Universiteit Utrecht

JÜLICH Forschungszentrum

WAGENINGEN UNIVERSITY & RESEARCH

Ecophysiological measurements during LIAISE field campaign

Hugo J. de Boer, Kevin van Diepen, Jerry Chen, Raquel Gonzalez Armas, Kim Faassen, Oscar Hartogensis, Jordi Vila, Wouter Mol, Mary Rose Mangan, Bastian Siegmann, Julie Kraemer …
… and many others!

Contact: h.j.deboer@uu.nl

Department of Environmental Sciences, Copernicus Institute for Sustainable Development, Utrecht University, The Netherlands

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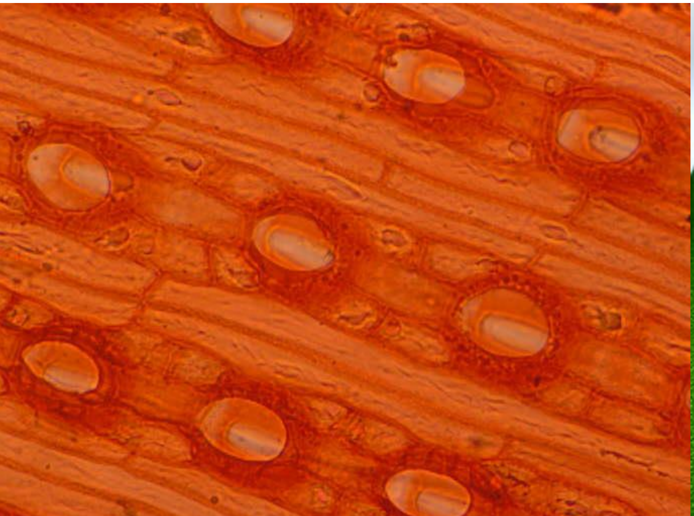
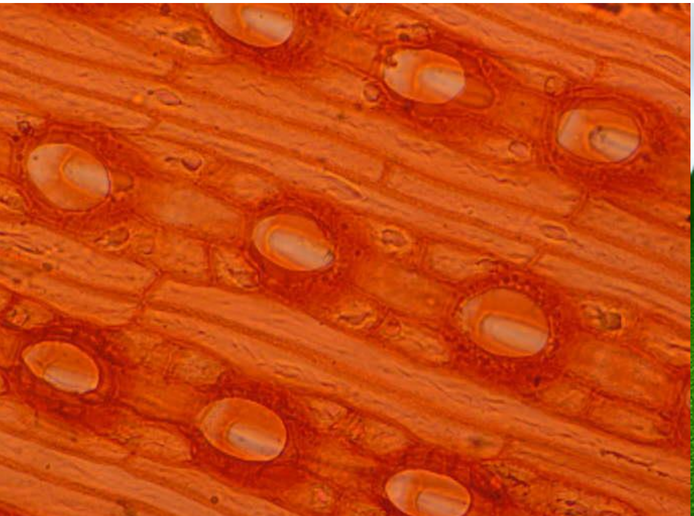


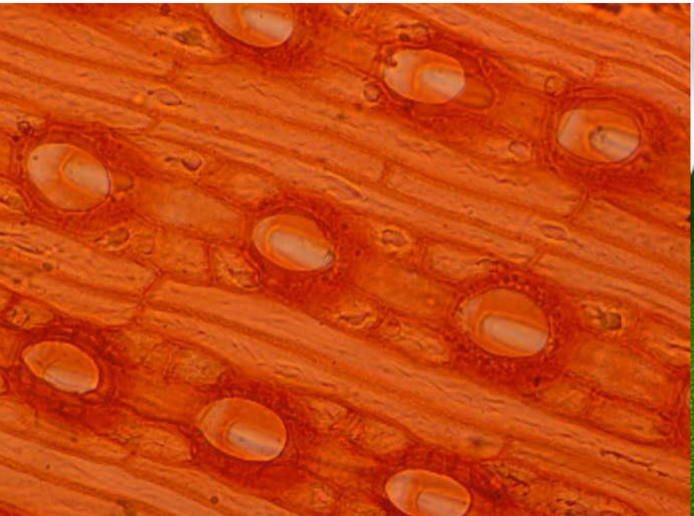
Main aims of our ecophysiological measurements

Ecophysiological characterization of the vegetated sites to:

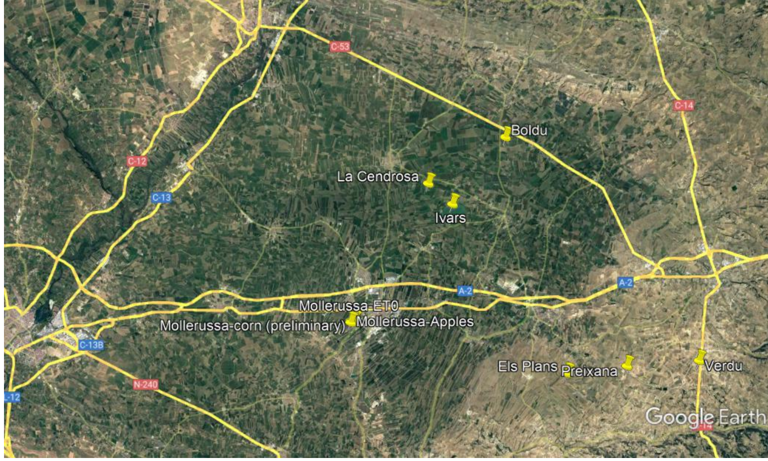
- provide vegetation-specific parameters for land surface models;
- provide leaf-level and canopy-level traits as ground-truth for remote sensing (SIF) and eddy covariance measurements;
- quantify diurnal patterns in leaf-level transpiration in response to drought stress;
- quantify partitioning of evaporation versus transpiration and photosynthesis versus soil respiration.



