EMerald Geomodelling

EM Geomodelling at EMR and feasibility for Sardinia site

Martin Panzner, EMerald Geomodelling
Søren Bjørn, Aarhus GeoInstruments
Christos Boufidis, Aarhus GeoInstruments

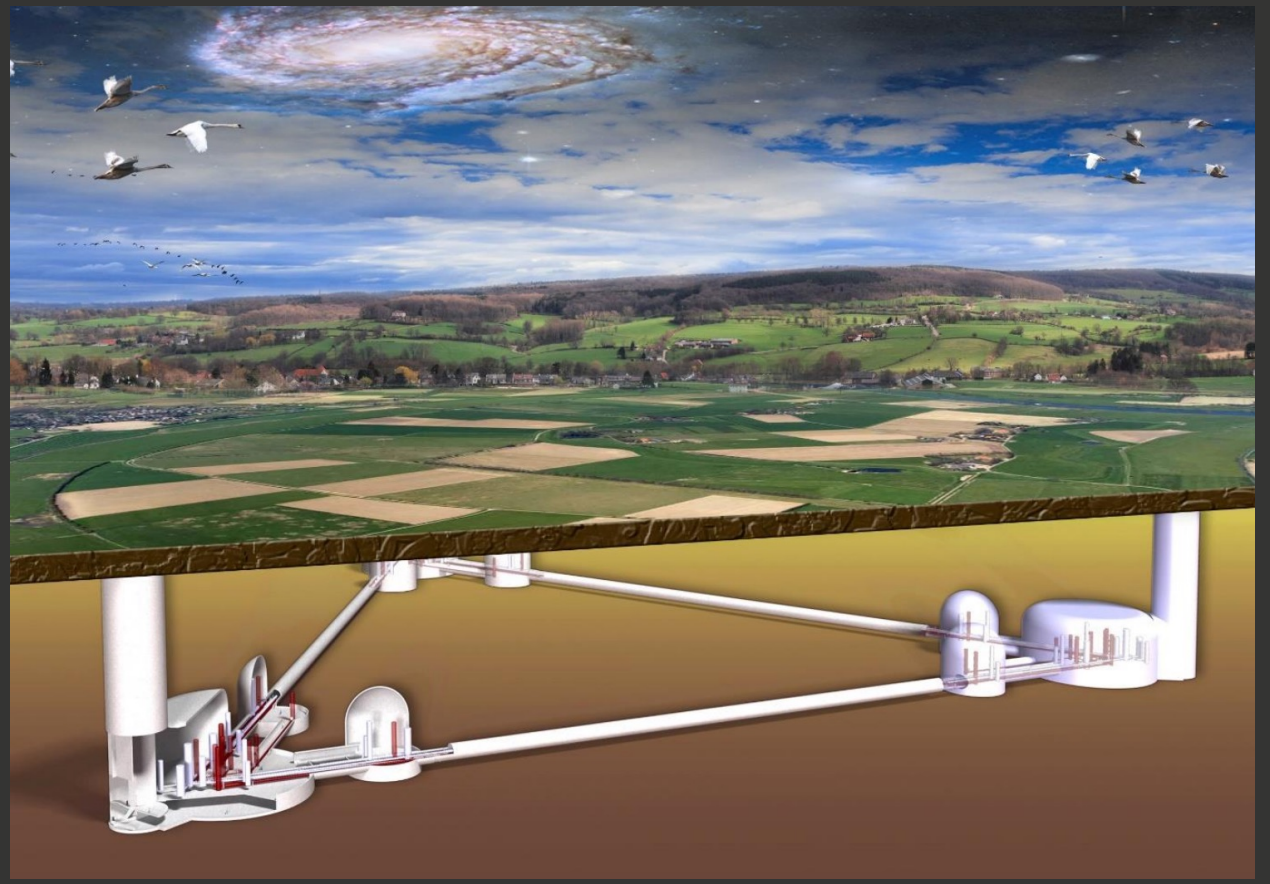
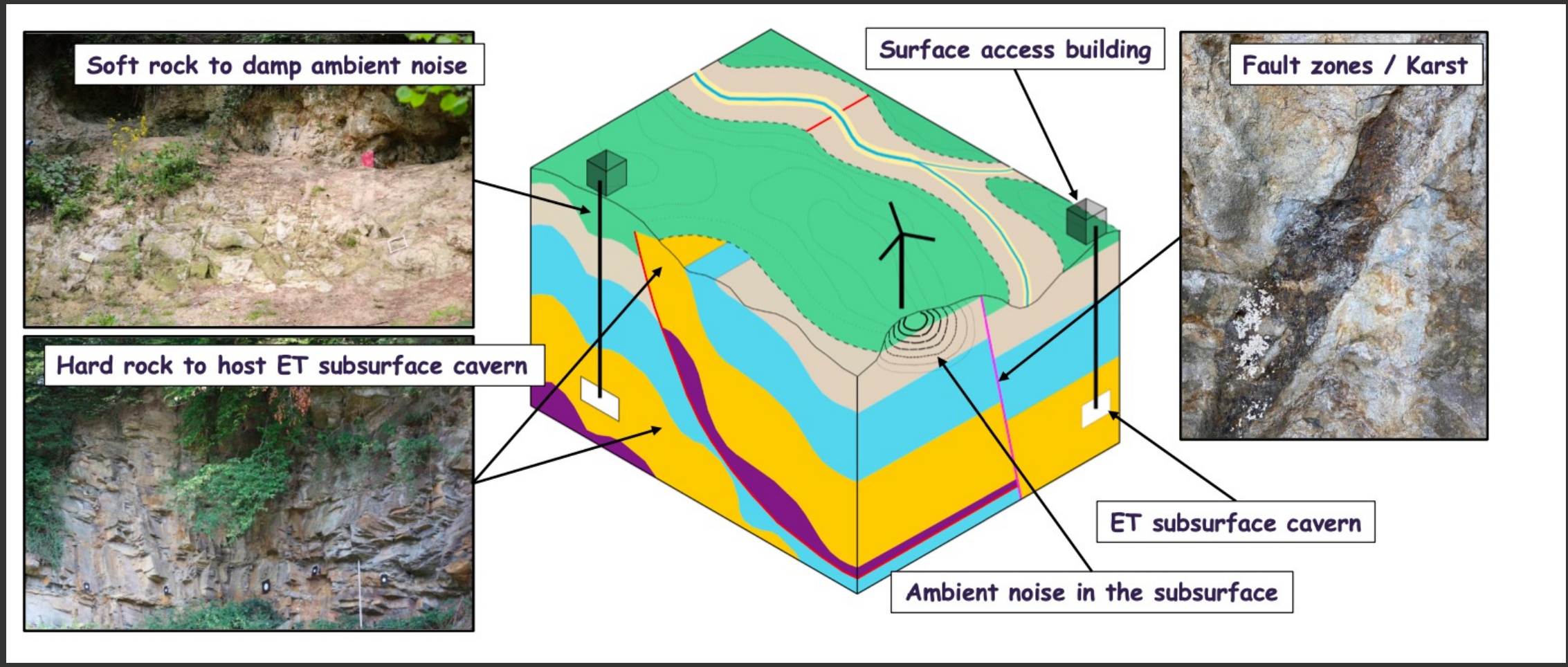


Image source: www.etpathfinder.eu

Outline

- Introduction
- TEM Field Test at EMR site: Beusdael
- Feasibility for Sardinia Site
- Summary and Conclusion

Mapping the geological risks for the Einstein Telescope



From presentation by: Hamdi, P., Zinser, J., Ott, J., Wannenmacher, H., Amann, F. 2021

Question to answer with this study

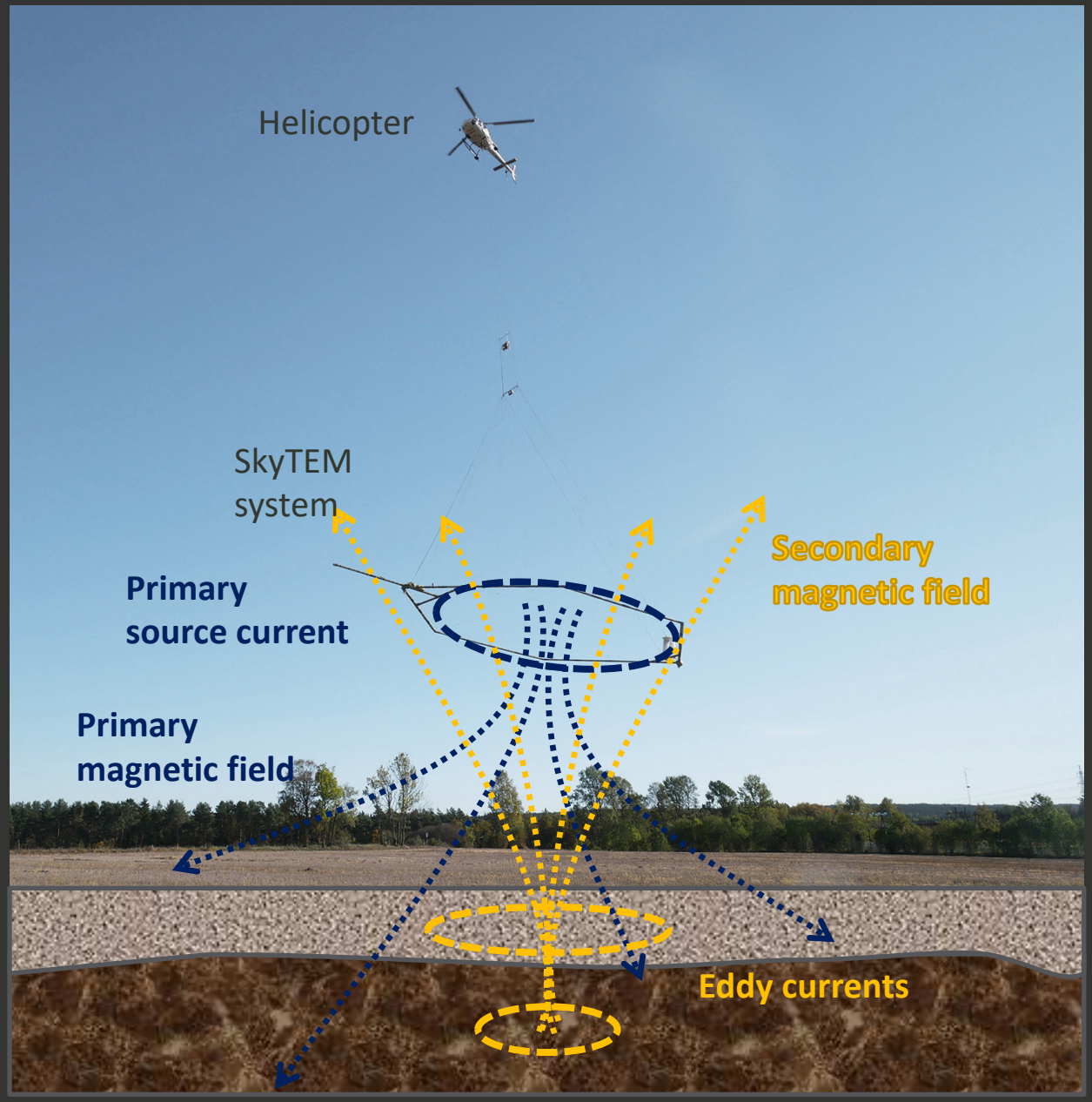
- Can the time domain EM (TEM) method be used to **quickly** map the thickness of, and variations within, the shallow soil/ sediment layer?

- Can the TEM method also map resistivity variations in the deeper solid rock units?

