Westfälische Wilhelms-Universität Münster

GEOPHYSIK WWU MÜNSTER

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Processing of aeromagnetic and semi-airborne electromagnetic data from multicopter surveying

Philipp O. Kotowski, M. Becken, J. Schmalzl, V. Schmidt, J. B. Stoll, A. Weyer, J. Weßel

AEROMAGNETICS

SENSOR CALIBRATION

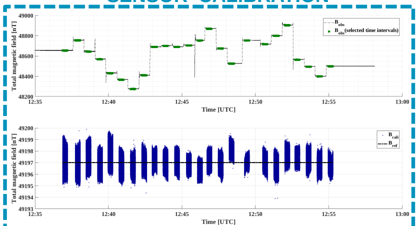

Figure 2: *Calibration of a three-axis fluxgate magnetometer. Top: non-calibrated data and 24 selected sensor orientations used to calculate calibration coefficients (offset, scaling and orthogonality error); bottom: comparison between calibrated data and reference data. The standard deviation of the calibrated total field with respect to the reference field amounts 0.75 nT.*

COMPENSATION FOR HEADING ERROR

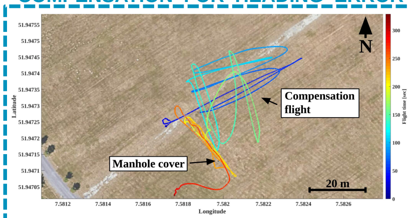

Figure 3: *Aeromagnetic test flight carried out in Münster. The flight is divided into a compensation flight in which different vehicle attitudes were realized and several flights above a magnetic anomaly (manhole cover).*

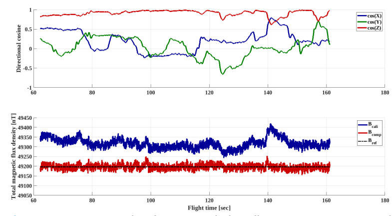

Figure 4: *Compensation for magnetic heading error. Top: occurred directional cosines with respect to the total field during the compensation flight; bottom: total magnetic field resulting from calibrated data (blue) and from compensated data (red).*

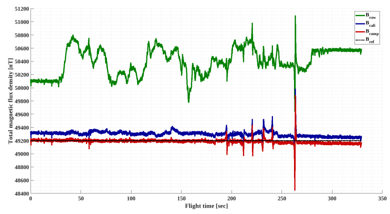

Figure 5: *Total magnetic flux density calculated from unprocessed sensor data (green), calibrated data (blue) and compensated data (red). Data of the entire flight is shown.*

SUMMARY

- The utilization of unmanned aerial vehicles (UAVs) like multicopters for geophysical surveying has many advantages. Thus, investigation areas can be surveyed in a short amount of time and independent of the terrain conditions. Nonetheless, unmanned aircraft systems have sufficient flexibility to enable high spatial and temporal data resolution.
- To make use of the benefits of a multicopter-based system in the context of aeromagnetic and semi-airborne electromagnetic (S-AEM) measurements, appropriate data processing is mandatory.

A reasonable interpretation of the acquired data is feasible only after suitable processing.

- The necessity of a calibration of different measuring systems and the capability to compensate for a magnetic heading error, caused by the multicopter, were studied. In addition, the quality of magnetic transfer function estimates was examined and also their suitability for deriving depth models of the electrical resistivity on site.
- A system consisting of a fluxgate magnetometer and a data logger could be calibrated in such a way that direction-dependent deviations of the total magnetic flux density amount **<1 nT after calibration**. It was also possible to minimize heading error influences so that **heading-dependent flux density variations of <10 nT** remained. The omission of a device calibration and a compensation for heading error can lead to magnetic flux density deviations of up to 600 nT.
- Estimated magnetic transfer functions reveal good spatial and spectral concordance. The result of an independently performed **geoelectric sounding verifies the good quality of the recorded S-AEM data**.
- The results lead to the conclusion that multicopter-based systems are suitable for both aeromagnetic and semi-airborne electromagnetic surveying. The methods and procedures elaborated here have enormous potential and can considerably facilitate future magnetic and electromagnetic investigations.

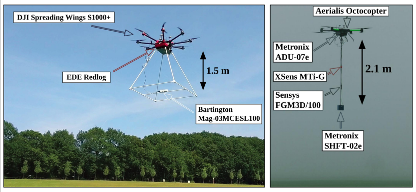

Figure 1: *Utilized setup for aeromagnetic surveying (left) and for S-AEM surveying (right). Listed are used devices and sensors.*

SEMI-AIRBORNE ELECTROMAGNETICS

TRANSFER FUNCTION ESTIMATES

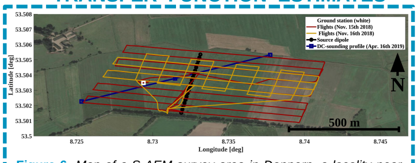

Figure 6: *Map of a S-AEM survey area in Donnern, a locality near Bremerhaven, Germany. Shown are the installed dipole source (black), S-AEM flights carried out on the 15th (red) and the 16th (yellow) of Nov. 2018, an induction coil triple ground station (white) and the profile of a Schlumberger Sounding carried out later on.*

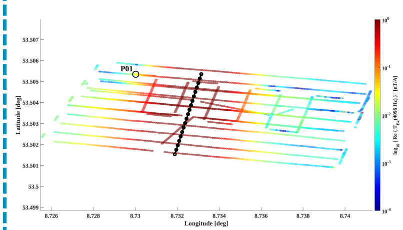

Figure 7: *Location-dependent magnetic transfer functions with equal spatial resolution estimated for all performed flights. The spatial distribution of absolute real values of the transfer functions for the z-component estimated for 4096 Hz is shown. The common Site P01 selected for comparison purposes is marked.*

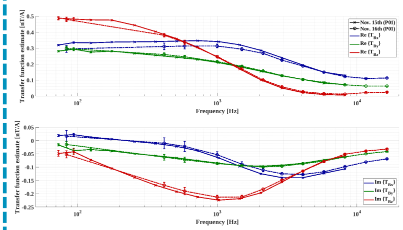

Figure 8: *Comparison of frequency-dependent transfer functions estimated at the same site (P01). Compared are the real and imaginary parts of the transfer function estimates for two different flights.*

MODELS AND INVERSIONS

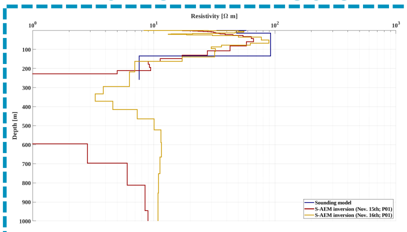

Figure 9: *Comparison between one-dimensional S-AEM inversions (red [Nov. 15th], yellow [Nov. 16th]) at the Site P01 and a five layer model based on a Schlumberger Sounding (blue). An initial subsurface resistivity of 45 Ωm was assumed for both inversions. The inversions were calculated for 42 layers..*

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Main references

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