Uncertainty assessment in life cycle analysis: contribution of sensitivity analysis

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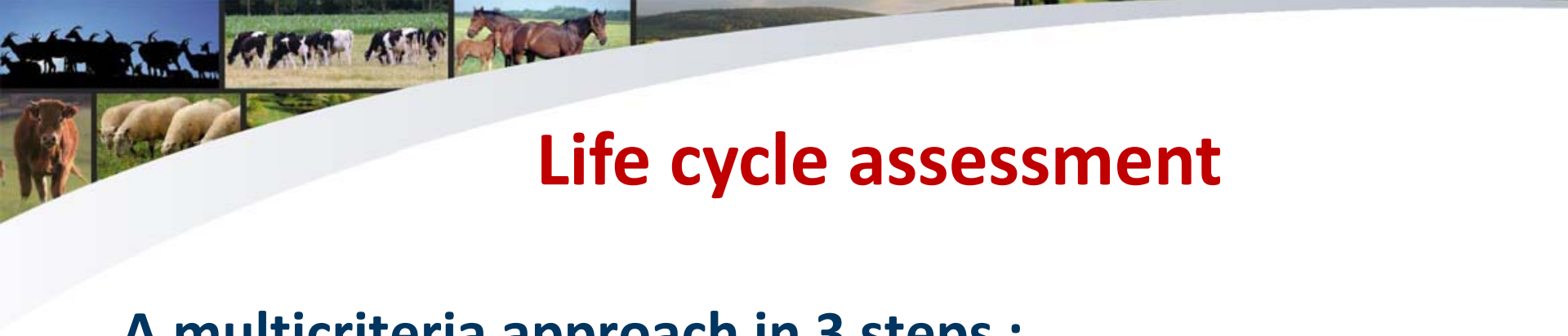
Context

- Livestock and environment, a sensitive topic
- Need to better quantify the impacts

