Solar-induced Chlorophyll Fluorescence for Detecting Ecosystem Photosynthetic Activity by High-resolution Spectrum Measurement in a Paddy Field in Japan

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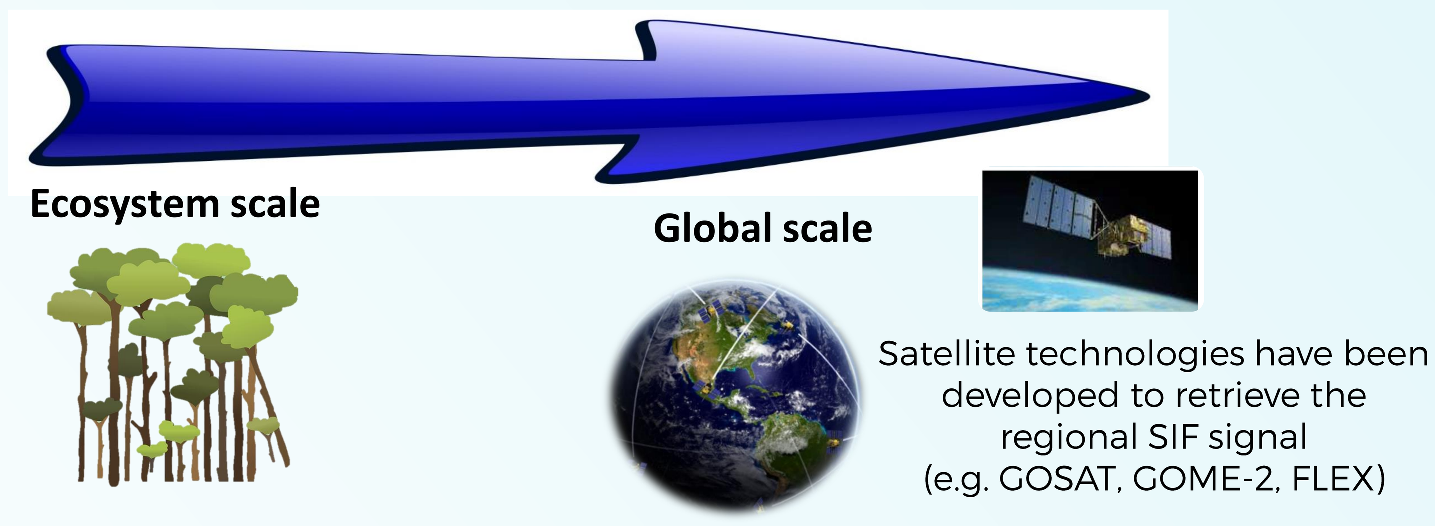
Abstract

Solar-Induced Chlorophyll fluorescence (SIF) at the canopy and global scale by satellite have been found the high correlation with photosynthesis and/or GPP (gross primary productivity). However, the ground-based measurement of SIF need to be validated. In this study. the high-resolution spectrum for SIF detection was measured at the Mase eddy flux site, Tsukuba, Japan. The study area is a rice paddy field, which is a main Asia crop type. The spectrum was measured from April to December in 2018 using five spectroradiometers; FLAME, HR4000 x 2, QE Pro x 2 (Ocean Optics, Dunedin, FL, USA). The interval time for record the irradiance is every with 5 minutes. The spectroradiometers were connected via fiber switches to three optical fiber cables, which detected the radiance from the sunlight and irradiance reflected from paddy field. The SIF was calculated by multispectral methods derived from the Fraunhofer Line Depth (FLD) principle, 2FLD and 3FLD, In this study, the preliminary results of SIF detection are shown in diurnal and seasonal change, which SIF signal is a promising proxy of photosynthesis tracking in the paddy field ecosystem..

