Generating rapid and cost-effective biomass calibration/validation datasets using hyperspectral narrowbands and other non-destructive methods

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ABSTRACT:

Observation-based crop biomass is important to reliably estimate a variety of ecophysiological and phenological processes determined from remote sensing. Destructive techniques are commonly used to estimate crop biomass in the field to calibrate/validate aerial and space-borne sensor-driven crop growth models, but are time-consuming and costly. Allometric equations facilitate rapid and cost-effective estimates of crop biomass. In this study, we generate Landsat resolution areal estimates of crop biomass for four leading global crops (alfalfa, cotton, maize, and rice) using allometric equations derived from a series of *in situ* non-destructive and hyperspectral remote sensing predictors. The predictors include: 1) crop height (H); 2) canopy intercepted photosynthetically active radiation (PAR) detected from a ceptometer; 3) canopy intercepted PAR detected from red-green-blue (RGB) band photographs (F_{APAR}); and 4) ground-level hyperspectral narrowbands (HNBs) from 350 to 2500nm. The predictors are evaluated with 70-30% calibration/validation subsets and three modelling techniques: 1) two-band hyperspectral vegetation indices (HVIs); 2) multiple band-HVIs (MB-HVIs) developed from Sequential Search Methods (SSM); and 3) MB-HVIs developed from Principal Component Regression (PCR). Overall, H is the single most important determinant of biomass and is included in all of the final models, except alfalfa. For alfalfa, F_{APAR} is the single most important predictor, but this is mainly a result of the unique management of this crop. Hyperspectral predictors of biomass when combined with either H or F_{APAR} using MB-HVIs developed from SSM, yield the highest R-square values with observed biomass: 0.84, 0.59, 0.91, and 0.86 for rice, maize, cotton, and alfalfa, respectively. Two-band HVIs also provided highly significant R-square values, but were generally lower and included more predictors. Based on these results, we can in the future use HNBs and HVIs combined with simple non-destructive measures to quickly and accurately estimate crop biomass for aerial or space-borne crop model calibration/validation.

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