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Short Communication

Opportunities and challenges of applications of satellite-derived sun-induced fluorescence at relatively high spatial resolution

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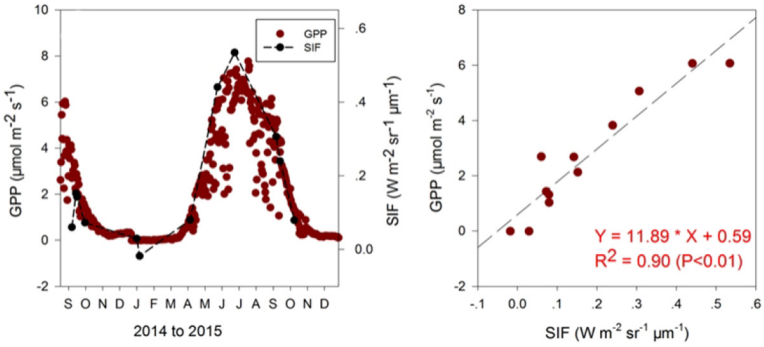
HIGHLIGHTS

- Satellite-derived SIF at relatively high-resolution advanced our estimations of GPP.
- For the 215 EC sites, the average times of OCO-2 passing through were 3.21 per year.
- Strong correlations between OCO-2 SIF and GPP were found in a mixed forest.
- Opportunities and challenges of applying the emerging OCO-2 SIF were discussed.

GRAPHICAL ABSTRACT

The seasonal trajectories and relationships of GPP and OCO-2 SIF at an EC site in a mixed temperate forest (US-PFa) from 2014 to 2015.



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ABSTRACT

Estimating gross primary production (GPP) regionally and globally remains challenging despite its primary role in driving ecosystem productivity and carbon cycling. Recently, satellite-derived sun-induced fluorescence (SIF) provides an alternative approach to investigate GPP from space. However, our ability to apply SIF to estimating GPP at large scales is still lacking, primarily because the SIF-GPP relationships at various spatial and temporal scales are not fully understood. The coarse spatial representativeness (around 0.5° or coarser) of previous satellite-derived SIF data makes it difficult to compare and validate with eddy covariance (EC) based GPP measurements. Orbiting Carbon Observatory-2 (OCO-2) has shown prospects in providing SIF at significantly improved spatial resolutions (around 1.3 km by 2.25 km) that are comparable to ground-based GPP measurements. However, OCO-2 operates at a 16-day revisiting schedule with a sparse spatial sampling strategy. We found that for most EC sites, the observations of OCO-2 passing through were extremely limited. The average number of successfully retrieved SIF by OCO-2 encompassing each site within a year was only 3.21 from 2015 to 2016. For an EC site with high companion OCO-2 coverages, we found a strong correlation between GPP and SIF. Despite challenges, the emerging high-spatial-resolution SIF data provide unprecedented opportunities to estimate GPP over time and space and its underlying mechanism. We recommend that to fully use the satellite-derived SIF data, a research agenda is critically needed to improve our understanding of the relationship between SIF and GPP across biomes, ecosystems, and even species. We advocate maintaining and upgrading current EC sites and adding ground-based SIF measurements to provide another scale of SIF observations. We also suggest

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constructions of new EC sites taking into consideration the scientific benefits that can be gained by locating sites within the belts within OCO-2 or other satellite-derived SIF missions.

Investigating photosynthesis of terrestrial vegetation remains challenging despite its primary role in driving ecosystem productivity and its importance towards understanding the global carbon cycle (Beer et al., 2010). Over the past decades, remotely sensed estimations of the photosynthetic potential of the global vegetation based on vegetation indexes (VIs) have been reported (Piao et al., 2013; Richardson et al., 2012; Turner et al., 2006; Yuan et al., 2010). For vegetation where the greenness and carbon uptake were strongly connected, reflectance-based retrievals of VIs provided accurate estimates of the seasonality of the gross primary productivity (GPP). Most VIs, however, reflects canopy structure rather than the photosynthetic capacity, an ecosystem function that changes with ecosystem types, the environment, and over time. Thus, the VIs-based estimations of photosynthesis show a strong uncertainty on different spatial and temporal scales and rarely represent the interannual variability (Gamon et al., 2015).

