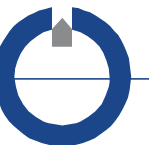


Hvor er vi på vej hen?

Anders Vest Christiansen, Line Meldgaard Madsen, Gianluca Fiandaca, Kim Engebretsen, Anders Kühl, Rizwan Asif, Adrian Barfod, Andy Kass, m.fl.

HydroGeophysics Group, Department of Geoscience, Aarhus University, Denmark



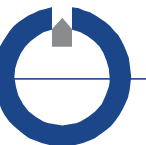
Forskningsfokus

- **Metoder:**

- DCIP
 - Cross-borehole
- NMR/MRS
 - Overfladenær
- TEM
 - tTEM
 - FloaTEM
 - SnowTEM
 - SoilTEM?
- MAG
 - tMAG

- **Numeriske udviklinger**

- 2D og 3D EM
 - Tæt kortlægning
 - Komplex geologi
- 3D DCIP
 - Cross-borehole
- Time-lapse
 - Tidsvarierende processer
- ANN / AI / Deep learning
 - Automatisk processering
 - Automatisk inversion



Forskningsfokus

- **Metoder:**

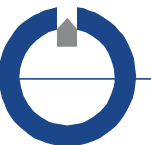
- DCIP
 - Cross-borehole
- NMR/MRS
 - Overfladenær
- TEM
 - tTEM
 - FloaTEM
 - SnowTEM
 - SoilTEM?
- MAG
 - tMAG

- **Anvendelser:**

- Forurening (flade og punkt)
- Hydrologi på land og til vands
- Råstoffer
- Arkæologi
- Mineraler (udland)

- **Numeriske udviklinger**

- 2D og 3D EM
 - Tæt kortlægning
 - Komplex geologi
- 3D DCIP
 - Cross-borehole
- Time-lapse
 - Tidsvarierende processer
- ANN / AI / Deep learning
 - Automatisk processering
 - Automatisk inversion



Forskningsfokus

• Metoder:

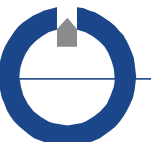
- DCIP
 - Cross-borehole
- NMR/MRS
 - Overfladenær
- TEM
 - tTEM
 - FloaTEM
 - SnowTEM
 - SoilTEM?
- MAG
 - tMAG

• Anvendelser:

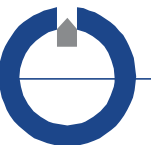
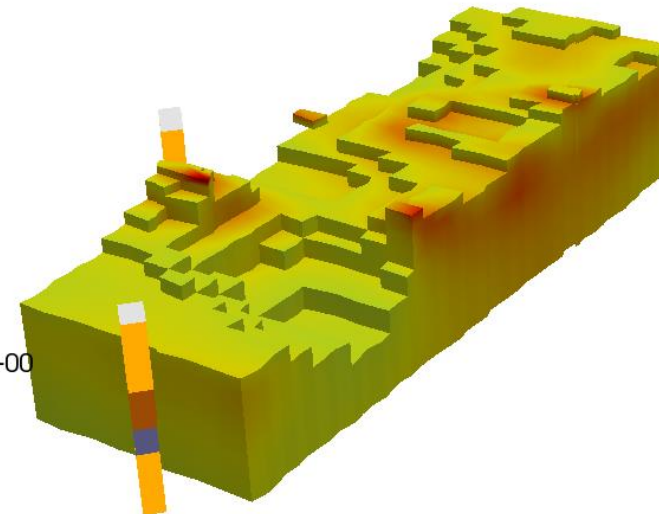
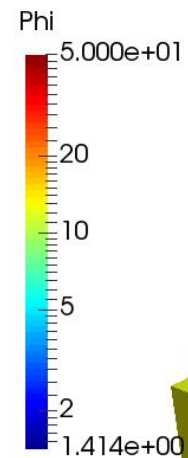
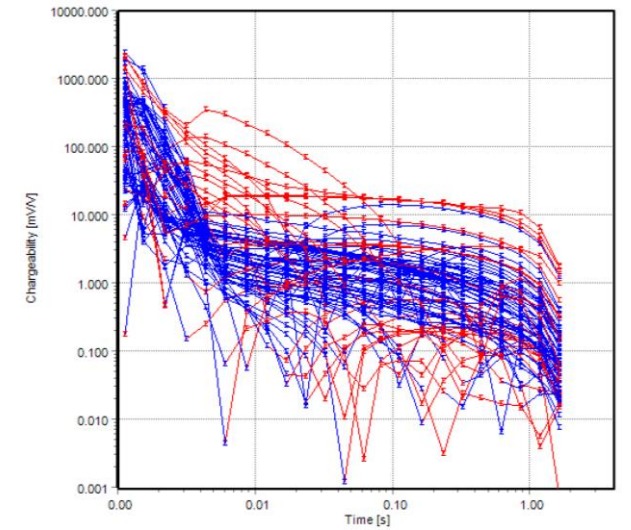
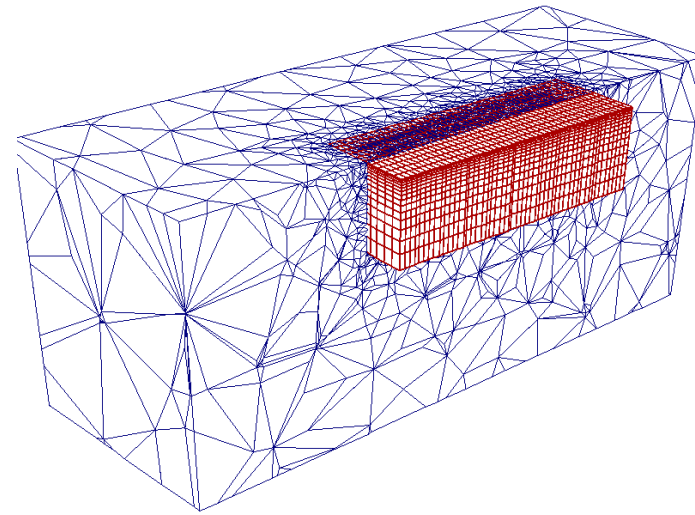
- Forurening (flade og punkt)
- Hydrologi på land og til vands
- Råstoffer
- Arkæologi
- Mineraler (udland)

• Numeriske udviklinger

- 2D og 3D EM
 - Tæt kortlægning
 - Komplex geologi
- 3D DCIP
 - Cross-borehole
- Time-lapse
 - Tidsvarierende processer
- ANN / AI / Deep learning
 - Automatisk processering
 - Automatisk inversion

