Physical and ecophysiological controls on the relationship between solar-induced chlorophyll fluorescence and gross primary productivity across diurnal and seasonal scales in the boreal forest

AGU ADVANCING EARTH AND SPACE SCIENCE

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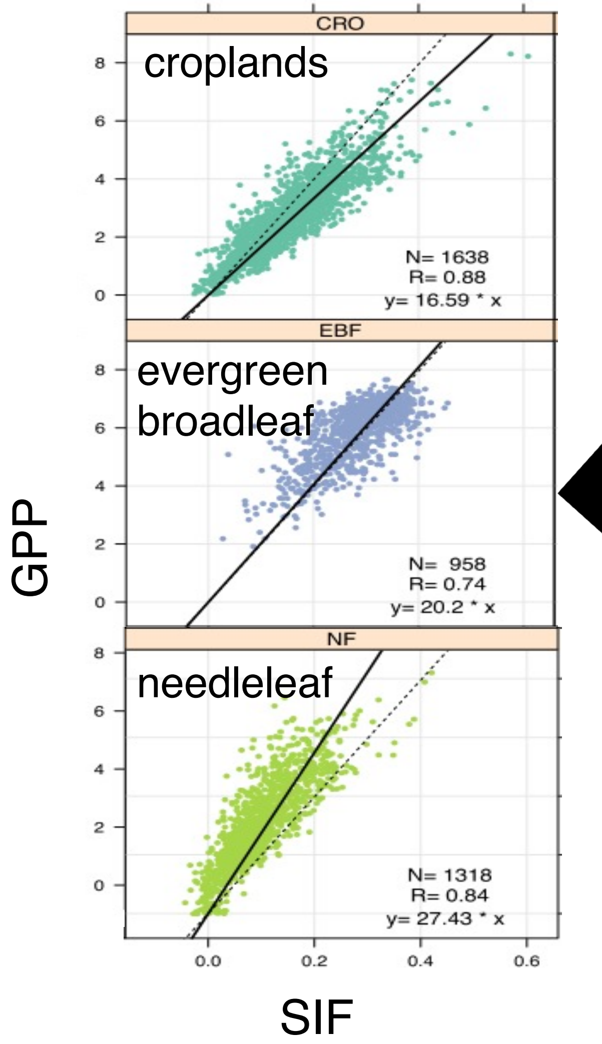
AOS the science surrounding us all

GRFP NSF GRADUATE RESEARCH FELLOWSHIP PROGRAM

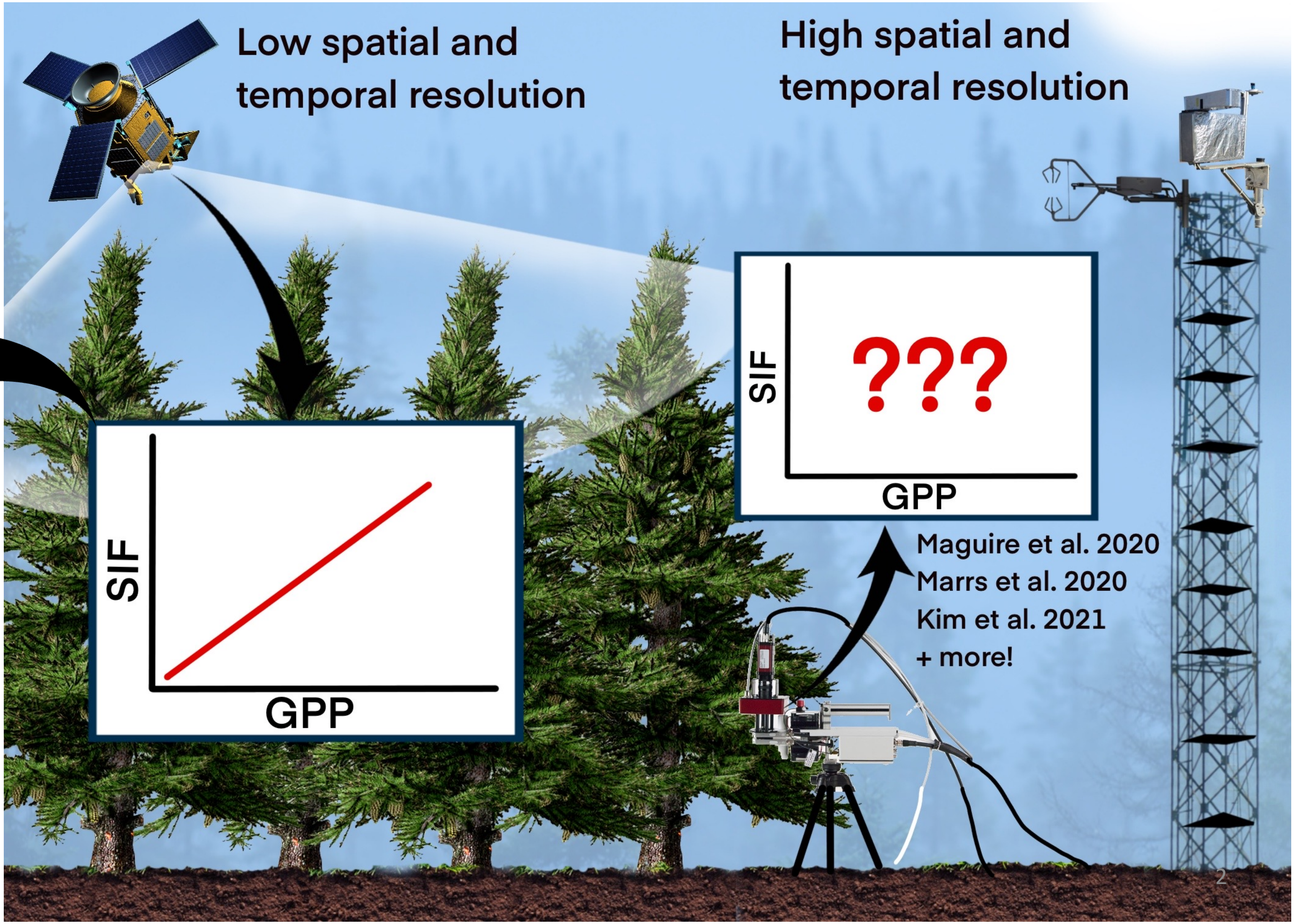
UCLA

ABoVE ARCTIC - BOREAL VULNERABILITY EXPERIMENT

SIF is a powerful proxy for GPP, however, smaller scale studies have highlighted nuance to the relationship between SIF and GPP



