

COASTAL –GILBES’ GROUP REPORT

(Performance period: September 1, 2009 to February 28, 2010)

RESEARCH COMPONENT

RESEARCH PROJECT SUMMARY FOR THE REPORTING PERIOD ONLY

Project	Tasks	CREST Researcher	Students involved	NOAA and Other Collaborators
Project (2) Field measurements in coastal waters for algorithm testing/development and satellite validation.	<p>Compare to satellite water leaving products and atmosphere retrievals.</p> <p>Inter-comparison of the below/above water signals with aircraft and satellite data as available.</p>	F. Gilbes	<p>Vilmaliz Rodriguez (M.S. Student)</p> <p>Natlee Hernández (M.S. Student)</p>	<p>Joaquín Trinanes (Acting NOAA CoastWatch Operations Manager for the Caribbean Regional Node)</p> <p>From UPRM: Eric Harmsen Roy Armstrong</p> <p>From CSU: Carlos Ramos-Scharrón</p>
Project (3) Improvement/ Development of algorithms for remote sensing of coastal waters.	<p>Analysis of optical field measurement together with Chl, TSS concentrations.</p> <p>Development of GIS database for land sea interactions in Mayaguez Bay.</p> <p>Development of GIS model for land-sea interactions in Mayaguez Bay.</p>	F. Gilbes	<p>Vilmaliz Rodriguez (M.S. Student)</p> <p>Natlee Hernández (M.S. Student)</p>	<p>Joaquín Trinanes (Acting NOAA CoastWatch Operations Manager for the Caribbean Regional Node)</p> <p>From UPRM: Eric Harmsen Luis Pérez-Alegría Roy Armstrong</p> <p>From CSU: Carlos Ramos-Scharrón</p>

Thrust: Remote Sensing of Coastal Waters

Project 2: Field measurements in coastal waters for algorithm testing/development and satellite validation

Project 3: Improvement/Development of algorithms for remote sensing of coastal waters

- **Relevance to NOAA’s mission and the strategic plan:** This project is well in view with NOAA’s vision and mission that establish a comprehensive understanding of the role of the oceans and coasts to meet our Nation’s economic, social, and environmental needs. It is aligned with the new priorities for the 21st century presented in the NOAA’s strategic plan and in regards of coastal and marine resources through an ecosystem approach to management. The research activities are helping to develop better and most cost-effective tools to monitor coastal processes.
- **Relevance to NOAA Line Office (i.e., National Weather Service, National Ocean Service) strategic plan:** This project provides critical support for NOAA’s missions of the National Ocean Service by using and validating environmental satellite data. Especially, it is creating an important database of bio-optical properties from coastal waters affected by rivers discharge. These field data are crucial to develop improved algorithms for the estimation of water quality parameters in coastal waters.
- **Supervising PI or Co-Is:** Fernando Gilbes Santaella
- **Publications (during performance period):**
 - Thesis Publication:**
 - ❖ Rodríguez-Guzmán, Vilmaliz (2009) Remote Sensing of Suspended Sediment in Mayagüez Bay Associated with Inland Soil Erosion Rates. University of Puerto Rico at Mayaguez, Department of Geology, 123 pages.
http://gers.uprm.edu/pdfs/thesis_vilmaliz.pdf
 - Book:**
 - ❖ Fernando Gilbes and students have continued working with their chapters for the peer-review book about the oceanography and remote sensing of Mayaguez Bay, including all the work sponsored by NOAA CREST. This book will be published in collaboration with the Center for Hemispherical Cooperation (CoHemis) of UPRM and the University of Puerto Rico Press.
- **Dollar amount of funds leveraged with CREST funds (during performance period):**

Project Title	Sponsoring Agency	PI/Co-PI/ Recipient/Group	Dollars	Start Date	End Date
Study of Benthic Habitats Using Hyperspectral Remote Sensing	NSF-CenSSIS	PI: Miguel Velez Co-PI: Fernando Gilbes among others	\$50,000	March 2000	February 2010

