Water Resources Engineering Assignment

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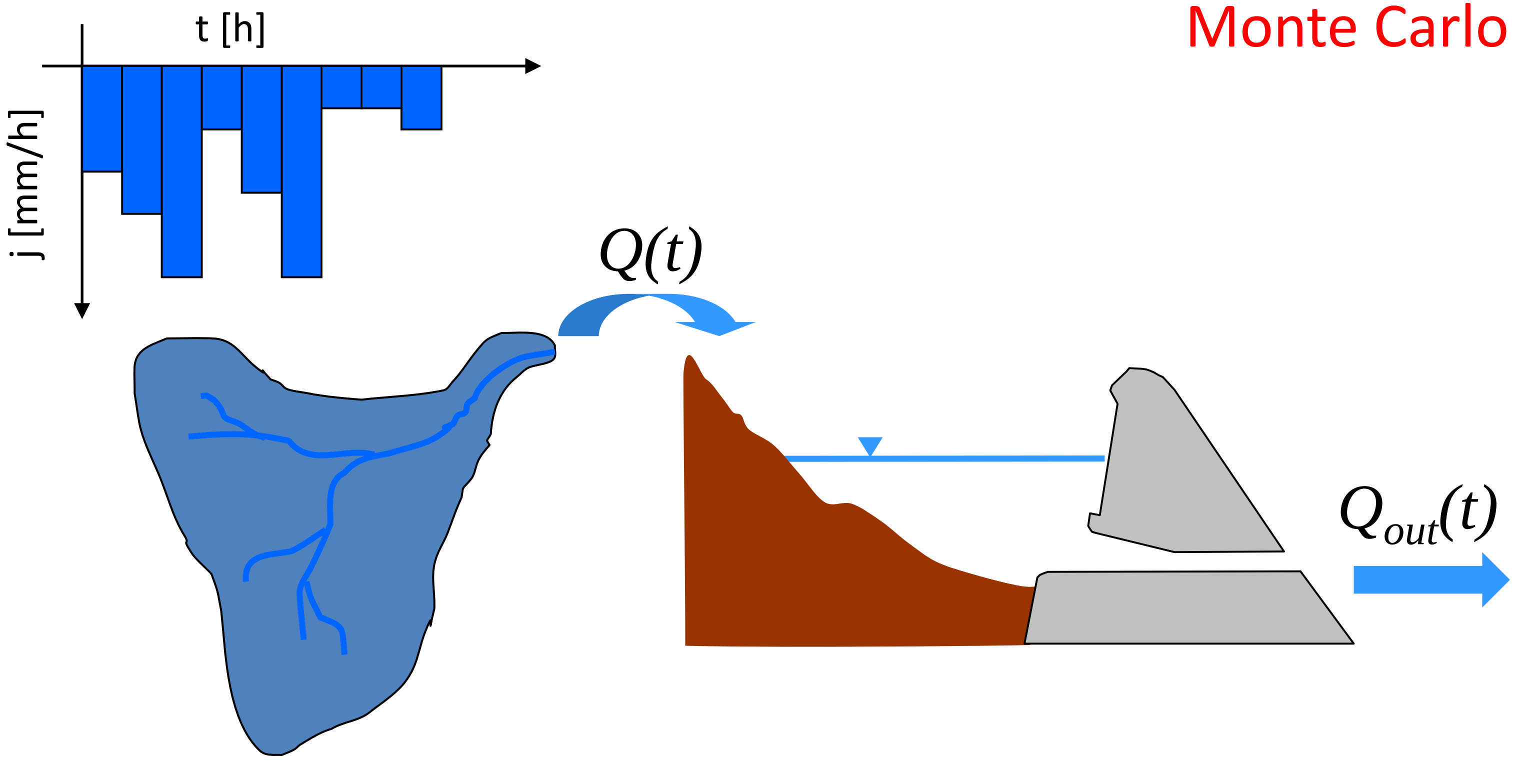
lecture: Tuesday 8.15-10 in room GR B3 30
exercise: Thursday 10.15-12 in room INF 3
office hours: Thursday 12-14 (GR C1 532 – GR C1 564)

