LIAISE WG1 – Surface Processes – meeting

Thursday 24 November 2022

Field Campaign July 2021, Spain
« Chlorophyll Fluorescence measurements »

LMD

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Objectives

- Build a dataset of fluorescence measurement at ground level
  - In support of airborne fluorescence measurement
  - At different scales : leaf to canopy
  - Using complementary measuring techniques : passive (SIF), active

- Investigate fluorescence dynamics in relation with environmental conditions (light, temperature, water status)
  - Changes in fluorescence yield and its relationship with photosynthesis efficiency (active measurements, gaz exchange)
  - How it affects SIF measurements at canopy level ?

- Upscaling effects from leaf to canopy
  - Red/far red ratio, emission spectrum
  - Retrieval of fluorescence yield from SIF

Instruments

- Active fluoresence measurements at leaf level + gaz exchange
- Passive fluorescence measurements at canopy level (SIF)
- Active fluorescence measurements at canopy (LIF)
- Passive fluorescence measurements at leaf level (spectrum)

Active fluorescence measurements at leaf level

❑ Licor 6400-XT

Light curves F=f(PAR), 5 leaves/day

Gaz exchange (Assimilation, stomatal conductance,…)

❑ Monitoring PAM

Continuous monitoring (night and day)

2 measuring heads in parallel

Parameters : Fs, Fm’ (saturating pulses)

