

Assessing gross primary production from solar-induced chlorophyll fluorescence

Field results and integration into biogeophysical models

J. Moreno¹, I. Moya², F. Miglietta³, U. Rascher⁴, M. Berger⁵, W. Verhoef⁶,
G. Agati⁷, A. Oliso⁸, P. Zarco-Tejada⁹, V. Rivalland¹⁰, F. Magnani¹¹

¹RSU, Univ. Valencia, Spain, ²CNRS-LMD, Paris, France, ³CNR-IBIMET, Firenze, Italy, ⁴Forschungszentrum Jülich GmbH, Germany, ⁵ESA-ESRIN, Frascati, Italy, ⁶NLR, Emmeloord, The Netherlands, ⁷CNR-IFAC, Firenze, Italy, ⁸INRA-CSE, Avignon, France, ⁹CSIC-IAS, Cordoba, Spain, ¹⁰NOVELTIS, Avignon, France, ¹¹DCA, Univ. Bologna, Italy (federico.magnani@unibo.it)

The FLEX mission. Measuring solar-induced fluorescence (SIF) from space

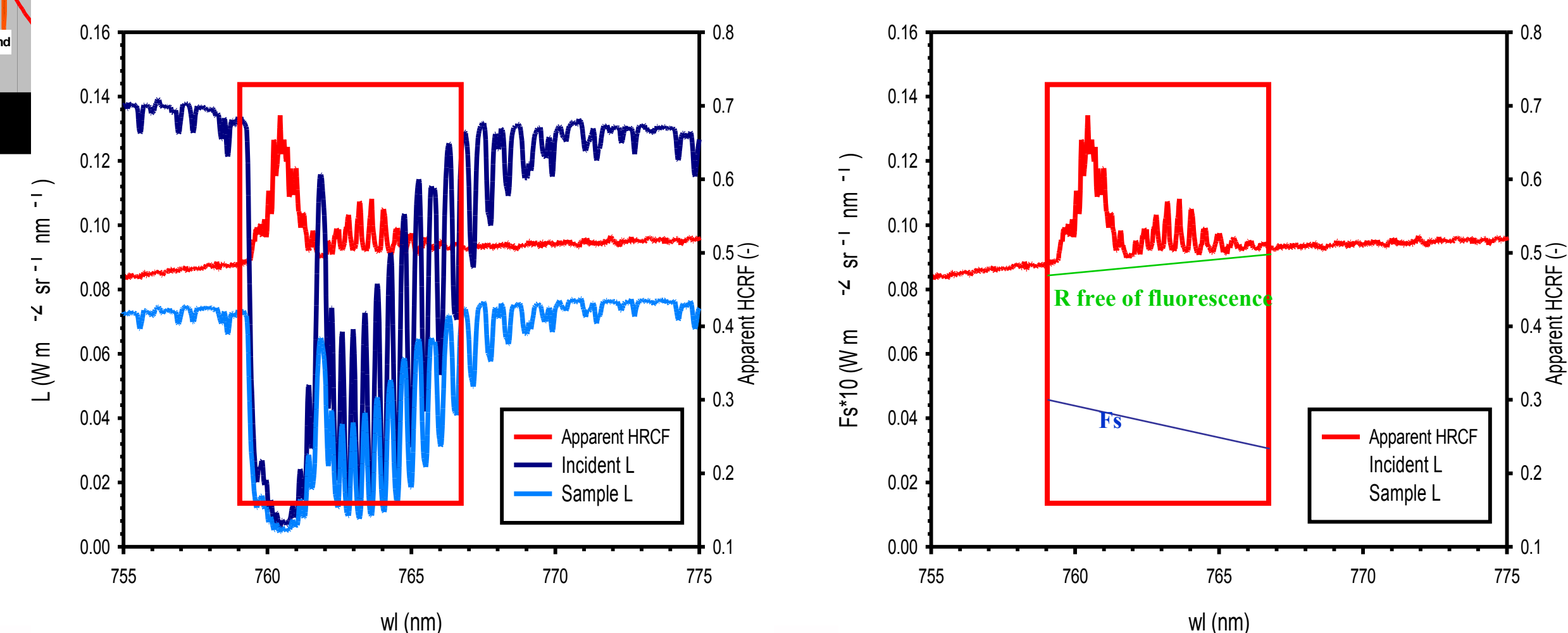
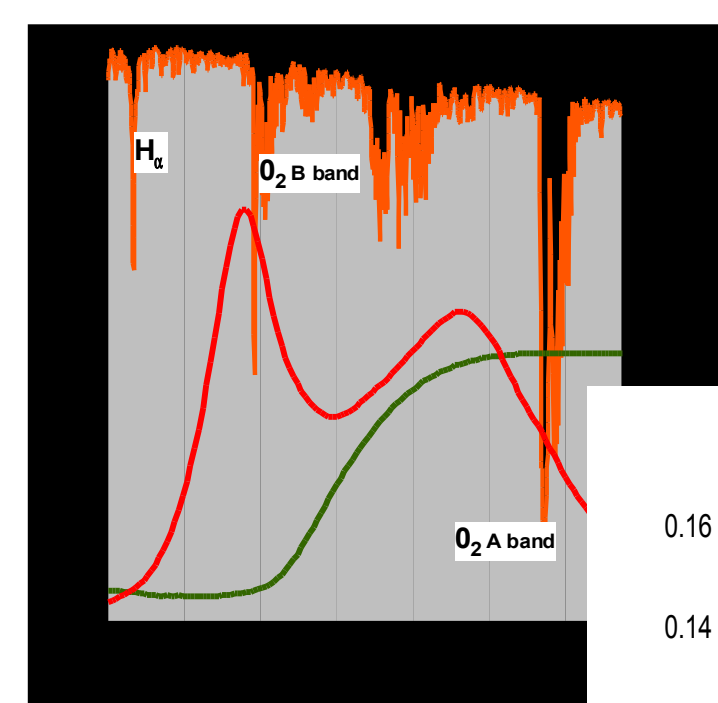
Light absorbed by photosynthetic antenna pigments is only partly used up in photochemistry, the remainder being dissipated through heat production or chlorophyll fluorescence. The possibility to use remote sensing methods to measure fluorescence emitted under natural solar illumination (**solar-induced fluorescence, SIF**) paves the way for the remote assessment of photosynthetic processes. Although less straightforward than for near-field pulse-saturated fluorescence, the interpretation of SIF signals is advancing, through the development of novel models of various detail.

