# *The Impacts of COVID 19: The Positive Reaction of Human Activity Reduction in the Caribbean*

Angelie T. Nieves Jiménez [1,2] angelie.nieves1@upr.edu

María C. Novoa García [1,3] maria.novoa1@upr.edu

1. University of Puerto Rico- Mayagüez
2. Department of Industrial Engineering
3. Department of Computer and Software Engineering

Universidad de Puerto Rico, Departamento de Geología P.O. BOX 9000, Mayagüez, PR 00681

**Abstract**

The COVID-19 pandemic has made a perpetual impact in the world we live in. Without a doubt, it has changed the perception of numerous things, many with a negative outcome, but for the environment a positive one. This study analyzes vegetation, CO, and chlorophyll content in the environment by comparing data before and after quarantine regulations take place in the Caribbean. This is because due to the lack of anthropogenic activities, the virus has indirectly helped cease some damaging components to the environment.

## I. Introduction

The novel coronavirus (COVID-19) or SARS-coV-2 has been the protagonist of a worldwide pandemic in the year 2020. The World Health Organization has commented that the outbreak commenced in December in Wuhan, China and commenced to spread worldwide in January confirming its first cases in Italy, Spain, and the US during that month. In the present, this virus has affected 191 countries or regions and as of December 9th, 2020, the global cases have spiked to 68, 347,376 and of those a death toll of 1,559,709 according to the John Hopkins University Coronavirus Research Center. This pandemic has changed every bit of an individual's life and most of them have come to a standstill. Many are missing daily activities such as going to work and school, eating lunch with family and friends, going to sports and concerts, traveling, etc. The lack of these actions contributes to a decrease in anthropogenic activity, thus being an effect from the situation. The question to be answered is: Does this decrease in human-induced effects such as gas emissions and water contamination become a noticeable and positive environmental impact in 2020?

In this research the Caribbean is the main area of study, and according to Murphy et al. 2020 the first confirmed COVID-19 case for this area was on March 1st, 2020 in the Dominican Republic. After that event, it spread throughout the whole Caribbean because of travel and activities that implied big crowds. To constrain the expansion of this virus, countries established individual quarantine regulations. According to the Centers for Disease Control and Prevention (CDC), Cuba closed its borders to non-Cuban citizens on March 20th, 2020 and international flights were suspended from arriving and departing on April 2nd, 2020. The Dominican Republic established its curfew on September 28th, 2020, being the last one to establish this type of restriction. A negative COVID-19 test is required to enter Puerto Rico and Jamaica, which curfew is also enforced. It is also important to note that most cruise ships cancelled their planned trips on the Caribbean, which contributed to containing the virus as much as possible.

During the first few months of lockdown, positive news roamed through newspapers and television programs that due to the lack of tourists in Venice, Italy, the canal waters were clearer and that even dolphins started to appear in the area. Braga et al. 2020 comment that the transparency is due to the lack of human activity and seasonal factors. This occurrence is an example of a positive effect COVID-19 indirectly has on ocean color and the environment. It has also been analyzed that emission reductions occurred in China during the first months of the city-lockdown period, contributing to a positive outcome. (Le et al. 2020; Field et al. 2020; Fan et al. 2020; Shrestha et al. 2020) Another factor bound to be affected in a way, is the vegetation surrounding cities. Ghosh et al. 2020 are able to analyze these type of pattern changes in their study and conclude that while trying to minimize COVID-19 spread, environmental degradation is also minimized.

Therefore, if a positive change was observed in cities such as China and Italy, and there is sustainable scientific evidence to make a statement, it is probable that a similar outcome can be the result of conducting the research with Caribbean as the main focus. In the study about to be administered, data and images obtained from before quarantine regulations and after are to be examined and compared with different environmental factors.

## II. Methodology

The purpose of this study is to determine and analyze if there is any change in the atmospheric composition, vegetation, and ocean color from anthropogenic effects due to COVID-19. Data and images from before quarantine regulations and after are obtained. The first information acquired must be before the 15th of March because that day is considered an average of the time regulations commenced in the Caribbean, while the after the 15th of May, is considered the time where regulations became more flexible and human-activity occurred again. It was decided that different areas of the Caribbean are going to be chosen and analyzed separately to be able to compare

quarantine regulations and anthropogenic behavior after the applied national government measures respectively, and if they have a positive effect in the environment. The area chosen is delimited between 23º 33′ 50″ N, 085º 17′ 52″ W, 11º 39′ 08″ N, 085º 04′ 41″ W, 11º 10′ 42″ N, 058º 26′ 50″ W, 23º 21′ 44″ N, 059º 01′ 06″ W. Using this specific area, the United States Geological Survey (USGS) Earth Explorer website was used to obtain images for them. For vegetation, the sensor used was Landsat 8 Collection 1-Level 1 OLI. This sensor orbits the Earth every 99 minutes and has a 16 day repeat cycle which means that for the timeline in this study, images are limited to the passing of the sensor before March 15th and after May 15th.

OLI images are obtained for analyzing vegetation before and after the timeline. The months chosen were March and June 2020. The Remote Sensing concept for this analysis is the vegetation indexes. The VI used is the NDVI. The sensor chosen was Landsat 8 OLI because it has the necessary bands for the NDVI calculation, a considerable spatial resolution and had available images of the area of study because the time resolution is 16 days. The program used was ENVI where the following tools were applied to the images: Dark Subtraction, NNDiffuse Pan Sharpening, Band Math, Build Raster Mask and Quick Mosaic. The Dark Subtraction was used to do an atmospheric correction, eliminating some of the atmosphere effect on the digital values. The NNDiffuse Pan Sharpening was applied to change the true color spatial resolution (30 meters) to the pan band resolution (15 meters). This tool was used in order to have a better resolution before applying the NDVI equation. The Band Math tool was used to write the NDVI formula and apply it to the image. Afterwards, a mask was applied to protect values from 0 to 1. All of these steps were taken for each image to then create a Mosaic using Quick Mosaic on ENVI (See images at the Results section). A Quick Stats was used to compare both images.

