Dynamics of river plumes as detected with AVIRIS

Eidalia González and Fernando Gilbes
Geological and Environmental Remote Sensing Laboratory
Department of Geology, University of Puerto Rico at Mayagüez

ABSTRACT

This study evaluated the dynamics of three river plumes in Mayaguez Bay and determined the distinct characteristics between them using the AVIRIS (Airborne Visible/Infrared Imagine Spectrometer) sensor. AVIRIS is a hyperspectral sensor with 224 spectral bands ranging from 400 to 2500 nm, strip lines of 11 km wide and spatial resolution of 18m. The wide range of bands improved the capabilities for remote sensing of more complex and turbid waters. The concentrations of suspended sediments were obtained from water samples collected at 10 stations along the Mayaguez Bay. These samples were compared with reflectance values from AVIRIS images acquired during the same day over the Bay (August 19, 2004). These data were used to develop an empirical algorithm to estimate the concentration of suspended sediment in the Mayaguez Bay using AVIRIS. The image of suspended sediments shows higher concentrations in the Añasco and Guanajibo plumes and smaller amounts in the Yaguez. The Añasco plume spread out farthest into the Bay with concentrations of 15.52 mg/l near the shore and 1.40 mg/l farther out the Bay. The Guanajibo plume had a unique shape because of waves that transport the sediments southward along the coast with a concentration of 5.46 mg/l. The Yaguez plume did not spread out far into the Bay but remained close to the shore with a concentration of 5.00 mg/l.

INTRODUCTION

Remote sensing has been a useful tool for detecting differences in ocean color produced by changes in suspended sediments due to rivers discharge. Changes in topography, weather, and human activities affect the dynamics of these sediments in coastal areas, like the Mayaguez Bay.

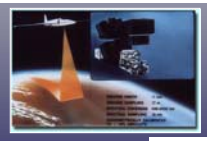
The main rivers in Mayaguez Bay are the Añasco, Yagüez and Güanajibo (Morelock et al., 1993). The sediments from the rivers are deposited on the shore or remain suspended all throughout the bay producing changes in ocean color. The study area reflects spatial variations in suspended sediments because of the seasonal changes in river discharge. The Mayaguez area has an annual precipitation range of 200-250 cm. From September through November there is more precipitation resulting with the maximum river discharge (Rodríguez, 2005).

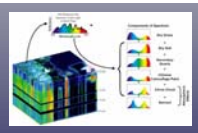
On August 19 of 2004 the aircraft sensor AVIRIS flew over Puerto Rico obtaining hyperspectral images of most of the coastline. AVIRIS is a hyperspectral sensor with 224 spectral bands ranging from 400 to 2500 nm, strip lines of 11 km wide and spatial resolution of from 4 to 20 m.

As part of this research project a method that included the proper combination of bands to better understand the sediment dynamics in the Mayaguez Bay was developed. The valuable spectral information obtained by AVIRIS allowed to detect differences in the three river plumes (Río Añasco, Río Guanajibo, and Río Yaguez) using the developed algorithm.

AVIRIS

AVIRIS is a high-quality sensor very appropriate to detect changes in ocean color produced by suspended sediments because of its high spectral (224 bands) and spatial (4 to 20 meters) resolution. AVIRIS makes it possible to separate more spectral signatures (real differences in materials in subtle spectral shape differences).



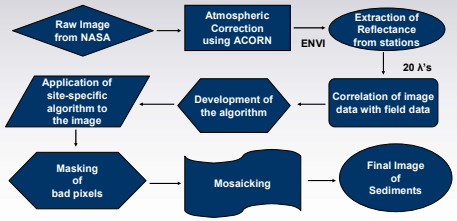


- 224 Spectral Bands
- Range from 400 to 2500 nm
- Strip lines of 11 km wide
- Spatial resolution from 4 m to 20 m (Puerto Rico mission was ~17 m)

GOALS AND OBJECTIVES

The main purpose of this research project was to evaluate the dynamics of the three main river plumes in the western coast of Puerto Rico and determine their distinct characteristics using the AVIRIS (Airborne Visible/Infrared Imagine Spectrometer) sensor. In order to accomplish this goal it was necessary to develop an empirical algorithm to estimate the concentration of suspended sediments using this sensor.

METHODOLOGY



RESULTS

Table 1. Bands, algorithm coefficients and values of correlation.

