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

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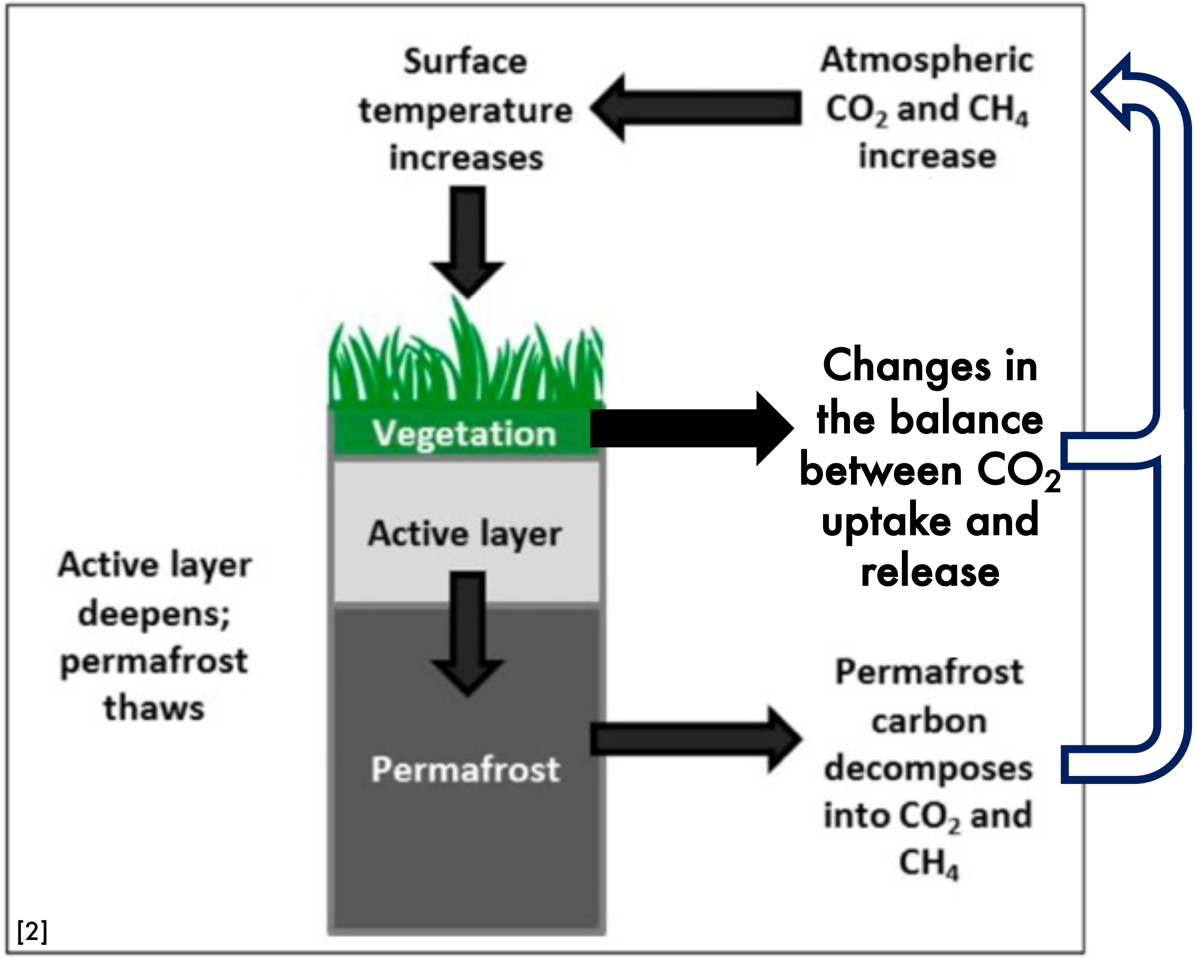
Climate change in the high Arctic is affecting the tundra[3]



The Arctic tundra carbon balance

Changes in the tundra→ 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?

