Uncertainties in N and GHG fluxes from agro-ecosystems in Europe

Hans Kros, Gerard Heuvelink, Gert Jan Reinds, Jan Peter Lesschen, Vicky Ioanidi, and Wim de Vries

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Outline

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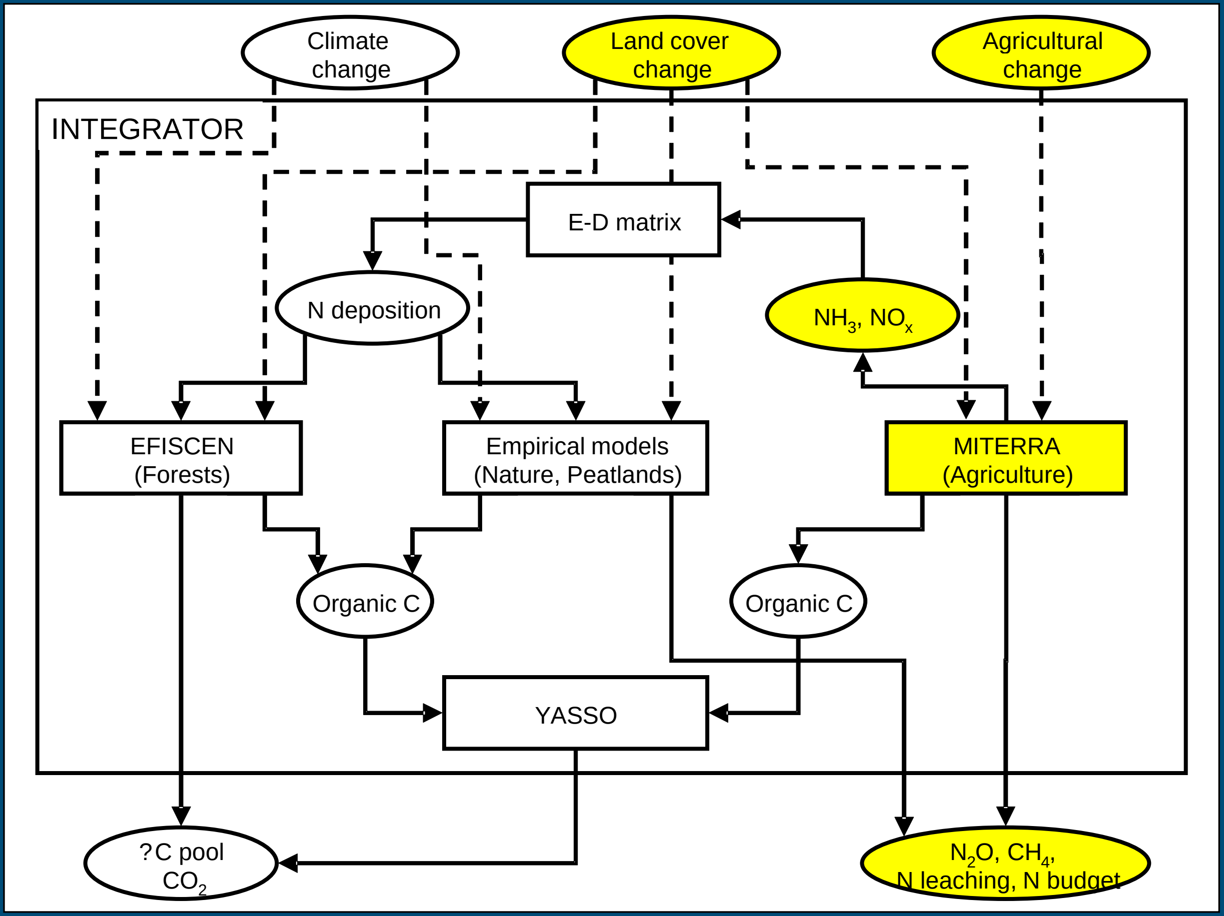
- The UA/UQ of INTEGRATOR
- Results
  - Uncertainty at European and National scale
  - Uncertainty contribution of parameter groups
  - Robustness analysis
- Conclusions

Introduction

- Aim INTEGRATOR
  - The INTEGRATOR model predicts European wide high resolution estimate of N and GHG fluxes with the associated uncertainties.

