Atmospheric Sciences 5200
Exercise 1: Parcel Model

1. (a) Code a saturation adjustment function (MATLAB) based on the algorithm described in the Parcel Model handout by modifying the template Matlab function `satadjust_dummy.m` (available from the class web page).
Input: $\theta^*, q_v^*, q_c^*, p^{n+1}$ (before adjustment; but after all other processes).
Output: $\theta^{n+1}, q_v^{n+1}, q_c^{n+1}$ (after adjustment).

   (b) Use your saturation adjustment code in the parcel model code `parcel.m` to calculate **and plot** $T(p)$ and $\theta(p)$ on one plot, and $q_v(p), q_c(p)$, and $q_w = q_v + q_c$ 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 $q_s(T^{n+1}, p^{n+1})$. 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, q_c, to rain water, which is assumed to fall out of the parcel immediately (irreversible). Use this very simple formulation of the conversion rate:

$$-\frac{dq_c}{dp} = -Cq_c,$$

   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.