

Exercise week 5 – Evapotranspiration

Exercise 1, on paper

1. **Question:** Which variables need to be computed before implementing the equation? Which measurements are needed? What are the units of the different terms? **Solution:**

To implement the FAO-PM equations one needs to first compute: the net radiation R_n in $\text{MJ}/\text{m}^2/\text{d}$, the gradient of the saturated vapor pressure curve Δ in $\text{kPa}/^\circ\text{C}$, the vapor pressure deficit VPD in kPa . To compute these terms and the FAO-PM equation, one needs measurement of: incoming radiation R_i ($\text{MJ}/\text{m}^2/\text{d}$), wind speed at 2 meters u_2 (m/s), temperature T ($^\circ\text{C}$), relative humidity R_h ($-$).

2. **Task:** Compute ET_0 for a hypothetical day where [...]

Solution: The formulas are:

- $R_n [\text{MJ}/\text{m}^2/\text{d}] = 86400/10^6 R_n [\text{W}/\text{m}^2]$
- $e_{as} = 0.611 \exp(\frac{17.27 T}{237.3+T}) [\text{kPa}]$
- $VPD = e_{as} (1 - R_h) [\text{kPa}]$
- $\Delta = 4098 \frac{e_{as}}{(T+237.3)^2} [\text{kPa}/^\circ\text{C}]$
- $ET_0 = \frac{0.408 \Delta R_n + \gamma \frac{900}{T+273} u_2 VPD}{\Delta + \gamma (1 + 0.34 u_2)} [\text{kg}/\text{m}^2/\text{d}]$

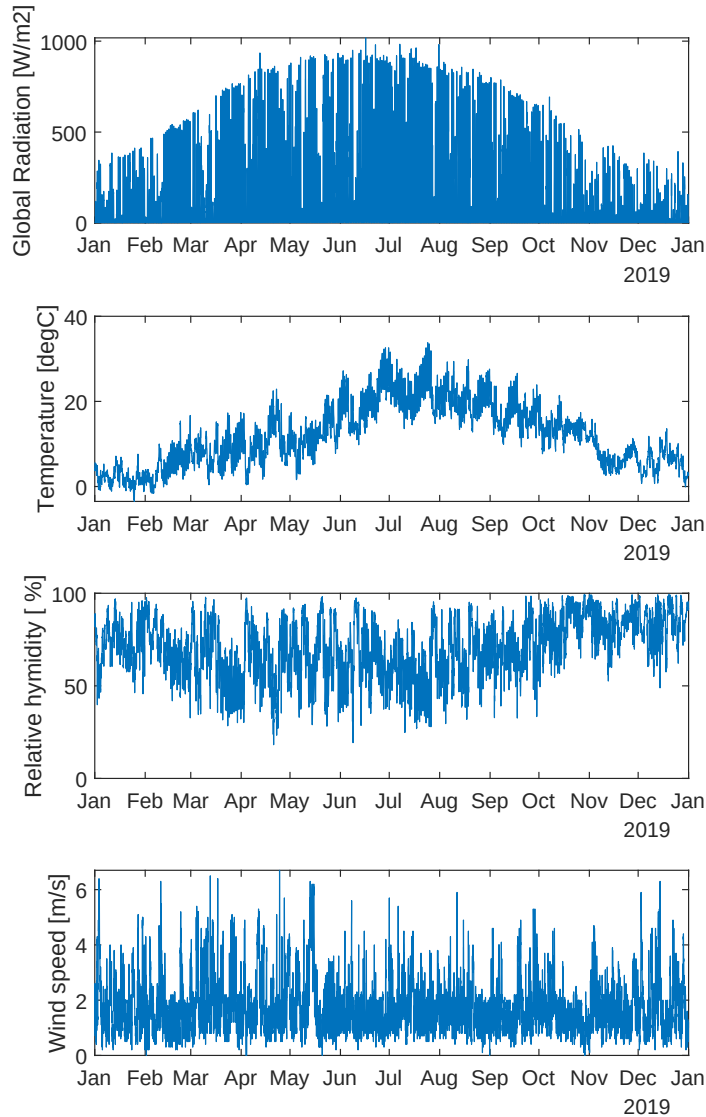
Using the given data and the psychrometric constant $\gamma = 0.066 \text{ kPa}/^\circ\text{C}$, one gets $R_n = 12.96 \text{ MJ}/\text{m}^2/\text{d}$, $e_{as} = 2.06 \text{ kPa}$, $VPD = 0.25 \text{ kPa}$, $\Delta = 0.13 \text{ kPa}/^\circ\text{C}$, $ET_0 = 3.29 \text{ kg}/\text{m}^2/\text{d}$ (equivalent to mm/d)