- Objective study
  - Analyse how uncertainties in model inputs and model parameters propagate to model outputs, focusing on uncertainties in:
    - continuous model inputs (livestock, N fertilizer, soil properties)
    - model parameters
  - neglecting uncertainties in scenario related model inputs (climate and land cover) and in categorical data (e.g. soil type, drainage status)

The INTEGRATOR model and UQ/UA boundaries



Considered in this study

Included uncertainty sources

- Soil properties:
  - soil physical data: texture
  - soil chemical data: pH, carbon content and nitrogen content (C/N ratio).

- Model parameters:
  - Livestock excretion data: Animal nrs, Excretion fac, Housing fac
  - Housing emission data: Emission frac (NH_3, N_2O, NO_x)
  - Nitrogen input data: Manure/fert application data, Ndep, Nfix, Nmin
  - Nitrogen uptake data: Yield, N contents, NUE
  - Soil emission data: Emission frac (NH_3, N_2O, NO_x)
  - Leaching and runoff data: leaching frac, runoff frac

Assignment of uncertainties

- For each model parameter we define at NCU level:
  - Distribution type (normal, lognormal)
  - Coefficient of variation for normal distribution and standard deviation for lognormal distribution
  - Minimum and maximum level
  - Cross correlation between certain parameters (at NCU level) when they exist (limited)
  - Spatial correlation ..

Spatial correlation

- Common geostatistical procedure: semi-variograms and cross variograms.
  - not an easy task since data are not available
  - Chosen for a more pragmatic solution

- Assumption 1: parameters are constant within an aggregated spatial unit. In INTEGRATOR we distinguish:
  - NCU
  - NUTS2/3
  - Country

- Assumption 2: Degree of spatial correlation is determined by the correlation between parameters in different spatial units:
  - NCUs within the same NUTS2/3 region (ρ_{NCU})
  - NUTS2/3 regions within the same country ($\rho_{NUTS2/3}$)
  - Countries within Europe ($\rho_{Country}$)

Robustness analyses (CV/SD)

- Since the information on the assigned CVs or SDs are rather uncertain we also apply perform a robustness analysis by using three uncertainty scenarios (Optimistic (O), Reference (R) and Pessimistic (P)).

Class of CV or SD	**O**pt (O)	**R**ef (R)	**P**es (P)
Low (L)	0.05	0.10	0.15
Moderate (M)	0.10	0.25	0.30
High (H)	0.40	0.50	0.60

1) Only in case of parameters which are defined as fraction

Robustness analyses (spatial correlation)

Class of correlation	**O**pt (O)	**R**ef (R)	**P**es (P)
Perfect (P)	1	1	1
High (H)	0.8	0.85	0.9
Moderate (M)	0.3	0.5	0.7
Low (L)	0.1	0.2	0.3
None (N)	0	0	0

Example of uncertainty assigment

Parameter	Code[1)]	Distribution[2]	CV	SD	Min	Max	Unit	ρ_{NCU}	ρ_{NUTS}	$\rho_{COUNTRY}$
Livestock excretion data										
— N excretion rates, dairy cattle	Nexf_ca	Normal	M		0	inf	kg N / head	P	H	M
Housing emission data										
— NH_3 emission fraction from housing systems	fNemhs_NH3	Normal	M		0	1	-	P	H	M
— N_2O emission fraction from housing systems (liquid)	fNemhsl_N2O	Lognormal		M	-inf	0	-	P	H	M
Nitrogen input data										
— National fertilizer N inputs	tNfe	Normal	L		0	inf	ton N / country	P	P	M
Soil emission data			M		0	inf				
— NH_3 emission factors from soil systems for all manure types	fNemap_NH3	Normal	M		0	1	-	M	M	L
— N_2O emission fractions from soil inputs [4)]	fNemsi_N2O	Normal	M		0	1	-	L	L	L
— Ratio between NO_x and N_2O emission fractions [5)]	rNON2O	Lognormal		0.75	-inf	0	-	M	L	L
Leaching and runoff data							-			
— N leaching fractions from the soil	fNle	Normal	M		0	1	-	M	M	L
— N leaching fractions from stored manure	flems	Normal	H		0	1	-	P	H	M