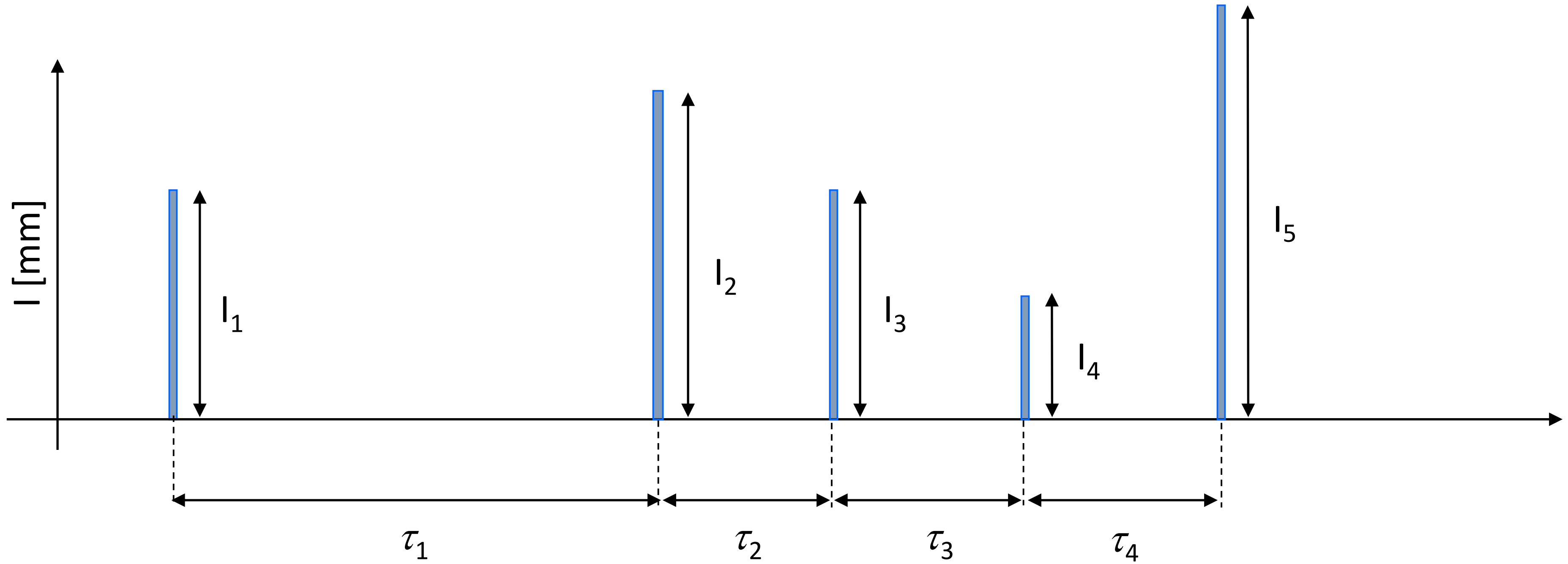
Monte Carlo approach



Steps

- Develop and calibrate a lumped 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.
- Transform generated rainfall into a generated time-series of discharge.
- Simulate the reservoir routing and the flood control operations for different maximum level for hydroelectric use.
- Measure the energy produced and the flooding probability.

single pulse rainfall model



Point model of rainfall. At daily timescale rainfall events are considered uncorrelated (no autocorrelation). The model neglects the temporal variablilty of rainfall within an event. Rainfall events are modelled as a Poisson process.

