The HICO Program for Hyperspectral Imaging of the Coastal Ocean from Space

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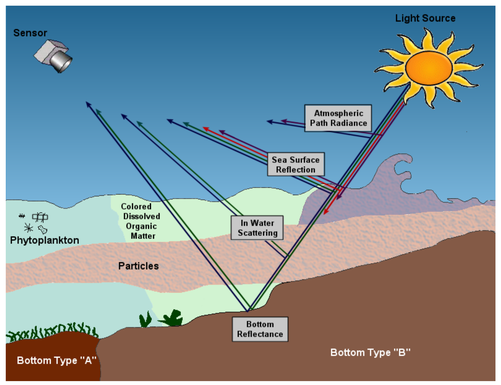
MARITIME HYPERSPECTRAL IMAGING OF THE COASTAL ZONE PRESENTS UNIQUE CHALLENGES

Coastal and riverine scenes are very complicated

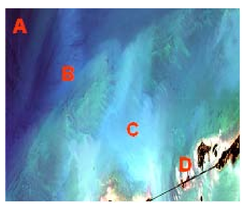
- Significant scattering from aerosols, surface, suspended solids, bottom
- Absorption by air, dissolved matter, and water
- Scattering and absorption are convolved



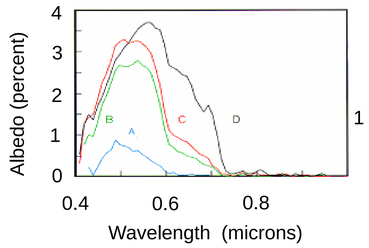
Detailed physical modeling is required to retrieve water inherent optical properties, bathymetry, bottom type, and other environmental products

Water scenes are dark (low albedo)

Coastal scene off Florida Keys



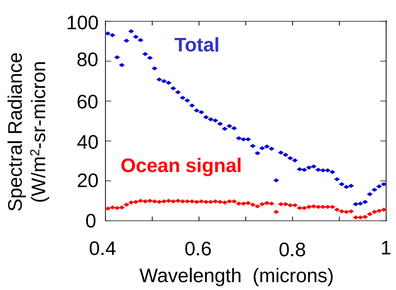
Effective surface albedo (percent)



Point A (deep water): 1% maximum albedo
Point D (shallow submerged bright sand): 4% maximum albedo

The atmosphere is brighter than the underlying scene

Modeled (using MODTRAN) spectral radiance above the atmosphere for 5% surface albedo and 45 degree solar zenith angle



Blue points: total spectral radiance including atmospheric scattering

Red points: upwelling spectral radiance from surface (the desired signal)

In blue wavelengths, the atmosphere is significantly brighter than the ocean
Surface glint is also significant compared to the water-leaving radiance
Atmospheric correction removes these signals to retrieve the ocean signal

INTRODUCTION

The HICO (Hyperspectral Imager for the Coastal Ocean) program is the first demonstration of environmental characterization of the coastal zone using a spaceborne maritime hyperspectral imager. HICO is sponsored by the Office of Naval Research as an Innovative Naval Prototype (INP), and will demonstrate products of utility to Naval forces such as bathymetry and on-shore vegetation maps. As an INP, HICO will also demonstrate innovative ways to reduce the cost and schedule of this space mission by adapting a proven aircraft imager architecture and using Commercial Off The Shelf (COTS) components where possible.

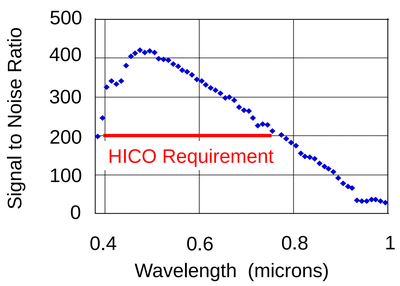
Visible and near infrared wavelengths in the approximate range 0.4 to 0.8 microns constitute the only portion of the electromagnetic spectrum that penetrates water and directly probes the water column. In the coastal environment where the water contains significant dissolved and suspended matter and the bottom may be visible, the scene image is spectrally complicated requiring well-calibrated hyperspectral imaging to retrieve bathymetry, bottom type, chlorophyll content, and water inherent optical properties. Furthermore the coastal ocean scene is dark, with an albedo of only a few percent, and from space it is viewed through the atmosphere which is significantly brighter in the visible wavelengths than the water surface, due to scattered sunlight. These conditions impose stringent requirements for the maritime hyperspectral imaging system which are in general not fully met by systems designed for land applications. The HICO imager, data system, and product algorithms will constitute the first spaceborne maritime hyperspectral system specifically designed for the coastal environment.

