Continuous passive measurements of canopy fluorescence at 687 and 760 nm

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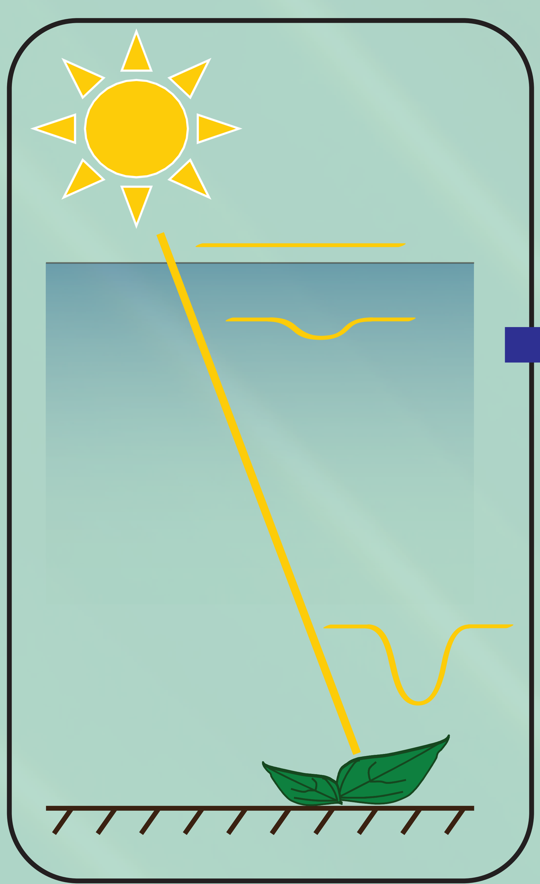
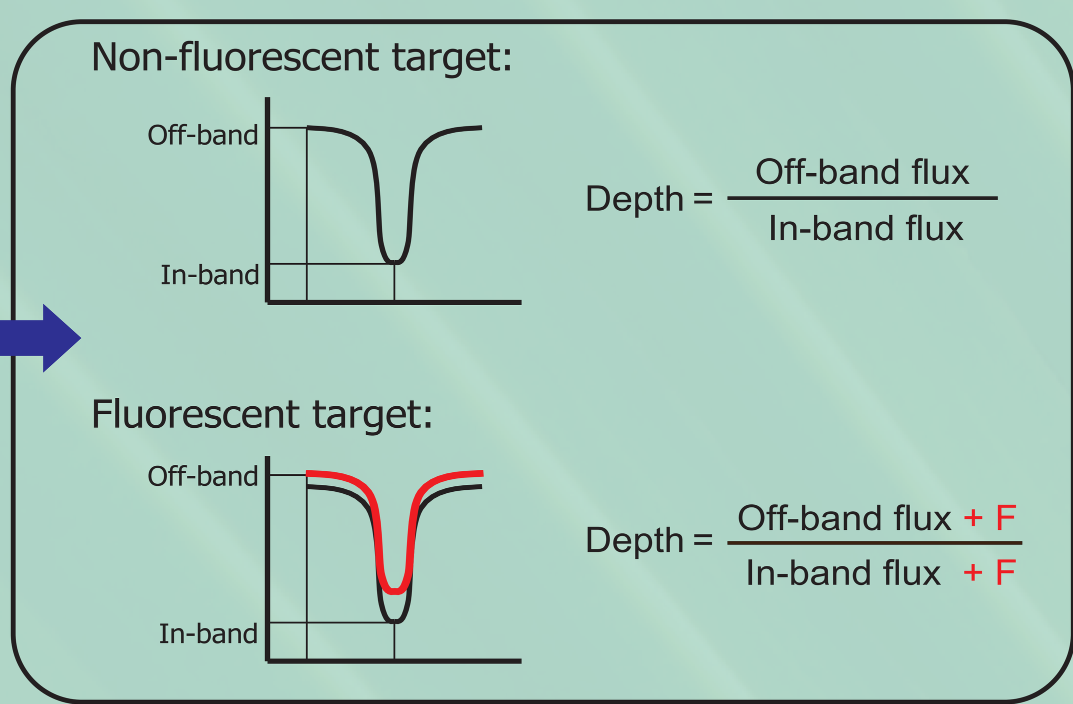
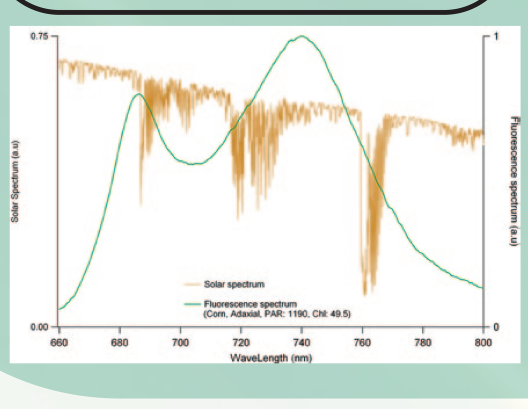
Passive measurements are supposed to be the best way to assess vegetation fluorescence from space (ESA report - Drusch et al. 2008). Recently the FLEX project was selected in phase A/B1 as a candidate for the next EarthExplorer ESA mission. However, an understandable view of the mechanisms that control fluorescence at the canopy level is still lacking. There is a need for an instrumentation that can provide long-term quantitative measurements at canopy level, under controlled conditions.

