

11^e Conférence internationale

LYON 2023

— L'eau dans la ville | Urban water

Organisée par

graie
PÔLE
EAU & TERRITOIRES

OTHU

MÉTROPOLE
GRAND LYON

nôvateCH

L'eau dans la ville | Urban water

Caractérisation des fonctions infiltration et filtration d'un ouvrage de gestion des eaux pluviales à la source

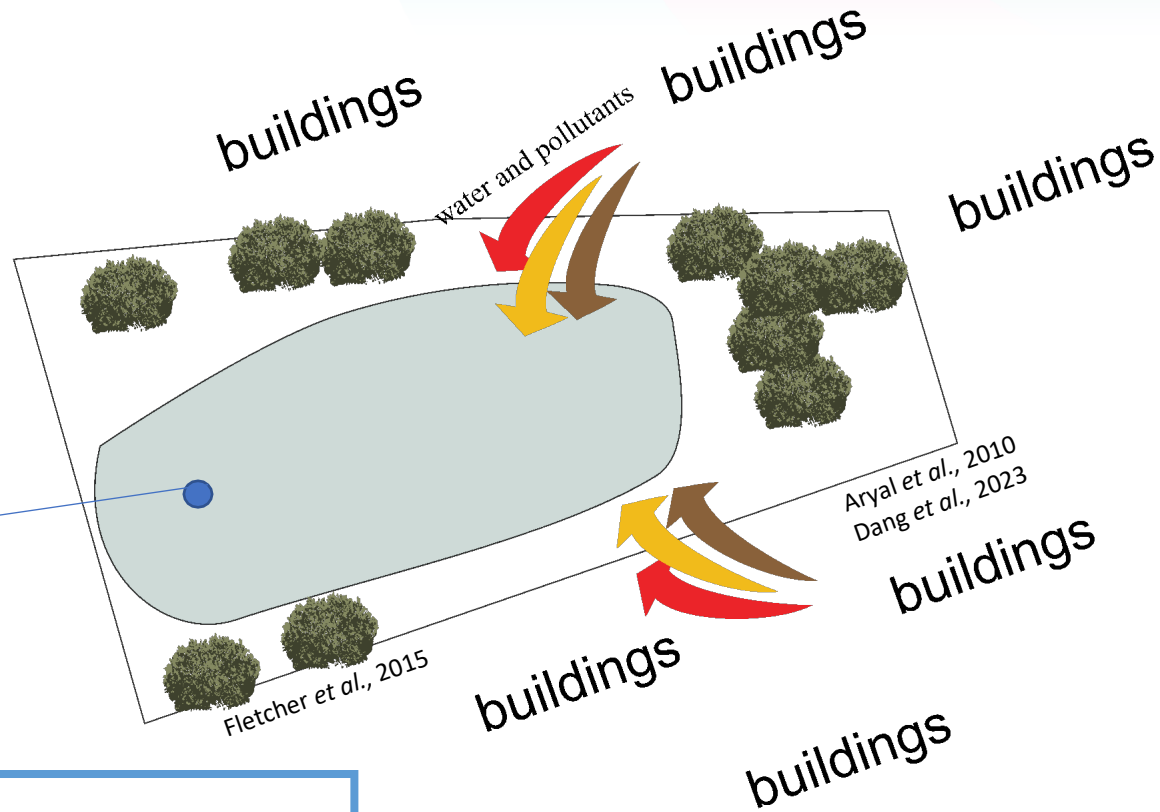
*Infiltration and filtration functions characterization of a
sustainable urban drainage system*

Gersende Fernandes, Simone Di Prima, Gislain Lipeme Kouyi,
Tim Fletcher, Laurent Lassabatere