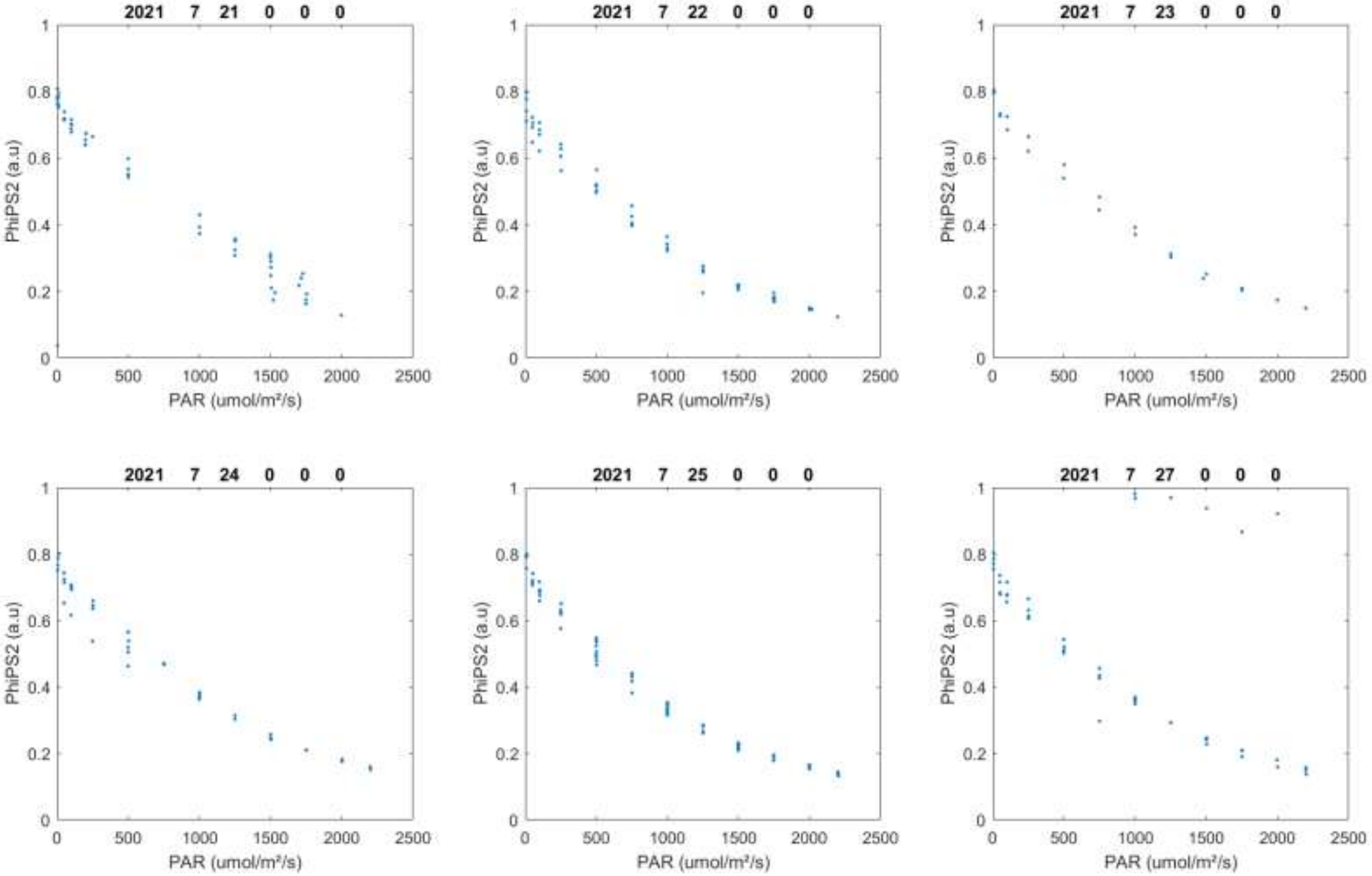
PSII yield, NPQ, ETR

❑ FluorPen 100

PSII yield, 4-6 leaves/day, n=30

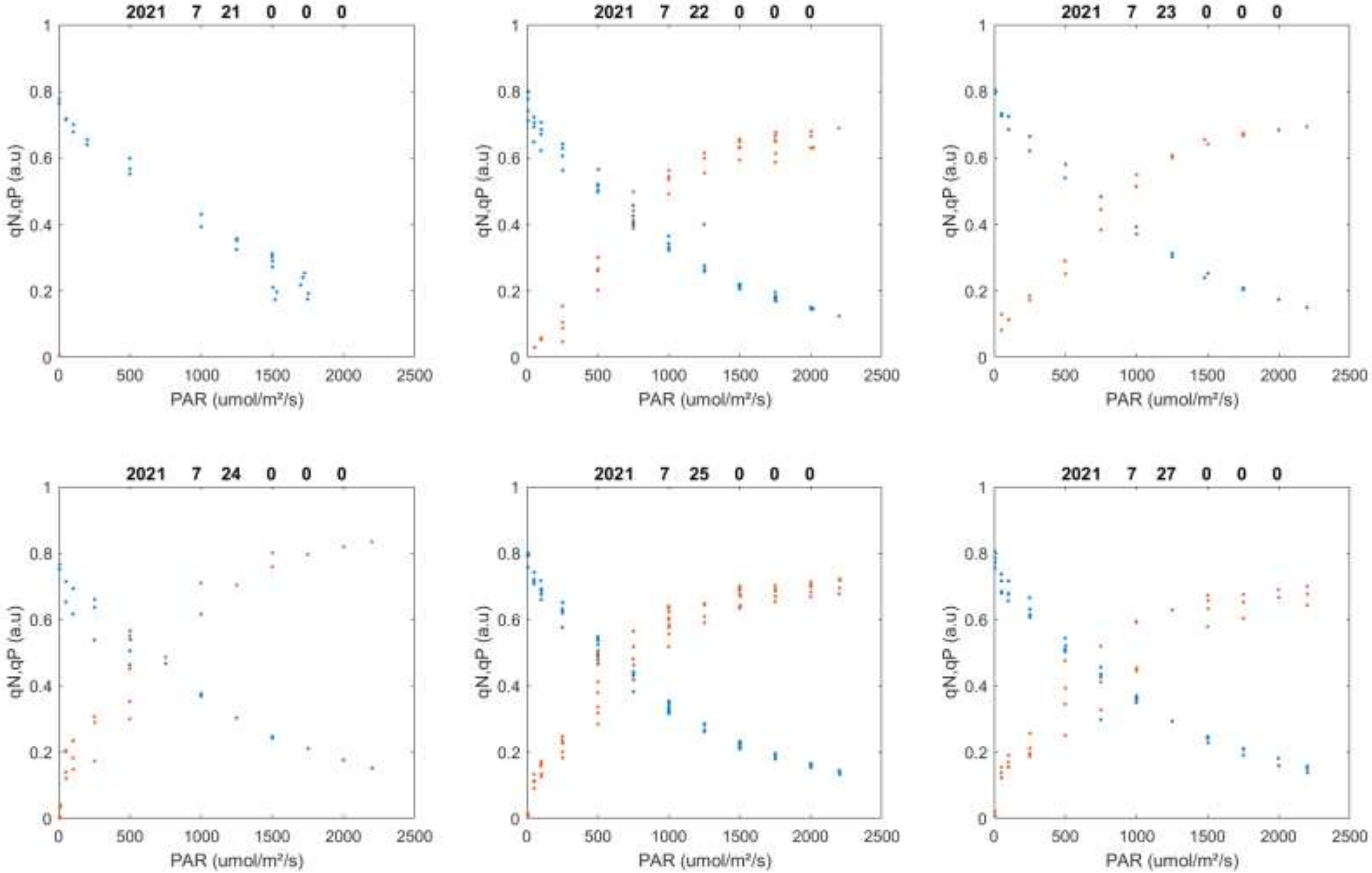
Fluorescence measurements at leaf level : (I) PSII photochemical yield

