Carbon flux drivers in the Arctic Critical Zone: a study-case in Spitzbergen, Norway

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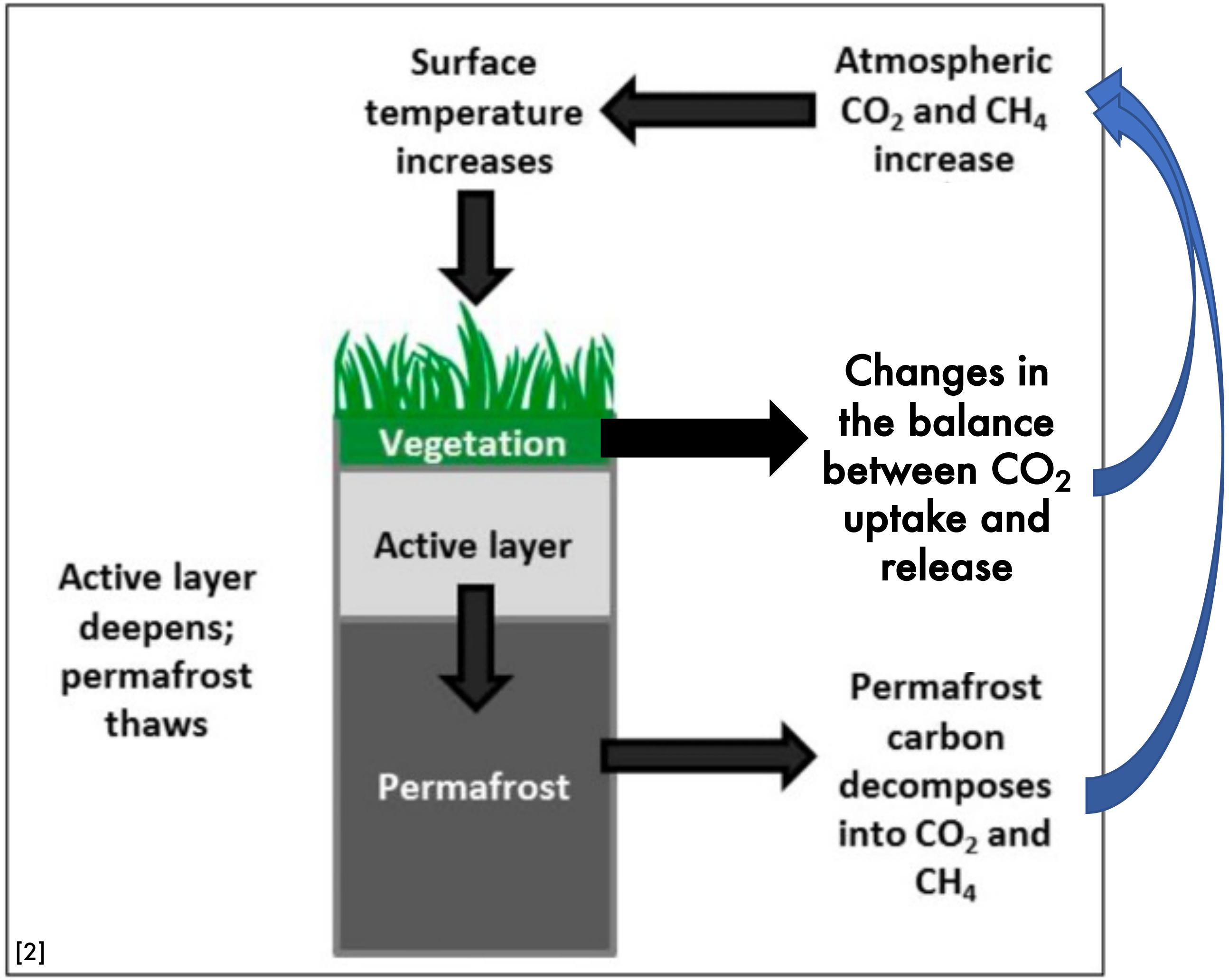
Climate change in the high Arctic is affecting the tundra[3]



The Arctic tundra carbon balance

Higher temperature → higher CO_2 uptake by photosynthesis

Higher temperature → higher CO_2 release by respiration

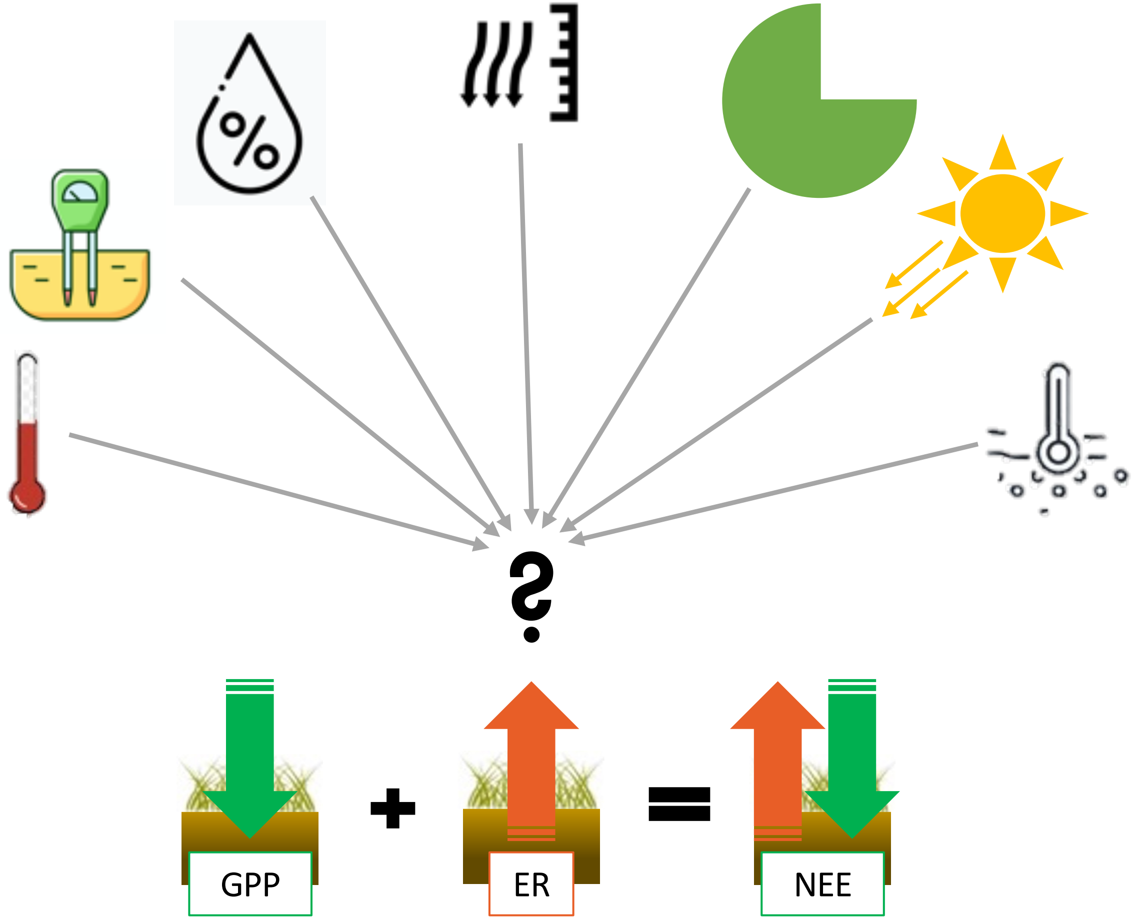
Current annual balance ~ zero[1]

WHAT WILL HAPPEN IN THE FUTURE?

