ATSC 5010 – Physical Meteorology I Lab
Lab6 – Pseudo-Adiabatic Processes

From last week's lab (Lab 5) we are able to predict how a parcel's temperature and dewpoint will change as the parcel is lifted (or descends) through the atmosphere. However, these predictions are only valid for parcels that remain unsaturated and no condensation occurs.

To consider changes within a parcel after saturation has occurred one needs to consider *saturated* or *pseudo-* adiabatic processes. If saturation is reached, and a parcel continues to cool, water will condense. The condensation of water 'releases' heat (through the latent heat of vaporization/condensation) that gets added back into the parcel (because the process is adiabatic---it doesn't got to the environment). Thus, a parcel that is saturated and continues to cool, will cool at a slower rate than an unsaturated parcel.

Difference between saturated and pseudo-adiabatic processes:

- In a **pseudo-adiabatic process**, the water that is condensed is removed from the parcel immediately. Thus, pseudo-adiabatic processes are not truly adiabatic (it is an open system since we are removing liquid substance from the parcel) and the process is then not fully reversible.

- In a **saturated adiabatic process**, the condensed water remains with the parcel. In this case, the cooling rate (for a parcel that is saturated and being lifted) is slightly different because the condensed water in the parcel contains some heat. A saturated adiabatic process is truly reversible.

For today's lab we will consider 'pseudo-adiabats'. Here we need to consider only that amount of heat that is added to the parcel due to latent heat (during the condensation process). For this we consider the equivalent potential temperature:

$$\theta_e = \theta \cdot exp\left\{\frac{L_{v0} w_s}{c_{pd} T}\right\}$$

The equivalent potential temperature is a function of w_s and T, recalling that w_s is a function of P and T.

So, in today's lab you will build a thermo-dynamic diagram called a pseudo-adiabatic chart. You will use your pseudo-adiabatic chart (and the information provided above) to answer questions for atmospheric processes that occur in a saturated parcel.

Exercise:

The procedure you build today will be very similar to our latest work on thermodynamic diagrams (you may want to use Lab5 as a starting point, note however, that the chart limits may have changed…)

1. This week's procedure will have the name "atsc5010_*yourname*_lab6"
2. Build a chart, similar to last week with the following characteristics:
   - Your chart background should be white, your axes and gridlines should be black solid lines, and the chart size 500 pixels (in x) and 600 pixels (in y)
   - Temperature range from -30 to +40 C (label every 10 degrees, 0.1 C resolution)
   - Pressure range from 1050 mb to 250 mb (label every 100 mb, 1000 to 300, 1 mb resolution)
   - Potential Temperature lines 250 to 460, label every other line, lines **thick**, solid "Dark Green"
   - Mixing Ratio lines (in g/kg): 0.5, 1, 2, 3, 4, 6, 8, 11, 15, 20, 30, 50, 75, 125, label every line, solid "red"
   - Equivalent Potential Temperature lines: 250 to 350 every 10 K, 370 to 450 every 20 K, 510 to 870 every 60K, **do not label any of the lines**, **dashed "Dark Green"**
   - Chart Title should read: "ATSC5010, Lab 6: Pseudo-Adiabatic Chart"

Computing saturation mixing ratio array and equivalent potential temperature:
It is OK to use a for-loop to compute saturation mixing ratio and equivalent potential temperature lines.

For this week's questions, I would like you to use your chart to answer the following questions. ***This week, it is not necessary to utilize IDL to code the answers****. For your answers—turn in a printout(s) out of your chart illustrating how you arrived at your answers.*

QUESTIONS:

1. Consider a parcel at 1000 mb, with a temperature of 30 C, and a dewpoint of 20 C. What is the mixing ratio and saturation mixing ratio of the parcel?
2. For the parcel in (1), what is the pressure and temperature at the LCL? What is mixing ratio and the dew point at the LCL?
3. Continue to raise the parcel to 600 mb. What is the temperature of the parcel? What is the dew point of the parcel? What is the mixing ratio? Is the mixing ratio greater than, less than or the same as it was at the beginning (1000 mb)? If it is different, explain.
4. At 600 mb, is the parcel warmer, colder, or the same as the temperature would be for a similar parcel beginning at 1000 mb with a temperature of 30 C being lifted to 600 mb that does not saturate. If the final temperatures are different explain why.
5. Take a saturated parcel at 750 mb and a temperature of 0C. What is the mixing ratio? What is the saturation mixing ratio?
6. Let the parcel descend to 1000 mb. What is the new temperature, dew point, mixing ratio, and saturation mixing ratio?

7. Begin with a parcel at 850 mb, with a temperature of 25 C and a dew point of 15 C. Raise the parcel to 400 mb. What is the mixing ratio and temperature of the parcel? Is the parcel saturated?
8. If the process in (7) were allowed to follow a *saturated adiabat* (instead of a pseudo-adiabat) in its ascent to 400 mb, would the final temperature be greater, less, or the same as your answer to (6)? Explain.
9. Begin with a parcel at 1000 mb with a temperature of 10 C and dew point of 0C. Raise the parcel to 600 mb. Then, allow the parcel to descend back to 1000 mb. Is the final temperature different than the initial temperature? What about the final dewpoint compared to the initial dew point? Explain.
10. Consider wet-bulb temperature. The Wet Bulb Temperature is defined as the temperature to which a parcel of air is cooled by evaporating water into it at constant pressure until the air is saturated. One can *estimate* the wet bulb temperature using a pseudo-adiabatic chart by taking a parcel with an initial temperature and dew point, raising the parcel until saturation is reached, and then following a pseudo-adiabat back down to the original level. What is the wet-bulb temperature for a parcel at 800 mb with a temperature of 20 C and a dew point of 5 C?
11. The distance between 900 mb and 1000 mb is *roughly* 1 km. Consider a layer that has an average temperature of about -20 C. <u>Estimate</u> the pseudo-adiabatic lapse rate between 1000 and 900 mb based on your chart. Compare this to an estimated pseudo-adiabatic lapse rate between the same pressure levels for a layer that has an average temperature of 20 C. Why the difference? Note that the dry adiabatic lapse rate is the same (9.8 C/km) for both layers. Which layer (the colder or the warmer) has a pseudo-adiabatic lapse rate closer to the dry adiabatic lapse rate? Explain.