


**Deltares**  
Enabling Delta Life

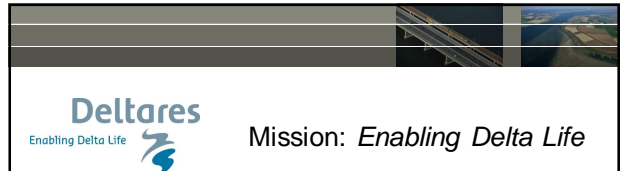
## Climate Proof Fresh Groundwater Supply

Gualbert Oude Essink  
P. de Louw, E. van Baaren, J. Deisman, P. Pauw  
Deltares, The Netherlands

[freshsalt.deltares.nl](http://freshsalt.deltares.nl)  
[zoetzout.deltares.nl](http://zoetzout.deltares.nl)



Pery Esther Marta Joost Pieter



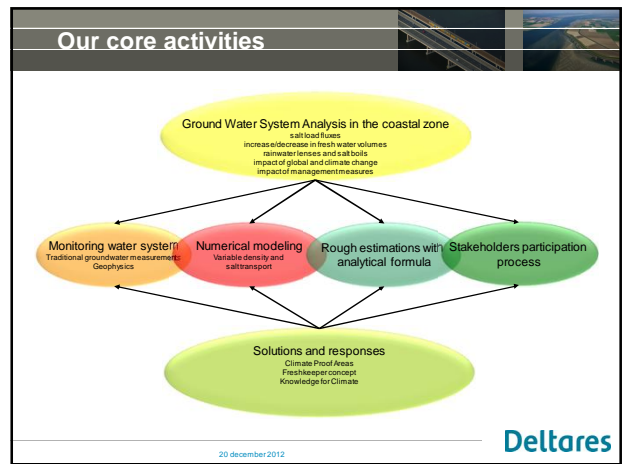
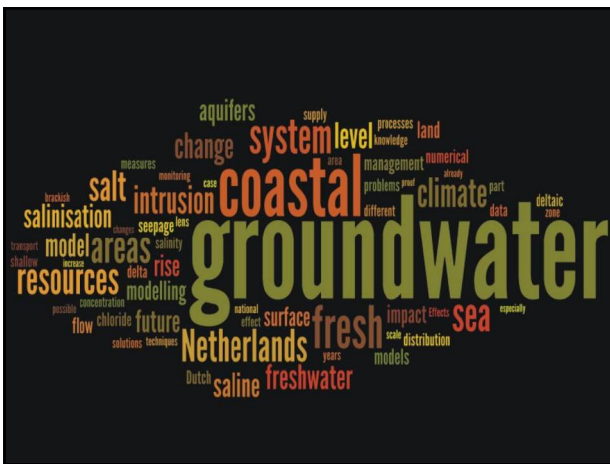

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Enabling Delta Life

**Mission: *Enabling Delta Life***

*To provide areas with fresh-salt issues enough and clean water in a sustainable way and at the right moment of time*

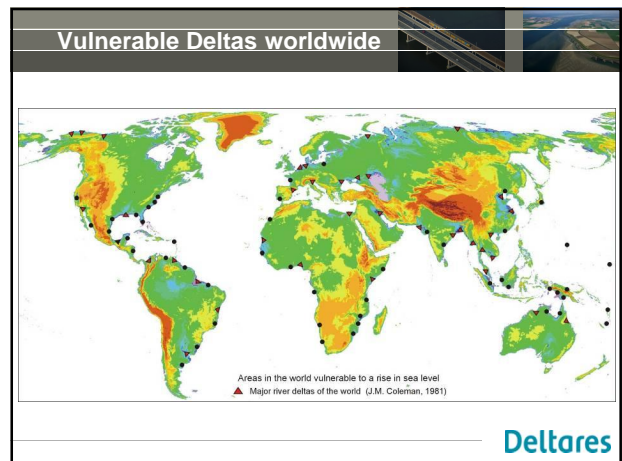
Can we make a difference?

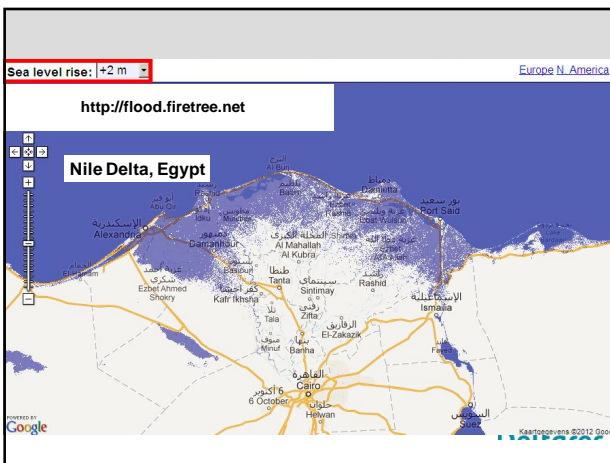
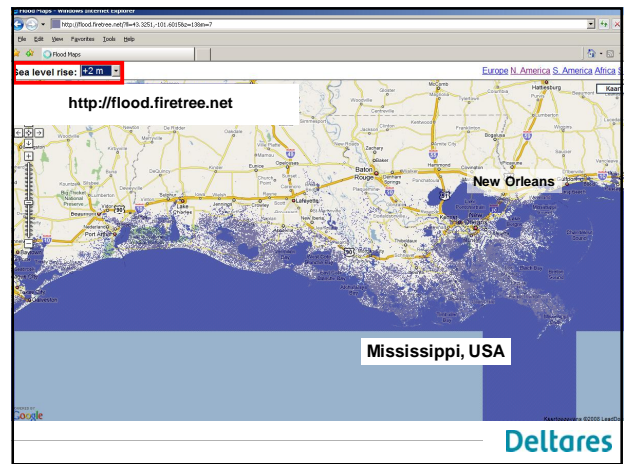
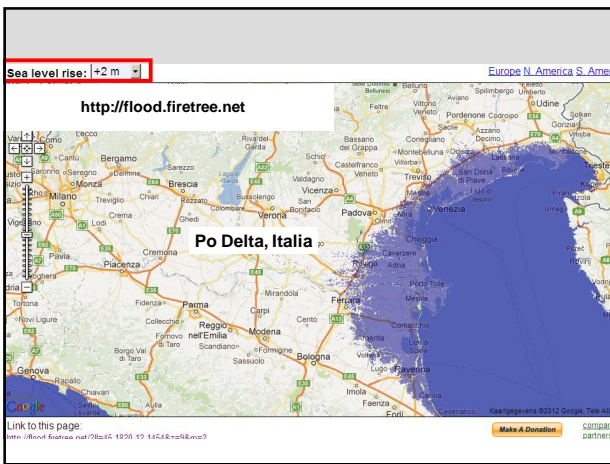
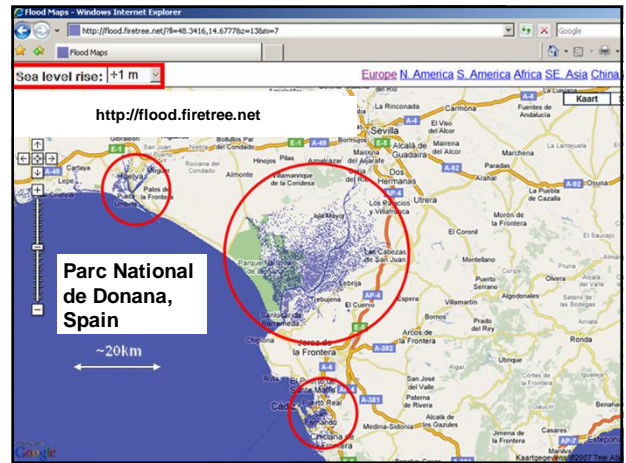
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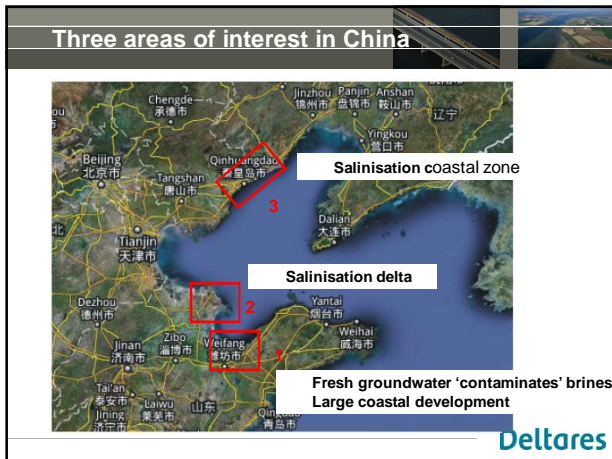



Sense of Urgency

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### Bezoek Qingdao

青岛海洋地质研究所  
Qingdao Oceanography Research Institute

青岛海洋地质研究所简介

青岛海洋地质研究所是隶属于中国地质大学(北京)的科研机构,主要从事海洋地质、海洋工程、海洋资源等方面的研究工作。研究所下设多个研究室,包括海洋地质学研究室、海洋工程研究室、海洋资源研究室等。研究所拥有先进的科研设备和雄厚的技术力量,为海洋地质领域的科学研究和工程应用提供了有力的支持。

所长: 王德成  
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电话: ...  
网址: ...

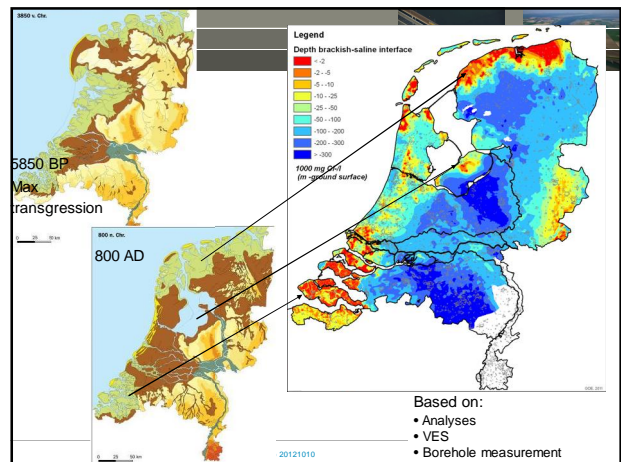
### Learn from other areas

Want to get an idea about the effects of climate change in your delta?