Another important factor that is said to be reduced because of the lack of anthropogenic activities is gas emissions. The data are obtained from the National

Center for Atmospheric Research's (NCAR) Atmospheric Chemistry Observations and Modeling (ACOM) Laboratory in Boulder, Colorado webpage. The measurements used come from the Measurements of Pollution in the Troposphere (MOPITT) missions. MOPITT is a sensor that has been operational 20 years now and has a 22kn spatial resolution. Specifically, this sensor is used to measure Carbon Monoxide (CO) and daily data can be obtained. Level 3 monthly image outputs and daily CO Total Column, CO Mixing Ratio Surface, CO Mixing Ratio 900mb, CO Mixing Ratio 800mb, CO Mixing Ratio 700mb, CO Mixing Ratio 600mb, and CO Mixing Ratio 500mb were the focus. With the worldwide CO raw data collected the Caribbean was separated and analyzed individually.

It was mentioned beforehand that tourism came to a halt and many cruises were cancelled. This matter contributed to a significant economic crisis for those islands that depend solely on tourism. Contrarily, it can be assumed that this tourism activity interruption contributed in a way to beneficiating the water quality and color on those islands that have much movement in ports. For this reason, a before and after ocean color comparison had to be made. The sensor used for this kind of analysis was Terra Moderate Resolution Imaging Spectroradiometer (Terra MODIS). This sensor's orbit around the Earth is timed so that it passes from north to south across the equator in the morning and acquires data every two days in 36 spectral bands. This data is complemented with the Aqua MODIS sensor which passes south to north over the equator in the afternoon every two days too. Due to this availability in data, monthly Level 3 Chlorophyll concentration products were collected for March 2020, May 2020 and May 2019. May 2019 was collected because chlorophyll is seasonal, and an accurate time-relative comparison had to be made.

## III. Results and Analysis

### A. OLI

Since the time frame was short, the selection of images was limited. The images

chosen had many clouds, the mask range was modified based on the digital values of the clouds. Some of the images had clouds with values from 0 to 0.2. This made the analysis difficult since some of the vegetation was masked. The Quick Stats showed that in June the mean value of NDVI was approximately 0.32 while in June the value increased to 0.37. This means that technically the vegetation got a little healthier. This can be accepted as a partial conclusion for the vegetation because of the clouds and how the mask was applied. Figures #1 and #2 represent the mosaics of True Color while Figures #3 and #4 represent the mosaics with NDVI and Mask applied.

