Deltares

Enabling Delta Life

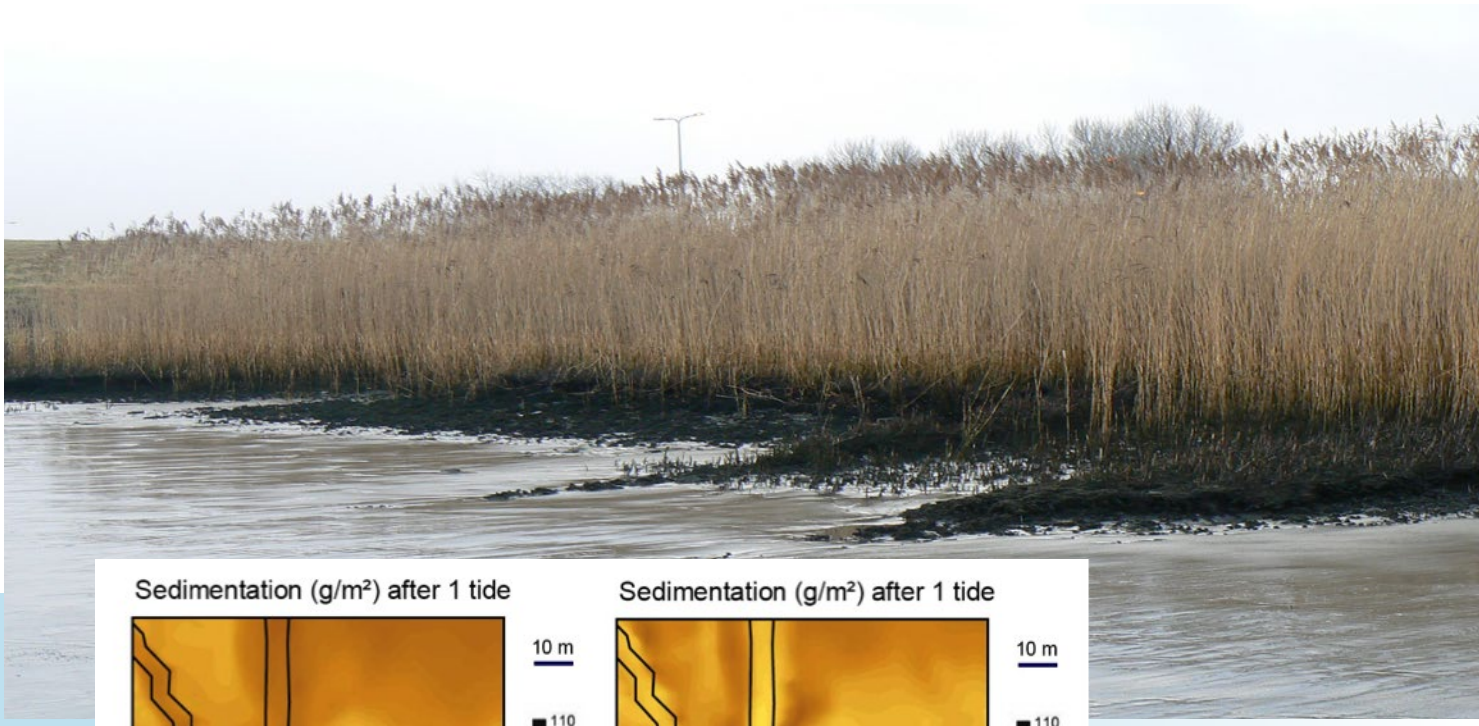
Vegetation modelling

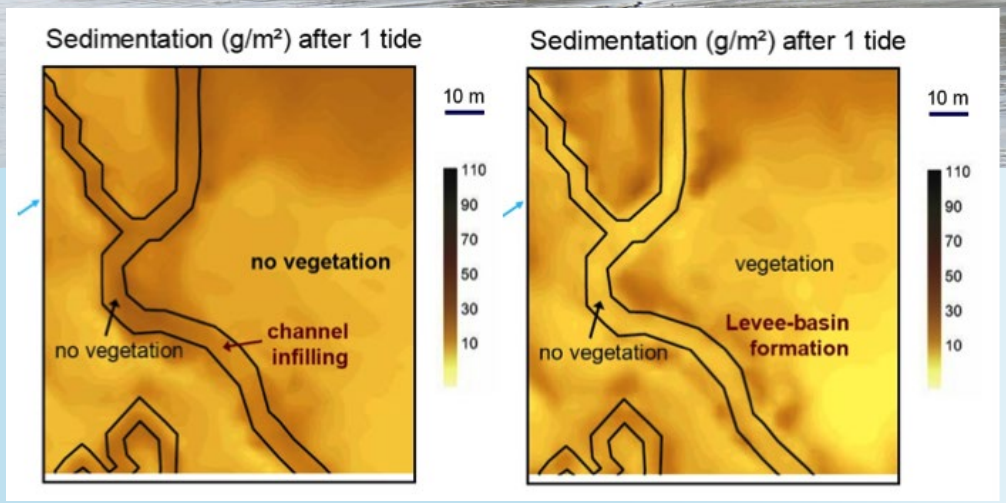
Vegetation plays a central role in many aquatic and semi-terrestrial ecosystems. Their interaction with other elements of these systems must be taken into account for correct quantification of processes that define the status of the studied system. Deltares is actively developing new methods for including vegetation in its modelling tools, ranging from interactions of vegetation with hydrodynamics and sediment dynamics to their effect on water quality and ecosystem status assessments. Most of these separate aspects can also be linked via the combined Delft Systems.

Vegetation modelling in D-FLOW and D-FLOW-Flexible Mesh

Vegetation affects flow patterns and roughness parameters in flowing waters. In 1D, 2D and 3D simulations vegetation can be included