RIP CURRENTS ON A BARRED BEACH

Andrea Ruju, rujua@unican.es
Pablo Higuera, higuerap@unican.es
Javier L. Lara, lopezjav@unican.es
Iñigo J. Losada, losadai@unican.es
Giovanni Coco, cocog@unican.es
Environmental Hydraulics Institute 'IH Cantabria', Universidad de Cantabria,
C/ Isabel Torres nº 15, Parque Científico y Tecnológico de Cantabria, 39011 Santander, Spain

INTRODUCTION

Rip currents are seaward oriented currents usually flowing through narrow channels that cut a longshore bar system. They are driven by short wave motion and interact with the underlying sandy bottom representing an important agent for beach forms evolution. In addition, rip currents are known to be among the most dangerous phenomena for beach users.

Due to their academic and practical importance, rip currents have received an increasing attention by the costal engineering community within the last decades (Dalrymple et al., 2011). A substantial number of field and laboratory investigations have addressed the problem of rhythmic nearshore circulation including rip currents. Moreover, a wide range of numerical studies dealing with rip circulation systems are present in the literature.

In this work we investigate rip current circulation by means of the three-dimensional numerical model OpenFOAM based on the Reynolds averaged Navier-Stokes (RANS) equations. The main objective of this work is to study the formation and subsequent evolution of 3D rip current circulation. Model experiments allow for high spatial resolution and so for the use of a quasi-continuum study of the rip circulation thus overcoming limitations related to field and laboratory studies. Moreover, the use of a 3D RANS model is motivated, amongst other different numerical approaches, because the vertical structure of the motion, nonlinearity and wave breaking are directly solved with any imposed assumptions.

NUMERICAL MODEL

OpenFOAM is an open source numerical model solving the three-dimensional Navier-Stokes equations for two phases using a finite volume discretization. The solver used in this study supports free surface flows out of the box, as well as several turbulence models (e.g. k-epsilon, k-omega, LES). Specific boundary conditions to generate waves have been developed. With this new add-on module different kind of waves can be predicted, including Stokes I, Stokes V, cnoidal, Boussinesq solitary wave theories. Also, irregular waves are supported. Simultaneous wave generation and active absorption at the boundaries has been developed to allow for long simulations, avoiding typical problems of this kind of models like increase in water level and agitation. For further details refer to Higuera (2011).

RESULTS

Model simulations have been carried out in a numerical wave tank resembling the geometry used in the laboratory study of Dronen at al. (2002). The fixed smoothed bottom bathymetry is constituted by a bar and a narrow cross-shore channel and thus extends over half a wavelength of a rhythmic rip system. Waves break over the bar and the residual energy is dissipated over a beach located at the end of the tank. Snapshot of a simulation of regular waves is represented in figure 1. Negative horizontal velocities observed in the cross-shore transect along the rip channel (lower panel) identify the development of a rip current. The running time of the simulations is chosen to allow waves and mean currents to reach a quasi steady state. Attention is dedicated to the analysis of the three-dimensional spatial variability as well as the slow oscillations in time of the rip current circulation. Comparisons between rip circulations driven by different wave cases and comparisons to the observations of Dronen at al. (2002) will be discussed during the presentation.

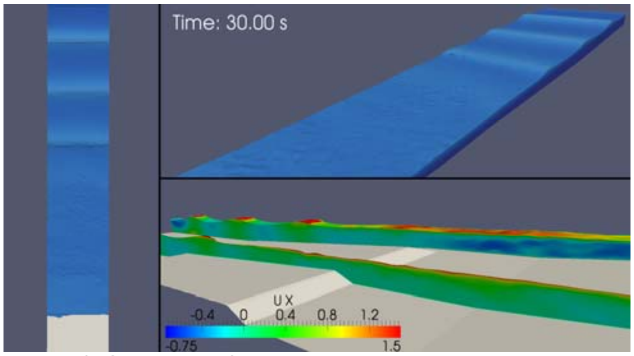

Figure 1. Snapshot of regular waves interacting with a bar and a narrow cross-shore channel. Left panel: top view of the free surface. Upper panel: side view of the free surface. Lower panel: cross shore transects of horizontal velocity

REFERENCES

Dalrymple, MacMahan, Reniers, Nelko (2011). Rip currents. Annual Review of Fluid Mechanics, 43, 551-581

Higuera, (2011). Adapting OpenFOAM to simulate Coastal Engineering processes. Master thesis, Universidad de Cantabria.

Dronen, Karunarathna, Frodsoe, Summer, Deigaar (2002). An experimental study of rip channel flow. Coastal Eng., 45, 223-238