Improving DC-Electrical Resistivity Imaging techniques for water infiltration detection and monitoring in earth hydraulic structures

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Summary

Summary

❑ Context

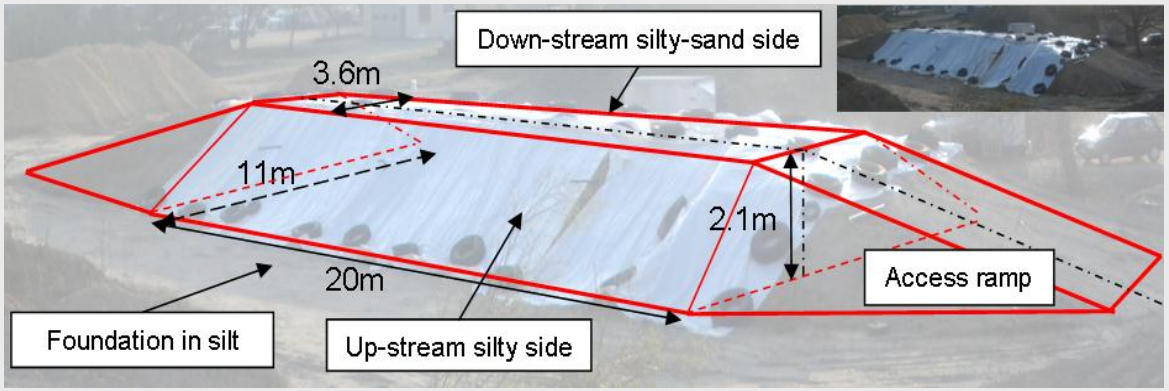
▪ Context and research needs

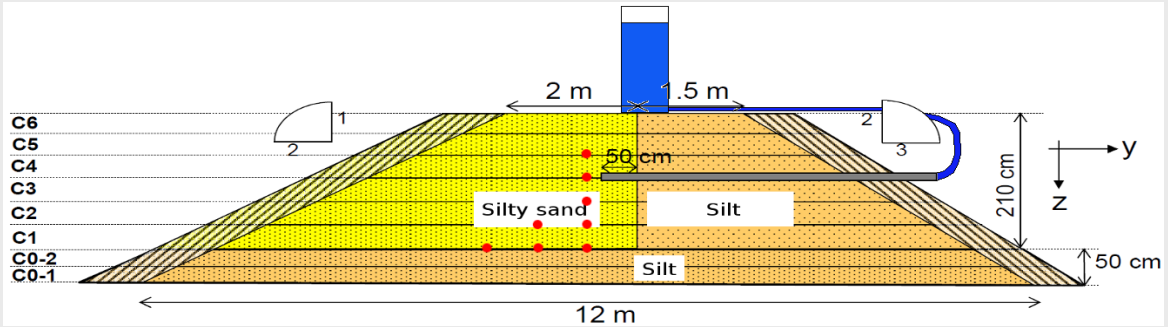
- France contains more than 7000 km of dikes
- Managers need diagnostic toolbox to ensure the security of their structures
- Electrical Resistivity Imaging is considered as a relevant method owing to its sensitivity to clay content and water content
- Dike 3D behavior generates artifacts and limits the relevance of the imaging result

1. Improve ERI concerning the previous limitations
2. Test the capacity of this new developments to detect an infiltration

Context

The experimental dike (DikExpE.R.T)

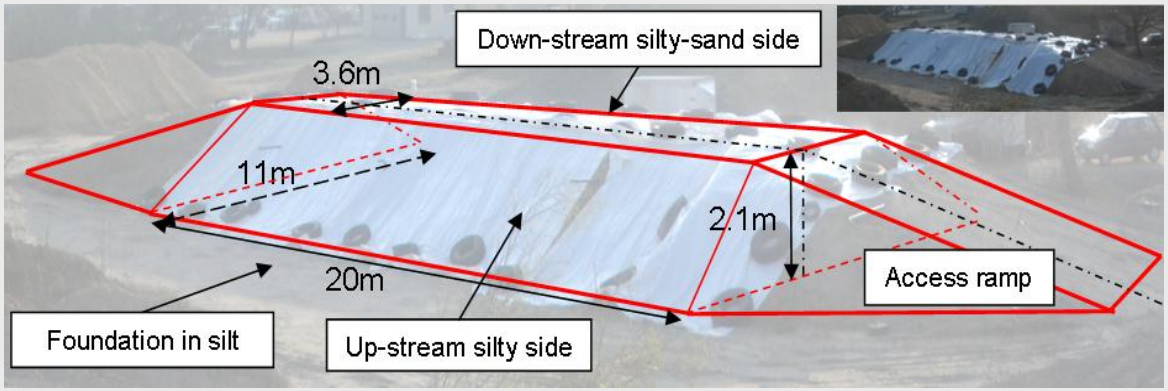


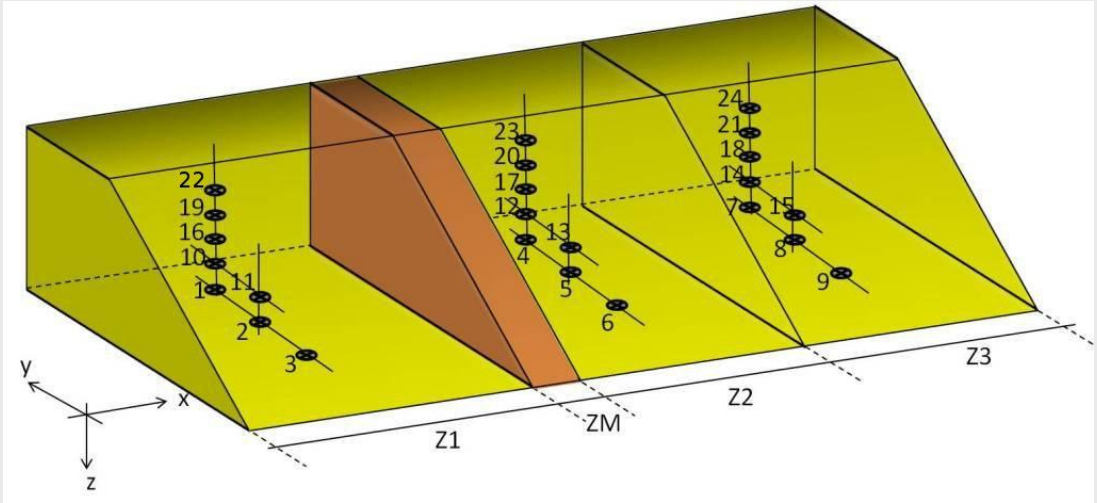


- To test and improve ERI developments an experimental dike was built at the Centre of Experimentation and Research of Rouen.
- The objective was to generate a continuous infiltration by a hydraulic system in the sandy part of the dike (in yellow).

Context

- **The experimental dike (DikExpE.R.T)**





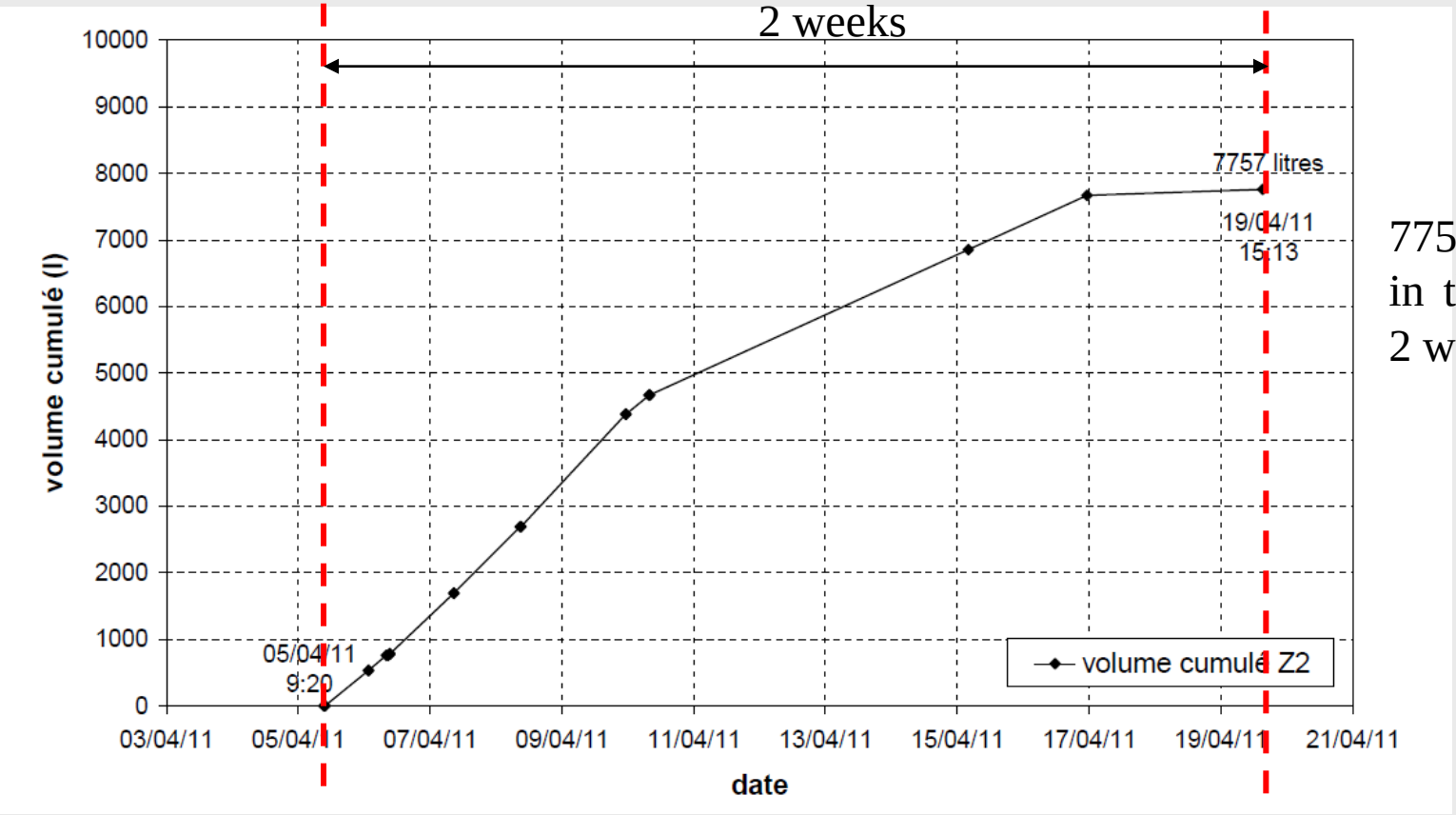
24 moisture probes were installed into the dike to monitor the evolution of the infiltration.

