A generic current source inversion algorithm for Mise-à-la-masse prospection : application on case studies

Tentatively in Computer and Geosciences

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Core ideas

* Propose an open source and generic algorithm to invert current source density in Mise-à-la-Masse prospection
* Model appraisal and uncertainties
* Show the application of the algorithm on three different contexts: plant root imaging, landfill leakage and salt intrusion monitoring
* Address pip to download the open source python package “pyMALM”: coming soon

Abstract

*Keywords:* Mise-à-la-masse, inversion, ERT, curent density

1. Introduction

* MALM Fundamentals: Parasnis 1973, Schlumberger, Stierman 1984

Survey using MALM

* Landfill/reservoir leakage MALM : (Binley et al., 1997), (Colucci et al., n.d.), (Binley et al., 1999), (De Carlo et al., 2013), (Ling et al., 2019b, 2019a)
* MALM applied to tracer injection/ contamination plume delineation: (Perri et al., 2018)
* Geotermal
* Deposit: (Bhattacharya et al., 2001)
* Karst: (Guérin et al., 2009), (Beasley and Ward, n.d.), (Chalikakis et al., 2011)
* Roots imaging MALM : (Mary et al., 2020, 2019, 2018), Peruzzo et al. in Plant and Soil

Processing of MALM

* Topography correction: (Oppliger, n.d.)
* Correction en 1/r ?
* (Ronczka et al., 2015) and (Heagy, 2018): explores using simulations the relation between the conductivity, the distribution of current density, the charge density and the electric field distribution for direct current resistivity with steel-cased wells Figure 4.14 (see also <https://em.geosci.xyz/index.html> )

Inversion in geophysics

* Inversion of streaming potentials: (Soueid Ahmed et al., 2013)
* Inversion current TDIP (without injection into the body): (Shao et al., 2018)
* Recent python library inversion codes of induced field:
  + ERT: (Blanchy et al., 2020), (Cockett et al., 2015) (Rücker et al., 2017)
* Recent python library inversion codes of natural potential field:
  + SP: (Soueid Ahmed et al., 2013)
  + Gravity: (Fedi, 2007; Florio and Fedi, 2018)
* Model appraisal: (Binley and Kemna, 2005), gars cours venice , (Ren and Kalscheuer, 2020)
* Inversion MALM : (Shao et al., 2018), (Binley et al., 1997), (Colucci et al., n.d.), (Binley et al., 1999), (Wondimu et al., 2018), (Hatanaka et al., n.d.), (Ling et al., 2019b, 2019a)
* The use of a-priori information in the form of:
  + (de Villiers et al., 2019)
  + Model depth-weighting: (Cella and Fedi, 2012), (Oldenburg and Li, n.d.)

Image appraisal and experimental design in MALM

* (Wagner, 2016) discussed experimental design against image appraisal.
* (Ronczka et al., 2015)
* How to use jacobian matrice to interpret sensitivity of model parameters (see eq. 5.20 from Binley and Kemna 2005)
  1. Background
  2. Potential of MALM for environmental studies
  3. Existing approaches for MALM inversion

