Frequent Synoptic Monitoring of Cyanobacterial Harmful Algal Blooms for Potential Prevention of Disease Outbreak

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November 21, 2022

Abstract

Cyanobacterial Harmful Algal Blooms (CyanoHABs) are progressively becoming a major water quality and public health hazard worldwide. Untreated CyanoHABs can severely affect human health due to their toxin producing ability, causing physiological and neurological disorders such as non-alcoholic liver disease, dementia to name a few. Transfer of these cyanotoxins via food-chain only accelerates public health hazards. CyanoHABs can potentially also lead to a decline in aquatic and animal life, hampering recreational activities at waterbodies and ultimately affecting the country's economy gravely. CyanoHABs require nutrient rich warm aquatic environments to bloom and their proliferation in increasingly warmer areas of the world can be an indirect indicator of global climate change. Many lakes in the United States have been experiencing such CyanoHABs in the summers, which only grow severe every coming year, and this is consistently leading to increased public health implications. A recent study (September, 2021) by the Centre for Disease Control quantified hospital visits with the trend of such CyanoHABs to indeed observe a strong correlation between the two. This necessitates a need for a user-friendly and accessible infrastructure to monitor inland and coastal waterbodies throughout the U.S for such blooms. We present a remote sensing-based approach wrapped in a lucid web-app, "CyanoTRACKER", which can help detect CyanoHABs on a global level and act as an early warning system, potentially preventing/lessening public health implications. CyanoHABs are dominated by the Phycocyanin pigment, which absorbs sunlight strongly around 620 nm wavelength. Owing to this specific absorption characteristic and the availability of a satellite band at exactly 620 nm, we use the opensource Sentinel-3 OLCI satellite data to detect the presence of CyanoHABs. CyanoTracker is a user-friendly Google Earth Engine dashboard, which is easily accessible via only a browser and an internet connection and allows for a variety of near-daily analysis options such as: a) select any location throughout the world and view satellite image based on date-range of choice, b) click on any pixel in the satellite image and detect presence/absence of cyanobacteria, c) visualize the spatial spread as well as the temporal phenology of an ongoing bloom or a potential incoming bloom. This dashboard is easily accessible to water-managers and in fact, anyone who wishes to use it with minimal training and can effectively serve as an early warning system to CyanoHAB induced disease outbreaks.

Place&Health2021

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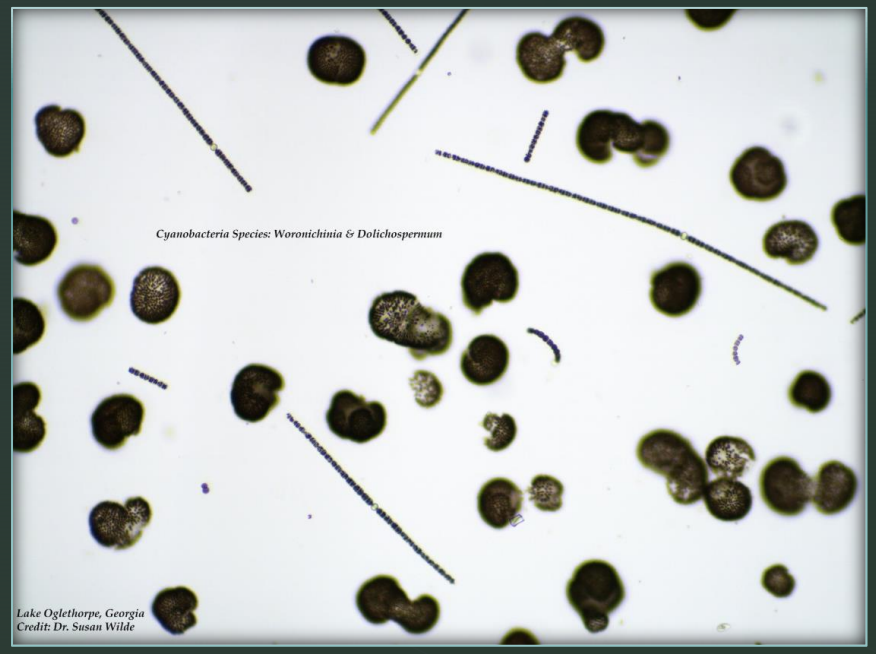
The University of Georgia

cyano TRACKER

The University of Georgia



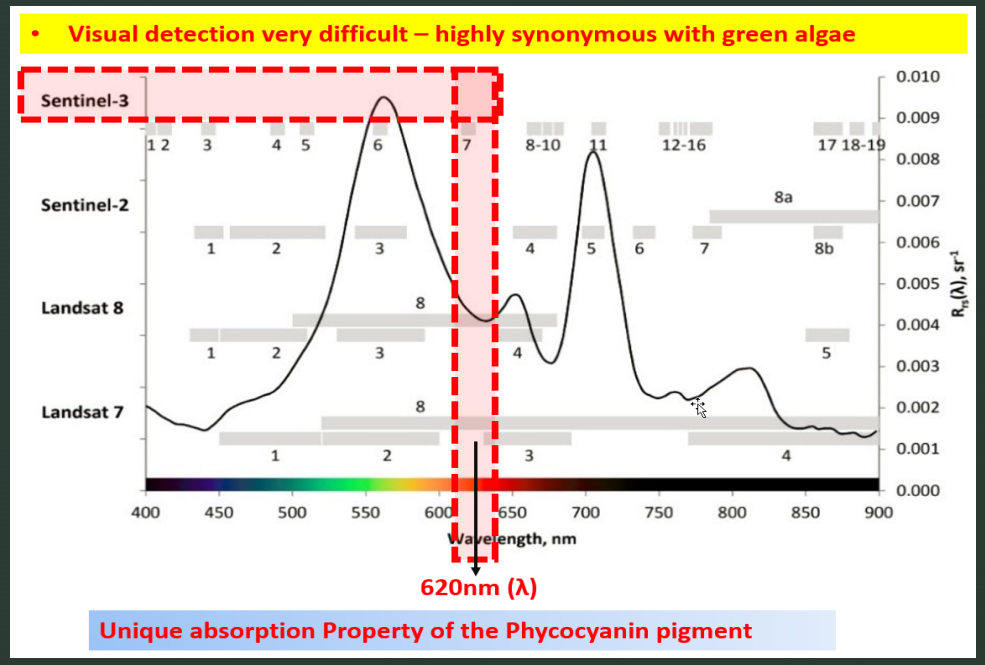
About Cyanobacterial Harmful Algal Blooms (CyanoHABs)

