Real-time geomagnetic data from a Raspberry Pi magnetometer network in the UK

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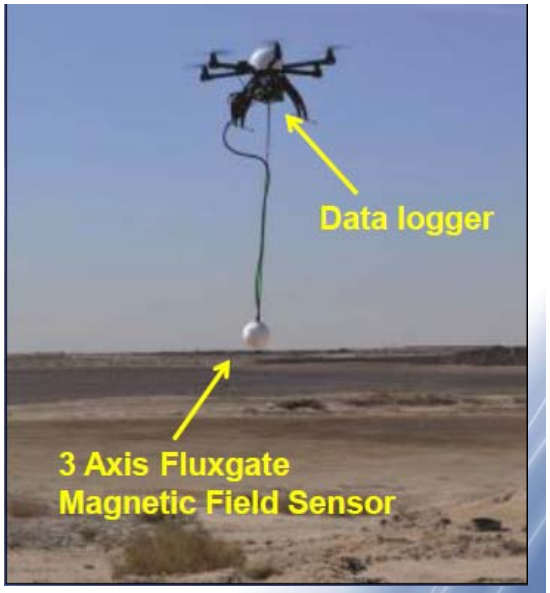
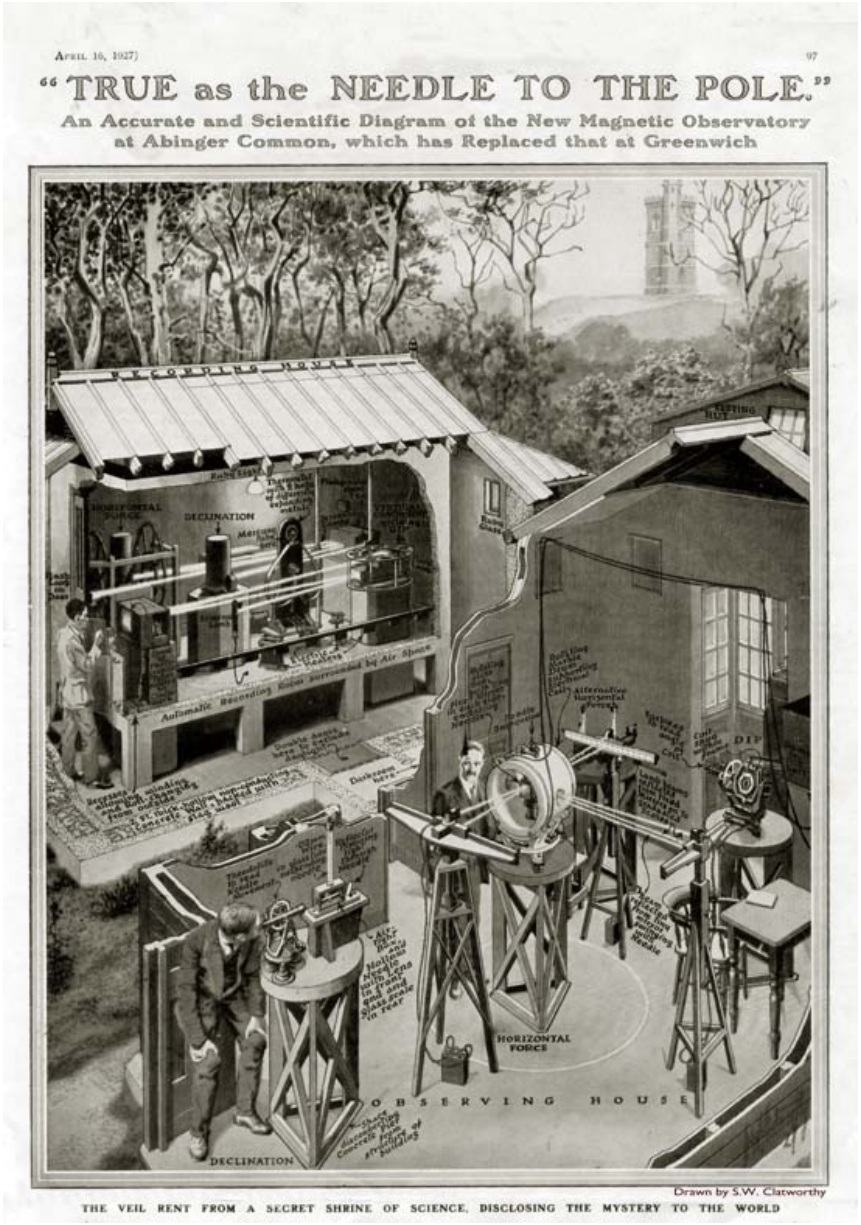
Background

- Cheap magnetic sensors are now everywhere (phones, gaming controls, drones)
- Can they be used for space weather or auroral science?
- Can a *scientific-level* sensor be made cheap enough that anyone can buy or build one?
- In 2014, we won an STFC Public Engagement grant (£10K) to build and run 10 magnetometers for schools



