U.S. NAVAL RESEARCH LABORATORY

Hyperspectral Remote Sensing

COASTAL AND OCEAN REMOTE SENSING BRANCH (CODE 7230)

AT A GLANCE

Who we are?

The hyperspectral group within the NRL Remote Sensing Division (RSD) was created in the 1990's to study the diverse coastal ocean in order to address Naval needs. Unlike multispectral sensors, which are suited for the study of the relatively uniform and slowly-changing open ocean, hyperspectral sensors can separate the complex mix of organic, inorganic, and bottom types in the littoral region along with identifying soil types and vegetation on the land. Since then the RSD has expanded its environmental research into inland waterways and terrestrial regions with an evolution of spectral sensors spanning the UV to LWIR. It has executed hundreds of field deployments over air, sea, and land using these sensors, and developed novel algorithms in order to process the data. It has developed laboratory spaces to perform in-house calibrations, develop new sensors and demonstrate new measurement techniques.

Current Interests

Hyperspectral Polarimetry, hyperspectral algorithm development, sensor design, sensor calibration, atmospheric modeling, geophysics

Point of Contact

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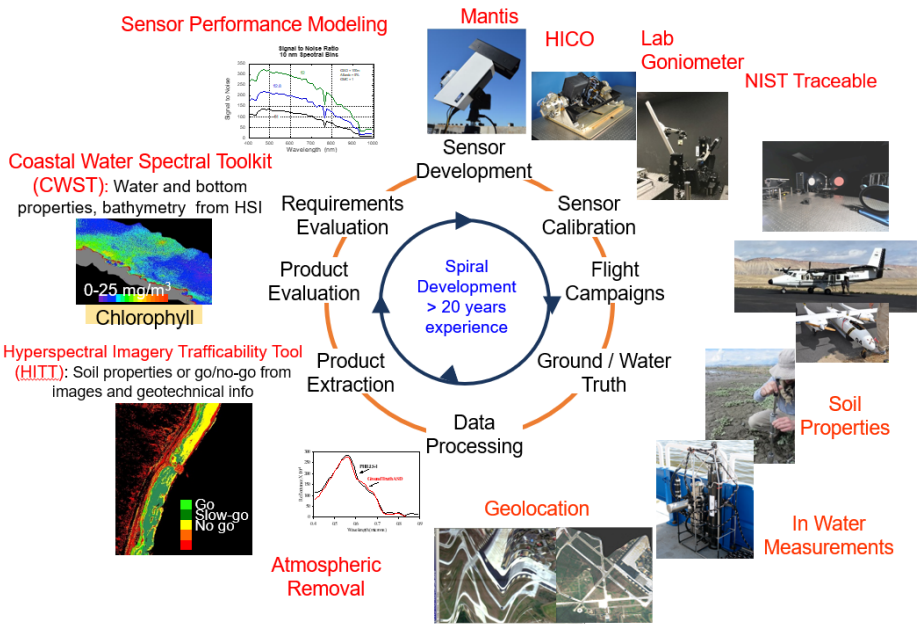
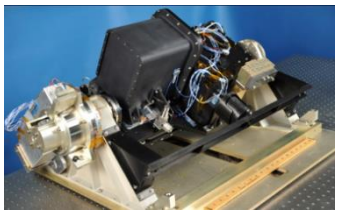
General Overview of Program

