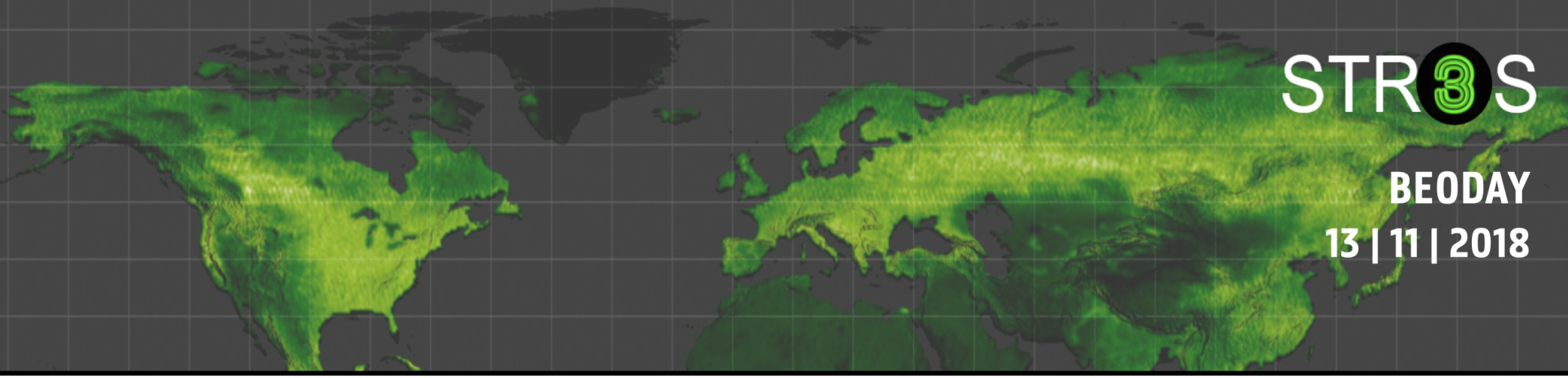

STR3S

BEODAY

13 | 11 | 2018

# Satellite sun-induced fluorescence to monitor transpiration: from ecosystem to global scales


Wouter Maes, Diego Miralles, Brianna R. Pagán

Contributions from: Pierre Gentine, Niko Verhoest, Wouter Dorigo, Kathy Steppe


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GHENT UNIVERSITY

# The Rationale

## Transpiration

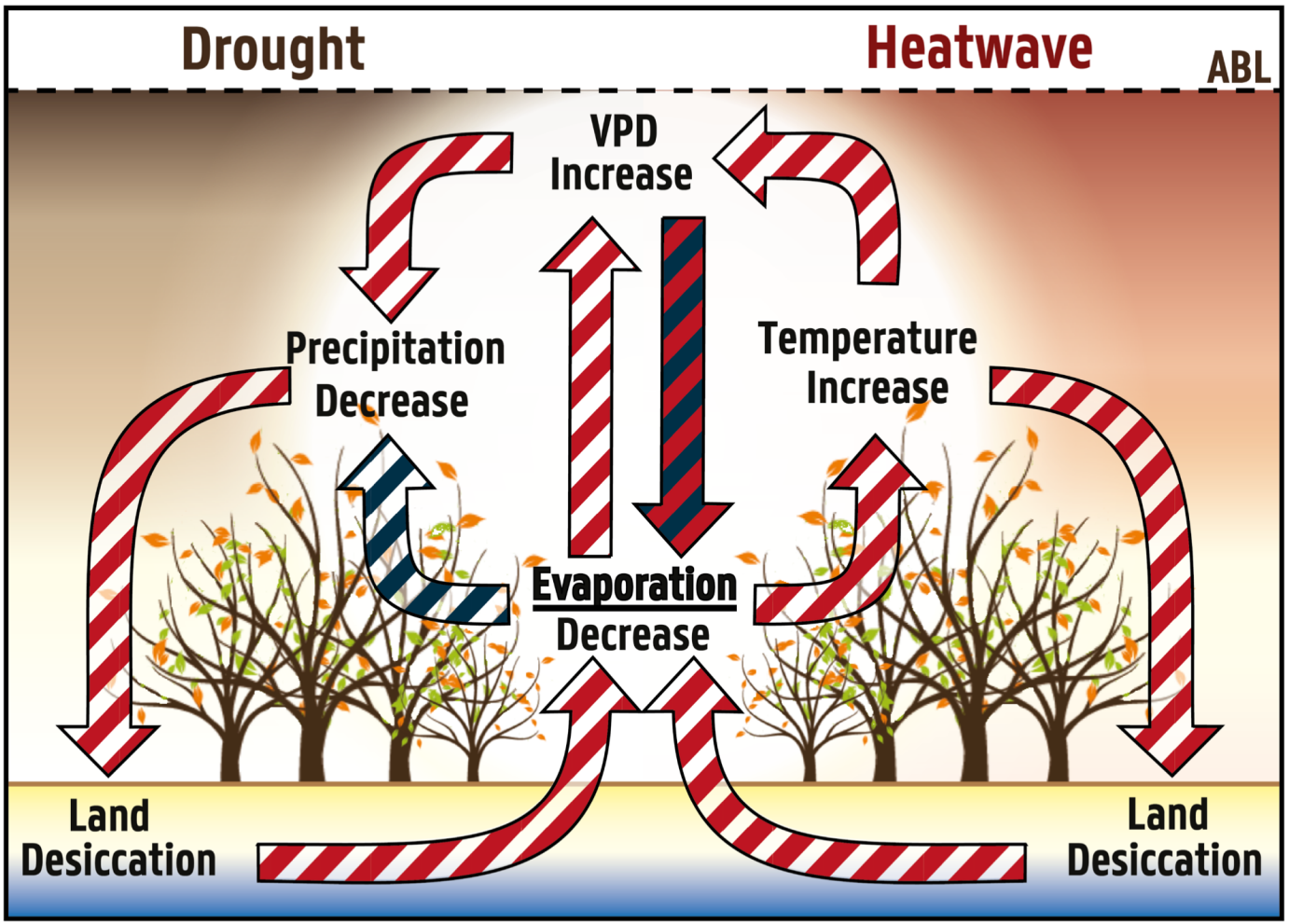
### Crucial for

- Water management
- Agriculture
- Climate change diagnostic
- Hydroclimatic extremes

### Yet, poorly understood

- Scarcity of global measurements
- No direct observation from space
- Little knowledge about large scale variability

