Utrecht University

Deltares

WP 2.1: Integrated and scalable high-resolution surface-groundwater modelling considering variable density flow

Het effect van verschillende model-resoluties op de berekende zoutvrachten en zoet-zout verdeling van de ondergrond in West-Nederland.

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Utrecht University

Marc Bierkens

Gualbert Oude Essink

Perry de Louw

12/10/2023

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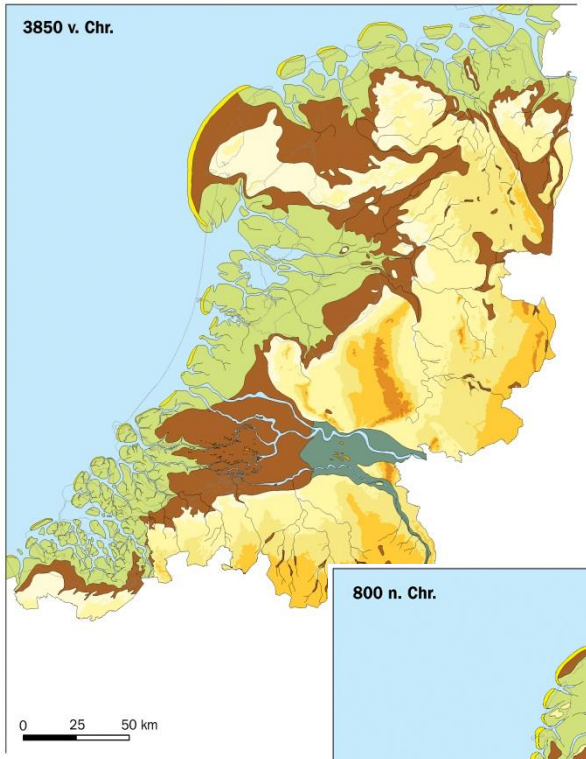
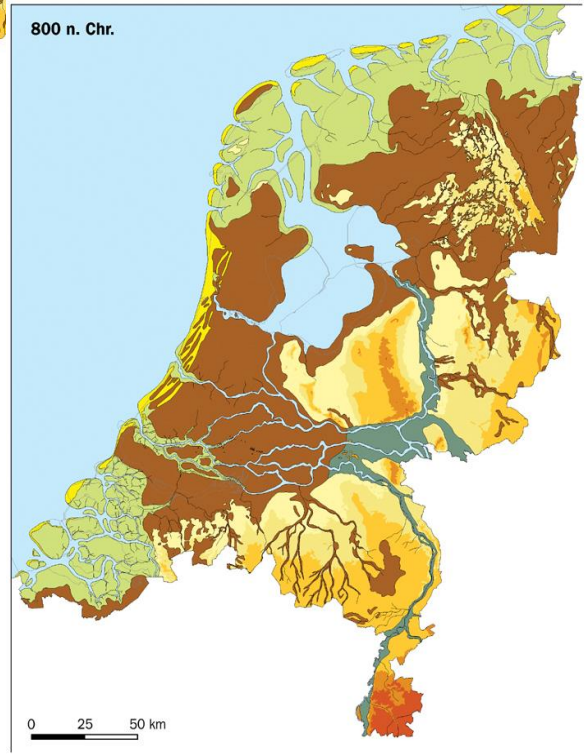
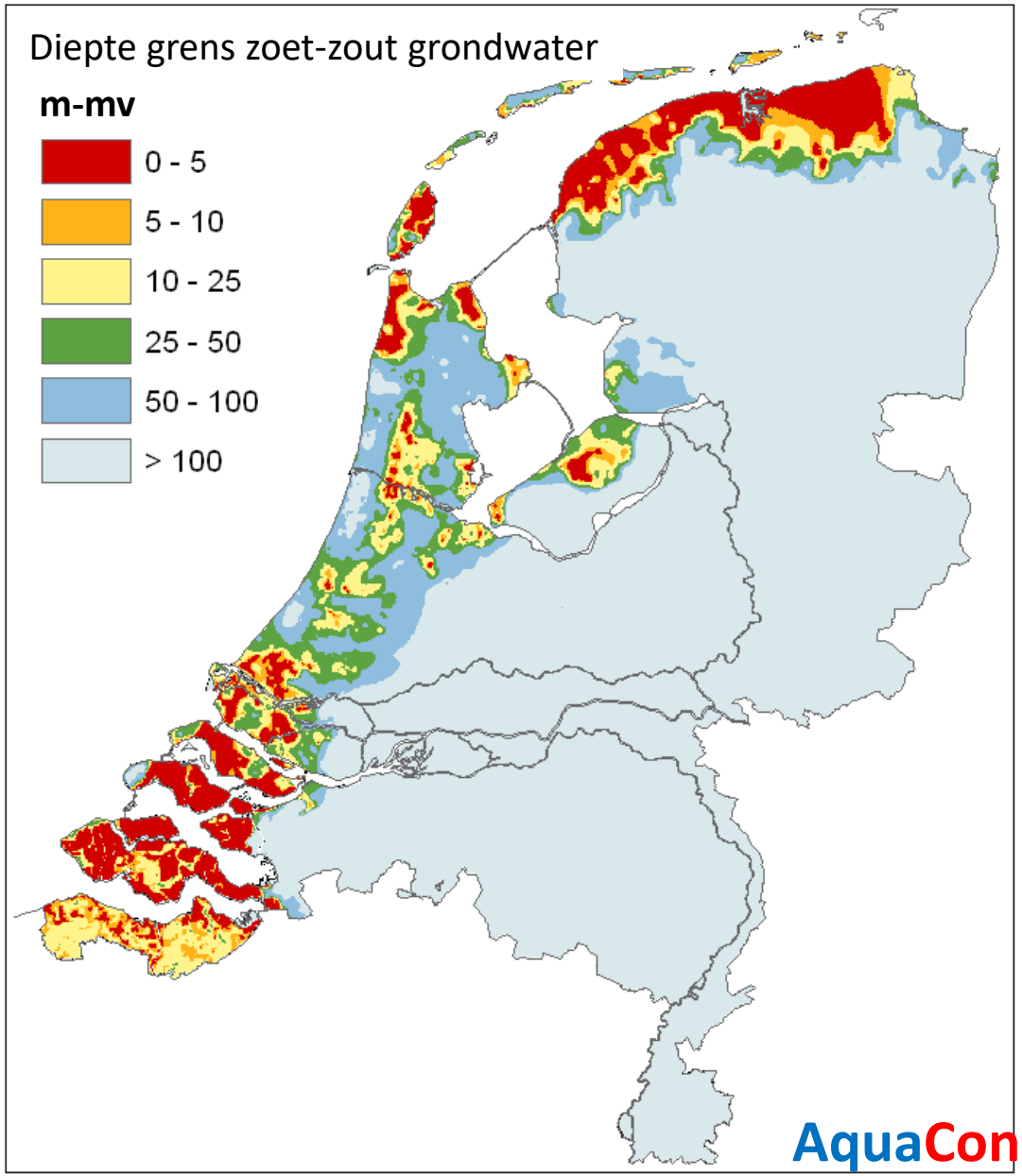
Waar komt het zout vandaan?



