Bio-physical interactions and adaptive coastal protection of dynamic vegetation patches (Ref IAP2-18-107)

Heriot-Watt University, The Lyell Centre for Earth and Marine Science and Technology, Institute for Infrastructure and the Environment

In partnership with School of Geographical and Earth Sciences, University of Glasgow

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Key Words	**Vegetation, wave, tide, bio-physical interaction, nature based coastal defence**

Overview

Coastal wetlands are vital natural defences against severe storms, flooding and coastal erosions (Nepf, 2012). They increase coastal resilience and also offer other ecosystem services such as carbon storage and biohabitat (Barbier et al., 2011; Hansen & Reidenbach, 2012).

Past studies of flow-vegetation interaction have been largely focused on homogeneous static vegetation. Studies of dynamics patches are mainly for unidirectional and uniform steady flow (Vandenbruwaene et al., 2011). There is a lack of understanding of the dynamic feedbacks between biological, ecological and physical processes of coastal vegetation in real world setting, which is critical to better manage and protect this disturbance-driven ecosystems in changing climate and accelerated sea-level rise. In this study, a sophisticated 3-D hydro- and morphodynamic model will be use to investigate the temporal and spatial variation of flow, flow separation and blockage, wake and vortex shedding effects, water level change, turbulence and mixing, turbidity and morphological change within and around dynamic vegetation patches subject to combined wave, tide and current actions. The model results will be fed into a scale-dependent colonization model of dynamic vegetation patches to predict the growth in patch size and time evolution of patch configurations which will in turn be incorporated in the updated hydro- and morphodynamic model. The marsh vegetation is relatively short in Scotland compared to *Spartina anglica* dominated marshes further south. With the expected range expansion of clonally spreading *Spartina anglica,* bio-physical feedbacks in Scottish marshes are likely to change too. The patch dynamics model will be applied to field sites with different tide and wave conditions and current dominance and spread of *Spartina anglica* in Scotland. The model will be used for scenarios with various expansion rates of *Spartina anglica*. The influence of *Spartina* patch expansion and coalescence on the interplay of biological, ecological and physical processes and the collective performance of vegetation patches as natural coastal defence will also be investigated. Growth rates and plant traits of *Spartina* and hydrodynamics at the field sites will be collected by UAV (Unmanned Aerial Vehicle) and ADV (Acoustic Doppler Velocimeter) and ADCP (Acoustic Doppler Current Profiler) and used to validate the model predictions. The outcome of the proposed two-way coupled bio-physical modelling and field study will provide new insight for the fundamental coupling mechanisms between biological and physical processes of dynamic vegetation patches with relevance to the current spread of *Spartina anglica*. Further insights into coastal protection function and resilience of contrasting salt marsh vegetation will be provided.

A

B

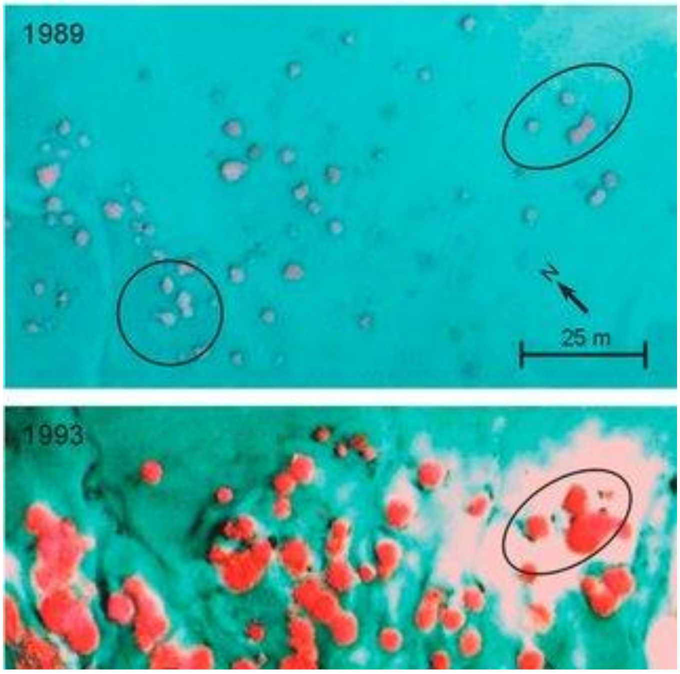

Figure 1 (a) Scale-dependent feedback around a vegetation patch is an important factor of plant developments. (b) Aerial photographs showing the time evolution of an intertidal landscape in SW Netherlands from 1989 to 1993 (Figure 1b of Vandenbruwaene et al., 2011). The lateral expansion of patches increase the patch size and decrease the interpatch distance (see patches within ellipse in 1989 and 1993). Flow acceleration and erosion in between the growing patches may then initiate channels and stop the lateral patch expansion (Vandenbruwaene et al., 2011).

Methodology

Open source and in-house hydrodynamic and morphodynamic model for vegetation flow developed by the supervisory team will be implemented to simulate the complex flow-vegetation-morphology interactions. The growth and evolution of vegetation patches and hydrodynamics at the field sites will be measured by UAV (Unmanned Aerial Vehicle) and ADV (Acoustic Doppler Velocimeter) and ADCP (Acoustic Doppler Current Profiler). The field observations will be used to validate the model predictions.

Timeline

Literature survey and learning hydrodynamic and morphodynamic models and model setup and executions in first year. Field site selection, field observations, data analysis, model applications and validations with existing physical tests and field data, journal and conference paper writing in the second year. Further model-data interpretations for different scenarios to pinpoint mechanisms of bio-physical interaction, thesis writing and journal publications in the third and first 6 months of the fourth year.

Training & Skills

The student will benefit from working with supervisors with different expertise on an interdisciplinary project, develop modelling and field observation skills, and interactions with faculty and students and postdocs at The Lyell Centre for Earth and Marine Science and Technology, Heriot-Watt University, School of Geographical and Earth Sciences, University of Glasgow and the IAPETUS community from 9 institutions and organizations.

The student will be a member of The Lyell Centre, participating in weekly research seminars and meetings. Lyell Centre currently comprises of 11 academic staff, 4 postdocs and 17 PhD students. All students in IAPETUS2 will be enrolled to receive a Postgraduate Certificate in Environmental Methods to demonstrate and recognize the importance of VITAE training. Working in the diverse scientific, geographical and socio-political settings of IAPETUS2 Partner institutions, the student will be trained to become an expert in communicating his/her research within and across disciplines, and to policy makers and the public.

References & Further Reading

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Further Information

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