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Methane flux quantification from lactating cattle using unmanned aerial vehicles

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Methane is a poorly constrained yet incredibly potent greenhouse gas, with poor agreement between top-down (measurement based) and bottom-up (inventory based) flux estimates, especially from local scale sources such as landfill sites, agricultural facilities and oil and gas infrastructure. In order to help constrain the global methane budget, we have demonstrated the ability to derive fluxes from lactating cattle downwind of a barn at a dairy farm near Blackpool in Lancashire, UK, using high precision methane concentration measurements sampled from an unmanned aerial vehicle (UAV) platform.

A modified DJI S900 hexacopter UAV was connected by 150 m of tubing to an off-axis integrated cavity output spectroscopy sensor (a Log Gatos Research Inc. Microportable Greenhouse Gas Analyzer) sampling at $\sim$10 Hz on the ground. Three emission fluxes from cattle in the barn were calculated alongside a single flux from an empty barn for a background estimate. Each flux calculation used sampling from two consecutive UAV flights to reduce uncertainty, resulting in an average sampling time of 31 minutes.

Fluxes were derived using a recently developed mass balancing approach, which has previously been tested using controlled flux release and requires geospatially mapped concentration measurements on a plane perpendicular to the wind direction. The modified mass balancing approach has been adapted to account for turbulent mixing observed from local scale point source emission plumes by gridding the plane perpendicular to wind direction into equally spaced flux sub-domains. The modified method also accounts for under-sampled areas in space.

We derived a background subtracted emission flux of (0.6 ± 0.4) g s^{-1}. This translates to each cow producing (300 ± 200) kg day^{-1} of methane, which is in broad agreement with previous estimates. This therefore demonstrates the successful application of our modified mass balancing approach to a natural methane emission source beyond our control and provides a means for future quantification of local scale emission plumes using UAVs.