Determining the physical characteristics of the suspended sediments in Mayaguez Bay and the relationship with the spectral responses

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Abstract

Three rivers, Añasco, Yagüez and Guanajibo, directly affect the Mayagüez Bay. Those rivers discharges impacts directly the Bay and the ecosystems that are in there. As an effort to understand how these river's sediments affects the bay, remotely sensed and in-situ measurements are going to be used. Determination of the suspended sediments physical characteristics will help us to understand the behavior of the spectral responses, for that the mineral composition and the grain sizes will be determined. XRD and the Sedigraph 5100 will be used to determine those. The MERIS ocean color sensor from the ESA (European Spatial Agency) data will be compared to the obtained results of in-situ measurements. Finally, all the data will be associated to the season in which was collected and related to the physical characteristics of the particles. In conclusion, the mineral composition is not an easy field to study but with those techniques we can understand it in a better way.

Introduction

The Mayagüez Bay is an environment that is complicated to study because is affected by several factors that complicate the remote sensing studies on this area. The remote sensing studies are limited by the spatial resolution of the Bay because it is too small to get the correct values on the correct places. The major factors that affect the Bay are the river discharges, which are three Grande de Añasco, Guanajibo and Yagüez (Figure 1).

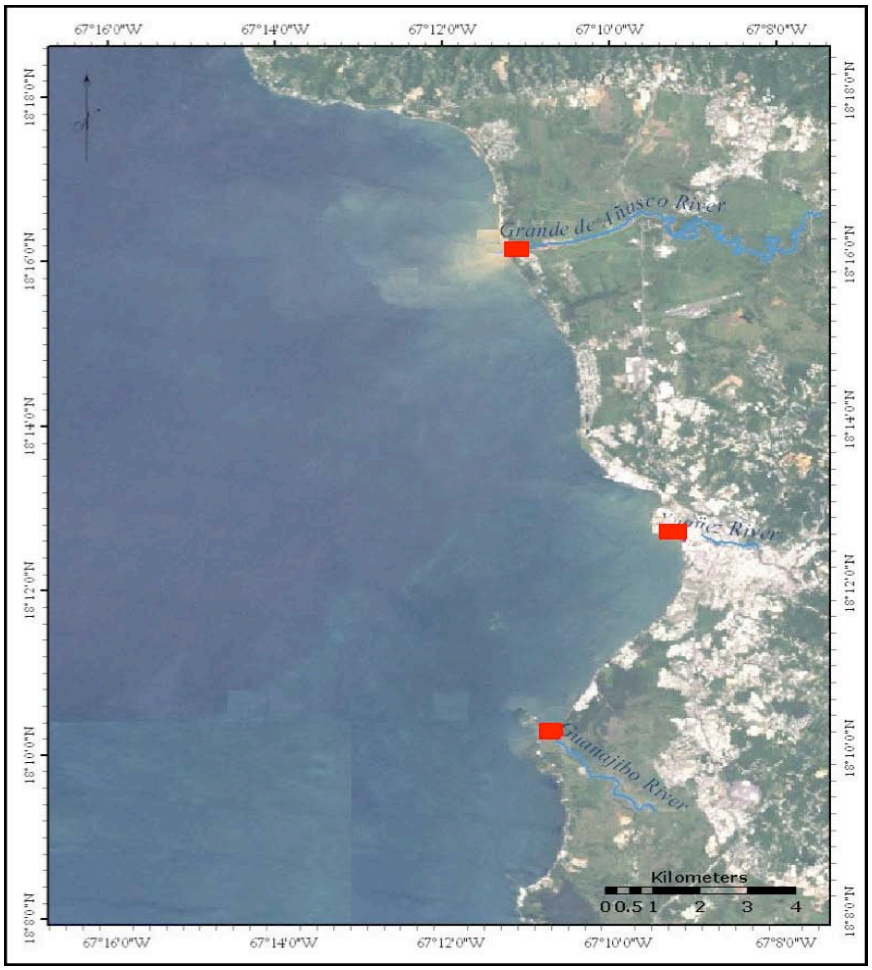

Figure 1: Mayagüez Bay and the stations in which the samples were taken.

The rivers discharges bring with them nutrients and sediments. In reality, each of the broadly defined water constituents may exhibit significant optical variability due to variations in species composition, particle size, shape, and refractive index, (Wozniak and Stramski, 2004). The sediments are made up of particles of sand, pebbles, clay minerals, pieces of shell, algal fragments and chemical precipitates (Nichols, 1999). Suspended mineral particles can play an important role in ocean optical properties, because such particles can be abundant in seawater, they scatter light efficiently owing to their high refractive index relative to that of water, and their absorption of light is generally not negligible (Wozniak and Stramski, 2004).

The process to suspend sediments is called suspension. This process is caused by turbulence in the flow that can produce sufficient upward motion to keep particles in the moving fluid more or less continually (Nichols, 1999).

By the other side a mineral is a natural occurring homogeneous solid with a definite (but generally not fixed) chemical composition and a highly ordered atomic arrangement, (Winter, 2002). An inorganic process usually forms it, and is very important to know its composition of the suspended sediments to understand the reflectance curves behaviors. To do these experiments we are going to use two techniques, which are X-Ray diffraction and thin sections. These two processes will help to determine the composition of these minerals. Also doing reflectance measures with spectroradiometers we can note how these minerals affect the reflectance curves.

