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Large-Scale Laboratory Observations of Turbulence and Shear Stresses in the Surf Zone

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ABSTRACT

Understanding the dynamics and physics of turbulence is important to the momentum mixing and sediment transport in surf zones. Studies reported by Ting and Kirby (1995; 1996) suggest that the mechanism of turbulent energy transfer is significantly different between the spilling and plunging breakers. The time-averaged turbulent kinetic energy (TKE) in the water column is relatively uniform over depth in a spilling breaker in comparison with plunging breakers (Yoon and Cox, 2010). Such results lead a hypothesis that the turbulence level in the water column should be related to the intensities of the jet impingement and the breaker type, which depend on the scale of the breaking wave, wave conditions, and bottom slopes (in terms of surf parameter). Few studies directly investigate how the turbulence statistics vary with wave conditions in the near-prototype scale breaking waves.

Studies of surf-zone turbulence have mostly been conducted in small-scale laboratory flumes (e.g., Ting and Kirby, 1996; Huang et al., 2009; among many others) and in fields (Ruessink, 2010). The large-scale flume experiment may be one of the solutions to fill the gap between the small-scale flume experiments and field observations (Yoon and Cox, 2010).

Except for turbulent motions, recent study indicates that the horizontal and vertical wave-induced velocities in many nearshore environments, $\tilde{u}$ and $\tilde{w}$, are not in quadrature due to effects of bottom slope, bottom friction and wave breaking (ex., Wilson, 2014). The magnitude of wave shear stress can be larger than the turbulent shear stress, and hence it may provide an additional contribution to the sediment suspension.

In this study, we conduct a large-scale experiment to investigate the vertical structure of turbulent and wave-induced motions in the surf zone. The main goals are to compare the turbulence properties, such as TKE distribution and wave shear stress, induced by different incident waves.