Geosci. Commun. Discuss.,
https://doi.org/10.5194/gc-2018-10-AC3, 2018
© Author(s) 2018. This work is distributed under
the Creative Commons Attribution 4.0 License.

Geoscience Communication
Discussions
Open Access

Interactive comment on "Building a Raspberry Pi School Magnetometer Network in the UK" *by* Ciarán D. Beggan and Steve R. Marple

Ciarán D. Beggan and Steve R. Marple

ciar@bgs.ac.uk

Received and published: 7 August 2018

Author's Response: Pierdavide: We thank you very much for reading through the manuscript and providing suggestions for improving it.

Some comments: In the introduction it is described how the low-cost magnetometers and acquisition chains, can provide instruments useful for citizen science. It would be important to cite some other projects. Later in the manuscript the school seismometers are mentioned, it could be important to introduce these other outreach projects here. Also, other citizen science projects on magnetism could be cited (e.g. CrowdMag)

Response: Correct - there are a number of geophysical networks along the lines of this project particularly for citizen scientists and schools. We have amended the first

paragraph as follows: "Over the past decade, the introduction of cheap reliable computing hardware and sensors, along with the ubiquity of high-speed Internet connections mean that it is now possible create low-cost open-science networks of geophysical sensors. This has encouraged the development of data-intensive networks, for example in climate studies (Weather Observation Website: wow.metoffice.gov.uk/), seismology (BGS School Seismology Project: www.bgs.ac.uk/schoolseismology/) or cosmic ray research (the TimPix Project: www.researchinschools.org/TIMPIX) where spatial and temporal gaps in the professional scientific networks may be filled or augmented. Some networks employ existing platforms such as mobile phones using in-built sensors to record data (e.g. CrowdMag, see www.ngdc.noaa.gov/geomag/crowdmag.shtml) while others create bespoke hardware with higher accuracy than general purpose systems. In geomagnetism, high-quality low-cost fluxgate sensors have become more widely available to allow accurate monitoring of the variation of the Earth's magnetic field over time ranges of several minutes to hours."

Section 2 presents the Earth magnetic field, its sources and the traditional observatories that are deployed for scientific research. There is very little information about the chains of magnetometers that exists, in many cases oriented for Space Weather applications. Some of them are used later in this work for the study of the September 2017 storm. It would be better to present them in this section, adding relevant references to these networks. Response: I think that is perhaps too much detail for a general audience. We do note that "The global scientific magnetic observatory network fulfils this role. However, there are presently only around 200 magnetic observatories worldwide, with a very uneven spatial coverage biased towards the northern hemisphere, and Europe in particular Love (2013). Data are freely available from most of these observatories at the INTERMAGNET website (www.intermagnet.org)." So someone can look at that reference for more information or any other the other references like INTERMAGNET.

Since this is an educational article, I think it would be useful to include a figure that defines the magnetic components, in particular the definition of D and I are missing in the text.

Response: Again, I think people interested in the detail can look up that information for themselves in Lowrie (2007) or Reda et al. (2011), for example or online.

Some additional details on clock synchronisation could also be added: how often the Raspberry Pi synchronise its clock to an internet server? Can these setting be optimised for the need of the project (e.g. every 10 s in between the record of samples).Which is the expected drift of the clock when the internet connection is lost? Response: The drift of the clocks is a few seconds per day in a random direction. In a test of 10 systems simultaneously running without a network connection for a week, none varied by more than plus or minus twenty seconds. A Raspberry Pi with a network connection checks a Network Time Protocol (NTP) server every two minutes as part of the background scheduling. Thus, even if the connection is lost for a couple of days, the time-stamp of the retrieved data will not be too far out. However, if the network connection is lost the data are placed into a file with '.bad' in the name to differentiate them from data collected when the Rpi was correctly synchronised. The text has been updated to read: "The Raspberry Pi is not fitted with a real-time clock and therefore it is important that it is connected to the internet in order to obtain and keep the correct time. The clock drift is on the order of several seconds per day, so a Network Time Protocol (NTP) server is polled every two minutes as part of the computer's routine job schedule. An internet connection is also required for the transfer of magnetic field data onto the web."

It think it would be very important to give more information on the schools targeted by this project and the educational notes provided: were they prepared for elementary, high schools, college . . . ? Response: Table 1 has been updated to denote this. It's a mixture of primary, secondary and university – mainly secondary (11-18 year old students).

A deeper discussion on the challenges of magnetometry could be extremely useful: traditionally magnetic observatory are located in isolated area, taking care that a sufficiently large radius around the sensor is preserved as much as possible from man-made noise. Schools clearly cannot meet this need. The focus could be put on the involvement of teachers and students on the project. Response: A good point and we do note the reasons why this is only partially successful. In the UK, teachers are constantly being barraged with new requirements for planning and improving lessons which takes up much of their time. Unless they are very interested in the project then their attention will wander after a few months. It is a trade-off of access to quiet sites within a (non-ideal) school environment and visibility to the students and teacher. While we (as scientists) can advise what to do, if the school cannot achieve the quality we desire, there is not much we can really do. The project is a public outreach one as much as a scientific experiment, so we have to be flexible and fit in with the school's capabilities.

From a different point of view, these installations can be analysed to develop strategies on geophysics data acquisition in environments where high level of man-made noise is expected. Strategies and algorithms to handle with the noise and retrieve geophysical signals could be developed. Response: Very true, I completely agree. I imagine machine learning or clever quality checking algorithms (e.g. using wavelets) could be used to discriminate between man-made or natural signals. Likewise cross-correlation with local scientific observatories would be another good check of geophysical versus manmade signals. This is an entire project in itself and beyond the scope of this article though!

Add the definition of the acronyms GDAS: Geomagnetic Data Acquisition System. Response: Added in the acronym

Add a reference to IGRF 12 generation. Response: Reference to Thebault et al (2015) added

Figure 1: add a) and b) to make more explicit what stated in the article text. Other elements (thermometer, ADC...) could also be indicated more explicitly on the figure for instance with labels and arrows. Response: We've updated the caption text with much more detail. I'm not sure adding more text to the photo will work.

Figure 3: add right vertical axis to show the unscaled deltaT. Response: As suggested by Reviewer 1 too, we have changed the graph and moved the axis to the right.

Figure 5: choose a different colour couple than orange/red that are hardly distinguishable on the figure. The video of the storm is very informative and could be added to the article as a supplement, in order to guarantee its availability over long time. Response: There's a wide variety of magnetic field changes over the course of the storm ($\pm$1000 nT) and I experimented with different colour scale limits. This version captures the essence of the electrojet moving south and north over time in the X component. I can use a different snapshot or place the other versions online if required?

Interactive comment on Geosci. Commun. Discuss., https://doi.org/10.5194/gc-2018-10, 2018.