Westfälische Wilhelms-Universität Münster

Applied Geophysics

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Inversion of HEM data from the sinkhole area “Heiliges Meer”

Motivation

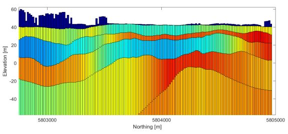
- “Heiliges Meer” is a lake with an area of 11 ha formed approx. 1000 years ago by a subrosion process which continues until today
- Geology: Under a mainly quarternary, 30 to 90 m thick overburden, Marl layers of several hundred meters thickness with veins of salt rocks are being leached, resulting in several sinkholes (> 20 m depth)
- Geological and hydrogeological models try to explain and predict the exact leaching process
- Geophysical models could contribute to a better understanding and knowledge
- Many geophysical and hydrological measurements were carried out and boreholes drilled
- In 2002, an area of approx. 2 km² was surveyed by the BGR with its helicopter-borne RESOLVE system, carrying five pairs of horizontal coplanar coils
- Objective of this work: Inverting the data, supporting with and comparing to existing geologic models

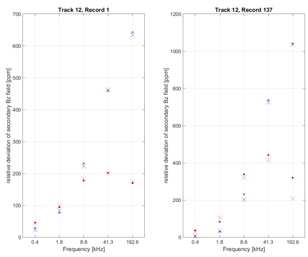
Method

- A code for 1D forward calculations using the Fast Hankel Transform was developed
- Inphase and quadrature parts of secondary field deviation for the five measurement frequencies (0.4 to 200 kHz) were used for inversion
- Different inversion schemes were applied:
  - Pointwise Occam inversion: 18 layers, fixed layer thicknesses, 0^{th} and 1^{st} order regularization
  - Laterally constrained Occam inversion: Additional constraints of resistivities
  - Pointwise Levenberg-Marquardt inversion, 5 to 7 layers with thicknesses being varied, 0^{th} order regularization
  - Laterally constrained Levenberg-Marquardt inversion: Additional lateral constraints on resistivity, layer thickness and layer depth (cf. Auken & Christiansen, 2004)
- Measured bird altitude was not yet corrected, thus, the 0^{th} order regularization is suspended for the topmost layer
- Regularization is also suspended for the expected contact between lakes and rock
- As starting model, a constant resistivity of 100 ohm-m or a model derived from apparent resistivities and centroid depths (Siemon & Sengpiel, 2000) can be chosen

▶ **Figure 4:** Comparison between good and bad data fit of the 6 layer LM-LCI (q = 2% resp. q = 9.5%). The blue dots and crosses refer to real parts, red ones to imaginary parts

▼ **Figure 5:** Lateally constrained irnverison can converge to models showing jumping resistivity distributions between wavy layers even for a starting model derived from app. resistivities





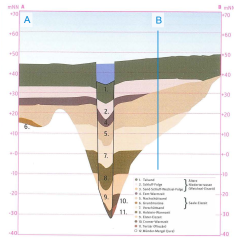
Problems

- Especially in the topmost layers, the inversion results show strong dependence on the starting model
- If the constraint strengths of resistivity and layer depth in LCI are chosen too low, the inversion result may show “jumping” resistivity distributions between adjacent wavy layers. This happens for both considered starting models
- The data basis is probably insufficient to resolve more of the layers in the geological model
- Anthropogenical effects are visible

Outlook

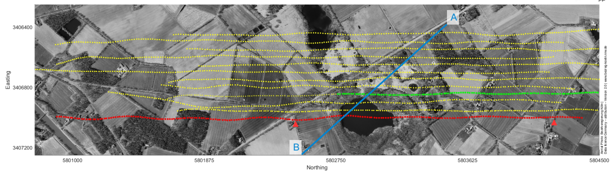
- Carry out inversion of all profiles together with lateral constraints between profiles
- Add a-priori information of geological and hydrogeological model
- Carry out joint inversion with other geophysical data

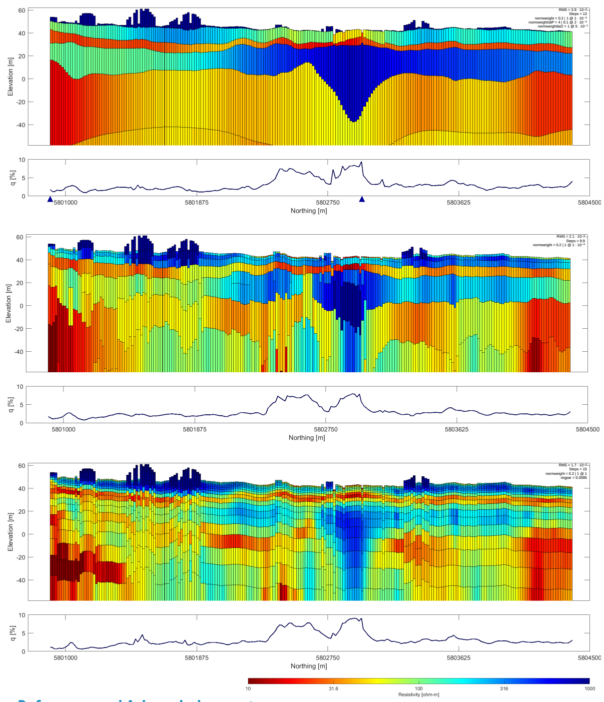
▶ **Figure 1:** Geological model in a profile transecting the Heiliges Meer (Terlutter, 2009, originally by Dölling & Stritzke, 2009)



▼ **Figure 2:** Overview of the flight lines of the BGR superimposed on an aerial photo of the measurement area. The red marked profile is used as an example in figures 3 and 4, the green marked points in figure 5. At the red triangles, anthropogenic effects are visible in the data of the red profile

▼▼ **Figure 3:** Comparison between different inversion models. From top to bottom: LM LCI with 6 layers and starting model by Siemon & Sengpiel's (2000) method – pointwise LM with 7 layers and constant resistivities as starting model – Occam inversion with fixed layer thickness. The plots below show q, the mean deviation from the measured data (Siemon & Sengpiel, 2000). Data of the records marked by blue triangles are shown in figure 4.





References and Acknowledgements

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