Mission Space Lab Phase 4 report

Team name: Magneto

Chosen theme: Life on Earth

Organisation name: American School of The Hague

Country: The Netherlands

1. Introduction

The purpose of this study was to investigate the potential factors influencing the Earth's magnetic field. Building upon the work of a previous Mission Space Lab research group, LAZOS22, who explored the impact of solar exposure on the Earth's magnetic field but did not establish a definitive link, we sought to examine whether it was solar activity or the geographical coordinates of longitude and latitude that affected the Earth's magnetic field.

The Earth's magnetism is governed by complex geophysical processes, including the movement of molten iron within the outer core and its interaction with the planet's rotation. Solar events, such as solar flares and coronal mass ejections, can perturb the Earth's magnetic field, leading to variations in magnetic field and the occurrence of magnetic storms and auroras.

Our research focuses on investigating the relationship between longitude, latitude, and the Earth's magnetism. We hypothesize that the magnetic field is influenced by latitude, particularly in proximity to the poles, where we anticipate higher magnetic field levels. Through careful analysis of the change in magnetic strength around the Earth, we aim to explain the intricate interplay between geomagnetic processes, solar influences, and the Earth's magnetic field.

2. Method

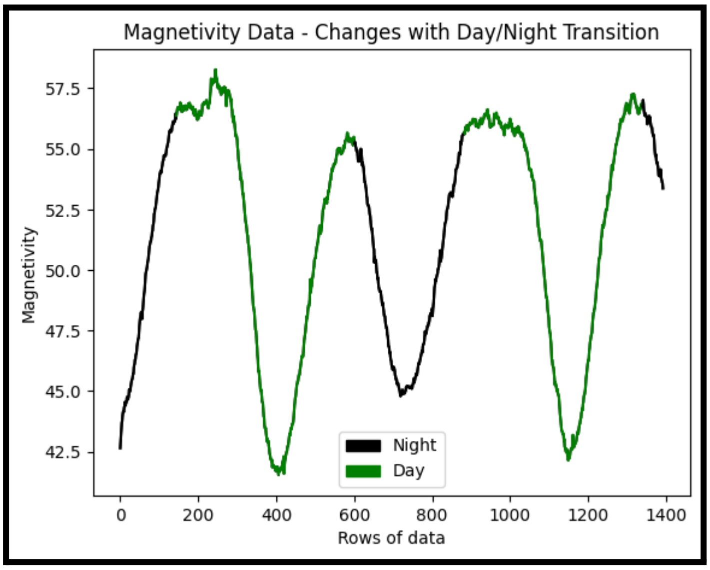
In our investigation, we collected multiple data points to assess the magnetic field. These data points included readings on the x, y, and z-axis, latitude and longitude, elevation, time of measurement, day/night classification, and photographs. Readings were taken at 7-second intervals over a duration of approximately 175 minutes, resulting in a dataset comprising approximately 1400 data points. To analyze the data, we used Pandas in Python. The link to the notebook is here. We conducted four main investigations:

1. We plotted the magnetic strength and whether it was Day or Night to see if there was any relationship between the data.
2. We plotted the ISS path on a world map and incorporated color-coded magnetic strength along the trajectory to investigate a potential correlation.
3. We found the two points where the ISS path intersected, and compared the magnetic strength between them to identify discrepancies
4. We plotted how the latitude affected the magnetic field and created a model for the behavior.

To calculate the magnetic strength, we used the vector sum formula B = $\sqrt{Bx^2 + By^2 + Bz^2}$, where Bx means magnetic strength on the x-axis, By is magnetic strength on the y-axis, and Bz is magnetic strength on the z-axis.