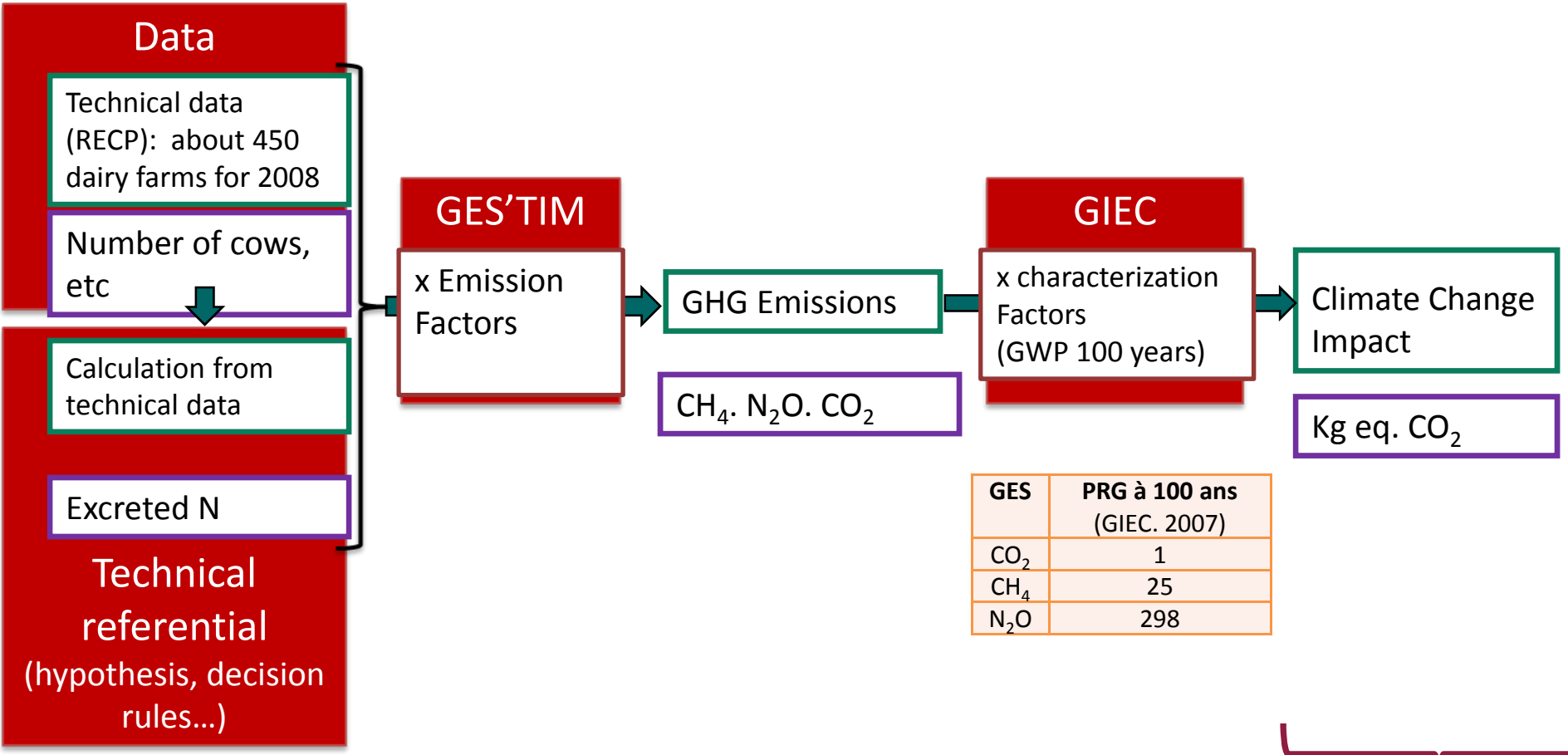


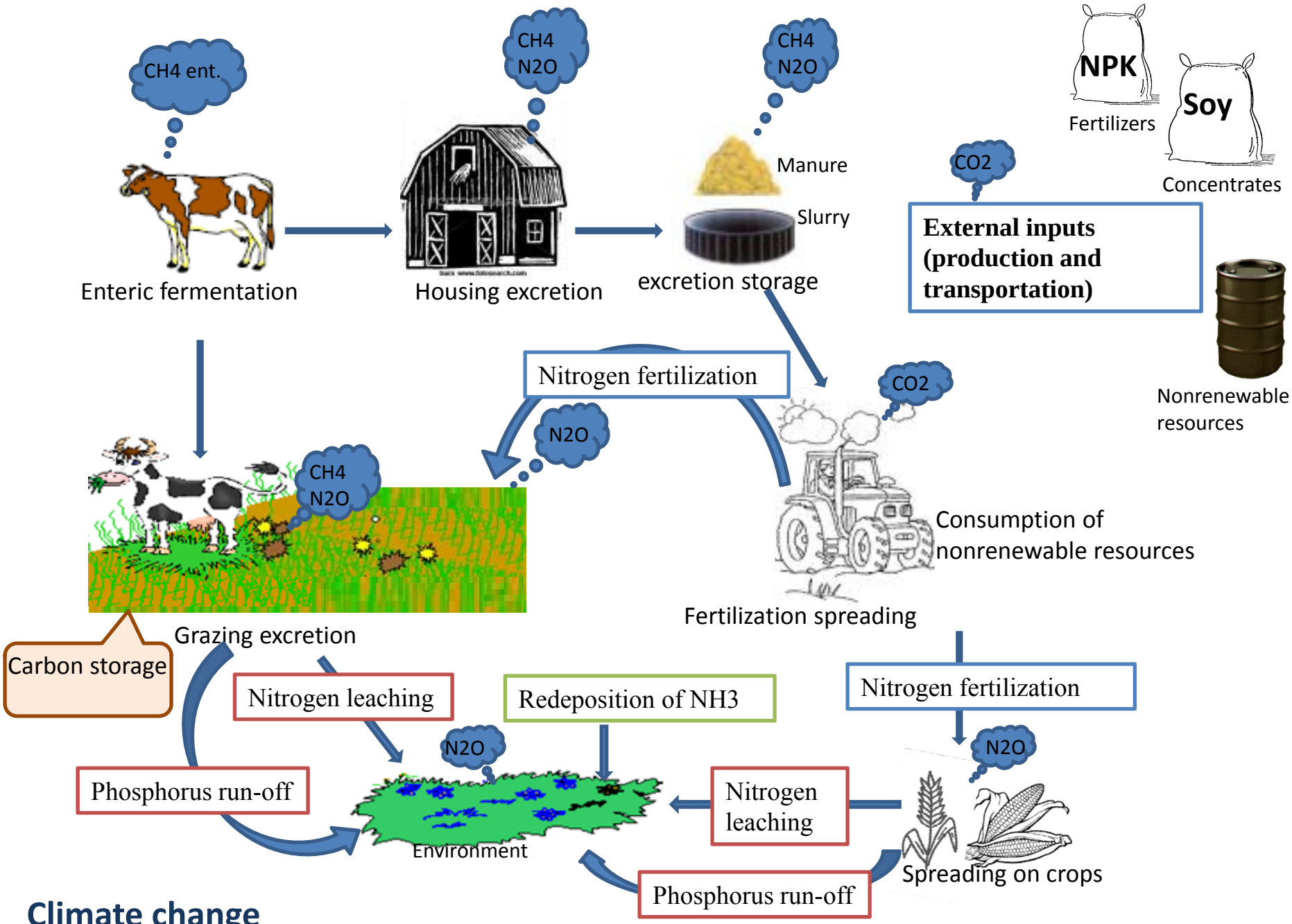
Life cycle assessment

A multicriteria approach in 3 steps :

1. Definition of objectives and systems to study
2. Flows inventory : emissions to soil, air and water
3. Assessment of impacts: global warming, acidification, biodiversity...

The calculation chain (Climate Change)




CH4 ent.
Enteric fermentation
CH4
N2O
Housing excretion
CH4
N2O
Manure
Slurry
excretion storage
NPK
Fertilizers
Soy
Concentrates
CO2
External inputs (production and transportation)
Nonrenewable resources
Nitrogen fertilization
N2O
CO2
Consumption of nonrenewable resources
Fertilization spreading
CH4
N2O
Grazing excretion
Carbon storage
Nitrogen leaching
Redeposition of NH3
Nitrogen fertilization
N2O
N2O
Phosphorus run-off
