COASTAL CHARACTERIZATION FROM HYPERSPECTRAL IMAGERY: AN INTERCOMPARISON OF RETRIEVAL PROPERTIES FROM THREE COAST TYPES

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Over the past three years, the Naval Research Laboratory (NRL) has conducted three coastal characterization studies in conjunction with other institutions. The most recent was a joint effort in May 2009 in which NRL, MIRC, NOAA, and NPS undertook a study of a mangrove coast region in Queensland, Australia. This study followed similar efforts in January and February 2009 in and around Kaneohe Bay and Waimanalo Bay, Hawaii (coral and volcanic coast types), and an earlier effort in September 2007 in the Virginia Coast Reserve (barrier island coast type) [1][2][3][4].

During each of the three studies, airborne hyperspectral imagery (HSI) was acquired over the site in conjunction with both land and water spectral and geotechnical measurements. During the experiments in Australia and Hawaii, HyMAP (www.hyvista.com) HSI was acquired over the study area, while in the 2007 Virginia Coast Reserve study, NRL's CASI (www.itres.com), a visible and near infra-red (VNIR) HSI sensor was used in conjunction with a Surface Optics (www.surfaceoptics.com) InGaAs SWIR HSI sensor operating in the 0.9-1.7 μm spectral region, and single channel Indigo Systems Merlin mid-wave IR camera operating in the 3-5 μm spectral range (www.corebyindigo.com/products/legacy.cfm). For coastal classification subtle variations in spectral properties of physical and biological features are very important—such as retrievals for bottom reflectance, beach composition, and leaf-area index.

Field measurements for calibration and validation focused on coastal properties including: shallow water bathymetry[1][2], beach grain size, moisture, and composition, as well as higher level beach properties, such as beach bearing strength [3][4] which are a function of these fundamental properties. Beach properties measured along transects consisted of grain size profiles, substrate moisture, bearing strength (dynamic deflection modulus), shear strength (California Bearing Ratio), as well as the *in situ* spectral reflectance and GPS location of each position. Calibration for shallow water bathymetry consisted of in-water spectral reflectance profiles measured with an Analytical Spectral Devices (ASD) spectrometer as a function of depth for various bottom types with validation data provided by soundings and beach surveys with post-processed kinematic (PPK) GPS in the intertidal zone. Other retrievals studied include vegetation mapping and the development of relevant spectral libraries. Vegetation spectral libraries included both canopy and leaf level spectral reflectance to retrieve vegetation coverage maps. In one of the experiments, VCR'07 and previous studies at the VCR prior to 2007, vegetation density has also been studied by NRL [5], in particular the mapping of salt marsh biomass.

For higher level beach properties such as bearing strength, which depends on more than one fundamental property, we have in the past adapted a look-up table approach [3][4], but this same analysis has also shown the potential for retrieving bearing strength as a mixture of other fundamental properties such as grain size distribution, moisture, and details of composition. This allows for the possibility of developing models in which these more fundamental variables are first retrieved and then used to model bearing strength for a particular coast type. The beaches in these coast types differ dramatically in terms of properties such as composition and grain size; these differences are due to the origin of the sands (for example, olivine and basalt of volcanic origin and calcite sands from the breakdown of coral in our sites in Hawaii compared with quartz sands at the VCR). These differences suggest the need to develop models specific to a particular coast type. In this application, the coast type is generalized by the governing biological and physical forces; many of which can be extracted from hyperspectral imagery.

Bathymetric products for the very shallow limit have been studied by us [1][2]. In the very shallow limit, two narrow regions of the near infra-red spectrum near 810nm (a local minimum in liquid water absorption) and 720 nm (an area of steep slope (drop-off)) have been seen to be optimal for retrieval of shallow depths in the < 2m range. In these wavelength regions and at these depths, the most important factors contributing to the reflectance are the water depth and the bottom type with the suspended constituents having less impact. These retrievals have been studied in all three coast types and validation of results is derived by comparison against inter-tidal PPK GPS. Deeper water models can also be developed from a variety of methods and merged with the shallow water model. For example, deeper water approaches based on in situ calibration data (e.g. from soundings) is one approach compared here against other methods such as [6].

This research illustrates improved methodologies in processing hyperspectral imagery by applying a modified coastal classification system [7]. Coasts are remarkably complex and dynamic, and our classification system is a work in process, but it is oriented toward supporting the remote sensing and mapping community. By collecting calibration and validation data for specific coast types, we can optimize post processing strategies to quickly exploit a hyperspectral cube for the subject coast types. Our relationships at the present time include fundamental biological and physical parameters that are consistent for barrier island, coral, and mangrove coasts. We continue to build coast type geodatabases [8] to develop a hierarchy of important coastal characteristics that range from nearshore bottom reflectance and in water optical measurements to soil parameters and leaf area index in maritime forests. Our goal involves grouping coastal areas into a set of identifiable classes for remote sensing and mapping applications. Our assumption is that we can generalize coasts based on similar biological, geological, physical, environmental, and historical settings.

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