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High Altitude Hyperspectral Imaging Spectroscopy

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Summary:

The Florida Environmental Research Institute (FERI) has previously flown three missions for the Naval Research Laboratory - Code 7230 (NRL). These missions were: Mobile Bay, Alabama - May 2002, Looe Key, FL - October 2002, and Fort Lauderdale - August 2003. This document is to serve as a summary of those missions.

The Mobile Bay flights in the spring of 2002 covered not only the inlet to Mobile Bay but some of the barrier islands including Dauphin Island. The mission included flights on May 19th, 20th, 21st, and 23rd. This mission was flown on the NOAA Citation (N52RF - http://www.aoc.noaa.gov/aircraft_cessna.htm) at an altitude of approximately 30,000'. The altitude of the aircraft, frame rate (21 f/s), speed (300 knots), and lens (17mm) generated a Ground Sample Distance (GSD) of 7m² and swath of 4.6km. During the entire mission, we covered approximately 975 sq km of area, which equated to 41 GB of raw data. More detailed flight parameters can be found here <http://www.flenvironmental.org/oldExperiments/>.

Key NRL Code 7230 participants included: Curtiss Davis, Marcos Montes, Jeffery Bowles, and William Snyder. They were instrumental in all aspects of the mission. NRL Code 7333 was also present during this mission. Key members included: Robert Arnone, Alan Weidemann, and Rick Gould. This mission was plagued by very hazy conditions making it difficult to atmospherically correct. However, this data has been worked up by Dr. Gould and was presented at the 2004 Ocean Optic Conference (*Gould, R. W., Arnone, R. A., Sydor, M., Kohler, D. D. R., and Bissett, W. P. An autonomous platform for spatial ocean color validation. Proceedings of Ocean Optics XVII, Fremantle, AU. 2004.*)

The Looe Key, FL mission in October of 2002 included flights on October 26th, 27th, 28th, 29th, and 30th. This mission was flown on the NOAA Shrike (N47RF -

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http://www.aoc.noaa.gov/aircraft_rockwell.htm) at two different altitudes (approximately 10,000' and 2,000'). At the higher altitude of the aircraft, frame rate (30 f/s), speed (150 knots), and lens (17mm) generated a GSD of 2m² and swath of 1.3 km. At the lower altitude of the aircraft, frame rate (30 f/s), speed (150 knots), and lens (17mm) generated a GSD of 0.4m² and swath of 0.25 km. During the entire mission, we covered approximately 315 sq km of area, which equated to 75 GB of raw data. More detailed flight parameters can be found here <http://www.flenvironmental.org/projects/looekey/flightlogs/>.

Key NRL Code 7230 participants included: Gia Lamela and W. Joseph Rhea. Key NRL Code 7333 members included: Alan Weidemann and Wesley Goode.

This mission was the first of two missions that were flown in conjunction with the Army Corp of Engineers' Bathymetric LIDAR system. The LIDAR aircraft flew all their lines at an altitude of 2,000'. The PHILLS flights flown at this altitude suffered from the inability of the aircraft to stay on the line. This was due to aircraft not being properly equipped to fly this type of mission.

The entire mission was plagued by very cloudy conditions. However, a small window of acceptable atmospheric conditions presented itself on the fourth day. This data has been worked up and has been published and presented widely (Kohler, D.D.R., Bissett, W.P., Steward, R.G. and Davis, C.O., 2004. *A New Approach for the Radiometric Calibration of Spectral Imaging Systems*. *Optics Express*, 12(11), Bissett, P., DeBra, S., Kadiwala, M., Kohler, D., Mobley, C., Steward, R., Weidemann, A., Davis, C. O., Lillycrop, J., Pope, R. Development, validation, and fusion of high resolution active and passive optical imagery. *Proceedings of Ocean Optics XVII*, Fremantle, AU. 2004., Bissett, W. P., DeBra, S., Kadiwala, M., Kohler, D.D.R., Mobley, C., Steward, R.G., Weidemann, A., Davis, C.O., Lillycrop, J., and Pope, R., 2005. *Development, Validation, and Fusion of High Resolution Active and Passive Optical Imagery*. 2005 Society of Photo-Optical Instrumentation Engineers in *Proceedings of SPIE Vol. 5809*, Bissett, W.P., Kohler, D.D.R., Davis, C.O., DeBra, S., Goswami, B., Kadiwala, M., Lillycrop, J., Mobley, C., Weidemann, A.D., Pope, R., and Steward, R., 2004. *Hyperspectral Imagery and Bathymetric LIDAR Data Fusion in the Florida Keys*. 5th annual JALBTCX workshop. St. Petersburg FL., Kohler, D.D.R., Bissett, W.P., Steward, R.G., Kadiwala, M.Y., DeBra, S.G., Mobley, C., Davis, C.O., Montes, M., Lillycrop, W.J., Weidemann, A., Goode, W. and Pope, R., 2003. *Active/Passive Data Fusion from LIDAR and HSI Sensors and the Retrieval of Bottom Classification in the Littoral Environment*, The Oceanography Society - Oceanology International Americas Ocean Conference, New Orleans, LA.)

The Fort Lauderdale, FL mission in August of 2003 included flights on August 12th, 16th, and 17th. This mission was flown on the NOAA Shrike (N47RF - http://www.aoc.noaa.gov/aircraft_rockwell.htm) at two different altitudes (approximately 10,000' and 2,000'). At the higher altitude of the aircraft, frame rate (30 f/s), speed (150 knots), and lens (17mm) generated a GSD of 2m² and swath of 1.3 km. At the lower altitude of the aircraft, frame rate (30 f/s), speed (150 knots), and lens (17mm) generated a GSD of 0.4m² and swath of 0.25 km. During the entire mission, we covered

approximately 88 sq km of area, which equated to 18 GB of raw data. More detailed flight parameters can be found here <http://www.flenvironmental.org/oldExperiments/>.

This mission was also plagued by poor atmospheric conditions making it difficult to atmospherically correct. This difficulty was compounded by an inability to coordinate a ground truth effort that occurred coincident with the over flights. This data has been worked up but due to difficulties with the atmospheric correction it has not been presented.

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High Altitude Hyperspectral Imaging Spectroscopy

The work in this effort centered on HyperSpectral Imaging (HSI) data collection and HSI sensor calibration. The data collection occurred at high altitudes (~30,000 ft.) off the coast of Mobile, AL and at lower altitudes (~10,000 ft) in the Florida Keys. These data have been used in multiple presentations and publications in the development of robust HSI data collection and processing techniques, which are suitable for the characterization of the Battle Space Environment via advanced signal processing. Specifically, the products produced from these HSI data include bathymetry, bottom reflectance, and water column inherent optical properties. The successful retrieval of these data products from an HSI data stream over low-light water targets require specific deployment criteria, as well as processing criteria, which were developed and applied in this project.

Further work was accomplished on the characterization and calibration of an NRL-designed imaging spectrometer, which has led to the ability to more accurately retrieve the above environmental information products from coastal ocean imaging spectroscopy. This work led to a significant alteration of the previous calibration and characterization procedure used at NRL, and has been published in a peer-review journal.