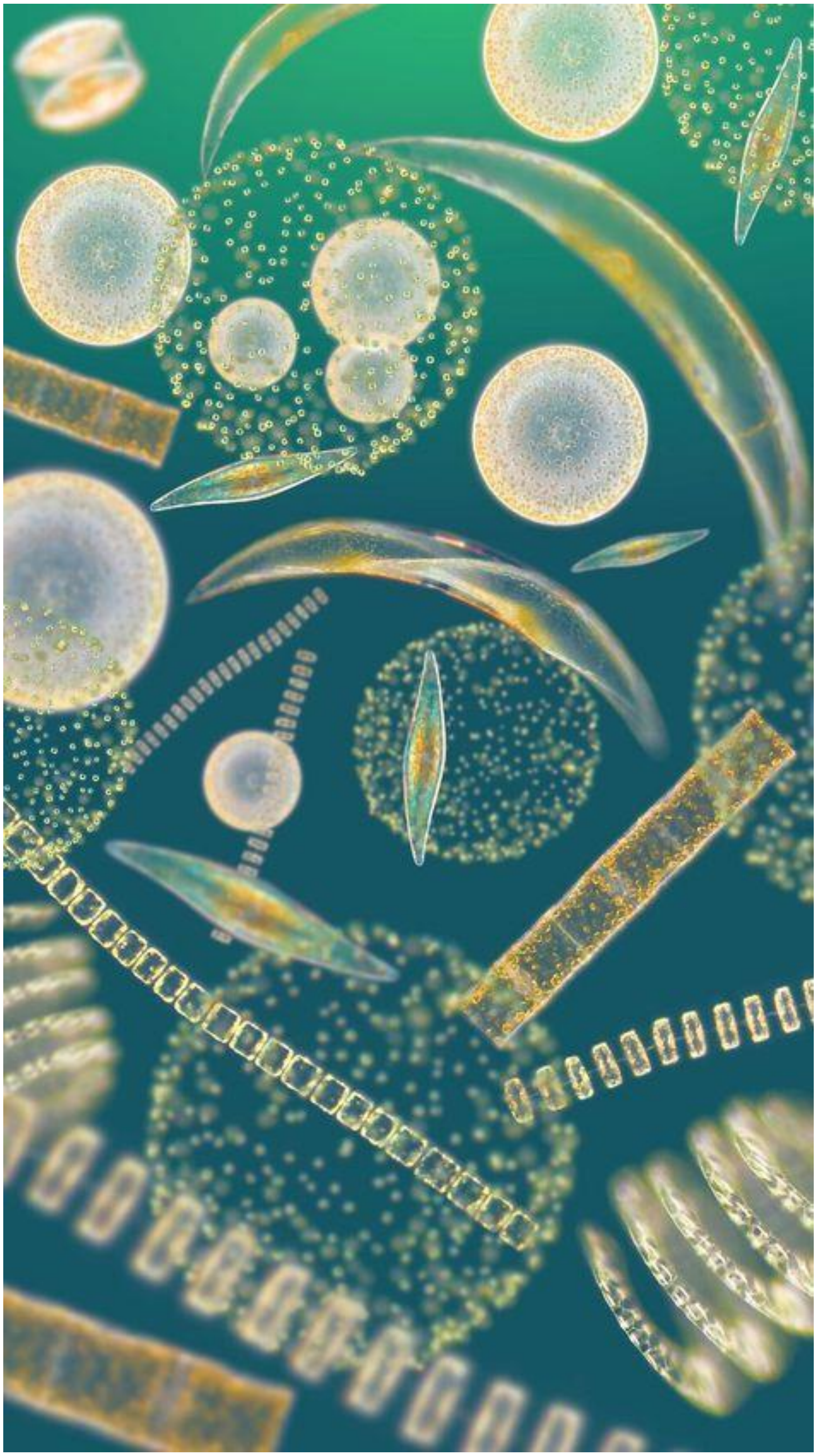

Phytoplankton monitor

INTELLIGENCE IN BIOLOGICAL SYSTEMS

SEMESTER-1

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AIM:

To Create an image recognition model that will determine the levels of phytoplankton in a water body using satellite images.