[1] Schuur et Al., 2015; [2] Kessler et Al., 2015; [3] IPCC, 2019

Biological carbon balance in the Arctic tundra

1. Large uncertainties
2. High interannual variability may mask the true long-term behaviour

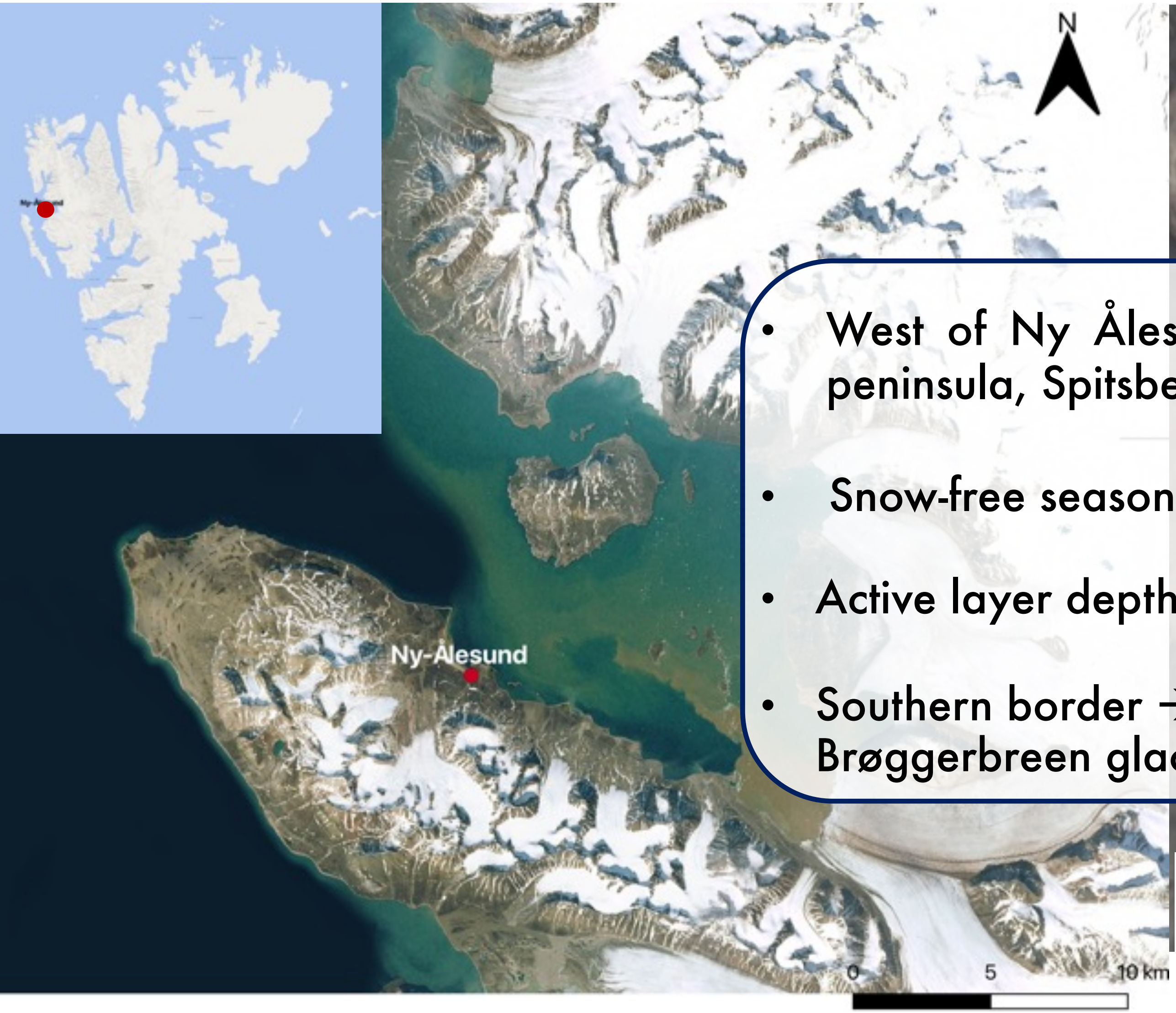


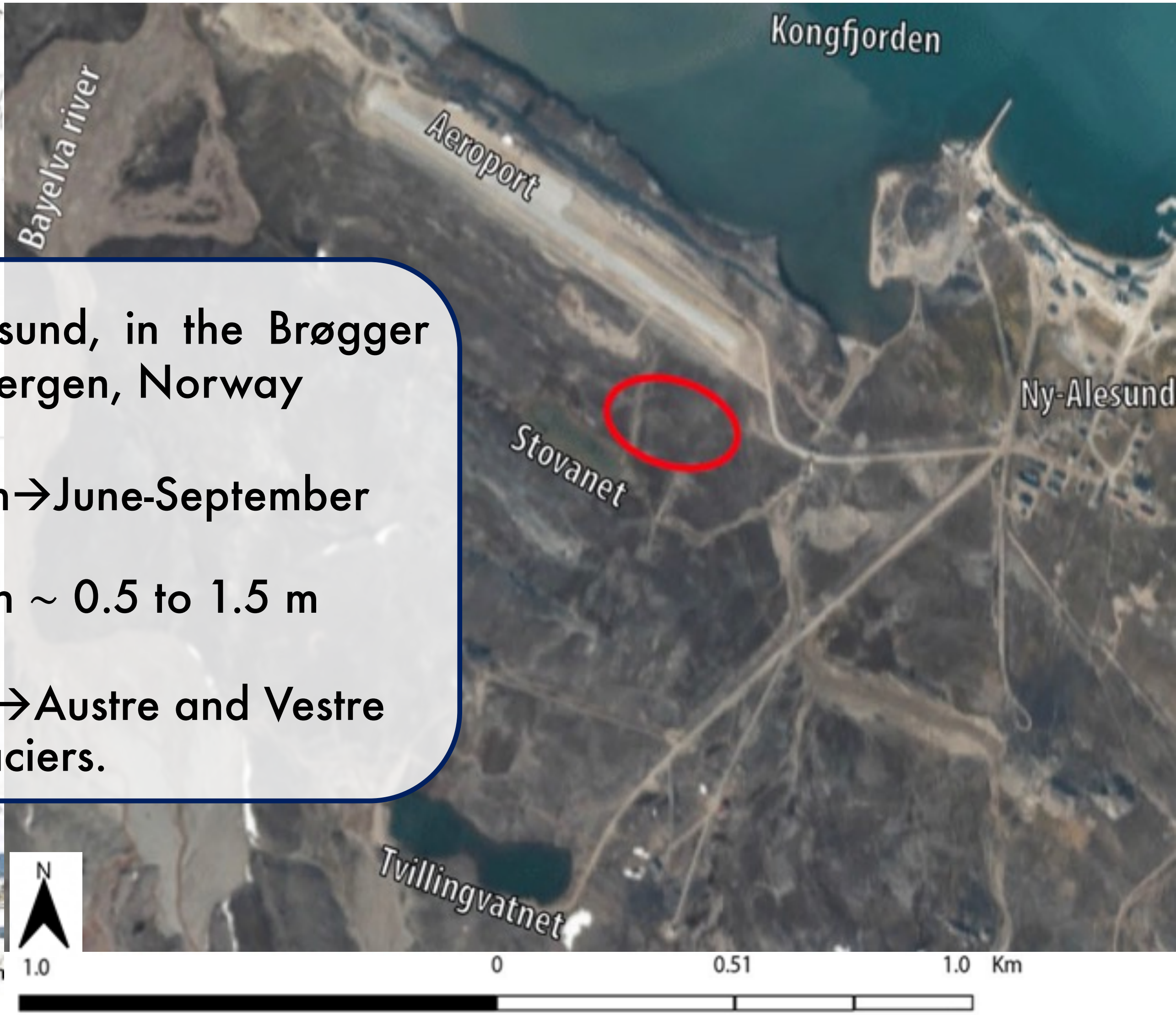
Identification of the Arctic carbon flux drivers

- Reduce current uncertainties in carbon balance
- Support prediction of climate change effects

[1] Magnani et Al., 2022

Bayelva Basin Ny Ålesund, Svalbard





- West of Ny Ålesund, in the Brøgger peninsula, Spitsbergen, Norway
