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UNDULAR BORE DEVELOPMENT OVER A LABORATORY FRINGING REEF

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INTRODUCTION

Several studies have reported the development of undular bores over fringing coral reefs (e.g, Gallagher, 1976; Nwogu and Demirbilek, 2010) but the importance of this phenomenon for reef hydrodynamics has never been studied. Yet, the transformation of a long wave (e.g., swell or infragravity wave) into an undular bore leads to significant modifications of the wave field. The formation of undulations is for example associated to a significant increase of the leading bore height. Moreover, if the undulations have enough time to develop (i.e. if the reef flat is wide enough), the initial long wave will ultimately split into a series of solitons (e.g., Grue et al., 2008). All this is likely to affect wave run-up. As reef-fronted coastlines are particularly vulnerable to flooding, a good understanding of long wave transformation over the reef flat, including their possible transformation into undular bores, is crucial.

In this study, we investigate undular bore development over reef-type profiles based on a series of laboratory experiments. More specifically, we aim to characterize the conditions under which undular bores develop, and analyse how their development affect the hydrodynamics at the toe of the reef-lined beach and the resulting wave run-up.

METHODOLOGY

The experiments analysed in this study were conducted in the 40 m-long wave flume of the Water laboratory at Delft University of Technology (Dekkers, 2017). The experimental set-up is summarized in Figure 1. Surface elevation and velocity were measured at 17 locations along the reef profile (Fig. 1), and run-up was measured on the beach.

Both regular and bichromatic wave conditions were run during this experiment. Because we hypothesized that both swell waves and infragravity waves can evolve into undular bores over the reef flat, we considered a relatively large range of regular wave conditions, ranging from typical pacific swell conditions ($T_{prototype}$=20s; $H_{prototype}$=1.6m) to relatively long infragravity waves ($T_{prototype}$=90s; $H_{prototype}$ =0.8m).

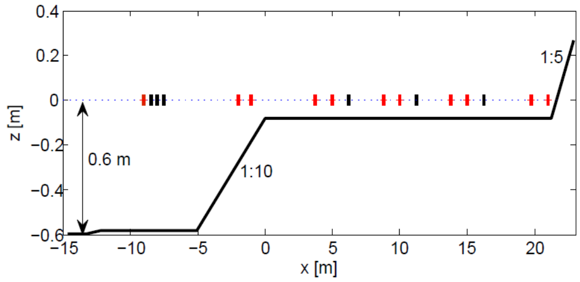

Figure 1 - Bed profile and position of the instruments. Black vertical lines: surface elevation measurements. Red vertical lines: co-located measurements of surface elevation and velocity. The wave maker is located at x=0.

PRELIMINARY RESULTS

Undular bores were observed on the reef flat for all regular wave cases considered. Figure 2 shows the transformation of the incoming signal at different locations for a wave case chosen to mimic a relatively short infragravity wave ($T_{prototype}$ = 45s; $H_{prototype}$ = 0.4m). In this case, the long wave start developing undulations on the outer part of the reef flat (x≈4m). Just before the toe of the beach (x=21m), the individual undulations are well-developed. The signature of the individual undulations is clearly visible in the run-up (see Fig. 2, top panel).

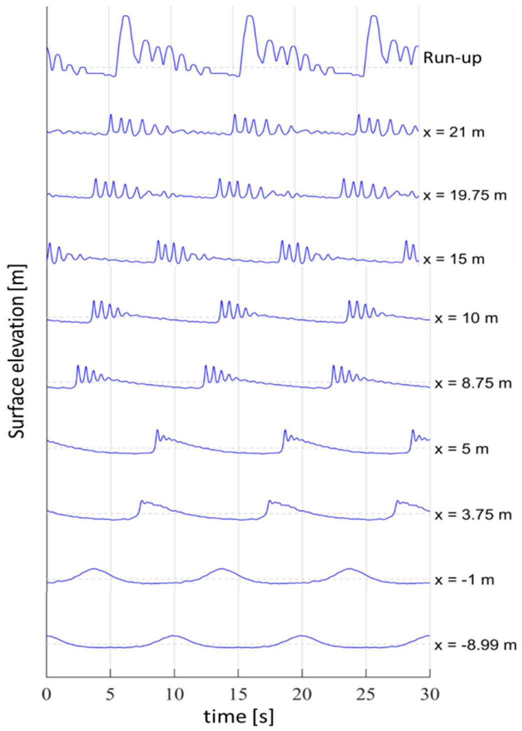

Figure 2 - Transformation of an incoming long wave of period T=10s and height H=2cm (scale factor: 20) across the laboratory fringing reef. The top panel shows the run-up time-series measured on the beach

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