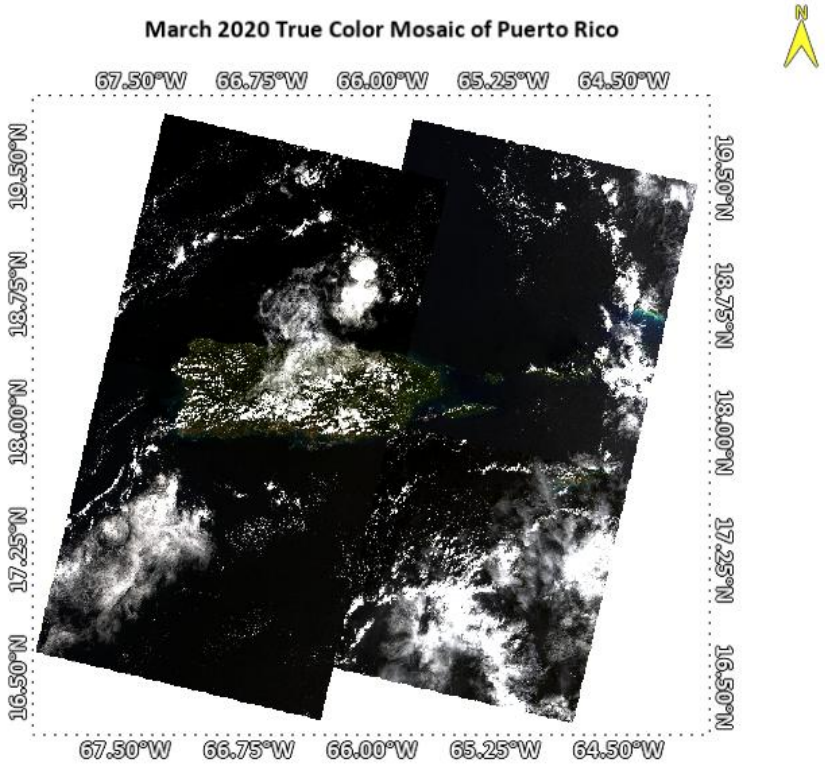



**Figure #1:** March 2020 True Color Mosaic of Puerto Rico

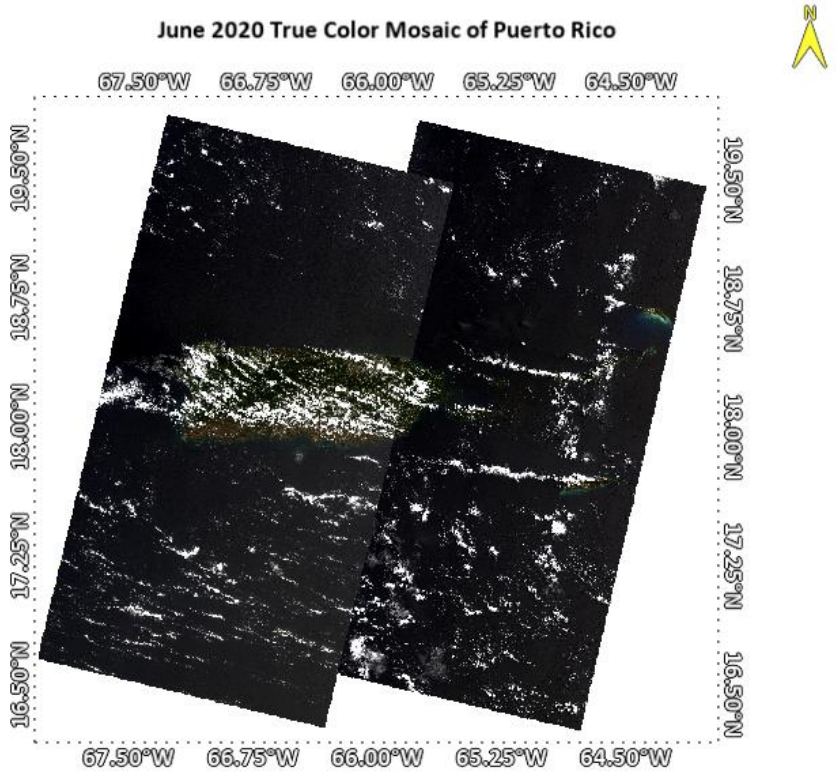



**Figure #2:** June 2020 True Color Mosaic of Puerto Rico

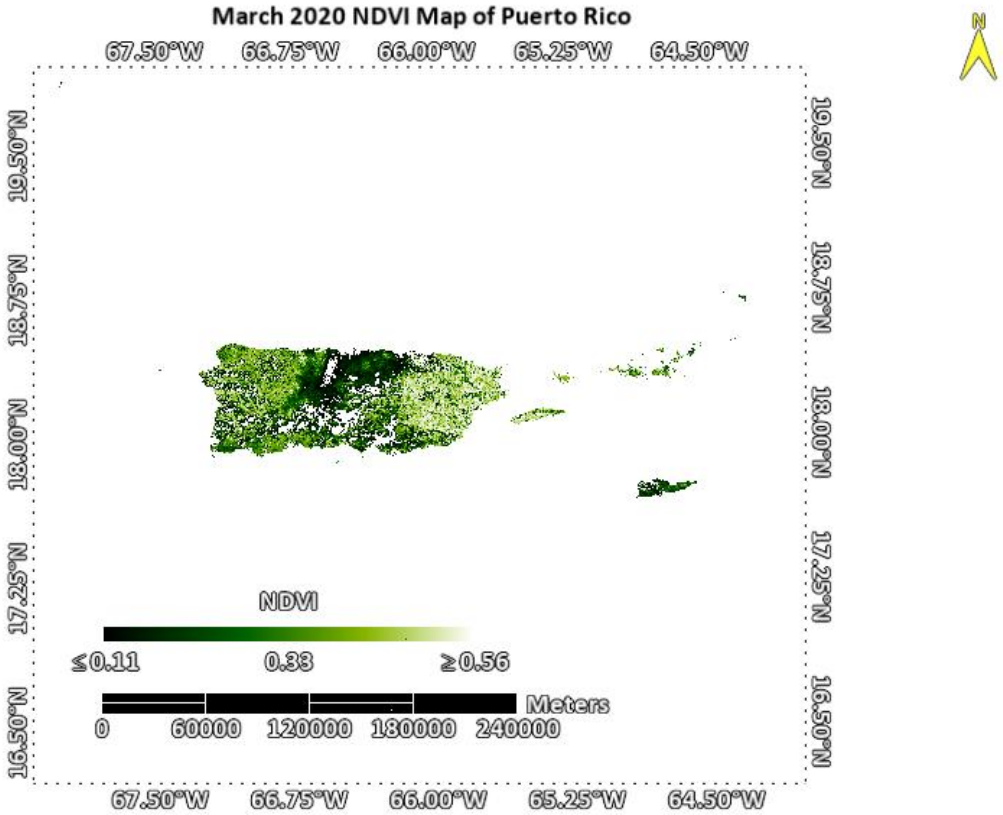



**Figure #3:** March 2020 NDVI Map of Puerto Rico

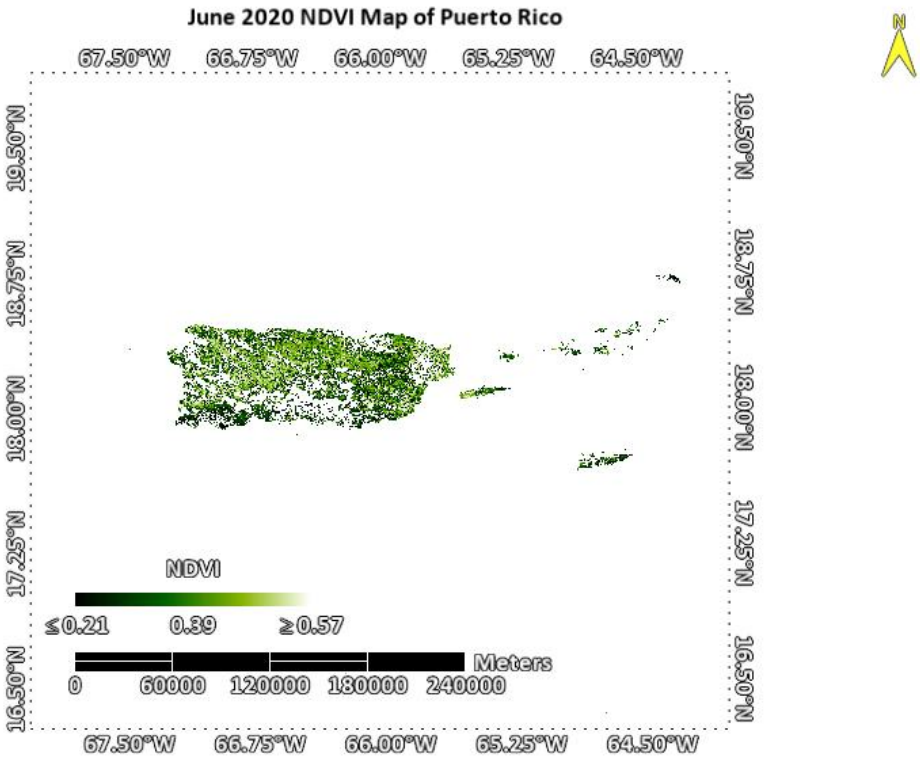
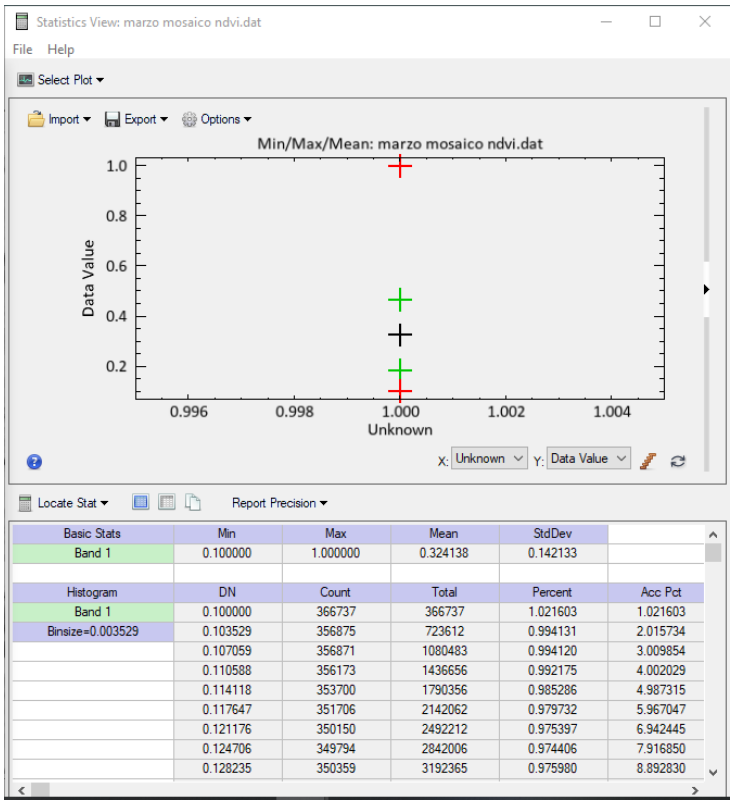
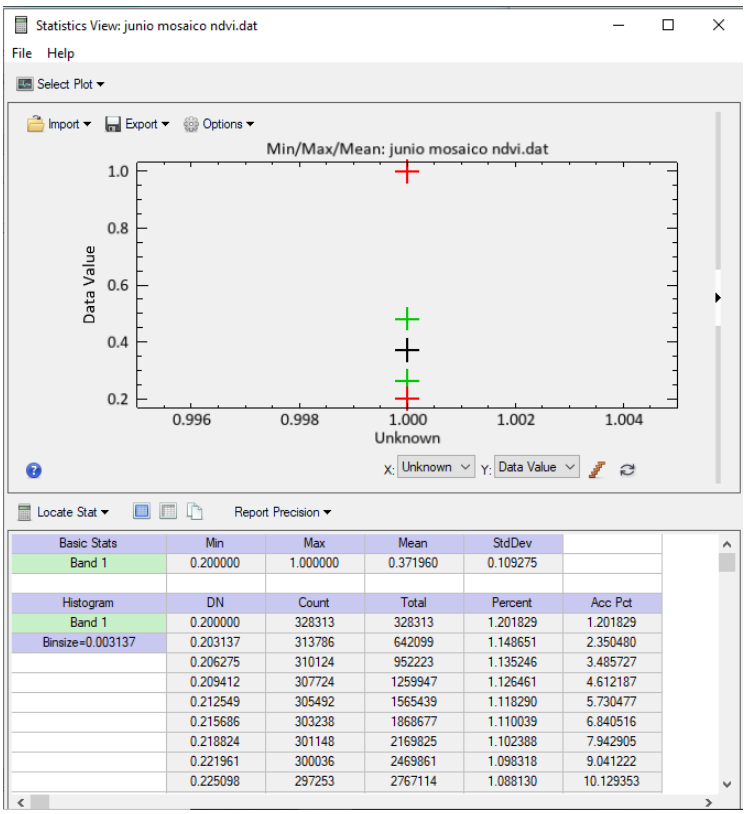



**Figure #4:** June 2020 NDVI Map of Puerto Rico




| Basic Stats | Min | Max | Mean | StdDev | |
|---|---|---|---|---|---|
| Band 1 | 0.100000 | 1.000000 | 0.324138 | 0.142133 | |
| | | | | | |
| Histogram | DN | Count | Total | Percent | Acc Pct |
| Band 1 | 0.100000 | 366737 | 366737 | 1.021603 | 1.021603 |
| Binsize=0.003529 | 0.103529 | 356875 | 723612 | 0.994131 | 2.015734 |
| | 0.107059 | 356871 | 1080483 | 0.994120 | 3.009854 |
| | 0.110588 | 356173 | 1436656 | 0.992175 | 4.002029 |
| | 0.114118 | 353700 | 1790356 | 0.985286 | 4.987315 |
| | 0.117647 | 351706 | 2142062 | 0.979732 | 5.967047 |
| | 0.121176 | 350150 | 2492212 | 0.975397 | 6.942445 |
| | 0.124706 | 349794 | 2842006 | 0.974406 | 7.916850 |
| | 0.128235 | 350359 | 3192365 | 0.975980 | 8.892830 |

