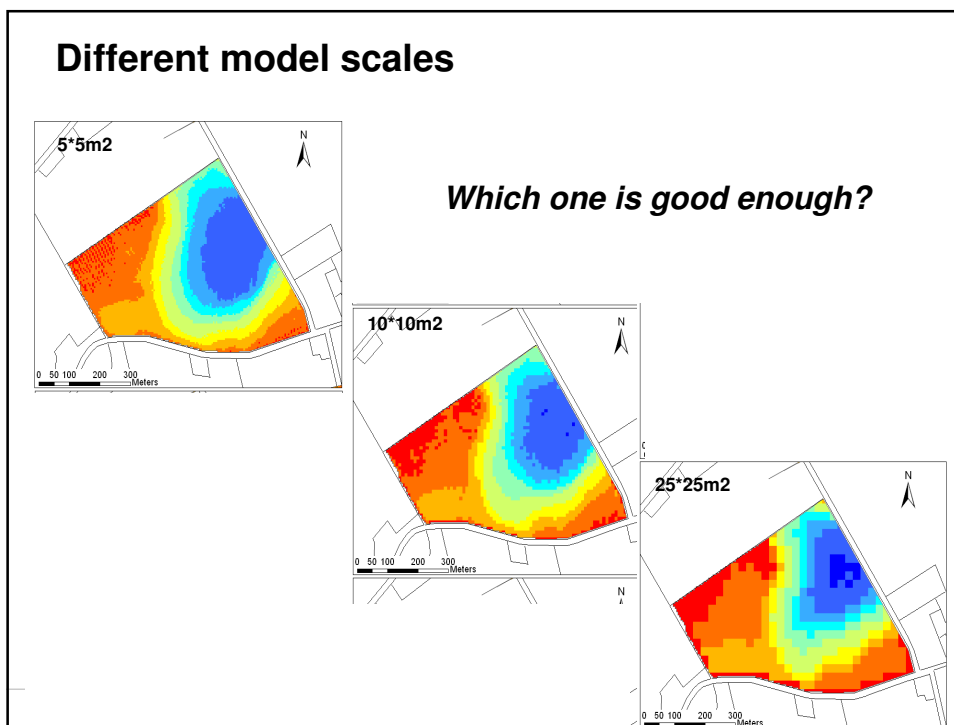
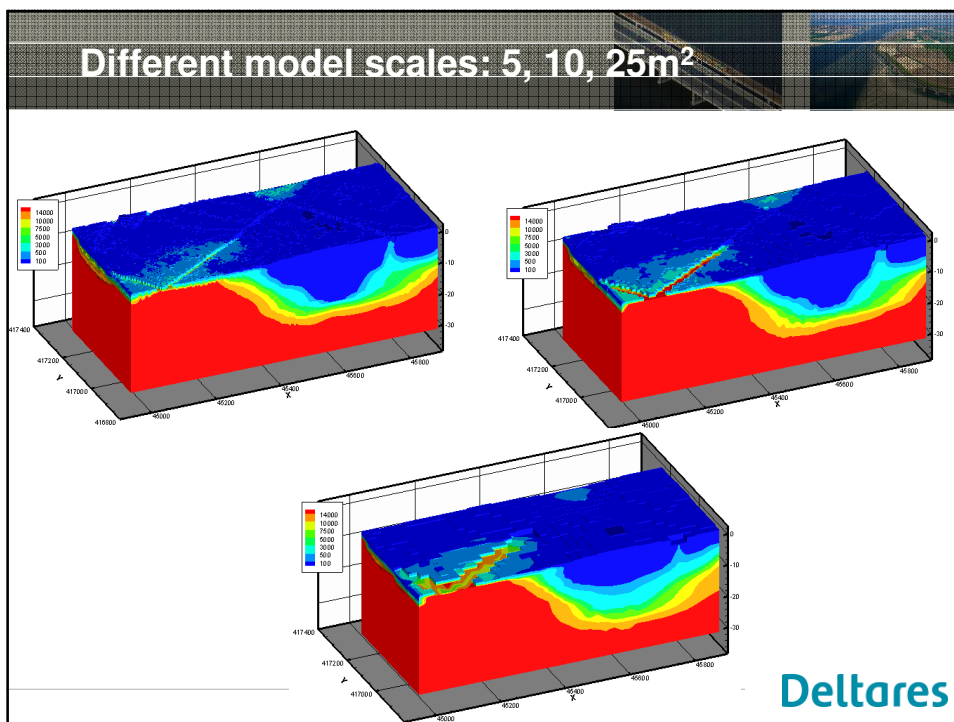


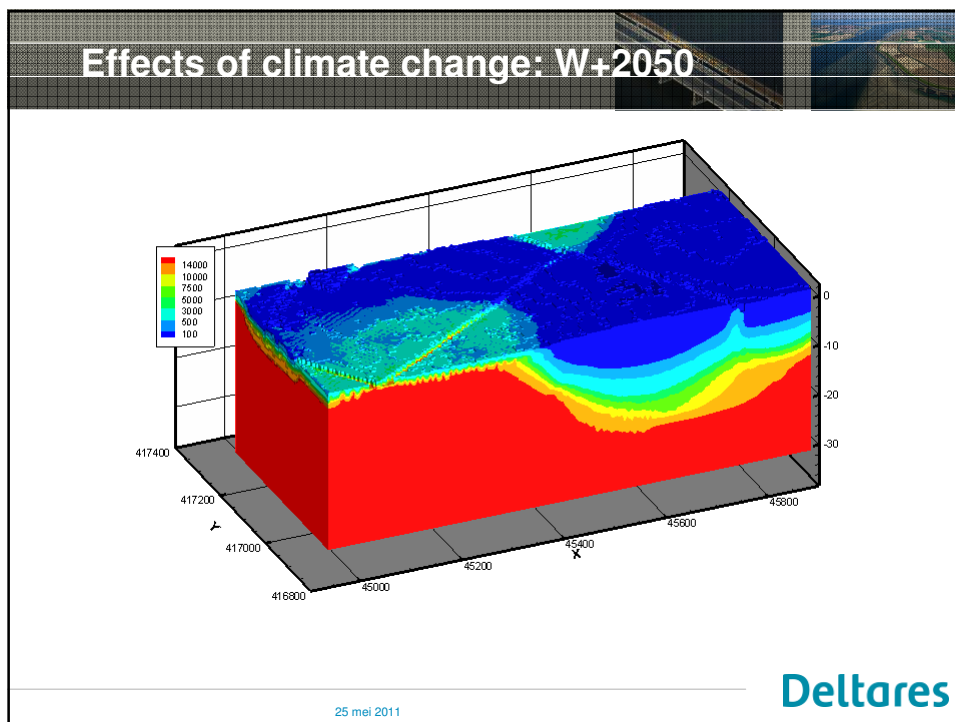
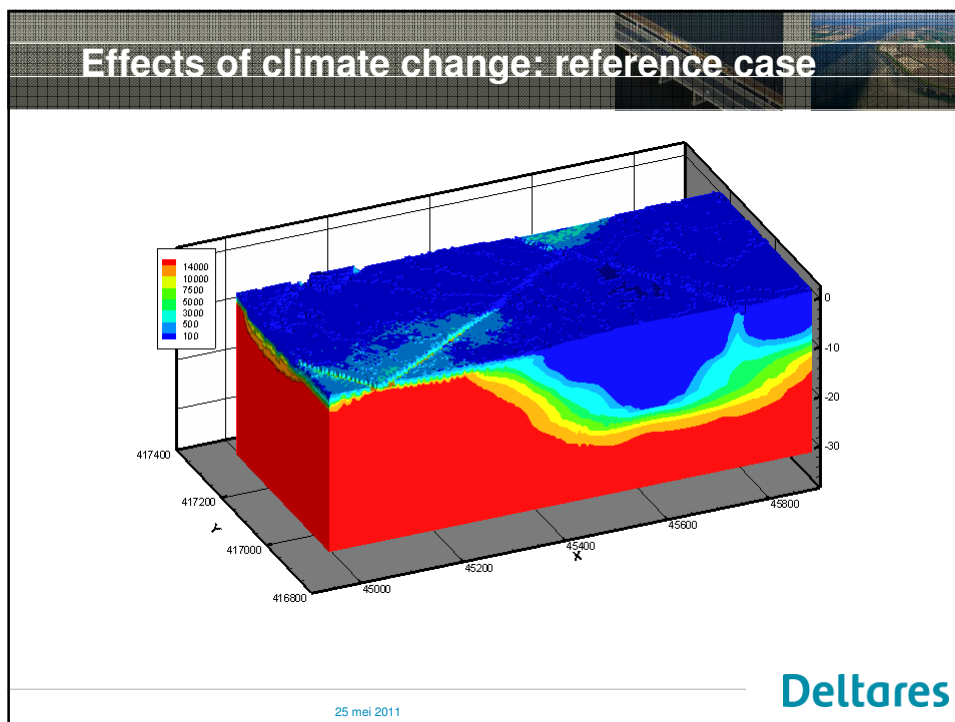
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