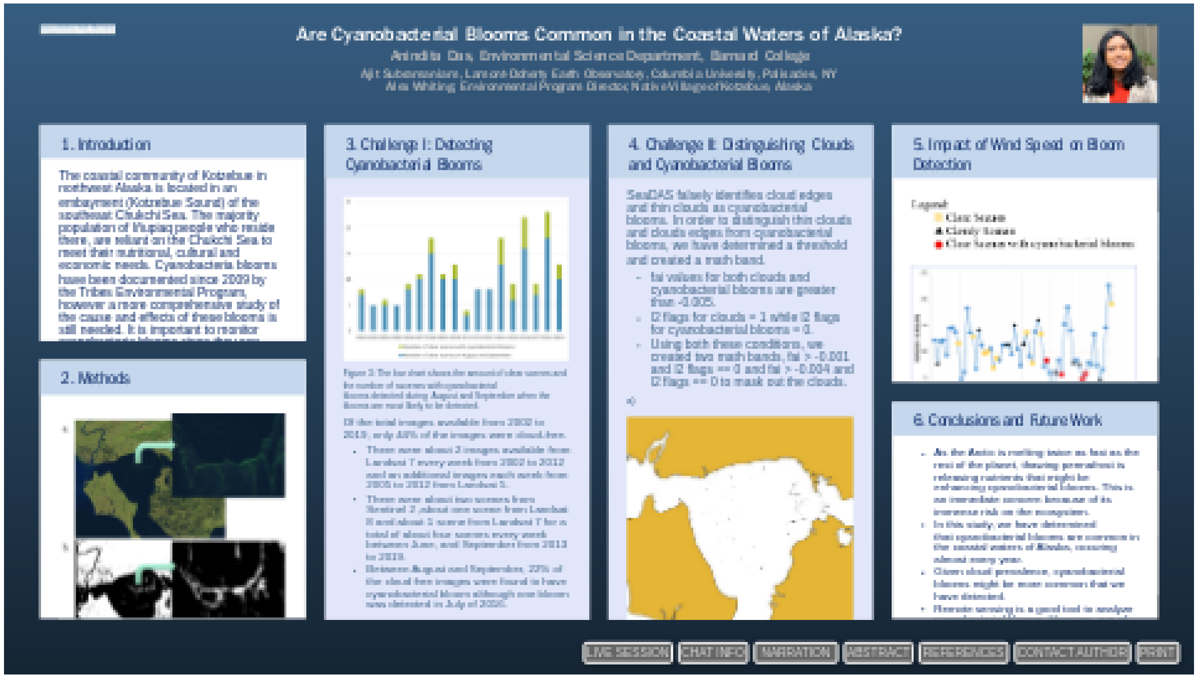
Are Cyanobacterial Blooms Common in the Coastal Waters of Alaska?



Anindita Das, Environmental Science Department, Barnard College

Ajit Subramaniam, Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY
Alex Whiting, Environmental Program Director, Native Village of Kotzebue, Alaska

PRESENTED AT:

1. INTRODUCTION

The coastal community of Kotzebue in northwest Alaska is located in an embayment (Kotzebue Sound) of the southeast Chukchi Sea. The majority population of Iñupiaq people who reside there, are reliant on the Chukchi Sea to meet their nutritional, cultural and economic needs. Cyanobacteria blooms have been documented since 2009 by the Tribes Environmental Program, however a more comprehensive study of the cause and effects of these blooms is still needed. It is important to monitor cyanobacteria blooms since they can have damaging impacts to the ecosystem and produce toxin levels harmful to people and wildlife. In this sparsely populated area that includes vast expanses of open water and shorelines, being able to remotely identify large bloom events through satellite photography, will facilitate a better understanding of the scope, timing and frequency of cyanobacteria blooms.