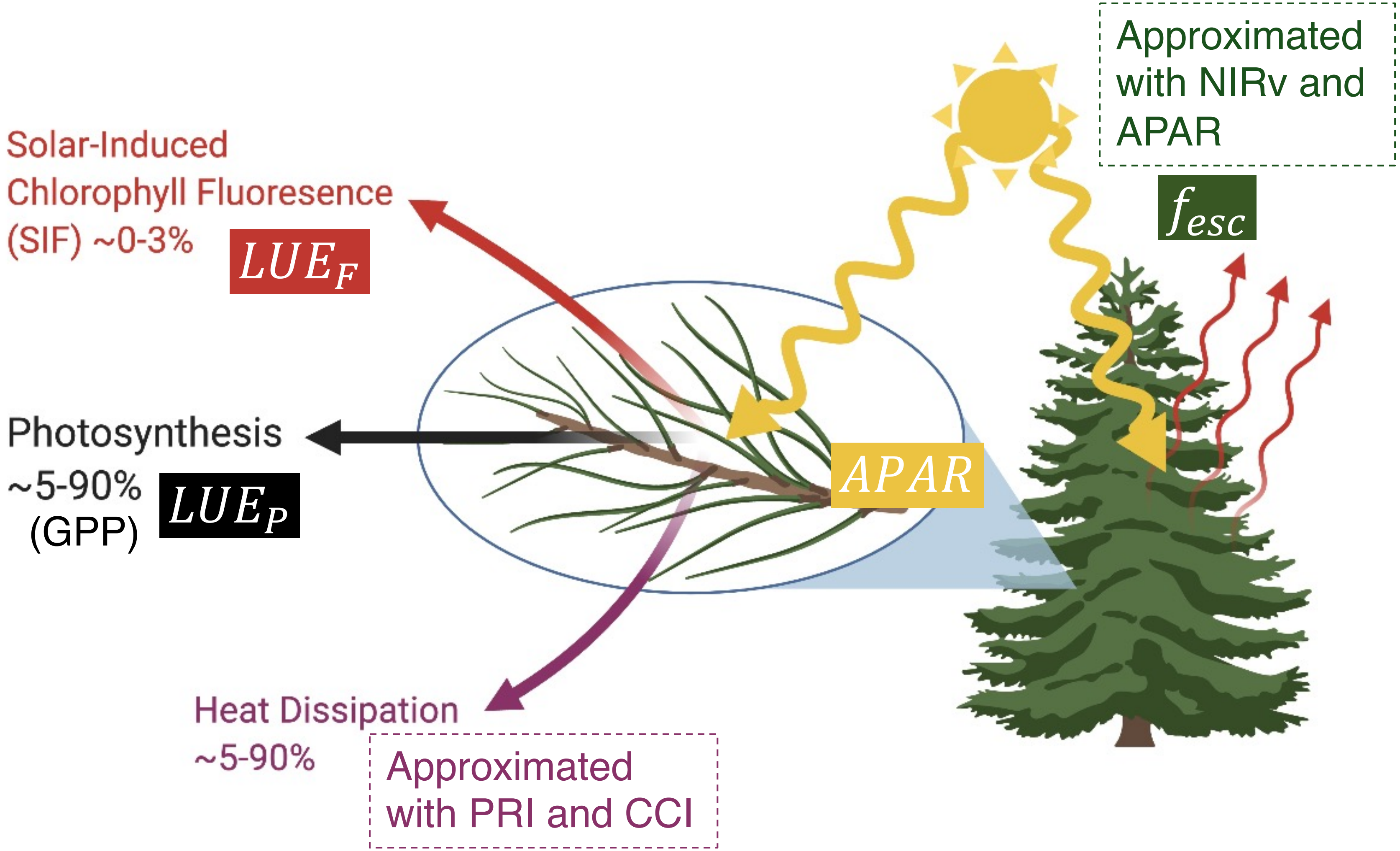
Sun et al., 2018



A SIF emission is one of three potential pathways an absorbed photon can take. We can use this information to relate SIF and GPP

$$GPP = APAR * LUE_P$$
$$SIF = APAR * LUE_F * f_{esc}$$

$$GPP = SIF * \frac{LUE_P}{LUE_F * f_{esc}}$$



Photon plant interactions over complex canopy structures (*physical*) create significant challenges for interpreting SIF and connecting it to plant productivity (*ecophysiological*)

