



## Questions & Answers Part 2 (Session A)

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to Amita Mehta ([amita.v.mehta@nasa.gov](mailto:amita.v.mehta@nasa.gov)) or Sean McCartney ([sean.mccartney@nasa.gov](mailto:sean.mccartney@nasa.gov)).

### **Question 1: Can we see the cyanobacteria at coastline or wetlands?**

**Answer 1:** Not in wetlands because of land interference. We can detect freshwater cyanobacteria in coastal estuaries. This algorithm is not meant to detect marine cyanobacteria.

Although not meant to detect marine cyanobacteria the product is provided for coastal depths up to 35 meters. The CyAN product has detected cyanobacteria blooms in coastal Florida and the Gulf Coast. These cyanobacteria blooms came from freshwater rivers into the coastal system. There is a paper focused on the Mississippi Gulf Coast. "Spatial and temporal characterization of cyanobacteria blooms in the Mississippi Sound and their relationship to the Bonnet Carré Spillway openings." Harmful Algae <https://doi.org/10.1016/j.hal.2023.102472>

### **Question 2: What is the formula for deriving the cyanobacteria index, and can it be applied in the case of water hyacinths?**

**Answer 2:** All details on the formula is provided in this peer-reviewed manuscript that is available with open access: <https://doi.org/10.1016/j.rse.2021.112685>. This algorithm will **not** detect hyacinths.

### **Question 3: Are the distributed images regular GeoTiff or cloud optimized GeoTIFF?**

**Answer 3:** These are regular GeoTiff images.

### **Question 4: I am based in Ghana, West Africa. Am I able to use the data for the CyAN app?**

**Answer 4:** You can still access and use the app, but it is limited to data within the United States. Sorry 😞. The source code for the app is publicly available so if someone else wanted to reuse the app and host the data specific to West Africa that is possible! Here is the GitHub repository <https://github.com/USEPA/EPA-Cyano-Web>



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### **Question 5: Is this data available globally?**

Answer 5: This data is only available for the contiguous United States and Alaska.

### **Question 6: For CyAN, one of the examples showed exporting summary stats to a .csv using a point & the surrounding 9 points. Is it possible to do a similar data summary retrieval for an entire lake?**

Answer 6: Yes, lake level stats are available in the web-based app. You can also get lake summary stats from EnviroAtlas:

<https://enviroatlas.epa.gov/enviroatlas/interactivemap> click on the “Harmful Algal Bloom” Tab on the left menu

<https://enviroatlas.epa.gov/enviroatlas/DataFactSheets/pdf/Supplemental/CyANextentandbloomfrequency.pdf>

### **Question 7: Can we apply the algorithm with the RS tool in other lakes outside the USA?**

Answer 7: The RSTools will only work with the CyAN GeoTiff data.

### **Question 8: How long does an event of Cyan bloom normally take in a lake? What is the concentration of cyan (in milligrams per cubic liter [mgC/L]) during the bloom event?**

Answer 8: Great questions and all of them can be answered by searching the data for your lake of interest, because is it different for each lake and period of time you might consider.

### **Question 9: Is the minimum lake size you can work with determined mostly by sensor resolution, or is land adjacency also an issue?**

Answer 9: Lake size, shape, land type, depth, and land adjacency all play a role in the area that can be resolved by satellite.

### **Question 10: CyAN is a great project/service! Why did you decide to base it on Sentinel-3 OLCI data?**

Answer 10: Sentinel-3 provided the best combination of spectral bands required to detect cyanobacteria, spatial resolution (300m to 1km), and daily temporal coverage of available missions.



**Question 11: What is the best way for validating the results or ground truthing for satellite derived data?**

Answer 11: Keep in mind that in situ discrete data isn't truth either and also has errors associated with the measures. So "ground truthing" is a misnomer. There is no single "best way" to validate. However, here are some options to consider:

<https://doi.org/10.1016/j.hal.2022.102191>

<https://doi.org/10.1016/j.rse.2021.112685>

<https://doi.org/10.1016/j.scitotenv.2021.145462>

**Question 12: Is there a significant difference between the West and East concerning Cyanobacteria blooms? More prevalent in the West than the East or vice versa and why?**

Answer 12: It isn't clear what is meant by West and East. We have looked at changes spatially and temporally that are available here:

<https://doi.org/10.1016/j.ecolind.2022.108990>

<https://doi.org/10.1016/j.ecolind.2021.107822>

<https://doi.org/10.1016/j.scitotenv.2023.165253>

<https://doi.org/10.1016/j.watres.2021.117377>

**Question 13: Is there any plan to make CyAN available for the rest of the world?**

Answer 13: There have been some discussions about making the product global, but currently there is no set plan for this effort. It would require a large investment in resources to produce, quality control, and maintain a global product. The satellite data and algorithms are available, so anyone interested could create the CyAN product for their area.