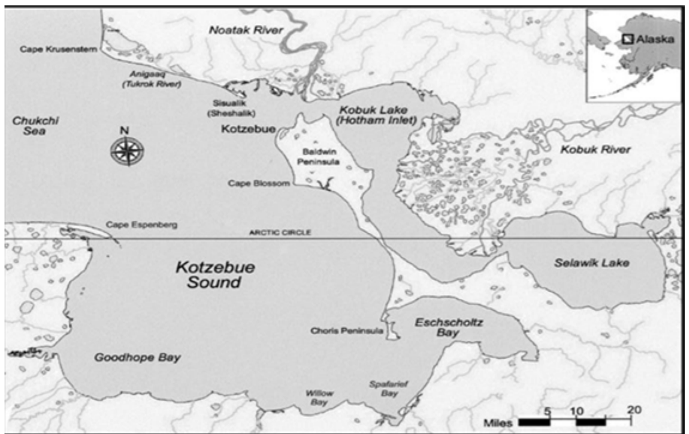


Figure 1: The map of Kotzebue Sound and surrounding areas. (Whiting et al, 2011)

2. METHODS

a.

b.

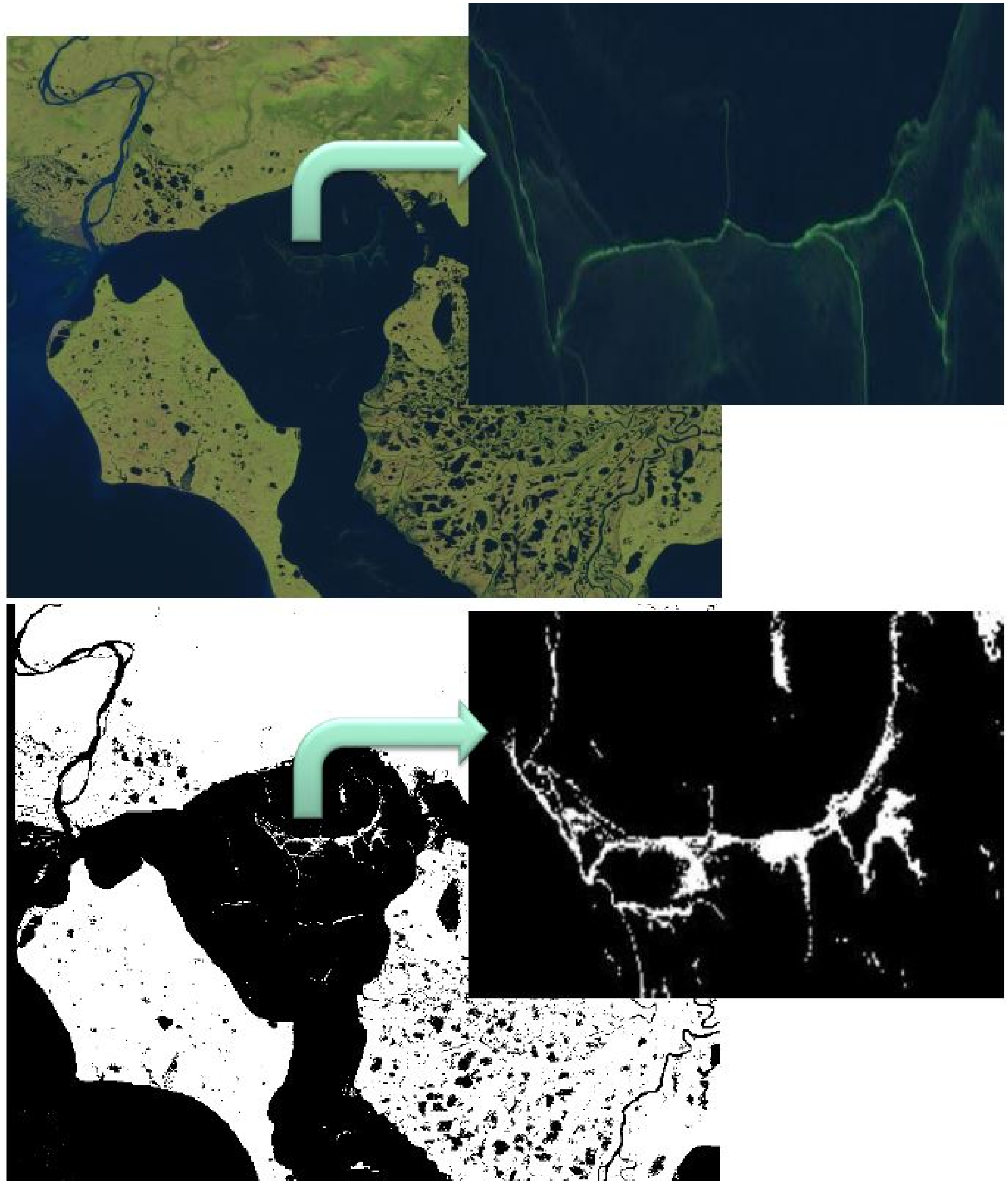


Figure 2a. A true color image downloaded from Sentinel- 2 showing an extensive cyanobacterial blooms on August 29, 2016.
2b. A processed image showing the same
cyanobacterial bloom with the fai index in SeaDAS.

- We used data from Landsat-5, Landsat-7, Landsat 8, and Sentinel 2 from mid-June to the end of September, each year from 2002 to 2019 when the waters around Kotzebue is ice-free.
- We have used ACOLITE to process clear scenes and create maps of floating algal index (fai).
- Processed images were viewed and analyzed using SeaDAS.
- Cyanobacterial blooms were detected visually and fai values.
- Developed thresholds to distinguish between fai and thin clouds
- We used wind data for Kotzebue from Iowa Environment Mesonet to investigate the impact of wind speed on detecting cyanobacterial blooms.

