MODELLING PESTICIDE VOLATILIZATION FROM CROP AT THE FIELD SCALE

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Outline

- Introduction – Context – Objectives of the study
- Materials and methods
    - Model
    - Experimental setup
- Results in terms of leaf temperature and pesticide volatilization fluxes (simulated *vs* measured)
- Conclusions and Perspectives

Context: Volatilization rates from crop, main involved factors identified

Volatilization rate

Active ingredient properties (+ formulation)

- *vapor pressure*
- *water solubility*
- *adsorption*
- *chemical reaction*

Meteorological conditions

- *temperature*
- *solar radiation*
- *rain/dew*
- *atmospheric humidity*
- *wind/turbulence*

Surface properties Soil / Plant

- *water content*
- *temperature*
- *soil Density*
- *OM content*
- *pH*

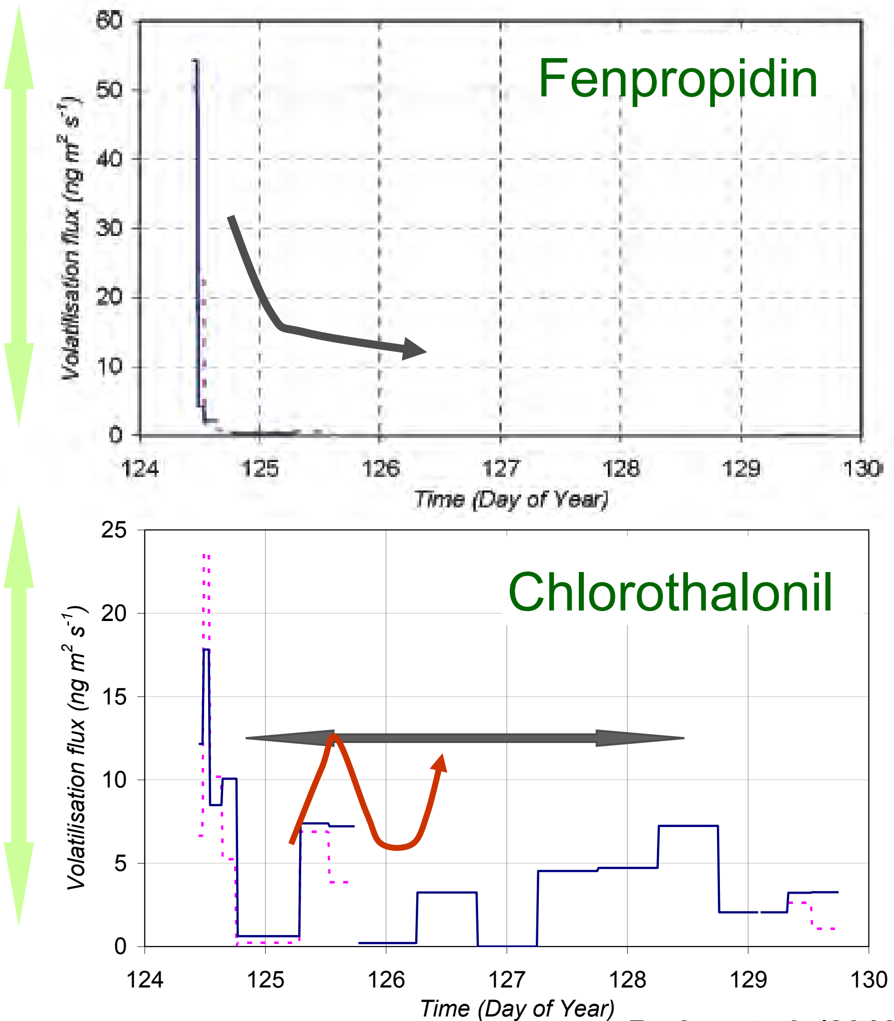
- *temperature*
- *crop 3D structure*
- *foliage surface*
- *nature surface*