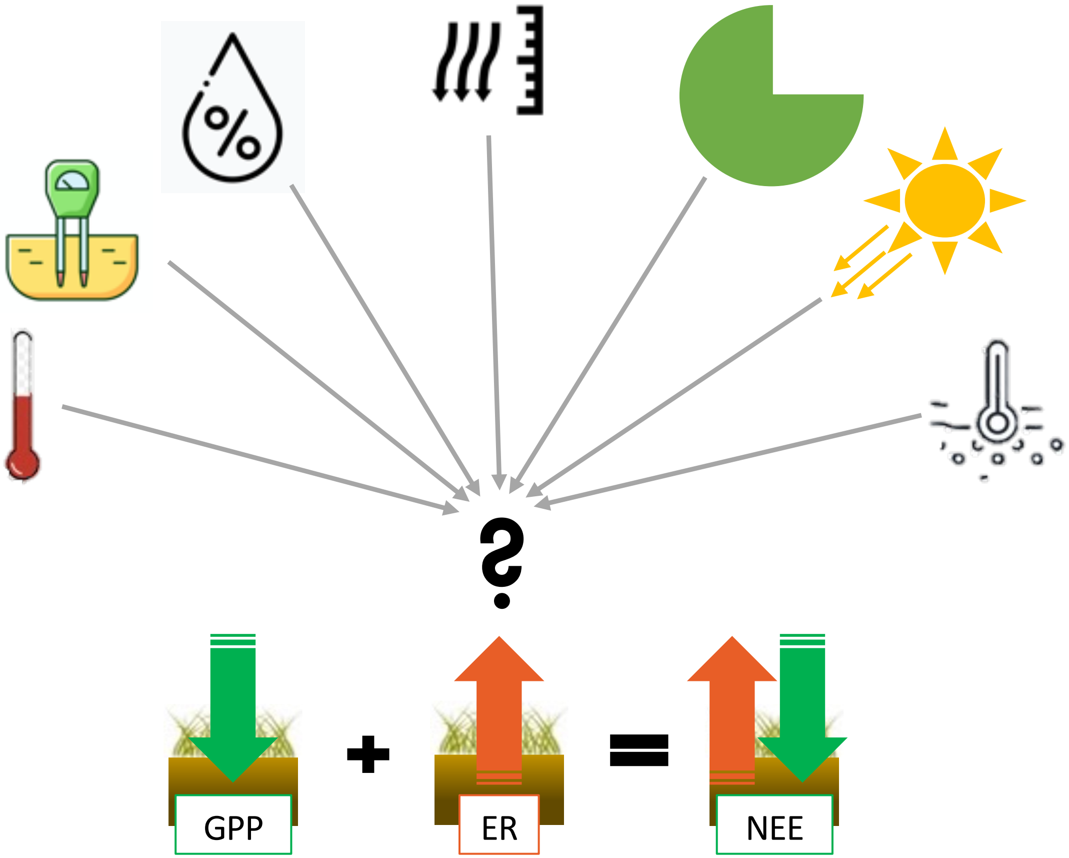
[1] Schuur et Al., 2015; [2] Kessler et Al., 2015; [3] IPCC, 2019

Biological carbon balance in the Arctic tundra

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

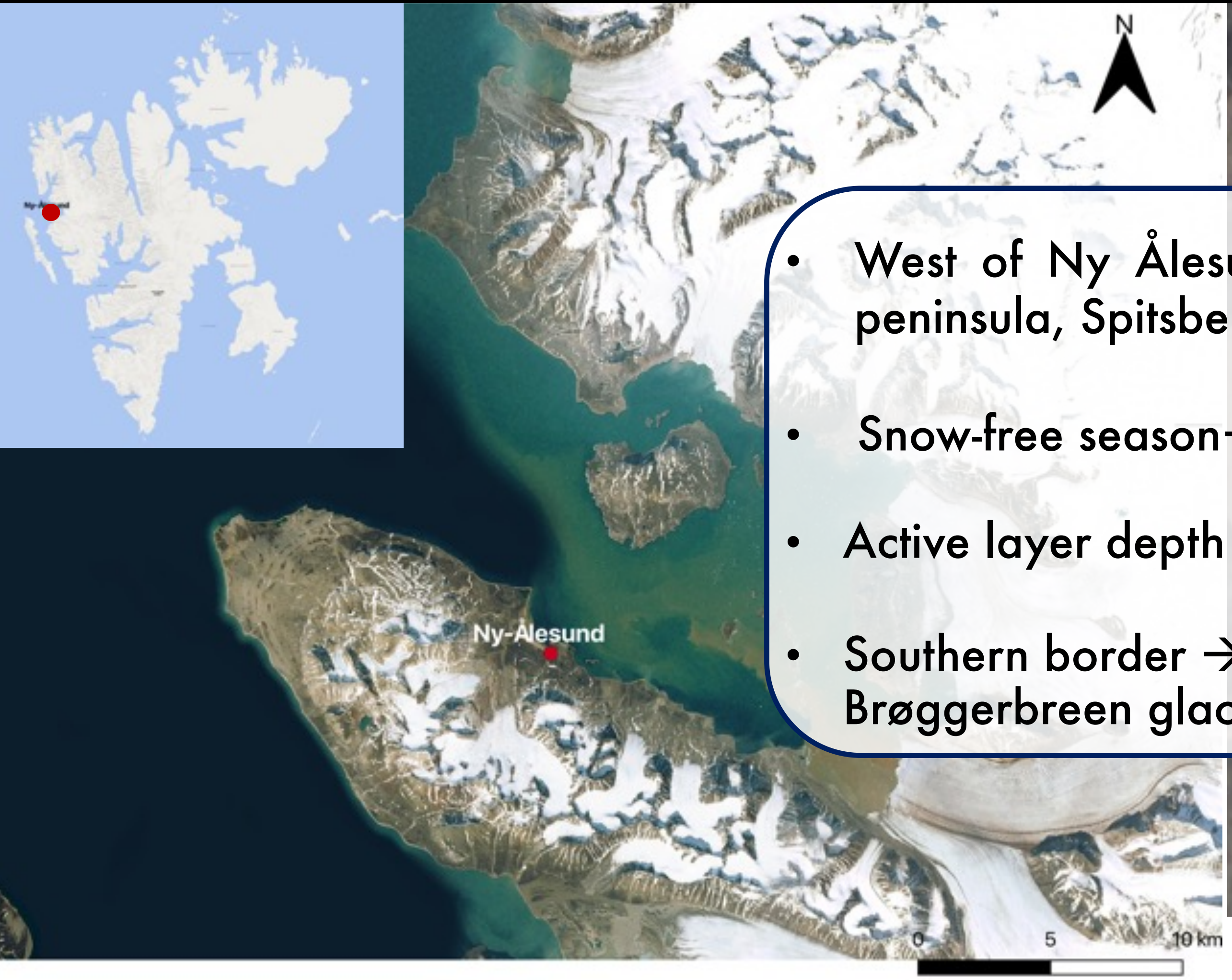
Identification of the Arctic carbon flux drivers

