Hydrologic performances of rain gardens

– from in-situ monitoring to modeling for a variety of contexts and designs

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Agenda

01. Introduction

02. Objectives

03. Experiments design

04. Methods

05. Research questions

01. Introduction

Why rain gardens?

As one of the Sustainable urban drainage systems(SUDS), the rain garden has multiple functions, which can be a solution to different challenges brought by urban stormwater.

At the same time, we know that:

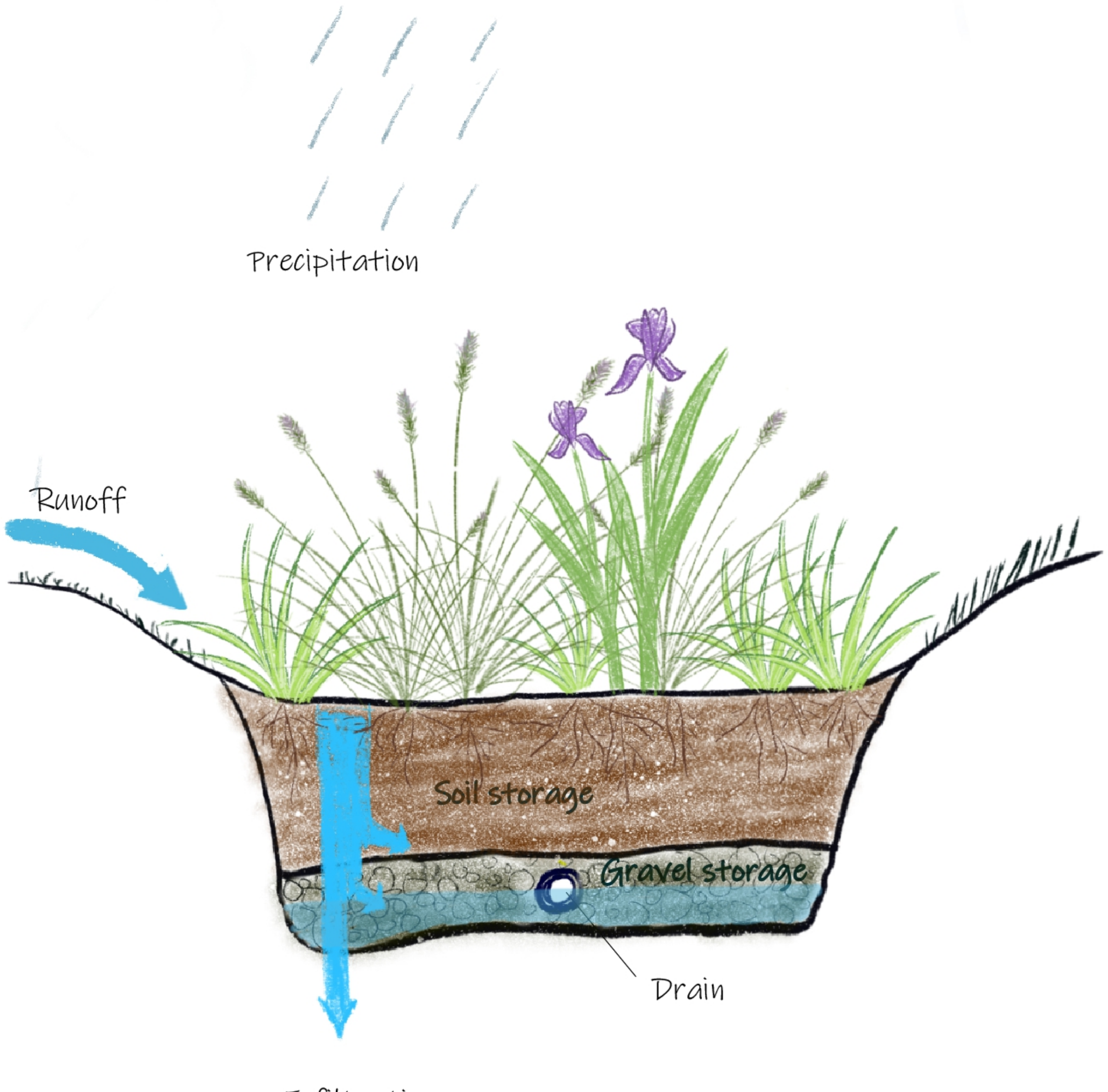
Rain gardens design & their implementation context are likely to have a strong influence on their performances.

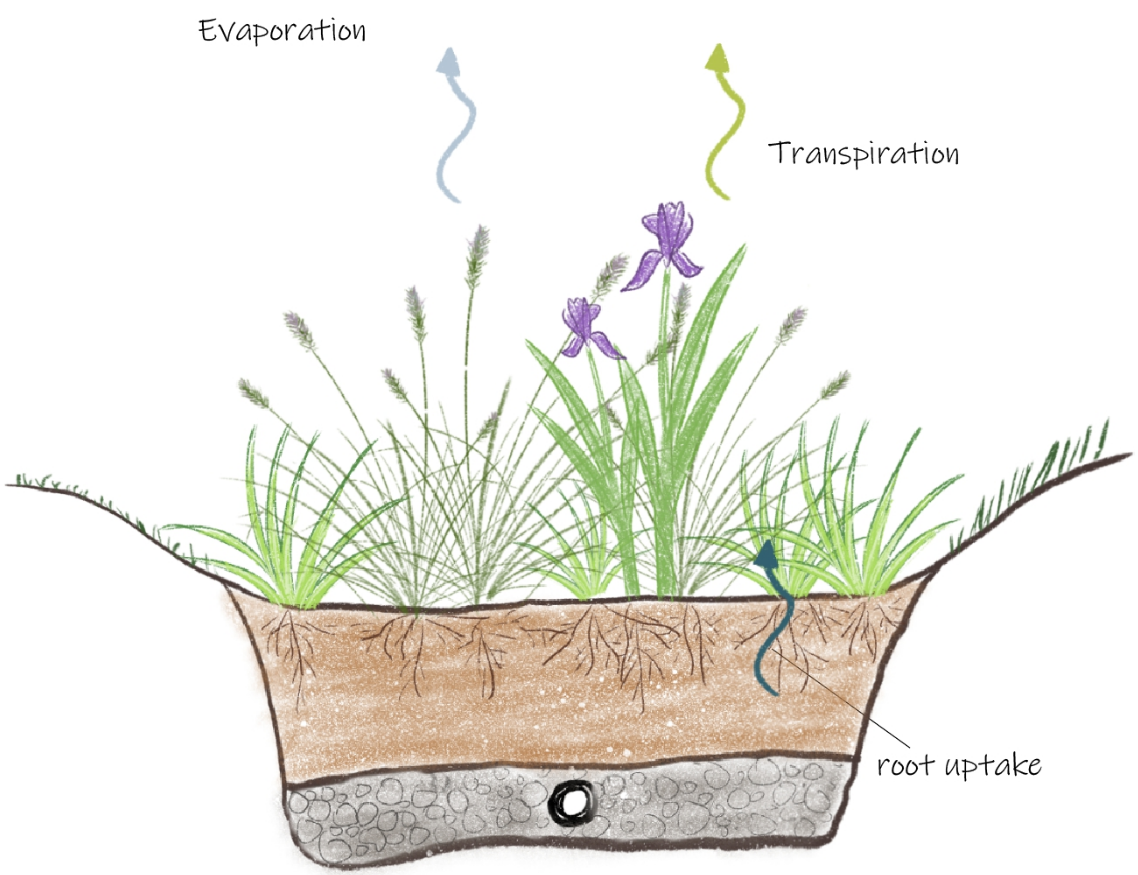
But:

Not completely understood today.

01. Introduction

What is a rain garden?





02. Objectives

The main objective of the project is to study the hydrological performance of rain gardens based on modelling and monitoring work on 3 prototype rain gardens.

Which can be divided to:

- To have a better understanding of the whole hydrologic process (water movement in the soil, vegetation's role)
- To represent the 3 rain gardens in HYDRUS model, and understand the limitations and respective applicability of HYDRUS 2D/3D, HYDRUS 1D models and other conceptual models i.e., SWMM)
- To give a scientific support for a rain garden design guideline (how the configuration and design parameters effect the hydrological performance of a rain garden?)

03. Experiments design

Subcatchment/infiltrate area ratio: 85 m^2/7 m^2

Sub catchment type: Asphalt pavement

Inflow type: center

System boundary: lined wall, with low permeability bottom soil

Soil type: Engineered media

Storage: temporally water storage

Subcatchment/infiltrate area ratio: 75 m^2/25 m^2

Sub catchment type: Roof

Inflow type: Gutter on the one side

System boundary: completely lined

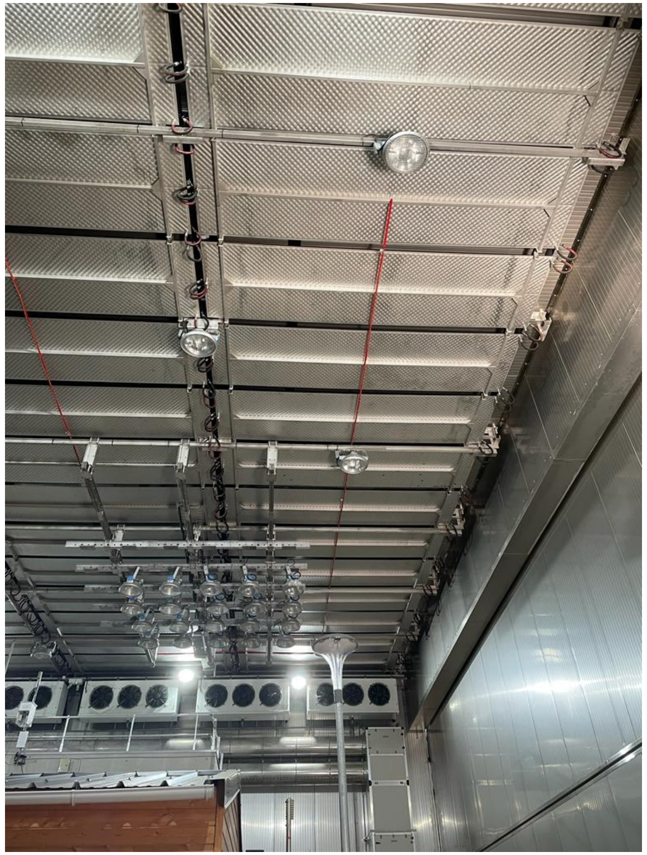
Soil type: local soil

Storage: different depth IWS

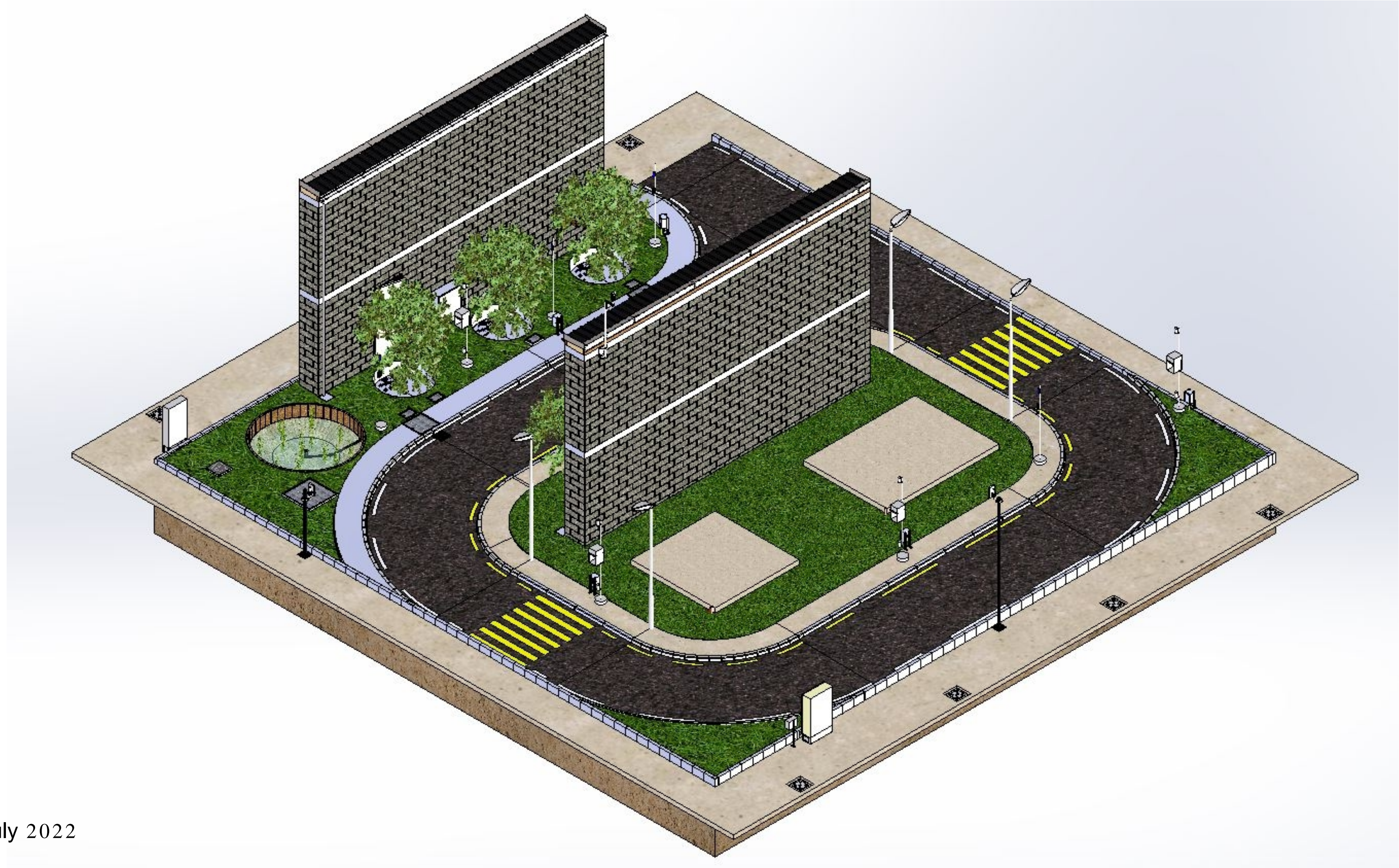
Sense City rain garden

Jardin du Breuil (Sauce: Cerema)