Introduction

The terrestrial ecosystem is the main sink of carbon storage through plant photosynthesis which can be expressed as gross primary productivity (GPP). Accurate tracking of photosynthesis in the ecosystem level is essential because it is involved in global carbon cycling and the carbon balance between land and atmosphere. Recently, Solar-Induced Chlorophyll fluorescence (SIF) has been used for tracking changes in plant photosynthesis at the global scale by satellite. However, the coarser spatial-temporal scale by satellite needs to be validated by performing a **ground-based SIF assessment** to better understand the dynamics of CO2 uptake by plants.



Objectives

To evaluate how the paddy field ecosystem would contribute SIF emission at ground-based measurement with different five kinds of spectroradiometers

Study Site

Location	Tsukuba, Ibaraki, Japan
Position	36.05°N, 140.03°E
Elevation	11 m ASL
Mean air temperature	13.7 °C
Mean precipitation	1200 mm
Vegetation type	rice paddy field (*Oryza sativa* L.; cultivar Koshihikari)
Planting period	Early-May →Transplanting seedlings Mid-September → Harvesting crop

Materials &Methodology

Spectroradiometer	Wavelengths (nm)	Pixels	SSI (Dispersion : nm/pixel)	FWHM (nm)	O2-A band Abs.	O2-B band Abs.
FLAME	399-1016	2048	0.33	0.66	✓	-
HR4000 (Wide range)	435-877	3648	0.12	0.24	✓	-
HR4000 (Narrow range)	628-823	3648	0.05	0.11	✓	-
QEPRO2081 (O2-B)	719-775	1044	0.05	0.23	-	✓
QEPRO2082 (O2-A)	668-735	1044	0.06	0.27	✓	-

Materials &Methodology

The spectrum was measured from April to December in 2018 using five spectroradiometers; FLAME, HR4000 x 2, QE Pro x 2 (Ocean Optics, Dunedin, FL, USA) with 0.11-0.66 nm of the full-width at half maximum (FWHM). For recording the irradiance with 5 minutes interval time, the spectroradiometers were connected via fiber switches (FSM1x8, Piezosystem Jena GmbH, Jena, Germany, and MOL-1x8-600-H, LEONI Fiber Optics GmbH, Föritztal, Germany) to three optical fiber cables:

- The first one was vertically set looking upward to the sky with cosine corrector (FOV of 180°, cable length of 6m).
- The second one was set looking downward at a viewing zenith angle of 45° as bare fiber (field of view (FOV) of 25°, cable length of 15m),
- the third one was vertically set looking downward with cosine corrector (FOV of 180°, cable length of 15m), and

