Mead 2017 SIF measurement campaign : first looks, questions and perspectives

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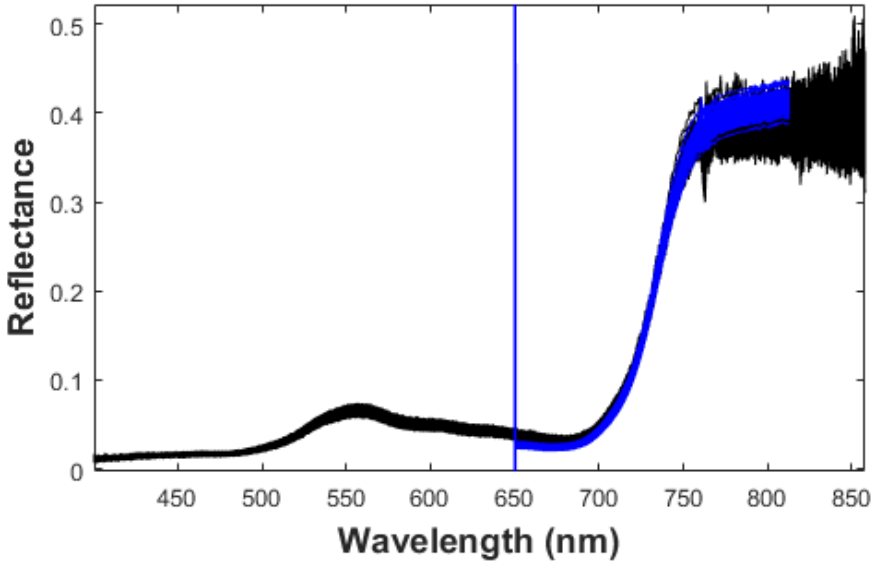
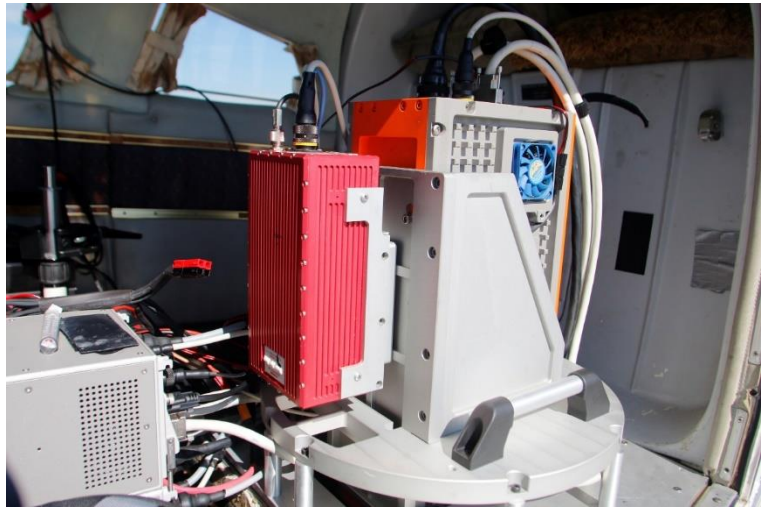
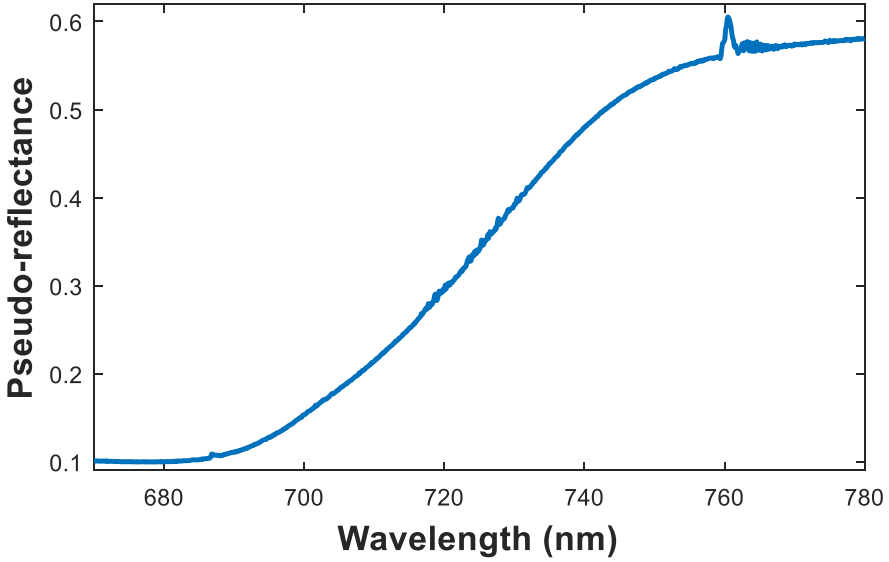
The Mead setup



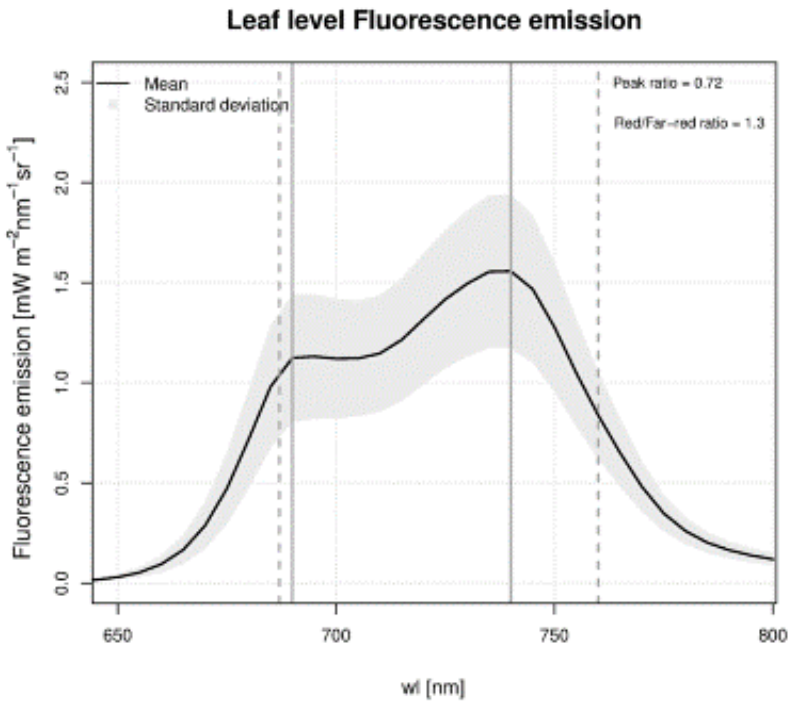
- Auto-optimized integration time
- New cosine-corrector
- Re-calibrated with 8 PPFD levels in an integrative sphere





