Analysis of different treatments schemes of ERT dataset in view of monitoring the structure of a soil tilled layer in space

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2D images of electrical resistivity (ER) of soil do not provide directly relevant informations on soil structural variability. A reconstruction process leading on inversion techniques for imaging the spatial distribution of resistivity is required. However in heterogeneous media, noise in ER dataset can restrict inverse processing. In this work, we have tested several schemes of ER treatment to obtain an accurate modelling of the soil structure variability in 2D from resistivity. Our approach gathered 4 steps: from raw ER dataset measured in field, on a plot locally and artificially compacted by wheel traffic to the final ERT compared to a visual morphological profile (VMP) of soil structure. We discuss then on the impact of filtering, meshing implemented in inversion process and time lapse constraint on final ER results.

Material and method

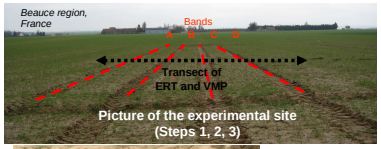
Site and in situ measurements

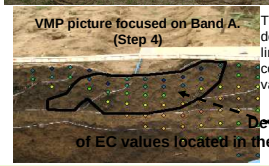
• **Step 1**: Compaction of 4 bands (A, B, C and D) by in-field wheel traffic at the soil field capacity (mass water content =23%)

• **Step 2**: 2D ERT perpendicular to the traffic direction.
ERT 14th april: reference model for time lapse method
ERT 11th June: ERT to be analysed
72 electrodes, spaced 10 cm apart, Wenner alpha array, Syscal Pro resistivity meter (IRIS Instrument). Resistivity (ER) expressed into conductivity (EC).

• **Step 3**: Description of the soil structure by VMP method at location of ERT. VMP picture and delineation of structural components.

• **Step 4**: Comparisons between in-field VMP picture and ERT results. Deviation coefficient of ERT values are given for structural zones delineated on VMP.

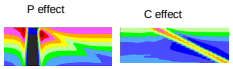




The compacted zone is delineated by the black line. Coloured dots corresponds to EC values after inversion.

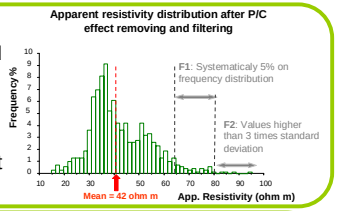
Filtering

• **F0: Systematic errors**
→ P and C effects due to faulty electrodes removed



• **F1: Outliers / frequency**
→ Distribution 5% of highest values removed

• **F2: Outliers/mean values**
→ Values higher than 3 times standard deviation removed (as suggested by Chilès et al. (1999) for asymetric frequency distibution)



Inversion (Res2Dinv software, Geotomo software. Loke and Barker, 1996)

Least-square smoothness constraint - Damping factor optimized (L-curve method) - Iterations stopped after 5 % of change in RMS

CONSTRAINT
• **Independent inversion**
•**Time lapse inversion**

MESHING

• **Normal mesh**
538 model blocks
720 apparent ER measured
Cell width= electrode spacing
10 % increasing cell length
→ Nodes between electrodes: 1
→ Inversion parameters < model cells

• **Refined mesh**
1692 model blocks
720 apparent ER measured
Cell width = ½ electrode spacing
10 % increasing cell length
→ Nodes between electrodes: 2
→ Inversion parameters > model cells

We have tested different schemes of treatment (filtering, meshing, inversion types) and analyzed their impact on 2D ERT results in term of soil structural variability. Faulty electrodes or/and voids, soils cracks can produce noise in ER dataset. Even if filtering is small, this last is required to facilitate convergence and to enhance the stability of inversion process.

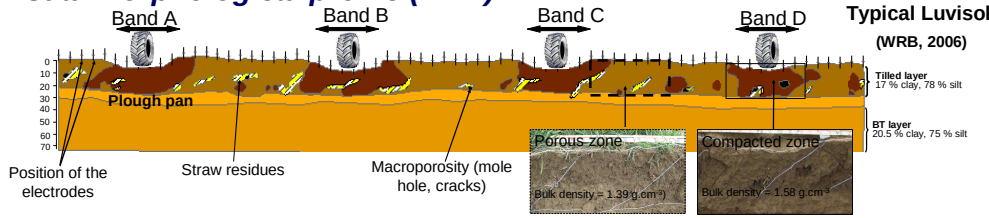
In addition better imaging of the soil structural variability is obtained when inversion is constrained (1) by a reference model obtained just after in-field compaction and (2) on a refined mesh. Further work would consist to test these schemes on ERT measured after in-field ploughing for which the soil structure is generally highly heterogeneous.

References

Loke, M.H., Barker, R.D., 1996. Rapid least-squares inversion of apparent resistivity pseudosections by a quasi-Newton method. Geophysical Prospecting 44, 131-152.
Chilès, J.P., Delfiner, P., 1999. Geostatistics Modeling Spatial Uncertainty. Wiley Series in Probability and Statistics

Results and discussion

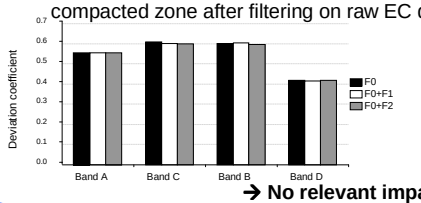
Visual morphological profile (VMP)



Compacted zones due to wheel tracks are clearly identified in the tilled layer on the VMP picture. We delineate also the plough pan at 30 cm depth and the BT layer.

Effects of filtering on inversion results

Deviation coefficients of modelled EC values sampled in the compacted zone after filtering on raw EC dataset.



Root mean square errors (RMSE, %) of inversions depending on filtering and meshing. after 7 iterations

Filtering + Meshing

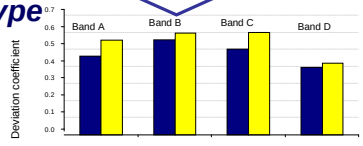
	Normal mesh	Refined mesh
F0	2.0	1.2
F0+F1	1.8	1.2
F0+F2	1.8	1.2

→ **No relevant impact of filtering and meshing on EC results.**

Inversions with F0+F2 filter and refined mesh

Effects of inversion type

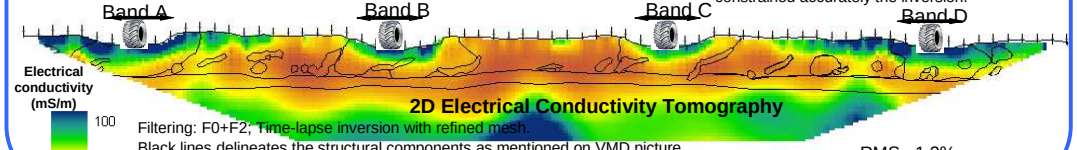
Deviation coefficients of modelled EC in the compacted zone after time-lapse and independant inversions



→ **Smallest deviation coefficients for time lapse EC results**

→**Time lapse inversion: sharply modelling of compacted zones.**

The reference ERT obtained just after compaction constrained accurately the inversion.



Filtering: F0+F2; Time-lapse inversion with refined mesh.
Black lines delineates the structural components as mentioned on VMD picture.

RMS= 1.2%

As expected, the most conductive zones correspond to the compacted bands. The plough pan is hard to identify.

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