

## ***Interactive comment on “Trace gas fluxes of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O in a permanent grassland soil exposed to elevated CO<sub>2</sub> in the Giessen FACE study” by M. K. Abbasi and C. Müller***

**Anonymous Referee #1**

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Referee comment on the ACPD manuscript:

Trace gas fluxes of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O in a permanent grassland soil exposed to elevated CO<sub>2</sub> in the Giessen FACE study

By M.K. Abbasi and C. Müller

General Comments

This manuscript reports laboratory (soil incubation) -based experimental investigations into processes controlling biogenic greenhouse gas (GHG) (CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>) fluxes in soil cores originating from permanent grassland, which has been exposed to either

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ambient (A) or elevated (E) CO<sub>2</sub> atmospheric mixing ratios during 9 years, as part of a long-term FACE experiment. This paper seeks, as a primary objective, to explain the results of a previous paper by Kammann et al (2008), in which it was reported that the stimulating effect of elevated CO<sub>2</sub> on N<sub>2</sub>O emissions was only visible or significant during "background" phases of vegetative growth with limited nitrogen (N) supply, and not in the short periods that followed N fertilisation in the field. The argumentation of the present paper is based on the premise that this was an unexpected result, that N<sub>2</sub>O emission should be enhanced (by elevated CO<sub>2</sub>) in soils when N supply is high.

The results shown here thus focus on trace gas flux measurements following fertilisation, and confirm that there are no substantial / significant differences in GHG emissions between the incubated A and E soils. The key conclusion of this study is, presumably, that total denitrification is higher in the E soil (36%) than in the A soil, but that the N<sub>2</sub>/N<sub>2</sub>O ratio is 33% higher in the E soil. Somehow the increased reduction rate of N<sub>2</sub>O to N<sub>2</sub> compensates exactly for the increased gross N<sub>2</sub>O production, so that elevated CO<sub>2</sub> has no effect on the actual (net) N<sub>2</sub>O emission.

These findings are interesting in their own right and should be published. The paper is logically structured and the experimental protocols and analysis of results are sound, but the discussion is rather protracted and can be confusing at times, especially the section on N<sub>2</sub>O emissions where there are repetitions and no clear picture emerges. Because there was no effect of elevated CO<sub>2</sub> on the net N<sub>2</sub>O emission, this section (4.2) could be streamlined and shortened, in order to better reflect the key findings of the paper, and place the emphasis on the enhancement of total denitrification and the altered N<sub>2</sub>/N<sub>2</sub>O ratio (Section 4.3), where clear effects of elevated CO<sub>2</sub> are to be found. The absence of effects on net GHG emissions was already featured in the Kammann et al paper, and need not be stressed again at length here. Rather, I would like to see a more detailed assessment of the actual mechanisms by which elevated CO<sub>2</sub> can affect total denitrification and N<sub>2</sub>/N<sub>2</sub>O ratios. There are also many typographical errors and technical corrections are needed, and the English must be checked and improved.

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## Specific Comments

p4203, l5-7: the stated objectives for this paper are twofold :CO<sub>2</sub> effect on N<sub>2</sub>O emissions and the processes of N<sub>2</sub>O and N<sub>2</sub> production. However, given the length of materials, figures, discussions devoted to CO<sub>2</sub> and CH<sub>4</sub> fluxes, the objectives should also include these, as part of a total GHG budget assessment.

p4203, section 2.2. Carbon content is given as 6.6 (with no units). One might expect a higher soil organic content from a soil that has been exposed to 9 years of elevated CO<sub>2</sub>, which presumably would have a significant bearing on the results of the incubations. This is not discussed anywhere. Are there no data?

p4208, l10: the 2-pool model by Stevens et al should be described very briefly in the methods.

p4209, l8-13, and Figure 5: how can a contribution to total N<sub>2</sub>O production be negative (from day 28 onwards)? N<sub>2</sub>O production cannot be negative, or are we somehow dealing with soil N<sub>2</sub>O consumption here? Please explain, or provide a corrected figure.

p4209, l21-23: Why is this unexpected? Shouldn't an enhanced biomass production and higher root biomass under elevated CO<sub>2</sub> lead to an increased soil organic matter pool, and to enhanced soil respiration and CO<sub>2</sub> flux? Or do you mean that it was unexpected that it was ONLY 20-25% ?

p4211, l14-16: I don't understand this statement : 'The high oxidation rates by N addition in the present study might be that after 6–7 years of FACE establishment, it is unlikely to have any inhibitory effect by elevated CO<sub>2</sub>'. It seems as though you are formulating an hypothesis, but it is fact that elevated CO<sub>2</sub> did not inhibit CH<sub>4</sub> oxidation rates: Fig.1 shows that CH<sub>4</sub> was more oxidised under elevated CO<sub>2</sub>. Further, not only did CH<sub>4</sub> oxidation increase in the elevated CO<sub>2</sub> treatment, but also in the control soil (Fig.1). So the positive effect of N addition on CH<sub>4</sub> oxidation cannot be attributed to the effect of elevated CO<sub>2</sub> alone.

