BEACH GROUNDWATER IMPACTS ON WAVE OVERTOPPING FLOODING

Marie-Pierre Delisle, University of California, Los Angeles, mpdelisle@ucla.edu
Yeulwoo Kim, Pukyong National University, Busan, South Korea, yarkim@pknu.ac.kr
Timu Gallien, University of California, Los Angeles, tgallien@seas.ucla.edu

INTRODUCTION

Coastal flooding is a growing socioeconomic and humanitarian hazard (e.g., Nicholls, 2010). Increased beach groundwater levels may inundate low-lying areas and simultaneously propagate swash impacts onto higher beach and backshore elevations. Generally, coastal flood modeling and risk assessment characterize only surface flows, neglecting beach groundwater and swash zone processes such as infiltration and porous media flow. Numerous studies have considered the effects of swash on groundwater (e.g., Gourlay, 1992). Infiltration leads to reduced wave runup (Pintado-Patino et al., 2015) and is promoted by low beach groundwater levels (Bakhtyar et al., 2011), suggesting that beach groundwater plays a critical role in infiltration/exfiltration processes. Notably, the impacts of beach groundwater on swash flows and subsequent consequences on coastal flooding have not been explored. Coastal flooding from wave overtopping is expected to occur around the maximum tide. However, recent field observations suggest maximum overtopping lags behind high tide and is in phase with maximum groundwater levels (Figure 1). In this study, a turbulence and depth resolving numerical model is developed to examine the interaction between beach groundwater and wave overtopping processes.

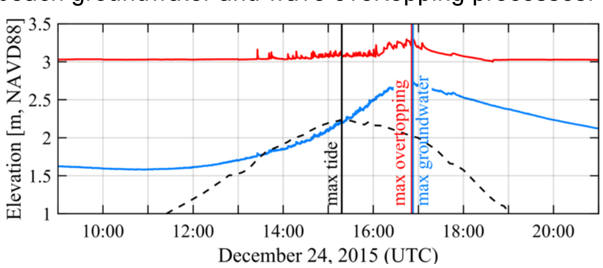

Figure 1 - Overtopping (red solid line) and groundwater (blue solid line) pressure sensor measurements with the tide (black dashed line) at Cardiff State Beach, CA, USA.

MODELING APPROACH

The free-surface resolving Reynolds-averaged Eulerian two-phase sediment transport model, SedWaveFoam (Kim et al., 2018), is integrated with the surface wave solver, olaFlow (Higuera et al., 2013), in the OpenFOAM framework to investigate the bi-directional relationship between swash and beach groundwater. The new model, sedOlaFlow, implements a fixed, porous sediment bed and is applied to a dam break-generated swash on a flat, sloping permeable sandy beach. Full flow profiles and pore pressure responses are resolved using Reynolds-averaged Eulerian two-phase flow equations for air-water mixture and dispersed sediment phases.

PRELIMINARY RESULTS

The two-dimensional model is validated using canonical laboratory flume observations of dam-break driven swash (Kikkert et al., 2013). Figure 2 shows a snapshot of the model domain during uprush (inset - backwash) and demonstrates that the modeled water surface agrees well with measured data (crosses). Modeling results suggest that antecedent groundwater levels impact swash excursion extent and duration. The influence of wave conditions, sediment characteristics, and beach slope on swash-groundwater interactions are further investigated. This research is a crucial step toward improved coastal flood modeling, prediction, and vulnerability assessment and will enable coastal communities to be better informed and prepared for the inevitable consequences of sea level rise.

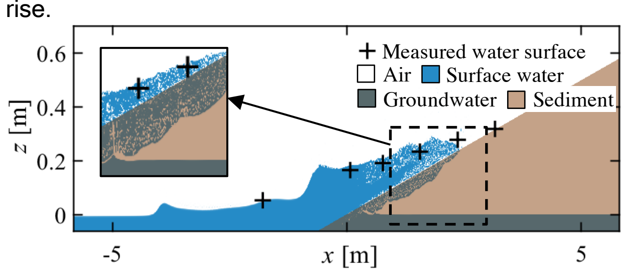

Figure 2 - Snapshot of numerical flume during uprush (1.5 s after bore arrival at toe) (crosses, measured data). Inset shows backwash (6 s after bore arrival at toe).

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