



British
Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

A horizontal banner at the top of the slide featuring a collage of four images: a volcanic landscape with glowing lava, a mountain valley with colorful autumn foliage, a close-up of a dark, textured rock surface, and a city skyline with skyscrapers.

Gateway to the Earth

Detecting the Earth's magnetic field and the aurora with a Rpi magnetometer

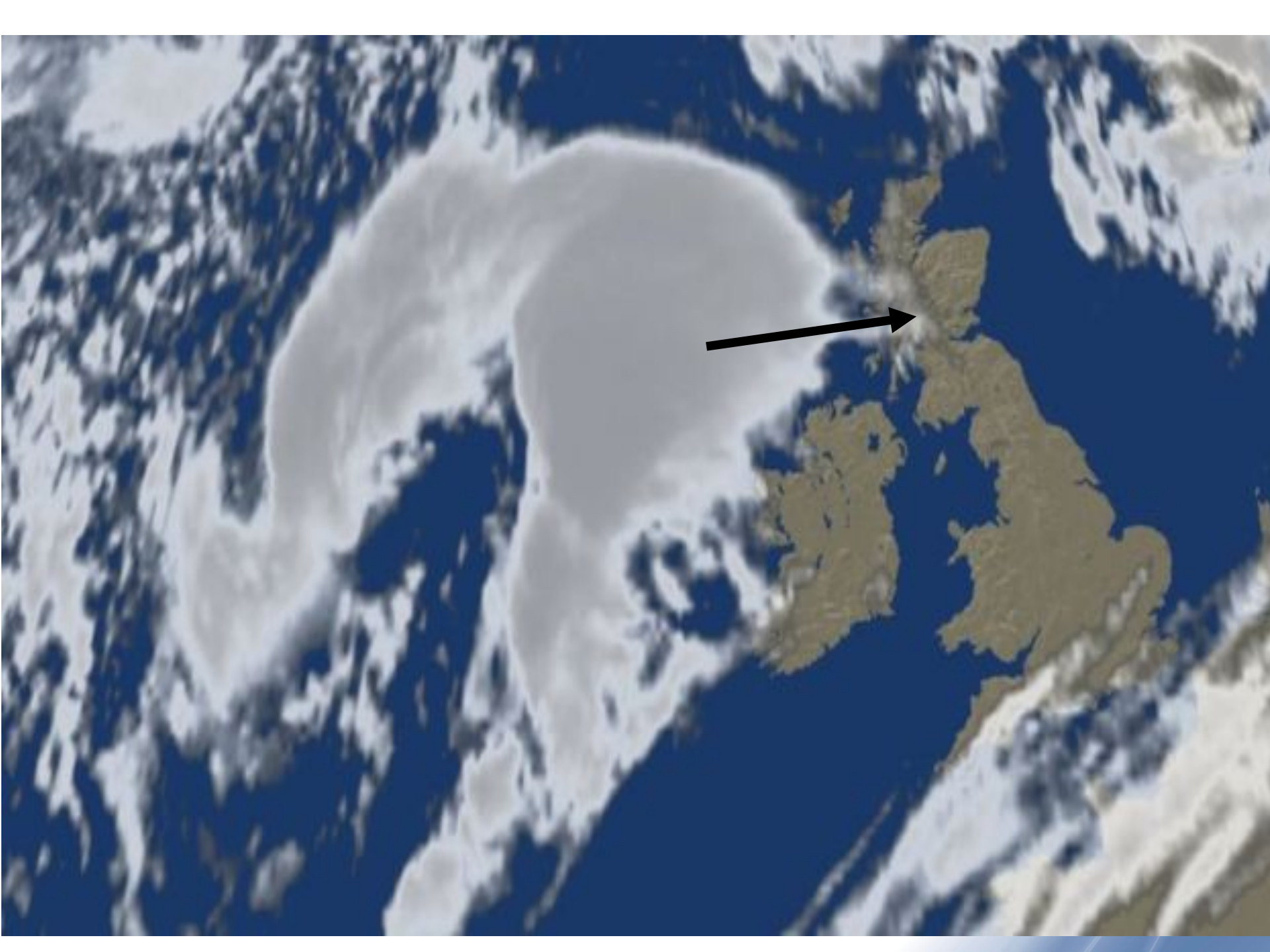
Dr. Ciarán Beggan
ciar@bgs.ac.uk

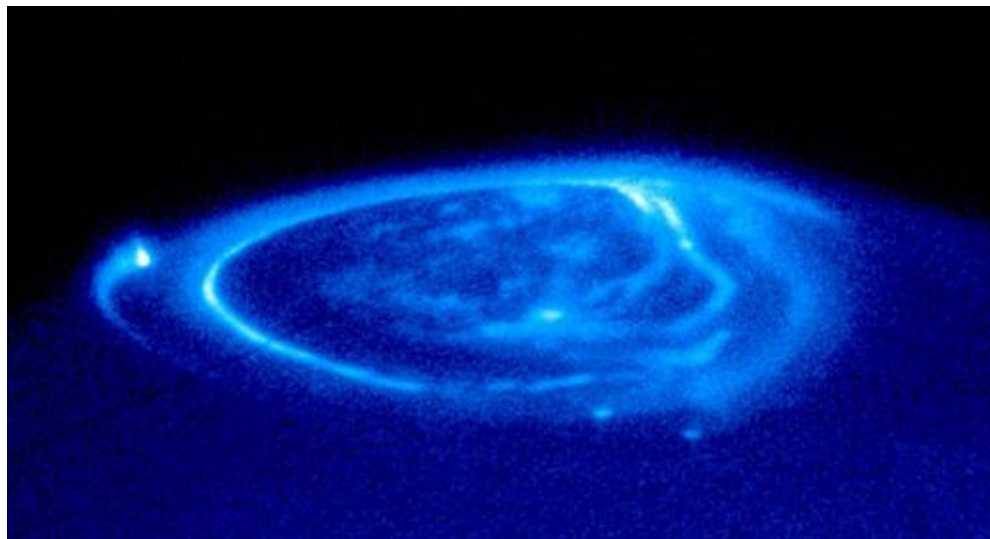
Raspberry Pi Jam: Codebase Edinburgh
30-Apr-2016

Aurora over Greenock in October 2015



Doug Collinson:
Northern Lights Over Cloch Lighthouse [07-Oct-2015]
<https://www.flickr.com/photos/60122552@N08/>

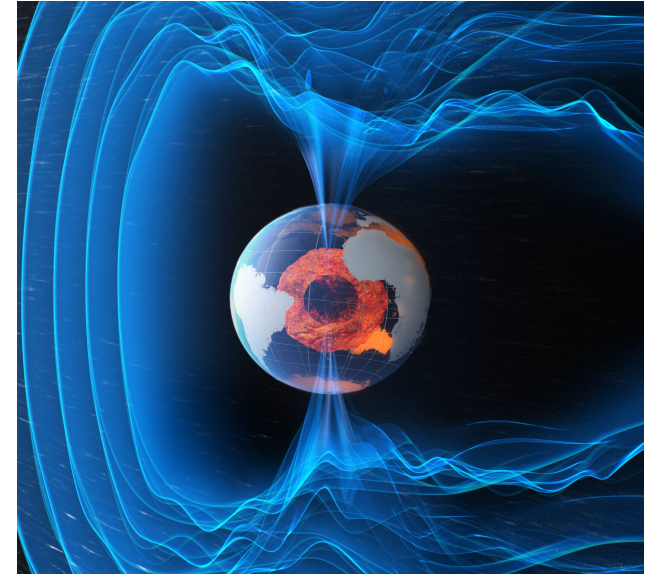




Where do the aurora come from?

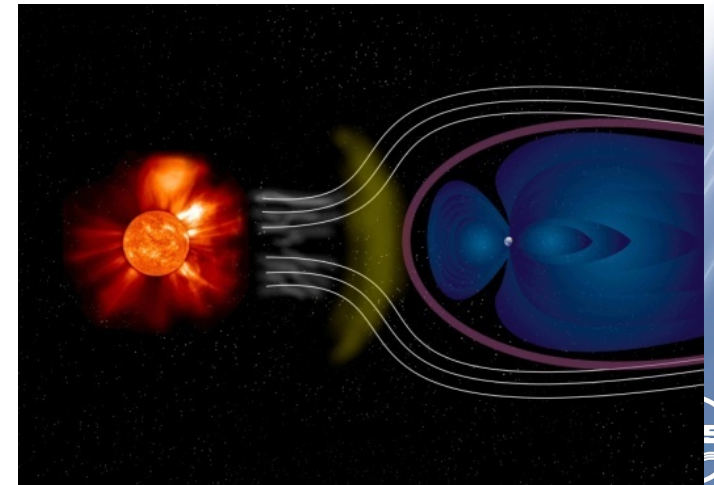
Core field

- Most of the field is from the **Earth's liquid iron core**
- Generated > 3500 km away
- Weaker than your average fridge magnet