3. Experiment results

Day/Night Cycle



<u>Fig 1: Magnetic Field Strength in Day and Night: Exploring Patterns and Transition Phenomena</u>

This graph depicts the variation in magnetic field strength throughout the day and night, with data points categorized as daylight (green) or nighttime (black). While no consistent pattern is observed linking magnetic field levels during day and night, a distinctive parabolic trend emerges during transition periods, characterized by an initial decrease followed by an increase in magnetic field strength. This phenomenon can be attributed to reduced interaction with solar winds, changes in ionospheric properties, and natural geomagnetic variations.

Latitude and Longitude

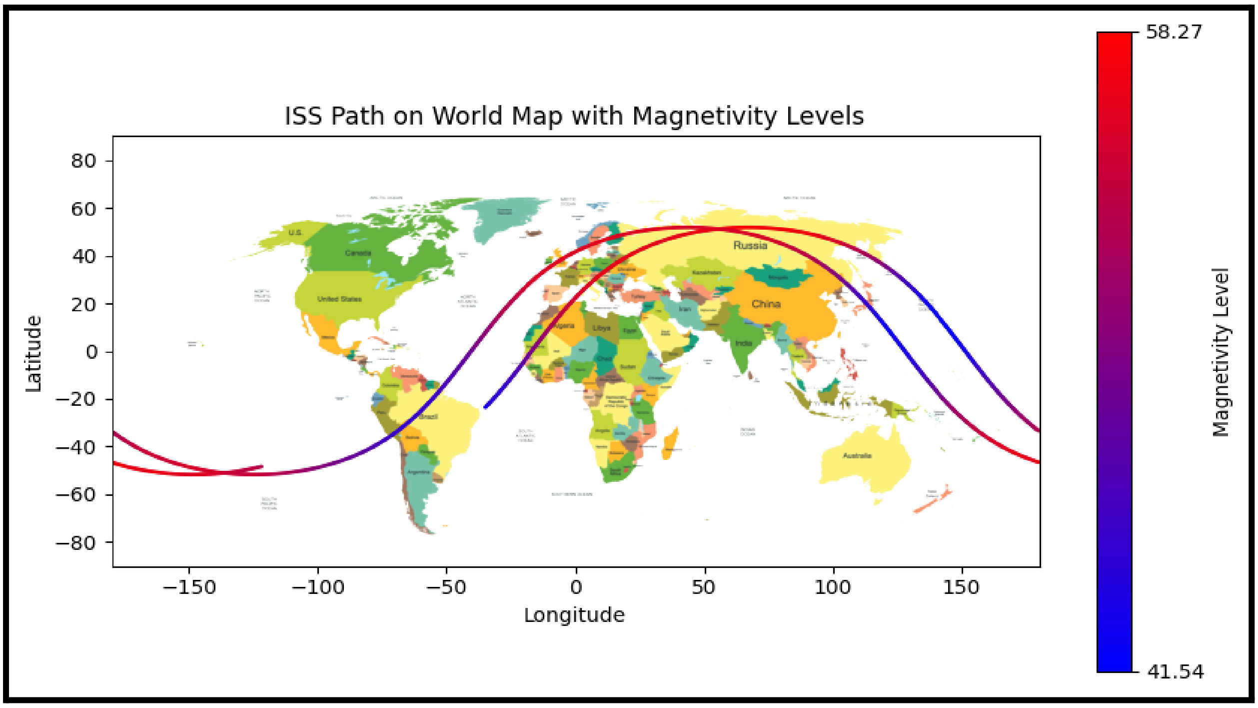
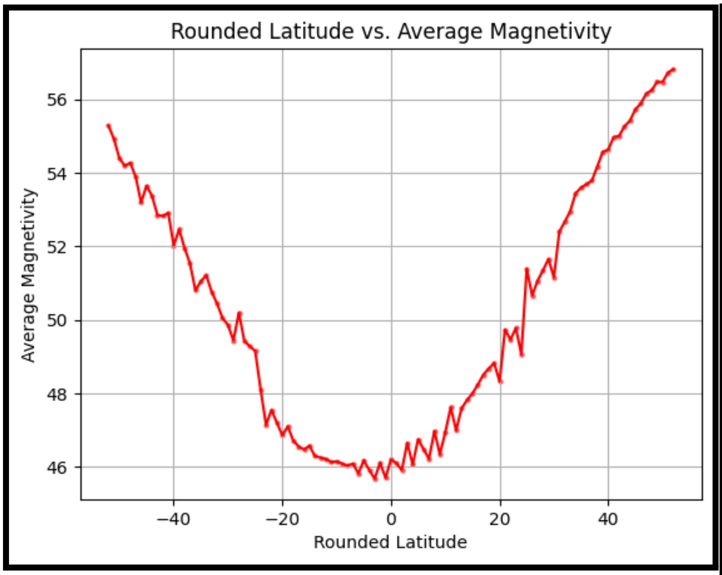