**Question 14: How do I delete unwanted location points (under my locations)??**

Answer 14: On the main splash page using the map, click on the unwanted pin and select "Remove".

**Question 15: Are there any recommendations for how to track HAB's in a smaller lake/reservoir?**

Answer 15: We are looking into the use of Sentinel-2 but that would be more general for chlorophyll-a.



**Question 16: Does the CyAN app exclusively apply to lakes and reservoirs in the United States, or is it suitable for other types of water bodies as well?**

**Additionally, does the size of the water body under investigation have any impact on its applicability with the CyAN app?**

Answer 16: The CyAN app does provide measures in estuaries and coastal waters out to the 35 meter isobath, and even some of the large rivers. Yes, smaller water bodies that aren't at least three pixels across may be less reliable.

**Question 17:  $C_{lcyano} = 10(DN * 0.011714 - 4.1870866)$ : Is this empirical equation holds true for any region of the world? Can I use this equation and Sentinel-3B data for any lake in India? Also, the DN value of which of the 21 spectral bands of Sentinel 3A/B to be used? Is there any need for radiometric correction?**

Answer 17: The  $C_{lcyano}$  is a relative index the the NDVI. This equation just converts the digital number of the geoTiff to the relative index of  $C_{lcyano}$ . Yes, it would apply anywhere. The ability to convert the  $C_{lcyano}$  the chlorophyll would require validation and it might need an updated conversion. For radiometric correction, we use ToA.

**Question 18: What is the need to define water leaving reflectance differently from normal reflectance? Can some algorithm for retrieving water-leaving reflectance from sensor-measured radiance values be shared for any generic sensor?**

Answer 18: You can use ToA reflectance and use correction since any other method can cause error.

**Question 19: At what level of cells/mL does it become dangerous?**

Answer 19: We recommend looking at the World Health Organization (WHO) recommendations here:

<https://www.who.int/publications/m/item/toxic-cyanobacteria-in-water---second-edition>

\*\*Guidances can also vary by region as well (US states).\*\*

**Question 20: Is bathymetry known for all included lakes? If not, how do you account for possible bottom reflectance?**

Answer 20: Modeled mean/max bathymetry is available through a few various open data sources. We typically remove the pixels adjacent to land to avoid bottom reflectance and we also apply a quality flag in the processing that limits this from happening



**Question 21: How does high turbidity affect the occurrence and sensing of cyanobacteria?**

Answer 21: In terms of sensing cyanobacteria, the algorithm is not really sensitive to turbidity.

**Question 22: How does the Hyperspectral dataset help in the continuous monitoring of Cyan Bloom?**

Answer 22: There isn't an operational hyperspectral mission that can be used for real time monitoring. However, when hyperspectral data becomes operationally available it would be beneficial in further separating cyanobacteria from other algae.

**Question 23: Is cyanobacteria concentration enough to comment on water quality?**

Answer 23: Sorry, I'm not sure what this means. Cyanobacteria concentration is one aspect out of many when it comes to water quality.

**Question 24: Is there any relation between DO, BOD with Cyanobacteria Index?**

Answer 24: Great question, we haven't looked at this.

**Question 25: is there a way to run a correlation between CyAN cell content with other water quality parameters to discover associations between them?**

Answer 25: Of course. This could be done as the data are publicly available here:  
<https://oceancolor.gsfc.nasa.gov/about/projects/cyan/>

**Question 26: Can we also monitor cyanobacteria development using Google Earth Engine? If yes, are there available codes for such analysis?**

Answer 26: Google Earth Engine hosts Sentinel-3 data but we don't use that platform.

**Question 27: How did you choose to use CI rather than MCI (max chlorophyll index) or any other indices?**

Answer 27: They are similar approaches. The MCI provides measures of chlorophyll, where our focus was cyanobacteria and not just chlorophyll. We are considering the MCI for Sentinel-2.



**Question 28: Does the presence of aquaculture systems in the lake also affect the development of cyanobacteria and how do you think the location of the fish cages will affect the spatial concentration of cyanobacteria?**

Answer 28: Another great question, but we haven't looked at this.

