

Combining hydrogeological modelling and geoelectrical monitoring to assess the performance of a multi-layer mine waste reclamation cover system

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1. Introduction

a) Mine waste reclamation cover to reduce water infiltration

What is its purpose ?

Prevent various types of contaminated drainage due to infiltration of H_2O in tailings released by mining activities [1]

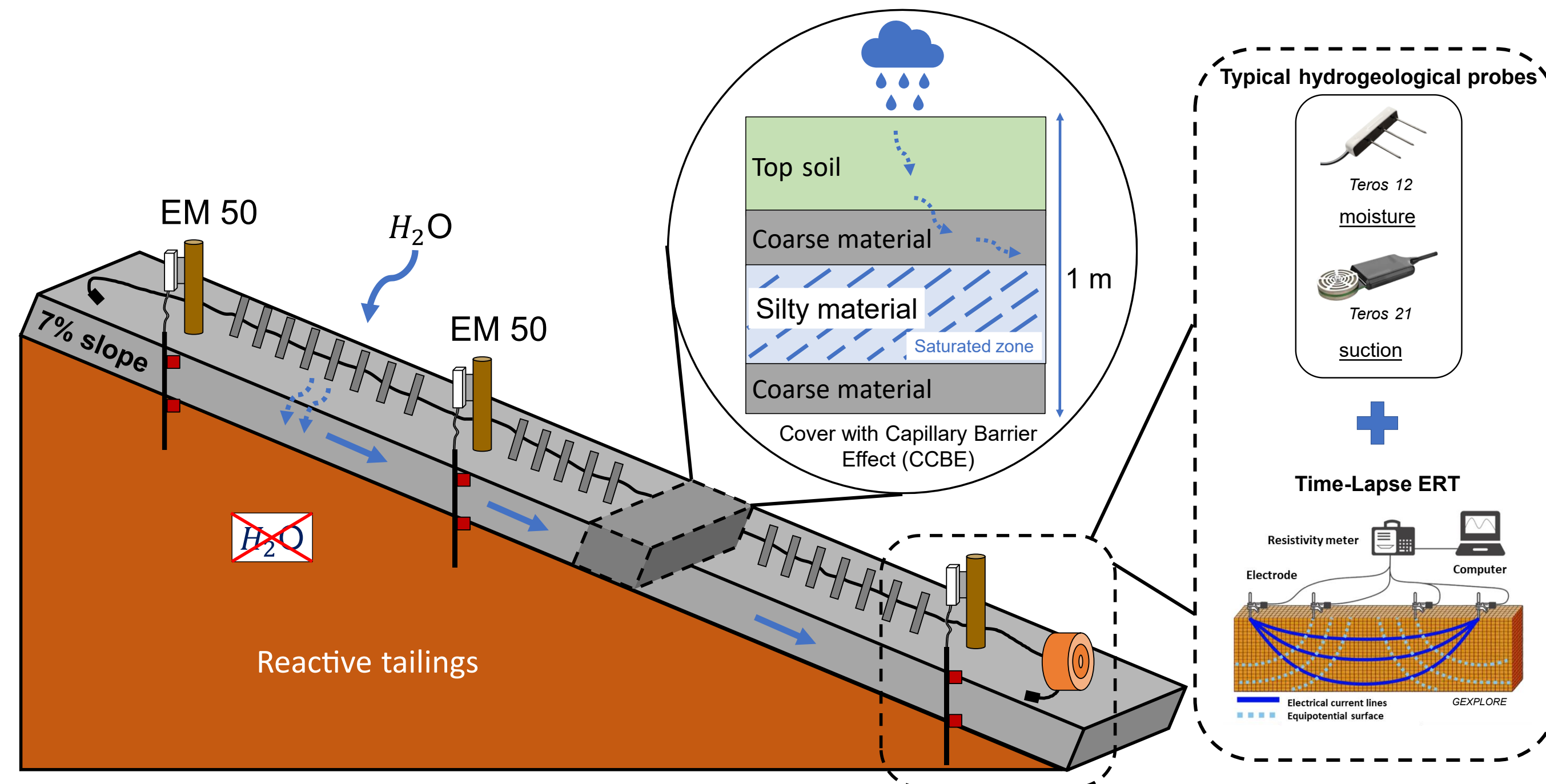
How it works ?

Divert water laterally down the slope and create a moisture-retaining layer that remains permanently saturated

What methods can be used to assess its performance ?

