# Accurate predictions of GPP and ET from SIF with mechanistic modelling at the parcel scale under natural climate conditions

**Quentin Beauclaire**[1], Simon De Cannière[2], François Jonard[3], Laura Delhez[1], Natacha Pezzetti[1], Bernard Longdoz[1]

[1]TERRA, Gembloux AgroBioTech - Université de Liège (ULiege), 5030 Gembloux, Belgium
[2]Earth and Life Institute, Université catholique de Louvain, 1348 Louvain-la-Neuve, Belgium
[3]Earth Observation and Ecosystem Modelling Laboratory - SPHERES Research Unit, Université de Liège (ULiege), 4000 Liège, Belgium
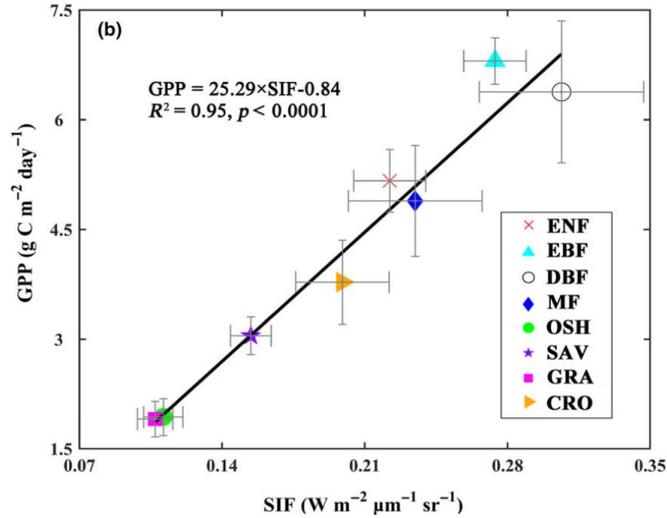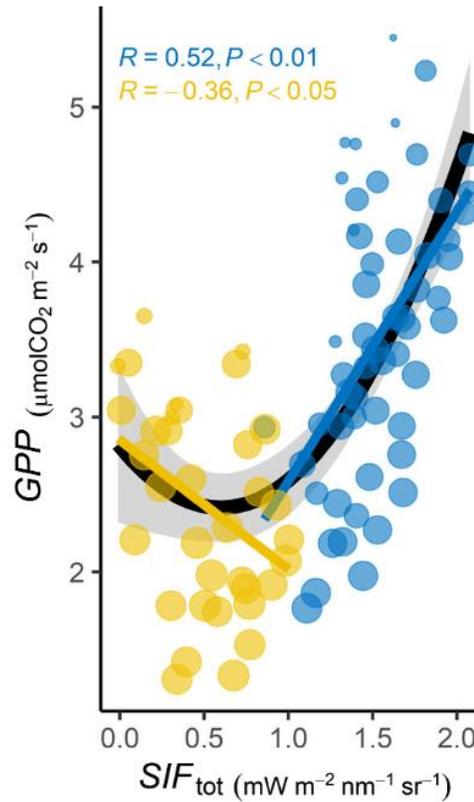
Jonard et al. (2020)
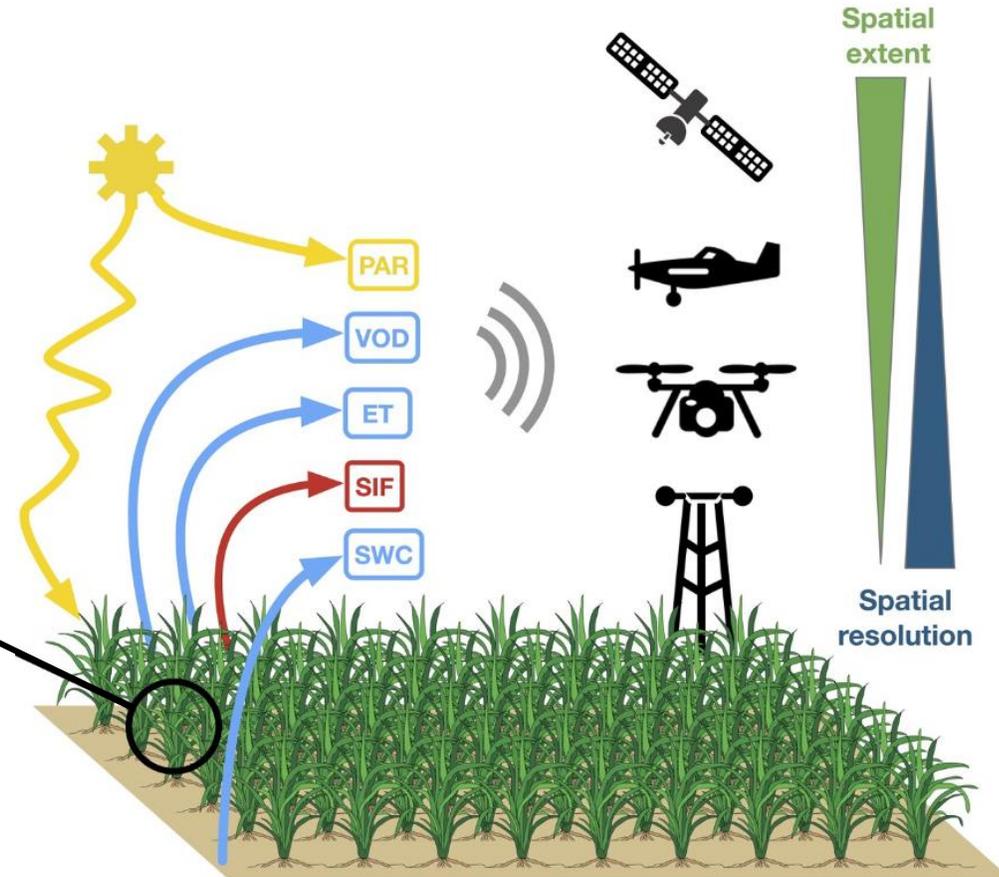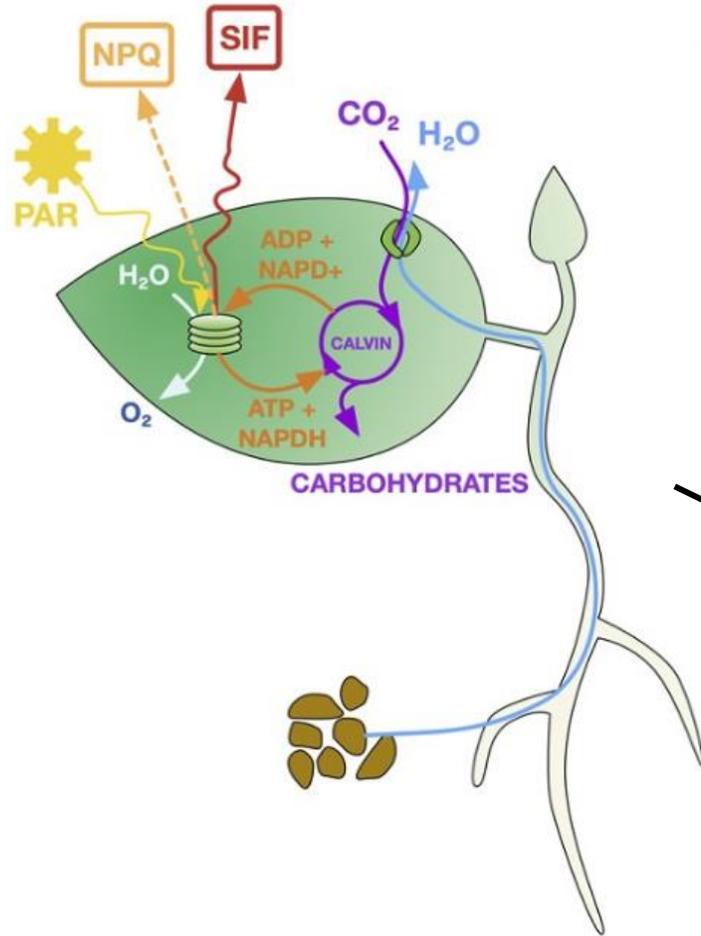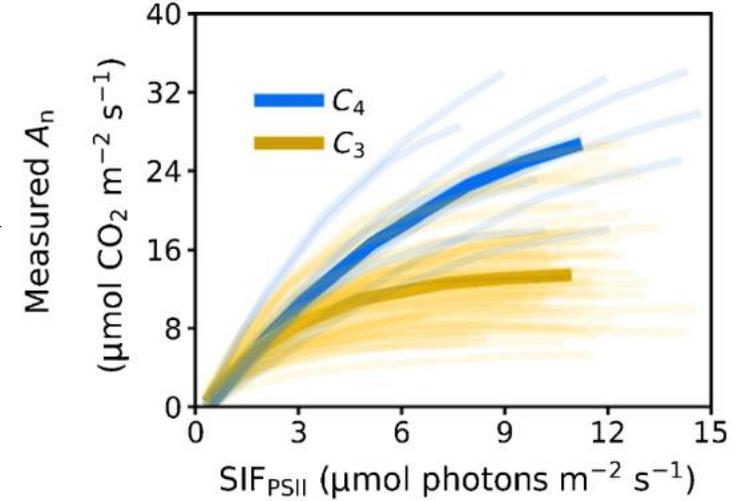
Global scale – OCO-2 (3km², 1:30 pm lt)