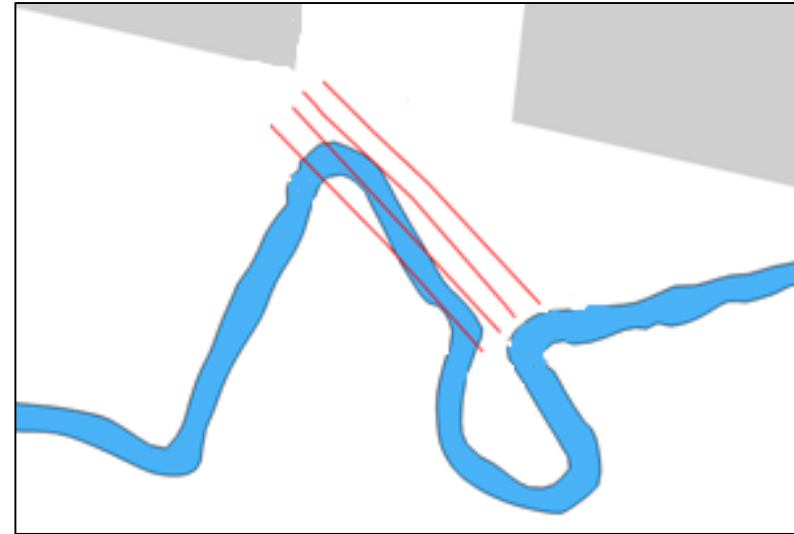
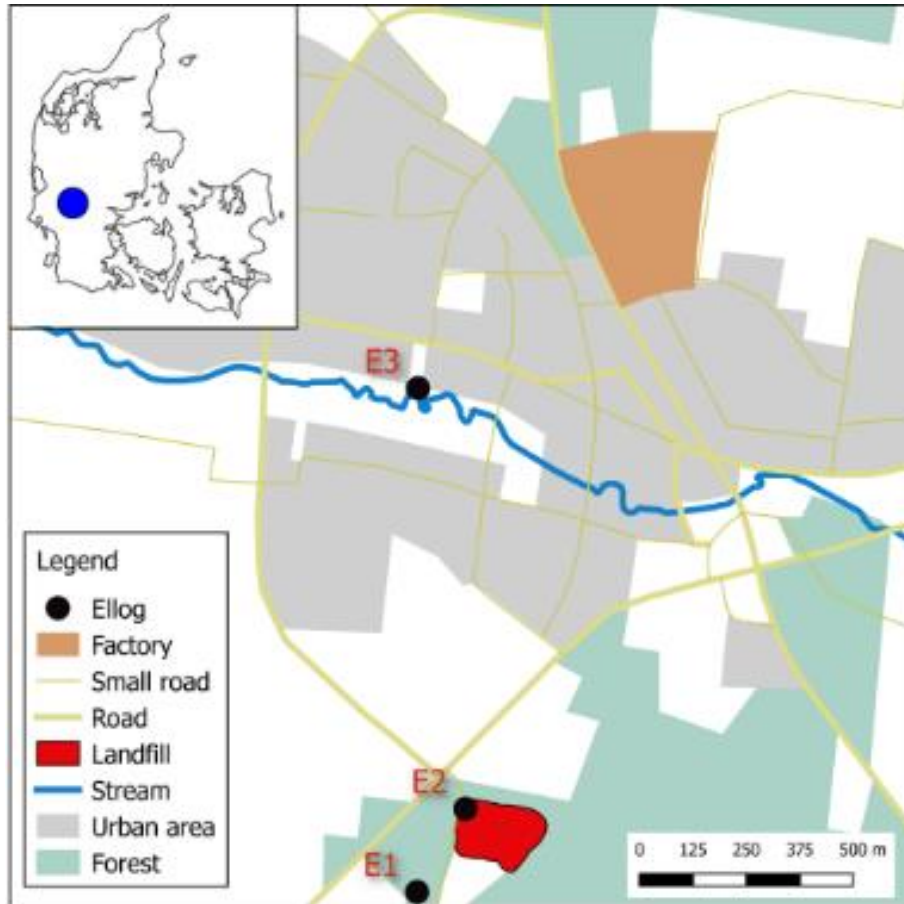


3D DCIP



Examples

Field data, Grindsted (Denmark)



Geophysical Journal International

Geophys. J. Int. (2018) 213, 770–785
Advance Access publication 2018 January 18
GJI Marine geosciences and applied geophysics

doi: 10.1093/gji/ggy018

Subsurface imaging of water electrical conductivity, hydraulic permeability and lithology at contaminated sites by induced polarization

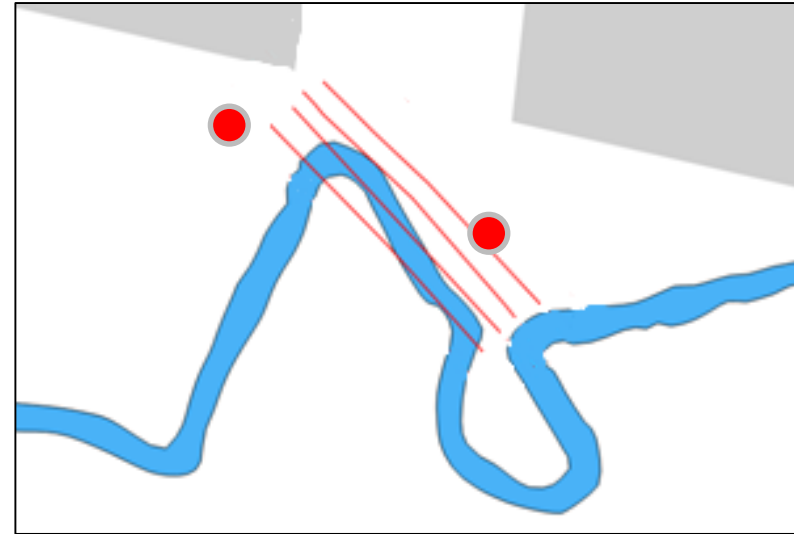
P.K. Maurya,¹ N. Balbarini,² I. Møller,³ V. Rønde,² A.V. Christiansen,¹ P.L. Bjerg,²
E. Auken¹ and G. Fiandaca¹

Examples

Field data, Grindsted (Denmark)

Setup

- 4 lines
 - 28 m x 84 m
 - 42 electrodes in each line
 - 2 meter between each electrode
-
- 2 boreholes

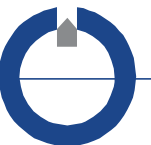
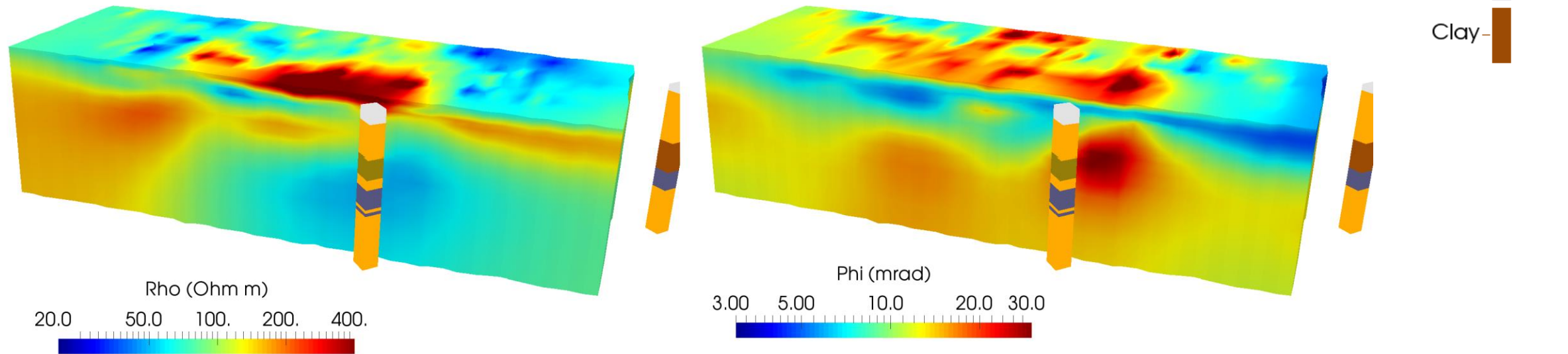


Subsurface imaging of water electrical conductivity, hydraulic permeability and lithology at contaminated sites by induced polarization

P.K. Maurya,¹ N. Balbarini,² I. Møller,³ V. Rønde,² A.V. Christiansen,¹ P.L. Bjerg,²
E. Auken¹ and G. Fiandaca¹

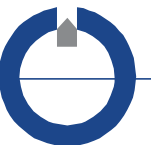
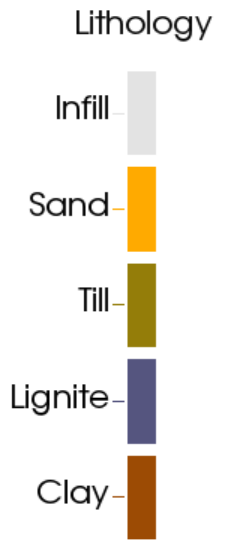
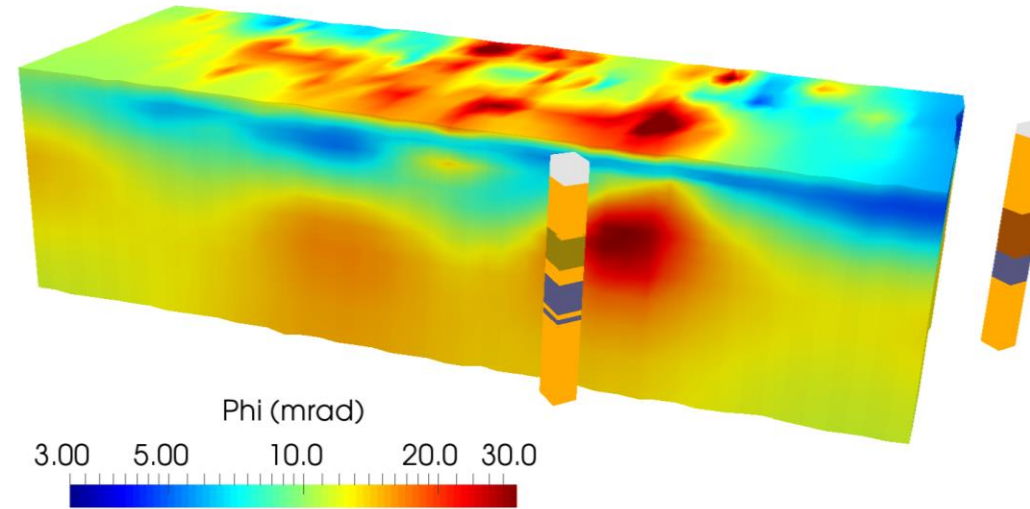
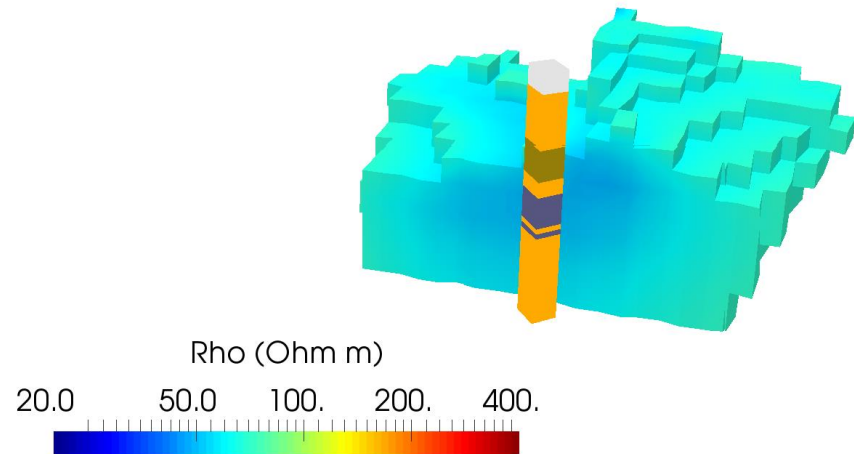
Examples