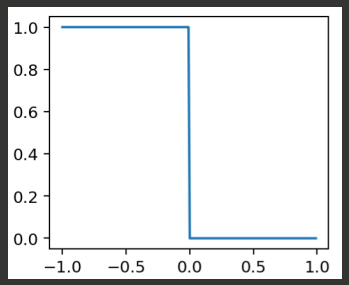
- Is it feasible to use airborne TEM for large scale mapping of the resistivity structures in the EMR site

The physics

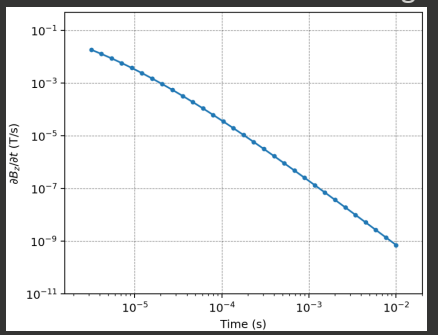
the transient time domain electromagnetic **TEM** method



Step-off source function:

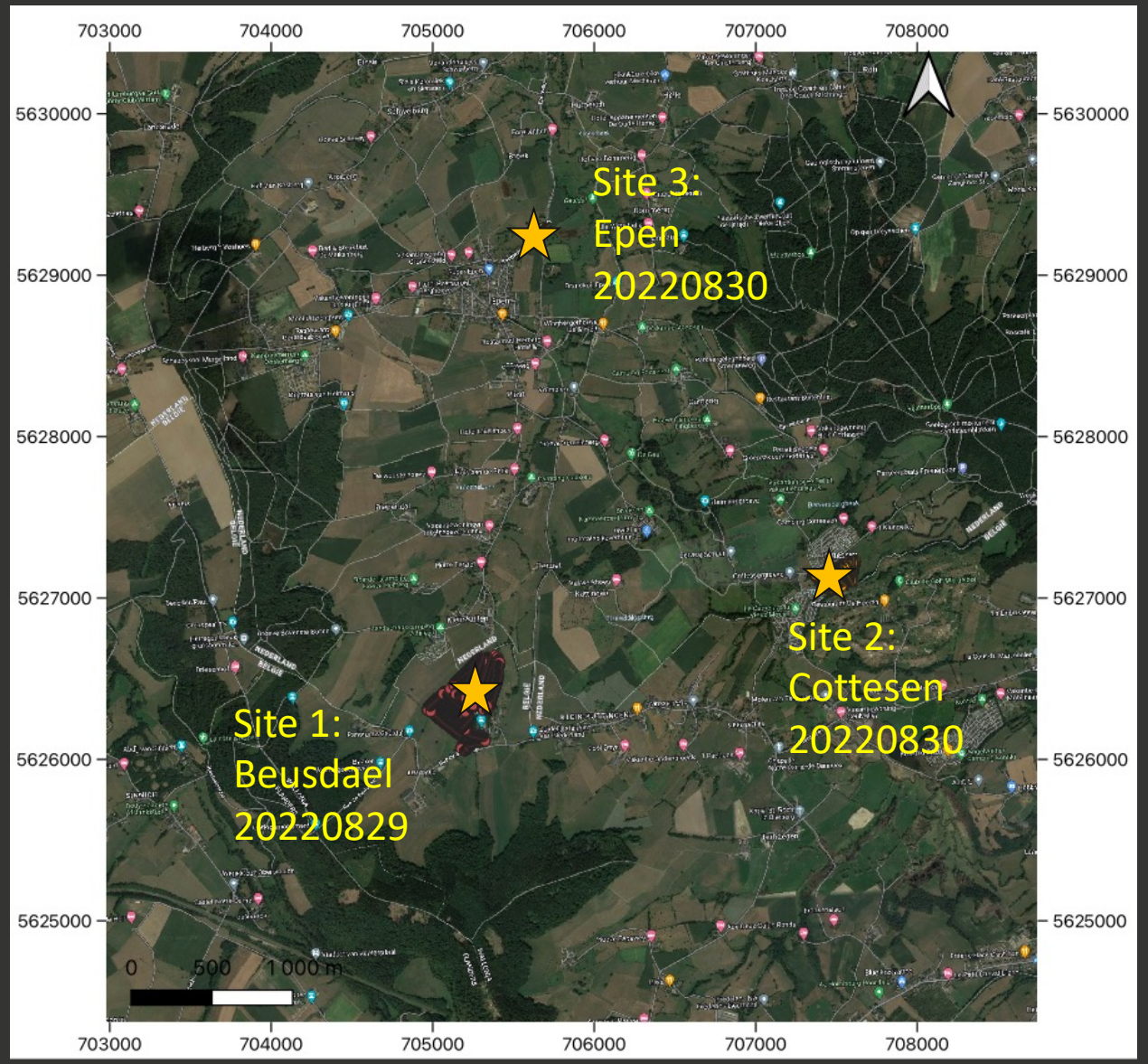


Measured transient of sec. mag. Field:



Under normal conditions:
Flight speed: 60-80 km/h,
Line-km/day: 200-300 km

Investigation sites in Terziet (NL/BE)



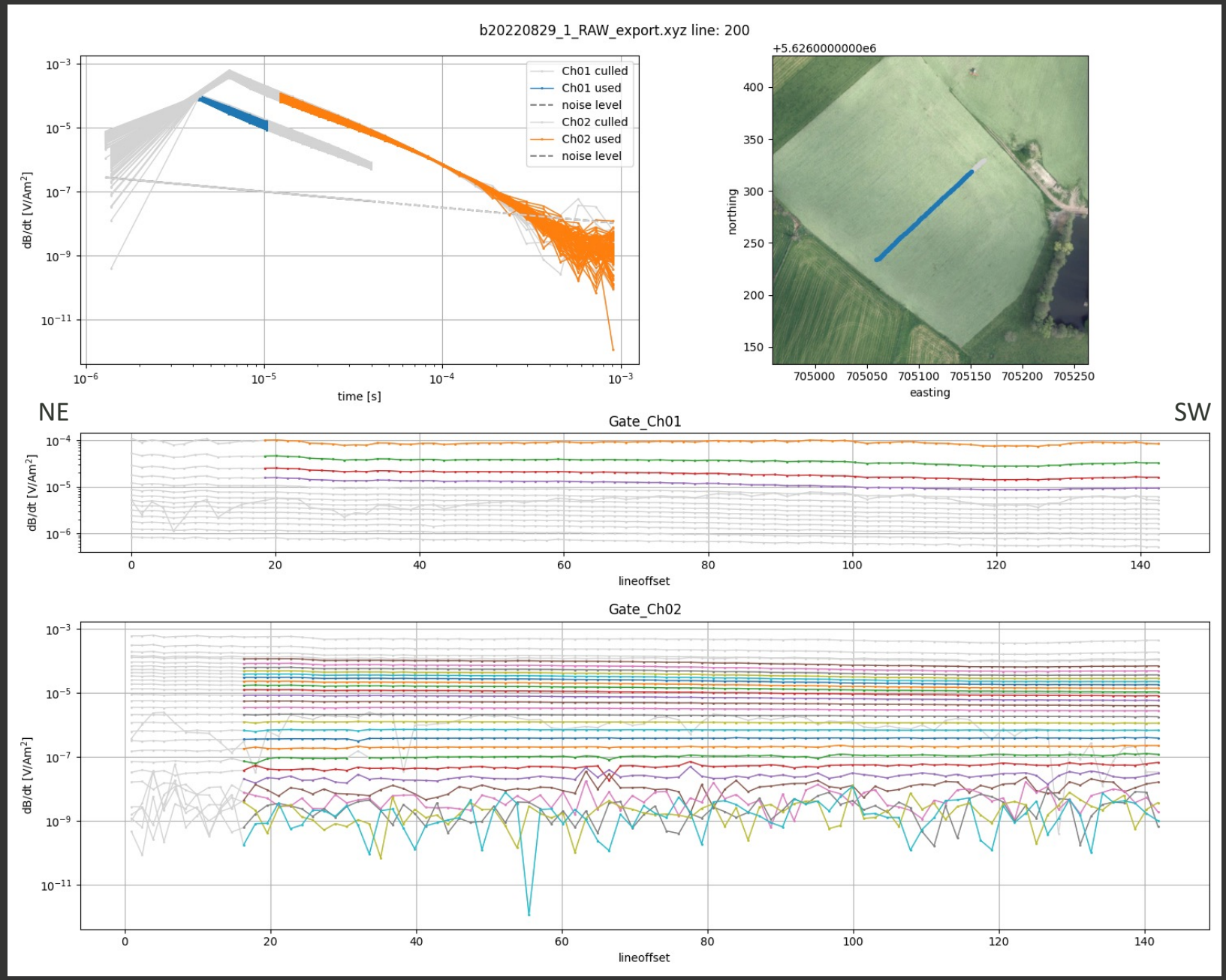
tTEM: Site 1 - Beusdael

Tx loop: 2.9m 2.9m, 1 turn
I max = 3A / 30A

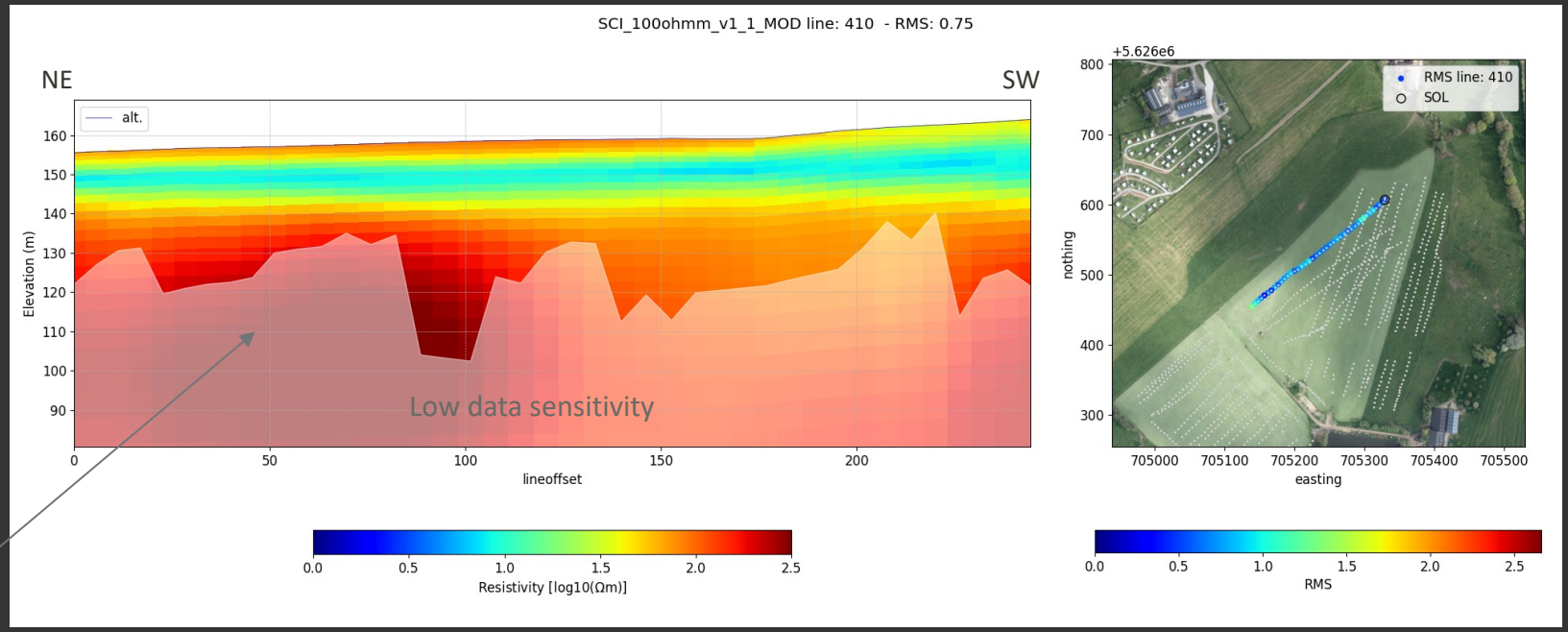
48 profiles / ~8km in less than ½ day
Normally: 10-15km/h, 50-100km/day