Measuring the Earth's magnetic field: in the past



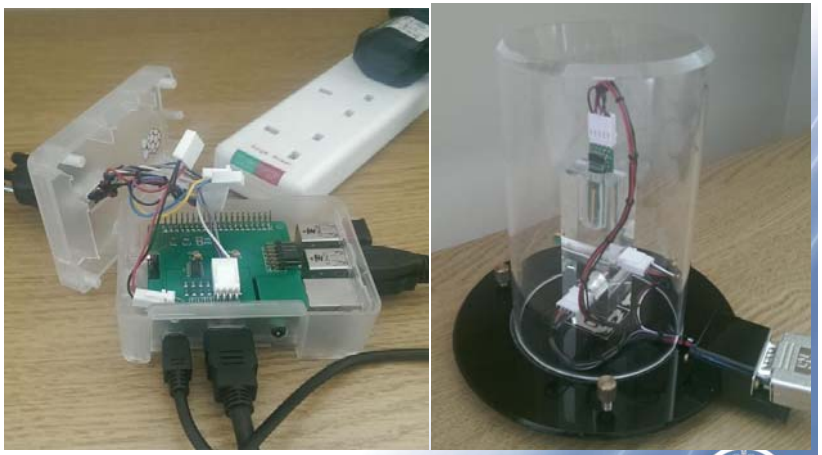
Measuring the Earth's magnetic field: present day

Scientific Magnetometer

- *Absolute* measurements
- Long-term magnetic cleanliness of site
  - Platform stability important
  - Temperature control/correction important
- Excellent for main magnetic field
- Cost per instrument: £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!