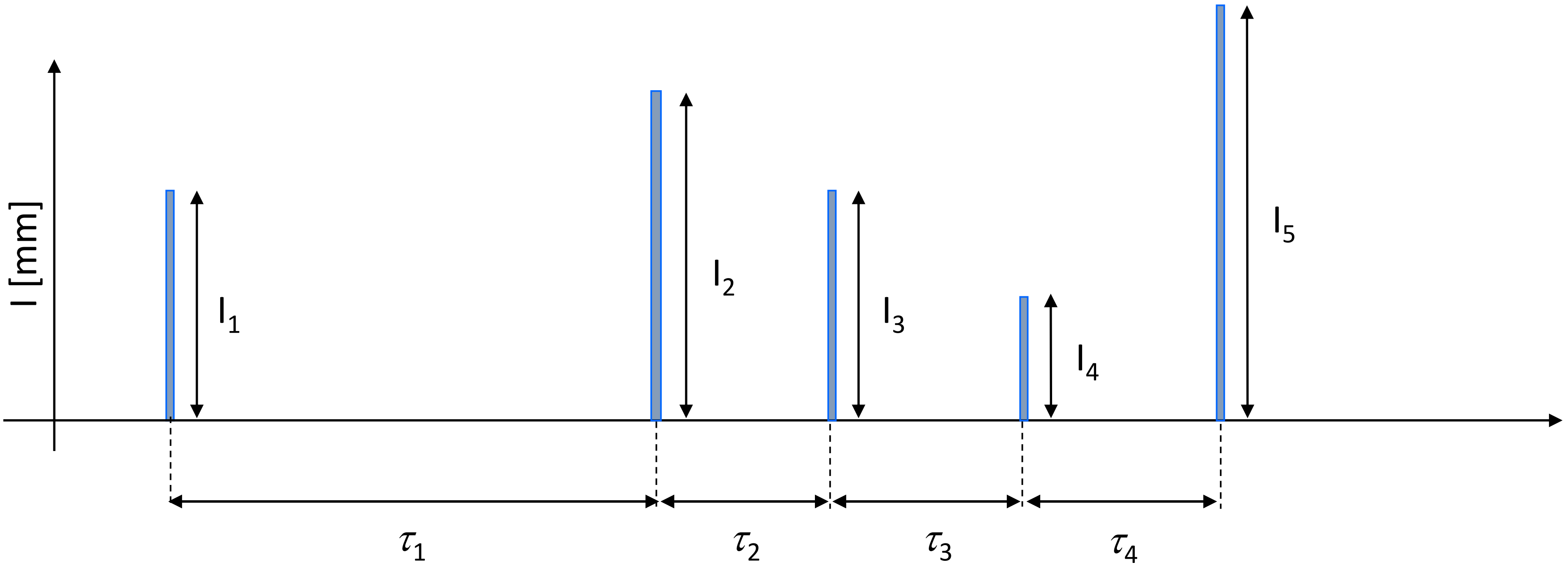
The process is described by 2 random variables

τ: event inter-arrival

I : precipitation depth

This model is typically used to generate rainfall at a daily time scale.

single pulse rainfall model



Both variables are exponentially distributed (one-parameter distribution)

