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Numerical study of resonant shallow flows past a lateral cavity: benchmarking the model with a new experimental data set

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Steady shallow flows past an open channel lateral cavity have been widely studied in the last years due to their engineering and environmental relevance, e.g. for river restoration purposes [1]. Such flows can induce the excitation of an eigenmode of a gravity standing wave inside the cavity, called seiche, which may be coupled with the shedding of vortices at the opening of the cavity. A complete understanding of such phenomenon is necessary as it may determine the mass exchange between the main channel and the cavity [2]. A numerical study of the resonant flow in a channel with a single lateral cavity is herein presented. Five different flow configurations at a fixed Froude number (Fr=0.8), measured in the laboratory [3], are used as a benchmark. Such experiments are reproduced using a high-order 2D depth-averaged URANS model based on the shallow water equations, assuming that shallow water turbulence is mainly horizontal [4]. The large-scale horizontal vortices are resolved by the model, whereas the effect of the small-scale turbulence is accounted for by means of a turbulence model. Water surface elevation and velocity measurements are used for comparison with the numerical results. A detailed comparison of the seiche amplitude distribution in the cavity-channel area is presented, showing a good agreement between the numerical results and the observations. Frequency analysis techniques are used to extract the relevant features of the flow. It is evidenced that the proposed model is able to reproduce the observed spatial distribution of oscillation nodes and anti-nodes, as well as the time-averaged flow field. The coupling mechanism between the gravity wave inside the cavity and the unstable shear layer at the opening of the cavity is also accurately captured.

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