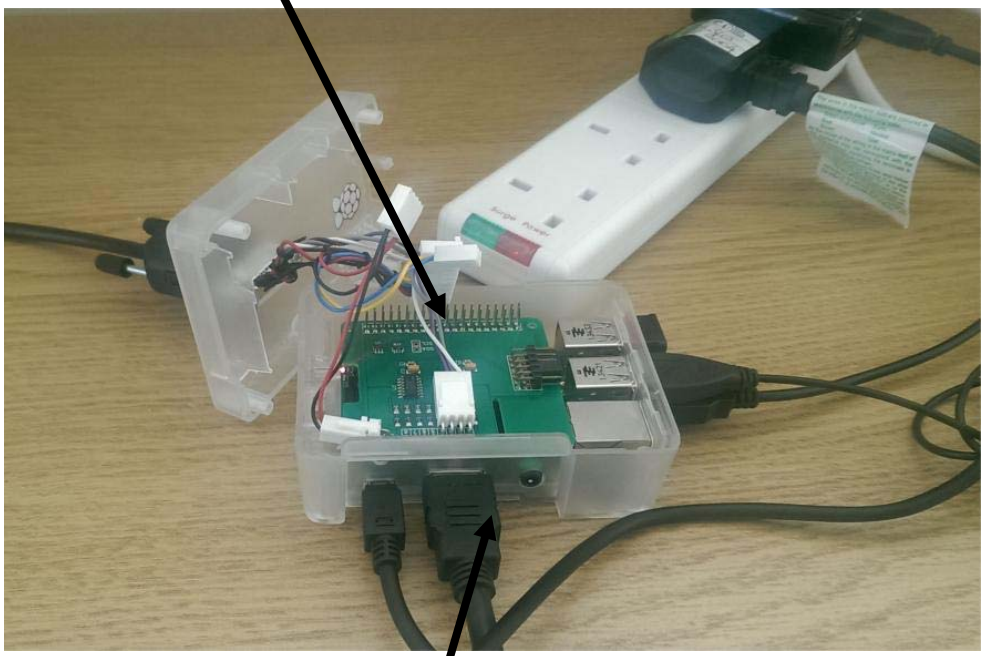


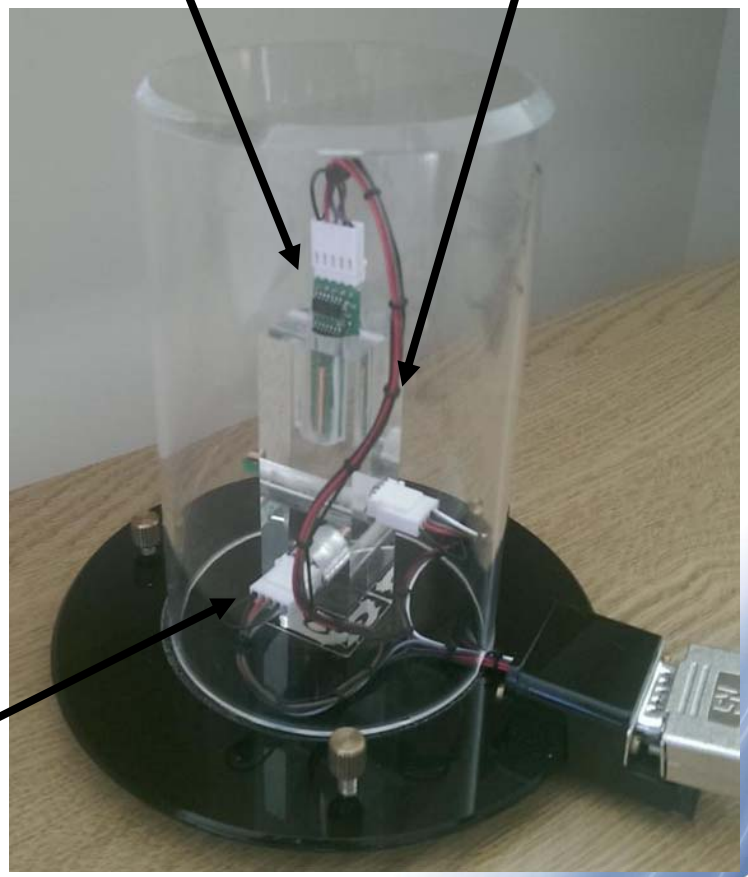
Building a magnetometer

Perspex mount

Stefan Mayer
FLC-100
fluxgate magnetometer

AB Electronics
17-bit digitiser

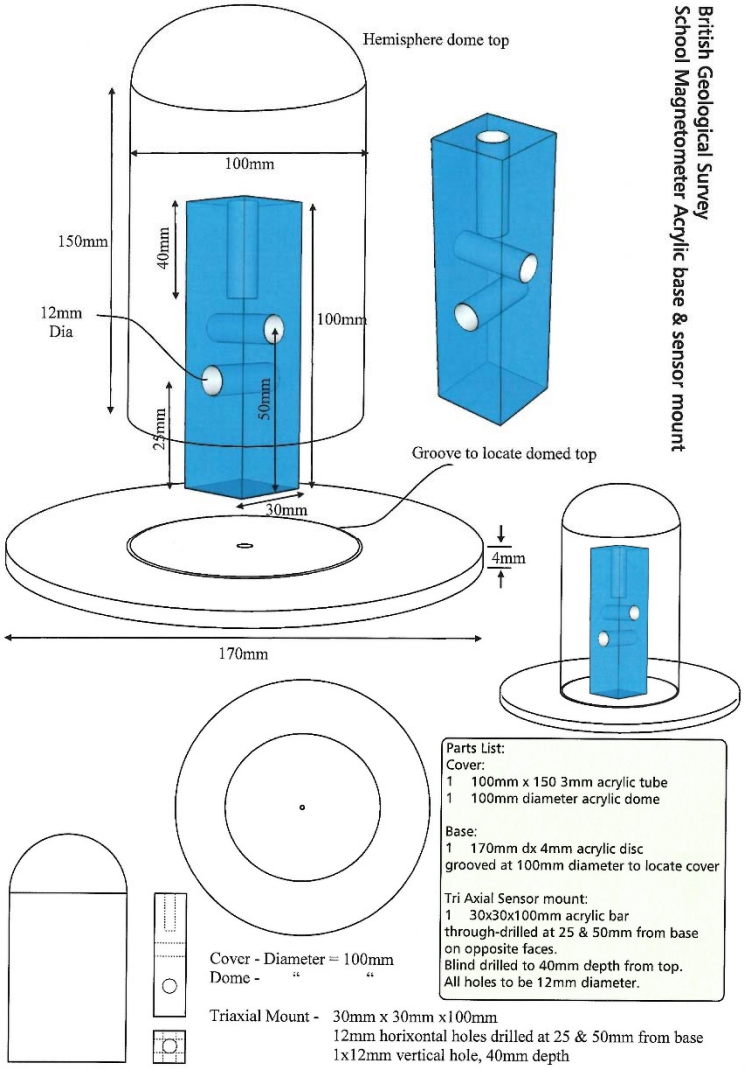




Raspberry Pi
computer

Adafruit TM36
thermometer

Construction

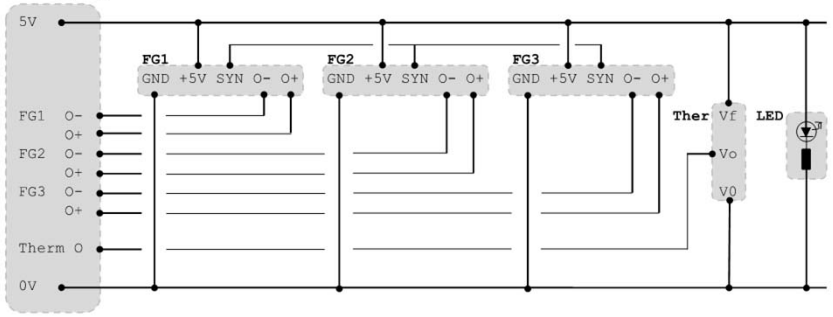


School Magnetometers

CABLE / CONNECTOR DIAGRAMS

Tim Taylor (photos Ciaran Beggan)

Wiring Diagram:

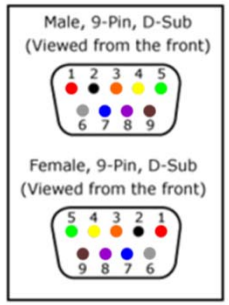


9 cores required in cable

Cable Colours:

10 core cable (shielded) to be used.

