Abstract View

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On the Effects Of Horizontal Variability of Wind Stress on the Dynamics of the Ocean Mixed Layer

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ABSTRACT

The one-dimensional bulk mixed-layer model of Niiler (1975) is extended to two (or three) dimensions to take account of horizontal variation in wind stress on mixed-layer dynamics. Both surface stirring (Kraus and Turner, 1967) and bulk shear (Pollard *et al.*, 1973) entrainment mechanisms are included. The development of horizontal structure in the upper ocean an the subseasonal to seasonal time scale is the focus of interest. An asymptotic two-timing technique is employed to simplify the dynamical equations. Wind-driven advection can be important in establishing and concentrating horizontal gradients of the sea surface temperature. Wind stress curl-driven vertical velocity can be as important as entrainment velocity in determining the horizontal distribution of mixed-layer depth. Several illustrative calculations are discussed. A case with initially horizontally uniform temperature, 0.05°C m^{-1} initial vertical gradient, and wind stress of 1 dyn cm^{-2} and scale of 1000 km, shows horizontal temperature gradients of ~ 0.01°C km^{-1} in the vicinity of the wind-driven convergence zone after 100 days integration. A similar case, except with initial horizontal gradient of 0.006°C km^{-1}, shows temperature gradients of 0.02°C km^{-1} after 100 days.

In wind-driven convergence zones, mixed-layer depths of 120 m can be achieved after 100 days, by a combination of entrainment and downwelling, mostly the latter, especially after long times. In divergent zones, steady mixed-layer depths can be achieved in less than 100 days through the competition between the effects of upwelling and entrainment. These steady depths range from 20 to 90 m, depending on location.