Multiplatform Remote Sensing for Coral Reef Community Assessment

Quinta Reunión Nacional de Percepción Remota y Sistemas de Información Geográfica en Puerto Rico

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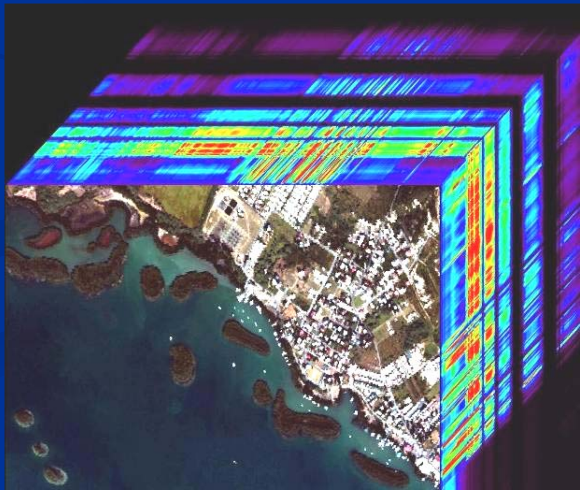
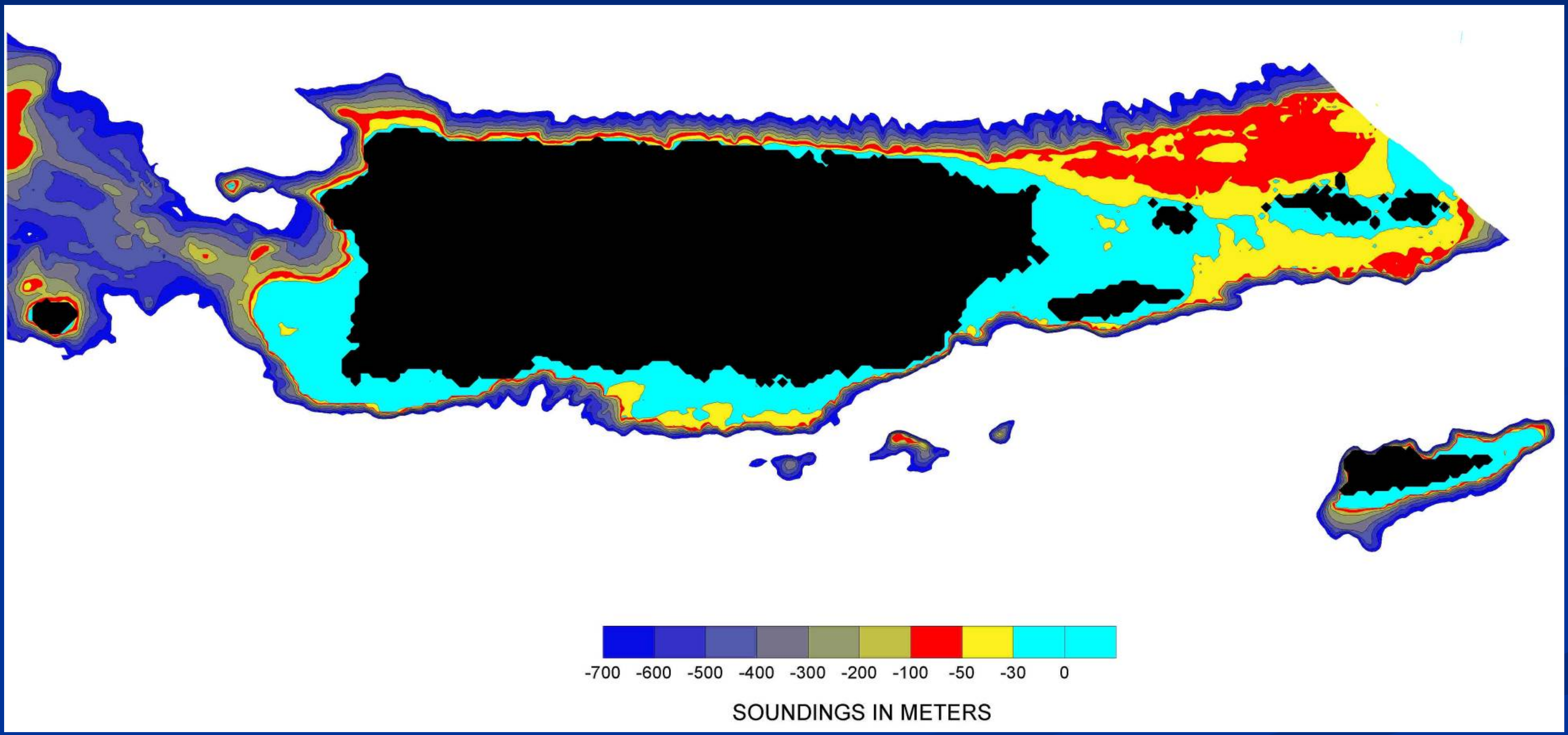


Bathymetry of Puerto Rico -Virgin Islands Geological Platform

Potential Reef Habitat



Remote Sensing Platforms and Sensor Requirements for Benthic Habitat Assessments

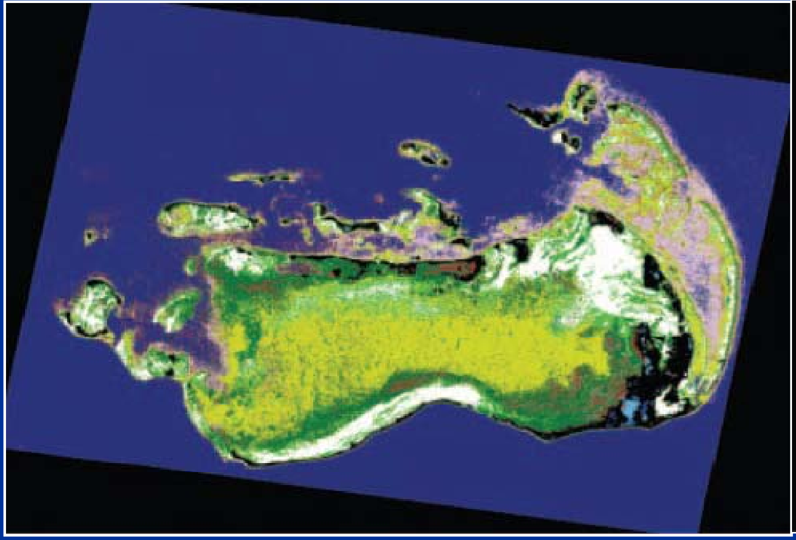
- Insular Shelf (0-30 m)
  - Satellite Sensors – Landsat TM, SPOT, IKONOS
  - Airborne Sensors – AVIRIS, AISA, Digital Camera Systems
- Upper Insular Slope (30 – 100 m)
  - Ship-based Acoustic Sensors
  - Autonomous Underwater Vehicles (AUV)
    - Optical and Acoustic Imaging
  - Remote Operated Vehicles (ROV)
    - Optical Imaging

