Integrated approaches to evaluate the whole-plant water relations in irrigated and rainfed *Olea europaea*

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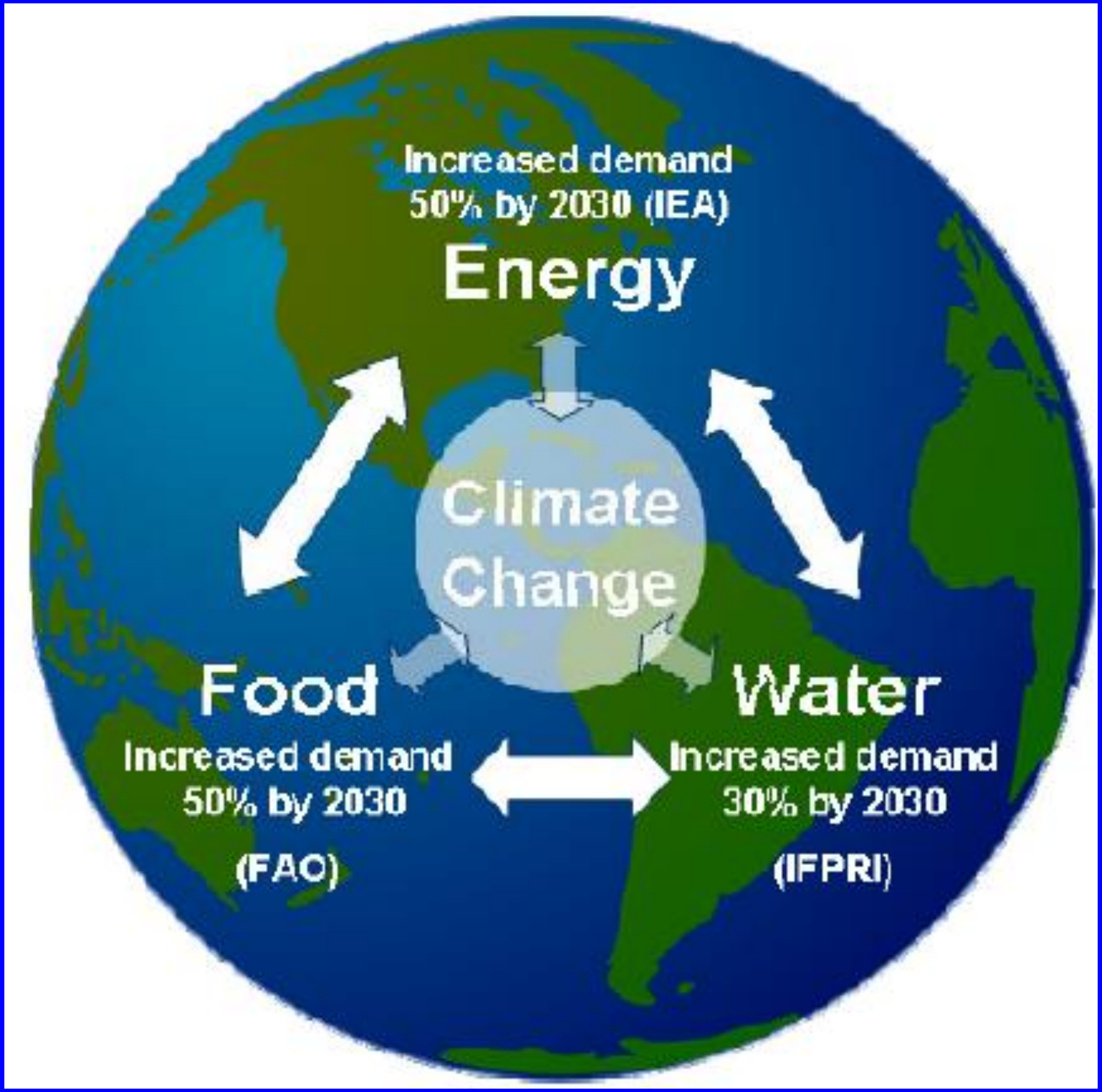
The "Grand Challenge" at planetary level: To double agricultural productions, halving the use of resources

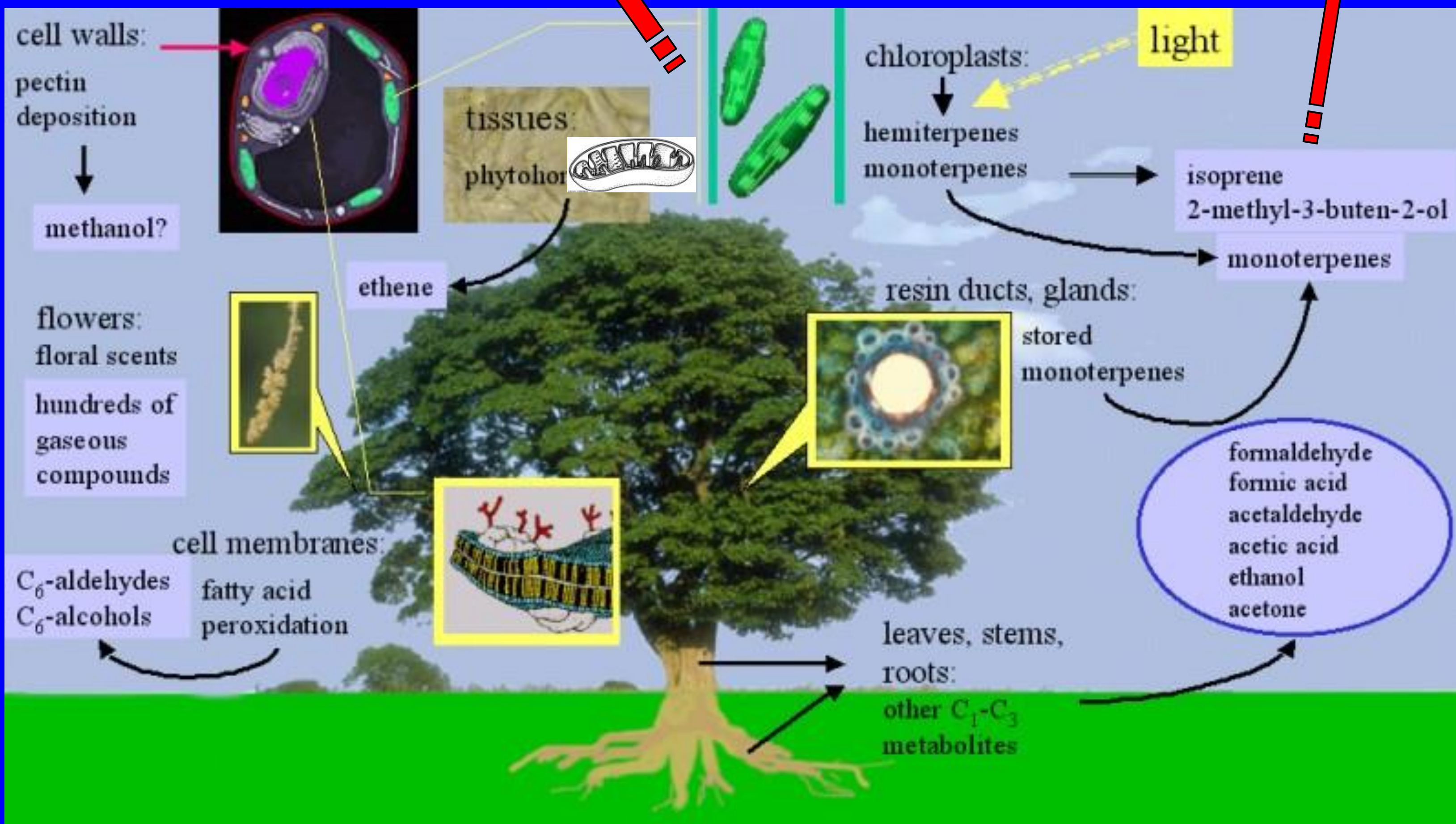
The 2030 "Perfect Storm" Scenario: World's rapidly growing demand for food, energy, water and land (Beddington 2009)