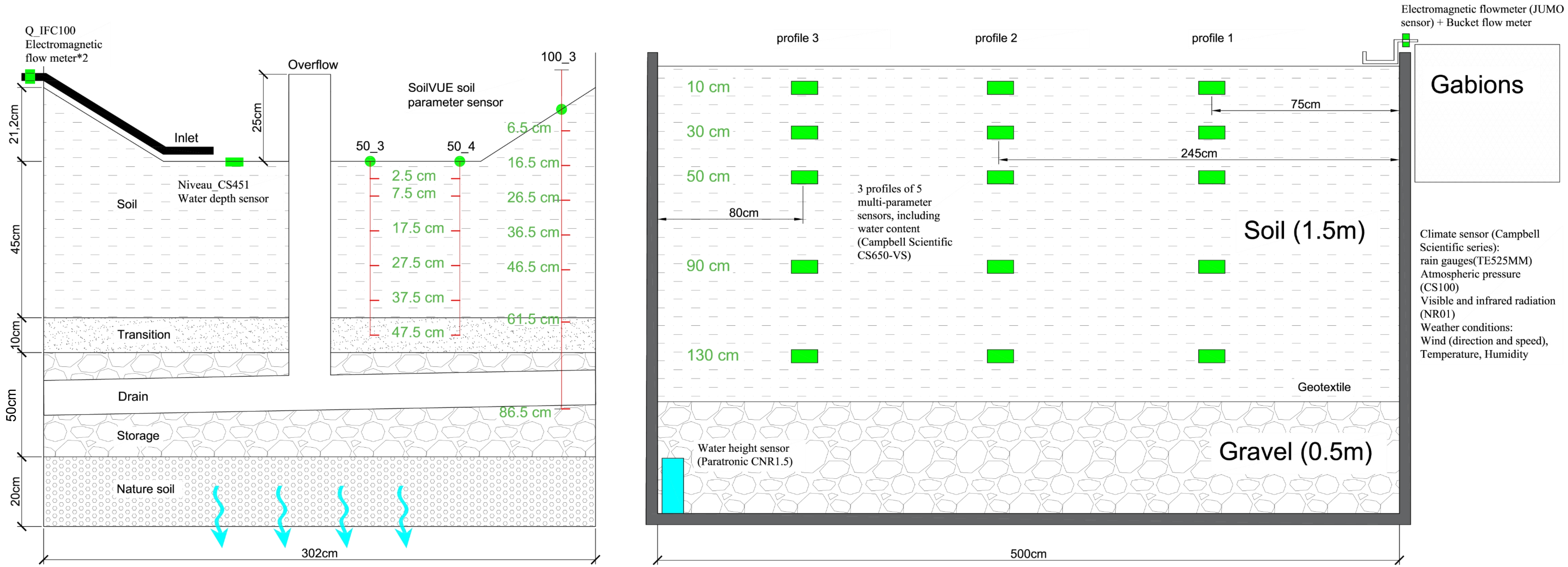
03. Experiments design



03. Experiments design

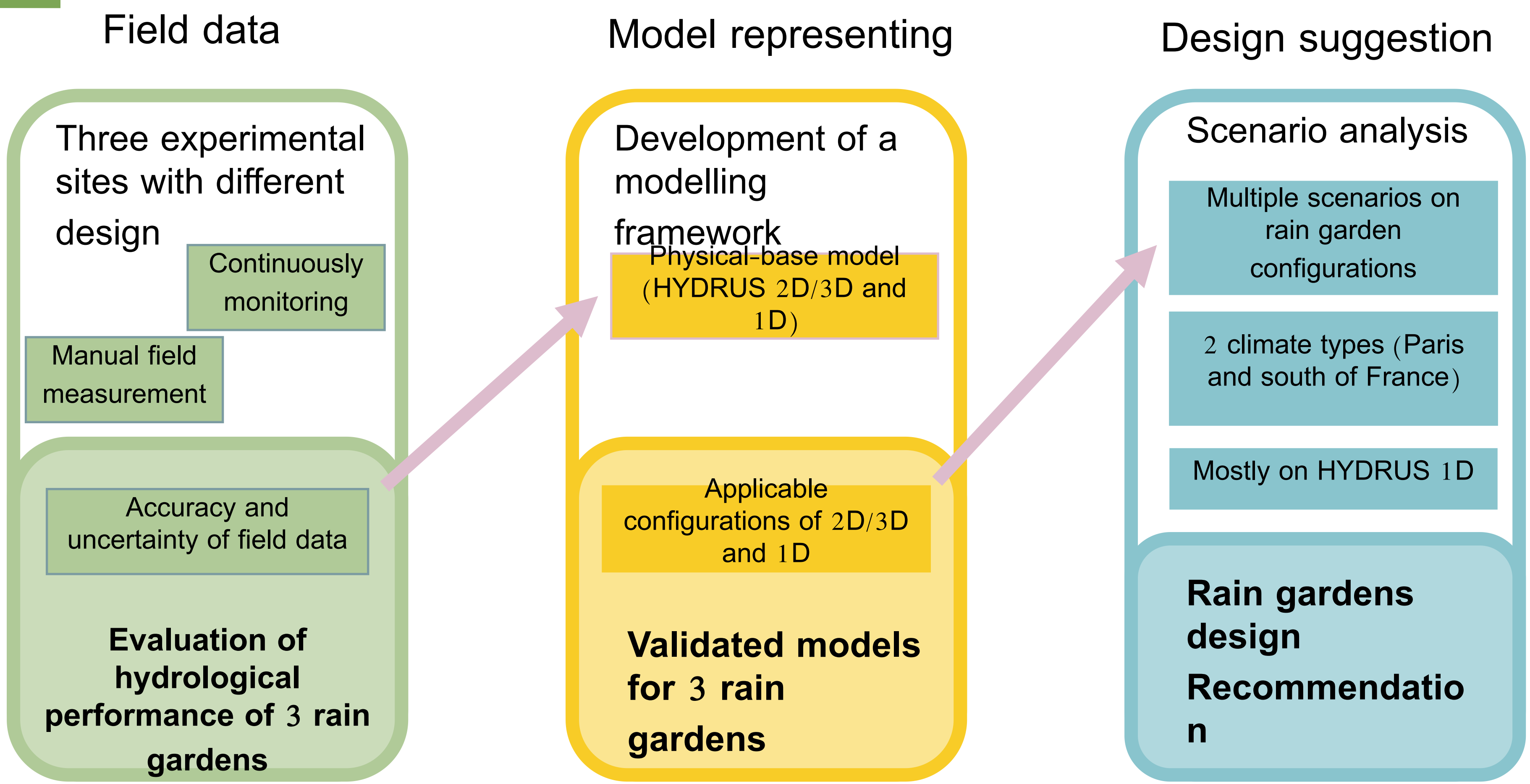


03. Experiments design



Cross section and sensor location of Sense city (left), Jardin du Breuil (right)

04. Methods



Field data
Three experimental sites with different design
Continuously monitoring
Manual field measurement
Accuracy and uncertainty of field data
Evaluation of hydrological performance of 3 rain gardens
Model representing
Development of a modelling framework
Physical-base model (HYDRUS 2D/3D and 1D)
Applicable configurations of 2D/3D and 1D
Validated models for 3 rain gardens
Design suggestion
Scenario analysis
Multiple scenarios on rain garden configurations
2 climate types (Paris and south of France)
Mostly on HYDRUS 1D
Rain gardens design Recommendation

05. Research questions

Model representing

Development of a modelling framework

Physical-base model (HYDRUS 2D/3D and 1D)

Applicable configurations of 2D/3D and 1D

Validated models for 3 rain gardens

How to represent a rain garden in models?

- **How to represent different configurations in a model?**
  a. The way inflow
  b. Distribution of vegetations
  c. Soil infiltration anisotropic
  d. Garden surface topography
  e. Shape of the rain garden
  f. The condition under the system
- **How these configurations affect the following hydrological process?**
  a. Lateral flow
  b. Exfiltration (also need to know how exfiltration affect the surrounding buildings)
- **Comparison between HYDRUS 1D and 2D/3D models:**
  a. The application and representativeness of each model
  b. The result accuracy and computation time
  c. Which kind of configuration can be modelled by 1D model without losing accuracy?

05. Research questions

How to design and which configuration shall we choose under different scenarios?

- **When shall we choose a line/non-lined system?**
  a. The difference between lined/non-lined (retention capacity, drying time, ET)
  b. Can surrounding soil make the garden more resilience from the drought?
  c. The process of exfiltration (rate? how to control?)
- **The effect of an internal water storage (IWS)**
  a. Functions of IWS, and how its performance change with the IWS depth
  b. How to transmit water into the substrate from the IWS
- **The role of an underdrain, when is it needed?**
- **The effect of capillary barrier?**
  a. How we manage capillary barrier effect by changing the rain garden configuration?
  b. Can capillary barrier increase storage, limit exfiltration or enhance ET?
- **The effect of other configurations (shape, subcatchment/garden surface rati**
  a. The role of these configurations, and how they affect rain gardens' performance (ET, infiltratio
  b. Can we compensate small but deep raingarden with more ET?

Design suggestion

Scenario analysis

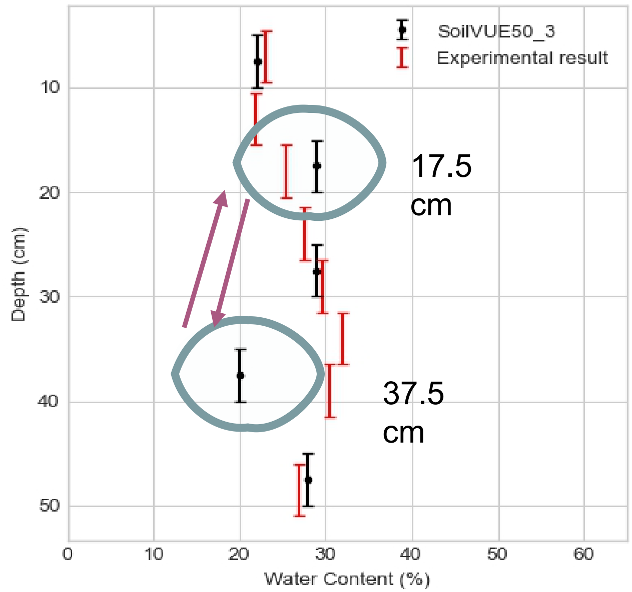
Multiple scenarios on rain garden configurations

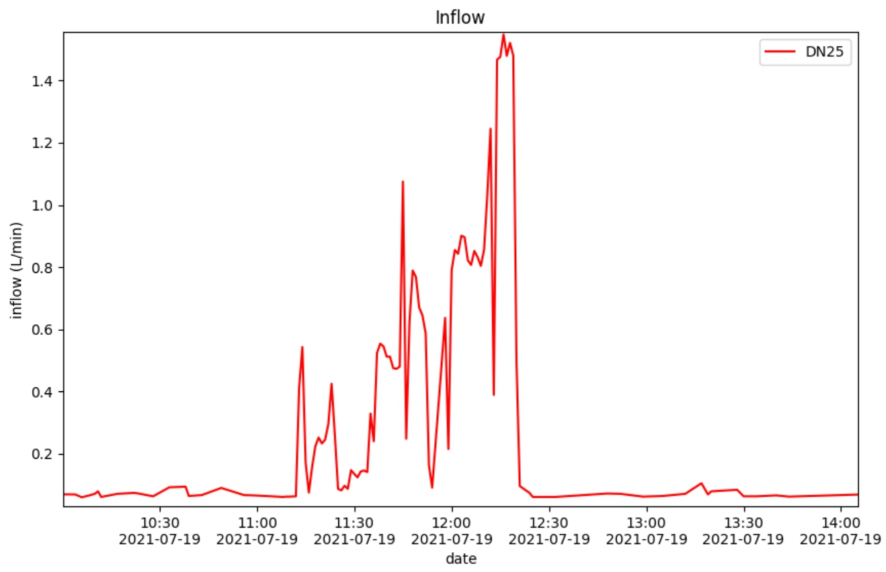
2 climate types (Paris and south of France)

