**Project:** Building an interception/transpiration module for a land model

**Objectives:** to familiarize novices to the challenges of computational hydrology including but not limited to (1) peer review of scientific assumptions and formulations, (2) code review, (3) create a stand-alone transpiration function than can be integrated into a land or hydrological model (4) report of the simulations alongside the assumption and possible fronts for development (5) understanding latent and sensible heat flux.

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**Pseudo-code source:** <https://github.com/ShervanGharari/Delft_2021>

**Questions and tasks**: In all the steps keep in mind that you can make any reasonable assumptions as long as you can justify and document. Check for division to zeros, if formulation return very large values, you can set a maximum value. Also keep in mind that this might be a rather difficult project/assignment, so lift as much as you can give the time you put for going through this!

1. read the formulations and see if you agree with all the units and assumptions. For example, is vapour pressure a function of elevation? If yes, which formulation will you use? For each formulation provide a number of parameters, hard coded coefficient, powers and constants, atmospheric variables. Approximately, what is the number of all these hardcoded and variables? Can you logically justify them? For example, is von Karman's constant a constant?

The firs equation is penman Monteith, what do we often call it when stomata conductance is set to very high values?

1. Can you approximate numerically the slope of saturated vapour pressure gradient based on formulation for saturated vapour pressure?
2. Check how scaling factors are working based on various environmental condition such as different soil moisture condition, vapour pressure deficit, etc (an example is provided).
3. Based on your assumption, calculate the rate of evaporation (interception) and transpiration for a summer day. Assume that downward short-wave radiation is 1000 Wm-2, downward long wave radiation is 300 Wm-2, air temperature of 30 degree and relative humidity of 30%. You can assume different condition for soil moisture, intercepted water on the leaves, LAI value, etc. To check your simulation, assume this rate is 3 times the daily average. What would be the daily interception, transpiration in mm day-1. What if soil moisture is lower than wilting point and no rain, what would be the sensible heat flux?
4. Based on the experience gained in the previous step, create a diagram of interception, transpiration module (function) that can be integrated in a land or hydrological model. What is needed? Example atmospheric forcing, states such as intercepted water or soil moisture, etc. make a clear picture of what is needed. This is important as in another part of the work other colleagues are working on other module for subsurface water movement and it is importance to integrate the module easily and efficiently.
5. Now if you are ready! You should be prepared to simulate your model for a given time series. Atmospheric variables based on ERA5 data set is provided for you. The variables are extracted for Delft. Estimate yearly transpiration (no interception) and with the assumption that is the soil moisture is always above stress level. Take care with the units of the timeseries provided for you!
6. Clean the Python pseudo-code (which should be actually done by this step!)

**Appendix:** Formulation and assumption for calculation of transpiration based on Penman/Monteith equations:

The slope of saturated vapour pressure (Pa K-1, kg m-1 s-2 K-1)

Net energy (W m-2, J s-1 m-2)

Dry air density (kg m-3)

specific heat capacity of air (fixed at 1000 J kg-1 K-1)

saturated vapour pressure [Pa, kg m-1 s-2]

vapour pressure [Pa, kg m-1 s-2]

Volumetric latent heat of vaporization. Energy required per water volume vaporized. [2453\*10\*\*6 J m−3]

Psychrometric constant [*γ* ≈ 66 Pa K−1, kg m-1 s-2 K-1]

stomata conductance [m s-1]

architectural conductance [m s-1]

aerodynamic conductance [m s-1]

saturated vapour pressure [Pa, kg m-1 s-2]

air temperature in degree Celsius [C]

air temperature in degree Celsius [C]

net radiation [W m-2, J s-1 m-2]

Ground flux [W m-2, J s-1 m-2]

albedo [-]

donward short wave radiation

doanward longwave radiation

surface longwave broadband emissivity (values close to 1 [-])

Stefan-Boltzmann’s constant [5.67 10-8 Wm-2K-4]

 pressure [Pa, kg m-1 s-2]

T= absolute temperature [K]

Rspecific= specific gas constant for dry air [287 J kg-1K-1]

maximum stomata conductance [m s-1]

temperature scale [-]

vapour pressure deficit scale [-]

photosynthetically active radiation scale [-]

soil moisture constraint scale [-]

air temperature in degree Celsius [C]

scaling of the vapour pressure deficit [4000 Pa] why 4000? From where it comes?!

minimum stomata resistance (200 s-1 m)

maximum stomata resistance (5000 s-1 m)

photosynthetic active radiation

minimum radiation for start of photosynthesis (for trees 100 W/m2, for crops 30 W/m2)

soil moisture level [-]

soil moisture level at saturation [-]

soil moisture level at critical point, stress starts [-]

soil moisture level at wilting point, transpiration ceases [-]

relationship between conductance and resistance

leaf area index; the area of the leaves per square area of vegetation cover [m2/m2]

active leave area index set to 0.5 [-] why?!

u wins speed [m s-1]

vegetation height [m]

k von Karman's constant, 0.40 [-]

at 0.5 [m s-1]; what is this? and does constant value makes sense for it?

Evaporation; a combination of the interception and transpiration

wet fraction; the ratio of interception storage to maximum interception storage

why not 0.5? or 0.1?