Li et al., (2018)

plot scale - heatwave



Martini et al., (2022)

Leaf scale



Han et al., (2022)

Which model should be used ?

Need for a mechanistic model of GPP from SIF at the plot scale (FLEX)

# Method
## MLR-USO model

Gu et al. (2019): Mechanisitic light response (MLR) model
- Based on the light reactions of photosynthesis
- Upgraded version of the Farquhar model using SIF
- Limited number of parameters

$$SIF_{TOT} = \frac{SIF_{TOC,760} \cdot f_{PSII} \cdot f_\lambda}{f_{esc}}$$

$$GPP_{SIF} = q_L \cdot \frac{\phi_{PSII,max} \cdot (1 + k_{DF}) \cdot SIF_{TOT}}{(1 - \phi_{PSII,max})} \cdot \frac{(C_i - \Gamma^*)}{(4C_i + 8\Gamma^*)}$$

| Fraction of open PSII centers | Maximum photochemical quantum yield | $CO_2$ concentration | $CO_2$ comp. point (f(T)) |

**Measured at the leaf scale**

**Measured by the SIF sensor**

**Constants/modelled**

$$ET_{SIF} = \underline{USO\ model\ (Medlyn\ et\ al.,\ 2011) + Penman\text{-}Monteith\ equation}$$

- How do MLR-USO model predictions correlate with EC data at the plot scale?
- Is the MLR-USO model robustness impacted by climate conditions (drought) ?