- 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

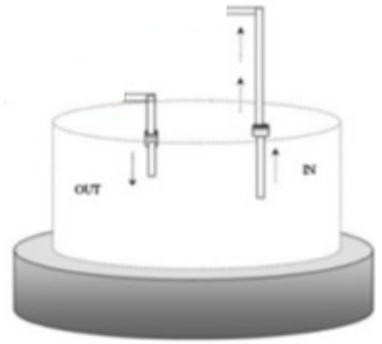
Portable transparent/shaded accumulation chamber + IRGA

NEE	ER
Net Ecosystem Exchange	Ecosystem Respiration

GPP=Gross Primary Production = NEE - ER

- Soil Temperature
- Soil Water Content
- Air Temperature
- Atm. Pressure
- Solar Irradiance
- Air Relative Humidity
- Vegetation cover category
- Green Fractional Cover[2] → RGB pictures

(Soil Temperature to Air Relative Humidity: Field sensors)



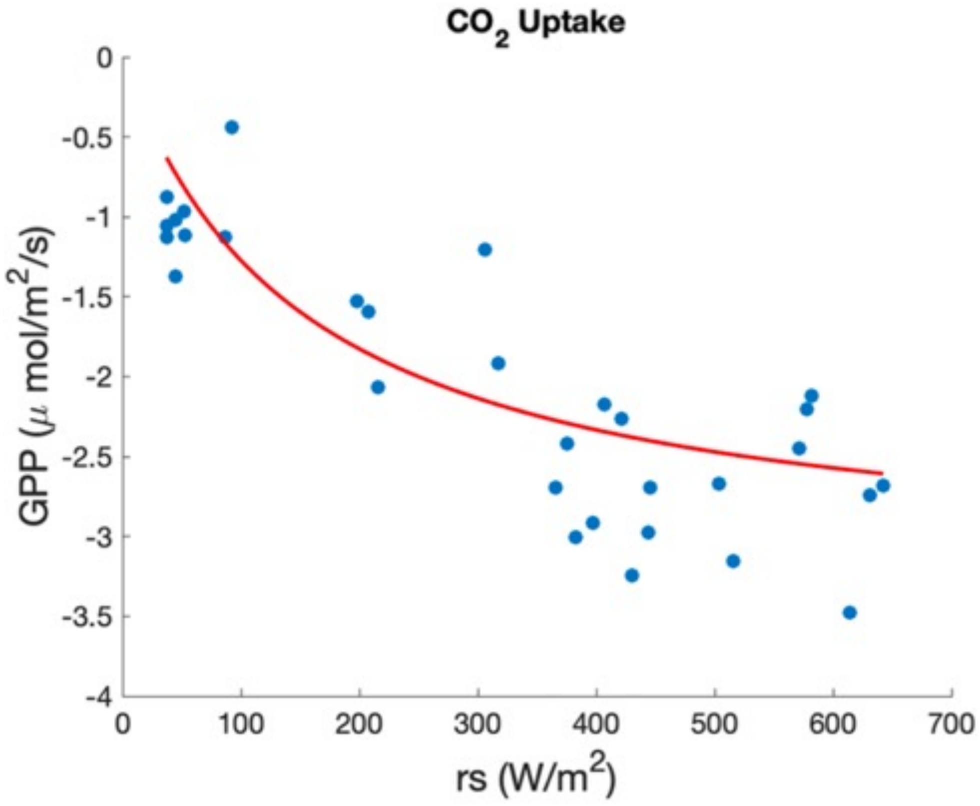
[1] Magnani et Al., 2022; [2] Liu & Pattey, 2010

