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Interactive comment on "Grazing related nitrous oxide emissions: from patch scale to field scale" *by* Karl Voglmeier et al.

Anonymous Referee #1

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The study presents N2O emission measurements of two grazing systems, which differed in the energy to protein balance of the cows' diet. Measurements were carried out by two independent approaches, eddy covariance and fast box technique, and the small scale fluxes (measured with fast box technique) were up-scaled to match EC flux footprints for comparison. The good match between the two approaches justified the disaggregation of the different emission sources (urine, dung, background) on the pasture. This enabled the authors to present EFs for total, urine and dung fluxes, indicating the need to disaggregate grazing related EFs by excreta type. This information is very valid for policy makers as well as for the scientific community. The methodologies used in the manuscript are scientifically sound and the manuscript is well structured. However, one main point that needs to be addressed is the final conclusion; I strongly

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disagree that you can conclude that an optimised diet (with additional maize silage) in system M leads to a 25% reduction effect for N2O emissions based on the smaller area needed for grazing. The authors need to take the N2O emissions related to the maize production used in the diet into account; otherwise this comparison is not valid. Generally the authors need to be more careful with figure and table captions. The structure of some tables needs to be improved and the authors need to be more carful with units, especially when presenting cumulative fluxes (table 5). There are many abbreviations that were not explained (e.g. ECM, FAD, Q, A, V) or not very clearly (FD, FU, FU,temp, Fbg), which makes equations difficult to understand (section 3.2.2 and 3.2.3). Improving figures and tables and explaining abbreviations will help to make the manuscript easier to read. I recommend this manuscript for publication in bg after thorough consideration of all the comments listed below.

Detailed comments:

Abstract:

P1, line 11 change “measurement of” to “measurement from”

P1, line 12 I suggest to change “The diet for the cows..” to “The diet for the two herds of cows”

P1, line 14 Change “animal budget model” to “animal nitrogen budget model”

P1, line 18 Replace “to the field” with “to field level”

P1, line 21 Add “due to the required greater area for grazing” at the end of the sentence. Please see general comment.

P1, line 25 insert “respectively” after “for urine and dung”

P1, line 26/27 This conclusion is not correct, as the N2O produced during the production of Maize fed to the animal is not included in the calculations!

Introduction:

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P1, line 30 Please add a reference for the GWP of N2O.

P2, line6 Please insert “from excreta” after “N loading... was shown previously” and insert N after exceptionally high..”

P2, line16 Please give a suggestion of how emissions could be reduced if individual contributions are better understood.

P2, line31 I suggest to change “..different systems (intensive-extensive, different crops, land / lake,...)” to “..different systems (e.g. intensive vs extensive, different crops, land vs lake)”

Material and Methods:

P3, line 15 use average values for clay, silt and sand from table 1

P3, line 17 Change “vegetation consists” to “vegetation consisted”

P3, line 17 The range of 10-50 and 7-40 % of Lolium and Trifolium is quite large; could you give an average $\pm$ stdev and the method of how it was assessed?

P3, line 19 I suggest to change the last sentence to: “ Beside the N input through excreta from the animals, N was applied through fertiliser at a rate of 120 kg N ha1 per year between 2007 and 2015.”

P3, line25 You write that the optimized protein content reduced the N input to the pasture. Did you measure this? Otherwise, just write that it was expected to reduce the N input to the pasture.

P3, line26/26 Please add “(see table 2)” at the end of the sentence

P4, line 7 Add comma after “soil conditions”

P4, line 18 Please add the name of the model and give a reference

P4, line18 Change “ In short, this model balances the N flows...” to “The model balances the N flow...”

P4, line18/20 Please add “(see table 2)” at the end of the sentence

P4, line20 I suggest to change this sentence to “For further details see Voglmeier et al (2018), where the uncertainty of the total N and urine/dung N was estimated to be 15 % ...”

P4, line20 Move this sentence up to the end of the sentence (line18-20)

P4, line27 add “respectively” after “X.21..”

P5, line3 change “blue areas in Fig. 3a)” to “dark blue areas in Fig. 3a”

P5, line8 change “..with the fast-box. . .” to “..with a fast-box. . .” to

P5, line10 change (Fig.2) to (Fig.2b)

P5, line11 insert “the” after “days after..”

P5, line17 replace “The gas..” with “The air..”

P5, line20-21 I am not quite sure if I understand this modification. Did you add a vent to the box? Then better to call it vent than inlet as the inlet is connected to the QCL. Please be more specific: I assume the 4 cm is the diameter and the 1m is the length of the vent tube and the 10 cm is the length of the foam material within the tube? What is the foam made of?

