Mise-à-la-masse forward modelling with explicit representation of root structure

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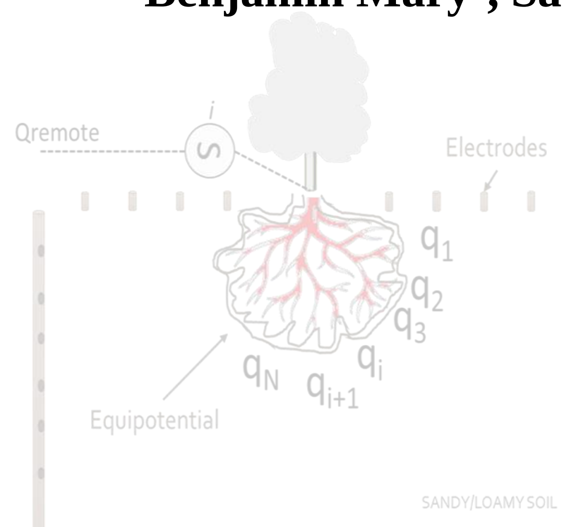

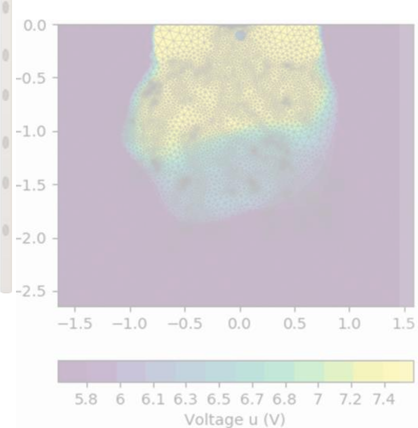

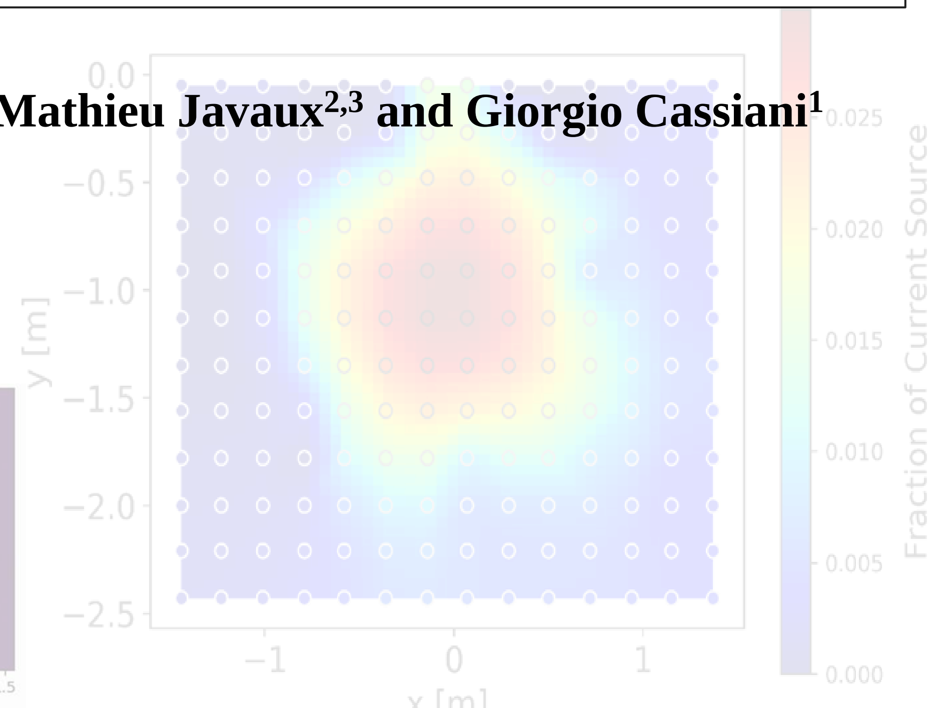

Introduction
Modelling results
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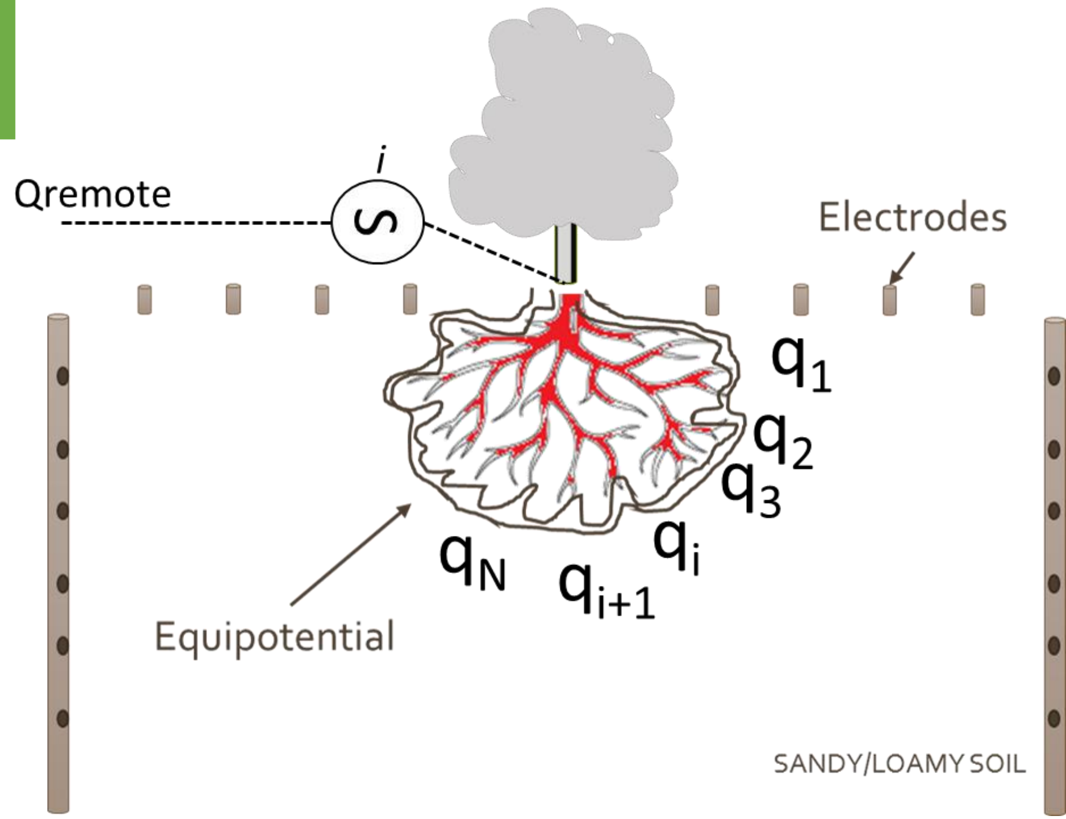
- 1 -
How much the MALM assumption hold ?