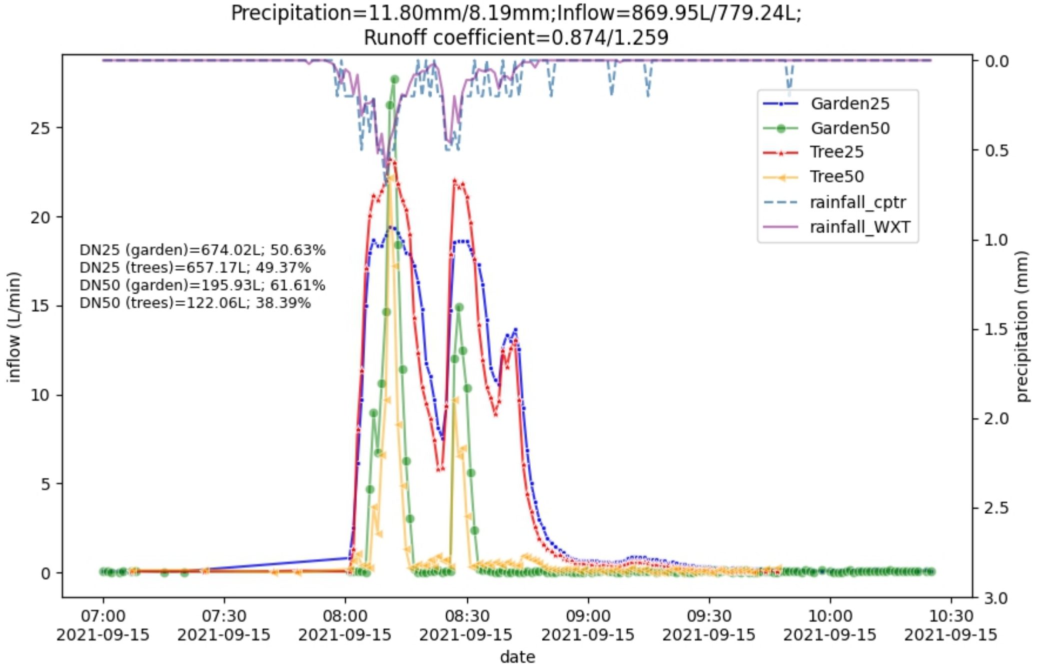
Rain gardens design Recommendation

Current issues on data

- High noise on inflow data
- The strange sensor measurement
- Wide range of heavy events runoff coefficient （from 0.2 to 1.8）







Thank you

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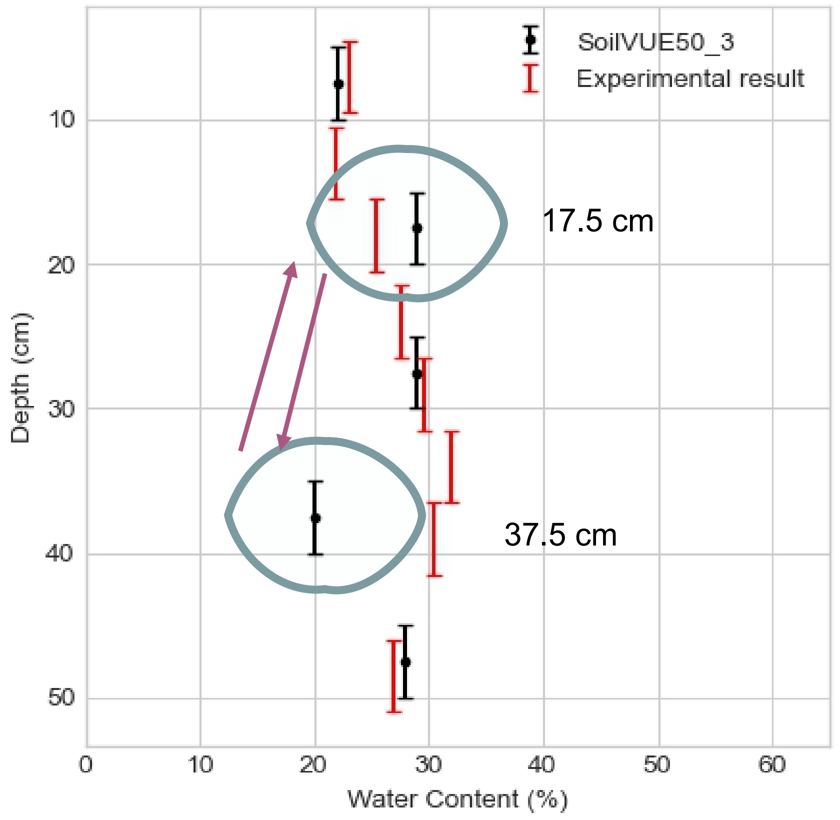
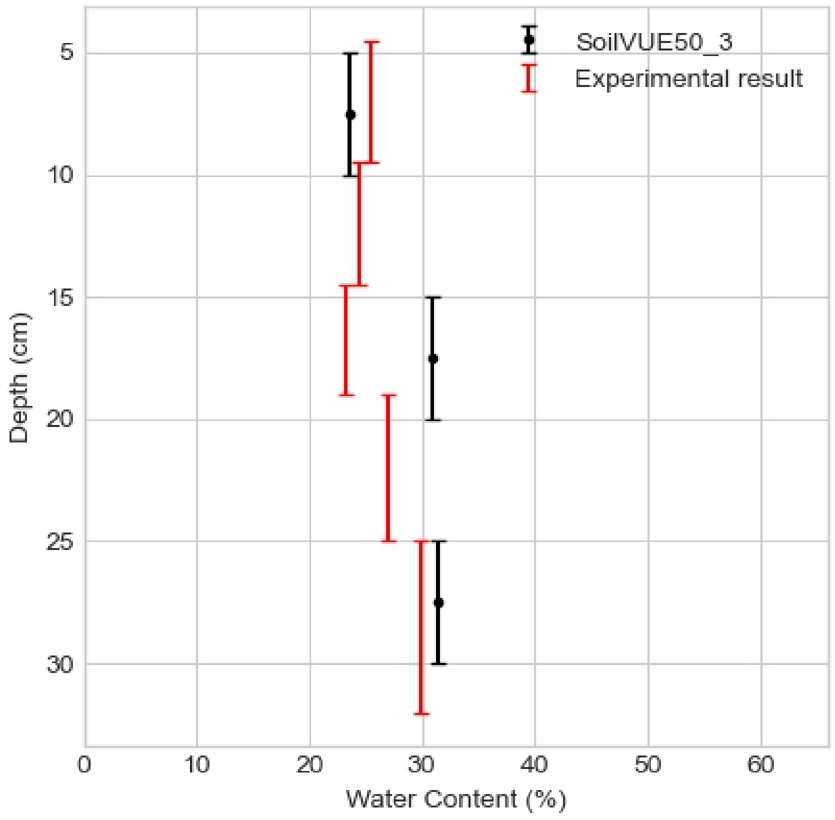
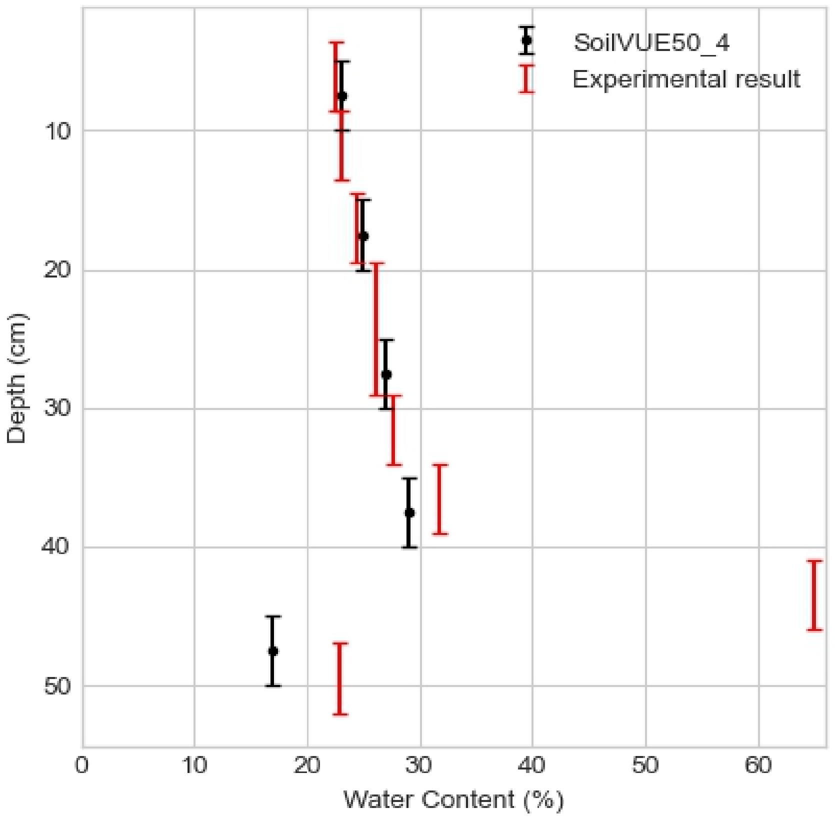
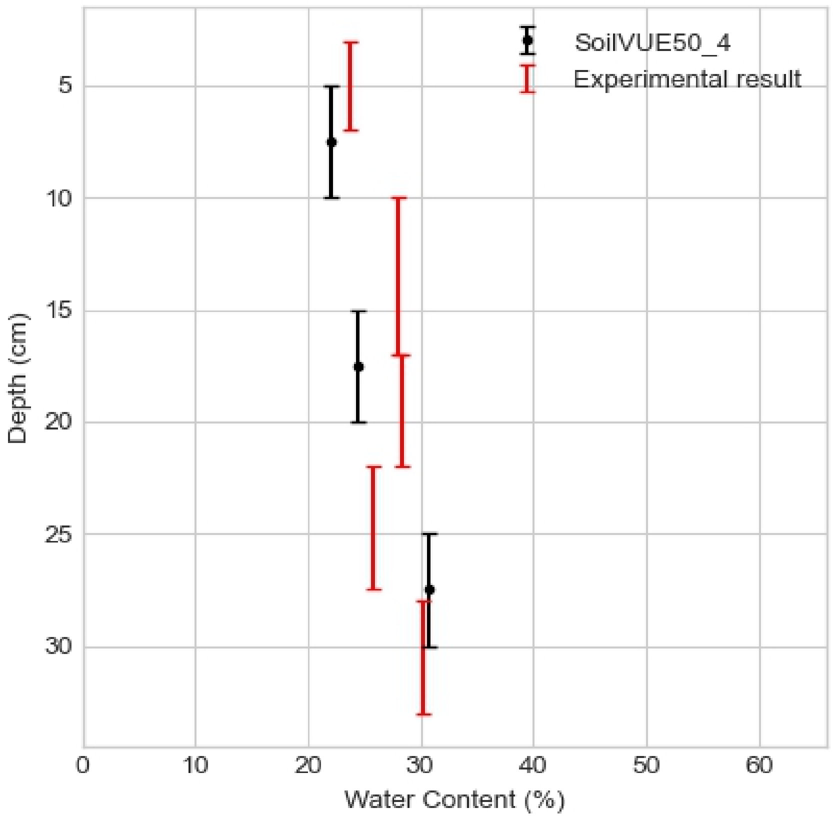
Soil water content



