Assessment of Lake Water Quality and Quantity Using Satellite Remote Sensing

CUNY CREST HIRES

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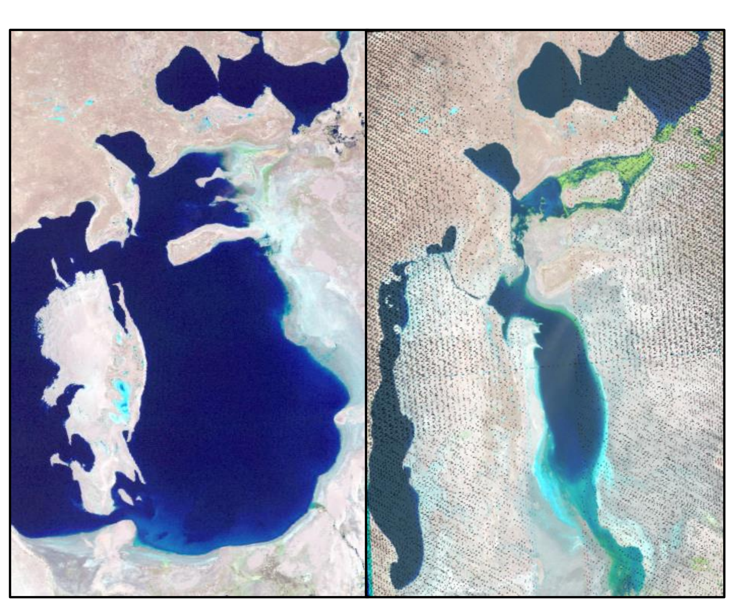
Background

- Remote sensing uses sensors mounted on satellites or aeroplanes to record reflected or emitted electromagnetic energy from the Earth's surface, without physically coming into contact with it. Since the amount of energy reflected at a specific wavelength depends on the intervening medium and the optical characteristics of the surface, features that have different optical properties can be distinguished by analyzing the reflectance in different portions of the electromagnetic spectrum [1].
- Higher spatial and temporal resolution satellite data also allows for the continuous monitoring of various environmental parameters across large regions, making it ideal for the assessment of water quality and quantity. In addition to physical properties such as surface area, remote sensing can be used to characterize optically active water constituents such as chlorophyll and total suspended solids [2].

Introduction

- Pollution from domestic, agricultural, and industrial wastes have resulted in excess sediment loading and nutrient enrichment, specifically nitrogen and phosphorus, contributing to the development of harmful algal blooms and eutrophication. Although these are natural processes that occur with ecological succession, anthropogenic activities have been shown to greatly accelerate them [3]. This is particularly concerning for freshwater ecosystems such as lakes as it can lead to a decrease in dissolved oxygen levels, fish kills, and consequently, a loss of biodiversity [4].
- In this study, 5 lakes will be analyzed using the Geographic Information System Mapping Technology, ArcMap. The lakes were each chosen for their significance to local communities: Aral Sea, Lake Dojran, Lake Kasumigaura, Lake Maggiore, and Lake Skaneateles.



Aral Sea in 1997 and 2017, respectively

Rationale

Current methods of water assessment rely heavily upon the collection of samples through geological field surveys and laboratory analysis of the respective samples, afterwards. Although these in-situ measurements offer high accuracy, they are often very time consuming and labor intensive [5].

