UAV BORNE HYPERSPECTRAL IMAGER FOR BENTHIC AND LITTORAL APPLICATIONS

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LONG-TERM GOALS

The long-term goal of this research is to develop remote sensing tools for assessing the biological and optical properties of the littoral ocean. Recent experience with aircraft imaging spectrometers has demonstrated their suitability for assessing water column and bottom optical properties in the littoral zone. The goal is to make imaging spectrometry practical by building a low cost imaging spectrometer optimized for the coastal ocean that is suitable for operation on manned or unmanned aircraft.

OBJECTIVES

The objective of this program is to provide a low cost, high performance imaging spectrometer system for imaging the coastal ocean and the software necessary to process the data. The instrument is to be flown on the ONR Unmanned Air Vehicle (UAV) Pelican in support of the Coastal Benthic Optical Properties (CoBOP) ARI and other ONR programs.

APPROACH

Earlier work has shown that imaging spectrometers are an excellent tool for passive remote sensing of the littoral zone. However, the existing high quality systems such as AVIRIS are large (350 kg) and expensive to build and operate. To address this problem NRL began the Portable Hyperspectral Imagers for Low Light Spectroscopy (PHILLS) project. Over the past three years the PHILLS project has built compact lightweight high

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performance imaging spectrometers for a variety of applications (Antoniades, et al., In Press). A PHILLS instrument optimized for the coastal ocean has been designed for aircraft operation as part of an NRL 6.2 program on Hyperspectral Imaging of the Littoral Zone. Here we propose building a similar system modified to be capable of fully remote operation for use on a UAV.

But the sensor alone is not adequate for littoral and benthic studies. Two approaches will be provided for processing and analysis of the data. First, laboratory calibrations and atmospheric correction will be applied which have been developed based on the experience with AVIRIS data (Gao, et al., 1993) and that are being adapted for the PHILLS data under current funding. Then existing models (e.g. Lee et al., 1994) can be applied to separate water column and benthic optical properties.

Second, the PHILLS project has developed the Optical Real-time Adaptive Signature Identification System (ORASIS; Bowles, et al., 1996) for automated endmember determination and subpixel demixing of arbitrary scenes. ORASIS exploits data obtained by hyperspectral imagers to identify objects not only by absorption band characteristics, which are severely modified by the water, but also by the small differences in the continuum reflectance of the dissolved substances. These small differences are responsible for the unique fingerprints associated with dissolved organic matter, resuspended sediments, etc. ORASIS is being continually refined, and adapted for automated operation. The standard version of ORASIS being used at the time will be used for post-flight processing and analysis of the imaging spectrometer data. A possible future option is the implementation of ORASIS processing in real time on the UAV.

TASKS COMPLETED

During the first year of this project (FY96) an initial instrument design was developed, and parts procured to assemble that instrument. Most parts arrived in June 1996 and an initial version of the instrument was flown in support of the July 1996 CoBOP Pilot experiment in the Dry Tortugas, Florida. The instrument provided high quality images, but had low sensitivity in the blue end of the spectrum because the proper grating was not available at the time of the overflight. The grating arrived and was installed in September 1996. Beginning in FY 97 test flights were conducted in the Pelican UAV. In November 1996 test flights were completed over test sites in the Santa Barbara Channel and Monterey Bay, California. Unfortunately, while installed in the Pelican the instrument was inadvertently soaked by fire sprinklers that were set off when the hanger was unoccupied. This severely damaged the instrument and ended the flight tests. That version of the instrument was reconditioned and calibrated and calibrated data was analyzed to assess data quality. The intensifier used in this design produced more noise than anticipated and the instrument signal to noise did not meet specifications. Over the past year alternate designs have been developed as part of a NRL 6.2 core funded project. That information was used to redesign the instrument to be used in this program. An improved instrument for ocean applications will be completed in fall 1997 and made available to support the CoBOP program in May 1998.

RESULTS

The goal of this program is to provide an imaging spectrometer for assessing optical properties of the littoral zone to operate on the Pelican UAV. The instrument was designed, parts procured and initial flights conducted. The instrument was installed on the Pelican and successfully operated by the pilot of the Pelican for three test flights. The initial instrument design did not meet signal to noise requirements. An improved version of the instrument is under construction and it will be tested, calibrated and used to support the CoBOP experiments during FY 98.

RELATIONSHIP TO OTHER PROJECTS

This program builds on the PHILLS instruments and ORASIS software developed at NRL under NRL core 6.1 and 6.2 funding and Central MASINT Office (CMO) funding. There is close synergy with the Spectral Signatures of Optical Processes in the Littoral Zone ARI which is a 6.1 NRL core program to understand the optical processes in the littoral zone and develop techniques to use imaging spectrometry to evaluate those processes. This program directly supports the ONR CoBOP program including providing overflights and supplying calibrated, atmospherically corrected PHILLS data to participants in that program. The instrument will be flow in support of the CoBOP experiment at Lee Stocking Island, Bahamas in May 1998. Data processing will be conducted overnight on the ground to provide products the next morning for analysis and experiment planning. Results from the CoBOP experiments will directly feed into the Hyperspectral Remote Sensing Technology (HRST) Program which has the goal of flying a hyperspectral imager in space for characterization of the littoral zone. Hyperspectral data collected during CoBOP will be used to develop algorithms for bathymetry and bottom characterization for use in the HRST Program.

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