Mission Space Lab Phase 4 Report – Team PIoneers

Team Name: PIoneers
Chosen theme: Life on Earth
Organisation: Tudor Vianu National Highschool of Computer Science
Country: Romania

Introduction

As we find it both captivating and imperative to investigate the acute problems of our planet, we chose to analyse the terrestrial vegetation, especially forest fires which are one of the most critical issues regarding global climate change.

Interested in using programming to analyse climate phenomena on Earth, we won last year's ESA Climate Detectives School Project, where we used our C++ programming knowledge to study deforestation in Romania. This year, we went one step further and created a 397-line code in Python to take pictures of Earth with the help of the ISS Astro Pi Izzy.

After scrutinizing the ISS data, we expected to observe the impact of deforestation and forest fires on land. Our approach consisted both of studying how an area looks pre, during and immediately post fire, as well as examining the NDVI historical values in order to observe the timeline of a burned area throughout healing. We aimed to monitor wildfires, proving that such an analysis could be done on an international level and therefore helping tackle the environmental crisis we are facing.

This report further intends to present the methods, results (together with relevant images & explanations), and conclusions of our investigation.

Method

In our program, we used Izzy's near-infrared camera with a blue optical filter and alternated in between 6 different algorithms (which all ran in less than one second, 5 based on picture pixels analysis and one exclusively on the position of the ISS compared to the Sun) to decide whether to keep (daytime) or delete (nighttime) the taken picture. Moreover, we added the current latitude and longitude of the ISS to the csv file, together with the pressure, temperature, and humidity measured by the Sense HAT.

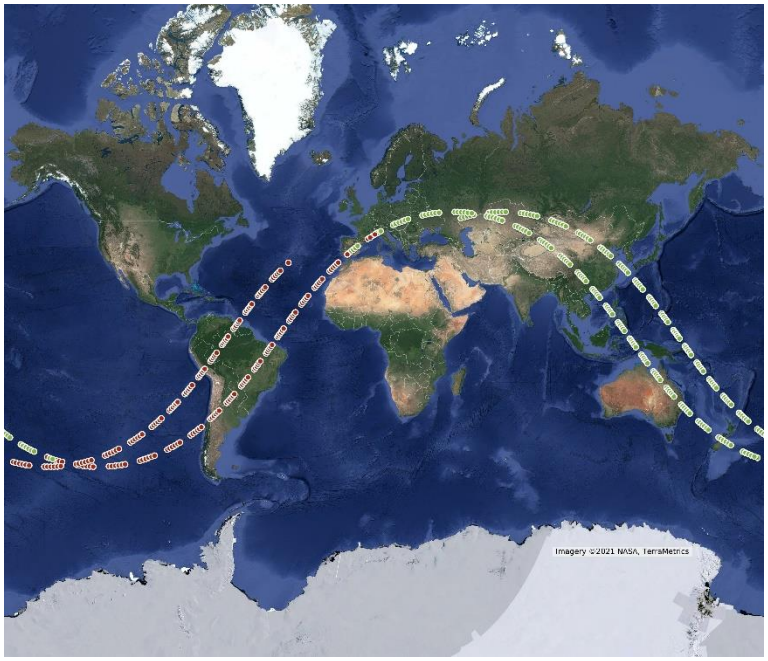


Figure 1 – Route of the ISS during the run of our code (April 28, 2021)

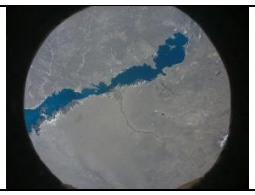
After creating another Python program, we determined the location (continent, country, area) and therefore plot the route of the ISS in the running time of our code using MyMaps, our map being available here.

Each point on the map was colour coded accordingly as daytime kept image or nighttime deleted image (See Figure 1). When clicking on a point, relevant information such as the ISS raw picture, NDVI version and Worldview link pop up.

Instruments we used to collect information about forest fires also include NASA's FIRMS and AppEEARS, as shown in the data processing scheme here.

