Coupled Wave-Bed Dynamics, Atchafalaya Shelf, Louisiana

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ABSTRACT
Recent work that studied the coupling between hydrodynamics and the muddy sea-floor on the Atchafalaya Shelf suggests that the amount of sediment in the water column is controlled by bottom shear stress, the erosion threshold of which is within 0.3-0.5 Pa. However, these results are based on the analysis of a small number of events. In this study, we investigate the applicability of these conclusions for a larger population of storms, as well as for different observation locations (e.g., near 7.5-m to 4-m isobaths), using observations of suspended sediment concentration and acoustic backscatter intensity collected in 2008 on the Atchafalaya inner shelf. The suspended sediment concentration profile is estimated based on the acoustic backscatter of the PC-ADP, and calibrated using independent OBS observations within the first 50-cm above the bed. A uni-dimensional bottom boundary model is used to reconstruct the vertical structure of the flow characteristics, and estimate parameters difficult to observe directly, such as bottom shear stress. The results generalize previous estimates of bed yield stress, allow for building a statistical model for the bed-reworking cycle (liquefaction, erosion, fluid-mud formation and consolidation processes) and represent a first step towards a forecasting model for wave-bed coupling in muddy environments.

KEY WORDS: bed reworking, cohesive sediment, muddy clinoform, ocean waves

INTRODUCTION
The coupling between turbulent flow and sediment processes in muddy environments has been investigated before (Trowbridge and Kineke, 1994; Sheremet and Stone, 2003; Allison et al., 2005; Sheremet et al., 2005; Jaramillo et al., 2009; Safak et al., 2010). In energetic events, surface waves can generate bottom stresses exceeding the shear strength of the bed, causing bed liquefaction and eventually the formation of fluid mud layers. The exact sequence of processes is controlled by the bed sediment properties and wave conditions. The high viscosities of dense near-bed fluid-mud layers provide an efficient mechanism of wave dissipation (e.g., Winterwerp et al., 2007).

Studies on the Atchafalaya Shelf (Jaramillo et al., 2009; Sheremet et al., 2011; Sahin et. al., 2011) suggest that bed-reworking by waves follows a predictable cycle, starting from liquefaction/fluidization, and leading to bed erosion, sediment resuspension, to fluid-mud formation through hindered settling, and eventually to dewatering and consolidation. These studies were mainly based on measurements of acoustic backscatter and flow velocities in the first meter above bed. Recently, Sahin et. al. (in review) further analyzed and quantified the process (critical shear stress for erosion, bed and suspended sediment evolution- bottom stress relationship) for an energetic storm. Their analysis suggests a range for the critical shear stress for erosion between 0.3-0.5 Pa, and a strong correlation between the evolution of suspended sediment mass and the bottom stress.

This study investigates the variability of this process for a larger population of storms, as well as for different observation locations. Suspended sediment concentration (SSC) is estimated based on PC-ADP (Pulse-Coherent Acoustic Doppler Profiler, Sontek/YSI) backscatter. A one-dimensional vertical (1DV) bottom boundary layer numerical model (Hsu et. al. 2009) is calibrated using suspended sediment concentration estimates and wave-current measurements to estimate the bottom stresses. Results obtained for a different storm and at a different depth are compared with the previous studies (Sahin et. al., in review), as an initial step to build a more general model of the interaction between near-bed hydrodynamics and muddy seafloors.

FIELD EXPERIMENT
The observations presented here were made during a field experiment conducted in the spring of 2008 on the muddy inner shelf fronting Atchafalaya Bay, Louisiana, USA, using instrumented platforms deployed near the 4-m and 7.5-m water isobaths (Figure 1a).

Each instrumentation set (Fig. 2) included a downward-looking PC-ADP, an upward-looking ADCP (Acoustic Doppler Current Profiler, 1200 kHz, Teledyne RD Instruments) and two OBSs (Optical Backscatterance Sensor, D&A instruments). The PC-ADPs have built-in pressure sensors, sampled velocity and backscatter profiles at 2-Hz in 27 bins of 3.2-cm, following a 30 cm blanking distance. The