In total 57 parameters

Application of the UQ/UA procedure

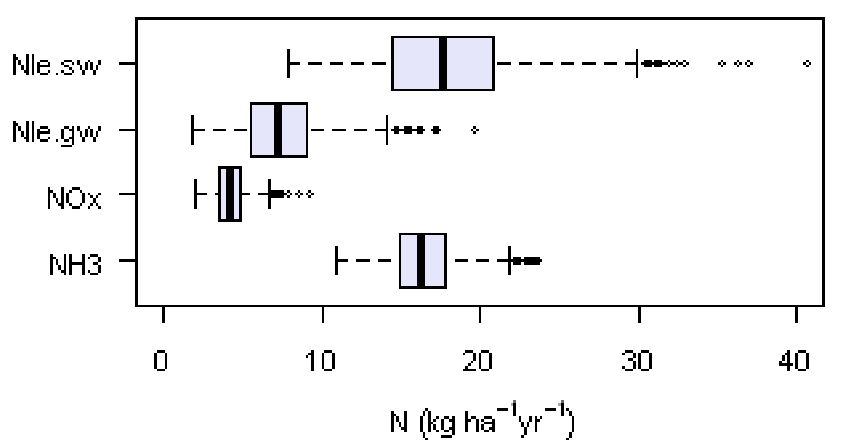
- Perform *1000* drawings from the (multivariate) normally distributed or log-transformed process parameters while taking into account cross-correlations and spatial correlations.
- Back-transform simulated values for log-transformed process parameters (e.g. those that are log normally distributed)
- Read realizations by INTEGRATOR and perform MC runs
- Analyse results

Uncertainty in N and GHG fluxes for the EU27

Uncertainty for the EU27 due the input uncertainty in generic, national, NUTS2/3 and NCU parameters in the European average outputs for the year 2000

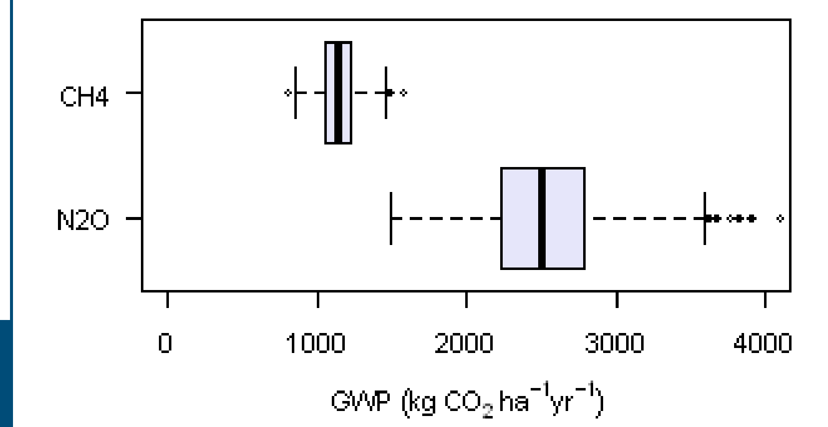
Model output	Mean	SD	P05	P50	P95	CV
	Kg N or CH_4 ha^{-1} yr^{-1}					(SD/Mean)
$CH_{4\ em}$	45.8	4.7	38.3	45.8	53.7	0.10
N_2O_{em}	5.4	0.9	3.9	5.3	7.2	0.17
$NO_{x\ em}$	4.2	1.0	2.7	4.2	6.0	0.24
$NH_{3\ em}$	16.4	2.1	13.1	16.3	20.3	0.13
$N_{le\ gw}$	7.5	2.6	4.0	7.2	12.2	0.34
$N_{le\ sw}$	18.0	4.9	10.8	17.6	27.0	0.27