**Question 29: Does the presence of cyanobacteria imply the imminent presence of toxins?**

Answer 29: No. Here is some additional info:

<https://doi.org/10.1016/j.hal.2022.102191>

<https://doi.org/10.1016/j.scitotenv.2021.145462>

**Question 30: Do cyanobacteria have any color? How do you identify the concentration?**

Answer 30: Cyanobacteria do have color and can vary in their color. With the algorithm, the wavelength of lights can impact the amount of cyanobacteria in a water body

**Question 31: Is there any relation between Cyanobacteria and human health in terms of disease incidence?**

Answer 31: Exposure to cyanobacteria and related toxins does have human health consequences such as rashes and respiratory issues, and this is a bit beyond our research. CDC is a great point of contact.

**Question 32: What is the accuracy of identifying cyanobacteria concentration by this method?**

Answer 32: As with any satellite data, accuracy is not 100 percent and it is dependent on a variety of factors, such as study area, in situ data, etc. See these sources for more information:

<https://doi.org/10.1016/j.hal.2022.102191>

<https://doi.org/10.1016/j.rse.2021.112685>

<https://doi.org/10.1016/j.scitotenv.2021.145462>

**Question 33: Is there any relation between CB and seasonality of any region?**

Answer 33: Cyanobacteria blooms do have seasonality and are sensitive to light levels, nutrients, temperature, etc. Certain warmer regions do have winter blooms

See the seasonal response here: <https://doi.org/10.1016/j.ecolind.2019.105976>



**Question 34: Is there any possibility to increase the benefits and world coverage of this program with other researchers in the world by institutional collaboration?**

Answer 34: We are always open to collaboration.

**Question 35: Were the cyanobacteria concentration estimated based on the surface concentration or was the average estimate at different depths of the lake considered?**

Answer 35: This is primarily surface, assumed to be the top 2 meters of the water column. This changes with concentration. Higher concentrations = shallower penetration depth.

**Question 36: Regarding the quality flag for land adjacency effects/bottom reflectance, is there a rule of thumb for eliminating a certain number of pixels around the shoreline (particularly in smaller lakes, like where Sentinel 2 would be applied)? Or is there a paper that describes a way to quality flag for bottom reflectance?**

Answer 36: Our CyAN products move one full pixel from the shoreline.

One paper discussing flags is here:

<https://doi.org/10.1016/j.dib.2019.104826>

**Question 37: What constitutes an "inland lake" for a coastal state, how far inland counts? I assume lakes like Pontchartrain [in Louisiana] or Okeechobee [Florida] will not work. Are they too brackish, shallow, what are the parameters?**

Answer 37: We do include Pontchartrain and Okeechobee, we also include estuaries and coastal lagoons.

**Question 38: Is there a way to integrate citizen science to get more data in the global south?**

Answer 38: Yes, but we haven't done it. CS can help with the validation of satellite products and satellites can help direct CS to locations to confirm HAB events.

**Question 39: What is the difference between chlorophyll-a and Cyanobacteria in water quality?**

Answer 39: Chlorophyll-a is present in all algae. We focus on cyanobacteria due to the potential for toxicity.



**Question 40: What pigments does your algorithm look for specifically? Is phycocyanin one of them?**

Answer 40: The algorithm is sensitive to chlorophyll and phycocyanin.

**Question 41: Why are you so concerned about the cyanobacteria concentration? Is it that harmful?**

Answer 41: Cyanos are known to cause environmental, human, and animal health issues.

**Question 42: Does climate change (e.g extreme weather events) exacerbate the increasing case of cb HAB's ?**

Answer 42: Warming temperatures are expected to increase cyanos, but the results up to recent days are currently mixed.

**Question 43: Since the estimated concentration were estimated from the surface values, does it imply that the result is underestimated. I read that the highest concentration of cyanobacteria may occur at depths ranging from 2 to 9 m.**

Answer 43: It depends on the system and mixing. The satellite passes mid-day when cyanos may be at the surface. We use the maximum detection to help reduce potential bias from depth.

**Question 44: If someone were to use drone multispectral imagery to perform a similar remote sensing analysis on water quality, what types of corrections would be necessary?**

Answer 44: This is complicated and probably more than can be answered in this session 😊.

**Question 45: What about carbon budget and carbon accounting for Cyanobacteria activity?**

Answer 45: Yes, this is a great question and something we haven't done.

