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Calculation of Sea Level Pressure From Local Pressure

The following are the equations for calculating the sea level pressure in inches of mercury from the local pressure as measured by your barometer (aneroid or mercury).

Suppose the following data:

1. The local pressure P is 988.69 millibars.
2. The outdoor temperature T is 85.2 degrees F.
3. The outdoor relative humidity RH is 65.0%.
4. Your elevation E is 720 feet above sea level.

First, calculate the saturation pressure of water vapor at the outdoor temperature (You could also look it up in the Smithsonian Meteorological Tables, available on this website):

$$e_{sat} = 6.11 \times 10^{7.5\left(\frac{T-32}{1.8\left(237.3+\frac{T-32}{1.8}\right)}\right)}$$

where 10 is raised to the 7.5(…) power. Using the actual values:

$$e_{sat} = 6.11 \times 10^{7.5\left(\frac{85.2-32}{1.8\left(237.3+\frac{85.2-32}{1.8}\right)}\right)}$$

Solving,

$$e_{sat} = 41.372\ millibars$$

Second, calculate the saturation mixing ratio for the outdoor air:

$$r_{sat} = \frac{0.62197\left(\frac{e_{sat}}{P}\right)}{\left(1-\left(\frac{e_{sat}}{P}\right)\right)}$$

Using the actual values

$$r_{sat} = \frac{0.62197\left(\frac{41.372}{988.69}\right)}{\left(1-\left(\frac{41.372}{988.69}\right)\right)}$$

Solving:

$$r_{sat} = 0.02716$$

Third, calculate the actual mixing ratio for the outdoor air:

$$r = \left(\frac{RH}{100}\right) r_{sat}$$

Substituting the actual values:

$$r = \left(\frac{65.0}{100}\right) \times 0.02716$$

Solving,

$$r = 0.0177$$

Fourth, calculate the virtual temperature. The virtual temperature is the temperature of dry air that has the same density as the moist air:

$$T_V = \frac{\left((459.69+T)\left(1+\left(\frac{r}{0.62197}\right)\right)\right)}{1+r} - 459.69$$

Substituting the actual values:

$$T_V = \frac{\left((459.69+85.2)\left(1+\left(\frac{0.0177}{0.62197}\right)\right)\right)}{1+0.0177} - 459.69$$

Solving:

$$T_V = 90.96\ degrees\ F$$

Fifth, calculate the sea level pressure from the hydrostatic equation:

$$P_{SL} = P \times exp\left(\frac{9.81\left(\frac{E}{3.2808}\right)}{287\left(273.16 + \left(\frac{T_V - 32}{1.8}\right)\right)}\right)$$

Where *exp* is the exponential function. Substituting the actual values:

$$P_{SL} = 988.69 \times exp\left(\frac{9.81\left(\frac{720}{3.2808}\right)}{287\left(273.16 + \left(\frac{90.96 - 32}{1.8}\right)\right)}\right)$$

Solving,

$$P_{SL} = 1{,}013.23\ millibars$$

You can see the advantage of doing the calculation in a spreadsheet, it's too tedious to do by hand for every barometer reading.