Uncertainty in N and GHG fluxes for the EU27



CV
0.27
0.34
0.24
0.13

N fluxes



CV
0.10
0.17

GHG fluxes

Uncertainty in the European averaged outputs for the year 2000

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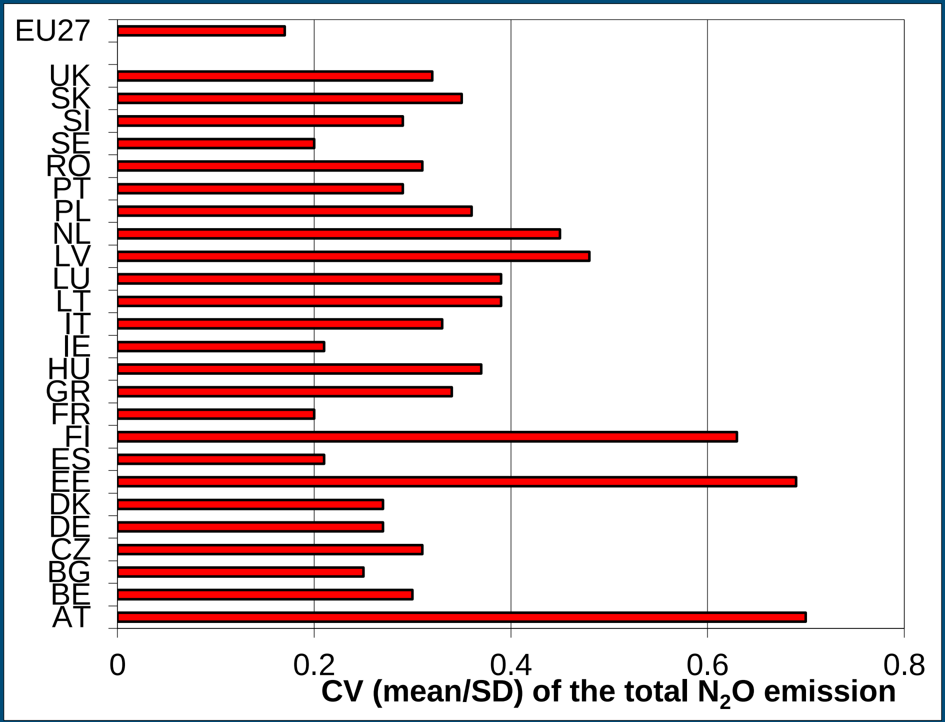
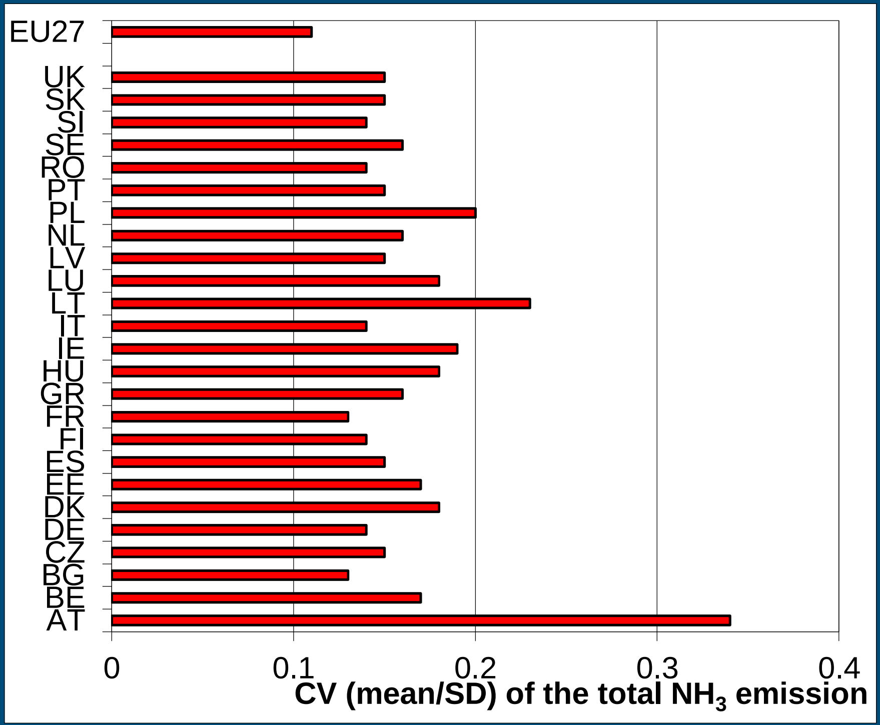
Uncertainty in N_2O and NH_3 emission per country