using either altered roughness parameters, using a trachytope roughness approach or by means of drag elements that extend into the water column. This approach has been applied in studies on e.g. salt marsh development (Temmerman et al. 2005), the influence of vegetation on river planform (Crosato & Saleh, 2011) and on sediment stabilization and turbidity reduction in tidal bays and lakes (Dijkstra & van Katwijk, submitted).

Also in the new D-FLOW-Flexible Mesh vegetation can be included in the modeling using an altered roughness approach or trachytopes. This method was used in studying the effect of vegetated filter beds in drainage channels in Singapore where trans-critical flow occurs during rainfall events.

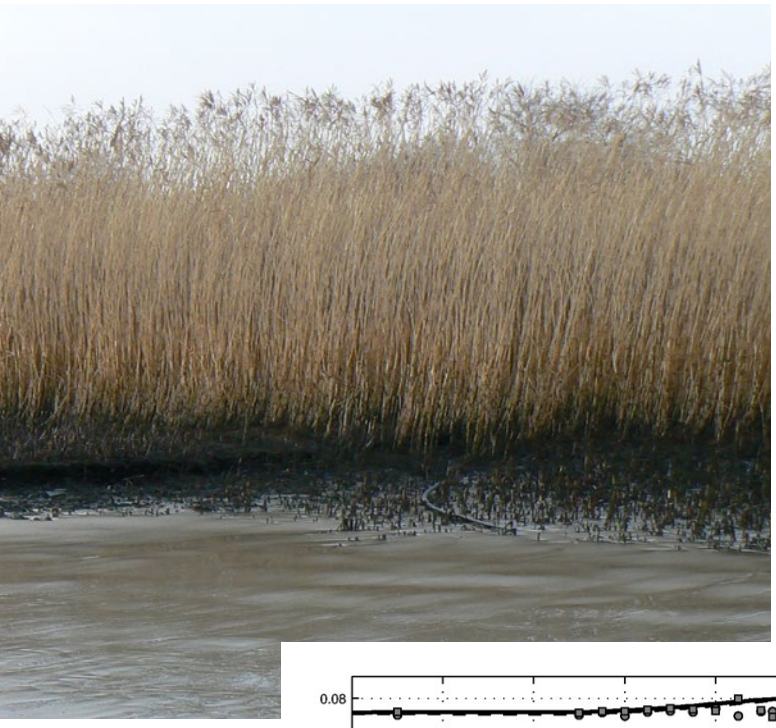




Impact of vegetation on flow routing and sedimentation patterns: Three-dimensional modelling of a tidal marsh (Image: Stijn Temmerman)

