Mission Space Lab Report

Introduction

Clouds are one of the most visible climatic phenomenon. Their formation is very complex and multifactorial. One of the possible factors determining the cloud formation is the type of underlying ground surface. To tackle this problem, as a preliminary approach, our team has decided to study how the statistical distribution of clouds is affected by the type of ground surface. In particular, we adressed how clouds are distributed along latitudinal and longitudinal gradients. This would help us to model any pattern that would show if some regions are more likely to have a covered weather or not.

Method

Our code to the ISS made use of the onboard NoIR camera to take pictures of the Earth from space, and save the coordinates of each one. The program ran for 3 hours on April 30 2020, recording a picture every 15 seconds only when the ISS was flying over the daytime side of the Earth. It saved 326 pictures, along with a CSV file containing the latitudes and longitudes.

Back on earth, the post-processing program masked clouds on each picture using a brightness threshold for each pixel. Any pixel with a brightness higher than the threshold (i.e. color range between the grayscale threshold and white) is considered as a cloud contaminated pixel. The thresholds are determined manually for each picture, since it's the easier way to deal with brigthness differences between pictures for a dataset this small. Then, for each picture, a cloud ratio is calculated, which is the proportion of cloud contaminated pixels over the total number of pixels. We focus on the region the ISS flew by.

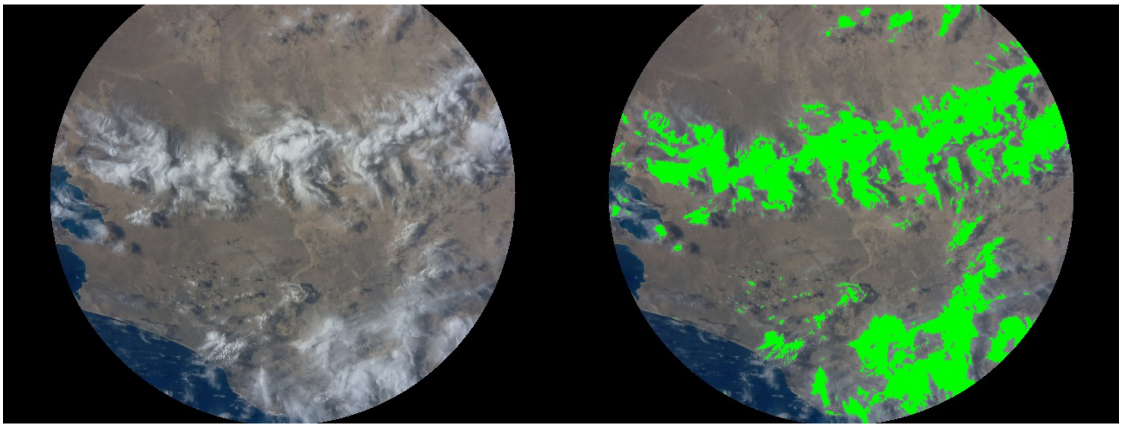

Figure 1: Example of cloud detection by our algorithm, original image on the left, cloud masking highlighted in green on the right.