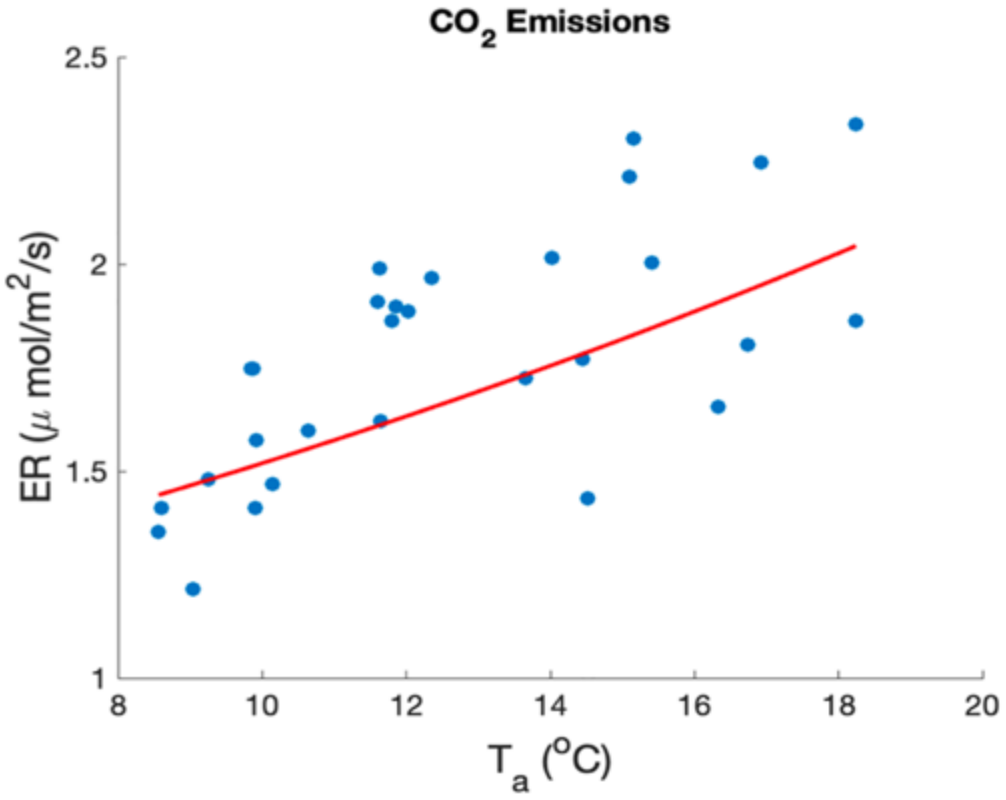
Temporal variability → point-scale measurements[1]

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

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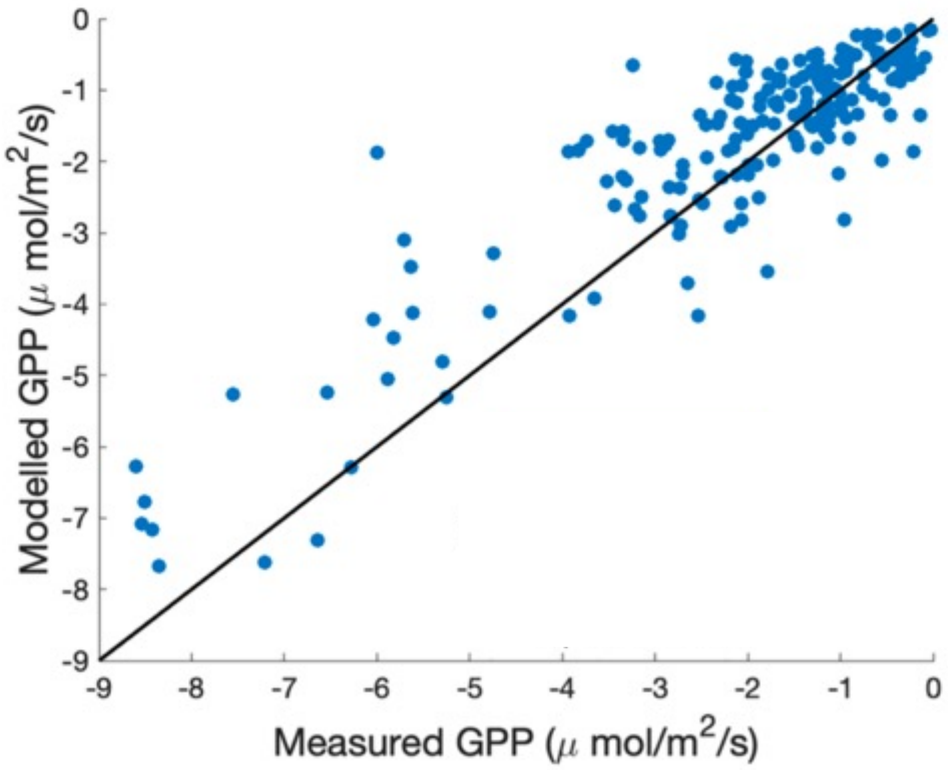
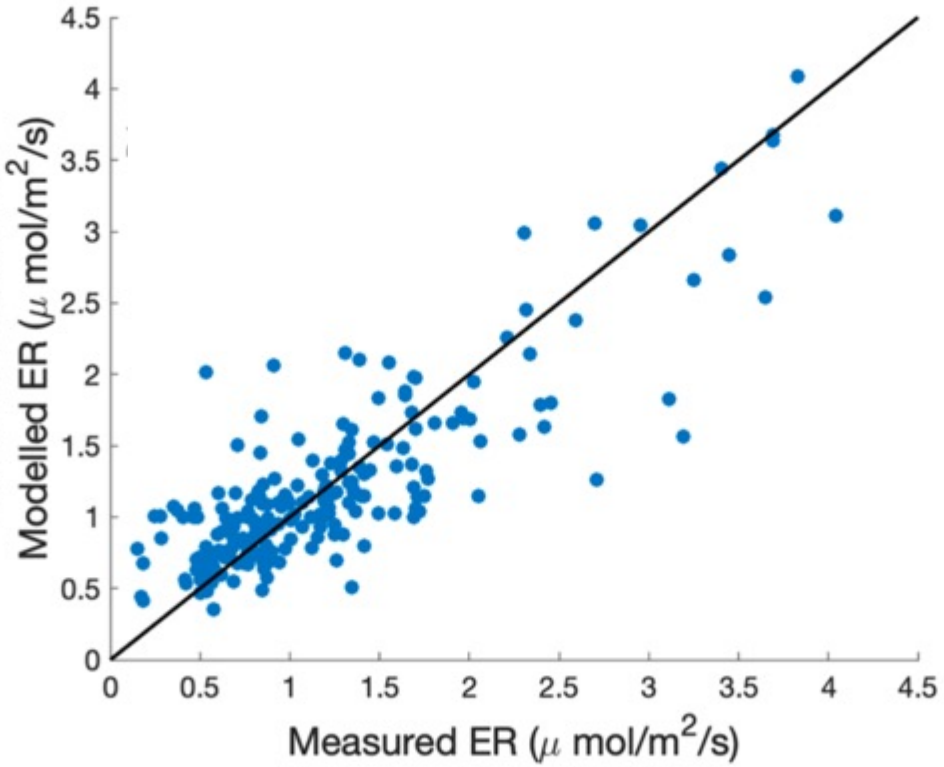
Spatial-temporal variability → site-scale measurements[1]