Introduction:

Phytoplankton are microscopic plant-like organisms that grow, multiply, and drift in the sunlit surface waters of most bodies of water on Earth. Phytoplankton occupy the base of the ocean's food chain. Most of them contain chlorophyll and produce energy from photosynthesis. When present in high concentrations in the water, the chlorophyll in their bodies gives the water a green color. Other phytoplankton secrete skeletal material composed of calcium carbonate. In high concentrations these can impart a light turquoise color to the water.

Normally phytoplankton are present and abundant in sunlit surface waters, but they are usually unnoticed by people on shore, passing by in boats, or flying over in aircraft. However, when conditions of temperature, sunlight, and water composition are perfect, explosive growth and procreation increase their numbers exponentially. These periods of explosive growth produce a green or turquoise color in and on the water, known as a "phytoplankton bloom".

Relationship between water colour and the level of phytoplankton:

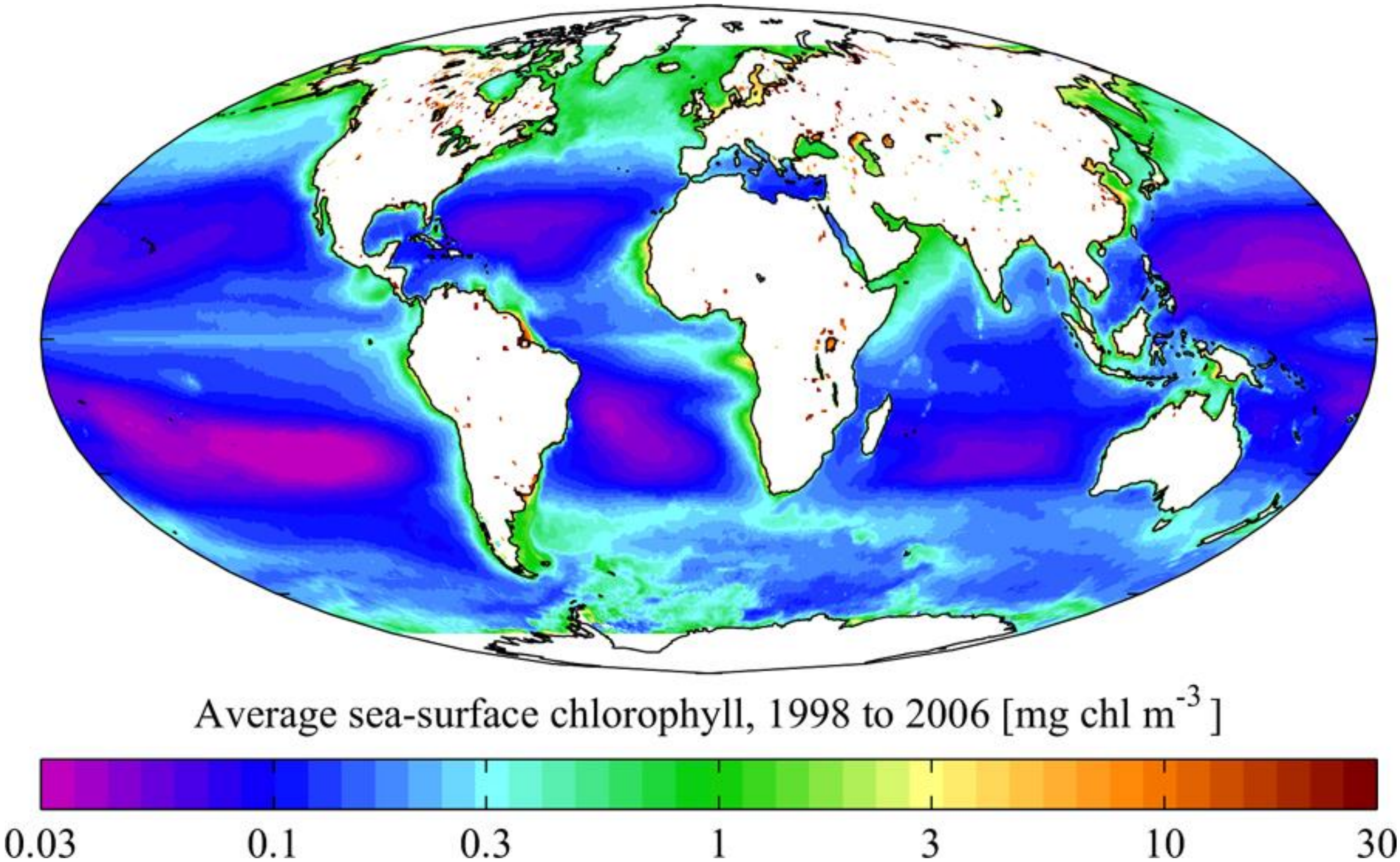
Training an algorithm with satellite images of ocean colour reveals the blooms and bursts of phytoplankton communities. Phytoplankton covers surface waters of the world's oceans, and pigments in their cells absorb certain wavelengths of light, like the chlorophyll that gives plants their green colour. Viewed from space, the colour of the ocean's surface changes depending on the phytoplankton growing there.