Soil, water and pollutants

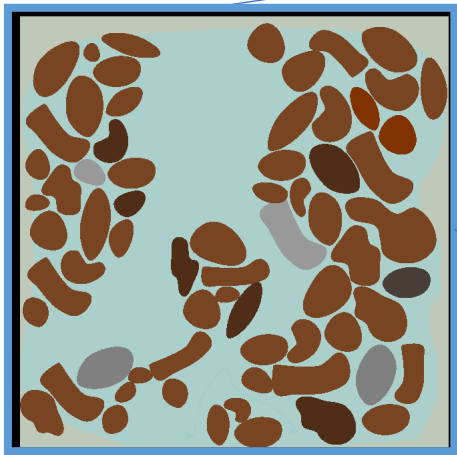


Bressy *et al.*, 2014

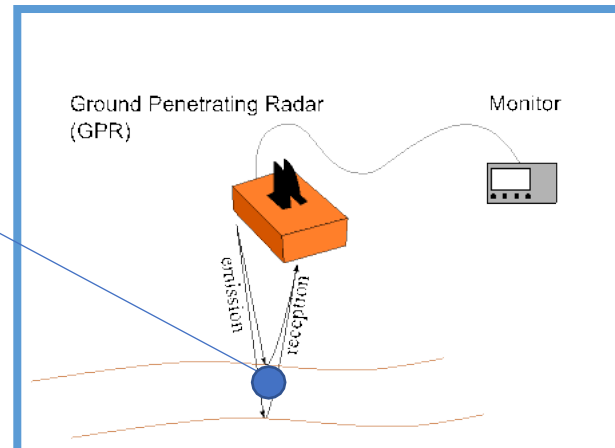


Aryal *et al.*, 2010
Dang *et al.*, 2023

Fletcher *et al.*, 2015



Ben Slimene *et al.*, 2017

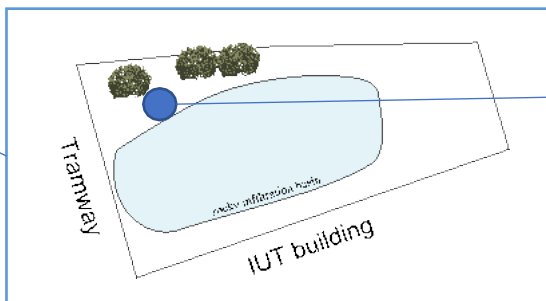


Di Prima *et al.*, 2020
Truss *et al.*, 2007
Allroggen and Tronicke, 2015

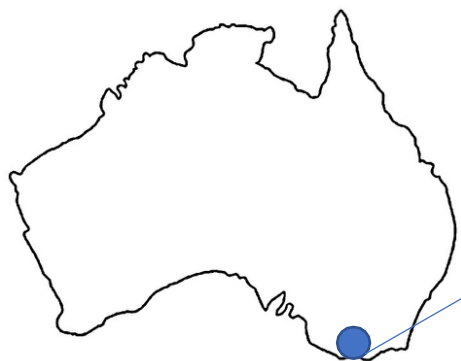


Objectives:

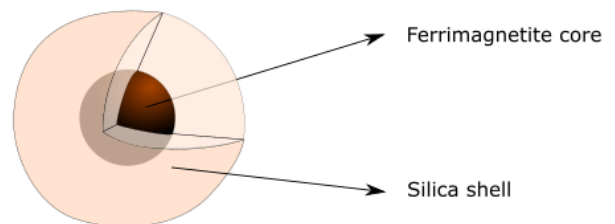
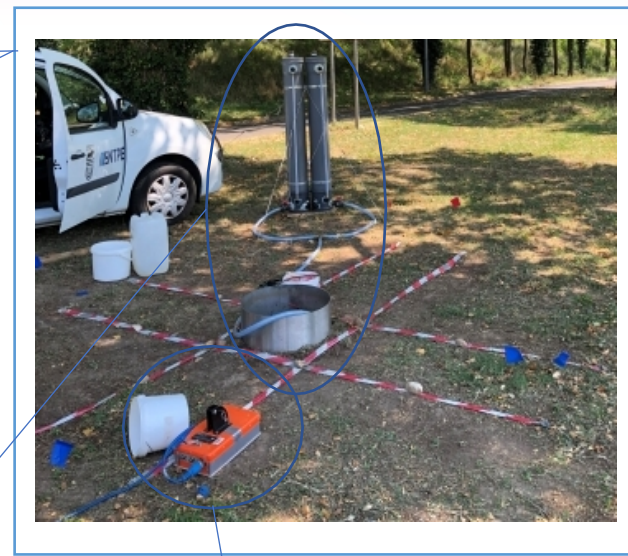
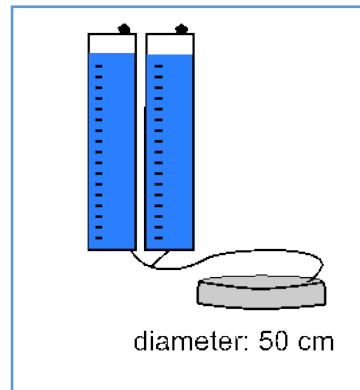
- To be representative of the heterogeneity of soils (including preferential flows)
- To determine hydraulic inherent parameters of soil (for SUDs management for example)
- To follow pollutants mobility and retention in soil (with GPR)



