M2 SIZE DISCRIMINATION OF INORGANIC SUSPENDED PARTICLES BASED ON THE ANALYSIS OF HYPERSPECTRAL ATTENUATION MEASUREMENTS.

Ramírez-Pérez M.[11], Torrecilla E.[12], Guillén J.[13], Piera J.[10]

Abstract

A method is described for discriminating the size of inorganic suspended particles based on hyperspectral attenuation spectra. In this study, the beam attenuation spectra of different samples with different suspended sediment sizes (i.e., from mud, <5 µm, to fine sand, 125-250 µm), were measured in the laboratory using a hyperspectral attenuation meter (VIPER instrument with a 5 cm path length and 1.7 nm spectral resolution). In order to classify the measured spectra according to their relative similarity, a hierarchical cluster analysis has been applied and the results have been represented in a Multi-dimensional scaling graphic. Our results show that the changes in the attenuation spectral signature are according to the particle size. The applied methodology clearly allows discriminating samples with different particle size ranges. The hyperspectral attenuation meter can therefore be considered a powerful instrument for these purposes, because of the high spectral resolution and relative lower cost compared to other commercial instruments. Furthermore, it is possible to design hyperspectral attenuation meters with smaller size and relatively low-consumption that could be incorporated into different observing autonomous platforms, such as gliders, profilers and autonomous underwater vehicles.

Keywords: hyperspectral attenuation spectra, particle size distribution, hierarchical cluster analysis, multidimensional scaling

INTRODUCTION

Information on mineral particle size distribution and concentration in the marine environment (shelf seas and estuaries) plays a key role because it controls the settling velocity and it influences the penetration of sunlight into the sea [1, 2]. During the last years, new optical sensors have been developed to determine the particle size distributions, such as the in situ particle size analyzer based on Laser In Situ Scattering and Transmissometry (LISST, Sequoia, Inc.). However, the high cost and the large dimensions of this instrument make it unsuitable for some kind of applications, particularly those addressed to estimate temporal and spatial variability of suspended particles size using autonomous platforms such as gliders or autonomous underwater vehicles (AUV's). In this sense, the beam attenuation meters can be considered a powerful alternative. They have a lower cost and with some adaptations they could be mounted on autonomous platforms due to their smaller dimensions.

METHODOLOGY

The main goal of this study is to assess the optical variability due to the size of suspended particles by analyzing the hyperspectral attenuation signature of different samples. With this aim, a methodology based on a hierarchical cluster analysis (HCA) is evaluated. This methodology is similar to the one proposed in [3] and allows classifying different attenuation spectra by exploring features in amplitude and shape of hyperspectral data. The results from the cluster analysis are represented in a multidimensional scaling (MDS) graphic, in order to visualize the clustering results on a low dimensional plot (2D).

This study has been carried out based on laboratory experiment. The attenuation spectra, obtained with a VIPER hyperspectral attenuation meter (TriOS, Inc.) at 1.7 nm resolution, have been measured for different pre-weighted marine sediment samples with different both grain sizes (i.e., from mud, <5 µm, to fine sand, 125-250 µm) and concentrations (i.e. 50, 100, 200, 500 and 1000 mg/L).

RESULTS

Fig. 1 shows the normalized mean attenuation spectrum characteristic for each particle size range. It is observed that the spectra change in both magnitude and shape according to the size of the particles present in each sample. At the same concentration, the attenuation increases when the particle size decreases, due to the greater number of particles in the sample.

The Multi-dimensional scaling graphic on the Fig. 2, depicts the similarities values obtained after the cluster analysis in a 2D plot. It is noted that samples corresponding to each particle size range can clearly be distinguished. Moreover, the particle size can also be estimated qualitatively given its distinct location on the MDS plot. The smallest particles are located on the left side of the graphic (i.e., higher attenuation) and the grain size increases (i.e., the attenuation decreases) as we move to the right side of the plot.

ACKNOWLEDGEMENT

This study was supported by Total Foundation (PHYTOSCOPE project) and the Spanish Ministry of Economy and Competitiveness (MESTRAL project, reference code: CTM2011-30489-C02-01).

REFERENCES

[1] Babin, M., Morel, A., Fournier-Sicre, V., Fell, F., Stramski, D., (2003). Light scattering properties of marine particles in coastal and open ocean waters as related to the particle mass concentration. Limnology and Oceanography 48, 843e859.

[2] Baker, E.T., Lavelle, J.W., (1984). The effect of particle size on the light attenuation coefficient of natural suspensions. . Journal of Geophysical Research 89, 8197e8203.

[3] Torrecilla, E., D. Stramski, R.A. Reynolds, E. Millan-Nunez and J. Piera (2011b). Cluster analysis of hyperspectral optical data for discriminating phytoplankton pigment assemblages in the open ocean. Remote Sensing Environment, 115, doi: 10.1016/j.rse.2011.05.014:2578§2593. Fig. 1. Representative normalized attenuation spectra for the different particle size ranges. The suspended sediment concentration is 500 mg/l.

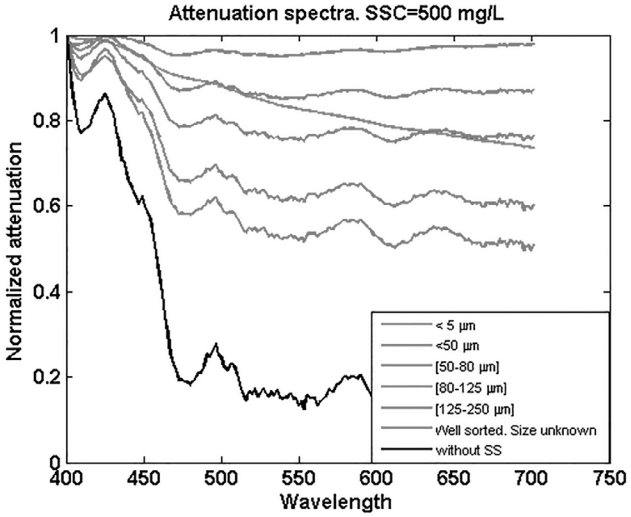

Fig. 1. Representative normalized attenuation spectra for the different particle size ranges. The suspended sediment concentration is 500 mg/l.

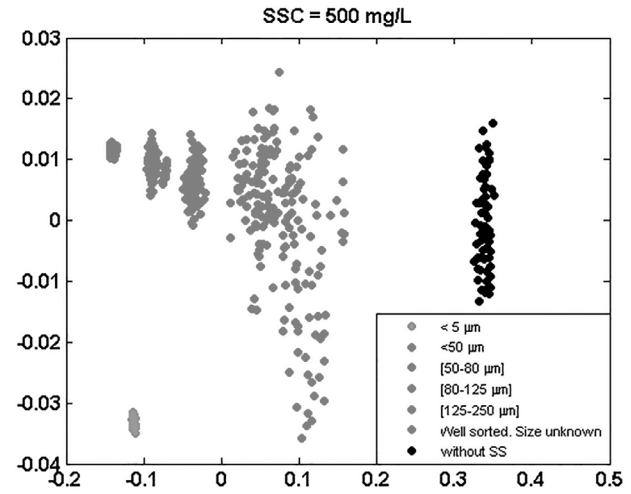

Fig. 2. Multidimensional scaling (MDS) graphic performed based on the similarities values obtained in the cluster analysis.