NAIADES

Webinar Series

NAIADES Workshop: Modelling & AI, and state analysis tools

JUNE. 15 , 2022
10-13.00 CET

ONLINE

Join Us!

Organised by

MANDAT INTERNATIONAL

UNESCO IHE DELFT

Jožef Stefan Institute

NAIADES Speakers

Vitens

External Speakers

Some info

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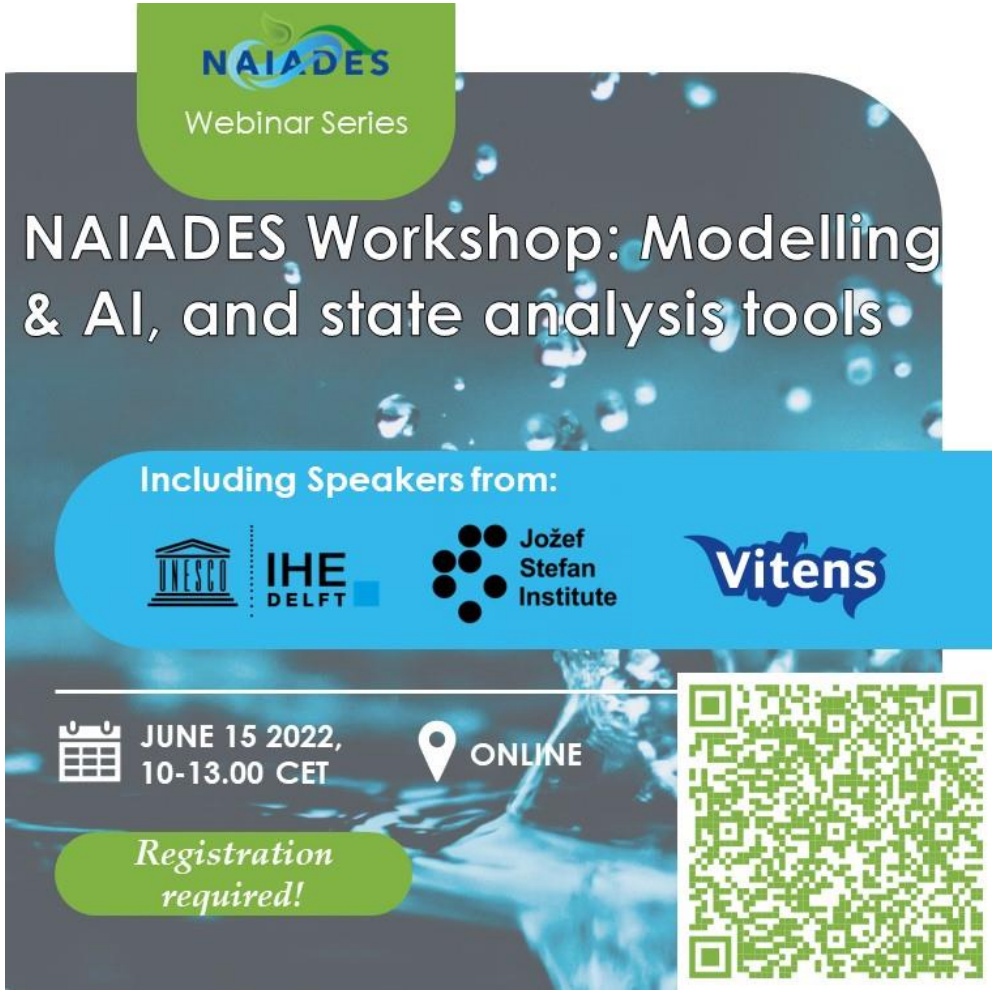
This session will be entirely recorded and published on the NAIADES channels.

Feel free to post your questions in the chat.

Please feel free to share your thoughts about the workshop on Twitter, via:

@naiadesproject, using #NAIADESwebinars



Chair

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Moderation by:

Aristotelis C. Tagarakis
Centre for Research and Technology Hellas (CERTH)

Agenda

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- **Model-based optimisation for optimal operation of Water Distribution Systems** Leonardo Alfonso, *IHE-Delft (NL)*
- **Training session on States Analysis tool** Alenka Guček, *Jožef Stefan Institute (SLO)*
- **Vitens: A digital water factory** Mario Castro Gama, *Vitens (NL)*

- **Wrap-up and Discussion**

Speakers

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Leonardo Alfonso
IHE-Delft (NL)

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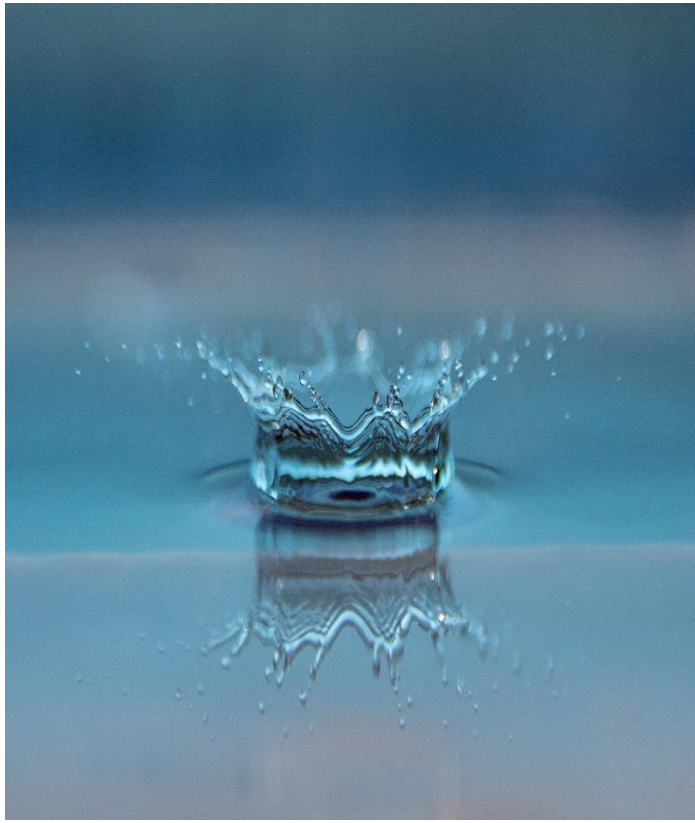
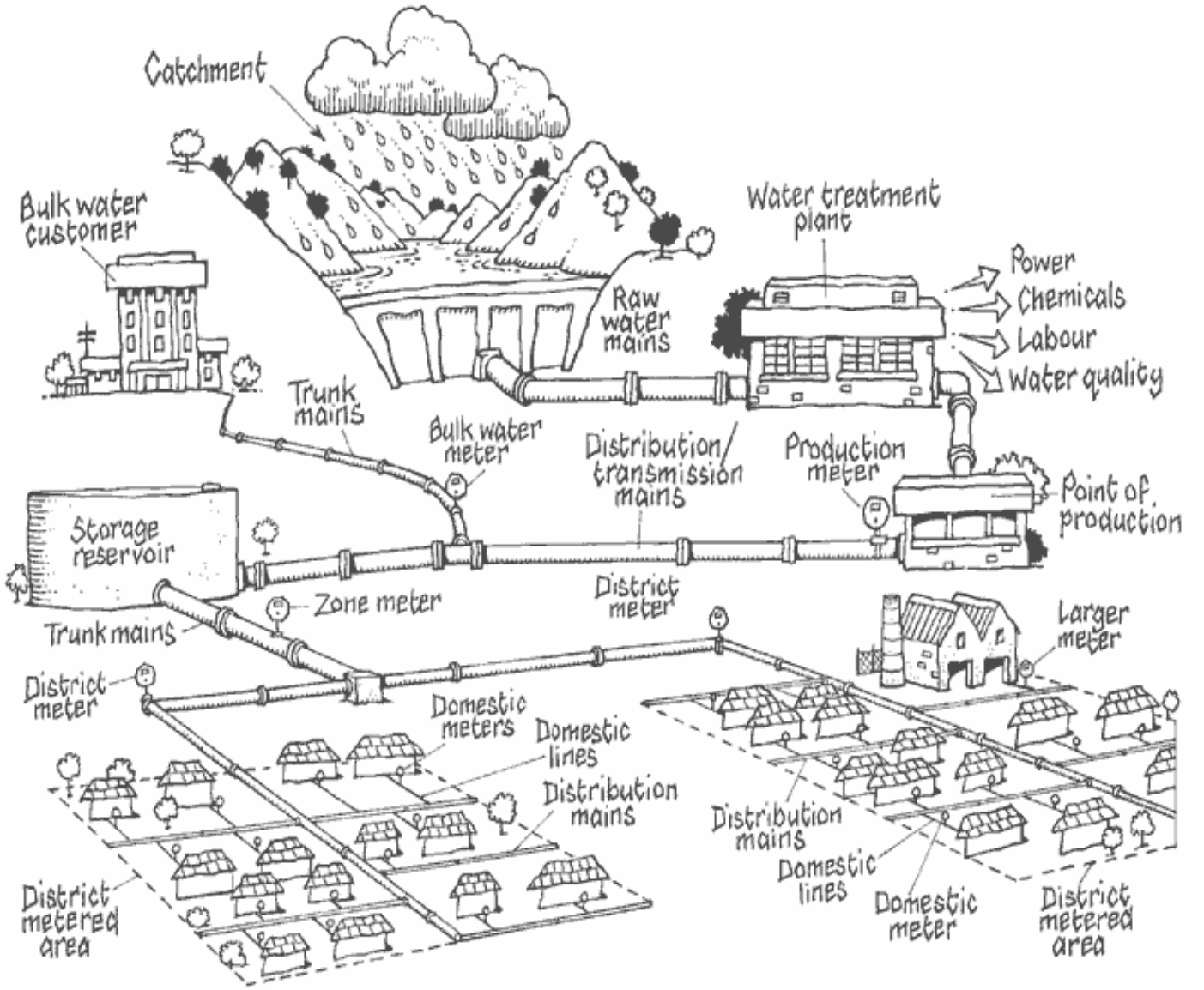
Model-based optimisation for optimal operation of Water Distribution Systems