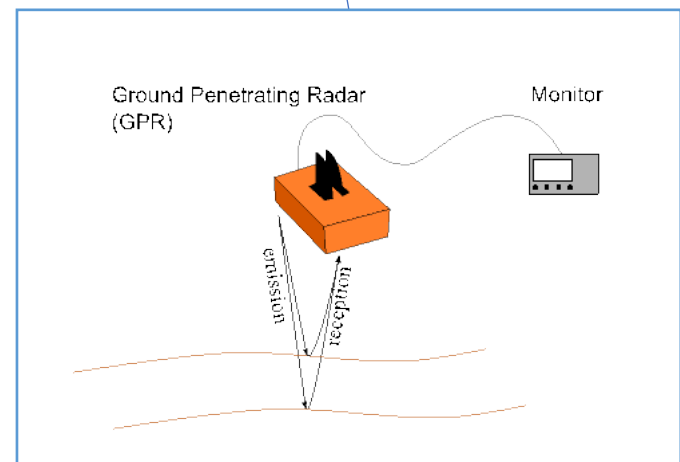
Goal: to test the method



Goal: to apply and improve the method

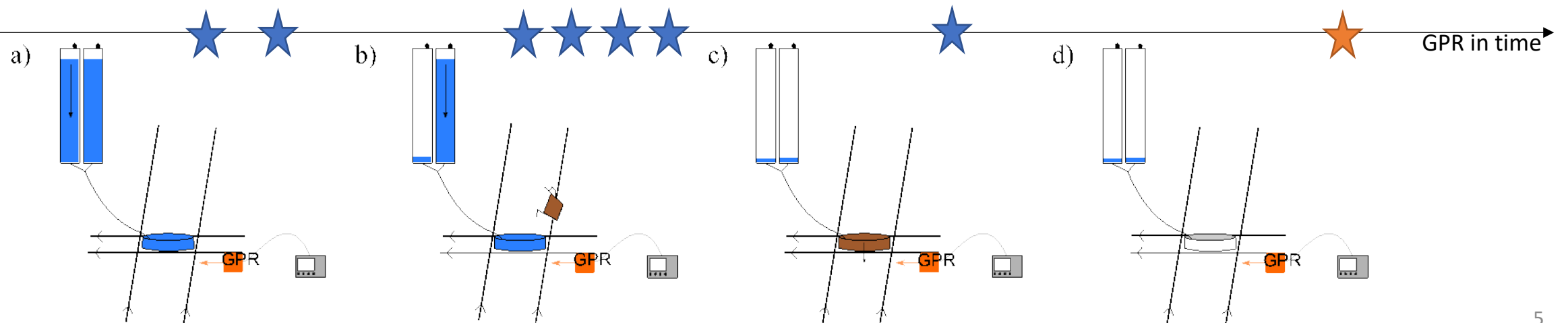


SPIONs
Superparamagnetic Iron Oxide Nanoparticles
Diameter: 20-80 nm



Method for the infiltration/filtration tests

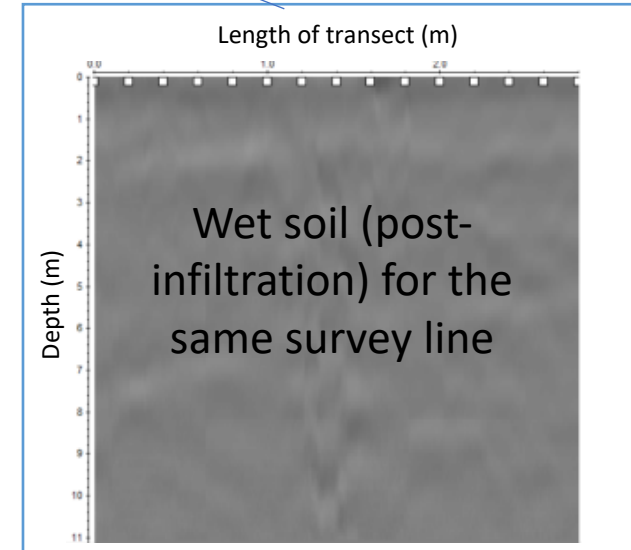
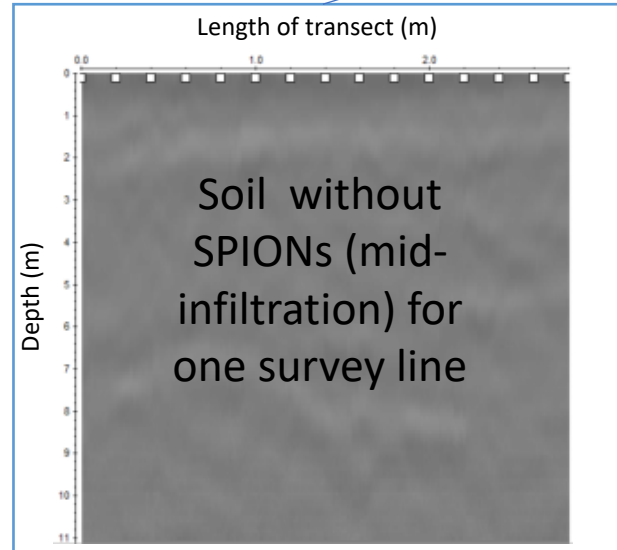
1. Put plastic inside the ring to avoid infiltration
2. Fill the reservoirs and the ring with water
3. Follow the survey lines with the GPR then start infiltration (a)
4. Open the second reservoir and start to pour the SPIONs (b)
5. Wait for ring infiltration (c)
6. Follow again the survey lines with the GPR (d)



Method for radargrams comparison (for time-lapse survey)

1. Filters: normalization, gains, reducing noises

Software: ReflexW



Method 1: structural similarity (Allroggen et Tronicke 2015)

