

Photo: Aurora in Kulusuk, taken by Niels Andersen, Ringe

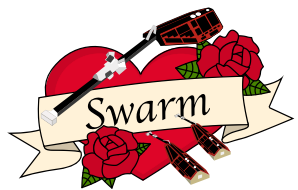


# Ground-based magnetometry

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Swarm 10 Year Anniversary & Science Conference 2024

Photo: Aurora in Kulusuk, taken by Niels Andersen, Ringe



# Ground-based magnetometry

can be divided in 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)

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Variometer data      Baselines

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



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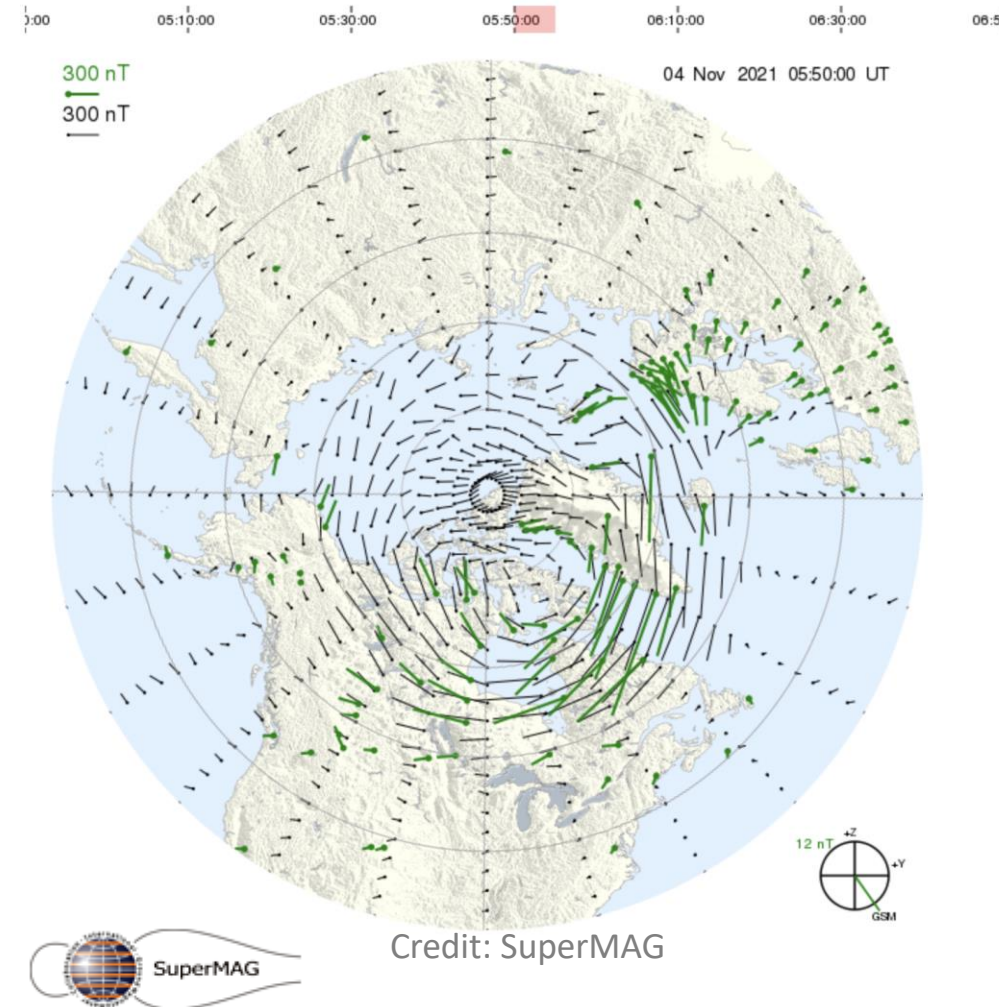
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Variometer station  
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Example of variometer and observatory data repository:  
SuperMAG