Earth Explorer missions are the result of a strategy within the Living Planet Programme of the European Space Agency where missions are designed to address issues raised by the scientific community whilst demonstrating breakthrough technology in observing techniques. The Agency released in 2005 a new Call for Ideas focused on key processes that are fundamental for improving our understanding of the changing Earth System. The FLEX (FLUorescence Explorer) mission is among the six selected. FLEX is dedicated to observing SIF globally together with additional complementary information on the vegetation cover and its environmental setting.

As part of the FLEX mission assessment phase, dedicated airborne campaigns and study activities were initiated in order to proof the mission concept, to consolidate the mission requirements and to develop the appropriate data processing tools and the necessary methods for assimilating the SIF signal into biogeophysical models with explicit description of vegetation dynamics.

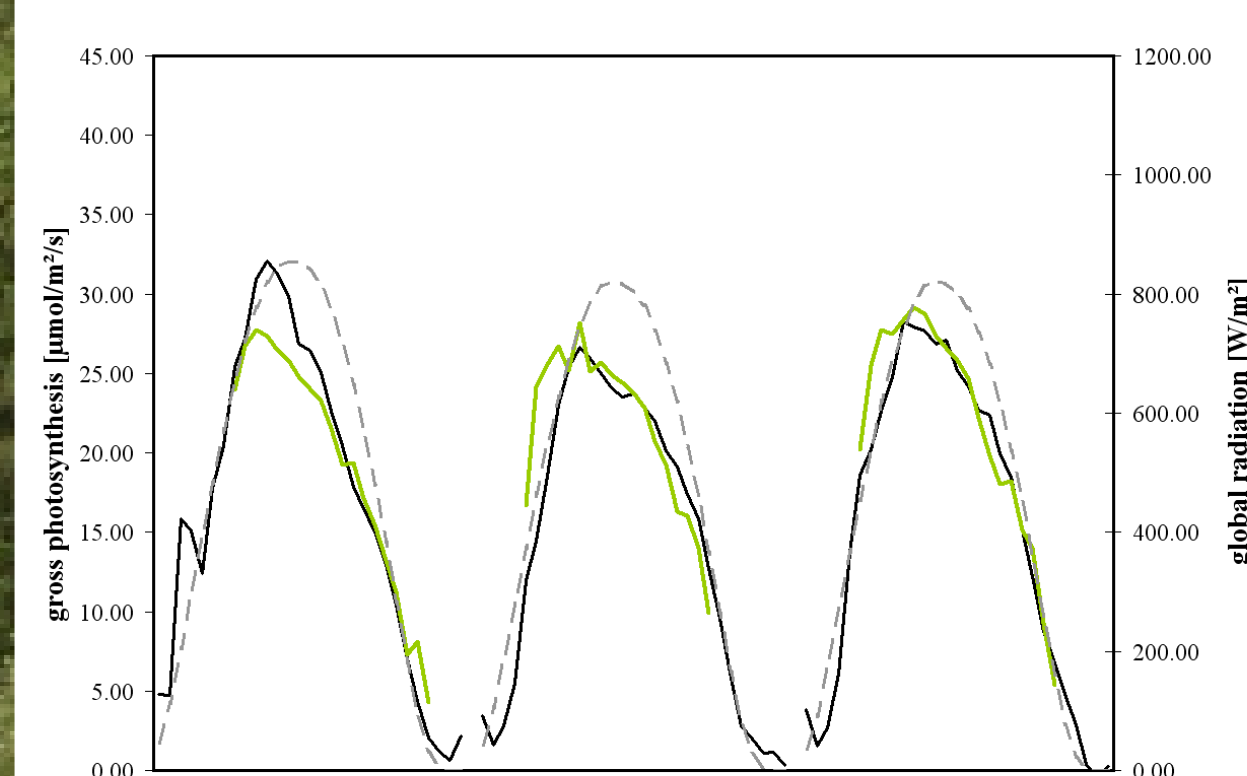
SIF retrieval by the Fraunhofer line in-filling principle

The retrieval of the SIF signal from leaf and canopy radiance is made possible by the overlap between the Chl fluorescence spectrum (red line, left) and two atmospheric oxygen absorption bands at ~ 680 (O₂ B) and 760 nm (O₂ A band). Apparent reflectance is increased by the emission as fluorescence of energy absorbed at lower wavelengths. Since reflectance and fluorescence are smooth, the latter can be retrieved by established or more refined algorithms developed as part of FLEX.

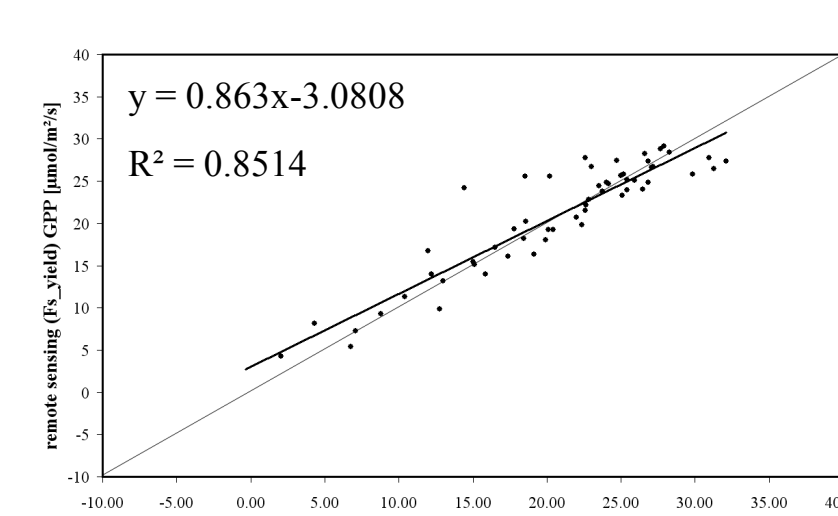


Estimating GPP from canopy fluorescence: ground measurements

Over the course of three campaigns in Les Landes (France), fluorescence yield from SIF measurements was found to be strongly correlated to canopy light-use efficiency. SIF and reflectance could explain 85% of the variability in GPP from eddy-covariance