- Function applied following a moving window

$$SS(x, y) = \frac{c_{xy} + a}{\sigma_x \sigma_y + a}$$

$$\text{with } c_{xy} = \frac{1}{N-1} \sum_{i=1}^N (x_i - \mu_x)(y_i - \mu_y)$$

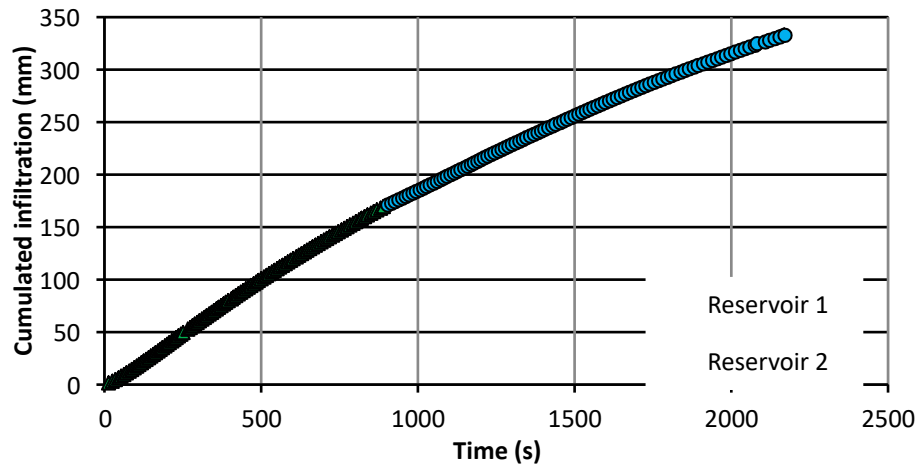
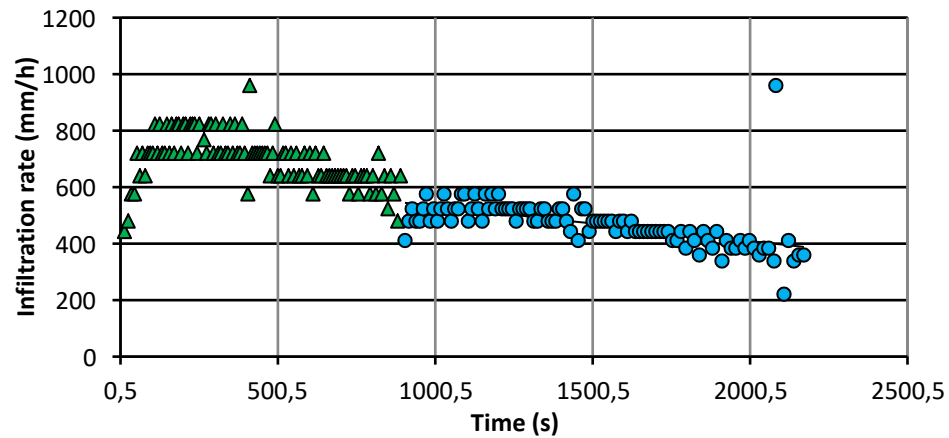
Method 2: standard deviation (Di Prima *et al.*, 2015)

- Difference between two radargrams
- Threshold chosen to visualize preferential flowpaths: 1.5*standard deviation (Di Prima *et al.*, 2015; Guo *et al.*, 2014)

Software: R

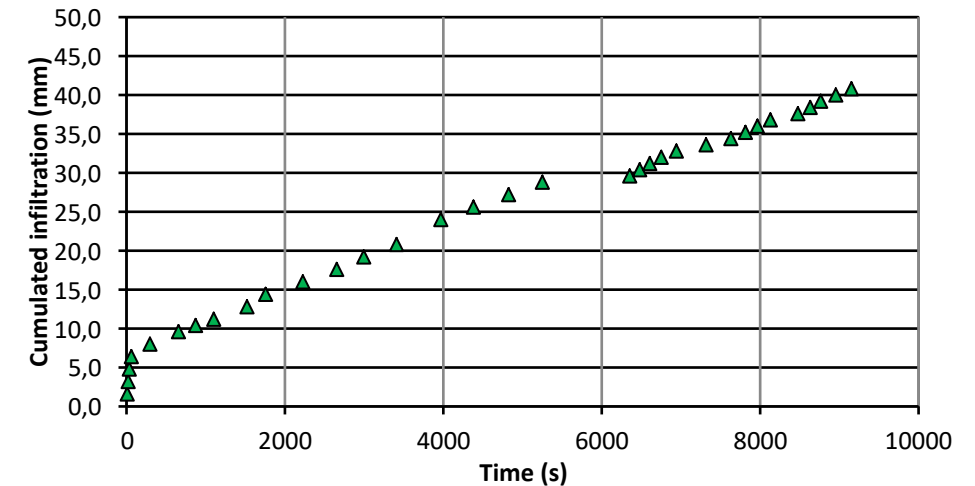
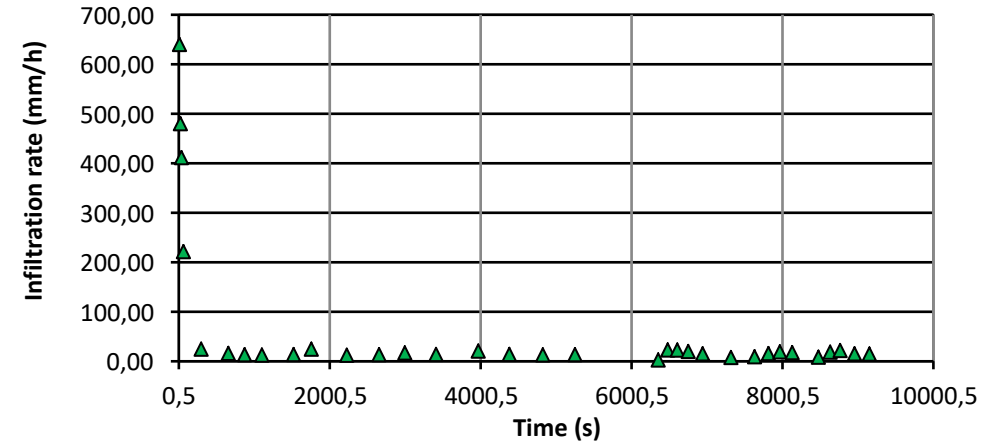
Infiltration results

Site 1 (IUT)



