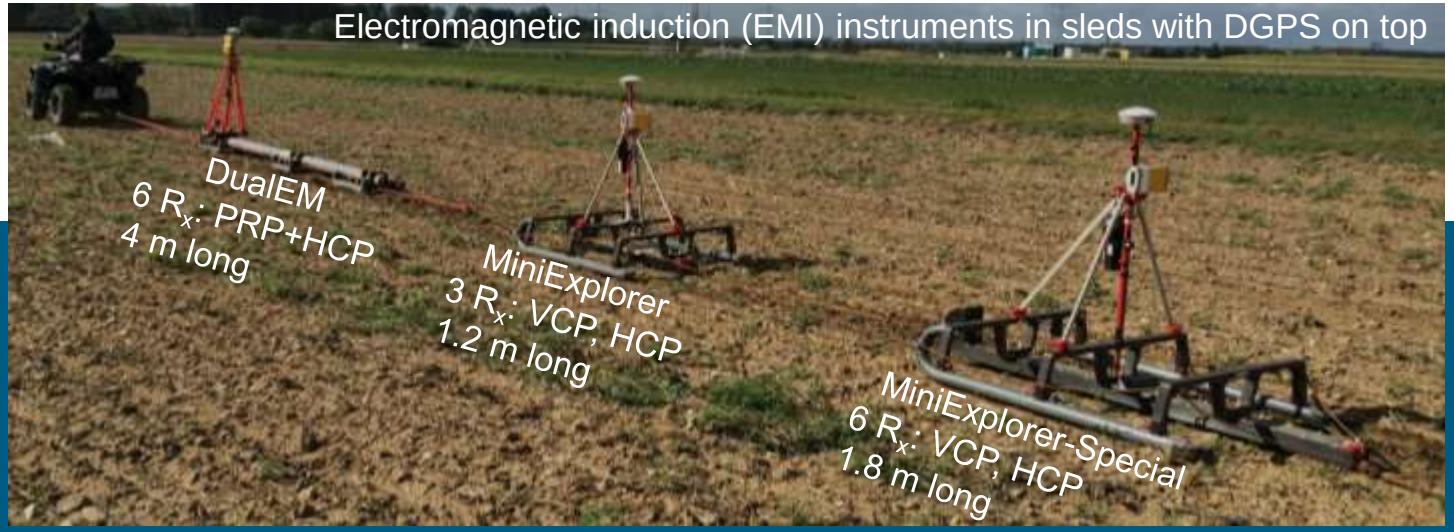
HELMHOLTZ GEMEINSCHAFT

JÜLICH FORSCHUNGSZENTRUM



Quantitative inversions of calibrated fixed-boom multi-coil EMI data

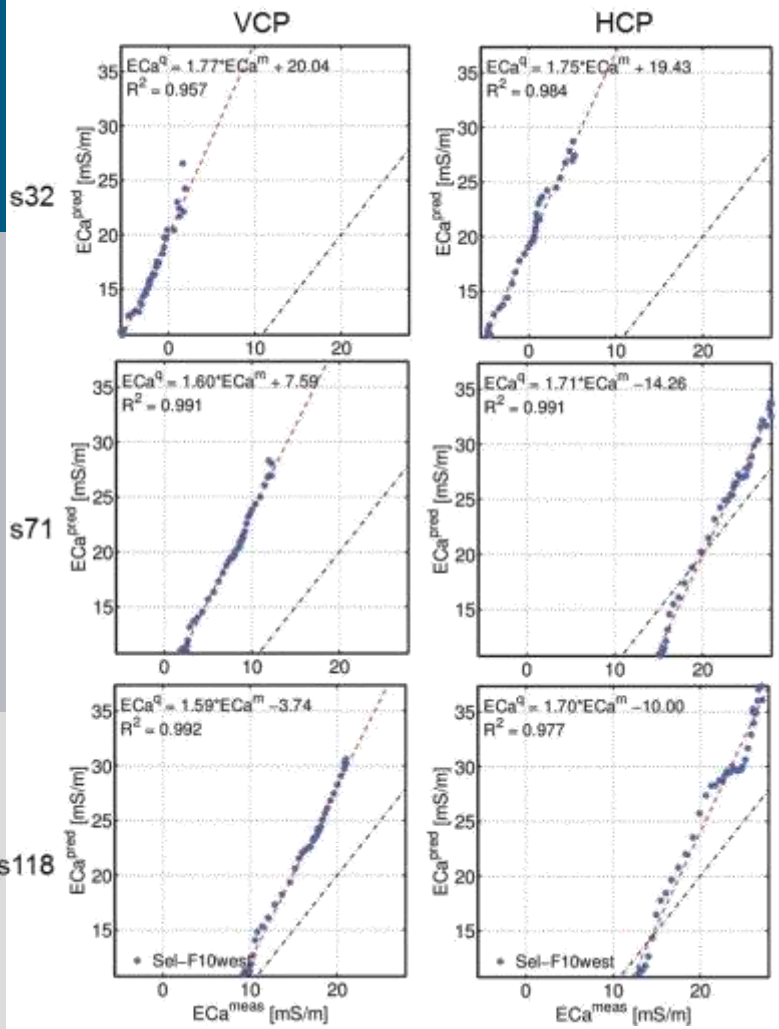
C. von Hebel, J. van der Kruk, A. Mester, M. Kaufmann, I. Dal Bo S. Huisman, C. Brogi, X. Tan, S. Rudolph, E. Zimmermann, H. Vereecken