Results

Firstly, with the help of a Python program, we obtained the NDVI version of all the 231 daytime photos received from the ISS (108 of land / 123 of water). Also examining NASA Worldview information about the fires in April 2021, we narrowed our investigation to the two most relevant areas:

		
Figure 2: Image 125	Figure 3: Image 144	Figure 4: Image 145
1. Chernobyl, known for the 1986 nuclear accident	2. Lake Balkhash, largest in Central Asia	

These images were superimposed over fires maps we created using information from NASA's FIRMS, as following:

Figure 5: Image 125 overlaying our Chernobyl Fires Map

Chernobyl map available here

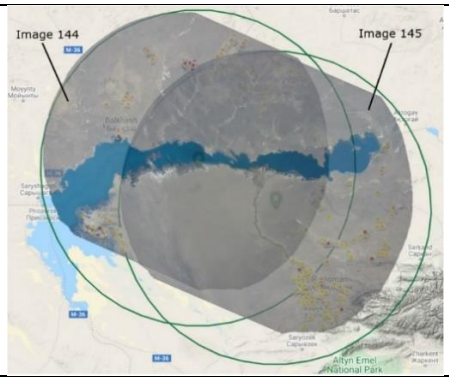


Figure 6: Images 144 & 145 overlaying our Lake Balkhash Fires Map

Lake Balkhash map available here

Conventional representation:

- current fires (April 27/28/29, 2021 - close to the run of our code)
- "historical" fires (recorded in March/June 2020)

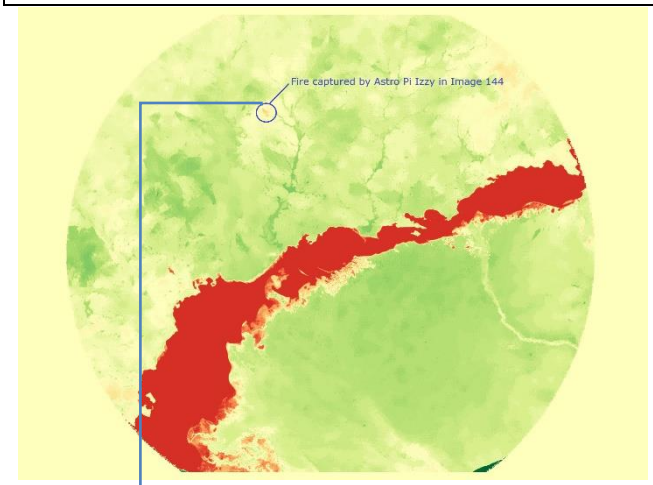


Figure 7: Image 144 NDVI

Fortunately, fires occurred during the run of our code and were captured in Image 144, as we noticed a red spot in Figure 7. However, the NDVI values were extremely low even before the fires (0.1), thus we reoriented to NBR and True Color analysis.

Studying the NBR pre-fire vs. post-fire, the burn scar is evident in Figure 10.

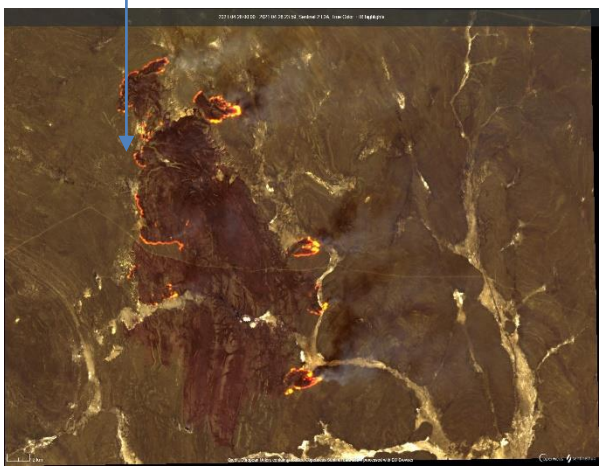


Figure 8: Active fire (Sentinel-2 True Color)

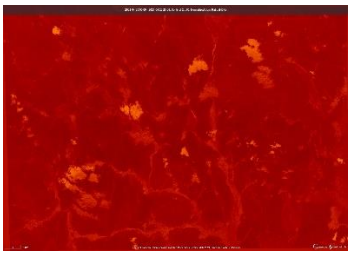


Figure 9:

Pre-fire NBR

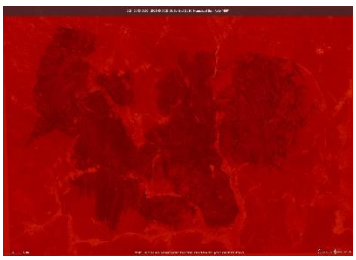


Figure 10:

Post-fire NBR

For the Chernobyl area, we analysed the multitemporal evolution of the NDVI in May 2018, 2019, 2020, and 2021 to see how the NDVI changed after some strong fires on April 13, 2020, and how quickly the vegetation recovered. Out of 20 fires studied, we conclude 20% of the areas had no NDVI improvement, 55% - slight improvement, and 25% - complete recovery one year post fire.