Band	Wavelength(nm)	a	b	Value of Correlation (R^2)
15	500.8	0.04	-0.55	0.58
16	510.5	0.03	-0.65	057
17	520.2	0.03	-0.27	0.75
18	529.8	0.02	-5.00	0.74
19	539.5	0.02	-4.21	0.78
20	549.0	0.02	-3.02	0.76
21	558.7	0.01	-1.89	0.73
22	568.3	0.01	-1.29	0.76
23	578.0	0.01	-0.62	0.74
24	587.6	0.01	0.42	0.77
38	768.2	0.02	1.96	0.74
39	778.6	0.03	1.80	0.75
40	789.2	0.04	2.43	0.75
41	799.8	0.07	2.24	0.80
42	809.3	0.08	0.99	0.81
43	818.9	0.08	0.51	0.80
44	828.5	0.07	0.40	0.80
45	838.0	0.10	0.85	0.89
46	847.6	0.08	0.03	0.82
47	857.2	0.08	-0.14	0.82

Figure 1. Suspended Sediment Concentration versus Reflectance in Band 46 (777nm).

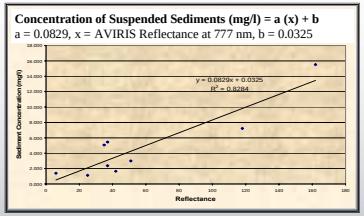


Figure 2. Mayaguez Bay as detected with AVIRIS Image

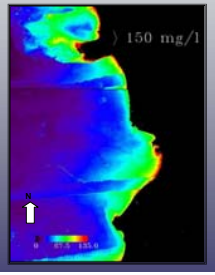


Figure 3. Suspended Sediment Concentration in Mayaguez Bay as measured by AVIRIS during August 19 of 2004.

CONCLUSIONS

- The principal factor for a high dynamics in the Mayaguez Bay is the river discharge.
- The AVIRIS image of suspended sediment concentration shows very well the various sediment dynamics of Mayaguez Bay.
- The three main rivers showed distinct characteristics between them; discharge, spreading of the plume and suspended sediment concentrations.
- The developed image showed higher amount of sediments in the Añasco and Guanajibo plumes and smaller amounts for the Yaguez.
  - The Añasco plume spread out farthest into the bay with a high suspended sediment concentration of 15.52 mg/l near the shore and 1.40 mg/l farther out into the Bay.
  - The Guanajibo plume had a unique shape because of waves that transport the sediments southward along the coast with a concentration of 5.46 mg/l.
  - The Yaguez plume did not spread out far into the bay but remained close to the shore with a concentration of 5.00 mg/l.
- The applied techniques and the developed algorithm demonstrated that remote sensing is a useful tool for detecting changes in ocean color produced by suspended sediments.

FUTURE WORK

Further studies should be conducted using other sensors, like MODIS, because data from this sensor is more frecuent. A critical factor for a better algorithm will be the amount of field data used to compare with reflectance values in the red and infrared range of the spectrum. More image processing to estimate the suspended sediment concentration for the whole island of Puerto Rico is needed.

REFERENCES

- Curran, P.J. and Novo, E.M.M., 1988, The Relationship between Suspended Sediment Concentration and Remotely Sensed Spectral radiance: A Review.J. Coastal Res., 4(3), pp. 351-368. .
- Gilbes, F, López, J.M. and Yoshioka, P.M., 1996, Spatial and temporal variations of phytoplankton chlorophyll *a* and suspended particulate matter in Mayagüez Bay, Puerto Rico:Journal of Plankton Research, v. 18, p. 29-43.
- Miller, R.L., Cruise, J.F., Otero, E. and López, J.M., 1994, Monitoring suspended particulate matter in Puerto Rico: Field measurements and remote sensing: Water Resources Bulletin, v.30, p. 271-282.
- Quiñones, J.A., 2005, Bio-optical Variability in Mayaguez Bay during the Rainy Season: Undergraduate Research, University of Puerto Rico at Mayaguez, Geology Department.
- Rodríguez, K., 2005, Determination of the Origin of the Sediments Discharge by the Río Grande de Añasco: Undergraduate Research, University of Puerto Rico at Mayaguez, Geology Department.

ACKNOWLEDGEMENTS: We appreciate the help of Dr. James Goodman from the CenSSIS project of the University of Puerto Rico at Mayaguez in the image processing. Mr. Wilfredo Alequín helped with the computing issues.