# ATOC 5050: Atmospheric dynamics

Homework assignment 1

Due: 5pm, 1 October 2009 (in class, or deliver to David's office)

1. The first law of thermodynamics expresses conservation of energy.

$$c_P \frac{d \ln T}{dt} - R \frac{d \ln p}{dt} = \frac{J}{T}$$

Starting here, do a scale analysis to show that an approximate form tells us that temperature changes are mostly due to imbalance between temperature advection and work done by expansion or compression (i.e., vertical transport of deviation from the dry adiabatic lapse rate):

$$\frac{\partial T}{\partial t} \approx -\left( u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} \right) + w(\Gamma - \Gamma d)$$

Make sure to explain how you scale each term in the full equation.

(Hint: Recall, Holton pg. 53, we can express a quantity as the some of a reference state and some deviation. E.g., $T_{total}(x,y,z,t) = T_0(z) + T(x,y,z,t)$, which leads to a useful expansion of $\ln T_{total}$)

2. Visit the NCAR/NCEP Reanalysis Atlas web site at NOAA http://www.cdc.noaa.gov/data/ncep_reanalysis/. Navigate the site to look at atmospheric fields on a day of interest sometime in the last 36 years (no earlier than 1973).

a) Obtain maps of geopotential height at 1000 and 500 and 300 hPa for a region centered on Denver. Scale you map such that it covers the continental USA. Save the graphics to hand in.

b) Over Denver, estimate the geostrophic wind speed and direction at each of the three heights.

c) Over Denver, estimate the 1000-500 hPa thickness, and derive the mean lower tropspheric temperature from this.

3. Go to the University of Wyoming web site (http://weather.uwyo.edu/upperair/sounding.html) and obtain a skew T-log p diagram of a balloon sounding from Denver for the same day of interest sometime in the last 36 years. *(Tip: the PDF version is higher resolution than the GIF)*

With your sounding, white down the definition (textual description and the pertinent equation) and explain your working to compute the quantities below. Construct a table with values for each of 800, 700, 500, and 300 hPa (as columns) with the following information:

a) Temperature
b) Dew point temperature
c) Water vapor (mass) mixing ratio
d) Saturation mixing ratio
e) Potential temperature
f) Equivalent potential temperature
g) Wind speed
h) Wind direction

Also list the numeric value of the following and mark them on your downloaded figure:

i) Any layers that may have cloud.
j) Identify any layers that are almost dry adiabatic
k) Identify any layers that are almost moist adiabatic
l) Determine the pressure of the tropopause on this day
(mark this with an arrow and a label)
m) Graphically determine the lifting condensation level
(list this, and mark this with an arrow)
n) Graphically determine the level of free convection
(mark this with an arrow and label)
o) Graphically determine the level of neutral buoyancy
(mark this with an arrow and label)
*p)* Shade the area for which there may be convective available potential energy.
(*Warning possible trick question – there may not be one!)*

(Tip: you might find that having so many labels on your figure becomes confusing. Feel free to include multiple copies of the diagram)