# Investigation of a coastal freshwater aquifer in Belgium:

## Joint Inversion of Differential Electrical Dipole Data and Transient Electromagnetic Data

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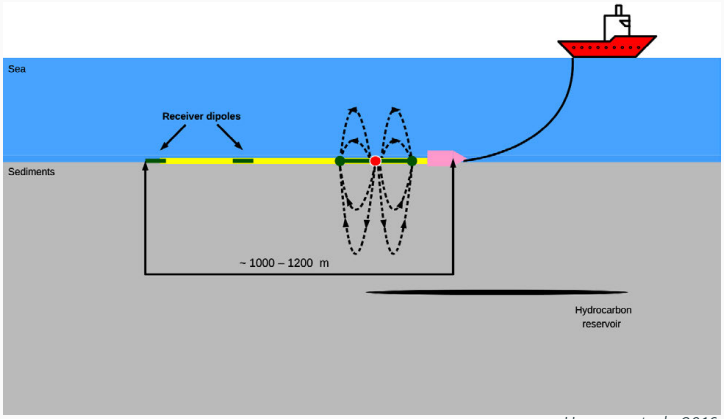
## Introduction - Differential Electrical Dipole

- Application for shallow marine environments
- Double dipole system, sharing common central electrode
- Enhanced lateral resolution for 2D structures *[Haroon, 2016]*
- Conditions
  - coupling of electrodes
  - equal current amplitudes




*Haroon et al., 2016*

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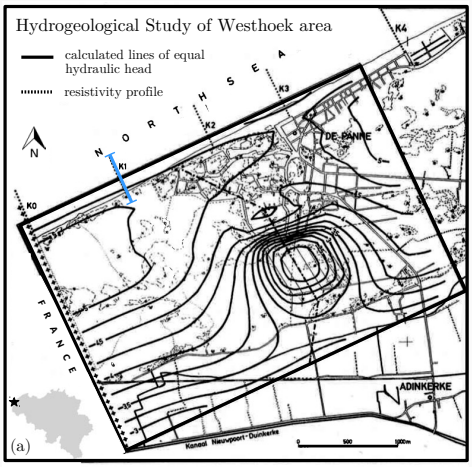
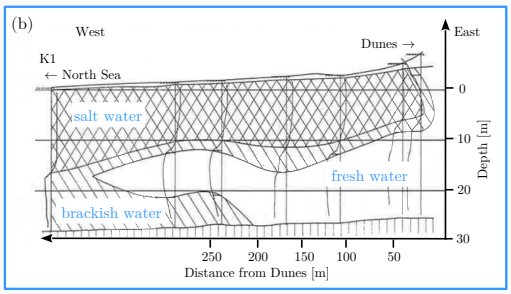
## Introduction - Motivation

- Feasibility study for newly developed `Differential Electrical Dipole` method in combination with `Transient Electromagnetic`




*(a), (b) modified after Lebbe, L., 1981*

- Development & Application of `joint inversion` to improve the subsurface resistivity model by including resolution of TEM and DED

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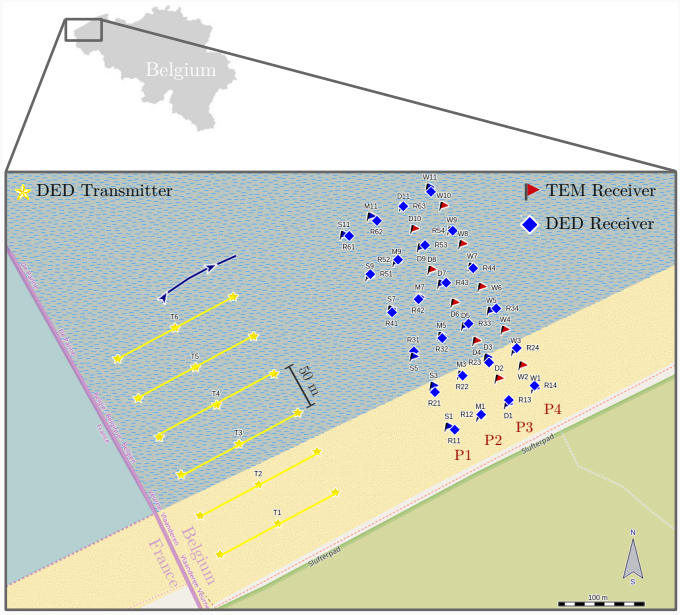
## field survey