Methods



Overview of the measurement sites



IRTA apple orchard
with irrigation treatment

IRTA maize field (C4 species)

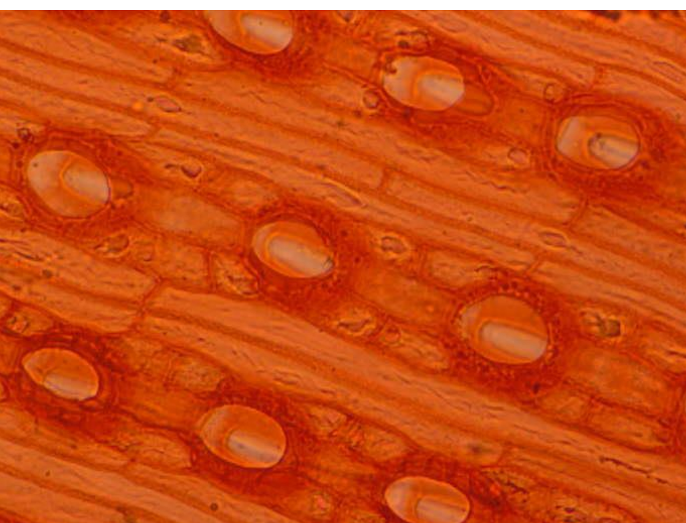
Preixana almond grove

La Cendrosa alfalfa field

Verdú vineyard

Overview of IOPs and ecophysiological measurements

Day	Site	Measurement
Thursday 15-7	IRTA apple	Light and CO2 response curves.
Saturday 17-7	Cendrosa Alfalfa	CO2 and light response curves, diurnal stomatal conductance (g_s) curves
Monday 19-7	Cendrosa Alfalfa	- Soil respiration, canopy properties (also measured on several other days) - Collaboration with Julich spectral measurements
Tuesday 20-7	Verdu wine	CO2 and light response curves, midday g_s and Amax, soil respiration, canopy properties
Wednesday 21-7	Preixana almond	CO2 and light response curves, midday g_s and Amax, soil respiration, canopy properties
Thursday 22-7	IRTA apple	- CO2 and light response curves, canopy properties and soil respiration. - Collaboration with Julich spectral measurements
Friday 23-7	IRTA apple	- CO2 and light response curves, diurnal curves. - Collaboration with Julich spectral measurements
Saturday 24-7	IRTA mais	- CO2 and light response curves. - Collaboration with Julich spectral measurements and soil respiration, canopy properties



Ecophysiological measurements conducted

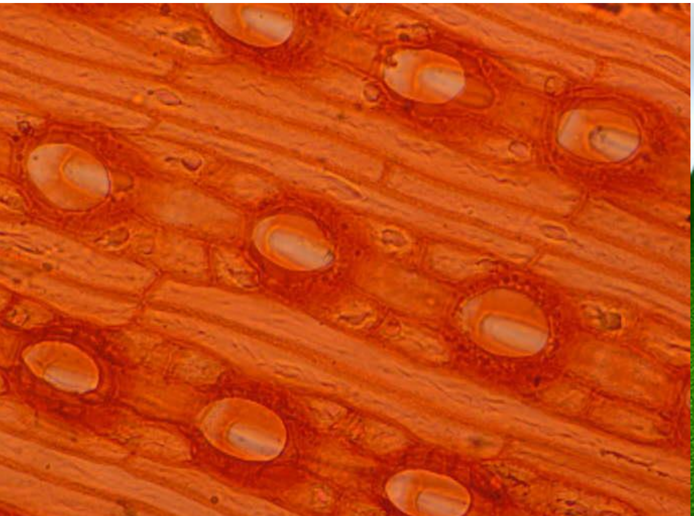
Leaf gas exchange with LI-6400XT

- Midday stomatal conductance at all vegetated sites
- Midday light-saturated photosynthesis (A_{max}) at all vegetated sites
- CO_2 response curves to derive V_{cmax} and J_{max} at most vegetated sites (Verdù vineyard was difficult due to closed stomata)
- Diurnal stomatal conductance at La Cendrosa
- Late-morning, midday and early-evening stomatal conductance and photosynthesis, together with SIF and leaf optical traits together with Jülich group (La Cendrosa, IRTA apple, IRTA maize)

Ecophysiological measurements conducted

Leaf traits

- Leaf size at all vegetated sites
- Specific leaf area (SLA) at all vegetated sites (*to be measured in the lab*)
- Leaf nitrogen content (N_{area} and N_{weight}) at all vegetated sites (*to be measured in the lab*)



Ecophysiological measurements conducted

Canopy properties and soil respiration

- Leaf Area Index (LAI) of vegetated parts with ACCUPAR LP-80.
- Soil respiration with PP systems SR-2 chamber & EGM5 CO_2 analyzer.
- Vegetated area fraction based on tree/row width and tree/row spacing for individual trees (almonds) and row crops (apple trees and grape vine).
- Canopy height with measurement tapes.

LAI: ACCUPAR LP-80

Soil respiration: SR-2 & EGM5

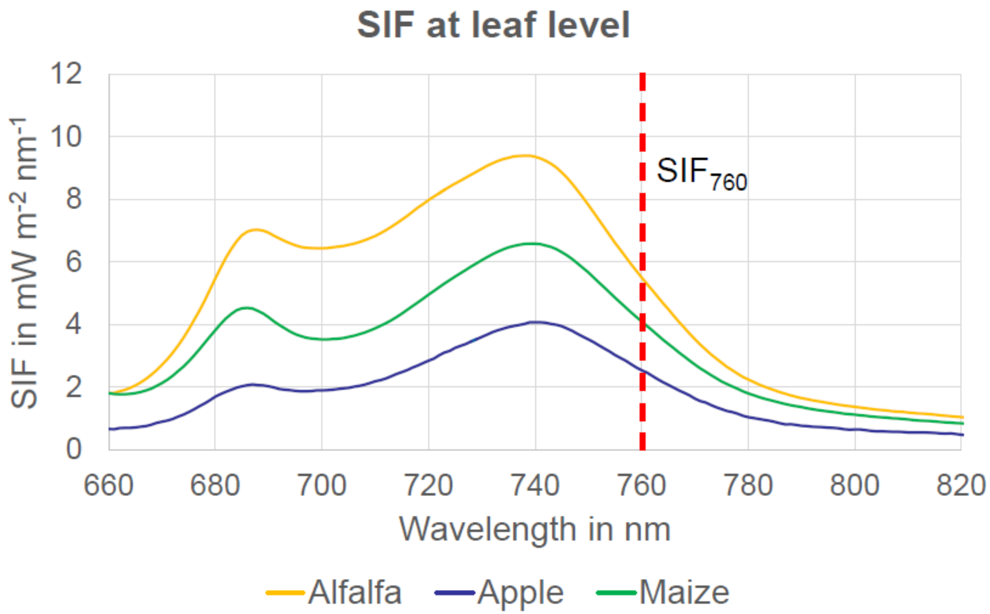
In-field collaborations

- Measurements conducted near EC stations to facilitate leaf to canopy scaling
- Combined measurements of photosynthesis and diurnal patterns in Solar Induced mesophyll Fluorescence (SIF) with Jülich, CESBIO and LTDA groups (Bastian Siegmann, Julie Kraemer, Valerie le Dantec, Giulia Tagliabue, Roberto Colombo and co-workers) at La Cendrosa, IRTA apple and IRTA maize sites.
- Combined measurements of stomatal conductance, leaf and stem water potential, canopy temperature and photosynthesis response curves at the IRTA apple site during IOP 22-7-2021 (IRTA / Joaquim Bellvert and co-workers).
- Comparison of stomatal conductance measured with porometer and LI6400XT (Janis Groh).

