LABORATORY STUDY OF SWASH-ZONE DYNAMICS ON DUNE EROSION

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INTRODUCTION
A storm passage results in acute beach erosion and loss of immense amounts of sand from the affected coastlines. Erosion may reach sand dunes which act as dynamic protective barriers, mitigating the impact of larger waves and storm surge. A dune starts being damaged by a storm when the wave runup is still confined in the swash zone; the region of beach foreshore which is intermittently influenced by the wave motion. Data acquisition in the highly dynamic zone is challenging during catastrophic weather conditions. Therefore, the fate of sand and the subsequent morphological change is difficult to predict. A near-prototype experiment was conducted to provide further insights in the physical mechanisms that result in dune erosion.

SIGNIFICANCE AND BACKGROUND
The growing public awareness of dune contribution to the prevention of coastal floods resulted in a number of recent studies (Figlus et al., 2011; van Gent et al., 2008; van Thiel de Vries et al., 2008). Previous experiments conducted in small wave flumes were limited by scale effects (Figlus et al., 2011), while others put a little emphasis on the examination of bed-load transport rates (van Gent et al., 2008; van Thiel de Vries et al., 2008). This work provides the opportunity to interpret the relative importance of waves, flows and load motion in the swash zone to the evolution of the dune morphology during extreme forcing conditions.

PHYSICAL MODEL DESCRIPTION
The study focuses on a coupled berm-dune system from the coast of Mantoloking, NJ, USA. The profile was scaled and constructed in a 104 m wave flume with a 0.21 mm median diameter sand (Fig. 1). Wave conditions and water levels representative of hurricane Sandy, on October 29-30, 2012 were simulated. The waves were mechanically generated in bursts of 300 s with a piston-type active absorbing wavemaker system. Time-series of the water surface elevations were collected with resistance wave gauges (WG) and ultrasonic distance meters (UDMs) placed from the offshore end of the profile to the upper dune face. State-of-art instruments were deployed at five stations in swash zone. Each station was equipped with sensors which could measure hydrodynamic and sediment processes. Near bed and sheet flow layer sediment concentrations were quantified with conductivity concentration profilers (CCPs). A pair of optical backscatter sensors (OBSs) measured the suspended sediment concentrations. Near bed highly resolved velocity profiles were recorded with acoustic Doppler profiling velocimeters (ADPVs) to estimate the shear stresses exerted on the bottom. Post-trial dune topographies were collected with an overhead Light Detection and Ranging (LiDAR) system to link instantaneous bed level changes to the event-scale evolution of the dune profile.

ONGOING AND FUTURE WORK
The findings underscore offshore-directed sediment transport with intermittent accretions between the stations. Visual observations during the experiment indicated that the dune erosion increased rapidly after the changes in berm geometry. The dune became a sediment source for the swash zone, where the hydrodynamics and morphodynamics altered drastically. The observations are combined with the results from the analysis on sediment transport mechanics. The transport rates are also related to the wave runup levels and wave overtopping.

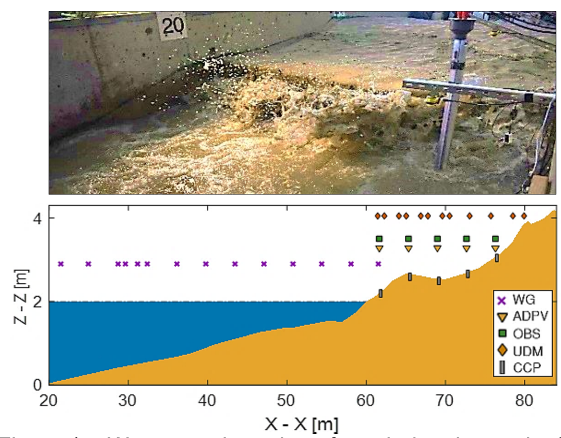

Figure 1 – Wave attack on dune face during the peak of the storm cycle, with H_{m0} = 2.74 m, T_p = 7.20 sec, h = 2.74 m (top). Instrumentation plan (bottom).

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REFERENCES
Figlus, Kobayashi, Gralher, Iranzo (2011): Wave-induced overwash and destruction of sand dunes. Vol. 1. Proceedings of 32nd ICCE. Sed. 34.
Van Gent, van Thiel de Vries, Coeveld, de Vroeg, van de Graaf (2008): Analysis of dune erosion processes in large-scale flume experiments. Coast. Eng. n.55. pp. 1041-1051.
Van Thiel de Vries, van Gent, Walstra, Reniers (2008): Analysis of dune erosion processes in large-scale flume experiments. Coast. Eng. n.55. pp. 1028-1040.