Comments on "Determining Height of the Nocturnal Boundary Layer"

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Yu (1978) compares three theoretical diagnostic parameterizations of the nocturnal boundary layer depth with Wangara data. The actual boundary layer depth is estimated in three different ways based on observed profiles of temperature (h_i), wind (h_u) and cooling rate (h_θ). The three theoretical estimates involve various functions of u_*/f and L. However, since f is constant and u_* is highly correlated with L for the data analyzed by Yu [$r(u_*,L)=0.92$], the estimates of the three theoretical models are highly correlated to each other ($r\geqslant 0.97$). Variations of L are dominated by variations of u_*.

On the other hand, the three different estimates of the actual boundary layer depth are poorly correlated with each other [$r(h_\theta,h_i)=0.58$, $r(h_\theta,h_u)=0.20$, $r(h_i,h_u)=0.19$]. Therefore, Yu is unable to conclusively test the three diagnostic methods because they are so highly correlated to each other and because there is considerable ambiguity in determination of the actual boundary layer depth. However, since routine profiles of turbulence quantities in the nocturnal boundary layer do not exist at a reasonably homogeneous site, Yu's approach is the only possibility.

Compared to the three diagnostic methods tested by Yu, we find simply L itself to have a comparable or slightly higher correlation with the three estimates of the actual boundary layer depth [$r(L,h_u)=0.49$, $r(L,h_i)=0.25$, $r(L,h_\theta)=0.43$]. The depth of the momentum jet averages approximately $20L$. One is reluctant to relate the boundary layer depth to only L since L is normally thought to be descriptive of only the surface layer and one expects Ekman scaling (Coriolis effects) to have some influence on the boundary layer depth (e.g., Zilitinkevich, 1972; Clarke and Hess, 1973). However, the Wangara nocturnal flow appears to participate in the frequently observed inertial oscillation in which case accelerations are important. Accelerations can reverse the constraining influence of Coriolis effects on the boundary layer depth. As an example, in the idealized case of oscillating Ekman flow, the depth scale $[K/|f|]^{\frac{1}{2}}$ is replaced by $[K/(\omega-|f|)]^{\frac{1}{2}}$ (Holton *et al.*, 1971), where K is the eddy diffusivity and ω the oscillation frequency of the acceleration. The point is that the influence of Coriolis effects on the depth of the nonstationary boundary layer is uncertain. The remaining obvious parameters influencing the depth of the nocturnal boundary layer include surface heat flux and surface friction velocity. The only reasonable combination of these parameters with units of length is L.

However, L, as well as the three diagnostic methods tested by Yu, all explain less than 25% of the variance of the estimates of the actual boundary layer depth. We conclude that the diagnostic estimates are greatly oversimplified and/or actual depths of the nocturnal boundary layer cannot be determined from profiles of momentum and temperature. Routine measurements of actual profiles of turbulence at different latitudes would be required to resolve this issue.

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