- Using SpecM calibration
- PCA-derived in scene reference
- NDVI-based adaptive filter pre-processing

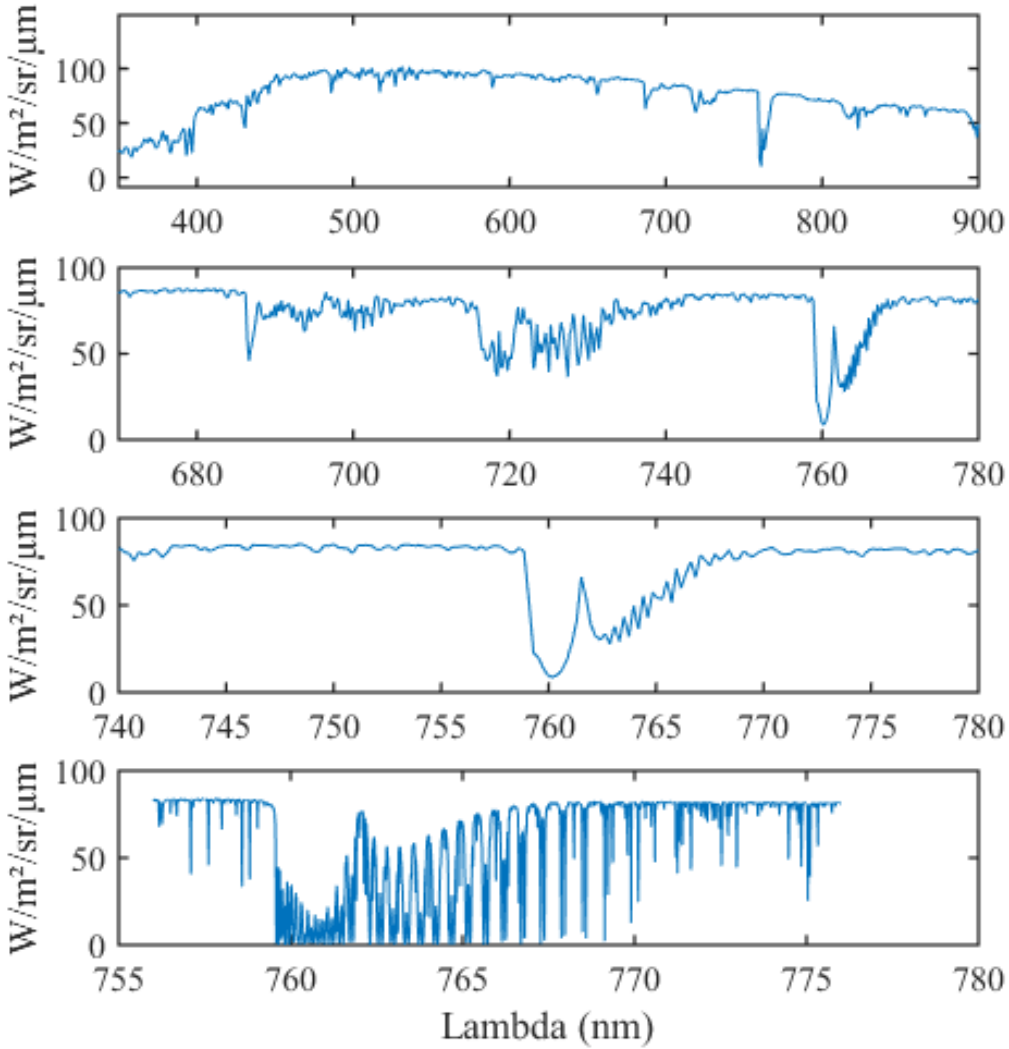
Sun-induced chlorophyll fluorescence



$$I_m(\lambda) = I_r(\lambda) + I_f(\lambda) + DN(\lambda)$$

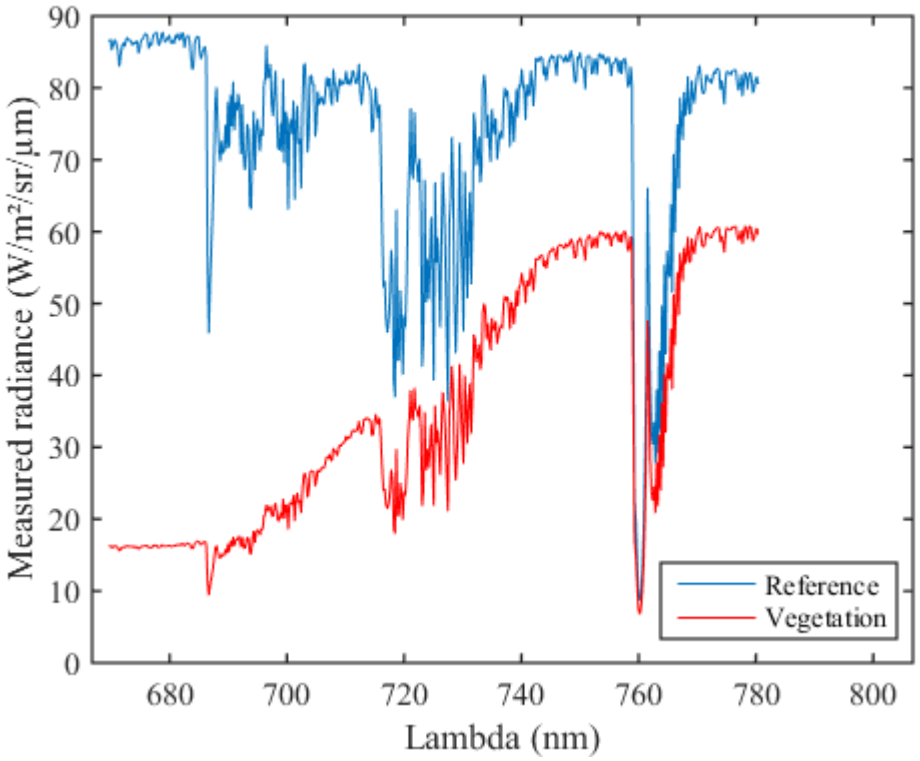
The SIF emission, is low : 0-3 W/cm²/sr/µm