BE-Lon (ICOS station class 2) + LI-6400XT + SIF (FloX)
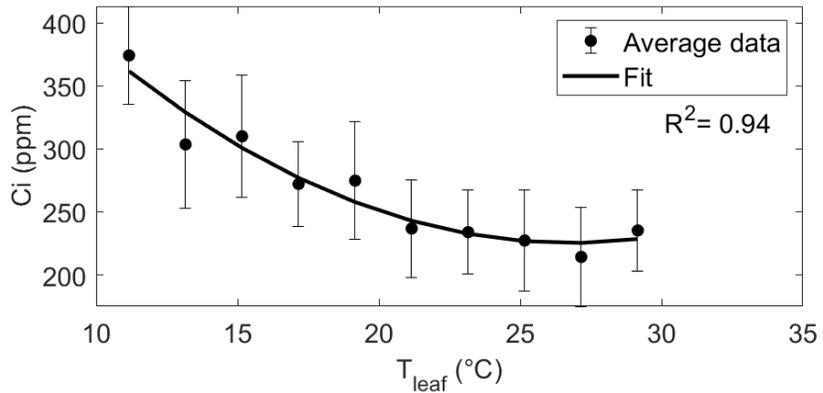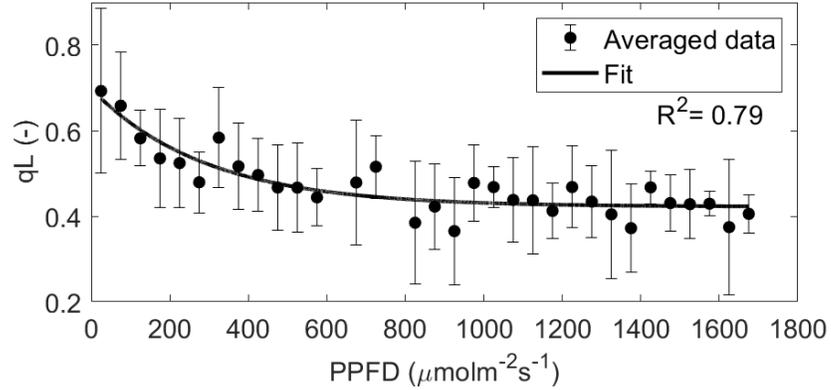
Winter wheat - February to July 2022

First study to test the MLR model under natural conditions at
the plot scale and to add the USO model for ET.
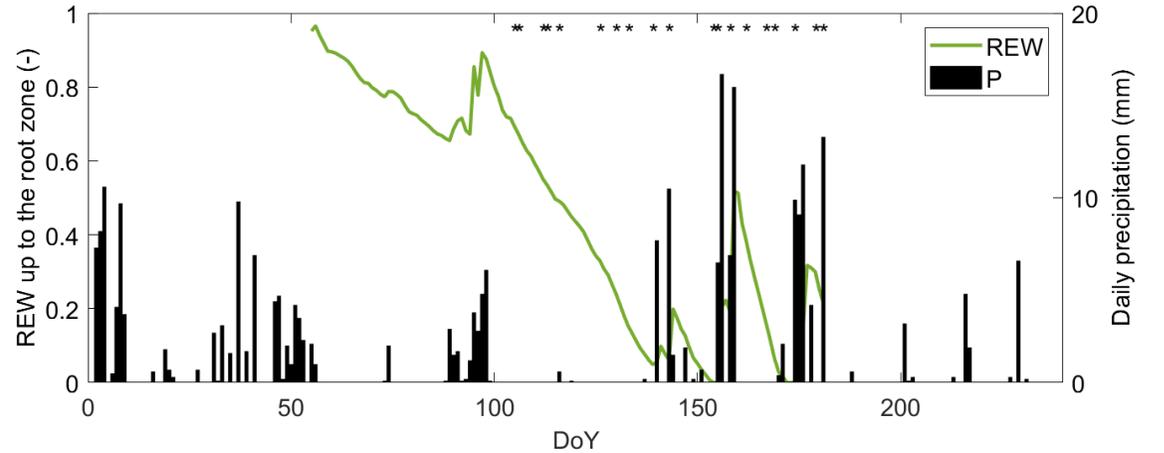
## Climate conditions and leaf level measurements



