Soil N_2O emissions from temperate cropland agroforestry and monoculture systems

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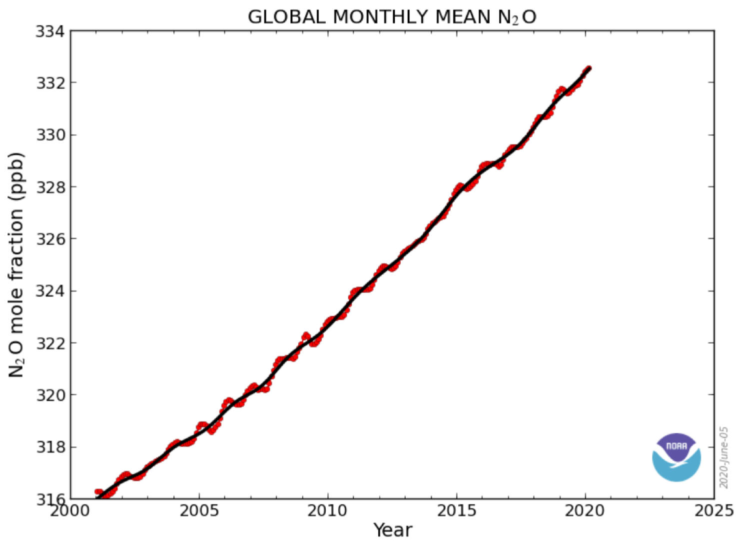
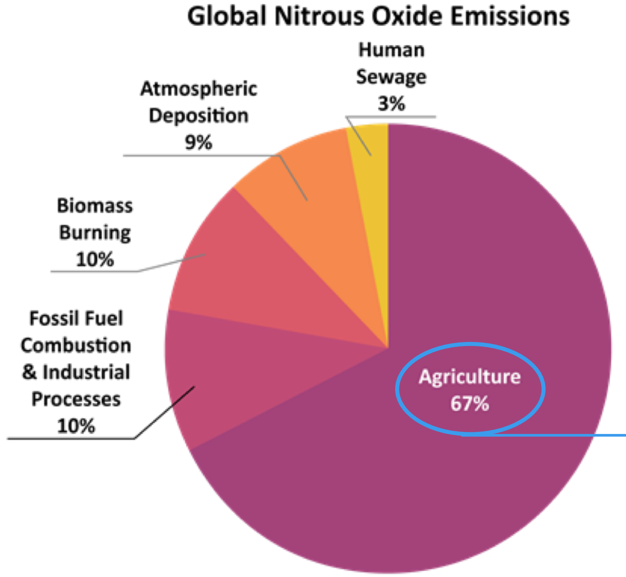
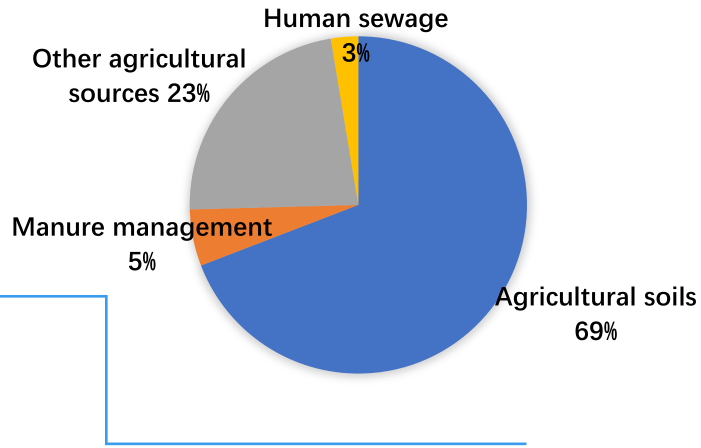
Introduction







Nitrous oxide (N_2O):

