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Unattended field spectrometric systems for continuous measurements of hyperspectral reflectance and fluorescence

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1. BACKGROUND AND OBJECTIVE

Earth observing systems provide information of plant photosynthetic status derived from structural/biochemical properties (eg. LAI, chlorophyll content). Recent RS techniques offer the opportunity to investigate the energy dissipation pathways through the *Photochemical Reflectance Index* (PRI) and the analysis of the *Sun-Induced Chlorophyll Fluorescence at O_2-A (F@760)* (Meroni et al., 2009). This contribution presents the development of **automatic spectrometric systems** capable of collecting unattended, continuous, long-term hyperspectral measurements to improve our knowledge on the relationships between vegetation optical properties and photosynthesis.

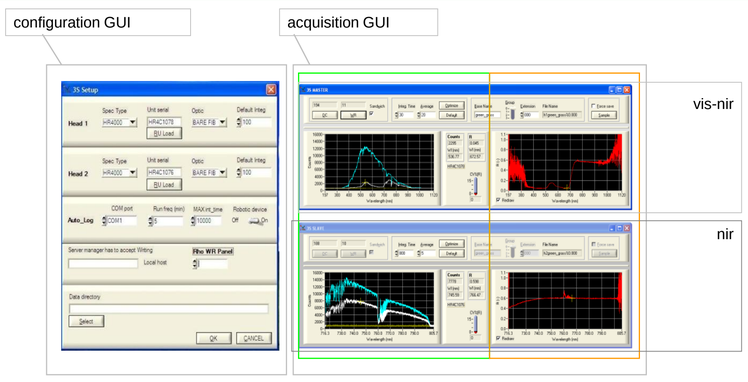
2. AUTOMATIC SPECTROMETRIC SYSTEMS

Detectors embedded

The automatic spectrometric systems developed (HSI-MRI) are able to simultaneously collect "***fine***" and "***ultra-fine***" spectrums using two spectrometers (Ocean Optics® High Resolution Spectrometers HR4000) sharing the same optical signal.

Spec.	FWHM (nm)	Sampling Interval (nm)	Spectral Range (nm)	Application
1	1 (*fine*)	0.25	400-1000	Irrad. measurements, ρ computation
2	0.1 (*ultra-fine*)	0.02	700-800	Fluorescence at O_2-A (F@760)

Data Acquisition Software



Data acquisition of HSI-MRI systems is carried out through a custom developed software: ***Auto3S***

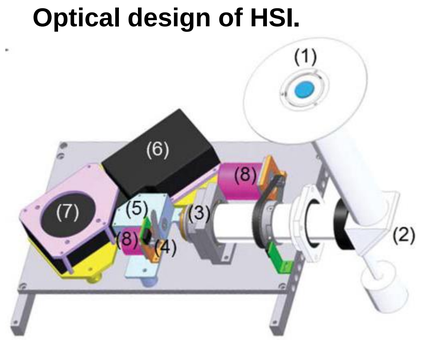
Meroni & Colombo: "3S : A novel program for field spectroscopy" 2009, Computer & Geoscience

2a. OPTICAL SYSTEM DESCRIPTION

HSI

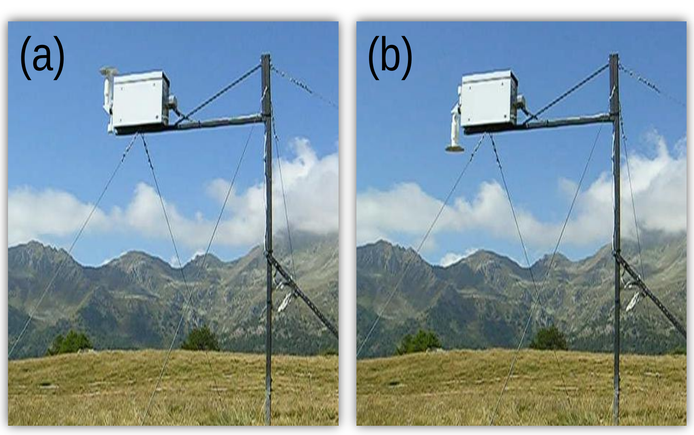
The **HyperSpectral Irradiometer (HSI)** (Meroni et al., 2011) is a custom designed instrument which employs a rotating arm to observe alternately the sky and the target surface. A cosine-response foreoptic is used to measure the solar incident irradiance (E^{TOT}) and the irradiance upwelling from the surface (E^{S}), allowing the computation of the BHR (Bi-Hemispherical Reflectance factor).