Field example, Grindsted (Denmark)



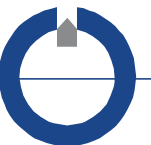
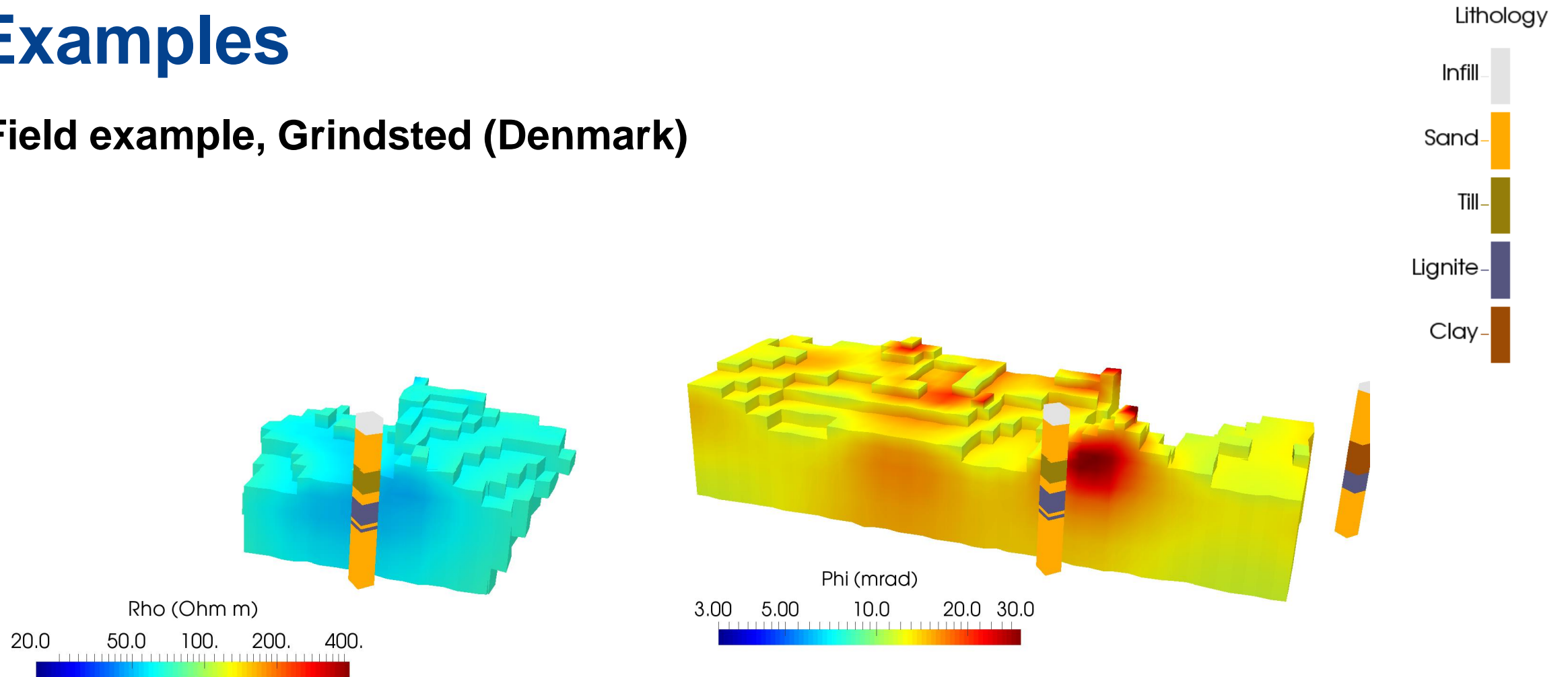
Examples

Field example, Grindsted (Denmark)



Examples

Field example, Grindsted (Denmark)



Forskningsfokus

- **Metoder:**

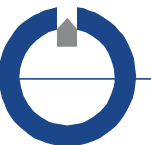
- DCIP
 - Cross-borehole
- NMR/MRS
 - Overfladenær
- TEM
 - tTEM
 - FloaTEM
 - SnowTEM
 - SoilTEM?
- MAG
 - tMAG

- **Anvendelser:**

- Forurening (flade og punkt)
- Hydrologi på land og til vands
- Råstoffer
- Arkæologi
- Mineraler (udland)

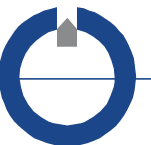
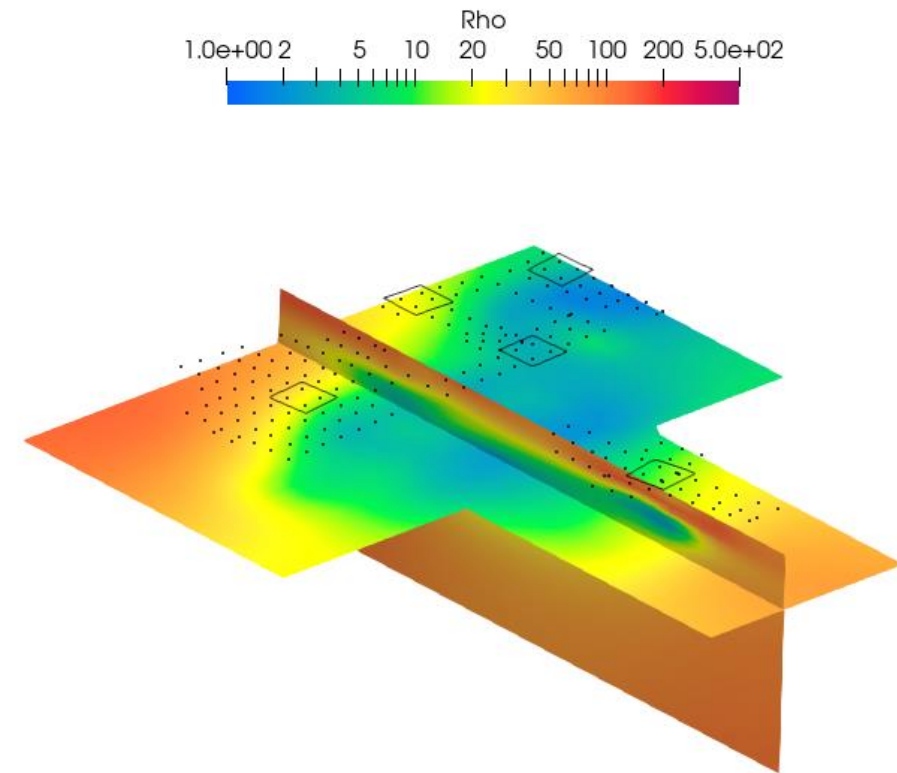
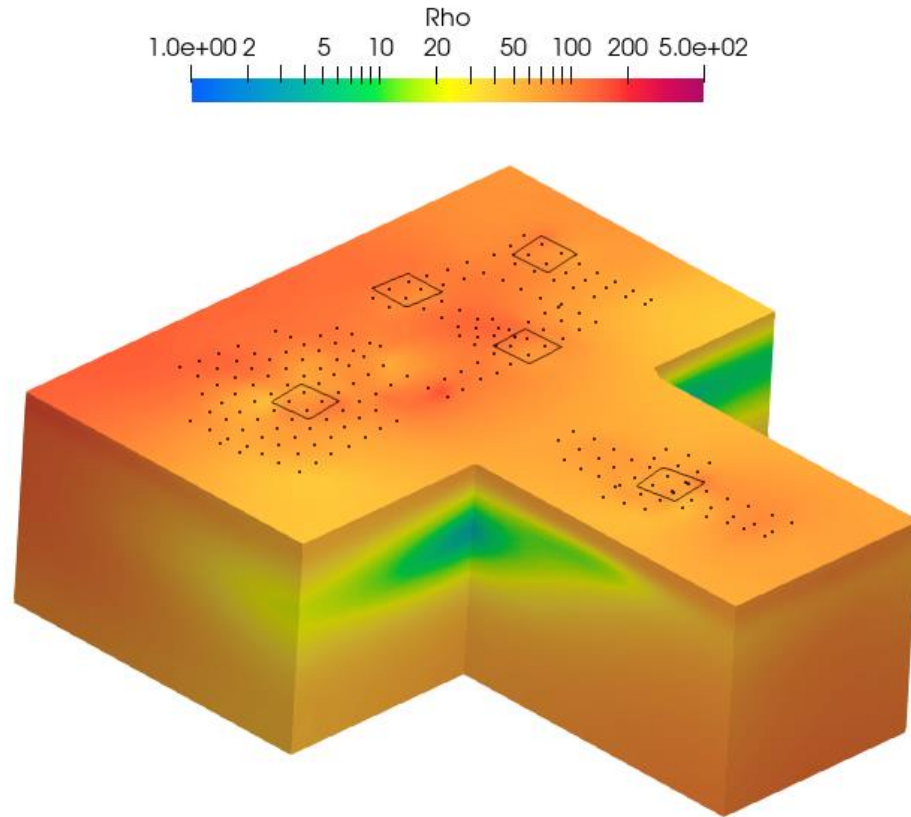
- **Numeriske udviklinger**

