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Space and Atmospheric Physics

First analysis of magnetospheric space weather data from the RadCube CubeSat

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1 Motivation

- RadCube: a technology demonstration CubeSat for space weather monitoring
- MAGIC: vector magnetometer which uses magnetoresitive sensors
- RadCube successfully launched to a polar low-Earth orbit on 17 August 2021
- Severe space weather is part of the UK Government National Risk Register
- Most recognisable effects of space weather are aurorae
- Geomagnetic storms can damage satellites, cause power blackouts and disrupt communications by inducing currents
- CubeSats offer low-cost opportunities for observation and monitoring of space weather
- This project aims to analyse the first data from MAGIC and demonstrate that the instrument is viable

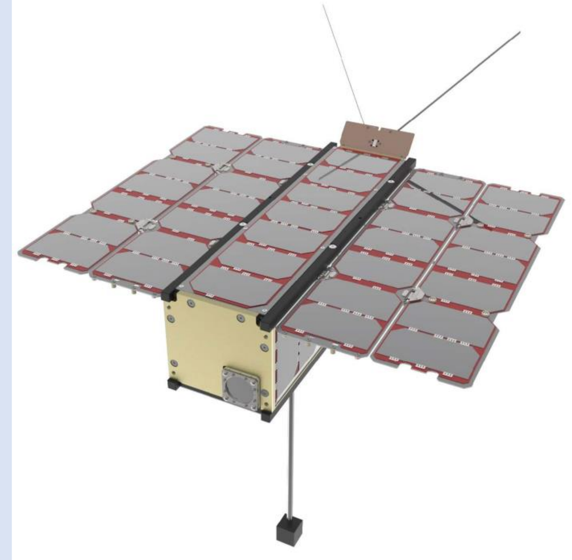

Fig. 1: Illustration of RadCube [1]