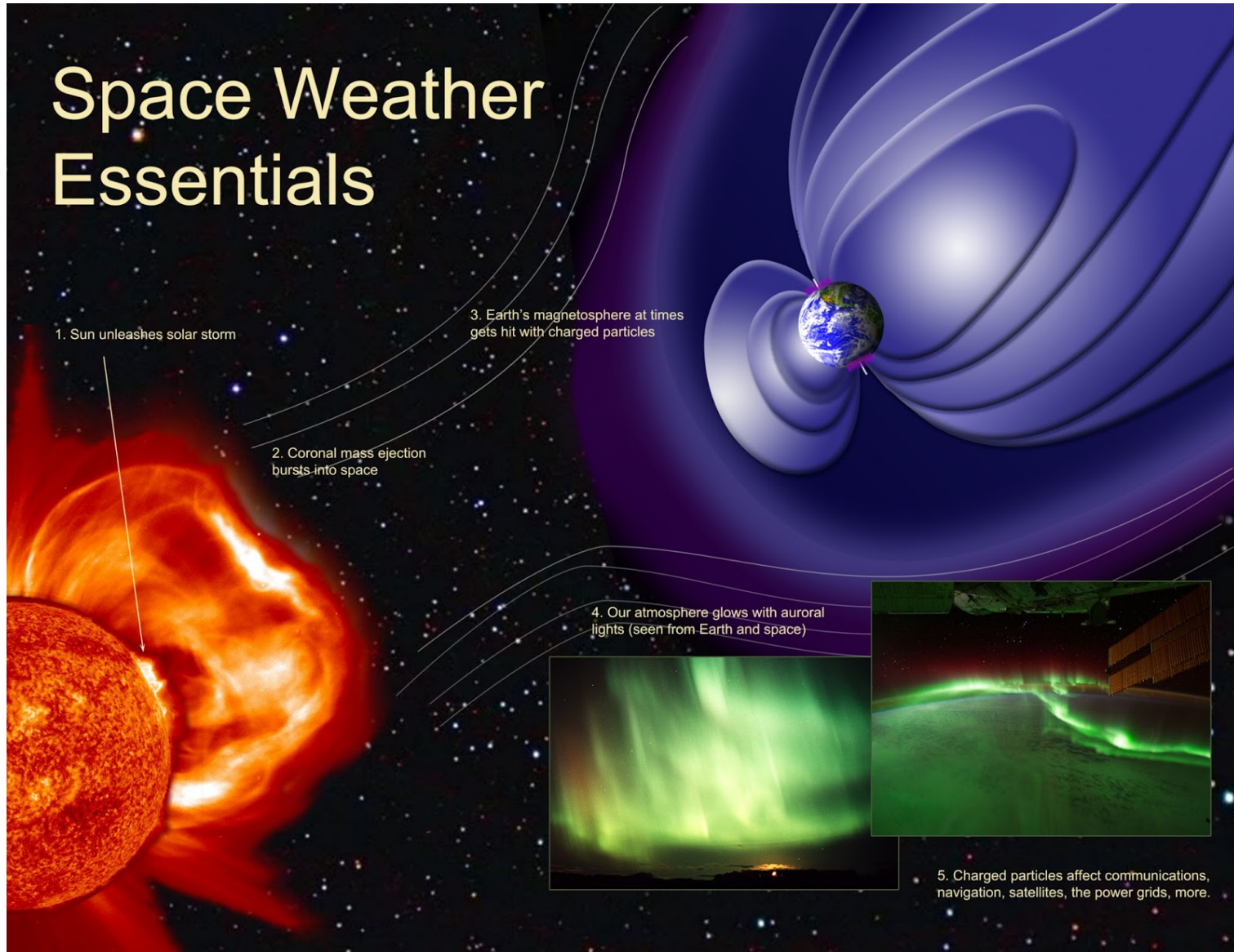


External field

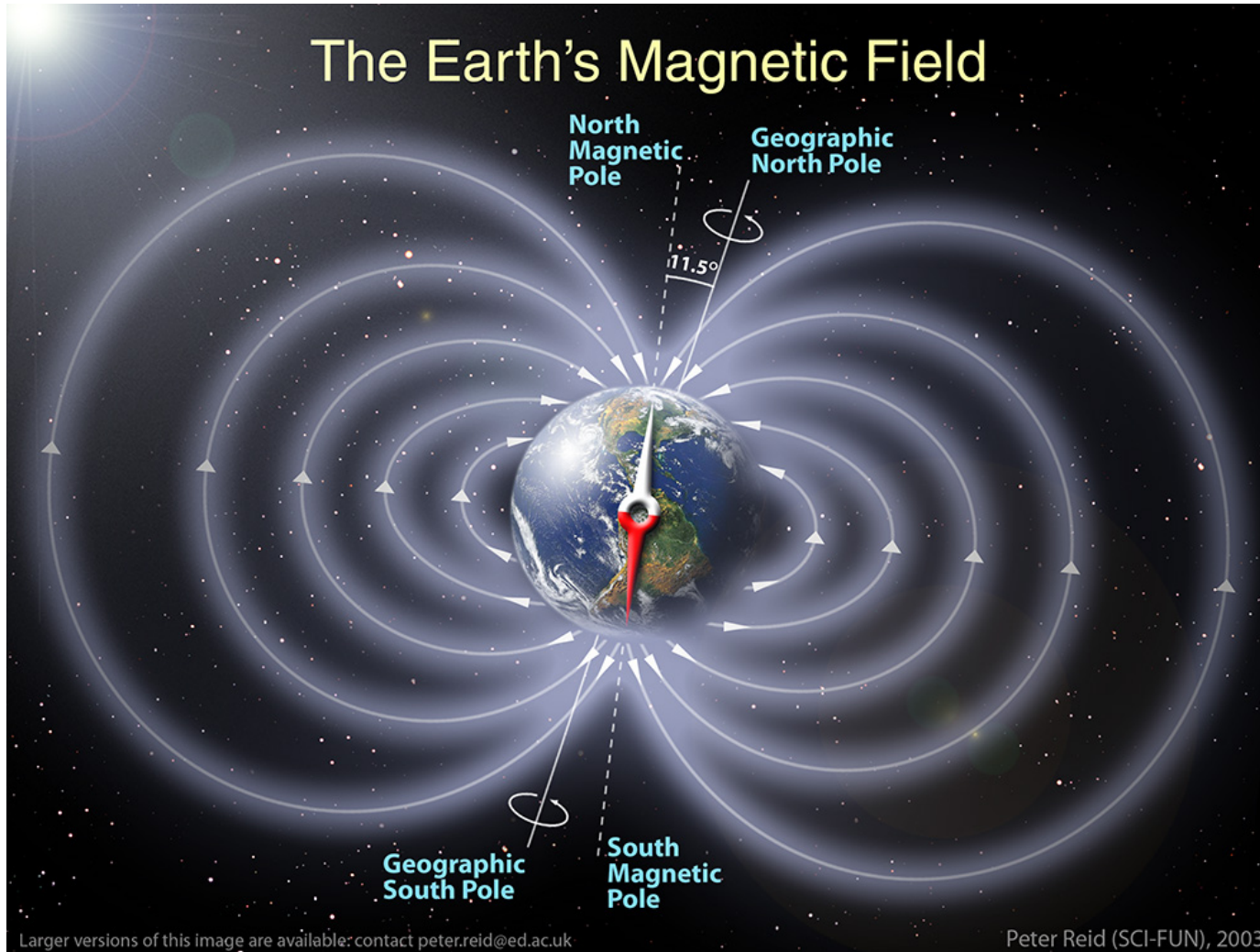
- Fields due to currents in the tenuous upper atmosphere:
- **ionosphere** (from about 100 km altitude)
- **magnetosphere** (>2 Earth radii)



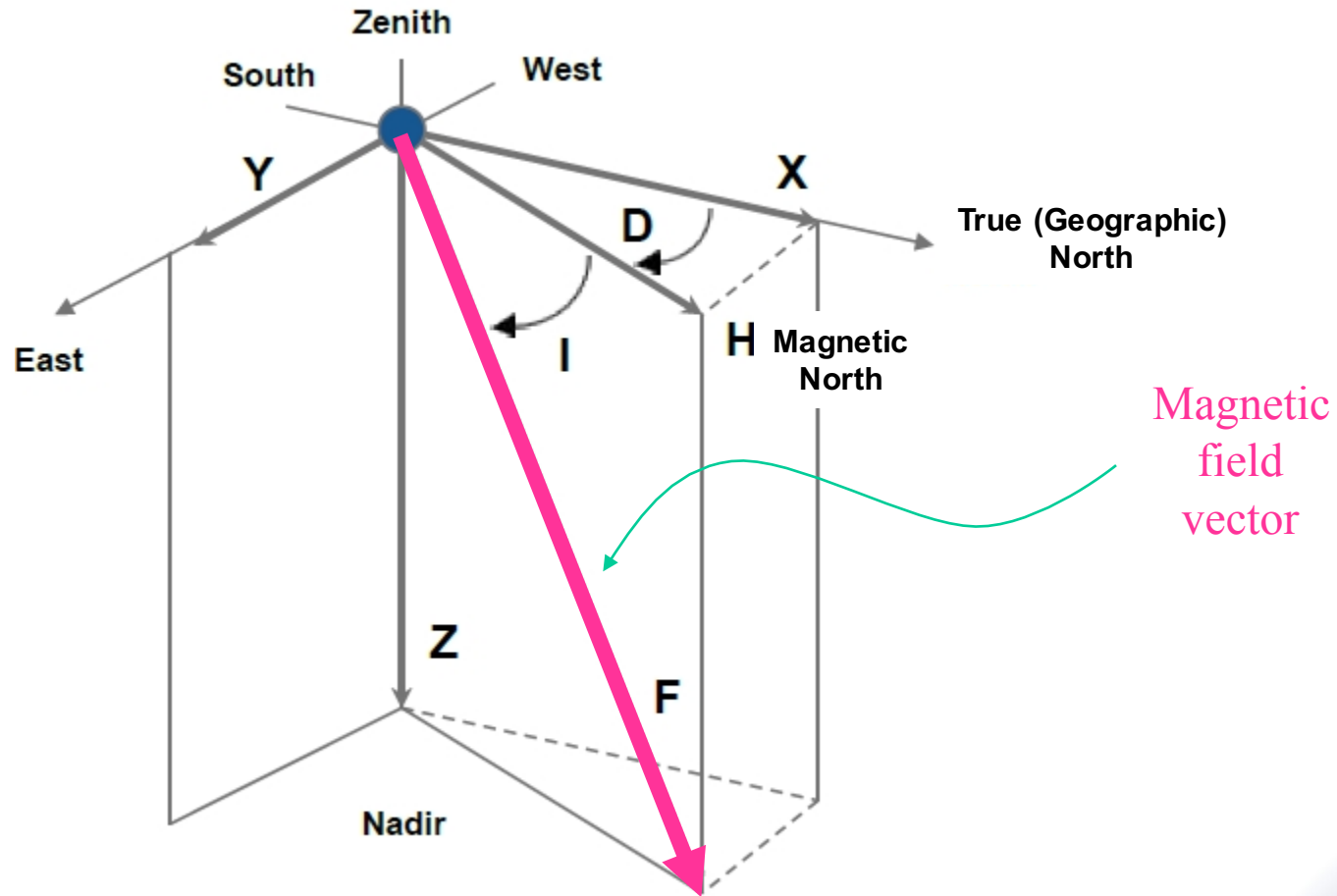
Where do aurora come from?



