

Modélisation hydrodynamique 3D pour l'évaluation de la qualité de l'eau en milieu urbain – Application au Bassin de La Villette (Paris, France)

3D hydrodynamic modelling for the assessment of water quality in urban waterbodies – Application to Bassin de La Villette (Paris, France)

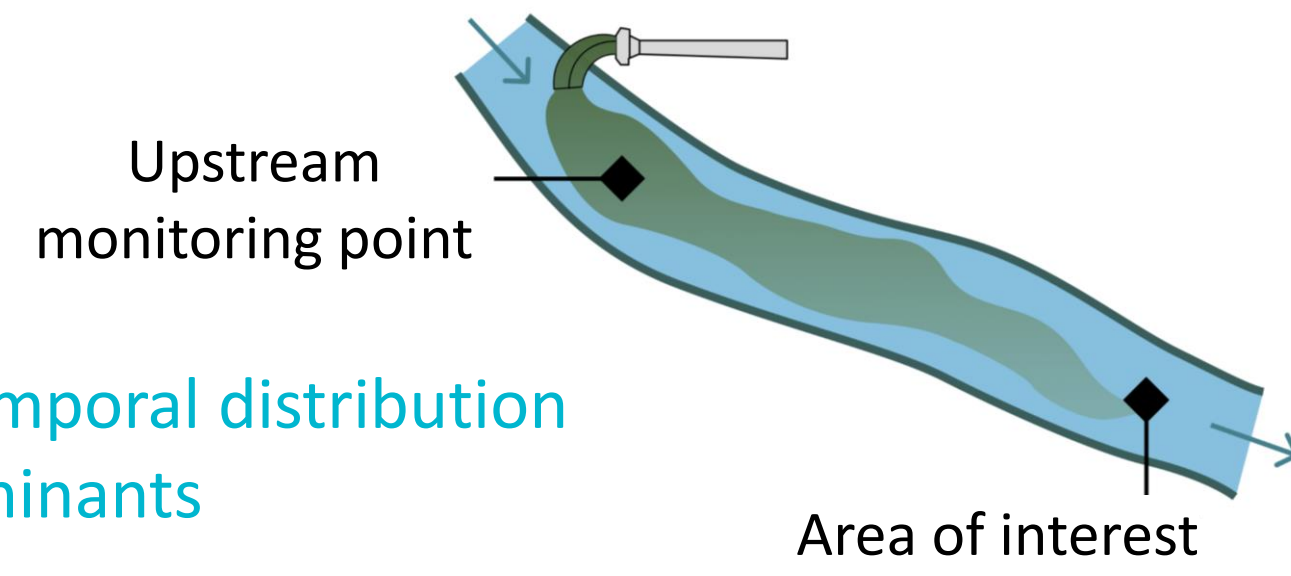
Decision-making for sanitary risk management

Monitoring of water quality

- Discharge variation
- Thermal stratification

Impact

Spatio-temporal distribution of contaminants



Objective

To simulate the impact of hydro-meteorological conditions on the waterbody hydrodynamics and microbiological contamination

- Opening or closure of a bathing area?