- Snow-free season→June-September
- Active layer depth ~ 0.5 to 1.5 m
- Southern border →Austre and Vestre Brøggerbreen glaciers.

July 2019 (Magnani et al. 2022)

Measured and derived variables for each sample point

Portable transparent/shaded accumulation chamber
+ IRGA

NEE
Net Ecosystem Exchange

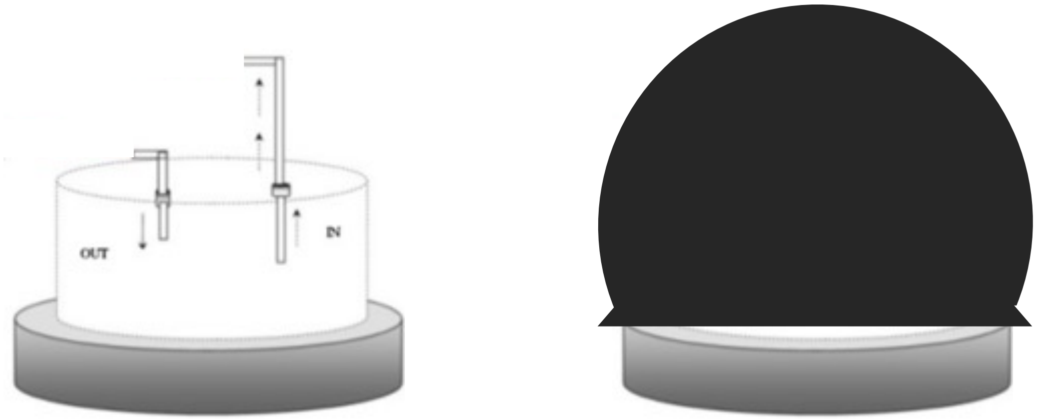
ER
Ecosystem Respiration

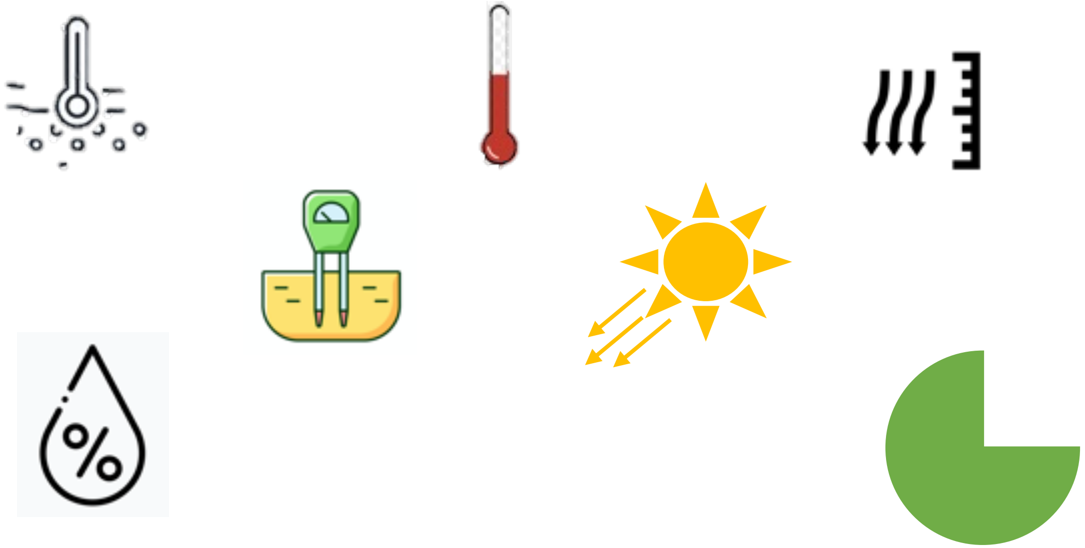
GPP=Gross Primary Production = NEE - ER

- Soil Temperature
- Soil Water Content
- Air Temperature
- Atm. Pressure
- Solar Irradiance
- Air Relative Humidity