5500 jaar geleden
Maximale zee-invloed



1200 jaar geleden
Meeste recente zeeinvloed



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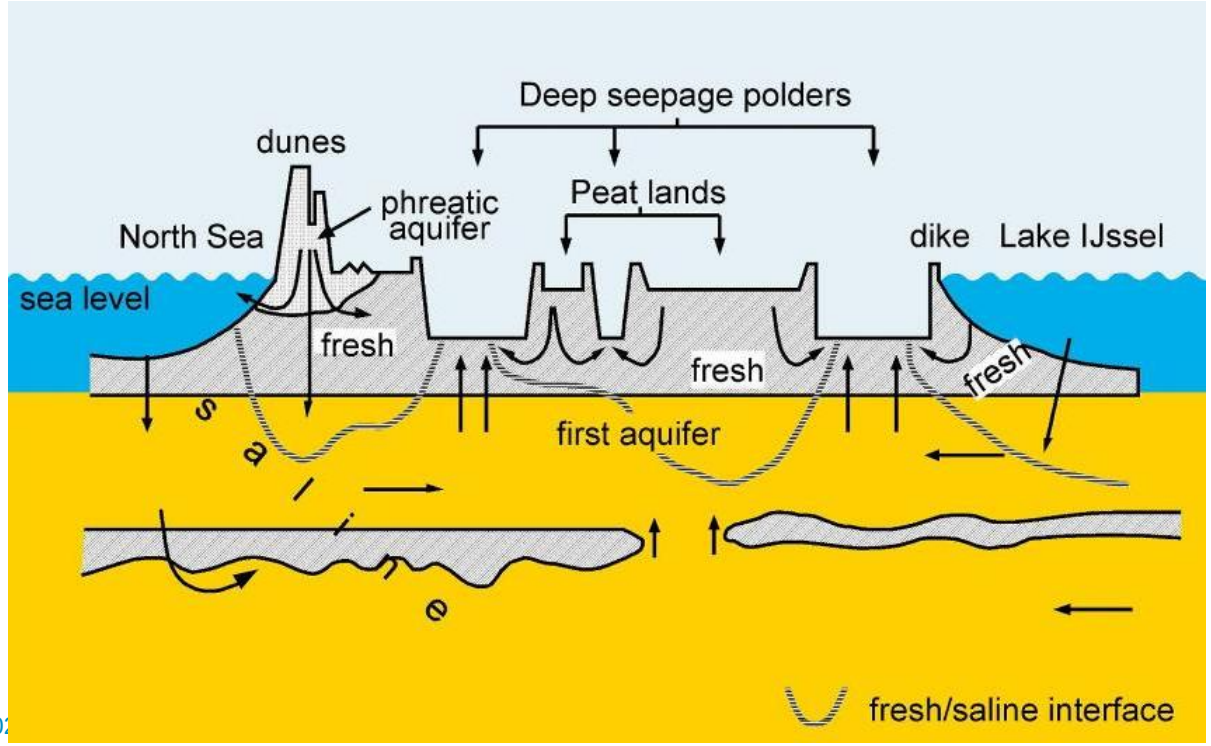
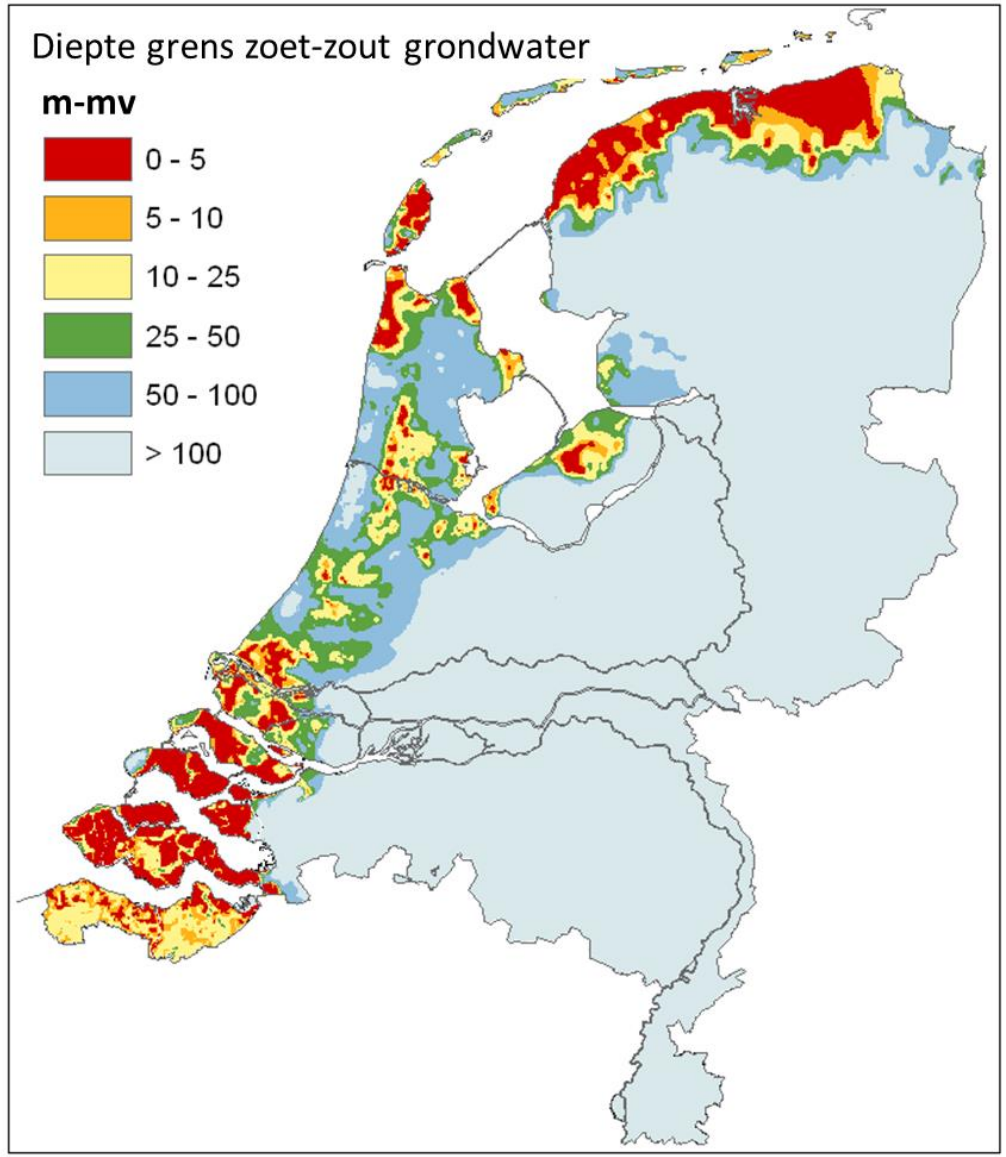
Zoute kwel leidt tot:

Verzilting van:

- oppervlaktewater
- ondiep grondwater
- wortel zone (gewas schade)





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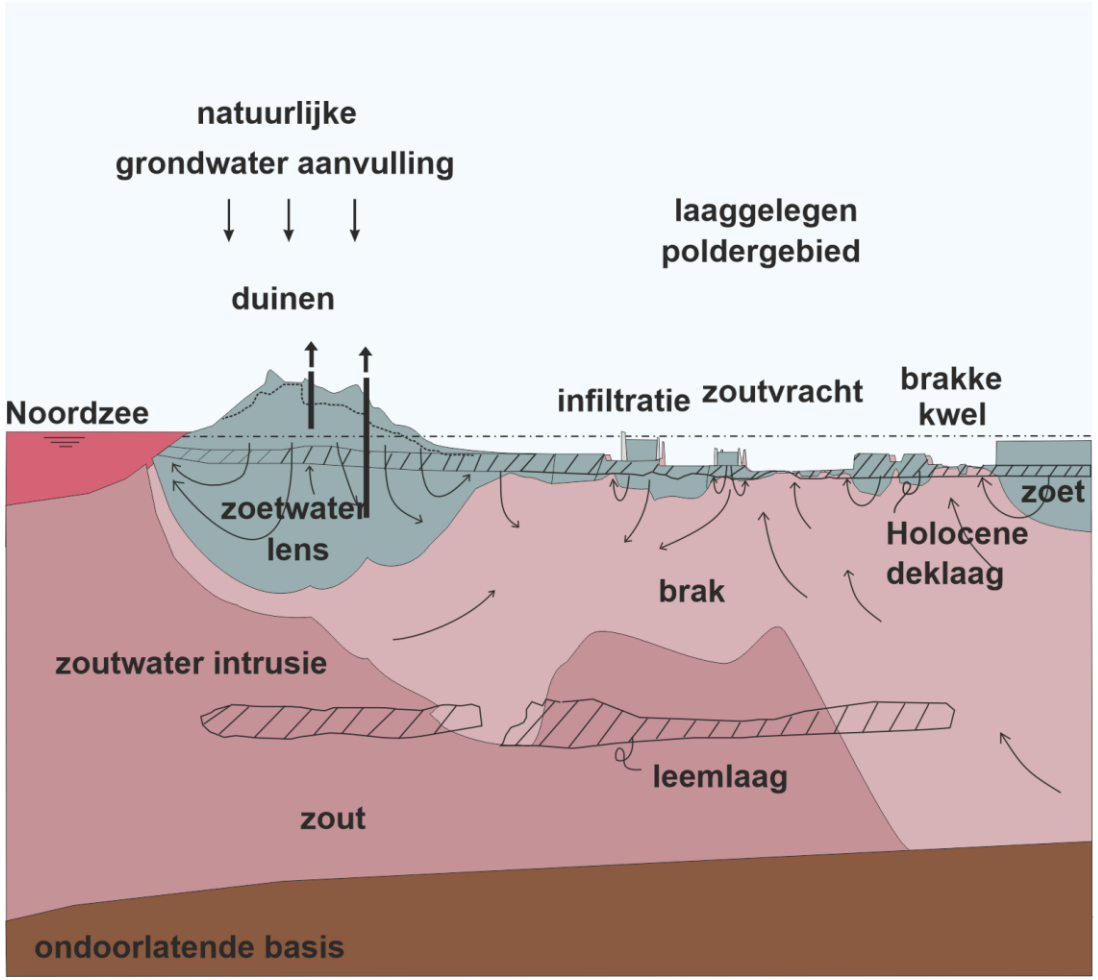
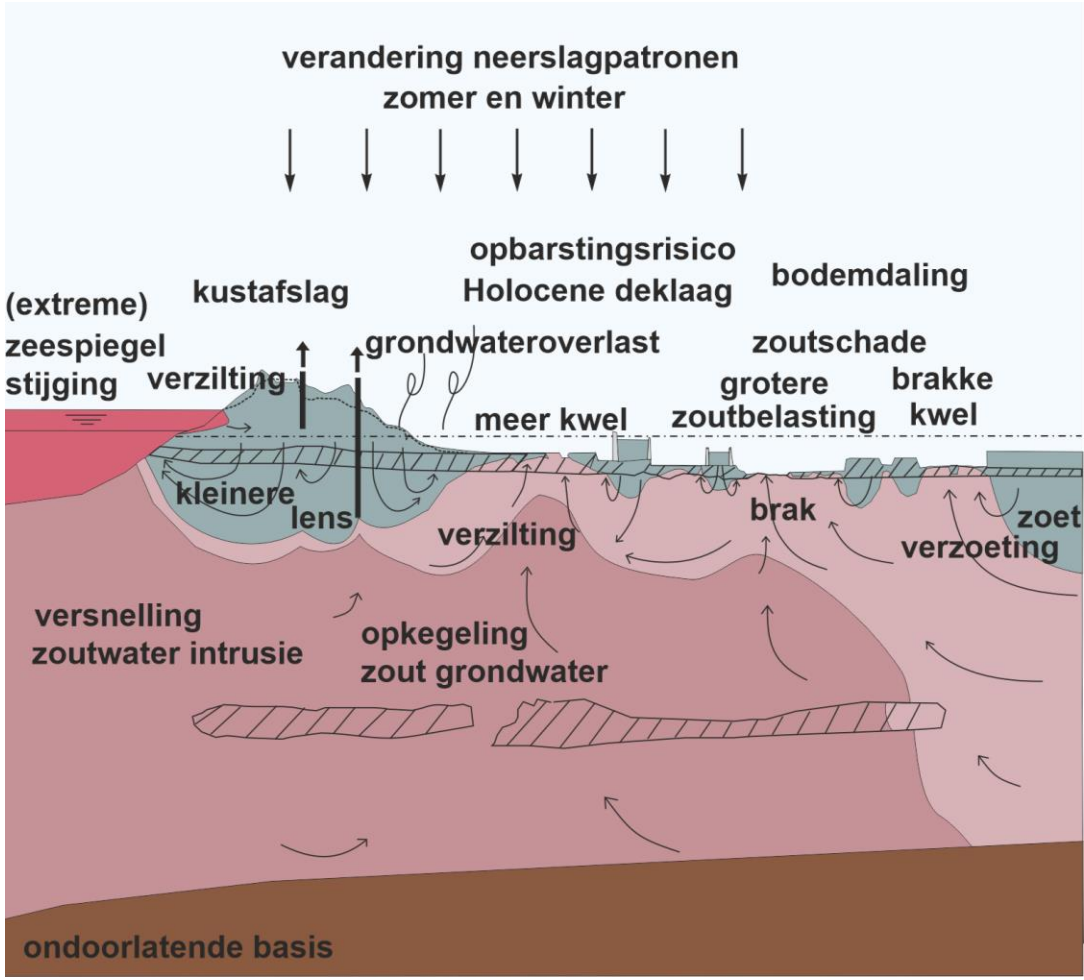
Grondwatersysteem kustgebied onder druk
Verzilting neemt toe

