6èmes Journées Scientifiques du SNO Observil

De l'acquisition de données à la modélisation : développement d'un écosystème de services numériques ouverts appliqué à la gestion intégrée des eaux pluviales en bassin versant urbain.

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Plan

1 Introduction
- The City Orchestra project
- Context and research questions

2 State of the art
- Water in cities
- Hydroinformatics
- FAIR

3 Results in progress
- Creation of an Urban Observatory
- FAIR by design observatory creation
- Generation of a theoretical and coherent drainage network

4 Modelisation

Call for projects: Smart and Sustainable Territories (France 2030)

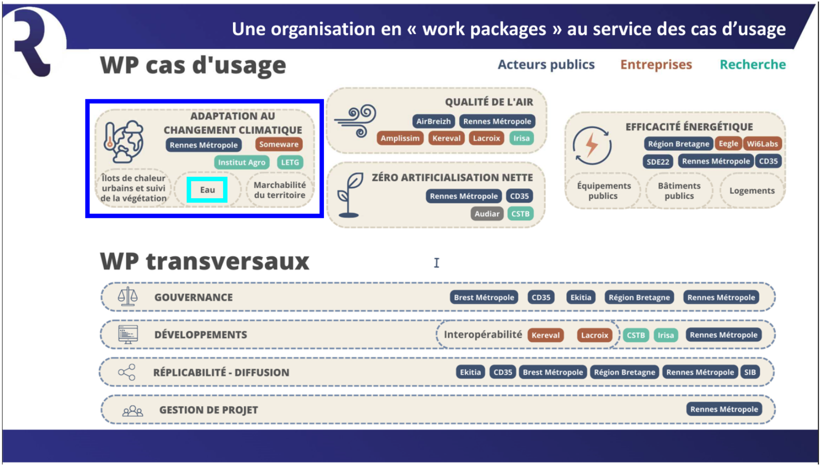
Goal

Harmonize data to support the ecological transition of territories

How?

Sharing knowledge and data through tool provision

Project partners and organization

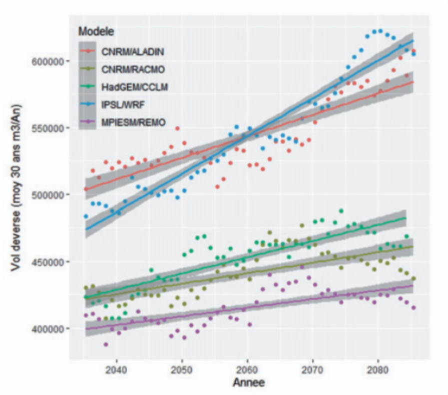


4 work packages for use cases and 1 orchestration work package (source Rennes Métropole)

Outline

Adaptation to global changes

1. Climate



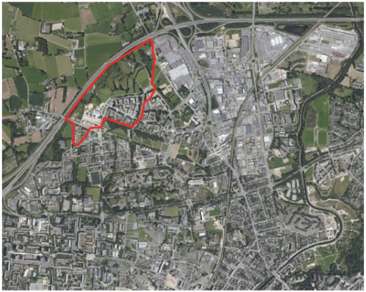
Annual overflow volume from a stormwater overflow structure in Valence, depending on different climate models (30-year moving average) Gogien et al. [2023]

Adaptation to global changes

2. Land use

Nord Ouest de Rennes (1950-65)

source : IGN (remonterletemps.ing.fr)



Aujourd'hui

2. Land use

2017 2020 2023

Evolution of the Beauregard district, Northwest Rennes

Initial question

urban system = complex

How can we represent hydrological processes
in a complex urban system ?