Leonardo Alfonso, IHE-Delft (NL)



Water Distribution Systems



Water Distribution Systems

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- Ideally, a WDS should:
  - Supply continuously (network always pressurized)
  - Supply every point with a certain pressure
  - Transport safe water
    - Water age
    - Leakages
    - Residual Chlorine

Water Distribution Systems are complicated

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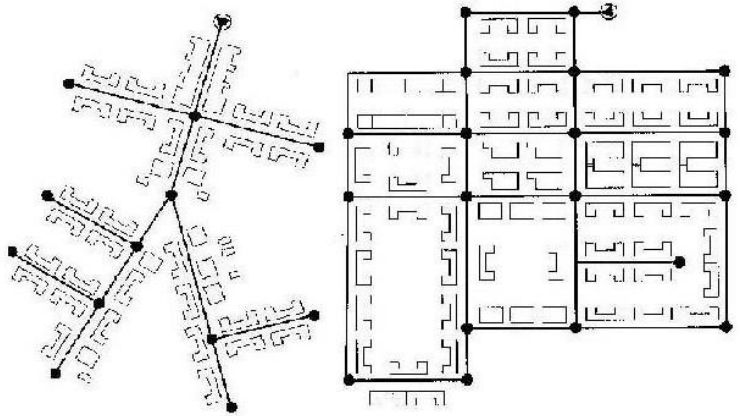
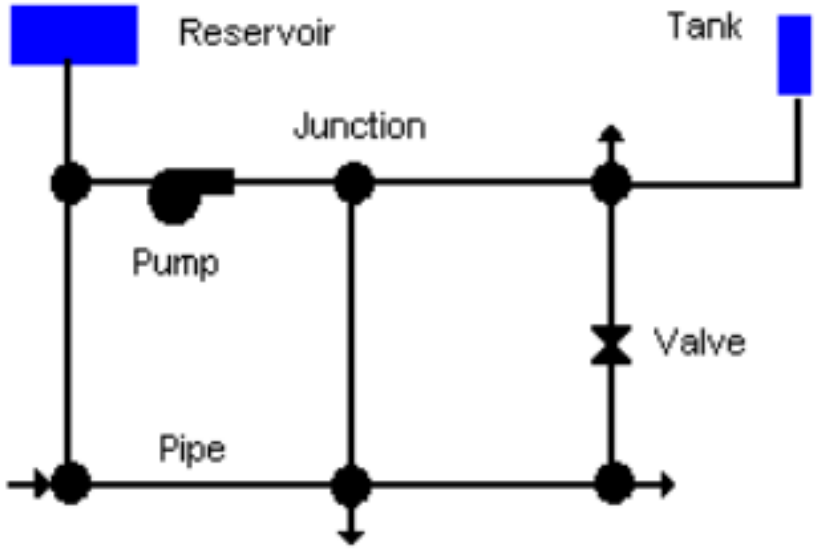
- WDS can be either branched or looped networks
- Water demands change in time
- Water may change direction in time
- Path followed by a drop of water is not trivial to estimate
- Many possibilities to operate / control them
  - Valves
  - Tanks
  - Hydrants
  - Pumps



Modelling for control / operation



$$H_i - H_j = h_{ij} = rQ_{ij}^n + mQ_{ij}^2$$

$$\sum_j Q_{ij} - D_i = 0 \qquad \text{for i} = 1,\ldots \text{N.}$$

WNTR
Water Network Tool for Resilience

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The Water Network Tool for Resilience (WNTR)

Python package designed by Sandia National Laboratories and the US Environmental Protection Agency to simulate and analyze resilience of water distribution networks.

- Modify network structure and operations
- Add response/repair strategies
- Simulate pressure dependent demand and demand-driven hydraulics
- Simulate water quality
- And more…

Klise, K.A., Murray, R., Haxton, T. (2018). An overview of the Water Network Tool for Resilience (WNTR), In Proceedings of the 1st International WDSA/CCWI Joint Conference, Kingston, Ontario, Canada, July 23-25, 075, 8p.

Julian Blank (blankjul [at] egr.msu.edu)
Michigan State University

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J. Blank and K. Deb, pymoo: Multi-Objective Optimization in Python, in IEEE Access, vol. 8, pp. 89497-89509, 2020, doi: 10.1109/ACCESS.2020.2990567

Interface

Function: minimize

Parameters: Problem, Algorithm, Termination

Optionals: Callback, Display, ...

Returns: Result

Related: Ask and Tell New, Checkpoints

Problems

Single-objective: Ackley, Griewank, Rastrigin, Rosenbrock, Zakharov, ...

Multi-objective: BNH, OSY, TNK, Truss2d, Welded Beam, ZDT, ...