Agricultural practices

- *application dose*
- *application time*
- *soil management*
- *formulation*
- *irrigation*
- *application technique*
- *droplet granulometry*

→ interception

Context: Volatilization rates from crop observed at the field scale (ng/m²/s)



Bedos et al. (2010)

e.g. two fungicides of wheat

- ❖ Various orders of magnitude
- ❖ Different time dynamics
- ❖ Diurnal cycle

Objectives of this study

- Model the pesticide volatilization from leaf
  at the field scale, in a mechanistic way
  i.e. taking into account main factors involved
  at an adapted time scale (infra-hourly)

- Test this model with dataset

- Study the contribution to the global volatilization from crop
  of the volatilization from soil and the volatilization
  from leaves

=> towards an emission module to be used for modelling the pesticide behaviour in the atmosphere at larger scales

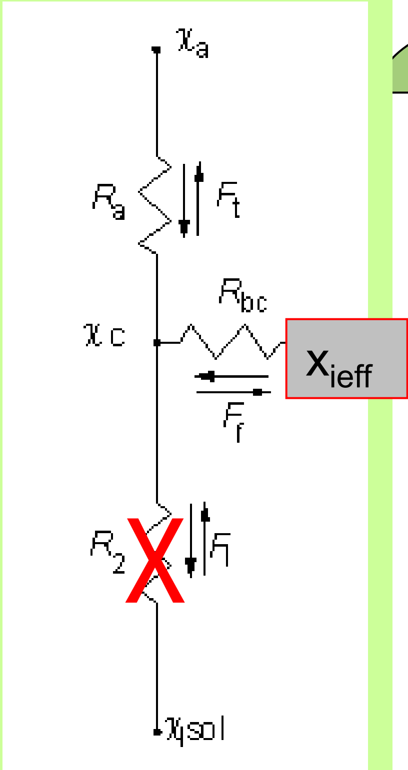
Material and Methods: The SURFATM model (Personne et al., 2009), volatilization from crop

Atmosphere

Leaf

Volatilization from leaves

Soil



Model describing exchange of pollutants between the soil-plant-atmosphere (parameterizations based on a transfer resistance concept (aerodynamic, boundary layer, stomatal, cuticular and soil resistances)

Adaptation to pesticides (following parameterization of Leistra, et al., 2004, PEARL)

$$F_c = -\frac{1}{R_{bc}}\left(\chi_c - x_{i_{eff}}\right)$$

→ Pesticide concentration available above the leaf

- F_c: volatilization fux from leaves
- R_{bc}: Crop boundary layer resistance
- χ_c: Pesticide concentration within the crop air

$$x_{i\,eff} = x_i \frac{Q(t)}{\lambda}$$

$$x_i = \frac{P_{sat}(T)M}{RT}$$

Competing processes

$$Q(t) = Q(t^{-1}) - (F_c - (K_{pen} + K_{\deg})Q(t^{-1}))\Delta t$$

Material and Methods: The SURFATM model, other processes

• an energy budget model for soil and leaf surfaces

• water transfer in the soil considered as a single reservoir with a dry layer at the surface

• a pollutant exchange model (fluxes of NH_3, O_3), which distinguishes the soil and leaf exchange processes and which is directly coupled to the energy balance via the soil and leaf surface temperatures

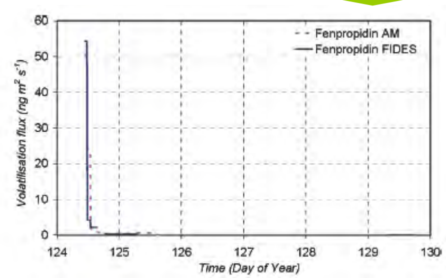
+ interception of the spraying solution by the crop (from Gyldenkaerne et al., 1999) implemented for the purpose of this study