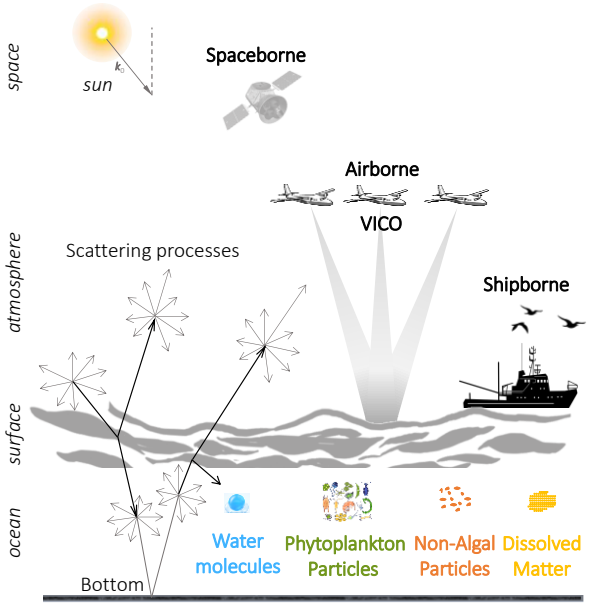


The basic paradigm for the Hyperspectral Remote Sensing is spiral development. New products to meet naval and other sponsor needs require the development of new, often very novel sensors. New sensor ideas are developed into actual hardware and measurement techniques that are proven out and calibrated in the lab before deployment to the field. Field campaigns are carried with in-situ ground and in-water truth measurements. Raw data is processed and calibrated, and then hyperspectral atmospheric algorithms applied in order to remove atmospheric effects. The resulting data cubes are then processed into products, using various tools developed within the group, and the final product assessed. This in turn pushes for the design of new and better sensors, leading to new and more accurate products. Some current areas of interest and notable historic programs are listed below.



HICO

Designed, fabricated, calibrated and characterized in the RSD, HICO was the first space-based hyperspectral imager designed for the coastal ocean. Operating aboard the ISS from 2009-2014, it collected over 10,000 data cubes used to develop space-based retrievals of coastal water properties, and acted as a pathfinder for future satellite missions.



Polarimetric Optical Closure: Layered Atmosphere-Ocean modeling with VICO and in-situ validation.

Airborne Polarized Observation Over Coastal Waters

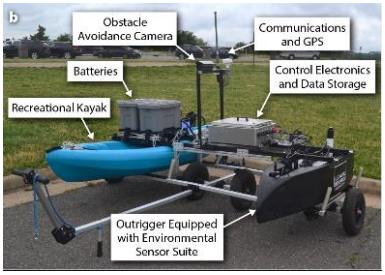
Objective: Understand how polarization properties combined with hyperspectral scalar information can increase the performance of the atmosphere and ocean inversion in complex environments.

NRL Airborne VICO: Versatile Imager for the Coastal Ocean

A major problem in coastal inversion algorithms using the top-of-the-atmosphere (TOA) total reflectance measurements is that atmospheric and surface effects dominate the signal measured at the wavelengths of interest. They typically contribute 90% (or more) of the TOA signal. These effects become more challenging when it comes to coastal waters where aerosols can be strongly absorbing due to black and brown carbon, and mineral dust from the nearby cities. Multi-angle polarimeters and hyperspectral radiometers contain rich information on the microphysical properties of aerosols and hydrosols, and therefore can facilitate detailed retrievals in the complex Atmosphere and Ocean (AO) system. Polarimetric (VICO) and hyperspectral airborne observations are used with radiative transfer simulations to improve the AO retrievals. Coincident ground truth measurements are used to validate these retrievals.

Autonomous Coastal Color Environmental Survey System: ACCESS

Objective: Understand small-scale variability in key properties of the coastal ocean and how such variability contributes to uncertainty in ocean color remote sensing products as a function of spatial resolution. This will result in more reliable mission planning information and better future sensor design. ACCESS is an autonomous surface vessel that can be attached to a recreational kayak and is equipped with multiple sensors. The current design includes sensors that can map the bottom and measure in-water color properties, currents, depth, and more.



Multispectral Lidar and Hyperspectral Polarimetry

Multispectral lidar (mounted on the aircraft below) and hyperspectral polarimetry are some of the newest programs within the hyperspectral group. Multispectral lidar has an advantage over passive hyperspectral as it can penetrate further into the water column leading to an enhancement of the passive data. It is particularly useful for bathymetry, particle size, layers, and organic and inorganic particle types. Hyperspectral polarimetry is a natural progression of the multispectral VICO. MANTIS (left), which measures the full sky downwelling irradiance and polarization, creates a hi fidelity input of downwelling irradiance for retrievals of water leaving radiance. Currently it is being used in conjunction with satellite data to fully determine atmospheric aerosol composition. Similarly, POLSPEC, a hyperspectral polarimeter that measures all four Stokes parameters is being employed in a multi-angle polarimetric field campaign to fully quantify hydrosol composition.

Post-Doc Opportunity: contact Jeffrey.bowles@nrl.navy.mil