Fig 2: Magnetic Field Strength plotted on ISS Path



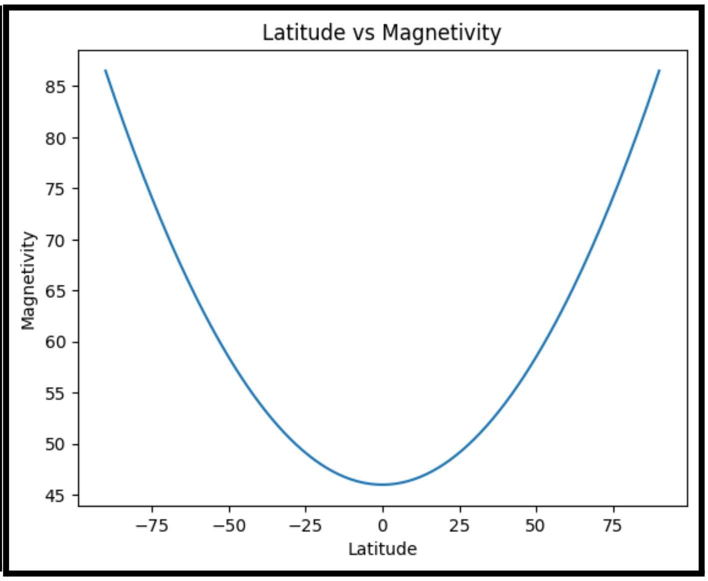


Fig 3: How latitude affects magnetic strength

Fig 4: Graph of f(x) provided below

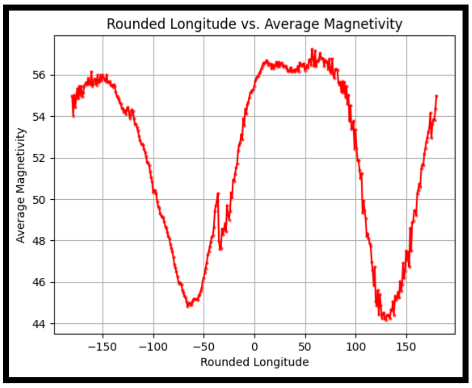


Fig 5: How longitude affects magnetic strength

Fig 2 depicts the magnetic strength along the ISS path, while Fig 3 explores the latitude-magnetic field relationship. The magnetic strength is significantly higher near the poles due to magnetic field convergence. Longitudinally, the magnetic strength shows no clear relationship. However, examining latitude reveals a parabolic relationship. Rounding latitudes and calculating the mean magnetic field strength yields the quadratic model:

$$f(x) = 0.005x^2 + 46.$$

The 0.00coefficient 5 represents the function's compression, and the estimated minimum magnetic strength is approximately forty six.

