Carbon – Nitrogen cycles: general concepts

Paul Robin, Mélynda Hassouna, Nouraya Akkal-Corfini

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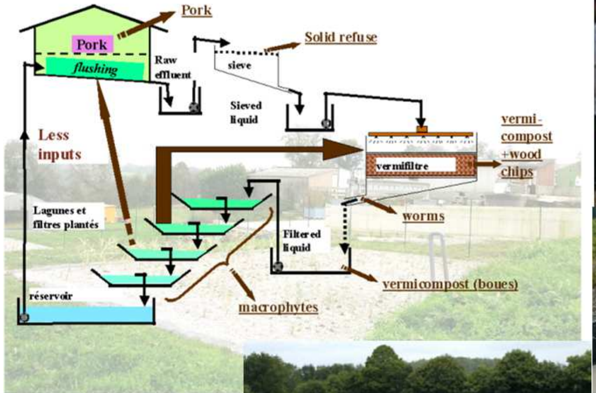


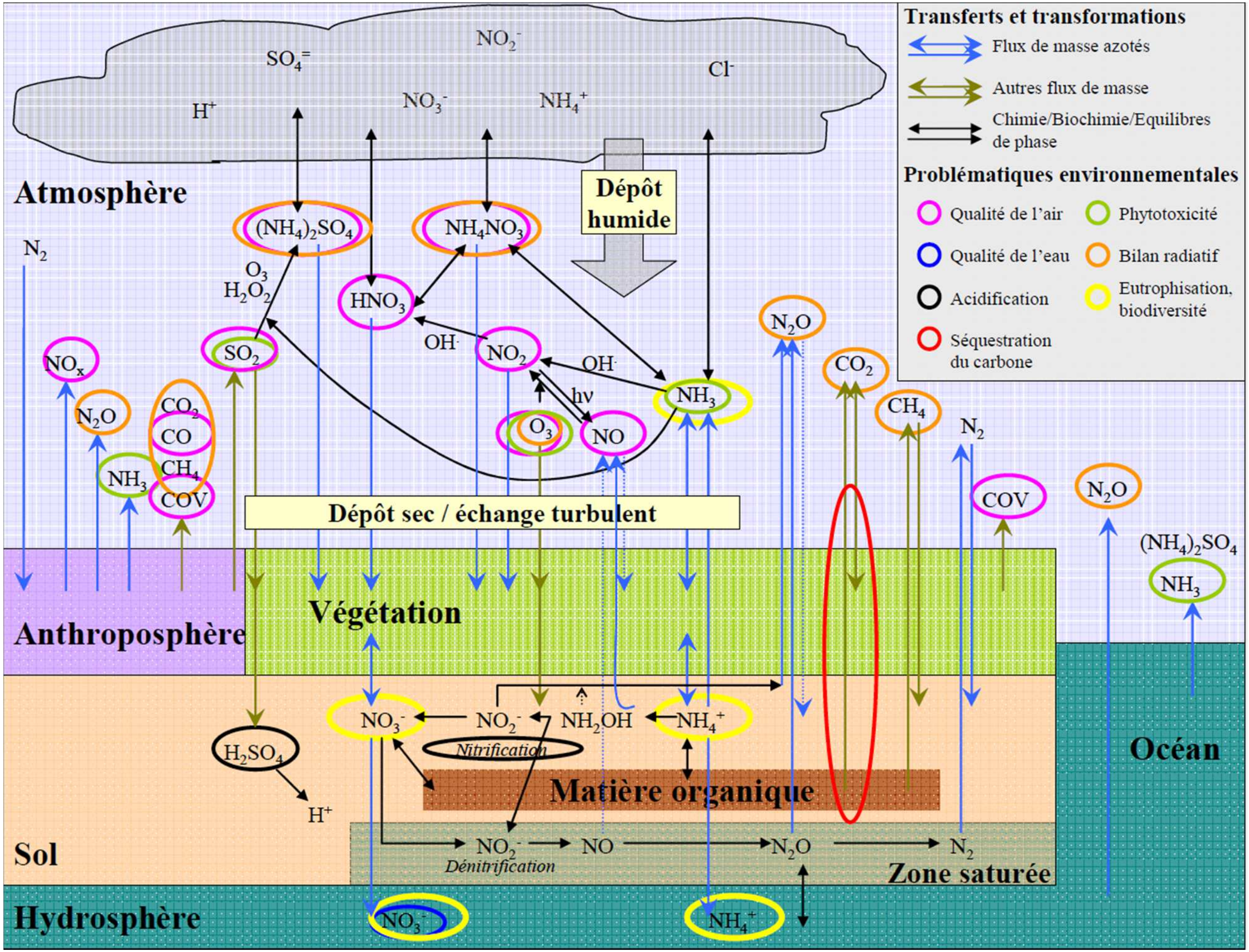
Outlines

- Introduction: scale considerations, not only C & N
- Interaction examples
  - chemical interaction controls pH
  - nature of Organic Matter
  - animal-manure; animal-crop complementarity
  - Urban-agricultural / food-non food succession
- Modelling challenges
- Take home messages