Developing a protocol to use remote sensing as a cost effective tool to monitor contamination of mangrove wetlands	University of Puerto Rico Sea Grant College	PI: Johannes Schelekens Co-PI: Fernando Gilbes	\$30,000 (No cost extension)	June 2006	May 2010
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- **Ongoing, New or Revised?:** Ongoing
- **Staff:** None
- **Students PhD:** None
- **Students MS:** Vilmaliz Rodriguez and Natlee Hernandez, UPRM-Dep. Of Geology
- **Students Undergraduate:** None
- **NOAA Collaborators:** A site-specific algorithm has been developed and tested to estimate Total Suspended Sediments (TSS) in Mayaguez Bay. This algorithm is being incorporated in NOAA-NESDIS system as a “testing product” of TSS for Puerto Rico in collaboration with Joaquin Trinanes, Acting NOAA Coast Watch Operations Manager for the Caribbean Regional Node.
- **Other Collaborators:** Eric Harmsen (UPRM-Department of Agricultural Engineering), Carlos Ramos-Scharrón (Department of Geosciences, Colorado State University), and Roy Armstrong (UPRM-Department of Marine Sciences).
- **Operational Impact:** The on-going project aims to develop the appropriate techniques to use ocean color sensors to monitor the conditions of coastal environments. Estimates of Chlorophyll and Suspended Sediments from space can be used as proxy for the quality of coastal waters. Continuous monitoring of such parameters with satellite sensors will help to better understand and manage our coastal environments.
- **Status of the project with respect to the goals/objectives and benchmarks previously identified:** Vilmaliz Rodriguez successfully defended her thesis on December 8, 2009. This work was fully funded by NOAA-CREST and covered several tasks of this thrust. A site-specific algorithm for the estimation of Total Suspended Sediments in Puerto Rico coastal waters was developed and its implementation as “testing product of the NOAA CoastWatch program is underway. Remote sensing reflectance measurements obtained with the GER-1500 spectroradiometer were used to estimate this parameter and compared with MODIS data. Her work also helped to create the on-line GIS-database of the GERS Lab (GERSVIEW) and to evaluate a model for land-sea interface studies. A new effort by Natlee Hernandez is now in progress to better understand the effect of suspended sediments on the remote sensing reflectance. Good progress has been obtained in all proposed tasks.

Tasks (For year IV as per the Milestone Chart)

Task: Compare to satellite water leaving products and atmosphere retrievals

In situ measurements of total suspended sediments (TSS), backscattering (bb and bbp), Remote Sensing reflectance (Rrs), and MODIS-Terra band 1 reflectance were spatially and temporally

compared. Spatial analyses indicated that absolute values of TSS, Rrs and bb increases with proximity to shoreline. It was observed that median values of bb and bbp vary spectrally, and higher difference in magnitude between these parameters was observed in shorter wavelengths and offshore stations. Good relationships resulted from TSS concentration and bbp linear regression analyses in all six analyzed wavelengths ($R^2=0.74-0.76$; $n=133$). Resultant correlation results between bb and Rrs using corresponding wavelength, show significant wavelength dependant variations where best relationship was observed at 620 nm ($R^2=0.78$; $n=61$). The relationship between Rrs and TSS indicate that the best wavelengths to estimate TSS are between 589 to 645 nm. The analysis of Rrs single band and Rrs ratio for derivation of TSS indicates that red to green ratio (Rrs_{655}/Rrs_{545}) present the best correlation results ($R^2=0.84$; $n=72$). Simultaneous MODIS reflectance band 1 data and *in situ* measurements of TSS concentration, bbp_{620} and Rrs_{645} were all positively correlated, but more data are required to better define and validate the results. Sensors with better spatial and spectral resolution are needed in order to generate operational products of TSS in these highly variable optical tropical waters. This work is part of Vilmaliz Rodriguez master theses.

Task: Intercomparison of below/above water signals with aircraft and satellite data as available.