3. CHALLENGE I: DETECTING CYANOBACTERIAL BLOOMS

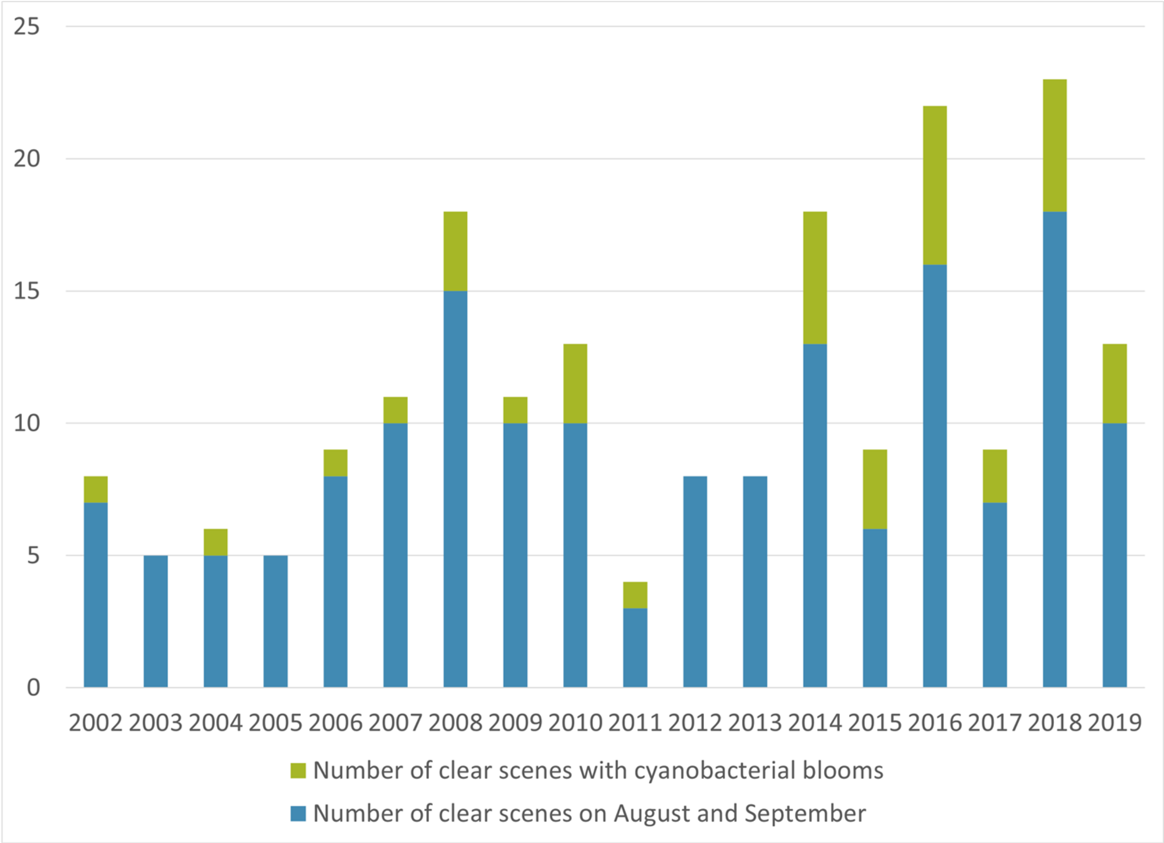


Figure 3: The bar chart shows the amount of clear scenes and the number of sscenes with cyanobacterial blooms detected during August and September when the blooms are most likely to be detected.

Of the total images available from 2002 to 2019, only 44% of the images were cloud-free.

- There were about 2 images available from Landsat 7 every week from 2002 to 2012 and an additional images each week from 2005 to 2012 from Landsat 5.
- There were about two scenes from Sentinel 2 ,about one scene from Landsat 8 and about 1 scene from Landsat 7 for a total of about four scenes every week between June, and September from 2013 to 2019.
- Between August and September, 22% of the cloud free images were found to have cyanobacterial bloom although one bloom was detected in July of 2016.

4. CHALLENGE II: DISTINGUISHING CLOUDS AND CYANOBACTERIAL BLOOMS

