On fresh-saline groundwater in deltaic areas

http://freshsalt.deltares.nl/

Leaflet fresh-saline groundwater Deltares online available

Introduction

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Dutch wiki-site
zoetzout,
deltares.nl
problems for farmers, what are agriculture and natural ecosystems of the world. Details as in-house as well as external natural resources.
al modelling techniques, monitoring tools and the knowledge to thoroughly investigate analytical issues and to implement innovative solutions.
Threats to fresh water resources

Permanent groundwater drainage keeps the polder areas sustainable in a large part of The Netherlands accelerate due to the anticipated sea level rise, climate change, future land subsidence and especially due to human factors like groundwater extraction and lowering of differentiated polder water levels. The processes described here for the Dutch situation prevail in many other deltas and coastal areas. Concluding, not taking any mitigation and/or adaptation measures will lead to a world-wide increase of salinisation.
Focus on regional and local processes

Deltares researchers investigate the processes of fresh, brackish and saline groundwater on different scales. On a regional scale, the effects of climate change, land, and water use change and the combined effects of preventive measures on groundwater salinisation are studied. Other studies give answers on how groundwater concentration changes affect surface water quality. On a local scale, the dynamics of fresh rainwater lenses on saline groundwater as a result of natural or artificial recharge are studied. These lenses allow agriculture where shallow groundwater is very saline. Other research topics are preferential groundwater flow via sandy layers and boils that connect deep saline aquifers with shallow aquifers and with fresh surface water bodies. These preferential flow paths largely contribute to the salinisation of Dutch low-lying areas. Our knowledge is not specific for the Netherlands and can be applied in similar deltaic areas around the world.

Solutions of salinisation problems

Deltares has the knowledge and expertise to study processes in combined fresh and saline groundwater systems. We develop and apply monitoring tools and techniques like the T-EC probe, EM-Slimflex and other online real-time measurement techniques. Moreover, Deltares has the modelling experience and the numeric compute codes (like MODENS3D/SEAWAT) at its disposal to simulate variable-density groundwater flow and coupled solute transport. Deltares is engaged in the design of specific measures needed for salinisation prevention and adaptation and for saline aquifer management. We have a long professional track record on groundwater salinisation studies built up during numerous relevant projects worldwide.

Leaflet (new)

Fresh-saline groundwater in deltaic and coastal areas

More Information

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Projects
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<td>SWIBANGLA Managing saltwater intrusion impacts in Bangladesh</td>
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**Publications**

**PhD theses**

1. Huizer, S. 2019. Fresh groundwater in large beach nourishments; Growth of freshwater resources in coastal areas, Utrecht University, Utrecht, 152 pp. [Download PhD thesis](https://doi.org/10.3390/w11091946)

**Articles**


Download: Powerpoint presentation sheets: pdf format
Download: Lecture Notes: Density Dependent Groundwater Flow
Download: Animations

Exercises

Vertical interface:
- Download: Vertical interface: pdf document
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- Download: Vertical interface: PMWIN files

Freshwater lens:
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- Download: Freshwater lens: PMWIN files

Henry’s problem:
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- Download: Henry’s problem: PMWIN files

Elder’s problem:
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- Download: Elder’s problem: PMWIN files

Download: word documents Henry, Elder, Vertical Interface, Freshwater Lens

Additional material

Download: info on numerical dispersion and oscillation: Chapter 8, p. 119-132

Download: animation Elder

Download: Solution exercises lecture notes

Total Commander: link

Download: Some Total Commander Hotkeys

Course Hazards and risk assessment GEO4-4425, Utrecht University, 20 March 2020

Topic: Vulnerability of groundwater systems to flooding events
Regional Workshop on Saltwater Intrusion Modeling & Implications of Sea Level Rise, July 23-24, 2014

Lecture Notes Density Dependent Groundwater Flow: Salt water intrusion in coastal aquifers

Auteur: Gualbert Oude Essink
Dictaat: Density Dependent Groundwater Flow

1 Introduction
2 Characteristics of a density dependent groundwater system
3 Freshwater head
4 The concept of a fresh-saline interface
5 Control of salt water intrusion
6 Numerical modelling
7 Salt water intrusion in the Netherlands
8 Heat transport in porous media: introduction

Lecture Notes Groundwater Modelling

Auteur: Gualbert Oude Essink
Dictaat: Groundwater Modelling

PART I Modelling Protocol
1 Introduction
2 Classification of mathematical models
3 Methodology of modelling
4 Data gathering

PART II Groundwater Modelling
5 Introduction
6 Mathematical description of hydrogeologic processes
7 Solution techniques
8 Numerical aspects of groundwater models
9 Some selected groundwater codes

Animations: examples of salinisation processes
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**Upcoming saline groundwater under a low-lying area**

