GPR APPLICATIONS ON SOIL [Spatial] VARIABILITY AND DRAINAGE SYSTEM DIAGNOSIS

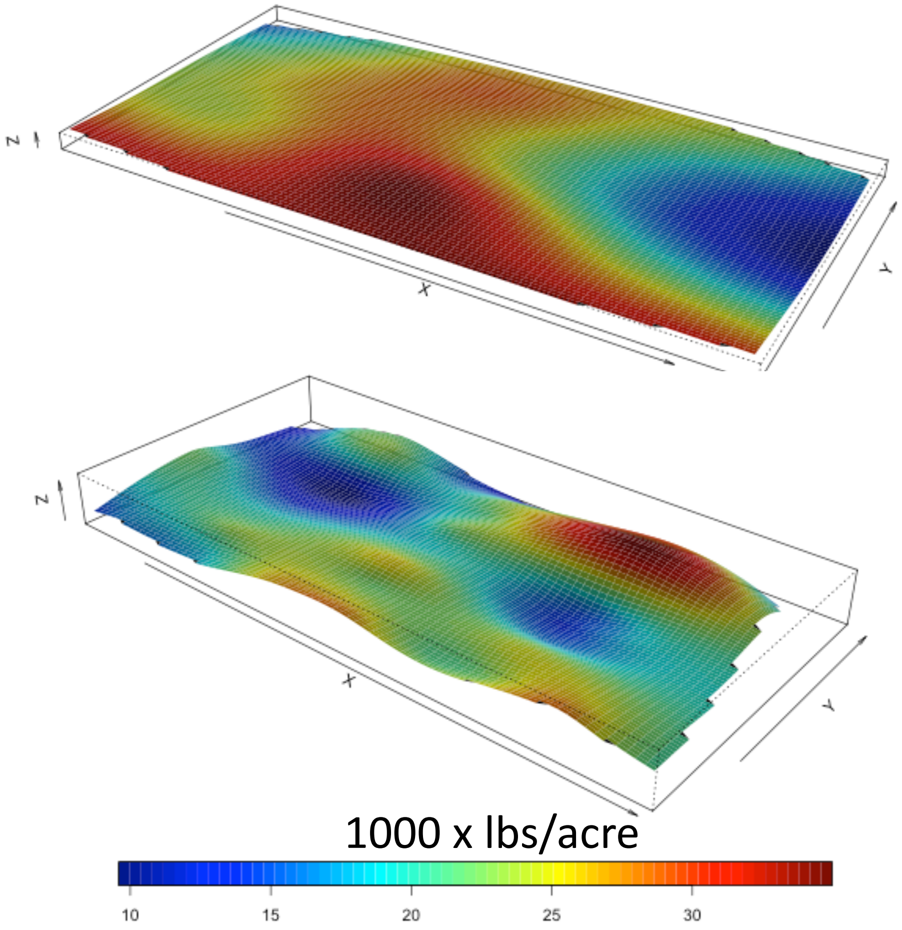
SILVIO J. GUMIERE, AWA MBODJ, JONATHAN LAFOND, CHRISTIAN DUPUIS

silvio-jose.gumiere@fsaa.ulaval.ca

Laval University

Spatial variability of yields, why?

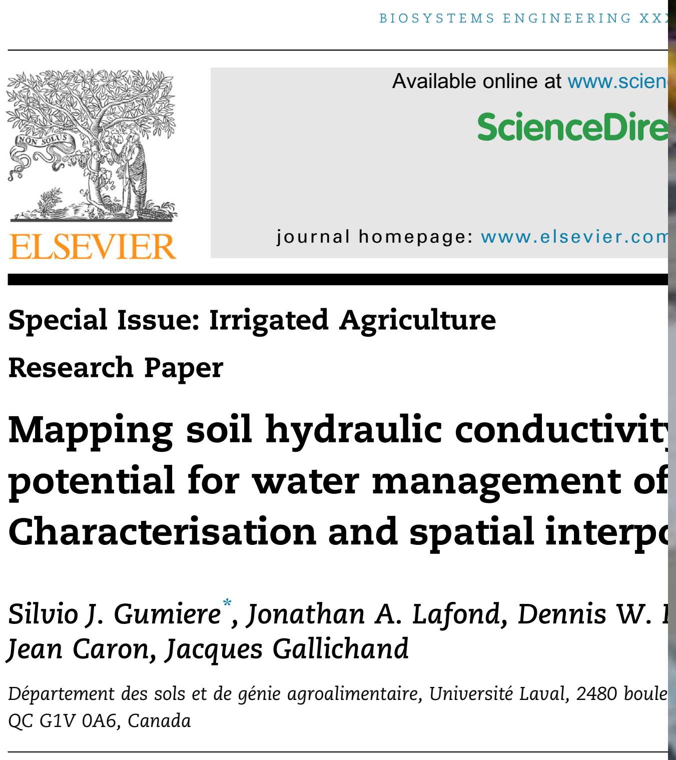
We would love to have high yields, uniformly distributed over the field, but!



May be a complex function of:

- Soil properties variability
- Drainage and irrigation problems
- Soil profile evolution
- Water table variability
- Genetic purity, etc…

Spatial variability


BIOSYSTEMS ENGINEERING XX

Available online at www.scien

ScienceDire

ELSEVIER

journal homepage: www.elsevier.com

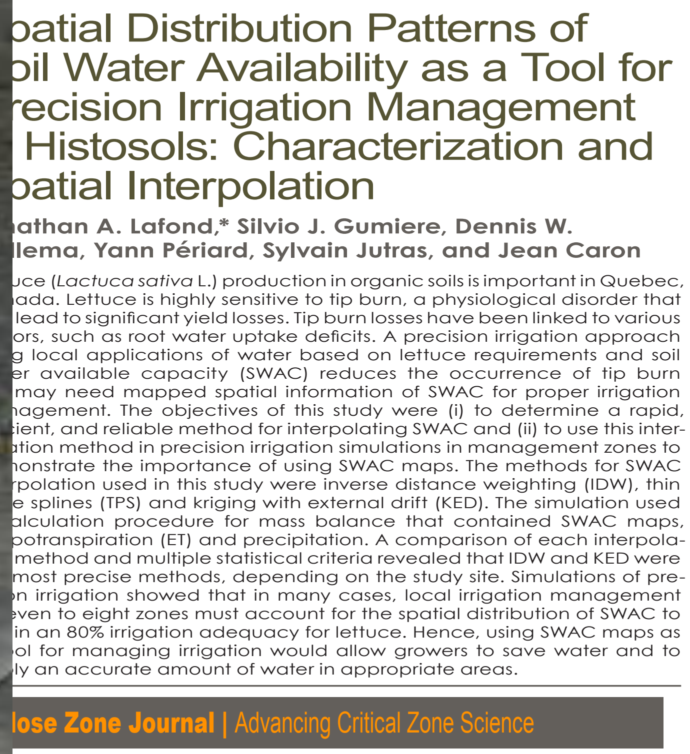
Special Issue: Irrigated Agriculture

Research Paper

Mapping soil hydraulic conductivit potential for water management of Characterisation and spatial interp

Silvio J. Gumiere[*], *Jonathan A. Lafond, Dennis W. I Jean Caron, Jacques Gallichand*

Département des sols et de génie agroalimentaire, Université Laval, 2480 boule QC G1V 0A6, Canada


patial Distribution Patterns of oil Water Availability as a Tool for recision Irrigation Management Histosols: Characterization and patial Interpolation

athan A. Lafond,* Silvio J. Gumiere, Dennis W. llema, Yann Périard, Sylvain Jutras, and Jean Caron

uce (*Lactuca sativa* L.) production in organic soils is important in Quebec, ada. Lettuce is highly sensitive to tip burn, a physiological disorder that lead to significant yield losses. Tip burn losses have been linked to various ors, such as root water uptake deficits. A precision irrigation approach g local applications of water based on lettuce requirements and soil er available capacity (SWAC) reduces the occurrence of tip burn may need mapped spatial information of SWAC for proper irrigation agement. The objectives of this study were (i) to determine a rapid, ient, and reliable method for interpolating SWAC and (ii) to use this inter- ation method in precision irrigation simulations in management zones to nonstrate the importance of using SWAC maps. The methods for SWAC rpolation used in this study were inverse distance weighting (IDW), thin e splines (TPS) and kriging with external drift (KED). The simulation used alculation procedure for mass balance that contained SWAC maps, potranspiration (ET) and precipitation. A comparison of each interpola- method and multiple statistical criteria revealed that IDW and KED were most precise methods, depending on the study site. Simulations of pre- n irrigation showed that in many cases, local irrigation management even to eight zones must account for the spatial distribution of SWAC to in an 80% irrigation adequacy for lettuce. Hence, using SWAC maps as ol for managing irrigation would allow growers to save water and to ly an accurate amount of water in appropriate areas.