Results

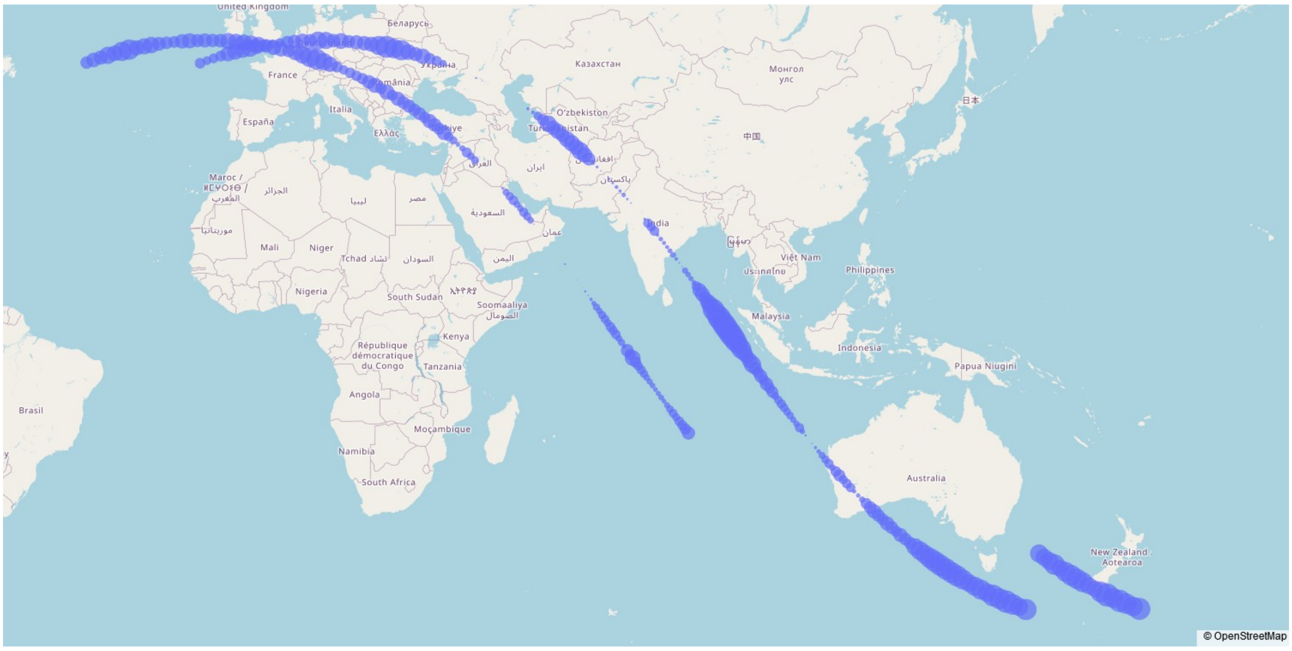

Figure 2: Cloud ratio of each picture along their coordinates, a bigger dot represents a higher cloud ratio (map tiles from *OpenStreetMap*)

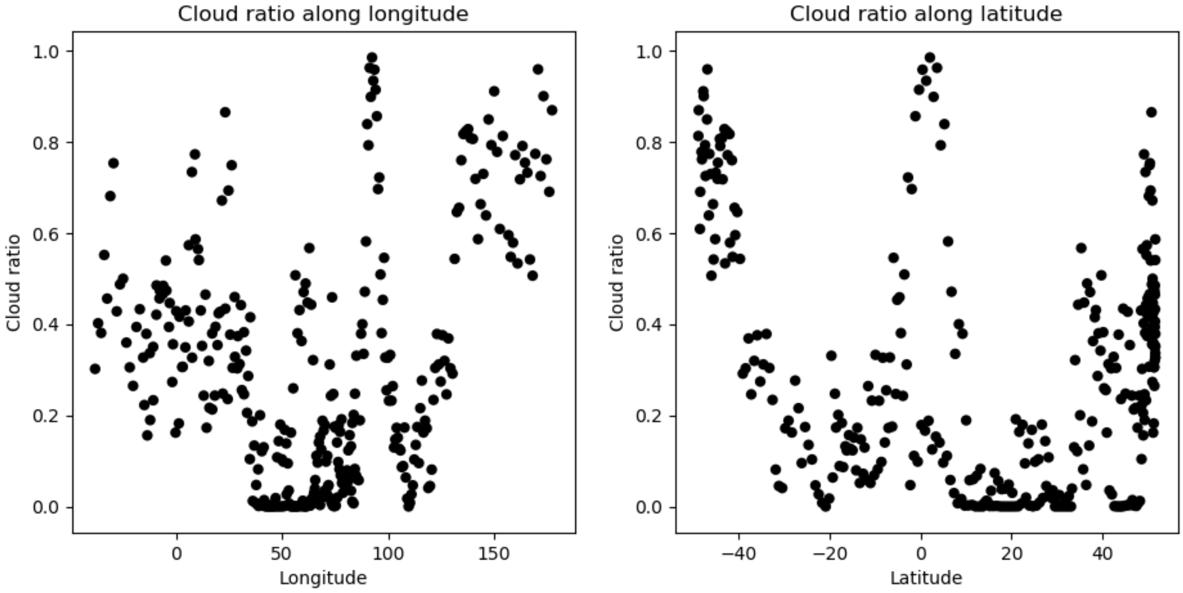

Figure 3: Cloud ratio along longitude (**3.1**) and latitude (**3.2**)

Figure 2 shows high and homogeneous cloud densities near the poles. On the other hand, the arid regions, such as the Middle-East tend to have a very low coverage. Figure 3.2 confirms the first observation about the polar regions in spite of the corresponding peeks in density at high and low latitudes. A peek around the equator in 3.2 indicates a high cloud density at this latitude. However since the cloud density varies to lower values on the equator along longitude (see the ratios in Indian Ocean on Figure 2) we cannot yet conclude on that hypothesis. Figure 3.1 is insufficient to conclude on any distribution of clouds along longitudes because of the limitations in longitudes flown by the ISS.

