GFLEX: Monitoring the diurnal time course of vegetation dynamics with geostationary observations

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Chlorophyll fluorescence is seen as a new signature of vegetation with high potential for global scale vegetation monitoring. Given the present state of the art, remote sensing of vegetation fluorescence from space can be considered as feasible. However, many unresolved questions remain about its interpretation and its use as a physiological indicator. At ground level, high frequency measurements are required to interpret the fluorescence signal. However, low sun-synchronous orbiting satellites are not adapted to capture the highly dynamical variations of vegetation because of their long repeat cycles. High frequency observations can be reached by geostationary platforms. The objective of the GFLEX is the use of a multispectral imaging system to assess photosynthesis dynamics by observing chlorophyll fluorescence and the photochemical reflectance index from a geostationary orbit. The possibility to merge GFLEX and OCAPI, an ocean colour geostationary project for marine applications is under discussion.

Challenge in vegetation remote sensing

Because of its photosynthesis activity the vegetation is responsible for the main CO_2 exchanges with the atmosphere.

> "*Over at least the last 30 years, the net result of all these processes has been uptake of atmospheric CO_2 by terrestrial ecosystems. It is critical to understand the reasons for this uptake and its likely future course. Will uptake by the terrestrial biosphere grow or diminish with time, or even reverse so that the terrestrial biosphere becomes a net source of CO_2 to the atmosphere ?*", IPCC report, 2007

We need a tool for global scale:

- GPP estimation
- Stress monitoring

Chlorophyll fluorescence

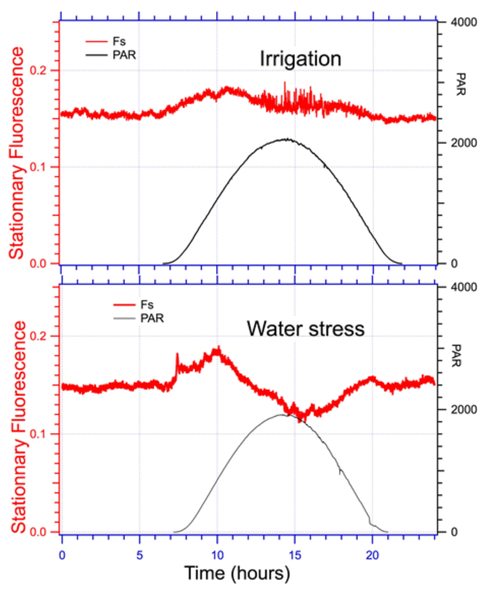
- Chlorophyll fluorescence is a light emission produced by photosynthetic pigments from their excited state
- Fluorescence occurs just after light absorption and is in **competition with photosynthesis and heat dissipation**
- Thus, **fluorescence yield varies** and these variations give a way to retrieve informations about plant physiological state

→ Fluorescence is a highly dynamical signal responding to all plant constraints

What we have learned from ground observations

Stress monitoring

Continuous measurement of fluorescence yield at canopy level on grapevine during a water stress.
Lopez et al., 2011



Continuous measurements ease the water stress diagnostic

GPP estimation

GPP and fluorescence share the same origin: the absorbed light:

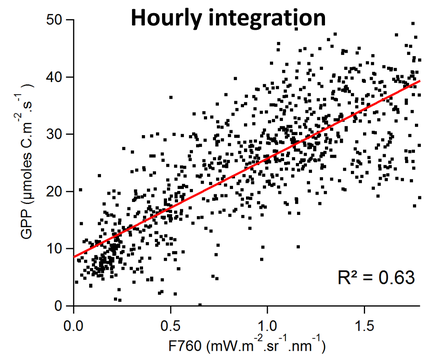
$$f = \Phi_f \,.\, APAR \,.\, \tau$$
$$GPP = LUE \,.\, APAR$$

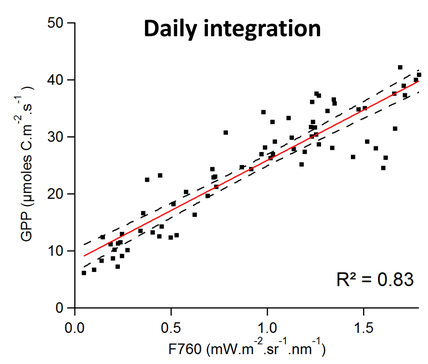
Linear correlation due to *APAR* but

$$\frac{\Phi_f}{LUE} \; vs \; PAR \neq cst$$

Hourly integration: high PAR variations

Daily integration: low PAR variations from day to day





Continuous measurements of fluorescence and GPP during the growth of a wheat field (80 days)

Daily integration increases correlation between *GPP* and *f*

Continuous measurements greatly ease the interpretation of the fluorescence signal

The GFLEX project and the OCAPI opportunity

GFLEX: *G*eostationary *Fl*uorescence *Ex*plorer

GFLEX is a geostationary satellite project embedding a passive fluorescence imager. A study proposal has been submitted to CNES in partnership with ASTRIUM. As they are close in term of technical approach and time-sampling requirements, CNES recommended to merge the GFLEX project with the OCAPI project. Discussions are ongoing.

- Fluorescence in O_2-A and O_2-B absorption bands
- PRI (Physiological Reflectance Index)
- < 500 m GSD
- 1 h revisit time

OCAPI : Ocean **C**olor **A**dvanced **P**ermanent **I**mager

OCAPI is a geostationary satellite project dedicated to ocean color measurements.
"[…] a breakthrough in ocean sciences thanks to hourly observations of ocean color in coastal zones and the open ocean from a geosynchronous orbit."

- Geostationary orbit
- 18 bands (3 bands close to fluorescence requirements in O_2-A)
- 500 m GSD
- 1 h revisit time