Hyperspectral remote sensing of water quality indicators following episodic rainfall events in southwestern Puerto Rico

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Abstract

Coral reefs have experienced declines of up to 80% in the last 30 years in the Caribbean Region. They are threatened by increasing turbidity resulting from poor land-use practices and pollution. Runoff from intense precipitation delivered by hurricanes and other tropical disturbances transports large volumes of sediment rich waters to the coast and insular shelf. Rain runoff also brings high nutrient loads which results in phytoplankton blooms that further decrease the amount of light reaching coral reefs. The impacts of episodic rainfall events on coral reefs have never been documented. This study will relate the intensity and residence time of turbidity plumes in southwestern Puerto Rico to coral bleaching and mortality using a combination of MERIS high resolution (300 m) data, HICO hyperspectral data, and *in situ* bio-optical and water quality measurements.

Statement of work

The main objective of this study is to evaluate the impacts of episodic rainfall events on water quality parameters affecting coastal environments in southwestern Puerto Rico. Of particular interest is to monitor and assess the impacts of these events on coral reefs. Coral ecosystem health and resilience can be inversely proportional to the residence time of high sediment and chlorophyll loads resulting from episodic rainfall events.

Background and Approach

Gilbes et al. (2001) estimated that the torrential rains and runoff associated with Hurricane Georges delivered one thousand metric tons of nitrate to the coastal waters of Puerto Rico during a five day period in September 1998. During three days in November 2003, an episodic rainfall event dumped more than 50 cm of rain over the interior of Puerto Rico. The resulting runoff and river discharge lead to phytoplankton blooms over

extensive areas around the island. In La Parguera, southwestern Puerto Rico, Chlorophyll-a (Chl-a) concentrations persisted for approximately two weeks and extended beyond the insular shelf.

The impact of episodic rainfall events on the coastal waters of Puerto Rico will be assessed with the use of satellite remote sensing technology. Daily and weekly averaged MERIS mapped products of Chl-a concentration and K490 will be used in a time series analysis to establish baseline conditions and to quantify the evolution of these parameters in the marine environment after the episodic events. HICO hyperspectral data will be used to supplement the MERIS data by providing higher spatial and spectral resolution data in coastal waters. This study will explore the capability for timely assessments of the impact of episodic events on coastal water quality in this region using ocean color remote sensing and *in situ* monitoring. In addition, a large database that will be generated of AOPs and IOPs, combined with simultaneous measurements of Chl-a, CDOM, and suspended sediments will contribute to global databases for algorithm development in Case-1 and Case-2 waters.

Schedule and Plans

Weekly bio-optical field sampling at six optically-deep stations in La Parguera and Guánica Bay (corner coordinates 17°59'13.5"N, 67°08'28.8"W; 17°59'13.5"N, 66°52'47.2"W; 17°52'48.3"N, 67°08'32.6"W; 17°52'48.3"N, 66°52'39.6"W) (Figure 1)

