Ocean Products Using a Look-Up-Table Approach

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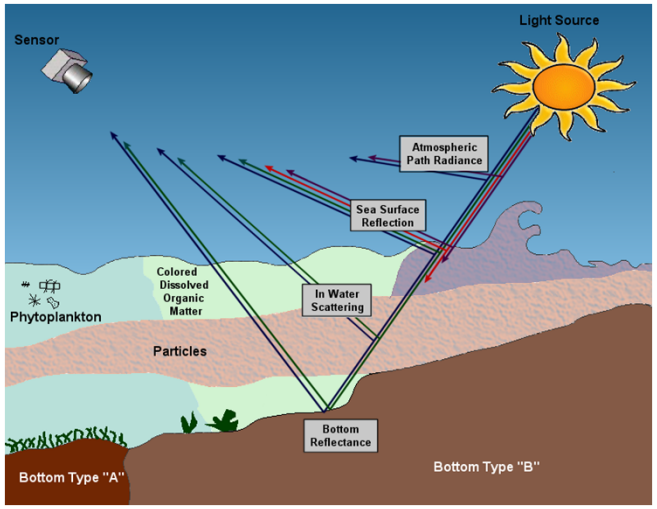
Overview

- Discuss exploitation of HICO data using the Coastal Waters Spectral Toolkit (CWST)
  - Package uses a Lookup Table approach to determining bathymetry, water constituents and bottom type information if available
  - Key Largo data
  - Lee Stocking Island
- Polarization sensitivity of the HICO imager

Example HICO Data Analysis Using the Look-Up-Table Method

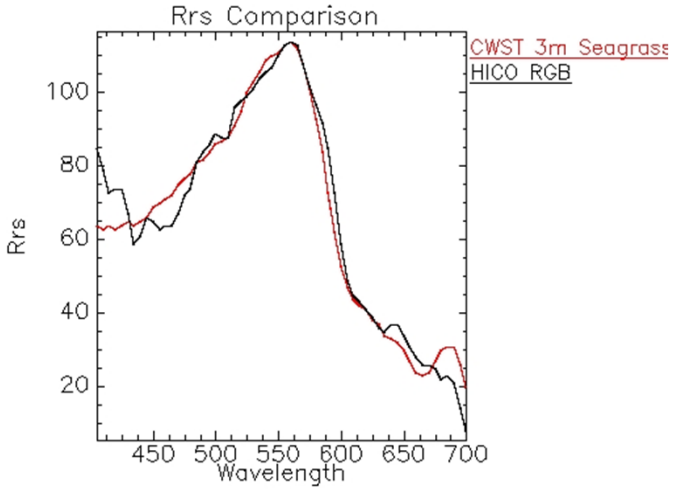
General Look-Up-Table Method

- Compute modeled water-leaving radiance for many (all expected) combinations of water depth, bottom type, and in-water parameters
- Store modeled spectra in look-up table
- For each water pixel in the scene, search the look-up table spectra to find the best match to the pixel spectrum
- The model parameters for the look-up table spectrum are assigned to the image pixel

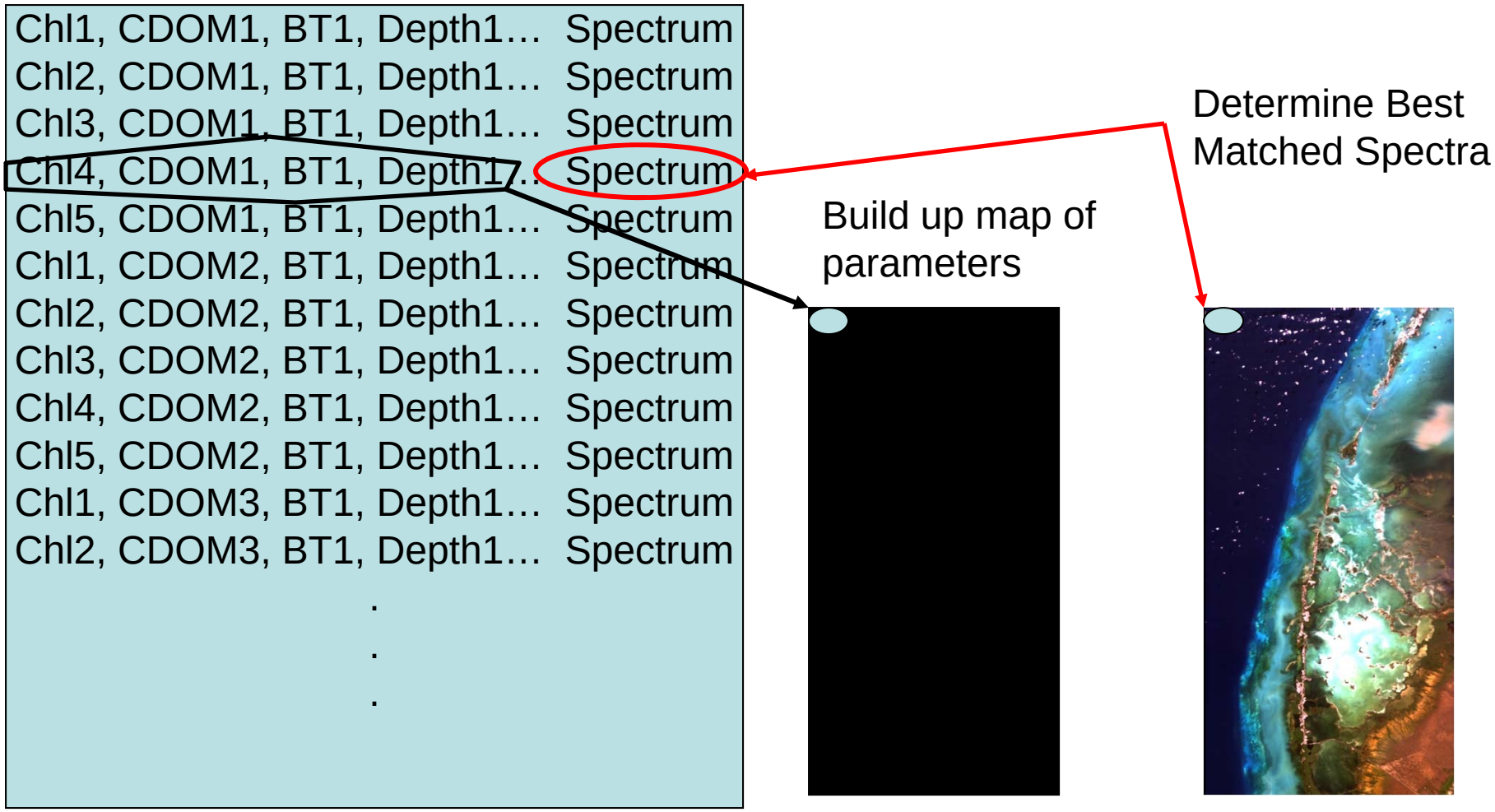


Application of Look-Up-Table Method

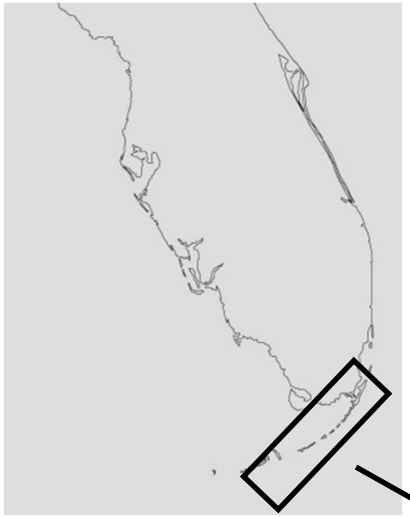
- Parameters that are varied
  - Chlorophyll A
  - Other accessory pigments
  - CDOM – slope and amount
  - Suspended sediments – type and amount
  - Water depth – range to 30 m, spacing increasing with depth
  - Bottom type – many available, down selected for particular locations
  - Phase function
  - Turn on or off, Raman, Chl and CDOM fluorescenece
- How to determine best match is an ongoing research issue
  - Currently using an un-weighted Euclidean distance

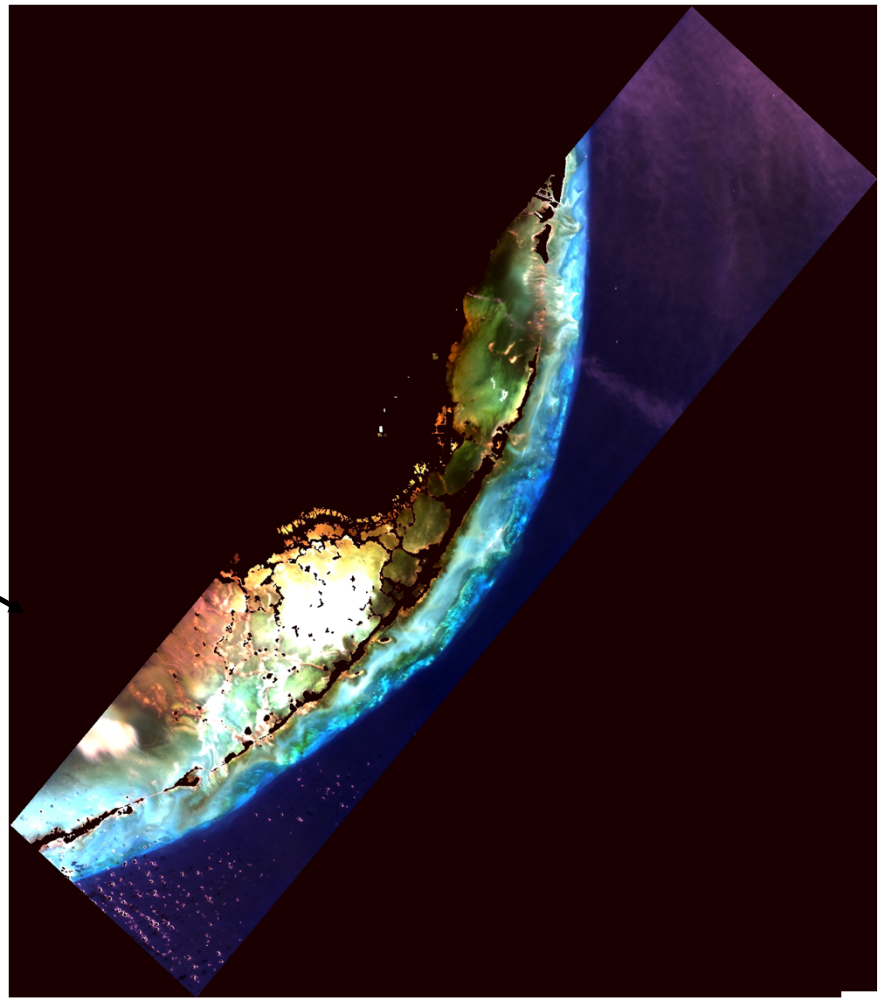


Mechanics of LUT Search



HICO Key Largo, FL





Parameters for spectra contained considered when processing Key Largo data

No. of Spectra = 1,924,146
Depth = 0-30m + Optically Deep
TSS = 0
CDOM = 0-1 m^{-1}
Pigment = ChlA 0-5 mg/m^3
Bottom Types = Coral Sand, Clean Seagrass, Brown Algae, Green Algae, Red Algae, and 18% Gray, Macrophyte, Coral Dichocoenia, Dark Sediment, Turf Algae, Ooid Sand, Biosand & Grass, Seagrass, Coral Montastria