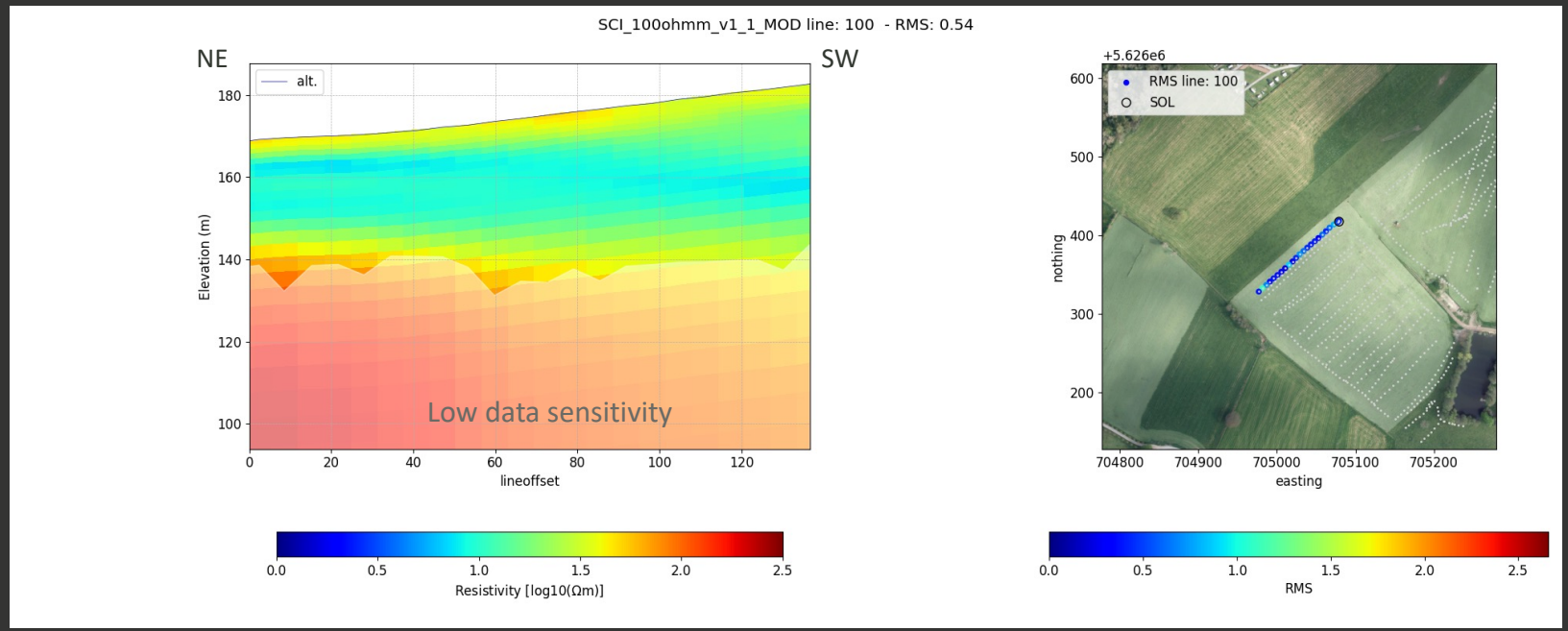
Data Quality and data selection

- Representative “Raw” data example
- 0.5s sampling rate (~1.5m)
- Dual moment data
  - HM: 30 A x 8.41 m^2 x 1 loop
  - LM: 3 A x 8.41 m^2 x 1 loop
- Usable gates
  - From 4.3e-06
  - up to ~3.7e-4s



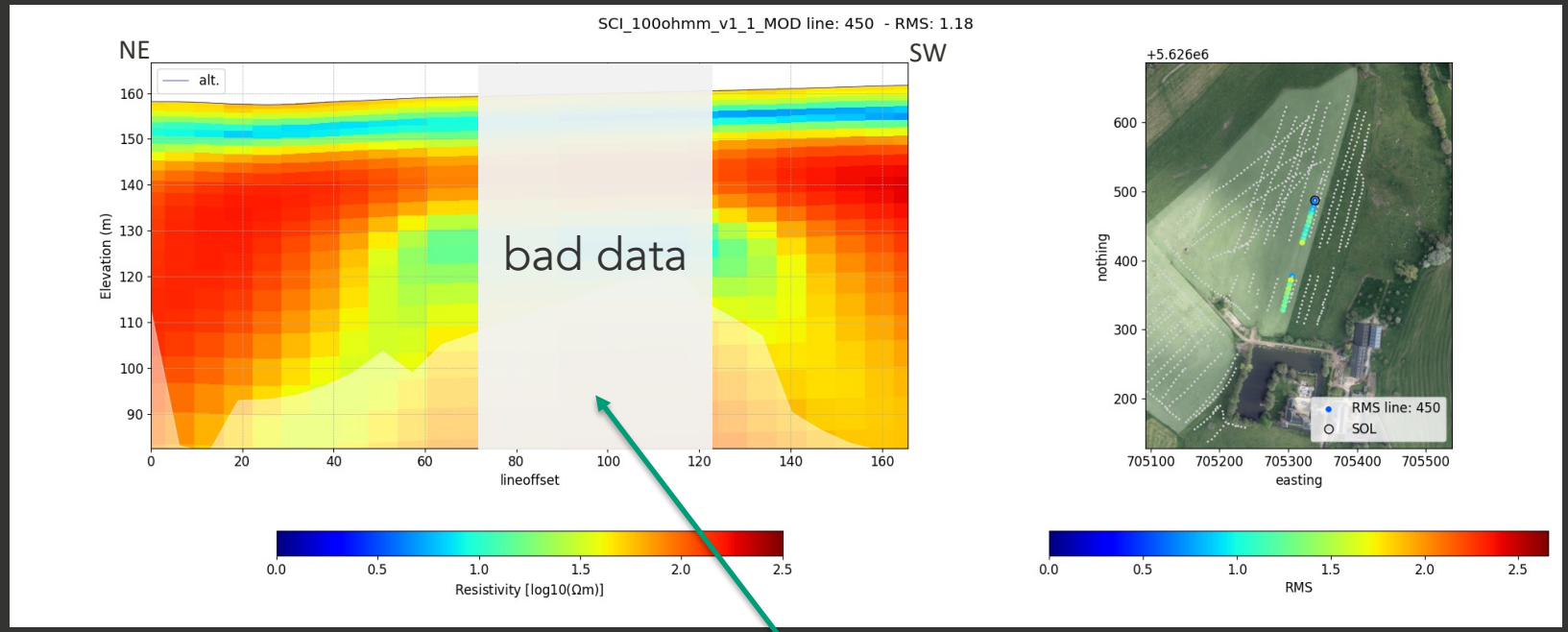
Beusdael: tTEM inversion selected lines

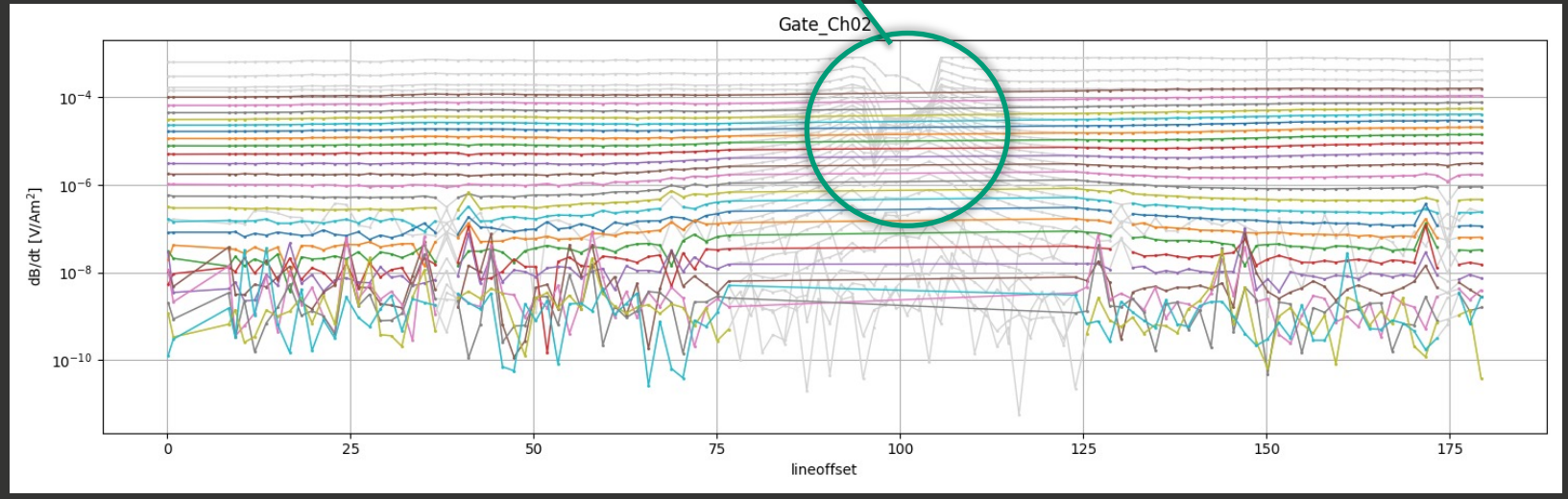




Vest Christiansen, Anders Auken, Esben
A global measure for depth of investigation
2012 , *Geophysics* , Vol. 77, No. 4
Society of Exploration Geophysicists
p. WB171-WB177