1. Structure of the code
   1. Linear formulation of the problem

### drawSparseMatrix pygimli

* 1. Inversions routines

**Data and model misfit**

Smoothness

Smallness

Anisotropy

**Optimization methods**

* 1. Model appraisal and uncertainties
  2. Simple implementation within Resipy

1. Applications
   1. Initial model m0 estimation
   2. TDIP inversion

Relaxation of Wr

* 1. Time-lapse inversion

1. Case studies
   1. Impact of ??
   2. Case of root system imaging
   3. Case of landfill leakage
2. Conclusion

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Figures

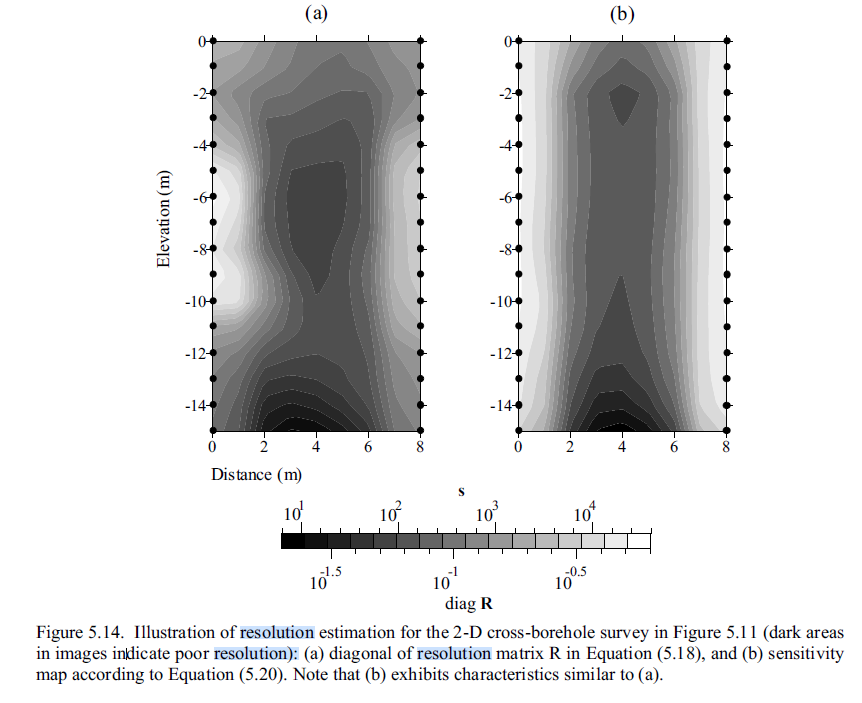
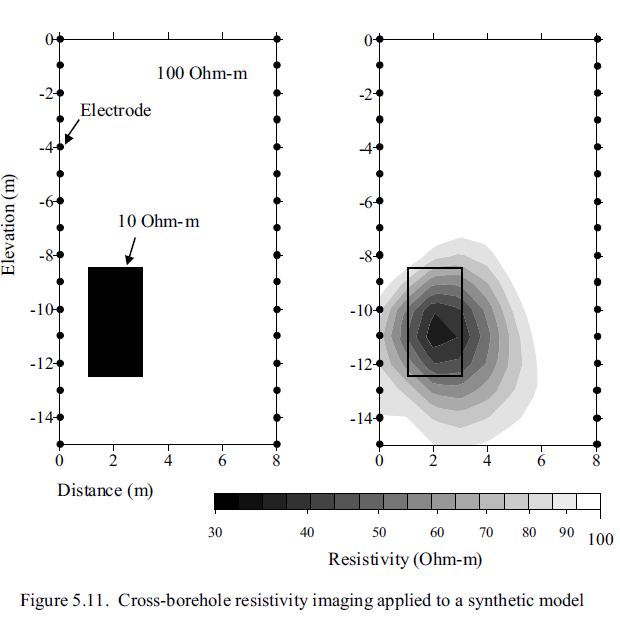