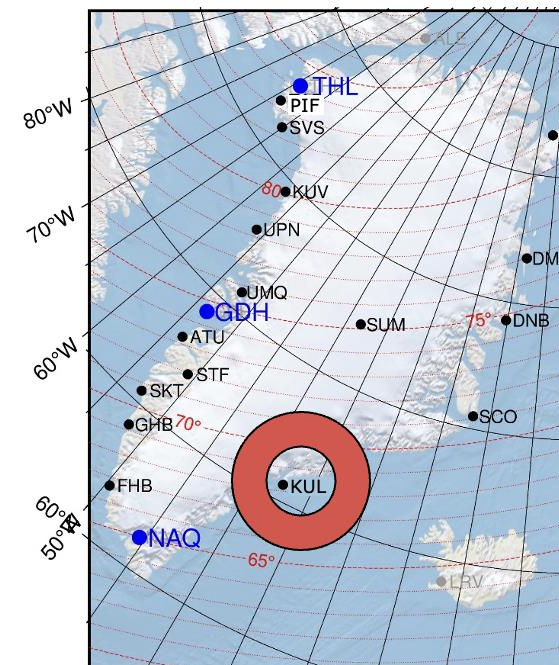


Credit: SuperMAG



# Variometer stations

installation of a new station: example from Kulusuk (KUL) 2021

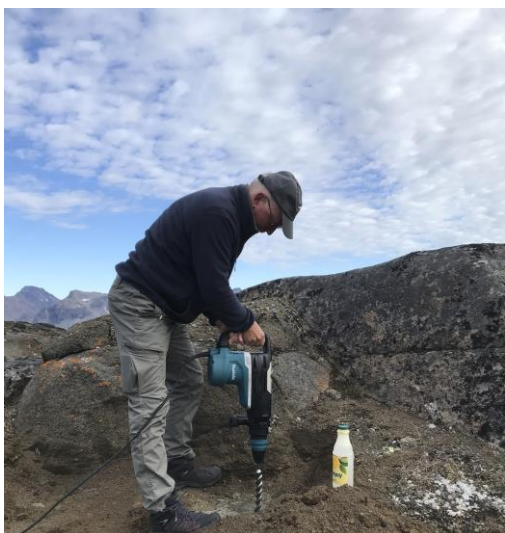


KUL is part of the MAG-SWE-DAN project, ESA Contract No. 4000128139/19/D

Sensor orientation  
HDZ, XYZ, DIF

Magnetic quiet location

Power, internet, cable protection, weather shield, etc.



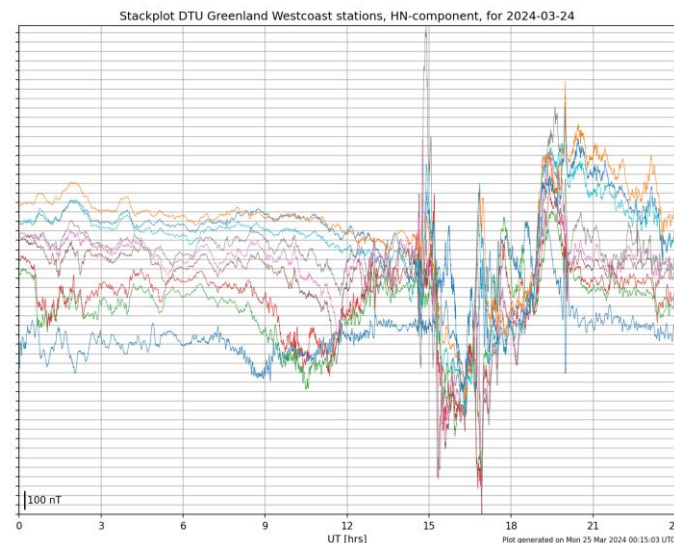
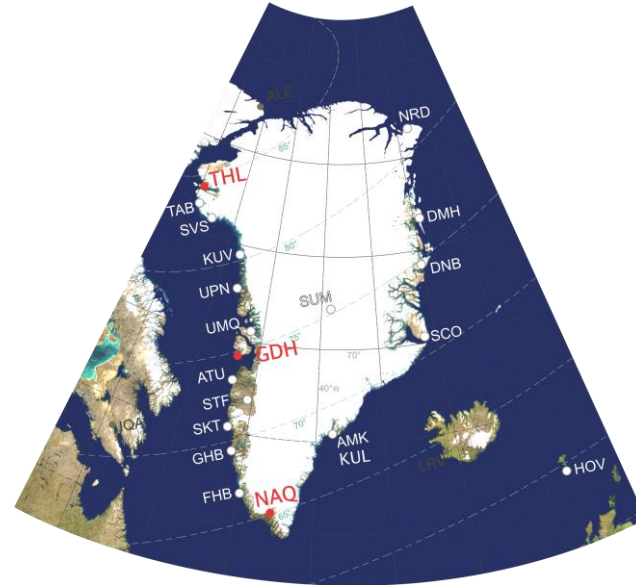


