Experimental investigation on salt marshes erosion

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1. Introduction

Edge erosion of salt marshes due to surface waves and tide forcing is likely the chief mechanism that models marsh boundaries and by which salt marshes in worldwide areas are being lost (Van de Koppel et al., 2005; Mariotti et al., 2010; Marani et al., 2011). To address this problem, an experimental investigation in a laboratory flume and field measurements collected in the lagoon of Venice were conducted to understand the main processes controlling marsh edge retreat with a focus on the erosion mechanisms caused by the impact of wind waves in the case of various tidal levels.

2. Experimental Activity

An undistorted physical model reproducing a salt marsh bank was built inside a 50 m long wave current flume where random surface waves were generated according to a given wave spectrum (JONSWAP, $H_S = 0.1$ m; $T_S = 1.4$ s; $\gamma = 2$) determined with data collected in the lagoon of Venice. The model was built with the soil collected in a marsh of the lagoon of Venice. In order to reveal vegetation effect on bank stability, two identical banks were built but for the inclusion of halophytic plants. The two banks were subjected to the same hydrodynamic forcing in terms of tidal excursion and waves. A first set of experiments was conducted reproducing only tidal waves, a second set with wind waves superimposed to tide. In addition to this activity, other experiments were carried out aiming to investigate the dynamic impact and transmission of the waves on and within the bank.

The following quantities were collected during the experiments: water content and pore water pressure inside the bank, water levels and velocities at various distances from the bank, dynamic pressures on the bank edge surface and internal pressure fluctuations due to wave impact. Bank profile and bottom topography at different times have also been collected to characterize the erosion rate and the evolution of bank retreat.

3. Morphological processes

Data and observations made during the experiments were processed and analysed through systematic identification of processes and preliminary quantification of bank changes.

Two types of mass failures were observed during the experiments: slides and slab (or toppling) failures. The former can be actually described as a combination of detachment of material under tensile stress along an arcuate surface and a contemporary slide, resulting in an alcove-shaped surface (Nardi et al., 2012).The latter were most frequently observed failures, consisting in the toppling of blocks and are often the consequence of deep tension cracks. In most cases the impact of wind waves caused the overturning of the block.

In both the unvegetated and vegetated scenarios, mass failures occurred in the first part of the experiment while the remaining part was characterized by particle by particle erosion. At the end both processes equally contributed to the total eroded volume. Effect of vegetation lead to a delay in block failures due the presence of roots, although the total eroded volume differed slightly between the two scenarios.

4. Hydrodynamic pressures

Pressure distribution acting on the vertical bank surface was analysed in order to determine the maximum wave thrust as a function of the water depth in front of the bank. Results show the wave thrust increases non-linearly with the average flow depth; moreover, this rate of increasing becomes almost negligible when the average flow level is higher than the bank top.

The transmission of pressure waves inside the bank soil was analysed through spectral methods observing a net damping in the wave spectra away from bank surface.

5. Conclusions

This investigation allowed us to identify the main morphological processes leading to bank retreat and the role played by vegetation on bank changes and erosion rate. Pressure measurements shown that wave forcing is strictly related to water depth in front of bank surface (Tonelli et al., 2011).

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