Different monitoring scales :

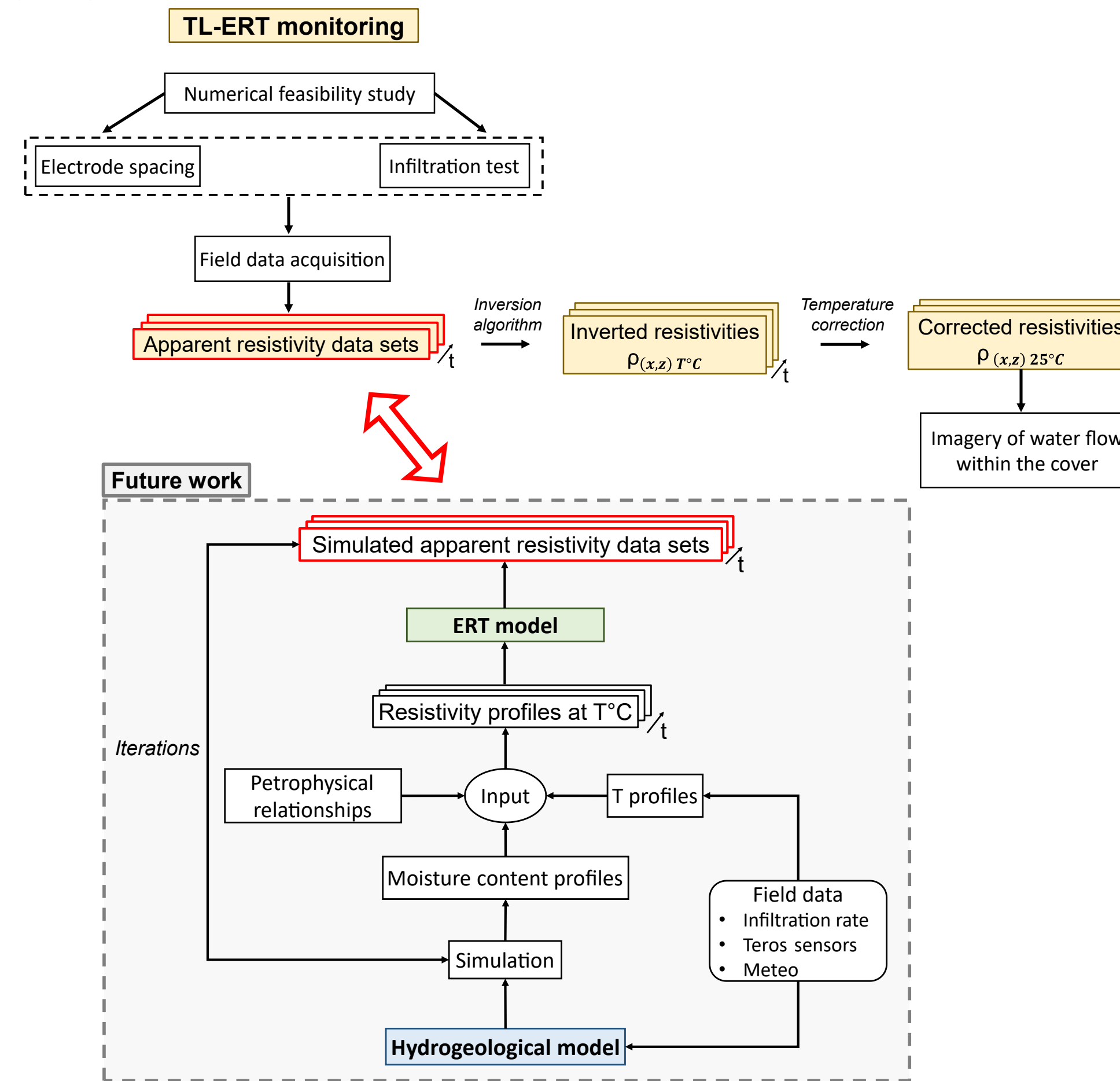
- Ponctual hydrogeological sensors to measure volumetric water content and suction
- Geoelectrical monitoring for wider spatial resolution and bigger investigation volume [2]



b) Objective

Applying Time Lapse Electrical Resistivity Tomography (TL-ERT) method at a Tailings Storage Facility (TSF) to monitor water flow dynamics within an inclined multi-layer cover system following an infiltration test