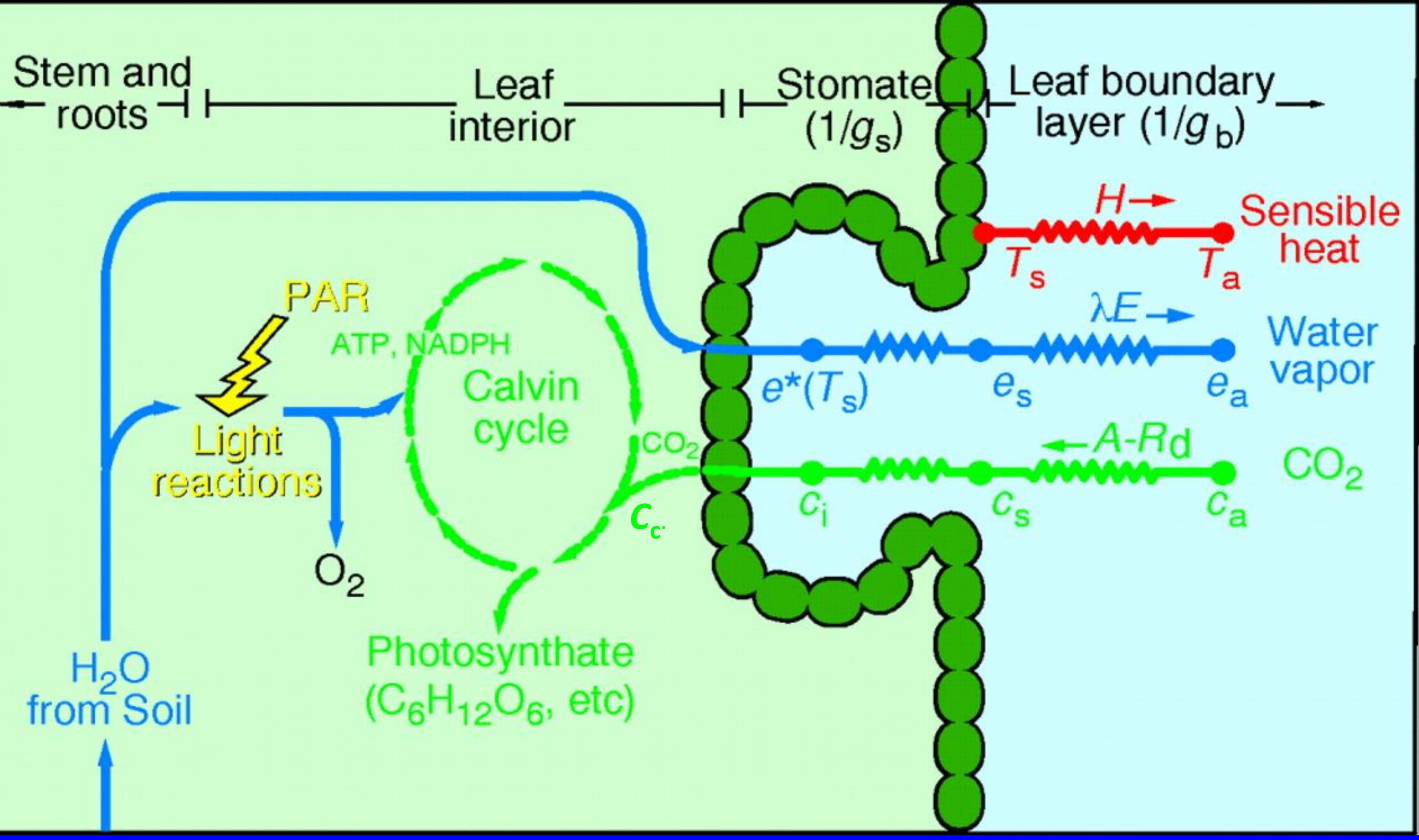
1. CO_2 uptake by photosynthesis

2. CO_2 release by respiration

3. BVOCs



Photosynthesis limitations (CO_2 supply or diffusive resistances)



METHODS

In vivo **gas exchange measurements of** → CO_2 → H_2O → **Isoprenoid emission**

CUVETTE SYSTEMS: allow to monitor and control continuously all environmental parameters (temperature, light intensity, RH%, $[CO_2]$ and $[O_2]$ air flow)

The variable *J* method: Estimation of diffusive limitations: fluorescence / gas-exchange

$E = gsH_2O\ (ei - ea)$

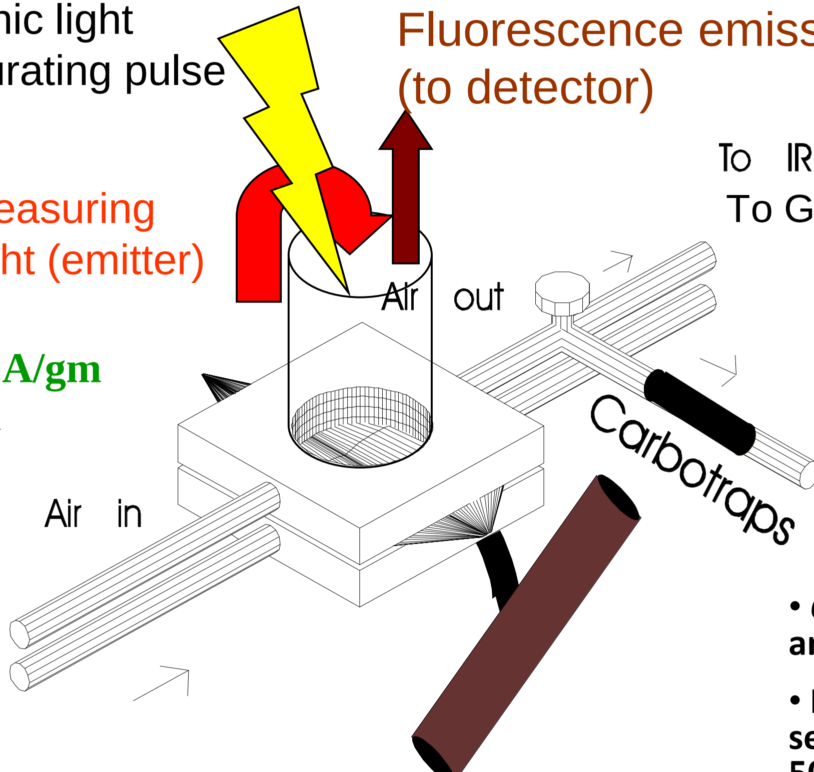
$gsH_2O = E / (ei - ea)$

$gs\ CO_2 = gsH_2O / 1.6$

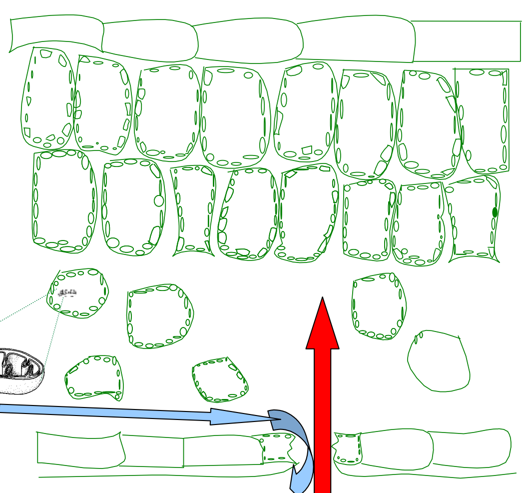
$A = gs\ (ca - ci)$

$ci = ca - A/gs$

$A = gm\ (ci - cc)\ \rightarrow\ cc = ci - A/gm$



(Proton Transfer Reaction Mass Spectrometer)