- 2D og 3D EM
 - Tæt kortlægning
 - Komplex geologi
- 3D DCIP
 - Cross-borehole
- Time-lapse
 - Tidsvarierende processer
- ANN / AI / Deep learning
 - Automatisk processering
 - Automatisk inversion



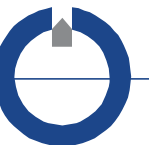
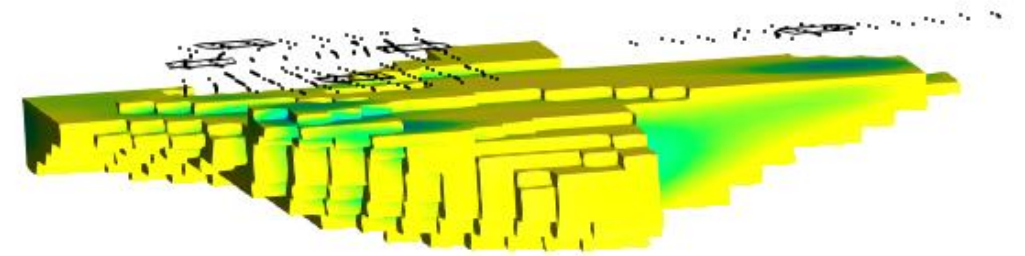
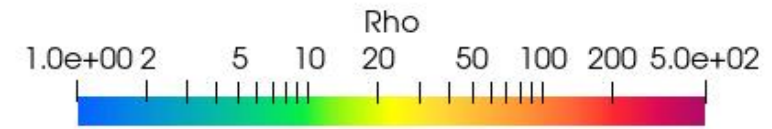
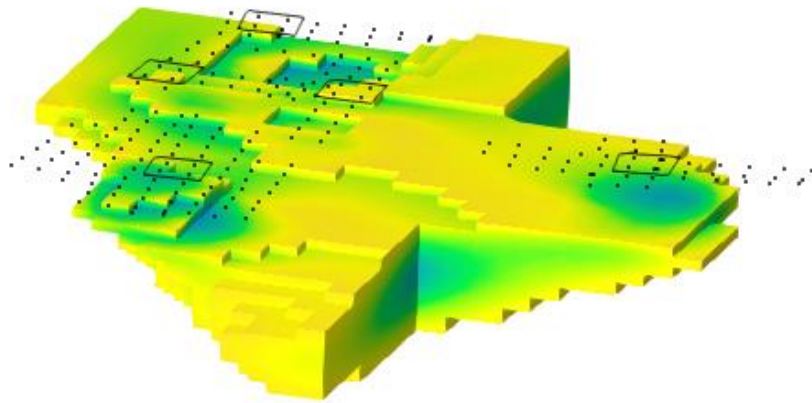
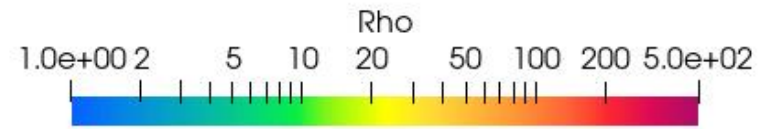
3D EM modelling - Mønsted

Inversion using domain decomposition



3D EM modelling - Mønsted

Inversion results - Clay layer



Forskningsfokus

- **Metoder:**

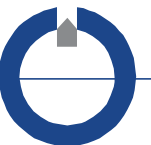
- DCIP
 - Cross-borehole
- NMR/MRS
 - Overfladenær
- TEM
 - tTEM
 - FloaTEM
 - SnowTEM
 - SoilTEM?
- MAG
 - tMAG

- **Anvendelser:**

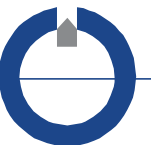
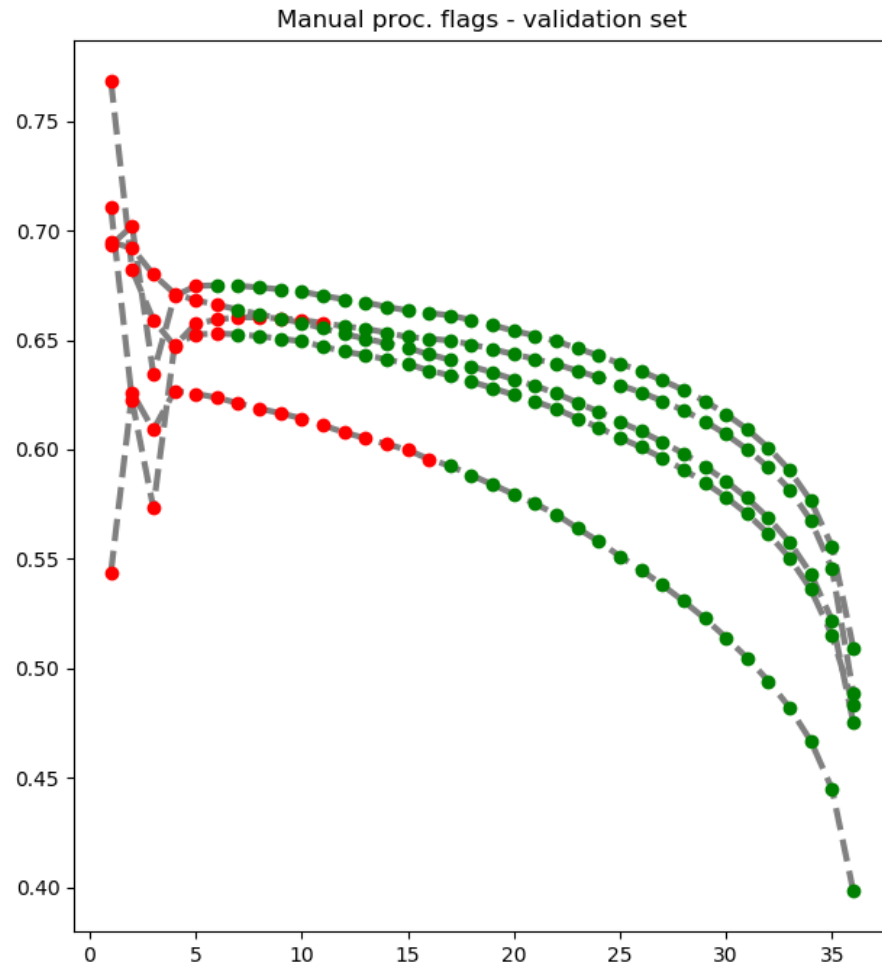
- Forurening (flade og punkt)
- Hydrologi på land og til vands
- Råstoffer
- Arkæologi
- Mineraler (udland)

