A comparison of farm-scale models to estimate greenhouse gas emissions from dairy farms in Europe

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Background

• Farm scale is essential when upscaling ruminant livestock production
  – significant flexibility in management
  – substantial internal nutrient cycling

• Farm models differ in:
  – Focus (production/economics/environment)
  – Purpose (supporting farmers/farm advisors, regulators)

• How would these differences affect results if the models were used to simulate the same dairy cattle farms?
Models

• SFarMod
  – optimised management
  – emission factors
  – portable
  – 30+ years experience

• Dairywise
  – optimised feed supply
  – empirical emission factors
  – location-specific (Netherlands)
  – 10+ years of experience
Models

• FarmAC
  – user inputs management
  – emission factors (except dynamic soil model)
  – portable
  – 1 year of experience

• HolosNor
  – user inputs management
  – emission factors
  – Canadian model, adapted for Norway
  – 2-3 years of experience
Standard factorial scenarios

- Warm x cool climate
- Sandy x clay soil
- Grass only x grass & maize

Dairy cows + followers (1:1)

600 kg LW & 7000 kg ECM/cow/yr

Cool climate grazing 5 months
Warm climate grazing 10 months
16 hours/day grazing

Minimum use of concentrates
No manure import/export

Plant-available N:
Grass 275 kg/ha/yr
Maize 150 kg/ha/yr
(Manure broadcast)

For each scenario, adjust cow numbers to match feed supply
RESULTS
Dairy cows per ha

HolosNor uses FarmAC livestock numbers

Differences in feed requirement models

For grass & maize - differences in area allocated to maize
Total farm GHG emissions (Mg CO₂ e / ha)

Note – pre-chain/post-chain not simulated

Grass only > grass & maize
Little effect of soil type – true for most variables
Emission intensity (kg CO\textsubscript{2} e / kg ECM)

Cool climate > warm
Grass only > grass & maize (except HolosNor)
FarmAC low – feed requirement model predicts lower intake necessary to achieve 7000 litres milk/yr
Manure methane emissions (kg CO₂ e / ha)

Higher for cool climate (more manure produced in housing)

Dairywise imposes Netherlands manure regulations concerning manure storage
Manure N$_2$O emissions (kg CO$_2$ e / ha)

Higher for cool climate (more manure produced in housing) but relationship between models differs relative to methane.
Field $N_2O$ emissions (kg $CO_2$ e / ha)

Differences between models in how they treat manure N and excretal N
Total farm indirect GHG emissions
(kg CO₂ e / ha)

Indirect = nitrous oxide emission resulting from nitrate leaching and ammonia emission
Large differences between models
Grass only > grass & maize
Effect of soil type in some models
Large differences between models (different emission factors)
Grass only > grass & maize
Conclusions (1)

• Total GHG emissions per kg milk and per ha were similar for all models
  – but this disguises some major differences between models
• Little effect of soil type
• All models tended to predict lower emissions for the warm climate
• More work necessary to understand the details of why models differ
Conclusions (2)

• Assumptions concerning farm management are important
  – need for more empirical data and better understanding of processes
• If used to prioritise mitigation measures, these models would give very different answers
• It has been a useful learning exercise