# Simulation of Radiative Transfer in a single leaf: Estimation of Chlorophyll Fluorescence measures by inversion of a coupled FRT and PROSPECT model

P.J. Zarco-Tejada[1], J.R. Miller[2], G.H. Mohammed[3], and T.L. Noland[3]

*[1]Centre for Research in Earth and Space Science (CRESS)*
*[2]Department of Physics and Astronomy, York University*
*[1,2]York University, 4700 Keele Street, Toronto M3J 1P3, Canada*
*[3]Ontario Forest Research Institute, Ontario Ministry of Natural Resources, Sault Ste. Marie P6A 2E5, Ontario, Canada*

## Abstract

This paper reports on quantitative results obtained with the Fluorescence-Reflectance-Transmittance (FRT) leaf radiative transfer model that simulates the chlorophyll fluorescence effects on leaf apparent reflectance. This work is a continuation of previous efforts to study such effects on vegetation apparent reflectance at different levels, leaf and canopy, and under different illumination conditions. Results from a series of laboratory measurements of spectral reflectance and transmittance of individual leaves and from a modeling study are presented which demonstrate that effects of natural chlorophyll fluorescence are observable in the red edge spectral region, and estimated using the FRT model. The coupled FRT and PROSPECT model is presented here that enables the estimation of photochemical efficiency by numerical model inversion. Measurements have been made with a Li-Cor Model 1800 integrating sphere apparatus coupled to an Ocean Optics Model ST1000 fibre spectrometer to provide two datasets for leaves with variable and constant chlorophyll content, respectively. The dataset of reflectance and transmittance from leaves with constant chlorophyll content allowed the study of chlorophyll fluorescence effects, without pigment variation, on specific fluorescence-sensitive optical indices calculated in the PS-II and PS-I optical region, such as the curvature index $(R_{675} \cdot R_{690})/(R_{683}^2)$. Dark-adapted and steady-state fluorescence measurements, such as Fv/Fm, Fm' and Ft were shown to be well estimated by model inversion of FRT+PROSPECT using experimental leaf reflectance and transmittance measurements. Ongoing research efforts deal with uncoupling the combined effects of chla+b and CF on leaf apparent reflectance.

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