Challenging the detection of solar-induced fluorescence from lower resolution field-measured spectrum in Japan

*Naohisa Nakashima[1], Tomoki Morozumi[1], KANOKRAT BUAREAL[3], Tomomichi Kato[1], Katsuto Tsujimoto[2], Tomoko Akitsu[4], Kenlo Nasahara[4], Keisuke Ono[5], Hiroyuki Muraoka[6]

1. Research Faculty of Agriculture, Hokkaido University, 2. Graduate School of Life Sciences, Tohoku University, 3. Graduate School of Global Food Resources, Hokkaido University, 4. Faculty of Life and Environmental Sciences, University of Tsukuba, 5. National Institute for Agro-Environmental Sciences, 6. River Basin Research Center, Gifu University

Solar-induced chlorophyll fluorescence (SIF) is considered as more direct remote sensing index to monitor photosynthetic activity than conventional vegetation indices. To detect the SIF, it has been suggested that an ultrafine spectral resolution (SR; full width at half maximum: FWHM < 0.3 nm) is generally required for the usual retrieval algorithms, e.g., Fraunhofer Line Depth (FLD) principle and spectral fitting method (SFM). However, the requirement of such high SR instrument suppresses the expansion of ground-based SIF measurement sites to be comparable as eddy flux tower network. On the other hand, the long-term spectral observations over multiple ecosystem types has been conducted under Phenological Eyes Network (PEN) by relatively lower SR spectroradiometer with the FWHM of 10 nm. Recently-proposed algorithm, area-ratio FLD (aFLD; Tsujimoto et al., in submission), demonstrated the consistent scaling ratio of SIF by aFLD from low SR spectrum to those by conventional algorithms from high SR spectrum in the green house experiments. In this study, therefore, we examined the applicability of aFLD to PEN data for SIF detection under the cross-validation of calculated SIFs using both an ultrafine- and a low- SR spectroradiometer data in two ecosystems: forest and grass in Japan.
Both low and high SR spectra have been recorded by MS-700 (Eko limited inc: FWHM = 10 nm) at 10 minutes interval and by QEPro (Ocean Optics, Inc., FWHM = 0.24 nm) at 5 to 15 minutes interval, respectively, since 2019 in both Takayama deciduous broad-leaf forest site in Takayama (TKY), and Mase rice paddy field site in Tsukuba (MSE), Japan. SIF values were calculated by aFLD for low SR, and by 3FLD and SFM for high SR data at 30 min interval during the growing season from April to September. To investigate the influence of SR on SIF value, virtual spectra in same SR as MS700 were also generated from QEPro data by resampling via moving average assumed of Gaussian distribution.
To reduce the inconsistency in the data quality among instruments, our analyses were conducted on the SIF values only in stable sky condition, eliminating those in rapidly crossing cloud quantitatively with outlier, true reflectance (not contaminated by fluorescence) of less than 0.4 and more than 0.8 calculated from QEPro, and/or with captured cloud passing visually by an automatic-capturing digital fisheye camera (ADFC).
In TKY site, the SIF values obtained from low SR by aFLD showed a strong correlationship with the reference SIF obtained from high SR by 3FLD (r^2 = 0.706, slope = 0.269). Although correlation coefficient between aFLD from low SR and SFM from QEP was still low (r^2 = 0.389), the slope of liner equation (= 0.130) was within the same range between 0.120 and 0.130.
This result suggested that we can easily obtain accurate values using a scaling factor although its absolute values of the retrieved SIF are higher than correct values. The analysis on the data in MSE site would be added on presentation day.

Keywords: Solar-induced chlorophyll fluorescence, Remote sensing, Spectral resolution