**. . . However**

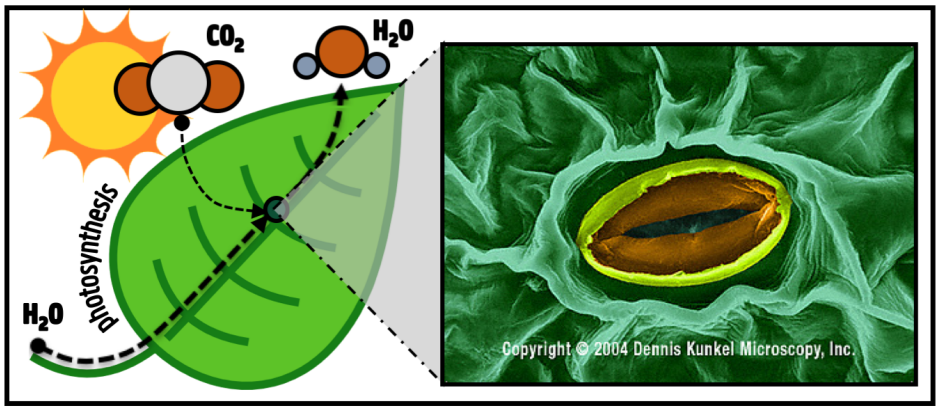


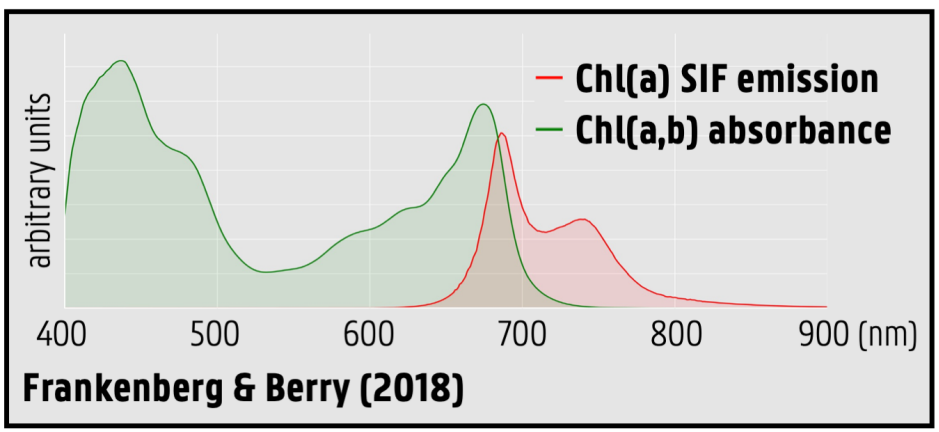

Miralles *et al.* (2018)

# The Rationale

**If...**

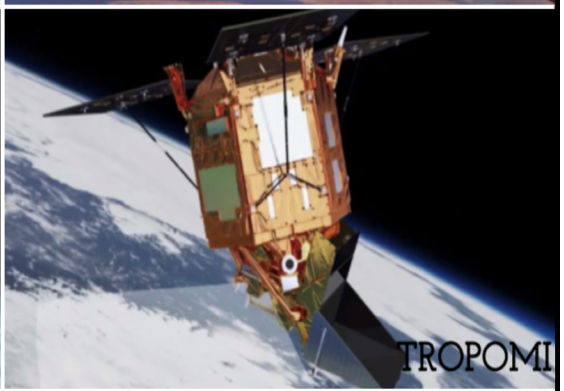
1. Transpiration is a byproduct of photosynthesis
2. Plants glow when they photosynthesize: SIF
3. The SIF emission can be sensed from satellite

