Atmos. Chem. Phys. Discuss., 15, C6624–C6629, 2015
www.atmos-chem-phys-discuss.net/15/C6624/2015/

Atmospheric Chemistry and Physics Discussions

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

Anonymous Referee #3

Received and published: 7 September 2015

General comments

This paper summarises the results and interpretation of two intensive periods of nocturnal measurement over 4 nights during 2011 and 2012 to estimate a local emission of methane where NBL estimates are compared with inventory estimates from the National Inventory (NIR) emission for methane, and two spatially explicit inventory estimates at national scale (SEI) and for local area (CHAI).

(1) P21786-Li22 It is very useful to see a comparison of NBL technique with inventory estimates, particularly for the local area "based on actual livestock data" and as the authors mention, few studies have done this. I feel it would add considerable value to this paper and broaden possible comparisons if the authors could give information

about the animal numbers for Chamau farmstead for CHAI and for the local area used with SEI estimates and from this add some estimates of emission per head estimated by the NBL method and how this compares to the numbers that have been used in NIR, SEI and CHAI because many animal science and the inventories are based on emission per head (in addition to giving the per area fluxes).

(2) I feel that a bit more analysis is warranted given the profiles of 2012 that appear remarkably well mixed with height (in Fig. 3). As mentioned on P21784, the profiles may be influenced by a relatively large area of order hundreds km2 and on P21785. The authors note the "well mixed" nature of the methane and its build through the night. There is useful discussion on P21780 and it appears that with increased wind aloft or possible jet activity may have been sufficient to keep the stable NBL stirred and as mentioned, it appears "that local sources only had a minor influence". However the CHAI would suggest that local sources were larger in 2012 than 2011; alternatives are that these sources have (i) mixed vertically through the lower atmosphere locally which seems unlikely, or (ii) that they have not been captured because too close and do not fall in measurement footprint for winds experienced at the measurement site which is solely "seeing" distant sources contributing to the NBL or (iii) both local and distant sources are well mixed. Can more analysis be done to understand the 2011 / 2012 differences add more interpretation? Figure 4 gives useful additional information for 2011, could a similar figure be looked at for 2012. Alternatively or further it would be instructive to look at the Richardson Number through each of the profiling periods; perhaps a critical number is always exceeded in 2012 to allow turbulent mixing to continue and is perhaps sufficient to mix up local emissions in spite of light wind at the surface (e.g. along lines of Grachev et al 2013) whereas perhaps turbulence is supressed in 2011 case. Whilst this may help explain differences in the profiles, there is also no sign of a capping in the methane profiles and if the NBL flux is only integrated to Zi (50m) then it looks like a substantial component of the flux is missed as it appears that methane above this height is well coupled to the surface layer. There is some discussion of uncertainly introduced by assumptions in Zi etc. This analysis depends to a degree on

whether the Chamau farmstead region a relative "hotspot" of methane emission or is it surrounded over the hundreds of km scale by land of similar or larger mean emission as this affects potential advection flux errors.

Grachev, A., Andreas, E., Fairall, C., Guest, P., and Persson, P. O.: The Critical Richardson Number and Limits of Applicability of Local Similarity Theory in the Stable Boundary Layer, Boundary-Layer Meteorology, 147, 51-82, 2013.

Reviewer questions: 1. Does the paper address relevant scientific questions within the scope of ACP? Yes

2. Does the paper present novel concepts, ideas, tools, or data? Yes, there are few other authors that have attempted this quite challenging method of validation

3. Are substantial conclusions reached? Yes in comparison with inventory estimates. Discussion of components of uncertainty would be valuable

4. Are the scientific methods and assumptions valid and clearly outlined? See point 2 above re interprtation of well mixed profiles and Zi assumptions

5. Are the results sufficient to support the interpretations and conclusions? A small amount of further analysis is suggested

6. Is the description of experiments and calculations sufficiently complete and precise to follow their reproduction by fellow scientists (traceability of results)? Yes

7. Do the authors give proper credit to related work and clearly indicate their own new/original contribution? Yes with Acknowledgements

8. Does the title clearly reflect the contents of the paper? Yes

9. Does the abstract provide a concise and complete summary? Yes

10. Is the overall presentation well structured and clear? Yes

11. Is the language fluent and precise? Yes

12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used? Yes

13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated? Not necessary

14. Are the number and quality of references appropriate? A few additional references may be useful. 15. Is the amount and quality of supplementary material appropriate? n/a

Specific remarks

P21768-Line11: the IPCC methodology for NIR could be cited: e.g. IPCC: IPCC Guidelines for National Greenhouse Gas Inventories. In: Prepared by the National Greenhouse Gas Inventories Programme, Eggleston, H. S., Buendia, L., Miwa, K., Ngara, T., and Tanabe, K. (Eds.), IGES, Japan, 2006.