Optical design of HSI.



(1) entrance cosine-response optic ;
(2) 45° folding mirror;
(3) aspheric achromatic multiplets;
(4) mechanical shutter;
(5) beam splitter plate;
(6) VNIR spectrometer;
(7) NIR spectrometer;
(8) Step motors.

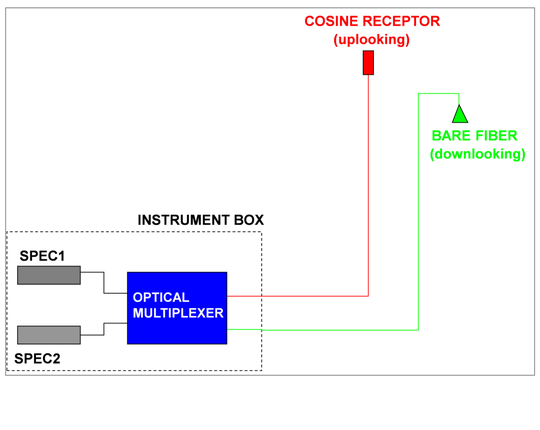
HSI in zenith (a) and nadir (b) view measuring the down- and up-welling irradiance, respectively.



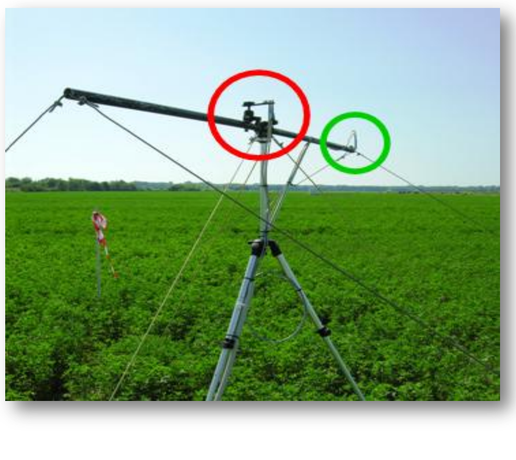
MRI

Multiplexer Radiometer Irradiometer (MRI) (Cogliati, 2011) employs an optical **multiplexer** (MPM2000, Ocean Optics®, USA) that switches the input of the spectrometers between incident irradiance (up-looking cosine-response optic) and radiance upwelling from the surface (down-looking bare fiber with a 25° FOV). MRI thus allows the measurement of the HCRF (Hemispherical-Conical Reflectance Factor).

Technical scheme of the Multiplexer Radiometer Irradiometer (MRI).



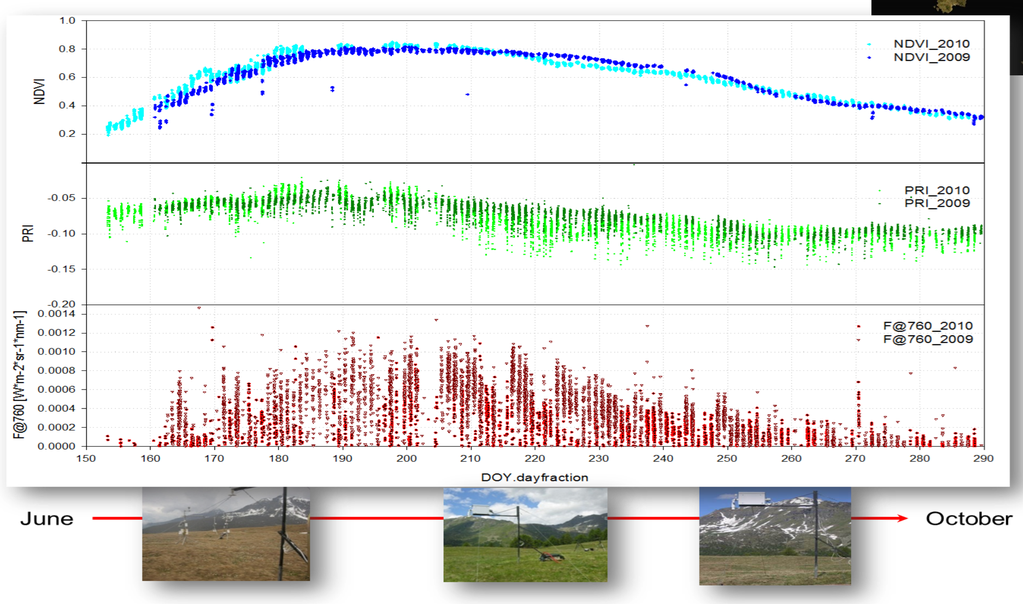
Typical setup of MRI installation in field.



