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Carbon dioxide and nitrous oxide fluxes from a legume-based grassland during contrasting seasons in eastern Finland

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Background

- Legume-based grasslands are important for meat and dairy industries in Europe.
- Legumes facilitate soil C sequestration and mitigation of N_2O emissions.
- EC technology has become sufficiently reliable to allow continuous measurements of C flows for periods of months to years.
- There is a lack of regionally based, ecosystem scale field experimental data on legume-based boreal grasslands.





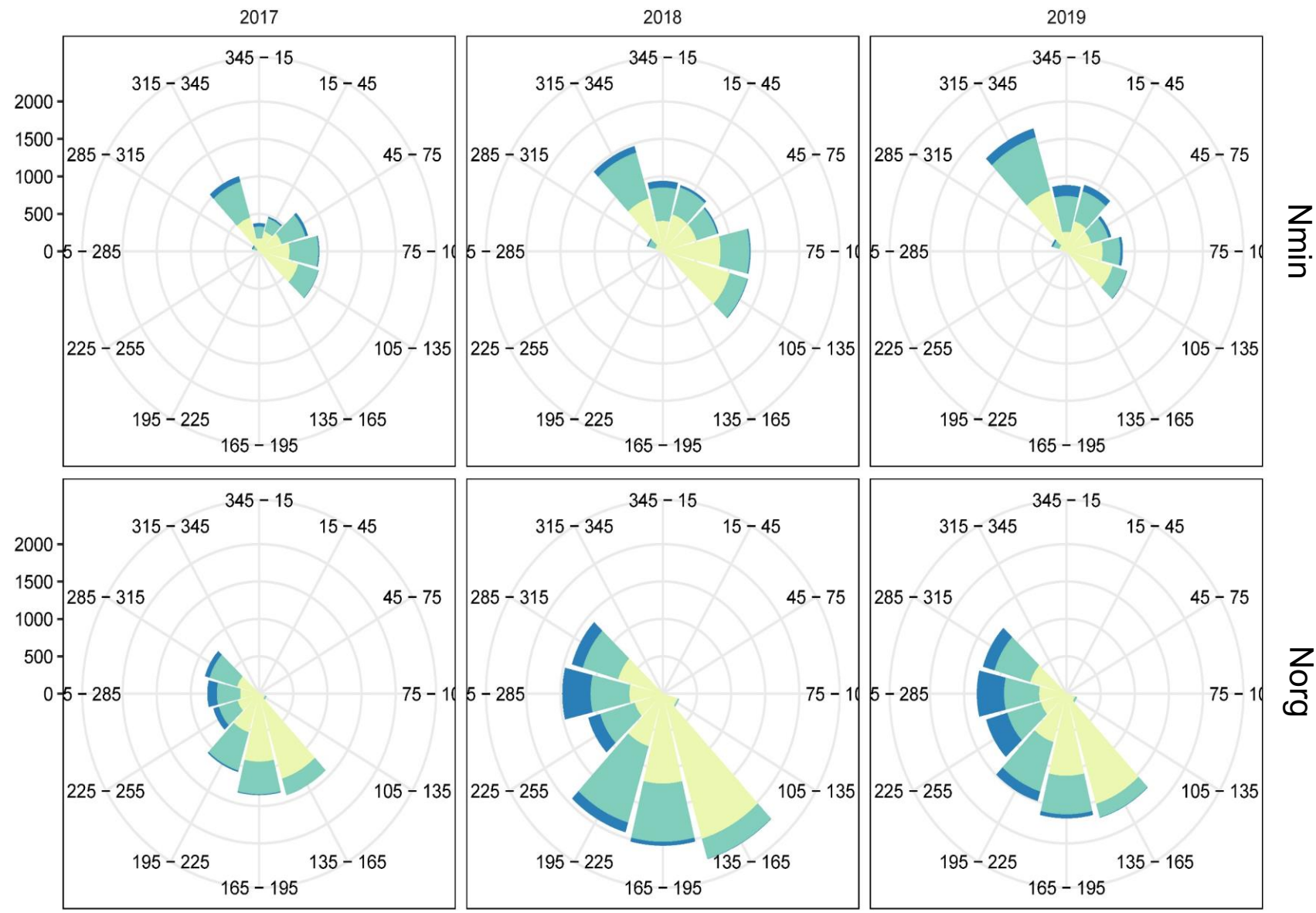
Study setup

- Quantify NEE and N_2O fluxes from two adjacent legume-based grasslands, timothy and red clover, added with mineral (MinN) and organic fertiliser (OrgN) using one EC system over a rotation cycle (May-Nov 2017 and 2019).
- Li-7000 infrared gas analyser for CO_2 and H_2O fluxes.
- Pulsed quantum cascade laser spectrometer for N_2O and H_2O fluxes.