nu



toekomst



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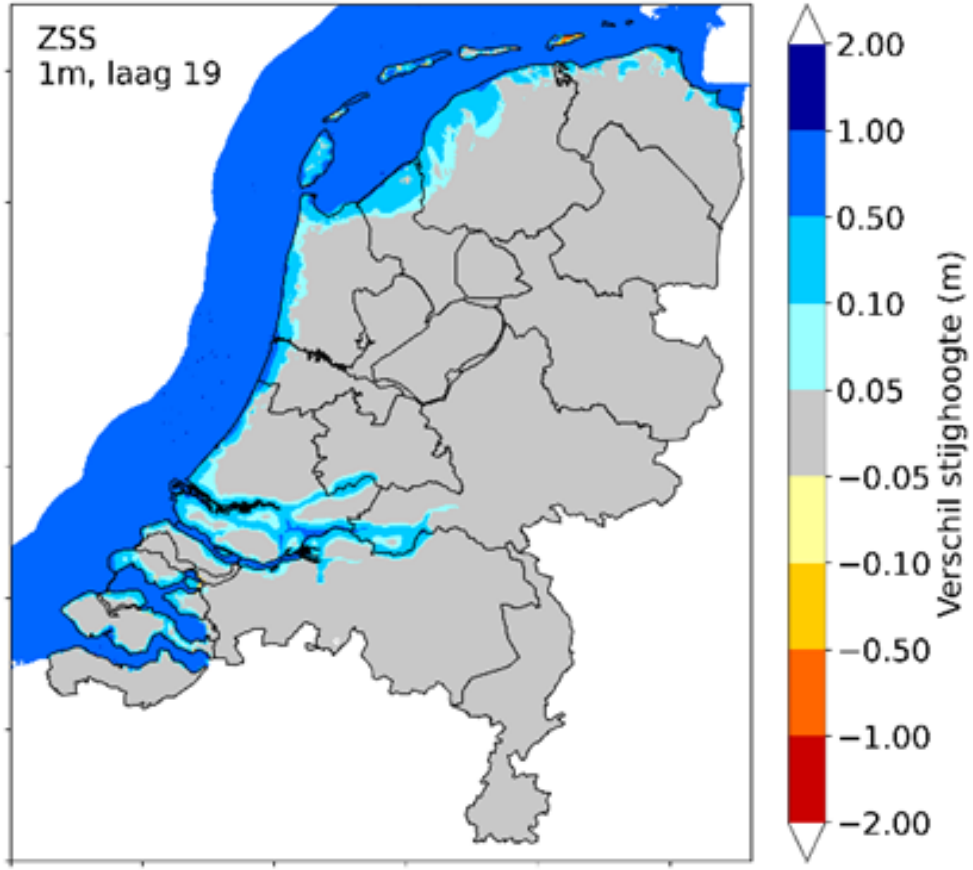
Verzilting neemt toe, zoetwaterbeschikbaarheid neemt af

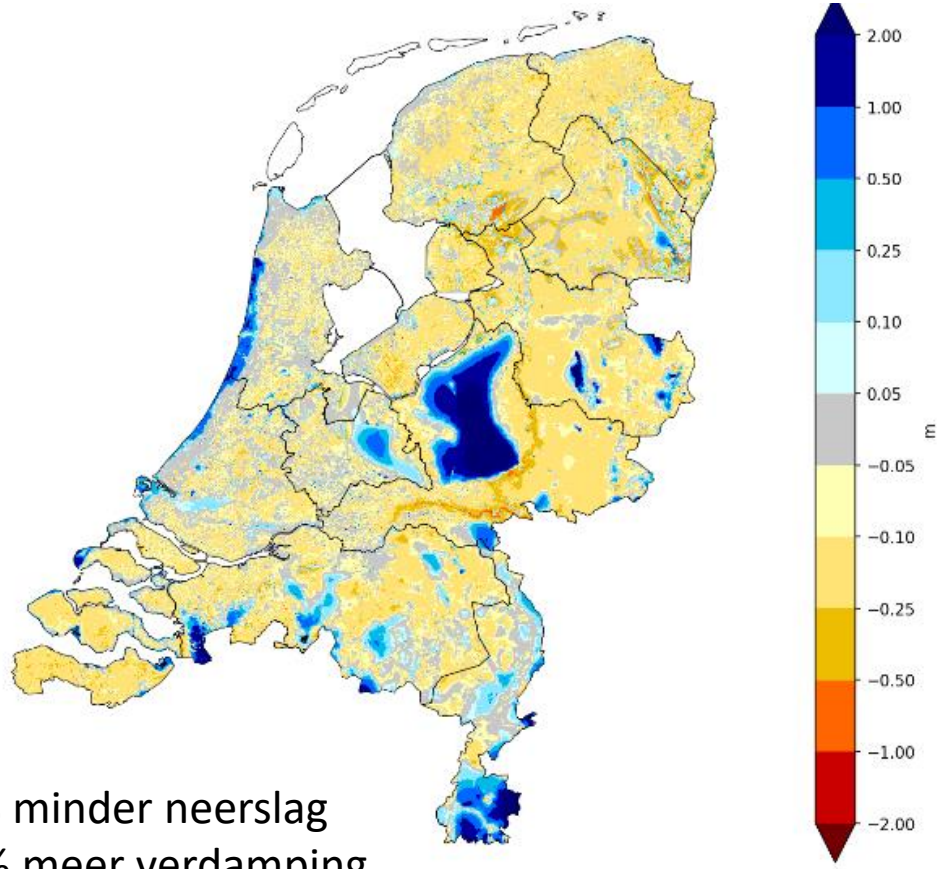
Zeespiegelstijging (1m, zichtjaar 2030)

Effect op stijghoogte WVP2



Deltascenario Warm (WH-klimaat in 2100)

Effect op zomergrondwaterstand



Zomer

- -23% minder neerslag
- +25% meer verdamping

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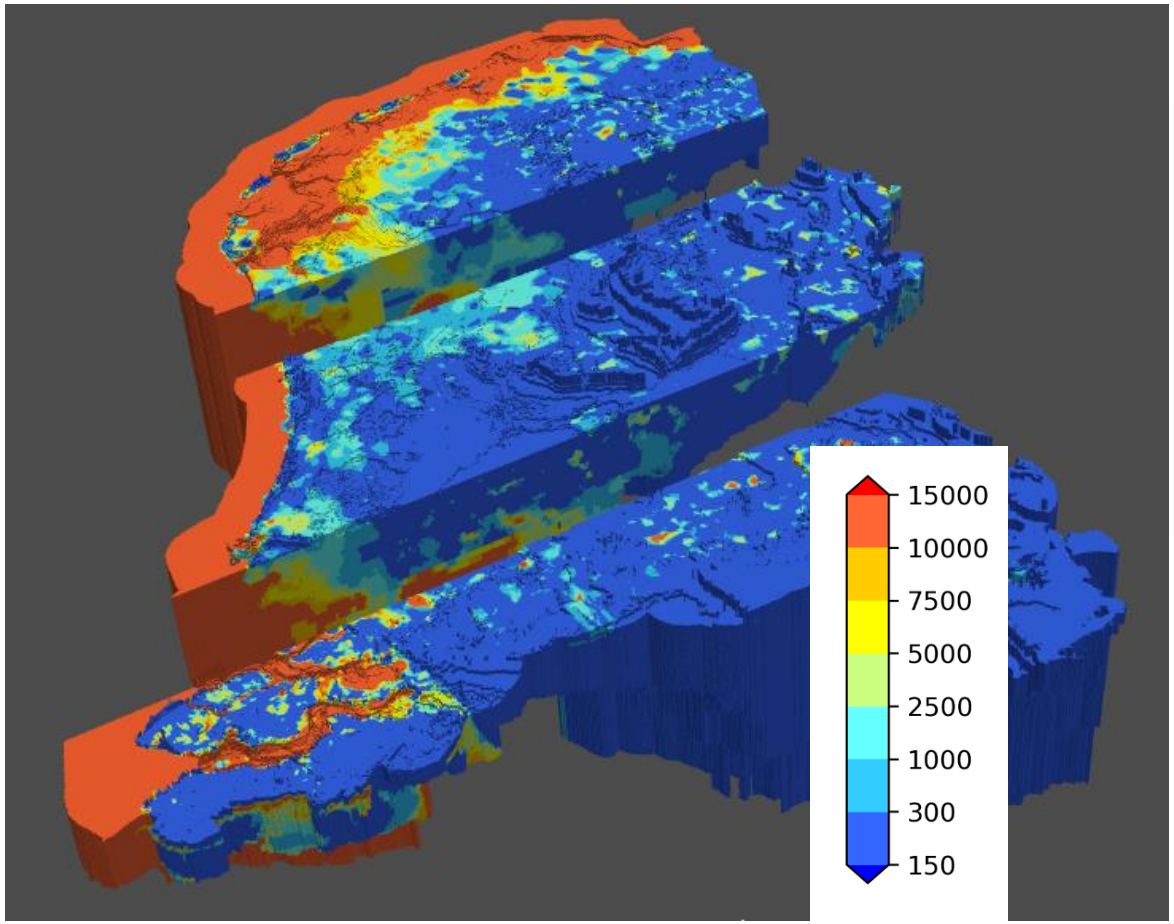
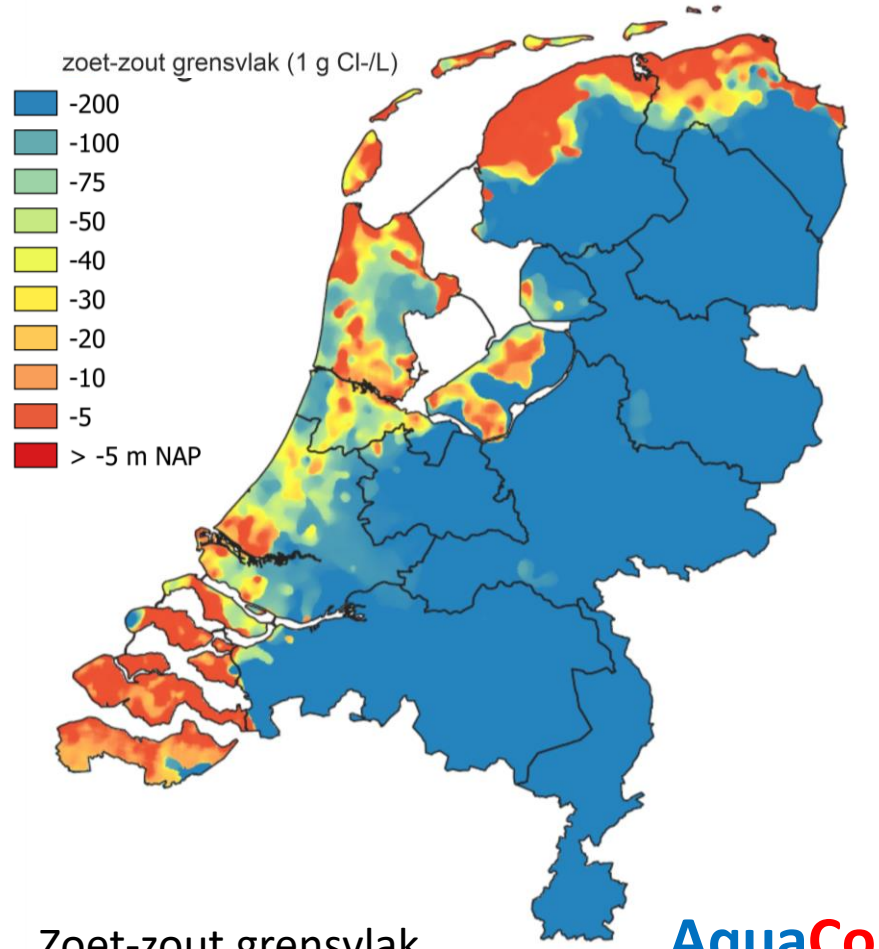
Waarom modelleren? Bijv. Landelijk Hydrologisch Model: zoet-zout