"Equal distribution of the current over the root system (low resistance xylem pathway)"

Dalton 1995

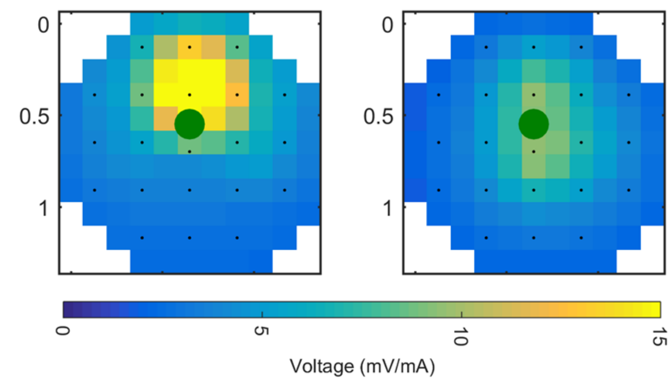


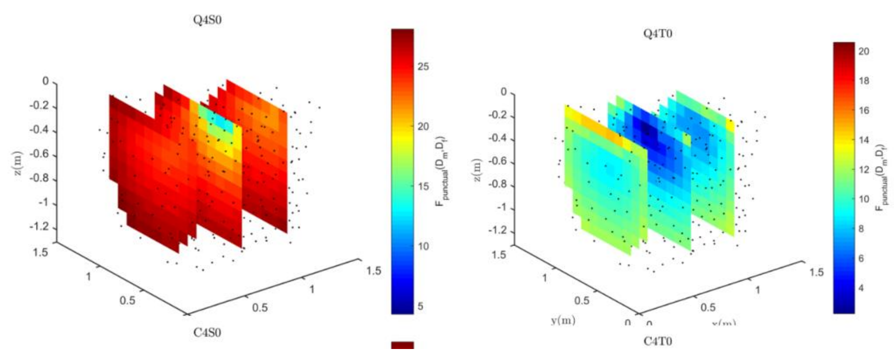
No consensus, empirical model
Need for proofs on current path

- 2 -
Modelling as a follow up to experimental work

Contrasted results depending on plant species
→ Woody VS herbeceous species

Voltage distribution for soil (left) and stem (right) injection





Distribution of current sources

Mary et al HESS

Peruzzo et al. (2019) (subm.)

Mary et al. (2019) ScriRep (subm.)

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Modelling assumptions

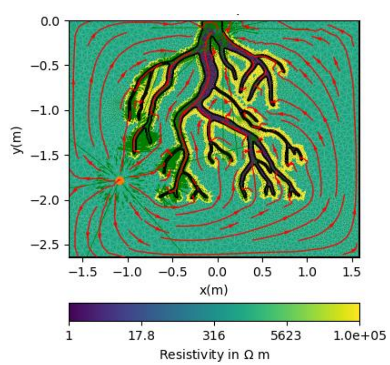
Root architecture
Root electrical properties
Root hydraulic conductivities

Soil type
Electrode configuaration

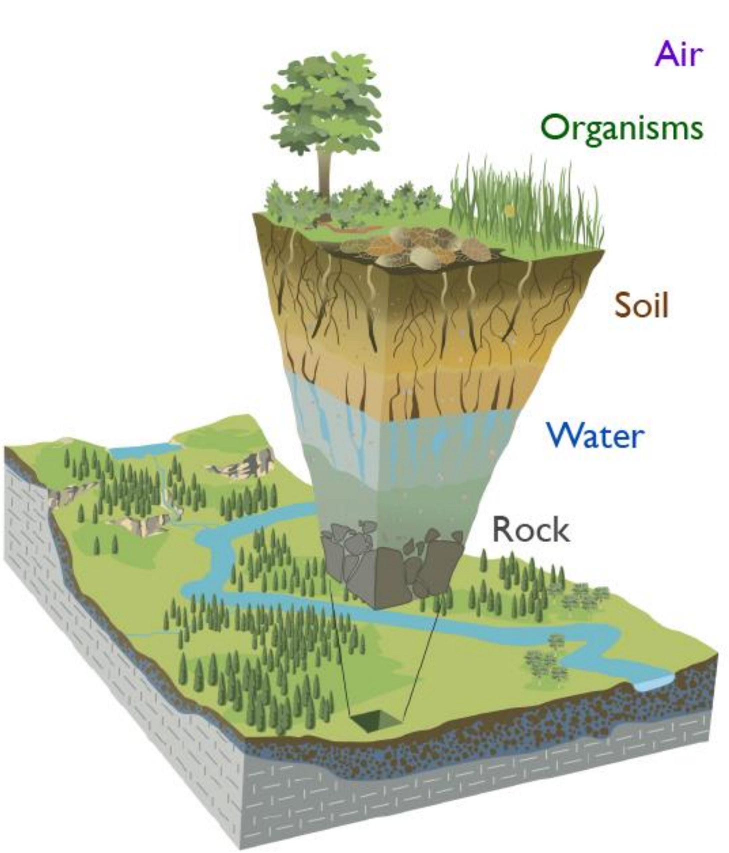
Root Model → ERT Fwd/inversion

Rao et al. (2018)
Biogeoscience (Discuss.)