# Variometer stations

## DTU Magnetometer network Greenland chain 50 years

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



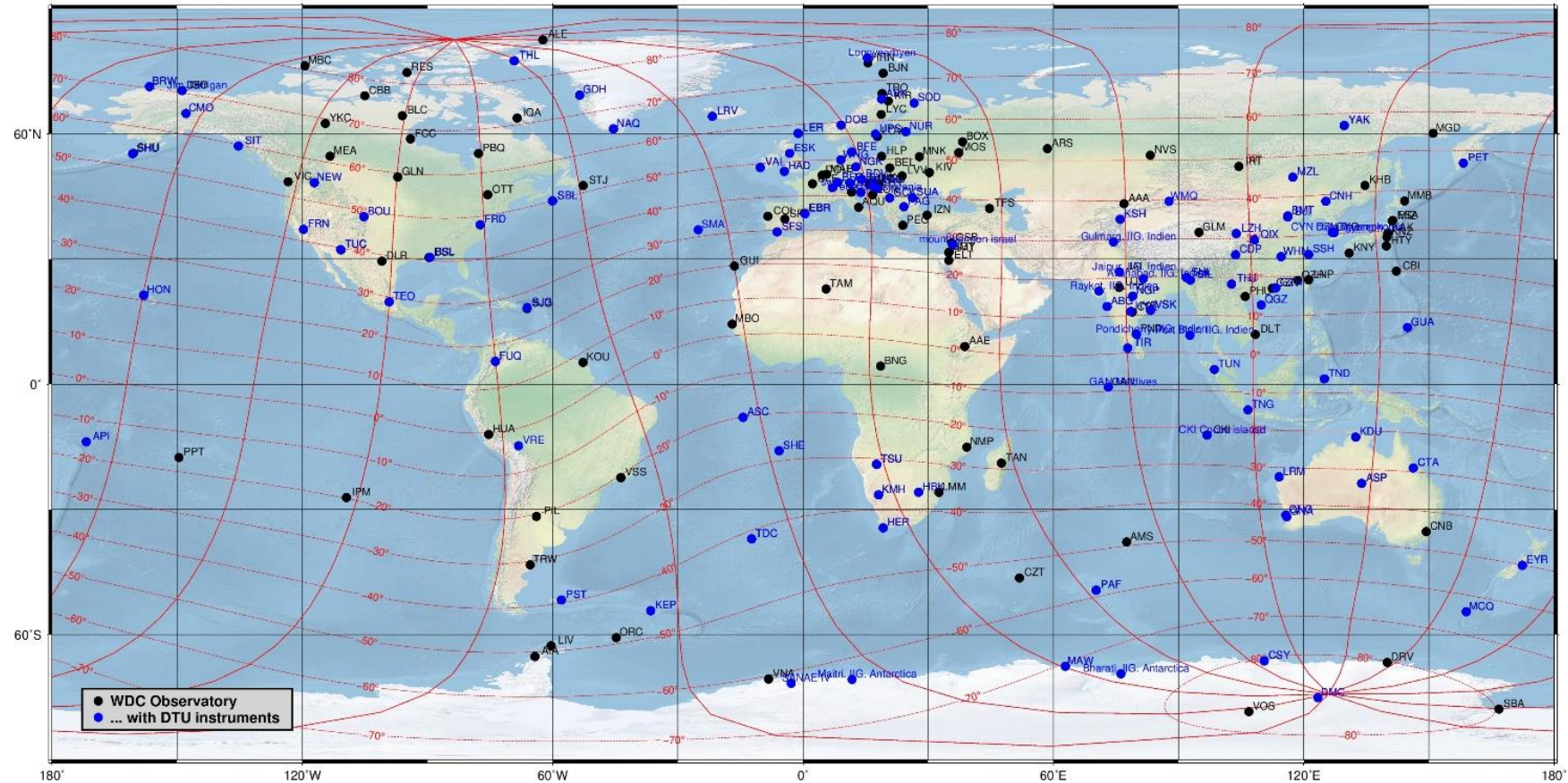


# Geomagnetic Observatories

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)

