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Turbulent kinetic energy dissipation rate in laboratory non-breaking surface waves

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Ocean-atmosphere exchange processes are known to decisively determine the sea state, the weather and our planet's climate. With the ultimate goal of a better understanding of the processes contributing with turbulent kinetic energy into both boundary layers above and below the sea surface, we consider the ocean surface wave phenomenon, and in particular we study non-breaking waves generated turbulence. Particle velocities of a non-stratified fluid in the presence of non-breaking waves were measured in the laboratory to determine their association with the occurrence of turbulence and its dependence on the wave slope. A total of 184 experiments with approximately monochromatic waves with slopes varying between 0.012 and 0.273 were analysed. The experiments were conducted in a small wave tank using an acoustic current profiler (Vectrino Profiler, Nortek). Velocity components u, v, and w, were measured in a fluid column 3.5 cm in length, in 35 cells 1 mm in thickness, approximately. The presence of Kolmogorov intervals (isotropic turbulence) was identified in the power spectra of the turbulent fluctuations (u', v' and w'). The various quantities, such as, mean intensity of the turbulent fluctuations, mean turbulent kinetic energy, intensity of the Reynolds stresses, turbulent kinetic energy dissipation rate, and the size of the macro-scale turbulent eddies are presented and analysed as a functions of the waves steepness. The longitudinal and vertical extensions of turbulent eddies are of the same order of magnitude, showing a tendency towards a proportional ratio. The turbulent kinetic energy dissipation rate was always greater than the values predicted by the law of the wall (between one and three orders of magnitude) regardless of the wave steepness, suggesting that the production of turbulent kinetic energy by the mean flow velocity shear is out of balance with its dissipation. Results of turbulent kinetic energy dissipation rate calculated directly through eddy covariance are compared with those from the inertial sub-range estimations.This is a contribution of SENER-CONACYT-Hidrocarburos 201441 project, and support from CONACYT-SENER Sustentabilidad Energética 249795 project is gratefully acknowledged.