LiCor 6400 XT



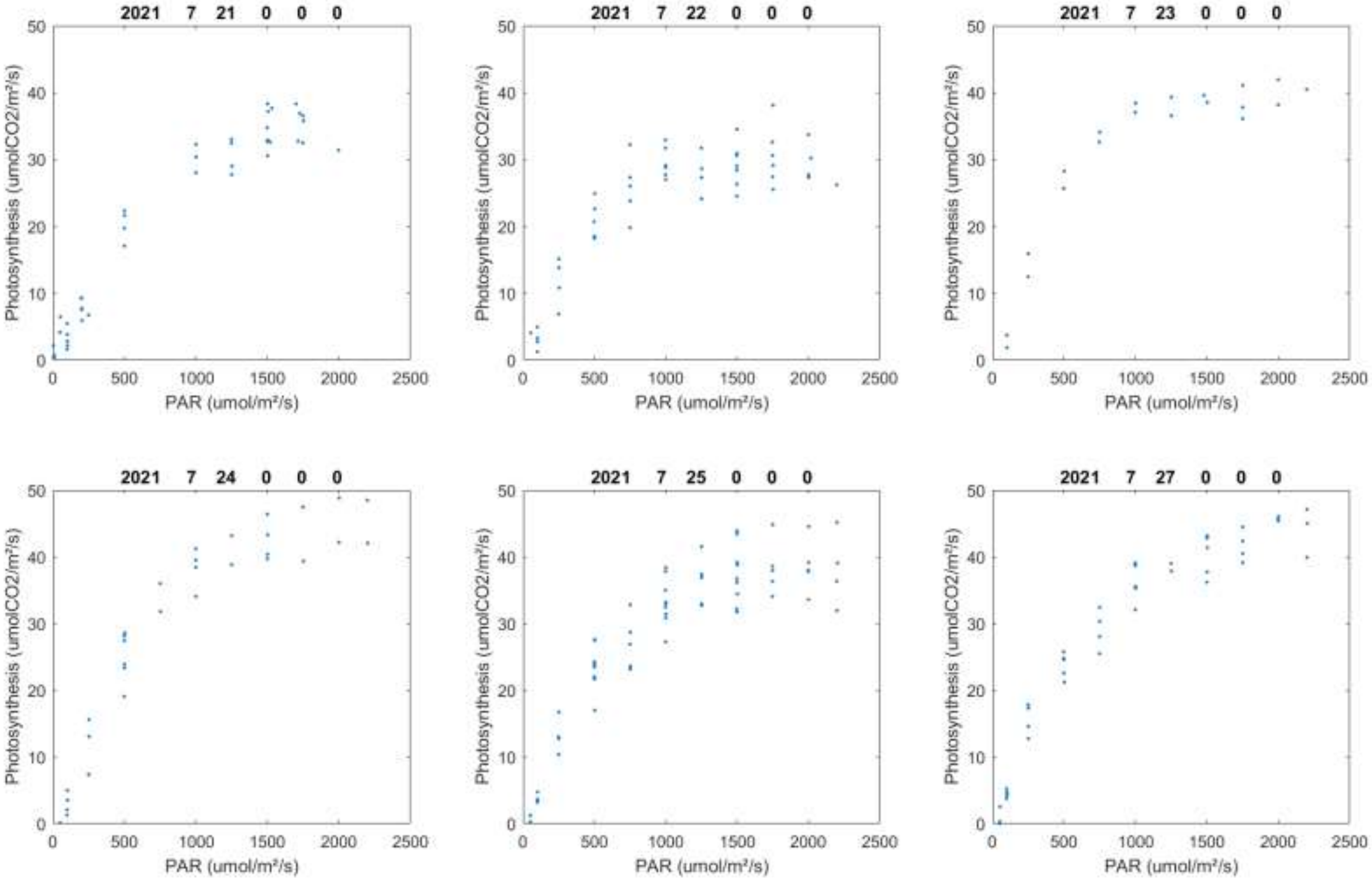
Fluorescence measurements at leaf level: (II) Quenching analysis