- **Numeriske udviklinger**

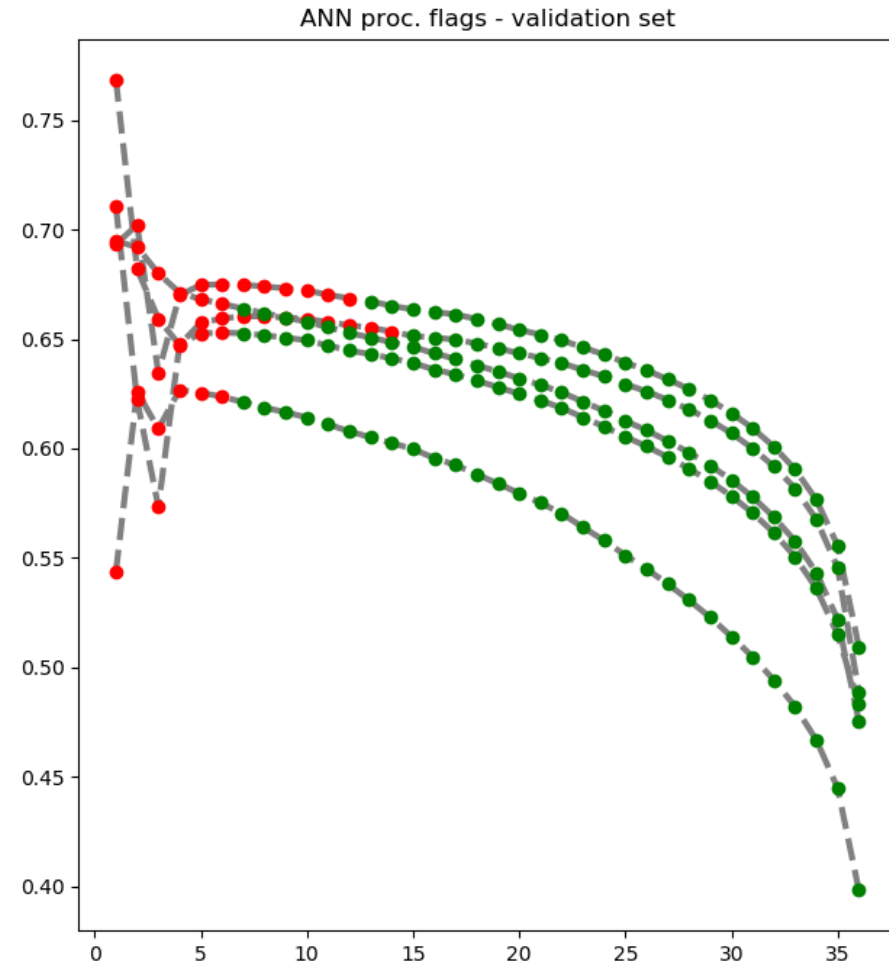
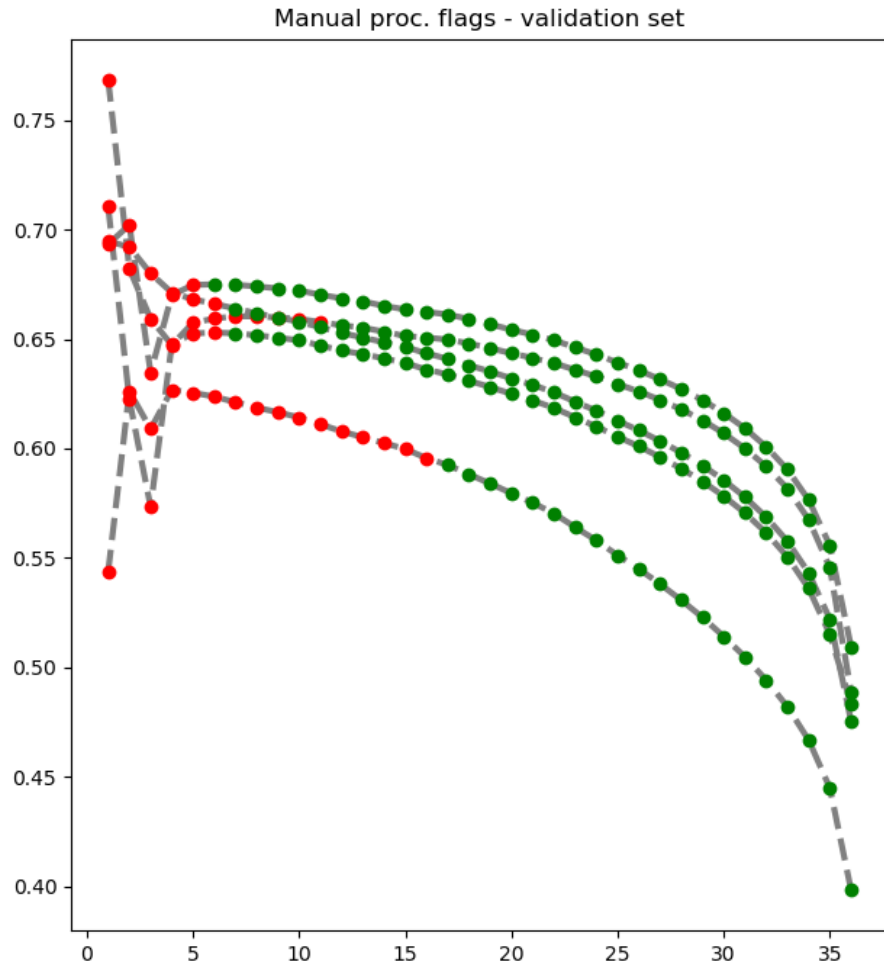
- 2D og 3D EM
 - Tæt kortlægning
 - Komplex geologi
- 3D DCIP
 - Cross-borehole
- Time-lapse
 - Tidsvarierende processer
- ANN / AI / Deep learning
 - Automatisk processering
 - Automatisk inversion