Outline

Modelling water in urban environments

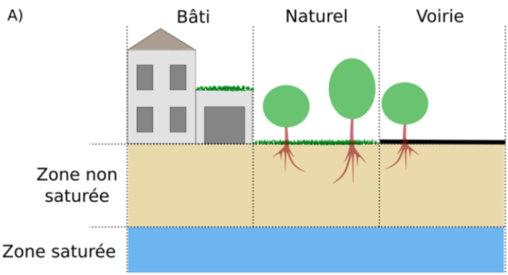
- 43 models dedicated to urban hydrology Salvadore et al. [2015]
- Each model has its own spatial and temporal specificities depending on the purpose
- Pophillat [2022]: Few are suitable for evaluating infiltration strategies (continuous and distributed surface and subsurface hydrology representation)

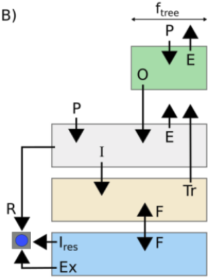
URBS (Urban Runoff Branching System)

Morena [2004] Rodriguez [2010] Li [2015] Pophillat [2022]

- Distributed model at cadastral parcel scale: Urban Hydrological Element (UHE)
- Includes integrated stormwater management features
- Detailed parcel-scale information (runoff, evaporation. . .)

UHE

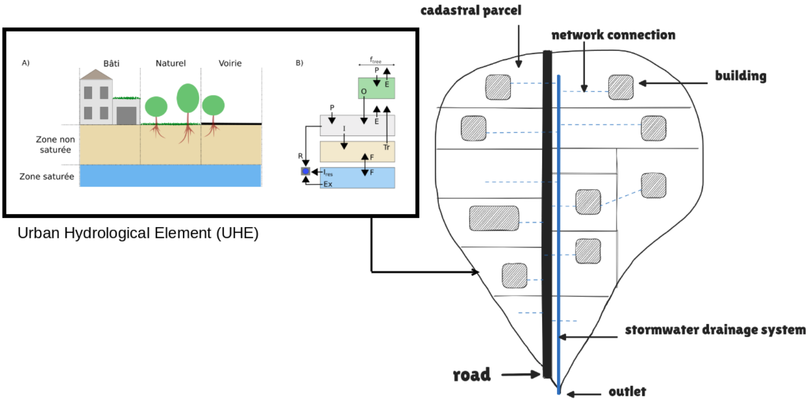




A) UHE

B) Water flows between UHE reservoirs

A distributed model



Model inputs and outputs

Model inputs:

- Climate time series (precipitation, PET)
- Land use, integrated management structures (swales, green roofs, etc.)
- Sewer network, natural streams
- Soil properties

Model outputs:

- Discharge (parcel scale, outlet)
- Runoff
- Infiltration
- Soil moisture
- Groundwater level
- Transpiration
- ...

Outline

Hydroinformatics integrates hydraulics, hydrology and environmental engineering to support water management decision making Loucks [2023]

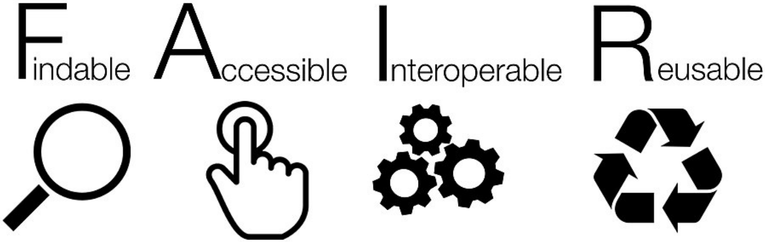
- GIS
- Remote Sensing
- **Optimisation, modelling software**
- **Data management software**
- Serious games
- AI

Data management software?

Data infrastructure for hydrological observatories Goodall et al. [2008], Horsburgh et al. [2009], Ames et al. [2012], Horsburgh et al. [2016] (CUAHSI)

- Common semantics
- Precise data description: database schema
- Data catalog
- Use of standards

FAIR



FAIR data principles, Wikimedia Commons

Box 2 | The FAIR Guiding Principles

To be Findable:
F1. (meta)data are assigned a globally unique and persistent identifier
F2. data are described with rich metadata (defined by R1 below)
F3. metadata clearly and explicitly include the identifier of the data it describes
F4. (meta)data are registered or indexed in a searchable resource