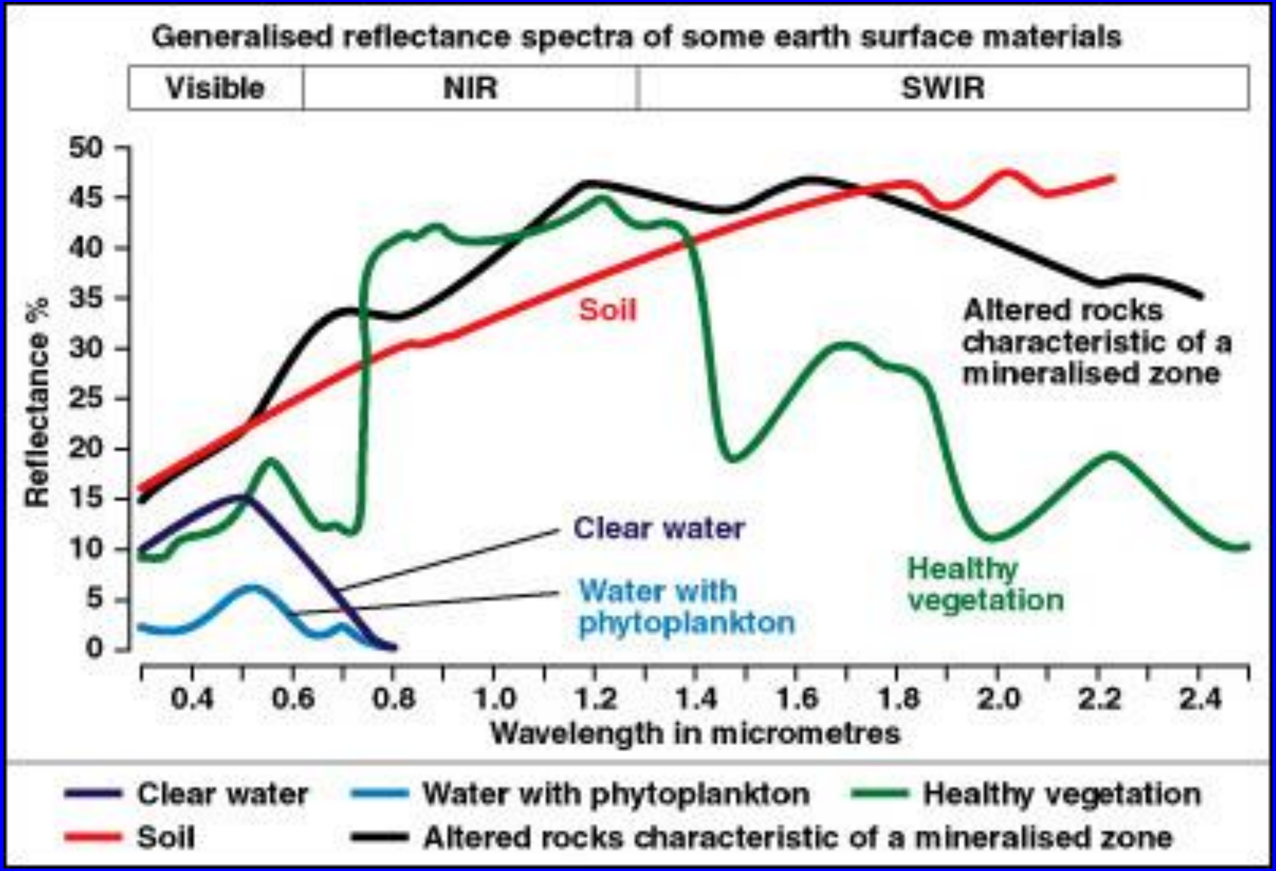


$^{13}CO_2$ → **Day Respiration**

- ***On line* analysis**
- **High sensibility 30-50 ppt**
- **Fast detection 0.1-1 sec/mass**

Reflectance spectra of different surfaces

Typical spectral reflectance curves for different type of material. Each material (e.g., vegetation, rock, soil, water, etc.) has its own spectral signature.



The electromagnetic radiation is reflected by the surfaces depending on their physical and chemical characteristics.

Assessing changes in physiological parameters induced by water stress using remotely sensed vegetation indices

International Journal of Remote Sensing
Vol. 29, No. 6, 20 March 2008, 1725–1743

Taylor & Francis
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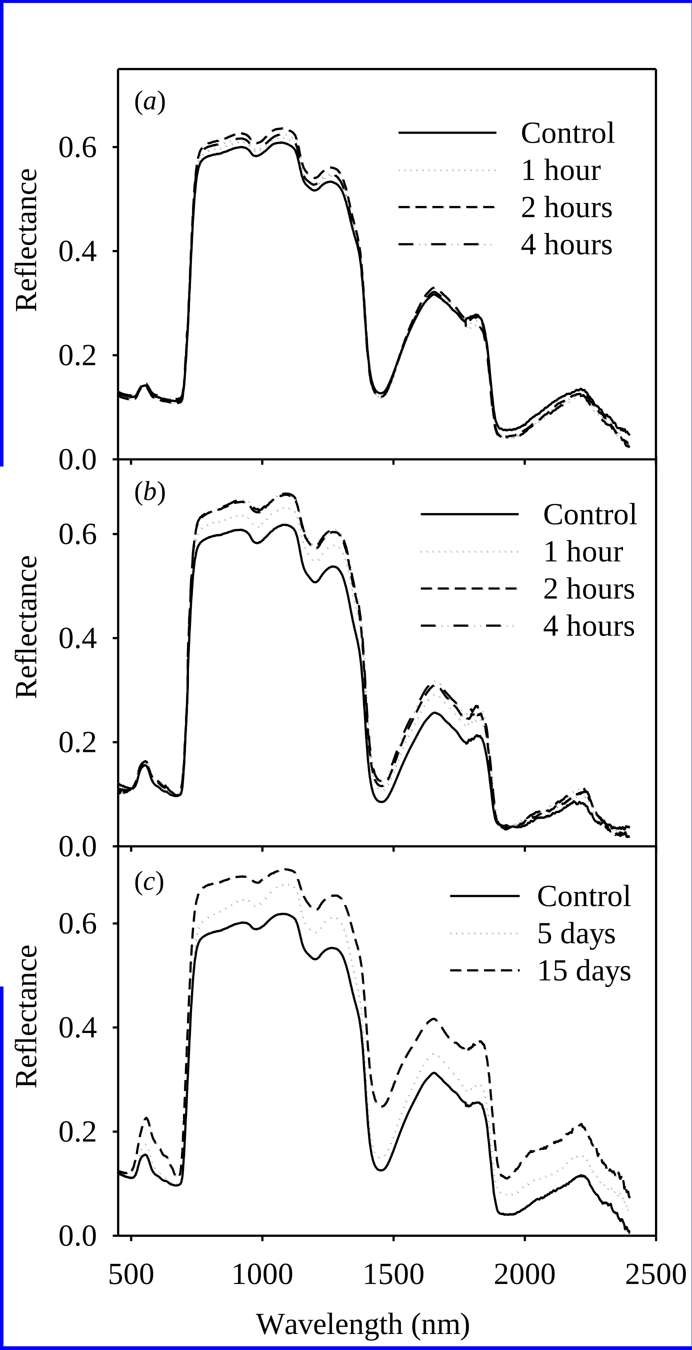
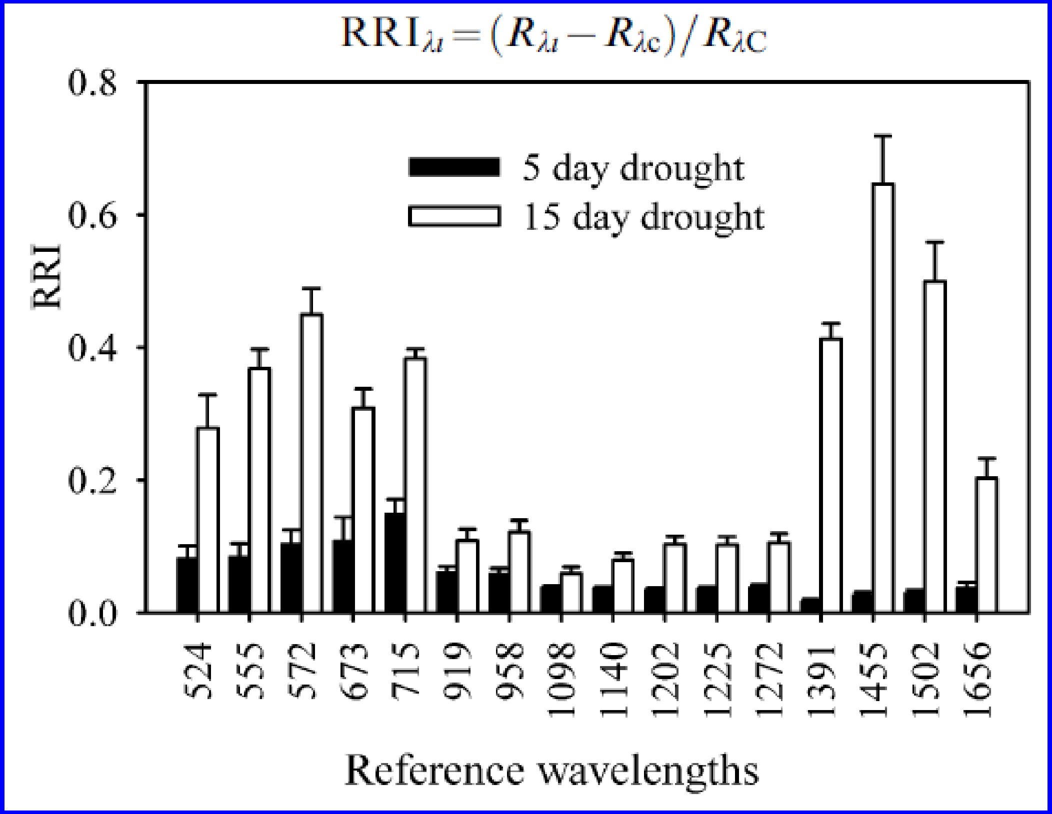
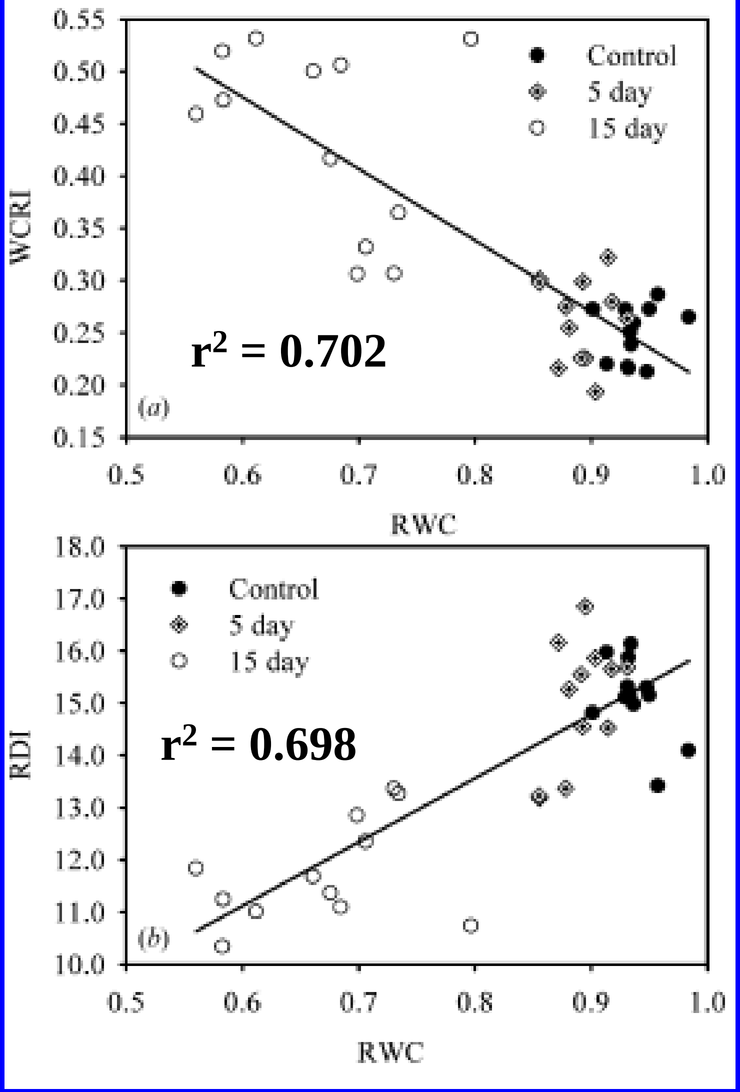
Associated changes in physiological parameters and spectral reflectance indices in olive (*Olea europaea* L.) leaves in response to different levels of water stress

