Modelling Changing Morphology and Density Dependent Groundwater Flow in a Dynamic Environment: Sand Motor

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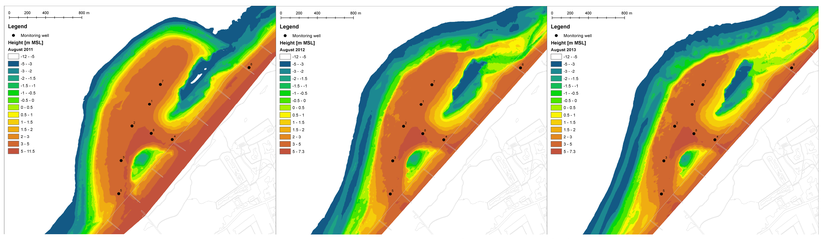
Introduction:

The prospect of sea level rise and increases in extreme weather conditions led to a new focus on coastal defence in the Netherlands. As an innovative solution for coastal erosion a mega-nourishment named the Sand Motor (also called Sand Engine)[1] has been constructed at the Dutch coast.

Photo of Sand Motor, taken 01-10-2013

In time this large body of sand of 21.5 million m^3 will be distributed along the coastline by wind, waves and currents. Thereby fighting coastal erosion in combining beach nourishment with natural forces.



Development of the Sand Motor 2011—2013

The size and position of the Sand Motor near coastal dunes might create opportunities for increasing fresh ground water resources. The transformation of the coastline can also lead to changes in groundwater flow and storage, possibly effecting ecological life, nearby agriculture or existing fresh groundwater abstractions.

Research questions:

- Can a mega-nourishment like the Sand Motor lead to a substantial growth in fresh water resources?
- How are the calculations effected by uncertainties in the morphological developments and climate change?

Method:

Field measurements: monitoring, analysis, ERT

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Build regional model (3D) (100 x 100 m cells, 32 layers)

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Calibration regional model

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Transient scenario's: morphology, climate change

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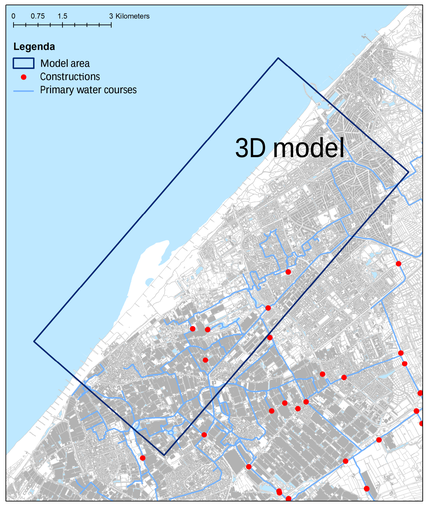
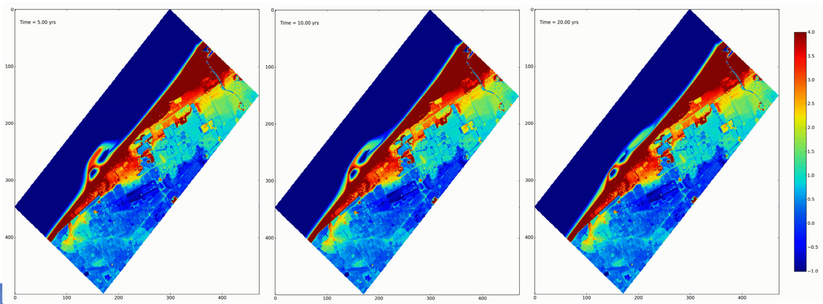
Potential change in fresh groundwater resources

Morphological change

The calculations of the potential change in fresh groundwater resources included the morphological changes of the Sand Motor for a period of 20 years.



Model area of Sand Motor



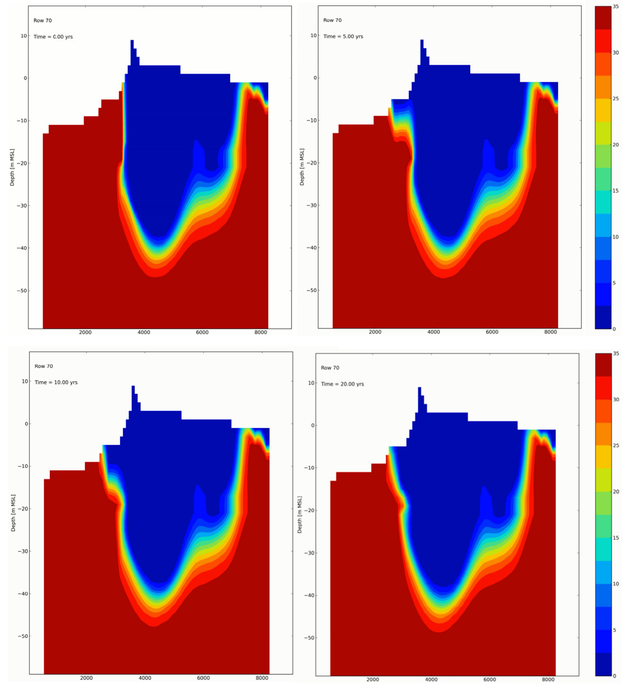
Projected morphological change of the Sand Motor after 5, 10 and 20 years

For the prediction of future morphological changes, we used results from Delft3D model calculations[2]. The calculated yearly change of the morphology were enforced to the model by changing:

- the height and thickness model cells
- the boundary conditions
- the precipitation surplus

Results:

For the calculations we used the variable density code SEAWAT version 4 (USGS)[3]. The initial situation was estimated by running the model for a period of 400 years, toward an equilibrium. This initial distribution combined with the projected morphological changes were used to calculate the potential change in fresh water resources.



Transects scenario with morphological changes with salinity [g/l] after 0, 5, 10, 20 years

The preliminary model calculations show that in a period of 20 years volume of fresh water gradually increases to ca. 12 Mm3 . In the nearby dune area 7-8 Mm^3 is abstracted yearly, therefore the first results are promising in increasing fresh groundwater resources. More model calculations will be performed to investigate the sensitivity of the change in the fresh, brackish and salt water distribution.

References:

1) Stive, M.J.F., et.al., 2013, *A new alternative to saving our beaches from sea-level rise: The Sand Engine,* Journal of Coastal Research 29 (5), 1001-1008
2) Mulder, J.P.M., Tonnon, P.K., 2010, *"Sand Engine": Background and design of a mega-nourishment pilot in the Netherlands,* Proc. Coastal Engineering Conference
3) Langevin, C.D., et.al., 2008, *SEAWAT version 4: A Computer Program for Simulation of Multi-Species Solute and Heat Transport,* USGS Techniques and Methods Book 6, Chapter A22.

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