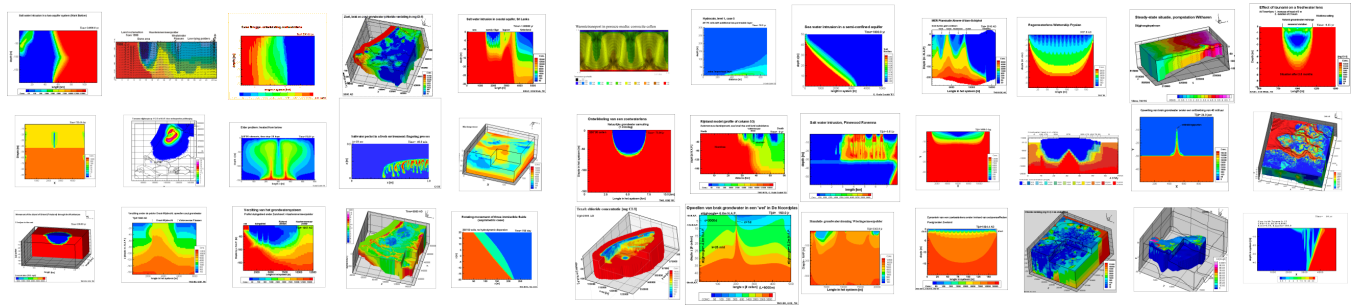


Modelling



Monitoring&data assimilation&numerical modelling complex (fresh-brackish-saline) water systems

Sub-local: fingering, salty sand boils
Sri Lanka (Tsunami 2004), Zandmotor
cell size=1cm-1m

Local: rainwaterlenses, heat-cold
Tholen, Schouwen-Duiveland
cell size=5-25m

Regional:
Zeeland, Gujarat/India, Philippines
cell size=100m

Goal:
To take largest cell size possible to
accurately model relevant salinisation
processes

National: salt load
South-Holland, NHI
cell size=250m-2km

Deltares
Enabling Delta Life

Monitoring&data assimilation complex (fresh-brackish-saline)

Characteristics:

- variable-density groundwater
- fresh, brackish and saline
- 3D, non-steady
- coupled solute transport
- heat transport

Assess combined effects:

- past land subsidence polders
- sea level rise
- changing recharge pattern
- land subsidence
- changing extraction rates
- adaption measures

Software (MODFLOW family):

SEAWAT, MOCDENS3D, MT3D, iMOD,
link NHI, etc.
parallel computing

NHI f
20.6f
250m
2010

No
62f
12f
19f

F
1
2
2
D



Peer-reviewed articles 3D fresh-saline modelling with MOCDENS3D

Faneca Sánchez, M., Gunnink, J., van Baaren, E.S., Oude Essink, G.H.P., Elderhorst, W., de Louw, P.G.B., Siemon, B., Auker, E. 2012. Modelling climate change effects on a Dutch coastal groundwater system using airborne Electro Magnetic measurements, *Hydrol. Earth Syst. Sci.*, 16, 4499-4516, doi:10.5194/hess-16-4499-2012.

[link to HESS](#)

Pauw, P.S., Louw, P.G.B., de, Oude Essink, G.H.P. 2012. Groundwater salinization in the Wadden Sea area of the Netherlands; quantifying the effects of climate change, sea level rise and anthropogenic interferences, *Netherlands Journal of Geosciences* 91-3, 373-383.

[link to NJG](#)

Oude Essink, G.H.P. and Kooi, H. 2012. Land-subsidence and sea-level rise threaten fresh water resources in the coastal groundwater system of the Rijnland water board, The Netherlands, p. 227-248, Chapter 13 in: *Climate Change Effects on Groundwater Resources: A Global Synthesis of Findings and Recommendations*, Treidel, H., Martin-Bordes, J.L. and Gurdak, J.J. (Eds), 401 p.

[link to Book](#)

Oude Essink, G.H.P., E.S. van Baaren, and P.G.B. de Louw 2010, Effects of climate change on coastal groundwater systems: A modeling study in the Netherlands, *Water Resour. Res.*, 46, W00F04, doi:10.1029/2009WR008719.

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Vandenbohede, A., Van Houtte, E., and Lebbe, L. 2009. Sustainable groundwater extraction in coastal areas: a Belgian example. *Environ Geol* (2009) 57: 735--747.

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Oude Essink, G.H.P. 2001. Salt Water Intrusion in a Three-dimensional Groundwater System in The Netherlands: a Numerical Study, *Transport in Porous Media* 43(1): 137-158.

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Oude Essink, G.H.P. 2001. Saltwater intrusion in 3D large-scale aquifers: a Dutch case, *Phys. & Chem. of the Earth* 26(4): 337-344.

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User Manuel MOCDENS3D

Vandenbohede, A. 2008, Ghent University, Visual MOCDENS3D± Visualisation and processing software for MOCDENS3D, a 3D density dependent groundwater flow and solute transport model.

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Reports, proceedings 3D fresh-saline modelling with MOCDENS3D

Oude Essink, G.H.P. 2001. Density dependent groundwater flow at the island of Texel, The Netherlands. Proc. 16th Salt Water Intrusion Meeting, Miedzyzdroje-Wolin Island, Poland: 47-54.

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Oude Essink, G.H.P. 1999. Simulating 3D density dependent groundwater flow: the adapted MOC3D. Proc. 15th Salt Water Intrusion Meeting, Ghent, Belgium: 69-79.

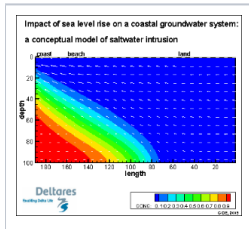
Oude Essink, G.H.P. 1998. MOC3D adapted to simulate 3D density-dependent groundwater flow. In: Proc.MODFLOW'98 Conference, October 4-8, 1998, Golden, Colorado, USA, Vol. I, 291-303.

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Animations: examples

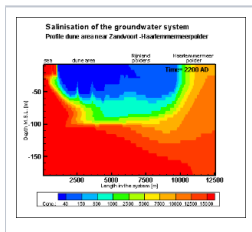
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[Henry's profile with sea level rise](#)



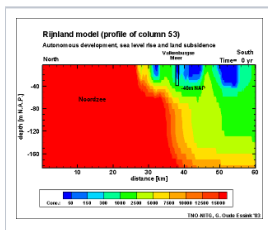
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[Dutch profile with extraction, upconing and low inland levels](#)



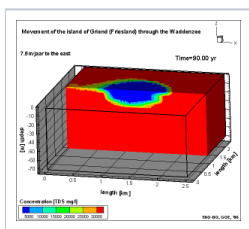
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[Profile over 3D model: autonomous salinisation, sea level rise](#)



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