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

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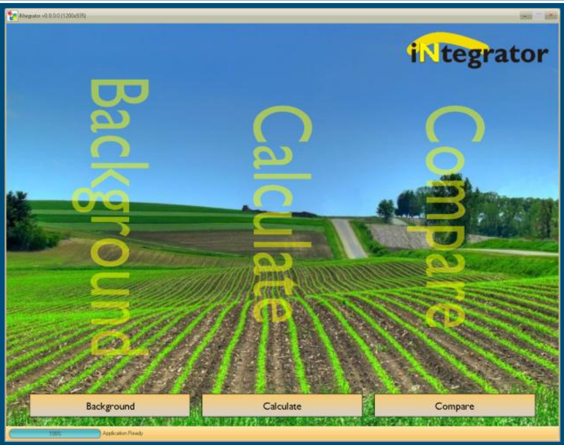
Outline



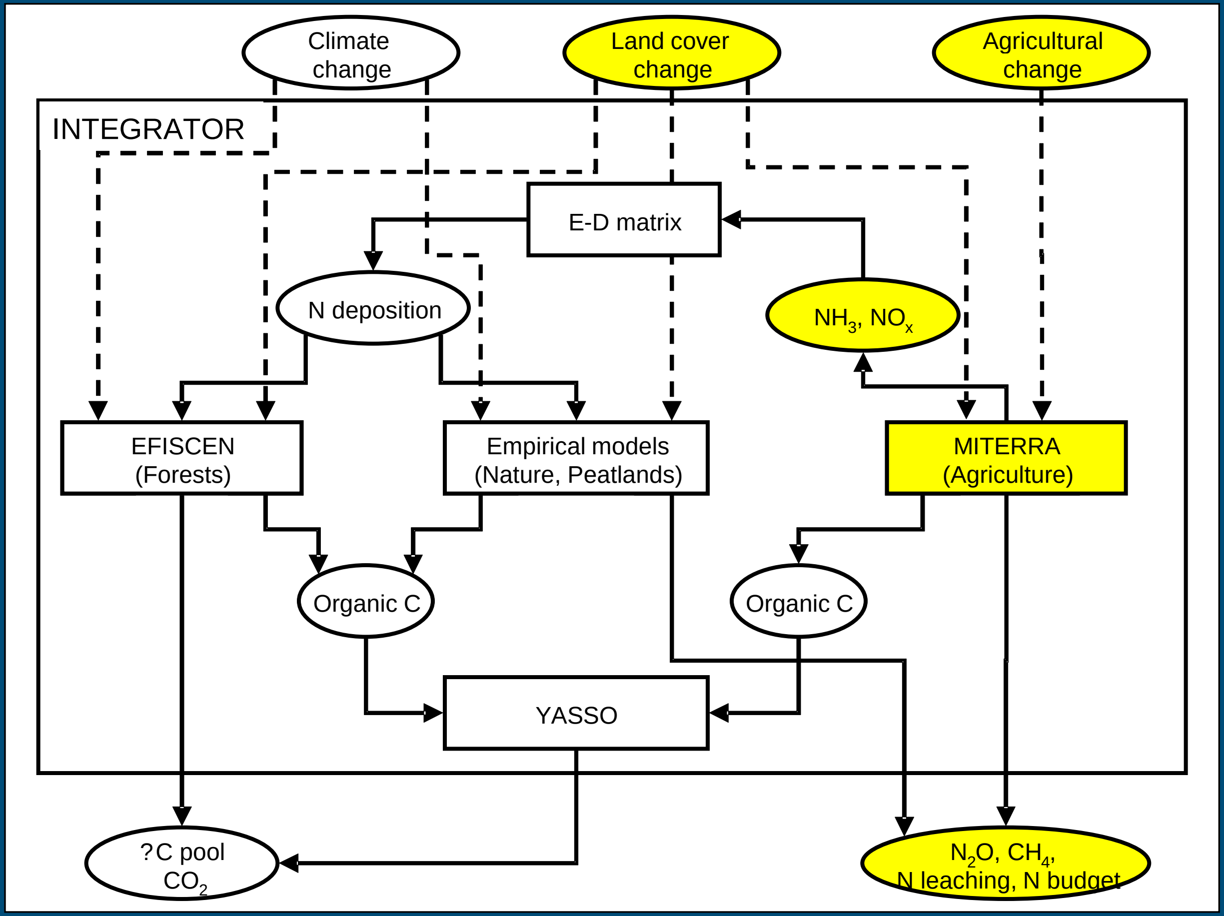
- Introduction
- The UQ/UA of INTEGRATOR
- Results
  - Uncertainty at European and National scale (UQ)
  - Uncertainty contribution of parameter groups (UA)
  - Robustness analysis
- Conclusions