But its relative importance is high within absorption lines.

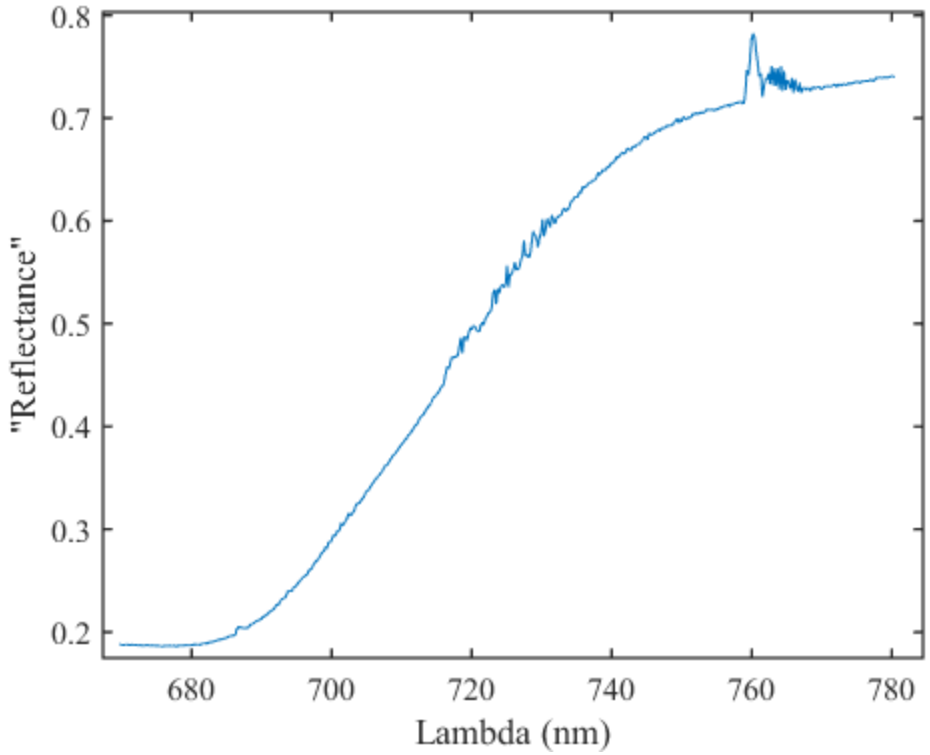


AISA IBIS measurements over Mead

Radiance Spectrum



Reflectance spectrum

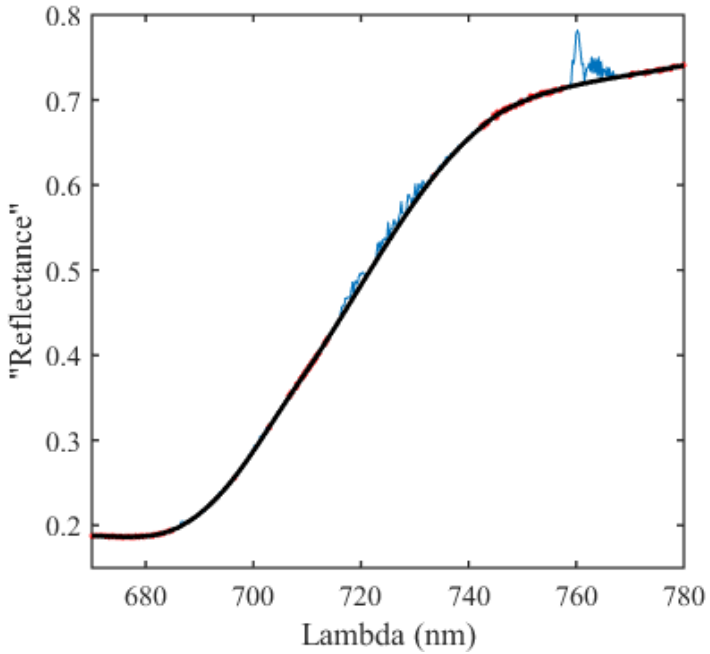


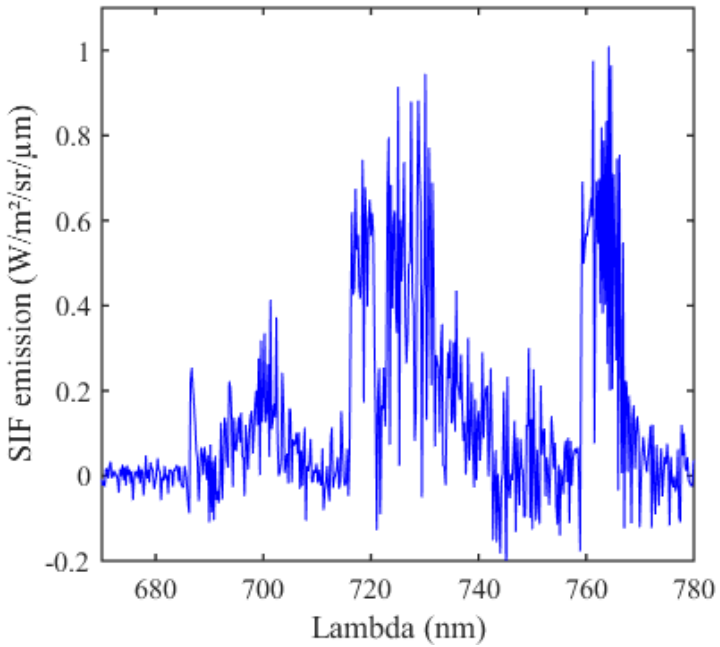
There is a detectable fluorescence signal at the instrument spectral resolution (around 0.7 nm)

How to get an in-scene reference ?