Evaluate past water management in the Dutch delta

Tabasco, Mexico 20121010

Deltares



### Salt in water is a problem

-drinking water:

- taste (100-300 mg Cl-/l)
- long term health effect
- norm: EC & WHO = 150 mg Cl-/l (live stock = 1500 mg Cl-/l)

-industry:

- corrosion pipes
- preparation food

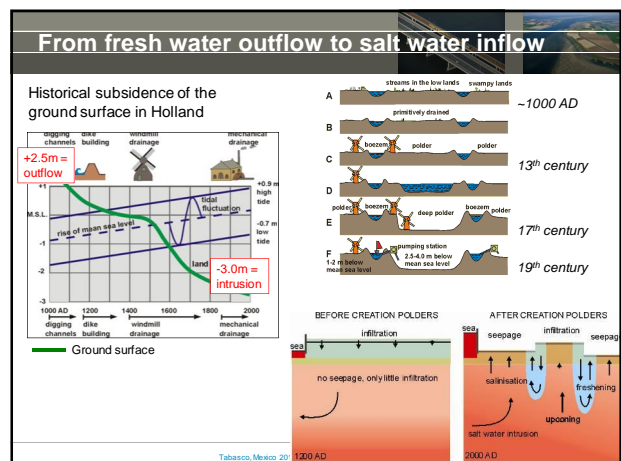
-irrigation/agriculture:

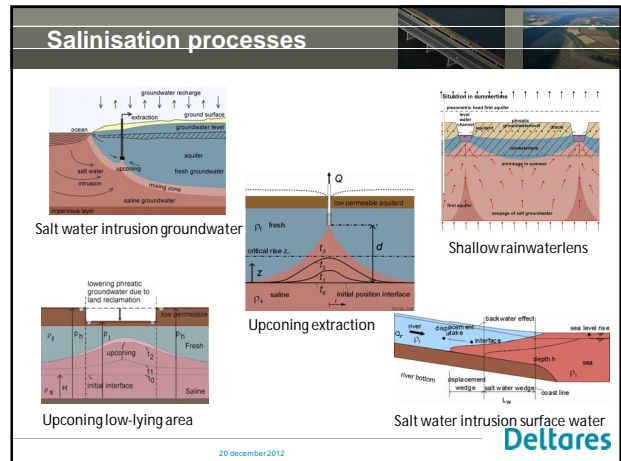
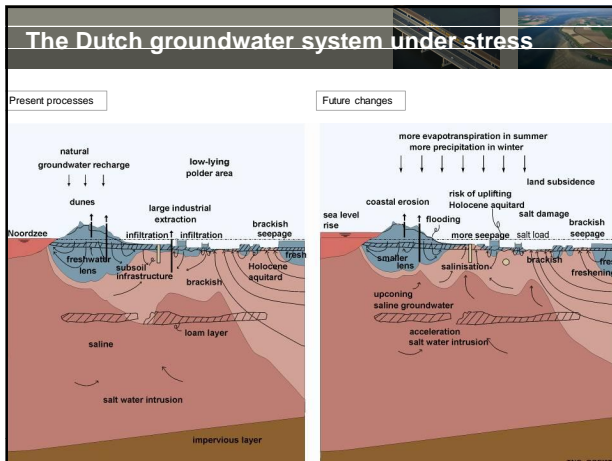
- production crops
- salt damage, e.g.

Grass ≥ 3606 mg Cl-/l  
Grains ≥ 4801 mg Cl-/l  
Potatoes ≥ 756 mg Cl-/l

salty water      fresh water

Tabasco, Mexico 20121010





### Groundwater in the future

We have to cope with...:

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

*Direct anthropogenic influence on groundwater is more important than climate effect*

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### Grondwater in kustgebieden: urgentiegevoel landbouw Interviews Zeeland

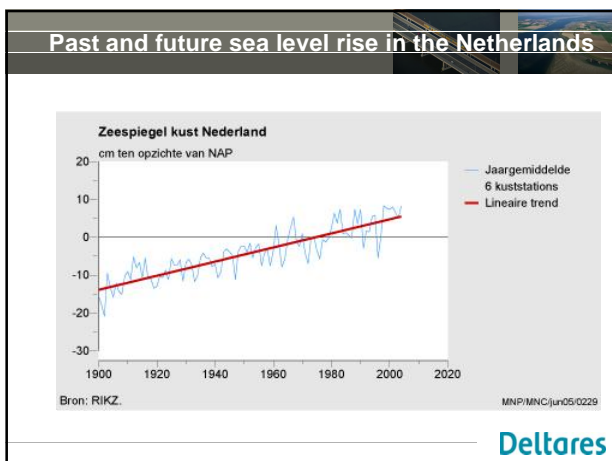
Zeeland, voorjaar 2011: >1.000 euro per ha voor water per tankwagen!

"Droogte: alle producten van slechtere kwaliteit. Wateroverlast, minder product, wel hoge kwaliteit"

"Lokale droogte nadeling: prijzen gaan niet omhoog. In droge jaren 20-30% minder opbrengst."

"onttrekkingscapaciteit grondwater te klein"

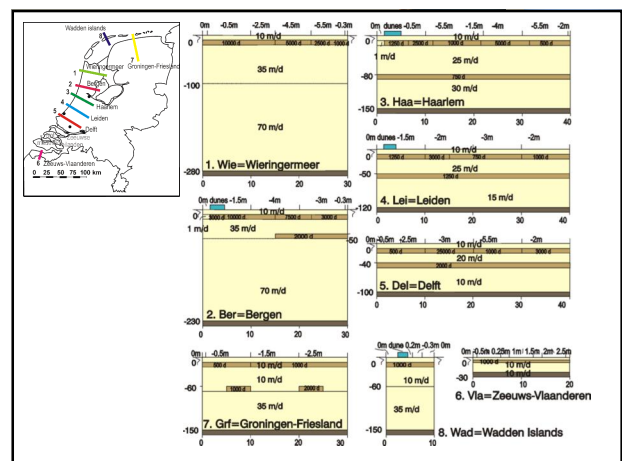
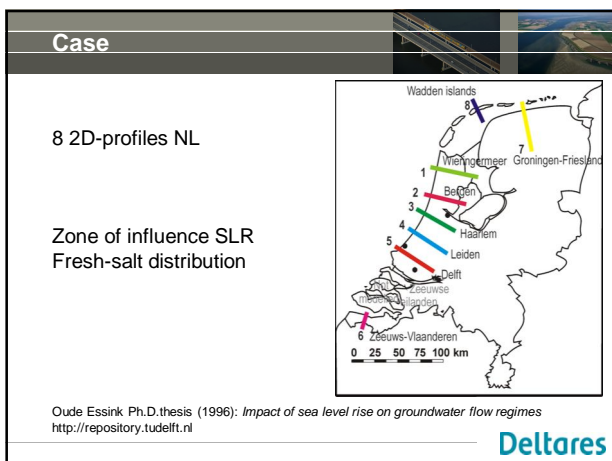
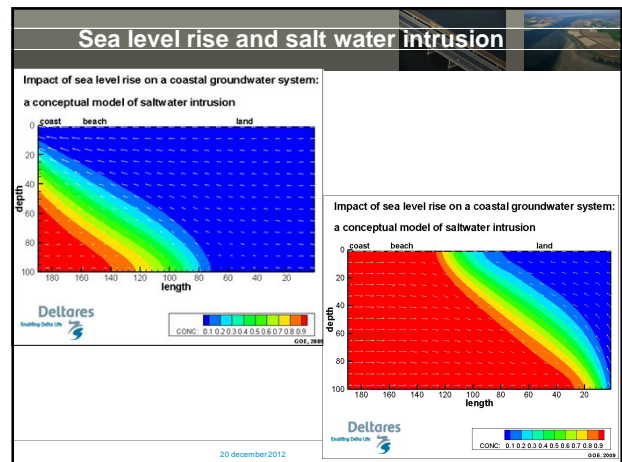
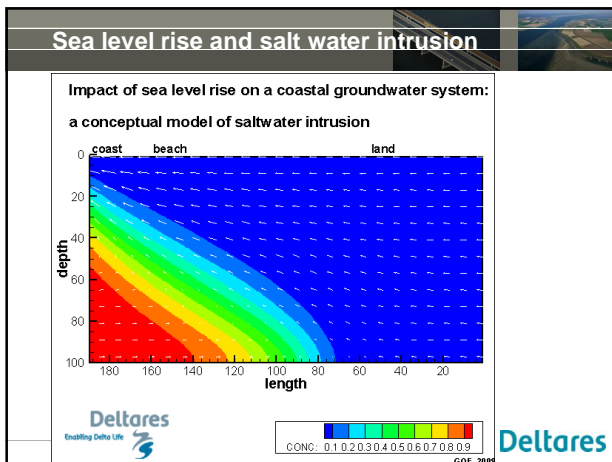
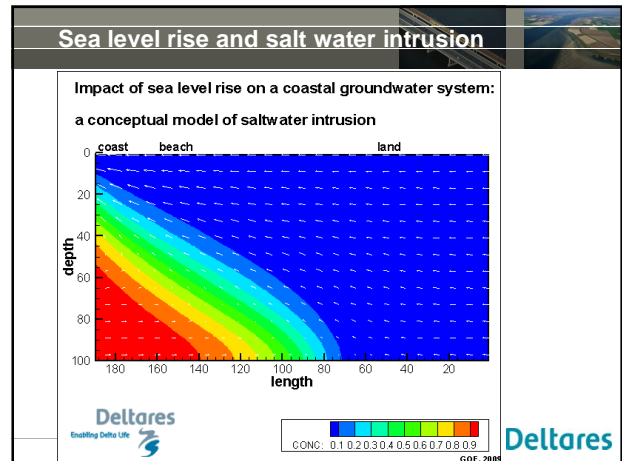
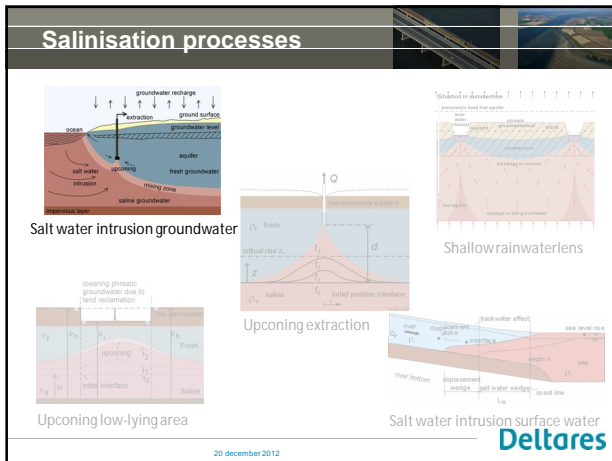
"Wat ik nu nog wil hebben? Veel zoet water!"

