AIDA
AIDA – From airborne data inversion to in-depth analysis
GEOTECHNOLOGIEN

Combination of 1D and 3D HEM conductivity models

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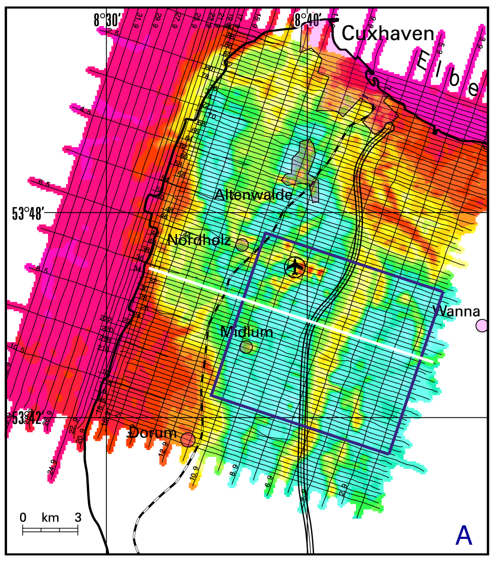
Introduction

Within the project AIDA, funded by the Federal Ministry of Education and Research grant 03G0, we are working on combining 1D/3D inversion of helicopter-borne electromagnetic (HEM) data. The principal idea is to restrict the demanding 3D inversion to regions where 1D inversion is not able to produce acceptable conductivity models. The challenging task is - besides 3D inversion itself - to define those areas where 1D inversion fails. The first step is to automatically identify, select, and classify these conductivity anomalies. A search algorithm is developed to browse the HEM data sets. In a next step, several image processing methods are deployed to extract the anomalies which are then handed over to the 3D inversion performed by the project partners at TU Bergakademie Freiberg. The search algorithm is tested on two HEM data sets: measured (left) and synthetic data (right) for our study area Cuxhaven. A HEM survey was conducted there in 2000. From its results, other geophysical methods, and borehole data a simplified, integrated 3D model of the Cuxhavener Rinne is derived. Synthetic HEM data are calculated for this model in order to make a comparison with the measured HEM data.

Measured data

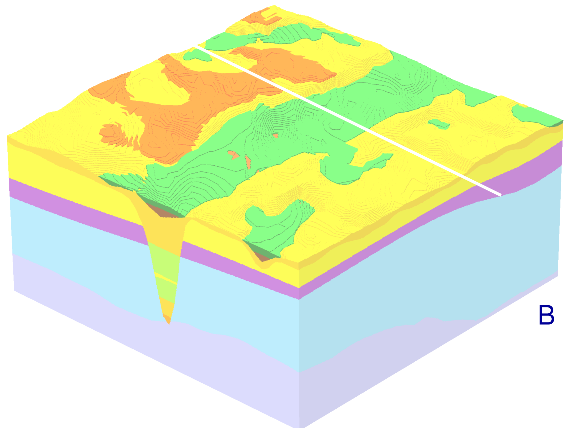
Figure A gives an overview of our study area Cuxhaven and shows the apparent resistivity at the frequency f = 1830 Hz. The blue box marks the area of further interest. Here, the Cuxhavener Rinne clearly appears as a SSW-NNE running conductive structure.



A

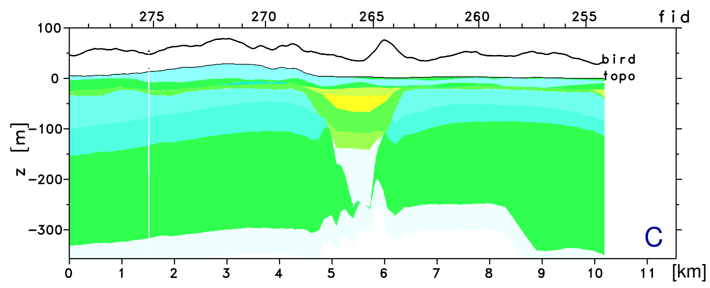
Geological 3D subsurface model

Initially the HEM data were inverted to resistivity-depth models using a Marquardt-Levenberg 1D inversion technique (Siemon, 2012). These models were analysed by means of geostatistical methods in GOCAD® to create a continuous 3D resistivity model by interpolation. Finally, the 3D resistivity model was correlated to borehole data and 2D seismic data to determine variations in lithology and to construct a more accurate geological 3D subsurface model (Steinmetz et al., 2012, Fig. B).