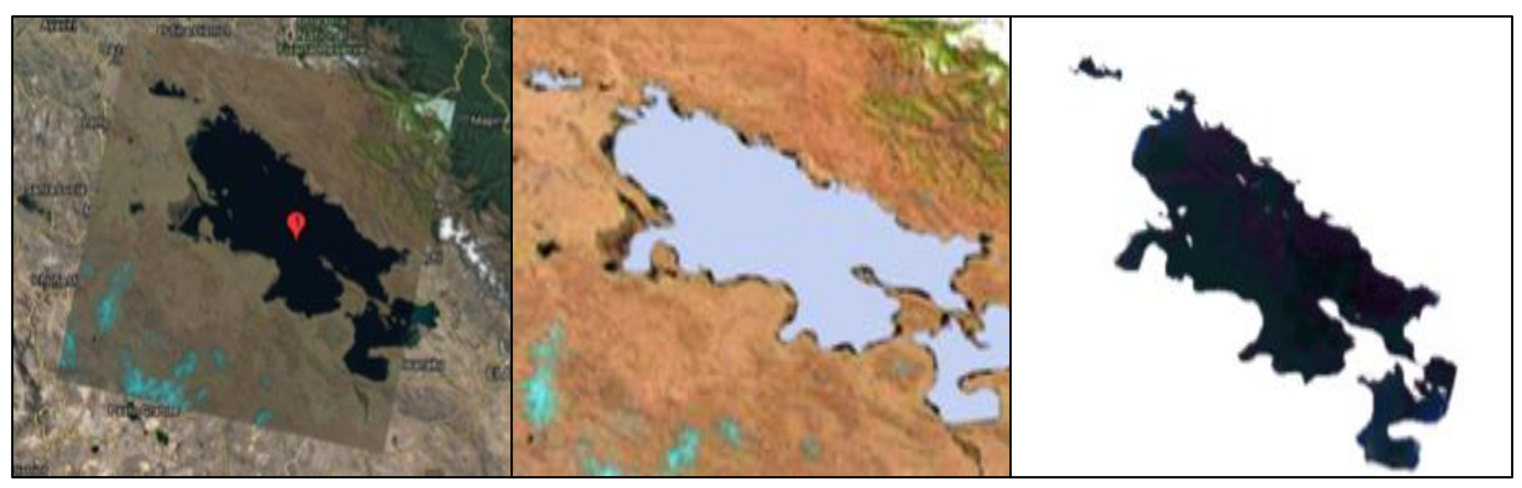
Objective

To utilize remote sensing to better monitor and manage water quality and quantity parameters such as surface area, chlorophyll, and total suspended sediments.

Methods

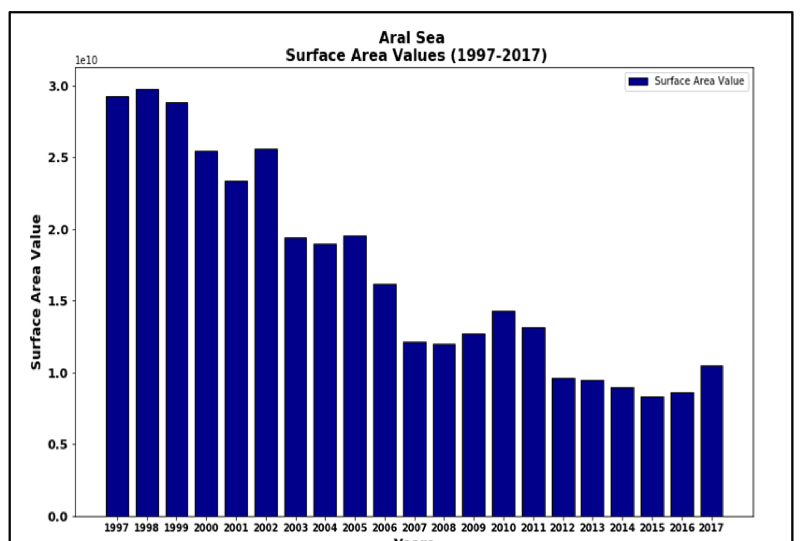
1. Satellite data extraction from Landsat using Earth Explorer
2. Create shapefiles to measure the surface area of the lakes
3. Analyze chlorophyll and TSS in RGB lake images

- 105 Landsat satellite lake images from 21 years were retrieved from the United States Geological Survey Earth Explorer website and analyzed using the Geographic Information System Mapping Technology, ArcMap.
- The empty data values were first eliminated using the Copy Raster feature.
- In cases where multiple images were required, in large lakes like the Aral Sea, the Mosaic to New Raster feature was used to combine the images.
- Shapefiles were then created using the Edit feature tool.
- Using the Polygon feature, each of the lakes were outlined carefully to assess surface area, chlorophyll concentrations, and turbidity.
- Data visualizations were created using Python to depict the relationships among the different mean band values.

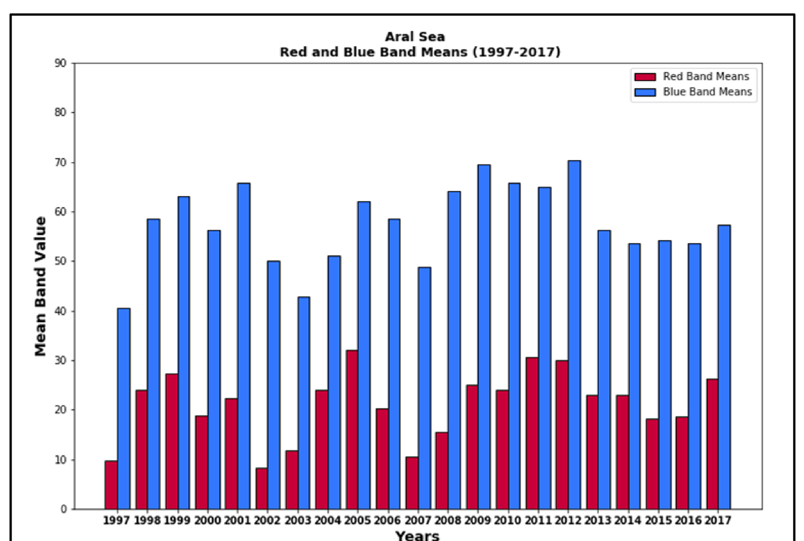


Satellite image of Lake Titicaca extracted from USGS database | Shapefile of Lake Titicaca using the Polygon tool | New file containing image of only the water bodies

