Temperature and moisture sensitivity of CH_4 and N_2O fluxes from European soils

Masterthesis

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Vienna, August 2014

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Acknowledgements

I would like to express my gratitude to my supervisor Prof. Sophie Zechmeister-Boltenstern for the valuable comments, remarks and help through the process of this master thesis. Furthermore I would like to thank Mag.[a] Christine Gritsch, who introduced me to the topic and accompanied me all the time. I would especially thank the academic and technical staff from the IBF. Working with you was instructive and and you were always helpful. A special thanks goes to Sebastian Radlwimmer, for introducing me to "R". And finally I would like to thank my familiy and Julia for their support.

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Abstract

Soils are important sources and sinks for greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O). Gas emissions as well as gas uptake can be attributed to microbial activity in soils. These processes are known to be sensitive to climate change. As part of the ÈCLAIRE EU-project, we examined CH_4 and N_2O fluxes from different land use types to better predict future feed-back effects on climate change. The nine study sites cover the four main land use types in Europe, incubation temperature and soil moisture served as modifiable climate parameters. Gas chromatography was used to determine gas concentration and gas fluxes were estimated by regression analysis. Thereby we hypothesized that (1) CH_4 and N_2O fluxes differ between the selected land use types, (2) CH_4 and N_2O fluxes increase with increasing soil moisture and that (3) the temperature sensitivity of CH_4 and N_2O fluxes differs between land use types. Our results indicate that CH_4 and N_2O fluxes are significantly different in soils from cropland, peatland, grassland and forest. We found soil moisture to be the main factor regulating CH_4 and N_2O emissions, as an increase in moisture content resulted in an exponential increase of CH_4 (R^2=0.28, p=0.000, peatland, UK-AMo) and N_2O (best fit: R^2=0.68, p=0.000, forest, IT-BFo) emissions. In contrast, CH_4 uptake had its optimum at medium moisture content, illustrated by a polynomial function (R^2=0.18, p=0.000, forest, FI-Hyy). Temperature sensitivity of CH_4 fluxes differed between the sites and between CH_4 emission (Q_{10}=52.5, peatland, UK-AMo) and CH_4 oxidation (Q_{10}=2.5, forest, IT-IFo). Temperature sensitivity of N_2O fluxes in mixed broadleaf stands (Q_{10}=2.5 and 4.9, respectively) was lower compared to coniferous stands (Q_{10}=12.9). Additionally, we could prove that the implementation of an electronic crimper had a significant positive effect on the accuracy of the conducted method.

Keywords: land use, methane, nitrous oxide, temperature sensitivity, moisture sensitivity , Q_{10}

Zusammenfassung

Böden sind wichtige Quellen und Senken für Treibhausgase wie Methan (CH_4) oder Lachgas (N_2O). Gasemissionen und Gasaufnahme können auf mikrobielle Aktivität in Böden zurückgeführt werden. Diese Prozesse sind empfindlich gegenüber klimatischen Veränderungen. Als Teil des ÈCLAIRE EU-Projektes wurden Methan und Lachgasflüsse von verschiedenen Landnutzungssystemen untersucht, um mögliche klimatische Rückkopplungseffekte besser verstehen zu können. Neun Standorte repräsentieren die vier Hauptlandnutzungstypen Europas, während die Inkubationstemperatur und Bodenfeuchte als modifizierbare klimatische Parameter herangezogen wurden. Mittels Gaschromatograph und Regressionsanalyse wurden die Gasflüsse errechnet. Es wurde angenommen, dass (1) die CH_4 und N_2O Flüsse sich zwischen den Landnutzungstypen unterscheiden, (2) die Gasemissionen mit steigender Feuchte steigen und (3) die Temperatursensitivität der CH_4- und N_2O-Freisetzung aus Böden von Grünland, Acker, Wald und Mooren unterschiedlich ist. Die Ergebnisse zeigten, dass sich die CH_4 und N_2O Flüsse zwischen den Landnutzungstypen signifikant unterscheiden. Die Bodenfeuchte scheint dabei einen großen Einfluss auf die CH_4 und N_2O Emissionen zu haben, da mit steigender Feuchte ein exponentieller Anstieg in CH_4 (R^2=0.28, p=0.000, Moor, UK-AMo) und N_2O (R^2=0.68, p=0.000, Wald, IT-BFo) gemessen wurde. Im Gegensatz dazu hatte die CH_4 Aufnahme ihr Optimum bei mittlerer Feuchte, einer polynomialen Funktion folgend (R^2=0.18, p=0.000, Wald, FI-Hyy). Hinsichtlich der Temperatursensitivität von CH_4 fanden wir Unterschiede zwischen den Landnutzungssystemen sowie zwischen den zwei Prozessen CH_4 Emission (Q_{10}=52.5, Moor, UK-AMo) und CH_4 Aufnahme (Q_{10}=2.5, Wald, IT-IFo). In Laubmischwäldern (Q_{10}=2.5 und 4.9,) fanden wir im Vergleich zu Nadelwäldern (Q_{10}=12.9) eine geringere Temperatursensitivät der N_2O Emissionen. Zusätzlich konnten wir beweisen, dass die Implementierung eines elektrischen Crimpers die Genauigkeit der verwendeten Methode signifikant verbesserte.

1. Introduction

1.1 Soils and climate change

Methane (CH_4) and Nitrous oxide (N_2O) are two important greenhouse gases (GHG). Their abundance in the atmosphere has increased for 150% (CH_4) and 20% (N_2O) respectively in the last 150 years (IPCC 2007). The concentration of CH_4 is 1.803 ppm and 324 ppb for N_2O nowadays. In total, there are six GHGs (IPCC 2007) and together they contribute to the global warming and climate change. GHG alter the earths energy balance by absorbing and re-emitting infrared radiation emitted by Earths surface. These effects of a changing climate are nowadays observable. The last three decades have been warmer at the Earth`s surface than all previous decades since instrumental measurements, and the first decade of the 21st century has been the warmest (IPCC 2013). On the other hand, the amount of precipitation has increased in the Northern hemisphere and additionally, an increase of heavy precipitation has been reported since 1950 (IPCC 2013).

Methane has its origin mainly in microbial processes (69%), but also for a certain extent in fossil fuel burning or biomass burning. These microbial processes are omnipresent in soils. The microbial process which leads to CH_4 production is called methanogenesis and its performed by a specific group of methanogenic Archaea (Conrad 2009). This group of Archaea decomposes organic material under the absence of oxygen, under anoxic conditions (Conrad 2009). There are natural and human sources of microbial CH_4 production, such as rice paddies and the holding of ruminants. The main natural CH_4 sources are wetlands (Nazaries et al. 2013). Soils are also the second most important sink for CH_4. The uptake of CH_4 through soils is called methanotrophy and its due to the microbial oxidation of CH_4 (Le Mer et al. 2001). But most of the CH_4 (80%) is photocemically oxidized by the reaction with OH radicals in the troposhere (Conrad 2009). Soil moisture and temperature both influence the CH_4 flux (Nazaries et al. 2013). The effect of temperature seems to be more pronounced for methanogenese (Singh et al. 2010) compared with methanotrophy (Le Mer et al. 2001). Soil moisture on the other hand influences the diffusivity of O_2 in soils and thus is a major control of methanotrophy (Smith et al. 2000; Le Mer et al. 2001).

Natural sources of N_2O are oceans, soils under natural vegetation and wetlands, whereas human sources of N_2O are mainly due to agricultural practices, biomass burning and industrial activities (Ussiri et al. 2012). Two third of the total N_2O production derives from microbial and fungal respiratory processes in soils, namely nitrification and denitrification (Thomson et al. 2012) with other processes involved, such as chemodenitrification or nitrifier – denitrification (Wrage et al. 2001). The following equations illustrate the major processes. Nitrification is an aerobic process where ammonium is oxidized to nitrate:

Equation 1: Nitrification

$$NH_4^+ \rightarrow NO \rightarrow NO_2^- \overset{\uparrow}{\rightarrow} NO_3^-$$

whereas denitrification is an anaerobic process where nitrate is reduced to N_2:

Equation 2: Denitrification

$$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \overset{\uparrow}{\rightarrow} N_2$$

If one of these processes is not fully completed, N_2O as a by-product is released (see ↑). Again, temperature and soil moisture strongly affect those processes(Skiba et al. 2000; Butterbach-Bahl et al. 2013).

This experiment was conducted to asses future climate impacts and feedback effects on soil greenhouse gas fluxes. Incubation temperature and soil moisture served as two independent climatic factors. The two – factorial study design allowed us to simulate multifaceted climate patterns, such as drought stress or heavy rainfall on different land use types. The investigated soils represent the main laind use types in Europe (Eurostat, 2014). We hypothized that

I. CH_4 and N_2O fluxes differ between land use types

II. CH_4 emissions increase with increasing moisture

III. CH_4 oxidation decreases with increasing moisture

IV. N_2O emissions increase with increasing moisture

V. The temperature sensitivity of the CH_4 fluxes differs between land use types

VI. The temperature sensitivity of the N_2O fluxes differs between the land use types

1.2 The ECLAIRE project

This study is part of the Eclaire project. Eclaire stands for Effects of Climate Change on Air pollution and Response Strategies for European Ecosystems. Its a four year project funded by the EU`s Seventh Framework Programme (FP7) for Research and Technological Development. The project involves 39 partner institutions. The reaseach activities are split to five components:

- Component 1: Emission and exchange processes
- Component 2: Emission and exchange at local to global scales
- Component 3: Ecological response and tresholds
- Component 4: Ecological impacts at European and regional scale
- Component 5: Integrated Risk Assesment & Policy tools

Each component is divided in several working packages. This study is part of Component 1 and working package 2 (WP2): Controlled studies on exchange processes. The objectives of WP2 is the study and quantification of key emission mechanism to provide targeted data that can be used to derive parameterisation of the emission processes for modeling emission processes and to obtain response curves of soil and litter emissions to meteorolical drivers, such as temperature and moisture) for CO_2, CH_4, O_3, N_2O, NO, NO_2 and NH_3 across a wide range of soils.

2. Materials and methods

2.1 Study site and soil sampling

Soil sampling was accomplished by nine research institutes in France, Switzerland, Italy, United Kingdom, Netherlands, Hungary and Ukraine. Nine study sites (see Figure 2-1) have been selected representing the four main land cover types in Europe, namely forest stands, arable land, grassland and peatland (EUROSTAT, 2014).

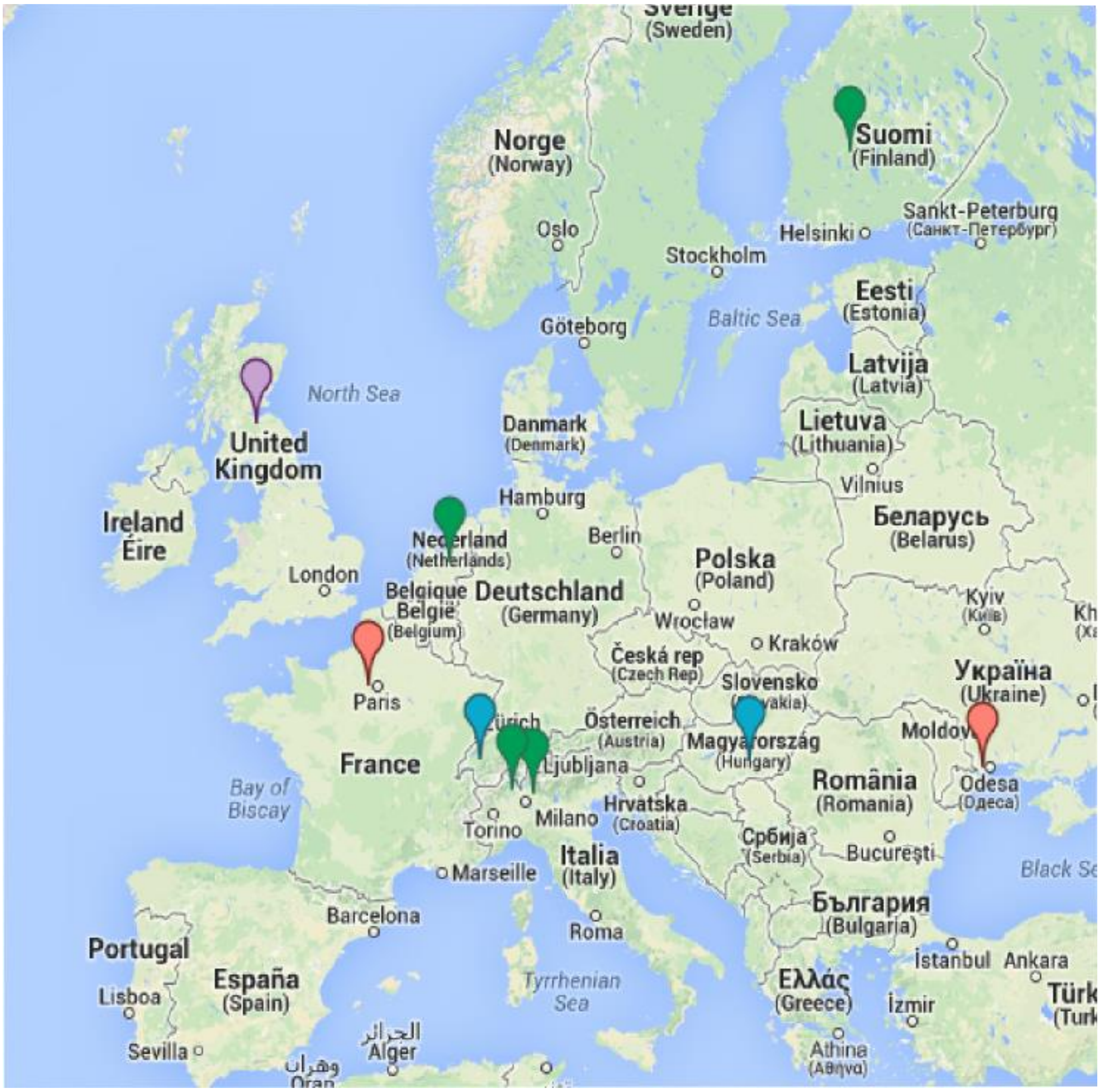

Figure 2-1: Study sites and land use types. Colours represent the land use types: arable=red; forest=green, grassland=blue; peatland=violet.

To facilitate a homogenous sampling design for the various sites, a manual for soil sampling has been developed and sent to the involved research institutes (see Appendix 1). Thereby, soil sampling conditions have been set at a soil temperature of 8 °C for at least five consecutive days in springtime. For each site, 36 stainless soil core cylinders were provided, each containing the first 6 cm of the mineral layer. Detailed informations on the study sites can be found in table 2-1.

Table 2-1: Study sites with related informations on land use, vegetation type, partner institutions, elevation (m), mean annual air temperature (°C) and mean annual precipitation (mm).

Land use	Site code	Site	Vegetation type	Partner institutions	Elevation [m]	Mean temperature [°C]	Mean preciptiation [mm]
Cropland	FR-Gri	Grignon, FR	Sinapis alba/ Zea mays/ Triticum spp./Hordeum vulgare	INRA	125	11.5	600
Cropland	UA-Pet	Petrodolinskoye, UA	Cropland site with crop rotation	ONU	66	10	464
Forest	FI-Hyy	Hyytiäla, FI	Pinus sylvestris	UHEL/FMI	181	3	700
Forest	IT-BFo	Bosco Fontana, IT	Mixed forest (mainly oak and hornbeams)	UNICATT	37	13.2	658
Forest	IT-IFo	Ispra, IT	mixed forest,; main species: Quercus robur (dominant),	JRC	210	12.2	1300
Forest	NL-Spe	Speulderbos, NL	Pseudotsuga menziesii	RIVM	52	9.7	925
Grassland	CH-Po	Posieux, CH	grassland	FDEA-ART	641	8.9	1075
Grassland	HU-	Bugac, HU	Festuca spp.	ERTI-FRI	111	10.4	562
Peatland	UK-AMo	Auchencorth Moss, UK	Calluna vulgaris, Juncus effusus	NERC	270	7.6	1000

2.2 Soil core preparation

Soil samples were sent to the Institute of Soil Research at the University of Natural Resources and Life Sciences, Vienna and were stored in a cooling room at 4°C. Before starting with the measurements, the soil samples had to be adjusted in 5 different moisture steps with six soil samples each. The following moisture steps were used: 10, 20, 40, 60, 80 and (100) in % - water filled pore space (WFPS). For the peatland site, instead of 10% WFPS a higher WFPS of 100 % was used, as the actual soil moisture for this site was higher compared to the other sites.

Three remaining soil sample of each site were taken to determine the actual water content through gravimetric moisture determination (Schmugge T.J. et al. 1980), which served as representive actual mean moisture content for the remaining soil samples per site. This mean moisture content was used to calculate the volumetric water content of each sample, which was muliplied by the particle density to get the estimated WFPS. The particle density was 1.1 g cm^{-3} for the peatland site, 2.0 g cm^{-3} for the forest site FI-Hyy and 2.65 g cm^{-3} for all other sites. The adjustment of a soil sample consists of either adding deionised water or air drying in the cooling room at 4°C, depending on the respective moisture level. Samples were weighed weekly and if necessary, deionised water was added, at least three days before measuring. After gas measurement, actual soil moisture content was determined for each soil sample. Mean actual moisture content was calculated for each group.

2.3 Incubation and gas sampling

To simulate different temperature events, an incubation system was used. Therefore the soil core samples were incubated at five consecutive temperature steps: 5, 10, 15, 20, 25°C. One additional soil core sample was placed inside the incubator to measure changing soil temperature in relation to changing air temperature. Only soil surface temperature was measured, since we assumed the temperature gradient within our soil sample is negligible (Reichstein et al. 2005). Altogether 22 soil core samples could be used in one test series. Soil core samples were put into adopted gas tight glass jars. Two additional glass jars served as control (“blanks”). Samples were incubated for 22 hours at the same temperature level. After incubation, the glass jars were flushed with compressed air and closed afterwards. To avoid underpressure inside the jar, 36 ml of compressed air was injected by syringe before taking the first gas sample. Gas samples of 12 ml were taken by glass syringe at intervals of 0, 10, 20 and 45 minutes. Gas samples were injected into evacuated glass vials sealed with a silicon septum and aluminium cap. After gas sampling, glass chambers were opened and temperature of the incubator was increased by 5°C. Gas sampling and the incubation procedure was repeated till a temperature of 25°C was reached.

2.4 **Gas measurement**

Gas samples were put into a Headspace – autosampler (Agilent 7697A) and analysed with an Agilent 6890N gas chromatograph. The carrier gas was Helium and two coloumns (GS Carbonplot 30m with 0.320 diameter and a 3 µm film) were used to separate the gas components in our gas samples. For CH_4 detection a flame ionisation detector (FID) was used. FID temperature was 300°C and Nitrogen gas (N_2) served as make-up gas. A ^{63}Ni µ-electron-capture-detector (µECD) with an detector temperature of 375°C was used to determine the nitrous oxide concentrations.

2.5 **Data management**

The resulting chromatograms were controlled and transferred into excel sheets. Gas flux was estimated through linear regression. Before calculating the gas flux we had to ensure that changes in the head space concentrations are not only due to fluctuation in ambient air concentration (see Figure 4-1 and 4-2). Therefore, the mean ambient air concentration and standard deviation of the mean of CH_4 and N_2O from the control chambers was calculated. The standard deviation served as treshold range.

Table 2-2: Accuracy of the conducted method. Number of observations (N) per site, number of gas fluxes set to null (N_0) per site and the ratio between N_0/N for CH_4 and N_2O in percent. In total, 150 observations per site were intended. N means number of observations after estimation through nRMSE and N_0 means observations were net change is less than double standard deviation.

Site	CH4			N2O		
	N	N_0	Ratio [%]	N	N_0	Ratio [%]
CH-Pos	122	97	80%	123	70	57%
FI-Hyy	104	35	34%	95	69	73%
FR-Gri	124	81	65%	139	128	92%
HU-Bug	129	103	80%	130	96	74%
IT-BFo	76	62	82%	122	56	46%
IT-IFo	113	72	64%	113	74	65%
NL-Spe	101	89	88%	99	79	80%
UA-Pet	117	97	83%	130	100	77%
UK-AMo	110	74	67%	113	99	88%

If the net change (=y_{max}-y_{min}) of the corresponding gas concentration was less than double the value of the standard deviation of the control chambers, the net gas flux was set to zero. If the net change of the gas concentration was higher than the doubled standard deviation, the estimated flux was accepted, provided that the normalized root-mean-square-error (nRMSE) of the estimated gas flux was below 40%. The following formula was used to calculate the RMSE:

Equation 3: RMSE

$$\mathrm{RMSE}=\sqrt{\frac{1}{\mathrm{n}}\sum_{\mathrm{i}=1}^{\mathrm{n}}(yi_1 - yi_2)^2}$$

where yi_1 is the observed concentration and yi_2 is the estimated concentration. The nRMSE was calculated in relation to the estimated flux:

Equation 4: nRMSE

nRMSE: $\frac{(y_{max} - y_{min})}{RMSE} \times 100$

To express the gas flux in µg CH_4-C m^{-2} h^{-1} for CH_4 and µg N_2O-N m^{-2} h^{-1} for N_2O respectively, the gas flux was corrected concerning temperature and chamber volume with the following formula:

Equation 5: CH_4 flux

CH_4: $R_s = \frac{M_C}{22.41} \times \frac{\Delta c}{A_c} \times V_c \times \frac{273}{(273+\Delta T)}$

Equation 6: N_2O flux

N_2O: $R_s = \frac{M_N}{22.41} \times \frac{\Delta c}{A_c} \times V_c \times \frac{273}{(273+\Delta T)}$

where Rs is the gas flux, M_C and M_N are the molecular weights of Carbon and Nitrogen, 22.41 is the volume of one mol gas at standard temperature and pressure, Δc is the estimated change in gas concentration over one 1h, A_c is the area of the soil sample, V_c is the volume of the glass chamber and ΔT is the air temperature during the incubation. To highlight the differences in our treatments, the gas flux is always expressed as mean flux, either per site, temperature or moisture level. In addition, the gas flux per moisture level (over all temperature levels) is related to the estimated WFPS when comparing it per site or land use type. Only if the the gas flux is expressed per site, temperature and moisture level, the actual WFPS was used.

2.6 **Data analysis**

Statistical data analysis was performed with R-Studio (Version 0.97.551). The data was tested for normal distribution with the Shapiro-Wilk test and variance homogenity was tested with the Levene test. Since the data was not normally distributed, the spearman rank correlation was used to asses the relationship between temperature or moisture and soil chemical parameters with regards to gas exchange. The Kruskal-Wallis test was used to compare gas fluxes between different sites, land use types, temperature and moisture. A post hoc test was performed using multiple comparisons between the treatment with the pgirmess package (V. 1.5.8.)

Regression analysis was performed to investigate the relation between temperature or moisture and the gas flux. Three different regression types were used: linear regression with the formula construct y=bx, exponential regression with the formula $y=b^x$ and polynominal regression with the formula $y=ax^2+bx+c$. Additionally, the differences in the control chambers after implementing the method were tested with a one-way ANOVA, as the data was normally distributed.

Temperature sensitivity of the gas flux is expressed by the Q_{10} value. Q_{10} values were calculated for sites, where a consecutive trend over several (≥3) temperature steps appeared and were calculated as follows:

Equation 7: Q_{10} value

$$Q_{10} = \frac{Respiration\ rate\ R_2\ at\ (T + 10)}{Respiration\ rate\ R_1\ at\ T}$$

Where R_1 is the flux rate at the initial temperature and R_2 is the flux rate at a temperature 10°C higher

3. **Results**

3.1 **Landuse type and CH_4 fluxes**

The Kruskal-Wallis test showed significant differences in CH_4 fluxes between the forest sites and the other land use types. All forest sites served as CH_4 sinks, with highest rates at -23.98 ± 2.92 µg CH_4-C m^{-2} h^{-1} at FI-Hyy followed by IT-IFo with an uptake rate of -9.57 ± 1.50 µg CH_4-C m^{-2} h^{-1}. The other two forest sites (IT-BFo and NL-Spe) revealed only small CH_4 uptake rates.

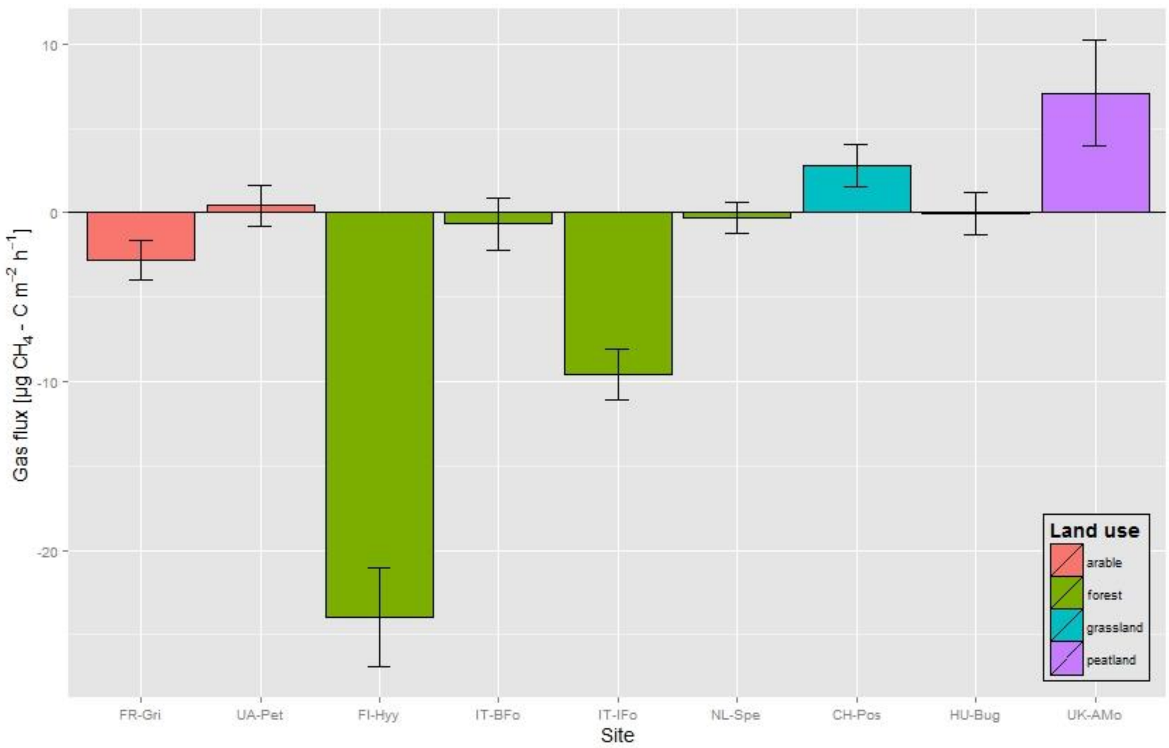

Figure 3-1: Mean CH_4 flux (µg CH_4-C m^{-2} h^{-1}) and standard error per site and land use type. Colours represent different land use types. arable=red; forest=green, grassland=blue; peatland=violet.

