

Effect of uncertainties in manure and fertilizer application on modelled N losses to surface and groundwater

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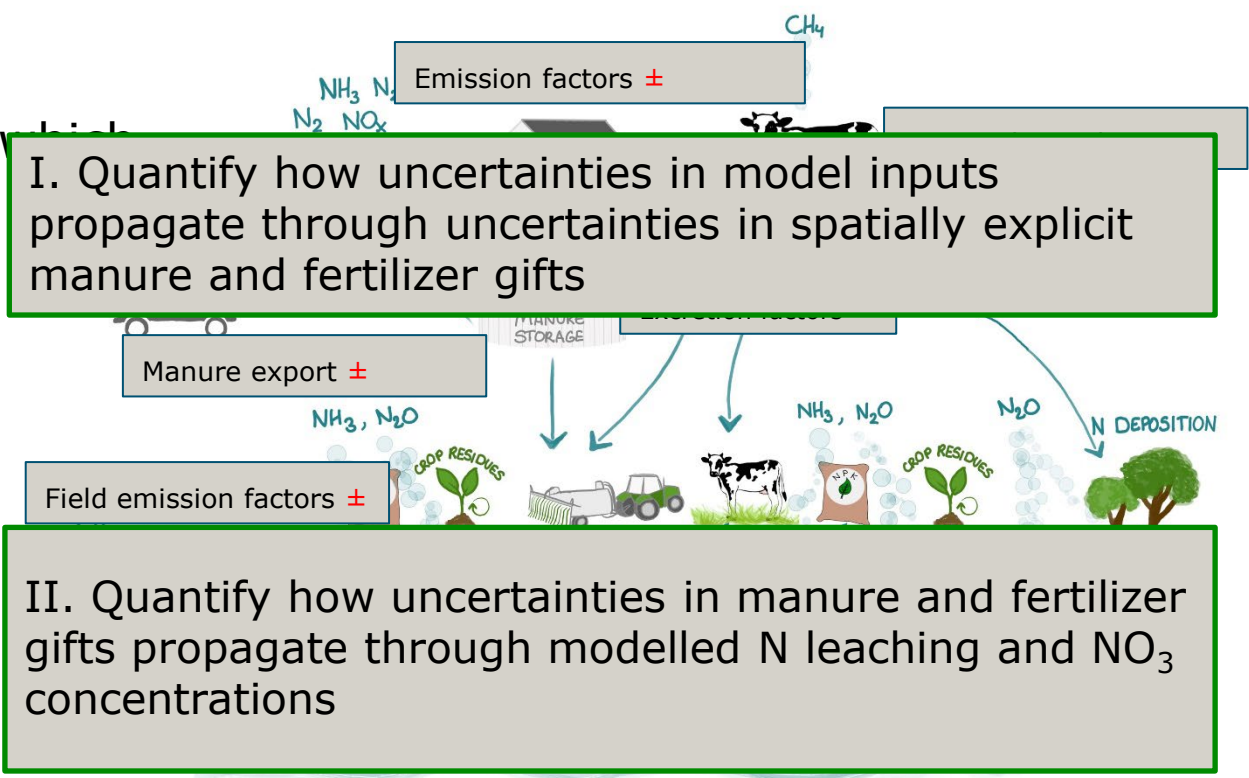


Content

- Error propagation in modelling manure distribution and resulting N leaching and nitrate concentration
- Quantification of uncertainty propagation
- Results:
 - Uncertainty in manure and fertiliser gifts
 - Uncertainty in N leaching and nitrate concentration
 - Comparison of the uncertainty in modelled nitrate concentration with observations
- Summary

Aim - Error propagation in modelling N leaching

Model inputs and parameters we are uncertain (\pm) about affect model outputs



The diagram illustrates the nitrogen cycle in agriculture with various stages and associated uncertainties. At the top, a cow is shown with a box labeled 'Emission factors \pm ' and arrows pointing to CH_4 , NH_3 , N_2 , and NO_x . Below this, a box labeled 'Manure export \pm ' is connected to a 'MANURE STORAGE' box. From storage, arrows lead to a tractor, a cow, and a fertilizer bag, with a box labeled 'Field emission factors \pm ' positioned above these. The tractor and cow are associated with NH_3 and N_2O emissions. The fertilizer bag is associated with N_2O emissions. Crop residues are shown with arrows pointing to the ground. Finally, an arrow labeled 'N DEPOSITION' points to trees. The entire process is overlaid with two large text boxes: Box I (top) and Box II (bottom).