For example, here is one of the most prominent phytoplankton blooms clearly visible from space. Near the Timor Sea in Australia. (All images used in this project are sourced from Google Earth.)

The difference in the colour of water is clearly visible, indicating the presence of large phytoplankton blooms.

We can say that the water body contains more phytoplankton if the colour is visibly green or blue-green, whereas the colour of water is bluer if the levels of phytoplankton are low.

Concept:

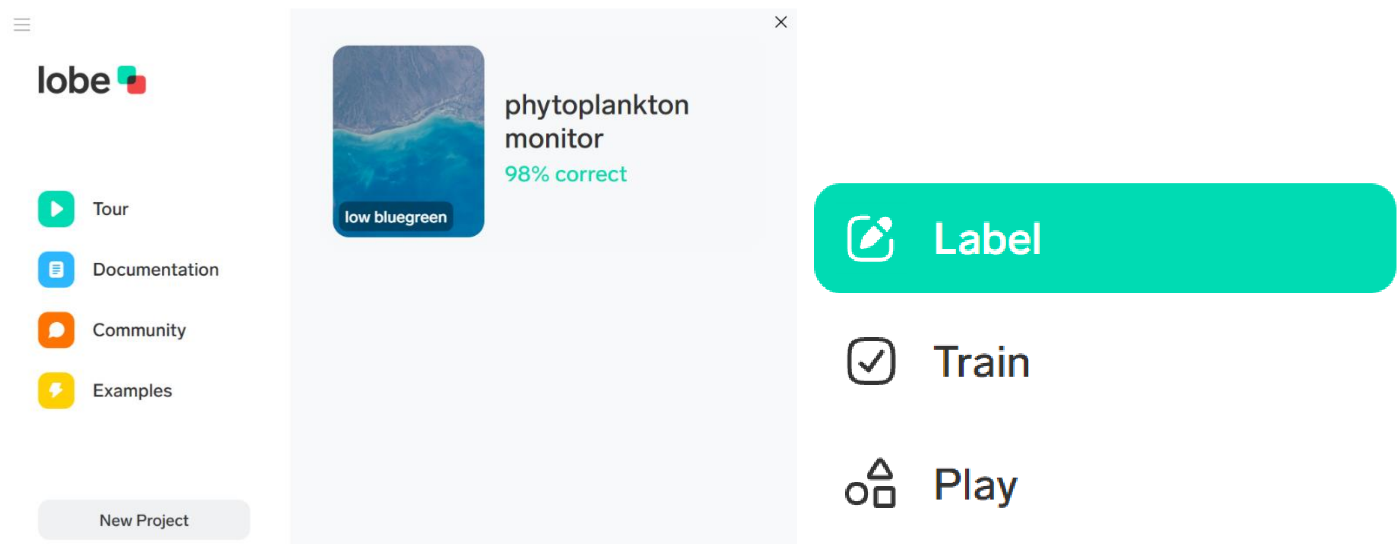


The image shown above, shows us the levels of phytoplankton on Earth as determined by the NASA Earth Observatory. The SeaWiFS (Sea-viewing Wide Field-of-View Sensor) has been collecting data for 6 years. The image shows the average ocean chlorophyll concentration measured since launch. Scientists can infer how much phytoplankton the ocean waters contain by measuring how much chlorophyll is present. The image reveals the close relationship between physical and chemical ocean processes—like temperature differences and nutrient upwelling from the deep ocean that happens near coastlines—and ocean plant life. Chlorophyll (and therefore phytoplankton) concentrations are higher in coastal areas than they are in the open ocean.

