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Improving the success rate of seagrass restoration projects: Development of a new bio-hydro-morphological modelling platform accounting for vegetation growth

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Important loss of seagrasses occurred worldwide during the last decades, resulting in less effective ecosystem services, the decline of environmental conditions and jeopardizing the survival of coastal ecosystems. To reverse the trend, seagrass restoration actions are essential. Despite increasing efforts made over the last decade, restoration projects still face challenges to be efficient, one of them being the accurate identification of suitable sites for restoration. This key step is highly dependent on a prior good knowledge of the physical stressors and on their interaction with seagrasses, which can only be analysed by numerical modelling at the relevant space and time scales.

This work aims at developing a coupled bio-hydro-morphological model able to consider the growth of vegetation in order to devise a successful strategy for the restoration. The model is applied first to the case of *Zostera* meadows in a mesotidal coastal lagoon (Arcachon Bay, France).

In this work, a coupled hydro-morphological model was improved to account for the effects of vegetation on a wide variety of bio-physical processes. This new modelling platform comprises the 3D hydrodynamic model MARS3D able to consider the feedback between leaf bending and the flow structure. The interactions between flow and seagrasses are computed through the production and dissipation of turbulent kinetic energy and the loss of momentum resulting from the drag exerted on the vegetation. This hydrodynamic model is combined to the spectral wave model WAVEWATCH III, in which the effect of vegetation on wave energy dissipation was recently implemented.
The process-based sediment transport model MUSTANG, which computes the evolution of the suspended sediment concentration in the water column and the sediment characteristics of the seabed, also constitutes this platform. This model includes the effect of the foliage on sediment deposition and the effect of root systems in the formulation of the sediment erodibility.
Finally, a vegetation growth model for *Zostera* computes the evolution of vegetation characteristics (production, loss and mortality) based on the external forcing (light, temperatures, hydrodynamics and desiccation). The spatial evolution of the meadows is modelled through rhizome extension, scouring as well as seed production and germination.

In Arcachon Bay, *Z.noltei* and *Z.marina* meadows have declined by 45% and 84%, respectively, since 1989, and their recolonisation is mainly hindered by physical stressors. A first analysis performed with a simple flow model accounting for vegetation provided a map of the most suitable areas for restoration. This new bio-hydro-morphological model aims at improving and refining these recommendations by providing a full set of parameters ranging from hydrodynamic variables to light availability. Then, the vegetation growth model would enable the verification of model predictions by testing the chosen restoration action through the artificial addition of seeds in the model. Besides determining the best areas for restoration, this model also provides information regarding the magnitude of the restoration effort (*eg.* surface, number of seeds) required for the recovery of the meadows in a given area.