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Interactive comment on "Management matters: Testing a mitigation strategy for nitrous oxide emissions on intensively managed grassland" *by* Kathrin Fuchs et al.

Anonymous Referee #1

Received and published: 1 June 2018

General Comments The manuscript by Fuchs et al. is well written and easily to follow. The authors report on a 2-year field study of eddy covariance N2O flux measurements on two side-by-side grasslands, one managed 'business as usual' (i.e. with frequent additions of organic fertilizer in the form of slurry) and the other with increased proportion of clover and no slurry application (i.e. nitrogen provided by biological fixation instead of organic fertilizer). The authors find that absence of fertilization in the field with increased clover resulted in significant reduction in N2O emissions.

I agree with the authors' justification of the lack of studies on year-round N2O fluxes for grassland systems. The flux measurement methodology used is sound (but see

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questions below) and the authors have collected a very complete set of supporting measurements to help in the interpretation of fluxes. The study contributes a solid dataset that could be valuable for future modelling efforts. I also liked the use of the GAM models to attribute the N2O flux to various covariates.

My main difficulty with the manuscript is the larger context of practicality of the management practice studied. The authors use the term 'fertilizer nitrogen' and 'fertilization' throughout but as far as I understand their experimental setup refers to substituting livestock-derived organic nitrogen with biologically fixed organic nitrogen. Substituting an external input such as synthetic fertilizer with N from biological fixation makes a lot of sense but presumably the dairy/pig farms have slurry that contains N and other nutrients to be recycled back to the soil. The authors used slurry that had been digested in a biogas plant so what will be the fate of this material if not returned to soil? Hence, the proposed mitigation management does not fit within a larger nutrient balance framework: grasslands are producing animal feed but the manure is not returned to fields and instead more nitrogen is added to fields through biological fixation. Perhaps there is some local context that would justify the proposed mitigation practice. If not, I am having a bit of difficulty in identifying the value of the research findings. Overall, I would like to see the dataset published but I think the argument for the value of the findings has to be much better articulated. Perhaps placing their measurements within an N budget framework would help making the manuscript a unique contribution.

Specific comments: Title: Use of legumes is a central theme of the manuscript but does not appear in the title. 'Management matters' is catchy but also well-known and a bit vague since it does not specifically identify which management.

Abstract L. 11: I think the suggested mitigation strategy is for replacing synthetic fertilizer with BNF not animal-derived N with BNF. Here and throughout need to identify if referring to organic or synthetic fertilizer. Check the consistent use of BNF vs. BFN throughout. L. 14: Could a broader objective statement be used here (i.e. quantify is a step in trying to answer a more meaningful objective); L. 17: 'To assess the effect of

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the mitigation strategy' on what? L. 18: No results of the 15N method are presented in abstract leaving the reader wondering why it is mentioned here. L. 21: Here and throughout, the authors use 'no management' which is not a very clear term. I think the authors mean during background or baseline emission periods (i.e. outside of emission events associated with management). Either the term is defined early on and used or different wording should be used. L. 24-25: Did the overall N input also decrease in the clover treatment? An overall decrease in N input is different than the argument of 'replacing fertilizer N with BNF' used at the start of the abstract. It is not surprising that N2O emissions are lower if N inputs decreased.

Page 2 L. 13-14: Instruments for EC measurements have been available for a least a decade. L. 17: 'abiotic factors are generally known' L. 18-19: N2O emissions strongly depend on management practices in most managed systems so I suggest to remove 'particularly grasslands'. L. 31: Here the authors refer to 'external fertilizer amendments' but slurry would not be considered an external amendment.

Page 3: L. 3-5: This statement seems a bit misleading given that this study is not dealing with synthetic fertilizer. L. 33: What is the reason for substituting the N fertilizer from organic origin that is already available on the farm?

Page 4: L. 3: Could the second objective be made more specific? 'to identify the drivers of N2O emissions' is a bit broad. L. 21: Is this 'dairy' liquid slurry? Why 'predominantly'? Table 1 refers to 'organic fertilizer': was there another source beside slurry? Was the aim to replace all the ∼260 kg N/ha with BNF? Table 2 shows a maximum of 130 kg N/ha from BNF. What is the recommended N input to sustain the N removed? L. 24-25: Where there any differences in texture, C content, etc. in the two fields monitored?

Page 5: L. 3: Was the control plot also grazed? If not, what are the implications of the different grazing regimes? L. 16: better to say 'digested cattle and pig slurry obtained from a local biogas plant'. If this digestate is not applied to land what is its fate?

Page 6: L. 7-8: Any replicates or just one sensor per depth? L. 9: How many locations of the 2 ha plots were monitored to determine impacts on microclimate?

Page 8: L. 3: How well does EddyPro work for processing N2O data? How were the lag times determined given that low N2O signal often means the cross correlation method for determining lag times will be off. The same applies to the corrections - if cospectra are being used for any of the corrections they may not be correct for periods with low N2O or CH4 signals. L. 16: Are there any biases associated with S or N flow being associated with different kinds of weather (rain occurrence, higher T, etc.)? Please expand on this potential impact. L. 24: Were directions always steady over this time period or did you use high frequency data to select the 10 min periods with steady wind direction?

Page 10: L. 34: Could more information be given on 'management'? Which 'Management' aspects? These are not quantitative variables or continuous so how was this handled?