Random samplings at site scale

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

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

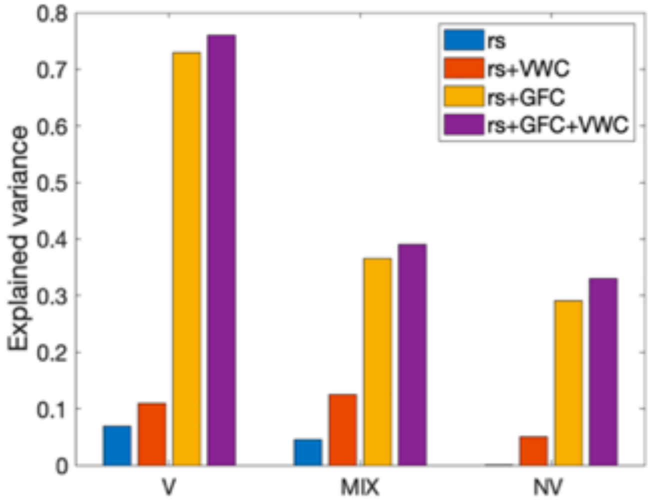


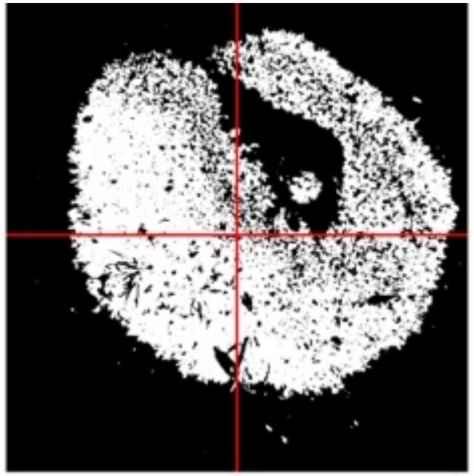


[1] Magnani *et Al.*, 2022. Microscale drivers of summer CO_2 fluxes in the Svalbard High Arctic tundra. *Sci Rep*