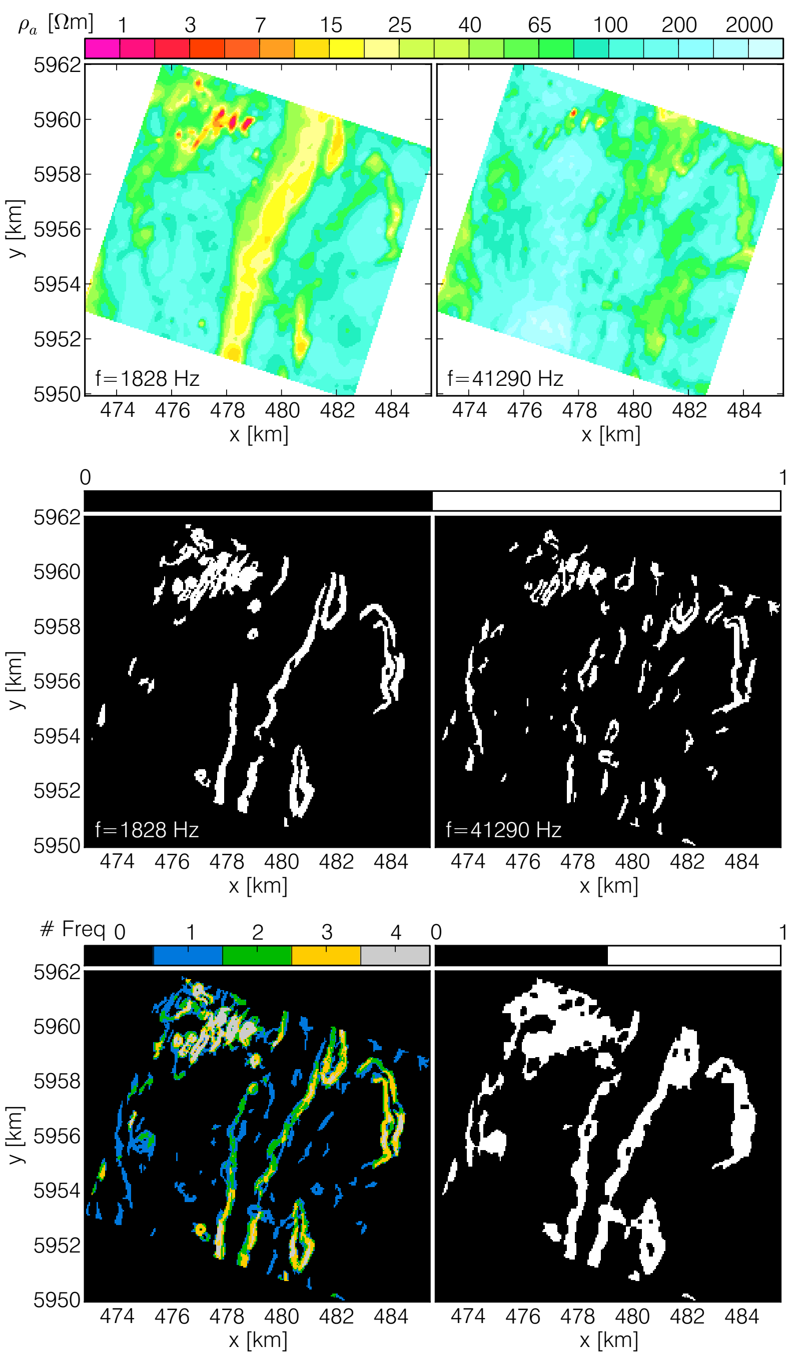

B

Synthetic data

In order to test whether the geological 3D subsurface model still fits the measured HEM data, the model has to be transformed back to a resistivity model. Therefore, each lithological unit is assigned with the mean value of the corresponding resistivities. This cross-check helps to improve and update the geological 3D subsurface model. 1D forward calculation is carried out at each measuring point to obtain synthetic HEM data (Siemon, 2012). Furthermore, it is planned to do a 3D forward calculation. Figure C shows a vertical resistivity section along a flight line (white line in Fig. A, B).