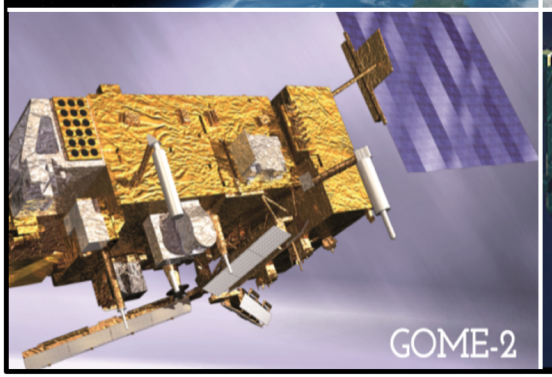


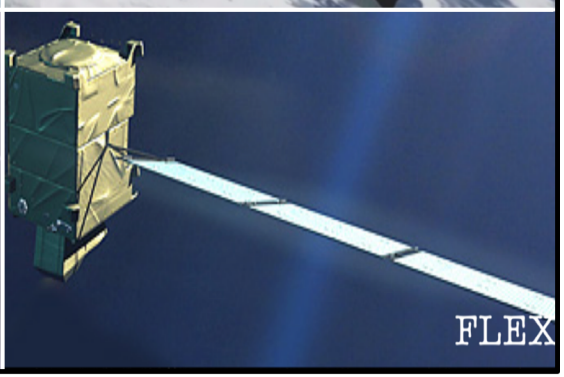




**Frankenberg & Berry (2018)**

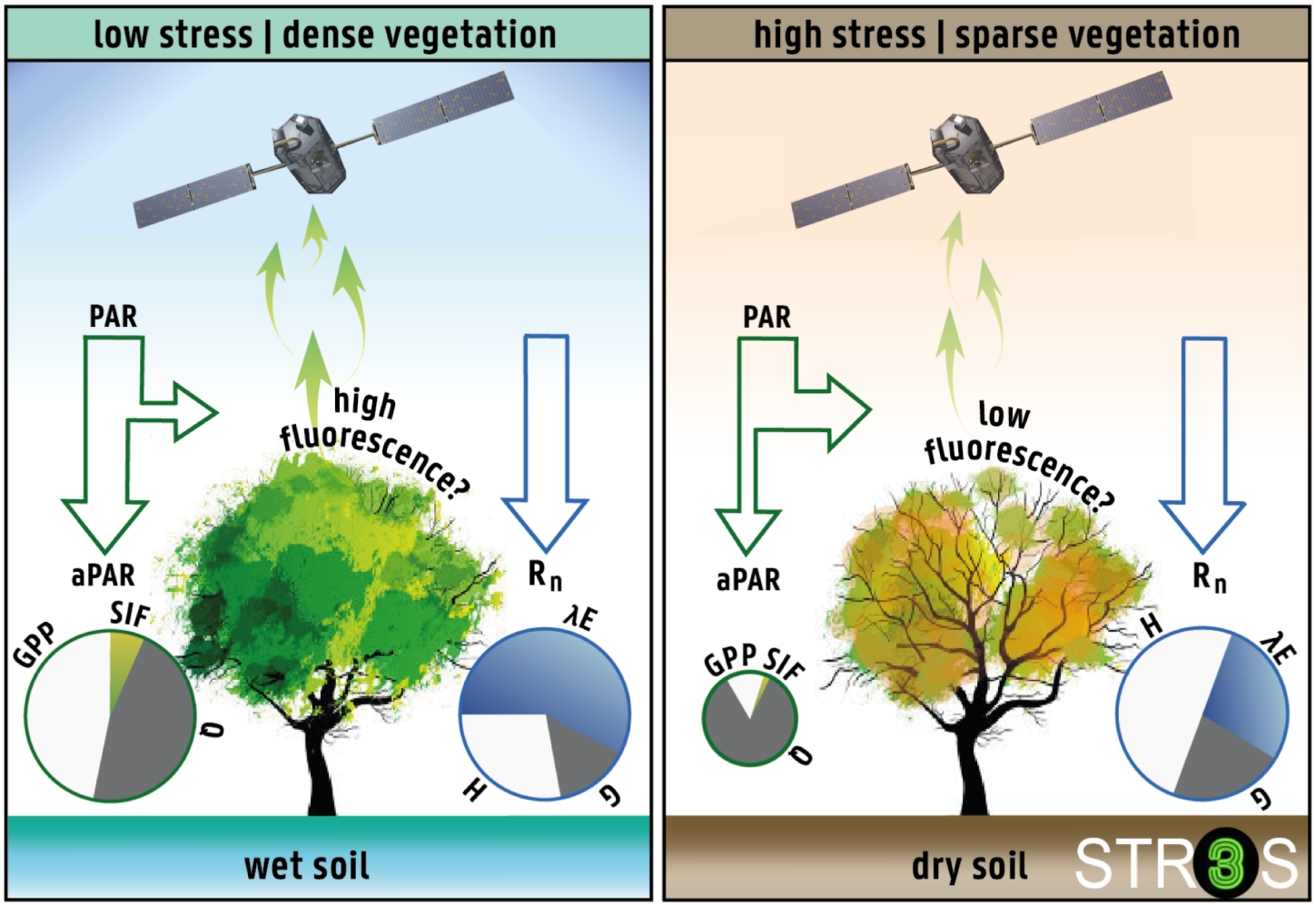


## Can SIF be used to diagnose transpiration?




*MIralles et al. (in prep.)*

# Team & Objectives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Niko Verhoest

UGent-LHWM
Ecohydrology
Transpiration
Soil Moisture
Data Assimilation
GLEAM
FLUXNET
VOD


Wouter Maes


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NY-CU
Fluorescence
Amazonia
GOME-2, SCIAMACHY
Ecohydrology
Micro-meteorology
FLUXNET

TU-Wien
Optical R.S.
Vegetation
Microwave R.S.
In-Situ Measurements
Soil Moisture
ISMN


Wouter Dorigo

UGent-PE
Ecology
Ecophysiology
Drought-stress
Hydraulic Function
Photosynthesis
Fluorescence

