ASTRO PI

MISSION SPACE LAB

Mission Space Lab Phase 4 Report

Team Name: AstroBakers (*Bakers)

Chosen Theme: Life in Space

Organisation Name: Wassenaar Coders

Country: The Netherlands

Introduction

The primary objective of our investigation was to create a map of Earth's magnetic field following ISS trajectory using the magnetometer sensor of the Sense HAT and examine how closely our data will match those of the World Magnetic Model 2020 Total Intensity Map [1]. Our expectation was to observe highest magnetic intensity when the ISS was closer to Earth's poles, and lowest intensity when the ISS was moving around the equator.

Our secondary objective was to acquire temperature, humidity, barometric pressure, acceleration, and gyroscope data to analyze the environmental conditions inside the ISS. As space enthusiasts, getting a better understanding of astronauts' lives in the ISS is a fascinating opportunity. Based on temperature and humidity measurements, we would also try to understand astronauts' activity. For example, rises on these measurements could be an indication of increased activity. Finally, we expected a significant peak in the accelerometer data if the ISS was given an orbital acceleration boost to keep it in the desired orbit.

Method

When planning our experiment, we wanted to measure as many variables as possible to acquire the most complete picture of the astronauts' life in space. Therefore, we used all the sensors available (except from the camera to respect the astronauts' privacy) to collect as much data as possible. However, we minimised the flight code by taking only measurements, so as to reduce the chances of errors and improve the code performance. The collected data was saved as CSV files.

The received data was parsed (e.g. making necessary conversions) and analysed using programs written specifically for this purpose, producing the necessary maps and graphs. We created a map to visualize the measured magnetic field versus the ISS trajectory and contour maps via interpolation. For the secondary mission, we created temperature, humidity, pressure and acceleration graphs against time and made use of rolling averages to gain a better understanding of our results.

Most of the graphs were created using Python, and some of them with R. The code of all the programs can be found at our GitHub page [2].

Results

Our program run in the 23rd of April from about 18:46 to 21:41. The ISS trajectory in this time interval is depicted in Figure 2.

By combining the measured magnetic field versus the coordinates we created the contour map of Figure 1. As we can

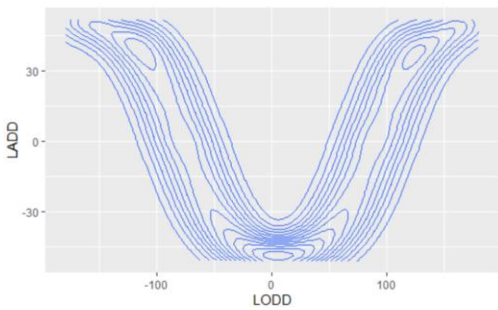

Figure 1: A contour diagram of magnetic measurements

see, the results match our expectations to some extent showing stronger magnetic field near the two poles. However, although our flight program was taking measurements every second, given that data collected in a limited ISS trajectory, it was still not enough to get a complete picture.

In Figure 2, along with the ISS trajectory, the actual magnetic field measurements using a colour coding are presented. As we can see, the measurements follow the expected trend in general. However, we observe that in the South America/Atlantic region the magnetic measurements are significantly stronger than in the Indian ocean.

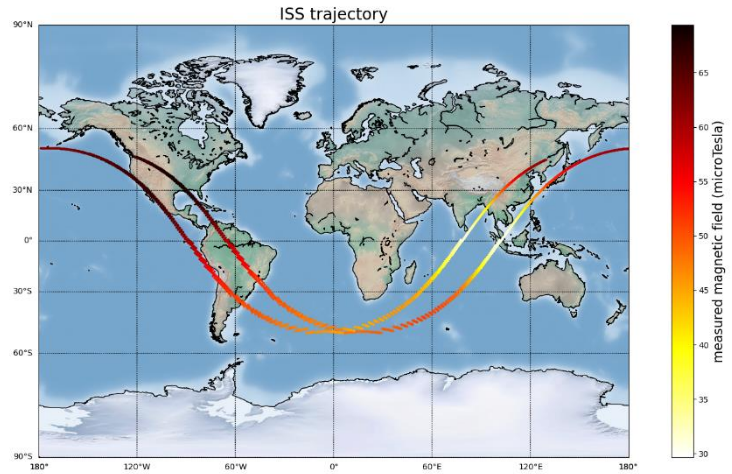

Figure 2: Actual Measured Magnetic Field vs ISS Trajectory

Regarding the humidity measurements (Figure 3), there are two striking observations. Firstly, there are a lot of fluctuations in short intervals throughout the runtime of our AstroPi. Secondly, the rolling average seems to significantly decrease from 19:15 to 20:00 before settling at ~31% for the rest of the runtime of our AstroPi. Thus, our rolling average suggests that after 19:15 the activity of the astronauts inside the ISS decreased; we assume that it could be dinner time, followed by some rest.