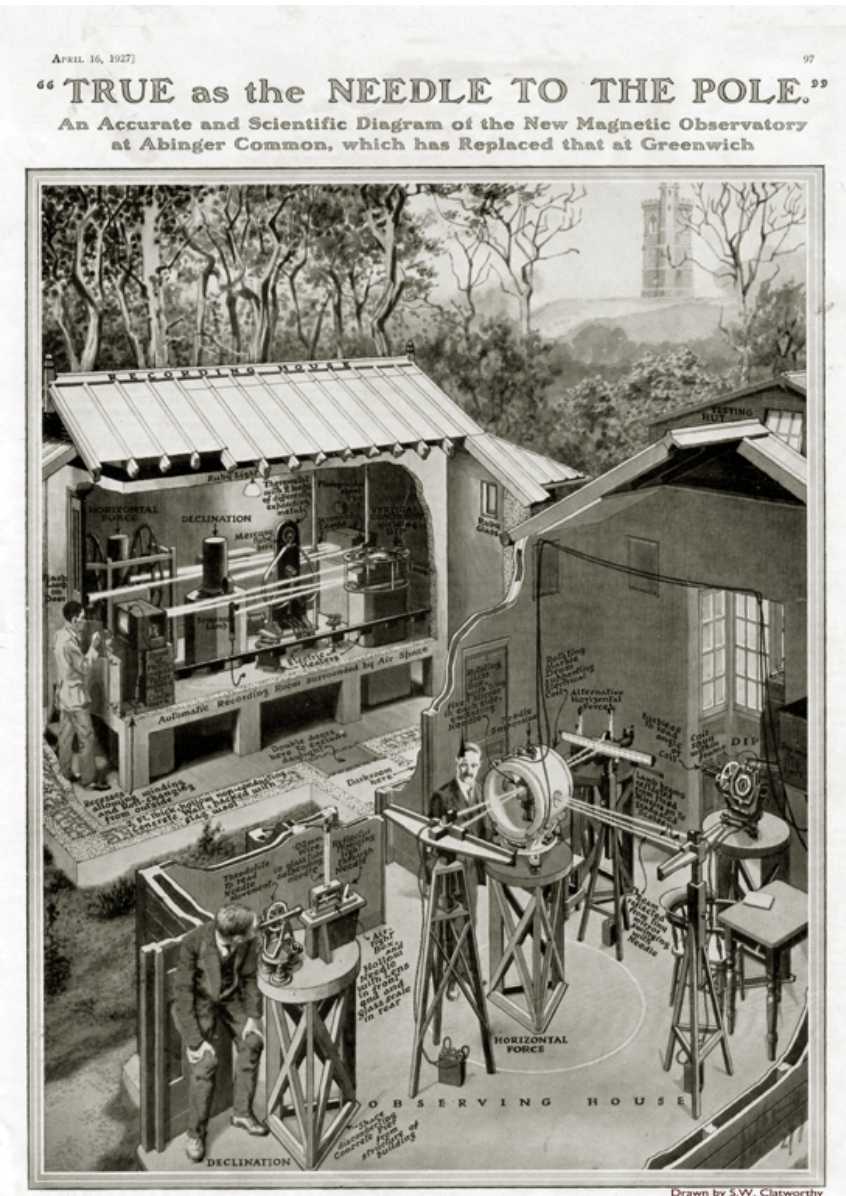
Some magnetic field words



Some magnetic field words



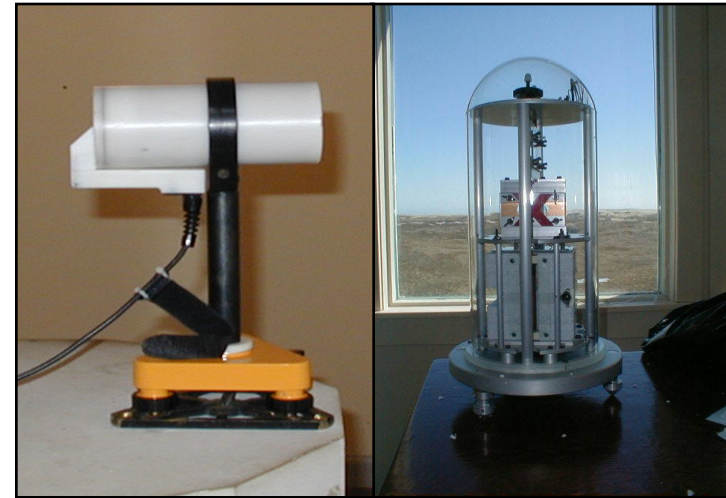
Measuring the Earth's magnetic field in the past



Measuring the Earth's magnetic field present day

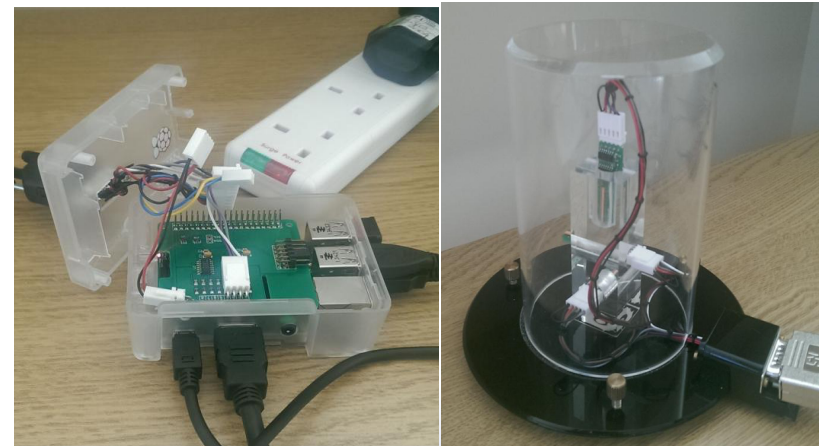
Scientific Magnetometer

- Absolute measurements
- Long-term magnetic cleanliness of site
 - Platform stability important
 - Temperature control/correction important
- Good for main magnetic field
- Cost: £15,000+



Raspberry Pi magnetometer

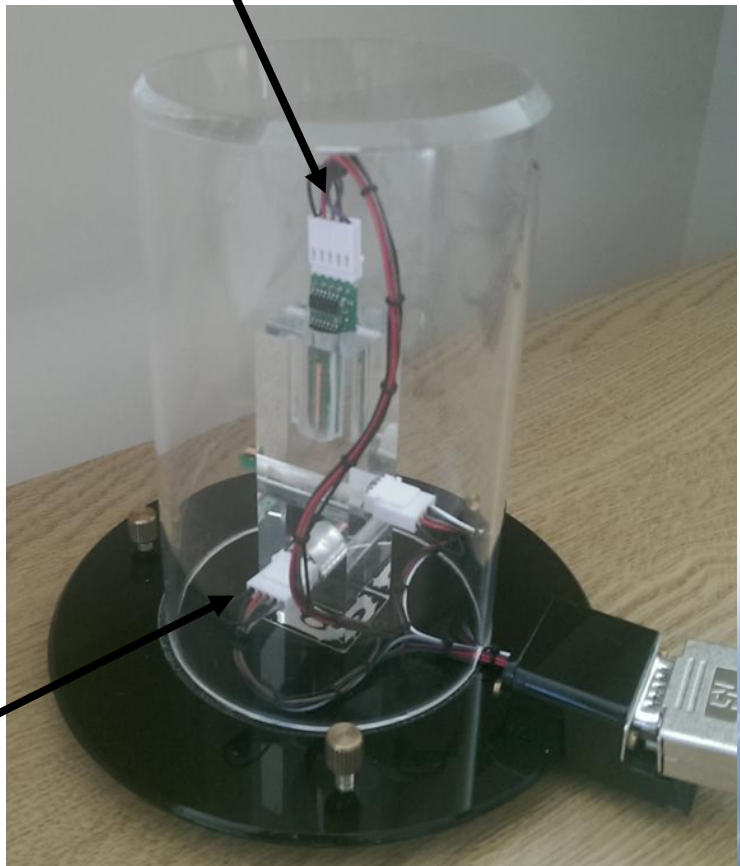
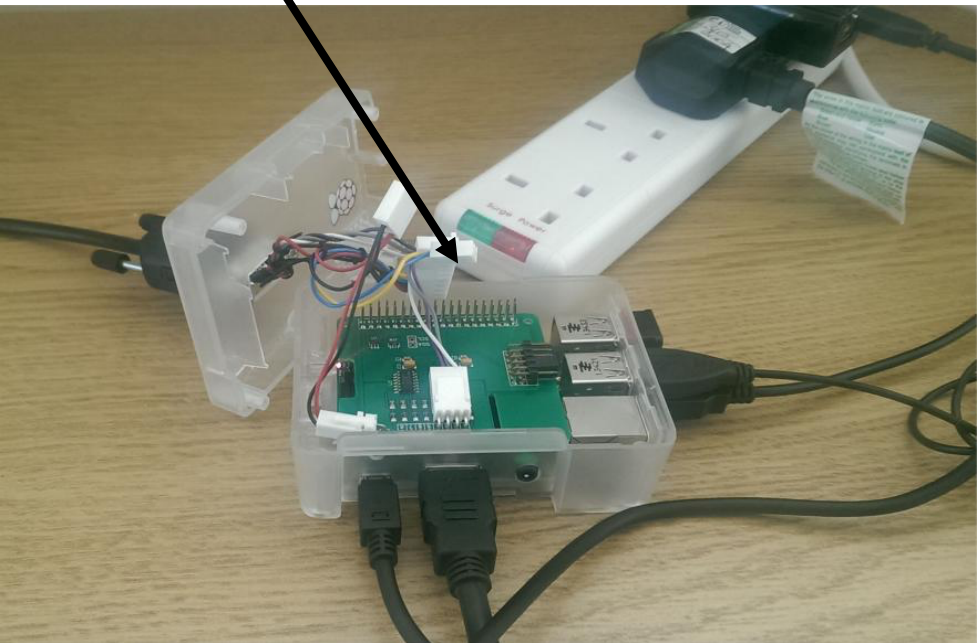
- Relative not absolute accuracy
- Not temperature controlled
- Good for external magnetic fields
- Cost: £150
 - ~100 times less accurate but more than good enough!