Introduction

1. Gaseous losses at various scales

- Animal: CO_2, H_2O, CH_4 are released (50% C, H_2O intake)
- House: CO_2, H_2O, NH_3, N_2O, N_2, CH_4 are released from manure, sometimes after air treatment (20-60% of excreted nitrogen)
- Farm: gases are also released but fields also collect rainfall and dry deposition => net emissions can be negative (e.g. C storage in forests increased by N_{gas} deposition; CH_4 sink by agricultural soils)
- Region: farm interacts with other activities; recycling or organic byproducts/biomass production can contribute to emission decrease



Nitrogen interactions (Fléchard, 2010)

Introduction

2. C-N are necessary but not sufficient to explain emission variability (to manage emission reductions)

- Climate influence=> temperature, rainfall
- Biological activity=> toxicities, synergies explain limiting or accelerating factors
- Non linearity of biology: feedbacks can be positive then negative around a threshold
- Scale effects=> analysis of biological & social functions (e.g. food chain)

Interaction examples: pH control in manure

CO_2 and NH_3 are both emitted from manure

$$NH_4^+ + H_2O \underset{}{\overset{K_{AN}}{\rightleftharpoons}} NH_3aq + H_3O^+$$

pH decrease

$$H\text{-}CO_3^- + H_3O^+ \overset{K_{AC1}}{\rightleftharpoons} CO_2 + 2\,H_2O$$

$$CO_3^{2-} + H_3O^+ \overset{K_{AC2}}{\rightleftharpoons} H\text{-}CO_3^- + H_2O$$

pH increase

- pH influences emissions and biological processes and is affected by C-N emission ratio

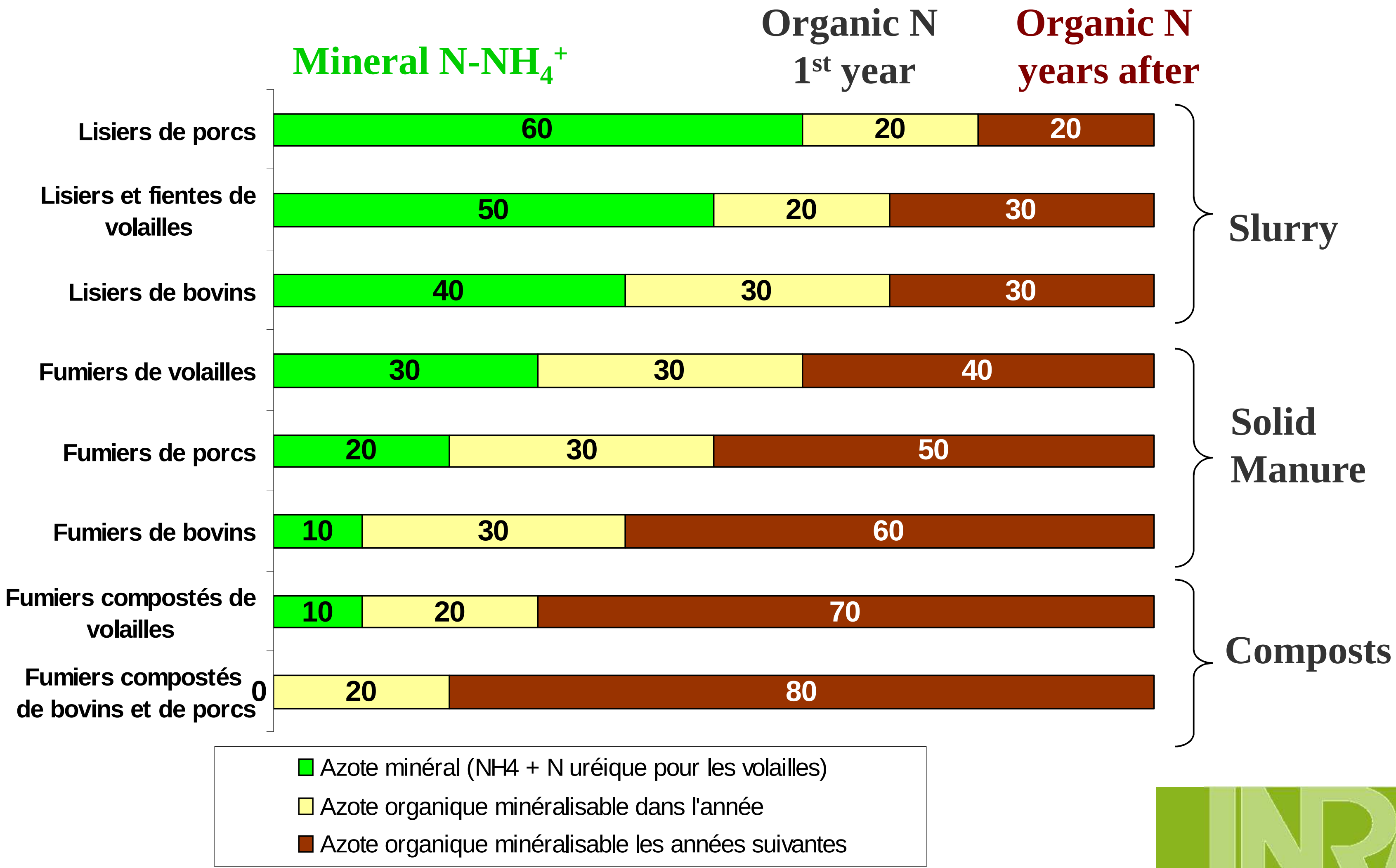
Interaction examples: nature of Organic Matter