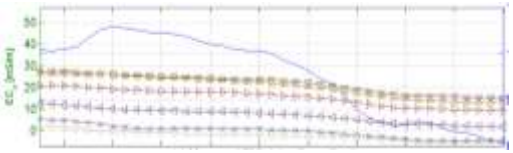
Institute of Bio- and Geoscience, Agrosphere, IBG-3

c.von.hebel@fz-juelich.de

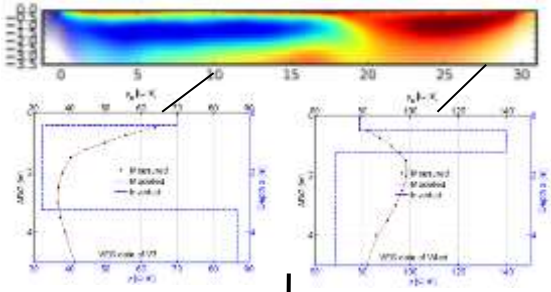
19. September 2017

Calibration of fixed-boom EMI data based on DC data





Multi-coil EMI data



exact EMI-FM

EC_a^{meas}

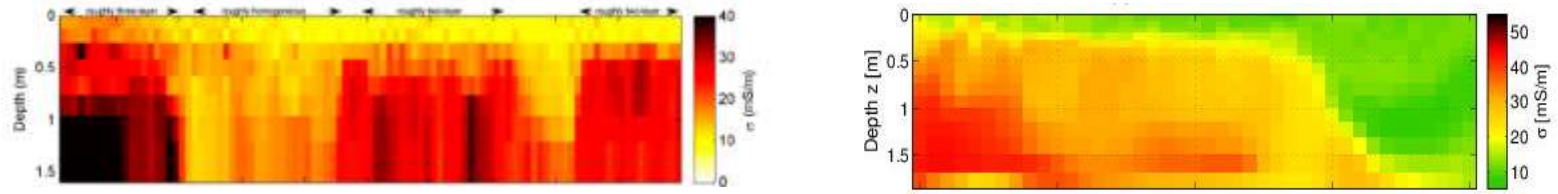
EC_a^{pred}

Linear regression

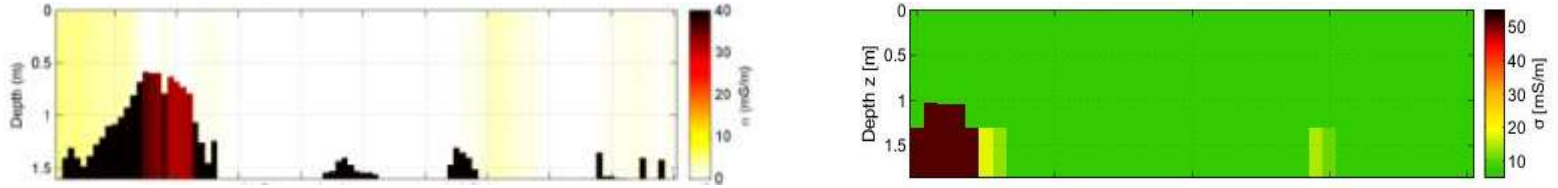
Calibration parameters

Quantitative and uncalibrated EMI data inversions compared to ERT reference along two transects