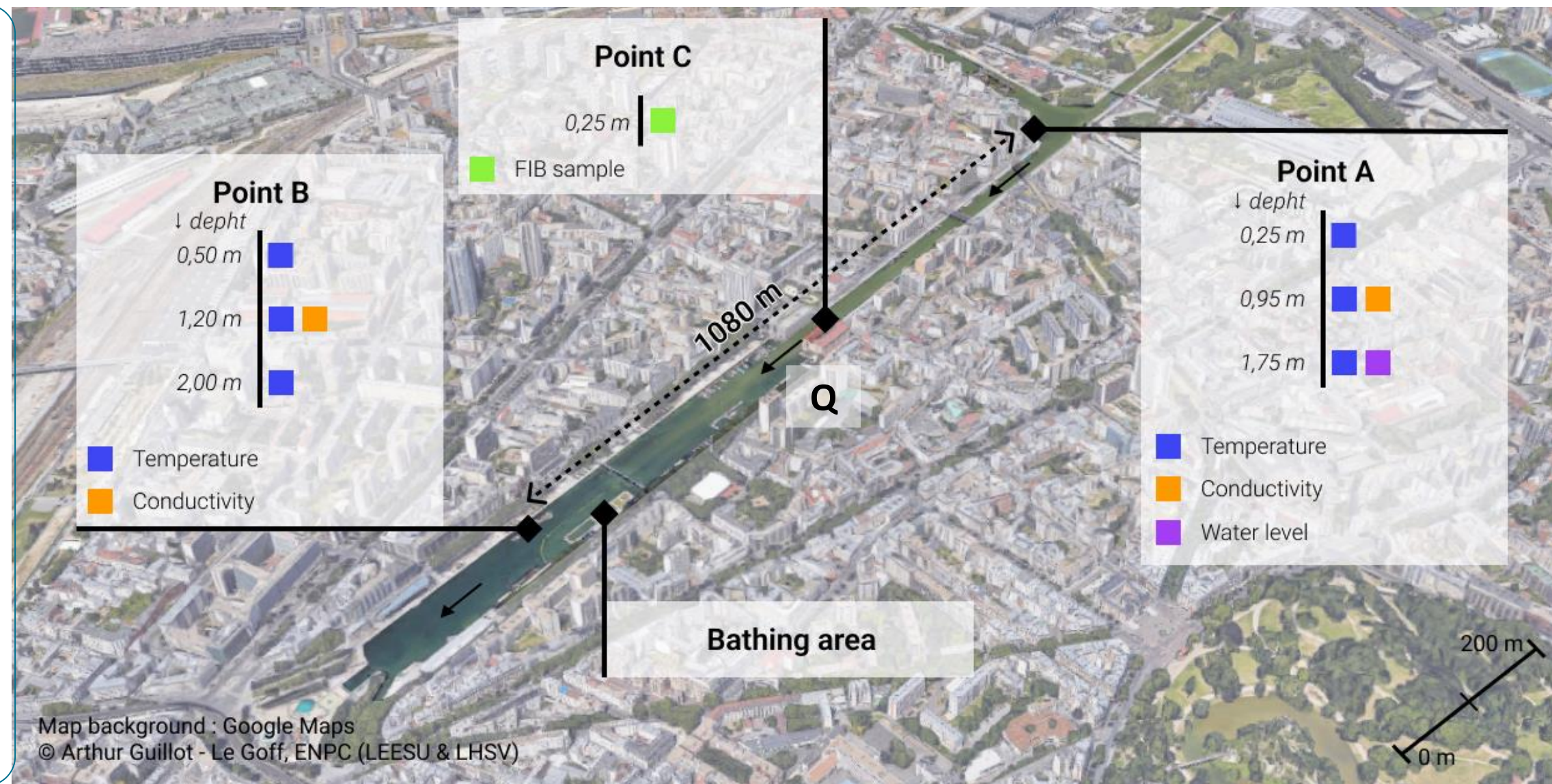
Study site

Bassin de La Villette (Paris)

- Canal
- Basin

25m wide, 800m long
75m wide, 700m long

Mean depth 3m
Mean flowrate 2m³/s



Field data

Continuous measurement at points A and B

Water temperature, conductivity at 25°C and water level

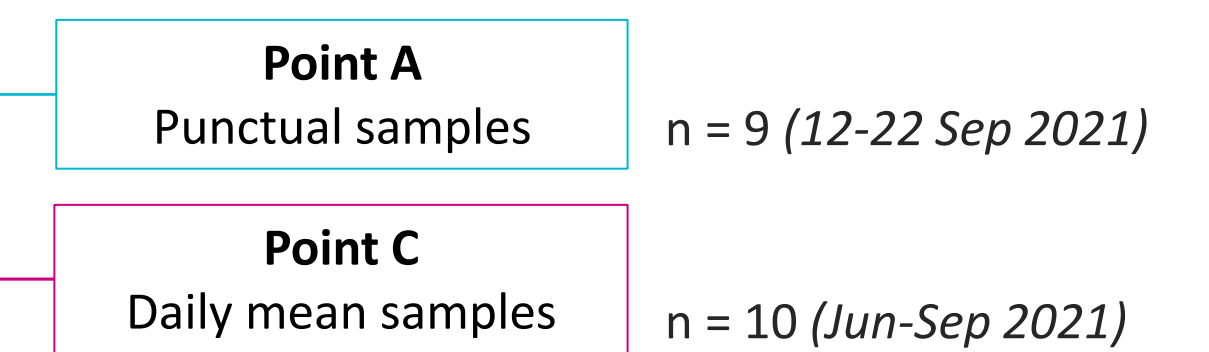
Δt = 20 min

Assessment of microbiological contamination

- Relationship between **fluorescent dissolved organic matter (FDOM)** and **faecal indicator bacteria (FIB)**