Figure 1: model appraisal and uncertainties

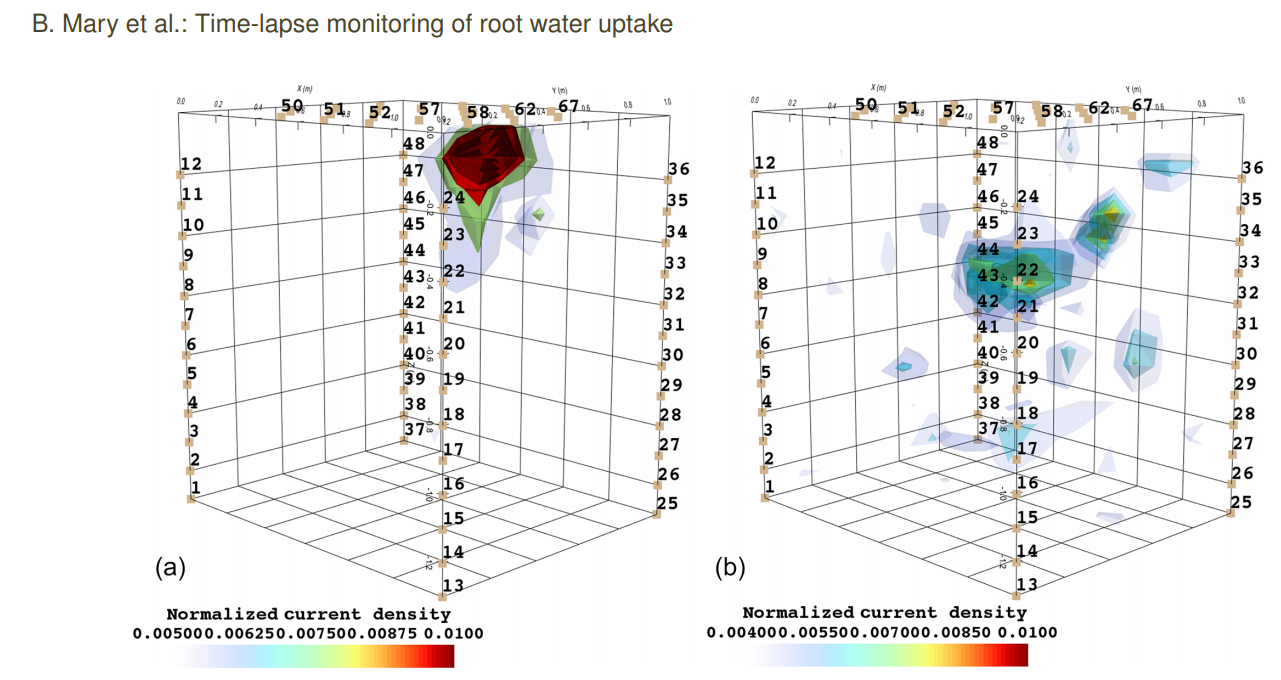


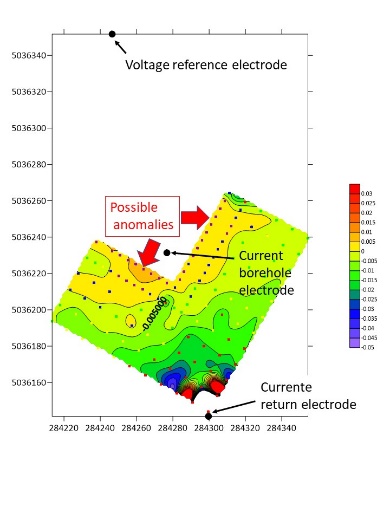
Figure 2: application of MALM on plants (ref Mary et al. 2020) and identifications of active roots areas after current inversion. The figure shows (a) the current distribution aftera single-source injection into the soil, (b) the current distribution for a stem injection. 