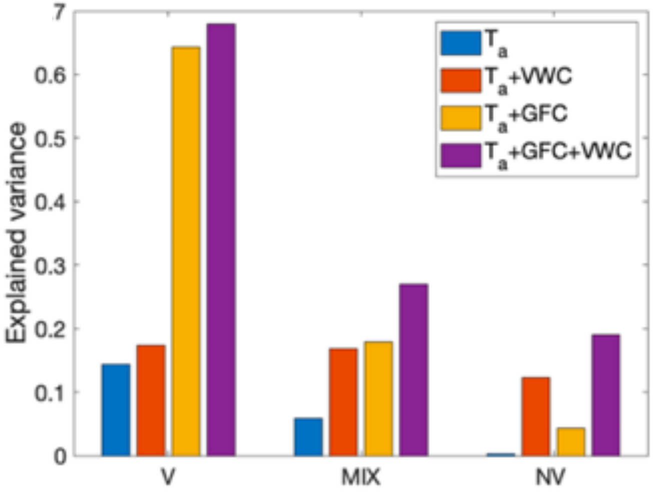
The role of the green fractional cover

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



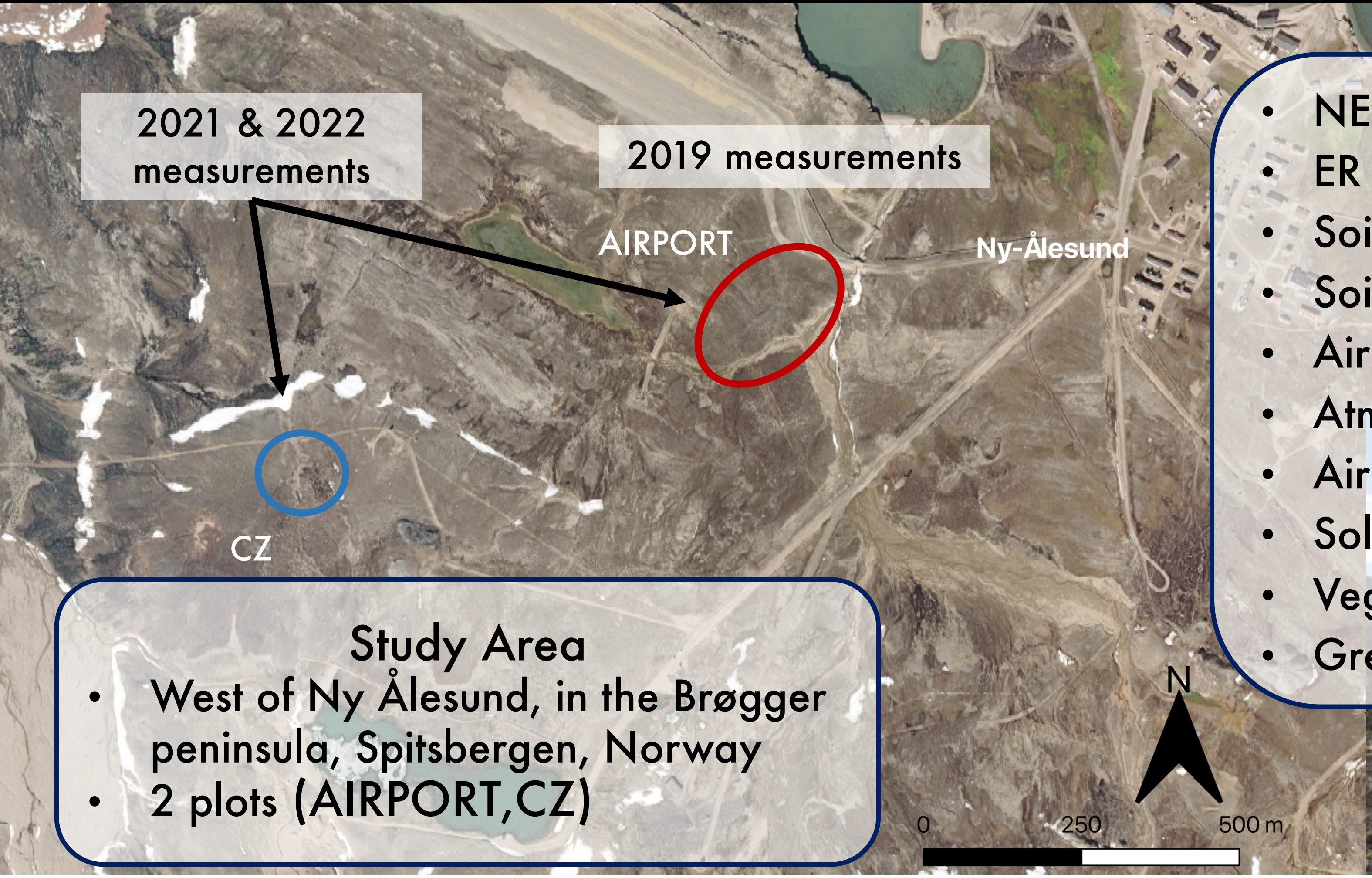


$$ER = (a_0 + a_1 GFC + a_2 VWC)\exp(b_0 T_a) + \varepsilon^{[1]}$$



[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
- 2 plots (AIRPORT,CZ)