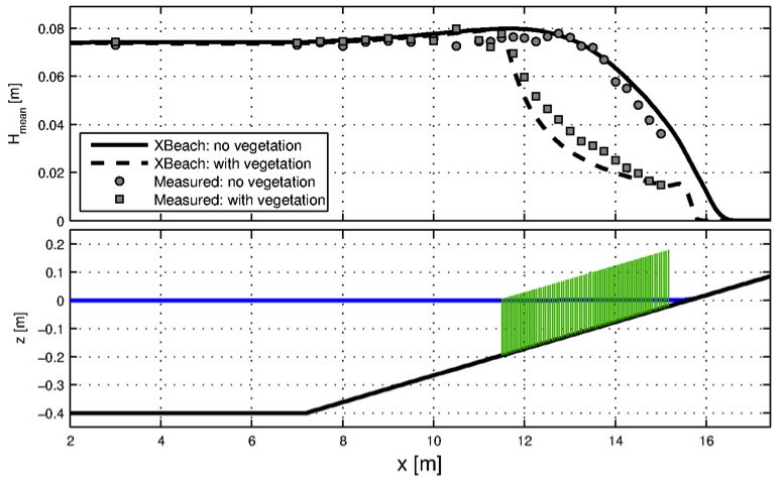
Vegetation modelling in D-WAVES

Following a similar approach as vegetation modelling in flow, vegetation is represented by rigid rods to model the effects on wave attenuation and wind-wave driven water level set-up. This approach has been used in the design of nature based flood defence systems in areas where wave attack on dikes was posing direct flood risks. By applying vegetation (willow forests) as a barrier the dike itself could remain lower and was less prone to wave attack during storms.



Vegetation modelling in XBeach

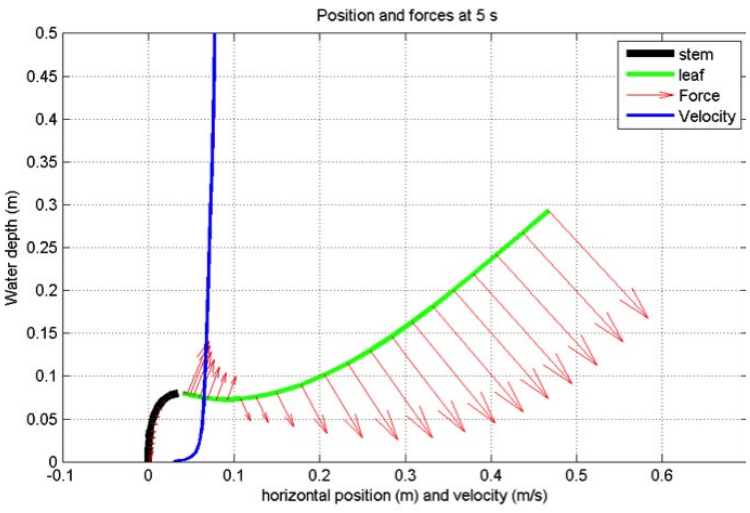
Vegetation can play an important role in both coastal safety and morphology, by reducing the wave impact on shorelines and providing shelter for (fine) sediments to settle. Recently, the open-source morphodynamic storm-impact model XBeach has been extended with a vegetation module to include damping by rigid vegetation. In the model a spatial distribution of different vegetation species can be specified, as well as a schematization in vertical sections per plant species. Currently, attenuation of short waves, long waves and flow by vegetation has been implemented and is being tested. In near future the effect of vegetation on sediment transport and morphology will be included as well.



Example of measured and computed wave propagation with and without vegetation.

DYNVEG – dynamic movement of vegetation with flow and waves

Most aquatic vegetation is flexible and moves with the flow. This adaptation to the hydrodynamic forcing affects the effective plant height and the drag that is exerted on the vegetation. In turn, the movement of the vegetation also affects the water flow itself. These feedbacks are modeled in a research-tool called DYNVEG that takes into account the biomechanical parameters of the modeled plant species. It allows for the assessment of the behavior of complex plants (plants with leaves and or buoyancy structures) in complex flow and waves and can be used as a pre-processor for further calculations using the rigid vegetation tools in D-waves and D-FLOW



Plant position and forces on different sections of the plant leaf depending on water velocity.