Direct vs. Indirect Monitoring of Coral Reefs Using Remote Sensing

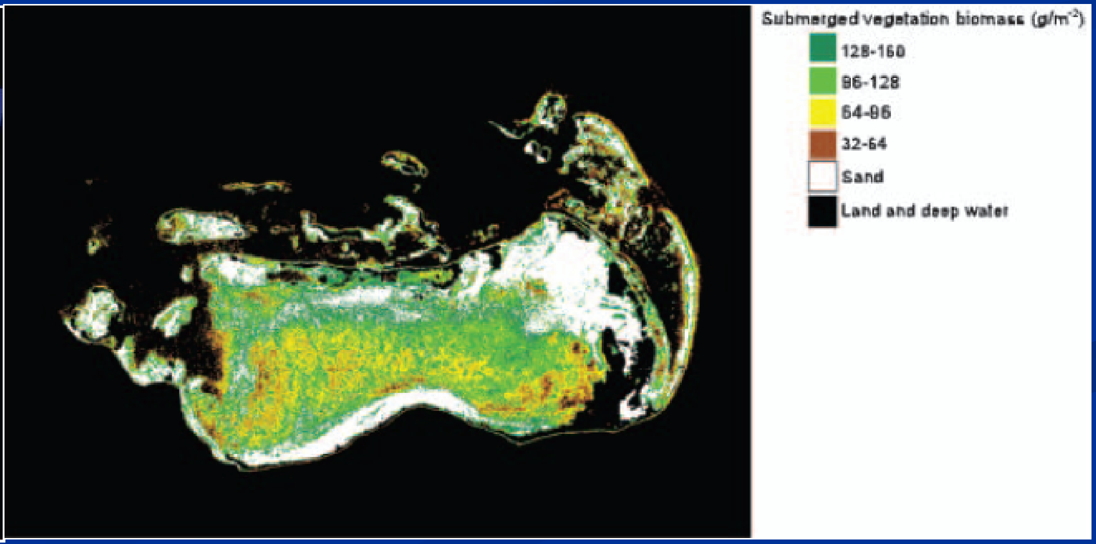
Direct – includes benthic mapping and characterization of coral reef and other biotopes using a “sensor down” approach.

Requires local knowledge of reef communities and utilizes image-specific statistics to drive a supervised classification. Requires atmospheric and water column corrections for multi-temporal analysis.

Landsat TM data for Los Roques, Venezuela:



Benthic Habitat Map

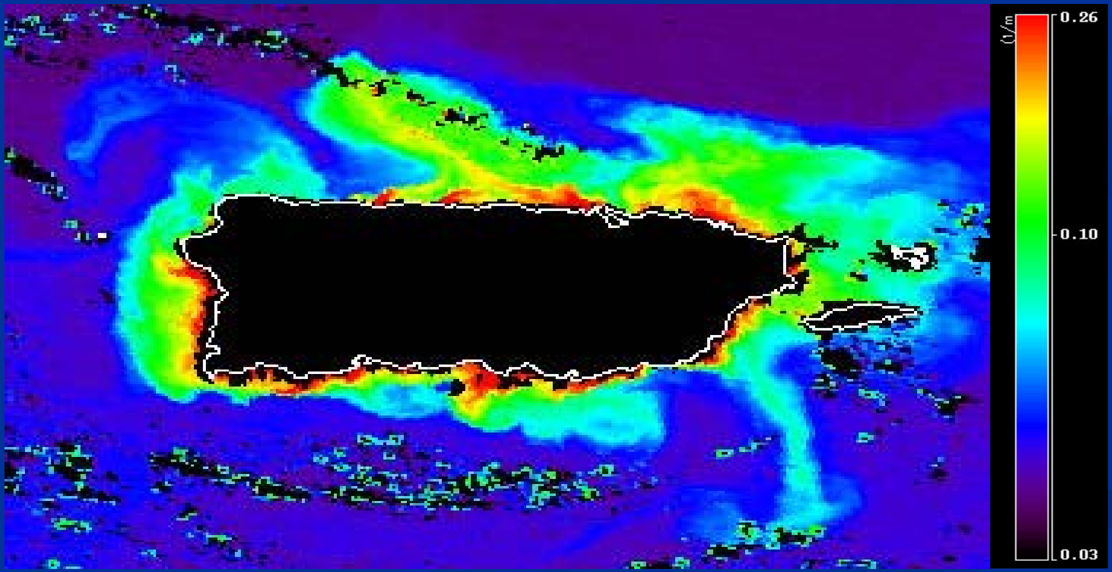


Seagrass Biomass Map

Direct vs. Indirect Monitoring of Coral Reefs Using Remote Sensing, cont.

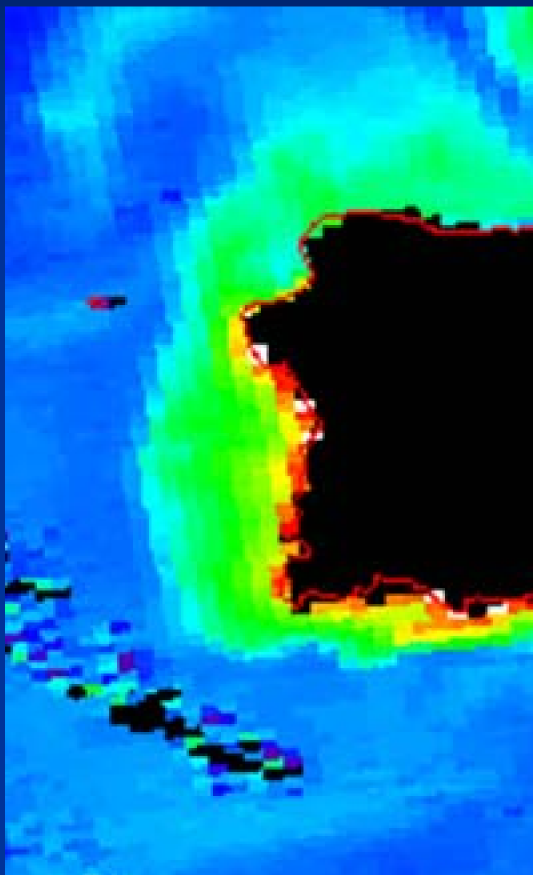
Indirect – addresses the oceanic environment around the reef.