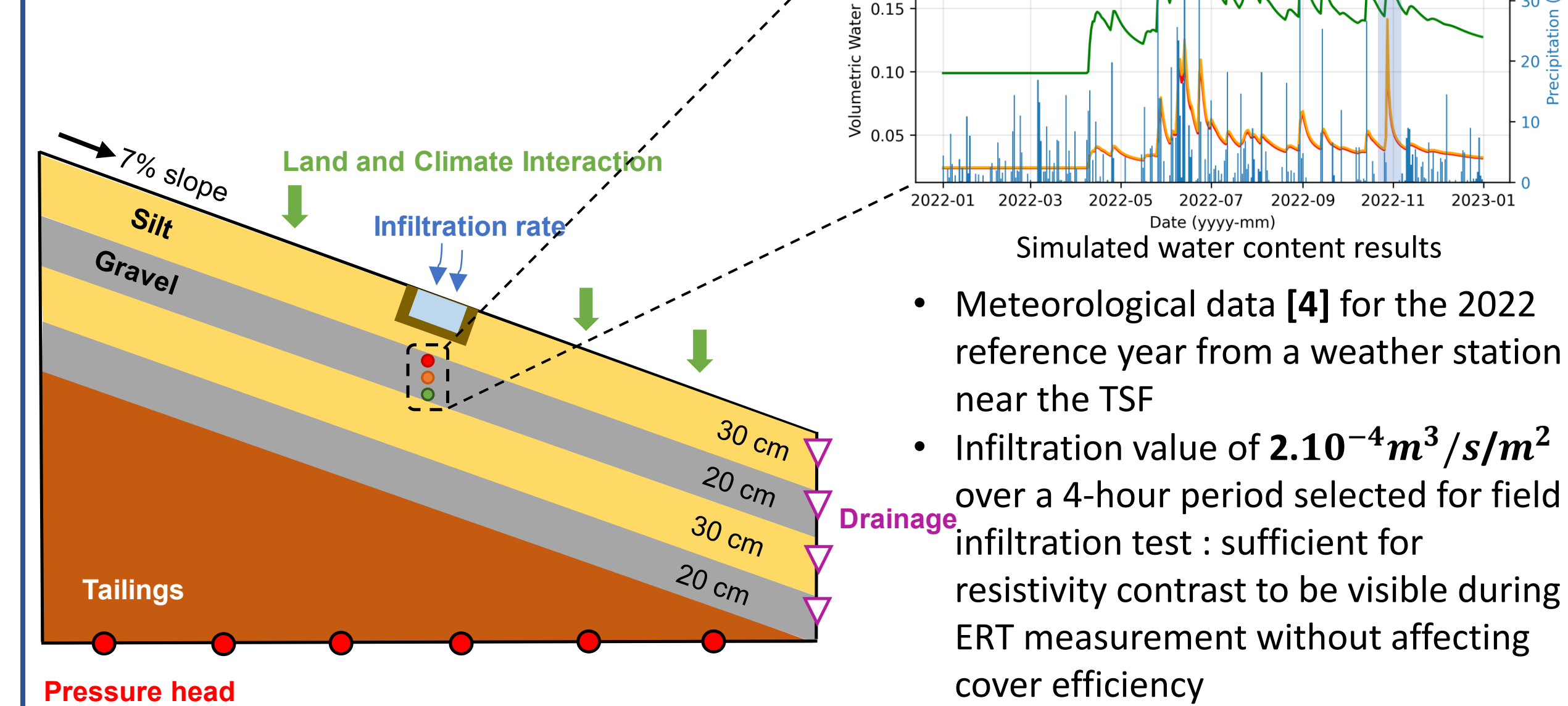
Workflow



2. Methodology for field work

a) Numerical feasibility study

Hydrogeological model inputs in SEEP/w [3]