## Field Survey - Study Area in de Panne




- 2 measurement campaigns in Nov 2016
- DED
  - 6 Transmitter locations
  - 24 $E_r$ stations
- TEM
  - 40 $\dot{B}_z$ stations

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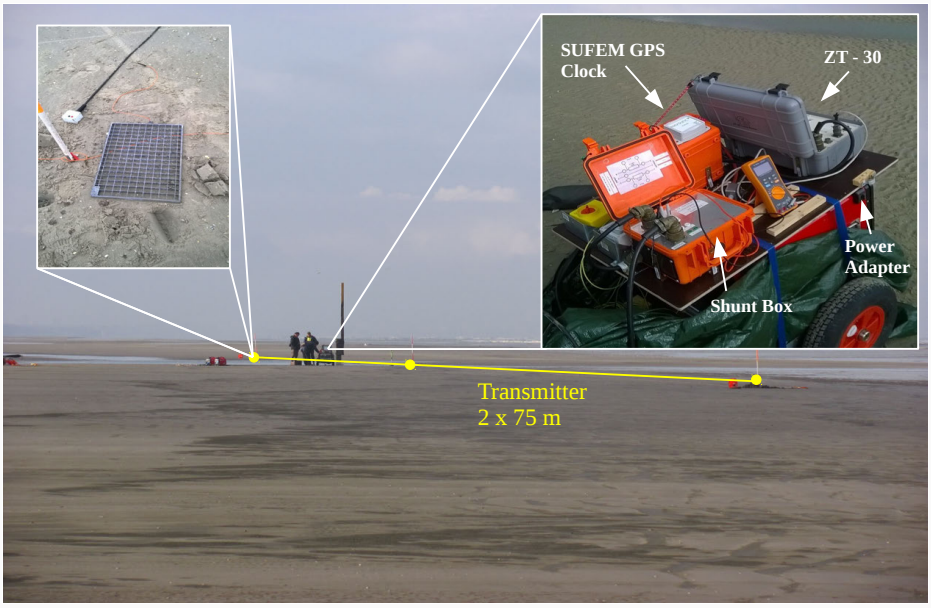
## Field Survey - DED Application

Transmitter Site

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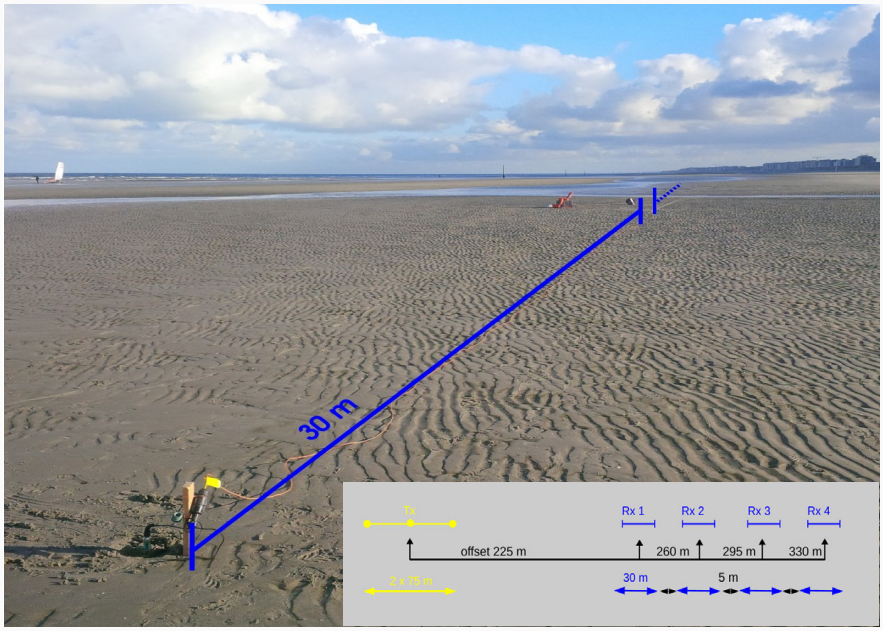
## Field Survey - DED Application