+ 96 electrodes to test the ability to monitor the evolution of the infiltration.

Summary

Infiltration study

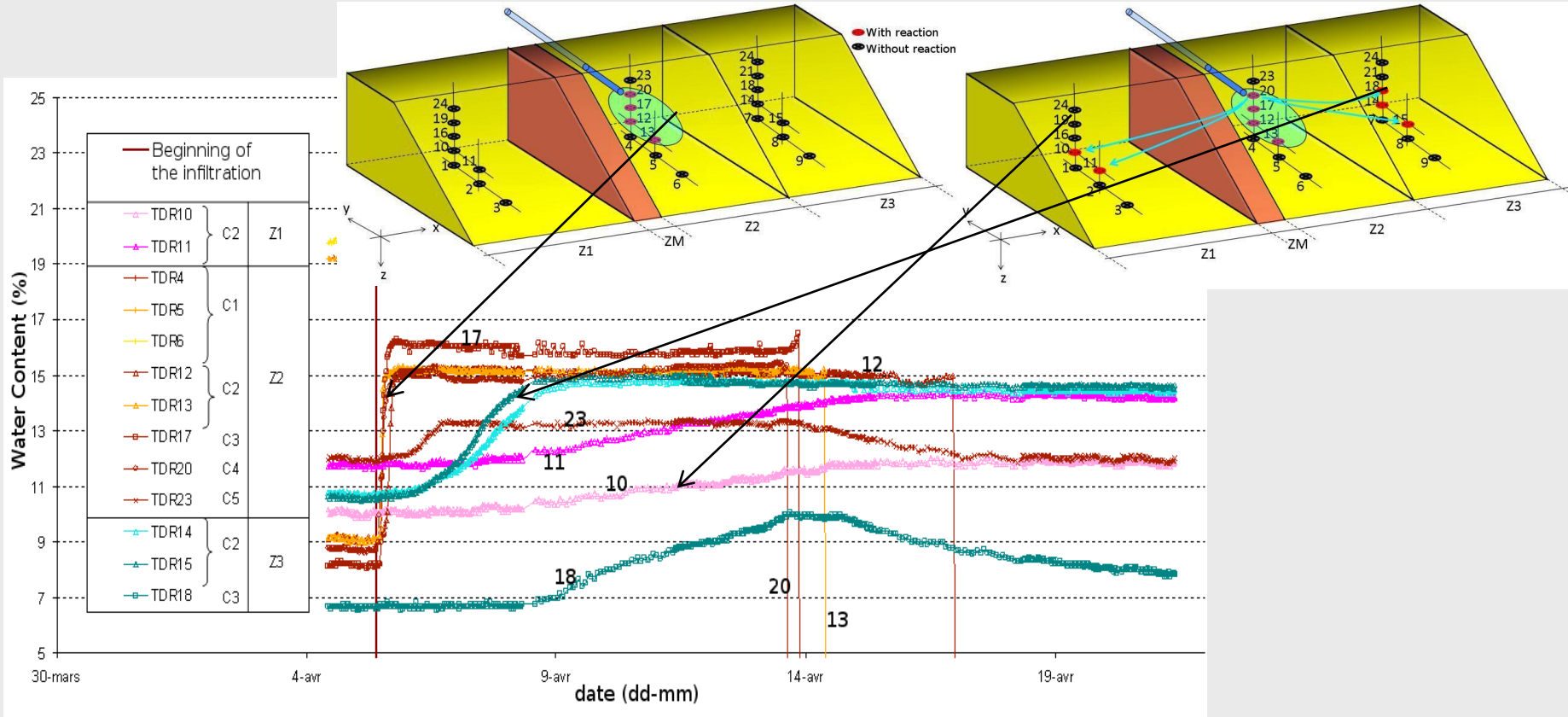
- **Infiltration in Zone 2 (central part of the dike)**



7757 liters are injected in the dike during the 2 weeks

Infiltration study

TDR results



Summary

❑ ERI development and results

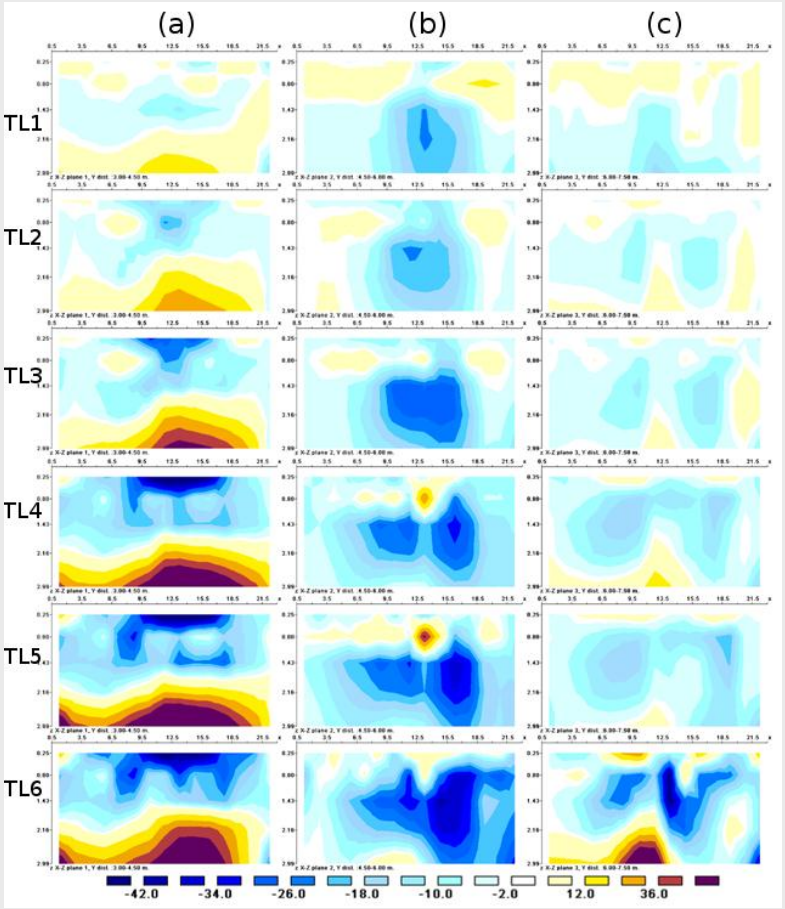
▪ InGEOHT 3D-

Limitations of conventional inversion softwares :

- 2D time lapse inversion, or 3D but without topography,
- Difficulty to insert *a priori* information.