N_2O NH_3

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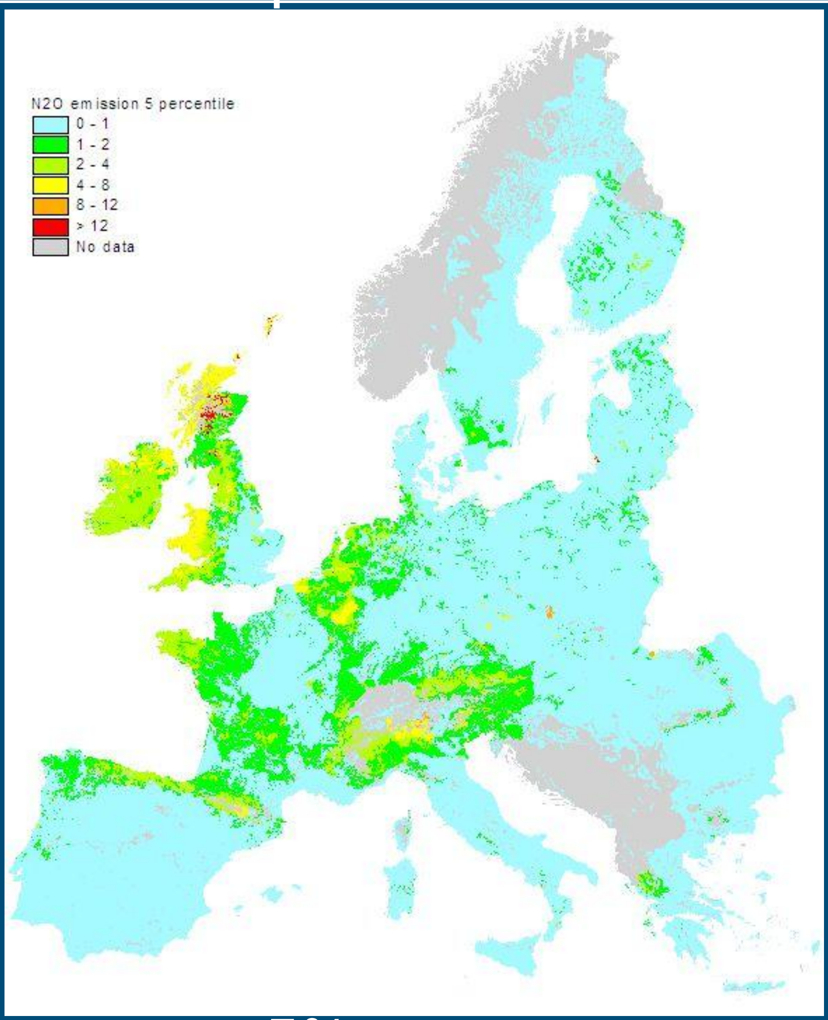
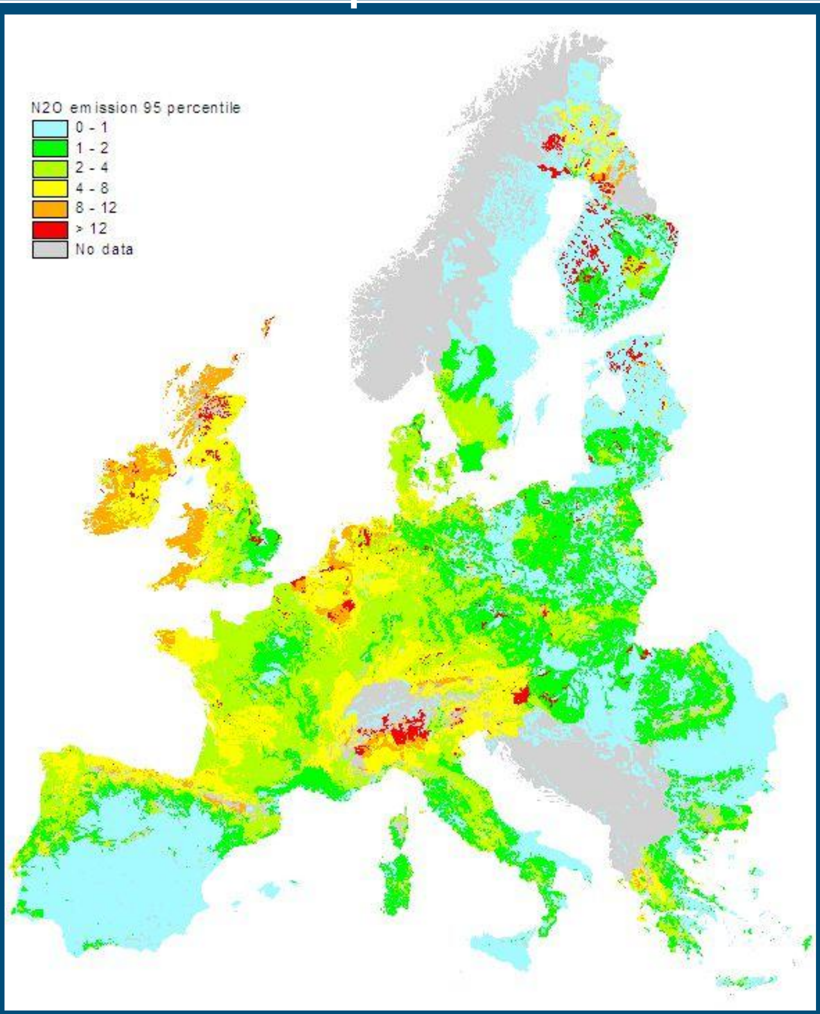
The 90% prediction of the N_2O emission per NCU in 2000