$q_L = f(PPFD)$
$C_i = f(T_{can})$

$\Phi_{PSII,max} = cst$
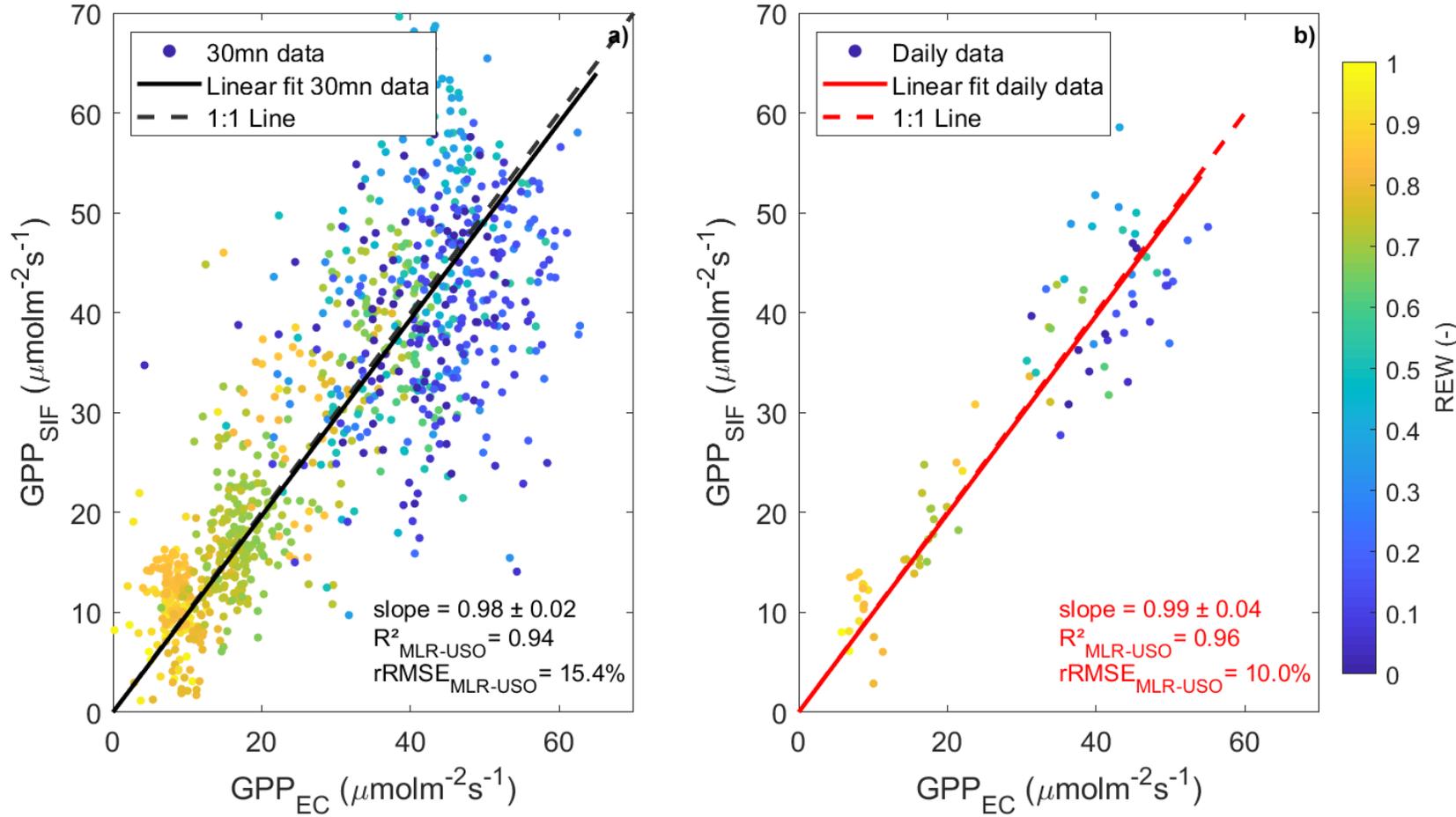$f_{PSII} = f(PPFD)$

Several drying-up episodes (DoY 100 and 140)

