UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH

Escola Superior d'Enginyeries Industrial, Aeroespacial i Audiovisual de Terrassa

ROBOTIC EXPLORATION OF THE SOLAR SYSTEM

REMOTE SENSING OF EARTH PROJECT

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1 Reason of interest

For this project, we choose the Great Barrier Reef in Australia since it is the world's largest living structure and, in fact, it is so large that it can be seen from space. It is the home for a massive amount of species. Sadly, climate change, water pollution and overfishing have led to the destruction of large areas of the Great Barrier Reef's coral systems and the species that live there in recent years.

Figure 1: Great Barrier Reef in Australia

2 Problem Definition

The goal in this project was to evaluate the temperature and chlorophyll levels in the Great Barrier Reef in Australia for different years (2005, 2010, 2015 and 2020) and for summer and winter of each one of those years. The natural and false colours were also analysed.

In order to extract the data for each year and for each season, the summer and winter periods correspond to those in Australia. Therefore, summer was considered to be from December to February and winter from June to August.

More specifically, the area represented in the figure was chosen for the analysis carried out during this report.

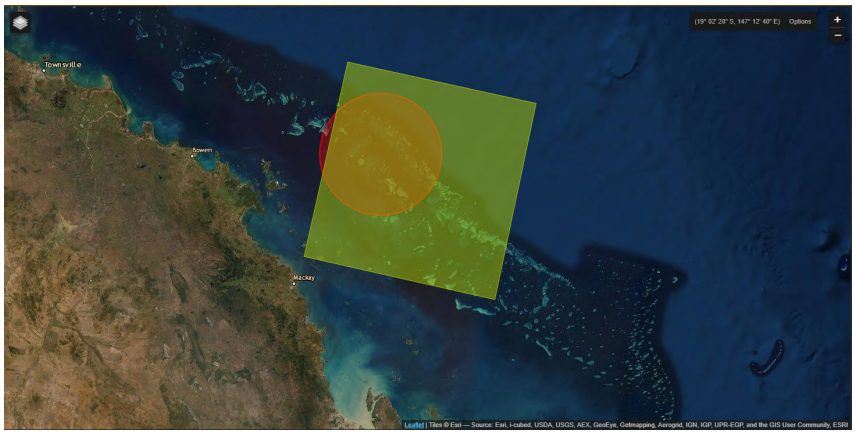

Figure 2: Earth View

3 Data source

This section contains all the details about the data used in this project, including the path, row, date and ID for each year and season.

	ID	Date	Path	Row
Summer 2005	LT05_L2SP_092074_20050104_20200902_02_T1	04/01/2005	92	74
Winter 2005	LT05_L2SP_092074_20050715_20200902_02_T1	15/07/2005	92	74
Summer 2010	LT05_L2SP_092074_20091201_20200825_02_T1	01/12/2009	92	74
Winter 2010	LT05_L2SP_092074_20100814_20200823_02_T1	14/08/2010	92	74
Summer 2015	LC08_L2SP_092074_20141215_20200910_02_T1	15/12/2014	92	74
Winter 2015	LC08_L2SP_092074_20150812_20200908_02_T1	12/08/2015	92	74
Summer 2020	LC08_L2SP_092074_20200114_20200823_02_T1	14/01/2020	92	74
Winter 2020	LC08_L2SP_092074_20200809_20200917_02_T1	09/08/2020	92	74

In order to have access to the images, the following link was also created:
`https://drive.google.com/drive/folders/1DjWKZHbFBegIy8qWsso7F7GsmsYc3OQG?usp=sharing`

4 Temperature

In this section the goal is to compare the temperature in the years of 2005, 2010, 2015 and 2020 both in summer and winter seasons.

Starting with the analysis in Summer, in 2005 is clear to conclude, by observing the figure 3 that there are really hot temperatures, specially in the bottom of the image, and also some areas with lower temperatures. Then, after 5 years, in 2010, it is possible to observe in figure 4 there was a sharp drop in the temperature that can be an indicator of the La Niña Phenomenon. This phenomenon is a pattern that describes the unusual cooling of the region's surface in the central and eastern tropical Pacific Ocean and makes part of a large phenomenon called the El Niño-Southern Oscillation (ENSO). The ENSO also includes another phenomenon called El Niño that is a a climate pattern that describes the unusual warming of the surface waters in the eastern equatorial Pacific Ocean. In fact this phenomenon can be seen 5 years later, in 2015, where in figure 5 it can be clearly observe a significant rise in temperature (warming of the water)compared to the previous example in 2010. Finally, observing the figure 6, it can be seen that during the last 5 years (from 2015 to 2020), the rise in temperature continued, with high temperatures visible throughout the all region.

