Quantifying infiltration rates within a MAR pilot site using DTS technology

Robin Glaude[1], Nataline Simon[2], Serge Brouyère[1]

1. Hydrogeology and Environmental Geology, University of Liège, Belgium
2. IMSE/COSYS, University of Gustave Eiffel, France

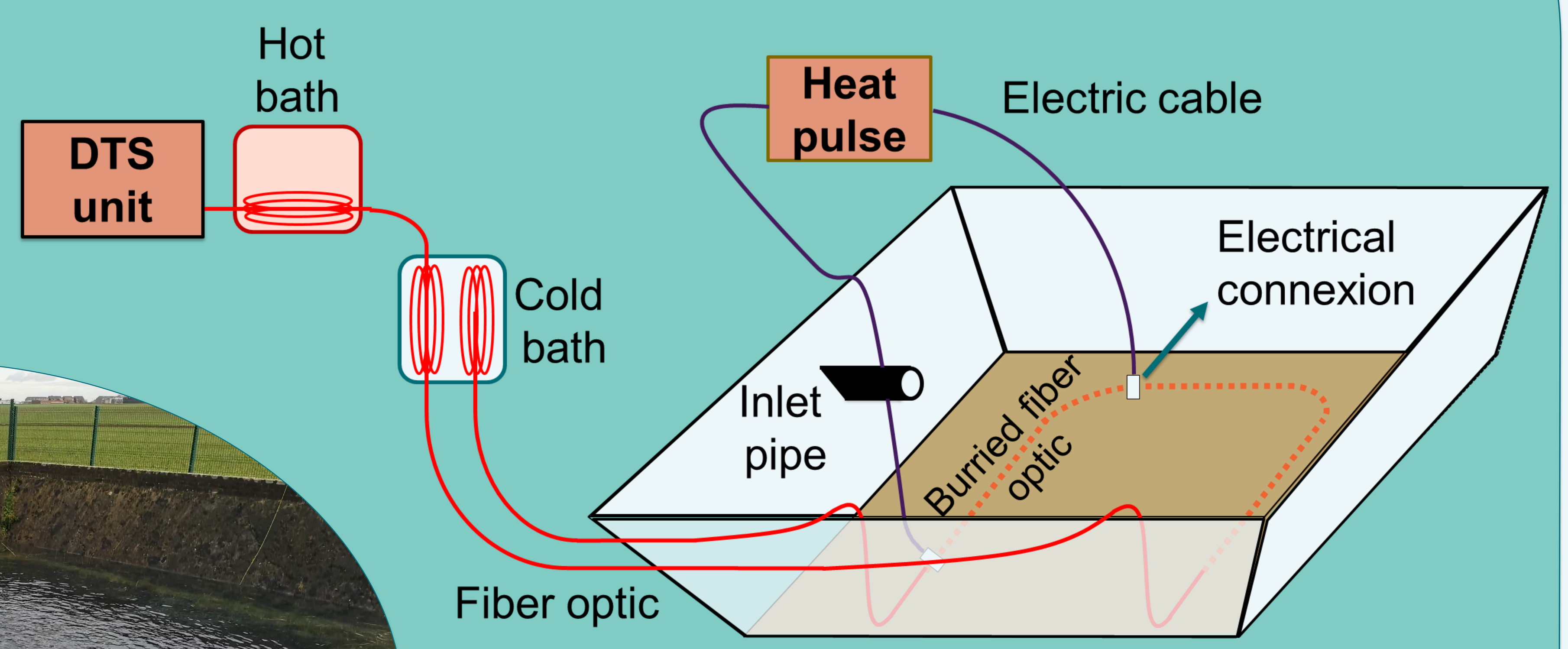
1. Background

- Managed Aquifer Recharge (MAR) is recognized as an effective tool for sustainable water management.
- Accurate estimation of soil infiltration capacity is essential for successful MAR design.
- Distributed Temperature Sensing (DTS) along a Fiber Optic (FO) cable has recently been used in hydrogeology field to quantify water fluxes.

Objectives

Demonstrate the combined use of passive and active-DTS measurements to assess infiltration rates and their spatial variability in a MAR pilot site.

2. DTS set up



Active-DTS

Active-DTS measurements involve heating a section of the burried FO cable and monitoring the induced temperature increase over time. Heating was conducted one day after the beginning of the basin replenishment for a duration of 9 hours and half.