Building a magnetometer?

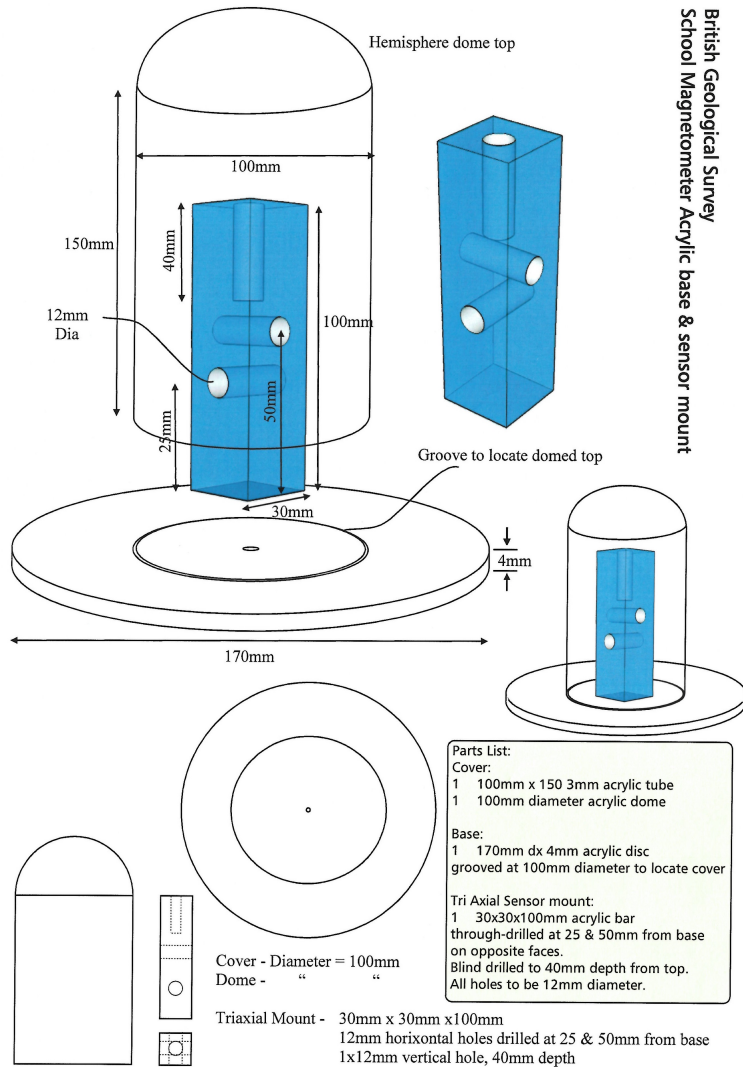
AB Electronics
17-bit digitiser

Stefan Mayer
FLC-100
fluxgate magnetometer



Adafruit TM36
thermometer

Construction

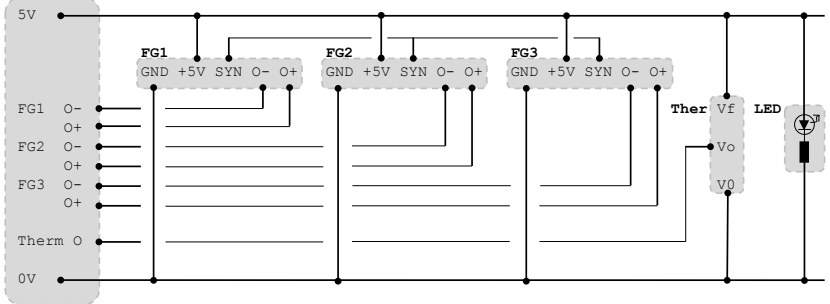


School Magnetometers

CABLE / CONNECTOR DIAGRAMS

Tim Taylor (photos Ciaran Beggan)

Wiring Diagram:

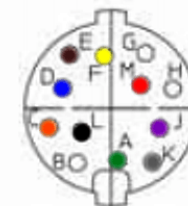
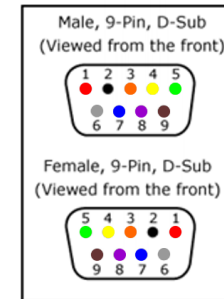


9 cores required in cable

Cable Colours:

10 core cable (shielded) to be used.

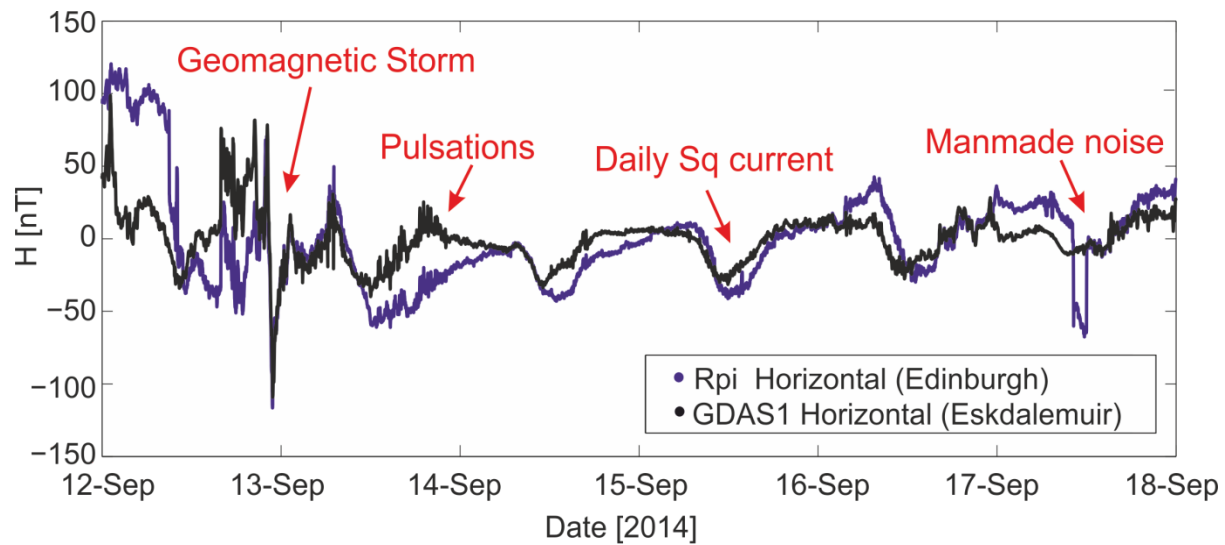
Colour	Rd	Or	Ye	Gr	Bu	Pu	Bl	Br	Gy	Wh
Use	+5	FG1+	FG2+	FG3+	FG1-	FG2-	0V	FG3-	The	xxx
Pin #	1	3	4	5	7	8	2	9	6	



female solder side



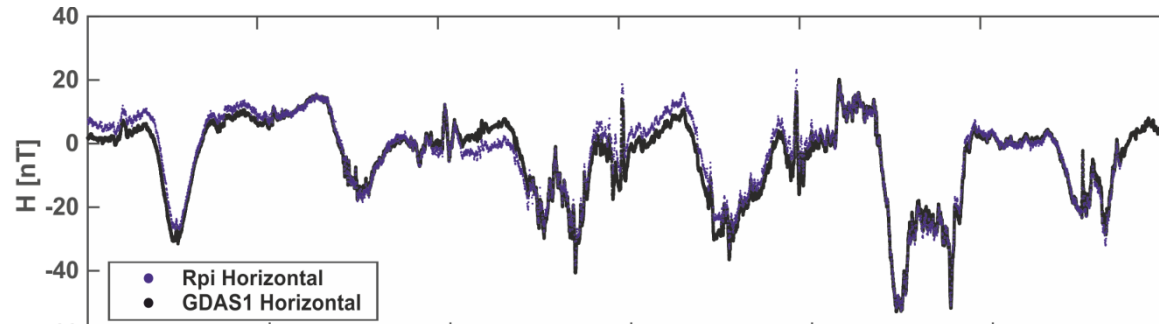
On Test in Edinburgh



On remote test



Complicated Graph!