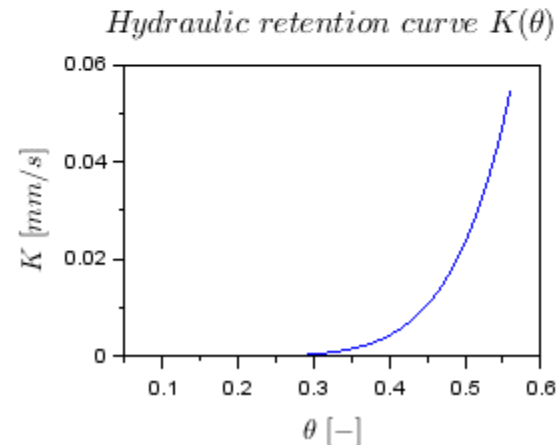
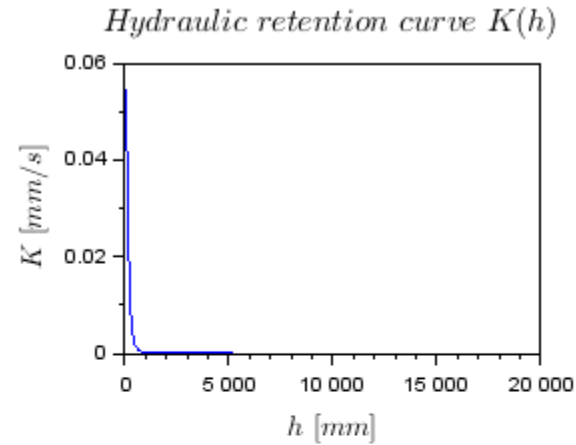
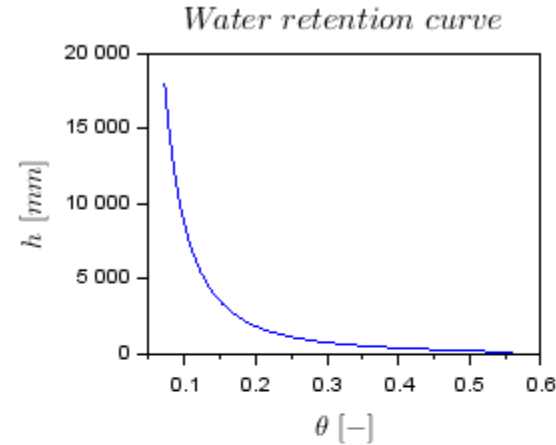
- Final infiltration rate: 360 mm/h
- Method works well

Site 2 (WICKS infiltration basin)



- Final infiltration rates between 10 and 20 mm/h
- But the infiltration is not complete

Infiltration results



With the BEST method
(<https://bestsoilhydro.net/>)

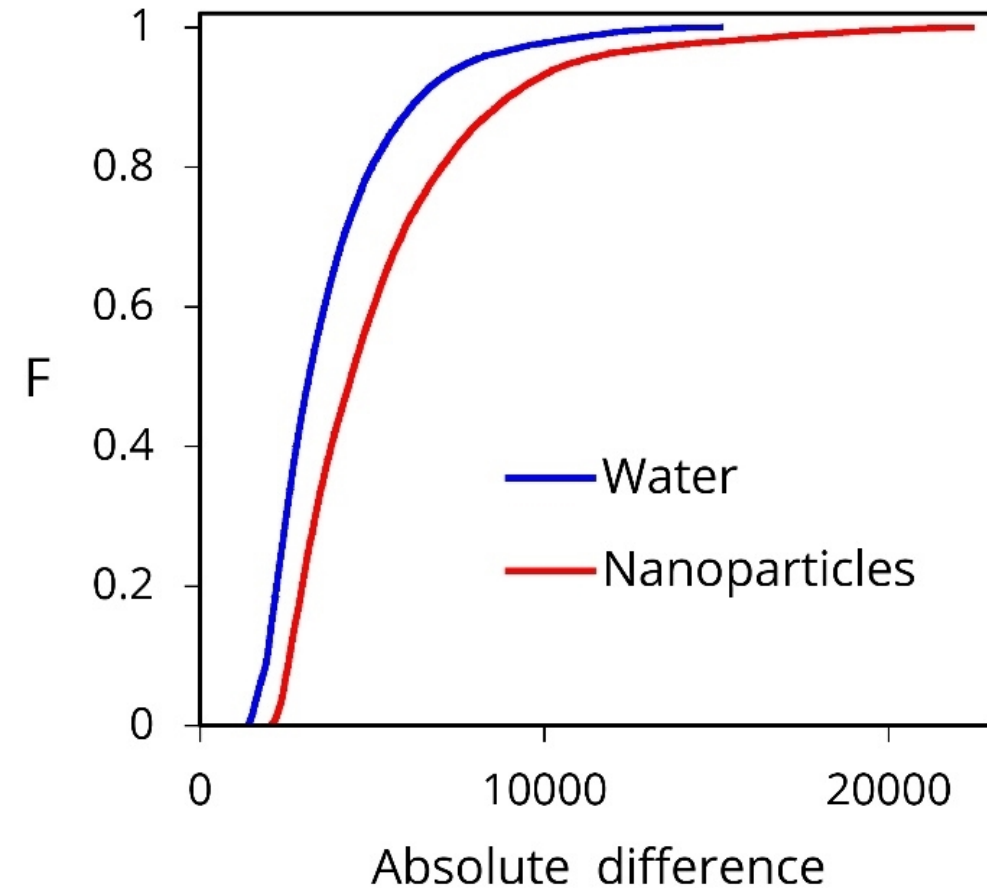
→ Good method to follow hydrodynamic parameters of SUDs in time