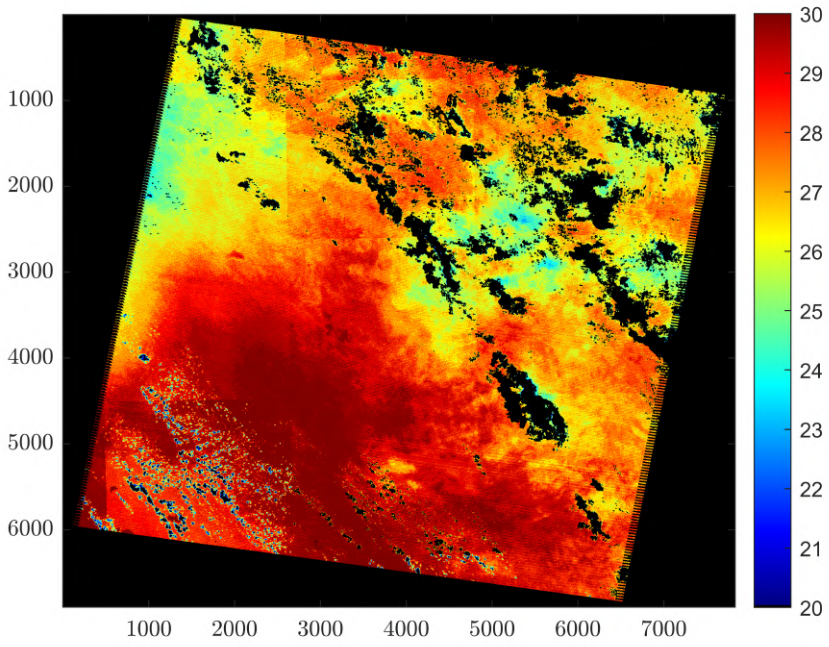

Figure 3: Temperature ($°C$) Summer 2005 from Landsat 5 Band 6

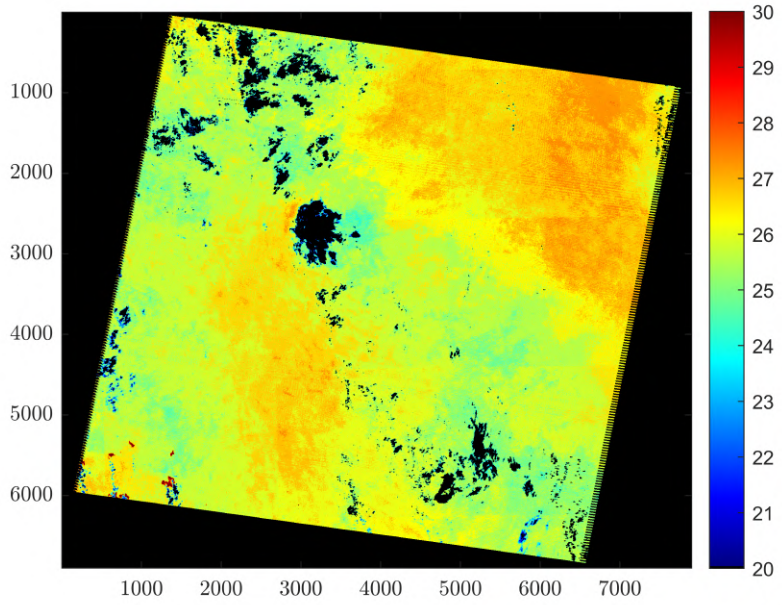

Figure 4: Temperature ($°C$) Summer 2010 from Landsat 5 Band 6

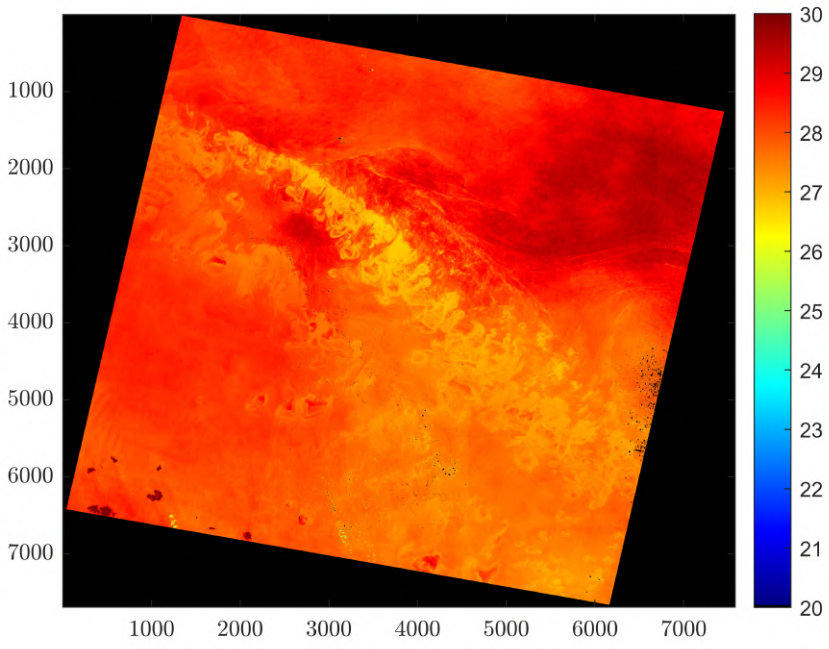

Figure 5: Temperature ($°C$) Summer 2015 from Landsat 8 Band 10

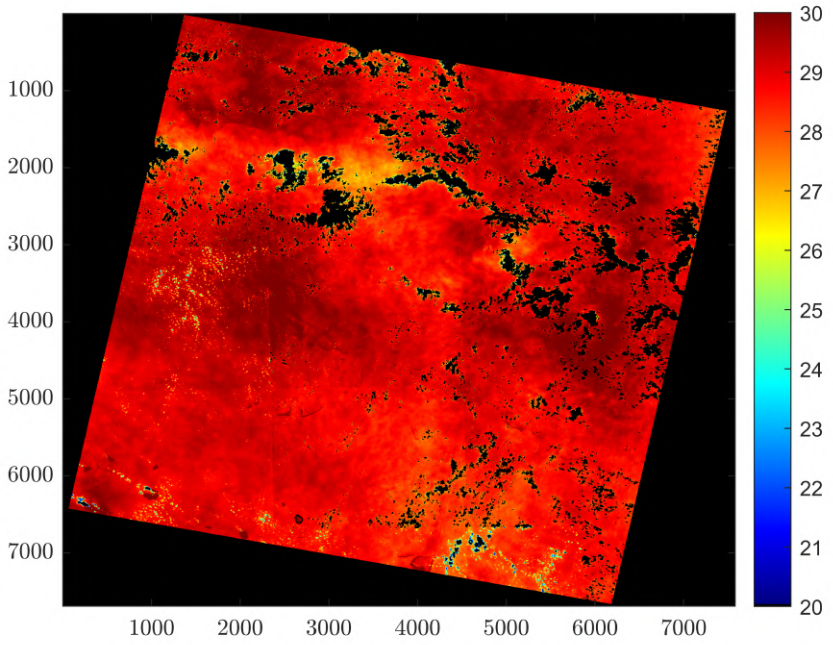

Figure 6: Temperature ($°C$) Summer 2020 from Landsat 8 Band 10

The next step is to analyse the Winter in each of the years. It is easy to conclude that from Summer to Winter there is a sharp drop of temperature of approximately 5° which is normal. In this way, observing figures 7, 8, 9 and 10, there are no very marked differences from year to year since the temperature values observed in any of the figures are quite similar.

