Review of manuscript bg-2020-38-manuscript-version4

This is my first review of an already revised manuscript by Stoy et al. The authors present about 2.5 months of EC flux measurements for methane over a snow-covered pasture field with a managed bison herd. By combining the camera image derived distribution of the animals with EC footprint models the average daily emission rate per animal was derived. The study adopts methods already presented in previous studies (Felber et al., 2015; Dumortier et al., 2017; 2019) with the new element of using camera images to visually determine the position of the animals on the pasture field.
Since, according to the authors, the study presents the first actual measurement of CH4 emissions by bison, the results are valuable despite the limited time period.
However, the manuscript presently suffers from a number of issues that need major revisions before the manuscript is suitable for publication. They are listed in the following comments.

MAJOR COMMENTS

1) line 24-25 (and throughout manuscript): I find it generally useful to apply two different footprint models in such a study. However, the animal emission results obtained with the two models should not be treated separately throughout the manuscript and in the abstract. This is not very useful (or even confusing) for the reader, unless the authors want to focus on the specific model differences in detail (which is in my understanding not the scope of this study). Instead, the authors should treat the difference induced by the two models as a part of the footprint model uncertainty. Thus, they should either take the average result of the two models as best guess or declare the preference of one of the models and use only that for the final results.

2) line 138-139: This statement is too optimistic. Heidbach et al. (2017) found considerable differences between different footprint models. For a feedlot experiment, Prajapati and Santos (2018) also found large differences in the spatial extension of footprint models (as mentioned later in lines 326ff.). Therefore, the (systematic) uncertainty effect of the footprint calculation seems to be underestimated in this study (see also comments 3 and 5), although the authors claim a conservative uncertainty estimation.

3) line 146-147: The calculation and use of individual ("unique") z_0 values for each half hour is problematic in my view. Such z_0 values can vary a lot (even if the roughness conditions in the footprint remains unchanged) especially at low wind speeds. I would therefore like to see the obtained roughness length values in this study and eventually recommend to constrain them to a plausible range. Otherwise, the uncertainty of the footprints may be much larger than expected.
The effect of grazing animals in the flux footprint on the effective roughness length z_0 has been analysed e.g. by Felber et al. (2015). It would be useful to compare those results with the findings in the present study.

4) line 160-170: The concept description of the footprint approach is not fully appropriate and unnecessarily complicated.
  a) Eq. 4 is in fact the generic definition (in a discretized math. form) of the footprint weight function ϕ_{ij} as presented e.g. by Schmid (1997). It is valid for all EC measurements.
  b) Eq. 5 is unnecessary and complicates the concept presentation. It would be much better to introduce here the (simplifying) assumption of equal average flux per bison $\langle f_{ij} \rangle$ in the following way: $F_{ij} = n_{ij} \langle f_{ij} \rangle$.
Inserted in Eq. 4 this directly leads to Eq. 6.

5) line 214-215: Obviously the methane emission by the bison was assumed to be a ground source in the footprint models (i.e. the snow surface in the present experiment). This is clearly questionable since the mouth/nose of a bison (main source) is not generally at ground level. I would assume an average height of 30 to 50 cm. In addition, the exhaled air has an upward inertia due to its high temperature (especially in winter) that leads to an even higher effective source height for the model. It needs to be discussed (or tested) what error/uncertainty is introduced by a wrong emission height.

6) line 260ff. The discussion of the obtained results in comparison to existing literature information is unsystematic and clearly insufficient. The methane emission of bovine animals mainly depends on the amount of feed intake and its (digestible) energy content (see line 64-65). The feed intake depends on the energy demand of the animal, which is itself a function of the body weight and the productivity (milk yield, weight gain). This has to be taken into account when discussing the different CH_4 emissions by different animals in other studies.
It could be checked whether existing functional relationships for bovine animals (depending on animal weight and feed amount and characteristics, as given in Table S1-S3) could be used to calculate emissions for comparison with the EC derived results.
The authors cited Kelliher and Clark (2010), Smith et al. (2016) and Hristov (2012) in the introduction (line 59-63) to point out the importance of bison CH_4 emission in pre-industrial times. These authors obviously use estimates of typical bison CH_4 emissions. Why are those results not included in the discussion in comparison to the results of the present study.

7) line 281-309: This section has a misleading title because it only discusses fluxes with bison absent from the pasture field. I also consider this part as quite speculative because it is based on a small dataset. Given that the soil/surface methane fluxes are negligible in comparison to the animal enteric fermentation emissions (Fig. 8), this section is not contributing significantly to the aims of the study and should be shortened drastically or should be fully omitted. In turn, the discussion of entheric CH_4 emission needs to be expanded (see previous comment).

8) Figure 3: This graph is not useful to provide a (quantitative) information of a typical flux footprint extension. It should be changed to a contour plot with contour lines enclosing areas of 50%, 70%, 90% contribution to the flux (as commonly provided in similar studies).
Also the u^* and z/L values of the displayed example should be indicated in the figure caption.

9) It would be useful to add a (short) specific Conclusions section

MINOR COMMENTS

line 25: "...similar to eddy covariance measurements of methane efflux from a cattle feedlot during winter". This is a very unclear statement. I suggest to clarify e.g. to: "...similar to previously reported eddy covariance derived cattle methane emissions in a feedlot during winter".

line 47-49: The message of this sentence is misleading. When comparing bison to other ruminants in agricultural production, the differences in productivity (rate of weight increase) and the general energy demand of the animal is much more important for the CH_4 emission than some grazing preference details.

line 52-55: It appears not logical that the authors first cite studies from 2013 and 2017 and afterwards state "Recent studies have revised methane emission estimates from livestock upward by over 10%" with citing of mainly older (!) studies. Please rephrase.

line 185: "perfectly aggregated" sounds strange in this context (because the animals need to be distant to each other, i.e. non-aggregated). I suggest to change to "perfectly distributed".

line 188: "...the true number of each bison..." is unclear. Moreover, what is the difference between the true number and the measured number? Please rephrase and clarify.

line 324-329: This is a quite unspecific discussion of the problem without a clear conclusion concerning the effect of footprint uncertainty (see comment 2 above).

line 338-340: It should be mentioned here, that eddy covariance might not be suitable to determine (separate) the efflux of individual animals on the pasture even if they can be identified and tracked (especially because they tend to move in groups).

Figure 7 caption: Change to "...from the study pasture near Gallatin Gateway ..."

ADDITIONAL REFERENCES

Prajapati, P., and E.A. Santos. 2018. Estimating methane emissions from beef cattle in a feedlot using the eddy covariance technique and footprint analysis. Agric. For. Meteorol. 258:18–28. doi:10.1016/j.agrformet.2017.08.004

Schmid, H.P. 1997. Experimental design for flux measurements: matching scales of observations and fluxes. Agric. For. Meteorol., 87, 179–200.