Effect of tropical storms on the bio-optical properties of coastal waters in Puerto Rico

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Abstract

The impact of tropical storms on the ocean color of coastal waters of Puerto Rico was analyzed. The changes in ocean color are due to the absorption and scattering of water optical properties. Data from the Moderate Resolution Imaging Spectroradiometer (MODIS) were used to generate images of products related with ocean color. Different parameters from the images selected for each event were related with *in situ* discharge data. All the signals detected with MODIS were affected by rivers discharge and rain. The study clearly demonstrate how water color parameters from satellite sensors and field meteorological parameters can be related. Dramatic changes in ocean color were detected for tropical storms Earl and Jeanne. The results support the use of remote sensing in this type of assessments and open the window for further studies in Puerto Rico and the Caribbean region.

Introduction

• The ocean color is affected by dissolved and suspended particles in the water, like phytoplankton, which affect certain wavelengths of the electromagnetic spectrum.

• These changes in ocean color, measured by the reflection of light, are due to the absorption and scattering of light.

• Ocean color helps to understand the life in the ocean by estimating the concentration of the constituents of the water such as the phytoplankton, dissolved organic matter, and suspended sediments in water.

• This study focused on the analysis and interpretation of how tropical storms affects the color of coastal waters in Puerto Rico.

• The work intended to validate the results using two different events. Also, images parameters and *in situ* discharge data were related. The signals detected by the MODIS sensor were evaluated in terms of how they were affected by rivers discharge and rainfall.

Methodology

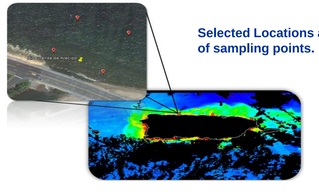
A. MODIS sensor:
Data from the Moderate Resolution Imaging Spectroradiometer (MODIS) were used to generate images of ocean color parameters. This sensor contains 36 bands but in this study only bands 8 to 16 were used.

B. SeaDAS data program :
The images were downloaded from internet and processed using the NASA developed software called SeaDAS (SeaWiFS Data Analysis System). This is a comprehensive image analysis package for the processing, display, analysis, and quality control of ocean color data.

I. The following parameters were extracted from the images:

•Chlor_a	•Rrs_443	•Rrs_645
•Kd_490	•Rrs_488	•Rrs_667
•Rrs_412	•Rrs_555	

C. At each river mouth, four points (i.e. pixels) were selected. These points were separated by five pixels.



Selected Locations and example of sampling points.

Results

• The selected images illustrate the concentration of chlorophyll-a before and after the passage of the hurricanes Earl and Jeanne in 2010 and 2004, respectively. Both passed over Puerto Rico as tropical storms.

• These images demonstrate how the phytoplankton chlorophyll-a and the K(490) were highly affected by rivers discharge, represented by intense colors (green to red). Lower concentrations are presented in blue and no data in black.

Hurricane Earl 2010

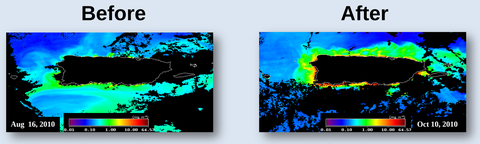


Figure 1. Chlorophyll-a as estimated using the MODIS satellite sensor before and after the tropical system. The scale is in mg m $^{-3}$.

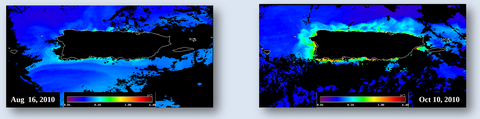


Figure 3. Kd_490 as estimated using the MODIS satellite sensor before and after the tropical system. The scale is in m $^{-1}$.

