Mission Space Lab Phase 4 Report

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Chosen theme: Life on Earth

Organisation name: SPŠE a VOŠ Pardubice

Country: Czech Republic

Introduction

The main objective of our mission is to find how vegetation on Earth has changed during the time. Vegetation helps us to fight global warming because plant covers are responsible for CO_2 reduction and also serve as water storage. Stored water is then evaporated and cools the plant's surroundings. One of the possible outcomes of our research might be finding areas with an alarming vegetation decrease. Photos taken by our program aboard the ISS will be compared with outcomes including LandSat and Sentinel. The vegetation comparison will be realized by the conversion of photos into NDVI (Normalized difference vegetation index).

Besides, we also developed a simple web application (pardubice-pi.cz) that presents all the photos taken in our experiment. The application offers two modes – one for browsing plain photos and other for browsing images transformed to NDVI. We also contacted other Astro Pi teams to ask for sharing their photos with us. Those photos can be found in our app as well.

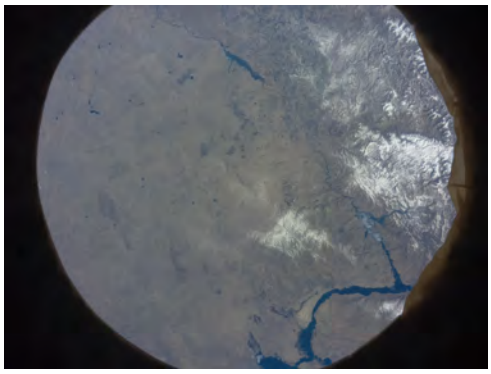
The expectations are that we will find enormous vegetation loses in the areas that are significantly affected by the deforestation.

Method

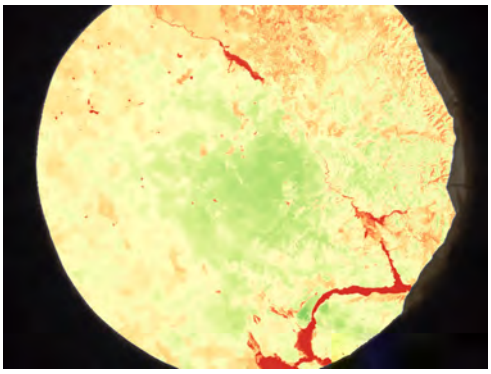
Our code onboard the ISS took photos of Earth and used an algorithm to determine the photo content. It had to decide whether the photo was taken during the day or in the night. The night photos were not stored to save the storage space. Data processing on Earth consisted of multiple steps. Firstly, we had to position images to the continuous line by OpenCV. Due to computational resources as well as complexity, the algorithm connects images only to straight lines and the shape of the ISS trajectory is not considered. However, we are working on an update that will take it into account. The connected images were then split into tiles that are used by the Leaflet library that runs our web app (pardubice-pi.cz).

Figure 1: Continuous line of our photos positioned in Google Earth.

Then taken photos were transformed to NDVI with the help of our Python program. We developed other scripts for counting pixel densities occurrences, NDVI difference calculation as well as clouds detection.



(a) Photo taken by Astro Pi Izzy



(b) NDVI

Figure 2: Photo to NDVI conversion.

To be able to compare our data with older observations, we used Google Earth Engine that contains plenty of datasets from many Earth observation missions.

Results

During the comparison of two NDVI images, there was a need to deal with different conditions while taking those photos. Unfortunately, caused errors were not linear and it is tough to annulate them. That is the reason why we developed a custom method on how to normalize NDVI images. This method is based on the assumption that larger areas did not change significantly. For both images, we create function visualising a dependency of pixel occurrences on NDVI transformed to range from 0 to 255.

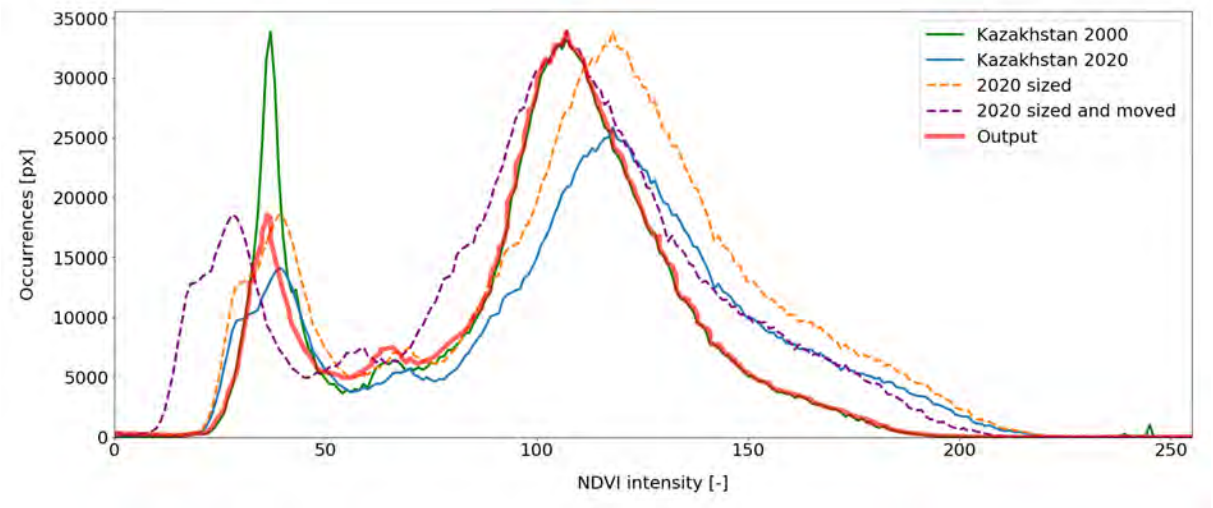
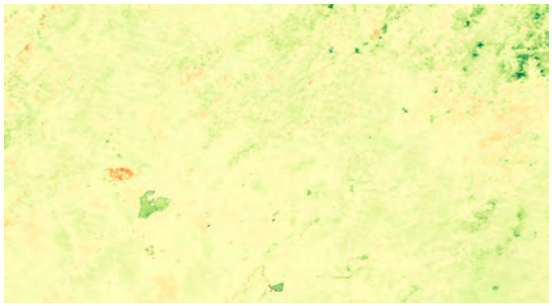
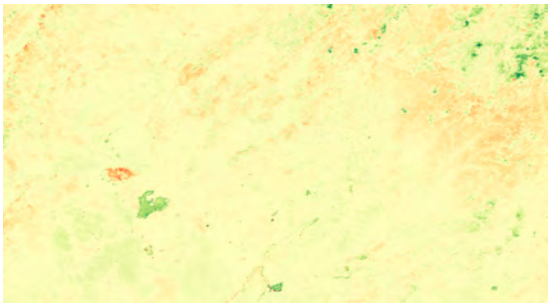