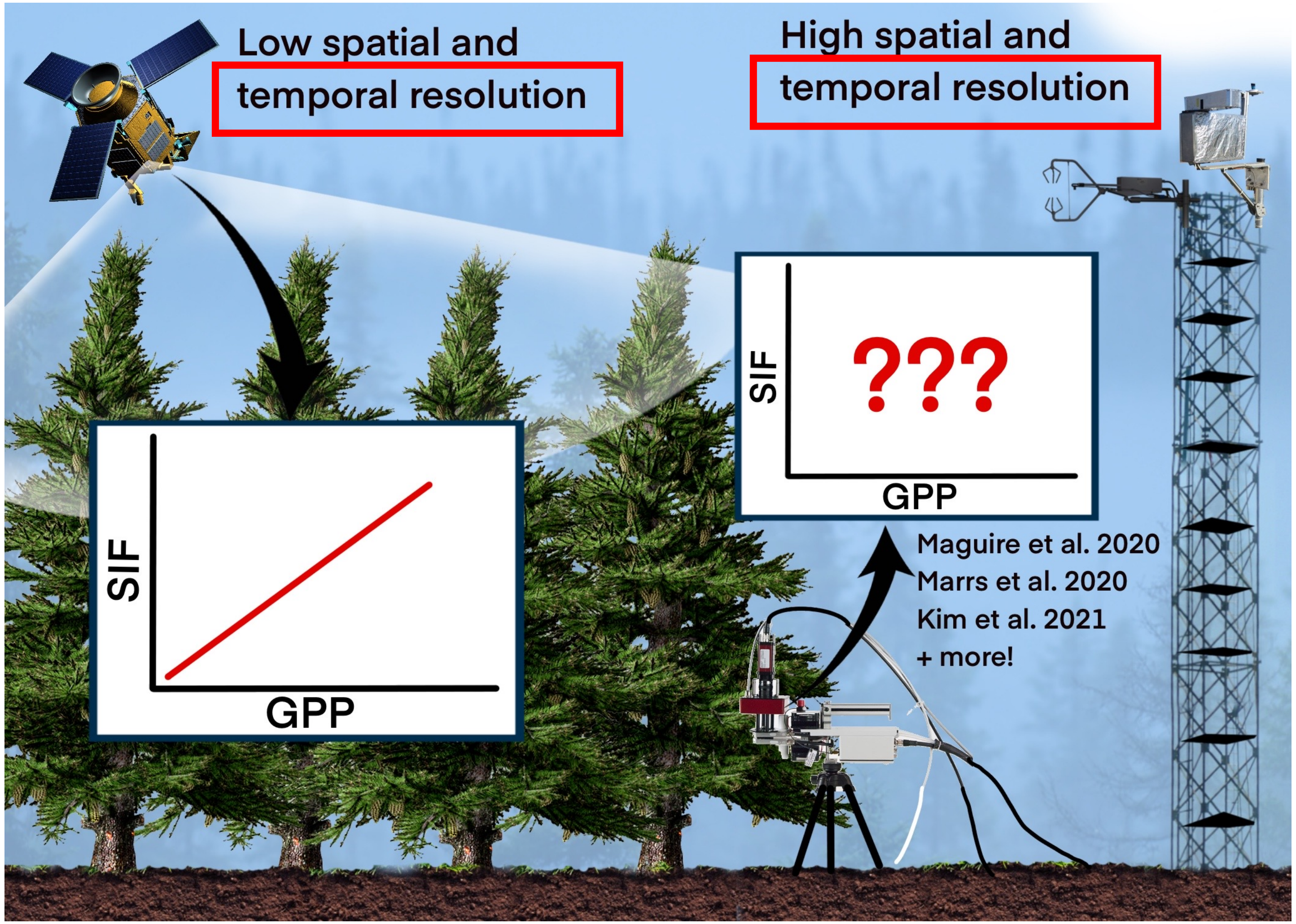
The goals of this study:

$$GPP = SIF * \frac{LUE_P}{LUE_F * f_{esc}}$$

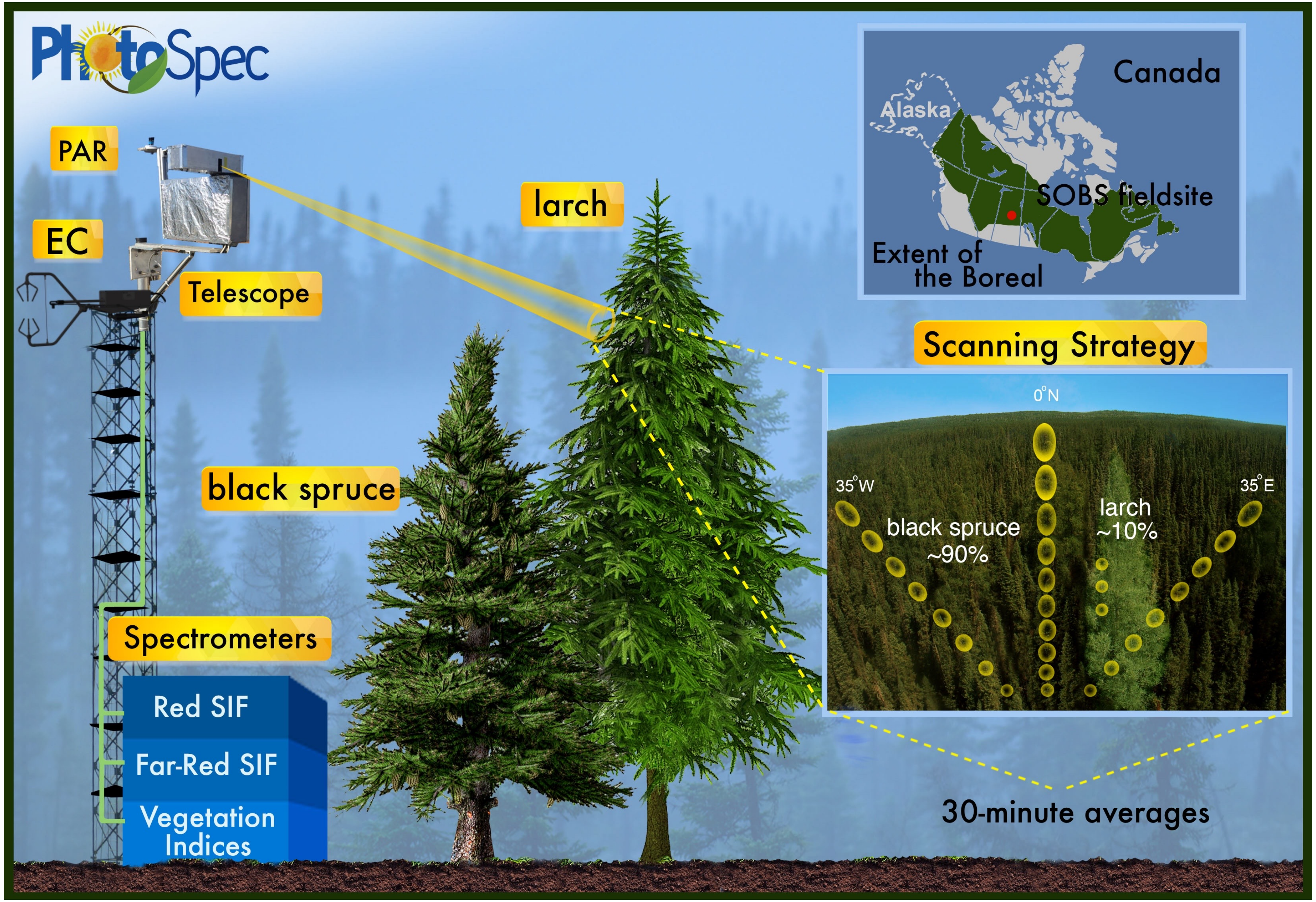
1. What are the relationships among SIF, VIs, and GPP?

