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A light intensity measuring system for sedimentation measurements on KM3NeT optical modules

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ABSTRACT

To measure variations of zenith dependence of sedimentation/bio-fouling on the optical modules (OMs) as considered by the KM3NeT consortium in the deep sea, we have used a grid of photodiodes distributed inside the glass sphere to measure the light intensity of two light sources located outside the glass sphere on a fixed position. The method is described and the data collected during the last three years in depths from 3100 m down to 5100 m, in the southeast Ionian sea, at sites near Pylos, Peloponnese, Greece, are discussed.

1. Introduction

The instrument used to measure sedimentation accumulation on glass spheres, deployed in the deep sea, with the code name LIMS (light intensity measuring system) was designed and built by the NESTOR and U-Athens group. We have constructed and deployed several LIMS units and have collected data from eighteen units, whereas two more units are still deployed. The data collected so far are reported along with studies on correlations with other environmental data.

2. Instrument description

2.1. Mechanical structure

The LIMS uses a rectangular steel frame. In the center of the frame the glass sphere is mounted using two rings made from Etalon. The glass sphere has 3 holes, two for the connectors for the upper and lower light sources and one for a vacuum port. Under the nadir of the glass sphere the "lower" LED is placed in a cone-shaped housing shining light on the glass sphere. The housing is made out of polycarbonate and the conical shape prevents the accumulation of sediment on the housing. Over the sphere and about 30 cm away from the perpendicular axis that passes through the center of the sphere, the upper LED housing is placed at an angle of about 30° from the horizontal plane, shining light on the upper hemisphere. The upper LED housing is cylindrical. To connect the two LED housings with the battery pack, which is inside the glass sphere, two deep sea cables with 7 conductors each were used, terminated in GISMA series 35, 7-pin dry-mateable connectors [1]. A photograph of a LIMS can be seen in Fig. 1 (left).

2.2. Electronics

LIMS has a number of light sensors ("light to voltage converter" by TAOS, type TLSB257 [2]), distributed inside the two hemispheres of the glass housings, similar to those that will house the photomultiplier tubes (PMT) of the KM3NeT detector. The light sensors are placed in four branches and in six different zenith angle positions for the upper hemisphere, and two branches and three different angles from the nadir for the lower hemisphere, corresponding to zenith angles 180°, 170° and 160° (Fig. 1 (bottom)). Specially designed low-power electronics systems were produced for data acquisition, data handling and software control and are located inside the glass sphere along with the power pack. The glass spheres are BENTHOS glass housing, 50 cm in diameter.

One LED (light emitting diodes by Agilent—now Avago-type HLMP-CB15 [3]) is fixed inside each of the two polycarbonate housings (with a reference photosensor for LED monitoring). Before the instrument is deployed the time interval between consecutive measurements is set. In the "measuring mode", the

