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HMWK #6

#1: Using the DRI and UNR data from the last homework assignment, calculate the average virtual temperature for the layer between these two stations using the hypsometric equation. Then calculate the virtual temperature at each of these stations, take the average value, and compare with the value you get from the hypsometric equation. Interpret. Make a graph of the average virtual temperature versus time for both of these methods. Also, make a scatter plot of the average virtual temperature from both methods, and compare using a linear regression model.

(refer to spreadsheet for calculations)

➔ The equation for estimating virtual temperature is:

$$T_v = \frac{T}{1 - \frac{e}{p}(1 - \varepsilon)}$$ where T is the measured temp, e the vapor pressure, p the atmos. pressure, and ε=0.622.

We are given T and p from measurements and therefore must estimate e from the relative humidity, which is also a measured variable, to solve for the virtual temperature. We could also estimate the virtual temperature indirectly by using the hypsometric equation:

$$T_v = \frac{g(Z_2 - Z_1)}{R_d \ln\left(\frac{P_1}{P_2}\right)}$$

The height difference between DRI and UNR is 143 meters (thickness of layer) and the atmospheric pressures at each station are measured quantities. The estimates of Virtual temperature using the hypsometric eqn. are included in Figure 1.

➔ To estimate e we can use the fact that:

$RH = 100\frac{e}{e_s}$, where e is vapor pressure and e_s is saturated vapor pressure.

Saturated vapor pressure can be determined using the relation:

$$e_s = 6.11mb * \exp\left(\frac{L}{R_v}\left[\frac{1}{273} - \frac{1}{T}\right]\right)$$

The resulting T_v's found using the relative humidities at both levels are averaged and plotted also in Figure 1.