C-N total contents are necessary but not sufficient to explain emission variability => quality, dynamics of bioavailability

- Depending on OM nature, compost will loose more OM or more water => dry matter content can decrease or increase during composting
- Depending on OM nature, compost volume will be stable or decrease => natural aeration can decrease or increase
- In soils: chemical stability depends on organic species, physical stability depends on particle size and clay content, biological stability depends on T & H_2O; OM stability affects fertility, C storage, N_2O emission, N losses as gas or leaching

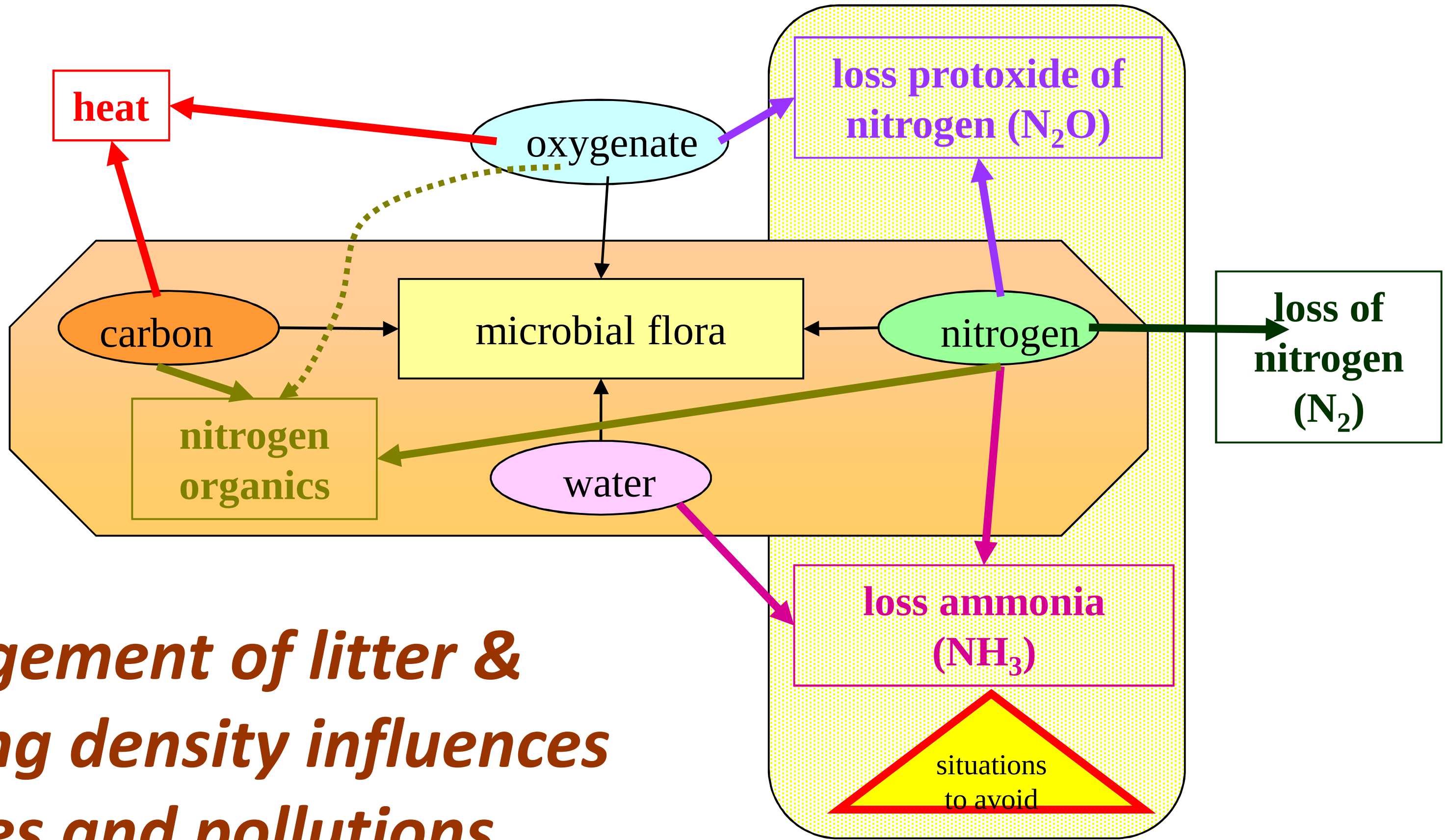
Interaction examples: nature of Organic Matter