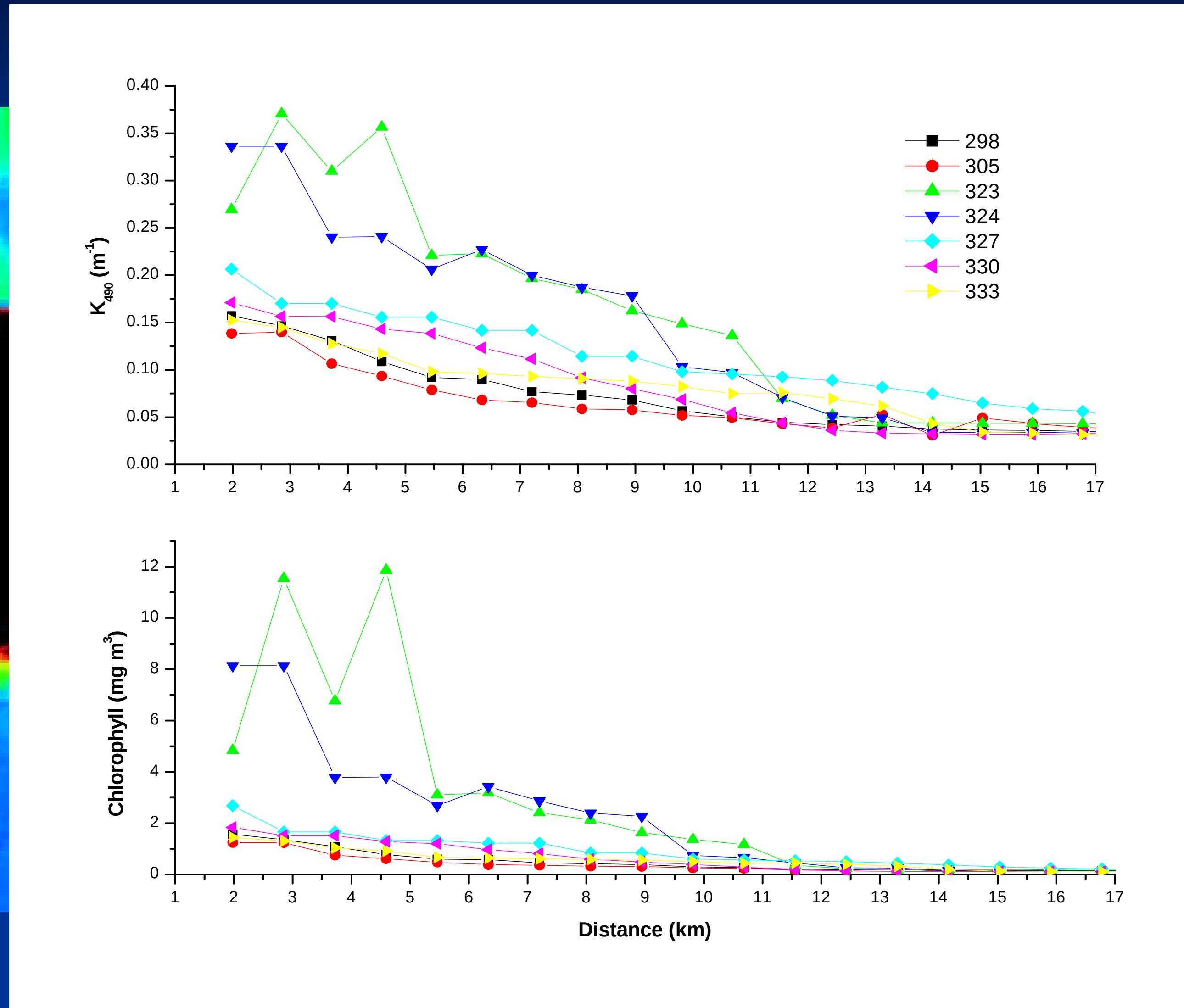
Sea surface temperatures (SSTs) and bleaching events.
Low salinities and high turbidity from episodic rainfall events.
Water optical properties (AOP and IOP) and coral reef parameters.



MODIS K490 November 20, 2003

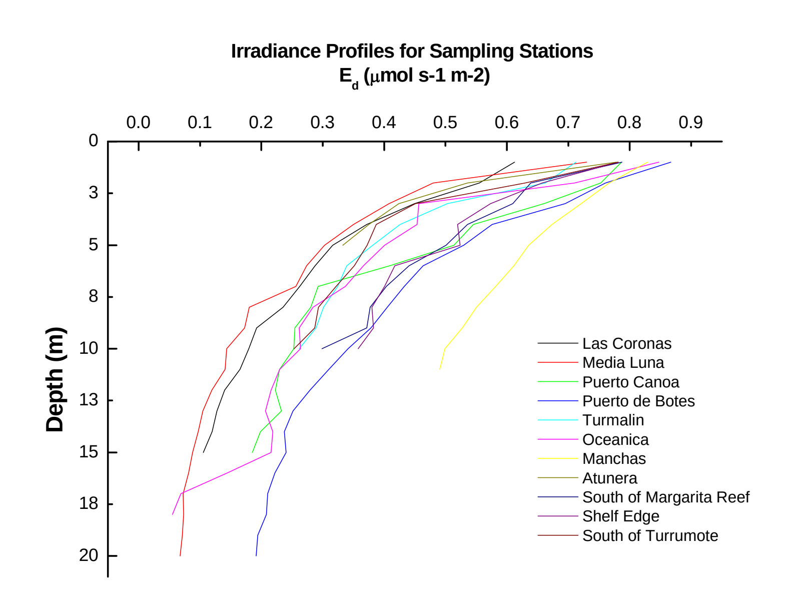
MODIS Time Series of K490 and Chlorophyll Associated with the November 13-15, 2003 Episodic Rainfall Event

