ON CORRECTING THE EFFECT OF SUN-SENSOR GEOMETRY ON SOLAR-INDUCED CHLOROPHYLL FLUORESCENCE MEASUREMENTS: A STUDY USING NUMERICAL SIMULATION AND SATELLITE OBSERVATION DATA

Haruki Oshio
School of Environment and Society, Tokyo Institute of Technology
4259-J3-24, Nagatsuta-cho, Midori-ku, Yokohama 226-8503, Japan
Email: oshio.h.aa@m.titech.ac.jp

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Satellite remote sensing of solar-induced chlorophyll fluorescence (SIF) has been used to improve the estimation accuracy of photosynthesis activity of terrestrial vegetation in recent years. Care must be taken in the interpretation of the spatiotemporal variation of observed SIF because the positional relationship between the satellite, the sun, and the target object affects the observed SIF value independently of the vegetation conditions. This has been pointed out in previous studies, and methods have been proposed to correct the effect of sun-sensor geometry using readily available satellite data products such as normalized difference vegetation index (NDVI). Such methods are simple and convenient; however, their applicability and how effective they are in correcting actual observation data have not fully been elucidated. Here, we investigated the validity of the simple correction method using radiative transfer simulation and satellite observation data.

For radiative transfer simulation, the FLiES-SIF model (Sakai et al., 2020) was used, which can take the three-dimensional geometry of individual trees into account. Three-dimensional data representing typical structures for various forest types (Yang et al., 2018) were used as input. Observations at various solar and viewing angles were simulated with different forest parameters. The results were used to investigate the applicability of the simple correction method proposed by Zeng et al. (2019). The simple method estimates the escape ratio (ratio of the observed SIF to the total SIF emitted from all leaves within the observation footprint) using physical quantities that can be estimated from satellite observation data: NDVI, reflectance in the near-infrared region, and the fraction of absorbed photosynthetically active radiation. It was discussed under what conditions the simple method would be effective.

The satellite-derived SIF data was analyzed over the Amazon rainforest where the tree density is high and the simulation results predicted that the correction would be effective. Data satisfying all the following criteria were used: (1) ratio of pixels with landcover of evergreen broadleaf forest ≥ 0.8, (2) ratio of pixels with valid NDVI value ≥ 0.8, (3) cloud fraction ≤ 0.2, and (4) phase angle between the sun and observation directions $\geq 10°$. MODIS products were used for land cover and NDVI data. The SIF data were divided into two groups, one with observation time around 13:00 local time and the other around 14:00 local time, and the seasonal variation was examined in each group. Even though NDVI and leaf area index were similar in both groups, SIF around 14:00 was always greater than SIF around 13:00, and the difference increased in October. The increase in SIF seemed unnatural given the vegetation characteristics of the site and meteorological conditions at the time. This increase was attributed to the increase in SIF around 14:00 due to the decrease in the phase angle (approaching the hot spot). The SIF yield (ratio of total SIF to the absorbed PAR) was calculated using the estimated escape ratio. The difference in SIF yield between different times was very small. For both observation times, in the dry season in the southern area, where there was a clear reduction in atmospheric and soil moisture, SIF decreased, suggesting a link to photosynthetic activity.

References

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