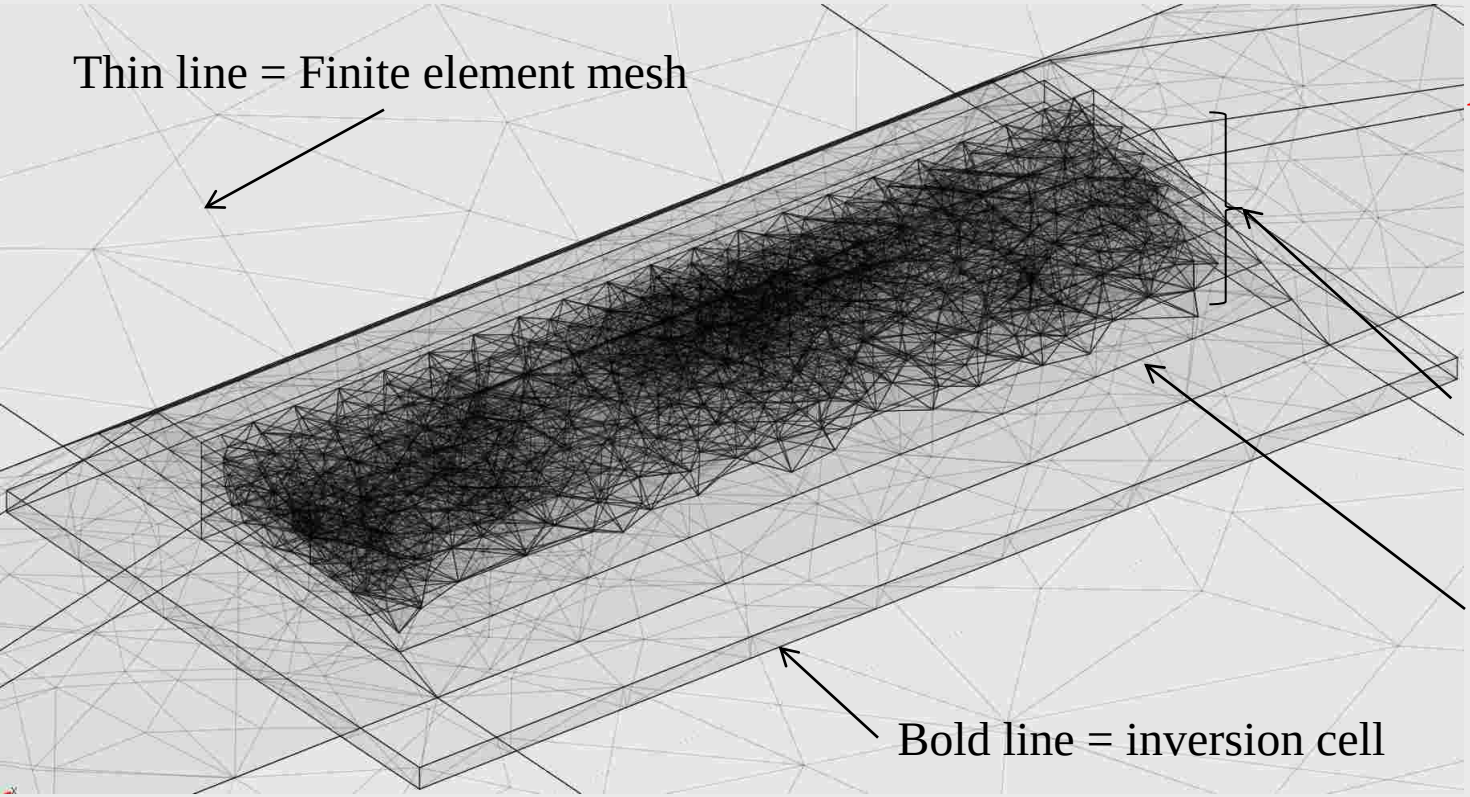
Consequences :

- Artifacts in the inversion result,
- Difficulty to interpret the result.



ERI development and results

- **InGEOHT 3D-**



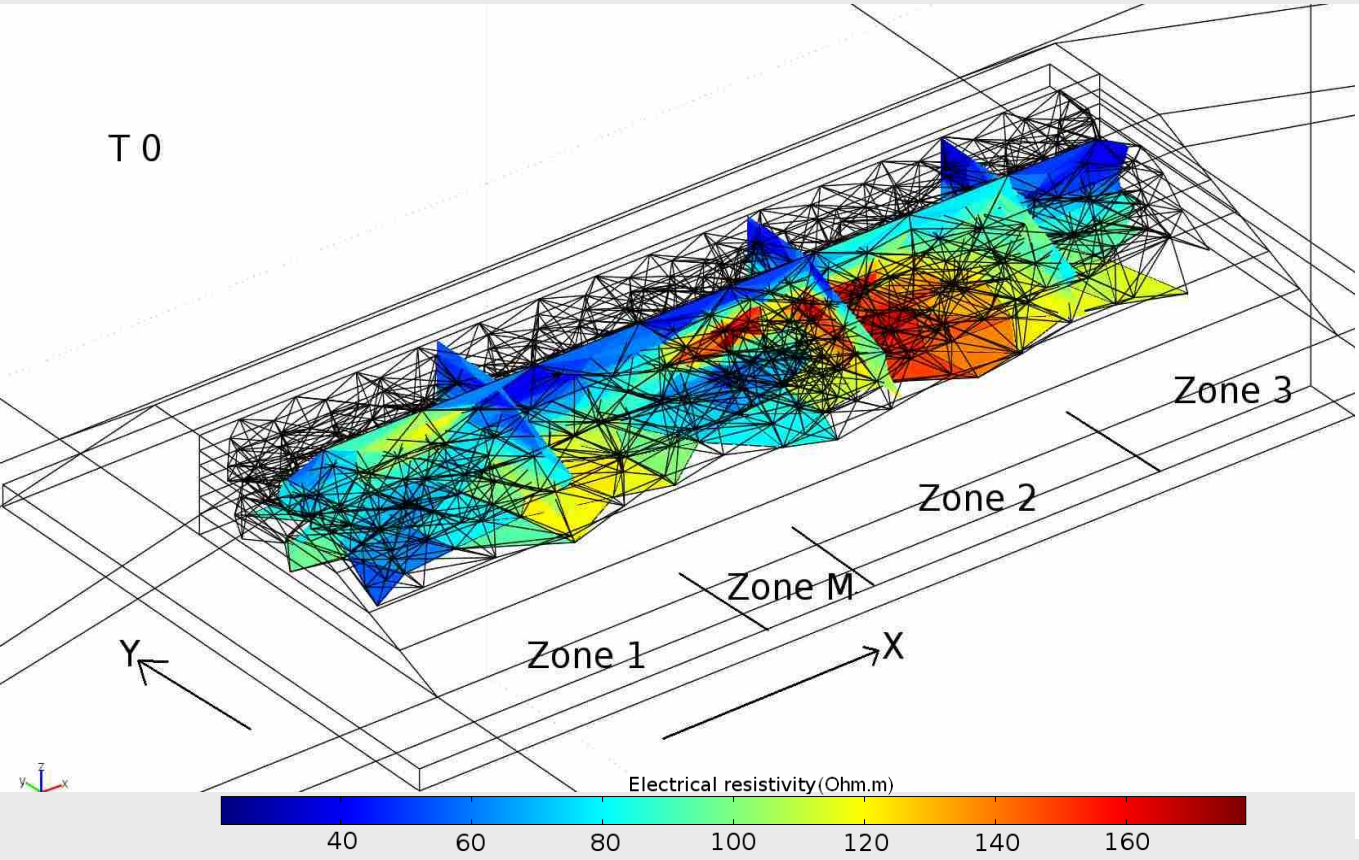
Importance of the *a priori* information

Only the sandy part is discretized for the inverse problem, because variations are expected to occur in this area

The topography of the dike and each compaction layer are explicitly defined

ERI development and results

- **Imaging results**

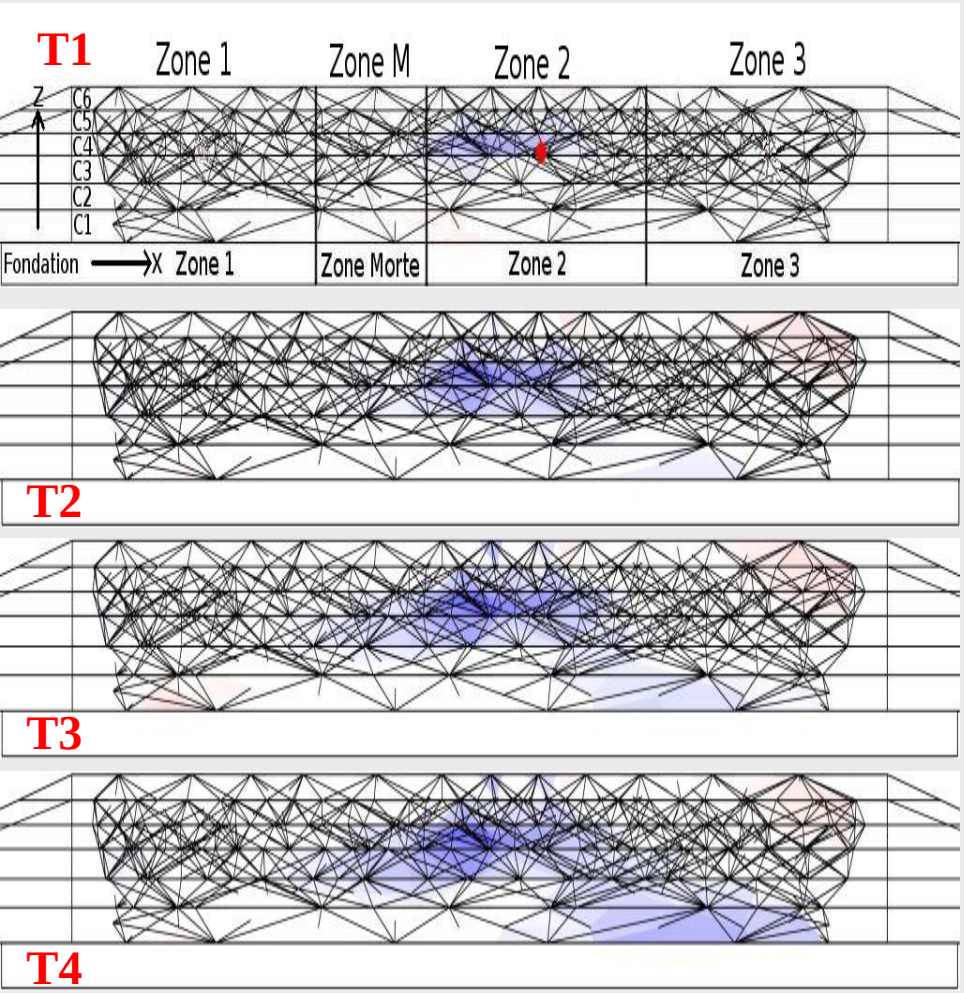


A set of electrical measurements was acquired before the beginning of the infiltration