2. How do the dynamics of LUE_P, LUE_F, and f_{esc} impact the relationship between SIF and GPP at varying temporal scales?

*in the boreal forest

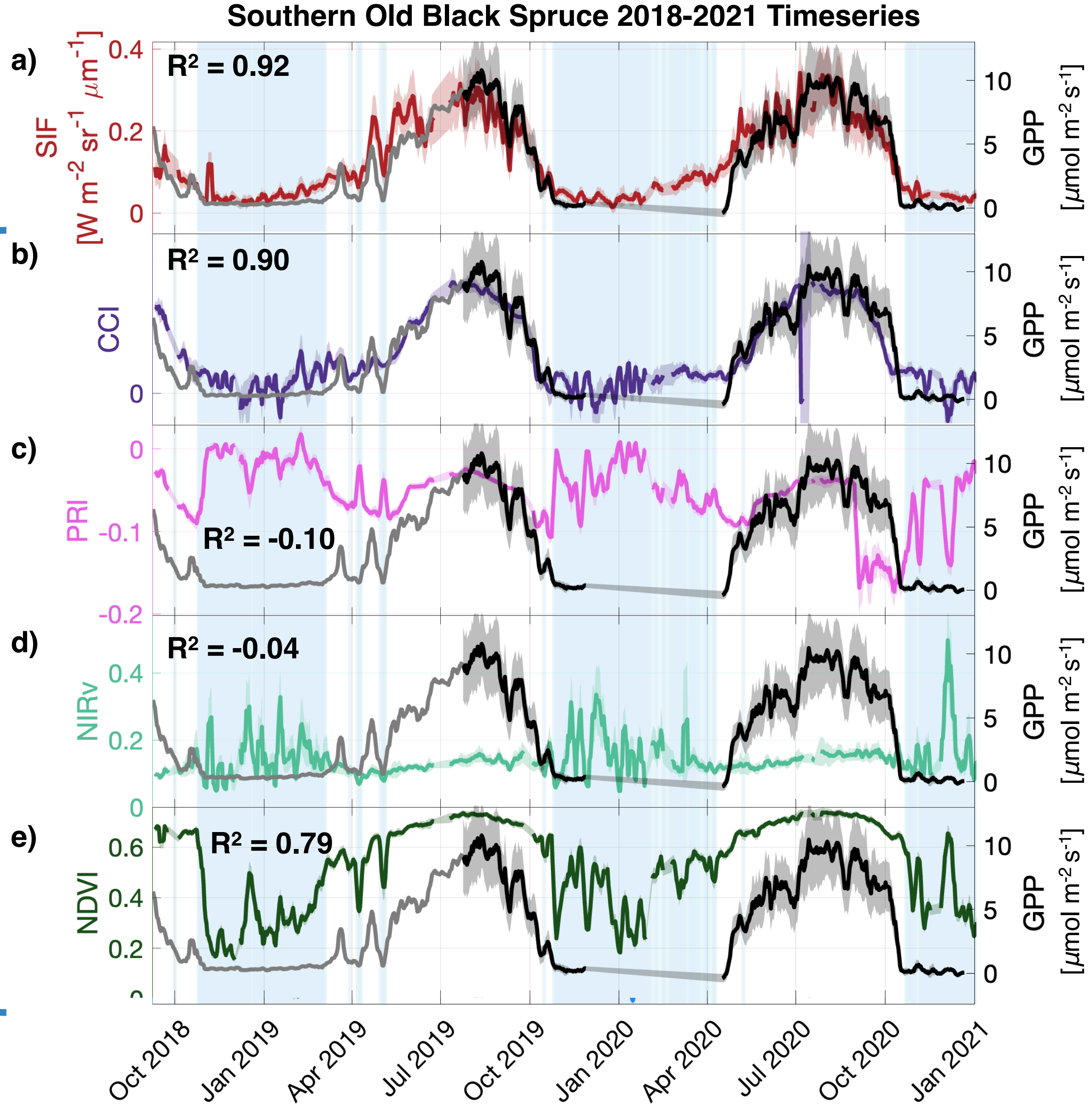


We collected data from PhotoSpec in a boreal mixed-species needleleaf forest



Pierrat et al., 2021
Pierrat et al., in revision
Grossmann et al., 2018

SIF and vegetation indices as a proxy for GPP