The land use type arable land served as small CH_4 sink, whereby one site (FR-Gri) served as CH_4 sink and the other site served as small CH_4 source. The land use grassland had one site with moderate CH_4 emissions (CH-Pos, 2.79 ± 1.28) and one site with almost null CH_4 flux (HU-Bug). The highest emission rate was found at the peatland UK-AMo with a mean flux of 7.09 ± 3.16 µg CH_4-C m^{-2} h^{-1}. Figure 4-1 and Table 4-1 show mean CH_4 fluxes by site and land use types. Among the different sites, significant differences were found for FI-Hyy and IT-IFo. Comparing CH_4 fluxes over the temperature ranges, no significant differences between temperature levels were found across sites. A positive correlation of CH_4 flux with temperature was traced for the peatland site, with the highest CH_4 flux at 25°C (25.81 ± 12.31). At IT-IFo, a negative correlation of temperature with CH_4 flux was found, with the highest uptake rate occuring at 20°C (-15.32 ± 3.9) and the lowest uptake rate at 10°C (-4 ± 2.51). Relatively high CH_4 emissions were found at 10°C (13.14 ± 9.95) for IT-BFo, whereas at all other temperature levels, CH_4 flux remained low for this site.

Table 3-1: Mean CH_4 fluxes and standard error per site and the number of observations (N). Bold letters and numbers represent the mean CH_4 fluxes and standard error per land use type and the number of observations (N) per land use type.

Land use	Site	N	CH_4 flux [µg CH_4-C m^{-2} h^{-1}]
Arable	FR-Gri	124	-2.81 ± 1.18
	UA-Pet	117	0.46 ± 1.21
		241	**-1.22 ± 0.85**
Forest	FI-Hyy	108	-23.98 ± 2.92
	IT-BFo	76	-0.64 ± 1.53
	IT-IFo	113	-9.57 ± 1.5
	NL-Spe	91	-0.33 ± 0.93
		388	**-9.66 ± 1.11**
Grassland	CH-Pos	122	2.79 ± 1.28
	HU-Bug	129	-0.02 ± 1.26
		251	**1.34 ± 0.9**
Peatland	UK-AMo	**110**	**7.09 ± 3.16**

The linear Regression model was not sufficient to describe the CH_4 flux as a function of temperature. At the forest site IT-BFo, an exponential relation between temperature and CH_4 fluxes was found (R^2=0.20 p=0.00). A polynomial relationship was found for IT-IFo (forest) and UK-AMo (peatland), but its determination coefficent remained very low (0.07 – 0.1). Table 3-4 lists the performed regression analyses for CH_4, the corresponding determination coefficent R^2 as well as significance levels for all sites. Analyzing the moisture levels across all sites, differences were observed between the moisture levels. CH_4 emissions increased significantly with increasing moisture level at the peatland site (UK-AMo). Highest emissions were measured at the peatland site at 100% WFPS (41.05 ± 12.9). An exponential function describes the effect of soil moisture on CH_4 flux at the peatland site (R^2=0.28, p=0.000). At the Finnish forest site (FI-Hyy), CH_4 uptake decreased significantly with increasing moisture. Highest uptake rates were measured at 20% WFPS (-37.93 ± 6.51) and the lowest uptake rate at 80% WFPS (-4.81 ± 8.48). A polynomial relation was found between CH_4 uptake and moisture for one forest site (FI-Hyy) and one arable land site (FR-Gri). Neither an exponential nor a polynomial relationship was found for the other sites. Figure 3-2 and table 3-2 provide an overview of CH_4 fluxes influenced by temperature. Figure 3-3 and table 3-3 show CH_4 fluxes influenced by soil moisture.

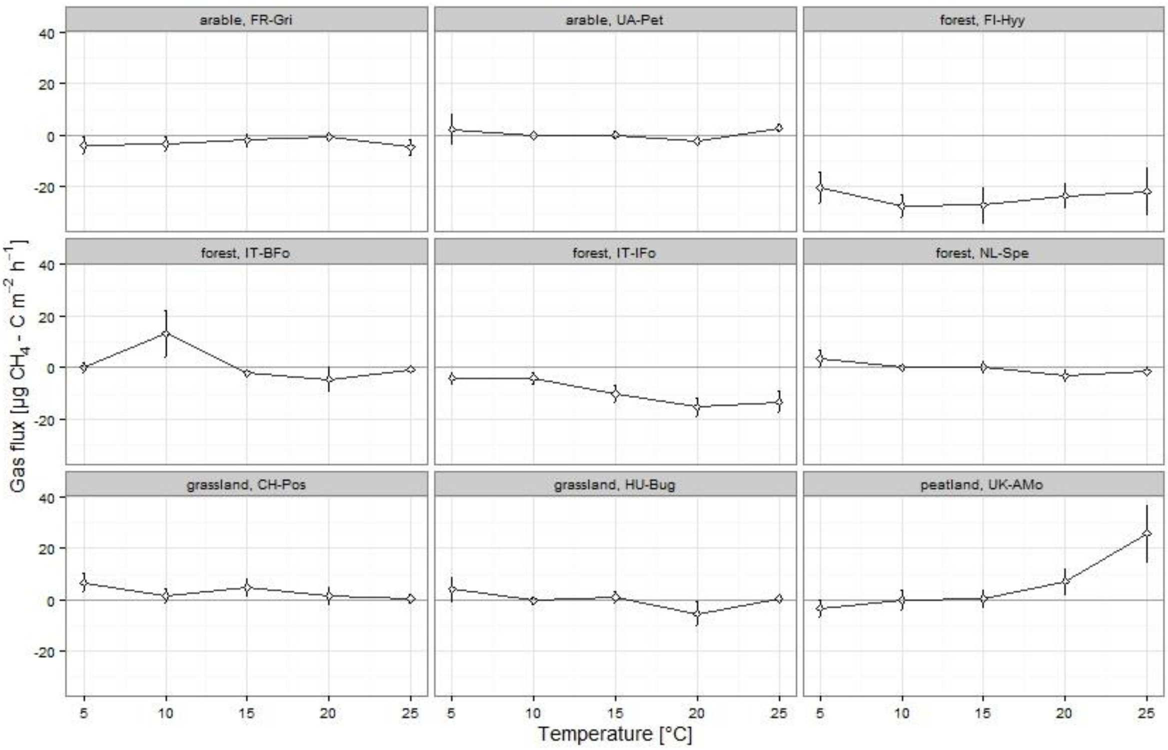

Figure 3-2: Mean CH_4 fluxes (µg CH_4-C m^{-2} h^{-1}) and standard error per site and land use type, influenced by temperature (over all moisture levels). Temperature levels are 5°C, 10°C, 15°C; 20°C and 25°C.

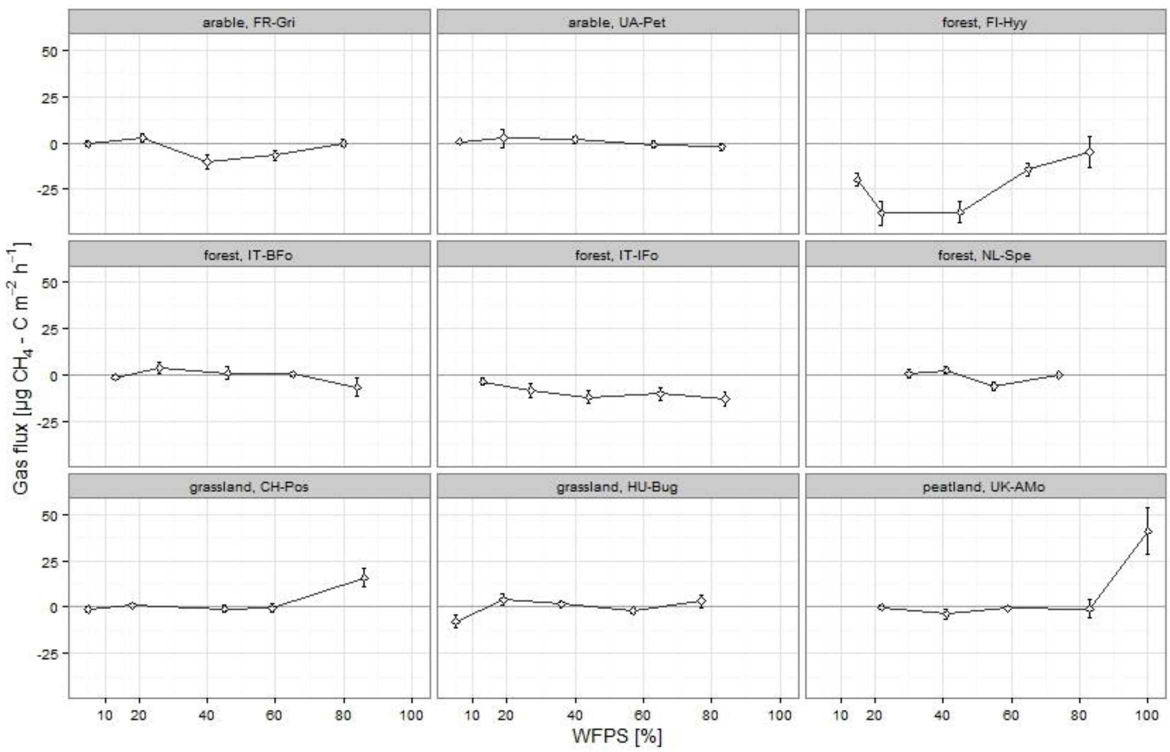

Figure 3-3: Mean CH_4 fluxes (µg CH_4-C m^{-2} h^{-1}) and standard error per site and land use type, influenced by soil moisture (over all temperatures). Moisture levels are in %-WFPS with the levels 10, 20, 40, 60, 80; only the peatland had a 100% WFPS instead of 10% WFPS.

Table 3-2: Mean CH_4 fluxes (µg CH_4-C m^{-2} h^{-1}) and standard error per site influenced by temperature and over all moisture levels. Bold letters represent the mean CH_4 fluxes and standard error per land use type.

Land use	Site	Temperature [°C]				
		5	10	15	20	25
Arable	FR-Gri	-3.84 ± 3.42	-3.26 ± 2.93	-1.86 ± 2.42	-0.53 ± 0.69	-4.69 ± 3.02
	UA-Pet	2.25 ± 5.87	-0.03 ± 1.06	0.16 ± 1.48	-2.28 ± 1.3	2.84 ± 1.37
		-1.16 ± 3.21	**-1.46 ± 1.43**	**-0.94 ± 1.48**	**-1.41 ± 0.74**	**-1.08 ± 1.77**
Forest	FI-Hyy	-20.27 ± 6.12	-27.41 ± 4.5	-27.09 ± 6.91	-23.49 ± 4.78	-21.76 ± 9.17
	IT-BFo	-0.03 ± 2.03	13.14 ± 8.9	-2.13 ± 1.46	-4.59 ± 4.59	-0.81 ± 0.81
	IT-IFo	-4.08 ± 2.29	-4 ± 2.24	-10.22 ± 3.24	-15.32 ± 3.49	-13.28 ± 4.28
	NL-Spe	3.49 ± 3.25	0 ± 0	0.15 ± 2.09	-3.25 ± 2.29	-1.67 ± 1.67
		-6.98 ± 2.53	**-7.89 ± 2.32**	**-10.84 ± 2.49**	**-12.28 ± 2.14**	**-9.58 ± 2.73**
Grassland	CH-Pos	6.57 ± 3.65	1.54 ± 2.6	4.73 ± 3.21	1.56 ± 3.27	0.38 ± 1.46
	HU-Bug	4.08 ± 4.5	-0.28 ± 1.44	1.02 ± 1.98	-5.34 ± 4.69	0.35 ± 0.86
		5.3 ± 2.88	**0.61 ± 1.46**	**2.77 ± 1.84**	**-1.75 ± 2.83**	**0.36 ± 0.81**
Peatland	UK-AMo	**-3.3 ± 3.4**	**-0.04 ± 3.82**	**0.49 ± 3.22**	**7.18 ± 5.01**	**25.81 ± 11.01**

Table 3-3: Mean CH_4 fluxes (µg CH_4-C m^{-2} h^{-1}) per site influenced by soil moisture and over all temperatures. Bold letters represent the mean CH_4 fluxes and standard error per land use type.

Land use	Site	Soil moisture [%WFPS]					
		10	20	40	60	80	100
Arable	FR-Gri	-0.58 ± 1.51	2.6 ± 2.47	-10.16 ± 3.93	-6.68 ± 2.81	-0.26 ± 1.86	x
	UA-Pet	0.57 ± 0.55	2.68 ± 4.94	1.87 ± 1.97	-0.73 ± 1.59	-2.11 ± 1.66	x
		-0.01 ± 0.8	**2.64 ± 2.84**	**-4.91 ± 2.54**	**-3.98 ± 1.74**	**-1.17 ± 1.24**	
Forest	FI-Hyy	-19.83 ± 3.61	-37.93 ± 6.51	-37.41 ± 5.5	-14.36 ± 3.59	-4.81 ± 8.48	x
	IT-BFo	-1.29 ± 1.29	3.8 ± 3.23	1.02 ± 3.49	0.45 ± 1.1	-6.69 ± 5.11	x
	IT-IFo	-3.64 ± 2.02	-8.36 ± 3.73	-11.85 ± 3.22	-10.17 ± 3.47	-13.07 ± 3.64	x
	NL-Spe	ND	0.5 ± 2.17	2.61 ± 1.82	-6.15 ± 2.49	0 ± 0	x
		-9.08 ± 1.9	**-12.22 ± 2.94**	**-12.51 ± 2.63**	**-8.12 ± 1.64**	**-6.31 ± 2.47**	
Grassland	CH-Pos	-1.1 ± 1.26	0.76 ± 0.96	-0.94 ± 2.11	-0.67 ± 2.38	15.95 ± 4.72	x
	HU-Bug	-7.75 ± 3.56	4 ± 2.96	1.71 ± 1.8	-2.02 ± 1.11	3.28 ± 3.49	x
		-4.42 ± 1.93	**2.41 ± 1.58**	**0.51 ± 1.37**	**-1.37 ± 1.27**	**9.75 ± 3.07**	
Peatland	UK-AMo	**x**	**-0.17 ± 1.35**	**-3.8 ± 2.63**	**-0.63 ± 0.63**	**-0.93 ± 5.03**	**41.05 ± 12.9**

Table 3-4: Regression analyses for CH_4 fluxes per site and the two independent factors temperature (TEMP,5°C - 25°C) and soil moisture (WFPS,10% -80%), the number of observations (N), determination coefficient (R^2) and significance level (p). Superscript letters represent the function used for regression analyses: [a]exponential function (y=bx); [b]polynomial function (y=ax2 + bx + c). N.S.= not significant

Land use	Site	Factor	N	R^2	p
Arable	FR-Gri	TEMP	124	-	N.S.
	UA-Pet		117	-	N.S.
Forest	FI-Hyy		104	-	N.S.
	IT-BFo		76	0.20	0.000[a]
	IT-IFo		113	0.07	0.017[b]
	NL-Spe		101	-	N.S.
Grassland	CH-Pos		122	-	N.S.
	HU-Bug		129	-	N.S.
Peatland	UK-AMo		110	0.10	0.002[b]
Arable	FR-Gri	WFPS	124	0.05	0.034[b]
	UA-Pet		117	-	N.S.
Forest	FI-Hyy		104	0.18	0.000[b]
	IT-BFo		76	-	N.S.
	IT-IFo		113	-	N.S.
	NL-Spe		101	-	N.S.
Grassland	CH-Pos		122	0.19	0.000[b]
	HU-Bug		129	-	N.S.
Peatland	UK-AMo		110	0.28	0.000[a]

3.2 Soil chemical and physical parameters and CH_4 fluxes

Spearman rank correlation showed a weak positive correlation between CH_4 fluxes and nitrate (Rho=0.15, p=0.000) and the pH was positively correlated with CH_4 fluxes (Rho=0.09, p=0.03). The C/N ratio was negatively correlated with CH_4 fluxes (Rho=-0.15, p=0.001). No correlation was found between ammonium and CH_4 fluxes and CH_4 fluxes and bulk density, respectively.

Table 3-5: Spearman rank correlation between CH_4 fluxes and the soil physical and chemical parameters. Rho= correlation coefficient; p=significance niveau

	Rho	**p**
CH_4 + ammonium	-	-
CH_4 + nitrate	0.15	0.001
CH_4 + bulk density	-	-
CH_4 + pH	0.10	0.030
CH_4 + C/N	-0.15	0.001

3.3 Temperature sensitivity of CH_4 fluxes

Q_{10} values were calculated to express the temperature sensitivity of CH_4 emissions for those sites, where a consecutive trend, being either gas uptake or emission, was measured over at least three temperature steps. The Q_{10} values represent gas fluxes per site over all moisture levels. Regarding CH_4, a consecutive trend in gas fluxes was found for two forest sites (FI-Hyy and IT-IFo) and the peatland UK-AMo (see Table 3-6). For all other sites, CH_4 fluxes did not indicate a trend. Notably, the obtained Q_{10} values differ strongly between the sites.

Table 3-6: Temperature sensitivity of CH_4 fluxes from selected sites with corresponding land use type. Process describes wether it is mainly gas uptake or emission at the site. T= Initial temperature

site	land use	process	T [°C]	Q_{10}
FI-Hyy	forest	uptake	15	0.8
IT-IFo	forest	uptake	10	2.5
UK-AMo	peatland	emission	15	52.5

We found the main process at the peatland to be CH_4 emission with an associated Q_{10} value of 52.5. Q_{10} values differ widely between the different moisture levels, which is illustrated in Figure 3-4. At lower and medium moisture levels between 22% WFPS and 85% WFPS, CH_4 fluxes were fluctuating between CH_4 uptake and emission with increasing temperature. Calculated Q_{10} values for those moisture levels are 1 in most cases. A considerable increase in CH_4 emissions was only detected at the highest WFPS level. Taking only the highest moisture level into account, the Q_{10} was downsized to 20.The main process at both forest sites was CH_4 oxidation, but Q_{10} values varied between the two sites.

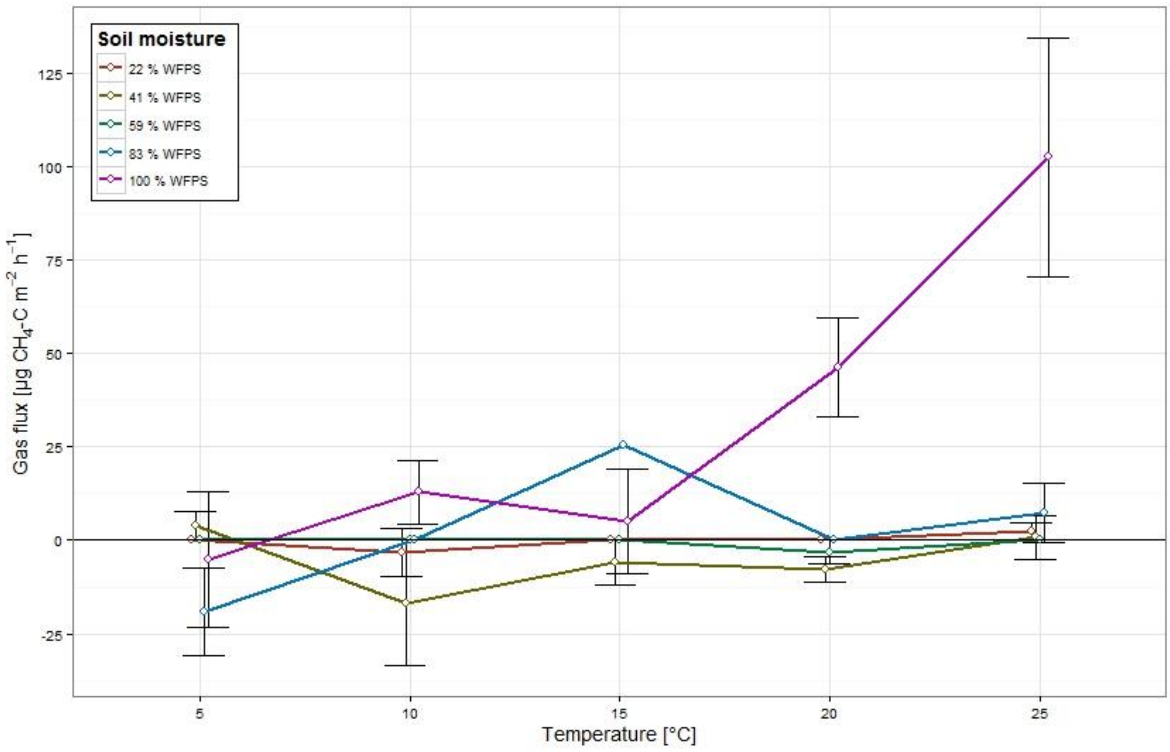

Figure 3-4: Mean CH_4 fluxes and standard error per temperature level at the peatland UK-AMo. Colours represent the different moisture levels

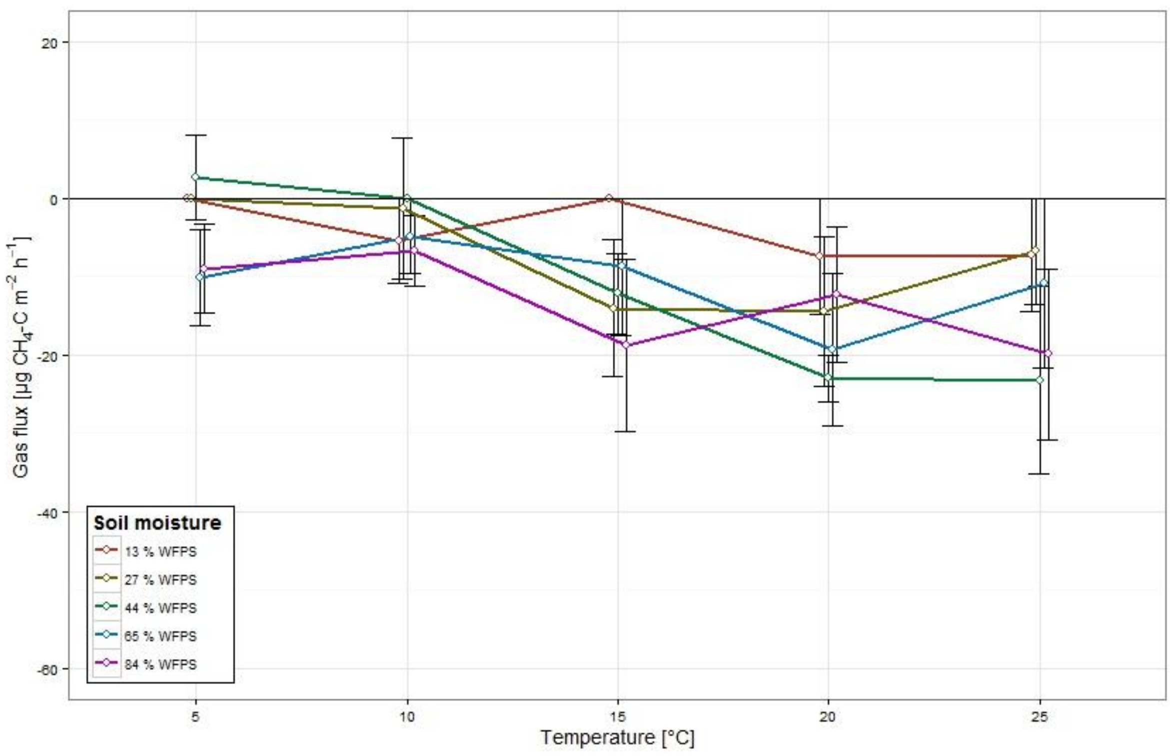

Figure 3-5: Mean CH_4 fluxes and standard error per temperature level at the forest site IT-IFo. Colours represent the moisture levels

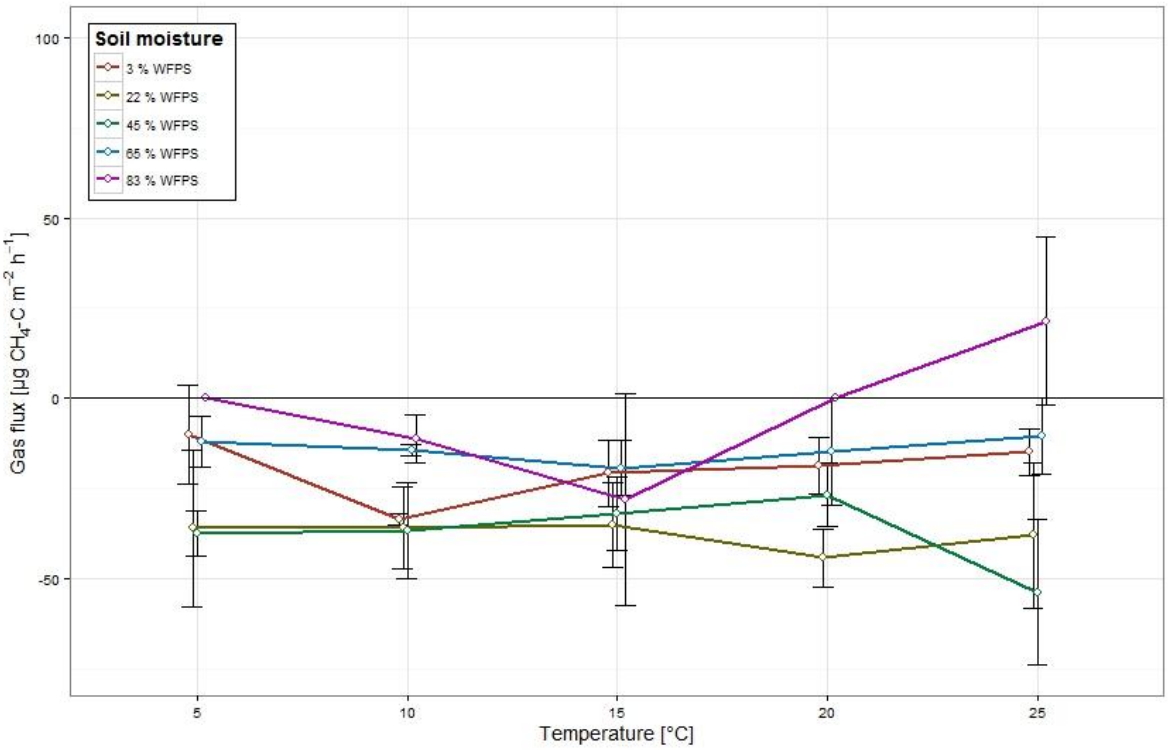

Figure 3-6: Mean CH_4 fluxes and standard error per temperature level at the forest site FI-Hyy. Colours represent the moisture levels

At IT-IFo, we found a Q_{10} of 2.5 which indicates an increase of CH_4 oxidation with increasing temperature. CH_4 uptake was present at almost all treatments except 44% WFPS and 5°C. In contrary to the peatland site, the forest sites showed no significant differences in temperature response between the moisture levels. At IT-IFo, the CH_4 uptake showed a slight increase with increasing temperature (Figure 3-5). At FI-Hyy, a Q_{10} of 0.8 was found, which indicates a decrease of CH_4 uptake with increasing temperature. CH_4 oxidation was present at all treatments, except at highest WFPS and highest temperature, were CH_4 emissions occured. The relationship between temperature sensitivity and soil moisture is illustrated in Table 3-7. Taking each moisture level on its own into account, a significant correlation between temperature and CH_4 flux was found for IT-IFo (Rho=-0.68 at 40% WFPS) and UK-AMo (Rho=0.66, 100% WFPS. No correlation was found for all other moisture levels at those sites. No correlation at all between CH_4 uptake and temperature was disclosed at the Finnish site.