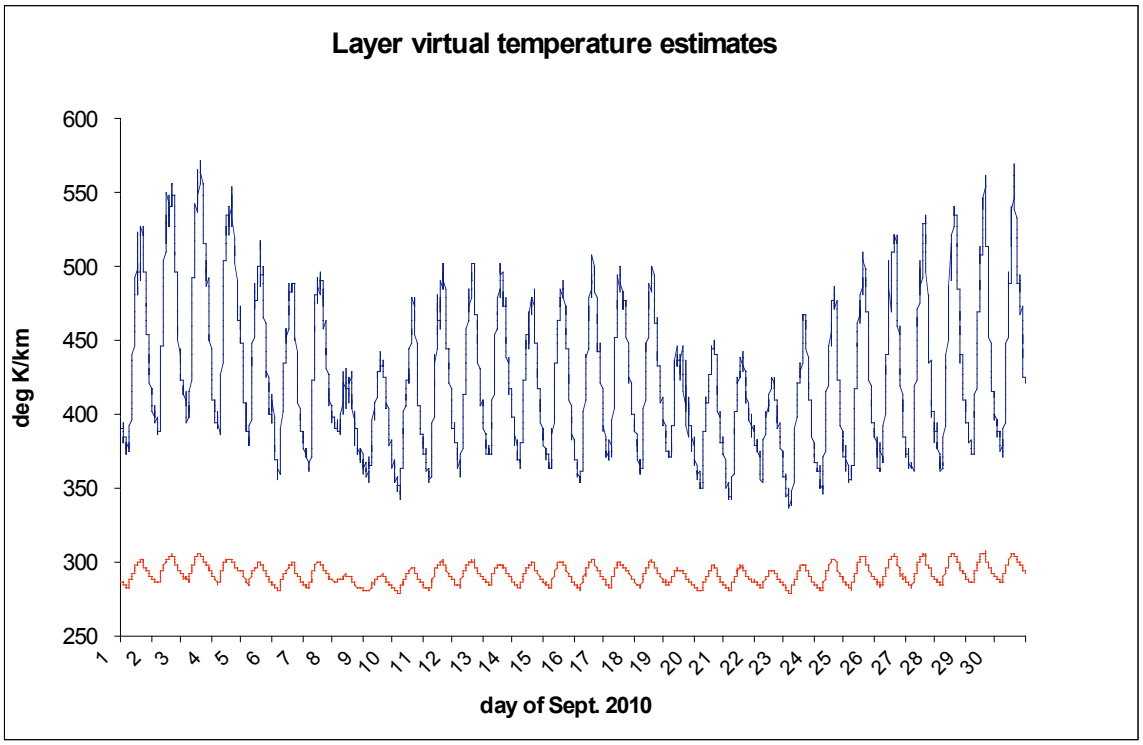
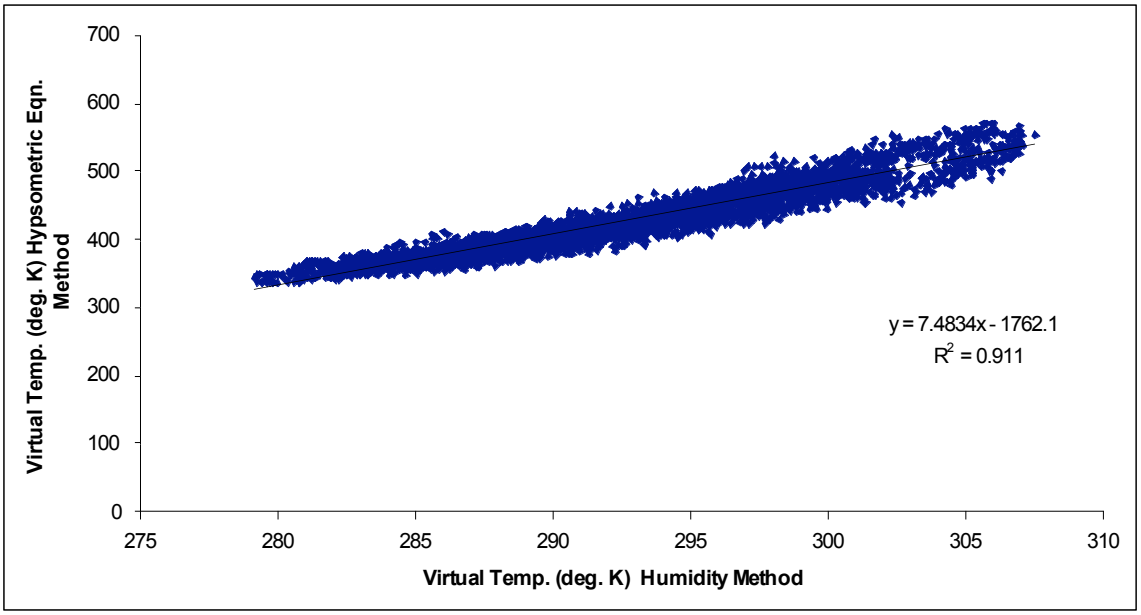


Figure 1. Plot of virtual temperatures for the Sept. 2010 period using both the hypsometric equation method (blue line) and humidity/averaged method (red line).

The values using the Hypsometric equation vary greatly from the values found using the humidity. These values are also too high, reaching unphysical values that suggest a huge fraction of water vapor in the air. There is obviously a measurement bias at one or both stations resulting in some error in pressure or elevation. In fact, using a T_v estimate of 290° K in the hypsometric equation results in a thickness of around 110 meters. This thickness estimate isn't too far from the 143 meters estimated. It is possible that the UNR barometer is higher than estimated or located up on a building (to explain the error).

Figure 2 includes a scatterplot comparing the two sets of measurements to each other. The plot indicates a near linear relationship with R^2 of 0.91, indicating a strong relationship. However, we would expect the slope to be near 1 even with measurement error; the observed slope is near 7.5.


Virtual Temp. (deg. K) Hypsometric Eqn. Method
700
600
500
400
300
200
100
0
275
280
285
290
295
300
305
310
Virtual Temp. (deg. K) Humidity Method
y = 7.4834x - 1762.1
R2 = 0.911