**Figure #5:** Quick Stats for March 2020




| Basic Stats | Min | Max | Mean | StdDev | |
|---|---|---|---|---|---|
| Band 1 | 0.200000 | 1.000000 | 0.371960 | 0.109275 | |
| | | | | | |
| Histogram | DN | Count | Total | Percent | Acc Pct |
| Band 1 | 0.200000 | 328313 | 328313 | 1.201829 | 1.201829 |
| Binsize=0.003137 | 0.203137 | 313786 | 642099 | 1.148651 | 2.350480 |
| | 0.206275 | 310124 | 952223 | 1.135246 | 3.485727 |
| | 0.209412 | 307724 | 1259947 | 1.126461 | 4.612187 |
| | 0.212549 | 305492 | 1565439 | 1.118290 | 5.730477 |
| | 0.215686 | 303238 | 1868677 | 1.110039 | 6.840516 |
| | 0.218824 | 301148 | 2169825 | 1.102388 | 7.942905 |
| | 0.221961 | 300036 | 2469861 | 1.098318 | 9.041222 |
| | 0.225098 | 297253 | 2767114 | 1.088130 | 10.129353 |

**Figure #6:** Quick Stats for June 2020

## B. MOPITT

In the worldview for the MOPITT L3 product in Figure #7 and #8, it can be observed that there was a global reduction of CO. In places like China and Africa, CO reduced from an extensive area of 400ppm to something between 280ppm-300ppm. For the Caribbean area, CO ranged from 80ppm to around 120ppm during the month of March 2020. After regulations, the CO range decreased to an average of 60ppm to 80ppm which is a substantial difference.