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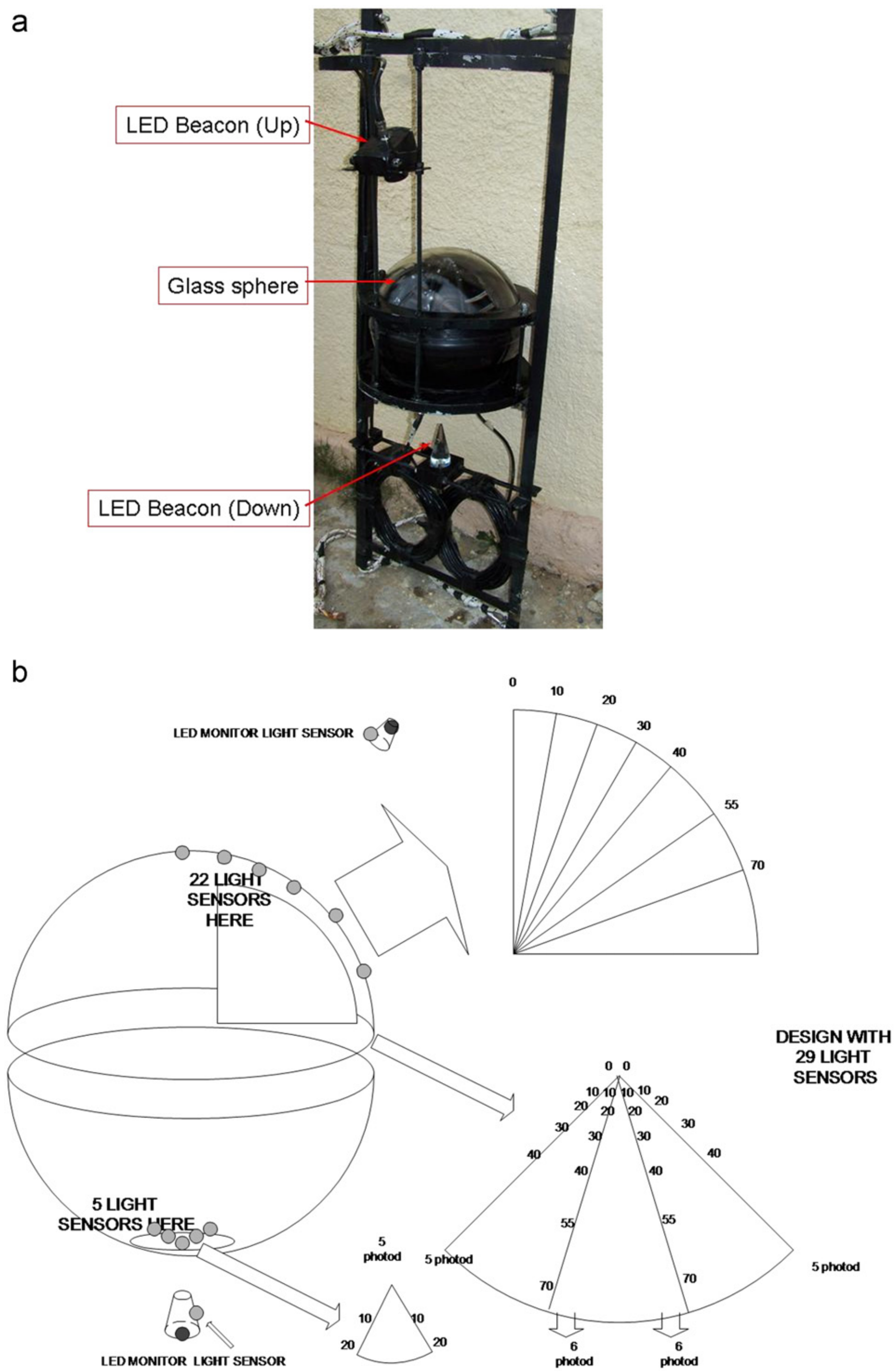

Fig. 1. Picture of a LIMS instrument (left) and schematic of the photodiode arrangement on the glass sphere. A total of 21 photosensors are placed in the upper hemisphere and 5 in the lower hemisphere.

measuring cycle starts by switching on the upper led. After waiting for 2 s the output of the 21 upper light sensor channels and the LED-monitor channel is digitized and stored to memory. After that the system switches off the upper LED. Then the lower LED is switched on and after two more seconds the output of the 5 light sensor channels and the LED-monitor channel corresponding to the lower hemisphere is digitized. The maximum output voltage value of the light sensor is 5 V and the digitization is 8 bit (256 steps). Temperature and battery voltage are also monitored. After the measuring cycle is completed the system goes to "sleep mode" until the set time interval (about 3 h) has passed for the next measuring cycle. Fig. 1 shows a picture of a LIMS and a schematic showing the distribution of the light sensors inside the glass housing.