2 Dipole moment

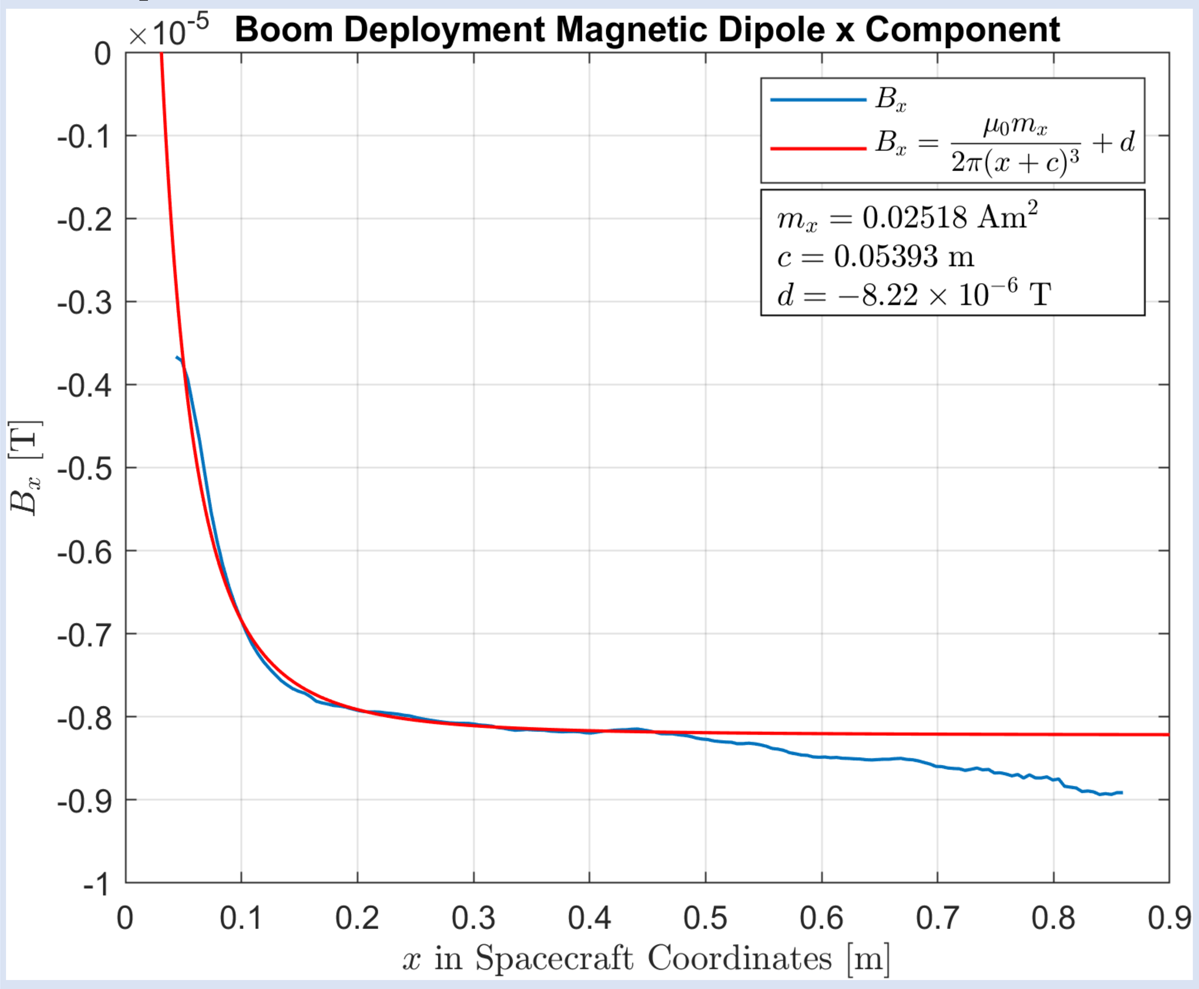

Fig. 2: Field variation over boom deployment

$$B_x = \frac{\mu_0 m_x}{2\pi(x+c)^3} + d$$

Spacecraft are demagnetised before lift-off, but may be remagnetised in handling and launch. The total dipole moment before launch was measured as $6.22\ mAm^2$ [2], while during analysis the x component of this moment appeared to now be $25.18\ mAm^2$.

3 Boom angle

The angle, θ, of the boom compared to the x direction can be found from the ratio of the predicted to measured fields. We hypothesise that θ will vary linearly with deployment distance if the boom is bending. At the end of deployment measurements indicate an angle of $\sim 22°$.