Geomagnetic Observatories in 2020



Credit: Nils Olsen

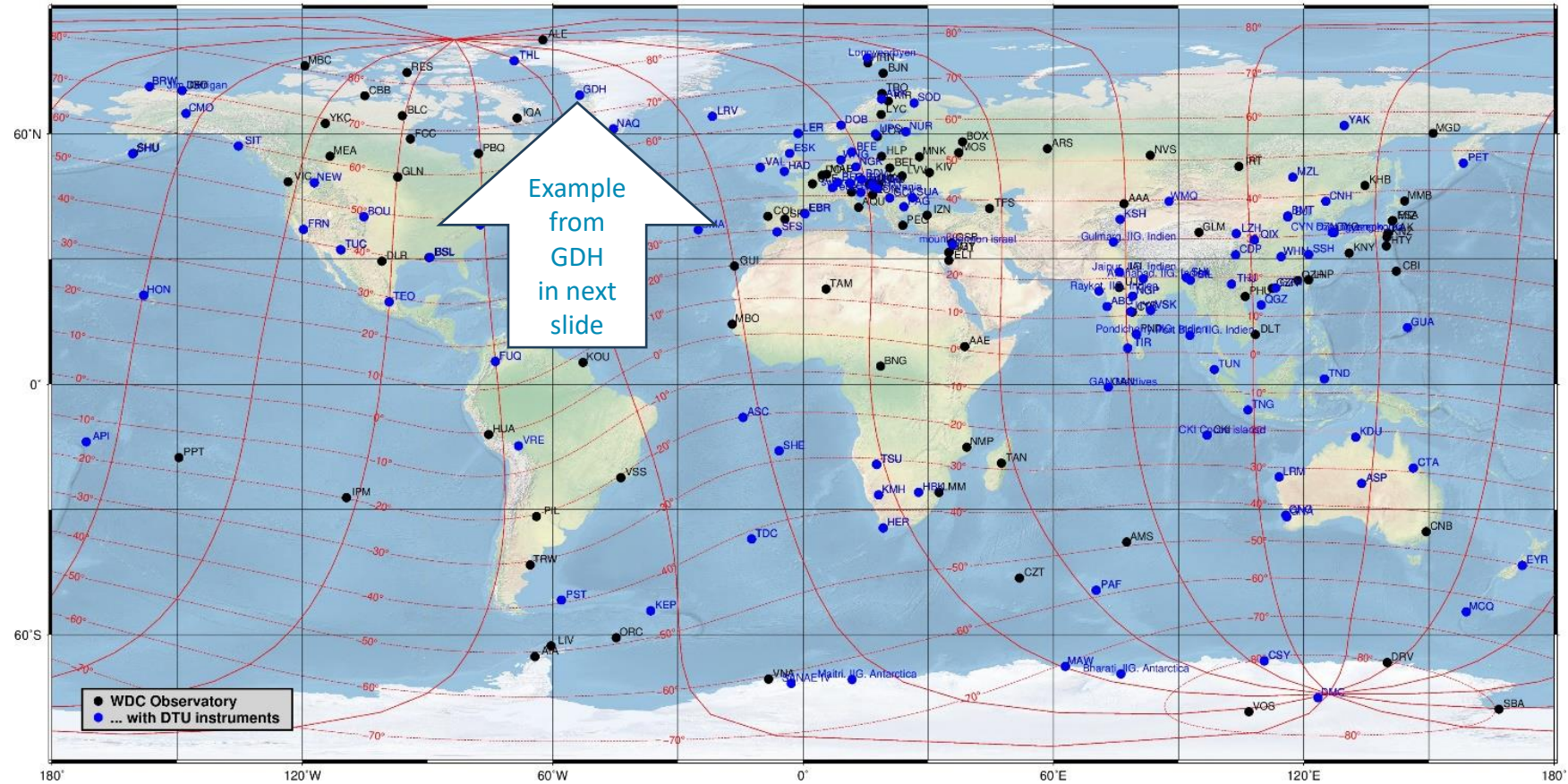


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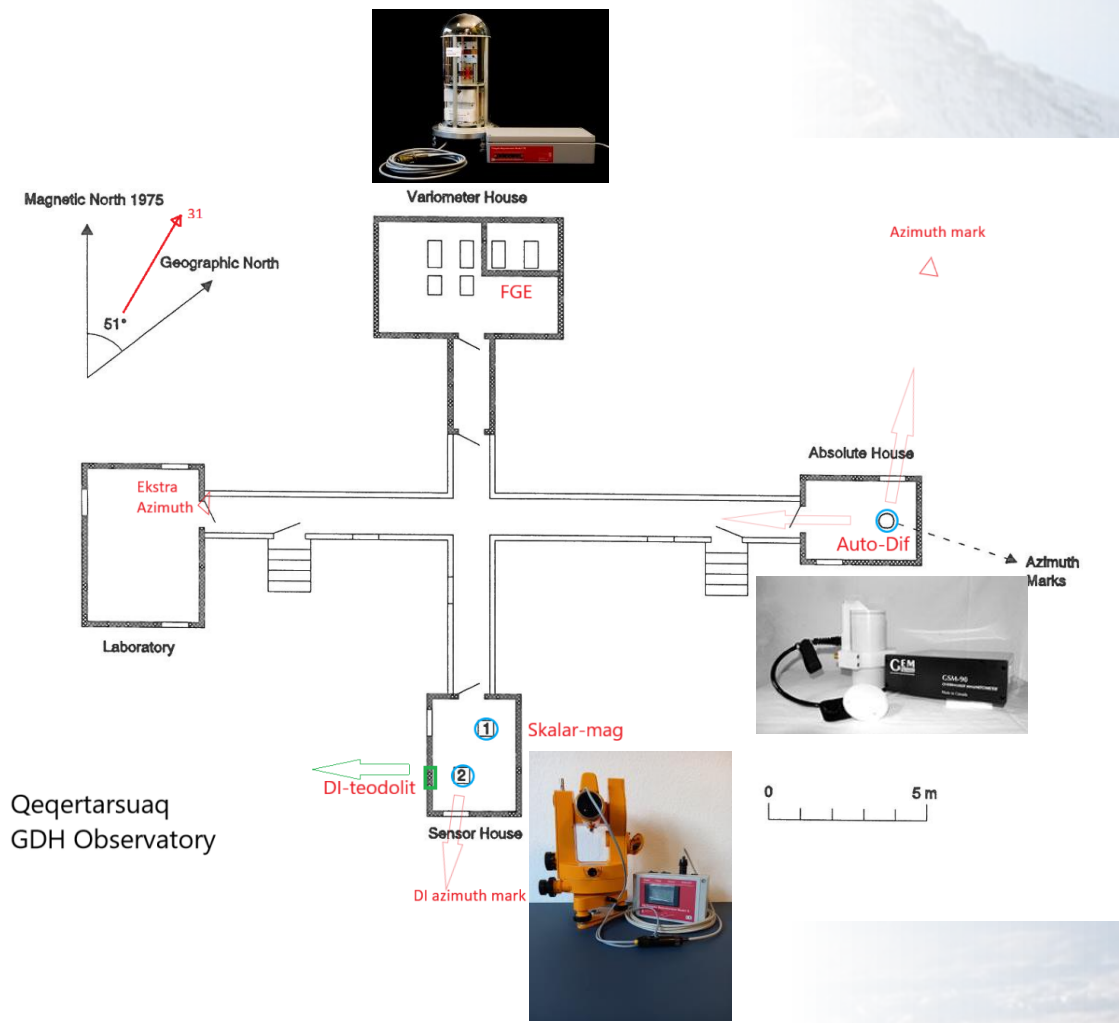


Credit: Nils Olsen



# Geomagnetic Observatories

Example from Qeqertarsuaq (GDH)