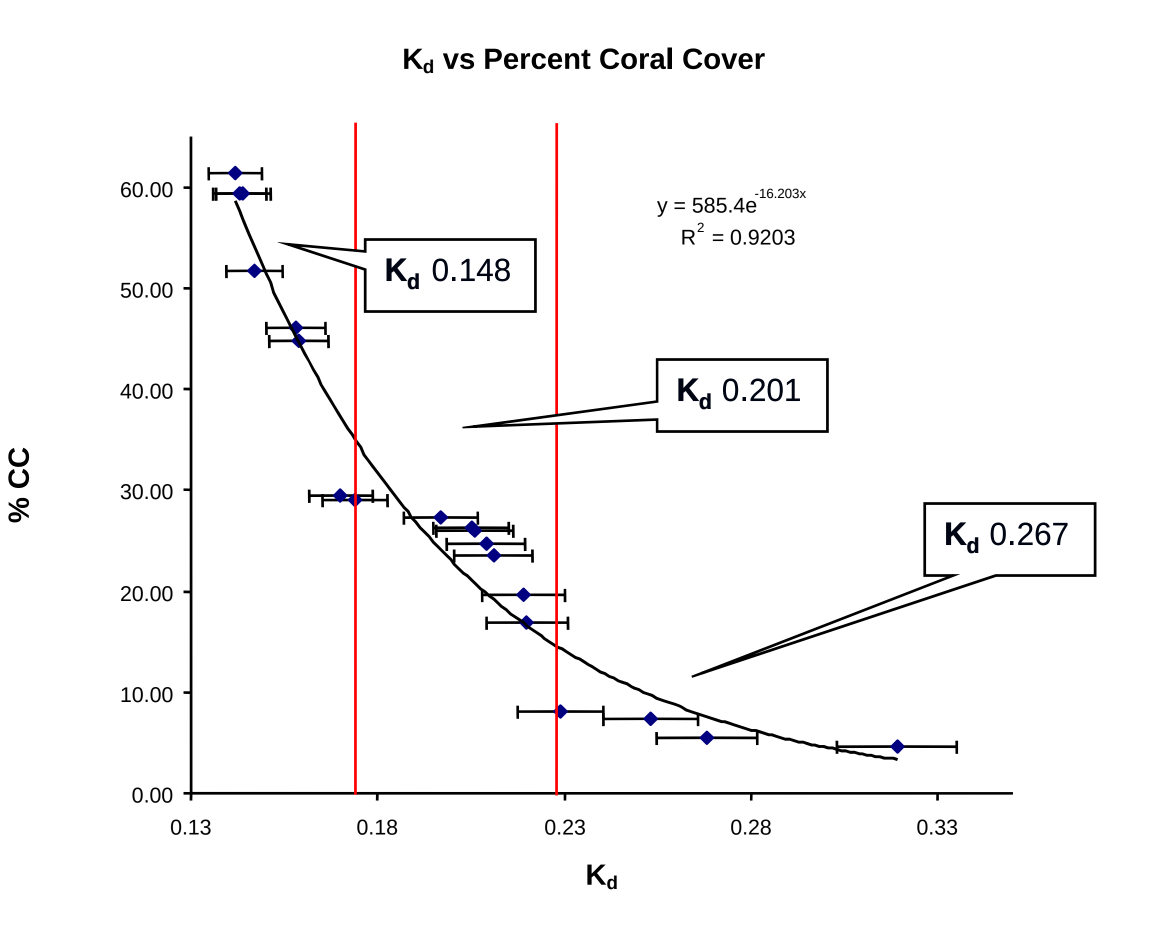




Julian days 317-319 – Rainfall Event

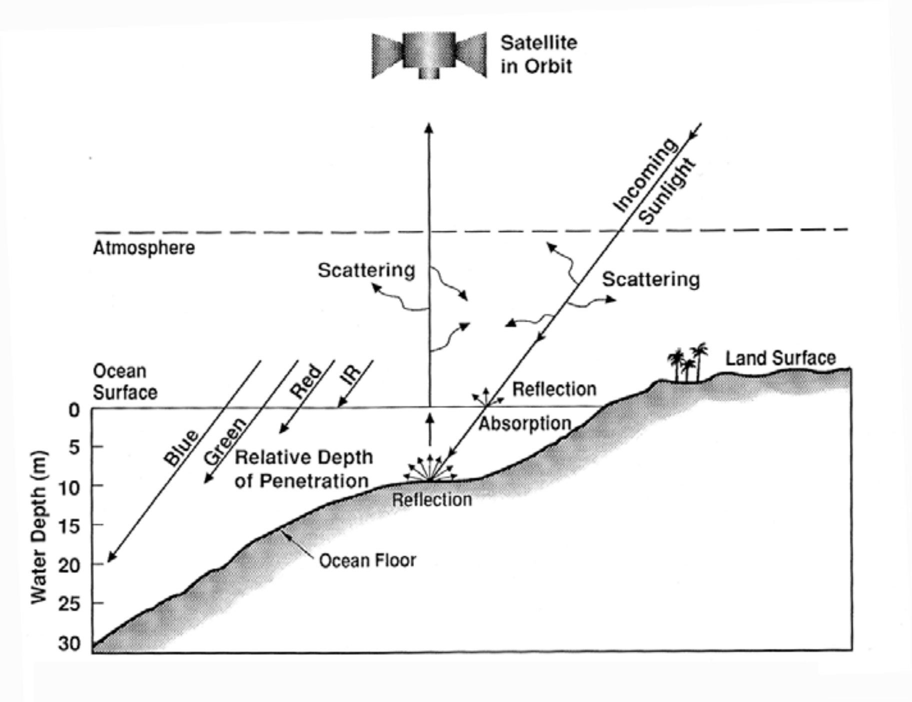
Indirect Methods: Kd (PAR) vs. Percent Coral Cover

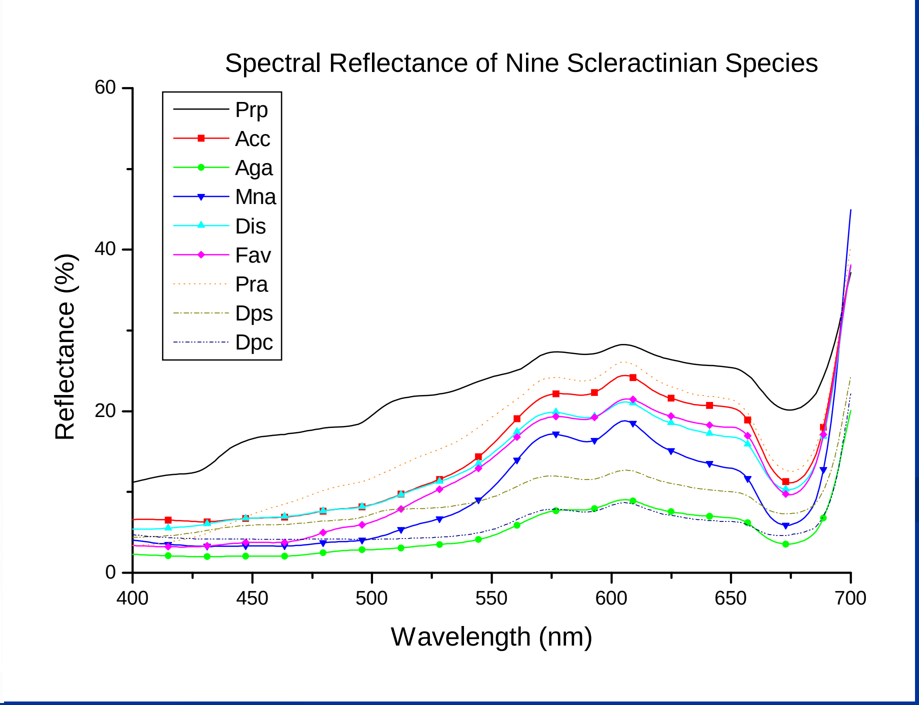




"Reef-Up" Habitat Mapping

- Physics based, uses Radiative Transfer Theory
- Uses spectral libraries of the reef components
- Its application is independent of site and image-specific statistics.





