Fresh groundwater resources in a large sand nourishment: Sand Engine

Sebastian Huizer, Marc Bierkens, Gualbert Oude Essink (Universiteit Utrecht and Deltares)

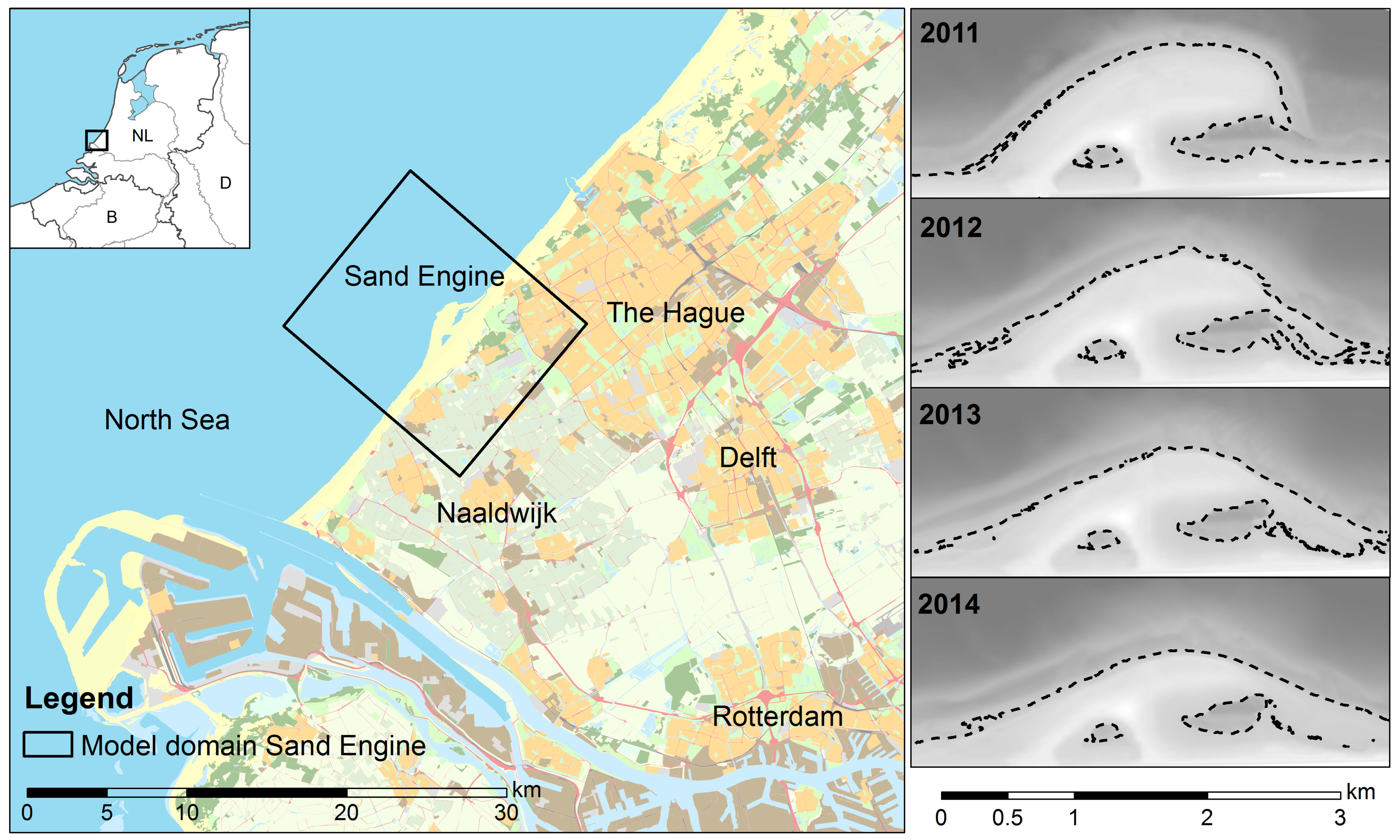
10 December 2015

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 Engine (also called Sand Motor)**[1] has been constructed at the Dutch coast.

Photo of Sand Engine, 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.



Model area of Sand Engine

The size and position of the Sand Engine near coastal dunes might create **opportunities for increasing fresh groundwater 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 Engine lead to a substantial growth in fresh water resources?
- What is the effect of the long-term morphological evolution of the Sand Engine on fresh groundwater resources?
- What is the effect of climate change (e.g. sea-level rise) on fresh groundwater in the Sand Engine?