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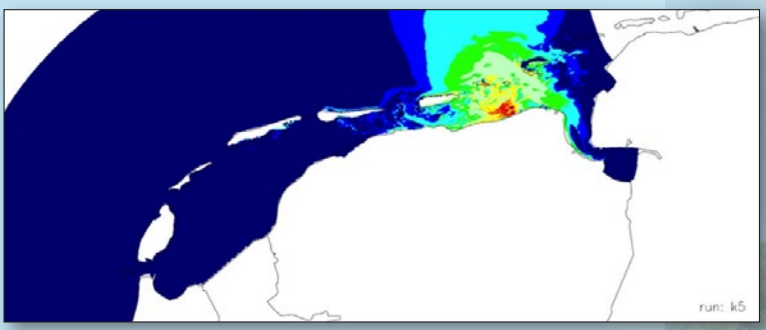
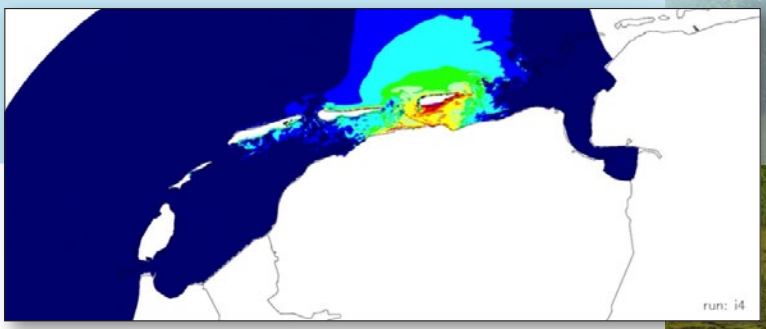
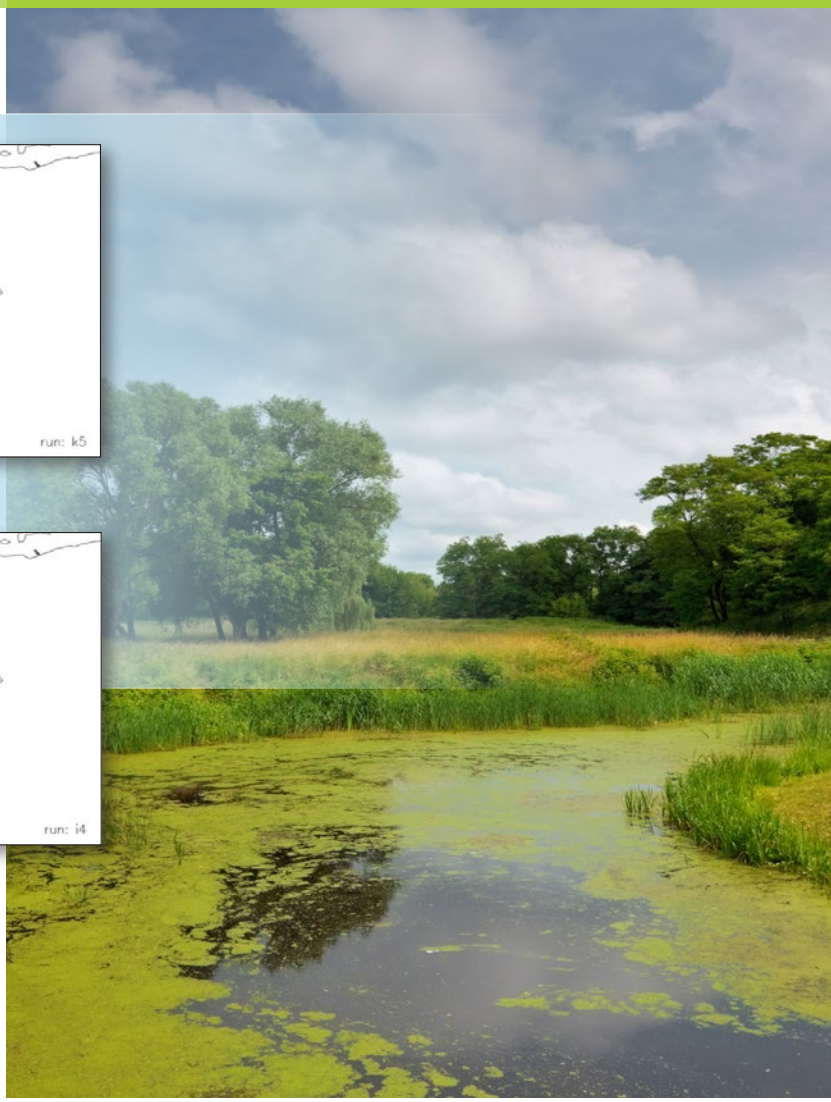