Page 12: L. 22: Odd wording: 'later clover parcel'; please edit. Was there a trend for lower yields for the 'clover' parcel before the experiment started? Is this related to differences in soil? L. 24: Was difference consistently <0 for all years? What are the implications for previous C input to soil and N2O fluxes during measurement period?

Page 14: L. 15-16: This interpretation assumes that there was no interaction between factors, i.e. all effects during non-events, called 'times without management' by authors, are due to sward composition while all effects during events was due to slurry application. Please discuss potential interaction effects.

Page 15: L. 23-24: 'In sum, our results indicate that N2O can be effectively reduced through the replacement of fertilizer N with N from BNF.' But was all slurry N replaced by BNF? Did the system have an N surplus before that could have been addressed by just matching the Slurry N input to crop needs? IF that is the case then the most achievable mitigation practice would be to adjust the slurry rates to the plant demand

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instead of using BNF.

Page 17: L. 31: 'Thus, we observed lower N2O emissions at higher levels of photosynthesis'. Higher levels of photosynthesis also correspond to periods of higher water loss as transpiration and lower water content as seen in your dataset. How can you separate these two confounding effects?

Page 19: L. 24: This brings up an important point. 'Permanent grasslands' are temporarily restored as was done with the study area in 2012. Does this restoration involve ploughing or a similar tillage at this site? If so, then authors should discuss the impact of incorporating a larger proportion of legumes into soil on the following N2O emissions.

L. 25-26: But what would farmers do with the slurry?

Technical corrections: Page 4: L. 5-6: Word missing here: 'while fertilization to play the dominant role in driving N2O emissions in the control parcel'. Page 5: L. 7: Mowing is only one of the activities used in harvesting (presumably biomass is also removed). I think it is less confusing if 'harvest' is used throughout. L. 8-9: Some of this information is already given on L 31 in previous page. L. 11: Please clarify the study years (2015-2016, correct). Are the data for 2014 presented? L. 17: Check table as 'herbicide' not mentioned. L. 20: I think you mean with instruments mounted on a mast... L. 21: Instead of 'lying' use 'placed'. L. 26: Instead of 'The air inlet for N2O, CH4 and H2O' use 'The air inlet for the absorption spectrometer'.

Page 6: L. 1: Should refer to Fig. 1 in this section. L. 13-15: Is this in addition to the 'soil sensors for microclimate measurements' mentioned in L. 9-10? Are matric potential and soil heat flux data presented? L. 26: Do you mean the 'average footprint'? Page 7: L. 20: Perhaps give info on clover proportion before (start of methods). The assumption is that proportion of establishment is the same as sowing composition. Did you check the final stand composition? L. 23: Use 'Gauss'. L. 29-30: CO2 molar density refers to the Licor measurements? Since CO2 was also measured with the QCLAS it may be helpful to inform the reader in EC section as to which data will be

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presented for CO2. Page 8: L. 6: ‘below’ instead of ‘above’ for N2O and CH4 values. L.14: fig 1 refers to Kljun et al 2004. L. 15: “Parcel” does not seem to be the correct term here. Do you mean ‘field’ or ‘plot’. Why is footprint so different for South vs North? Page 9: L. 13: What was the ‘similar management practice’ in 2014? Please explain earlier in text. L.15: I suggest ‘Three management types and one natural event type’ be changed to ‘Three management-derived events and one natural event’ Page 11: L. 3: Check citation. What does ‘these’ refer to? L. 23: Sentence not complete. Page 12: L. 20: Table has SE as 0.5 not 0.6. Page 13: L. 8-9: I am not sure what is being compared here (within years or across years): biomass at the clover parcel was lower (5.1 $\pm$ 0.3 t ha-1 yr-1) in 2015 and similar (4.8 $\pm$ 0.2 t ha-1 yr-1) in 2016. L. 10-11: But values are indicated as ‘ab’ so not different? Page 14: L. 8: This statement is confusing: ’periods without management’. L. 10-11: ‘a 2.5-fold increase in N2O emissions during the seven days following slurry amendment compared to no management (Table 4).’. It is hard to find this information in table; please help reader by giving values...

L. 11: ‘It is important to state that the management effect exists in addition to the effect explained’ is not clear, please edit.

Page 16: L. 21: I do not consider soil conditions as not ‘external’ factors. . .

Page 17: L. 11: ‘Clo-0’ is not used in table, please use consistent terminology.

Page 19: L. 24: This brings up an important point. ‘Permanent grasslands’ are temporarily restored as was done with the study area in 2012. Does this restoration involve ploughing or a similar tillage at this site? If so, then authors should discuss the impact of incorporating a larger proportion of legumes into soil on the following N2O emissions.

L. 25-26: But what would farmers do with the slurry?

Figure 1: Add explanation of ‘blue dots’ into figure caption. Why are there many more contour lines in the footprint for the N plot vs. S plot?

Figure 2: Please indicate if symbols are for daily values.

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Figure 6b: not referred to in text.

Figure 8: letter a, b, ...missing from graphs. X-axis scale for CO2 flux seems to be wider than dataset.

Table 2: Was means test applied to treatments within a year or across two years? The latter (I think) but some of the discussion in text seems to consider ab different than b or a... Letters are missing for last row and 3rd last row year 2016 data.

Table 4: Use 'harvest' instead of 'mowing'.

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