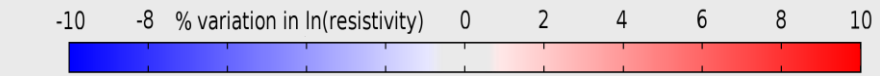
This figure presents the 3D electrical resistivity variations into the sandy part of the structure

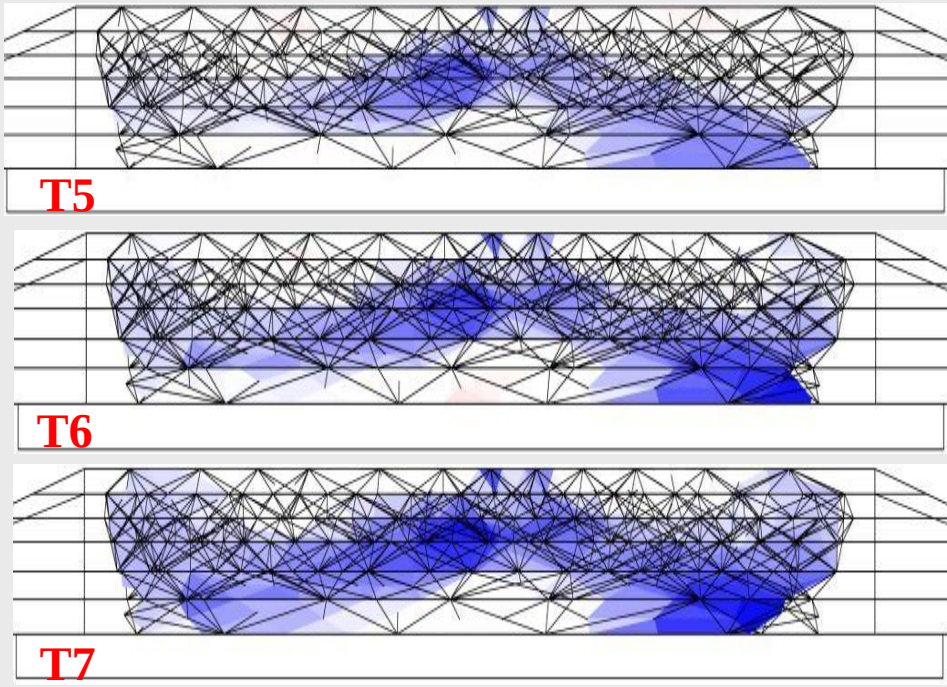
This model is selected as a reference model for the futur monitoring

ERI development and results



7 sets of measurements are acquired at 7 different moments after the beginning of the infiltration





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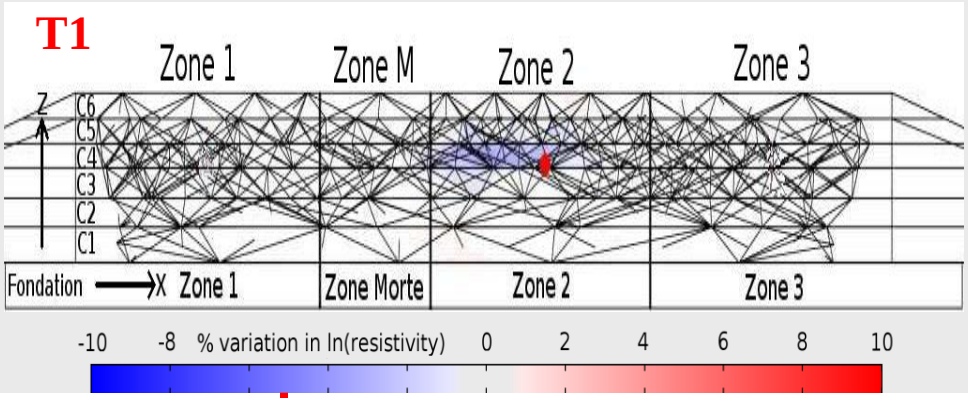

