

Patterns of Transport Partitioning in the Nearshore

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LONG-TERM GOALS

The ultimate goal of the present work is to develop numerical models of sediment transport in the nearshore which will permit the prediction of the evolution of nearshore bathymetry given the appropriate forcing parameters. The present work fits into this goal by seeking to understand what are the relevant forcing parameters and to determine how sediment is mobilized and transported in response to those parameters. The work is particularly focused on areas where the sediment response appears to be different from that observed in steady flow conditions.

OBJECTIVES

The primary objective for this project was to analyze the data from the “Fluid-Sediment Interactions in the Nearshore” experiment at SandyDuck97. Analysis was performed with the goal of examining how total sediment transport is distributed among contributions due to mean currents, incident waves and infragravity motions and to examine how this distribution changes with location in the nearshore as well as vertical position.

APPROACH

During the SandyDuck97 experiment, instruments were deployed at 9 clusters which were arranged to form intersecting longshore and cross-shore lines. Each cluster was composed of sensors which provide a vertical profile of sediment concentration and fluid velocity in the bottom 50 cm of the water column. Cross-spectra of the velocity and concentration signal have been performed in order to provide a spectral representation of the sediment transport signal. This signal was then partitioned into frequency bins to represent the transport contributions arising from mean currents, incident waves, and infra-gravity motions. The results were then examined to determine the relative contribution of each component to the total transport signal and to observe how this contribution changed, both as a function of location within the surf-zone as well as elevation above the bed.

WORK COMPLETED

During the project, a complete analysis methodology for the data sets was developed. Some of the issues which made this particularly difficult include; a moving bottom reference requiring frequent determination of the at rest bed location in order to provide elevation reference to the measurements; intermittent sensor fouling by floating debris; and signal bias due to instrument scour which is strongly

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dependent on the degree of instrument burial. This methodology was then applied to a subset of the data in order to examine sediment partitioning during high energy storm conditions. Time periods in this subset were identified in which the data were reasonably stationary and free of bias. The measurements in these periods were subsequently validated by comparing estimates of integrated cross-shore sediment transport derived from the measurements with rates determined from bathymetric changes. The vertical distribution of the relative contribution of each transport component to total sediment transport was determined and the results examined for patterns.

An attempt was also made to find independent forcings for the important transport components by looking at correlations between the incident transport component and various parameters which quantify wave velocity and acceleration asymmetry. This analysis was performed using averages values over time periods corresponding roughly to wave groups as well as on a wave by wave basis.

RESULTS

Significant results from this project include:

In terms of sign, integrated cross-shore sediment transport rates derived from the measurements showed complete agreement with rates determined from bathymetric changes and the magnitudes agreed within a factor of 3.

Net cross-shore sediment transport is seen to be a balance between mean transport and incident wave transport. The infra-gravity contribution is typically less than 10%.

The relative contribution between mean and incident wave cross-shore transport is seen to be a function of height above the bed. The strong correlation between high velocity under wave crests and high concentration spikes can result in near bed domination of the wave driven transport component. The rapid disappearance of these spikes at distances greater than about 5 cm above the bed (Figure 1) results in the progressive dominance of mean transport with increasing elevation above the bed. This pattern commonly results in situations where the direction of net transport reverses as the bed is approached.

The nearbed region ($z < \sim 5\text{cm}$) is observed to provide over 50% of the transport even in such energetic conditions. This result completely ignores any contribution to the total transport which occurs below the at rest bed level.

No significant independent correlation has been found between the mean incident wave driven cross-shore sediment transport and commonly used indices of velocity and acceleration asymmetry.

