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A whole farm approach based on farm management practices data coupled with crop and grassland mechanistic models.

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Abstract

GHG emissions occur at several stages within the farm operation and it is therefore unavoidable to combine nutrient cycling and farm operating through an integrated whole farm approach. FarmSim is a simulation framework allowing to estimate the emissions taking into account farmer's practices through two dynamic and mechanistic models for grassland and crops management.

Les émissions de gaz à effet de serre surviennent à différents niveaux dans le fonctionnement des exploitations agricoles et il est donc incontournable de combiner cycles des éléments et fonctionnement de la ferme dans une approche intégrée globale à l'exploitation. FarmSim est un cadre de simulation permettant d'estimer les émissions en prenant en compte les pratiques agricoles au moyen de modèles dynamiques pour la conduite des prairies et des cultures.

Introduction

Dairy farming is the largest agricultural source of the greenhouse gases (GHG), methane (CH₄) and nitrous oxide (N₂O) in Europe. But these emissions have mainly been considered for individual gases and for separate parts of the farm and, as a result, mitigation measures are either single-gas or source-oriented. However, these mitigation options must address the whole production chain (Weiske et al., 2006). Organic farming has been considered as a possible strategy for reducing GHG emissions: organic ruminant livestock systems are frequently low inputs systems and aim for being self-sufficient. They are often mixed farming systems and combine grassland and crops to produce home-grown roughage, feedstuffs and other cash crop products. Organic farming especially present a real opportunity to enhance soil carbon storage through grass-crop rotations with a special concern to grass-legume leys, intercrops and tillage techniques (Smith et al., 2004). It is rather difficult to measure GHG emissions, both from pastures and croplands, but also through the livestock production chain. A full accounting of the GHG budget is required (Soussana et al., 2006) cause of the trade-offs between gases and compartments: their relevance can be best understood at the farm level through a full accounting and modelling approach (Schils et al., 2005).

From a first attempt, a farm simulation model relying on Pasim grassland model was proposed (Salètes et al., 2004). The poster presents some recent advances, extending FarmSim model through a best accounting of croplands emissions.

A whole farm approach

A crop-livestock farm is simultaneously a management and a production unit where fields, batches of animals, buildings, machinery and stores contribute to the environmental balance generating energy and matter exchanges, especially through GHG.

The emissions of GHG are related to carbon and nitrogen flows and environmental conditions. Therefore we consider carbon and nitrogen cycling through a whole farm system approach (Figure 1) in order to quantify and assess the main processes that lead to GHG release or uptake by the farm and to simulate the resulting farm GHG balance. The interactions between the different fluxes are especially strong in the organic mixed crop-livestock farms with ruminants: effluents are recycling on the fields to contribute to home-grown fodder, feeds and straw supply for animals. Conversely, inputs are rather low even farm operating needs some purchased feedstuffs, electricity and fuel. A balance extended to these inputs is therefore relevant.

A simulation framework coupling two mechanistic models

FarmSim has been designed to describe the above and below ground C and N fluxes in cattle farms, and calculate the net balance of GHG emissions through a consistent description of the farm features and practices including grazing animals. FarmSim is structured into 9 modules, requiring detailed data inputs on the farm structure, meteorological conditions, soils, animals, grassland and cropland management, but also animal winterfeeding strategy, waste production system and imported resources.

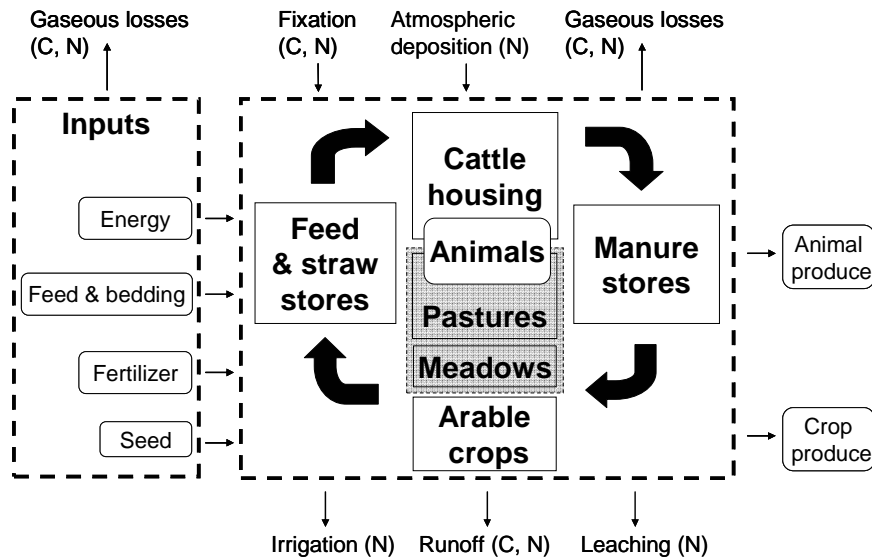


Figure 1 – Carbon (C) and nitrogen (N) fluxes from a whole mixed crop livestock farm approach

FarmSim involves a strong connection to the Pasture Simulation model PaSim, a grassland model originated from the Hurley Pasture model (Thornley, 1998). PaSim is a dynamic model operating at the plot scale (Riedo et al., 1998). The emissions from croplands are calculated by the CERES-EGC model: This latter is based on a mechanistic fully dynamic model modified to suit French conditions (Gabrielle and Kengni, 1996). CERES simulates the dynamic of water, carbon and nitrogen in soil-crop systems. All the other emissions are calculated using IPCC methodology (Tier 2) through emission factors. FarmSim model was rewritten from Visual Basic® to Java® allowing to convert it into an object-oriented language to make implementing and progress more easy.

From farmer's practices to modelling data

Coupling with PaSim and CERES-EGC allows to give a special attention to management regime suited on grassland and cropland fields. The main step of model inputs relies on a description of the farmer's practices and their translation into the models' variables. Different grassland types may be distinguished, mainly from their management regime, waiting for PaSim model will be able to take into account grassland species composition. For each grassland type, information is required about time, nature and intensity of removed grass, through indications of cutting or grazing regime, and thus grass yield or stocking density. In addition, organic fertilizer applications are needed in regard with spreading time and rate. For croplands, the required data aim to describe the different crops involved in the farm cropping system relying on the plant variety and the following practices' data: seeding time and density, time and rate of organic fertilizer applications, harvesting time and crop residues fate. According to the tillage and mechanical weeding no detail can be accounted yet. At the moment, no animal production model is included into FarmSim. Therefore, emissions associated with animal winterfeeding, livestock housing and manure storage remain calculated in a spreadsheet module, according to IPCC methodology.

Before to use FarmSim for estimating GHG emissions from different organic farms, we have to test the sensitivity of model outputs to models' parameters. Another perspective we have consists into the ability to simulate several years scenarios in order to take into account converting period of farms to the organic farming system, but also to test the effects of chaining up of climatic events.

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