AIR-WATER INTERACTION OF PADDLE WAVES UNDER WIND FORCING

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INTRODUCTION

The air-water interaction has been long studied in ocean physics, due to its importance to natural hazard and impact on human activities (Semedo, 2010). For example, the action of the wind (with or without waves) plays an important role on oil spills horizontal and vertical propagation. Several studies in the literature provided advancements for a better comprehension of gases, mass and momentum exchanges at the interface (Sullivan and McWilliams, 2010, Grare et al., 2013). However, the subject is wide and many aspects are still unsolved, especially it is quite hard to extract data from the air and water boundary layer. A useful method to acquire data at the air-water interface is by cameras, which are not intrusive and can investigate the velocity field in water close to the surface. Numerous methods, such as Particle Image Velocimetry (PIV) and particle tracking velocimetry (Clavero et al., 2016), can extrapolate a huge amount of information in water.

EXPERIMENTS AND METHODS

We perform an experimental study of regular waves generated by paddles propagating under the action of the wind. The experiments were carried out in a wave flume located in Granada (figure 1). The wave flume is 16-m long and 1-m wide, and is composed by two paddles generating and actively absorbing waves, A wind tunnel provides wind acting on the top of the wave flume, with a strong interaction between air and water,

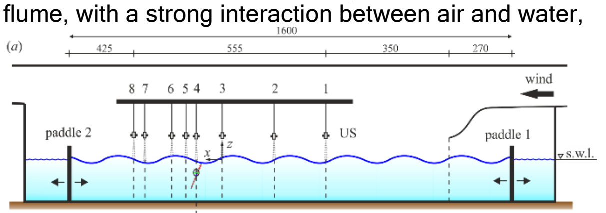

Figure 1 – A sketch of the wave flume used for experiments

Four conditions were tested: wind-only waves (paddles off), paddle plus wind waves (both following and opposing) and paddle-only waves (wind off). The air velocity was measured with a Pitot tube, while the free surface elevation was measured with acoustic probes. We used two cameras with a data rate of 7.14 Hz and applied a stereoscopic PIV technique to reconstruct the 3D velocity field in a plane.

RESULTS

The triple decomposition of a generic variable p is $p = \overline{p} + \tilde{p} + p'$, where $\overline{p}$ is the mean component obtained through a time average, $\tilde{p}$ is the periodic component obtained through a phase average and p' is the fluctuating (turbulent) component which remains after time and phase averages. We apply a triple decomposition to the velocity field and to the free surface elevation. In figure 2, we report an example of the periodic horizontal velocity varying with the wave

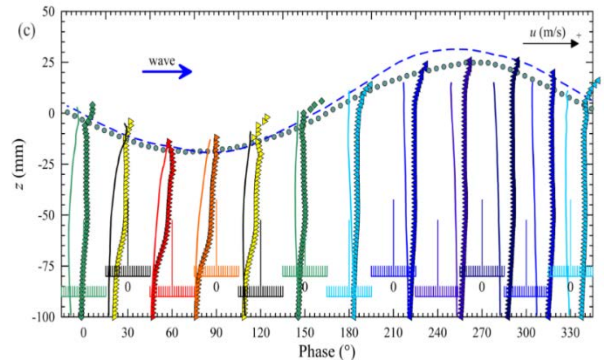

Figure 2 – Periodic horizontal velocity $\tilde{u}$ at varying wave phase

phase. Figure 3 shows the vertical distribution of the turbulent kinetic energy in water. Results show that opposing wind induces weaker turbulent kinetic energy near the surface but penetrates deeper in the water column. If selected for oral presentation, we will discuss the importance of sea surface boundary layer under waves and winds based on laboratory experiments and scale analysis.

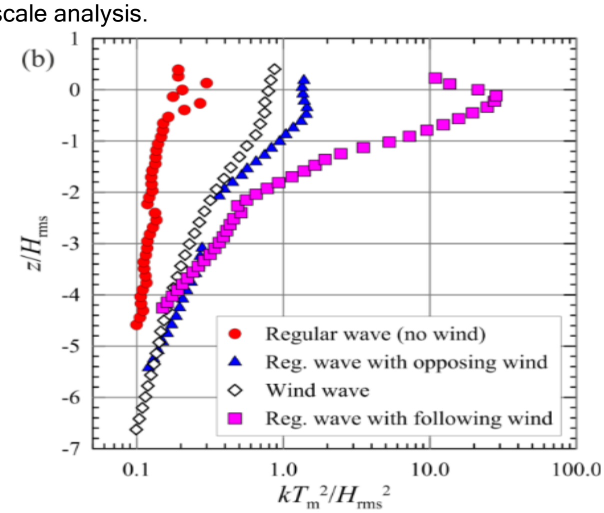

Figure 3 – Vertical distribution of the turbulent kinetic energy for different experimental conditions

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