- Laboratory analysis

- FDOM at UV wavelengths
- FIB measurement (*E. coli*)

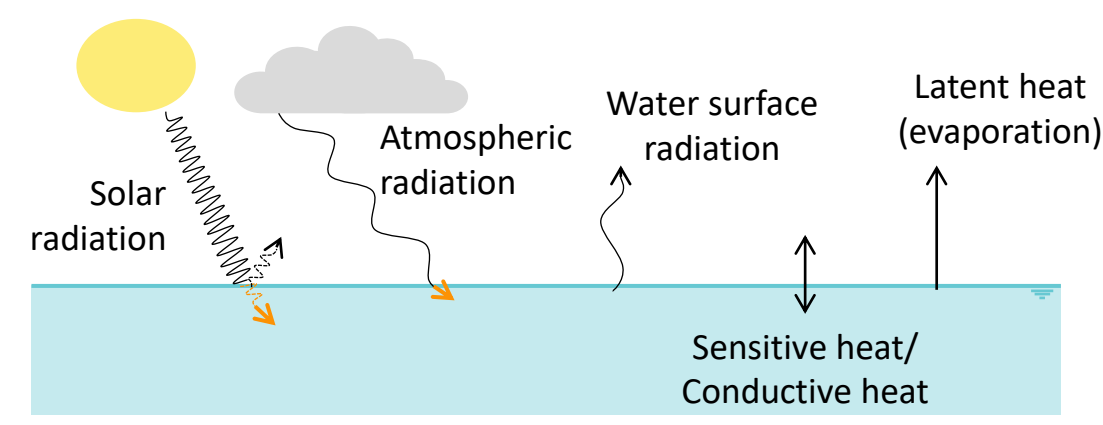


Hydrodynamic model

TELEMAC-3D v8p3 for Linux

openTELEMAC

- 10 horizontal layers (0.3 m)
- Vertical turbulence model: mixing length
- Computation timestep: 20 s
- Meteorological forcing (Orly, Météo France)
- Outflow discharge from water level: Manning-Strickler equation