In this work we present a field platform for continuous fluorescence measurement over crop canopies. Since 2008, the crane based platform is operative and simulates airborne measurements.

Passive measurement of fluorescence







The sunlight-induced fluorescence is obtained by comparing the depth of the atmospheric oxygen absorption band in the solar irradiance spectrum to the depth of the band in the radiance spectrum of the plants. The algorithm is described in Daumard et al. 2010.

Oxygen absorption bands: A-band : 760 nm
B-band : 687 nm

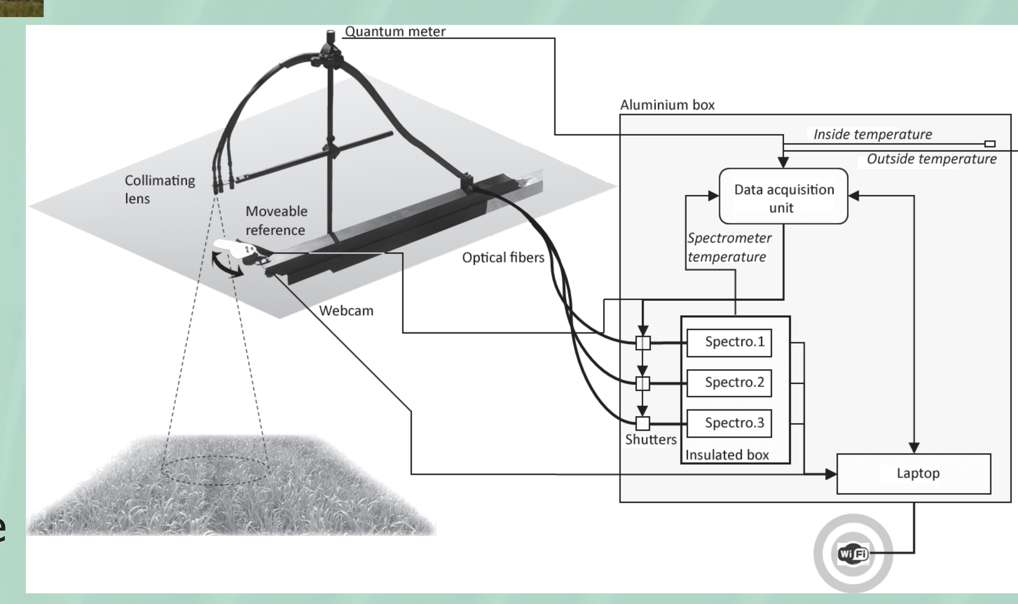
A field-platform dedicated to quantitative passive fluorescence measurements

The platform is based on a 21 m high crane surrounded by agricultural fields. A hundred meters railway allows to move the crane along a north-south axis.