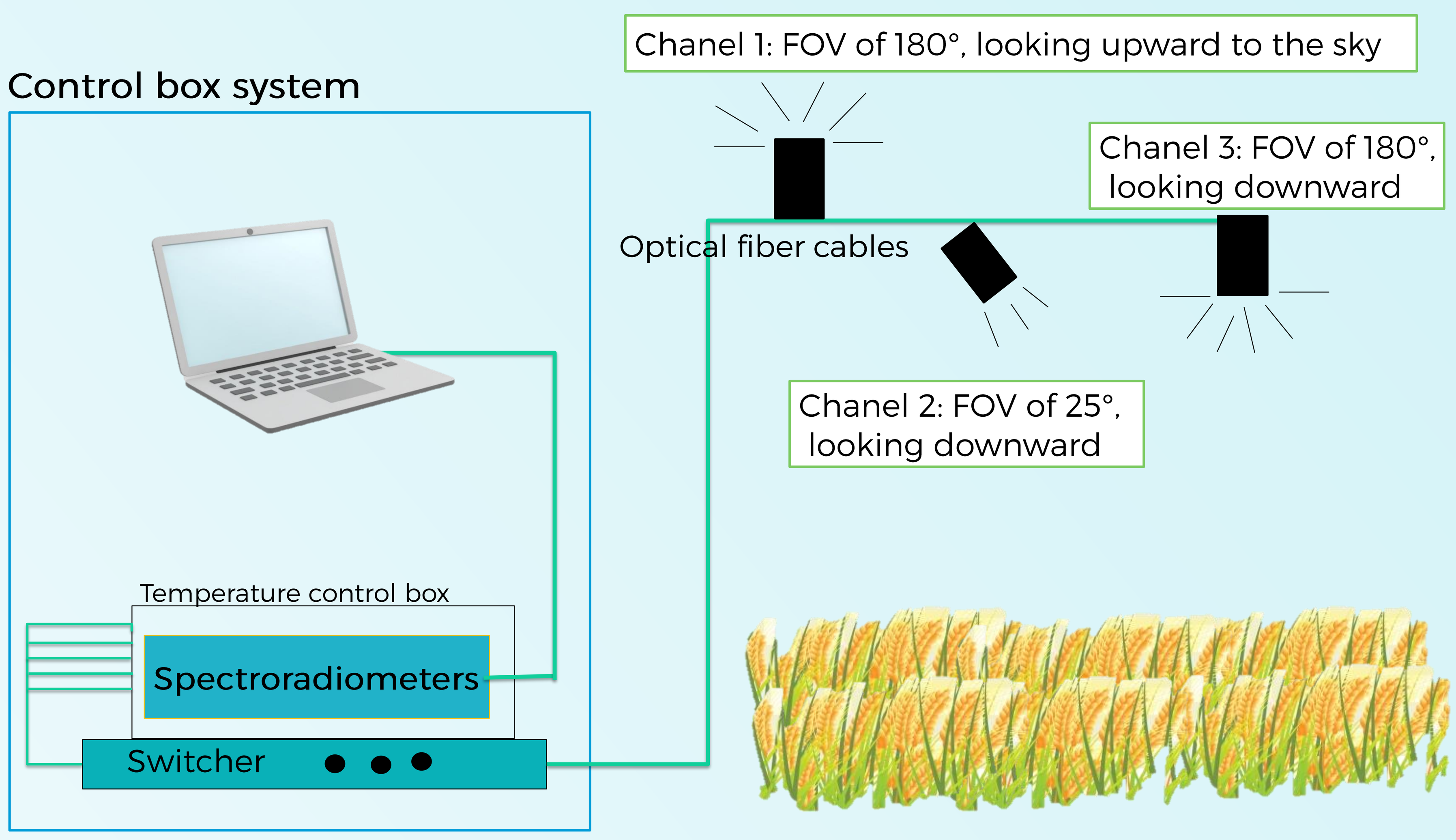


Figure 1. The Experimental system

Results

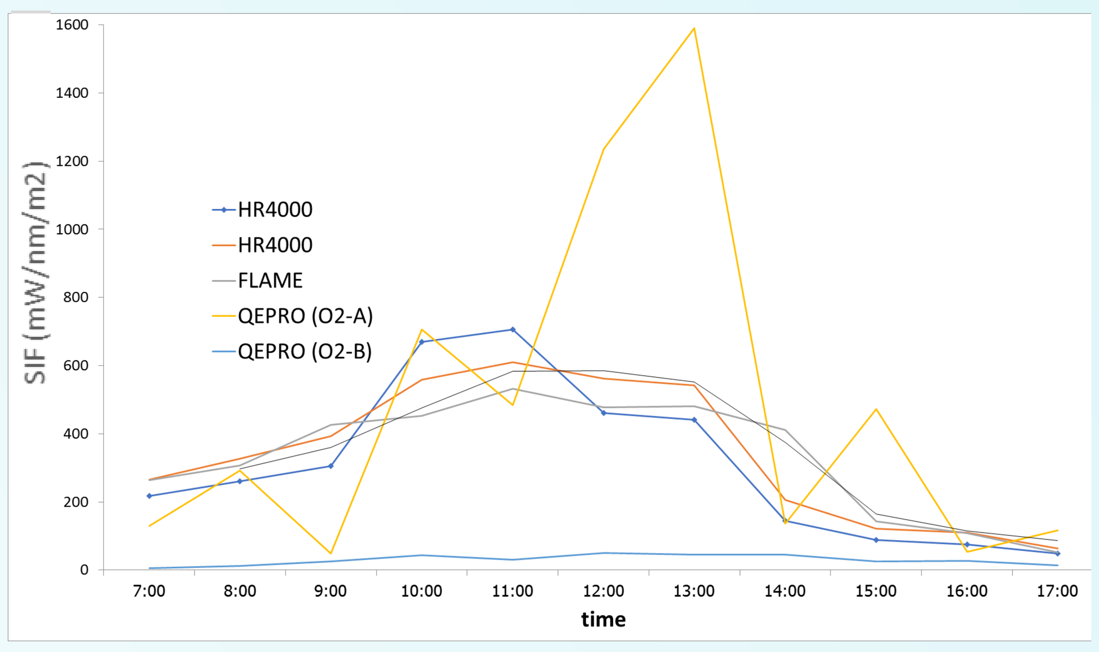


Figure 2. The diurnal change of detected SIF from 5 spectroradiometers during 7.00-17.00 on 15th June, 2018

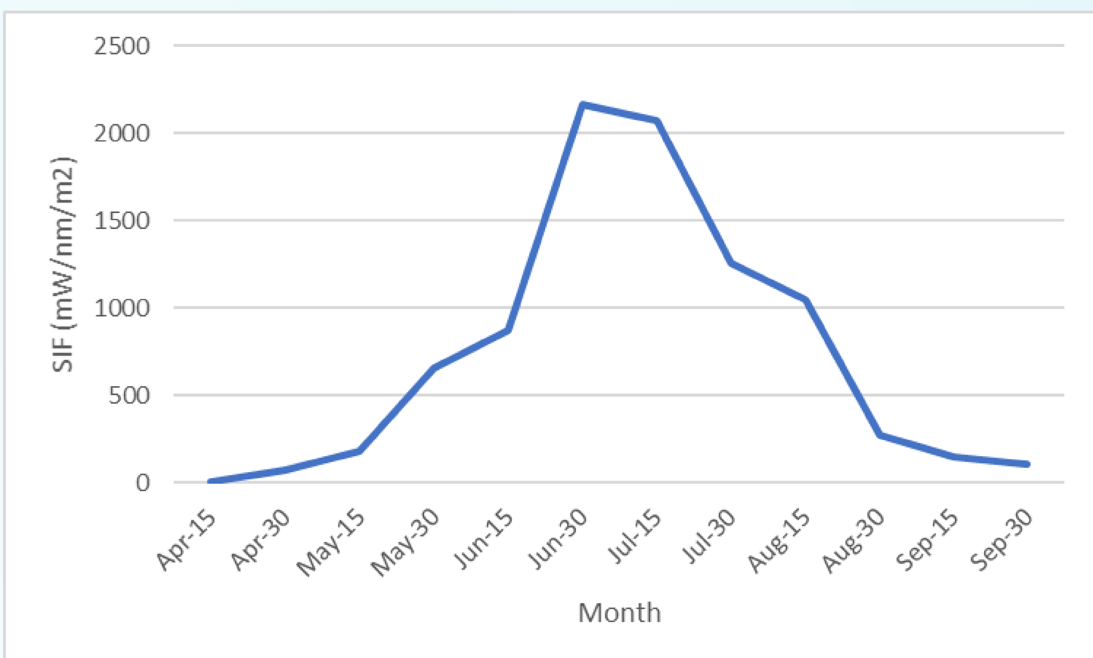


Figure 3. The seasonal change of detected SIF from HR4000 (wide range) during 11.00-13.00

The dynamic of diurnal and seasonal changes of SIF from various five spectroradiometers has the similar pattern. Moreover, SIF results also showed the similar trend with Absorbed photosynthetically active radiation (APAR)