Space Kludgers to Investigate Correlations of Astro Pi Izzy Image Datasets and a Variety of Atmospheric and Anthropogenic Parameters Provided by ESA and NASA

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Chosen theme:	Life on Earth
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https://www.esa.int/Education/AstroPI/And_the_finalists_of_the_2019-20_Astro_Pi_Challenge_Mission_Space_Lab_are

Introduction

The purpose of this project is to gather images of the earth in the near-infrared and visible spectrum using the camera module of Astro Pi Izzy and then study the correlation of vegetation to a number of other parameters, including emissions of CO_2 and other anthropogenic and biogenic emissions as recorded and provided by the Copernicus ESA project and data hub.

Vegetation can be deduced via the Normalized Difference Vegetation Index (NDVI), a simple graphical indicator calculated by relative differences between the near infrared and the visible components of light reflected from a geographical region.

Atmospheric emissions measurements are available from the Emissions of Atmospheric Compounds and Compilation of Ancillary Data (ECCAD), part of the European Space Agency Copernicus project, while population density maps are provided by the NASA Socioeconomic Data and Applications Center (SEDAC).

The goal of this experiment is to identify how atmospheric emissions and population density correlate with each other in different terrain types. The hypothesis is that extensive vegetation affects the consistency of the atmosphere in a beneficial way, while big cities with high population density undermine it.

Method

We created a Python program (390 lines of code) to collect imagery from Astro Pi Izzy's blue-filtered camera. To account for any ISS local event that could skew imaging data, we used the rest of available sensors to record temperature, humidity, pressure, and accelerometer data. The program also calculated at run time whether it was daytime, using the PyEphem library. This information was then used to dynamically adjust the imagery recording rate so that more images are recorded during daytime rather than during night ensuring an optimal use of the available 3GB storage. Images were stored as lossless JPEG, with EXIF metadata attached; a detailed log of all measurements and calculations was stored as CSV file.

Post experiment, we manually identified daytime, cloud-free images of land, processed them using the ImageJ image processing software to calculate maps of Normalized Difference Vegetation

Index (NDVI), and compared this with NDVI data from Copernicus displayed via the ESA SNAP software.

Finally, we calculated population density and atmospheric emissions in selected areas using the SEDAC population density on-line tools and the ECCAD online emission maps.

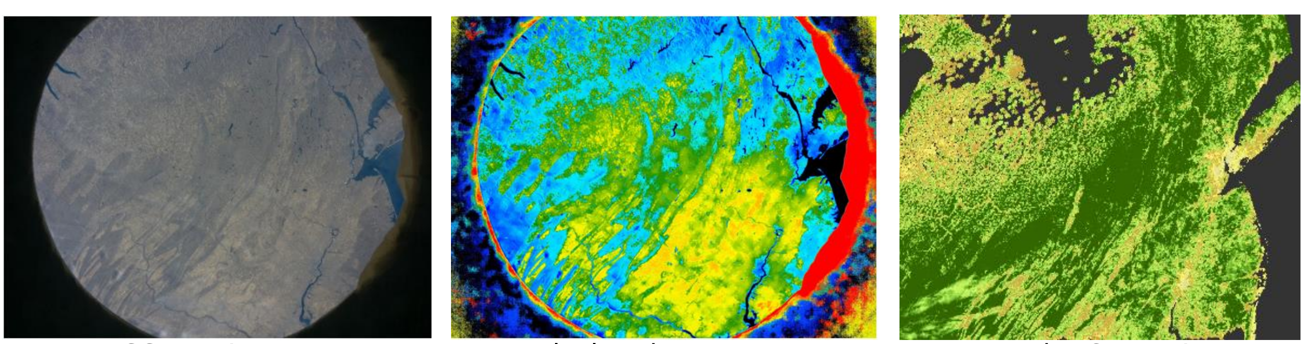
Results

The experiment run on ISS 3 hours and produced 857 images. The trajectory of ISS during the execution of our code is shown in Figure 1, as a series of the acquired images mapped on the globe using the QGIS software. Apparently, ISS flight was mostly over water, limiting the amount of useful data we collected.