MALM simulation → MALM Inversion → Current path/density



Introduction



After Chorover et al., Catalina-Jemez CZO

Framework

The Earth's Critical Zone
Nation Research Council (2001): top of the tree canopy to the bottom of our drinking water aquifers.

Particular attention shall be devoted to the Soil-plant-atmosphere interactions:

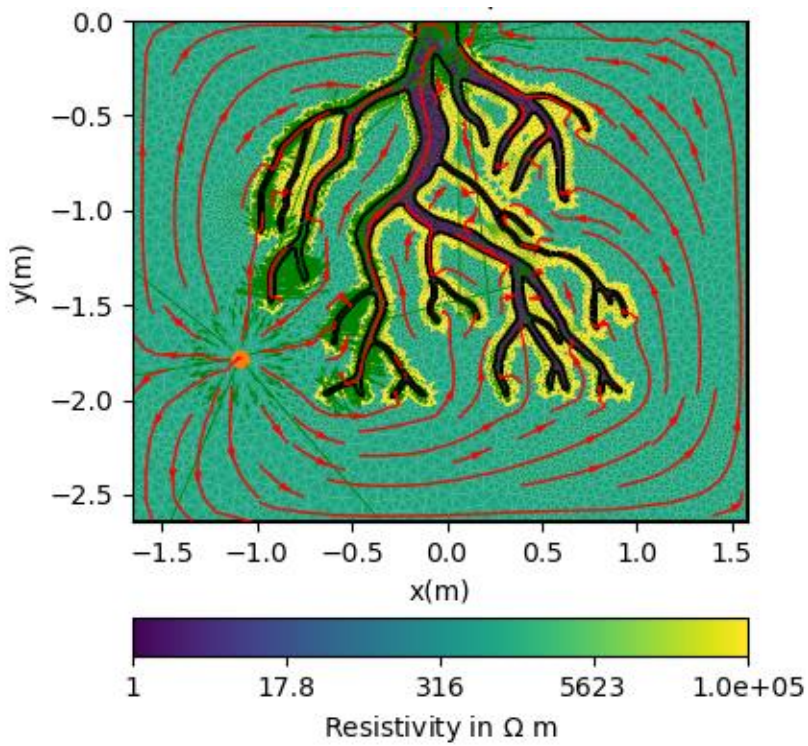
- Water path
- Role of the roots in the redistribution and uptake of the water

Ultimately there is a need to monitor or phenotype root system

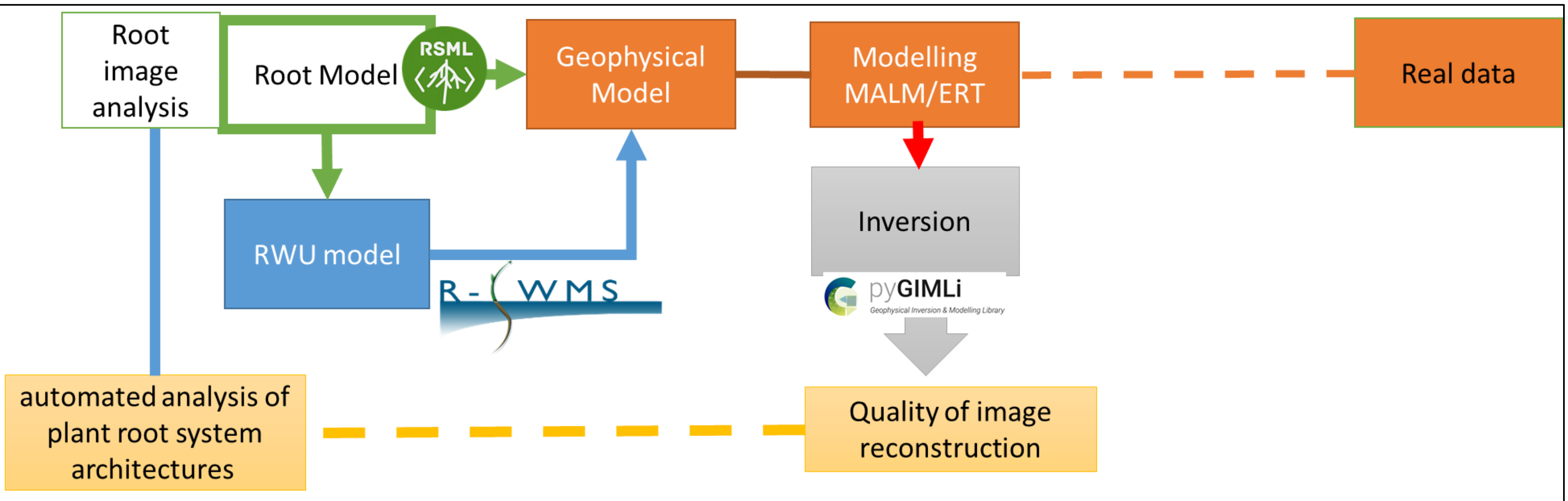
Introduction

Objectives

1. understand current pathway through the root system
2. quality of image reconstruction using ERT and MALM
3. comparison between experimental and simulated data



Introduction



Data processing flowchart

Modelling

The simple 2d synthetic model

Only root of 1° order
2 physical entities within the mesh:

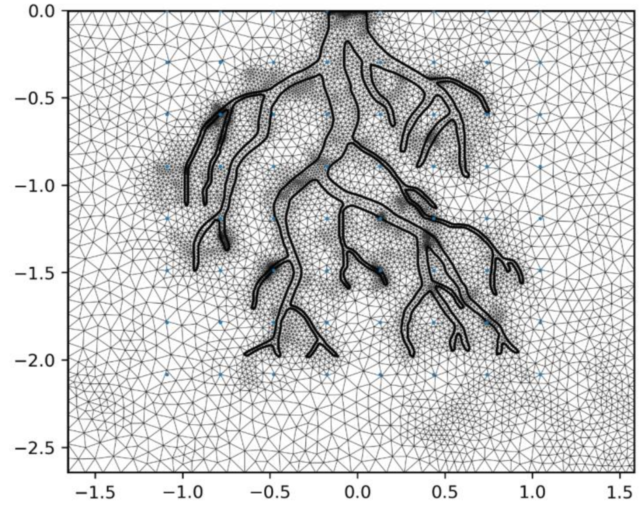
- Root
- Soil

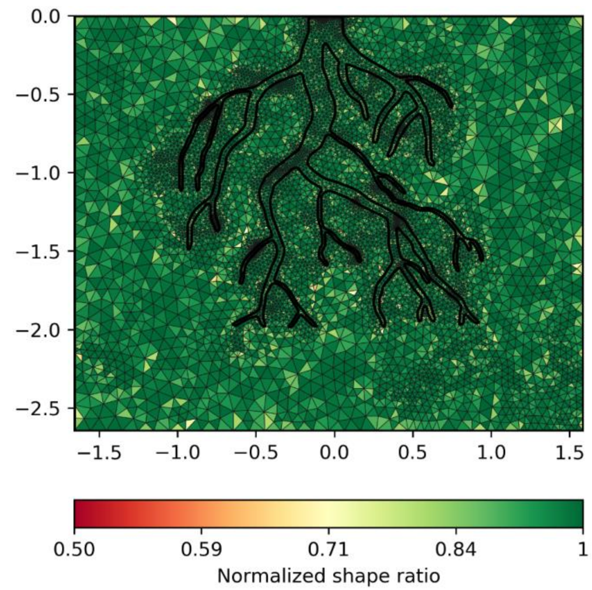
Varying schemes :

- Surface electrodes
- Boreholes electrodes
- Full coverage electrode (mimic rhizotron experiment)

And protocols:

- Wenner Schlumberger, Dipole-Dipole or Pole-Pole





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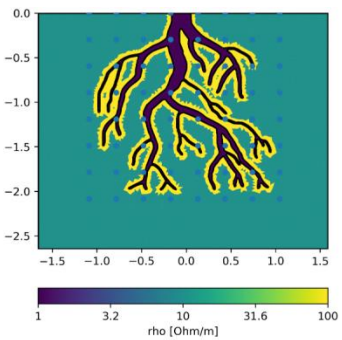
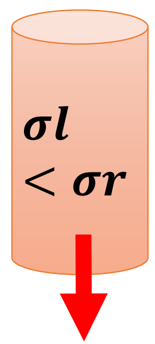
Modelling

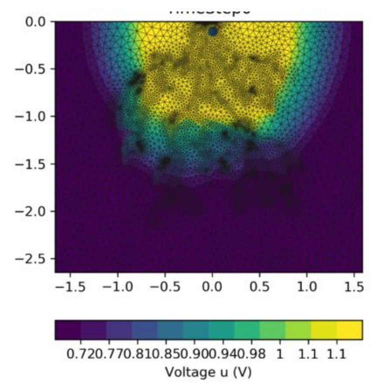
Effect of bark layer

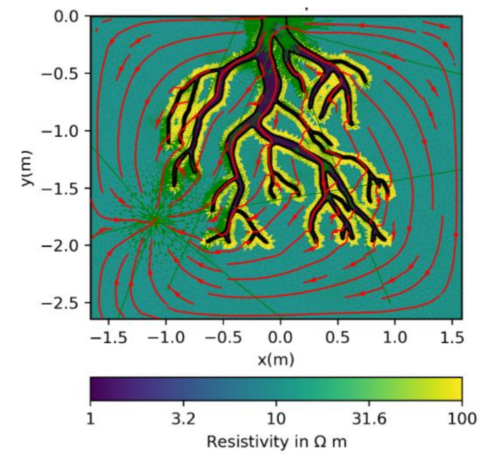
Initial model / Assumption / Voltage distribution / Current streamlines