3. Deployments

Several LIMS units were deployed on mooring lines using the HCMR's R/V "AIGAIO" and NESTOR's R/V "LYDIA" at the NESTOR N4.5D and N5.2D sites; typical site depths are 4500 and 5200 m, respectively. Each instrument was deployed for about 6 months. Two units were attached on each mooring line and at different depths. The HCMR's moorings were also equipped with sediment traps and current meters.

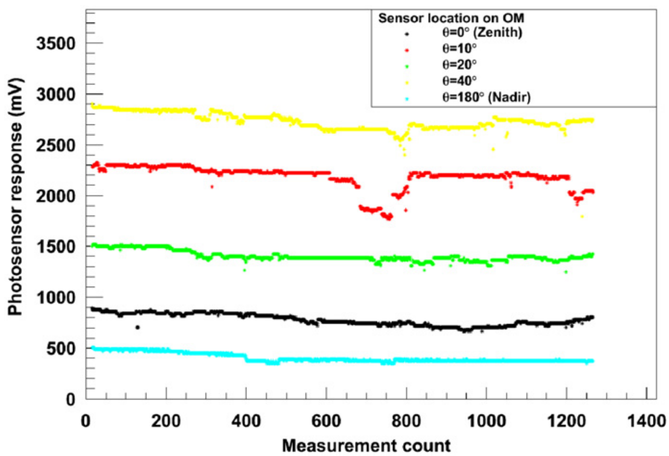

Fig. 2. Typical raw LIMS data. Each line shows the voltage of a single channel. Measurements are taken every 3 h.

4. Data

The LIMS takes one measurement every 3 h. Fig. 2 shows raw LIMS data, one channel per zenith angle is shown. The analysis data were averaged every 9 measurements corresponding to 30 h of data, 3 h $\times$ 9 measurements cycles and the one dark measurement cycle (no LED light) which is excluded. These average values were adjusted with the reference light sensors to compensate light source output drift and normalized to the first five days' average (channel averages). Zenith averages were produced by averaging the response of photosensors with the same zenith angle.

In Fig. 3 the normalized averages of the sensors at the various zenith positions are shown for the LIMS deployed at N4.5D site at 3200 m depth for the period October 2007–April 2008.

Since the LIMS were deployed in mooring lines with current meters and sediment traps, the data were show in the same graph of the data of the closest current meter and sediment trap (Fig.3). No apparent correlation has been observed between the LIMS data and the closest current meter and sediment trap in this