- Selecting potential pixels devoid of fluorescence emission :
  - Negative NDVI
  - Linearly decreasing spectra
  - Least negative SIF when used for retrieval
    - ➢ 1300 to 5200 potential reference pixels
- PCA on selected pixels, rescaling the obtained PCA component
- Other pre-processing step : weighted gaussian filter, using normalized absolute NDVI difference as a weight
- Missing steps : PSF correction, non-linearity correction, georeferencing and reprojection.

Coarse SIF recovery from pseudo-reflectance

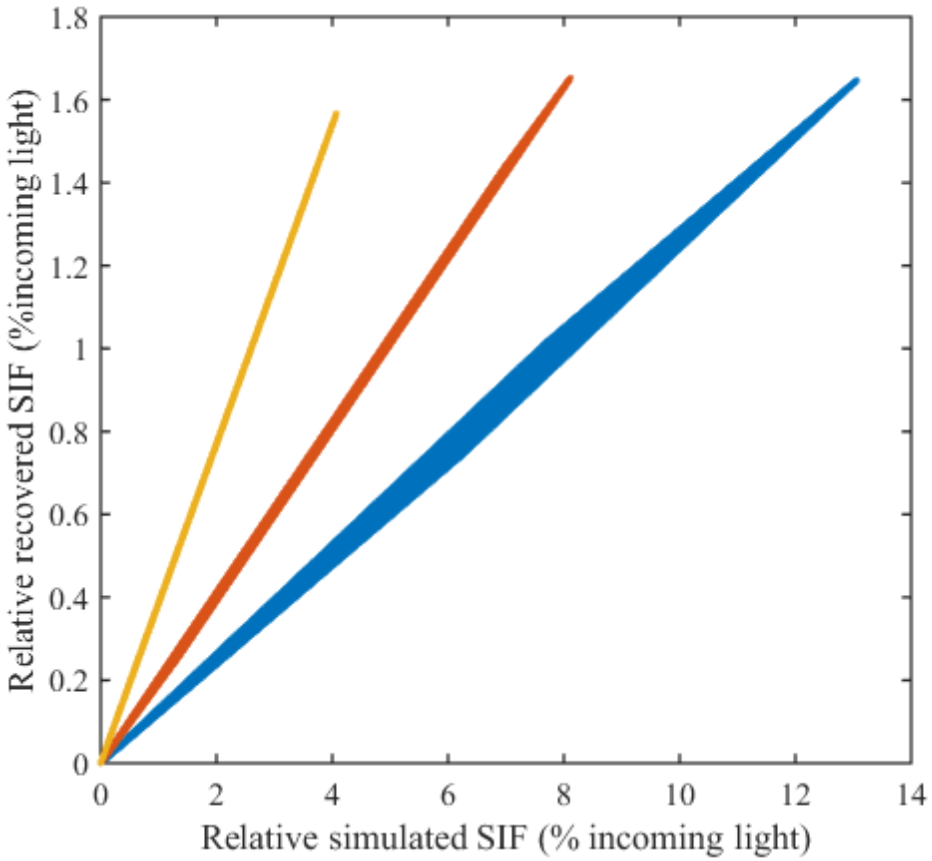




Hypotheses :

- SIF emission << reflected light out of the absorption lines => can be neglected for both vegetation and reference
- Continuous reflectance spectrum without features within the absorption lines => can be interpolated

Sensitivity analysis of retrieval method



- Realistic range : 0-2%, maybe 5% for extreme cases.
- The recovered SIF is not corrected for the effect of reflectance here (simple sum over the range instead of area under the curve), thus the different ranges and slopes.

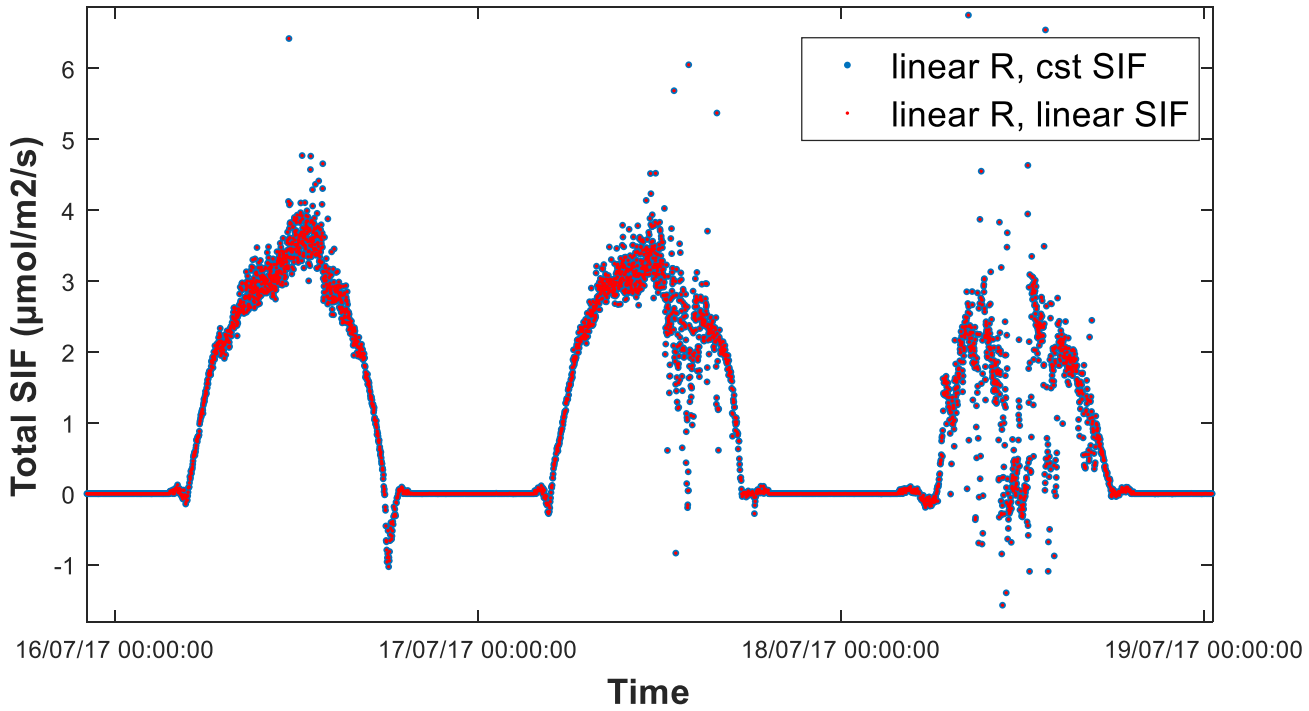
Otherwise, the relationship is strongly linear through the realistic range.