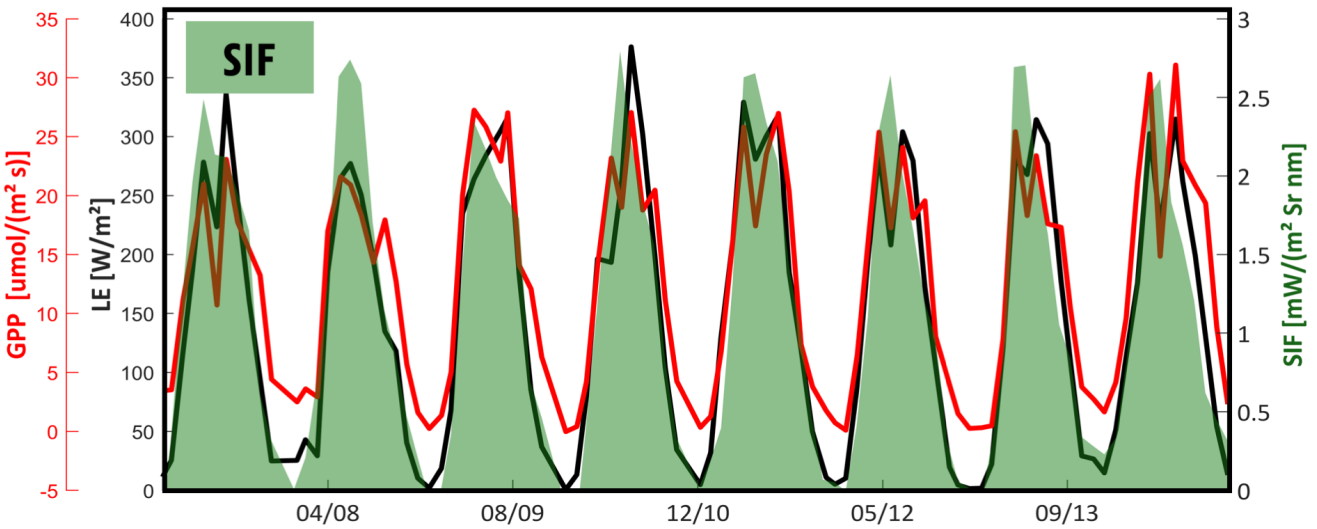

Kathy Steppe

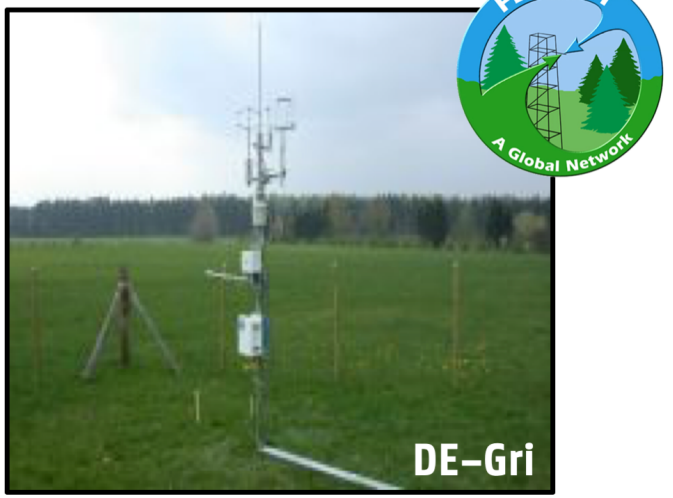
## 3BJECTIVES

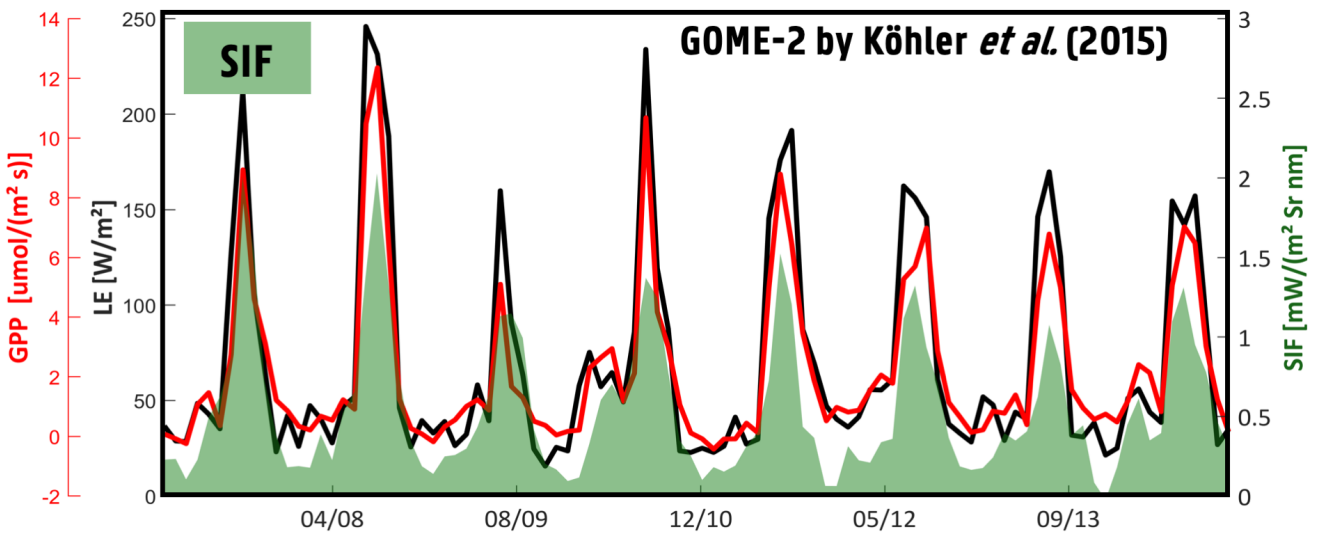
① To show the potential of SIF to reflect vegetation stress and its impact on transpiration