Comparing magnetic field of two locations

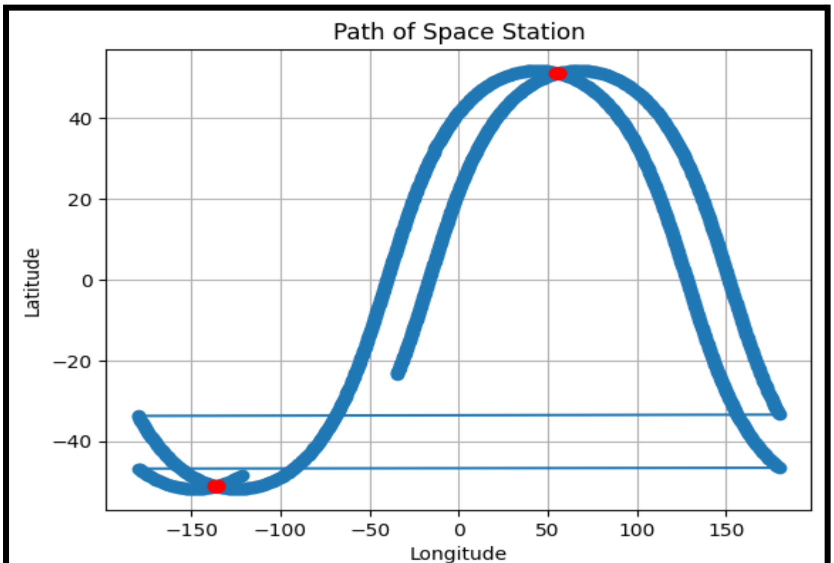


Fig 6: Stable Magnetic Strength at Overlapping Locations: Evidence of Latitude's Impact on Earth's Magnetic Field

Fig 6 shows overlapping locations where the ISS revisits during two revolutions around Earth. Rows 230 and 1000 correspond to latitude 51.018 and longitude 54.4214, while rows 600 and 1370 correspond to latitude -51.0975 and longitude -136.687. Comparing magnetic strength readings within each set reveals small differences. In the first set, values of approximately 57.07 and 56.23 differ by 0.84 units (1.5%). The second set has readings of around 55.23 and 55.22, differing by 0.01 units (less than 0.02%). These findings suggest stable magnetic strength levels over time at specific latitudes, supporting the influence of latitude on Earth's magnetic field.

4. Learnings

As a two-person team with different skill levels, task allocation posed no challenges. Both team members contributed significantly to the project, each excelling in their respective areas of expertise. One team member focused on coding and played a key role in program development for data retrieval, while the other demonstrated exceptional skills in mathematical analysis and data interpretation. Through our collaborative efforts, we successfully produced our final report.

Despite our limited experience as young scientists (9th grade), we took a calculated risk in exploring magnetic field strength and achieved rewarding results. However, we encountered challenges in understanding the puzzling relationship within our day/night data, which could be further clarified with additional data. Nonetheless, this project presented invaluable learning opportunities, encompassing the entire experimental process from ideation and program development to result analysis and the composition of a comprehensive final report. Moving forward, we intend to uphold a similar approach in our future endeavors.

Our experiment choice was unique and demanding but not excessively abstract. We efficiently developed the program with minimal debugging required. The only aspect that felt rushed was the analysis due to the timing of data acquisition.

In conclusion, our collaborative efforts as a dedicated two-person team, working in our spare time outside of school, led to a rewarding learning experience despite the encountered challenges.

5. Conclusion

Our research supports the notion that the magnetic strength is higher near the poles and lower closer to the equator, supported by compelling graphs illustrating global magnetic field variations and the parabolic relationship with latitude. However, our methodology falls short of providing definitive answers. While we recognize the subtle influence of solar wind and sunlight on Earth's magnetic field, our data alone cannot establish a clear cause-and-effect relationship. The primary factors influencing the magnetic field—whether it is the sun, location, or a combination—remain open for further exploration. We encourage future researchers to embrace this challenge and consider investigating the impact of atmospheric conditions on magnetic field fluctuations. Nonetheless, our work contributes to advancing knowledge in the field, building upon the foundation laid by our predecessors. We hope our report inspires further investigation into the magnetic field. As we conclude, a compelling question emerges: How can we harness the knowledge of these magnetic field fluctuations to develop innovative technologies for navigation and geomagnetic studies?