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Discussion on Methods to Quantify the Watertable Overheight in a Coastal Unconfined Aquifer

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Under the action of tides on sloping sandy beaches, coastal groundwater levels fluctuate, resulting in watertable overheight above the mean sea level. The watertable overheight is an important parameter related to the formation of groundwater circulation and the estimation of submarine groundwater discharge (SGWD). The generation of watertable overheight is attributed to the formation of seepage face on the beach, moving boundary condition due to the slope and non-linearity of tidal propagation. While the seepage face formation is not well understood, the latter two mechanisms have been quantified previously. Based on a linearised one-dimensional Boussinesq model, we focus on methods to quantify the watertable overheight induced by the moving boundary condition. There are less than three methods according to literatures (Philip, 1973; Nielsen, 1990; Li et al., 2000; Callaghan and Nielsen, 2004; Song et. al. 2005), that is, the perturbation method, Fourier series expansion and numerical simulation. All studies were based on perturbation solutions with the same perturbation parameter,

$$\varepsilon_0 = A\cot(\beta)\sqrt{\frac{n_e\omega}{2KD}}$$

(A and ω are tidal amplitude and frequency, respectively; β is the beach angle; K, n_e and D are the hydraulic conductivity, effective porosity and mean thickness of the aquifer, respectively). Each approach was adopted to deal with the moving boundary problem, but the range of validity and accuracy of the solutions provide predictions of the watertable overheight are different. In this paper, we present a new approach to solving the Boussinesq equation with the least square method, then together with the other three methods, we discuss on the range of validity and accuracy of the watertable overheight.

Keywords: tidal water table fluctuation, moving boundary, Boussinesq equation, Fourier series, the least square method