Analysis of the relationship between the GPP and SIF from remote sensing data using theoretical model

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In the photosynthetic processes, a part of the excess energy is relaesed as chlorophyll fluorescence. On ecosystem-level scale, recently, it is known that the solar-induced chlorophyll fluorescence (SIF) correlates gross primary production (GPP), from both remote sensing and ground-based studies, reminding us that the GPP can be better-estimated using SIF data.

The mathematical models are a one of the tools to analyze correlation between the GPP and the SIF at leaf scale. The model, used in this study, is constructed based on the reaction kinetics and able to explain the relationship between fluorescence and photosynthesis that has been reported in previous studies. In the model, the absorption energy is divided and used in four phenomena; photochemistry, a constitutive thermal dissipation, energy-dependent heat dissipation and fluorescence emission; and the coefficients for probabilities of excitations to follow a certain pathway with K, or quantum yields with Φ are used to examine the variation of the photosynthesis efficiency for excitation light. Thus the model is directly applicable to examine the relationship of SIF to GPP. Most of the previous studies, the photosynthesis is estimated using short-term chlorophyll fluorescence data measured by pulse amplitude-modulated (PAM). Therefore, they did not examine the seasonal and annual changes of fluorescence, although the parameter values are estimated approximately.

The spectral analysis of SIF has been studied by several applications with mathematical models. In particular, PROSPECT model [Jacquemoud & Baret, 1990] derived the spectral reflectance at a single leaf using eco-physiological properties such as chlorophyll and carotenoid concentrations. FlourMODleaf model [Pedrós et al., 2010], based on PROSPECT model, is structured to predict the reflectance, transmittance, upward and downward chlorophyll emission of a leaf and to obtain the fluorescence spectrum over the solar spectrum.

In this presentation, we would like to show the first results of estimating the GPP using SIF data in Takayama broad leaf forest (TKY) site, Japan with above SIF model, and examined the seasonal and annual changes in correlation between SIF and GPP at the leaf level. Additionally, to examine the emitted fluorescence spectrum, we analyzed the spectral distribution applying the FluorMODleaf model using data set of TKY.

Keywords: Theoretical model, Phothosynthesis, Chlorophyll fluorescence