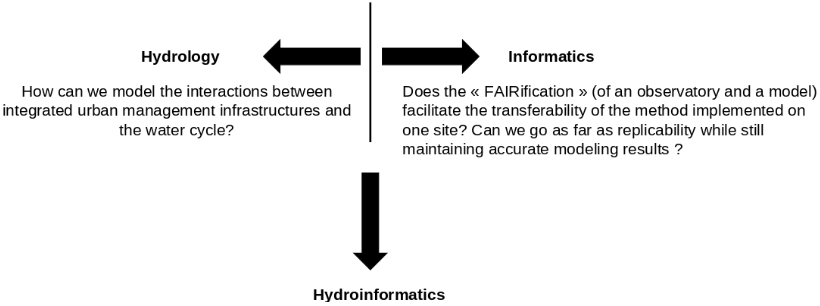
To be Accessible:
A1. (meta)data are retrievable by their identifier using a standardized communications protocol
A1.1 the protocol is open, free, and universally implementable
A1.2 the protocol allows for an authentication and authorization procedure, where necessary
A2. metadata are accessible, even when the data are no longer available

To be Interoperable:
I1. (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation.
I2. (meta)data use vocabularies that follow FAIR principles
I3. (meta)data include qualified references to other (meta)data

To be Reusable:
R1. meta(data) are richly described with a plurality of accurate and relevant attributes
R1.1. (meta)data are released with a clear and accessible data usage license
R1.2. (meta)data are associated with detailed provenance
R1.3. (meta)data meet domain-relevant community standards

The FAIR Guiding Principles Wilkinson et al. [2016]

How to develop a solution generic enough to represent a complex urban environment?



Outline

Creation of an Urban Observatory

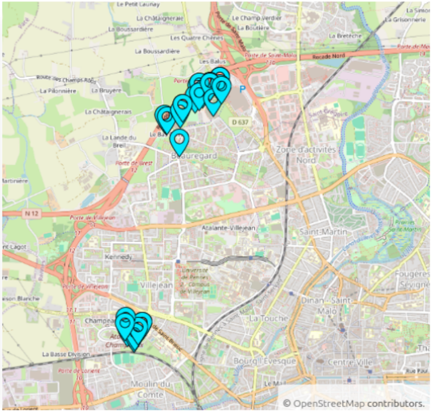
Atalante Champeau **Beauregard**

Data acquisition: 26 measurement points (12 in real time)

- 19 at Beauregard (4 out of service)
- 7 at Institut Agro Rennes

Propriété Observée

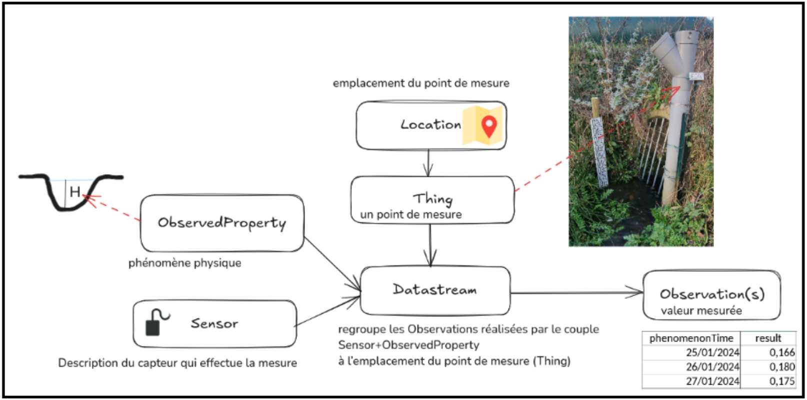
- ☐ Soil temperature
- ☐ Soil relative humidity
- ☐ Stream stage
- ☐ Groundwater depth
- ☐ Stream water temperature
- ☐ Groundwater temperature
- ☐ Air temperature
- ☐ Air relative humidity
- ☐ Streamflow
- ☐ Precipitation amount
- ☐ Groundwater Level
- ☐ Surface water velocity



