Geophysical Research Abstracts
Vol. 21, EGU2019-12877, 2019
EGU General Assembly 2019

An optimized high spatial resolution fluorescence dataset to better understand terrestrial ecosystem dynamics of productivity

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Mapping and monitoring the spatial and temporal patterns of gross primary productivity (GPP) through the use of satellite remote sensing is of paramount interest to enhance our understanding of terrestrial ecosystem dynamics. While the rate of terrestrial photosynthesis cannot be directly measured from space, research in the last years has demonstrated that sun-induced chlorophyll fluorescence (SIF) retrieved from satellite spectrometers can be a highly valuable proxy. However, the SIF signal is very small and notoriously difficult to measure, requiring high spectral resolution and signal-to-noise ratio, which generally comes at the expense of revisit frequency and spatial detail. As a result, current SIF datasets with decently long time series, such as the widely used GOME-2 data, have a spatial resolution on the order of 0.5° (approximately 50 km), which is too coarse for many applications in land science. While new and future missions will provide information at finer spatio-temporal scales, this doesn't solve the issue for the past for which the longest possible archive is necessary.

By leveraging on a proven downscaling methodology, here we provide an optimized SIF dataset at a 0.05° (approximately 5 km) spatial resolution covering the period 2007-2018 with a revisit frequency of 8 days. The increase in spatial resolution of the original GOME-2 SIF retrieval is obtained by locally constraining a light use efficiency (LUE) modelling approach at every time step based on different explanatory biophysical variables (LST, NDWI, NIRv) derived at the finer spatial resolution from other satellite instruments (namely MODIS Aqua and Terra). By adopting this modelling approach, we ensure that this data-driven downscaling follows physical constraints based on our physiological understanding of the relationships between GPP, radiation, water availability and temperature, unlike other approaches based on purely empirical machine learning techniques. An exhaustive validation of the downscaled product is done based on yet another satellite, OCO-2, which provides SIF at fine resolution (∼3 km2) but with a very sparse and discontinuous spatial sampling scheme for the period 2015-2017.

To illustrate the value of this new dataset for improving our understanding of the dynamics in terrestrial ecosystem productivity, we further analyse it for distinct plant functional types across various gradients of environmental variables (temperature, radiation, precipitation). This enables the characterization of ecosystem response functions in terms of SIF to environmental drivers and stresses, which should further lead to potential improvements of global vegetation models.