② To conform a dataset of transpiration incorporating vegetation stress from SIF

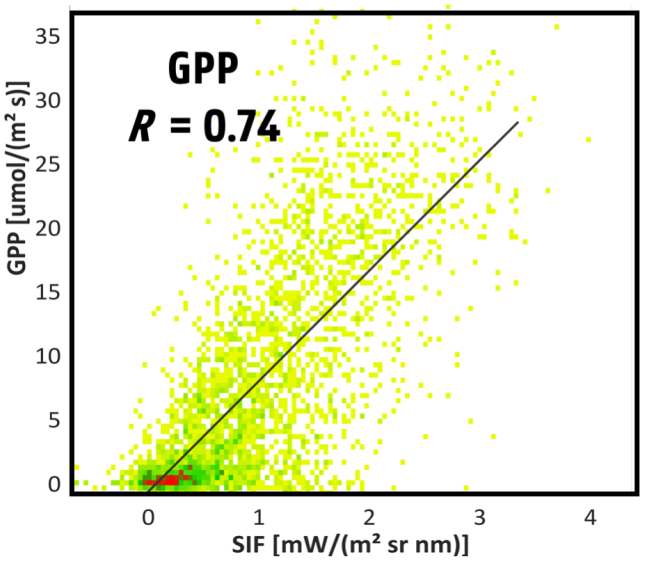
# Direct Comparison

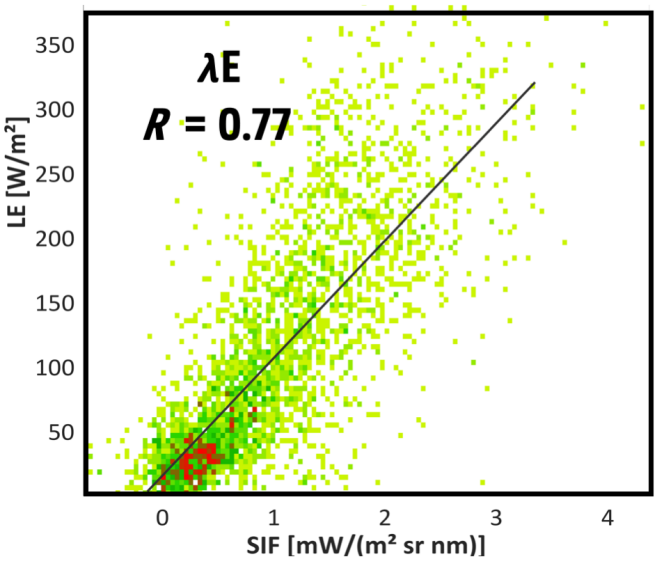


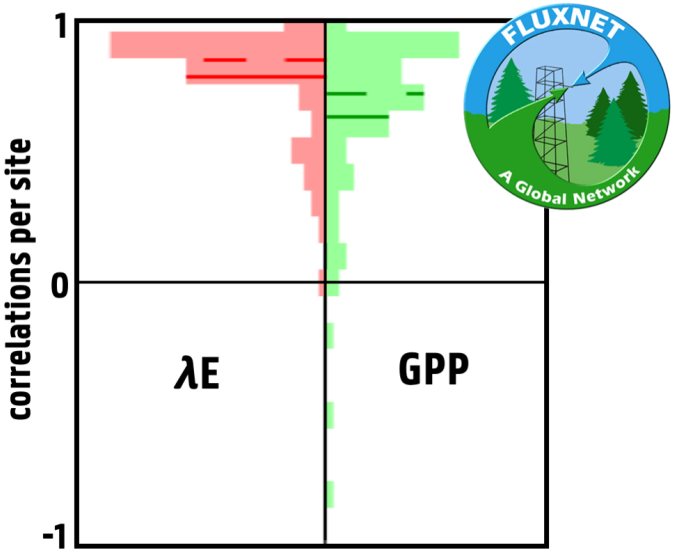



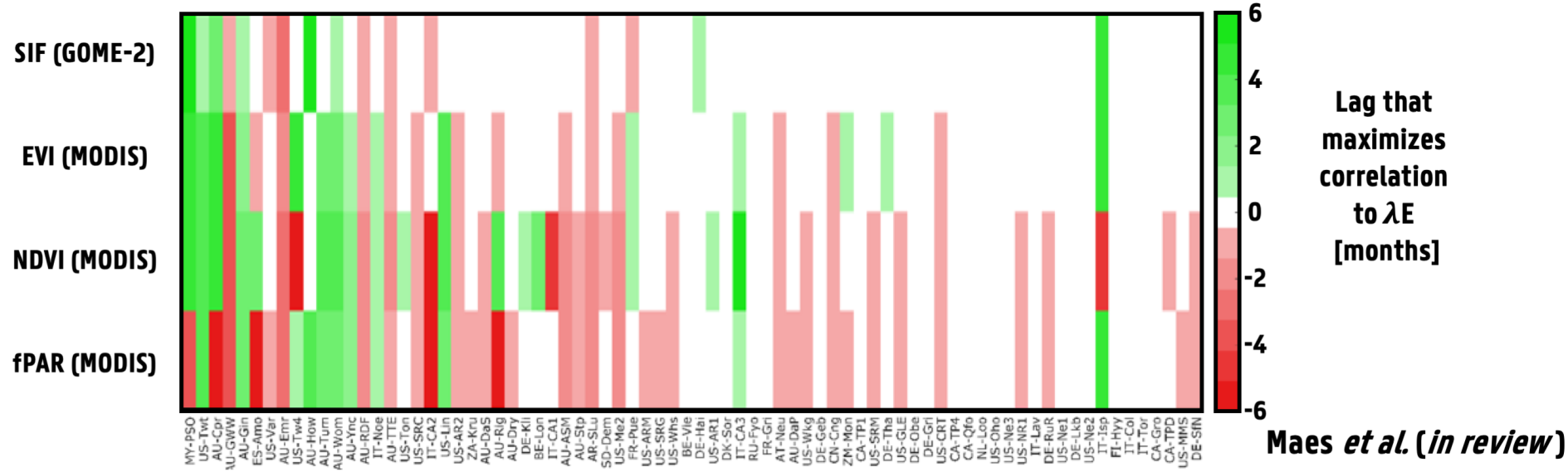




# Direct Comparison

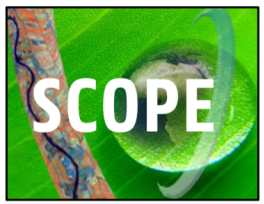


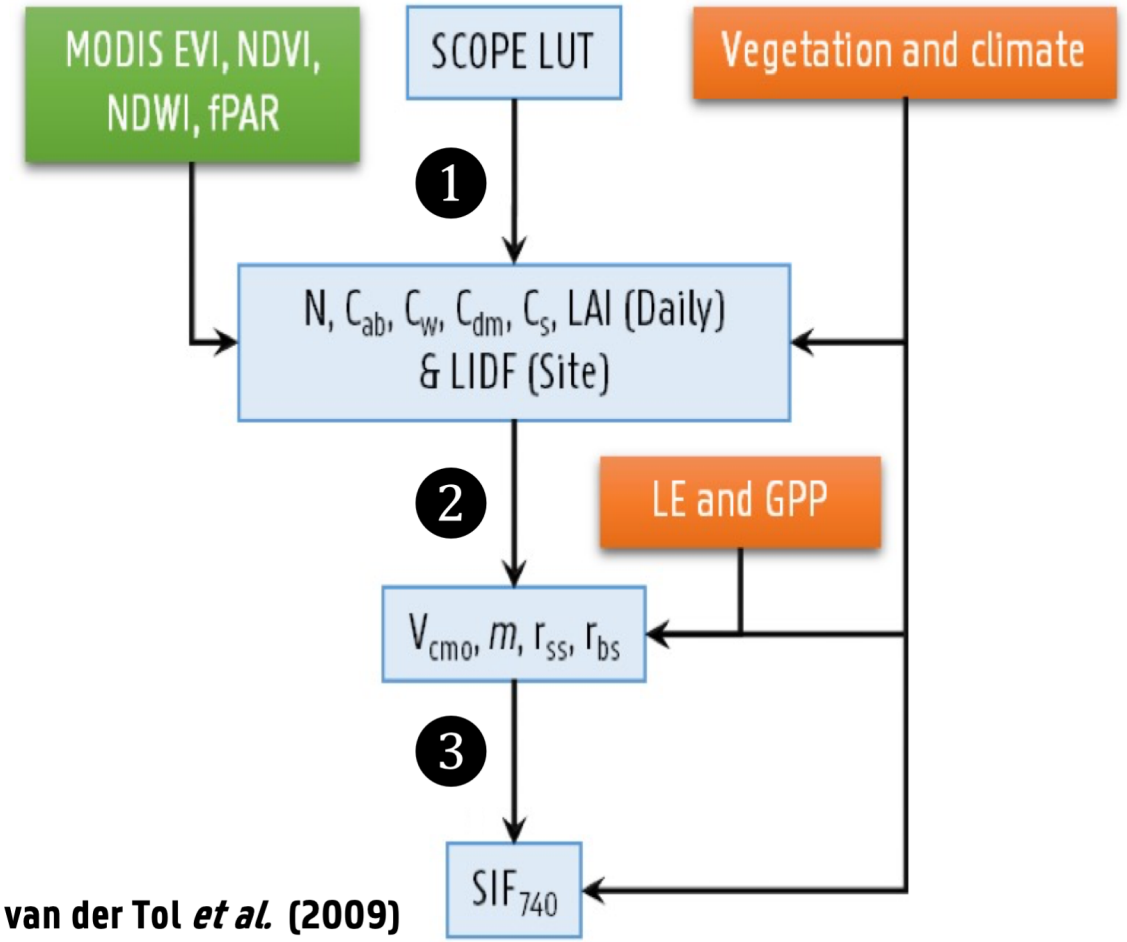



# Mechanistic Understanding




van der Tol *et al.* (2009)

**1 – Estimation basic leaf properties**

(a) LAI and distribution (LIDF) estimated together with others (N, Cab, Cw, Cdm) following look-up-table (LUT) inversion (Zhang *et al.*, 2014)

(b) Optimization based on RMSE of simulations against MODIS EVI, NDVI, NDWI and fPAR

(c) Temporal smoothing of daily properties

**2 – Bio-chemical/physical parameters**

(a) Biochemical parameters ($V_{cmo}$, $m$) and surface resistance ($r$) also via inversion.

(b) Optimization based on RMSE of GPP and $\lambda E$ simulations against measured GPP and $\lambda E$

(c) Tower forcing ($T_{air}$, $SW_{In}$, $SW_{out}$, $P$, $u$, $e$, $CO_2$, sm)