One of the interesting insights that came out of the generation of this multi-year chlorophyll map is the identification of the region of the world's oceans that has the lowest chlorophyll concentration.

In this project, we hope to design an image recognition algorithm using LOBE (a software by Microsoft) Which enables us to train a custom machine learning model that can classify data and detect objects, such that the predictions made by our image recognition model matches the findings made by NASA.

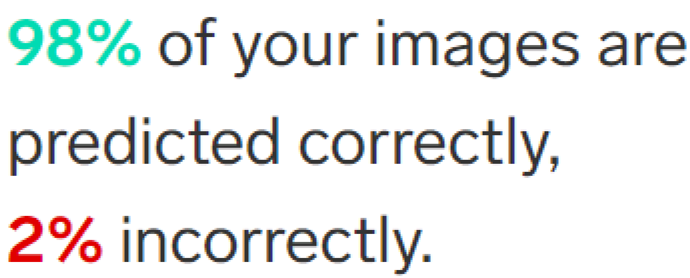
We use LOBE to train the algorithm



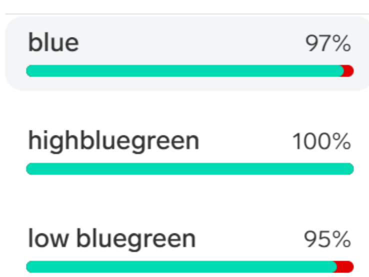
The software allows us to label the database, train the model, and use the Play function to plug an image into the algorithm. The predictions are then added to the database to increase its accuracy.

Procedure:

- We first train the algorithms to predict the levels of phytoplankton by giving it a database of satellite images of water bodies and labelling each picture with the result expected by us.
- For our convenience we have classified the images into three groups:
  - **Blue** – Lowest levels of phytoplankton (0.1 mg chl m^{-3})
  - **Low Bluegreen** – low level of phytoplankton (0.3 mg chl m^{-3})
  - **High Bluegreen** – high levels of phytoplankton (1 mg chl m^{-3})
- We were able to successfully train our model such that it will be able to predict the levels of phytoplankton in the ocean with an accuracy of **98%**