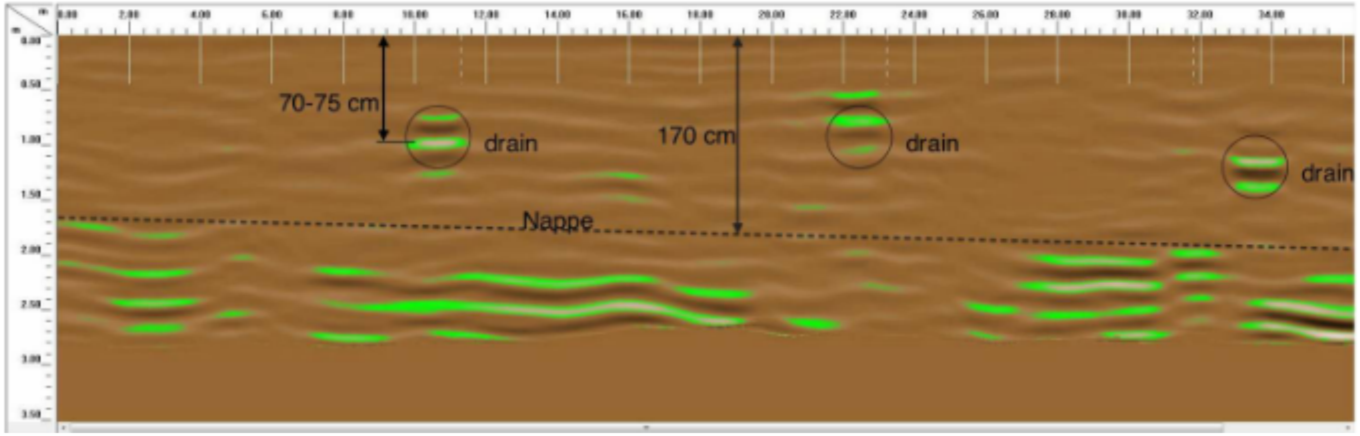
lose Zone Journal | Advancing Critical Zone Science

No more digging, please!!!

We need an alternative !!!

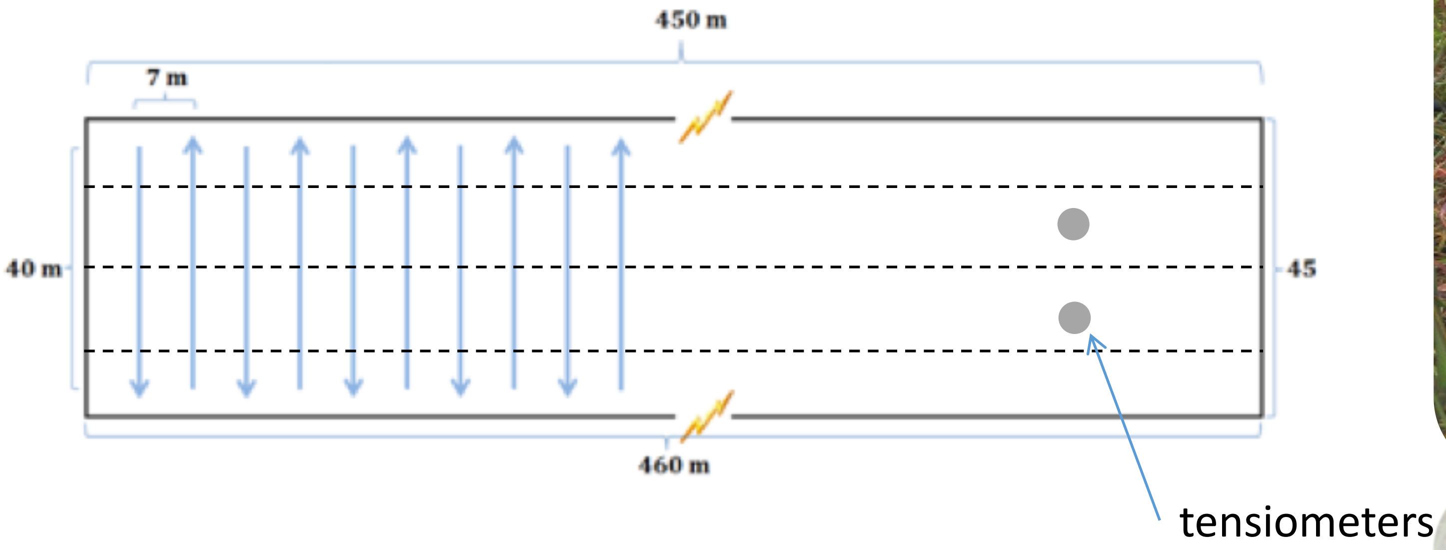
GPR an alternative!

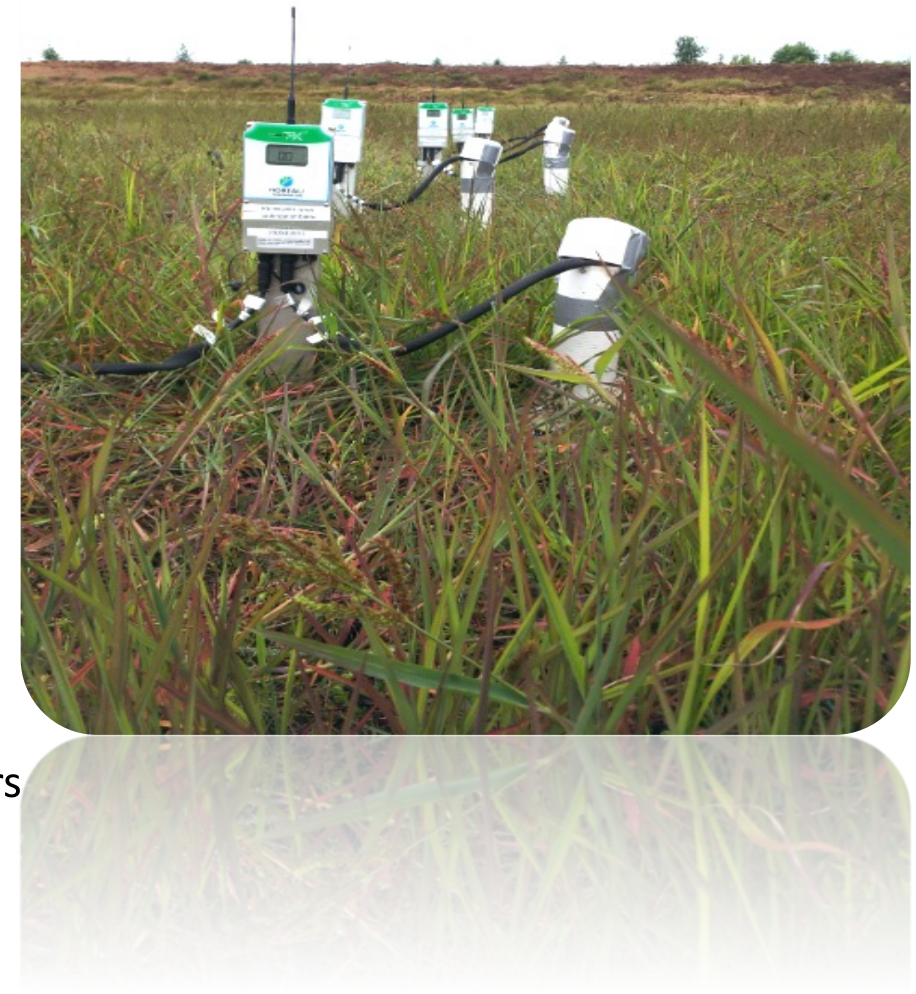
- Non destructive geophysical method
- Based on electromagnetic waves interaction
- Subsurface characterization : stratigraphy, topography and hydrogeology
- Objects and discontinuities localization