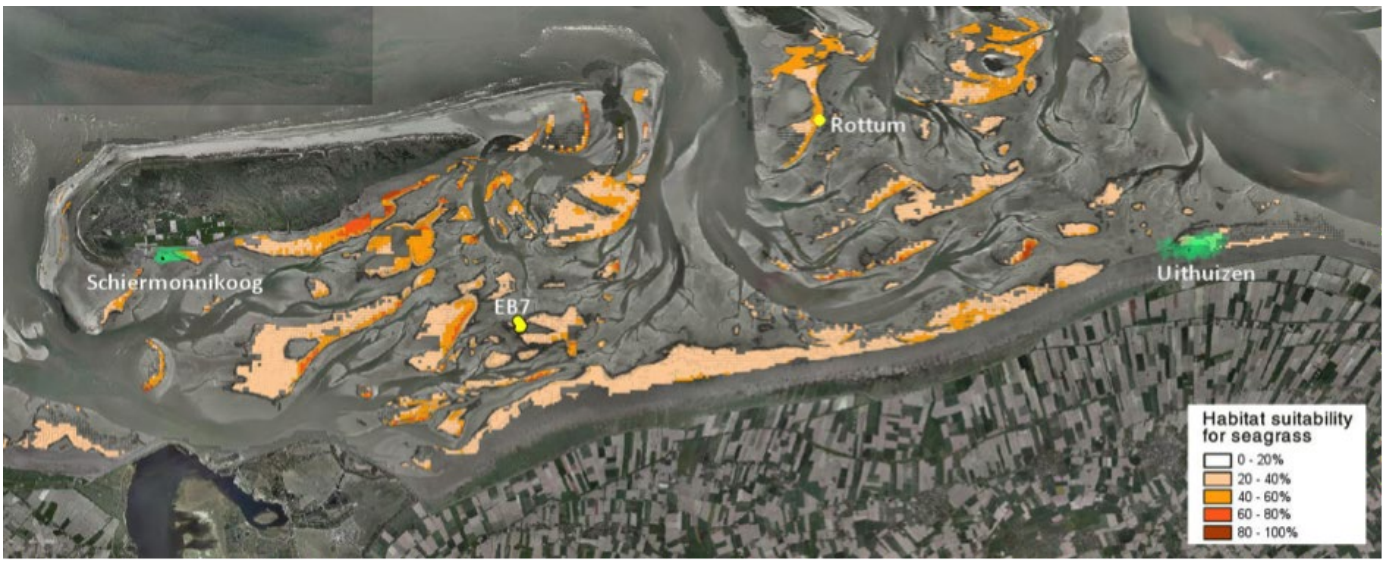
Results of the dispersal model with seeds released at 2 potential restoration sites in the Wadden Sea





Seed dispersal modelling in D-PART

Seed dispersal of plants is essential for their long term survival. In the Wadden Sea seagrass has difficulty re-establishing because there is no natural dispersal of seeds towards potentially suitable habitat. Efforts to restore seagrass need to take both habitat suitability for adult plants as well as seed dispersal patterns into account, to ensure that a newly established meadow can be self-sustaining in terms of seed supply. This effect was modeled using D-PART to follow the passive distribution of seagrass seeds by the flow in the system. In the model, seed bearing shoots were released at potential restoration sites and allowed to disperse in the system for 3 weeks. After 3 weeks the shoots disintegrate and the seeds sink to the bed. Sites were chosen that had a high retention time as well as a high probability of colonizing other suitable habitat.



Habitat suitability map of the eastern part of the Wadden Sea, with in green seagrass occurrence after 2 years of restoration and in yellow two locations where new seagrass populations were observed after the two years, almost certainly originating from the restoration sites.