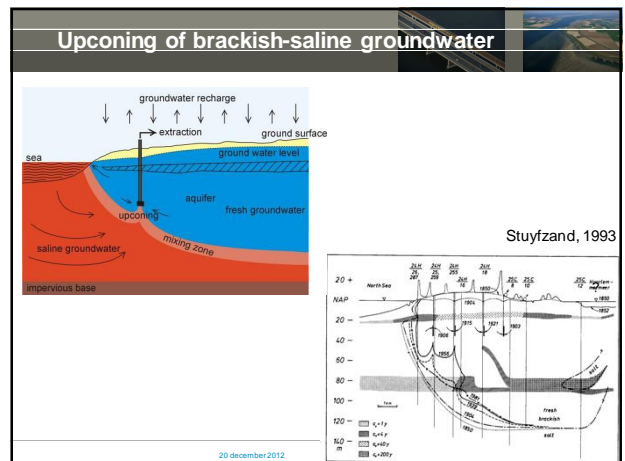
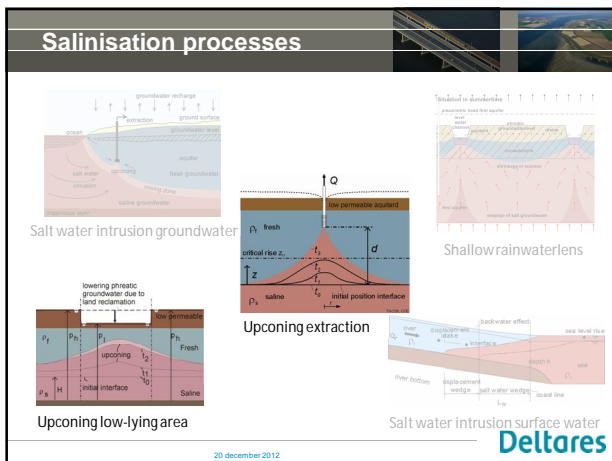
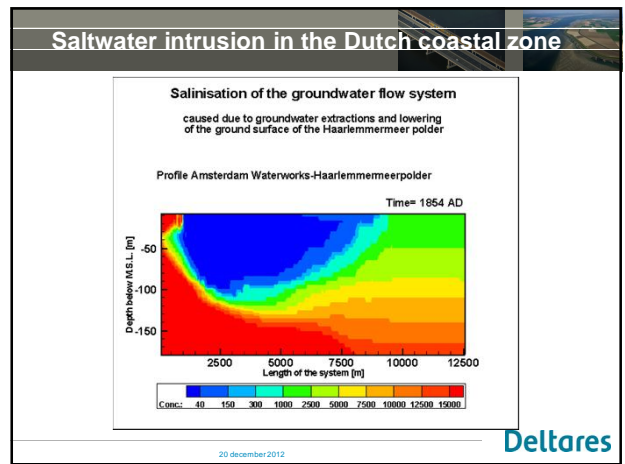
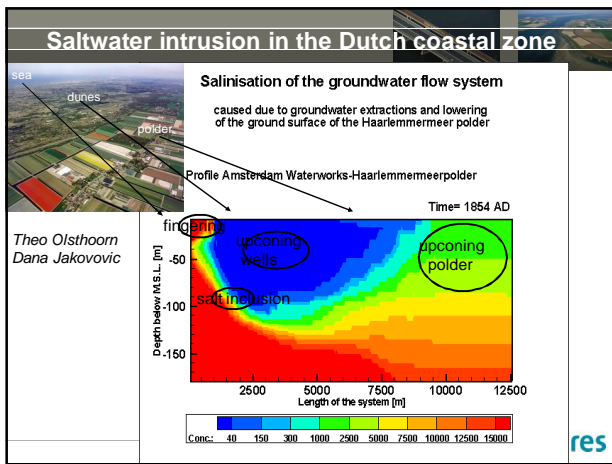
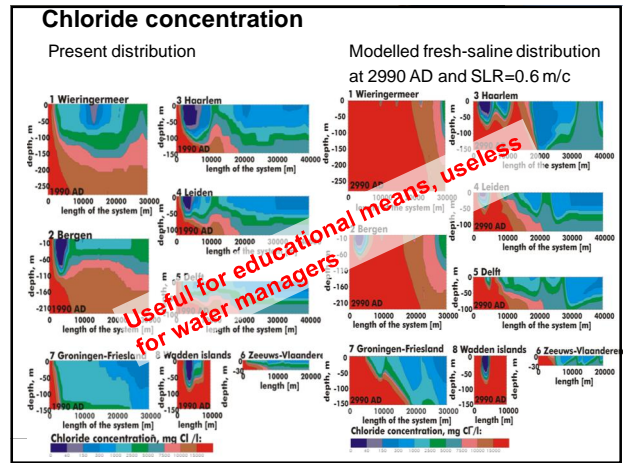
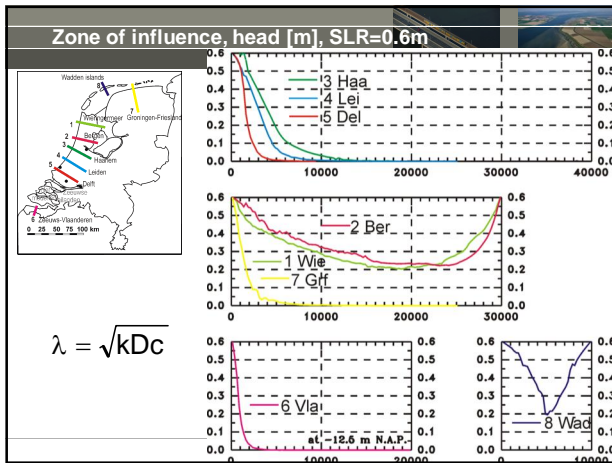


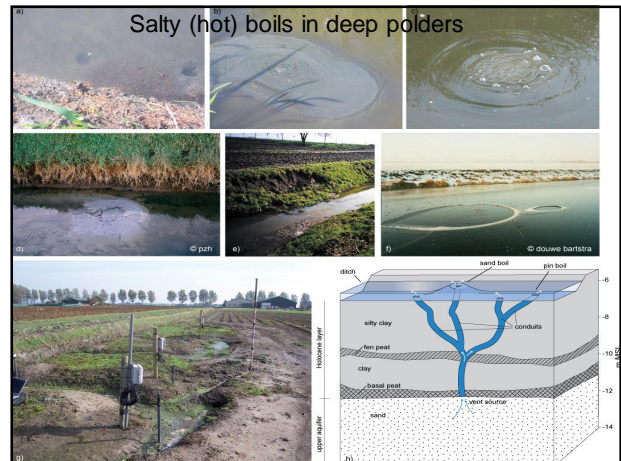
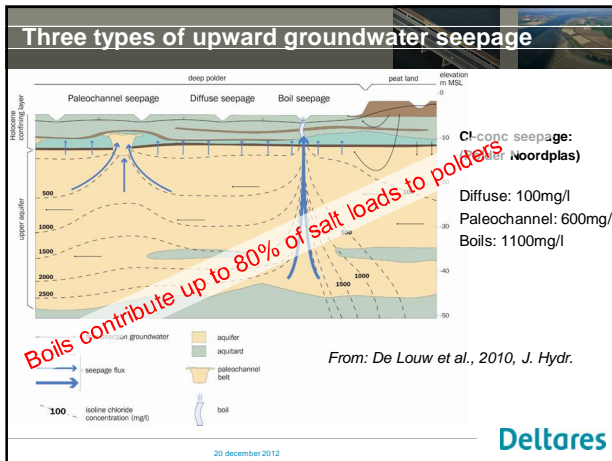
### Model input (5/5): climate scenarios (KNMI06)

2100	G	G+	W	W+	C	C+
Worldwide temperature rise in 2050	+1°C	+1°C	+2°C	+2°C	+3°C	+3°C
Worldwide temperature rise in 2100	+2°C	+2°C	+4°C	+4°C	+6°C	+6°C
Change airstream pattern Western Europa	no	yes	no	yes	no	yes
<b>Winter</b>						
Average temperature	+1,8°C	+2,3°C	+3,6°C	+4,6°C	+5,4°C	+6,9°C
Coldest winter day each year	+2,1°C	+2,9°C	+4,2°C	+5,8°C	+6,3°C	+7,8°C
Average precipitation	7%	14%	14%	28%	21%	42%
<b>Summer</b>						
Average temperature	+1,7°C	+2,8°C	+3,4°C	+5,6°C	+5,1°C	+8,4°C
Hottest summer day each year	+2,1°C	+3,8°C	+4,2°C	+7,6°C	+6,3°C	+11,4°C
Average precipitation	6%	-19%	12%	-38%	18%	-57%
<b>Sea level rise</b>						
Absolute rise (cm)	35-60	35-60	40-85	40-85	45-110	45-110

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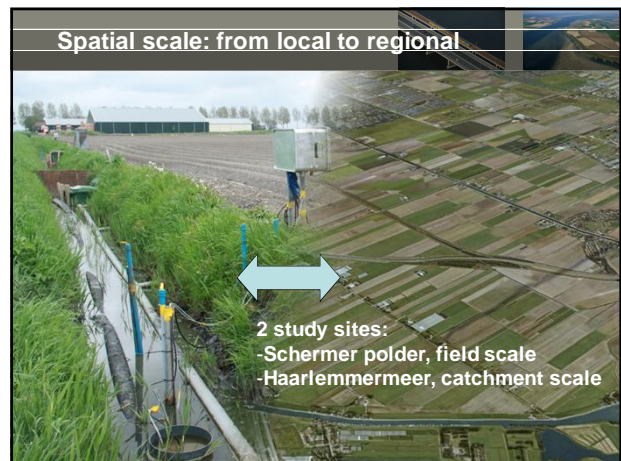
### PhD Research