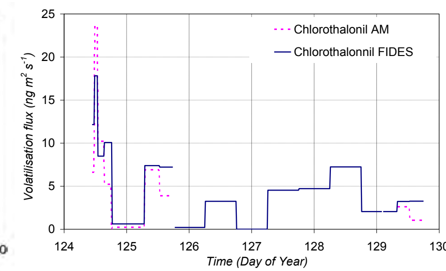
Material and Methods: Experimental set-up (Bedos et al., 2010)

Two fungicides: ***Chlorothalonil*** (7.6 10^{-5} Pa) and ***Fenpropidin*** (1.7 10^{-2} Pa)

Flux measured from May 4 to May 9

Aerodynamic
+ Inversion method
Loubet et al. (2010)

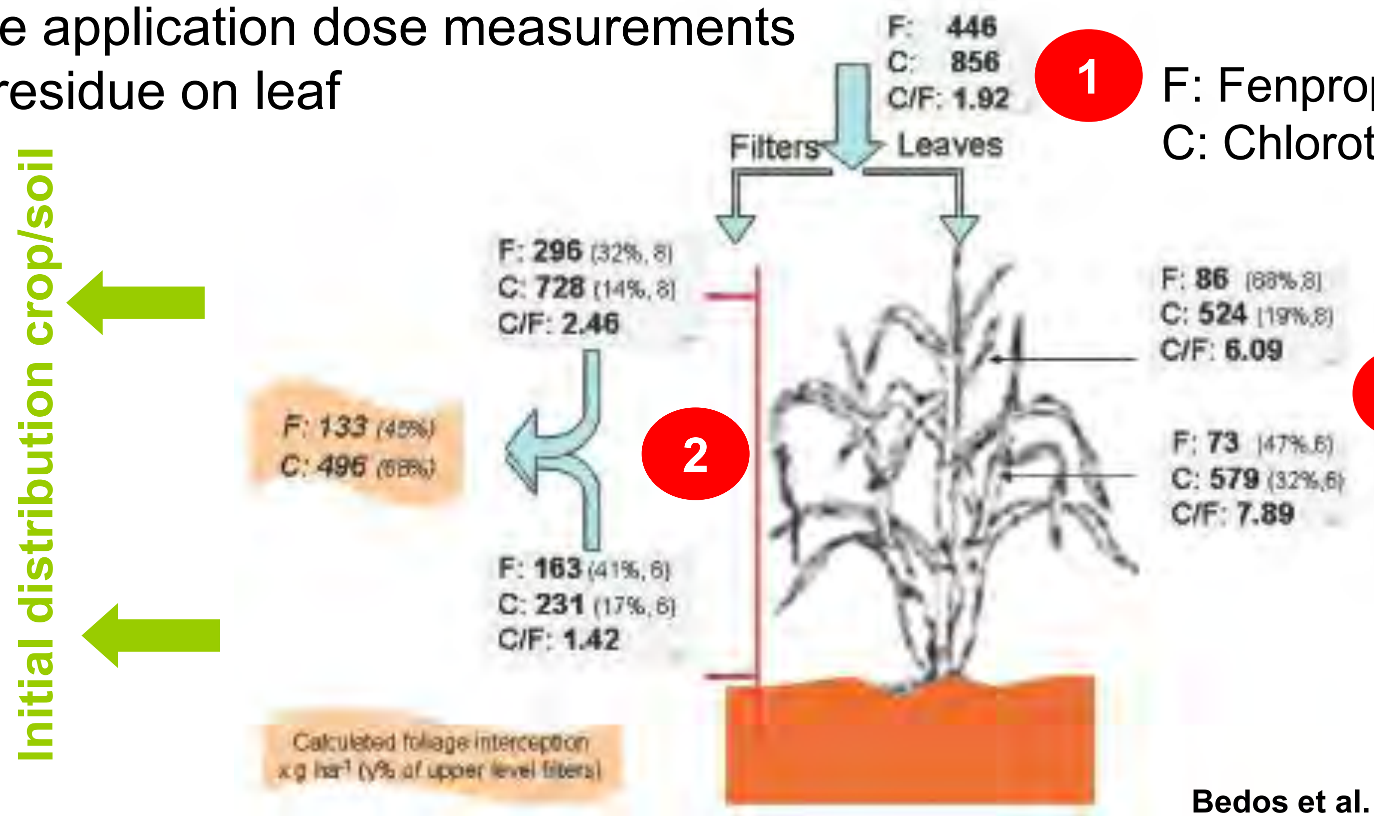