Percentage of nitrogen available for plants in various manures resulting from cattle, pig or poultry



Interaction examples: animal-manure interactions

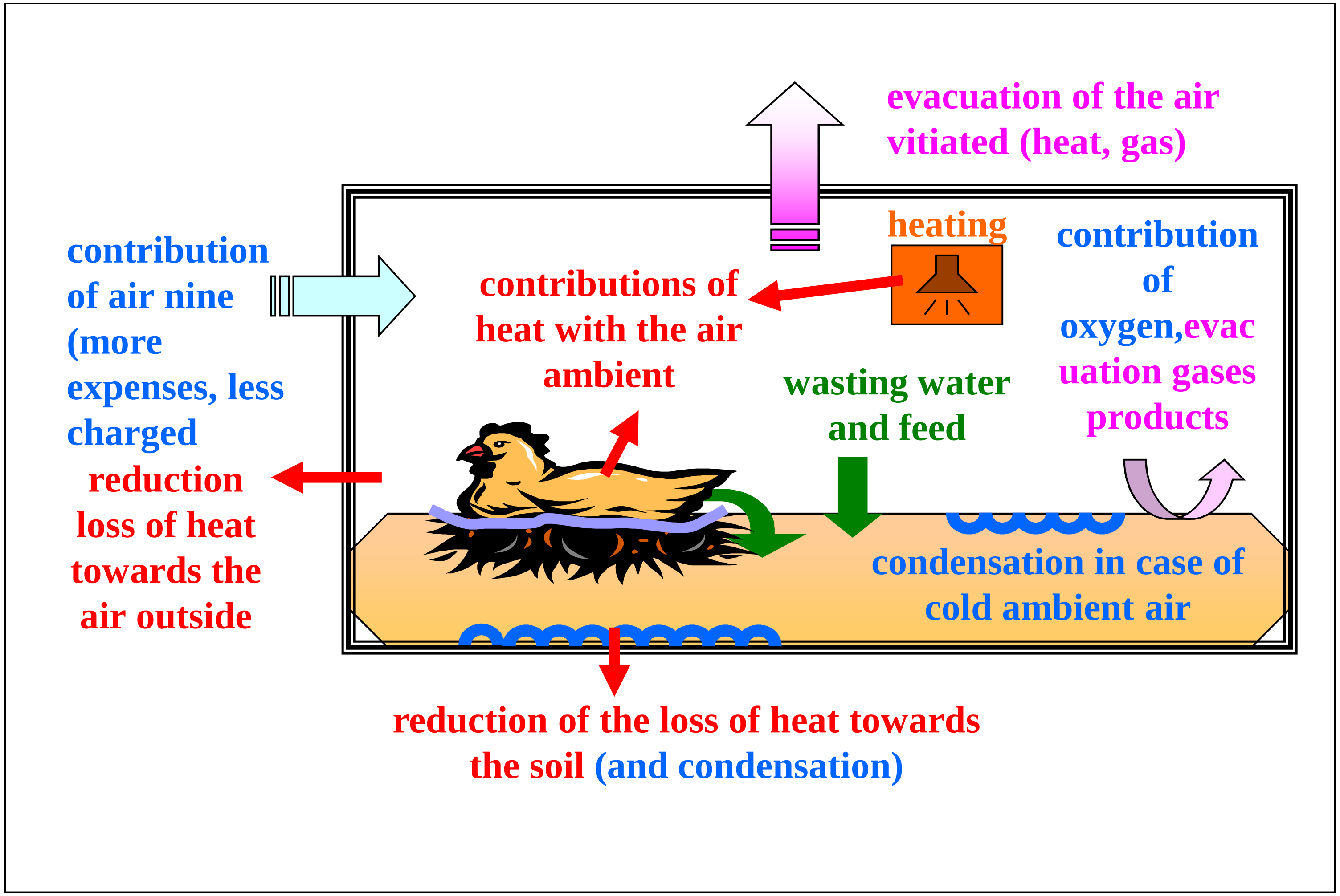
Animal behavior determines place and amount of excretion (high N & H_2O inputs)