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p4212, l5-6: the sentence is not clear and should perhaps be rephrased something like this: 'However, N<sub>2</sub>O emissions were only measured during a short time period (specify which) in the Kammann et al. (2008) study'

p4211, l10-11: In which way do the lab incubation experimental conditions 'resemble the period after N fertilizer application' at the FACE site? I am not convinced that incubated soils with constant moisture and temperature resemble much soil underlying a growing grass system with changing weather and environmental conditions.

p4216: the conclusion provides a summary of the results but no synthesis. It could be stated that, given the nature of this study and the incubations of two soils under strictly identical conditions of temperature and moisture, the most likely factors influencing the differences in GHG exchange between soils from the ambient and elevated CO<sub>2</sub> treatments are organic matter content (which presumably is higher in the E treatment, although this information is not provided), microbial community structure and enzyme dynamics. These are the legacy of the 9 years of FACE experiment, and they determine the memory effects that might be determined from lab incubations.

Also, while the paper set out to explain differences in GHG emissions for the periods that follow N fertilisation (as opposed to background conditions), this is not mentioned in the conclusion, which makes rather general statements. The added value of this paper should be a comparative analysis of GHG fluxes from FACE experiments for background situations vs fertilisation periods.

## Technical Corrections / Language

Abstract, p4200, l2: Suggest change to: " Long-term field observations showed that N<sub>2</sub>O fluxes observed shortly after N application were not significantly affected by elevated CO<sub>2</sub> in the Giessen Free Air Carbon dioxide Enrichment (FACE) study"

p4200, l19: insert full stop "." between '...CO<sub>2</sub> treatments' and 'CO<sub>2</sub> did not have...'

p 4201, l11: the accumulation of GHG in the atmosphere DOES alter the Earth's radia-

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tive balance, and IS LIKELY responsible for climate change. This must be rephrased.

p4201, l15: delete 'in stratospheric ozone depletion and'. This is already mentioned on l17-18.

p4201, l23: 'Fluxes of CO<sub>2</sub>' should be changed to 'Respiration fluxes of CO<sub>2</sub>'

p4201, l27: similarly, 'seasonal soil CO<sub>2</sub> flux' could be changed to 'soil CO<sub>2</sub> efflux'

p4202, l21: change 'et al' to 'et al'

p4202, l26: insert 'N<sub>2</sub>O stimulation by elevated CO<sub>2</sub> in this N limited grassland'; delete final 's' in ecosystems'

p4203, l3-4: change to: 'To explain the N<sub>2</sub>O response to CO<sub>2</sub> it is particularly important...'

p4203, l5: Suggest add 'and when most of the annual N<sub>2</sub>O is produced' at the end of the sentence after 'emissions occur'.

p4205, l10: Change to 'DEA analysis was carried out...'

p4206, l15: change to '...but the differences were not significant (p>0.05).'

p4207, l16: change to: 'After N application the flux rates..."

p4209, l20: change to 'The observed effect of the soil having 25% higher CO<sub>2</sub> fluxes under CO<sub>2</sub> enrichment for the last 6 years...'. By the way, p4206, l14, it says 20%.

p4210, l28: change to 'Reduced CH<sub>4</sub> oxidation in response to elevated CO<sub>2</sub> have been generally linked to lower diffusion rates'

p4211, l1: change to '...moisture level does not play a major role...'

p4211, l13-14: change to '...oxidation rates during a field study at the Giessen FACE site.'

p4212, l2-3: the wording is ambiguous. I suggest changing the sentence to: ' Results  
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of the previous study on the Giessen FACE site indicated significantly higher N<sub>2</sub>O emissions under elevated CO<sub>2</sub> throughout the vegetation period...'

p4212, l12: insert 'between the ambient and elevated treatments', after '...significantly different...' and before '...during the period...'

p4212, l26: change 'cas' to 'was'

p4213, l5: 'from 4.7% to 8%'

p4213, l21: change to: 'Baggs and Blum (2004) reported that the response of N<sub>2</sub>O emissions to elevated CO<sub>2</sub> in grass swards'

p4213, l25-26: this sentence is ambiguous. Please rephrase thus: 'Observations in the Giessen FACE study are unexpected because enhanced N<sub>2</sub>O emissions in the elevated CO<sub>2</sub> treatment (vs ambient) were only observed during times of low N availability'

p4213, l28 to p4214, l1: suggest change to 'elevated CO<sub>2</sub> either did not alter N<sub>2</sub>O fluxes, or even reduced N<sub>2</sub>O emissions (Hungate et al., 1997; Mosier et al., 2002, 2003; Welzmueller et al., 2008).'

p4214, l4: change to 'the lower N availability in the mineral pool for soil microbes..."

p4214, l5: change to 'for soil microbes due to enhanced plant uptake"

p4214, l7: "...lead to increased N"

p4214, l10: delete 'Alternately'; suggest replace with 'Conversely'

p4214, l12: '...with suggestionS of increased..."

p4214, l29: '...reported that an increase in substrate...'

p4215, l2 "...trace gas fluxes were not..."

p4215, l21 '..was similar..."

p4215, l23-24: '...proposed different time lags for ..."

p4216, l7: '...show that despite..."

p4216, l16: 'Most of the studies conducted so far have suggested higher N<sub>2</sub>O emissions...'

p4216, l20 '...over a long period'

p4217, l4 '...are most likely affected by long term...'

Figure captions: in Figs 1, 2, 3 and 4, 'expose' must be changed to 'exposed'

Figure 5: if the Y-axis really represents the fraction of N<sub>2</sub>O production attributed to NO<sub>3</sub>- reduction, then the data are wrong, there can't be a negative N<sub>2</sub>O production.

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Interactive comment on Atmos. Chem. Phys. Discuss., 11, 4199, 2011.