What roles for modeling and simulating frameworks?

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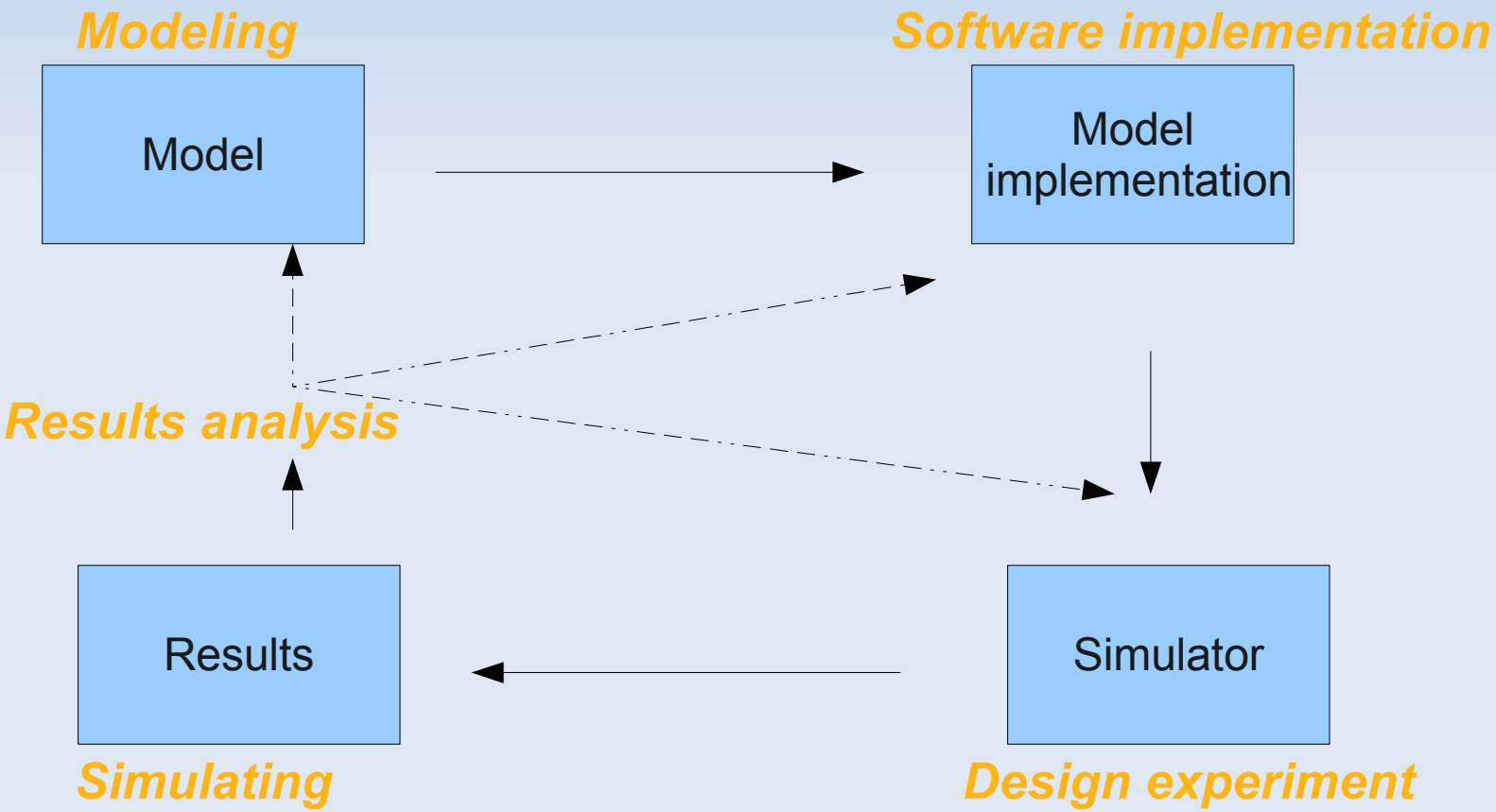
RECORD: modeling and simulating platfom for cropping systems

What's new, what's next in dynamic system modeling in agronomy
Journée internationale du RMT modélisation
7 sept 2010

- Modeling and simulating : concepts and definitions
- Reasons for the use of modeling and simulating FW in agronomy/environmental science
- Some illustrations --> RECORD
- Conclusion

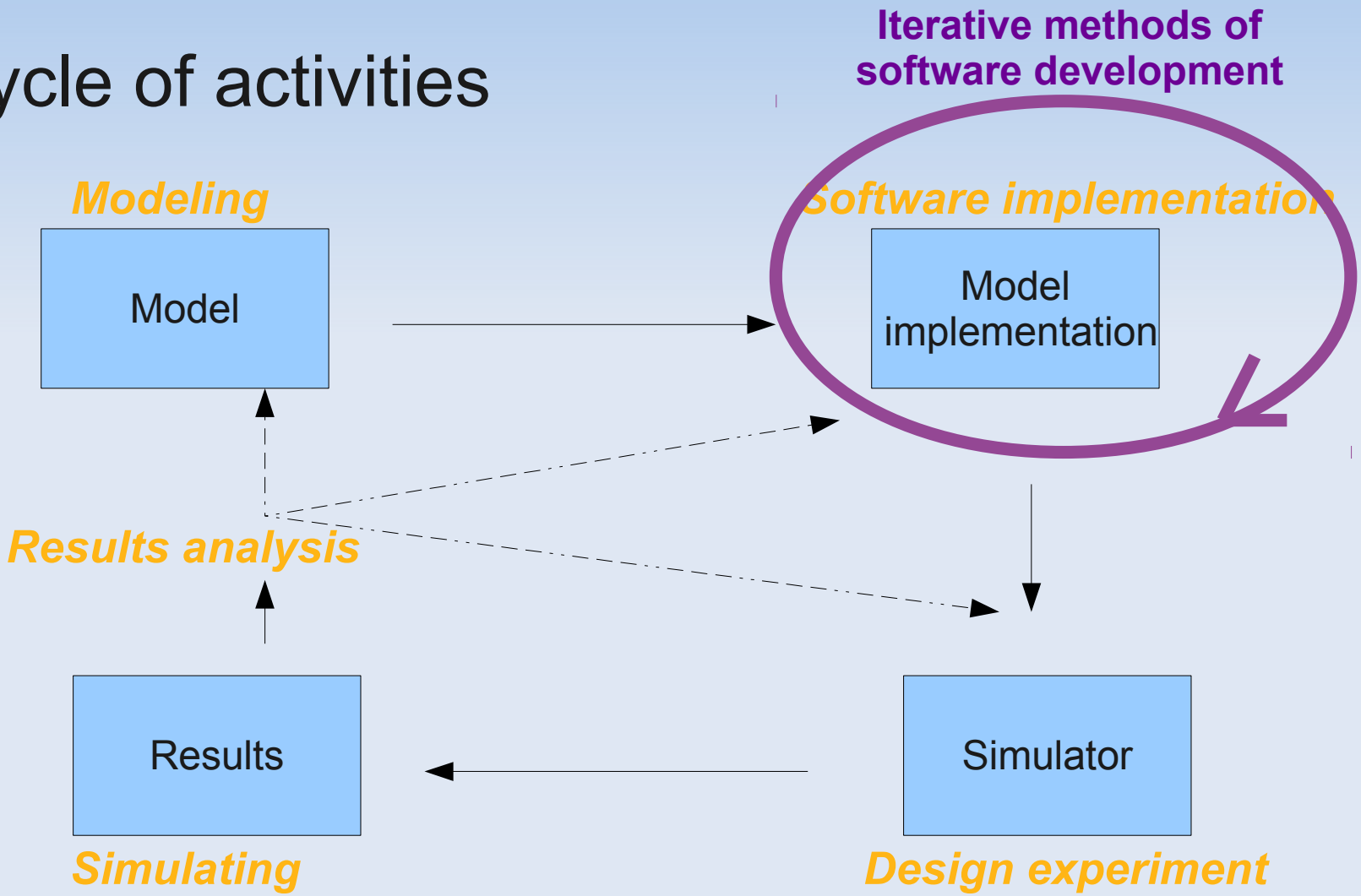
Modeling and simulating: concepts and definitions