Limitations

- Atmospheric correction ?
  - Atmosphere transmittance measurement ?
- Sensor dependent ?
  - Inter-calibration ?
  - Robust retrieval methods ?
  - Standardization ?
- Scale dependent ? Do we have the variability needed for SCOPE to fit ?
- How to use the full spectra and retrieve more information ?

Retrieval hypothesis : D-flox data

- Reflectance and SIF vary linearly with wavelength within O2A => positive slopes for SIF.
- Reflectance vary linearly with wavelength, and SIF is constant within O2A



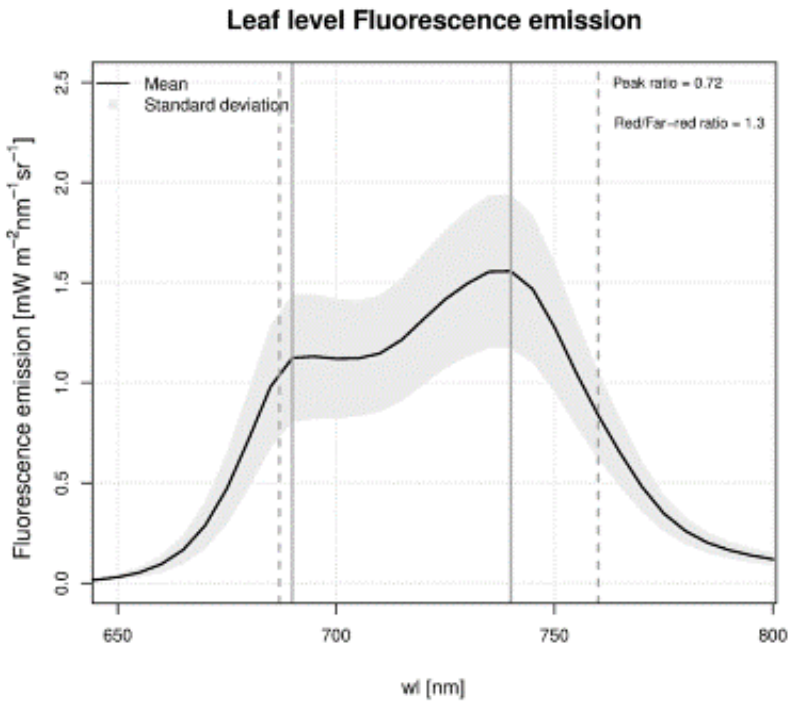
Perfectly similar results :

- ➢ We can afford more DoF for Reflectance

SIF coefficients do not make sense :