probability density function

$$f(x) = p\,e^{-px} \quad x > 0$$

mean

$$\langle x \rangle = 1/p$$

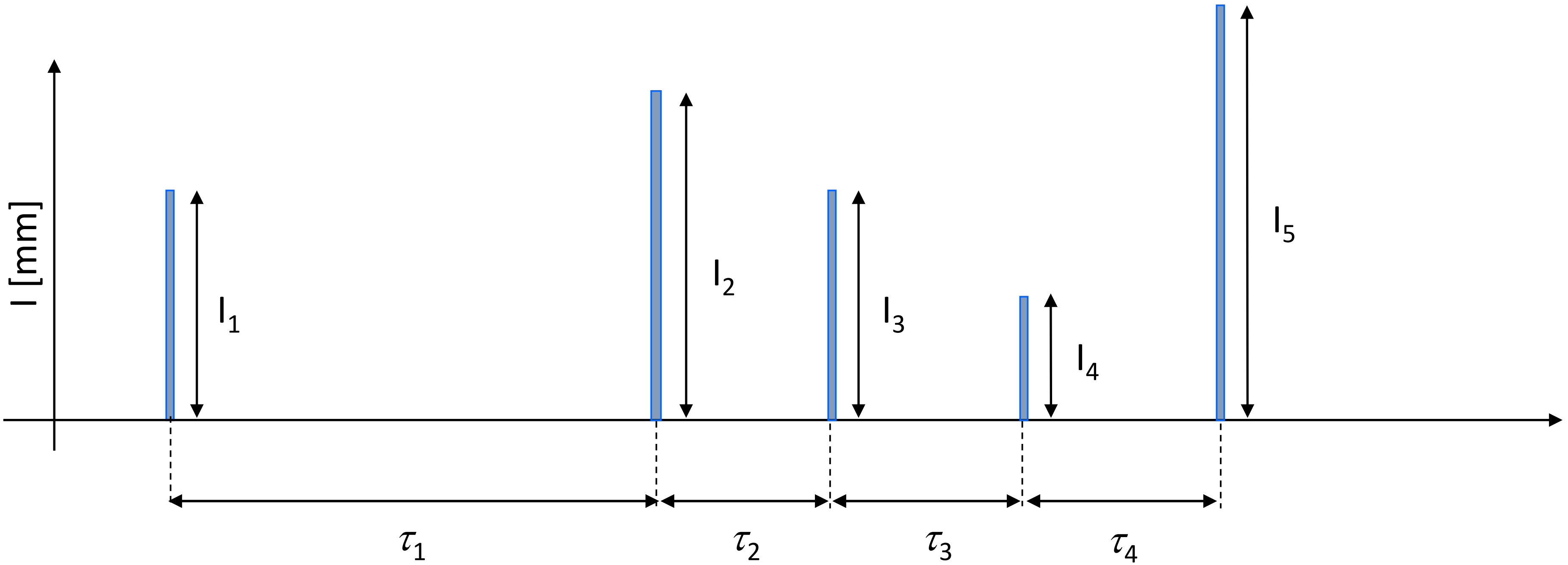
cumulative probability function

$$F(x) = P[X < x] = 1 - e^{-px}$$

variance

$$\sigma^2(x) = 1/p^2$$

single pulse rainfall model



2 parameters

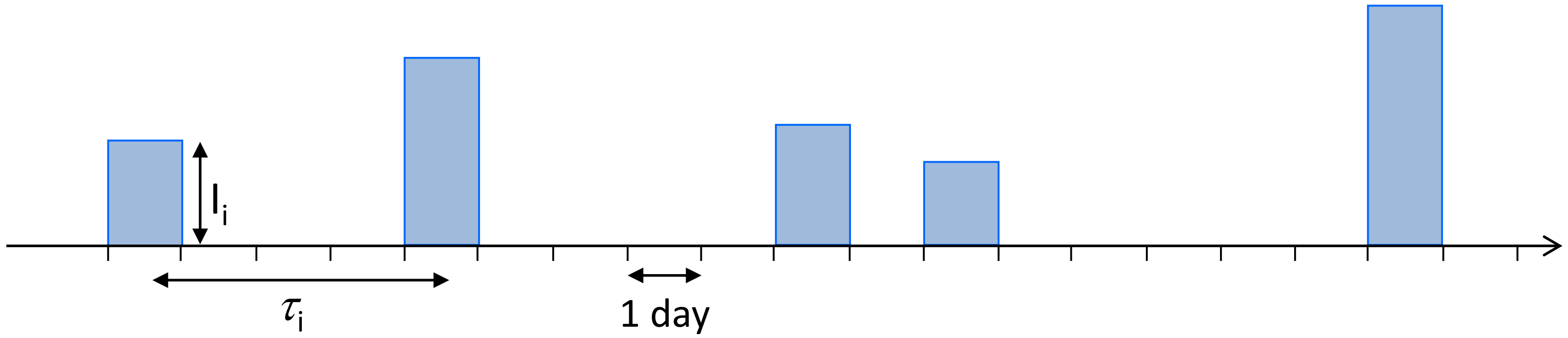
$$f(\tau) = \lambda e^{-\lambda\tau} \longrightarrow \langle \tau \rangle = 1/\lambda$$ mean event inter-arrival, λ: Poisson rate

$$f(i) = \frac{1}{\alpha} e^{-\frac{i}{\alpha}} \longrightarrow \langle I \rangle = \alpha$$ mean precipitation

single pulse rainfall model

calibration

1) upscale observed rainfall from hourly timescale to daily timescale



2) direct estimate of the two parameters (mean inter-arrival and mean precipitation)