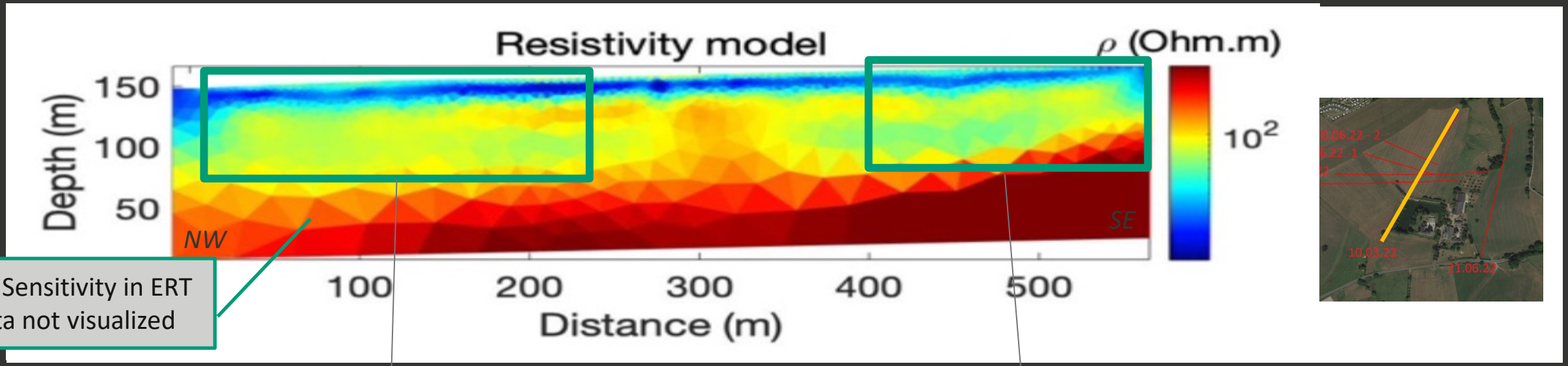
Beusdael: tTEM inversion selected lines





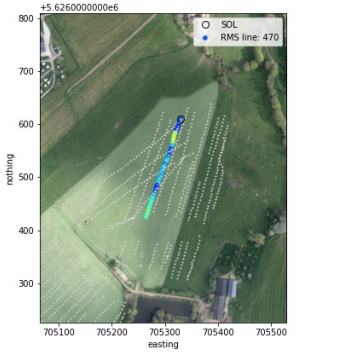
Comparison to ERT* data

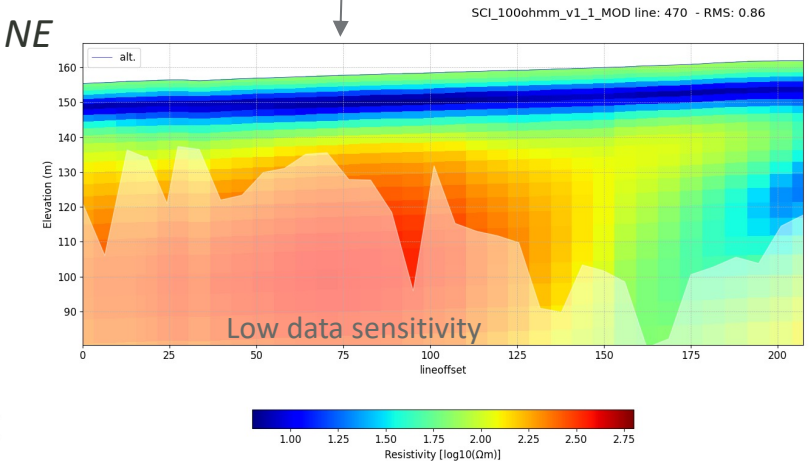
*by Joost Hase & Yannick Forth



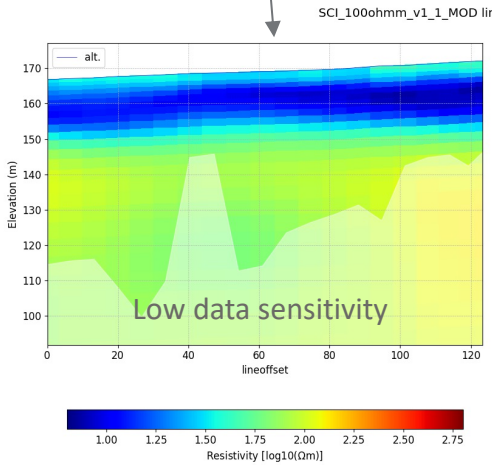
Low Sensitivity in ERT data not visualized

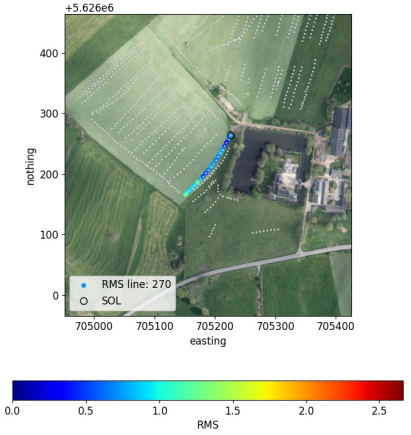
NE





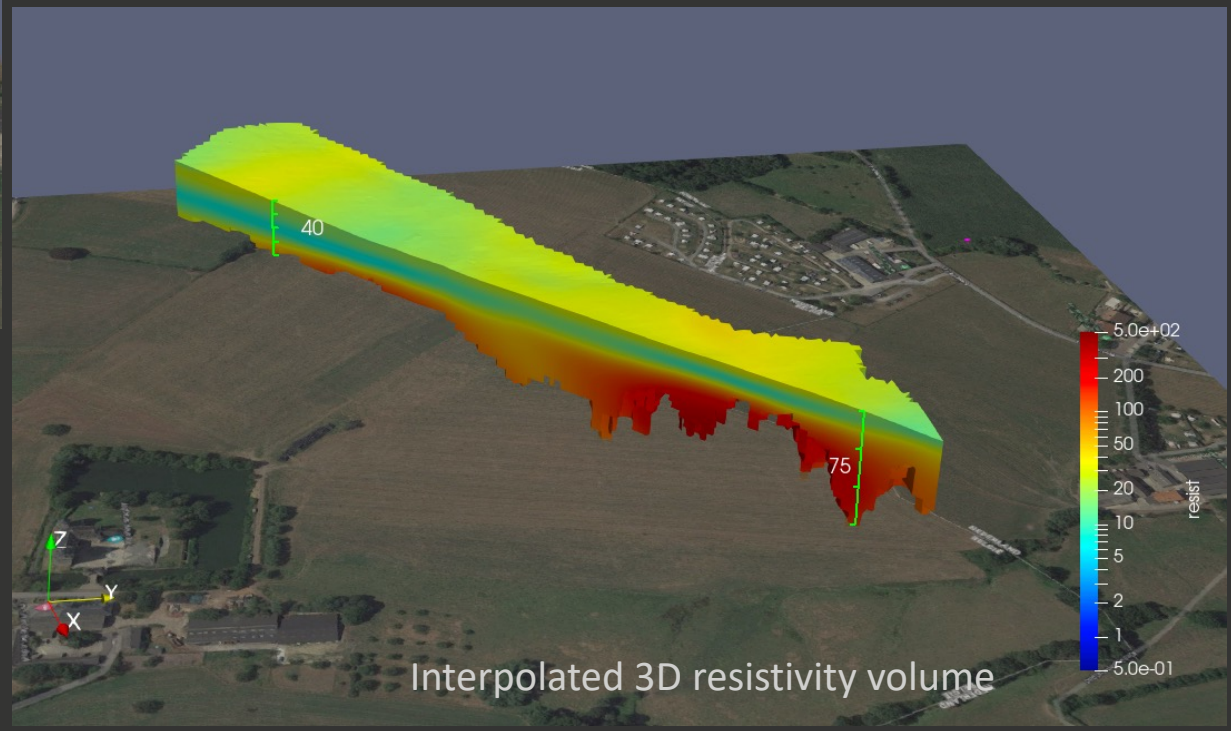
SW





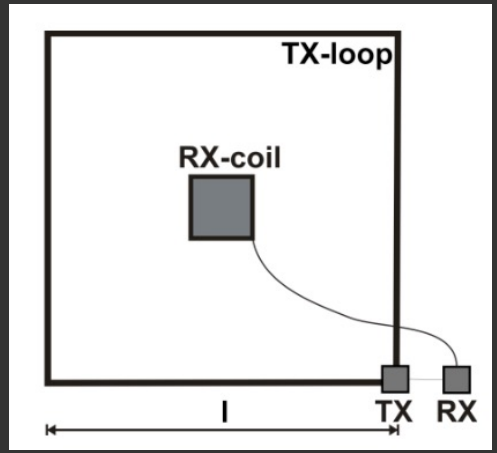
3D visualization of tTEM resistivities

Measured tTEM resistivity sections



Interpolated 3D resistivity volume

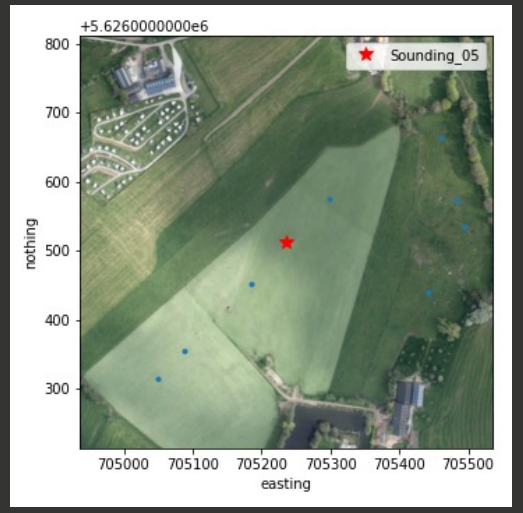
WalkTEM: Site 1 - Beusdael

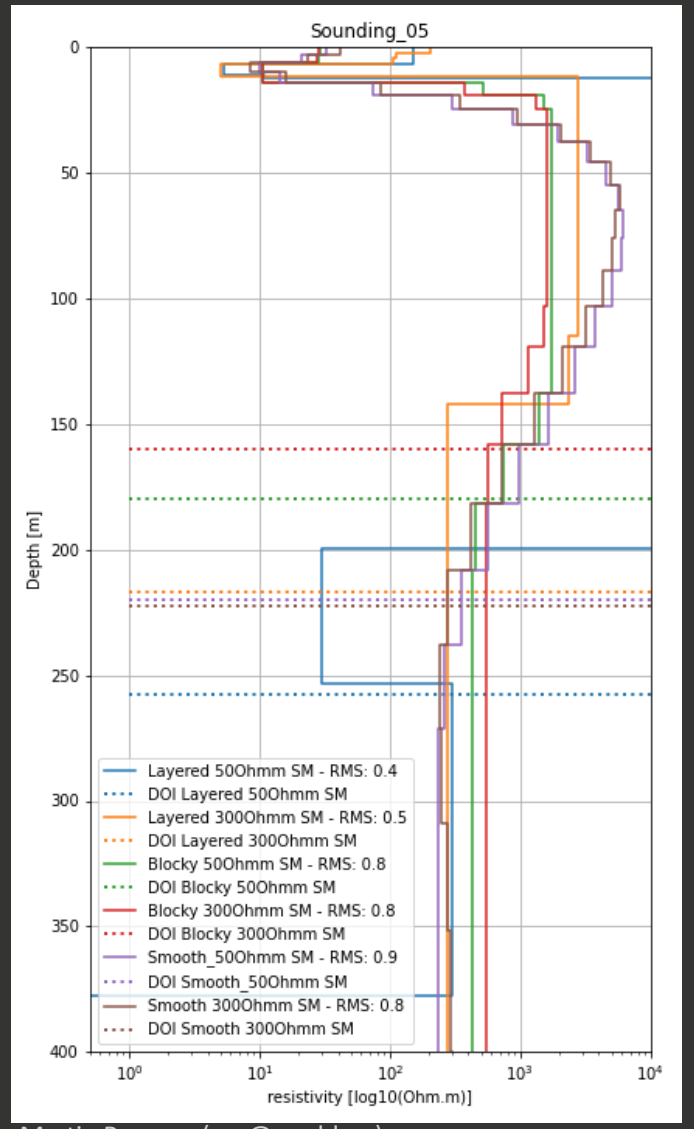


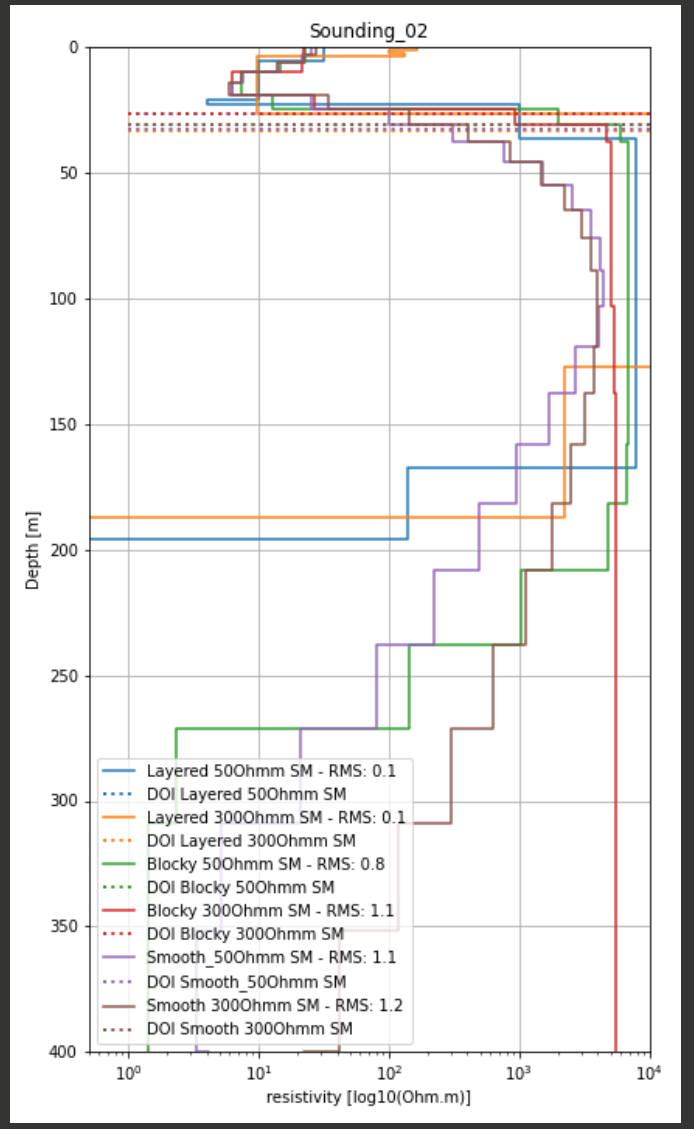
Tx loop: 50m x 50m, 1 turn
Rx loop: 10m x 10m, 1 turn
I max = 2.4A / 25 A