- Wat is de huidige situatie, wat komt er op ons af en wat kunnen we er aan doen?



Geïnterpoleerde 3D zoet-zout verdeling (mg Chloride^{-} / L)

- Ingezet voor Delta programma Zoetwater, Kennisprogramma Zeespiegelstijging
- Zoet-zout verdeling ondergrond, nu en toekomst



Zoet-zout grensvlak

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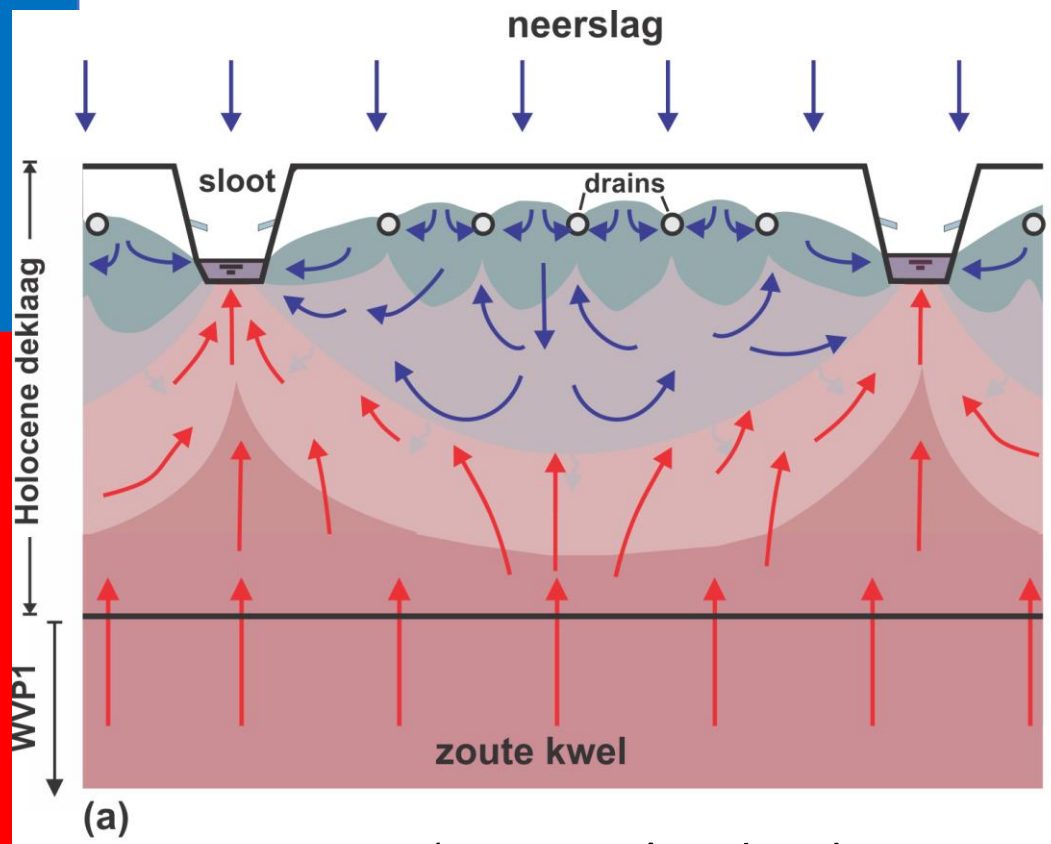
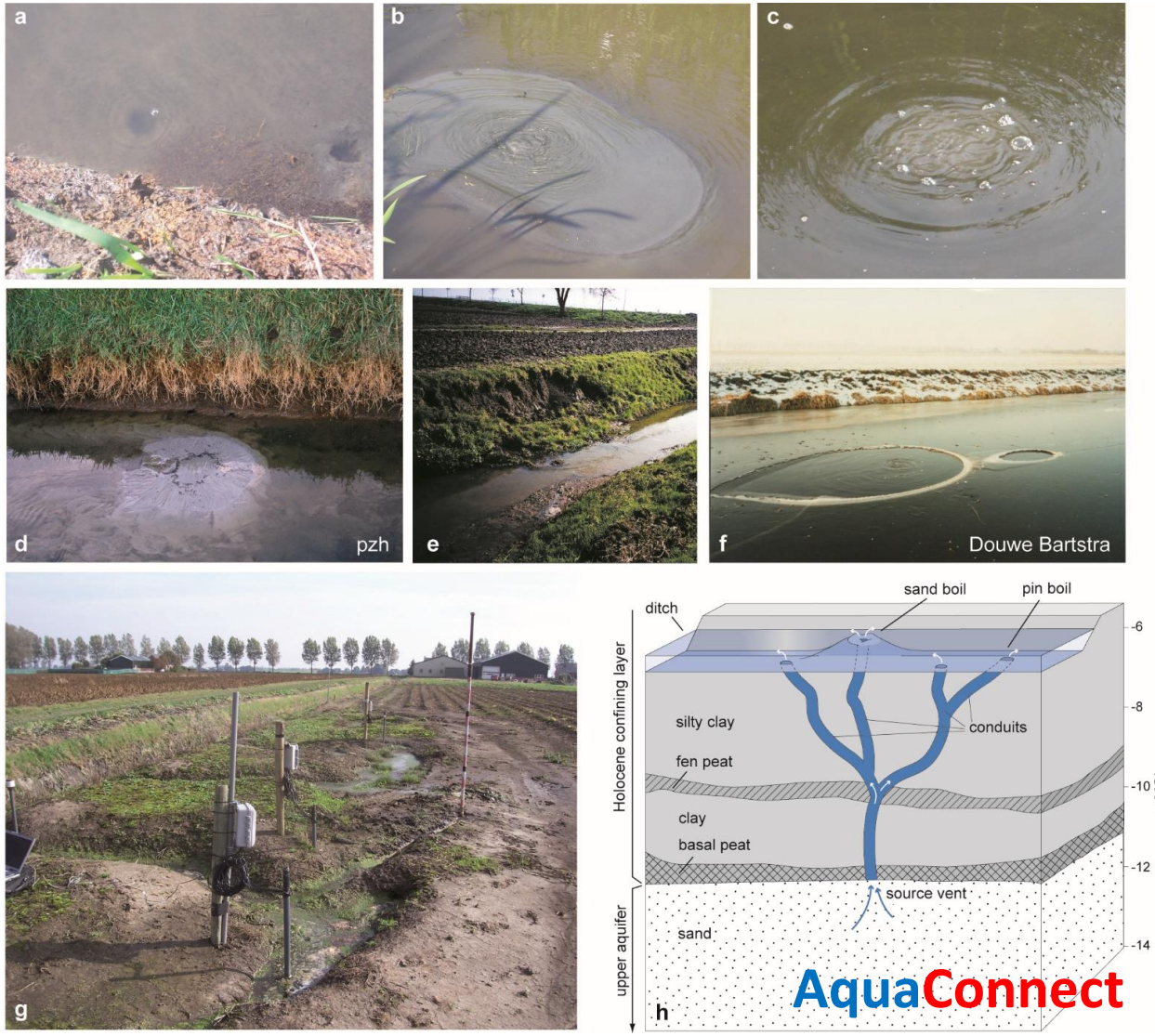
Verziltingsprocessen spelen vaak op locale schaal