+ micrometeorological conditions: evaporation, sensible heat flux, leaf and soil surface temperatures

Material and Methods : Experimental set-up

Focus on the application dose measurements
+ pesticide residue on leaf



F: Fenpropidin
C: Chlorothalonil

Bedos et al. (2010)

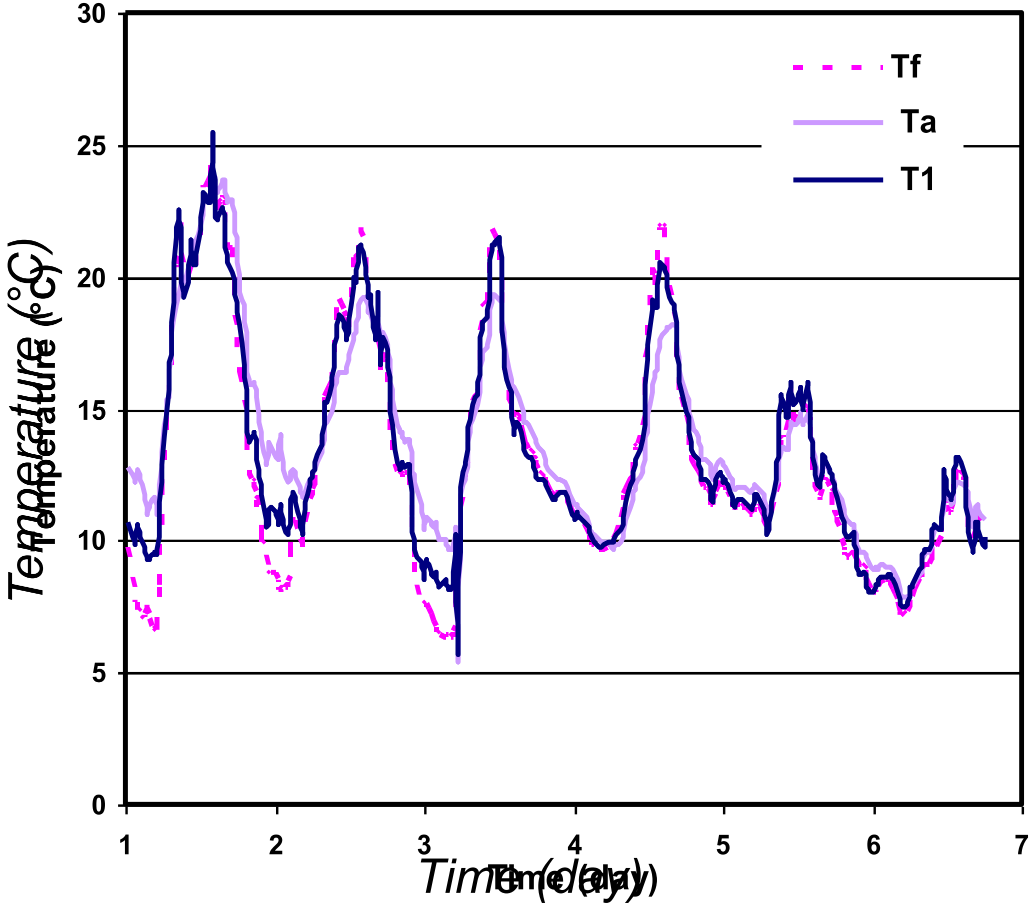
⇒ Interception of the application by the crop : input data for the volatilization model