In-field collaborations: diurnal patterns in SIF and leaf-level photosynthesis

Measuring SIF at the leaf level (from both sides)

Fluowat



- double peak SIF emission at leaf level (650-800 nm)

In-field collaborations: diurnal patterns in SIF and leaf-level photosynthesis

Working principle of the FLUOWAT

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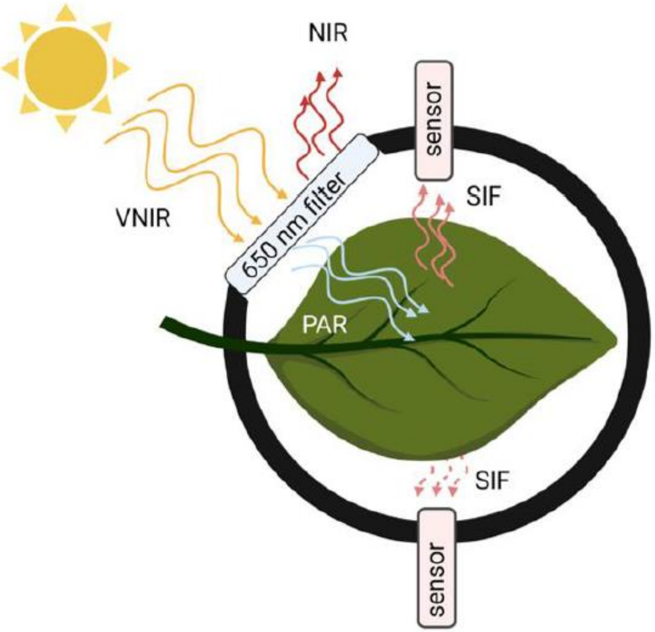
- FLUOWAT leaf clip conected to a spectrometer
- Incoming radiation > 650 nm blocked by cut-off filter
- Measured light by the spectrometer (sensor) only consists of the SIF signal emitted from both leaf sides



In-field collaborations: diurnal patterns in SIF and leaf-level photosynthesis

Calculating SIF yield at 760 nm

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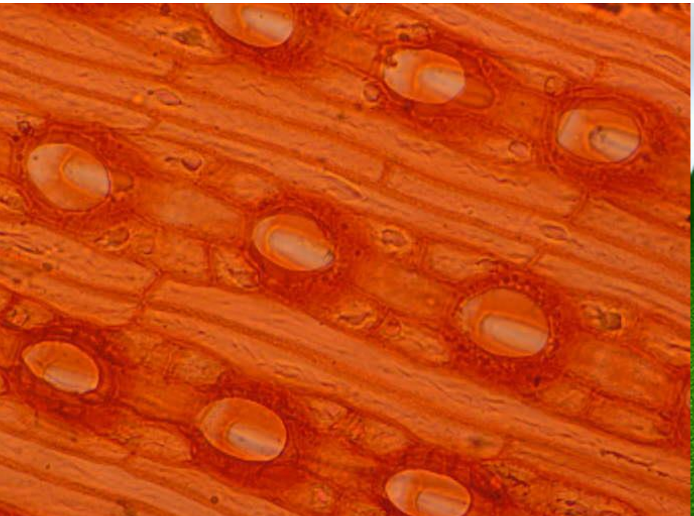
- SIF mainly driven by PAR (APAR)
- Goal: normalizing absolute measured SIF for the influence of APAR by calculating SIFyield
- PAR (in $mWm^{-2}s^{-1}$) measured by the upward looking fibre of a D-FloX system
- Absorbance (A in %) estimated from PolyPen leaf measurements

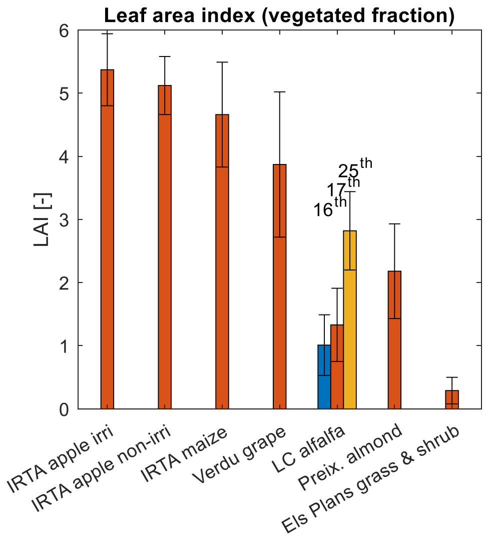
$$\mathrm{APAR} = \mathrm{PAR} \times \mathrm{A} \qquad (1)$$

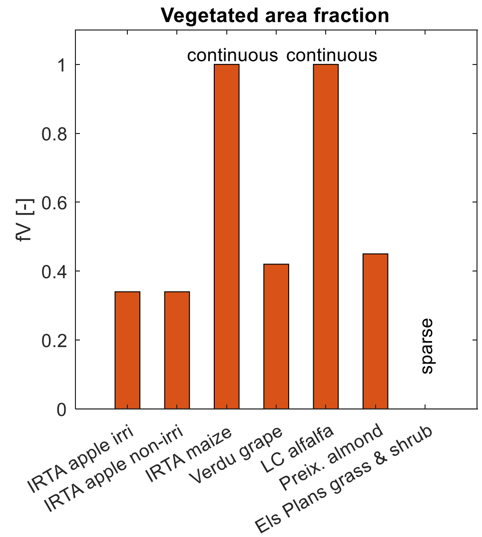
$$\mathrm{SIF}_{760}\mathrm{yield} = \frac{\mathrm{SIF}_{760}}{\mathrm{APAR}} \qquad (2)$$

