EGU26-11204, updated on 18 Nov 2026
https://doi.org/10.5194/egusphere-egu26-11204
EGU General Assembly 2026
© Author(s) 2026. This work is distributed under
the Creative Commons Attribution 4.0 License.

Preliminary results of a cost-effective optical imaging and deep learning system for algal bloom monitoring in Lake Lugano

alessandro centazzo, daniele strigaro, claudio primerano, massimiliano cannata, and camilla capelli
University of Applied Sciences and Arts of Southern Switzerland, Institute of Earth Sciences, Department of Environment Constructions and Design, Switzerland (alessandro.centazzo@supsi.ch)

Algal blooms represent a significant challenge for the sustainable management of freshwater habitats, strongly affecting water quality, biodiversity, ecosystem functioning, and human activities. Their occurrence is often driven by complex interactions between natural processes and anthropogenic pressures [1–3]. Consequently, there is a growing demand for monitoring strategies capable of capturing the spatial and temporal variability of algal dynamics while supporting a holistic assessment of water habitat health. Traditional monitoring approaches typically rely on point-scale in situ measurements or satellite remote sensing products, which, although essential, are often limited by spatial resolution, revisit frequency, operational costs, or deployment constraints [4]. In this context, low-cost, image-based sensing systems represent a promising complementary solution, enabling continuous and visually explicit observations at local to regional scales.

This contribution presents preliminary results from an in situ monitoring system based on cost-effective optical imaging cameras combined with deep learning-based image analysis. The proposed approach is developed within the framework of the WINCA4TI (Water Interactions with Nature, Climate and Agriculture for Ticino) Interreg project, which aims to foster cross-border innovation in environmental monitoring through low-cost sensing technologies and data-driven methods. The system is designed to complement high-end in situ instrumentation and satellite observations by providing flexible, scalable, and cost-effective monitoring capabilities, with a specific focus on the automatic characterization of algal bloom phenomena to support near-real-time detection and decision making.

The monitoring system relies on compact cameras and optical sensors operating in the visible and near-infrared spectral ranges, deployed on fixed platforms suitable for long-term observations and on-site (edge) processing. Image data are initially combined with in situ measurements to build a reliable reference dataset, which is subsequently exploited to enable image-only monitoring. The computational workflow integrates image preprocessing, including illumination normalization and water surface masking, with deep learning–based image segmentation to

derive spatial and temporal indicators of algal presence, surface coverage, and bloom dynamics.

Preliminary results demonstrate the capability of the proposed approach to capture fine-scale spatial and temporal patterns of algal blooms, bridging the gap between localized field measurements and large-scale remote sensing products. The findings suggest that low-cost image-based monitoring systems can enhance the responsiveness and resilience of water management strategies, particularly where traditional monitoring is constrained by cost, logistics, or spatial coverage.

- Strigaro D., Capelli C. (2024). An open early-warning system prototype for managing and studying algal blooms in Lake Lugano. https://doi.org/10.5194/isprs-archives-XLVIII-4-W12-2024-143-2024

- Bosse K. R., Fahnenstiel G. L., Buelo C. D., Pawlowski M. B., Scofield A. E., Hinchey E. K., & Sayers M. J. (2024). Are harmful algal blooms increasing in the Great Lakes? https://doi.org/10.3390/w16141944

- Zeng K., Gokul E. A., Gu H., Hoteit I., Huang Y., & Zhan P. (2024). Spatiotemporal expansion of algal blooms in coastal China seas. https://doi.org/10.1021/acs.est.4c01877

- Ogashawara I. (2019). Advances and limitations of using satellites to monitor cyanobacterial harmful algal blooms. https://doi.org/10.1590/S2179-975X0619