Receiver Site

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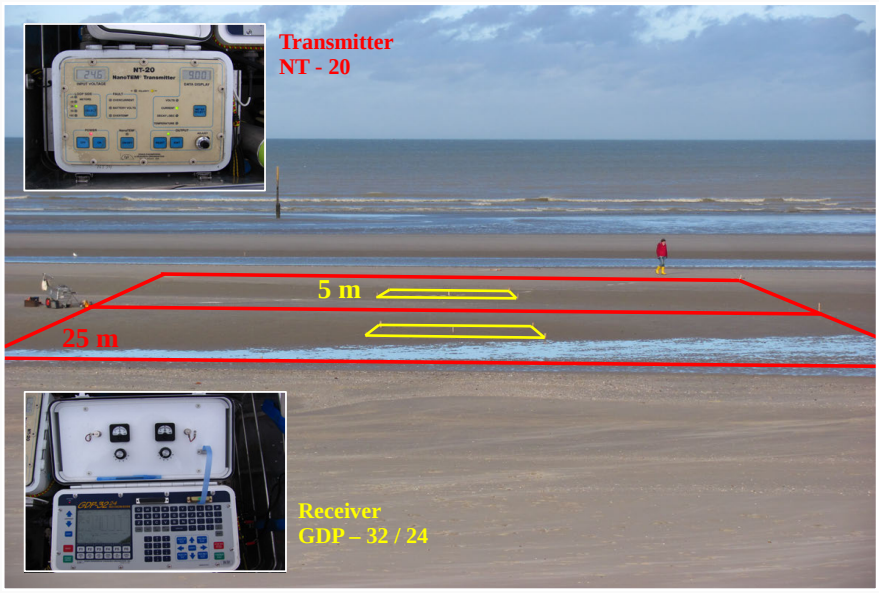
## Field Survey - TEM Application

Loop by loop measurements

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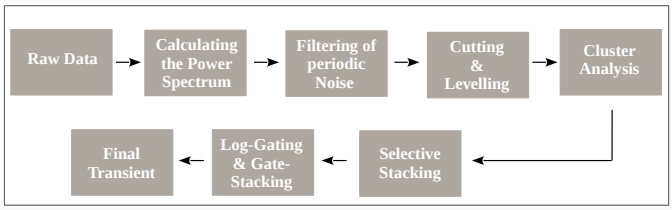
## data processing

## DED Processing

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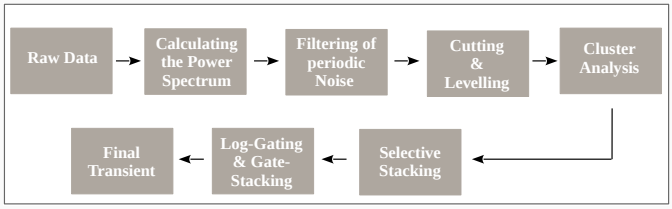
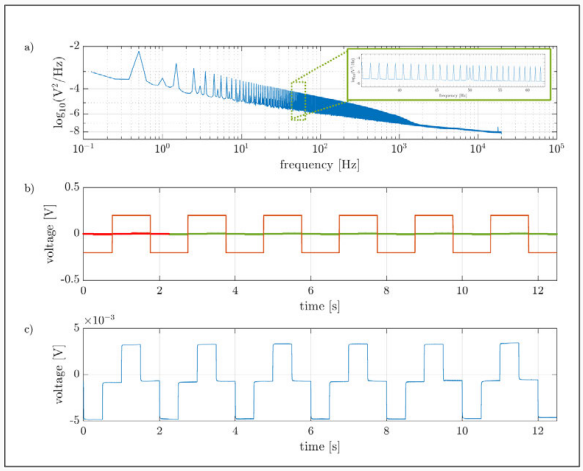
## DED Processing

