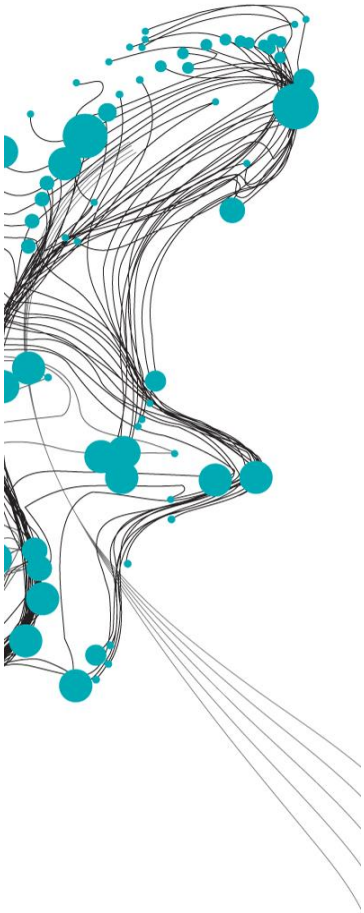
Extending Lorentz' network model for the Dutch Wadden Sea



Between 1918 and 1926 the State Committee on the Zuiderzee investigated the hydrodynamic effects of damming the Dutch Zuiderzee ahead of the prospected construction of the so-called Afsluitdijk. The State Committee, chaired by physicist and Nobel laureate H.A. Lorentz, developed a network model based on the governing equations of fluid flow, rather than on empirical relationships in order to assess the effects of the closure dam on the water motions in the Wadden Sea.

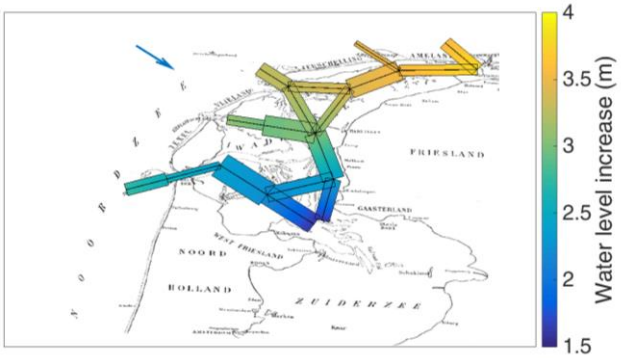


Figure 1: water level increase simulated by our stationary storm-surge model.

Strongly simplified network models were developed to simulate tidal water motions and an equilibrium response to a steady wind forcing, thereby ignoring the transient phase towards this equilibrium. This study aims at developing a non-stationary network model to study the transient behaviour of storm-surges based on the simplification Lorentz used.

First the simulations from the State Committee have been resimulated. The resulting water level increase of the rebuilt storm-surge model is shown in Figure 1. The results show a good quantitative and qualitative agreement with the values found by the State Committee.

Next a non-stationary model – allowing for a time-varying solution forced by a time-dependent wind stress – has been developed and used: (1) to mimic the equilibrium model by including a ramp up and ramp down period, (2) to model the 22/23 December 1894 storm on which the equilibrium model was based, (3) to simulate the 5 December 2013 'Sinterklaas' storm for which recent water level and wind stress measurements are available.

The results show that: (1) the non-stationary model is able to mimic the stationary model when the same forcing is applied, (2) the water levels during the 22/23 December 1894 peak after the wind stress has peaked, (3) the 5 December 2013 storm is simulated well qualitatively and reasonably quantitatively (as can be seen in Figure 2).

The results indicate that a simple network model can be used to simulate storm surges in the Wadden Sea. Despite the simplifications the model performs relatively well since water levels are simulated reasonably accurate. Using this model the temporal behaviour of storm surges has been studied such as the peak timing and the rise and fall of the water level.

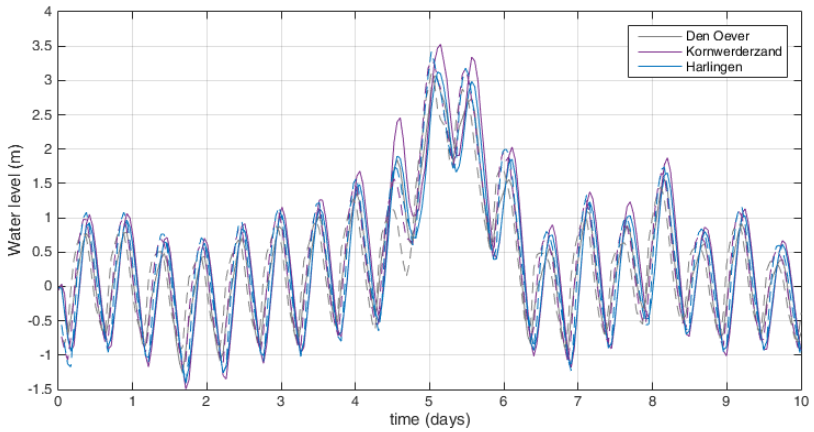


Figure 2: Water levels at three selected locations for the 5 Dcember 2013 storm simulation. Solid lines indicate simulation results and dashed lines measurements from Rijkswaterstaat (see live.waterbase.nl).

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