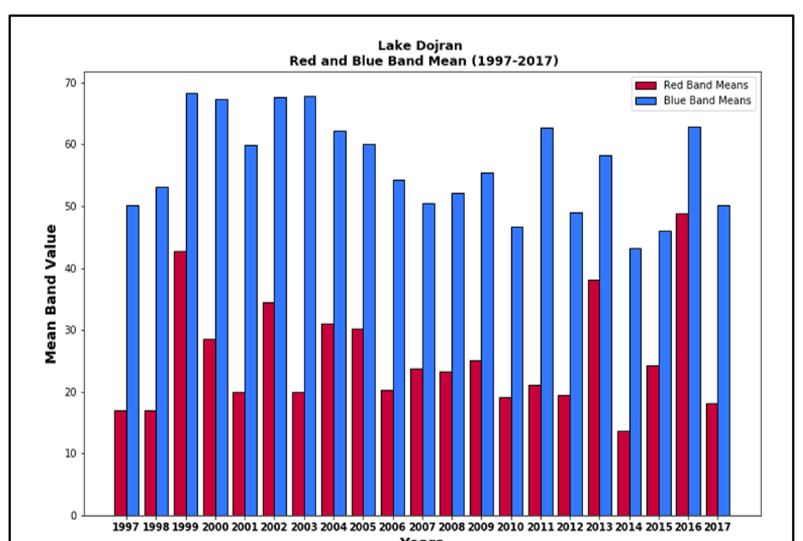
Results



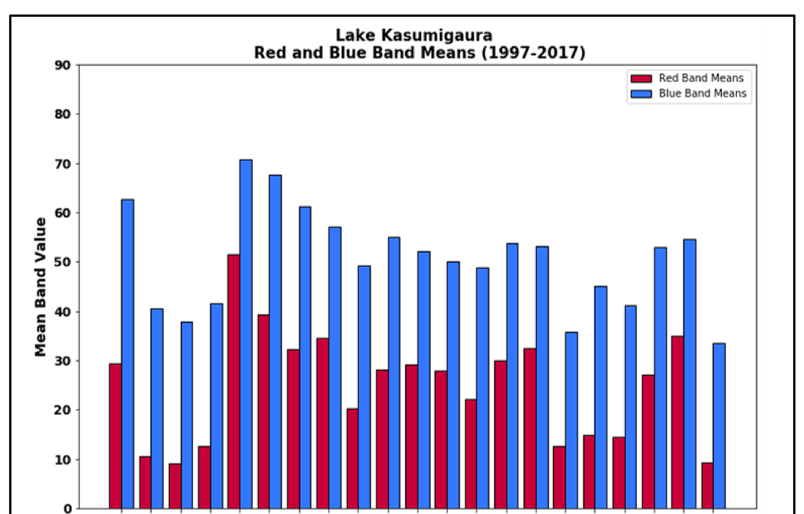
Graph representing Aral Sea Surface Area Values over the course of 21 years



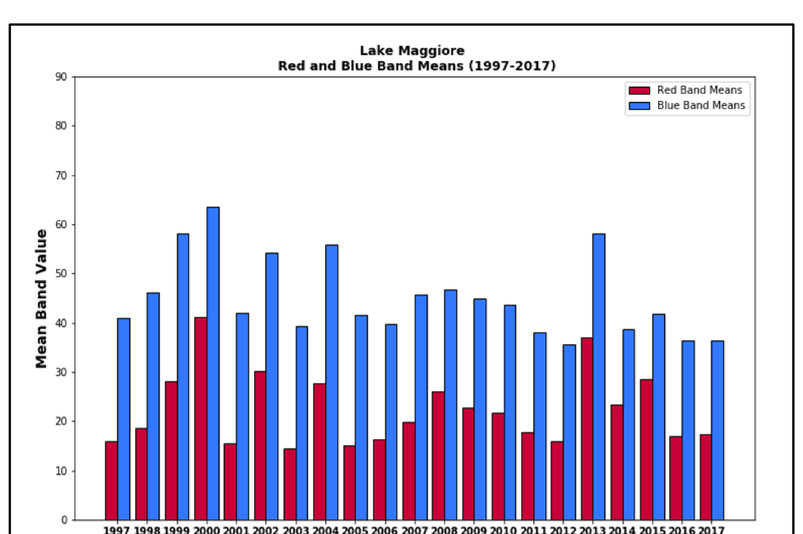
Graph of Aral Sea representing the Red and Blue Band Mean Values (1997 - 2017)