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

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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 … If uncertainty assigned independently to each NCU it disappears completely at the European scale

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)

- Since the information on the assigned CVs 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

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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 / countr y	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

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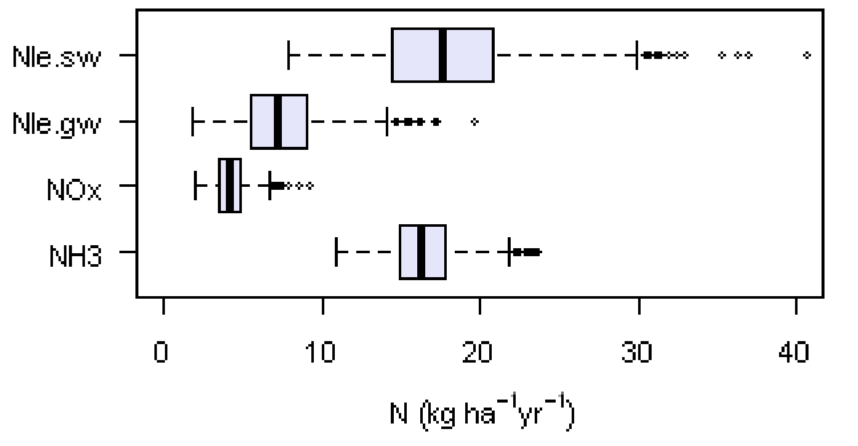
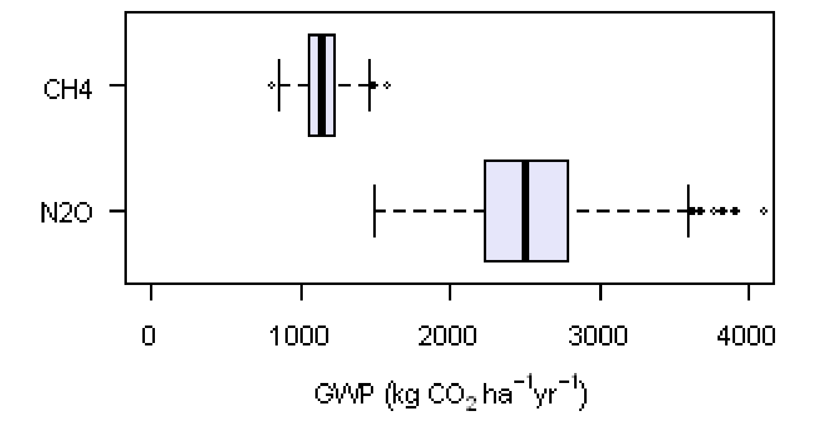
Application of the UQ/UA procedure