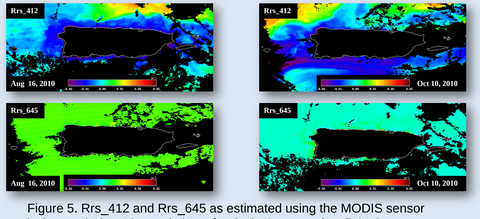
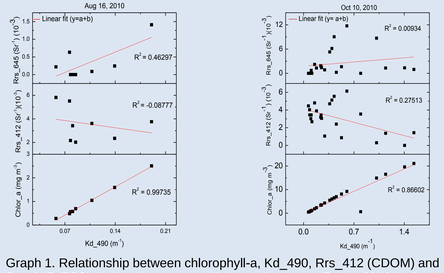


Figure 5. Rrs_412 and Rrs_645 as estimated using the MODIS sensor before and after. The scale in sr $^{-1}$ units is the same for all the images.



Graph 1. Relationship between chlorophyll-a, Kd_490, Rrs_412 (CDOM) and Rrs_645 (TSS) during the passage of the tropical storm Earl at 2010. Left figures were before the passage of the tropical storm and those on the right were after the passage.

Hurricane Jeanne 2004

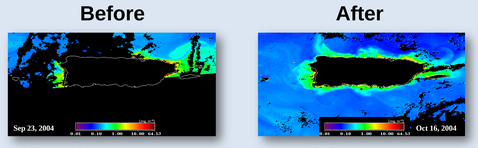


Figure 2. Chlorophyll-a as estimated using the MODIS satellite sensor before and after the tropical system. The scale is in mg m $^{-3}$.

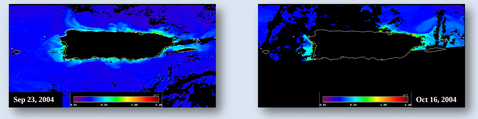


Figure 4. Kd_490 as estimated using the MODIS satellite sensor before and after the tropical system. The scale is in m $^{-1}$.

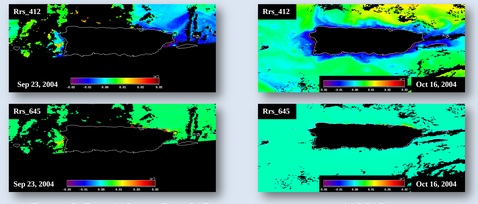
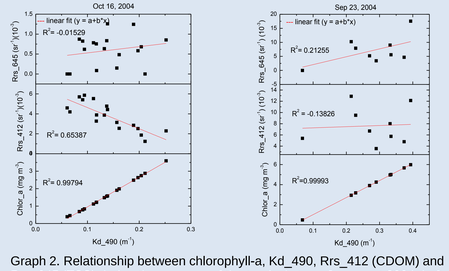


Figure 6. Rrs_412 and Rrs_645 as estimated using the MODIS sensor before and after. The scale in sr $^{-1}$ units is the same for all the images.



Graph 2. Relationship between chlorophyll-a, Kd_490, Rrs_412 (CDOM) and Rrs_645 (TSS) during the passage of the tropical storm Jeanne at 2004. Left figures were before the passage of the tropical storm and those on the right were after the passage.

Discussion and Conclusion

• The processed images clearly showed that before the passage of the tropical system the concentration of chlorophyll-a was much less than a month after the event. It was also found that the effect of high rivers discharge is not immediate after the passage.

• The passage of Jeanne in 2004 and Earl in 2010 caused significant changes in ocean color around Puerto Rico. These changes were due to the discharges of organic matter and nutrients as produced by the pass of the tropical system.

• These nutrients increase the concentrations of phytoplankton and therefore increase the chlorophyll detected by MODIS.

• The diffuse attenuation coefficient at 490nm (Kd_490) is:
  - ➢ directly proportional to the chlorophyll-a and the total suspended sediment (Rrs_645).
  - ➢ inversely proportional to the colored dissolved organic matter (Rrs_412).

Future Work

• Compare the results with real temperature data from buoys.
• Determine the meaning of each negative value obtained from the images using L2_flags SeaDAS parameter.
• Select more pixels in each image to obtain less variability in the results and a better fit on the graph.

Acknowledgments

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