FLOW CHARACTERISTICS IN SWASH OF TRANSIENT LONG WAVES

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MOTIVATION

The flow of water on a beach is of fundamental importance in coastal engineering. It controls the sediment transport and hence beach morphology. It also affects coastal structures through forces imparted on them and coastal flooding when beach overtopping occurs. The most common approach to numerically model this flow is to use depth-averaged equations (also known as shallow water equations). However, there is a lack of fundamental understanding of the flow produced by different transient wave forms. A better understanding would lead to better validation of numerical models. It would also allow engineers to more easily evaluate fluid forces on coastal structures and the risks of beach overtopping without the need to carry out expensive numerical simulations.

LABORATORY EXPERIMENTS

The experimental setup is shown in Fig. 1:

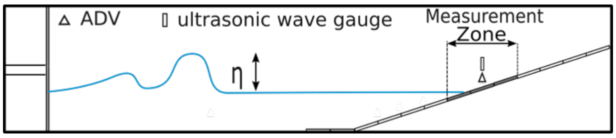

Figure 1 - Laboratory setup for large-scale experiments.

Different transient long waves where were generated in region of constant water depth of 1.75 m. These wave forms included solitary waves (SW), successive solitary waves (SSW), and undular bores (UB). For each transient waveform, the maximum velocity of the wave paddle, which is proportional to the maximum wave height, was kept the same. However, due to the dispersive and non-linear effects, the waveforms evolved to slightly different wave heights as seen in Fig. 2. The flow characteristics on the beach are considered from data within the measurement zone, where the mean flow evolution was measured using an ultrasonic wave gauge and an acoustic Doppler velocimeter.

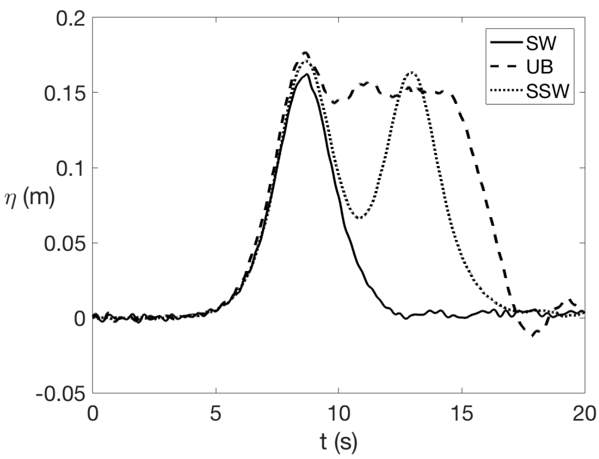

Figure 2 - Free surface displacement time series for different transient waveforms in the constant depth region.

RESULTS

To evaluate the differences in the flow on the beach due to differences in waveform in the constant depth region, we combine measurements of flow depth (h) and flow velocity (u) to evaluate the positive characteristic variable (α) from the shallow water equations (see Peregrine 1972). The time series of these quantities for the different waveforms are shown in Fig. 2.

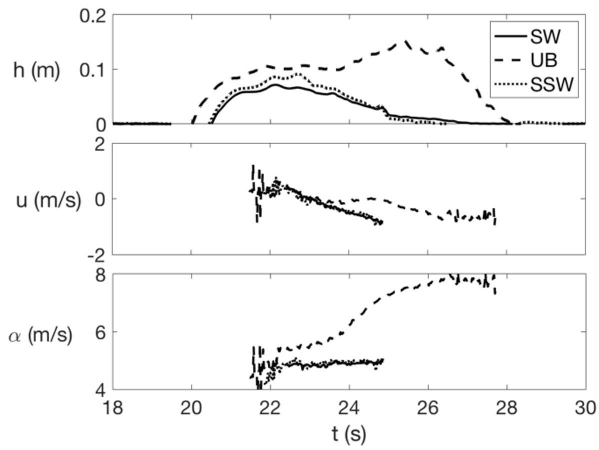

Figure 3 - Mean flow evolution in the measurement zone on the beach for different transient waveforms.

The value of α is constant for the solitary wave, which suggests a strong similarity between the swash of a solitary wave and a dam-break flow as previously shown in Pujara et al. (2015). The data for the successive solitary waves are very similar to the solitary wave, which is somewhat surprising given that two distinct wave peaks are observed in Fig. 1. The case of the undular bore is most interesting. It shows that extra volume of water behind the wave front in the undular bore results in a vastly different flow on the beach. The is broadly consistent with the alternative model of the swash proposed by Guard & Baldock (2007), but this data allows us to examine the merits of this model in detail. In particular, we examine whether the volume and momentum fluxes of the flow in that model reproduce the data and if not, whether the model is conservative in its estimates. This has important implications for engineering calculations of forces and beach overtopping volumes.

REFERENCES

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