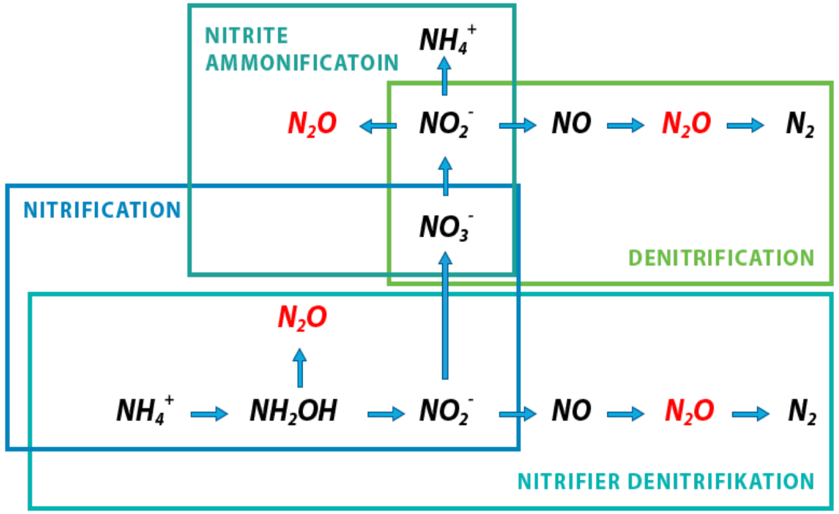
- With a global warming potential (GWP_{100}) 298 times higher than CO_2[1,2]
- Main contributor to the depletion of the stratospheric ozone layer [3,4]

Global source:

- Agriculture represents the largest anthropogenic source[1,2]
- Emissions from agricultural soils dominate[5]

Production:

- Microbial nitrification and denitrification[6]



Source: GMD, 2020; www.agropages.com; Reay et al., 2012. [1]IPCC, 2013; [2]Robertson et al., 2000; [3]Ravinshakara et al., 2009; [4]Portmann et al., 2012; [5]Moiser et al., 1998; [6]Braker and Conrad, 2011

Introduction

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Agroforestry

-- Trees combined with crops and/or livestock on the same unit of land

Benefits:

-- Higher water-use efficiency[1]

-- More efficient use of available nutrients[2]

-- Higher value of ecosystem services[3]

Question:

No systematic comparison was conducted of soil N_2O emission between cropland agroforestry and monoculture systems in Western Europe

Objectives:

To quantify the spatial-temporal dynamics of soil N_2O fluxes and to determine the controlling factors from cropland agroforestry and cropland monoculture systems

[1]Schwendenmann et al., 2010 ; [2]Pardon et al., 2017 ; [3]Graves et al. 2007

Experimental design

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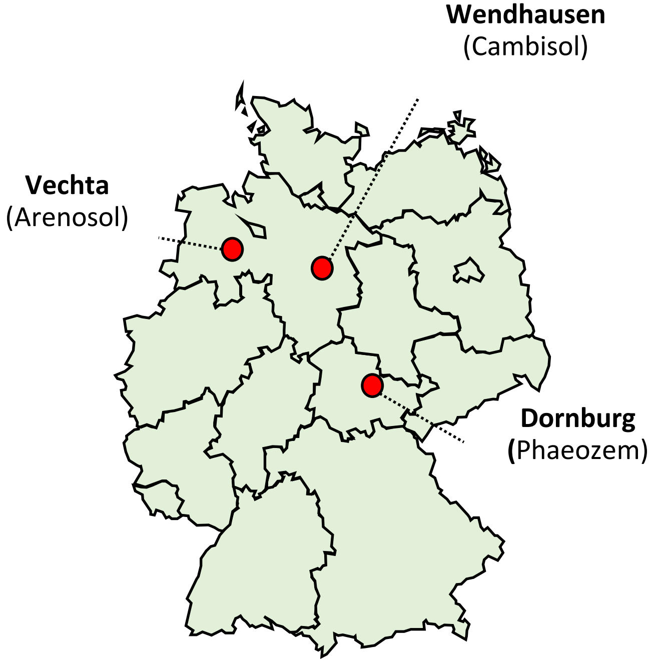