Preliminary results



Canopy properties across sites



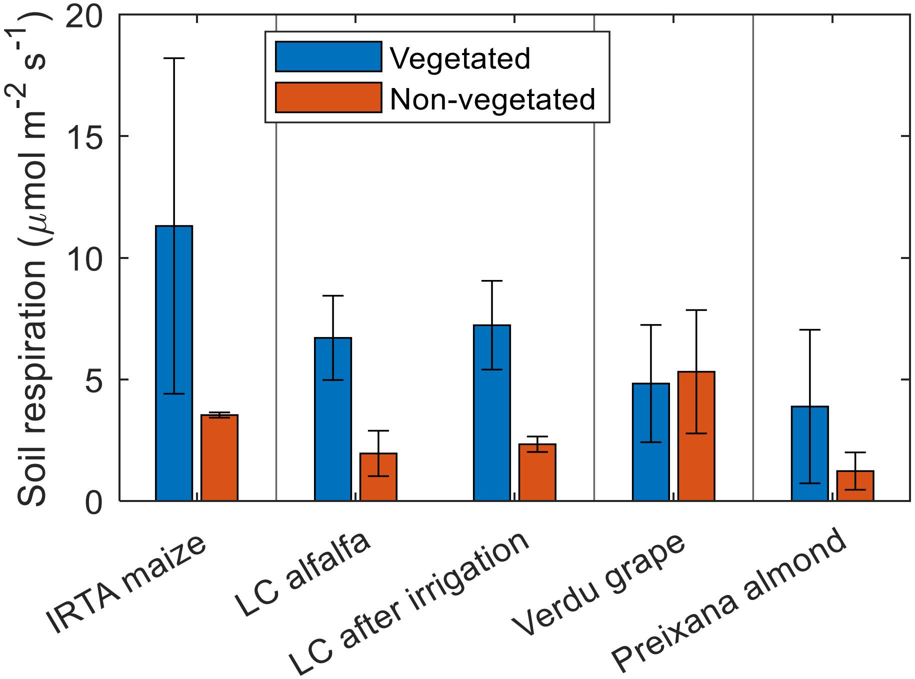


LAI and vegetated fraction (fV):

- Site-specific values of LAI and fV for modelling.
- Growing alfalfa canopy captured in LAI.
- Canopy structure parameters relevant for in-canopy turbulence.

Site	Vegetation structure	Vegetated fraction fV [-]
IRTA apple	open rows	0.34
IRTA maize	dense rows	fully covered
Verdú grape	open rows	0.42
La Cendrosa alfalfa	random	fully covered
Preixana almond	open rows	0.45
Els Plans shrub and grass	random	sparse, partly dry / dead

Soil respiration across sites

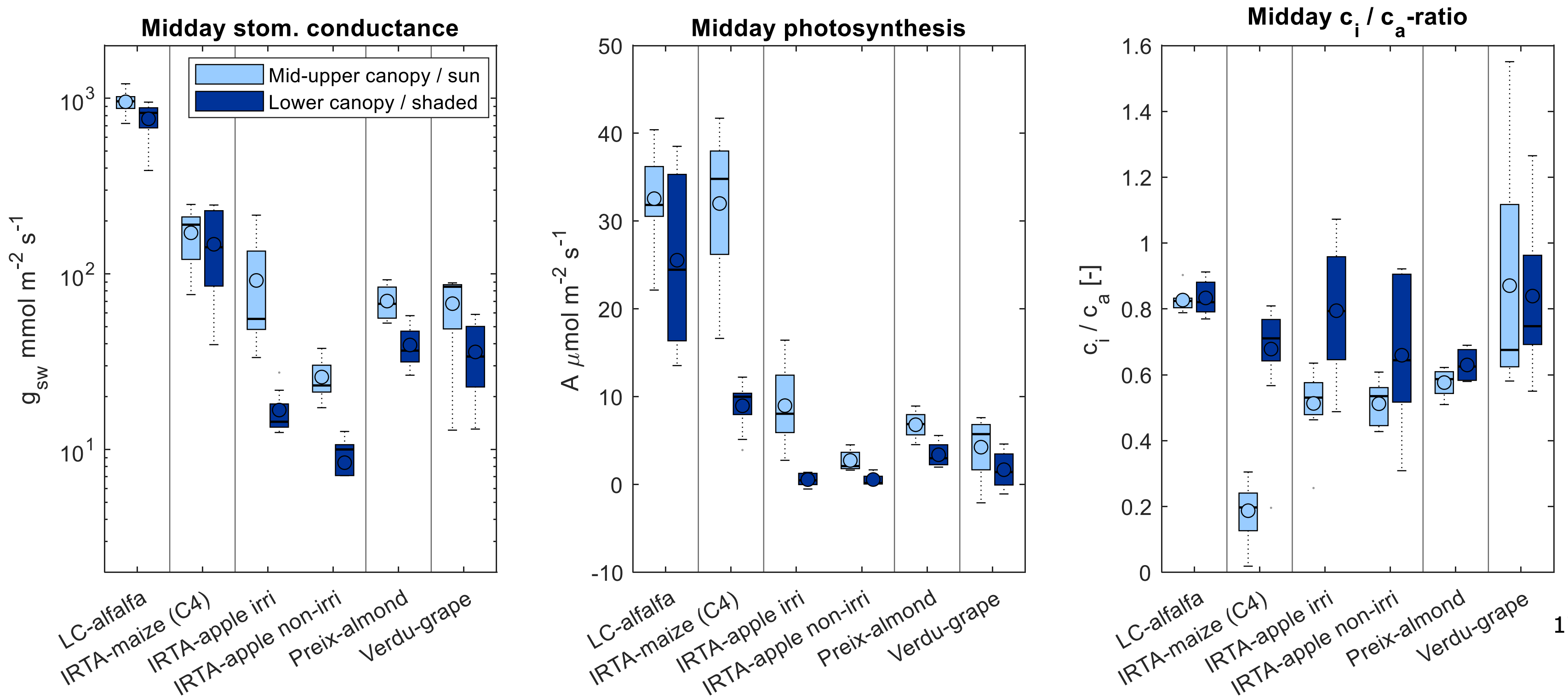


Soil respiration:

- Strong *local* influence of vegetation on SR, except for vineyard
- Small effect of irrigation on SR at LC
- Site-specific values can be calculated for modelling (SR and fV)