- A distinct group of phytoplankton
- Adaptable to a *variety* of aquatic environments
- Need nutrient rich waters and warm temperature to bloom
- Multiply quickly to form colonies or blooms
- Can be potentially linked to global climate change

CyanoHABs: Toxicity, Health Hazards and Economic Impacts

- CyanoHABs can be toxic – affect the entire waterbody
- Fishes, corals and aquaculture, cattle can die
- Hepatotoxins and Neurotoxins – hazardous to humans too
- Degrade water quality and hamper recreational activity
- Adversely effect a nation's economy

Remote Sensing of CyanoHABs

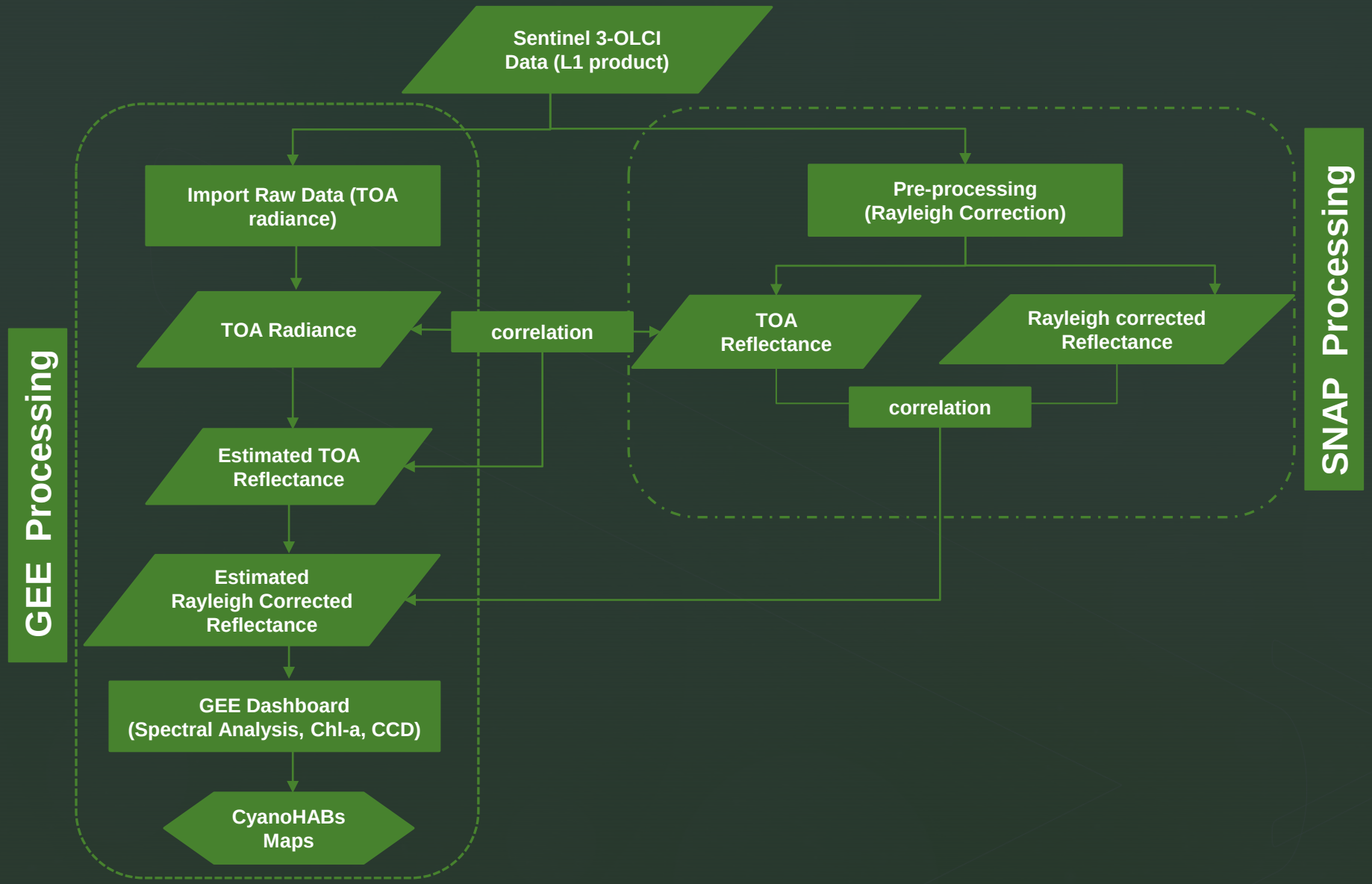


- Visual detection very difficult – highly synonymous with green algae
- Phycocyanin pigment absorbs light strongly at 620nm
- This absorption feature used to detect CyanoHABs
- Sentinel-3 – only opensource satellite sensor to have a dedicated 620 nm band