Methodology

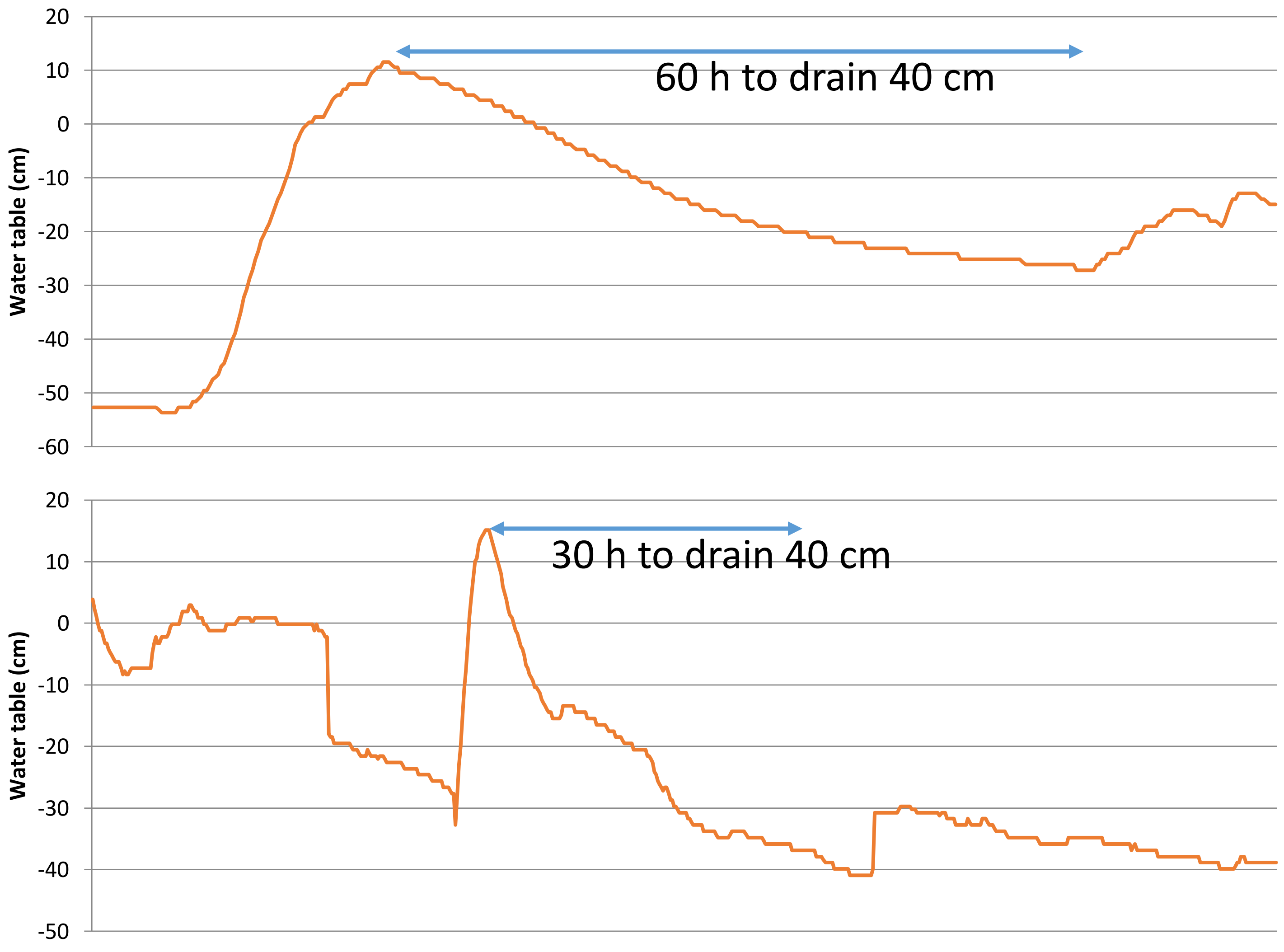
- Drainage speed after 6h irrigation





Drainage after 6h irrigation

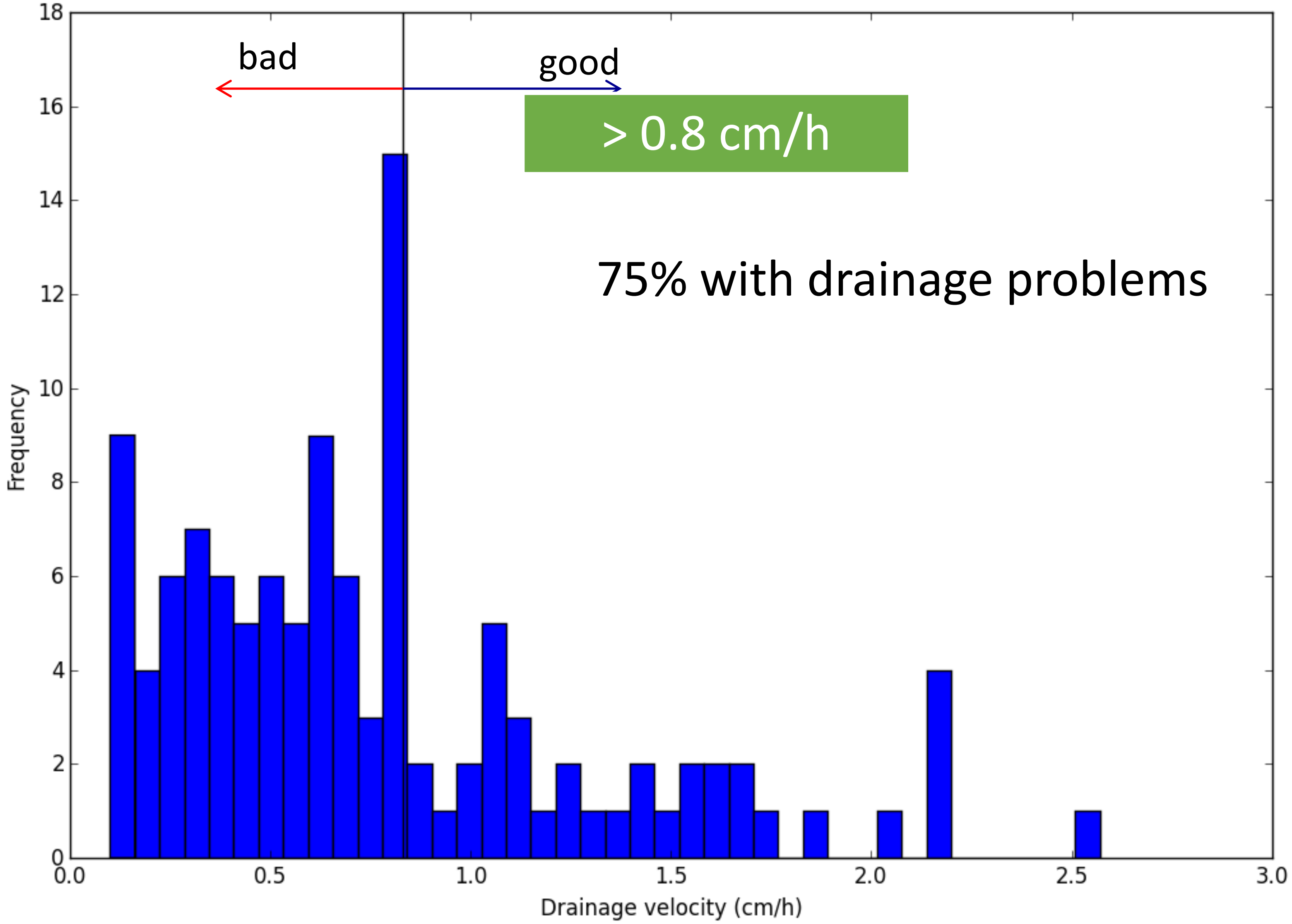
The norm is: **40 cm in 24-48h**



Drainage problem

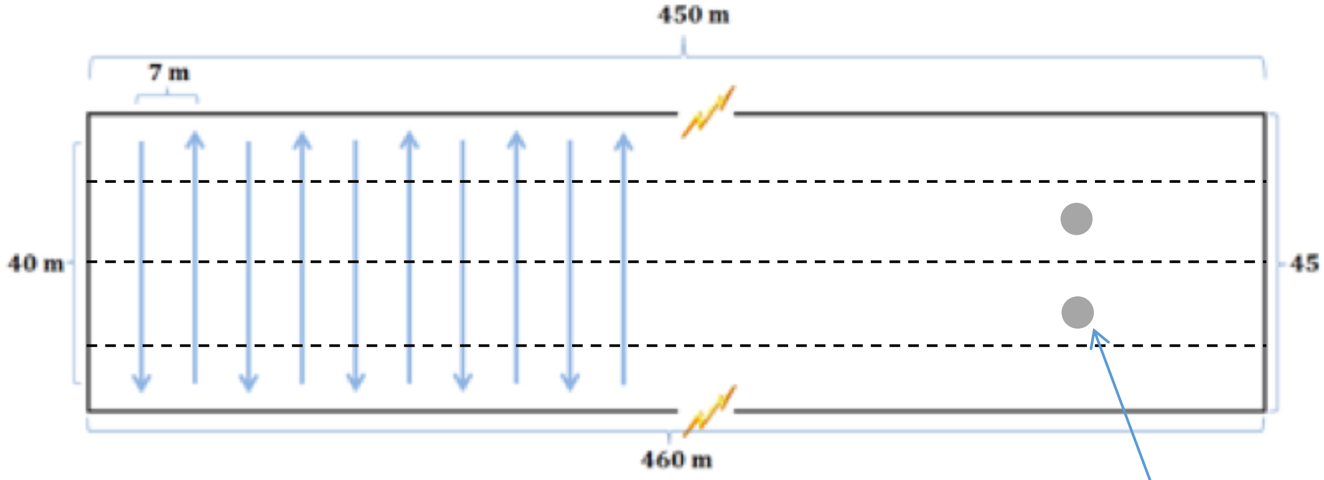
Normal drainage

In 40 fields , 2013-2014



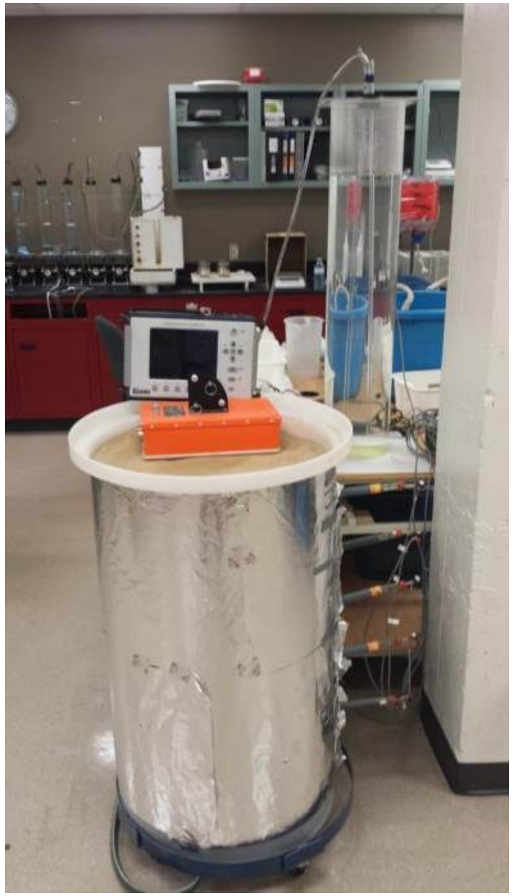
Methodology

- Drainage speed after 6h irrigation
- Winter and summer surveys (40 fields)
- Systematic sampling of soil cores

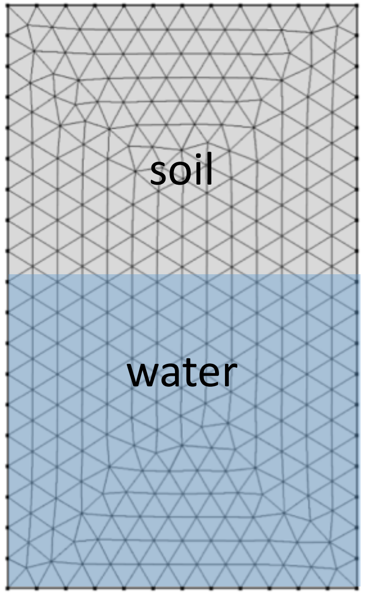