- 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 EU-27



CV
0.27
0.34
0.24
0.13



CV
0.10
0.17

N fluxes

GHG fluxes

Uncertainty in the European averaged outputs for the year 2000

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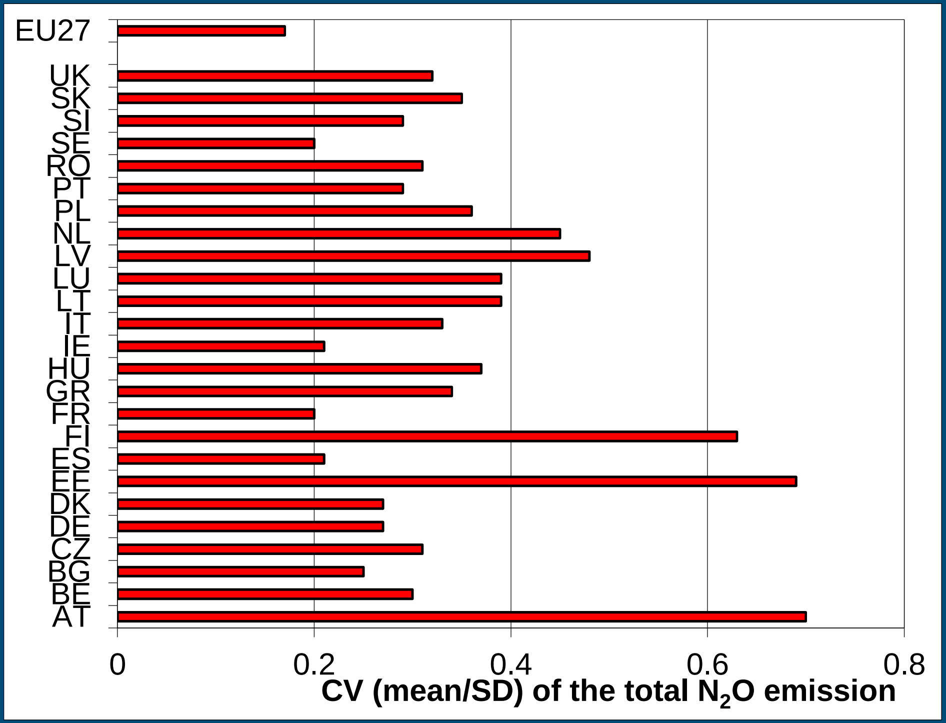
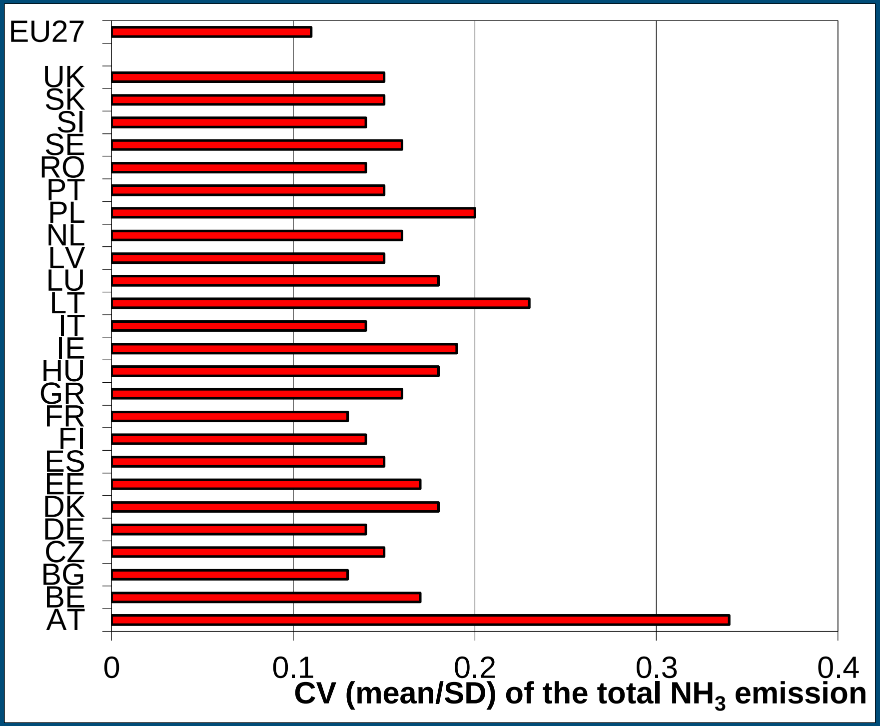
Uncertainty in N_2O and NH_3 emission per country