c) Field ERT set up

TL-ERT parameters

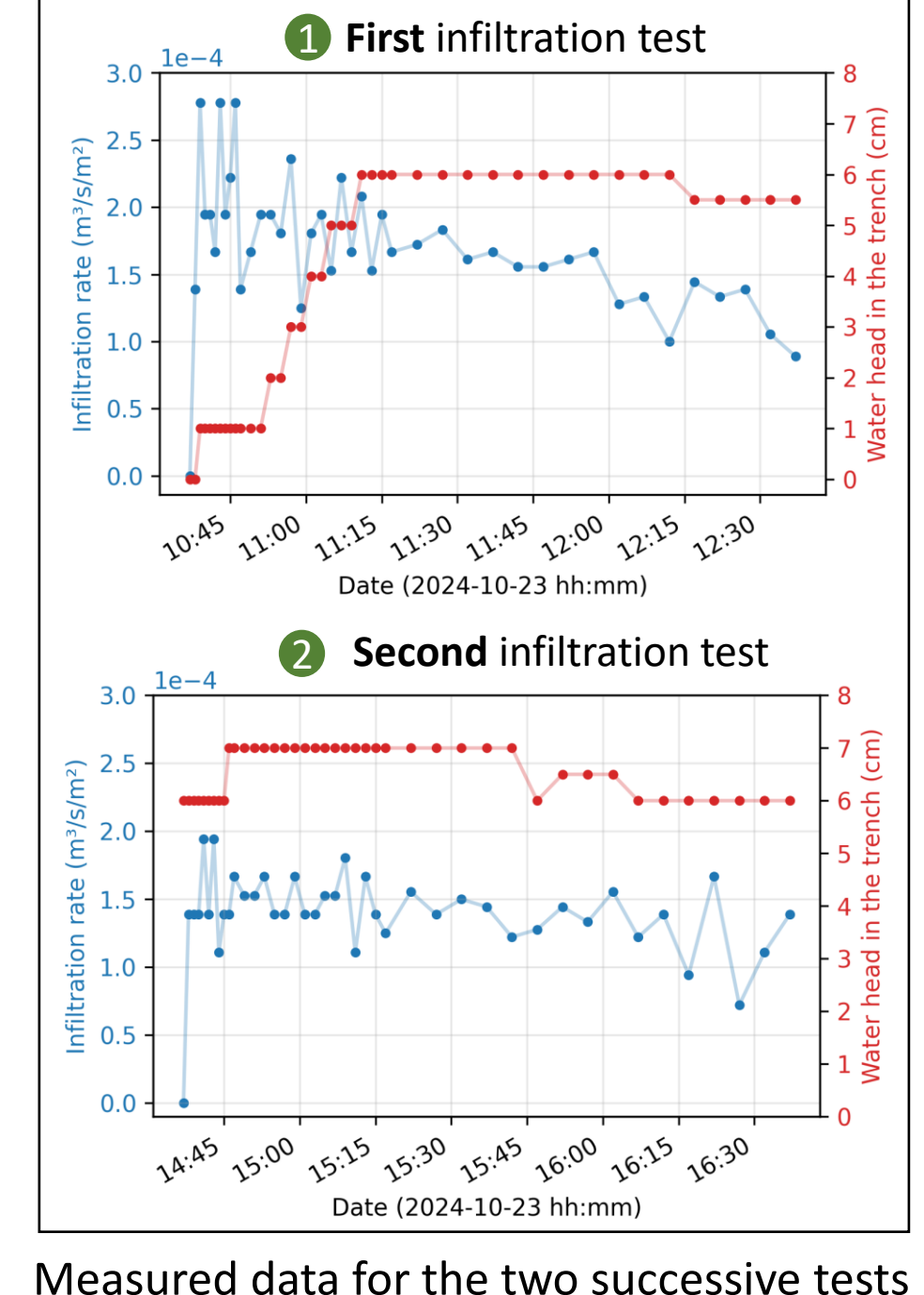
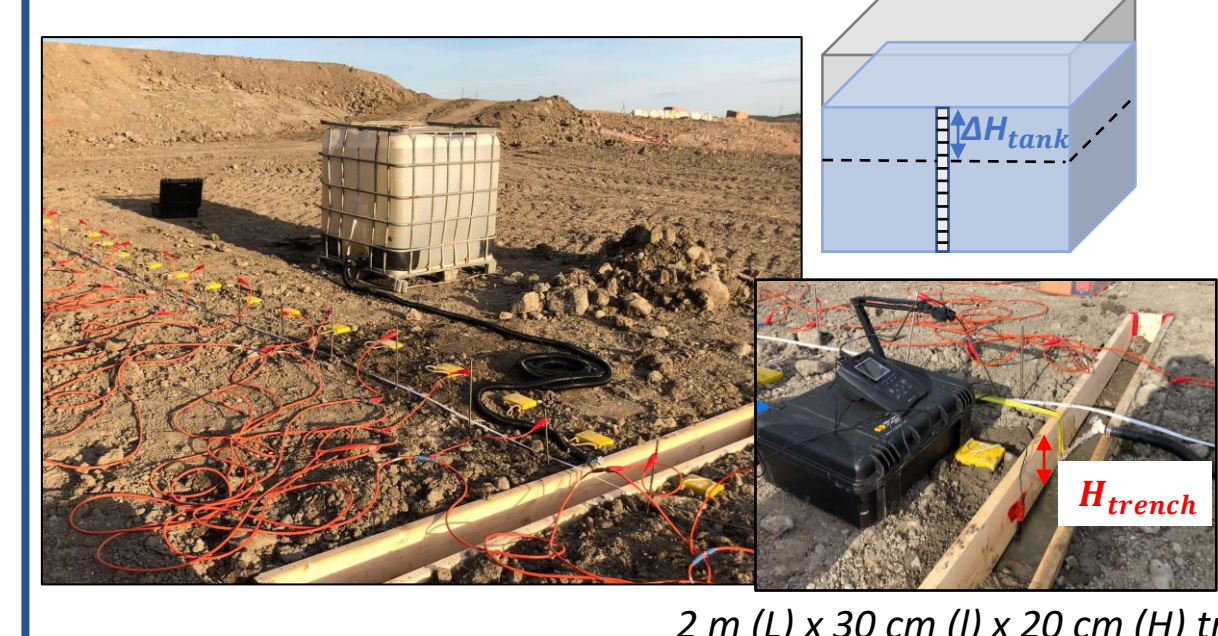
- Profile of 64 electrodes spaced 0.5 m apart in Wenner's 4-channel configuration
- Acquisition frequency : every 1 hour from 22/10 to 24/10 and every 6 hours until the end of the field campaign on 30/10
- 63 ERT imageries in total



b) Infiltration test setup

Infiltration test parameters

- ≈ 2000 L of salt water ($\sigma \approx 1000 \mu S/cm$) injected into the trench over a 4-hour period, with a 2-hour pause in the middle to refill the tank
- Simultaneous measurement of water level in tank and trench at regular intervals of 1 min, 2 min and 5 min

