

Abstract

Quantification of the impact of stress on terrestrial plant photosynthetic rates at the global scale is crucial for understanding the global carbon cycle, especially under a changing climate. Vegetation responses to stress can manifest first as plant physiological responses, and at later stages through changes in canopy structure. In this study we assess whether Solar Induced Fluorescence (SIF), as observed by instruments on board of satellites, can adequately capture both of those responses.

Methods

Data

The data we used for this study include:

- Temperature, precipitation, radiation, relative humidity and soil moisture from the ERA5 reanalysis.
- Gross Primary Productivity (GPP) estimated from Eddy Covariance measurements, from the FluxNet2015 Dataset.
- Satellite retrievals of solar induced chlorophyll fluorescence (SIF) from the GOME-2 and OCO-2 missions.
- SIF reconstructions based on optical vegetation indices, climate reanalysis and SIF retrievals from the GOME-2 and OCO-2 missions.
- Enhanced Vegetation Index (EVI), Normalized Difference Vegetation Index (NDVI) and Near-Infrared Reflectance of Vegetation (NIRv) retrieved using the AQUA and TERRA MODIS sensors.

Methods:

- Comparison between in-situ GPP and satellite SIF monthly z-score anomalies.
- Estimation of the sensitivities of GPP, and SIF anomalies to climate anomalies using a linear model $Y_z = \sum_{i=1}^n a_i X_{z_i}$ (Y_z : GPP or SIF anomalies, X_{z_i} : soil moisture, temperature, radiation and relative humidity anomalies)

All analyses were performed at a 16-day temporal scale and a 0.5° spatial scale.

Results

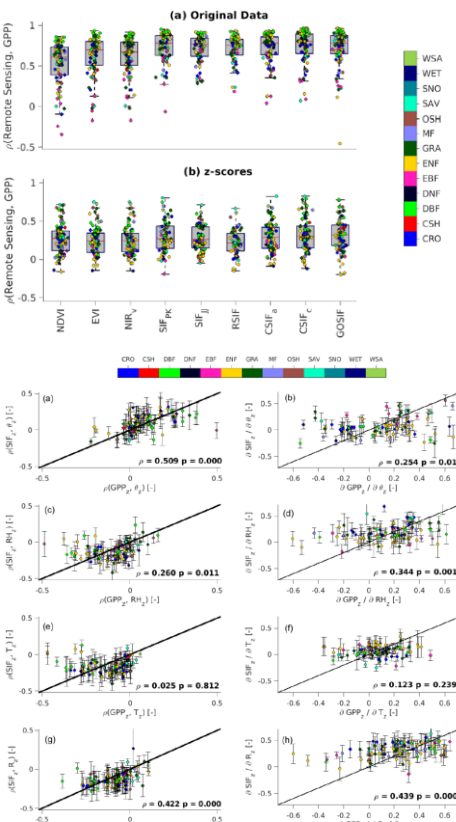


Fig 3: Comparison between the sensitivity of eddy covariance GPP anomalies and SIF anomalies on climate anomalies

Take Home Messages

- Satellite SIF retrievals anomalies have a low correlation with in-situ observations, even at a coarse 16-day scale.
- Climate anomalies explain a very small fraction of SIF anomalies, particularly in the tropics where satellite SIF retrievals can have low quality problems.
- SIF anomalies show similar sensitivities to climate as traditional vegetation indices, particularly in water limited ecosystems, likely due to high sensitivity in changes in vegetation structure.

Fig 1: Comparison between eddy covariance GPP anomalies and SIF and vegetation index anomalies for all FLUXNET 2015 sites

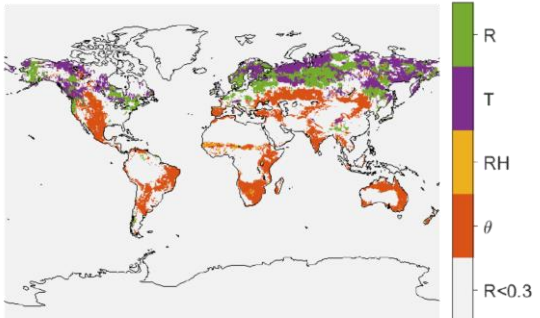


Fig 2: Variable with the most explanatory power for explaining SIF monthly anomalies according to the linear model

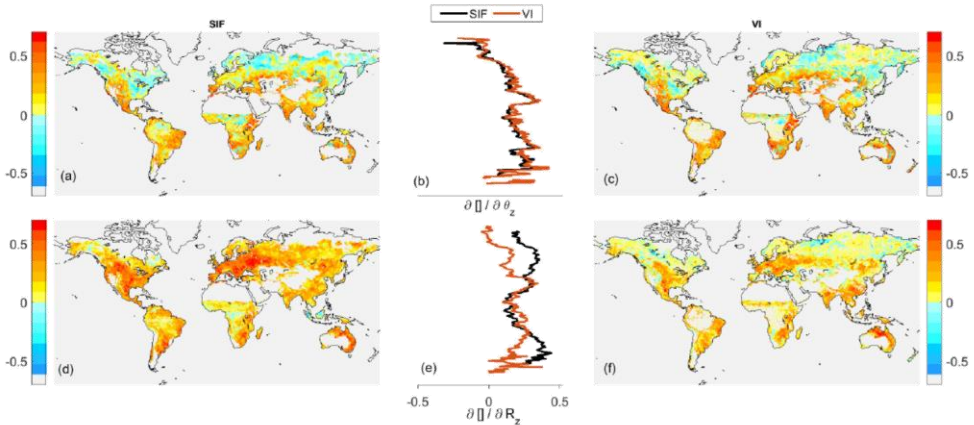


Fig 4: Comparison between the sensitivities of SIF and vegetation index anomalies vs soil moisture and radiation anomalies. Soil moisture refers to the soil depth with the highest explanatory power. Grey areas show a model $R^2 < 0.3$