Table 3-7: Spearman rank correlation between CH_4 fluxes and temperature for each moisture level (WFPS, 10%-100%), Determination coefficient (Rho), significance level (p). X= no gas fluxes measured for this moisture level

Site	Soil moisture [% WFPS]											
	10		20		40		60		80		100	
	Rho	p	Rho	p	Rho	p	Rho	p	Rho	p	Rho	p
FI-Hyy	-	-	-	-	-	-	-	-	-	-	x	x
IT-IFo	-	-	-		-0.68	0.00	-	-	-	-	x	x
UK-AMo	x	x	-	-	-	-	-	-	-	-	0.66	0.00

3.4 Landuse type and N_2O fluxes

The Kruskal – Wallis test showed significant differences in N_2O fluxes between land use types and sites. The arable land sites differed significantly from forest and grassland sites and the peatland site differed significantly from the forest sites. Apart from that, no differences were found between land use types. Within the forest sites we found significant differences between FI-Hyy and the three other forest sites. The highest N_2O emissions were found at the forest site IT-BFo with 358.86 ± 78.73 µg N_2O-N m^{-2} h^{-1}. Similarly, high N_2O emissions were also found for the two other forest sites (NL-Spe and IT-IFo) with mean flux rates of 43.09 ± 27.18 and 17.71 ± 4.86 µg N_2O-N m^{-2} h^{-1} respectively. Grassland sites differed among each other, with a high N_2O flux at CH-Pos at a rate of 102.78 ± 29.13 µg N_2O-N m^{-2} h^{-1} and a relatively low N_2O flux at HU-Bug (6.07 ± 1.56 µg N_2O-N m^{-2} h^{-1}). Within the arable land sites, no significant differences were found. At the peatland site and the two arable land sites, N_2O flux was almost null. Mean fluxes of N_2O broken down by site can be found in figure 3-7.

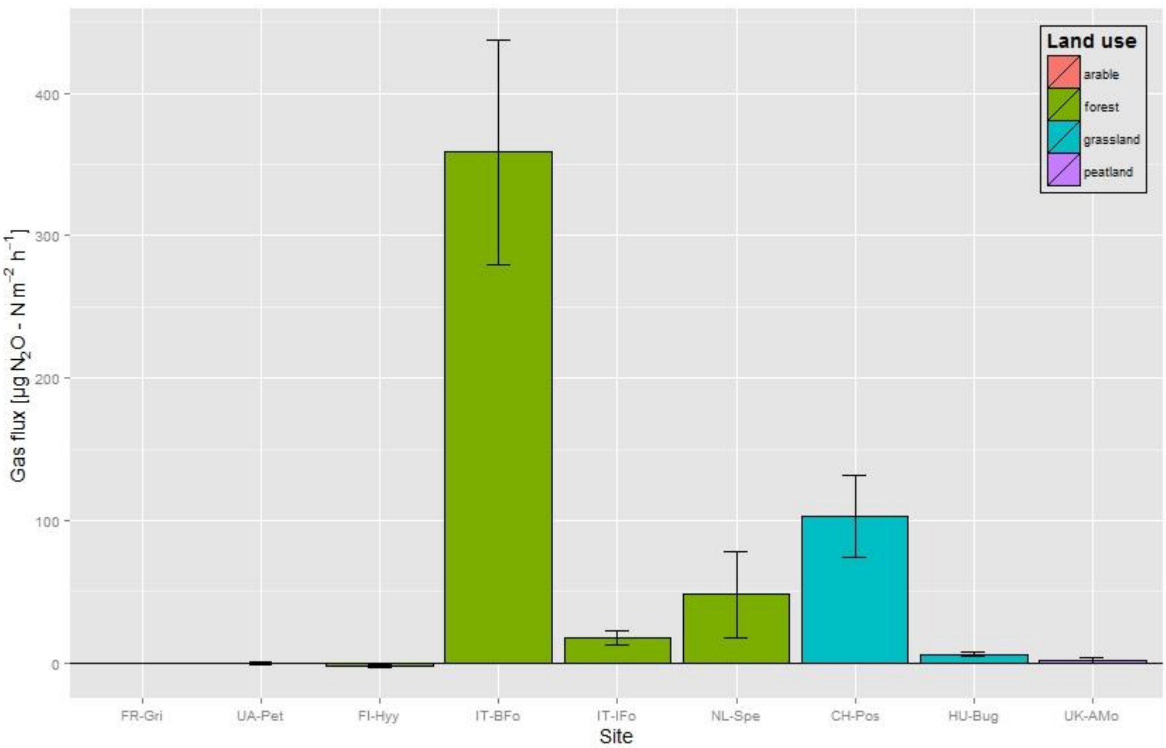

Figure 3-7: Mean N_2O flux (µg N_2O-N m^{-2} h^{-1}) and standard error per site and land use type. Colours represent the land use types. arable=red; forest=green, grassland=blue; peatland=violet.

When looking at the effect of temperature at each site (see Figure 3-8 and table 3-9), no significant differences in N_2O fluxes were found. A postive correlation between N_2O flux and temperature was found (R=0.32, p=0.00) at the arable land site (FR-Gri), but N_2O flux remained very low with a maximum of 1.18 ± 1.03 µg N_2O -N m^{-2} h^{-1} at 25 °C. A negative correlation of N_2O flux and temperature was found for the forest site FI-Hyy, where we measured an emission of N_2O at the lowest temperature level (5°C) and an uptake of N_2O at the highest temperature level (-7.18 ± 1.97 at 25°C). Again, the highest N_2O emissions were found at the forest site IT-BFo at 20°C with 775.51 ± 343.33 µg N_2O-N m^{-2} h^{-1}. Also for NL-Spe, we found high N_2O emissions at 25°C. At IT-IFo, the highest N_2O emissions were found at 15°C. For FI-Hyy, N_2O flux was low and fluctuated between N_2O uptake and emission.

Table 3-8: Mean N_2O fluxes and standard error per site and the number of observations (N). Bold letters and numbers represent the mean CH_4 fluxes and standard error per land use type and the number of observations.

Land use	Site	N	N_2O flux [µg N_2O-N m^{-2} h^{-1}]
Arable	FR-Gri	139	-0.29 ± 0.36
	UA-Pet	130	-0.44 ± 0.78
		269	**-0.36 ± 0.42**
Forest	FI-Hyy	95	-2.59 ± 0.75
	IT-BFo	122	358.86 ± 78.73
	IT-IFo	113	17.71 ± 4.86
	NL-Spe	89	47.93 ± 30.2
		419	**118.86 ± 24.95**
Grassland	CH-Pos	123	102.78 ± 29.13
	HU-Bug	130	5.79 ± 1.53
		253	**52.94 ± 14.48**
Peatland	UK-AMo	**113**	**1.29 ± 1.99**

High N_2O emissions were also found at the grassland site CH-Pos, with a maximum rate of 194.15 ± 120.56 µg N_2O -N m^{-2} h^{-1} at 10°C. For HU-Bug, the highest emissions were found at 15°C. At the arable land sites, N_2O flux was very low, with highest emissions at UA-Pet at 15°C. Emissions at the peatland site were also very low and decreased with increasing temperature. N_2O flux could be described with temperature at FI-Hyy, FR-Gri and UA-Pet (all polynomial), but the determination coefficent remained low with R^2 between 0.03 and 0.11 (see Table 3-10). For all other sites, N_2O fluxes could not be described with temperature.

Separated by soil moisture levels (Figure 3-9 and table 3-10), differences were found at three forest sites (IT-BFo, IT-IFo and NL-Spe), two grassland sites (CH-Pos and HU-Bug) and one arable land site (UA-Pet). Spearman correlation showed up a positive correlation between moisture and N_2O flux for all sites, except the forest site FI-Hyy. Correlation coefficients range between 0.19 (UK-AMo) and 0.76 (IT-BFo). N_2O emissions increased with increasing moisture levels at the forest sites, with highest emissions at 60%WFPS (865.15 ± 286.39) at IT-BFo and 80%WFPS at NL-Spe (174.37 ± 109.49) respectively. At IT-BFo, significant differences were found between high moisture content (60-80% WFPS) and low moisture contents (10-40%WFPS). Also for IT-IFo, significant differences were detected between high and low moisture content, except for 40% and 60% WFPS with maximum rate of 52.5 ± 17.15 µg N_2O-N m^{-2} h^{-1}(80%WFPS). Even though we observed a high N_2O emissions at NL-Spe with a maximum rate of 174.37 ± 109.49 µg N_2O-N m^{-2} h^{-1} at 80%, significant differences resulted only between 20% and 80% WFPS. For the grassland site CH-Pos, differences were found between low moisture levels (10%-40% WFPS) and high moisture levels (60-80% WFPS), with highest emission of 410 ± 110.41 µg N_2O-N m^{-2} h^{-1} at 60% WFPS. At HU-Bug, significant differences were found between 10% and 80% WFPS. For the arable land sites, significant differences were found between 10% and 80% WFPS at UA-Pet. No differences were found for the peatland site UK-AMo. An exponential relationship between moisture and N_2O flux was found for the grassland sites (CH-Pos and HU-Bug) and three forest sites (IT-BFo, IT-IFo and NL-Spe) with a maximum R^2=0.76 at IT-BFo. A polynomial relationship was found at the two arable land sites (FR-Gri and UA-Pet) and one forest site (FI-Hyy) with highest R^2=0.17 at UA-Pet. Only for the peatland site, neither an exponential nor a polynomial relation was found. All figures and tables for mean N_2O fluxes influenced by temperature and soil moisture as well as the results from regression analysis are shown in the following pages.

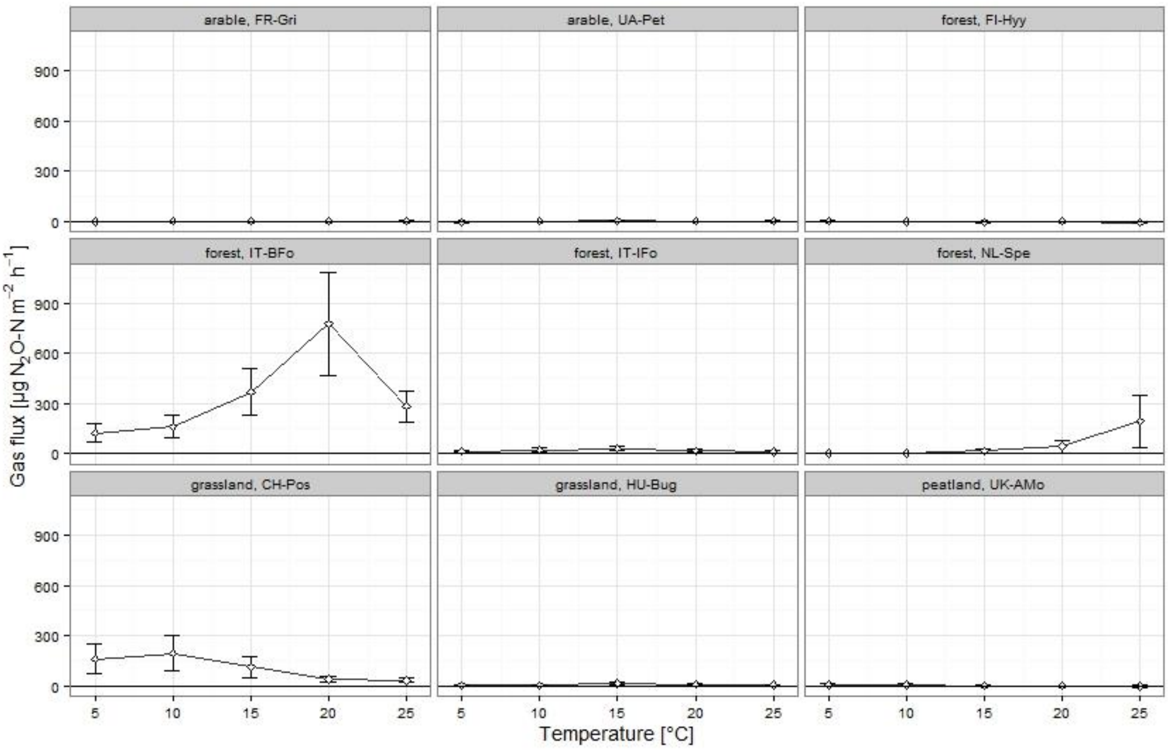

Figure 3-8: Mean N_2O fluxes (µg N_2O-N m^{-2} h^{-1}) and standard error per site and land use type, influenced by temperature (over all moisture levels). Temperature levels are 5°C, 10°C, 15°C; 20°C and 25°C.

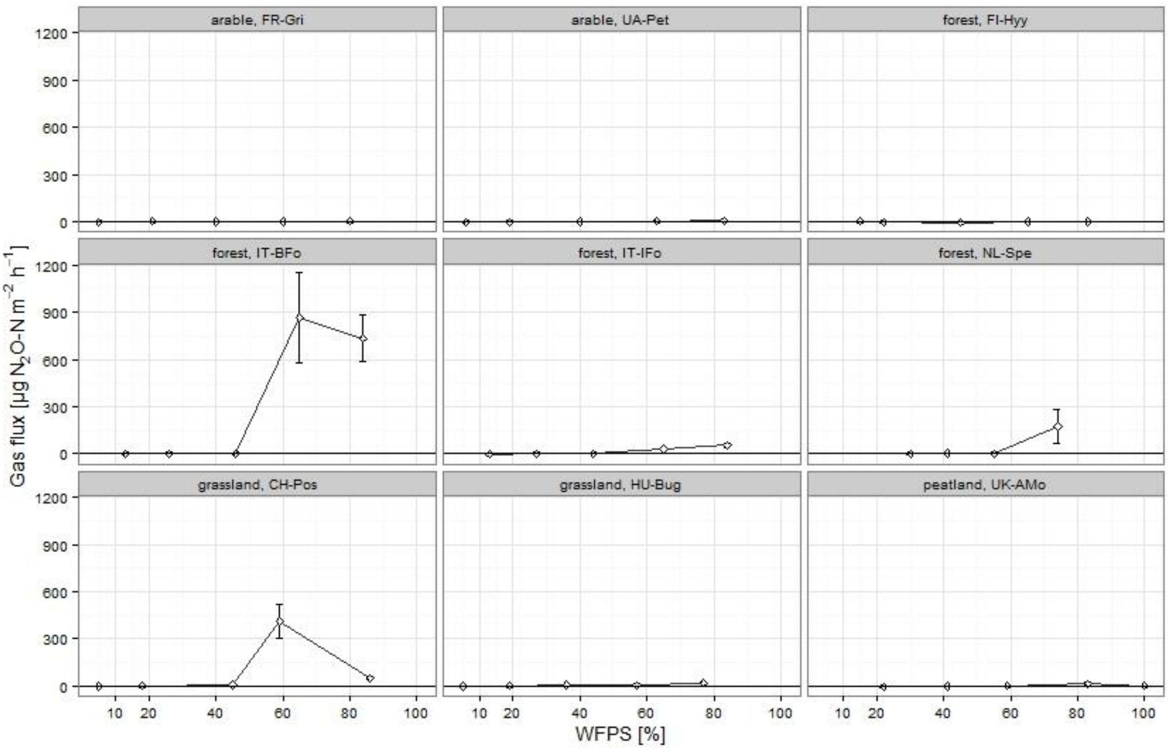

Figure 3-9: Mean N_2O fluxes (µg N_2O-N m^{-2} h^{-1}) and standard error per site and land use type, influenced by soil moisture (over temperatures). Moisture levels are in %-WFPS with the levels 10%, 20%, 40%, 60%, 80%; only the peatland had 100% WFPS instead of 10% WFPS.

Table 3-9: Mean N_2O fluxes (µg N_2O-N m^{-2} h^{-1}) per site and land use type influenced by temperature and over all moisture levels. Bold letters represent the mean CH_4 fluxes and standard error per land use type.

Land use	Site	Temperature [°C]				
		5	10	15	20	25
Arable	FR-Gri	-3.02 ± 1.28	-0.78 ± 0.54	0.45 ± 0.45	0.41 ± 0.41	1.18 ± 0.92
	UA-Pet	-5.24 ± 1.82	-0.6 ± 1.41	3.07 ± 1.34	0.54 ± 0.54	0.13 ± 2.55
		-4.16 ± 1.12	**-0.69 ± 0.74**	**1.69 ± 0.69**	**0.47 ± 0.33**	**0.67 ± 1.31**
Forest	FI-Hyy	1.31 ± 0.91	-2.69 ± 1.29	-4.75 ± 3.04	-0.59 ± 0.59	-7.18 ± 1.76
	IT-BFo	122.45 ± 57.46	159.94 ± 66.94	368.33 ± 139.67	775.51 ± 307.09	282.58 ± 91.42
	IT-IFo	12.03 ± 6.35	19.83 ± 12.91	29.81 ± 13.68	15.71 ± 10.14	8.76 ± 7.05
	NL-Spe	2.52 ± 1.76	2.22 ± 1.76	14.83 ± 11.38	42.47 ± 38.14	192.45 ± 159.78
		32.2 ± 14.07	**50.59 ± 20.34**	**131.82 ± 49.13**	**239.66 ± 96.19**	**130.73 ± 45.48**
Grassland	CH-Pos	161.45 ± 89.42	194.15 ± 107.84	112.27 ± 62.82	39.84 ± 15	31.58 ± 12.36
	HU-Bug	2.14 ± 2.26	1.77 ± 1.26	13.86 ± 7.35	9.14 ± 3.3	3.77 ± 2.02
		80.02 ± 44.85	**88.89 ± 50.06**	**65.41 ± 33.61**	**23.94 ± 7.65**	**17.43 ± 6.38**
Peatland	UK-AMo	**5.88 ± 6.44**	**5.02 ± 4.95**	**-0.02 ± 0.91**	**0 ± 0**	**-4.55 ± 5.35**

Table 3-10: Mean N_2O fluxes (µg N_2O-N m^{-2} h^{-1}) per site and standard error influenced by soil moisture and over all temperatures. Bold letters represent the mean N_2O fluxes and standard error per land use type.

Land use	Site	Soil moisture [%WFPS]					
		10	20	40	60	80	100
Arable	FR-Gri	-2.85 ± 1.11	0.53 ± 1.23	0 ± 0	0 ± 0	1.13 ± 0.64	x
	UA-Pet	-4.33 ± 1.37	-3.07 ± 2.02	-1.79 ± 1	1.96 ± 1.79	5.61 ± 1.79	x
		-3.59 ± 0.88	-1.31 ± 1.21	-0.86 ± 0.49	0.89 ± 0.81	3.25 ± 0.95	
Forest	FI-Hyy	0.7 ± 1.93	-4.24 ± 1.7	-6.01 ± 1.66	-2.49 ± 1.37	0.01 ± 1.23	x
	IT-BFo	-1.52 ± 1.05	-0.24 ± 1.16	0.02 ± 1.66	865.15 ± 286.39	735.36 ± 152.02	x
	IT-IFo	-1.95 ± 1.09	-0.49 ± 0.49	1.22 ± 1.24	30.27 ± 10.36	52.5 ± 17.15	x
	NL-Spe	ND	-1.21 ± 0.83	3.01 ± 1.44	1.35 ± 0.94	174.37 ± 109.49	x
		-1.05 ± 0.76	-1.41 ± 0.53	-0.41 ± 0.84	278.82 ± 98.77	271.47 ± 59.86	
Grassland	CH-Pos	-3.03 ± 1.25	0.48 ± 1.33	6.02 ± 3.1	410.32 ± 110.41	49 ± 9.82	x
	HU-Bug	-1.49 ± 1.12	2.28 ± 1.11	5.46 ± 2.2	3.64 ± 1.53	19.8 ± 6.57	x
		-2.23 ± 0.83	1.38 ± 0.87	5.73 ± 1.85	210.68 ± 62.2	33.46 ± 6.1	
Peatland	UK-AMo	x	-4.72 ± 4.24	-0.92 ± 0.64	-0.65 ± 2.05	13.16 ± 8.14	0.84 ± 0.84

Table 3-11: Regression analyses for N_2O fluxes per site and the two independent factors temperature (TEMP, 5°C - 25°C) and soil moisture (WFPS,10% -80%), the number of observations (N), determination coefficient (R^2) and significance level (p). Superscript letters represent the function used for regression analyses: [a]exponential function (y=bx); [b]polynomial function (y=ax2 + bx + c). N.S.= not significant

Land use	Site	Factor	N	R^2	p
Arable	FR-Gri	TEMP	139	0.11	0.000[b]
	UA-Pet		130	0.08	0.004[b]
Forest	FI-Hyy		95	0.08	0.020[b]
	IT-BFo		122	-	N.S.
	IT-IFo		113	-	N.S.
	NL-Spe		99	-	N.S.
Grassland	CH-Pos		123	-	N.S.
	HU-Bug		130	-	N.S.
Peatland	UK-AMo		113	-	N.S.
Arable	FR-Gri	WFPS	139	0.08	0.003[b]
	UA-Pet		130	0.17	0.000[b]
Forest	FI-Hyy		95	0.11	0.004[b]
	IT-BFo		122	0.68	0.000[a]
	IT-IFo		113	0.36	0.000[a]
	NL-Spe		99	0.2	0.000[a]
Grassland	CH-Pos		123	0.33	0.000[a]
	HU-Bug		130	0.18	0.000[a]
Peatland	UK-AMo		113	-	N.S.

3.5 Soil chemical and physical parameters and N_2O fluxes

The N_2O fluxes was positively correlated with ammonium and nitrate concentrations, but the determination coefficent was low (Rho=0.09 and Rho=0.14 respectively). There was no correlation between N_2O fluxes and pH. A negative correlation was found between C/N ratio and N_2O fluxes (Rho=-012, p=0.007), as well as between N_2O fluxes and bulk density. Considering only the forest sites, the correlation between C/N ratio and N_2O fluxes indicated a much stronger relationship (Rho=-0.34, p=0.00).

Table 3-12: Spearman rank correlation for the N_2O fluxes and soil physical and chemical parameters. Rho= correlation coefficient. p= significance niveau

	Rho	p
N_2O + ammonium	0.09	0.047
N_2O+ nitrate	0.14	0.002
N_2O + bulk density	-0.12	0.000
N_2O + pH	-	-
N_2O + C/N	-0.12	0.007

3.6 Temperature sensitivity of N_2O fluxes

Q_{10} value determination was only feasible for the forest stands (see Table 3-13), since all other sites showed no steady increase of N_2O emissions over at least three temperature steps. Initial temperature varied between the sites, from 5°C (IT-IFo) up to 15°C (NL-Spe). The reported Q_{10} values ranged from 2.5 (IT-IFo) to 12.9 (NL-Spe). Q_{10} values for the forest sites increased with increasing temperature, and the coniferous forest had a much higher Q_{10} than the deciduous forests.

