Partitioning Net Ecosystem Exchange from peatland vegetation into autotrophic and heterotrophic components

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Peatland CO_2 emissions in the Netherlands

- Netherlands peat meadows subside and emit CO_2
- Estimated at 2-3% of total NL emissions
- The NL Climate Agreement prescribes reduction target of 1 Mt/y in 2030 from peatlands areas.

Research consortium NOBV

→ *How big are emissions really?*

→ *Identify processes*

→ *How effective are measures?*

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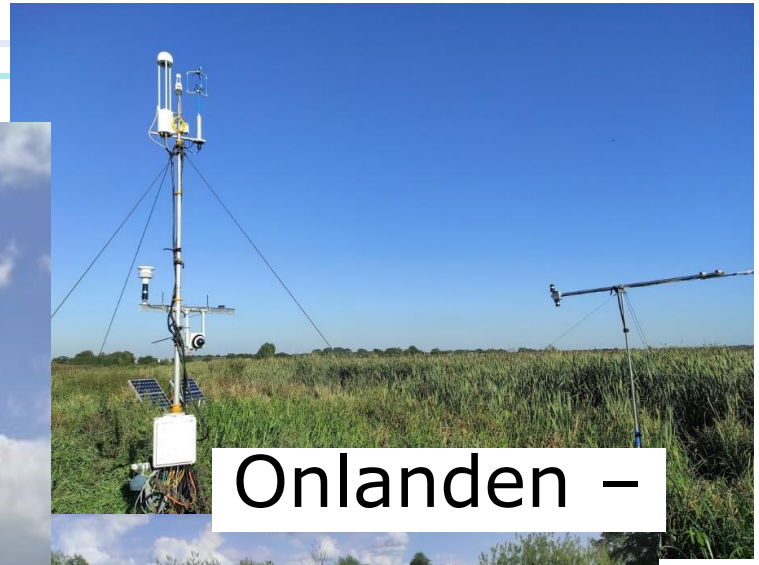
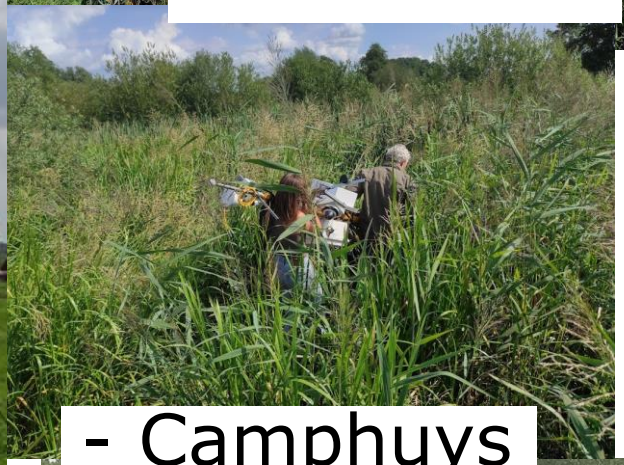
Some of the sites..