5% perc



95% perc

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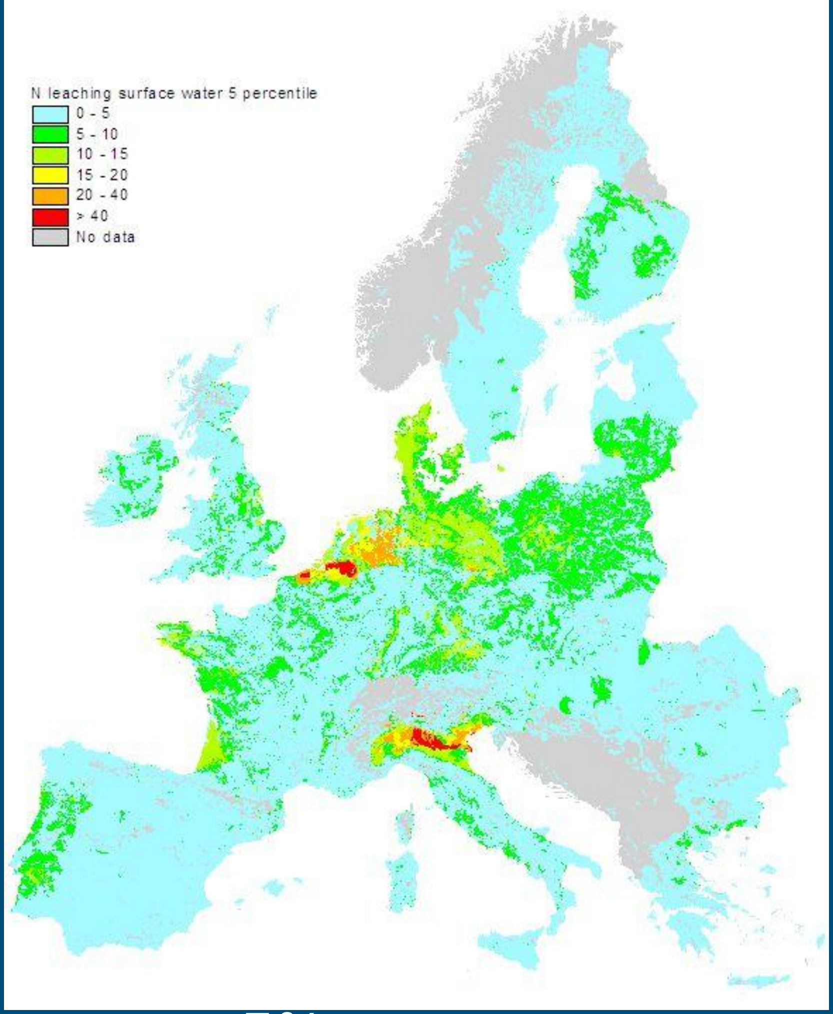
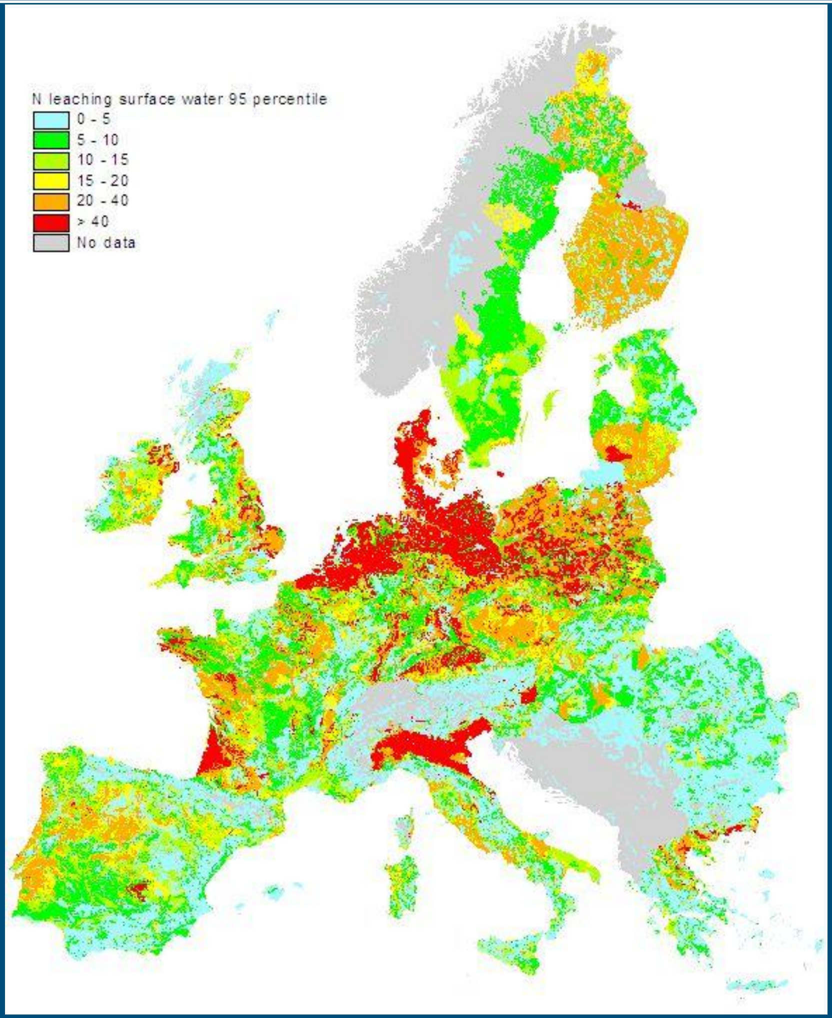
The 90% prediction of the $N_{le\ sw}$ per NCU in 2000