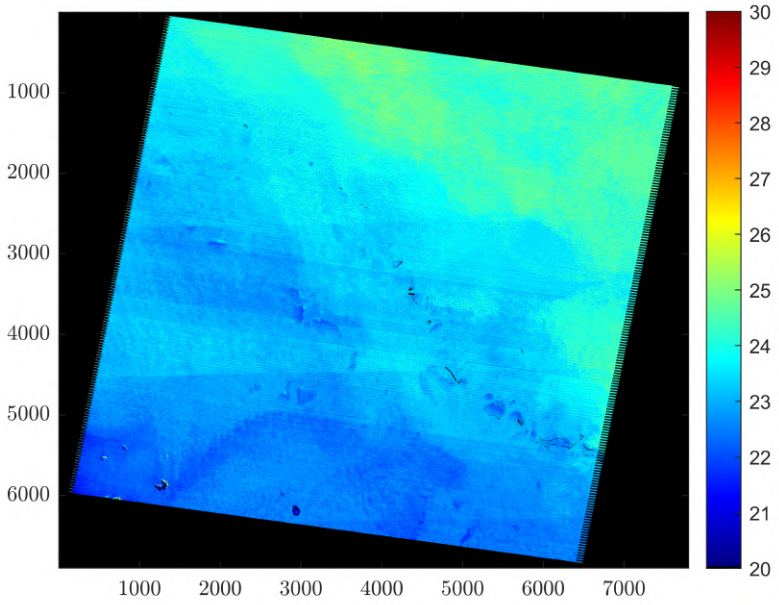

Figure 7: Temperature ($°C$) Winter 2005 from Landsat 5 Band 6

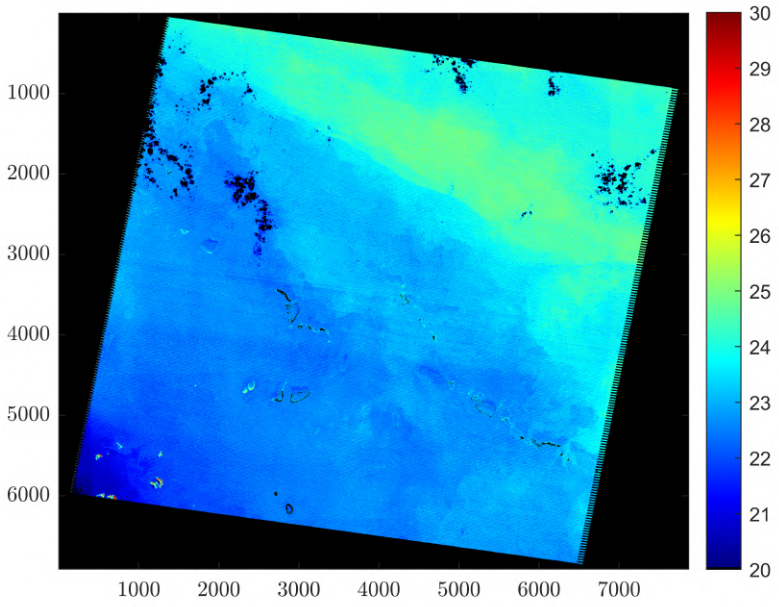

Figure 8: Temperature ($°C$) Winter 2010 from Landsat 5 Band 6

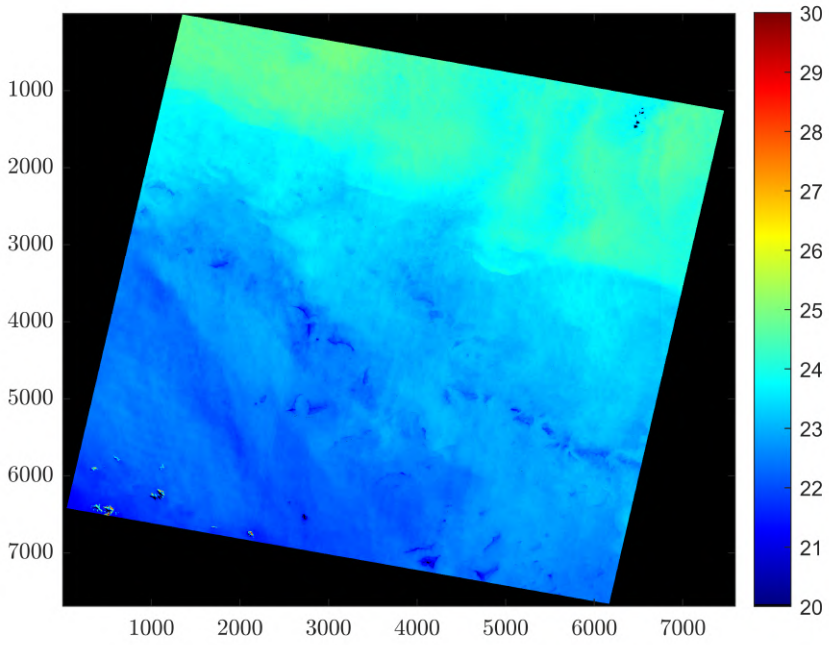

Figure 9: Temperature ($°C$) Winter 2015 from Landsat 8 Band 10

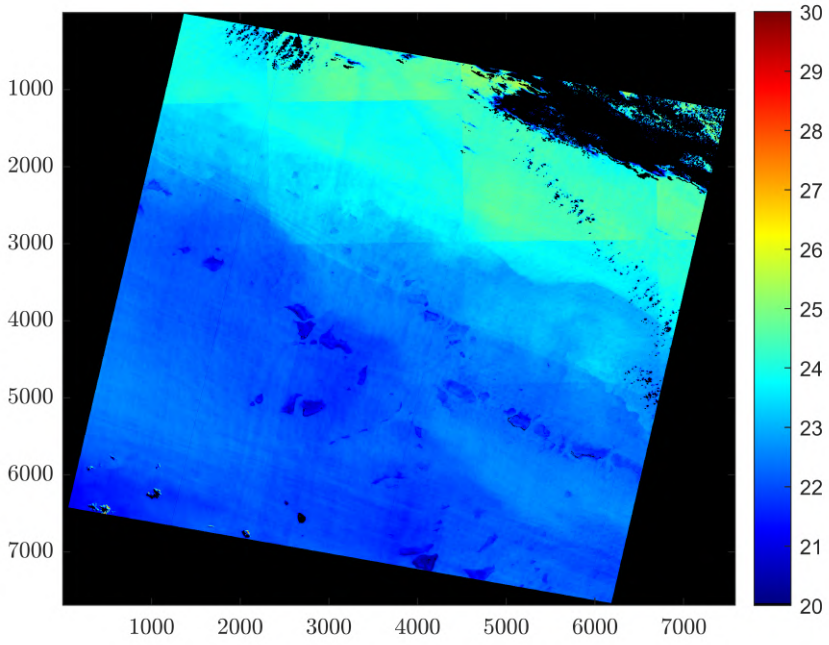

Figure 10: Temperature ($°C$) Winter 2020 from Landsat 8 Band 10

5 Chlorophyll

Another important analysis is the chlorophyll concentration (in mg/m^3), since it is an indicator of whether the corals are healthy.

An interesting event to observe in this analysis would be coral bleaching. Coral bleaching happens when the corals are stressed by changes in conditions such as temperature, light or nutrients. Therefore, when the water is too warm or too cold (situations of extreme temperatures), the corals expel the symbiotic algae called *zooxanthellae* living in their tissues causing them to turn completely white.