Figure 1**:** Course of the ISS during the run of our program shown by pictures

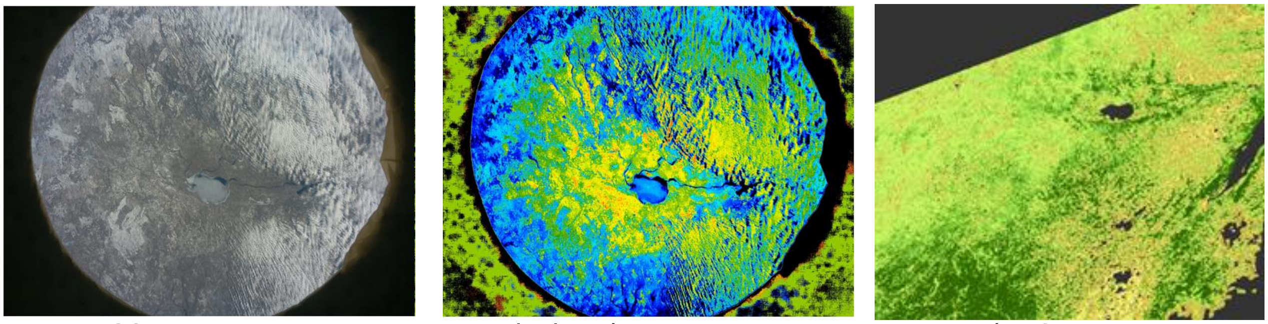
Manual analysis identified 59 images of land that were further processed. Three representative geographical areas of interest were chosen (Figures 2-4):

(1) New York, USA, with significant vegetation and extremely high population density: **207.3 persons/km^2**.
(2) Lake Saint-Jean in Quebec, Canada, with significant vegetation, and considerably lower population density: **1.6 persons/km^2**.
(3) Cascade Mountains in Calgary, Canada, with relatively reduced vegetation and low population density: **10.7 persons/km^2**.



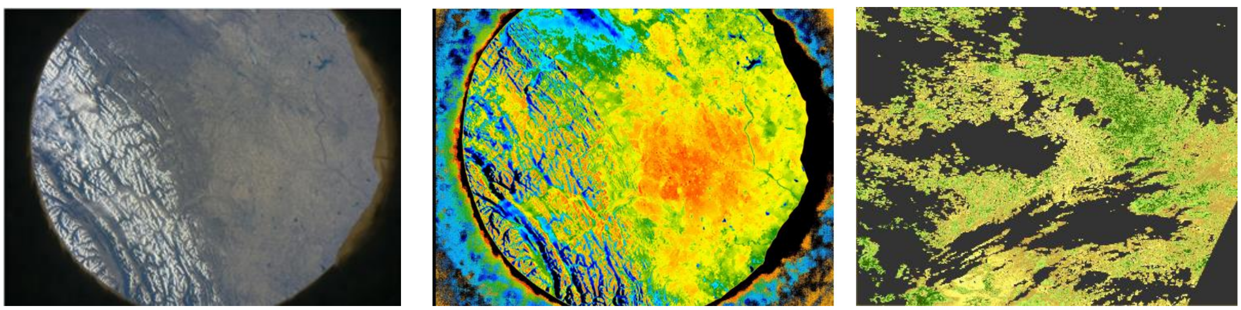
ISS raw image | calculated NDVI map | NDVI by Copernicus

Figure 2: Area around New York, USA, *imagery and NDVI maps.*



ISS raw image | calculated NDVI map | NDVI by Copernicus

Figure 3: Lake Saint-Jean in Québec, Canada, *imagery and NDVI maps.*



ISS raw image | calculated NDVI map | NDVI by Copernicus

Figure 4: *Cascade Mountains in Calgary, Canada, imagery and NDVI maps.*

The NDVI maps calculated from the ISS imagery produced similar results for vegetation as compared to the Copernicus NDVI maps. However, the latter present significantly higher resolution, and are more appropriate for further correlations. The low quality of the calculated NDVI maps maybe due to the interference of the ISS window in front of the camera, the contamination of the red channel with RGB light and the contamination of the blue channel with NIR light.

The anthropogenic and biogenic emissions were calculated as mean values of the respective regions of interest in the online ECCAD maps and are shown in the following charts.