Cycle of activities



Modeling and simulating: concepts and definitions

Cycle of activities



Modeling and simulating: concepts and definitions

“a framework is a reusable, ‘semi-complete’ application that can be specialized to produce custom applications”. (Fayad et Schmidt, 1997)

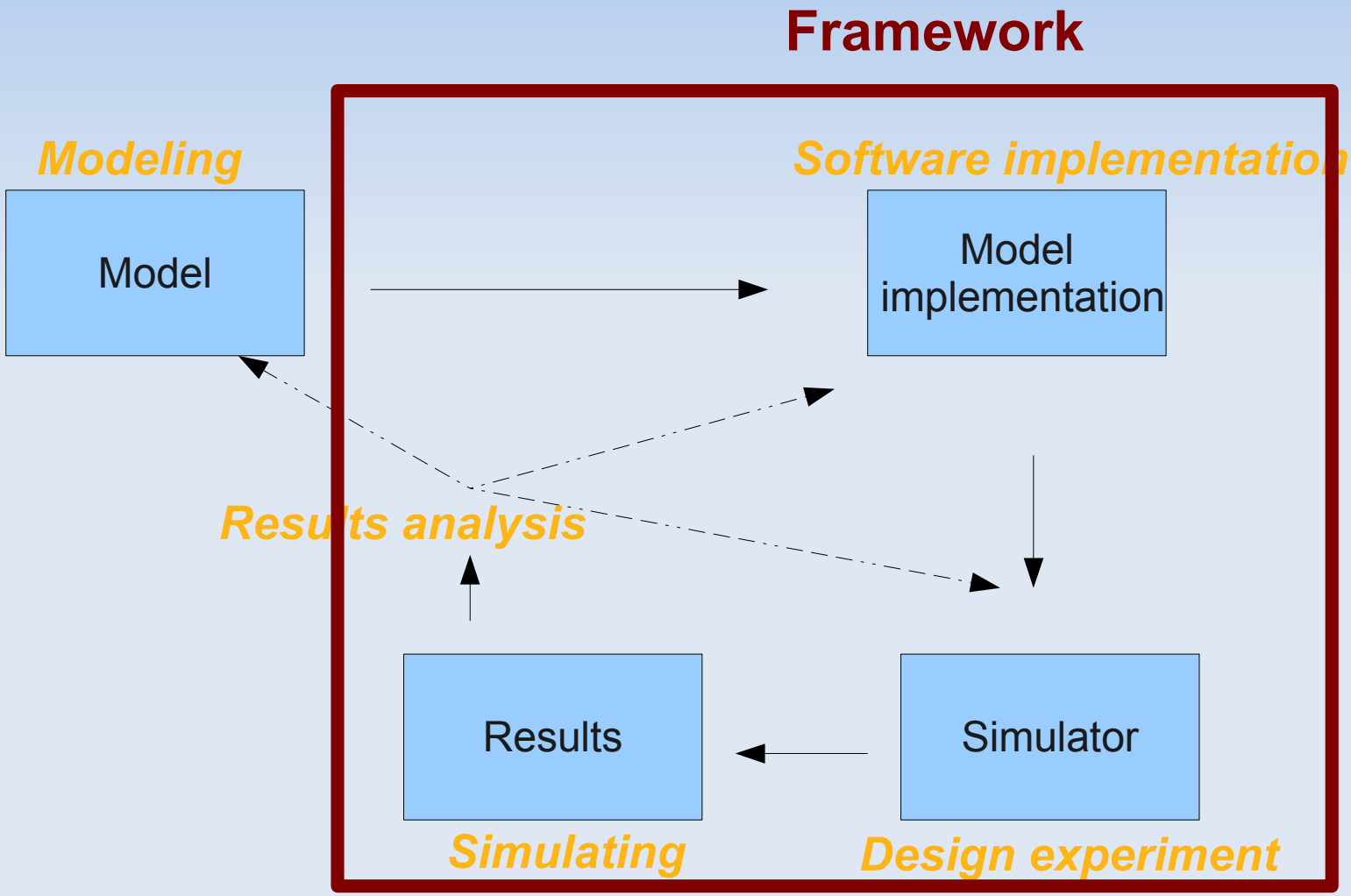
“a framework is an integrated set of domain-specific software components that can be reused to create applications”. (Brugali et al., 1997)

“a framework enables the assembly of simulation models from previously and independently developed models” (Hillyer et al., 2003)

“a framework is an architectural design for object oriented systems. It describes the components of the system and the way they interact”, (Campbell et al, 1991)

(in this presentation, platform = FW)