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

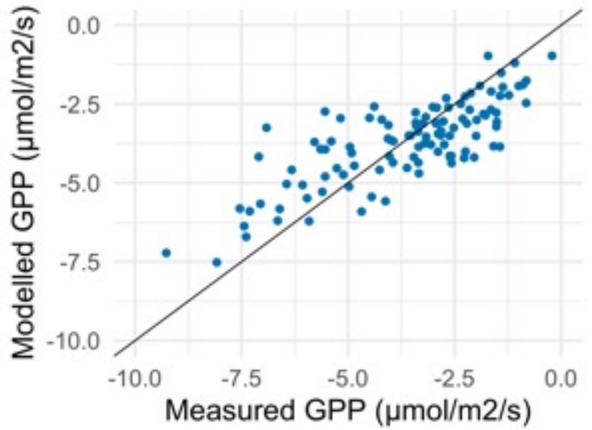
2022 GPP & ER modelling

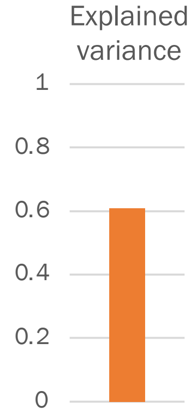
$$GPP = \frac{F_{max}\alpha rs}{F_{max}+\alpha rs}(1 + A_1 GFC + A_2 VWC) + \varepsilon$$ [1]

Vascular vegetation cover class

Parameters:

	Estimate	Std. Error	t value	Pr(>|t|)	
F_max	-4.869292	1.111751	-4.380	2.8e-05	***
α	-0.016773	0.004485	-3.740	0.000299	***
A1	2.876000	0.800996	3.591	0.000502	***
A2	-0.007904	0.003693	-2.140	0.034643	*



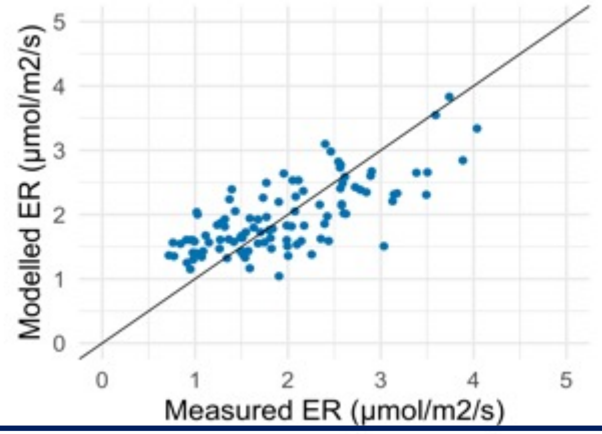


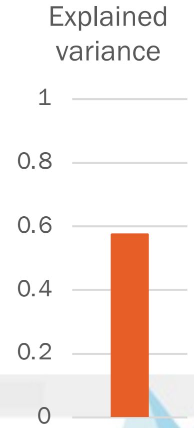
$$ER = (a_0 + a_1 GFC + a_2 VWC)\exp(b_0 T_a) + \varepsilon$$ [1]

Vascular vegetation cover class

Parameters:

	Estimate	Std. Error	t value	Pr(>|t|)	
a0	0.298000	0.140591	2.120	0.0365	*
a1	1.840823	0.323366	5.693	1.26e-07	***
a2	0.012325	0.003750	3.287	0.0014	**
b0	0.043308	0.006741	6.424	4.52e-09	***