Environment
Nitrogen leaching
Spreading on crops
Phosphorus run-off
Climate change

Uncertainty in life cycle assesment

- **Important number of steps with uncertainties on activity data and parameters**

→ Difficulty to validate all the hypothesis and characterize the distribution of the whole set of parameters

  - Emission factors : uncertainty known more or less
  - Characterization factors: uncertainty little known

Which method to take uncertainty into account?

- Resampling methods : recommanded by IPCC
- Sensitivity analysis
- Analytical methods
- Fuzzy sets

→Limits : almost 250 parameters, few knowledge of the distribution of the different parameters

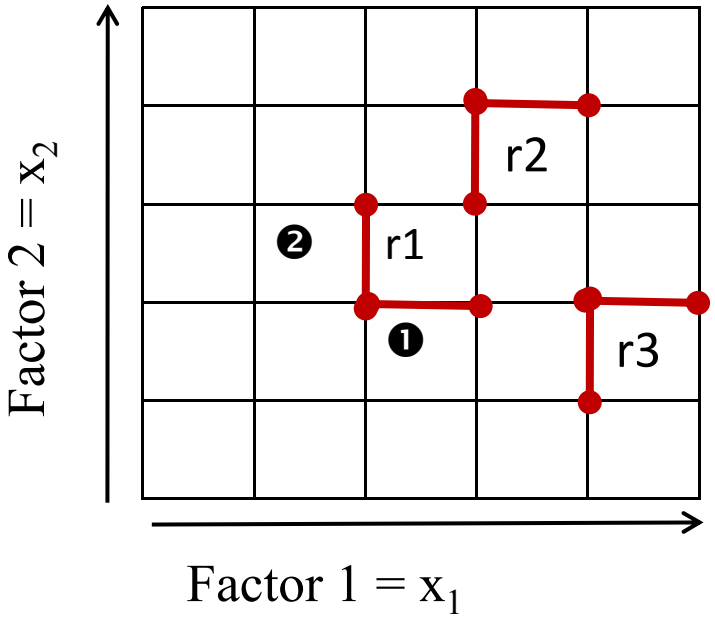
Sensitivity analysis before resampling methods to target the parameters of interest