Data sharing

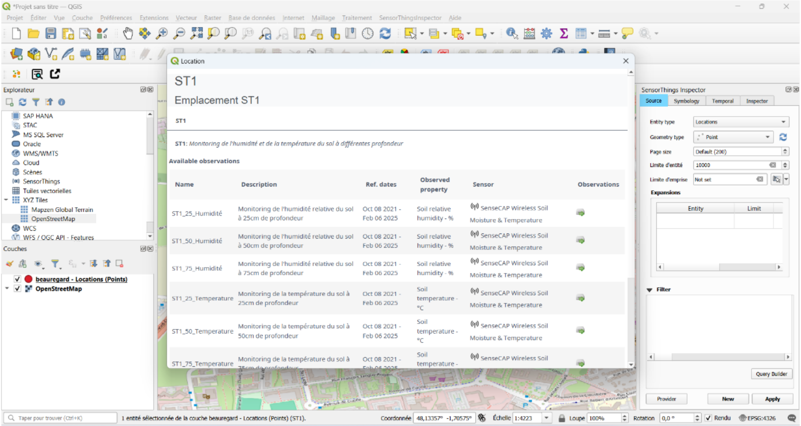
- **Open-access data:** `https://frost.geosas.fr/beauregard/v1.1/`
- **OGC SensorThings API:** Standard interoperable
- **Service referenced in a catalog:** `https://geosas.fr/geonetwork/srv/api/records/ff3ae11e-a774-4ca0-9eac-e966f3df82d5`
- **Visualization and download interface:** `https://geosas.fr/stav/espace/decouverte/?config=https://geosas.fr/stav/config/sur-rennes.json`