Table 3-13: Temperature sensitivity of N_2O fluxes for selected sites with corresponding land use type. Process describes wether it is mainly gas uptake or emission at the site.. T= Initial temperature

site	land use type	process	T [°C]	Q_{10}
IT-BFo	forest	emission	10	4.9
IT-IFo	forest	emission	5	2.5
NE-Spe	forest	emission	15	12.9

Also, Q_{10} values differed notably at the forest stands, when considering each moisture level on its own. At IT-BFo for instance , considerable N_2O fluxes were found only at higher moisture content (68% and 85% WFPS). At lower moisture content, N_2O flux was almost null (see Figure 3-10). The corresponding Q_{10} values where 7.2 for 65% WFPS and 3.8 for 85% WFPS compared to an overall Q_{10} of 4.9. At low and medium moisture content (11% - 50% WFPS), corresponding Q_{10} values are 1.

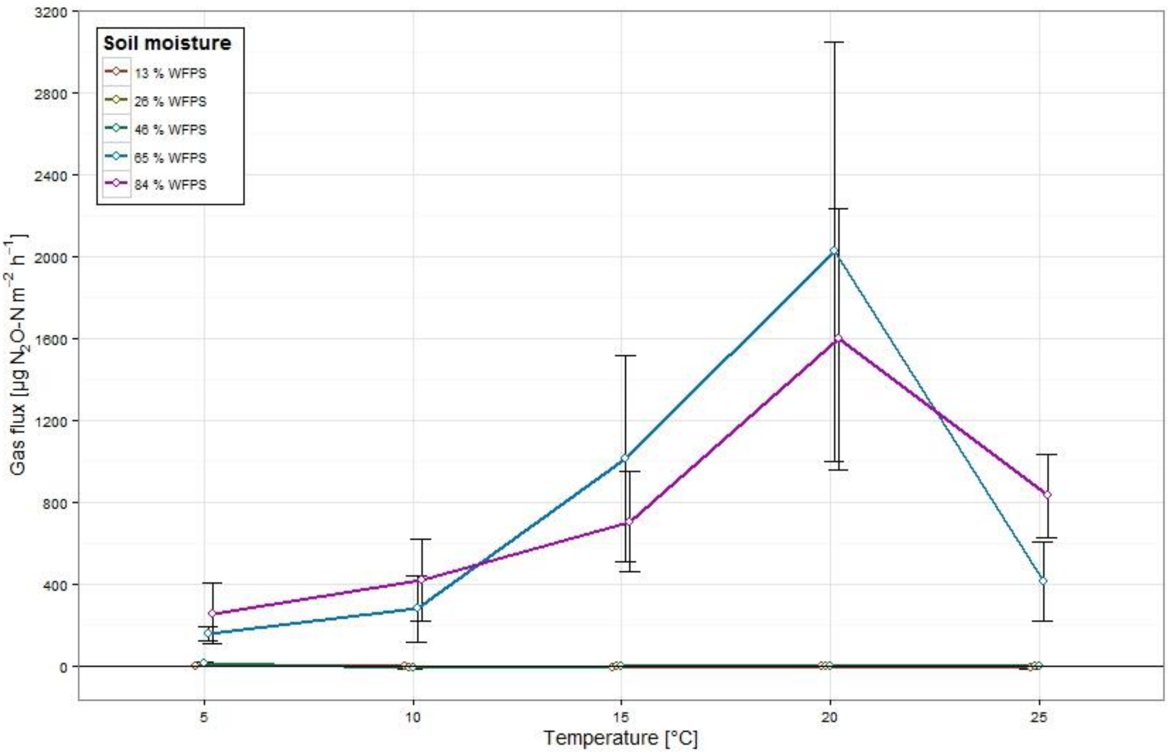

Figure 3-10: Mean N_2O fluxes (µg N_2O-N m^{-2} h^{-1}) and standard error at the forest site IT-BFo. Colours represent the moisture levels

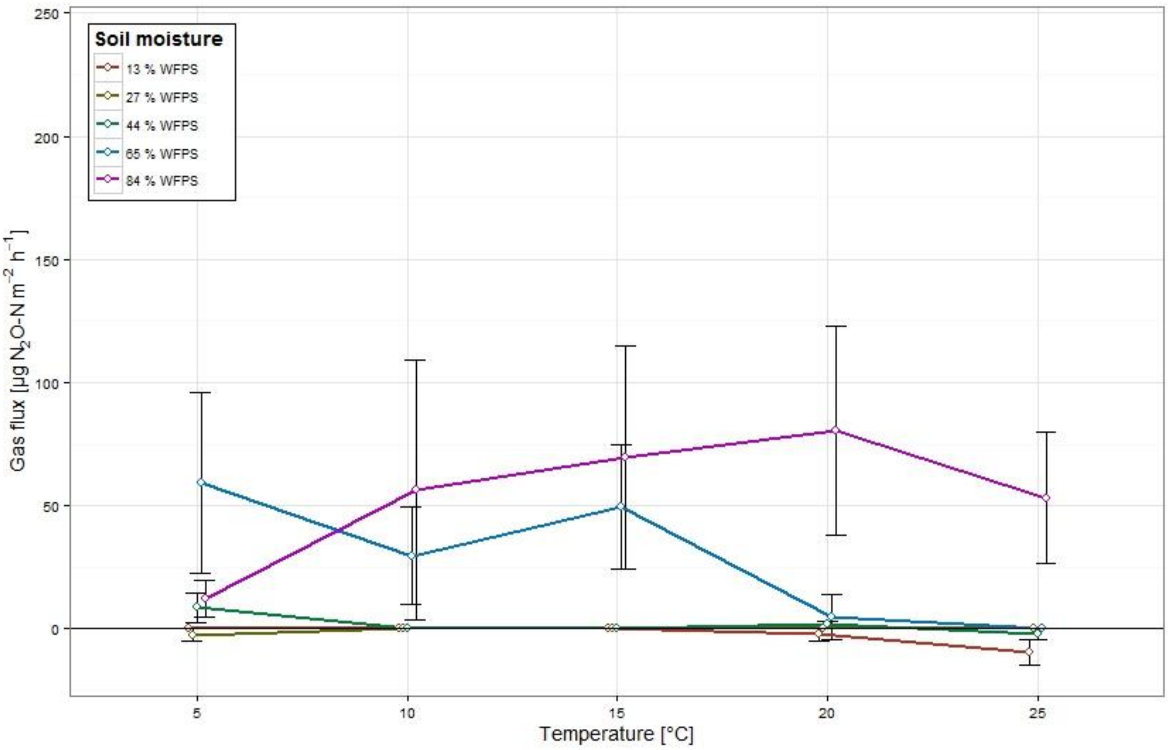

Figure 3-11: Mean N_2O fluxes (µg N_2O-N m^{-2} h^{-1}) and standard error at the forest site IT-IFo. Colours represent the moisture levels

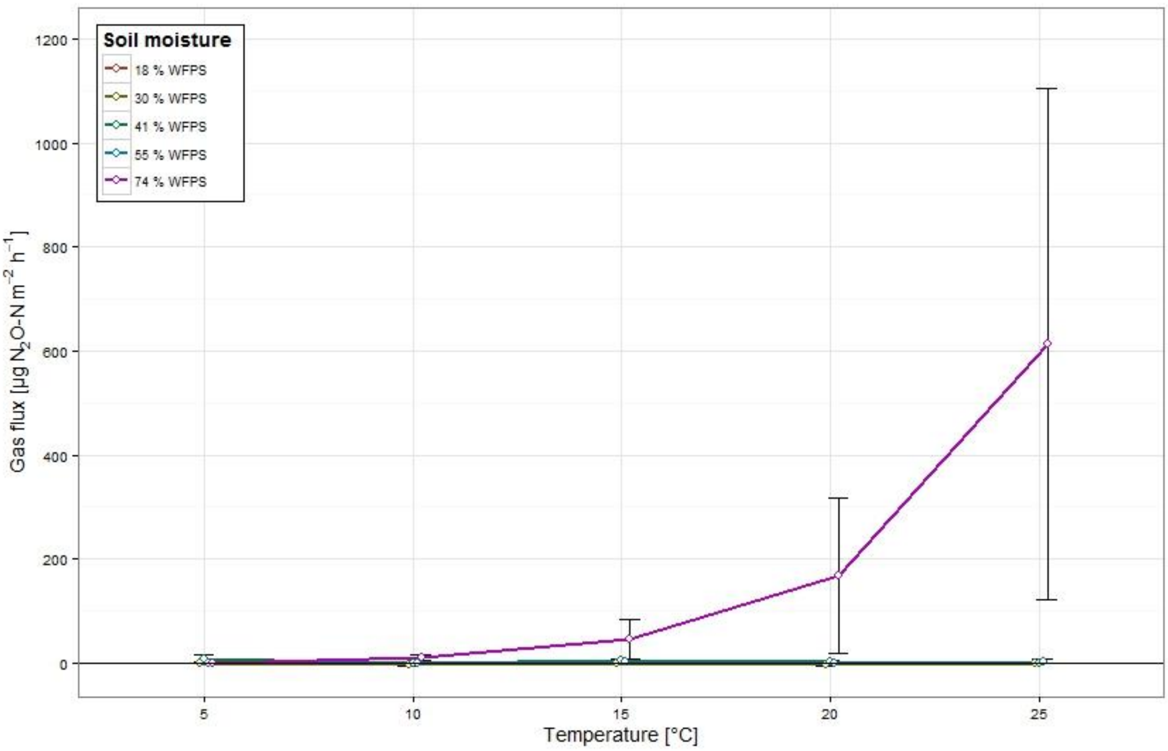

Figure 3-12: Mean N_2O fluxes (µg N_2O-N m^{-2} h^{-1}) and standard error at the forest site NL-Spe. Colours represent the moisture levels

There were also remarkable differences between the moisture levels at IT-IFo (Figure 3-11). For instance, at lower moisture levels (13% - 44% WFPS), N_2O emissions remained very low and increased with rising temperature only at 85% WFPS. Yet, at 65% WFPS, N_2O emission decreased with increasing temperature. As the N_2O flux decreased with highest temperature for all moisture levels, there might be a lack in nutrient supply at this site. Considering each moisture level on its own, Q_{10} values are 0.8 (65% WFPS) and 5.3 (85% WFPS) compared to an overall Q_{10} of 2.5.

At NL-Spe (Figure 3-12), large N_2O emissions only occured at 79% WFPS with a Q_{10} of 13.6. At lower moisture content, N_2O flux remainded almost null with resultating Q_{10}´s of 1. The overall Q_{10} for this site is 12.9. Table 3-14 shows the results from the spearman rank correlations for each moisture level. There is a strong correlation between temperature and N_2O flux at highest WFPS for all three sites. At lower WFPS, no common trend is apparent. Another positive correlation has been found for 20% WFPS at IT-BFo. For IT-IFo, temperature and N_2O flux is negatively correlated at 10% WFPS and 60% WFPS. No more correlation between N_2O flux and temperature was found for NL-Spe.

Table 3-14: Spearman rank correlations between N_2O fluxes and temperature for each moisture level (WFPS, 10%-100%), Determination coefficient (Rho), significance level (p). X= no gas fluxes measured for this moisture level

	soil moisture [%WFPS]									
site	10		20		40		60		80	
	Rho	p	Rho	p	Rho	p	Rho	p	Rho	p
IT-BFo	-	-	0.53	0.02	-	-	-	-	0.47	0.01
IT-IFo	-0.53	0.01		-	-	-	-0.48	0.02	0.40	0.04
NL-Spe	-	-	-	-	-	-	-	-	0.56	0.01

4. Discussion

4.1 Land use type and CH_4 fluxes

According to our results we can at least partially accept our hypotheses (I), that CH_4 fluxes are different between the land use types. We were able to demonstrate that the mean CH_4 fluxes differ between the forest sites and all other sites. Between the arable land, grassland and wetland sites, no significant differences in CH_4 fluxes were found. This might be due to the fact, that the CH_4 fluxes were very low at those sites under the investigated moisture conditions. As an explanation for low CH_4 fluxes in soils, von Fischer et. al. (2007) argued that usually CH_4 production and CH_4 consumption occur simultanously. Accordingly net fluxes of CH_4 fluxes may be low. Schaufler et. al. (2010) explained low CH_4 flux rates from different soils and land use types in an incubation experiment by the occurence of the above mentioned two processes. In line with these observations, we found low CH_4 fluxes at six sites, where CH_4 fluxes fluctuated between emission and uptake. Thus, our results may be explained by these two contrasting processes.

At the forest soils, CH_4 uptake was found at all four sites, with relatively high uptake rates at two sites (FI-Hyy and IT-IFo). These results are reinforced by the widely acknowledged essential role of forest soils as a methane sinks (Smith et al. 2000; Nazaries et al. 2013). Smith et. al. (2000) suggested that the highest CH_4 oxidation rates could be found at well drained forest soils, which we were able to confirm. Highest oxidation rates ocurred at the two forest soils (FI-Hyy and IT-IFo) characterised by a coarse soil texture (uS) and mean bulk densities of 0.46 g cm^{-3} (IT-IFo) and 0.61 g cm^{-3} (FI-Hyy) respectively.

Regarding CH_4 emissions, wetlands are the most important natural sources of CH_4 (Bridgham et al. 2013; Nazaries et al. 2013). This corresponds with our results, where the highest CH_4 emissions were found at the peatland site (UK-AMo) followed by the grassland site CH-Pos. CH_4 flux at the second grassland site was almost null. In total, grassland sites served as a minor CH_4 source. But almost all CH_4 emissions at the grassland sites were measured at the highest WFPS at CH-Pos. This indicates the important role of soil moisture for CH_4 emissions, which will be discussed below. In contrast to our results, other studies reported grassland sites as low CH_4 sinks (Imer et al. 2013; Kong et al. 2013) or did not even find CH_4 emissions under waterlogged conditions (Hartmann et al. 2011). We attribute our results to fertilizer application, which may inhibit CH_4 oxidation in grassland or cropland sites, as nitrifying bacteria preferentially oxidize ammonium over CH_4 (Mosier et al. 1997). Especially at HU-Bug, the mineral N content was quite high which may have inhibited CH_4 oxidation. Cultivation and or disturbance of soils, as is the case at agricultural sites, may also reduce CH_4 uptake (Boeckx et al. 2001). At our cropland sites, CH_4 flux was very low and the land use type arable land served as small CH_4 sink. Land management at our cropland sites included a simple crop rotation (white mustard - maize - wheat - barley) and surface tillage at FR-Gri and a monocropping system with mainly grain at UA-Pet. Both crop rotation and tillage have an effect on CH_4 uptake as they influence the soil compaction and thus the availability of O_2. A field experiment reported a reduced CH_4 uptake of up to 40% under a monocropping system (barley) compared to a simple crop rotation (barley-pea) in a no-tillage system (Sainju et al. 2012). Our result are in line with those findings, as CH_4 oxidation was predominant at those site with crop rotation (FR-Gri), whereas CH_4 emission was predominant at the site with a monocropping system (UA-Pet).

4.2 Temperature sensitivity of CH_4 fluxes

The effect of temperature on the CH_4 cycle is not fully explored (Nazaries et al. 2013). However, we found a positive correlation of CH_4 production with temperature for the peatland site UK-AMo (Rho=0.24, p=0.02) plus a very high Q_{10} value of 52.5. The very high Q_{10} value is due to the fact, that the gas flux at the initial temperature was nearby zero (0.49 ± 3.22) and thus, an increase in CH_4 emissions lead to a high Q_{10} value.

According to a study regarding temperature sensitivity of CH_4 production (Segers 1998), methanogenic processes can be divided into three phases, which have different responses in time to temperature change. These three phases are affected indirectly (phase I = carbon mineralisation and rate of electron acceptor depletion) and directly (phase II = effect on methanogenic activity and III = substrate availability) by temperature (Segers 1998). Particularly the temperature dependence of phase I may have had an influence on our results, as the rate of electron acceptor depletion takes much more time at lower temperatures and until this phase has finished, no CH_4 will be produced (van Hulzen et al. 1999). As we have incubated our soil samples at five consecutive temperature steps each, this may have led to a delayed temperature response of our samples according to the three phase model. This time lag was not only reported for CH_4 production. A recent field experiment also reported an indirect temperature effect on CH_4 uptake (Kern et al. 2012). To asses the temperature effect on CH_4 flux, a longer incubation time may help to ensure that phase I has been established. But it has to be noted, that this would led to artificial conditions. A better solutions might be the use of inhibitors, to asses each processe on its own. For example, methylfluorid (CH_3F) can inhibit the CH_4 oxidation at a concentration of 0.1% whilst it does not inhibit CH_4 production when its concentration is less than 1% (Chan et al. 2000). Whereas methyl chloride (CH_3Cl) inhibits CH_4 production without inhibiting CH_4 oxidation at concentrations <0.1% (Chan et al. 2000).

The effect of temperature on CH_4 oxidation at our sites is small, although we found a positive correlation between temperature and CH_4 oxidation for one forest site (IT-IFo, Rho=0.22, p=0.02). But for the remaining four sites with CH_4 oxidation as main process, no temperature influence was found. Smith et.al. (2000) suggested, that limitations in substrate supply, mainly due to the combined effects of diffusion resistance (f.e. clayey soils) and low atmospheric concentrations could be an explanation for that.

The obtained Q_{10} values for CH_4 oxidation were 2.5 (IT-IFo) and 0.8 (FI-Hyy), which illustrate the weak effect of temperature on CH_4 oxidation. A further reason for the weak relationship between temperature and CH_4 flux could be the overall low gas flux. The results did not reveal a temperature sensitivity for most sites and it is very likely that land use may not be a explanatory variable for the temperature response of CH_4 fluxes as stated in the hypotheses (I). Other factors such as nutrient availability or soil moisture may play a more important role in that case (Davidson et al. 2006) and as mentioned above, a separate study of both processes may reveal better results concerning the temperature effect on CH_4 fluxes.

4.3 Soil moisture sensitivity of CH_4 fluxes

We can accept our second hypothesis (II) at the peatland site, where CH_4 emissions increased significantly with higher moisture content. At all other sites, emissions did not increase significantly with soil moisture. It has to be noted, that only for the peatland site soil core samples were adjusted to 100% WFPS, which is a waterlogged condition.

The water content strongly affects both CH_4 production and oxidation (Roger and Le Mer 2001). An elevated moisture table in soils increases the anaerobic zones, in which CH_4 is produced and concurrently decreases the aerobic zones of CH_4 oxidation (Le Mer et al. 2001; Smith et al. 2003). Additionally, estimates assume that 50%-90% of methane produced in soils is immediately oxidized in the aerobic zones of the soil (Nazaries et al. 2013). We had two sites (CH-Pos and UK-AMo) with significant CH_4 emissions basically at highest WFPS (80% and 100%) and CH_4 uptake at all other moisture levels. As the oxidation of CH_4 mainly occurs in the first few centimeters of the mineral soil (Butterbach-Bahl et al. 2002; Reay et al. 2005), these few centimeters of aerobic zone in the soil determine wether it is a source or a sink of CH_4. A exponential relationship between soil moisture and CH_4 flux illustrates this at the wetland site (R^2=0.29).

Highest uptake rates were measured at a medium moisture content (20% WFPS – 60% WFPS) at two forest sites (FI-Hyy, NE-Spe) one arable land (FR-Gri) site and the wetland site (UK-AMo). In general, CH_4 oxidation is reduced at a higher moisture content (>80% WFPS) due to limitations in O_2 availability and gas diffusity (Smith et al. 2003). At very low moisture content, CH_4 oxidation is limited due to the osmotic stress and desiccation of methanotrophic bacteria (van den Pol-van Dasselaar et al. 1998; Nazaries et al. 2013). A polynomial regression was applied to describe CH_4 oxidation as a function of soil moisture, with reasonable results only for some of the sites (FI-Hyy, FR-Gri and CH-Pos) and with a maximum R^2=0.19. Interestingly, for one forest site (IT-IFo), highest CH_4 uptake rates were found at highest moisture (80% WFPS). In contrast to a study by K. A. Smith (2000), CH_4 uptake did not decrease with decreasing pH, but highest uptake rates were found at sites with low pH (FI-Hyy pH 3.1; IT-IFo pH 3.4). An explanation could be that we removed the litter layer from the topsoil, which would serve as an diffusion barrier on the soil surface of acidic soils (Smith et al. 2000).

4.4 **Land use type and N_2O fluxes**

The land use type and management strongly affects emissions of nitrous oxide (Smith et al. 2004). Especially agricultural soils and their management contribute to the global N_2O emissions and the emission potentials of agricultural soils are of one magnitude higher than that of natural ecosystems (Vilain et al. 2014). Especially after fertilization, N_2O emissions increase significantly due to the high availability of mineral N (Smith et al. 1998). A field experiment reported an increase in N_2O emissions two weeks after fertilizer application and N_2O flux returned to background level after two months (Gu et al. 2013). Table 4-1 lists all nine study sites and associated Nitrogen depositions, includingt the amount of fertilizer applications at the cropland sites.

Table 4-1: Nitrogen (N) deposition per site in kg per ha and year. Values consits of dry and wet depositions. Data obtained by authors via personal communication (site manager) and via literature research.

land use	site	N deposit [kg ha-1 yr-1]	source
Cropland	FR-Gri	6[1]	site manager
Cropland	UA-Pet	11[2]	site manager
Forest	FI-Hyy	7.4	(Korhonen et al. 2012)
Forest	IT-BFo	15	(Francaviglia et al. 1995)
Forest	IT-IFo	31	site manager
Forest	NL-Spe	45	(Schaufler et al. 2010)
Grassland	CH-Po	20	(Schaufler et al. 2010)
Grassland	HU-Bug	13	(Schaufler et al. 2010)
Peatland	UK-AMo	8	(Drewer et al. 2010)

[1] Fertilization: 200 kg ha-1 yr-1, mineral and organic fertilizer

[2] Fertilization: 88 kg ha-1 yr-1, mainly mineral fertilizer

Concerning our results, it was to be expected, that our agricultural soils served as a net source of N_2O. Surprisingly, both cropland soils in our experiment served as small N_2O sinks. However, recent research has not emphasized on this issue yet, because of the much higher N_2O emissions compared to N_2O uptake rates (Chapuis-

Lardy et al. 2007). There are some key factors influencing the N_2O uptake rate like low mineral N availability, the availability of O_2 and soil pH, whereby denitrification, nitrifier denitrification and aerobic denitrification may be the main processes regarding N_2O uptake in soils (Chapuis-Lardy et al. 2007). At our cropland sites, we found a low content of mineral N, which on the one hand limits N_2O production (Dobbie et al. 2001) and on the other hand enhances N_2O uptake. The low mineral N content also indicates, that there was no fertilization for a longer period. As most of the N_2O uptake took place at low and medium WFPS, aerobic denitrification and nitrifier denitrification may be the processes influencing N_2O uptake.

In contrast to the unexpected low emissions from croplands, the highest N_2O emissions were found at the forest sites with a mean flux of 116.02 ± 24.38 µg N_2O-N m^{-2} h^{-1}. Moreover, the variability of N_2O fluxes was greatest within the forest sites. The deciduous forest site of IT-BFo had the highest N_2O emissions with 358.86 ± 78.73 µg N_2O-N m^{-2} h^{-1}, whereas at the coniferous forest FI-Hyy, a small N_2O uptake was detected. Several studies have reported high N_2O emissions from forest sites (Schindlbacher et al. 2004; Luo et al. 2012), often accompanied with high N deposits (Kitzler et al. 2006; Ullah et al. 2008). As it can be seen in Table 5-1, our forest sites received the highest N deposits among our study sites which may have led to the high N_2O emissions.

Also the forest type influences N_2O emissions, for instance deciduous forests enhance N_2O emissions compared to coniferous forests due to quality of litter (C:N ratio) and higher microbial activity (Ambus et al. 2006). Compared with another laboratory study, we obtained similiar results for the coniferous forest sites (Schaufler et al. 2010). Within forest sites, only the boreal forest site FI-Hyy showed very low N_2O fluxes. This forest site had the highest C/N ratio of all study sites and thus nitrogen is hardly accessible for microorganisms at this site (Schindlbacher et al. 2004).

The grassland sites served as a N_2O source, but variation between both sites was large with higher N_2O emissions at the intensively managed grassland CH-Pos. In fact on such sites, higher N inputs through urine and dung and increased soil compaction through the trampling effect of grazing animals can cause higher N_2O emissions compared to extensively managed grasslands (Oenema et al. 1997; Imer et al. 2013).

4.5 Temperature sensitivity of N_2O fluxes

We did not find a direct effect of temperature on N_2O emissions. Only for one site, N_2O flux was positively correlated with temperature (FR-Gri, Rho=0.32, p=0.000). This may be attributed to the fact that the relationship between temperature and N_2O fluxes was tested over all moisture levels, similar to the study by Schaufler (2010). There are indeed better results, when considering each moisture levels on its own for some sites. We could not prove hypotheses VI, as we only got reliable Q_{10} values over all moisture contents for one land use type.