N_2O

NH_3

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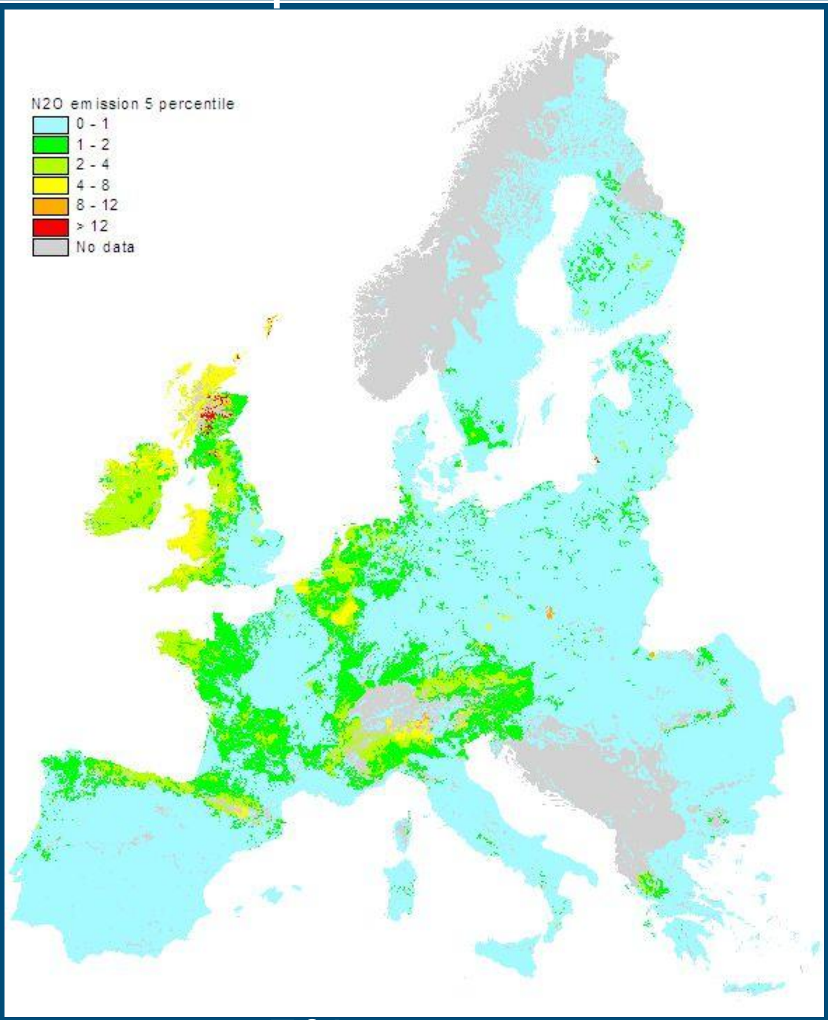
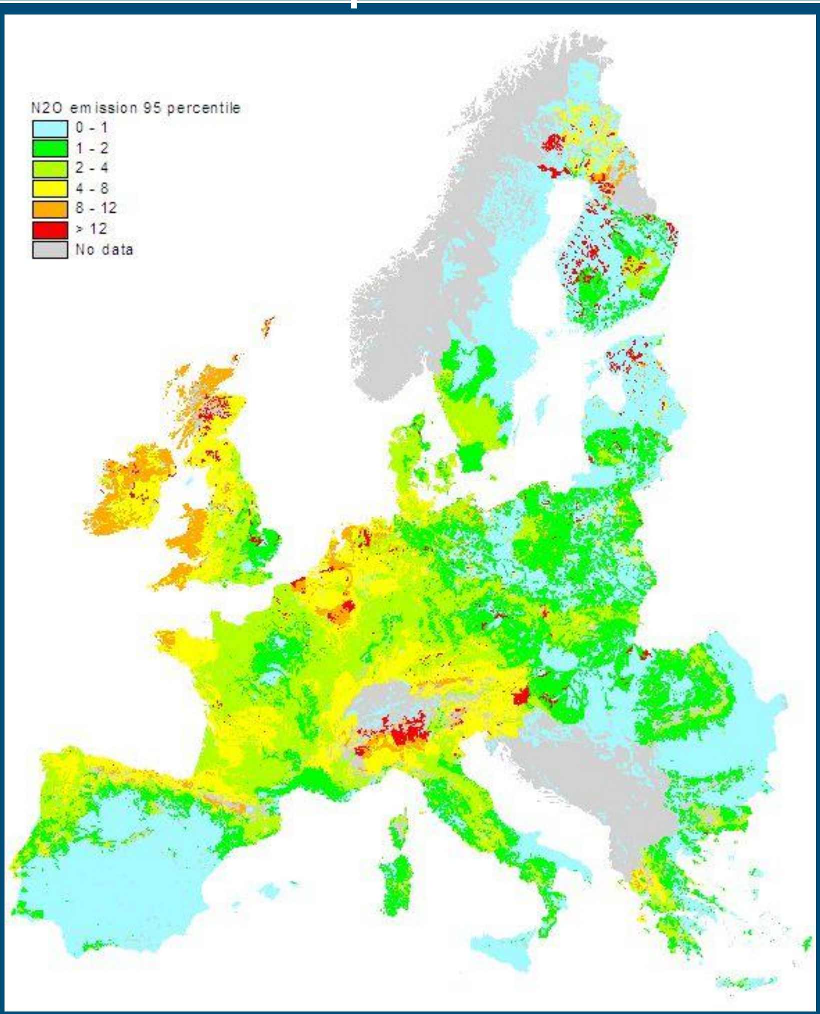
The 90% prediction of the N_2O emission per NCU in 2000