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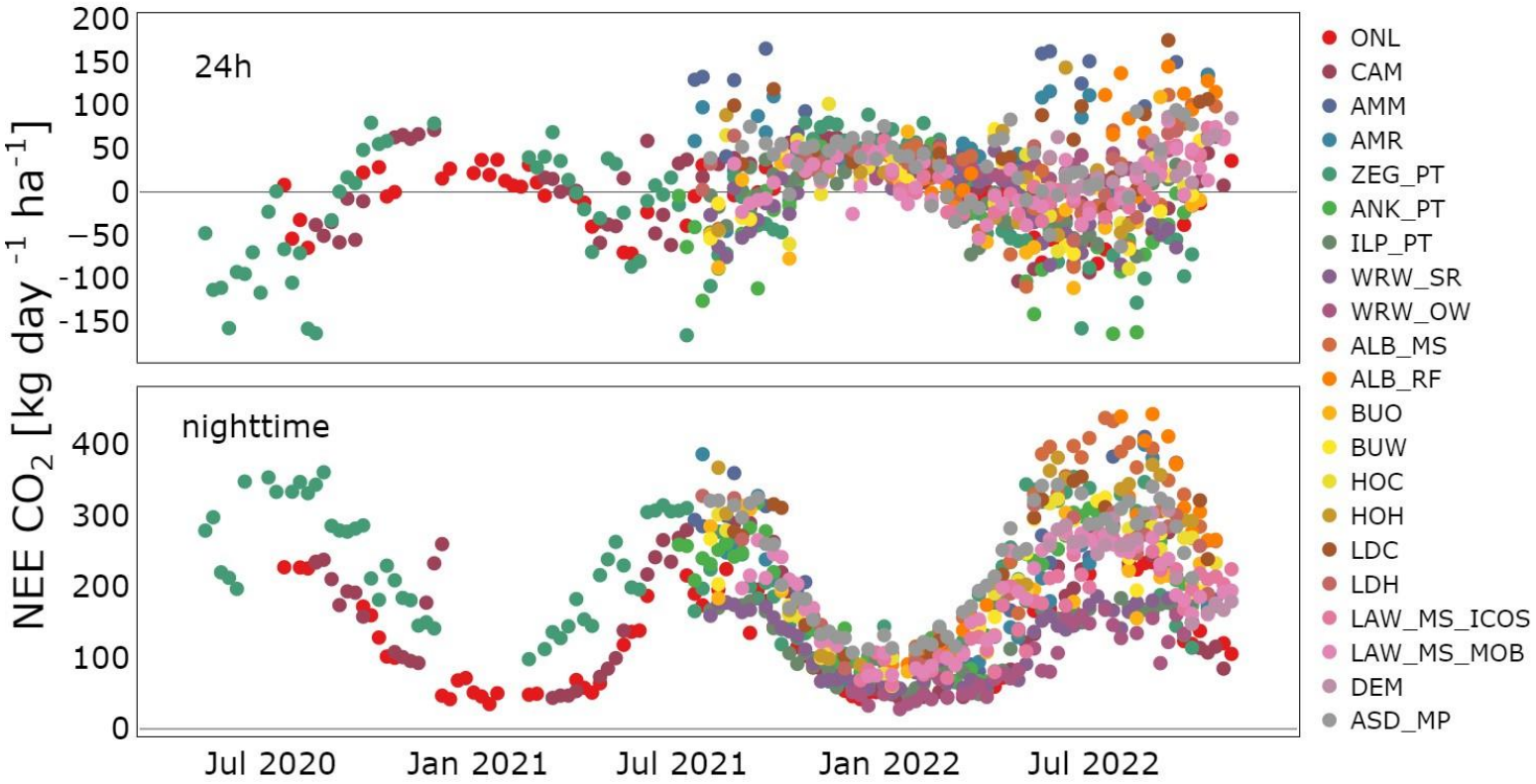
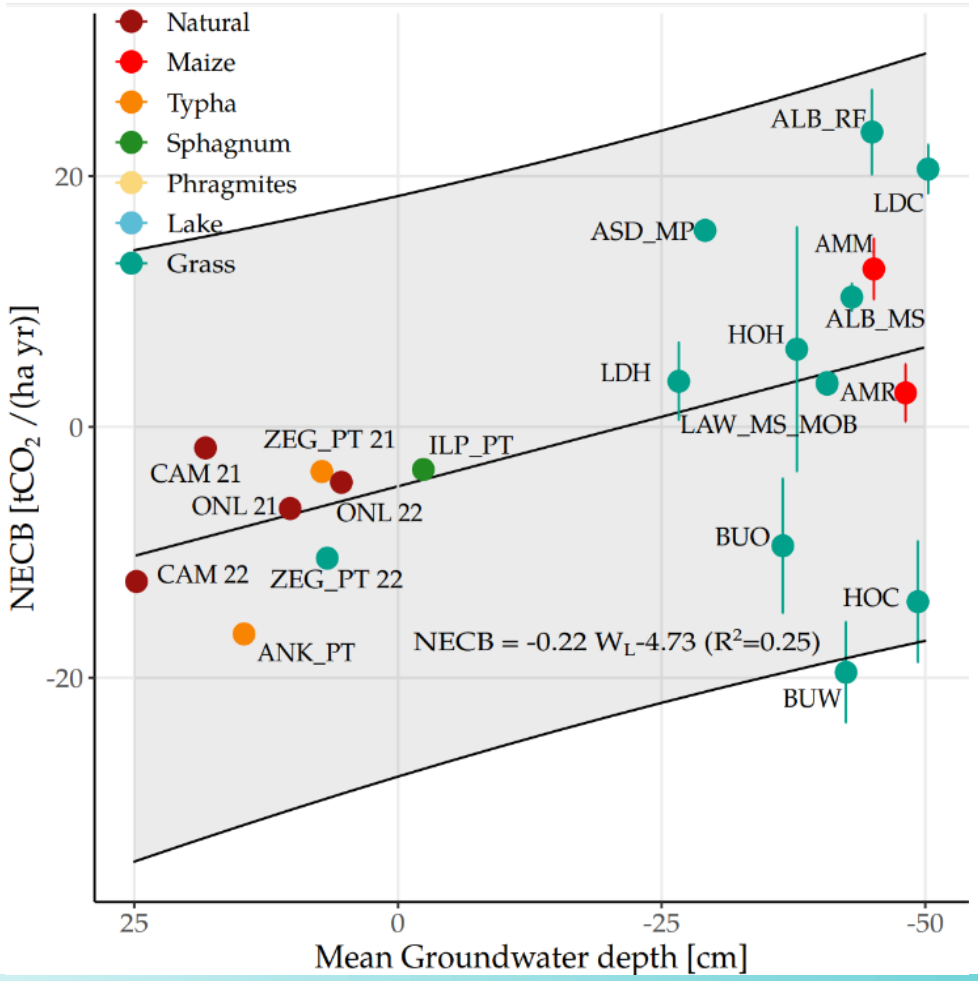
Dataset


24h
nighttime
NEE CO_2 [kg day^{-1} ha^{-1}]
200
150
100
50
0
−50
-100
-150
400
300
200
100
0
Jul 2020
Jan 2021
Jul 2021
Jan 2022
Jul 2022
ONL
CAM
AMM
AMR
ZEG_PT
ANK_PT
ILP_PT
WRW_SR
WRW_OW
ALB_MS
ALB_RF
BUO
BUW
HOC
HOH
LDC
LDH
LAW_MS_ICOS
LAW_MS_MOB
DEM
ASD_MP

Net Ecosystem Carbon Budget (NECB):

'peat oxidation' ≠ Reco

Assuming $NECB_{year}$ represents net peat loss or gain



Bataille et al, report & in prep 2024

How to estimate *sub-annual* peat oxidation and eliminate need for import/export terms?

