Mission Space Lab Phase 4 report outline

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Chosen theme: Life on Earth

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1. Introduction

What environmental factors does quality of life depend on? We wanted to explore the possibility of doing a research about this topic using the ISS as our laboratory. There are many environmental factors that can influence the quality of life of living beings, including humans: the presence of water, the climate of the area, air quality, among others, may be the most important. With the possibilities that this mission brings us, our main goal was to make a comparative analysis of the quality of life in urban areas about which the ISS could give us the following information: the **albedo**, or fraction of the radiation reflected by the earth's surface, relevant to ambient temperature; the **NDVI** (Normalized Difference Vegetation Index), is a simple effective index for quantifying green vegetation. It provides a measure of the state of vegetation healthy, based on how plants reflect certain wavelengths of light. And the third parameter we can measure is the **magnetic field** of the Earth, which is a shield against dangerous radiation coming from space.

2. Method

We built a python code (*main.py*) to measure the magnetic field every 12 seconds using the magnetometer of the IMU sensor, and also to take pictures in the visible range, but only during the daytime hours in order to save storage space. A total of 549 pictures (2592 x 1944 resolution) were taken during the three hours of experiment. The date and location (longitude, latitude and altitude) of the ISS were also taken in each measurement.

To calculate the albedo we created another code (*my_albedo.py*) in which each image is processed by transforming it into a set of red (clouds), green (land) and blue (sea) pixels. Then the percentage of pixels of each type is calculated, and each percentage is multiplied by its corresponding albedo value: clouds = 0.70; land =

0.25; sea = 0.10[1]. Then, we obtain the albedo value of each picture with a weighted media of all the pixels, according to this formula:

$$albedo = \%clouds \cdot 0.70 \ + \ \%land \cdot 0.25 \ + \ \%sea \cdot 0.10$$

The code also has cropped each image to avoid the ship window.

We have used NDVI data from the Sentinel-2 satellite for those significative areas where the ISS flew over in its trajectory, using the EO Browser portal[2].

Finally, all data have been integrated using Google Map and Google Earth applications for better visualization[3,4]. All data, codes and images can be found in our GitHub repository[5].

3. Experiment results

In *Figure 1* we show the magnetic field measured at all locations the ISS passed during our experiment. Lighter colors show a lower value and darker colors a more intense value of the field.

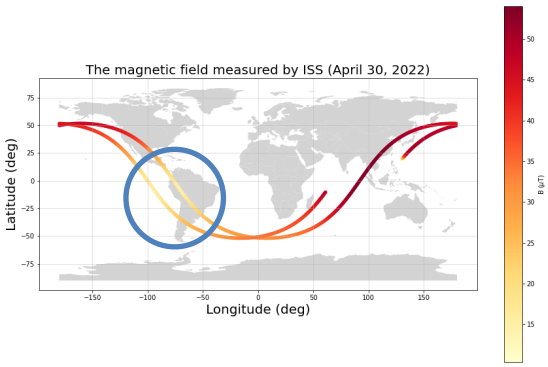

Figure 1: Magnetic field measured by ISS. The blue circle can be the known magnetic anomaly of the South Atlantic.

As we can see, we have fully captured the anomaly found in the South American region. In this region, since the Earth is not a perfect dipole, the magnetic field is much smaller (also taking into account the fact that this area was measured during the daylight, so it is less intense; we can compare it to the colors obtained in the

[1] https://en.wikipedia.org/wiki/Albedo

[2] https://apps.sentinel-hub.com/eo-browser/

[3] https://www.google.com/maps/d/u/0/edit
mid=1ujfFcGC8JmCYlhX6rz_fMRB0Z_eMl2o&usp=sharing

[4] https://youtu.be/uam6r9mebkA

[5] https://github.com/davidpamos/ASTRO-5

region near Somalia, of the same latitude, and measured at night). Somehow this affects the inhabitants of these places due to a larger exposition to cosmic radiation.

Figure 2 show an image taken from Ciudad del Carmen in the Yucatan peninsula (Mexico), one of the urban areas that we have analyzed.

