Water Resources Engineering
Exercise

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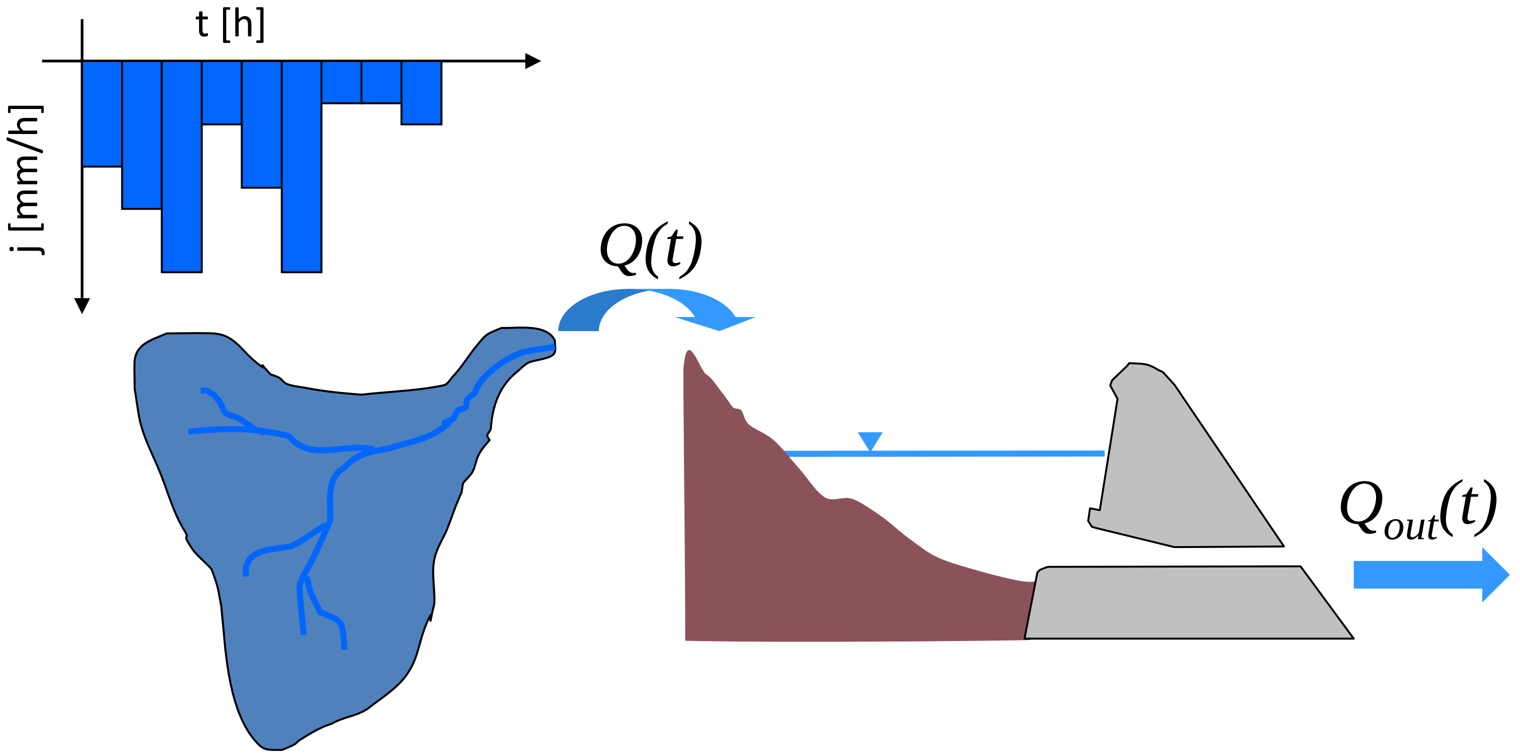
lecture: Tuesday 8.15-10 in room GR B3 30
exercise: Thursday 10.15-12 in room INF 3
office hours: Thursday 12-14 (GR C1 532 – GR C1 564)

