Sun-induced chlorophyll fluorescence reveals strong representativeness of ecosystem-level photosynthesis in rice paddy field in Mase Japan

*Tomomichi Kato[1], Katsuto Tsujimoto[2], Kenlo Nasahara[3], Tomoko Akitsu[3], Keisuke Ono[4], Akira Miyata[4]

1.Research Faculty of Agriculture, Hokkaido University, 2.Graduate School of Agriculture, Hokkaido University, 3.Faculty of Life and Environmental Sciences, 4.National Institute for Agro-Environmental Sciences

Chlorophyll fluorescence emission from ecosystem induced by sunlight (Sun-Induced Fluorescence: SIF) is now a key factor to accurately estimate the ecosystem-level photosynthesis activity as suggested by satellite studies, and has been recently detected by satellites [Frankenberg et al., 2011; Guanter et al., 2012; Joiner et al., 2013] and measured at field stations [Daumard et al., 2010; Porcar-Castell, 2011]. However, the few example of field-based assessment on the representation ability reduces its value for the availability to better understand the dynamics in CO_2 uptake by land ecosystem.
To elucidate the potential of SIF to estimate ecosystem GPP in typical Asian crop type, the canopy-top SIF was calculated from the spectrum data in Japanese rice paddy field in Mase in central Japan (36°03′N, 140°01′E, 11 m a.s.l.), and compared with eddy-tower measured GPP on half-hourly and daily bases during seven years from 2006 to 2012. The rice (Oriza sativa L.; cultivar Koshihikari) was transplanted in May and harvested in September normally. The SIF was estimated from the spectrums of downward Sun irradiance and upward canopy-reflected irradiance measured at the height of 3m above ground by HemiSpherical Spectro-Radiometer (HSSR), consisting of the spectroradiometer (MS-700, Eko inc., Tokyo, Japan) with the full-width at half maximum (FWHM) of 10 nm and wavelength interval of 3.3 nm. The SIF around 760nm (O2-A band: SIF_{760}) was calculated according to the Fraunhofer Line Depth principle [Maier et al., 2003] with several additional arrangements.
The GPP increased almost linearly as both SIF_{760} and APAR (Absorbed Photosyntethically Active Radiation) increased based on monthly-averaged diurnal courses during the growing season in 2006. The slopes of their regression lines differed much among the months in APAR, but in SIF_{760}. These nearly constant relationships among the months between GPP and SIF_{760} were kept for all the observation years. Daily averaged GPP and SIF_{760} indicated similar seasonality for multiple years although the conventional vegetation indices, NDVI and EVI, showed the smoothed temporal variations but with longer maximum period than GPP showed. Thus, those strong relationships of SIF to GPP confirmed that the SIF is a quite useful proxy of ecosystem-level photosynthesis in the rice paddy field.

Keywords: spectroradiometry, remote sensing, carbon cycle

