M2 ESTIMATING UNDERWATER LIGHT DIFFUSE ATTENUATION WITH LOW-COST DEVICES: OPTIMAL SENSOR CONFIGURATION ANALYSIS USING RADIATIVE TRANSFER MODELS

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Abstract

The Citclops European Project aims to develop low-cost technologies to estimate parameters related to water optical properties. The light diffuse attenuation coefficient (Kd) is one of those parameters, which provide information related to water transparency. As a potential low-cost solution for Kd estimation, a moored instrument has been designed based on the open-hardware Arduino platform and quasi-digital (light-frequency) sensors. The present contribution analyses, using a model based approach, the configuration of the light sensors of this system (sensitivity and vertical position) to assure the optimal Kd estimation.

Keywords – Buoy technology; Low cost sensors; Do it yourself; Oceanographic instrumentation and sensors

I. INTRODUCTION

In the marine environments, a widely adopted, scientific way to assess the status of water bodies is by measuring their optical properties (as indicators of, e.g., sewage impact, dissolved organic matter, sediment load or gross biological activity). With these ideas in mind, the Citclops European Project [1] aims to develop systems to retrieve data on seawater optical properties using low-cost sensors.

The cBuoy is a moored system for low-cost sensing, based on the open hardware platform Arduino and quasi-digital sensors that measure light irradiance at different depths. A detailed description of the system components can be found in [2]. The present contribution is focused on the analysis for the optimal sensor configuration: the depth at which the sensors must be placed and their sensitivity level (gain control) to measure the light diffuse attenuation coefficient (Kd) optimally.

II. THE MEASURAMENT SYSTEM

The cBuoy contains an Arduino working as a control and transmission unit and several quasi-digital optical sensors placed at different depths. The sensors convert irradiance measurements into frequency. By simply 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 large light fluctuations caused by focusing of sunlight by surface waves. This large time integration allows obtaining robust estimations of vertical light extinction without the need to take into account potential measurement artifacts caused by the state of the surface waves.

The light-to-frequency converter used is the TSL230RP-LF [4]. According to the sensor specifications, the output frequency has a linear dependence with the light intensity. These sensors have 3 configurable sensitive levels. In the first version of the cBuoy prototype, the sensors are set to the highest sensitivity configuration. The initial test measures with the cBuoy indicate that the sensors close to the surface could be saturated depending on the environmental conditions. The proposed analysis is focused on finding the optimal sensor configuration to enable Kd in a wide range of environmental conditions.

III. DEPTH AND SENSITIVITY OF SENSORS IN ORTHER TO CALCULATE THE DOWNWELLING DIFFUSE ATTENUATION COEFICIENT

The simulations for the optimal sensor configuration are focused on estimating the downwelling irradiance Ed(z) variability. Beer's law states that intensity of light decreases exponentially as a function of depth in the water column and is described mathematically as:

(1)

where: Ed(z)is the downwelling irradiance at given depth, E0 is the irradiance at the surface, Kd is the light diffuse attenuation coefficient and z is the depth.

To estimate the Ed(Z) variability, radiative transfer models (Hydrolight and Ecolight, [5]) are used. The irradiance at the surface (E0) will depend mainly on the meteorological conditions (sun position, cloud coverage,..) and the light diffuse attenuation coefficient (Kd) on the distribution of the different optical components (phytoplankton, sediments, colored organic matter) in the water column. Fig.2 shows an example of two modeled Ed(z) at different environmental conditions.

IV. SUMMARY

The cBuoy is a low-cost moored system designed to estimate the Kd parameter related to water transparency. The buoy contains sensors that measure the light irradiance at different depths. By using radiative transfer models, several numerical simulations are preformed with different environmental conditions to estimate the optimal sensor configuration (sensitivity and the depth placement).

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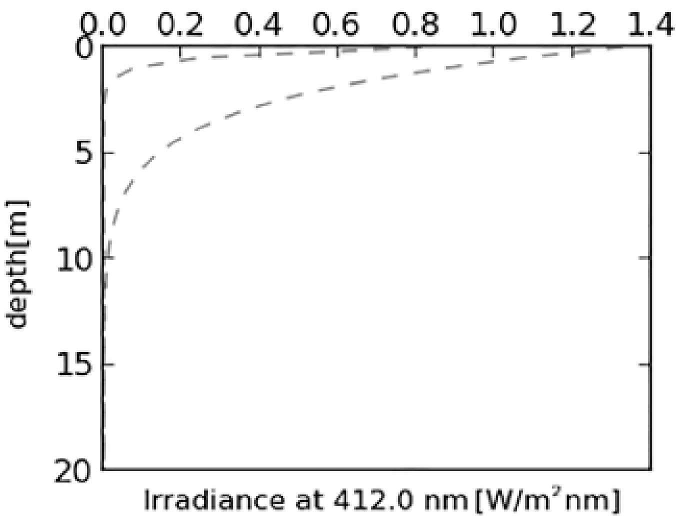

Fig.1. Simulations of Ed(Z) (at 410 nm) at different environmental conditions