tasks



Step

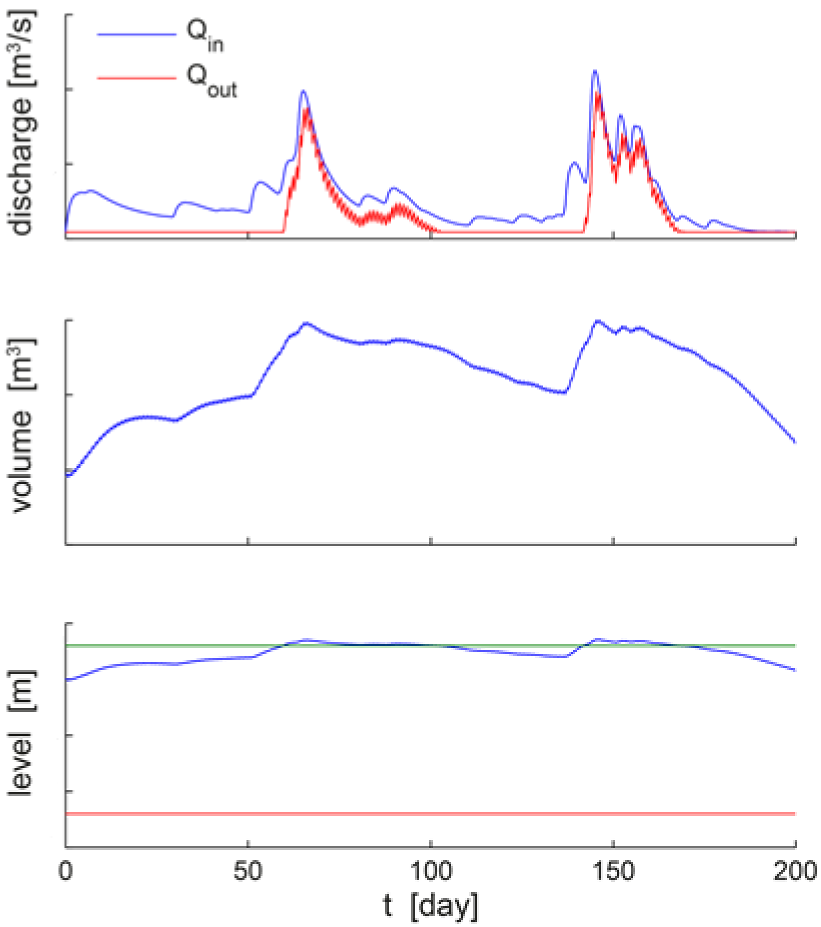
- Develop and calibrate a continuous hydrological model to transform rainfall into discharge. The model is fitted based on the available dataset.
- Generate rainfall time series with the same statistical properties of the observed ones.
- Simulate the reservoir routing whitout flood control practice.
- Implement flood control practice
- Measure the energy produced and the flooding probability for different values of volume allocated for flood control

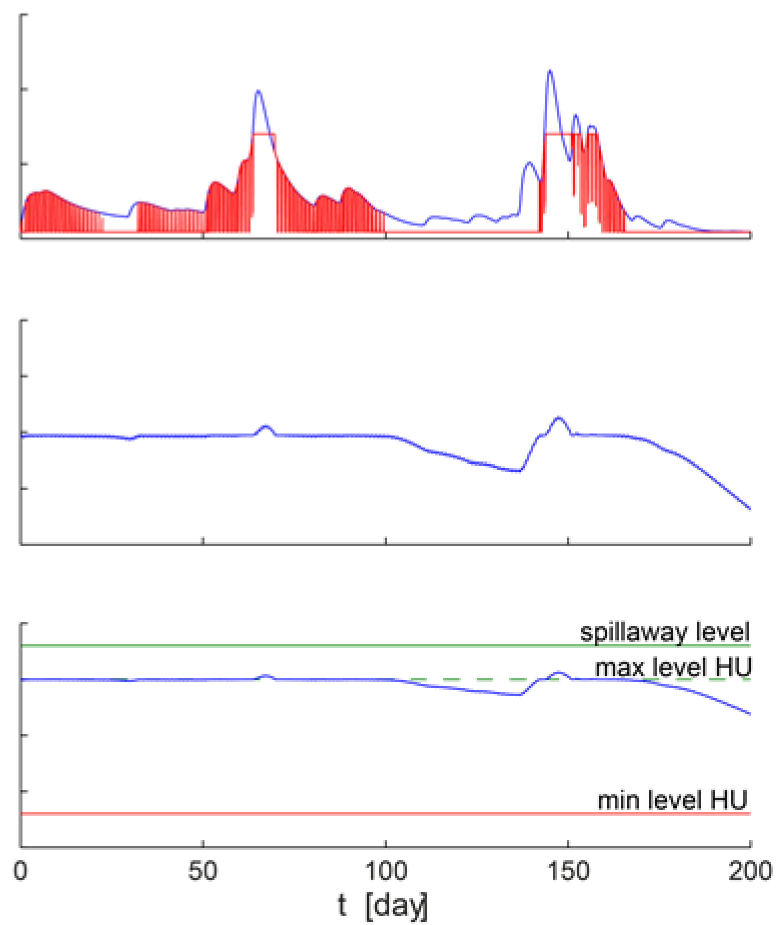
Implement flood control practice

Initial configuration, no flood control practice (implemented last week). The opening of the sluice gate is operated so that the discharge through the gate equals the minimum flow.