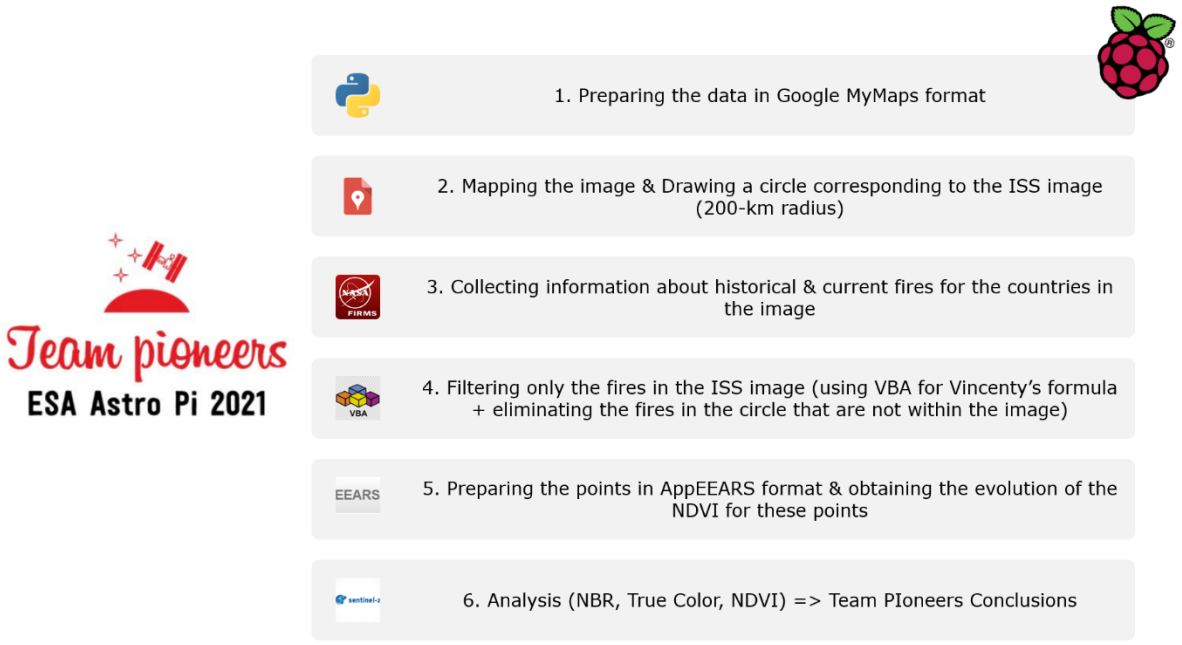


Figure 11: Data Processing Scheme

Conclusion

Our experiment proved to be a success, the results of the post-flight analysis exceeding our expectations. Luckily, we had the ISS passing over two important areas: the Chernobyl Exclusion Zone and Lake Balkhash (because of the active fire when Image 144 was taken).

With the help of such strong data and accurate instruments like NDVI, NBR, and True Color, we were able to compare how an area looks pre (Figure 9), during (Figures 7 & 8) and immediately post fire, the vegetation damage being clearly shown in Figure 10.

What is more, we extended our analysis to examining the NDVI historical values before a fire and up to one year after. In this way, we tried to estimate whether this timeline is sufficient for a burned area to heal, our investigation showing that, in more than half of the cases, only a slight improvement of the NDVI is registered in one year, although in 1/4 cases the vegetation easily gets back to the level before the fire.

Therefore, by performing similar algorithms, forest fires could easily be monitored by the authorities to limit the effects of such an acute issue on the planet we all share.