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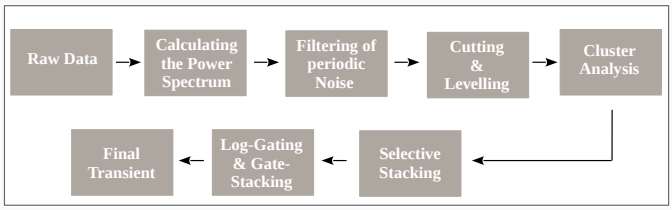
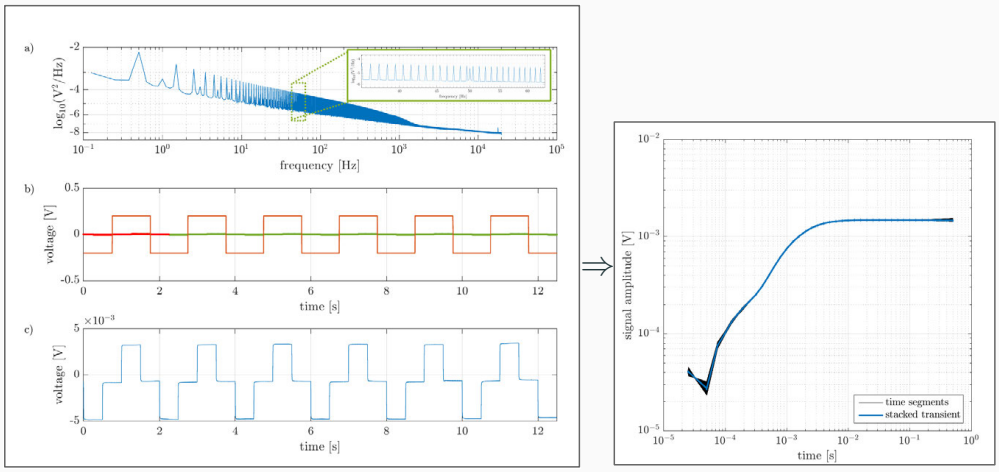
## DED Processing

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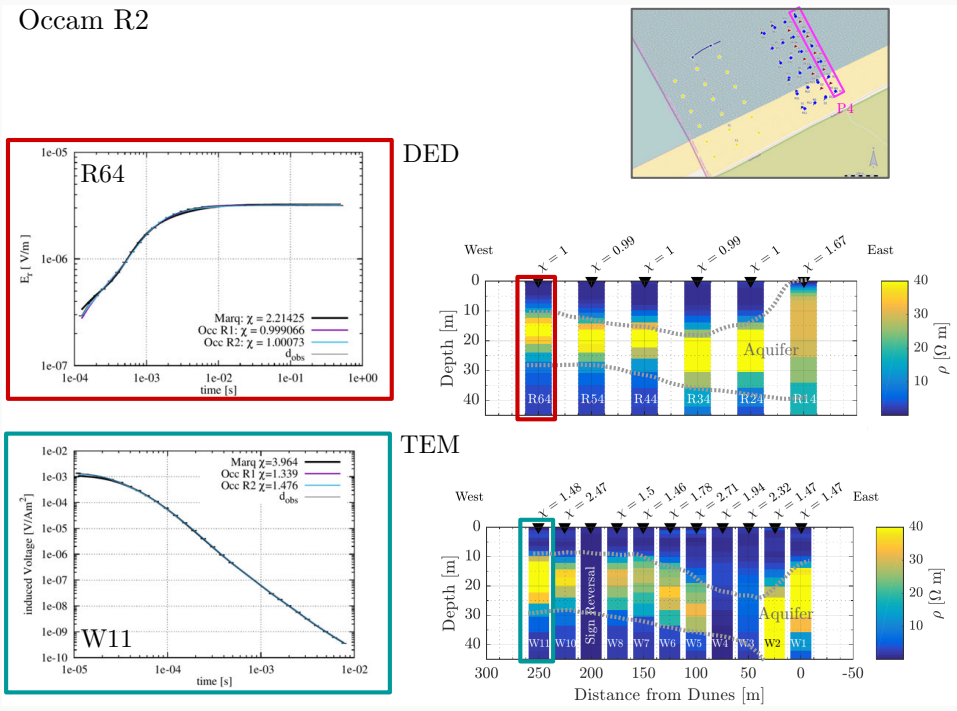
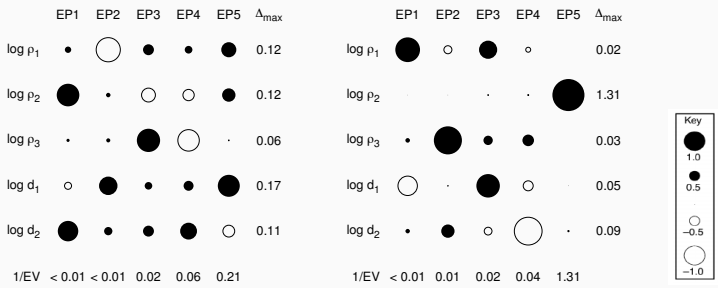
## 1d inversion results