tensi0meters

Calibration and validation in controlled conditions

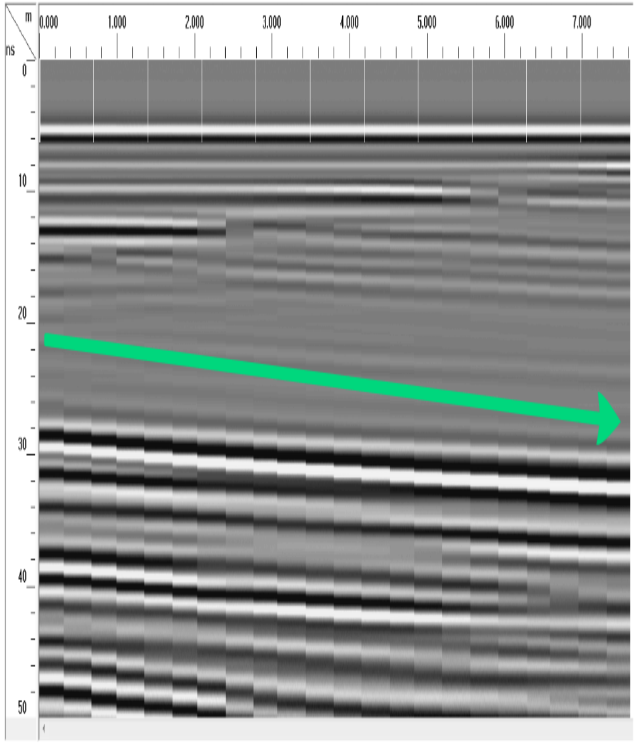


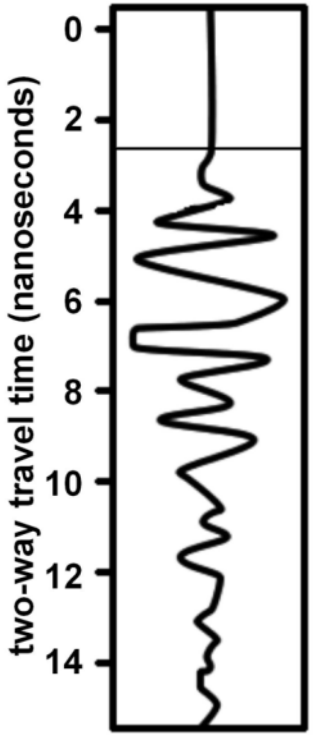
Maxwell equations solution with FEM



$$\nabla \cdot \mathbf{D} = \rho$$
$$\nabla \cdot \mathbf{B} = 0$$
$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$
$$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$$

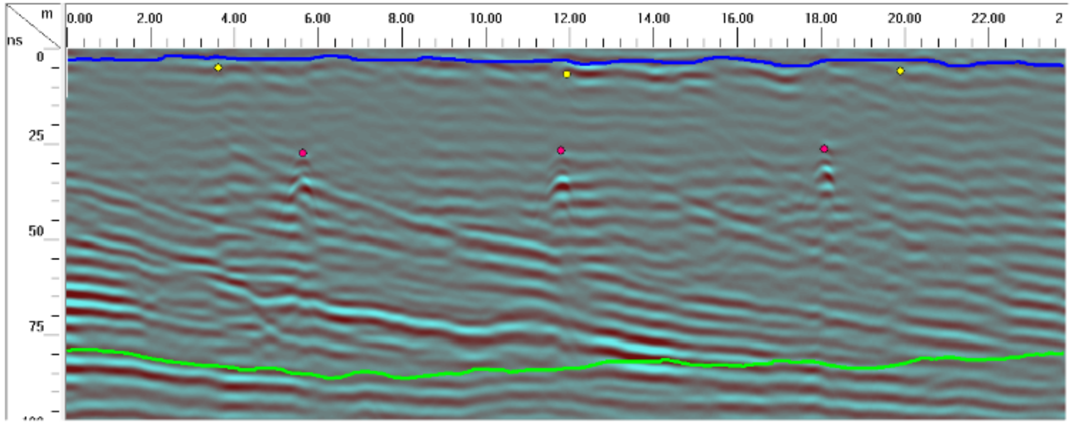
$$\bar{J} = \sigma \cdot \bar{E}$$
$$\bar{D} = \epsilon \cdot \bar{E}$$
$$\bar{B} = \mu \cdot H$$



