OBSERVATIONS OF HORIZONTAL AND VERTICAL SEDIMENT FLUXES ON A SANDBAR IN THE SUSPENDED AND SHEET FLOW LAYERS

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SIGNIFICANCE AND MOTIVATION

The majority of prior sandbar migration studies have been conducted from the morphological standpoint, whereby, (i) bathymetric profiles are recorded over periods of time ranging from days to decades, at frequencies ranging from hourly to yearly (Ruessink et al., 2003), and (ii) hydrodynamic observations typically consist of far-field wave and environmental conditions. Subsequent modeling efforts have generally focused on tuning parameters in the sediment transport formulations (suspended load and bed load) to maximize model skill in predicting observed beach profiles over time (Fernández-Mora et al., 2015; Hoefel and Elgar, 2003). However, little emphasis at the operational level has been placed on tuning coastal morphology models to the true relative contributions of the physical processes (e.g. suspended load, bed load and/or sheet flow) that drive the changing bathymetry. This is due, in part, to the lack of detailed sediment transport observations (field and lab) under realistic wave forcing conditions and spatially variable bathymetry. Such a modeling approach leads to the improper quantification (magnitude and/or direction) of each modeled sediment transport component under skewed-asymmetric and/or breaking waves, often observed in the surf zone.

The present study aims to better understand the physical mechanisms responsible for driving cross-shore sediment transport over a sandbar by quantifying (a) the vertical exchange of sediment at the near-bed interface (i.e. pick-up layer), and (b) intra-wave horizontal sediment fluxes in the suspended load and sheet layers.

LABORATORY EXPERIMENT

The sandBAR SEDiment transport experiment (BAR-SED) was conducted in 2015 in the large wave flume at Oregon State University (Mieras et al., 2017). A fixed, barred beach profile was constructed to near-field scale based on observed profiles at Duck, NC (1:3), with a sediment pit installed on the sandbar crest. The hybrid profile minimized the complication of separating the forcing and response under active morphological adjustment, allowing for the isolation of small-scale, wave-induced bed response (and sediment transport) due to large-scale wave forcing. Two different sediments were tested, with median grain diameters of 0.17 mm (S1) and 0.27 mm (S2). This paper covers 21 different cases (12 with S1; 9 with S2) under field-scale, monochromatic wave forcing typified with either erosive or accretive conditions.

An array of sensors was positioned over the sandbar crest to measure velocity and sediment concentration profiles in the sheet flow and suspended load layers. The velocity profile spanning the water column was measured with a vertical array of 6 Nortek Vectrinos, while near-bed velocity profiles were measured using 2 Nortek Vectrino profilers. Suspended sediment concentration profiles were measured with 2 dual-arrays of fiber optic backscatter sensors, and near-bed concentration profiles were measured using 4 conductivity concentration profilers (Lanckriet et al., 2013).

PRELIMINARY RESULTS

The wave-induced sediment fluxes were determined via phase-averaging the product of velocity (u and w) and concentration across the N wave ensembles ($10 \leq N \leq 67$) for each of the 21 wave cases. Horizontal sediment transport rates in the suspended layer and sheet flow layer were of the same order of magnitude and slightly out of phase. Conversely, vertical sediment fluxes in the sheet layer were an order of magnitude smaller than in the suspended layer, and were generally more in phase with horizontal velocity, due to boundary layer streaming. As a result, peaks in vertical sediment flux correlated well with peaks in sheet flow layer thickness.

In addition, for each wave case, the average elevation of the inflection point in the sheet flow layer concentration profile was well correlated with the elevation of maximum wave-averaged horizontal sediment flux. This result has implications for the definition of, and quantification of, flux through the pick-up layer in process-based sediment transport models. This study is one of the first large-scale experiments to quantify both horizontal and vertical sediment fluxes and transport rates in both the suspended load and sheet flow layers, providing a valuable data set for the future improvement of coastal sediment transport models.

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