The model is run with measured applied amount on leaves, with an application assumed at 10:30 (end of the real application)

⇒Need to improve the estimation of the application dose

Cf. Workshop 2008 (Cambridge)

Results Comparison of modelled and measured surface temperature of leaves



Tf : the measured leaf temperature

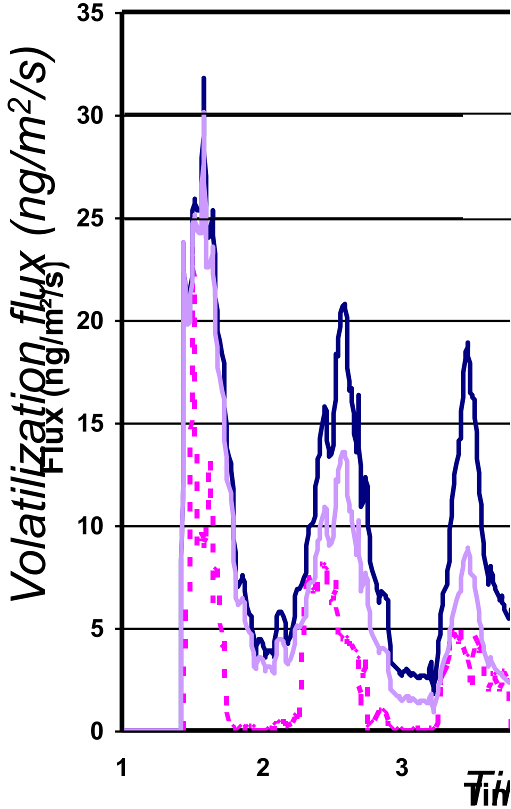