Modeling and simulating: concepts and definitions



An overview of softwares used in Agricultural Systems research

STICS

APSIM

CERES

RECORD-VLE

OMS

MODCOM-APES

OpenMI

Matlab

Stella

R

GAMS

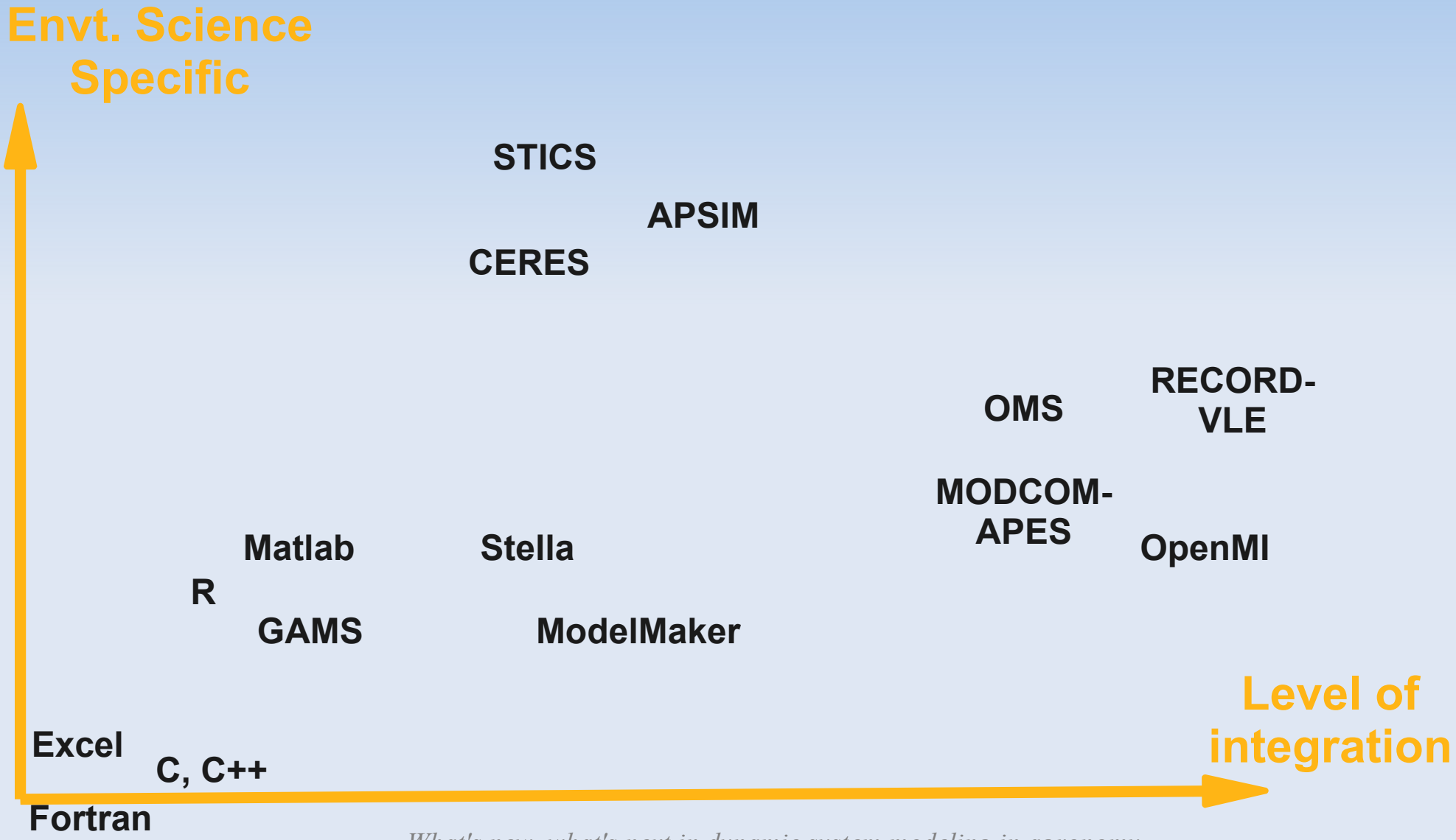
ModelMaker

Excel

C, C++

Fortran

An overview of softwares used in Agricultural Systems research



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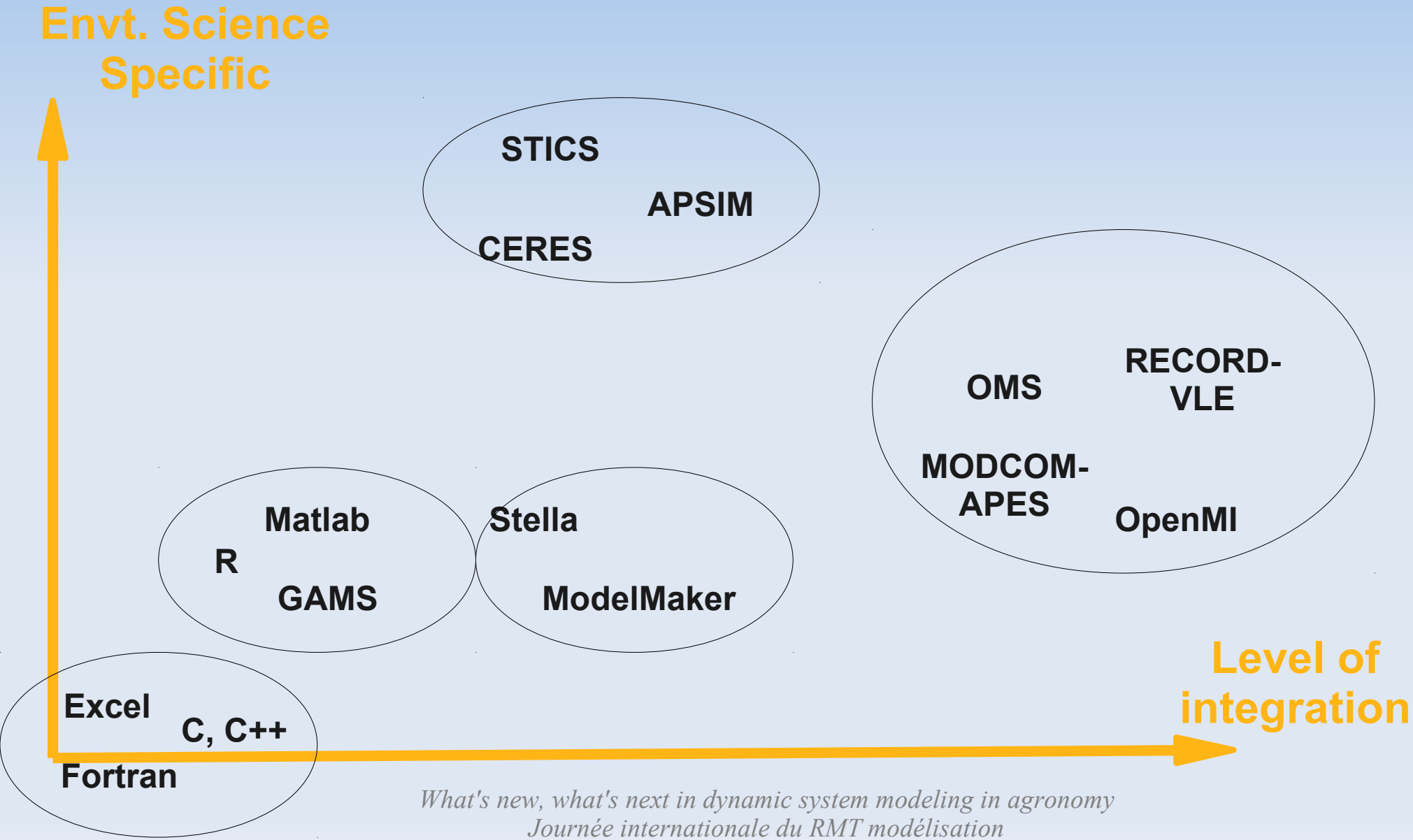
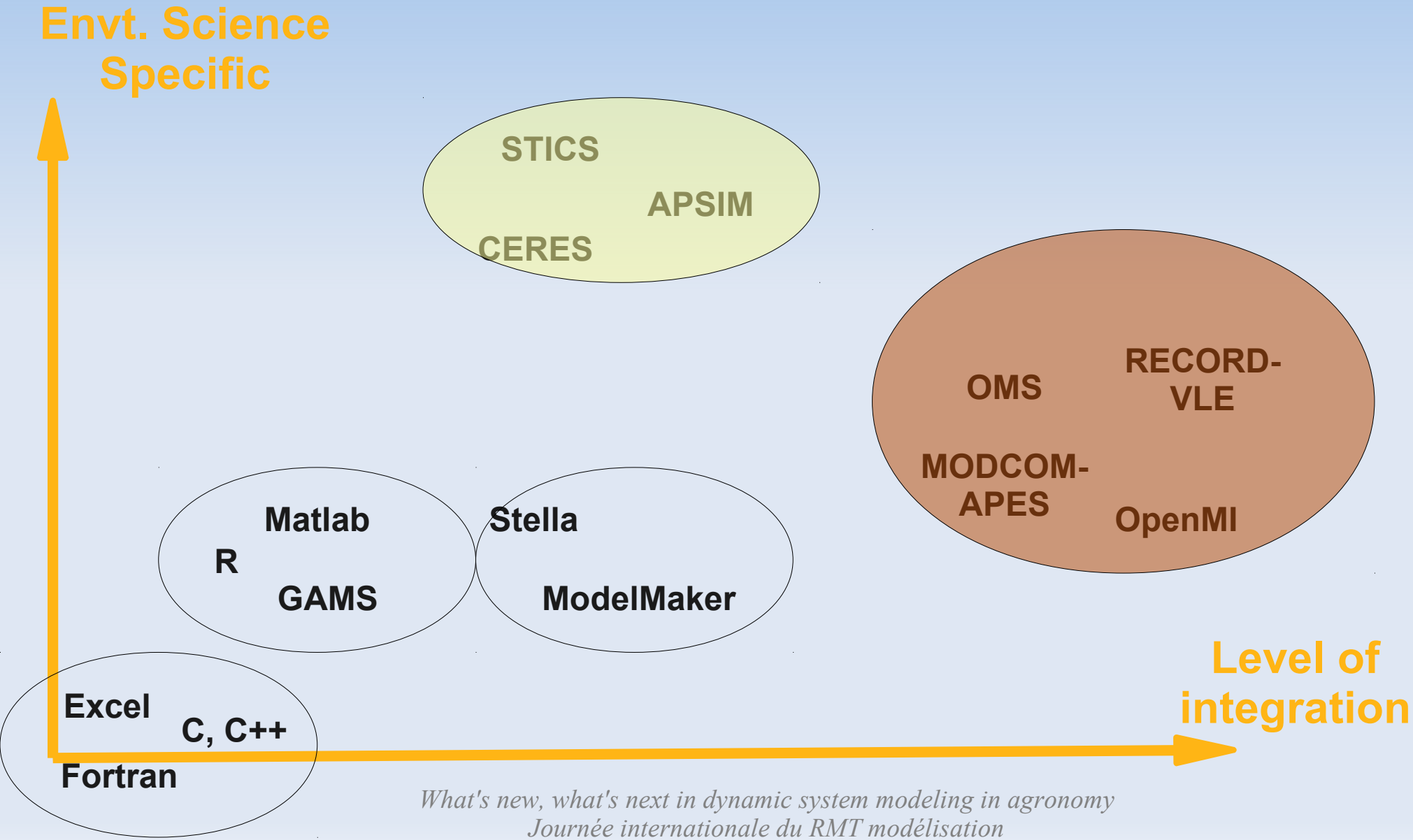


An overview of softwares used in Agricultural Systems research



Reasons for the use of modeling and simulating FW in agronomy/environmental science

3 important reasons:

- Dealing with complexity
- Re-using modules for different models