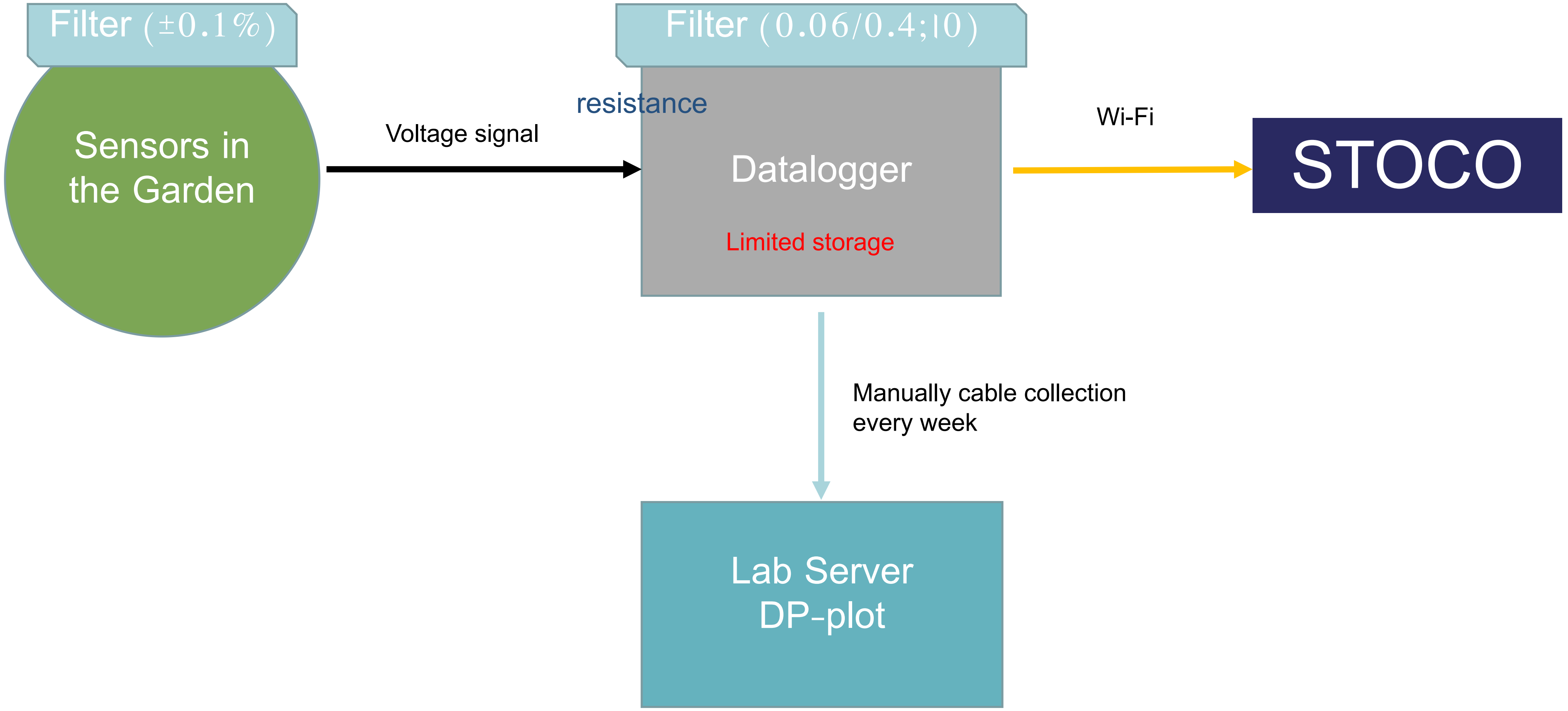


Soil water content

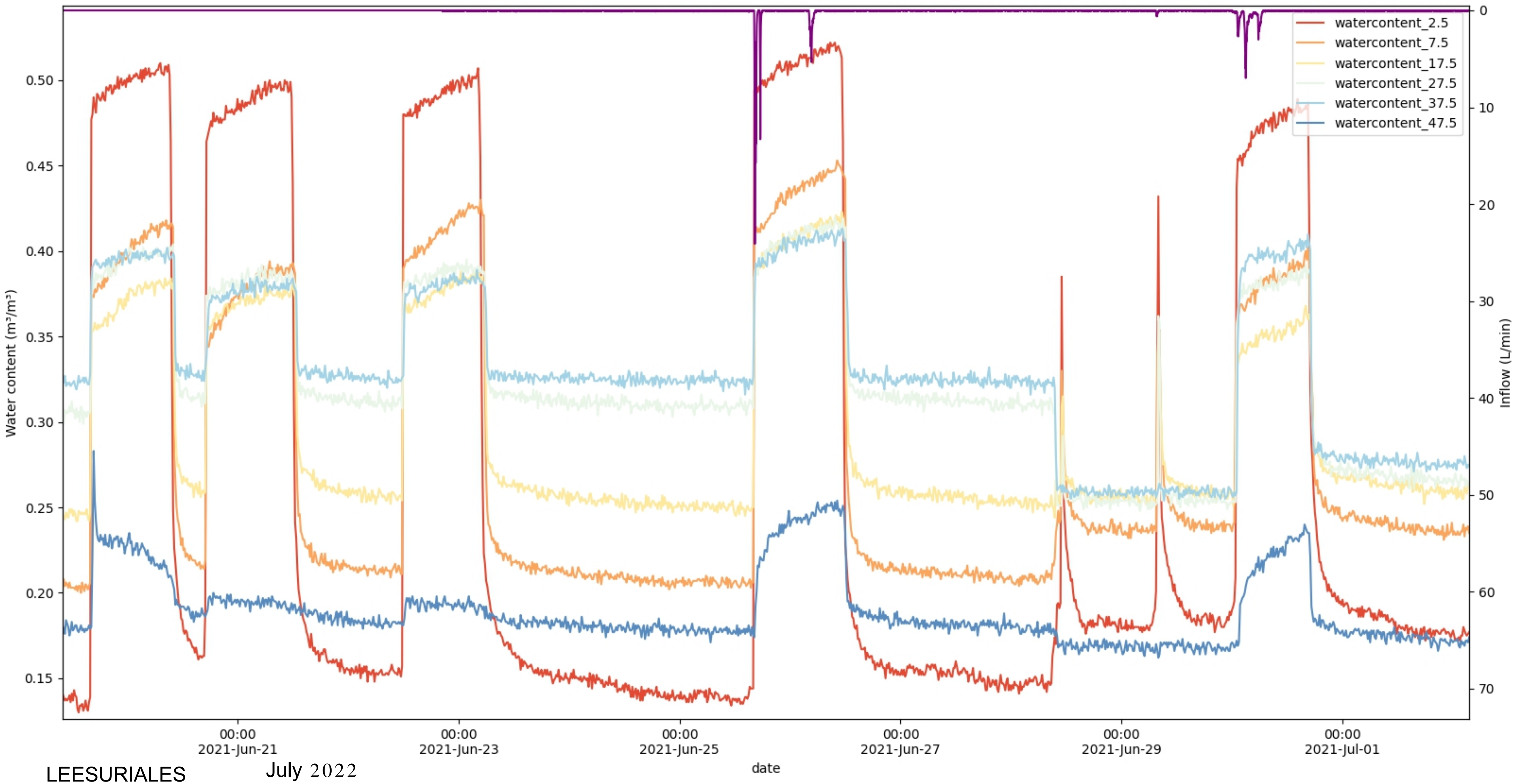




Current issues on data

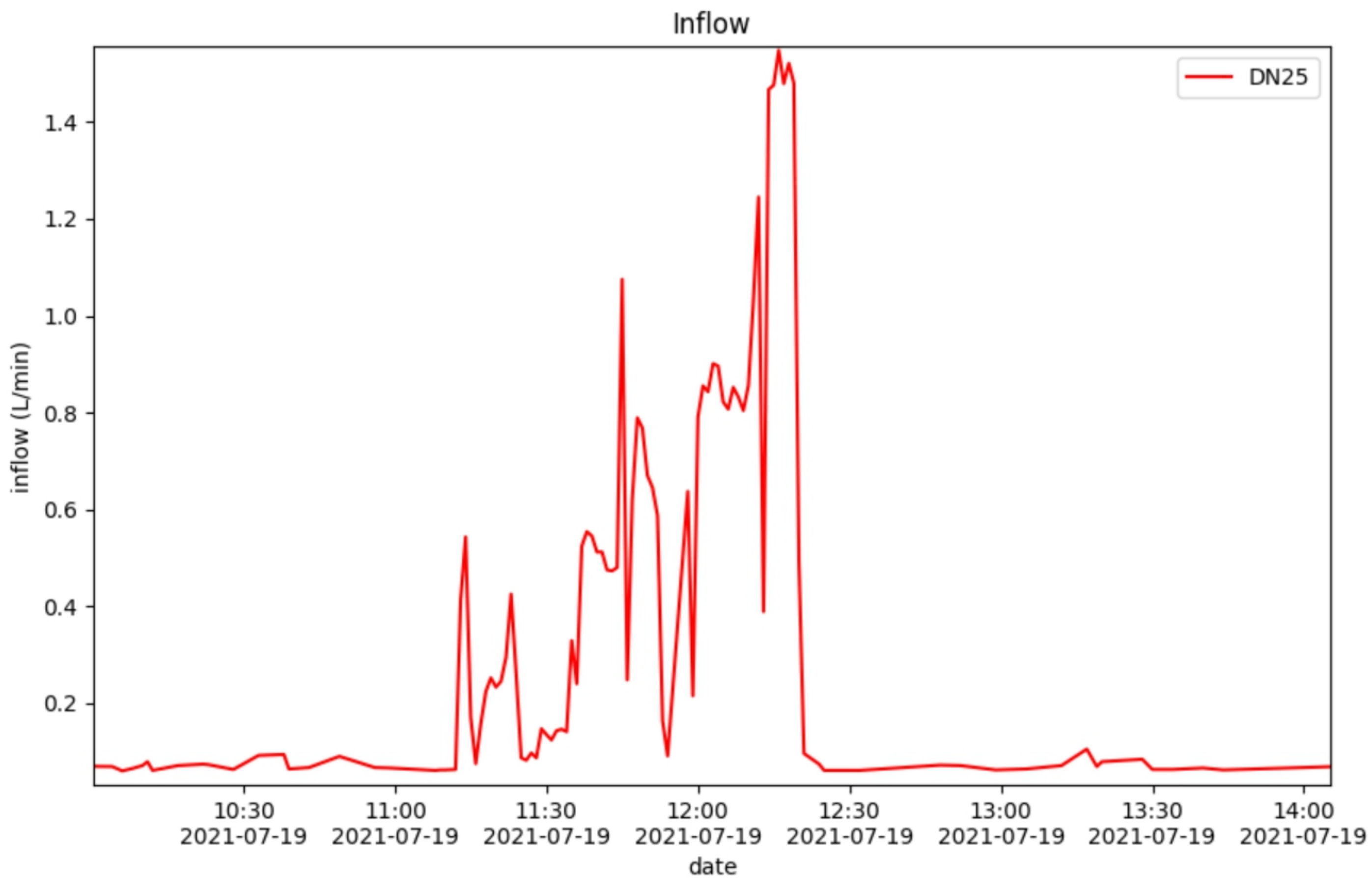


Soil water content

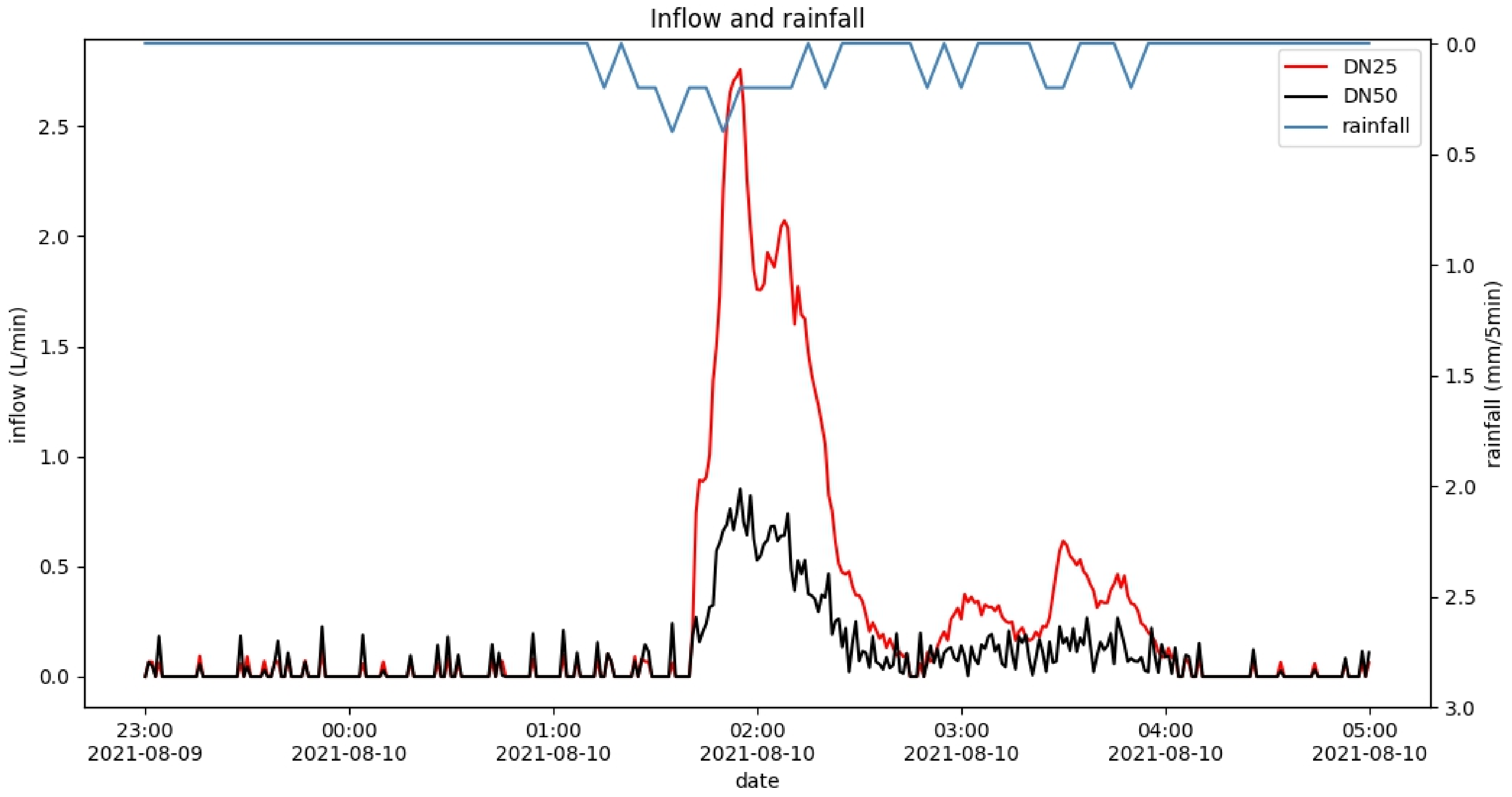


Soil water content from sensor 50_4

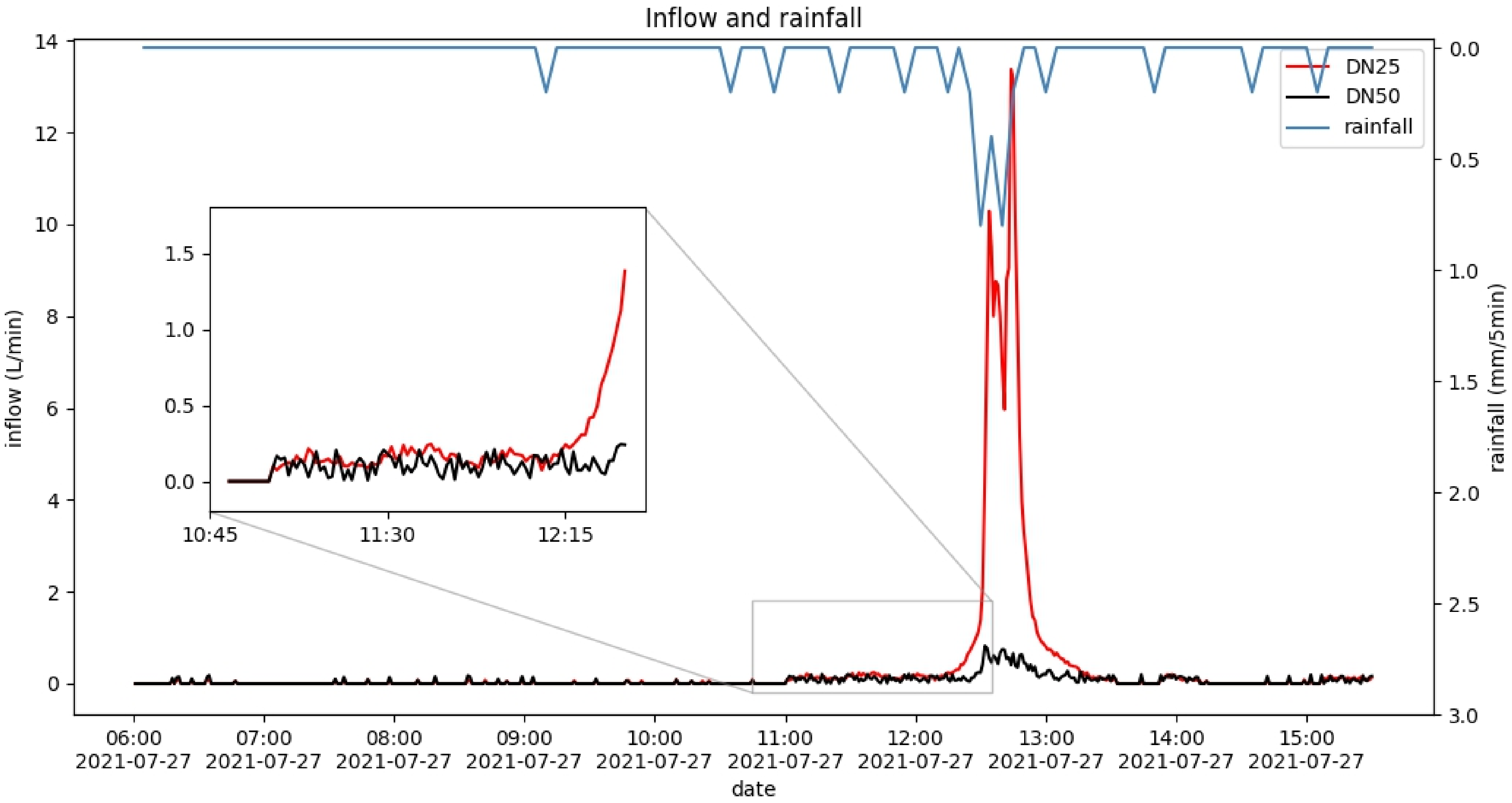