Pre-tests separating water and SPIONs

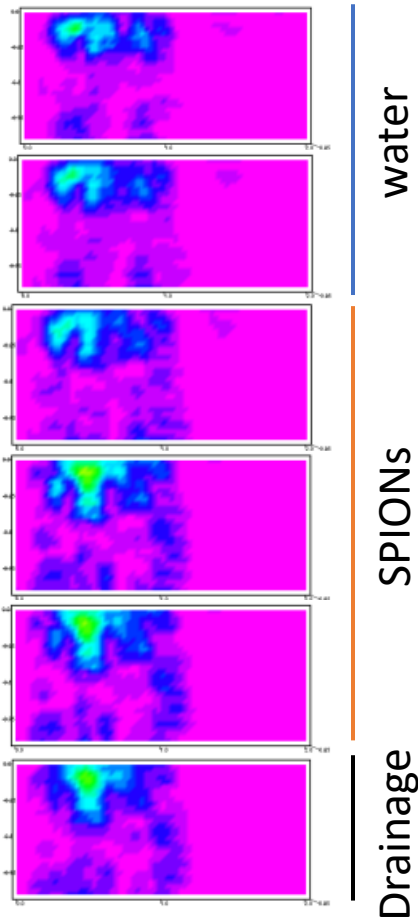
- Water **OR** SPIONs infiltrated in different rings
- Followed by the GPR before and after infiltration

Filtration result 1

- There is a difference of signal between water and SPIONs
- The SPIONs signal seems higher



Filtration result 2: still complicated to differentiate water and SPIONs



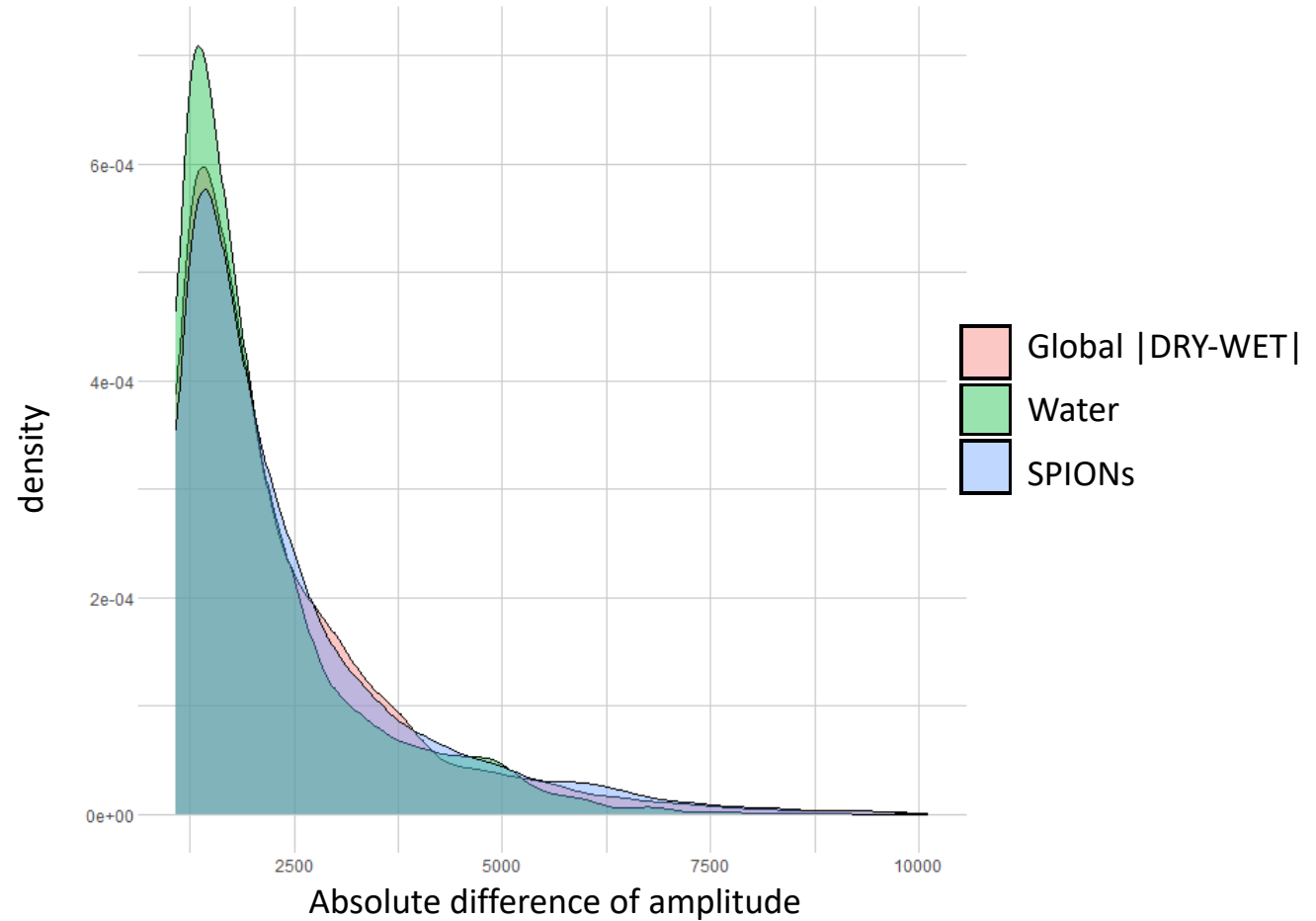
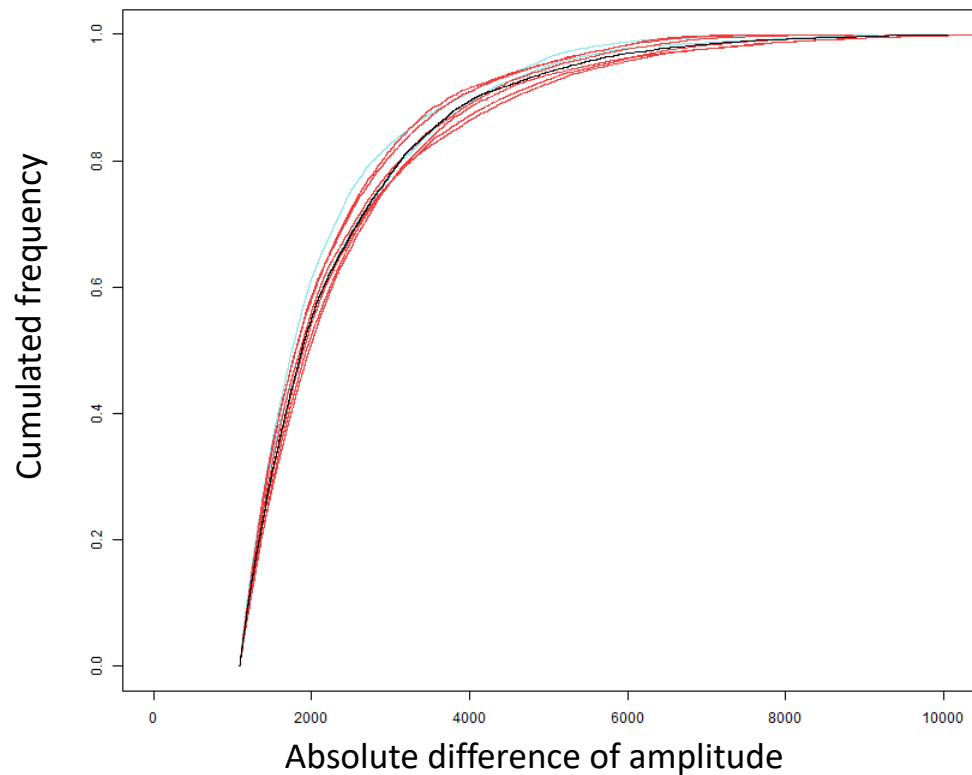
Visualization on RockWorks