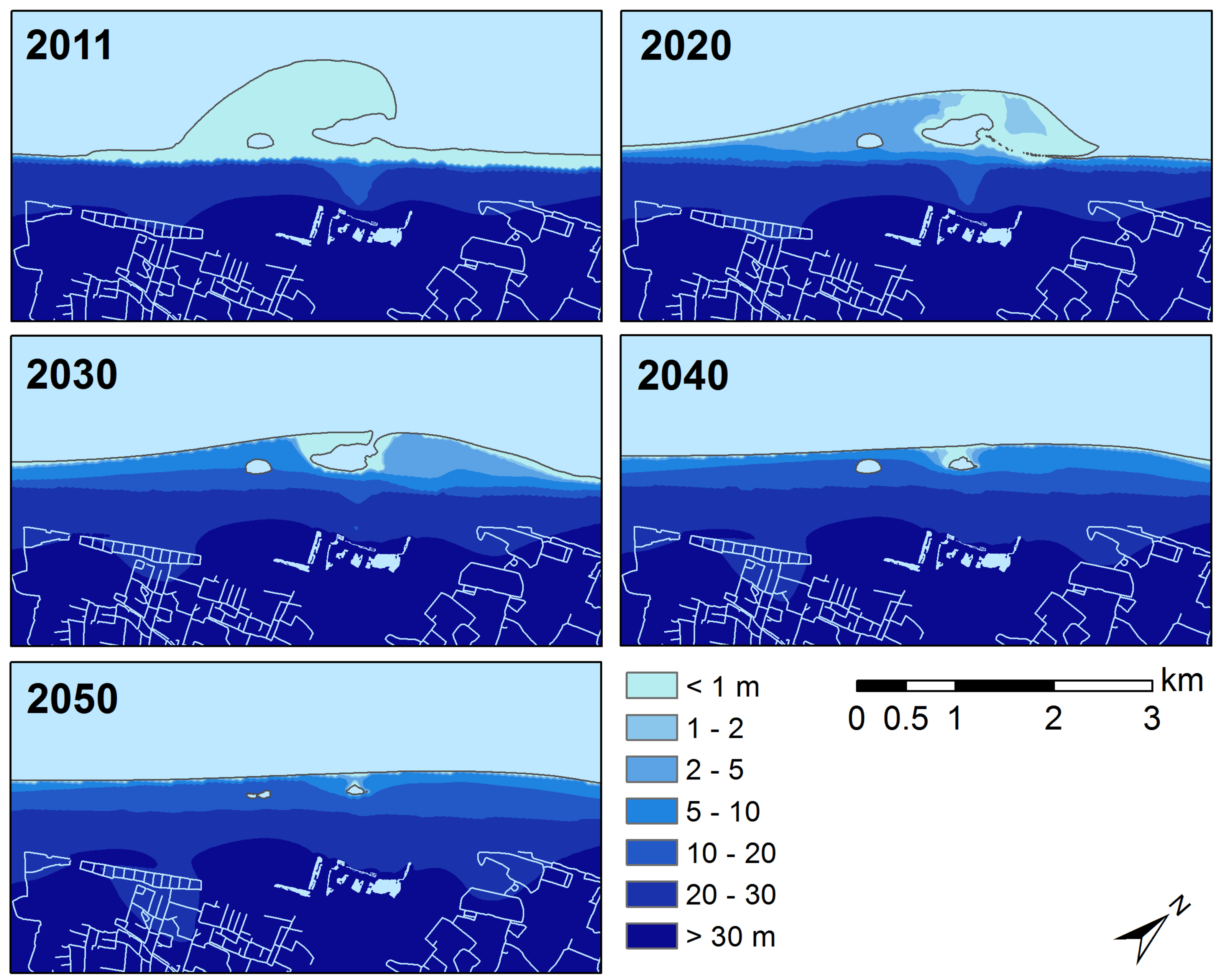
Method

For the quantification of the fresh groundwater resources we have constructed a 3D groundwater model, in which variable-density groundwater flow and salt transport was simulated with the computer code SEAWAT (50 x 50 m cells, 50 layers).

The **long-term morphological evolution of the Sand Engine** was predicted with a detailed Delft3D model for the period 2011 to 2050. For every quarter in this period the simulated morphology was enforced to the model by adapting the height of model cells, the boundary conditions, and the precipitation surplus.