Management of litter & stocking density influences N losses and pollutions

Interaction examples: animal-manure interactions

At house scale: influence on thermal balance



Interaction examples: animal-manure interactions

At house scale: consequences on composition and emissions

Factors influencing the manure composition

- ventilation
- animal density
- soil (concrete, earth), the litter
- drinking equipment
- health of the livestock
- feed
- animal species
- storage
- treatment or spreading equipments

Interaction examples: animal-manure interactions

At house scale: consequences on composition and emissions

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Interaction examples: urban-agricultural exchanges

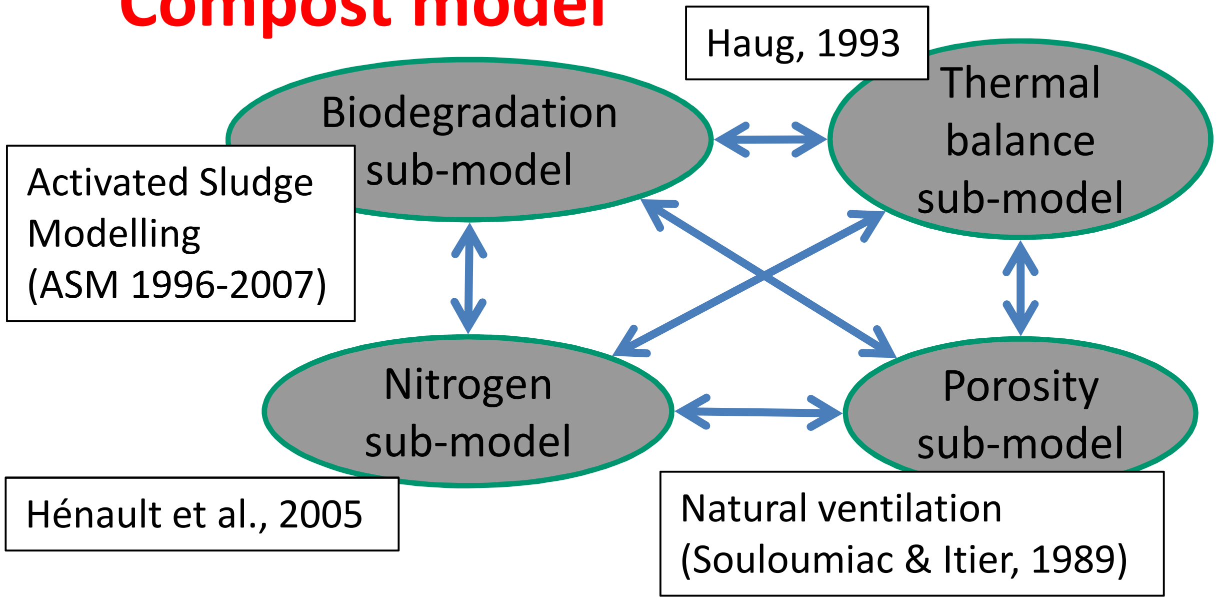
Urban-agricultural recycling can improve nutrient efficiency at region scale

