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Estimation of gross ecosystem production by means of hyperspectral reflectance and fluorescence measurements in terrestrial ecosystems

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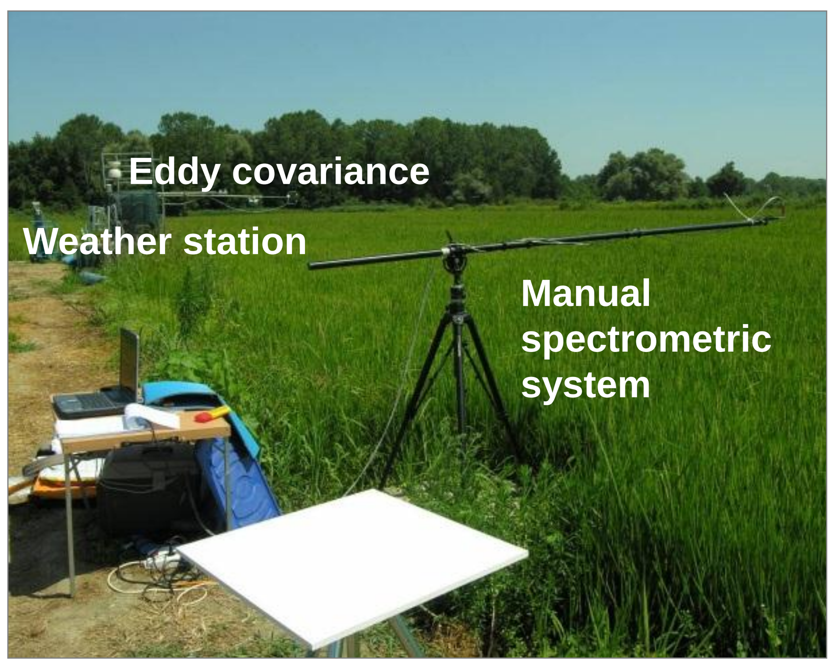
1 BACKGROUND AND OBJECTIVES

In recent years, a growing number of studies has recognized the importance of collecting field spectroscopy observations at flux towers for a better understanding of the **relationships between photosynthesis and optical signals**. Such data are intended to "bridge the gap" between the flux tower and satellite observations, enabling the latter to be used for scaling up carbon estimates to regional and global level. The **SpecNet** (Spectral Network) project (Gamon et al. 2006, 2010) and the "Spectral Sampling Tools for Vegetation Biophysical Parameters and Flux Measurements in Europe" **EU COST action** (Eurospec action, ES0903 http://cost-es0903.fem-environment.eu/) have been recently established to promote these activities.

The present contribution investigates the possibility of **monitoring Gross Primary Productivity (GPP)** of three terrestrial ecosystems (i.e. rice field, alfalfa crop and alpine grassland in Italy) from high spectral resolution **field spectroscopy** measurements.