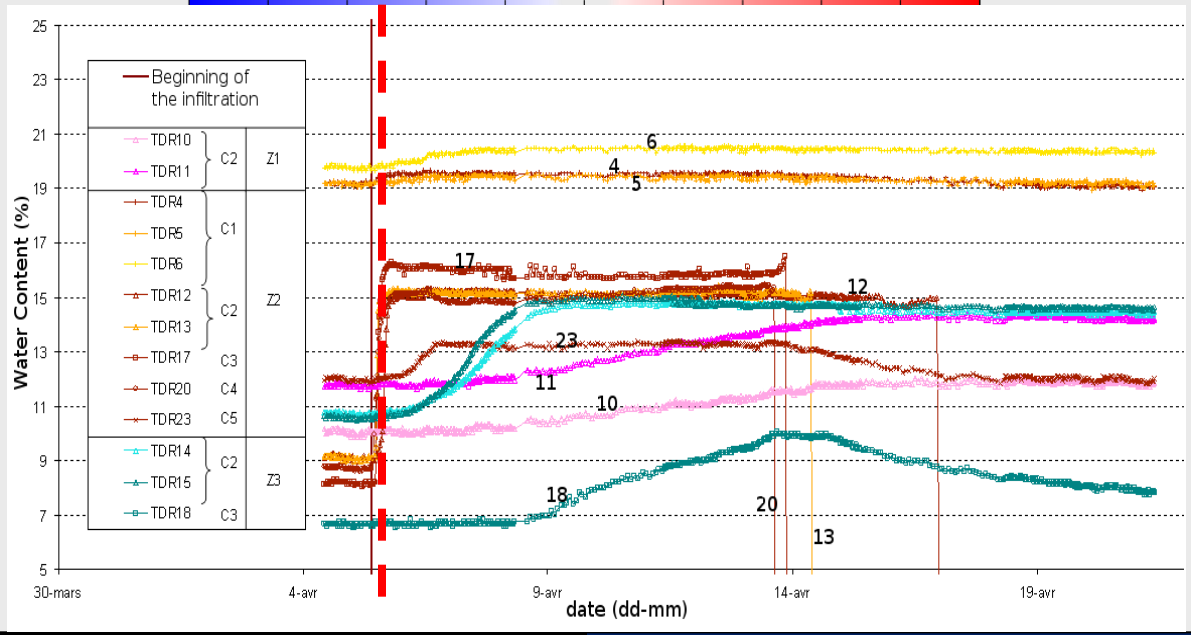

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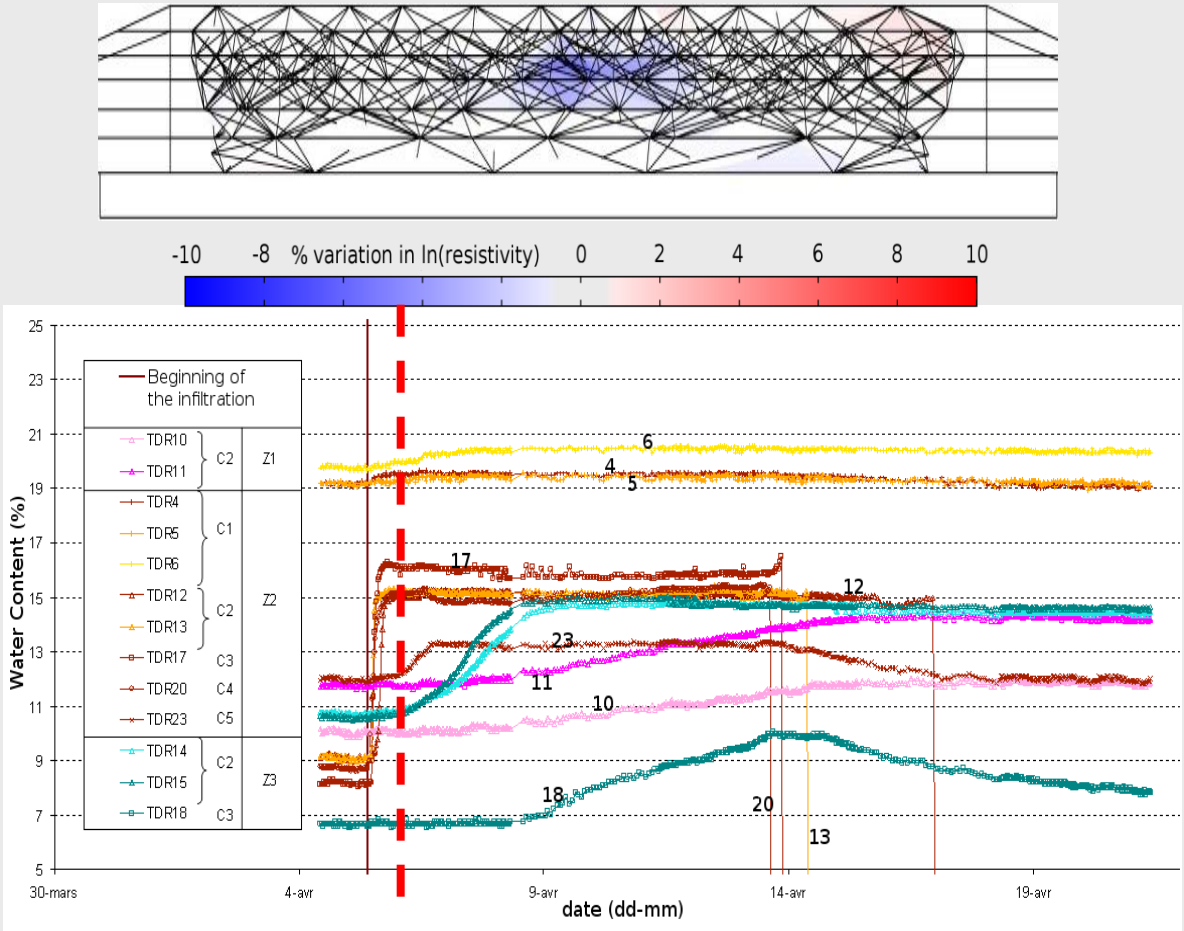

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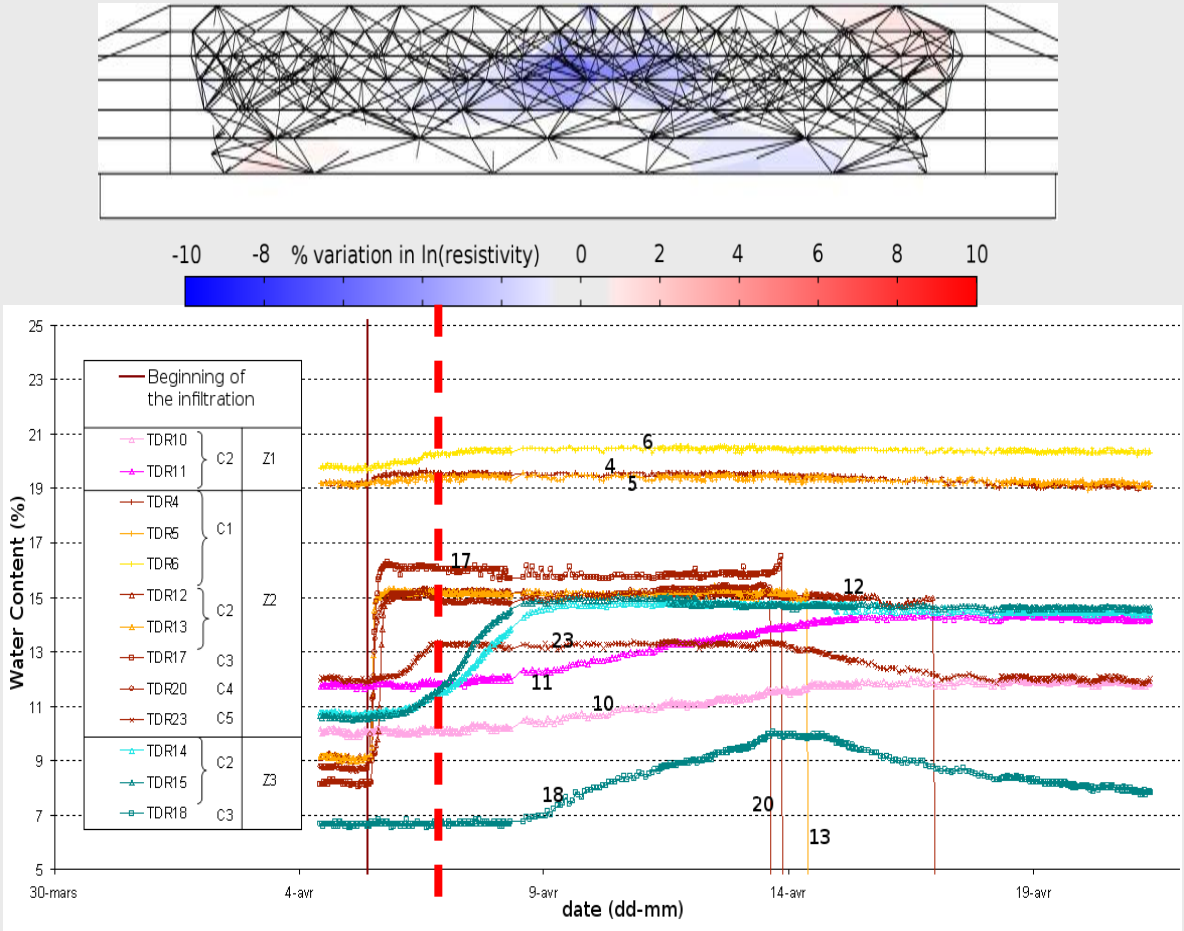

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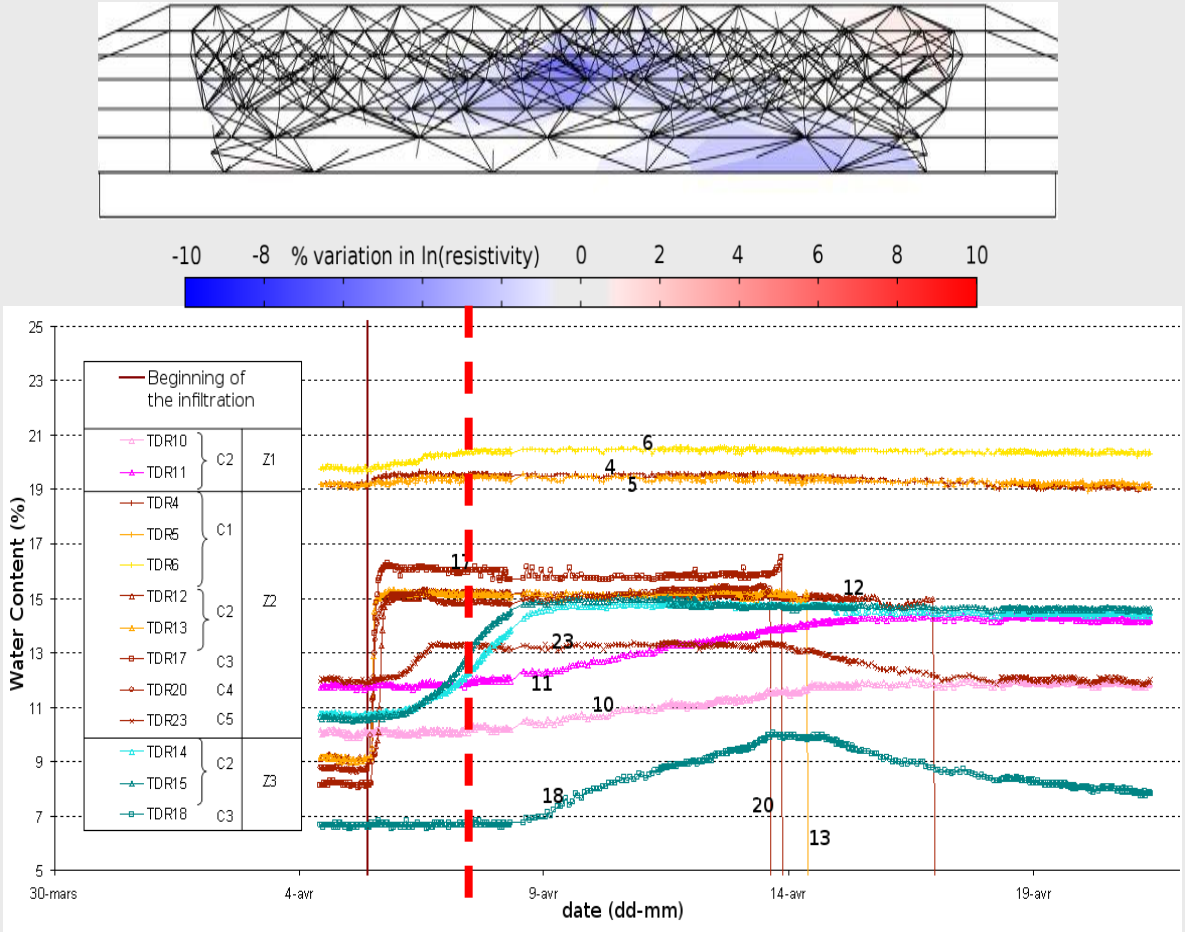