## 1D Inversion Results - Data Fit of Profile 4



## 1D Inversion Results - Resolution Analysis




*a) DED, Station R64* *b) TEM, Station W11*

- SVD of weighted Jacobian matrix $\mathbf{J} = \mathbf{USV}^T$
- Model Parameter Combination:
  - **DED**: $\rho_2 \cdot d_2$
  - **TEM**: $\rho_1 / d_1$

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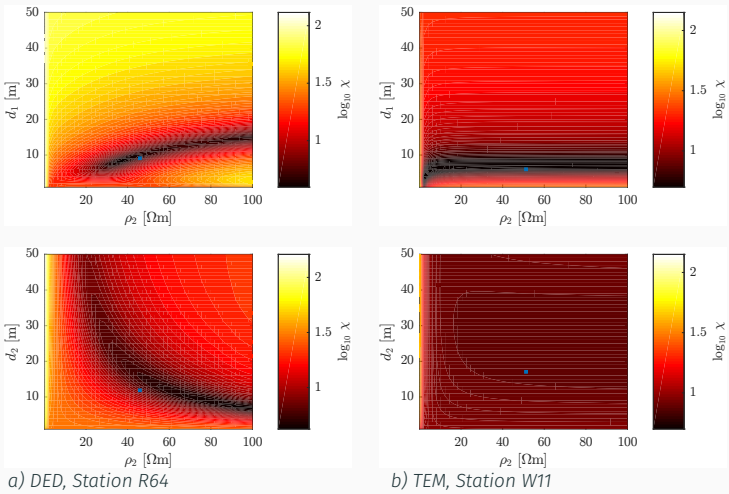
## 1D Inversion Results - Model Parameter Variation




*a) DED, Station R64* *b) TEM, Station W11*

$\rho_2$ - $d_1$ equivalence domain

- **DED** long & narrow
- **TEM** longer & narrow

$\rho_2$ - $d_2$ equivalence domain

- **DED** longer & narrow
- **TEM** complete coverage

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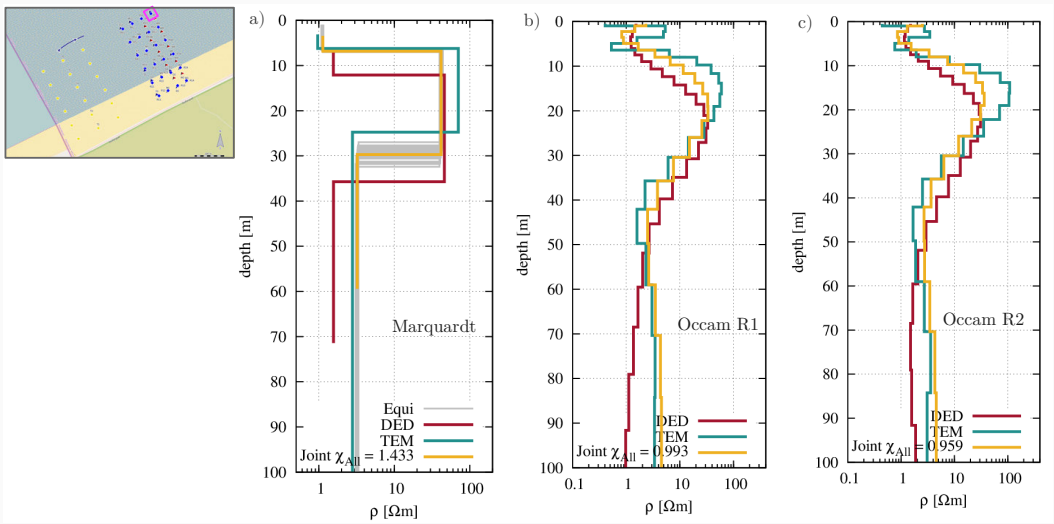
## 1d joint inversion