C



Starting point

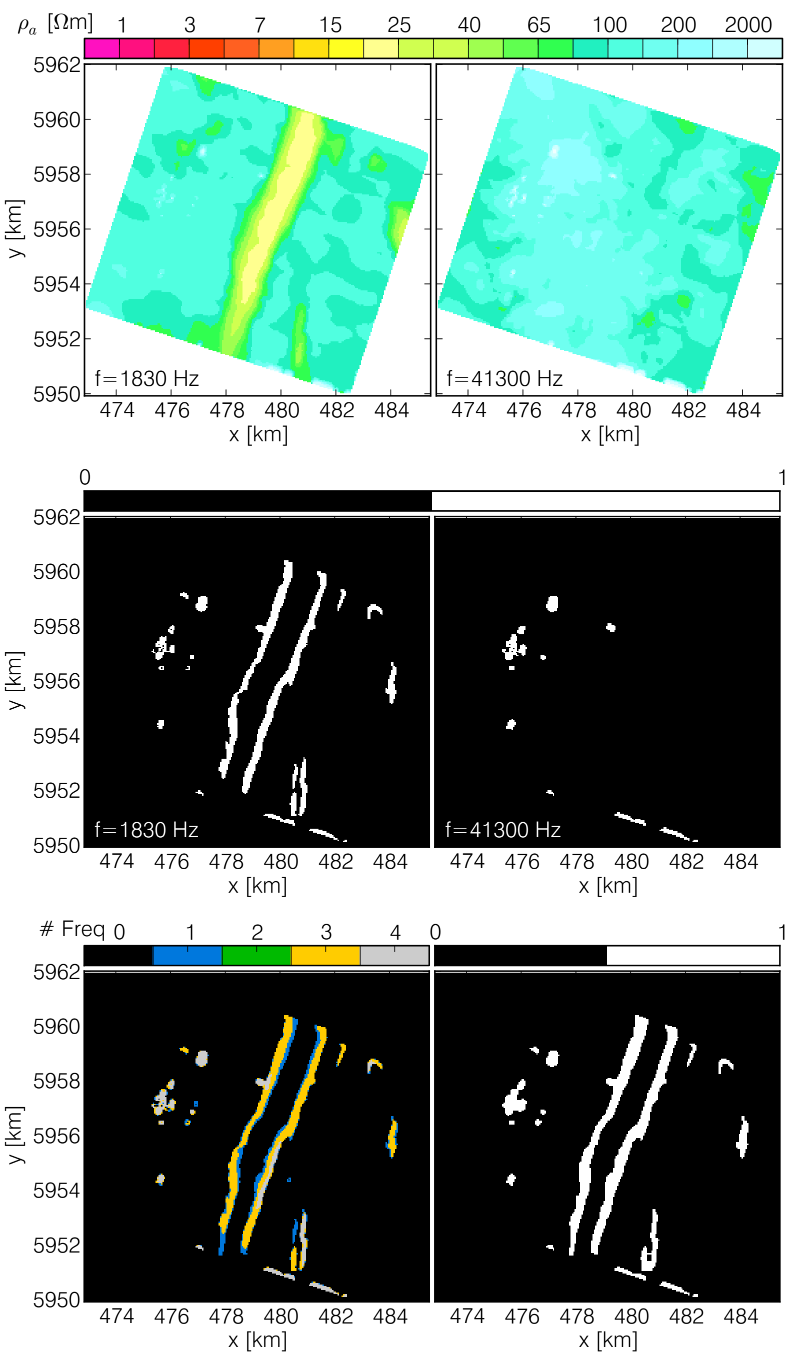
The measured and synthetic secondary field data are transformed to apparent resistivities ρ_a (Siemon, 2012). Then, for each frequency a grid of the logarithmic ρ_a is produced with a cell size of 50 m (figures left and right). The search algorithm is tested on low and high frequency apparent resistivity grids (left and right part of each figure, respectively).

Search algorithm

At first, the Sobel operator is applied to the ρ_a grids to get the gradient of the apparent resistivities (Richards, 1986). Afterwards the images are rescaled to grey values of 0 to 255. Second, a double thresholding algorithm is used to extract dominant edges in the images (Canny, 1986). This algorithm applies one high and one low threshold to an image. The two thresholds are automatically calculated from the grid values. The resulting binary images are shown on the left and right hand side.

Results

The single images at each frequency as the result of the image processing methods are summed up to get an overview of the areas where laterally varying conductivity structures (anomalies) exist and how many frequencies detect it (left part of the figures left and right). Areas which are only marked by one frequency are neglected (right part of the figures left and right). For both data sets the detected anomalies are consistent with the edges of the Cuxhavener Rinne as regions of lateral conductivity contrasts. These white areas require 3D modelling.



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References:

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