Monitoring of the saltwater/freshwater transition zone at Jever for groundwater quality assessment using the SAMOS system

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Objectives

1. contribution of geophysical data to structure and parameter models (e.g. Schneider et al. 2018)
2. observation of spatial and temporal changes of the saltwater/freshwater interface for groundwater quality assessment (e.g. Grinat et al.2019)
3. improvement in preinvestigation and monitoring analysis of SAMOS (Saltwater Monitroing System)
4. transfer of knowledge (Human Capacity Development)

Approach for best SAMOS localization

- regional scale:
  → airborne-EM (HEM) survey as base for coarse localization
- local scale:
  → single HEM flight line and 2D-ERT (electrical resistivity tomography) at area of interest for exact SAMOS localization
- depth range for SAMOS: → borehole geophysics
- installation of SAMOS system

Test-site and pre-investigation

test-site and profile location:

- north-west of Bremen at the Ems-Jade canal
- HEM resistivity data cover the whole coastal region
- concentration of installed chloride monitoring:
  → 30 m depth ≤20 mg/l
  → 55 m depth ≈ 450 mg/l (increasing)
- no spatial information (transition zone, horizontal changes)

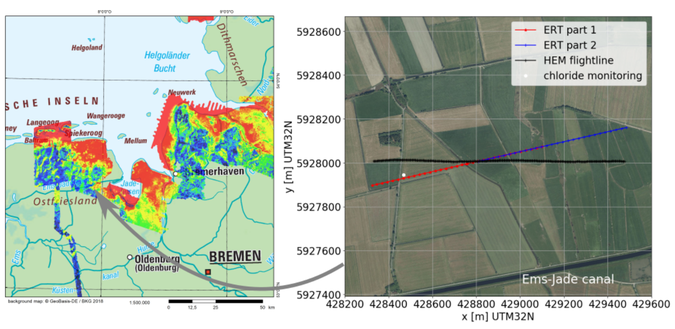

Fig. 1: Left: Resistivity map from HEM survey (Siemon et al. 2019), groundwater salinization marked red. Right: ERT pofiles, single HEM flight line and monitoring position.

pre-investigation:

- resolve lateral changes with HEM + ERT for better resolution
- flight line extracted from HEM → laterally constrained inversion (LCI) using pyGIMLi
- $\rho \approx 12\,\Omega$m saltwater intrusion (yellow part in HEM and ERT results)

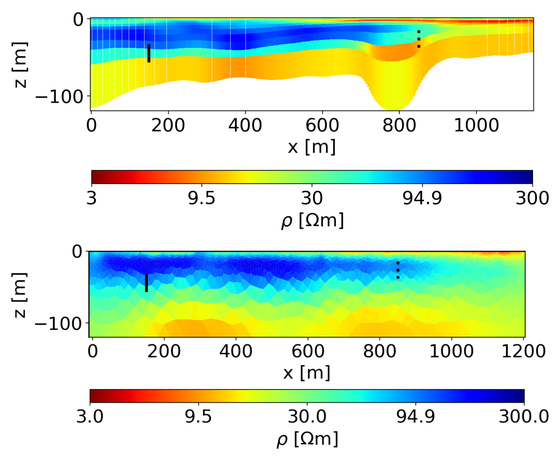

Fig. 2: Top: HEM and bottom: ERT inversion result. The black line marks the SAMOS position.

SAMOS monitoring system

Details:

- SAMOS is a vertical electrode chain permanently installed (filled open borehole)
- 80 ring-electrodes with d_{elec}=5 cm and h_{elec}=2 cm and 11 temperature sensors
- 20 m long electrode part with 0.25 m electrode spacing
  → larger spacing possible if larger transition zones appear

Monitoring:

- SAMOS installed in depth range of 35 - 55 m
- started in December 2018
- one measurement per day with Wenner-α and dipol-dipole configuration
- geologic information show a 1 m thick clay layer at 44 m depth surrounded by sand
- influences due to drilling process most dominant in first depth level

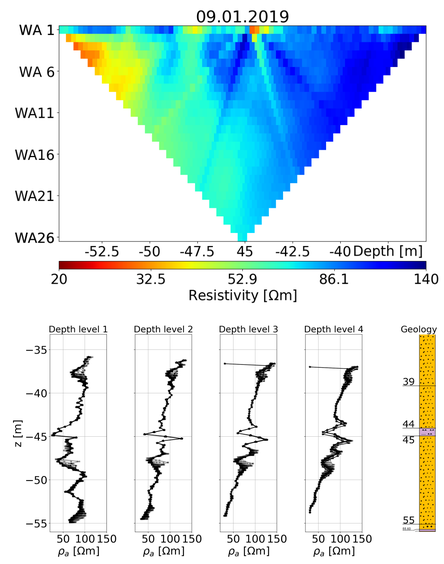

Fig. 3: Pseudosection of a Wenner-α configuration (top) and all timesteps for the first four depth levels (bottom).