SensorThings API

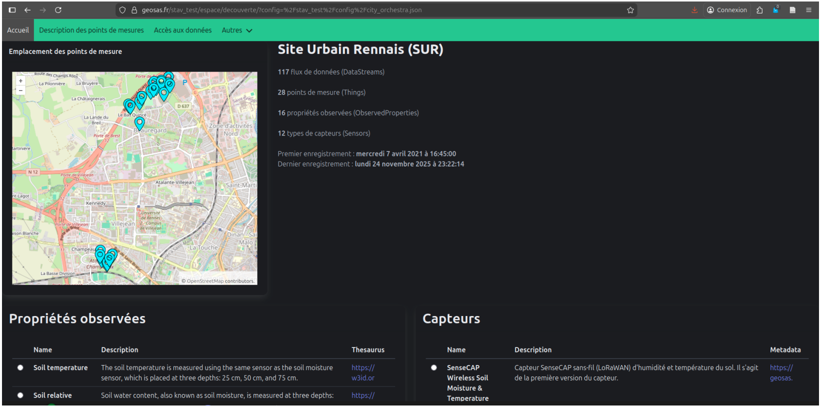


https://geosas.fr/sofair-book

Creation of an Urban Observatory

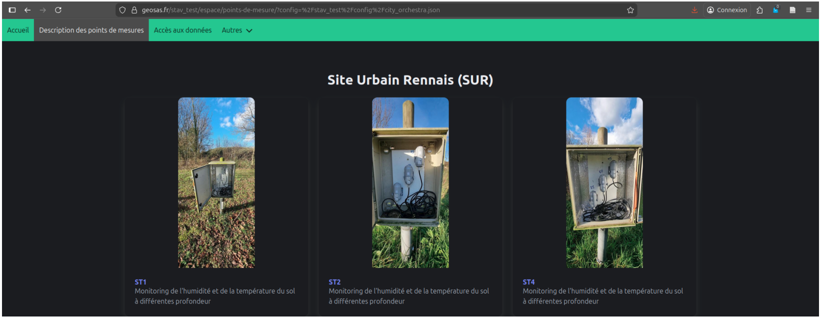


Interface de visualisation en open source `https://github.com/geosas/STAV`

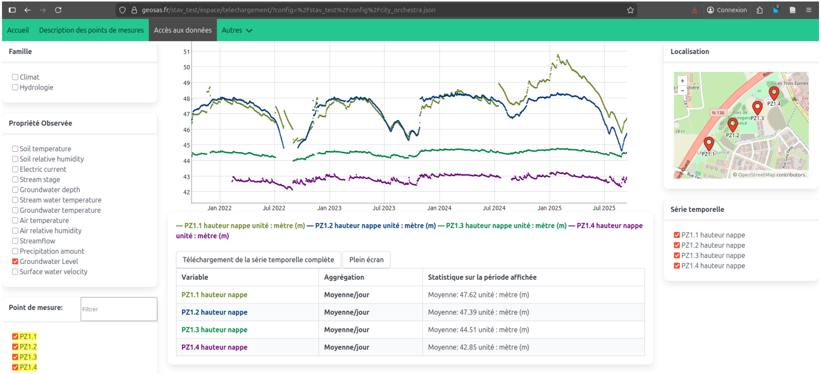


`https://geosas.fr/stav` providing access to 8 observatories as well as any observatory compliant with the OGC SensorThings standard.

Creation of an Urban Observatory

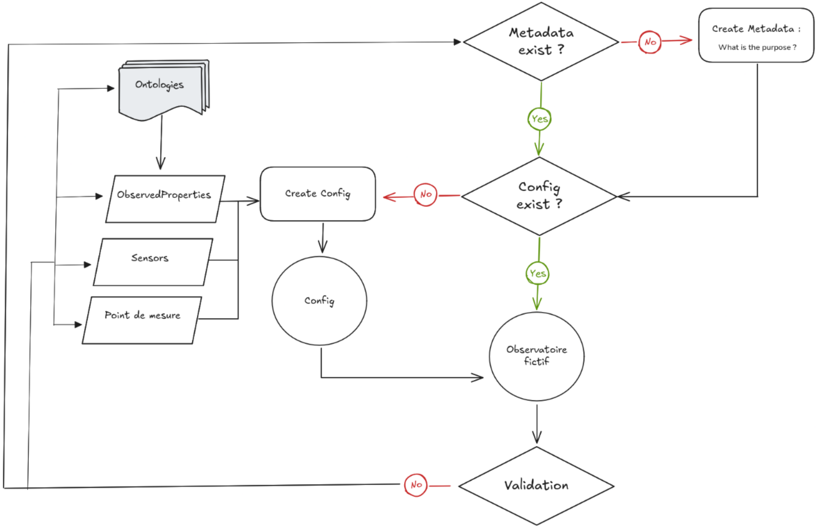


Creation of an Urban Observatory



Outline

FAIR by design observatory creation



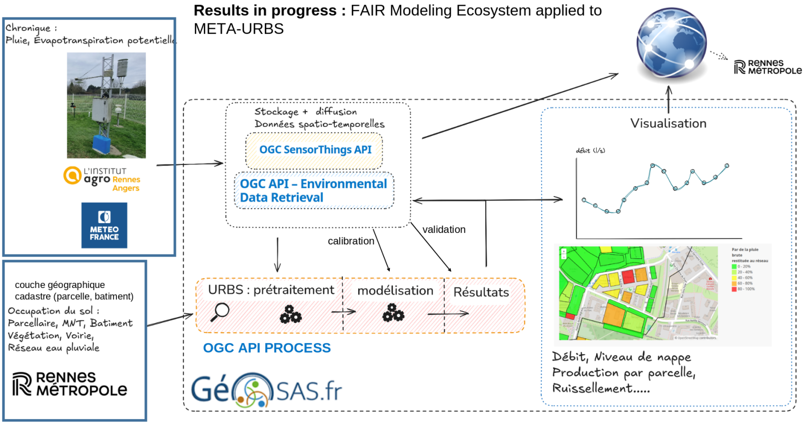
Article in preparation

A fictional observatory already FAIR

Thanks to the SensorThings API (OGC standard), without realising it:

- It is already shareable (and interoperable)
- Contains no real data
- Uses a fictitious measurement point

