ID 16- MEASUREMENT ERRORS WITH LOW-COST CITIZEN SCIENCE RADIOMETERS

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Abstract— The KdUINO is a Do-It-Yourself buoy with low-cost radiometers that measure a parameter related to water transparency, the diffuse attenuation coefficient integrated into all the photosynthetically active radiation. In this contribution, we analyze the measurement errors of a novel low-cost multispectral radiometer that is used with the KdUINO.

Keywords— Diffuse attenuation coefficient; low-cost; citizen science; radiometer and Arduino.

INTRODUCTION

A widely adopted, scientific approach to assess the environmental status of water bodies consist in measuring their optical properties, such as color and transparency. The transparency of natural waters is affected by the presence of dissolved organic matter, sediment load and gross biological activity, which are considered water quality indicators.

The KdUINO is a DIY (Do-It-Yourself) moored system, based on the open hardware platform Arduino [1] and quasi-digital sensors that measure light irradiance in the photosynthetically active radiation (PAR) at different depths. The buoy is very easy to build and to use. Its cost is less than 100 $. This type of devices increments the marine citizen science community and crowdsourcing capabilities, allowing a much larger spatial and temporal monitoring of parameters related to water quality. A detailed description of the system components is in [2].

The irradiance measurements allow calculating the diffuse attenuation coefficient parameter (Kd), a parameter related to water transparency. Kd in the PAR is used in some biological studies. However, the value of Kd in multiple wavelength regions could be very useful for more precise biological studies and remote sensing calibration of satellites.

In this contribution, we will analyze the measurements and results of the KdUINO with a new "homemade" multispectral sensor. Its cost is less than 5 $. We will validate the sensors and estimate the measurement errors. We will demonstrate we can obtain a multispectral Kd parameter whose value is similar to the Kd calculated with expensive high precision instruments.

DISCUSSION

The new version of the KdUINO contains several multispectral optical sensors. The sensors [3], placed at different depths in a water column, convert the multispectral irradiance measurements into frequency. By counting the number of cycles over large periods of time (several minutes), it is possible to obtain a time-integrated measurement of irradiance values near the water surface, reducing the measurement variability derived from the significant light fluctuations caused by focusing of sunlight by surface waves [4].

The sensors measurements are subject to some errors, both electronic and mechanic:

Sensor tolerance: Sensors are available with an absolute output frequency tolerance. However, the sensor tolerance is not specificity in the technical specifications.

Changes in wavelength illumination: The technical specifications of the sensor contain imprecise information on the outcome variation as a function of wavelength. This imprecise information induces some errors in the calculation of Kd.

Encapsulation: The response of the sensors depends on the form and material of the capsule. The capsules are "homemade" and the irradiance measurement can change depending on the how you made them.

METHODOLOGY AND RESULTS

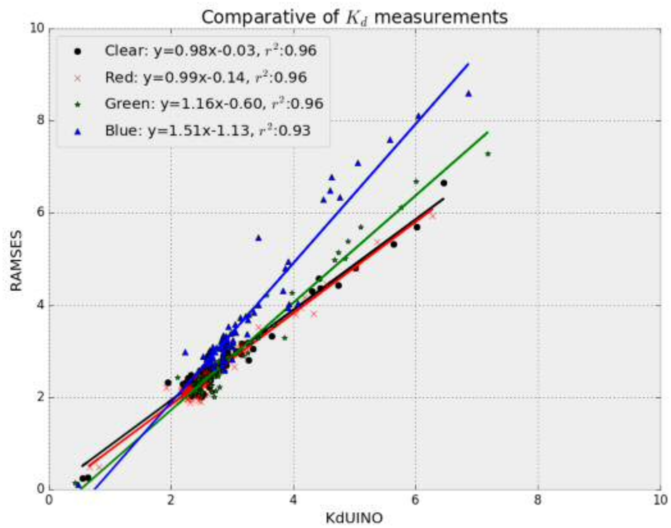
We compared more 100 estimations of Kd in the wavelength ranges of the reds, blues, greens and visible (clear) obtained from data from the KdUINO with the novel sensors and another common-used oceanographic instrument, the RAMSES [5] (the cost of the scientific instrument is higher than 10000 Euros). Laboratory results indicate a substantial similarity between the two sets of values (see Figure 1) as noted in the concluding section.

CONCLUSION

According to our preliminary results, with the KdUINO measurements and a post-processing data analysis, it is
possible to obtain the Kd parameter with an error of around 10%.

Fig. 1. Comparison of Kd results in four wavelength ranges (red, blue, green and visible) with two different instruments. They are high linearly correlated.

We conclude that the KdUINO with the multispectral sensors is a very useful and inexpensive tool to study the variability of the Kd. Many KdUINOs can be deployed and placed in a wide sea area where, for the same price, just one of any other oceanographic instrument could be used. According to the price and the easy development of the device, we consider that the KdUINO could be an excellent citizen science tool.



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