A parsimonious software sensor for estimating the individual dynamic pattern of methane emission from cattle

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Supplementary material S1

Influence of the turnover rate of a respiration chamber on methane output

In a respiration chamber, the rate of methane produced (g/min) by the animal (y_{a}) and the rate of methane production measured in the chamber (y_{c}) are related by the following mass balance model

$$\frac{\mathrm{d}y_{\mathrm{c}}(t)}{\mathrm{d}t} = b \cdot \left(y_{\mathrm{a}}(t) - y_{\mathrm{c}}(t)\right), \tag{1}$$

where b (min^{-1}) is the turnover rate of the chamber. The magnitude of b determines how fast the trajectory of y_{c} will follow the trajectory of y_{a}. The higher b, the faster y_{c} converges to the trajectory of y_{a}. As displayed in Figure S1, a wrong choice of the turnover rate will imply an important mismatch between the dynamics of methane produced by the animal and the dynamics of the methane flux of the chamber. An adequate turnover rate guarantees that the dynamic of y_{a} is mirrored by the dynamics of y_{c}, that is that the approximation $y_{\mathrm{c}} \approx y_{\mathrm{a}}$ (used in this work) is consistent.

In theory, a very high turnover rate of the respiration chamber is ideal to capture the dynamics of methane produced by the animal. In practice, however, attention should be paid to very high turnover rates, since the gas flux at the outlet of the camber might be too fast for the gas analyser to produce consistent measurements. The rate of sampling of the gas analyser must be considered to select the optimal turnover rate. Since the overall efficiency of a respiration chamber depends on the extraction, conduction, and gas analysis (Gardiner *et al.*, 2015), both turnover rate and sampling rate are determining elements of the accuracy of respiration chambers for measuring methane emissions from livestock.

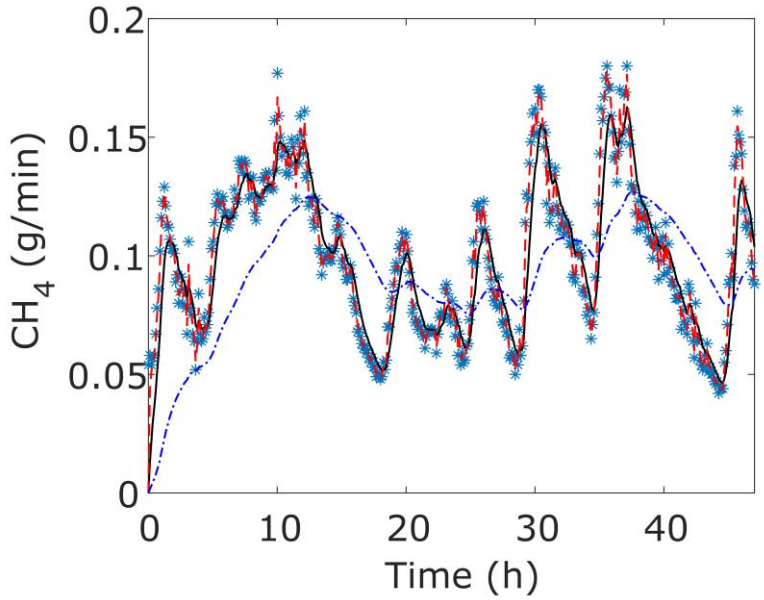

Figure S1 Simulation study. Virtual data of methane production by the animal (*) are compared with the output from a respiration chamber using Eq. (1) at three turnover rates: 0.004 min-1 (blue -.), 0.4 min-1 (red --), 0.04 min-1 (solid black line). The turnover rate of the respiration chambers used in this study was 0.04 min-1.

References

Gardiner TD, Coleman MD, Innocenti F, Tompkins J, Connor A, Garnsworthy PC, Moorby JM, Reynolds CK, Waterhouse A and Wills D 2015. Determination of the absolute accuracy of UK chamber facilities used in measuring methane emissions from livestock. Measurement 66, 272-279.