**Ontwikkeling van een zuwetwaterlens**

**3D salinity groundwater distribution of the Nile Delta, Egypt**

CRYSTECHSALIN

Download: Proceedings Meeting 21-24 September 2002, Scanzano, Italy

Homage Prof. Custodio:

article: Salinisation of groundwater resources in the Dutch Deltaic Area: modelling, monitoring, Climate Change and Solutions

**News**

**General**

Homepage Salt Water Intrusion Meetings

Saltnet

2018

- 25th Salt Water Intrusion Meeting in Gdansk, 17-22 June, 2018

Presentations:

- De Louw, P.G.B., Bootasma, H., Kooi, H., Kramer, M., Erkens, G. 2018. Land subsidence by peat oxidation leads to enhanced salinization through boils in Dutch polders
- Zamrsky, D., Oude Essink, G.H.P., Bierkens, M.F.P. 2018. Estimating characteristic times of regional groundwater systems along the global coastline with regard to past sea level fluctuations and sediment accumulation patterns
- Van Engelen, J., Bierkens, M.F.P., Oude Essink, G.H.P. 2018. 3D Paleohydrogeological modelling of the Nile Delta
- Oude Essink, G.H.P., Mulder, T., Van Engelen, J., Zamrsky, D., Pham Van, H., Weerasekera, W., Meggiorin, M. 2018. Building up D salinity models for estimating fresh groundwater resources in major deltas under global and climate stresses

Posters

- America, I., De Louw, P.G.B., Bier, G., Van der Zee, S. 2018. Influence of tides, bathymetry, lithology and regional flows on the salinization process in nature area the Rammegors

2017

- 2017 23-28 April: European Geosciences Union, General Assembly

- Wanted: Ghent University Belgium: Assistant Prof. Hydrogeology

2016

- 2016 4-8 July, 24th Salt Water Intrusion Meeting: Cairns, Australia
- 2016 10-13 May, 4th Int. Climate Change and Adaptation Conference, Rotterdam, The Netherlands

2015

- 2015, 9-12 June: AquaConSoil, Copenhagen, Denmark: Sustainable Use and Management of Soil, Sediment and Water Resources
- 2015 12-17 April, EGU, Vienna, Austria, 27 April - 2 May 2014.

2014

- International Conference Deltas in Times of Climate Change II, 24-26 September 2014 - Download the Flyer (check Fresh Water Management)
- IAEG XII Congress, Torino September 15-19, 2014: Engineering Geology for Society and Territory, 1.4 - Climate change; impacts on natural resources and hazards
- Regional Workshop on Saltwater Intrusion Modeling & Implications of Sea Level Rise: July 23-24, 2014, South Florida Water Management District
- 23rd Salt Water Intrusion Meeting, Husum, Germany, 16-20 June 2014
- Presentation: Esther van Baaren, Bouke Ottow, Marco Arts, Pieter Pauw, Gualbert Oude Essink, Sharing precious water volumes in the Water Farm
- Presentation: Marta Faneca, Gualbert Oude Essink, Gijs Janssen, Roelof Stuurman, Yangxiao Zhou, SWIBANGLA, Managing Salt Water Impacts in Bangladesh
- Presentation: Pieter Pauw, Controlled level drainage to expand freshwater lenses below creek ridges
- Presentation: Sebastian Huizer, Can a large sand suppletion lead to a substantial increase in fresh water resources?: The Sand Motor Project
- Presentation: Gualbert Oude Essink, Daniel Zamrsky, Marta Faneca, Global Quick Scan of the Vulnerability of Groundwater systems to Tsunamis (and other flooding events)
- Poster: Esther van Baaren, Perry de Louw, Gualbert Oude Essink, Regional variable-density groundwater flow model: a Dutch case in the southwestern delta
- EGU, Vienna, Austria, 27 April - 2 May 2014

2013

- Summer School, 1-5 July, 2013: Fresh and Salt Groundwater in Deltaic Regions: Mathematics, Numerical Modeling and Applications
- AquaConSoil, Barcelona, 16-19 April 2013, 12th International UFZ-Deltares Conference on Groundwater-Soil-Systems and Water Resource Management
- EGU, Vienna, Austria, 07-12 April 2013: Groundwater resources in a changing environment
- EGU, Vienna, Austria, 07-12 April 2013: Freshwater-saltwater interactions and density-driven flow