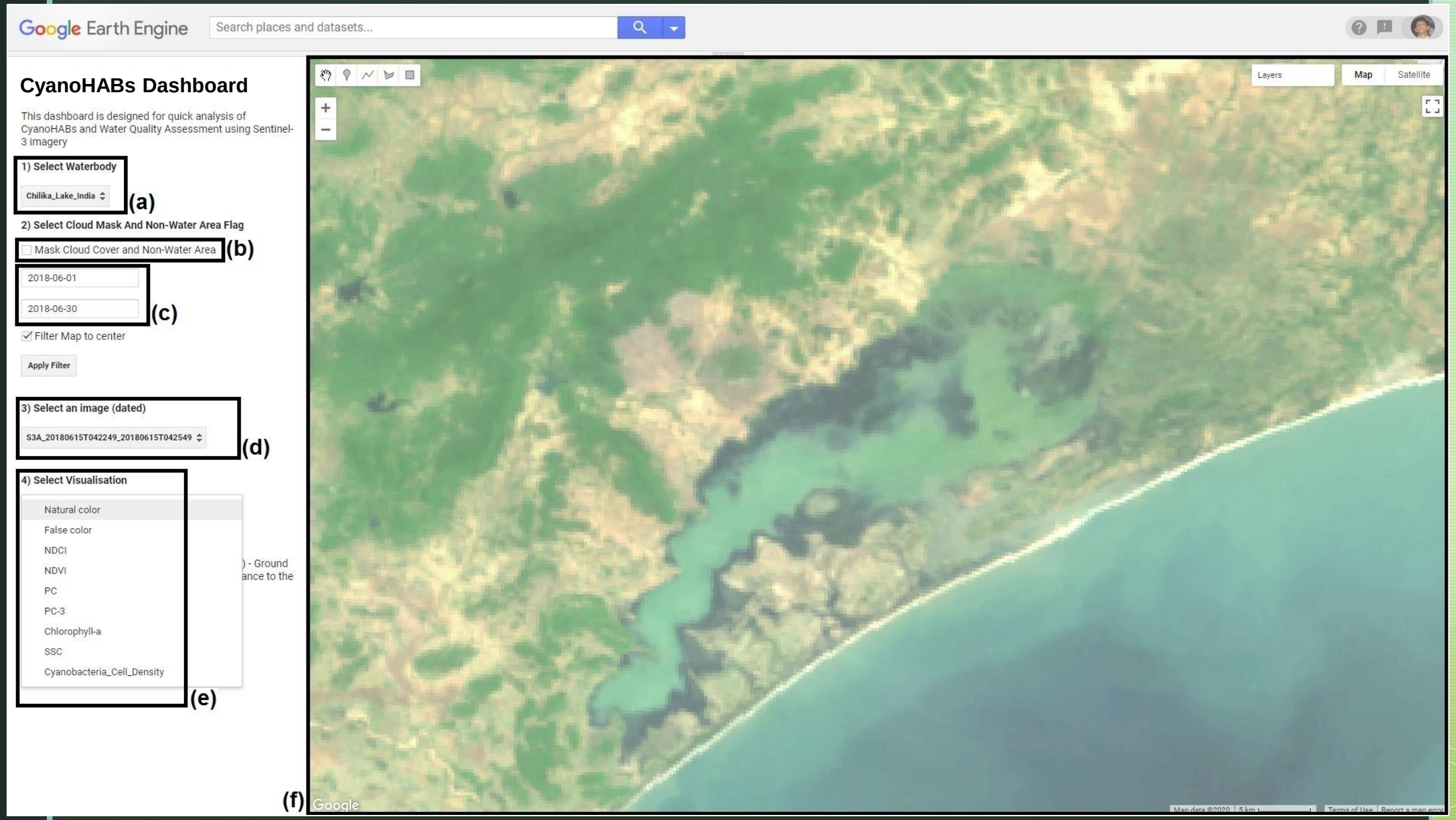
Overall Objective

- Monitor global inland and coastal water bodies for CyanoHABs using remote sensing (Sentinel-3)
- Develop an accessible, web-based dashboard for quick analysis and visualization of remotely sensed CyanoHABs
- Ultimately aid in better decision making of water quality and serve as early warning system to take timely action

