ROBUST ESTIMATION OF CROP RESIDUE COVER VIA MULTI/HYPERSPECTRAL SENSING

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1. INTRODUCTION

Agricultural crop residues play a significant role in nutrient cycling, carbon sequestration, and soil erosion (including wind and water) [1]. Long-term use of conservation tillage can lead to increased soil organic carbon content, improved soil structure and increased aggregation compared with plow-tilled soils [2]. It can also improve infiltration of water, reduce erosion associated with flooding, reduce fertilizer requirements, and ultimately improve air and water quality. Although the pressure for its use in ethanol production has been reduced by short term lower energy costs, it is still removed in areas of drought to make up for shortages in forage for animal feed. Crop residue management is an important part of any conservation tillage system. Thus, residue cover is an important indicator of soil tillage intensity and conservation management practices.

Traditional methods for estimating crop residue depend on direct human analysis. These include line-transect techniques within individual fields developed by USDA-NRCS [3] which are time consuming and not suitable for regional analysis [4], and the National Crop Residue Management Survey, which is used to estimate management practices aggregated at a county level [5]. These windshield surveys contain errors due to subjective interpretation and limited site distance into fields, and are conducted once annually, typically in spring, due to cost and manpower restrictions. Also, between the first harvesting of crops in late summer and the end of planting in spring, weathering will affect the condition of resulting residue, and the amounts of residue present may vary greatly as the timing of tillage depends on the ability to access fields and the availability of equipment. This affects information available on (i.e. carbon) dynamics in the fields which varies with tillage timing. Therefore, more frequent sampling with greater spatial detail is required to analyze the fate of crop residue from harvest until planting of the following crop.

Remote sensing of crop residue can improve on these methods in several ways. Multispectral satellites have extended coverage area and frequent revisit times. With these revisit times, multiple acquisitions are possible to detect changes in tillage and residue cover between growing seasons. This will be crucial as atmospheric conditions may prevent collection of data. Finally, field and sub-field level analysis is possible using satellite imagery, which allows for more detailed analysis of residue cover over ground based techniques.

Previous efforts to estimate crop residue cover fractions for multispectral data have focused on the creation of indices based on the available bands. Some of these have included the Normalized Difference Index (NDI) [6] and the Crop Residue Index Multiband (CRIM) [7] using Landsat Thematic Mapper band differences and ratios. Results based on multispectral remotely sensed data are generally successful only at local scales due to the impact of soil moisture, vegetation water content and local soils. Improved, more robust cover estimates have been obtained using methods based on hyperspectral data, such as the Cellulose Absorption Index (CAI) [8] and the constrained linear spectral unmixing analysis (CLSMA) [9]. Hyperspectral based analyses is limited by spatial coverage, while multispectral analyses are limited by discriminating spectral information. The goal of this study is to develop methods for exploiting the advantages of existing multispectral (coverage, frequency of acquisition) and hyperspectral (spectral resolution) sensors to improve estimation of residue cover operationally over extended areas.

2. METHODOLOGY

In November 2008, Hyperion and ALI data were simultaneously acquired over a primarily agricultural region with some riparian zones in west-central Indiana. Crops in this area are typically rotated between soybean and corn, and tillage practices vary from intensive tillage with very low residue cover to conservation tillage (including no-till) with little disturbance of the residue. These fields are typically <20 ha, and are representative of Midwest farming practices. Near concurrent airborne hyperspectral data were also acquired by SpecTIR over a subset of the Hyperion scene. Crop residue cover in the study area was measured using the USDA line-point transect method. Vertical and oblique photographs and notes on tillage intensity were recorded for each location. A wide area augmented system (WAAS) enabled GPS receiver recorded positions for each sampling location. Additional fields were also characterized through visual interpretation.

3. RESULTS

Crop residue cover was estimated for the airborne and hyperspectral Hyperion data using the CAI method and CLSMA. After suitable accuracy was obtained by eliminating mislabeled fields, the resulting classification map was used to create an area-of-interest layer for a co-registered ALI scene. An empirical study that included the impact of soils type, green vegetation, and moisture content of the residue and soils was conducted [10, 11]. Ongoing work includes evaluation of the impact of weathering over the winter season and extension of the work to include other multispectral data acquired over extended areas of the U.S. Corn Belt (Landsat, ASTER, and AWIFS).

4. REFERENCES

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