2012

- AGU, San Francisco, 3-7 December 2012: H52B. Measurement, Modeling, and Management of Coastal Aquifers II
- Presentation: Gualbert Oude Essink, Impact of global and climate stresses on fresh water resources in the coastal zone: a Dutch example (Invited)
22nd Salt Water Intrusion Meeting, Buzios, Brazil, June 17-21, 2012
Presentation: Esther van Baaren, The Water Farm: self-sufficient in water
Presentation: Gualbert Oude Essink, Local Climate Proof Fresh Groundwater Supply: adaptation water management strategy with national impact?
Presentation: Gualbert Oude Essink, Geophysics Applied to Coastal Aquifer Studies
Presentation: Joost Delsman, Salt lead to an agricultural catchment: ‘seepage flux times concentration’, or is there more to it than that? Insights from a multi-scale tracer study
Presentation: Esther van Baaren, Climate Proof Areas: Innovative solutions for improving the freshwater availability
Poster: Pieter Pauw, Large scale drainage measures to increase freshwater supply from sandy creek deposits
Poster: Gualbert Oude Essink, Airborne Geophysics: a powerful tool to start up fresh groundwater management in the coastal zone

Two-day meeting on fresh and saline issues, 31 May-1 June 2012, organized by Knowledge for Climate, De Waterdienst and STOWA
Poster: Gualbert Oude Essink, Airborne Geophysics: a powerful tool to start up fresh groundwater management in the coastal zone

IV Int. Conf. on Technology Seawater Intrusion in Coastal Aquifer, Alicante, Spain, April 24-26 2012
Presentation: Marta Faneca, Effect of geological uncertainties on the salinisation of surface water systems in deltaic areas
Presentation: Gualbert Oude Essink, Local Climate Proof Fresh Groundwater Supply: adaptation water management strategy with national impact?

2011
World Delta Summit, The Pulse of Deltas and the Fate of our Civilization, Jakarta Indonesia, 21-24 November 2011

2010
International Centre for Advanced Mediterranean Agronomic Studies CIHEAM course, 22-27 March 2010, Zaragoza, Spain, teaching Quantitative methods

21st Salt Water Intrusion Meeting 21-25 June 2010, Azores, Portugal

Deltas in Times of Climate Change 29 September- 1 October, Rotterdam, the Netherlands

Blog stream
Create a blog post to share news and announcements with your team and company.

Internship
Student already contribute a number of years to our projects on fresh and salt groundwater in the coastal area. Sometimes with nice reports, sometimes with great results, article worthy! As such, this made that we are a strong supporter of guiding students through internships or thesis (both MSc and PhD)! We have already had students from Dutch universities (WUR, UU, VU), Universities of Applied Sciences (Zeeland, Larensteijn) and institutions like UNESCO-IHE. Foreign (PhD) students were welcome (Universities of Aachen, Ghent, Firenze, Bologna, Roma (La Sapienza)).

We have quite a few new topics, from numerical modeling to water system analysis using monitoring techniques. Just contact us, or the students below via e.g. LinkedIn!
New topics:

- Freshwater management techniques as a bridge between water demand and supply in the Mekong Delta, Vietnam (including fieldwork provinces Ben Tre or Tra Vinh)
- Analysis of upconing of saline groundwater under deltaic areas (numerical study)
- Effect of model parameters (e.g. solute solvers, grid convergence) on variable-density groundwater and salt transport benchmark cases (e.g. Henry, Hydrocoin, upconing; numerical analysis using iMOD-SEAWAT)
- Fresh groundwater resources management at a farmers level in the province of Zeeland, The Netherlands: setting up robust web-based clipping tools; a modelling study
- Assessing submarine groundwater discharge along coastal stretches: a global analysis
- Setting up a 3D variable-density groundwater flow model simulating salt water intrusion in a deltaic area: possible cases: the Bengal, Indus, Po, Yangtze, Pearl river deltas

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Examples past studies since 2005:

2019

- Colin Mainz, Utrecht of Aachen, Germany, Variable-density groundwater flow and coupled salt transport models of the Chao Phraya Delta, Thailand

2018

- Lars Geitenbeek, Utrecht University, Saline groundwater extraction as a measure to increase the freshwater availability: A case study for the western parts of the Netherlands
- Hugo Hagendoorn, Delft University of Technology, Measuring and modelling to optimise a salinity monitoring network for use in the optimal control of flushing: Case study: Lissertocht catchment
- Tobias Mulder, Utrecht University, Constructing 3D variable-density groundwater flow models for six deltas using global data sets

2017

- Wayangi Lakshani Weerasekera, IHE-Delft, 3D Variable-density Groundwater Modelling of the Red River Delta, Vietnam

2016

- Lubna Badi, Utrecht University, BSc, Securing freshwater supply with measures to diminish the effect of sea-level rise by climate change (Literature review on state-of-art SWI research and a case study on SIDS in the Pacific)
- Björn Bolhuis, Utrecht University, Developing an automated open source system for coastal multi-hazard assessment and management of water resources in a changing climate (Based on the Coastal Hazard Wheel system)