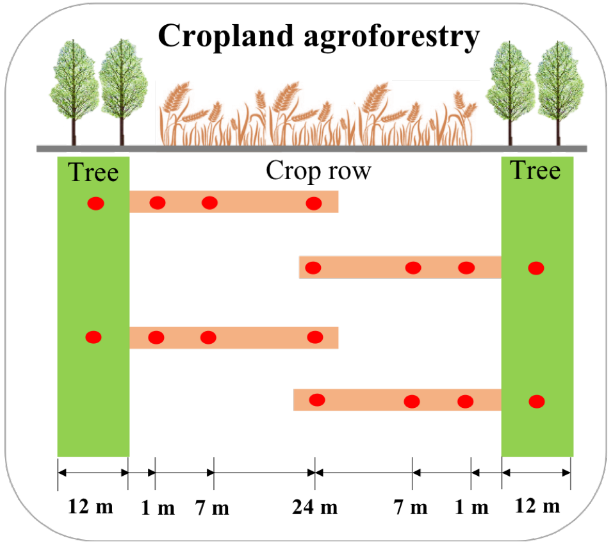

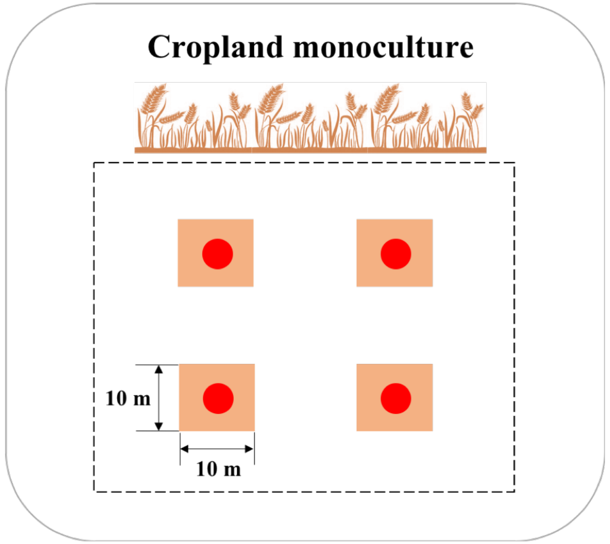

● : Sampling points

Cropland agroforestry:

Tree row, in the crop row at distances of 1 m, 7 m, and 24 m from the tree row.

Cropland monoculture: Center of each replicate plot.

Monthly measurement: N_2O fluxes, soil temperature, water-filled pore space, and mineral N (NH_4^+ and NO_3^-)

Management practices

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Soil type/ Study site	Study year	Crop rotation	Sowing	Harvesting	Tillage	Fertilization date	Fertilization date (kg N-P-K ha^{-1} yr^{-1})	N input (kg ha^{-1} yr^{-1})
Calcaric Phaeozem/ Dornburg	2018/2019	Winter wheat	Oct 2017	Jul 2018	Oct 2018	04.04.2018	133–0–0	213.0
						17.05.2018	80–0–0	
	2019/2020	Summer barley	Mar 2019	Jul 2019	Oct 2019	01.04.2019	36.1–21.6–30.5	36.1
Vertic Cambisol/ Wendhausen	2018/2019	Winter wheat	Oct 2017	Jul 2018	Aug 2018	06.03.2018	70–0–0	166.0
						20.04.2018	60–0–0	
						14.05.2018	36–0–0	
	2019/2020	Maize	Apr 2019	Oct 2019	Nov 2019	07.05.2019	101.0–0–0	101.0
Arenosol/ Vechta	2018/2019	Rye	Oct 2017	Jul 2018	Aug 2018	01.04.2018	188.0–26.4–107.8	188.0
	2019/2020	Maize	Apr 2019	Sep 2019	Sep 2019	28.04.2019	153–72.6–62.3	153.0