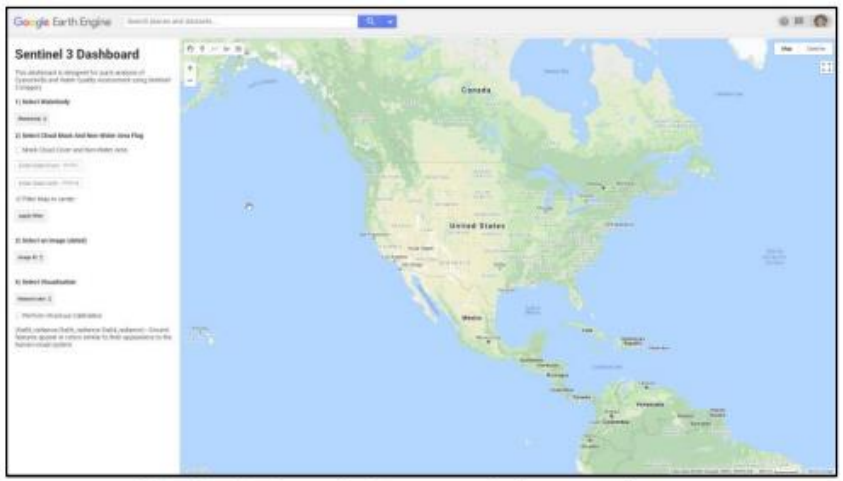
Methodology



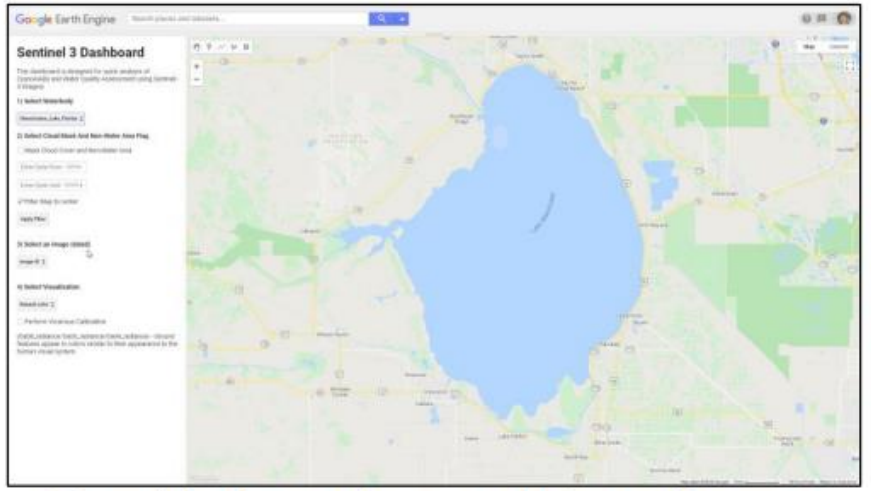
Google Earth Engine Dashboard Interface



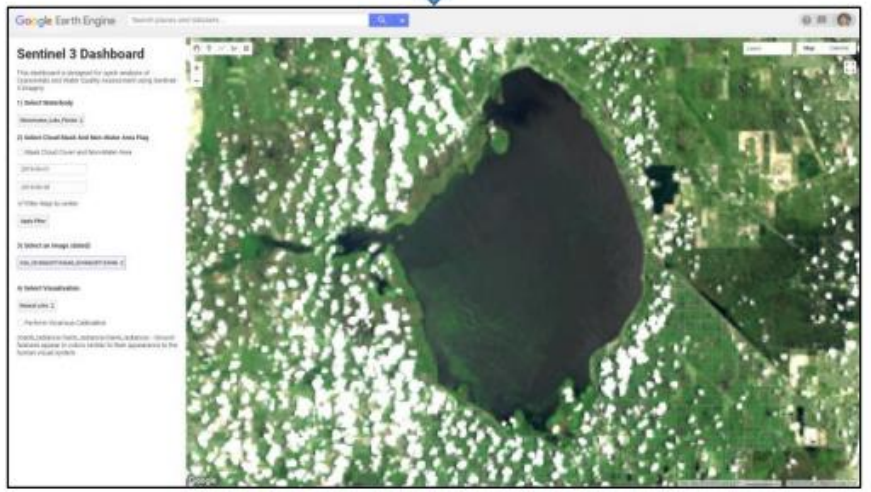
Dashboard Interface – Loading Imagery



GEE Dashboard Interface



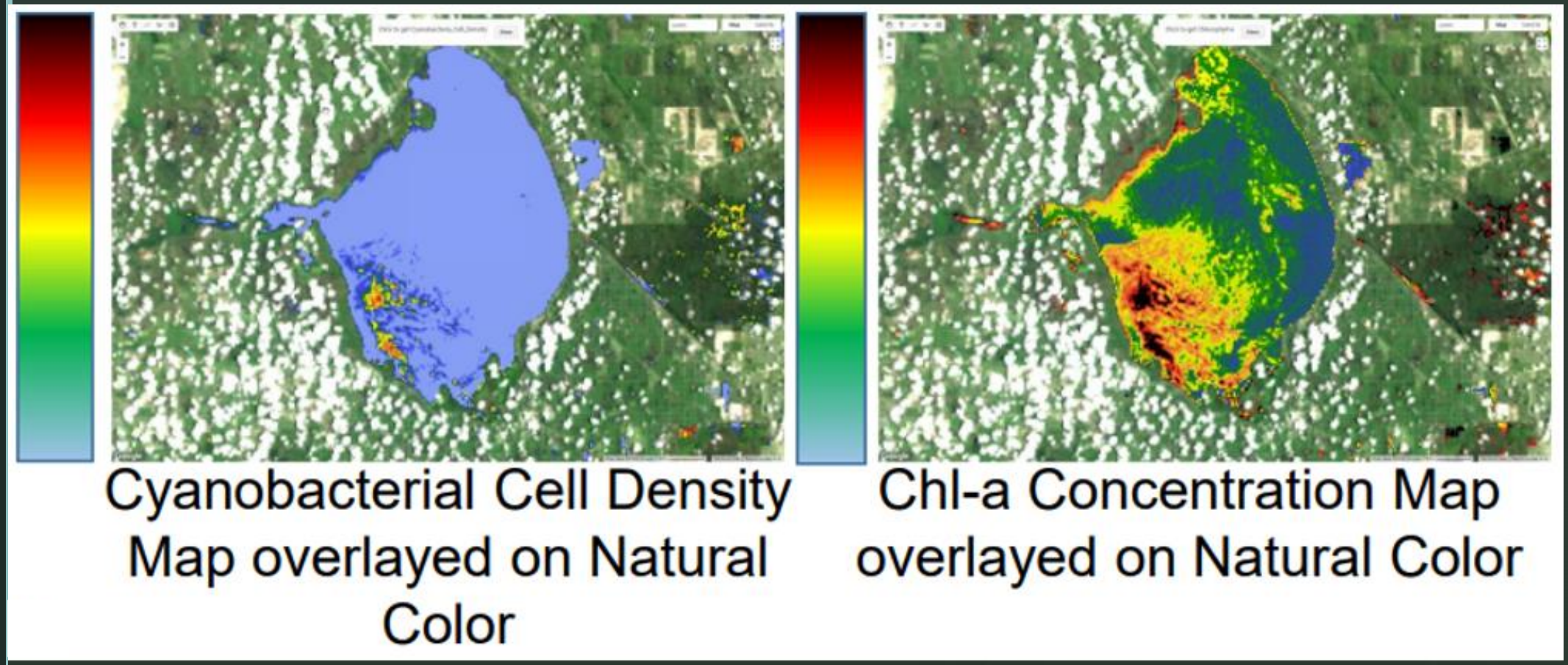
Provide Location and Date-Range



Natural Color Image

Cloudy pixels and Non-water Pixels masked

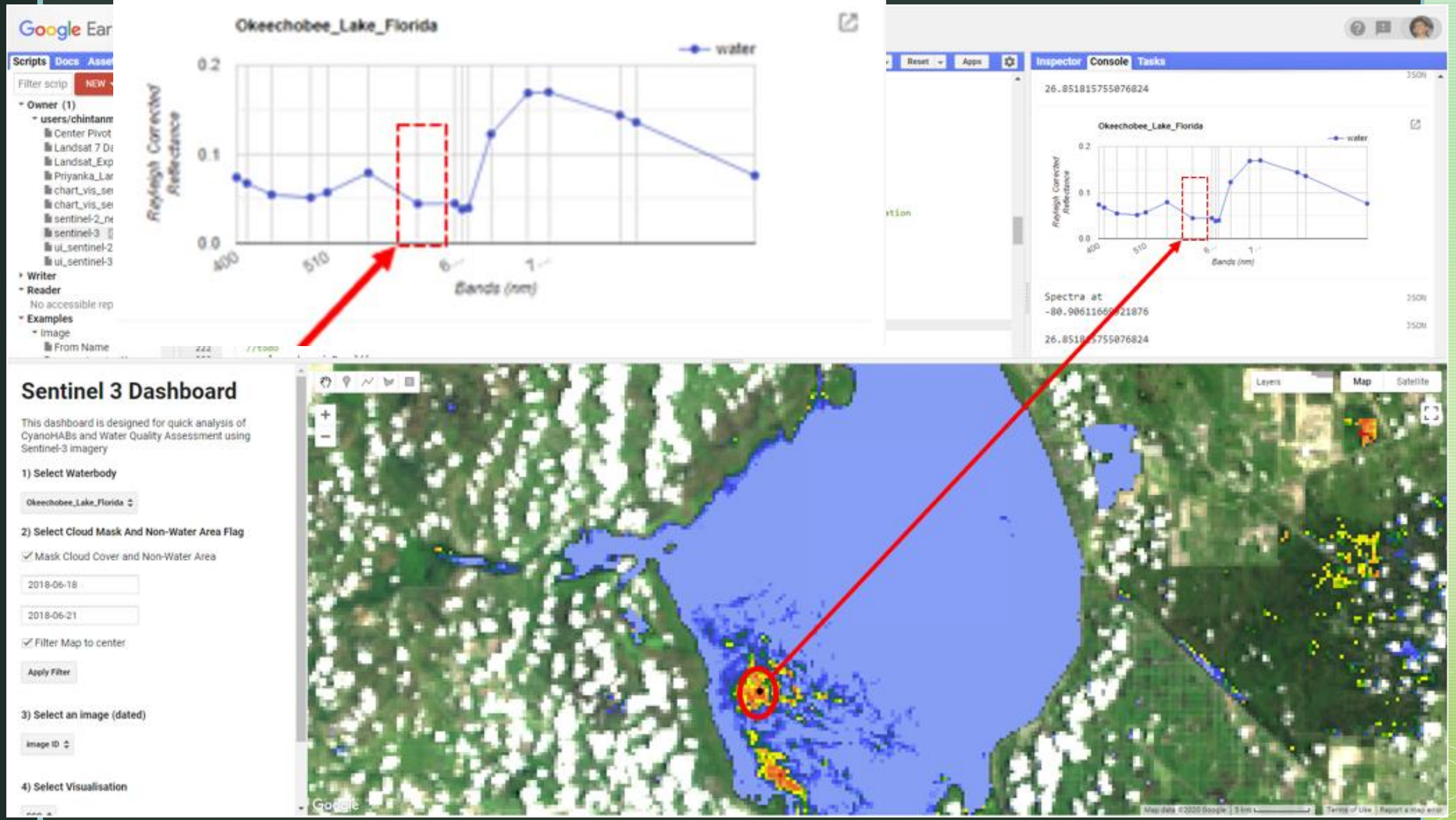
Dashboard Interface – Visualizations & Functionalities