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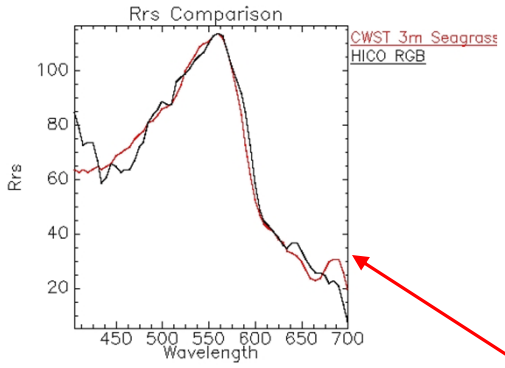
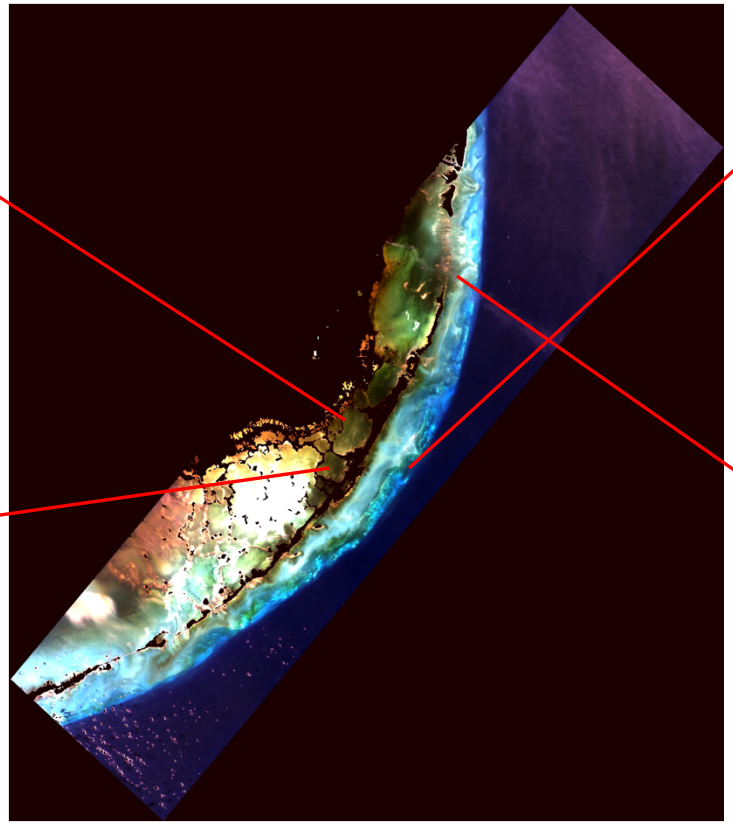
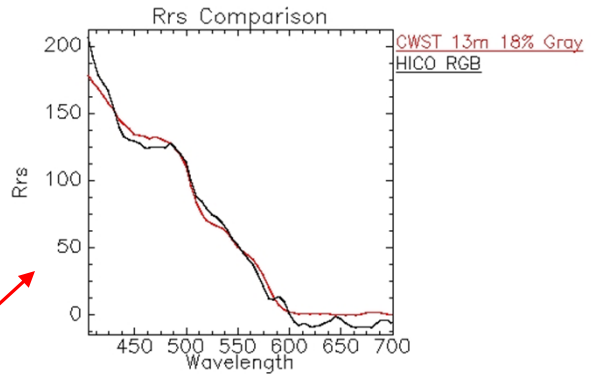
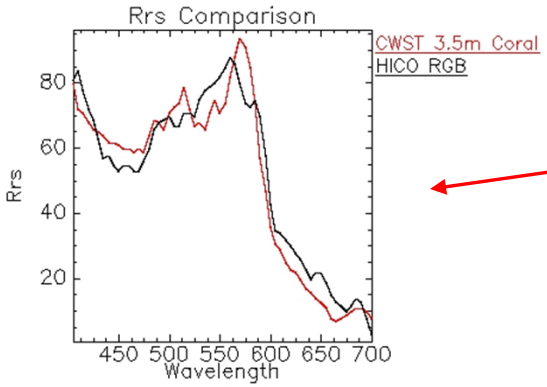
Key Largo, FL Rrs Comparison

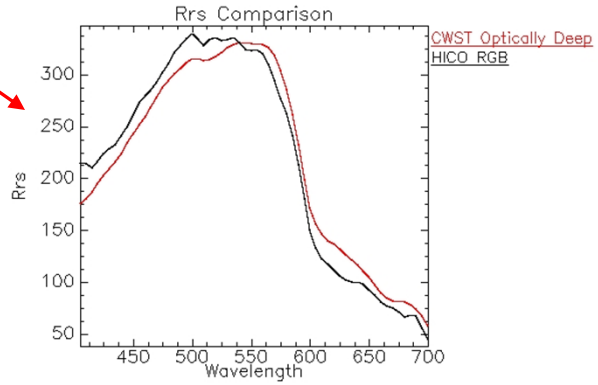
$$Metric = \frac{\sqrt{(HICO - LUT)^2}}{\sqrt{(HICO)^2}}$$



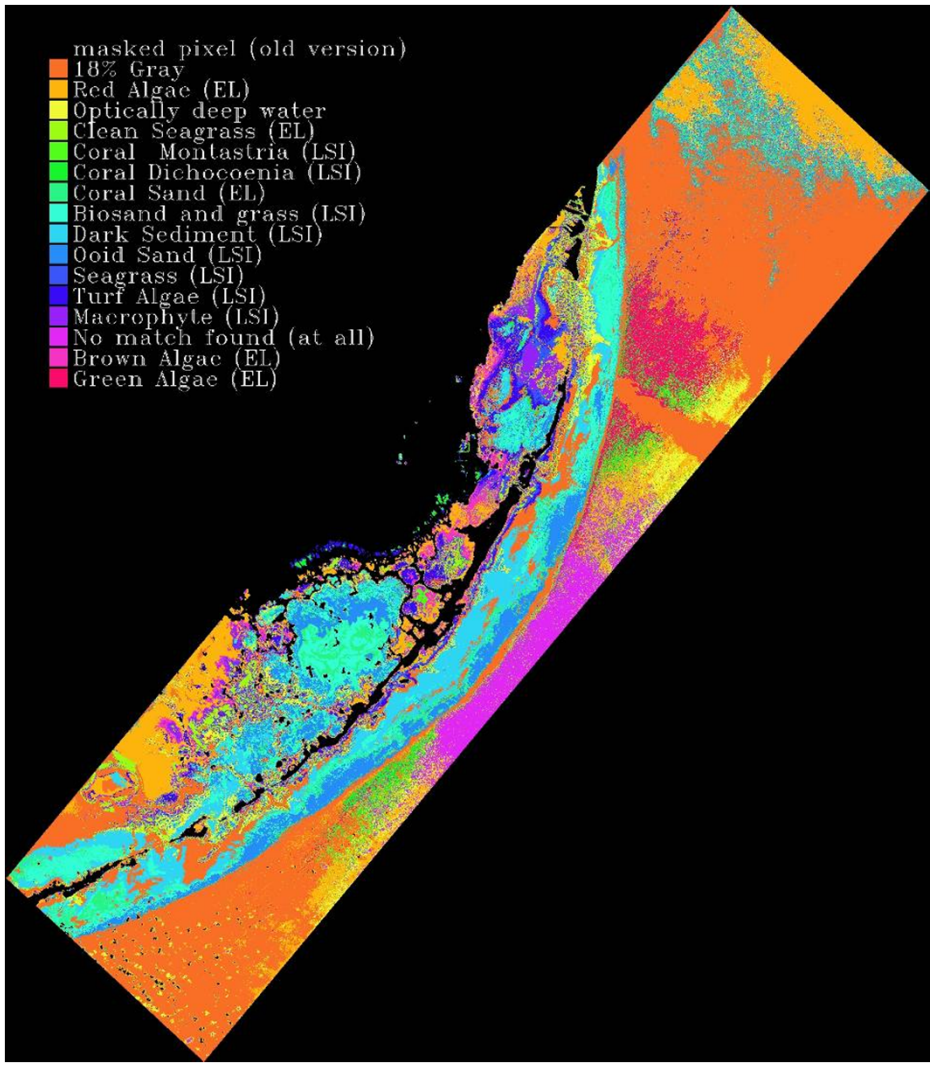








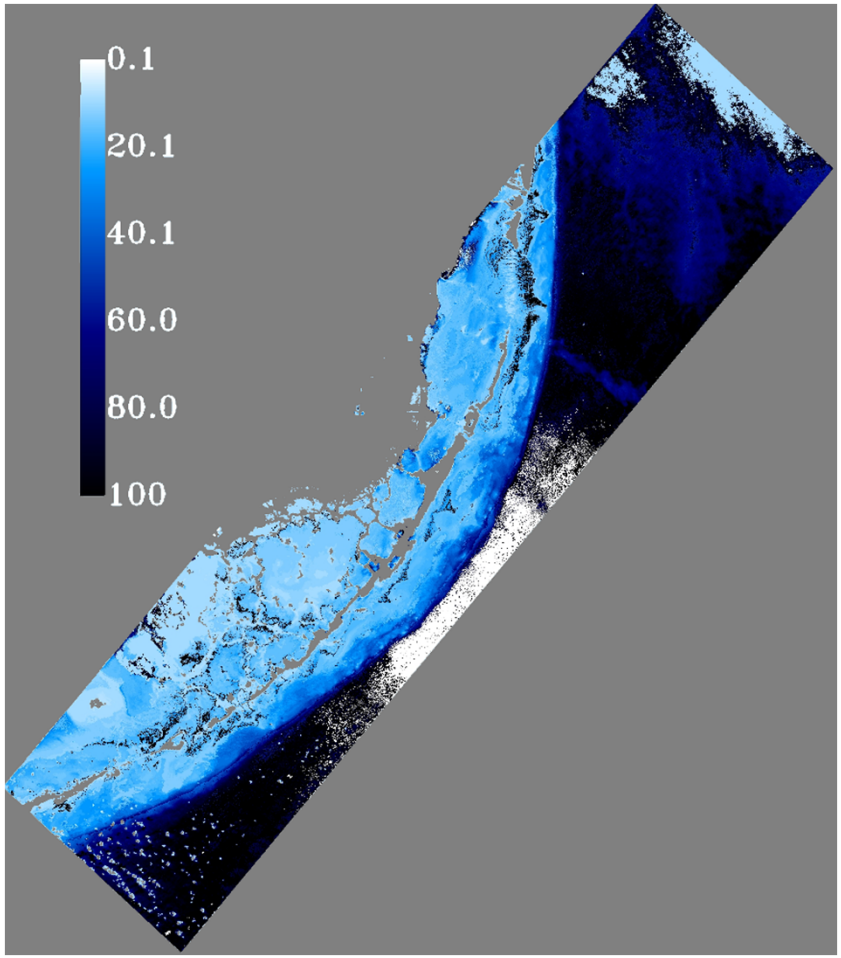
Key Largo, FL



CWST Bottom Type Class Map retrieved using the following flat file parameters:

No. of Spectra = 1,924,146
Depth = 0-30m + Optically Deep
TSS = 0
CDOM = 0-1 m-1
Pigment = ChlA 0-5 mg/m^3
Bottom Types = Coral Sand, Clean Seagrass, Brown Algae, Green Algae, Red Algae, and 18% Gray, Macrophyte, Coral Dichocoenia, Dark Sediment, Turf Algae, Ooid Sand, Biosand & Grass, Seagrass, Coral Montastria

Key Largo, FL



CWST Depth Map retrieved using the following flat file parameters:

No. of Spectra = 1,924,146
Depth = 0-30m + Optically Deep
TSS = 0
CDOM = 0-1 m-1
Pigment = ChlA 0-5 mg/m^3
Bottom Types = Coral Sand, Clean Seagrass, Brown Algae, Green Algae, Red Algae, and 18% Gray, Macrophyte, Coral Dichocoenia, Dark Sediment, Turf Algae, Ooid Sand, Biosand & Grass, Seagrass, Coral Montastria

Note: White is no match

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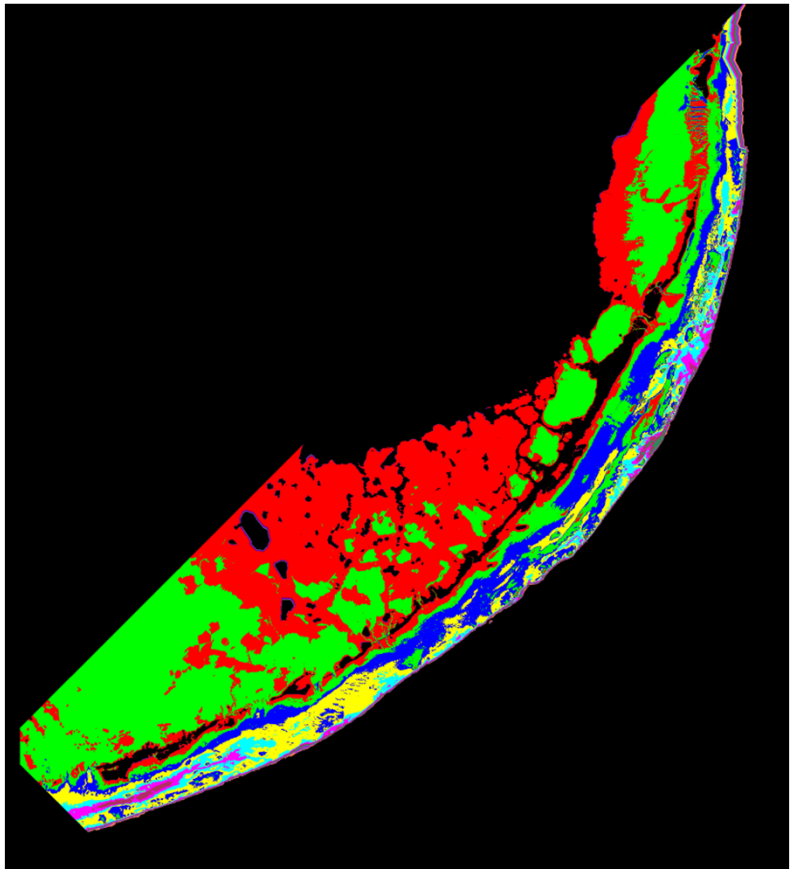
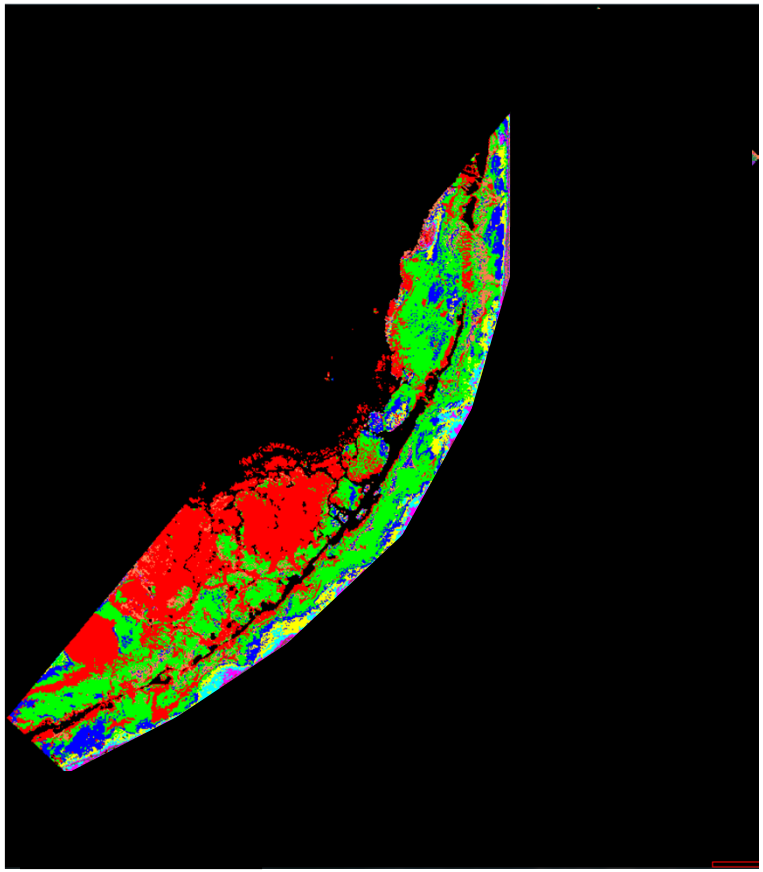
Key Largo Depth Comparison
HICO 11/13/09

