Ground-based magnetometry

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Ground-based magnetometry can be divided into several categories, for example:

* Variometer stations
* Geomagnetic observatories
* Repeat Stations
* MT stations

Focus in this talk
Variometer stations

- Magnetometer designed for continuous recording without strict requirements to absolute accuracy
- Short term variations: high resolution baselines: may be slowly drifting
- Excellent data to study intense, short lived, rapid and local events

Instrumentation: Magnetometer, for example 3-axis Fluxgate Magnetometer Model FGM – FGE built by Lars W. Pedersen and Jan Oechsle. Data loggers example to the right, windows laptop, and Linux magrec datalogger from MinGeo.

Variometer station Ittoqqortoormiit, SCO (and Jan)
Variometer stations

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\begin{align*}
S_x &= k_x U_x + X_0 \\
S_y &= k_y U_y + Y_0 \\
S_z &= k_z U_z + Z_0
\end{align*}
\]

**Variometer data**

**Baselines**

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![Variometer data and baselines](image)

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Example of variometer and observatory data repository: SuperMAG

Credit: SuperMAG
Variometer stations
installation of a new station: example from Kulusuk (KUL) 2021

KUL is part of the MAG-SWE-DAN project, ESA Contract No. 4000128139/19/D

Sensor orientation
HDZ, XYZ, DIF

Magnetic quiet location

Power, internet, cable protection, weather shield, etc.
The Greenland magnetometer chain was established in 1972-73, to investigate the coupling between the solar wind, the magnetosphere and the ionosphere.

Johannes Wilhjelm & Eigil Friis-Christensen
Geomagnetic Observatories

Around 150 observatories in the world

Most of these data are distributed through International Real-time Magnetic Observatory Network (INTERMAGNET) and World Data Centre for Geomagnetism (WDC)
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Geomagnetic Observatories
Example from Qeqertarsuaq (GDH)
Geomagnetic Observatories

Many geomagnetic observatories provide long timeseries from one specific location, calibrated quality-controlled data and provisional data in near real time.

Example of definitive data from Qeqertarsuaq from 1926-2023:
(note: jump in 1975 due to new location 500m away, dashed lines show adjusted means by jump values)

Data to geomagnetic indices, like for example the IAGA endorsed Dst (red), Kp (green), AE (blue) and PC (magenta) indices shown in the figure.

Swarm triggered initiatives in the observatory community

Quasi-Definitive data (initiated by Arnaud Chulliat)
Prompt baseline-corrected and quality-controlled observatory data

BGS AUX_OBS data (initiated by Susan Macmillan)
Quality-checked and corrected observatory data

Resolution No.5 (2009): Quasi-definitive magnetic observatory data

IAGA, recognising the importance of prompt baseline-corrected observatory data for the production of geomagnetic indices and geomagnetic models such as the IGRF, noting that several individual users and groups of users, such as the Mission Advisory Group of the upcoming ESA Swarm satellite mission, have expressed their interest in and need for such data, encourages magnetic observatories to produce baseline-corrected quasi-definitive data shortly after their acquisition.

BGS AUX_OBS data available at ftp://ftp.nerc-murchison.ac.uk/geomag/Swarm/AUX_OBS

Minute data 2 years prior the Ørsted satellite
Satellite and ground-based data - a fantastic combination
examples: geomagnetic field modelling and polar electrojet studies

From ground magnetometer data
Happy birthday Swarm!

Fluxgate theodolite
To measure Inclination and Declination

Variometer
To measure the variation of Earth’s magnetic field in three directions orthogonal to each other

“kransekage” Danish cake filled with candy
Geomagnetic observatories
New installation, example from Pituffik (PIF), 2023