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Lake SkyWater - a portable optical buoy for easily measuring water-leaving radiance in lakes based on the skylight-blocked approach (SBA)

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Spaceborne optical sensors are a useful tool for monitoring water quality in oceans, lakes and rivers on a large scale, at high frequency and at relatively low costs. Based on water colour algorithms, many key biogeochemical parameters are operationally estimated from satellite data (e.g. chlorophyll-a concentration). Calibrating and validating these algorithms requires a huge collection of high-quality *in situ* radiometric data, such as the water-leaving radiance L_w (or the remote sensing reflectance R_{rs}), necessitating high-level expertise and expensive material.

One of the most robust methods to measure L_w is the skylight-blocked approach (SBA), which allows L_w to be measured directly at the air-water interface. Compared with the conventionnal “above-water” method, the measurement is not contaminated by light reflected from the surface (including both sky- and sun-glint), thanks to the use of a cone-shaped screen attached to the downward-facing radiance sensor (which measures L_w) that fully blocks all downward radiance at the air-water interface.

Our open-source system “Lake SkyWater” was designed around the idea of making *in situ* radiometry measurements in lakes user-friendly and affordable, while retaining the accuracy and robustness required for scientific and operational purposes. We have created a semi-autonomous buoy that implements the SBA method. Lake SkyWater is low-cost (<1 k€, excluding the cost of the two radiometers), lightweight, and easy to transport and deploy. Our new device addresses one of the main ongoing issues with the SBA protocol: the issue with the radiance sensor measuring water being in the direct sun shadow of the deployment platform.

Our device consists of two commercially available radiometers that use the MODBUS RTU protocol (e.g., TriOS RAMSES G2) controlled by open-source TinkerForge modules and mounted to a rotating platform attached on top of an inner-tube (the buoy). Everything has been optimised for maximal portability (allowing it to be taken on a commercial flight): 1) the buoy is inflatable and 2) the structure is made of lightweight anodised aluminium profiles and PETG 3D-printed parts, and

can be disassembled and transported in a suitcase/bag (the longest part measures 745x40x20 mm). The buoy's position, its absolute orientation as well as its tilt are recorded (thanks to the embedded GNSS receiver and the 9-DOF IMU), and the solar azimuth angle is derived from the buoy's positioning data. This enables the system to calculate the motor adjustments needed to keep the radiance sensor on the sunny side of the instrument. Our device hosts its own WiFi network and can be controlled wirelessly over a mobile phone, tablet or PC. Additionally, the radiometric buoy can be transformed into a fully autonomous monitoring system by plugging in a Raspberry Pi to act as a data logger.

Lake SkyWater was designed in the context of my PhD thesis dedicated to the calibration and validation of water colour algorithms for Petit-Saut Reservoir in French Guyana.