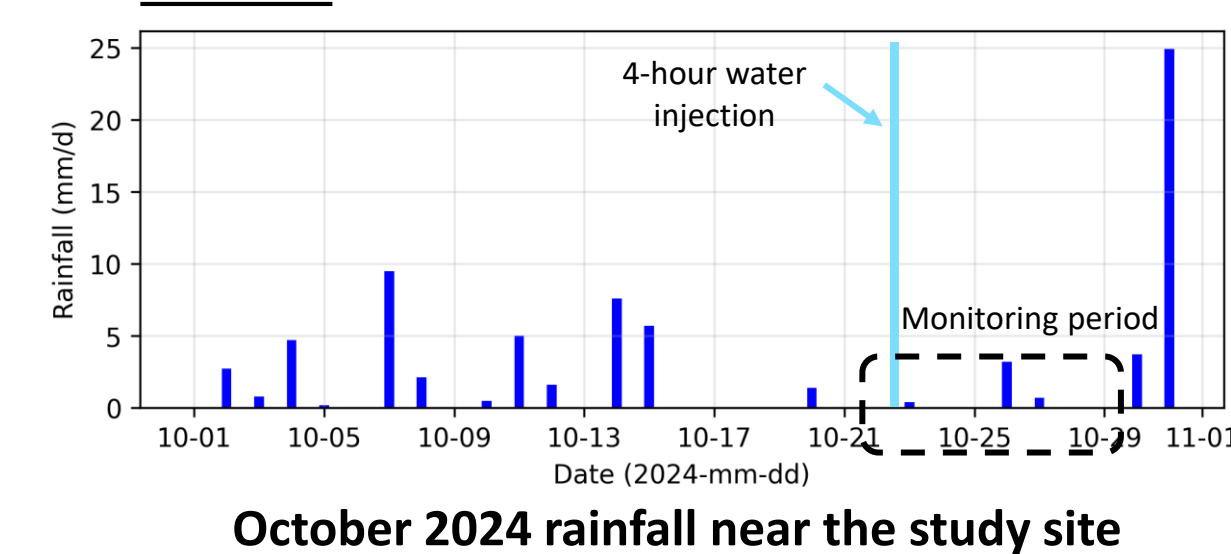


3. Geoelectrical monitoring results

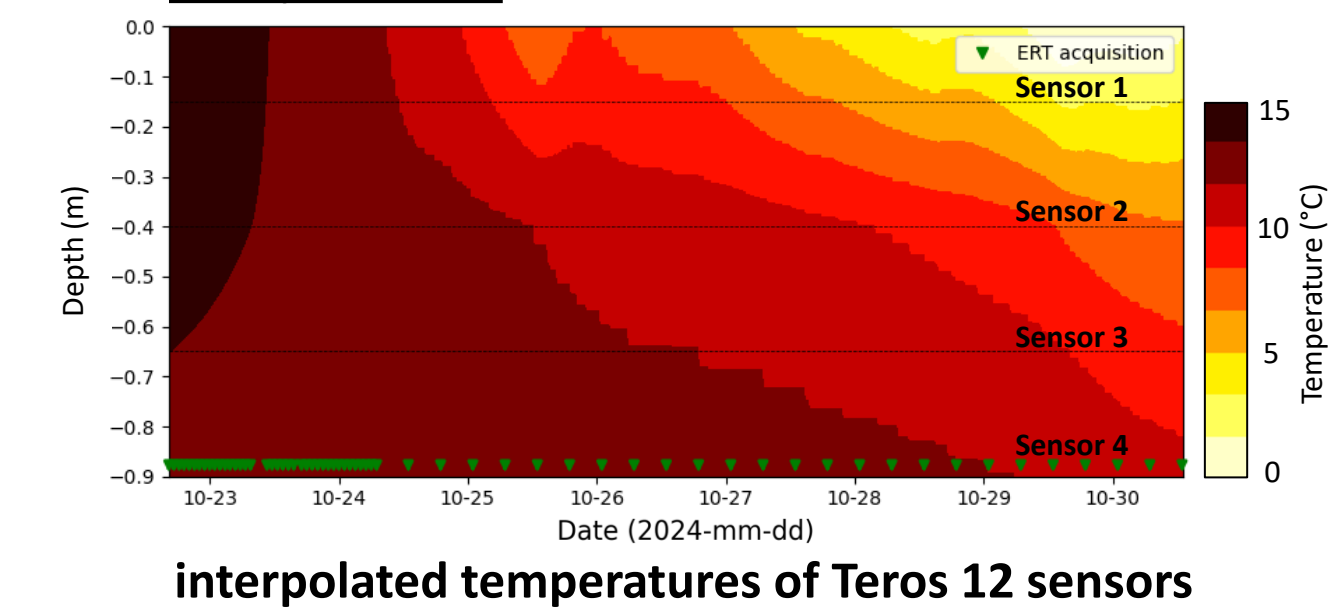
