Homework Assignment #6

ECE 597UU/697UU, Fall 2009

(Posted on the course website on Thu, 29 Oct; due in class on Thu, 5 Nov)

Problem 1 (6 pts.): *Surface energy budget*

(a, 2 pts.) Suppose the "available energy" $R_{\mathrm{N0}} - G_0$ at the surface is 500 Wm^{-2}. Suppose the Bowen ratio is $B = 3$. Find the sensible heat flux and the latent heat flux. Are these dry or humid conditions?

(b, 2 pts.) Suppose the sun's zenith distance is 60 degrees, and there is fresh snow on the ground (surface albedo $a = 0.8$). Suppose we have ideal conditions, such that there is no shortwave absorption from the atmosphere and no downward longwave radiation from clouds etc. What would the maximum possible available energy at the surface be? Explain step by step!

(c, 2 pts.) As (c), but now assume that there is a high-level cloud layer that causes downward longwave radiation equivalent to a black body radiating at a temperature of $-50^{\mathrm{o}}\mathrm{C}$. Suppose $\varepsilon_s =$ 1.0 for fresh snow. Determine R_{L0}^d. What would the maximum available energy be now, assuming there is no reflection of longwave radiation?

Problem 2 (6+x pts.): *Typos in Chapter 7 of Houghton*

(a, 6 pts.) Find three typos in the equations of Chapter 7 of the 3rd edition of Houghton's *The Physics of Atmospheres*. Give the correct equations and explain!

(extra credits) If you find more typos in the equations of Chapter 7, you get 2 extra credits for each additional typo, assuming you offer correction and explanation.

Problem 3 (3 pts.): *Turbulence in the NBL*

Suppose the (actual) temperature in the NBL increases with 1 K per 100 m. Determine the critical shear (i.e., the minimum value of $|\partial u/\partial z|$) for the onset of turbulence. Discuss your result in the context of the concept of the low-level jet.

Extra-credit problem (6 pts.): *Pressure as a function of height*

Using the hydrostatic equation and the gas equation, and assuming a dry atmosphere, determine $p(z)$ under the following sets of assumptions.

(a, 2 pts.) Isothermal atmosphere: $T(z) = T_0 = \mathrm{const.}$

(b, 2 pts.) Polytropic atmosphere: $T(z) = T_0 - \gamma z$, $T_0 = \mathrm{const.}$, $\gamma = \mathrm{const.}$

(c, 2 pts.) Show that the solution for (b) in the limit of $\gamma = 0$ is equal to the solution for (a).