28-Oct

29-Oct

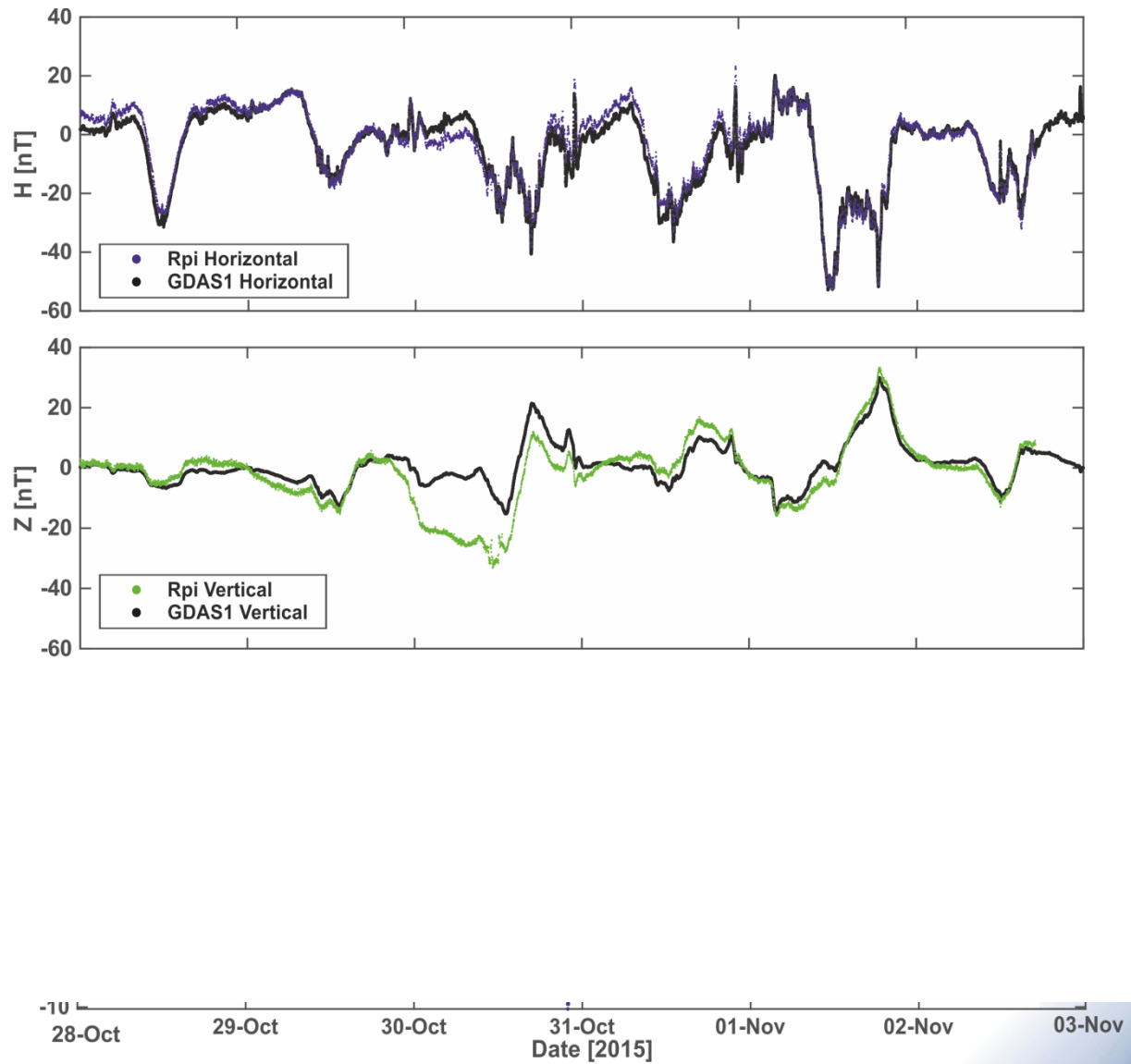
30-Oct

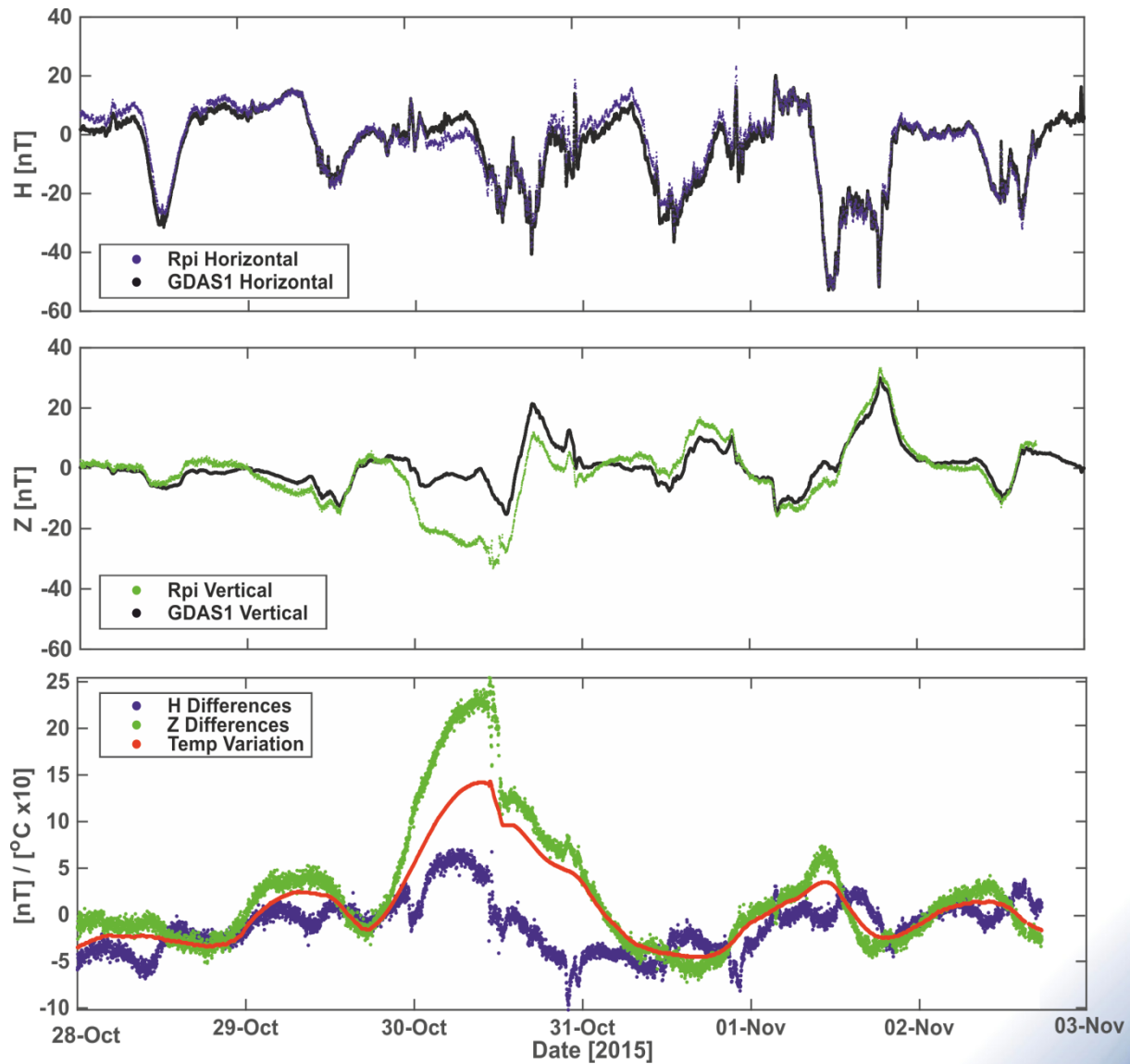
31-Oct
Date [2015]

01-Nov

02-Nov

03-Nov





More info: geomag.bgs.ac.uk

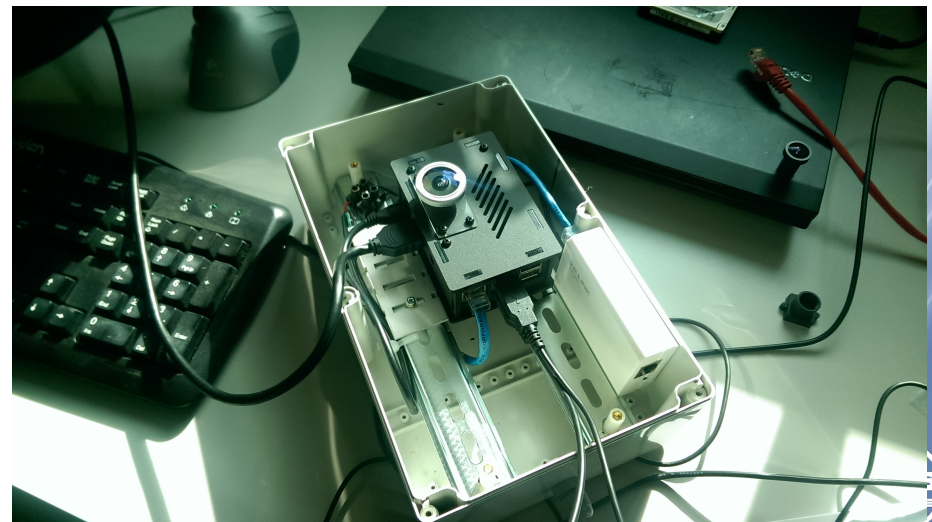
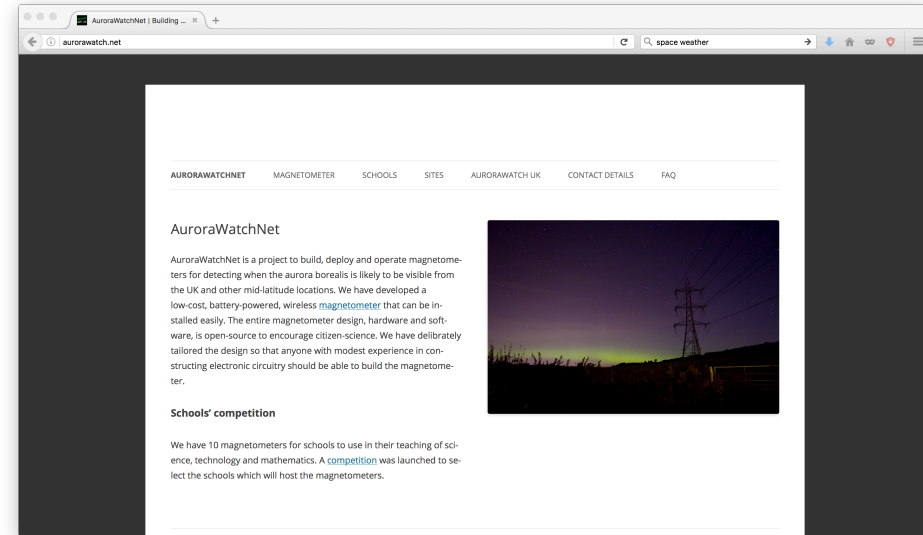
The screenshot shows a Safari browser window displaying the website geomag.bgs.ac.uk. The page layout includes a top navigation bar with links for 'About us', 'Contact us', 'Downloads', 'Jobs', and 'Shop'. Below this is a search bar and the word 'Geomagnetism'. A secondary navigation bar lists 'Home', 'Research', 'Operations', 'Data & Services', and 'Education'. The main content area features a 'Home' section with buttons for 'Geomagnetic Activity Alert', 'Geomagnetic coordinate calculator', 'New observatory', 'WMM 2015', and 'Sign-up for alerts'. A prominent alert banner reads 'Geomagnetic disturbance alert - 7-8th October 2015' and contains a video player showing a space scene. Text below the video states: 'There is an increased chance of a geomagnetic disturbance throughout the next 48 hours due to effects from a coronal hole high speed stream. More information on the alert.' To the right, a 'Latest News' sidebar lists several articles, including 'Geomagnetic activity alert 07-Oct-2015' and 'New quasi-dipole geomagnetic coordinate calculator'. Below the news is a 'Tweets' section showing a tweet from @BGSspaceWeather about solar wind speed.