Results: Temporal changes of N_2O fluxes

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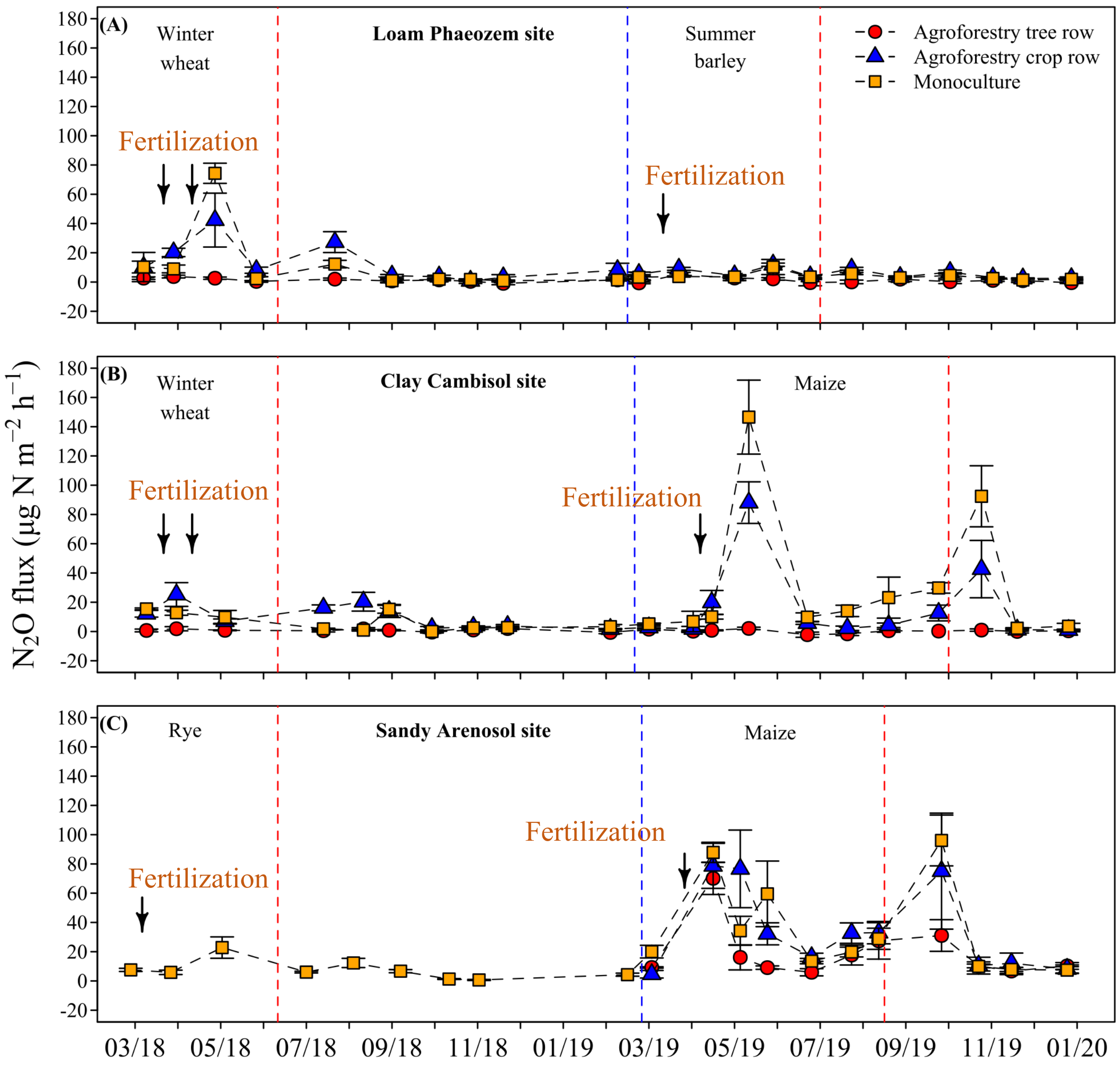