Many-objective: DTLZ, WFG

Constrained: CTP, DASCMOP, MODAct, MW, CDTLZ

Related: Problem Definition, Gradients, Parallelization New

Algorithms

Single-objective: GA, DE New, PSO, Nelder Mead, Pattern Search, BRKGA, ES New, SRES New, ISRES New, CMA-ES

Multi-objective: NSGA-II, R-NSGA-II

Many-objective: NSGA-III, R-NSGA-III, U-NSGA-III, MOEA/D, AGE-MOEA New

Related: Reference Directions, Constraint Handling, Convergence

Customization

Variable Types: Binary, Discrete, Permutation, Mixed, Custom

Examples: Biased Initialization, Subset Selection, Traveling Salesman

Hands-on!

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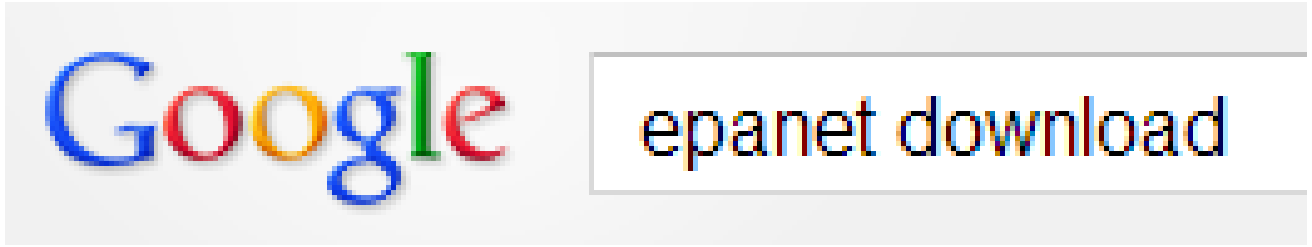
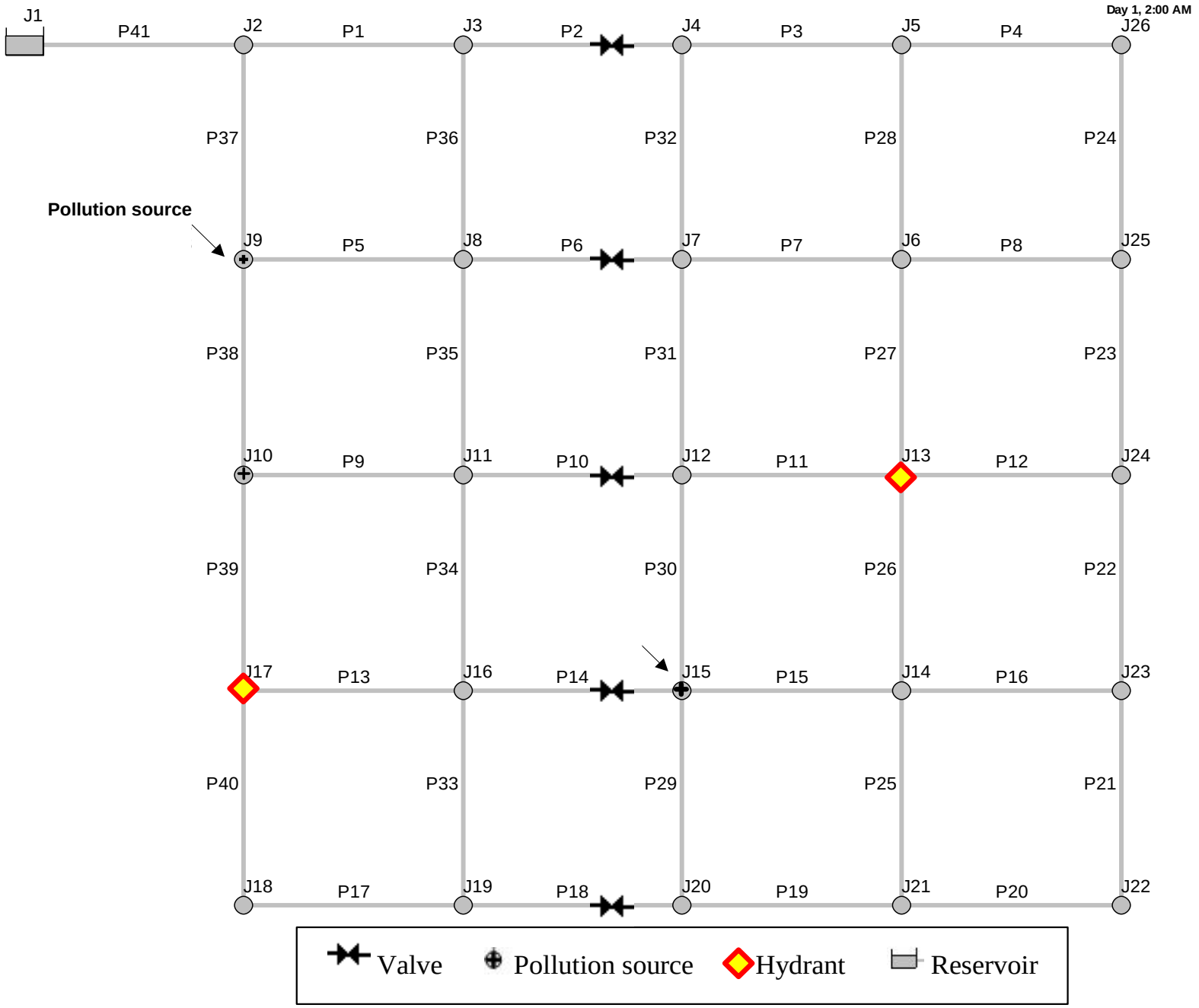
Download and install EPANET



Download handout from the given link


Day 1, 2:00 AM
J1
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P36
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P24
Pollution source
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P19
J21
P20
J22
Valve
Pollution source
Hydrant
Reservoir

