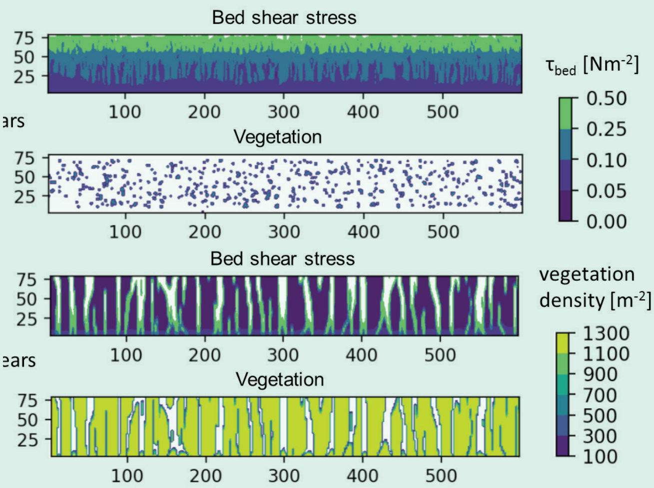
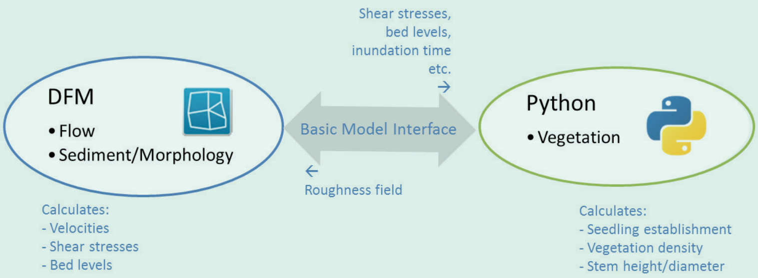
VEGETATION MODELLING TO ASSESS THE DEVELOPMENT AND PERFORMANCE OF NATURE-BASED FLOOD DEFENCES

Given the problems of subsidence and sea level rise on many of the world's delta coasts, there is rising interest in natural and nature-based flood defences (NBFD) as way of combining affordable and adaptive coastal defences with other ecosystem services. This has created a demand for tools that can quantify the development and performance of natural or nature-based systems such as salt marshes and mangroves, ecosystems that are known to undergo rapid geomorphological development within decades, the time scale at which they are expected to defend the coast.



Modelled development of a bare intertidal flat into a salt marsh



Exchange of essential variables between the morphodynamic model (DFM) and the ecological model

In addition, the development of nature-based systems results from a two-way interaction between ecological and physical (hydrodynamic and morphodynamic) processes. The coupled modelling of bio-geo-morphological systems is therefore needed for the design and evaluation of NBFDs in scenarios of climate change. Assessments of this kind will help to create confidence in the long-term resilience and actual performance of systems of this kind.

During the last decade, Deltares has worked with universities and other research institutes to develop and apply modelling tools and approaches that simulate the effects of biota on flow and sediment transport in numerical models such as Delft3D and XBeach. Conversely, the effect of environmental conditions such as flow velocity and inundation time on the development of organisms has been incorporated in D-Water quality and other growth models. The combination of physical and biological models has been used in several research projects and has often resulted in important quantification of anticipated behaviour (such as Temmerman et al., 2007 and Van Oorschot et al., 2015) but complexity in practice meant that simple, effective assessments remained elusive.

By using the Delft Flexible Mesh model in combination with Python – both of which are open source – we created a fast and flexible coupling platform to answer questions of this kind and to make possible NBFD assessments that were previously thought to be too complicated and costly. The Python interface allows for the development of ecological models with varying levels of complexity that are linked through memory pointers with essential variables describing the vegetation in the hydro- and morphodynamic code. This allows for the relatively independent development of both parts of the coupled code, while at the same time retaining fast in-memory exchanges during run time. In the past year, this novel combination has been validated using earlier studies and a good match was found with actual landscape development.

In 2018, the modelling suite will be further expanded with the wave models XBeach (van Rooijen et al., 2016) and SWAN. The development of community models for vegetation dynamics in Python scripts will be facilitated with an online platform to share functions and settings for ecological models. Overall, this should improve the transparency and applicability of biophysical models. Collaboration with early-adaption users will provide feedback on additional modelling needs.

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Further reading:
Van Rooijen et al., (2016). Modeling the effect of wave-vegetation interaction on wave setup. Journal of Geophysical Research