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Interactive comment on "Eddy covariance methane flux measurements over a grazed pasture: effect of cows as moving point sources" *by* R. Felber et al.

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General comments:

Felber et al. propose and innovative approach combining EC flux measurements on moving sources, geo-localized at high-frequency (5s), in order to derive an emission per unit source. This is applied to the important topic of methane emission from cows due to enteric fermentation but may also be of interest for other thematic/gases. They develop the associated methodology, proposing some adaptation to the flux computation procedure and data filtering commonly applied on trace gas turbulent fluxes. They also test the reliability of obtained emissions per unit source, pointing to some

limitations, main one likely coming from the use of a too crude footprint model for the evaluation of the footprint contribution of moving point sources.

The experiment was well designed and conducted over a whole grazing season though it ended in only 3% of usable data for testing the reliability of deduced emissions per unit source. This was due mainly to the absence of the cows for almost half of the time (too low productivity of the pasture) and to strong data filtering associated to signal pollution by nearby sources (farm). Despite the reduced dataset, remaining data were sufficient to reach the goals of the study.

The analysis and results are presented in a transparent and reproducible way, ending in an original and useful paper for the flux community.

With the aim of improving further the manuscript, I have some general comments/suggestions/questions:

1. I would appreciate the addition of one or two sentences in a visible part of the paper stating clearly that authors are lacking information on cows' activity in their study. The consequences being that they are not able to discuss meaningfully the diel CH4 cow emission cycle and to investigate how much of the 30-min variability is coming from the variation in cow's activity. In addition, their use of the term "grazing" for all moments when cows were in the paddocks is misleading, cows spending part of their time ruminating/idling, especially during the night.

2. I'm wondering about the best strategy for computation of the 30 min FP weight (Eq3). You chose to combine your positions with the footprint at a time step of 5s in order to optimize the use of your position information. In doing so, you compute a FP over an interval of only 5s. What is the physical meaning of this 5s footprint and how is it linked to a cow position taken simultaneously? For example, with a wind blowing from the South at a windspeed of 2 m s-1 and a cow located 100m away South of the mast, methane emitted by the cow will take 50s to reach the mast. If there is a wind direction shift during these 50s, your 5s FP weight will be totally wrong. On the other

hand, making a 30 min average of a cow positions and combining it with the 30 min average footprint will also raise this type of questions. So pragmatically, my question is: was the computed flux per cow sensitive to the computation strategy? Might be useful for other teams.

3. The immediate vicinity of the studied pasture should be better described, especially in the wind sectors that were not filtered out. Was it crops or pastures? If it was pastures, do cows were present in these nearby pastures during the experiment? The measured signal could have been significantly polluted by the presence of cows on these possible nearby pastures, amplified by herd behavior at times when cows were also present on the principal pasture.

4. Removal of outliers is always questionable for data showing a huge variability. In this case significant and natural flux variability can arise for important cow footprint weight events due to the cow movement or changing wind direction. The authors should precise how they define exactly an outlier (P3429L23: How is this R boxplot function working?) and how they can distinguish between an outlier and natural variability?

5. "In 92% of the cases when cow fluxes could be measured more than 70% of all GPS devices delivered usable data" (P3430L28). Meaning that among these 92%, you often have several cows (0 to 6 over 20) that are not localized. What did you do with these "missing" cows? Did you simply ignore them in the cow footprint weight calculation or did you position them at the mean of measured cows positions for this 5s data? In all cases, rather than simply concluding that "it was considered as sufficient for the quantification of cow FP contribution", you should recognize that this is also a significant source of (random) uncertainty in the CH4 emissions/cow estimation.

6. Authors do not make use of the traditional u* filtering for exclusion of low turbulence events where turbulent fluxes do not represent the true exchange anymore. Probably some of their data filtering steps overlap with the u* filtering but they should make it more clear to which extend.

Specific comments:

P3422L21-29: Objectives formulation involves non-trivial concepts like "compensation for heterogeneous distribution" and "footprint weight" not yet introduced and therefore difficult to understand for non-experts. Please make it more explicit.

P3426L5-7: Meaning that the calibration was strongly affected the first half of August, when cows were back on the pasture. What did you do with the data?

P3426L22: What do you mean by "the noise level was determined as minimum of the SD of the 10Hz data". On which time window?

P3427L4: Why did you use linear detrending and not block averaging? Did it have significant influence on the computed fluxes?

P3427L26-29: I agree that CO2 can usefully be used for analyses of high-frequency losses. However, elsewhere you mention that many CH4 fluxes were well above the detection limit. So why these CH4 data were not used for spectral analyses? If this is because spectra have some specificity for cows related fluxes, please comment.

P3428: Why "around"? You can give the precise value.

P3428L21: Why "statistically" more representative?

P3428L14-21: Please add a reference for this definition of the flux detection limit.

P3428L26: How was this range of acceptable tilt angles defined?

P3430L4: Precise on which part of the cow and with what kind of fixations the GPS were installed and if the selected position was efficient to avoid damages on the GPS. It may be a useful info for other teams.

P3430L13: Our own experience with the dilution of precision information given by the GPS systems is that the time evolution of this variable shows from time to time abrupt changes not correlated to the error in the localization. It therefore makes it difficult to

simply define a threshold on DOP above which data should be discarded. Did you observe the same behavior?

P3430L14: Which criteria were used for identifying visually a “bad data”?

P3430L26: How do you know the spatial accuracy of your EC footprint model? Please add at least a pertinent reference.

P3431Eq2: This equation has two unknowns: z0 and d. What about the displacement height d? You probably equated it to a fraction of the vegetation height z. But did you have a dynamic evolution of z based on field measurements? I guess this is extremely difficult due to non-uniform grazing within your different paddocks.

P3432Eq3: I fully understand this average FP weight quantity but I think you should rather use the total footprint weight of the herd when you plot a dependent variable like the flux or z0 in function of the footprint weight. This remark holds at least for fig 7, 8, 9. Of course, in your case, the number of cows stays constant during the whole experiment so it will not change the figures but fundamentally, your dependent variable depends on the total footprint weight and not on the mean footprint weight. If you agree with this comment, introduce the total footprint weight in LSU m-2 (the denominator of Eq4) and change the text and the figures accordingly.

P3432L15-17: What is the quantitative impact of this “blurring procedure” on the final flux per head estimation? Is it really a useful step?

P3439L10: Baldocchi et al. 2012 do not define how their detection limit was computed, making the comparison difficult.

P3440L15-19: There you discuss random uncertainties. Please separate more clearly the discussion about random and systematic uncertainties.

P3445L24-26: I found this sentence confusing, please re-formulate.

Fig4: It took me some time to understand the meaning of the blue line. It’s indeed

useful to show that successive positions are correlated but it should be commented in the main text or the legend. However, given the high number of figures in your paper, I would suggest to remove this one, information in the text being self-explaining.

Fig7: This important plot is a bit confusing. Probably due to the expression (“most of the diagram”) used in the legend when describing the zero FP weight case. Use rather something like “left panel containing most of the points”. Or you could group all “soil” cases and label this group “FP weight <= 10-7”? Also I do not understand why you have so many gray points in the same y-axis range as colored points. According to your legend, gray points that are within panels containing also colored points should be outliers. And an outlier should be by definition “out of the range”.

Technical corrections:

P3420L20-21: I prefer: “Methane is after carbon dioxide the second most important human induced greenhouse gas, contributing about 17% . . .” making it more clear that it is not two separate information.

P3421L2: “to assess their effect on global scale”.

P3422L27: Comparable to what?

P3431L20: typo: replace z by z0.

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