MinN

OrgN



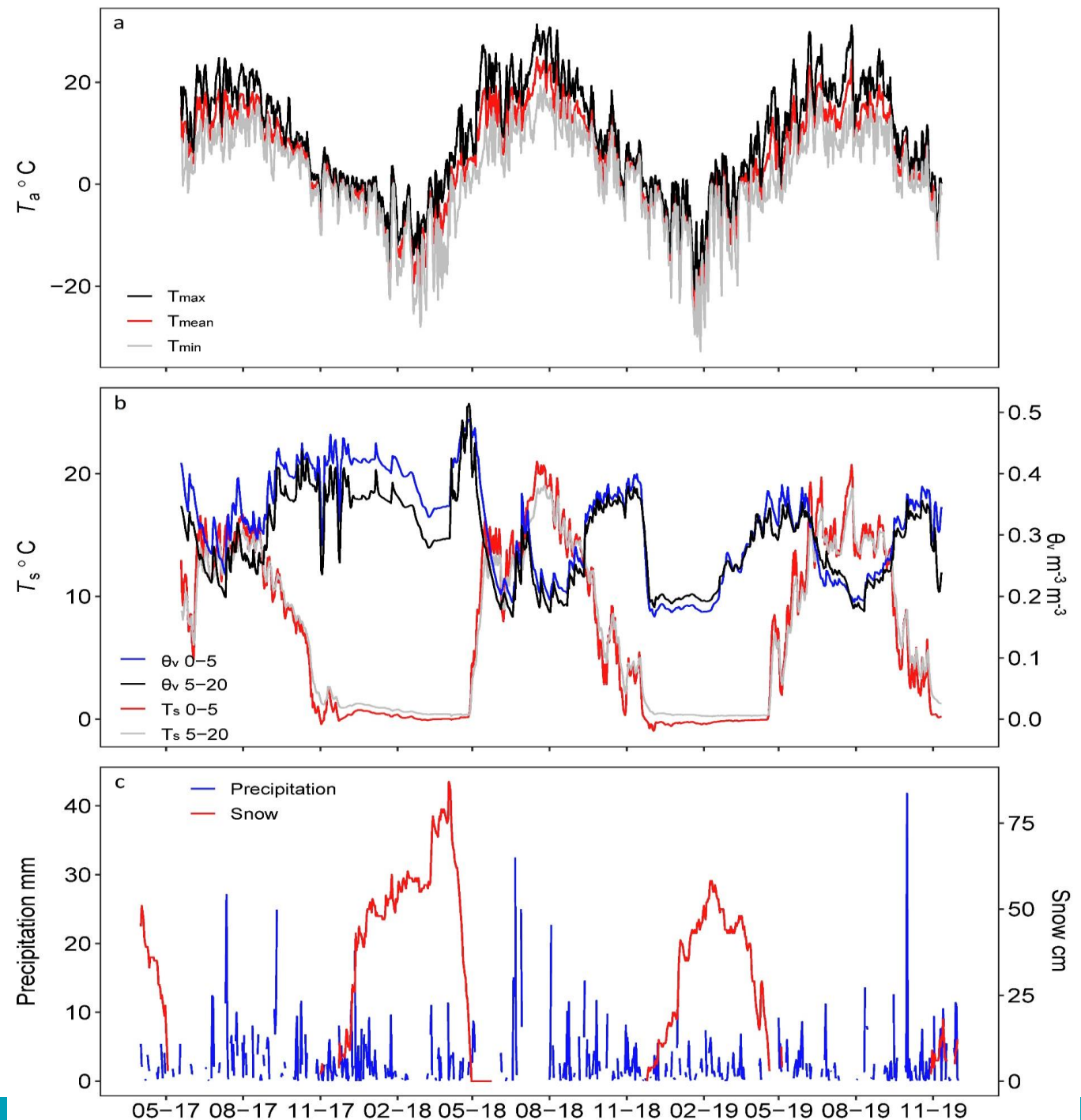




Results

Climatic conditions

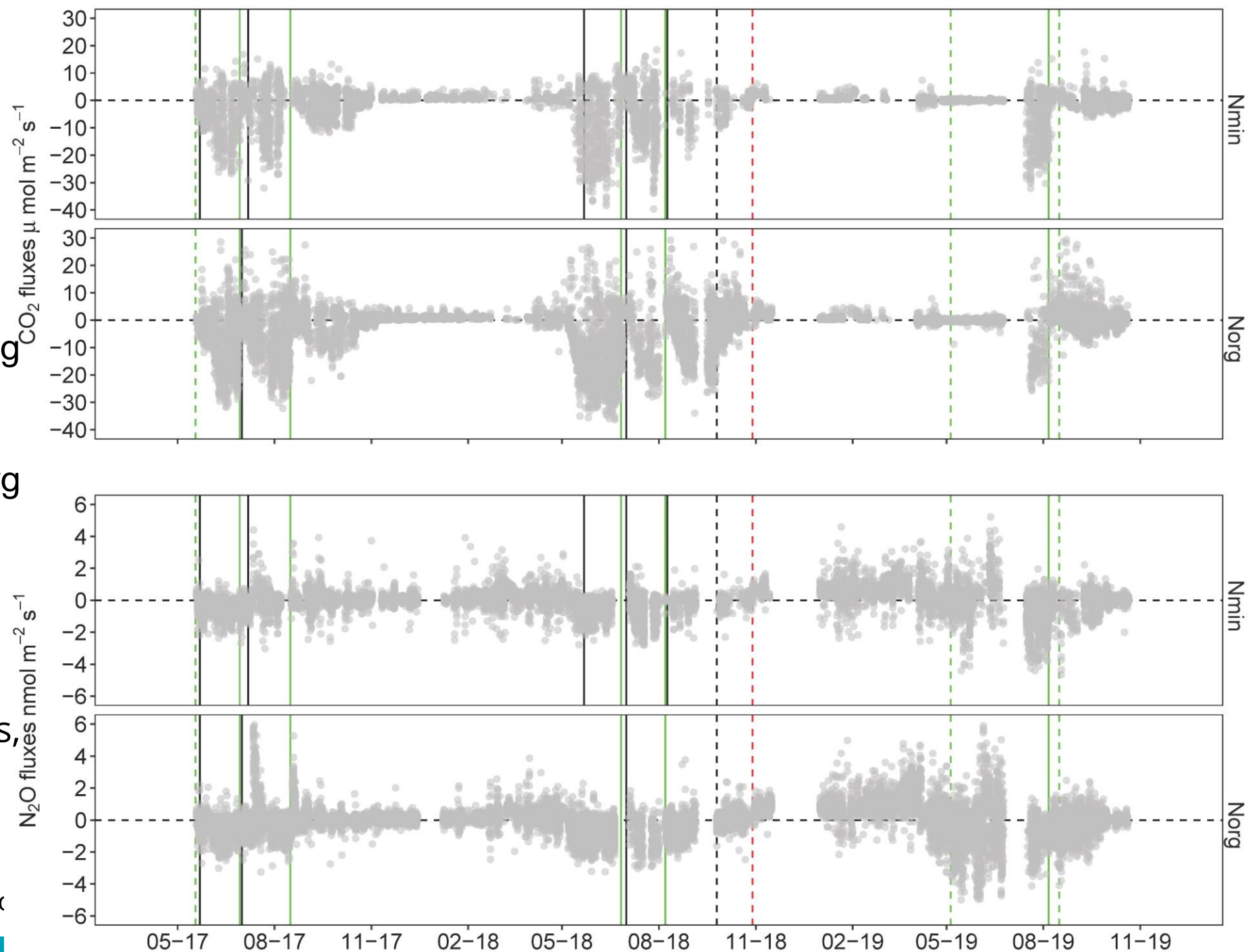
- MAT in this study site was 3.9, 4.6, and 4.2°C in 2017, 2018, and 2019, resp, which were 0.7, 1.4, and 1.0°C warmer than the 30-YM, 3.2°C, resp.
- MAP was 462, 324, and 371 mm in 2017, 2018, and 2019, resp, which were all lower than the 30-YM (612 mm).
- GS lasted 136, 155 and 142 days in 2017, 2018, and 2019, resp.