5% perc



95% perc

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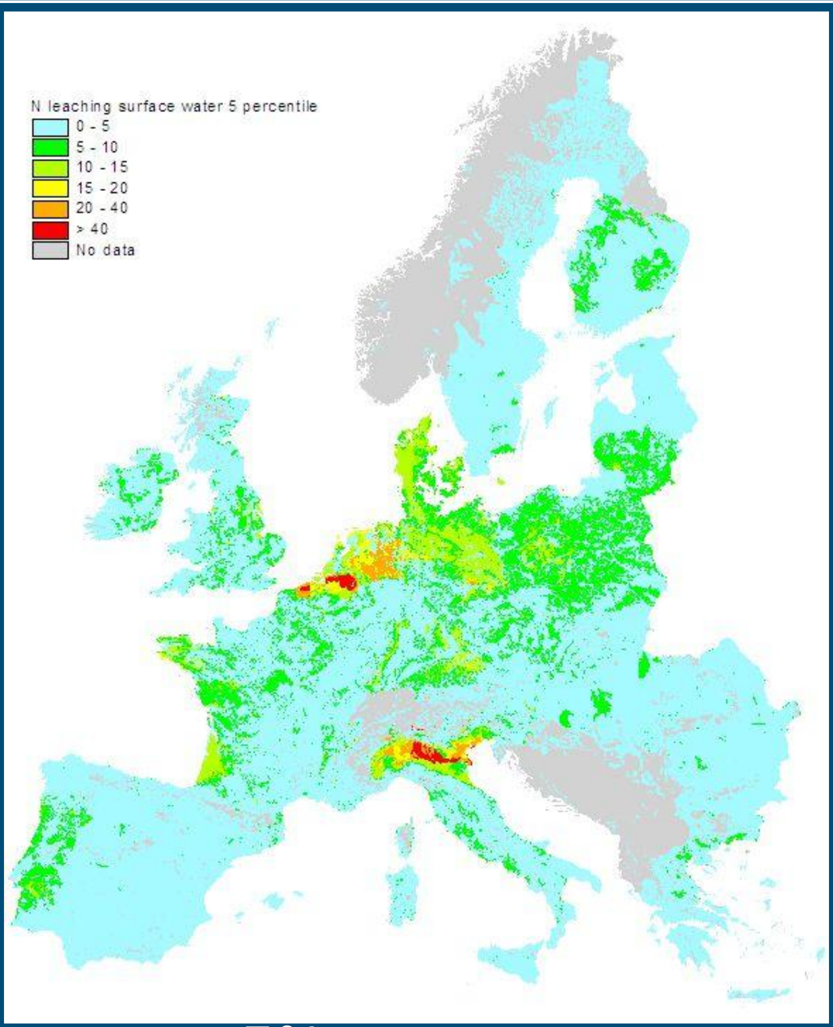
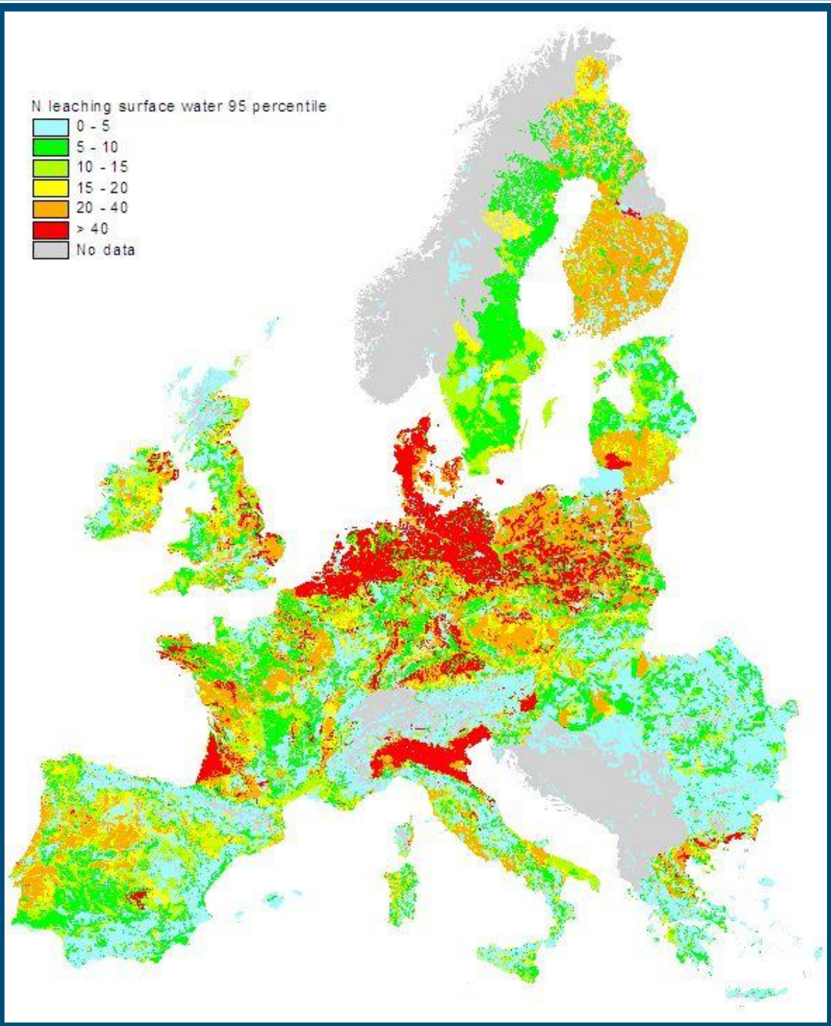
The 90% prediction of the $N_{le\ sw}$ per NCU in 2000