Inflow data noise



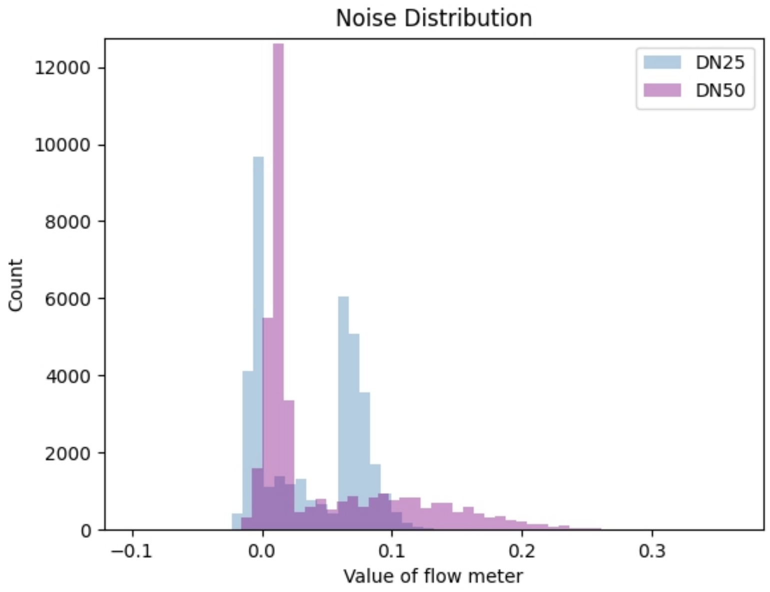
Inflow data noise



Inflow data noise



Inflow data noise

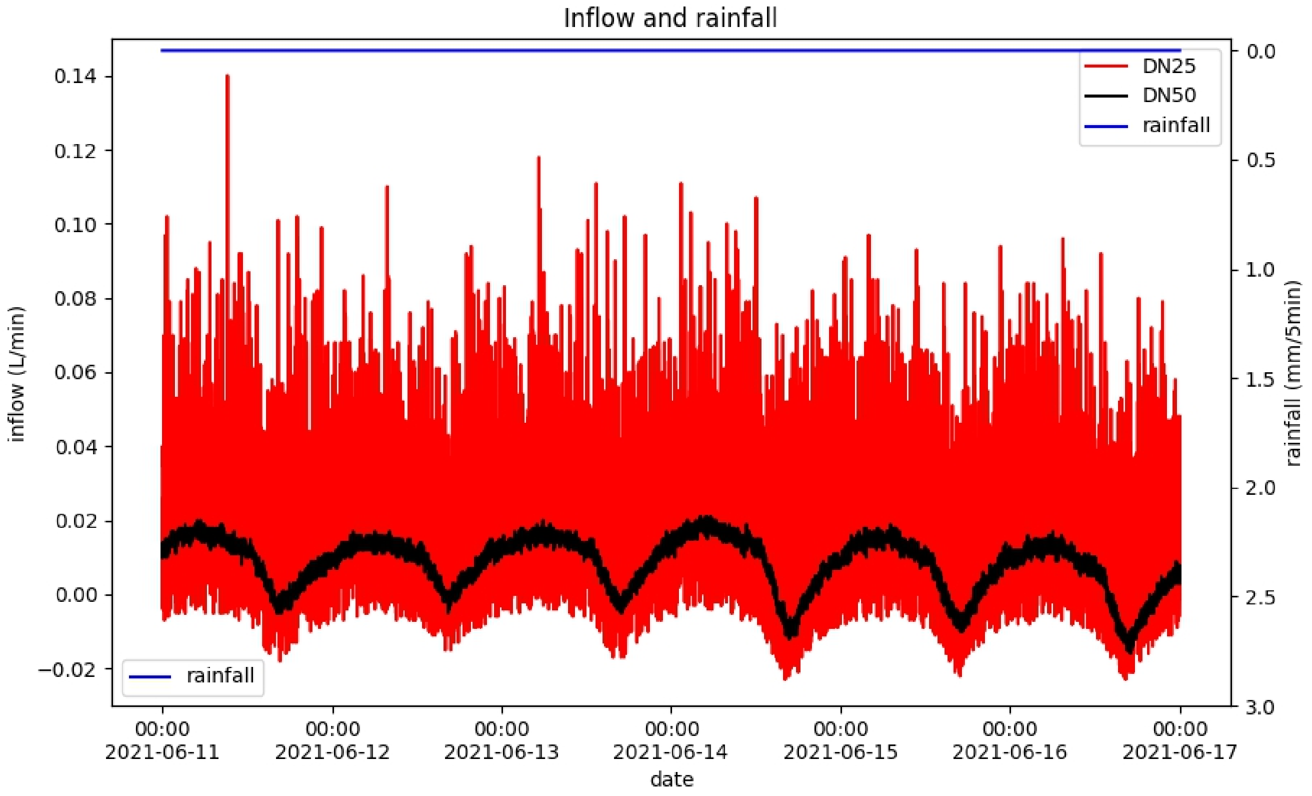


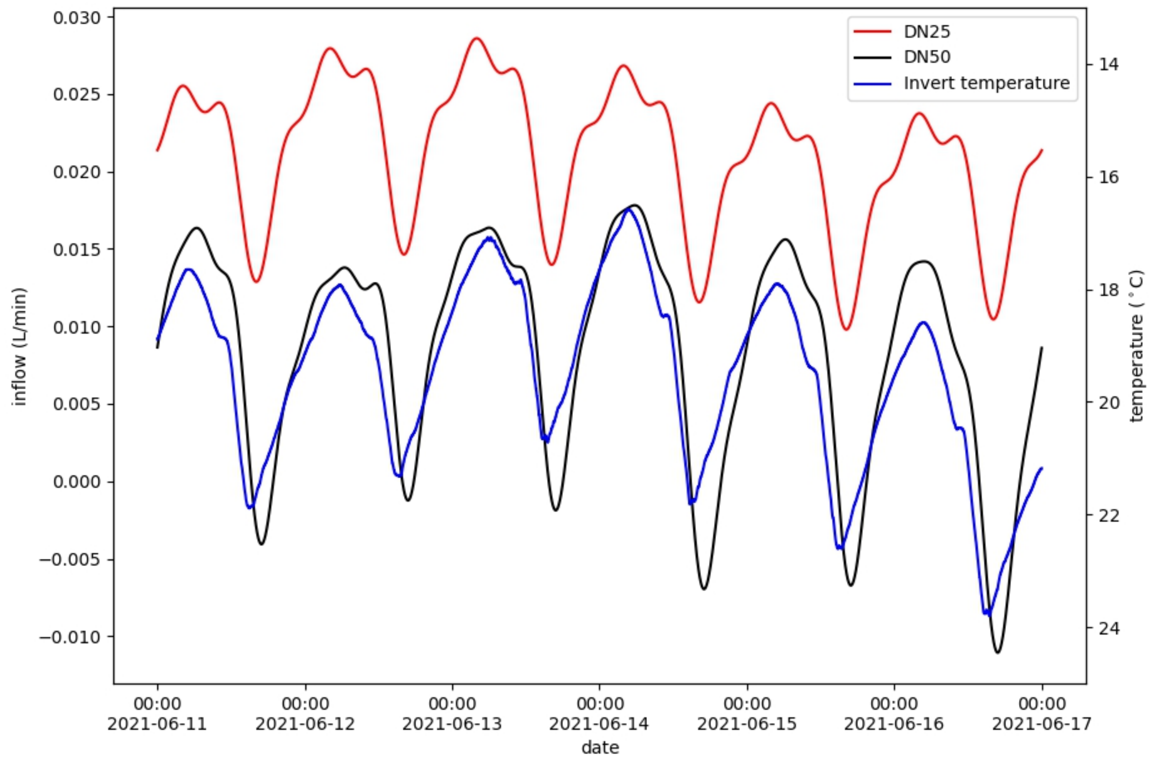
Filter :
DN25 < 0.06L/s
DN50 < 0.4L/s

Objectives:
1. Remove the Non-white noise
2. Smooth the data
3. Detect the early inflow