Passive-DTS

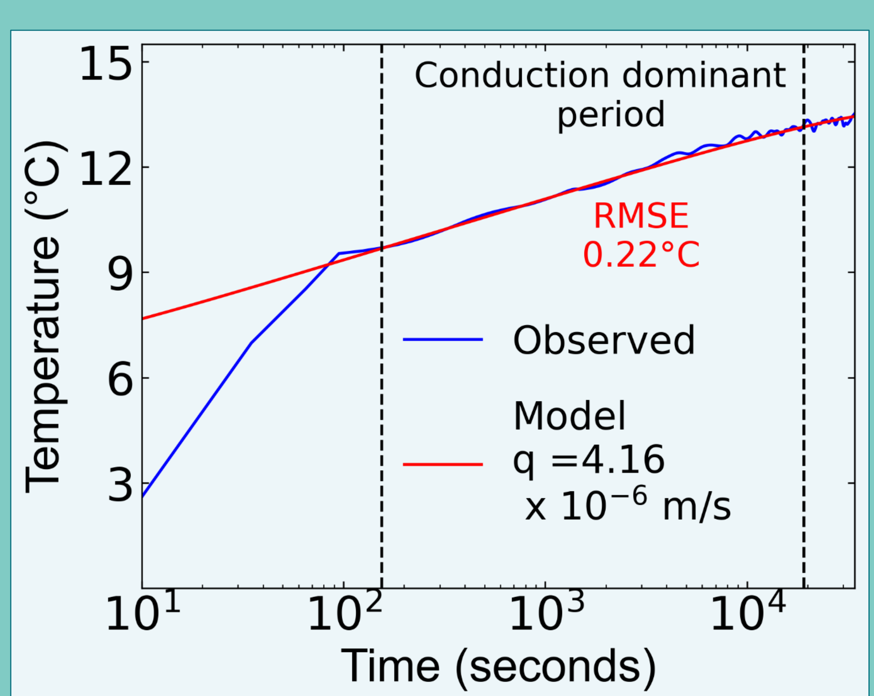
Passive-DTS measurements involve continuously recording natural temperature variations along the entire FO cable throughout the infiltration test. These measurements track soil temperature decrease during basin replenishment with cold groundwater.

3. Results

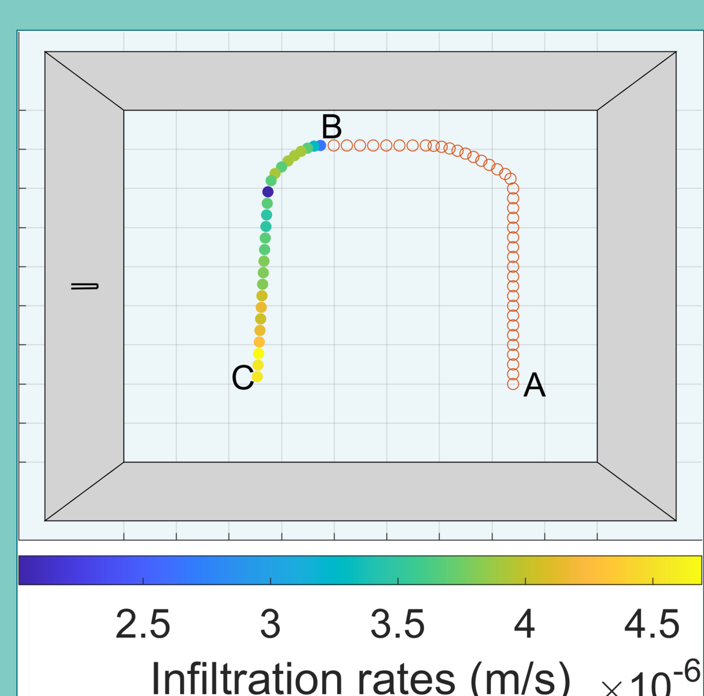
Active-DTS

The reproduction of the temperature response during both conduction and advection phases provides respectively estimates of the thermal conductivity of the surrounding soil and the infiltration rate at this specific location.

A thermal response analytical model is used to reproduce thermal observations for every measurement point along the heated section of FO cable (B to C). A map of the infiltration rate is then obtained by displaying the obtained infiltration rate for each measurement location along the FO cable.



