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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Validation of farm-scale methane emissions using nocturnal boundary layer budgets" *by* J. Stieger et al.

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We thank all three reviewers for their careful assessment and constructive criticism. In our view this is one of the most positive experiences we had so far to see the critical evaluation that really helps us to improve our manuscripts, and still values the quite challenging issues that everyone faces who tries to carry out such an experiment.

We will do our best to address all issues criticised by the three reviewers along the lines specified in the two separate replies to Reviewers #2 and #3, and will proceed as specified below in this final response to the points mentioned by Reviewer #1.

As we clearly mention in our manuscript (in our conclusions), we learned from the change in experimental concept that although we potentially could obtain a better esti-

mate for $\Delta\bar{c}/\Delta t$ to determine the top of the NBL (z_i) by letting the tethered balloon stay at a given height for some time, we loose the very important information on the vertical structure within the NBL, which can only adequately be measured by a slow, but continous and steady motion of the tethered balloon during ascents and decents. Due to this, we will face the same limitations for the revised manuscript, that we cannot carry out exactly the same analysis in all aspects for the 2012 campaigns as we can with the 2011 data. Originally we were convinced that the approach used in 2012 should advance our skills beyond what we did in 2011. On hindsight, our results could not meet our own expectations, but we learned a lot and hence we are grateful to see the constructive critique by all three reviewers. This should be valuable and helpful for other scientists who take the challenge of trying to advance the NBL budgeting approach and hopefully prevents them from trying out the variant we used in 2012.

Specific response to Reviewer #1

(*We copied the reviewer's text in italics* and provide our response in normal font.)

The MS describes the application of nocturnal boundary layer (NBL) budgeting using tethered balloons and tower-based instrumentation to measure livestock methane emissions from a typical Swiss farmstead leading to a validation of inventory estimates of the emissions. The authors conclude that the NBL budgeting fluxes were in good agreement with local inventory estimates based on current livestock numbers and default emission factors, which provides confidence that the Swiss national inventory report reliably represents the national livestock methane emissions.

Specific comments

(1) The MS is well written and should prove to be very useful for those contemplating boundary layer budgeting as it brings out a number of problems in applying the technique including changing atmospheric conditions, estimating the height of the inversion

layer, advection, the sometime presence of more than one layer within the boundary layer, the differences in the concentration gradients between ascents and descents and mixing of the CH4 concentrations in the vertical profiles.

Thank you for this explicit statement. As we mentioned in our final response above, we're having the same view on this, knowing that there is still room for improvement and others may profit from our experience.

(2) I think the numbers of the various livestock emitting CH4 should be given

This will be done.

(3) I feel that there is a need to show, or at least comment on, the daytime methane fluxes before making assertions about verifying inventory emissions from just NBL measurements. The NBL estimates come from only 4 nights. There is no information on daytime fluxes (which might have been obtained from the methane gradients measured on the tower) but as I read it, the calculation procedure used by the authors to validate the inventory estimates assumes that the daytime mean flux equals that in the night.

During daytime the CBL budget method (e.g. Cleugh et al., 2004) is probably the one that is most promising for measuring daytime fluxes, since gradients are typically too small to allow for robust calculations of fluxes during daytime. Originally, we measured eddy covariance fluxes from the grassland surface (excluding emissions from cattle) which was too small a flux to be accurately detected by eddy covariance (see Hiller et al., 2012) and hence neglected this flux in the NBL approach. With an improved laser absorption spectrometer we later confirmed these small fluxes of CH_4, even during a prescribed disturbance of the grassland (see Merbold et al., 2014).

So, the regionally relevant flux of CH_4 at our locality (as in other farm areas where the distance to water table below a grassland is several meters) is not the exchange with the grassland surface, but the emissions from farm animals and possibly manure

storage and spreading. We only briefly discuss the diel cycle of livestock CH_4 emissions (line 15, page 21,785). In an earlier paper where we presented daytime flux measurements using a small aircraft (Hiller et al., 2014) we discussed this aspect in slightly more detail in Section 4.1. We did not want to repeat this, but realize that in this context here it could be a valid addition to mention this aspect about (a) daytime flux measurements, and (b) the diel cycle of ruminant activity in more detail.

Typographical errors

We will correct all typographical errors listed by the reviewer.

References

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