I. Quantify how uncertainties in model inputs propagate through uncertainties in spatially explicit manure and fertilizer gifts

II. Quantify how uncertainties in manure and fertilizer gifts propagate through modelled N leaching and NO_3 concentrations

See: #21 Predicting the effects of fertilizer policy on the nutrient leaching and runoff in the Netherlands. Piet Groenendijk

INITIATOR - LWKM – Core elements

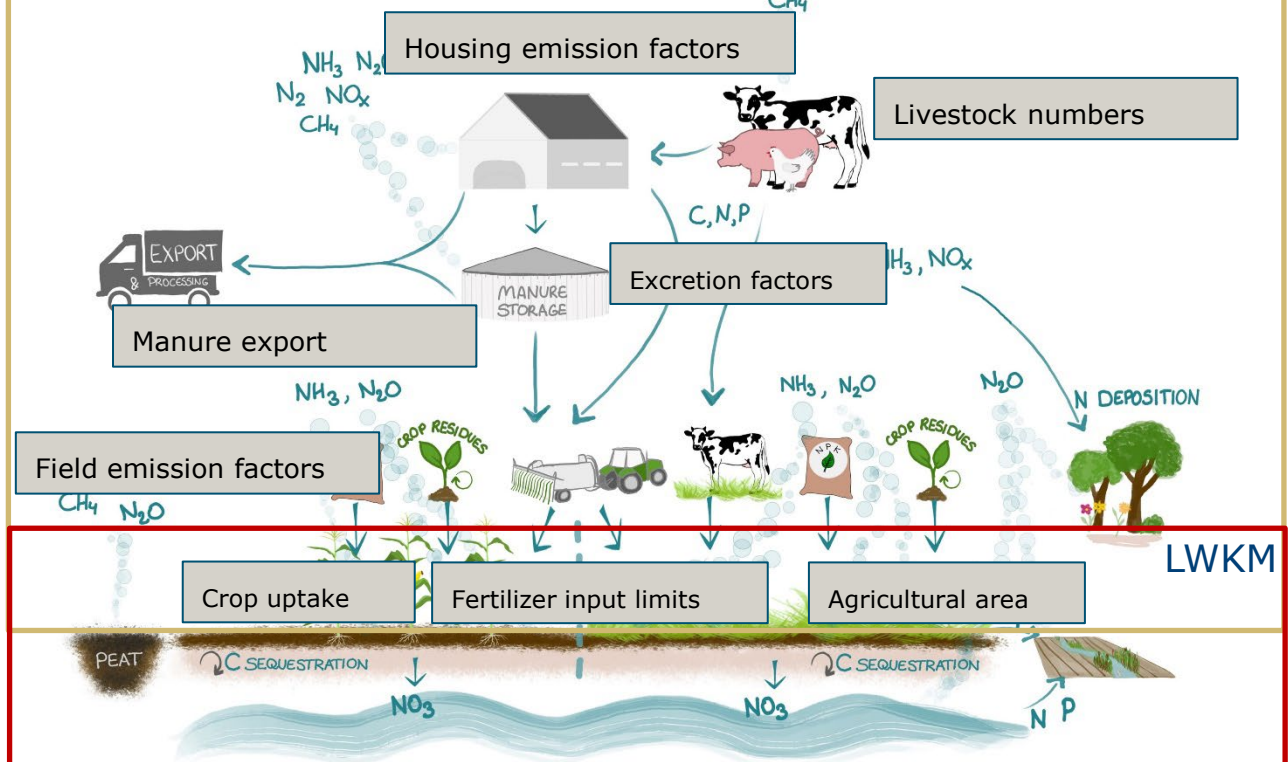
Spatial distribution of

- **Manure and fertilizers (INITIATOR)**

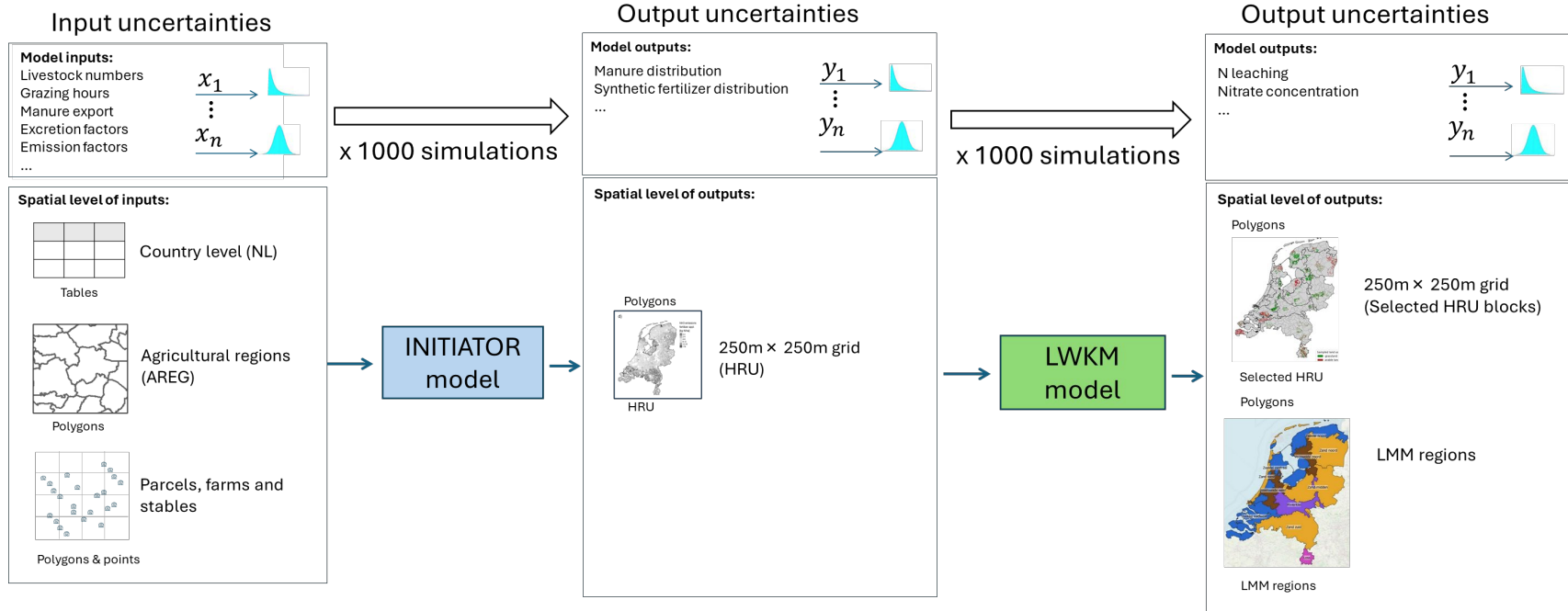
- **N leaching to groundwater and surface water (LWKM)**

in Dutch agriculture

INITIATOR (De Vries ea, 2023; Lessmann ea, 2025)



Monte Carlo simulation



Based on [Lessmann et al. \(2025\)](#)

