DEVELOPING A METHOD TO MONITOR SEDIMENTATION PROCESSES IN MAYAGÜEZ BAY USING MODIS DATA

NOAA-CREST

UPRM

Vilmaliz Rodríguez-Guzmán and Fernando Gilbes-Santaella

Geological and Environmental Remote Sensing Laboratory

Department of Geology, University of Puerto Rico at Mayagüez

Abstract

This project aims to develop a method to monitor sedimentation processes in a coastal environment by using remote sensing technology. The main objectives of this study were to generate, validate and apply an algorithm to estimate suspended sediment concentration (SS) based on remote sensing reflectance (R_{rs}) and MODIS data. It was expected to establish the relationship between in situ measurements of SS and R_{rs}, to then apply the generated equation to MODIS band 1 and band 2 data (620-670 nm and 841-876 nm, respectively). Considering that R_{rs} values are significantly lower than MODIS data, a second relationship was established associating band 1 and band 2 of R_{rs} and MODIS data. The algorithm produced was validated by applying both resultant equations to six MODIS images from which in-situ data was available. In general, the estimations of the algorithm tended to sub-estimated field measurement values, however, abundance and spatial variations of these estimations responded as expected. An application component was included in this study, which consisted on estimate total river discharge by applying the algorithm produced to an image associated to a storm event. This allowed to calculated total mass for a determined area based on SS concentration. This study provided a base to the desire method but various refinements are still needed to be applied in the approach for more reliable results.

Objectives

- Develop a site-specific algorithm to estimate SS concentration based on MODIS data.
- Validate the generated algorithm using *in situ* SS measurements.
- Estimate total river discharge for a storm event by applying the generated algorithm.

Methods

Field Work

(a)

(b)

(c)

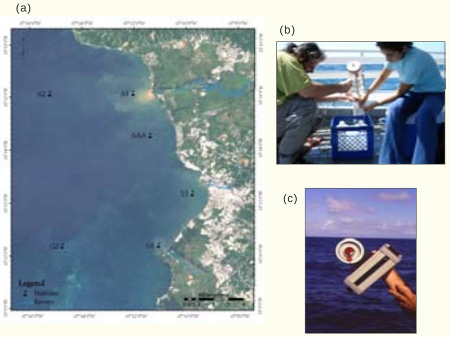


Figure 1.(a) Study area showing the areas of river discharge and the location of the six monitored stations. **(b)** Water samples were collected in each station illustrated in Fig. 1a **(c)** Spectoradiometer GER-1500- Gives measurements of R_{rs} within the range of ~370-1000 nm.

Processing of MODIS Data

Download MODIS images corresponding to cruises dates MOD02QKM (Band 1/620-670 nm; Band 2/841-876 nm)

- Georeferentiation UTM NAD83
- Spatial Subset
- Atmospheric Correction Dark subtract User Value

Algorithm development, validation and application

1. Calculate mean R_{rs} within the ranges corresponding to MODIS Band 1 and 2
2. Establish the relationship between R_{rs} and SS concentration and between R_{rs} and MODIS data
3. Apply the developed equations to MODIS band 1 data to estimate SS concentration, and then compare estimated vs. measured values
4. Select an image associated to a storm event and apply the algorithm produced; then, calculate a total mass of SS discharge within the area of interest

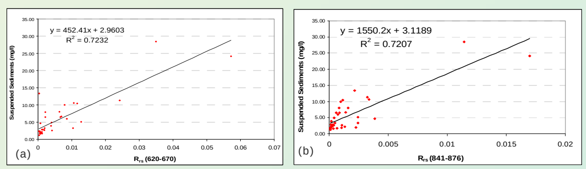
Results

A significant relationship was established (R^2=0.72; n=38) between SS concentration and R_{rs} corresponding to the spectral band 1 and 2 of MODIS (Fig. 2 a-b). Considering that both bands showed a good correlation with SS measurements, a second relationship was establish incorporating both bands in one equation. The results of this approach are illustrated in figure 2 c, where the comparison between the estimated and measured SS are shown, and the R^2 increased to 0.78. Before applying the equation previously defined on MODIS reflectance product, it was necessary to define the relationship between R_{rs} and MODIS reflectance. The results indicates a strong relationship between R_{rs} and MODIS reflectance corresponding to band 1, but the opposite for the values representative of band 2 (Fig. 2 d-e). This analysis indicates that the equation that included Band 1 only should be applied to estimate SS concentration using MODIS. The two resultant equations were:

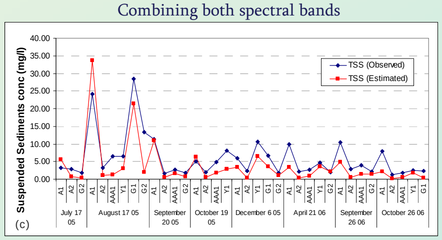
$$\mathbf{y} = 0.4033 * \text{band } 1 - 0.0006 \quad (1)$$

$$\mathbf{SS} \text{ (mg/l)} = 452.41 * y + 2.9603 \quad (2)$$

Relationship between SS and R_{rs} in two spectral bands (MODIS band 1 & 2)



Combining both spectral bands



SS = 337.26 *(Band 1) + 854.12 *(Band 2) R^2= 0.78

Relationship between R_{rs} and MODIS band 1 & 2

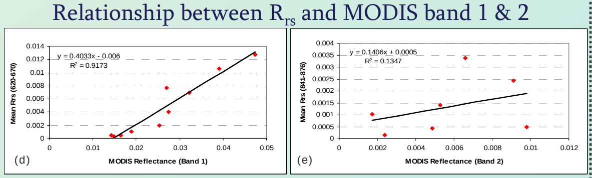


Figure 2.Graphics illustrating how the equations were defined **(a)** SS conc vs. MODIS band 1 **(b)** SS conc vs. MODIS band 2 **(c)** Combining spectral bands **(d)**Mean R_{rs} (620-670nm) vs. MODIS band 1 **(e)** Mean R_{rs} (641-678nm) vs. MODIS band 2

SS Estimated with MODIS

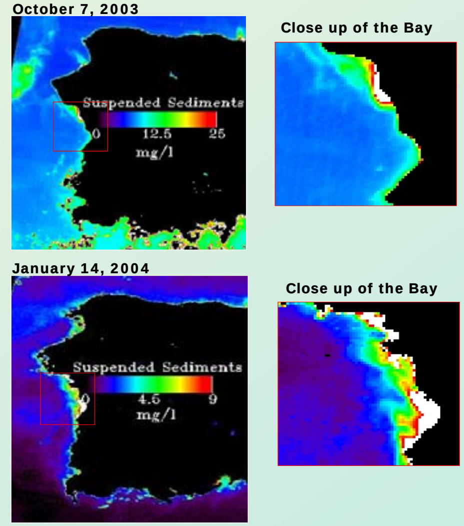


Figure 3.Generated images with equation 1 and 2 to MODIS band 1 reflectance data **(a)** October 7, 2003 **(b)** January 14, 2004

Validation Results

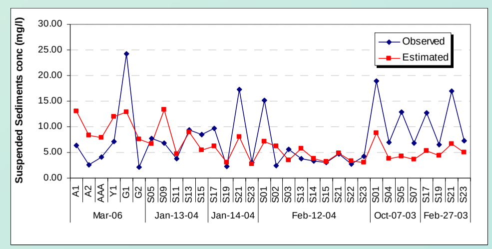


Figure 4. Comparison between estimations and *in situ* measurements

Six products of SS concentration were generated based on images corresponded to dates with *in situ* measurements. These products illustrate the important contribution of the rivers to the SS distribution in the bay (Fig. 3). The estimations of the algorithm are, in general, underestimate the measurements (mean error= $\pm$ 5.23) but the relative variations responded as expected (Fig. 4).

Discharge after a storm event

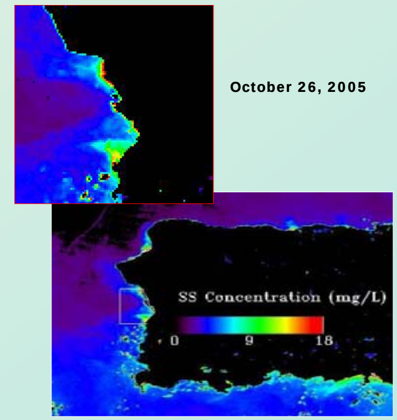


Figure 5.SS concentration after a significant rainy event

This study also attempted to estimate total SS discharge for a significant rainy event. A total of 83 days within 2005 were identified with significant rainy events. The image selected correspond to a day after one of these events (Fig. 5). The results of this analysis not only provided spatial distribution of SS concentration but also mass of sediments within bay area at a surface level (0.5m). Based on this mass, total discharge for the selected event was estimated as 392.32 metric Tons.

Conclusions

- Both R_{rs} spectral ranges (620-670 and 641-678nm) presented a significant relationship with SS concentration.
- The best algorithm to estimate SS concentration included only Band 1 data.
- The estimates using the algorithm responded similarly to the observations; although it showed underestimations.
- The developed method allowed to calculate total mass of suspended sediments for the desired area at 0.5 m

Acknowledgements

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