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


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Calibration of fixed-boom EMI data based on DC data

Multi-coil EMI data

\[ EC_a^{\text{meas}} \]

\[ EC_a^{\text{pred}} \]

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.

Inversion scheme:
- **Shuffled complex evolution (SCE)**
  - Global optimization
  - 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

Correlation of $\sigma_i$ with soil texture and leaf area index (LAI)

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

<table>
<thead>
<tr>
<th>Property</th>
<th>$R^2$ of top-soil ($\sigma_1$, property)</th>
<th>$R^2$ of sub-soil ($\sigma_3$, property)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAI</td>
<td>0.04</td>
<td>0.71</td>
</tr>
<tr>
<td>Sand</td>
<td>0.003</td>
<td>0.18</td>
</tr>
<tr>
<td>Silt</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>Clay</td>
<td>0.04</td>
<td>0.76</td>
</tr>
</tbody>
</table>

$\rightarrow$ Quasi-3D EMI inversion obtains similar structures as previous ERT

Quasi-3D EMI

von Hebel et al., WRR 2014
References and acknowledgements

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


Influence of field setup on EMI measurements

<table>
<thead>
<tr>
<th>Coil separation (s) [cm]</th>
<th>VCP ECa shift* [mS/m]</th>
<th>HCP ECa shift* [mS/m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>71</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>118</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

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