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Titulaire d'un diplôme de master bioingénieur : sciences agronomiques,
à finalité spécialisée,

présentera en vue de l'obtention du grade et du diplôme de

DOCTEUR EN SCIENCES AGRONOMIQUES ET INGENIERIE BIOLOGIQUE,

le 12 novembre 2020, à 9h00 précises, en visioconférence :

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Cette dissertation originale a pour titre :

« Can Eddy-covariance be used on a pasture? Estimation of cattle and soil- plant methane emissions and transfer to other greenhouse gases ».

Le jury est composé comme suit :

Président : Prof. Y. BECKERS, Professeur ordinaire,
Membres : Prof. B. HEINESCH (Copromoteur), Prof. M. AUBINET (Copromoteur), Prof. J. BINDELLE, Dr. K. KLUMPP (INRAE Clermont-Ferrand, France), Dr. N. ARRIGA (European Commission, Joint Research Center, Ispra, Italie).

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Abstract

Much debate has arisen as to the contribution of natural and anthropized ecosystems to the global production of greenhouse gases (GHG), ways to limit this contribution or how to use ecosystems as carbon sinks. To provide solid ground for this debate, reliable data is required. Eddy-covariance (EC) is commonly used to measure gaseous exchanges from homogeneous ecosystems (crops, forests…). However, in its standard form, it may be biased when working with heterogeneous ecosystems, especially grazed pastures where cattle is an important, but also moving and intermittent GHG source. In this thesis, using data from the Dorinne ecosystem station, a Belgian pasture grazed by Belgian Blue beef, we disentangled cattle methane (CH_4) and carbon dioxide (CO_2) exchanges from soil-plant exchanges. This work allowed us estimate cattle CH_4 and CO_2 emissions and compute an un-biased pasture GHG budget. Our work therefore opens the door to a wider use of EC on grazed pastures and thus the monitoring of this important ecosystem.

In practice, EC measures gaseous exchanges from an area upwind from the measurement mast. Each area contribution to the measured flux can be computed using a mathematical model (footprint model). We combined this footprint model with cattle positions on the pasture, obtained using GPS-collars, and EC in order to estimate cattle CH_4 emissions. The proposed method was validated through an artificial tracer experiment where source recovery rates were between 90 and 113% and no bias was associated with atmospheric conditions or the distance between the source and the measurement mast. Applying this validated method on grazing Belgian Blue cows led to estimated CH_4 emissions of 220 ± 35 $gCH_4\ head^{-1}\ day^{-1}$. Cow's behavior was also monitored and presented a clear daily pattern of activity with more intense grazing just after sunrise and right before sunset. However, no significant CH_4 emission pattern could be associated with it, indicating that the diurnal emission variation might be lower than the measurement uncertainty range.

We extended our method to cattle CO_2 emissions. To avoid the need for cattle geolocation, we used CH_4 fluxes as an indicator of cattle presence in the footprint. This allowed us by-passing labor intensive handling of cattle, thus making our method easier to use on a large number of test sites. Using this method, estimated cow CO_2 emissions were of 3.2 ± 0.5 $kgC\ head^{-1}\ day^{-1}$. Moreover, we computed a pasture GHG emission (CO_2, CH_4 and N_2O) of 629 ± 296 $gCO_{2eq}\ m^{-2}\ yr^{-1}$. This figure should be handled with some precautions as it is site specific, dependent on budget boundaries and subject to annual variations.