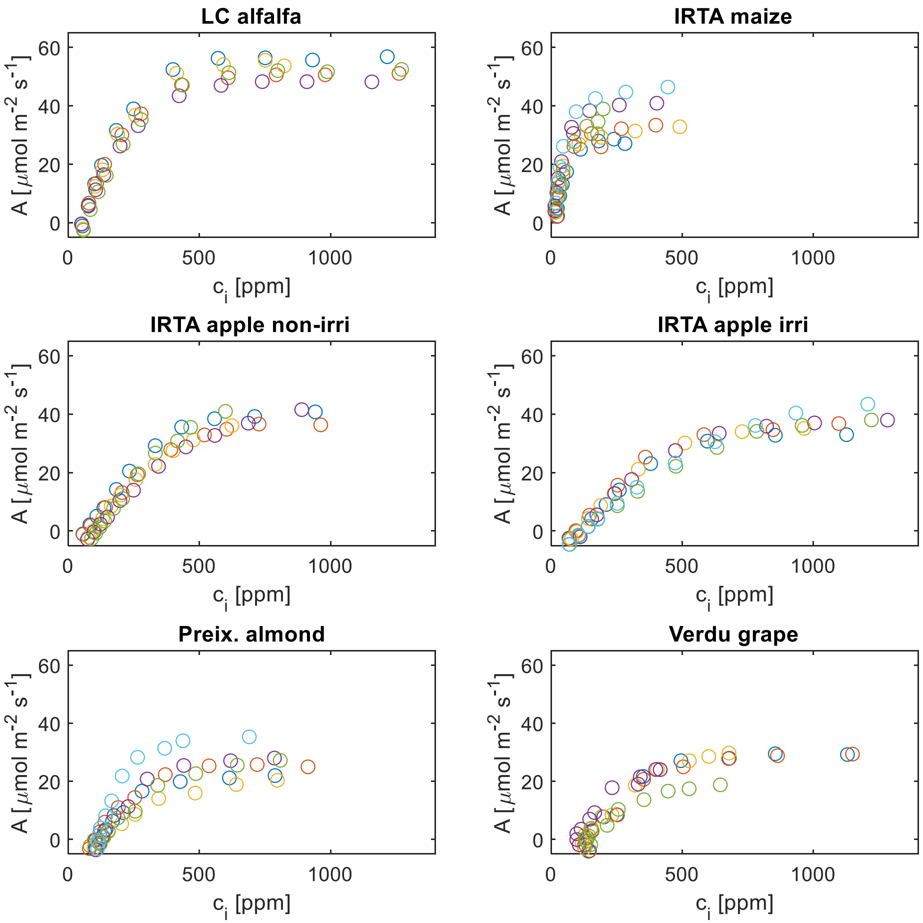
Midday leaf gas exchange across sites

- Measured between 11:00 and 15:00 with PAR resembling sun/shade light levels of the specific canopy.
- Clear differences between sun-lit and shaded leaves.
- Stomatal conductance (g_{sw}) in alfalafa is extremely high with very high ci/ca-ratios (0.5 – 0.7 is typical).
- Maize can function at very low ci/ca-ratios due to C4 photosynthesis.

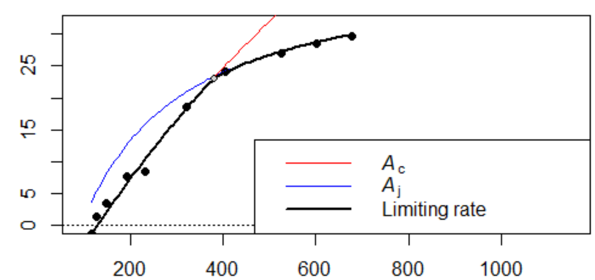


Photosynthesis traits across sites

- CO_2-response curves (and light-response curves, not shown) measured across sites.
- Response curves used to fit Farquhar model of photosynthesis to derive key photosynthesis traits for modelling (V_{cmax}, J_{max} and R_d).

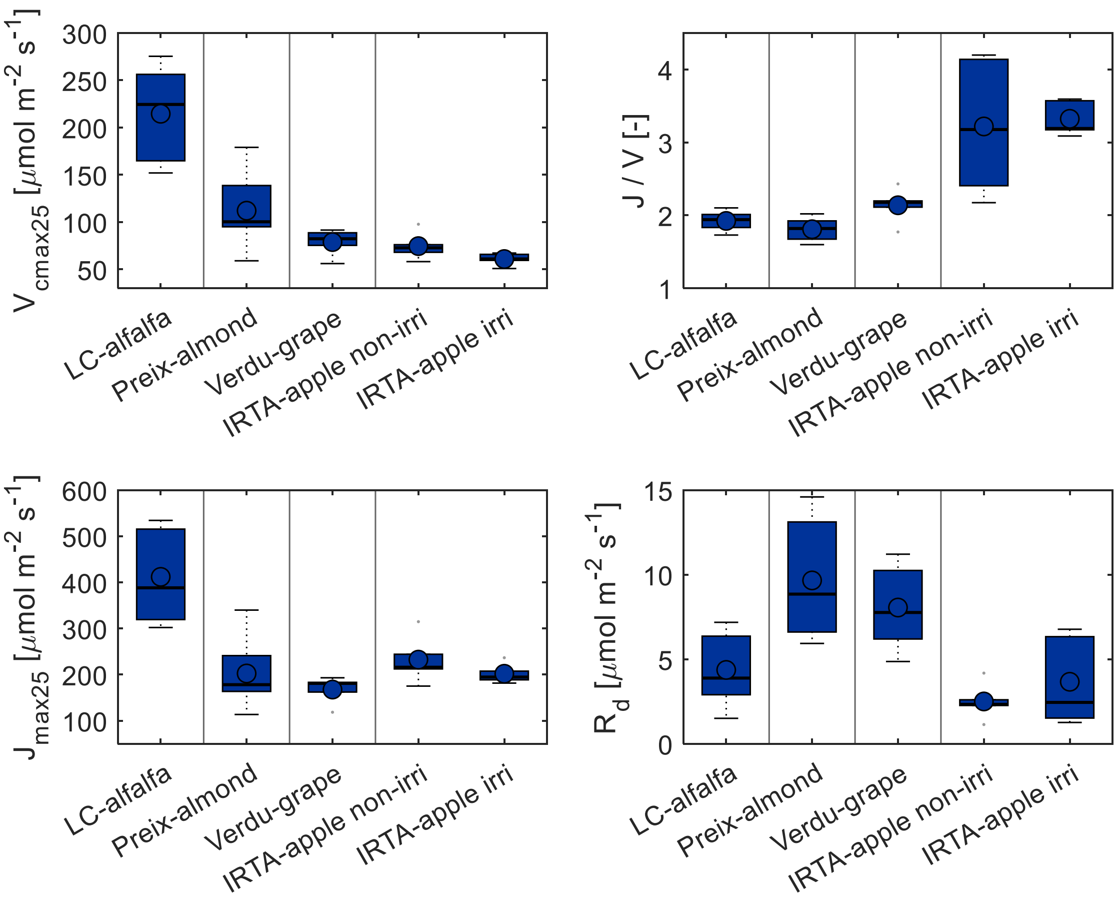


Fit Farquhar model of photosynthesis (V_{cmax}, $J_{max,}$ R_d)



Photosynthesis traits across sites

- Considerable differences across the sites / species.
- Photosynthesis traits V_{cmax}, J_{max} and R_d are key inputs for vegetation models and can be based on these site-specific measurements.
- Maize C4 photosynthesis traits still need to be fitted using specific approach.