Starting in the Summer of 2005 , as can be observed in the figure 11, the concentration of chlorophyll in the region was not very high being the highest value equal to 0.7 mg/m^3.

Then, returning to the previous analysis regarding temperature in the Summer, it was seen that from 2005 to 2010 the La Niña (cooling) incident happens and from 2010 to 2015 there is the El Niño (warming) episode. In this way, and taking into account the presented definition of coral bleaching, it is expected to observe this bleaching of the corals since La Niña and El Niño caused extreme differences in temperature. Therefore, it can really be seen in the figure 12, where there are clear white areas in the corals, indicative of huge bleaching.

Afterwards, in 2015 as can be seen in figure 13, there is no more coral bleaching and the concentration of chlorophyll in the corals is bigger than in the surroundings. Then, 5 years later, in 2020 as can be seen in figure 14, there was an increase in the concentration of chlorophyll in the region.

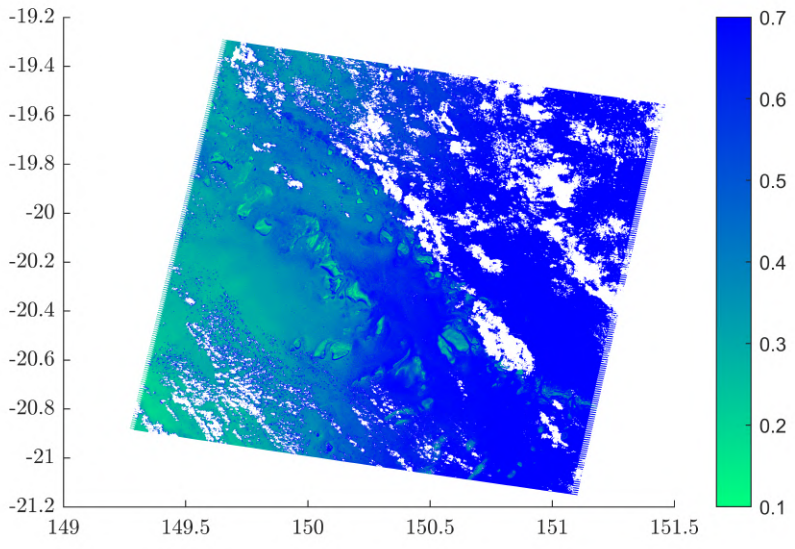

Figure 11: Chlorophyll (mg/m^3) Summer 2005 from Landsat 5 Band 1, 2, 3 and QA_pixel