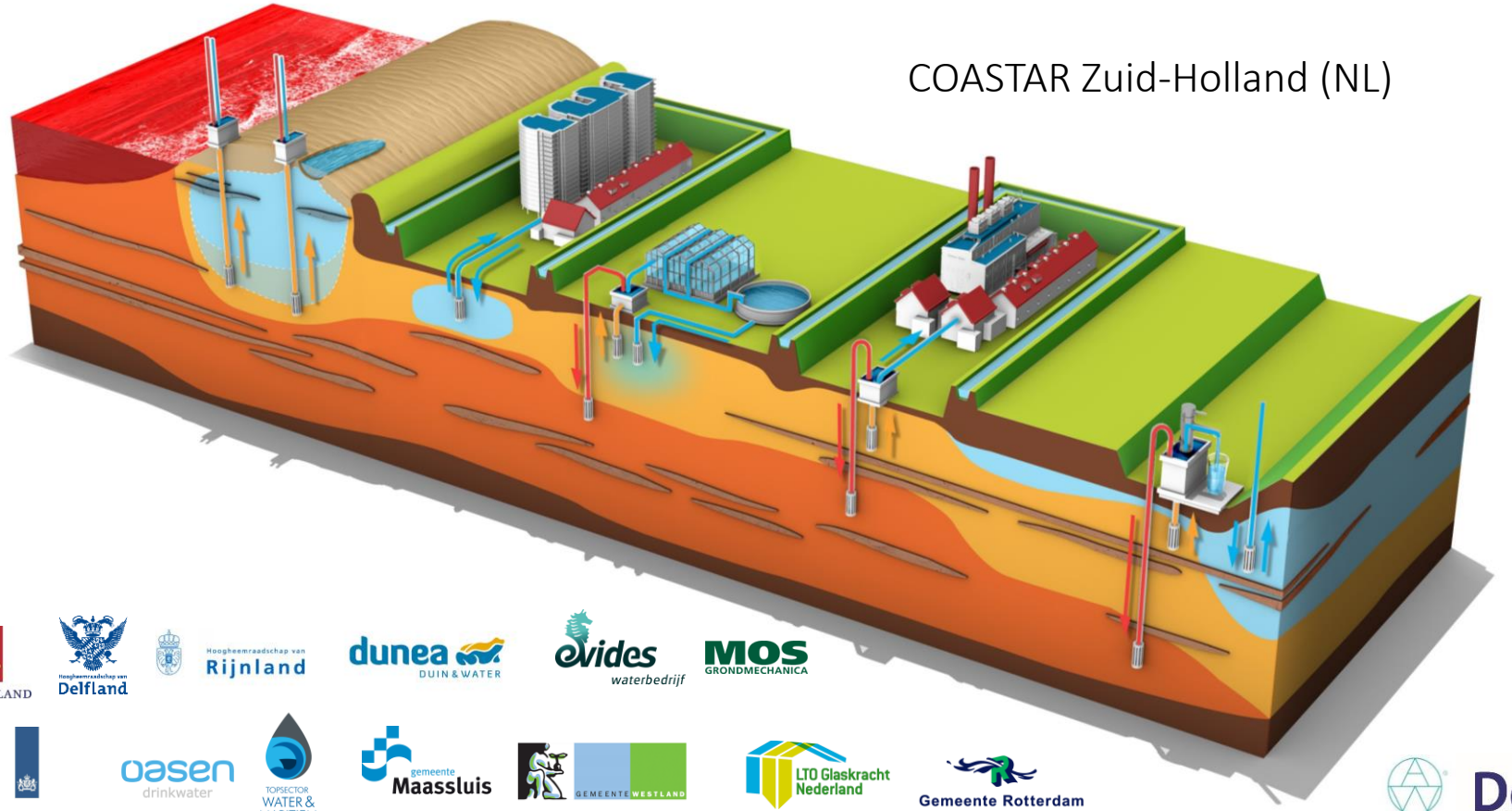
Zoutwater ‘upconing’ onder sloten

Wellen dominante verziltingsbron in diepe polders



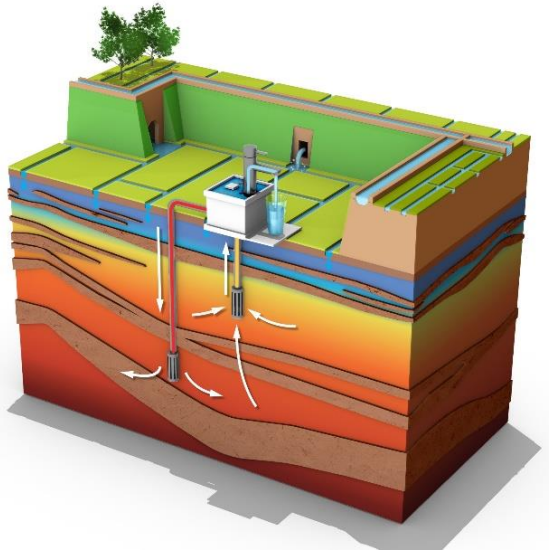
Regionaal: grootschalig gebruik van de ondergrond voor een robuuste watervoorziening en waterbeheer door:

- het dichten van het gat tussen watervraag en wateraanbod over tijd en ruimte
- vóórkomen van verzilting door brak grondwater te gebruiken voor de zoetwaterproductie



COASTAR Zuid-Holland (NL)

Brak grondwater onttrekking polder



www.coastar.nl

provincie Zuid Holland · Hoogheemraadschap van Delfland · Hoogheemraadschap van Rijnland · dunea duin & water · Evides waterbedrijf · MOS Grondmechanica · oasen drinkwater · Topsector Water & Maritiem · gemeente Maassluis · Gemeente Westland · LTO Glaskracht Nederland · Gemeente Rotterdam · Allied Waters · Deltares · KWR · ARCADIS

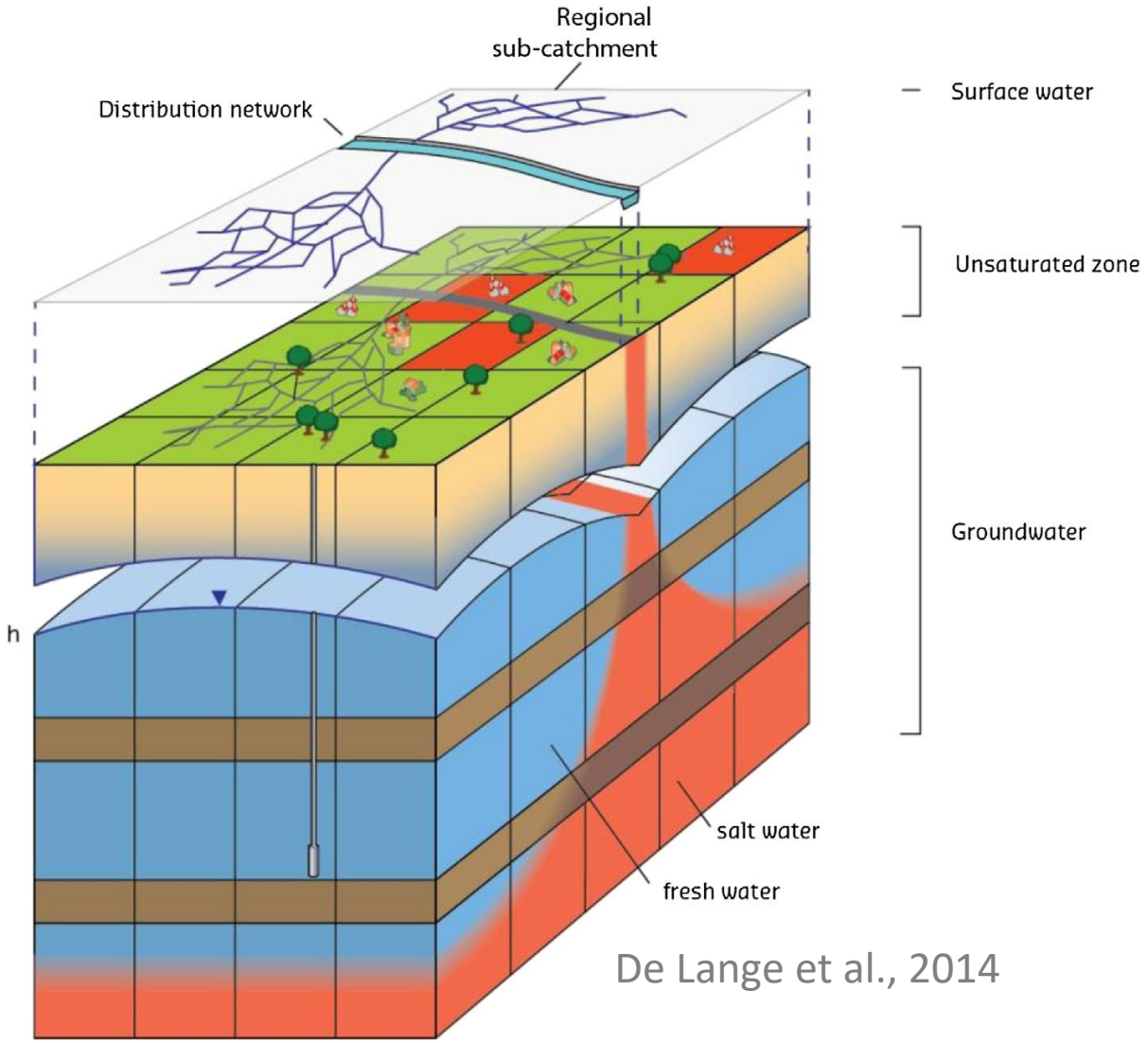
Deltaprogramma | Zoetwater

General project aim

Develop seamlessly scalable (between regional and local scale) Integrated Groundwater-Surface water Models (IGSMs) that consider groundwater flow and salinity transport

We will use these models for:

- Calculating the current and future groundwater head and groundwater salinity distribution under different climate (sea level rise) and anthropogenic pathways.
- Test water storage and distribution measures aimed at achieving local to regional water self-sufficiency



