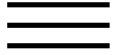# Hyperspectral vegetation indices and novel algorithms for predicting green LAI of crop canopies: Modeling and validation in the context of precision agriculture.

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# Hyperspectral vegetation indices and novel algorithms for predicting green LAI of crop canopies: Modeling and validation in the context of precision agriculture

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## Abstract

A growing number of studies have focused on evaluating spectral indices in terms of their sensitivity to vegetation biophysical parameters, as well as to external factors affecting canopy reflectance. In this context, leaf and canopy radiative transfer models are valuable for modeling and understanding the behavior of such indices. In the present work, PROSPECT and SAILH models have been used to simulate a wide range of crop canopy reflectances in an attempt to study the sensitivity of a set of vegetation indices to green leaf area index (LAI), and to modify some of them in order to enhance their responsivity to LAI variations. The aim of the paper was to present a method for

minimizing the effect of leaf chlorophyll content on the prediction of green LAI, and to develop new algorithms that adequately predict the LAI of crop canopies. Analyses based on both simulated and real hyperspectral data were carried out to compare performances of existing vegetation indices (Normalized Difference Vegetation Index [NDVI], Renormalized Difference Vegetation Index [RDVI], Modified Simple Ratio [MSR], Soil-Adjusted Vegetation Index [SAVI], Soil and Atmospherically Resistant Vegetation Index [SARVI], MSAVI, Triangular Vegetation Index [TVI], and Modified Chlorophyll Absorption Ratio Index [MCARI]) and to design new ones (MTVI1, MCARI1, MTVI2, and MCARI2) that are both less sensitive to chlorophyll content variations and linearly related to green LAI. Thorough analyses showed that the above existing vegetation indices were either sensitive to chlorophyll concentration changes or affected by saturation at high LAI levels. Conversely, two of the spectral indices developed as a part of this study, a modified triangular vegetation index (MTVI2) and a modified chlorophyll absorption ratio index (MCARI2), proved to be the best predictors of green LAI. Related predictive algorithms were tested on CASI (Compact Airborne Spectrographic Imager) hyperspectral images and, then, validated using ground truth measurements. The latter were collected simultaneously with image acquisition for different crop types (soybean, corn, and wheat), at different growth stages, and under various fertilization treatments. Prediction power analysis of proposed algorithms based on MCARI2 and MTVI2 resulted in agreements between modeled and ground measurement of non-destructive LAI, with coefficients of determination ($r^2$) being 0.98 for soybean, 0.89 for corn, and 0.74 for wheat. The corresponding RMSE for LAI were estimated at 0.28, 0.46, and 0.85, respectively.

## Keywords

Hyperspectral; Spectral indices; Green LAI; Prediction algorithms; Chlorophyll content; Precision agriculture

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