- Increase of the pattern in time
- Changes when the SPIONs are injected

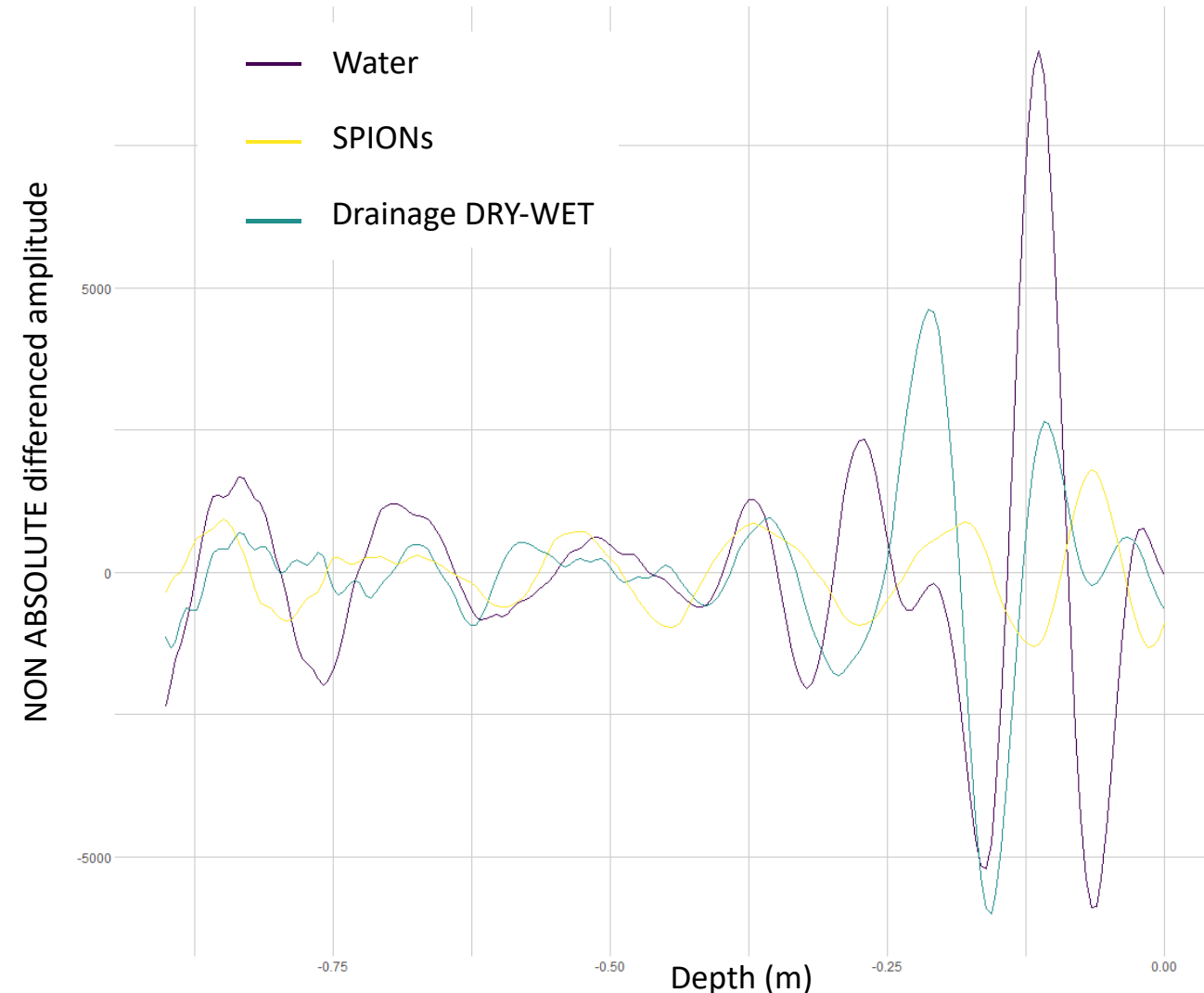
Is it possible to differentiate « water signal » and « SPIONs signal »?