**Question 46: What kind of cloud mask/haze correction does CYAN use? How have the recent forest fires & wildfire smoke affected the availability of the product?**

Answer 46: Fires smoke does cause loss of detection, similar to clouds. The quality flags can be found here:

[https://repository.library.noaa.gov/view/noaa/20270/noaa\\_20270\\_DS1.pdf](https://repository.library.noaa.gov/view/noaa/20270/noaa_20270_DS1.pdf)





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**Question 47: Do you give all lakes the same rating thresholds (low, medium, high etc) or do you have to customize it for different types of lakes? How about quantifying the cell counts from CI? From the app?**

Answer 47: We don't rate lakes. For the app the thresholds can be adjusted for the user's levels of concern.

**Question 48: What is the accuracy of cyanobacteria concentration for the United States of any lake you studied by this method?**

Answer 48: This was answered earlier in question 32.

**Question 49: Are there any studies where the mixed method of satellite and local knowledge has been used for managing high CB levels?**

Answer 49: All the time. A great example is here:

<https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020GH000254>

<https://youtu.be/fUJYPJ6Bky0>



## Questions & Answers Part 2 (Session B)

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to email Amita Mehta ([amita.v.mehta@nasa.gov](mailto:amita.v.mehta@nasa.gov)) or Sean McCartney ([sean.mccartney@nasa.gov](mailto:sean.mccartney@nasa.gov)).

### **Question 1: Is CYAN data available for the rest of the world apart from Continental US (CONUS)?**

Answer 1: Sorry, CyAN data is only available for the US. If someone is interested in processing, hosting, and distributing the data for other parts of the globe, all our processes are publicly available and can be replicated.

### **Question 2: Are Cyanobacteria blooms seasonal?**

Answer 2: Some of the seasonal changes are detailed here:  
<https://doi.org/10.1016/j.ecolind.2019.105976>

### **Question 3: Can we apply machine learning to develop a model that predicts cyanobacteria blooms using the remote sensing spectral signature with in-situ measurements?**

Answer 3: Sure, sounds like a great idea! We have a forecasting model that is explained here: <https://doi.org/10.3389/fenvs.2020.581091>

\*\*A national forecasting model is currently under journal review.\*\*

### **Question 4: Is the app only for android?**

Answer 4: The mobile app is only for Android. The web-app will work with iOS, Windows, Mac, Linux, etc.

### **Question 5: How accurately is the cell concentration calculated?**

Answer 5: As with any satellite data product there is uncertainty and error. It is dependent on a variety of factors, such as study area, clouds, validation efforts, etc. The cell conversion accuracy is detailed here: <https://doi.org/10.1016/j.rse.2014.06.008>  
However, we have moved onto an improved measure using chlorophyll with this method: <https://doi.org/10.1016/j.rse.2021.112685>



**Question 6: Can we predict the cyanoHAB before it starts? Maybe with field condition data, other remotely sensed data and past history of the blooms and understanding how these blooms are initiated and progressed?**

Answer 6: Here is an example of our ability to forecast cyanoHABs:

<https://doi.org/10.3389/fenvs.2020.581091>

There are a bunch of other approaches to forecasting available in the literature.

**Question 7: Do algorithms differ from lake to lake or does the same algorithm work for all lakes?**

Answer 7: The CyAN project currently uses the Clcyano algorithm for all lakes.

**Question 8: Are there some similar products from the Copernicus program?**

Answer 8: The CyAN Clcyano algorithm is not part of the Copernicus program. The SNAP tool provides the MPH algorithm, which is different than Clcyano, but similar in that it attempts to separate cyanobacteria.

**Question 9: What measures are in place for assessing the Cyan bacteria using advanced imaging sensors (hyperspectral imaging)?**

Answer 9: Hyperspectral data will be beneficial but this isn't something we worked on during the project. There are no hyperspectral satellites that are operational at this time and our focus was operational monitoring.

**Question 10: Is this data available only for lakes or for rivers and estuaries as well?**

Answer 10: The project focused on lakes and reservoirs, but the data does include estuaries and even larger rivers. The sensor being used has a 300 meter resolution, so size is a constraint.

**Question 11: Is there an implemented Early Warning System (EWS) for HABs in the USA?**

Answer 11: We assume EWS=early warning service? Yes, CyAN is the EWS for cyanoHABs in the US. NOAA provides a similar service for marine HABs.