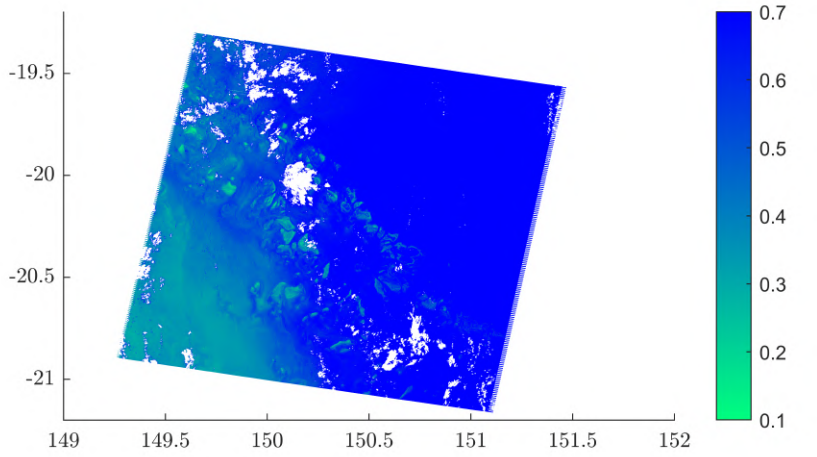

Figure 12: Chlorophyll (mg/m^3) Summer 2010 from Landsat 5 Band 1, 2, 3 and QA_pixel

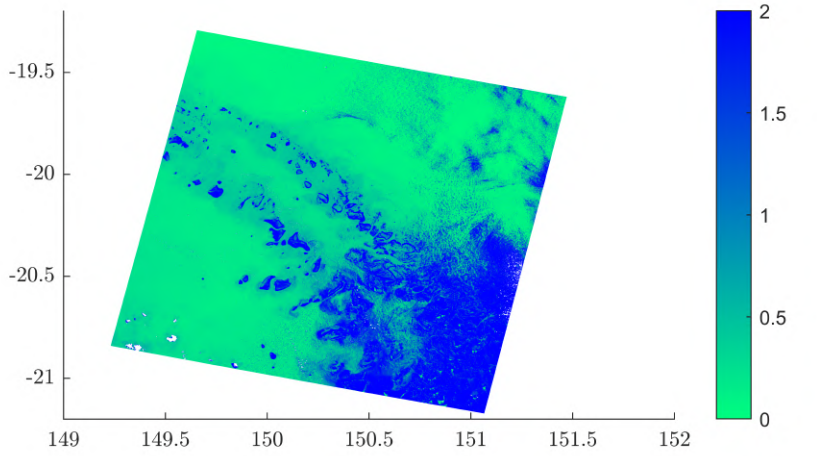

Figure 13: Chlorophyll (mg/m^3) Summer 2015 from Landsat 8 Band 1, 2, 3 and QA_pixel

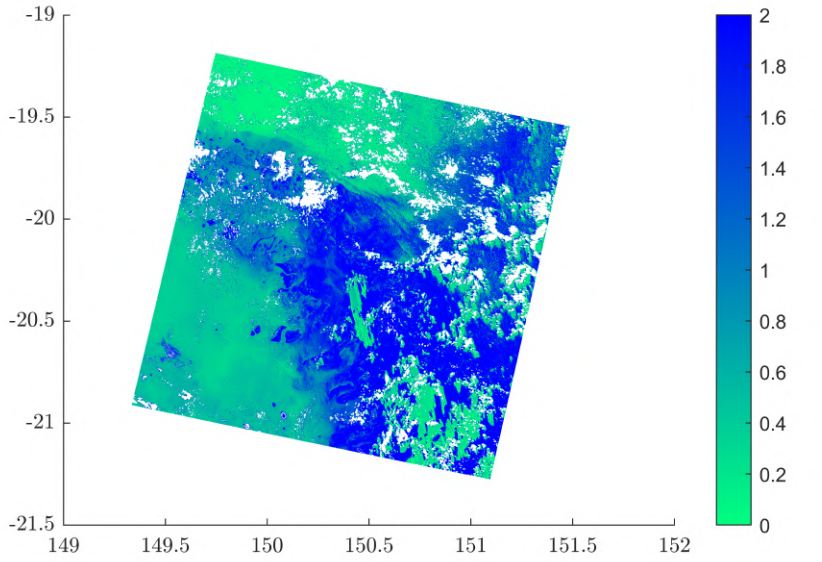

Figure 14: Chlorophyll (mg/m^3) Summer 2020 from Landsat 8 Band 1, 2, 3 and QA_pixel

Finally, analysing the concentration of chlorophyll in the Winter, it can be concluded that from 2005 (figure 15) to 2010 (figure 16) there are no major differences and the corals have the highest concentration comparing to the surroundings, as can be seen by the blue colour of the graph. Subsequently, in 2015, observing the figure 17, there was an increase in the concentration of chlorophyll not only in the corals themselves but in the region around, which remains relatively the same in 2020 as illustrated in the figure 18.

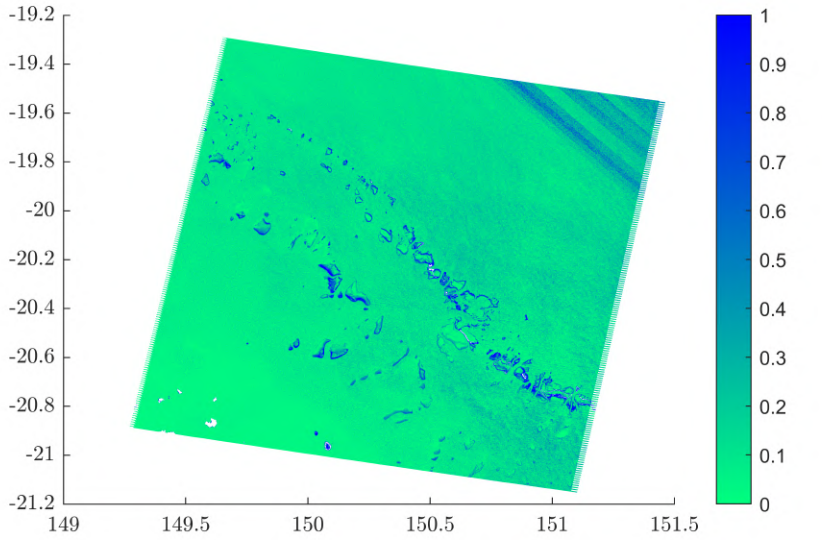

Figure 15: Chlorophyll (mg/m^3) Winter 2005 from Landsat 5 Band 1, 2, 3 and QA_pixel