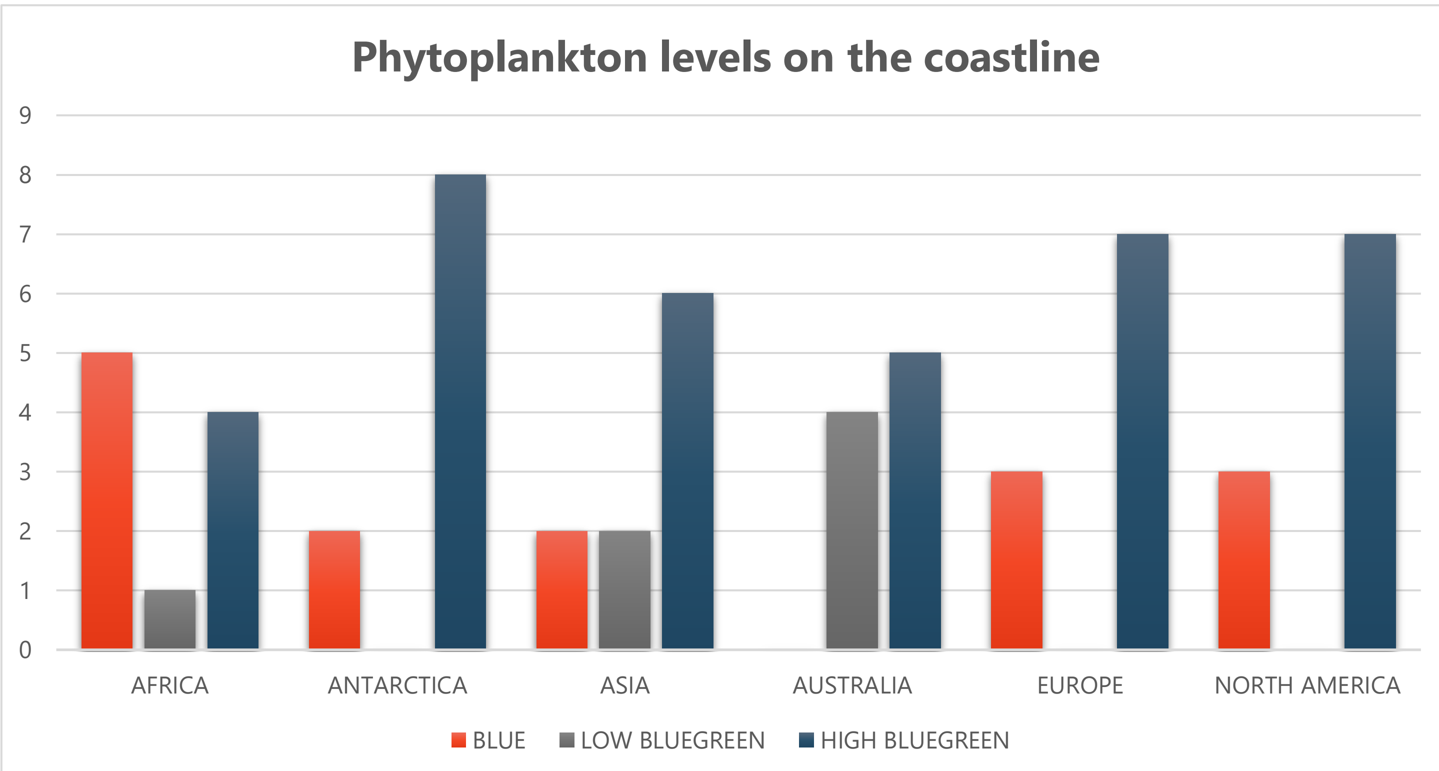


With the accuracy of the individual groups as such



- Once the training of the model is complete, we can use the model to predict the levels of phytoplankton in a water body with satellite images of the water body taken from Google Earth.

- As we saw in the NASA prediction, the sea-surface chlorophyll levels are high in the coastal areas.
- First, we focus on the water bodies near the coastal areas
- We pick ten locations on the coast for each continent (70 locations) and let the image recognition model predict the levels of phytoplankton there. Shown below are the results obtained by doing so.



The results obtained for each location is recorded in an excel spreadsheet. Here is an example of the predictions of Africa.

sno	place	prediction	country	continent	ocean
6	mediterranian sea	blue	libys	africa	mediterranian sea
11	lake victoria	high bluegreen	uganda	africa	lake victoria
12	cape town	blue	south africa	africa	south atlantic ocean
29	marohita	high bluegreen	madagascar	africa	marohita
30	lake malawi	low bluegreen	malawi	africa	lake malawi
31	bissau	high bluegreen	guinea bissau	africa	bissau
32	gulf of guinea	blue	nigeria	africa	gulf of guinea
33	north atlantic ocean	blue	morocco	africa	north Atlantic ocean
34	jemsa	high bluegreen	egypt	africa	Gulf of suez
35	bight of bonny island:	blue	santo antonio	africa	gulf of guinea

- As we can see from the bar graph above, we can see that the majority of locations picked on the coastline have high levels of phytoplankton.
- Therefore, our predictions of phytoplankton levels near the coastline correspond to those of NASA.

