MAE578 Fall 2011 Homework #4

Parameters for moist air

1. An air parcel has an initial temperature of 28°C and initial specific humidity of 13 g/kg. It is initially located at the 1000 hPa pressure level. (a) What is the relative humidity, γ, and the partial pressure of water vapor, *e*, for this air parcel? (b) If we adiabatically lift this air parcel to the 920 hPa level, will the adiabatic cooling be enough to trigger condensation in the parcel? If not, what is the relative humidity of the air parcel at that pressure level? **[2 points]**

Stability of a moist atmosphere

2. Within the range of $0 \le z \le 10$ km, an atmospheric column has its temperature profile given as

$$T(z) = 300°K - \alpha z , \quad \alpha = 9\ °K/km ,$$

and its vertical profile of relative humidity given as

$$\gamma(z) = 0.9 \exp(-z/\beta) , \quad \beta = 10 \text{ km}.$$

The surface pressure is also known to be p(0) = 1000 hPa. Using p(0) as the reference level, find the vertical profiles of potential temperature, $\theta(z)$, and equivalent potential temperature, $\theta_e(z)$, for this atmosphere. Compare them by plotting the two profiles (for the range of $0 \le z \le 10$ km) together. Then, obtain the profiles of $d\theta/dz$ and $d\theta_e/dz$ and plot them together. Comment on the effect of moisture on the static stability of this atmospheric column. If a calculation of the vertical profile of pressure (by hydrostatic balance) is needed in an intermediate step, you may assume that the contribution of water vapor to pressure loading is negligible (such that p(0) = 1000 hPa is the surface pressure for dry air). This assumption might imply some physical inconsistencies but is fine for the purpose of our exercise. *Note: Strictly speaking, the stability of a moist atmosphere would depend not only on the environmental vertical profile of θ_e but also on the detail of how we perturb that profile, for instance the level at which an adiabatic uplifting commences. Nevertheless, we can still discuss the influence of moisture on stability in the spirit of Sec 4.5.3 in the textbook.* **[4 points]**

Using static neutrality to infer vertical structure

3. **(a)** Solve Prob 8 of Chapter 4 in textbook. **(b)** If the atmosphere in that problem is in hydrostatic balance, how will pressure vary with height between the surface and tropopause? **[2 points]**