

**ESE 134: Cloud and Boundary Layer Dynamics (HW 2, due April 30):**

[Problems adapted from Stull (1988).]

1. **Dimensional analysis.** Suppose the wind speed  $\bar{u}(z)$  near the surface at night is a function of  $g/\bar{\theta}_v$ ,  $\overline{w'\theta'_v}$ ,  $\partial\bar{p}/\partial x$ ,  $\partial\bar{\theta}_v/\partial z$ ,  $z_0$  (roughness length), and  $u_g$  (geostrophic wind). On which nondimensional groups can the mean wind speed depend?
2. **Similarity theory.** Given the following wind speeds  $u(z)$  measured at various heights  $z$  in a neutral boundary layer, find the roughness length  $z_0$ , friction velocity  $u_*$ , and the shear stress  $\tau_0$  at the ground. What would you estimate the wind speeds to be at 2 m and 10 cm above the ground? (Assume the von Karman constant is  $\kappa = 0.35$ .)

$z$ (m)	$u$ (m s <sup>-1</sup> )
2000	10.0
1000	10.0
500	9.5
300	9.0
100	8.0
50	7.4
20	6.5
10	5.8
4	5.0
1	3.7