- Providing support for commonly needed services

(F. van evert et al, 2006)

Dealing with complexity

In Western Agricultural Systems research:

----> Increased recognition that system of interest is complex
(different domains, different scales ...)





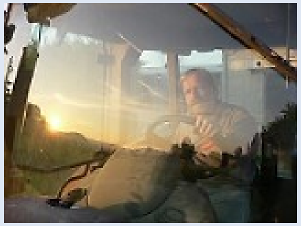
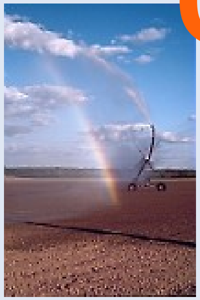


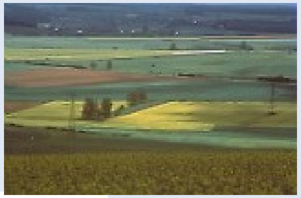


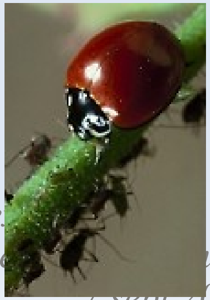




Cropping systems









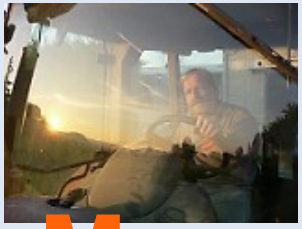
Climate



Crops + Soil



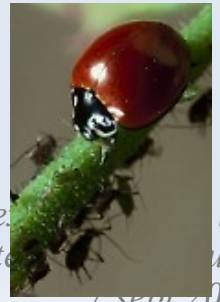
Pests



Management




Biodiversity



Landscape


Dealing with complexity

How to deal with this complexity?
Decomposition into sub-systems (until manageable complexity)
Hierarchical decomposition