Qeqertarsuaq  
GDH Observatory

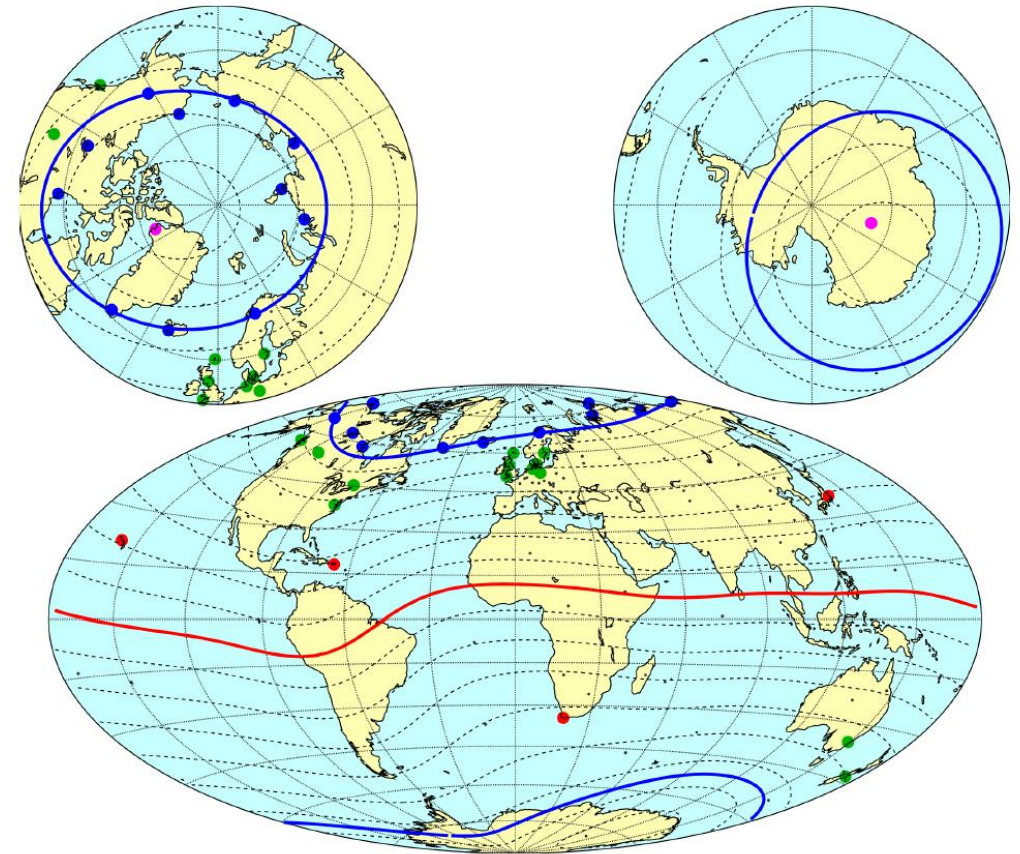
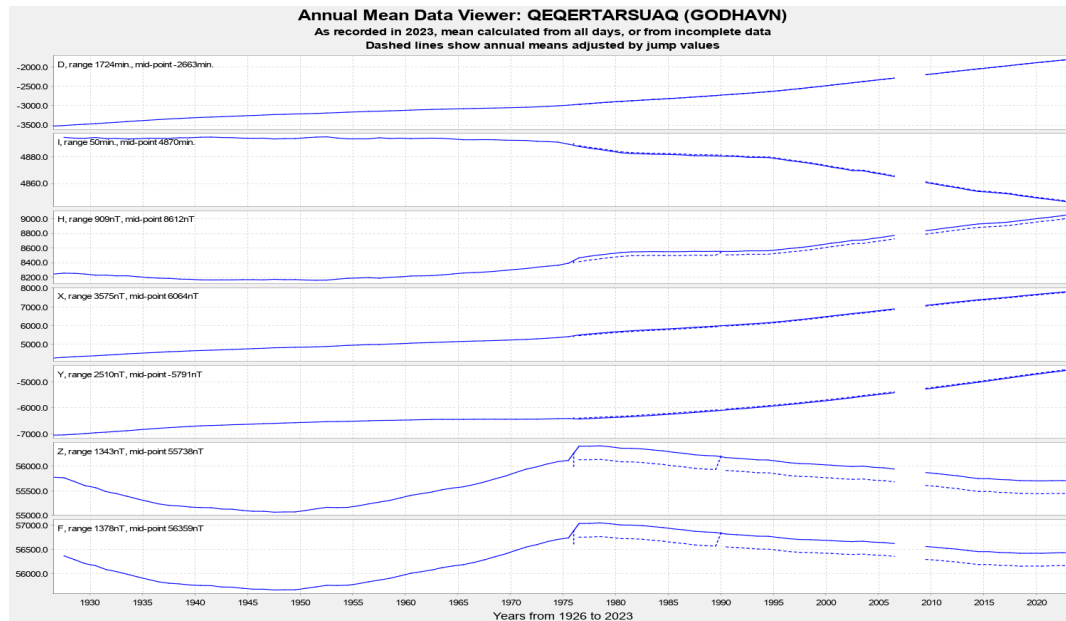




# Geomagnetic Observatories

Many geomagnetic observatories provides 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

*Credit: On the usage of geomagnetic indices for data