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A global 2007-2015 spaceborne sun-induced vegetation fluorescence time series evaluated with Australian flux tower observations

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The Gross Primary Production (GPP) of the terrestrial biosphere is a key quantity in the understanding of the global carbon cycle. GPP is the amount of atmospheric carbon fixed through the process of plant photosynthesis and it represents the largest ecosystem gross flux of CO_2 between the atmosphere and the Earth surface.
To date, monitoring of GPP has not been possible at scales beyond that of a single agricultural field or natural ecosystem. At those scales, networks of eddy-covariance towers provide a platform to measure Net Ecosystem Exchange (NEE) of carbon at high temporal resolution, although with only sparse spatial coverage. Satellite observations can bridge that gap by providing the spatial distributions and changes over time of vegetation-related spectral indices. These “greenness indicators”, however, tend to return the potential carbon uptake by plants rather than the actual uptake since short term environmental changes affecting plant productivity (e.g., water availability, temperature, nutrient deficiency, diseases) are not well captured. Sun-induced plant fluorescence (SiF), however, is tightly related to photosynthetic activity in the red and near-infrared wavelength range, and SiF can be retrieved from spaceborne measurements from sensors with good signal-to-noise ratios and fine spectral resolutions.
We use optical data from the Global Ozone Monitoring Instrument 2 (GOME-2A) satellite sensor to infer terrestrial fluorescence from space. The spectral signatures of atmospheric absorption, surface reflectance, and fluorescence radiance are disentangled using reference hyperspectral data of non-fluorescence surfaces (desserts) to solve for the atmospheric absorption. An empirically based principal component analysis (PCA) approach was applied.
Here we show a global 2007-2015 times series of sun-induced vegetation fluorescence derived from GOME-2A observations which we have compared with GPP data derived from twelve Net Ecosystem Exchange flux tower measurements in Australia. Correlations for individual towers range from 0.37 to 0.84. They are particularly high for managed biome types. Furthermore, we show that deseasonalized Australian SiF time series are able to clearly indicate the break of the Millennium Drought during the local summer of 2010/2011. It illustrates the strong potential of SiF data to monitor vegetation activity in relation with meteorological anomalies which may have impact on the ecosystem carbon budget and thus affect our climate at the long range.