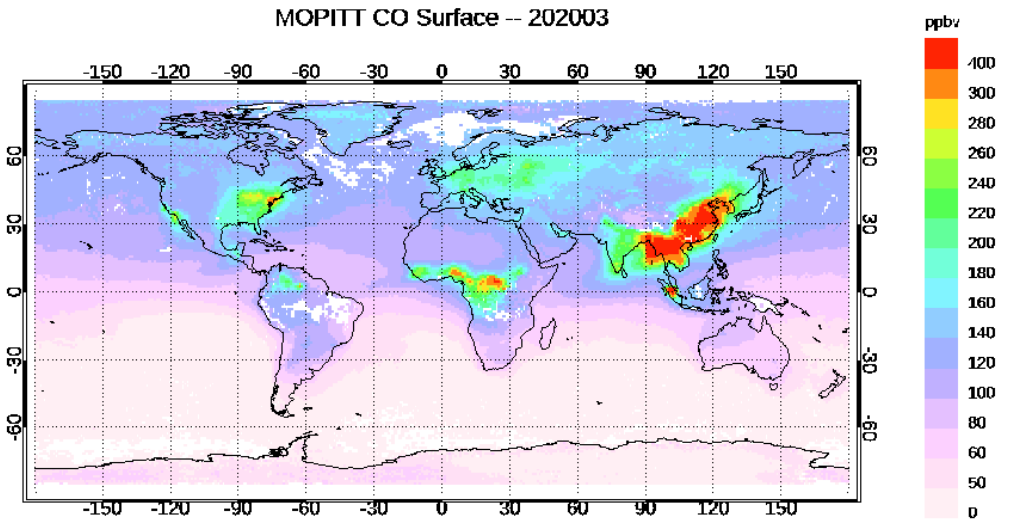



**Figure #7:** MOPITT worldwide view for CO Surface concentration during the month of March 2020.

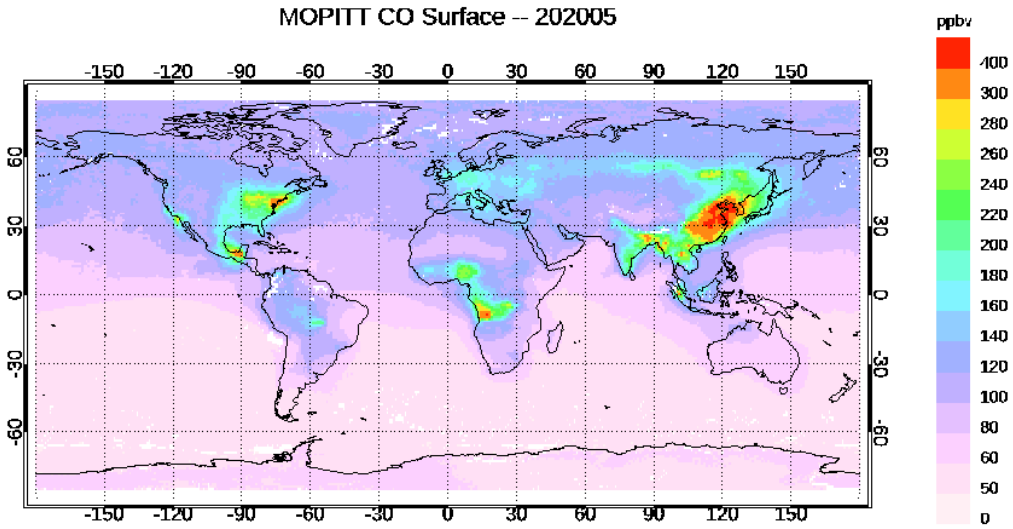



**Figure #8:** MOPITT worldwide view for CO Surface concentration during the month of May 2020.

Quantitatively in Figure #9 and #10 it can be observed that the average CO Mixing Ratio Surface decreased from 173.98ppm to 126.419ppm after quarantine

regulations. In both of the figures it is seen that CO decreases gradually from the surface to the 500hPa pressure line. For the month of March 2020 in Figure #9, the change went from a 173.978ppm to 87.999ppm which accounts for a 85.979ppm difference. For the month of May 2020 in Figure #10, the change went from a 126.419ppm to 85.822ppm which accounts for a 40.597ppm difference which is half of the CO March difference but proves that there is a decrease in the CO Mixing Ratio Surface for the month of May 2020.