5% perc



95% perc

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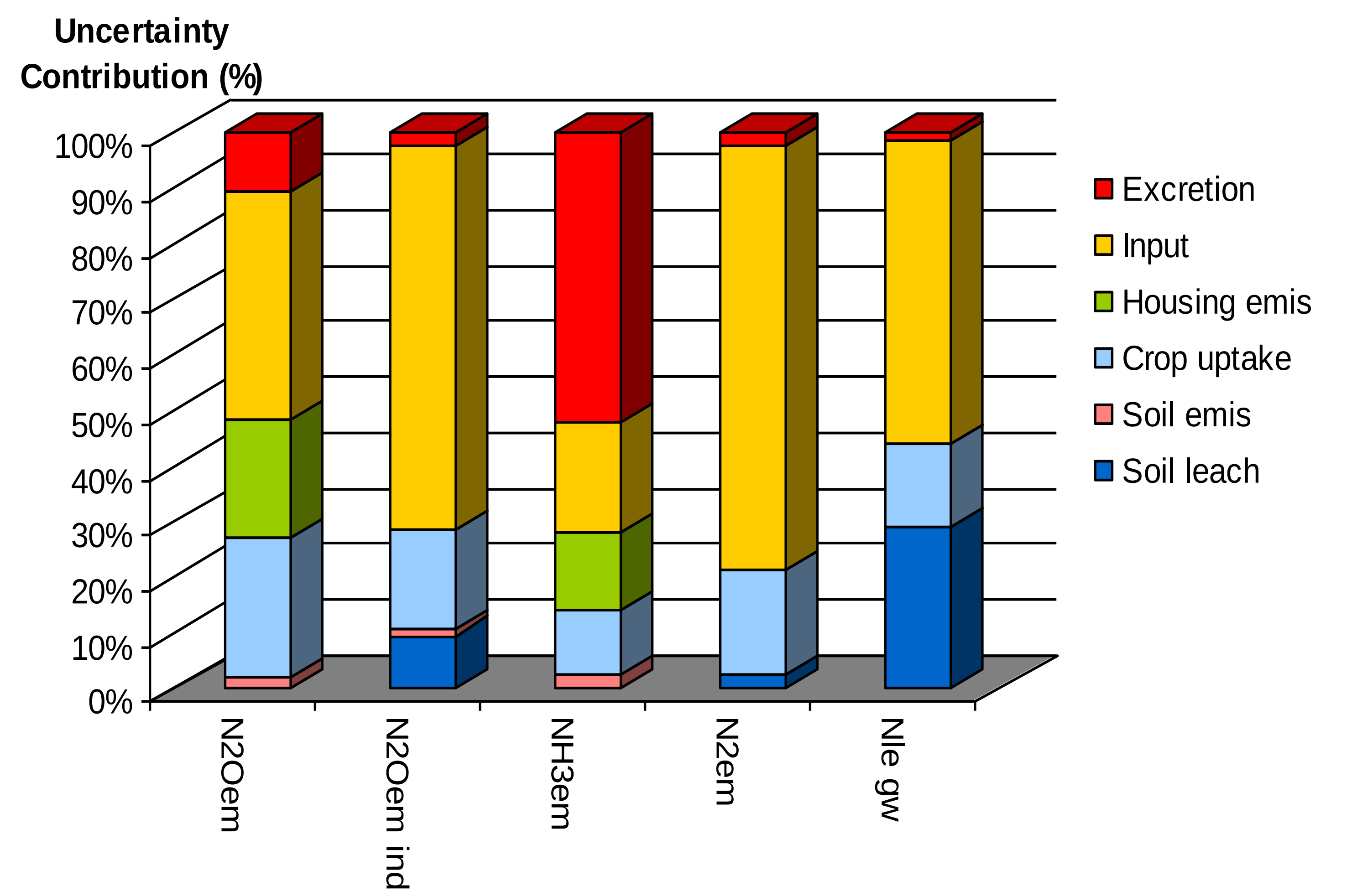
Uncertainty contribution of various inputs



