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Study of the lacustrine phytoplankton productivity dependence on solar radiation, on the basis of direct high-frequency measurements

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One of the main components of the carbon cycle in lakes is phytoplankton. Its in situ photosynthesis and respiration are usually studied with traditional methods (dark and light bottle method, ^{14}C labelling technique). These methods, relying on sampling and incubation, may lead to unrealistic results. They also have a poor temporal resolution, which does not allow the non-linear relationship between photosynthetically active solar radiation (PAR) and photosynthesis to be properly investigated. As a consequence, the phytoplankton net primary productivity (NPP) cannot be parameterised as a function of ambient variables.
In 2008 an innovative free-water approach was proposed. It is based on non-dispersive infrared air CO_2 probes that, by building an appropriate system, can be used to measure the CO_2 concentration in the water at a high-frequency. At that time, the method was tested only on 3 days of data. Here, we deployed it on a boreal lake in Finland for four summers, in order to calculate the NPP and verify its dependence on PAR. The set-up was completed by an eddy-covariance system and water PAR and temperature sensors.
In analogy with the procedure typically used in terrestrial ecology, we obtained the phytoplankton NPP computing the mass balance of CO_2 in the mixed layer of the lake, i.e. the superficial layer where the conditions are homogeneous and most of the photosynthetic activity takes place.
After calculating the NPP, we verified its dependence on PAR. The theoretical model we used was a saturating Michaelis-Menten curve, in which the variables are water temperature and PAR. The equation also contains parameters typical of the phytoplankton communities, which represent their maximum potential photosynthetic rate, their half-saturation constant and their basal respiration. These parameters allow the NPP to be parameterised as a function of T and PAR.
For all the analysed year, we found a very good agreement between theory and data (R^2 ranged from 0.80 to 0.88) and we were able to estimate the phytoplankton communities parameters.
In conclusion, the approach used proved to be suitable for productivity studies in aquatic ecosystems. In our opinion, it represents a great improvement over the traditional methods and should be widely adopted. This would reduce the gap in the CO_2 exchange measurements between aquatic and terrestrial ecology, where high frequency measurements are very common. It would also help us achieve a better understanding of the biological processes behind the CO_2 exchange and would expand our knowledge on the carbon cycle in aquatic ecosystems, which is still limited.