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Jet-wall Interaction in Shallow Waters

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In this work some numerical simulations and experiments, carried out to investigate jet-wall interaction in shallow waters, are described and discussed. Basically, the work aims at the environmental effects of marine structures, e.g. the modifications of the hydrodynamic field due to the interaction of river runoff with a shallow, coastal water body, in the presence of marine structures. Stratification effects are neglected and the focus is on barotropic features, e.g. the interactions between the flow from the river and harbour structures. The numerical analysis was carried out by the classic depth-averaged shallow water equations, and the numerical solution of the discrete problem was achieved by a finite difference method. The experiments were performed in a shallow water tank, obtaining the flow field by PIV. The results point up the importance of the Coanda effect in this framework. The comparison between the numerical solutions and the experimental data shows a meaningful agreement.

INTRODUCTION

On entering shallow coastal waters, river discharge spreads under the effects of marine environment forcing. Typically, civil engineering works give rise to several significant environmental effects along the coast, by means of flow pattern modification. The motivations of this work relate to the problem of polluted fresh-water concentration along the near shore, under the effect of marine structures. The question to be solved is: How does the polluted river water spread, and how can such spreading be improved, from the point of view of water quality along the shore. The problem is complex, due to the interactions of the river flow with the sea stream and with marine structures. This configuration is the combination of 2 flow fields encountered in fluid mechanics, known as the jet in a cross-flow and the impact jet on a wall. The presence of alongshore streams was neglected, i.e. only the forcing terms due to the river runoff were taken into account since, in the present case, major phenomena are assumed to be involved with river flow–harbour structure interaction.

A very large number of numerical models for coastal circulation simulation can be found in the literature; for instance, Casulli (1990) and Borthwick and Barber (1992) can be mentioned (as well as the their bibliography); more recently, Zhou and Stansby (1999), Guillou and Nguyen (1999), and Liska and Wendroff (1999) have proposed new methods. At the present time, due to the large availability of computational power, most of the interest in the coastal engineering community is devoted to 3-dimensional models, hydrostatic and nonhydrostatic. In fact, in several cases it is important to predict the vertical structure of the flow due to salinity and/or temperature variations, thus requiring a 3-D model (e.g. Balas and Ozhan, 2000; Winters et al., 2000; and Li and Wang, 2000).

On the other hand, sometimes the geometry of the problem allows the use of depth-averaged equations, which indeed are still widely, successfully used in the applications. Sometimes, in flow computations concerning large shallow embayments, turbulent horizontal mixing is not carefully taken into account and assumed to be of secondary importance with respect to the vertical mixing; at least, a constant eddy viscosity is used (that is, simulations are performed in so-called laminar conditions, see e.g. Casulli and Cheng, 1992). On the other hand, unless the horizontal scale is very large, horizontal turbulent shear needs some care, in particular in the presence of vertical walls, since in such cases rather misleading results could be obtained, as laminar computations give rise to flow patterns which strongly depend on the constant eddy viscosity value. In this paper, the spreading jet in simple-shaped domains is investigated both numerically (hydrostatic depth-averaged equations) and experimentally (PIV). The numerical solution was achieved by a finite difference method (Lalli et al., 2002), and the experiments were performed in a shallow tank, briefly described below. First of all, the results concerning jet-parallel wall interaction are shown, pointing out how the Coanda effect gives rise to a flow field resembling the backward-facing step flow. The comparison between the numerical solutions and the experimental data shows a meaningful agreement. Next, the flow in a simple-shaped channel-harbour was analysed. Also in this case the numerical velocity field compares to the experimental data in a rather satisfactory manner, although the eddy viscosity is modelled by means of a simple algebraic scheme (Uittenbogaard and van Vossen, 2004). Finally, numerical results are shown for the environmental problem of the Pescara channel harbour (on Italy's Adriatic Sea coast). In this case, the presence of a lateral jetty strongly diverts the river mouth flow and, as a

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