## 1D Joint Inversion Result - DED, TEM and Joint

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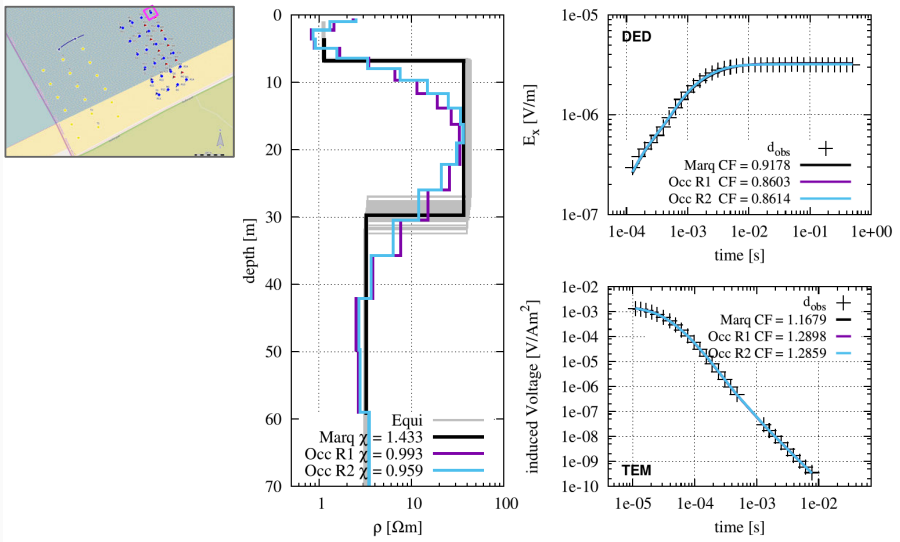
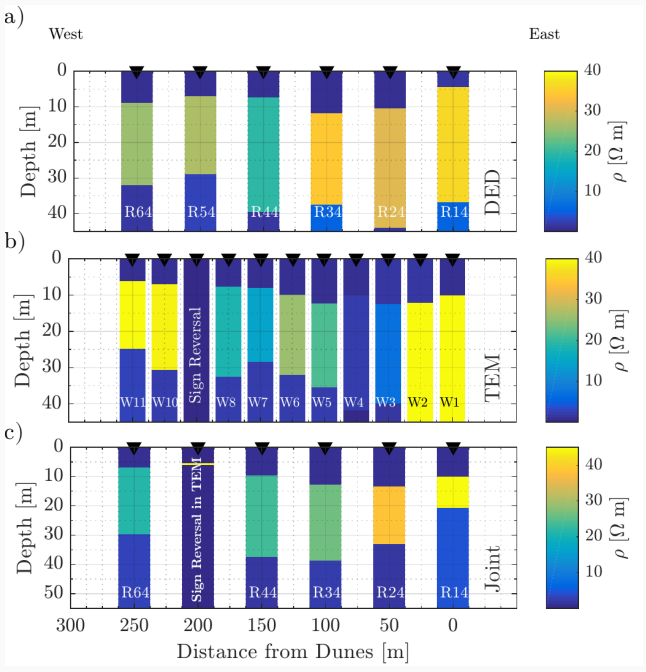
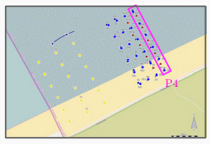
## 1D Joint Inversion Result - Data Fit of Station R64





