Abstract View

Volume 7, Issue 2 (March 1977)

Journal of Physical Oceanography
Article: pp. 248–255 | Abstract | PDF (650K)

A Realistic Model of the Wind-Induced Ekman Boundary Layer

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(Manuscript received 16 September.1976, in final form October 20, 1976)

DOI: 10.1175/1520-0485(1977)007<0248:ARMOTW>2.0.CO;2

ABSTRACT

A physically realistic and general model for the vertical eddy viscosity in a homogeneous fluid is proposed. For an infinitely deep ocean the vertical eddy viscosity increases linearly with depth from a value of zero at the free surface. Based on this model a general theory is developed for the drift current resulting from a time-varying surface shear stress. Explicit expressions are given for the temporal development of the drift current in the vicinity of the free surface and for the steady-state response to a suddenly applied uniform shear stress. The steady-state solution predicts the effective Ekman layer depth to be proportional to the square root of the wind shear stress and reproduces the experimentally observed logarithmic velocity deficit near the free surface. The angle between the surface drift current and the wind stress is found to be somewhat smaller (of the order 10°) than predicted by Ekman's classical solution. For the unsteady response to a suddenly applied wind stress the present model predicts a much shorter response time than that found by Fredholm based on a constant vertical eddy viscosity assumption. The application of the proposed vertical eddy viscosity model to finite depth conditions, including the effects of slope currents, is outlined.