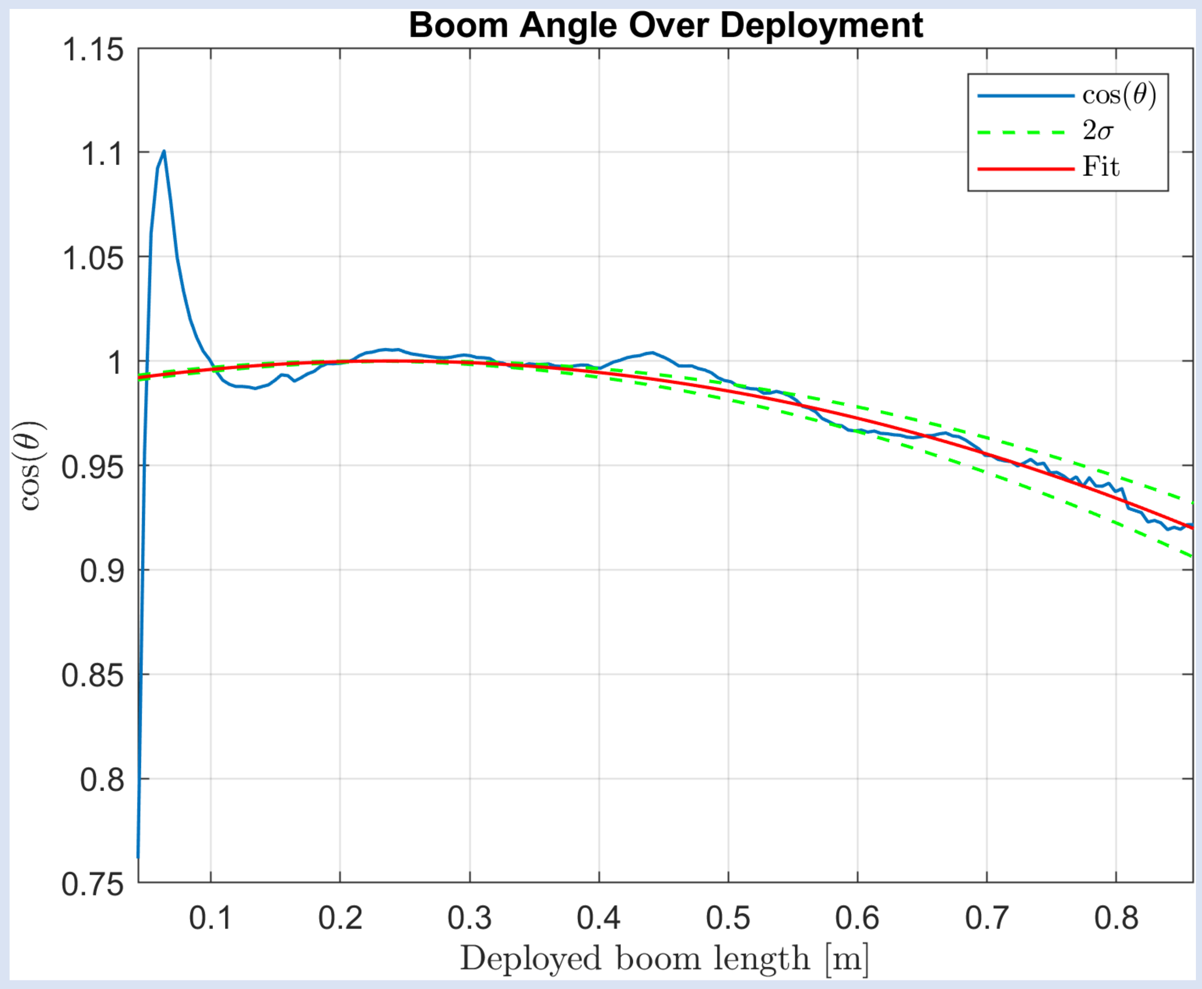

Fig. 3 (above): Predicted boom angle with deployment distance.