SeaDAS falsely identifies cloud edges and thin clouds as cyanobacterial blooms. In order to distinguish thin clouds and clouds edges from cyanobacterial blooms, we have determined a threshold and created a math band.

- fai values for both clouds and cyanobacterial blooms are greater than -0.005.
- l2 flags for clouds = 1 while l2 flags for cyanobacterial blooms = 0.
- Using both these conditions, we created two math bands, fai > -0.001 and l2 flags == 0 and fai > -0.004 and l2 flags == 0 to mask out the clouds.

a)

b)

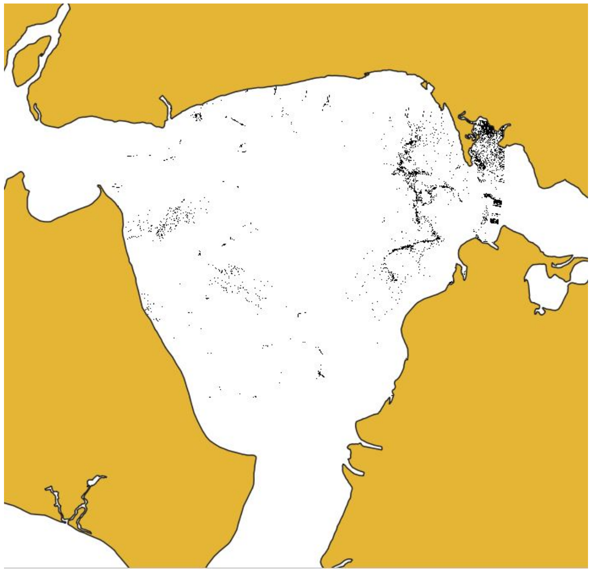


Figure 5: a) Math band: fai>-0.001 and l2flags = 0

b) Math band: fai>-0.004 and l2flags=0

- When fai > - 0.001 was used, some blooms were missed out and when fai > -0.004 was used, some speckling were visible which were counted as blooms.
- Since the difference between the total number of pixels was and found that the difference in area was 0.19%, we will be using fai> -0.004 to calculate mask out cloud edges.