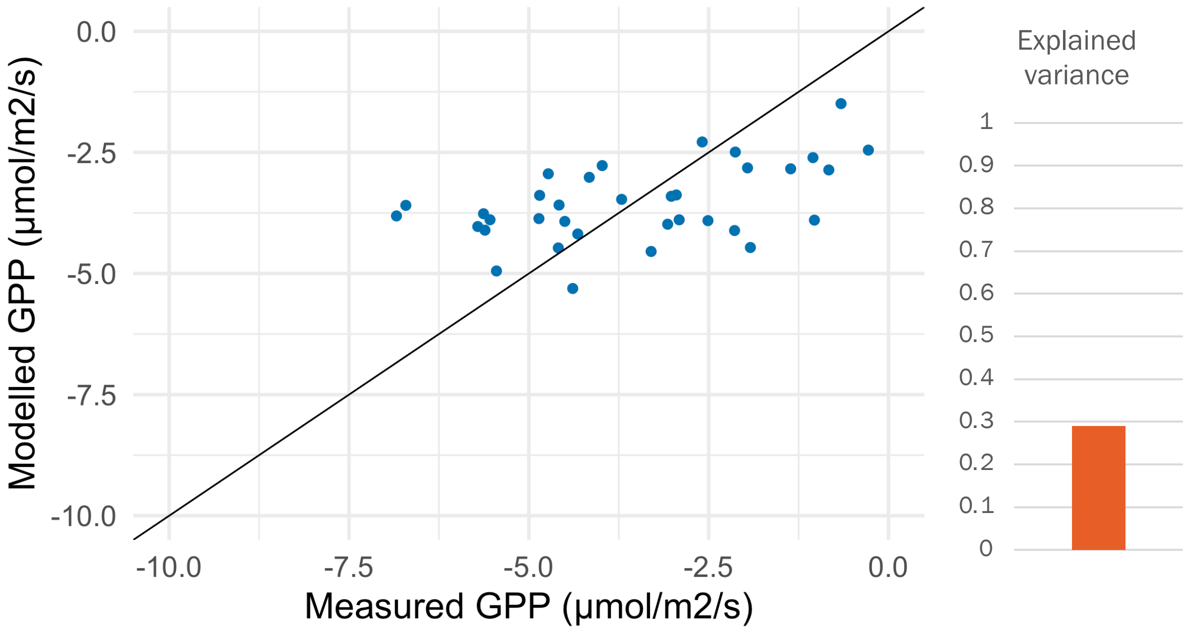
[1] Magnani *et Al.*, 2022

2021 GPP & ER modelling

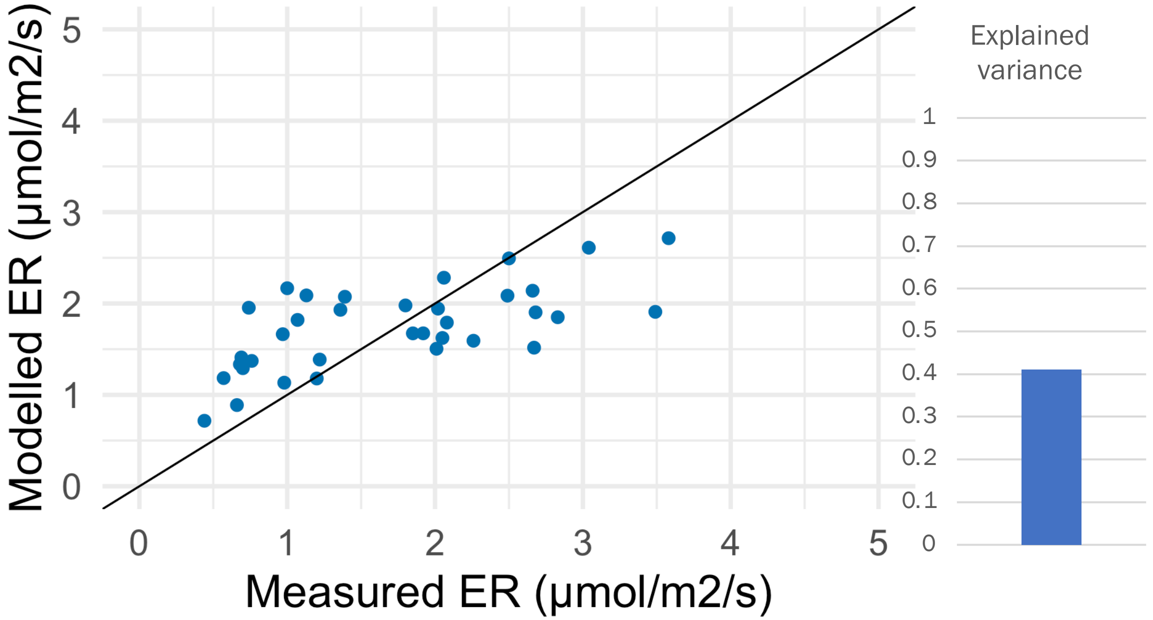
$$GPP = \frac{F_{max}\alpha rs}{F_{max}+\alpha rs}(1 + A_1 GFC + A_2 VWC) + \varepsilon$$ [1]

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

Vascular vegetation cover class



Vascular vegetation cover class



[1] Magnani *et Al.*, 2022

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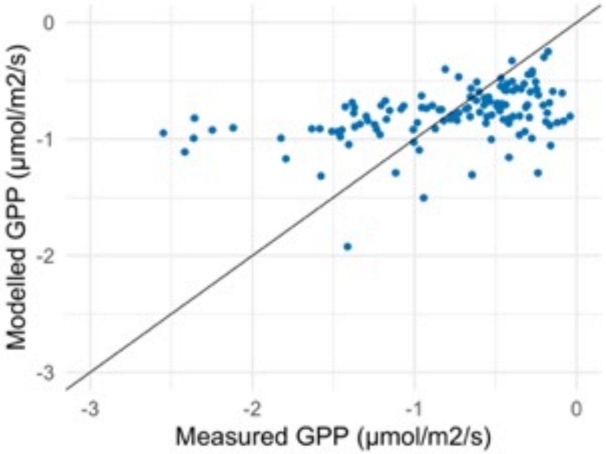
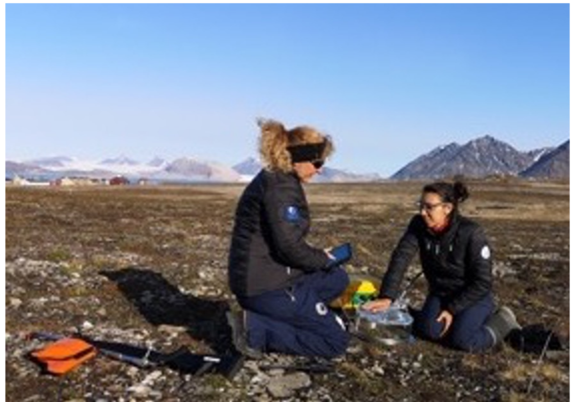
Future steps

1. Understand the drivers characterizing the 2021 variability

2. Understand the drivers of the non-vascular component



3. Study inter-annual variability



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Thank you for your attention

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