- High seasonal variability intra-and inter-annually
- Fertilizer stimulate N_2O emission
- Crop residues might regulate N_2O production during after harvest season

N_2O fluxes from agroforestry crop row:

$$F_{Crop} = (4\times F_{1m} + 18\times F_{7m} + 2\times F_{24m})/24$$

F_{1m}: N_2O fluxes in the 1 m distance from tree row

F_{7m}: N_2O fluxes in the 7 m distance from tree row

F_{24m}: N_2O fluxes in the 24 m distance from tree row

Results: N_2O emission

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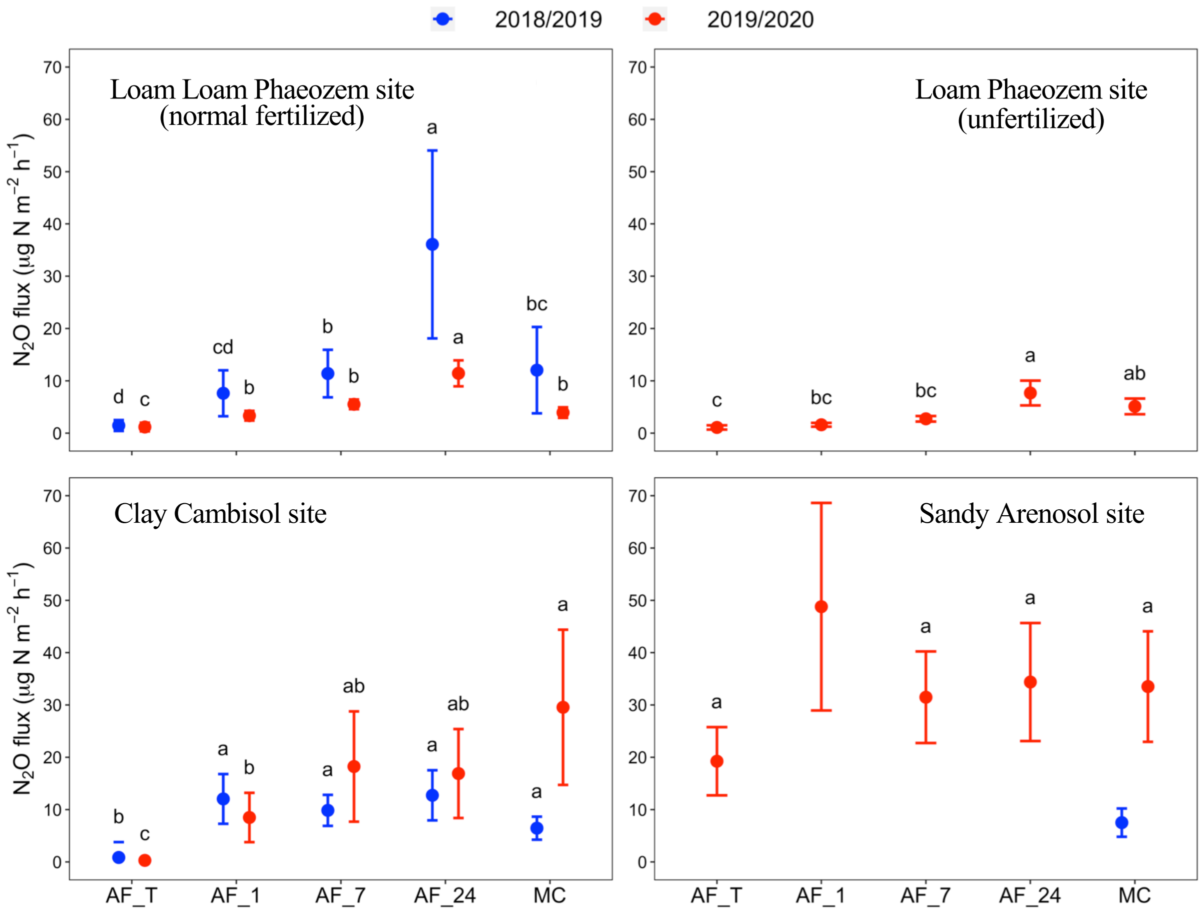