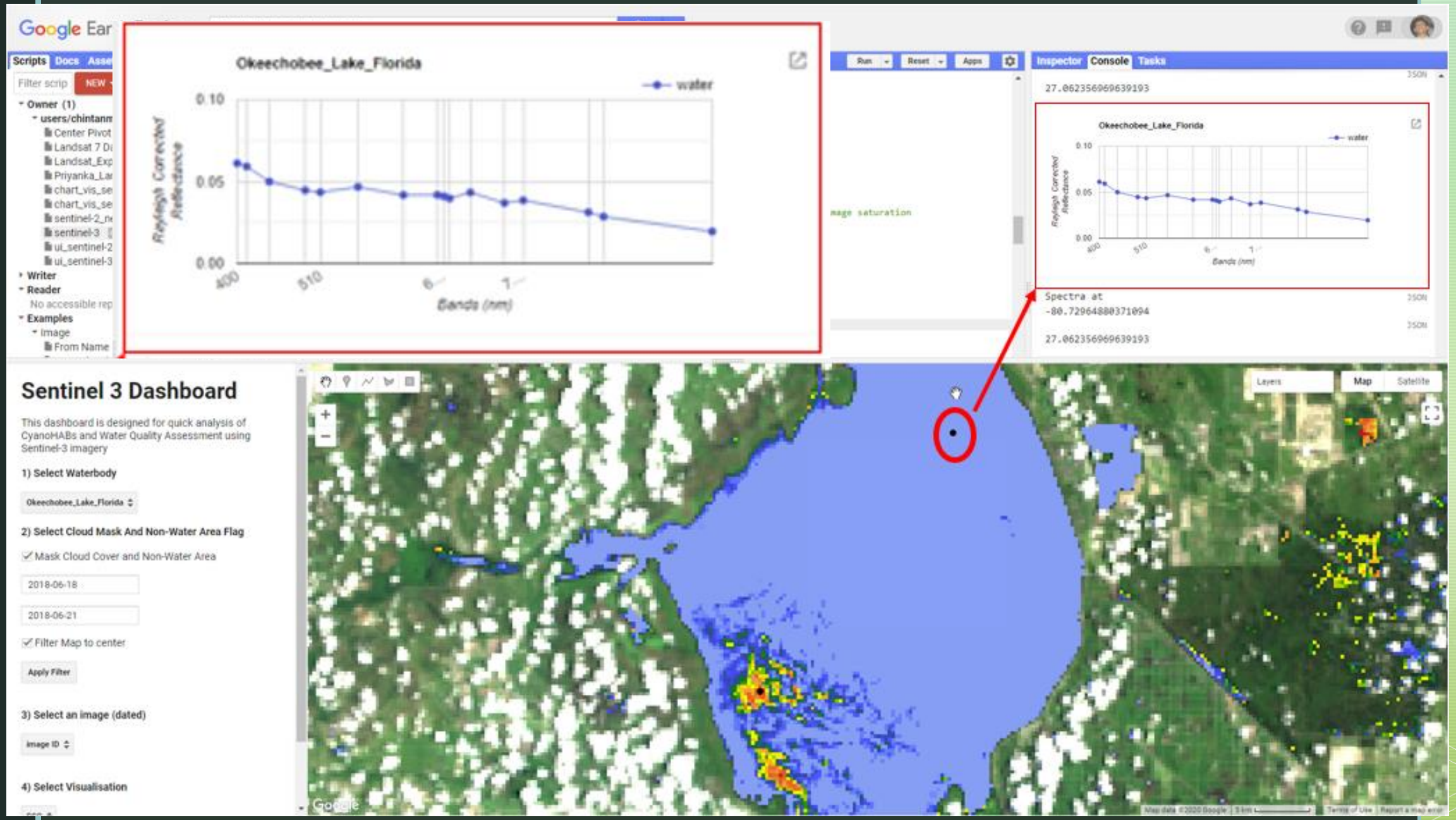
Cyanobacterial Cell Density Map overlayed on Natural Color