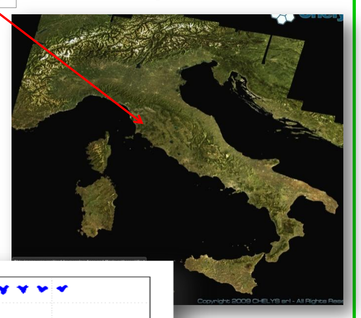
2b. FIELD CAMPAIGNS

HSI, Experimental Site

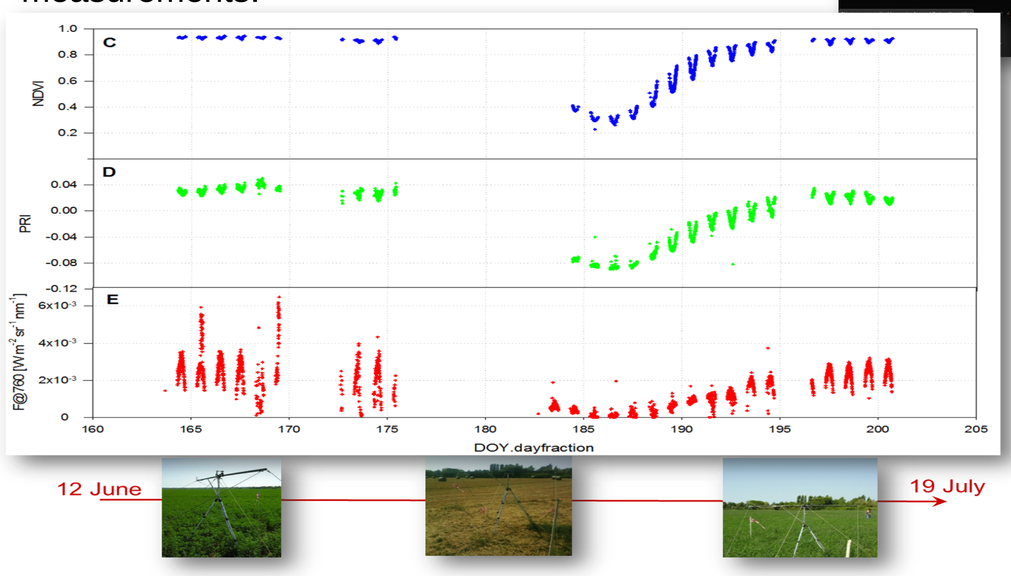
HSI was operated (2009/2010) in an alpine grassland (Italy, 45.84 N, 7.58 E, 2210 m ASL) equipped with an eddy flux station. Spectral measurements were acquired during daylight with a 5-minute sampling step during the growing season.



MRI, Experimental Site



The **MRI** was employed in summer 2009 for the ESA campaign "Sen3Exp" near Pisa (Italy, 43.67 N, 10.30 E, 4 m ASL). In this experiment two growing cycles of an **alfalfa crop** were monitored for 27 days in coordination with eddy flux measurements.



3. CONCLUSIONS

- The development of two different automatic systems addresses the need to study the best optical equipment and measurement configuration (e.g. upwelling radiance, L^S; upwelling irradiance, E^S) to quantify local scale vegetation properties and actual photosynthetic rate.
- Spectral sampling has been coordinated with eddy flux measurements to increase our understanding of the link between optical signals and gross primary productivity.
- Both spectral systems collect ground-truth observations that can be used to calibrate a RS hyperspectral imager and to validate retrieved products.

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