P5, l22 As you don’t show or discuss any soil respiration measurements, I suggest to delete this information.

P5, line22/23 Insert “N2O” after “The increase in. . .”

P5, line24 Insert “the” after “The inflow off. . .” I assume by “the inlet” you mean “ the vent”? As the FB chamber is a closed dynamic system (acc. to Hensen et al.2006).

P5 line26 please add explanations to all abbreviations used in equation 1 (V, A, Fcham)

P6 line12 please give the make of the thermocouple

P6 line21-22 I suggest to delete “because sometimes. . ..for further processing.” and replace with “. . .measurements (see also Fi. 3b), in order to exclude possible old urine patches (of previous management rotations).”

P7 line13 Instead of “separated” I suggest to write “The distance of the inlets of the QCL from the centre of the sonic head were around 20 cm. . .”

P7 line14 Replace “some 20 meters” with “ about 20 meters”

P7 line18 I suggest to change “the measurements and fluxes of an online flux calculation” to “ the N2O concentrations and fluxes, calculate with an on line flux calculation,. . .”

P7 line24 500; add unit

P7 line25 Move the reference after “technique”

P8 line1 insert “was used” after “ . . .the default lag.”

P8 line4 change “..can lead to significant..” to “..can lead to a significant. . .”

P8 line12 change (see Fig 2) to (see Fig. 2c). Please show the harvest event in the Figure (see comments to Figures)

P8 line23 Change “..due to low u* (<0.07 ms-1)” to “. . .due to low friction velocity (u*, <0.07 ms-1)

P8 line24 change “(-2°-6°)” to “(-2° to 6°)”

P8 line27 Change “The data gaps had a diurnal pattern..” with “ The occurrence of data gaps showed a diurnal pattern. . .” and join the two sentences together “. . .during the night, which was driven by. . .”

P8 line 33 Can you give a time period for the soil temperature classes?

P9 line16 change “(either the other system..” to “(either the other grazing system..”

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P9 line18 insert (bLS) after “footprint model”

P10 line20 Delete “number” before “ratio”

P10 line23 insert “of N2O” after “measurements”

P10 line25 change “were analysed for potential driving parameters (excreta age, soil temperature, soil moisture).” To “were analysed for the potential driving parameters excreta age, soil temperature and soil moisture.”

P11 line8/9 This last sentence is not clear. Please clarify which fluxes you are talking about (individual emission source; paddock or system M/G?)

Results:

P11 line12 “they varied significantly”; significantly different from what? Background fluxes?

P11 line13 mention the harvest, were they increased after the harvest?

P12 line14 change “were related to the days after EOG (defined as excreta age, Sect. 2.4.2) deltatEOG” to “were related to the excreta age deltatEOG (defined as days after end of grazing (EOG), Sect. 2.4.2)”

P12 line15-19 In Figure 8 FU,temp and FD,temp are fluxes averaged over 3 days, while in the text you are describing average daily values (?), which is confusion. I suggest to show average daily values in Figure 8, or use different abbreviations (e.g. FU,temp3d vs FU,temp1d), or only discuss 3d averages in the text. Its not clear what the “absolute highest FUtemp“ is (5117 ug N2O-N m-2h-1), if the highest average value is 660 ug N2O-Nm-2h-1.

P12 line20 you mention that Dung related emissions “showed a relation to excreta age”, please mention what kind of relation. Please change “dung patch emissions” to “dung patch fluxes”

P12 line25 Were the background fluxes not also sign. smaller compared to dung patch emissions? Looks like it in figure 8.

P12 line26 I suggest to change ". . .to the averaged measured flux values within 3 days." to "to the measured flux values average over 3 days"

P12 line32 How do you justify to set negative values to zero?

P13 line6 As "FD,temp" is not influenced by environmental conditions it equals FD (?)This should be stated here.

P13 line6 Please move "was found" to the end of the sentence ending on line7.

P13 line7-14 Please define the three sectors. I suggest to insert (<0.27, 27-33, >0.33) after ". . .by three different VWC sectors." It would help to show this in a graph.

P13 line13 do you mean "similar values" or comparable to what? Can you add a stdev?

P14, line17 It's not clear where the grazing period ends, therefore please add this information into the table (see comments table 10b).

P14 line25-27 these two sentences are not very clear. What do you mean by variations? The magnitude of fluxes varied less? I suggest to replace "rather limited" with "less pronounced"

P14 line29 change "emission" to "emissions". I suggest to replace "comparable" with "similar"

P15 line2 But in Figure 11 it looks like fluxes were slightly higher for up-scaled FB fluxes.

