Atmospheric Sciences 6150
Exercise 3: Parcel Model
Due February 14, 2013

1. (a) Code a saturation adjustment function (MATLAB or Fortran) based on the algorithm described in the Parcel Model handout.
   Input: $\theta^*, w^*, l^*, p^{n+1}$ (before adjustment; but after all other processes).
   Output: $\theta^{n+1}, w^{n+1}, l^{n+1}$ (after adjustment).

   (b) Use your saturation adjustment code to calculate **and plot** $T(p)$, $\theta(p)$, and equivalent potential temperature[1] $\theta_e = \theta \exp(L w_s / c_p T)$ on one plot, and $w(p), l(p)$, and total suspended water $w_t = w + l$ on a second plot, as a parcel ascends adiabatically from $p = 1000$ mb, where it is saturated at $T = 20°\text{C}$, to $p = 250$ mb. Print your code and plots. *Be sure to label the axes and curves on your plots.*

   The adiabatic ascent can be separated into two processes for computational purposes: (i) Dry adiabatic expansion from p^n to p^{n+1}, followed by (ii) isobaric saturation adjusment. Assume that all condensend water remains in the parcel (reversible).

   For the saturation adjustment to be accurate, $\theta^{n+1} - \theta^*$ must be small because of the linear approximation to $w_s(T^{n+1}, p^{n+1})$. Keeping $\theta^{n+1} - \theta^* \leq 1$ K is sufficient for this. Using $\Delta p = p^{n+1} - p^n = -10$ mb should satisfy this criterion.

   You can determine what Δp is sufficient yourself by using your skew-T log p diagram to compare your calculated $T(p)$ with $T(p)$ along the appropriate saturation adiabat. Some values from this saturation adiabat:

p (mb)	T (°C)
1000	20
750	9
500	- 9
250	- 48

   (c) Same as (b) except:
   (1) Allow precipitation to form by converting cloud water, l, to rain water, which is assumed to fall out of the parcel immediately (irreversible). Use this very simple formulation of the conversion rate:

   $$-\frac{dl}{dp} = -Cl,$$

   for $dp/dt < 0$ only, with $C = 2 \times 10^{-2}$ mb^{-1}.
   (2) After the parcel has reached 250 mb, it descends to 1000 mb.

[1] The equivalent potential temperature is the potential temperature of a parcel that has ascended pseudo-adiabatically until all water vapor has been condensed.