As seen in the prediction, the sea-surface chlorophyll levels are low in the open oceans and seas.

- We pick a random location in each large water body (Seas/Oceans)
- We let the image recognition model predict the levels of phytoplankton there. Shown below are the results obtained by doing so.

sno	ocean	prediction
1	north atlantic ocean	blue
2	carribien sea	blue
3	south atlantic ocean	blue
4	indian ocean	blue
5	arabian sea	blue
6	red sea	blue
7	black sea	blue
8	caspian sea	blue
9	andaman sea	blue
10	bay of bengal	blue
11	ionian sea	blue
12	labrador sea	blue
13	mediterranian sea	blue
14	pacific ocean	blue
15	south china sea	blue
16	tyrrhenian sea	blue

- As we can see, the predictions of all locations turned out to be blue
- This indicates that the levels of phytoplankton in open water bodies such as oceans and seas are low
- This observation also corresponds with the pre-determined observations by NASA.

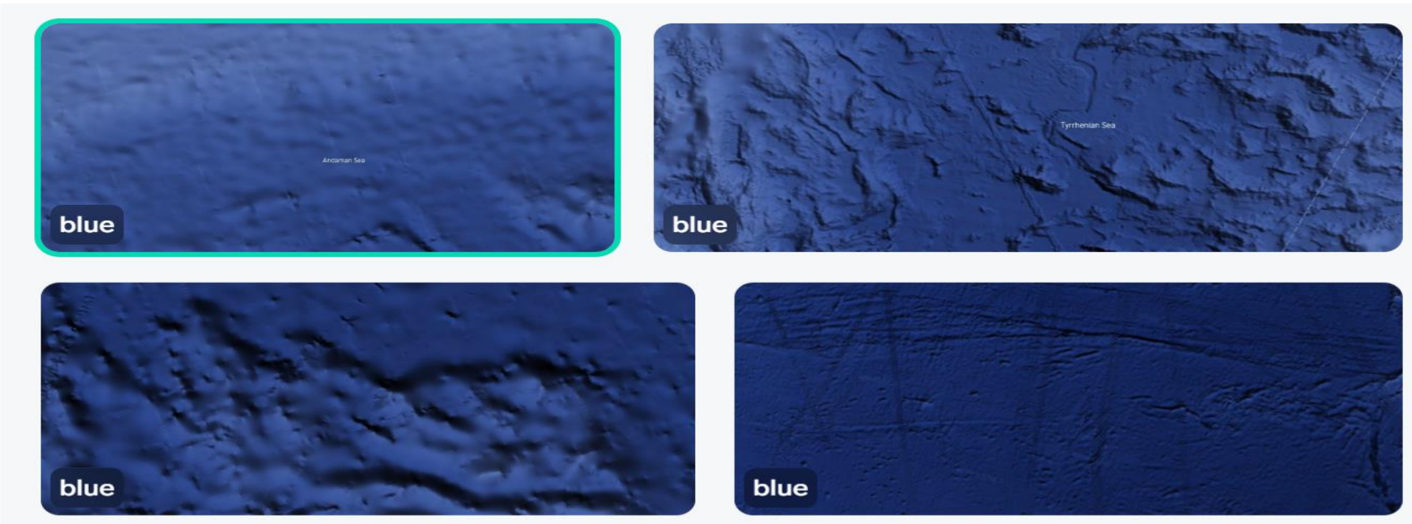
Therefore, we can say that. If an image plugged into our algorithm is classified as

Classification	Chlorophyll levels (mg chl m^{-3})
Blue	0.03 – 0.1
Low blue-green	0.2 – 0.7
High blue-green	1 - 3