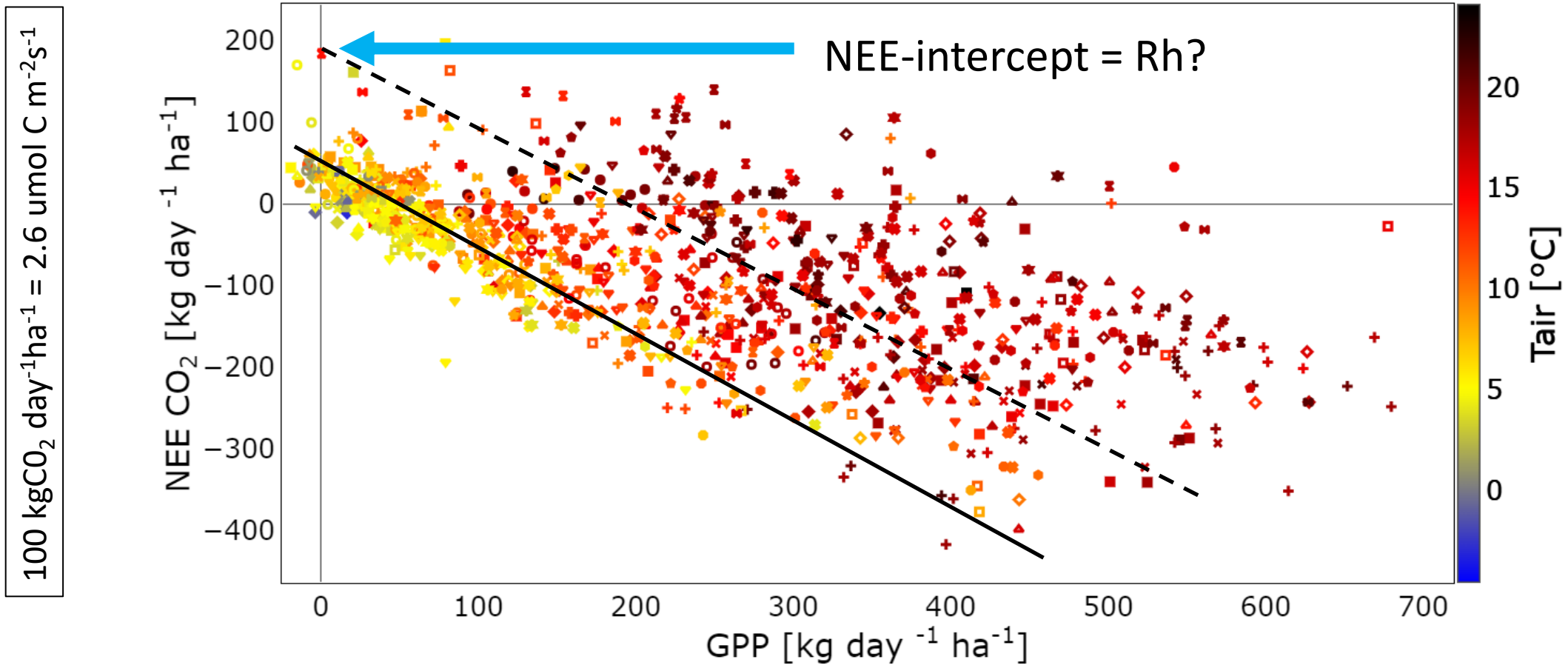
- NEE = -GPP + Re = -GPP + Ra + (Rh+peat oxidation)

- Assume *for grassland/crop*:
  → *if no photosynthesis for longer periods, no biomass, no Ra*
  Then: Ra proportional to GPP and biomass *at multiday- time scale*

- Re= a*GPP + (Rh+peat oxidation)

→ Is respiration really proportional to GPP?