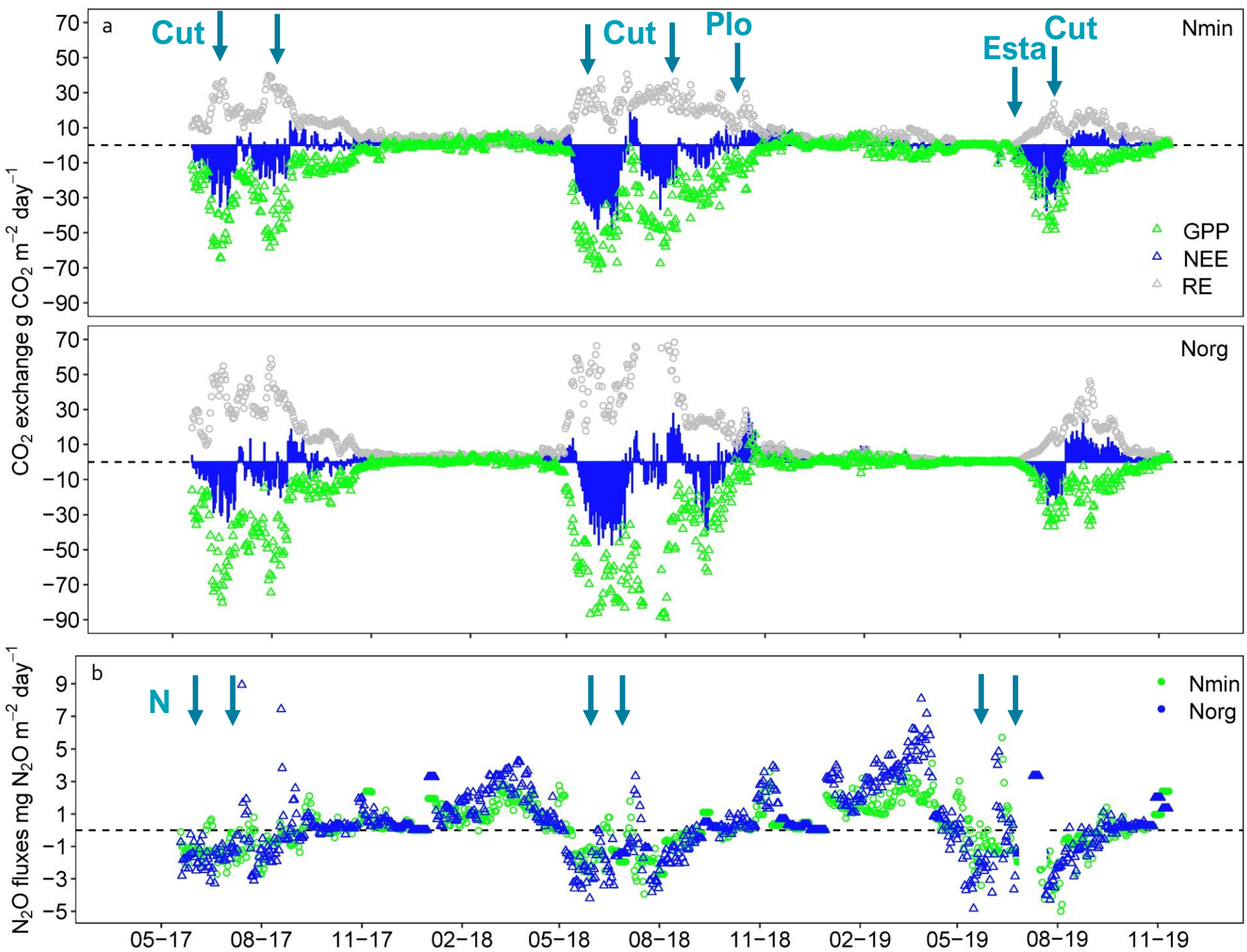
Half-hour measured CO_2 and N_2O fluxes

- N_2O DC of Nmin or Norg was 30 and 44%.
- CO_2 DC of Nmin or Norg was 20 and 33%.
- Changes in CO_2 and N_2O following major management practices, were generally well observed.