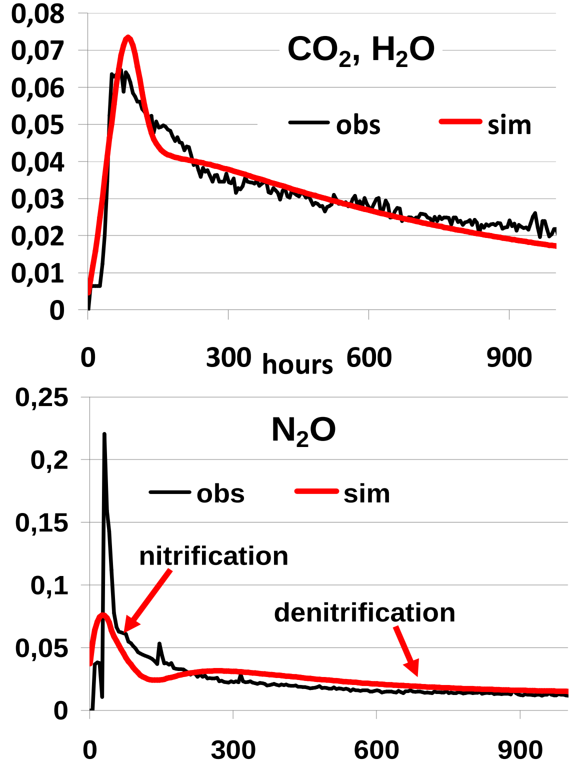
- Agricultural reuse of organic by-products
- Non-food/feed crops for contaminated OM
- Food/non food needs of urban populations and industries
- Heat & water availability for crop productions can increase productivity when they are limiting factors
- Wild animals & functions for non food requirements (recycling, hygienisation, recreation, etc.)

Modelling challenges

Models for knowledge integration: emission prediction

Compost model





➔ climate input at hourly time step

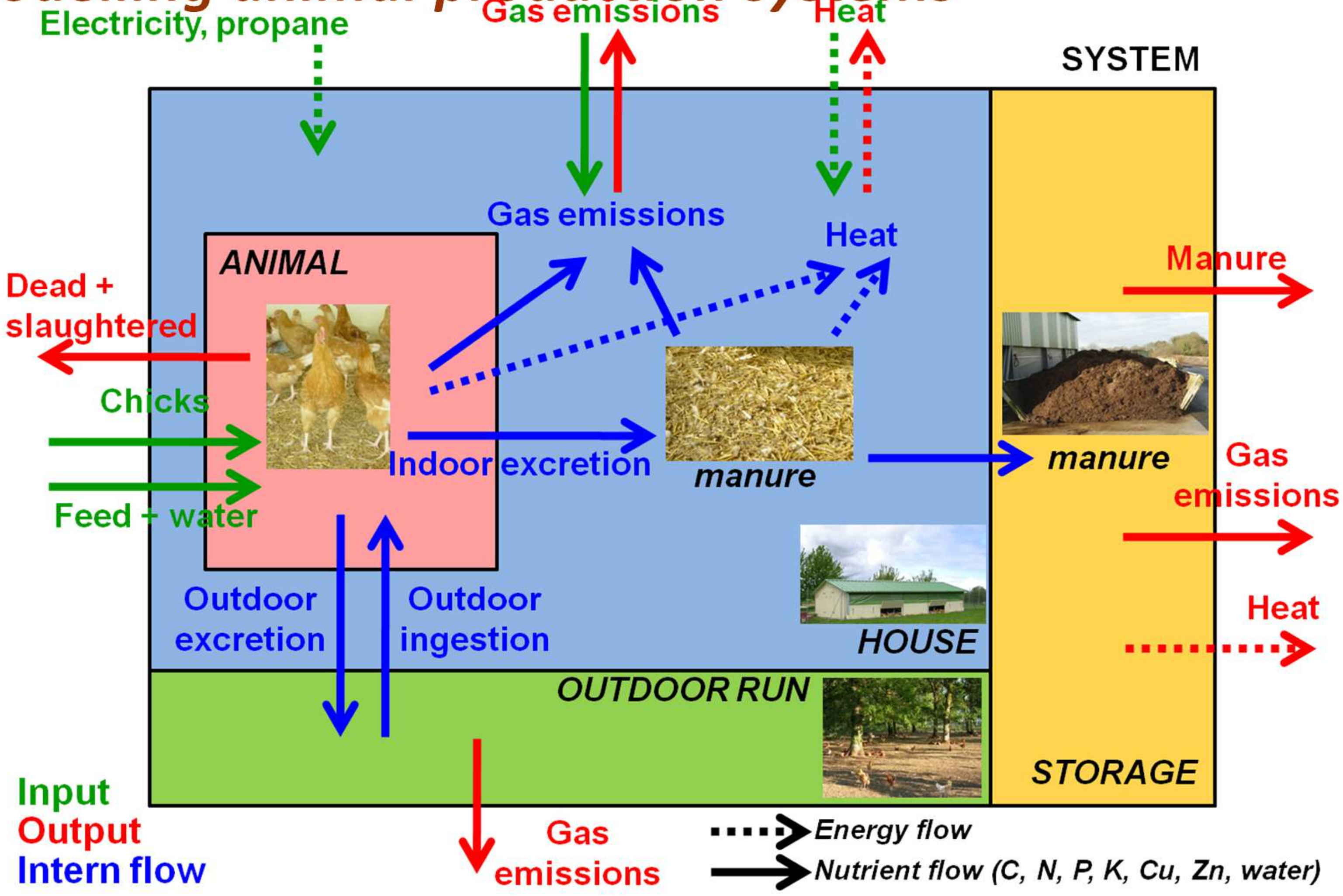
➔ 5 parameters specific of manure + 25 based on literature and experiments