Recently, global consistent measurements of satellite-derived sun-induced fluorescence (SIF) that are deemed to directly represent photosynthesis processes provide an alternative approach to investigate GPP

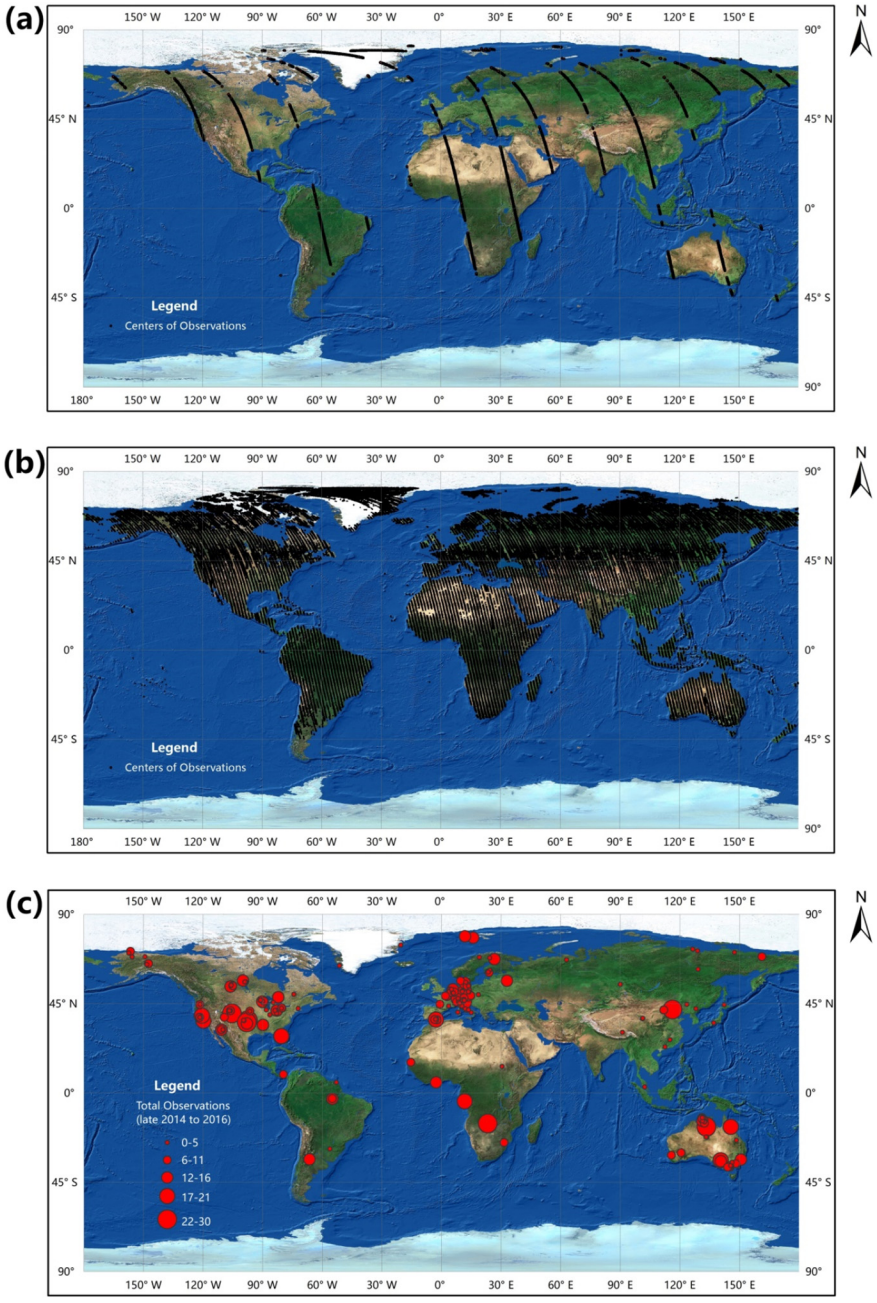

Fig. 1. OCO-2 observation swaths information. (a) OCO-2 observation swaths on July 31, 2016; (b) the coverages of OCO-2 from August 1 to September 1, 2016 that consist of two complete revisiting schedules; (c) the times of observation of OCO-2 over Fluxnet sites from late 2014 to 2016. All figures were generated using ArcMap 10.2 (www.esri.com).