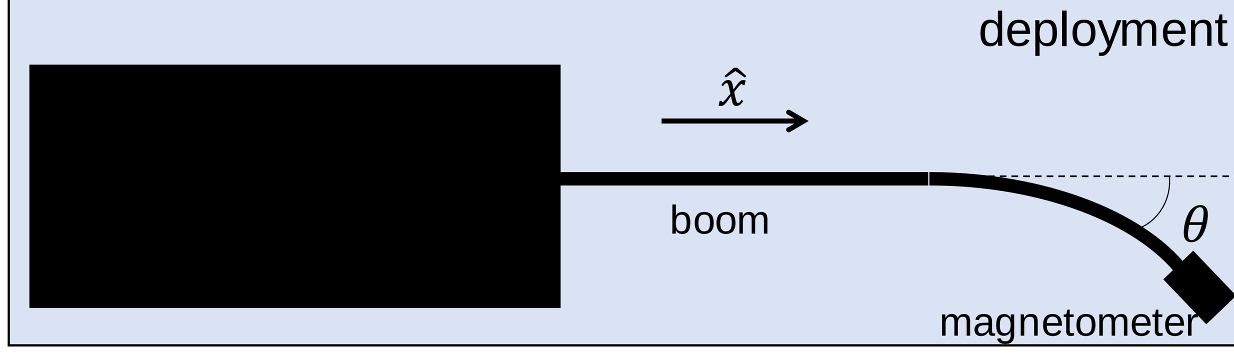

Fig. 4 (left): Diagram of boom bending

4 Attitude control

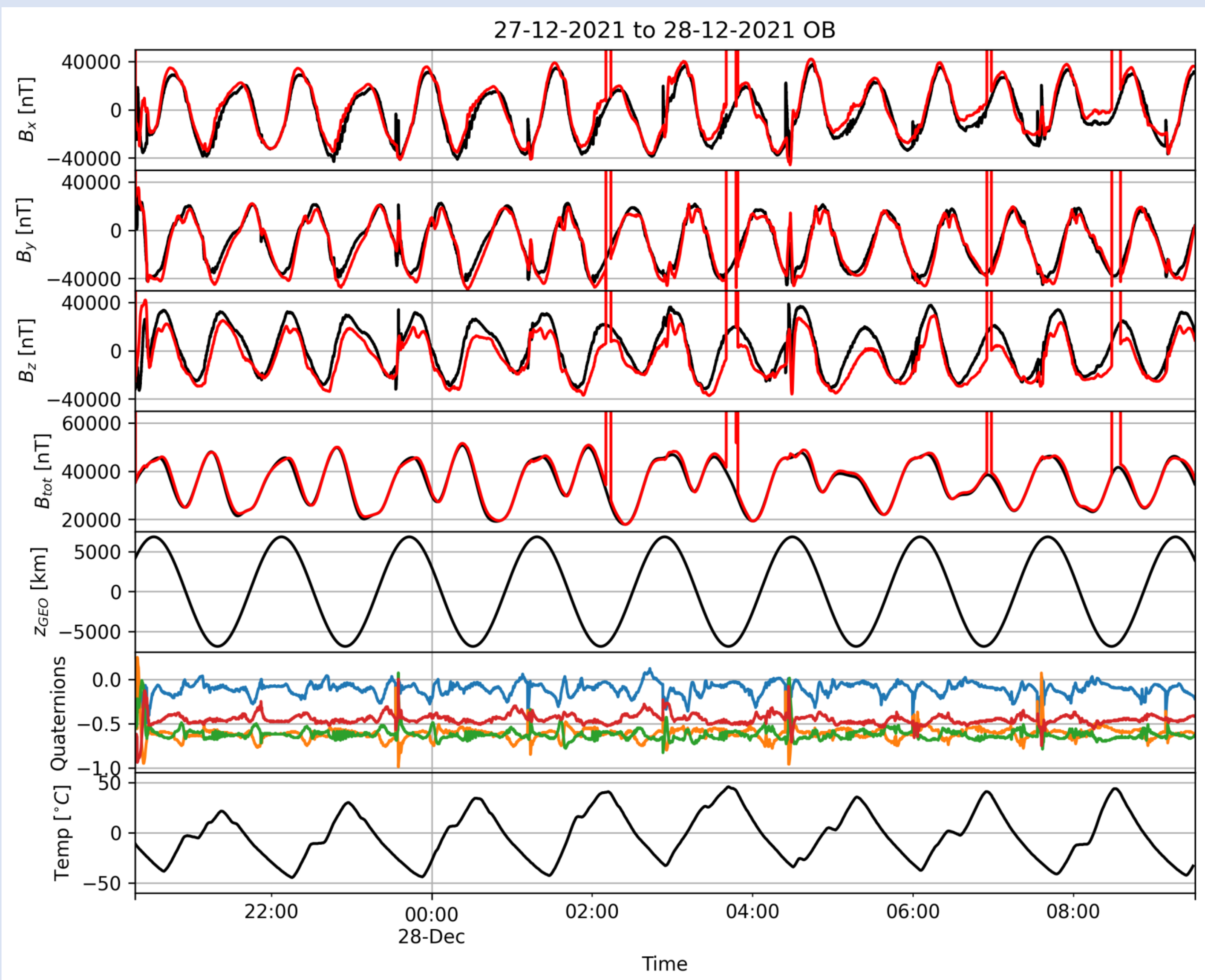

Fig. 5: Magnetic field components and total, z in geographic coordinates, quaternions and outboard temperature over multiple orbits

- International Geomagnetic Reference Field (IGRF): model of the Earth's main field
- Quaternions: describe rotation in spacecraft frame determined using the relative position of stars from a camera
- Rapid variation in quaternions near the North Pole could reflect the transition from night- to day-side of the Earth and the camera becoming saturated
- Field variation suggests attitude (orientation) of spacecraft changing

