NEW CCM TECHNIQUE FOR MEASURING SHEET FLOW CONCENTRATIONS AND VELOCITIES

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Paper topic: Laboratory and field observations and techniques

1. Introduction

The sheet-flow layer (SFL) is a thin layer with high sediment concentrations oscillating above an immobile bed. An SFL occurs under conditions with high instantaneous velocities and can contribute substantially to net sediment transport rates near the coast (Dohmen-Janssen and Hanes, 2002). Conductivity-based instruments are best suitable to measure concentrations and particle velocities in the SFL, with the CCM (Conductivity Concentration Measurement) technique being most widely applied. The instrument consists of one or more small probes that penetrate the SFL from below, and which are part of a robust tank that is buried in the beach. These CCM tanks are used mainly during flume and tunnel experiments. A generally encountered problem is that the bed level is not steady and the CCM probe height has to be adjusted frequently. Therefore, we designed a new CCM instrument with a new technique that enables the mobile probe to track the vertical position of a set target sediment concentration automatically. We present results of test experiments in a small oscillatory flow tunnel and its first application in a large wave flume.

2. Methodology

Two new CCM tanks were developed at the UT, equipped with a PLC controller that compares the measured conductivity (sampling rate: 1000 Hz) to a set target value and converts it to a new probe height (control rate: 50 Hz). This technique enables the users to track the position of a target concentration, with an adjustable speed.

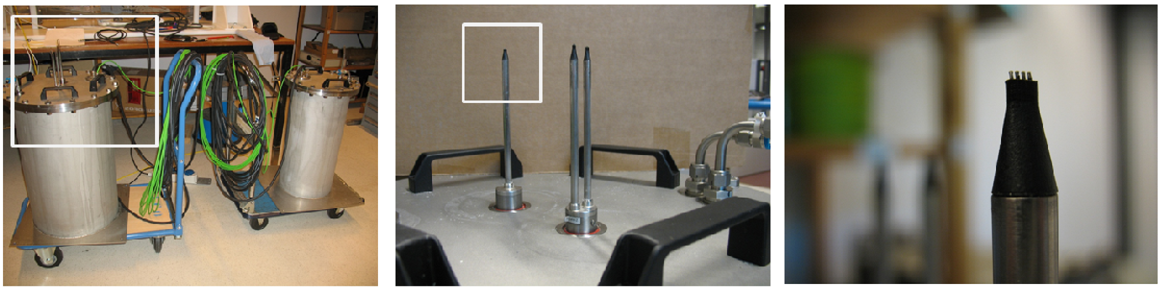

Figure 1. CCM Tanks. Middle and right photo: close-ups of probe.

The new CCM tanks and tracking system were extensively tested in a small oscillatory flow tunnel. A sine-form wave (T=1.8 s, v_{max}=1.2 m/s) was produced by a piston, which was enough to create a SFL of several mm's for the fine-grained sand used (D_{50} = 0.13 mm).

The new technique was applied for the first time during the CoSSedM experiments, in a large-scale flume at UPC, Barcelona. Here, the CCM tanks were placed in the swash zone and sediment concentrations and velocities in the SFL under bichromatic wave conditions were measured.

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3. Results

Tests in the small oscillatory flow tunnel showed that the present tracking technique is suitable to follow bed-level changes on a wave-averaged time-scale while measuring concentrations and grain velocities at a prescribed mean concentration level. We did not manage to track the intra-wave fluctuations of concentrations, probably due to the stochastic nature of the concentration signal.

During the CoSSedM flume experiments, the target concentrations of the tracking system were changed every minute. By fitting a curve through the measured position of a certain concentration, we could derive the wave-averaged position of a certain concentration with respect to a reference level that was moving in time (Figure 2 left). Spectrograms of the probe's position show clear peaks at the frequencies of the wave group (0.06 Hz) and those of the two bichromatic wave components (0.30 and 0.24 Hz – somewhat distorted by wave evolution) and their harmonic components (Figure 2 right). This indicates that morphodynamic behavior of the swash zone is influenced by individual waves as well as by wave groups.

4. Conclusions and Expectations

A new CCM technique for measuring sheet-flow concentrations and velocities is presented. The new tracking system opens opportunities for measuring sheet-flow characteristics in case of aggrading/degrading beds. The probe can follow gradual erosion and sedimentation automatically, while at the same time measuring particle concentrations and velocities. The flume experiment showed that the probe responds to changes in bed level or sheet-flow behavior caused by individual waves and wave groups.

Upcoming months, the CoSSedM data will be analyzed more thoroughly. Specifically we will zoom into the intra-wave and intra-group behavior of the SFL as measured by the CCM tank. Corresponding water velocity and pressure measurements will be used to improve our understanding of the sediment dynamics in the swash zone SFL. The new CCM tanks will subsequently be used during a set of breaking-wave experiments.

Acknowledgements

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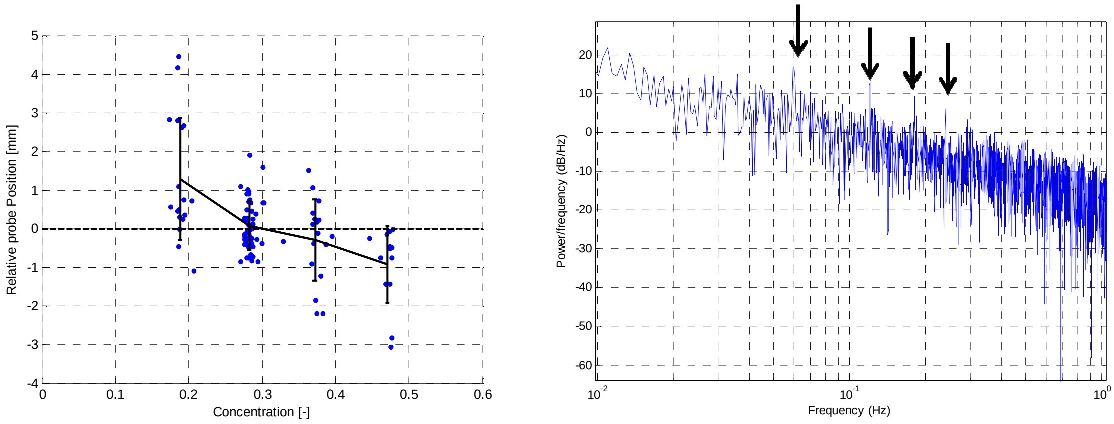

Figure 2. Left plot: Wave-averaged concentrations and positions relative to reference level (= position where C = 0.3 m^3/m^3). Solid and dashed lines respectively indicate mean per concentration class and corresponding standard deviation. Right plot: spectral plot of probe's position during one of the CoSSedM runs.

Reference

Dohmen-Janssen, C. M. and D. M. Hanes (2002). *Sheet flow dynamics under monochromatic nonbreaking waves*. Journal of Geophysical Research **107**(C10). *doi: 10.1029/2001jc001045*.