NOAA Bathymetry



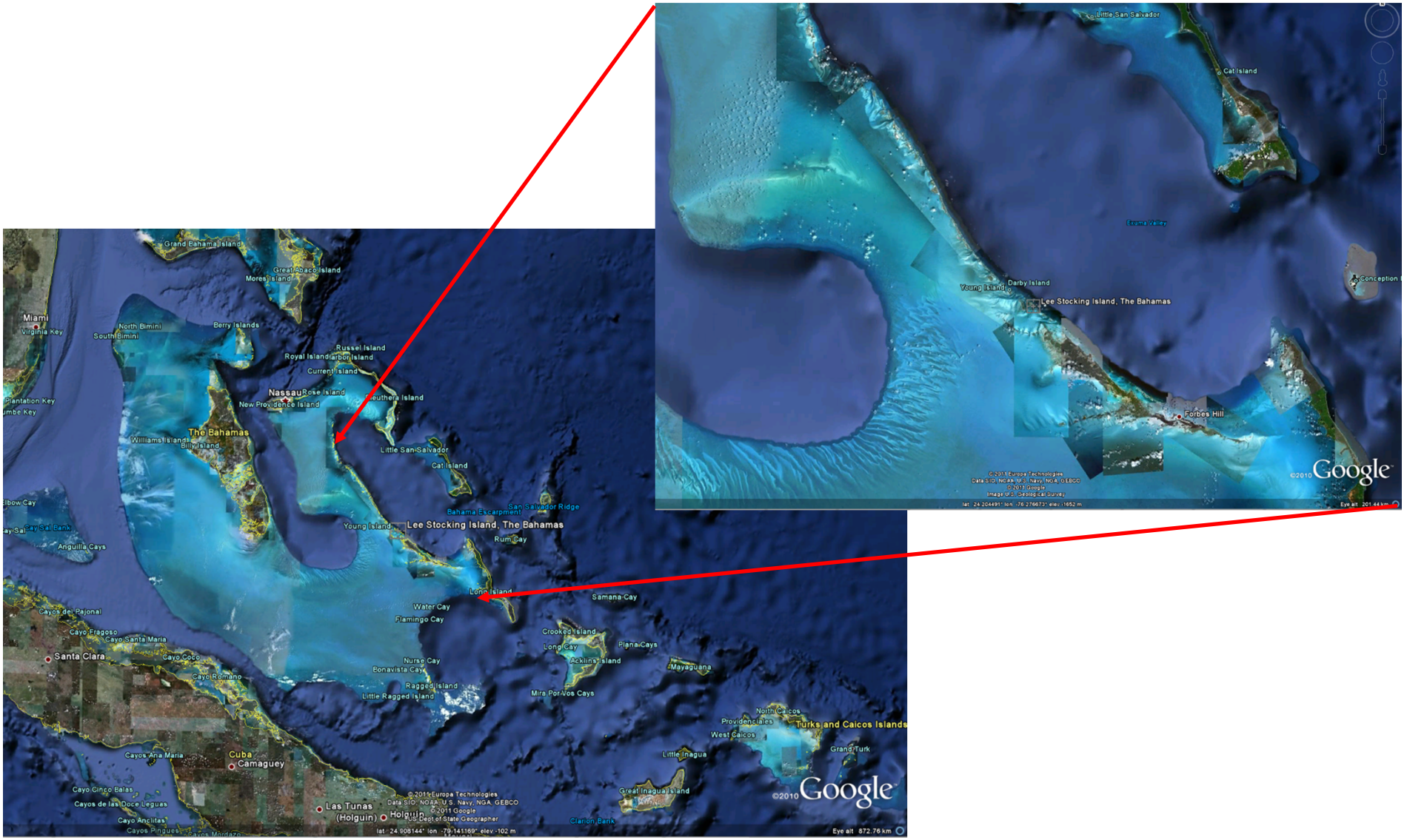
HICO-LUT output



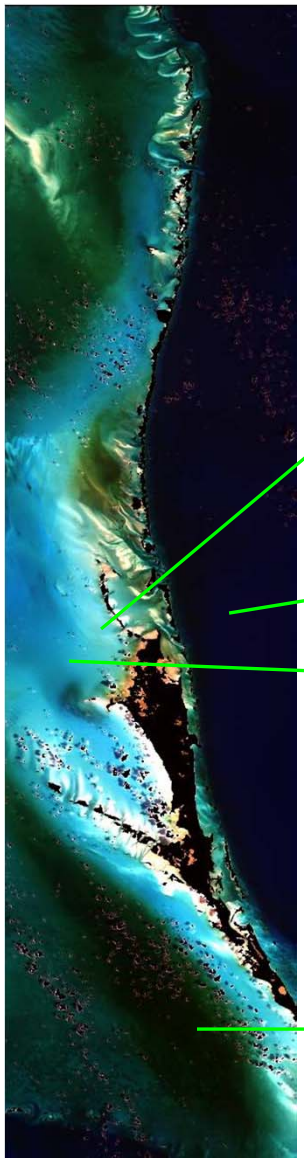
HICO Sensitivity

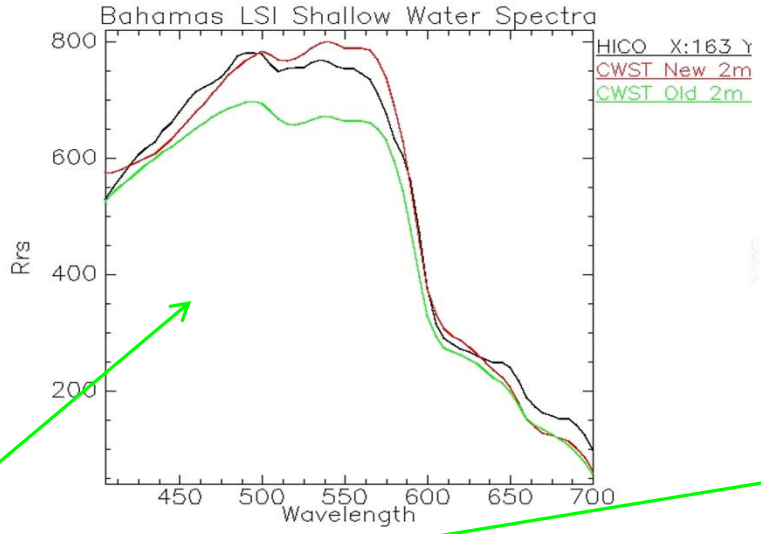
- Is HICO sensitive enough to determine mixed bottom information?
- Using LSI HICO data used different LUT that contained
  - 1)only pure bottoms
  - 2) pure bottoms with 50/50 mixtures
  - 3) pure bottoms, 50/50 and 75/25 mixtures