The decomposition is performed according 2 ways:
- software principles
- structure principles (commonly used)

Dealing with complexity

Requested feature for the FW:
Composition of sub models ----> model

needs

- Hierarchical decomposition
- Modularity
- Coupling

Dealing with complexity

Some differences among the FW:

- Hierarchical decomposition:
  - one to several levels (APSIM ---> RECORD-VLE)
- Modularity
  - one module = one model function
  - Granularity (depends on domain of interest, software efficiency ...)
- Coupling:
  - Different types: strong or weak
  - Coupling different formalisms (RECORD-VLE)

Re-using modules for different models

2 systems can often share one or more sub-modules

Requested feature for the FW:
Common pool of sub-modules.

Performed :
Sub-modules are integrated in the FW
Users can download the sub-modules from a repository (web site, svn ...)

Providing support for commonly needed services

- Engine of simulation
- Numerical integration
- Management of Input / Output (links with databases, GIS ...)
- Statistical , numerical (optimization) methods

And also ...

- Capitalisation of models

- Modules library, specific of the domain of interest

- Take into account different types of users:
Modelers, linkers, people who just want to use models

.Better software developments:
a lot of tools (documentation from the source code, collaborative tools (versioning, wiki, forum ...))

Illustration: RECORD

RECORD : an **integrated framework** to build evaluate and simulate cropping systems

INRA project (department EA & department MIA)
To help the French researcher community working on cropping systems development,

The building phase of the RECORD modelling framework is quite over (kick off, scheduled on end 2010)

Web site: http://record.toulouse.inra.fr

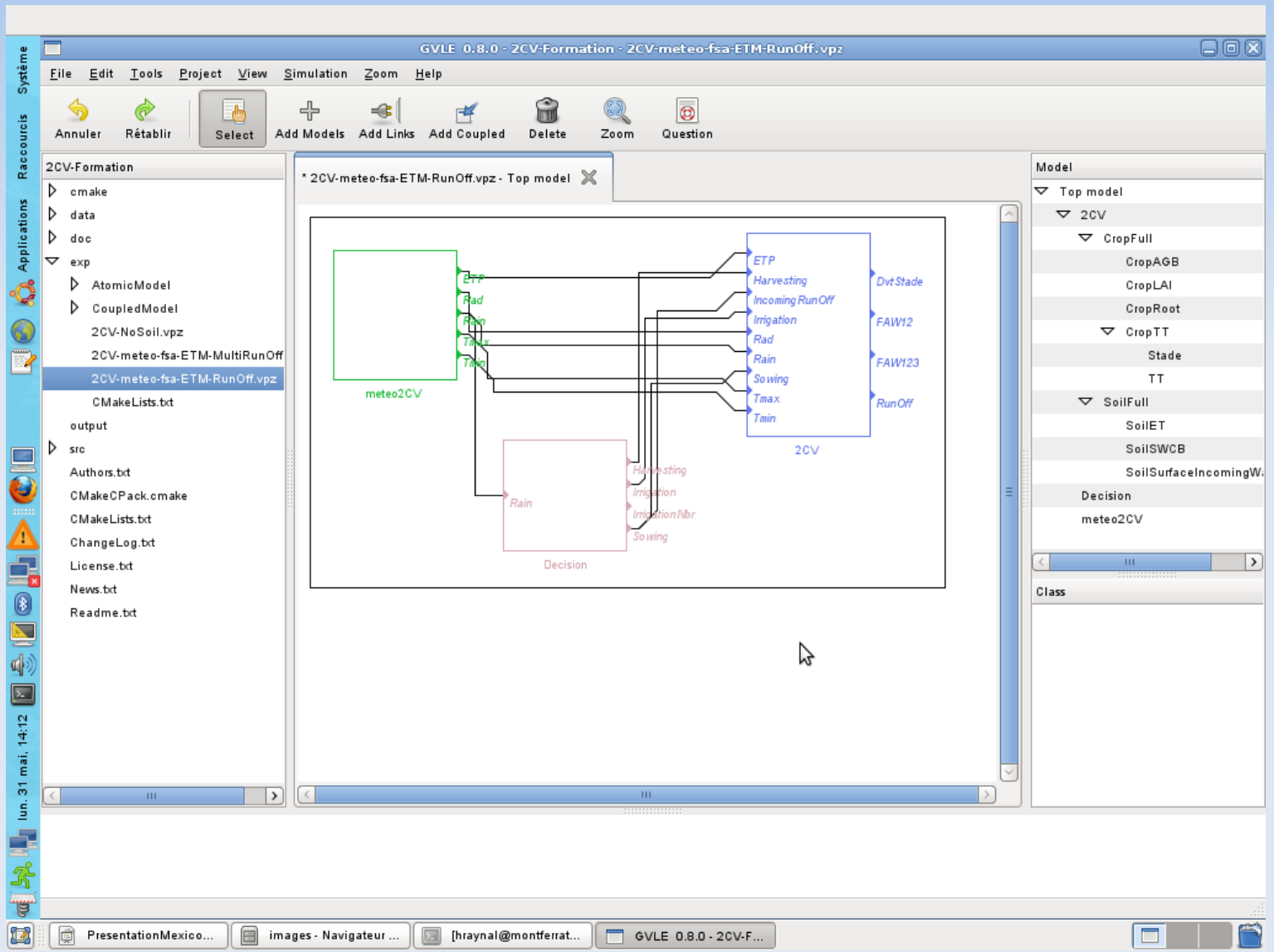
Illustration: RECORD

Software used for the RECORD project: : VLE .
Website : http://www.vle-project.org

Formalism DEVS , used for dynamic systems modeling (B. P. Zeigler, 1976)

Convenient for dynamic systems modeling and the requirements needed by the RECORD project.

