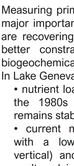


High-resolution spatiotemporal heterogeneities of water optical properties in a large lake to infer physical and biogeochemical drivers of primary production



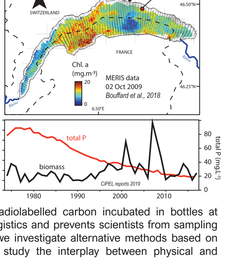
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Introduction

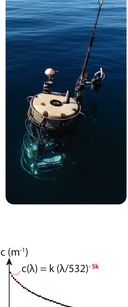
Measuring primary production (PP) is of major importance to evaluate how lakes are recovering from eutrophication and better constrain their role in global biogeochemical cycles.
In Lake Geneva (Switzerland),

- nutrient loads have decreased since the 1980s but primary production remains stable.
- current measurements conducted with a low resolution spatially (1 vertical) and temporally (bi-monthly) can't explain why.



The classical sampling method involving radiolabelled carbon incubated in bottles at selected depths is associated with heavy logistics and prevents scientists from sampling the short-term dynamics of PP. Therefore, we investigate alternative methods based on oxygen sensors and optical properties to study the interplay between physical and biological processes

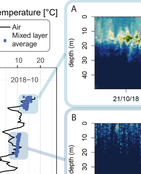
Methods



We have deployed since October 2018 a sophisticated autonomous profiler in Lake Geneva, Switzerland, near the LéXPLORE research platform. The so-called Thetis profiler (Wetlabs) measures with a centimeter resolution hyperspectral absorption and attenuation, backscattering and fluorescence at discrete wavelengths, hyperspectral reflectance, along with temperature, dissolved oxygen and conductivity. The profiler was deployed over contrasted seasons and recorded these parameters every three hours over the top 50 m of the water column.

We looked into spatiotemporal heterogeneities of a set of inherent optical properties and physico-chemical variables:

- Sk: spectral attenuation slope
- aLH550 and aLH676: absorption line height peaks for 550 and 676 nm, respectively. } Wetlabs ACS
- CHL: Chlorophyll a concentration
- CDOM: Chromophoric dissolved organic matter concentration (data not shown here) } Wetlabs ECO Triplet
- b_700: particulate backscattering (data not shown here)
- O2 concentration (data not shown here) } SeaBird SBE63 and SBE49
- Temperature



Sk can be seen as a proxy for average particle size in the volume being sampled

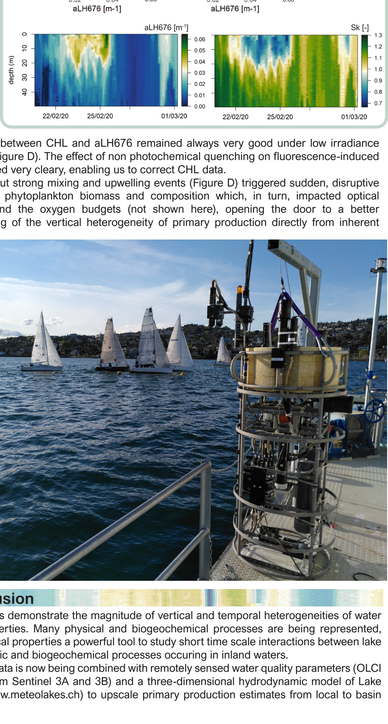
aLH676 is a good proxy for all species of phytoplankton concentration

aLH550 is an indicator for red pigments (e.g. phycoerythrin)

Results and Discussion

We collected more than 1000 profiles between October 2018 and April 2020, over contrasted seasons and physical conditions.





Observations revealed large spatiotemporal heterogeneities of optical properties as a result of seasonal and short-term (weekly to sub-daily) physical and biogeochemical processes. Absorption peaks at different wavelengths revealed the presence of different phytoplankton communities (see above where aLH550 was significant over October 2018 (Figure A) but almost completely absent in November/December 2018 (Figure B)).

Spectral attenuation slope Sk was inversely proportional to aLH676 (Figure D), suggesting a change in particle size distribution. At the daily scale, particles were getting larger during the day (decreasing Sk) and smaller over night (increasing Sk) as a result from diurnal growth/division-and-loss of phytoplankton cells over day/night (Figure C). Over longer timescales, this linear relationship resulted from a direct link between phytoplankton biomass and average particle size.

Correlations between CHL and aLH676 remained always very good under low irradiance conditions (Figure D). The effect of non photochemical quenching on fluorescence-induced CHL appeared very cleary, enabling us to correct CHL data.
Short-lived but strong mixing and upwelling events (Figure D) triggered sudden, disruptive shifts in the phytoplankton biomass and composition which, in turn, impacted optical properties and the oxygen budgets (not shown here), opening the door to a better understanding of the vertical heterogeneity of primary production directly from inherent



Conclusion

These results demonstrate the magnitude of vertical and temporal heterogeneities of water optical properties. Many physical and biogeochemical processes are being represented, making optical properties a powerful tool to study short time scale interactions between lake hydrodynamic and biogeochemical processes occuring in inland waters.
This in situ data is now being combined with remotely sensed water quality parameters (OLCI products from Sentinel 3A and 3B) and a three-dimensional hydrodynamic model of Lake Geneva (www.meteolakes.ch) to upscale primary production estimates from local to basin scale.

Want to know more?
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