P. SUN†, A. GRIGNETTI‡, S. LIU†, R. CASACCHIA‡, R. SALVATORI‡, F. PIETRINI§, F. LORETO§ and M. CENTRITTO*‡



Sun *et al.*, *International Journal of Remote Sensing*, 2008





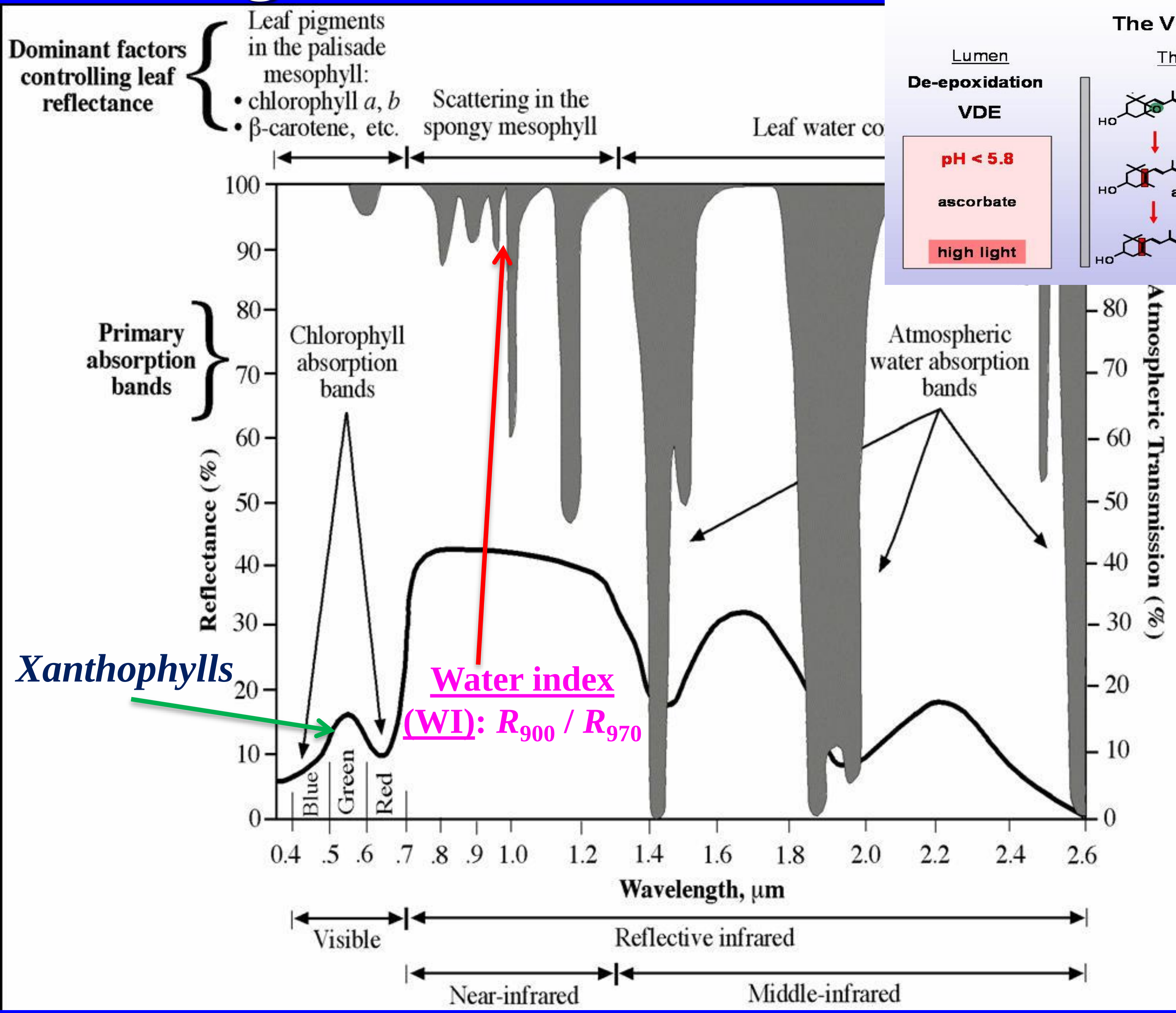
Relative reflectance increment (RRI) determined at different reference wavelengths in water-stressed olive saplings after five and 15 days from the onset of water stress.