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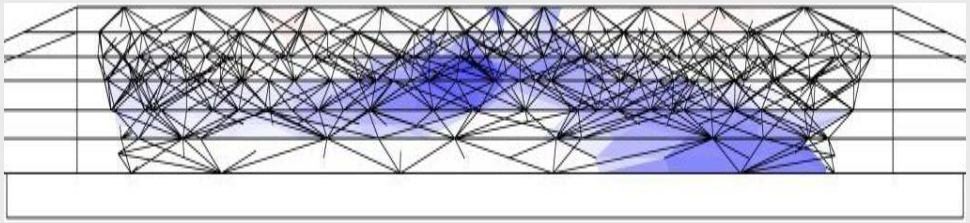

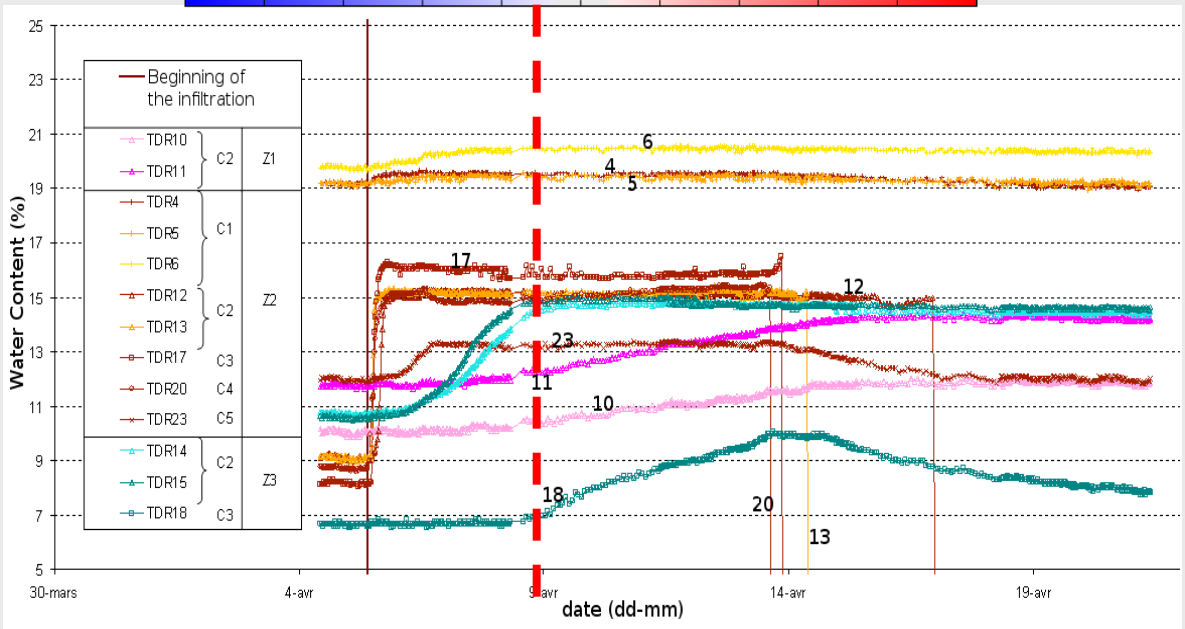

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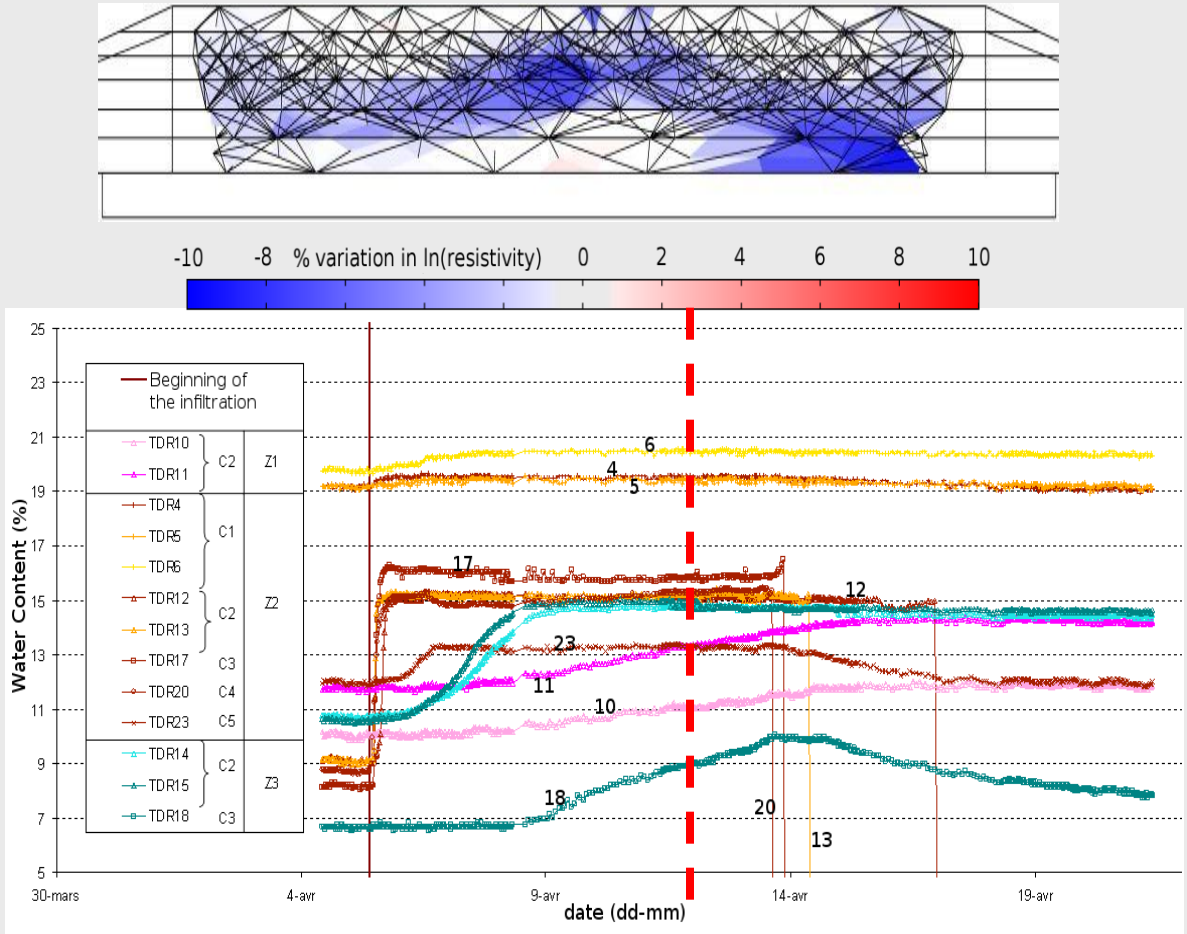

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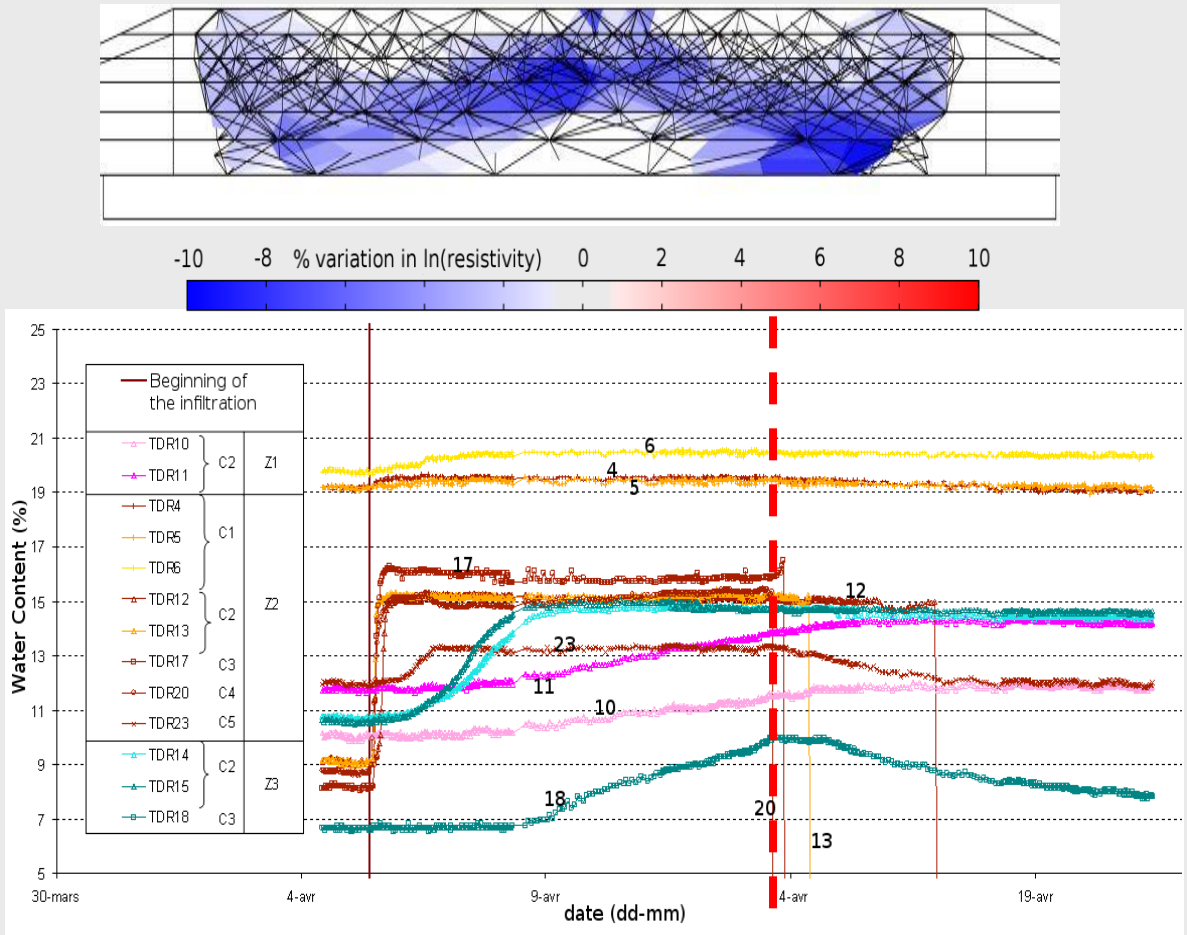
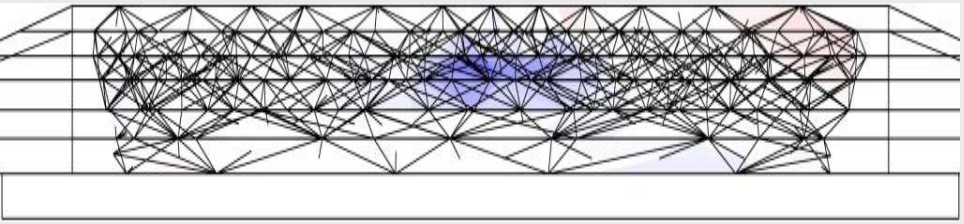