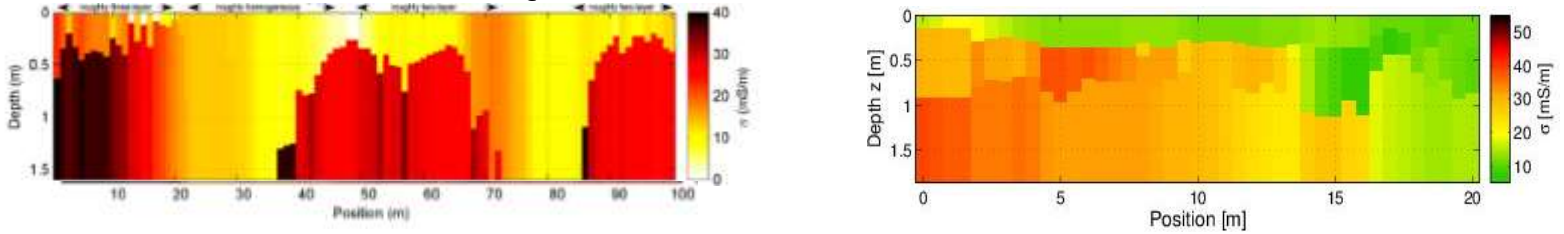
Reference ERT inversion



Uncalibrated EMI data inversion



Quantitative EMI data inversion

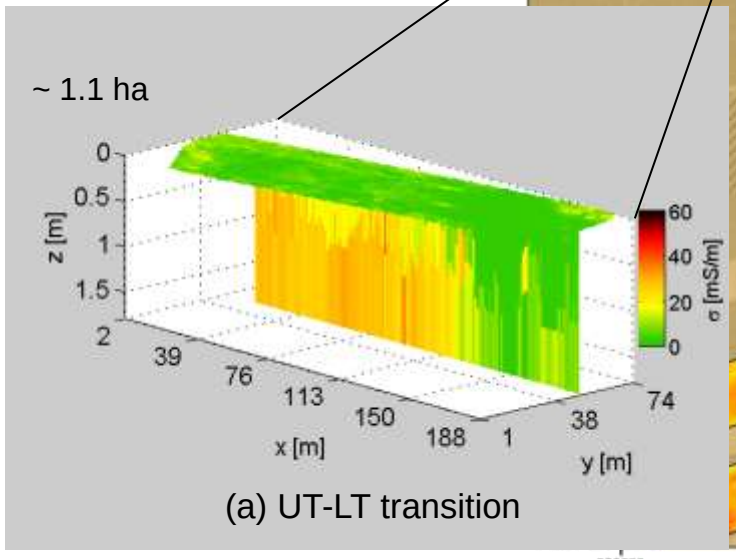


120 m transect: 2-layer inversion
EM 38: VCP&HCP, 100 cm offset, 14.6 kHz
Profiler: 122 cm offset, 8 &15 kHz
On-site calibrated systems
(Mester et al., VZJ 2011)

30 m transect: 3-layer inversion
Multi-coil CMD-MiniExplorer:
VCP&HCP, offsets: 32, 71, 118 cm offset, 30 kHz
Factory-calibrated system
(von Hebel et al., WRR 2014)

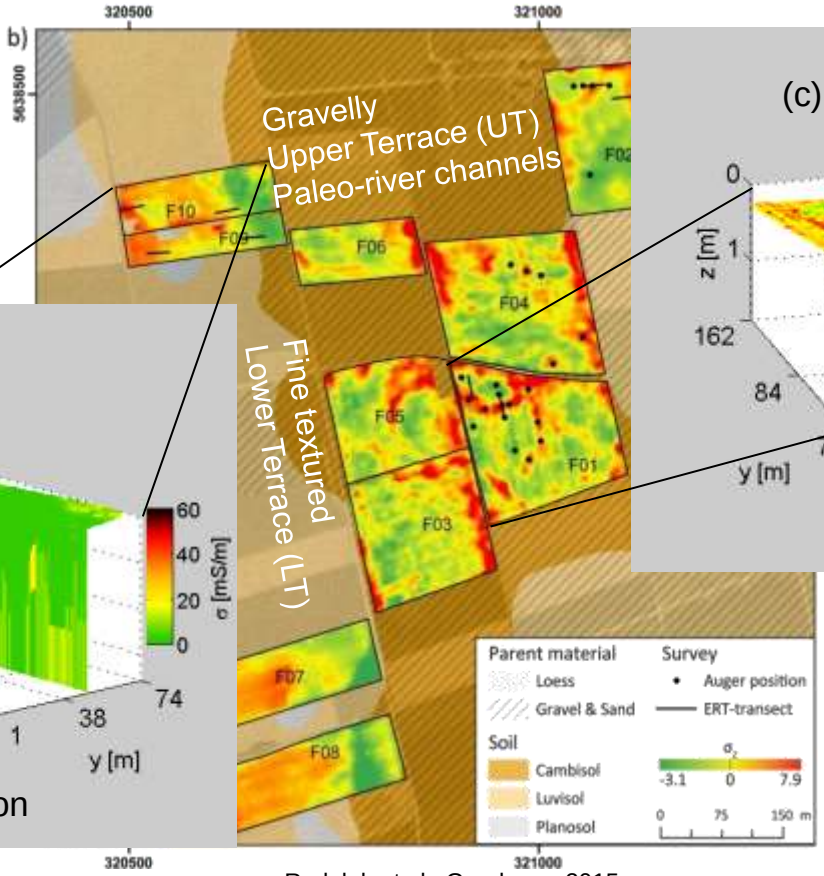
EMI data and quantitative quasi-3D inversions