- ➢ SIF may need to be more constrained

Sun-induced chlorophyll fluorescence



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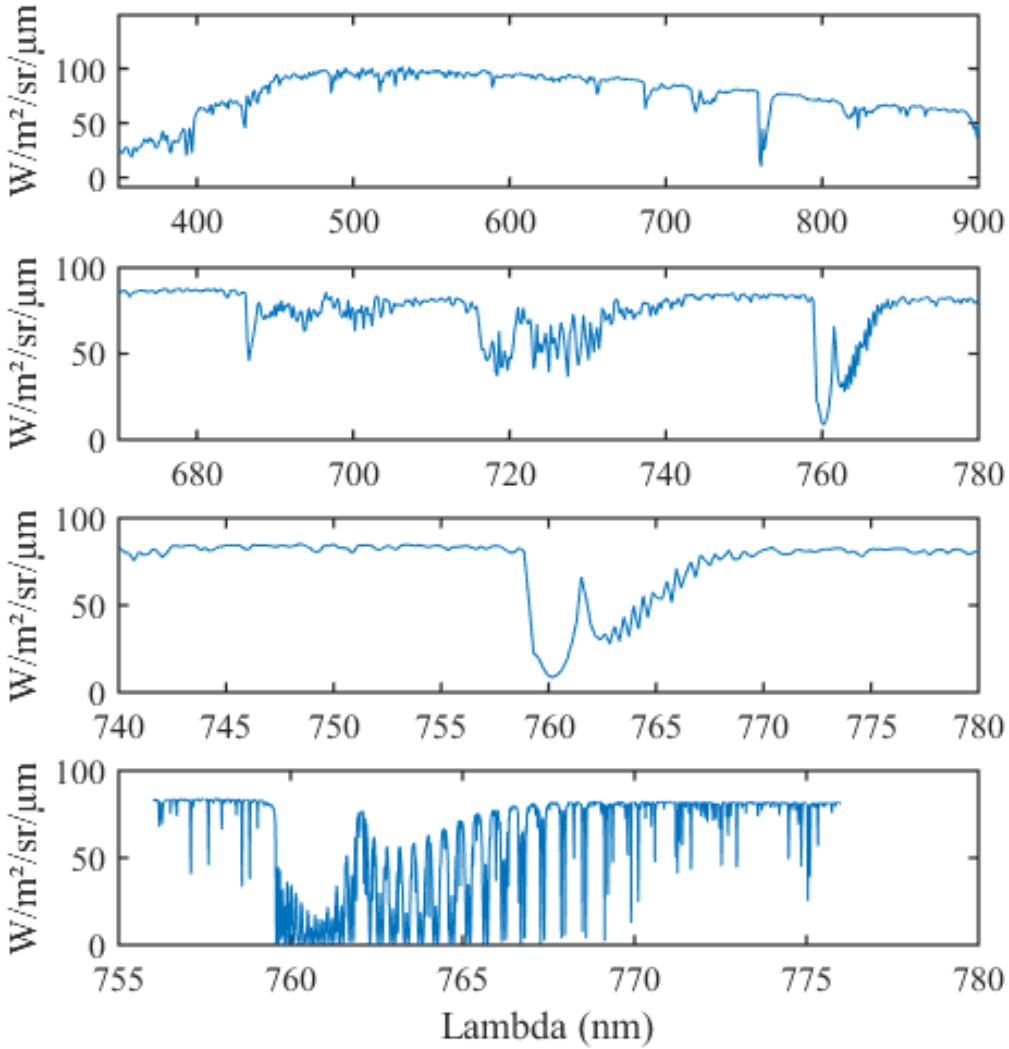
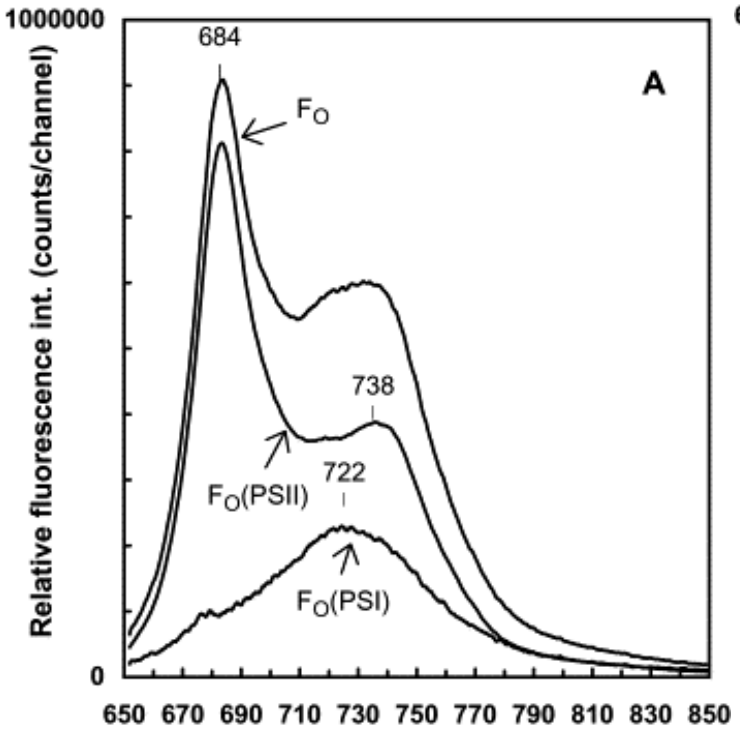
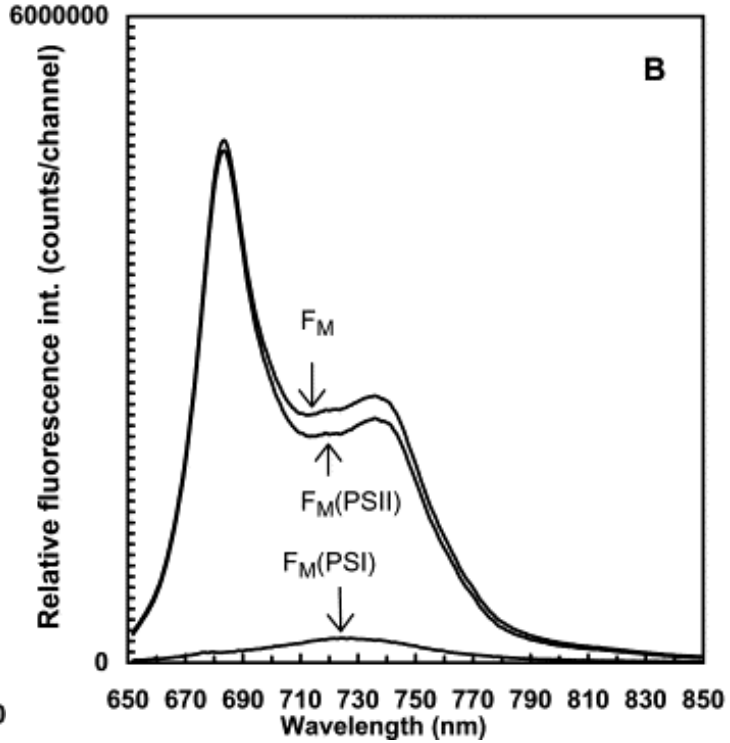