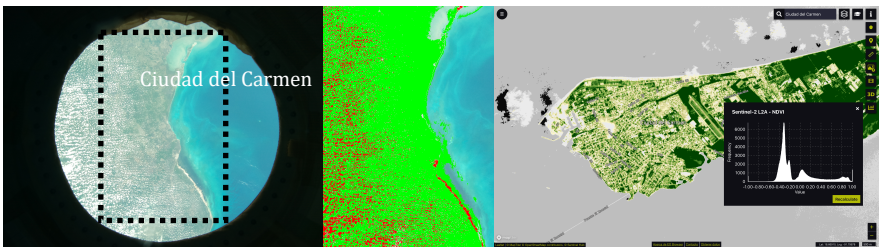

Figure 2: Left: Image from Ciudad del Carmen in the Yucatan peninsula (Mexico) taken by ISS. The dotted rectangle is the cropped image treated for albedo. Center: Cropped and processed image for estimating the albedo. Right: NDVI image taken by Sentinel 2.

In *Table 1* we show the results obtained for the magnetic field, the albedo and the NDVI from the urban areas where the ISS passed during the experiment

City	B (μT)	B/B_{mean}	Albedo	$Albedo/Albedo_{mean}$	NDVI
Las Vegas (USA)	40	1.4	0.29	1.3	0.11
Phoenix (USA)	39	1.4	0.31	1.3	0.12
Albuquerque (USA)	38	1.3	0.31	1.3	0.12
Ciudad del Carmen (Mexico)	28	1.0	0.21	0.9	-0.30
San Pedro Sula (Honduras)	25	0.9	0.23	1.0	0.29
Asunción (Paraguay)	20	0.7	0.16	0.7	0.85
Porto Alegre (Brazil)	23	0.8	0.26	1.1	0.70
Viña del Mar (Chile)	23	0.8	0.21	0.9	0.01
Santiago de Chile (Chile)	23	0.8	0.21	0.9	0.01
Bahía Blanca (Argentina)	26	0.9	0.16	0.7	0.33

Table 1: Results of the experiment

4. Learnings

In our project, the work distribution was determined according to the abilities of each member. In programming two of the members were the main contributors, although all of us helped on it. In the final phase, the work was distributed by sectors, two of us were dedicated to magnetism analysis, three of us learned about the EO Browser portal and how to get NDVI values and images. And finally, one of us took care of doing the albedo analysis.

In all this time we have dedicated to the project we have learned to trust each other's abilities more. We have been more aware of the great utility of handling programming skills today, when dealing with a large set of data.

Perhaps, in order to improve the analysis of so many images and data that we have received, we would need more time to do so.

5. Conclusion

It's not an easy task to compare quality of life between different urban areas, with just three estimated parameters: the magnetic field, the albedo and NDVI. Anyway, we were able to draw some conclusions:

1. It does not seem to us that the magnetic field, despite the anomaly in the South Atlantic, is crucial when evaluating the quality of life of one area compared to another. Although the differences can be great between different areas, as it can be seen in Table 1, we have to take into account the fact that the magnetic field has not been measured under the same conditions. In some areas it has been measured during the day and in others at night, without forgetting that the values are not on the surface, but more than 400 km high.

2. Combining a low albedo value with a high NDVI value leads us to an area with a lot of vegetation and warm, with a tropical climate, as in Asuncion. At the other extreme, combining a high albedo value with a low NDVI value leads us to an arid zone with little vegetation, where the thermal oscillations are stronger, such as in the desert (Las Vegas, Phoenix and Albuquerque). Then, the best areas may be those where albedo values are intermediate and NDVI is between 0.2 and 0.4, as in San Pedro Sula in Honduras or Bahia Blanca in Argentina.

Of course, all these conclusions do not take into account other environmental factors and the social and economic factors of a region.

Curiosity: Some of the pictures taken by the ISS when passing over New Mexico (USA) on April 30, revealed two active forest fires. We consulted the local press, and indeed, on April 26 two fires broke out in Calf Canyon and Hermits Peak (New Mexico) (see *Figure 3*).

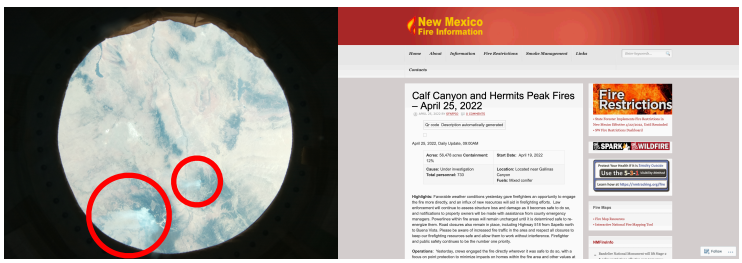

Figure 3: Left: Image taken by ISS last April 30, showing two fires. Right: The new in the local press