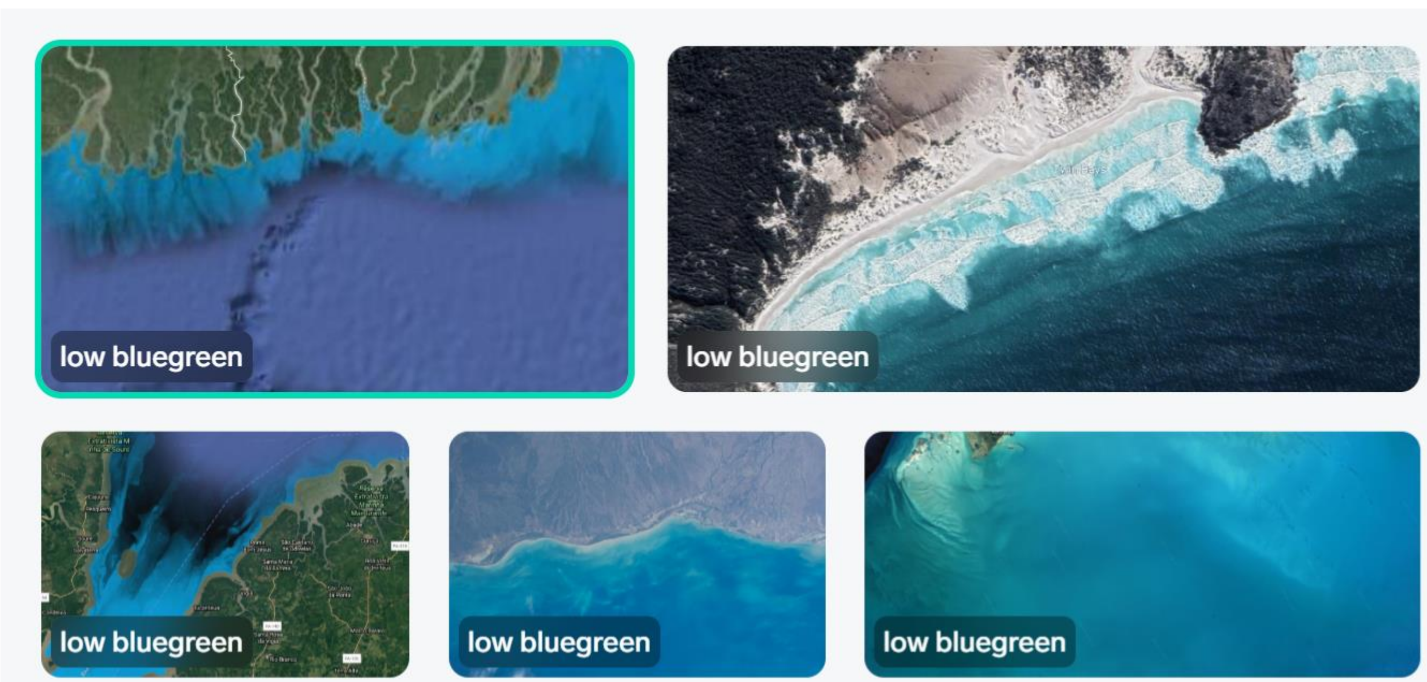
Images

Here are some of the images we used to train the model for better understanding.