All the details for build are here:

ftp://ftp.nerc-murchison.ac.uk/geomag/ciaran/Rpi_Magnetometer_build.zip

Next steps

- Real-time data delivery to AuroraWatch UK in Lancaster
- Deploy to a 10 schools around the UK
- Wait for some big aurora
- Also working on an Rpi AuroraCam ...



Thank you

- Come see the demonstration after lunch!

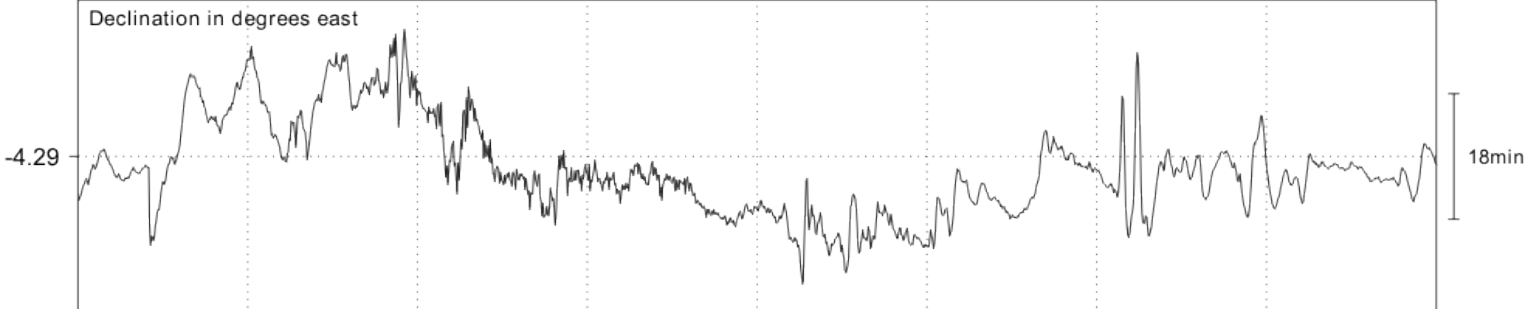
Other slides

BGS Magnetogram

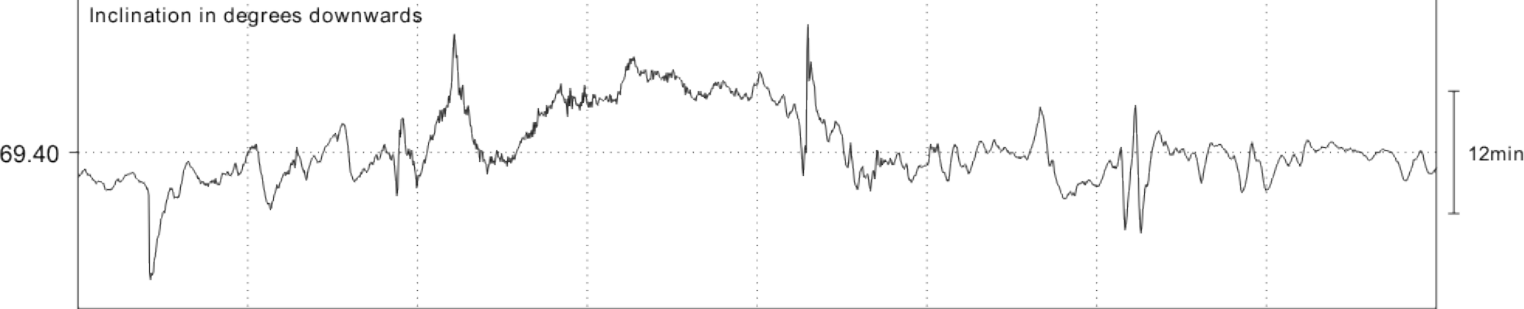
National Geomagnetic Service, BGS, Edinburgh