selection in internal field modelling, K. Kauristie et al, 2017.*

# Swarm triggered initiatives in the observatory community

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

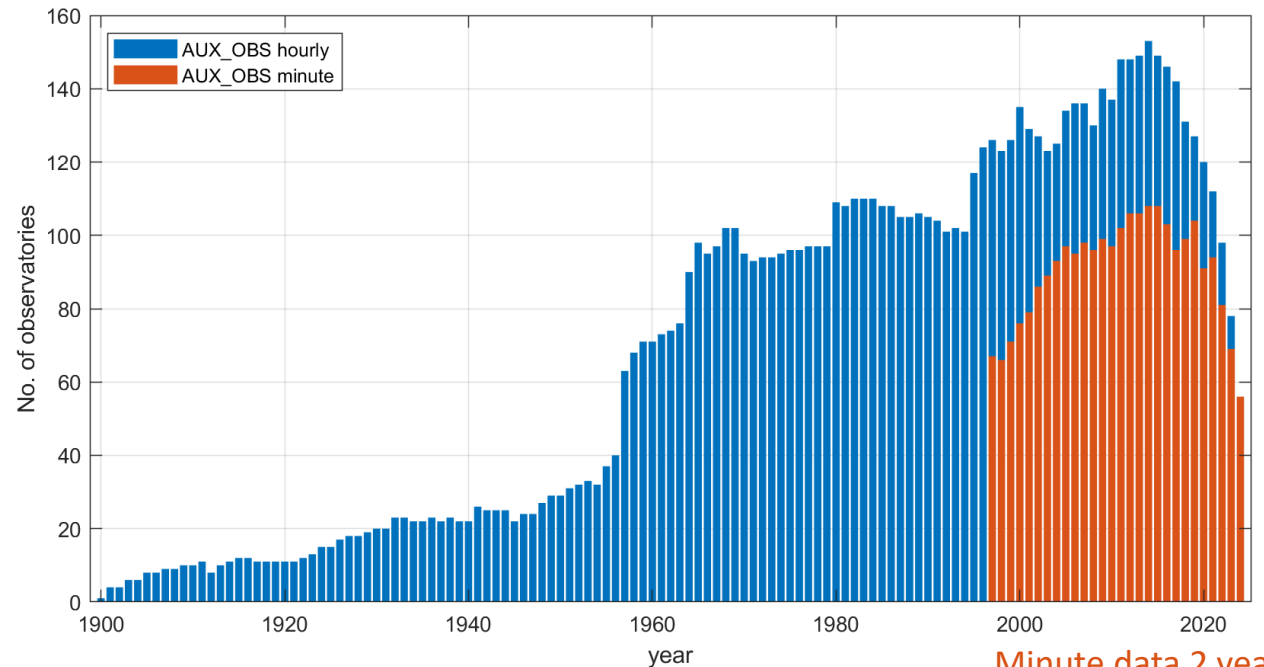
## Resolution No.5 (2009): Quasi-definitive magnetic observatory data