a) Inversion results

Parameters impacting TL-ERT results

Rainfall

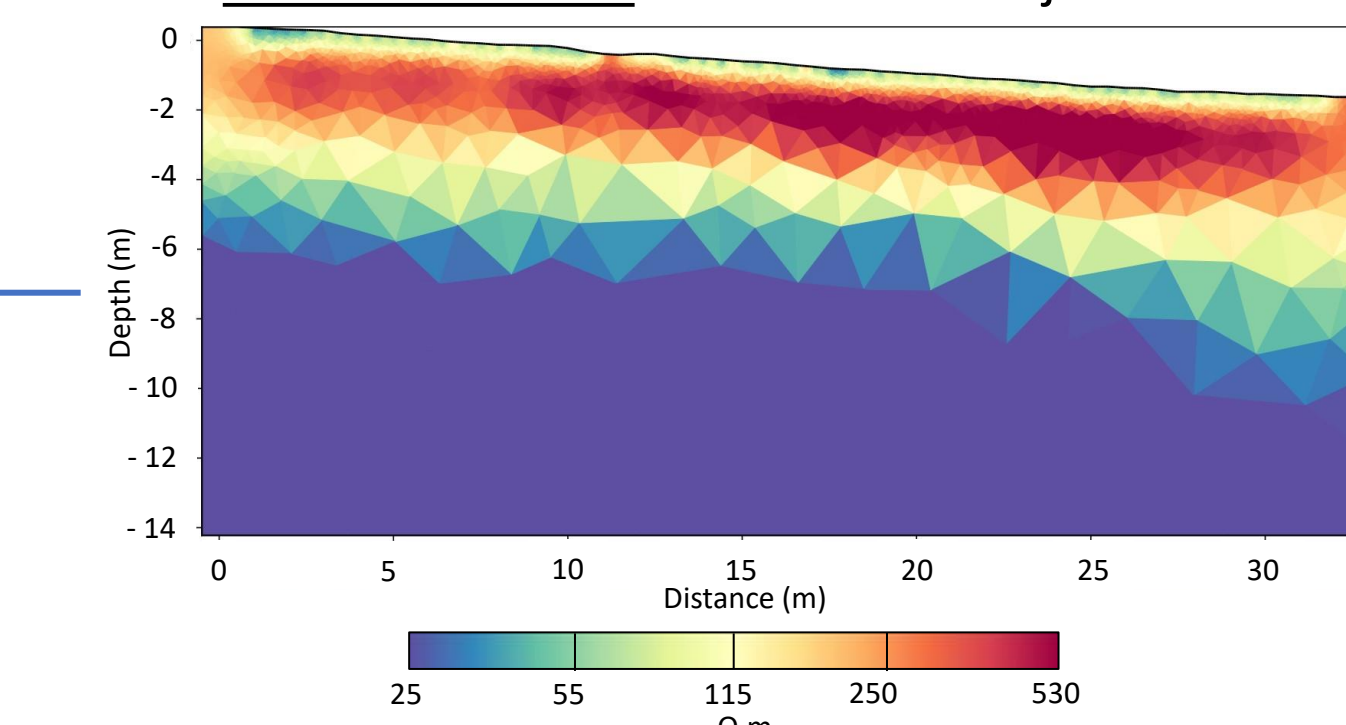