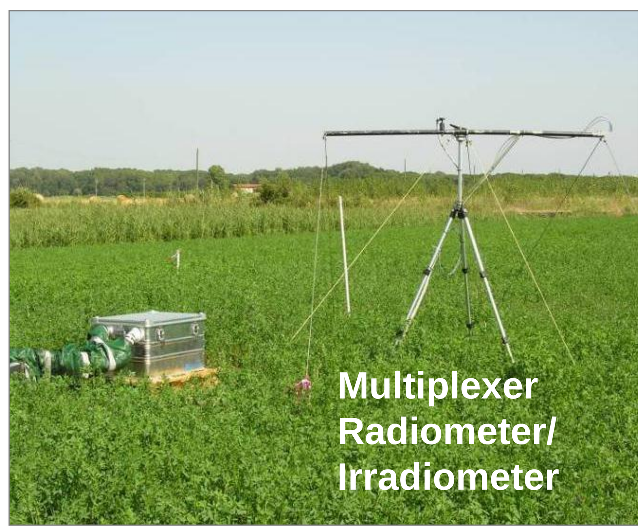
2 EXPERIMENTAL SITES

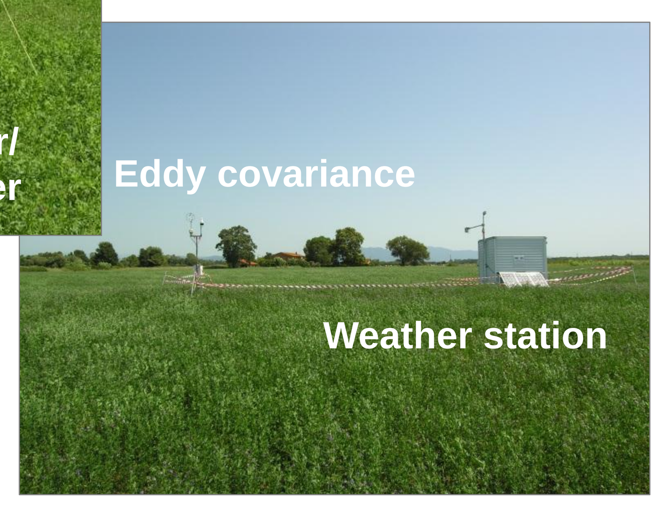
Rice field



Castellaro (Northern Italy, 45.06 N, 8.67 E, 88 m a.s.l.)
Rossini et al. (2010, AFM, 150,1283-1296)

Alfalfa field

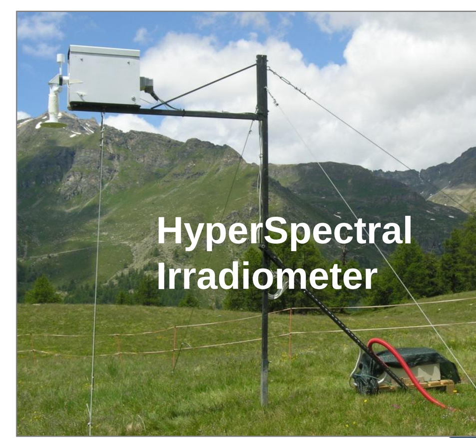


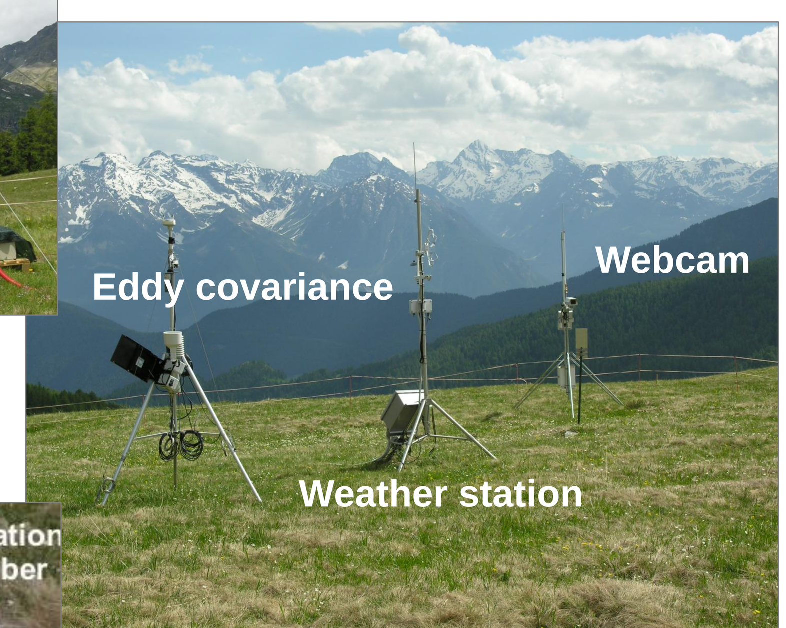


Pisa (central Italy, 43.67 N, 10.30 E, 4 m a.s.l.)

Subalpine pasture

Torgnon (NW Alps in Italy, 45.84 N, 7.58 E, 2210 m a.s.l.)





