Remote Estimation of Net Ecosystem Carbon Dioxide Exchange in Crops: Principles, Algorithm Calibration and Validation

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Accurate estimation of spatially distributed CO2 fluxes is of great importance for regional and global carbon balance studies. Tower-based instruments provide flux data from a small footprint area and scaling beyond the footprint to the region is quite challenging. We developed a technique that relates tower-based mid-day CO2 exchange data with remotely sensed reflectances in the near infrared and either the green (around 550 nm) or the red-edge (near 700 nm) spectral ranges, to accurately estimate net ecosystem CO2 exchange (NEE) in commodity crops. The technique, which is solely based on remotely sensed data, was tested for mid-day NEE estimation in irrigated and rainfed maize and soybean during three seasons (2001 through 2003). The technique provides accurate estimations of mid-day NEE in crops, explaining more than 88% of NEE variation in maize and 86% in soybean, and shows great potential for remotely tracking crop NEE. The technique was validated by an independent data set; root mean square error in predicting mid-day NEE in the range 0-2.5 mgCm-2s-1 was 0.3 mgCm-2s-1 using NIR and red-edge bands and 0.38 mgCm-2s-1 using NIR and green bands. The developed technique will improve our understanding of how to retrieve crop ecosystem CO2 exchange synoptically. By improving the accuracy of retrievals, we will advance the understanding of regional and global carbon dynamics, reducing the uncertainties attendant to NEE estimation in crops.