5% perc



95% perc

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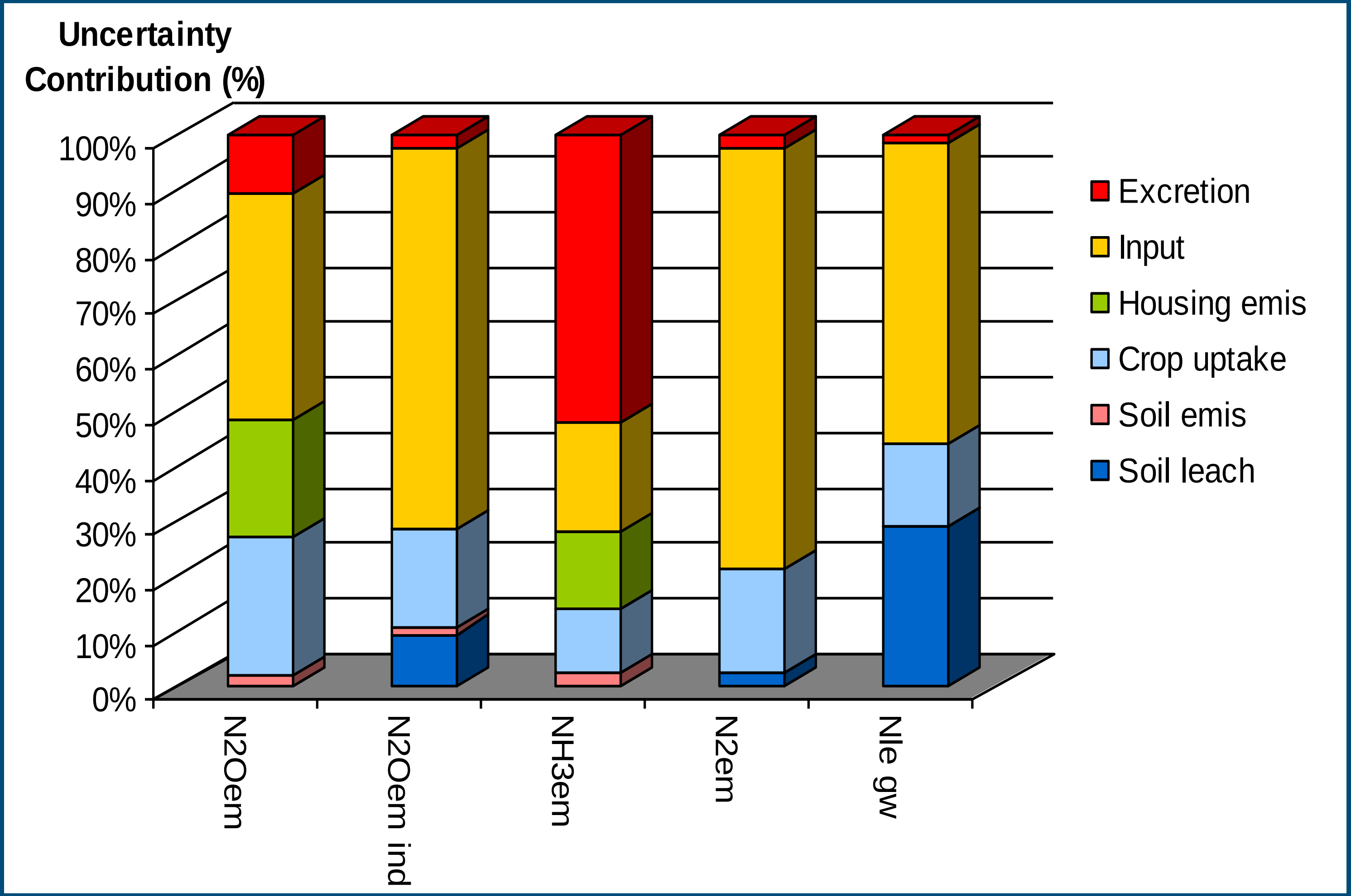
Uncertainty contribution of various inputs