5. IMPACT OF WIND SPEED ON BLOOM DETECTION

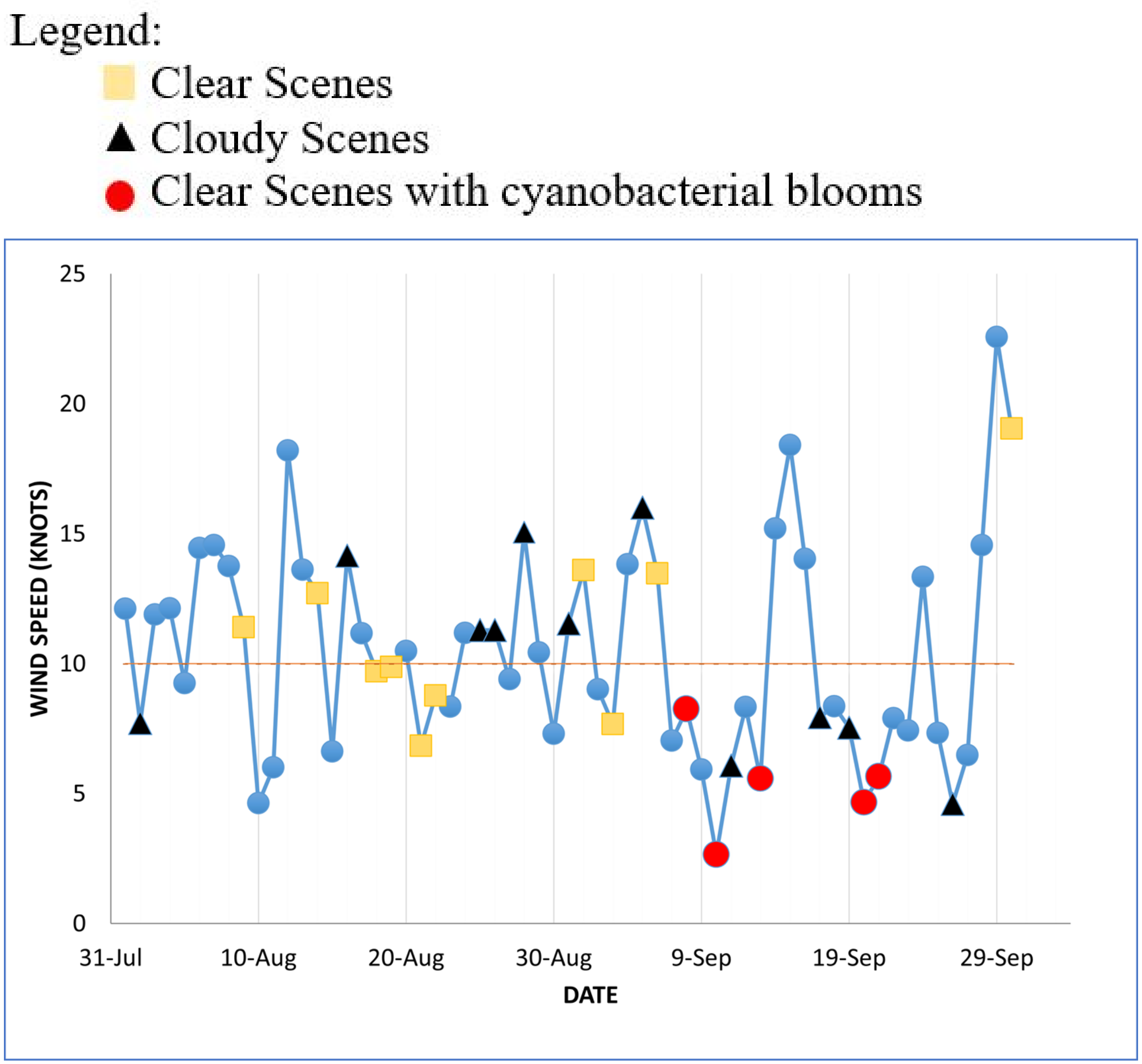


Figure 4: The graph shows the affect of windspeed on the dates cyanobacterial blooms were detected for 2018.

- Cyanobacterial blooms were detected in five clear scenes in 2018 when the wind speed was lower than 10 knots.
- This trend has been observed in other years as well.

