Preliminary results on particle dynamics due to interacting breaking-induced and nearbed vortices

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During wave breaking, vorticity is generated at the air-water interface, and surface vortices typically move downward, as an effect of either spilling or plunging breakers in a 2D or 3D fashion. Further, sharp discontinuities in the seabed promote flow separation and generation of nearbed vortices, as in correspondence of submerged sandbars. Such vortices can suspend and transport granular particles with different size and density, like sediments or micro plastics. The interaction between surface (breaking-induced) vortices and nearbed structures is an important link between the upper and lower boundaries of the wave body and leads to complex patterns of tracers' transport.

To inspect the above dynamics, laboratory tests are currently ongoing at the Università Politecnica delle Marche (Italy). A 50m-long wave flume hosts a 2D physical model made of contiguous sloping platforms. The trajectories of slightly negatively buoyant particles (d_p=1.1g/cm^3; St≈10^{-4}-10^{-2}) are reconstructed by PTV measurements. Long-exposure visualizations are used to describe the phenomenon (Fig.1a), while high speed measurements allow to evaluate the vortex-vortex interactions (Fig.1b).

Numerical simulations are also run, using the in-house code Xdolphin3D (Xie et al., 2020) to replicate and extend the range of parameters of the experimental tests. 2D RANS simulations have been run to check the interaction between surface and nearbed vortices shoreward of the discontinuity, while particle tracking and 3D LES are being undertaken to inspect complex vortical structures, difficult to measure in the lab experiments (Fig.1c).

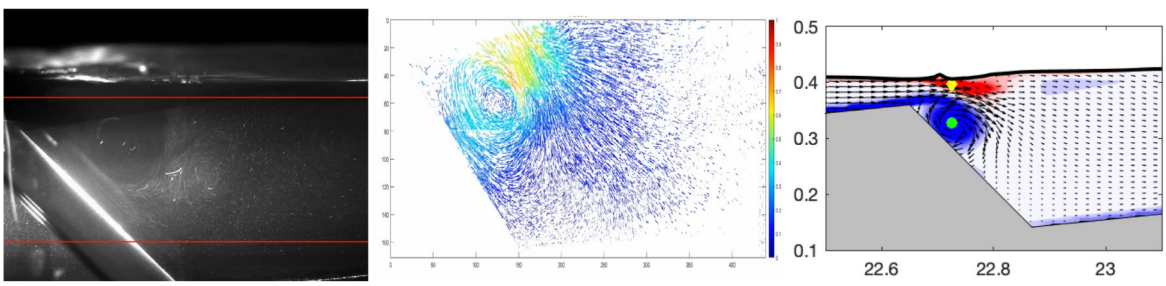

Figure 1: Visualization of the phenomenon (a). Trajectories of particles from the PTV analysis (b) and numerical test (c).

References

Z. Xie, T. Stoesser, S. Yan, Q. Ma & P. Lin. A Cartesian cut-cell based multiphase flow model for large-eddy simulation of three-dimensional wave-structure interaction. Computers & Fluids, 2020, 213, 104747.