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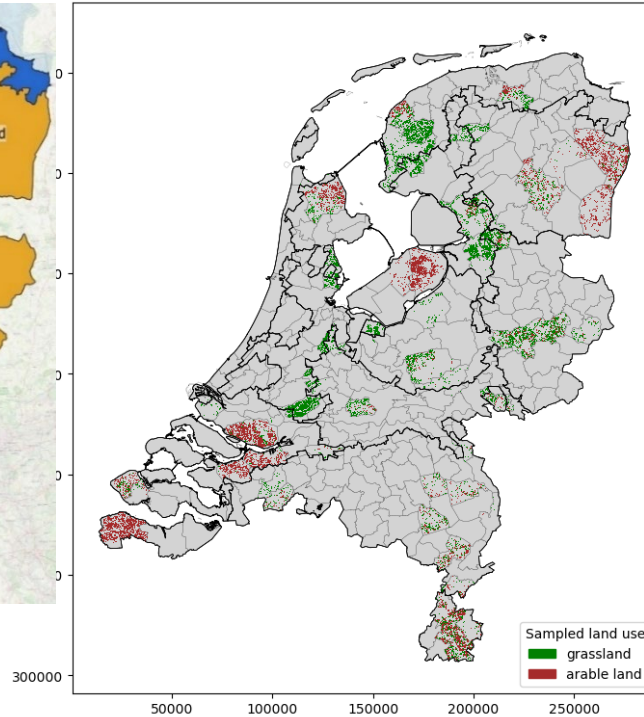
2

Selected blocks for LWKM model

LMM ¹⁾ regions



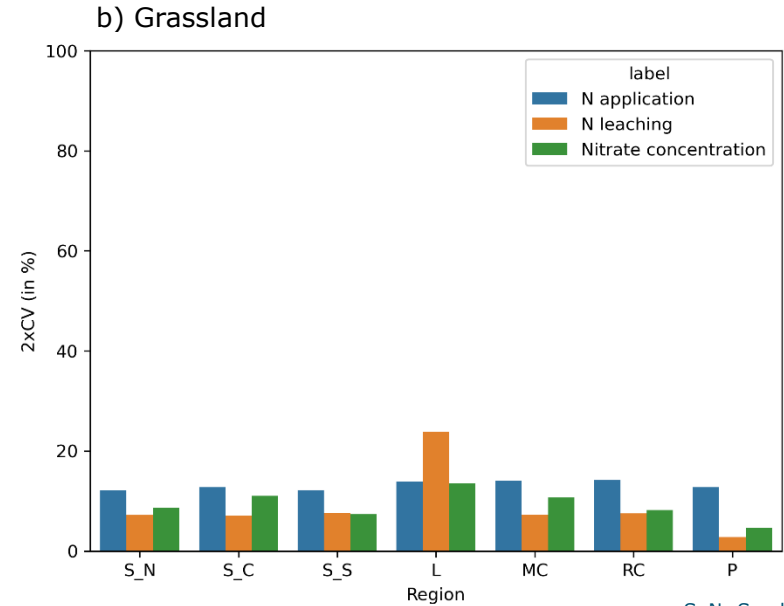
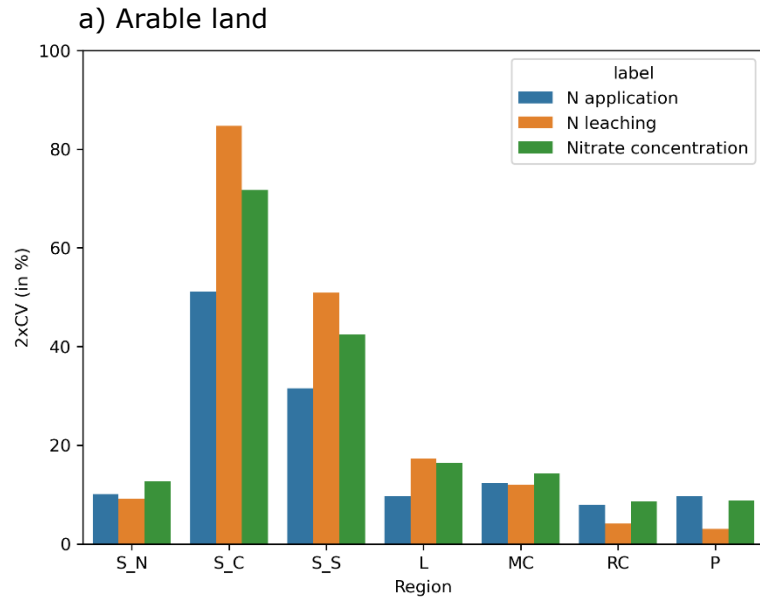
Selection of nine HRU²⁾ blocks