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.

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BGS AUX\_OBS data (initiated by Susan Macmillan)  
Quality-checked and corrected observatory data



Minute data 2 years prior  
the Ørsted satellite

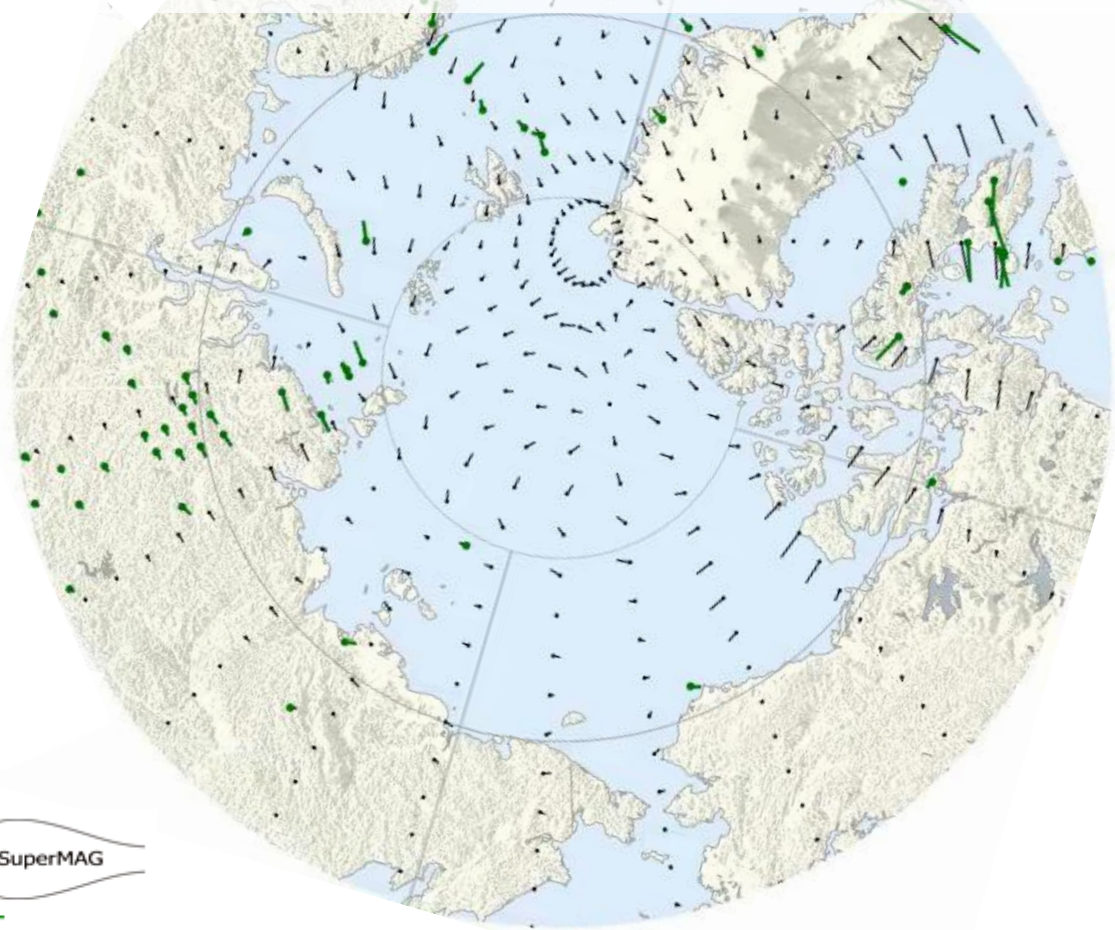
BGS AUX\_OBS data available at

[ftp://ftp.nerc-murchison.ac.uk/geomag/Swarm/AUX\\_OBS](ftp://ftp.nerc-murchison.ac.uk/geomag/Swarm/AUX_OBS)