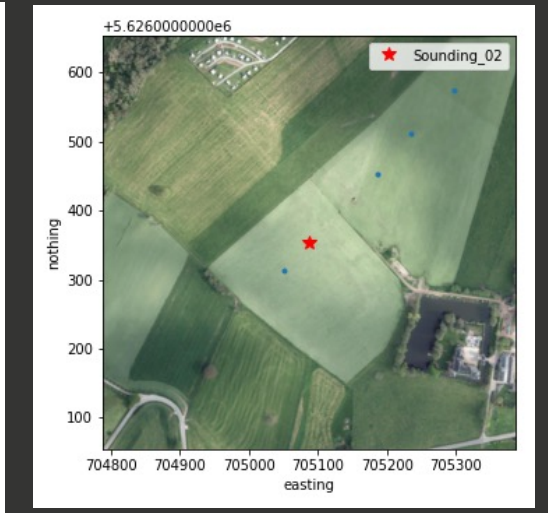
Image: Søren Bjørn, AGI

Beusdael: WalkTEM inversion results



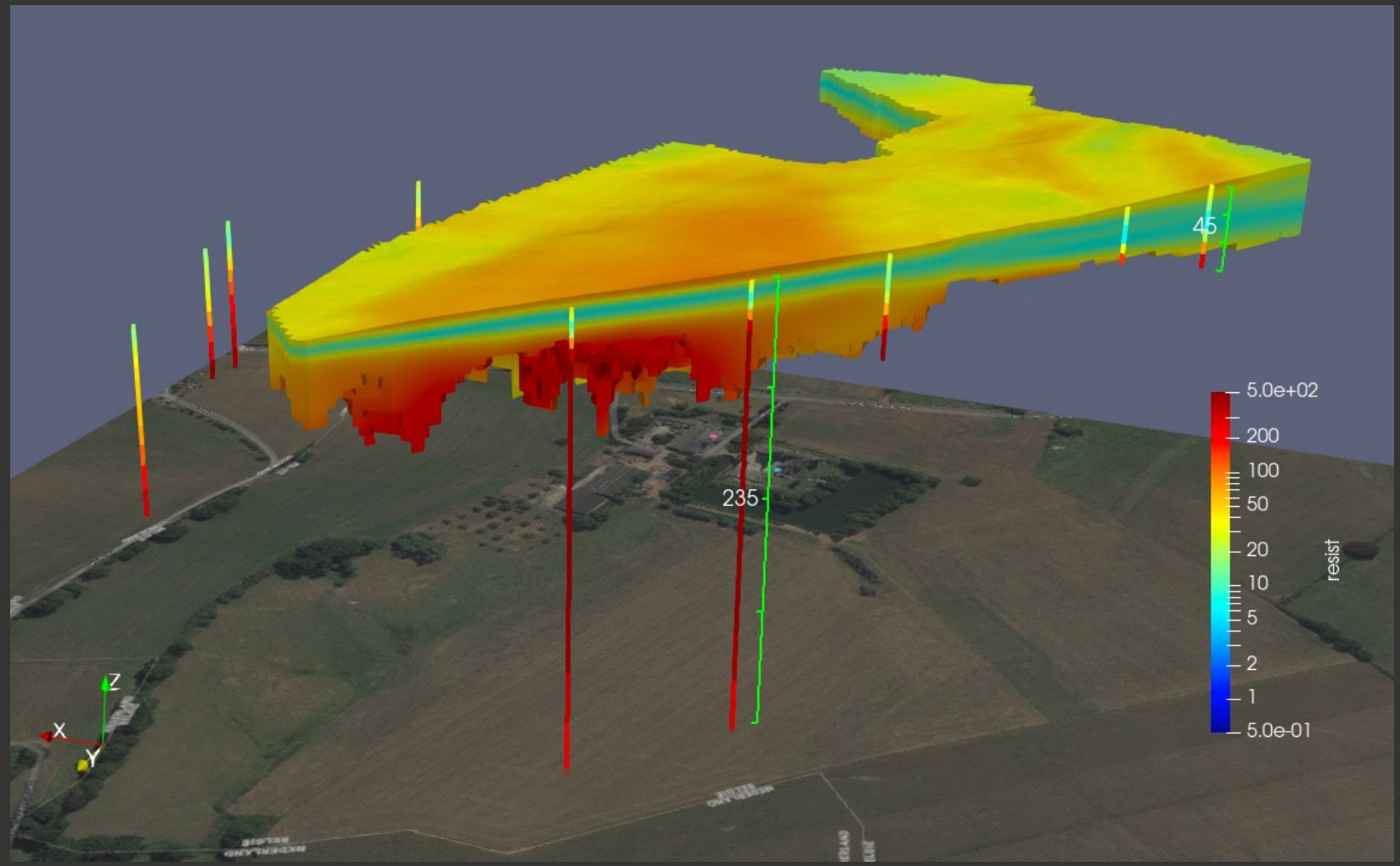






Beusdael: 3D integration of tTEM and WalkTEM data

- Good consistency between tTEM 3D resistivity model and WalkTEM soundings in the shallow subsurface
- WalkTEM data indicate reduced resistivities in the deeper subsurface
- SkyTEM's airborne TEM systems would be comparable or better than walkTEM

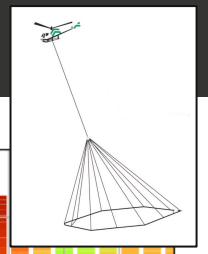


Interface detection using an ANN

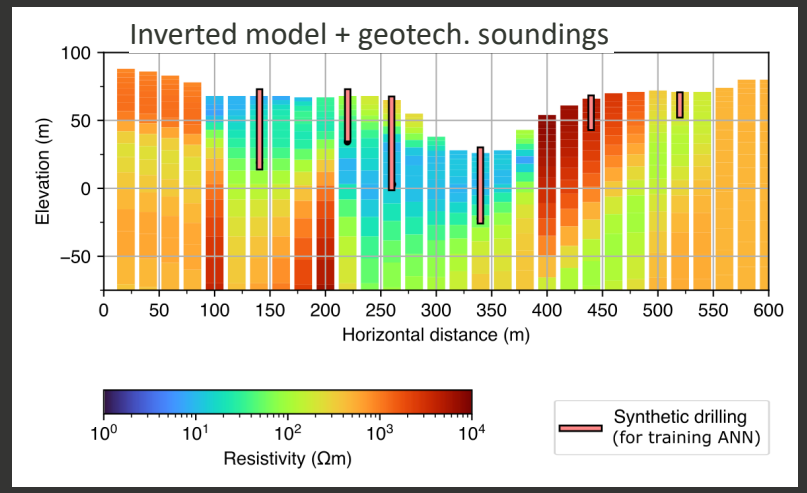
EMerald Geomodelling

Lysdahl, A. K., Christensen, C. W., Pfaffhuber, A. A., Vöge, M., Andresen, L., Skurdal, G. H., & Panzner, M. (2022). Integrated bedrock model combining airborne geophysics and sparse drillings based on an artificial neural network. *Engineering Geology*, *297*, 106484.

