4-64 Evaluating HE-DNDC for greenhouse gas fluxes and yield prediction in boreal timothy grasslands under slurry and mineral nitrogen fertilization

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ABSTRACT

The dairy industry covers nearly 70% of the agricultural area in North Savo, Finland, making it central to food security and rural livelihoods. A key challenge is to sustain high forage yields while reducing environmental impacts. Nitrogen use efficiency (NUE) in grasslands is often low, and evaluating both mineral fertilizers and slurry applications is essential to identify management strategies that can improve it. Nutrient management also shapes the greenhouse gas (GHG) balance of grasslands, yet the complexity and long-term nature of these systems make field experiments both challenging and costly. To address this, process-based models are increasingly applied to grassland systems to assess management scenarios and their impact on GHG emissions and yield. However, most such models were developed for temperate or tropical climates and remain insufficiently validated in boreal conditions. The Heat-exchange DNDC (HE-DNDC), a modified version of the Denitrification–Decomposition model designed to better represent freeze-thaw dynamics and energy exchange in cold environments, offers particular potential for Finnish grasslands.
With this motivation, we used GHG flux data collected from six experimental plots in Maaninka, Eastern Finland (63.07°N, 12.54°E; loamy soil, pH 6.1) with timothy grass (*Phleum pratense* L., cv. 'Nuutti'). The treatments included only mineral fertilizer (no slurry) with 0, 250, and 350 kg N ha^{-1} yr^{-1}, and slurry (30 t at the beginning of the season + 30 t after the first cut) with 0, 250, and 350 kg N $ha^{-1}yr^{-1}$. GHG fluxes were measured from 0.6 m × 0.6 m flux plots using closed chambers during snow-free periods and the snow-gradient method under snow cover. Biomass harvested from the flux plots was used to estimate yield. HE-DNDC will be calibrated and validated against these observations, and preliminary modeling results will be presented.
This study has three main aims: (1) to test whether HE-DNDC can reproduce seasonal GHG fluxes in both growing and non-growing seasons, (2) to evaluate its performance in simulating biomass yield under mineral fertilizer and slurry treatments at different nitrogen levels, and (3) to estimate the net GHG balance under these management strategies. We expect that HE-DNDC will provide improved predictions of both GHG fluxes and yield in Finnish grasslands, which differ from most other European systems due to long winters, snow cover, and multiple harvests. By doing this, we aim to demonstrate the potential of process-based models to support sustainable nitrogen management and scenario analysis in boreal grasslands, thereby contributing to climate-smart strategies for the Finnish dairy sector.

KEYWORDS: boreal grasslands, nitrogen use efficiency, HE-DNDC model, slurry application, greenhouse gas fluxes