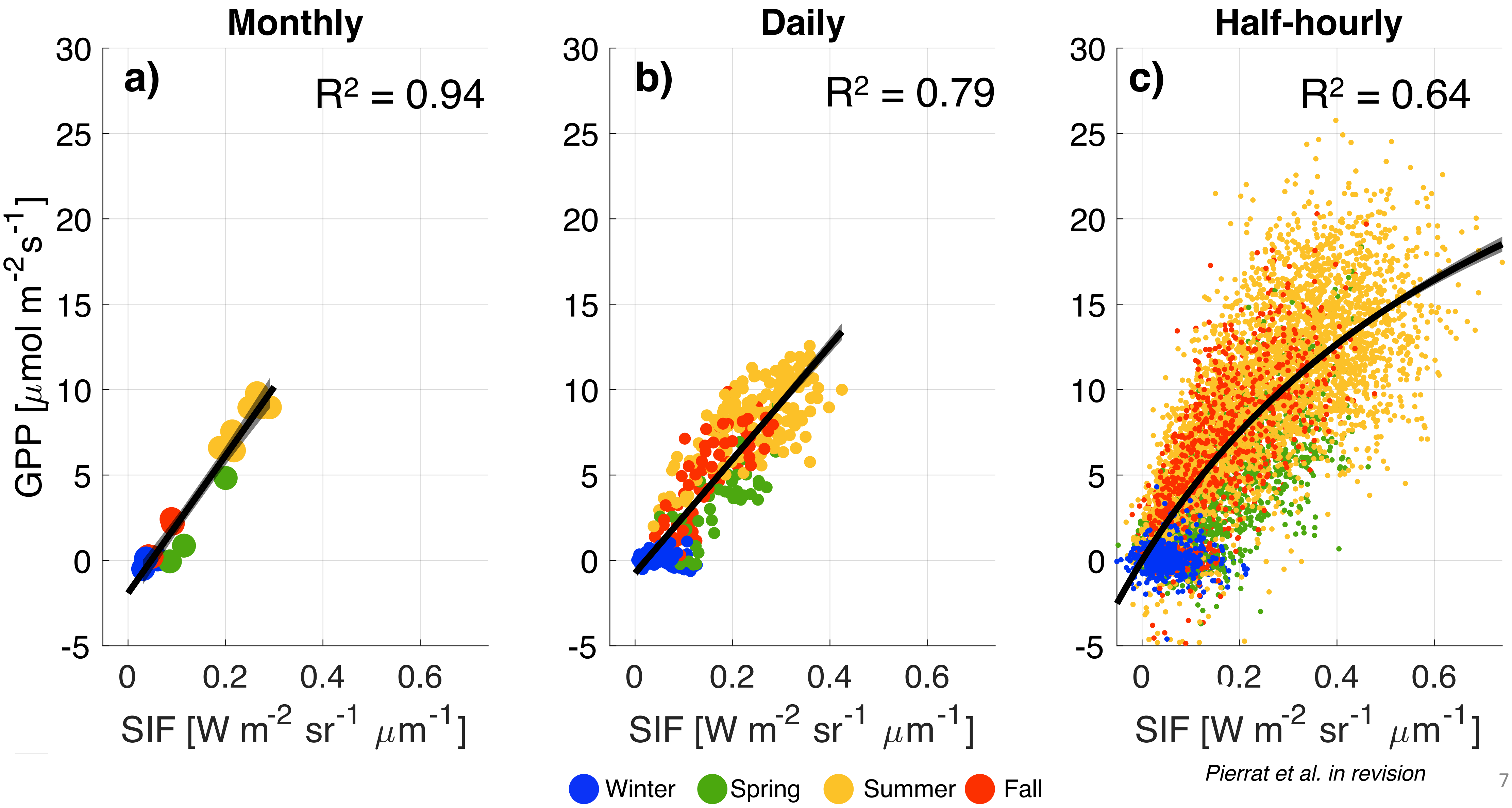
Snow impacts all VIs

Physiologically sensitive metrics (SIF, CCI, PRI*) show seasonal correlations with GPP

Structurally sensitive indices (NDVI and NIRv) show little seasonal variation

Pierrat et al. in revision

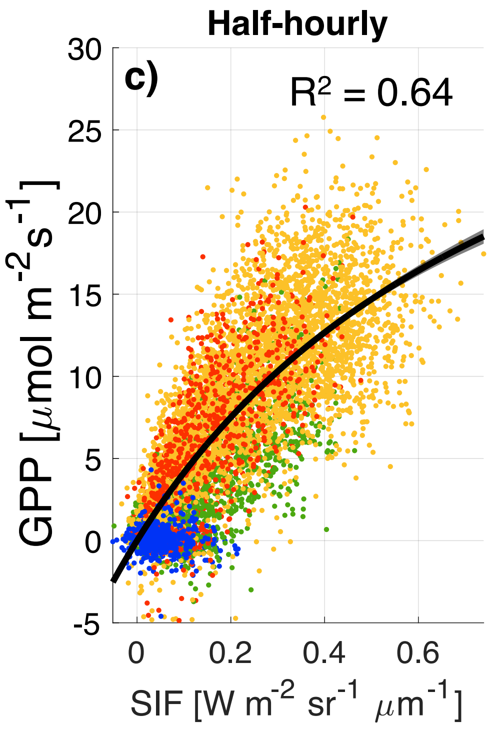
The SIF-GPP relationship becomes **increasingly non-linear** at high temporal resolutions