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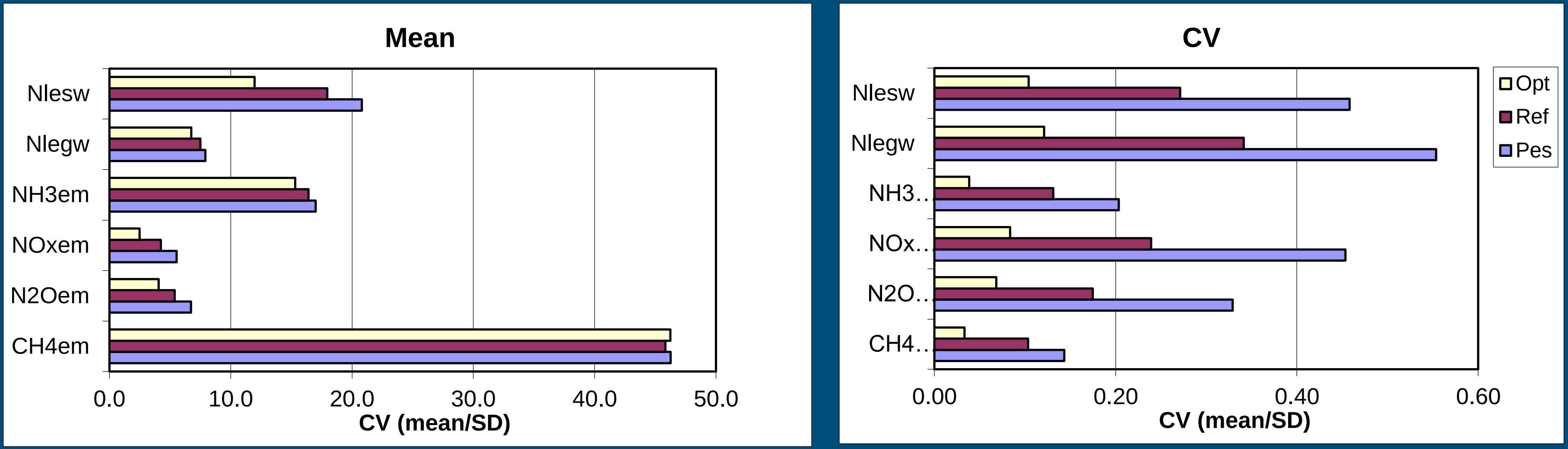
Robustness Analysis

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



CV: ~ 0.5

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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 (~50% vs ~30%)

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