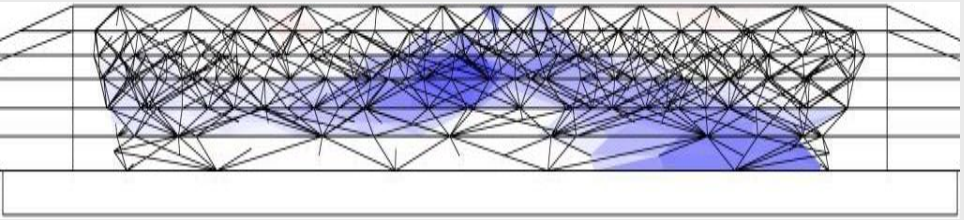
Summary

❑ Conclusion & Outlooks

Electrical Resistivity is not a parameter directly related to soil erosion evolution



$$\rho_{t1} = \rho_w a \Phi^{-m} S_{w_{t1}}^{-n}$$

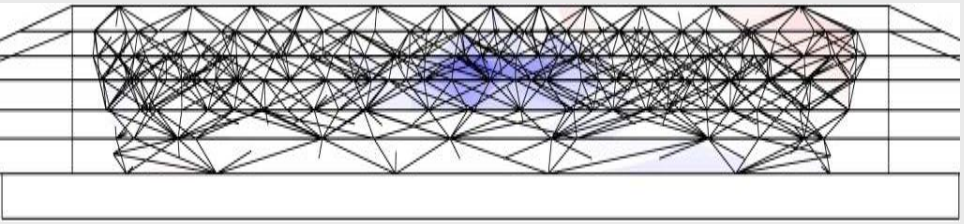


$$\rho_{t2} = \rho_w a \Phi^{-m} S_{w_{t2}}^{-n}$$

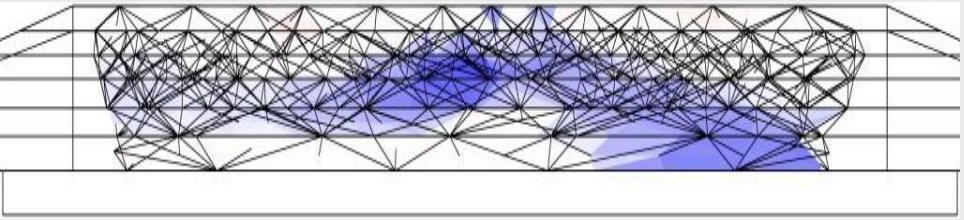
Archie law

ρ_{t1} : Resistivity at time 1; ρ_w : Resistivity of the infiltration water;
Φ : Porosity; S_w : Water saturation; $^{-n}\&^{-m}$: Cementation exponent

❑ Conclusion & Outlooks



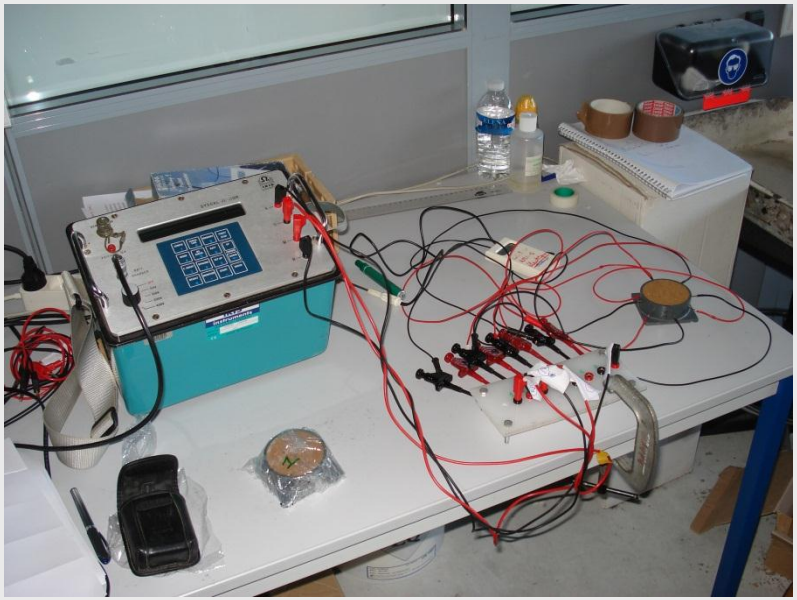
$$\rho_{t1} = \cancel{\rho_w a \Phi^{-m}} S_{w_{t1}}^{-n}$$



$$\rho_{t2} = \cancel{\rho_w a \Phi^{-m}} S_{w_{t2}}^{-n}$$

Ratio between the result at time 1 and 2 gives the evolution of the water saturation

❑ Conclusion & Outlooks



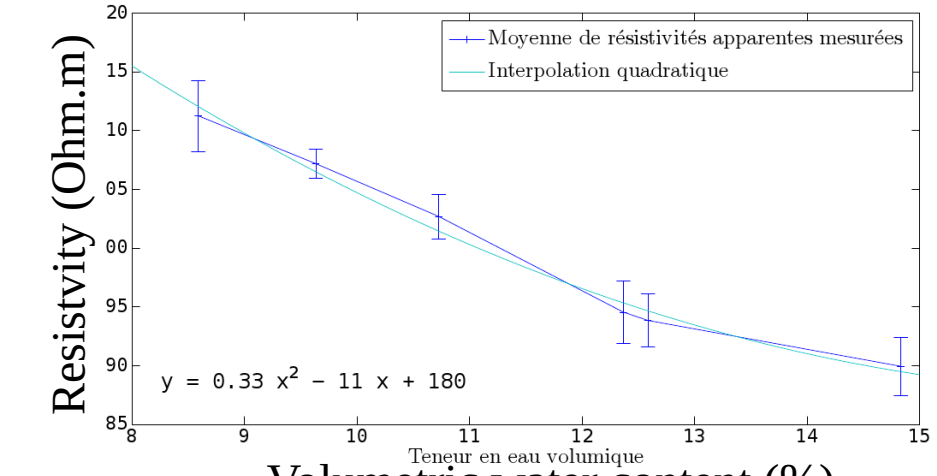
Qualitative correlation

Quantitative correlation

A parametric study was performed recently on the sand

Objective :

