FarmAC model

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Training session 1
Schedule for day

09:00* – 10:00  Overview of the science behind FarmAC (Nick)
10:00 – 11:00  Using the model via the user interface (Ib).
11:00 – 12:00  The users use the two example farms implement their mitigation measures

13:30 – 14:00 Summing up of the experiences from the day
14:00 – 14:30 Preparation for next training session

*Times are GMT
FarmAC model

- Focusses on livestock farming systems
  - Can be used for arable agriculture
- Intended to have wide applicability
- Simple enough that demand for inputs and parameters is manageable
- Complex enough to describe consequences of mitigation/adaptation measures
- Mass flow for C and N
  - Consistency between GHG and N emissions
  - Capture knock-on effects
Results from FarmAC

- N inputs, outputs and losses
- C inputs, outputs and losses
- Livestock and crop production
- Greenhouse gas (GHG) emissions
- Indicators
Deposition
Fixation
Fertiliser
Manure

NO₃

NH₃, N₂O, N₂

Storage losses

Exported

NH₃, N₂O, N₂

Runoff

Exported

Exported

Exported
Structure of presentation

- Soil organic matter dynamics
  - Complex – will consider briefly
- Arable farm (cereal cropping)
- Livestock
- Manure management
- Grazed grass
Soil organic matter

- Three types of soil carbon
- Fresh organic matter (FOM)
  - e.g. crop residues, decomposes in months
- Humus organic matter (HUM)
  - partially stabilised organic matter, decomposes in years
- Resistant organic matter (ROM)
  - very stable organic matter, decades/centuries
- Temperature and moisture effects
Adaptation and Projection simulations

- Adaptation = simulate for many years to stabilise soil model
- Projection = run model for 10-20 years to calculate results
Crop sequences

- Define for each crop
  - Crop products (e.g. grain, straw)
  - Start and end dates
  - Rainfed or irrigated
- Bare soil is a ‘crop’
- No gaps in sequence
- Last day of last crop = first day of first crop - 1
Crop products and residues

- main product (crop yield)
- Secondary product (may or not be harvested)
- above-ground crop residue
- root + leaf senescence
Yield modelling

- Potential yield (water and N unlimited)
  - for all crop products
  - input by users
- Calculate water-limited yield (soil water model)
- Calculate N uptake at water-limited yield
  - includes N in above and below-ground crop residues
- Calculate mineral N available
- Mineral N or maximum uptake determines yield
- Assume sufficient P and other nutrients
Calculating mineral N available (1)

- **Mineral N available = mineral N input - losses**

- **N inputs**
  - atmosphere
  - N fixation
  - fertiliser
  - manure
  - urine
  - mineralised soil, manure organic N, dung and crop residue N

- **Does not distinguish between ammonium and nitrate**
N fixation

- Calculate maximum N yield
- Calculate mineral N supply (fertiliser, manure, soil mineralisation etc)
- \( N \text{ fixation} = N_{\text{fixationFactor}} \times (\text{max } N \text{ yield} - \text{mineral } N \text{ supply}) \)
Calculating mineral N available (2)

N outputs

- Ammonia emission, which varies between
  - fertiliser, manure, urine
  - application method
- \( \text{N}_2\text{O} \) and \( \text{N}_2 \) emission
  - \( \text{N}_2\text{O} \) via emission factor (varies between sources)
  - \( \text{N}_2 = \text{N}_2\text{O} \times \text{factor} \)
- N leaching is determined by soil water model
Mineral N available

Urine N
Fertiliser N
Fixed N
Atmospheric N
Manure TAN

Mineral N input

Faecal N
Manure organic N
Crop residues

Mineral N available

N₂O
N₂
NH₃
NO₃
Soil water model

Evapotranspiration

Rain

Snow

Crop

Evaporation pool

Root zone

Sub zone

Drainage
Processing/storage losses

▪ Losses will occur from crop products that are harvested and stored
  ➢ cut but not collected
  ➢ losses during processing (especially silage making)
▪ Losses are subtracted prior to becoming available for feeding or export
Crop production is averaged
Livestock (ruminants)

- Numbers are entered as average annual population
- Important to include seasonal diets
  - e.g. dairy cattle (crop growing season), dairy cattle (winter/drought)
Annual averaged population (AAP)

- AAP ≡ 365 feeding days ≡ results of a census

Example 1:
- Census finds an average of 1 beef calf, aged 6 months to 1 year (AAP = 1)
- Feeding days = 183.25 = 0.5 year
- Production = 2 beef calves per year
Annual averaged population (AAP)

- **Example 2:**
  - 10 dairy cattle grazed for 6 months, housed for 6 months
  - Define 5 cattle with grazing diet
  - Define 5 cattle with housed diet
Feed ration and production

- Feed ration is input (feed items = crop products)
- Energy partitioning
  - Energy intake calculated
  - Energy partitioned between maintenance, growth and milk production
- Protein to faeces calculated using RedNex* equation
  - Remainder partitioned to production
  - Protein availability may limit production
- Does not currently account for walking/climbing

Manure management

Species group (e.g. cattle)

Livestock type e.g. dairy cattle

Housing type e.g. traditional

Pasture

Manure storage type e.g. dungheap

Manure storage type e.g. slurry pit

Manure type e.g. farmyard manure

Manure type e.g. slurry
Livestock housing

- **Housing** = any place livestock are kept when not grazing
  - includes corrals, stock yards
- **NH₃ emission** = emission factor * manure TAN
- **CO₂ emission** = urine C
- C and N is added in feed waste and bedding
- Remaining C and N passes to manure storage
Manure storage

- $\text{NH}_3$ emission = emission factor * manure TAN
- $\text{N}_2\text{O}$ emission = emission factor * total manure N
- $\text{N}_2$ emission = factor * $\text{N}_2\text{O}$ emission
- Runoff/leakage TAN = factor * manure TAN
- Runoff/leakage organic N = factor * manure organic N
- Remaining C and N available for field application
Grazed crop products and excretion

- For crop products used as feed items for livestock
  - Surplus = Production of crop product > livestock consumption
  - Deficit = Production of crop product < livestock consumption
- For most crop products:
  - Surplus is exported from farm
  - Deficit is imported to farm
- Grazed crop products are an exception
  - Production must equal consumption
Grazed crop products

- Production of grazed products is specified at the scale of the crop
- If this production is not achieved, the model will report an error
- If this production is exceeded, the surplus production will be converted to crop residue
Grazed yield

Enough production

More than enough production

residue