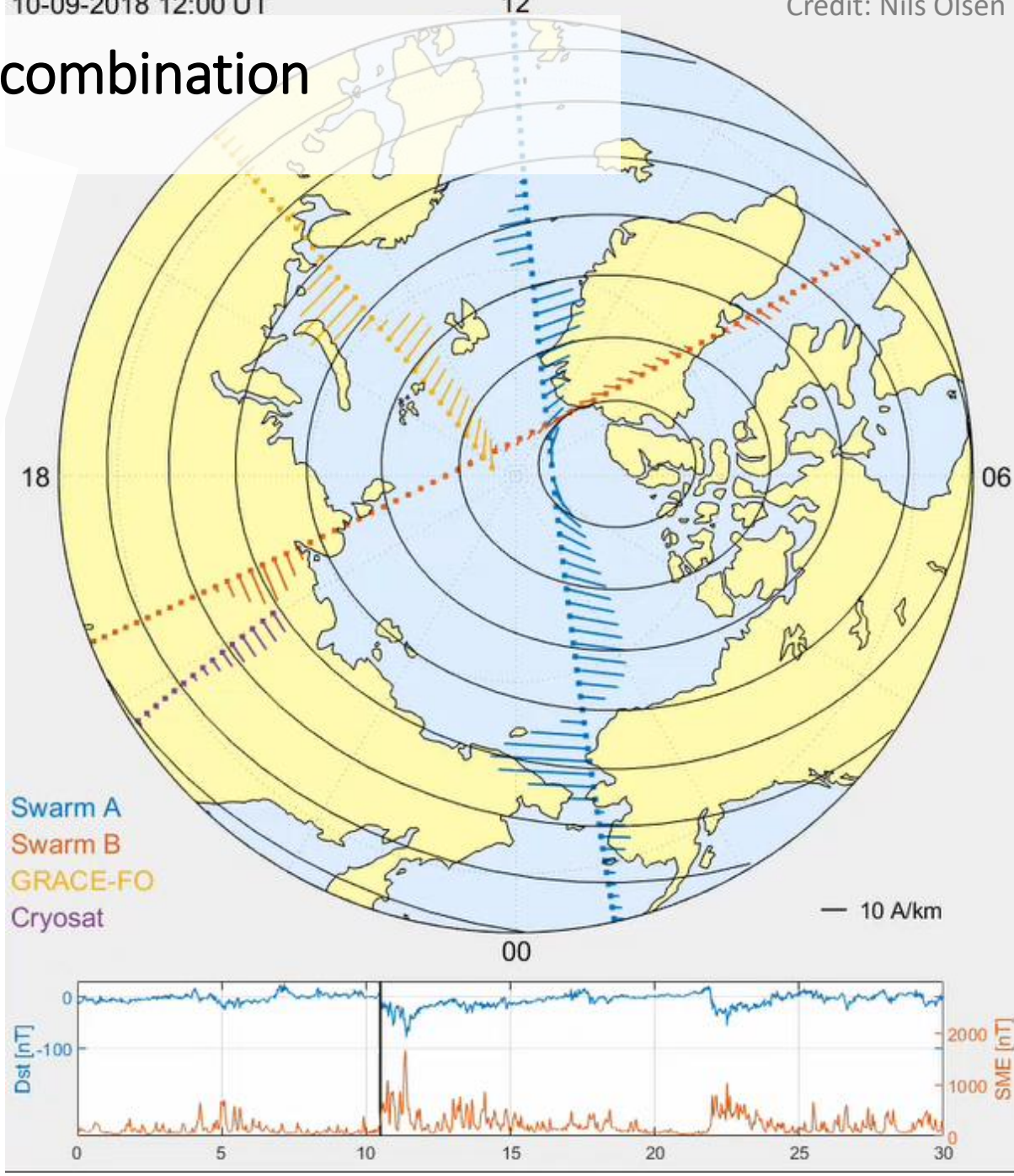


# Satellite and ground-based data - a fantastic combination

examples: geomagnetic field modelling and polar electrojet studies



From ground magnetometer data





Happy birthday  
Swarm!



Fluxgate theodolite  
To measure Inclination and Declination



“kransekage” Danish  
cake filled with candy

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



# Geomagnetic observatories

New installation, example from Pituffik (PIF), 2023