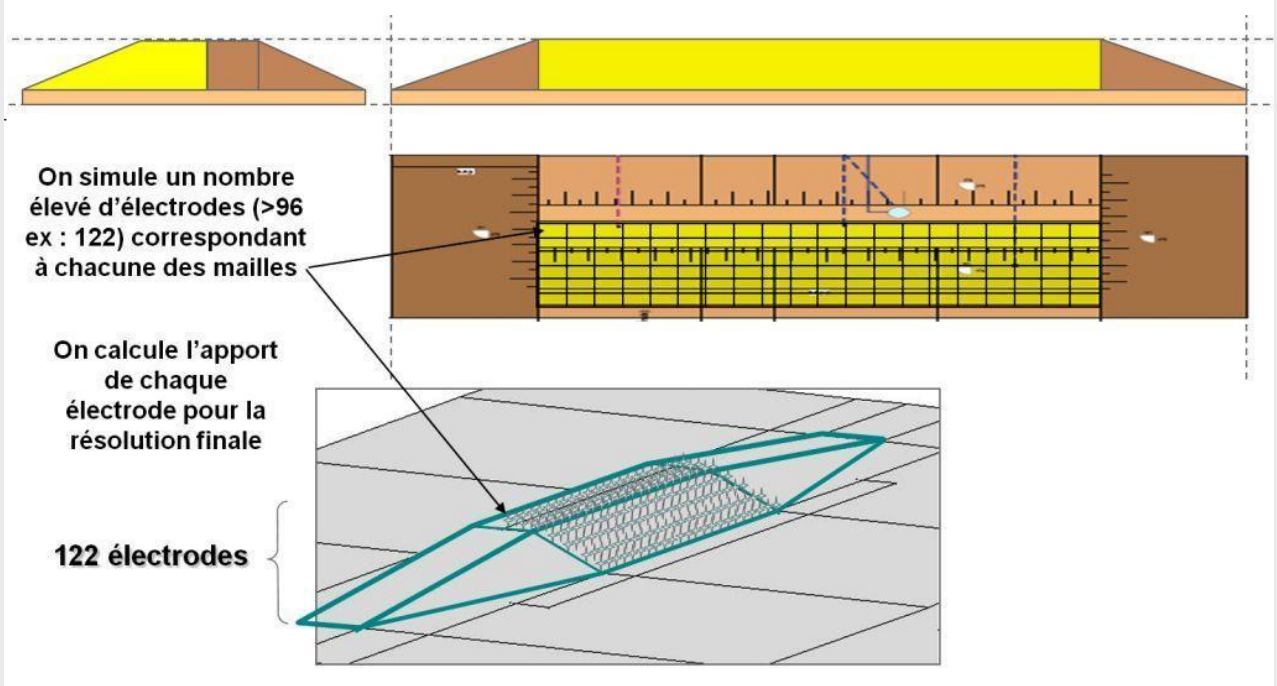
- Create a law for this sand to interpret the resistivity evolution as a water content evolution



THANK YOU FOR YOU ATTENTION

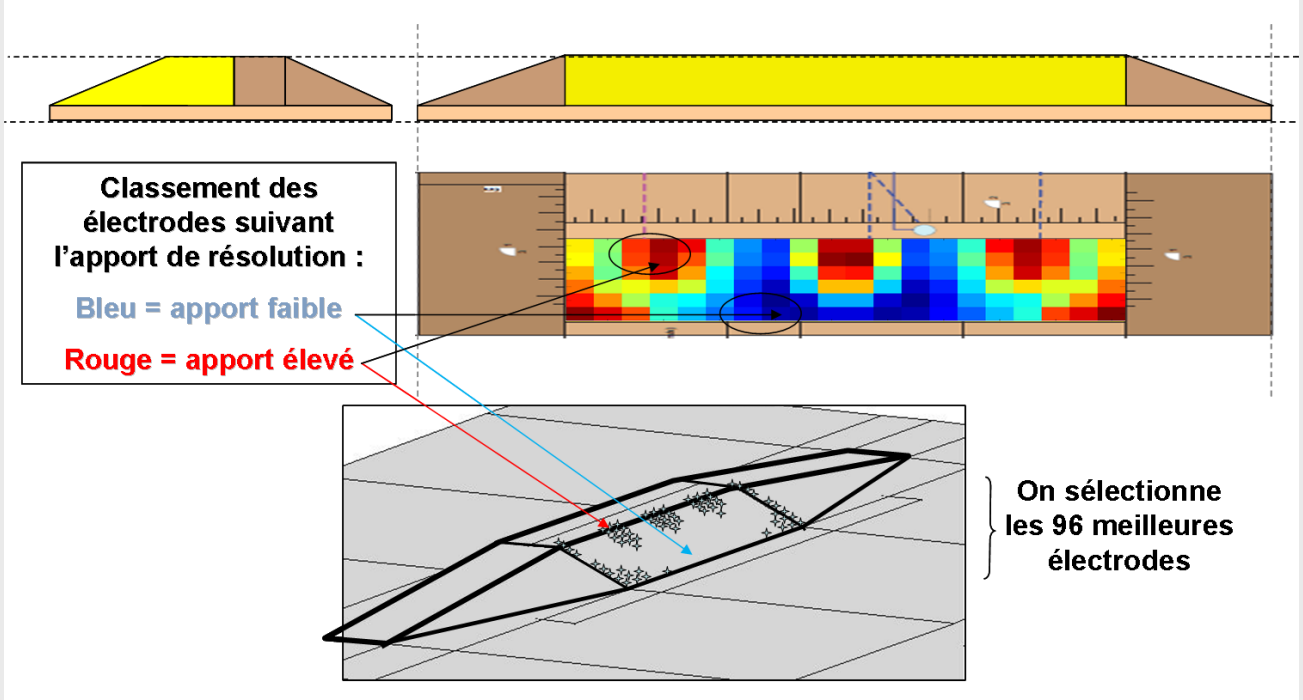
ERI development and results

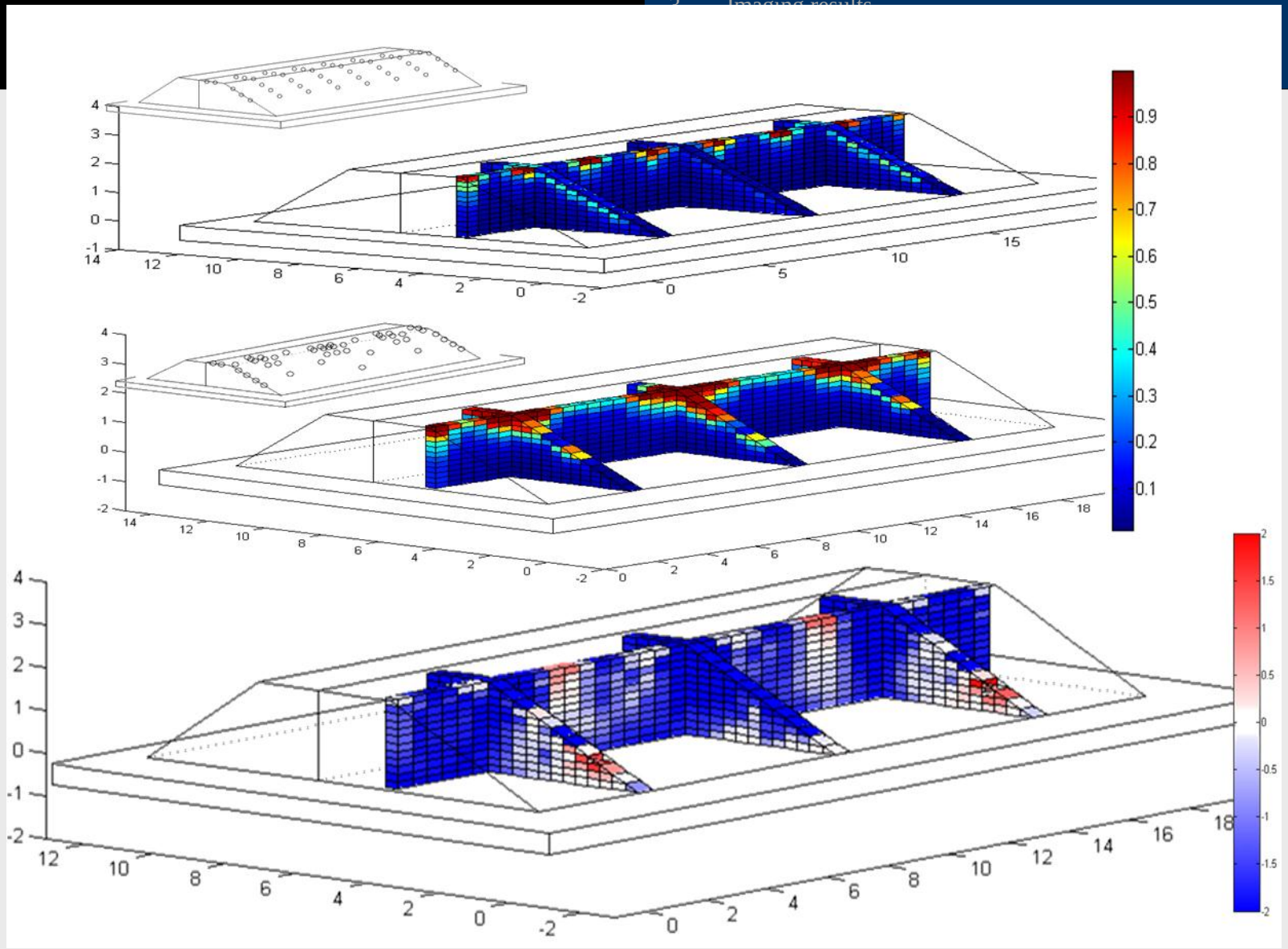
Optimization of electrodes location



ERI development and results

Optimization of electrodes location

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