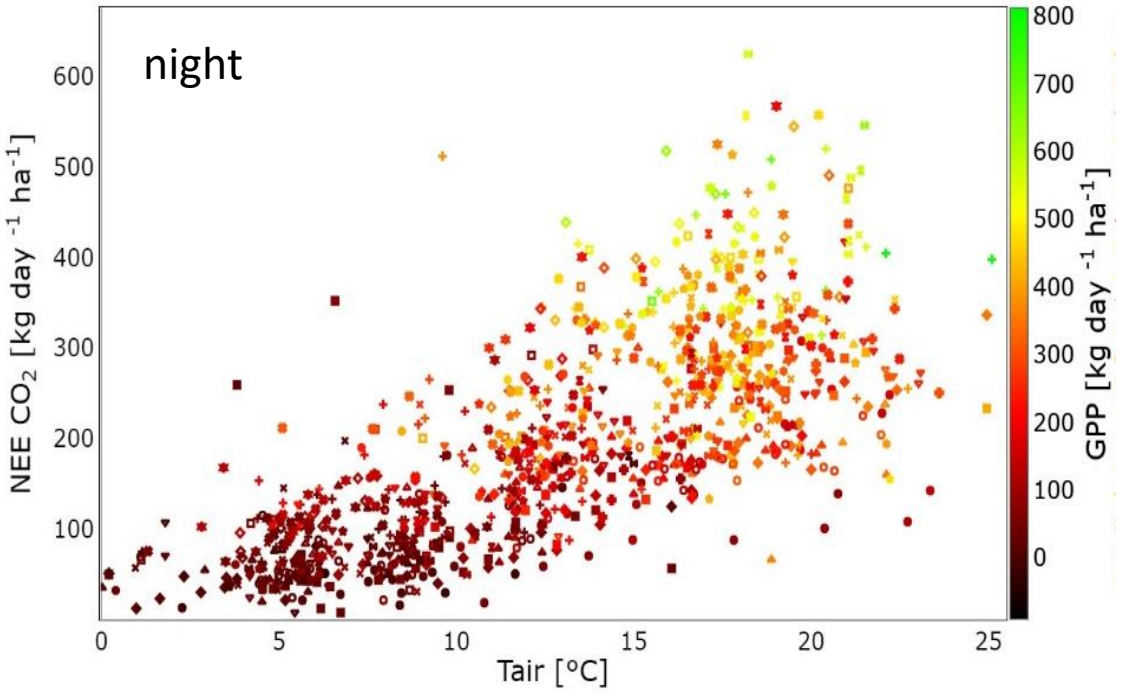
Weekly GPP and NEE correlated

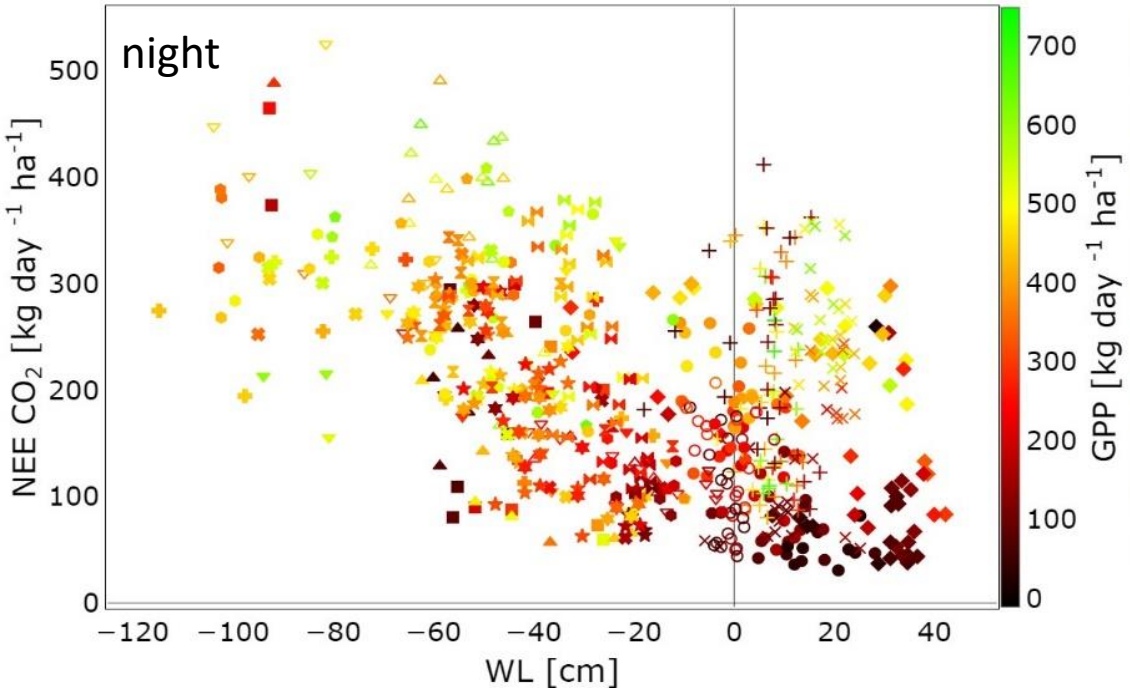


100 $kgCO_2$ $day^{-1}ha^{-1}$ = 2.6 umol C $m^{-2}s^{-1}$

NEE_{night} responses depend on GPP

Weekly averages





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Propose semi-empirical fit

$$\mathrm{NEE}_{CO_2-night} = \overbrace{\alpha\,\mathrm{GPP}}^{\mathrm{R}_a} + \overbrace{\frac{\beta}{1+\exp(\gamma\ W_L)}\exp(\delta\ T_{\mathrm{air}})}^{R_{h_{\mathrm{long}}}}$$

Linear term **sigmoidal term** **exponential factor**

Statistics….

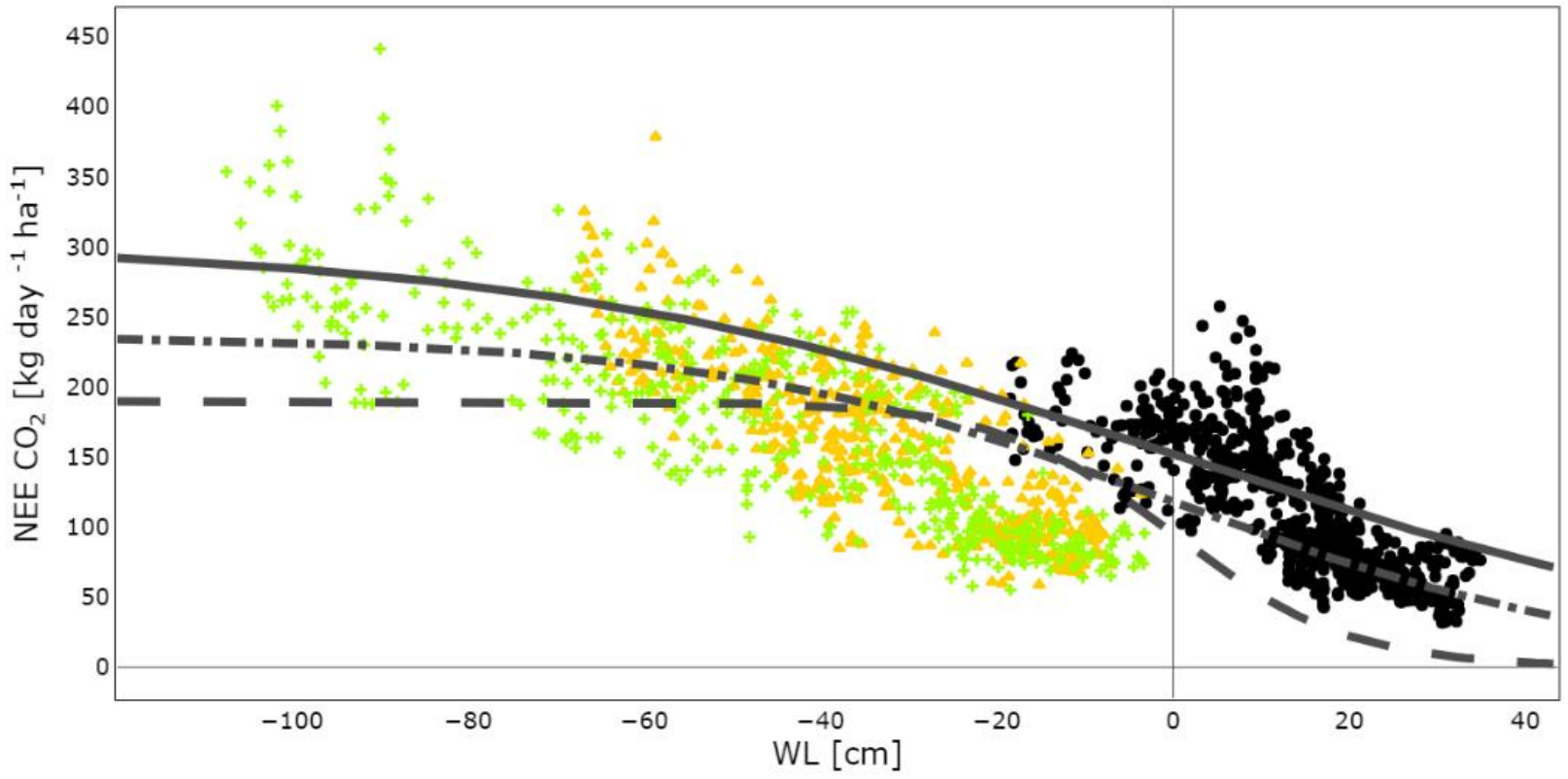
$$NEE_{CO_2-night} = \overbrace{\alpha\, GPP}^{R_a} + \overbrace{\frac{\beta}{1+\exp(\gamma\ W_L)}\exp(\delta\ T_{air})}^{R_{h_{long}}}$$