Demonstration of automatic optimization using WNTR and PYMOO

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15 June 2022

Optimisation of Water Distribution Networks with PYMOO and WNTR libraries

United Nations Educational, Scientific and Cultural Organization

IHE DELFT Institute for Water Education in partnership with UNESCO

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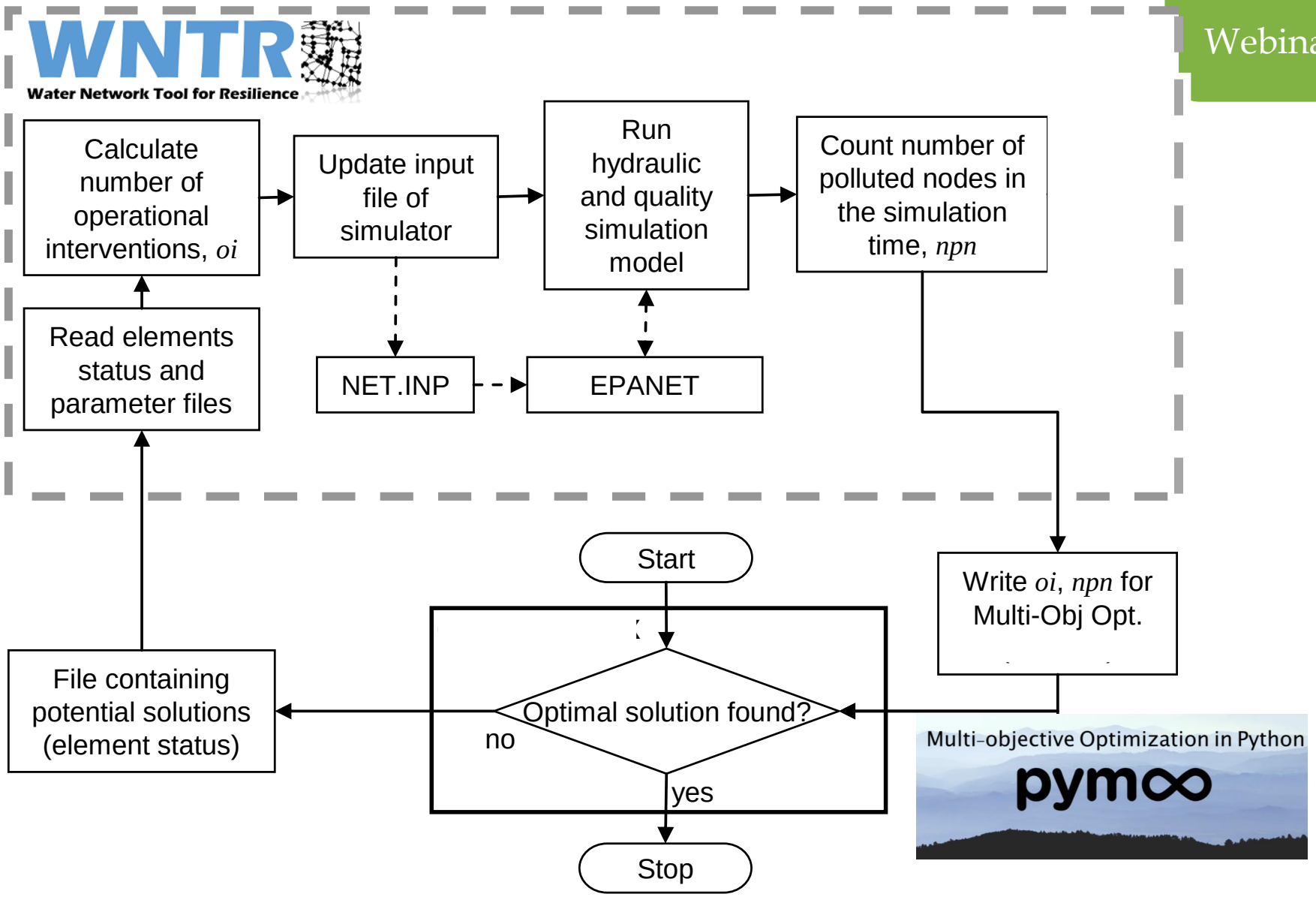
WNTR
Water Network Tool for Resilience
Calculate number of operational interventions, oi
Update input file of simulator
Run hydraulic and quality simulation model
Count number of polluted nodes in the simulation time, npn
Read elements status and parameter files
NET.INP
EPANET
Start
Write oi, npn for Multi-Obj Opt.
File containing potential solutions (element status)
Optimal solution found?
no
yes
Stop
Multi-objective Optimization in Python
pymoo

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Speakers

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Alenka Guček
Jožef Stefan Institute

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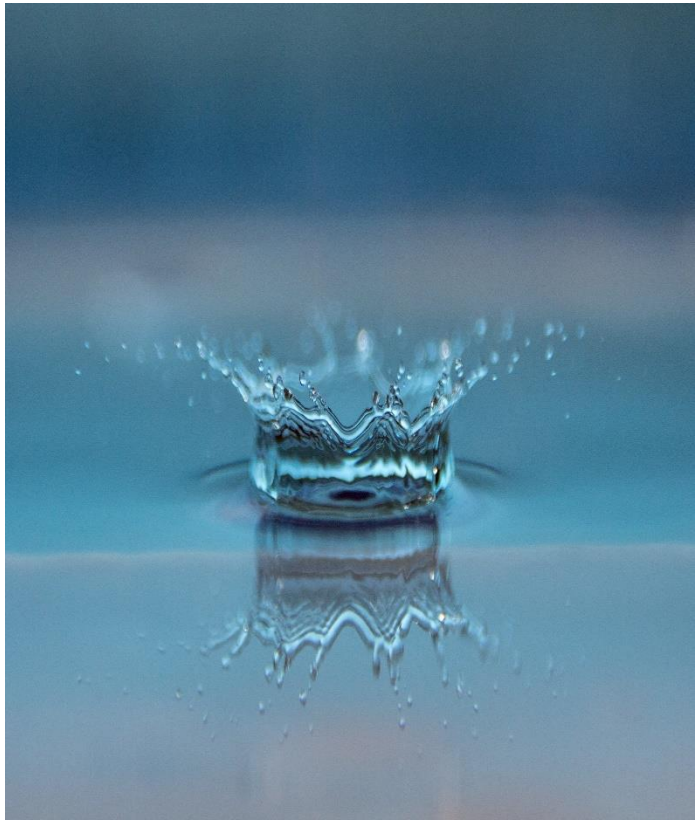
Training session on States Analysis tool

Alenka Guček, Jožef Stefan Institute (SLO)



Motivation

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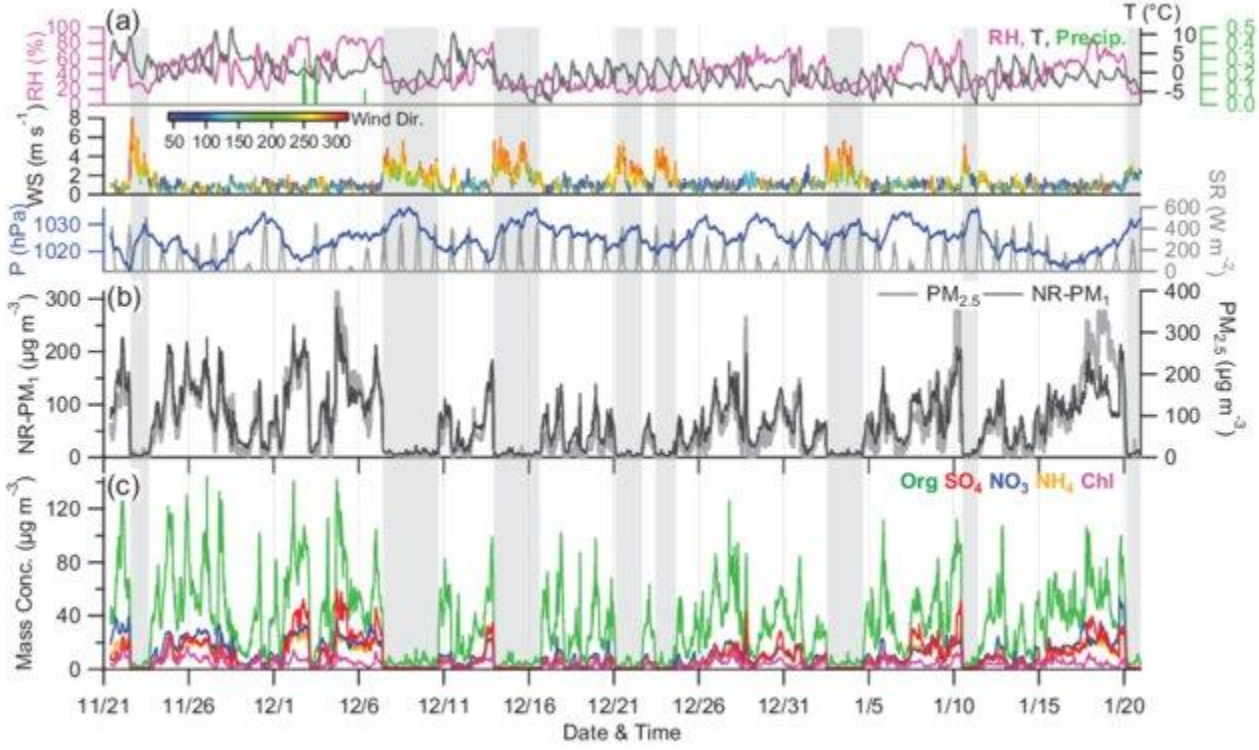
- Multivariate timeseries visualizations issues:
  - Overlap of data points
  - Missing interaction between variables
  - Difficult to interpret

- User has to zoom, isolate needed variables and remove the others



Sun et al, 2013, Atmospheric Chemistry and Physics

NEED FOR A BETTER ANALYTICAL TOOL!

