Combining hyperspectral vegetation indices for a better estimation of crop chlorophyll content for application to precision agriculture

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Recent studies have demonstrated the usefulness of optical indices from hyperspectral remote sensing in the assessment of vegetation biophysical variables both in forestry and agriculture. Those indices are, however, responsive to variations of several vegetation and environmental properties such as: Leaf Area Index (LAI), leaf chlorophyll content and background soil reflectance. The chlorophyll content is an indicator of photosynthesis activity, and is linked to the nitrogen concentration in green vegetation. For this reason, remote sensing techniques promise a potentially efficient tool to assess the spatial variability of nitrogen in the agricultural landscapes, and the response to nitrogen application. To this purpose, an accurate and quick estimation of the vegetation chlorophyll content will help in advising farmers about supplying adequate nitrogen quantities and preventing excessive nitrogen losses to the environment. This paper presents a combined modelling and indices-based approach to determine the crop chlorophyll content while minimizing LAI (vegetation parameter) influence and underlying soil (background) effects. This combined method has been developed first using simulated data, and followed by evaluation in terms of quantitative predictive capability using real hyperspectral data. Simulations consist in leaf and canopy reflectance modeling with *PROSPECT* and *SAIL* models, which are followed by application to hyperspectral *CASI* imagery that were collected over corn crops in three experimental farms from Ontario and Quebec, Canada. Results presented are from the L'Acadie, Quebec, Agr. & Agri-food Canada research site.

In this study we developed an index that integrates advantages of indices minimizing soil background effects and indices that are sensitive to chlorophyll concentrations. Simulated data have shown that the proposed index is both very sensitive to chlorophyll content variations, and very resistant to the variations of LAI. Through application of this index to CASI hyperspectral reflectance data images of predicted leaf chlorophyll content were generated. Evaluation showed chlorophyll variability, over crop plots with various levels of nitrogen, which revealed a striking agreement with ground truth: leaf chlorophyll content estimations from CASI images are very similar to leaf chlorophyll content measurements in the laboratory from plot field sampling.

Presented at the International Symposium of Spectral Sensing Research (ISSSR), Quebec City (Canada), June 10th-15th, 2001.