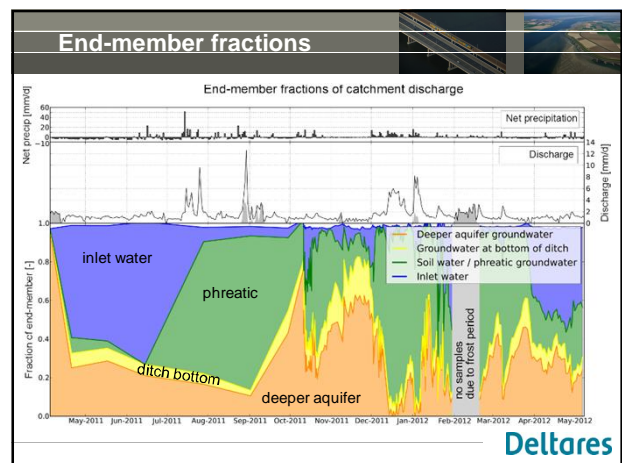
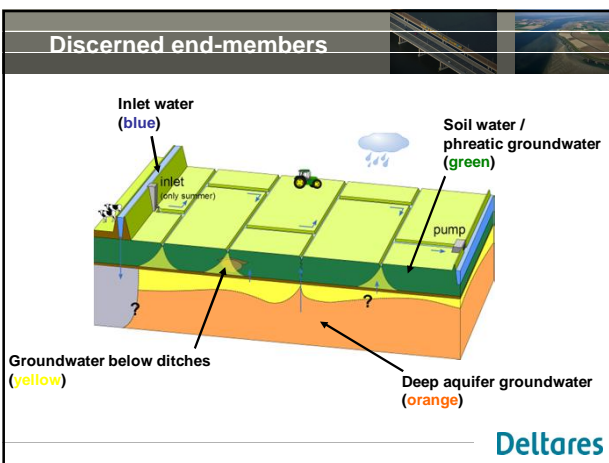
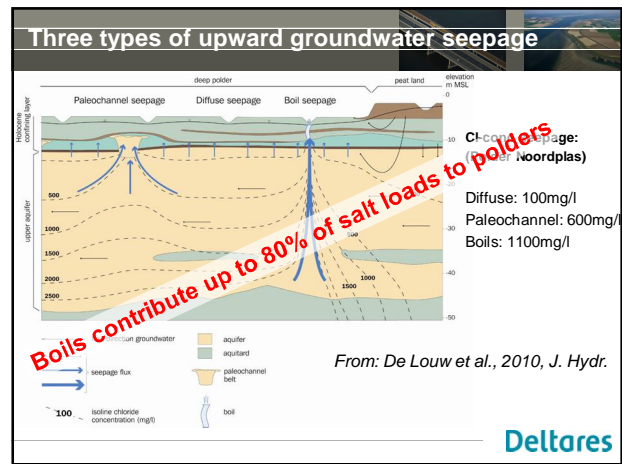
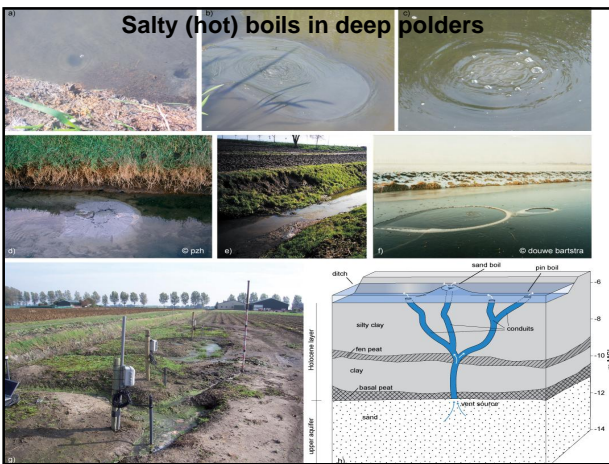
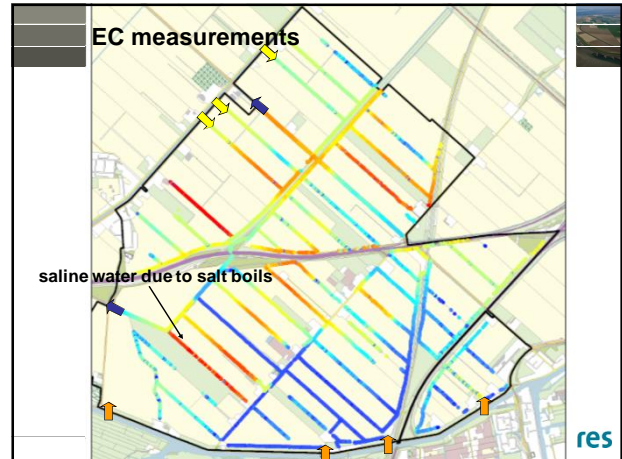
#### Adaptating to drought and salinisation in the coupled groundwater – surface water system

- What adaptation strategies can we use, to cope with a drier and more saline future?
- Evaluate effects of possible measures to drought / salinisation
- Knowledge gaps in (extreme) summer hydrology

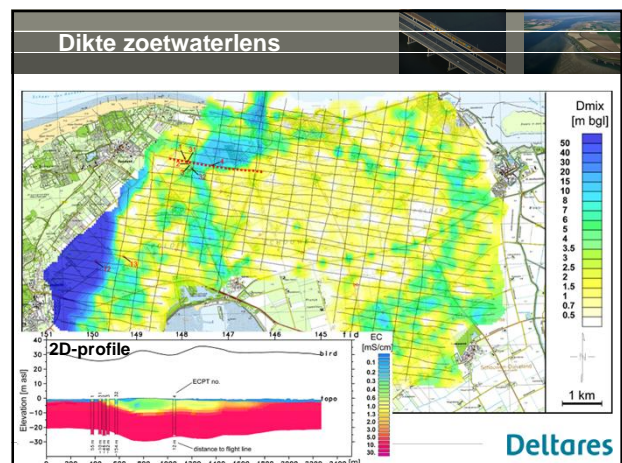
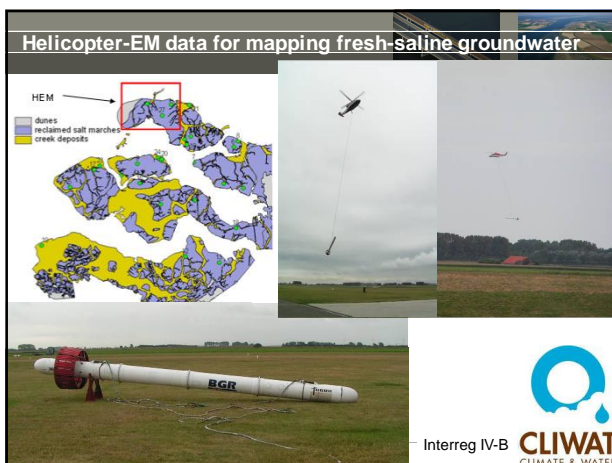
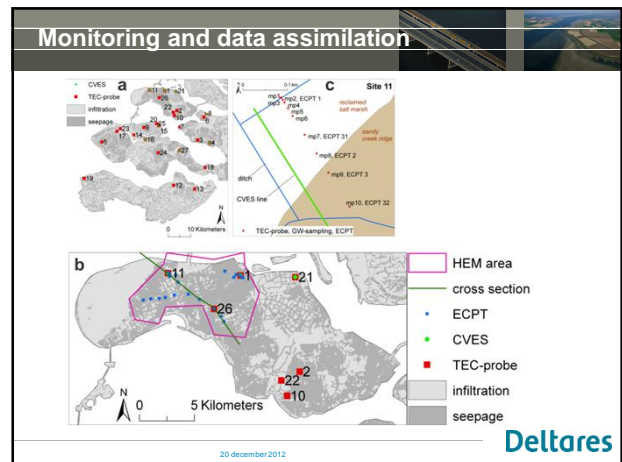
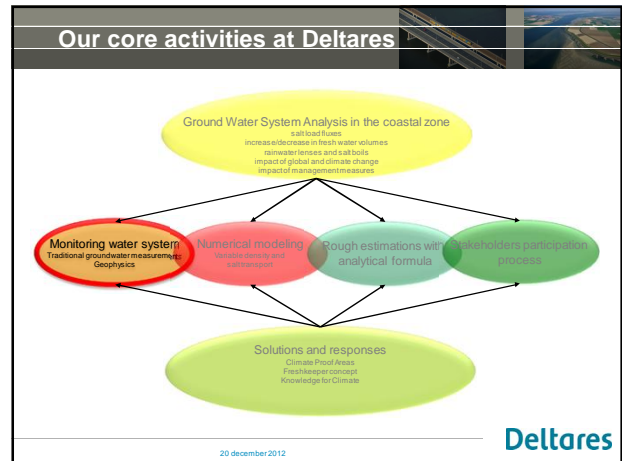
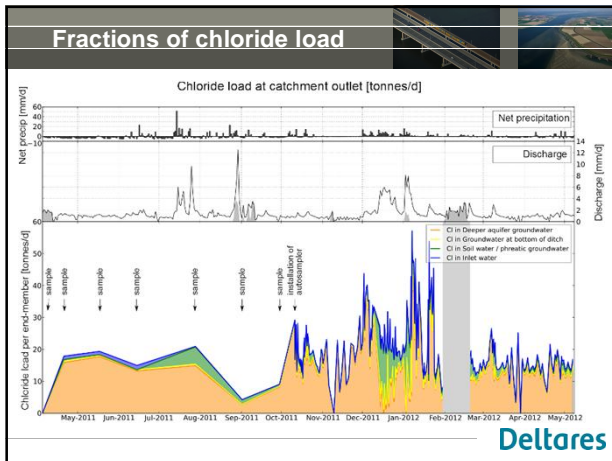
- ✓How does the functioning of the hydrological system change in dry summers?
- ✓What causes the spatial and temporal variation in salt load?
- ✓How can we adequately describe this system quantitatively?
- ✓How will climate change affect the hydrological system?
- ✓What is future water demand?