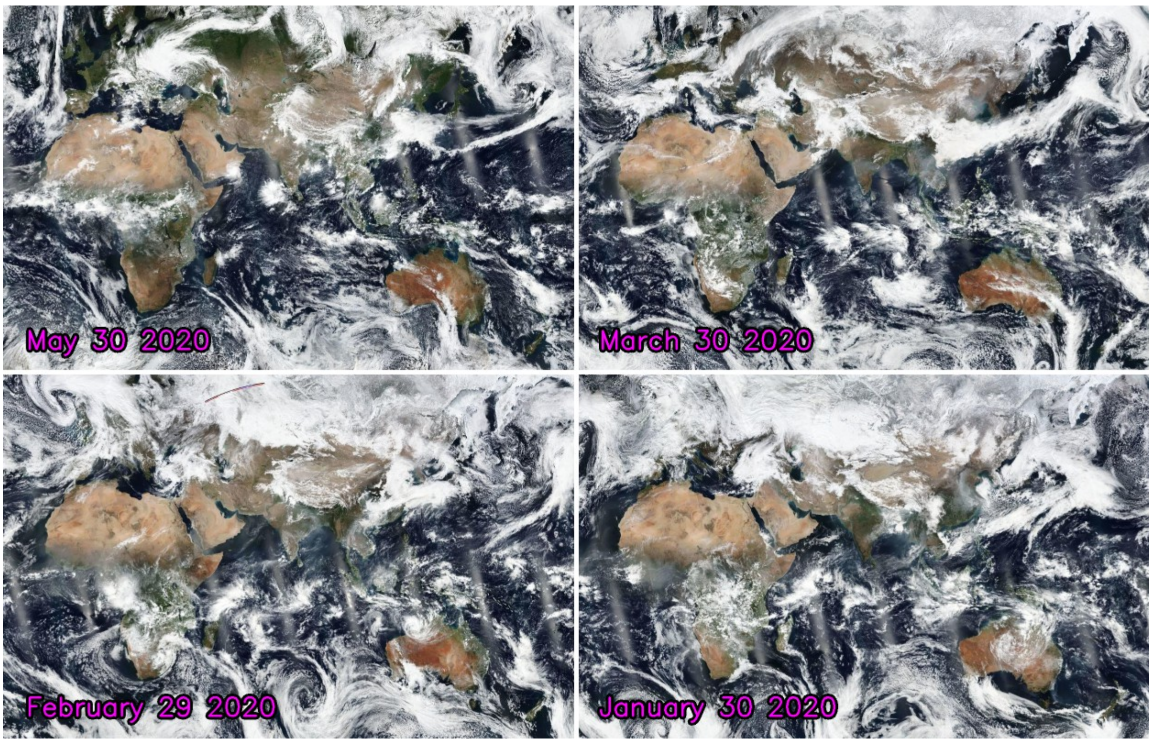

Figure 4: Comparison of real satellite images from *zoom.earth* over the months around the date the code ran on the ISS

Comparing our estimations to satellite pictures (Figure 4) confirms a higher cloud coverage near the poles as previously noticed. The presence of a regular cloud band along the equator corroborates the hypothesis of a higher coverage over equatorial regions. Noticeably, some regions, such as the rainforests, are more covered (see Central Africa and Indonesia).

Conclusion

Our study indicates that regions close to poles are usually more covered with clouds than others. We can also note a cloud belt around the equator, which becomes denser over the rainforests. One can interpret this specificity because of the high humidity in this type of region. Arid regions, however, appear way less covered. Oceans tend to follow the same principles : cloudy poles and an equator belt. Further research is needed to understand how the surface topology and vegetation affect the cloud distribution.

Our experiment only ran for three hours over a particular region of the Earth with a small dataset which lays to a high uncertainty. We could run the experiment longer to cover most of the globe surface. A longer experiment would also give us the possibility to statistically analyze the variation over time of cloud distribution to model seasonality. In this case, our bruteforce algorithm would not work, and an automatic cloud masking algorithm would be necessary.