BGR Bundesanstalt für Geowissenschaften und Rohstoffe

GEOZENTRUM HANNOVER

CLIWAT CLIMATE & WATER

Comparison of Small-Scale CPT Data and Large-Scale AEM Resistivity Models in Northern Friesland, NL

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Introduction

Climate change simulations indicate a sea-level rise and increasing rainfall in the North Sea region. This will lead to higher groundwater levels and a forced outwash of nutrients and pollutants from industrial areas, agriculture and landfills. The transnational Interreg project CLIWAT (climate & water, http://cliwat.eu/) was initiated by partners from Belgium, The Netherlands, Germany and Denmark. The aim of the project is to determine the effects of a possible climate change on groundwater systems, surface water and the fresh/salt-water boundary in the North Sea and Baltic Sea region. The project is co-funded by the European Union.

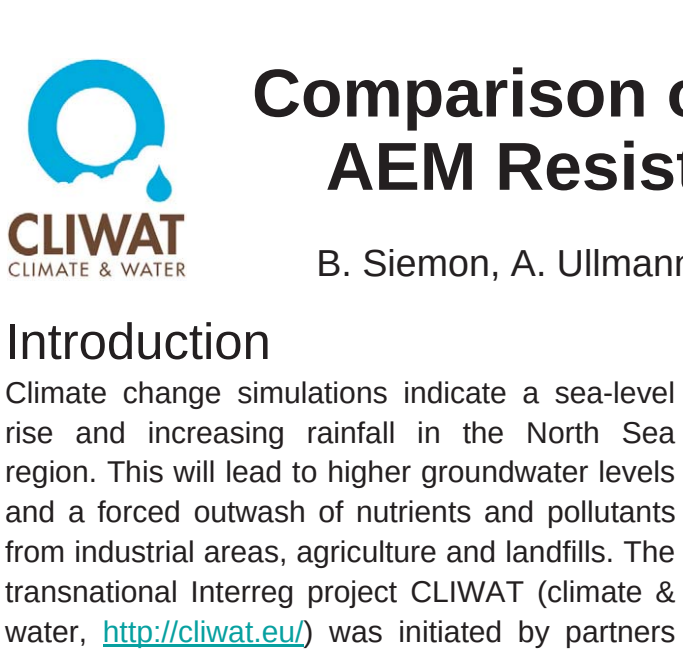

Fig. 1: *Pilot areas of the CLIWAT project (A–G) and BGR airborne survey areas (134–137)*

Airborne Surveys

One of the seven pilot areas (**A**–**G**) is situated in Northern Friesland (**C**, Fig. 1), where airborne electromagnetic surveys (area 137) were flown to reveal the subsurface resistivity distribution as input to a groundwater model setup. The German Federal Institute for Geosciences and Natural Resources (BGR) operates a standard frequency-domain HEM system (Resolve). The Hydrogeophysics Group (HGG) of the University of Aarhus uses a time-domain helicopter-borne system (SkyTEM) specially designed for both shallow and deep investigations (Fig. 2 and 4).

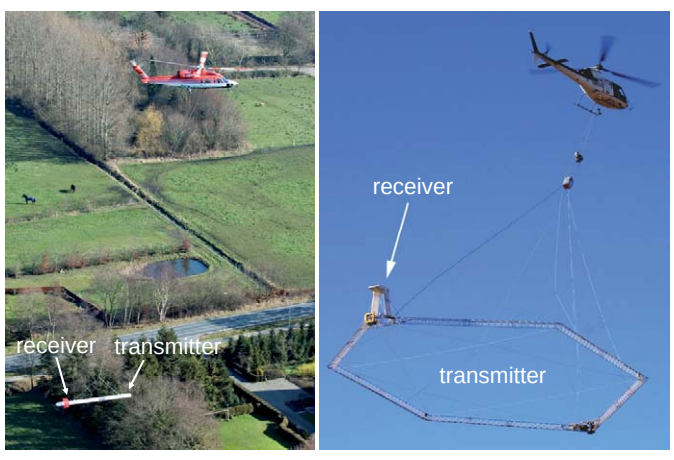

Fig. 2: *Helicopter-borne electromagnetic systems: Resolve (left) and SkyTEM (right)*

Cone Penetration Tests

Cone penetration tests were conducted on behalf of the Dutch project partners. The CPT truck of Wiertsema & Partners (Fig. 3) is able to derive both penetrometer and conductivity (ECPT) data. The latter was converted to resistivity to compare local ECPT results with resistivity models derived from the large-scale AEM surveys.

Fig. 3: *Field demonstration of the CPT truck during a CLIWAT workshop on Terschelling*

Comparison HEM vs. SkyTEM

The HEM data were inverted to resistivity-depth models using a five-layer single-site inversion strategy providing resistivities down to 30 to 60 m depth. For the SkyTEM data, a spatially constrained 19-layer smooth inversion strategy was used providing model depths of 160 m. The HEM resistivities are displayed at several depths below sea level and compared with the SkyTEM interval resistivities at corresponding depths. Generally, both model sets agree well. Within the upper 5 m, however, some discrepancies occur (Fig. 5).