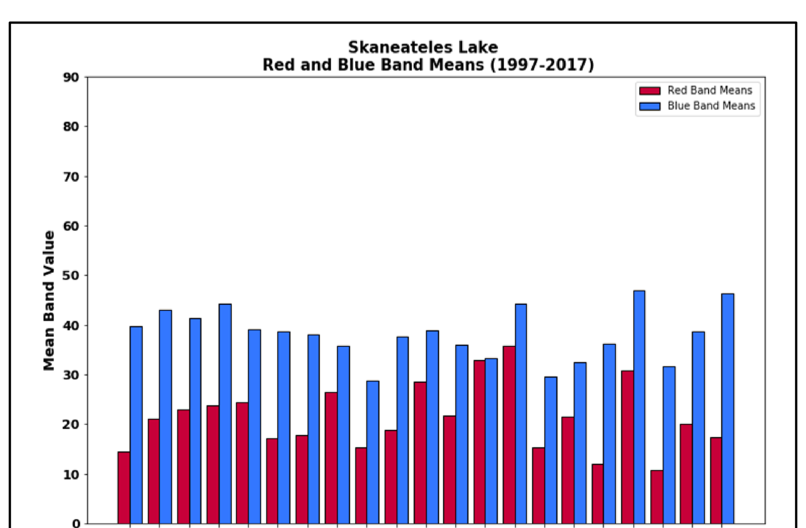
Graph of Dojran Lake representing the Red and Blue Band Mean Values (1997 - 2017)



Graph of Lake Maggiore representing the Red and Blue Band Mean Values (1997 - 2017)



Graph of Lake Kasumigaura representing the Red and Blue Band Mean Values (1997 - 2017)

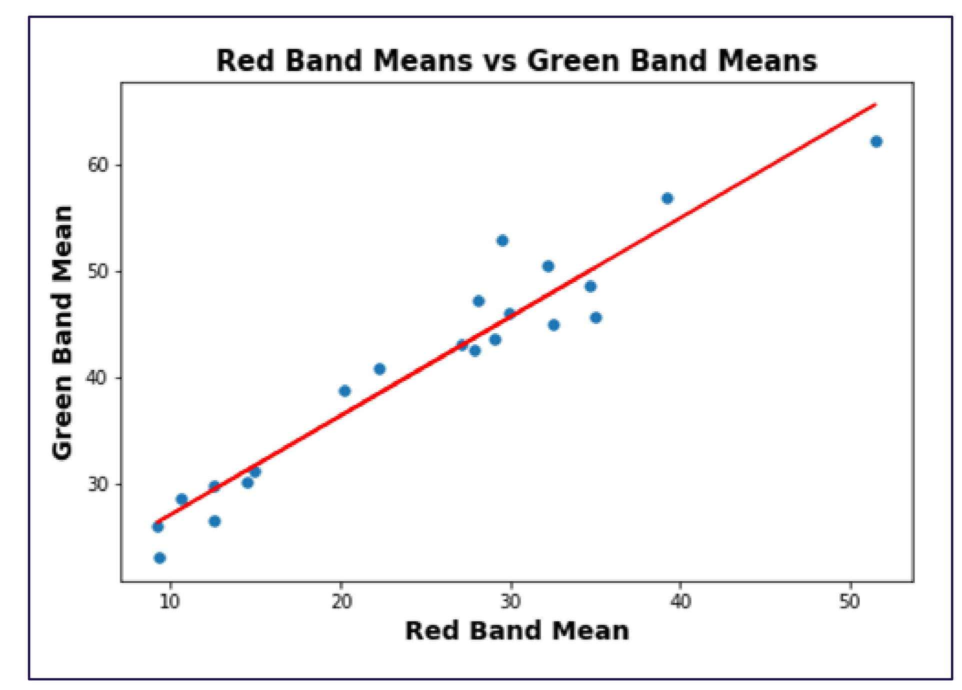


Graph of Lake Skaneateles representing the Red and Blue Band Mean Values (1997 - 2017)

Conclusion and Discussion

5 different lakes were studied and analyzed over a 21 year period. Data across all lakes indicate:

- Greater blue band values in comparison to the red band values, which is best illustrated in the Aral Sea.
- This drastic depiction between the red and blue mean values is the result of more blue being reflected than red and the lack of chlorophyll which mostly absorbs red wavelength. It can also be due to the high levels of TSS available in the water which absorbs blue wavelength.
- The surface areas of all the lakes generally stayed constant but in the case of the Aral Sea it noticeably decreased, with its graph depicting a negative correlation. This decrease in surface area proves consistent with in-situ measurements, with a major reason being diversion of water for irrigation.



Predictive Model:

Green Band Mean = 0.9284875759315228(Red Band Mean) + 17.817692894978723

R^2= 0.93 $p<0.05$

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