ANN – processing of DCIP

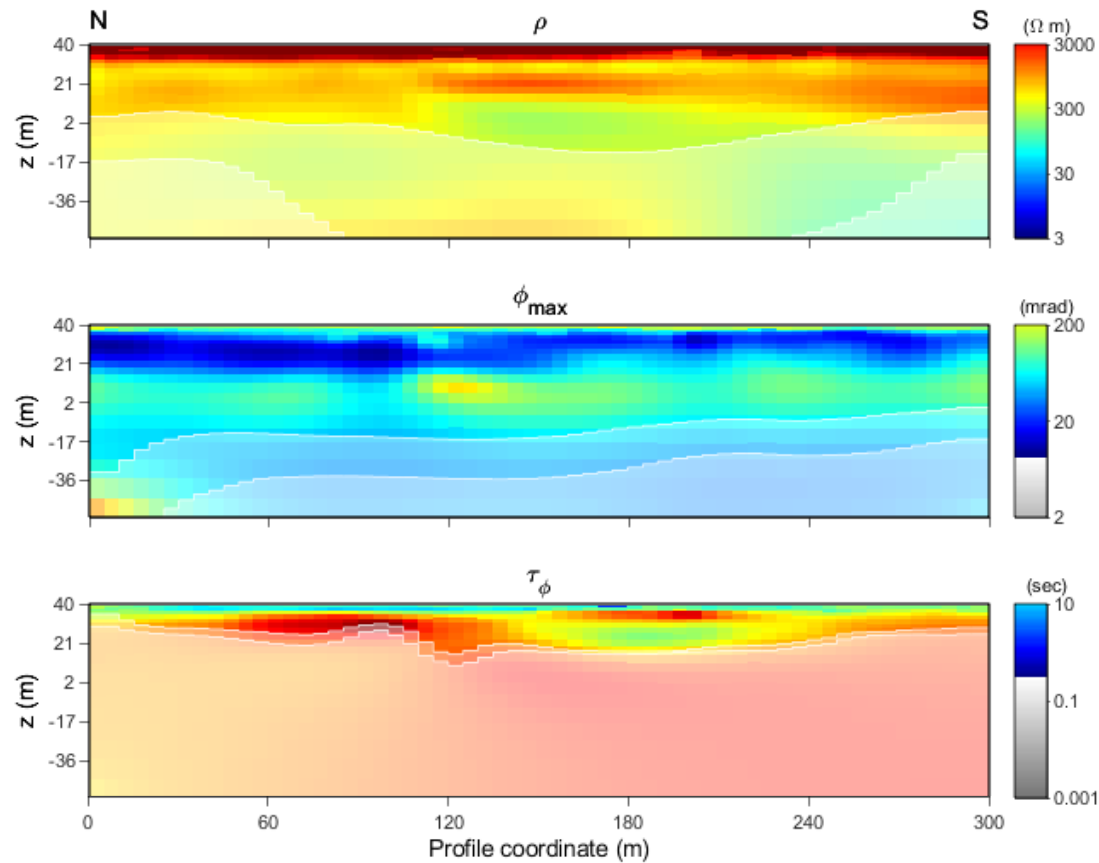


ANN – processing of DCIP

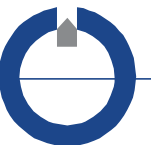
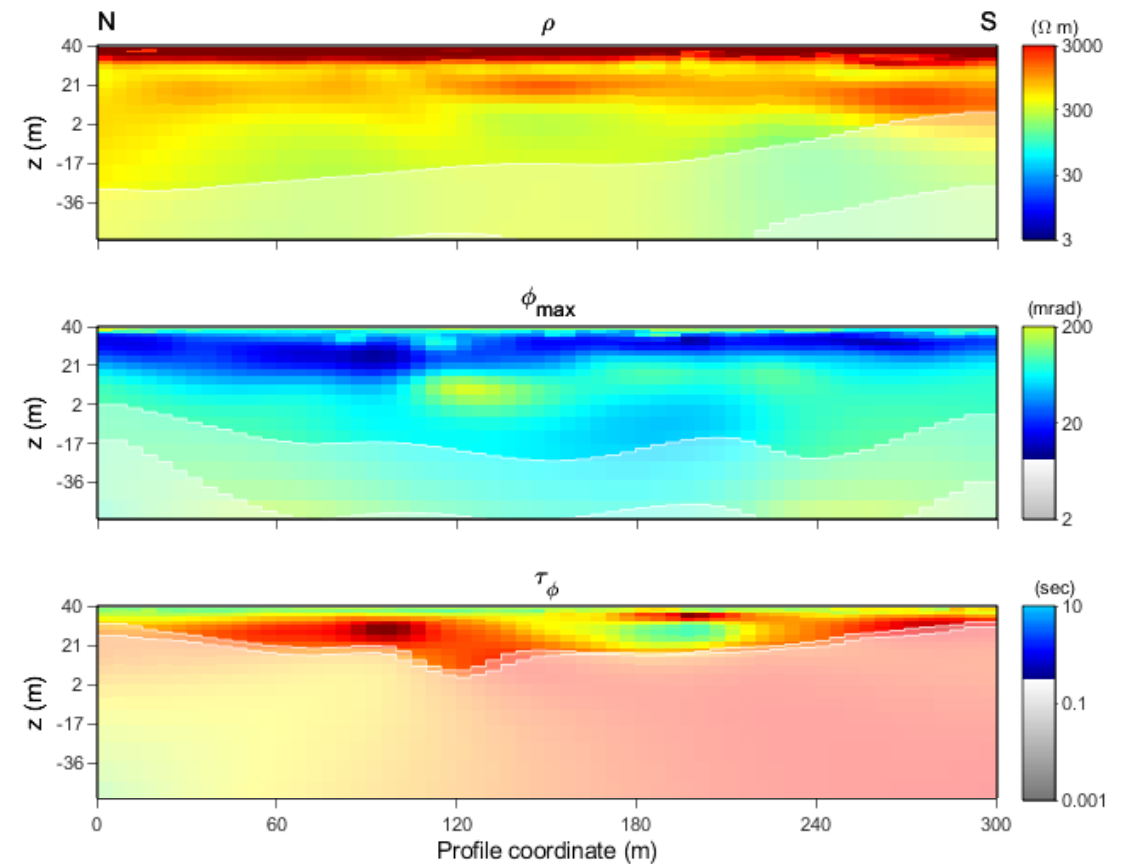


ANN – processing of DCIP

Profile 8 EEM2019 processedDCIP LL inv 2D MPA L2



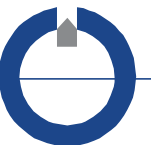
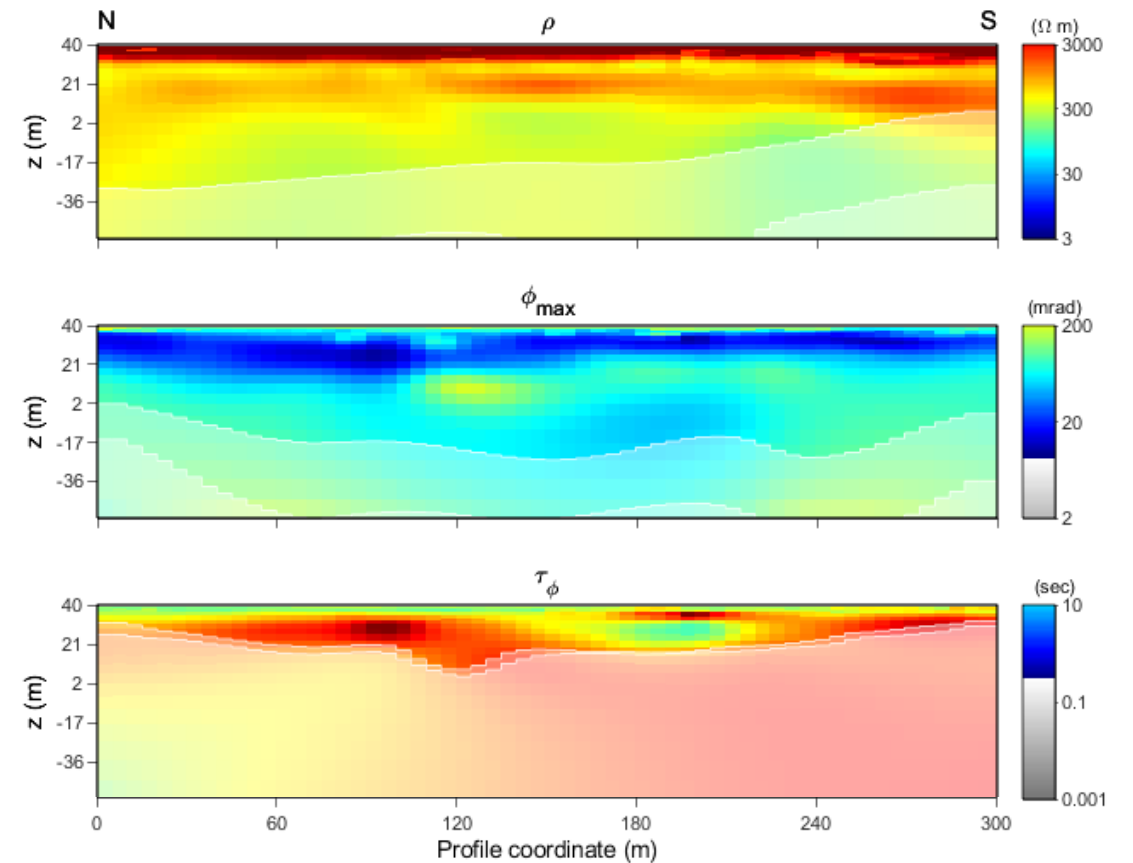
Grindsted 8b ANN processed inv 2D MPA L2



ANN – processing of DCIP

- **Perspektiver**
 - Hurtig processering
 - Real-tid datahåndtering

Grindsted 8b ANN processed inv 2D MPA L2



Forskningsfokus

- **Metoder:**

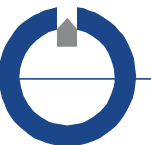
- DCIP
 - Cross-borehole
- NMR/MRS
 - Overfladenær
- TEM
 - tTEM
 - FloaTEM
 - SnowTEM
 - SoilTEM?
- MAG
 - tMAG