Sensitivity analysis (SA)

- Local SA : analytical method for models with few factors
- Global SA : based on the decomposition of the variance
- Screening method more fitted to problems with a lot of parameters
  - ↳ Morris analysis allows to distinguish the effects according to their importance and their linearity/or interaction

Morris's OAT Design (1991)

- One at time : only one factor varies at each simulation, r repetitions per factor → r*(p+1) simulations



Repetition 1

$d^1_{x1} = ❶ = \Delta y / \Delta x_1$

$d^1_{x2} = ❷ = \Delta y / \Delta x_2$

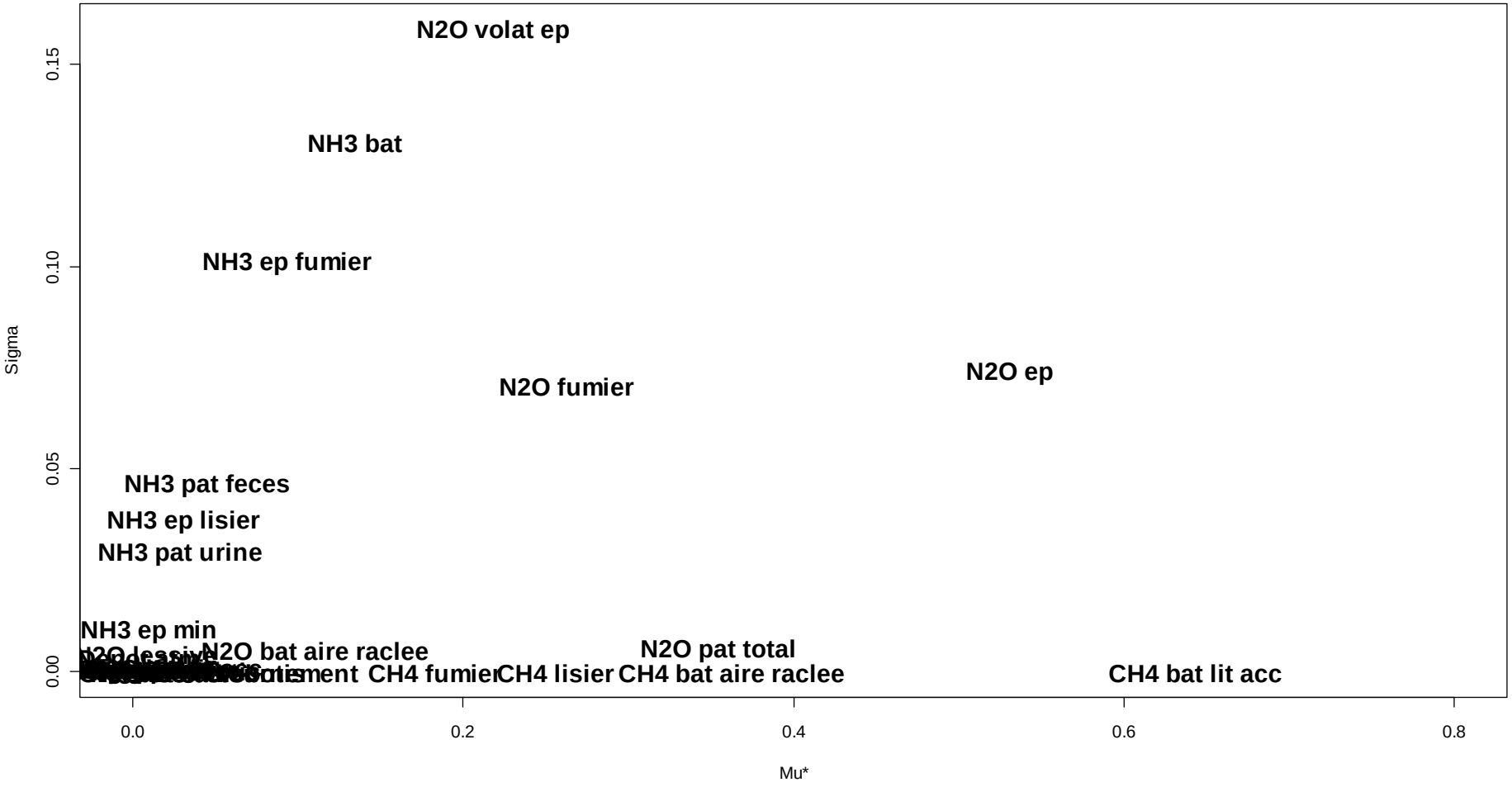
After r repetitions

$\mu^*_{x1} = E(|d^i_{x1}|).\ i \in \{1 \ldots r\}$

$\sigma_{x1} = \sigma(d^i_{x1}).\ i \in \{1 \ldots r\}$

- High mean → influence of the factor on the output
- High standard deviation → interaction or non linear effect

Morris's results



	Mu*	sigma	Mu*	sigma
FE CH4 bâtiment aire raclee	0.362	0.000	0.120	0.042
FE CH4 bâtiment lit acc	0.643	0.000	0.205	0.071
FE CH4 bâtiment caillebotis	0.036	0.000	0.013	0.004
FE CH4 fumier	0.183	0.000	0.063	0.022
FE CH4 lisier	0.256	0.000	0.083	0.029
FE CH4 pâturage	0.005	0.000	0.002	0.001
FE NH3 bâtiment	0.135	0.131	0.015	0.015
FE N2O bâtiment aire raclee	0.110	0.005	0.019	0.001
FE N2O bâtiment lit acc	0.026	0.001	0.005	0.000
FE N2O bâtiment caillebotis	0.009	0.000	0.002	0.000
FE N2O fumier	0.262	0.071	0.059	0.010
