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Oil dispersion, turbulent diffusion and transport in the surface layer of sea

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Oil spilled at sea often entrained by breaking waves in stormy conditions and forms clouds of oil droplets that are dispersed by subsurface turbulence and shear currents. In this paper we consequently consider main mechanisms of oil dispersion - wave breaking, formation of oil droplet sizes spectre by breaking waves, turbulent diffusion and transport by wind currents and Stokes drift. We simulated the intermittent mixing by breaking waves using time-dependent 1D model with two-equation $k - \epsilon$ turbulence closure derived by horizontal averaging of Langmuir circulation model (McWilliams et al., 1997). The wave-breaking layer with a half of significant wave height thickness was included into consideration. An injection of the turbulence by penetrating breakers in this layer was parameterized by the source terms in the model equations. The results of Monte-Carlo simulations support assumption that the observed log normal distribution of dissipation rate is associated with breaking of the multiscale waves. Time averaged profiles of dissipation rate agree with measurements and stationary solutions. However, temporally intermittent mixing governs the scales of breakup of oil droplets in the wave-breaking layer. Almost all statistical models of break-up of an immiscible fluid immersed into a turbulent flow were not able to fit observed distribution of oil droplet size. Instead, the new model of the breakup based on Kolmogorov (1941) approach was proposed to reproduce observed lognormal distribution of oil droplet sizes. The 3D Lagrangian model of oil spill based on Smoothed Particle Hydrodynamics (SPH) approach was developed to simulate surface slick, dispersed oil transport and diffusion in the surface layer. The calculations show that knowledge of mean characteristics of breaking wave field is not enough to simulate breakup and dispersion of liquid and gas in the surface layer. The detailed results of simulations of oil dispersion in the wave enhanced layer for stormy conditions by linked model of surface turbulent layer and 3D Lagrangian model of oil spill are presented.