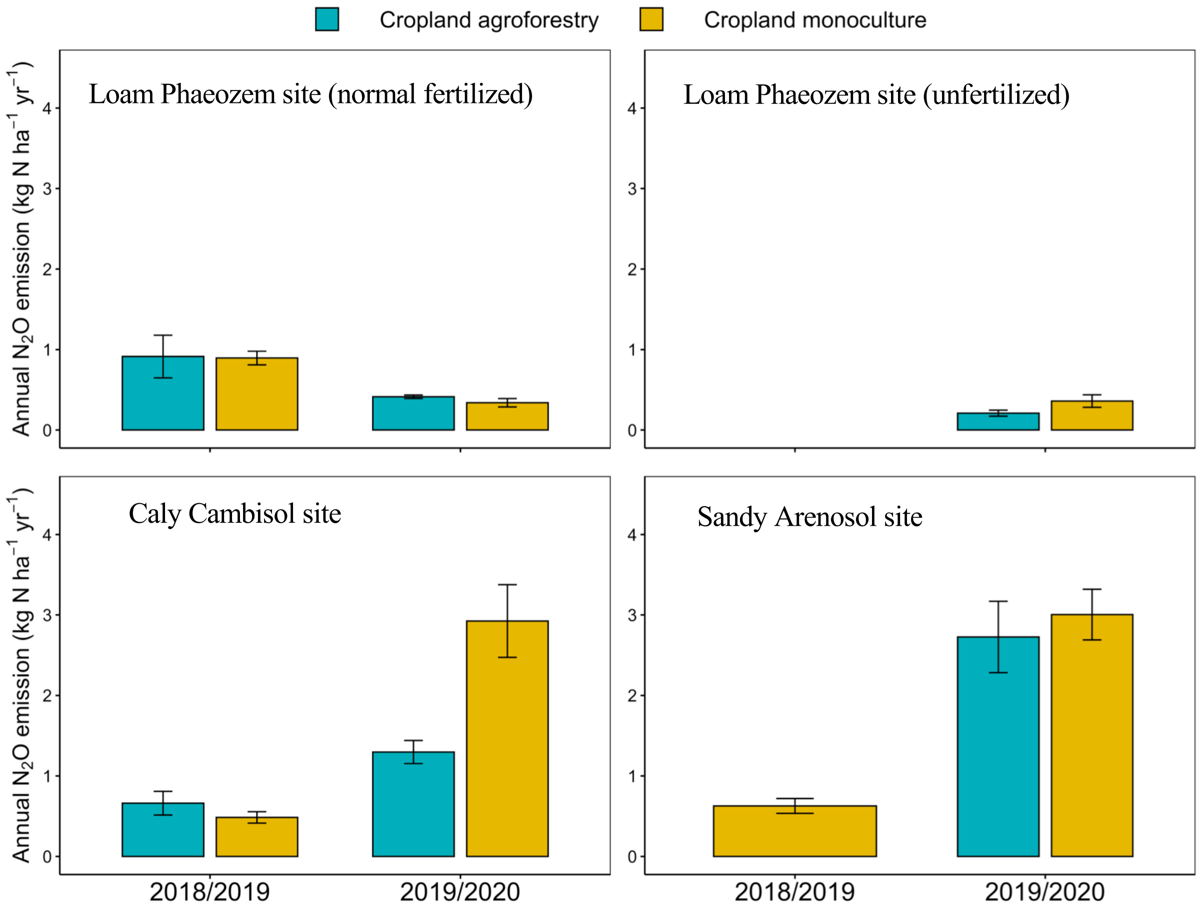

AF: Cropland agroforestry **MC:** Cropland monoculture

AF_T, 1, 7, 24: Sampling locations in cropland agroforestry

N_2O emission from cropland agroforestry:

$$E_{AF} = (6\times E_{\text{tree}} + 4\times E_{\text{1m}} + 18\times E_{\text{7m}} + 2\times E_{\text{24m}})/30$$