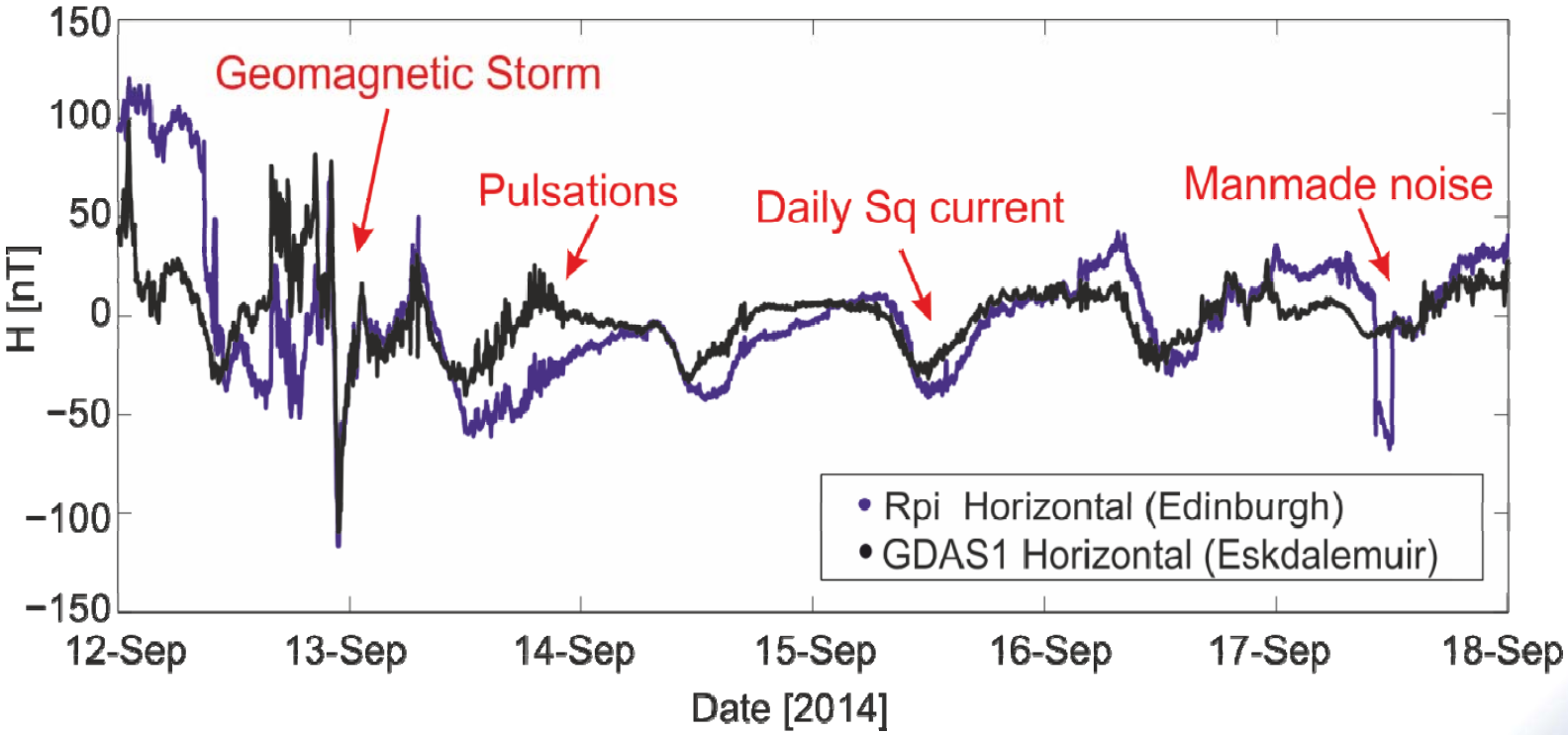
Colour	Rd	Or	Ye	Gr	Bu	Pu	Bl	Br	Gy	Wh
Use	+5	FG1+	FG2+	FG3+	FG1-	FG2-	0V	FG3-	The	xx
Pin #	1	3	4	5	7	8	2	9	6	