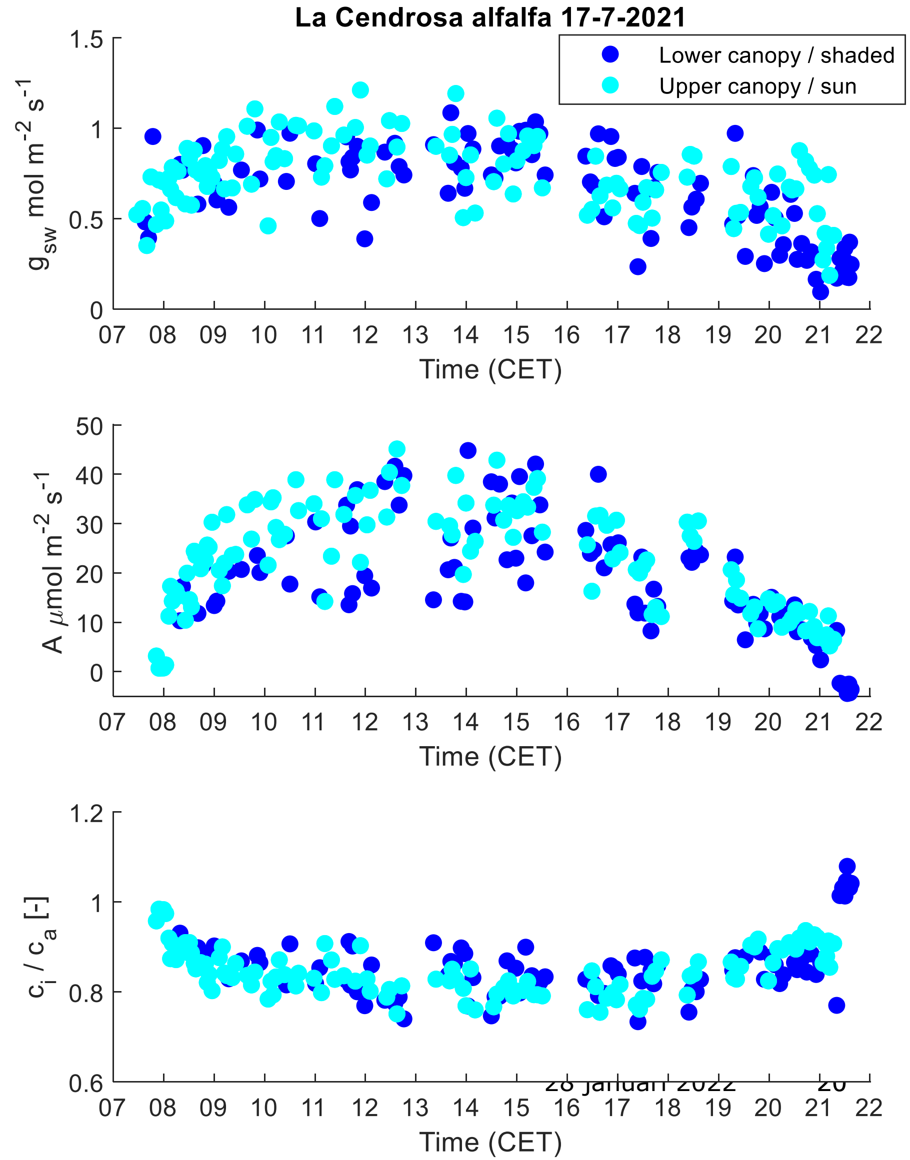
Diurnal patterns in leaf gas exchange

La Cendrosa alfalfa (17-7-2021)