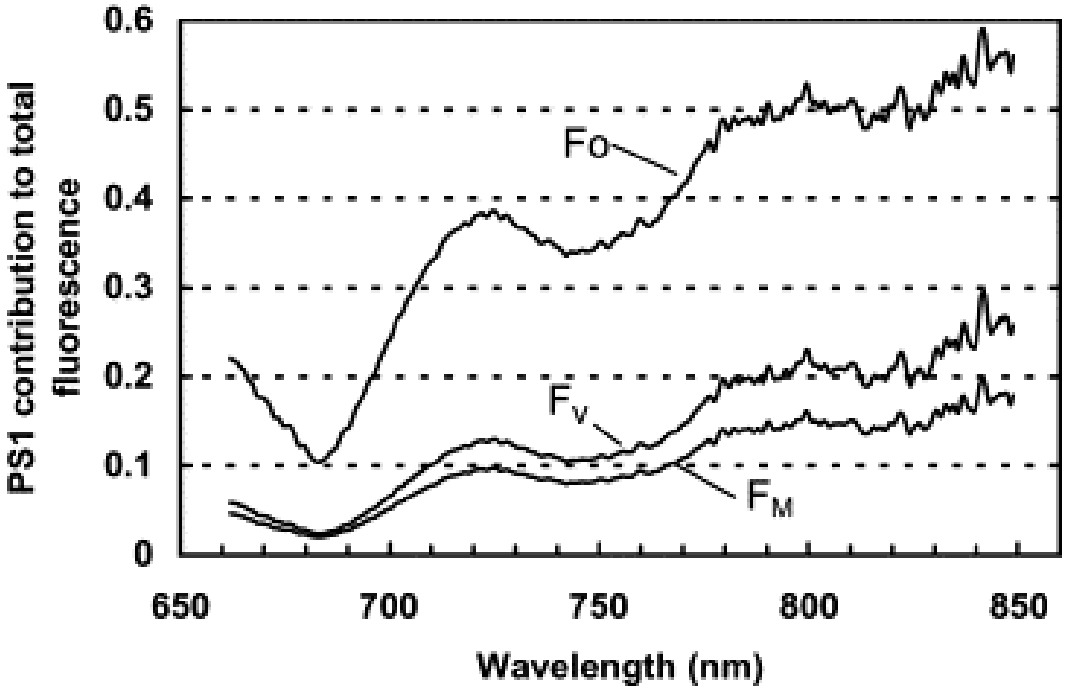
Fluorescence emission spectrum



Low light



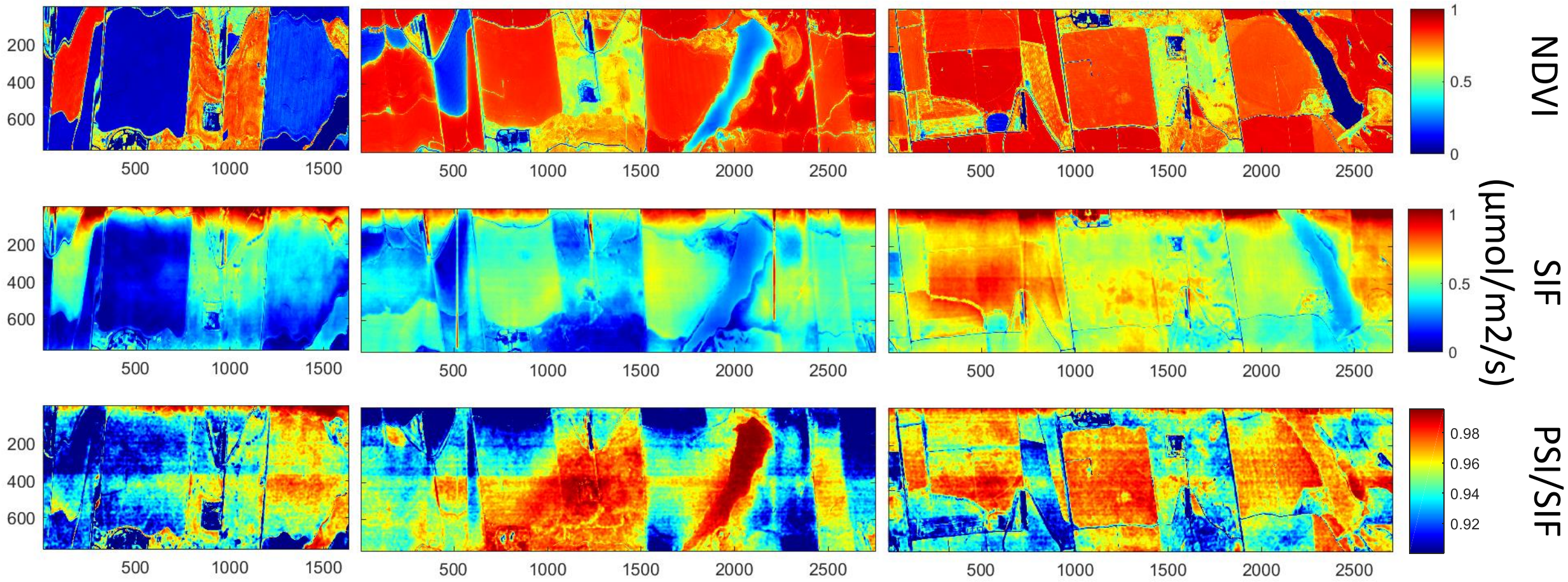
High light



PSI/SIF

Franck et al. 2002

Full-range retrieval



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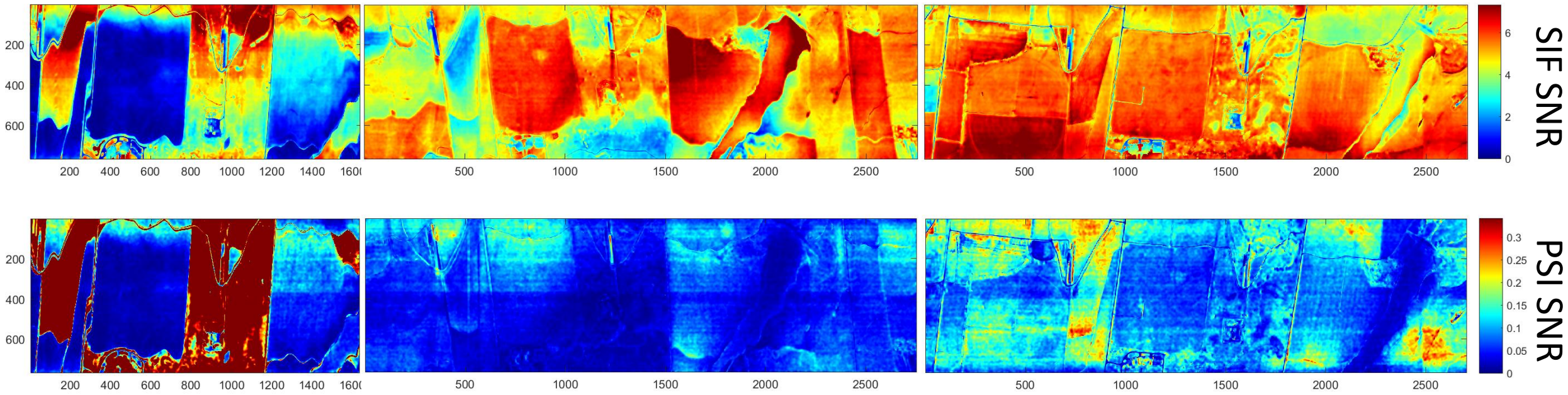
Full-range retrieval