Spectral Library of Coral Reef Benthic Components

Spectral Reflectance Data using GER-1500 Spectroradiometer

Coral Reef Benthic Components

Coral Rubble

Acropora cervicornis

Montastraea annularis

Gorgonians

Siderastrea siderea

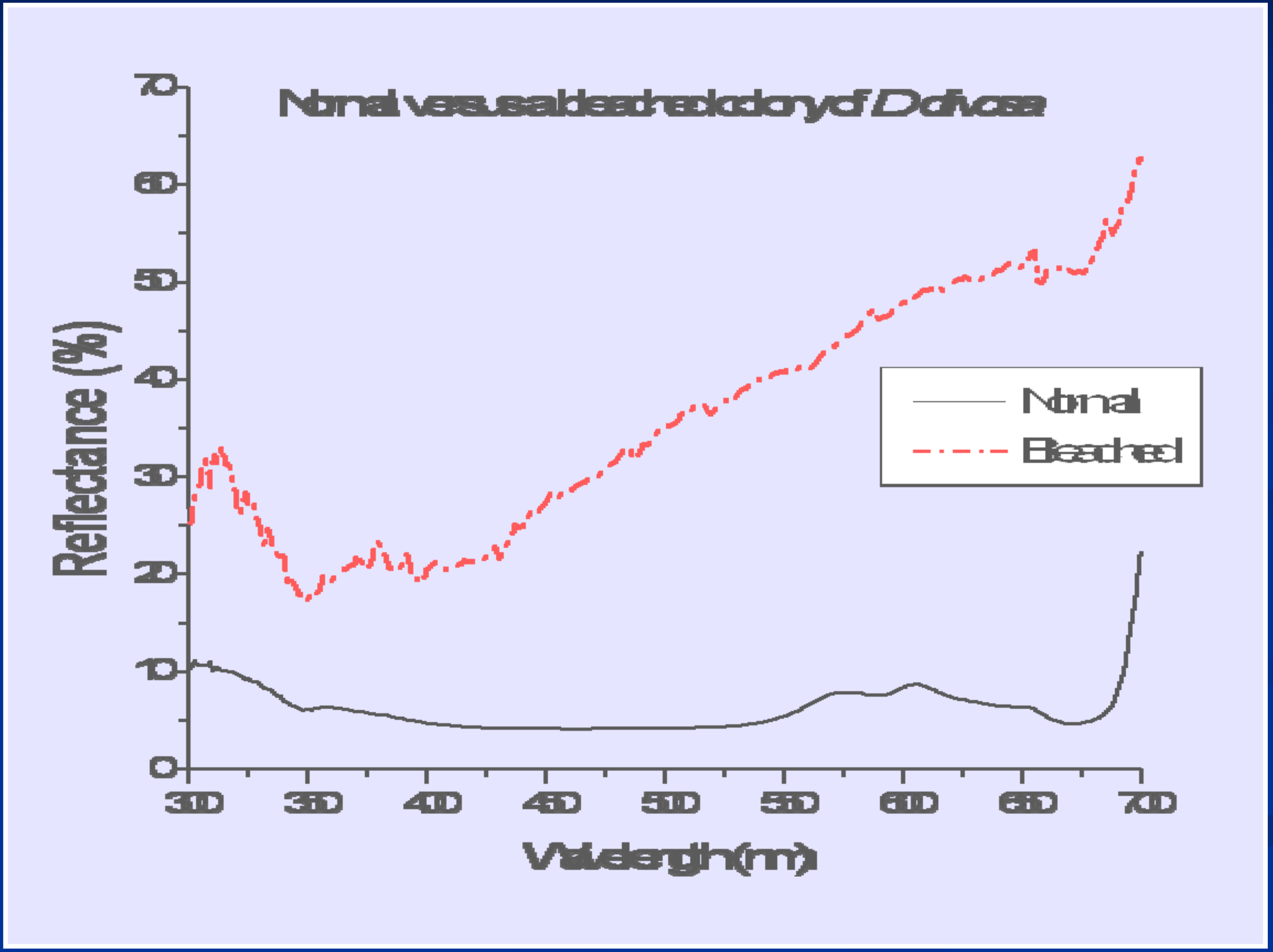
Porites porites

Dictyota spp.