- Heat exchange between water and atmosphere

Relationship between FDOM and FIB

Peak T: Tryptophan-like fluorescence

- Protein-like
- Proxy of FIB concentration
- Ex 275 nm, Em 340 nm

$$[E. coli] = f(\text{peak T})$$

R² = 0.64, p < 0.001

Simulation results

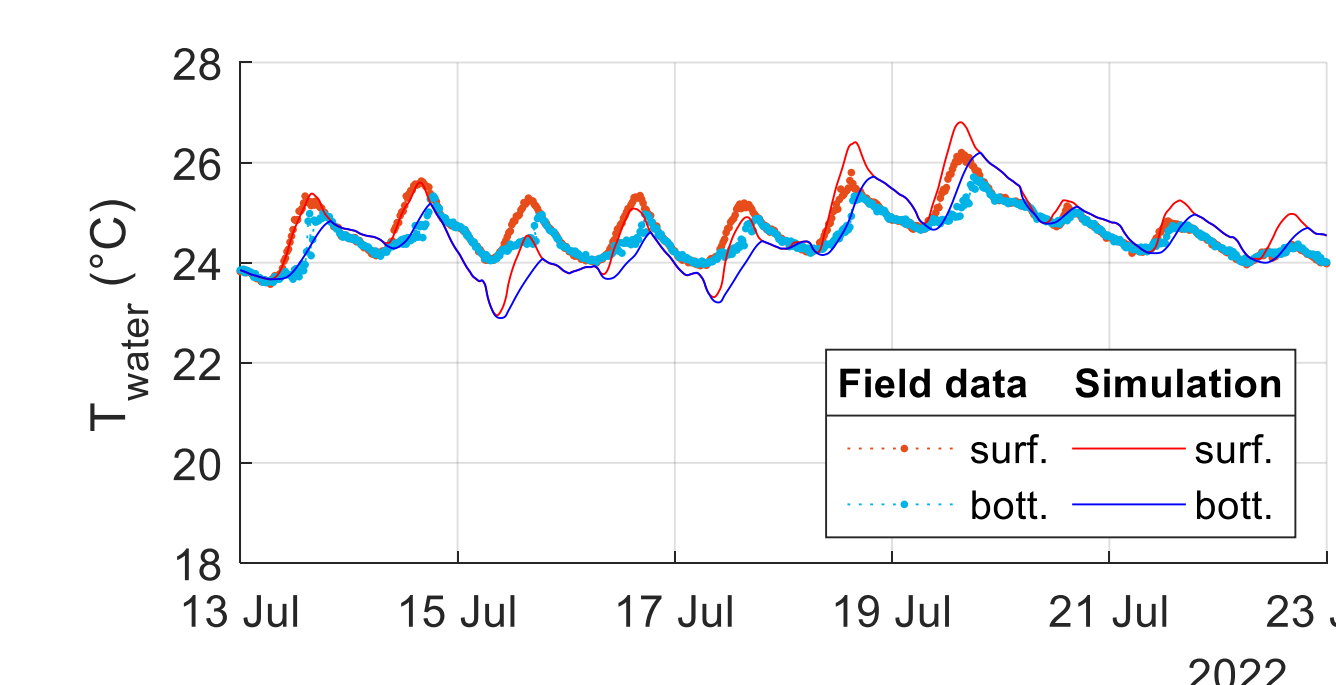
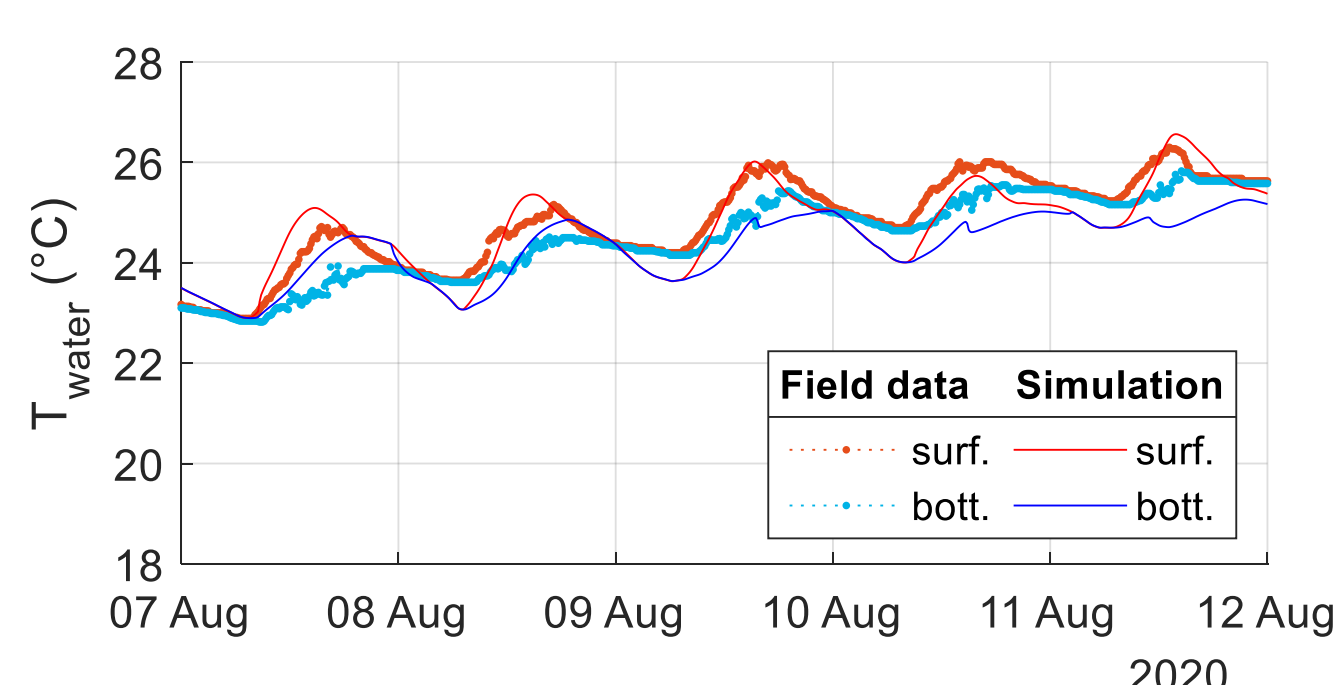
Model validation