Ta : the measured air temperature

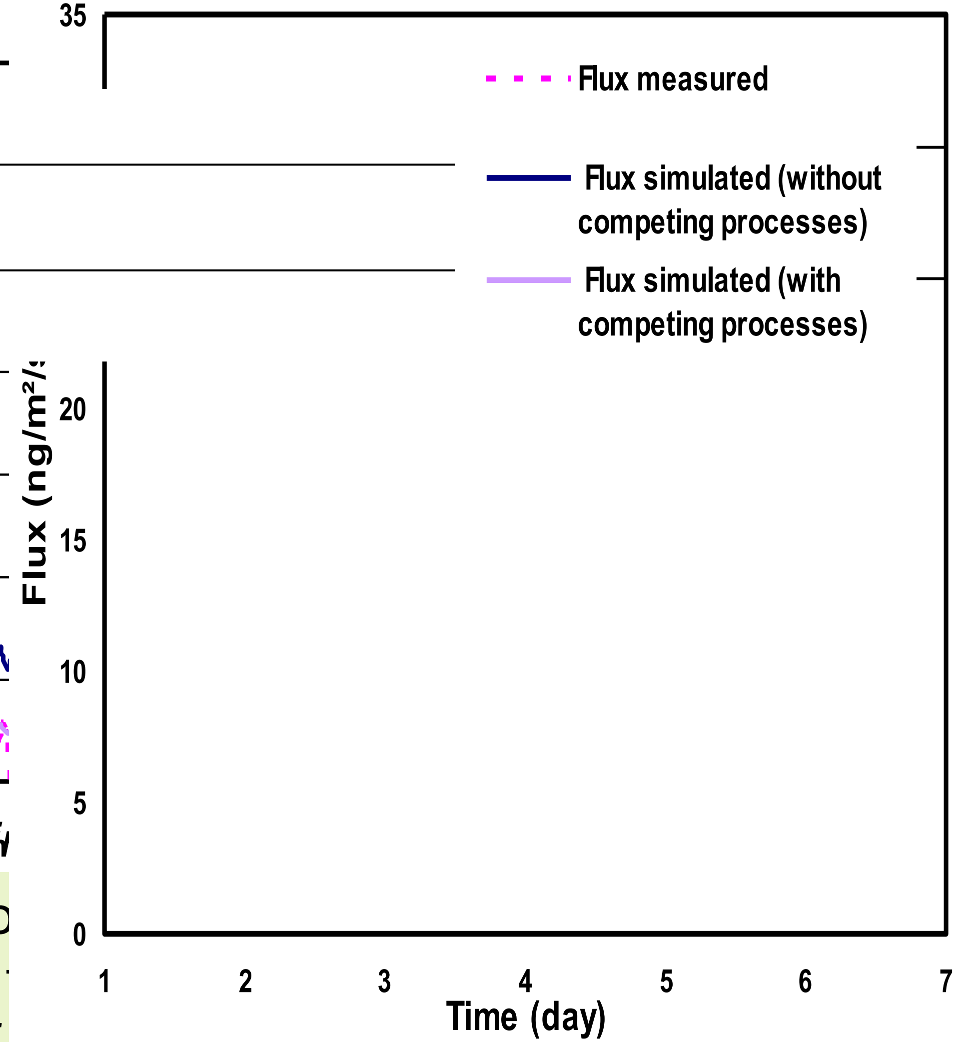
T1 : the simulated leaf temperature

⇒ Pretty good agreement

⇒ Leaf temperature and air temperature different (Tf-Ta= 2°C during daytime)

Results Comparison of modelled and measured flux volatilization of Chlorothalonil





ing processess)

processess)

esses:

lorothalonil

g et al. (2008)