RECORD: model decomposition using the graphical interface



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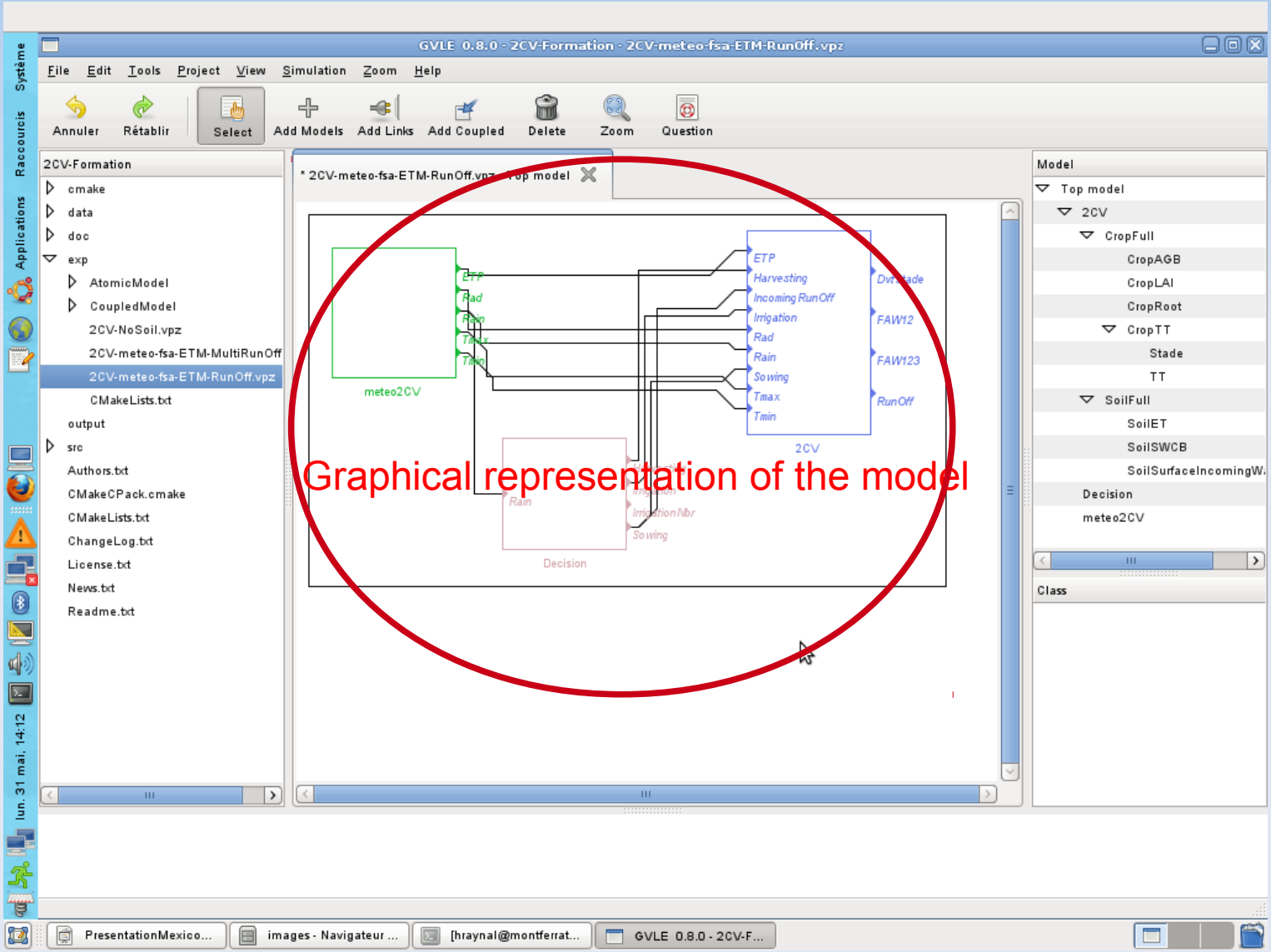

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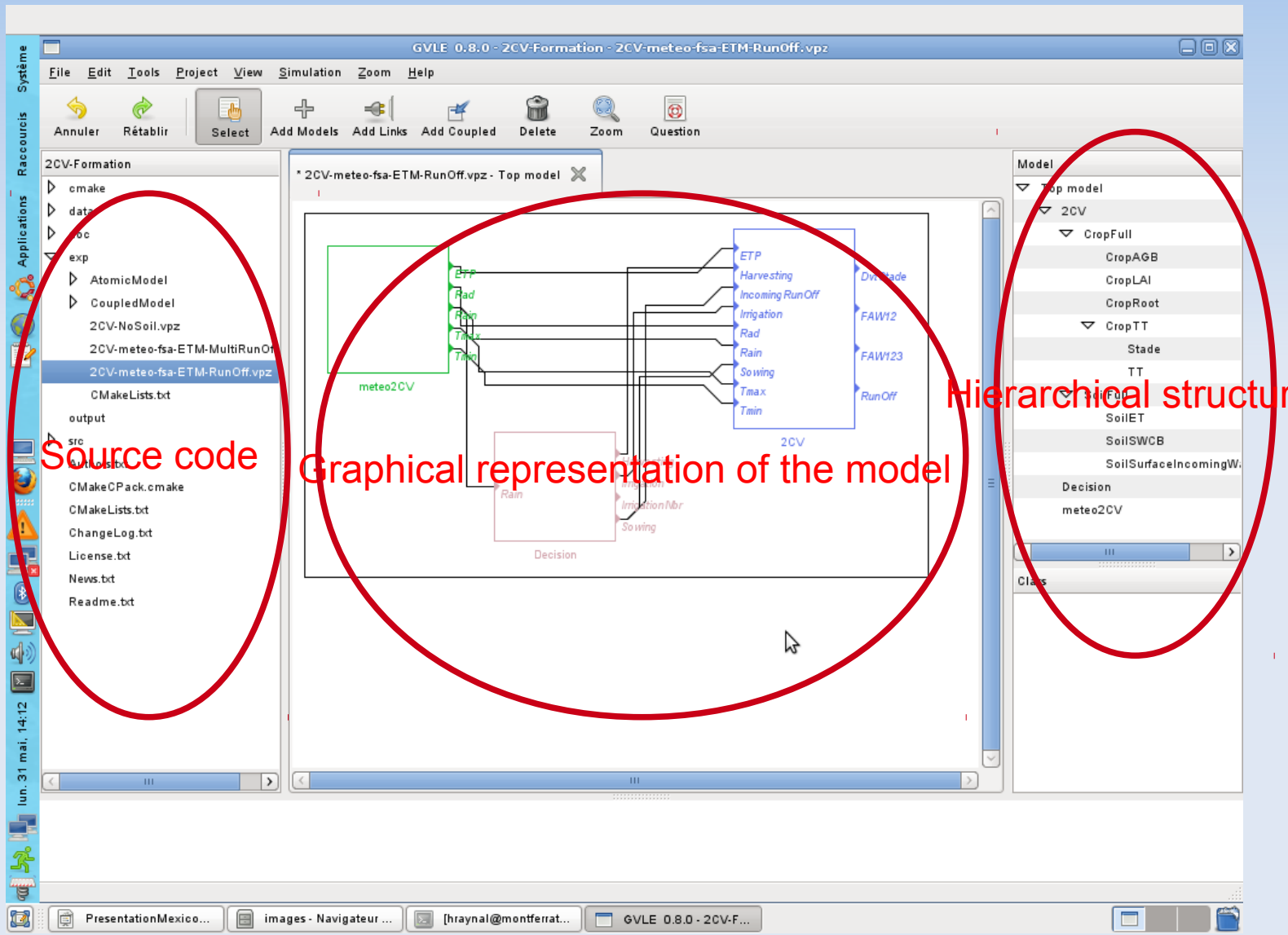

