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UAV-based aeromagnetic gradient measurements and inversion

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Rotary wing UAV's are used in aeromagnetic measurements for UXO detection. That way, contaminated areas can be mapped fast and with high resolution. Until today, only the total magnetic intensity (TMI) is evaluated, even when a three axis fluxgate magnetometer is flown. In this project, we use two three component fluxgate sensors, an inertial measurement unit (IMU) and a GPS antenna. The IMU allows for a projection of the magnetic data into the geographic coordinate system as well as the calculation of the sensor positions relative to the GPS antenna. With this system, it is possible for the first time to evaluate the component gradients between the magnetometers.

The sensors are attached to the UAV via a versatile, T-shaped boom hanging below the UAV with the sensors positioned in a horizontal distance of 50 cm. The total mass of the flight system is about 5 kg with an air time of 15 minutes.

For the inversion, we use a dipole model which calculates the magnetic data for all sensor positions. Because the sources of the magnetic anomalies are unknown as a general rule, there is no distinction between induced and remanent magnetisation. Instead, the three components of the magnetic moment are fitted alongside the positions of the anomaly sources. The number of dipoles to be fitted and their initial parameters are arbitrary. For the inversion, the TMI and component gradients between the sensors are considered.

In order to analyse the accuracy of the complete system, we conducted surveys over a test field of 100 x 20 m, separated into four sections with varying anomaly configurations. As anomaly sources, we used neodymium magnets which we characterised in laboratory measurements. For optimal coverage and to compare flight directions, the test field was surveyed both lengthways and crossways with a sensor height of 1.5 m above ground. Inversion results show that when component gradients are used, overlapping anomalies can be separated and parameterised. The mean errors of the derived anomaly positions are 5 cm, the total magnetic moment can be determined with an accuracy of 0.35 Am^2, whereby the errors in direction (declination and inclination) are 4 ° and 2 °, respectively.