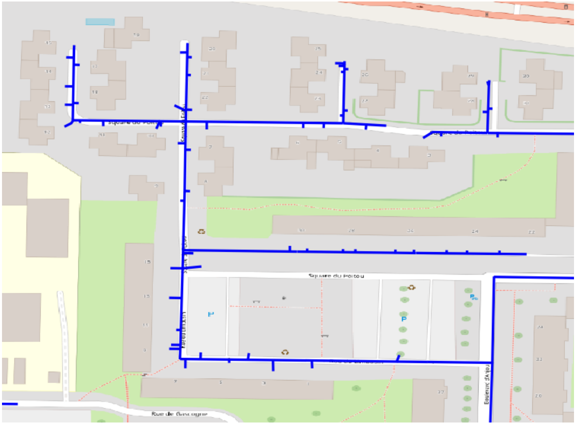
Article in preparation



From an observatory to a modelling ecosystem

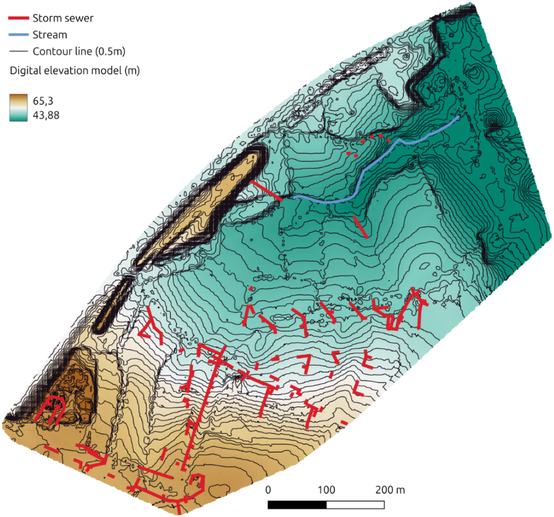
Outline

The model requires a stormwater drainage network

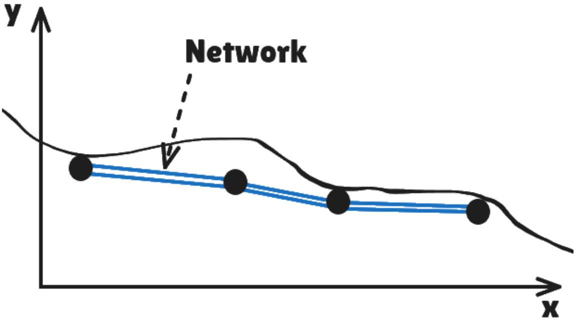


Feasible Sanitary Sewer Network Generation Using Graph Theory Turan et al. [2019]

In a disconnected context?

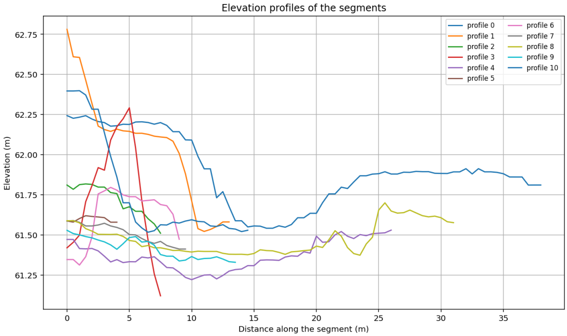


An underground network



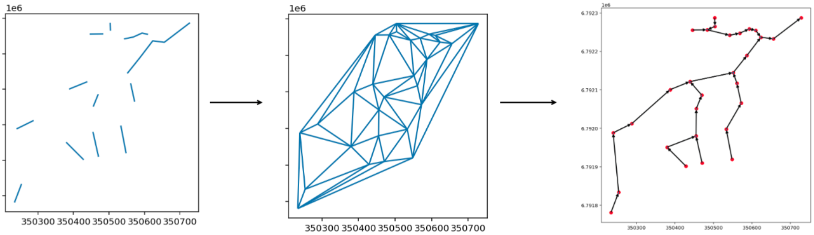
The network is buried and the information to qualify it is poor

