Geophysical Research Abstracts
Vol. 21, EGU2019-12814, 2019
EGU General Assembly 2019

Disentangling canopy structure and leaf physiology contributions to far-red sun-induced chlorophyll fluorescence and studying their relationships to photosynthesis

Benjamin Dechant (1), Youngryel Ryu (1), Grayson Badgley (2), Yelu Zeng (2), Joseph A. Berry (2), Yongguang Zhang (3), Zhaohui Li (3), Qian Zhang (3), Yves Goulas (4), Ji Li (3), Minseok Kang (5), and Ismaël Moya (4)

(1) Research Institute of Agriculture and Life Sciences, Seoul National University, Republic of Korea, (2) Dept. of Global Ecology, Carnegie Institution for Science, Stanford, CA, USA, (3) International Institute for Earth System Sciences, Jiangsu Provincial Key Laboratory of Geographic Information Science and Technology, Nanjing University, Nanjing, China, (4) Dynamic Meteorology Laboratory, Ecole Polytechnique, Palaiseau, France, (5) National Center for AgroMeteorology, Seoul, Repubic of Korea

Sun-induced chlorophyll fluorescence (SIF) has recently become an important topic in large scale photosynthesis research. This is mainly related to the selectivity of SIF for vegetation on the one hand and the close mechanistic relationships to photosynthesis on the other hand. The latter, however, is already nonlinear at the leaf level and further complicated by the canopy scattering of far-red SIF. This scattering process, which is strongly affected by the structure of the canopy, results in only a fraction of SIF photons emitted at the leaf-level to escape the canopy. The challenge for canopy-level SIF research is therefore to disentangle the contributions related to canopy structure and leaf physiology. While it is widely assumed that the latter has the stronger relationship to photosynthesis, this has not been tested experimentally at the canopy scale so far.

We used a recently developed approach to estimate the canopy escape probability of far-red SIF to analyze the contributions of canopy structure and leaf physiology separately. For this, we conducted a combined analysis for three in-situ datasets from a rice paddy, a wheat and a corn field that all had fPAR, PAR, far-red SIF, GPP and canopy reflectance observations covering most of the growing season. Our analysis focused on half-hourly observations both at the level of fluxes involving the absorbed radiation as well as at the level of light use efficiencies, which excludes the radiation component.

We found that canopy structure effects dominated the seasonal component of the SIF escape probability and that this was the cause of a positive correlation of the latter to photosynthetic light use efficiency. The estimated total SIF yield of all leaves in the canopy, in contrast, was dominated by diurnal variations and was almost entirely uncorrelated to photosynthetic light use efficiency. Furthermore, our findings confirm the strong relationships between NIRv to both SIF and GPP at short time scales and the site level that were previously only reported at large spatial and long temporal scales. Thus, our findings bridge gaps between spatio-temoral scales and challenge the widely held assumption that the leaf physiology component in SIF provides most of the additional information for photosynthesis estimation that goes beyond APAR. We think that our approach has the potential to unify previous findings into a coherent picture that could enable the community to more easily identify the advantages and limitations of different methods of estimating GPP from remotely sensed observations.