5 Changing angle

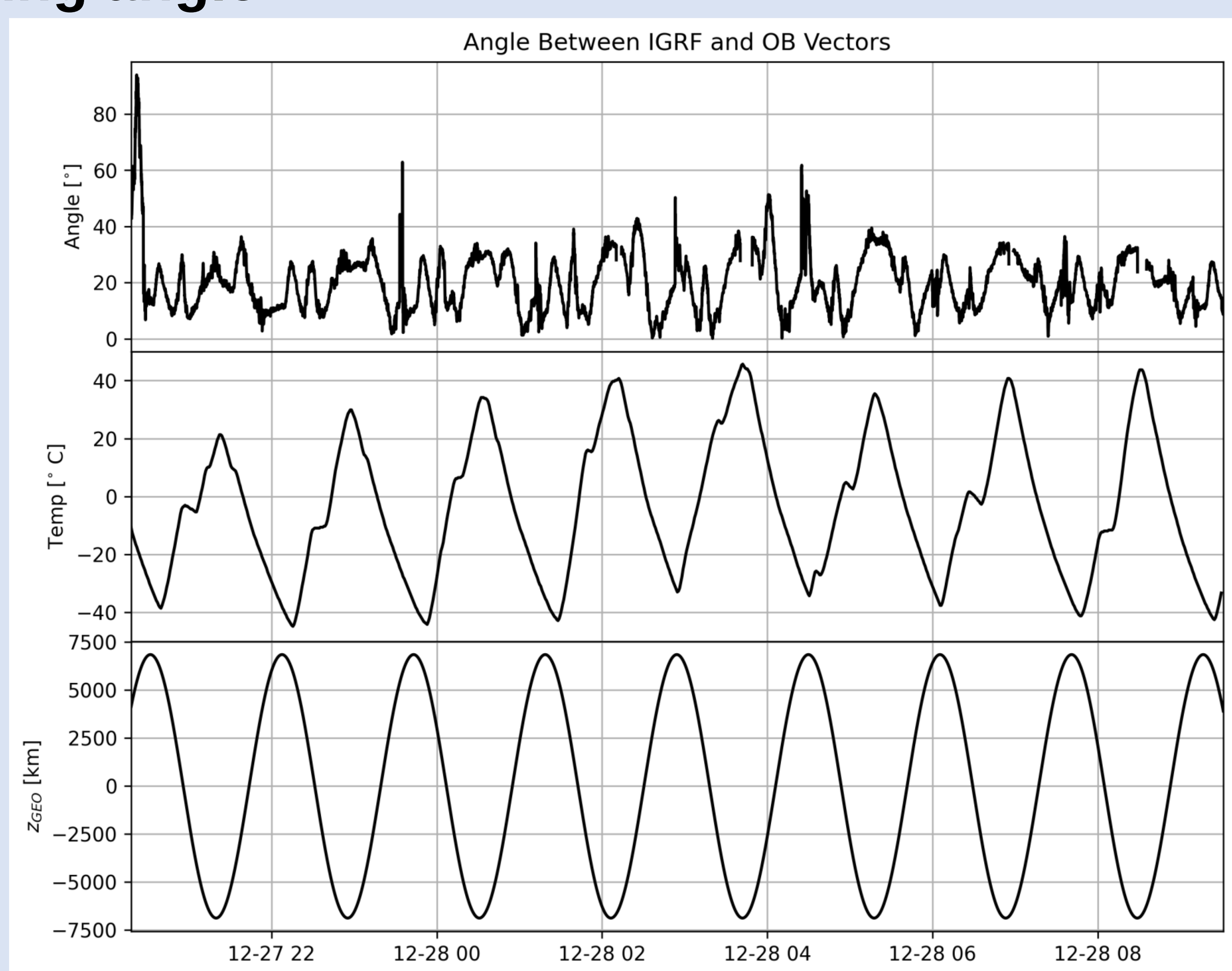

Fig. 6: Angle between predicted and measured field vectors with temperature and z in geographic coordinates.

The boom is made from copper and folds itself from a wound up flat strip to a cylindrical shape as it deploys [3]. Temperature is highly varying and could be causing distortion of the boom and therefore strain on the cable from the magnetometer. This suggests the angle between predicted and measured field may vary over the orbit with temperature due to changes in the boom.