GDAS-1 Fluxgate Data (derived from) Eskdalemuir lat: 55.317N lon: 356.800E

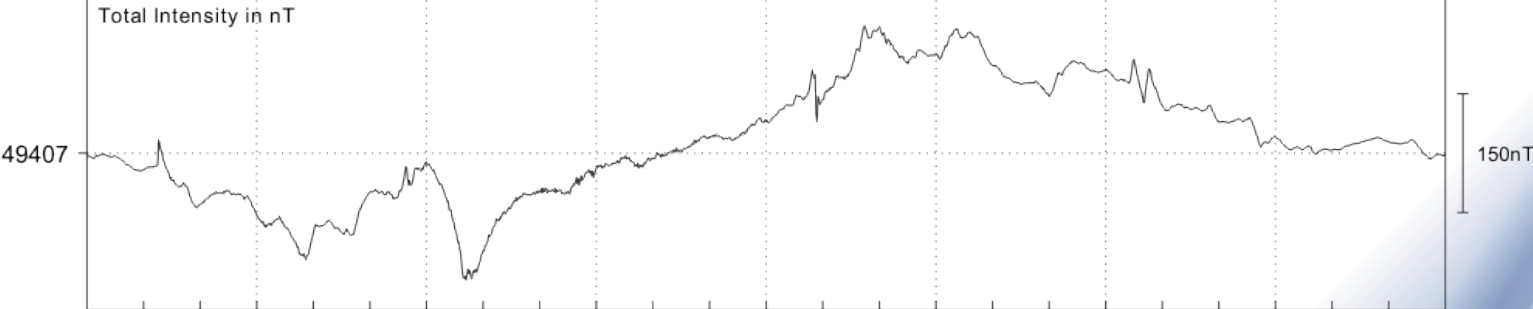
Dec



Inc



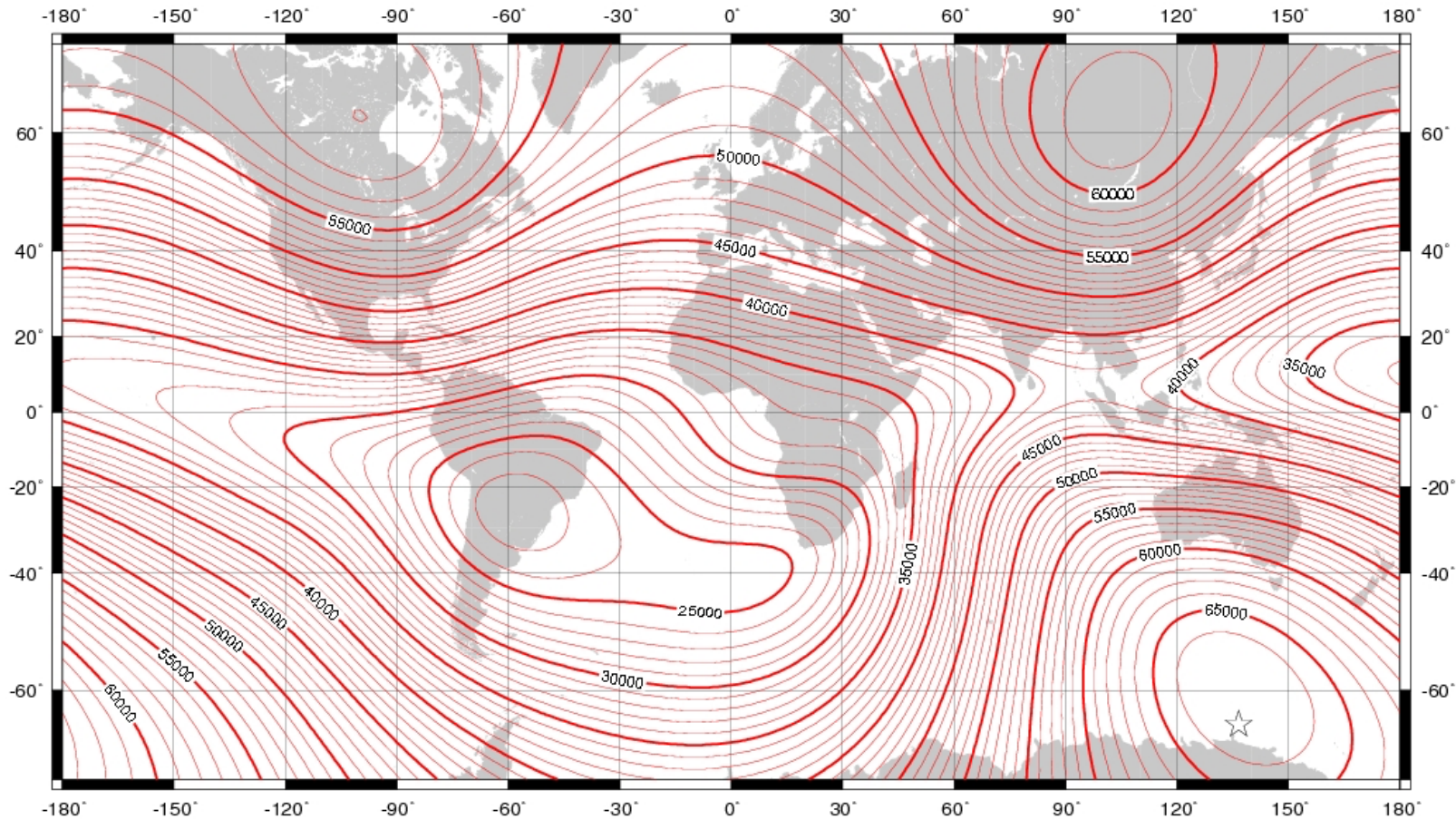
F



Date: 11-09-2005 Hour (UT) Day number: 254

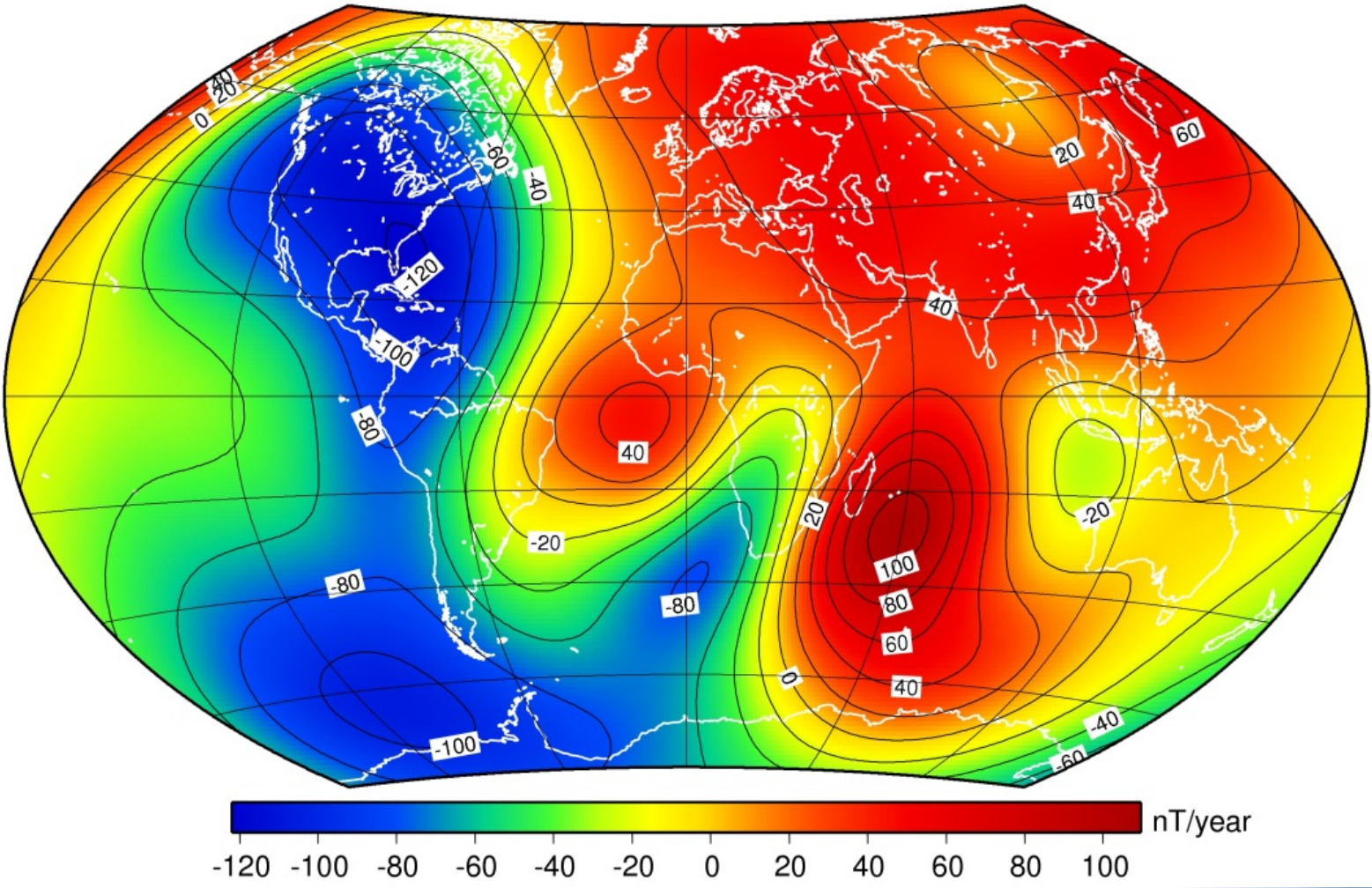


Main Field map: Total Field strength (nT)

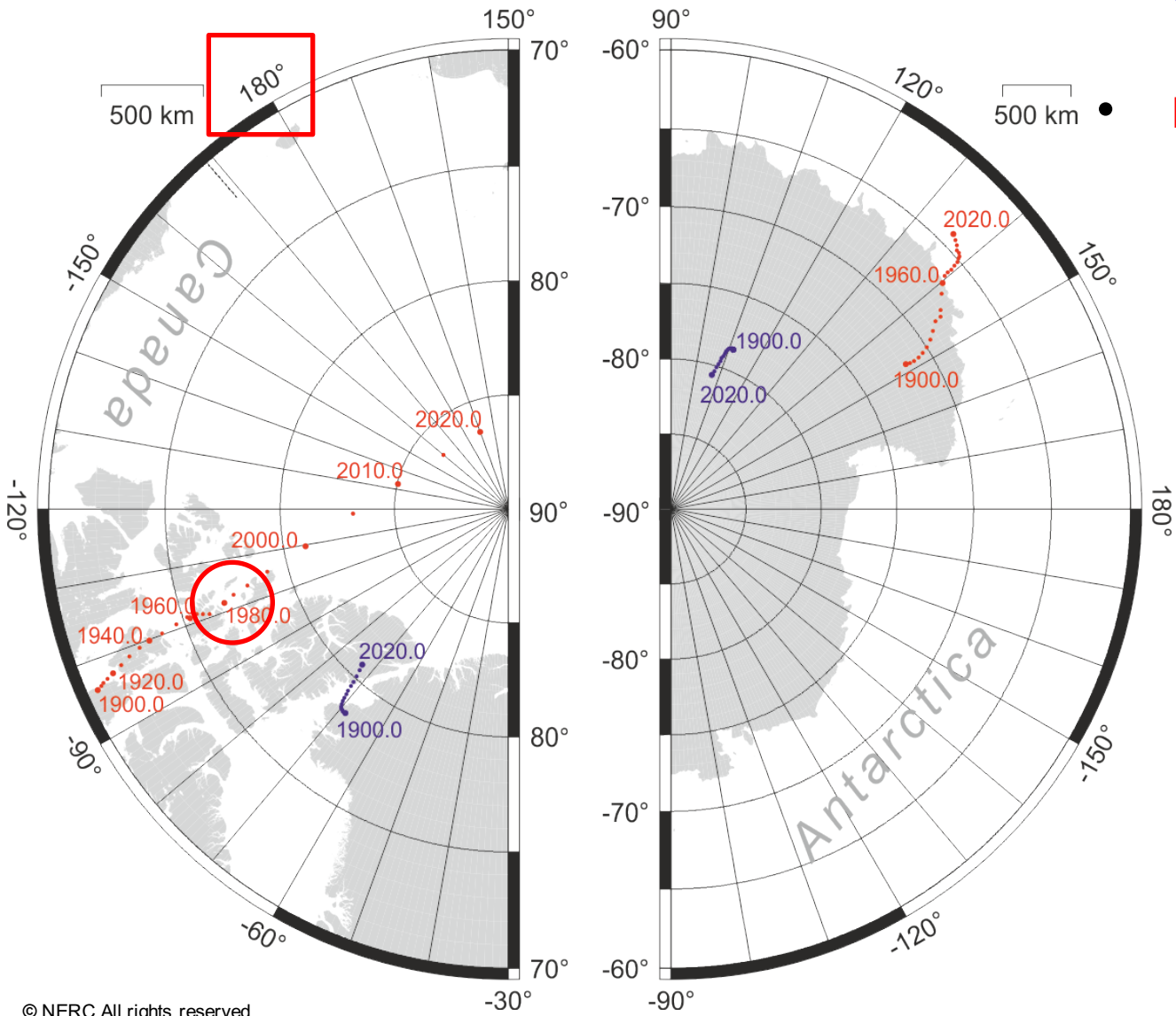


Total intensity (F) at 2015.0 from the World Magnetic Model (WMM2015). Contour interval is 1000 nT, white star is location of a magnetic pole and projection is Mercator. This is an example of an isodynamic chart. Credit: British Geological Survey (Natural Environment Research Council).

Main field total intensity change in 2015 (nT/yr)

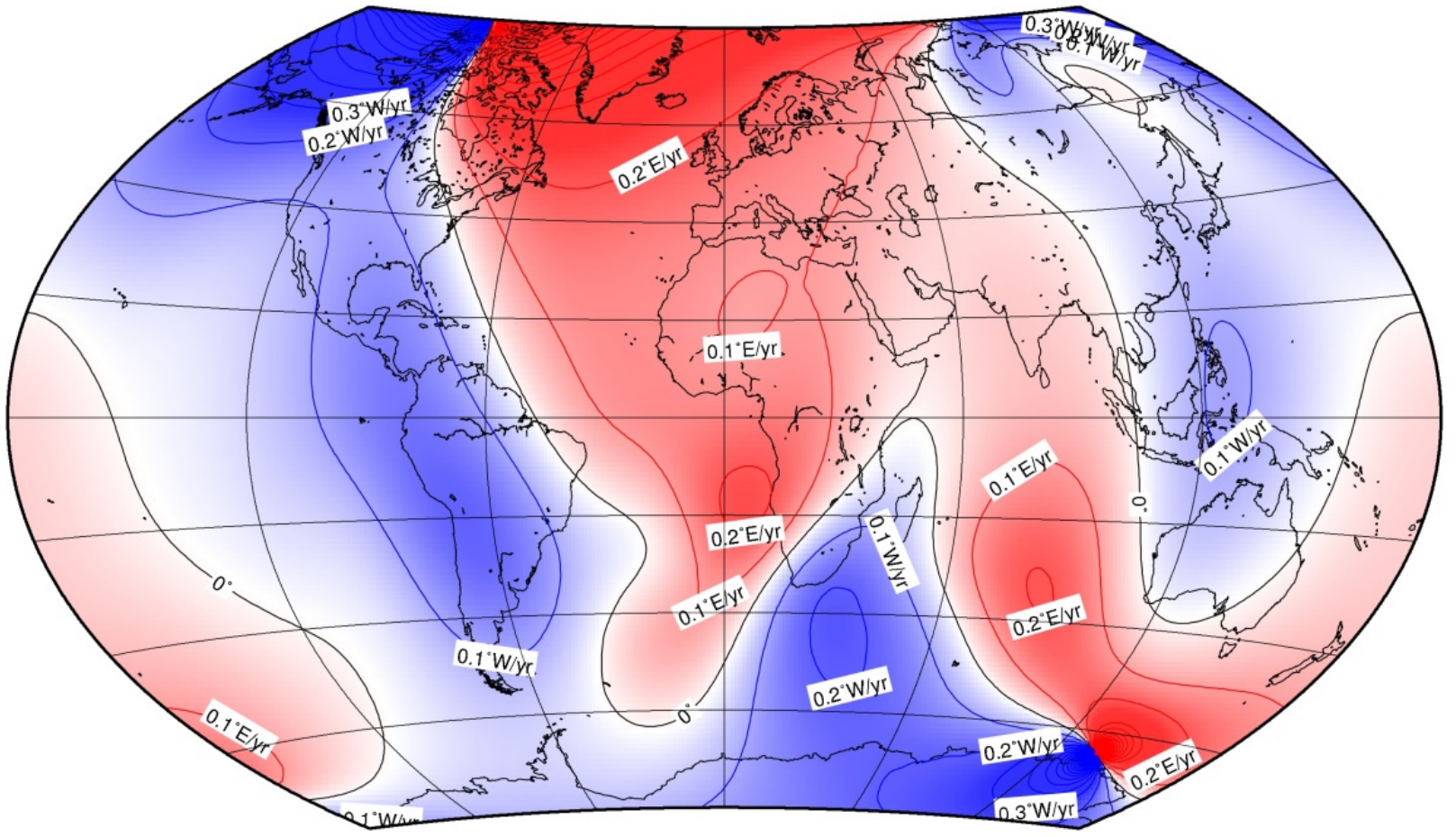


Change of the Main Field: Poles Apart



- **Geomagnetic Pole**
 - global best fit dipole
- **Magnetic 'Dip' Pole**
 - where inclination is 90°
 - actually a diffuse region