(NAIADES 4.4, AI empowered critical water consumption monitoring)

Our solution

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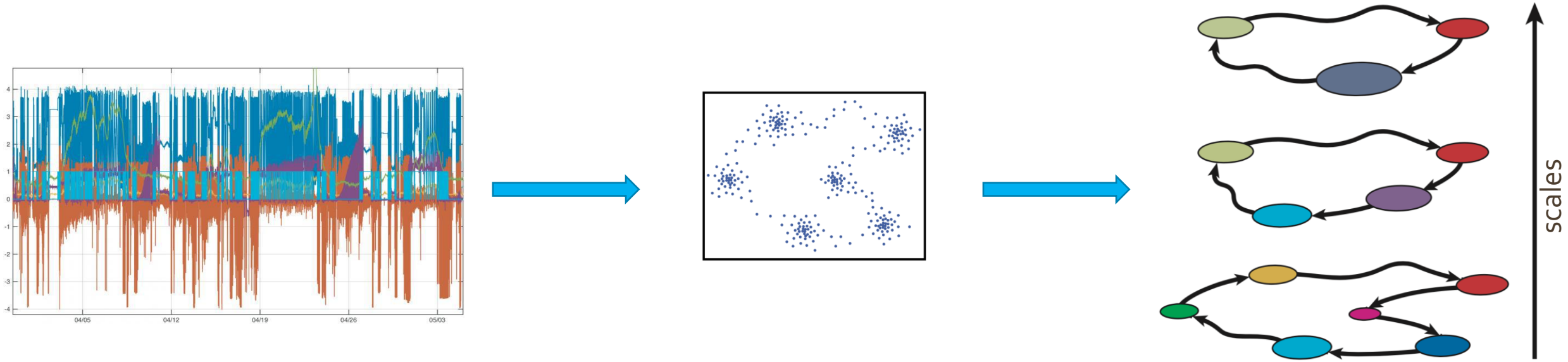
Our approach is abstraction of timeseries data to states and transitions

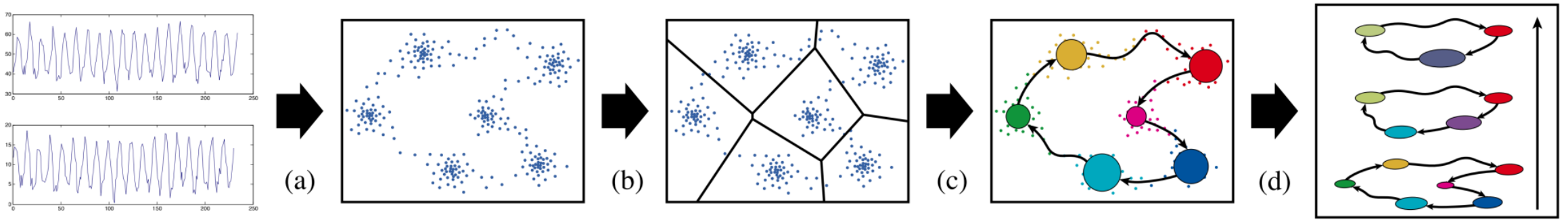
Abstraction is hiearchical (data can be observed on several levels/scales of detail)



Luka Stopar

multivariate timeseries -> hiearchical abstraction -> typical states

Methodology



Luka Stopar

(a) Static time series embedding

(b) Constuction of states

(c) Transitions between states

(d) Hiearchy

- Mean-linkage aggromerative clustering (based on a distance)
- Iterative min-cut based splitting (based on transitions)