We found Q_{10} values of the decidous forest were much lower (IT-BFo =4.9 and IT-IFo=2.5) compared with the coniferous forest (NE-Spe=12.9). This is in line with observations from a laboratory experiment, where N_2O emissions from several forest soils (mixed broadleaf and coniferous) showed an exponential increase with increasing temperature (Schindlbacher et al. 2004). Hence, the explanatory power of obtained Q_{10} values (over all moisture levels) is rather poor as the temperature sensitivity of N_2O emissions strongly depends on the moisture content (see Figures 4-10 to 4-12). We observed an increase of N_2O emissions under very wet conditions for several sites. Also the heat buffering capacity of soil water may play an important role, not only in different soil layers (Mills et al. 2013), but rather within soil layers as it is discussed for the soil respiration – temperature relation. Additionally, denitrification is very sensitive to temperature shifts (Butterbach-Bahl et al. 2013). As it is discussed below, we found denitrification as the main cause for N_2O emissions at our sites, which could explain the high Q_{10} values. Comparing the magnitude of Q_{10} values from our forest sites, it is remarkable that Q_{10} values are in the same range than those found at arable soils (Dobbie et al. 2001). Putting aside the coniferous forest NL-Spe, temperature sensitivities of decidous forests match those found for denitrification in grassland sites (Dolman et al. 2008).

4.6 Soil moisture sensitivity of N_2O fluxes

Concerning our results, we can confirm the large effect of soil water on N_2O emissions. We observed increasing N_2O emissions with increasing soil moisture at all sites, except the Finnish forest site. N_2O emissions peaked between 60% WFPS and 80% WFPS at each site. An exponential function showed the best fit between soil moisture and N_2O flux. The highest N_2O emissions were found at IT-BFo 60% WFPS

(2026 ±1023), which is in the same range as reported N_2O emissions during extreme weather events in field studies (Zona et al. 2011). During this extreme weather event, the monthly precipitation (= 185mm) exceeded the average monthly precipitation (=75mm) for more than two times and led to an increased WFPS of 80% for several weeks (Zona et al. 2011).

N_2O emissions declined slightly (IT-BFo) or sharply (CH-Pos and UK-AMo) with highest WFPS. These findings suggests, that denitrification is the main process causing N_2O emissions at our sites, which partly coincidences with our findings on temperature sensitivity. Furthermore, the optimum WFPS for N_2O production through nitrification is in the intermediate moisture range and for denitrification it is in the range of 60% to 80% WFPS (Smith 1997; Paul 2006), which is in line with our findings. The decrease in N_2O emissions with highest moisture contents can be explained by the fact that denitrification processes are fully completed under waterlogged or water saturated conditions and thus, N_2 is the end product (Paul 2006). Nitrification is likely to have played a minor role at our study sites, as the N_2O emissions at medium WFPS are almost zero at almost all sites. Hence, for one site (HU-Bug), a certain amount of total N_2O emissions was emitted under aerobic condition (< 60% WFPS) and therefore nitrification processes may have contributed to the N_2O emissions.

It has to be noted that soil samples were measured immediately after receiving them from the partner institutions once the estimated WFPS was reached. However, some samples had to rest for several weeks in the cooling room because of too high WFPS upon receival or if a processing delay occured. This may have led to an slow but steady release of N_2O during the air drying. Laboratory experiments have shown that under high nutrient and water supply the dentrififyer activity reaches its maxium at 4°C after 50 h, but the maximum activity for temperatures above 4°C are reached after 10 h (Braker et al. 2010). Even after fertilizer application, the production of N_2O declined after 10 days rapidly (Bateman et al. 2005). Thus we cannot exclude, that during the air drying in the cooling room N_2O was produced through denitrification and hence has led to lower N_2O emissions during the experiment.

4.7 Experimental Design

During our experiment we had to deal with fluctuations of CH_4 and N_2O concentrations in the ambient air (see Figure 4-1 and 4-2). Fluctuations in the ambient air is a problem as low gas fluxes from our soil samples may get diguised by it. During our experiment, two possible problems were figured out. At the beginning of our experiment, we used air coming from the incubator to flush our chambers.

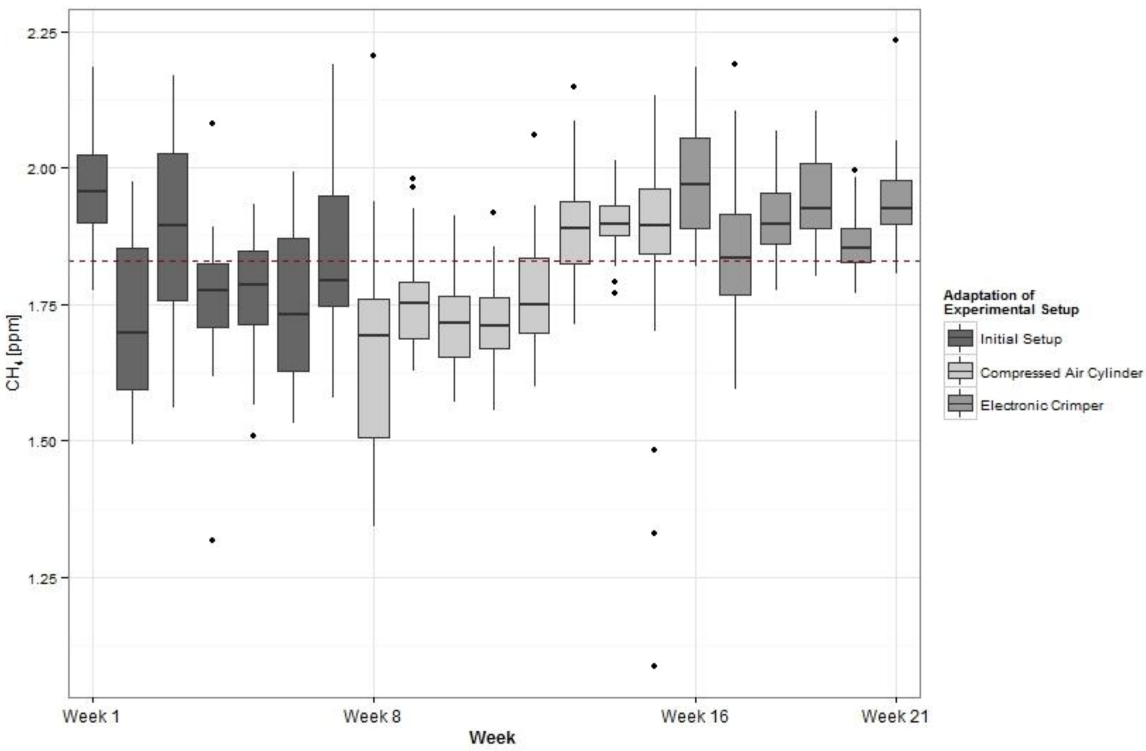

Figure 4-1: Boxplots of obtained CH_4 concentrations (ppm) in the control chambers. Each boxplot represents one week during the experiment. Dashed line=mean concentration. Colours represent the three different experimental conditions : Initial setup, implementation of a compressed air cylinder and the implementation of an electric crimper.

As the air came from the laboratory air conditioning, we could not determine the exact concentrations of CH_4 and N_2O from that air. Thus, concentrations may have been larger than natural ambient air condition. This problem was fixed by replacing it with a Linde© compressed air cylinder in the 8^{th} week of the experiment. In the 16^{th} week, we made our second implementation and replaced the manual Crimper by an electronic crimper and decapper (Agilent©). This was the best way to ensure that each vial had been treated and closed the same way. Both adaptations had effects on the ambient air concentrations. To prove whether our adaptations had a significant effect or not, analysis of variance was used. Therefore, the obtained gas concentrations of our control chambers (from now on referred as blanks) were divided into three groups. The first group features gas concentrations which belong to the initial experimental setup (see material and methods) and is named “Initial Setup”. The second group contains all obtained gas concentrations from the blanks after installing the compressed air cylinder (“Compressed air cylinder”).

Table 4-2: Mean CH_4 and N_2O concentration (c) in ppm, number of obseravtions (N) and the standard deviation (SD) in the control chambers during the experiment and for each adaptation.

Adaptation		CH_4			N_2O	
	N	c [ppm]	SD	N	c [ppm]	SD
Initial Setup	273	1.813	0.155	277	0.334	0.063
Compressed air cylinder	312	1.785	0.148	313	0.337	0.059
Electric Crimper	239	1.914	0.096	240	0.352	0.054

Finally, the third and last group consists of all gas samples which we got after implementing the electric crimper (“Electric Crimper”). Figure 4-1 shows the mean CH_4 concentration of the control chambers for each week during the experiment. The different grey scales in Figure 4-1 represent the different adaptations of our method.

Analysis of variance revealed a significant effect of both adaptations on CH_4 concentrations. The installation of the compressed air cylinder reduced the fluctuation of ambient air ($p=0.039$). But an even the greater influence resulted from the switch to an electric crimper. Variations in gas concentrations were significant between the “Initial Setup” and “Electric Crimper” as well as between “Compressed Air cylinder” and “Electric Crimper”. Both differences were at a significance niveau $p=0.000$. Table 4-1 shows the mean CH_4 concentration and related standard deviation. Figure 4-2 shows the mean N_2O concentrations of the blank chambers during the whole experiment. Interestingly, only the second adaptation “Electric Crimper” had a significant influence on the ambient air concentration of the blanks ($p=0.000$). As it can be seen in Figure 4-1 and Table 4-1, the implementation of the electronic crimper reduced the fluctuation in ambient air CH_4 (SD) of more than 35%.

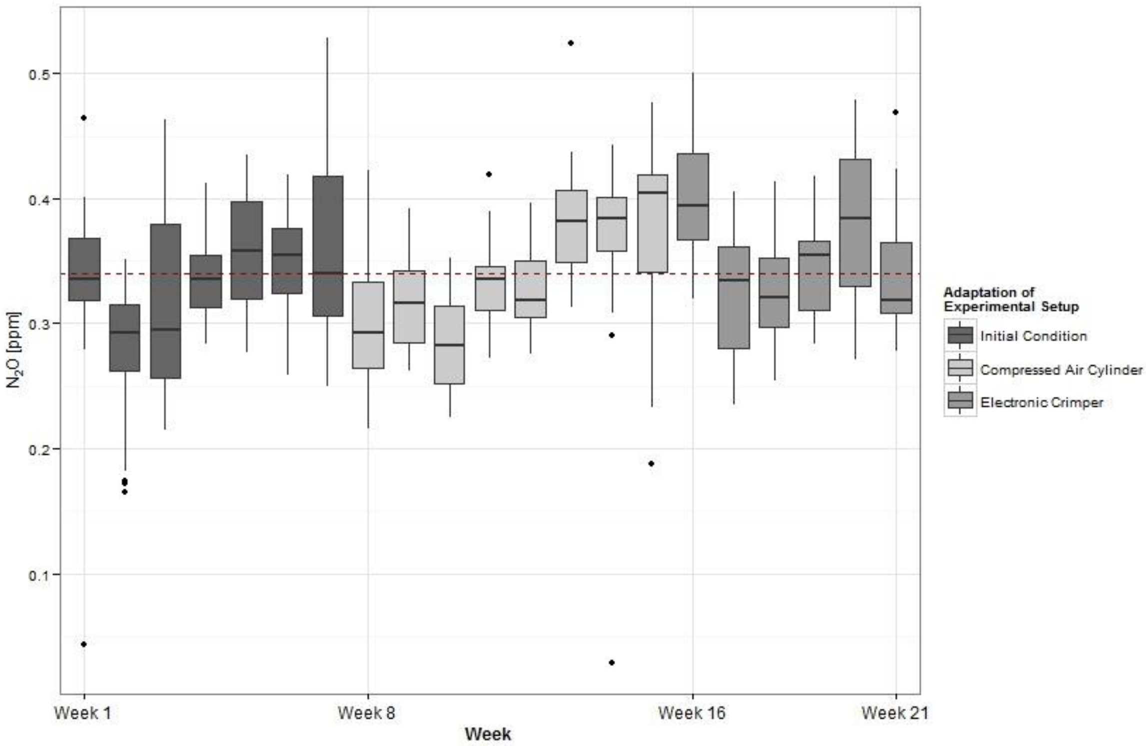

Figure 4-2: Boxplots of obtained N_2O concentrations (ppm) in the control chambers. Each boxplot represents one week during the experiment Dashed line=mean concentration. Colours represent the three different experimental conditions : Initial setup, implementation of a compressed air cylinder and the implementation of an electric crimper.

This is of crucial importance, as the double standard deviation serves as the threshold range for the soil gas estimation. Hence, a reduction in ambient air fluctuation is in accordance with an improvement of the accuracy of the applied method. This also applies for the fluctuation in ambient air N_2O, but with limited improvements. The variation in N_2O ambient air was only reduced by 15%. This indicates, that improvement of N_2O detection may be more a question of the analyzing device than method of the handling.

5. Conclusion

This thesis contributes to the estimation of effects of climate change on CH_4 and N_2O fluxes in natural and human European ecosystems. On behalf of CH_4 we were able to demonstrate how higher precipitation and an intensification in extreme weather events alters the CH_4 fluxes in two ways: Higher precipitation increases the anaerobic zones in soils which leads to higher CH_4 production and concurrently decreases the aerobic zones of CH_4 oxidation in soils. This reaction was clearly seen at the Finnish forest sites, which suggests that the ability of northern forest soils to oxidize CH_4 may be reduced under predicted future climate conditions. Furthermore, an increase in temperature will lead to higher CH_4 emissions from peatland sites under wet conditions. This fact also reflects the issue of synchronous changes such as rising temperature and precipitation and its effect on CH_4 flux and further research has to be done on interdependency of both factors.

Global warming will also alter the N_2O fluxes from soils. The study reinforces knowledge on the net sources of N_2O, like forests and grasslands. Interestingly, our study showed that cropland sites can serve as small N_2O sinks under N-limiting conditions. Further research has to be done, to verify those findings. In general we predict, that an increase in extreme weather events with elevated precipitation will increase the N_2O emissions under non N-limiting conditions. Under very wet conditions N_2O emissions may increase significantly, especially with increasing temperature. The effect of land use type on the temperature sensitivity seems to play a minor role, as resulting Q_{10} values for forest sites correspond with those found at arable and grassland sites.

This laboratory experiment was used to simulate multiple climatic conditions and its effect on different soils and land uses. The results show, that in some cases one climate parameter can describe up to 68% of the variation of the N_2O flux. But for a better approvement of the effect of one parameter more research has to be done. Our results revealed insufficient gas fluxes under most conditions or even missed gas fluxes at all. Thus, for future experiments, a bigger sample size will facilitate confident data to asses each climatic parameter. Moreover, this will allow to approach the interdependency of both climatic parameters. Additionally, the low gas fluxes need a precise and accurate method. We could prove, that the implementation of an electric crimper improves the accuracy for more than 35%. These findings may contribute to future experimental setups and help assessing actual CH_4 and N_2O fluxes more precisely.

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7. Appendix

Appendix 1: Soilcore sampling manual

Purpose of soil sampling at selected ÉCLAIRE flux network sites:

A simple soil bioassay will be conducted for 9 sites by BOKU University, Vienna. This assay will be used to estimate emission potentials for N_2O, NO_X, CH_4 and CO_2. Soils will be incubated under defined WFPS ((5) 20, 40 or 60, 80 (100) %) and 5 different temperatures (5, 10, 15, 20 and 25°C).

Data will be used for model parameterisation and interpretation of field flux data at ÉCLAIRE sites and to reveal key unknowns in microbial C-N cycling and C-N gas emissions by experimental investigations. Data will be made available to the partners.

Our sampling strategy is to probe all soils (mineral soil: 0-6cm) at similar soil temperatures (**8°C** for a couple of days).

Soil core sampling:

- **What we provided:** 2 BOXES with 38 soil cylinders, 76 plastic plates, 38 plastic bags, one role of silver tape, a wooden board, 6 plastic bags for litter samples, 12 ice accumulators, one measuring stick (20 x 20 cm)

- **What you should provide:** A hammer , a small shovel, a permanent marker (water proofed), a knife, a shear

To-Do before sampling:

- Put ice accumulators into the freezer
- Wait until the soil has a temperature of 8 °C for a couple of days. Assign 6 randomly distributed plots of about 10 m² in an area of appox. 50 x 50 m.

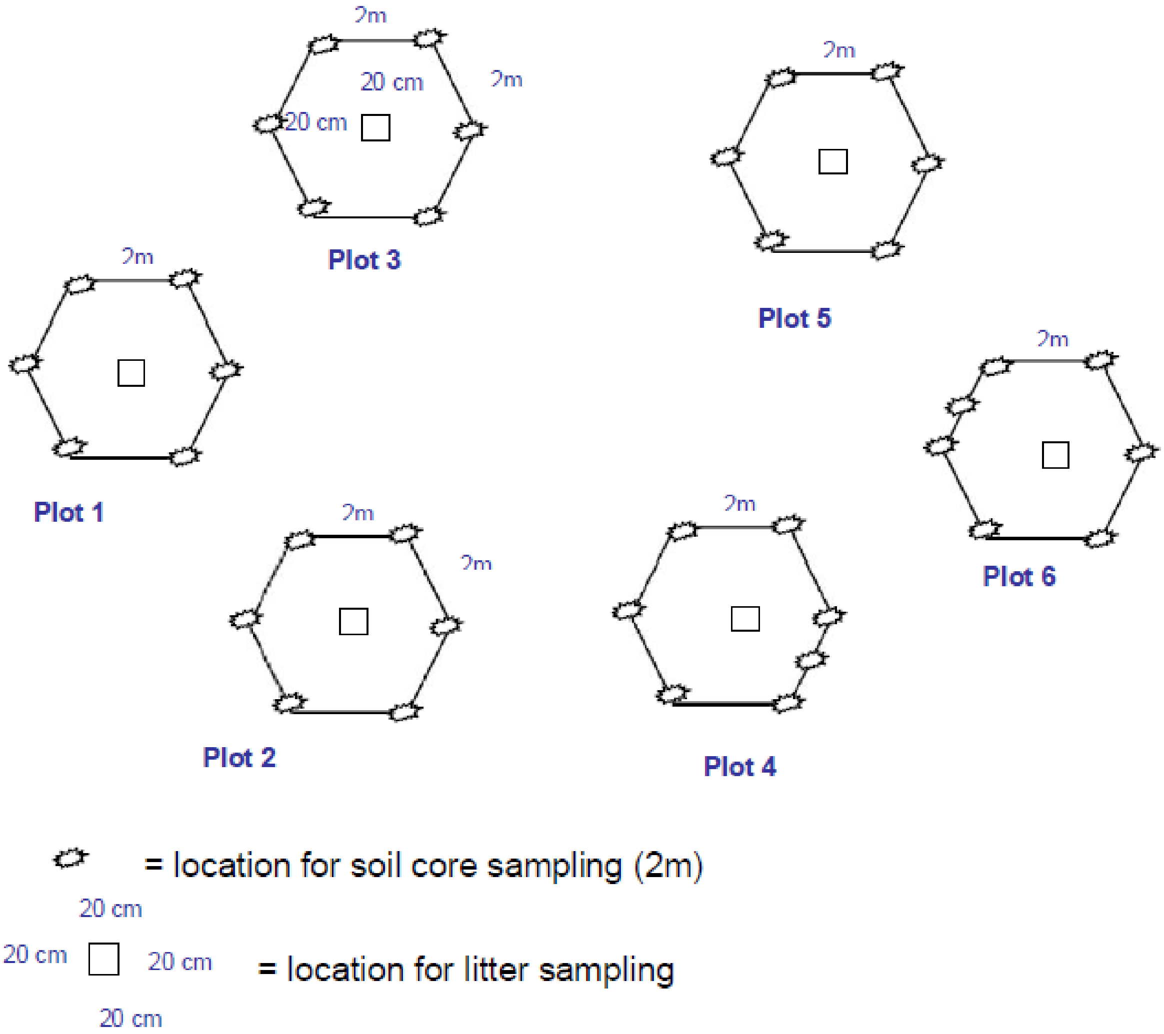
Litter sampling in forests:

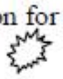
- Pool 6 litter samples (L, F, H horizon) with the aid of the measuring stick (20 x 20 cm) from the area surrounded by 6 soil sampling plots into one plastic bag. Please provide the litter depth with each sample (very important!) and write the litter depth with the permanent marker on the outside of the litter bag.

Litter sampling in Grasslands:

- Cut the grass of 6 areas with the aid of the measuring stick (20 x 20 cm) from the area surrounded by 6 soil sampling plots into one plastic bag. Please provide the grass hight with each sample (very important!) and write it with the permanent marker on the outside of the litter bag.

Schema of sampling in the field:



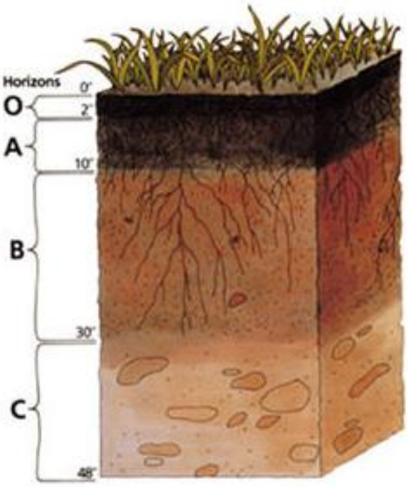
LITTER SAMPLING:	
	1.) Measure the litter depth and grass length, respectively.
	2.) Place the measuring stick (20 x 20 cm) at the area surrounded by the 6 soil sampling plots
	3.) Put all litter inbetween the measuring stick into the litter bag GRASSLANDS: Cut grass within the measuring stick down to 0,5 cm above soil and put it into the litter bag
	4.) Label the plastic bag with a permanent marker as follows: 1) Site name 2) Date of collection 3) Plot number 4) Litter depth or grass length
SOIL SAMPLING:	
	1) FOREST SITES: remove the litter at each location for soil core sampling, marked as  GRASSLAND SITES: cut the grass down to 0,5 cm above soil edge

	2.) Mark the inner side of the cylinder 1 cm under the upper (grinded part=bottom of cylinder) edge of the cylinder
	3) Put he provided soil core (with the grinded end on bottom!) on the mineral soil trying to avoid disturbances (roots, stones, etc.)
	4) Put the enclosed wooden board on top of the cylinder
	5) Drill in the cylinder with a hammer into the soil. Not too hard as the soil should not be compacted.

	6.) The mineral soil should reach the upper labelled black mark on top of the cylinder. GRASLANDS: The mineral soil should reach the upper labelled black mark on top of the cylinder, **NOT the upper edge of the cut grass**
	7.) Put one of the plastic plates on top of the cylinder and take the shovel to lift the cylinder with the soil out.
	8.) Carefully remove the surmounting soil with the knife, if necessary cut small roots with a shear.
	9.) Put the soil cylinder into a plastic bag and between two plastic plates.

