A validation of satellite derived cyanobacteria detections with state reported events and recreation advisories across U.S. lakes

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Supplemental Material

Table S1. List of state health advisory websites, where historical state recreation advisory data were available from nine states including Oregon, Ohio, California, Kansas, New York, New Jersey, Idaho, Wyoming, and New Hampshire.

State	URL
California	https://data.ca.gov/dataset/surface-water-freshwater-harmful-algal-blooms
Idaho	https://www.deq.idaho.gov/water-quality/surface-water/cyanobacteria-harmful-algal-blooms/
Kansas	https://www.kdheks.gov/algae-illness/index.htm
New Hampshire	https://www4.des.state.nh.us/DESOnestop/BasicSearch.aspx
New Jersey	https://www.nj.gov/dep/wms/bfbm/cyanoHABevents.html
New York	https://www.dec.ny.gov/chemical/83332.html
Ohio	http://publicapps.odh.ohio.gov/beachguardpublic/
Oregon	https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/RECREATION/HARMFULALGAEBLOOMS/Pages/archive.aspx
Wyoming	https://www.wyohcbs.org/

Table S2. A summary of the current thresholds used by nine states with public records of recreation advisories. Records of recreation advisories that occurred between 2008 and 2018 within these nine states were used in this study. The thresholds outlined here may not reflect what was used in the past, but they do highlight the amount of variation in sampling frequency, thresholds, and procedure that exists between states.

State	Risk Thresholds	Reference
California	- $\geq 0.8\ \mu g\ L^{-1}$ microcystin, detection of anatoxin-a, or $\geq 1\ \mu g\ L^{-1}$ cylindrospermopsin for cautions - Higher thresholds for different warning tiers	(California Water Quality Monitoring Council, 2016)
Idaho	- Identify potential toxin-producing cyanobacteria species $> 20,000$ cells mL^{-1} and analyze water samples for toxins - Advisories are lifted once two samples, collected a week apart, had toxin levels $< 4\ \mu g\ L^{-1}$ for microcystin and $< 8\ \mu g\ L^{-1}$ for cylindrospermopsin	(Idaho Department of Environmental Quality, 2021)
Kansas	- Microcystin toxins $> 4\ \mu g\ L^{-1}$ and/or the concentration of cyanobacteria $> 80,000$ cells mL^{-1} in addition to verified visual confirmation - Thresholds increase as advisories increase from warnings to hazard level - Removal of any level advisory included microcystin $< 8\ \mu g\ L^{-1}$ in two samples collected a week or more apart	(Kansas Department of Health and Environment, 2020)
New Hampshire	- Advisories are issued when cell concentrations are $> 70,000$ cells mL^{-1}	(New Hampshire Department of Environmental Services, 2021)
New York	- Public and trained participants report events and submit digital photographs, reports, microscopic confirmation of cyanobacteria dominance, or measures where cyanobacteria chlorophyll levels are $\geq 25\ \mu g\ L^{-1}$ - In absence of these observations microcystins $\geq 4\ \mu g\ L^{-1}$ with a digital photograph or report	(New York Department of Environmental Conservation, 2020)
Oregon	- WHO guidelines, cell counts $> 100,000$ cells mL^{-1}, toxicity levels $\geq 8\ \mu g\ L^{-1}$ microcystin or anatoxin-a detected, or a combination of two or more of these observations	(Oregon Department of Environmental Quality, 2011)

	- Advisories are ended one week after both a cell count and toxin concentration are below the WHO thresholds	
Ohio	- 8, 8, 15 and 0.8 µg L^{-1} for microcystin, anatoxin-a, cylindrospermopsin, and saxitoxin, respectively - Advisories are ended after two consecutive samples collected at least one week apart show cyanotoxin levels below these threshold levels	(Ohio Environmental Protection Agency, 2020)
Wyoming	- Microcystin concentration > 10 µg L^{-1} or cell counts > 20,000 cells mL^{-1} - Sampling continues weekly until the *in situ* measures are < 10 µg L^{-1} microcystin or counts are < 20,000 cells mL^{-1}	(Wyoming Department of Environmental Quality, 2018)

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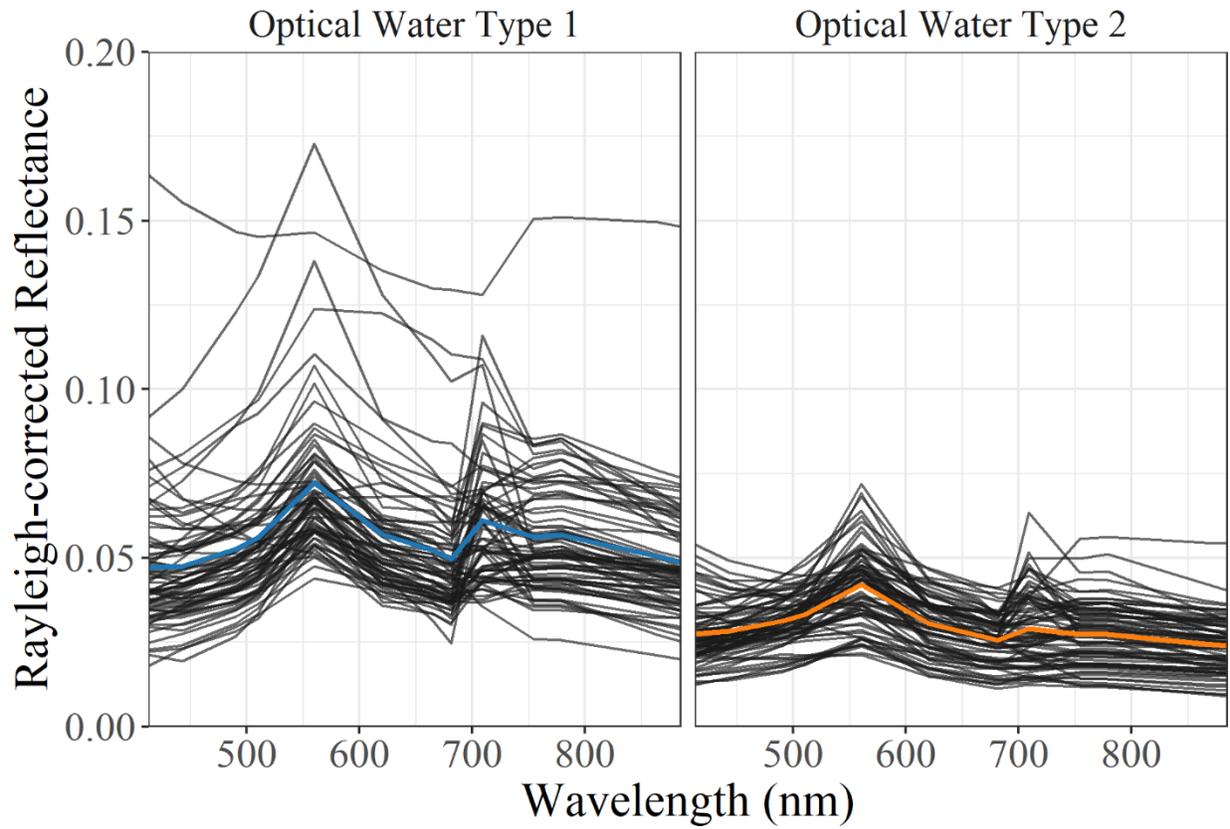
Figure S1. The spectral profiles of the 210 lakes where state reported events and recreation advisories occurred sorted into two clusters representing optical water types using fuzzy c-means. The black lines represent the individual lake reflectance profiles, and the colored lines represent the mean reflectance profiles of the optical water types.

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