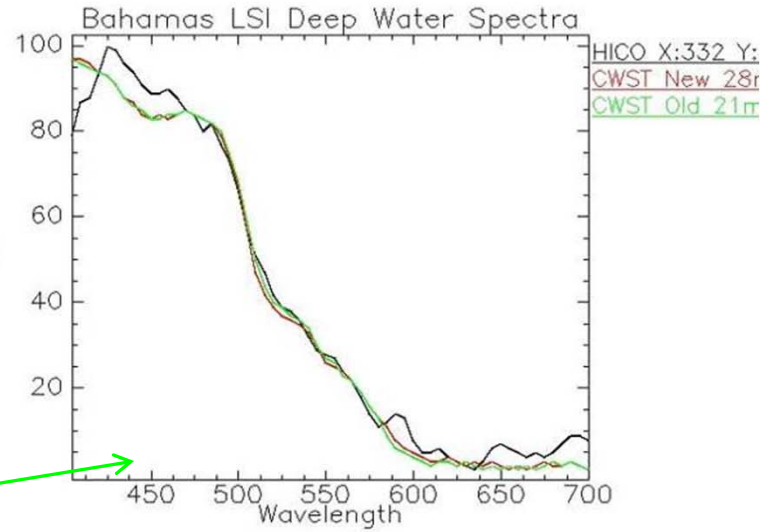
Lee Stocking Island

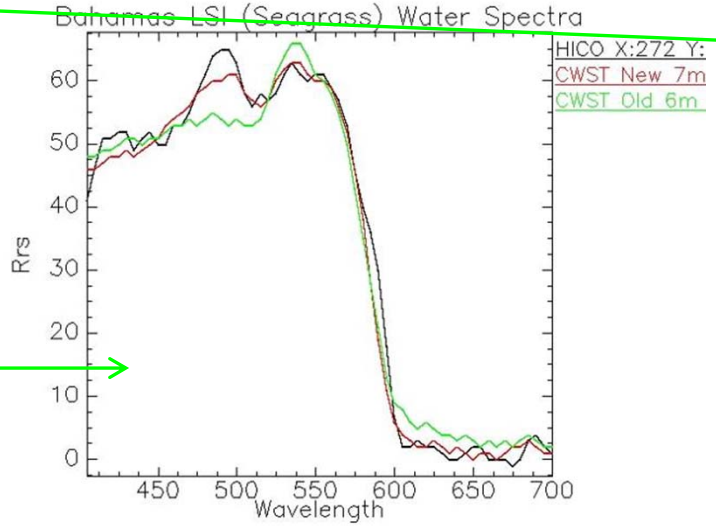


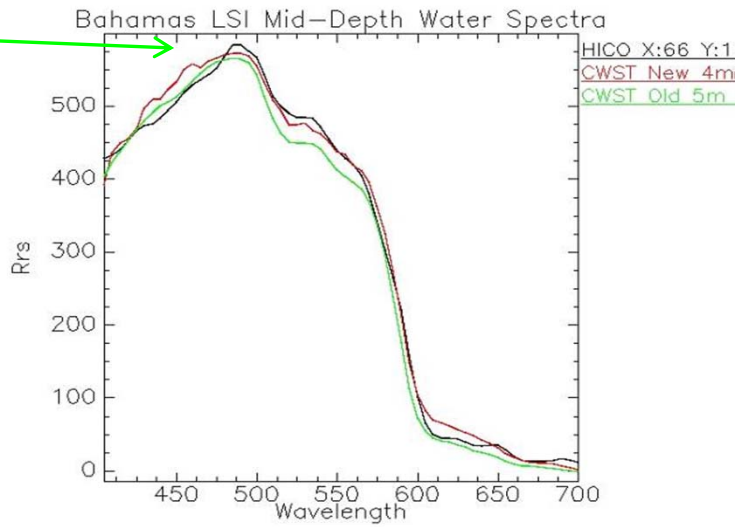
2010167 Bahamas LSI



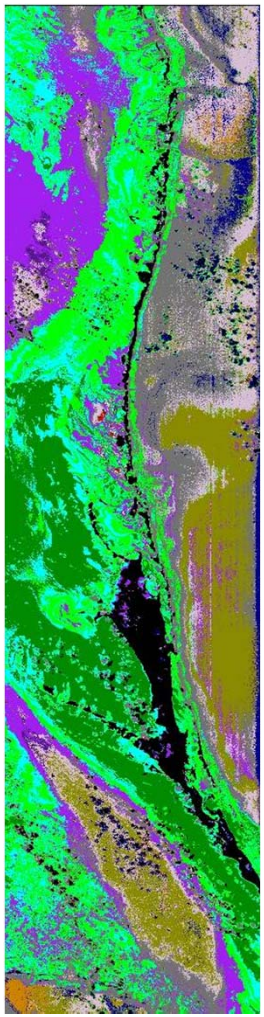




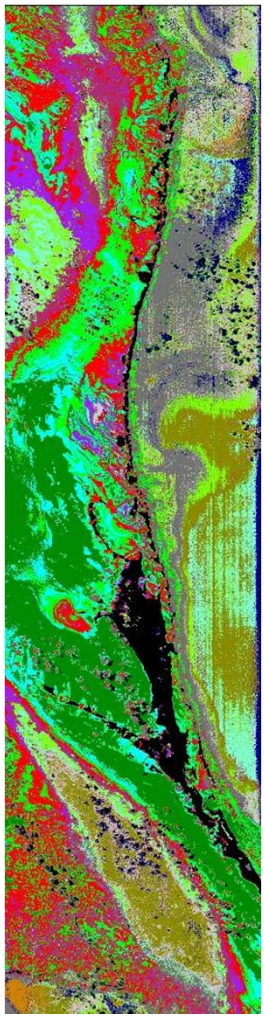




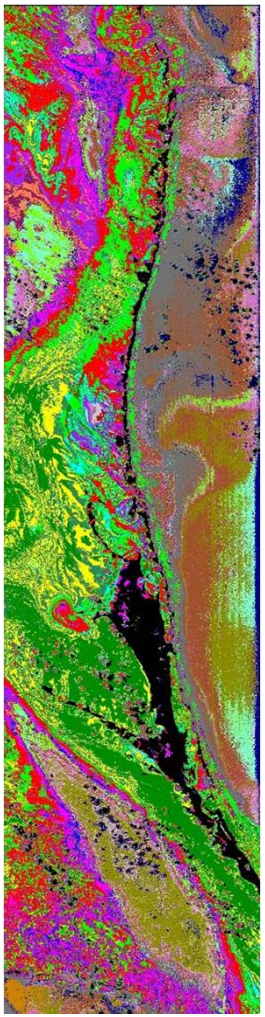
Mixed Bottoms



EL + LSI
Finer Depth Grid

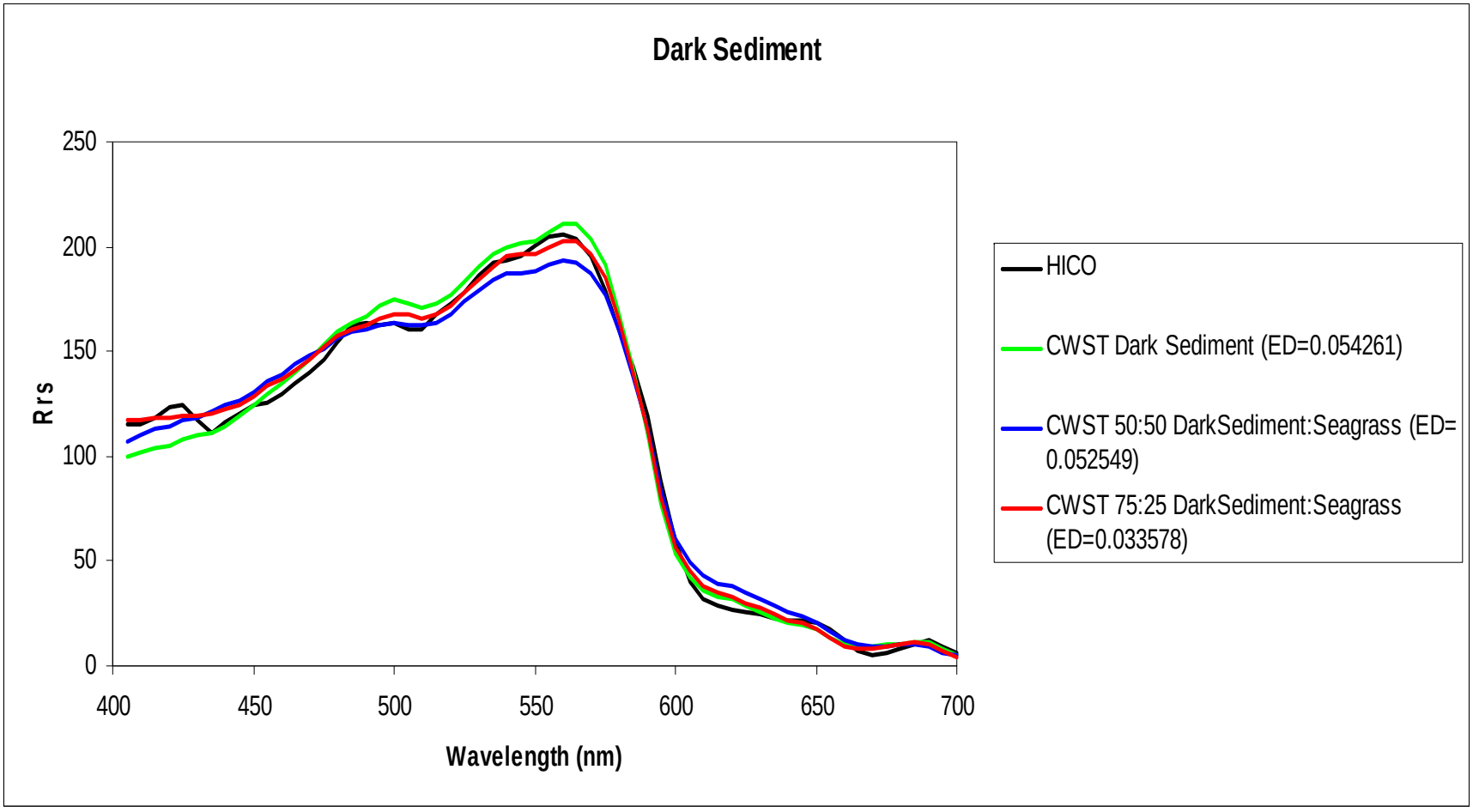


EL + LSI + 50:50
mixes

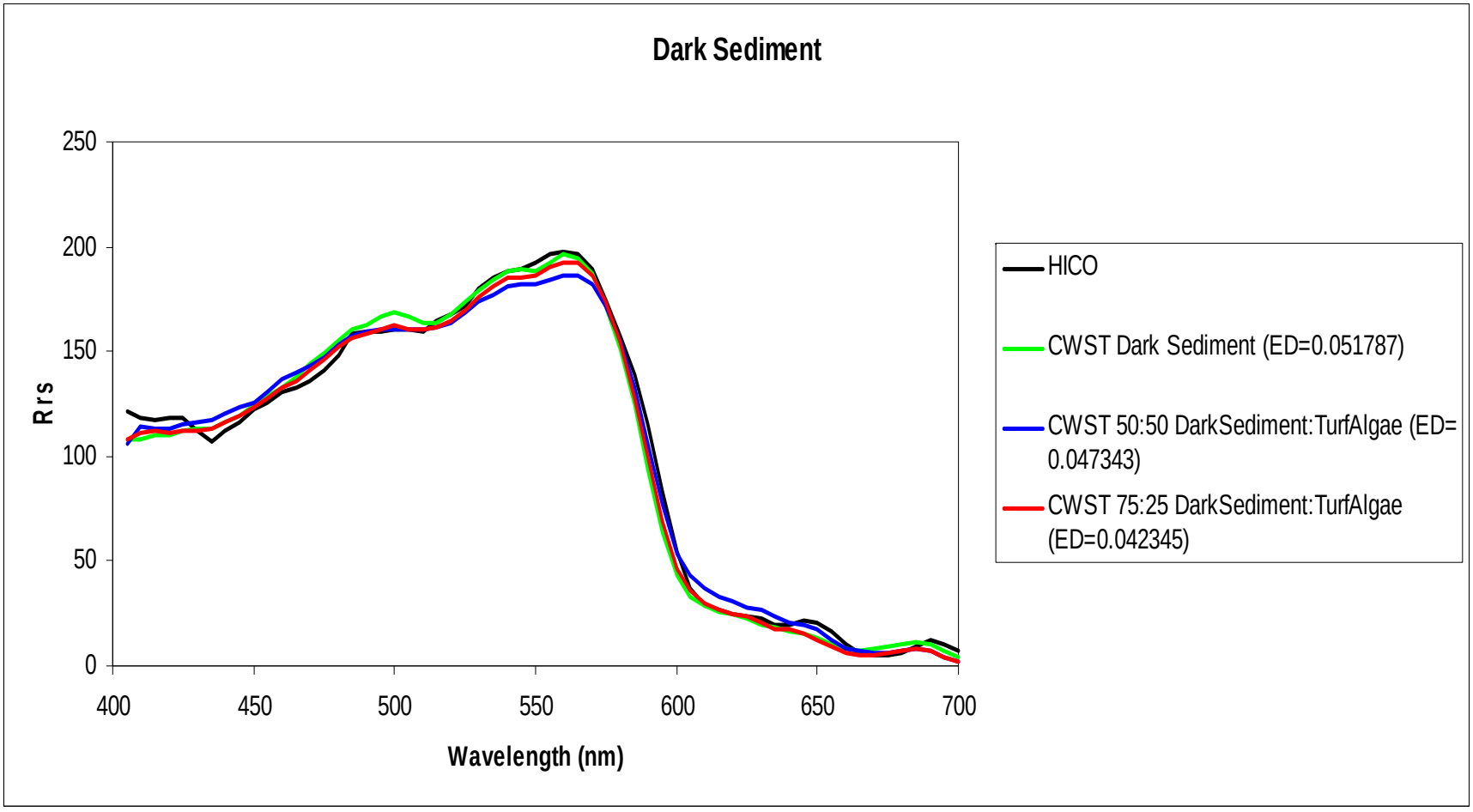


EL + LSI + 50:50
+ 25:75 mixes

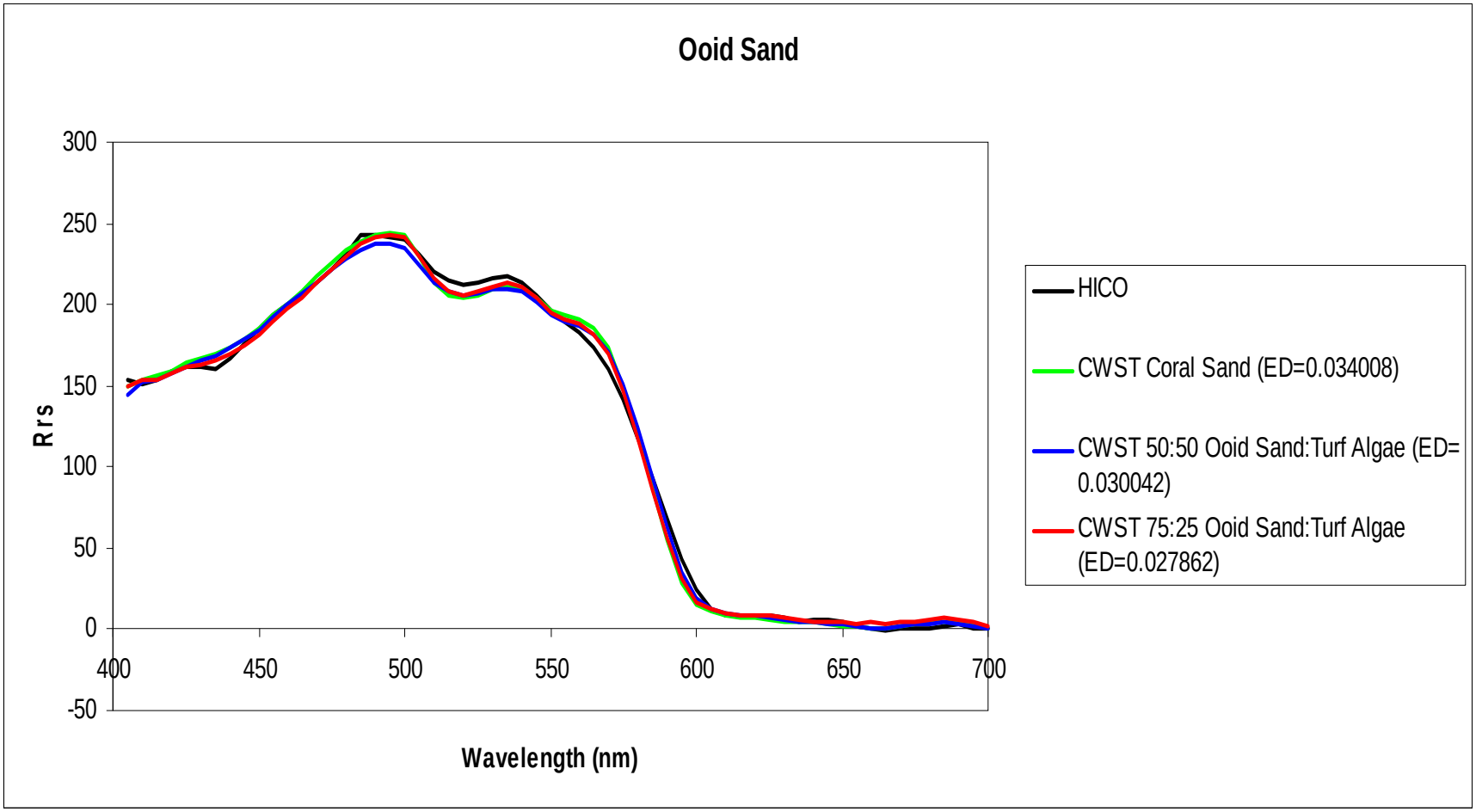
Mixed Bottoms
Dark Sediment/Seagrass



Mixed Bottoms
Dark Sediment/Turf Algae



Mixed Bottoms
Ooid Sand/Turf Algae



Mixed Bottom Statistics

- We performed six separate CWST retrievals using different subsets of the database:

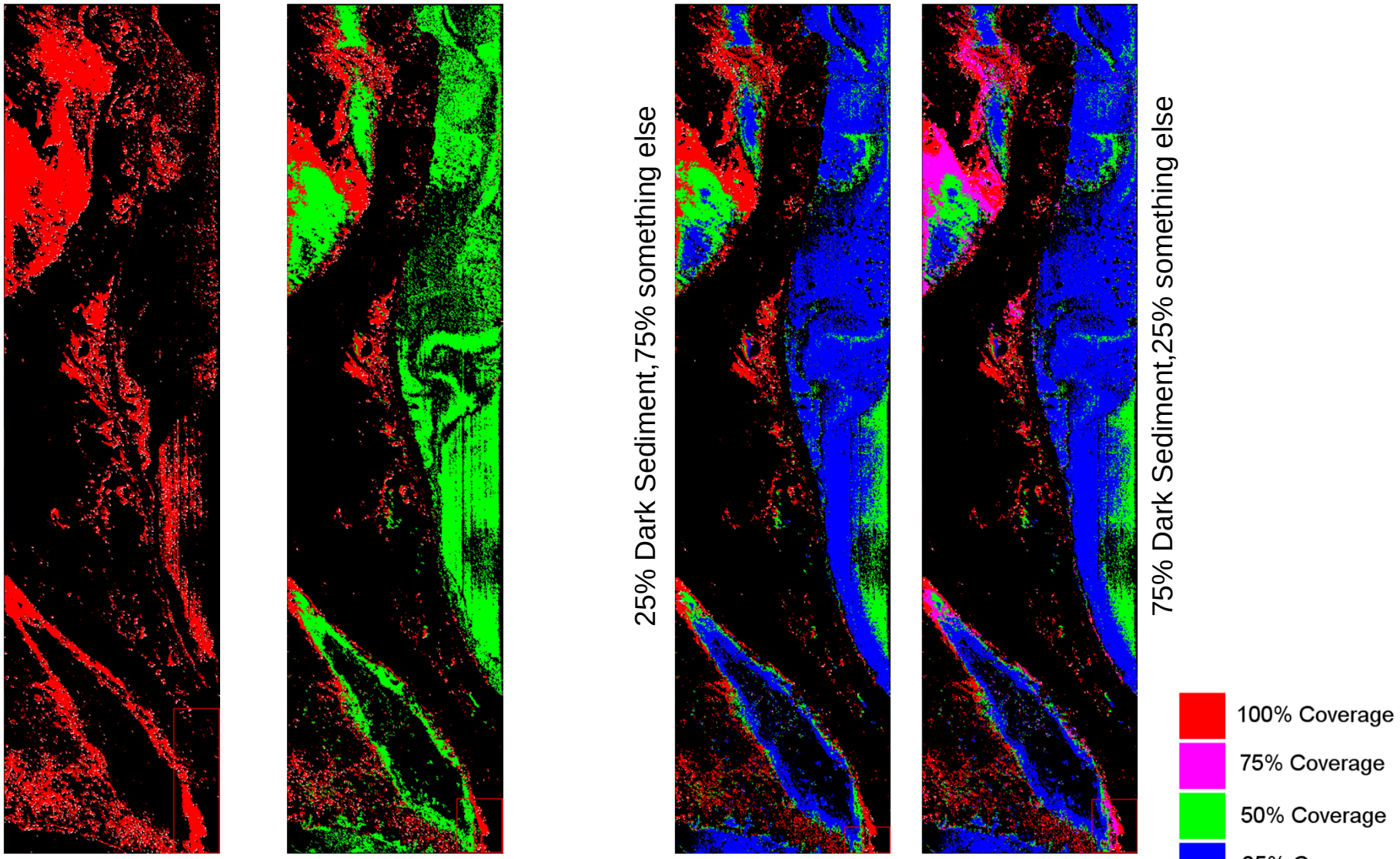
- CHL-A = 0-5mg/m3
- CDOM = 0-1 m-1
- No TSS

- 1) Pure Bottoms = 1,924,146 spectra
- 2) Pure Bottoms + 50:50 mixed bottoms 2,322,141 spectra
- 3) Pure Bottoms + 50:50 and 25:75 mixed bottoms = 3,135,292 spectra

- We derived statistics from retrieved Euclidian Distance/HICO Magnitude for the ***entire*** HICO image

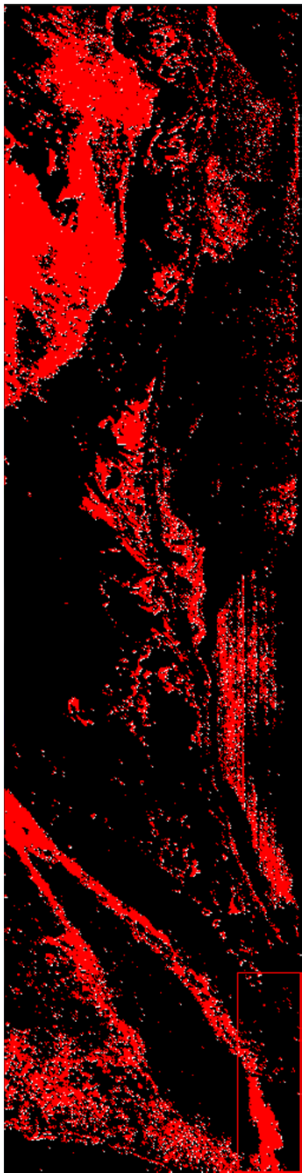
,	**Min**	**Max**	**Mean**	**StDev**	**Points**
Pure Bottoms (fine depth grid)	0.000503	11.95546	0.009726	0.076473	1,012,000
Pure Bottoms +50/50 Bottoms (fine depth grid)	0.000474	8.535275	0.009193	0.077433	1,012,000
All the above +25/75 Bottoms (fine depth grid)	0.000373	8.695241	0.008164	0.078247	1,012,000

Dark Sediment Retrievals



Dark Sediment Statistics

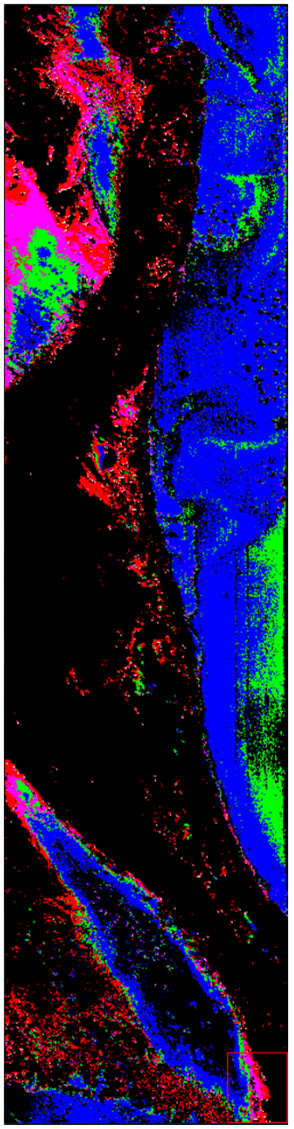
To get a feel for how the statistics changed in specific areas of the images as we added mixed bottoms we used the original 100% bottom coverage for dark sediment to create a ROI. Looking at the stats for those pixels as the mixtures (50:50 mixes and 25:75 mixes) are added provides the results below



	Min	Max	Mean	StDev	Points
EL+LSI Bottoms (100% Dark Sediment)	0.000662	0.78491	0.004084	0.007053	126,240
EL+LSI+5050 Bottoms (100% Dark Sediment)	0.000475	0.868923	0.002874	0.005747	126,240
EL+LSI+2575 Bottoms (100% Dark Sediment)	0.000373	0.650189	0.002562	0.004925	126,240

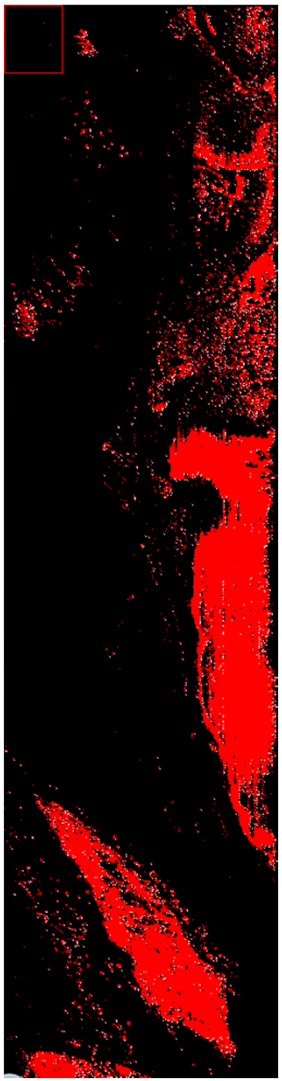
Dark Sediment Statistics

To get a feel for how the statistics changed in specific areas of the images as we added mixed bottoms we used the bottom map that contained the any amount of dark sediment and created a ROI. The results below demonstrate how the stats of the match changes as mixtures are allowed.