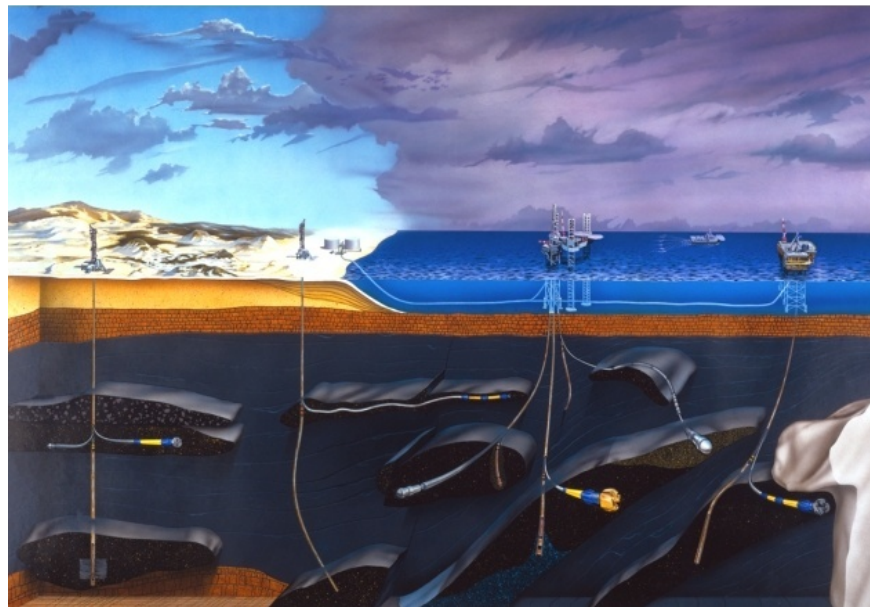
Declination 2015



Applications?

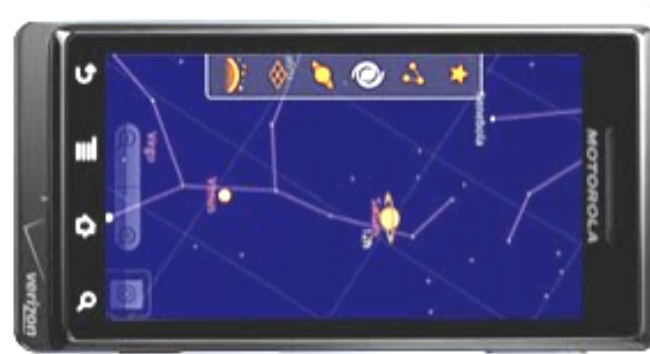
Directional drilling for hydrocarbons

- Avoid well collisions
- Aim for smaller targets



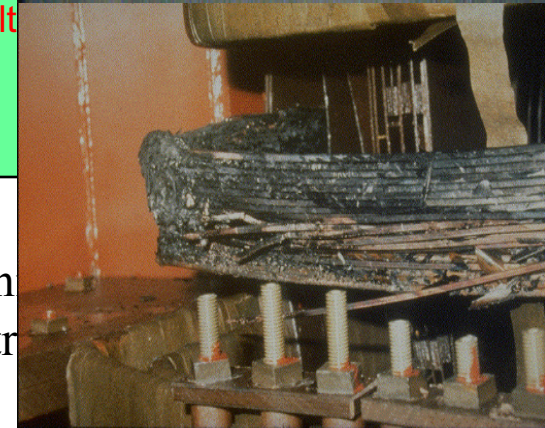
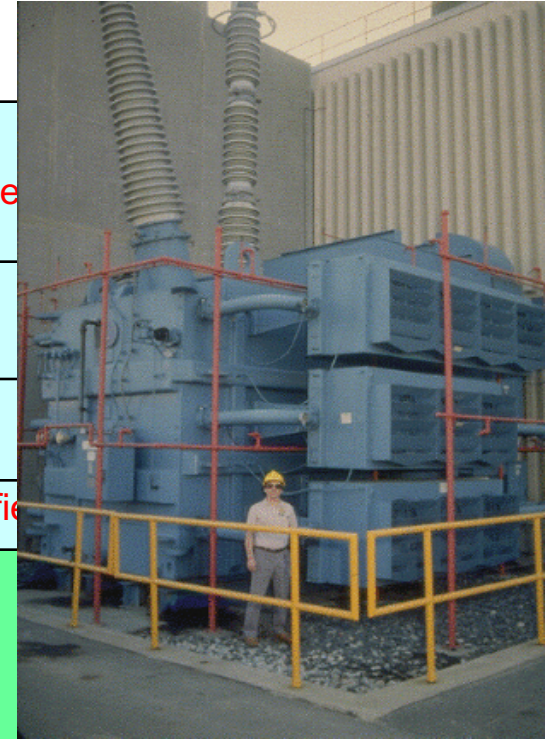
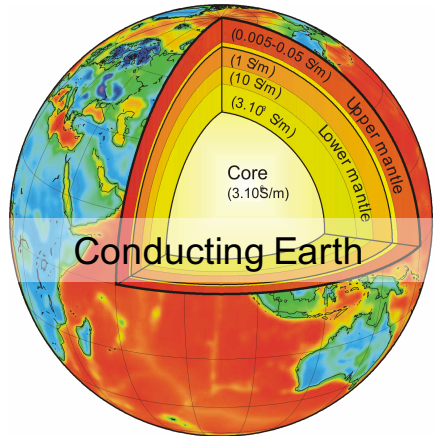
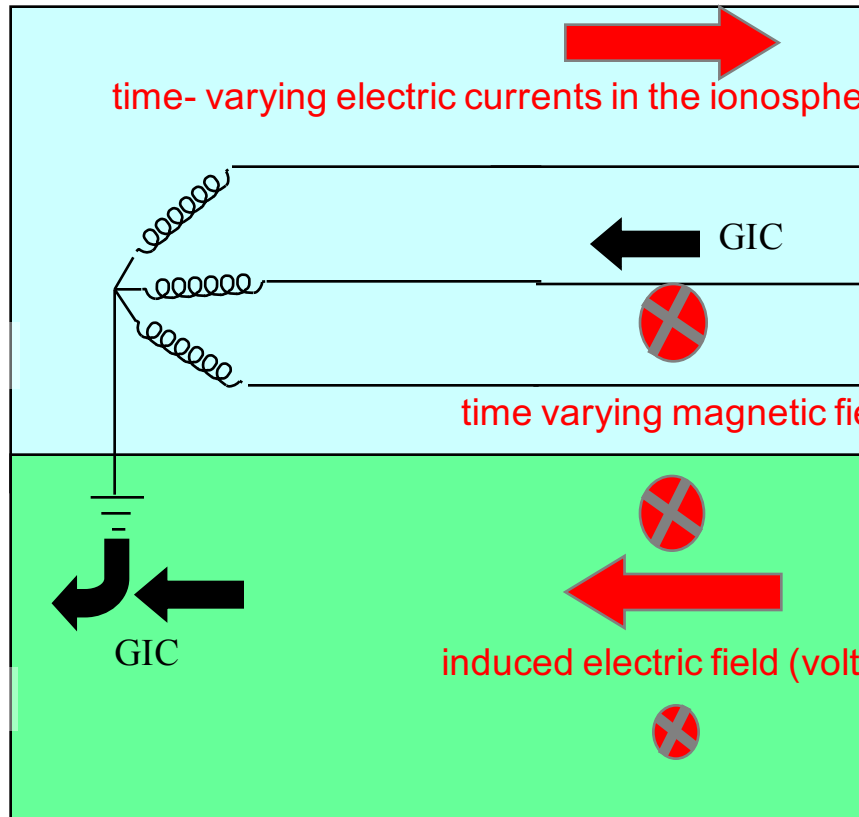
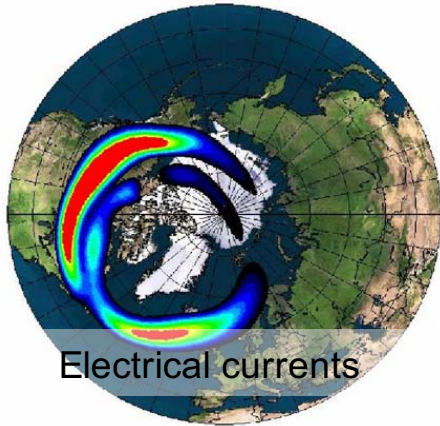
Orientation of maps on a smart phone using **digital compass** and magnetic declination model

‘Augmented reality’
e.g. Google Sky



What is the risk from Geomagnetically Induced Currents?

Secondary induced currents flow into grounded infrastructure



DC offset in transformer causes: voltage harmonics
flux escape from core; overheating; destruction