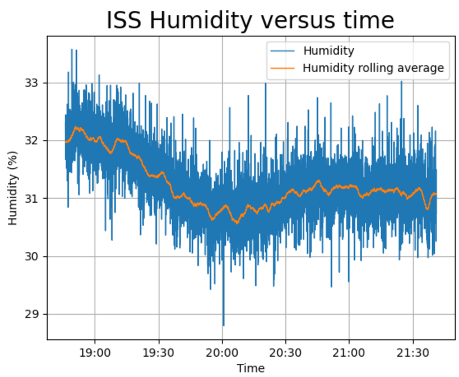

Figure 3: Humidity in ISS versus Time

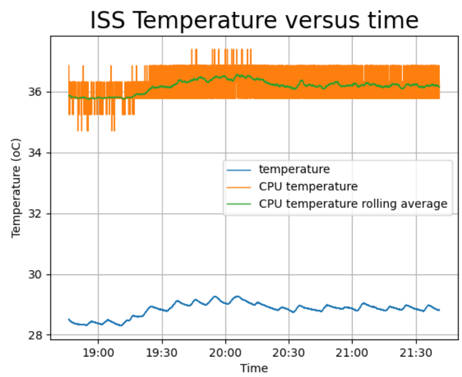

Figure 4: Temperature in ISS versus Time

Moreover, we notice that temperature in the ISS stayed quite stable at around 28-29 ^{o}C, which is much higher than expected. After looking at the CPU temperature rolling average, we observed that its fluctuation is almost identical to the ones of the environment temperature readings. This shows the significant impact of the CPU to environmental temperature measurements. Hence, an analysis can't be made for astronaut activity using temperature data. In addition, after comparing with some similar measurements on Earth, we believe that the actual temperature inside the ISS should be 7°C to 8°C lower than the one recorded by the Sense HAT.

Finally, pressure and acceleration measurements did not present any remarkable fluctuations. From that we understand that neither an O_2 re-pressurisation in the ISS nor an orbital acceleration boost took place. The last is confirmed by comparing the date our code run with the data in [5].

Conclusions

The biggest finding of our investigations was the difference in the magnetic measurements between the South Atlantic and Indian Ocean regions. After some research, we understood that this is due to the South Atlantic Anomaly (SAA) [3] and its effect to the Van Allen radiation belt. The Van Allen radiation belt is an area of energetic charged particles, which extends from an altitude of 640 to 58,000 km from the Earth [4]. In the South Atlantic region the magnetic field of the Earth is weaker [1],[3], causing the Van Allen radiation belt to dip down to about 200 km at that region [4]. Since the ISS orbits at a height of 400 km, at the South Atlantic region it passes through the Van Allen radiation belt, experiencing an increase in magnetic field. The effect of the SAA is depicted in Figure 2, where it is shown that ISS experiences a stronger magnetic field than expected in the South Atlantic region as it passes through the Van Allen radiation belt. On the contrary, the SAA is not noticeable in Figure 1, as the interpolation used to produce the contours "cleaned" the anomaly.

From the above we understand that aerospace engineers when designing satellites that are expected to operate inside the Van Allen zone need to seriously consider its effects to their scientific measurements and operational activities.

References

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[3] NASA, "NASA Researchers Track Slowly Splitting "Dent" in Earth's Magnetic Field", 2020 [Online]. Available: https://www.nasa.gov/feature/nasa-researchers-track-slowly-splitting-dent-in-earth-s-magnetic-field

[4] Wikipedia, "Van Allen radiation belt", 2021 [Online]. Available: https://en.wikipedia.org/wiki/Van_Allen_radiation_belt

[5] Heavens Above, "Height of the ISS", n.d. [Online]. Available: https://www.heavens-above.com/IssHeight.aspx