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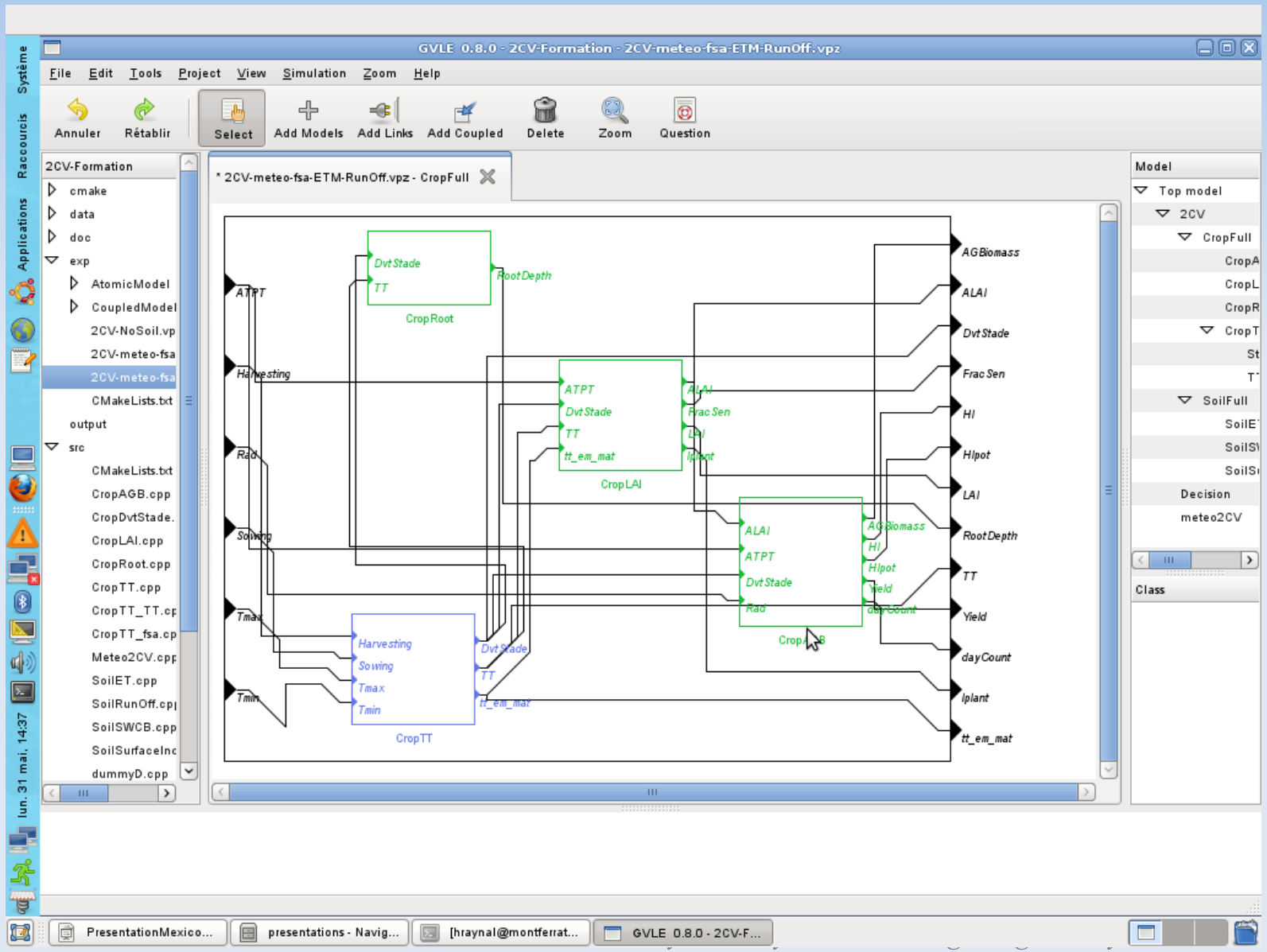

Source code of a submodule: CropLAI

*CropLAI.cpp (~/.vle/pkgs/2CV-Formation/src) - gedit

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*CropLAI.cpp

```
63
64      virtual void compute(const vle::devs::Time& /*time*/)
65      {
66        if (DvtStade() == BARE_SOIL)
67        {
68              FracSen = 0.0;
69              Iplant = 0.0;
70              LAI = 0.0;
71              ALAI = 0.0;
72        }
73        else
74        {
75              switch((int) DvtStade()){
76                    case SOWING :
77                          FracSen = FracSen(-1);
78                          break;
79                    case EMERGENCE :
80                    case MAX_LAI :
81                    case FLOWERING :
82                    case CRITICAL_GRAIN_ABORTION :
83                    case LEAF_SENESCENCE :
84                    case MATURITY :
85                          FracSen = std::max(0.,
86                                std::min(1.,
87                                      p1sen*exp(p2sen*TT()/tt_em_mat())));
88                          break;
89                    }
90              switch((int) DvtStade()){
91                    case FLOWERING :
92                    case CRITICAL_GRAIN_ABORTION :
93                    case LEAF_SENESCENCE :
94                    case MATURITY :
95                    case SOWING :
96                          Iplant = Iplant(-1);
97                          LAI = LAI(-1);
98                          ALAI = (1 - FracSen()) * LAI();
99                          break;
100                   case EMERGENCE :
101                   case MAX_LAI :
102                         double dIplant = 0;
103                         Iplant = p1logi / (1 + (p1logi / lai0 - 1) * std::exp(-p2logi * TT()));
```

C++ Largeur des tabulations: 8 Lig 103, Col 1 INS

PresentationMexico... presentations - Navig... [hraynal@montferrat... GVLE 0.8.0 - 2CV-F... *CropLAI.cpp (~/.vle/...