	10.) Fix everything with silver tape and label the wrapped cylinder with a permanent marker as follows: • Site name • Date of collection • Plot number • Core number
	Split up everything into the 2 Styrofoam boxes and put the frozen ice accumulators (6 for each box) into them.
	Send the box by express mail service to the following address: **BOKU - University of Natural Resources and Life Sciences Vienna** **Institute of Soil Research** **z.H.: Christine Gritsch** **Peter Jordan Str. 82** **A-1190 Vienna, Austria**
	If you have any questions, please contact: **Tel: +43-(0)1-47654-3143** **E-mail: christine.gritsch@boku.ac.at**

DEFINITIONS:



O) Organic matter: Litter layer of plant residues in relatively undecomposed form.
A) Surface soil: Layer of mineral soil with most organic matter accumulation and soil life. This layer eluviates (is depleted of) iron, clay, aluminum, organic compounds, and other soluble constituents. When eluviation is pronounced, a lighter colored "E" subsurface soil horizon is apparent at the base of the "A" horizon. A-horizons may also be the result of a combination of soil bioturbation and surface processes that winnow fine particles from biologically mounded topsoil. In this case, the A-horizon is regarded as a "biomantle".
B) Subsoil: This layer accumulates iron, clay, aluminum and organic compounds, a process referred to as illuviation.
C) Parent rock: Layer of large unbroken rocks. This layer may accumulate the more soluble compounds

8. Raw data

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
arable	FR-Gri	1	5	5	-9.94	-13.43
arable	FR-Gri	2	5	5	-2.04	-14.60
arable	FR-Gri	3	5	5	-20.53	-22.41
arable	FR-Gri	4	5	5	0.00	0.00
arable	FR-Gri	5	5	5	0.00	-11.26
arable	FR-Gri	6	5	5	0.00	-13.90
arable	FR-Gri	1	21	5	0.00	0.00
arable	FR-Gri	2	21	5	0.00	ND
arable	FR-Gri	3	21	5	0.00	0.00
arable	FR-Gri	4	21	5	ND	ND
arable	FR-Gri	5	21	5	0.00	0.00
arable	FR-Gri	6	21	5	0.00	0.00
arable	FR-Gri	1	40	5	0.00	ND
arable	FR-Gri	2	40	5	0.00	ND
arable	FR-Gri	3	40	5	ND	0.00
arable	FR-Gri	4	40	5	0.00	0.00
arable	FR-Gri	5	40	5	0.00	0.00
arable	FR-Gri	6	40	5	-82.69	0.00
arable	FR-Gri	1	60	5	15.57	0.00
arable	FR-Gri	2	60	5	26.20	0.00
arable	FR-Gri	3	60	5	0.00	0.00
arable	FR-Gri	4	60	5	0.00	0.00
arable	FR-Gri	5	60	5	-30.32	ND
arable	FR-Gri	6	60	5	-7.25	0.00
arable	FR-Gri	1	80	5	3.55	0.00
arable	FR-Gri	2	80	5	0.00	0.00
arable	FR-Gri	3	80	5	0.00	0.00
arable	FR-Gri	4	80	5	0.00	0.00
arable	FR-Gri	5	80	5	-0.15	0.00
arable	FR-Gri	6	80	5	0.00	0.00
arable	FR-Gri	1	5	10	30.38	0.00
arable	FR-Gri	2	5	10	0.00	0.00
arable	FR-Gri	3	5	10	0.00	-9.91
arable	FR-Gri	4	5	10	0.00	0.00
arable	FR-Gri	5	5	10	0.00	0.00
arable	FR-Gri	6	5	10	0.00	0.00
arable	FR-Gri	1	21	10	ND	0.00
arable	FR-Gri	2	21	10	0.00	0.00
arable	FR-Gri	3	21	10	0.00	0.00
arable	FR-Gri	4	21	10	0.00	0.00
arable	FR-Gri	5	21	10	-10.89	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
arable	FR-Gri	6	21	10	0.00	-12.62
arable	FR-Gri	1	40	10	-18.44	0.00
arable	FR-Gri	2	40	10	-15.10	0.00
arable	FR-Gri	3	40	10	ND	0.00
arable	FR-Gri	4	40	10	ND	0.00
arable	FR-Gri	5	40	10	ND	0.00
arable	FR-Gri	6	40	10	-23.43	0.00
arable	FR-Gri	1	60	10	ND	0.00
arable	FR-Gri	2	60	10	ND	0.00
arable	FR-Gri	3	60	10	-28.15	0.00
arable	FR-Gri	4	60	10	ND	0.00
arable	FR-Gri	5	60	10	0.00	0.00
arable	FR-Gri	6	60	10	0.00	0.00
arable	FR-Gri	1	80	10	ND	0.00
arable	FR-Gri	2	80	10	0.00	0.00
arable	FR-Gri	3	80	10	ND	ND
arable	FR-Gri	4	80	10	-15.88	0.00
arable	FR-Gri	5	80	10	ND	0.00
arable	FR-Gri	6	80	10	16.28	0.00
arable	FR-Gri	1	5	15	-7.98	0.00
arable	FR-Gri	2	5	15	13.49	0.00
arable	FR-Gri	3	5	15	0.00	0.00
arable	FR-Gri	4	5	15	0.00	0.00
arable	FR-Gri	5	5	15	0.00	0.00
arable	FR-Gri	6	5	15	0.00	0.00
arable	FR-Gri	1	21	15	ND	0.00
arable	FR-Gri	2	21	15	ND	0.00
arable	FR-Gri	3	21	15	ND	ND
arable	FR-Gri	4	21	15	15.62	0.00
arable	FR-Gri	5	21	15	0.00	0.00
arable	FR-Gri	6	21	15	0.00	0.00
arable	FR-Gri	1	40	15	ND	0.00
arable	FR-Gri	2	40	15	-13.03	0.00
arable	FR-Gri	3	40	15	0.00	0.00
arable	FR-Gri	4	40	15	0.00	0.00
arable	FR-Gri	5	40	15	0.00	0.00
arable	FR-Gri	6	40	15	-17.87	0.00
arable	FR-Gri	1	60	15	0.00	0.00
arable	FR-Gri	2	60	15	ND	0.00
arable	FR-Gri	3	60	15	ND	0.00
arable	FR-Gri	4	60	15	ND	0.00
arable	FR-Gri	5	60	15	-21.50	0.00
arable	FR-Gri	6	60	15	-20.09	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
arable	FR-Gri	1	80	15	0.00	13.05
arable	FR-Gri	2	80	15	12.39	0.00
arable	FR-Gri	3	80	15	-24.58	0.00
arable	FR-Gri	4	80	15	20.84	0.00
arable	FR-Gri	5	80	15	0.00	0.00
arable	FR-Gri	6	80	15	0.00	0.00
arable	FR-Gri	1	5	20	0.00	0.00
arable	FR-Gri	2	5	20	0.00	0.00
arable	FR-Gri	3	5	20	0.00	0.00
arable	FR-Gri	4	5	20	0.00	0.00
arable	FR-Gri	5	5	20	0.00	0.00
arable	FR-Gri	6	5	20	-16.99	0.00
arable	FR-Gri	1	21	20	0.00	0.00
arable	FR-Gri	2	21	20	6.82	0.00
arable	FR-Gri	3	21	20	0.00	0.00
arable	FR-Gri	4	21	20	-5.58	ND
arable	FR-Gri	5	21	20	0.00	0.00
arable	FR-Gri	6	21	20	0.78	ND
arable	FR-Gri	1	40	20	ND	0.00
arable	FR-Gri	2	40	20	0.00	0.00
arable	FR-Gri	3	40	20	0.00	0.00
arable	FR-Gri	4	40	20	0.00	0.00
arable	FR-Gri	5	40	20	0.00	0.00
arable	FR-Gri	6	40	20	0.00	0.00
arable	FR-Gri	1	60	20	0.00	0.00
arable	FR-Gri	2	60	20	0.00	0.00
arable	FR-Gri	3	60	20	0.00	0.00
arable	FR-Gri	4	60	20	0.00	0.00
arable	FR-Gri	5	60	20	0.00	0.00
arable	FR-Gri	6	60	20	0.00	0.00
arable	FR-Gri	1	80	20	0.00	0.00
arable	FR-Gri	2	80	20	ND	0.00
arable	FR-Gri	3	80	20	0.00	0.00
arable	FR-Gri	4	80	20	0.00	0.00
arable	FR-Gri	5	80	20	0.00	11.52
arable	FR-Gri	6	80	20	0.00	0.00
arable	FR-Gri	1	5	25	0.00	0.00
arable	FR-Gri	2	5	25	0.00	0.00
arable	FR-Gri	3	5	25	0.00	0.00
arable	FR-Gri	4	5	25	-3.80	0.00
arable	FR-Gri	5	5	25	0.00	0.00
arable	FR-Gri	6	5	25	0.00	0.00
arable	FR-Gri	1	21	25	52.97	24.83

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
arable	FR-Gri	2	21	25	0.00	0.00
arable	FR-Gri	3	21	25	ND	ND
arable	FR-Gri	4	21	25	0.00	ND
arable	FR-Gri	5	21	25	0.00	0.00
arable	FR-Gri	6	21	25	ND	0.00
arable	FR-Gri	1	40	25	ND	0.00
arable	FR-Gri	2	40	25	-13.68	0.00
arable	FR-Gri	3	40	25	-17.93	0.00
arable	FR-Gri	4	40	25	0.00	0.00
arable	FR-Gri	5	40	25	-21.31	0.00
arable	FR-Gri	6	40	25	ND	0.00
arable	FR-Gri	1	60	25	-16.62	0.00
arable	FR-Gri	2	60	25	-27.03	0.00
arable	FR-Gri	3	60	25	-15.61	0.00
arable	FR-Gri	4	60	25	-17.74	0.00
arable	FR-Gri	5	60	25	0.00	0.00
arable	FR-Gri	6	60	25	-17.77	0.00
arable	FR-Gri	1	80	25	-18.83	8.19
arable	FR-Gri	2	80	25	0.00	0.00
arable	FR-Gri	3	80	25	0.00	0.00
arable	FR-Gri	4	80	25	ND	0.00
arable	FR-Gri	5	80	25	0.00	0.00
arable	FR-Gri	6	80	25	0.00	0.00
arable	UA-Pet	1	6	5	0.00	-12.50
arable	UA-Pet	2	6	5	0.00	-19.46
arable	UA-Pet	3	6	5	0.00	-20.81
arable	UA-Pet	4	6	5	0.00	-14.55
arable	UA-Pet	5	6	5	-5.07	-20.23
arable	UA-Pet	6	6	5	0.00	-17.82
arable	UA-Pet	1	19	5	0.00	ND
arable	UA-Pet	2	19	5	ND	ND
arable	UA-Pet	3	19	5	110.24	0.00
arable	UA-Pet	4	19	5	0.00	0.00
arable	UA-Pet	5	19	5	-56.59	-30.94
arable	UA-Pet	6	19	5	0.00	0.00
arable	UA-Pet	1	40	5	ND	ND
arable	UA-Pet	2	40	5	ND	0.00
arable	UA-Pet	3	40	5	0.00	0.00
arable	UA-Pet	4	40	5	18.59	0.00
arable	UA-Pet	5	40	5	0.00	0.00
arable	UA-Pet	6	40	5	0.00	0.00
arable	UA-Pet	1	63	5	ND	0.00
arable	UA-Pet	2	63	5	ND	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
arable	UA-Pet	3	63	5	ND	0.00
arable	UA-Pet	4	63	5	0.00	0.00
arable	UA-Pet	5	63	5	0.00	0.00
arable	UA-Pet	6	63	5	0.00	0.00
arable	UA-Pet	1	83	5	0.00	0.00
arable	UA-Pet	2	83	5	0.00	0.00
arable	UA-Pet	3	83	5	-17.67	0.00
arable	UA-Pet	4	83	5	0.00	0.00
arable	UA-Pet	5	83	5	ND	0.00
arable	UA-Pet	6	83	5	ND	ND
arable	UA-Pet	1	6	10	0.00	0.00
arable	UA-Pet	2	6	10	0.00	-11.90
arable	UA-Pet	3	6	10	0.00	0.00
arable	UA-Pet	4	6	10	12.77	0.00
arable	UA-Pet	5	6	10	0.00	-12.57
arable	UA-Pet	6	6	10	0.00	0.00
arable	UA-Pet	1	19	10	0.00	0.00
arable	UA-Pet	2	19	10	0.00	ND
arable	UA-Pet	3	19	10	0.00	0.00
arable	UA-Pet	4	19	10	0.00	-13.85
arable	UA-Pet	5	19	10	0.00	ND
arable	UA-Pet	6	19	10	-12.80	-17.05
arable	UA-Pet	1	40	10	ND	0.00
arable	UA-Pet	2	40	10	ND	0.00
arable	UA-Pet	3	40	10	0.00	0.00
arable	UA-Pet	4	40	10	ND	0.00
arable	UA-Pet	5	40	10	0.00	0.00
arable	UA-Pet	6	40	10	12.91	0.00
arable	UA-Pet	1	63	10	0.00	0.00
arable	UA-Pet	2	63	10	0.00	0.00
arable	UA-Pet	3	63	10	ND	0.00
arable	UA-Pet	4	63	10	0.00	0.00
arable	UA-Pet	5	63	10	0.00	0.00
arable	UA-Pet	6	63	10	ND	0.00
arable	UA-Pet	1	83	10	-13.56	0.00
arable	UA-Pet	2	83	10	0.00	0.00
arable	UA-Pet	3	83	10	0.00	0.00
arable	UA-Pet	4	83	10	0.00	0.00
arable	UA-Pet	5	83	10	0.00	18.61
arable	UA-Pet	6	83	10	0.00	19.84
arable	UA-Pet	1	6	15	0.00	0.00
arable	UA-Pet	2	6	15	0.00	0.00
arable	UA-Pet	3	6	15	0.00	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
arable	UA-Pet	4	6	15	0.00	0.00
arable	UA-Pet	5	6	15	0.00	0.00
arable	UA-Pet	6	6	15	0.00	0.00
arable	UA-Pet	1	19	15	ND	0.00
arable	UA-Pet	2	19	15	0.00	0.00
arable	UA-Pet	3	19	15	0.00	0.00
arable	UA-Pet	4	19	15	20.82	12.95
arable	UA-Pet	5	19	15	0.00	0.00
arable	UA-Pet	6	19	15	ND	16.82
arable	UA-Pet	1	40	15	ND	0.00
arable	UA-Pet	2	40	15	ND	0.00
arable	UA-Pet	3	40	15	ND	0.00
arable	UA-Pet	4	40	15	ND	0.00
arable	UA-Pet	5	40	15	0.00	0.00
arable	UA-Pet	6	40	15	ND	ND
arable	UA-Pet	1	63	15	-17.72	26.03
arable	UA-Pet	2	63	15	0.00	0.00
arable	UA-Pet	3	63	15	0.00	0.00
arable	UA-Pet	4	63	15	ND	ND
arable	UA-Pet	5	63	15	0.00	0.00
arable	UA-Pet	6	63	15	ND	ND
arable	UA-Pet	1	83	15	0.00	0.00
arable	UA-Pet	2	83	15	0.00	0.00
arable	UA-Pet	3	83	15	ND	11.29
arable	UA-Pet	4	83	15	ND	ND
arable	UA-Pet	5	83	15	0.00	0.00
arable	UA-Pet	6	83	15	0.00	12.59
arable	UA-Pet	1	6	20	0.00	0.00
arable	UA-Pet	2	6	20	0.00	0.00
arable	UA-Pet	3	6	20	0.00	0.00
arable	UA-Pet	4	6	20	0.00	0.00
arable	UA-Pet	5	6	20	0.00	0.00
arable	UA-Pet	6	6	20	0.00	0.00
arable	UA-Pet	1	19	20	0.00	0.00
arable	UA-Pet	2	19	20	8.11	0.00
arable	UA-Pet	3	19	20	0.00	0.00
arable	UA-Pet	4	19	20	0.00	0.00
arable	UA-Pet	5	19	20	0.00	0.00
arable	UA-Pet	6	19	20	0.00	0.00
arable	UA-Pet	1	40	20	0.00	0.00
arable	UA-Pet	2	40	20	0.00	0.00
arable	UA-Pet	3	40	20	ND	0.00
arable	UA-Pet	4	40	20	0.00	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
arable	UA-Pet	5	40	20	-17.17	0.00
arable	UA-Pet	6	40	20	0.00	ND
arable	UA-Pet	1	63	20	0.00	ND
arable	UA-Pet	2	63	20	-16.51	ND
arable	UA-Pet	3	63	20	0.00	0.00
arable	UA-Pet	4	63	20	0.00	0.00
arable	UA-Pet	5	63	20	0.00	ND
arable	UA-Pet	6	63	20	0.00	0.00
arable	UA-Pet	1	83	20	0.00	0.00
arable	UA-Pet	2	83	20	0.00	0.00
arable	UA-Pet	3	83	20	-14.14	0.00
arable	UA-Pet	4	83	20	ND	ND
arable	UA-Pet	5	83	20	-24.17	12.99
arable	UA-Pet	6	83	20	0.00	ND
arable	UA-Pet	1	6	25	0.00	0.00
arable	UA-Pet	2	6	25	0.00	0.00
arable	UA-Pet	3	6	25	0.00	0.00
arable	UA-Pet	4	6	25	0.00	0.00
arable	UA-Pet	5	6	25	9.38	0.00
arable	UA-Pet	6	6	25	0.00	0.00
arable	UA-Pet	1	19	25	0.00	0.00
arable	UA-Pet	2	19	25	0.00	-11.92
arable	UA-Pet	3	19	25	0.00	-12.89
arable	UA-Pet	4	19	25	ND	ND
arable	UA-Pet	5	19	25	0.00	-16.85
arable	UA-Pet	6	19	25	0.00	ND
arable	UA-Pet	1	40	25	0.00	ND
arable	UA-Pet	2	40	25	ND	-13.31
arable	UA-Pet	3	40	25	0.00	-17.40
arable	UA-Pet	4	40	25	ND	-15.93
arable	UA-Pet	5	40	25	0.00	0.00
arable	UA-Pet	6	40	25	17.52	0.00
arable	UA-Pet	1	63	25	ND	32.44
arable	UA-Pet	2	63	25	0.00	-11.39
arable	UA-Pet	3	63	25	ND	ND
arable	UA-Pet	4	63	25	0.00	0.00
arable	UA-Pet	5	63	25	ND	0.00
arable	UA-Pet	6	63	25	19.61	0.00
arable	UA-Pet	1	83	25	ND	0.00
arable	UA-Pet	2	83	25	18.79	29.13
arable	UA-Pet	3	83	25	0.00	0.00
arable	UA-Pet	4	83	25	0.00	0.00
arable	UA-Pet	5	83	25	0.00	22.31

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
arable	UA-Pet	6	83	25	0.00	19.06
forest	FI-Hyy	1	15	5	ND	ND
forest	FI-Hyy	2	15	5	ND	0.00
forest	FI-Hyy	3	15	5	16.82	ND
forest	FI-Hyy	4	15	5	-19.40	ND
forest	FI-Hyy	5	15	5	ND	0.00
forest	FI-Hyy	6	15	5	-27.67	0.00
forest	FI-Hyy	1	22	5	ND	ND
forest	FI-Hyy	2	22	5	0.00	0.00
forest	FI-Hyy	3	22	5	-28.87	0.00
forest	FI-Hyy	4	22	5	-32.82	0.00
forest	FI-Hyy	5	22	5	0.00	0.00
forest	FI-Hyy	6	22	5	-118.25	ND
forest	FI-Hyy	1	45	5	ND	ND
forest	FI-Hyy	2	45	5	-19.74	ND
forest	FI-Hyy	3	45	5	-29.31	0.00
forest	FI-Hyy	4	45	5	-46.17	0.00
forest	FI-Hyy	5	45	5	-37.00	0.00
forest	FI-Hyy	6	45	5	-55.78	0.00
forest	FI-Hyy	1	65	5	ND	ND
forest	FI-Hyy	2	65	5	ND	ND
forest	FI-Hyy	3	65	5	0.00	0.00
forest	FI-Hyy	4	65	5	-28.54	0.00
forest	FI-Hyy	5	65	5	-19.20	0.00
forest	FI-Hyy	6	65	5	0.00	0.00
forest	FI-Hyy	1	83	5	0.00	ND
forest	FI-Hyy	2	83	5	0.00	0.00
forest	FI-Hyy	3	83	5	0.00	9.91
forest	FI-Hyy	4	83	5	ND	ND
forest	FI-Hyy	5	83	5	0.00	13.72
forest	FI-Hyy	6	83	5	0.00	ND
forest	FI-Hyy	1	15	10	ND	ND
forest	FI-Hyy	2	15	10	ND	0.00
forest	FI-Hyy	3	15	10	-33.87	0.00
forest	FI-Hyy	4	15	10	-34.03	ND
forest	FI-Hyy	5	15	10	-36.81	0.00
forest	FI-Hyy	6	15	10	-29.43	0.00
forest	FI-Hyy	1	22	10	ND	ND
forest	FI-Hyy	2	22	10	0.00	-12.89
forest	FI-Hyy	3	22	10	-42.81	-20.70
forest	FI-Hyy	4	22	10	-48.88	-13.80
forest	FI-Hyy	5	22	10	-21.71	-11.73
forest	FI-Hyy	6	22	10	-65.59	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
forest	FI-Hyy	1	45	10	ND	ND
forest	FI-Hyy	2	45	10	0.00	0.00
forest	FI-Hyy	3	45	10	-34.47	0.00
forest	FI-Hyy	4	45	10	-59.74	0.00
forest	FI-Hyy	5	45	10	ND	0.00
forest	FI-Hyy	6	45	10	-52.52	0.00
forest	FI-Hyy	1	65	10	ND	ND
forest	FI-Hyy	2	65	10	ND	ND
forest	FI-Hyy	3	65	10	-11.00	0.00
forest	FI-Hyy	4	65	10	ND	0.00
forest	FI-Hyy	5	65	10	-16.01	0.00
forest	FI-Hyy	6	65	10	-15.73	ND
forest	FI-Hyy	1	83	10	-25.03	0.00
forest	FI-Hyy	2	83	10	-20.67	0.00
forest	FI-Hyy	3	83	10	0.00	0.00
forest	FI-Hyy	4	83	10	ND	ND
forest	FI-Hyy	5	83	10	ND	0.00
forest	FI-Hyy	6	83	10	0.00	0.00
forest	FI-Hyy	1	15	15	ND	ND
forest	FI-Hyy	2	15	15	0.00	13.16
forest	FI-Hyy	3	15	15	0.00	ND
forest	FI-Hyy	4	15	15	-38.69	23.27
forest	FI-Hyy	5	15	15	-22.74	ND
forest	FI-Hyy	6	15	15	-42.63	ND
forest	FI-Hyy	1	22	15	ND	ND
forest	FI-Hyy	2	22	15	0.00	0.00
forest	FI-Hyy	3	22	15	-42.07	ND
forest	FI-Hyy	4	22	15	-48.20	ND
forest	FI-Hyy	5	22	15	ND	ND
forest	FI-Hyy	6	22	15	-50.14	ND
forest	FI-Hyy	1	45	15	ND	ND
forest	FI-Hyy	2	45	15	0.00	-13.75
forest	FI-Hyy	3	45	15	-18.72	0.00
forest	FI-Hyy	4	45	15	-52.93	-14.64
forest	FI-Hyy	5	45	15	-36.53	-16.05
forest	FI-Hyy	6	45	15	-52.14	-22.52
forest	FI-Hyy	1	65	15	ND	ND
forest	FI-Hyy	2	65	15	ND	ND
forest	FI-Hyy	3	65	15	-19.33	ND
forest	FI-Hyy	4	65	15	-37.40	-15.61
forest	FI-Hyy	5	65	15	-20.50	-15.95
forest	FI-Hyy	6	65	15	0.00	0.00
forest	FI-Hyy	1	83	15	-143.96	-13.99

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
forest	FI-Hyy	2	83	15	0.00	0.00
forest	FI-Hyy	3	83	15	16.67	0.00
forest	FI-Hyy	4	83	15	ND	ND
forest	FI-Hyy	5	83	15	-13.78	0.00
forest	FI-Hyy	6	83	15	0.00	0.00
forest	FI-Hyy	1	15	20	ND	ND
forest	FI-Hyy	2	15	20	-13.66	0.00
forest	FI-Hyy	3	15	20	0.00	0.00
forest	FI-Hyy	4	15	20	-12.00	ND
forest	FI-Hyy	5	15	20	-21.26	0.00
forest	FI-Hyy	6	15	20	-46.41	0.00
forest	FI-Hyy	1	22	20	ND	ND
forest	FI-Hyy	2	22	20	-33.36	-12.94
forest	FI-Hyy	3	22	20	-43.32	0.00
forest	FI-Hyy	4	22	20	-60.21	ND
forest	FI-Hyy	5	22	20	-20.85	0.00
forest	FI-Hyy	6	22	20	-63.56	0.00
forest	FI-Hyy	1	45	20	ND	ND
forest	FI-Hyy	2	45	20	0.00	0.00
forest	FI-Hyy	3	45	20	-22.34	0.00
forest	FI-Hyy	4	45	20	-53.17	0.00
forest	FI-Hyy	5	45	20	-21.96	0.00
forest	FI-Hyy	6	45	20	-36.56	0.00
forest	FI-Hyy	1	65	20	ND	ND
forest	FI-Hyy	2	65	20	ND	ND
forest	FI-Hyy	3	65	20	0.00	0.00
forest	FI-Hyy	4	65	20	-44.70	0.00
forest	FI-Hyy	5	65	20	ND	0.00
forest	FI-Hyy	6	65	20	0.00	0.00
forest	FI-Hyy	1	83	20	ND	0.00
forest	FI-Hyy	2	83	20	0.00	0.00
forest	FI-Hyy	3	83	20	0.00	0.00
forest	FI-Hyy	4	83	20	ND	ND
forest	FI-Hyy	5	83	20	ND	0.00
forest	FI-Hyy	6	83	20	0.00	0.00
forest	FI-Hyy	1	15	25	ND	ND
forest	FI-Hyy	2	15	25	0.00	0.00
forest	FI-Hyy	3	15	25	0.00	-13.00
forest	FI-Hyy	4	15	25	-31.62	ND
forest	FI-Hyy	5	15	25	-25.81	-11.54
forest	FI-Hyy	6	15	25	-17.09	0.04
forest	FI-Hyy	1	22	25	ND	ND
forest	FI-Hyy	2	22	25	0.00	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
forest	FI-Hyy	3	22	25	-41.52	ND
forest	FI-Hyy	4	22	25	-37.77	0.00
forest	FI-Hyy	5	22	25	0.00	ND
forest	FI-Hyy	6	22	25	-110.28	0.00
forest	FI-Hyy	1	45	25	ND	ND
forest	FI-Hyy	2	45	25	-132.28	-13.28
forest	FI-Hyy	3	45	25	-20.36	-15.87
forest	FI-Hyy	4	45	25	-41.21	-18.39
forest	FI-Hyy	5	45	25	-28.76	-13.56
forest	FI-Hyy	6	45	25	-46.14	-16.13
forest	FI-Hyy	1	65	25	ND	ND
forest	FI-Hyy	2	65	25	ND	ND
forest	FI-Hyy	3	65	25	0.00	ND
forest	FI-Hyy	4	65	25	ND	-10.79
forest	FI-Hyy	5	65	25	-31.66	0.00
forest	FI-Hyy	6	65	25	0.00	0.00
forest	FI-Hyy	1	83	25	88.46	-9.49
forest	FI-Hyy	2	83	25	0.00	0.00
forest	FI-Hyy	3	83	25	15.79	ND
forest	FI-Hyy	4	83	25	ND	ND
forest	FI-Hyy	5	83	25	-18.48	ND
forest	FI-Hyy	6	83	25	ND	ND
forest	IT-BFo	1	13	5	ND	0.00
forest	IT-BFo	2	13	5	0.00	0.00
forest	IT-BFo	3	13	5	0.00	0.00
forest	IT-BFo	4	13	5	ND	ND
forest	IT-BFo	5	13	5	0.00	0.00
forest	IT-BFo	6	13	5	0.00	0.00
forest	IT-BFo	1	26	5	0.00	ND
forest	IT-BFo	2	26	5	ND	ND
forest	IT-BFo	3	26	5	7.07	ND
forest	IT-BFo	4	26	5	ND	ND
forest	IT-BFo	5	26	5	ND	ND
forest	IT-BFo	6	26	5	ND	ND
forest	IT-BFo	1	46	5	ND	12.33
forest	IT-BFo	2	46	5	-8.48	ND
forest	IT-BFo	3	46	5	ND	ND
forest	IT-BFo	4	46	5	ND	5.23
forest	IT-BFo	5	46	5	ND	25.00
forest	IT-BFo	6	46	5	ND	ND
forest	IT-BFo	1	65	5	ND	ND
forest	IT-BFo	2	65	5	ND	ND
forest	IT-BFo	3	65	5	13.25	193.68