- **Anvendelser:**

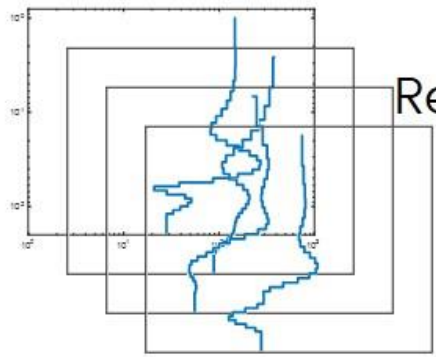
- Forurening (flade og punkt)
- Hydrologi på land og til vands
- Råstoffer
- Arkæologi
- Mineraler (udland)

- **Numeriske udviklinger**

- 2D og 3D EM
 - Tæt kortlægning
 - Komplex geologi
- 3D DCIP
 - Cross-borehole
- Time-lapse
 - Tidsvarierende processer
- ANN / AI / Deep learning
 - Automatisk processering
 - Automatisk inversion



Forward modelling of TEM data with NN



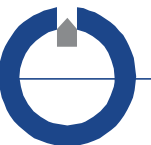
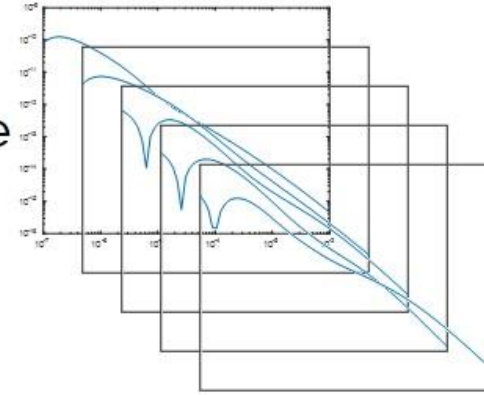
Resistivity Model



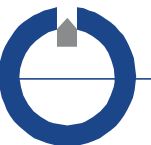
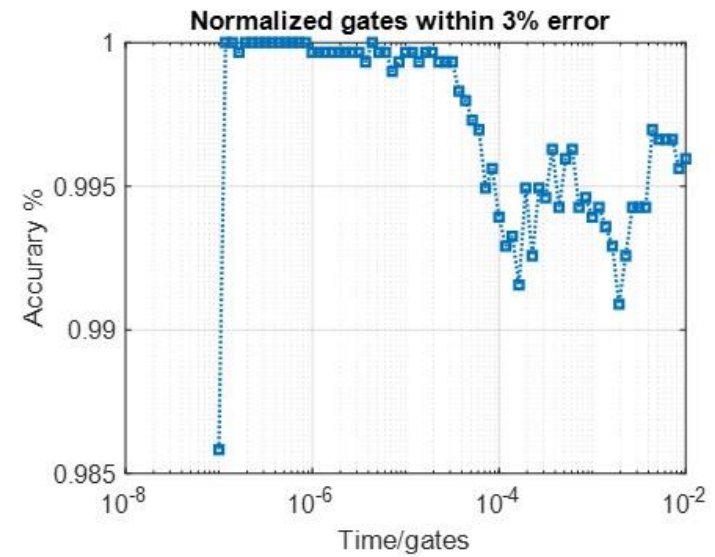
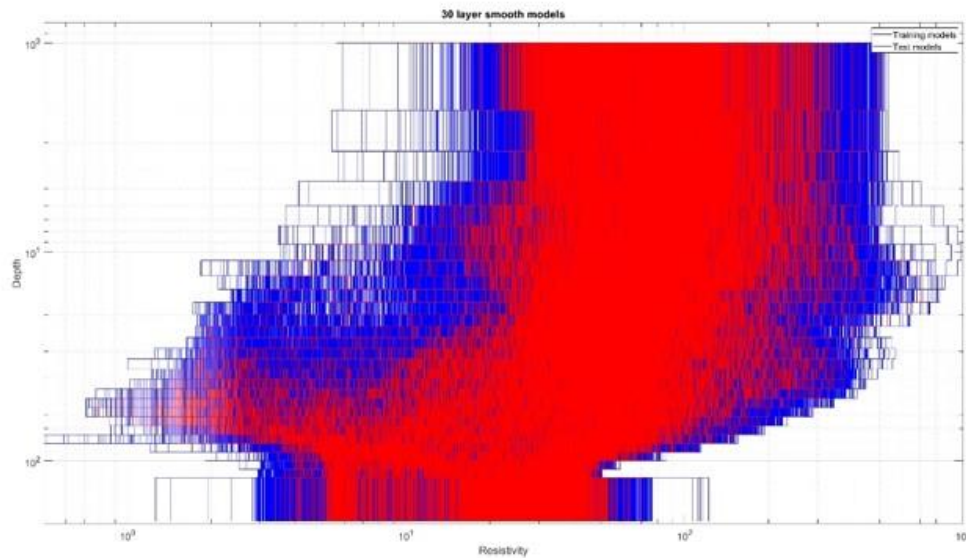
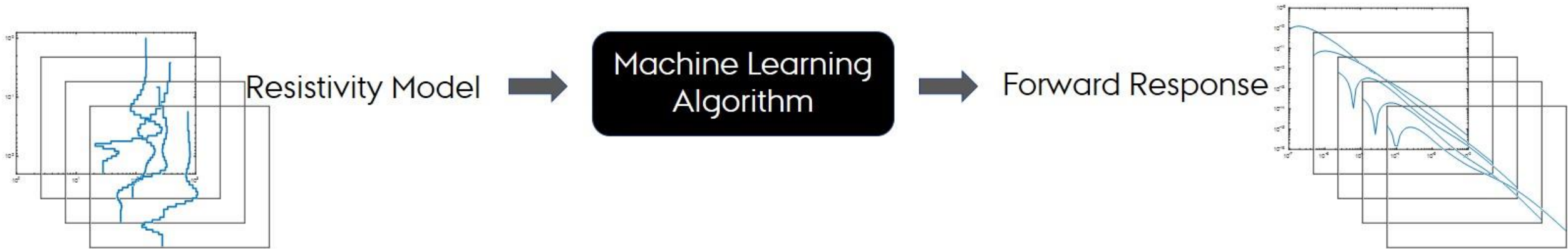
Machine Learning
Algorithm



Forward Response



Forward modelling of TEM data with NN



Forskningsfokus

- **Metoder:**

- DCIP
 - Cross-borehole
- NMR/MRS
 - Overfladenær
- TEM
 - tTEM
 - FloaTEM
 - SnowTEM
 - SoilTEM?

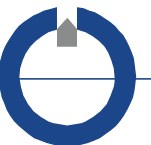
- MAG
 - tMAG

- **Anvendelser:**

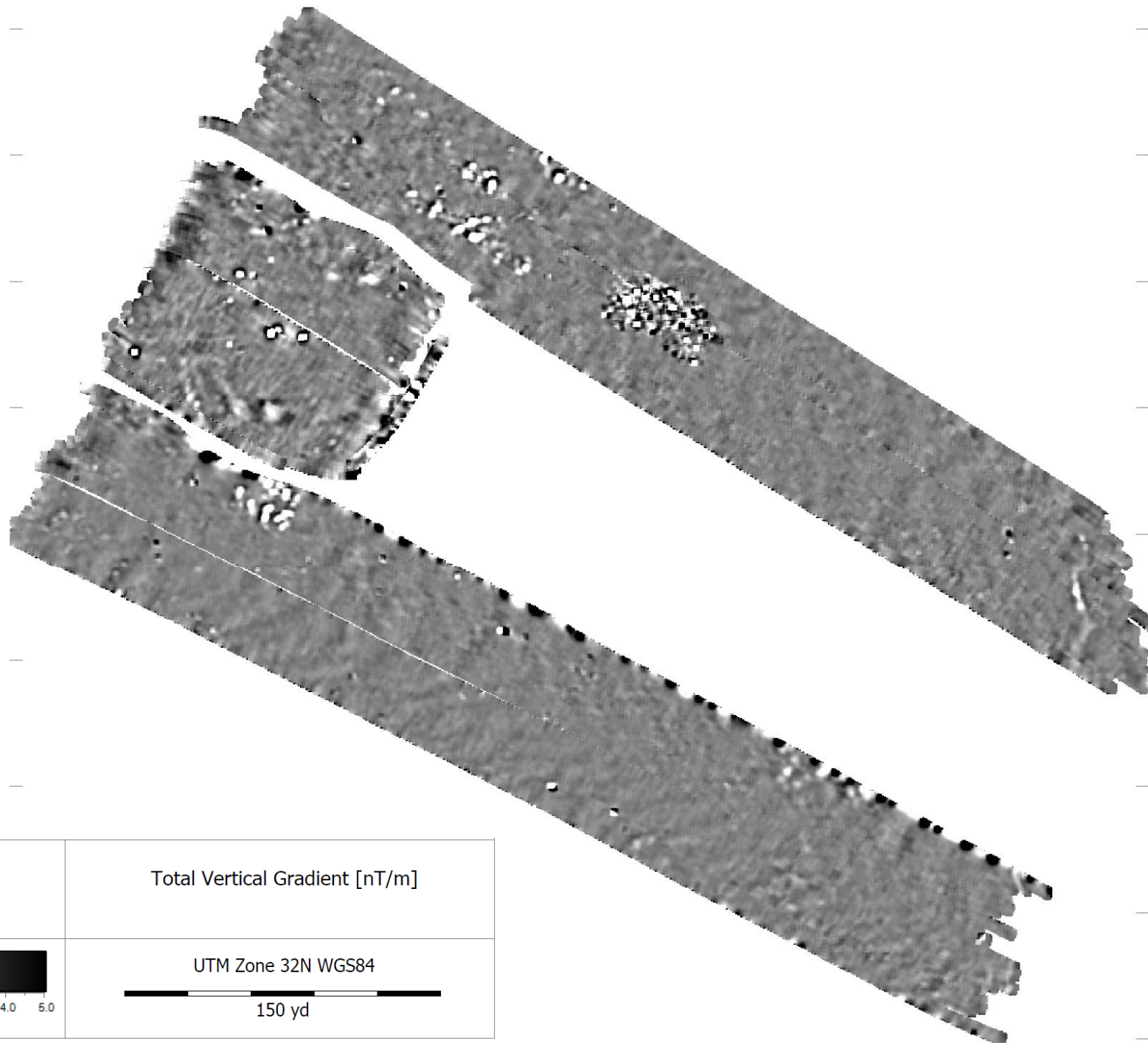
- Forurening (flade og punkt)
- Hydrologi på land og til vands
- Råstoffer
- Arkæologi
- Mineraler (udland)