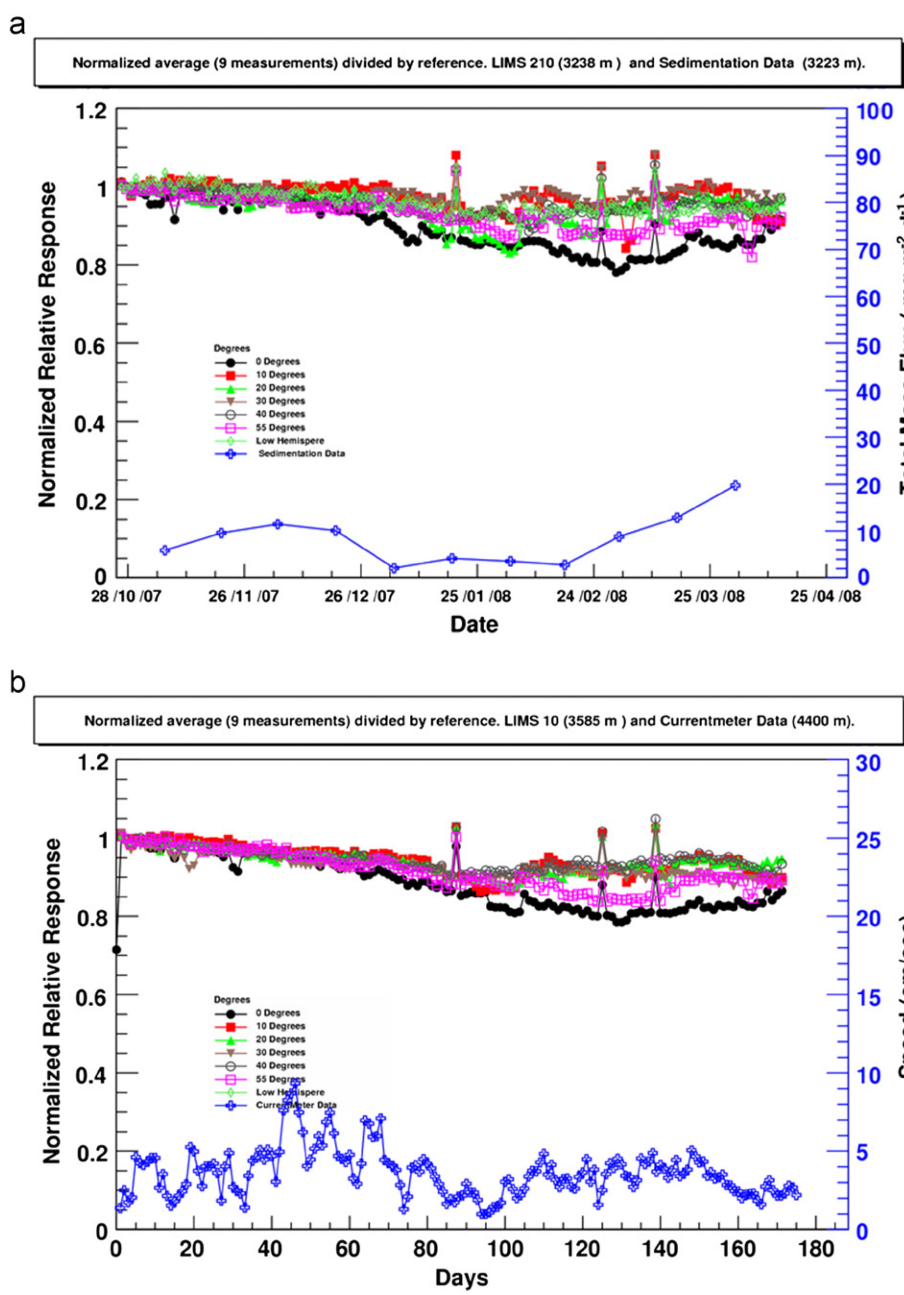

Fig. 3. Typical zenith averages and current meter (up) or sediment trap (down) for the same period. Each LIMS data point corresponds to a 30 h period.

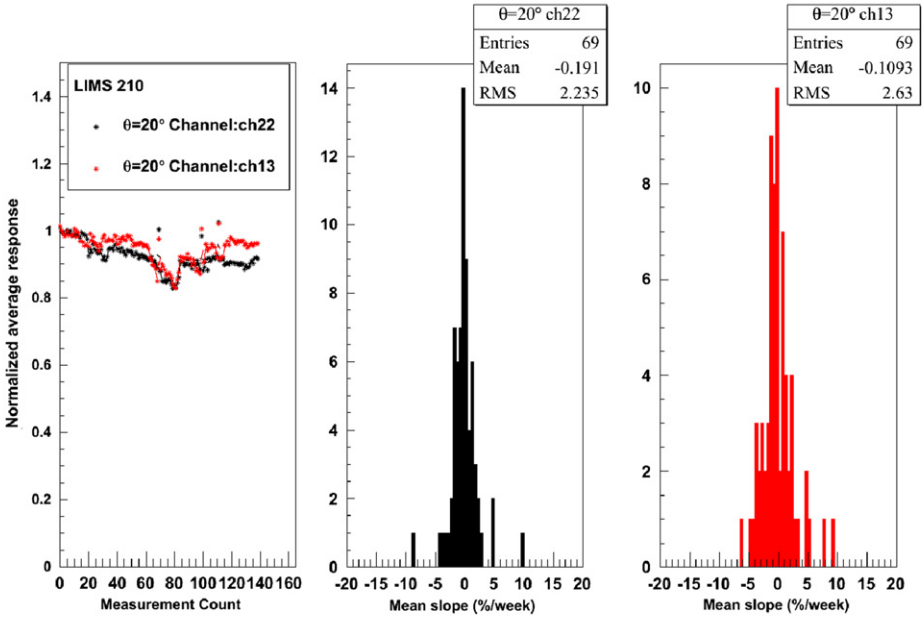

Fig. 4. Typical 30 h channel averages for two photosensors at 20° from zenith (left) and the histograms of slopes for each channel.

