Abstract View

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A Multi-Limit Mixed-Layer Entrainment Formulation

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ABSTRACT

The second-moment equations for buoyancy flux and density-fluctuation variance in the entrainment zone of a mixed layer are combined to yield an entrainment rate (w_e dependence having the nature of Turner's relation. That is, $w_e q^{-1}$ is seen as a function solely of an interfacial Richardson number (Ri_e) involving q where q^2 is twice the interfacial turbulence kinetic energy (TKE). The mean thickness of the entrainment layer is found to be a satisfactory representation of the integral length scale near the mixed-layer interface which was used by Turner. The TKE equation in the entrainment layer is then utilized to evaluate Ri*e* so that w_e can be obtained. This procedure allows the TKE equation to be solved past the point at which the interfacial-shear bulk Richardson number, Ri*v*, becomes critical, and into the more unstable regime beyond where the experiment of Ellison and Turner can give guidance. Previous entrainment parameterizations which retain the critical-Ri_v concept predict infinite entrainment rates at the critical point and negative ones beyond.

The present entrainment results are shown as a function of the various Richardson numbers: Ri_v, Ri_T based on the friction velocity, and Ri_* based on the convective velocity scale, for values of each ranging from near zero to 1000. Comparison is made with previous results, which the present results resemble only in narrow regions of parameter space. For typical values of Ri_T or Ri_*, w_e is found to be enhanced by 10–20% if Ri_v drops from ∞ to 5, and by a factor of from 3 to 8 if it drops to its critical value, $(\mathrm{Ri}_v)_{\mathrm{crit}}$ near 0.7–1.0.

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