ABSTRACT

ESTIMATING PLANT CANOPY TRANSPIRATION BY REMOTE SENSING UNDER NATURAL CONDITION

by

Hidenori Furuuchi

Master of Science in Environmental Science

California State University, Chico

Spring 2008

This research develops estimates of canopy transpiration using reflectance and derivative indices extracted from remotely sensed chlorophyll fluorescence measurement under natural condition. The experiment was carried out in the Big Chico Creek Ecological Reserve located in the foothills of the Sacramento Valley about 10 miles northeast of Chico, California. Diurnal changes of leaf-level gas exchange (carbon assimilation rate \( A \), stomatal conductance \( g_s \) and transpiration rate \( E \)), chlorophyll fluorescence and canopy-scale remote sensing were measured with the top canopy of valley oak (\textit{Quercus lobata}) every 20 minutes from 10:30 to 16:30 over one month (September 29\textsuperscript{th} to November 4\textsuperscript{th}). The irradiance (Photosynthetic active radiation, PAR) in the leaf chamber was coupled with the solar radiation. Soil moisture data was taken at the base of valley oak hourly.
The results indicated *Q. lobata* experienced super-saturated irradiance (PAR). The surfeit of PAR caused photoinhibition indicated by a decrease in the quantum efficiency of photosystem II \( (r^2 = 0.648 \text{ with } Fv'/Fm' \text{ and } r^2 = 0.73 \text{ with } \Phi_{PSII}) \) and open reaction center \( (qP; r^2 = 0.699) \). The excess absorbed quantum energy was dissipated as heat through Xanthophyll cycle and other processes (photorespiration and the water-water cycle) rather than energy emission as steady state chlorophyll fluorescence (Fs). An increase in leaf temperature caused by the activity of Xanthophyll cycle was associated with a decrease in Fs \( (r^2 = 0.381) \) and an increase in evaporative cooling through E \( (r^2 = 0.800) \) and water use efficiency (WUE; \( r^2 = 0.872 \)).

Estimation of Fs by remote sensing successively tracked these physiological processes. Reflectance indices, R690/R600 and \((R675xR690)/R683^2\), modified with 690 nm that was one of 2 peaks of chlorophyll fluorescence emission spectra were related with a change in quantum efficiency of PSII including \( Fv'/Fm' \), \( \Phi_{PSII} \) and \( qP \) \( (r^2 = 0.234 \text{ to } 0.356) \) that were influenced by diurnal cycle of PAR and a change in the solar zenith angle. On the other hand, derivative indices \((D705/D722, D730/D706 \text{ and } (D720-D703)/D707)\) using 720 nm the other peak of fluorescence spectra and a reflectance index, R740/R800, reflected a change in leaf temperature \( (r^2 = 0.360 \text{ to } 0.377) \) and E \( (r^2 = 0.526 \text{ to } 0.662) \) as a result of Xanthophyll cycle in terms of photochemical reflectance index (PRI: \( r^2 = 0.436 \text{ to } 0.790 \)). These indices were also found to be a good indicator of plant water content in terms of water band index \( (r^2 = 0.396 \text{ to } 0.575) \).