LiCor 6400 XT



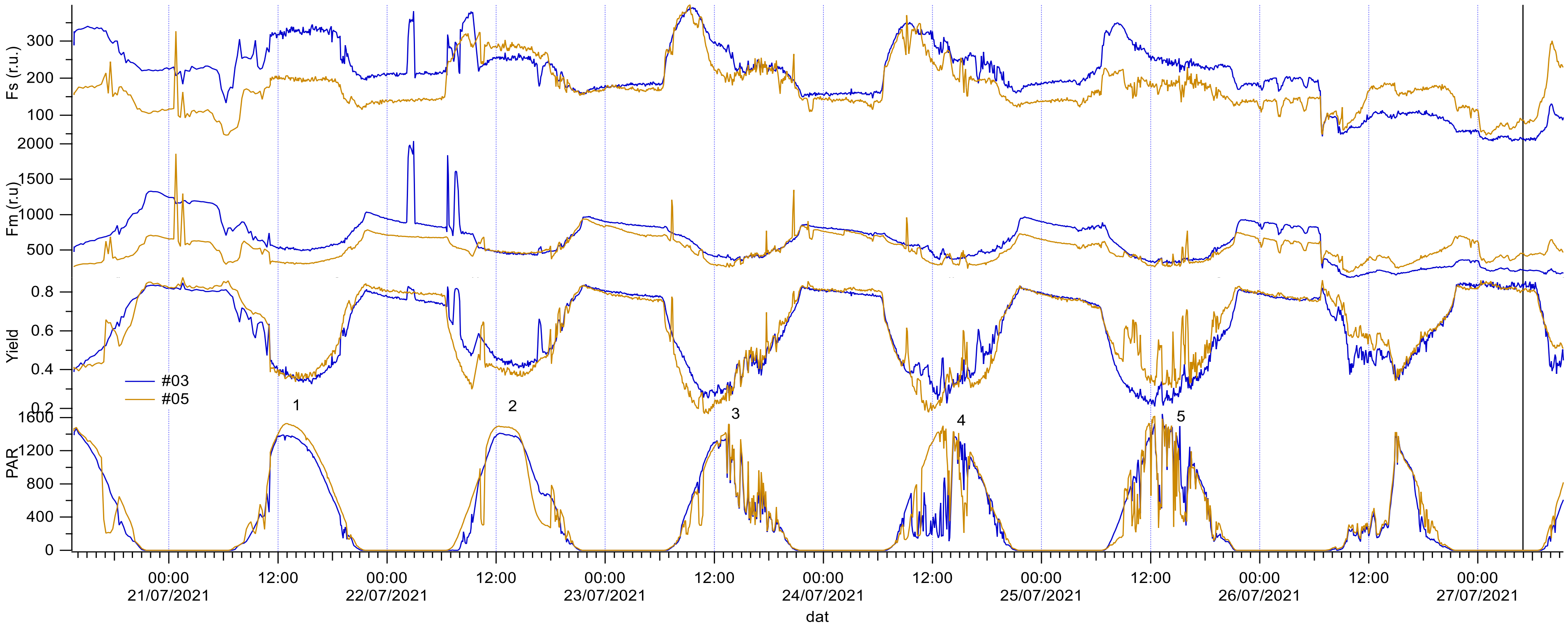
Gaz exchange measurements at leaf level (Licor)

LiCor 6400 XT



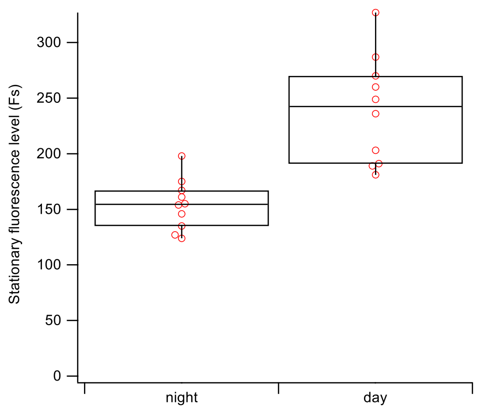
Continuous monitoring of fluorescence at leaf level: raw data of Monitoring PAM

- Raw data are affected by spurious changes caused leaf mis-placement, artefactual shadows, rapid growth of nearby stems
- Changes in stationary fluorescence level are observed, from night to day, during the day: how it affect interpretation of airborne data according to time of flight?
- PSII photochemical yield is the most reproducible variable.