100 $kgCO_2$ $day^{-1}ha^{-1}$ = 2.6 umol C $m^{-2}s^{-1}$

Site/category	$\alpha \pm$ SE (P), group [1]	$\beta \pm$ SE (P), group [kg ha^{-1} day^{-1}]	$\gamma \pm$ SE (P), group [cm^{-1}]	$\delta \pm$ SE (P), group [$°C^{-1}$]	Residual [kg ha^{-1} day^{-1}]
Nature Wet (CAM, ONL)	0.178 ± 0.019 ($<2^{-16}$) ,a	136.1 ± 8.13 ($<2^{-16}$),a	0.027 ± 0.003 ($<2^{-16}$),a	0.053 ± 0.004 ($1.09 \cdot 10^{-13}$)a	74.65
Paludiculture (ZEG,ANK)	0.302 ± 0.026 ($<2^{-16}$) ,b	133 ± 12.91 ($<2^{-16}$),a	-0.026 ± 0.014 (0.06),b	0.039 ± 0.005 ($4.52 \cdot 10^{-11}$)b	50.96
Paludiculture_sph (ILP)	0.087 ± 0.039 (0.026) ,c	92.5 ± 6.91 ($<2^{-16}$),b	0.035 ± 0.01 ($6.1 \cdot 10^{-4}$),c	0.063 ± 0.005 ($<2^{-16}$) c	50.15
Pasture hi	0.26 ± 0.02 ($<2^{-16}$) ,d	78.28 ± 5.7 ($<2^{-16}$),c	0.1 ± 0.02 ($2.7 \cdot 10^{-7}$),d	0.059 ± 0.003 ($<2^{-16}$)d	42.02
Pasture lo	0.26 ± 0.036 ($9.42 \cdot 10^{-13}$) ,d	97.61 ± 10.53 ($<2^{-16}$),b	0.039 ± 0.01 ($1.3 \cdot 10^{-3}$),c	0.059 ± 0.004 ($<2^{-16}$) c	65.92
Crop lo (AMM/AMR)	0.4 ± 0.068 ($5.9 \cdot 10^{-8}$) ,e	71.74 ± 31.59 (0.0255),c	0.023 ± 0.04 (0.55),c	0.07 ± 0.01 ($1.57 \cdot 10^{-10}$)c	66.11

Fitted empircal model for Rh+peat oxidation, GPP=0

100 $kgCO_2$ $day^{-1}ha^{-1}$ = 2.6 umol C $m^{-2}s^{-1}$



Nature wet (GPP=0)

Nature wet (GPP=0,Tair= 15°C)

Pasture hi (GPP=0)

Pasture hi (GPP=0,Tair= 15°C)

Pasture lo (GPP=0)

Pasture lo (GPP=0,Tair= 15°C)

(note: lines are NOT a fit to the points!)

Kruijt et al in prep 2024

Take home and discuss

- GPP is *derived from* mean night-time NEE and day-time NEE. We are effectively looking at night-time NEE vs day-time NEE and these can be independent.
- Our Rh estimate is actually all NEE that is not correlated to (weekly) GPP
- Is this heterotrophic respiration plus… what? - Ra from perennial, woody, non-active biomass?

- Test approach on wider set of ecosystems, account for biomass
- Or resort to fitting process-based models to derive peat oxidation

Thank you for attention – Questions?