Visual representation

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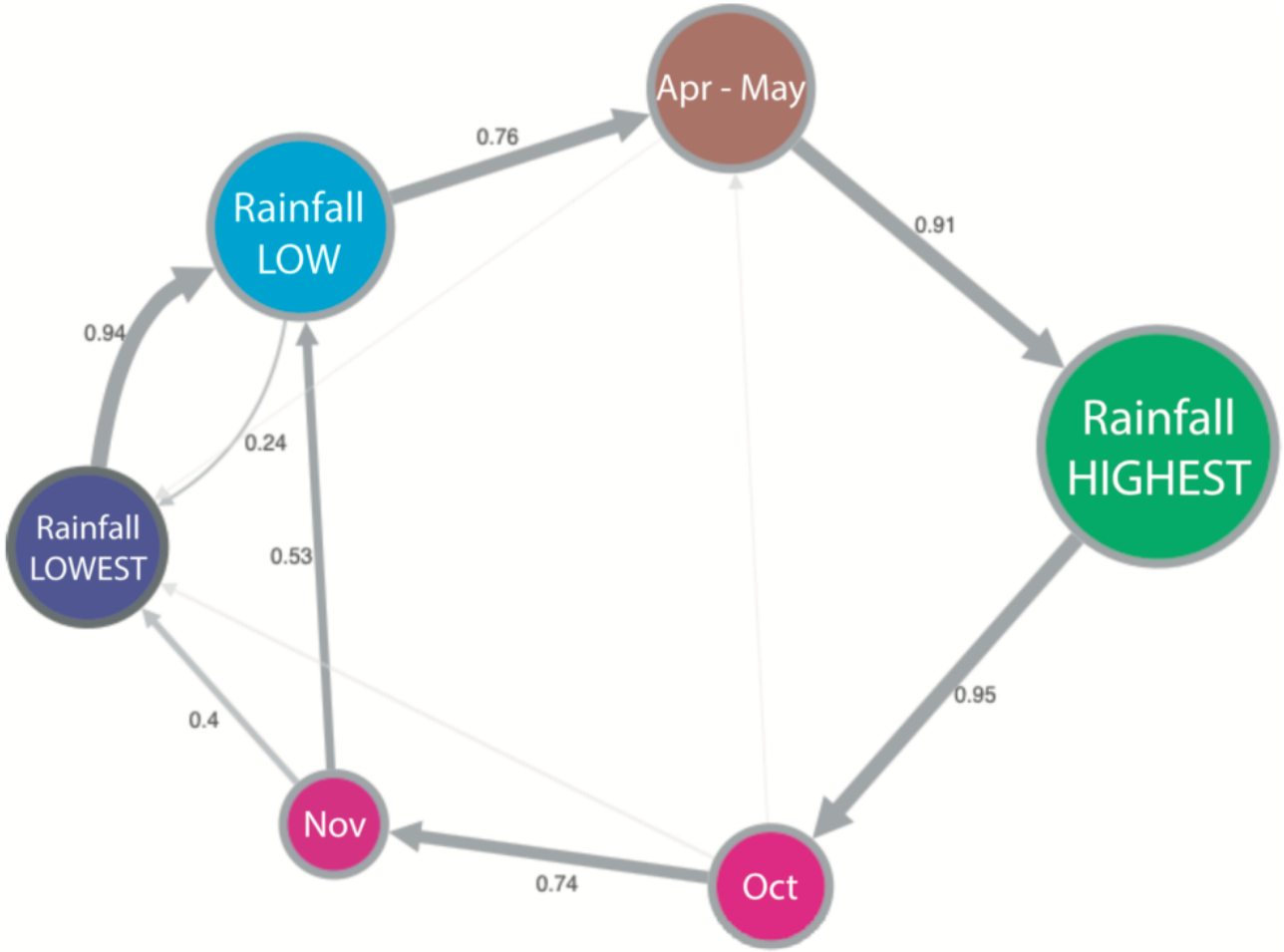
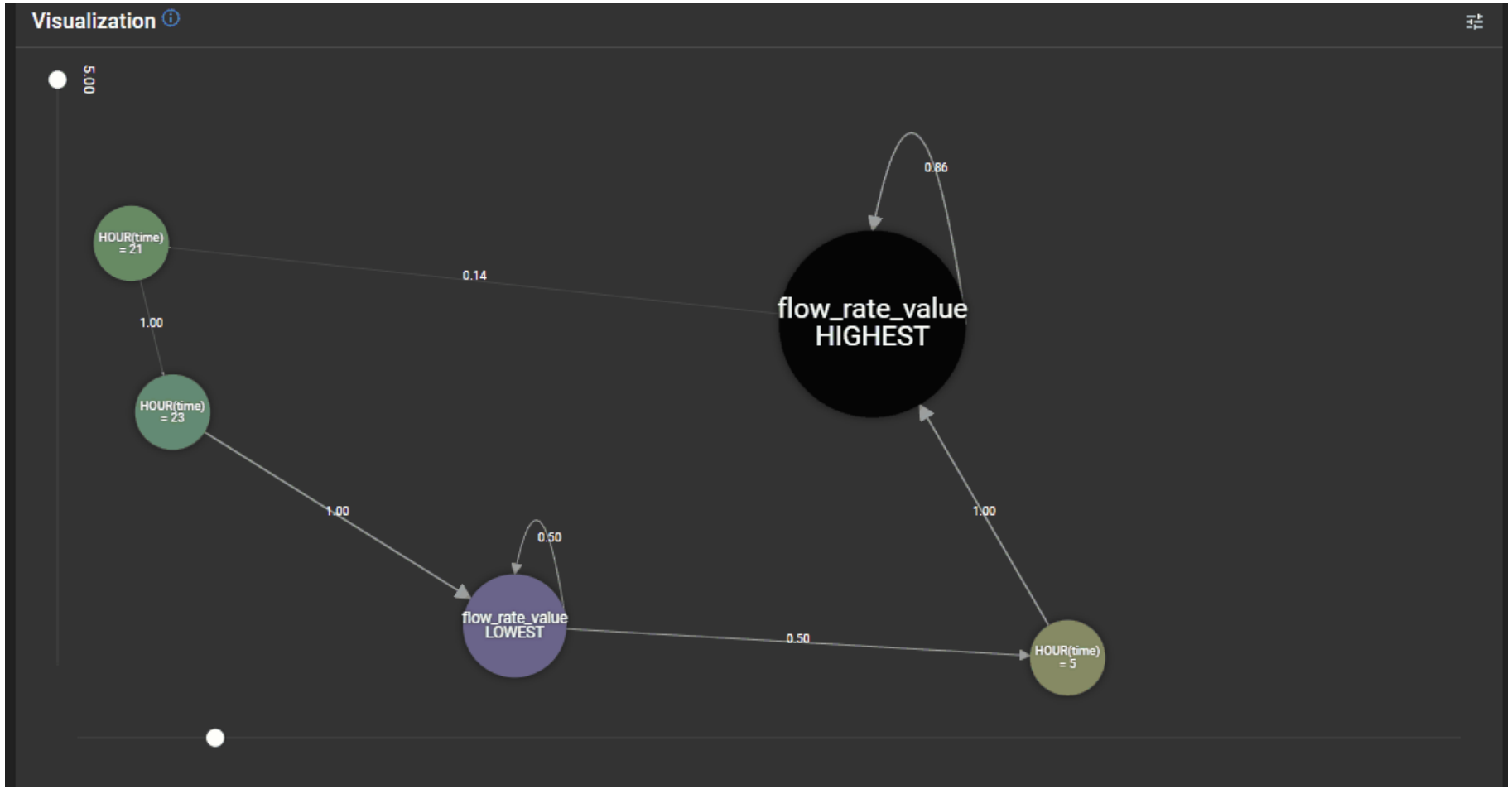
- Timeseries drawn as a static graph
  - States are nodes
  - Transitions are edges