Tested solution:
1. Fourier transform
2. Wavelet filter
3. Moving window average method

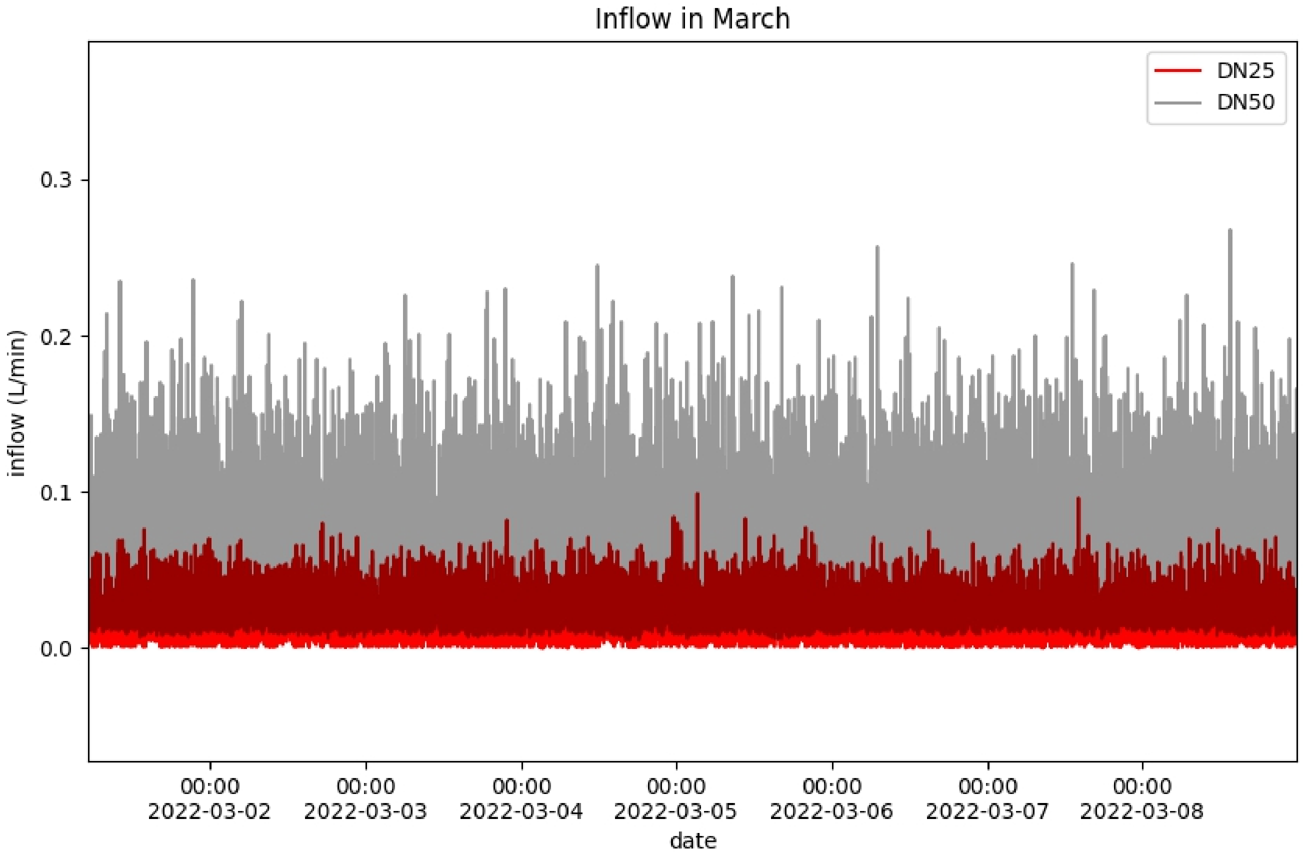
Fourier transform

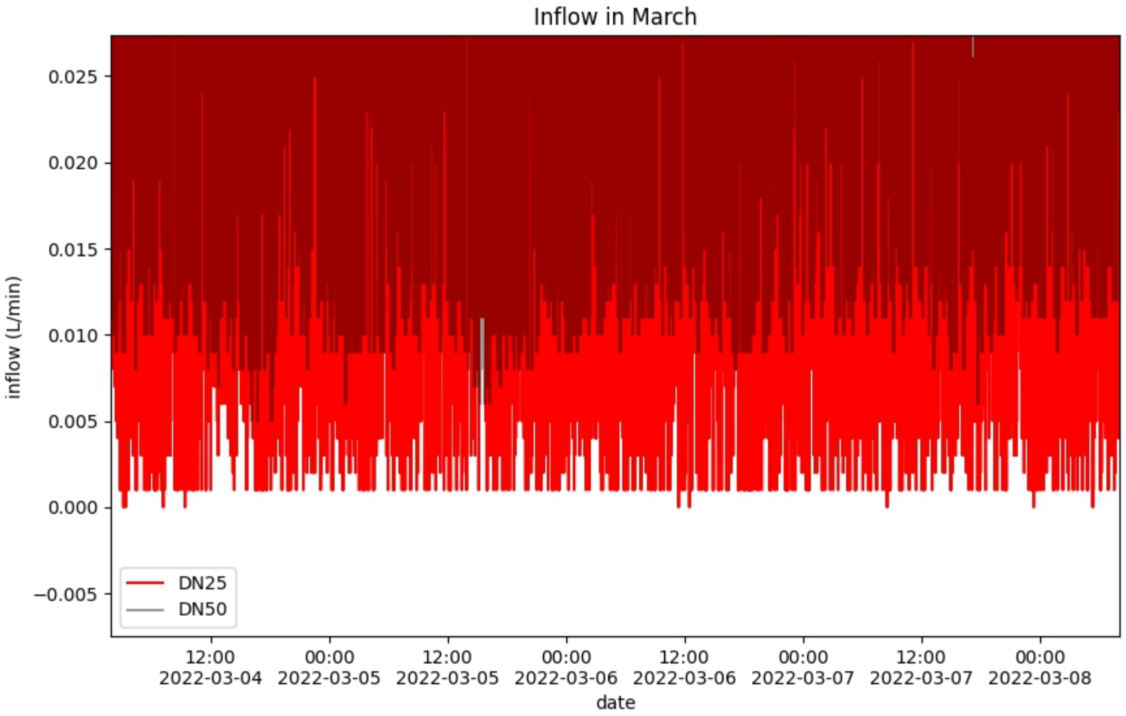




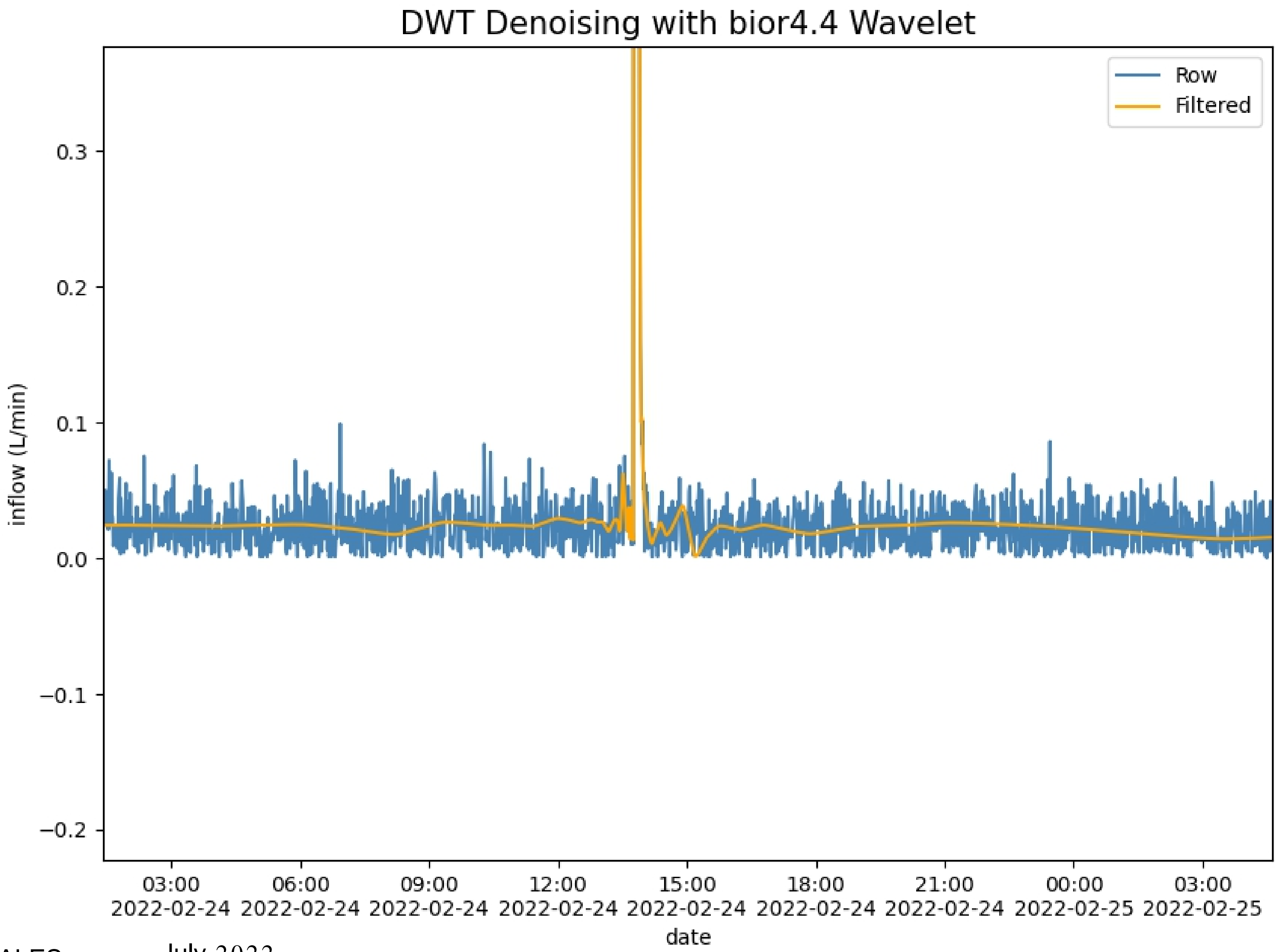
Fourier transform

two baseline of 0.0215 (DN25), 0.0603 (DN50),

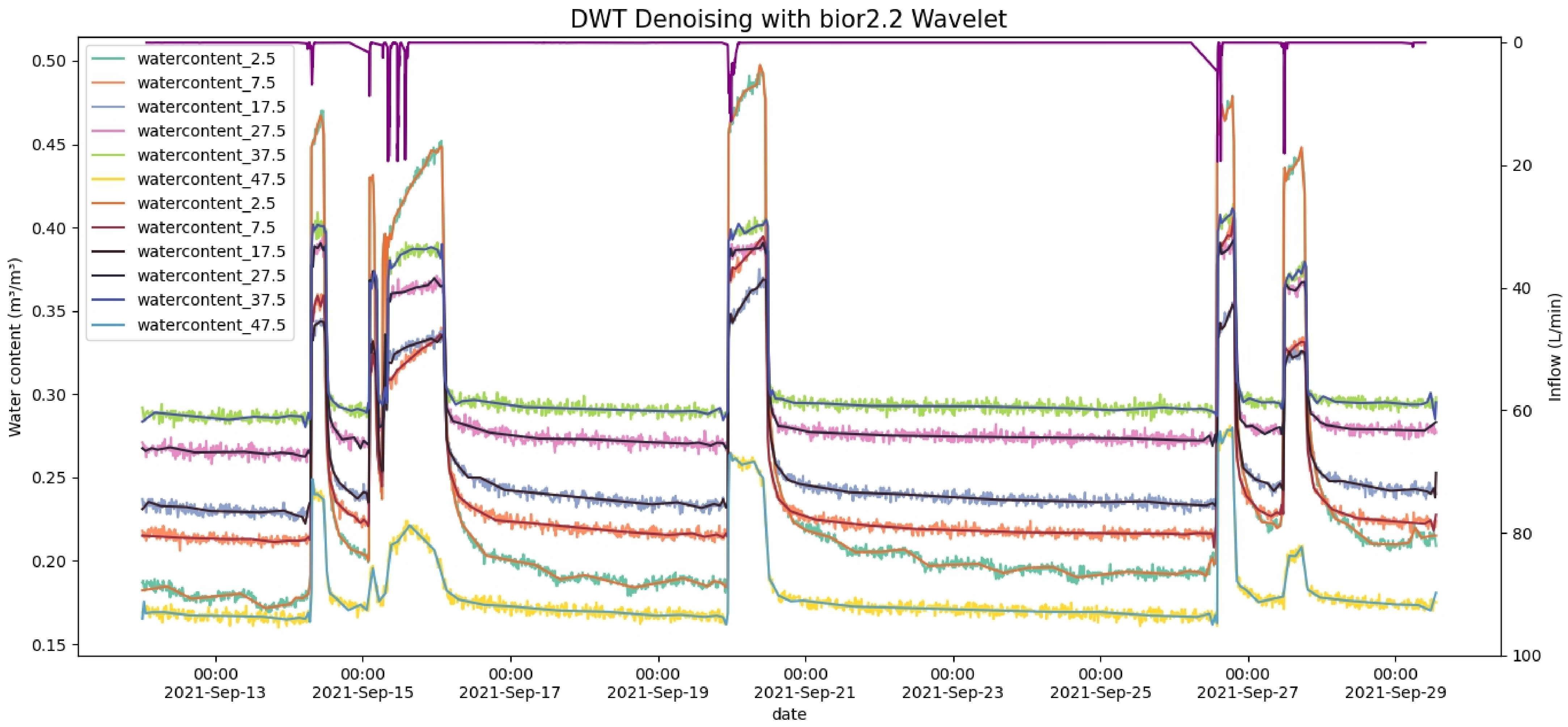




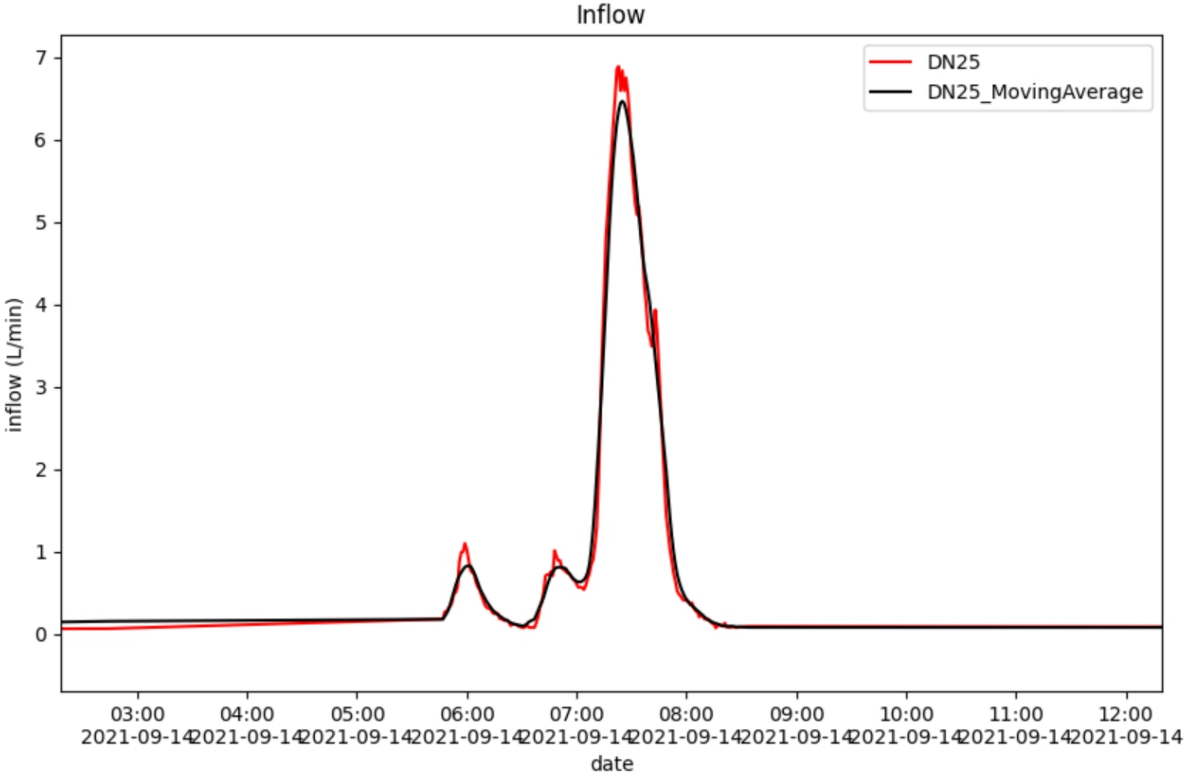
Smooth the data-wavelet

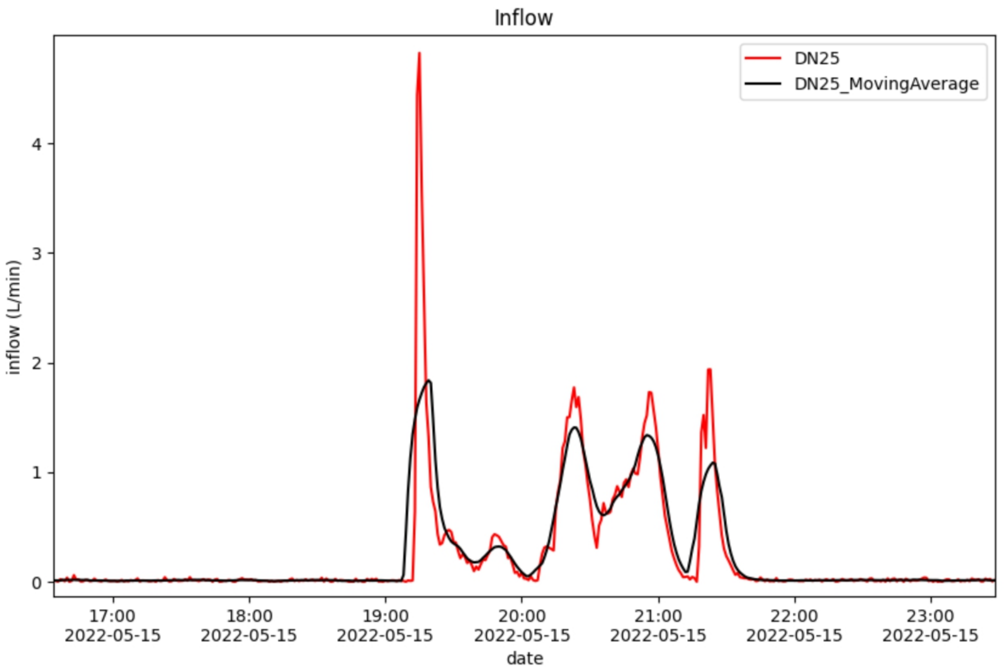


Smooth the data–wavelet

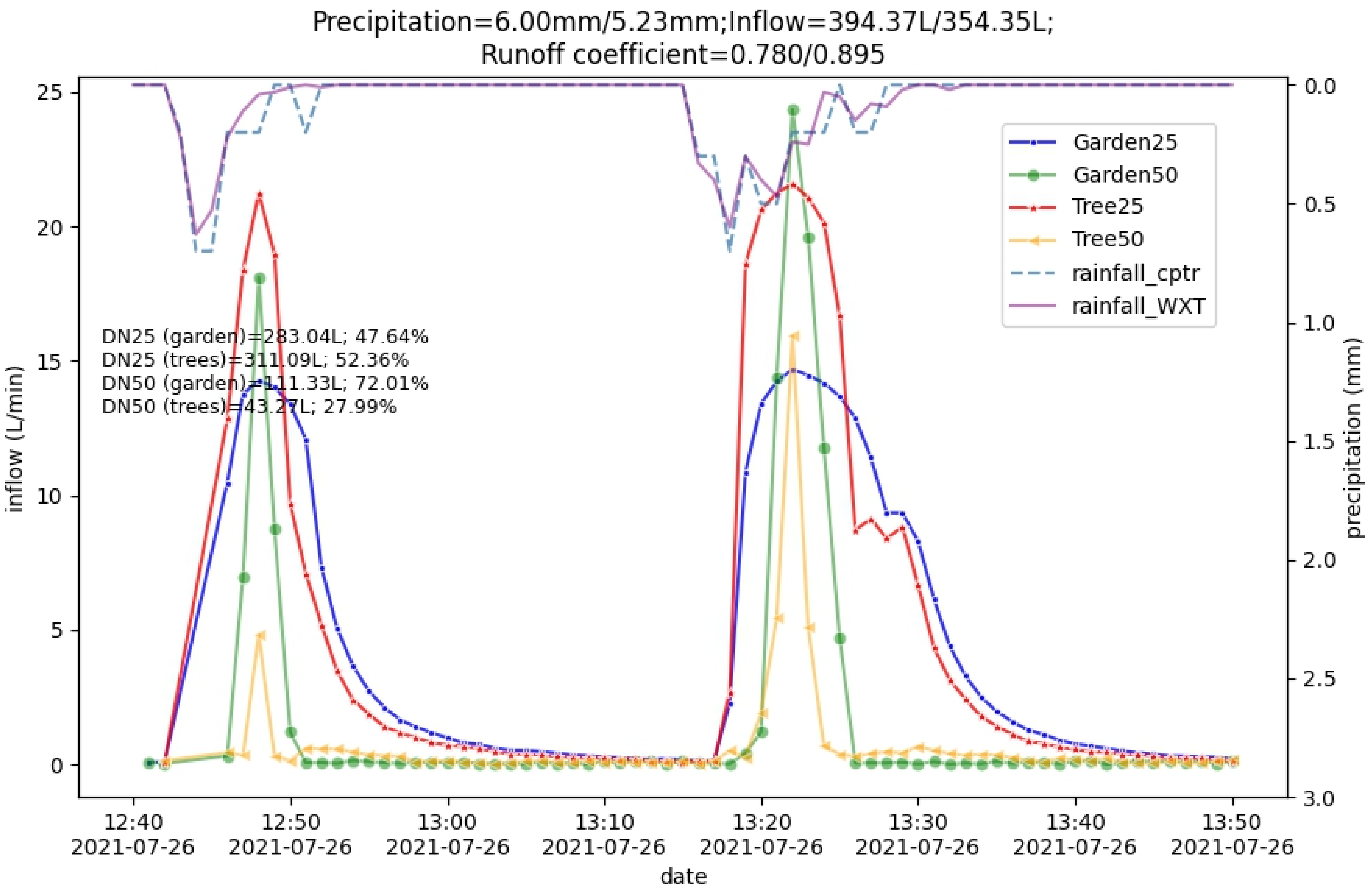


Moving window average