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
forest	IT-BFo	4	65	5	ND	95.03
forest	IT-BFo	5	65	5	ND	ND
forest	IT-BFo	6	65	5	-6.90	189.79
forest	IT-BFo	1	84	5	ND	13.11
forest	IT-BFo	2	84	5	ND	12.53
forest	IT-BFo	3	84	5	ND	903.62
forest	IT-BFo	4	84	5	-5.19	492.95
forest	IT-BFo	5	84	5	ND	58.65
forest	IT-BFo	6	84	5	ND	79.68
forest	IT-BFo	1	13	10	ND	0.00
forest	IT-BFo	2	13	10	ND	0.00
forest	IT-BFo	3	13	10	0.00	0.00
forest	IT-BFo	4	13	10	ND	ND
forest	IT-BFo	5	13	10	ND	0.00
forest	IT-BFo	6	13	10	ND	0.00
forest	IT-BFo	1	26	10	0.00	0.00
forest	IT-BFo	2	26	10	ND	ND
forest	IT-BFo	3	26	10	ND	ND
forest	IT-BFo	4	26	10	34.56	-8.29
forest	IT-BFo	5	26	10	39.60	-13.58
forest	IT-BFo	6	26	10	ND	ND
forest	IT-BFo	1	46	10	ND	-13.74
forest	IT-BFo	2	46	10	ND	-14.58
forest	IT-BFo	3	46	10	ND	-9.87
forest	IT-BFo	4	46	10	ND	-16.38
forest	IT-BFo	5	46	10	ND	14.37
forest	IT-BFo	6	46	10	39.20	-1.82
forest	IT-BFo	1	65	10	ND	-3.84
forest	IT-BFo	2	65	10	ND	48.43
forest	IT-BFo	3	65	10	ND	454.79
forest	IT-BFo	4	65	10	ND	153.30
forest	IT-BFo	5	65	10	ND	12.17
forest	IT-BFo	6	65	10	ND	1027.60
forest	IT-BFo	1	84	10	ND	107.53
forest	IT-BFo	2	84	10	ND	88.55
forest	IT-BFo	3	84	10	-12.10	998.10
forest	IT-BFo	4	84	10	ND	1111.82
forest	IT-BFo	5	84	10	ND	36.87
forest	IT-BFo	6	84	10	-9.30	186.88
forest	IT-BFo	1	13	15	ND	0.00
forest	IT-BFo	2	13	15	ND	0.00
forest	IT-BFo	3	13	15	0.00	-17.98
forest	IT-BFo	4	13	15	ND	ND

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
forest	IT-BFo	5	13	15	0.00	0.00
forest	IT-BFo	6	13	15	0.00	0.00
forest	IT-BFo	1	26	15	-16.61	0.00
forest	IT-BFo	2	26	15	ND	ND
forest	IT-BFo	3	26	15	0.00	0.00
forest	IT-BFo	4	26	15	0.00	0.00
forest	IT-BFo	5	26	15	ND	0.00
forest	IT-BFo	6	26	15	0.00	0.00
forest	IT-BFo	1	46	15	0.00	0.00
forest	IT-BFo	2	46	15	0.00	0.00
forest	IT-BFo	3	46	15	ND	0.00
forest	IT-BFo	4	46	15	ND	0.00
forest	IT-BFo	5	46	15	-17.46	0.00
forest	IT-BFo	6	46	15	ND	0.00
forest	IT-BFo	1	65	15	0.00	0.00
forest	IT-BFo	2	65	15	0.00	17.75
forest	IT-BFo	3	65	15	ND	2035.43
forest	IT-BFo	4	65	15	ND	1126.89
forest	IT-BFo	5	65	15	ND	21.93
forest	IT-BFo	6	65	15	0.00	2888.75
forest	IT-BFo	1	84	15	ND	794.44
forest	IT-BFo	2	84	15	0.00	526.28
forest	IT-BFo	3	84	15	ND	164.47
forest	IT-BFo	4	84	15	0.00	1628.66
forest	IT-BFo	5	84	15	ND	31.36
forest	IT-BFo	6	84	15	0.00	1095.35
forest	IT-BFo	1	13	20	ND	0.00
forest	IT-BFo	2	13	20	0.00	0.00
forest	IT-BFo	3	13	20	0.00	0.00
forest	IT-BFo	4	13	20	ND	ND
forest	IT-BFo	5	13	20	0.00	0.00
forest	IT-BFo	6	13	20	0.00	0.00
forest	IT-BFo	1	26	20	0.00	0.00
forest	IT-BFo	2	26	20	ND	ND
forest	IT-BFo	3	26	20	0.00	0.00
forest	IT-BFo	4	26	20	ND	0.00
forest	IT-BFo	5	26	20	0.00	0.00
forest	IT-BFo	6	26	20	0.00	10.91
forest	IT-BFo	1	46	20	ND	0.00
forest	IT-BFo	2	46	20	0.00	0.00
forest	IT-BFo	3	46	20	0.00	ND
forest	IT-BFo	4	46	20	ND	0.00
forest	IT-BFo	5	46	20	ND	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
forest	IT-BFo	6	46	20	0.00	0.00
forest	IT-BFo	1	65	20	0.00	0.00
forest	IT-BFo	2	65	20	0.00	0.00
forest	IT-BFo	3	65	20	ND	3552.94
forest	IT-BFo	4	65	20	ND	2481.96
forest	IT-BFo	5	65	20	0.00	21.11
forest	IT-BFo	6	65	20	ND	6104.65
forest	IT-BFo	1	84	20	0.00	1325.78
forest	IT-BFo	2	84	20	0.00	3891.10
forest	IT-BFo	3	84	20	ND	50.99
forest	IT-BFo	4	84	20	0.00	993.00
forest	IT-BFo	5	84	20	-87.13	ND
forest	IT-BFo	6	84	20	0.00	1730.73
forest	IT-BFo	1	13	25	ND	ND
forest	IT-BFo	2	13	25	0.00	0.00
forest	IT-BFo	3	13	25	ND	-16.87
forest	IT-BFo	4	13	25	ND	ND
forest	IT-BFo	5	13	25	0.00	ND
forest	IT-BFo	6	13	25	-19.38	0.00
forest	IT-BFo	1	26	25	ND	6.63
forest	IT-BFo	2	26	25	ND	ND
forest	IT-BFo	3	26	25	0.00	0.00
forest	IT-BFo	4	26	25	0.00	0.00
forest	IT-BFo	5	26	25	0.00	0.00
forest	IT-BFo	6	26	25	0.00	0.00
forest	IT-BFo	1	46	25	0.00	0.00
forest	IT-BFo	2	46	25	0.00	0.00
forest	IT-BFo	3	46	25	ND	0.00
forest	IT-BFo	4	46	25	0.00	0.00
forest	IT-BFo	5	46	25	0.00	0.00
forest	IT-BFo	6	46	25	0.00	0.00
forest	IT-BFo	1	65	25	0.00	0.00
forest	IT-BFo	2	65	25	0.00	64.40
forest	IT-BFo	3	65	25	0.00	ND
forest	IT-BFo	4	65	25	0.00	1070.74
forest	IT-BFo	5	65	25	0.00	426.30
forest	IT-BFo	6	65	25	0.00	510.17
forest	IT-BFo	1	84	25	0.00	389.65
forest	IT-BFo	2	84	25	0.00	849.07
forest	IT-BFo	3	84	25	0.00	454.91
forest	IT-BFo	4	84	25	0.00	1749.40
forest	IT-BFo	5	84	25	0.00	955.33
forest	IT-BFo	6	84	25	0.00	604.72

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
forest	IT-IFo	1	13	5	0.00	0.00
forest	IT-IFo	2	13	5	0.00	0.00
forest	IT-IFo	3	13	5	0.00	0.00
forest	IT-IFo	4	13	5	0.00	0.00
forest	IT-IFo	5	13	5	0.00	0.00
forest	IT-IFo	6	13	5	ND	ND
forest	IT-IFo	1	27	5	ND	0.00
forest	IT-IFo	2	27	5	0.00	0.00
forest	IT-IFo	3	27	5	ND	-12.29
forest	IT-IFo	4	27	5	ND	0.00
forest	IT-IFo	5	27	5	ND	ND
forest	IT-IFo	6	27	5	0.00	0.00
forest	IT-IFo	1	44	5	13.11	-2.86
forest	IT-IFo	2	44	5	ND	ND
forest	IT-IFo	3	44	5	0.00	10.31
forest	IT-IFo	4	44	5	ND	ND
forest	IT-IFo	5	44	5	-5.06	17.98
forest	IT-IFo	6	44	5	ND	ND
forest	IT-IFo	1	65	5	0.00	ND
forest	IT-IFo	2	65	5	-24.86	ND
forest	IT-IFo	3	65	5	ND	132.02
forest	IT-IFo	4	65	5	0.00	31.70
forest	IT-IFo	5	65	5	-15.76	13.65
forest	IT-IFo	6	65	5	ND	ND
forest	IT-IFo	1	84	5	0.00	47.76
forest	IT-IFo	2	84	5	ND	0.00
forest	IT-IFo	3	84	5	-27.18	0.00
forest	IT-IFo	4	84	5	-17.72	12.24
forest	IT-IFo	5	84	5	0.00	0.00
forest	IT-IFo	6	84	5	0.00	14.23
forest	IT-IFo	1	13	10	-21.71	0.00
forest	IT-IFo	2	13	10	0.00	0.00
forest	IT-IFo	3	13	10	0.00	0.00
forest	IT-IFo	4	13	10	0.00	0.00
forest	IT-IFo	5	13	10	ND	0.00
forest	IT-IFo	6	13	10	ND	ND
forest	IT-IFo	1	27	10	19.31	0.00
forest	IT-IFo	2	27	10	0.00	0.00
forest	IT-IFo	3	27	10	-24.68	0.00
forest	IT-IFo	4	27	10	ND	0.00
forest	IT-IFo	5	27	10	ND	ND
forest	IT-IFo	6	27	10	0.00	0.00
forest	IT-IFo	1	44	10	0.00	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
forest	IT-IFo	2	44	10	0.00	0.00
forest	IT-IFo	3	44	10	ND	0.00
forest	IT-IFo	4	44	10	0.00	0.00
forest	IT-IFo	5	44	10	0.00	ND
forest	IT-IFo	6	44	10	ND	ND
forest	IT-IFo	1	65	10	0.00	0.00
forest	IT-IFo	2	65	10	-28.72	0.00
forest	IT-IFo	3	65	10	0.00	121.88
forest	IT-IFo	4	65	10	0.00	42.70
forest	IT-IFo	5	65	10	0.00	0.00
forest	IT-IFo	6	65	10	0.00	12.76
forest	IT-IFo	1	84	10	0.00	318.42
forest	IT-IFo	2	84	10	0.00	0.00
forest	IT-IFo	3	84	10	-26.11	0.00
forest	IT-IFo	4	84	10	-14.03	0.00
forest	IT-IFo	5	84	10	0.00	0.00
forest	IT-IFo	6	84	10	0.00	19.83
forest	IT-IFo	1	13	15	0.00	0.00
forest	IT-IFo	2	13	15	0.00	0.00
forest	IT-IFo	3	13	15	0.00	ND
forest	IT-IFo	4	13	15	0.00	0.00
forest	IT-IFo	5	13	15	0.00	ND
forest	IT-IFo	6	13	15	ND	ND
forest	IT-IFo	1	27	15	0.00	0.00
forest	IT-IFo	2	27	15	-20.00	0.00
forest	IT-IFo	3	27	15	-35.93	0.00
forest	IT-IFo	4	27	15	0.00	0.00
forest	IT-IFo	5	27	15	ND	ND
forest	IT-IFo	6	27	15	ND	0.00
forest	IT-IFo	1	44	15	0.00	0.00
forest	IT-IFo	2	44	15	-15.98	0.00
forest	IT-IFo	3	44	15	-20.37	0.00
forest	IT-IFo	4	44	15	-24.32	0.00
forest	IT-IFo	5	44	15	0.00	ND
forest	IT-IFo	6	44	15	ND	ND
forest	IT-IFo	1	65	15	0.00	10.98
forest	IT-IFo	2	65	15	-43.60	17.91
forest	IT-IFo	3	65	15	0.00	139.49
forest	IT-IFo	4	65	15	0.00	116.91
forest	IT-IFo	5	65	15	ND	0.00
forest	IT-IFo	6	65	15	0.00	11.95
forest	IT-IFo	1	84	15	0.00	292.63
forest	IT-IFo	2	84	15	0.00	35.67

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
forest	IT-IFo	3	84	15	-32.24	0.00
forest	IT-IFo	4	84	15	-42.53	0.00
forest	IT-IFo	5	84	15	ND	40.67
forest	IT-IFo	6	84	15	ND	49.30
forest	IT-IFo	1	13	20	0.00	0.00
forest	IT-IFo	2	13	20	ND	0.00
forest	IT-IFo	3	13	20	0.00	0.00
forest	IT-IFo	4	13	20	-29.52	-11.89
forest	IT-IFo	5	13	20	0.00	0.00
forest	IT-IFo	6	13	20	ND	ND
forest	IT-IFo	1	27	20	0.00	0.00
forest	IT-IFo	2	27	20	-24.48	0.00
forest	IT-IFo	3	27	20	-47.79	0.00
forest	IT-IFo	4	27	20	0.00	0.00
forest	IT-IFo	5	27	20	ND	ND
forest	IT-IFo	6	27	20	0.00	0.00
forest	IT-IFo	1	44	20	-22.58	6.34
forest	IT-IFo	2	44	20	-23.65	ND
forest	IT-IFo	3	44	20	-32.20	0.00
forest	IT-IFo	4	44	20	-22.75	0.00
forest	IT-IFo	5	44	20	-13.63	0.00
forest	IT-IFo	6	44	20	ND	ND
forest	IT-IFo	1	65	20	-16.81	-13.51
forest	IT-IFo	2	65	20	-46.47	ND
forest	IT-IFo	3	65	20	0.00	10.45
forest	IT-IFo	4	65	20	ND	17.01
forest	IT-IFo	5	65	20	-13.91	ND
forest	IT-IFo	6	65	20	ND	ND
forest	IT-IFo	1	84	20	0.00	197.49
forest	IT-IFo	2	84	20	0.00	22.08
forest	IT-IFo	3	84	20	-51.45	ND
forest	IT-IFo	4	84	20	-22.43	12.95
forest	IT-IFo	5	84	20	0.00	ND
forest	IT-IFo	6	84	20	0.00	89.03
forest	IT-IFo	1	13	25	0.00	-11.55
forest	IT-IFo	2	13	25	0.00	ND
forest	IT-IFo	3	13	25	-28.88	-17.41
forest	IT-IFo	4	13	25	0.00	0.00
forest	IT-IFo	5	13	25	ND	ND
forest	IT-IFo	6	13	25	ND	ND
forest	IT-IFo	1	27	25	0.00	0.00
forest	IT-IFo	2	27	25	0.00	0.00
forest	IT-IFo	3	27	25	-33.63	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
forest	IT-IFo	4	27	25	0.00	0.00
forest	IT-IFo	5	27	25	ND	ND
forest	IT-IFo	6	27	25	0.00	0.00
forest	IT-IFo	1	44	25	ND	0.00
forest	IT-IFo	2	44	25	ND	ND
forest	IT-IFo	3	44	25	-29.64	0.00
forest	IT-IFo	4	44	25	-39.88	-8.53
forest	IT-IFo	5	44	25	0.00	0.00
forest	IT-IFo	6	44	25	ND	ND
forest	IT-IFo	1	65	25	0.00	ND
forest	IT-IFo	2	65	25	-54.03	0.00
forest	IT-IFo	3	65	25	0.00	0.00
forest	IT-IFo	4	65	25	0.00	0.00
forest	IT-IFo	5	65	25	ND	0.00
forest	IT-IFo	6	65	25	0.00	ND
forest	IT-IFo	1	84	25	-15.53	79.50
forest	IT-IFo	2	84	25	0.00	18.00
forest	IT-IFo	3	84	25	-64.88	ND
forest	IT-IFo	4	84	25	-38.85	0.00
forest	IT-IFo	5	84	25	0.00	ND
forest	IT-IFo	6	84	25	0.00	115.17
forest	NL-Spe	1	18	5	ND	ND
forest	NL-Spe	2	18	5	ND	ND
forest	NL-Spe	3	18	5	ND	ND
forest	NL-Spe	4	18	5	ND	ND
forest	NL-Spe	5	18	5	ND	ND
forest	NL-Spe	6	18	5	ND	ND
forest	NL-Spe	1	30	5	ND	ND
forest	NL-Spe	2	30	5	0.00	0.00
forest	NL-Spe	3	30	5	ND	0.00
forest	NL-Spe	4	30	5	0.00	0.00
forest	NL-Spe	5	30	5	0.00	0.00
forest	NL-Spe	6	30	5	0.00	0.00
forest	NL-Spe	1	41	5	37.71	26.74
forest	NL-Spe	2	41	5	ND	ND
forest	NL-Spe	3	41	5	ND	0.00
forest	NL-Spe	4	41	5	32.90	0.00
forest	NL-Spe	5	41	5	ND	18.61
forest	NL-Spe	6	41	5	0.00	0.00
forest	NL-Spe	1	55	5	-14.79	0.00
forest	NL-Spe	2	55	5	0.00	0.00
forest	NL-Spe	3	55	5	ND	ND
forest	NL-Spe	4	55	5	ND	ND

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
forest	NL-Spe	5	55	5	0.00	0.00
forest	NL-Spe	6	55	5	0.00	0.00
forest	NL-Spe	1	74	5	ND	ND
forest	NL-Spe	2	74	5	0.00	ND
forest	NL-Spe	3	74	5	0.00	0.00
forest	NL-Spe	4	74	5	0.00	0.00
forest	NL-Spe	5	74	5	0.00	0.00
forest	NL-Spe	6	74	5	0.00	0.00
forest	NL-Spe	1	18	10	ND	ND
forest	NL-Spe	2	18	10	ND	ND
forest	NL-Spe	3	18	10	ND	ND
forest	NL-Spe	4	18	10	ND	ND
forest	NL-Spe	5	18	10	ND	ND
forest	NL-Spe	6	18	10	ND	ND
forest	NL-Spe	1	30	10	ND	ND
forest	NL-Spe	2	30	10	0.00	ND
forest	NL-Spe	3	30	10	0.00	0.00
forest	NL-Spe	4	30	10	0.00	0.00
forest	NL-Spe	5	30	10	0.00	-11.63
forest	NL-Spe	6	30	10	0.00	0.00
forest	NL-Spe	1	41	10	0.00	0.00
forest	NL-Spe	2	41	10	0.00	0.00
forest	NL-Spe	3	41	10	0.00	0.00
forest	NL-Spe	4	41	10	0.00	0.00
forest	NL-Spe	5	41	10	0.00	0.00
forest	NL-Spe	6	41	10	0.00	0.00
forest	NL-Spe	1	55	10	0.00	0.00
forest	NL-Spe	2	55	10	ND	0.00
forest	NL-Spe	3	55	10	ND	ND
forest	NL-Spe	4	55	10	ND	ND
forest	NL-Spe	5	55	10	ND	ND
forest	NL-Spe	6	55	10	0.00	0.00
forest	NL-Spe	1	74	10	0.00	14.23
forest	NL-Spe	2	74	10	0.00	0.00
forest	NL-Spe	3	74	10	0.00	19.64
forest	NL-Spe	4	74	10	0.00	ND
forest	NL-Spe	5	74	10	0.00	0.00
forest	NL-Spe	6	74	10	0.00	17.70
forest	NL-Spe	1	18	15	ND	ND
forest	NL-Spe	2	18	15	ND	ND
forest	NL-Spe	3	18	15	ND	ND
forest	NL-Spe	4	18	15	ND	ND
forest	NL-Spe	5	18	15	ND	ND

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
forest	NL-Spe	6	18	15	ND	ND
forest	NL-Spe	1	30	15	ND	ND
forest	NL-Spe	2	30	15	14.14	0.00
forest	NL-Spe	3	30	15	0.00	0.00
forest	NL-Spe	4	30	15	17.84	0.00
forest	NL-Spe	5	30	15	0.00	0.00
forest	NL-Spe	6	30	15	14.19	0.00
forest	NL-Spe	1	41	15	0.00	0.00
forest	NL-Spe	2	41	15	0.00	0.00
forest	NL-Spe	3	41	15	0.00	0.00
forest	NL-Spe	4	41	15	0.00	17.48
forest	NL-Spe	5	41	15	0.00	ND
forest	NL-Spe	6	41	15	0.00	ND
forest	NL-Spe	1	55	15	-19.01	10.13
forest	NL-Spe	2	55	15	-24.09	ND
forest	NL-Spe	3	55	15	ND	ND
forest	NL-Spe	4	55	15	ND	ND
forest	NL-Spe	5	55	15	0.00	0.00
forest	NL-Spe	6	55	15	0.00	0.00
forest	NL-Spe	1	74	15	ND	ND
forest	NL-Spe	2	74	15	0.00	0.00
forest	NL-Spe	3	74	15	0.00	193.88
forest	NL-Spe	4	74	15	0.00	0.00
forest	NL-Spe	5	74	15	0.00	30.71
forest	NL-Spe	6	74	15	0.00	0.00
forest	NL-Spe	1	18	20	ND	ND
forest	NL-Spe	2	18	20	ND	ND
forest	NL-Spe	3	18	20	ND	ND
forest	NL-Spe	4	18	20	ND	ND
forest	NL-Spe	5	18	20	ND	ND
forest	NL-Spe	6	18	20	ND	ND
forest	NL-Spe	1	30	20	ND	ND
forest	NL-Spe	2	30	20	ND	0.00
forest	NL-Spe	3	30	20	-35.67	-12.60
forest	NL-Spe	4	30	20	0.00	0.00
forest	NL-Spe	5	30	20	0.00	0.00
forest	NL-Spe	6	30	20	0.00	0.00
forest	NL-Spe	1	41	20	0.00	0.00
forest	NL-Spe	2	41	20	0.00	0.00
forest	NL-Spe	3	41	20	0.00	0.00
forest	NL-Spe	4	41	20	0.00	0.00
forest	NL-Spe	5	41	20	0.00	0.00
forest	NL-Spe	6	41	20	0.00	18.33

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
forest	NL-Spe	1	55	20	0.00	0.00
forest	NL-Spe	2	55	20	-22.80	0.00
forest	NL-Spe	3	55	20	ND	ND
forest	NL-Spe	4	55	20	ND	ND
forest	NL-Spe	5	55	20	0.00	0.00
forest	NL-Spe	6	55	20	0.00	0.00
forest	NL-Spe	1	74	20	ND	ND
forest	NL-Spe	2	74	20	0.00	0.00
forest	NL-Spe	3	74	20	ND	762.72
forest	NL-Spe	4	74	20	0.00	0.00
forest	NL-Spe	5	74	20	0.00	80.97
forest	NL-Spe	6	74	20	0.00	0.00
forest	NL-Spe	1	18	25	ND	ND
forest	NL-Spe	2	18	25	ND	ND
forest	NL-Spe	3	18	25	ND	ND
forest	NL-Spe	4	18	25	ND	ND
forest	NL-Spe	5	18	25	ND	ND
forest	NL-Spe	6	18	25	ND	ND
forest	NL-Spe	1	30	25	ND	ND
forest	NL-Spe	2	30	25	0.00	ND
forest	NL-Spe	3	30	25	0.00	0.00
forest	NL-Spe	4	30	25	ND	ND
forest	NL-Spe	5	30	25	0.00	ND
forest	NL-Spe	6	30	25	ND	ND
forest	NL-Spe	1	41	25	0.00	0.00
forest	NL-Spe	2	41	25	0.00	0.00
forest	NL-Spe	3	41	25	0.00	0.00
forest	NL-Spe	4	41	25	0.00	0.00
forest	NL-Spe	5	41	25	0.00	0.00
forest	NL-Spe	6	41	25	0.00	0.00
forest	NL-Spe	1	55	25	0.00	14.12
forest	NL-Spe	2	55	25	-30.08	0.00
forest	NL-Spe	3	55	25	ND	ND
forest	NL-Spe	4	55	25	ND	ND
forest	NL-Spe	5	55	25	0.00	0.00
forest	NL-Spe	6	55	25	0.00	0.00
forest	NL-Spe	1	74	25	ND	ND
forest	NL-Spe	2	74	25	0.00	78.96
forest	NL-Spe	3	74	25	0.00	2564.93
forest	NL-Spe	4	74	25	0.00	47.11
forest	NL-Spe	5	74	25	0.00	363.54
forest	NL-Spe	6	74	25	0.00	10.55
grassland	CH-Pos	1	5	5	0.00	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
grassland	CH-Pos	2	5	5	0.00	-15.96
grassland	CH-Pos	3	5	5	0.00	-17.33
grassland	CH-Pos	4	5	5	-13.61	-16.53
grassland	CH-Pos	5	5	5	0.00	-12.90
grassland	CH-Pos	6	5	5	ND	ND
grassland	CH-Pos	1	18	5	0.00	0.00
grassland	CH-Pos	2	18	5	0.00	ND
grassland	CH-Pos	3	18	5	0.00	15.55
grassland	CH-Pos	4	18	5	0.00	ND
grassland	CH-Pos	5	18	5	21.20	14.35
grassland	CH-Pos	6	18	5	0.00	0.00
grassland	CH-Pos	1	45	5	ND	ND
grassland	CH-Pos	2	45	5	ND	ND
grassland	CH-Pos	3	45	5	0.00	0.00
grassland	CH-Pos	4	45	5	0.00	0.00
grassland	CH-Pos	5	45	5	0.00	0.00
grassland	CH-Pos	6	45	5	0.00	0.00
grassland	CH-Pos	1	59	5	0.00	1123.56
grassland	CH-Pos	2	59	5	36.43	1666.21
grassland	CH-Pos	3	59	5	ND	169.62
grassland	CH-Pos	4	59	5	ND	272.68
grassland	CH-Pos	5	59	5	ND	352.68
grassland	CH-Pos	6	59	5	ND	ND
grassland	CH-Pos	1	86	5	ND	0.00
grassland	CH-Pos	2	86	5	ND	0.00
grassland	CH-Pos	3	86	5	0.00	0.00
grassland	CH-Pos	4	86	5	0.00	ND
grassland	CH-Pos	5	86	5	54.33	0.00
grassland	CH-Pos	6	86	5	39.68	ND
grassland	CH-Pos	1	5	10	0.00	0.00
grassland	CH-Pos	2	5	10	0.00	0.00
grassland	CH-Pos	3	5	10	7.43	0.00
grassland	CH-Pos	4	5	10	0.00	-13.07
grassland	CH-Pos	5	5	10	9.40	0.00
grassland	CH-Pos	6	5	10	ND	ND
grassland	CH-Pos	1	18	10	0.00	0.00
grassland	CH-Pos	2	18	10	0.00	0.00
grassland	CH-Pos	3	18	10	0.00	0.00
grassland	CH-Pos	4	18	10	0.00	ND
grassland	CH-Pos	5	18	10	0.00	0.00
grassland	CH-Pos	6	18	10	0.00	0.00
grassland	CH-Pos	1	45	10	ND	ND
grassland	CH-Pos	2	45	10	0.00	44.05