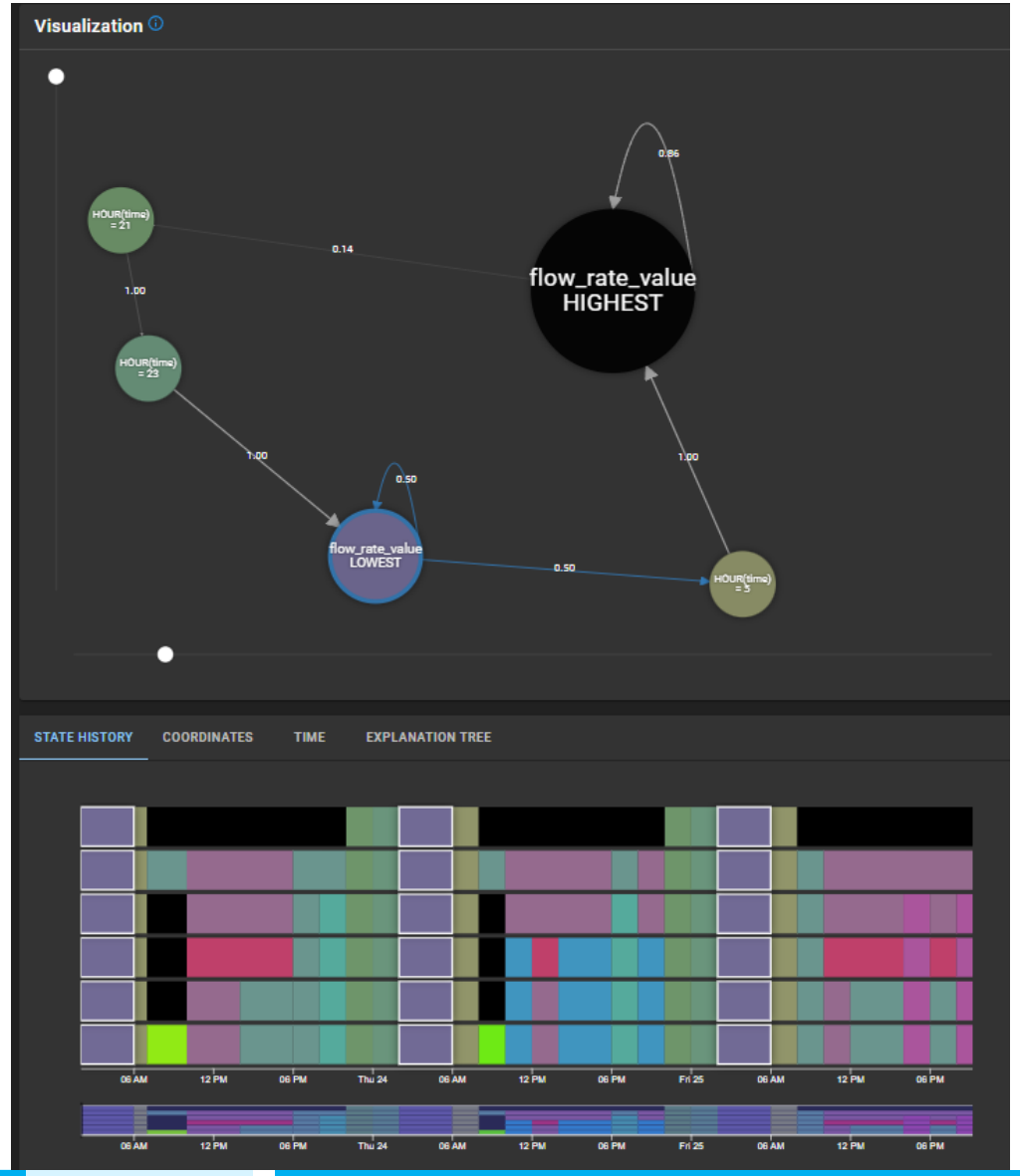
Hierarchical strucutre



Vertically: Granulation (expansion/collapse) of states

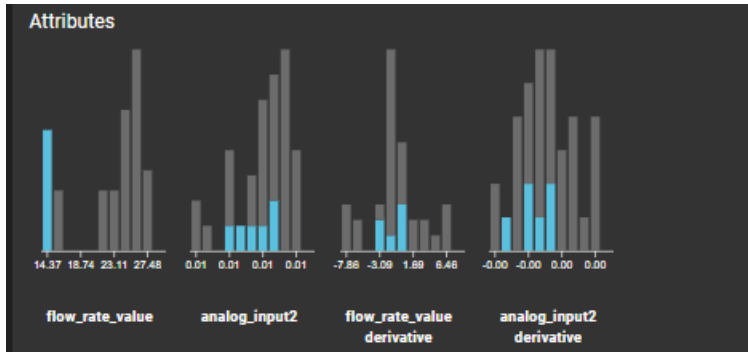
Horizontally: Minimal transition rates

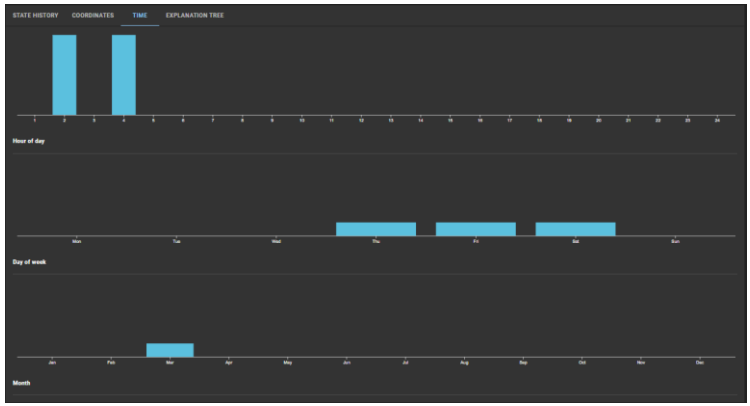
Auxilary views



Analysis of a single state:

- State history window
- Histograms to show its distribution compared to overall state
- Temporal granularity
  - Daily
  - Weekly
  - Monthly
  - Yearly

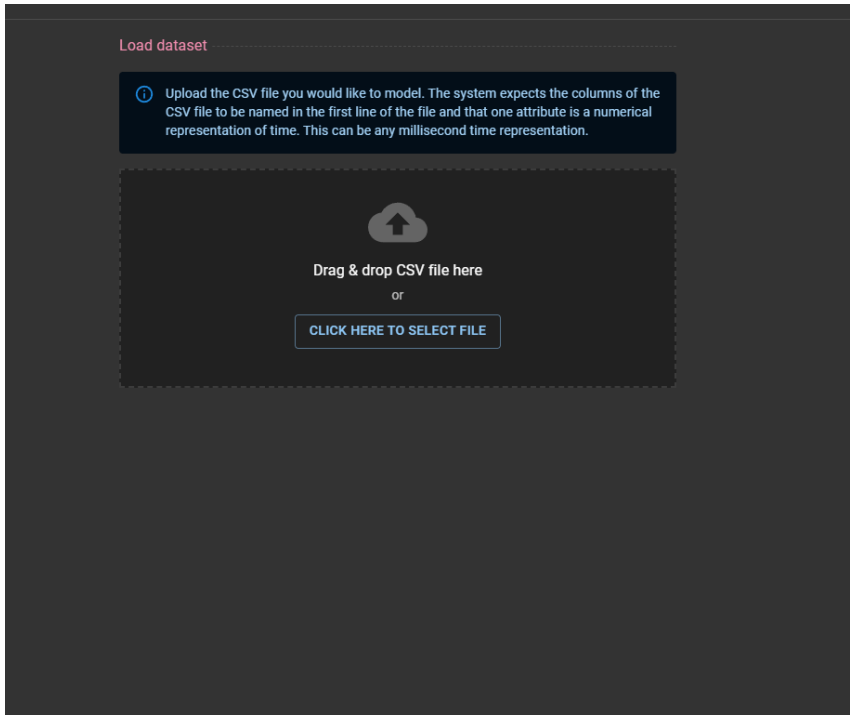


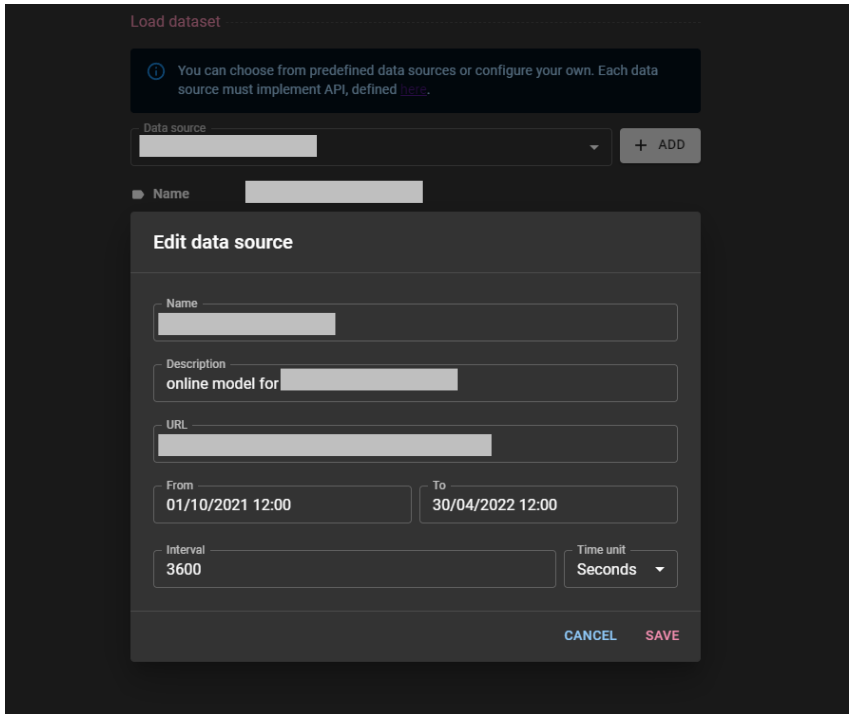


Data input

- **Settings (optional)**:

- Offline models (.csv format)
- Online models (data from NAIADES service)
- UNIX timestamp is required (atm)!





