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Hydrodynamics and Morphodynamics of Mangrove Swamps in the Mekong Delta, Vietnam: Waikato Component

Julia Mullarney
School of Science, University of Waikato
Private Bag 3105
Hamilton, 3240, New Zealand
phone: 64 (7) 838-4597 fax: 64 (7) 856-0115 email: juliam@waikato.ac.nz

Karin R Bryan
School of Science, University of Waikato
Private Bag 3105
Hamilton, 3240, New Zealand
phone: 64 (7) 838-4123 fax: 64 (7) 856-0115 email: k.bryan@waikato.ac.nz

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LONG-TERM GOALS

The long-term goal is to examine the interactions between vegetation, hydrodynamics, and morphology in mangrove swamps. We aim to quantify these interactions and also to develop a simplified coupled hydrodynamic and morphological model incorporating these interactions and associated feedback mechanisms.

OBJECTIVES

Our primary objectives will focus on three areas:

1. The role of the pneumatophore (root) and small-scale structures in damping flows and creating turbulence and the extent to which they enhance the trapping of sediment. We will also examine how the spatial heterogeneity of the vegetated regions directly affects the hydrodynamics.
2. The role of wind-driven flows and wind-generated waves within the mangrove regions. In particular how these flows alter sediment transport and deposition regimes within the swamp.
3. The spatial distribution of bottom roughness and canopy drag within different regions of the mangrove swamps.

APPROACH

We will conduct hydrodynamic measurements at high resolution within the mangrove swamp located at the seaward edge of Cu Lao Dung Island in the Mekong Delta, Vietnam. Pulse-coherent ADCPs, ADVs and profiling ADVs (the Nortek Vectrino Profiler, 100Hz temporal resolution, vertical resolution 1 mm over profiles of 30 mm) will be deployed in a mobile array over scales of meters. The

array will be re-located on daily timescales throughout the swamp regions to encompass a broad range of environmental conditions ranging from the sparsely-vegetated swamp-edge region, regions densely populated by pneumatophores and the densely-treed region far into the swamp. We will also focus at least one deployment around a small natural channel at the SW corner of the Island to provide preliminary indications of the relative importance of baroclinic effects.

The fieldwork will also involve careful quantification of vegetation properties and densities. We will undertake these measurements using standard surveying techniques (m^2 quadrats in the pneumatophore regions). However, we have also recently begun discussion with a colleague from Washington State University (Dr Nick Strigul) who has had significant success reconstructing tree-trunk geometry in 3D using a technique involving multiple overlapping photographs. Given pneumatophores are of similar complexity to tree trunks, we will test this technique in the first field experiment and if successful we will refine the experimental procedure for the winter field experiment (probably in March 2015). These results would provide precise 3D measurements of geometry suitable for direct input into numerical simulations (such as those planned by DRI participant Steven Jachec).

Our measurements will be incorporated into the parameterizations of a simplified morphological model. The first stage of the morphological model is to develop a simplified 3-box structure to represent the (1) channel, (2) fringing pneumatophore and (3) canopied region. The three boxes will be coupled using the sediment transport flux across the boundaries between boxes. Roughness and sediment transport processes will be parameterized within each region using a combination of literature values and the results obtained from measurements in the field program. The model will be used to isolate the key drivers on the morphological stability of the swamp.

WORK COMPLETED

The primary focus of this year has been to develop working relationships with Vietnamese colleagues and other DRI researchers and to prepare for the first major field deployment in September to October 2014. PI Mullarney attended an initial workshop in Vietnam, which provided an opportunity to meet other participants and discuss logistical considerations. Additionally, Mullarney gave a short course presentation to Vietnamese colleagues and students on new tools and techniques for measuring small-scale flows. During the visit to the field site, it was observed that there were moderate waves (0.3 - 0.6 m wave height and occasionally breaking) within the mangroves, which may also provide an avenue for future research.

Following on from the workshop in February, an integrated deployment plan has been developed with the other tropical delta DRI participants working in the mangroves (Figure 1). Fieldwork preparations have been completed, the frames for the moveable array have been constructed and the majority of equipment has been shipped and cleared through Vietnamese customs and is ready for use (the remaining equipment will be transported in person by the field team). Lastly, a student (Benjamin Norris) has been recruited and commenced his PhD in September 2014 and will be participating in the upcoming fieldwork.

