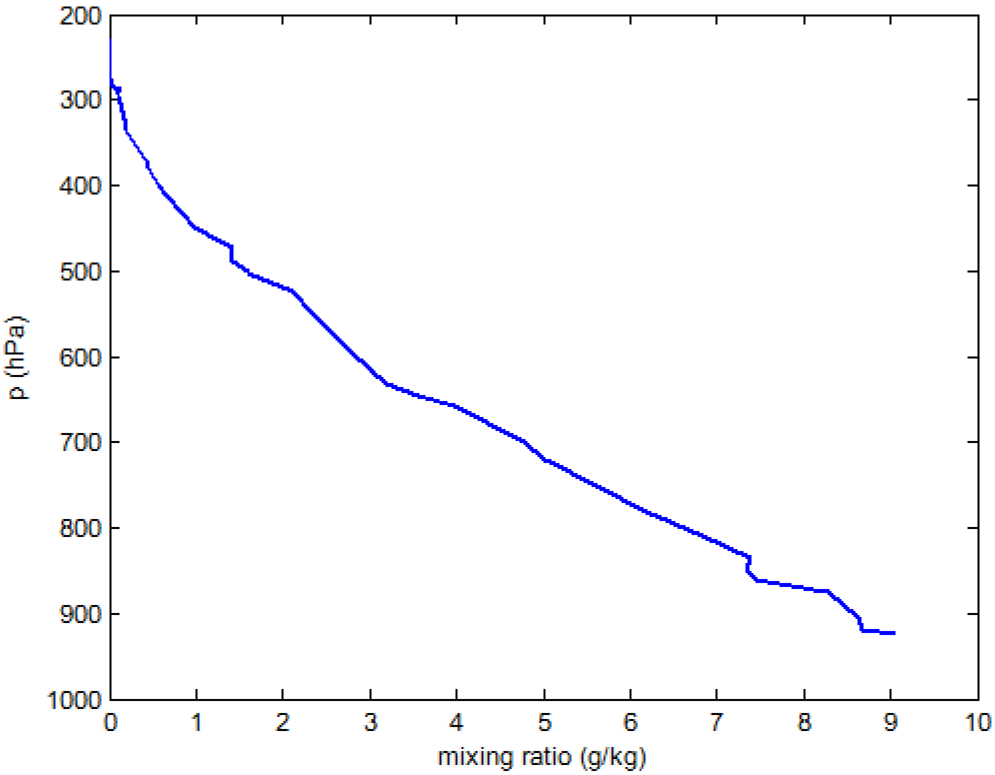
# MAE578, Spring 2015    Homework #3

1. (30%) This problem is a sequel to Prob 1 of HW2. Previously, you have produced a plot of $\Gamma$ vs. $\Gamma_d$ using the data of temperature as a function of pressure. Using an augmented data set which now includes the observed mixing ratio as a function of pressure, try to calculate the (moist) saturated adiabatic lapse rate, $\Gamma_S$, and add the vertical profile of $\Gamma_S$ as a function of z to the existing plot of $\Gamma$ and $\Gamma_d$ (all three should be arranged as a function of z). Based on the plot, discuss how the inclusion of moisture alters the conclusion about static stability.

Note: Because the upper troposphere and stratosphere are extremely dry, the data is truncated at the level of p = 230 hPa. Above that level, the observed mixing ratio is zero such that $\Gamma_S$ and $\Gamma_d$ are the same. For this exercise, please restrict the comparison among $\Gamma$, $\Gamma_{S,}$ and $\Gamma_d$ to below that level. No need to plot the profile of $\Gamma$ above 230 hPa, even if you already have the data from HW2.

The augmented data set and a matlab code (listed below) for reading the data will be posted to our class website. As a quick check, a plot of mixing ratio as a function of pressure is attached below as the output of the code. The mixing ratio (third column in the data file) is in g/kg. Temperature and pressure are in °C and hPa as before.

