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Bi-Directional Fluorescence Distribution and its Correction for Estimates of Gross Ecosystem Productivity and Photosynthetic Light-Use Efficiency

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Passive measurement of solar-induced chlorophyll fluorescence (SIF) presents a new way for directly estimating the photosynthetic activities. In this study, one diurnal multi-angular spectral experiment and three independent diurnal flux experiments were carried out on winter wheat and maize to assess directional emission of SIF for estimating photosynthesis activities. Firstly, the Bi-Directional Fluorescence Distribution Function (BFDF) of SIF was investigated. A BFDF shape similar to the red Bi-Directional Reflectance Distribution Function (BRDF) was observed for the directional SIF emissions at 688 nm. Secondly, the relationship between the directional emission of canopy SIF and BRDF reflectance was examined, finding a strict linear correlation between SIF and reflectance at 688 nm, with an R2> 0.80 for all seven BRDF observations on winter wheat. Then, a BFDF correction model for the canopy SIF at 688 nm was presented by dividing by the canopy reflectance, and about 65.3% of the directional variation was successfully removed. Finally, the BFDF-corrected SIF signals were linked to photosynthetic activities, including gross ecosystem productivity (GEP) and photosynthetic light-use efficiency (LUE), and the determination coefficients between photosynthetic activities and the BFDF-corrected SIF increased for most cases. For GEP, the determination coefficients were slightly improved from 0.563, 0.382, and 0.613 (for raw SIF signals) to 0.592, 0.473, and 0.640 for all three diurnal experiments. For LUE, the determination coefficients increased from 0.393, and 0.358 to 0.517, and 0.528 for two experiments, while deceased slightly from 0.695 to 0.607 for one experiment. Therefore, according to the above preliminary results, the canopy SIF cannot be regarded as isotropic, and the directional emission SIF may be an important uncertainty in estimates of GEP and LUE.