- When wind speed is high, vertical mixing of the water occurs which drives cyanobacterial blooms away from the surface of the water and hence cannot be detected by satellites.
- Before the scenes with cyanobacterial blooms are detected, the water needs at least one calm day for the bloom to appear on the surface.
- On a few days, such as August 10, when the conitions were favorable to detect cyaobacterial blooms, satellite images were not available.

6. CONCLUSIONS AND FUTURE WORK

- As the Arctic is melting twice as fast as the rest of the planet, thawing permafrost is releasing nutrients that might be enhancing cyanobacterial blooms. This is an immediate concern because of its immense risk on the ecosystem.
- In this study, we have determined that cyanobacterial blooms are common in the coastal waters of Alaska, occuring almost every year.
- Given cloud prevalence, cyanobacterial blooms might be more common that we have detected.
- Remote sensing is a good tool to analyze cyanobacterial blooms. However, one of the major drawbacks of using optical satellites was cloud covered areas. Since over half of the images available in the satellites were cloudy over the waters around Kotzebue, they could not be investigated for blooms.
- In the future, we will quantify these blooms and use using other environmental factors such as precipitation and air temperature to understand their impact on detecting blooms.

ABSTRACT

The community of Kotzebue, located on the coast of Kotzebue Sound, which is northeast of the Bering Straits adjacent to the Chukchi Sea, is reliant on the waters around Kotzebue Sound for food and economy. There have been reports of cyanobacterial blooms in these waters around Kotzebue but they have not been systematically studied yet, because the region is sparsely populated with few in-situ observations. Cyanobacteria often form surface blooms in freshwater and coastal ecosystems which can be detected using remote sensing techniques. Cyanobacteria are found to have low nutritional value and many species of cyanobacteria produce cyanotoxins, and thus can be harmful to aquatic life and cause public health hazards. In addition, consumption of decaying cyanobacterial blooms by microbes depletes oxygen level which can lead to hypoxia, adversely impacting the benthic community. As the Arctic is warming twice as fast as the rest of the planet due to climate change, thawing permafrost is releasing nutrients that might be enhancing cyanobacterial blooms in the coastal, marine and lacustrine waters of Alaska. In this study, we used remote sensing to study phytoplankton biomass, turbidity and cyanobacterial blooms between mid-June to end of September each year from 2002 to 2019 when the waters around Kotzebue are ice-free. Using images from Landsat-5, Landsat-7, Landsat-8 and Sentinel-2, processed using ACOLITE software, we investigated spatial and temporal changes in cyanobacterial blooms. Initially, we used a combination of true-color images and fai (floating algal index) to detect cyanobacterial blooms. We then created determined a threshold to create a math band in order to distinguish thin clouds and cloud edges from cyanobacterial blooms. There were about 2 images available from Landsat 7 every week from 2002 to 2012 and an additional image each week from 2005 to 2012 from Landsat 5. There were about two scenes from Sentinel 2 ,about one scene from Landsat 8 and about 1 scene from Landsat 7 for a total of about four scenes every week between June, and September from 2013 to 2019. Of these, only 44% of the images were cloud-free. Of the cloud-free images, 22% were found to have a cyanobacterial bloom between August and September for an average of two to four scenes every year. Most of the cyanobacterial blooms were detected in Kobuk Lake near Kotzebue, and nearby sites in Hotham Inlet and Selawik Lake.In addition, we observed that wind speed has an impact on when we can detect cyanobacterial blooms.

REFERENCES

Whiting, A (2011). Combining Inupiaq and Scientific Knowledge. Ecology in Northern Kotzebue Sound, Alaska

Vanhellemont, Q., 2019. Adaptation of the dark spectrum fitting atmospheric correction for aquatic applications of the Landsat and Sentinel-2 archives. Remote Sensing of Environment 225, 175–192

H.W. Paerl, J. HuismanClimate change: A catalyst for global expansion of harmful cyanobacterial blooms, Environ. Microbiol. Rep., 1 (1) (2009), pp. 27-37

Hu, C. (2009). A novel ocean color index to detect floating algae in the global oceans. Remote Sensing of Environment, 113(10), 2118-2129.