Filtration result 2: still complicated to differentiate water and SPIONs

→ Look at the frequency curves



Filtration result 2: still complicated to differentiate water and SPIONs



→ Look at specific traces (« columns of data ») with differenced amplitudes (but not absolute)

$$v = \frac{0.3}{\sqrt{\epsilon_r}}$$

Water relative permittivity > soil relative permittivity

→ Wave celerity decreases with water

→ Wave celerity even more low with SPIONs than water

→ But is it because the steady state is not reached? Or because of the SPIONs presence?

Conclusions and further research

- Good tool for hydraulic parameters survey in time (infiltration)
- Could be used with nanotracers followed by GPR, but limits still exist in the protocol, especially on SPIONs and water signal separation

Solutions:

- Improve the accuracy of the method (tests already made in Melbourne)
- Test the concentration and type of SPIONs impact (ongoing analysis)
- Another nanotracer? Couple it with another device?

Thank you!

Do not hesitate to contact me: gersende.fernandes@entpe.fr

Bibliography:

- Allroggen, N., Tronicke, J., 2015. Attribute-based analysis of time-lapse ground-penetrating radar data. *Geophysics* 81, H1–H8. <https://doi.org/10.1190/geo2015-0171.1>
- Aryal, R., Vigneswaran, S., Kandasamy, J., Naidu, R., 2010. Urban stormwater quality and treatment. *Korean J. Chem. Eng.* 27, 1343–1359. <https://doi.org/10.1007/s11814-010-0387-0>
- Ben Slimene, E., Lassabatere, L., Simunek, J., Winiarski, T., Gourdon, R., 2017. The role of heterogeneous lithology in a glaciofluvial deposit on unsaturated preferential flow - a numerical study. *J. Hydrol. Hydromech.* 65, 209–221. <https://doi.org/10.1515/johh-2017-0004>
- Bressy, A., Gromaire, M.-C., Lorgeoux, C., Saad, M., Leroy, F., Chebbo, G., 2014. Efficiency of source control systems for reducing runoff pollutant loads: Feedback on experimental catchments within Paris conurbation. *Water Res.* 57, 234–246. <https://doi.org/10.1016/j.watres.2014.03.040>
- Dang, D.P.T., Jean-Soro, L., Béchet, B., 2023. Pollutant characteristics and size distribution of trace elements during stormwater runoff events. *Environ. Chall.* 11, 100682. <https://doi.org/10.1016/j.envc.2023.100682>
- Di Prima, S., Winiarski, T., Angulo-Jaramillo, R., Stewart, R.D., Castellini, M., Abou Najm, M.R., Ventrella, D., Pirastru, M., Giadrossich, F., Capello, G., Biddoccu, M., Lassabatere, L., 2020. Detecting infiltrated water and preferential flow pathways through time-lapse ground-penetrating radar surveys. *Sci. Total Environ.* 726, 138511. <https://doi.org/10.1016/j.scitotenv.2020.138511>
- Fletcher, T.D., Shuster, W., Hunt, W.F., Ashley, R., Butler, D., Arthur, S., Trowsdale, S., Barraud, S., Semadeni-Davies, A., Bertrand-Krajewski, J.-L., Mikkelsen, P.S., Rivard, G., Uhl, M., Dagenais, D., Viklander, M., 2015. SUDS, LID, BMPs, WSUD and more – The evolution and application of terminology surrounding urban drainage. *Urban Water J.* 12, 525–542. <https://doi.org/10.1080/1573062X.2014.916314>
- Guo, L., Chen, J., Lin, H., 2014. Subsurface lateral preferential flow network revealed by time-lapse ground-penetrating radar in a hillslope. *Water Resour. Res.* 50, 9127–9147. <https://doi.org/10.1002/2013WR014603>
- Truss, S., Grasmueck, M., Vega, S., Viggiano, D.A., 2007. Imaging rainfall drainage within the Miami oolitic limestone using high-resolution time-lapse ground-penetrating radar. *Water Resour. Res.* 43. <https://doi.org/10.1029/2005WR004395>