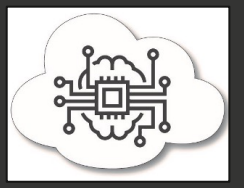
Geophysics

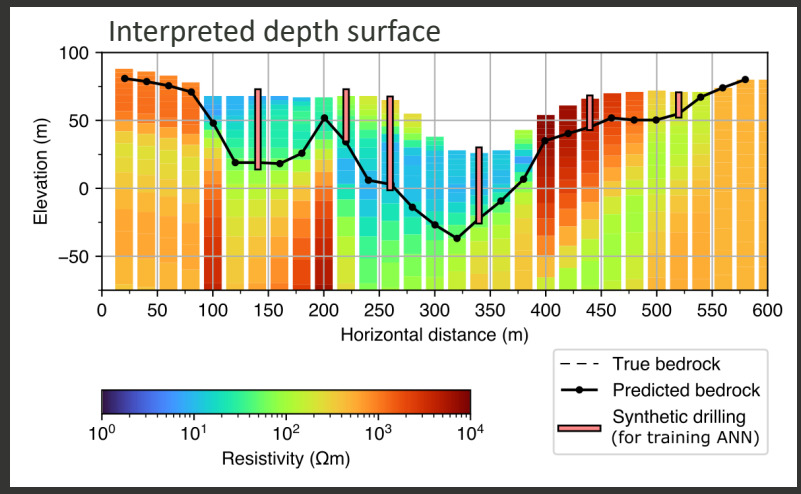


+ Geotech

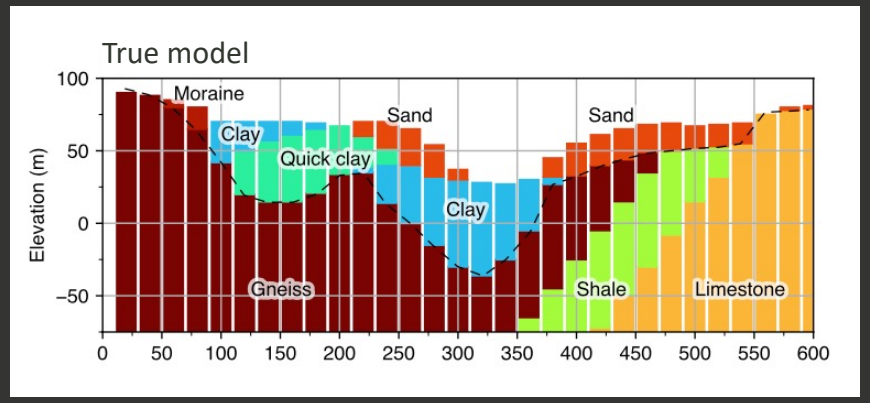


+ Machine-learning



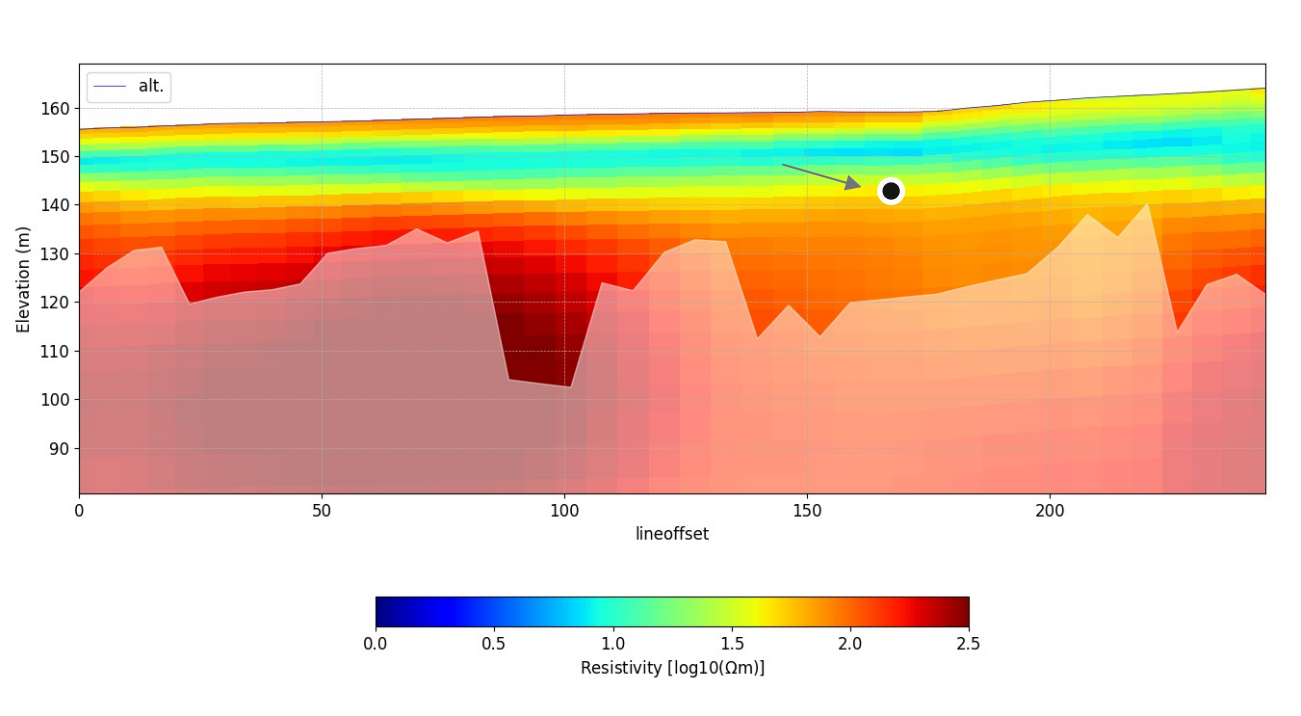


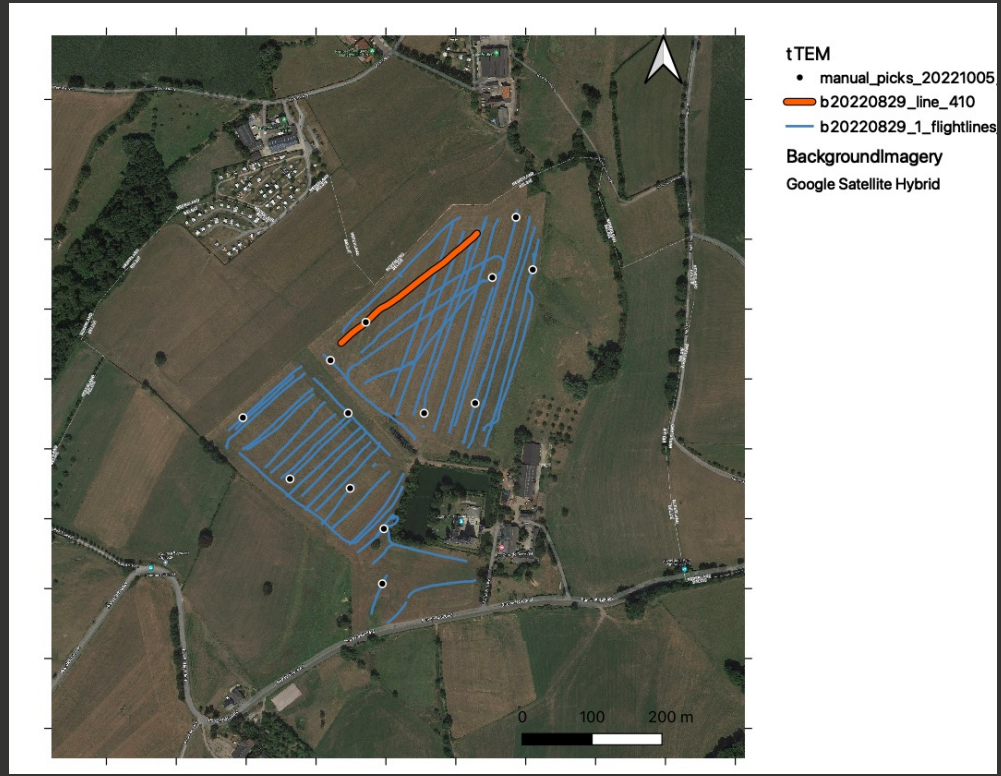
= Better subsurface interpretation



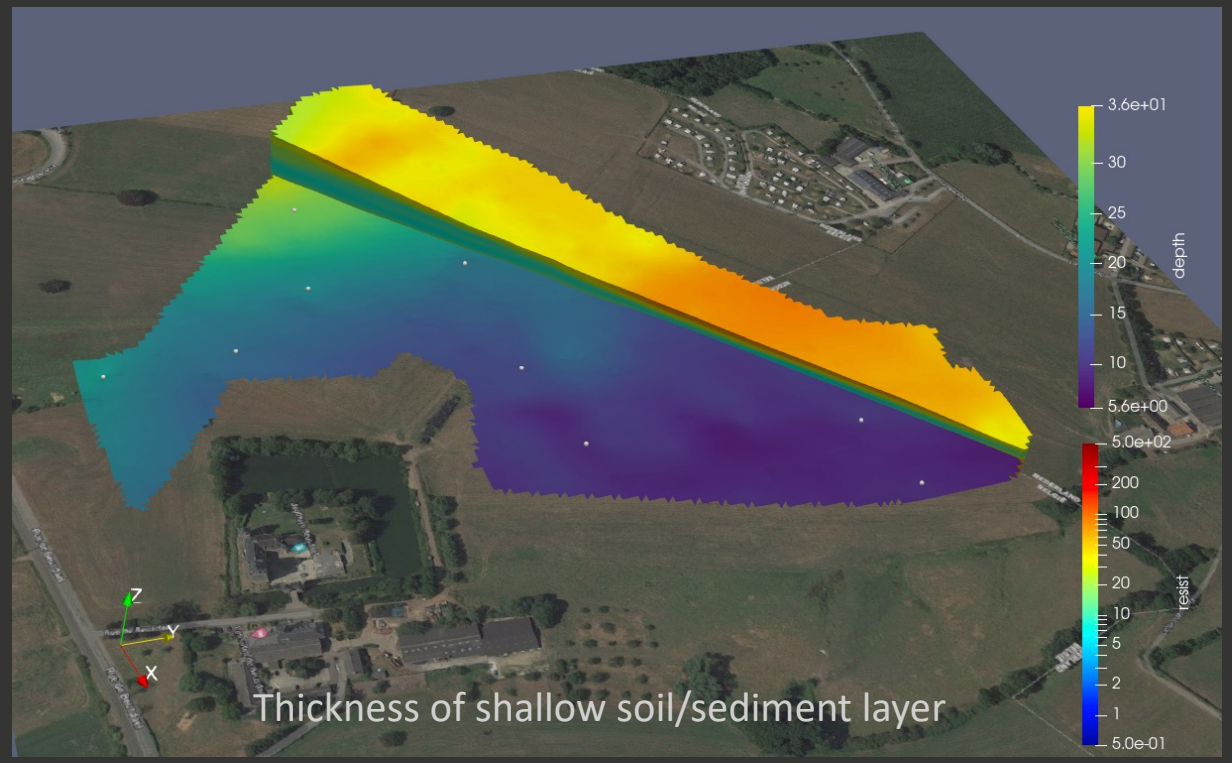
Manually picked training data

To train the ANN bases interpretation of the shallow soil layer

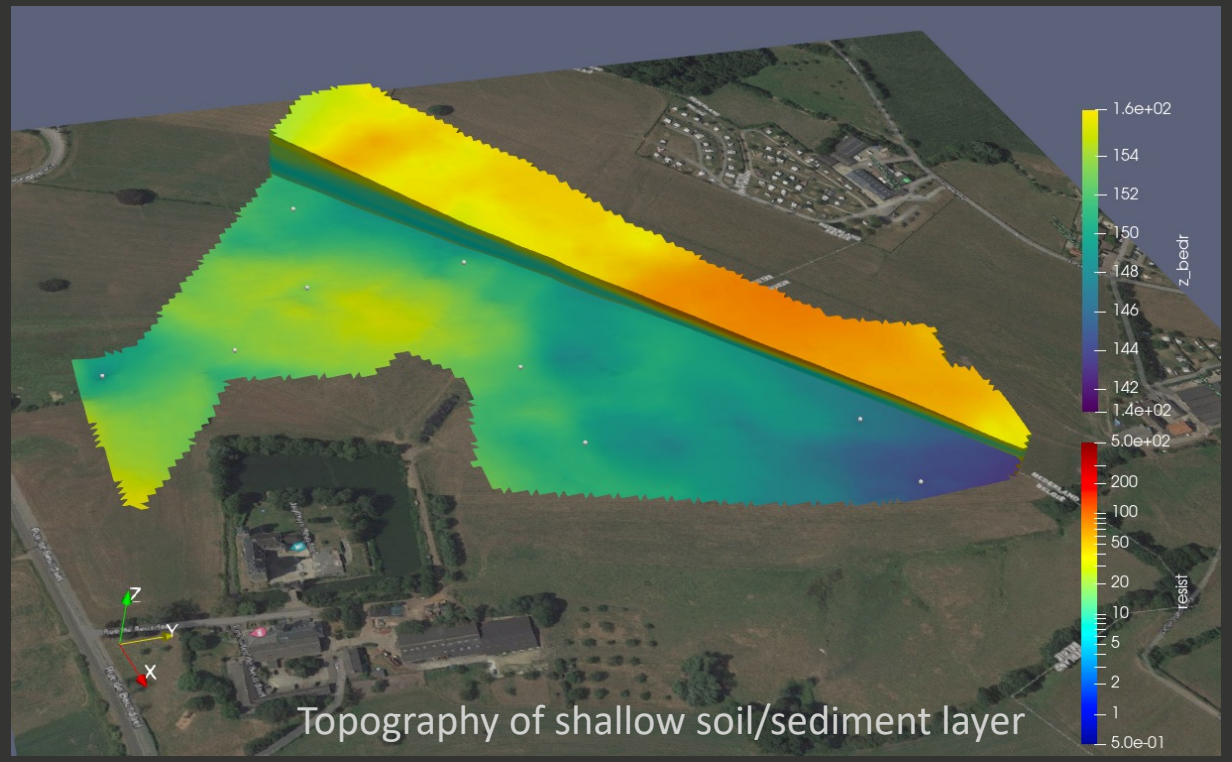




Beusdael: ANN interface interpretation

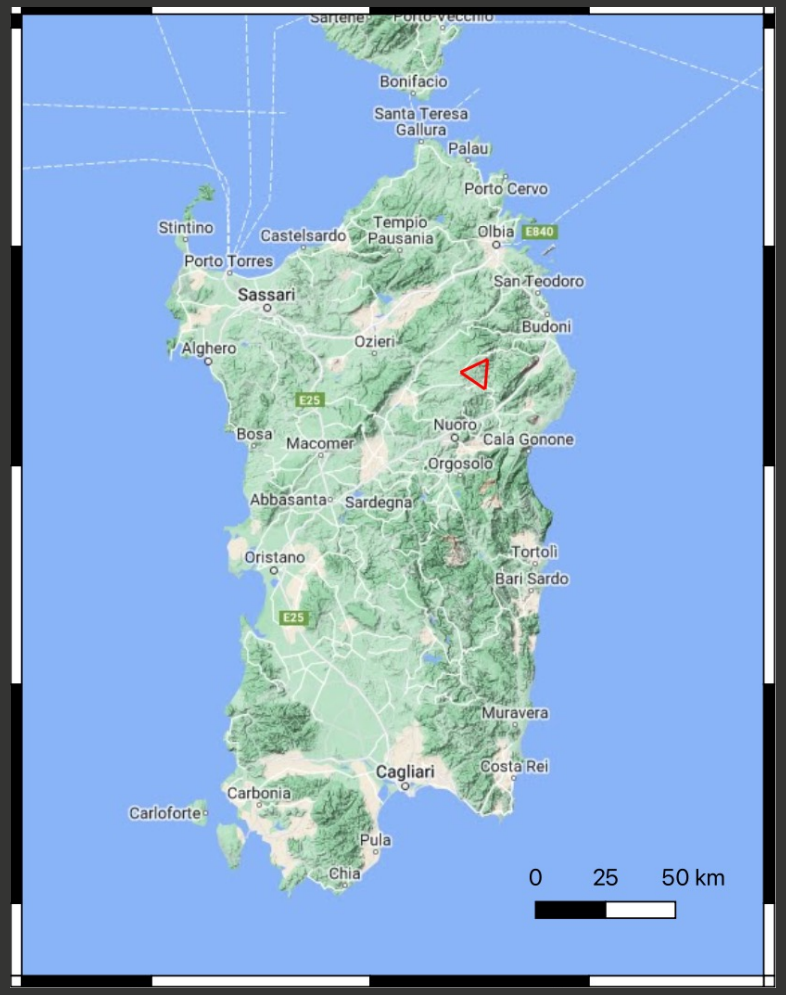


Thickness of shallow soil/sediment layer



Topography of shallow soil/sediment layer