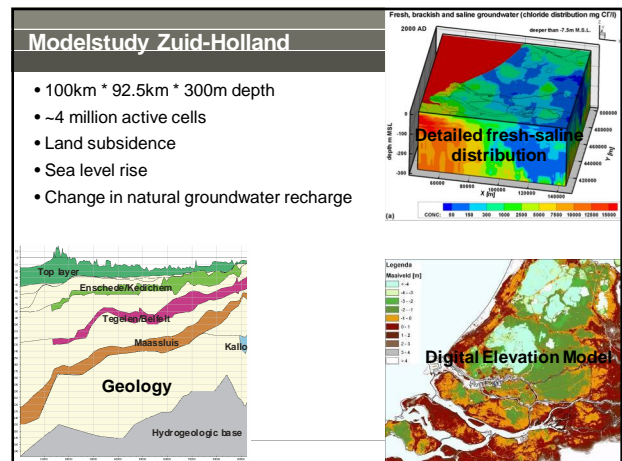
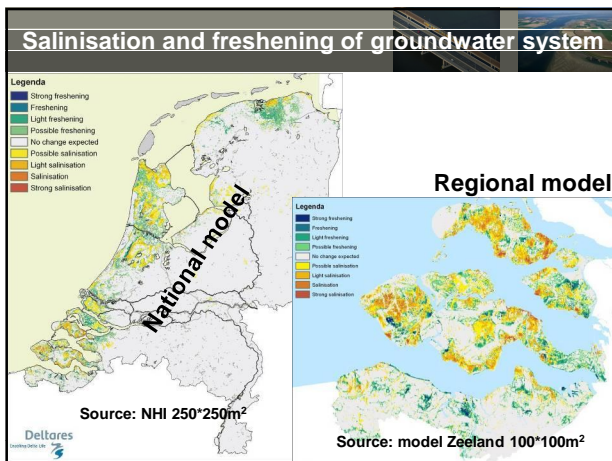
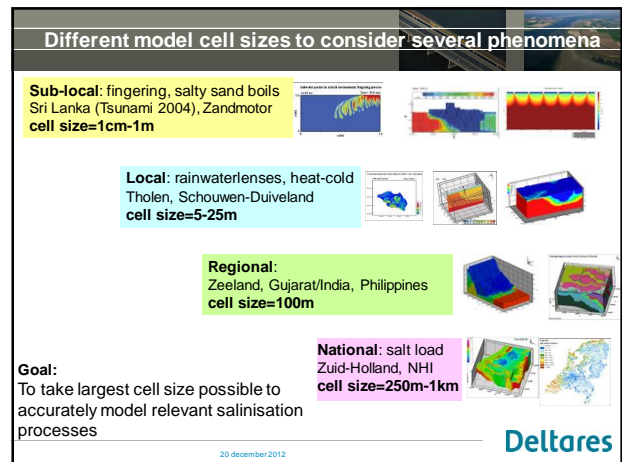
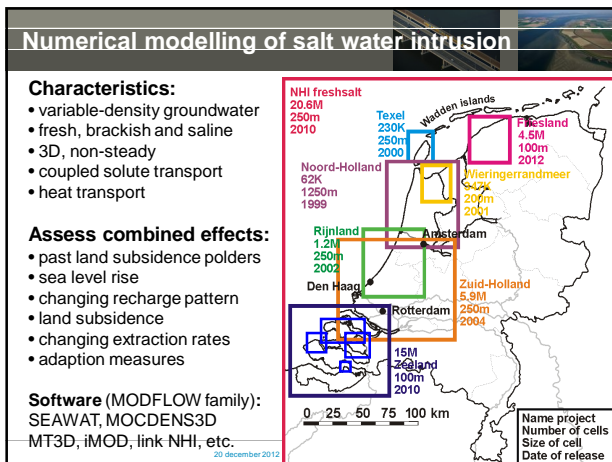
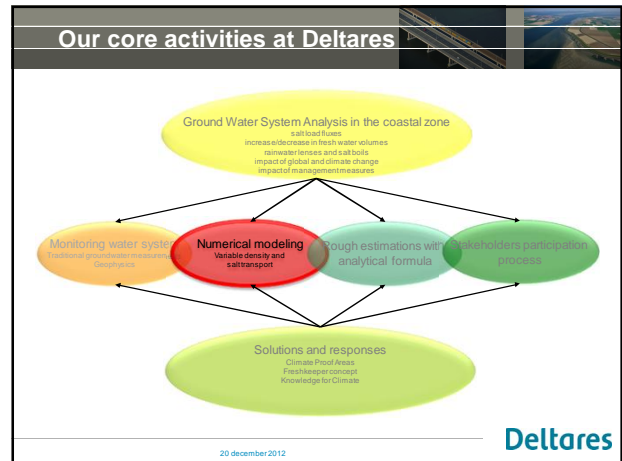
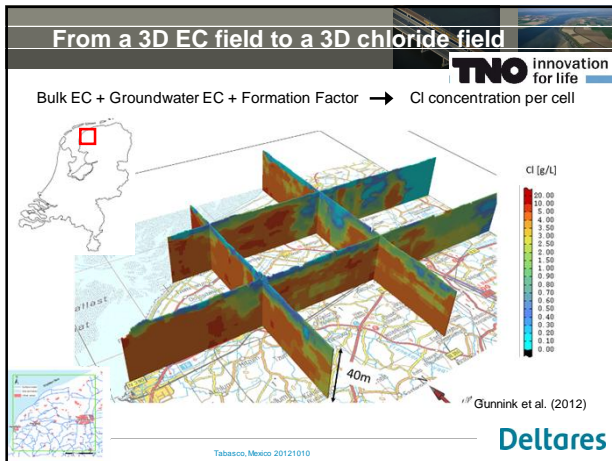
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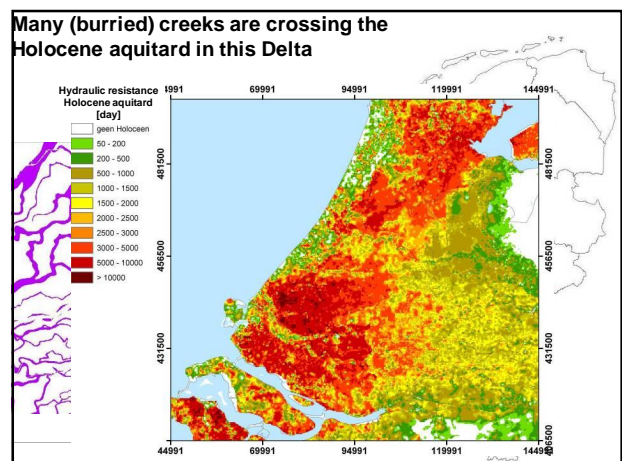
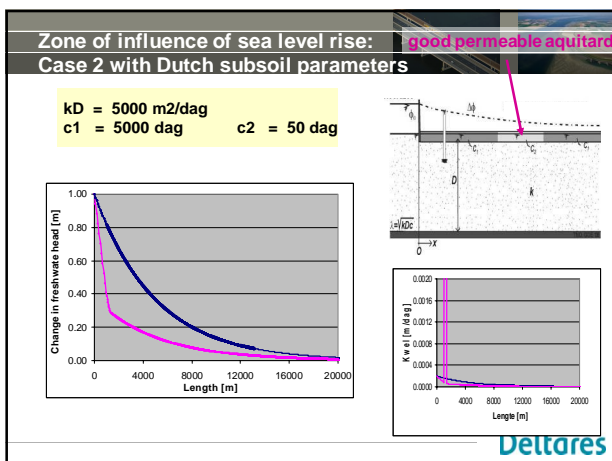
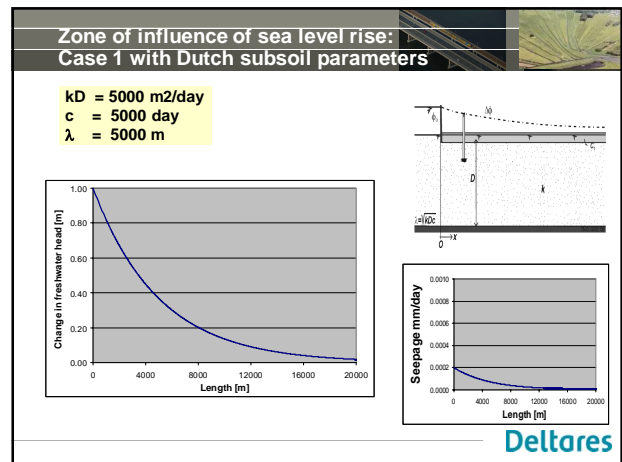
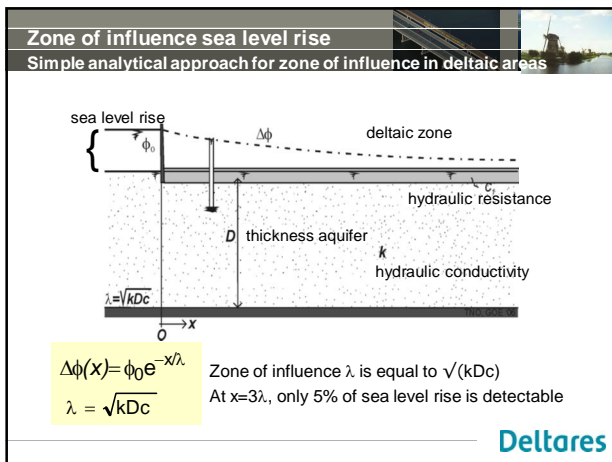
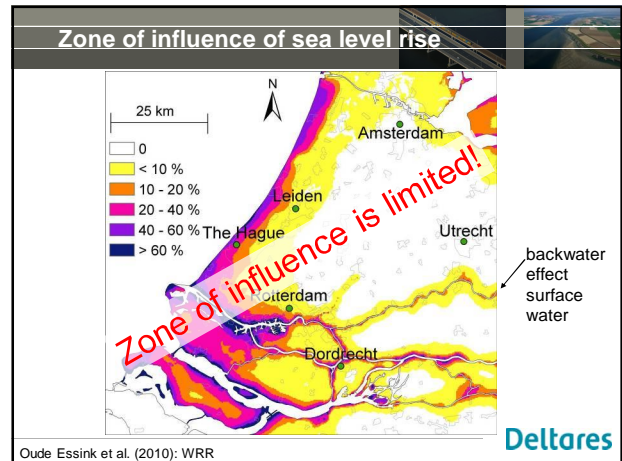
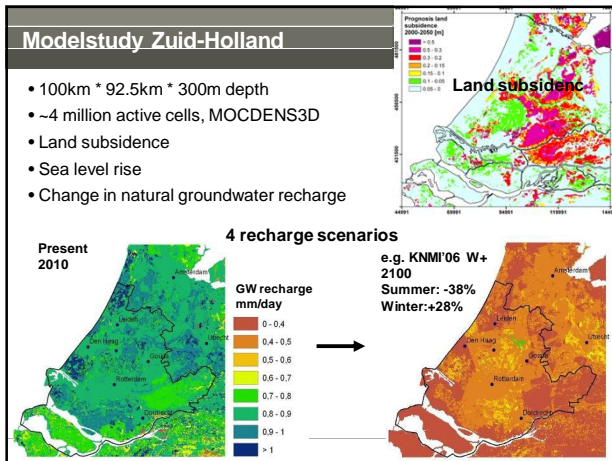