THE SPACE-BASED HYPERSPECTRAL IMAGER FOR THE COASTAL OCEAN (HICO) TO DEMONSTRATE NAVAL COASTAL ENVIRONMENTAL PRODUCTS WORLDWIDE

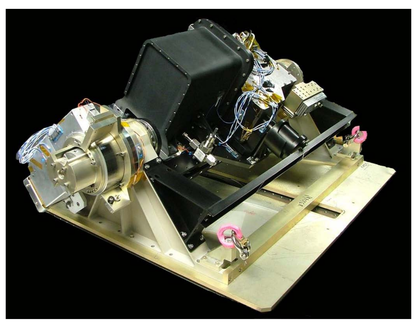
Baseline HICO on-orbit imaging system performance confirmed by preflight calibration and characterization.

- Ground Sample Distance: 100 m at nadir
  - Sufficient for many coastal environmental features
- Spectral coverage: 0.38 to 1.0 microns
  - Includes all water-penetrating wavelengths
- Spectral binning: 0.0057 microns spectral bin width
  - Sufficient to resolve spectral features in coastal scenes
- Signal to Noise Ratio: greater than 200 to 1 for water-penetrating wavelengths, assuming 5 percent effective surface albedo and 0.011 micron spectral bins
  - Required for sufficient residual signal to noise after atmospheric correction

Measurements confirm Modeled HICO Signal to Noise Ratio for each 0.01 micron-wide spectral bin For 5% surface albedo



- Radiometric accuracy: 5% or better
- Polarization sensitivity: 5% or less
- Scene size: 50 x 200 km (nominal)
  - Appropriate for coastal scene sizes
- On-orbit lifetime: one year minimum
  - Required to collect data over all seasons



HICO Flight Hardware

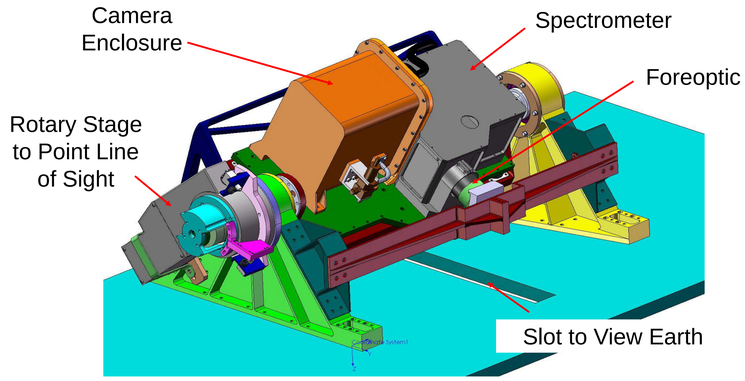
Planned HICO environmental demonstration products

Water inherent optical properties, chlorophyll, particulates and CDOM
Bathymetry and bottom-type mapping
Seasonal models for representative coastal types worldwide

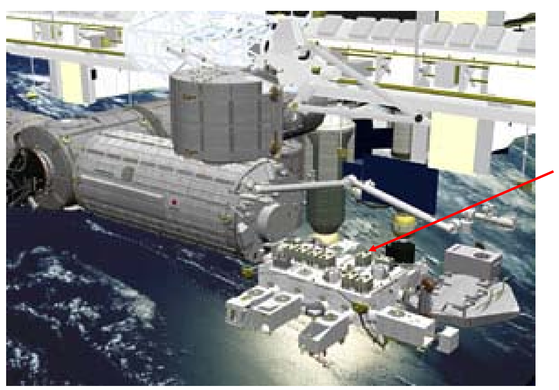
HICO IS AN *INNOVATIVE NAVAL PROTOTYPE* SPONSORED BY THE OFFICE OF NAVAL RESEARCH

HICO uses Commercial Off The Shelf components and a hermetic enclosure for the camera and electronics

- Enables use of rugged aircraft-grade hardware
- Saves significant cost and development time
- Enables rapid transition from laboratory to flight



HICO Flight Hardware Completed July 2008. HICO is manifested for a September 2009 launch to the Japanese Experiment Module on the International Space Station



Experiment location for HICO on the Japanese Experiment Module – Exposed Facility

HICO is integrated and flown under the direction of DoD's Space Test Program