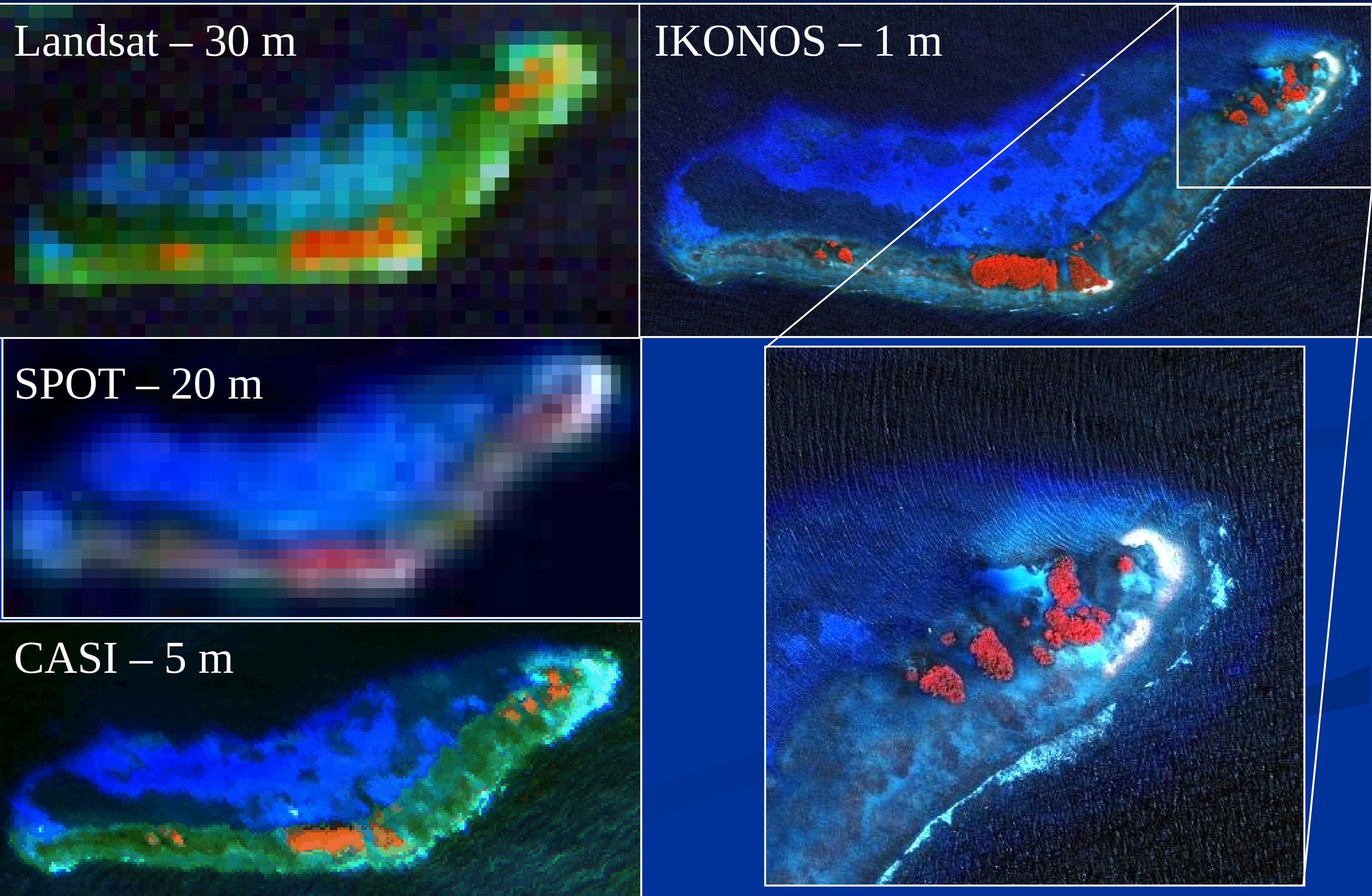
Thalassia testudinum

Coral Reef Bleaching

Coral Bleaching Spectral Response



Spatial Resolution Requirements for Coral Bleaching Detection



Sub-meter Digital Camera Imagery

- NASA's Cirrus Digital Camera System (DCS)
  - Hasselblad camera body, Kodak camera back and CCD array
  - 40 – 70 cm resolution from 12,000'
- Fireball Information Technologies DCS
  - 16 Mpixel camera – 7 cm at 3,000'

NASA DCS - St. Croix, USVI

FIT DCS – La Parguera

AVIRIS 2005 Hyperspectral Mission

Airborne Visible-Infrared Imaging Spectrometer

(AVIRIS) 224 spectral bands

- 224 Spectral Bands, 400-2500 nm
- Spectral Resolution 10 nm
- Twin Otter Aircraft

Puerto Rico Flighlines

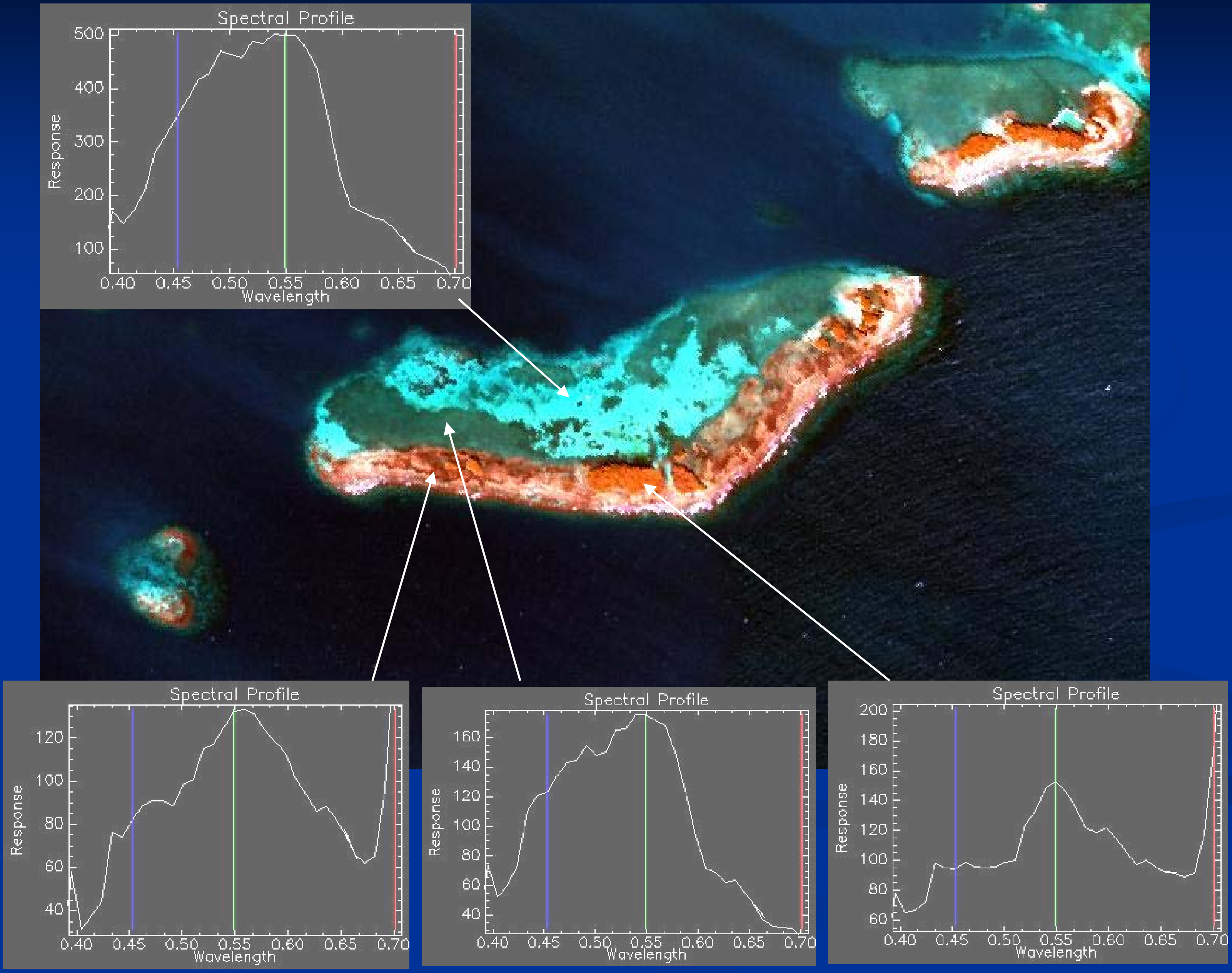
- December 12-13, 2005
- Altitude 3.5 km
- Pixel Size ~3.5 m