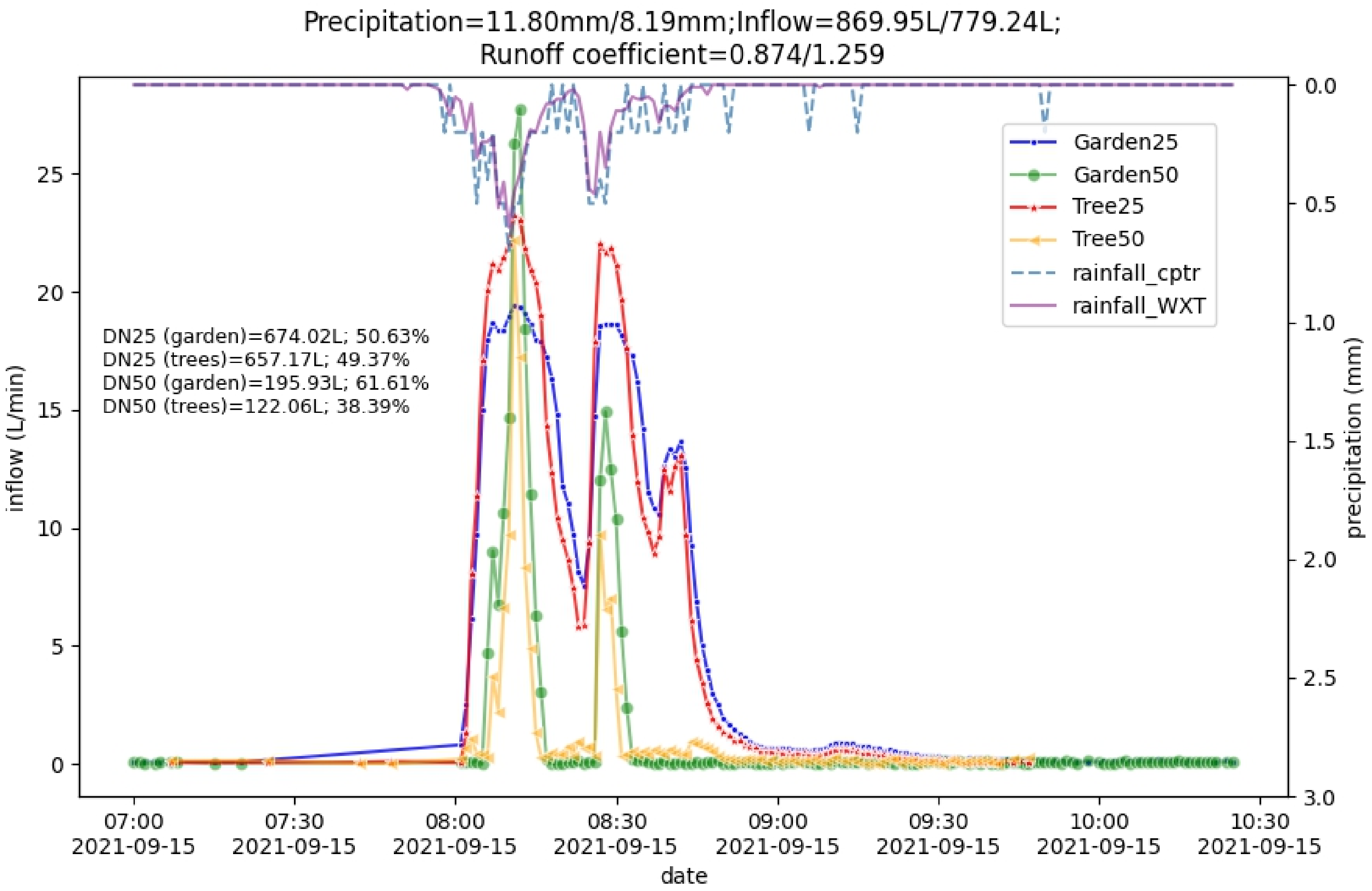




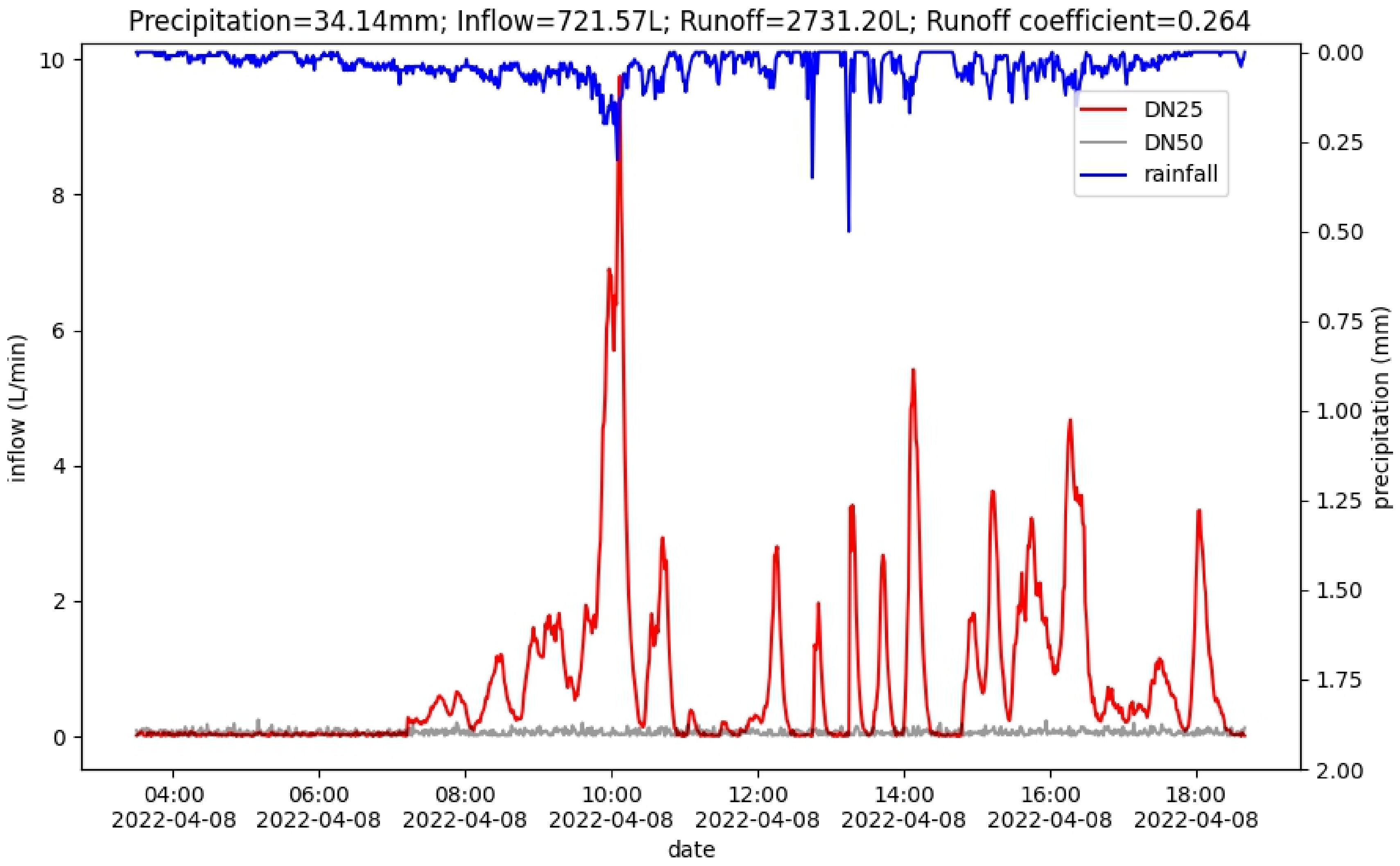
Runoff coefficient



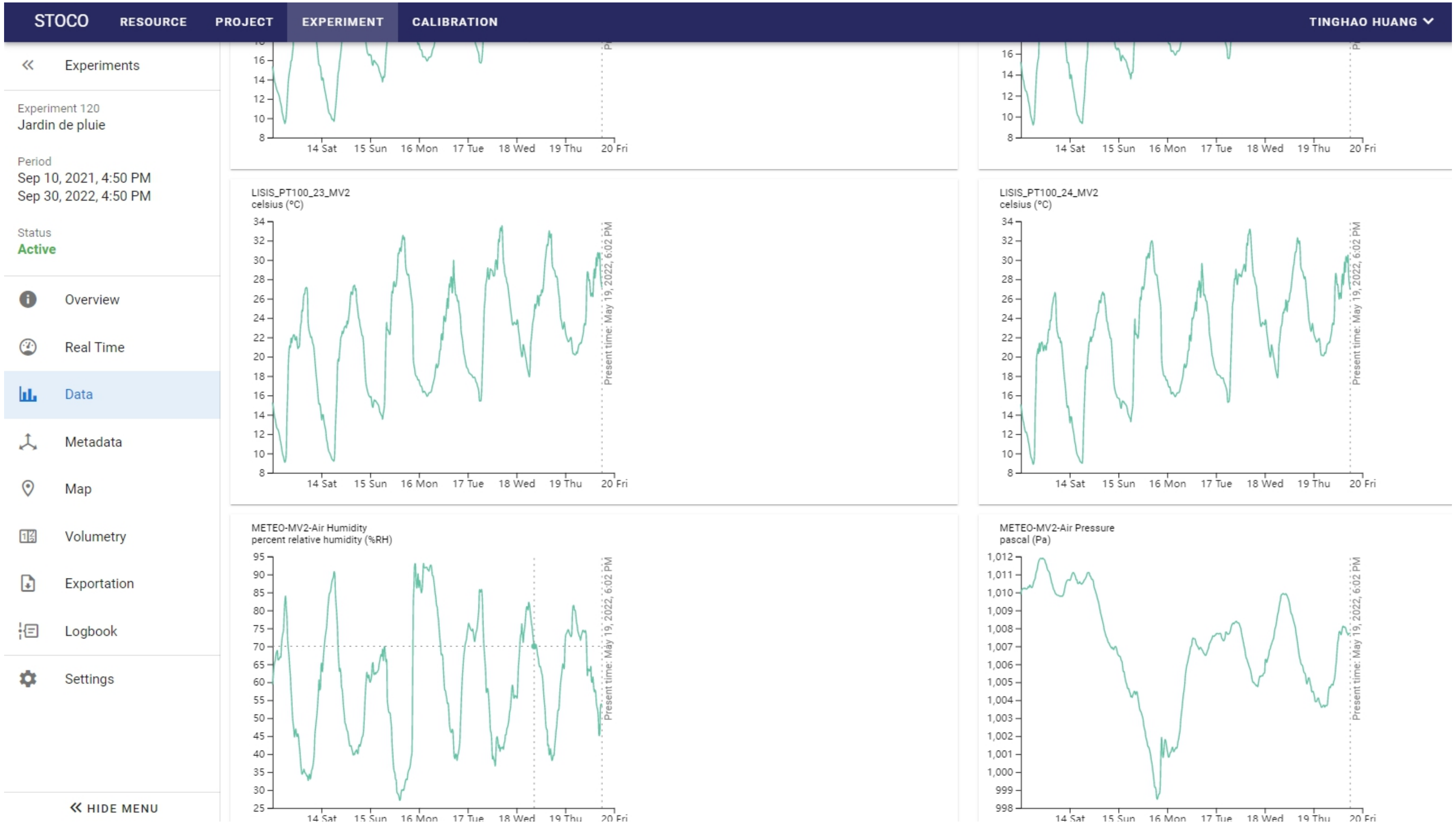
Runoff coefficient



Runoff coefficient



STOCO

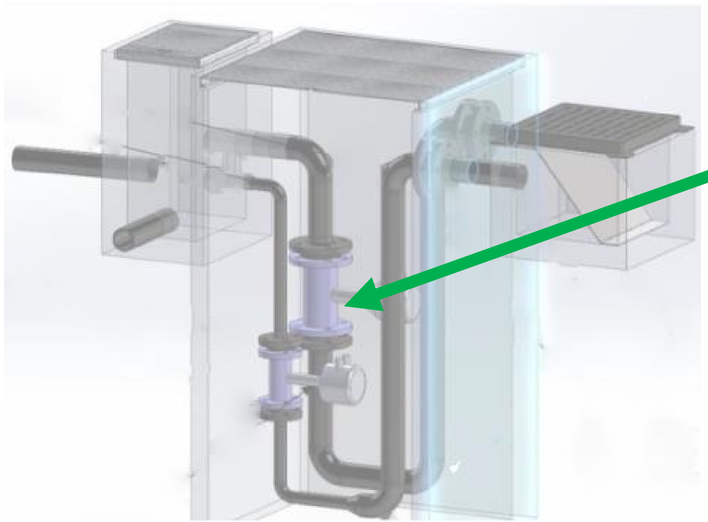


STOCO
RESOURCE
PROJECT
EXPERIMENT
CALIBRATION
TINGHAO HUANG
Experiments
Experiment 120
Jardin de pluie
Period
Sep 10, 2021, 4:50 PM
Sep 30, 2022, 4:50 PM
Status
Active
Overview
Real Time
Data
Metadata
Map
Volumetry
Exportation
Logbook
Settings
HIDE MENU
LISIS_PT100_23_MV2
celsius (°C)
LISIS_PT100_24_MV2
celsius (°C)
METEO-MV2-Air Humidity