Must:
Calibration of fixed-boom EMI data for reliable quantitative inversions.

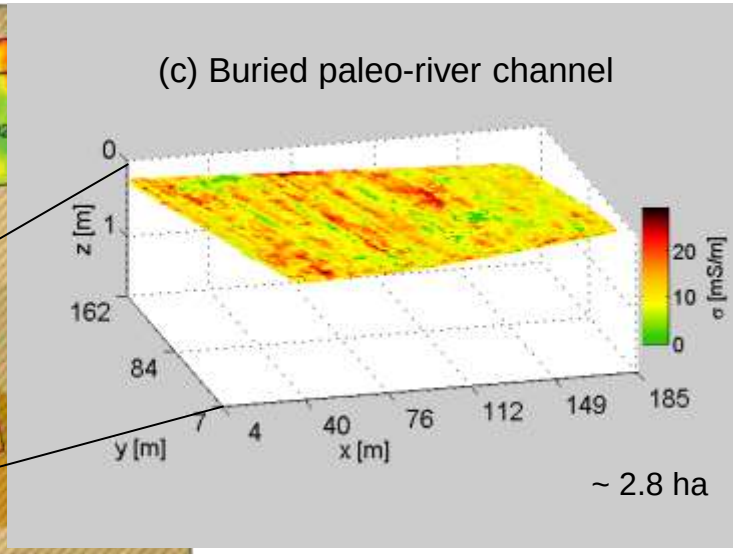


(a) UT-LT transition

von Hebel et al., WRR 2014



Rudolph et al., Geoderma 2015



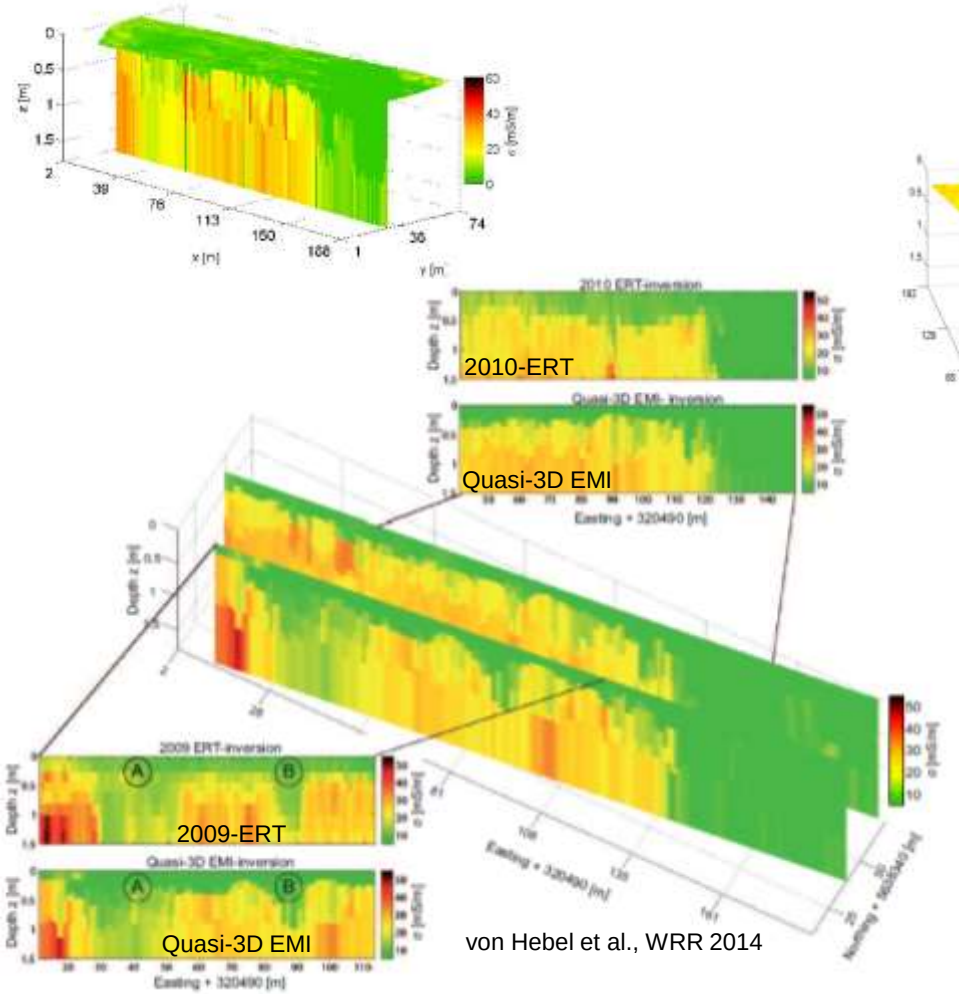
Inversion scheme:

*Shuffled complex evolution (SCE)**
- ✓ Global optimization (* Duan etal. 1996)
- ✓ L1-norm , no regularization --> Sharp layer boundaries

Exact Maxwell-based EMI forward model
- ✓ Horizontal layer
- ✓ No assumptions except quasi-static approximation

Validation and application of quantitative quasi-3D EMI data inversion

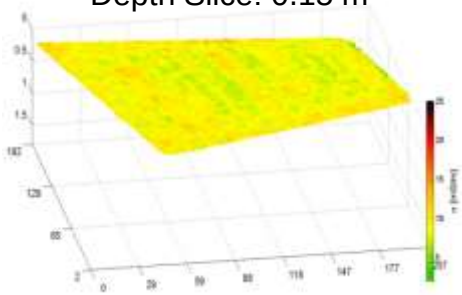
Validation at UT-LT transition field



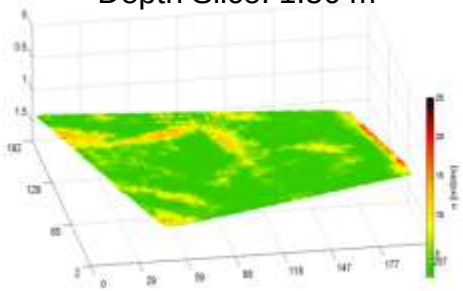
→ Quasi-3D EMI inversion obtains similar structures as previous ERT

Correlation of σ_i with soil texture and leaf area index (LAI)

Top-soil σ_1
Depth Slice: 0.15 m



Sub-soil σ_3
Depth Slice: 1.50 m



Property	R^2 of top-soil (σ_1 , property)	R^2 of sub-soil (σ_3 , property)
LAI	0.04	0.71
Sand	0.003	0.18
Silt	0.03	0.08
Clay	0.04	0.76

→ Quasi-3D EMI inversion result: buried paleo-river channel and not ploughing layer responsible for plant performance.

References and acknowledgements

- SFB/Transregio 32
- TERENO
- CROPSENSe
- ACROSS
- Jülich super-computer-center (JSC).

von Hebel, C. , S. Rudolph, A. Mester, J.A. Huisman, P. Kumbhar, H. Vereecken, J. van der Kruk. 2014.
Three-dimensional imaging of subsurface structural patterns using quantitative large-scale multi-configuration electromagnetic induction data, Water Resources Research, 50(3), 2732–2748.