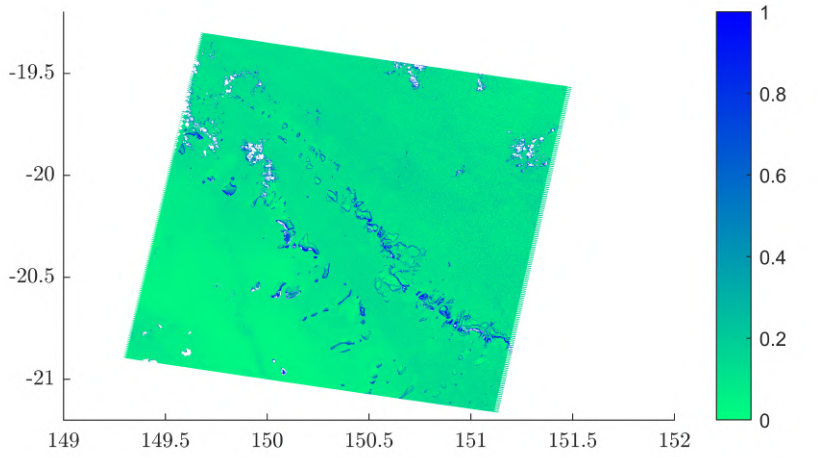

Figure 16: Chlorophyll (mg/m^3) Winter 2010 from Landsat 5 Band 1, 2, 3 and QA_pixel

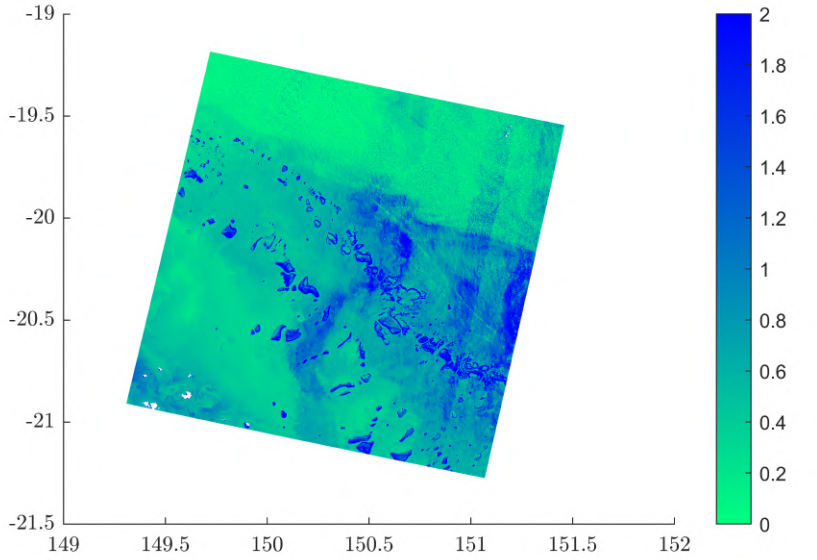

Figure 17: Chlorophyll (mg/m^3) Winter 2015 from Landsat 8 Band 1, 2, 3 and QA_pixel

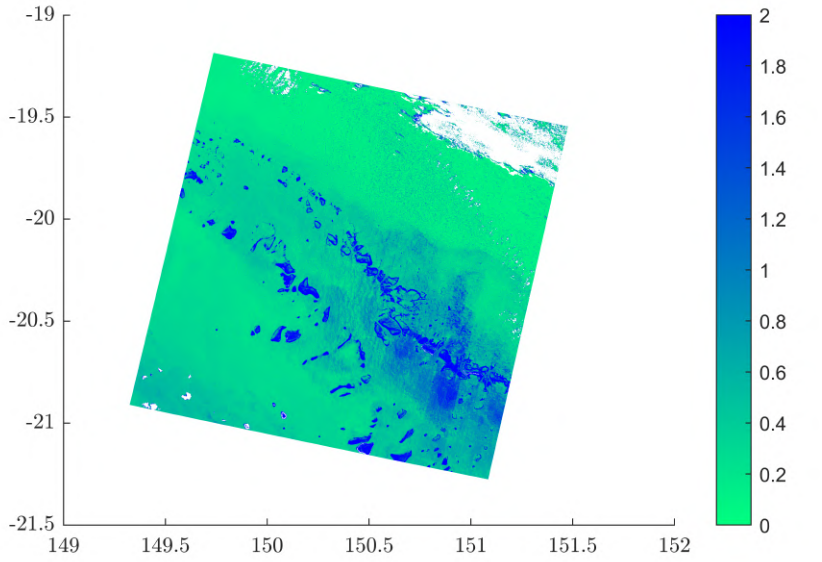

Figure 18: Chlorophyll (mg/m^3) Winter 2020 from Landsat 8 Band 1, 2, 3 and QA_pixel

6 Natural Colour and False Colour

A natural colour composite is an image displaying a combination of the visible red, green and blue bands to the corresponding red, green and blue channels on the computer display. The resulting composite resembles what would be observed naturally by the human eye: vegetation appears green, water dark is blue to black and bare ground and impervious surfaces appear light gray and brown. Therefore, the bands 2,3,4 were used for Landsat 5 (2005 and 2010) and the bands 3,2,1 were used for Landsat 8 (2015 and 2020).