Bark

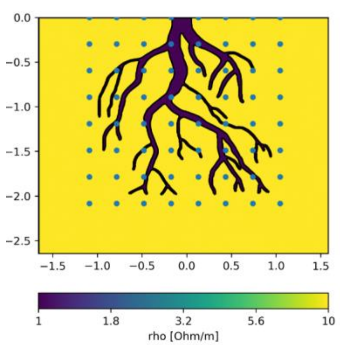


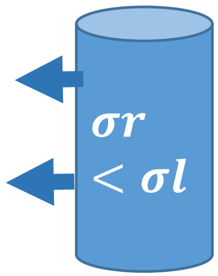


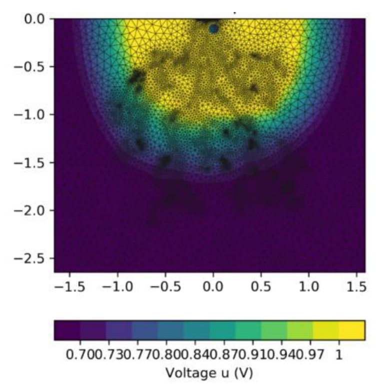


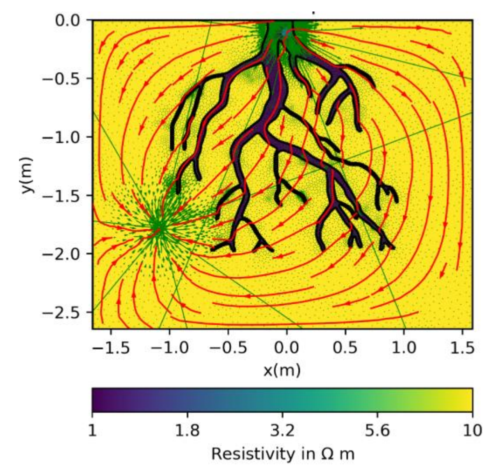


No Bark





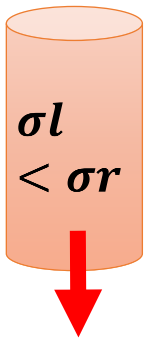


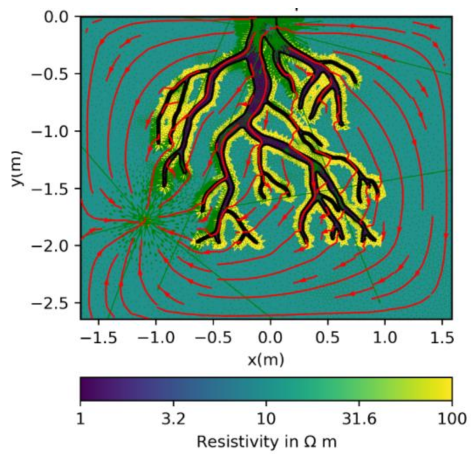


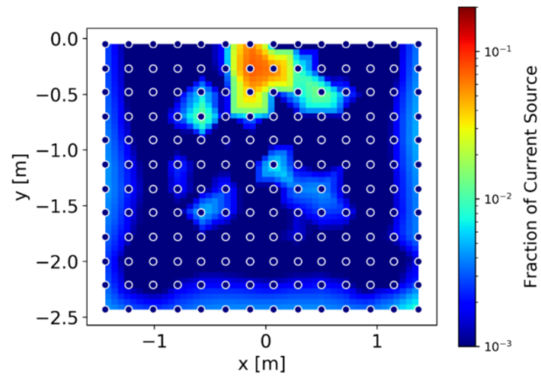
Modelling

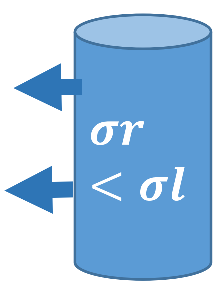
Effect of bark layer

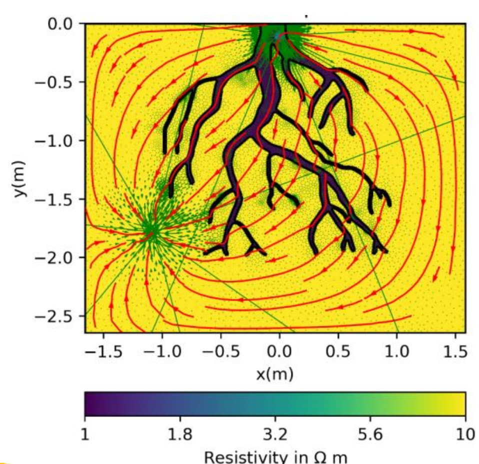
Assumption | **Voltage distribution** | **Current density**