Chl-a Concentration Map overlayed on Natural Color

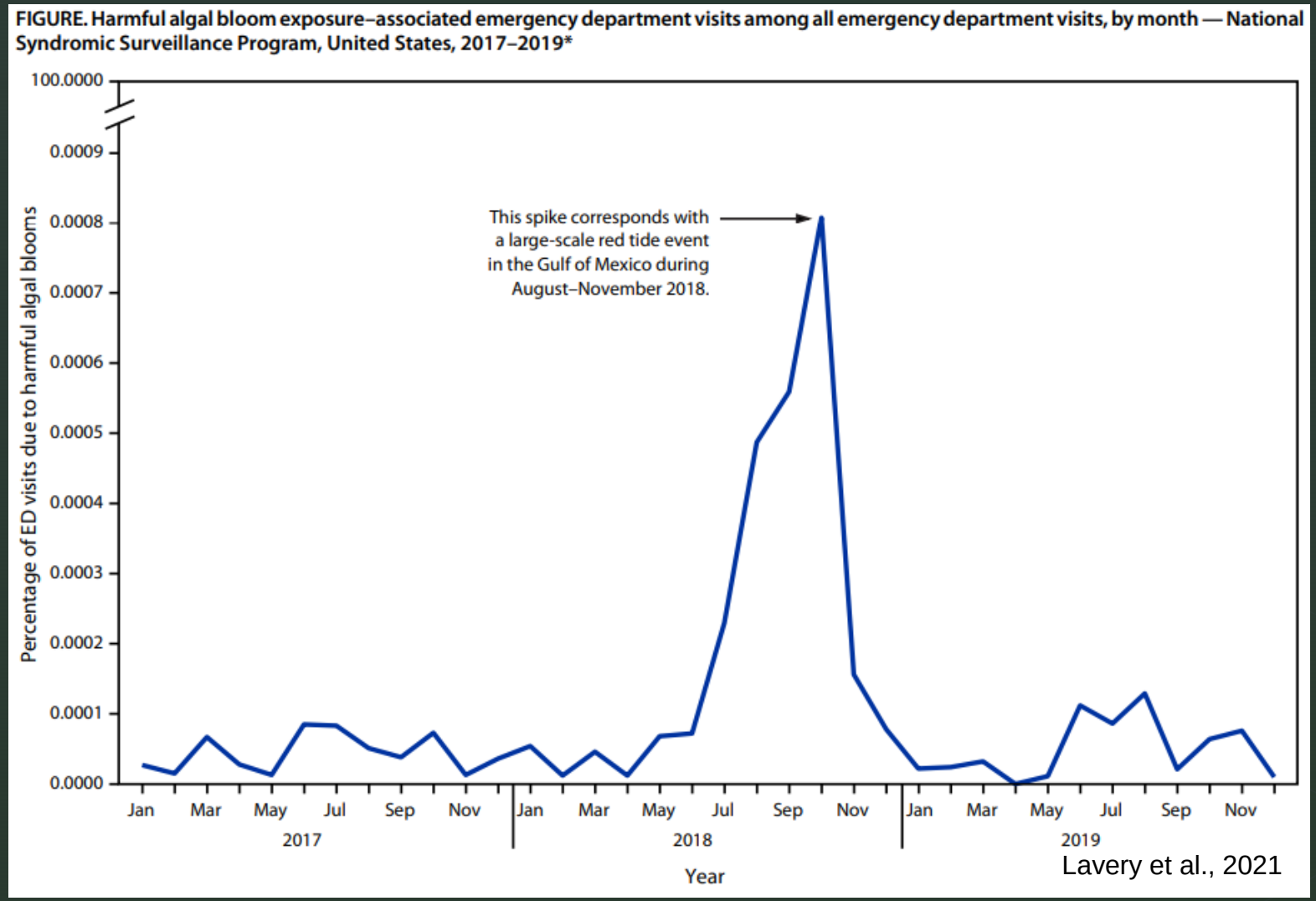
Detecting a CyanoHAB – Bloom Location



Detecting a CyanoHAB – Non-bloom location



Using this tool to prevent potential Disease Outbreak due to CyanoHABs



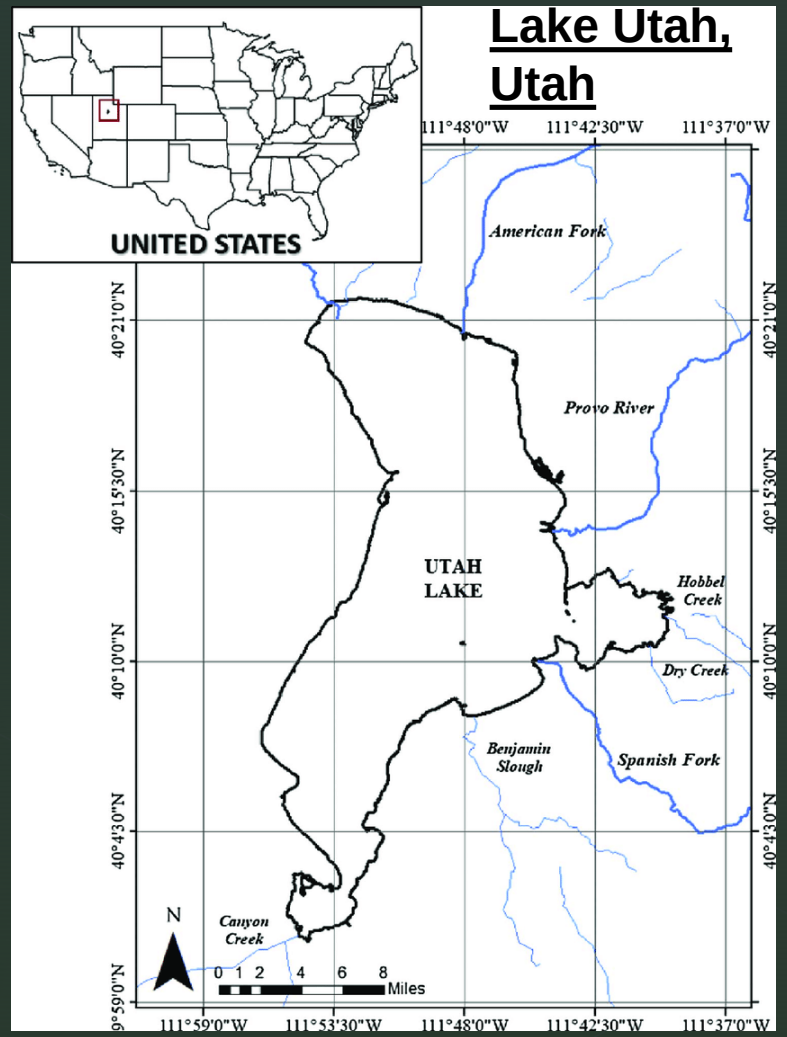
Lavery et al., 2021

CDC Recently published a study correlating ER visits with the boom in harmful algal blooms in the GOM area