3 METHODS

Spectral data

These spectral systems use a couple of HR4000 spectrometers (OceanOptics, USA).
More details in the poster by Cogliati et al.

Spec	FWHM (nm)	Spectral range (nm)	Application
1	1	350-1050	Irrad. measurements, ρ and VIs computation
2	0.1	700-800	Sun-induced Chl fluorescence at O_2-A

LUE models

Different formulations of the light use efficiency (LUE) model were tested.

Formulations differ with respect to the methods selected for ε and APAR estimation based on remote sensing techniques.

$$GPP = \varepsilon \times APAR = \varepsilon \times fAPAR \times PAR$$

Photochemical Reflectance Index
$PRI = (R_{531} - R_{570})/(R_{531} + R_{570})$

Index of F_{760} efficiency
$Fy_{760} = F_{760}/PPFD$

Traditional vegetation indices (VI):

Normalized Difference Vegetation Index
$NDVI = (R_{800} - R_{680})/(R_{800} + R_{680})$

MERIS Terrestrial Chlorophyll Index
$MTCI = (R_{753.75} - R_{708.75})/(R_{708.75} - R_{681.25})$

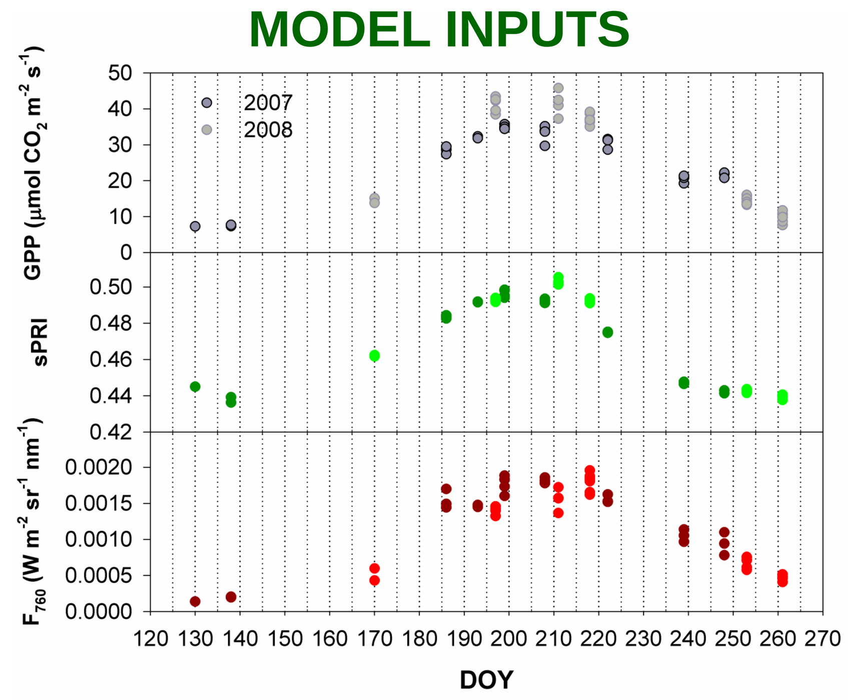
F_{760} estimated with the Spectral Fitting Method

	ε	APAR	Model formulation
1	Const.	f(VI, PAR)	GPP = (a VI + b) x PAR
2	f(sPRI)	f(VI, PAR)	GPP = (a sPRI + b) x (a_1 VI + b_1) x PAR
	f(Fy_{760})	f(VI, PAR)	GPP = (a Fy_{760} + b) x (a_1 VI + b_1) x PAR
3	f(sPRI)	f(F_{760})	GPP = (a sPRI + b) x (a_1 F_{760} + b_1)