Exercise 2, on a computer

1. **Task:** Import the meteorological data downloaded from MeteoSwiss for year 2019

Solution: The data is described in the file `meteo_pully_2019_legend.txt` and in particular at lines 40–43.

2. *Display meteorologic data in a plot*



3. **Task:** Compute a simplified net radiation as [...]

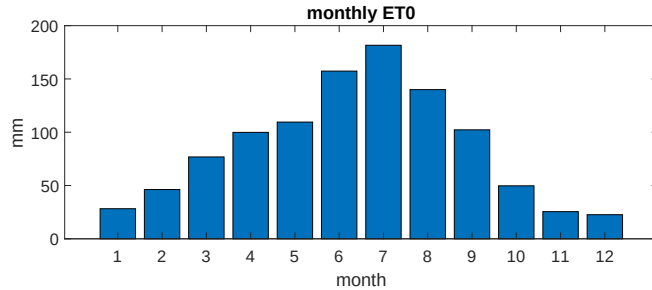
Solution: The formula to compute R_n in $\text{MJ}/\text{m}^2/\text{d}$ starting from the data is $R_n = 0.9 R_g (1 - 0.23) 86400/10^6$, where again the term $86400/10^6$ is needed to convert W into MJ/d.

4. **Task:** Compute ET_0 in mm/h for the entire year 2019

Solution: Except for R_n , which is computed above, the formulas are the same as in the exercise on paper. Just note that the result is in mm/d so you need to divide by 24 to get ET_0 in mm/h .

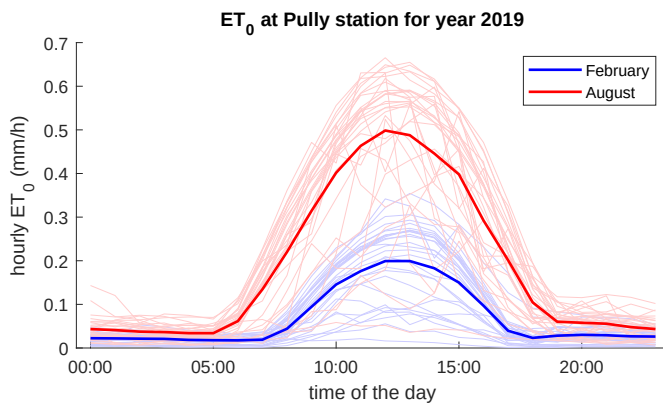
5. **Task:** Compute the total ET_0 (in units of mm) for each month.

Solution: As for the exercise of week 1, you can take advantage of the function `month` applied to a datetime object. The monthly ET_0 is:



6. **Task:** Take the hourly ET_0 during February and August only. For each of these two months, plot the daily evolution of ET_0 during each day [...]

Solution: A possible graphical representation of the results is:



7. **Question:** What are the main differences in ET_0 between February and August ? Why?

Solution: ET_0 in February has a lower magnitude and occurs over a shorter period of the day compared to August. This is because these two months have very different meteorologic conditions: February has lower incoming radiation and temperature and higher relative humidity. To be more precise, one could make a plot to compare the meteorologic conditions during these two months.

8. **Optional Question:** ET can be seen as the sum of a radiation-induced ET and a turbulence-induced ET . Which component is stronger in this dataset?

Solution: The FAO-PM equation can be broken into two components:

- $ET_{0r} = \frac{0.408 \Delta R_n}{\Delta + \gamma(1+0.34T)}$ radiation term
- $ET_{0a} = \frac{\gamma \frac{900}{T+273} u_2 VPD}{\Delta + \gamma(1+0.34T)}$ aerodynamic term

A plot with the difference $ET_{0r} - ET_{0a}$ shows that radiation dominates most of the times, but there are occasional times when the aerodynamic is larger (values lower than 0 in the plot)