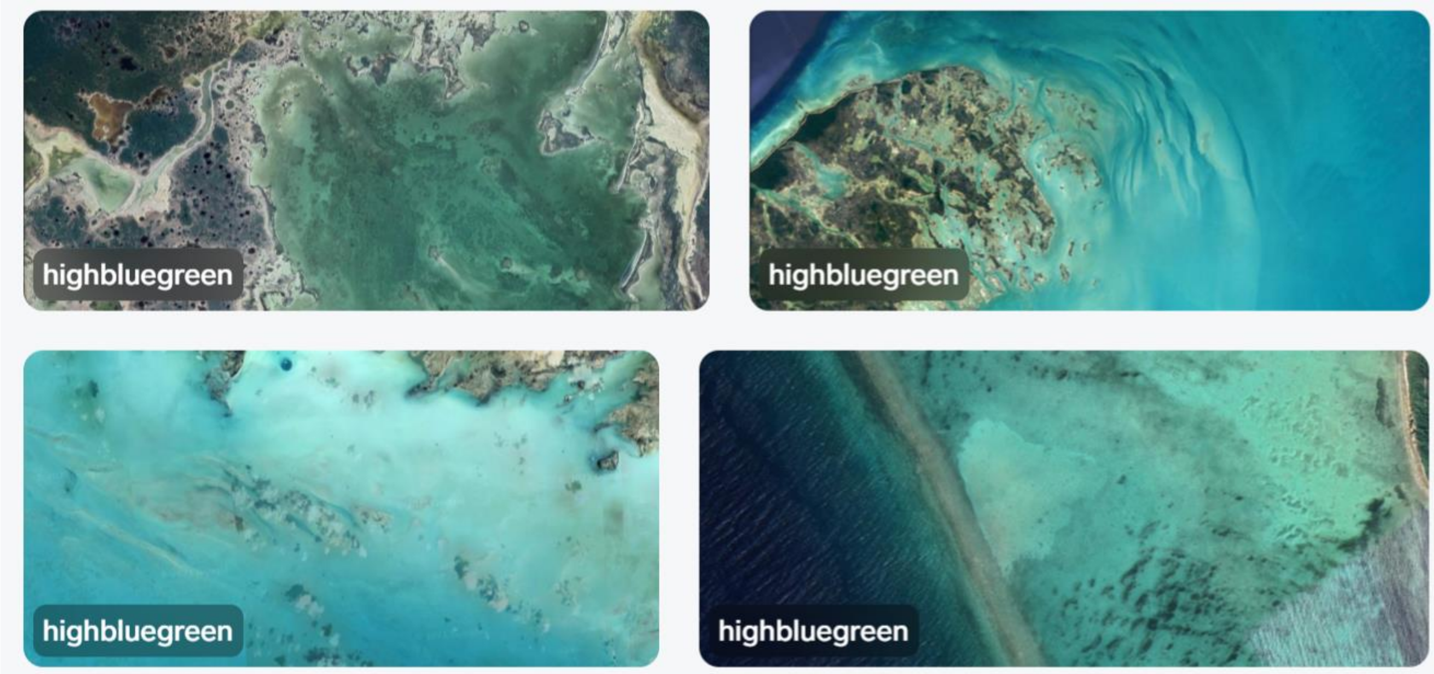
BLUE:



LOW BLUE-GREEN:



HIGH BLUE-GREEN:



Possible Applications:

The biggest concern faced by Human Beings in the 21st century is Climate change, Global warming and Pollution levels. Large amounts of deforestation has led to the rise of pollutants in the atmosphere. The most obvious solution to this problem is to restore the forests. But most people don’t know that there are millions of more tiny organisms called Phytoplankton to take into account.

Phytoplankton is the dominating class in providing O_2 (oxygen) in the atmosphere. It is believed that phytoplankton photosynthesis only produces half of the planet's air for breathing, but if you think about it, our ocean covers 71 percent of the Earth. Scientists estimate that they produce an astonishing **50 to 85 %** of the Earth's oxygen**!**

Also, according to the National Geographic website, students have calculated that 70% of the Earth's oxygen is produced by phytoplankton (Prochlorococcus) as well as other aquatic plants while the forest and other inland plant and trees produce only 28% of the oxygen we breathe!

However too much phytoplankton can also be harmful for the ecosystem. When too many nutrients are available, phytoplankton may grow out of control and form harmful algal blooms (HABs). These blooms can produce extremely toxic compounds that have harmful effects on fish, shellfish, mammals, birds, and even people.

Nowadays, global warming has caused the levels of phytoplankton in the waterbodies to decrease in an alarming rate. Therefore, our model may be used to determine the preexisting levels of phytoplankton in the water and take precautionary measures or to reverse the damage caused to phytoplankton by external agents to prevent drastic changes in our environment.

CONCLUSION:

Therefore, we have succeeded in creating a fairly accurate image recognition model to predict the levels of phytoplankton in waterbodies using satellite images which can be used to monitor impact of climatic change on phytoplankton which in turn hugely impacts humanity in a largely unforeseen way

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