De Lange et al., 2014

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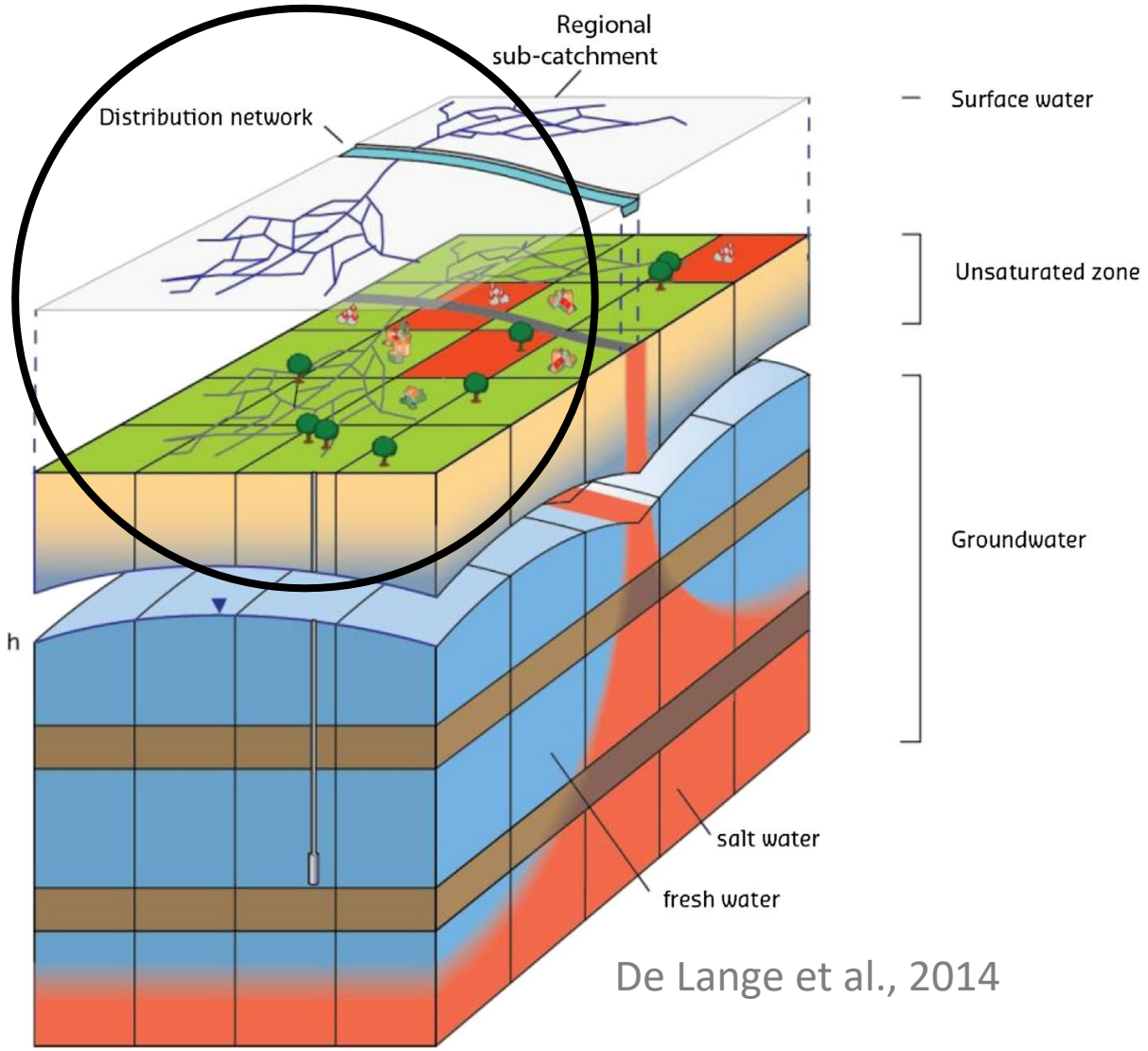

De Lange et al., 2014

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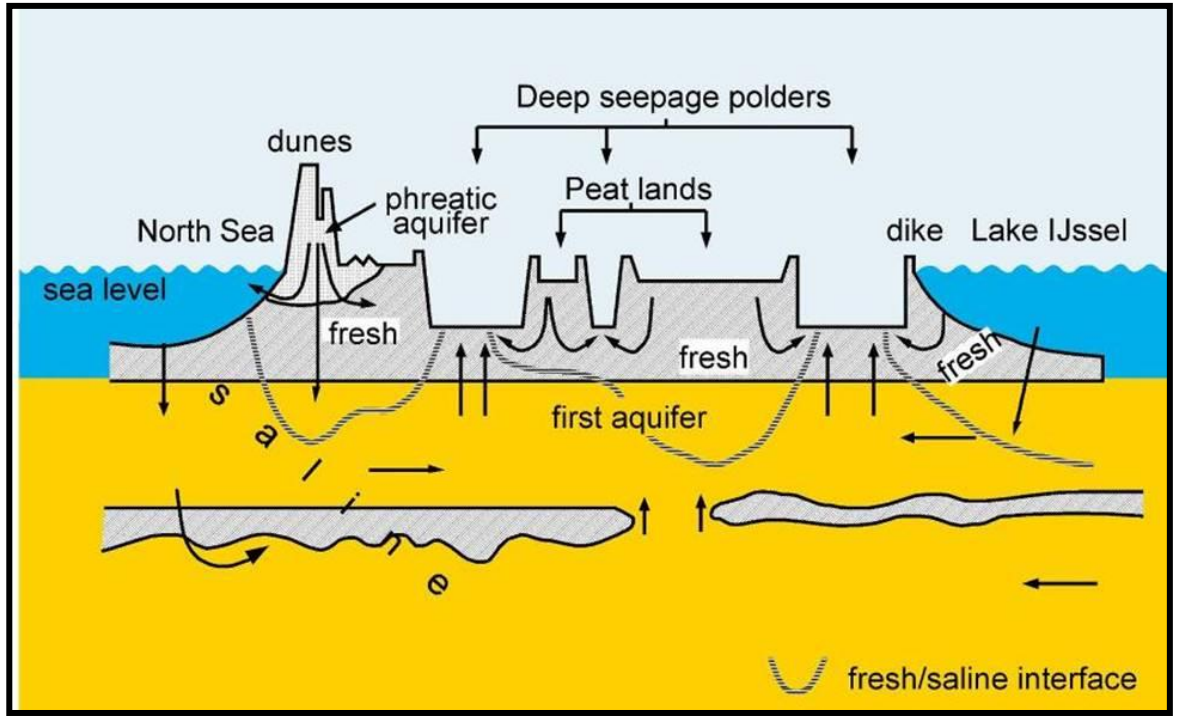
Current research

What are the effects of grid and boundary conditions scaling on the accuracy and computational efficacy of estimating groundwater salinity distributions ?

Hypotheses: Higher grid resolution in **I**ntegrated **G**roundwater-**S**urfacewater **M**odels (**IGSM**'s) should generally yield better results, but it is unclear what is the "sweet-spot" for grid resolution v/s result accuracy v/s runtimes.



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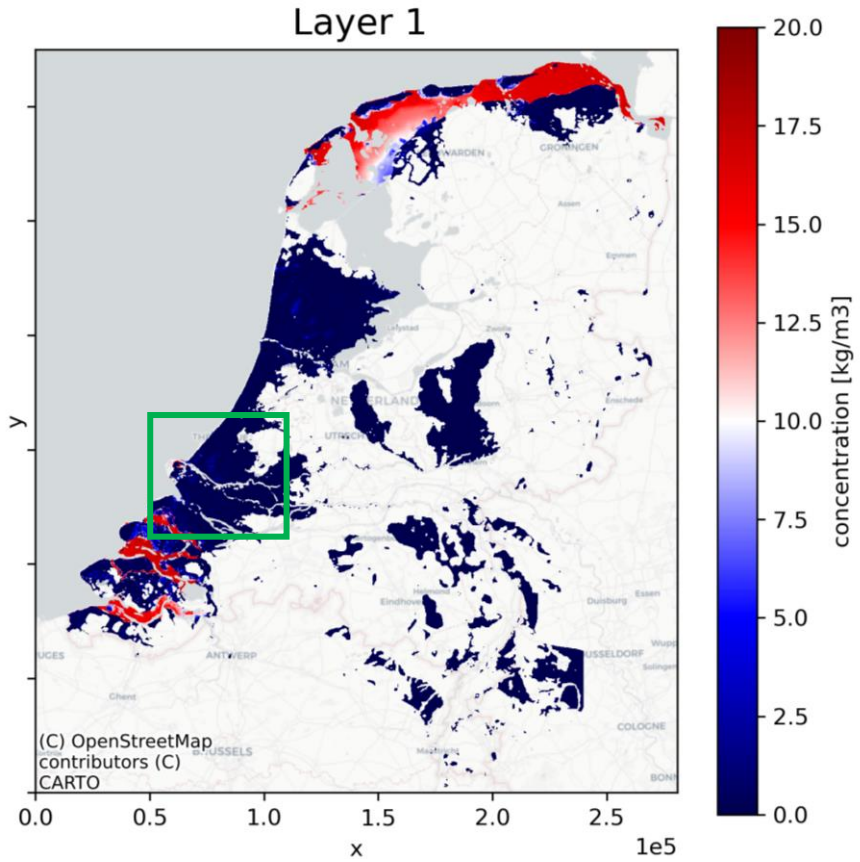
What we are working with

We re-purposed existing tools developed by Deltares to create a reproducible workflow:

- Study case: Delfland (province of Zuid-Holland)
- Software: iMod-WQ (parallelized version of SEAWAT).
- 100 years of simulation.
- Using the results of LHM fresh-salt 3-meter SLR scenario.



LHM fresh-salt groundwater concentration distribution

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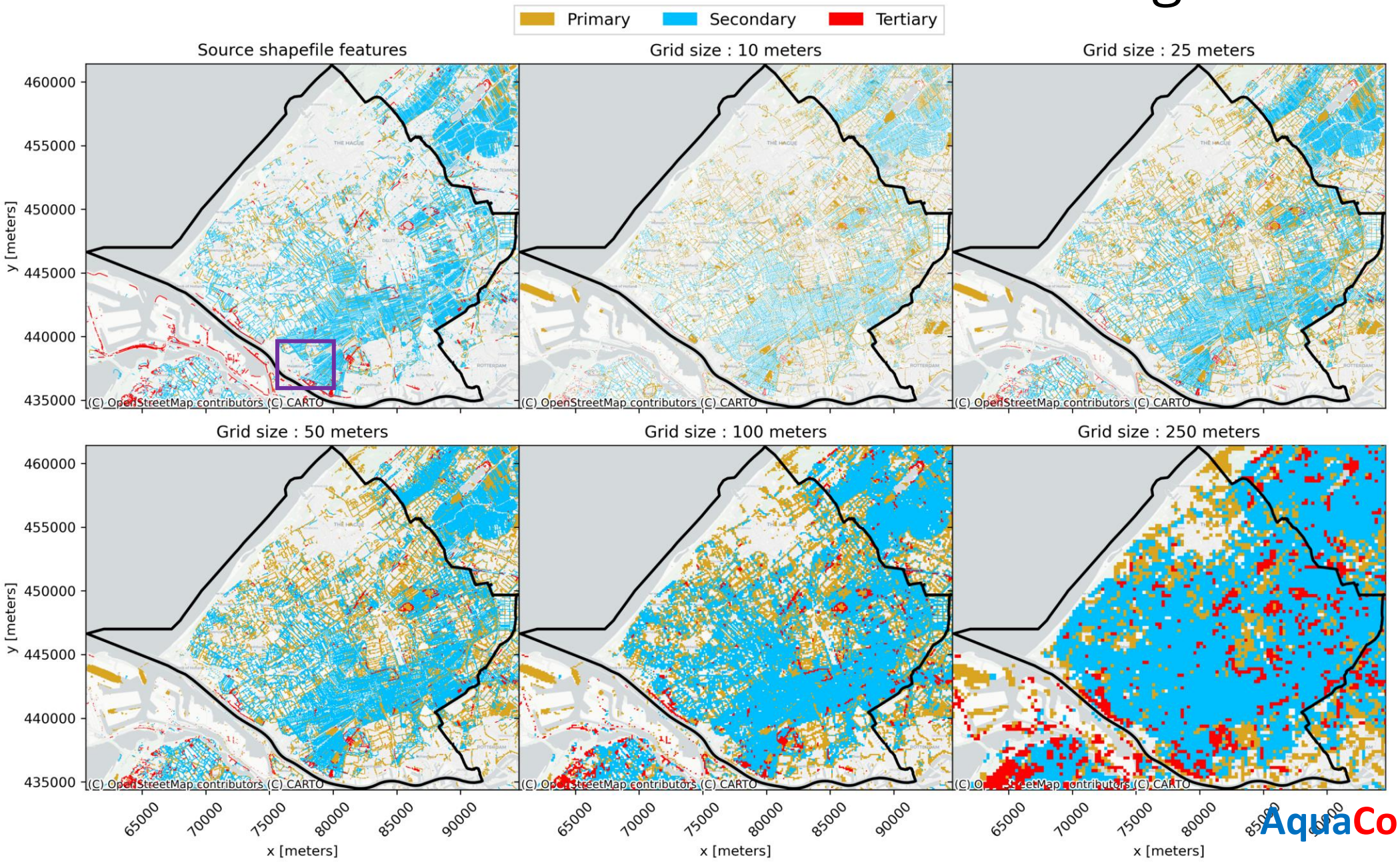
Surface water discretization on different grid sizes