} Field sensors

- Vegetation cover category
- Green Fractional Cover[2] → RGB pictures





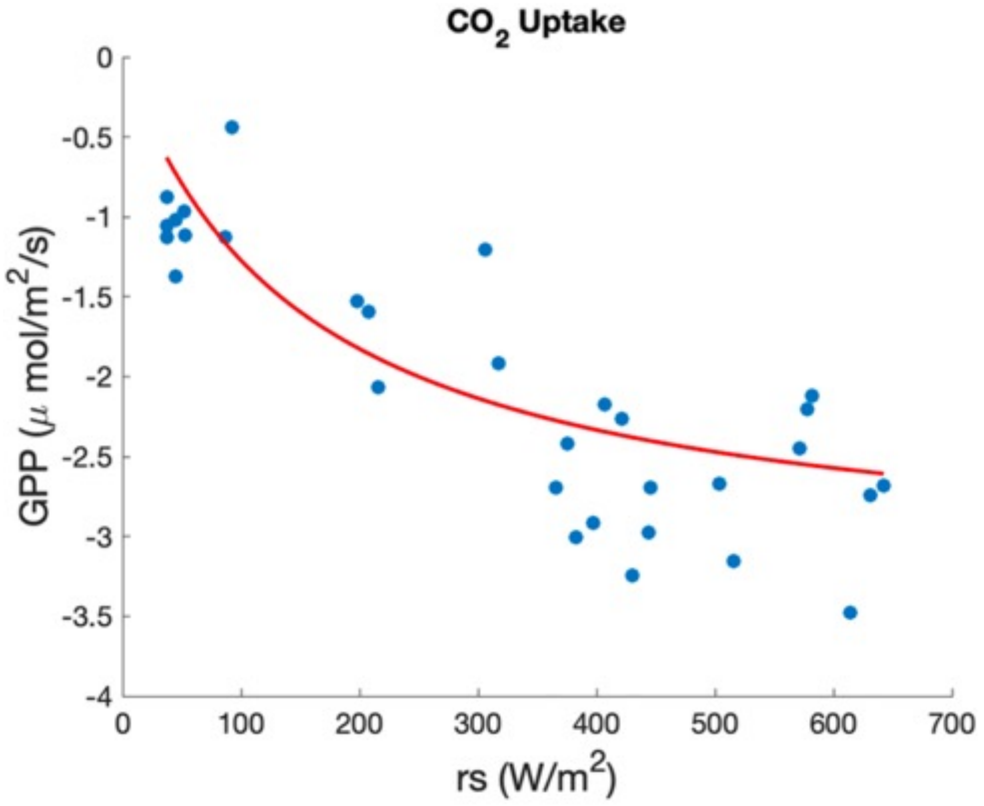
[1] Magnani et Al., 2022; [2] Liu & Pattey, 2010

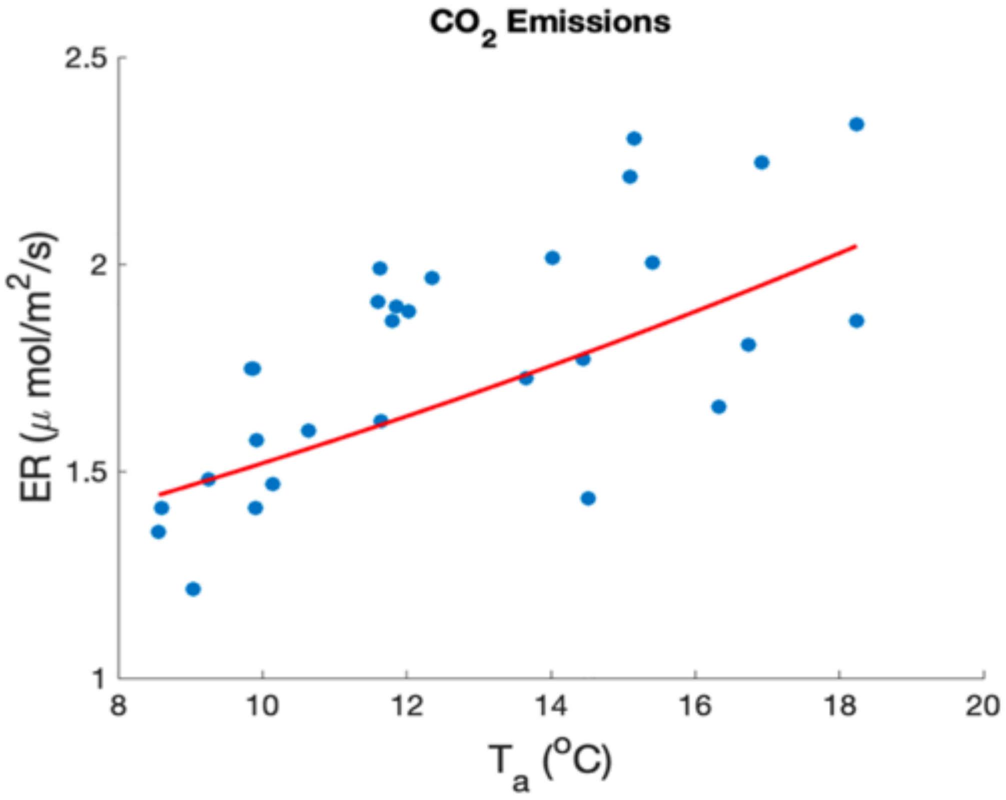
Temporal variability → point-scale measurements[1]

24h samplings

$$GPP = \frac{F_{max}\alpha\mathbf{rs}}{F_{max}+\alpha\mathbf{rs}} + \varepsilon^{[2]}$$

$$ER = \mathbf{a}\exp(b_0 T_a) + \varepsilon^{[3]}$$





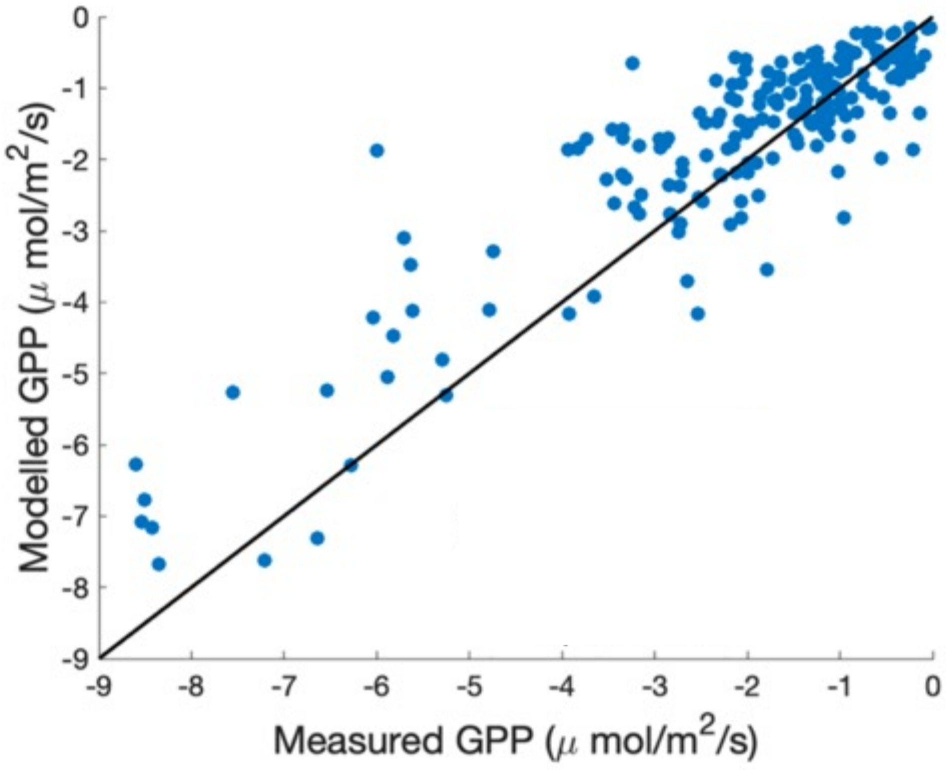
[1] Magnani et Al., 2022; [2] Ruimy et Al., 1995; [3] Lloyd & Tylor, 1994

