Monitoring of sedimentation processes using a GIS-based model and MODIS images

NOAA-CREST

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Abstract

Mayagüez Bay, located at the west coast of Puerto Rico, provides excellent conditions to study variations of sediment input associated, either, to local conditions and river discharge. Eight stations distributed along the bay were sampled in 9 research cruises for bio-optical measurements and Total Suspended Solids (TSS). Different parameters, such as, salinity, Chl-*a* fluorescence, Total Suspended Solids (TSS), bb 620, and bb 675 were studied to determine the relationship between them, and to identified spatial and temporal variations of these parameters along the bay. A correlation between the backscattering coefficient (b_b) and TSS was made using all six HydroScat wavelengths. The resulted highest correlation was found at $b_b(675)$, which was used to estimate TSS at four depths. This study also aims to produce a land-sea interface analysis using erosion data of the watershed and its relation to TSS input. An algorithm, calibrated for Mayagüez Bay conditions, is going to be applied to MODIS images to estimate TSS. The results are expected to provide recommendations to better apply Remote Sensing in coastal waters.

Introduction

Mayagüez Bay is located at the west coast of the island of Puerto Rico and it is directly influenced by three of the most important rivers on this area: Grande de Añasco, Yagüez and Guanajibo rivers. Many studies have been developed in the bay to better understand variations in bio-optical properties (Grove, 1977, Miller et al., 1994, Cruise et al., 1994 & Gilbes et al., 1996), but an erosion study in a watershed scale is still necessary. This study will be extended to Mayagüez Bay watershed to determine the higher potential sediments sources of the rivers using GIS. We expect that the combination of the sedimentation study in the bay and the erosion assessment in the watershed will generate results with multidisciplinary applications.

Objectives

- Estimate soil erosion rates within the Mayagüez bay watershed using RUSLE
- Estimate annual suspended sediment delivered to Mayagüez Bay using MODIS images
- Calculate sediment yields as: product of erosion rates multiply by sediment delivery ratios
- Establish the relationship between the Mayagüez Bay watershed annual erosion rates and the annual suspended sediment transport

Methods

The data in this study included measurements collected since July 2005 to March 2006 during 9 research cruises. A total of eight stations distributed along the Mayagüez Bay are visited during these cruises for bio-optical measurements, where six of them are monitored for Total Suspended Solids (TSS). Interpolations of the different parameters were made using the 3D analyst extension tool of ArcGIS 8.3. To estimate soil erosion in the watershed we are going to combine GIS data layers based on the Revised Universal Soil Loss Equation (RUSLE) (Wischmeier, 1976). Finally, MODIS images are going to be used to estimate the sediment input to the bay.

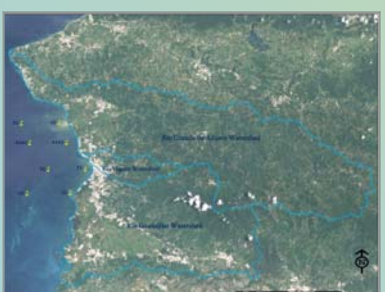

Figure 1. Study area: Mayagüez Bay and its watersheds

Figure 2. Bio-optical rosette

Results

Our results are focused on interpolations based on measurements of salinity (psu), Chl-*a* fluorescence, TSS (mg/l) and b_b620 (nm). Spatial and temporal variations are observed on all the parameters. It is suggested that the backscattering coefficient (b_b) at 675 nm can be used to estimate TSS; therefore it is a very important parameter for this project. The high values observed during the dry season at Guanajibo station were attributed to wave and current-driven processes like re-suspension. This phenomenon, which has been observed in several studies (Morelock, 1983; Miller et al., 1994), is also nicely observed along the water column (Fig. 6, 7, 8 & 9).

Dry season and Rainy season comparisons

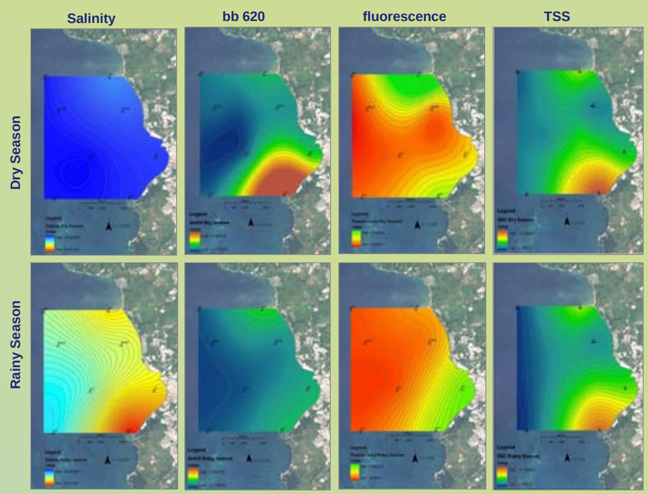

Figure 3. Interpolation results of salinity, b_b 620, fluorescence and TSS during dry and rainy seasons

Backscattering analysis for TSS estimation

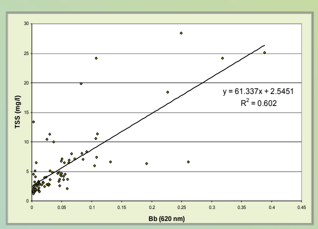

Figure 4. b_b (620 nm) vs. TSS

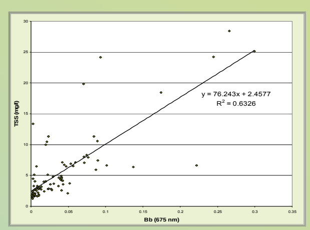

Figure 5. b_b (675 nm) vs. TSS

Total Suspended Solids Based on Bb(675) in Rainy Season

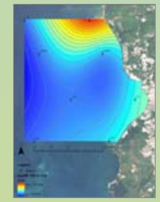

Figure 6. TSS estimation at 0.5 m

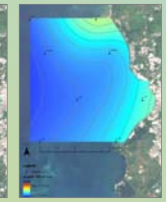

Figure 7. TSS estimation at 1.0 m

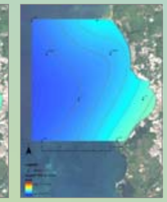

Figure 8. TSS estimation at 1.5 m

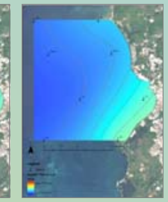

Figure 9. TSS estimation at 2.0 m

Conclusions

The used interpolation method showed to be effective in providing good results for analysis and interpretation of the data collected with the bio-optical rosette. Re-suspension events are expected to have and important influence in our future results. After analyzing all six HydroScat wavelengths for TSS estimation, all of them showed a positive relationship with TSS and b_b at 675 nm showed the highest correlation coefficient (R^2=0.63).

Next Steps

All the RUSLE factors are going to be define for the study area to incorporate them into the GIS. A different analysis and a quality control process will be made as an attempt to better establish the relationship between backscattering and TSS. Finally, downloading and processing procedure of the MODIS images will begin.

Literature Cited

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