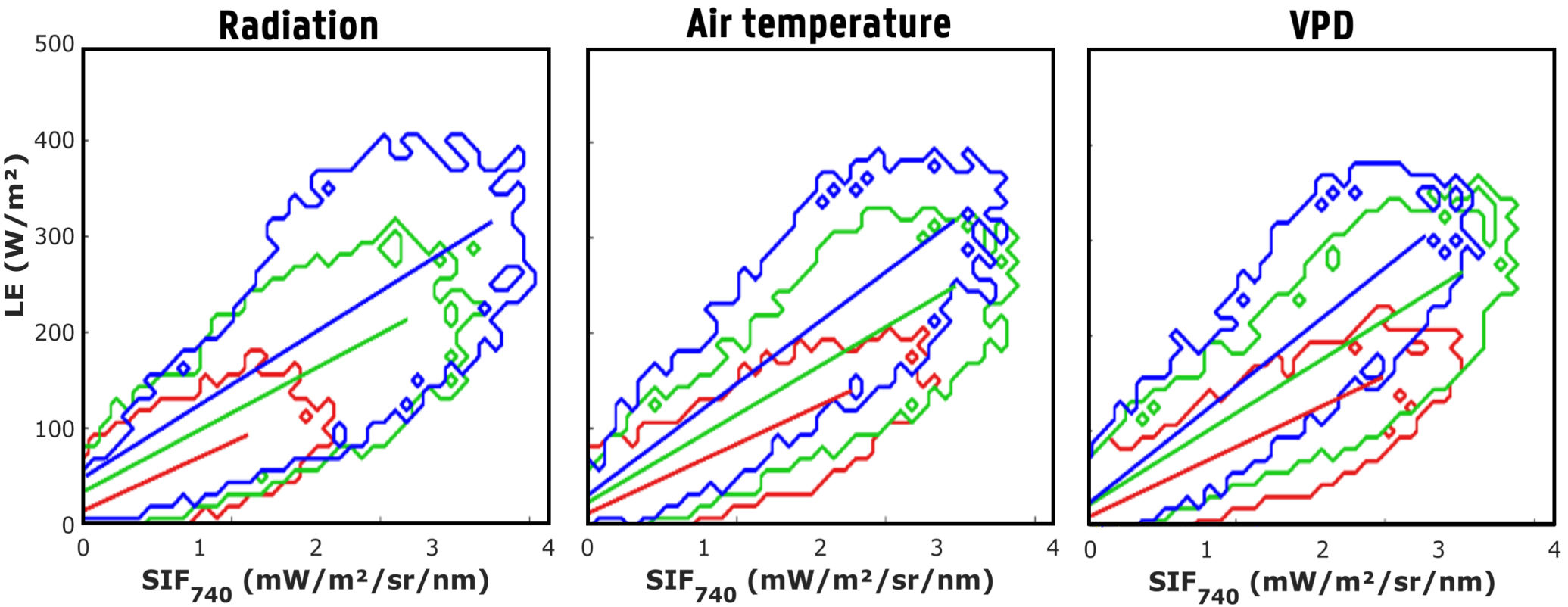
**3 – SIF extraction**

(a) Whole spectrum and selected bands (only if energy balance optimisation successful)

* [ 53 inputs (13 forcing, 8 optimised, 32 left constant) ]

SCOPE

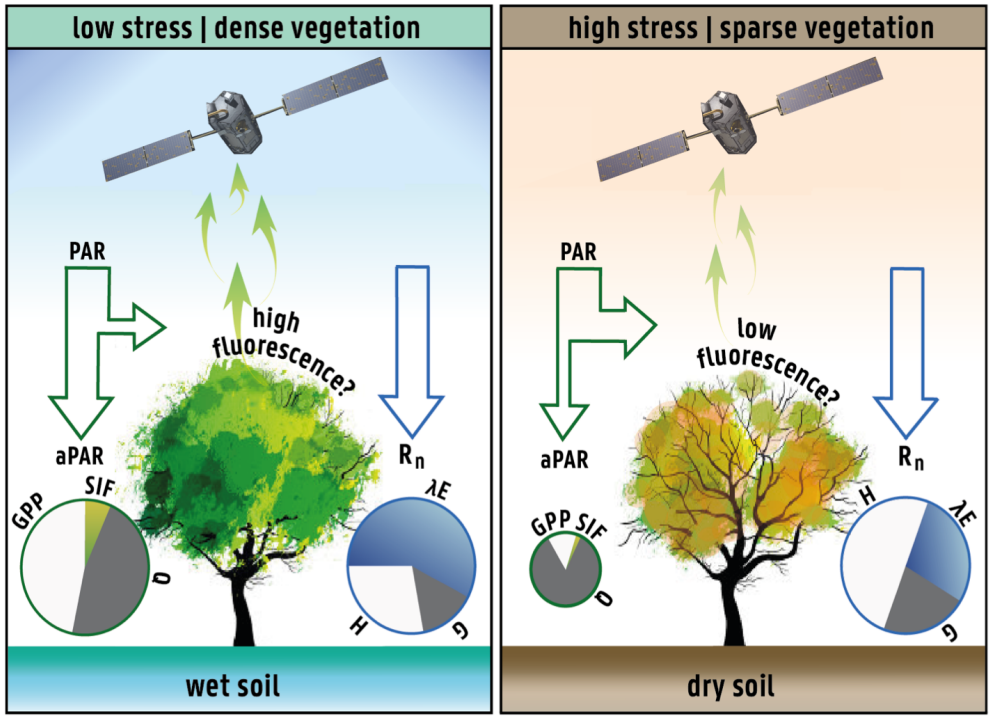
**The relationship SIF–Transpiration is the most affected by the atmospheric demand for water**



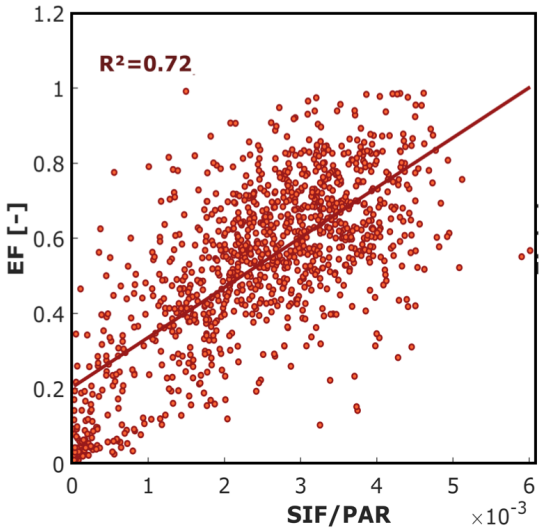

Maes *et al.* (*in review*)

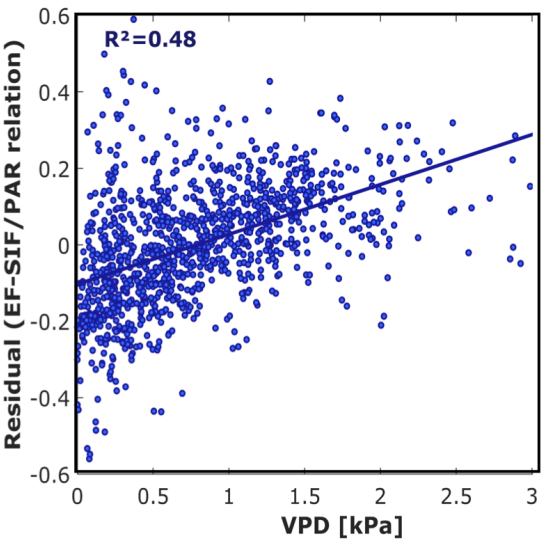
# Evaporative Fraction

1. Correlations between SIF and λE may be due to incoming solar energy
2. More mechanistic approach: validity of SIF/PAR as estimate of EF?
3. Correlation and residual related to VPD variability, potentially due to WUE