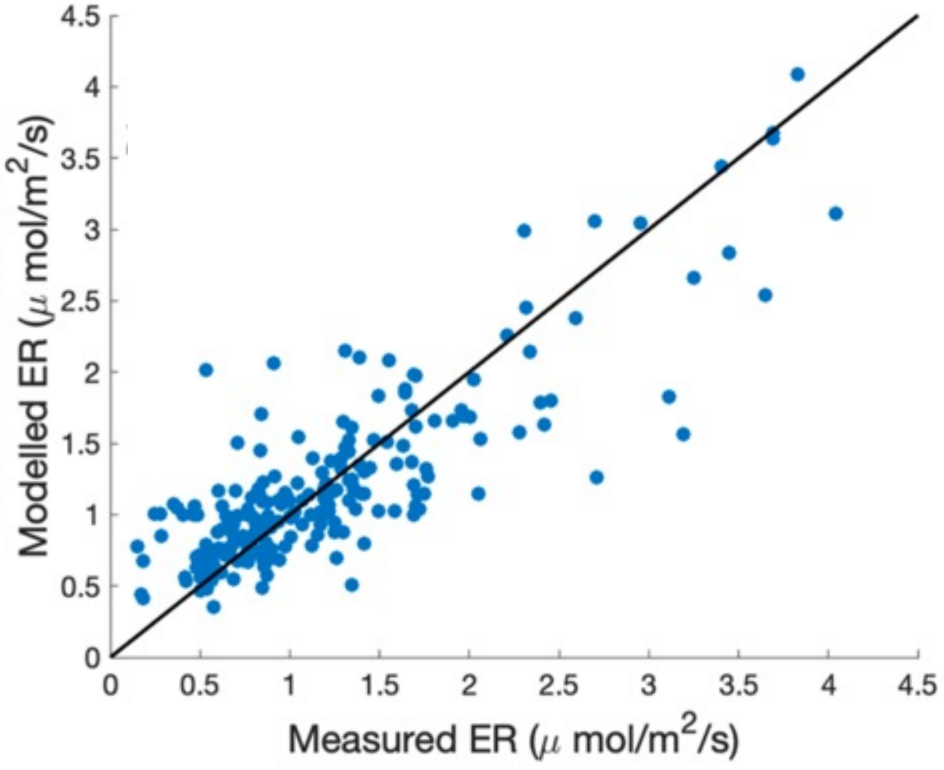
Spatial-temporal variability → site-scale measurements[1]

Random samplings at site scale

$$GPP = \frac{F_{max}\alpha \mathbf{rs}}{F_{max}+\alpha \mathbf{rs}}(A_0 + A_1 GFC + A_2 VWC) + \varepsilon^{[1]}$$

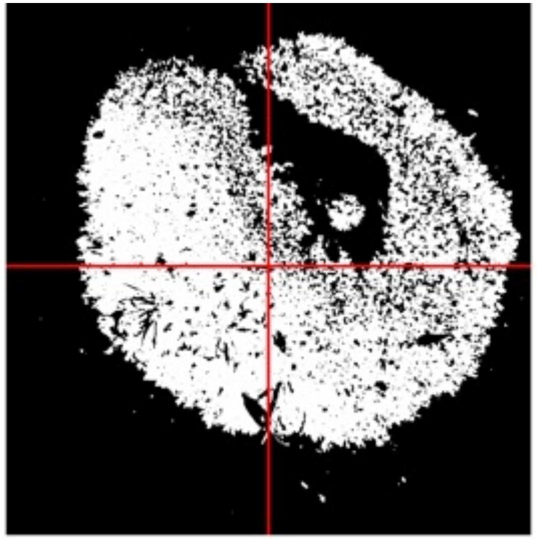
$$ER = (a_0 + a_1 GFC + a_2 VWC)\exp(b_0 T_a) + \varepsilon^{[1]}$$



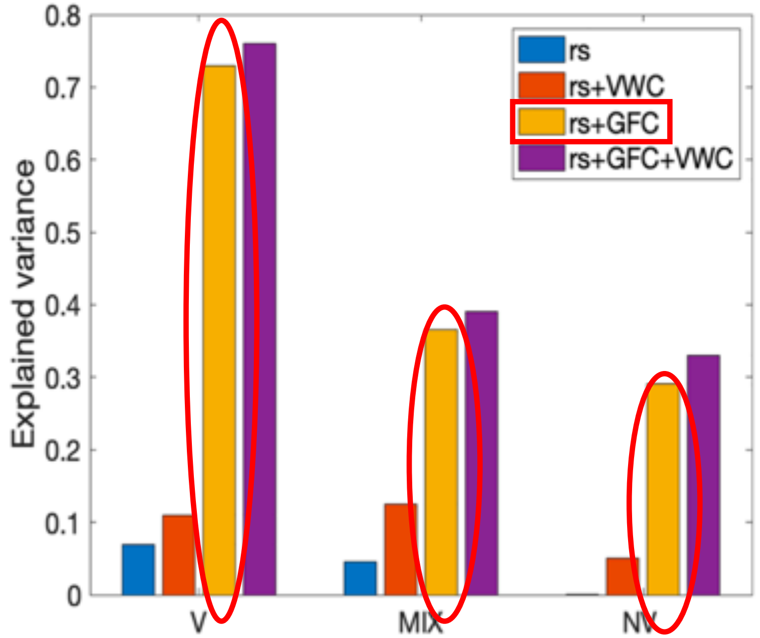


[1] Magnani *et Al.*, 2022. Microscale drivers of summer CO_2 fluxes in the Svalbard High Arctic tundra. *Sci Rep*