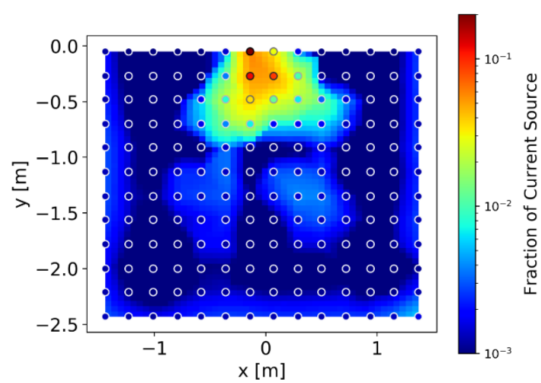












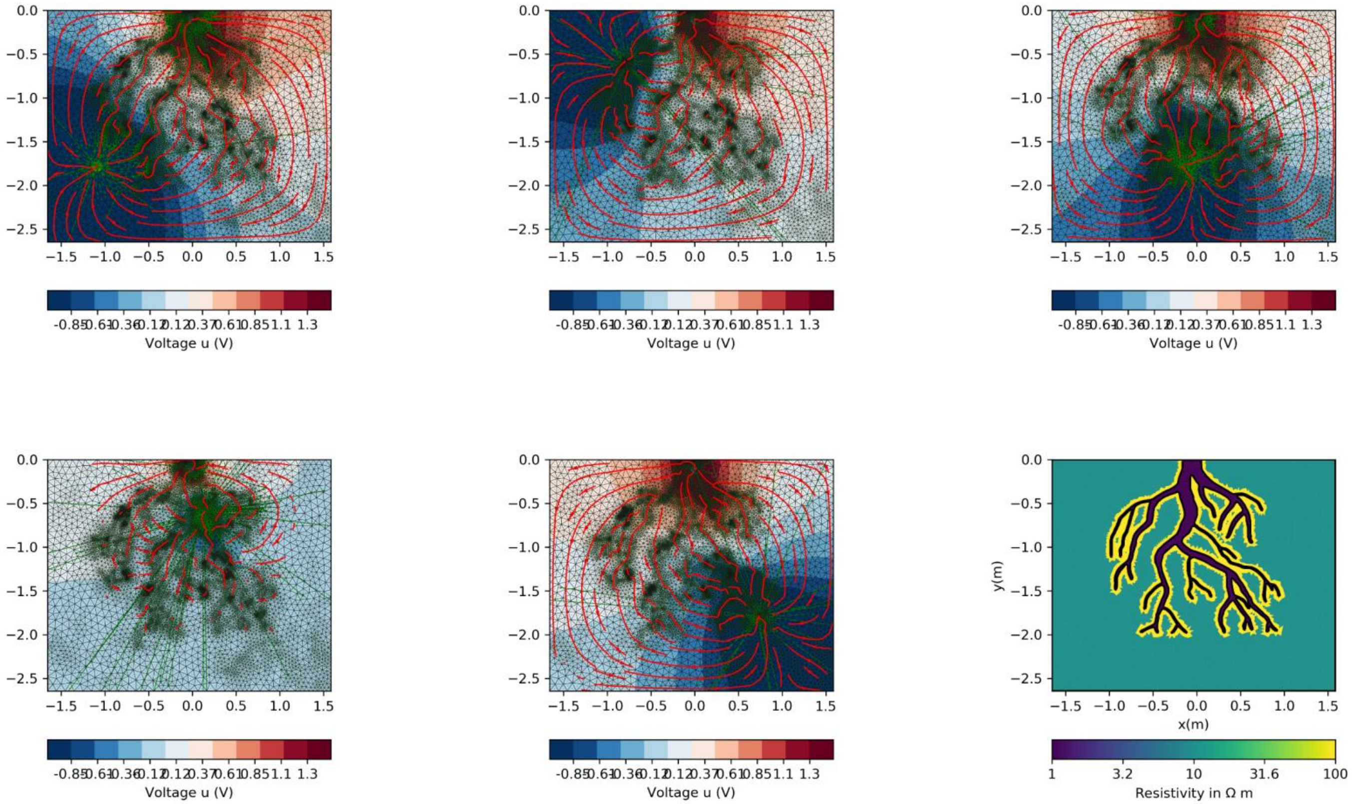
Effect of bark layer

Inversion likely found a local minima

No significant effects ultimetly after inversion of current sources density

Modelling

Effect of the return electrode



Current path is conditionned by return electrode location

Quantification of the anisotropy in MALM as a tool to phenotype the root system

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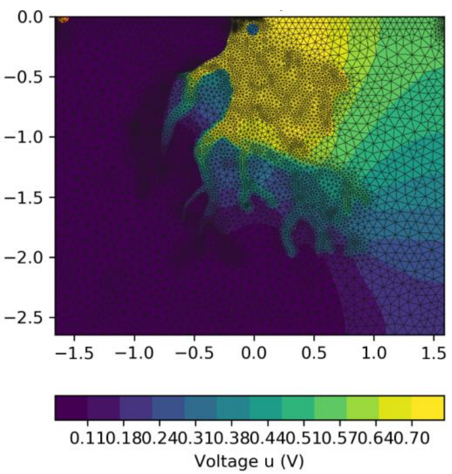
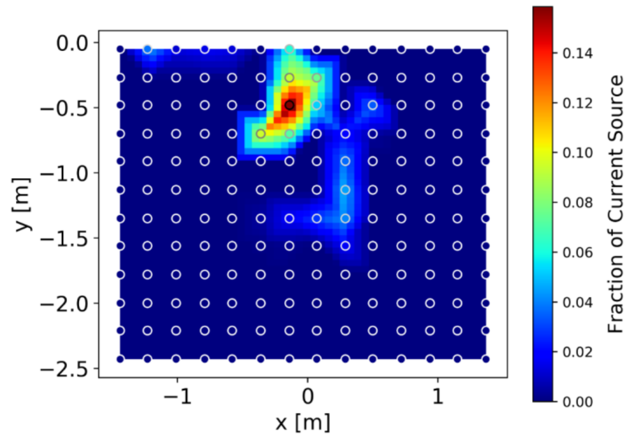
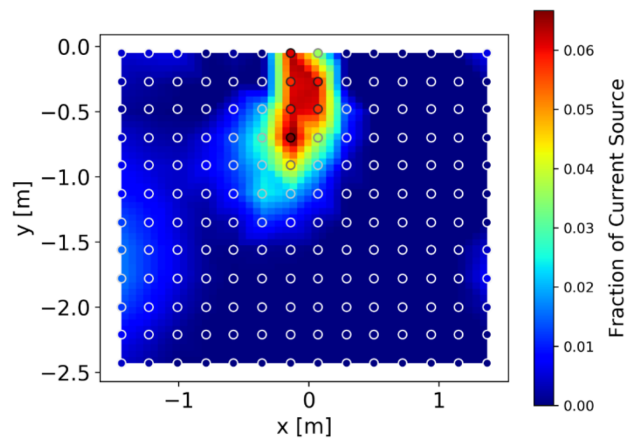
Modelling



Surface electrodes



+ Boteholes electrodes



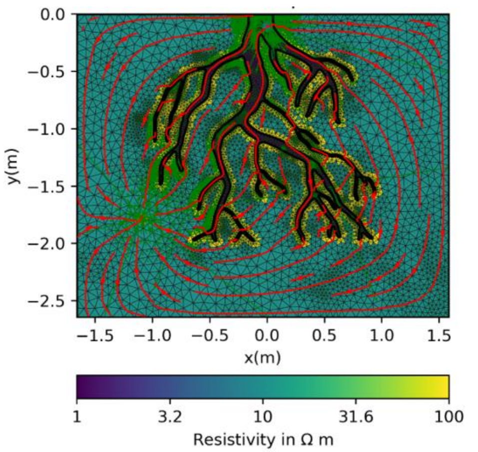
Effect of electrodes locations

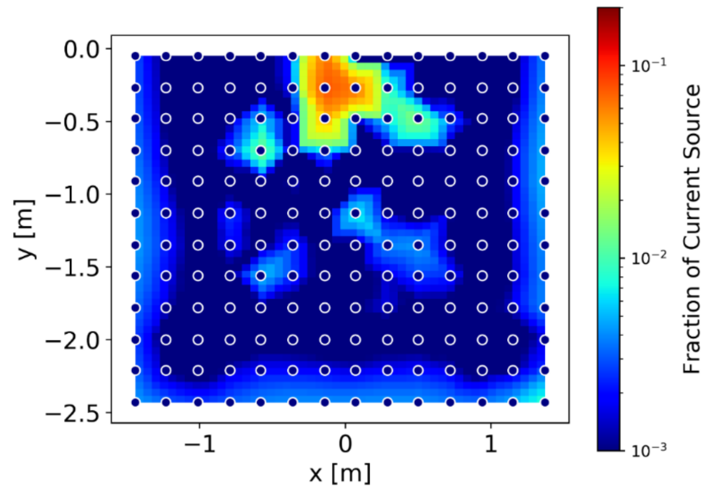
Boreholes are crucial information

No boreholes need for a correction of the sensitivity (depth weighting factor)