¹⁾ <https://www.rivm.nl/en/news/rivm-creates-overview-of-nitrogen-monitoring-in-water-in-europe>

²⁾ Hydrological Response Unit (i.e. the support of the LWKM, consisting of one or more 250m×250m cells)

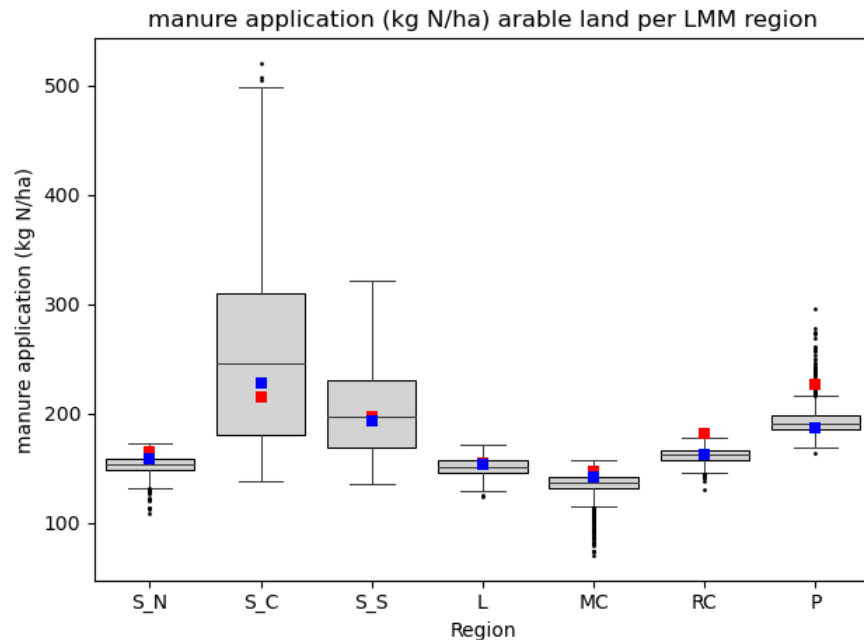
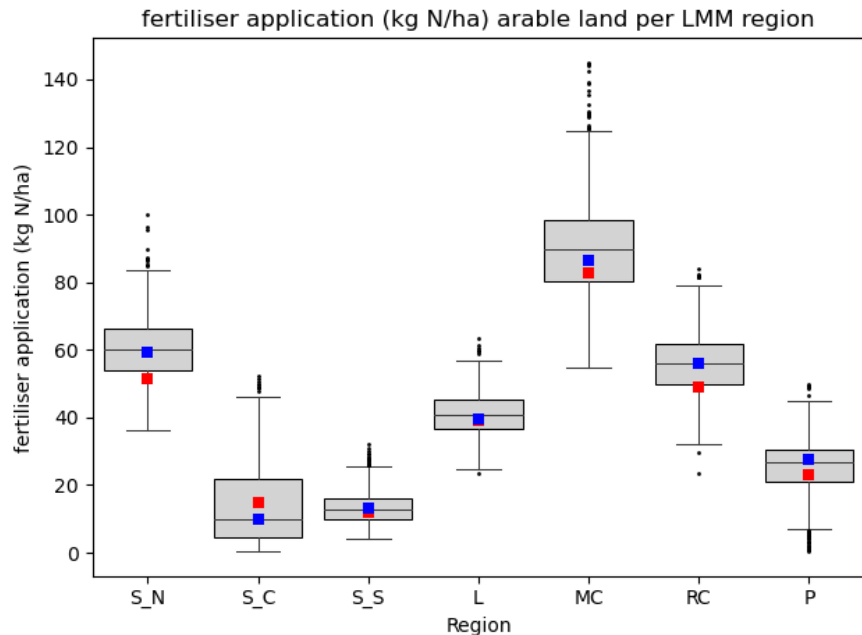
Propagation of uncertainty in N application of manure and fertilizers to N leaching and Nitrate concentration at the level of LMM region