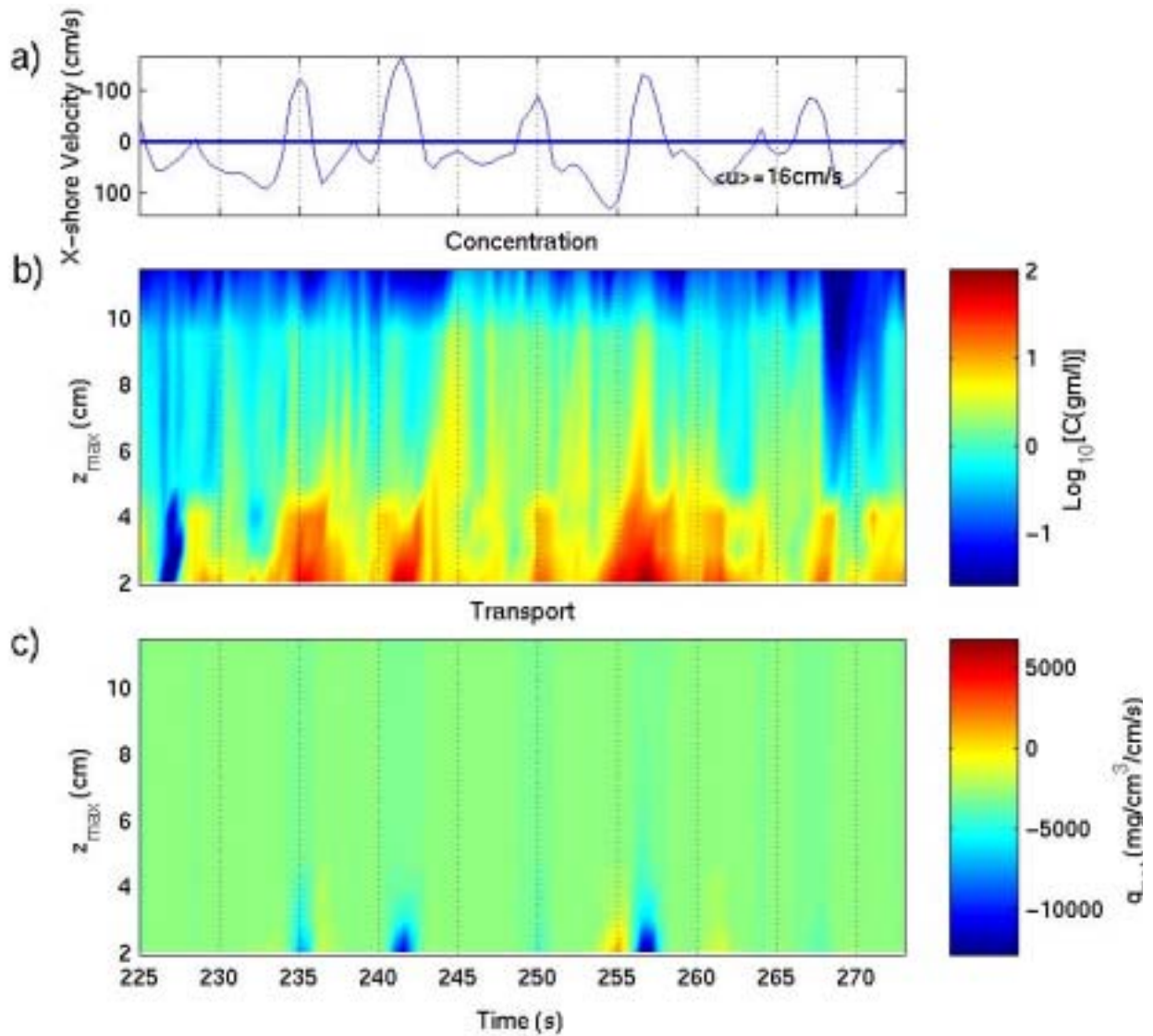


Figure 1. Plot of cross-shore velocity (a.), sediment concentration (b.) and cross-shore transport (c.) for one wave group. The figure demonstrates how, near the bed, the greatest sediment concentrations are strongly correlated with the higher velocity onshore flows. This results in an onshore directed wave coherent transport which is greater than the mean transport. The highest concentration short duration spikes are confined to the region near the bed ($z < 5 \text{ cm}$) with the result that mean transport can be the dominant signal at higher elevations.

IMPACT/APPLICATIONS

The results of this project suggest that successful modeling of nearshore sediment transport may be achieved by independent modeling of the mean and incident transport components although how such modeling might occur is not suggested by the data. It is also seen that measurements of sediment transport in the nearshore which ignore the bottom 5 cm of the water column may not even properly resolve the proper direction of net sediment transport.

TRANSITIONS

The data from this project has been collected and is being used in conjunction with Drs. A. Ogston and R. Sternberg (Univ. Washington) and R. Beach.

RELATED PROJECTS

None

PUBLICATIONS

Conley, D.C., Beach, R., “Cross-shore sediment transport partitioning in the nearshore during a storm event”. Submitted to Journal of Geophysical Research, Oceans.