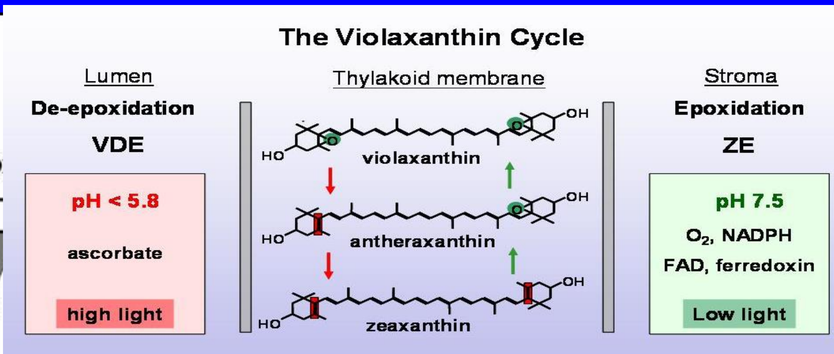
Relationships between relative water content (RWC) and (*a*) water content reflectance index (WCRI) and (*b*) relative depth index (RDI).

Dominant factors affecting leaf reflectance

Photochemical Raflectance Index (PRI) (Gamon *et al.*, 1997):

$(R_{531} - R_{570}) / (R_{531} - R_{570})$





Water absorption bands:

0.97 µm

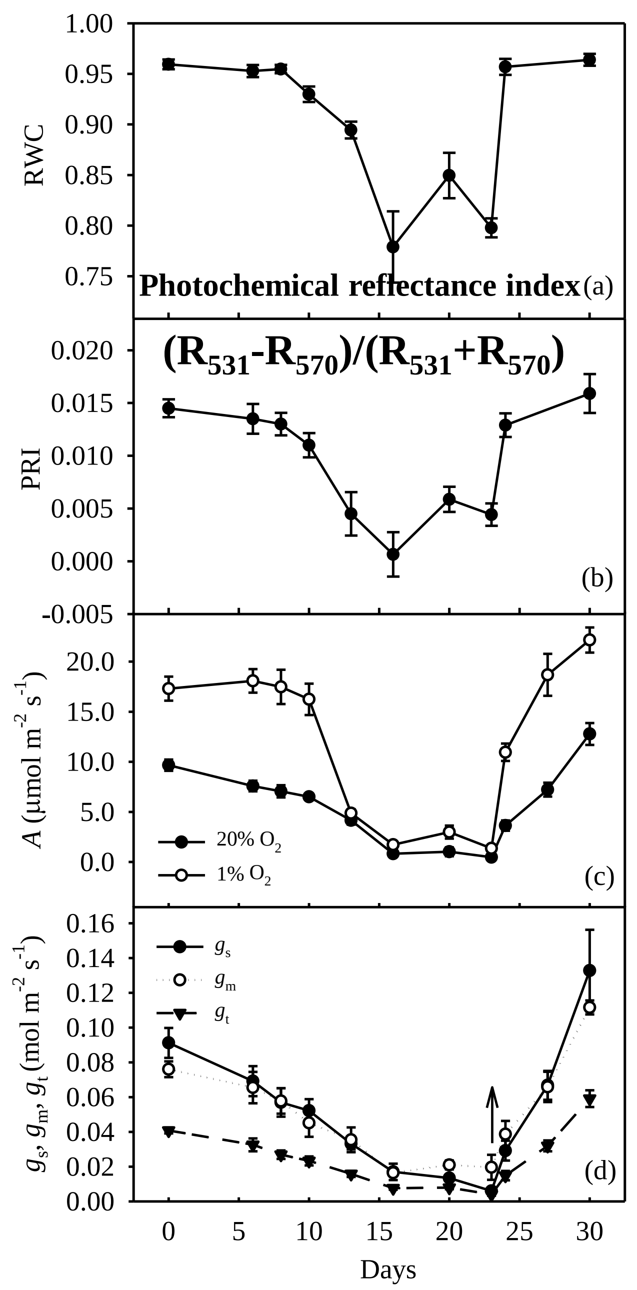
1.19 µm

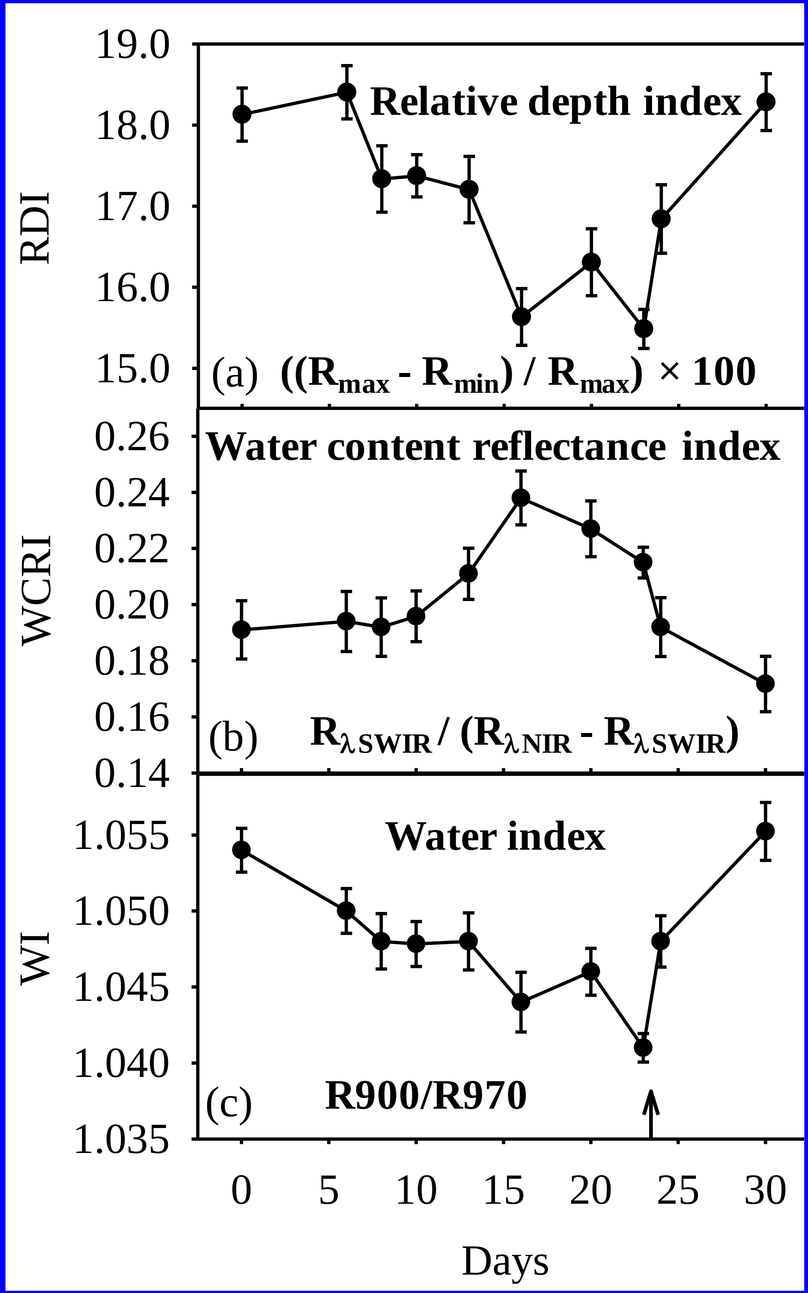
1.45 µm

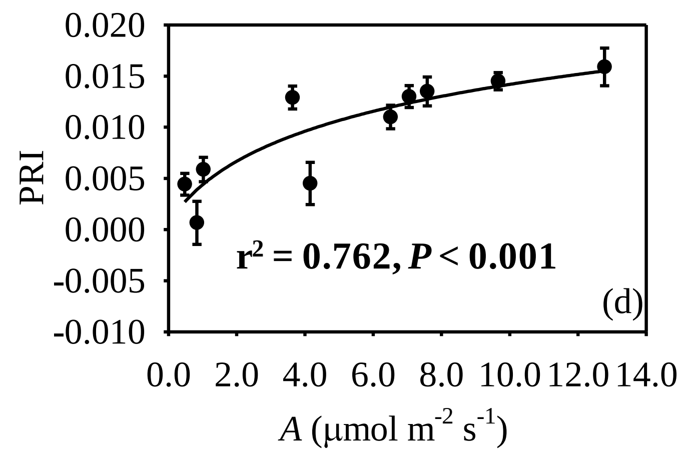
1.94 µm

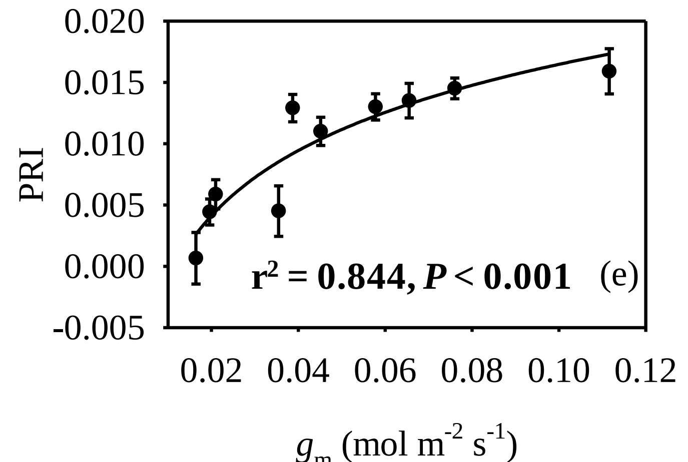
2.70 µm

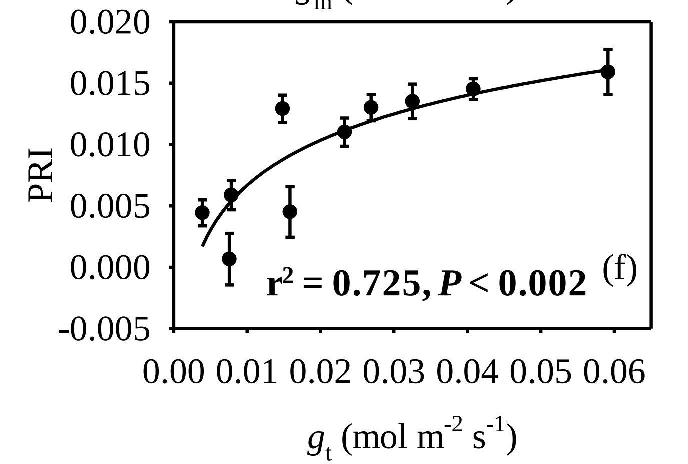
Laboratory experiment: Tsonev *et al.* (*International Journal of Agriculture and Biology*, 2014) - Sun *et al.*, 2014 (*PlosOne*)

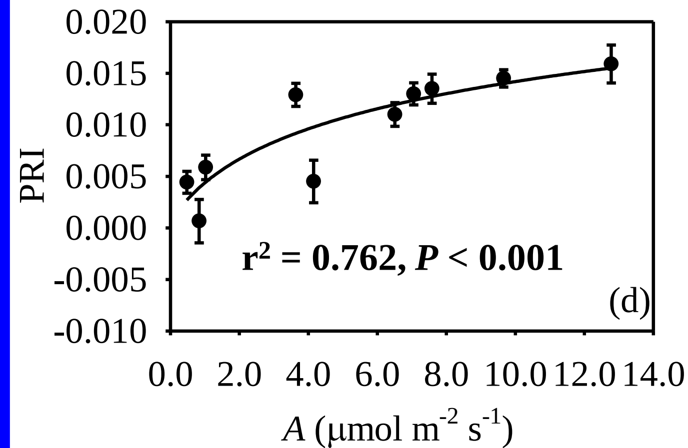


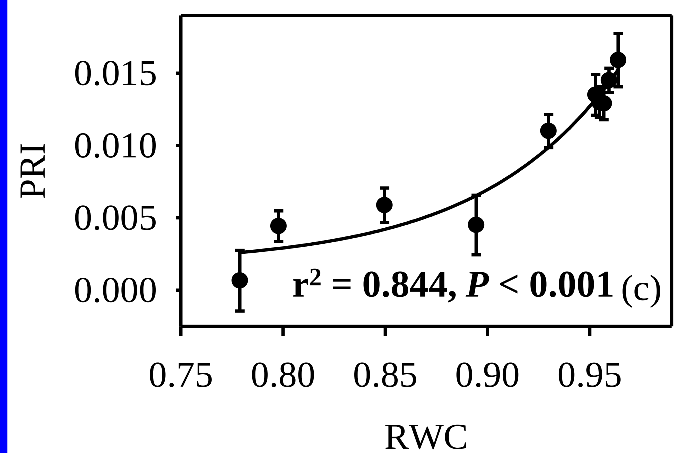


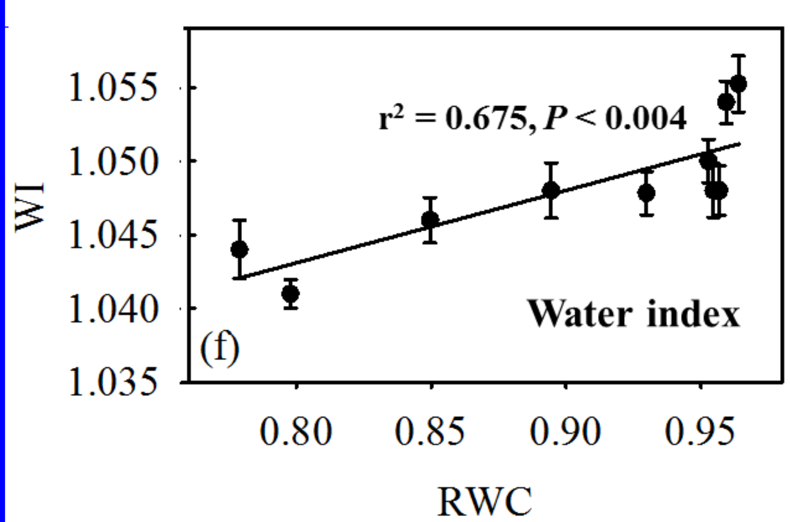

PRI
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0
A (µmol m-2 s-1)
r2 = 0.762, P < 0.001
(d)


PRI
0.020
0.015
0.010
0.005
0.000
-0.005
0.02 0.04 0.06 0.08 0.10 0.12
gm (mol m-2 s-1)
r2 = 0.844, P < 0.001
(e)


PRI
0.020
0.015
0.010
0.005
0.000
-0.005
0.00 0.01 0.02 0.03 0.04 0.05 0.06
gt (mol m-2 s-1)
r2 = 0.725, P < 0.002
(f)


PRI
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0
A (µmol m-2 s-1)
r2 = 0.762, P < 0.001
(d)


PRI
0.015
0.010
0.005
0.000
0.75 0.80 0.85 0.90 0.95
RWC
r2 = 0.844, P < 0.001
(c)


WI
1.055
1.050
1.045
1.040
1.035
0.80 0.85 0.90 0.95
RWC
r2 = 0.675, P < 0.004
Water index
(f)

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journal homepage: www.elsevier.com/locate/envexpbot

Assessing gas exchange, sap flow and water relations using tree canopy spectral reflectance indices in irrigated and rainfed *Olea europaea* L.