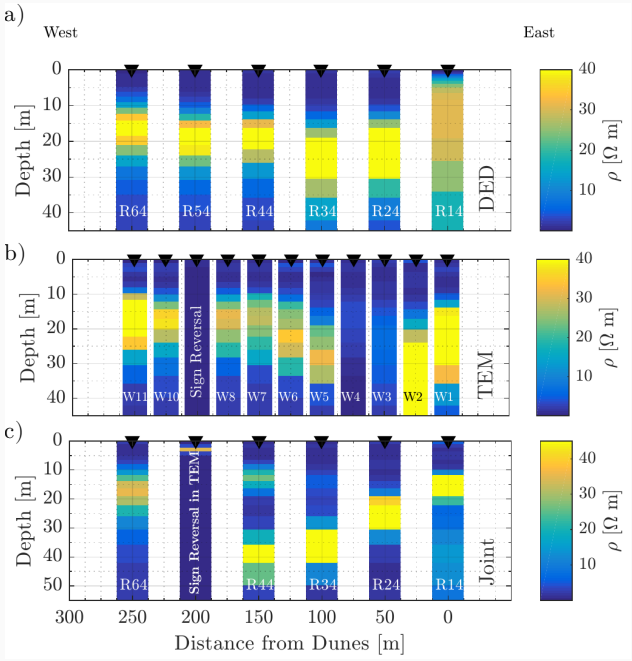

## 1D Joint Inversion Result - Comparison of Marquardt Models

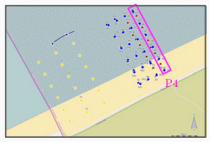


- Resistivity
  - $\rho_{Aquifer} > 20\,\Omega$m
  - East: resistive
  - West: less resistive
- Depth Range
  - **DED** → 6 - 42 m
  - **TEM** → 8 - 46 m
  - **Joint** → 8 - 38 m

## 1D Joint Inversion Result - Comparison of Occam R2 Models



- Depth Range
  - **DED** → 12 - 35 m
  - **TEM** → 10 - 45 m
- Thickness Range
  - **Joint** → const thickness of 10 m

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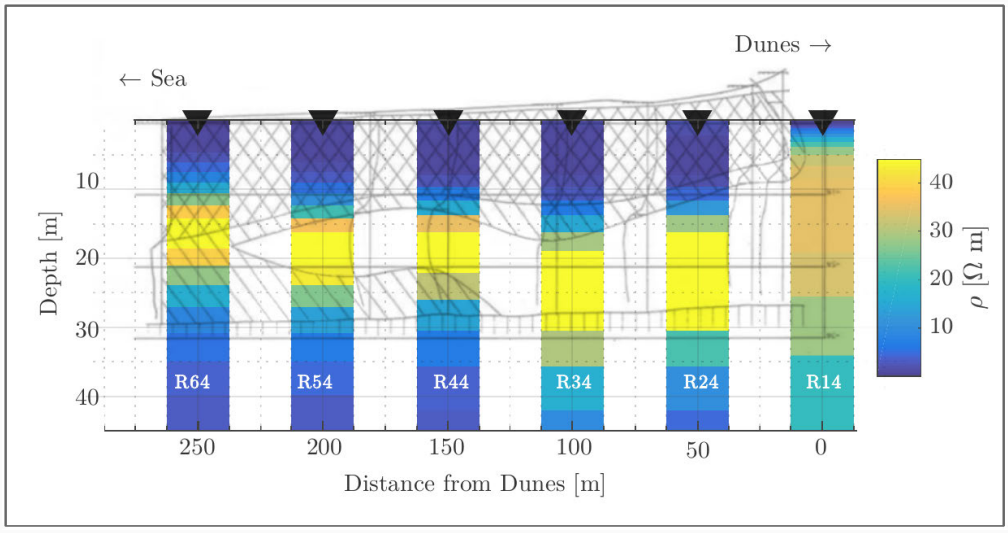
## Comparison

Hydrogeological Study vs DED Occam R2 result

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conclusion

## Conclusion

→ First land - based DED application
→ Indication of depth and thickness of the aquifer with DED & TEM
→ DED: sensitivity towards resistive aquifer layer
→ Joint Inversion
  ▷ Development of 1D joint inversion algorithm

  Freshwater Aquifer

  ▷ Decrease in thickness
  ▷ Resistivity consistent with DED

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Thank you for your attention!