ASTRO PI

MISSION SPACE LAB

Mission Space Lab Phase 4

Team Name: Albedo

Chosen theme: Life on Earth

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Introduction

Global warming is a major issue of the twentieth century. It is therefore essential to understand how it works. Among the parameters that influence global warming is the Earth's albedo. According to Wikipedia, albedo is the measure of the diffuse reflection of solar radiation out of the total solar radiation and measured on a scale from 0, corresponding to a black body that absorbs all incident radiation, to 1, corresponding to a body that reflects all incident radiation. Here, we want to estimate the Earth's albedo.

A method for estimating the Earth's albedo is important to provide climate models. It will also make it possible to follow the evolution of the Earth's albedo over time and for example to see the importance of certain changes such as the melting of the poles.

More than a precise value of the albedo of the earth we would expect to obtain an order of magnitude.

Method

We sent a python program to the ISS to take pictures of the Earth every 30 seconds. We store the time and coordinates for every picture in the EXIF photo properties and in a csv file as a backup.

We then analyzed the photos on Earth. We had a total of 331 photos, but we analyzed only 149 of them because the others were black.

For each photo we have categorized the surfaces into 3 categories: cloud, land and sea. The difference between these categories was made according to the RGB values of each pixel.

On all our pictures there is the sides of the sight glass which is visible. This represents about 30% of the image which is black. In order to take into account this, we multiplied the results obtained by 1.43.

From the literature[1] we took average albedo values for each surface: 0.25 for land, 0.15 for sea and 0.8 for clouds.

Thus, knowing the percentage of each of the surfaces and the corresponding albedo, we were able to go back to an average albedo for the Earth.

The code we used for the analysis is on GitHub:
https://github.com/Eliot999/AstroPi2021

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

Results

Below 2 examples to illustrate with 2 pictures the results that we had.

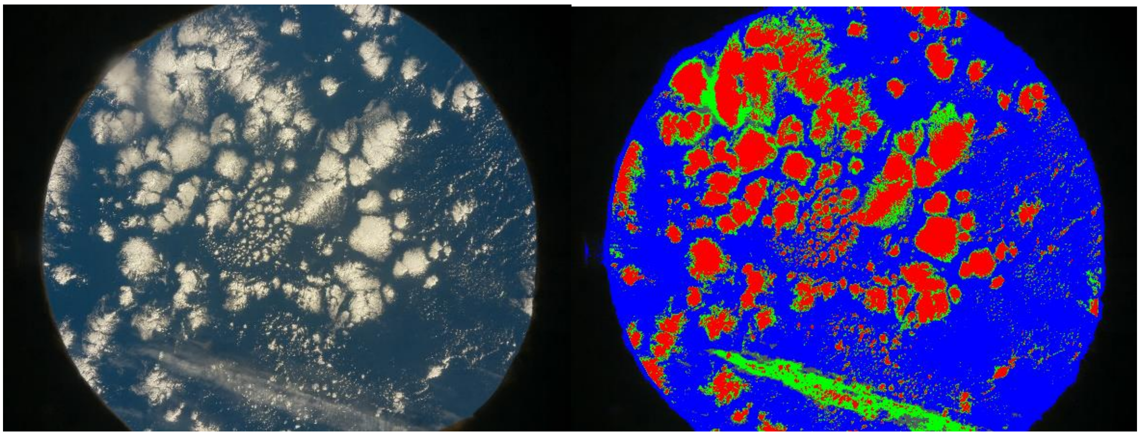

Illustration 1: on the left the original picture, on the right the treated picture with sea in blue (45%) clouds in red (15%) and land in green (9%).

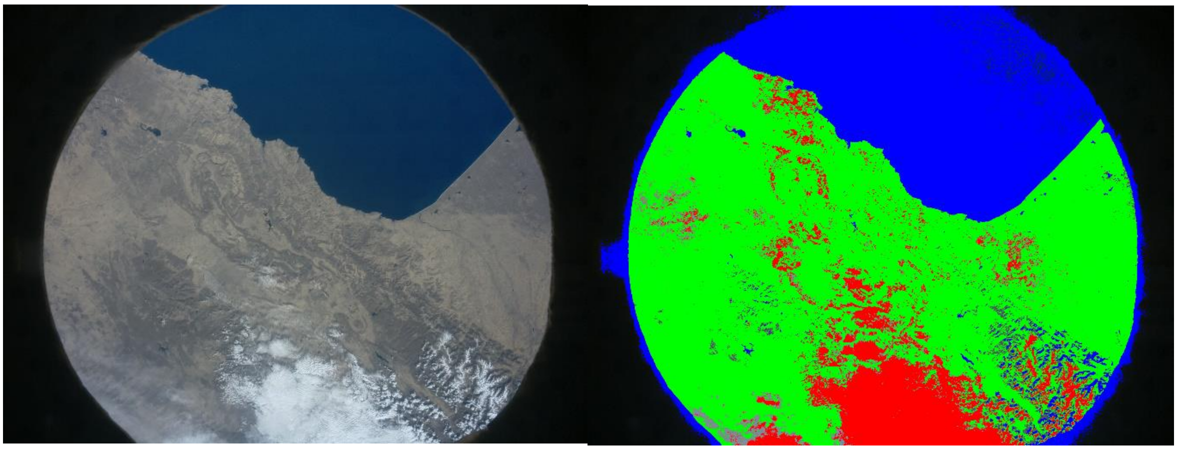

Illustration 2: on the left the original picture, on the right the treated picture with sea in blue (22%) clouds in red (8%) and land in green (43%).

The table below is the summary of all the areas measured on all the 149 photos.

	Percentage of Land	Percentage of Sea	Percentage of Clouds	Total
Distribution (as a percentage of the total image)	40%	14%	16%	70%

Table 1: Percentage of each area for all the pictures we analyzed.

As we have the albedo values for each of the surfaces (from the literature), we just have to do a calculation taking into account the sight glass (by multiplying the result obtain by 1.43):

$$(0.4 \times\ 0.25 + 0.14 \times 0.15 + 0.16 \times 0.8) \times 1.43 =\ 0.356$$

Thus, we obtain an Earth's albedo of approximately 0.36.

Conclusion

We obtained a terrestrial albedo of approximately 0.36. We are therefore quite close to the classically estimated value for the terrestrial albedo, which is around 0.3 to 0.35. However, our methods have many limitations.

First, we took average values for each of the surfaces (0.25 for land, 0.15 for sea and 0.8 for clouds). However, these values are very approximate. For example, depending on the land, the albedo will not always be 0.25 and the same goes for the other surfaces. This therefore represents a major bias in our measurements.

Second, we have subdivided our images into 3 different surfaces. However, the reality is much more complex than that and there are many more different surfaces. For example, we could take our photos and process them including new surfaces such as forests or ice / snow.

Finally, we have only treated a small portion of the Earth which obviously does not allow us to have a global vision.

However, the fact that we have obtained a credible value, may suggest that the method may perhaps approach results which allow us to have an order of magnitude, and this is ultimately what we hoped for at the beginning.