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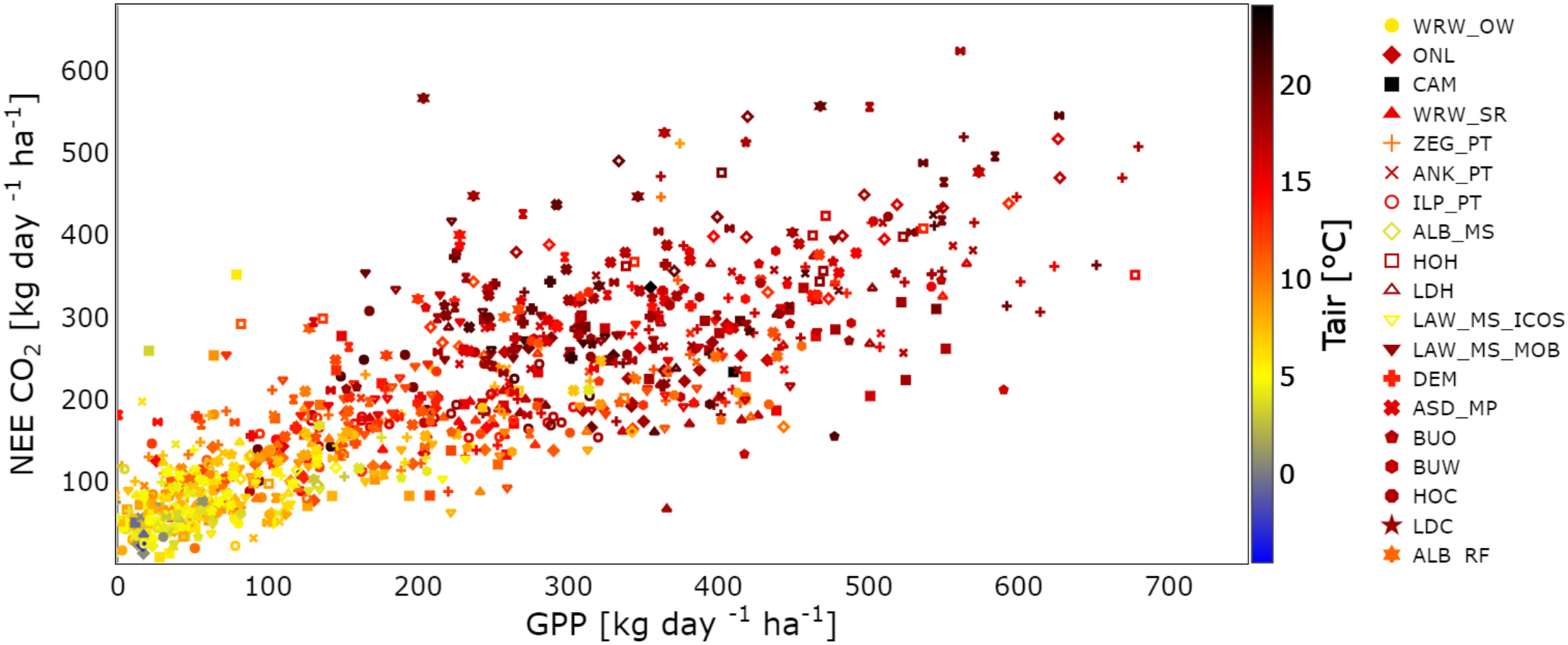
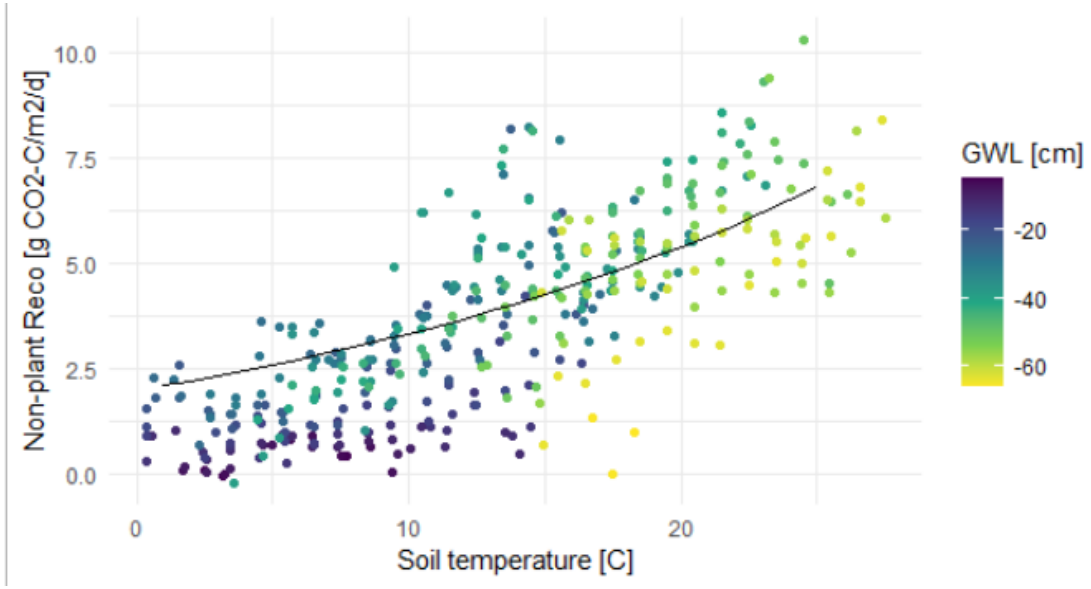
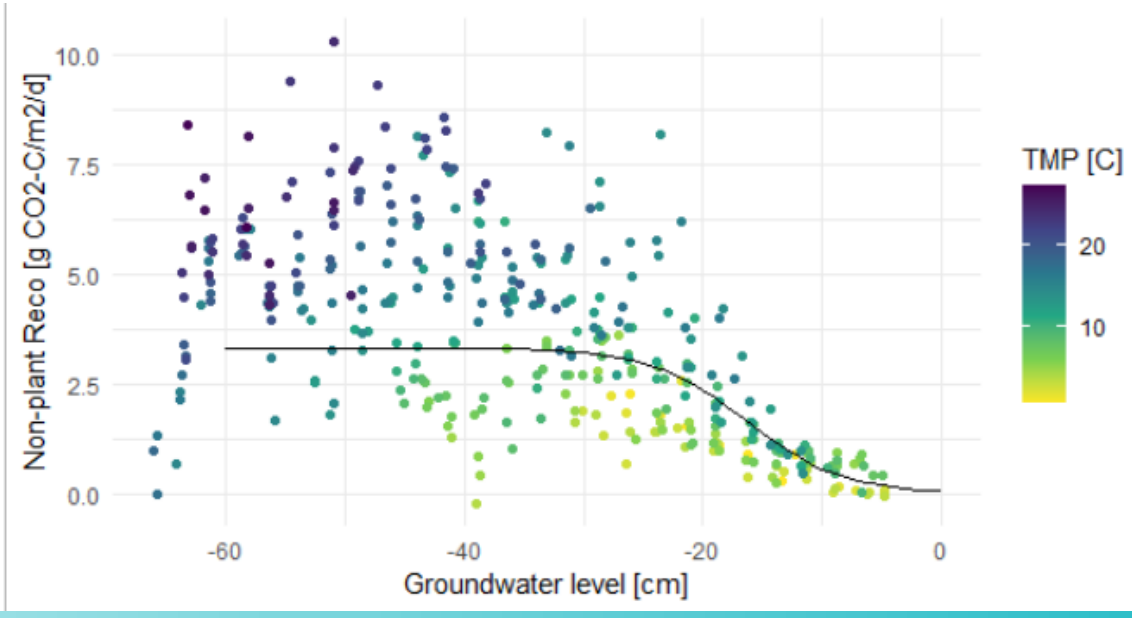
NEE_{night} vs GPP



Fit *on chamber data* including biomass estimates

- NEE_night = -a*GPP + b*biomass + function(SoilTemp, GWL, SoilMoist)