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
grassland	CH-Pos	3	45	10	0.00	0.00
grassland	CH-Pos	4	45	10	0.00	ND
grassland	CH-Pos	5	45	10	0.00	0.00
grassland	CH-Pos	6	45	10	-44.61	-25.63
grassland	CH-Pos	1	59	10	0.00	1943.02
grassland	CH-Pos	2	59	10	0.00	1791.45
grassland	CH-Pos	3	59	10	0.00	91.78
grassland	CH-Pos	4	59	10	0.00	528.14
grassland	CH-Pos	5	59	10	0.00	194.24
grassland	CH-Pos	6	59	10	0.00	0.00
grassland	CH-Pos	1	86	10	0.00	0.00
grassland	CH-Pos	2	86	10	31.83	0.00
grassland	CH-Pos	3	86	10	ND	ND
grassland	CH-Pos	4	86	10	ND	105.65
grassland	CH-Pos	5	86	10	0.00	0.00
grassland	CH-Pos	6	86	10	36.12	ND
grassland	CH-Pos	1	5	15	0.00	0.00
grassland	CH-Pos	2	5	15	-21.03	0.00
grassland	CH-Pos	3	5	15	0.00	0.00
grassland	CH-Pos	4	5	15	-4.20	0.00
grassland	CH-Pos	5	5	15	6.65	0.00
grassland	CH-Pos	6	5	15	ND	ND
grassland	CH-Pos	1	18	15	0.00	ND
grassland	CH-Pos	2	18	15	0.00	0.00
grassland	CH-Pos	3	18	15	ND	ND
grassland	CH-Pos	4	18	15	0.00	0.00
grassland	CH-Pos	5	18	15	0.00	0.00
grassland	CH-Pos	6	18	15	0.00	0.00
grassland	CH-Pos	1	45	15	ND	ND
grassland	CH-Pos	2	45	15	0.00	28.90
grassland	CH-Pos	3	45	15	0.00	0.00
grassland	CH-Pos	4	45	15	0.00	0.00
grassland	CH-Pos	5	45	15	15.00	0.00
grassland	CH-Pos	6	45	15	0.00	0.00
grassland	CH-Pos	1	59	15	0.00	1214.74
grassland	CH-Pos	2	59	15	ND	673.06
grassland	CH-Pos	3	59	15	0.00	0.00
grassland	CH-Pos	4	59	15	ND	402.56
grassland	CH-Pos	5	59	15	0.00	62.35
grassland	CH-Pos	6	59	15	0.00	0.00
grassland	CH-Pos	1	86	15	0.00	ND
grassland	CH-Pos	2	86	15	26.15	ND
grassland	CH-Pos	3	86	15	63.71	ND

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
grassland	CH-Pos	4	86	15	ND	67.99
grassland	CH-Pos	5	86	15	0.00	ND
grassland	CH-Pos	6	86	15	27.19	20.29
grassland	CH-Pos	1	5	20	0.00	0.00
grassland	CH-Pos	2	5	20	0.00	0.00
grassland	CH-Pos	3	5	20	0.00	0.00
grassland	CH-Pos	4	5	20	0.00	0.00
grassland	CH-Pos	5	5	20	0.00	0.00
grassland	CH-Pos	6	5	20	ND	ND
grassland	CH-Pos	1	18	20	0.00	15.52
grassland	CH-Pos	2	18	20	0.00	0.00
grassland	CH-Pos	3	18	20	ND	0.00
grassland	CH-Pos	4	18	20	0.00	0.00
grassland	CH-Pos	5	18	20	0.00	0.00
grassland	CH-Pos	6	18	20	11.59	0.00
grassland	CH-Pos	1	45	20	0.00	11.36
grassland	CH-Pos	2	45	20	ND	ND
grassland	CH-Pos	3	45	20	0.00	27.73
grassland	CH-Pos	4	45	20	0.00	0.00
grassland	CH-Pos	5	45	20	0.00	0.00
grassland	CH-Pos	6	45	20	7.89	0.00
grassland	CH-Pos	1	59	20	0.00	72.73
grassland	CH-Pos	2	59	20	ND	369.78
grassland	CH-Pos	3	59	20	0.00	ND
grassland	CH-Pos	4	59	20	-25.94	142.08
grassland	CH-Pos	5	59	20	-25.15	0.00
grassland	CH-Pos	6	59	20	0.00	0.00
grassland	CH-Pos	1	86	20	0.00	76.80
grassland	CH-Pos	2	86	20	0.00	58.33
grassland	CH-Pos	3	86	20	70.53	67.49
grassland	CH-Pos	4	86	20	0.00	54.29
grassland	CH-Pos	5	86	20	0.00	41.90
grassland	CH-Pos	6	86	20	ND	137.62
grassland	CH-Pos	1	5	25	0.00	0.00
grassland	CH-Pos	2	5	25	0.00	0.00
grassland	CH-Pos	3	5	25	0.00	0.00
grassland	CH-Pos	4	5	25	-12.06	0.00
grassland	CH-Pos	5	5	25	0.00	0.00
grassland	CH-Pos	6	5	25	ND	ND
grassland	CH-Pos	1	18	25	-11.40	-11.26
grassland	CH-Pos	2	18	25	0.00	0.00
grassland	CH-Pos	3	18	25	0.00	-9.26
grassland	CH-Pos	4	18	25	0.00	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
grassland	CH-Pos	5	18	25	0.00	-12.96
grassland	CH-Pos	6	18	25	0.00	0.00
grassland	CH-Pos	1	45	25	ND	ND
grassland	CH-Pos	2	45	25	ND	23.86
grassland	CH-Pos	3	45	25	0.00	28.24
grassland	CH-Pos	4	45	25	0.00	0.00
grassland	CH-Pos	5	45	25	0.00	0.00
grassland	CH-Pos	6	45	25	0.00	0.00
grassland	CH-Pos	1	59	25	ND	47.68
grassland	CH-Pos	2	59	25	0.00	301.82
grassland	CH-Pos	3	59	25	0.00	0.00
grassland	CH-Pos	4	59	25	0.00	68.64
grassland	CH-Pos	5	59	25	0.00	0.00
grassland	CH-Pos	6	59	25	0.00	0.00
grassland	CH-Pos	1	86	25	0.00	58.70
grassland	CH-Pos	2	86	25	0.00	52.87
grassland	CH-Pos	3	86	25	33.25	33.00
grassland	CH-Pos	4	86	25	0.00	39.64
grassland	CH-Pos	5	86	25	0.00	124.62
grassland	CH-Pos	6	86	25	0.00	138.77
grassland	HU-Bug	1	5	5	-16.51	0.00
grassland	HU-Bug	2	5	5	0.00	0.00
grassland	HU-Bug	3	5	5	0.00	0.00
grassland	HU-Bug	4	5	5	0.00	0.00
grassland	HU-Bug	5	5	5	-15.45	0.00
grassland	HU-Bug	6	5	5	0.00	0.00
grassland	HU-Bug	1	19	5	0.00	0.00
grassland	HU-Bug	2	19	5	56.53	ND
grassland	HU-Bug	3	19	5	0.00	0.00
grassland	HU-Bug	4	19	5	0.00	0.00
grassland	HU-Bug	5	19	5	49.86	19.61
grassland	HU-Bug	6	19	5	0.00	0.00
grassland	HU-Bug	1	36	5	44.42	20.25
grassland	HU-Bug	2	36	5	ND	0.00
grassland	HU-Bug	3	36	5	18.35	0.00
grassland	HU-Bug	4	36	5	0.00	ND
grassland	HU-Bug	5	36	5	0.00	0.00
grassland	HU-Bug	6	36	5	0.00	ND
grassland	HU-Bug	1	57	5	0.00	ND
grassland	HU-Bug	2	57	5	0.00	0.00
grassland	HU-Bug	3	57	5	ND	0.00
grassland	HU-Bug	4	57	5	-16.55	0.00
grassland	HU-Bug	5	57	5	ND	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
grassland	HU-Bug	6	57	5	ND	ND
grassland	HU-Bug	1	77	5	0.00	16.10
grassland	HU-Bug	2	77	5	ND	-14.65
grassland	HU-Bug	3	77	5	ND	ND
grassland	HU-Bug	4	77	5	ND	30.31
grassland	HU-Bug	5	77	5	-30.95	-22.50
grassland	HU-Bug	6	77	5	ND	ND
grassland	HU-Bug	1	5	10	0.00	0.00
grassland	HU-Bug	2	5	10	0.00	0.00
grassland	HU-Bug	3	5	10	0.00	0.00
grassland	HU-Bug	4	5	10	ND	0.00
grassland	HU-Bug	5	5	10	0.00	0.00
grassland	HU-Bug	6	5	10	0.00	0.00
grassland	HU-Bug	1	19	10	0.00	0.00
grassland	HU-Bug	2	19	10	0.00	0.00
grassland	HU-Bug	3	19	10	0.00	0.00
grassland	HU-Bug	4	19	10	0.00	0.00
grassland	HU-Bug	5	19	10	0.00	0.00
grassland	HU-Bug	6	19	10	-20.53	ND
grassland	HU-Bug	1	36	10	0.00	0.00
grassland	HU-Bug	2	36	10	0.00	0.00
grassland	HU-Bug	3	36	10	0.00	0.00
grassland	HU-Bug	4	36	10	0.00	0.00
grassland	HU-Bug	5	36	10	0.00	0.00
grassland	HU-Bug	6	36	10	0.00	0.00
grassland	HU-Bug	1	57	10	0.00	0.00
grassland	HU-Bug	2	57	10	0.00	0.00
grassland	HU-Bug	3	57	10	0.00	0.00
grassland	HU-Bug	4	57	10	0.00	0.00
grassland	HU-Bug	5	57	10	0.00	0.00
grassland	HU-Bug	6	57	10	0.00	0.00
grassland	HU-Bug	1	77	10	0.00	19.99
grassland	HU-Bug	2	77	10	28.27	0.00
grassland	HU-Bug	3	77	10	-15.42	0.00
grassland	HU-Bug	4	77	10	ND	31.45
grassland	HU-Bug	5	77	10	0.00	0.00
grassland	HU-Bug	6	77	10	ND	0.00
grassland	HU-Bug	1	5	15	0.00	ND
grassland	HU-Bug	2	5	15	ND	ND
grassland	HU-Bug	3	5	15	0.00	0.00
grassland	HU-Bug	4	5	15	0.00	0.00
grassland	HU-Bug	5	5	15	-16.56	0.00
grassland	HU-Bug	6	5	15	ND	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
grassland	HU-Bug	1	19	15	0.00	ND
grassland	HU-Bug	2	19	15	-17.16	ND
grassland	HU-Bug	3	19	15	18.50	14.78
grassland	HU-Bug	4	19	15	28.72	0.00
grassland	HU-Bug	5	19	15	0.00	0.00
grassland	HU-Bug	6	19	15	0.00	0.00
grassland	HU-Bug	1	36	15	0.00	ND
grassland	HU-Bug	2	36	15	0.00	37.11
grassland	HU-Bug	3	36	15	0.00	ND
grassland	HU-Bug	4	36	15	-14.81	0.00
grassland	HU-Bug	5	36	15	0.00	0.00
grassland	HU-Bug	6	36	15	0.00	0.00
grassland	HU-Bug	1	57	15	ND	22.09
grassland	HU-Bug	2	57	15	0.00	23.68
grassland	HU-Bug	3	57	15	0.00	16.14
grassland	HU-Bug	4	57	15	0.00	ND
grassland	HU-Bug	5	57	15	0.00	0.00
grassland	HU-Bug	6	57	15	0.00	0.00
grassland	HU-Bug	1	77	15	0.00	ND
grassland	HU-Bug	2	77	15	28.86	ND
grassland	HU-Bug	3	77	15	0.00	0.00
grassland	HU-Bug	4	77	15	0.00	145.43
grassland	HU-Bug	5	77	15	0.00	ND
grassland	HU-Bug	6	77	15	0.00	18.00
grassland	HU-Bug	1	5	20	-19.55	0.00
grassland	HU-Bug	2	5	20	-11.48	0.00
grassland	HU-Bug	3	5	20	ND	ND
grassland	HU-Bug	4	5	20	-82.38	-28.18
grassland	HU-Bug	5	5	20	ND	0.00
grassland	HU-Bug	6	5	20	-31.90	-11.94
grassland	HU-Bug	1	19	20	0.00	12.55
grassland	HU-Bug	2	19	20	ND	10.14
grassland	HU-Bug	3	19	20	0.00	0.00
grassland	HU-Bug	4	19	20	0.00	0.00
grassland	HU-Bug	5	19	20	0.00	0.00
grassland	HU-Bug	6	19	20	0.00	0.00
grassland	HU-Bug	1	36	20	ND	12.94
grassland	HU-Bug	2	36	20	0.00	35.95
grassland	HU-Bug	3	36	20	0.00	22.77
grassland	HU-Bug	4	36	20	0.00	13.06
grassland	HU-Bug	5	36	20	0.00	0.00
grassland	HU-Bug	6	36	20	0.00	0.00
grassland	HU-Bug	1	57	20	ND	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
grassland	HU-Bug	2	57	20	ND	21.67
grassland	HU-Bug	3	57	20	-16.15	0.00
grassland	HU-Bug	4	57	20	0.00	0.00
grassland	HU-Bug	5	57	20	-15.70	0.00
grassland	HU-Bug	6	57	20	0.00	0.00
grassland	HU-Bug	1	77	20	ND	31.62
grassland	HU-Bug	2	77	20	54.24	20.18
grassland	HU-Bug	3	77	20	0.00	0.00
grassland	HU-Bug	4	77	20	0.00	65.34
grassland	HU-Bug	5	77	20	0.00	34.51
grassland	HU-Bug	6	77	20	0.00	24.54
grassland	HU-Bug	1	5	25	0.00	0.00
grassland	HU-Bug	2	5	25	0.00	0.00
grassland	HU-Bug	3	5	25	0.00	0.00
grassland	HU-Bug	4	5	25	0.00	0.00
grassland	HU-Bug	5	5	25	0.00	0.00
grassland	HU-Bug	6	5	25	0.00	0.00
grassland	HU-Bug	1	19	25	0.00	0.00
grassland	HU-Bug	2	19	25	0.00	0.00
grassland	HU-Bug	3	19	25	0.00	0.00
grassland	HU-Bug	4	19	25	0.00	ND
grassland	HU-Bug	5	19	25	0.00	0.00
grassland	HU-Bug	6	19	25	0.00	0.00
grassland	HU-Bug	1	36	25	0.00	0.00
grassland	HU-Bug	2	36	25	0.00	0.00
grassland	HU-Bug	3	36	25	0.00	0.00
grassland	HU-Bug	4	36	25	0.00	0.00
grassland	HU-Bug	5	36	25	0.00	0.00
grassland	HU-Bug	6	36	25	0.00	0.00
grassland	HU-Bug	1	57	25	0.00	0.00
grassland	HU-Bug	2	57	25	0.00	14.71
grassland	HU-Bug	3	57	25	0.00	0.00
grassland	HU-Bug	4	57	25	0.00	0.00
grassland	HU-Bug	5	57	25	0.00	0.00
grassland	HU-Bug	6	57	25	0.00	0.00
grassland	HU-Bug	1	77	25	0.00	31.45
grassland	HU-Bug	2	77	25	22.39	0.00
grassland	HU-Bug	3	77	25	-11.93	1.81
grassland	HU-Bug	4	77	25	0.00	48.36
grassland	HU-Bug	5	77	25	0.00	0.00
grassland	HU-Bug	6	77	25	0.00	12.95
peatland	UK-AMo	1	22	5	0.00	0.00
peatland	UK-AMo	2	22	5	0.00	-13.61

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
peatland	UK-AMo	3	22	5	0.00	0.00
peatland	UK-AMo	4	22	5	0.00	0.00
peatland	UK-AMo	5	22	5	0.00	0.00
peatland	UK-AMo	6	22	5	0.00	0.00
peatland	UK-AMo	1	41	5	19.66	0.00
peatland	UK-AMo	2	41	5	0.00	0.00
peatland	UK-AMo	3	41	5	ND	0.00
peatland	UK-AMo	4	41	5	0.00	ND
peatland	UK-AMo	5	41	5	0.00	0.00
peatland	UK-AMo	6	41	5	0.00	0.00
peatland	UK-AMo	1	59	5	0.00	0.00
peatland	UK-AMo	2	59	5	0.00	ND
peatland	UK-AMo	3	59	5	0.00	-15.34
peatland	UK-AMo	4	59	5	ND	ND
peatland	UK-AMo	5	59	5	ND	ND
peatland	UK-AMo	6	59	5	0.00	19.22
peatland	UK-AMo	1	83	5	-28.37	ND
peatland	UK-AMo	2	83	5	0.00	0.00
peatland	UK-AMo	3	83	5	ND	ND
peatland	UK-AMo	4	83	5	0.00	144.92
peatland	UK-AMo	5	83	5	ND	0.00
peatland	UK-AMo	6	83	5	-48.37	0.00
peatland	UK-AMo	1	100	5	ND	0.00
peatland	UK-AMo	2	100	5	ND	0.00
peatland	UK-AMo	3	100	5	ND	0.00
peatland	UK-AMo	4	100	5	-20.65	0.00
peatland	UK-AMo	5	100	5	-25.74	ND
peatland	UK-AMo	6	100	5	30.92	0.00
peatland	UK-AMo	1	22	10	-32.99	0.00
peatland	UK-AMo	2	22	10	14.24	0.00
peatland	UK-AMo	3	22	10	0.00	0.00
peatland	UK-AMo	4	22	10	0.00	0.00
peatland	UK-AMo	5	22	10	0.00	0.00
peatland	UK-AMo	6	22	10	0.00	0.00
peatland	UK-AMo	1	41	10	ND	0.00
peatland	UK-AMo	2	41	10	-33.49	0.00
peatland	UK-AMo	3	41	10	ND	ND
peatland	UK-AMo	4	41	10	0.00	0.00
peatland	UK-AMo	5	41	10	ND	0.00
peatland	UK-AMo	6	41	10	ND	0.00
peatland	UK-AMo	1	59	10	0.00	0.00
peatland	UK-AMo	2	59	10	0.00	ND
peatland	UK-AMo	3	59	10	0.00	-12.96

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
peatland	UK-AMo	4	59	10	ND	ND
peatland	UK-AMo	5	59	10	ND	ND
peatland	UK-AMo	6	59	10	0.00	0.00
peatland	UK-AMo	1	83	10	0.00	0.00
peatland	UK-AMo	2	83	10	ND	0.00
peatland	UK-AMo	3	83	10	ND	ND
peatland	UK-AMo	4	83	10	ND	112.09
peatland	UK-AMo	5	83	10	ND	ND
peatland	UK-AMo	6	83	10	ND	16.25
peatland	UK-AMo	1	100	10	ND	0.00
peatland	UK-AMo	2	100	10	ND	0.00
peatland	UK-AMo	3	100	10	15.29	ND
peatland	UK-AMo	4	100	10	0.00	0.00
peatland	UK-AMo	5	100	10	0.00	0.00
peatland	UK-AMo	6	100	10	36.25	0.00
peatland	UK-AMo	1	22	15	0.00	0.00
peatland	UK-AMo	2	22	15	0.00	0.00
peatland	UK-AMo	3	22	15	0.00	0.00
peatland	UK-AMo	4	22	15	0.00	0.00
peatland	UK-AMo	5	22	15	0.00	0.00
peatland	UK-AMo	6	22	15	0.00	0.00
peatland	UK-AMo	1	41	15	0.00	0.00
peatland	UK-AMo	2	41	15	0.00	0.00
peatland	UK-AMo	3	41	15	0.00	ND
peatland	UK-AMo	4	41	15	0.00	ND
peatland	UK-AMo	5	41	15	0.00	0.00
peatland	UK-AMo	6	41	15	-35.41	ND
peatland	UK-AMo	1	59	15	0.00	0.00
peatland	UK-AMo	2	59	15	0.00	ND
peatland	UK-AMo	3	59	15	0.00	0.00
peatland	UK-AMo	4	59	15	ND	ND
peatland	UK-AMo	5	59	15	ND	ND
peatland	UK-AMo	6	59	15	0.00	ND
peatland	UK-AMo	1	83	15	ND	-12.76
peatland	UK-AMo	2	83	15	ND	ND
peatland	UK-AMo	3	83	15	ND	ND
peatland	UK-AMo	4	83	15	25.39	12.38
peatland	UK-AMo	5	83	15	ND	0.00
peatland	UK-AMo	6	83	15	ND	0.00
peatland	UK-AMo	1	100	15	ND	0.00
peatland	UK-AMo	2	100	15	-23.32	ND
peatland	UK-AMo	3	100	15	0.00	0.00
peatland	UK-AMo	4	100	15	ND	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
peatland	UK-AMo	5	100	15	0.00	0.00
peatland	UK-AMo	6	100	15	43.65	0.00
peatland	UK-AMo	1	22	20	0.00	0.00
peatland	UK-AMo	2	22	20	0.00	0.00
peatland	UK-AMo	3	22	20	ND	ND
peatland	UK-AMo	4	22	20	0.00	0.00
peatland	UK-AMo	5	22	20	0.00	0.00
peatland	UK-AMo	6	22	20	0.00	0.00
peatland	UK-AMo	1	41	20	0.00	0.00
peatland	UK-AMo	2	41	20	0.00	0.00
peatland	UK-AMo	3	41	20	-13.14	0.00
peatland	UK-AMo	4	41	20	-14.92	0.00
peatland	UK-AMo	5	41	20	0.00	0.00
peatland	UK-AMo	6	41	20	-18.18	0.00
peatland	UK-AMo	1	59	20	0.00	0.00
peatland	UK-AMo	2	59	20	-12.59	0.00
peatland	UK-AMo	3	59	20	0.00	0.00
peatland	UK-AMo	4	59	20	ND	ND
peatland	UK-AMo	5	59	20	ND	ND
peatland	UK-AMo	6	59	20	0.00	0.00
peatland	UK-AMo	1	83	20	ND	0.00
peatland	UK-AMo	2	83	20	0.00	0.00
peatland	UK-AMo	3	83	20	ND	ND
peatland	UK-AMo	4	83	20	0.00	0.00
peatland	UK-AMo	5	83	20	0.00	0.00
peatland	UK-AMo	6	83	20	0.00	0.00
peatland	UK-AMo	1	100	20	37.03	0.00
peatland	UK-AMo	2	100	20	15.78	0.00
peatland	UK-AMo	3	100	20	74.59	ND
peatland	UK-AMo	4	100	20	ND	0.00
peatland	UK-AMo	5	100	20	23.28	ND
peatland	UK-AMo	6	100	20	80.44	0.00
peatland	UK-AMo	1	22	25	0.00	0.00
peatland	UK-AMo	2	22	25	0.00	0.00
peatland	UK-AMo	3	22	25	0.00	0.00
peatland	UK-AMo	4	22	25	0.00	0.00
peatland	UK-AMo	5	22	25	0.00	-118.43
peatland	UK-AMo	6	22	25	13.80	ND
peatland	UK-AMo	1	41	25	20.55	0.00
peatland	UK-AMo	2	41	25	0.00	0.00
peatland	UK-AMo	3	41	25	ND	-10.19
peatland	UK-AMo	4	41	25	0.00	0.00
peatland	UK-AMo	5	41	25	0.00	0.00

Land use	site	plot	mean.wfps	temperature	µg CH_4-C m^{-2} h^{-1}	µg N_2O-N m^{-2} h^{-1}
peatland	UK-AMo	6	41	25	-16.24	-12.88
peatland	UK-AMo	1	59	25	0.00	ND
peatland	UK-AMo	2	59	25	0.00	0.00
peatland	UK-AMo	3	59	25	0.00	0.00
peatland	UK-AMo	4	59	25	ND	ND
peatland	UK-AMo	5	59	25	ND	ND
peatland	UK-AMo	6	59	25	0.00	ND
peatland	UK-AMo	1	83	25	14.00	16.72
peatland	UK-AMo	2	83	25	-19.96	0.00
peatland	UK-AMo	3	83	25	ND	ND
peatland	UK-AMo	4	83	25	0.00	0.00
peatland	UK-AMo	5	83	25	20.22	0.00
peatland	UK-AMo	6	83	25	23.16	0.00
peatland	UK-AMo	1	100	25	65.32	20.07
peatland	UK-AMo	2	100	25	0.00	0.00
peatland	UK-AMo	3	100	25	156.83	0.00
peatland	UK-AMo	4	100	25	42.95	ND
peatland	UK-AMo	5	100	25	203.77	0.00
peatland	UK-AMo	6	100	25	146.66	0.00