Do marshes attenuate storm surges? Observations of peak water levels along channelized marsh transects

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Coastal and estuarine wetlands are increasingly valued for their role in mitigation of flood risks by damping of flood waves such as storm surges (Temmerman *et al.*, 2013). However, studies on the quantification of storm surge attenuation by wetlands for varying geomorphology and hydrodynamic conditions are scarce and are mostly based on specific surge events. We use *in-situ* water level observations and hydrodynamic modelling to study the influence of marsh channel geometry on tidal propagation and storm surge attenuation for varying hydrodynamic boundary conditions in Saeftinghe, a 3000ha tidal marsh along the Western Scheldt Estuary (SW Netherlands).

Water level measurements were conducted at several locations in and around a 4km long main channel in Saeftinghe during a series of spring-to-neap cycles and a severe storm surge. Our observations show that damping or amplification of peak water levels depends on the height of the tidal wave compared to the elevation of the marsh platform. Undermarsh tides with peak water levels below the marsh platform are amplified up to $4 cm \cdot km^{-1}$ along the converging marsh channels. Overmarsh tides with peak water levels above the marsh platform are mainly attenuated, with maximum attenuation rates along marsh channels of up to $5 cm \cdot km^{-1}$ for tides that inundate the platform by 0.5-1.0m. Conversely, during the highest recorded storm tide with peak water levels of 1.6m above mean platform elevation no attenuation was measured. The highest attenuation rates of up to $70 cm \cdot km^{-1}$ are found over short transects on the vegetated marsh platform, due to additional friction exerted by marsh vegetation.

In addition to the field measurements, a two-dimensional hydrodynamic model of Saeftinghe is set up with TELEMAC-2D to assess a wider range of marsh transects and peak water levels. The effect of marsh vegetation is herein implemented by increased bottom friction. The model is able to adequately represent the observed amplification and attenuation rates. Mean errors of modelled attenuation rates are within $1.5 cm \cdot km^{-1}$ along most transects. Model results indicate that tides are only attenuated along transects where the channel width is small compared to the extent of the marsh platform, while tides are amplified along wider channels where the influence of the platform is less. Moreover, the model results confirm the dependency of flood wave damping and amplification on the peak water level relative to the marsh platform elevation for channel transects where the influence of the marsh platform is significant. Finally, model simulations in which the levee that surrounds the marsh is removed and the marsh platform is extended, demonstrate that storm surge attenuation can be minimized if the marsh storage area is limited. This probably explains why the highest recorded storm tide was not attenuated.

References

Temmerman S., P. Meire, T.J. Bouma, P.M.J. Herman, T. Ysebaert, and H.J. De Vriend. 2013. Ecosystem-based coastal defence in the face of global change. Nature 504:79-83. doi:10.1038/nature12859