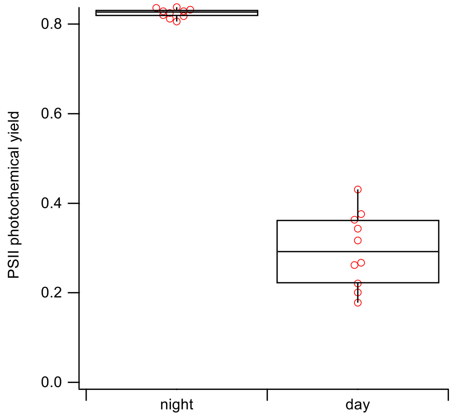


Fluorescence at leaf level : day vs night values

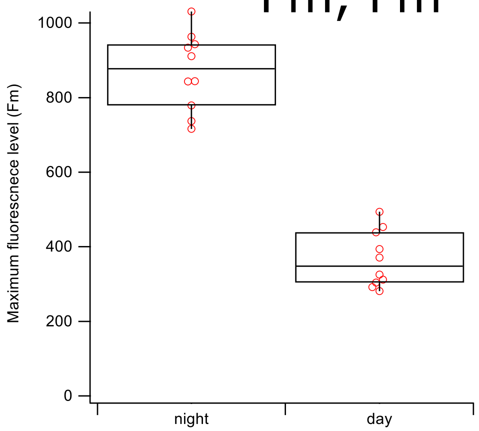
Fs



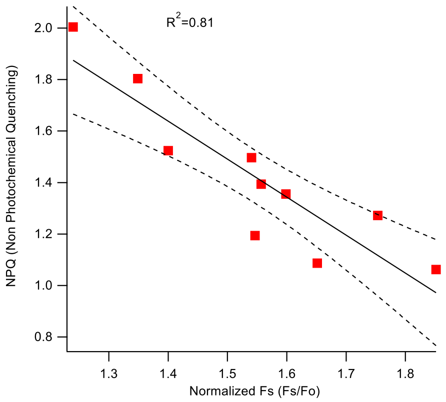
PSII yield



Fm, Fm’

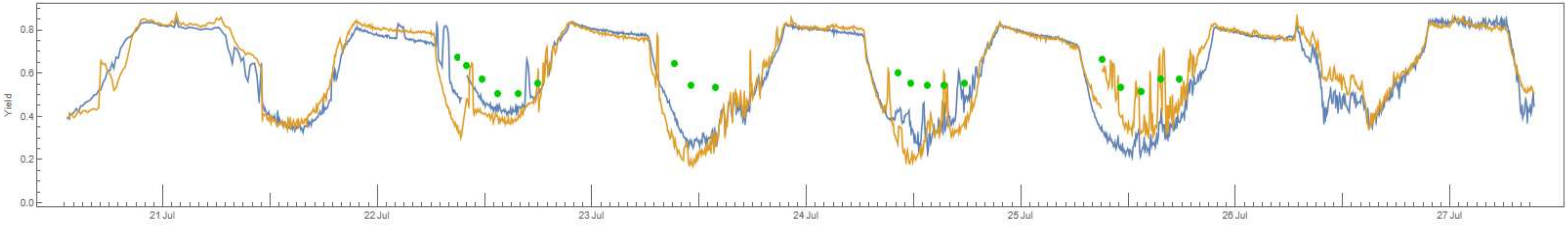


NPQ vs Fs/Fo



Monitoring PAM vs FluorPen

PSII photochemical yield:
- Green dots : FluorPen
- Lines : Monitoring PAM

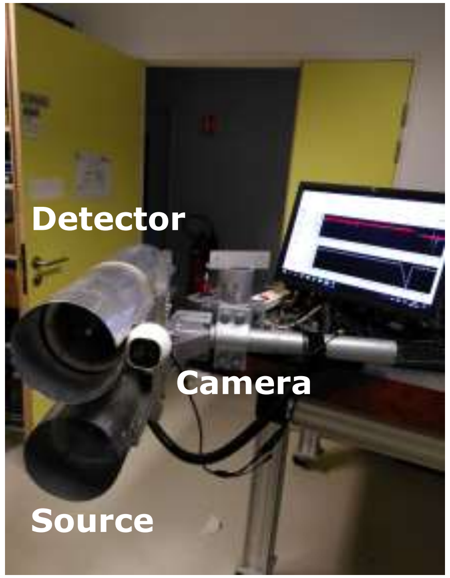


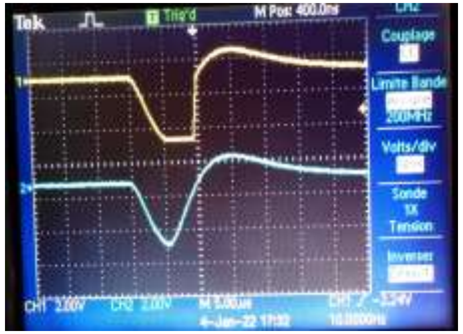
FluorPen overestimate PSII yield compared to MoniPAM

FluorPen : yield >0.5

MoniPAM and Licor 6400-XT more consistent

Fyield at canopy level :the fluorescence µlidar LedFlex





Detected pulses of fluorescence

LedFlex fluorescence microlidar (Moya et al., 2019)

Light source:

- Peak wavelength : 465 nm
- Spectral width : 23 nm
- Total radiant flux : 6 W
- Pulse duration : 5 µs
- Frequency : 0-1kHz

Dectector:

- Fresnel lens 20 cm
- Spectral banwidth : 725-800 nm
- High speed photodetector insensitive to continuous light