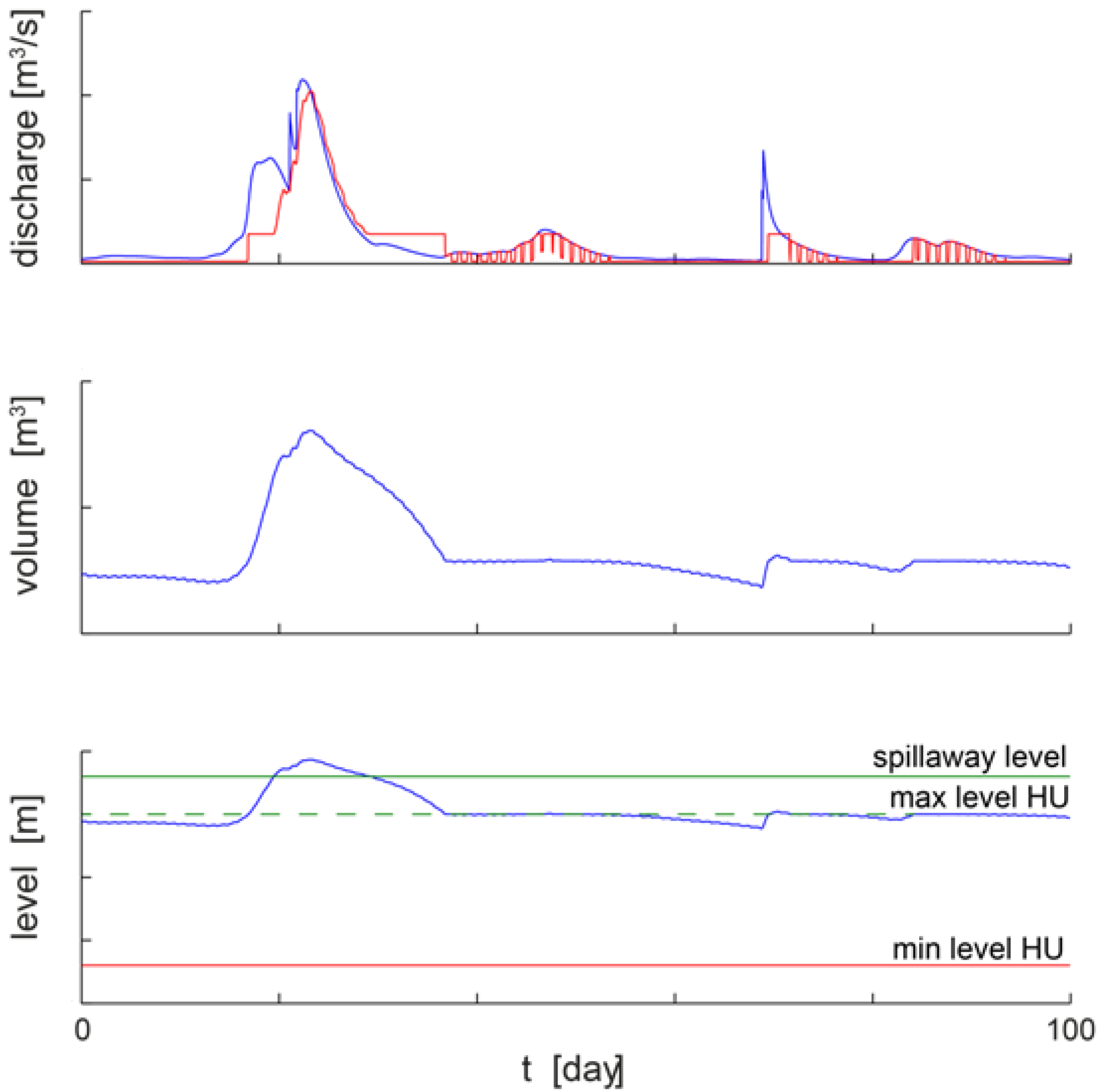
The opening of the sluice gate is operated so that

- the discharge through the gate is larger than the minimum flow and lower than 150 m^3/s;
- the level is kept, if possible (i.e. if the gate discharge is within the aforementioned limits) below the maximum level for hydroelectrical use;
- if the maximum level for hydroelectrical use is exceeded, the reservoir is emptied as fast as possible.





