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The Challenge of Reconciling Bottom-up Agricultural Methane Emissions Inventories with Top-down Measurements

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Abstract

Agriculture is estimated to produce more than 40% of anthropogenic methane (CH_4) emissions, contributing to global climate change. Bottom-up, IPCC based methodologies are typically used to estimate the agriculture sector's contribution, but these estimates are rarely verified beyond the farm gate, due to the challenge of separating interspersed sources. We present flux measurements of CH_4, using eddy covariance (EC), relaxed eddy accumulation (REA) and wavelet covariance obtained using an aircraft-based measurement platform and compare these top-down estimates with bottom-up footprint adjusted inventory estimates of CH_4 emissions for an agricultural region in eastern Ontario, Canada. Top-down CH_4 fluxes agree well (mean ± 1 standard error: EC = 17 ± 4 mg CH_4 m^{-2} d^{-1}; REA = 19 ± 3 mg CH_4 m^{-2} d^{-1}, wavelet covariance = 16 ± 3 mg CH_4 m^{-2} d^{-1}), and are not statistically different, but significantly exceed bottom-up inventory estimates of CH_4 emissions based on animal husbandry (8 ± 1 mg CH_4 m^{-2} d^{-1}). The discrepancy between top-down and bottom-up estimates was found to be related to both increasing fractional area of wetlands in the flux footprint, and increasing surface temperature. For the case when the wetland area in the flux footprint was less than 10% fractional coverage, the top-down and bottom-up estimates were within the measurement error. This result provides the first independent verification of agricultural methane emissions inventories at the regional scale. Wavelet analysis, which provides spatially resolved fluxes, was used to attempt to separate CH_4 emissions from managed and unmanaged CH_4 sources. Opportunities to minimize the challenges of verifying agricultural CH_4 emissions inventories using aircraft flux measuring systems are discussed.

https://doi.org/10.1016/j.agrformet.2017.09.003

The study reported here in this Research Brief was not funded by the beef checkoff, but is made available to expand the usefulness of this checkoff-funded website for those interested in beef sustainability. Internal links within this document are funded and maintained by the Beef Checkoff. All other outgoing links are to websites maintained by third parties.