P21768-Line16 statement "require detailed knowledge of the transport pathways of tracers and the location of active CH4 sources with which they must be collocated to provide realistic flux estimates" needs clarification. For the individual animal measurements, (Johnston, Deighton) the SF6 tracer source is typically loctated in the rumen to be collocated with the main source location of enteric methane. It is unclear what if any short-comings the authors are suggesting with this technique.

P21768-Line18 : "for the validation of an emission inventory that is supposed to cover the total of all known and unknown (or neglected) source components. " Atmospheric verification will potentially see all sources of methane to the area, the emission inventory does not need to account for natural methane sources. This point is discussed by Hiller et al 2014a who note that natural and semi-natural sources make up only 3% of the total emissions in Switzerland. Can the authors comment whether emissions in the study region are likely to be affected by any natural sources?

P21769-Line8: The authors state that "Little is known about the temporal variability"

I note that Harvey et al, 2002 recommends that "In order to compare nocturnal measurements with daytime or 24 h measurements, any systematic diurnality in flux needs to be accounted for." They suggest that " In general, the diurnal pattern of methane emissions is linked closely to animal feeding patterns, which in turn may be linked to times of availability of fresh feed" and that systematic difference may occur where there are set feeding times or feeding habits if freely grazing. Can the authors comment on whether there could be any systematic biases in ruminant sourced methane due to any regular diurnal patterns of feeding?

Harvey, M. J., Brailsford, G. W., Bromley, A. M., Lassey, K. R., Mei, Z., Kristament, I. S., Reisinger, A. R., Walker, C. F., and Kelliher, F. M.: Boundary-layer isotope dilution/mass balance methods for measurement of nocturnal methane emissions from grazing sheep, Atmos Environ, 36, 4663-4678, 2002.

P21769-Line14: "only few projects, so far, have directly validated livestock CH4 emission estimates via atmospheric concentration measurements without the deployment of chambers". Few projects should be clarified, and only refs to Denmean and Grobler given. There have been a number of studies at a number looking at free grazing animal emissions using a variety of techniques without the deployment of chmbers e.g. Judd et al 1999, Lassey et al 2011, 2013, Laubach and Kelliher, 2004, 2005a,b, Laubach et al 2008, Wratt et al 2001 etc. and with comparison with chambers, e.g.: Grainger et al 2007

Grainger, C., Clarke, T., McGinn, S. M., Auldist, M. J., Beauchemin, K. A., Hannah, M. C., Waghorn, G. C., Clark, H., and Eckard, R. J.: Methane emissions from dairy cows measured using the sulfur hexafluoride (SF6) tracer and chamber techniques, J Dairy Sci, 90, 2755-2766, 2007.

Judd, M. J., Kellier, F. M., Ulyatt, M. J., Lassey, K. R., Tate, K. R., Shelton, I. D., Harvey, M. J., and Walker, C. F.: Net methane emissions from grazing sheep, Global Change Biol., 5, 647-657(611), 1999.

Lassey, K. R., Pinares-Patiño, C. S., Martin, R. J., Molano, G., and McMillan, A. M. S.: Enteric methane emission rates determined by the SF6 tracer technique: Temporal patterns and averaging periods, Anim Feed Sci Technol, 166–167, 183-191, 2011.

Lassey, K. R.: On the importance of background sampling in applications of the SF6 tracer technique to determine ruminant methane emissions, Anim Feed Sci Technol, 180, 115-120, 2013.

Laubach, J. and Kelliher, F. M.: Measuring methane emission rates of a dairy cow herd by two micrometeorological techniques, Agric For Meteorol, 125, 279-303, 2004.

Laubach, J. and Kelliher, F. M.: Methane emissions from dairy cows: Comparing open-path laser measurements to profile-based techniques, Agric For Meteorol, 135, 340-345, 2005a.

Laubach, J. and Kelliher, F. M.: Measuring methane emission rates of a dairy cow herd (II): results from a backward-Lagrangian stochastic model, Agric For Meteorol, 129, 137-150, 2005b.

Laubach, J., Kelliher, F. M., Knight, T., Clark, H., Molano, G., and Cavanagh, A.: Methane emissions from beef cattle – a comparison of paddock- and animal-scale measurements, Aust. J. Exp. Agric., 48, 132-137, 2008.

P21771-Line 10 Please give tube diameter as this affects Reynolds number for the tube and how fast and degree of turbulence in gas transported

Figure 2: what is explanation for the sharp cut-off at 150m in the kriged plot, is this an artifact of the analysis? Further, in a similar way to the 2012 profiles, if Zi is found to be 50m there would appear to be a component of the methane plume that has mixed above this height and do the authors consider possibility of flux underestimation from this by not integrating the whole vertical extent or ignoring the -Fent at the top of the NBL?

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 21765, 2015.