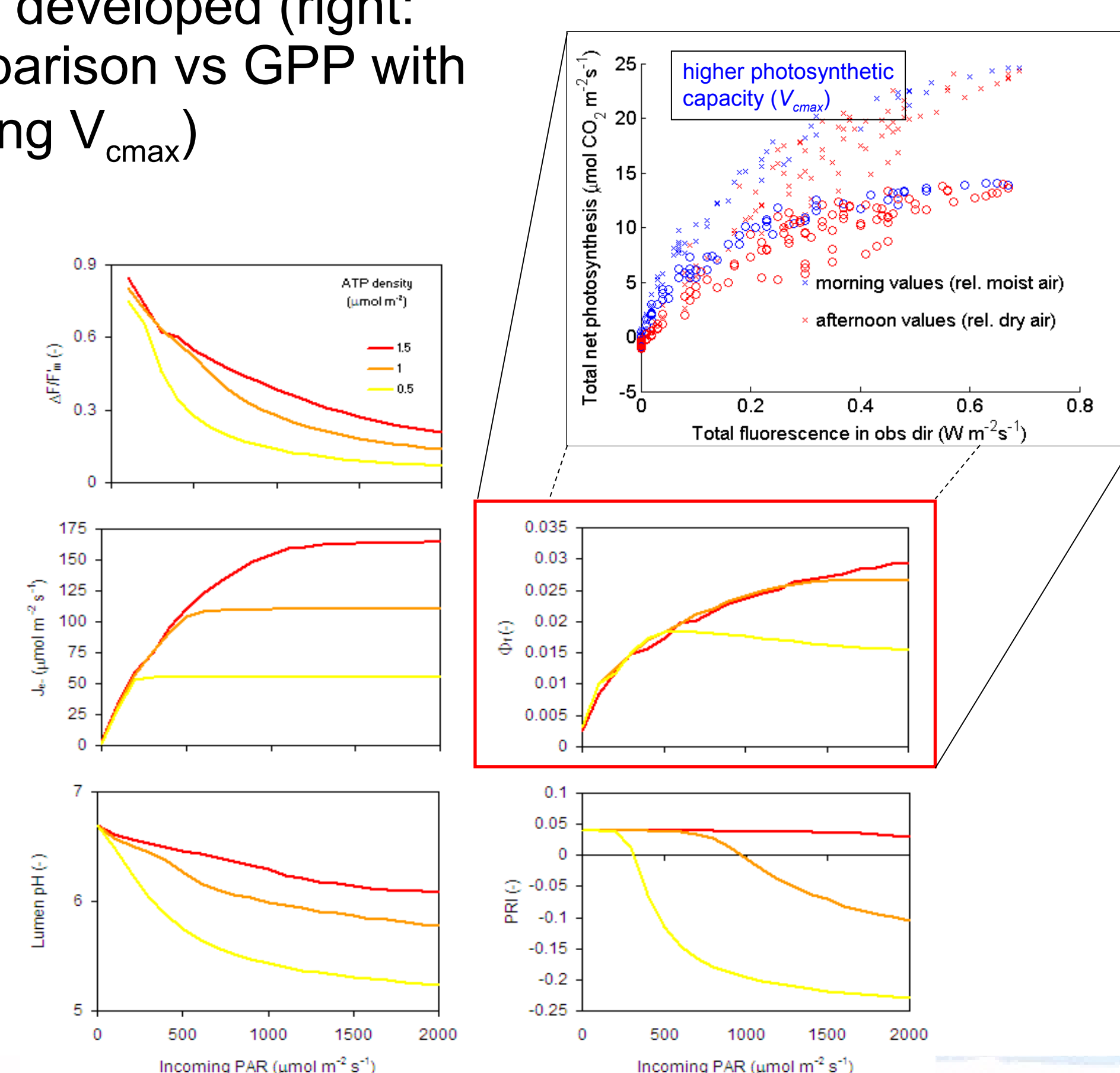


- GPP calculated from EC data (black) and from RS data (green)
- $GPP_{RS} = PAR * fAPAR * LUE$
- $LUE = 1 / FS_{yield} * k$



Coupling SIF with photosynthesis. Advances in modelling fluorescence

A process-based model of electron transport and fluorescence has been developed (left: response to PAR with varying J_{max}). A coherent semi-empirical model suitable for canopy-level applications has also been developed (right: comparison vs GPP with varying V_{cmax})



Estimating C exchange from airborne SIF measurements at the landscape level

Airborne campaigns have been carried out in parallel with ground measurements. Both SIF and eddy-covariance NEE were measured from paired planes. After carefully checking for footprint comparability, fluorescence yield was found to be strongly related to large-scale C exchange over a variety of vegetation types and crops