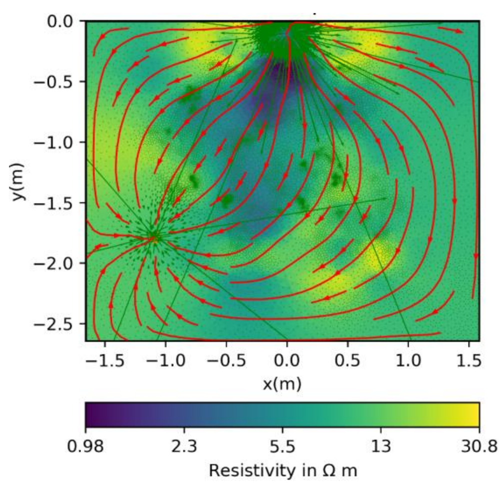
Modelling

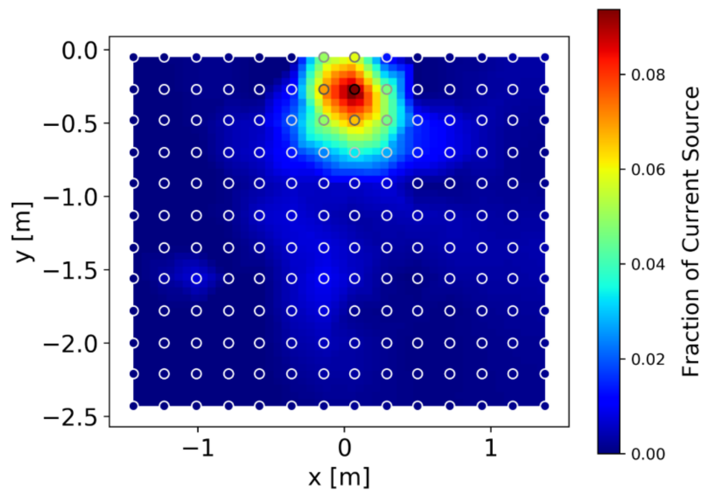
Initial resistivity map





Inverted ERT





Effect of soil initial model

ERT uncertainties propagate during MALM simulation

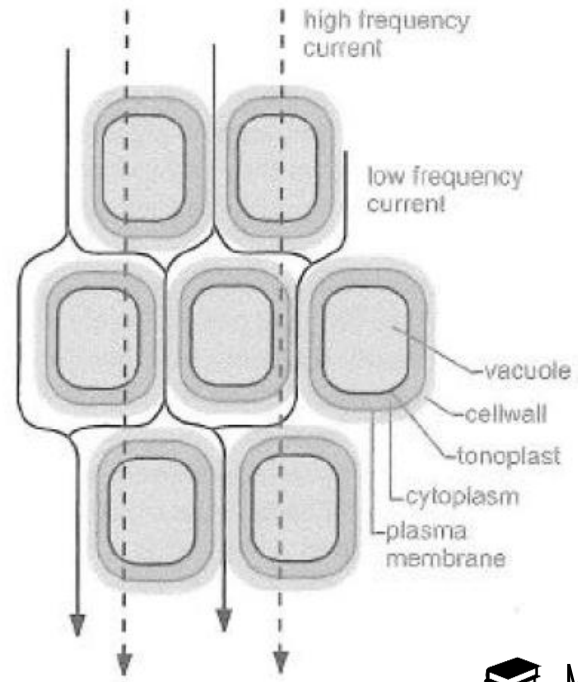
Tends to overestimate the current location in depth

Perspectives

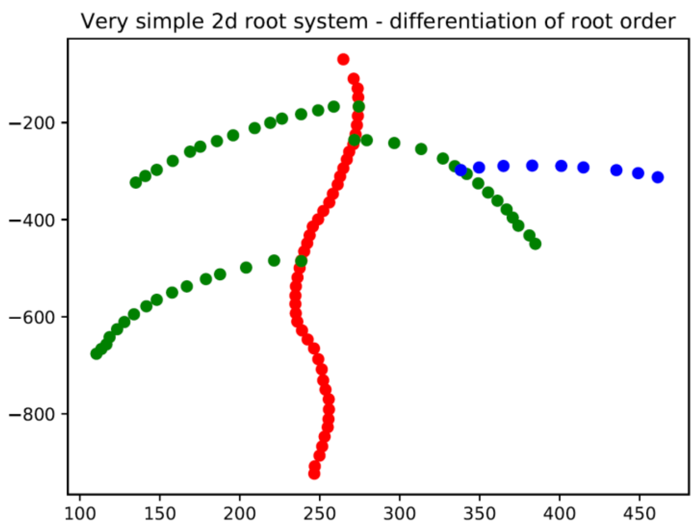
Use real root system as input (RSML or MTG formats)

Geophysical data assimilation into an hydrological model

Extend ERT to EIT



Mancuso 2012



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WASA PROJECT WAter Saving in Agriculture

