HORIZON 2020

Remotely quantifying vegetation productivity: exploiting sun-induced fluorescence-photosynthesis relationships through field and modelling methods

Sprawozdania

Informacje na temat projektu

FLUOPHOT

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Podsumowanie kontekstu i ogólnych celów projektu

The consequences of global change will largely depend on the future trajectory of primary productivity on Earth, being a critical driver in setting the upper limits of the planet's carrying capacity. Earth observation is one of the most powerful tools available to assess the functioning and productivity of the Earth's vegetation in response to its environment. This functioning and productivity in the biosphere are mainly driven by photosynthesis, the critical reaction sustaining life on Earth by converting atmospheric carbon into biomass.
Currently, it is not possible to measure the actual photosynthetic activity of the vegetation remotely. However, current improvements in Earth Observation technology allow the detection of a signal emitted directly from the photosynthetic machinery of plants: the sun-induced chlorophyll fluorescence (SIF). Due to latest imaging spectrometry the retrieval of SIF became a novel research area aiming at mapping SIF from a site-specific scale towards a global scale. The Fluorescence Explorer (FLEX) proposed within the European Space Agency's (ESA) series of 'Earth Explorer' satellite missions will be launched in 2022 and detect terrestrial SIF. Flying in tandem with Sentinel-3, FLEX will take advantage of its optical and thermal sensors which will lead to an integrated package of measurements to assess plant health.
However, still some efforts are required for establishing well-funded relationships between SIF and photosynthesis under different plant physiological states. For this, FLUOPHOT's main objective were to further improve the accuracy of plant productivity based on the remote SIF retrieval by establishing relationships between SIF emission and photosynthetic activity under different physiological plant conditions. An important knowledge deficit is the link between SIF and regulated protection mechanisms, a third energy dissipation pathway of vegetation to be taken into account for the energy balance.

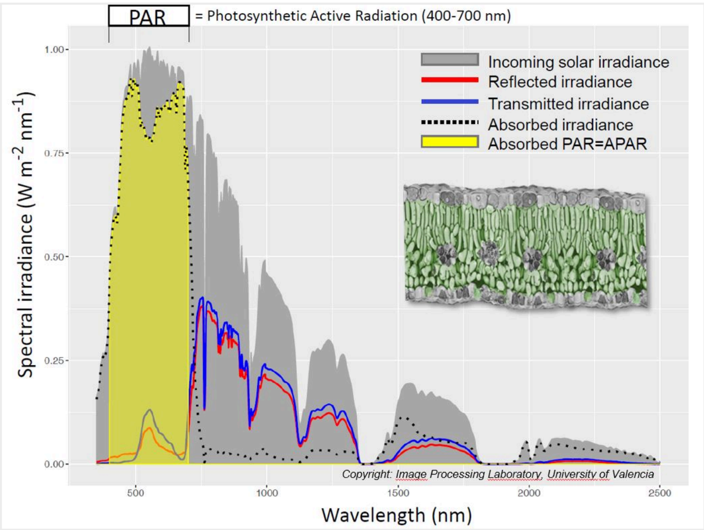
Prace wykonane od początku projektu do końca okresu sprawozdawczego oraz najważniejsze dotychczasowe rezultaty

The use of the full SIF spectrum in combination with the optical domain as indicators of photosynthesis and plant productivity has still not been fully exploited. For two years, FLUOPHOT focussed on this knowledge gap, and specifically on the remote observation of the photoprotection mechanisms at the leaf level. This information is required to obtain a better link between the sun-induced fluorescence and the actual photosynthesis of vegetation. In absence of physiological stress and under non-saturating light conditions, a more direct (linear) link between photochemistry and SIF emission might be established. However, in contrast, when stress occurs, photoprotection mechanisms are activated and controlled heat dissipation or non-photochemical energy quenching (NPQ) becomes more competitive in the energy dissipation balance. Thus, in order to establish the link between SIF and photosynthesis unambiguously, simultaneous measurements of the controlled energy dissipation mechanisms are needed. The in-depth identification and description of specific spectral contiguous signatures linked to the various photoprotection mechanisms are still poorly

understood, especially from a proximal or remote sensing point of view.
During the project, hyperspectral datasets at both the leaf and the canopy level were collected for several plant species, while monitoring the dynamical fluorescence and photoprotection mechanism during adaptation to high light intensity. In this way, the dynamical hyperspectral responses to plant physiological processes were assessed and interpreted.
Based on this experimental work, novel insights on the spectral behaviour of vegetation linked to the physiological processes were revealed. The in vivo occurrence of both quick and slowly activated photoprotection mechanisms could be identified from the optical data. The absorbance shifts in the range 500-780 nm are found to be strong and related to the organizational changes of the photosynthetic apparatus. With this, FLUOPHOT brought first insights in the remote observation of plant photoprotection, which is manifested over a wide spectral range of the optical domain. These findings might pave a way towards a further non-invasive spectral investigation of the non-photochemical energy quenching (NPQ) mechanisms, which is, in combination with F measurements, of a high importance for assessing plant photosynthesis in vivo and in addition from remote observations.

Innowacyjność oraz oczekiwany potencjalny wpływ (w tym dotychczasowe znaczenie społeczno-gospodarcze i szersze implikacje społeczne projektu)

The spectral characterization of the NPQ mechanisms are, in combination with SIF retrieval, of a high importance for assessing vegetation photosynthesis from remote sensing. Both processes control the electron transport to the photosynthesis reaction centres and are therefore indispensable for the development of higher-level satellite mission products for the FLEX-S3 mission. FLUOPHOT’s results are in direct support of ESA’s FLEX/S3 tandem mission as they provide new insights in the functional behaviour of vegetation, detectable by remote observations. Future work will focus on the development of retrieval algorithms for obtaining biophysical parameters related to photosynthesis from proximal to airborne observations.
Considering FLEX’s unprecedented combination of spectral and spatial resolution, the benefits to societal and environmental applications of this innovative mission will be profound. FLUOPHOT’s results will however induce further steps in the optical understanding of plant physiological process measurable at different spatial scales at which vegetation monitoring is currently taking place.



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