Figure 3: NDVI normalization.

Since most of the areas are made up of similar NDVI values, we can only move points on the X-axis in the way it almost copies the original function (we developed a simple program to help us with the task). The same moves are applied to the NDVI values to get the normalized image.



(a) without normalization



(b) with normalization

Figure 4: NDVI change.

With the help of our normalizing method, we found small areas with a significant vegetation loss compared to observation from dataset MOD13A2.006[1] that contains data from the year 2000. Our first discovery was an NDVI decrease around the town Ust'-Kamenogorsk in Kazakhstan. There are also small red places that were caused by the snow covering mountains

[1] https://developers.google.com/earth-engine/datasets/catalog/MODIS_006_MOD13A2

and larger area with smaller changes caused by agricultural activities. Second significant vegetation loss was observed at Gosudarstvennyy Prirodnyy Zakaznik Tsasucheyskiy Bor in Russia that suffered huge vegetation loss. We also found that NDVI of lakes Barun-Torey and Zun-Torey significantly increased. This might be caused by algae or cyanobacteria that can be found in stationary water. On the other hand, NDVI of the Irtysh river did not change which is probably caused by the water flow.

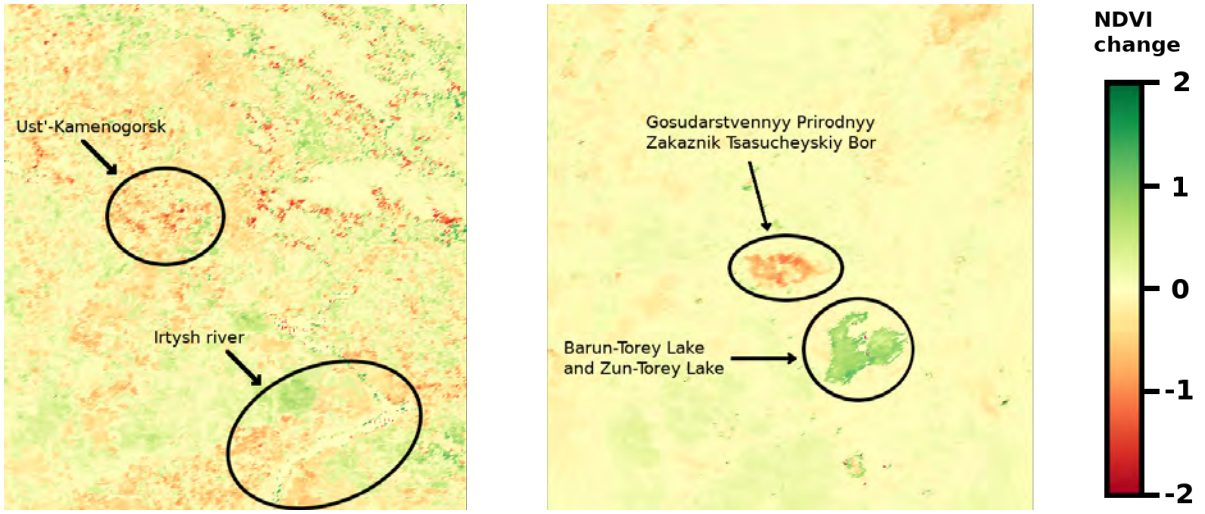


Figure 5: NDVI change over 20 years.

Besides, our app (pardubice-pi.cz) presents photos taken at the ISS. It also contains photos from other teams that provided us with their photos.

Conclusion

Our program running at the ISS was a great success because it managed to take photos with the right frequency that led to sufficient photo overlaps. These overlaps with the correct GPS position allowed us to connect photos precisely to the continuous line. Due to computational limitations, we were not able to transform images to the shape of the ISS trajectory, but we will resolve this issue in an upcoming app update.

During our research, we were surprised by the small increases in the amount of vegetation of large areas. We expected mostly decrease even at larger areas but the increase might be caused by the different atmospheric conditions each photo was taken in. However, we managed to normalize photos based on the dependency of NDVI values on pixel occurrences and find the areas with vegetation decreases.

In addition, we developed a web app (pardubice-pi.cz) that contains photos from our mission and also from mission of other teams. We appreciate their enthusiasm!

To sum up, we enjoyed working on the Astro Pi project! All our code can be found at our GitLab.