APPLICATION OF INTEGRATED HYPERSPECTRAL AND LIDAR IMAGERY FOR THE CHARACTERIZATION OF TERRESTRIAL ECOSYSTEMS

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1. INTRODUCTION

The integration of passive and active imaging systems offers significant advantages for studying terrestrial ecosystem dynamics and composition. High resolution passive imagers offer the ability to characterize terrestrial canopy coverage, leaf color, and basic compositional identification. More advanced hyperspectral imagers offer the ability to determine vegetation stress, chemical composition, photosynthetic productivity, and provide more sophisticated species identification. Augmentation of the hyperspectral imaging with 3-dimensional (3D) imaging technologies, such as synthetic aperture radar and lidar systems adds a vertical and volumetric dimension to the characterization of these ecosystems. The combination of hyperspectral imagery with 3D imaging enables in-depth and detailed analysis of terrestrial structure, health and species identification using current remote sensing technology. Our analysis focuses on the use of lidar and hyperspectral imagers. All the hyperspectral instruments have been produced by Northrop Grumman Aerospace Systems, while the lidar systems are both in-house and commercial instruments.

2. BACKGROUND

Recognizing the need, and the technical feasibility of this type of environmental assessment, the National Research Counsel has advocated two future NASA satellite missions to measure terrestrial ecosystem health and structure, the DESDynI and HyspIRI missions. The DESDynI mission will orbit an L-band synthetic aperture radar (SAR) and a Lidar to image 3D structure and land deformation. Key goals of the DESDynI mission will be to quantify fine-scale patterns of forest structure (height, crown size, basal area, biomass) and changes in structure over large extents using radar (Polarimetry and Interferometry) and lidar (small footprint waveforms) [1]. The European Space Agency is also evaluating the potential mission, BIOMASS, which would orbit a p-band SAR system. The HyspIRI mission will orbit a visible to long-wave infrared hyperspectral imager. Key goals of the HyspIRI mission will be to quantify ecosystem function, physiology, chemical composition, and seasonal activity expressed in terrestrial vegetation. We have approached the challenge of these multiple missions for terrestrial characterization by integrating the components, specifically a hyperspectral visible – infrared imager [2] with commercial and 3D-flash lidar systems [3] for applied research. An integrated system for manned platforms has been demonstrated by the Carnegie Airborne Observatory [4]. NGC is validating capabilities for designs with paths to other platforms, including high altitude systems, such as Global Hawk unmanned aerial systems, and pathfinders for future satellite systems.

3. Paper Focus

This paper focuses on the applied use of the integrated datasets for extraction of terrestrial 3D structure and biogeochemical attributes. We will present our analysis on the several different ecosystems that have been imaged; from orchards in the San Joaquin Valley of central California, to ecological reserves in Northern and Southern California, to tropical forests in Costa Rica. The orchards are highly structured dimensionally and well-controlled physiologically, so they represent well-constrained areas for study. In additional, the orchards have been parametrically studied for yield production modulating water, fertilization, and environmental metrics across grids within the orchards over several years. Extensive ground control, both chemical soil and leaf composition, as well as physical and chemical inputs to the orchard over multiple years provide good metrics to evaluate the trends seen in the remote sensing imagery. The ecological reserves allow a study of the natural temperate forest ecosystem. The natural ecosystems extend from Redwood temperate, to lowland chaparral, to humid tropical forests. Characterization of 3D structure, above ground biomass, canopy coverage and health will be studied across the various forests, evaluating the utility of the passive and active imagery and the performance of the imagers for these applications.

4. References

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