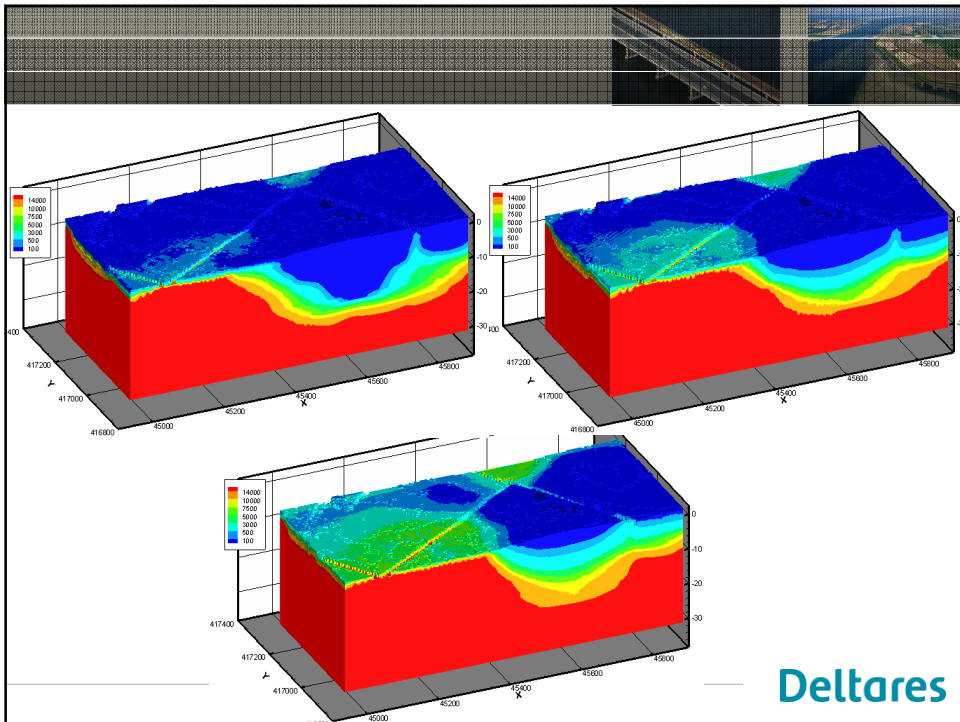
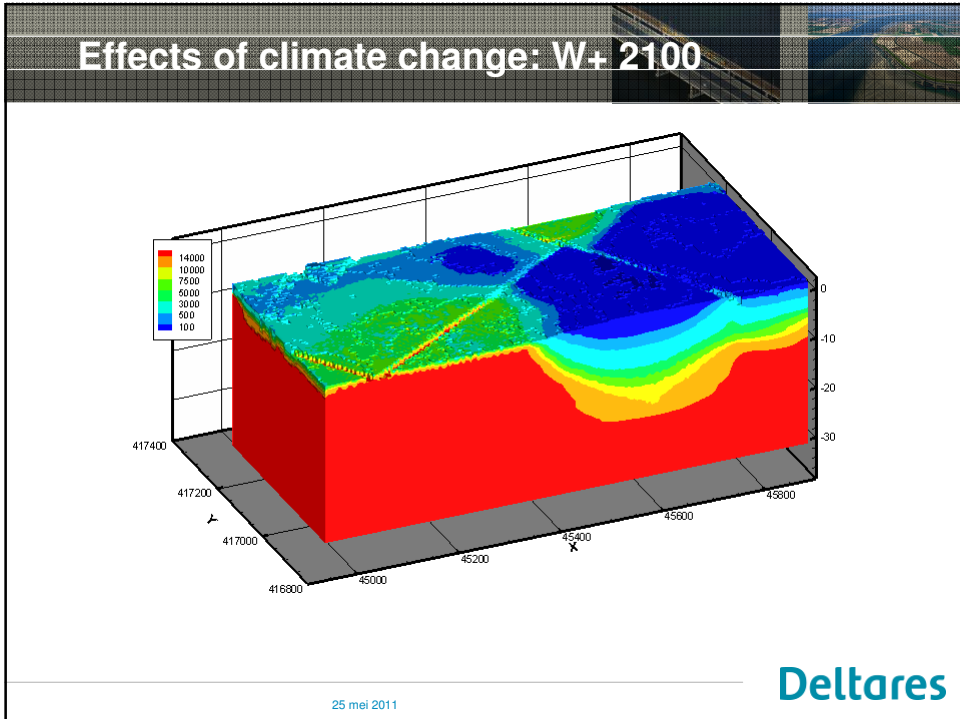
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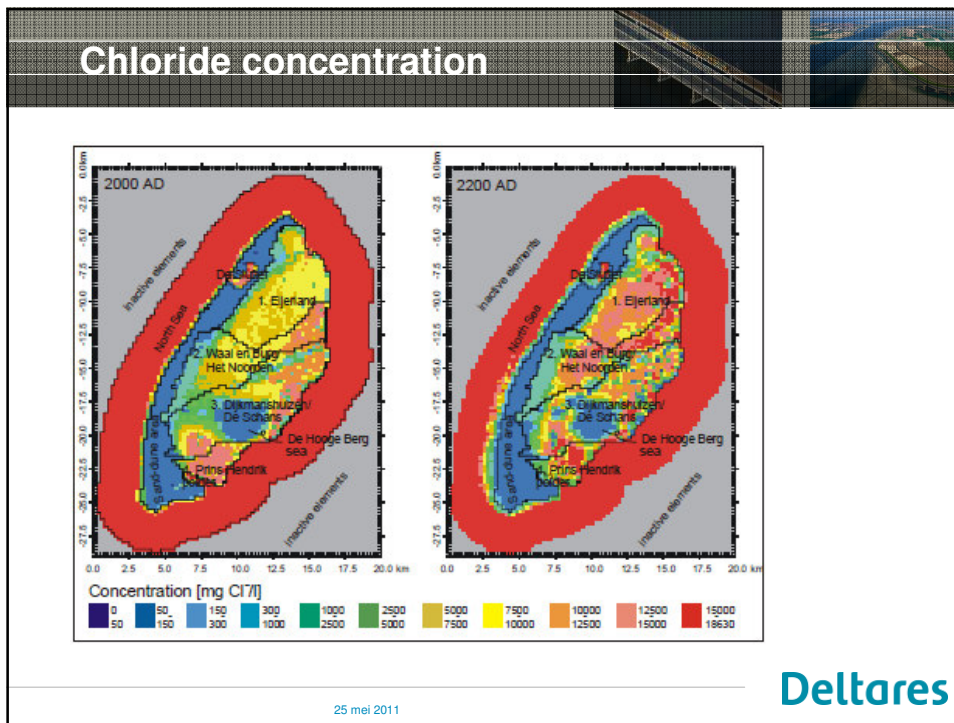
