Calculating Evapotranspiration

Done according to the following equation circled in yellow. Notice that this simplified equation assumes what is highlighted in Green (regarding albedo, resistance, and crop height): Also in our code we set Kc (the crop coefficient to =1 but should be adjusted accooridng to specific crop and physiological age coefficient. The Units needed for each variable are shown in red highlight. So for instance the Solar radiation gives us readings in W/m2 (after calibration of mVs). We must convert this to MJ/ m2* day (*seconds in a day and /by 10^6 joules per megajoule).

Penman Monteith Evapotranspiration calculation ([https://link.springer.com/book/10.1007/978-3-319-46116-8 (chapters 5](https://link.springer.com/book/10.1007/978-3-319-46116-8),9, 10)

10.2.2 Penman -Monteith-FAO Method

This equation has become the standard for ET_0 calculation as proposed by FAO. Applying the Penman -Monteith equation (Eq. 9.16) to a hypothetical grass canopy of height 0.12 m and canopy resistance 69 s m^{-1} we can deduce the ET_0 (mm day^{-1}) for 24-h periods as:

$$ET_0 = \frac{\Delta R_n + 0.5\, VPD \cdot U_2}{2.45\,[\Delta + 0.067\,(1 + 0.33 U_2)]} \tag{10.3}$$

where Δ (kPa K^{-1}) is the slope of the saturation vapor pressure function versus temperature (Eq. 9.13), R_n is the net radiation (MJ m^{-2} day^{-1}), VPD is vapor pressure deficit (kPa) and U_2 is wind speed at 2-m height (m s^{-1}).

The value of Δ (kPa K^{-1}) can be calculated as:

$$\Delta = \frac{4098 e_s}{[237.3 + T]^2} \tag{10.4}$$

$$e_s = 0.61078 \exp\left(\frac{17.27T}{237.3 + T}\right) \tag{5.2}$$

where e_s is expressed in kPa and T is temperature (°C). The atmosphere is usually not saturated, thus, e_a is lower than e_s for that temperature.

$$ET = K_c\ ET_0 \quad (10.1)$$

Assume Kc, Rn, Windspeed all=1 for now.

**Windspeed here is assumed to be at 2 m height while we may do it above this height.

Or (https://www.fao.org/3/X0490E/x0490e06.htm):

The Penman-Monteith form of the combination equation is:

$$\lambda ET = \frac{\Delta (R_n - G) + \rho_a c_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma \left(1 + \frac{r_s}{r_a}\right)} \quad (3)$$

where R_n is the net radiation, G is the soil heat flux, (e_s - e_a) represents the vapour pressure deficit of the air, ρ_a is the mean air density at constant pressure, c_p is the specific heat of the air, Δ represents the slope of the saturation vapour pressure temperature relationship, γ is the psychrometric constant, and r_s and r_a are the (bulk) surface and aerodynamic resistances. The parameters of the equation are defined in Chapter 3.

"A hypothetical reference crop with an assumed crop height of 0.12 m, a fixed surface resistance of 70 s m^{-1} and an albedo of 0.23."

From the original Penman-Monteith equation (Equation 3) and the equations of the aerodynamic (Equation 4) and surface resistance (Equation 5), the FAO Penman-Monteith method to estimate ET_o can be derived (Box 6):

$$ET_o = \frac{0.408 \Delta (R_n - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma (1 + 0.34 u_2)} \quad (6)$$

where

ET_o reference evapotranspiration [mm day^{-1}],
R_n net radiation at the crop surface [MJ m^{-2} day^{-1}],
G soil heat flux density [MJ m^{-2} day^{-1}],
T mean daily air temperature at 2 m height [°C],
u_2 wind speed at 2 m height [m s^{-1}],
e_s saturation vapour pressure [kPa],
e_a actual vapour pressure [kPa],
e_s - e_a saturation vapour pressure deficit [kPa],
Δ slope vapour pressure curve [kPa °C^{-1}],
γ psychrometric constant [kPa °C^{-1}].