Data inversion

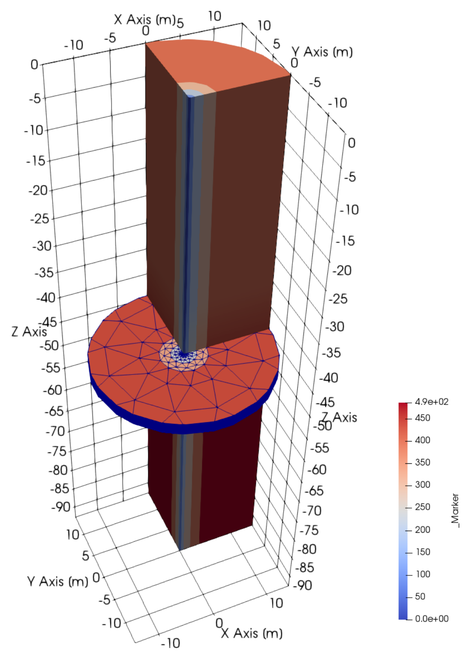

Fig. 4: FE-mesh example used for inversion.

Inversion:

- buried electrodes along a line:
  - ▷ cylindersymmetrical FE-mesh needed
  - ▷ marker change along z-direction but kept constant horizontally
  - ▷ cylindrical slices to allow horizontal resistivity variations
- electrode chain is insulator → hollow-cylinder
- ring-electrodes incorporated with CEM (Complete Electrode Model, Rücker & Günther (2011))
  → possible to model true geometry of electrodes
- mesh generation and inversion done with pyBERT and pyGIMLi

Interpretation:

- resistivity anomalies in the center caused by drilling process
  → expected to disappear in the future
- low resistive anomaly in the center at 44 m depth corresponds to a clay lense (Geologic information in Fig.3)
- freshwater/saltwater-transition zone at 40 - 52 m depth

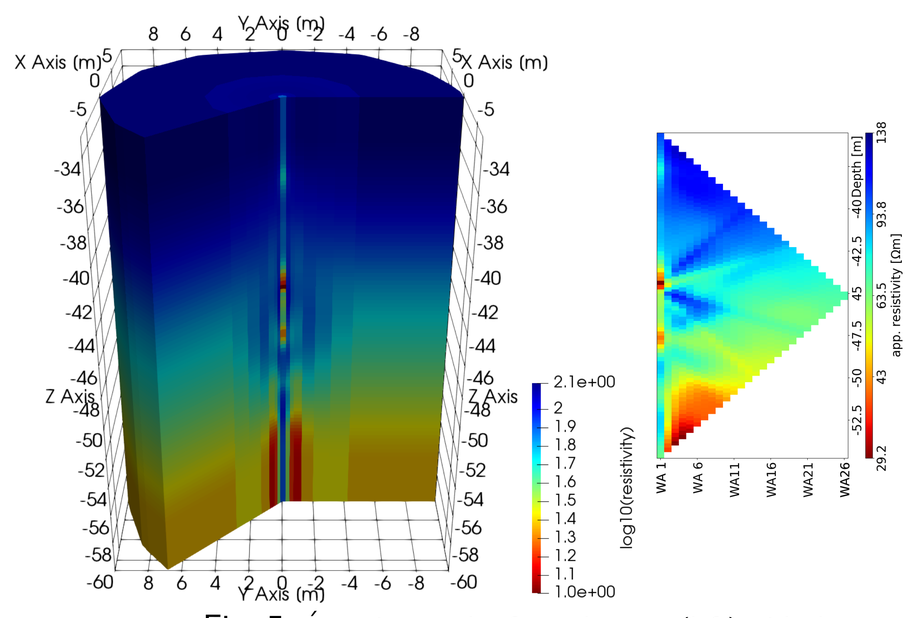

Fig. 5: Inversion result of one data-set (left) with the corresponding forward response (right).

To Do

1. further improvement of HEM inversion
2. installation of second monitoring system until mid 2019
   → spatial temporal observation of freshwater/saltwater transition zone
3. combination with surface based measurements (ERT)
4. half automated time-series processing
5. stable timelapse inversion

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