# Magnetometer Calibration Facility

Josef Wilfinger, Roman Leonhardt, Werner Magnes, Aris Valavanoglou, Niko Kompein, Gerhard Berghofer

**Only well-calibrated magnetometers produce reliable data and a good calibration requires a magnetically stable environment with precise references. The new three-meter Merritt coil system in the Conrad Observatory provides all these features. Integrated in the magnetic measurement system of the observatory, it can compensate the changing Earth's magnetic field and apply accurate calibration fields to the magnetometer under test. During a magnetically quiet day, the variation of the residual magnetic field in the centre of the coil system is <1 nT.**

Accurate magnetometers must be calibrated to produce reliable data. Calibration is typically achieved through compensation of the environmental magnetic field (e.g. the natural Earth's magnetic field) around the magnetometer under test and the generation of a well-known calibration field with a coil system. The Conrad Observatory is an ideal place for this kind of calibration setup. It is far away from artificial disturbers and the available reference magnetometers provide very precise measurements of the Earth's magnetic field with a delay of less than 2 seconds.

Figure 1: Three-meter Merritt coil system for magnetometer calibration in the calibration cavern of the Conrad Observatory.

In 2017, the Space Research Institute of the Austrian Academy of Science (ÖAW) and the Central Institute for Meteorology and Geodynamics (ZAMG), which operates the Conrad Observatory, started a cooperation for the installation of a large and precise calibration facility. The Spanish company Serviciencia S.L.U. was selected to build a three-axes Merritt coil system with a side length of approximately three meters (Figure 1). The coil assembly consists of two separate Merritt coil systems along each axis. The first one compensates the Earth's field using measurements provided by the reference variometer of the observatory. During a magnetically quiet day, the residual field varies with less than 1 nT peak-to-peak in 24 hours (Figure 2). The second coil system applies the calibration field with a dynamic range of ±90,000 nT and a resolution of about 0.2 nT. The used current source electronics equipment for the coils consist of six BE2811 (iTest) and is located in a separate compartment 15 m from the coils. This moves unnecessary disturbances away from the coil system and provides thermally stable conditions that minimize field drifts.

In order to achieve a stable ∼0 nT residual field at the centre of the coil system, it is necessary to synthesize the inverted Earth's magnetic field vector with the three compensation axes. Three steps of matrix and vector operations are involved in this synthesis. These are the rotation of the measured Earth's magnetic field vector to an artificially defined and coil-based orthogonal coordinate system, the compensation of DC effects and the transformation to the real non-orthogonal coil system via non-orthogonality angles, which were determined by scalar measurements [1].

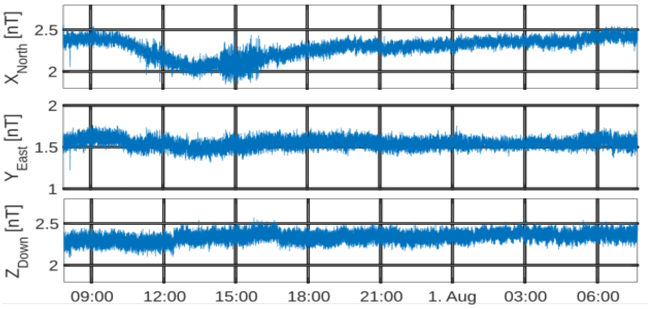


Figure 2: The residual field in the centre of the coil system during 24 hours. A moving average filter reduced the Digital FluxGate [2] data from 128 Hz to 2 Hz.

A graphical user interface and a network socket provide an easy handling of the coil and the possibility to automate and record the calibration process.

**References:**

[1] A. Zikmund et al.: Magnetic calibration by using non-linear optimization method, IEEE Trans. Magn., 51, 4000704, 2014.
[2] C. Russell et al.: The magnetospheric multiscale magnetometers, Space Sci. Rev., 199, 189-256, 2016.

**Authors:**
Josef Wilfinger[1], Roman Leonhardt[2], Werner Magnes[1], Aris Valavanoglou[1], Niko Kompein[2], Gerhard Berghofer[1]
1) Space Research Institute - Austrian Academy of Science, Graz, Austria
2) Central Institute for Meteorology and Geodynamics, Vienna, Austria

**Corresponding author:**
Josef Wilfinger
Space Research Institute, Austrian Academy of Sciences
Schmiedlstraße 6, 8042 Graz, Austria
Tel.: +43 (316) 4120 569
e-mail: josef.wilfinger@oeaw.ac.at