Water temperature

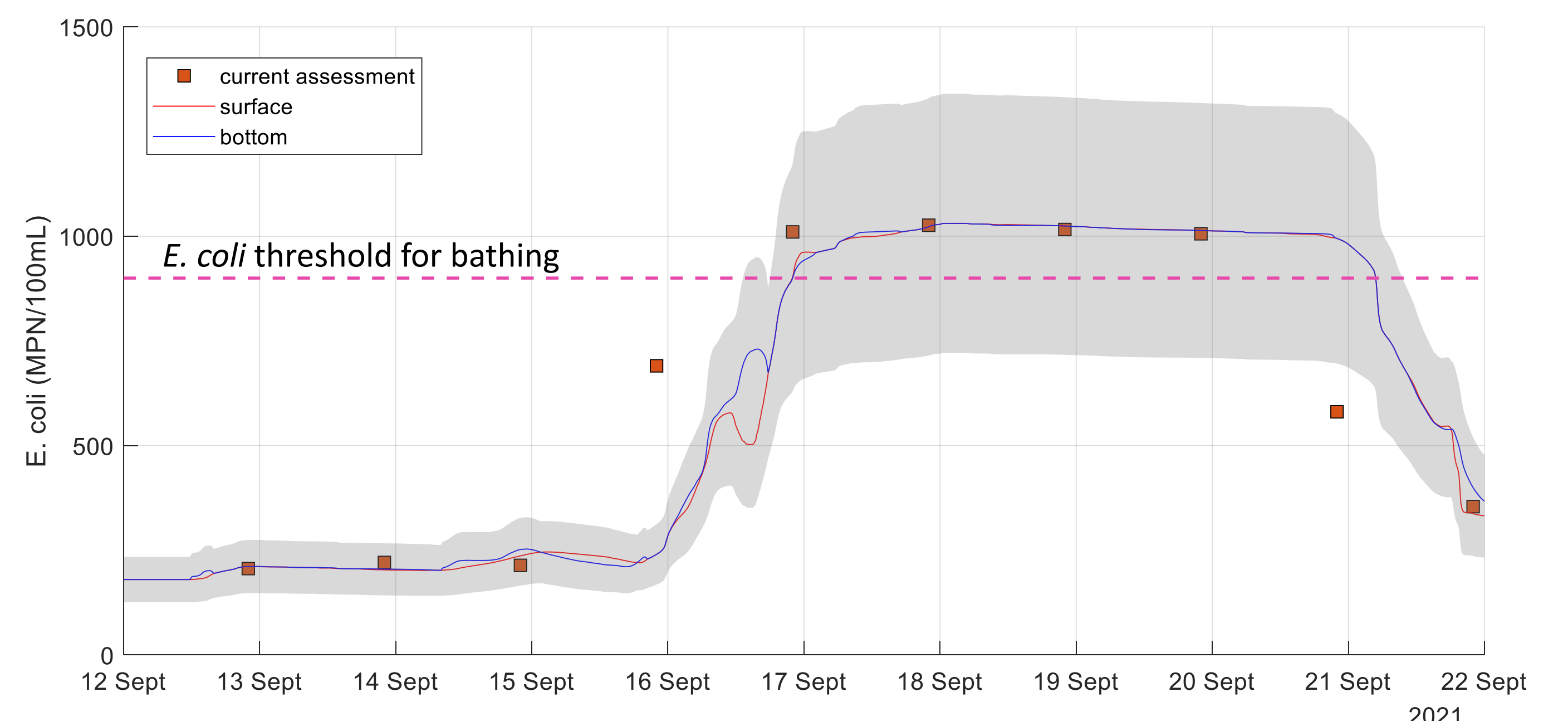
- 7-12 Aug 2020: RMSE = 0.37 °C

R² ≈ 0.8

- 13-23 Jul 2022: RMSE = 0.26 °C



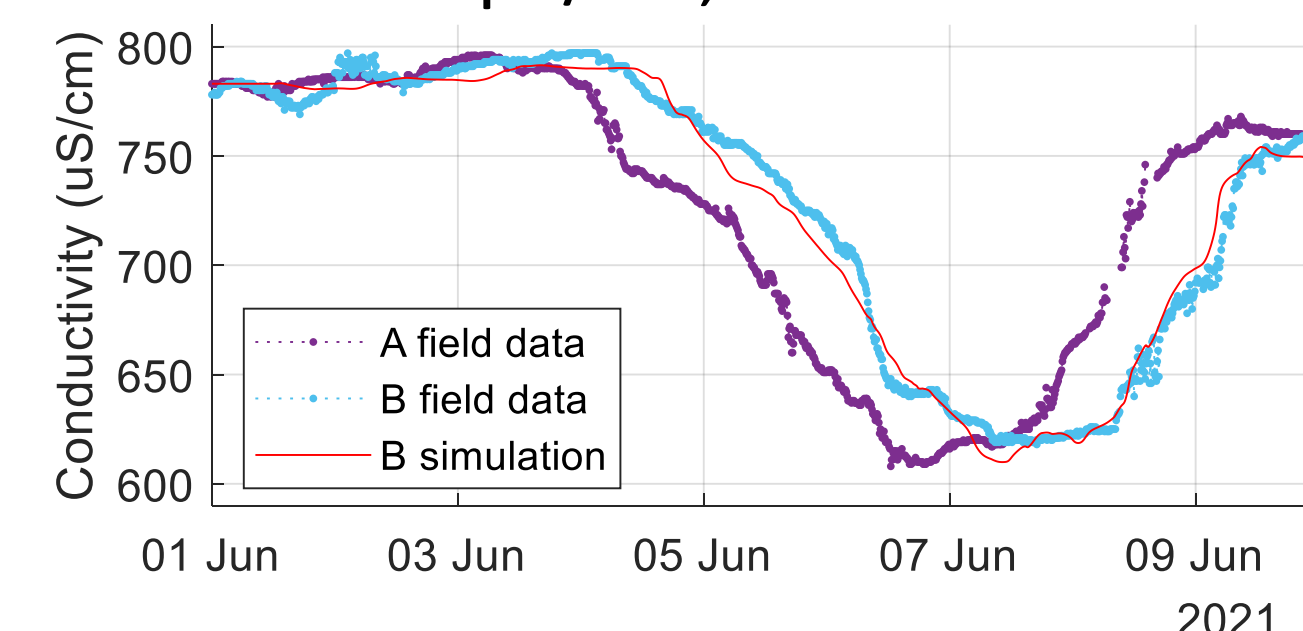
Transfer of bacterial contamination



Tracer transfer – Validation with conductivity

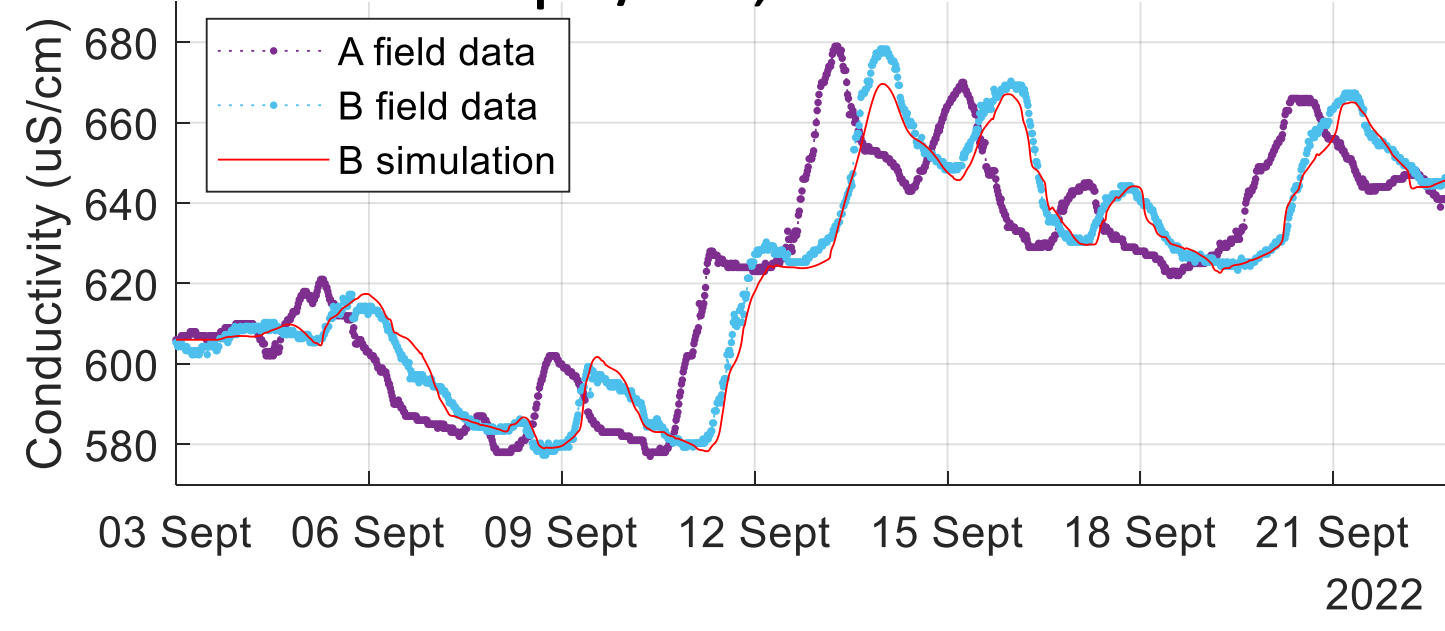
- 01-10 Jun 2021

RMSE = 8 μS/cm, r² = 0.98



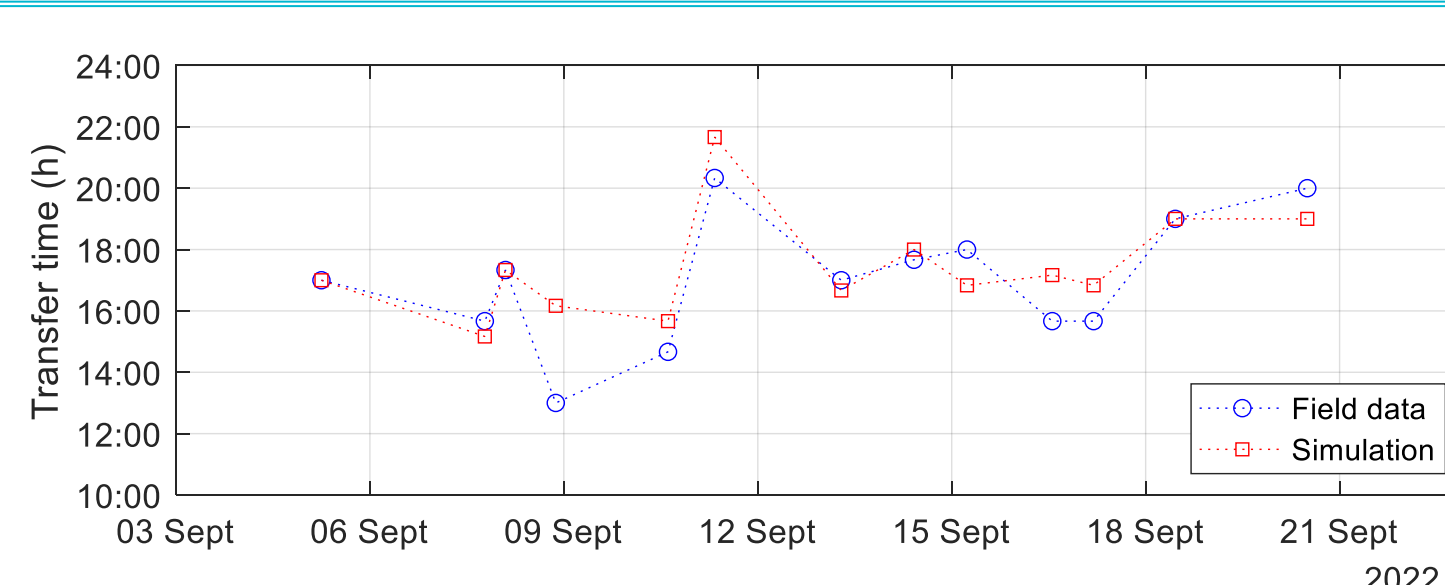
