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

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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. Understanding 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. Understanding the interplay of waves and currents within the mangrove regions. In particular how these flows alter sediment transport and deposition regimes within the swamp.
3. Quantifying and modeling the spatial distribution of bottom roughness and canopy drag within different regions of the mangrove swamps.

APPROACH

Two major field deployments, one in September-October 2014, and a second in February-March 2015, will be conducted, and supported my morphological modeling. This work is undertaken in close collaboration with colleagues at the University of Waikato, Hamilton, New Zealand (Mullarney and Bryan), who have been funded through a separate grant from ONR Global. WSU and Waikato personel function as a single team in the field, and Henderson will visit Hamilton, New Zealand, for more than 2 months during October 2014- January 2015.

Hydrodynamic measurements are obtained 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, 50 Hz temporal resolution, vertical resolution 1 mm over profiles of 30 mm) are deployed in a mobile array to resolve scales of ranging from meters to millimeters. High accuracy pressure gauges resolve the small horizontal pressure gradients that force water through the swamp. Frequent (nearly daily) re-location of the array throughout the swamp encompasses a broad range of environmental conditions ranging from the tidal flats, to the swamp-edge where pneumatophores are especially dense, and into the interior of the swamp. Instruments may also be deployed around a small natural channel at the SW corner of the Island to provide observations from a relatively wave-free environment.

The fieldwork also involves detailed quantification of vegetation geometry. In addition to standard surveys (m^2 quadrats in the pneumatophore regions), we have adapted sophisticated image-processing algorithms to reconstruct sub-mm-scale three dimensional vegetation geometry using multiple overlapping photographs (this work undertaken through collaboration of applied mathemetician and vegetation modeller Nick Strigul, an unfunded WSU colleague who is developing similar techniques for sampling the geometry of large trees). These results will provide precise 3D measurements of geometry required for rigorous testing of drag parameterizations, and suitable for direct input into numerical simulations (such as those planned by DRI participant Steven Jachec).

University of Waikato colleagues will work to incoporate these measurements into the parameterizations of a simplified morphological model.

WORK COMPLETED

The primary focus of this year has been to prepare for and begin the first major field deployment, in collaboration with Vietnamese colleagues and other DRI researchers . This field deployment began on schedule, and will continue into October 2014. PI Henderson attended an initial workshop in Vietnam, which provided an opportunity to meet other participants, discuss logistical considerations, and share expertise with new tools and techniques for measuring small-scale flows. Henderson then returned to Vietnam in September, to undertake major field operations in collaboration with Waikato and other DRI investigators. During September, fieldwork was progressing satisfactorily.

RESULTS

A major field experiment is underway in the Mekong Delta during September-October 2014 (Figure 1). Water velocities within pneumatophore canopies are being successfully collected at unprecedented high resolution (mm-scale, 50Hz). The instruments required to obtain such measurements were intended for deployment in benign laboratory environments, and their successful deployment and recovery in the challenging Mekong environment has been a major success of the project to-date. We are also pleased that steps taken to improve the accuracy of pressure measurements have allowed us to resolve the small pressure gradients responsible for forcing mean currents through the swamp vegetation. Photographic surveys have been used to reconstruct the three-deimensional vegetation geometry with an accuracy not previously possible. Since it is not possible to test models for vegetation drag without accurate measurements of vegetation geometry, and since traditional vegetation surveying techniques are extremely labor-intensive, we believe that the new photographic vegetation surveys will facilitate a new, more rigorous approach to the testing of models for flow through vegetation. Although regulations preventing night-time monitoring of instrumentation have significantly limited deployment durations, we are hopeful that the detail of these observations will provide a valuable foundation for analysis as the project proceeds.

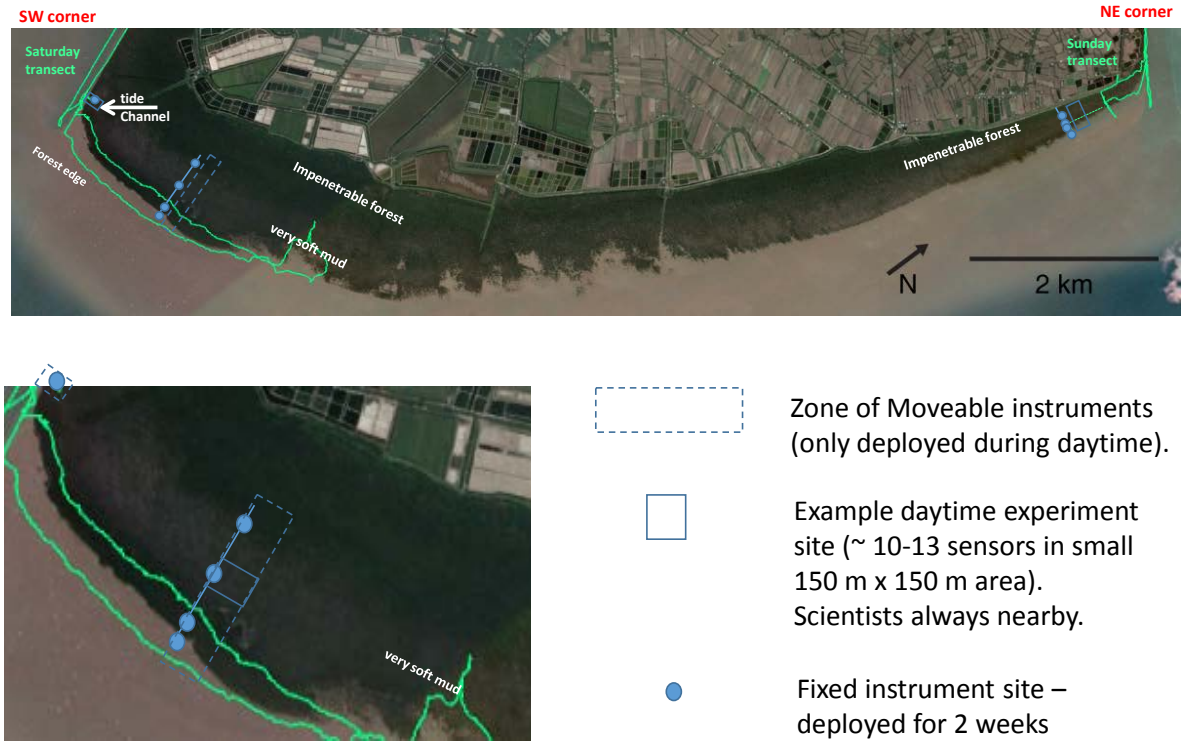

Figure 1. Integrated deployment plan for deployments in the mangrove fringe of Cu Lao Dung Island in the Song Hau distributary of the Mekong River (courtesy of Andrea Ogston). An additional instrument transect will be maintained in the centre by Vietnamese colleague Dr Hong Phuoc.

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

In addition to ongoing close collaborations with the University of Waikato, we have discussed possible collaborations with Vietnamese investigator Huong Phuoc, and other DRI investigators. A proposal has been submitted to the New Zealand Marsden Fund for similar work within New Zealand Mangrove swamps (PIs Mullarney and Bryan, with funding for involvement by Henderson). This proposal, which has received encouraging preliminary reviews, would fund work within a canopy of much smaller, but much denser vegetation, facilitating intriguing comparisons with ONR-funded observations in the Mekong.