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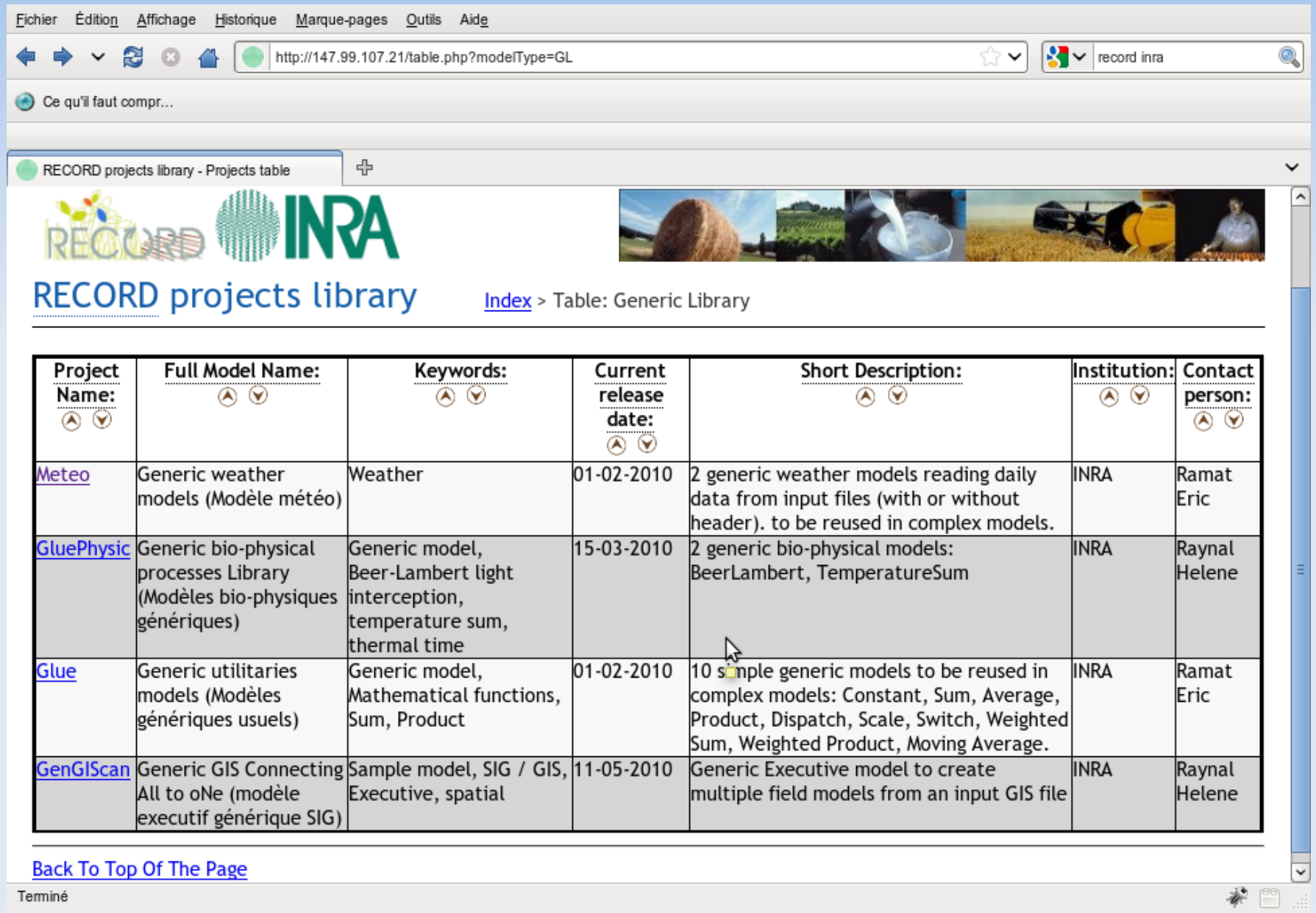
RECORD : repository of submodules



Project Name:	Full Model Name:	Keywords:	Current release date:	Short Description:	Institution:	Contact person:
Meteo	Generic weather models (Modèle météo)	Weather	01-02-2010	2 generic weather models reading daily data from input files (with or without header). to be reused in complex models.	INRA	Ramat Eric
GluePhysic	Generic bio-physical processes Library (Modèles bio-physiques génériques)	Generic model, Beer-Lambert light interception, temperature sum, thermal time	15-03-2010	2 generic bio-physical models: BeerLambert, TemperatureSum	INRA	Raynal Helene
Glue	Generic utilitaries models (Modèles génériques usuels)	Generic model, Mathematical functions, Sum, Product	01-02-2010	10 simple generic models to be reused in complex models: Constant, Sum, Average, Product, Dispatch, Scale, Switch, Weighted Sum, Weighted Product, Moving Average.	INRA	Ramat Eric
GenGISScan	Generic GIS Connecting All to oNe (modèle executif générique SIG)	Sample model, SIG / GIS, Executive, spatial	11-05-2010	Generic Executive model to create multiple field models from an input GIS file	INRA	Raynal Helene

To point out

Possible to choose the formalism :(choice according to the pb of modelisation)
---> API for modeling using different formalisms:
Difference equation, differential equation, statechart, cellular automata, activity plans, dynamic graphs ...

Coupling sub-modules with heterogeneous formalisms

Modeling management practices

Multi-simulations

Coupling to R software

Dynamic modeling

Some projects under development

ANR ACASSYA:
« Accompagner l'évolution agro-écologique
des sytèmes d'élevage dans les bassins v

Coupling 2 models

TNT2: soil model - water catchment

MELODIE: model of farming systems (coupling cattle models (cows, pigs), crop rotations, crop manure speading ...)

Spatial interaction (wide territory, accurate interactions on a wide territory)
Dynamic plan for management practices

Some projects under development

ANR MicMac

« Conception et évaluation par expérimenta
modélisation de prototypes de SdC intégrés à bas niveau d'intrants »

WP6: Design and implementation of the « MicMac modelling software environment »

Improve cropping systems (environemental considerations, sustainable cropping systems)

Coupling STICS with other models (pesticides flux, pests ...)
Databases integrations
Optimization of management practices

Some projects under development

Project SUNFLO

Crop model for sunflower
Interactions Variety * management

Cooperation with CETIOM:
Development of a web interfaced application.
Projet CASDAR « Amélioration de la productivité et de la qualité du tournesol à l'échelle du bassin de collecte d'une coop »

Perspectives

And now, what's next in FW?

What do you need?

***Some challenges to discuss*:**

More integration ?

Links to databases (important to improve assessment activity, for example ...)

Methods for sensitivity analysis ...

Generic submodules

Inter operability between FW ?