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Modelling of turbulence beneath breaking waves

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The main pathways for the mechanical energy input from the atmospheric boundary layer to the ocean are wind stress, breaking waves and Stokes drift forcing. We simulated a joint action of wind stress, Stokes drift and wave breaking on the near-surface turbulent layer using time-dependent 1D model with two-equation $k - \epsilon$ turbulence closure. The model equations are derived by horizontal averaging of Langmuir circulation model (McWilliams et al., 1997). The wave-breaking layer with thickness of half significant wave height was included into consideration. An injection of turbulence by penetrating breakers in this layer was parameterized by source terms in the momentum equation, turbulent kinetic energy k and dissipation rate ϵ equations. We consequently simulated the isolated breaking event,intermittent mixing by breaking waves and vertical structure of wind and wave driven non-stratified sea. The numerical and analytical self-similar solutions were obtained to describe isolated breaking event. It was shown that resulted turbulent layer can be considered as a wake-type current with small net momentum. The evolution of layer in time t includes two sequential stages: (I) Diffusive turbulent layer with dynamically inactive mean velocity; (II) Momentum driven turbulent layer. The self-similar solutions for area averaged turbulent kinetic energy E and square mean vorticity Ω^2 are $E \sim t^{-1}$ and $\Omega^2 \sim t^{-1}$ that agree well with observed in laboratory experiment of Melville et al. (2002) asymptotics and field measurements. The Monte-Carlo simulations of intermittent mixing were carried out. Both simulated and observed (Agrawal et al., 1992) distribution of near-surface dissipation support assumption that observed quasi-lognormal distribution of dissipation rate is associated with breaking of waves in many scales. Time averaged profiles of dissipation rate agree with measurements and stationary solutions. However, temporally intermittent mixing governs the scales of breakup and entrainment in water of air bubbles and oil droplets in the wave-breaking layer. The vertical structure of wind and wave driven non-stratified sea was studied numerically for different regimes: Ekman,

Ekman-Stokes, Ekman-Wave Breaking and Ekman-Stokes-Wave Breaking.

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