PECRE Grant for: "Detecting, modelling and analysing the morphology of salt marshes"

Final report to MASTS

1 SUMMARY

MASTS - PECRE funding was awarded to G. Goodwin along with a British Society for Geomorphology "Postgraduate Conference Attendance" grant. The combined funds were used to support travel and accommodation costs for G. Goodwin during a visit to 1) Louisiana State University (LSU) – College of the Coast and Environment in Baton Rouge (LA), 2) the American Geophysics Union's Fall Meeting in New Orleans (LA), 3) Florida State University (FSU) – Earth, Ocean and Atmospheric Sciences in Tallahassee (FL). The visit extended from 08/11/2017 to 22/12/2017.

Two research projects emerged from the visit, each having been identified as potential publishing material:

1. Modelling the development of pioneer patches
2. Analysing the margin geometry of salt marshes

2 MODELLING THE DEVELOPMENT OF PIONEER PATCHES

In collaboration with Giulio Mariotti (LSU) as well as – potentially – Brad Murray (Duke University), we propose to build a model explaining the development stages of patches. We will then compare the model outputs to field observations to determine whether the growth of patches is biologically or hydro-dynamically determined and reconstruct sequences of patch growth.

2.1 PRECURSORS

Previous models have shown that patches promote channelisation in growing salt marshes (Temmerman et al., 2007). The development of vegetation, which may be simulated by the window of opportunity concept (Hu et al., 2015), slows flow within and in the immediate vicinity of the patch (Bouma et al., 2013) and facilitates further growth. Patch morphology has been observed and tied to depositional processes (Balke et al., 2012), but no model exists to predict and explain their development.

2.2 METHODS

The model uses the particle-based hydrodynamic model OpenFOAM to determine the field of shear stress values around the patch for different forcing conditions and patch morphology. Changing the forcing conditions and morphologies will enable us to construct a library of shear stress fields, which we will use to represent stresses on two axes of an individual patch: one axis will be parallel to the shore, the other perpendicular to it. We will then simulate the establishment and growth of vegetation along these two axes. The fit of the model will be estimated by its capacity to replicate observed patch morphology according to the categories established in (Balke et al., 2012).

2.3 European Geosciences Union – Poster Abstract

The most productive area of a prograding salt marsh is its interface with the tidal flat, the pioneer zone. There, frequent flooding increases the trapping of suspended particles and bare or sparsely vegetated sediment is available for clonal colonisation by halophytes. Due to hydrochorous seed dispersal, pioneer marsh areas may be detached from the main platform, taking the form of vegetated patches. As they expand and gain elevation, these patches will either merge or remain separated by a channel; eventually, they will form a new platform that may connect with the main marsh.

Here we present a model representing the hydrodynamics, sediment transport and biology of an individual patch. Using the particle-based hydrodynamic model OpenFOAM, we represent the 3-D stress field in the environment of a patch. Simulations are run for different conditions of 1) current, 2) water depth, 3) wave height and 4) patch morphology. The resulting set of shear stress fields will serve as input for a sediment transport model and vegetation development model based on the Window of Opportunity concept.

With this model, we will describe the progressive development of patches by comparing them to the morphology of patches observed on the field. This will enable us to explain why patches retain their circular aspect despite current asymmetries and how the conditions of patch development favour patch merging or channel formation.

3 Analysing the margin geometry of salt marshes

In collaboration with Jaap Nienhuis (FSU), we propose to develop a series of analysis tools focusing on the margin of coastal marshes. Particularly, we will focus on the morphology of eroding scarps and its link to hydrodynamic forcings (e.g. wave height, tidal range and coastal configuration). The analysis tools will be made public and added to the open-source software LSDTopoTools.

3.1 Precursors

The Topographic Identification of Platforms (TIP) method is an unsupervised algorithm that extracts saltmarsh platforms and their outlines from high-resolution DEMs, recently developed by the University of Edinburgh. This method is currently online in the form of a discussion paper (https://www.earth-surf-dynam-discuss.net/esurf-2017-60/esurf-2017-60.pdf). We use this method to determine the outline of marshes to be studied.

3.2 Methods

To realise our study, we propose to devise a set of XXX analysis tools:

1. An outlining tool will enable us to determine simplified outlines for coastal marshes. A simplified outline will ignore the mouths of tidal creeks.
2. A swathing tool will enable us to automatically retrieve the geometric properties of marsh scarps and their neighbouring tidal flats in 2.5D.

The properties of the scarps will be matched to hydrodynamic forcings. This method will be applied to multiple samples chosen within a variety of coastal marshes within, but not limited to, the United Kingdom.