Improved hydrogeophysical imaging with ERT using direct push as prior data and geostatistics

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Motivation

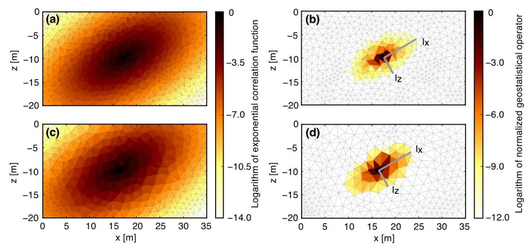
- Resistivity as proxy for salinity
- Electrical Resistivity Tomography (ERT) as efficient 2D imaging method
- Ambiguity of inversion results due to limited resolution and data quality (smoothness constraint problem)
- Direct push (DP) data are accurate point data that often contradict ERT inversion results

Idea

- apply DP data as (error-bearing) measurements in a joint inversion
- use DP-based geostatistics for regularization operator

Geostatistical Regularization

Correlation matrix (left) including anisotropic ranges Ix/Iz with arbitrary angle leads to extended smoothness operator (right) that independent on mesh discretization (Jordi et al. 2018)

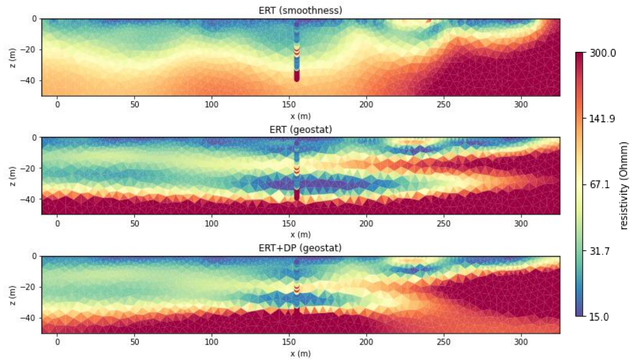


Incorporate Direct push data

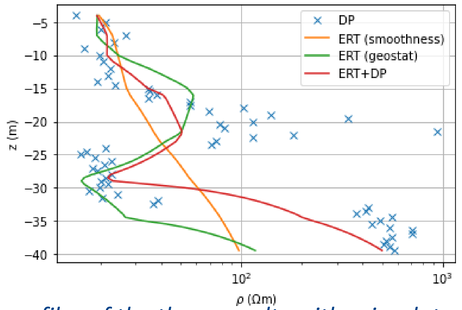
Use DP as data with errors in joint inversion *pyGIMLi*: combine *ERTModelling* with *PriorModelling* with *JointModelling framework*

Simple example

Investigation of bedrock above sand/clay layer interbedding
Wenner/Schlumberger a=5m ➔solves thin-layer problems



Inversion result with classical smoothness, geostatistical regularization (Ix/Iz=50/5m) and with DP data.



Depth profiles of the three results with prior data.

References

Jordi et al. (2018): Geostatistical regularisation operators for geophysical inverse problems on irregular meshes. GJI 213, 1374-1386, doi:10.1093/gji/ggy055.

Rücker et al. (2017): pyGIMLi: An open-source library for modelling and inversion in geophysics, Comp. & Geosc. 109, 106-123, doi:10.1016/j.cageo.2017.07.011.

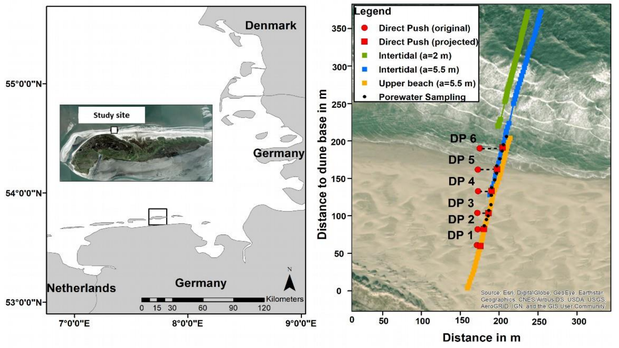
Test site and experimental setup

Research unit DYNADEEP investigates processes at dynamic beaches on Spiekeroog

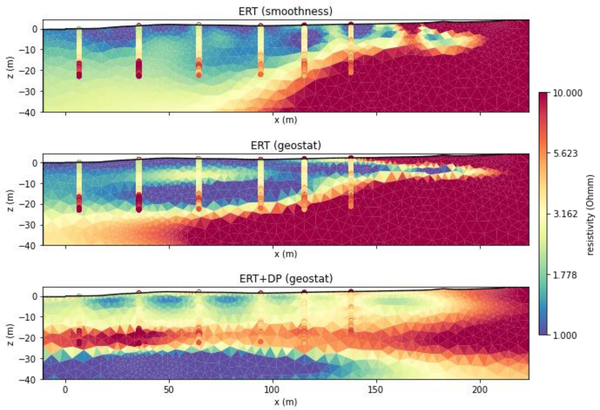
- main thesis: salinity dynamics is driven by changing beach morphology & stormfloods
- Regular (6-week) ERT & DP monitoring
- SAMOS station for continuous monitoring

Data:

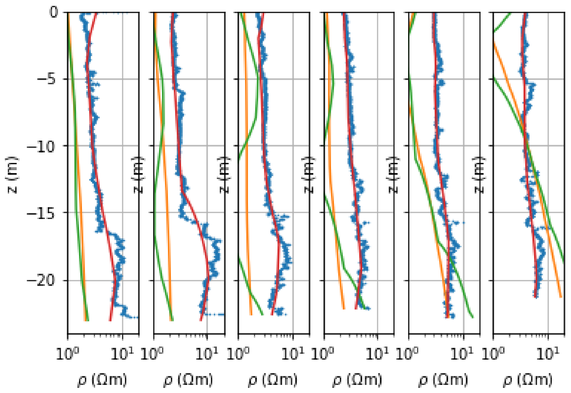
- a=5m profile at the high water line
- six DP soundings up to depths of 20m
- ERT data of rather poor data quality
- variogram analysis Iz=8m, Ix=70m guess



Location of test site (left), ERT profiles & DP points (right).



Result of smoothness, Ix/Iz=70/8m & with DP data.



Depth profiles of the three results with prior data.

Interpretation

- freshwater discharge below saltwater
- classical smoothness completely misses DP
- even geostatistics yields wrong depth
- combination reveals saltwater wedge

Conclusions

- geostatistics is superior to smoothness
- variogram allows proper regularization
- DP data significantly enhance ERT images
- simple implementation in pyGIMLi