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On the Fluid Dynamical Theory of Turbulent Gas Transfer Across an Air-Sea Interface in the Presence of Breaking Wind-Waves

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ABSTRACT

It is shown that in order to describe the transfer of gases in the liquid near the air-sea interface, the vertical structure of three-dimensional small-scale turbulence in turbulent *patches* generated by breaking waves must be considered. The dependence of eddy diffusivity on distance from a gas-liquid interface inside such turbulent patches is determined, and the pseudothickness of the molecular diffusion sublayer for gases with main resistance to transfer in the liquid phase is calculated. The proposed theory indicates that the appropriate transfer velocity (ratio of gas flux to its concentration difference) is proportional to $Pr^{-1/2}[\nu\epsilon_\nu(0)]^{1/4}$, where $\epsilon_\nu(0)$ is the dissipation of turbulent energy uniformly distributed in the upper part of the turbulent patch, ν is the viscosity and Pr the Prandtl number. Also, the pseudothickness of the molecular diffusion layer has been found to be proportional to $Pr^{-1/2}\eta$, where η = lsqb;$\nu^3/\epsilon_\nu(0)]^{1/4}$, Kolmogoroff's internal scale. It is noted that the dependence of gas transfer across the air-sea interface on the Prandtl number and wind in the proposed theory is different from the results of simple parameterizations based on the analogy with shear-flow turbulence over *rigid surfaces*. The only external parameter in our theory is $\epsilon_\nu(0)$; methods for its determination from the energy balance in the equilibrium interval of the spectrum of wind-generated gravity waves, as well as applications of the theoretical results to field conditions, are discussed.

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