Spatio-Temporal Maps, Monitoring Waterbodies

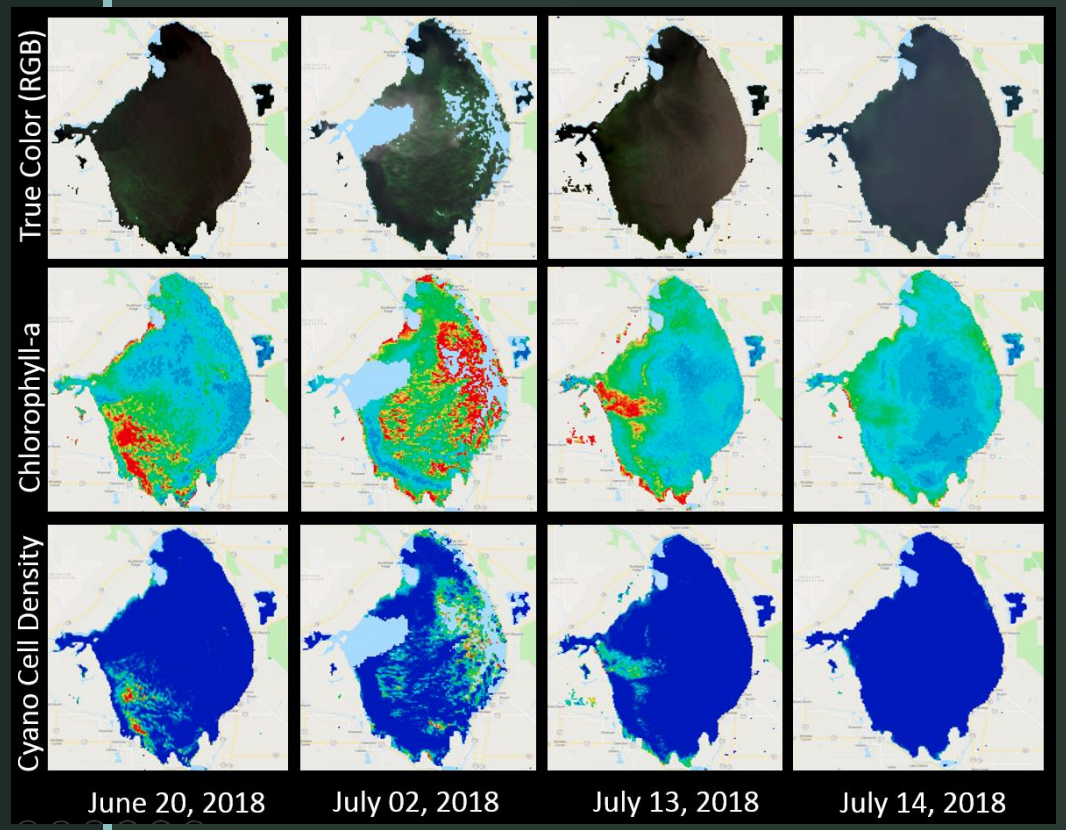
Lake Okeechobee, Florida, US

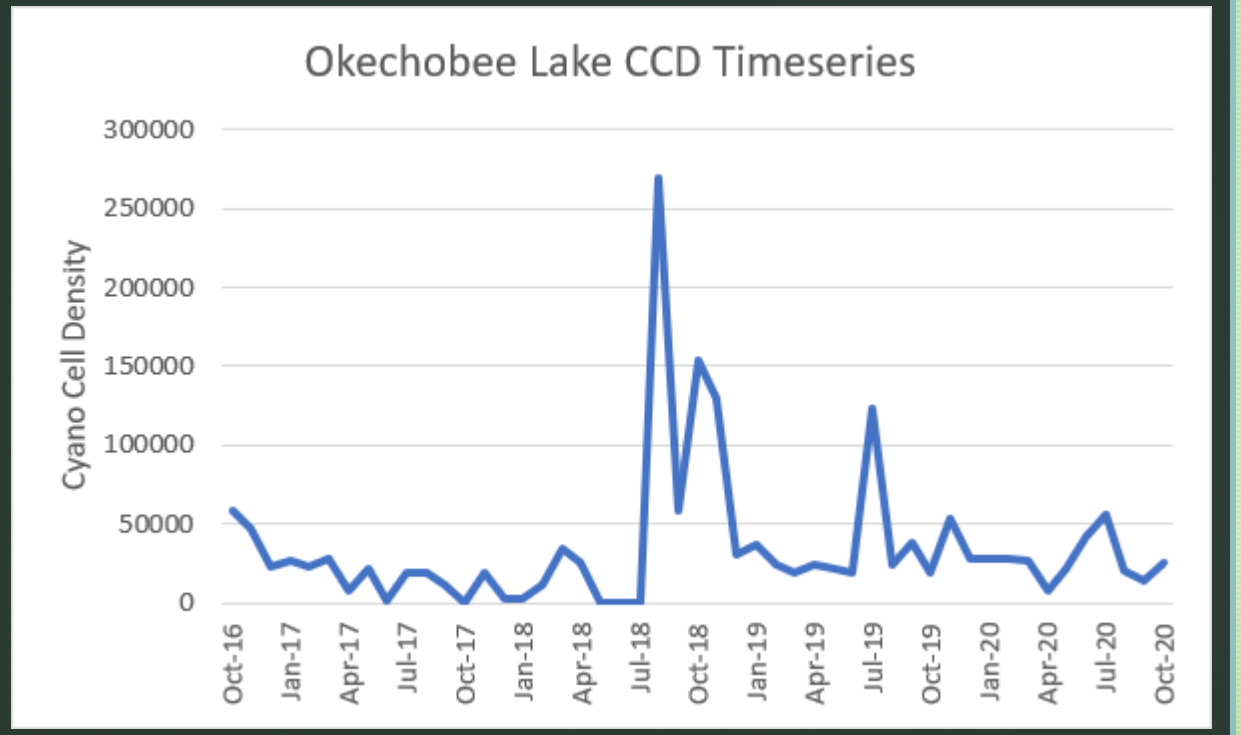
Suffered from heavy Cyanoblooms in 2018



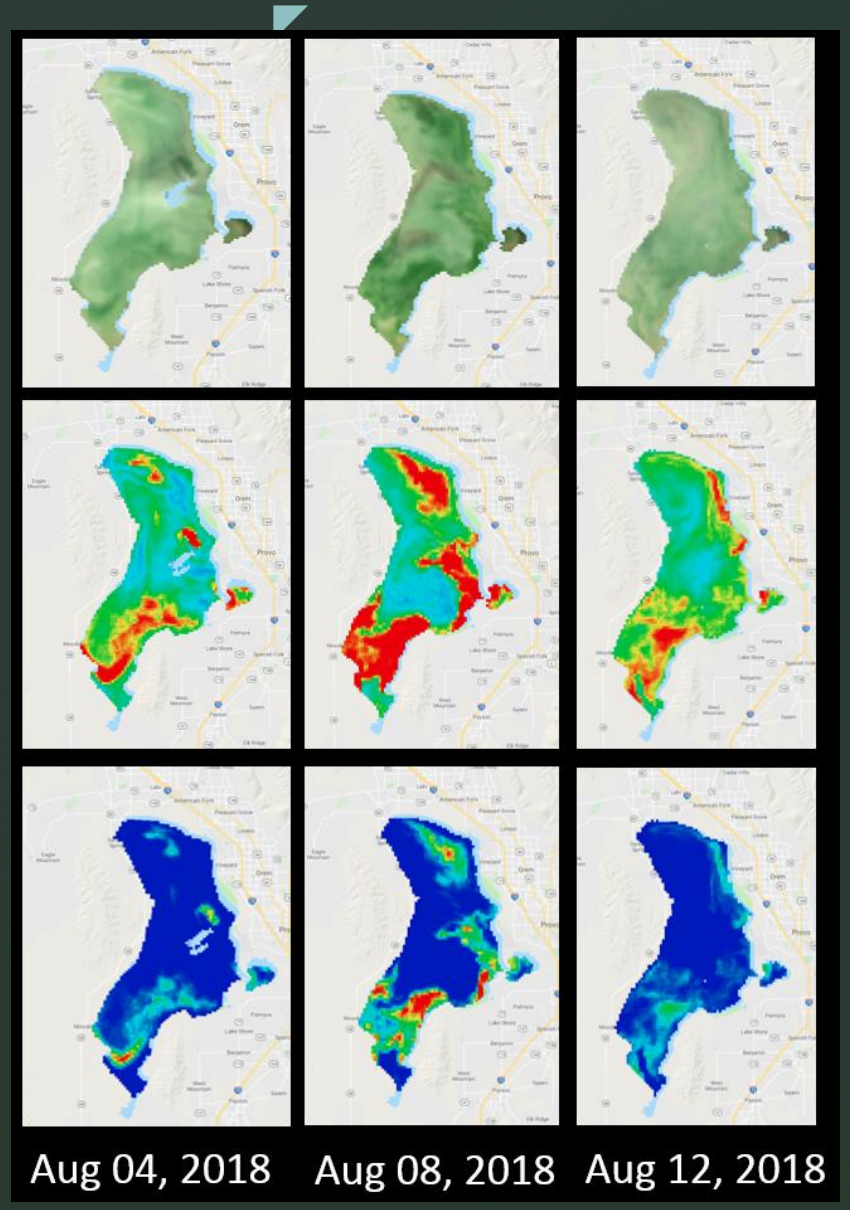
Map credits: B.Page et. al, 2017

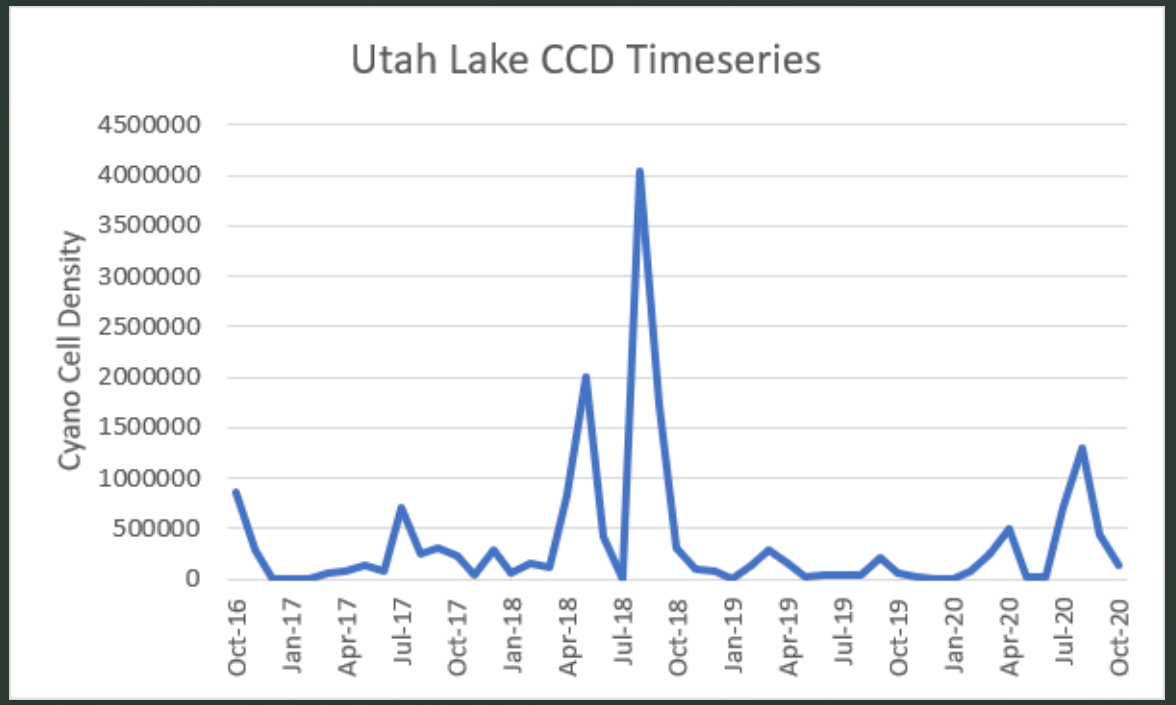
CyanoHAB Spatio-Temporal Maps: Lake Okeechobee





CyanoHAB Spatio-Temporal Maps: Lake Utah





Conclusion

- A GEE dashboard was developed for rapid detection and monitoring of CyanoHABs using Sentinel-3 data
- This dashboard can be easily shared with water resource managers who can follow simple steps to detect cyanobacteria and visualize the affected region within waterbodies
- This is very helpful and cost saving tool for lake managers in planning their field trip and forming management strategies timely
- Moreover, it can be used as an **early warning system** to prevent **potential disease outbreak in humans as well as other livestock** due to CyanoHABs
- Similar dashboard can be developed in future for other satellite sensors such as Landsat 8 and Sentinel 2 for monitoring other water quality parameters for smaller water bodies





THANK YOU

Questions?