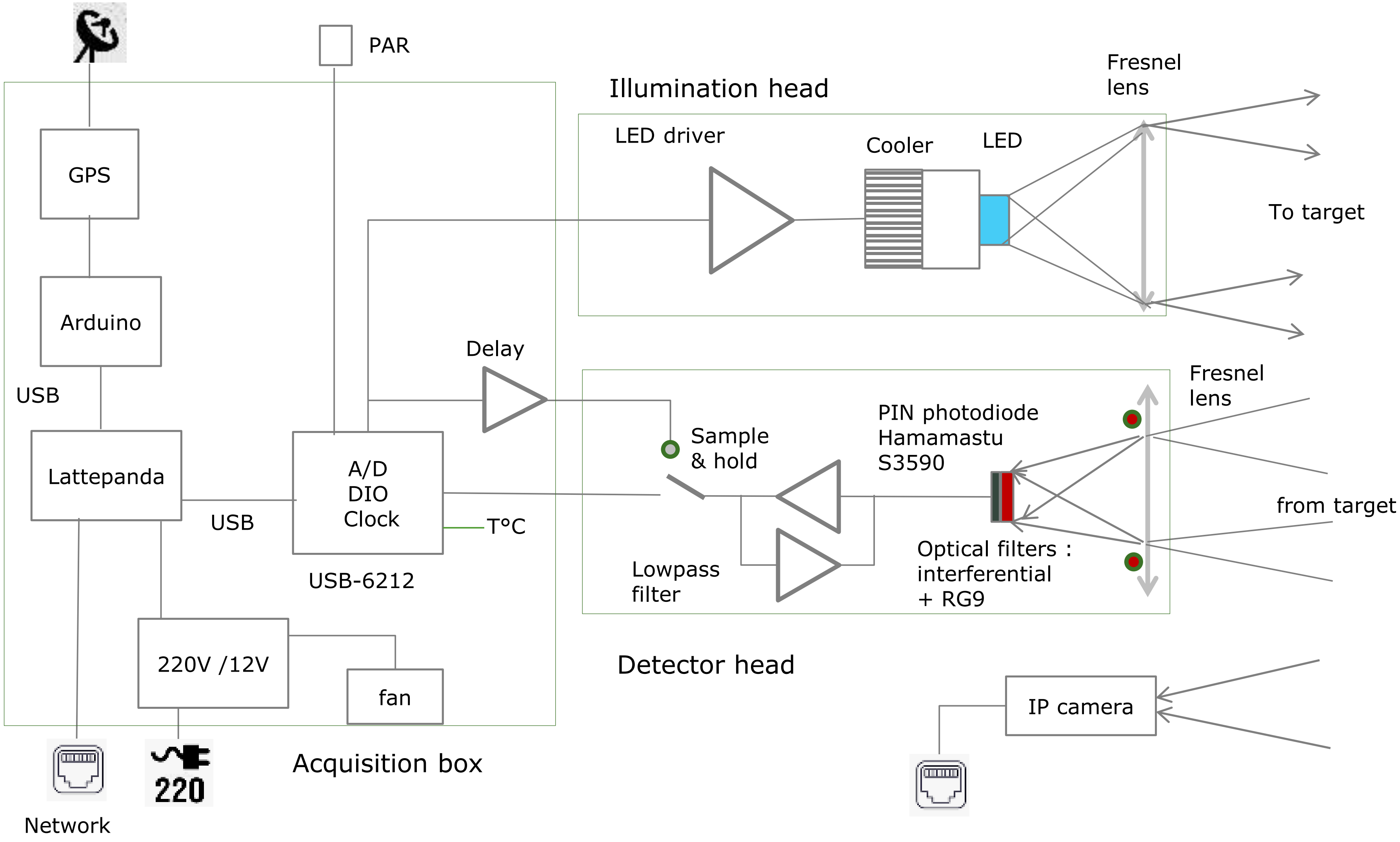
Measuring period : 2 s

Measuring distance : up to 10 m

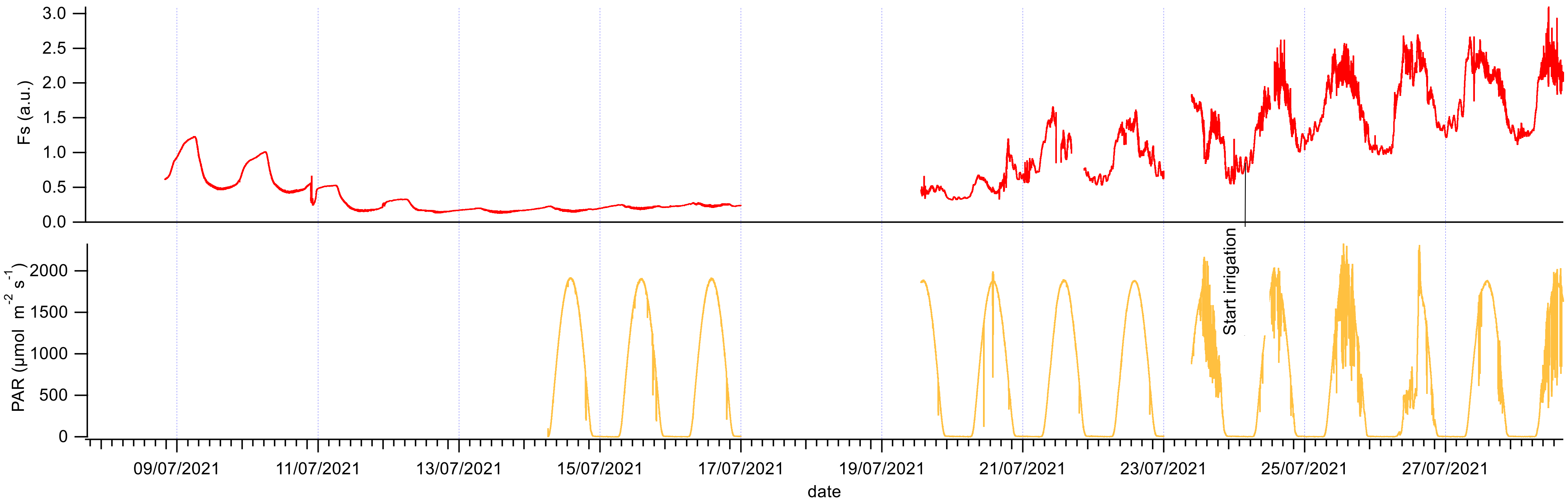
Measured signals:

- Stationary fluorescence level (Fs)
- Far red vegetation radiance
- PAR

LIF1, a fluorescence microlidar for continous monitoring of fluorescence yield at canopy level