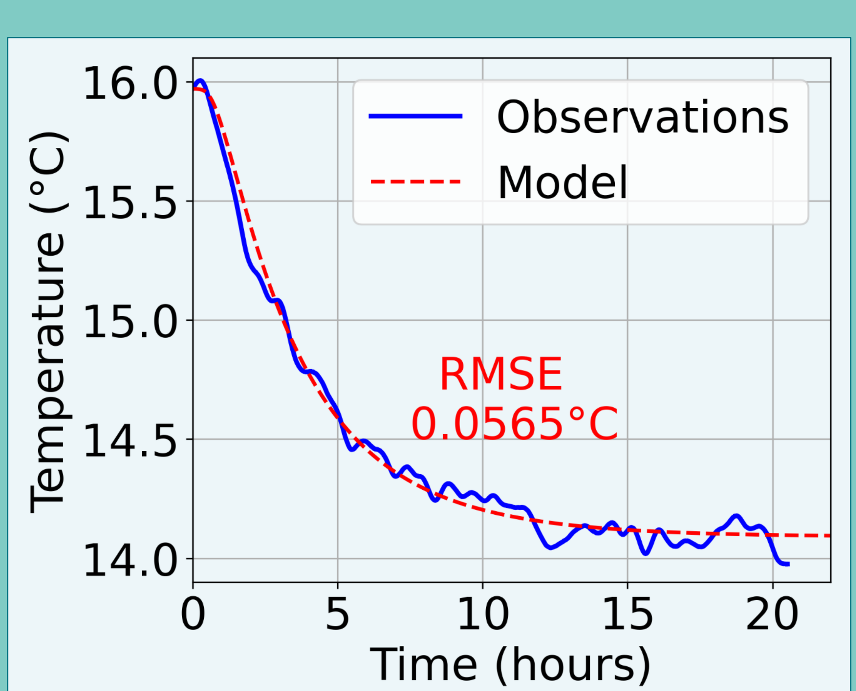
Individual meas. point



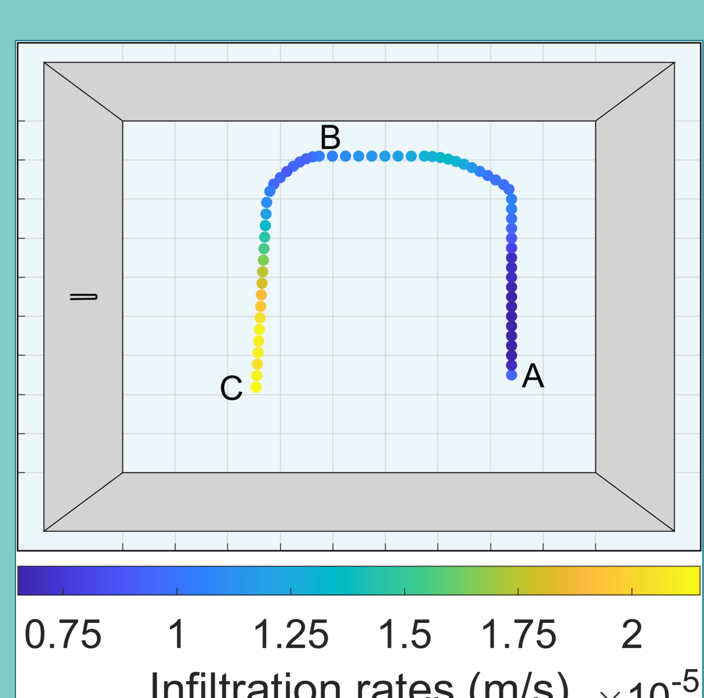
All meas. points

Passive-DTS

The passive-DTS measurements recorded during the filling process of the infiltration basin were interpreted using a heat transfer numerical model that includes fluid flow. The input flow introduced into the model that leads to the closest match for each thermal response is considered as an accurate estimation of the recharge rate during the beginning of the infiltration test. As for active-DTS measurements, a map is then obtained by displaying infiltration rates estimates over space.



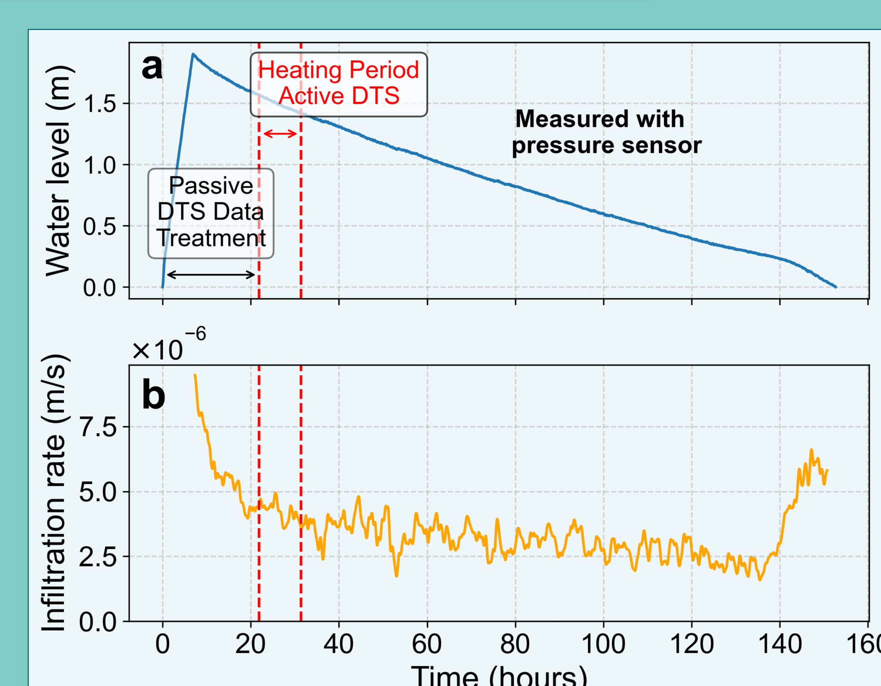
Individual meas. point



All meas. points

4. Infiltration dynamics

Mean infiltration rates estimated with active-DTS (3.79×10^{-6} m.s^{-1}) and passive-DTS (1.25×10^{-5} m.s^{-1}) measurements differ by one order of magnitude.



This discrepancy is most likely attributed to the dynamics of infiltration rather than parameter sensitivity as higher recharge rates are observed at the start of the infiltration.

5. Conclusion

Active-DTS: enables precise measurement of small flux variations and thermal conductivity.

Passive-DTS: provides baseline recharge rate but relies on natural temperature variations.

Combined Approach: the use of both methods improves overall infiltration rate estimation accuracy and allows the covering of a larger spatial domain.

Contact

Robin.Glaude@uliege.be