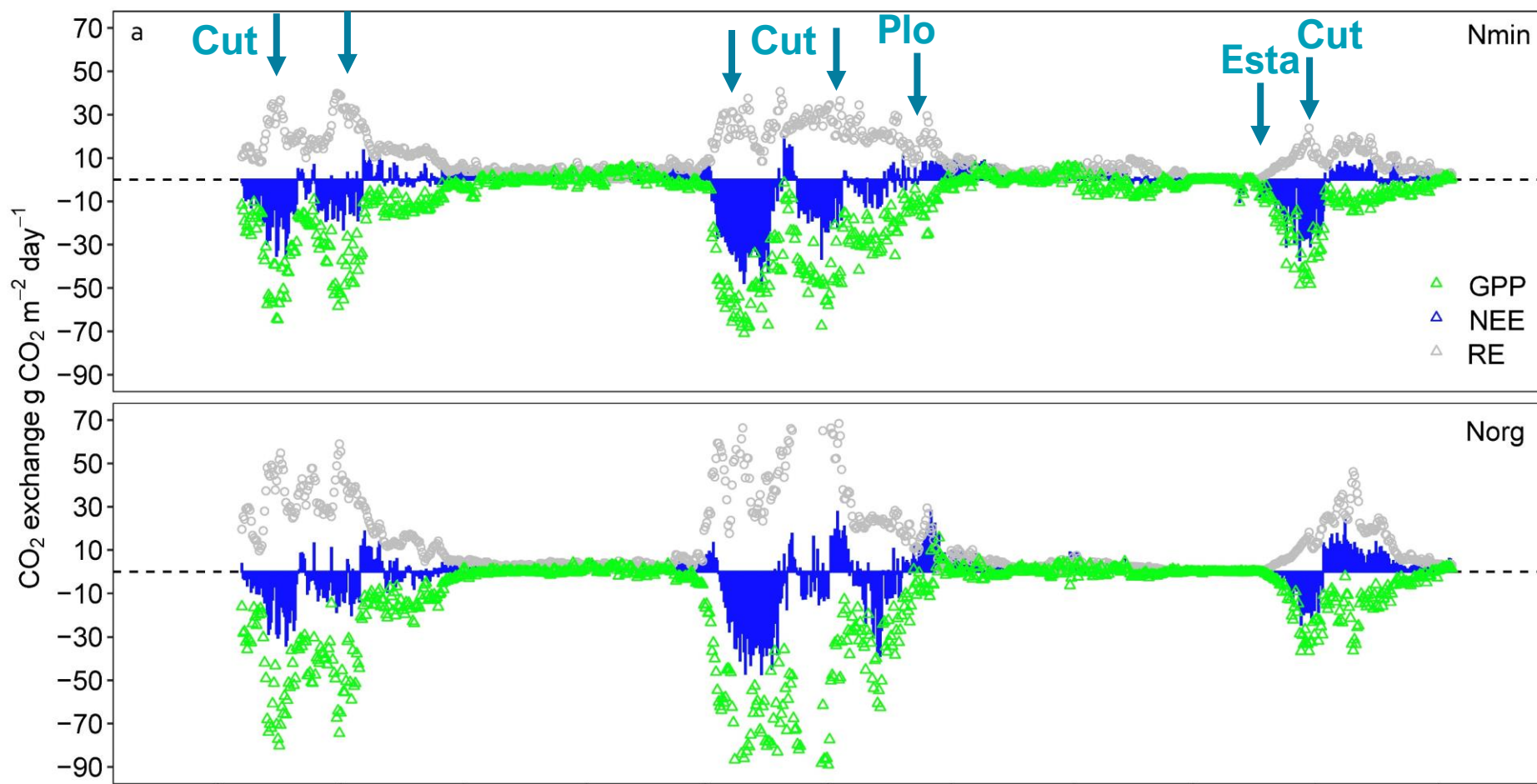


Daily fluxes





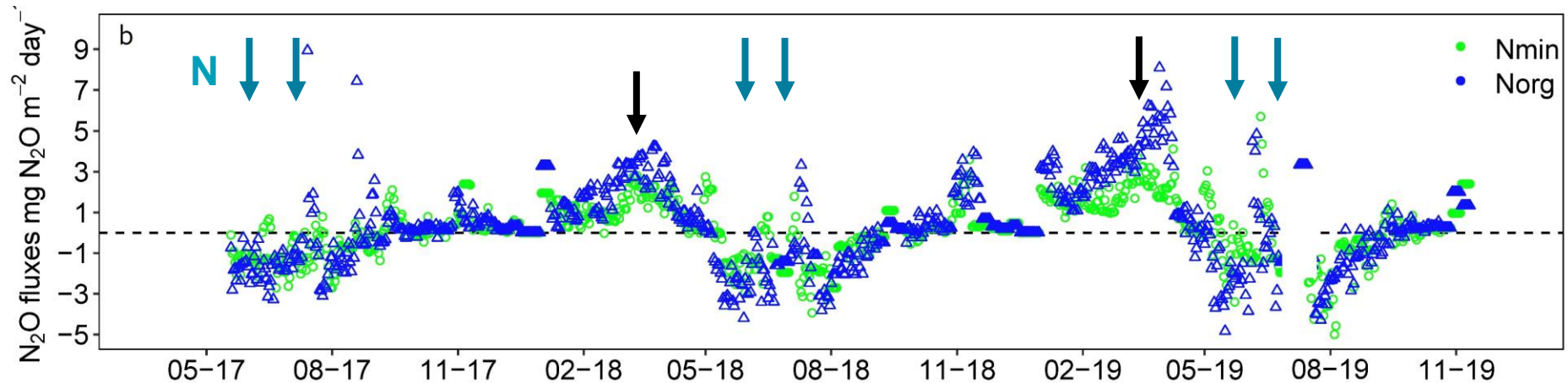
CO₂ fluxes



- Removal of vegetation (first cut, June) turned the ecosystem to a CO₂ source.
- N fertilisation after 1st cut, the ecosystem maintained a steady net uptake of CO₂.
- Second cut in August turned the ecosystem into a source of CO₂ again.
- The CUE, NEE/GPP, was 0.24 in 2018, implying more favorable conditions in 2018 uptaking CO₂.