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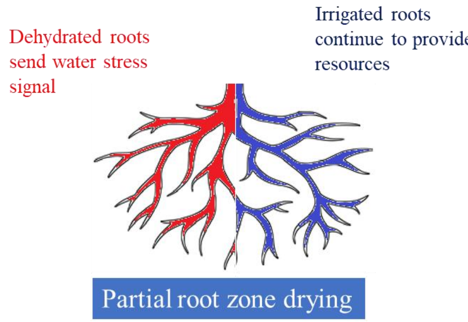
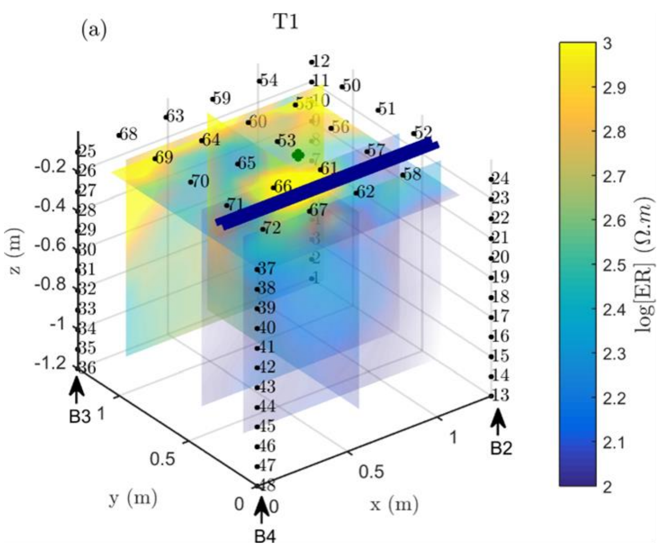
Modelling

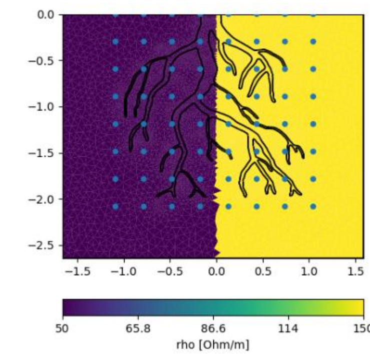


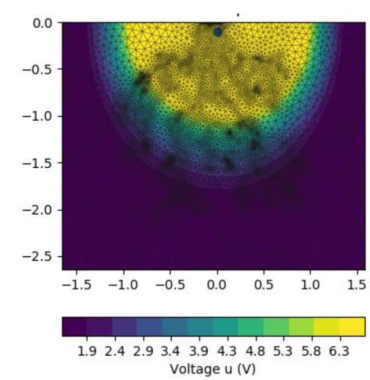
Consoli et al. 2016

Effect of irrigation patterns

Real datasets collected on Citrus (Italy)







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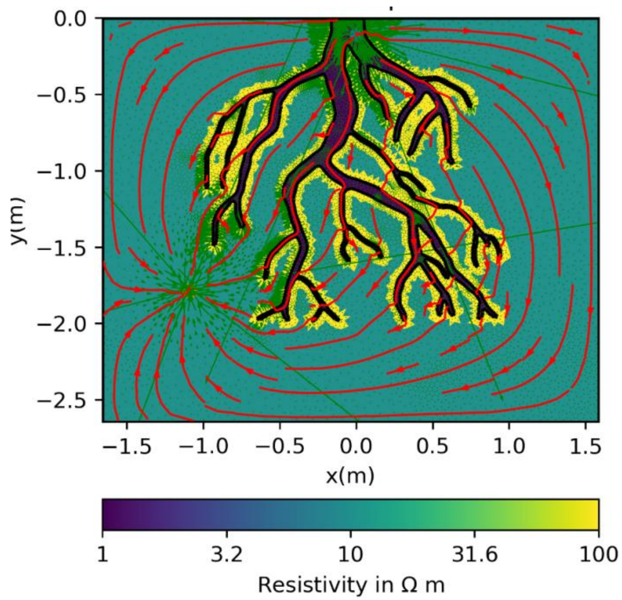
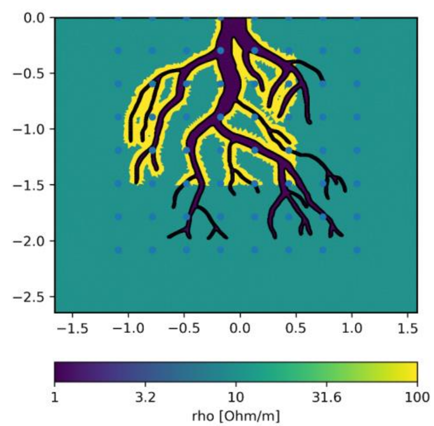
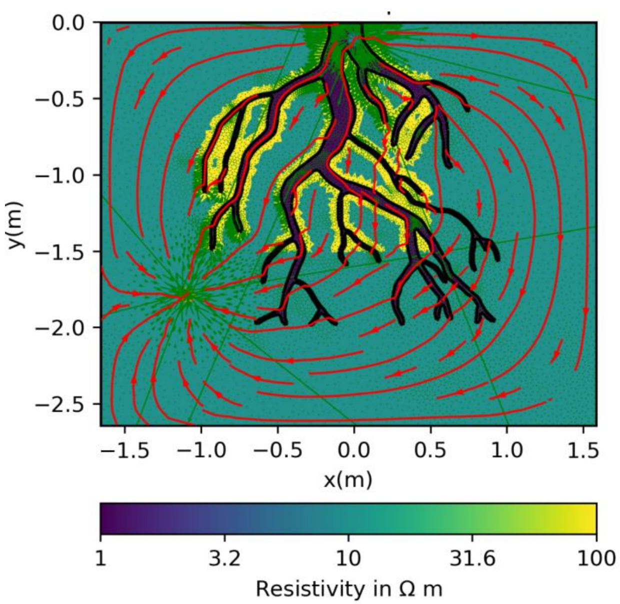
Modelling

Full bark



No full bark





Current pathway
versus
Root order

Mimic
secondary order
root type

Preferential
current pathway
through in the
no-bark area

2’

Modelling

Inversion of current density: punctual source case