6 Anomalies

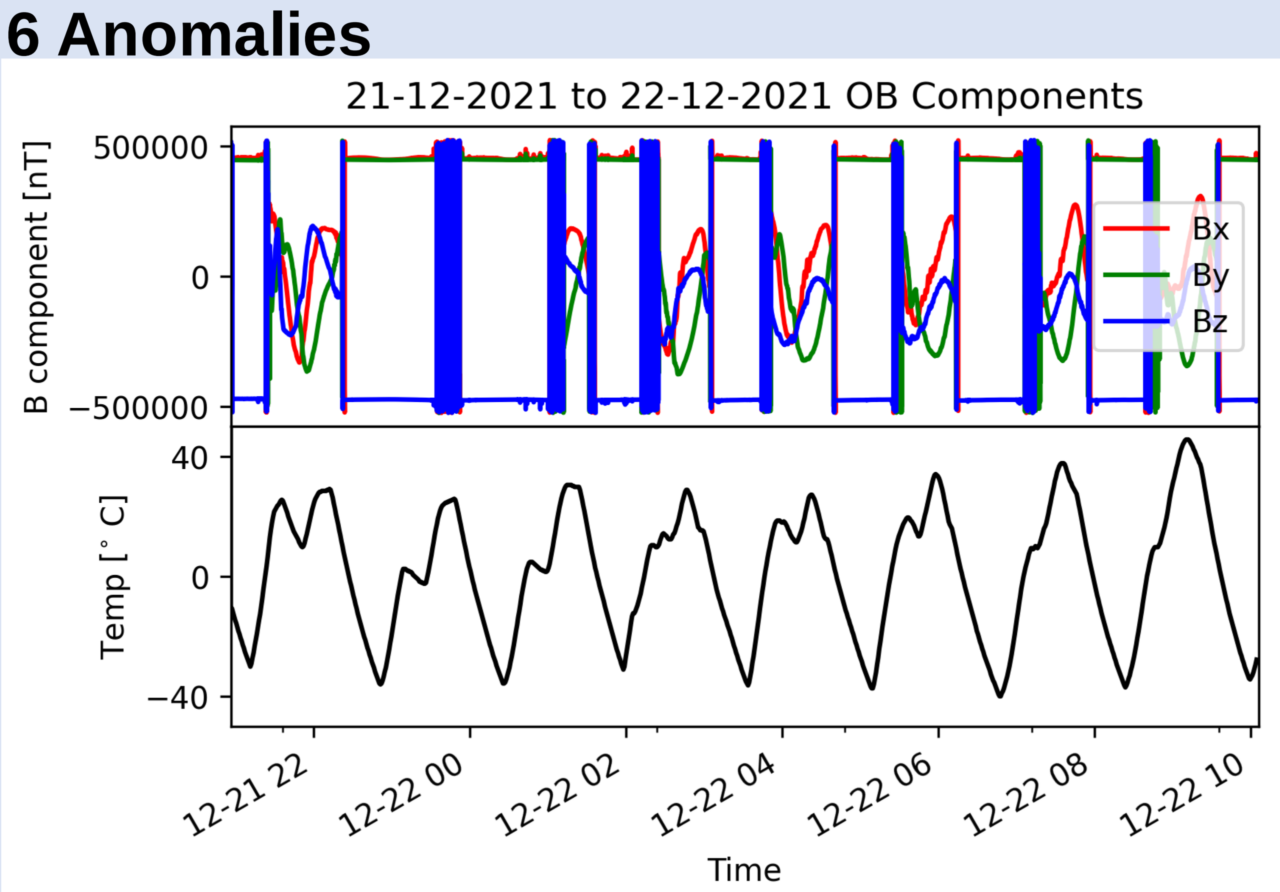

Fig. 7: An example of a period of data with many anomalies relating to temperature

Anomalous data is seen at both hot and cold temperatures, making up ~25% of all data collected. This could be due to boom distortion and the cable to the outboard magnetometer experiencing strain.

7 Conclusions + Future work

- RadCube's boom may have distortion which varies with temperature
- Magnetic field measurements experience differences to the predicted values and vary with temperature
- RadCube may have become re-magnetised since pre-launch preparations
- Anomalies are seen in the outboard magnetometer data which correspond to both hot and cold temperature extremes where the effect on the boom needs to be investigated further
- If proven to operate well, magnetometers like MAGIC would be suitable for use on other CubeSats for space weather monitoring
- This could give us more warning of incoming space weather events and allow for mitigation of the effects in future

[1] https://www.esa.int/ESA_Multimedia/Images/2017/11/RadCube [Accessed: 17 Feb 2022]
[2] RADCUBE CubeSat magnetic moment test report, ESA, 2021.
[3] RadMag Boom System EBB functional test report, Astronika, 2019.