Stomatal conductance

Photosynthesis

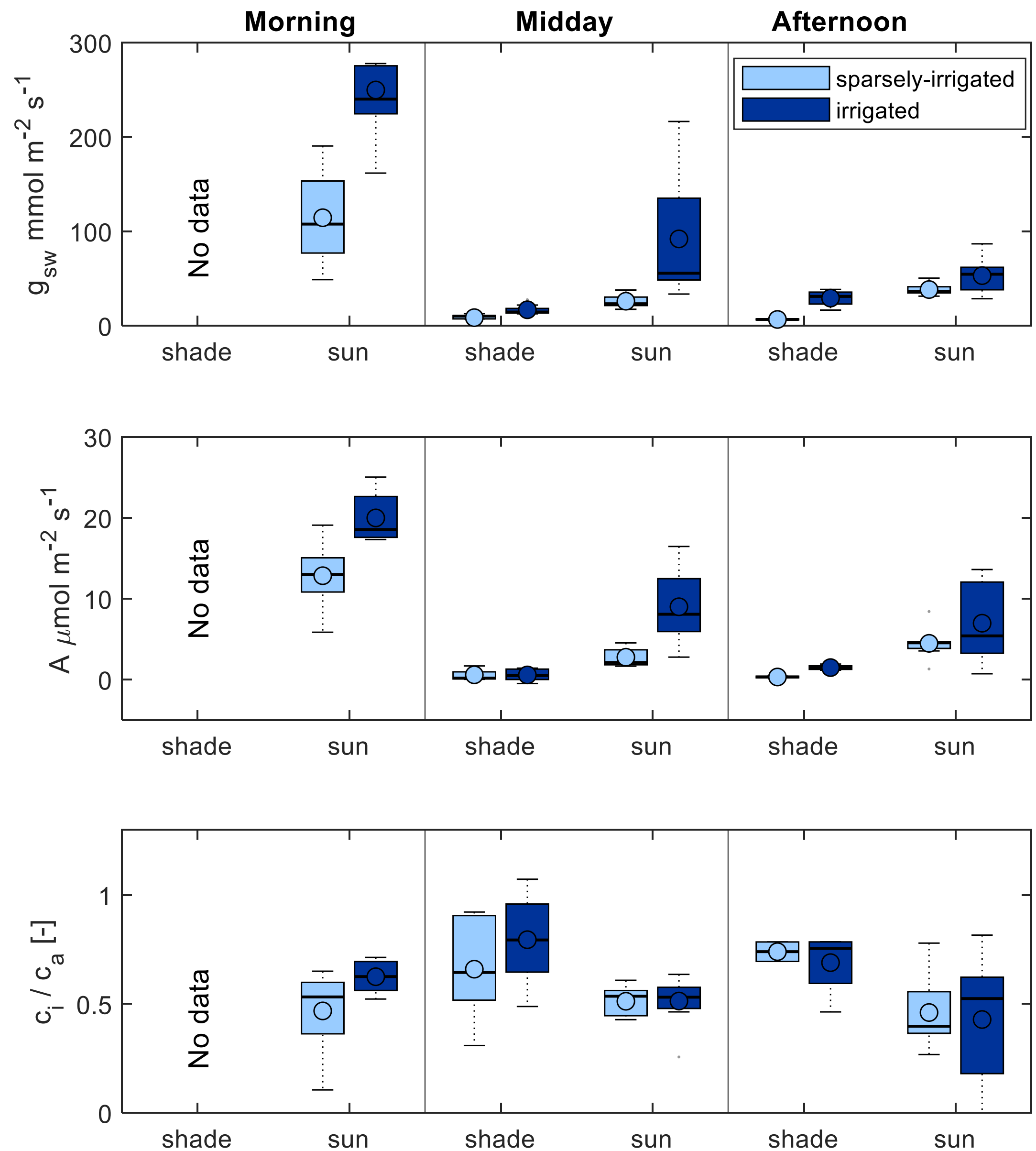
c_i / c_a - ratio



Diurnal patterns in leaf gas exchange

IRTA apple 22-7-2021

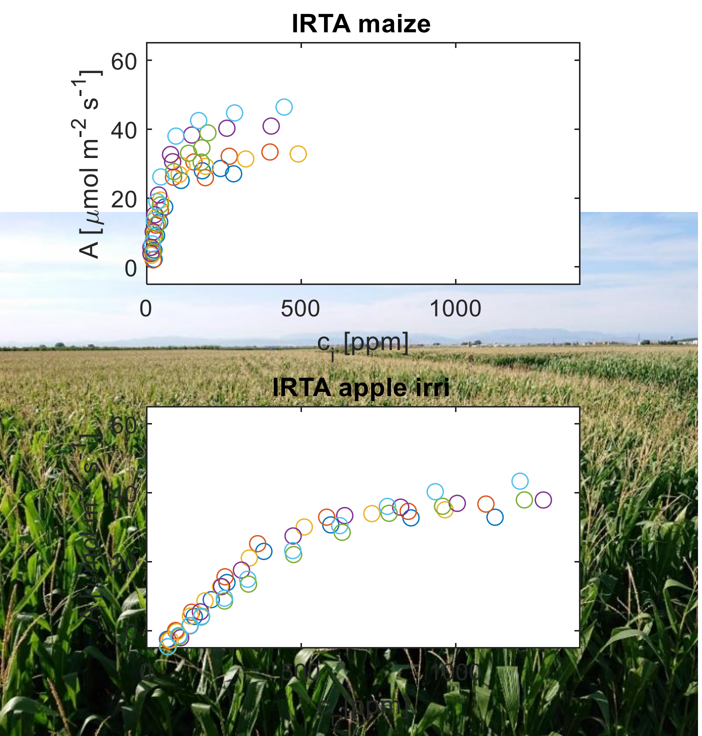
- Clear differences between irrigated and sparsely-irrigated side.
- Stomatal closure during the day in upper canopy
- Evidence of diurnal hysteresis between VPD and evaporation due to stomatal response.