Giovanni Marino[a,b], Emanuele Pallozzi[c], Claudia Cocozza[b], Roberto Tognetti[b], Alessio Giovannelli[d], Claudio Cantini[d], Mauro Centritto[a,*]

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Ecohydrol. (2014)
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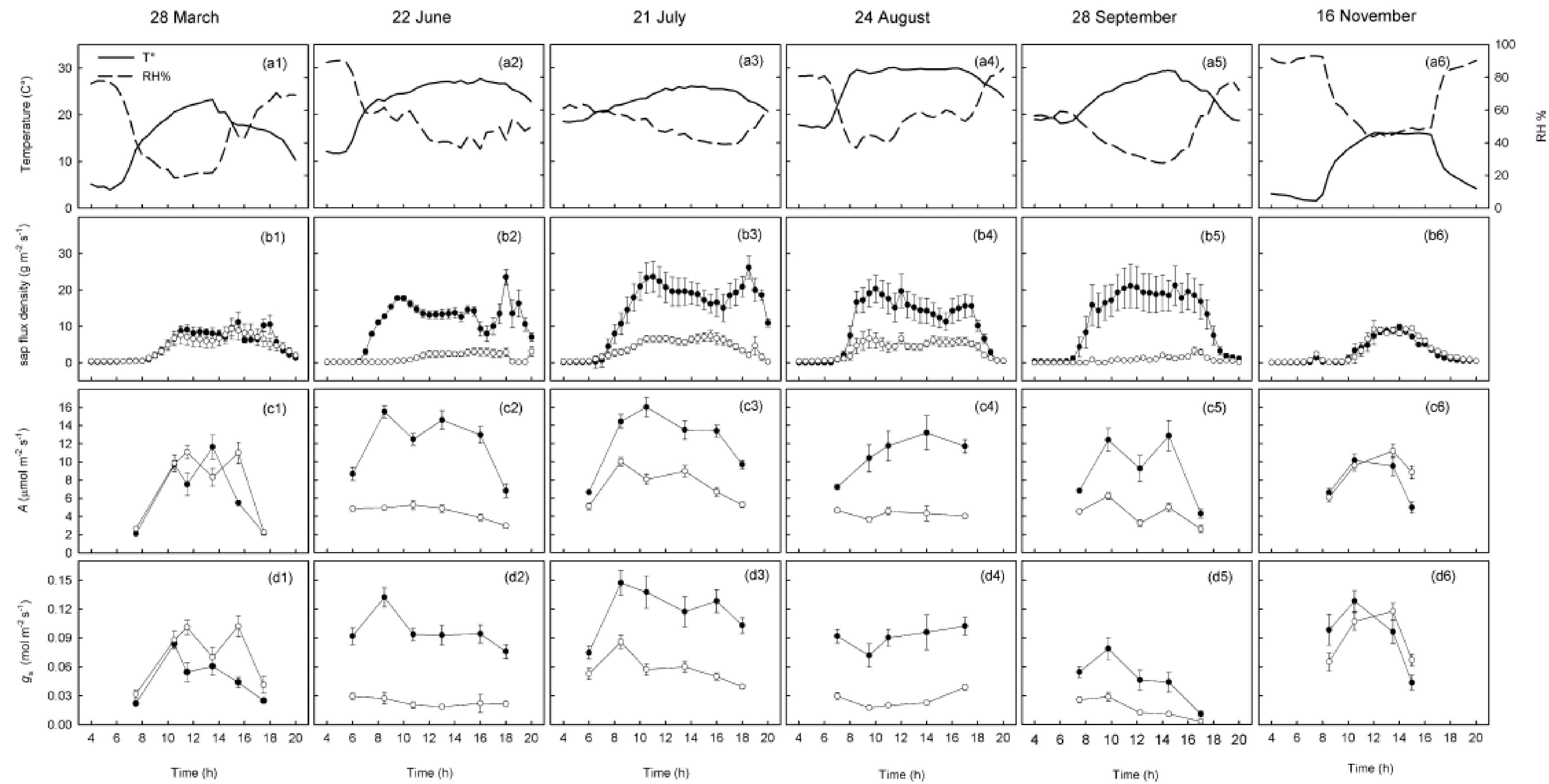
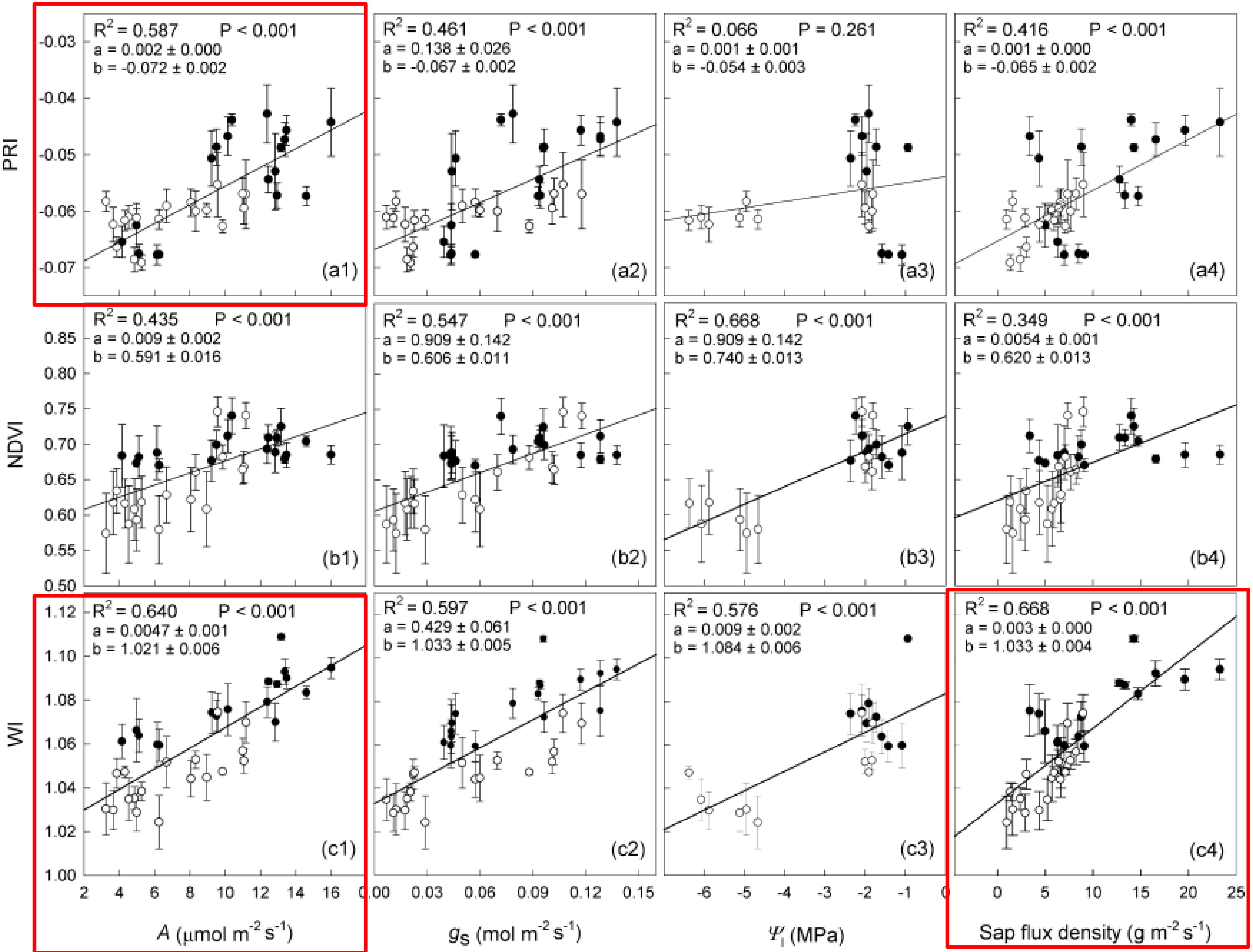
Simultaneous measurements of stem radius variation and sap flux density reveal synchronisation of water storage and transpiration dynamics in olive trees

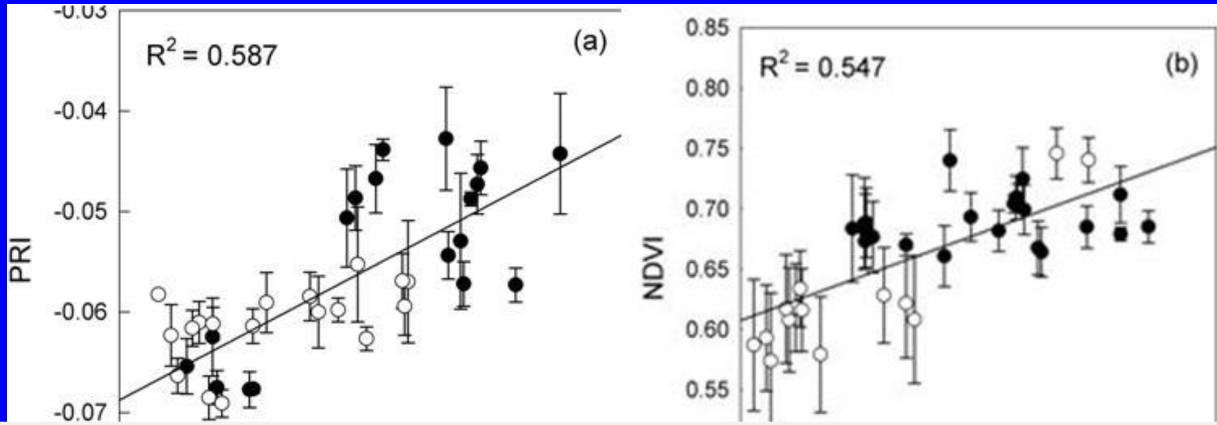
Claudia Cocozza,[1*] Giovanni Marino,[1,2] Alessio Giovannelli,[3] Claudio Cantini,[3] Mauro Centritto[2] and Roberto Tognetti[1,4]