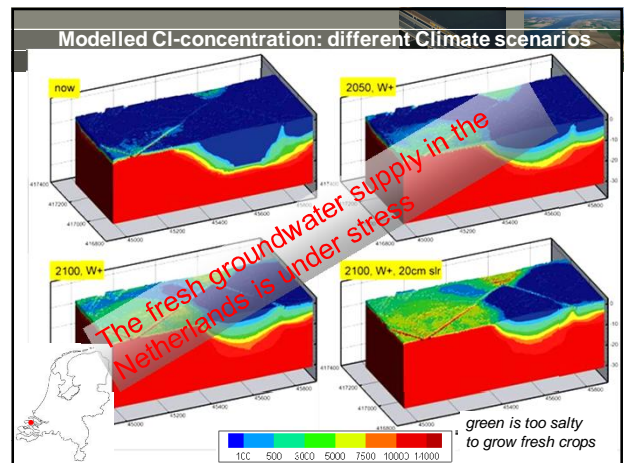
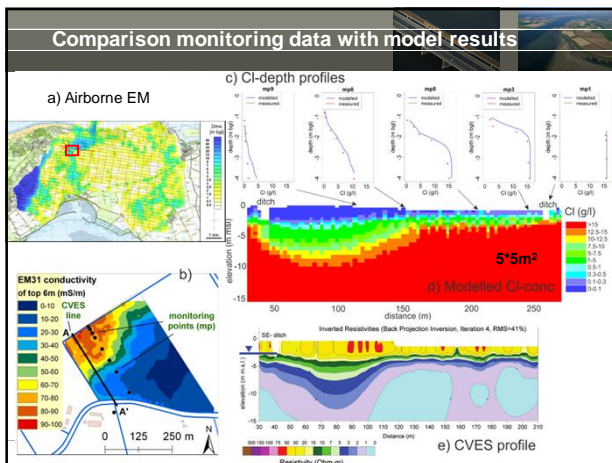
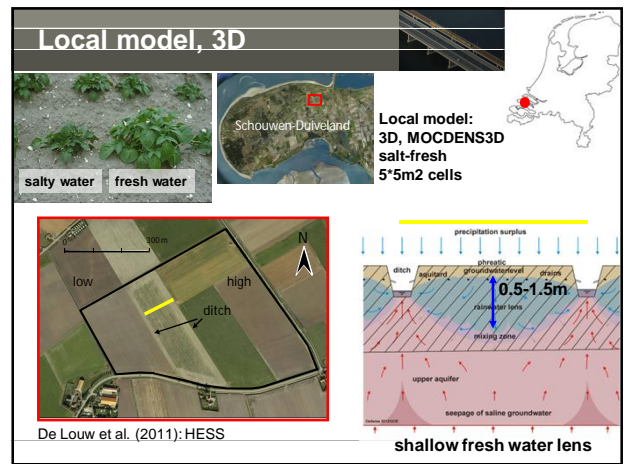
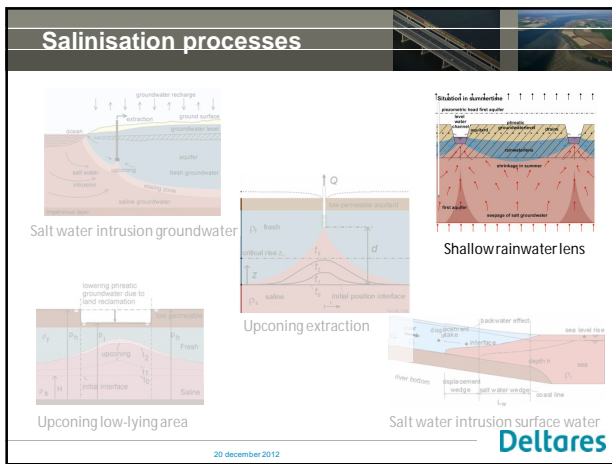
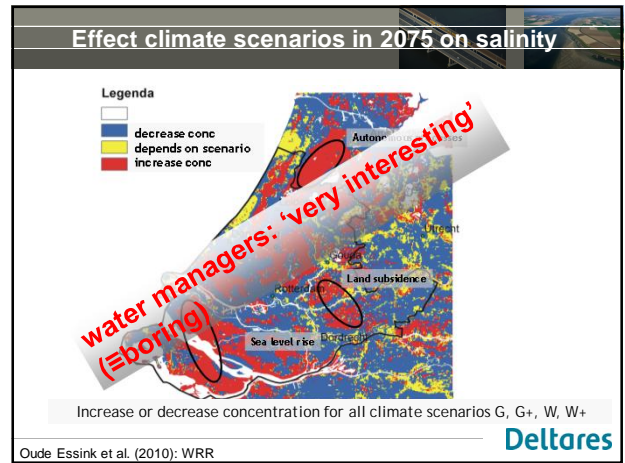
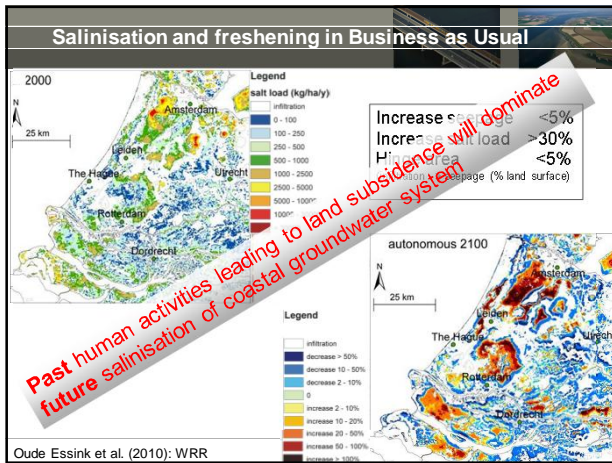


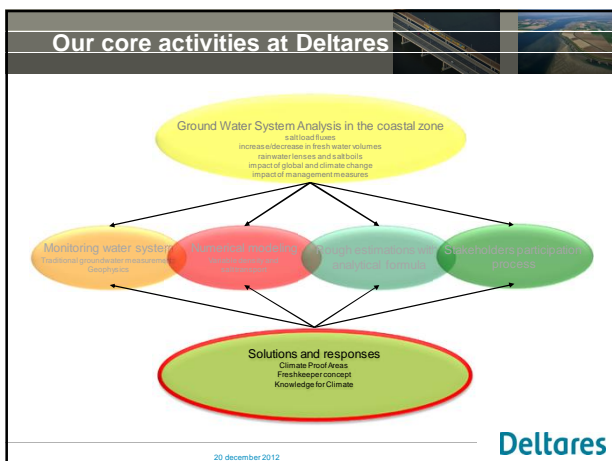
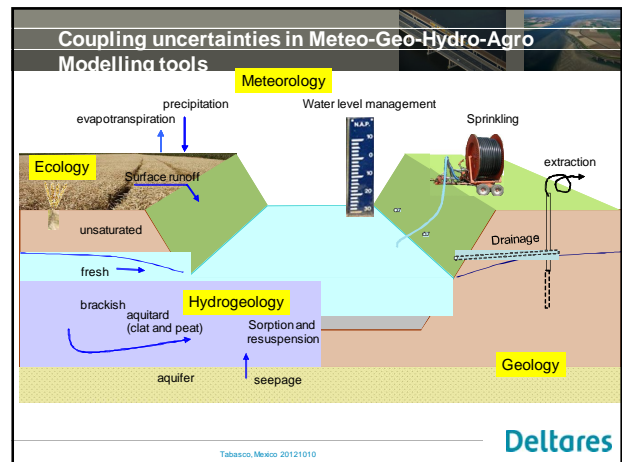
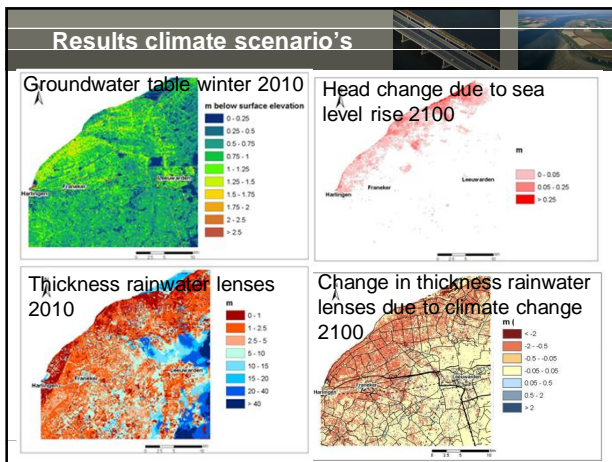
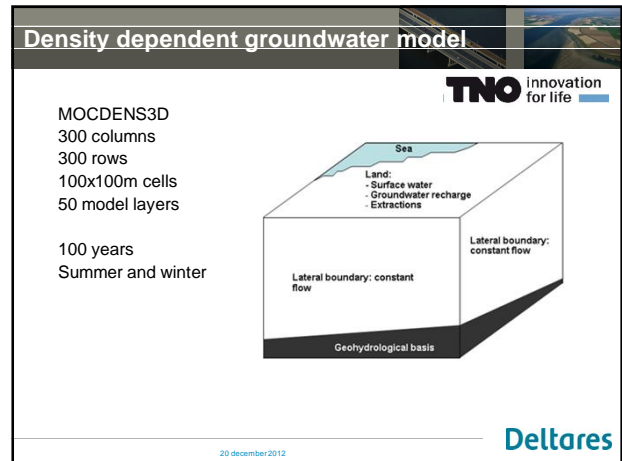
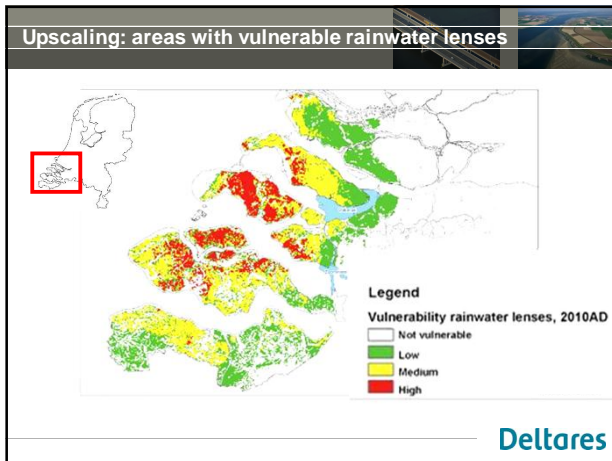












### Delta Program and National Water Plan

Two main goals for water management of our national government:

- To protect The Netherlands from flooding
- To make Fresh Water Supply Climate Change Proof

Assessing the effects of:

- Changing water management (lake, mine, dam, lake higher water level)
- Droughts
- Land subsidence
- Sea level rise and change precipitation pattern
- Coming year: Nutrient emissions and pesticide leaching, etc.
- Adaptation and mitigation strategies

Tools: Deltamodel and Netherlands Hydrological modeling Instrument

*To implement Delta Program (2015-2050): 7,0 billion euro per year*

### Solutions and responses

Local solution fresh groundwater supply

climate and global change

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### What should be the response?

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Many local solutions fresh groundwater supply

climate and global change

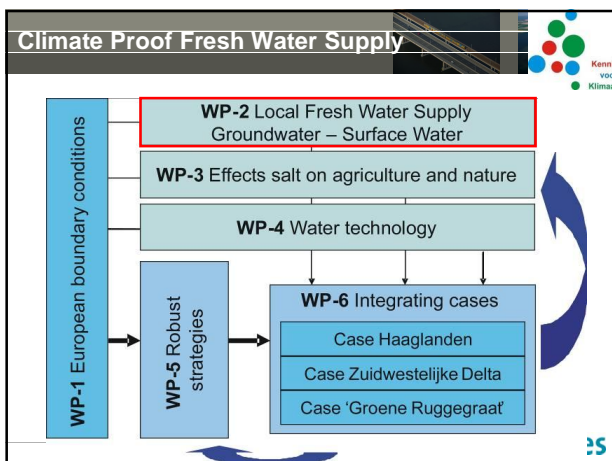
Many local solutions for fresh groundwater supply can have regional impact!

