



Breakout Workshop:

**Blueprint for large-scale, operational,
Earth Observation-based systems for Harmful Algal Blooms monitoring**

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Scope and Goals

Several studies have recently indicated an increasing trend in Harmful Algal Bloom (HAB) frequency, intensity and duration across the globe (Feng et al., 2024; Huisman et al., 2018). HABs can have significant ecological and socio-economic impacts. The potential of Earth Observation (EO) in HAB monitoring has been amply demonstrated. Numerous projects and test cases have been documented (e.g., IOCCG, 2021 and references therein) and diverse regional and national systems are in place (e.g. Anttila et al., 2018; Binding et al., 2021; Wynne et al., 2021).

The diversity of HAB characteristics and effects and of the environments where they are observed challenges the implementation of ‘one size fits all method’ for their detection (IOCCG, 2021). Methods are usually optimized for local environmental conditions and the relevant phytoplankton species, and a large number of regional algorithms have been developed for ocean, coastal and inland waters. However, harmonization and cross-calibration are needed to apply existing approaches at broader scales, particularly considering the growing interest in integrating EO data into decision-making processes and water-related policies implementation. In fact, the lack of a standard/harmonized approach hinders HAB identification methods portability to environments different than those for which they have been implemented.

The objective of this BW is to propose recommendations leading to an agreed blueprint for large scale, effective, operational, EO-based systems for HABs. First, a clear definition of HAB which applies in the context of EO would clarify the scope of these systems and support the choice of proper methods and their harmonization. The BW should then identify a strategy to reconcile the diverse methods, including robust criteria to identify effective thresholds defining HAB presence. It should also discuss how to supersede the regional/empirical character of HAB-related approaches and relate them to a more formal framework based on first principles.

Key Questions

1. Which methods or set of methods would better support large scale applicability? How could they be harmonized or cross- calibrated to enlarge their portability to the largest number of waterbodies?
2. Which robust methods should be applied to identify effective thresholds and criteria to detect/delineate HAB presence across different water bodies?
3. What is missing in the community: which approaches (optical theory, Artificial Intelligence) and which knowledge (data on optical properties of individual species, on spatial scales and patterns, shared data bases of HAB events) can support improved algorithm performance and harmonization? In general, what is needed to supersede the regional/empirical character often found in HAB EO activities?

References

- Anttila, S., Fleming-Lehtinen, V., Attila, J., Junntila, S., Alasalmi, H., Hällfors, H., Kervinen, M., and Koponen, S. 2018. A novel earth observation based ecological indicator for cyanobacterial blooms, *International Journal of Applied Earth Observation and Geoinformation*, vol. 64, no. October 2017, 145–55
- Binding, C. E., Pizzolato, L., and Zeng, C. 2021. EOLakeWatch; delivering a comprehensive suite of remote sensing algal bloom indices for enhanced monitoring of Canadian eutrophic lakes, *Ecological Indicators*, vol. 121, 106999
- Feng, L., Wang, Y., Hou, X., Qin, B., Kutser, T., Qu, F., Chen, N., Paerl, H. W., and Zheng, C. 2024. Harmful algal blooms in inland waters, *Nature Reviews Earth & Environment*, vol. 5, no. 9, 631–44
- Huisman, J., Codd, G. A., Paerl, H. W., Ibelings, B. W., Verspagen, J. M. H., and Visser, P. M. 2018. Cyanobacterial blooms, *Nature Reviews Microbiology*, vol. 16, no. 8, 471–83
- IOCCG. 2021. Observation of Harmful Algal Blooms with Ocean Colour Radiometry. Bernard, S., Kudela, R., Robertson Lain, L. and Pitcher, G.C. (eds.), IOCCG Report Series, No. 20, International Ocean Colour Coordinating Group, Dartmouth, Canada.
- Wynne, T., Meredith, A., Stumpf, R., Briggs, T., and Litaker, W. 2021. Harmful Algal Bloom Forecasting Branch Ocean Color Satellite Imagery Processing Guideline, NOAA Technical Memorandum NOS NCCOS, vol. 296, 48