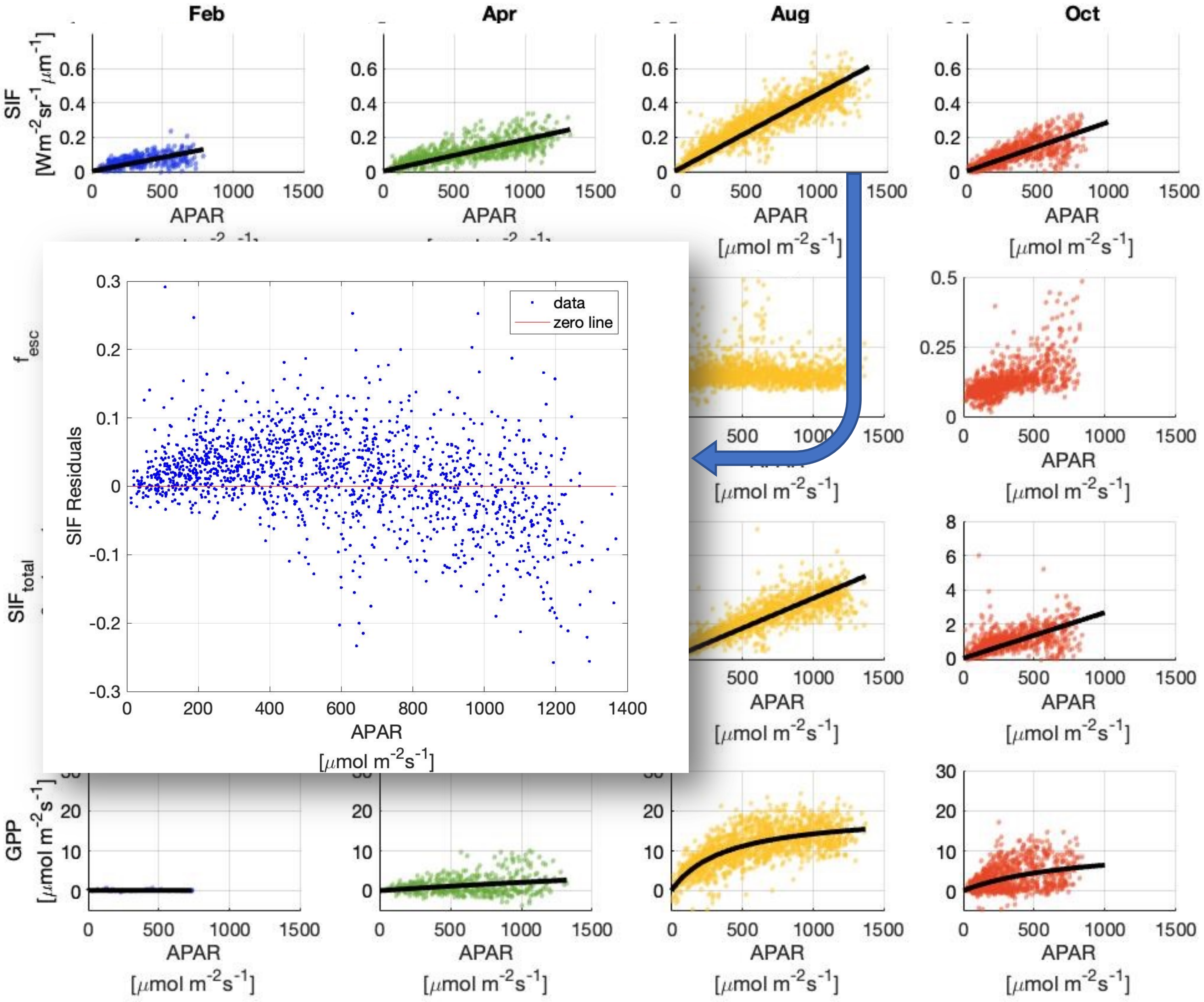


Pierrat et al. in revision

Light saturation of GPP is the primary driver of the non-linear SIF/GPP relationship at a half-hourly resolution

$$GPP = SIF * \frac{LUE_P}{LUE_F * f_{esc}}$$





$$SIF = APAR * \boxed{LUE_F * f_{esc}}$$

$$f_{esc} = \frac{NIRv}{fPAR}$$

Zeng et al., 2019

$$\frac{SIF}{f_{esc}} = SIF_{total} = APAR * LUE_F$$

$$GPP = APAR * LUE_P$$

$$LUE_P = \frac{GPP_{max} * APAR}{c + APAR}$$

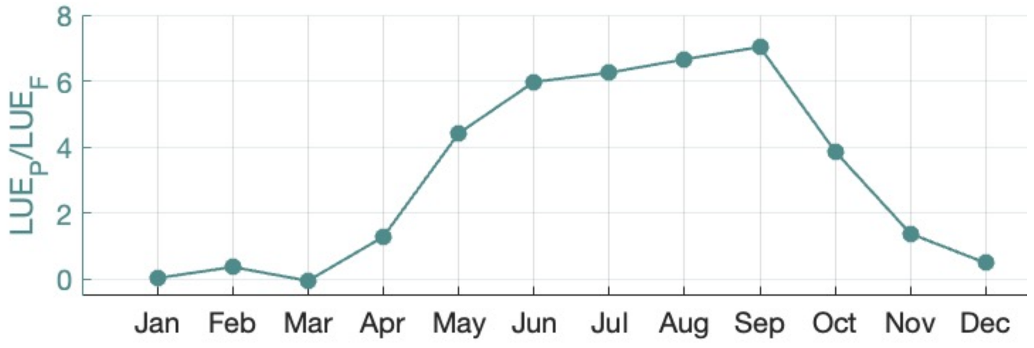
Co-variation between LUE_F and LUE_P drives the seasonal convergence of SIF and GPP, but there is a seasonal dependence

