ABSTRACT

Galloza, Magda S. PhD., Purdue University, August 2013. Remote Sensing based Residue Cover Integrated into APEX for Estimating Soil Erosion. Major Professors: Melba Crawford and Bernard Engel.

A key function of land cover is to protect the soil, thus decreasing erosion and preventing land deterioration by water and wind erosion. Crop residue provides multi-faceted contributions, including short-term (e.g. moderation of soil temperature, and increase in water use efficiency) and long-term benefits (e.g. soil quality, biodegradation of pollutants, and soil organic carbon sequestration). Commercial agricultural has increased interest in cellulosic crops, which may consequently alter practices, resulting in increased removal of crop residue to be used as feedstock. Accurate residue cover information would improve the assessment of the impact of changes in crop management practices on water quality and quantification of any adverse effects on ecosystem sustainability due to soil erosion. Various studies have demonstrated that spectral indices derived from remotely sensed data can effectively be used to quantify crop residue cover, if adequately calibrated using in situ data. Remotely sensed (RS) residue cover information provides the advantage of a wide coverage and increased availability when quantifying the environmental impact of soil erosion.

The objectives of this study are to: (1) Evaluate the capability of airborne and space-based multispectral/hyperspectral data for predicting residue cover using empirical models; (2) Explore a method for jointly exploiting multispectral and hyperspectral RS data to improve estimates of crop residue over extended areas; (3) Quantify long-term and short-term soil erosion when incorporating RS residue cover estimates into a modeling approach using the Agricultural Policy Environmental eXtender (APEX) model; and (4) Identify conditions for which RS residue cover information becomes critical to include when quantifying the impact of soil erosion at a field scale level.

Residue cover estimates were evaluated for Landsat Thematic Mapper ™ and the Advanced Land Imager (ALI), a prototype for the Landsat Data Continuity Mission (LDCM). ALI data consistently yielded crop residue models based on the Normalized Difference Tillage Index (NDTI) with lower root mean square error (RMSE) values than those developed using Landsat TM data. The Cellulose Absorption Index (CAI) derived from the SpecTIR hyperspectral airborne data resulted in improved residue cover estimates compared to both the NDTI based models and from the Hyperion spaceborne hyperspectral sensor. However, the hyperspectral data have more limited coverage. A framework based on Cumulative Distribution Function matching method was successfully investigated to leverage the superior predictive capability of hyperspectral based indices to “calibrate” multispectral based indices predictions over extended regions. Observation operators derived from the CDF matching method were successful in scaling multiple data sets to achieve models with lower RMSE.

Crop residue cover digital maps were derived from the multispectral and hyperspectral remotely sensed data to investigate the impact of incorporating residue cover data into the APEX model

for field scale predictions of soil erosion associated with different agricultural management systems. The APEX model was modified to incorporate residue cover data from the various RS products. The results indicate that incorporating improved residue cover estimates from the hyperspectral airborne SpecTIR data into the APEX model improves soil erosion estimates under conventional management practices that result in low residue coverage. ALI residue cover products provided no statistical differences ($p<0.05$) in soil erosion results compared with results from the original APEX model, while TM data yielded significantly lower estimated values ($p<0.05$) than the original APEX model. Results demonstrated that percentage slope higher than approximately three percent, and increased precipitation events (>110 mm) during the "critical months" of April-May-June period are characteristics to consider for the inclusion of RS SpecTIR residue cover data in APEX for soil erosion quantification, while slope length seems to be a non-critical factor. However, when erosion control measures are studied for residue removal with conventional management practices, this study suggests that RS residue cover data be incorporated in the analysis, regardless of the slope percentage and residue type at the field. The research demonstrated the potential value of jointly exploiting the hyperspectral and multispectral data, where available. Regional characteristics where the use of RS data becomes critical for soil erosion estimates provided in this study can provide guidance when designing best management practices that can be implemented to increase soil quality sustainability. This is essential to strategically prioritize RS data collection for cost-effective and successful conservation practice implementation.