➔ influence of C & N biodegradability, porosity and humidity

D. Oudart, 2012. Ph.D. thesis, Crête d'Or Entreprise, CIRAD, INSA Toulouse, INRA

Modelling challenges

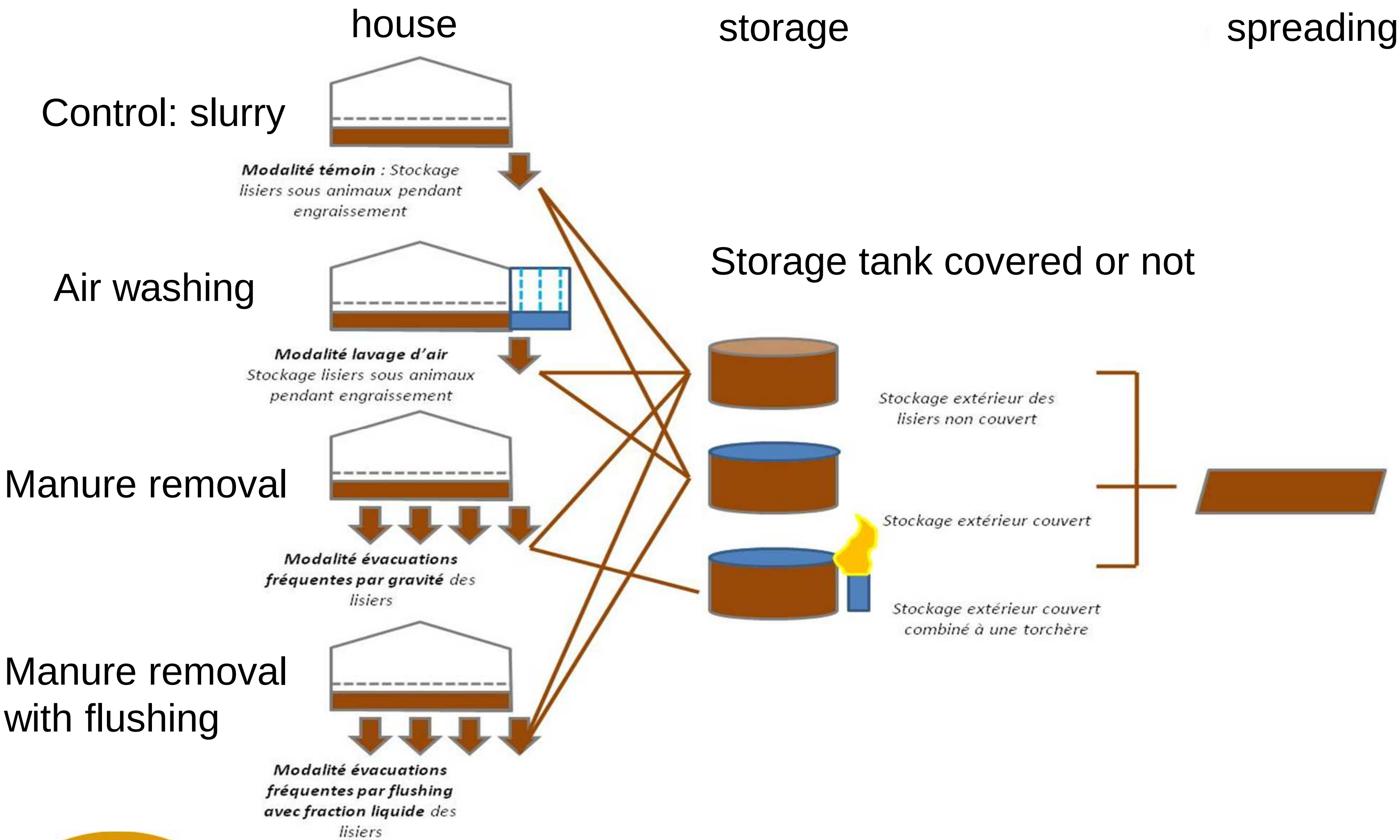
Modelling animal production systems



Méda, B., 2011. Ph.D. thesis, Agrocampus Ouest, Rennes. Retrieved from http://tel.archives-ouvertes.fr/tel-00662627

