CEVE 101: Project 03

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We begin by loading the required packages.

```
using Revise
using RainwaterHarvesting
```

Setting the file path

Next, we specify the path to the rainfall data file and read it in.

```
filepath = "data/1.txt"
rainfall_data = RainfallData(filepath)
```

```
RainfallData for station: ABAIARA
  Location: -7.3615277777778, -39.0355
  Years of data: 41
  Total days: 14974
```

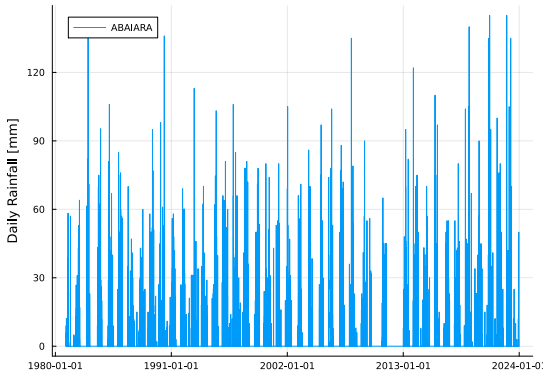
If we dig under the hood a bit, we can see that there are two main pieces of information:

- `station_info`: a dictionary containing information about the station, such as its name and location.
- `annual_data`: a dictionary mapping years to `AnnualRainfallData` objects, each containing the date and precipitation data for a given year.

Plotting the Data

We can plot the data for one or all of the years to verify that it looks correct.

```
plot(rainfall_data)
```



Discussion

Insert discussion here

Understanding the Theoretical Model

Let's explore the model that simulates the rainwater harvesting system.

Mass Balance Equation

The mass balance model for the rainwater tank is given by:

$$V_{t+1} = V_t + Q_t - C_t | 0 \leq V_t \leq V_{\max}$$

- V_t: the volume of water in the tank at time t
- Q_t is the volume of water added to the tank at time t
- C_t is the volume of water consumed at time t
- $V_{\max}$: the maximum volume of the tank

Inflow (Q_t)

Inflow is calculated as

$$Q_t = \eta \times A \times \max(P_t - F, 0).$$

- η: the runoff coefficient, which accounts for losses due to evaporation, spilling, etc.
- A: the area of the roof (we will use square meters)
- P_t: the precipitation at time t (we will use millimeters per day)
- F: the first flush volume (we will use millimeters). The first flush volume is often discarded, so that each time it rains the first bit of water (which is usually dirty) is not used (see here for more details).

Consumption

Consumption is modeled as:

$$C_t = \begin{cases} 74.1 & \text{day of year} > 150 \\ 0 & \text{day of year} \leq 150 \end{cases}$$

This makes two major assumptiuons. First, the household begins using water from the tank after the 150th day of the year. This is based on the idea that the rainy season lasts for about the first 150 days of the year, and so they may have other sources of water before then. The second assumption is that each household consumes 74.1 liters per day during the dry season. How does this compare to your household's water usage?

Model Implementation and Testing

Defining the Model Parameters

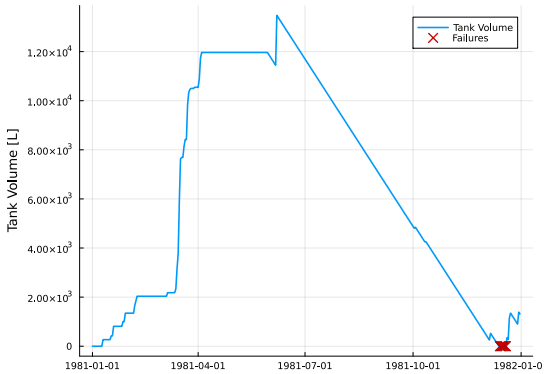
We can define the model parameters with sensible default values. You will have the opportunity to change these values later.

```
param = ModelParameters(
    runoff_coefficient=0.85,
    roof_area_m2=45.0,
    first_flush_mm=2.0,
    tank_capacity_L=16000.0
)
```

Running the Simulation for One Year

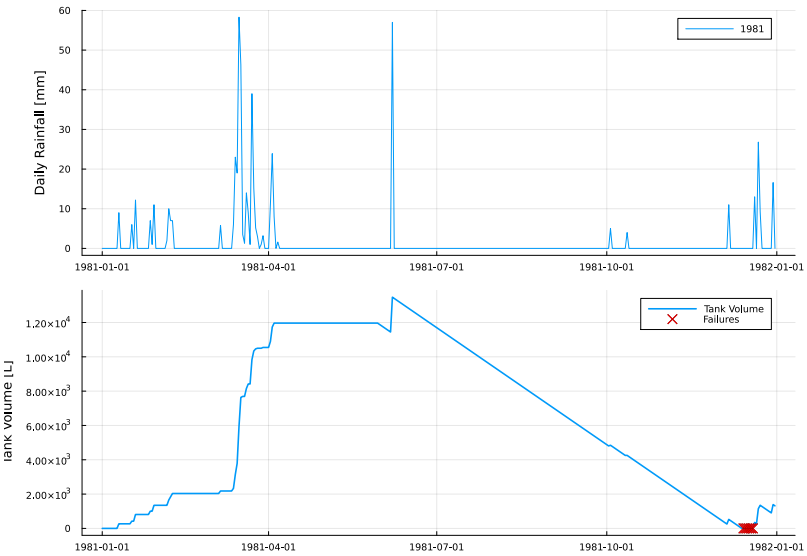
Let's run the model for the year 1981.

```
rainfall_1981 = rainfall_data.annual_data[1981]
results_1981 = run_timesteps(rainfall_1981, param)
p1 = plot(results_1981)
```



To compare rainfall and tank volume:

```
p2 = plot(rainfall_1981)
plot(p2, p1, layout=(2, 1), size=(1000, 700), link=:x)
```



Observe how the tank's water level responds to rainfall events. Note any periods when the tank runs dry or overflows.

Reliability Analysis

We can run simulations for all years, one at a time, and then check how many times the tank runs dry. You can run simulations for all years at once with the following code:

```
all_years = sort(collect(keys(rainfall_data.annual_data)))
all_results = [run_timesteps(rainfall_data.annual_data[year], param) for year in all_years]
any_failures = [!isempty(result.failure_dates) for result in all_results]
println("Number of years with failures: ", sum(any_failures), " out of ", length(all_years))
```

```
Number of years with failures: 4 out of 41
```