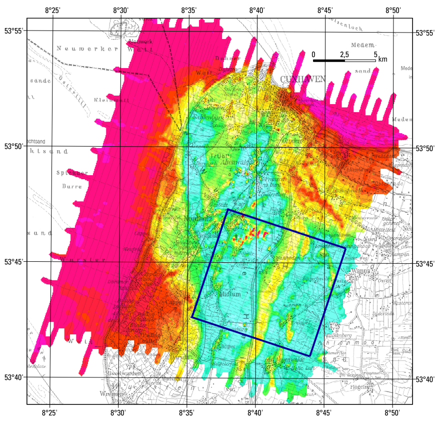
Classification of induction anomalies in helicopter-borne electromagnetic data sets

Angelika Ullmann, Bernhard Siemon, Uwe Meyer

Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)

Study area Cuxhaven



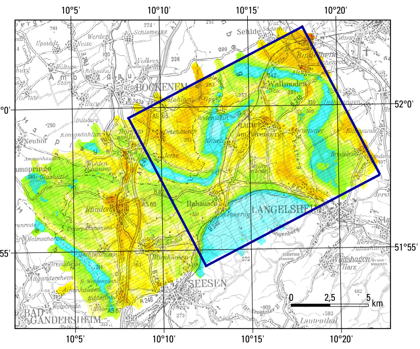
The figure on the left gives an overview of our study area Cuxhaven and shows the apparent resistivity at the frequency f = 1830 Hz. The geological setting at this site contains a buried valley, the Cuxhavener Rinne, which clearly appears as a SSW-NNE running conductive structure (yellow). The blue box marks the area of further interest.

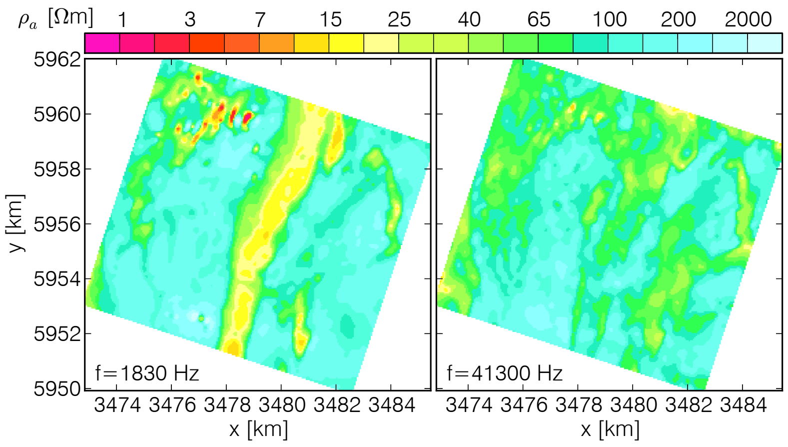
Introduction

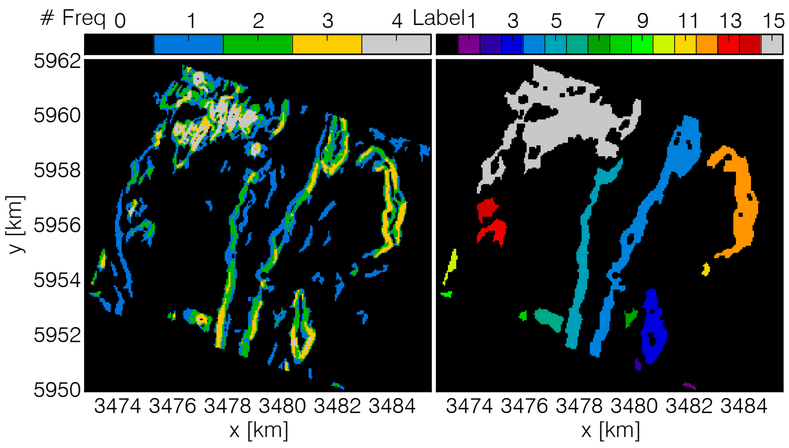
Within the project AIDA, funded by the Federal Ministry of Education and Research grant 03G0, we are working on combining 1-D and 3-D inversion of helicopter-borne electromagnetic (HEM) data. As conductivity structures with strong lateral variations (induction anomalies) are not reproducible by 1-D inversion a multidimensional inversion is required. Thus, the information where such induction anomalies occur in a HEM data set is crucial. A search algorithm is developed to browse the HEM data sets to automatically identify, select, and classify these induction anomalies. The identified induction anomalies are classified by region-based shape descriptors which are known from image processing. The four shape descriptors compactness, eccentricity, elongatedness, and deficit of convexity are grouped to five different classes using the k-means algorithm. The search algorithm is tested on HEM data sets for our study areas Cuxhaven (left) and Rhüden (right).