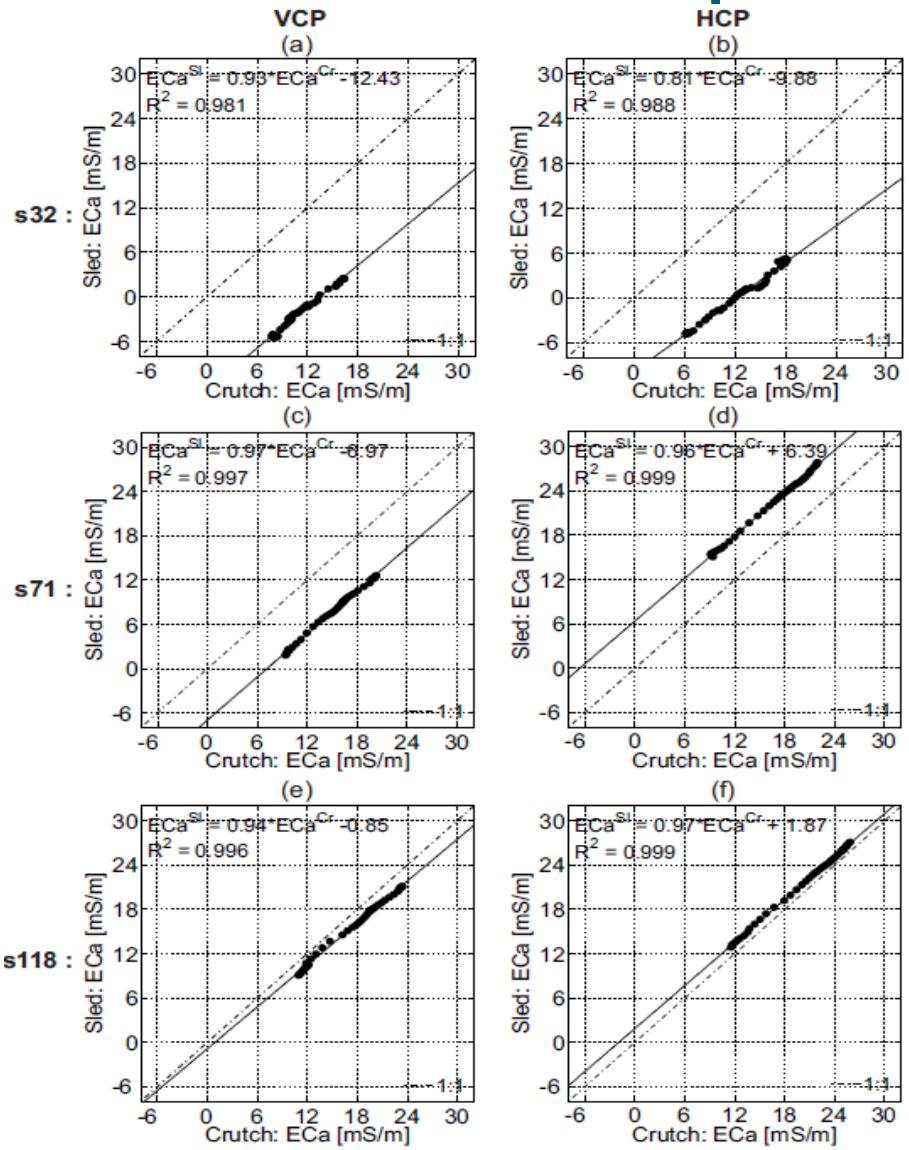
Rudolph, S. , J. van der Kruk, C. von Hebel, M. Ali, M. Herbst, C. Montzka, S. Pätzold, D.A. Robinson, H. Vereecken, L. Weihermüller. 2015.
Linking satellite derived LAI patterns with subsoil heterogeneity using large-scale ground-based electromagnetic induction measurements, Geoderma, *241*, 262-271.

Mester, A., J. van der Kruk, E. Zimmermann, H. Vereecken. 2011.
Quantitative two-layer conductivity inversion of multi-configuration electromagnetic induction measurements,
Vadose Zone Journal, 10(4), 1319-1330.

Lavoué, F., van der Kruk, J., Rings, J., André, F., Moghadas, D., Huisman, J.A., Lambot, S., Weihermüller, L., Vanderborght, J., Vereecken, H., 2010. Electromagnetic induction calibration using apparent electrical conductivity modelling based on electrical resistivity tomography.
Near Surf. Geophys. 8 (6), 553–561.

Duan, Q.Y. ,V. K. Gupta, S. Sorooshian. 1993.
Shuffled Complex Evolution Approach for Effective and Efficient Global Minimization, Journal of Optimization Theory and Applications, 76(3), 501-521

Influence of field setup on EMI measurements



Coil separation (s) [cm]	VCP ECa shift* [mS/m]	HCP ECa shift* [mS/m]
32	13	12
71	7	6
118	2	1

ECa shift = mean(abs(crutch-sled))