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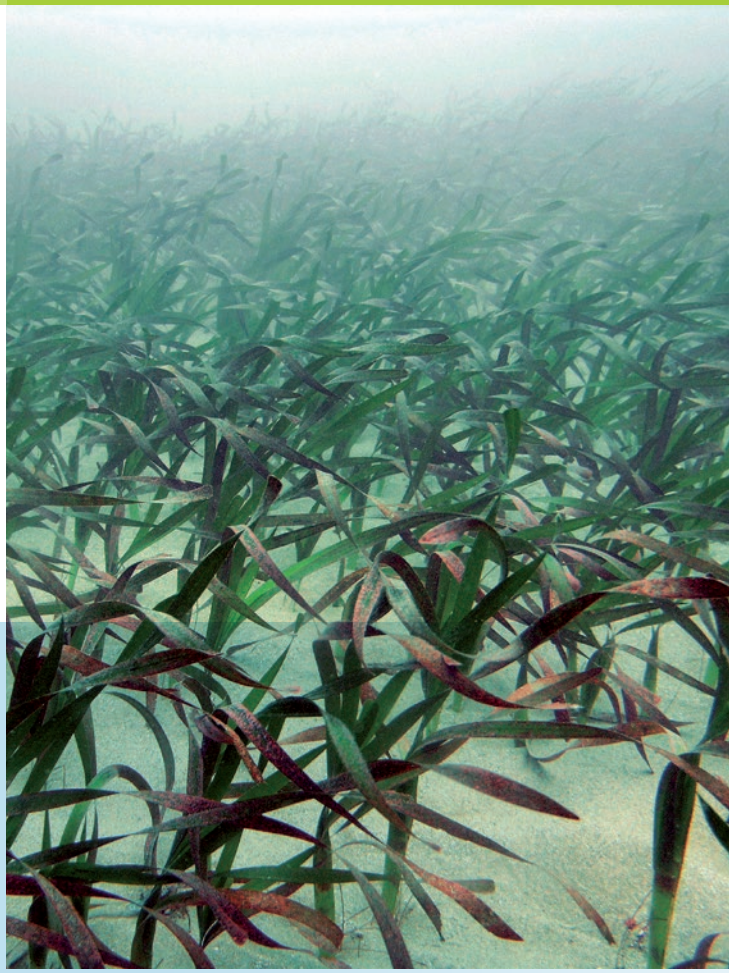
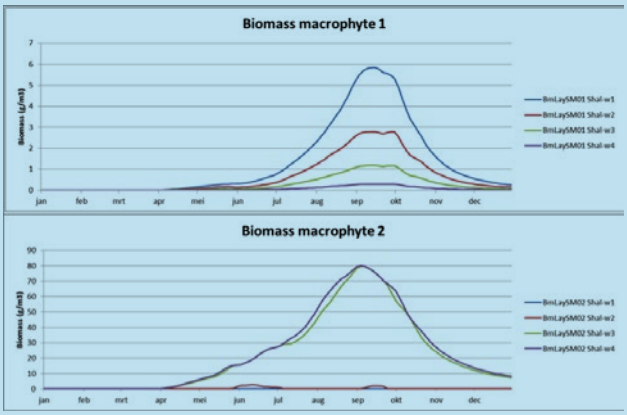
Vegetation modelling in D-WAQ

Vegetation competes with algae for nutrients and light needed for growth. Within the D-WAQ system the seasonal biomass development of both aquatic and terrestrial plants can be modelled in relation to the relevant chemical and biotic processes. Nutrients can be taken up both via water and soil; and light and CO_2 are included as sources needed for growth and decay. Direct competition between various types of plants is also included, as is the translation of the vegetation biomass to parameters relevant for the input needed within D-FLOW or D-waves.

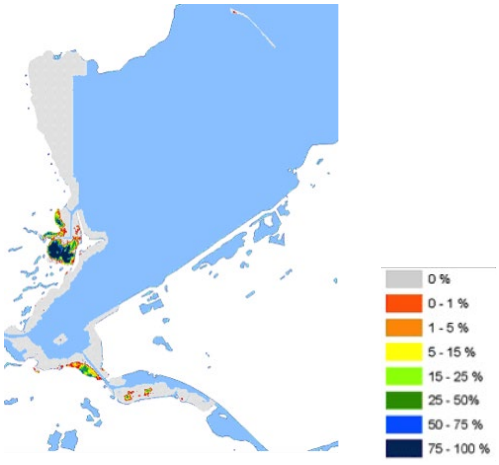




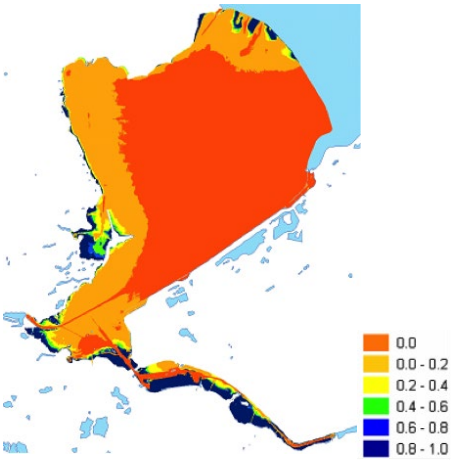
Seasonal distribution of biomass of 2 morphologically different macrophytes over 4 vertical water layers (w1 = top layer, w4 = bottom layer)