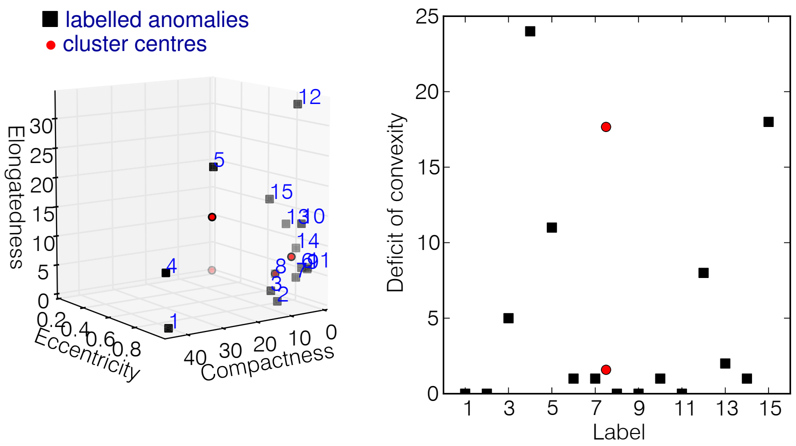
Study area Rhüden

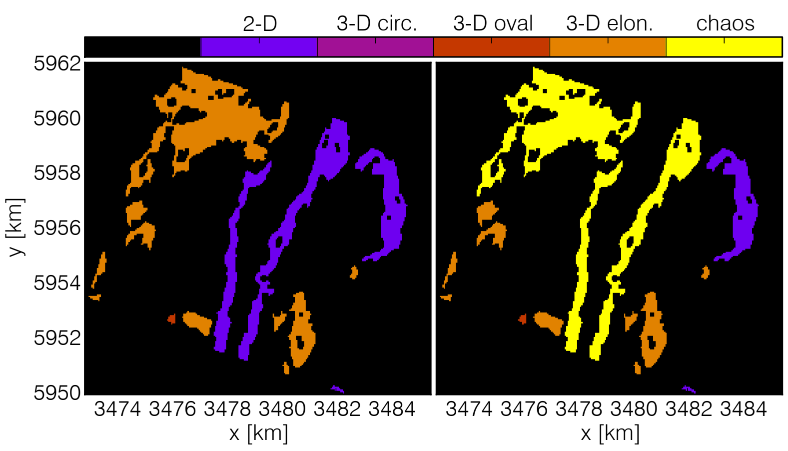
The figure below gives an overview of our study area Rhüden and displays the apparent resistivity at the frequency f = 1830 Hz. The north-west edge of the Harz Mountains clearly appears as a resistive structure in the lower middle part of the map (blue). The complex Mesozoic strata to the north and west can be distinguished due to their different conductivities. The blue box marks the area of further interest.











Starting point

The measured secondary field data are transformed to the half-space parameter apparent resistivity ρ_a (Siemon, 2001). Then, 2-D grids of the logarithmic ρ_a are produced with a cell size of 50 m at four frequencies (e.g. figures left and right). These 2-D grids serve as the starting point for the search algorithm.

Search algorithm

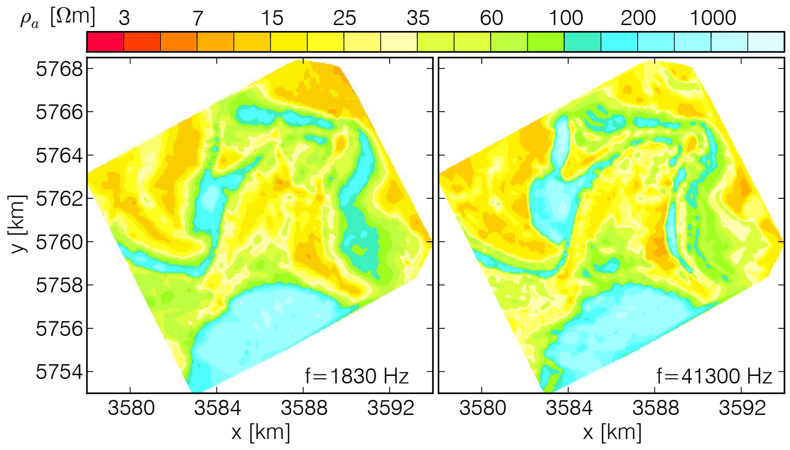
The search algorithm uses several image processing methods (Sonka et al., 1993; Canny, 1986) to automatically identify and select induction anomalies present in the two HEM data sets. The basis are grids of the total horizontal gradient of ρ_a. Only areas with strong gradients are selected and the corresponding indicators are summed up to show anomalies at multiple frequencies (left part of figures left and right). A labelling algorithm (Sonka et al., 1993) is applied to the results in order to identify connected anomalous areas (colour-coded, right part of figures left and right).

