Deterioration of Survival Situation of world's largest living Structure —— The Great Barrier Reef

Introduction

In normal conditions, coral presents a variety of colors such as green, blue, yellow, brown, red, purple and so on. However, these colors are not owned by the coral itself, but from the symbiotic algae living inside the corals. Coral relies on the existence of tiny symbiotic algae in the body, and algae provide over 90% of the energy coral needs through photosynthesis. If the symbiotic algae leave or die, the coral will turn white and eventually die of nutrient loss. This phenomenon is called coral bleaching.

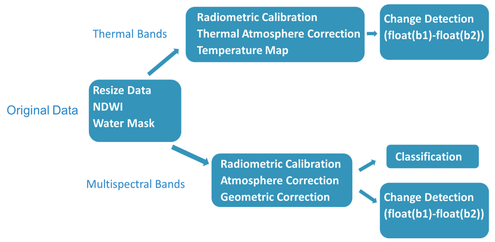
Three important and wide-range coral bleaching events used to happen in the history, respectively in 1998, 2002, 2014. The latest event lasted for nearly three years, which is the first time in history that coral bleaching happened consecutively in two years, and it caused great destruction to the Great Barrier Reef. Studies show that the record breaking ocean heat wave across Great Barrier Reef in 2016 has made most coral ecosystems at an unprecedented risk of collapse. Half of the coral reef is believed to have been killed in this event.

Project Goals

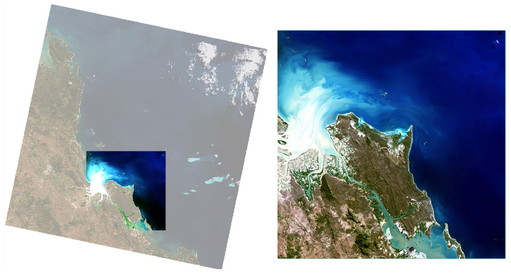
In this project, I will try to investigate the specific links between climate warming and the survival situation of the coral in Great Barrier Reef by comparing the temperature changes and the distribution of coral before and after the bleaching event.

Methodology

In this project, original data will be used for study of thermal research and distribution of coral reefs, which means that thermal bands will be used to obtain temperature maps, and multi-spectral bands will be used to analyze the distribution of coral reefs. Here is the main workflow.



The range of whole northeastern coastline of Australia is too wide for this project. So original data is resized to the short region near Gladstone. Three satellite images respectively obtained in July of 2002, 2013, and 2017.



The range of whole northeastern coastline of Australia is too wide for this project. So original data is resized to the short region near Gladstone. Three satellite images respectively obtained in July of 2002, 2013, and 2017 are used from USGS Earth-explorer.

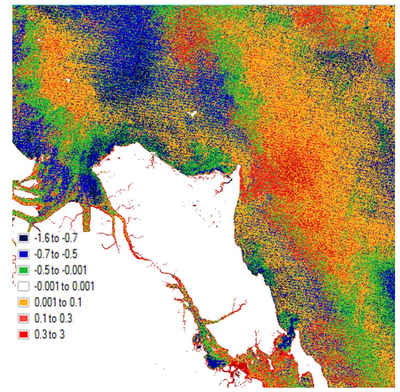
NDWI: $$\mathrm{NDWI} = \frac{\mathrm{Green} - \mathrm{NIR}}{\mathrm{Green} + \mathrm{NIR}}$$

Considering this project mainly focuses on water, it's better to remove land features. To extract water body, NDWI (normalized difference water index) is used to conduct normalization difference processing to enhance water information. The formula to calculate NDWI is based on the normalized ratio index of green band and near infrared band.