S_N: Sand North
 S_C: Sand Central
 S_S: Sand South
 L: Loess
 MC: Marine Clay
 RC: River Clay
 P: Peat

Relative uncertainty ($2 \times CV \times 100\%$)

Uncertainty in N application manure and fertilizers, arable land



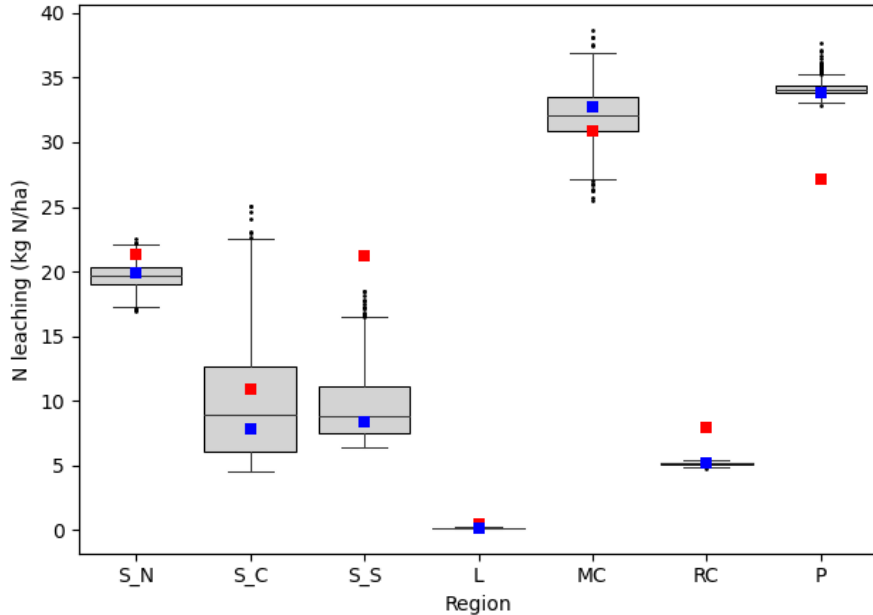
Blue square: Area-weighted means from reference run (without uncertainty) from sampled HRUs

Red square: Area-weighted means from reference run for all HRUs

S_N: Sand North
S_C: Sand Central
S_S: Sand South
L: Loess
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Uncertainty in N leaching and nitrate concentration, arable land

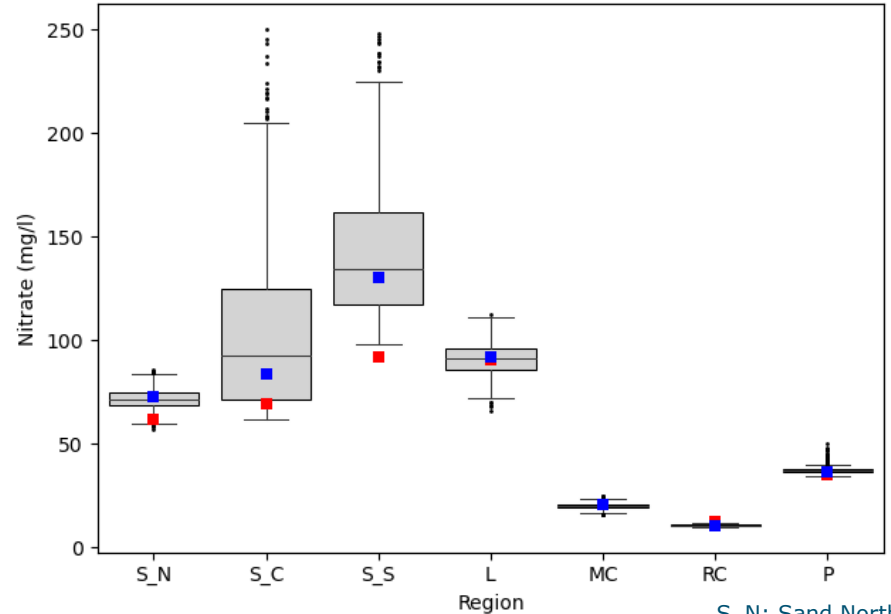
N leaching (kg N/ha) arable land per LMM region