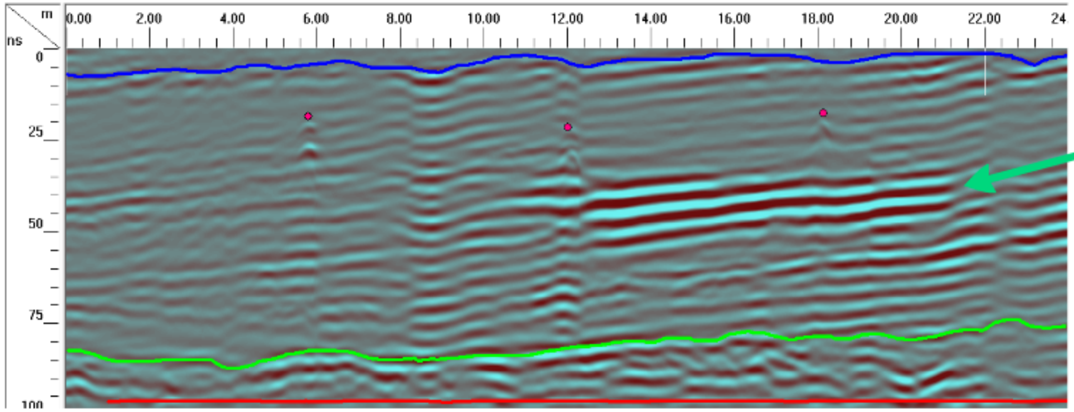


Results: Objects and soil layers

Scan 1



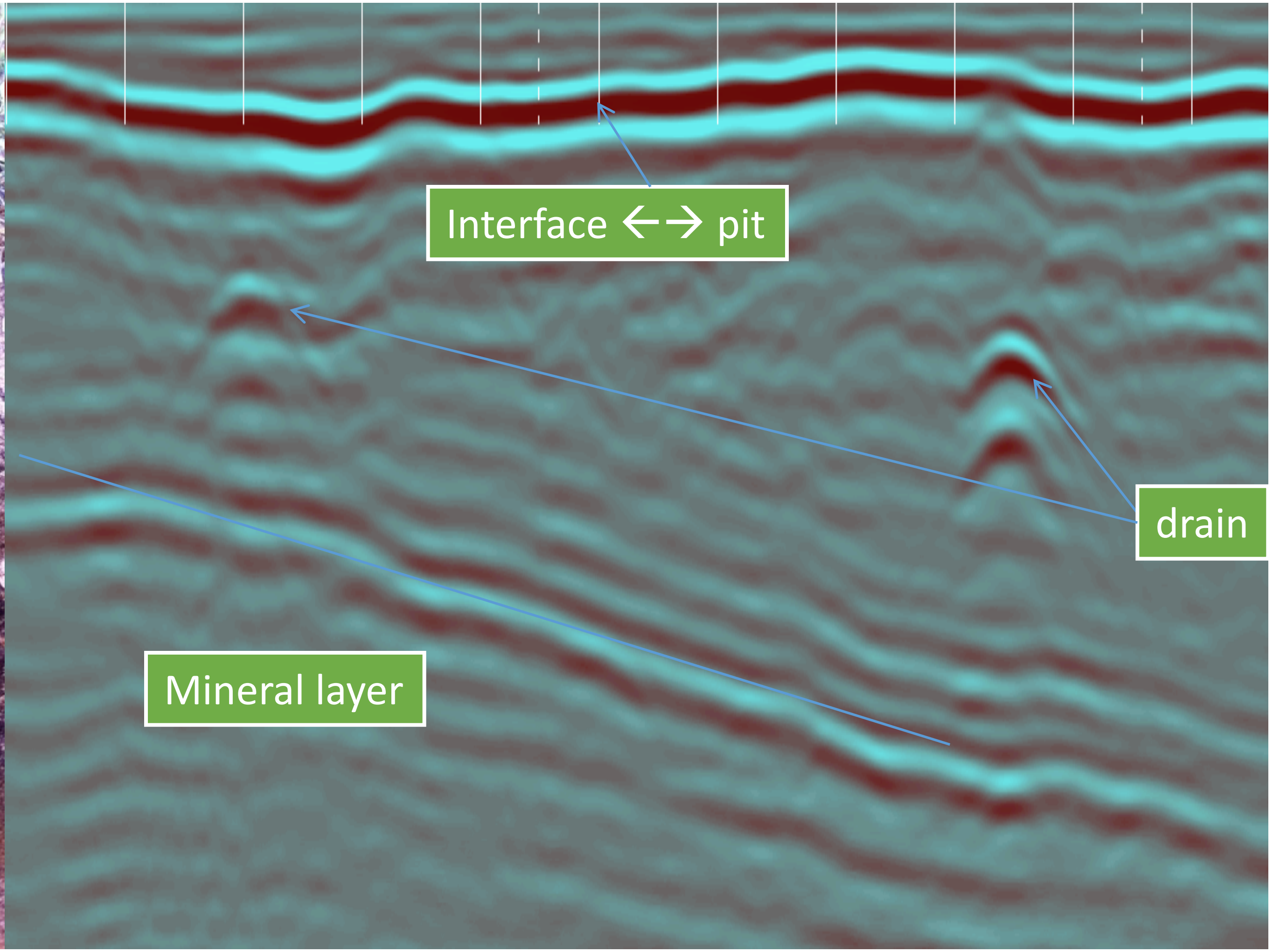
Scan 2



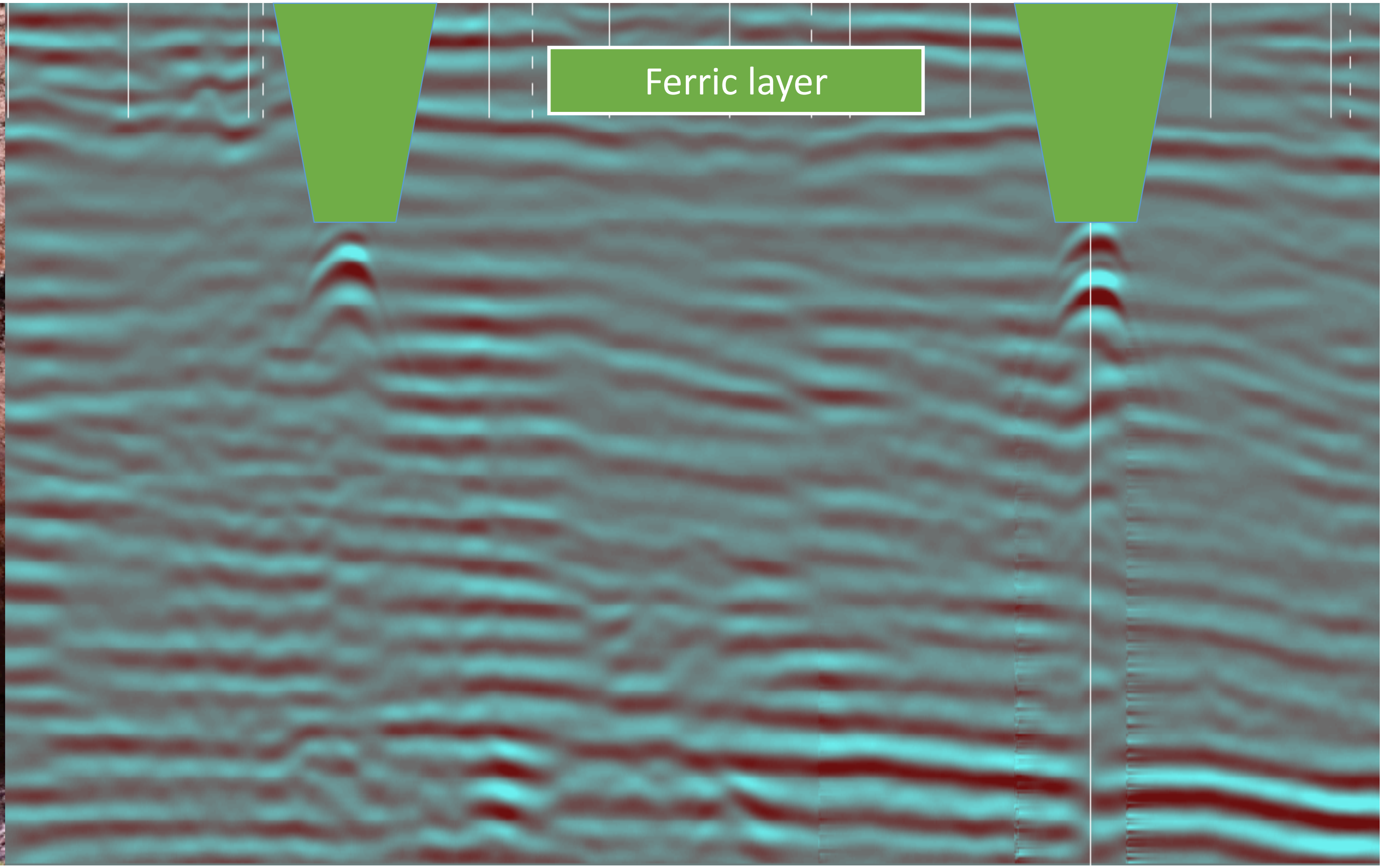
- Groundwater level
- Original material
- Level where the noise takes over the signal
- Presence of a drain
- Presence of an irrigation conduit

