Mission Space Lab Phase 4 Report

Team Name: Phoenix

Chosen theme: Life on Earth

Organisation name: Virum Gymnasium

Country: Denmark

Introduction

When a volcano erupts, it releases volcanic ash. The ash provides nutrients to the nearby soil and makes the land fertile. Our team aimed to investigate the vegetation surrounding volcanoes by using the NDVI (Normalized Difference Vegetation Index) [1], and we hypothesized that we should see a higher concentration of healthy vegetation around recently erupted volcanoes.

NDVI takes advantage of the fact that plants absorb light in the blue and red area of the electromagnetic spectrum and re-emit it as near-infrared (NIR) [2]. We therefore used a camera that captures NIR with a blue filter on, and thus we were

able to calculate the ratio between blue and NIR light as a method of determining the density of photosynthetic activity in a specific area [3].

Additionally, we wanted to study volcanic activity and make possible predictions of future eruptions. This aspect is highly interesting since it is a relatively new method of predicting volcanic activity with the ability of predicting eruptions several years before the usual practice [4].
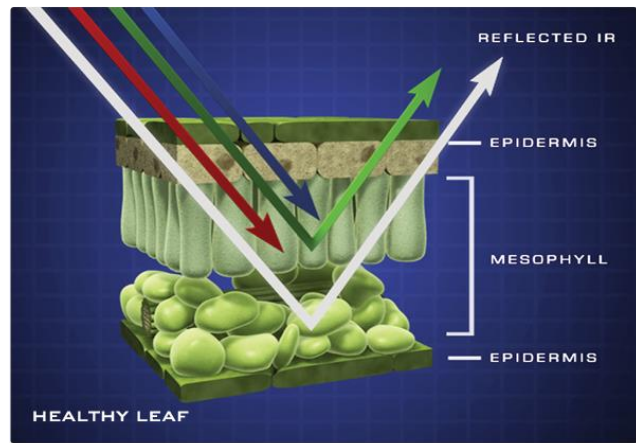

Figure 1: A figure showing re-emitted NIR light from chlorophyll in plant cells.

Method

Our program made use of the NoIR camera with the blue filter on ISS and took images in 10-second intervals. With every image, the corresponding geographical data was stored in a CSV file and the EXIF data of the given image. The images were stored in JPEG format at their maximum resolution (2592x1944).

Due to the target being volcanoes on land, we added a few conditions, which the program checked for while running. This way, we could save storage space by avoiding unnecessary images. One of these made use of the PyEphem astronomy library which we used to calculate the dot product between two
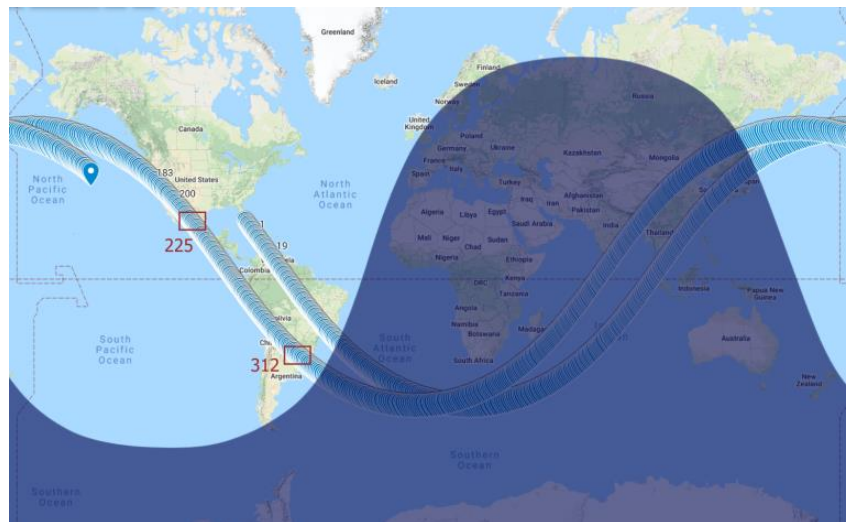

Figure 2: Map of route with marked day and night zone and location of picture 225 and 312.

vectors representing the Sun and ISS and checking if the angle between them was less than 90° before taking photos. Furthermore, the program checked for a few predetermined areas of ocean, and avoided taking images when ISS positioned over those, except for a few known volcanoes in those areas.

After receiving the data, we picked out a few relevant images and ran them through another program we have written. The program color mapped the images through NDVI and gave us a visual representation of the difference in vegetation in the different images.

Results

Fortunately, we were able to capture the Volcano *Colima*, which is situated in Mexico (see Figure 2). Colima is one of the 16 so called Decade Volcanoes [5] identified as being worthy of further study as it is the most prominent volcanic center of the western Mexican Volcanic Belt with frequent eruptions every decade.
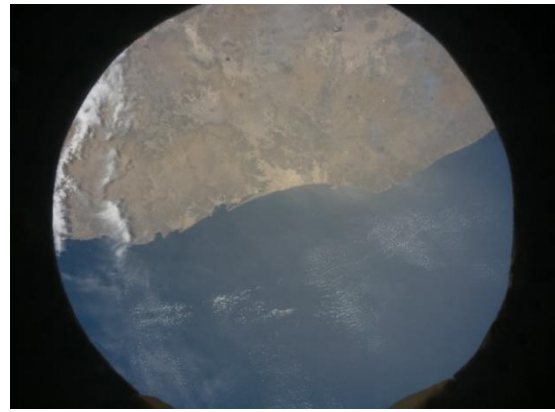