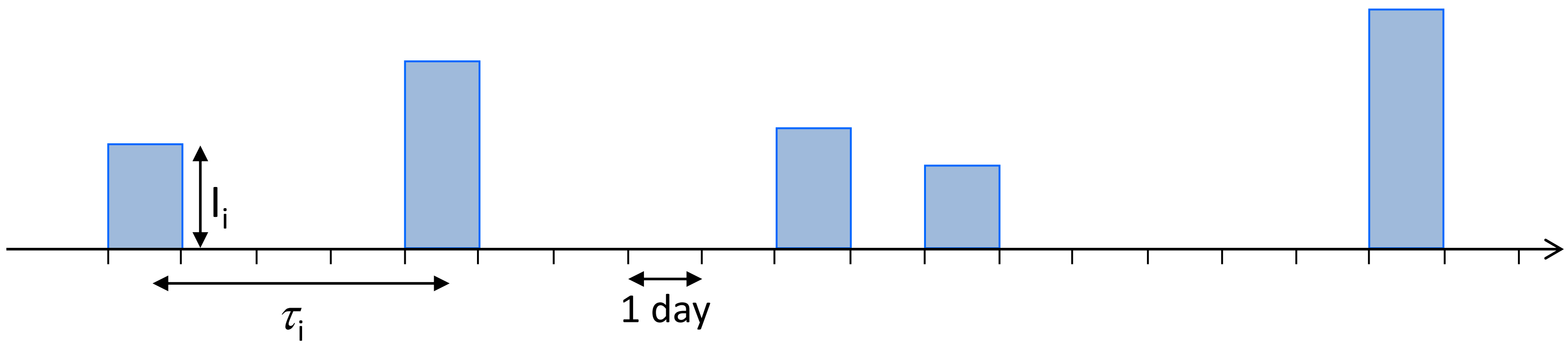
$$\langle \tau \rangle = \frac{\sum \tau_i}{n.of\ rainy\,days} = \frac{n.of\ days}{n.of\ rainy\,days} \quad \longrightarrow \quad \lambda = \frac{1}{\langle \tau \rangle} = \frac{n.of\ rainy\,days}{n.of\ days}$$

$$\alpha = \frac{\sum I_i}{n.of\ rainy\,days}$$

To account for the intra-annual variability of rainfall (i.e. seasonality), we estimate different parameters α and λ for each month.

single pulse rainfall model

generation of a rainfall time series 100 years long



For a generic day of month *m*

- a rainfall event occurs with probability $\lambda(m)\Delta t$, Δt =1 day (first definition of a Poisson process);
- If a rainfall events occurs, the rainfall depth I is extracted from an exponential distribution with mean $\alpha(m)$;

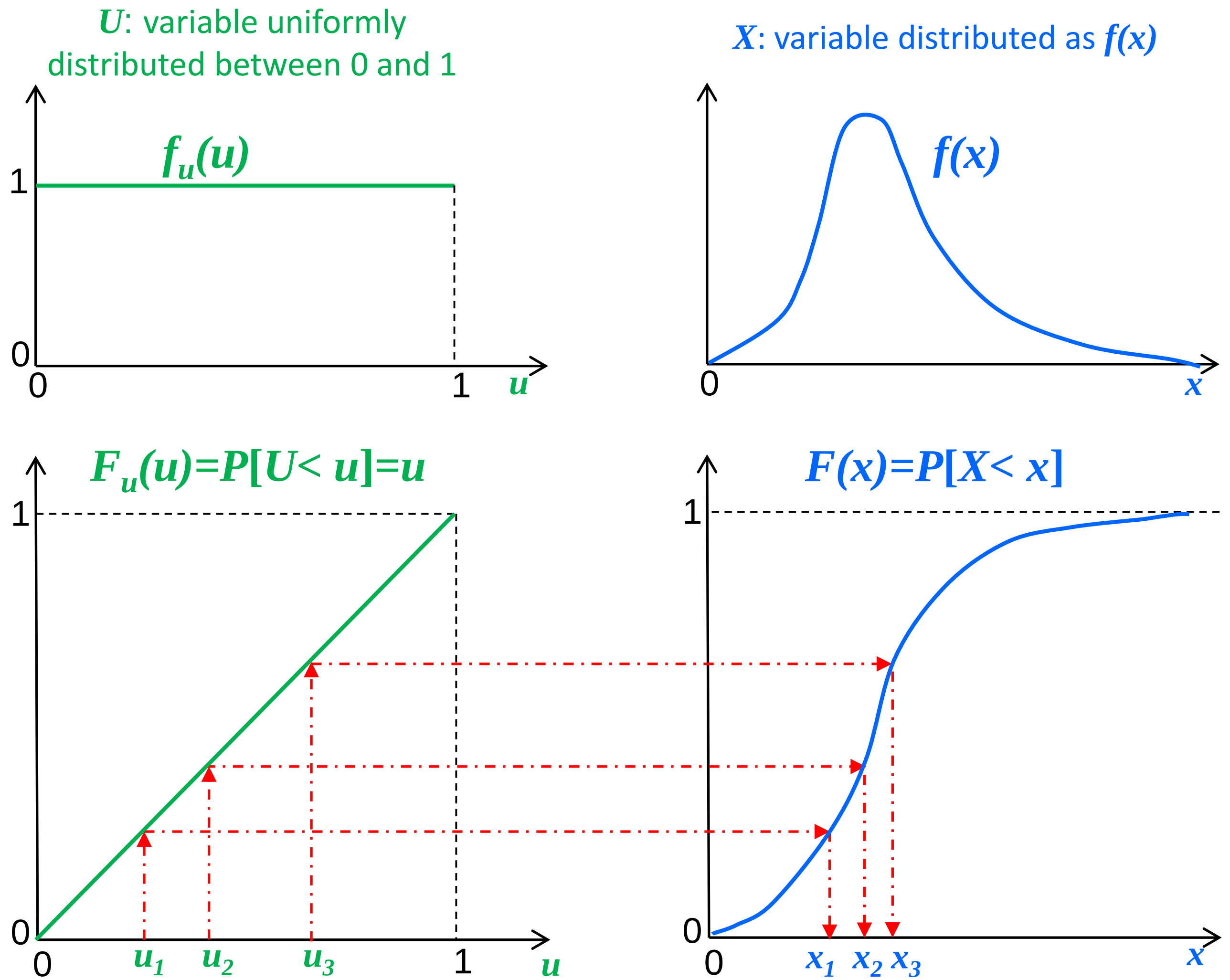
the two points above are repeated for all the days and all the months of the generation period.

