Response to comments on 'First In Situ Measurements of the Prototype Tesseract Fluxgate Magnetometer on the ACES-II Low Sounding Rocket' by reviewer #2 on February 15th 2024

We thank the referee for the constructive comments which we have incorporated into the manuscript. The reviewer raised important issues about the comparison between the heritage science ring core magnetometer and the Tesseract magnetometer as well as other corrections, which we address below. Referee comments are in plain text our responses in italics and any content added to or changed in the manuscript are in "quoted italics"

The authors present the design of a prototype fluxgate magnetometer based on its pre-flight characteristics and an evaluation of its performance during a short flight aboard sounding rocket ACES-II. The paper is well written, understandable and an appropriate number of citations is included. The ability of the new magnetometer to perform geophysical magnetic field measurements in the space environment is clearly demonstrated.

General comments:

1. The primary (science) magnetometer, which is the main reference for the in-flight comparison, should be briefly discussed and relevant literature should be cited.

We agree with the reviewer's assessment that a discussion of the science magnetometer should be included. The ring core sensor used in this paper is based a heritage design for a spaceborne fluxgate magnetometer first developed by Acuña et al., 1978 which used 1" diameter S1000 ringcores from Infinetics. The design is nearly identical to the sensors described by Miles et al., 2013 and Wallis et al., 2015.

The following context about the design of the heritage ring core science magnetometer, along with the relevant citations, have been added to Line 143 where the ringcore sensor is introduced, Line 143 now reads: "The ring core sensor's design has its heritage in the NASA MAGSAT (Acuña et al., 1978) which uses two 1" diameter ring cores which are each wound with two orthogonal solenoidal coils, providing two measurements in the plane of each ring. The design is nearly identical to the sensors described by Miles et al., 2013 and Wallis et al., 2015."

And in Line 260 the text now reads: "The same process described above was used to de-spin and calibrate the heritage ring core geometry sensor, which uses the same design described in Miles et al., 2013."

2. The pre-flight calibration of the three Euler angles of the rotation matrix and its accuracy should be discussed, as it is assumed to be the main cause of the difference between the prototype and the primary (science) magnetometer.

The reviewer highlights the importance of the rotation in the calibration, especially since it is suspected that it may be a possible contributor to uncertainty of our calibration. We agree that this is important information to include, and the following context has been added to clarify on line 81:

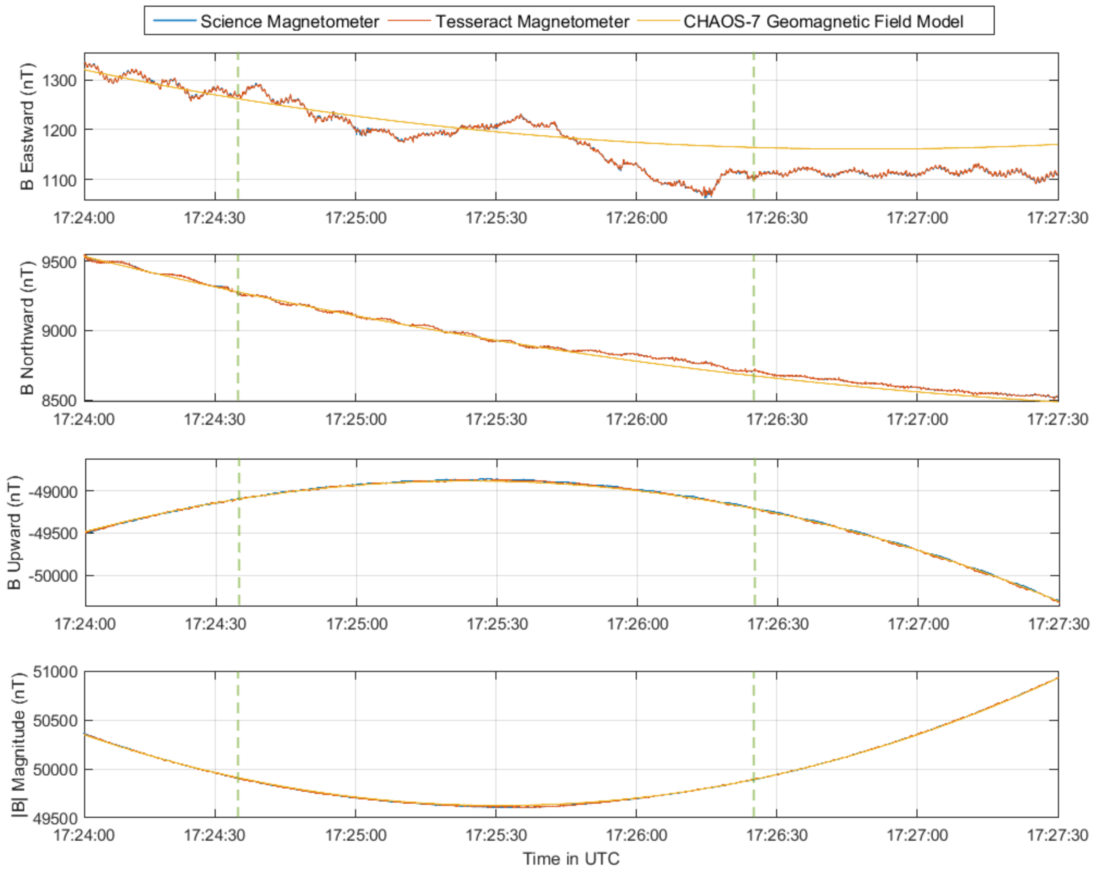
"R is a 3x3 rotation matrix consisting of three Euler angles that describe a rotation from the sensor frame into the frame of the rocket ACS. Uncertainty in the measurement of the Euler angles is dependent ability to accurately align the ACS with the coil system during calibration. We estimate that this alignment is good for angles larger than 0.05 degrees."

3. It is not clear for how long the magnetometer was actively measuring.

We agree with the reviewer that the length of time that the instrument was measuring should be stated explicitly in the body text. We have added this information on line 240 which now reads: "The Tesseract Magnetometer took measurements of the ambient magnetic field over the course of the flight from launch, until 17:28:50 UTC when connection to the rocket was lost upon reentry."

4. It is said that a quiet period between 17:24:00 and 17:24:30 was used for the in-flight calibration, but not the entire 30 seconds are shown in Figure 6. What do the data look like before the "quiet period"?

The reviewer points out that Figure 6 does not show the entire quiet period and cuts off the plot too early. We thank the reviewer for bringing this error to our attention. The new Figure 6 in the revised manuscript plots the magnetic field starting at 17:24:00 UTC and shows the complete quiet area where the instrument was calibrated from beginning to end. The new Figure 6 is shown below and has also been incorporated into the revised version of the manuscript:

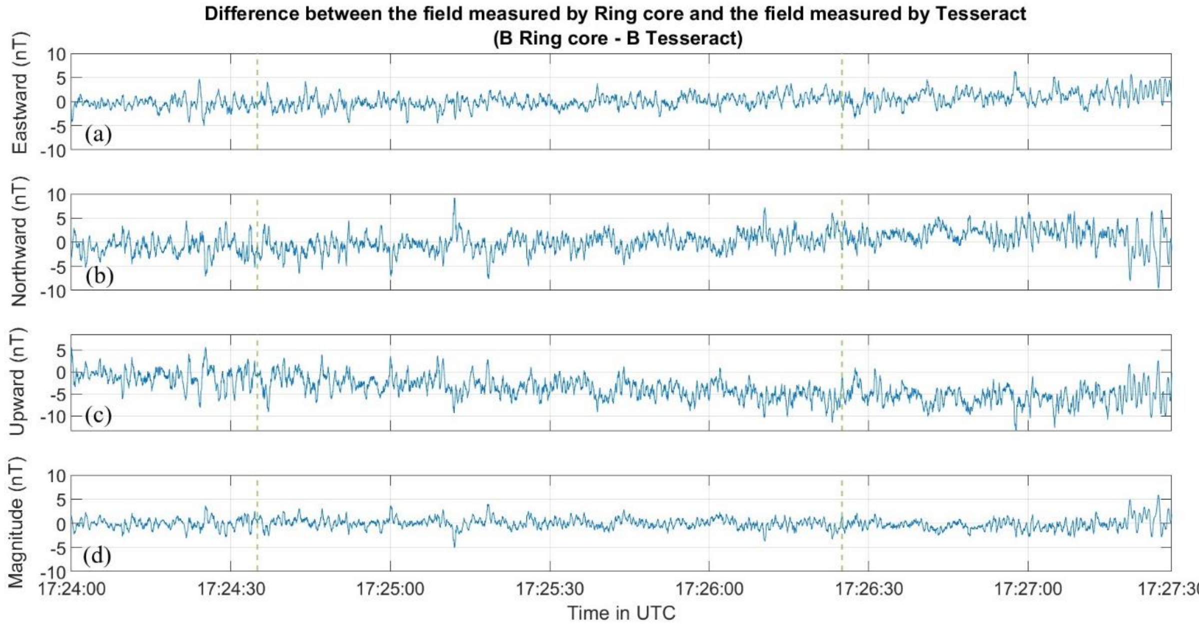


5. The measured and the modelled field obviously agree to within 25 nT RMS outside of the scientifically interesting period. What is the standard deviation of the difference within the mentioned crossing of the active auroral arc? The plots in Figure 6 do not indicate a big difference between the two phases.

We agree with the reviewer that including the RMS deviation between the measured and model field in the active auroral region is a figure that is useful to include for comparison and for completeness. We have added this information in a sentence on line 290: "In the region associated with the auroral arc the measured field and model field agree within 37 nT RMS in each axis."

6. The performance discussion would benefit from plotting the difference between the prototype and science magnetometer to deepen the demonstration of the good match. The mentioned alignment mismatch between the two sensors could be calibrated based on the flight data which would further reduce the reported RMS deviation.

We agree with the reviewer's assessment that plotting the difference between the field measured by Tesseract and the field measured by the Ring core science magnetometer would be *illustrative in demonstrating the agreement between the sensors and help to reinforce the main result of the paper: that the Tesseract magnetometer performed as expected as a functioning magnetometer over the course of the flight. We have added a new Figure 7 which plots the difference between the sensor's measurements in each axis on line 286:*



We have also added a figure caption on line 287 which reads: "Figure 7: The difference between the magnetic field measured by the heritage ring core science magnetometer and the magnetic field measured by the Tesseract is plotted for the Eastward (a) Northward (b) and Upward (c) directions along with the scalar (d) field. The region where the rocket payload is expected to have crossed the auroral arc is bounded by dashed green lines."

Changes to the numbering of the subsequent figures have also been made accordingly in the revised manuscript.

7. A comparison of the filtered data from both magnetometers would show that also the actual science event was measured correctly by the prototype sensor.

We agree with the reviewer that a plot showing the agreement of the magnetic field measured by Tesseract and the magnetic field measured by the science magnetometer in the science region would demonstrate that the science region was measured correctly by the prototype. A Figure 7 has been added, which shows the difference between the field measured by the Tesseract and the field measured by the ring core. The region of data bounded by the green dashed lines shows the difference of the fields measured by the two sensors in during the science event.

A sentence is also added which quantifies the agreement between the two sensors in the science event region:

Line 283 now reads: "The Tesseract and Ring core measured the same field in the region of auroral activity (bounded by green dashed lines in Figure) to within 5.53 nT RMS in all three axes."

Specific comments:

The following changes have been made as suggested in the revised version of the text:

Line 35: The instrumental noise of the MMS sensors in low range is less than 8 pT/sqrt(Hz).

Line 146: … to measure thermal electrons.

Line 231: … detailed science analysis of it will …