Physical **H**ydrology for **E**cosystems

BEE 3710

Assignment #7: Potential Evapotranspiration (Due 3/13)

1a) If the air temperature is 20^{o}C and the relative humidity is 40%, what are: the vapor density, dew-point temperature, and vapor density if the air were "saturated?"

1b) If the dew-point temperature is 15^{o}C and the air temperature is 20^{o}C, what are: the relative humidity and vapor density?

2) If the air temperature is 10^{o}C and vapor density of the air is saturated, is it possible to have any evaporation? If not, why. If so, explain and give an example.

3) Derived the Penman's mechanistic equation for estimating PET. Recall the suite of equations you'll need (variables are defined in your "Daily Potential Evapotranspiration" handout):

Energy Balance: $Q_e = Q_{rn} - Q_h$ (kJ/m^2)

Sensible Heat Equation: $Q_h = C\left(\frac{T_s - T_a}{r_h}\right)$ (kJ/m^2)

Latent Heat Equation: $Q_e = \lambda_v\left(\frac{\rho_{vs}^o - \rho_{va}}{r_v}\right)$ (kJ/m^2)

Penman Approximation: $\rho_{vs}^o = \rho_{va}^o + \Delta(T_s - T_a)$ (kg/m^3)

Resistance Assumption: $r_v = r_h$ (d/m)

You should get:

$$Q_e = \frac{\Delta(Q_{rn}) + \frac{C}{r_v}\left(\rho_{va}^o - \rho_{va}\right)}{\left(\Delta + \frac{C}{\lambda_v}\right)} \quad \text{(kJ/m}^2\text{)}$$

Also show how to transform Q_e into PET (mm/day)

4) The Penman equation can be written somewhat more simply for daily PET:

$$PET = \frac{\Delta(Q_s + Q_{la} - Q_{lt}) + \gamma f(u)\left(\rho_{va}^o - \rho_{va}\right)}{(\Delta + \gamma)}\left(\frac{1}{\lambda_v \rho_w}\right) \quad \text{(m/d)}$$

where PET is in cm/day, Δ is the slope of the saturation-vapor-density-curve (kg m^{-3} ^{o}C^{-1}), γ is the psychrometric constant (C/λ_v = 4.95x10^{-4} kg m^{-3} C^{-1}), Q_s, Q_{la}, and Q_{lt} are the solar, atmospheric long wave, and terrestrial long wave radiation (kJ/m^2), respectively, ρ^o_{va} is the saturated vapor density at the air temperature (kg m^{-3}), ρ_{va} is the actual vapor density of the air (kg m^{-3}), $f(u)$ is the wind function (kJ d m^{-1} ^{o}C^{-1}) [$f(u) = \lambda_v/r_v$ = 458,000(1+u), where u is the average daily windspeed (m s^{-1})], λ_v is the latent heat of vaporization (2500 kJ kg^{-1}). The right-most term in the equation above converts from kilograms of evaporation per square meter of ground into meters of evaporation; ρ_w is the density of water (1000 kg m^{-3}). Make sure all your units work. Priestly and Taylor (1972) proposed the following simplified, approximate form of the Penman equation:

$$PET = \alpha \frac{\Delta}{(\Delta + \gamma)} (Q_s + Q_{la} - Q_{lt}) \left(\frac{1}{\lambda \rho_w} \right) \quad (2)$$

where α is typically around 1.26.

Calculate PET using the Penman or Priestly-Taylor equation for the location assigned in lab. Turn in a graph of one year of PET and work-by-hand of one or two days of PET.

Extra Credit: Determine the average annual PET for Ithaca and compare this estimate with the estimates/calculations of **ET** from homework #2 (the watershed assignment).

Summarize your results in some succinct way so that comparisons are easy. For example, use a table and/or graphs. In which method do you have the most and least confidence? **Do not hand in a print-out of a spreadsheet!!!!**