Flight lines for La Parguera, Southwestern PR

26 Flighlines

Solar azimuth lines

Atmospherically-Corrected AVIRIS Image



Water Column Corrections

- Lyzenga's "depth invariant" bands

$Y_{i,j} = X_i - (K_i/K_j)X_j$ where $X_i = \ln(L_i - L_{i\infty})$

- Benthic Reflectance Model

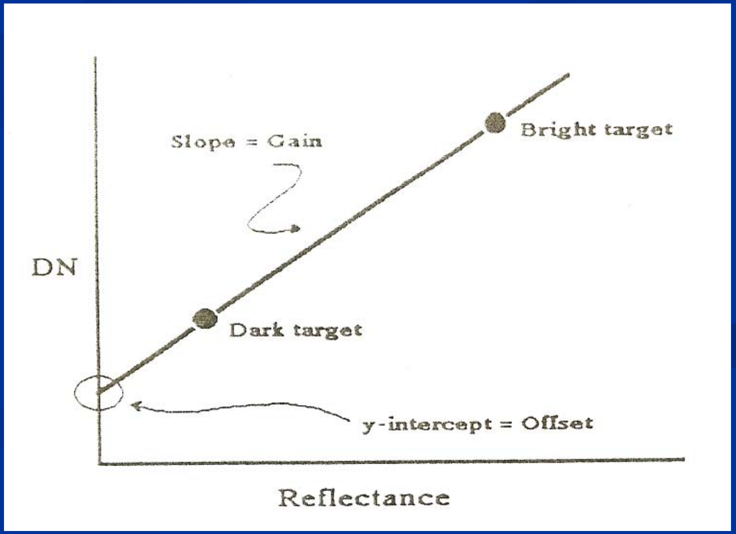
$$R_b = \frac{\frac{1}{0.54}R_{rs}(z=a) - \left(1 - e^{-2kz}\right)R_w}{e^{-2kz}}$$

- Empirical Line Method

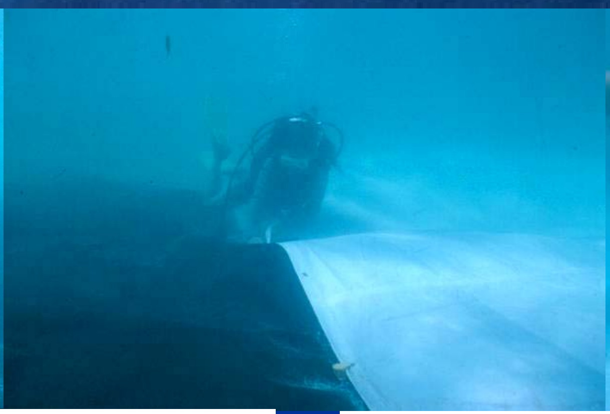
Relies on field measurements of homogeneous area or "flat fields"

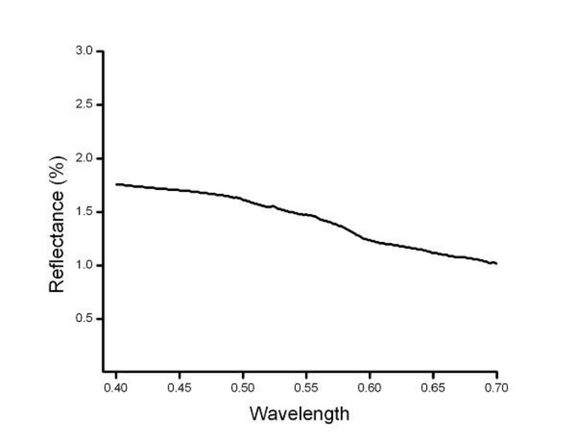
DN(b) = ρ(b)A(b) + B(b)

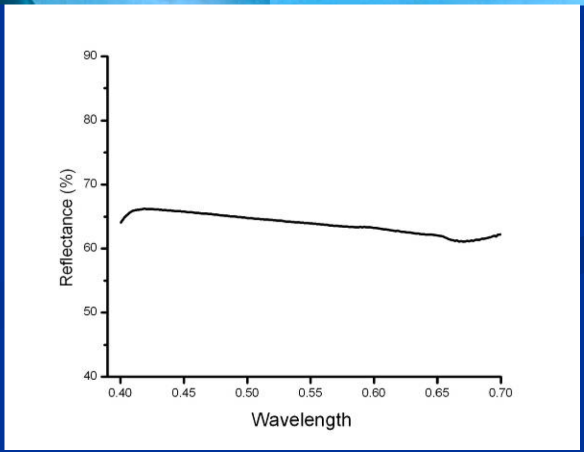
ρ = reflectance of surface material
A = multiplicative term, B = additive term



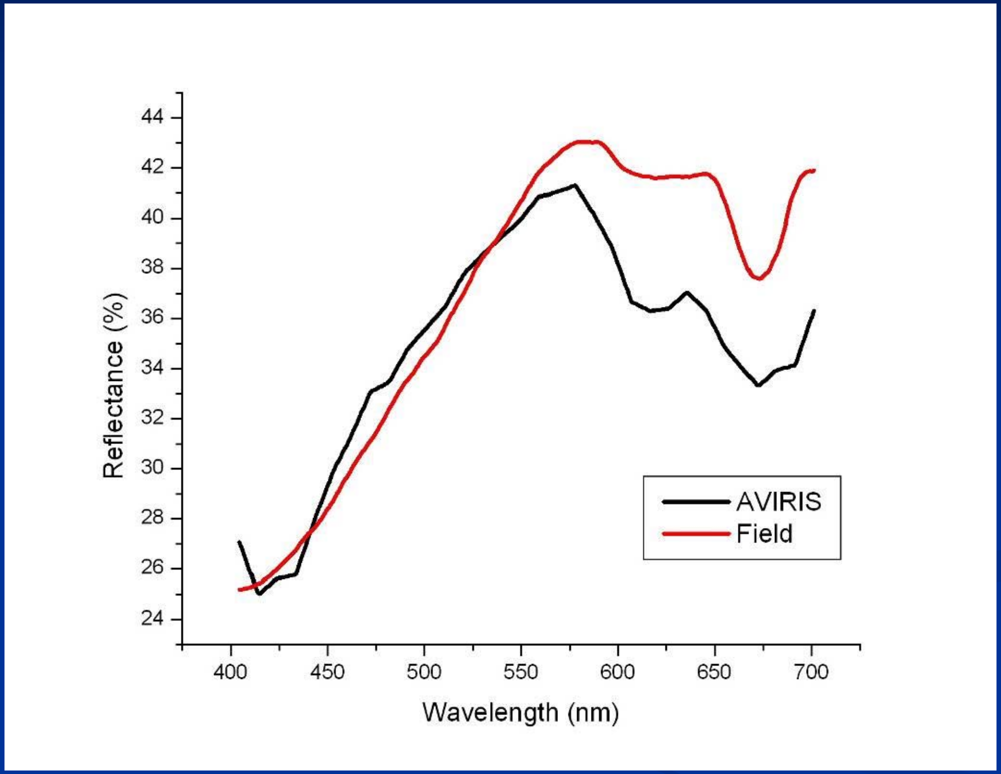
Underwater Flat-Field Calibration Targets for Water Column Correction