Figure 3: voltage distribution from field acquisition

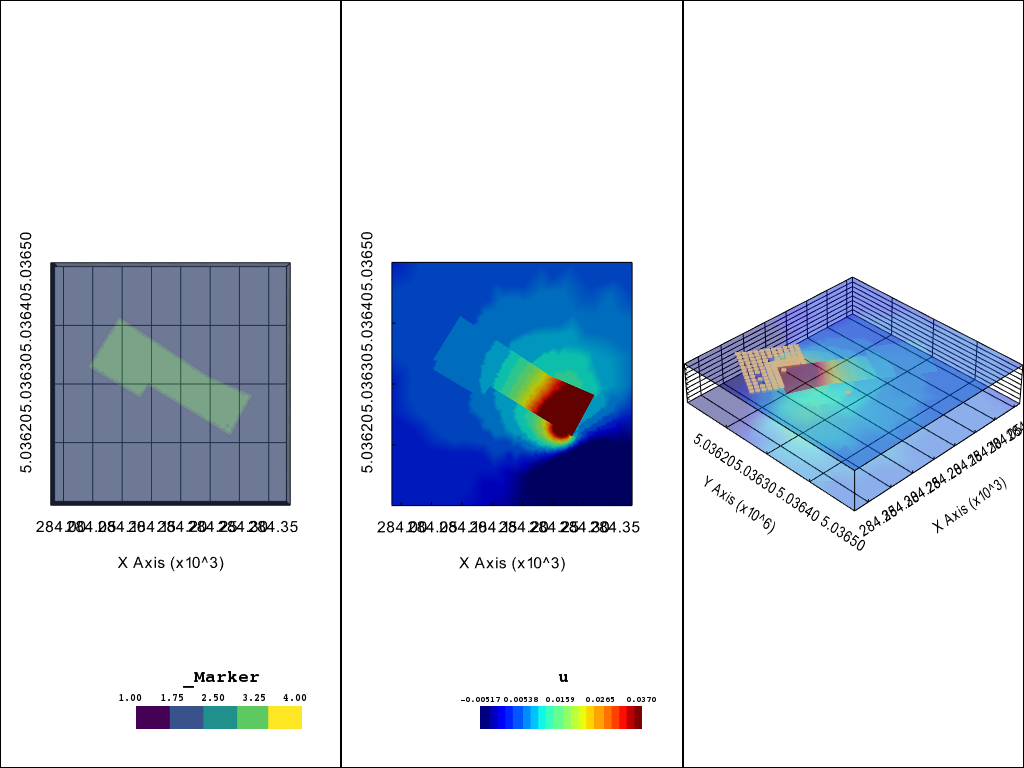
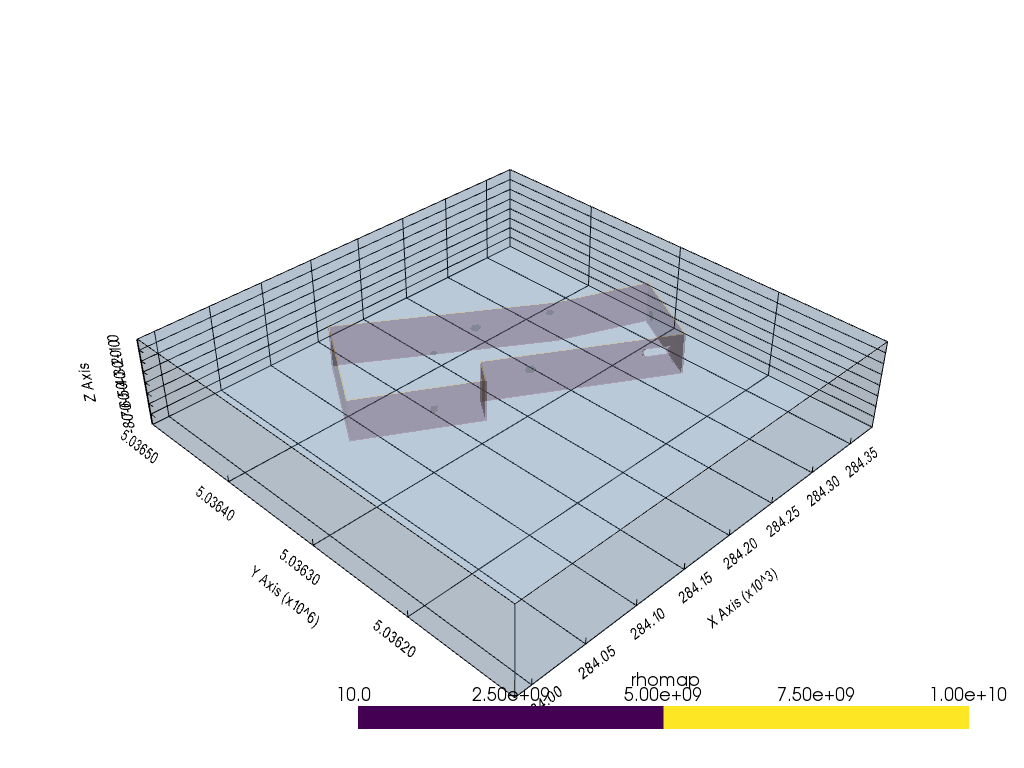


Figure 4: Application of the algorithm on a 3d landfill leakage (Landfill Porto Marghera). (a) initial map of resistivity showing the landfill delineation and the presence of a hole in the liner. (b) result of potential field u for the MALM simulation

Figure 5: Application of the algorithm on a 3d landfill leakage (Landfill Porto Marghera). Current density distribution: left without anomaly, right with anomaly.

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