Feasibility for using TEM at Sardinia



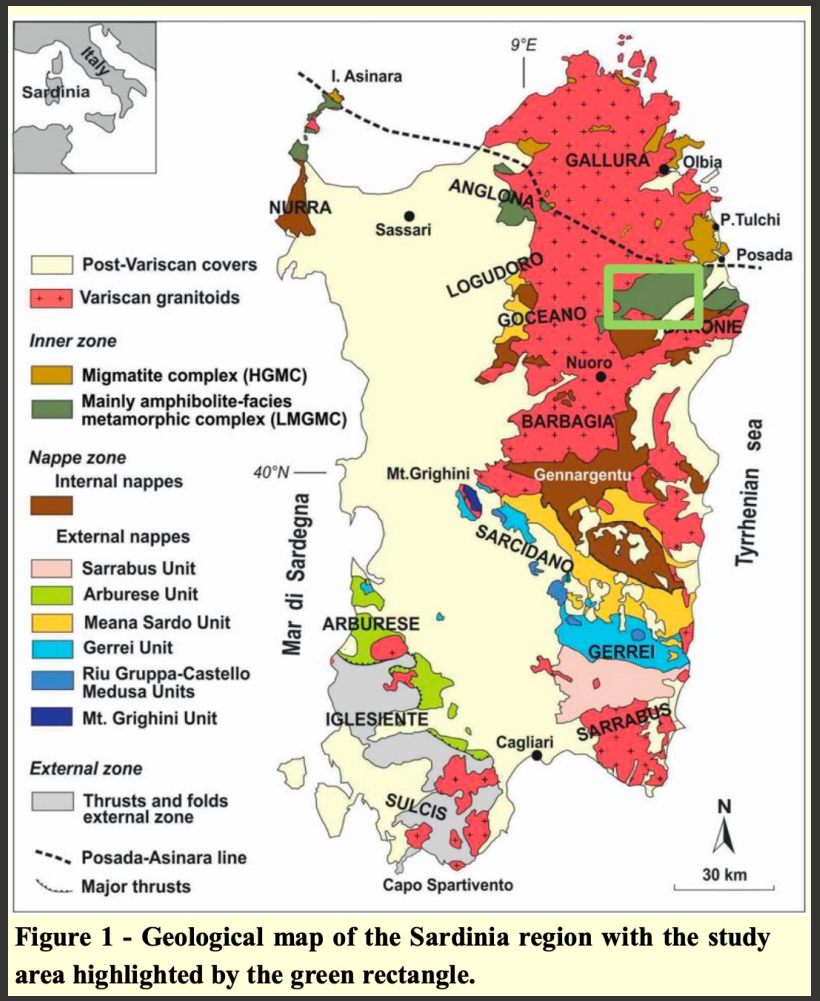


Figure 1 - Geological map of the Sardinia region with the study area highlighted by the green rectangle.

Paper/Poster by

V. LONGO 1*, G.L. CARDELLO 1, G. OGGIANO 1, Characterizing the hydro-structural setting of the Einstein Telescope site of Sardinia (Italy): insights from Electrical Resistivity Tomography , ET-conference, 8-11- Nov. 2021 Nuooro

Earlier ERT Survey Results

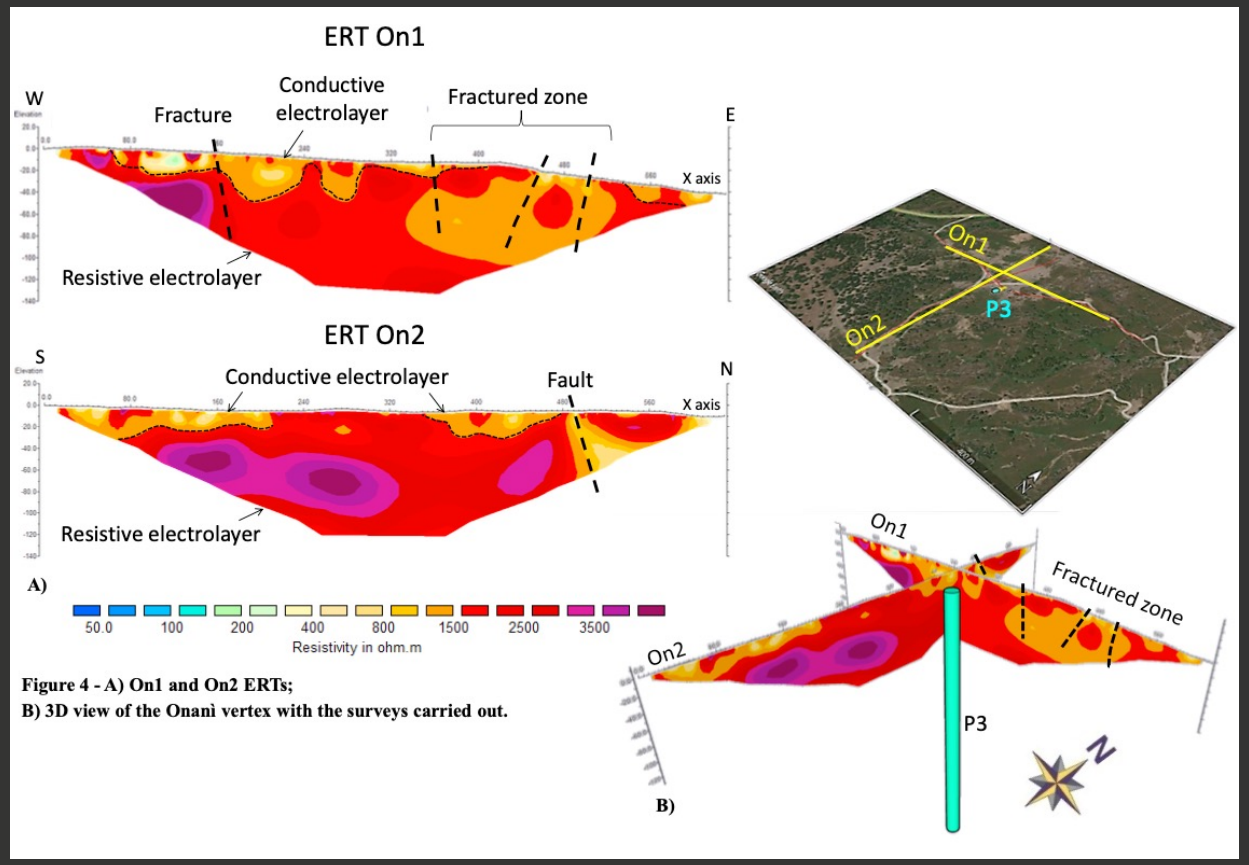


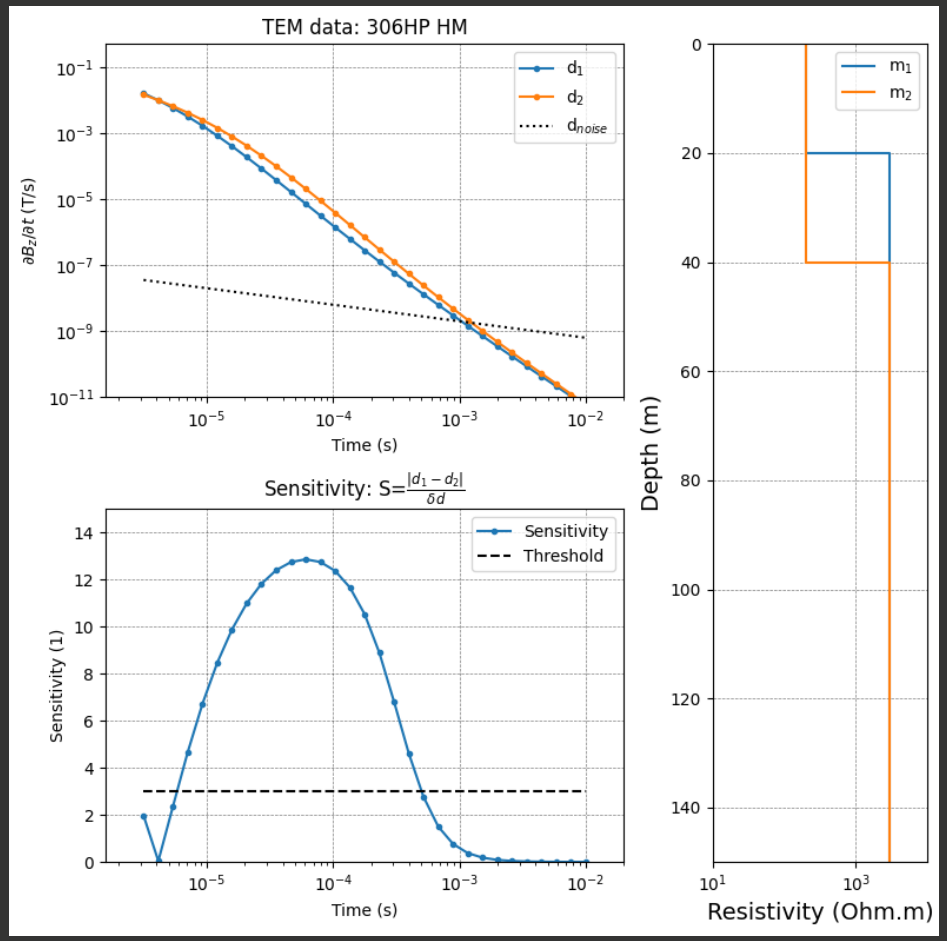
Figure 4 - A) On1 and On2 ERTs;
B) 3D view of the Onanì vertex with the surveys carried out.