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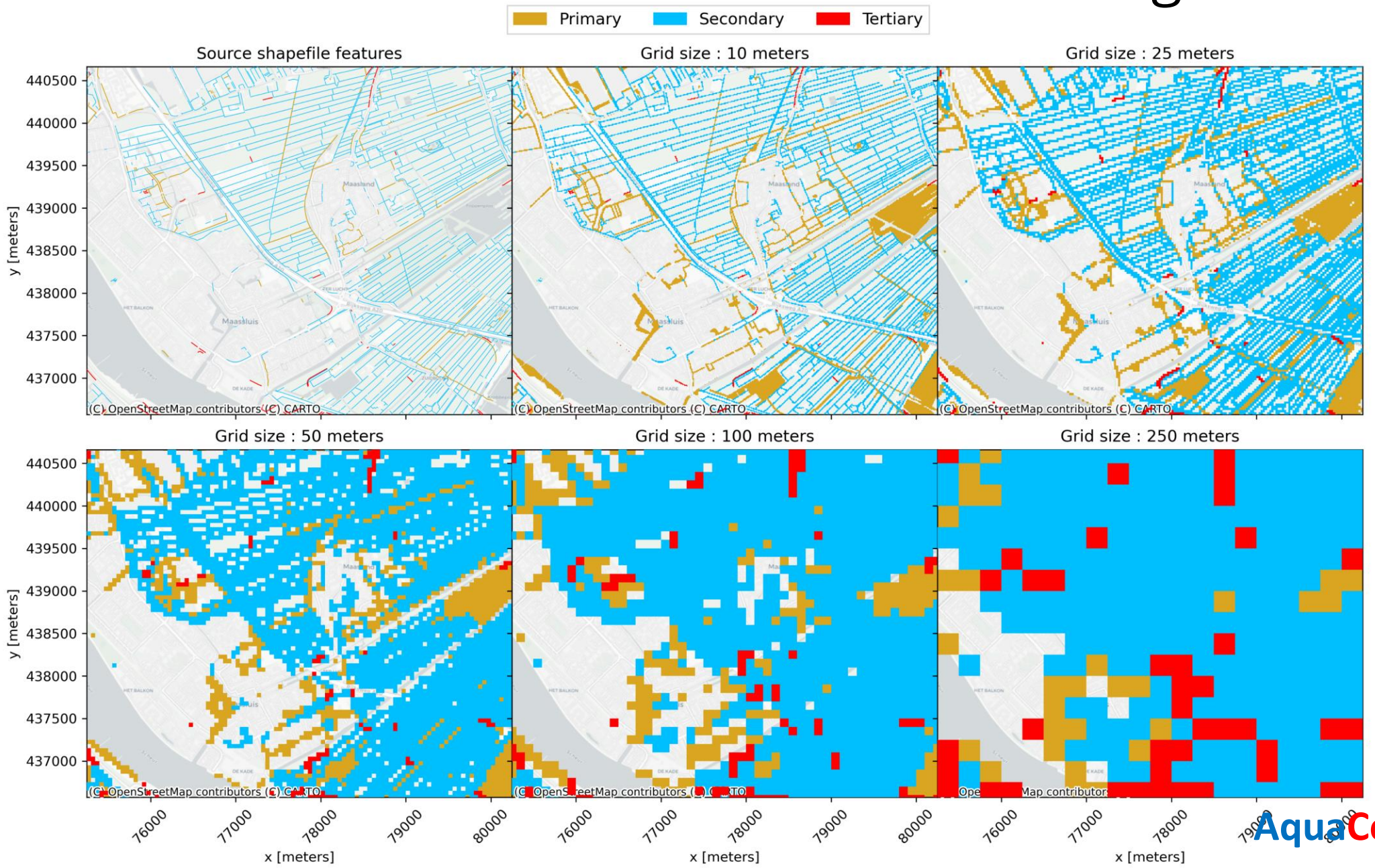

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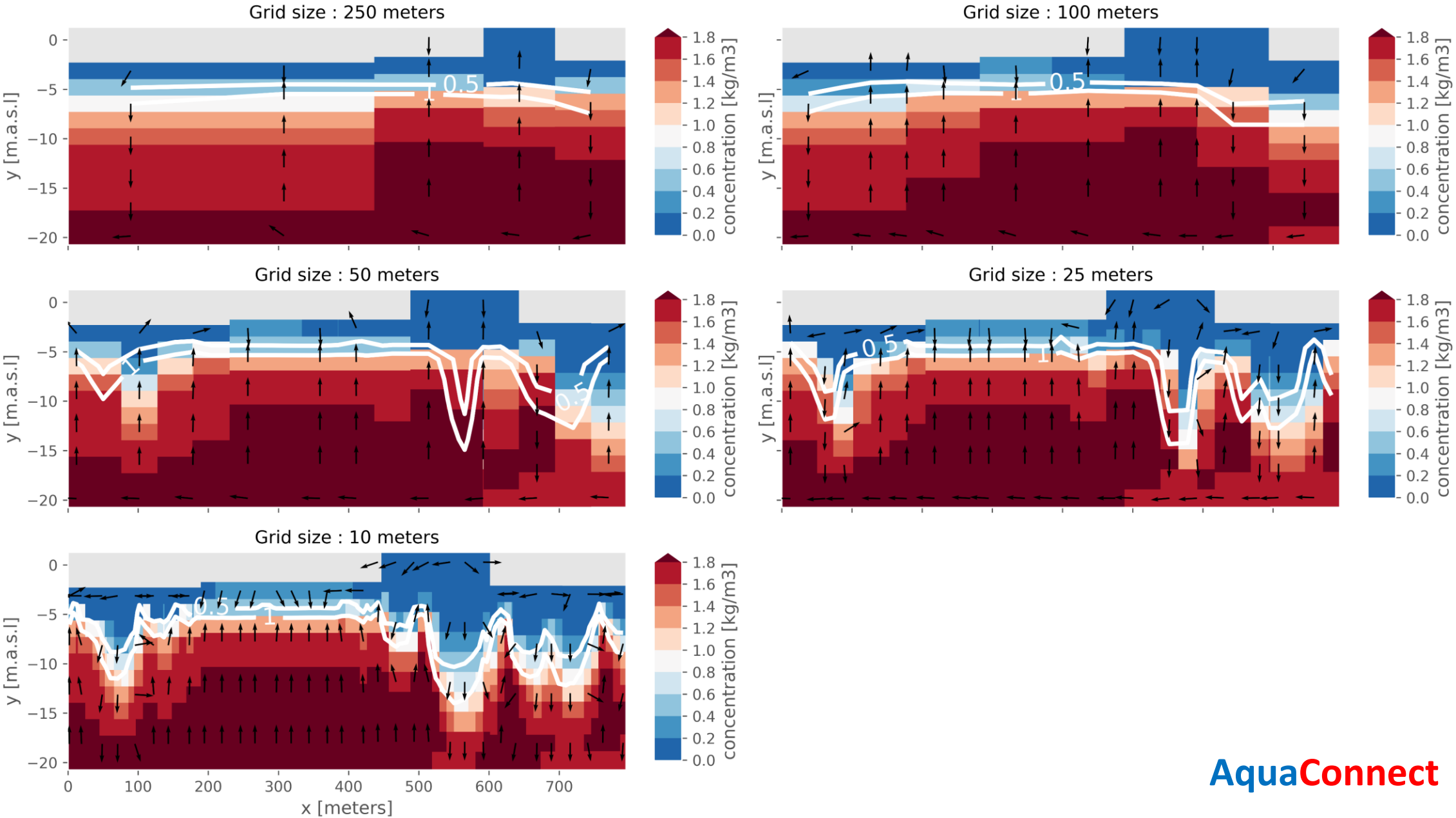
Groundwater salinity distribution