percent relative humidity (%RH)
METEO-MV2-Air Pressure
pascal (Pa)
Present time: May 19, 2022, 6:02 PM
14 Sat
15 Sun
16 Mon
17 Tue
18 Wed
19 Thu
20 Fri

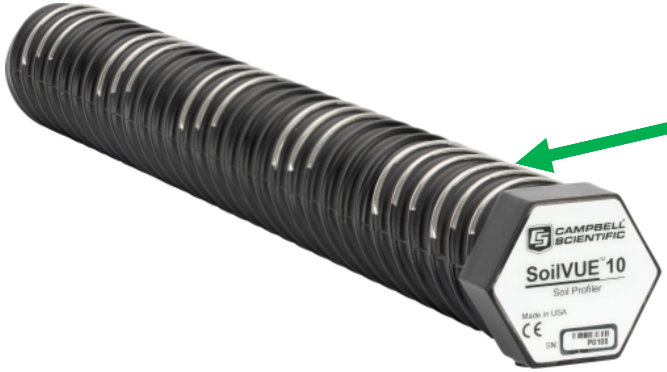
"

A **TDR moisture sensor** employs time-domain reflectometry (TDR) to measure moisture content indirectly based on the correlation to electric and dielectric properties of materials, such as soil, agrarian products, snow, wood or concrete.

03. Methods &
Experiments design



Inflow monitoring system (Sauce: Yassine, 2021)



SoilVUE10 sensor (Sauce: Campbellsci.com)