Figure 3: Image 225 taken with Astro Pi Izzy on ISS.
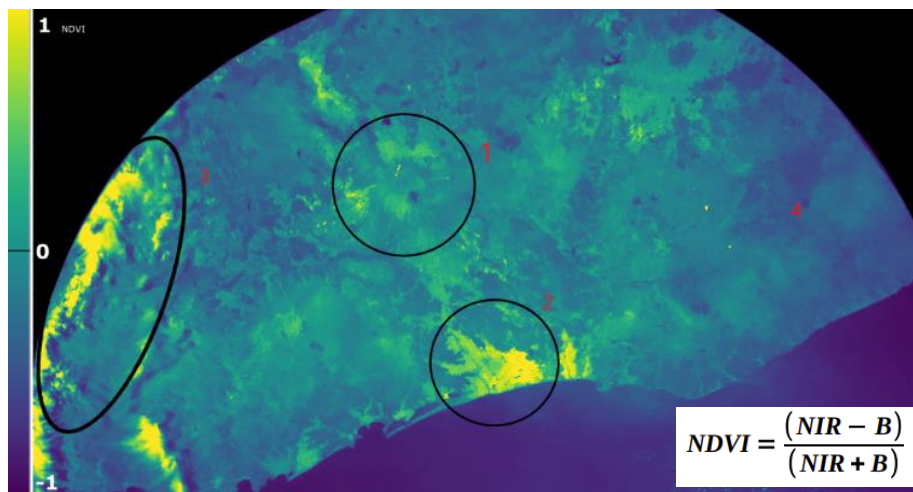

$$NDVI = \frac{(NIR - B)}{(NIR + B)}$$

Figure 4: NDVI color map of Colima (1) and its surroundings. (3) is clouds and not to be confused with healthy vegetation.

Looking at Colima in NDVI ((1) on Figure 4) we can see a significant increase in vegetation growth density in a large area around the volcano when compared to areas further away like (4), which is also farmland. If we look closely, we can see a river, *Rio Ameria*, connecting Colima and the Pacific Ocean, on the border of which is a clear increase in NDVI. This river ends at (2), which is an area full of agricultural farms. Consequently, the soil contains both natural fertilizer from Colima and artificial fertilizers resulting in a tremendous NDVI increase.

If we look even closer at the upper right of Colima we can actually see a belt of increased NDVI. According to a new theory this indicates that the volcano is to erupt at this exact spot within the next few years. Recent earthquakes around Colima supports this claim [6].

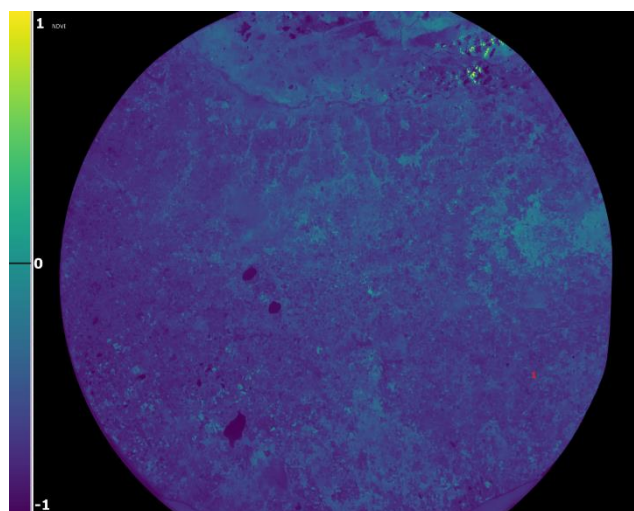Image 225 of Colima is taken within the Ring of Fire and the

Figure 5: NDVI color map of image 312 in Argentina (Figure

western Mexican Volcanic Belt. This means that the surrounding soil has been influenced by volcanic activity within the last 1000 years. To figure out how that affects the soil we compare it to Figure 5 which is an NDVI representation of agricultural soil outside of the Ring of Fire and not affected by Colima. When comparing the two it is clear that Colima and the surrounding volcanic activity indeed are boosting the soil and thereby the vegetation and NDVI.

Conclusion

We started out with the hypothesis that volcanic activity is fertilizing the surrounding soil which should be seen as an increase in photosynthetic activity. To see this through we produced a successful piece of code that took pictures based on the location of ISS, the Earth and Sun.

The information derived from the images of Colima supports our hypothesis as it is apparent that the area with volcanic activity has a significantly higher NDVI output than similar areas without volcanoes.

The limiting factors in our experiment are the relatively small sample size and the inability to compare vegetation across several years. In addition, NDVI is not the most delicate way of measuring vegetation growth and there are several other factors that we have not taken into account when comparing Figure 4 and 5.

Colima is an exceptionally active volcano and erupted as recently as 2017. With our data we can say with relative certainty that Colima is to erupt within the next couple of years along its southern slope. If this turns out to be correct, it will be logical to implement these systems around the world for volcanic predictions and for the safety of the citizens around them.

References

A GitHub repository with project code and data can be found here:

https://github.com/n0ugat/phoenix

[1] Article on NDVI:
https://en.wikipedia.org/wiki/Normalized_difference_vegetation_index
[2] Article on NIR: https://science.nasa.gov/ems/08_nearinfraredwaves
[3] Article on correlation between healthy vegetation and NIR emission:
https://earthobservatory.nasa.gov/features/MeasuringVegetation/measuring_vegetation_2.php
[4] Article on correlation between tree rings and volcanic activity:
https://www.sciencedaily.com/releases/2017/03/170309111952.htm
[5] Article on The Decade Volcanoes:
https://en.wikipedia.org/wiki/Decade_Volcanoes
[6] Article on earthquakes near Colima:
https://www.volcanodiscovery.com/colima.html#quakeTable