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Biogeosciences Discussions

Interactive comment on "Temporal and spatial variations of CO_2, CH_4 and N_2O fluxes at three differently managed grasslands" *by* D. Imer et al.

Anonymous Referee #2

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To understand how GHG emissions respond to environmental and management forcings, the authors of the present paper have quantified temporal and spatial variations of manual chamber based CO2, CH4 and N2O soil fluxes of three Swiss grasslands differing in altitude and management. The manuscript is clear with regard to objectives and results presented. However, there is some methodological problems which might affect results, discussions and conclusions.

General comments:

The manuscript presents soil emissions and it is not clear from the introduction if the overall GWP of the references (Soussanna et al., 2007 and Schulze et al., 2009) include other emissions, e.g. CH4 from livestock. Please specifiy.

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Material and Methods section need to be extended by number of cattle/ sheep, duration of grazing, fertilization (organic or inorganic, how much nitrogen applied) and how chamber measurements represent potential hot-spots of urine and/ or excrement patches. Did you measure in higher time intervals after fertilization/ during grazing etc? Furthermore for N2O fluxes nitrogen fixing species such as clover is important which is common in grasslands. Please give any information on this rather than referring only to Zeeman et al., 2010. Even though frost-thaw emissions can substantially contribute to annual N2O emissions in grasslands in higher altitude, nothing is said about their importance for your sites. Furthermore, I suggest including soil physical and chemical properties.

The geostatistic is only based on 16 chambers mostly placed in equidistance at linear transects rather than grids in varying mesh sizes. What was the rational for choosing linear transects for spatial variation? Beside the relatively low number of chamber position I question if this design allows you to make sound geostatistics. The minimum distance of 5-7m could be to low for spatial variation in soil GHG emissions which can vary on dm scale, in particular in grazed systems with urine and excrement patches.

The PCA and derived variables driving GHG emissions do not consider grazing/ fertilization i.e. nitrogen input. However, for N2O emissions N availability might be the main driver for magnitude of emissions. This might also the reason why your model was less predictive than for CH4 and CO2. Even though you did not include fertilization in the statistical evaluation larger sections of the discussion deal with it. Could you include e.g. days after fertilization into your regressions?

The motivation of the intensive field campaign for identifying diurnal patterns of CH4 and N2O fluxes in September is unclear. Your findings are only valid for the situation of exactly these 48 hours in September 2010 and do not allow a generalization since the pattern will may vary across seasons and e.g. for N2O with nutrient availability after fertilization. Thus, the use of it is rather limited. Since the data is included in the overall flux measurements I would suggest shorten this part in particular the section 3.2.1.

and also 4.2

The method of flux calculations is not completely sound. I question assumed linearity, at least no detailed criteria for potential evaluation of non-saturation is presented, and filtering of out of range values and values not different from zero which may leads to bias of calculation of mean site fluxes. What can we learn from comparison of soil chamber measurements with Eddy data at your sites. At least you mention agreement with soil CO2 fluxes (see also specific comment)

Specific comments:

Introduction:

P2637; Ln20: is this only soil emission, or does it include other emissions like CH4 from livestock? P2637; Ln22ff: The altitudinal variation is rather a climatic variation. Therefore, I would rather write . . .do not consider grasslands in higher elevation “with cooler and wetter climatic conditions which may lead to higher soil CH4 and N2O emissions”. P2638; Ln4: change into: which are characteristic for CH4 and N2O fluxes between climatic or management driven pulse events. P2638; Ln22: add “soil” CO2, CH4 and N2O fluxes

Material and Methods:

P2639; Ln9-10: It says (CHA) winter location for sheep and cattle. Was urine patches and feces included in the chamber measurements? Can you provide number of animals and time of grazing. P2639; Ln18ff: Give more details on animal numbers also for FRU. At this site also fertilization is relevant. Again what type mineral or organic, how much nitrogen is added? P2639; Ln24ff: AWS animal numbers, time of grazing? Manure, how much nitrogen? P2640; Ln7: chamber height in average was 0.136m. How did you manage to include the plants if they were growing higher? Did you correct the headspace volume; otherwise you may substantially overestimate fluxes. P2640; Ln10ff: I see a problem in the different distances of chamber positions and I doubt that