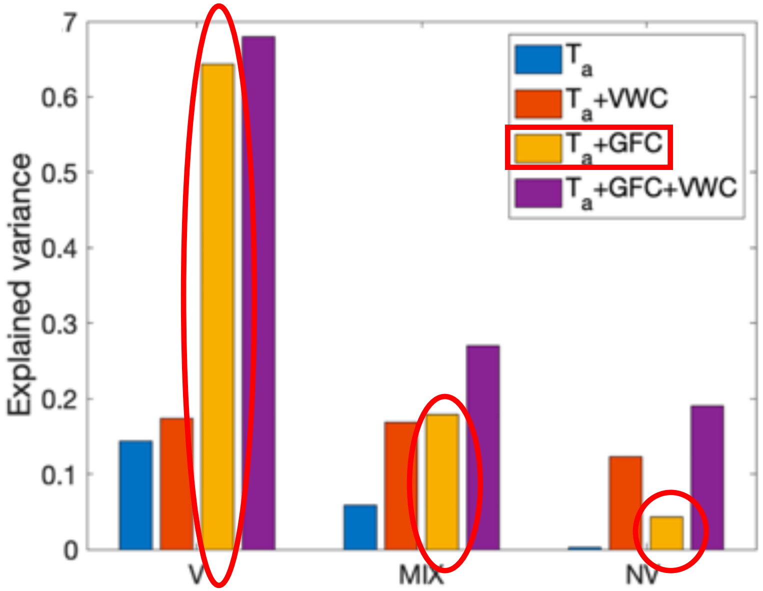
The role of the green fractional cover



$$GPP = \frac{F_{max}\alpha rs}{F_{max}+\alpha rs}(A_0 + A_1 GFC + A_2 VWC) + \varepsilon^{[1]}$$



$$ER = (a_0 + a_1 GFC + a_2 VWC)\exp(b_0 T_a) + \varepsilon^{[1]}$$



[1] Magnani *et Al.*, 2022. Microscale drivers of summer CO_2 fluxes in the Svalbard High Arctic tundra. *Sci Rep*

2021 & 2022 Field campaigns

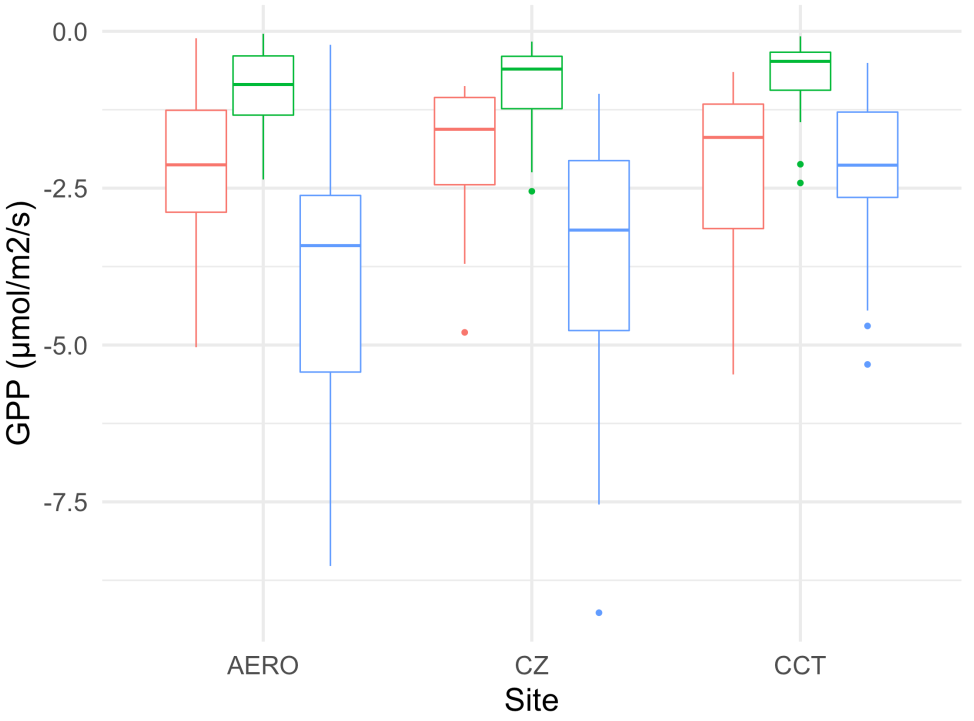
Study Area

- West of Ny Ålesund, in the Brøgger peninsula, Spitsbergen, Norway
- 3 plots (AIRPORT,CCT,CZ)

- NEE
- ER
- Soil Temperature
- Soil Water Content
- Air Temperature
- Atm. Pressure
- Air relative humidity
- Solar Irradiance
- Vegetation cover category
- Green Fractional Cover