FE NH3 pâturage urine	0.028	0.029	0.006	0.003
FE NH3 pâturage feces	0.045	0.046	0.009	0.004
FE N2O pâturage urine	0.000	0.000	0.000	0.000
FE N2O pâturage feces	0.000	0.000	0.000	0.000
FE N2O pâturage total	0.354	0.000	0.088	0.002
FE NH3 épandage min	0.010	0.010	0.002	0.001
FE NH3 épandage fumier	0.093	0.101	0.018	0.009
FE NH3 épandage lisier	0.030	0.032	0.006	0.003
FE N2O épandage	0.531	0.074	0.105	0.009
FE N2O volatisation épandage	0.218	0.159	0.049	0.014
FE N2O lessive	0.007	0.005	0.001	0.000
FE N2O residu	0.015	0.000	0.003	0.000
FE N2O retournement	0.070	0.000	0.012	0.000
FC CH4			0.961	0.089
FC N2O			0.014	0.004

Impacts on Monte-Carlo analysis (previous study)

- 3 parameters retained by sensitivity analysis vs 10 parameters
- Hypothesis: Normal distribution and CV of 50% for the different parameters
- Variation on the GHG/1000L of milk of the 403 farms (2σ/Mean)

Number of parameters	Mean	Sd	Min	P5	P95	Max
3	7.31	2.91	2.81	4.03	12.74	24.23
10	6.47	4.12	1.85	2.68	15.03	23.94

Discussion

- Identification of the most influential factors on the GHG : preponderant effect of CH4 and the concerned emission factors
- Importance to target the EF upon which we want to do the analysis
- It will be more interesting to have a finer analysis to study the interactions : maybe restrict the study at each compartment

Thanks to every partners of this project.

Thank you for you attention !