NUMERICAL MODELING OF TSUNAMI RUNUP WITH DIFFERENT APPROACHES

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INTRODUCTION

Most Tsunami models that have been applied in the past are based upon the Nonlinear Shallow Water Equations (NSWE), which is a sufficient approximation for the propagation of very long shallow waves in the open ocean. However, to account for the amplification of nonlinearity and frequency dispersion effects near the coast the inclusion of Boussinesq terms becomes more and more important in this area. In connection with the development of these models several different approaches have been proposed to allow for the runup of waves at beaches. In the present paper three of these models will be compared by means of a one and a two dimensional benchmark test. Furthermore the influence of Boussinesq terms as well as bottom friction on the shoaling and runup behavior of long waves shall be examined.

BENCHMARK TESTS

The first benchmark test considers one dimensional runup on a plane beach with a 1/10 slope. Initial conditions and subsequent water surface elevations, velocities and shoreline excursions are given by an analytical solution of Carrier et al. (2003), based upon the NSWE. The second benchmark relies on a 1/400 scale laboratory experiment of the 1993 Okushiri tsunami. Water surface excursions at the open boundary and data for reference come from the laboratory measurements. This example makes much higher demands on the runup strategies due to its two-dimensional extent.

RUNUP METHODS

The first method to account for wave runup in a Boussinesq model was proposed by Madsen et al. (1997). Within this concept the governing equations are solved for the whole domain and in regions of negative water depth, i.e. above mean water level, narrow slots are assumed, which make the waves running up the beach due to a radically decreased cross section width. This method is referred to as "Slot Concept".

Another strategy, proposed by Strybny (2004) also solves the governing equations over the whole computational domain, whereas in areas of negative water depth a very thin residual water film with zero velocity is assumed. Hence, it will be referred to as "Wet Slope Concept".

The third runup method is referred to as "Dry Node Concept" and was developed by Lynett et al. (2002). In contrast to the before mentioned concepts, here, dry computational nodes are consciously excluded from the solution of governing equations. To allow the wet-dry interface to lie in between two nodes and to keep the order of discretization at the boundaries the unknown variables at dry nodes are extrapolated from their wet neighbors.

RESULTS

Figure 1 shows a time series of shoreline position for the one dimensional benchmark comparing the analytical solution with the numerical solutions for the different runup methods. Runup is identified by negative values and rundown leads to positive values in shoreline position. The Dry Node Concept shows almost no observable difference to the analytical solution. The Wet Slope and the Slot Concept on the other hand only show satisfactory results for rundown but markedly differ from the analytical solution for runup.

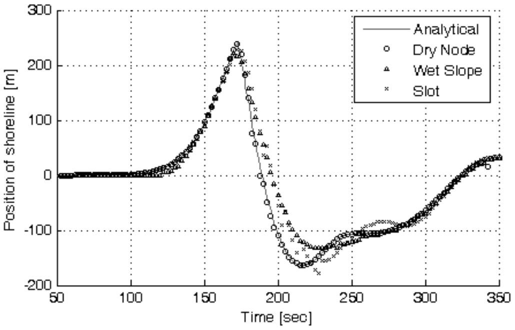

Figure 1 – Comparison between analytical and numerical solutions for runup in benchmark one.

A more thorough discussion of the capabilities, advantages and disadvantages of each runup method for this case and the two dimensional benchmark is given in the full paper. Moreover, the importance of the inclusion of Boussinesq terms is analyzed and finally the influence of trees or other obstacles on the runup patterns is estimated by inclusion of a quadratic bottom friction term.

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