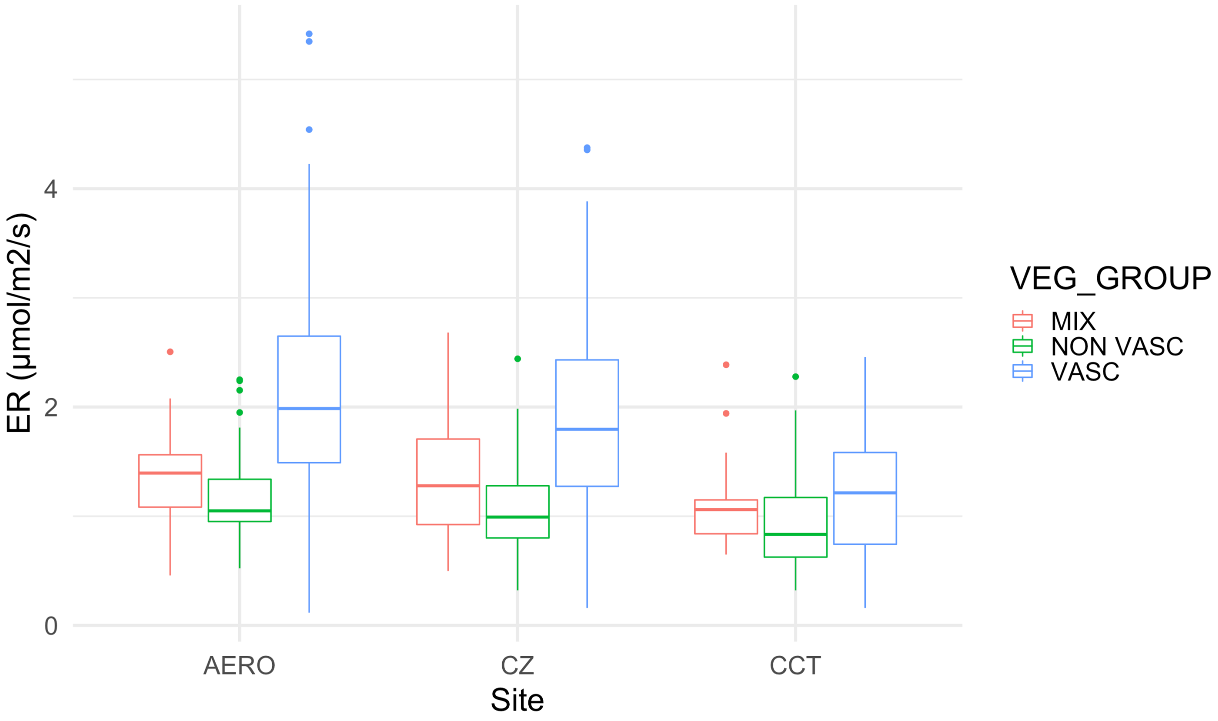
2022

GPP



n	Mean	SD	Median	Min	Max	SE
322	-2.1854	1.8965	-1.5413	-9.2666	-0.0404	0.1057

ER



n	Mean	SD	Median	Min	Max	SE
324	1.4773	0.8505	1.2637	0.1162	5.4183	0.0472

The analysis is ongoing – for now, a few hints on the behavior of the non-vascular component

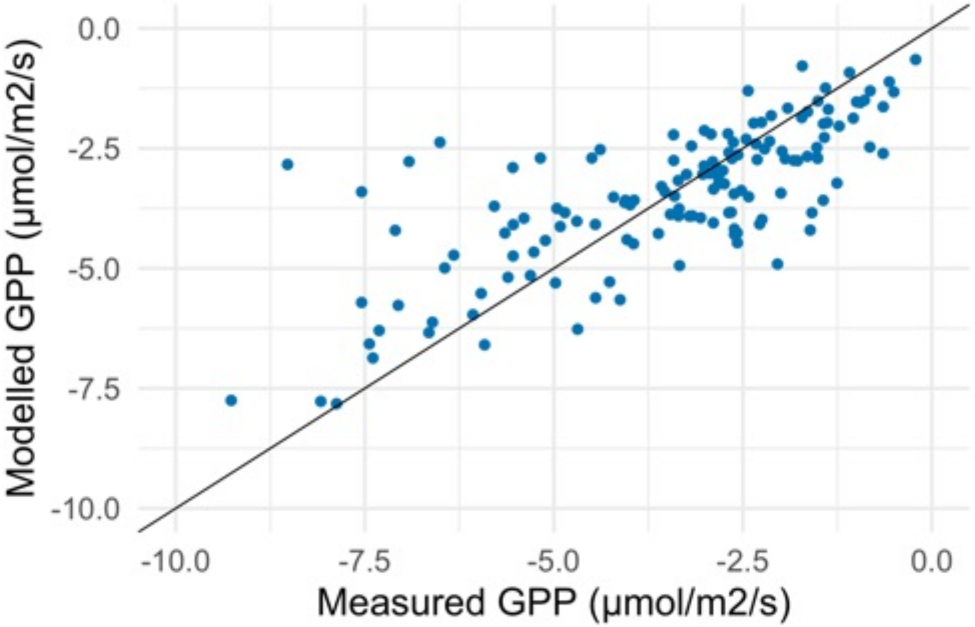
Gross Primary Production

$$GPP = \frac{F_{max}\alpha \mathrm{rs}}{F_{max} + \alpha \mathrm{rs}}(1 + A_1 GFC + A_2 VWC) + \varepsilon$$

Vascular

Parameters:

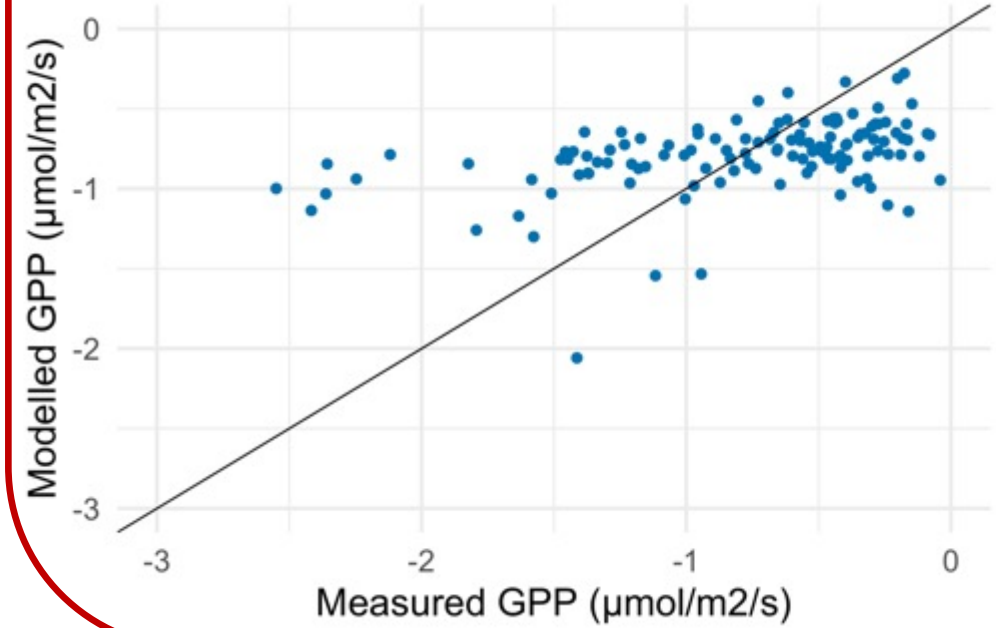
	Estimate	Std. Error	t value	Pr(>|t|)	
a	-4.9591768	1.6271959	-3.048	0.002768	**
b	-0.0081528	0.0023556	-3.461	0.000718	***
A1	4.4738890	1.3831109	3.235	0.001527	**
A2	-0.0003765	0.0071122	-0.053	0.957862	

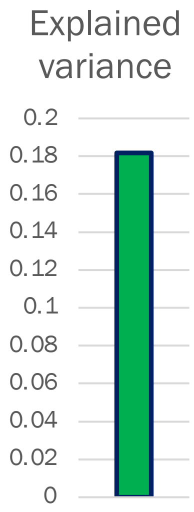


Non-Vascular

Parameters:

	Estimate	Std. Error	t value	Pr(>|t|)	
a	-0.476555	0.225517	-2.113	0.0367	*
b	-0.004279	0.002839	-1.507	0.1344	
A1	7.108185	4.178395	1.701	0.0915	.
A2	0.028797	0.028636	1.006	0.3166	