Blue square: Area-weighted means from reference run (without uncertainty) from sampled HRUs

Red square: Area-weighted means from reference run for all HRUs

Nitrate (mg/l) arable land per LMM region



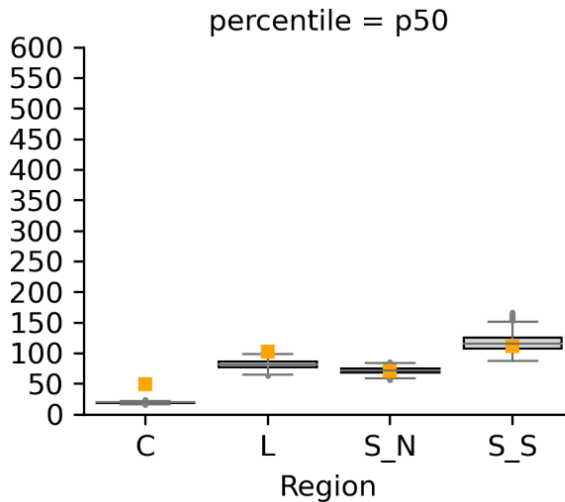
Uncertainties are:

- High in sand (C&S) areas: due to large uncertainty in application
- low in peat areas: due to large contribution of (uncertain) background and denitrification (damping effect)

S_N: Sand North
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Comparison of simulation uncertainty Nitrate concentration with LMM observations, arable land

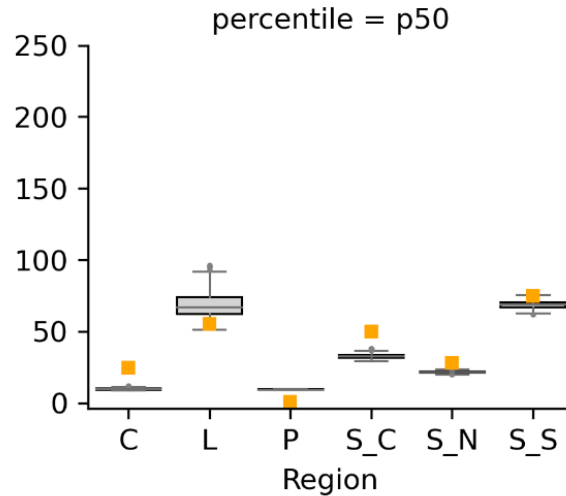
Simulated vs. Observed Percentiles per Region: Arable land



Orange squares: Observations based on LMM data

Comparison of simulation uncertainty Nitrate concentration with LMM observations, grass land

Simulated vs. Observed Percentiles per Region: Grassland



Orange squares: Observations based on LMM data

C: Clay
L: Loess
S_C: Sand Central
S_N: Sand North
S_S: Sand South

Summary

1. Uncertainty propagation in model outputs:

- Range in uncertainty in manure and fertilizer application is wide for arable land (10-50%) and narrow for grassland (15-18%); at the level of LMM region
- Uncertainty in N leaching and NO₃ concentration is high for arable land in S_C (70% - 80%) and low for grassland (5% for peat/clay – 20% for loess)

2. Comparison with observations:

- Observations for arable land: compared quite well for sand, but less well for loess and clay
- Observations for grassland: simulated uncertainty is often smaller than the spread found in observations (observations often falling outside uncertainty bands)

3. Attention points for further research:

- Selected HRU plots are not representative for the whole LMM region (esp. for Sand South)
- Uncertainties in the LWKM model were not addressed

Thank you very much!



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