Abstract View

Volume 8, Issue 4 (July 1978)

Journal of Physical Oceanography
Article: pp. 557–570 | Abstract | PDF (1.08M)

On the Structure and Dynamics of the Oceanic Bottom Boundary Layer

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(Manuscript received June 24, 1977, in final form March 13, 1978)

DOI: 10.1175/1520-0485(1978)008<0557:OTSADO>2.0.CO;2

ABSTRACT

The Mellor and Yamada (1974) Level II turbulence closure scheme is used to study the oceanic bottom boundary layer (BBL). The model is tested against observations of the BBL obtained on the western Florida Shelf reported in Weatherly and Van Leer (1977) and in turn conclusions about the BBL made in that paper are tested against the model. The agreement between the model and the observations is good. The predicted and observed BBL thickness is ~10 m which is appreciably less than $0.4\, u_*/f \approx 30$ m, where u_* is the friction velocity and f the Coriolis parameter. The reason for the discrepancy is attributed to the BBL being formed in water which initially was stably stratified and characterized by a Brunt Vasäilä frequency N_0. It is suggested that the oceanic BBL thickness should be identified with the height at which the turbulence generated in the BBL goes to zero and on dimensional grounds it is proposed that this thickness is $A\, u_*/f(1 + N_0^2/f^2)^{1/2}$, where A is a constant. The Level II model indicates that this is a good approximation over the range $0 \leq N_0/f \lesssim 200$ provided $A \approx 1.3$. Other features common to the predicted results and observations are 1) the vertical profiles of temperature and current direction which are very similar, with most of the direction changes (Ekman veering) occurring at the top of the BBL where the density stratification is largest, 2) a jet-like structure in some of the speed and direction profiles; and 3) appreciably more total Ekman veering than expected for a comparable BBL formed in neutrally stratified water.

The one-dimensional BBL formed under an along-isobath current in a stably stratified ocean is investigated for the case when the bottom is inclined relative to the horizontal isotherms. It is found that the BBL may no longer have the signature of a simple, vertically well-mixed layer because of Ekman-veering-induced upwelling (downwelling) of cooler (warmer) water in the BBL.

The profile of down-the-pressure gradient velocity component in the BBL is found to closely resemble the downslope

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flow of a heavier fluid discussed in Turner (1973). The Froude number stability criteria given in Turner (1973) when applied to the Level II model results suggest that the BBL formed in a stably stratified ocean is, in a Froude number sense, stable or marginally stable on continental margins while it is unstable in the deep ocean.

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