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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Trace gas fluxes of CO_2, CH_4 and N_2O in a permanent grassland soil exposed to elevated CO_2 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 CO2, CH4 and N2O in a permanent grassland soil exposed to elevated CO2 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) (CO2, N2O, CH4) fluxes in soil cores originating from permanent grassland, which has been exposed to either

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Interactive Discussion

Discussion Paper

ambient (A) or elevated (E) CO2 atmospheric mixing ratios during 9 years, as part of a long-term FACE experiement. 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 CO2 on N2O 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 N2O emission should be enhanced (by elevated CO2) 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 N2/N2O ratio is 33% higher in the E soil. Somehow the increased reduction rate of N2O to N2 compensates exactly for the increased gross N2O production, so that elevated CO2 has no effect on the actual (net) N2O emission.

These findings are interesting in their own right and should be published. The paper is logically structured and the experimental protocole and analysis of results are sound, but the discussion is rather protracted and can be confusing at times, especially the section on N2O emissions where there are repetitions and no clear picture emerges. Because there was no effect of elevated CO2 on the net N2O 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 N2/N2O ratio (Section 4.3), where clear effects of elevated CO2 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 CO2 can affect total denitrification and N2/N2O 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 :CO2 effect on N2O emissions and the processes of N2O and N2 production. However, given the length of materials, figures, discussions devoted to CO2 and CH4 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 CO2, 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 N2O production be negative (from day 28 onwards)? N2O production cannot be negative, or are we somehow dealing with soil N2O 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 CO2 lead to an increased soil organic matter pool, and to enhanced soil respiration and CO2 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 CO2'. It seems as though you are formulating an hypothesis, but it is fact that elevated CO2 did not inhibit CH4 oxidation rates: Fig.1 shows that CH4 was more oxidised under elevated CO2. Further, not only did CH4 oxidation increase in the elevated CO2 treatment, but also in the control soil (Fig.1). So the positive effect of N addition on CH4 oxidation cannot be attributed to the effect of elevated CO2 alone.

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p4212, l5-6: the sentence is not clear and should perhaps be rephrased something like this: 'However, N2O 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 CO2 treatments are organic matter content (which presumably is higher in the E treatment, although this information is not provided), microbial community struture 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 N2O fluxes observed shortly after N application were not significantly affected by elevated CO2 in the Giessen Free Air Carbon dioxide Enrichment (FACE) study"

p4200, l19: insert full stop "." between '...CO2 treatments' and 'CO2 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 CO2' should be changed to 'Respiration fluxes of CO2'

p4201, l27: similarly, 'seasonal soil CO2 flux' could be changed to 'soil CO2 efflux'

p4202, l21: change 'et a1' to 'et al'

p4202, l26: insert 'N2O stimulation by elevated CO2 in this N limited grassland'; delete final 's' in ecosystems'

p4203, l3-4: change to: 'To explain the N2O response to CO2 it is particularly important...'

p4203, l5: Suggest add 'and when most of the annual N2O 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 CO2 fluxes under CO2 enrichment for the last 6 years...'. By the way, p4206, l14, it says 20%.

p4210, l28: change to 'Reduced CH4 oxidation in response to elevated CO2 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 N2O emissions under elevated CO2 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 N2O emissions to elevated CO2 in grass swards'

p4213, l25-26: this sentence is ambiguous. Please rephrase thus: 'Observations in the Giessen FACE study are unexpected because enhanced N2O emissions in the elevated CO2 treatment (vs ambient) were only observed during times of low N availability'

p4213, l28 to p4214, l1: suggest change to 'elevated CO2 either did not alter N2O fluxes, or even reduced N2O emissions (Hungate et al., 1997; Mosier et al., 2002, 2003; Welzmiller 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..."

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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 N2O 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 N2O production attributed to NO3- reduction, then the data are wrong, there can't be a negative N2O production.

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