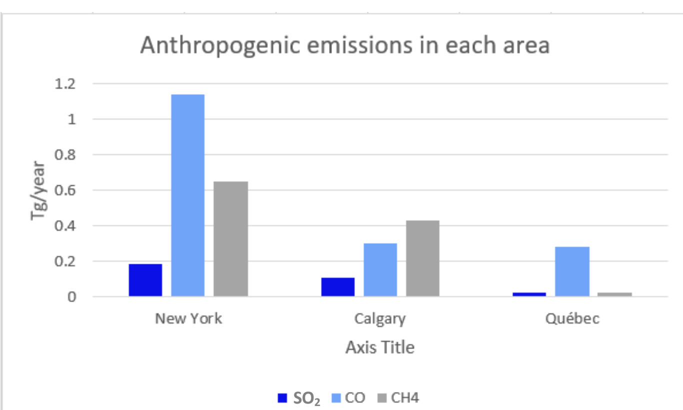


Figure 5: *Anthropogenic emissions in each area*

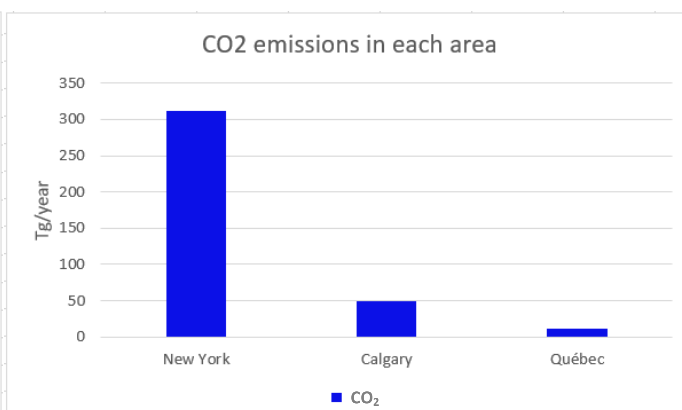


Figure 6: *Anthropogenic CO_2 emissions in each area*

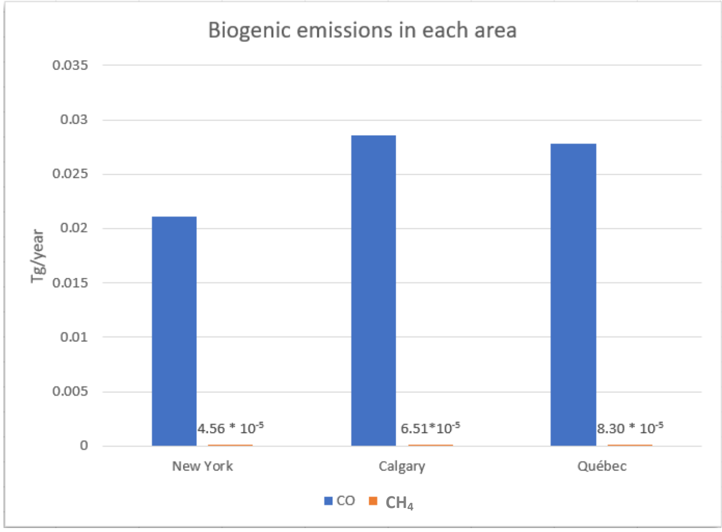


Figure 7: *Biogenic emissions in each area*

Conclusion

Overall, acquiring and processing earth imagery via Astro Pi Izzy has proven to be straightforward and enjoyable. Exploiting Copernicus data sets and tools was demanding, albeit worth the effort, due to the abundance of different data sets and the wealth of information that can be mined.

The imagery acquired via Astro Pi Izzy produced an adequate number of land photos to enable calculation of NDVI maps depicting vegetation in the selected example areas. However, due to limiting factors such as camera resolution and sensor inefficiencies, that have been mentioned above, the calculated NDVI maps showed less vegetation than the respective higher resolution Copernicus NDVI data. Therefore, we used the Copernicus data for correlations and to draw conclusions.

Our experiment showed that in all three example geographical areas, there is a linear correlation between population density and the atmospheric emissions considered. The extend of vegetation however does not correlate with population density, as the three example geographical areas show variable correlation of vegetation with population density.

We can also deduce that despite the abundance of vegetation around New York, the atmosphere’s composition remains full of harmful anthropogenic emissions, so the influence of people overcomes plants’ activities to remedy harmful anthropogenic emissions.