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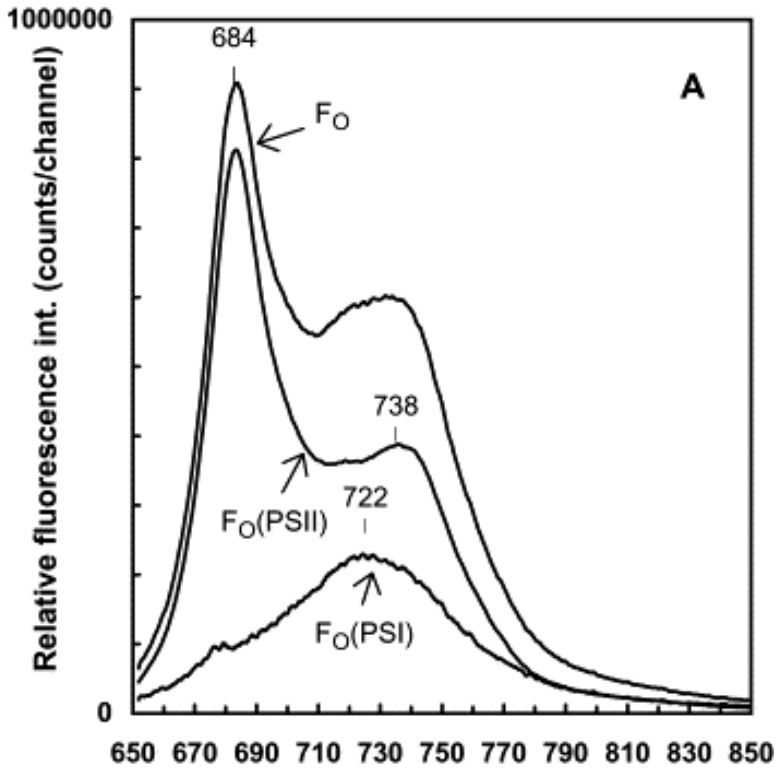
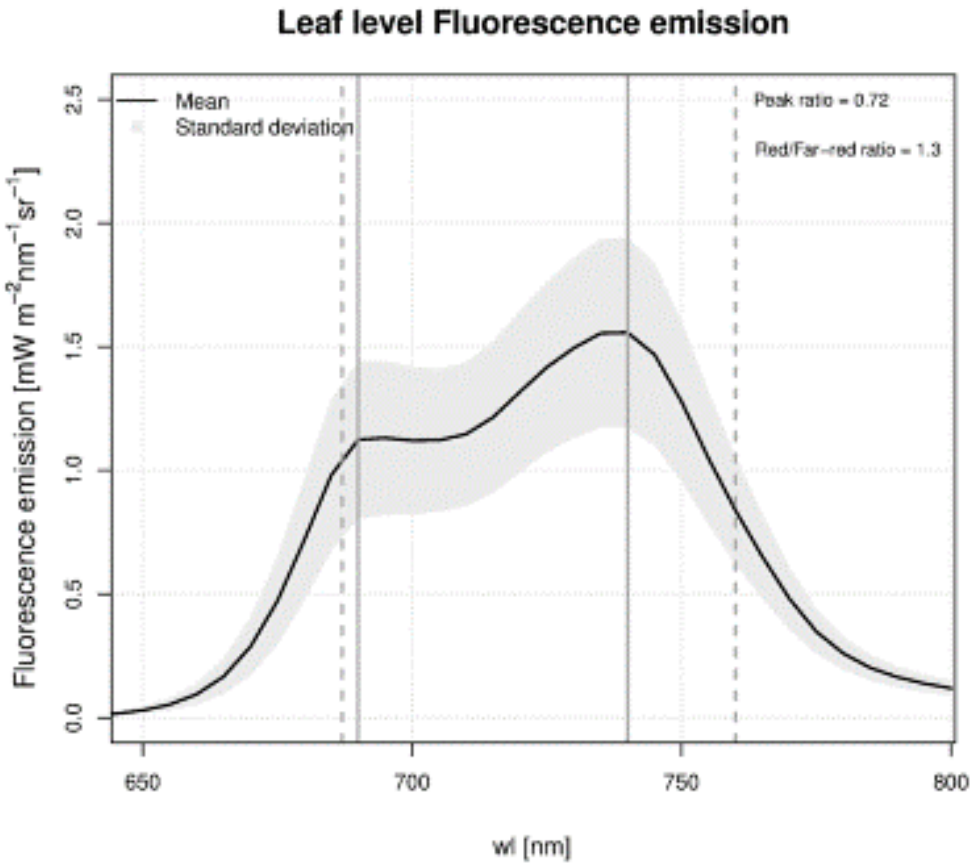
Why is the PSI/SIF ratio wrong ?





- Reabsorption probably matter.

Perspectives : airborne

- Atmospheric correction : atmosphere transmittance measurement ?
- Validation versus D-flox/Hercules
- Inter-calibration of airborne platforms ?
- Validation of PSI/PSII emission spectra ?
- Relationship between Fv’/Fm’ and PSII/SIF.
- Further constraining reflectance (PROSAIL-type model ?)
- Taking re-absorption into account

Perspectives : ground-based

- Validation of SIF estimations (PSI/PSII-like light source)
- Validation of SIF yields (PSI/PSII or pyridine-doped PDMS)
- Model inversion to cross-validate SIF/SIF yield, PSII/SIF versus Fv’/Fm relationship
  - Bayesian inversion
  - Fitting in frequency domain
- Active fluorescence measurements at canopy scale (fixed and mobile) ?

Thanks for your attention