LedFlex microlidar: time series of canopy fluorescence yield



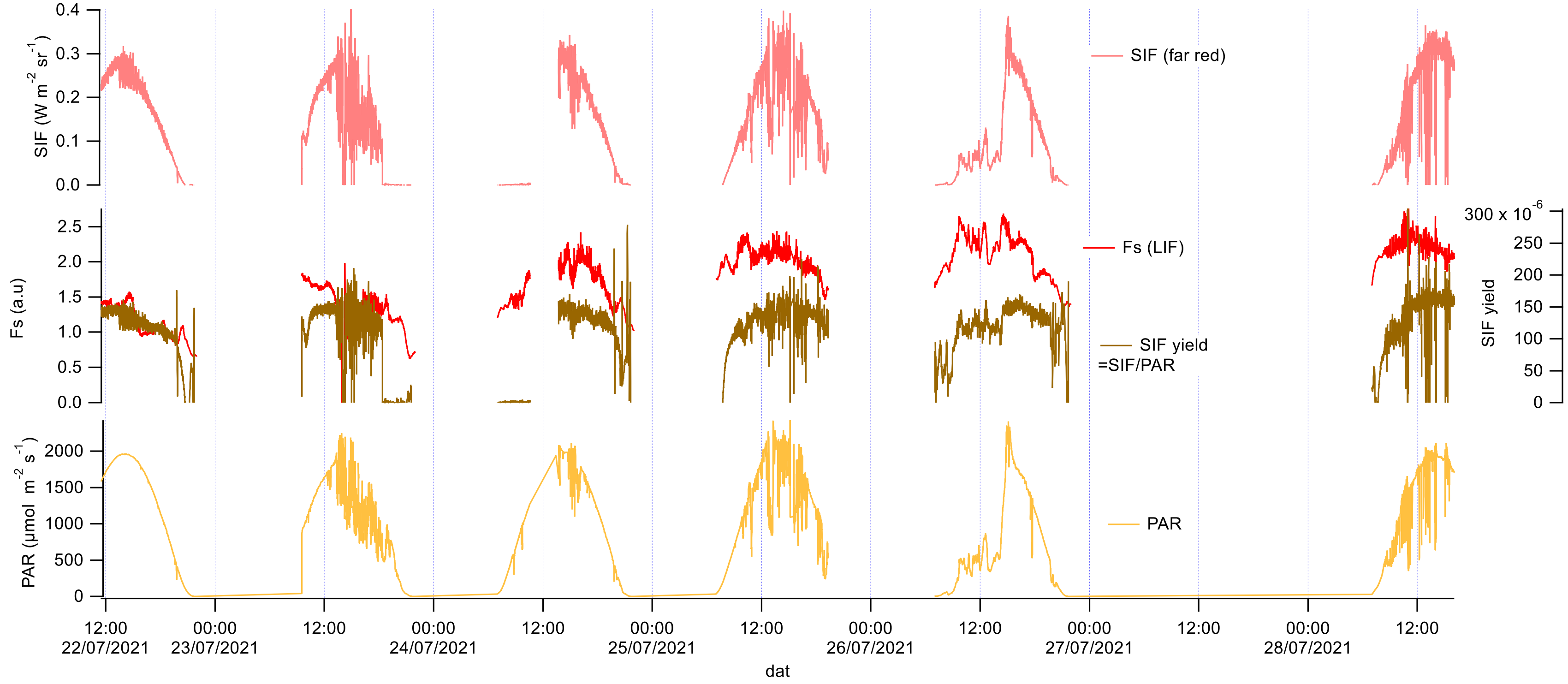
- Failure of the LedFlex microlidar from 17/07 to 19/07. The signal became very noisy starting from 19/07. EM interference, power supply?
- Large changes in Fs from day to night (≈ x2)
- Increase of Fs after irrigation (≈ +20-30%)