- 03-22 Sep 2022

RMSE = 3 μS/cm, r² = 0.99



Transfer time estimation

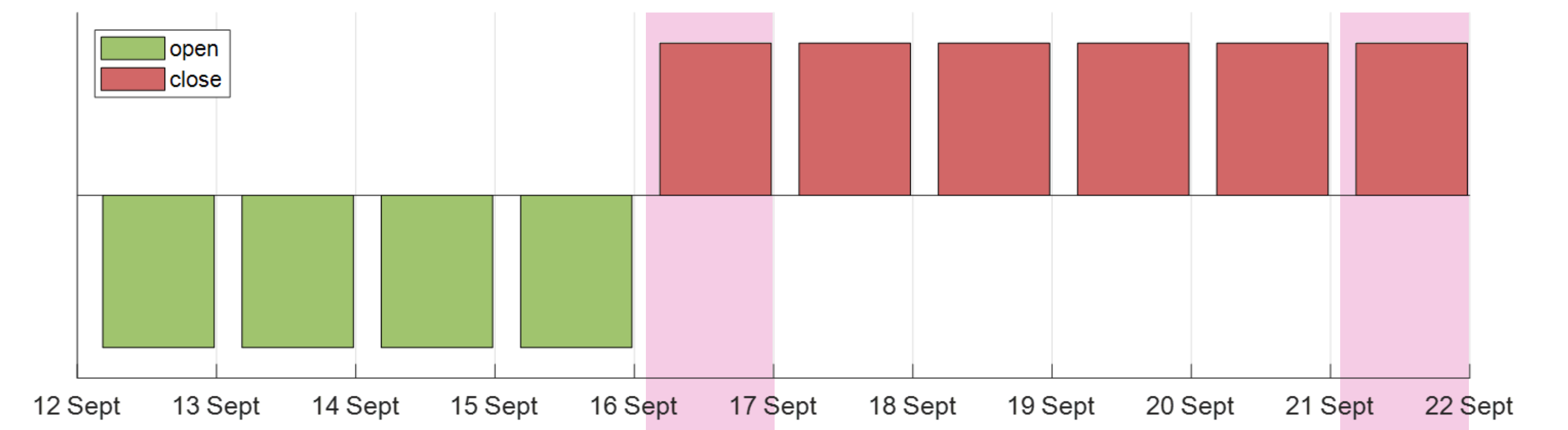
- Time lag between local peaks and troughs
- Time lag range [12-22h]
- Good estimation of mean flow velocity [1.5-2.0 cm/s]



Opening/closure estimation

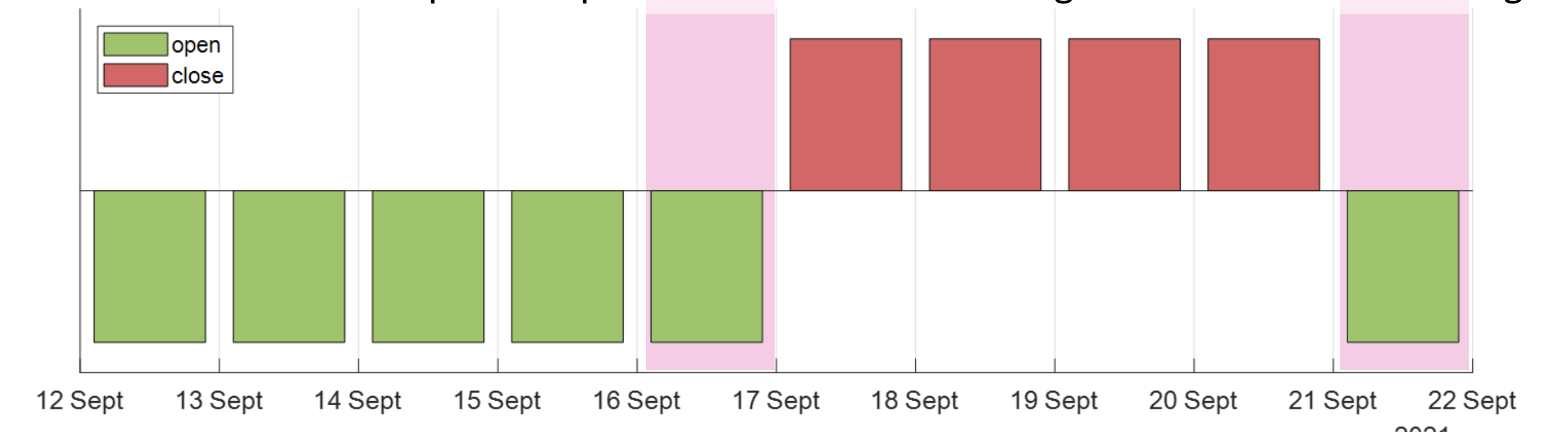
- Model prediction

- Continuous estimation



- Current warning system

- Assessment from upstream punctual information the night before decision-making



Model provides continuous information about FIB evolution

Conclusion

- Thermal stratification: up to 1.5 °C between bottom and surface
- Accurate tracer transport: Conductivity from points A to B
- Good mean flow velocity estimation
- Transfer of bacterial contamination

Continuous monitoring + Telemac-3D



Anticipation of the FIB level in the area of interest

Early warning system for decision making and sanitary risk attenuation

novatech

L'eau dans la ville | Urban water

LYON 2023

Natalia Angelotti de Ponte Rodrigues, Arthur Guillot – Le Goff, Rémi Carmigniani, Romero Lacerda, Françoise Lucas, Mohamed Saad, Philippe Dubois, Brigitte Vinçon-Leite

LEESU

École des Ponts ParisTech

LABORATOIRE D'HYDRAULIQUE SAINT-VENANT

OPUR