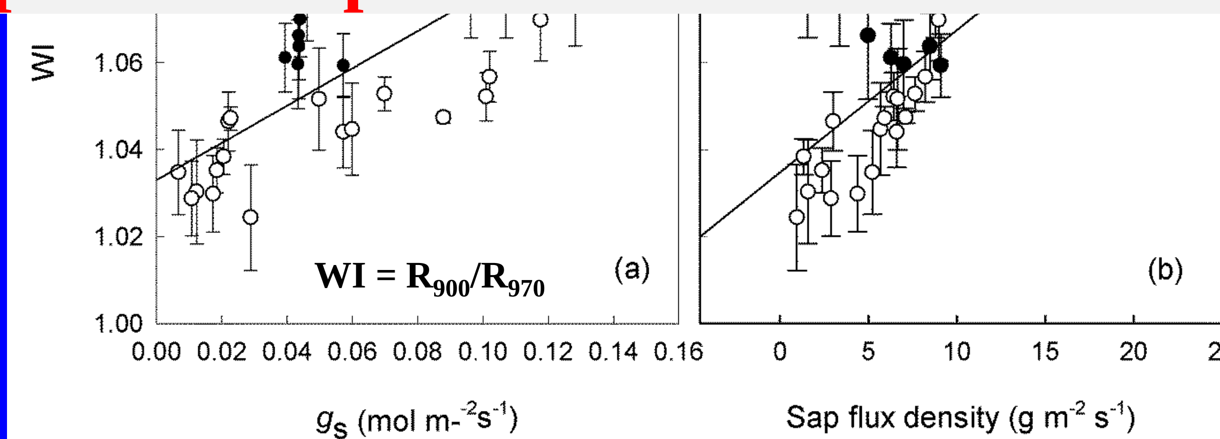


PRI
NDVI
WI
R^2 = 0.587 P < 0.001
a = 0.002 ± 0.000
b = -0.072 ± 0.002
(a1)
R^2 = 0.461 P < 0.001
a = 0.138 ± 0.026
b = -0.067 ± 0.002
(a2)
R^2 = 0.066 P = 0.261
a = 0.001 ± 0.001
b = -0.054 ± 0.003
(a3)
R^2 = 0.416 P < 0.001
a = 0.001 ± 0.000
b = -0.065 ± 0.002
(a4)
R^2 = 0.435 P < 0.001
a = 0.009 ± 0.002
b = 0.591 ± 0.016
(b1)
R^2 = 0.547 P < 0.001
a = 0.909 ± 0.142
b = 0.606 ± 0.011
(b2)
R^2 = 0.668 P < 0.001
a = 0.909 ± 0.142
b = 0.740 ± 0.013
(b3)
R^2 = 0.349 P < 0.001
a = 0.0054 ± 0.001
b = 0.620 ± 0.013
(b4)
R^2 = 0.640 P < 0.001
a = 0.0047 ± 0.001
b = 1.021 ± 0.006
(c1)
R^2 = 0.597 P < 0.001
a = 0.429 ± 0.061
b = 1.033 ± 0.005
(c2)
R^2 = 0.576 P < 0.001
a = 0.009 ± 0.002
b = 1.084 ± 0.006
(c3)
R^2 = 0.668 P < 0.001
a = 0.003 ± 0.000
b = 1.033 ± 0.004
(c4)
A (μmol m^{-2} s^{-1})
g_S (mol m^{-2} s^{-1})
Ψ_l (MPa)
Sap flux density (g m^{-2} s^{-1})

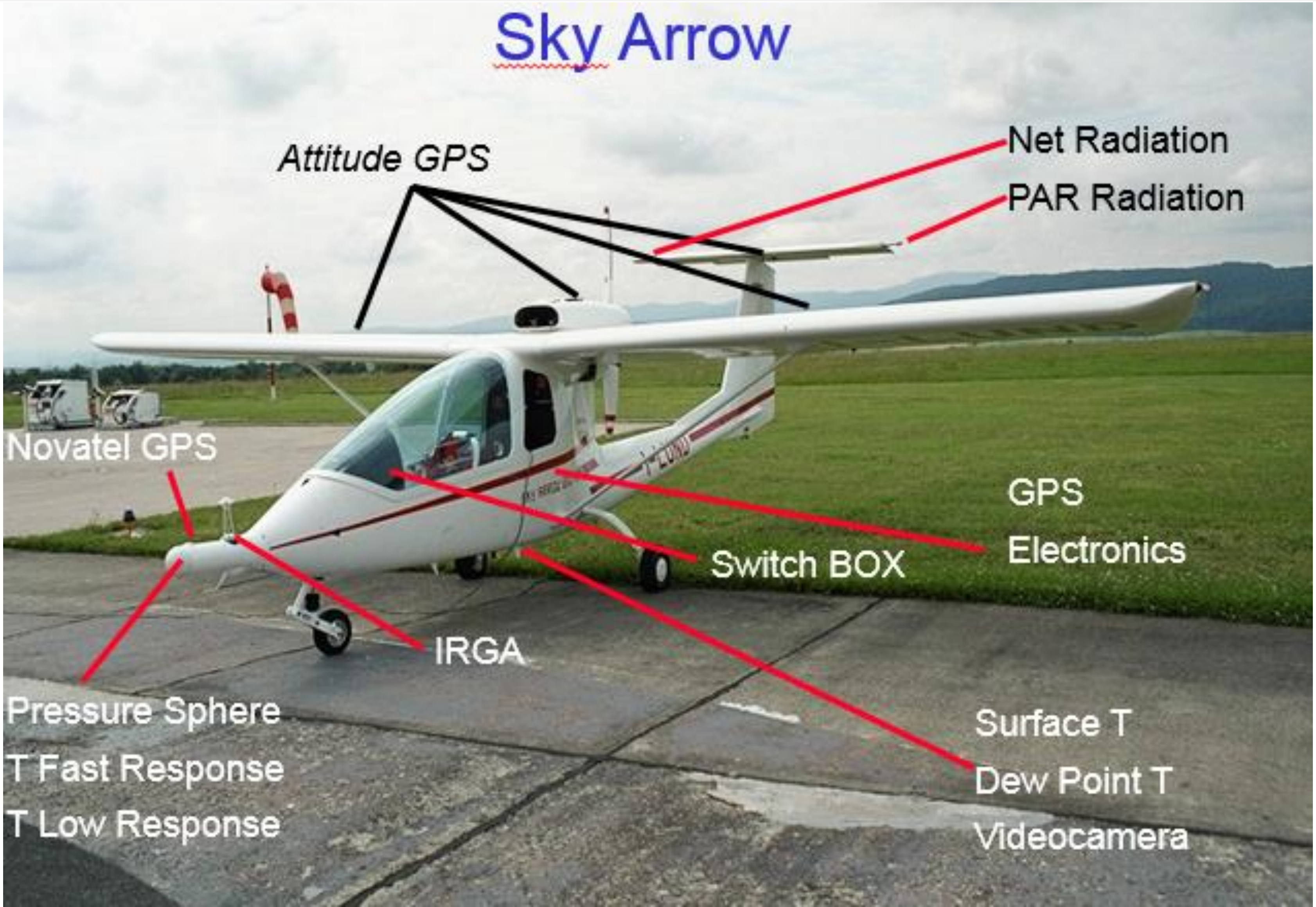
Marino *et al.*, *Environmental and Experimental Botany*, 2014



PRI and WI measured at the tree canopy can be used for fast, nonintrusive detection of water stress: these indices are promising predictive tools of the impact of drought on photosynthetic activity, water status and whole-plant transpiration.



Real time measurements of gas exchange in the atmosphere combined with simultaneous measurements of vegetation reflectance spectra.



Thank you!