MODELING BEACH GROUNDWATER SUPERELEVATION DUE TO WAVE RUNUP AND OVERTOPPING AT A REFLECTIVE BEACH

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INTRODUCTION

Coastal aquifers are highly dynamic groundwater systems. Sea level rise will raise coastal water tables resulting in increased risk of shallow or emergent groundwater (Befus et al., 2020). Marine water level fluctuations cause the beach groundwater table to oscillate over a relatively large range. Wave action further elevates beach groundwater through wave setup (Li & Barry, 2000), and infiltration from runup (Kang, 1994). Groundwater models that incorporate waves typically only consider setup, assuming infiltration from wave runup is negligible. This may be incorrect at steeper beaches with large runup excursions. Wave runup may also cause overtopping of beach crowns or dunes, resulting in ponded water in the back beach causing extended periods of elevated groundwater and flooding (e.g., Ludka et al., 2018). This work aims to quantify the magnitude and duration of wave runup and overtopping impacts on beach groundwater by modeling water table oscillations at Imperial Beach, a reflective beach in southern California.

METHODS

The multiphase flow and reactive transport simulator PFLOTRAN (Hammond et al., 2014) is used to model groundwater table response to tide, runup, and setup at Imperial Beach during an overtopping event. The model resolves variably saturated flow, accommodates unstructured meshing required to resolve beach topography, and allows seepage face formation. Imperial Beach is a narrow estuary-backed sandspit, with foreshore beach slopes ranging from 1/6 to 1/13. The model domain consists of a ~0.05m^2 voronoi mesh constructed using foreshore topographic observations.

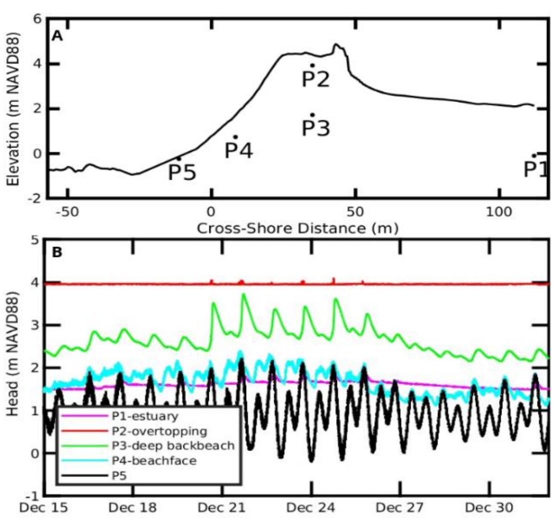

Figure 1 – A) Cross-shore transect at Imperial Beach, CA. B) Pressure sensor measurements.

Model results are compared to measurements from stacked collocated buried pressure sensors in the back beach (Fig 1) from December 2014. The model is forced on the ocean side using tide with wave setup, mean runup, or Stockdon $R_{2\%}$ runup added. In situ estuary pressure measurements are used to force the estuarine boundary.

RESULTS AND DISCUSSION

The model consistently underestimates groundwater head when forced using tide only or wave setup, but overestimates when $R_{2\%}$ is used (Figure 2). The model is generally able to reproduce measured groundwater heads when forced using mean wave runup, except during overtopping events (Figure 2, Dec 21-26). Measured groundwater heads were up to 80cm above those predicted by the model when overtopping occurred. Groundwater levels in the backbeach remained elevated above antecedent average conditions for up to 3 days.

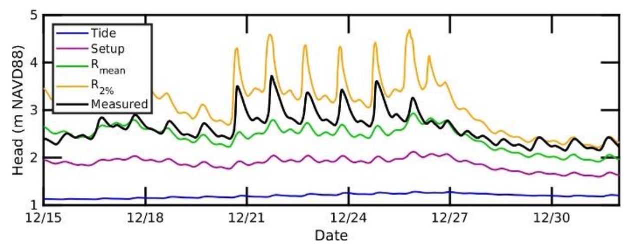

Figure 2 – Modeled versus observed (black) groundwater fluctuations at 35 meters inland (P3).

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