False colour images are a representation of a multi spectral image produced using any bands other than visible red, green and blue as the red, green and blue components of the display. False colour composites allow us to visualize wavelengths that the human eye can not see. Therefore, the bands were used for Landsat 5 (2005 and 2010) and the bands were used for Landsat 8 (2015 and 2020).

In the following images, it is possible to see that with using the natural colour allows to see clearer the corals and using the false colour it is possible to notice, in the left corner of the image as can be seen for example in figures 24 and 30, the land represented in green.

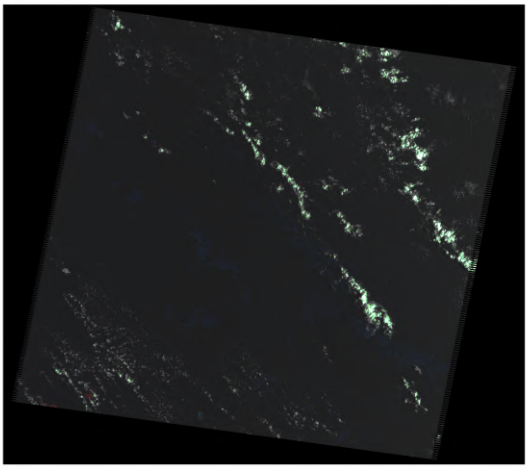

Figure 19: Original image Summer 2005

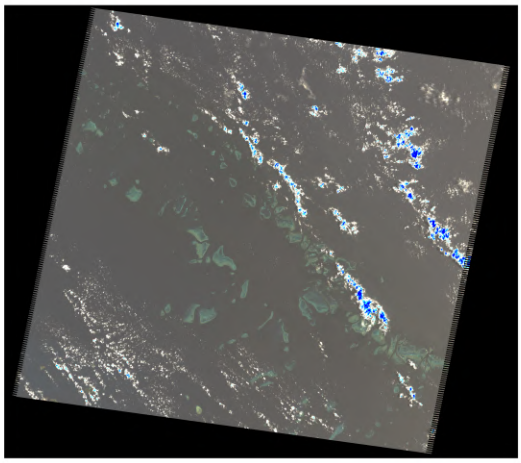

Figure 20: Natural Colour Summer 2005

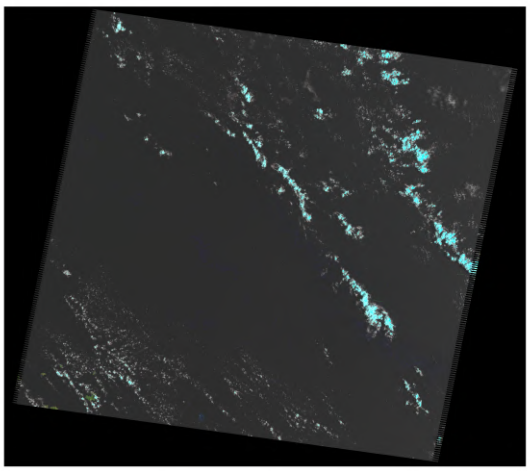

Figure 21: False Colour Summer 2005

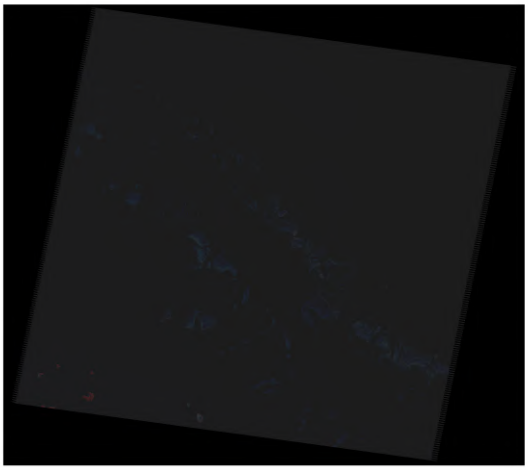

Figure 22: Original image Winter 2005

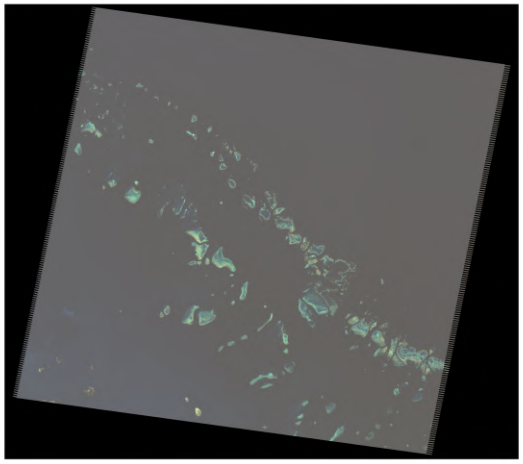

Figure 23: Natural Colour Winter 2005

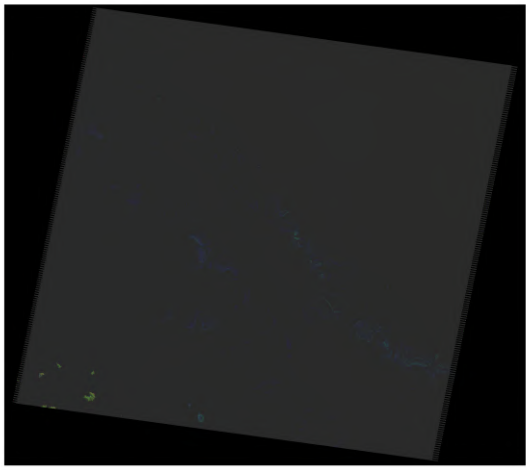

Figure 24: False Colour Winter 2005

