**CE 374K Hydrology Computation of Atmospheric Water Conditions Spring 2013**

**Example:** The weather conditions in Austin on the morning of 24 January 2013 were air temperature 69°F, relative humidity 73%, and air pressure 30.25 in Hg. Calculate the corresponding vapor pressure, specific humidity, vapor density and dew point temperature.

**Solution:**

1. First, let’s convert everything to SI units:

**Air pressure** of 30.25 in Hg = **102.43 kPa**. I did this with a web converter <http://www.onlineconversion.com/pressure.htm> The conversion factor is 1 inch Mercury = 3.386 kPa.

**Air temperature** of 69°F = (69-32)\*(5/9) = **20.55°C**

1. Determine the saturated vapor pressure, es, for the current air temperature.

In applying this equation, there are couple of common errors, one is substituting 273 for 237 in the lower part of the radical, and another is to ensure that you have the temperature in °C**.** Note that the resulting saturated vapor pressure is in Pa not kPa.

1. Determine the actual vapor pressure using the saturated vapor pressure and the relative humidity:

Hence the **vapor pressure** corresponding to these atmospheric conditions is **1766 Pa.**

1. The specific humidity, qv, is determined as:

The points to be careful about in this calculation are that the vapor pressure, e, is in Pascals and the air pressure, p, is in kPa and has to be converted to Pa.

Hence the **specific humidity** corresponding to these atmospheric conditions is **0.0107 kg/kg**, which says that the water vapor makes up about 1% of the moist air by weight.

1. The vapor density, v, is determined using the Ideal Gas Law:

where Rv is the gas constant for water vapor. Gas constants for specific gases are related to the Universal Gas constant through their molecular weights. In this instance, the gas constant for water vapor can be computed from the gas constant for dry air, Rd = 287 J/kg°K, using:

where 0.622 = 18/28.9 which is the ratio of the molecular weights of water vapor (18) and the average molecular weight of dry air (28.9 – a mixture of Nitrogen at 28 and Oxygen at 32). Hence, the vapor density can be determined using T = 273 + 20.55 = 293.55 K as

Hence the **vapor density is 0.013 kg/m3**. At a sea level in a standard atmosphere, the density of air is about 1.225 kg/m3, so you can again see that the water vapor constitutes about 1% of the air in Austin in these conditions.

Notice that in using the Ideal Gas Law, the temperature, T, is absolute temperature in degrees Kelvin. Switching back and forth between T in degrees Centigrade and T in degrees Kelvin is confusing, and there isn’t any other way of doing it than knowing the units of T in each equation in which you use it.

1. To obtain the dewpoint temperature, we have to find the temperature, T, for which the current vapor pressure (1766 Pa) would represent saturated air.

So, in this instance

And I used the Solver Addin to Excell to solve this equation to give T = 15.54°C. Hence the **dewpoint temperature is 15.54°C** which corresponds to 60°F. This is not much below the observed air temperature of 69°F, so you can see why we have foggy conditions in Austin in the early morning at this time of year.