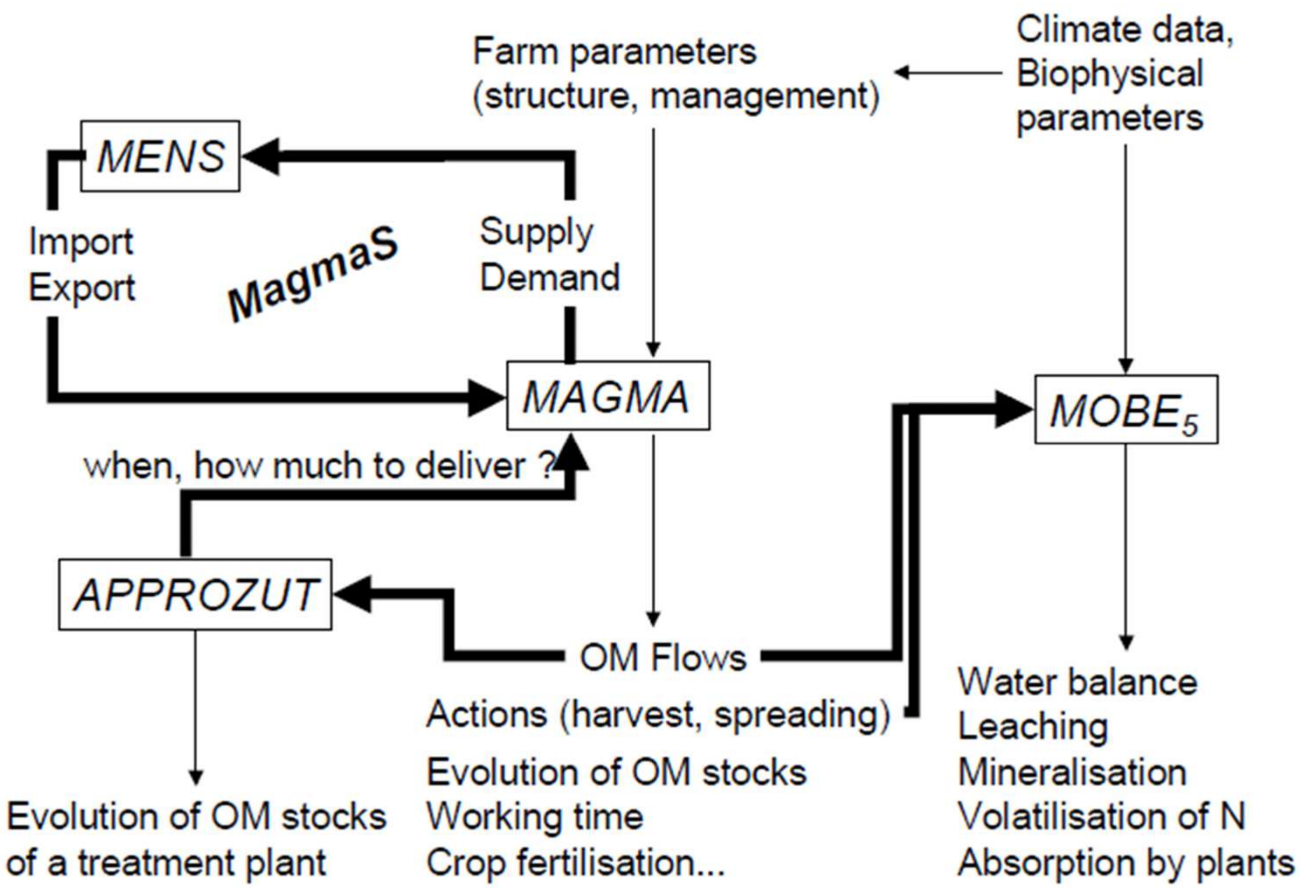
Modelling challenges

System experiments for model calibration



Modelling challenges

Modelling actor behavior for biomass recycling



Guérrin & Paillat, 2003

Modelling challenges

Conclusions

- Models for understanding, discussing, management
- Models for data interpolation and data mining
- Management of model quality, model uses, knowledge integration: long term strategy for model and experimental data development is necessary to integrate various disciplines & scales

Take back home

- C-N interactions are far from sufficient to explain emissions
- System/scale choices influence interactions to consider
- Chemical & physical parameters are less influent than biological interactions
- Increasing dilution increases biological interactions and reduces emission risks => better adapted to less controlled environments
- Modelling is a key issue to improve management but long term strategies are required for relevant development and uses for management purposes

Thanks for your attention