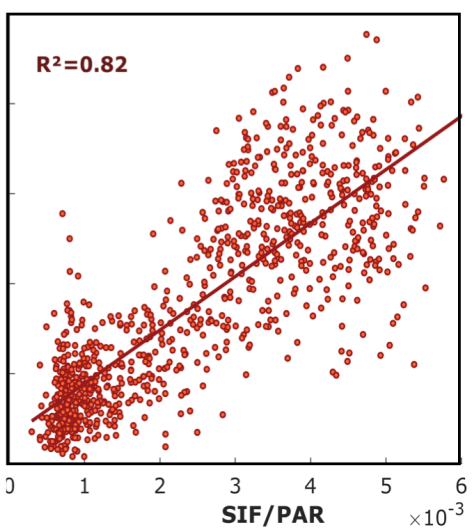


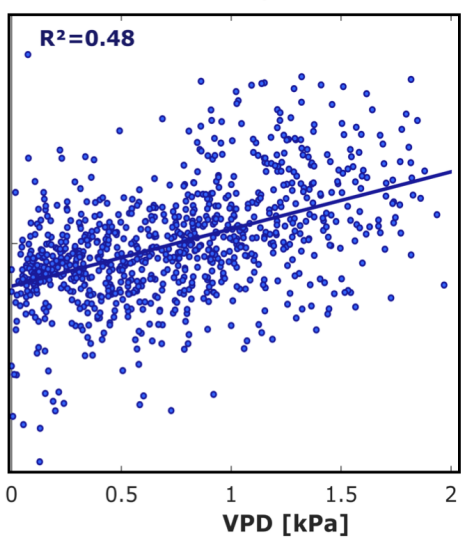

## DE-Gri (grassland)



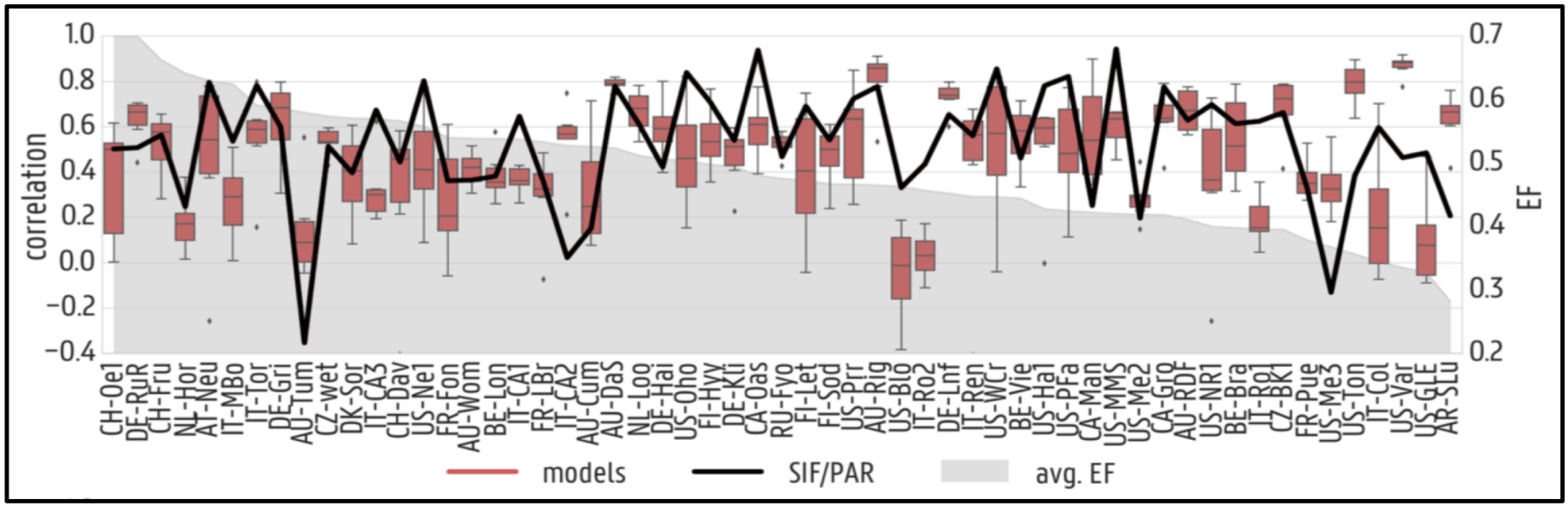



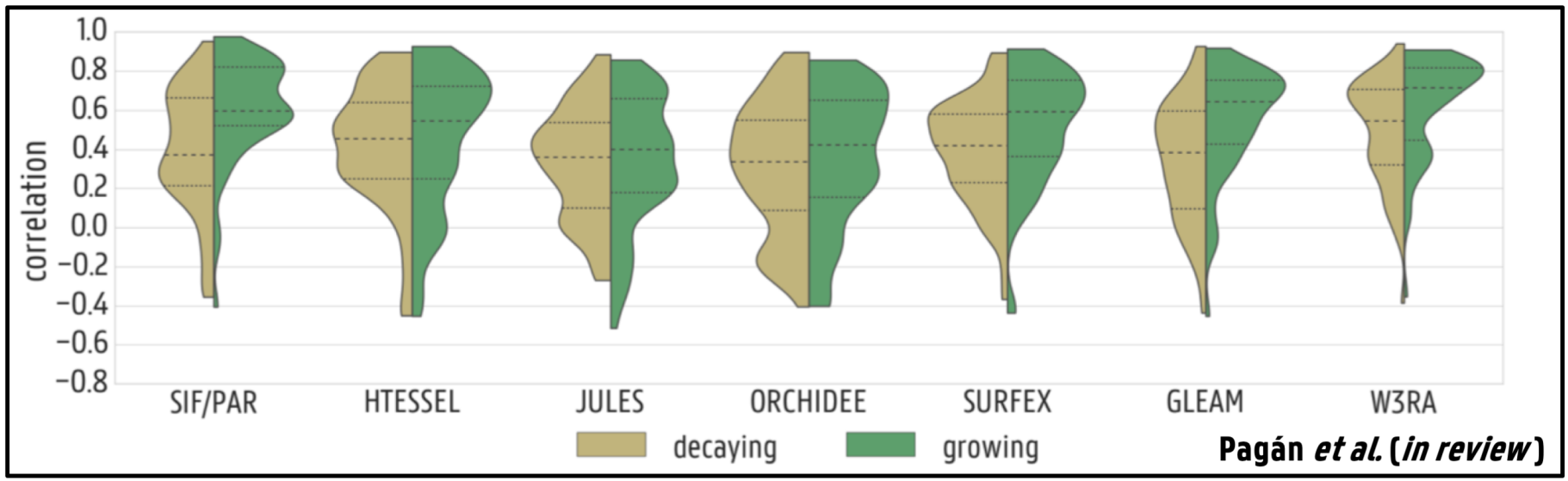

## US-MMS (forest)



# Climate Model Benchmarking

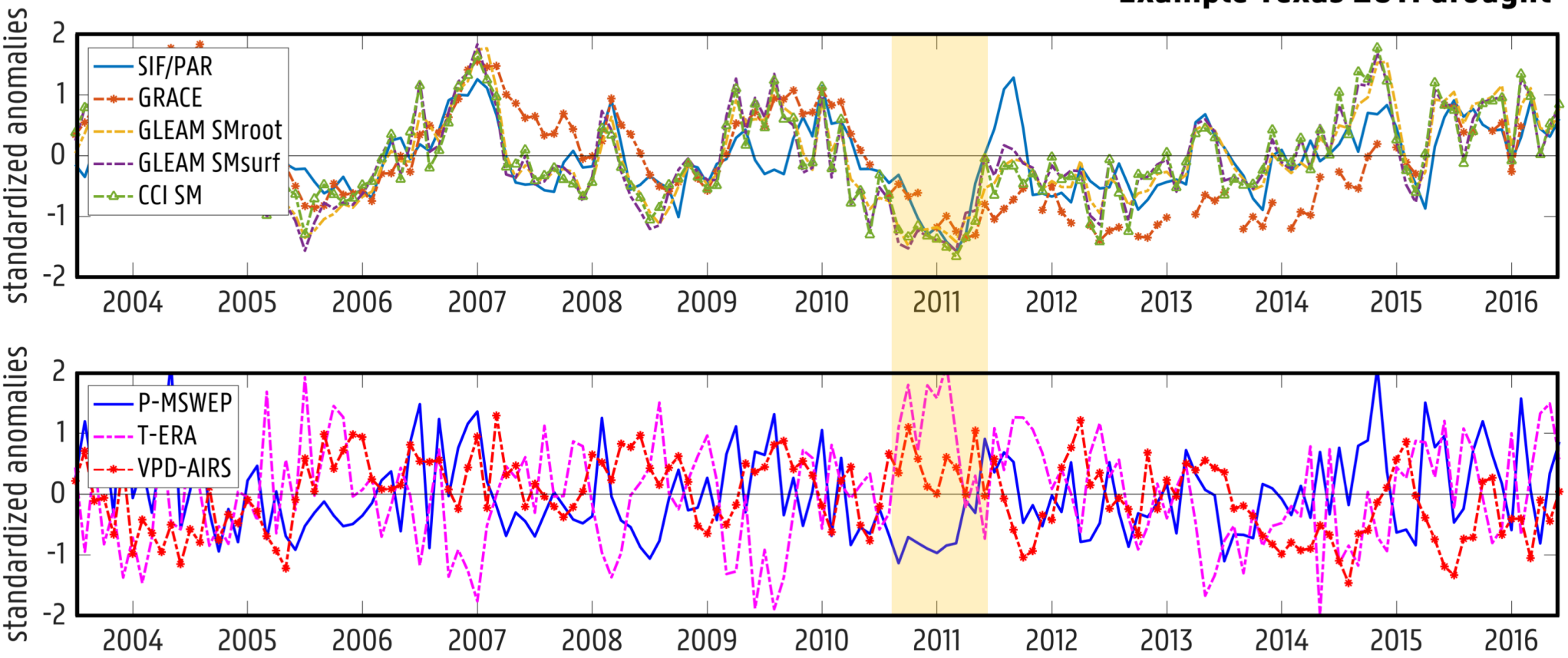



**Pagán *et al.* (*in review*)**

## Can it be used for drought early-warning?

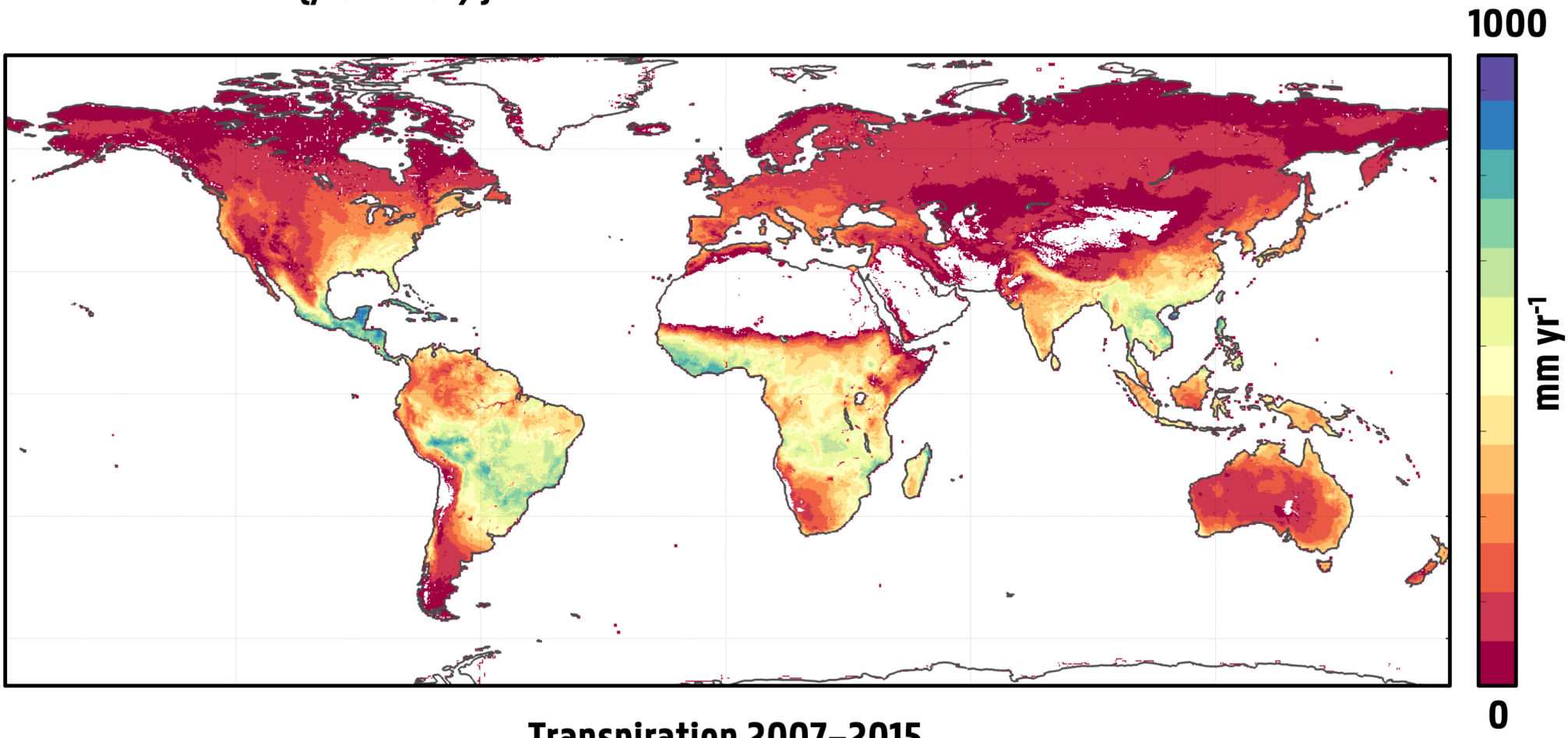
### Example Texas 2011 drought



# Global Transpiration

**Can that be scaled up globally?**

(*preliminary*)




**Transpiration 2007–2015**

# Conclusion

- Correlation of SIF to $\lambda E$ (and $T$) as high as for GPP or higher
- Mechanistically connected via stomata conductance and sharing drivers
- Factors influencing the SIF–$T$ relationship are mostly meteorological
- SIF/PAR can be used to diagnose EF with higher skill than for most LSMs
- Combined with VPD and temperature, feasible to derive transpiration globally
- New SIF sensors, better data, opening opportunities