Aero-Ground Joint Inversion/Geophysical Application of Unmanned Aerial Systems

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Joint Inversion of Airborne and Ground Electromagnetic Data

Introduction

Geophysical data inversions often suffer from the uncertainties and non-uniqueness. To obtain the unique and meaningful model from the geophysical inversion, the inverted models are constrained by using the information from various sources. The constraints are the information from the local geology and lithology, sequential and joint inversion of two or more data sets belonging to the same structure.

To reduce the ambiguities associated with the inversion of single data set , two or more data sets, which basically infer to the same geoelectrical structure, are jointly inverted. As the sensitivity of two data sets for resistive and conductive structures is different, therefore, the joint inversion helps in overcoming the limitations of the two data sets.

For example, transient electromagnetic (TEM) method has poor sensitivity to resistive layers as a thin resistive layer is ignored in TEM response, whereas in direct current resistivity (DC) method current cannot penetrate through the highly resistive layers. Thus, joint inversion of DC and TEM data is advantageous and in principle will overcome the limitations of individual data set (Fig. 1).

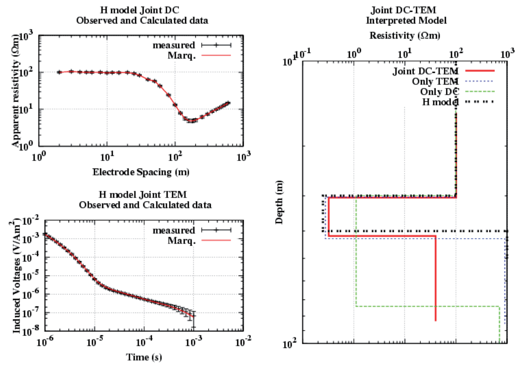

Figure 1: The joint inversion of DC and TEM data and their fitting for a synthetic H-type model (Sudha, 2010).

In helicopter-borne electromagnetic (HEM), large areas can be covered, but to enhance the lateral and vertical resolution, HEM data will jointly be inverted with the ground based EM methods.

The idea is that the capability to resolve the near surface structures with radiomagnetotelluric (RMT) is higher, however, deeper electrical conductivity structures can be well resolved by TEM. On the other hand, HEM provides better lateral coverage. Therefore, the joint inversion of HEM, TEM and RMT would yield quasi-2D images of the electrical conductivity over a large depth interval (Fig. 2).

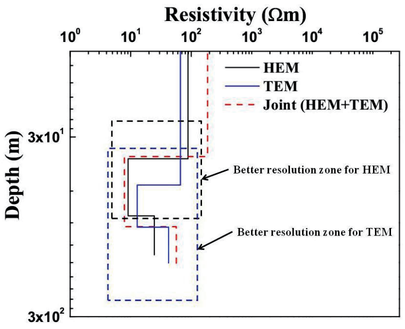

Figure 2: An schematic example: joint inversion of HEM and TEM.

Proposed Plan

The 1D numerical inversion codes, which were developed by the Cologne geophysics group for the interpretation of single methods (TEM and RMT), will be extended to accomplish the numerical joint inversion with the HEM data.

Initially, the joint inversion scheme will be validated on synthetic data with different noise levels. After the successful implementation of joint inversion on synthetic data, it will be applied to the field data.

In general, the measuring grid of different sounding methods does not overlap, which makes it inconvenient to accomplish the joint inversion. Therefore, we propose a method, e.g. downscaling, which would combine the individual grids to a joint grid.

Additional RMT measurements will be carried out on the sites, which were already investigated by HEM and TEM.

A Geophysical Measuring Platform Using an Unmanned Aerial System

Pilot Project

Figure 3: Autonomous UAS flight during the aeromagnetic survey near Cologne.

In a pilot project in 2009/2010 an Unmanned Aerial System (UAS) was utilized for the first time to test its performance and its applicability to aeromagnetic measurements (Fig. 3). The sensor assembly consists of a fluxgate sensor, electronics and a data acquisition system. The results of the magnetic measurements were promising.

Figure 4: Scout B1-100. Developed by Aeroscout GmbH, Switzerland Weight 43 kg Payload 18 kg.

UAS (e.g. Fig. 4) have a great versatility in terms of payload capacity and the ability to hover or fly at slow speed over areas of interest. An UAS can fly at low altitude, because of their precision navigation and computer controlled flight.

Results

Buried Objects

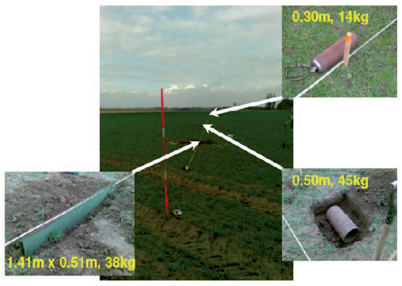

Figure 5: View of the survey area over centre profile including three buried objects.

In order to test the performance of UAS-magnetics, we buried three magnetic objects (Fig. 5) and carried out the magnetic and gradiometer measurements. The UAS measured data is compared with the ground measured data (Fig. 6).

Ground and UAS Magnetic Data

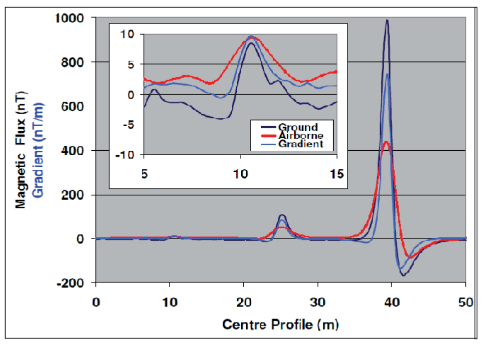

Figure 6: Comparison of the results from ground measurement and from the UAS. Displayed is the total intensity and vertical gradient as a function of profile distance. The local normal earth magnetic field (48600 nT) was subtracted from the data.
(Stoll et al. 2010, Tezkan et al. 2011)

Future Program

Figure 7: Datalogger developed by Metronix.

Since we could show that UAS can be successfully applied to perform magnetic measurements, our next aim will be UAS-VLF/LF measurements. Therefore we will utilize a data logger developed by Metronix (Fig. 7), which is capable of measuring magnetic transfer functions from 10 to 300 kHz. A system of three perpendicular oriented coils (Fig. 8) will be used for magnetic field measurements. To minimize the total weight, to fit the payload of the UAS, modifications of the data logger and the coil system are planned.

We intend to develop a suspension with maximal stability at minimal noise level. Therefore, some initial measurements with varying distance between instruments and UAS have been conducted early in 2010. Additional noise measurements are planned.

The investigation of the impact of the flight caused oscillation on the data is planed. First UAS-VLF/LF data will be observed this spring. The main focus of our study will be to process and to model the measurements using conductivity models.

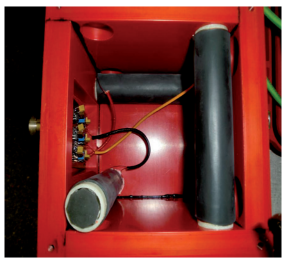

Figure 8: VLF/LF sensor – consisting of three perpendicular coils.

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