A global spatially contiguous solar-induced fluorescence (CSIF) dataset using neural networks

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ABSTRACT (ENGLISH)

Satellite-retrieved solar-induced chlorophyll fluorescence (SIF) has shown great potential to monitor the photosynthetic activity of terrestrial ecosystems. However, several issues, including low spatial and temporal resolution of the gridded datasets and high uncertainty of the individual retrievals, limit the applications of SIF. In addition, inconsistency in measurement footprints also hinders the direct comparison between gross primary production (GPP) from eddy covariance (EC) flux towers and satellite-retrieved SIF. In this study, by training a neural network (NN) with surface reflectance from the MODerate-resolution Imaging Spectroradiometer (MODIS) and SIF from Orbiting Carbon Observatory-2 (OCO-2), we generated two global spatially contiguous SIF (CSIF) datasets at moderate spatiotemporal (0.05 4-day) resolutions during the MODIS era, one for clear-sky conditions (2000–2017) and the other one in all-sky conditions (2000–2016). The clear-sky instantaneous CSIF ($CSIF_{clear\text{-}inst}$) shows high accuracy against the clear-sky OCO-2 SIF and little bias across biome types. The all-sky daily average CSIF ($CSIF_{all\text{-}daily}$) dataset exhibits strong spatial, seasonal and interannual dynamics that are consistent with daily SIF from OCO-2 and the Global Ozone Monitoring Experiment-2 (GOME-2). An increasing trend (0.39 %) of annual average $CSIF_{all\text{-}daily}$ is also found, confirming the greening of Earth in most regions. Since the difference between satellite-observed SIF and CSIF is mostly caused by the environmental down-regulation on SIF_{yield}, the ratio between OCO-2 SIF and $CSIF_{clear\text{-}inst}$ can be an effective indicator of drought stress that is more sensitive than the normalized difference vegetation index and enhanced vegetation index. By comparing $CSIF_{all\text{-}daily}$ with GPP estimates from 40 EC flux towers across the globe, we find a large cross-site variation (c.v. = 0.36) of the GPP–SIF relationship with the highest regression slopes for evergreen needleleaf forest. However, the cross-biome variation is relatively limited (c.v. = 0.15). These two contiguous SIF datasets and the derived GPP–SIF relationship enable a better understanding of the spatial and temporal variations of the GPP across biomes and climate.

DETAILS

Subject: Temporal resolution; Datasets; Ecosystems; Chlorophylls; Daily; Vegetation; Drought; Neural networks; Primary production; Eddy covariance; Chlorophyll; Resolution; Ozone; Towers; Training; Fluorescence; Reflectance; Covariance; Terrestrial ecosystems; Temporal variations; Satellite observation; Spectroradiometers; Photosynthesis; Greening; Satellites; Data sets; Ozone monitoring; Environmental regulations; Pollution monitoring; Spatial discrimination; Slopes (topography); Terrestrial environments; Imaging techniques; Dynamics; Droughts; Global ozone; Vegetative index; Earth; MODIS; Vegetation index

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