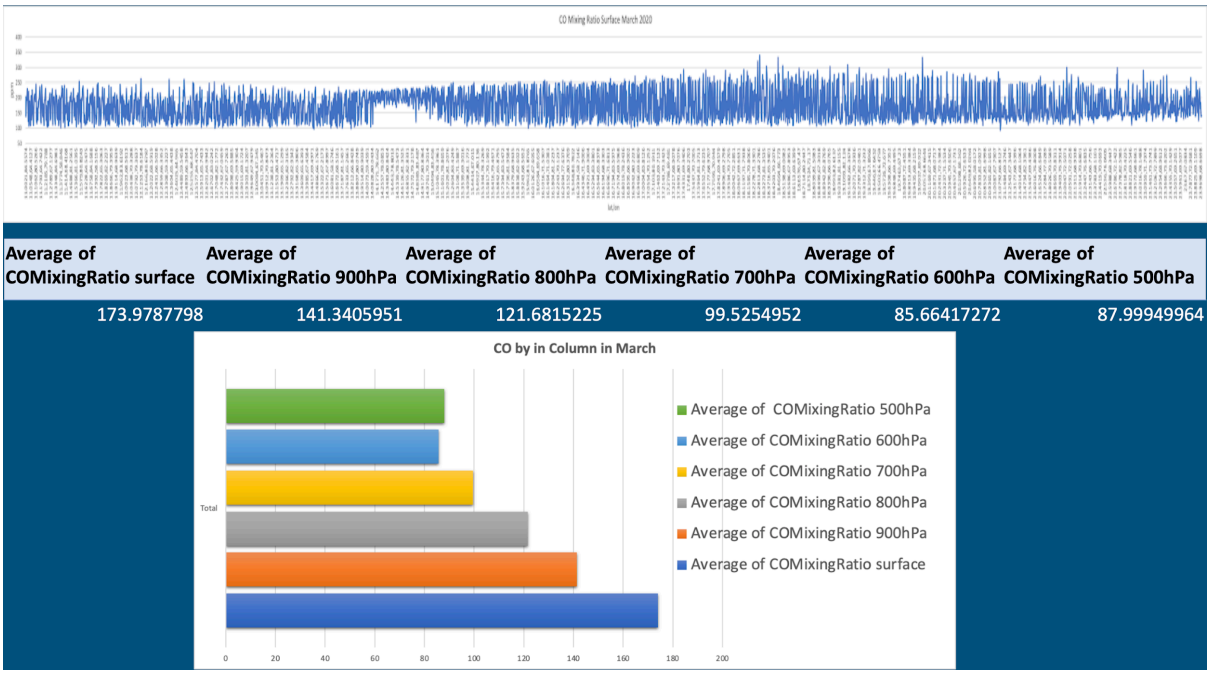



**Figure #9:** MOPITT Caribbean data statistics for CO concentration during the month of March 2020.

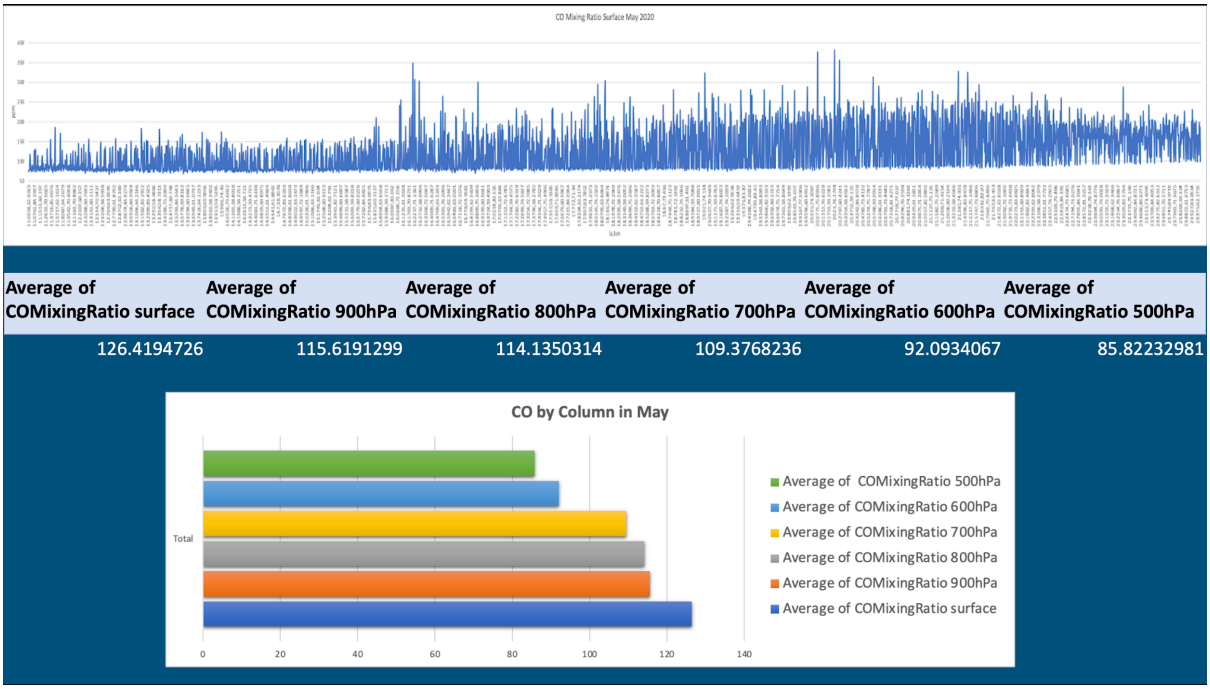



**Figure #10:** MOPITT Caribbean data statistics for CO concentration during the month of May 2020.

## C. MODIS

In Figures #11, #12, and #13, chlorophyll concentration per cubic meter of seawater for the whole world each month of March 2020, May 20202 and May 2019. Areas of low quantity of phytoplankton and where chlorophyll amounts were low are denoted by blue. Areas of high quantity of phytoplankton and where chlorophyll amounts were higher are denoted by dark green. Chlorophyll seasonal variability can be seen at the images, when comparing differences between a year and another.