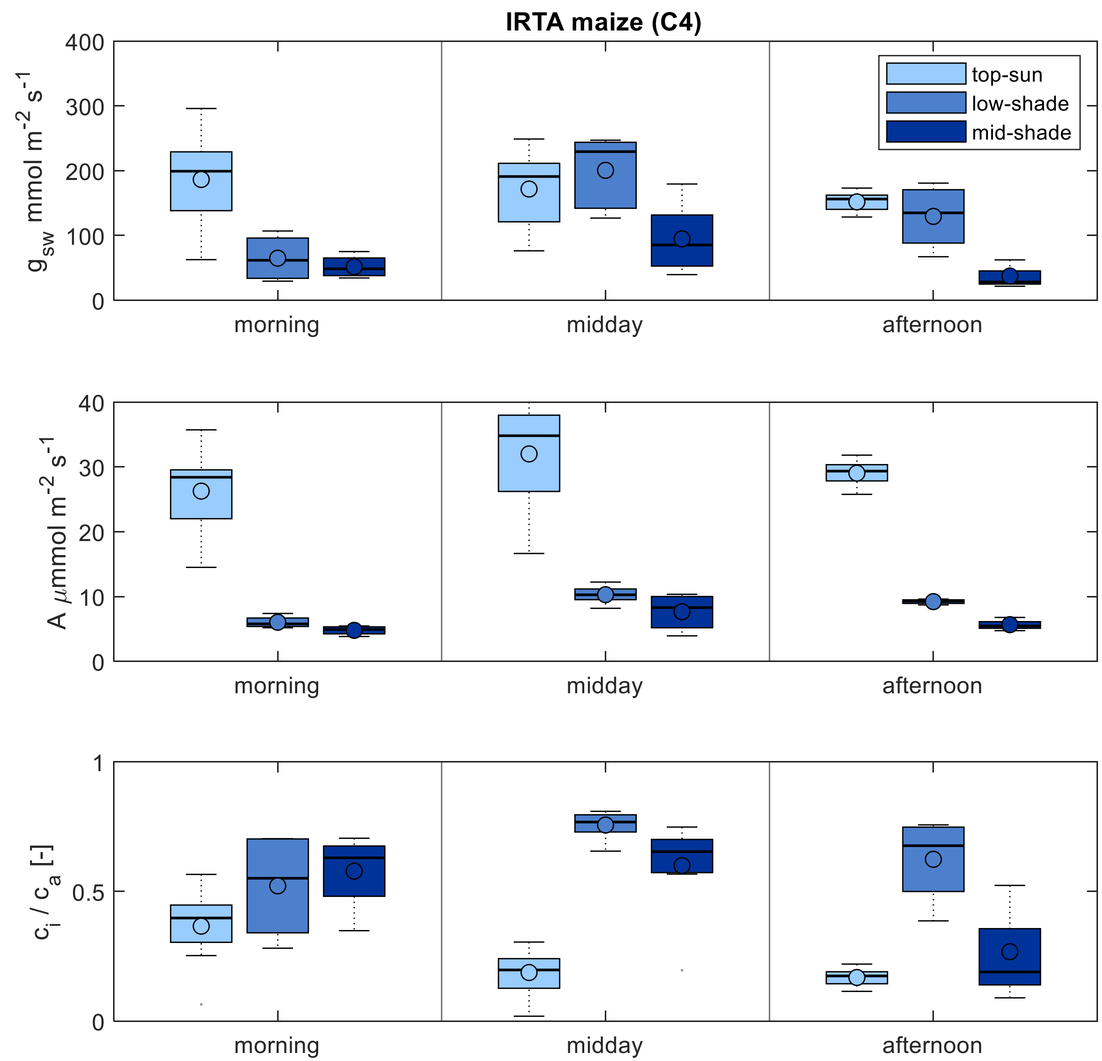


Diurnal patterns in leaf gas exchange

IRTA maize (C4) 24-7-2021

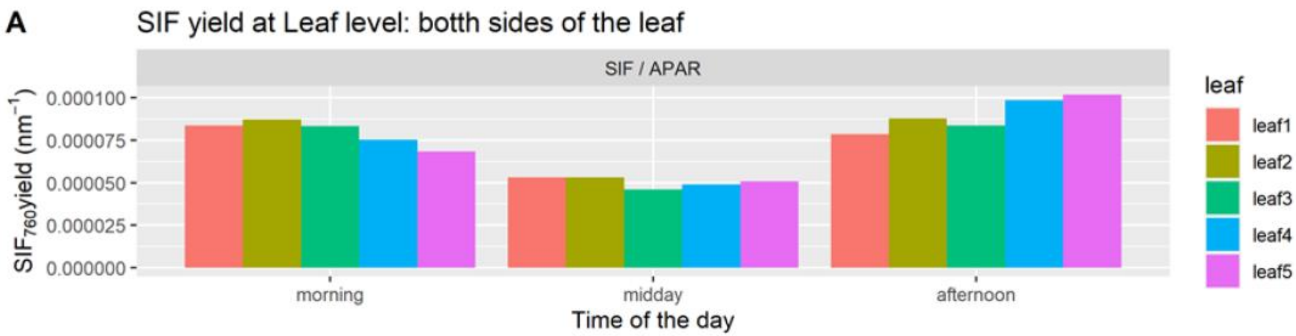
- Stomatal closure during the day in upper canopy
- Less pronounced compared to the nearby apple orchard.
- Little effect of stomatal closure on *A* due to C4 photosynthesis

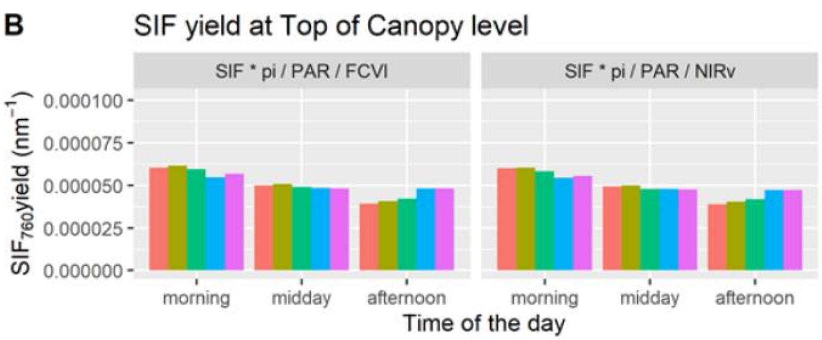


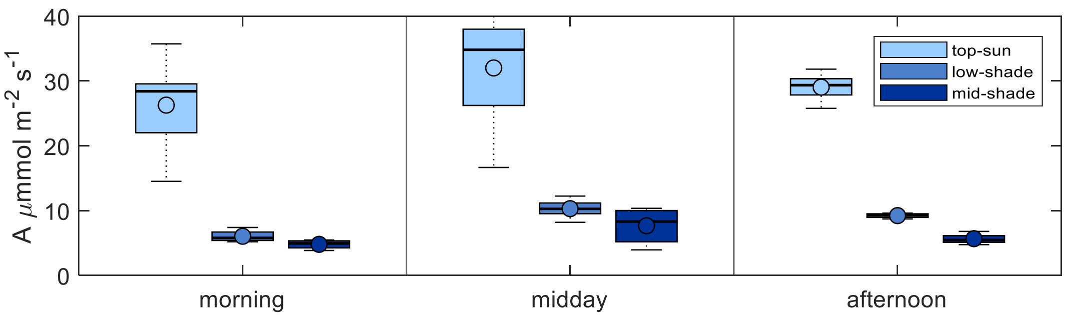


In-field collaborations: SIF

Diurnal SIF measurements of maize (24 July 2021)





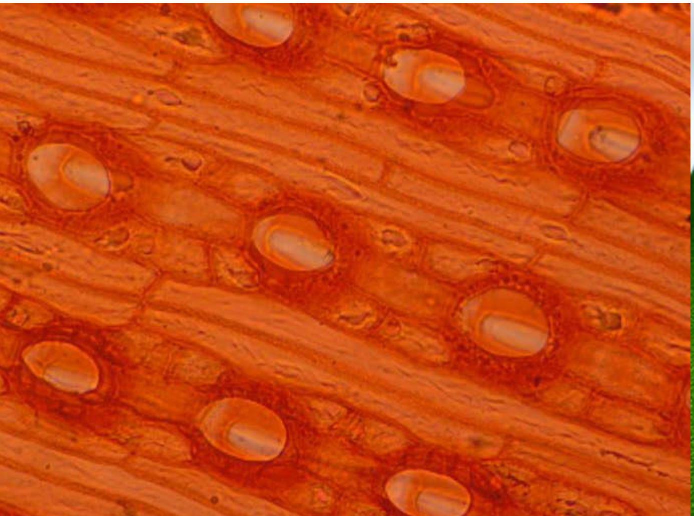


Conclusions

- Leaf-level and canopy-level data collected for five vegetated sites.

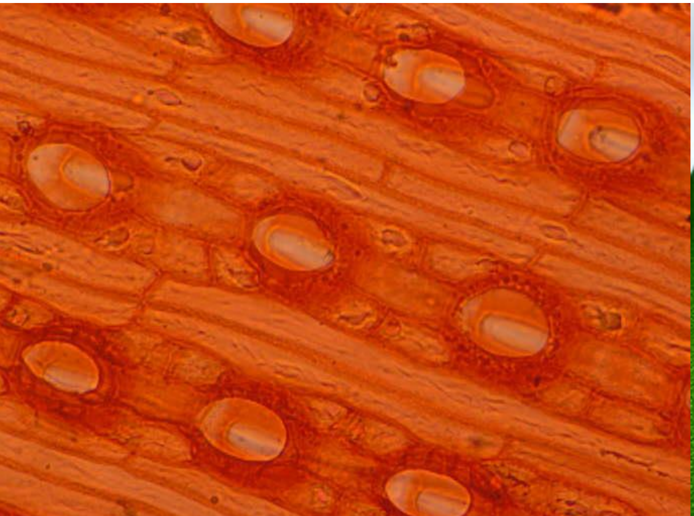
- Site-specific model parameters are needed to account for the differences between sites.

- Data now available for input and validation for modelling and remote sensing.



Outlook

- Follow-up meetings with 'ecophys' groups to discuss coordinated analyses.
- Lab analyses of leaf N and P and other classic leaf traits (LMA, stomatal traits).
- Modelling of canopy fluxes of water and carbon with vegetation-specific parameters.
- Understanding of leaf – canopy – landscape scaling relationships in data and models.
- Hysteresis in the diurnal relationships VPD-ET and PAR-photosynthesis.



Thank you very much!

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