- Argillaceous deposit or
- Ferrous concretion

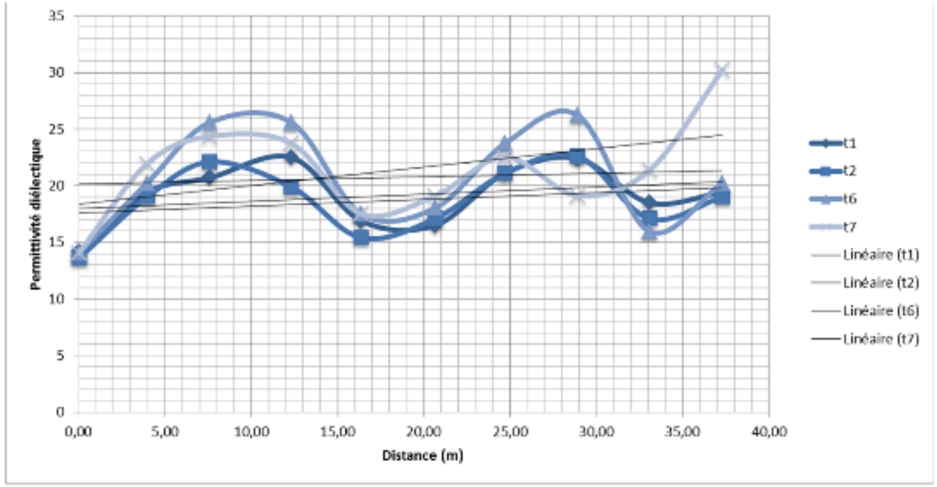
Results: Objects and soil layers

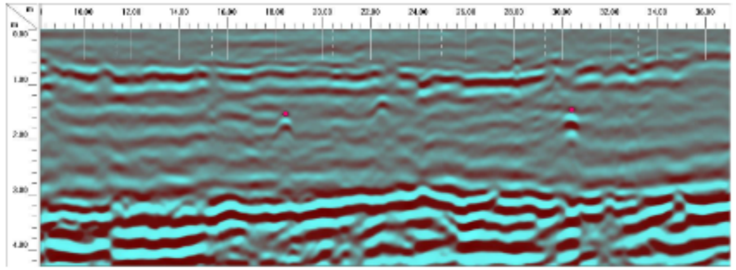


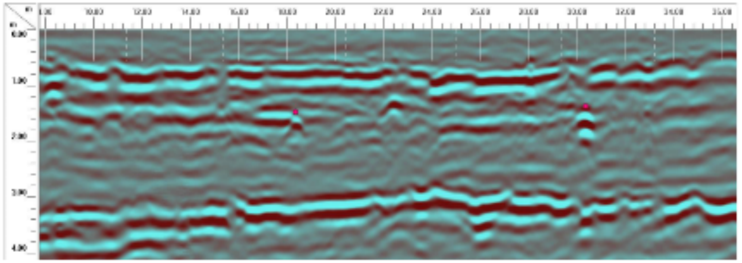
Results: Objects and soil layers

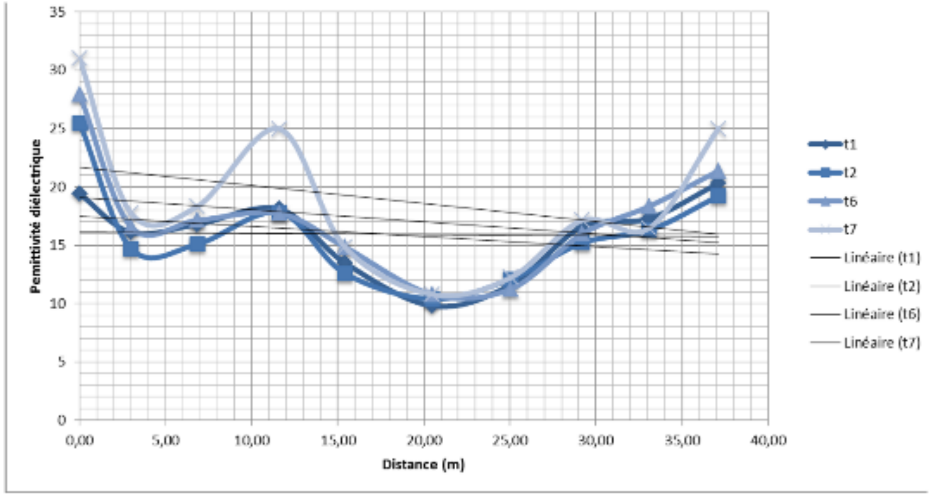


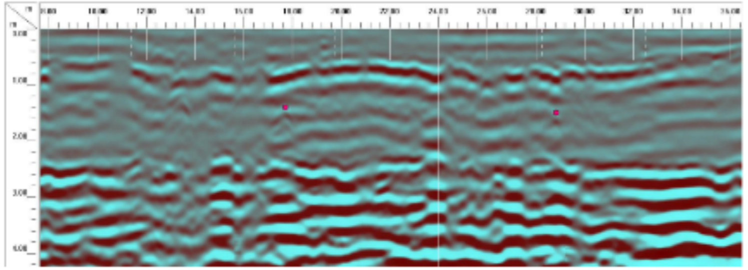
Results: Temporal variability