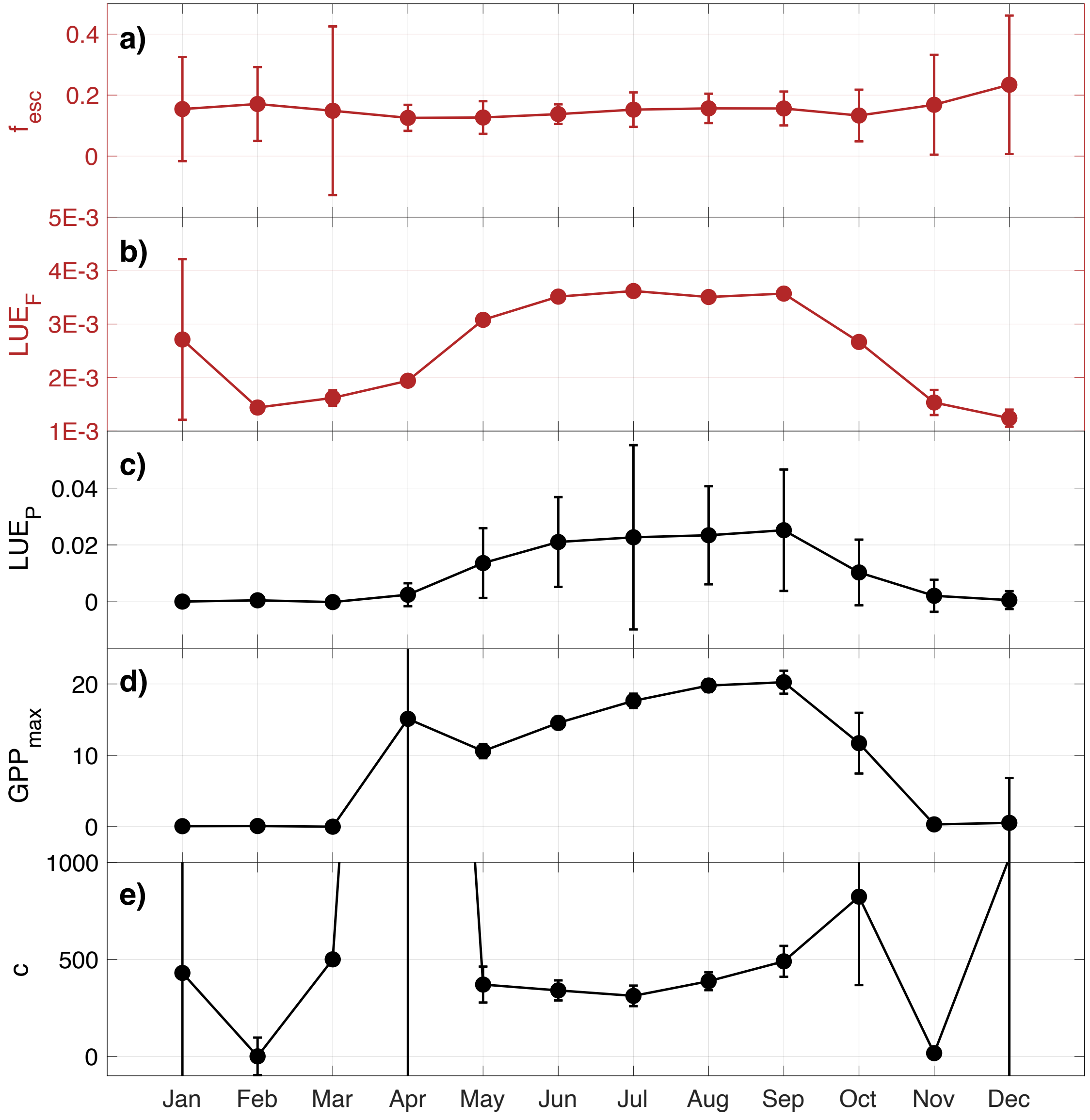
$$GPP = SIF * \frac{LUE_P}{LUE_F * f_{esc}}$$

$$SIF = APAR * LUE_F * f_{esc}$$

$$GPP = APAR * LUE_P$$

$$LUE_P = \frac{GPP_{max} * APAR}{c + APAR}$$





Calculated using NIRv following *Zeng et al., 2019*

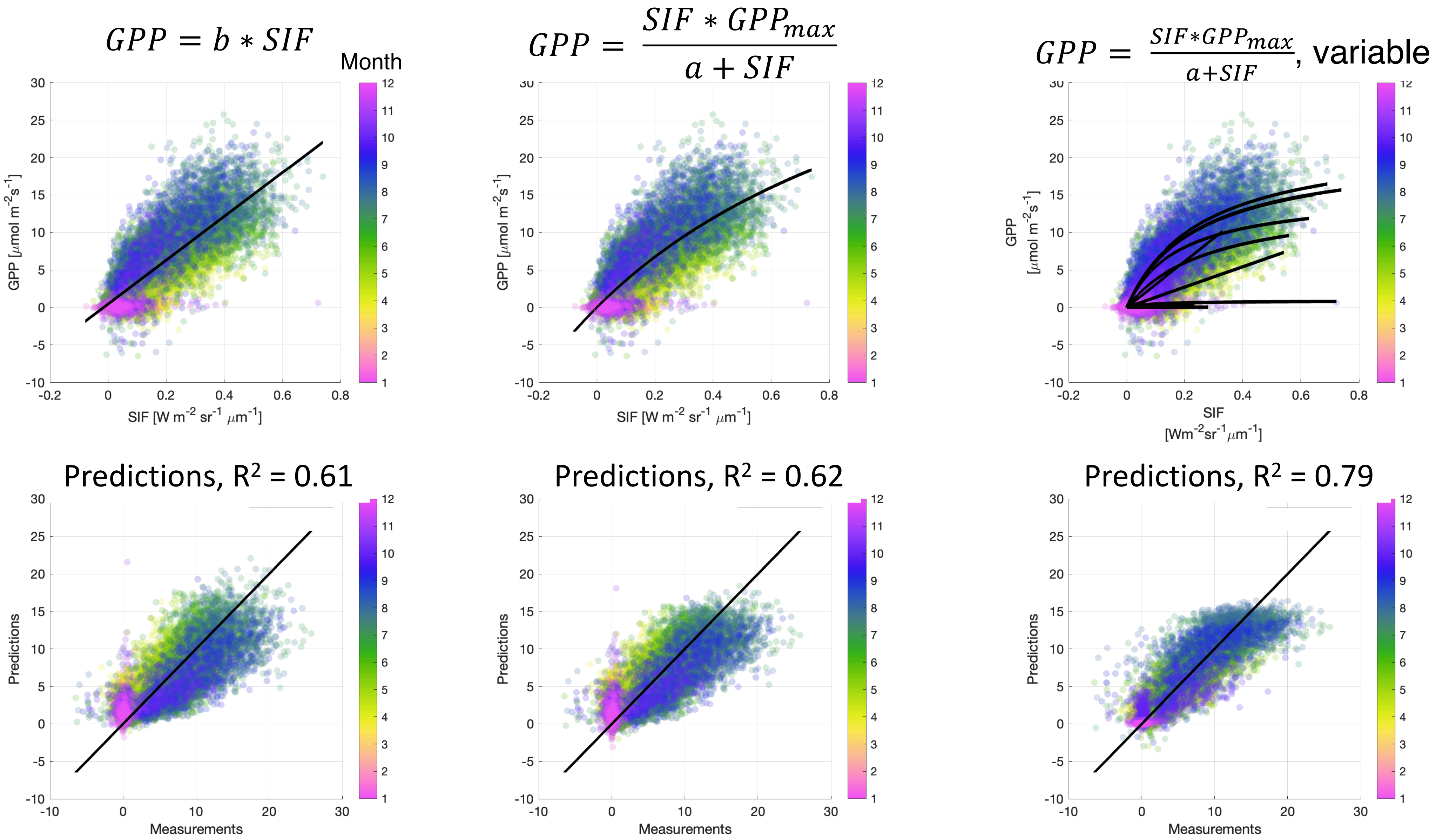
Calculated from light response curves of SIF_{total}