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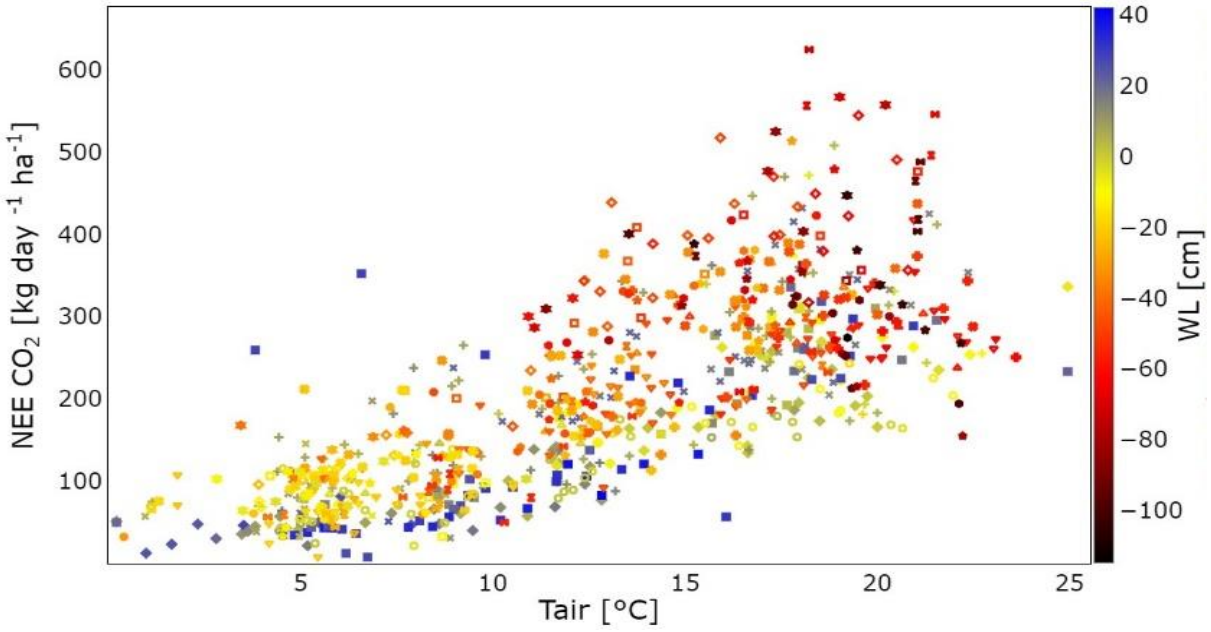
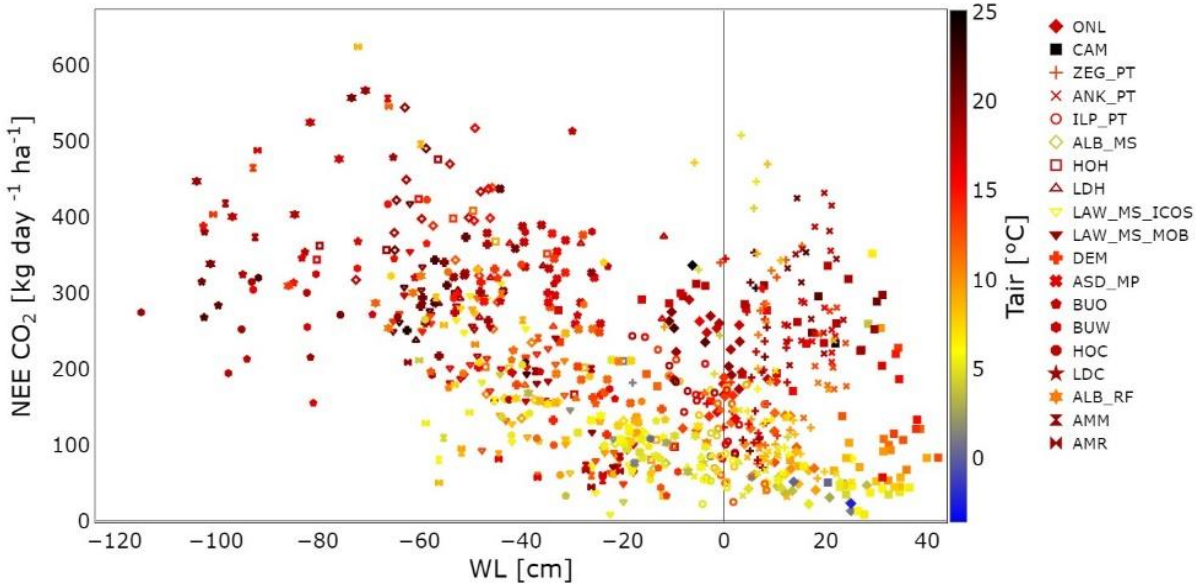
NEE short-term responses – Tair & Waterlevel
(weekly average, nighttime)





Estimate peat oxidation at annu

N(et)E(cosystem)C(arbon)B(udget):