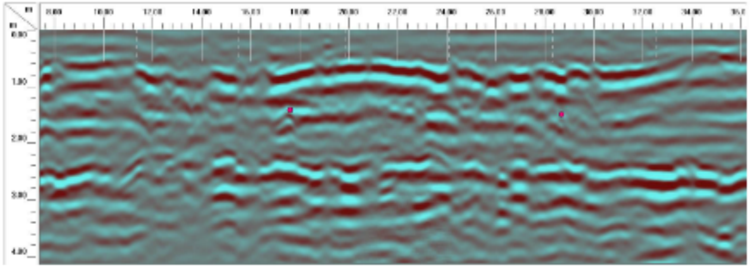




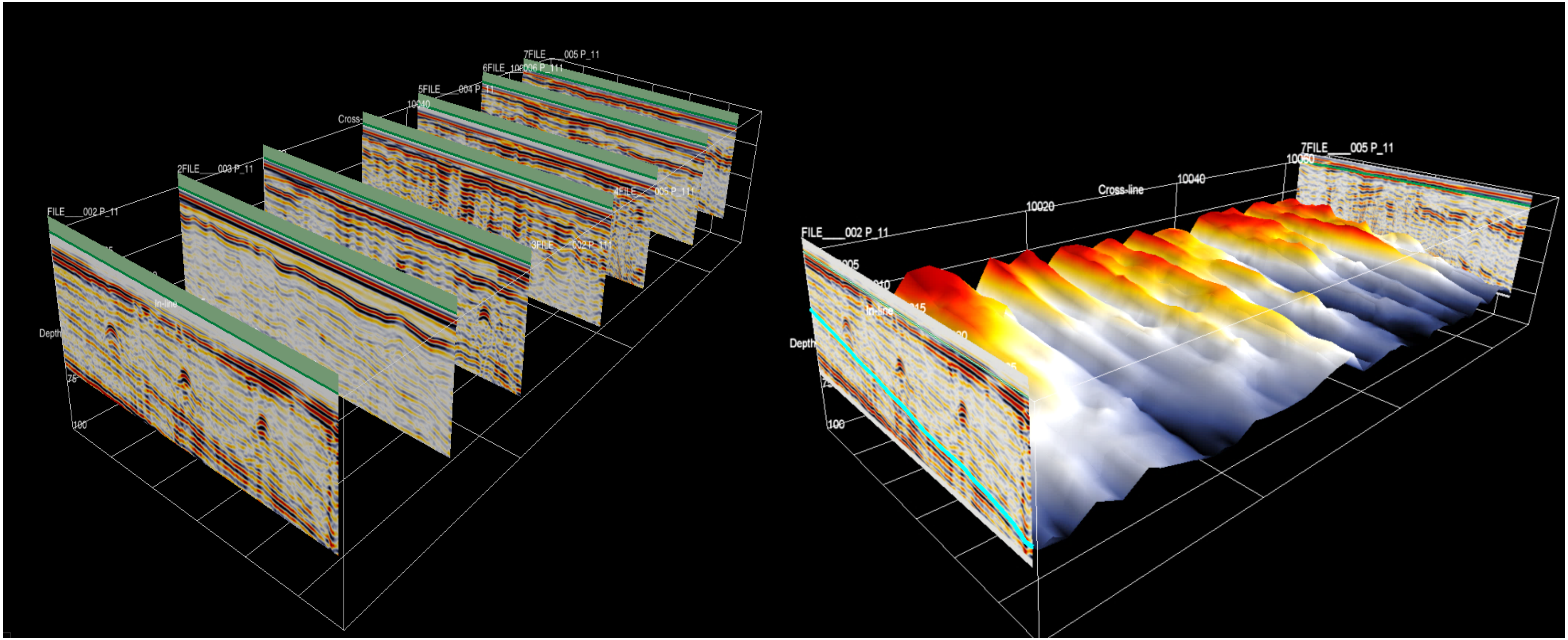




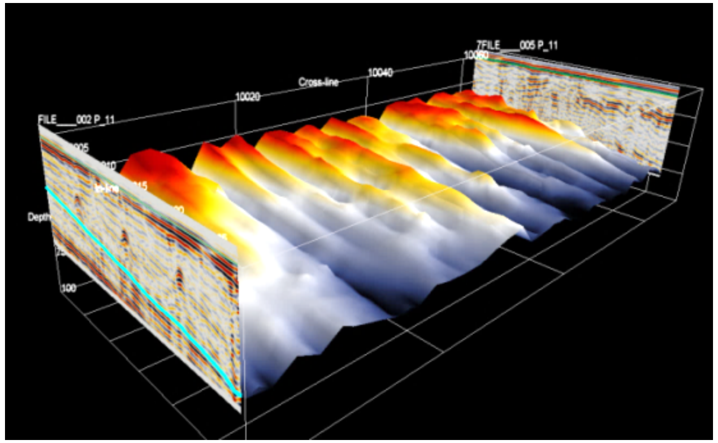




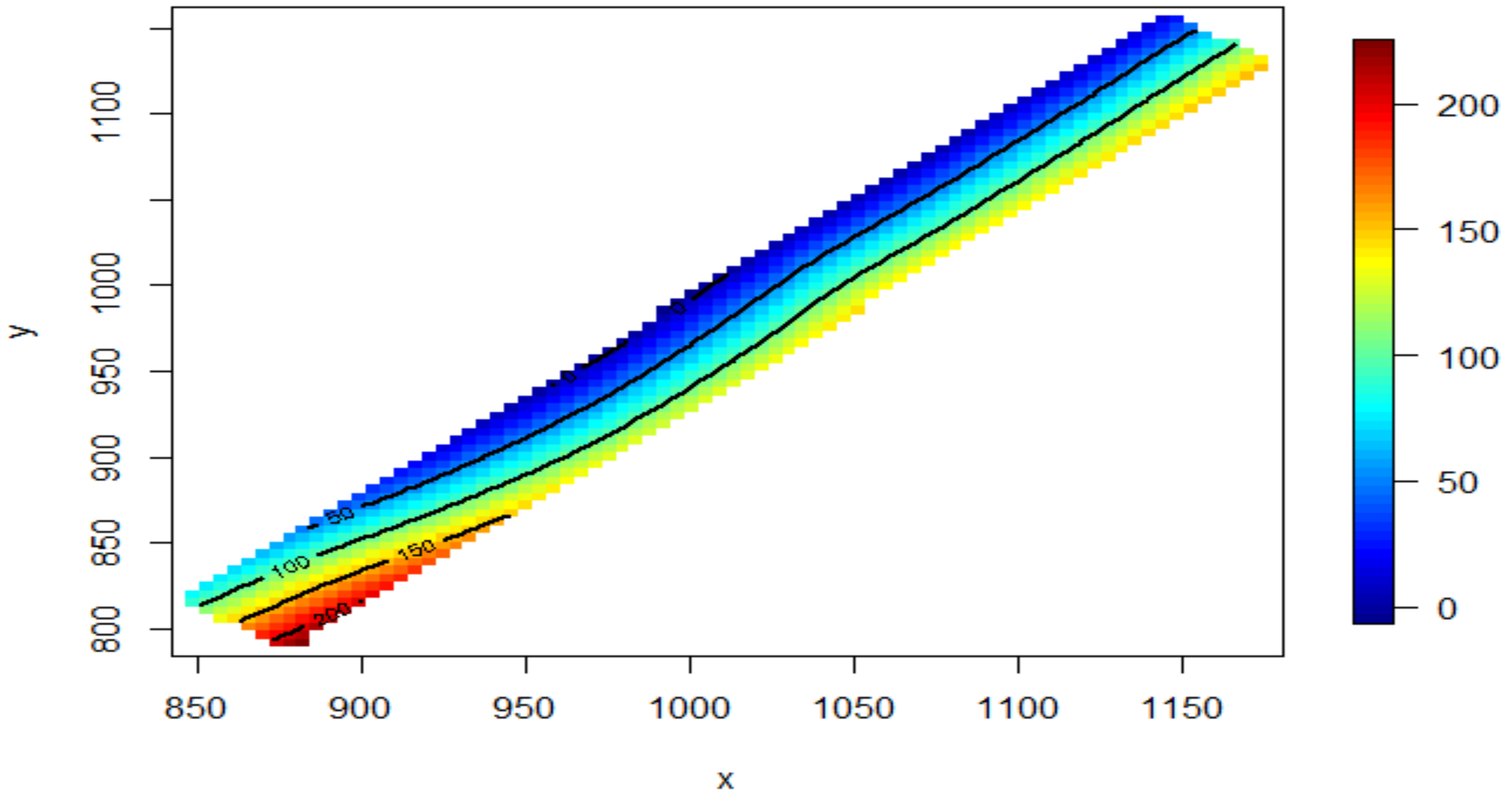
Results: 3D subsurface modeling



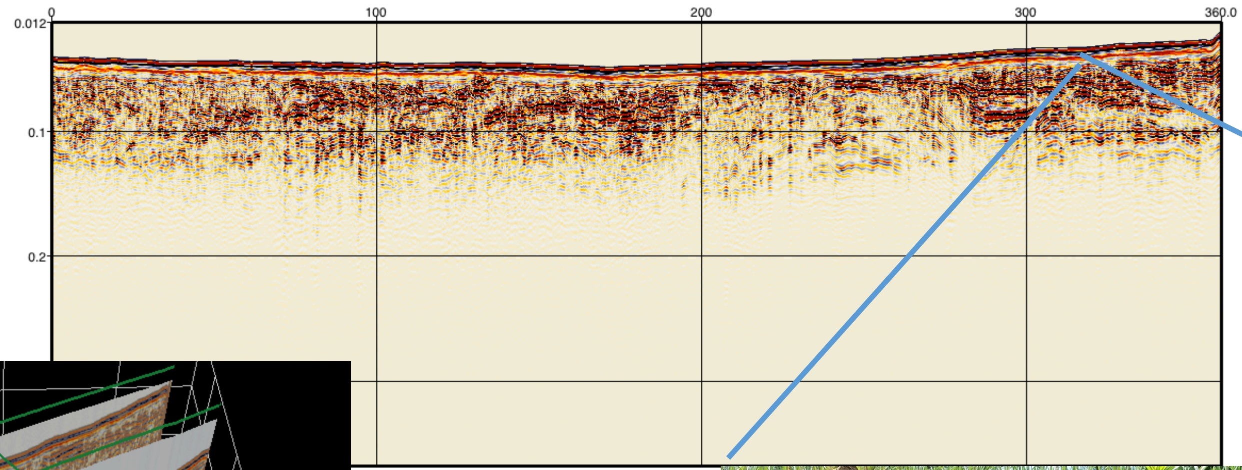
Results: Hydrodynamic properties

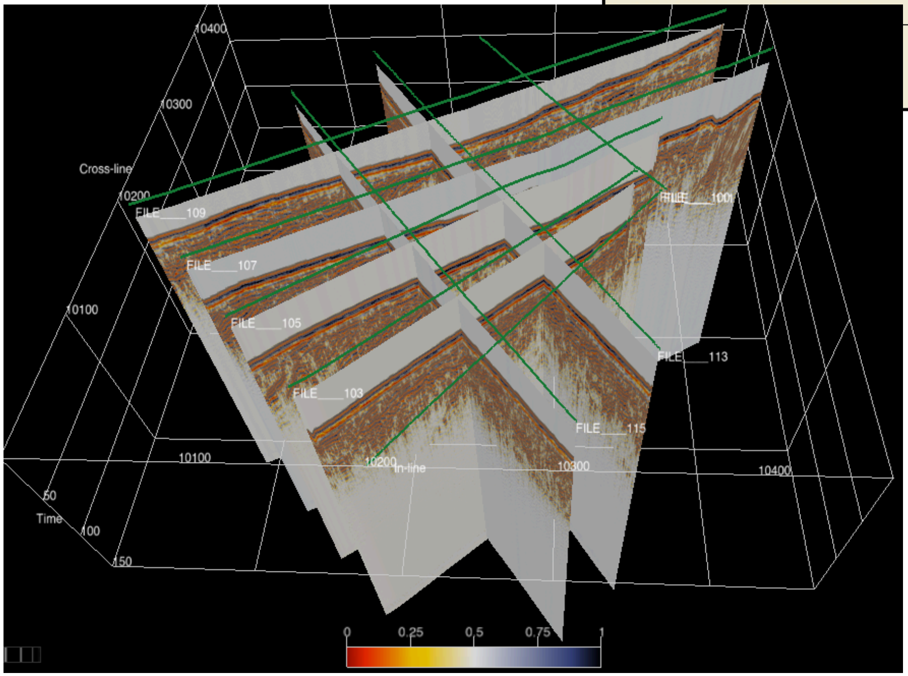


Saturated hydraulic conductivity (cm/day)



