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Investigation of wave undertow and turbulence using LDA and ADV measurements

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ABSTRACT

Cross-shore currents induced by breaking waves are often assumed to be responsible for sediment transport and changes in the bathymetry, as well as for seaward transport and dispersion of possible polluting substances released by coastal sources. The mechanism responsible for these phenomena is the undertow, driven by the vertical imbalance of the depth-varying momentum flux and the depth-uniform pressure gradient due to the setup.

The present research aims to investigate the behavior of breaking waves propagating on a sloped bottom, focusing on the modifications of undertow and Reynolds shear stresses from the shoaling zone up to the surf zone. Two experiments were carried out in two different laboratory wave flumes of the Department of Civil, Environmental, Building Engineering and Chemistry of Bari Technical University (Italy). The first one investigates two regular waves breaking on a fixed sloping bottom, which were examined by means of a LDA system to measure their cross-shore and vertical velocities. The second experiment refers to an irregular wave characterized by a narrow banded spectrum, developing on a movable sloped bottom, whose cross-shore, long-shore and vertical velocities were measured by a 3D ADV.

Starting from the Navier-Stokes equation and applying the ensemble-averaging technique, a simple expression was derived to describe the undertow profile. Previous research disregarded the contribution of the wave Reynolds stresses in this equation, considering them small in comparison with the contribution of the turbulent Reynolds stresses and the wave set up. The formulation shown in this study highlights that when the wave Reynolds stresses are taken into account an improved agreement is obtained between measured and modelled undertow.