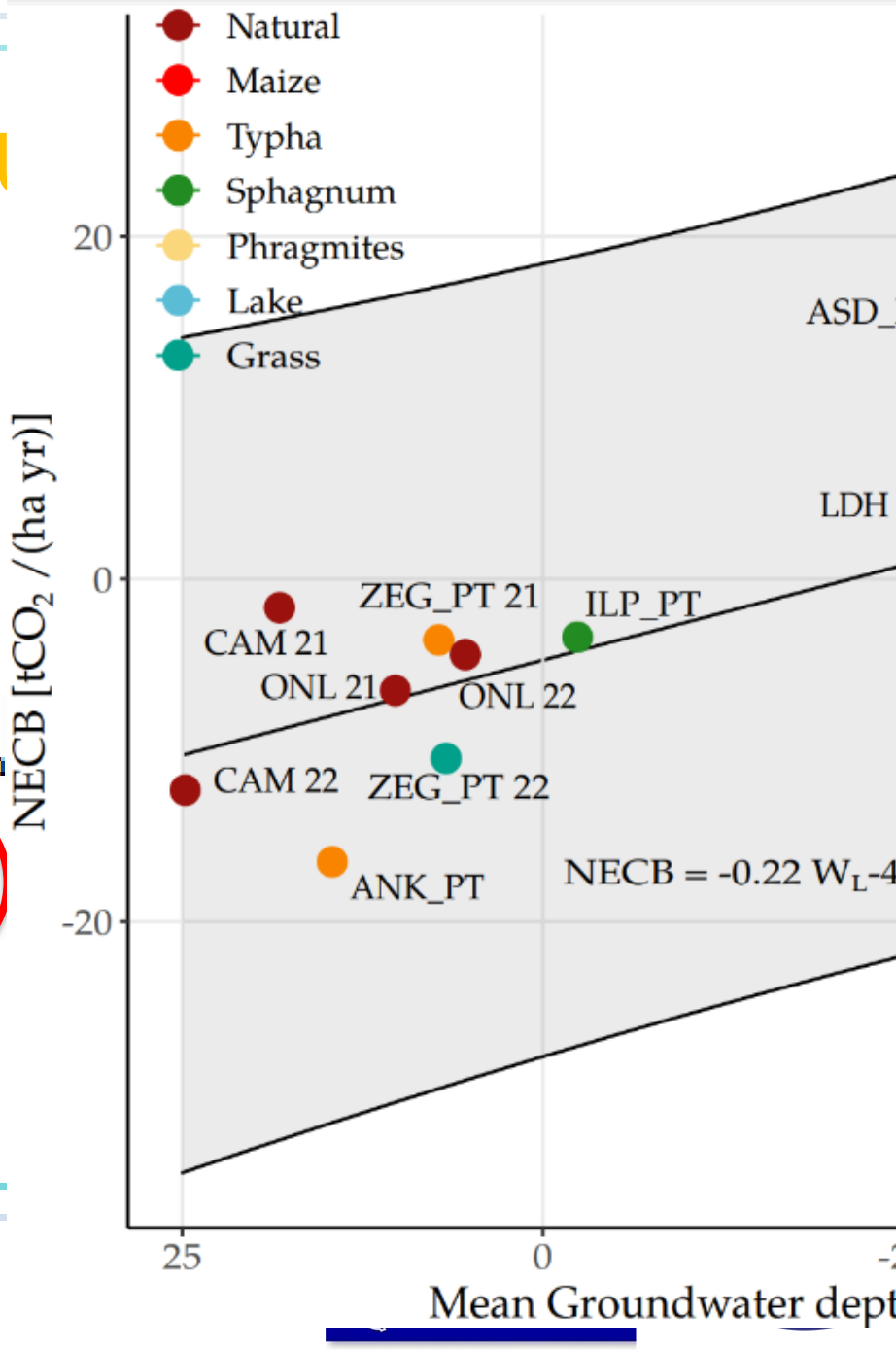
$$\mathrm{NECB} = \mathrm{NEE}^{\mathrm{year}} + F_{\mathrm{harvest}} - \mathrm{F}_{\mathrm{manure}} + \mathrm{F}_{\mathrm{grazing}}$$

$$\mathrm{NEE}^{\mathrm{year}} = -\left(\mathrm{NPP}^{\mathrm{year}} + \mathrm{R}_h^{\mathrm{year}}\right)$$

$$\mathrm{NPP}^{\mathrm{year}} = F_{\mathrm{harvest}} + \mathrm{NPP}^{\mathrm{year}}_{\mathrm{remainin}}$$

$$\mathrm{R}_h^{\mathrm{year}} = R^{\mathrm{year}}_{h_{\mathrm{short}}} + R^{\mathrm{year}}_{h_{\mathrm{long}}}$$

$$\mathrm{NECB} = \mathrm{NPP}^{\mathrm{year}}_{\mathrm{remaining}} + R^{\mathrm{year}}_{h_{\mathrm{short}}} + R^{\mathrm{year}}_{h_{\mathrm{long}}} - \mathrm{F}_{\mathrm{manure}} + \mathrm{F}_{\mathrm{grazing}}$$



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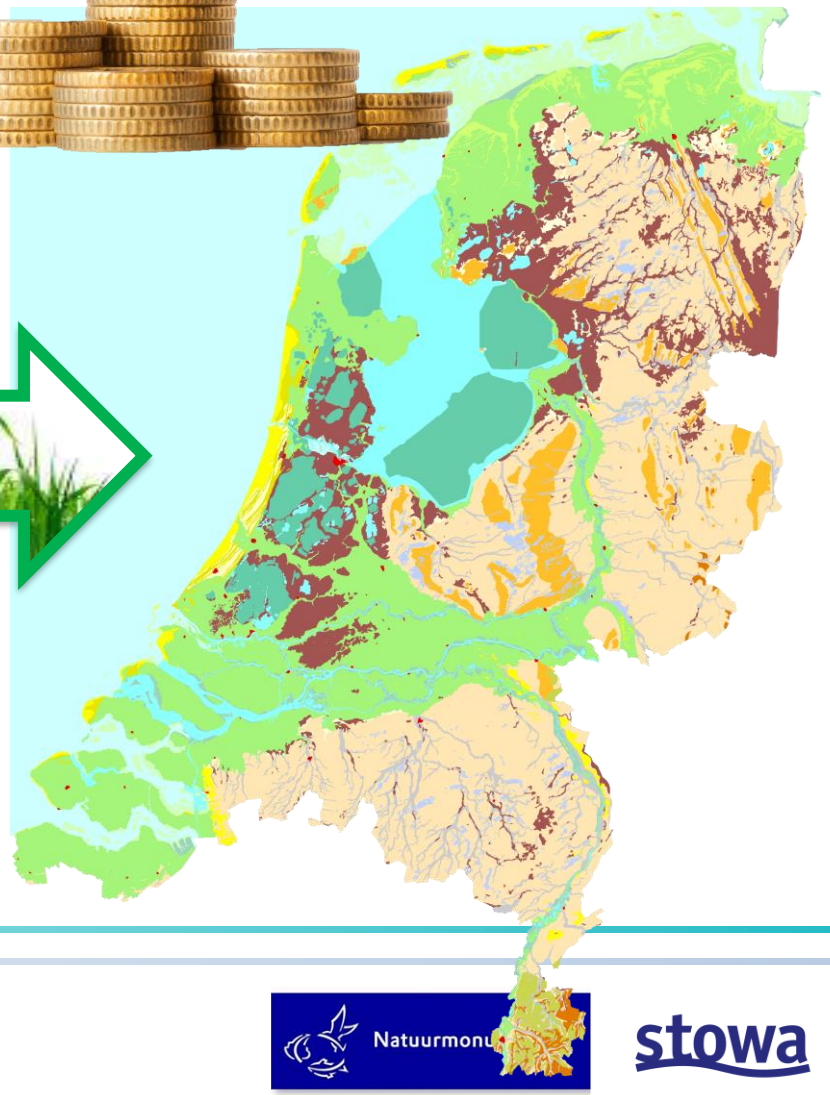
Dutch geology

CO_2



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