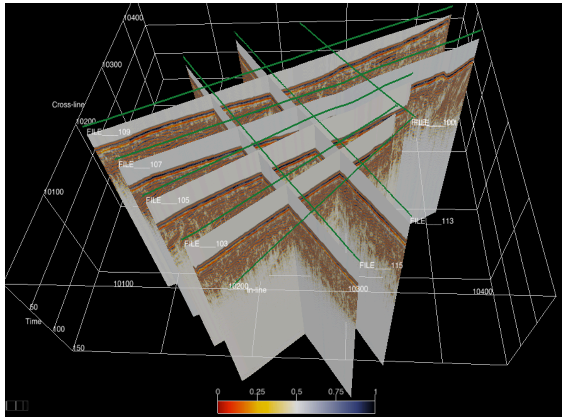
Results: Compaction layer

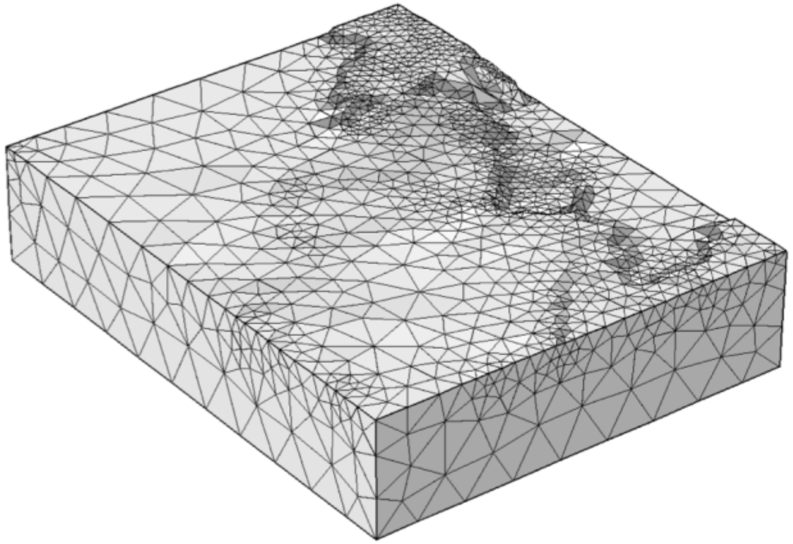




Hydrological modeling assistance: impact on groundwater

GPS grid
+
GPR layer

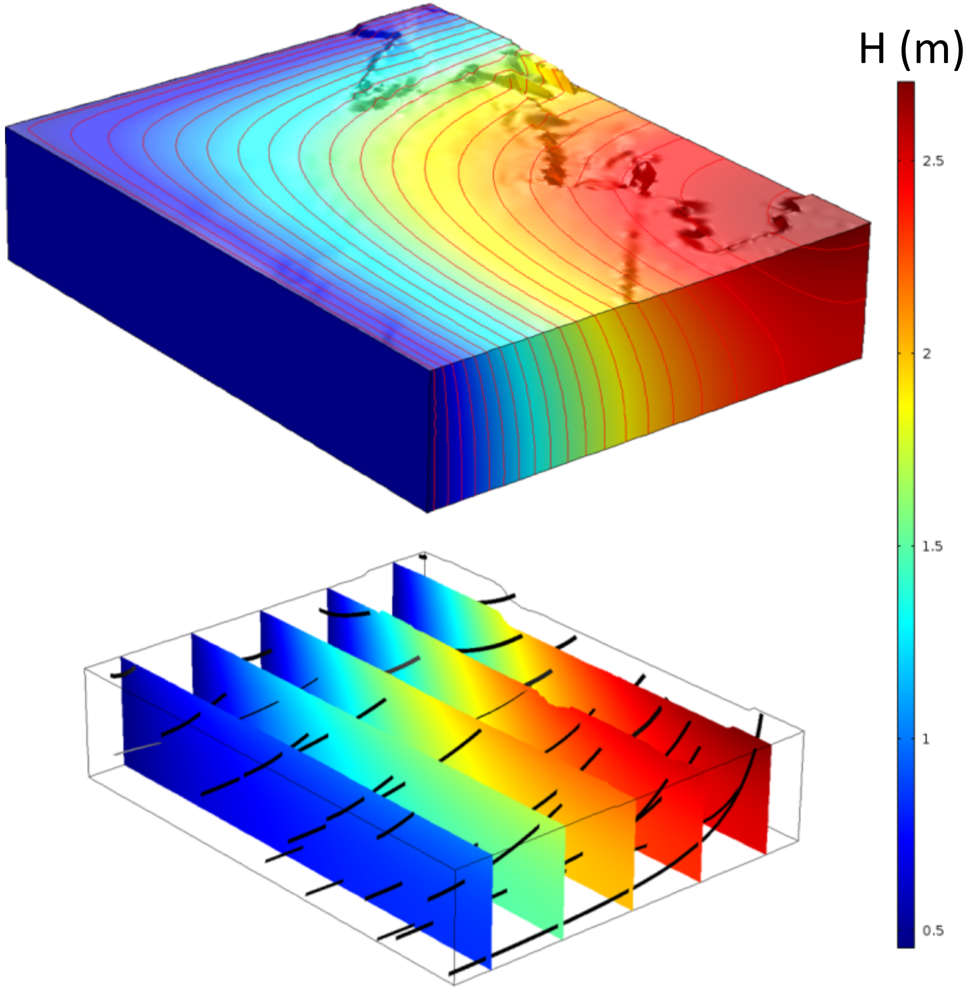




CATHY model (Camporese *et al.*, 2010)

$$\frac{\partial Q}{\partial t} + c_k \frac{\partial Q}{\partial s} = D_h \frac{\partial^2 Q}{\partial s^2} + C_k q_s$$

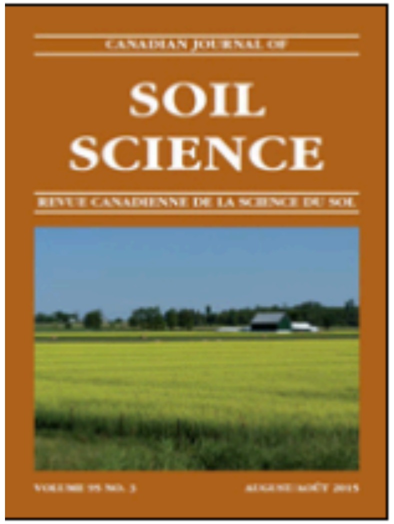
$$S_w S_s \frac{\partial \psi}{\partial t} + \varphi \frac{\partial S_w}{\partial t} = \vec{\nabla}.\left[K_s K_r(\psi)\left(\vec{\nabla}\psi + \vec{\eta}_z\right)\right] + q_{ss}$$



Conclusion

- 75% of cranberry fields with some drainage problem
- Most of fields present different layers with flux restrictions
- GPR could be used to indicate some hydrodynamic soil properties at the soil profile scale
- GPR also could be used for large scale farm stratigraphy, helping hydrological modelling setup.

Canadian Journal of Soil Science
Special Issue



2014 Impact Factor : 1.0

Precision Agriculture and Soil-Water Management in Cranberry Production:

- Irrigation and drainage
- Environmental impact
- Water management
- Fertilization
- Precision agriculture techniques

Call for papers: August 1st, 2015
Deadline for manuscript submission: January 15th, 2016
1st round of review completed: March 15th, 2016
2nd round of review completed: May 15th, 2016
Publication: July–August 2016

Contact: silvio-jose.gumiere@fsaa.ulaval.ca

“*Data! Data! Data!*” he cried impatiently. “*I can't make bricks without clay.*”

Sherlock Holmes

Questions???