Temperature

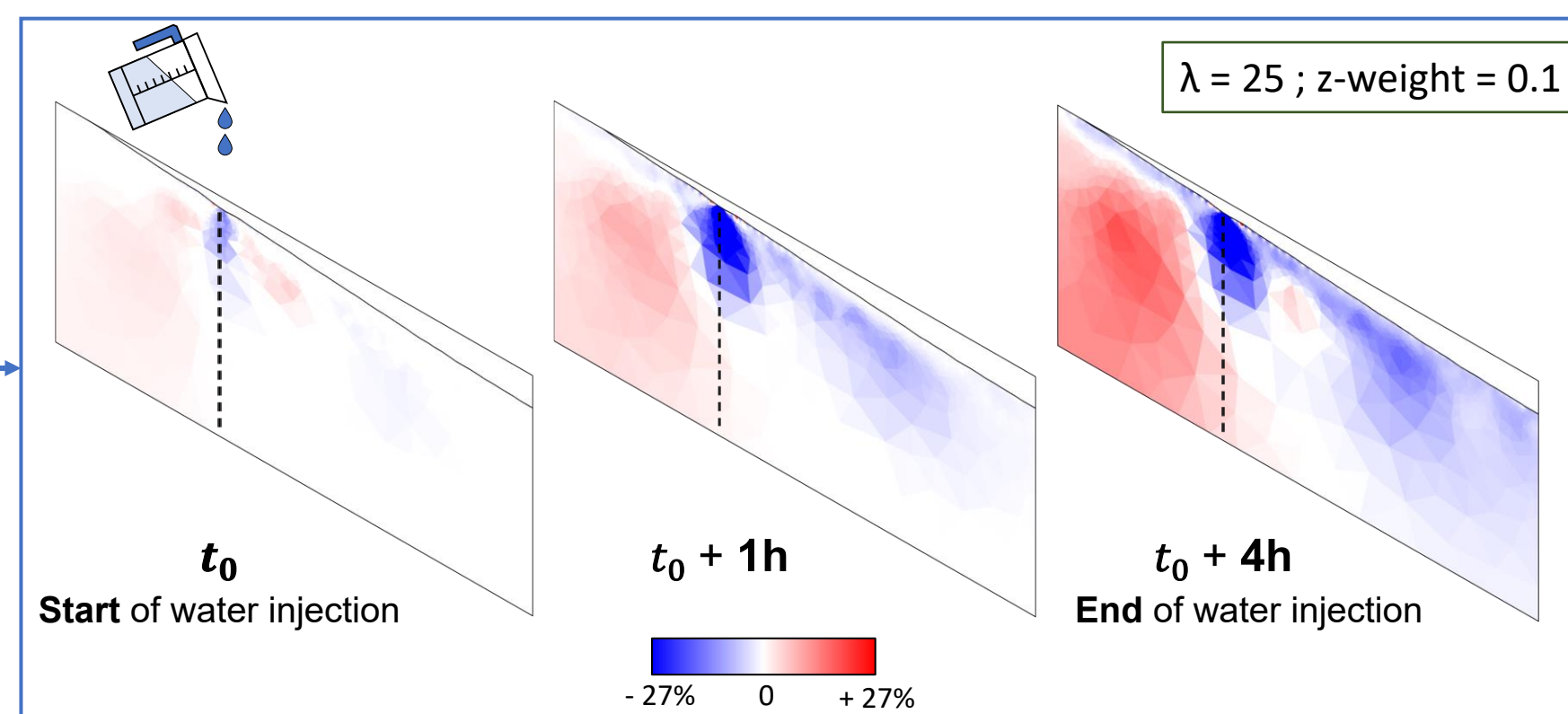


TL-ERT inversion with pyGIMLI [5]