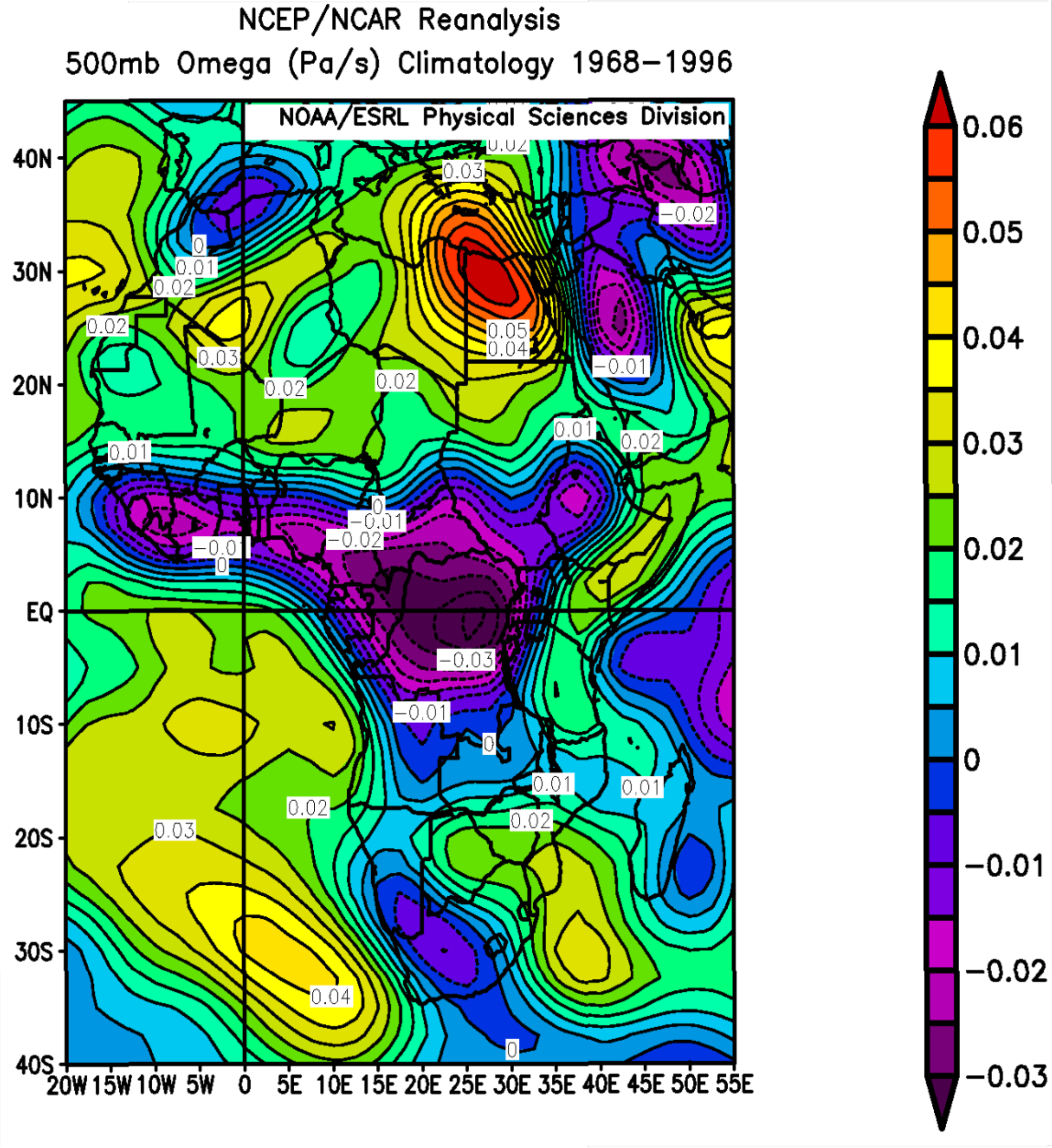
```
clear; fid1 = fopen('mae578_2015_data3var.txt','r');
for n = 1:51
    p1 = fscanf(fid1,'%f7.1'); T1 = fscanf(fid1,'%f7.1');
    mr1 = fscanf(fid1,'%f7.2');
    p(n) = p1; T(n) = T1; mr(n) = mr1;
end
plot(mr,p,'b-','LineWidth',2); axis([0 10 200 1000])
xlabel('mixing ratio (g/kg)'); ylabel('p (hPa)'); set(gca,'YDir','reverse')
```



2. (40%) Solve Prob 11 in Chapter 4 of the textbook. (Note: Depending on your approach, the given information of "$p_T$ = 330 mbar" might be redundant.)

3. (30%) Solve Prob 12 in Chapter 4 of the textbook. Attached below is a plot of the observed long-term climatology of the vertical velocity in p-coordinate at the 500 hPa level over Africa. Is your estimate of the vertical velocity over Sahara from Part (c) of that problem consistent with observation?

Note: The quantity shown in the plot is ω (≡ dp/dt) instead of the vertical velocity in z-coordinate, w. As indicated in the plot, it has the unit of Pa/s. (1 mbar = 1 hPa = 100 Pa.) Note that a positive value of ω means *downward* motion. In fact, vertical velocity is not directly observed. The so-called observed vertical velocity, as shown, is derived from the vertical integration of horizontal divergence (based on the observed horizontal velocity at multiple pressure levels) by the continuity equation. The plot was constructed with the online analysis tool at NOAA Earth Systems Research Lab, Physical Science Division website (http://www.esrl.noaa.gov/psd), using the "NACP/NCAR Reanalysis data".


NCEP/NCAR Reanalysis
500mb Omega (Pa/s) Climatology 1968–1996