In situ sun-induced fluorescence

SIF1 instrument

- Lab made high resolution spectroradiometer
- 2x HR2000+ spectrometers (0.4-0.5 nm; 1 nm), cooled
- Incident light measured on a moving spectralon panel
- Simultaneous acquisition of PAR, canopy surface temperature
- Dark noise acquired at each acquisition sequence
- Integration time controled on incident PAR
- Max. acquisition speed ≈1000 acquisition sequences/hour
- Management, acquisition, data storage controled by a Labview software, with graphics user interface operable at distances
- Efficient data storage in .tdms hierarchical format
- SIF retrieval with Spectral Fitting Methods (SFM) and 3FLD, 4FLD (Matlab)

SIF and Fs time series: retrieval of fluorescence yield from SIF

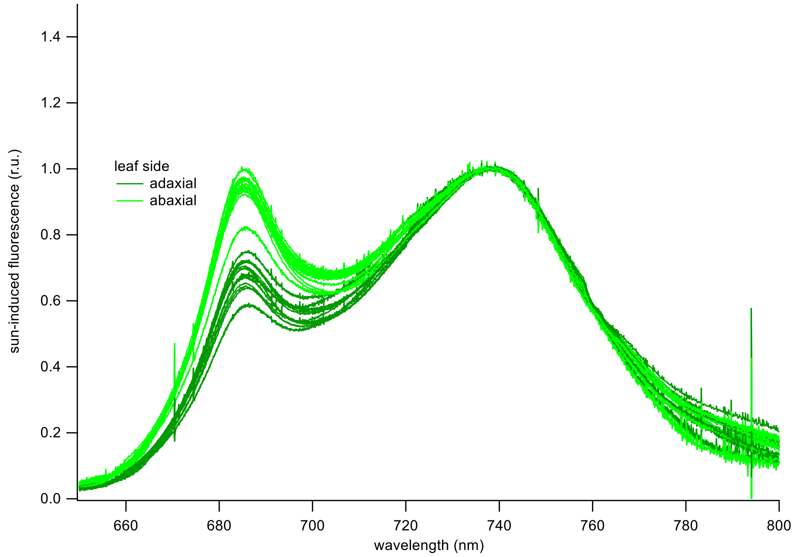


- SIF and PAR are strongly correlated as APAR is a main driver of SIF (as well as GPP)
- Normalizing SIF by PAR gives an apparent fluorescence yield, which is better correlated with fluorescence yield measured by the LIF lidar (Fs).

Sun-induced fluorescence at the leaf level: emission spectrum

Direct measurement of SIF using a complementary combination of lowpass and highpass filters:

- Acquire SIF at leaf level over the entire emission spectrum (adaxial and abaxial leaf sides)
- Deduce form factors for 3FLD and 4FLD retrieval algorithms
- Data for canopy modellers (FluSpec, FluorMODleaf, SCOPE, DART,…)



Conclusions

- We collected fluorescence data at leaf and canopy level, with both active and passive techniques
- We experienced some technical issues (LIF, SIF)
- Dataset not very extensive (SIF), some quality issues (noisy LIF signal, …)
- Some insight about the dynamics of fluorescence yield using different and complementary techniques (continuous monitoring, light curves) and spatial scales (leaf, canopy). Analysis is on going.
- Attempts to retrieve fluorescence yield from SIF, still on going
- We can provide data for modellers (fluorescence emission spectra, light curves,…)
- Data on canopy structure has been acquired by CESBIO, useful for modelling
- Other long term field campaigns ongoing in 2022, 2023 (SIF, LIF, EC) : sunflower (Auradé, Toulouse), oak forest (Barbeau, Fontainebleau)