4 RESULTS

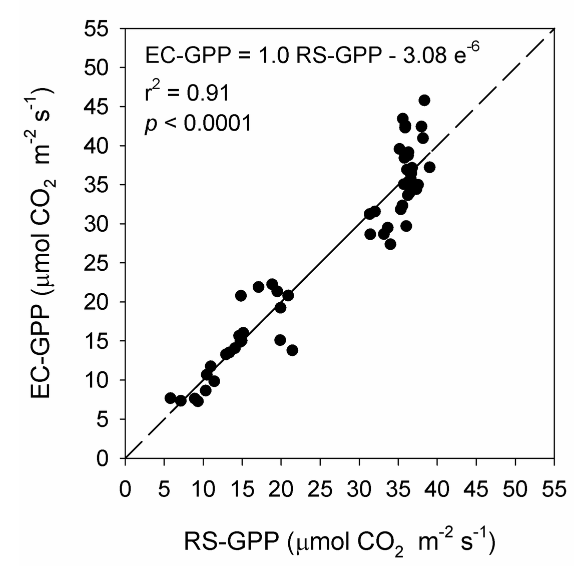
MODEL INPUTS | **BEST PERFORMING MODEL** | **MOD vs. OBS**

Rice field

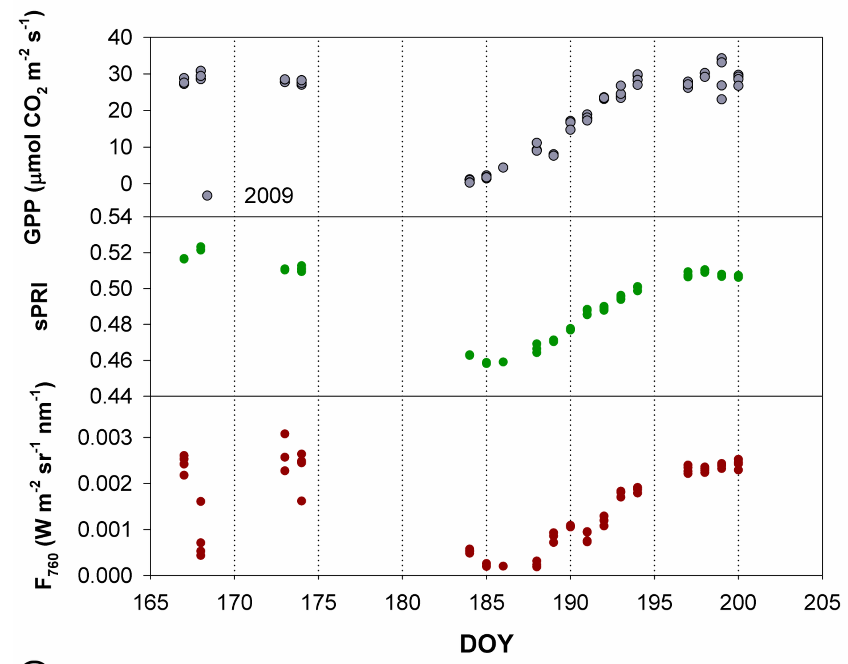


$GPP = (a\ sPRI + b) \times (a_1 F_{760} + b_1)$

$r^2_{cv} = 0.9$
$rRMSE_{cv} = 13.7\%$

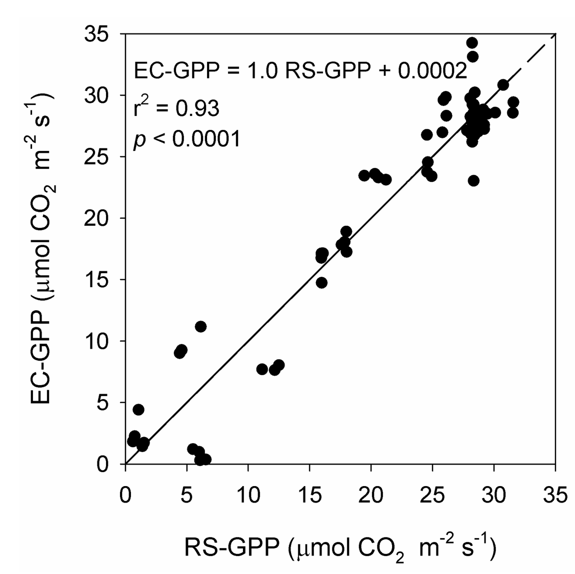


Alfalfa field

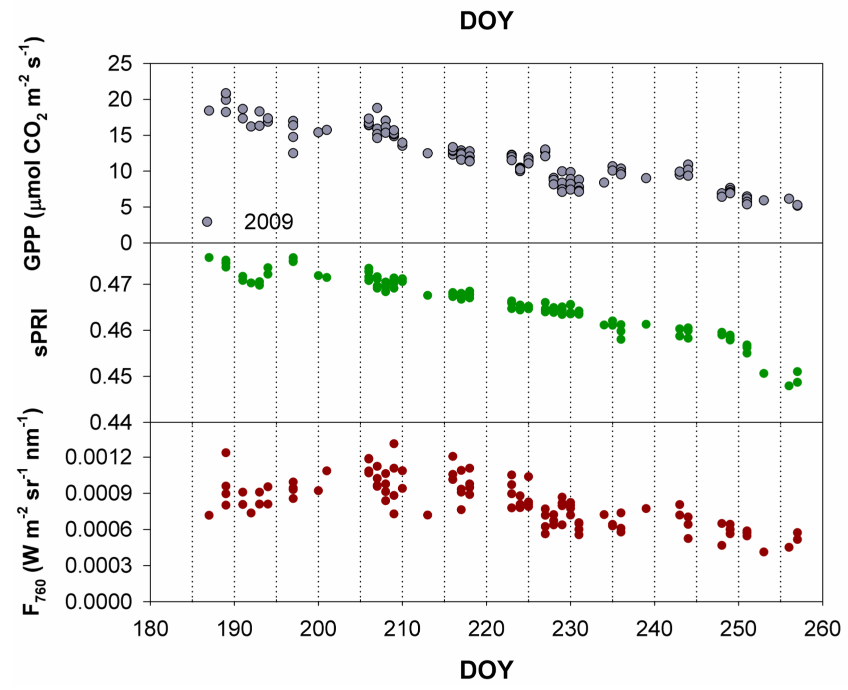


$GPP = (a\ sPRI + b) \times (a_1 F_{760} + b_1)$

$r^2_{cv} = 0.92$
$rRMSE_{cv} = 13.58\%$

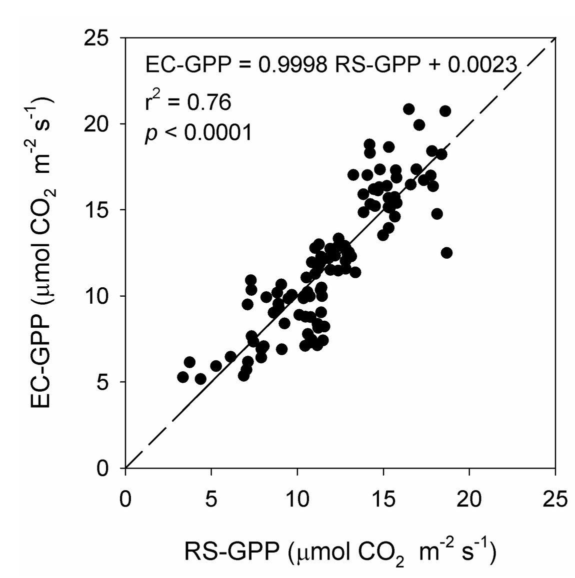


Subalpine pasture



$GPP = (a\ sPRI + b) \times (a_1 F_{760} + b_1)$

$r^2_{cv} = 0.74$
$rRMSE_{cv} = 16.75\%$



5 CONCLUSIONS

- Results show that the use of **Fy_{760} and PRI to model ε** instead of holding ε constant improves the estimation of GPP.
- We successfully test the use of **F_{760} to model the PAR absorbed** by the photosynthetic components of vegetation. This model is very attractive because it is entirely based on RS quantities without requiring any ancillary measurement (e.g. incident PAR).
- The use of remote as opposed to proximal spectral sensors for GPP estimation based on models developed in this study may become a powerful tool in better understanding the **spatio-temporal variations of productivity on a broader scale**.

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