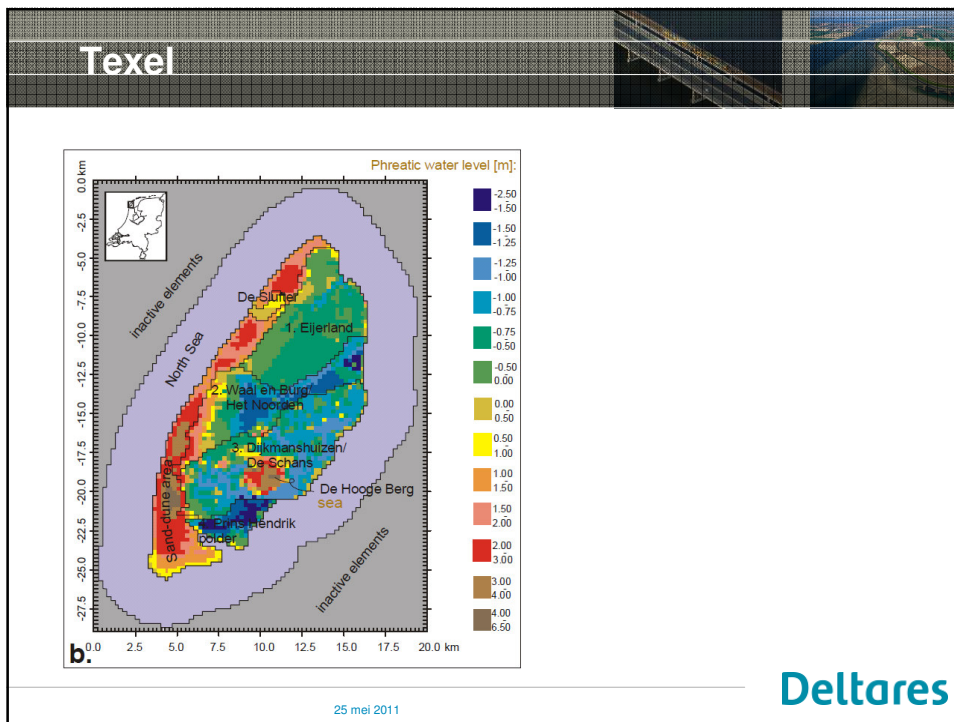
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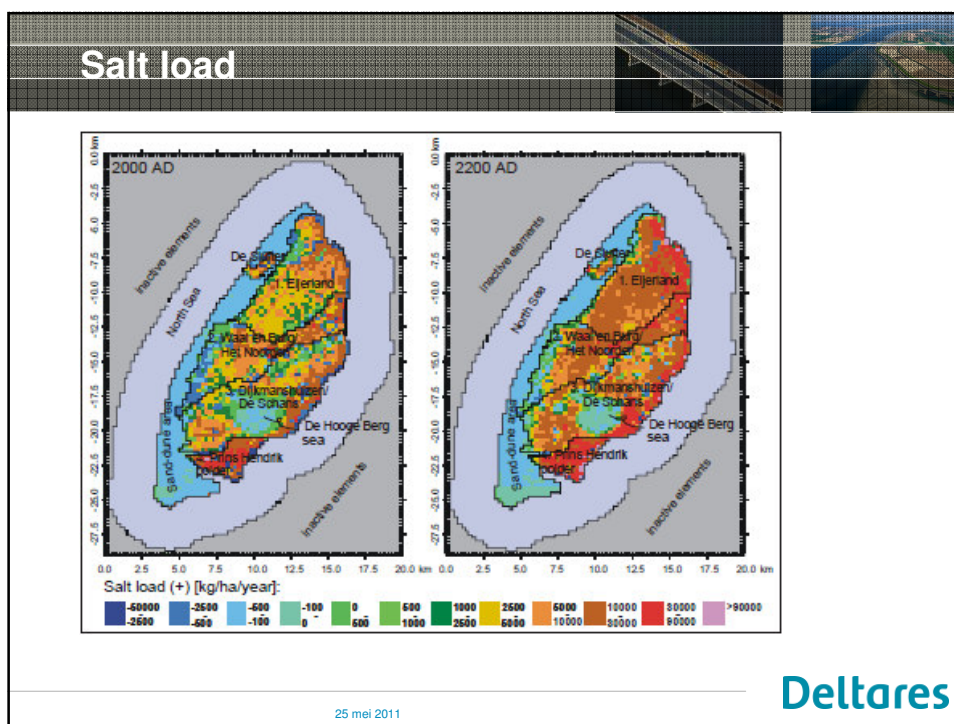
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To be continued...

- Implementing more realisations of 3D geology and initial 3D fresh-saline
 - Analyse the differences
- Running climate change scenarios (on national and regional level)
 - Effect on surface water (salt load)
 - Effect on root zone (rainwater lenses)
 - Effect on freshwater volumes (drinking water)
- Compare model results of different scales and give recommendations

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