Monitoring and better understanding of sediment flux and processes in coastal environments are important to maintain water quality and geomorphologic balance. Development and validation of an algorithm to estimate total suspended sediment (TSS) was performed based on *in situ* remote sensing reflectance (Rrs) and MODIS/Terra band 1 data. Two image processing methods, based on two image analysis packages with predefined routines, were evaluated and compared in order to determine the most suitable method for the study area. Analyses of *in situ* data showed a significant relationship between TSS and *in situ* Rrs at 645 nm ($R^2=0.73$) indicating positive response of this parameter in the interested region of the spectrum. Developed algorithms were evaluated by applying resultant equations to two MODIS images from which *in situ* data were available. In the validation analysis the lower error was encountered when using an exponential equation, however linear equations estimations followed better the tendency of measured values. TSS estimations of all three algorithms presented values within the range of *in situ* observations and spatial patterns characteristic of coastal environments. Additional data and pre-processing parameters should be evaluated in order to improve validation results and produce TSS operational products for tropical coastal waters. This work is part of Vilmaliz Rodriguez master theses.

Task: Analysis of optical field measurement together with Chl, TSS concentrations

A new effort has started in order to understand how the sediments of the Añasco, Yagüez and Guanajibo rivers affect the optical signal of Mayagüez Bay. The planed work is based on recent findings by Vilmaliz Rodriguez and it will be performed by Natlee Hernandez. Remotely sensed and *in-situ* measurements are going to be used. Determination Physical and geological characteristics of the suspended sediments will help us to understand the behavior of the spectral responses. The XRD and the Sedigraph 5100 instruments will be used to determine the mineral composition and the grain sizes. The MERIS ocean color sensor from the ESA (European Spatial Agency) data will be compared to in-situ measurements. Finally, all the data will be associated to the season in which was collected and correlated to the physical characteristics of the particles. During this semester field work and laboratory analyses will begin by Natlee.

Task: Development of GIS database for land sea interactions in Mayaguez Bay

Quality control of all data collected in Mayaguez Bay was continued during the reported period. In addition, new analyses of the collected radiometric data were started. This data set was not included during the first round of processing because the nature of processing and quality control is more complicated and requires particular attention. Transfer of knowledge between Vilmaliz Rodriguez and Natlee Hernandez continued in order to further develop the GERSVIEW database.

Task: Development of GIS model for land-sea interactions in Mayaguez Bay.

The Revised Universal Soil Loss Equation (RUSLE) was applied to Mayaguez Bay watershed by defining raster layers (pixel size = 10 m) of associated factors in a GIS based model. Spatially variable soil erosion rates and sediment yields estimations, from 2001 to 2005, were estimated for this basin. Validation results indicated that the equation published by Boyce (1975) to calculate sediment delivery ratios (SDR) responded to conditions of the area, while the other two equations evaluated for the same purposes (Vanoni, 1975 and USDA, 1972) tended to overestimate this parameter. Sediment yield estimations generated for year 2004 for Rosario river sub-watershed (32,365 Mg/yr) were highly comparable to field measurements at USGS gauge station (33,622 Mg/yr) showing the great potential of the developed model. MODIS data for twenty dates of 2004 were used to generate suspended sediment load products corresponding to northern and southern parts of the bay. Results of the northern area showed a fairly good relationship ($R^2=0.71$) with Añasco river discharge measurements, but additional values of high river discharge are required to strengthen this association. This work is part of Vilmaliz Rodriguez master theses.

Future Tasks (From the Milestones)

Efforts for developing site-specific algorithms for suspended sediments will continue. This will include a better understanding of the physical and geological characteristics of sediments. Other optical data are being organized and they are getting ready for the GIS databases. Very soon they will be exported to ArcIMS and be published in the web. This activity will allow people to access and manipulate the data via internet for better understanding of land-sea interactions in Mayaguez Bay. Natlee Hernandez (new M.S. student), will continue working with this important aspect of the project. Another publication by Vilmaliz Rodriguez will be submitted to a peer-review journal very soon. The PI and other students will continue working with the chapters of the Mayaguez Bay book.

Appendix: The following links include publications related with work of this report period.

http://gers.uprm.edu/pdfs/thesis_vilmaliz.pdf

http://gers.uprm.edu/pdfs/report_natlee_feb10.pdf