Results

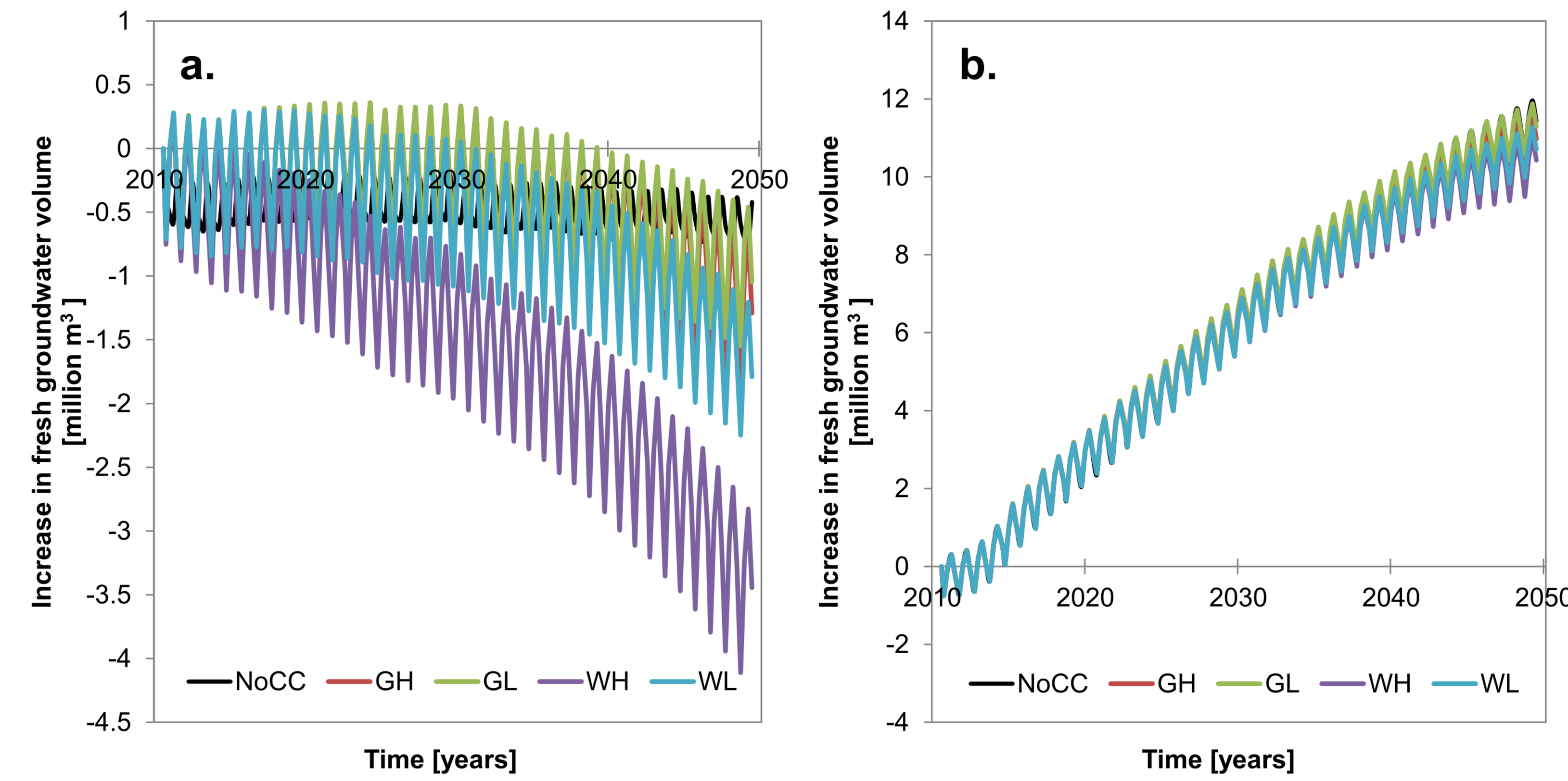
The model was calibrated with measurements of groundwater heads and salinities before the construction of the Sand Engine, and the absolute mean error between observed and simulated heads was 0.27 m and between observed and simulated TDS concentrations was 1.17 $g\ l^{-1}$. In addition, the simulations with the Sand Engine were verified with recent (2014-2015) groundwater head and salinity measurements in the Sand Engine.



Thickness of fresh groundwater [m] near the Sand Engine from 2011 - 2050

Results

The simulations show that climate change, and in particular sea-level rise, leads to a decrease in the volume of fresh groundwater and an increase in the volume of saline groundwater in the reference situation without the Sand Engine. The construction of the Sand Engine leads to a gradual increase of the fresh groundwater volume of 0.3 to 0.5 million m^3 per year. The long-term predictions of the precipitation and evapotranspiration within the four adopted climate scenarios have a limited effect on the total volume groundwater.



Increase of the volume of fresh groundwater in the situation without Sand Engine (a) and situation with Sand Engine (b) in the period 2011 to 2050

Discussion & conclusions

Local mega-nourishments such as the Sand Engine might become an effective solution for the threats that many low-lying coastal regions face, and with this study we have shown that **fresh groundwater resources can grow substantially within the lifespan of the nourishment**. The results in this study show that for the Sand Engine, the construction of a mega-nourishment can lead to increase of fresh groundwater.

However, the increase in fresh groundwater resources is highly dependent on the shape and location of the mega-nourishment, the precipitation surplus and local circumstances. Therefore dependent on the design and location of the mega-nourishment this may provide an opportunity to combine coastal protection with the protection of fresh groundwater resources.

More information:
s.huizer@uu.nl
sebastian.huizer@deltares.nl
zoetzout.deltares.nl

Universiteit Utrecht
Deltares
Enabling Delta Life
STW
NatureCoast
BUILDING WITH NATURE