Annual N2O emission between AF and MC:

Loam Phaeozem site and Sandy Arenosol site: No difference

Clay Cambisol site: no difference in 2018/2019, AF < MC in 2019/2020

Results: Relationships between N_2O fluxes and soil factors

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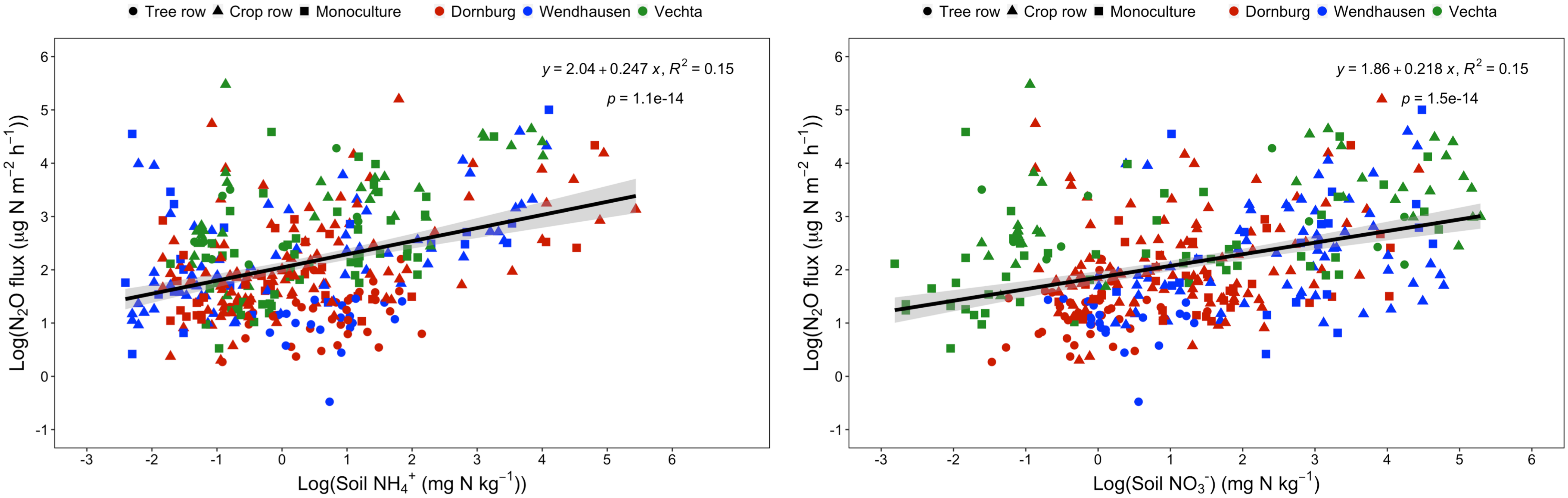

Across all sites, the positive correlations between soil N_2O fluxes with mineral N support the major controlling roles of NH_4^+ and NO_3^- in the production of N_2O from soil.

Conclusions

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- Cropland agroforestry has the potential to decrease soil N_2O emissions compared to monoculture but unreasonable fertilization management may reverse this trend
- Spatial variation of soil N_2O fluxes in agroforestry crop row may be affected by trees in agroforestry system
- Soil mineral N and WFPS were major controlling factors for N_2O fluxes in cropland agroforestry and monoculture systems

Other studies in our project:

Session BG3.19 – Exchange of GHG and reactive gases in agricultural ecosystems

EGU21-886: Gross rates of soil N_2O emission and uptake and denitrification gene abundance in temperate cropland agroforestry and monoculture systems by Jie Luo et al.

Session SSS9.7 - 'Impact of conventional agriculture and organic farming on soil functions

EGU21-10463 :Soil-N cycling in temperate alley cropping agroforestry and monoculture croplands by Xenia Bischel et al.