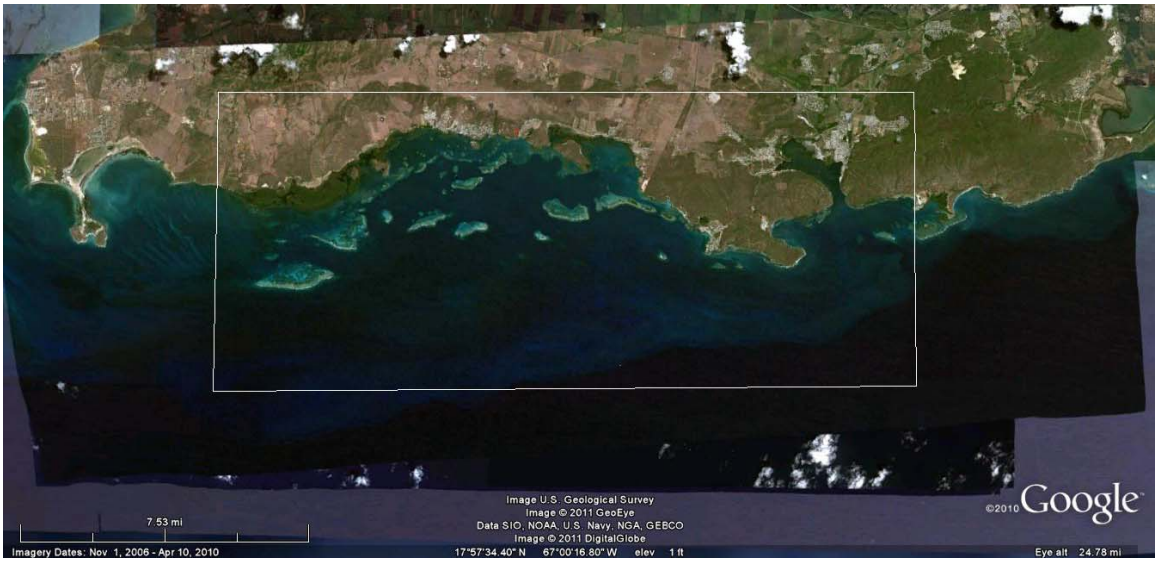

Figure 1. Study area (white box) in southwestern Puerto Rico.

started in March 2011 and will extend to the summer of 2011. Additional samplings will take place during and after episodic rainfall events from now until December 2012. The selected stations will be sampled with an existing profiling sensor package that contains a CTD to measure temperature and salinity, a WetStar fluorometer for chlorophyll fluorescence, an ac-9 for absorption and attenuation, and a HydroScat-6 for backscattering. Water-leaving radiance and the above-surface downwelling irradiance

will be measured using a GER 1500 spectro radiometer to calculate the remote sensing reflectance. Concentration of phytoplankton chlorophyll-a will be obtained using the fluorometric method of Welshmeyer (1994) with a TD-700 fluorometer from Turner Designs. Optical absorption spectra of the colored dissolved organic matter (CDOM), $a_g(\lambda)$, will be determined with a Perkin Elmer double-beam spectrophotometer following the method described by Bricaud et al. (1981). Total suspended sediments concentration will be determined gravimetrically following the procedures outlined by Strickland and Parsons (1972).

We will validate MERIS products and HICO level 2B products with the field data. Level 2A atmospherically corrected remote sensing reflectance data and level 2B standard data products from HICO are requested for orbital overpass over Puerto Rico beginning in March 2011.

Deliverables

1) Validation of HICO standard data products.
2) Yearly participation in HICO Data Team Meetings.

References

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Welschmeyer, N. 1994. Fluorometric analysis of chlorophyll a in the presence of chlorophyll b and pheopigments. Limnology and Oceanography, 39:1985-1992.

Personnel

Roy Armstrong will lead this work. The weekly bio-optical and water quality sampling is in collaboration with Julio Morell and Belitza Broco from the Caribbean Coastal Ocean Observing System (CariCOOS) as part of a MERIS high resolution data validation initiative. See http://www.caricoos.org

Facilities

The Bio-optical Oceanography Laboratory (http://bio-optics.uprm.edu) on Magueyes Island, southwestern Puerto Rico, has 10 computer workstations for image processing

using IDL/ENVI and SeaDAS software, ArcView GIS, 4TB raid storage, and a wide variety of field and laboratory equipment for oceanographic and atmospheric measurements. In addition to the instruments mentioned previously, the field instrumentation includes a Satlantic Corp. Profiler II equipped with two MicroPro submersible hyperspectral radiometers that provide 148 channels of upwelling radiance and downwelling irradiance (350-800 nm), a WET Labs ECO BB2F backscattering meter, two GER-1500 spectroradiometers, a Solar Light PAR and UV profiling radiometer, and a Microtops II portable sunphotometer. Our laboratory also operates a permanent UV-PAR monitoring station (Biospherical Instruments GUV-511) that has been operational since 1995. This is also the site of a NASA AERONET sunphotometer and a Multi-filter rotating shadow-band radiometer (MFRSR). Both instruments measure aerosol optical depth. The laboratory has dedicated use of a 21' open boat (R/V Boriken) for access to the field.