Discussion:

P15, line15 delete brackets around "manually applied".

P15, line20/21 I don't understand this sentence

P15, line25 Include “(data not shown)” at the end of “other characteristics” as you didn’t show any productivity (yield). Delete “Also” at the beginning of the next sentence.

P15, line 26 Change “(FB system emissions)” to “FB up-scaled to system emissions)”

P15, line 28-p16 line 4 This paragraph is difficult to understand. I strongly disagree that you can conclude that an optimised diet in system M leads to a 25% reduction effect for N2O emissions based on the smaller area needed for grazing. You need to take the N2O emissions related to the maize production into account, otherwise this comparison is not valid.

P16, line 18/19 This sentence is not clear. Change to “Hence the EFs for excreta retrieved from manually applied urine and dung patches and those retrieved by the EC method”

P16, line 23 1.03 kg N2O-Nha-1y-1, please explain in more detail how this value was calculated. This value should have been shown in the results section 3.3.2.

P16, line 26 Change “events in previous” to “events from previous”

P16, line 26/27 This last sentence is out of context

P17, line4 delete brackets around “or urine patch emissions”.

P17, line16 Delete “additionally” and “certain”

P17, line21 Insert “upscaled” after “..led to very high”

P19, line11 Insert “us” after “..for lending”

References:

Change order of Flesch 2005 and Flesch 2004

Tables:

Table 1: As soil depth is not really a parameter I suggest to re-arrange the table;

one column for each soil depth, with missing values in each column as the different parameters have not been measured in all soil layers

Table 2: What does ECM stand for? Please explain abbreviation (maybe in footnote). Have the animals been weighted before and after the experiment? Was the weight increase considered in the calculations of the excretion (heavier animals will excrete more)? Table capture: I suggest to change “and resulting urine N and faeces N of the Swiss dairy ….” To “ and resulting modelled urine and faces N using the Swiss dairy…”

Table 3: Please add information of flux measurement method (FB)

Table 4: Please describe what the different equations are: Parameterisations of 3 day average fluxes from EB measurements, split into background, dung and urine fluxes.

Table 5: I assume that you are showing cumulative fluxes. You need to mention this together with the time scale (per GOP?). I suggest to simplify the table by only having two parts; add a dotted line above the N input and to move the FB urine and FB dung fluxes above the EFs. Please add N input from dung. What does FAD stand for? What is ”EC integral system emission EC,” ? Reading in the text (P15, line 28-31) I have the impression these fluxes are up-scaled FB fluxes to the whole system. If they are EC emissions, please describe more carefully in the text. The unit is confusing as it is an emission (concentration per area per time). Reading in the discussion I understand what you mean, but in the table it’s not clear. Maybe you can explain in a foot note. “EF total” is calculated from EC, while “EF urine” and “EF dung” are calculated from up-scaled FB measurements (or not?) This needs to be stated clearly.

Figures:

Figure 1: P29 line4 Insert “(triangles)” after “the two EC towers…”

Figure 2 b): Move the legend, or change the scale so the bars for the high precipitation events in June and July are not cut off.

Figure 2d): Add arrows for fertiliser application dates and for harvest date

Figure 3: Change the area showing a) to being transparent

Figure 5: Please explain the reason for dotted frame. It's confusing that the lines connecting #dung and # urine patches to "Paddock flux dung patches" and "paddock flux urine patches" cross the arrows leading to "paddock flux background" and "paddock flux urine patches", it looks like they are feeding into them as well. Try to show clearer (maybe with a curved line over the crossing line).

Figure 6: Add arrows for exact fertilisation and harvest events. Add the date of the skipped value. It would be good to include the information of grazing periods in the graph to explain the increased fluxes.

Figure 7: I suggest to change the unit to ug N2O-N m-2h-1, it makes it easier to read the values in the graph and to compare to values you describe in the text (for Figure8, where ug N2O-N m-1h-1 are used). In the legend insert "from different sources" after "the comparison of fluxes.." and add the information that the fluxes were measured with FB technique.

Figure 8: Same comments about units as for Fig. 7. Please add in legend that fluxes were measured with FB. Are there any standard errors for the background fluxes, or were they too small to be seen? I suggest to change to x-axis description to "age of excreta [d]". Give information about the fitted curves (refer to equation 3+4).

Figure 9: Same comments about units and mentioning that FB method was used as for Fig. 7.

Figure 10: It would help to add the grazing period in either Fig 10 b) or c)

Figure 12: I suggest to replace "emission" with "flux" in y-axis for Figure a)

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