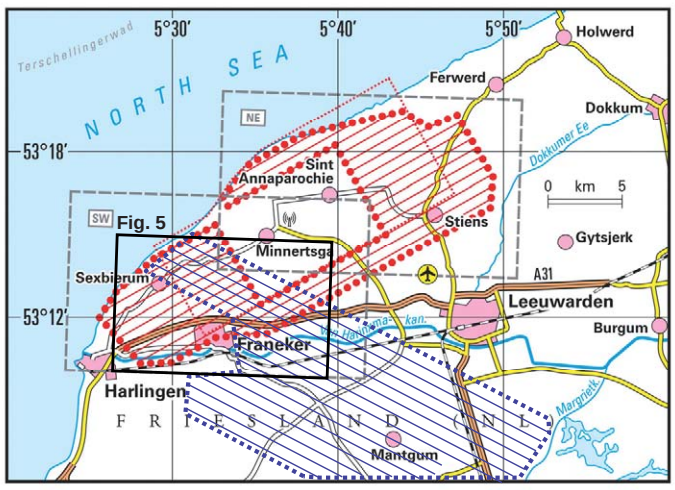

Fig. 4: *HEM (red dots & stripes) and SkyTEM (blue dots & stripes) survey areas in Northern Friesland*

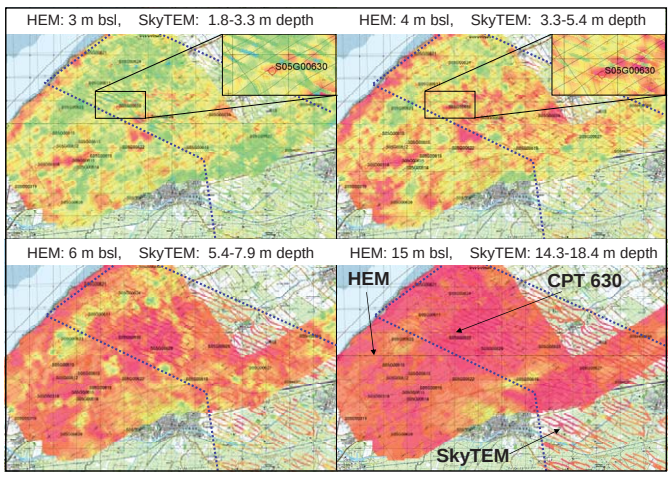

Fig. 5: *Comparison of resistivity maps (HEM) and lines (SkyTEM) in the overlap area (colours cf. Fig. 6)*

Comparison ECPT vs. AEM

Close to the CPT site 630 the AEM resistivity models were compared with ECPT data (Fig. 6).

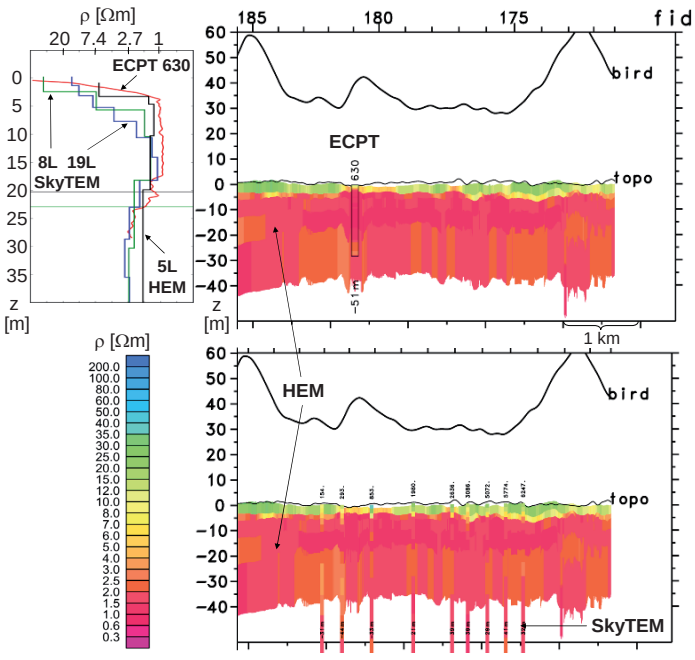

Fig. 6: *Comparison of HEM (resistivity sections), ECPT and SkyTEM models (resistivity columns) and a HEM-SkyTEM-ECPT resistivity-depth plot.*

EC derived from AEM data

Scatter plots of AEM and ECPT values were produced to investigate if reasonable EC values can be derived from AEM models. The mean values are as expected and the variations are acceptable. Thus, EC values can be derived from AEM models for the area between the CPT sites.

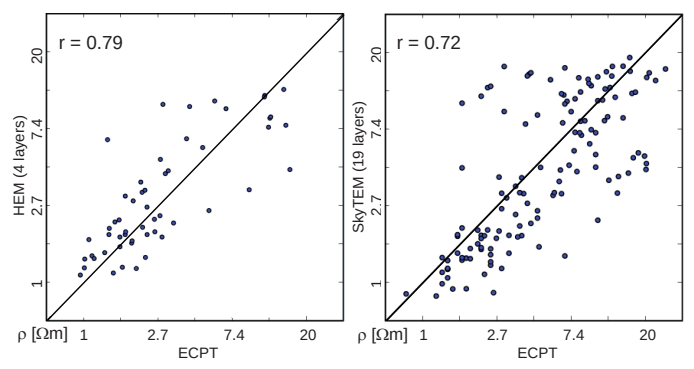

Fig. 7: *Scatter plots of HEM (left) and SkyTEM (right) vs. ECPT; HEM substratum values are not used*

Conclusions

The consistency of the ECPT measurements having a footprint of a few centimetres with the AEM models having a footprint of some hundred metres was surprisingly good. This indicates that the spatial continuity of the resistivity is varying at a spatial scale comparable to the footprint of the airborne data.

References

Siemon, B., Christiansen, A.V. & Auken, E., 2009. A review of helicopter-borne electromagnetic methods for groundwater exploration. Near Surface Geophysics, 7, 629-646.

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