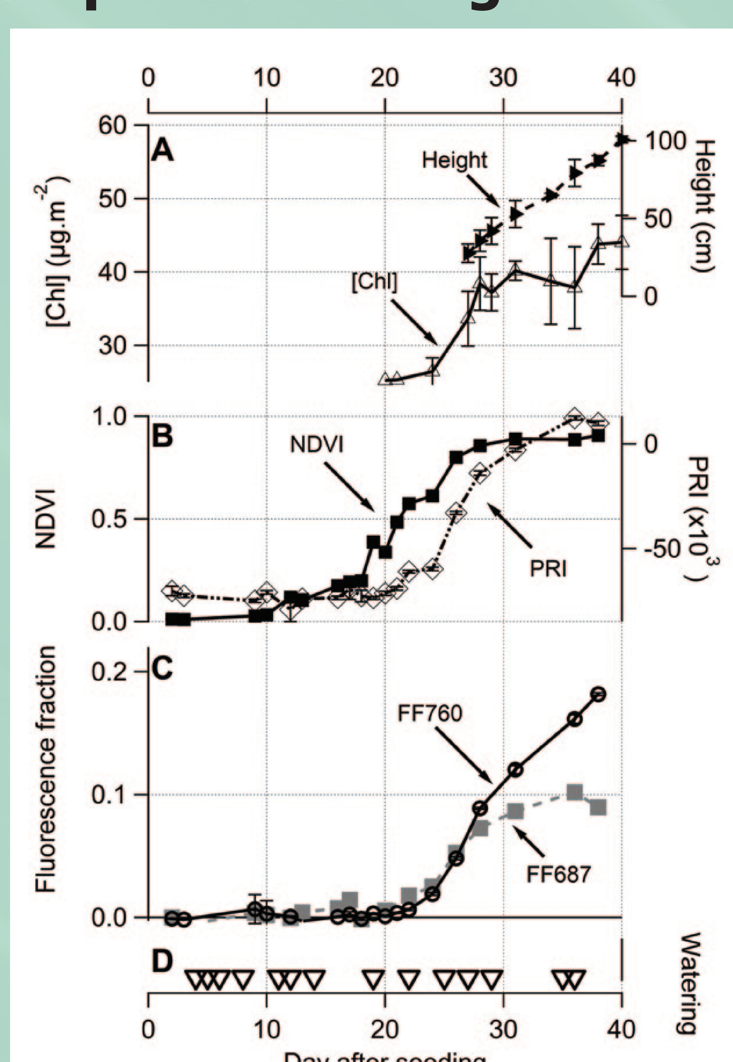
TriFlex is a fully automatic instrument designed to passive measurement of fluorescence in A and B oxygen absorption bands.

Two spectrometers allows to measure in parallel vegetation radiance and irradiance.

A third spectrometer measures the reflectance of the vegetation.