= 0,14 d^{-1}

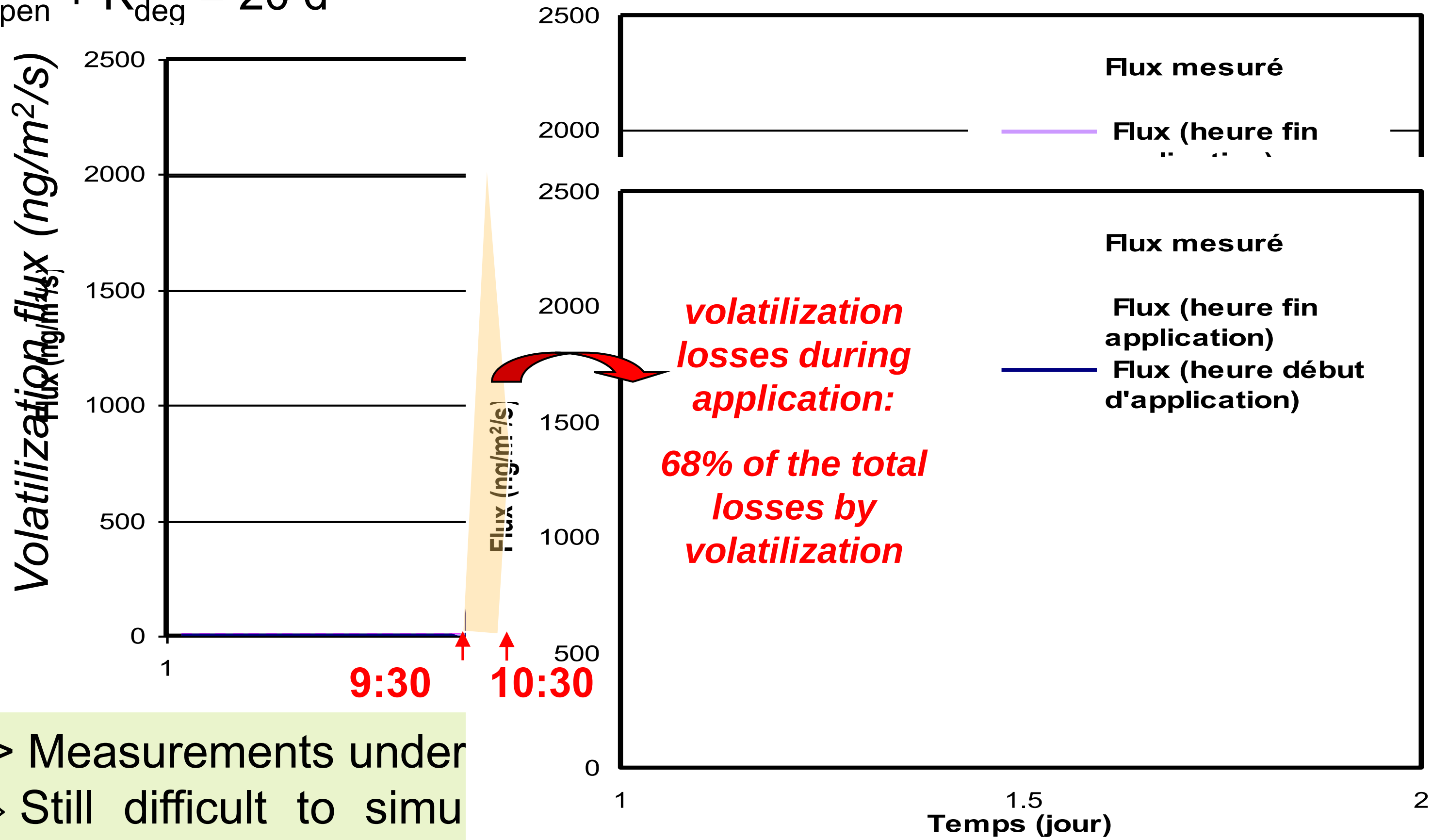
ation)= 0,23 d^{-1}

⇒ Taking into acco … describing the volatilization …

⇒ Overestimation of early volatilization fluxes and under estimation of later ones

Results: Comparison of modelled and measured flux volatilization of Fenpropidin

No values found in the litterature for competing processes, best results found for $K_{pen} + K_{deg} = 20\ d^{-1}$



rocessess
10:30
measured

rocessess
9:30
Sprayed dose
interception)

=> Measurements under ... egun too late

⇒ Still difficult to simu ... ue on leaves overestimated at the time of the end of application *vs* the measured one (not shown) => fast dissipation and/or effect of formulation involved?

Conclusions: volatilization from plant surfaces

- description of the volatilization fluxes is possible when the coefficients for competing processes are known

- to go further on, we have to:
  - Analyse the time evolution of pesticide residue on leaves
  - Mechanistically describe competing processes
  - Measurements : better estimate residue on leaves and early stage volatilization

- Study the contribution of volatilization from soil and from leaves

Perspectives: *Coupling « off-line » SURFATM and Vol'Air-Pesticides*

Volatilization fluxes
from leaf surfaces

+ soil surface temperature measured

Energy budget (evaporation)