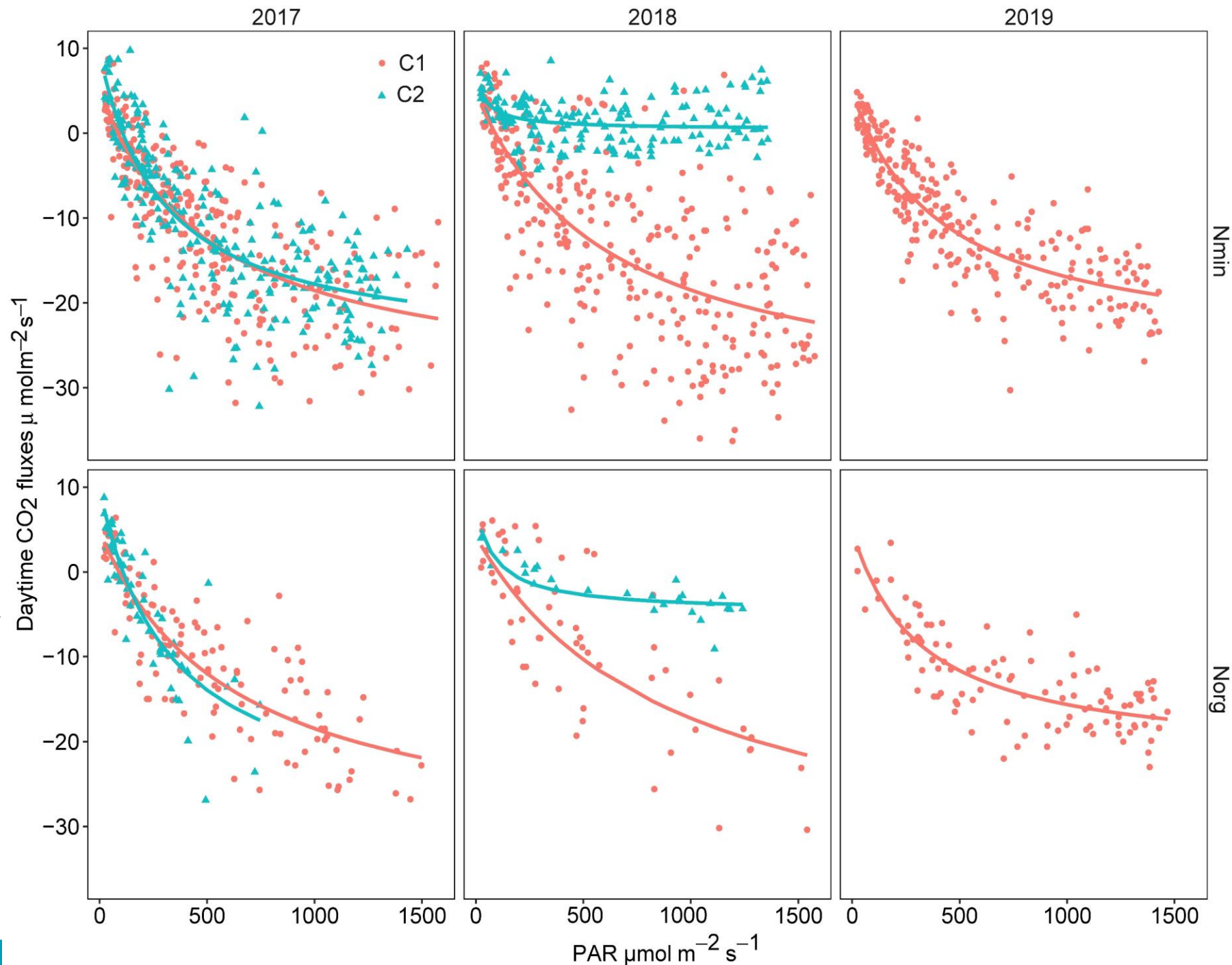
- Increased **N availability** due to fertilisation is widely known as the main driver of N₂O emissions.
- The increased N₂O emissions following cut events may be because of increased rhizodeposition.
- **Free-thaw** also significantly increased N₂O emissions.





Nonlinear regression NEE and PAR

- High values of estimated P_{\max} and α in 2018, 1st cut with Norg, implying favourable climatic conditions for high CO_2 uptake.
- High CO_2 uptake capacity with applying of organic fertilise on the 2nd year of the establishment of the grassland.





- The net C balance estimated as the sum of seasonal NEE, N₂O fluxes, crop yield, N_{min} and N_{org}, particularly N_{min}, showed strong soil organic C sequestration potential over the three years, especially in a climatically extreme year, 2018 with the dry and warm condition.

Year	2017		2018		2019	
Treatment	N _{min}	N _{org}	N _{min}	N _{org}	N _{min}	N _{org}
R _E	796	1421	747	2015	268	765
GPP	1519	1965	1743	2850	725	560
NEE	-723	-544	-996	-835	-457	205
DM	280	233	279	298	160	118
N ₂ O	-51.3	11.9	-94	-76.2	-73.8	-44.9
NECB g C m ⁻²	428	315	689	514	275	-336



Summary

- The method is applicable for measuring CO₂ and N₂O fluxes from two adjacent boreal grasslands using one EC system.
- Based on a rotation cycle, the legume-based grasslands in the boreal region have a strong C sequestration potential, particularly in the warm and dry year.



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Thank you!