Comparison of vegetation indexes during crop growth



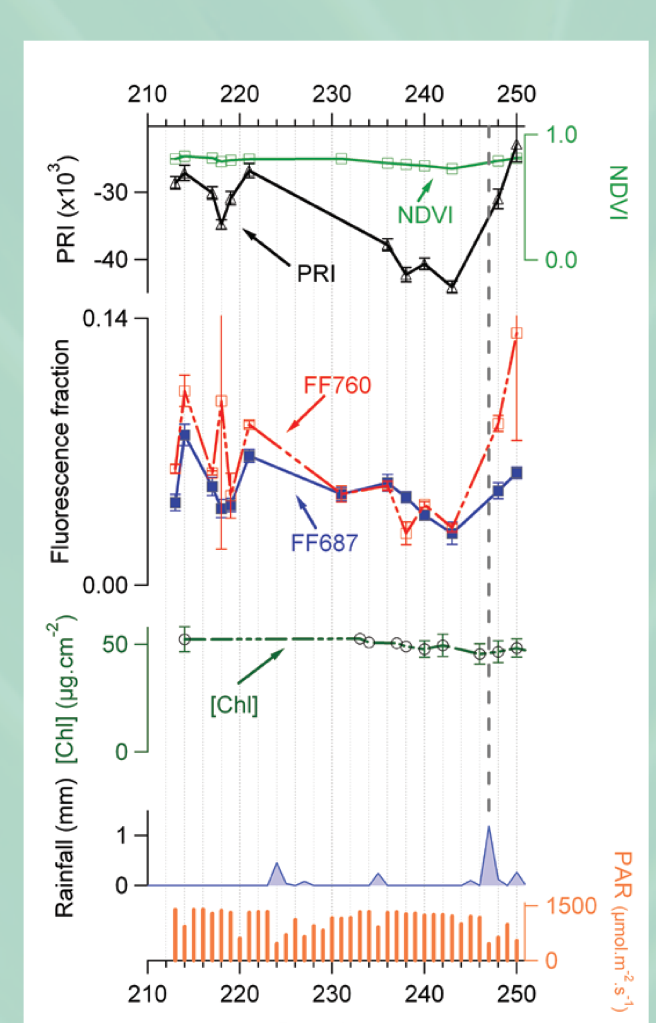
FF687 = Fs687/L(685)*
FF760 = Fs760/L(685)*

* L(685) radiance can be substituted by the radiance of any well absorbed wavelength

Among the differents indexes, FF760 better tracks the vegetation growth.

Daumard, F., Goulas, Y., Champagne, S., Fournier, A., Ounis, A., Olioso, A., & Moya, I. (2011). Continuous monitoring of canopy level sun-induced chlorophyll fluorescence during the growth of a sorghum field. IEEE TGRS, submitted

Water stress detection



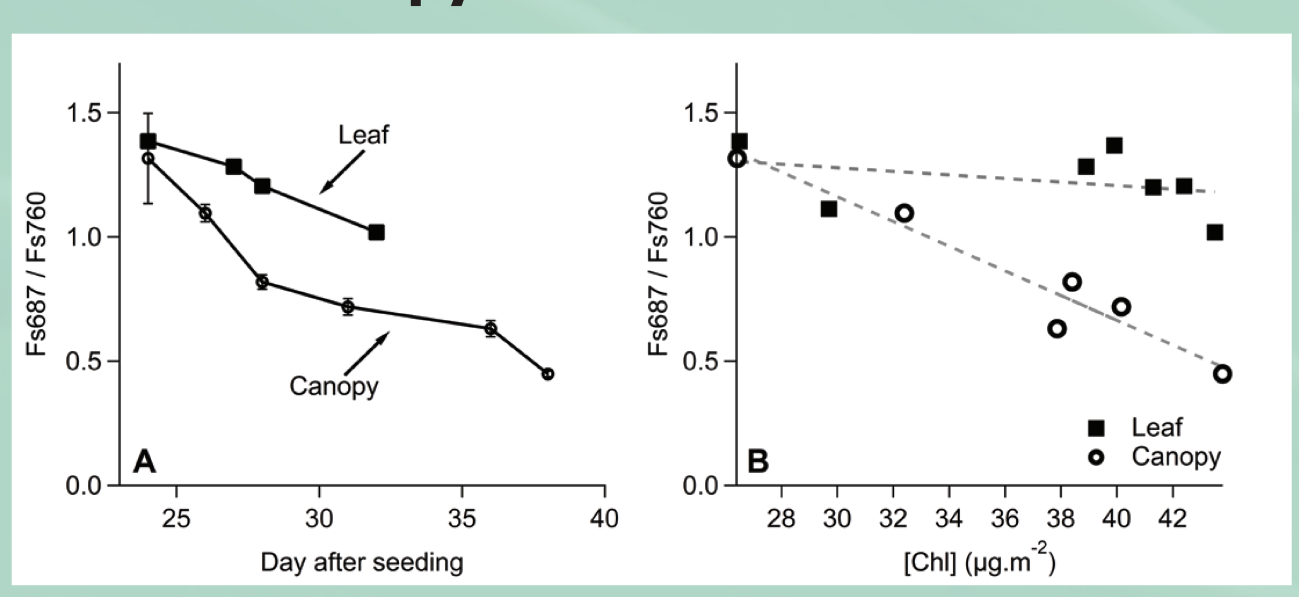
Both PRI and FF shows evidence of a reversible water-stress.

