Exercise week 1 – Hydrologic Balance

These 2 exercises are based on a local water balance of a soil volume. Consider a patch of soil covered with vegetation, with root zone depth Z and porosity n. Surface runoff is assumed to be negligible and all precipitation $P(t)$ enters the soil as infiltration flux $I(t)$. Outflows comprise evaporation and transpiration (jointly expressed as evapo-transpiration $ET(t)$) and leakage $L(t)$ from the bottom.

Exercise 1, on paper

Task: make a sketch of this hydrologic system, highlighting the appropriate control volume and the relevant fluxes. Write down a mass-balance equation for this system.

Task: discretize the mass-balance equation. Then, compute the evolution of the soil water storage $S(t)$ over time, knowing that the initial soil moisture is $s_0 = 0.4$, soil depth is $Z = 1000\,mm$, porosity is $n = 0.35$ and using the mean hydrologic fluxes reported in Table 1.

timestep [-]	time[d]	P[mm/d]	ET[mm/d]	L[mm/d]
1	0.0	0.00	0.28	0.86
2	0.5	0.00	1.02	0.78
3	1.0	0.00	0.94	0.62
4	1.5	0.00	1.18	0.62
5	2.0	0.00	1.10	0.62
6	2.5	0.00	1.84	0.62

Table 1: Average fluxes of precipitation, evapotranspiration and leakage over timesteps of 12 hours. All fluxes are measured in millimeters-per-day [mm/d]. The `time` variable marks the beginning of the timestep.

timestep	-	1	2	3	4	5	6
time	[d]	0					
$S(t)$	[mm]	140					

Table 2: Result for the water storage $S(t)$, rounded to the first decimal digit

Exercise 2, on a computer

Open the data file `data2020.dat` with a text editor (Notepad++ is excellent). How does the file look like? How many headerlines you have? Now open the Matlab file `ex1.m` in the Matlab editor and read it. Note that you can read and edit the file in any text editor.

1. This first section automatically loads the data: precipitation, evapotranspiration and leakage. Each flux is measured in millimeters-per-day [mm/d] at hourly time step (this means that each measurement represent the **average** flux over a 1-hour interval).

   Question: over how much time were those variables recorded?

2. Making plots.

   Task: make plots of the imported fluxes as a function of time. Report the fluxes in mm/d and time as the number of days elapsed since the first measurement.

3. Let's do some simple statistical analysis of the fluxes:

   Task: compute the mean and the standard deviation of each variable.

   Question: what is the difference between using `std(`*`variable`*`,0)` and `std(`*`variable`*`,1)`? How many rainy hours are there in the dataset? What is the average precipitation on a rainy hour?

   Task: Compute the total volume of precipitation, evapotranspiration and leakage that crosses the control volume.

   Question: Does the balance close (meaning total inputs ≈ total outputs)?

   Optional Question: Knowing that precipitation data has been taken from a city in canton Valais, is it more likely that it comes from Sion or from Brig? Why?

4. Evolution of the soil water storage:

   Task: compute and plot the evolution of the soil storage $S(t)$ over time by implementing and solving a hydrologic balance. The initial soil moisture is $s_0 = 0.4$. Assume n and Z equal to those in exercise 1.

   Question: How often is $S(t)$ lower than 100 mm?