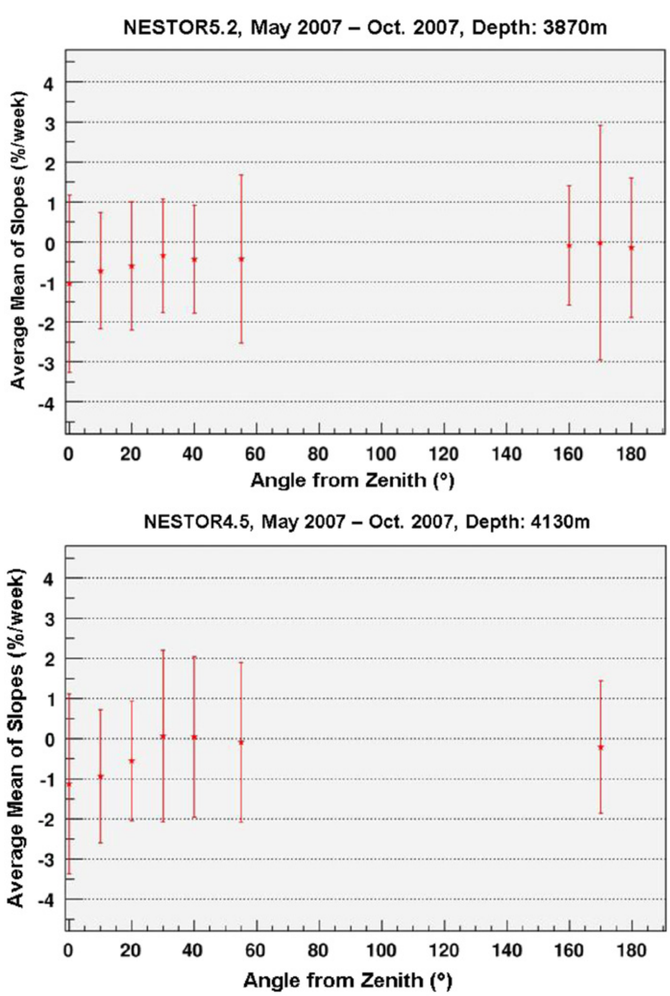

Fig. 5. Typical average mean slope values versus zenith angle of the photosensors.

deployment, at N4.5D site at 3200 m depth for the period October 2007–April 2008.

Further investigation was performed in order to express the variation in the observed light as a %/week. We call these values "slopes". For this analysis, every 3 sequential 30 h averages, corresponding to 90 h of data, a linear fit is performed and its slope is expressed in %/week. Fig. 4 shows the normalized averages for two photosensors and histograms of their slopes.

Moreover the same calculation was performed for the zenith averages and the corresponding slopes as a function of the zenith angle are shown in Fig. 5 for LIMS data from the period May 2007 to October 2007 for the sites N4.5D and N5.2D.

5. Conclusions

No apparent correlation has been observed between the LIMS data (deployed at N4.5D site at 3200 m depth, October 2007–April 2008) and the current meter and sediment trap data from the relevant time period (Fig. 3).

As can be seen in Fig. 5, at the sites N4.5D and N5.2D for the period May 2007–October 2007 the variation in the measured light intensity, within the errors, does not depend on the angle from zenith of the glass sphere.

To date, the analysis of all LIMS data is in progress.

Acknowledgments

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