Using the flood control practice described before, during large floods, if the volume for flood control is not large enough, the spillway is activated and Q_{out} exceeds 150 m^3/s.



Implement flood control practice

The opening of the sluice gate is operated so that

- the discharge through the gate is larger than the minimum flow and lower than 150 m^3/s;
- the level is kept, if possible (i.e. if the gate discharge is within the aforementioned limits) below the maximum level for hydroelectrical use
- if during floods the maximum level for hydroelectrical use is exceeded, the reservoir is emptied as quick as possible.

All the above conditions can be implemented as follows.

At each timestep, the opening of the sluice gate is operated so that the volume at the end of the timestep equals (if possible, i.e. if the gate discharge is within the aforementioned limits) the volume corresponding to the maximum level for hydroelectrical use ($V_{max,HU}$).

$$\mathrm{V}_{\mathrm{max,\,HU}} = V(t+\Delta t) = V(t) + [Q(t) - Q_{HU}(t) - Q_g(t)]*\Delta t$$

Therefore, the discharge through the gate can be computed as:

$$Q_g(t) = \max\begin{cases} Q_{347} \\ \min\begin{cases} \dfrac{V(t) + [Q(t) - Q_{HU}(t)]*\Delta t\text{-}\mathrm{V}_{\mathrm{max,HU}}}{\Delta t} \\ 150 \end{cases} \end{cases}$$

where Q(t) is the input discharge.

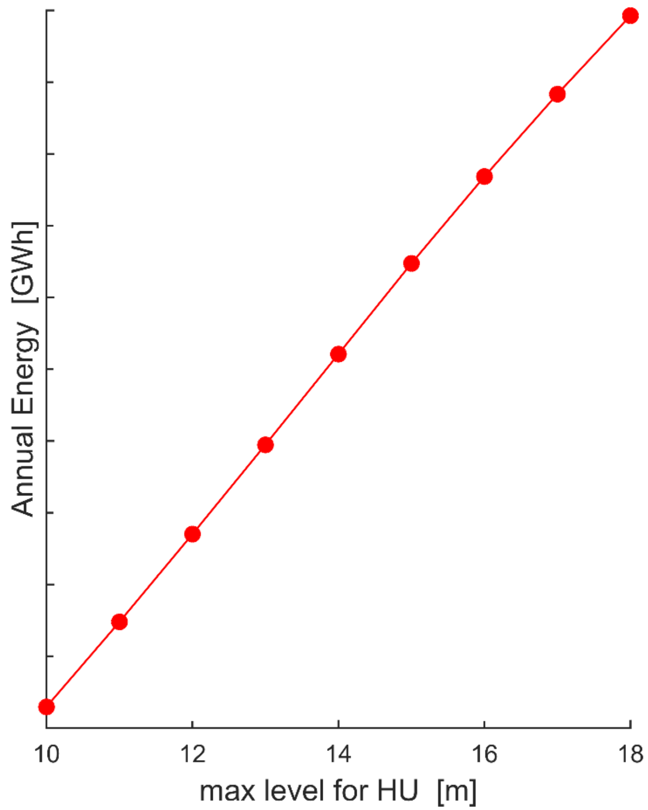
Tip: start simulating the system for a period shorter than 100 years (e.g. 10 years). When everything looks ok, go for the long simulation (100 years of simulation takes about 1 minute of computational time)