Vegetation modelling in HABITAT

Getting a grip on the potential locations for different types of vegetation to occur is not only driven by water quality and water quantity: sediment type, history, connectivity and vegetation management also influence the potential habitat for vegetation. To assess if a location is potentially suitable for vegetation the software system HABITAT allows for combination of knowledge rules and input data in a GIS-environment. Direct linkage with other software input or output is possible. Output maps can be used by e.g. D-WAQ for further assessment of the biomass development over time.



Chara coverage in Lake Marken, 2004



Modelled Chara habitat suitability

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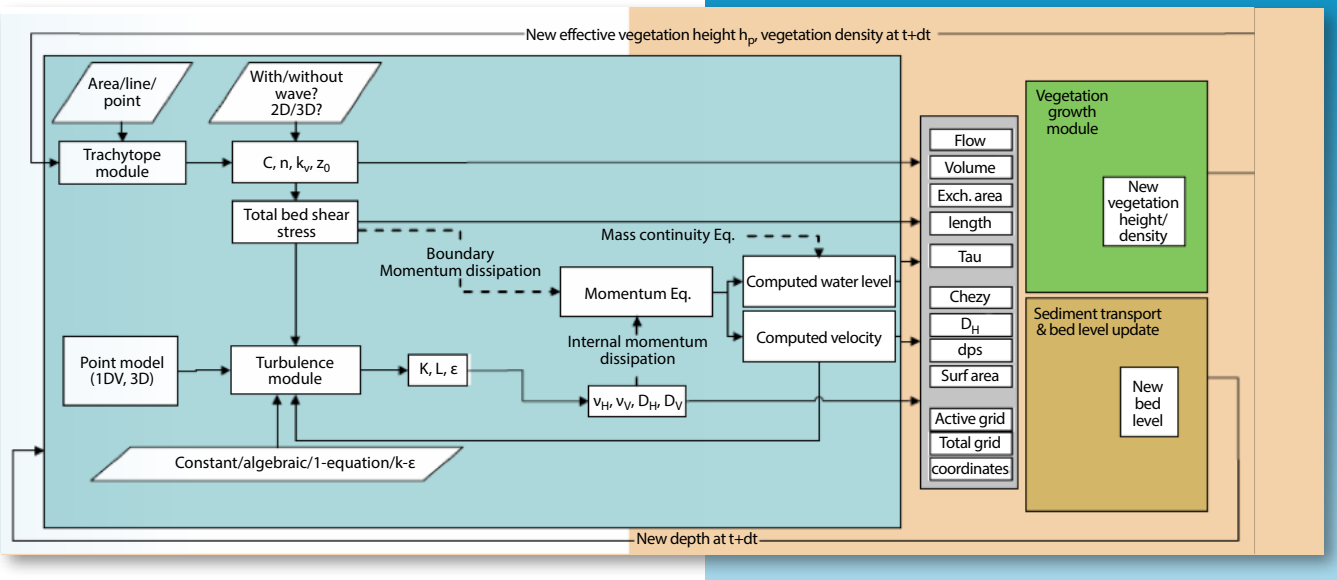
Combining modules for integrated vegetation modelling

As vegetation biomass develops over time, it is needed to include this development in hydrodynamic calculations, especially when vegetation is potentially affecting the flow and wave patterns substantially. An online feedback loop was developed to translate the calculated biomass of vegetation in D-WAQ to suitable input parameters for D-FLOW.



References

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Temmerman, S., Bouma, T. J., Govers, G., Wang, Z. B., De Vries, M. B., & Herman, P. M. J. (2005). Impact of vegetation on flow routing and sedimentation patterns: Three-dimensional modeling for a tidal marsh. Journal of Geophysical Research, 110(F4), F04019. doi:10.1029/2005JF000301

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