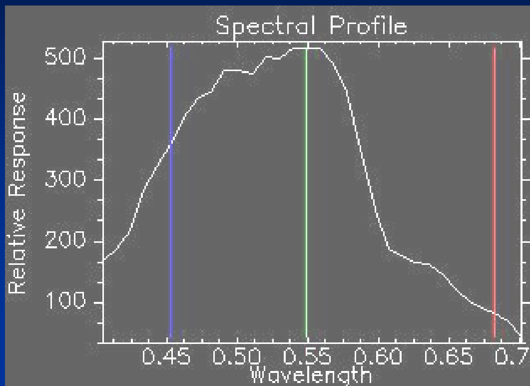
Water Column Correction Validation

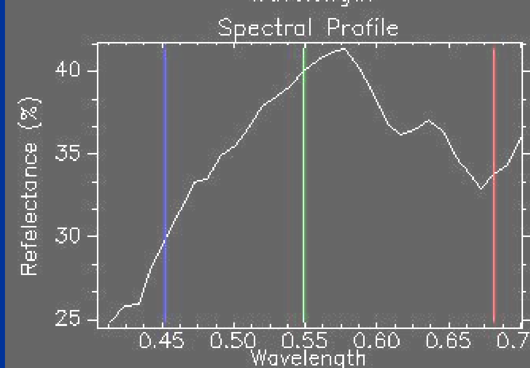


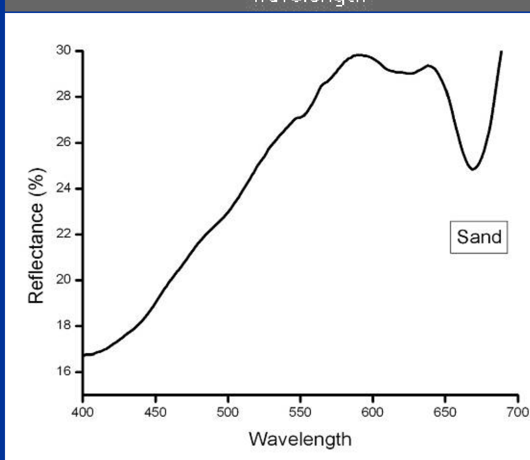
- AVIRIS agrees with field values within 10% from 400-600 nm and up to 18% between 600-700 nm.
- Spectral features are preserved, mostly corresponding to pigment absorption by microbial layers.

AVIRIS Benthic Spectra After Water Column Correction

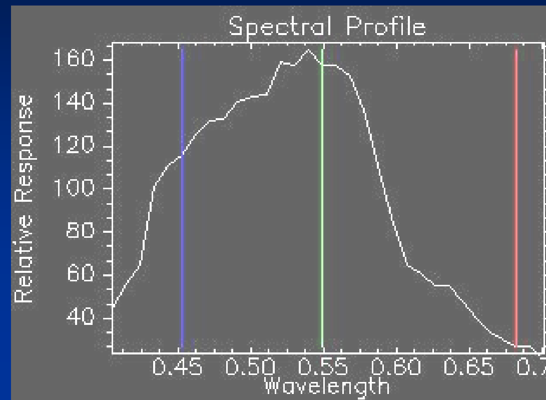
Sand

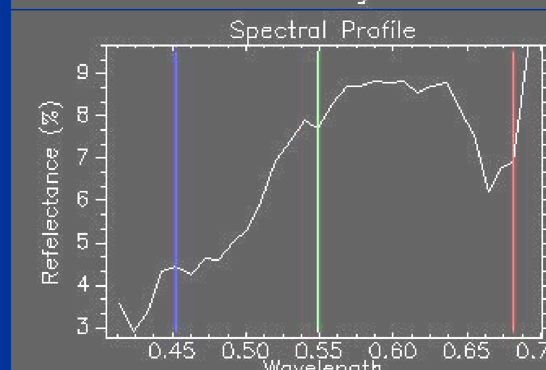


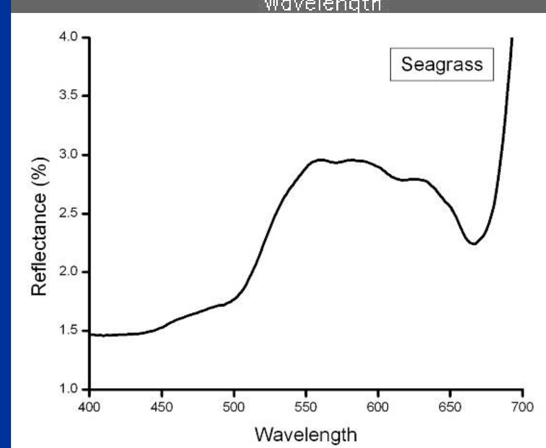




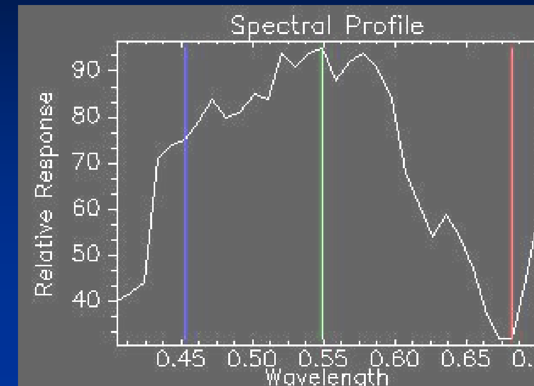
Seagrass

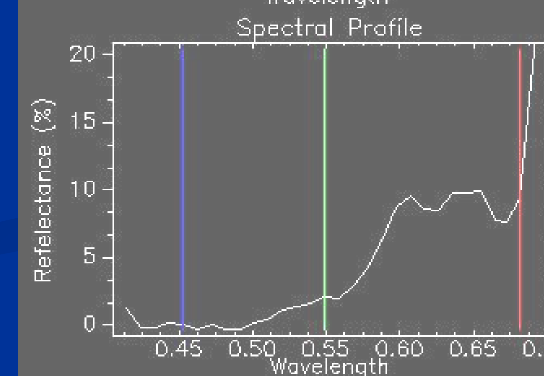


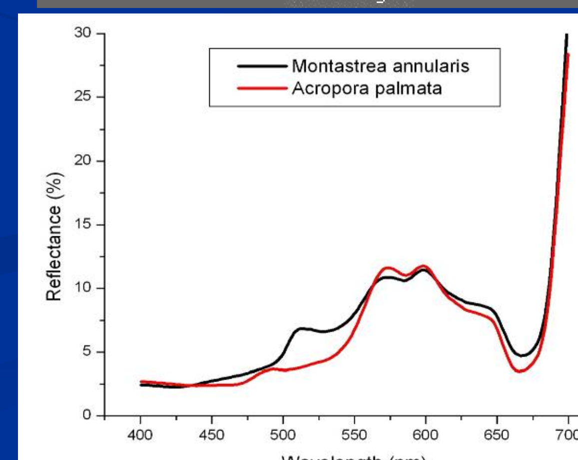




Coral







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