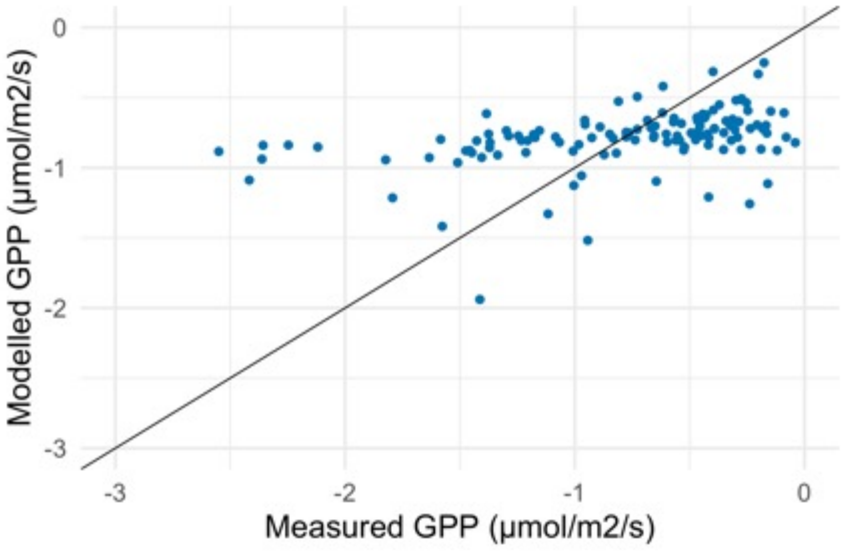


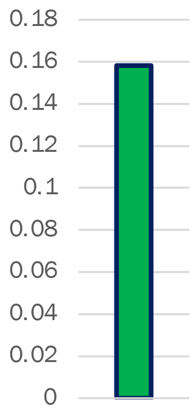


Gross Primary Production
Non-Vascular

$$GPP = \frac{F_{max}\alpha rs}{F_{max} + \alpha rs}(1 + A_1 GFC) + \varepsilon$$

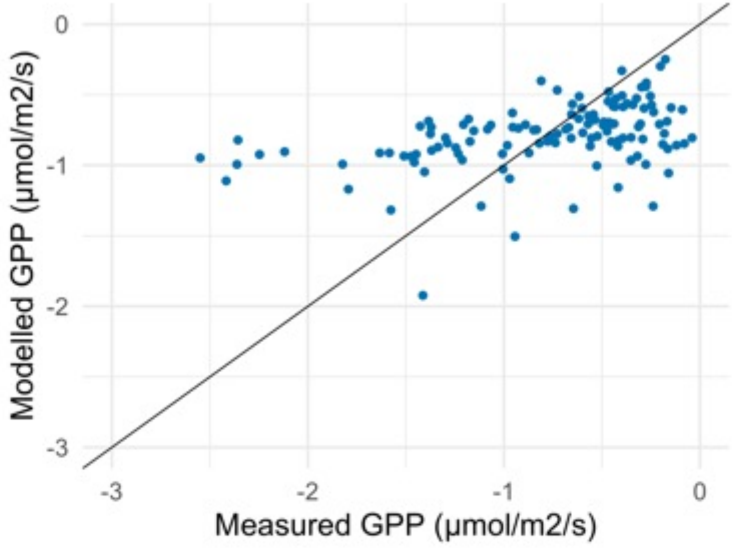
```
Parameters:
    Estimate Std. Error t value Pr(>|t|)
a   -0.844035   0.126824  -6.655 8.73e-10 ***
b   -0.008404   0.003849  -2.183  0.03096 *
A1   3.980858   1.312641   3.033  0.00297 **
```

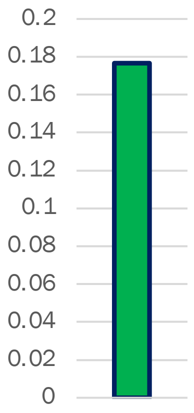




$$GPP = \frac{F_{max}\alpha rs}{F_{max} + \alpha rs}(1 + A_1 GFC + A_2 AirRH) + \varepsilon$$

```
Parameters:
    Estimate Std. Error t value Pr(>|t|)
a   -1.244900   0.249299  -4.994 2.03e-06 ***
b   -0.042529   0.070129  -0.606  0.54537
A1   2.371869   0.906523   2.616  0.01003 *
A2  -0.008086   0.002758  -2.932  0.00404 **
```

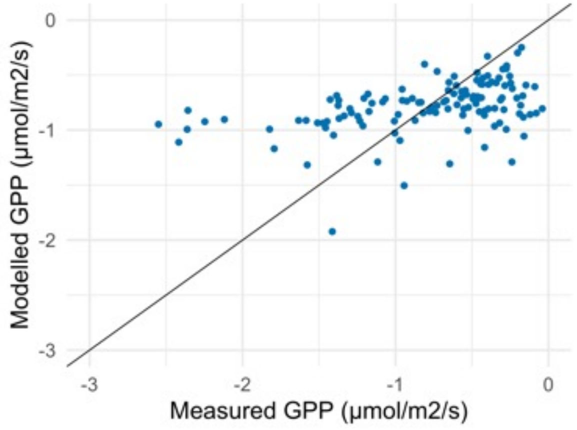




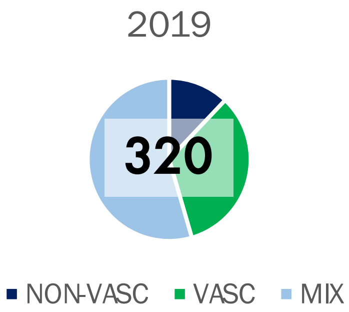
Future steps

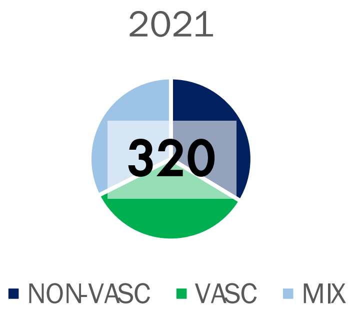
Understand the drivers of the non-vascular component

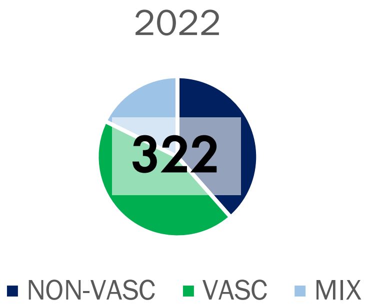
Suggestions welcome!

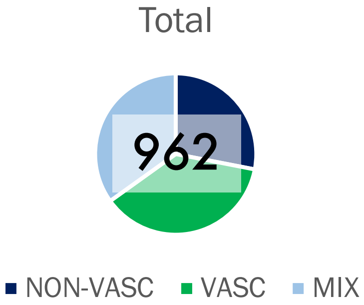


Study inter-annual variability









Thank you for your attention

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