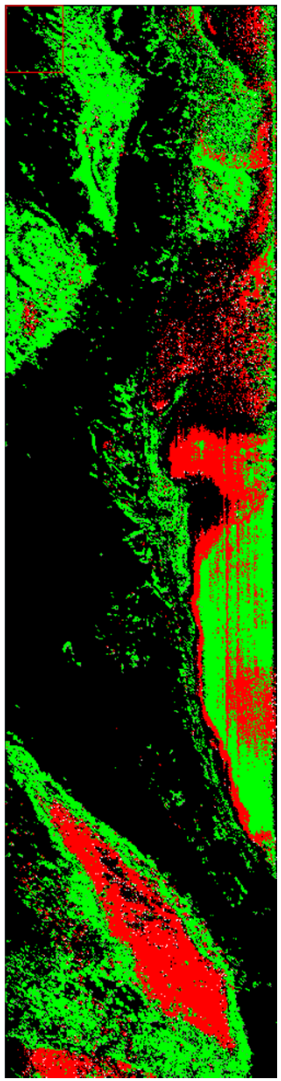


	Min	Max	Mean	StDev	Points
EL+LSI Bottoms (100% Dark Sediment)	0.000662	3.187632	0.003893	0.014755	230,406
EL+LSI+5050 Bottoms (100% Dark Sediment)	0.000498	3.313233	0.003424	0.020256	230,406
EL+LSI+2575 Bottoms (100% Dark Sediment)	0.000373	3.442001	0.003049	0.017653	230,406

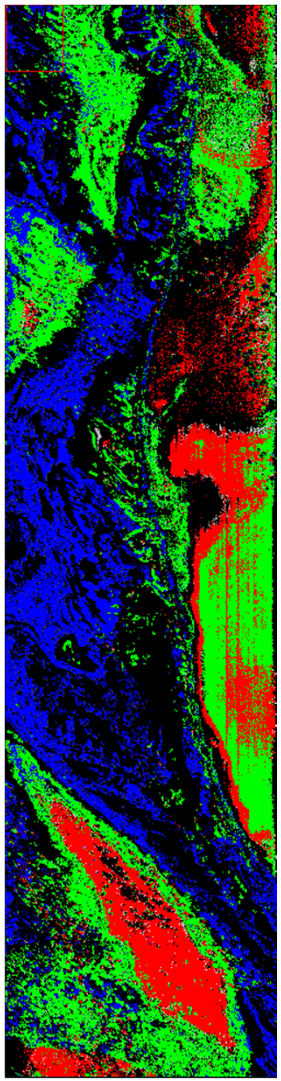
Seagrass Retrievals



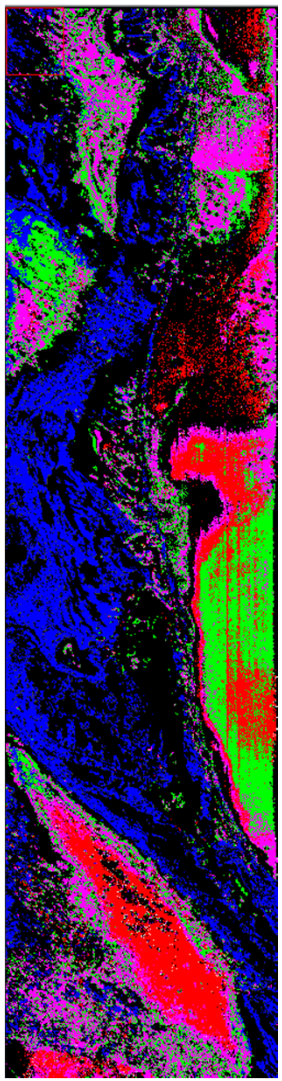
Using only pure pixels



Adding 50/50 mixes

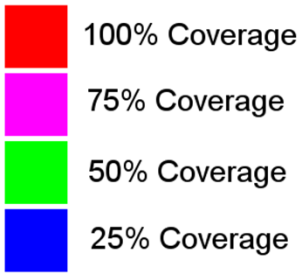


25% seagrass,75% something else



75% seagrass,25% something else

Adding 75/25 mixes



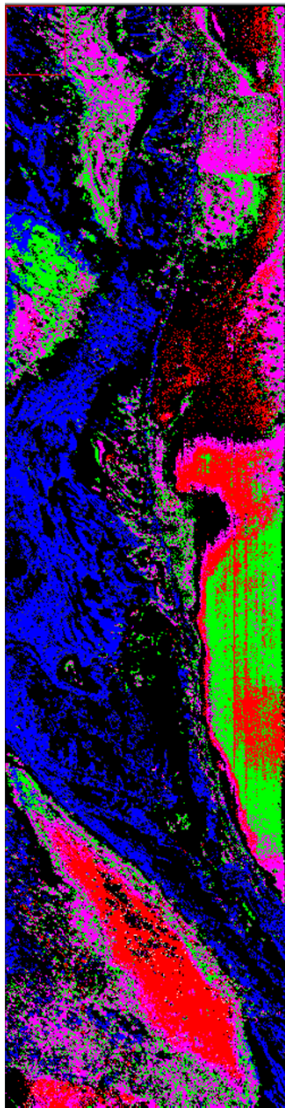
Seagrass Statistics

- To get a feel for how the statistics changed in specific areas of the images as we added mixed bottoms we used the original 100% bottom coverage for dark sediment to create a ROI. Looking at the stats for those pixels as the mixtures (50:50 mixes and 25:75 mixes) are added provides the results below

	Min	Max	Mean	StDev	Points
EL+LSI Bottoms (100% Seagrass)	0.000561	0.741725	0.003872	0.015312	114,165
EL+LSI+5050 Bottoms (100% Seagrass)	0.000561	1.676985	0.003778	0.015686	114,165
EL+LSI+2575 Bottoms (100% Seagrass)	0.000561	1.279532	0.003513	0.012563	114,165

Seagrass Statistics

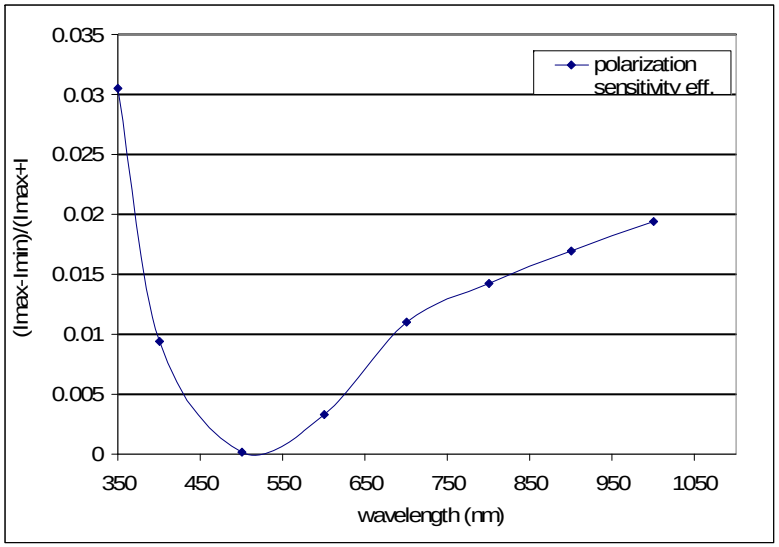
- To get a feel for how the statistics changed in specific areas of the images as we added mixed bottoms we used the original 100% bottom coverage for Seagrass to create a ROI. Looking at the stats for those pixels as the mixtures (50:50 mixes and 25:75 mixes) are added provides the results below.

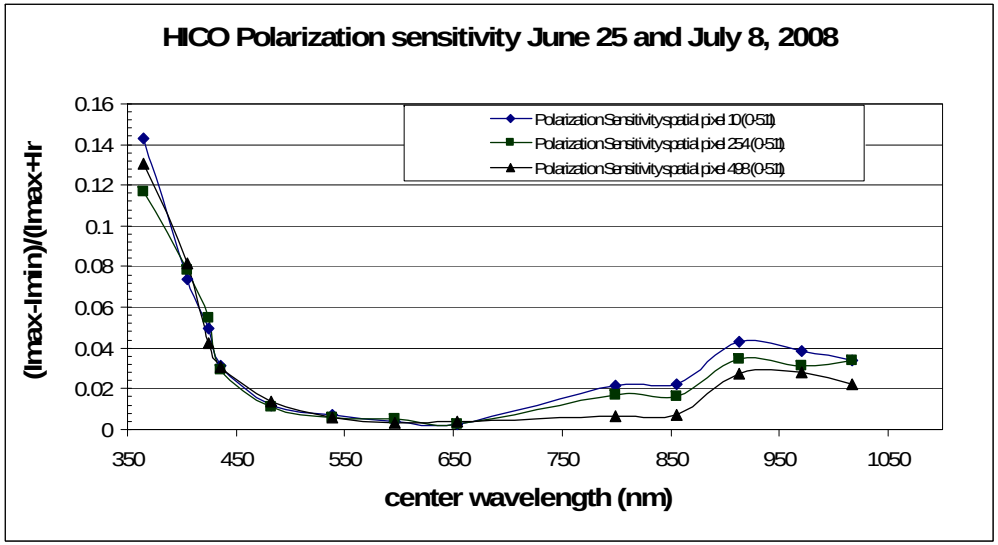


	Min	Max	Mean	StDev	Points
EL+LSI Bottoms (100% Seagrass)	0.000561	2.079264	0.005029	0.016751	240,494
EL+LSI+5050 Bottoms (100% Seagrass)	0.000475	3.398143	0.004647	0.022254	240,494
EL+LSI+2575 Bottoms (100% Seagrass)	0.000373	3.522326	0.00351	0.016925	240,494

HICO Polarization Sensitivity

- HICO has significant polarization sensitivity
- In worst case scenario (~80% polarized), could reduce, or increase, TOA radiance by 4% at 400 nm

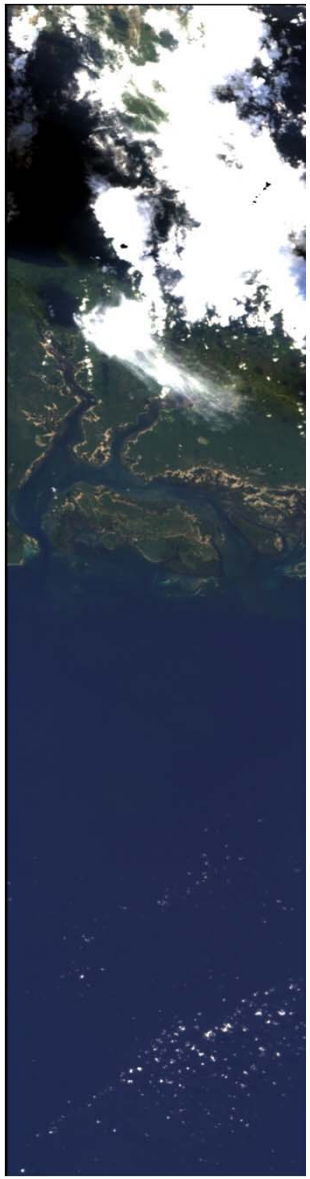




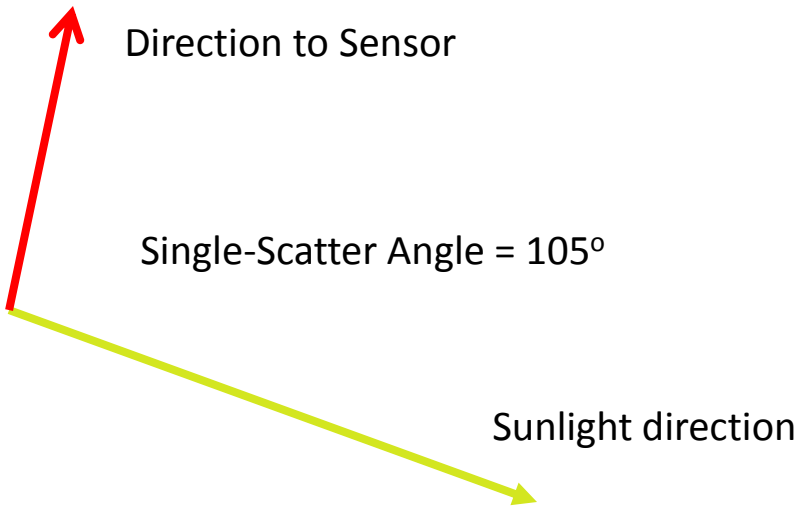
Calculated for Grating Only

Laboratory Measurements

Particularly Bad CASE Kenyan Banks Scene (12/06/09)