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the minimum distance of 5-7m is applicable for spatial variation in soil GHG emissions which can vary on dm scale, in particular in grazed systems with urine and excrement patches. P2640; Ln16ff: This sentence is not needed. P2640; Ln18ff: Did you increase measurement frequency after fertilization or grazing. The growing season per se does not say anything about event driven emissions due to management. What about frost-thaw emissions. What about contribution of frost-thaw emissions which can be substantial in your systems? P2640; Ln22ff: What was the motivation to measure diel patterns of CH_4 and N_2O emissions in September 2010? Was this date chosen because of management issues e.g. grazing or manuring? Please indicate also at what sites you did this intensive field campaign. Merge this section with P2642; Ln 13ff. P2641; Ln6ff: This statement is very general. The linearity does not depend only on the closure time but also on the magnitude of flux. After fertilization you have substantial N_2O fluxes (up to 15 nmol N_2O m-2 sec-1,) and I doubt that your statement is still valid. Did you test also non-linear calculations for periods of high fluxes? There might be a problem also with the linearity of your ECD detector at high concentrations at high flux conditions. Did you calibrate your ECD for high concentrations because potentially without calibration you may underestimate concentrations? P2641; Ln15: does this mean you converted CO_2 into CH_4 with a methanizer? Provide details. P2640; Ln20ff: What were the criteria for non-occurrence for saturation? P2642; Ln4ff: To my opinion out of range values cannot be filtered by using +/- 10 SD. For these measurements you need to check the 4 measurements representing the increase of concentration over time. If the increase follows a plausible pattern you cannot discard fluxes, which can be real due to hot spots (urine/feces patches) or hot moments e.g. frost-thaw. Another issue is that at times when you have fluxes not differing from zero (at the detection limit) you might have $r2 <0.8$. But if you delete these values your mean would be biased towards overestimation of fluxes. Same for CO_2 fluxes. I think it is too easy to delete values below 0. Again, you need to go back to the single concentration measurements.

Results:

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P2644; Ln7ff: There is a trend of CH_4 emissions at wintertime, might be correlated with high water contents, which may also explain sporadic CH_4 emission events in other seasons. P2644 Ln15ff: How representative is the mean flux for your system under grazing. P2645 Ln11ff: I am not sure but it seems you have used CO_2, CH_4 and N_2O fluxes altogether in the PCA. Why didn't you do the PCA for any of the fluxes. E.g. you did also not include N fertilization/ grazing which is probably the main driver for N_2O emissions. P2645 Ln25ff: Are you sure that capillary rise and hydraulic redistribution in the vascular plant root system have the capacity to be SWC replenished? P2646 Ln 6ff: The PCA and derived variables driving GHG emissions do not consider grazing/ fertilization i.e. nitrogen input. However, for N_2O emissions N availability might be the main driver for magnitude of emissions. This might also the reason why your model was less predictive than for CH_4 and CO_2. P2647 Ln 9ff: The motivation of this experiment is not fully clear, since your findings are only valid for the situation of exactly these 48 hours. Thus, the use of it is rather limited, you can mainly say that you found or not found a diurnal pattern. We know that the occurrence and magnitude of diurnal patterns can vary depending on soil environmental conditions over seasons even days. Thus, repeating this experiment let's say for typical seasonal conditions, spring, summer, winter, autumn, or after fertilization would have increased the usefulness of the data.

Discussion:

P2650 Ln4ff: I question if the sampling design (transect with 12-16 chambers; 5-7m minimum sampling distances allows for sound application of geostatistics (see general comment) P2652 Ln23ff: Can you provide some details, what is agree? Section 4.3 and Fig.9 rather focus on CH_4 and do not provide new information except that inclination was correlated with soil moisture. Not sure if this section is needed. If than provide more details of N_2O and CO_2 and why they differ among each other.

Conclusions:

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P2655 Ln7ff: Inclination is just one part, but there could be also topographic depressions which are wetter than elevated parts. Further it depends where you are at the slope. You can have water and nutrient flows along topographic gradients and reflow and accumulation down slope with impacts on GHG fluxes. Thus, I found your conclusion is too general. More important at least for N2O urine patches and spatial spreading of excrements will have a higher impact on magnitude of emissions than inclination.

Interactive comment on Biogeosciences Discuss., 10, 2635, 2013.

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