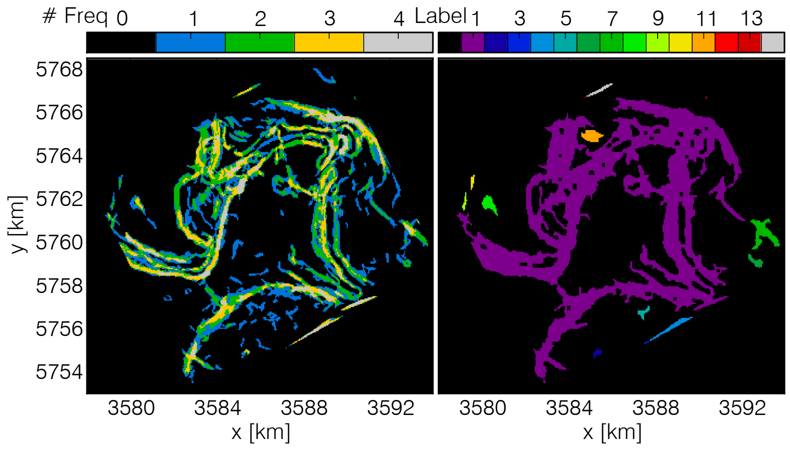
Classification

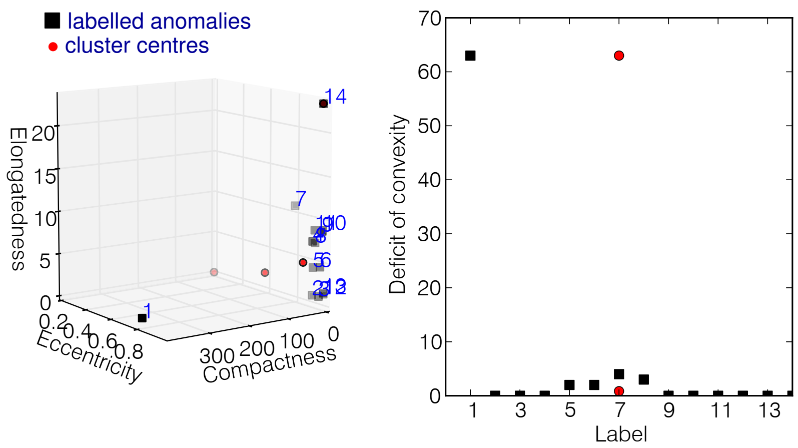
The identified induction anomalies are sorted in five different classes ('2-D', '3-D circular', '3-D oval', '3-D elongate', 'chaos'). In two steps, the region-based shape descriptors compactness, eccentricity, elongatedness, and deficit of convexity (Sonka et al., 1993) are grouped to the corresponding classes by using the k-means algorithm (Lloyd, 1982). First, the induction anomalies are divided into 2-D and 3-D structures, in which the 3-D structures are differentiated into circular, oval, or elongated shapes (left part of figures left and right). Second, big induction anomalies consisting likely of overlapping single induction anomalies induced by different bodies in or on the subsurface are classified as 'chaos' (right part of figures left and right).

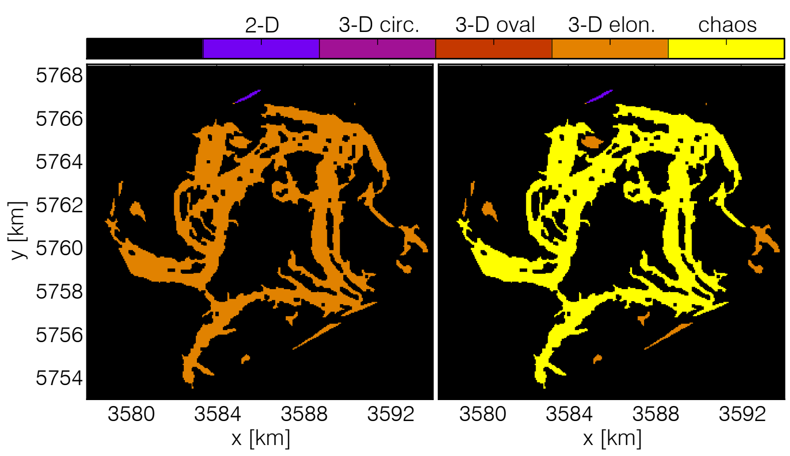
Conclusion

The newly developed search algorithm is able to automatically identify, select, and classify induction anomalies in HEM data sets. The method is successfully tested on HEM field data. The observed geological bodies in these areas are detected and classified as 2-D and 3-D structures by the search algorithm (figures left and right). These classification results will be used for optimised 3-D model set-up.









Contact:

Angelika Ullmann
Email: angelika.ullmann@bgr.de

References:

Canny, J. (1986). A computational approach to edge detection. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, *8*(6), 679–698.
Lloyd, S. P. (1982). Least Squares Quantization in PCM. *IEEE Transactions on Information Theory*, *28*(2), 129–137.
Siemon, B. (2001). Improved and new resistivity-depth profiles for helicopter electromagnetic data. *Journal of Applied Geophysics*, *46*, 65–76.
Sonka, M., Hlavac, V., & Boyle, R. (1993). *Image Processing, Analysis and Machine Vision.* Chapman & Hall Computing.

Funded by:

Bundesministerium für Bildung und Forschung