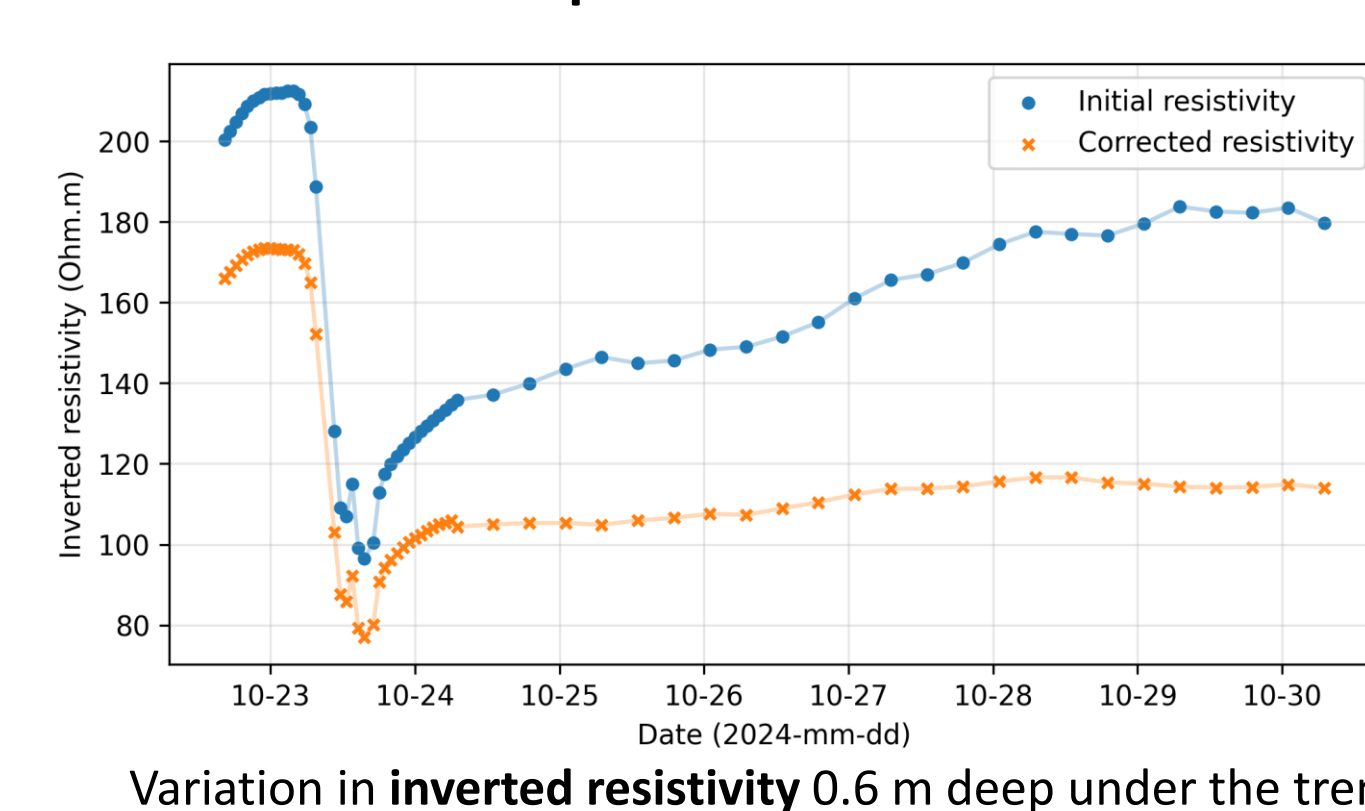
Reference model : before water injection



Ratio : Current model / Reference model



Temperature correction



Formula used :

$$\rho_{corr} = \rho \cdot [1 + t_c \cdot (T - T_{std})] \quad [6]$$

- $t_c = 0.016 \text{ } ^\circ C^{-1}$
- $T_{std} = 25 \text{ } ^\circ C$

By removing the effect of temperature on the inverted data, resistivity no longer increases after the infiltration test.

b) Discussion

- Capacity of TL-ERT method to identify the spread of water towards the end of the slope based on inversion ratio results
- Conventional inversion process unable to recover layer thicknesses due to the high resistivity contrast and low layer thickness

➡ Necessity to combine the usual processing of ERT data with other approaches such as :

- ✓ Generation of Vertical Electrical Sounding (VES) inversion profiles to recover the different layer thicknesses at a given position and use them as ERT inversion constraints
- ✓ Simulation of synthetic apparent resistivity data sets from combined hydrogeological and geophysical modeling, for direct comparison with field data

4. Conclusion

Key points

- A numerical feasibility study is useful prior to the field campaign to optimize the quality of the data obtained.
- Geoelectrical monitoring provides an overview of water propagation in the mine cover, complementing the information provided by point sensors.
- The integration of hydrogeological modelling in the TL-ERT data processing phase is necessary to better assess water flow paths within the mine cover.
- In the long term, this joint approach could be used to refine the accuracy of hydrogeological models and thus better predict the behavior of multi-layer mine waste reclamation cover systems.

5. References

- [1] Hard Rock Mine Reclamation: From Prediction to Management of Acid Mine Drainage. Bussière, B. and Guittouy M. (Eds), Chapter 10, CRC Press, Boca Raton, p. 225-269. [2] Dimech, A., Bussière, B., Cheng, L., Chouteau, M., Fabien-Ouellet, G., Chevê, N., Isabelle, A., Wilkinson, P., Meldrum, P., Chambers, J. E. 2024. Monitoring moisture dynamics in multi-layer cover systems for mine tailings reclamation using autonomous and remote time-lapse electrical resistivity tomography. Canadian Geotechnical Journal. (ja). [3] Geo-Slope International Ltd. 2015. Seepage modelling with SEEP/W, an engineering methodology. Calgary, AB, Canada. [4] Environnement et Changement climatique Canada. [5] Rücker, C., Günther, T., Wagner F.M. 2017. pyGIMLI: An open-source library for modelling and inversion in geophysics. Computers & Geosciences, 109: 106-123. [6] Ma, R., McBratney, A., Whelan, B., Minasny, B., Short, M. 2011. Comparing temperature correction models for soil electrical conductivity measurement. Precision Agriculture, 12(1) : 55-66.