**Question 12: To study harmful algal blooms, which of these software do you recommend using GEE, ArcMAP, ArcPRO RS Tools or SeaDAS?**



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Answer 12: All of the software are helpful in studying HABs. We have used all of these in addition to R, Python, and SNAP.

**Question 13: What is the range of values for the low, medium, and high level of the concentration of cyanobacteria?**

Answer 13: This is set by the user of the app.

**Question 14: Is there a database that allows me to determine the type of cyanobacteria through the spectral signature?**

Answer 14: Not that we are aware of at this time.

**Question 15: Can the same algorithm be applied using Landsat 9 OLI imagery that offers higher resolution, or is the algorithm limited to certain satellites that have resolution of 300m?**

Answer 15: Unfortunately, no. Landsat doesn't have the same spectral bands. We wish it did and hope future missions might 😊. The algorithm is limited more on spectral bands than it is the spatial resolution.

**Question 16: What bands are used to compute this index?**

Answer 16: Algorithm details and bands are provided here:

<https://doi.org/10.1016/j.rse.2021.112685>

**Question 17: Podría explicar cómo funciona el algoritmo para la identificación de las cianobacterias?**

**[Eng.] Could you explain how the algorithm for the identification of cyanobacteria works?**

Answer 17: Refer to the following link for an explanation on how the algorithm for the identification of cyanobacteria works:

<https://doi.org/10.1016/j.rse.2021.112685>

**Question 18: Could Synthetic Aperture Radar (SAR) be used to study harmful algal blooms?**

Answer 18: Yes, it would probably be informative.

**Question 19: How is the cell concentration calculated? Is it based on the color from a remote sensing image?**



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Answer 19: The cell count conversion is more to relate the imagery to something people are used to. Specific details are here: <https://doi.org/10.1016/j.rse.2014.06.008>  
We have been switching away from cell counts to chlorophyll using this method <https://doi.org/10.1016/j.rse.2021.112685>

### **Question 20: Does cyanobacteria track with Land Surface Temperature (LST) meaning does higher LST lead to hotter lakes?**

Answer 20: Great question, we haven't looked at that specifically. Higher temperature is expected to increase cyanos.

### **Question 21: How do you solve cases that are close to the shore but the spatial resolution doesn't reach these? By interpolation means?**

Answer 21: We quality mask pixels at the land-water interface. Mixed land/water pixels are flagged.

### **Question 22: How different are Chlorophyll-a concentration vs. Cyanobacteria (HAB)'s? Which algorithms would you suggest for Sentinel-3 (OCI) and Landsat series to separate them both?**

Answer 22: Chlorophyll is an indicator of phytoplankton+cyanobacteria. The Clcyano works well for Sentinel-3. Another option might be the MPH (maximum peak height) algorithm. Landsat doesn't have the bands required to separate chl from cyano. Sentinel-2 might be able to provide chlorophyll.

### **Question 23: In the last session we discussed how different lakes with similar characteristics, one with in situ measurements used to calibrate the models and used to detect the water quality. Can we do this for cyanobacteria identification for lakes where data might be lacking?**

Answer 23: Sure. We haven't validated every single lake in CyAN, but we try to validate as many lakes as possible.

### **Question 24: Are there any algorithms focused on analyzing E. coli by means of remote sensing?**

Answer 24: E. coli would have to create a spectral signature for the satellite to detect. There have been studies that have combined temperature and sediment to model E.coli. So, perhaps satellite detected sediment/turbidity with temperature could be used to develop a model for E.coli.



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### **Question 25: How beneficial will the new PACE and SBG missions be?**

Answer 25: PACE has 1 km resolution so might be beneficial in the Great Lakes. The future Surface Biology and Geology (SBG) mission is higher resolution, so we could get into more lakes, but low revisit so infrequent measures. Both are hyperspectral that will help improve separation.

### **Question 26: Could you tell us how accurate the algorithm is so far, just a general figure to understand the effectiveness of the algorithm?**

Answer 26: Here are the results on the algorithm comparison to chlorophyll:

<https://doi.org/10.1016/j.rse.2021.112685>

Keep in mind that the in situ data have errors too. In situ data can have errors 30-60%. The algorithm performs relatively well with a multiplicative bias of 11% and mean absolute error of 60%.

### **Question 27: Is field measurement data collected for model validation available to the public?**

Answer 27: Yes, we used public data from the Water Quality Portal here:

<https://www.waterqualitydata.us/>