female
solder side

male
solder side

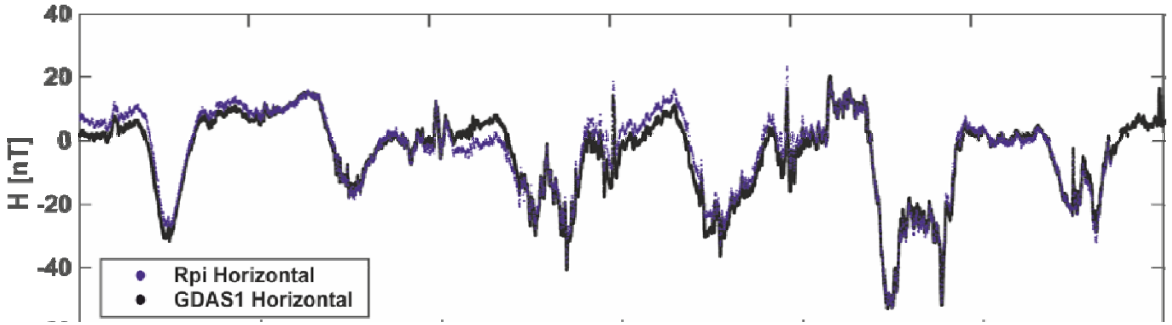
On Test in Edinburgh

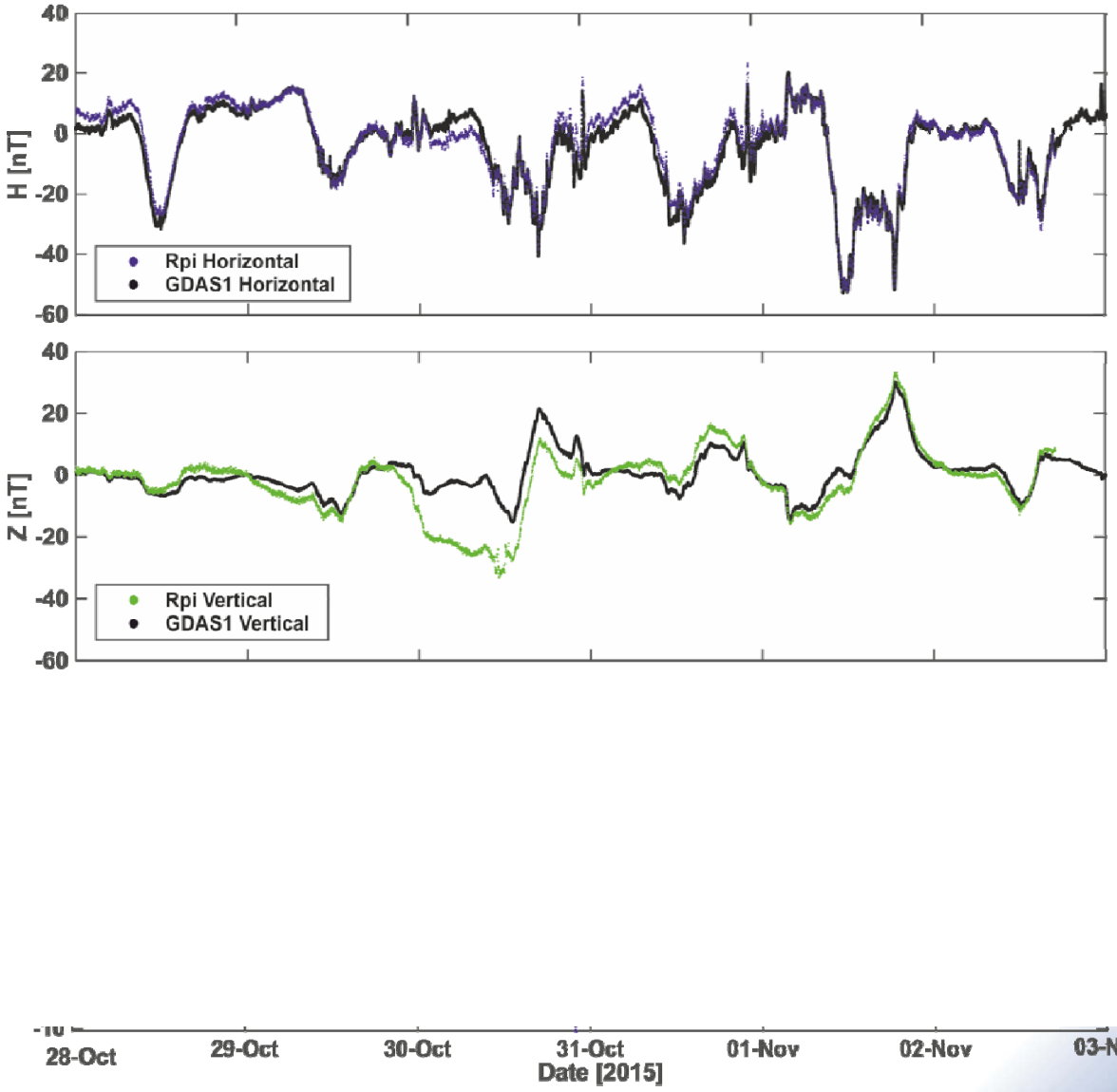


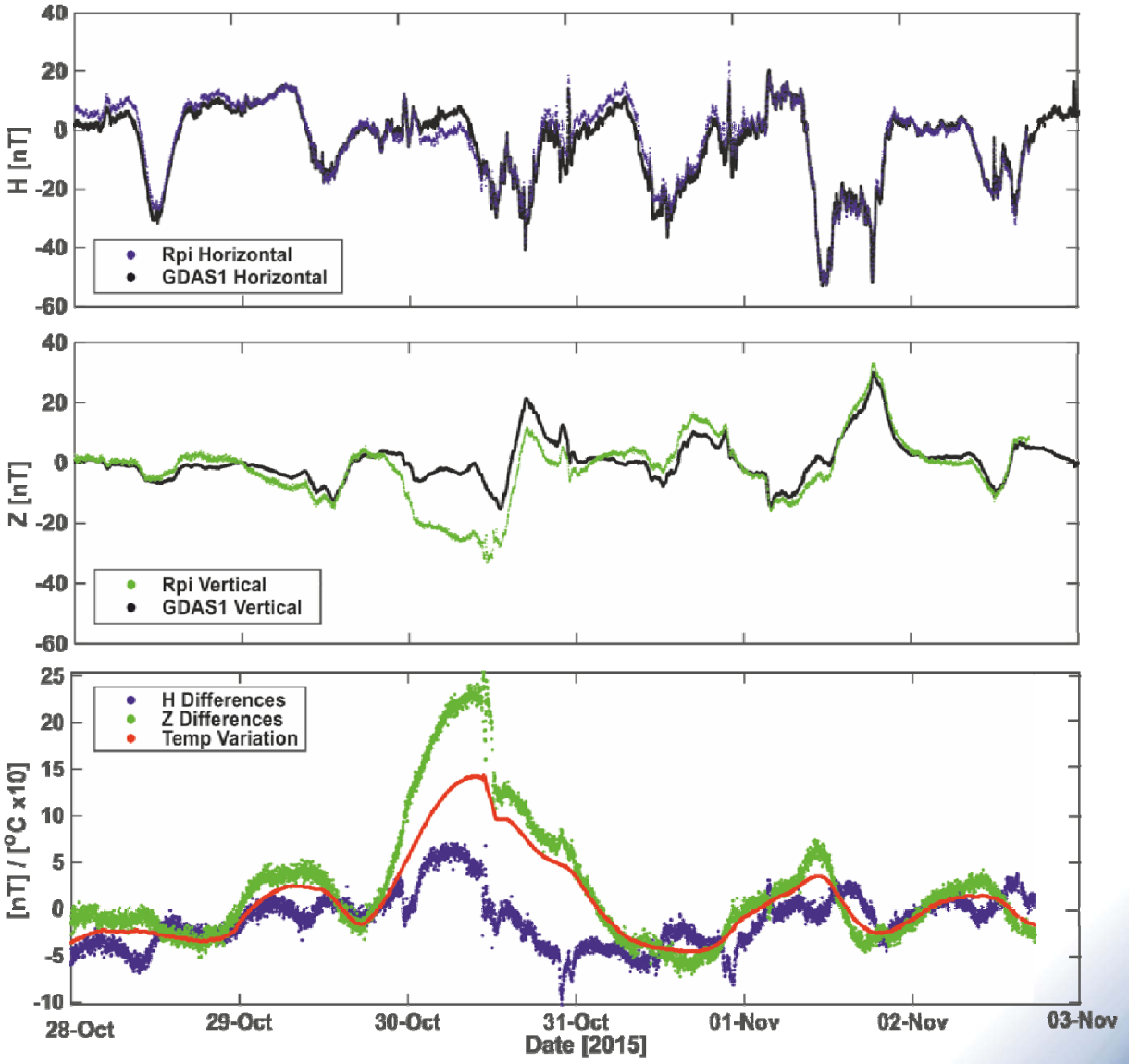
On remote test at ESK

- Placed on test for a month in Eskdalemuir observatory (Oct-2015)
- 10 systems run simultaneously in the non-magnetic lab
- Comparison to GDAS system for temp stability, noise etc
- Some issues found (e.g. interferences from crossing cables)
- RMS ~ 1nT (< 30 minutes)