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### Key activities

- upscaling local cases to regional strategy
- assess economical feasibility
- increase impact: communicate our showcases
- working together

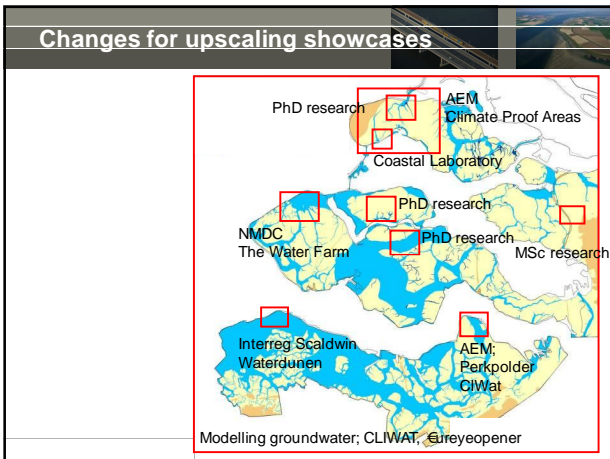
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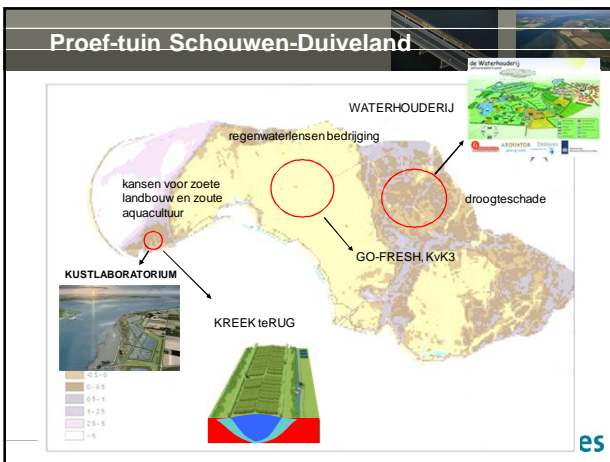
### Partners and stakeholders

<h4>Partners</h4> <ul style="list-style-type: none"> <li>• Deltares</li> <li>• Wageningen University</li> <li>• KWR - Watercycle Research</li> <li>• VU University of Amsterdam</li> <li>• University of Twente</li> <li>• Alterra</li> <li>• Delft University of Technology</li> <li>• Utrecht University</li> <li>• TNO - Env. Health and Safety</li> <li>• Acacia Water</li> </ul>	<h4>Stakeholders</h4> <ul style="list-style-type: none"> <li>• RWS South-Holland</li> <li>• City of Rotterdam</li> <li>• Water Board Schieland</li> <li>• Province South-Holland</li> <li>• Water Board Delfland</li> <li>• Municipality Westland</li> <li>• Municipality Pijnacker</li> <li>• Ministry of Economic Affairs, Agriculture and Innovation</li> <li>• Ministry of Infrastructure and the Environment</li> <li>• STOWA</li> <li>• OASE</li> <li>• Water Board Rijnland</li> </ul>
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**Budget 5Meuro, 4 years**



- ### Combineren grondwater projects in Proeftuin ZWD
- GO-FRESH, Knowledge for Climate
  - De Waterhouderij
  - Climate Proof Areas
  - CliWat
  - Kustlaboratorium
  - De KREEK TeRUG
  - Spin-off De Zandmotor
- Deltares



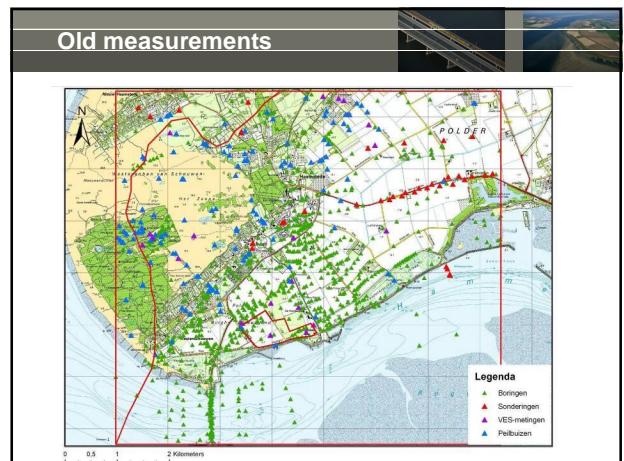
### The Coastal Lab

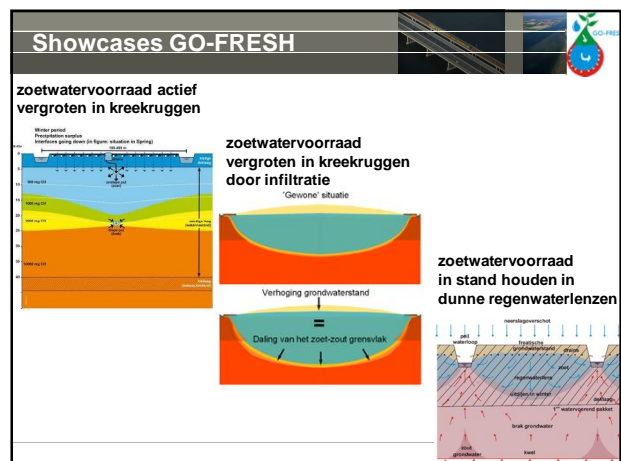
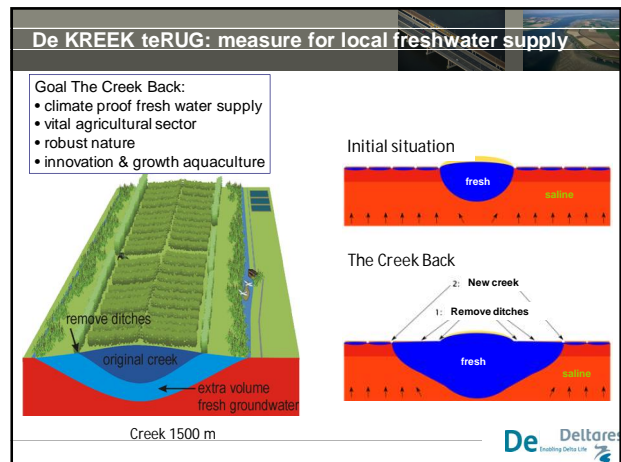
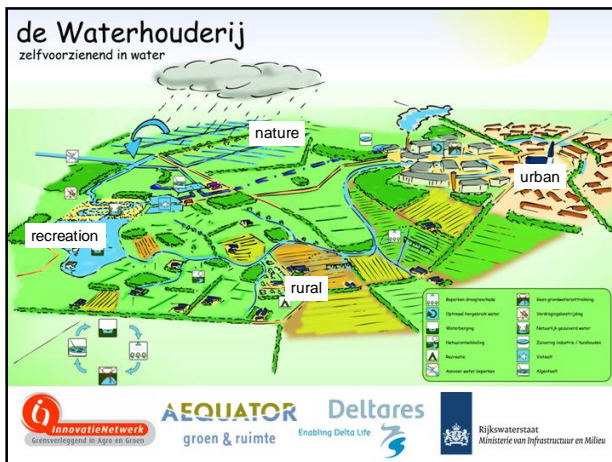
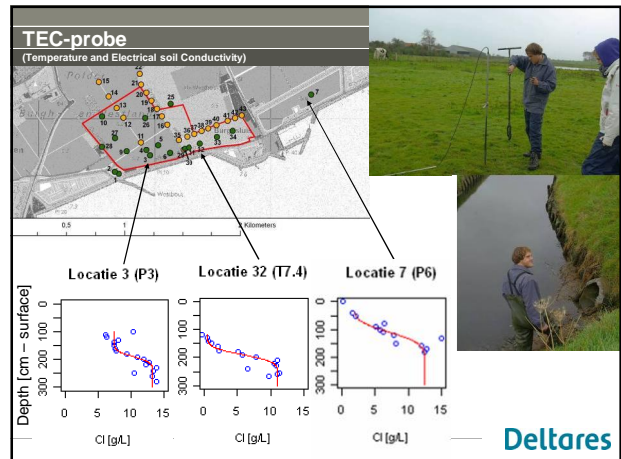
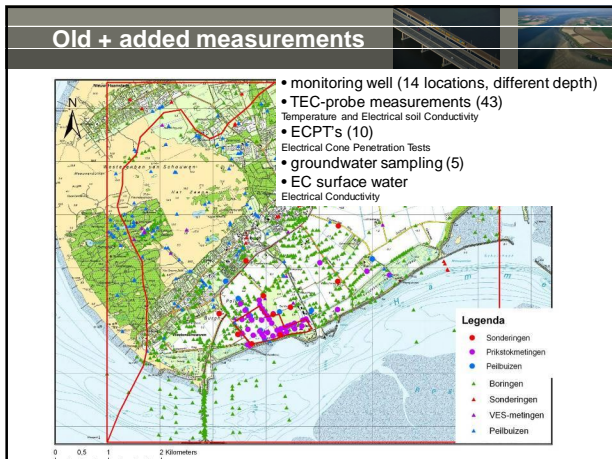
- Het Zeeuwse Landschap (NGO)
- Dutch Dream Fund Lottery
- 45 ha, on island Schouwen-Duiveland

Pilot project for:

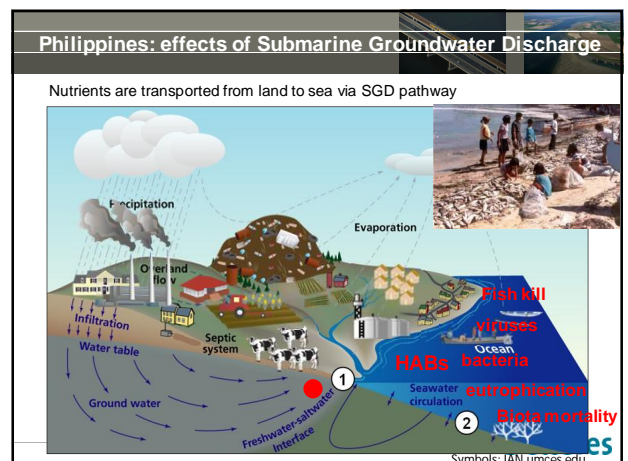
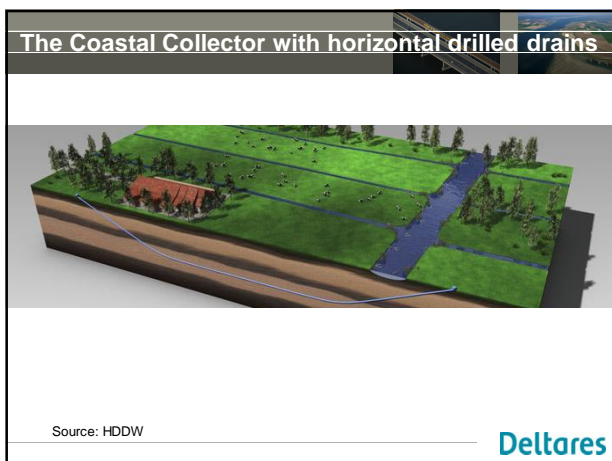
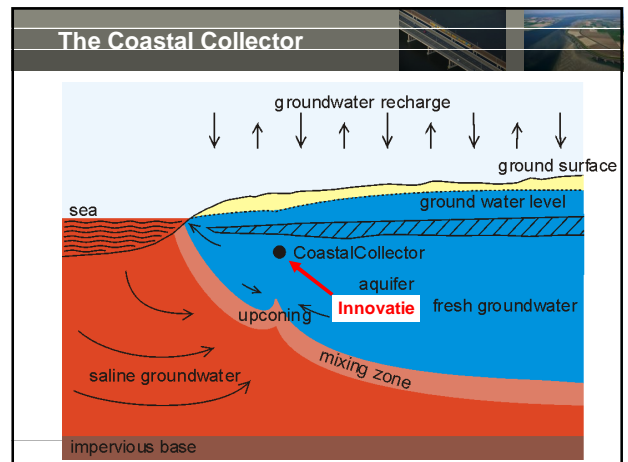
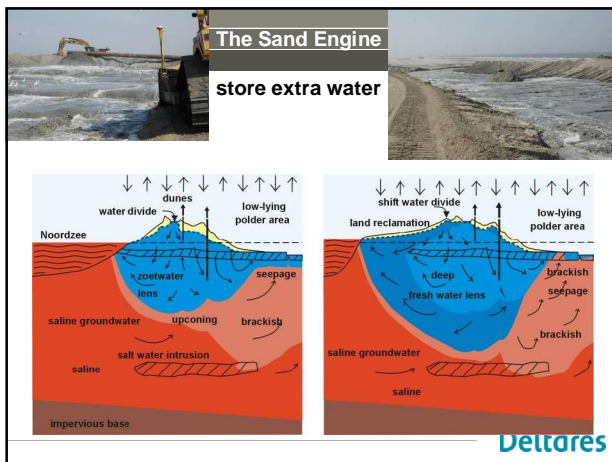
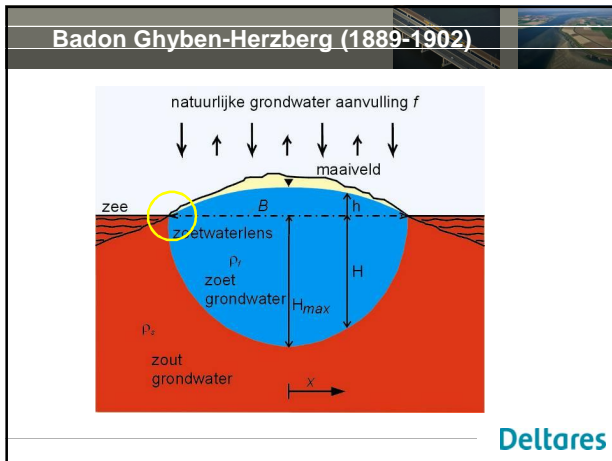
- aquaculture
- nature development
- landscape experience

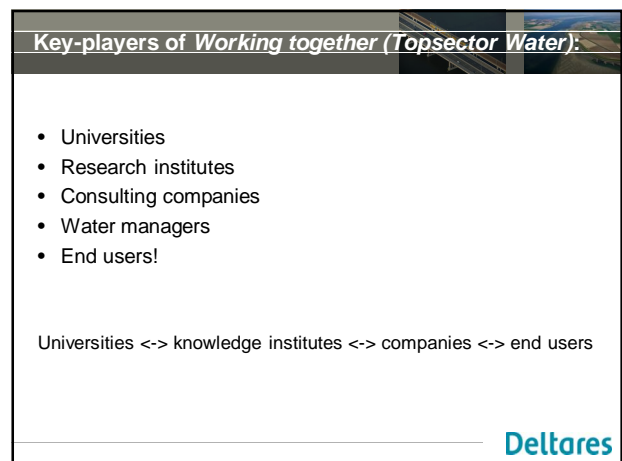
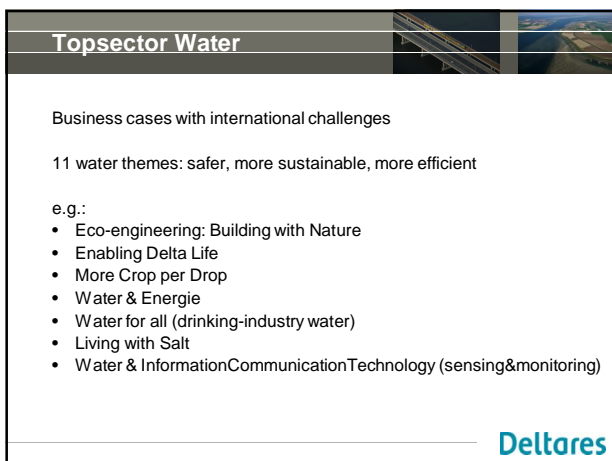
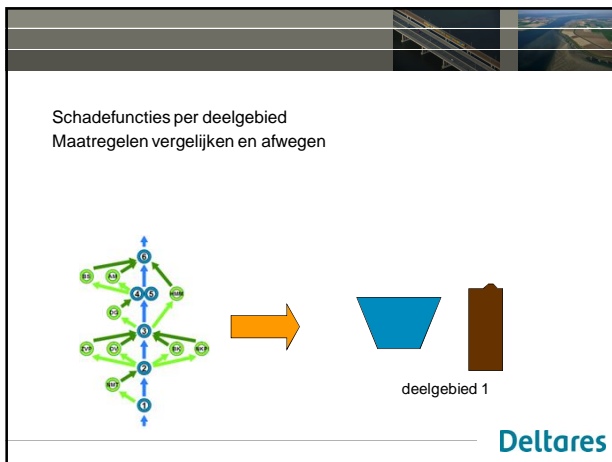
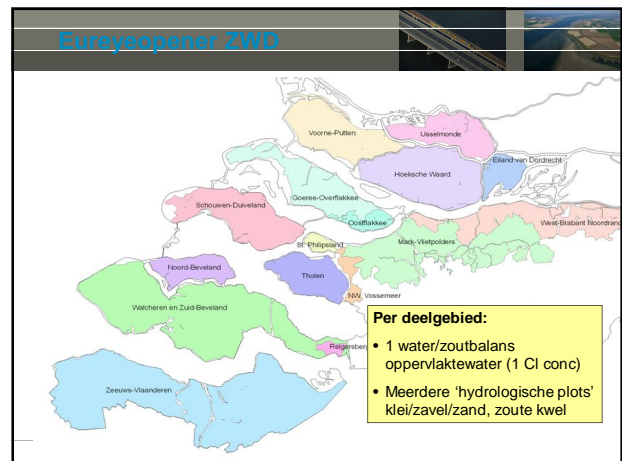
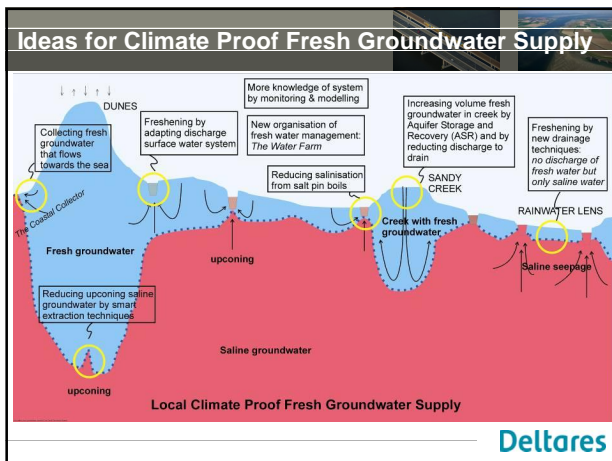
This requires a monitoring campaign and a flexible, high resolution, transient, calibrated density dependent groundwater model with coupled salt transport...

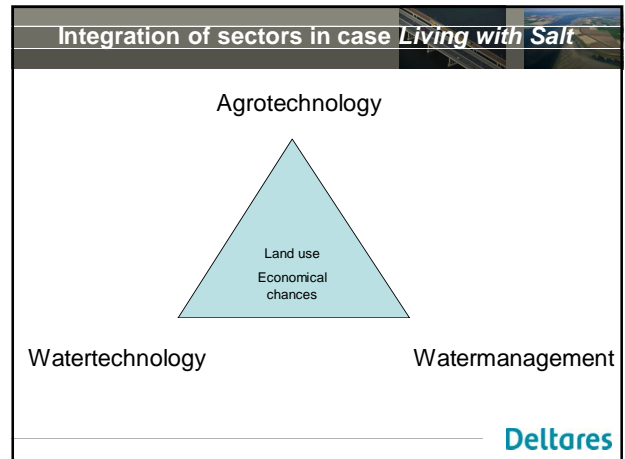
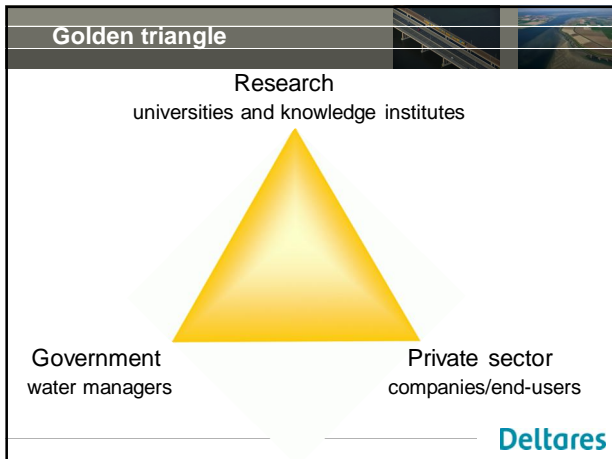












**Topsector Water: *Living with Salt***

**Solutions – Technology responses**

**Delta Technology**  
Water system, water demand & supply, interaction fresh-salt, models, smart-sensors

**Water Technology**  
Desalination, brine disposal problems, Aquifer Storage and Recovery, use of sewage water

**Agro Technology**  
Salt resistant crops, drainage innovations

*STW NWO Preproposal WATER NEXUS*

Deltares

**STW NWO preproposal WATER NEXUS**

Deltares

**Partners in *Living with Salt***

Watertechnology

- Paques, Voltea, WETSUS

Agrotechnology

- Prinse en Dingemanse
- Stichting Zeeuwse Tong

Sensortechniques watermanagement

- Dacom

NL consultancies

- Haskoning, Arcadis

Knowledge institutes

- Wageningen UR, Deltares, Acacia Water

Deltares