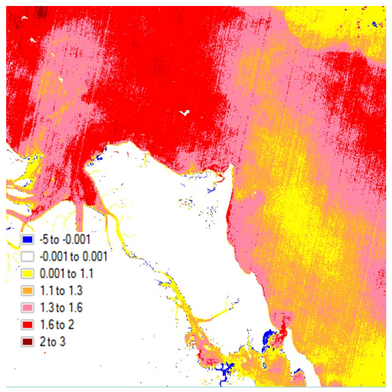
Results and Analysis

Temperature Change Detection

In these two maps, warm colors represent increase, while cool colors represent decrease. From 2002 to 2013, temperature hasn't changed a lot, so the climate is stable enough for corals to grow and recover. However, from 2013 to 2017, the picture shows a warm tone, indicating that the temperature of ocean has overall risen. Most areas have increased by 0 to 2 Kelvin. The El Nino phenomenon indeed seriously affects the ocean currents near the Great Barrier Reef, which is unfavorable to the growth of coral.



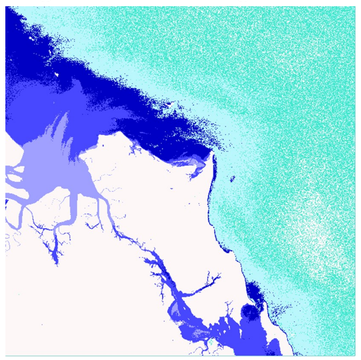
From 2002 to 2013



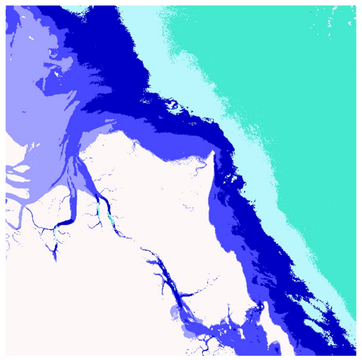
From 2013 to 2017

Reflectance Classification

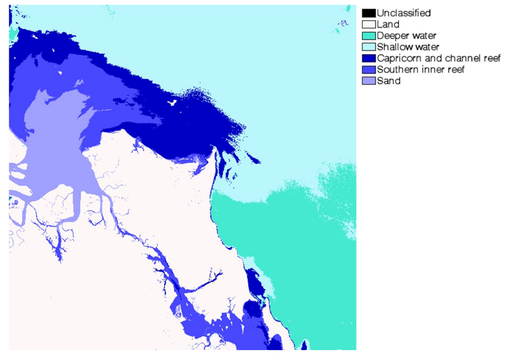
Classification results are finally determined by spectral curves. They show that the geographical features are divided into six types, two types of corals, deep water, shallow water, sand, and land. After bleaching event in 2002 ended, climate tends to become stable, and there is no large-scale temperature increase, so the next ten years could be a good recovery period for corals. It is obvious that the distribution area of coral is enlarged. However, after the outbreak of the El Nino in 2014, the Great Barrier Reef has suffered from a huge impact. It can be seen from the map that the area of coral has been sharply reduced, and the possibility of the recovery of the dead coral has been very little because of the prolonged water warming.



2002/7/24



2013/7/30



2017/7/30

Discussions

Remote sensing methods find that ocean warming caused the corals fading and dying from 2014 to 2017. However, the spectral characteristics of corals are complex. The six curves in this project are easy to be classified, but it is difficult to carry out more detailed classification by direct comparison of curves. A commonly used method is to carry out the first order differential equation of the spectral curve, and to enlarge the subtle changes in the spectrum. This work is not carried out in this project, which is a limitation. Although there are many difficulties in the application of remote sensing, the fine coral spectrum analysis is of great significance to the design of sensor bands and the monitoring of coral reef ecosystem. It is necessary to enrich the spectral data and establish a comprehensive spectral database of coral reef substrate.

Data Source: USGS Earth Explorer

References: Hedley JD, Roelfsema CM, Phinn SR, Mumby PJ. *Environmental and sensor limitations in optical remote sensing of coral reefs: implications for monitoring and sensor design.* Remote Sensing, 2012, 4(1): 271-302.

Joyce KE, Phinn SR. *Bi-directional reflectance of corals* [J]. International Journal of Remote Sensing, 2002(23）: 389- 394

Projected by: Ya Han

Presented on May 9, 2018

CEE-0189-01: Introduction to Remote Sensing

Thank you to Professor Magaly Koch and Vahid Rashidian

Tufts UNIVERSITY | School of Engineering