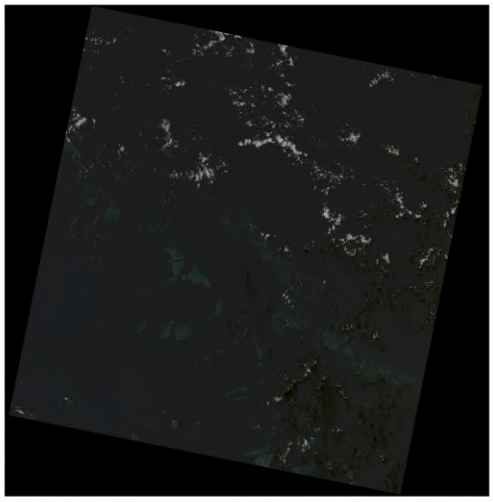

Figure 25: Original image Summer 2020

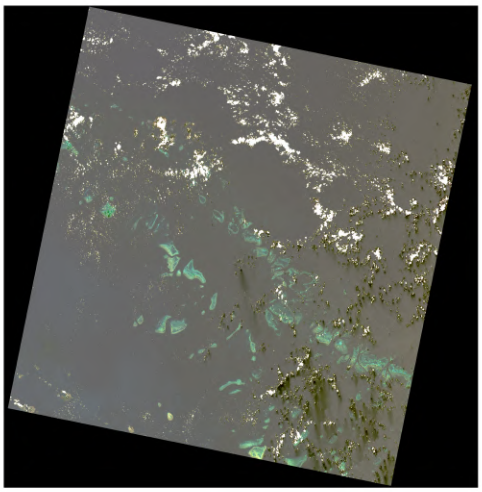

Figure 26: Natural Colour Summer 2020

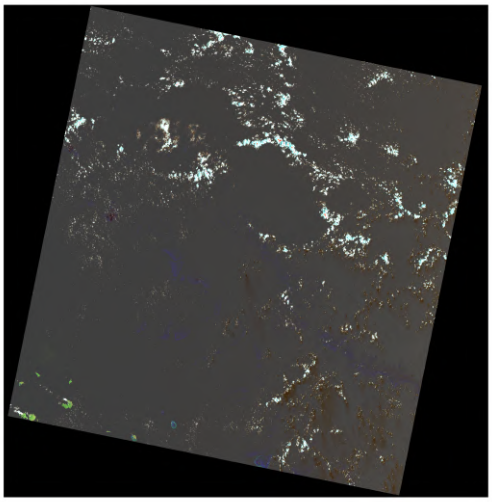

Figure 27: False Colour Summer 2020

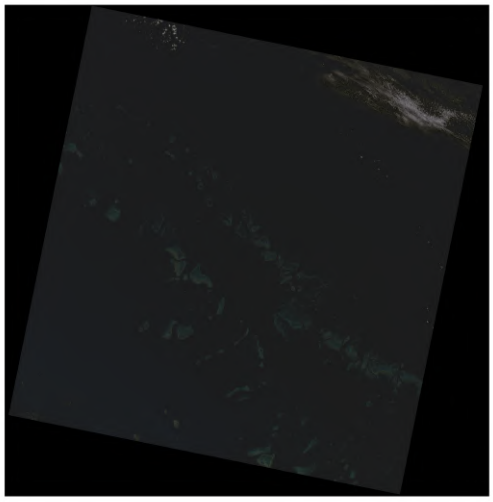

Figure 28: Original image Winter 2020

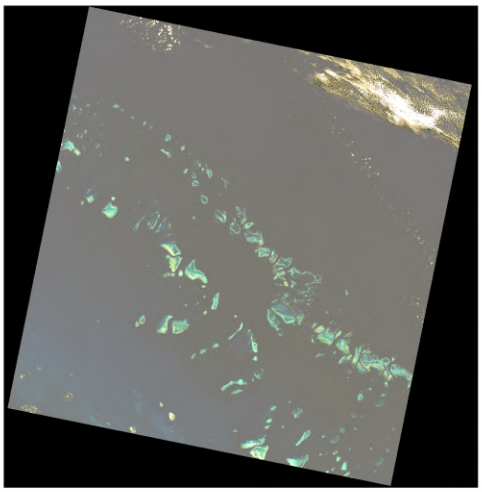

Figure 29: Natural Colour Winter 2020

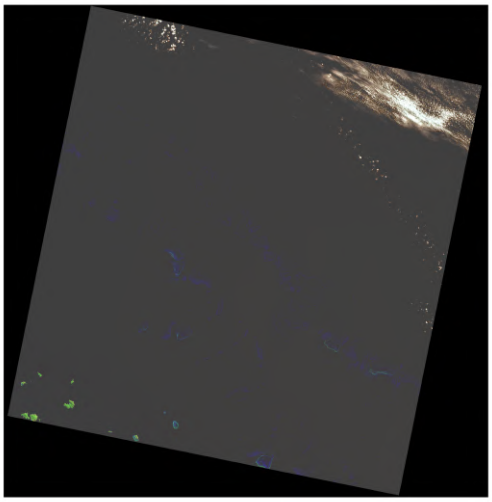

Figure 30: False Colour Winter 2020

References

[1] Olivia Rosane. *2020 Great Barrier Reef Bleaching Event Is Most Widespread to Date.* URL: https://www.ecowatch.com/great-barrier-reef-bleaching-2020-2645655957.html.

[2] Lindsay Patterson. *Mark Eakin: 2010 Is Bad Year For Coral Reefs Around The World.* URL: https://earthsky.org/earth/mark-eakin-warm-oceans-causing-worldwide-coral-bleaching-in-2010.

[3] National Oceanic and Atmospheric Administration. *What is coral bleaching?* URL: https://oceanservice.noaa.gov/facts/coral_bleach.html.

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[5] El Niño. *El Niño.* URL: https://www.nationalgeographic.org/encyclopedia/el-nino/.