NDVI and [Chl] remain constant

After a rainy day (247) we see the reversion of water stress on FF and PRI

Daumard, F., Champagne, S., Fournier, A., Goulas, Y., Ounis, A., Hanocq, J.F., & Moya, I. (2010). A Field Platform for Continuous Measurement of Canopy Fluorescence, IEEE TGRS,48.

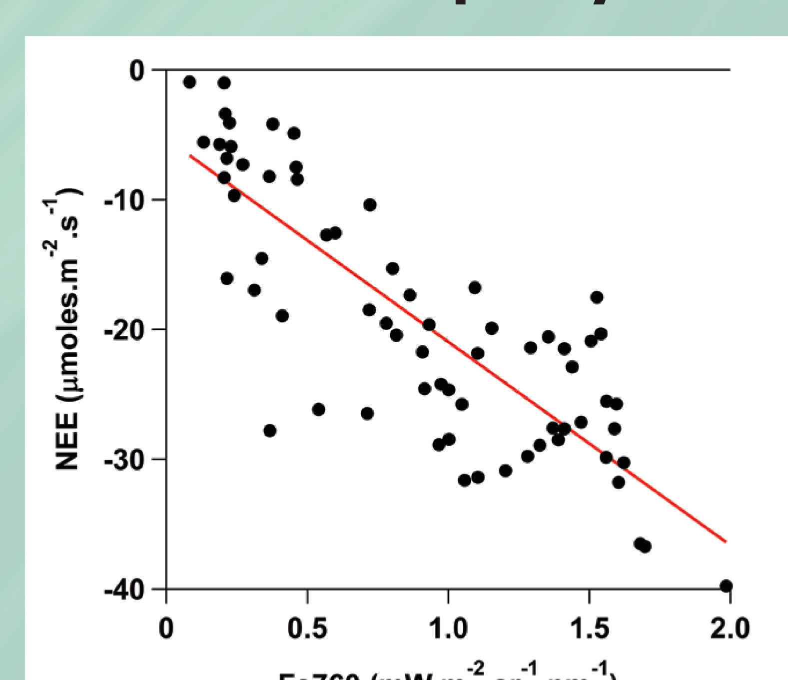
Canopy structure affects sun-induced canopy fluorescence ratio...



... as a result of fluorescence radiative transfer within the canopy: Fs687 is strongly absorbed whereas Fs760 is not.

Similar results are obtained in Moya et al. 2006, Fournier et al. 2011.

Fs760 fluorescence flux as a proxy of CO_2 assimilation



Net Ecosystem Exchange versus Fs760 on a wheat field during its growth

At leaf level, fluorescence flux (Fs) depends on both fluorescence yield (Φ_f) and absorbed radiation (APAR): Fs = Φ_f x APAR. However, at canopy level i) APAR is difficult to determine ii) Fs also depends on the radiative transfer within the canopy. This makes Φ_f retrieval very complex.

More interesting is the good correlation between Fs760 and Net Ecosystem Exchange during the growth of a wheat field.

This open a new perspective for CO_2 estimation based on fluorescence measurements if a similar relationship can be obtained for other vegetation types and conditions.