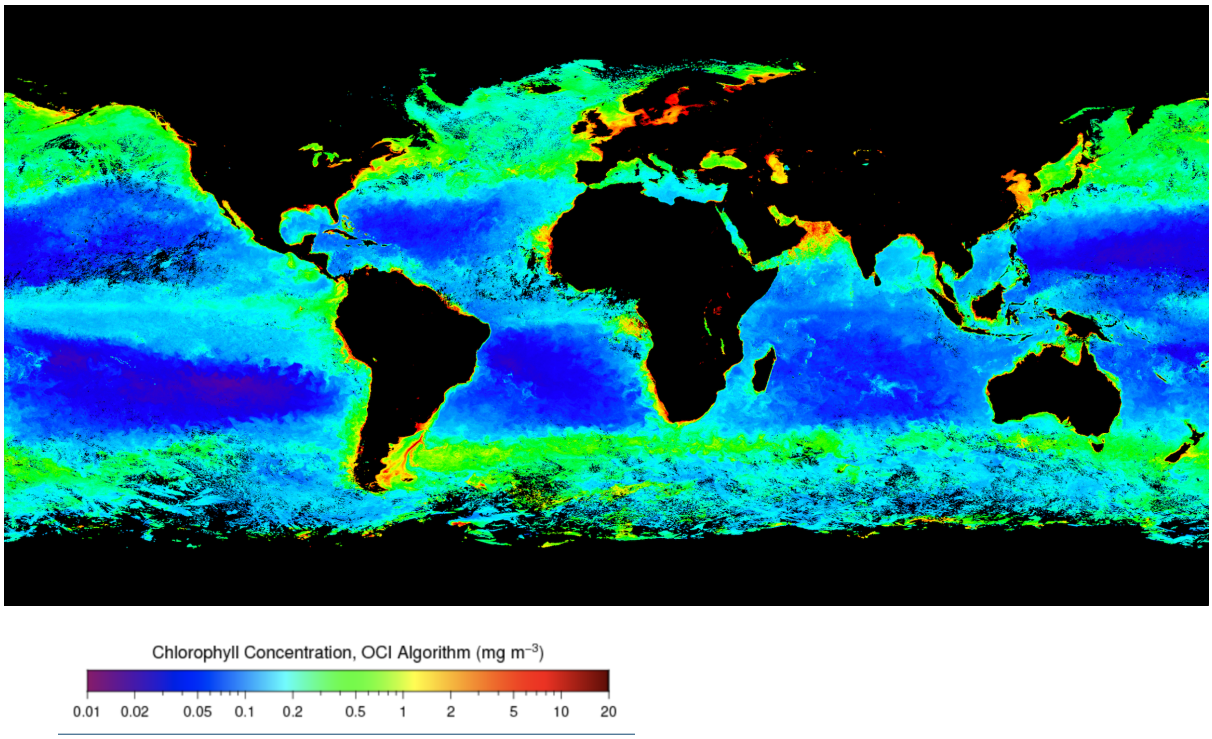



**Figure #11:** Terra MODIS L3 worldwide view for Chlorophyll concentration during the month of March 2020.

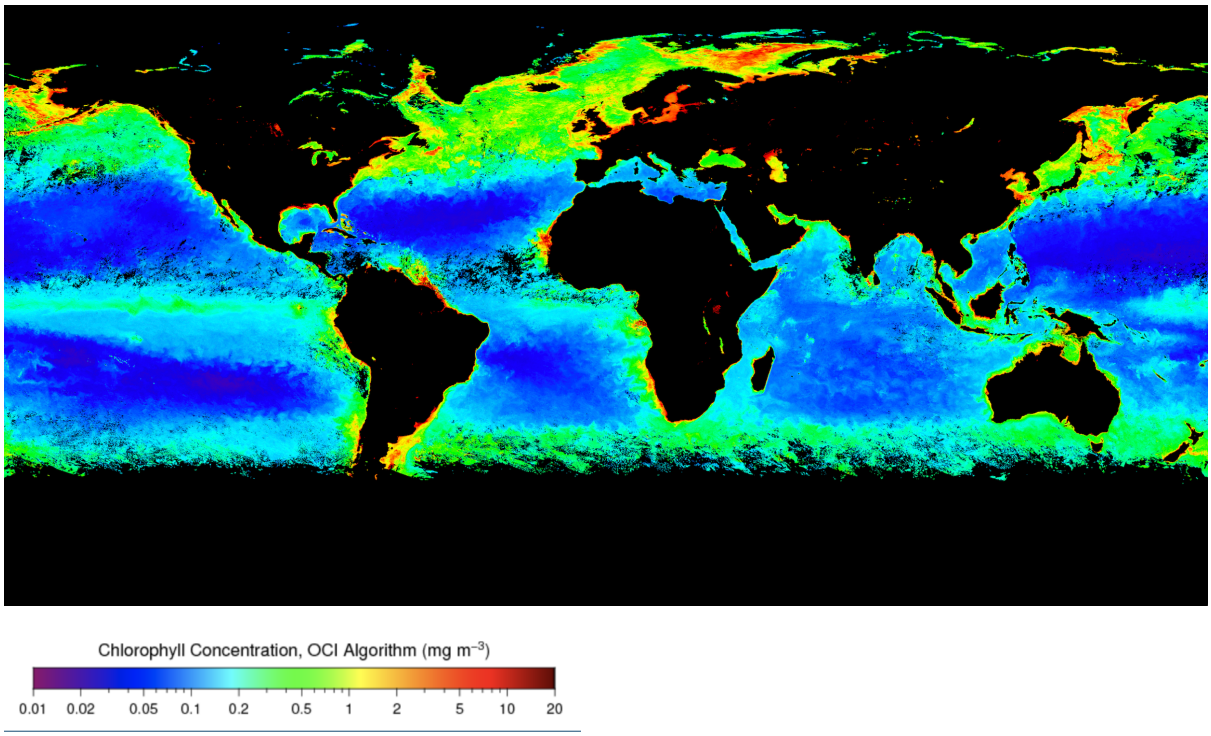



**Figure #12:** Terra MODIS L3 worldwide view for Chlorophyll concentration during the month of May 2020.

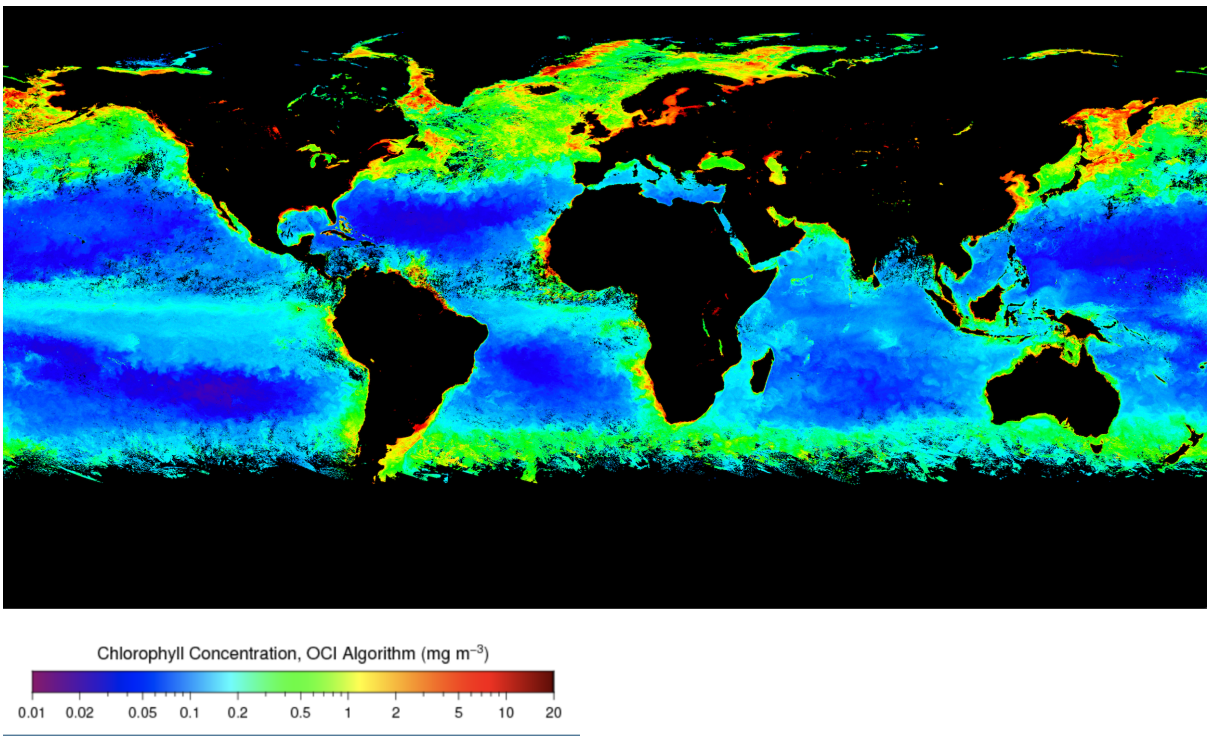
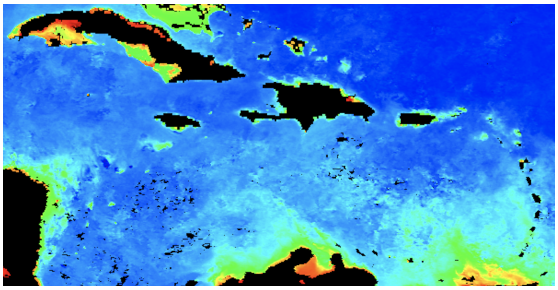
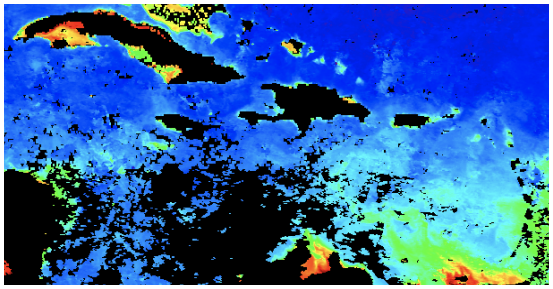



**Figure #13:** Terra MODIS L3 worldwide view for Chlorophyll concentration during the month of May 2019.

For Figures #14 and #15 a comparison is made for the months of March 2020 and May 2020. It can be seen that for the month of May, Chlorophyll concentrations are higher for the 2020 year, meaning that phytoplankton living in coastal areas have the necessary nutrients to survive. Also, when comparing the March 2020 to the May 2020 image, Chlorophyll concentrations are higher in May, when it should be in March because of cooler waters. It can be said that the human-activity reduction due to COVID-19, can be seen looking at ocean water color images.





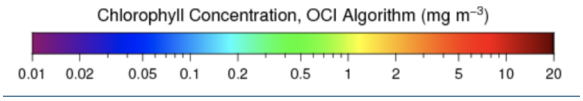



**Figure #14:** Terra MODIS L3 Caribbean view for Chlorophyll concentration during the month of March 2020(left) and May 2020(right).

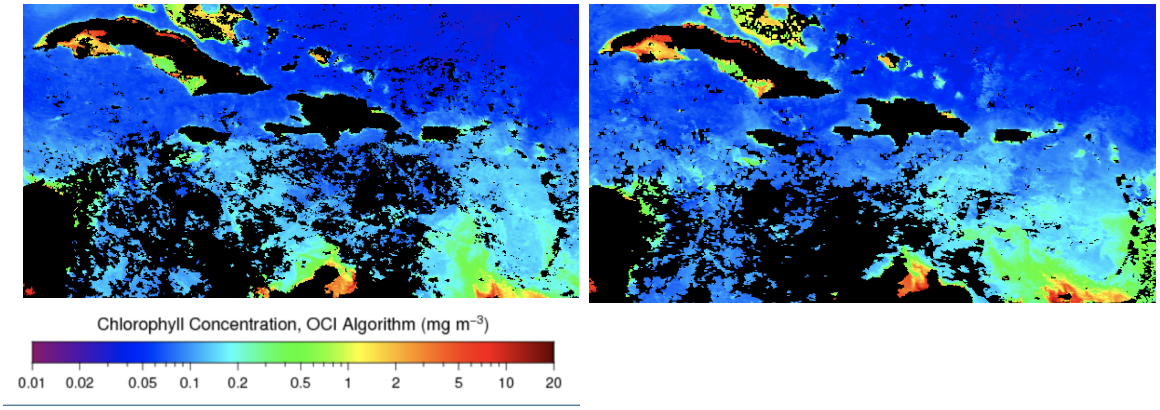



**Figure #15:** Terra MODIS L3 Caribbean view for Chlorophyll concentration during the month of May 2019(left) and May 2020(right).

## IV. Conclusions

It can be said that COVID-19 has influenced human activity and thus environmental factors have changed. In some places some factors have changed more than others, for example, vegetation cannot be seen clearly in Puerto Rico, but was seen clearly in other studies. A clear and impactful change in atmospheric composition was CO concentration over the Caribbean and the whole world. Analyses indicate that numbers decreased way lower than the average indication that anthropogenic emissions will continue to be a worrying component when all quarantine regulations are lifted, and humans return to normal. Some of the highest CO concentrations during the month of May in the Caribbean account for the Dominican Republic, which according to the CDC, during the timeframe of this study, no quarantine regulations were in place. Chlorophyll concentrations seem to be higher after COVID-19 and this is due to the lack of movement in the ports of some of the islands. Without the

continuous arrival of tourists, phytoplankton have more nutrients available than usual and thus chlorophyll concentration is higher than normal. This study makes a scientific contribution to understanding the impact anthropogenic activities have on the environment and how COVID-19 indirectly helped lessen environmental impact.

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