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Internal wave generation on finite element model BOUSS1D_iw: comparison with experimental data

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ABSTRACT

This paper presents a description of a finite element numerical model, BOUSS1D_iw based upon the Boussinesq equation derived by Nwogu (1993). Special attention is given to the procedure implemented into this model for wave generation, by using a source function. In order to validate BOUSS1D_iw model, two literature test cases were chosen. First the BOUSS1D_iw model (one dimensional version) is applied to the simulation of the wave propagation over a constant depth flume considering a regular wave generated in the centre of the flume, to test the source function procedure implemented into the model. After, it is applied to the experiments performed by Dingemans (1994): i.e., the wave propagation over a submerged sill, to analyze the model's performance when simulating the main phenomena involved in nearshore wave propagation, with special attention to nonlinear effects. Comparison between the BOUSS1D_iw numerical results, experimental results and results from another numerical model (Kirby et al (1998)), for time series of water surface elevation and power spectrum, are presented and discussed.

KEY WORDS: Boussinesq; Finite Elements; Source Function; BOUSS1D_iw model

INTRODUCTION

The most important physical effects associated with the nonlinear wave transformation of waves in nearshore regions can be described by Boussinesq-type equations (Kirby (1997)). One example of this class of equations was introduced by Nwogu (1993). These equations describe the nonlinear evolution of waves over a sloping impermeable bottom without considering wave breaking. Their range of validity extends from shallow up to intermediate water depths. Therefore, they seem adequate to describe the wave field outside and inside harbors and sheltered zones.

Walkley (1999) developed a finite element numerical model based upon the Boussinesq equation derived by Nwogu (1993). The Finite Element Method (FEM) is used for the spatial discretisation while the time integration is carried out by using SPRINT package (Berzins 1985). The problem is formulated for the free surface water elevation, the velocity and an auxiliary variable. The boundary conditions included in the model are of three types: generation, radiation and reflection condition.

The generation condition implemented in Walkley (1999) does not deal with the reflected waves inside the domain or incident on the generation boundary. The difficulties arise from the fact that the well-posed initial boundary value problem is unknown for most forms of the model equations. Though it is possible to specify incident wave conditions at the entrance boundary, the characteristics of reflected waves in the computational domain cannot be determined *a priori*. One approach is to generate waves using source function methods, which consist of wave generation inside the domain combined with sponge layers. With these methods, reflected waves are able to propagate through the generation region and dissipate in the sponge layers, without introducing instabilities in the numerical solution. These are specially suited for long simulation times and geometrically complex domains.

The objective of the present work was to replace the internal generation condition in Walkley's (1999) model by a source function following the procedure described by Wei et al. (1999) in his finite difference model. In this method, the source function is derived by a linearized form of the Boussinesq equations and by using Green's functions, an explicit relation between the desired surface wave amplitude and the source function amplitude is obtained. As in Wei et al.'s (1999) method, a Gaussian function is used to distribute the generated wave over several mesh points.

In order to validate the model, and especially its new wave generation condition, the new finite element model, named BOUSS1D_iw, is applied to literature test cases: the simulation of the wave propagation over a constant depth flume considering a regular wave generated in the centre of the flume (Wei *et al.* 1999) and the simulation of wave propagation over a submerged sill, studied experimentally by Dingemans (1994). Numerical results are compared with experimental data and/or numerical results of other models, such as FUNWAVE (Kirby *et al.* (1998)). The comparison of results is performed in terms