1 **SURFATM**

Crop

VOLT'AIR forced **2**

Bare soil

volatilization fluxes
from bare soil under a crop

Concentration in gaseous phase of pesticides in the soil surface layer

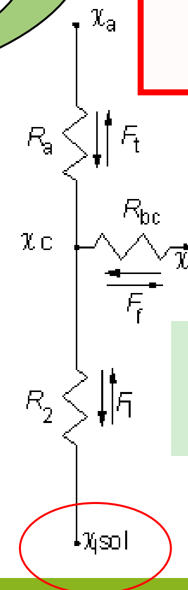
3

Taking into account exchanges with soil

SURFATM forced

Soil+crop

Volatilization fluxes
from soil under a crop
and from leaf surfaces

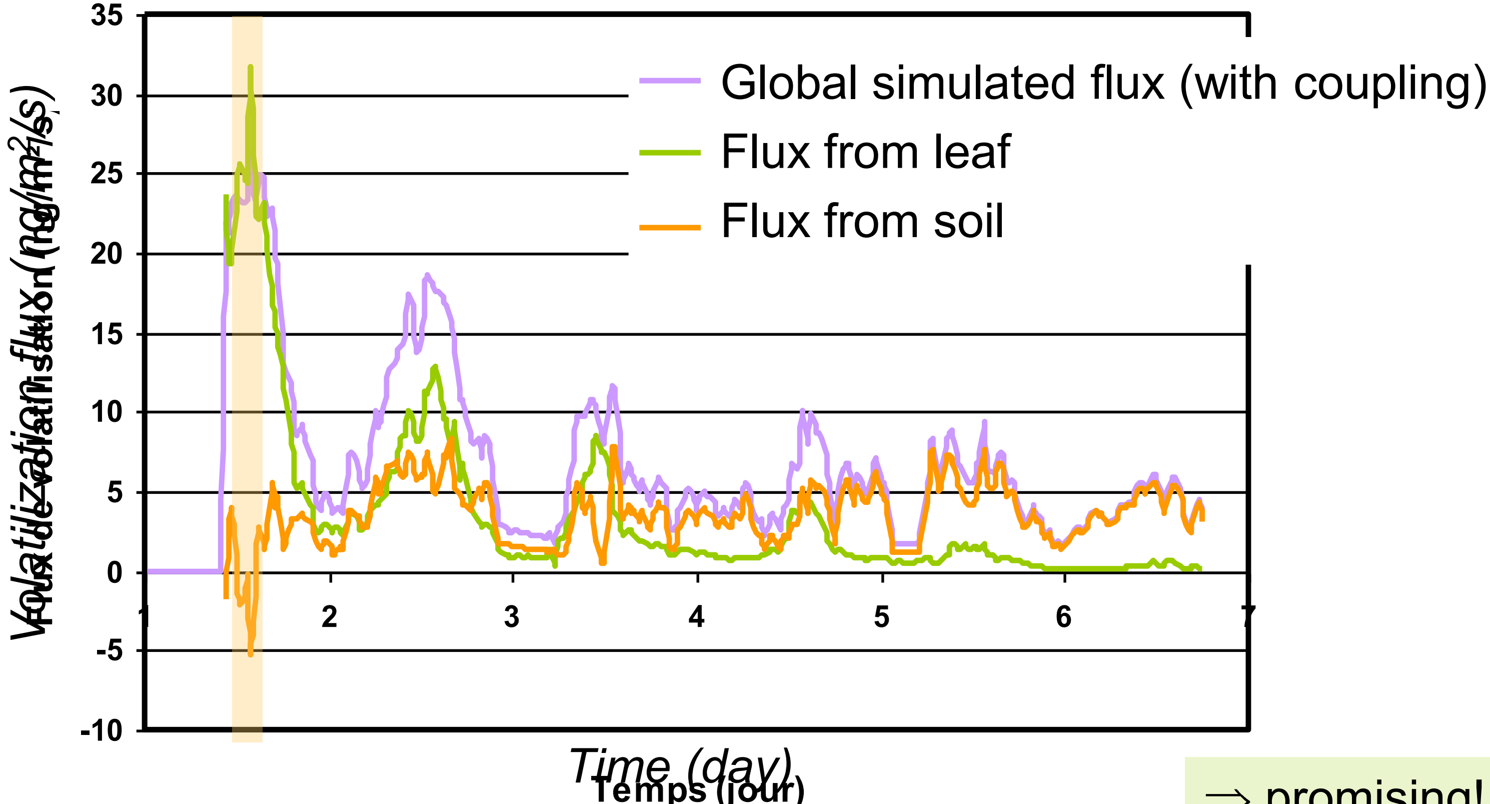


« activate » soil exchanges

Perspectives: *Coupling « off-line » SURFATM and Vol'Air-Pesticides*

First results:

* contribution of volatilization from soil and from leaf surfaces as a function of time
* Deposition on soil just after application



⇒ promising!

Thank you for your attention

Special thanks to E. Van Den Berg for his help on the parameterization of volatilization