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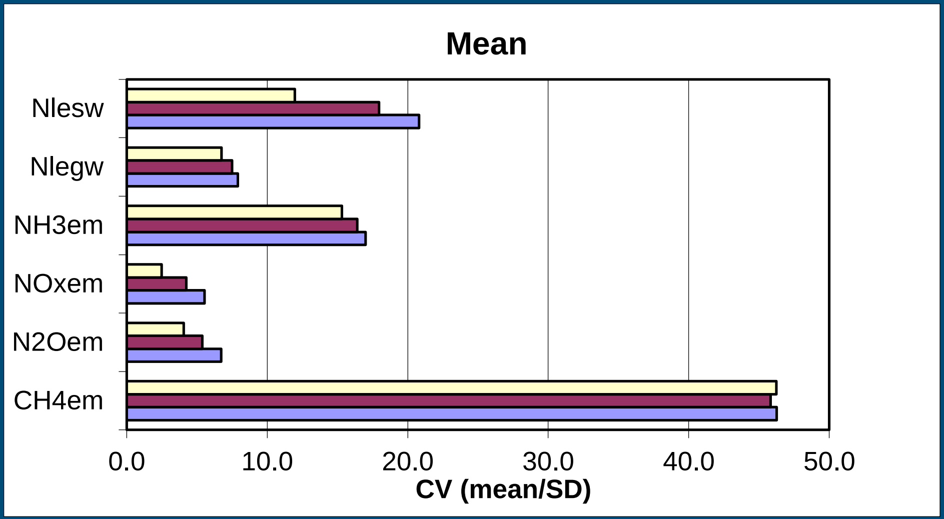
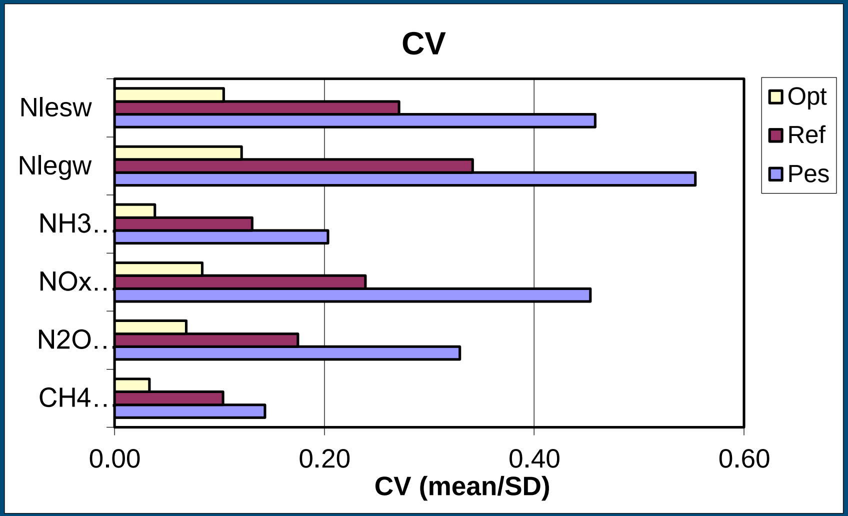
Robustness Analysis

- Effect of scenarios:
  - optimistic (Opt)
  - reference (Ref)
  - pessimistic (Pes)
- on the overall mean and CV in the European average





Conclusions

- Uncertainty varies from 10-35% and increases in direction: CH_{4em} , $NH_{3\ em}$ < N_2O_{em} , $NO_{x\ em}$ <$N_{le\ gw/sw}$, $N_{2\ em}$
- Uncertainty for Europe as a whole is smaller as per country.
- Uncertainty contribution is mainly determined by:
  $NH_{3,\ em}$: excretion, inputs
  N_2O_{em} : inputs, housing emission fractions
  N_{le} : inputs, leaching fractions
- Robustness analysis shows a significant uncertainty in the uncertainty assessment (-30% vs 70%)

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