Calculated as GPP/APAR

Calculated from light response curves of GPP

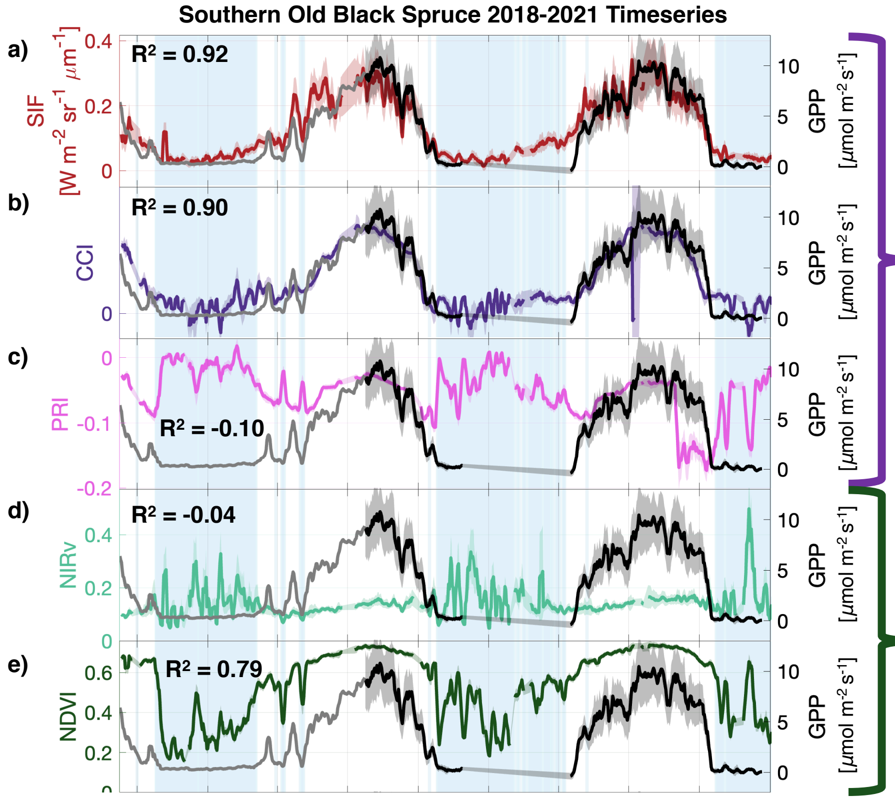
Pierrat et al. in revision

A seasonally variable SIF-GPP relationship can help account for nuances in the seasonal variability of f_{esc}, LUE_F, and LUE_P



Conclusions:

1. What are the relationships among SIF, VIs, and GPP across varying temporal scales?

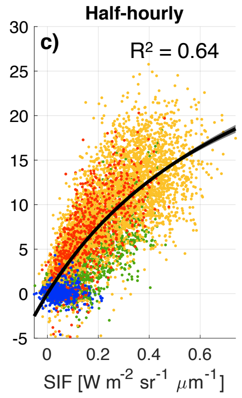


Physiologically sensitive metrics (SIF, CCI, PRI) show seasonal correlations with GPP

Structurally sensitive indices (NDVI and NIRv) show little seasonal variation

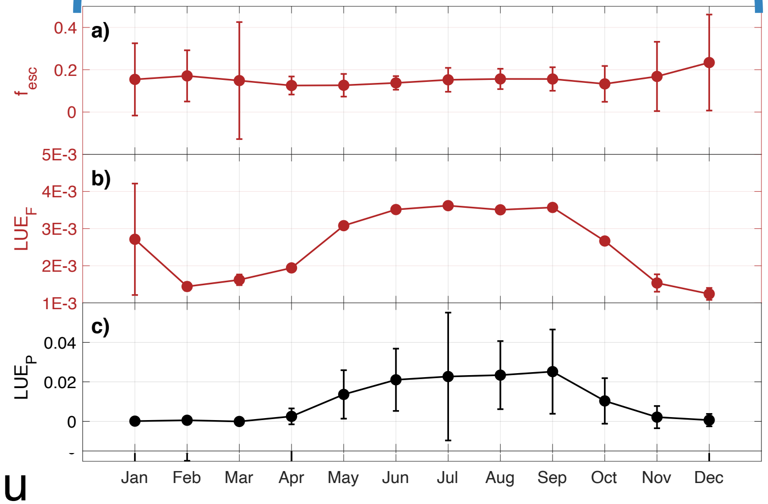
Snow needs to be considered!

2. How do the dynamics of LUE_P, LUE_F, and f_{esc} impact the relationship between SIF and GPP at varying temporal scales?



Diurnal nonlinearity due to light saturation of GPP/LUE_P

Co-variation between LUE_F and LUE_P drives seasonal convergence



A seasonally variable SIF-GPP relationship will help account for additional nuances to the SIF-GPP relationship

Questions?

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