2015

- Steven Ros, Utrecht University, The Nile Delta, Egypt: creating a fresh-salt water model
- Marjolein Vogels, Utrecht University, Modelling the central coastal groundwater system of Bangladesh
2014

- Jan Snel, Wageningen UR, Oplossingen ten behoeve van zoetwatervoorziening voor de landbouw op Schouwen-Duiveland
- Mieke Hulshof, Wageningen UR, Spatial scales in salinity modeling, case Waterdunen, Zeeland (Folkert Hellinga Award 2014)
- Daniel Zamrsky, Wageningen UR, Coastal vulnerability to tsunami impacts and modelling SWI in aquifers situated in the most vulnerable areas
- Carlos Rosado de Palacio, Utrecht University, Water system analysis and numerical modelling of a coastal aquifer in western Mexico: a case study

2013

- Marjan Sommeijer, Wageningen UR, Identifying suitable locations for infiltration of fresh water in creek ridges
- Thomas Boerman, Utrecht University, Fresh water lenses under creek ridges: a pilot study in Zeeland to increase fresh water supply
- Pieter Winters, Universiteit Gent, België, Estimating flow patterns to an agricultural ditch by inverse modeling of temperature and salinity measurements

2012

- Maitri Fischer, Utrecht University, Managing freshwater lenses in a Dutch coastal setting - increasing freshwater availability by aquifer storage and recovery
- Martijn Visser, Utrecht University, Aquifer storage and recovery in a fossil creek bed - managing droughts in a brackish environment
- Irene Lugten, Utrecht University, The effects of salt water intrusion from the Dintel into the surface and groundwater in the region
- Kyra Hu-A-Ng, Utrecht University, Understanding Holocene coastal development and the resulting evolution of groundwater chloride distribution in the North-West coastal region of the Netherlands - a historical modelling approach

2010

- Bernard Voortman, Utrecht University, Impact of climate change on the region properties and thickness and form of rainwater lenses in the Province of Zeeland (in Dutch), contribution to Hydrol. Earth Syst. Sci., 15, 3659-3678
- Aileen Mirasol-Robert, Utrecht University, Analysis of Submarine Groundwater Discharge to Manila Bay - 3D Density Dependent Hydrogeological Modeling of the South-eastern coastal zone of Bataan, Philippines
- Dagmar Schnitzer, Utrecht University, Response of a fresh-brackish groundwater system to hydrological management in and around the Naardermeer wetland, the Netherlands (in Dutch)

2008

- Tommaso Letterio, Uni of Firenze, Italy

2007

- Bas de Veen en Sjors Stevens, VU Amsterdam, Monitoring campaign rainwater lenses in the province of Zeeland (in Dutch)
- Corne Prevo, HZ University of Applied Sciences, Aquatische Ecotechnologie: Rainwater lenses in the province of Zeeland (in Dutch)
- Francesco Sergi, La Sapienza, Roma, Italy, Salinisation processes in the Province of Zeeland, the Netherlands, contribution to Near Surface Geophysics, 401-412, 2007
- Marian Koskamp, Wageningen UR, Model study of chloride concentration in soil moisture and shallow groundwater in a saline seepage system (in Dutch)
- Valentina Marconi, Uni of Bologna, Italy, Characterization of shallow fresh groundwater lenses in the Province of Zeeland with 2D geo-electrical surveys
- Vesna Tripkovics, UNESCO-IHE, Salt water intrusion in The Province of Zeeland, the Netherlands - water system analysis and numerical modeling

2006

- Elles Bader, VU Amsterdam, Salinisation and freshening processes in the Netherlands, with special attention to the Wieringermeerpolder (in Dutch)
- Piet Maljaars en Runa Wils, Larenstein University of Applied Sciences, Rainwater lenses in saline seepage systems (in Dutch)

2005


Course

Course Groundwater in the coastal zone

18-20 September 2014, Delft – The Netherlands

download flyer for detailed information
Description:

The course will provide participants with (1) principles and procedures of variable density groundwater flow and coupled solute transport, (2) salinisation of groundwater systems and fresh-saline groundwater flow phenomena in the coastal zone, (3) monitoring techniques for fresh-brackish-saline water systems and (4) modelling experiences through hands-on training in computer workshops. On completion of this course the participants are able to understand, quantify and monitor groundwater flow processes in the coastal zone and to construct some (relatively simple) models on variable density groundwater flow and coupled salt transport. A field visit to the south-western part of the Netherlands will provide participants some field experiences in handling monitoring techniques to understand fresh-saline groundwater systems.

Contact

The following persons participate in the fresh-salt research on this wiki:

G-EMMA

G-EMMA is software written to facilitate end-member mixing analysis within a GLUE uncertainty assessment framework.

G-EMMA has its own website: http://g-emma.deltares.nl/

Recently updated
G-EMMA

Navigate space