- **Numeriske udviklinger**

- 2D og 3D EM
 - Tæt kortlægning
 - Komplex geologi
- 3D DCIP
 - Cross-borehole
- Time-lapse
 - Tidsvarierende processer
- ANN / AI / Deep learning
 - Automatisk processering
 - Automatisk inversion

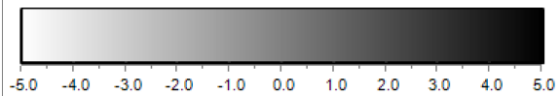


tMAG

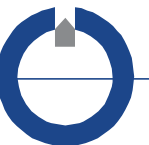
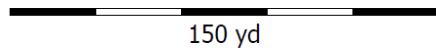


Højer tMag

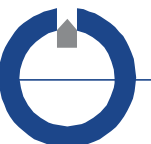
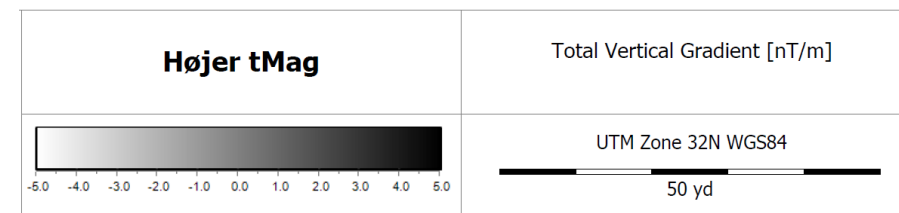
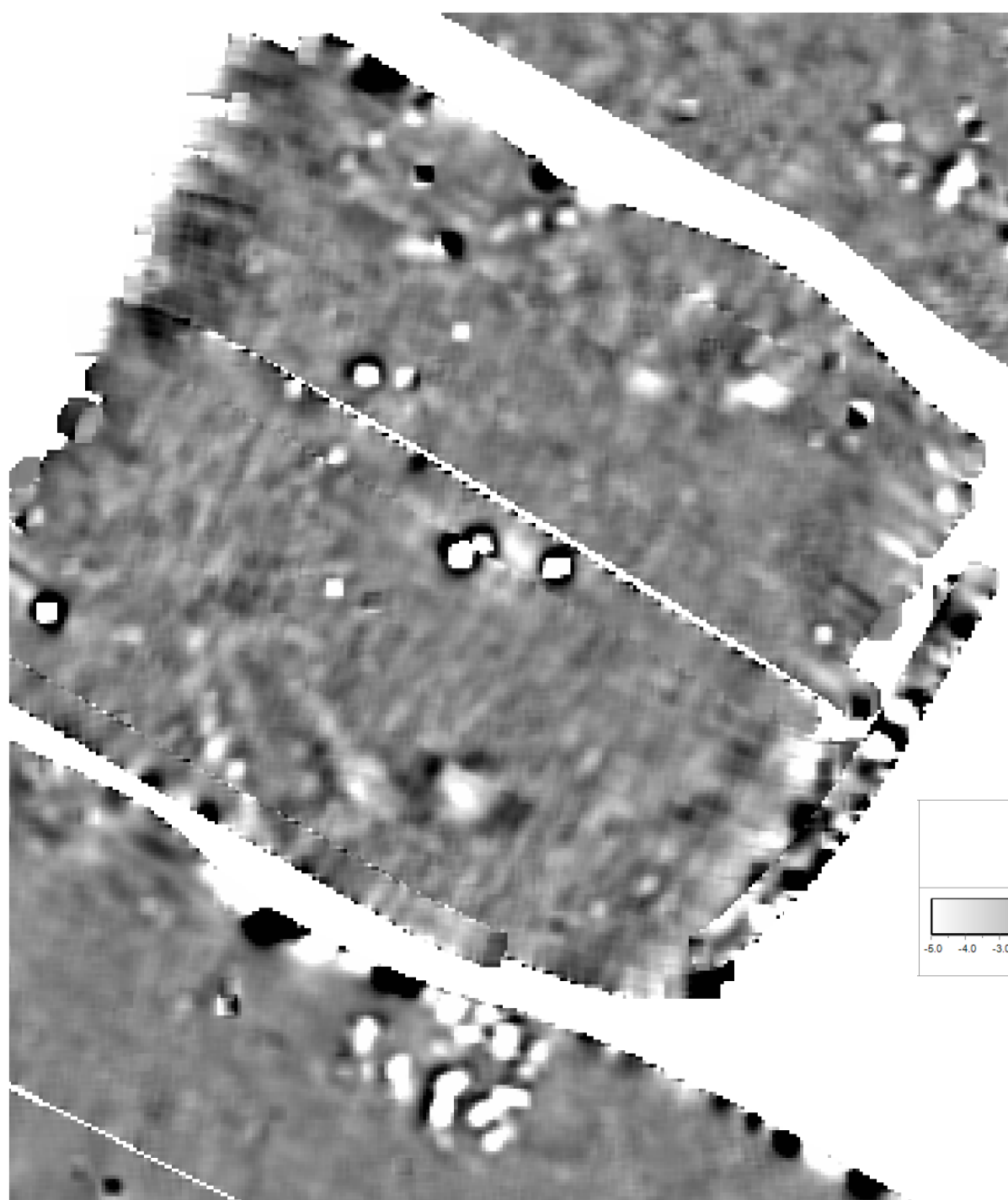
Total Vertical Gradient [nT/m]



UTM Zone 32N WGS84



tMAG



Instrumenter

- **Metoder:**

- DCIP
 - Cross-borehole

- NMR/MRS

- Overfladenær

- TEM

- tTEM

- FloaTEM

- SnowTEM

- SoilTEM?

- MAG

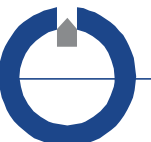
- tMAG

- **Anvendelser:**

- Forurening (flade og punkt)
- Hydrologi på land og til vands
- Råstoffer
- Arkæologi
- Mineraler (udland)

- **Numeriske udviklinger**

- 2D og 3D EM
 - Tæt kortlægning
 - Komplex geologi
- 3D DCIP
 - Cross-borehole
- Time-lapse
 - Tidsvarierende processer
- ANN / AI / Deep learning
 - Automatisk processering
 - Automatisk inversion



Perspektiver

- **Mere fleksible og effektive instrumenter**
- **Time-lapse målinger**
 - Processer
 - Oprensning
 - Jordfugtighed
 - Vandspejlsændringer
- **Hurtigere, automatiseret processering og inversion**
 - Real-time resultater
 - On-line visualisering
- **2D og 3D resultater**
 - Mere realistisk billeder især hvor geologien er meget kompleks
 - Sprækker og forkastninger