Use the rand function to obtain uniformly distributed (pseudo)random numbers.

Problem: generation of random variables exponentially distributed

inverse transformation method

method for the generation of a set of random variables $(x_1, x_2, x_3, \dots, x_n)$ which follow a generic probability density function $f(x)$ starting from uniformly distributed variables

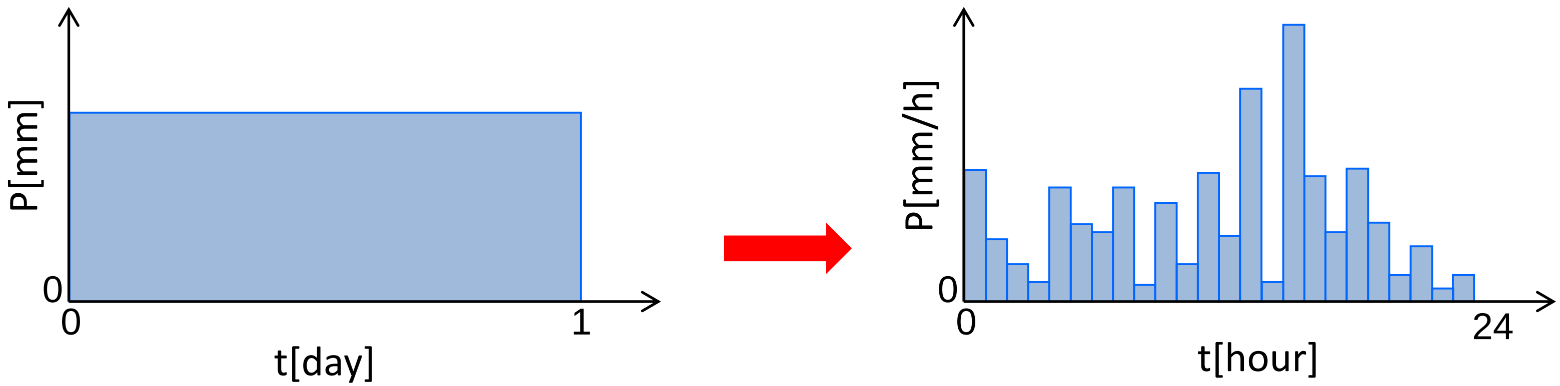


$$x_i = F^{-1}(F_u(u_i)) = F^{-1}(u_i)$$

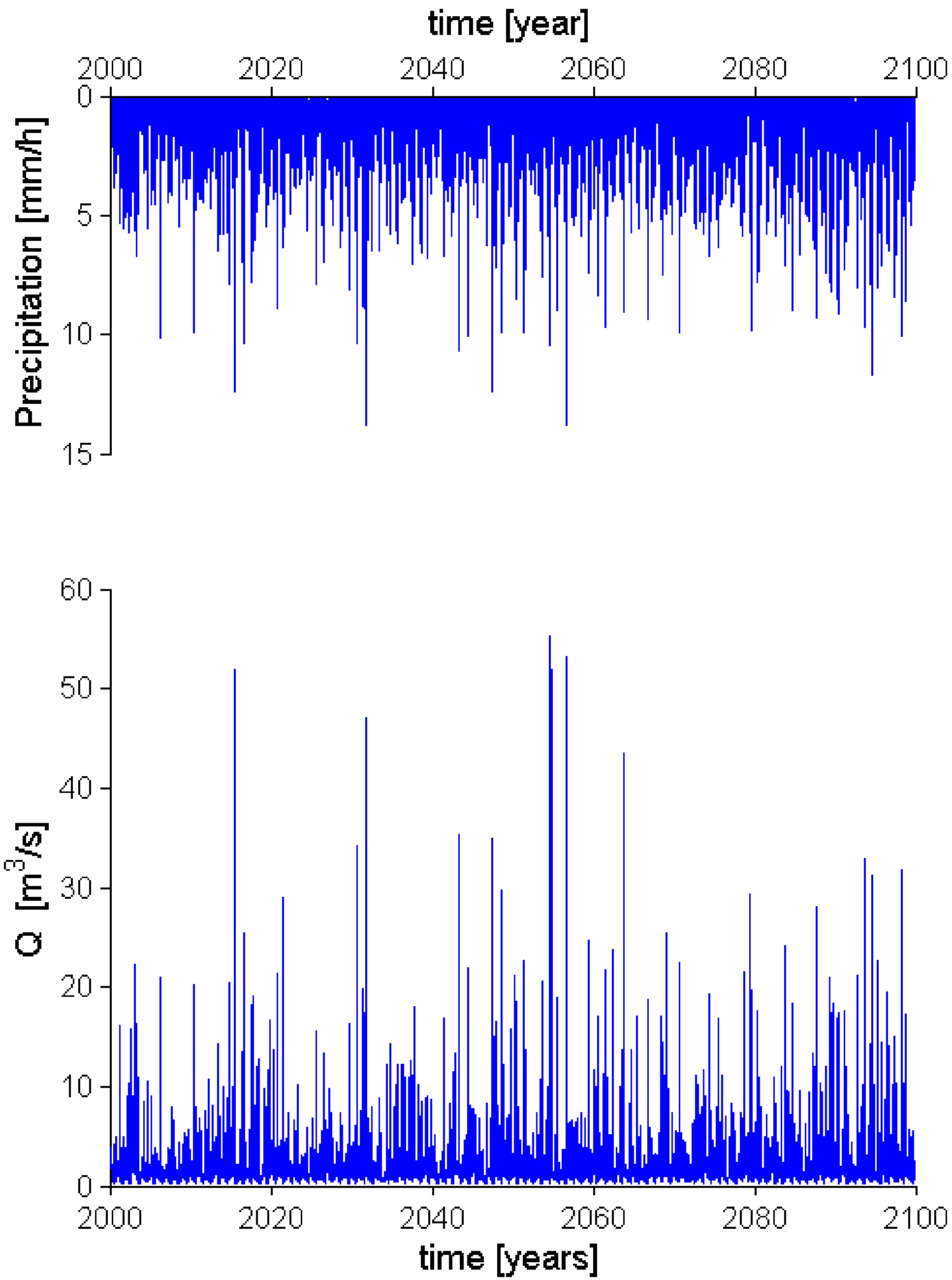
$(u_1, u_2, u_3, \dots, u_n)$ → $(x_1, x_2, x_3, \dots, x_n)$

downscaling of generated rainfall

The generated rainfall is at daily timescale. The developed hydrological model runs at hourly timescale. We thus need to downscale the generated precipitation form daily timescale to hourly timescale. We use a random downscaling procedure which assumes that the rainfall intensity of every hour is a random variable exponentially distributed (the procedure is already implemented in the function downscaling.m)



generated discharge



Run the fitted hydrological model with the downscaled generated rainfall as input to obtain a 100-year-long sequence of discharge