Leaf-level measurements in a wide range of REW values

# Results
## MLR-USO vs EC data : GPP



Very good correlation, no systematic bias
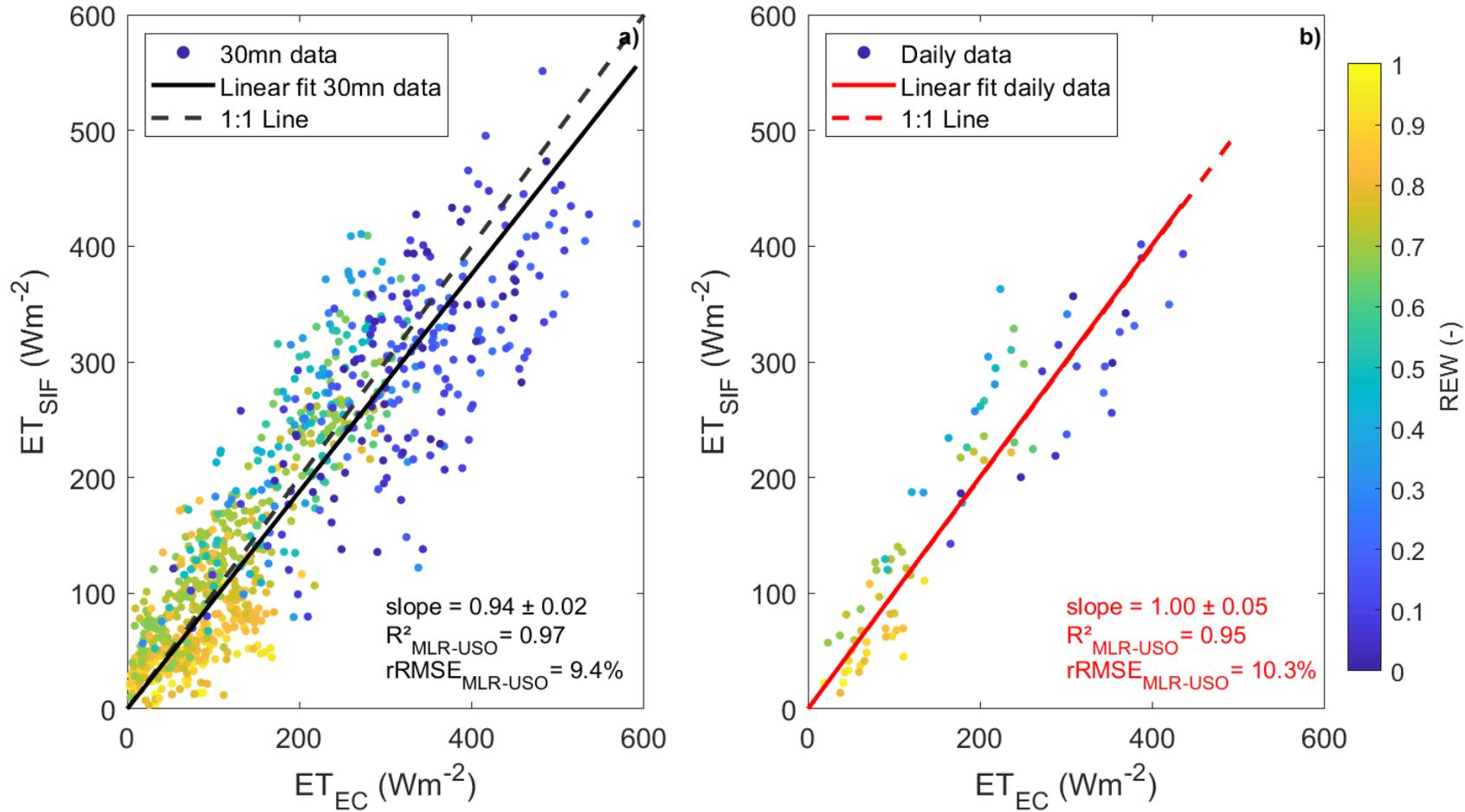
Very good correlation, no systematic bias

# Conclusion

- MLR-USO model predicted carbon and water fluxes from SIF at a high accuracy ($R^2>0.9$, rRMSE<15%)
  - Parcel scale (winter wheat)
  - Wide range of PPFD, VPD, REW…

- SIF was the only variable that could reproduce the effects of drought on ecosystem physiology (no effects of REW on parameters were observed)

# Future perspectives

- Applicability of the MLR-USO model :
  - at larger space scales (RS data – FLEX)
  - for other ecosystems (forests)

- Mapping of GPP an ET at regional scales by coupling LSMs, RS data and the MLR-USO model