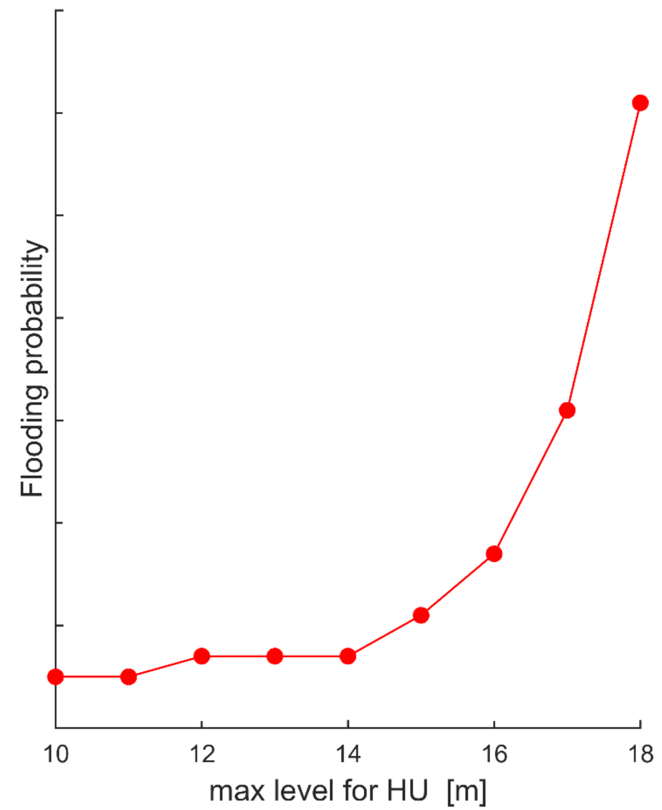
tasks

- Assume a maximum level for HU (e.g. $l_{max,HU}$ = 15 m).
- Compute the corresponding maximum volume for HU ($V_{max,HU}$).
- Simulate reservoir routing
- Compute the average annual energy production in GWh.
- Compute the probability that Q_{out} exceeds 150 m^3/s. For numerical reasons, the conditions should read $Q_{out} > 151$ m^3/s.

-Repeat the tasks of the previous slide for different values of the maximum level for HU (from 10 to 18 m) to obtain the final results of the assignment. Use the same sequence of generated discharge (100 years long) to simulate the reservoir routing for different values of maximum level for HU.

-final goal: estimate the power production and the flooding probability as a function of the volume (i.e. of the maximum level for hydroelectric use) reserved for flood control.





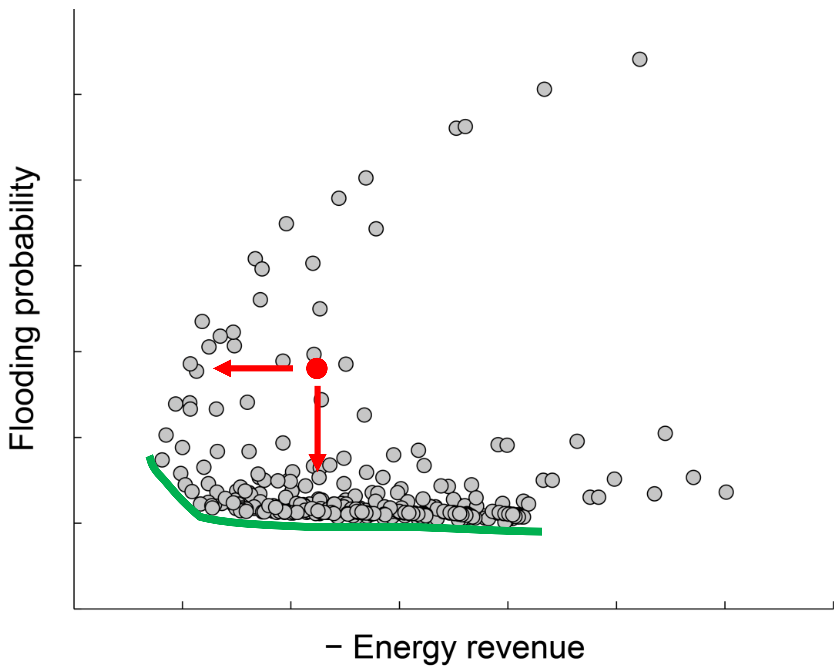
Multi-criteria optimization

NB: This part of the assignment is facultative.

In a separate script (`Lastname_MultiCriteria.m`), modify the previous reservoir routing by accounting for:

- seasonally varying maximum levels for hydroelectric use.
- different values for the design discharge to the turbine Q_T.

Run the reservoir routing and plot flooding probability against average annual energy production for all possible combinations of seasonal $l_{max,HU}$ and Q_T. Implement a procedure that identifies all non-dominated solutions. The template for this file is not given.



Suggested settings:

- Length of the discharge time series: 30 years at least (if too long, it takes too much time; if too low, your results will be highly affected by stochasticity).
- Use one value of $l_{max,HU}$ from April to October and a second one from November to March.
- For both seasons, $l_{max,HU}$ ranges from 13 m to 18 m with a step size of 0.5 m.
- Q_T ranges from 50 m^3/s to 70 m^3/s, with a step size of 5 m^3/s.
- Suppose that the turbine efficiency η does not change as a function of Q_T.

Elaborate on the influence of decision variables on the determination of non-dominated solutions. Do not exceed 400 words. Figures are allowed.