Rock type / Geologic feature	Electric resistivity [Ωm]
Bedrock	2000+
Shallow weathering zone	150 – 1000
Fault zone, fractured rock (weakness zone)	500 - 1000

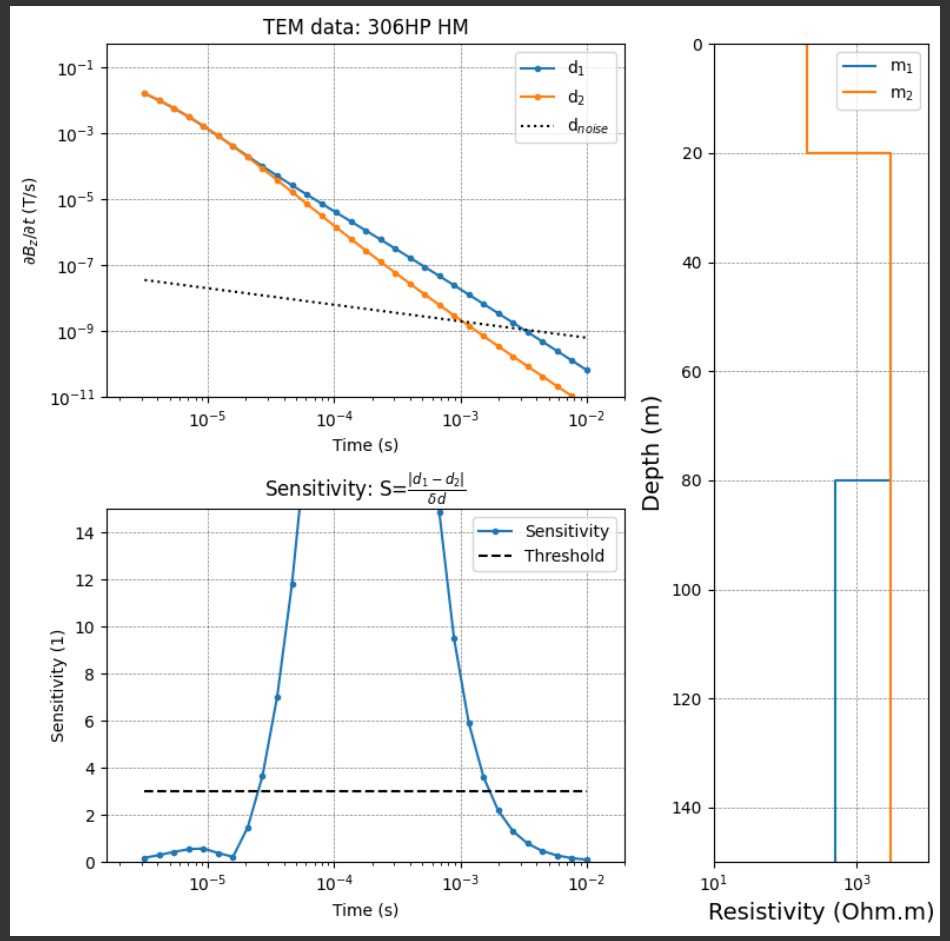
Paper/Poster by
V. LONGO 1*, G.L. CARDELLO 1, G. OGGIANO 1, Characterizing the hydro-structural setting of the Einstein Telescope site of Sardinia (Italy): insights from Electrical Resistivity Tomography , ET-conference, 8-11- Nov. 2021 Nuooro

Sensitivity analysis

Shallow soil / weathered rock

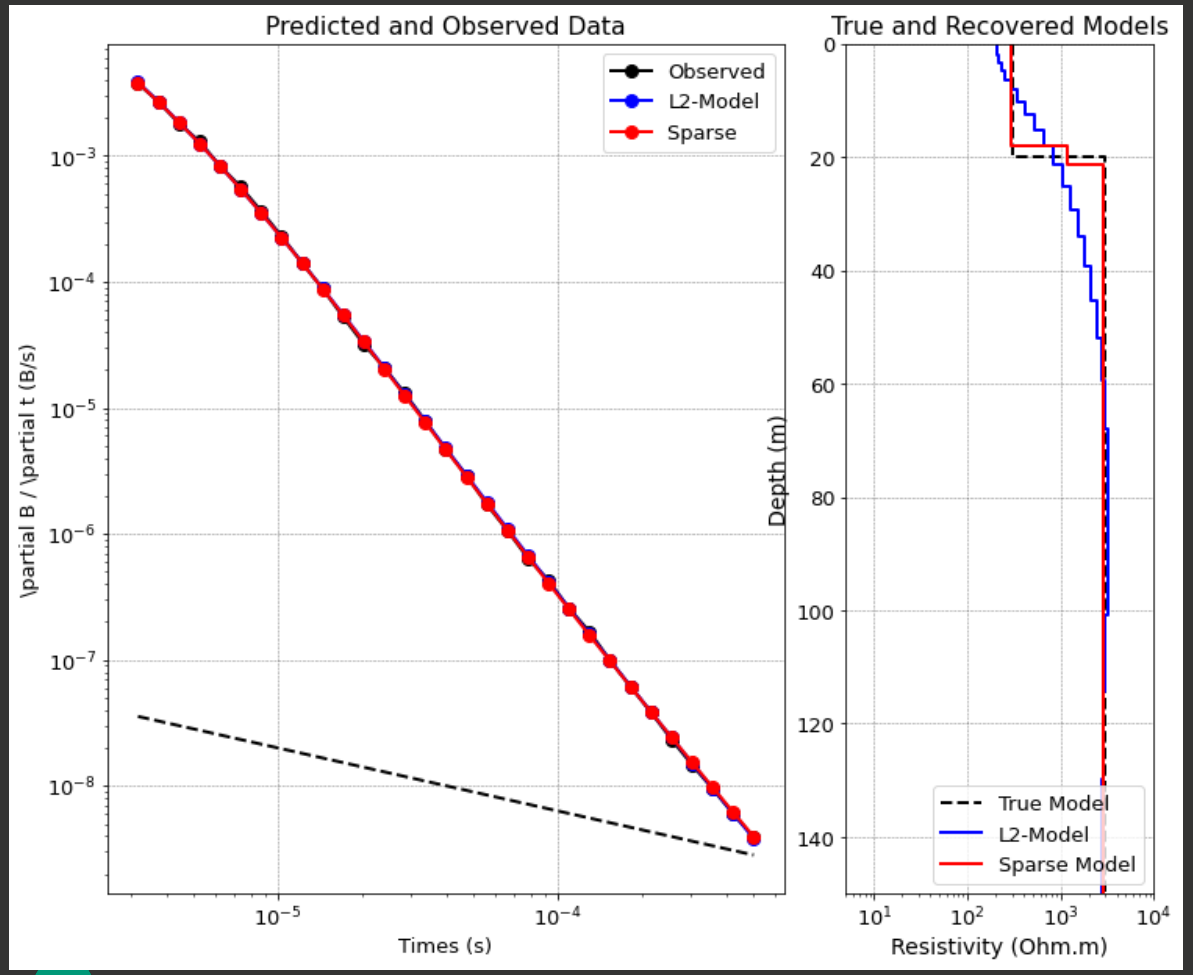


Deep weakness zone

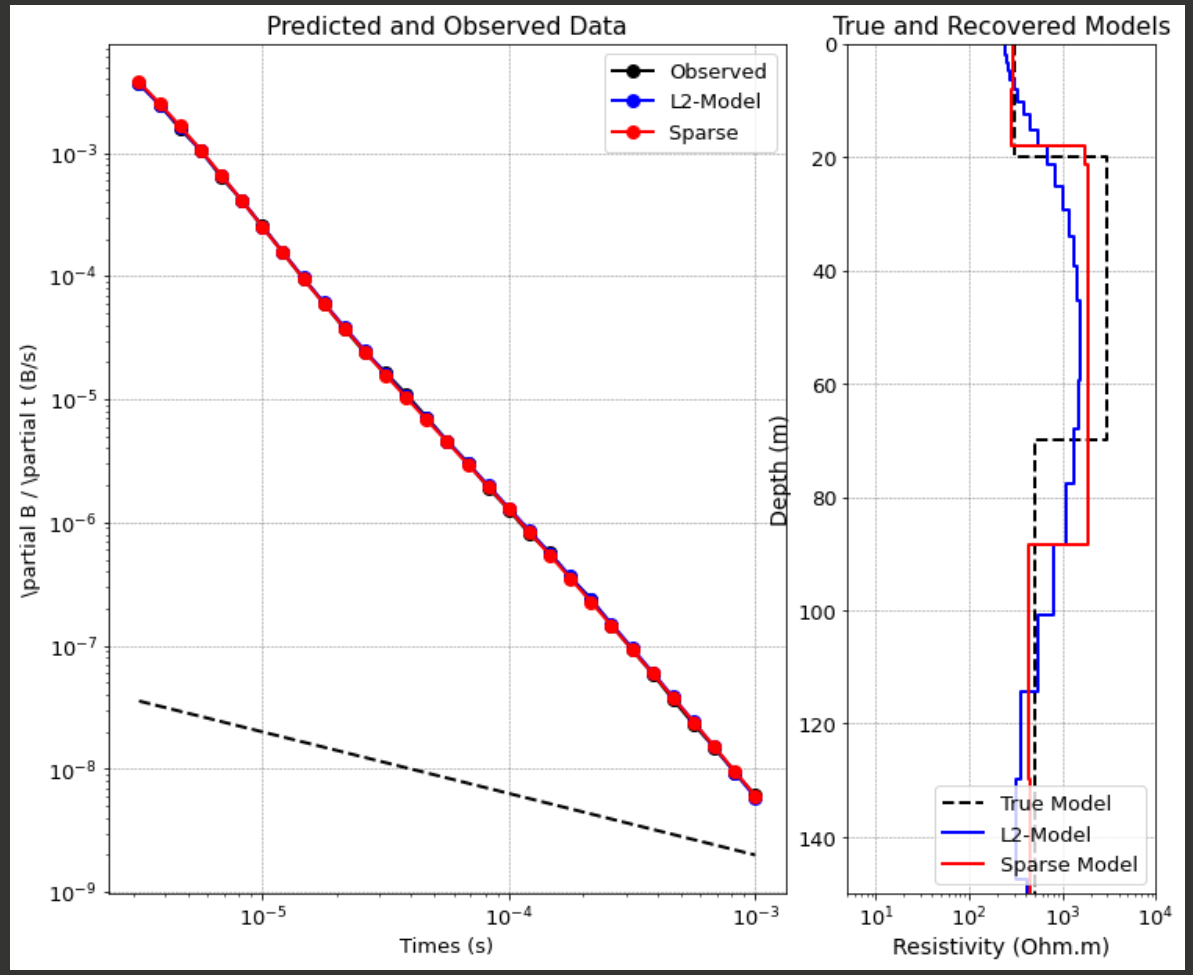


Inversion study

Shallow soil / weathered rock



Deep weakness zone



Summary and Conclusion

- TEM is superior if it comes to acquisition speed and areal coverage
- TEM can robustly resolve the upper weak soil/sediment layer
- Late time TEM data can be used to map deep resistivity variations at grater than 50m depth, requires bigger TEM systems (walkTEM/SkyTEM)
- TEM data can be diluted by manmade infrastructure
  - fences, roads, buried cables/pipes, powerlines, housing
  - limits use, especially for mapping the deep subsurface with big TEM systems.
- Sardinia is well suited for TEM
  - Good data sensitivity
  - Less infrastructure