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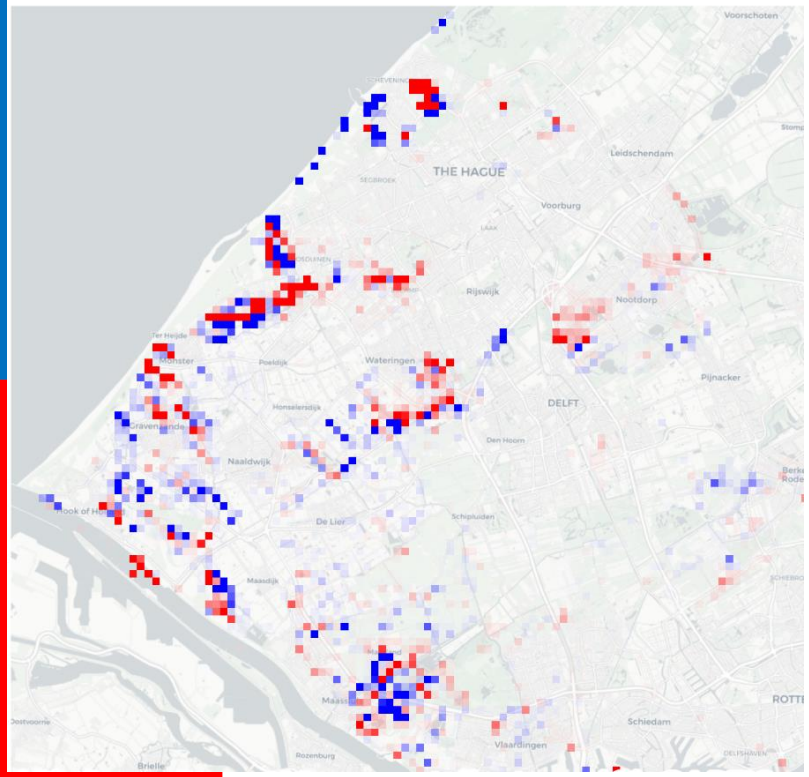
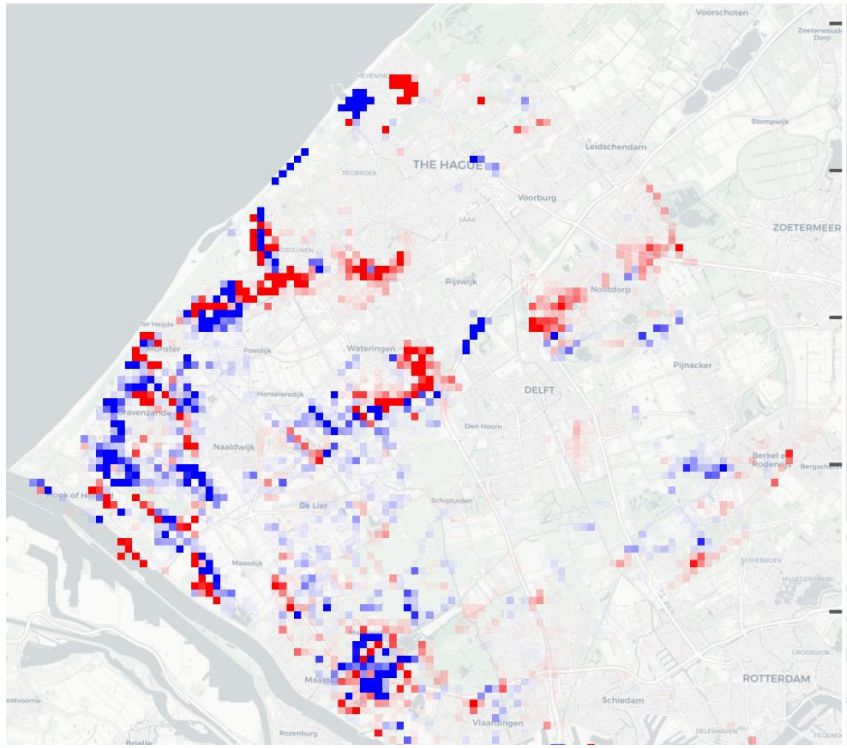
Salt loads to the surface

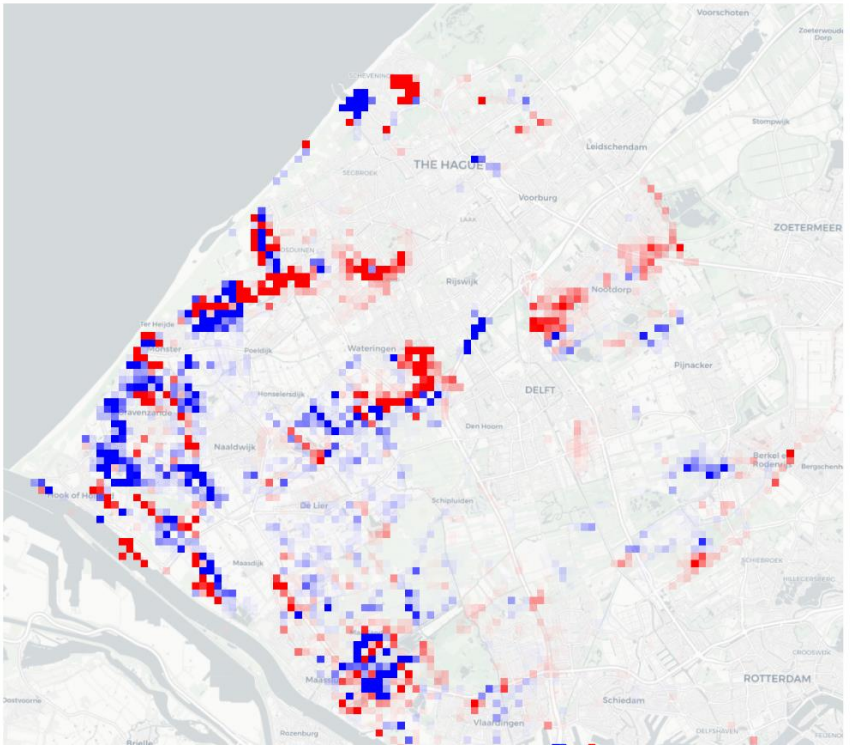
Grid size : 100 meters



Grid size : 25 meters



Grid size : 10 meters



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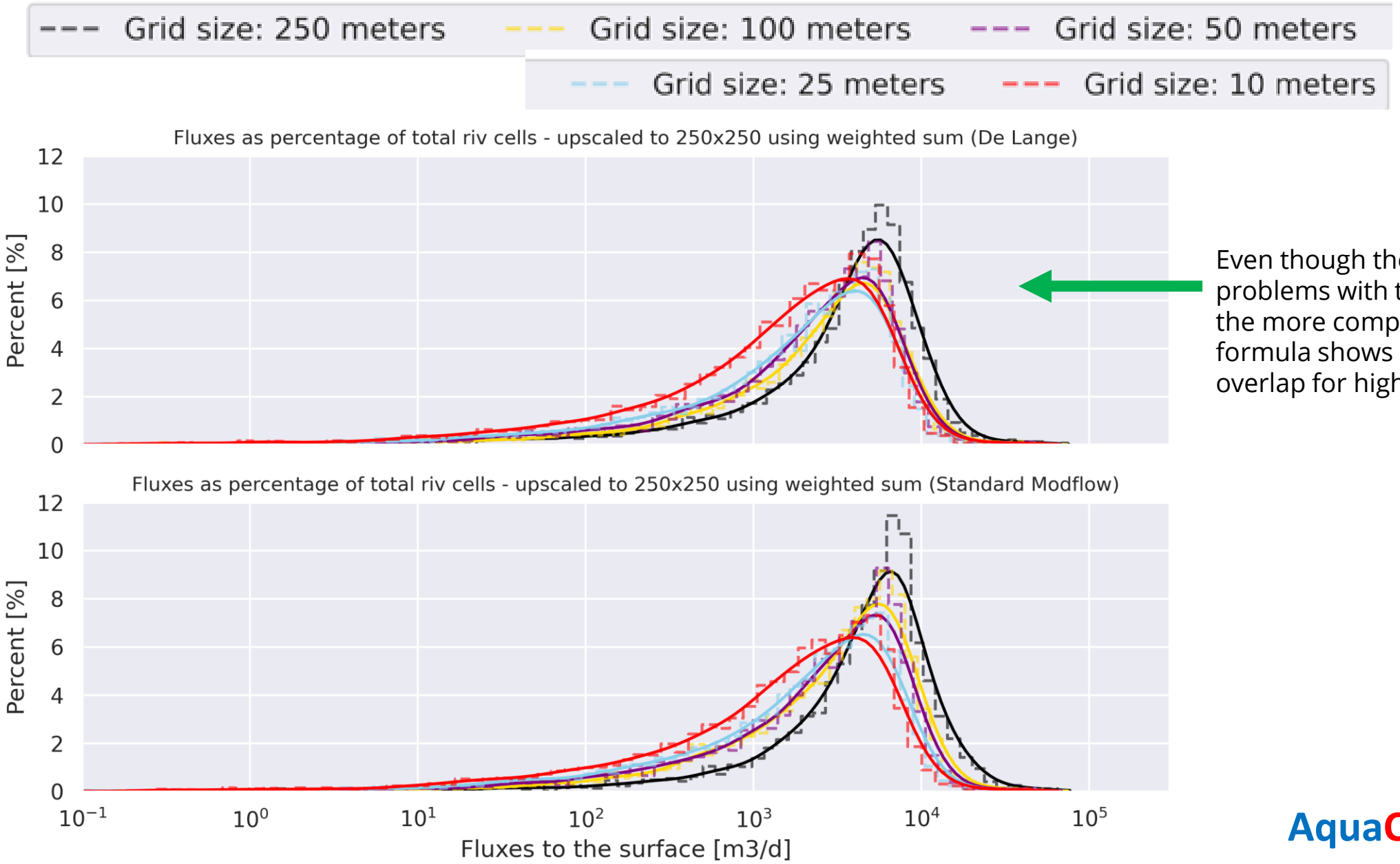
Fluxes to the surface



Even though there are problems with the scaling, the more complex De Lange formula shows much better overlap for high fluxes.

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Runtimes on the Dutch supercomputer Snellius

Grid size [m]	Cell Number	Run time [hours]	Cores	RAM usage [GB]
10	289,768,050	59.00	256	1010
25	46,412,457	8.25	96	57
50	11,644,776	2.73	32	14
100	2,932,566	1.07	32	5
250	475,410	0.33	32	3

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Summary

- Fully scripted workflow to clip/regrid any area of LHM fresh-salt.
- Up-coning / down-coning visible from 50 meters grid resolutions and finer.
- 10-meter grid resolution at a regional scale seems not feasible yet.
- There are issues with flux scaling that propagate to salt load values. This translates to higher resolution models showing local higher peak salt loads while the total regional mass remains similar across resolutions.

What's next:

- Finish first publication.
- Add complexity to the models (pumping, seasonality).
- Test a brine reinjection scenario.

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Utrecht University

Thank you for your attention
Questions?

Deltares

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