At Eskdalemuir in the Scottish Borders, UK





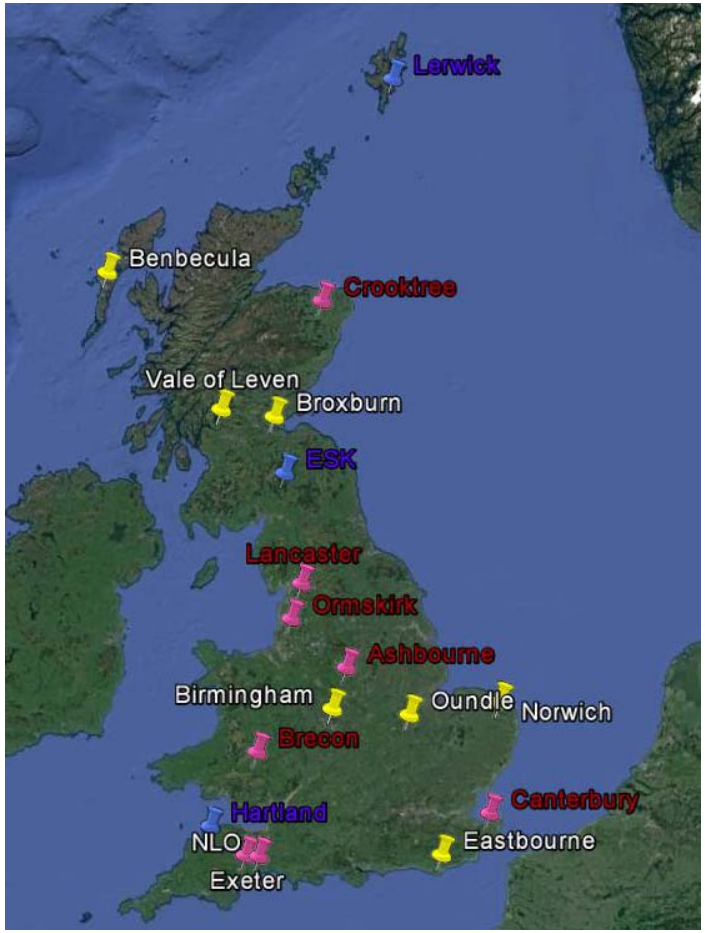


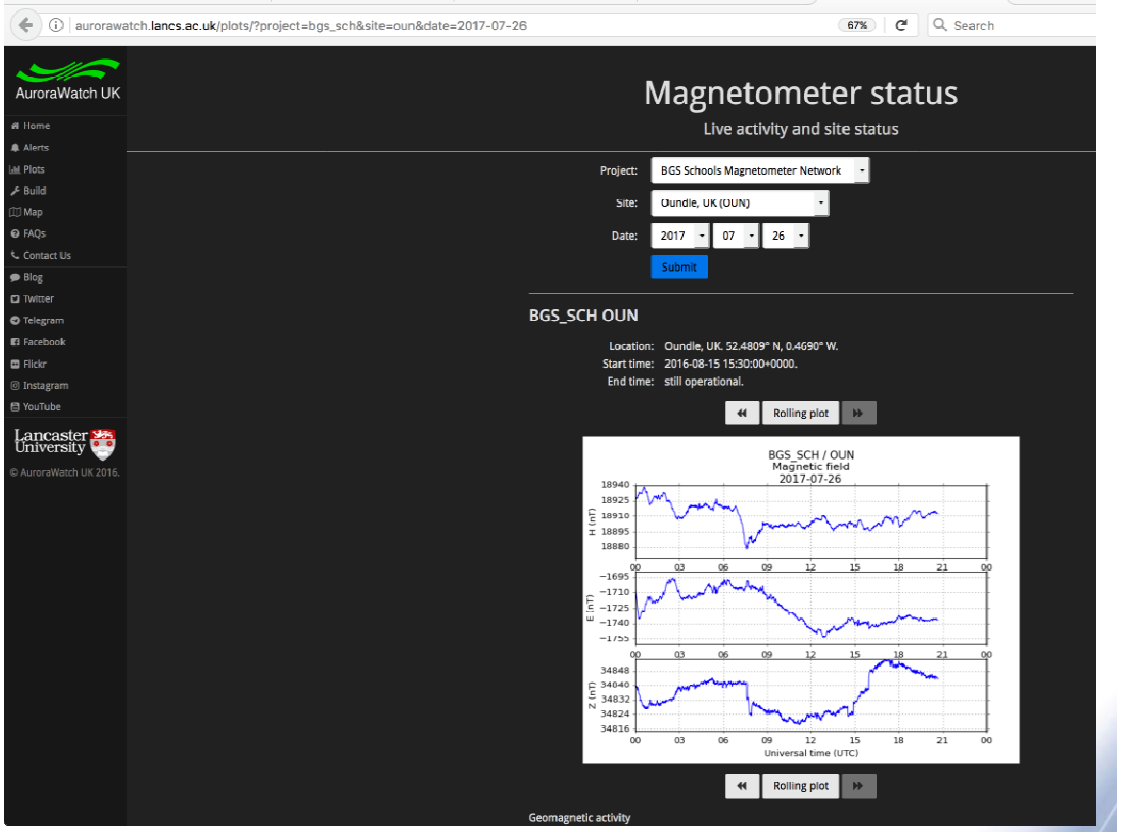
Deployment to schools

- We approached teachers of physics either directly via email or personal introduction
  - Attended an IOP Physics teacher workshop
  - Asked friends/family/colleagues in particular regions of the UK

- Eventually managed to get 9 schools to take the systems
  - Mixed response - some run continuously, some for a while and are switched off
  - Real-time data collection from across the UK
  - Internet access seems to be the hardest part!

