San Francisco State University Spring 2018
Department of Earth & Climate Sciences

ERTH 260: Physical Processes in the Atmosphere

Inclass Exercise 7: **Working With Soundings: Relative Humidity and Mixing Ratio Lines on Thermodynamic Diagrams (100 pts)**
Due Friday 16 March 2018

Table 1 below gives the mixing ratio information you will be using in Lab 7 and discussed in the lecture portion of the class. As explained in class, the mixing ratio information can either be calculated or determined experimentally for various dew point temperatures.

| **Table for Celsius Temperature** | |
|---|---|
| Temperature (°C) Or Dew Point Temperature (°C) | Saturation Mixing Ratio (g / kg) Or Mixing Ratio (g / kg) |
| -40 | 0.1 |
| -30 | 0.3 |
| -20 | 0.8 |
| -10 | 1.8 |
| 0 | 3.8 |
| 5 | 5.4 |
| 10 | 7.6 |
| 15 | 10.6 |
| 20 | 14.7 |
| 25 | 20.1 |
| 30 | 27.2 |
| 35 | 36.6 |
| 40 | 49.0 |

Table 1. Mixing Ratios (g/kg) for various dew point temperatures

As we will see in the lecture portion of the class, the data actually represent the amount of water vapor present in a kilogram of air when the relative humidity is 100%, at the end point of the virtual experiment we will run in class during the lecture. It represents the absolute maximum value of water vapor that can be sustained in a kilogram air parcel at a given temperature.

However, as will be seen, it takes time for that water vapor to actually "develop" in that air parcel (the time it takes for the virtual experiment we run in class to get to completion). At times before that, less water vapor will be present. This allows us to develop the concept of RELATIVE HUMIDITY. It turns out that the dew point of the air parcel will always give us enough information to determine the actual amount of water vapor present in a kilogram air parcel (mixing ratio; w). The actual temperature will give us the information of the end point of the experiment run in the lab and is called the saturation amount of water vapor (saturation mixing ratio; $w_s$).

The relative humidity humidity can simply be obtained by

$(w/w_s) \times 100 = RH\ (\%)$

It turns out that both w and $w_s$ are also dependent upon pressure and can be plotted on thermodynamic diagrams. Thus, thermodynamic diagrams like the Stüve and the Skew-T/Log p can be used to calculate relative humidity.

Figure 1 is the sounding for KOUN for 12 UTC March 6, 2017.

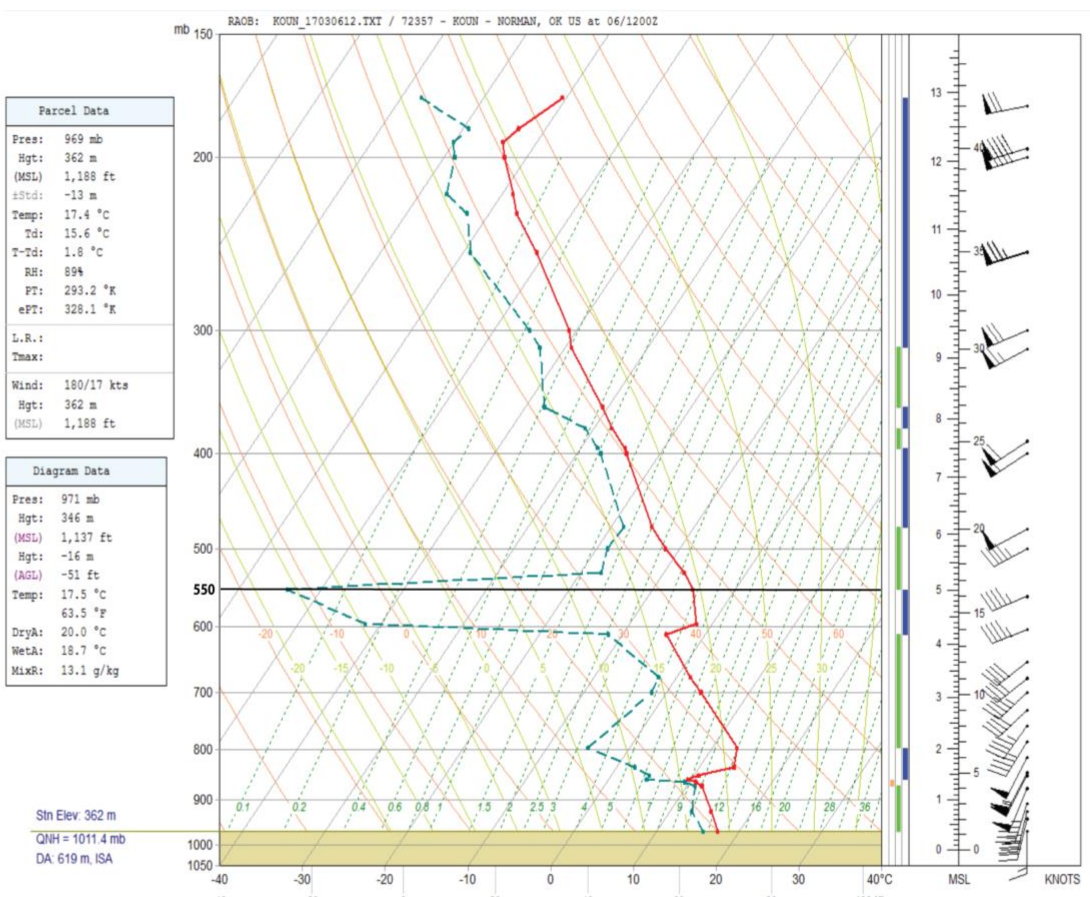


Figure 1: Sounding for KOUN for 12 UTC March 6, 2017

Exercise 1

1. Determine the relative humidity at the surface and at 500 mb (using the steps outlined in the Appendix. Show all work.) (50 pts)
2. Assume that there is an air parcel at the surface with the same temperature and dew point as shown in the environment. The summary of data for that air parcel is shown in the box at upper left. Answer in complete sentences.
    a. Explain why the surface pressure is so low (not near 1000 mb). (10 pts)
    b. Why is the bottom of the sounding paper colored with brown shading? (10 pts)
    c. The entry labeled PT is the Potential Temperature. How is the potential temperature shown here consistent with the labeling on the adiabats? (10 pts)
3. Assume that there are two air parcels at Oklahoma City both with RH 100%. One air parcel has a temperature of 30C and the other a temperature of 10C. Say that all the water vapor in each parcel precipitates out as rainfall. Answer in complete sentences
    a. Which air parcel would be associated with more rainfall and why? (10 pts)
    b. How much more rainfall would occur (either as a ratio or an amount in g) would occur for the air parcel you've chosen? (10 pts)

Appendix

a. Highlight the mixing ratio line that extends from the temperature for the level or parcel being considered;
b. Label this line with the interpolated value of saturation mixing ratio in g/kg;
c. Highlight the mixing ratio line that extends from the dew point temperature for the level or parcel being considered;
d. Label this line with the interpolated value of mixing ratio in g/kg;
e. Divide the value in (d) by the value in (b) and multiply by 100—this gives the relative humidity in %.