Setting alerts on non-wanted states

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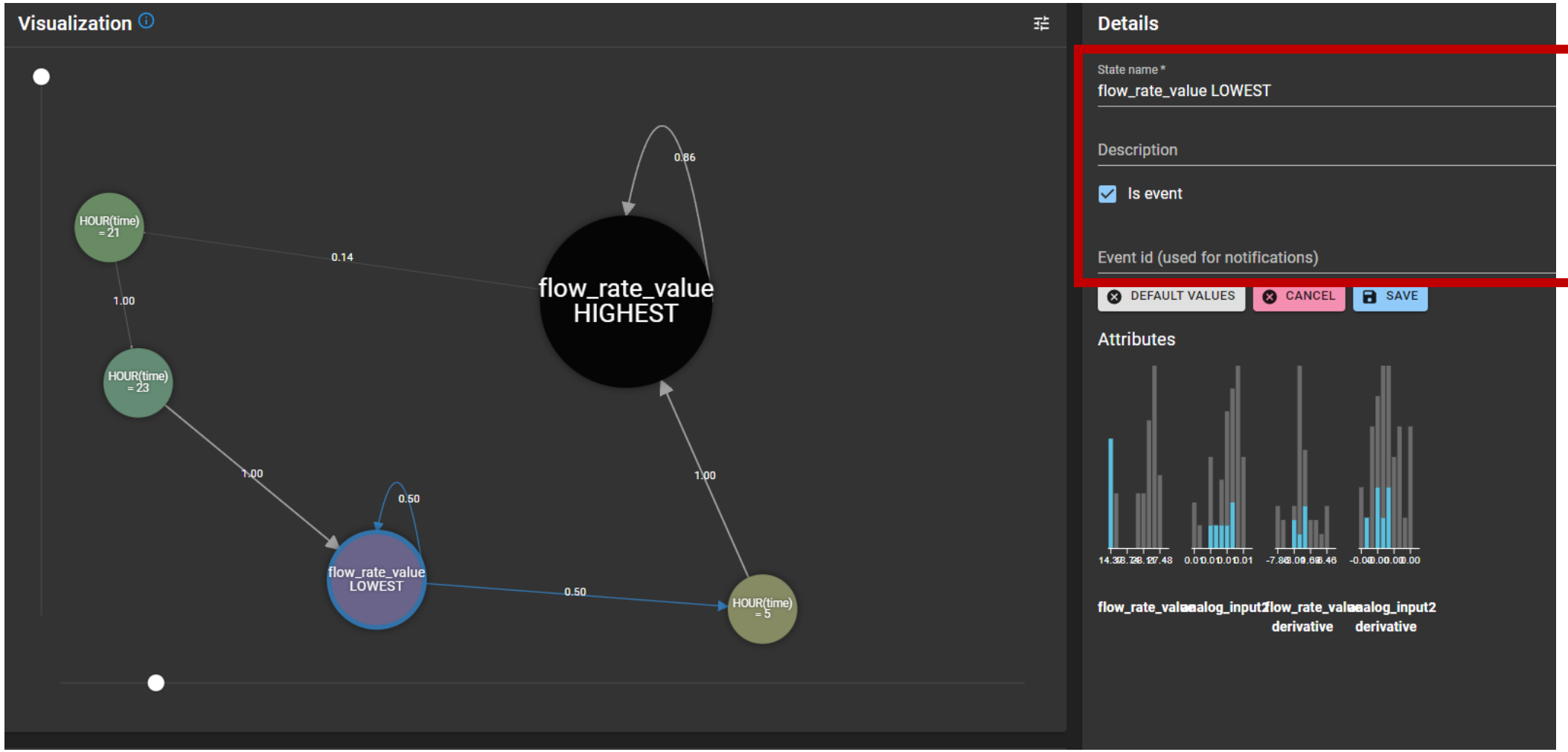

Demo

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http://atena.ijs.si:8080/login

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Speakers

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Mario Castro Gama
Vitens (NL)

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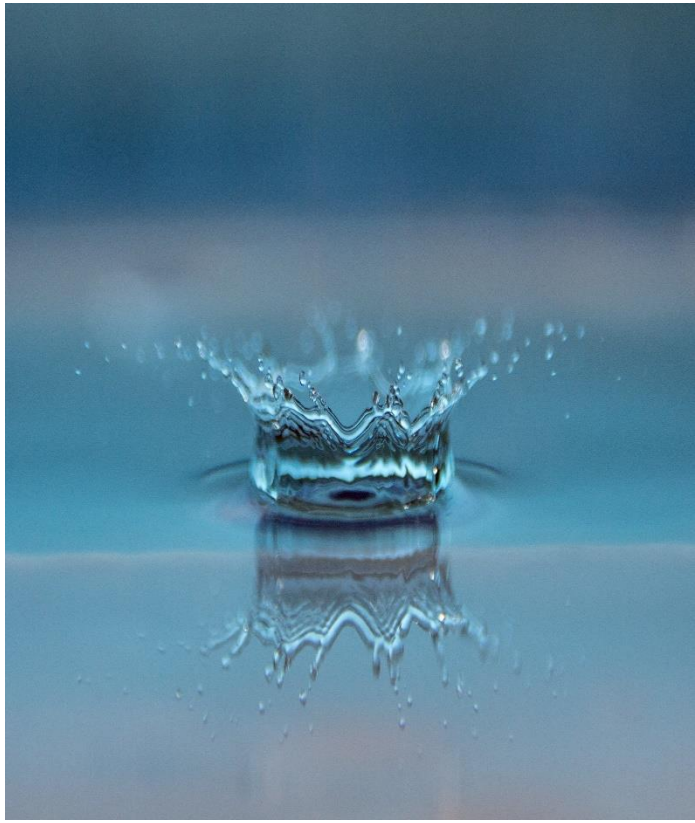
Vitens: A digital water factory

Mario Castro Gama, Vitens (NL)



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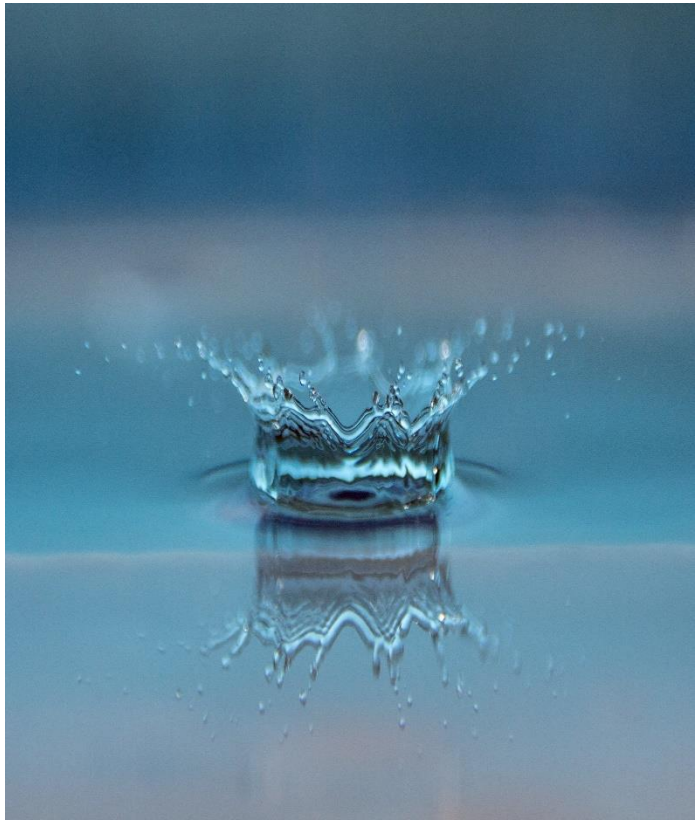
Panel discussion & Wrap-up



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