Assignment 2 – Detailed instructions

Items marked **in bold** must be included in the report.

1 Curve Number (CN) method

Specific goal: Compute effective precipitation J_e and infiltration I intensity for three different rainfall events using the Curve Number method.

1. Data import: Import the two rainfall events included in the files `event_1.mat` and `event_2.mat`, each of them containing hourly rainfall intensity J [mm/h] during a 4-hour event. Then, you have to create a third event using the DDF curves you obtained in your Assignment 1. Consider an event that lasts 4 hours and has return period 100 years. Use the mean rainfall intensity of the entire event over each of the 4 hours. It is convenient to include these 3 events into a matrix with one event per column.

2. Compute the average CN of the catchment: The file `SCSpars.mat` includes three variables that describe the three types of soil cover present in the catchment, their curve number and the respective proportion (in %) of occupation. Compute the average CN for the catchment.

3. Implement the CN method: Use the average CN to compute the potential maximum soil moisture retention S of the catchment. Then, for each of the 3 events, compute:
   a) The cumulative precipitation (P $[mm]$);
   b) The initial abstraction (I_a $[mm]$);
   c) The cumulative infiltration (F_a $[mm]$);
   d) The cumulative effective precipitation (P_e $[mm]$);
   e) The infiltration intensity (I $[mm/h]$);
   f) The effective rainfall intensity (J_e $[mm/h]$);

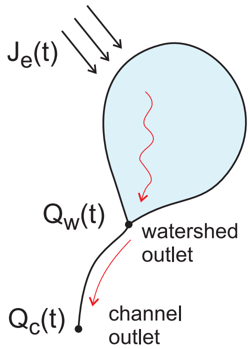
4. **Show rainfall separation in a figure**: Make a figure that includes, for each event: the rainfall intensity J $[mm/h]$, the infiltration intensity I $[mm/h]$ and the effective precipitation intensity J_e $[mm/h]$. Please use the same limits for the y-axis in the three events. You can either use one figure and three subplots or three different figures for the three events. Line plots with markers or bar plots are equally fine.

5. **Compute**: how much volume of effective rainfall is produced in total for each of the three events.

6. Save results: save J, J_e and I for event 3 to a matlab file `output_part1.mat`.

2 Discharge at a watershed and at a channel outlet

Specific goal: use two different instantaneous unit hydrographs to transform the effective precipitation into streamflow at the outlet of a watershed and then streamflow at the end of a channel.



1. Prepare precipitation data: choose a timestep `dt` and downscale the effective precipitation J_e from hourly time steps to `dt` time steps (as in Exercise week 8).

2. Generate two (discretized) IUHs:
   - The watershed IUH is assumed to be a gamma distribution with shape and scale parameters given in `IUHpars.mat`.
   - The channel IUH is an inverse Gaussian (see additional lecture notes on GIUH), whose formula is:

   $$f_c(t) = \frac{L}{\sqrt{4\pi D}\, t^{3/2}} \exp\left(-\frac{(L-ct)^2}{4Dt}\right).$$

   Assume the propagation celerity c is 0.3 m/s, the hydrodynamic dispersion D is 10^6 m^2/h and the channel length L is 10 km. Depending on your discretization, it might be that the first timestep will have a NaN (it happens if you divide by 0). If this occurs, there is no problem but you need to force the IUH to be 0 in the first timestep.
   - Check if the area under each IUH is close to 1.
   - Feel free to adapt the cutoff length, the number of timesteps or to use different discretizations to improve the numerical accuracy of your computations.

3. **Figure**: Show the two IUH's in the same figure. Feel free to cut the x-axis to focus on the early part of the IUH.

4. Convolution 1: Implement an explicit convolution (no function `conv`) of the effective precipitation with the IUH of the watershed, to obtain the discharge at the watershed outlet.

5. Convolution 2: Implement an explicit convolution (no function `conv`) of the discharge at the watershed outlet with the IUH of the channel to obtain the discharge at the end of the channel.

6. **Figure**: In one single figure, plot the intensity of effective precipitation, the discharge at the catchment outlet and the discharge at the channel outlet. Feel free to cut the x-axis to focus on the early part of the curves.

7. **Compute**: the discharge peak and the time when the peak occurs, both for the catchment outlet and for the channel outlet.

8. Save results: save the dt and the watershed IUH to a file `output_part2.mat`.

3 Discharge from surface and subsurface contributions at a watershed outlet

Specific goal: computing discharge by considering both the surface and subsurface runoff contributions, each one characterized by a IUH. No channel is considered here.

1. Prepare precipitation data: load the `dt` and watershed IUH from previous part. Then, load precipitation data from file `precipitation_data.txt`, which includes one year of hourly rainfall intensity (standard MeteoSwiss format). Downscale hourly rainfall to `dt` time steps (as done in part 2). Note that for this part your computations will have the same `dt` as in the previous part. You can change the `dt` if you want, but then don't forget to also re-define the IUH over the changed `dt`.

2. Separation into effective precipitation and infiltration: use a simplified approach with fixed fractions $J_e(t) = 0.3\,J(t)$ and $I(t) = 0.1\,J(t)$.

3. Surface contributions: use the watershed IUH from previous part and do a convolution with the effective precipitation.

4. Subsurface contributions: generate a new IUH for the subsurface contribution. This IUH is again a gamma distribution, with the same shape parameter as the surface IUH and a scale parameter that is 10 times larger than the surface IUH. Do a convolution between this IUH and the infiltration intensity.

5. Total discharge: compute the total discharge that comes from surface and subsurface runoff contributions. The vectors that store these fluxes likely have different lengths, so you can crop them to the length of the downscaled precipitation vector.

6. **Figure**: make a single figure with two subplots to show data from the month of November only. On the top plot, show surface runoff, subsurface runoff and total runoff. On the bottom plot, show a time series with the relative proportion of surface runoff over total runoff.

7. **Compute**: the number of timesteps that the total discharge is 'high' (in this case, higher than 0.2 mm/h) and the number of timesteps that it is 'low' (in this case, lower than 0.002 mm/h). What is the percentage of timesteps with high and low flows over a year?

4 Additional questions

1. In Part 1, why we don't observe any effective rainfall at the beginning of event number 2?

2. In Part 2, what would happen to the discharge if the channel were twice as long? Why? *(you don't need to make computations to respond to this question)*

3. Consider the runoff response to an effective precipitation J_e of 10 mm/h. How does the runoff response change if J_e occurs after a prolonged dry period? How is it different from the response during a wet period?