An underground network



example of upstream-downstream profile

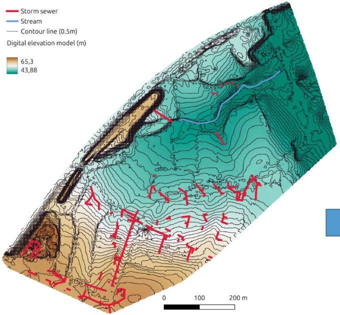
Directed Minimum-Weight Spanning Tree



Incomplete network **Delaunay triangulation** **Theorical network**

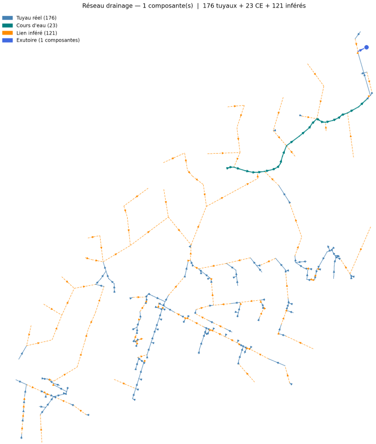
Chu–Liu/Edmonds' algorithm

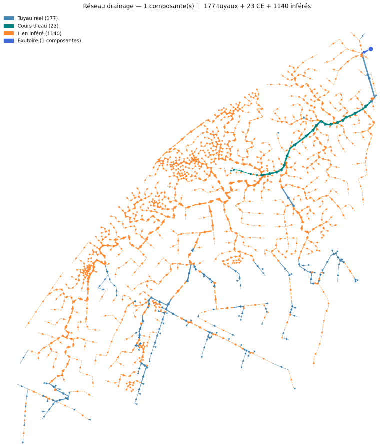
Directed Minimum-Weight Spanning Tree



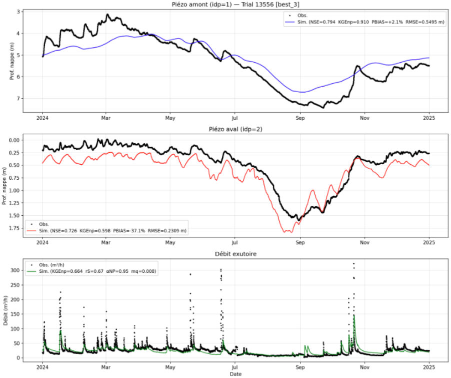
Theorical network with UHE

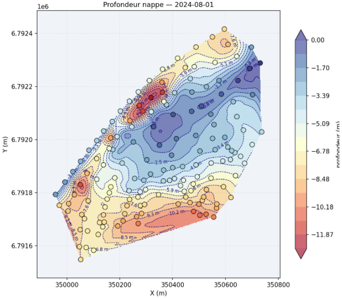
Directed Minimum-Weight Spanning Tree





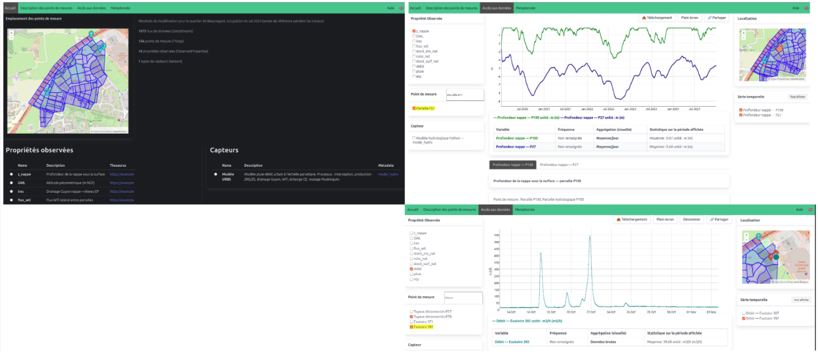
Modelisation





Modelisation

Modeling results: integrated into the existing ecosystem, ensuring compatibility with surrounding services and data flows.



Thank you for your attention

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