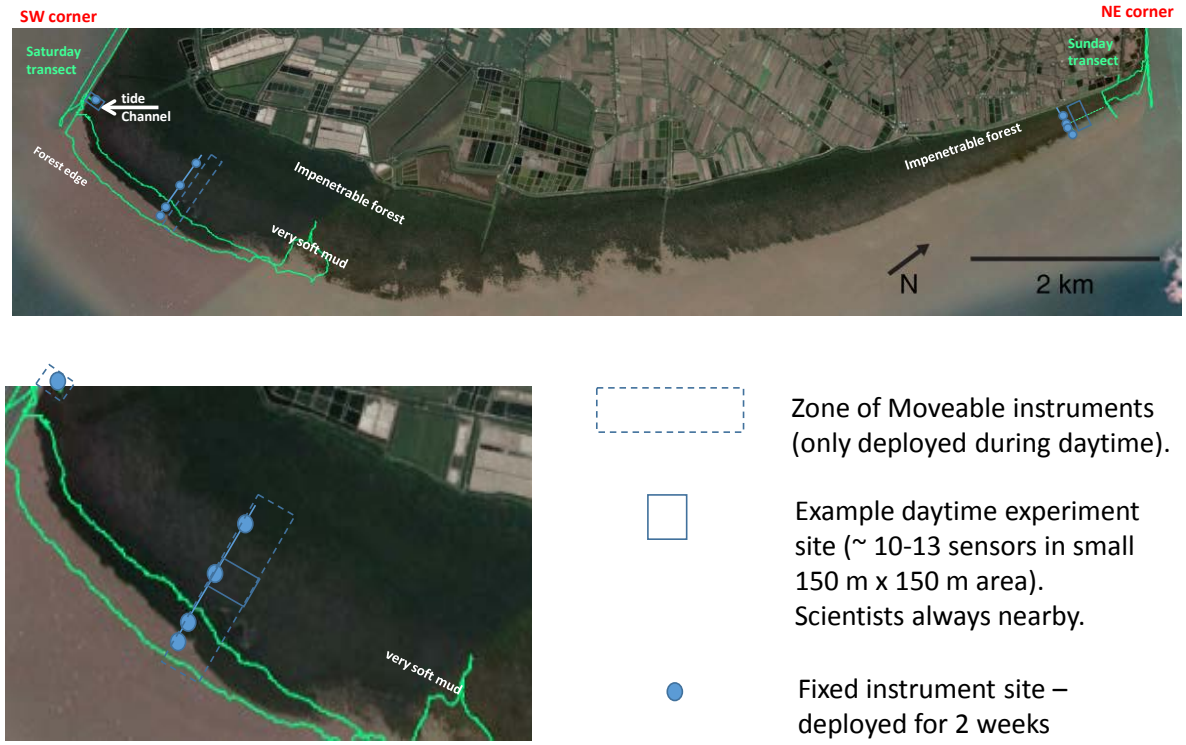

Figure 1. Integrated deployment plan for deployments in the mangrove fringe of Cu Lao Dung Island in the Song Hau distributary of the Mekong River (courtesy of Andrea Ogston). An additional instrument transect will be maintained in the centre by Vietnamese colleague Dr Hong Phuoc.

RESULTS

A comprehensive literature review has been done to inform the preliminary develop stages of the model architecture. At this stage, key measurements will needed on the roughness height and flow-blocking potential within the 3 regions. These measurements will determine the structure of the bedshear stress parameterization in each of the regions, which will ultimately determine the boundary-fluxes. A number of potential equations have been trialed, but further development awaits results of the field deployment.

IMPACT/APPLICATIONS

The observations and idealized model will improve ability to predict the complex interplay between flows, plant growth, and patterns of sediment erosion and deposition. We will also be able to provide direct measurements of flows and results of our vegetation surveys for ground-truthing of remote sensing measurements and for use in the calibration and validation of 3D numerical modeling being undertaken by other DRI researchers.

RELATED PROJECTS

We have a related project "The influence of wind and waves on the existence of stable intertidal morphology in meso-tidal basins" (with PhD student Stephen Hunt, funded by the Commonwealth Scholarship fund) which seeks to further our understanding of the role of intertidal storage on tidal asymmetry and sediment transport. The results from this study may assist in the interpretation of flow routing within the mangrove swamps.