When we have a water body, the reflectance curves are affected by optical properties of the water, roughness of the surface, angles of observation and illumination and in some cases reflectance from the bottom, (Campbell, 2002). These effects on the reflectance combined with the sediments are very variable. In the case of the mineral particles suspended in seawater with concentrations of O□0.1g□3 or higher also have significant influence on ocean reflectance, (Wozniak and Stramski, 2004).

Another aspect that influences the reflectance is the sediment concentration. This is also a very important factor in the Mayagüez Bay because we have different seasons. Two distinctive seasons have been identified in the Mayagüez Bay (Gilbes et al., 1996), a dry season (January to May) and a rainy season (August to November). In the rainy season we have more concentration of sediments the amount of suspended sediment will also going to increase. By the other side if the concentration is lower, we can define that is dry season. As suspended sediment concentration increases, the spectral properties of the water body changes, the wavelength of peak reflectance shifts from in maximum in the blue region toward the green, (Campbell, 2002).

That reflectance variability can be associated not only with variations in the mineral mass concentration but also with changes in the type and size of mineral particles, (Wozniak and Stramski, 2004).

Finally, the main concern in this project is to know how the composition and concentration of the minerals on the suspended sediments change along the three rivers and in one year. And how those changes affect the spectral response from the remote sensors (satellite and in-situ). Our hypothesis is that the composition of the mineral on the

suspended sediments changes as we change in mouth discharge of the different rivers. Also the mineral concentration will change along time but not the mineral composition.

Methodology

The methodology for this project will be focused on three major steps, first the sample collection, second the laboratory work and finally, the data processing and analyses.

Sample Collection

The sample stations are going to be three, located inside each river, Añasco, Yagüez and Guanajibo, as Figure 1 shows. Surface water is going to be taken to ensure that this is the signal that the remote sensors will receive. The sampling dates will be during a period of a year. The main objective of the sampling strategy is to capture the events days, meaning as events cold fronts (dry season) and river discharges (rainy season). There will be a sample of each event during a year for the comparison between seasons and factors that affect the suspension of sediments.

Reflectance Measures

In each sampling event GPS coordinates will be taken. Also the optics of each station will be measured. The optical measures include particle backscattering, upwelling and down-welling irradiances. The last three measures are going to be taken using the GER-1500 to obtain the remote sensing reflectance.

Laboratory Work

Once the samples are taken, the next step is to filter the water using a filter system and a filter size depending on the grain size determined. Then the organic matter will be removed. Also, when the samples are already filtered, another reflectance measure will be taken to the filter (with and with out organic matter).

Data Analyses

To know the variability of the suspended sediment compositions and grain sized distribution during the seasons and in the three rivers, a variance analyses id going to be done. The remote sensing reflectance’s are going to be related to the mineral composition, season of the year and grain size. Another thing to be done with the reflectance is the analyses of the spectral slope.

MERIS sensor imagery

The 300m products of the MODIS ocean color sensor will be used from the Mayagüez Bay. Products like reflectance and backscattering will be compared to the in-situ measurements. Correlations between offshore behaviors of the river's plumes of reflectance with in-situ measurements will be done.

Determination of physical characteristics

Mineral composition: The knowledge of the mineral composition of the suspended sediments is very important because those inorganic material affects the directly the reflectance curve. To determine the chemical components of the suspended particles X-Ray diffraction method will be used. X-rays are electromagnetic radiation with wavelengths between about $2x10^{-6}$μm and $1x10^{-2}$μm in the electromagnetic spectrum. Because X-rays have wavelengths similar to the size of atoms, they are useful to explore within crystals, (Stephen, 2008).

Grain Size Determination: The suspended sediments have a very small particle diameter. For that reason is important to use a method that can measure to the sub-micrometer size. For this we are going to use the Sedigrph 5100. This equipment measures grain sizes from 3micrometers up to 0.1, which is the range of size particles.

Preliminary Results

X-Ray Diffraction:

Añasco Beach Station	Quartz (SiO_2)
	Albite($CaAlSi_3O_8$)
	Labradorite($CaNaAlSi_2O_8$)

Guanajibo Mouth Station	Quartz (SiO_2)
	Albite ($NaAlSi_3O_8$)
	Leucite ($KFeSi_2O_6$)

ICP-MS:

Yagüez Beach Station	
Na (Sodium)	Cr (Chromo)
Mg (Magnesium)	Fe (Iron)
Al (Aluminum)	Ni (Nickel)
K (Potassium)	Cu (Cobalt)

Ca (Calcium)	Zn (Zinc)
Mo (Molybdenum)	Cd (Cadmium)
Ba (Barium)	

Discussion

Based on the results obtained we can know that each station has a different chemical composition. On the XRD analysis we can detect four different minerals. They were Quartz, Calcium Albite, Labradorite and Leucite. They are classifies as silicates because all of them are composed by Silica and Oxygen. The elements founded using the ICP-MS are related to the elements that compose the minerals founded by the XRD. They were Na, Mg, Al, K, Ca, Cr, Fe, Ni, Cu, Zn, Mo, Cd and Ba.

Conclusion

The study of the suspended sediments on the Mayagüez Bay is a goal to reach for the better understanding of the optics of the area. They were cited references that shows that the mineral composition of the suspended sediments affect directly the spectral response of the water. The four techniques (XRD, Spectroscopy, ICP-MS and SEM) mentioned on this project are very useful to understand the mineral composition of the area of study. We conclude that the mineral composition varies along the different stations but all have Quartz as common mineral. The grain size cannot be determined using the SEM on this sample case.

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