Real-time data available for free



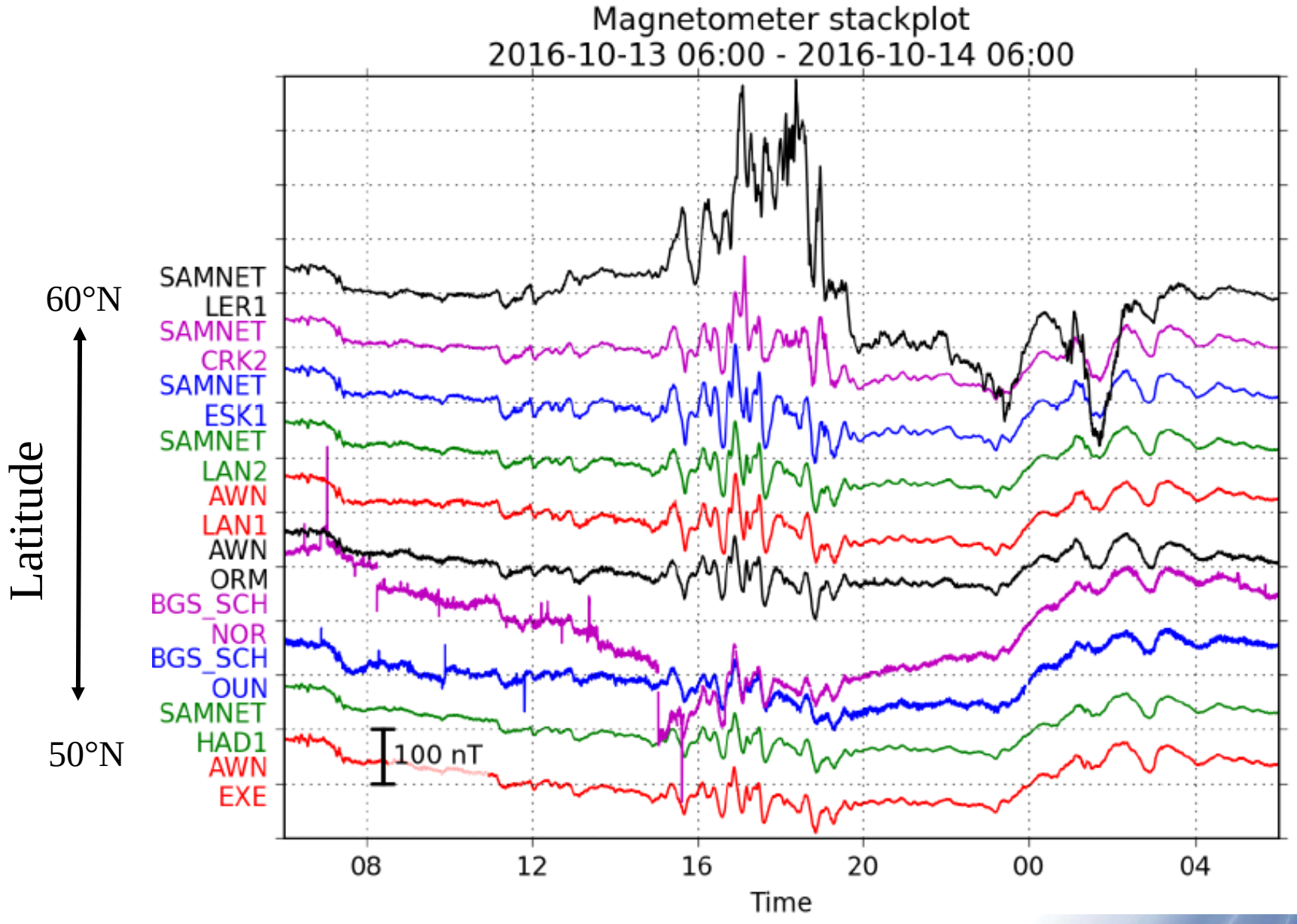


http://aurorawatch.lancs.ac.uk/plots/

Yellow: BGS School Magnetometer
Pink: AuroraWatch Magnetometer
Blue: BGS Observatory

Geomagnetic storm: October 2015

Doug Collinson:
Northern Lights Over Cloch Lighthouse, western Scotland
https://www.flickr.com/photos/60122552@N08/



Lessons learned?

1. Doing this voluntarily takes a lot of time
2. Building the systems was the cheapest part
3. Software takes much longer
4. Teachers often seem enthusiastic but …
5. School internet is often completely locked down
6. Maintaining a network like this continuously does take a lot of effort
7. Still awaiting the ‘big’ one to show off the usefulness of such a large network

More information?

- General information
  - www.geomag.bgs.ac.uk
  - www.aurorawatch.net
- Real-time plots and data (2 day lag)
  - http://aurorawatch.lancs.ac.uk/plots/
- AuroraWatch Code (plotting and uploading)
  - https://github.com/stevemarple

All the details for parts and build:

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

Thank you for listening

Questions?

(Next project: Raspberry Pi AuroraCam)