Solar Zenith Angle = 69.8°
HICO View Angle from Nadir = 5.3°



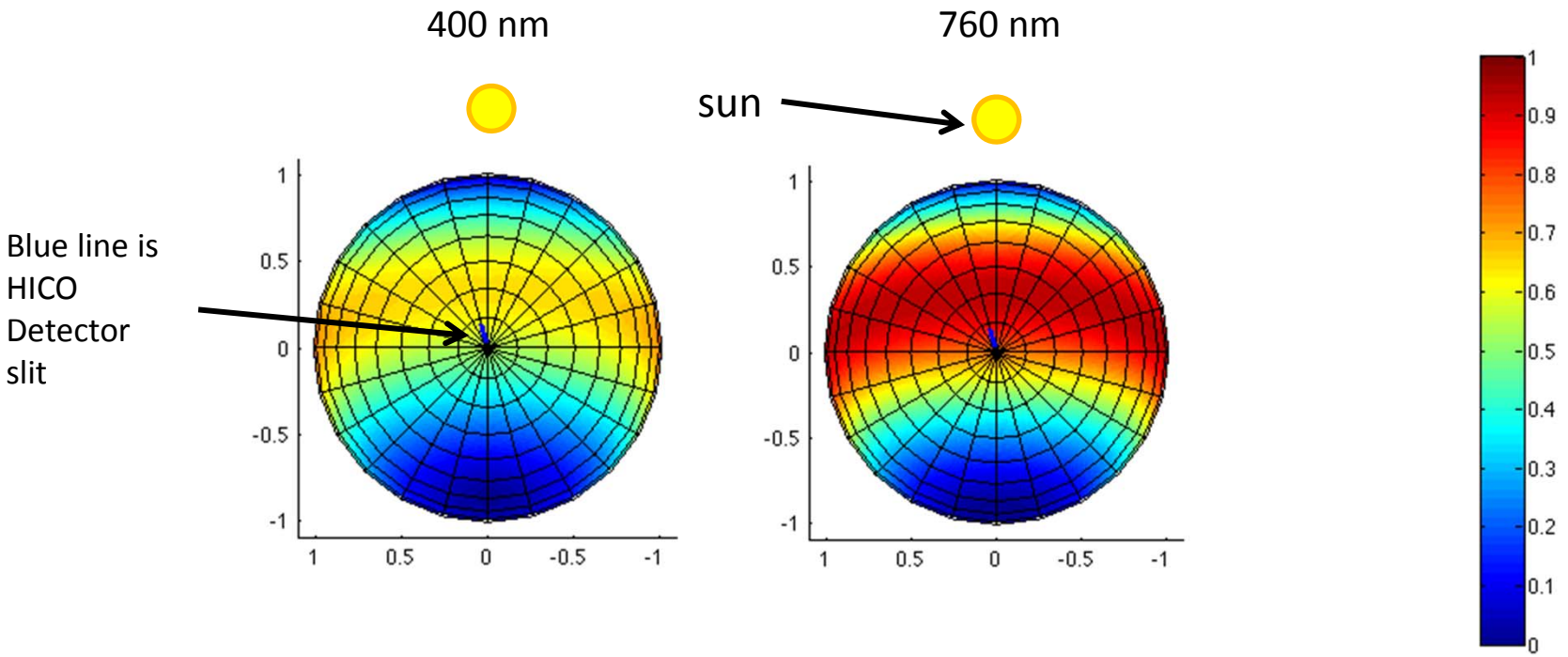
Radiance entering HICO is highly polarized

Results of a Coupled Atmosphere-Ocean Radiative Transfer Code

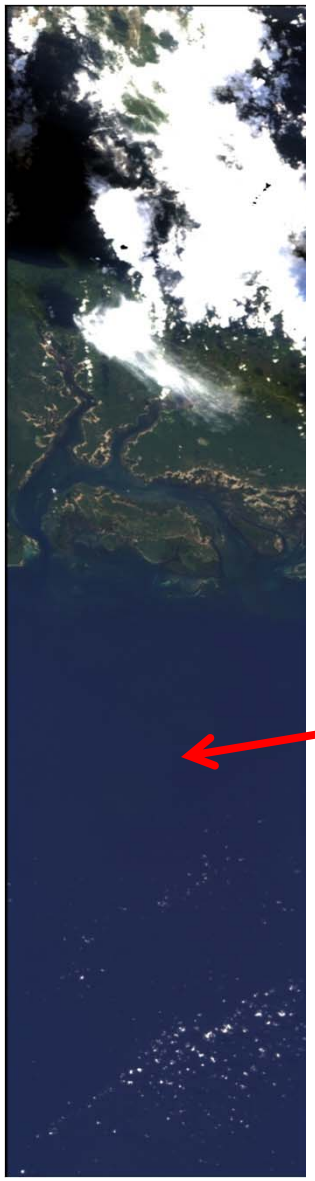
Atmospheric Parameters:
- Ozone = 244 DU
- Water Vapor = 3.5 cm
- Aerosol Optical Depth @550 < 0.1

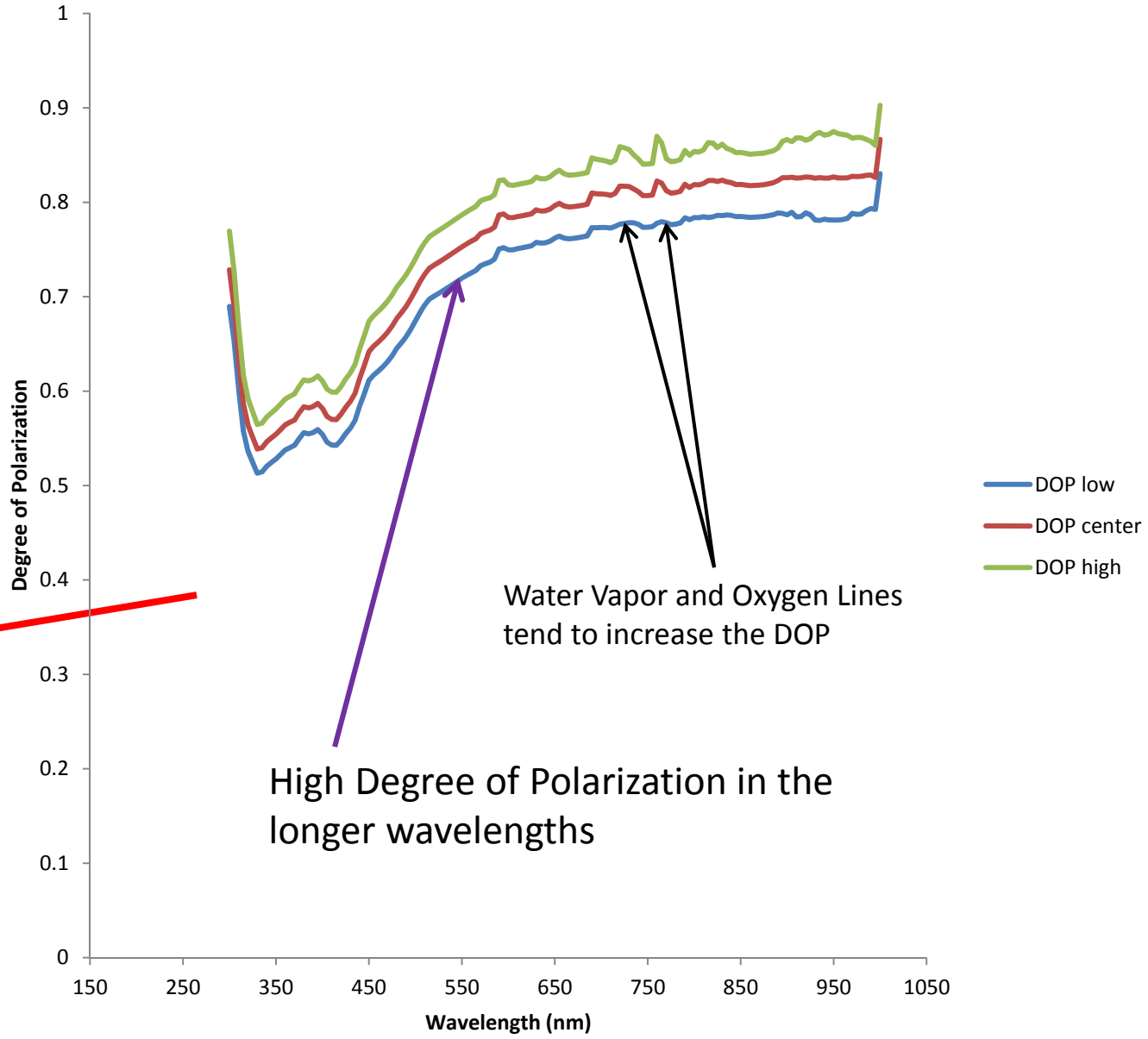
Ocean Parameters:
- Clear Ocean Water
- Optically Deep

Top of the Atmosphere Polarization Structure



TOA Degree of Polarization along the slit





Summary

- HICO supports reasonable exploitation of imagery for retrieval of bathymetry, water constituents, and bottom type information
- What level of detail is possible in the retrieved information is not known
- There are polarization effects in the sensor that appear large enough to significantly impact top of the atmosphere radiance
  - Investigation into handling this is ongoing